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Documentation of the Fourth Order Band Model

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Preface

We have decided to compile a preliminary documentation of the new GLAS Fourth Order General Circulation Model. The present documentation has not been subjected to a careful editing process; we hope that its possible usefulness will compensate for some of its defects. The model dynamics (COMP0, COMP1 and COMP2) is still undergoing minor improvements, especially in the time differencing scheme which we hope will improve its efficiency. The "physics" routine (COMP3) has not been documented because it is being thoroughly revised. The present version of COMP3, similar to the one used in the GLAS/GISS models (see the documentation by Tsang and Karn), with modifications introduced by Y. Sud (1979) is included in the code. Criticisms and suggestions for improvement will be reatly appreciated, since a final documentation will be prepared in 1980.

We are very grateful to all the people that have helped us generously. In particular, Dr. N. Rushfield had a major impact in the process of making the model operational. W. Connelly, D. Edelmann, D. Han, S. Breining, P. Anolick and M. Almeida were very helpful in the development of the model. The documentation was expertly and cheerfully typed by S. Mathis; D. Edelmann and D. Rosen have also cooperated in its compilation. We want to express our special gratitude toward Dr. Y. Sud, who offered us generously both his advice and his time in the development of the "physics" routine, and most especially to Dr. M. Halem without whose many useful suggestions, constant encouragement, and long patience, this work would not have been finished.

Eugenia Kalnay-Rivas

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I. Introduction

The band fourth order model is a GCM which uses quadratically conservative, fourth order horizontal space differences on an unstaggered grid and second order vertical space differences with a Matsuno (forward-backward) or a smooth leapfrog time scheme to solve the primitive equations of motion.

This program numerically solves these equations one latitude band at a time which greatly reduces the amount of computer core storage needed to run the program. It also uses the same variable names, order of computations, I/O, post-processing as the standard second order GCM. Appropriate modifications have been made for the fourth order differences and leapfrog scheme. (See the 1978 Goddard Modeling and Simulation Research Review for an overview of the fourth order band model.)

The main feature of this model is that fourth order approximations are used for all the horizontal derivatives. The derivative $\frac{\partial q}{\partial x}$ is approximated by

$$\frac{4}{3}\left(\frac{q(x+\Delta x)-q(x-\Delta x)}{2\Delta x}\right) - \frac{1}{3}\left(\frac{q(x+2\Delta x)-q(x-2\Delta x)}{4\Delta x}\right)$$

and the derivative $\frac{\partial}{\partial x}(qT)$ by

$$\frac{4}{3}\left[\frac{(T(x)+T(x+\Delta x))(q(x)+q(x+\Delta x)) - (T(x)+T(x-\Delta x))(q(x)+q(x-\Delta x))}{4\Delta x}\right]$$

$$-\frac{1}{3}\left[\frac{(T(x)+T(x+2\Delta x))(q(x)+q(x+2\Delta x)) - (T(x)+T(x-2\Delta x))(q(x)+q(x-2\Delta x))}{8\Delta x}\right]$$

The second approximation is derived by averaging the flux qT to yield a conservative form of the dynamic equations. Note that if T is equal to 1 the second equation reduces to the first.

The primary variables are the horizontal components of the wind velocity, $\mathbb{V}=(u,v)$, the temperature, T, the specific humidity, q, and the shifted surface pressure, π, ($\pi=P_s-P_{top}$, $P_{top}=10$ mb).

The secondary variables are the geopotential, ϕ, the vertical wind velocity, $\dot{\sigma}$, and the pressure, p.

The following pages give the differential equations of motion for the GCM model with the initial and boundary conditions. This is followed by the equations with the corresponding fourth order approximations which use the same notation as the current second order model. A complete description of the primitive equations with the σ coordinate system is found in the Arakawa UCLA notes (1976).

II. Primitive Equations of Motion

1.&2. Horizontal momentum equations

$$\mathbb{V}\frac{d\pi}{dt}+\pi\frac{d\mathbb{V}}{dt} = \frac{\partial \pi\mathbb{V}}{\partial t} + \nabla\cdot(\pi\mathbb{V}\mathbb{V}) + \frac{\partial}{\partial\sigma}(\pi\dot{\sigma}\mathbb{V})$$

$$= -\pi\nabla\phi - \pi\sigma\frac{RT}{p}\nabla\pi - (f+u\frac{\tan\phi}{a})\,\mathbb{k}\times\pi\mathbb{V} + \pi\mathbb{F}$$

3. Continuity equation

$$(3.1)\quad \frac{\partial\pi}{\partial t} + \nabla\cdot(\pi\mathbb{V}) + \frac{\partial}{\partial\sigma}(\pi\dot{\sigma}) = 0\ , \quad \text{or}$$

$$(3.2)\quad \frac{\partial\pi}{\partial t} = -\int_0^1 \nabla\cdot(\pi\mathbb{V})\,d\sigma = -\nabla\cdot\int_0^1 \pi\mathbb{V}\,d\sigma$$

4. Equation of state

$$\alpha = \frac{RT}{p}$$

5. First law of thermodynamics

$$\frac{\partial\pi T}{\partial t} + \nabla\cdot(\pi\mathbb{V}T) + \frac{\partial}{\partial\sigma}(\pi\dot{\sigma}T) = \frac{\pi\omega\alpha}{C_p} + \frac{\pi Q}{C_p} \qquad (\omega=\frac{dp}{dt})$$

From $\theta = T/p^k$, $p=p_T+\sigma\pi$, $\omega=\dot{\sigma}\pi+\dot{\pi}\sigma$, $\dot{\pi}=\frac{\partial\pi}{\partial t}+\mathbb{V}\cdot\nabla\pi$, $k=R/C_p$ we get

$$\frac{\partial\pi\dot{\sigma}T}{\partial\sigma} = p^k\,\frac{\partial\pi\dot{\sigma}\theta}{\partial\sigma} + \pi\frac{\dot{\sigma}\alpha\pi}{C_p}$$

Replacing in 5,

$$\frac{\partial\pi T}{\partial t} + \nabla(\pi\mathbb{V}T) + p^k\,\frac{\partial\pi\dot{\sigma}\theta}{\partial\sigma} = \frac{\pi\sigma kT}{p}(\frac{\partial\pi}{\partial t} + \mathbb{V}\cdot\nabla\pi) + \frac{\pi Q}{C_p}$$

6. Humidity equation

$$\frac{\partial\pi q}{\partial t} + \nabla\cdot(\pi\mathbb{V}q) = 0$$

7. Hydrostatic equation

$$\frac{\partial\phi}{\partial p^k} = -C_p\theta \qquad (\text{from } \frac{\partial p}{\partial\phi} = -\rho = -\frac{1}{\alpha})$$

Of the variables $\pi, u, v, T, q, \phi, \alpha, \dot{\sigma}$ we update the 5 primary variables π, u, v, T, and q using equations 1,2,3.2,5 and 6. From equations 3.1, 4, and 7 we can obtain ϕ, α, and $\dot{\sigma}$ which are our secondary variables. Note that $p=\sigma\pi+p_{top}$.

Sea level pressure (used only in the smoothing routine SMSHAP)

$$\text{Hydrostatic eq.} \Rightarrow \frac{\partial p}{\partial \phi} = -p = -\frac{1}{\alpha} = -\frac{p}{RT} \therefore \log\left(\frac{SLP}{p}\right) = -\int_{\phi_s}^{0} \frac{d\phi}{RT}$$

$$\therefore \ SLP = p(\sigma=1)\ \exp\left(\frac{\phi_s}{R\overline{T}}\right)$$

DERIVATION OF THE EQUATIONS AT THE POLES

Consider the continuity equation

$$\frac{\partial \pi}{\partial t} + \nabla.(\pi \mathbb{V}) + \frac{\partial \pi \dot{\sigma}}{\partial \sigma} = 0$$

coupled with a conservation equation $\frac{dT}{dt}$=S which can be expanded into

$$\frac{\partial \pi T}{\partial t} + \nabla.(\pi \mathbb{V} T) + \frac{\partial \pi \dot{\sigma} T}{\partial \sigma} = \pi S$$

If we integrate this equation over a polar cap of radius $\Delta\phi$

$$\int_0^{2\pi} \int_{\frac{\pi}{2}}^{\frac{\pi}{2}-\Delta\phi} \frac{\partial \pi T}{\partial t} a^2 \cos\phi d\phi d\lambda = - \int_0^{2\pi} \int_{\frac{\pi}{2}}^{\frac{\pi}{2}-\Delta\phi} \nabla.(\pi \mathbb{V} T) a^2 \cos\phi d\phi d\lambda$$

$$- \int_0^{2\pi} \int_{\pi/2}^{\pi/2-\Delta\phi} \frac{\partial \pi \dot{\sigma} T}{\partial \sigma} a^2 \cos\phi d\phi d\lambda - \int_0^{2\pi} \int_{\pi/2}^{\pi/2-\Delta\phi} \pi S a^2 \cos\phi d\phi d\lambda$$

and we assume the value of $\frac{\partial \pi T}{\partial t}$ to be approximately constant over the polar cap

$$\int_0^{2\pi} \int_{\pi/2}^{\pi/2-\Delta\phi} \frac{\partial \pi T}{\partial t} a^2 \cos\phi d\phi d\lambda \simeq \left(\frac{\partial \pi T}{\partial t}\right) \int_0^{2\pi} \int_{\pi/2}^{\pi/2-\Delta\phi} a^2 \cos\phi d\phi d\lambda$$

$$= 2\pi a^2 (1-\cos\Delta\phi) \; \left(\frac{\partial \pi T}{\partial t}\right)_{NP}$$

The first term in the rhs is, using Gauss' theorem

$$-\int_0^{2\pi} \int_{\pi/2}^{\pi/2-\Delta\phi} \nabla.(\pi \mathbb{V} T) a^2 \cos\phi d\phi d\lambda = -\int_0^{2\pi} \pi v T \; a \sin\Delta\phi d\lambda$$

This can be approximated as

$$-\frac{2\pi}{IM}\sum_{i=1}^{IM}\pi_i v_i T_i \; a \sin\Delta\phi$$

The third term on the rhs is

$$\int_0^{2\pi}\int_{\pi/2}^{\pi/2-\Delta\phi}\frac{\partial\pi\dot{\sigma}T}{\partial\sigma}\, a^2\cos\phi\, d\phi\, d\lambda \simeq 2\pi a^2(1-\cos\Delta\phi)\left(\frac{\partial\pi\dot{\sigma}T}{\partial\sigma}\right)_{NP}$$

and similarly with the source term.

From these equations we obtain

$$\boxed{\left(\frac{\partial\pi T}{\partial t}\right)_{Pole} = -(-1)^m\,\frac{\cot\Delta\phi/2}{aIM}\sum_{i=1}^{IM}(\pi_i v_i T_i)_{\frac{\pi}{2}-\Delta\phi} - \left(\frac{\partial\pi\dot{\sigma}T}{\partial\sigma}\right)_{Pole} + S}$$

since $\frac{2\pi a}{IM}\sin\Delta\phi\Big/2\pi a^2(1-\cos\Delta\phi) = \frac{2\sin\Delta\phi/2\cos\Delta\phi/2}{IMa\;2\sin^2\frac{\Delta\phi}{2}} = \frac{\cot\frac{\Delta\phi}{2}}{aIM}$

This formulation is used in the continuity, momentum temperature and moisture equations. Note that the first term changes sign in the South Pole (m=1). In the momentum equations we make use of the transformation

$$U_i = -\sin\lambda u_i - (-1)^m\cos\lambda v_i$$

$$V_i = (-1)^m\cos\lambda u_i - \sin\lambda v_i$$

where m=1 for the South Pole and m=2 for the North Pole. U_i, V_i are the "cartesian" velocities at longitude λ_i, and u_i, v_i the corresponding spherical velocities.

The pressure gradient terms are computed making use of Green's Theorem: $\iint\frac{\partial Q}{\partial x}\,dxdy = \oint Q dy$; $\iint\frac{\partial P}{\partial g}\,dxdy = -\oint P dx$

For example

$$\int_{0}^{2\pi}\int_{\pi/2}^{\pi/2-\Delta\phi} \frac{\partial\phi}{\partial x}\, a^2\cos\phi\, d\phi\, d\lambda = -\oint \phi a\Delta\phi(-\cos\lambda d\lambda)$$

$$\phi = \frac{\pi}{2} - \Delta\phi$$

$$\approx + \frac{a\Delta\phi 2\pi}{IM} \sum_{i=1}^{IM} \phi_i \cos\lambda_i$$

In the U-momentum equation we have then the following pressure terms

$$\left(\frac{\partial\pi U}{\partial t}\right)_P = - \frac{\Delta\phi}{a(1-\cos\phi)IM} \sum_{i=1}^{IM} \left(\phi_i + \left(\frac{\sigma RT}{\rho}\right)_P \pi_i\right)\cos\lambda_i$$

and similarly for πV .

In the model we have approximated $\Delta\phi \simeq 2\sin\frac{\Delta\phi}{2}$

Then $$\frac{\Delta\phi}{a(1-\cos\phi)IM} \simeq \frac{1}{a\sin\frac{\Delta\phi}{2}\, IM}$$

Based on this formulation we construct the fourth order scheme at the Poles by taking $\frac{4}{3}$ of the differences evaluated at $\Delta\phi$ from the Poles (as expanded here), minus $\frac{1}{3}$ of the differences at $2\Delta\phi$ from the Poles.

This formulation is <u>not conservative</u> at the Poles. However we have found that this has had no noticeable effect in the conservation of mass or energy in the model. In our shallow water experiments we studied a set of equations that were quadratically conservative, but inconsistent at the Pole, and another scheme analagous to the GFDL scheme, which is both quadratically conservative and consistent at the Poles, but suffers from a serious truncation error near the Poles in the pressure gradient term. The scheme that we chose gave better results than the other two (Kalnay-Rivas, 1976).

Computation of the horizontal pressure gradient as suggested by N. A. Phillips

(1) Let $\theta = \bar{\theta} + \theta'$, $\bar{\theta} = 280°K/1000^k$ i.e. constant

(2) $\phi = \bar{\phi} + \phi'$, $k = R/Cp = .286$

$$\frac{\partial \bar{\phi}}{\partial p^k} = -Cp\bar{\theta} \quad \therefore \; \bar{\phi} = \phi_0 - Cp\bar{\theta}p^k \quad \text{with } \phi_0 = Cp\bar{\theta}1000^k$$

(3) $T = \bar{T}(p) + T'$, $\bar{T}(p) = \bar{\theta}p^k$

Thus our new dependent variables are

$$\phi' = \phi + Cp\bar{\theta}\,(p^k - 1000^k)$$

$$T' = T - \bar{\theta}p^k$$

In this way $\pi(\nabla\phi + \frac{\sigma RT}{p}\nabla\pi)$, the pressure gradient in the momentum equations gets transformed into

(4)
$$\pi(\nabla_\sigma\bar{\phi} + \nabla_\sigma\phi' + \sigma R\bar{\theta}\frac{p^k}{p}\nabla\pi + \frac{\sigma RT'}{p}\nabla\pi)$$

$$= \pi(\nabla_\sigma\phi' + \frac{\sigma RT'}{p}\nabla\pi) + \pi(\nabla_\sigma\bar{\phi} + \sigma R\bar{\theta}\frac{p^k}{p}\nabla\pi)$$

But the second parenthesis is zero:

$$\nabla\bar{\varphi} + \sigma R\bar{\theta}\,\frac{p^k}{p}\,\nabla\pi = -Cp\bar{\theta}\nabla p^k + R\bar{\theta}\frac{p^k}{p}\nabla p = 0$$

In regions of steep orography, the second parenthesis in (4) is much larger than the first. When the horizontal pressure gradient terms are computed in their original form, the near cancellation of the two terms introduces large truncation errors. The procedure suggested by Phillips greatly reduces this truncation error. We have chosen a simpler definition of ϕ_o than the one suggested by Phillips.

III. Finite Difference Variables and Grid

The notation used in fourth band model is the same as the standard GLAS(GISS) second order GCM except that we use a non-staggered horizontal grid. A complete description of the variables can be found in the TSANG-KARN documentation of the GISS 9 level model.

Let u_{ijk}, v_{ijk}, T_{ijk}, q_{ijk}, π_{ij} be the

finite difference approximations to the primary variables u,v,T,q, and π at the mesh point $(i\Delta\lambda, j\Delta\phi, (k-\frac{1}{2})\Delta\sigma)$. Also the scaled variables $\pi u, \pi v$, ...are approximated by πu_{ijk}, πv_{ijk}, ...

The finite difference equations also use the following geometric arrays:

$$DXP(j) = m_j = a \cos\phi_j \Delta\lambda, \quad DYU(j) = n_j = a\Delta\phi_j ,$$

We use a factor of 12 in DXYP to make our scaled fourth order differences simpler.

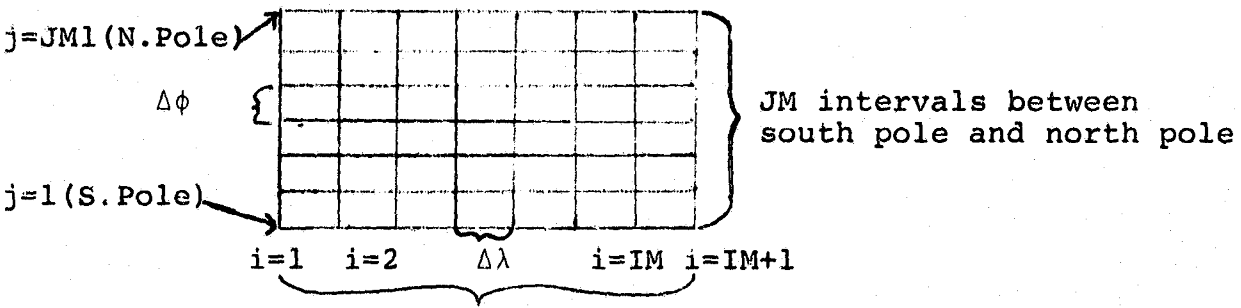
$$DXYP(j) = 12.m_j \cdot n_j , \quad \Pi_{ij} = DXYP(j) \cdot \pi_{ij} , \quad U^*_{ijk} = n_j \pi_{ij} U_{ijk}$$

$$\dot{S}_{ijk} = \Pi_{ij} \cdot \dot{\sigma}_{ijk} , \quad ADLDP = 12.a^*\Delta\lambda\Delta\phi , \quad V^*_{ijk} = m_j \pi_{jj} V_{ijk}$$

$$F_{ijk} = DXYP(j) f_j + ADLDP \cdot SIN\phi_j \, U_{i\ell j}$$

Horizontal Grid

The fourth order band model uses an unstaggered grid in the horizontal direction.



IM intervals in the longitudinal direction and periodic, i=IM+1 is identical to i=1.

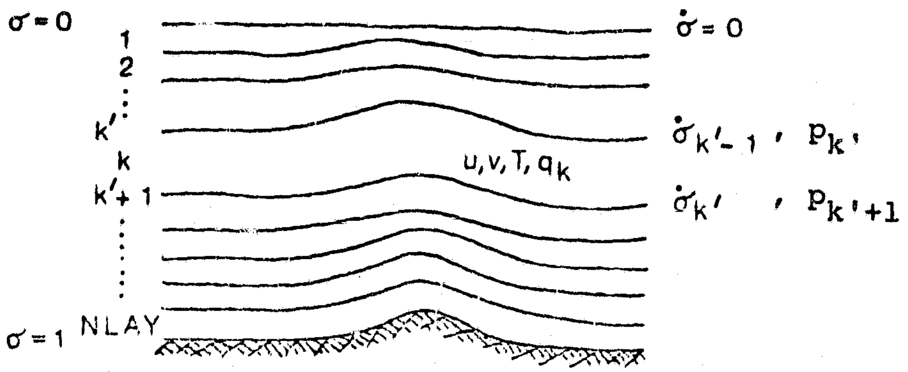
$\Delta\lambda$ = DLON = $\frac{2\pi}{IM}$ $\Delta\phi$ = DLAT = $\frac{\pi}{JM}$

$\lambda_i = (i-1)\Delta\lambda-\pi = (i-1)5°-180°$ $\phi_j = (j-1)\Delta\phi - \frac{\pi}{2} = (j-1)4°-90°$

JSP = 1 JNP = JM1 = JM+1

Vertical Grid

The vertical grid is staggered; the values of all the variables u,v,T,q,π, ... except $\dot{\sigma}$ are computed at the center of each layer. The values of $\dot{\sigma}$ are computed at the edges of the layers.



In the case of uniform vertical resolution and NLAY=9 vertical layers,

$$\sigma_k = \text{SIG}(K) = \frac{k-1}{9}(0,1/9,\ldots 1)$$

$$\sigma_{k'} = \text{SIGE}(K) = \frac{2k-1}{18} = (\frac{1}{18},\ldots,\frac{17}{18})$$

and $\Delta\sigma = 1/9$.

$\dot{\sigma}_{ijk}$ and its scaled version $\dot{S}_{ijk}$ are defined at the eight interior edges, i.e. for σ_k' with k=1 to 8 since $\dot{\sigma}(0)=\dot{\sigma}(1)=0$ from the boundary conditions. The pressure $p_{k'}=\pi\sigma_{k'}+p_{TOP}$ is defined at the same level as $\dot{\sigma}_{k'-1}$.

Note for level k we need $\dot{S}_{ijk}$ and $\dot{S}_{ijk-1}$ to form the second order vertical differences:

$$\dot{S}_{ijk}\ (V_{ijk}+V_{ijk+1}) - \dot{S}_{ijk-1}(V_{ijk}+V_{ijk-1}) \ .$$

III-2 Periodic Filtering of Short Waves

An integral part of the numerical scheme is the periodic application (every ISMTH steps, generally 2 hours) of a 16th order Shapiro filter. This has the effect of removing waves shorter than $4\Delta x$, which are not resolved in the model, while waves longer than $4\Delta x$, which are accurately computed by the difference scheme, are not affected by the filter (Kalnay-Rivas and Hoitsma, 1979).

The filter is applied to an array q_j in the following way:
Let $d_+ (q_j) = q_{j+1}-q_j$, $d_- (q_j) = q_j-q_{j-1}$

Then a Shapiro filter of order 2N is given by

$$\bar{q}_j = q_j-(-1)^N(d_+ d_-)^N q_j$$

The response of the filter applied to a wave of the form $q_j=Q \exp(i\frac{2\pi}{L}\Delta xj)$ is

$$\bar{q}_j = (1 - \sin^{2N} \frac{\pi\Delta x}{L}) q_j$$

The 2-dimensional filter is applied as a product of 1-dimensional filters (first in longitude, then in latitude). In latitude we filter the fields on great circles formed by meridians of longitude λ and $\lambda+\pi$, where $0\le \lambda <\pi$. We are presently filtering only potential temperature and sea level pressure. These fields were chosen because they are not very affected by orography. Winds are not currently filtered, because the adjustment between mass and velocity fields does not allow the development of short waves in the winds alone. However, in the tropics, where the adjustment of winds to the mass field is minimal, the winds are somewhat noisy, and we may opt to filter them too.

IV. Boundary Conditions

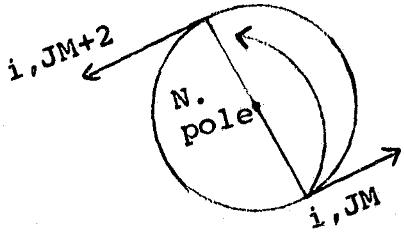
Periodicity in the Zonal (East-West) direction

$\Pi_{IM+mj} = \Pi_{mj}$ $m=1,2,3,\ldots,$ $j=2,\ldots,JM$

$Q_{IM+mjk}=Q_{mjk}$ $m=1,2,3,\ldots,$ $j=2,\ldots,JM,$ $k=1,\ldots,NLAY$

for $Q=u,v,T,q,\phi,\dot{\sigma},\pi u,\pi v,\ldots$

Boundary conditions at the north and south poles. Define the array INDEX as follows:



$$\text{INDEX}(i) = i + \frac{IM}{2} \qquad i=1,2,\ldots,\frac{IM}{2}$$

$$\text{INDEX}\left(i+\frac{IM}{2}\right) = i \qquad i=\frac{IM}{2}+1,\ldots,IM$$

i.e., INDEX: $\frac{IM}{2}+1,\ \frac{IM}{2}+2,\ldots,IM,1,2,\ldots,\frac{IM}{2}$

Then we can define

$\pi_{iJM+2} = \pi_{\text{INDEX}(i)JM}$ for the points needed "beyond" the North Pole,

and $\pi_{i0} = \pi_{\text{INDEX}(i)2}$ for the points "beyond" the South Pole

and similarly for T,q,ϕ.

For the horizontal velocity $V=(u,v)$ we have

$$V_{iJM+2k} = -V_{iJMk}$$

$$V_{i0k} = -V_{i2k}$$

V. Finite Difference Equations

THE ZONAL (U) MOMENTUM EQUATION

$$\frac{\partial \pi u}{\partial t} = -\frac{1}{a\cos\phi}\left[\frac{\partial(\pi u\cdot u)}{\partial\lambda} + \frac{\partial(\pi v\cos\phi\cdot u)}{\partial\phi}\right] - \frac{\partial(\pi\dot{\sigma}u)}{\partial\sigma}$$

$$-\frac{\pi}{a\cos\phi}\left[\frac{\partial\phi}{\partial\lambda} + \frac{\sigma RT}{p}\frac{\partial\pi}{\partial\lambda}\right] + \left(f + \frac{u\tan\phi}{a}\right)\pi v + \pi F_x$$

$$\frac{\partial \Pi U_{ijk}}{\partial t} \quad \text{COMP1: HA:} \quad = \Big\{ 4.*[(\overbrace{U^*_{ijk} + U^*_{i-1jk}}^{PU1_{i-1/2j}})(U_{ijk}+U_{i-1jk}) - (\overbrace{U^*_{ijk}+U^*_{i+1jk}}^{PU1_{i+1/2}})(U_{ijk}+U_{i+1jk})]$$

$$-.5[(\overbrace{U^*_{ijk}+U^*_{i-2jk}}^{PU2_{i-1}})(U_{ijk}+U_{i-2jk}) - (\overbrace{U^*_{ijk}+U^*_{i+2jk}}^{PU2_{i+1}})(U_{ijk}+U_{i+2jk})$$

$$+4* [(\overbrace{V^*_{ijk}+V^*_{ij-1k}}^{PV1})(U_{ijk}+U_{ij-1k}) - (V^*_{ijk}+V^*_{ij+1k})(U_{ijk}+U_{ij+1k})]$$

$$-.5*[(V^*_{ijk}+V^*_{ij-2k})(U_{ijk}+U_{ij-2k}) - (\overbrace{V^*_{ijk}+V^*_{ij+2k}}^{PV2})(U_{ijk}+U_{ij+2k})$$

VA:

$$+.5*[\dot{S}_{ijk-1}(U_{ijk}+U_{ijk-1}) - \dot{S}_{ijk}(U_{ijk}+U_{ijk+1})]/\Delta\sigma_k \Big\}$$

COMP2: PG:

$$+(\pi_{ij}*n_j*\{8*[\phi'_{i-1jk}-\phi'_{i+1jk}+\frac{\sigma_k RT'_{ijk}}{p_k}(\pi_{i-1j}-\pi_{i+1j})] +$$

$$[\phi'_{i+2jk}-\phi'_{i-2jk}+\frac{\sigma_k RT'_{ijk}}{p_k}(\pi_{i+2j}-\pi_{i-2j})]\Big\}$$

C: COMP3

$$+ F_{ijk}*\pi_{ij}*V_{ijk}) + (\Pi F_x)$$

Note: COMP1, COMP2, COMP3 are the names of the three subroutines where the different terms are computed. HA: Horizontal advection terms. VA: Vertical advection terms. PG: Pressure gradient terms. C: Coriolis term.

Also note that PV2 is set equal to zero for j=0 and j=JM, i.e., there is no transport of mass across the poles.

THE MERIDIONAL (V) MOMENTUM EQUATION

$$\frac{\partial \pi V}{\partial t} = - \frac{1}{a\cos\phi} \left[\frac{\partial (\pi u \cdot v)}{\partial \lambda} + \frac{\partial (\pi v \cos\phi v}{\partial \phi} \right] - \frac{\partial \pi \dot{\sigma} v}{\partial \sigma}$$

$$- \frac{\pi}{a}\left[\frac{\partial \phi}{\partial \phi} + \frac{\sigma RT}{p} \frac{\partial \pi}{\partial \phi}\right] - \left(f+\frac{u\tan\phi}{a}\right) \pi u + \pi F_y$$

COMP1: HA:

$$\frac{\partial \Pi V_{ijk}}{\partial t} = \{ 4.*[(U^*_{ijk}+U^*_{i-1jk})(V_{ijk}+V_{i-1jk})-(U^*_{ijk}+U^*_{i+1jk})(V_{ijk}+V_{i+1jk})$$

$$-.5[(U^*_{ijk}+U^*{}_{i-2jk})*(V_{ijk}+V_{i-2jk})-(U^*_{ijk}+U^*_{i+2jk})(V_{ijk}+V_{i+2jk})$$

$$+4.*[(V^*_{ijk}+V^*_{ij-1k})(V_{ijk}+V_{ij-1k})-(V^*_{ijk}+V^*_{ij+1k})(V_{ijk}+V_{ij+1k})$$

$$-.5*[(V^*_{ijk}+V^*_{ij+2k})(V_{ijk}+V_{ij-2k})-(V^*_{ijk}+V^*_{ij+2k})(V_{ijk}+V_{ij+2k})$$

VA:

$$+.5*[\dot{S}_{ijk-1}(V_{ijk}+V_{ijk-1})-\dot{S}_{ijk}(V_{ijk}+V_{ijk+1})]/\Delta\sigma_k \}$$

COMP2: P:

$$+(\pi_{ij}*m_j*\{8.*[\phi'_{ij-1k}-\phi'_{ij+1k}+ \frac{\sigma_k RT'_{ijk}}{p_k} (\pi_{ij-1}-\pi_{ij+1})]$$

$$+ [\phi'_{ij+2k}-\phi'_{ij-2k}+ \frac{\sigma_k RT'_{ijk}}{p_k} (\pi_{ij+2}=\pi_{ij-2})]\}$$

C: COMP3:

$$-F_{ijk}*\pi_{ij}*U_{ijk})+(\Pi F_y)$$

THE THERMODYNAMIC ENERGY EQUATION

$$\frac{\partial \pi T}{\partial t} = -\frac{1}{a\cos\phi}\left[\frac{\partial \pi UT}{\partial \lambda} + \frac{\partial \pi V\cos\phi \cdot T}{\partial \phi}\right] - p^k \frac{\partial \pi \dot{\sigma} T/p^k}{\partial \sigma}$$

$$+ \frac{\pi\sigma KT}{p} \left(\frac{\partial \pi}{\partial t} + \frac{U}{a\cos\phi} \frac{\partial \pi}{\partial \lambda} + \frac{V}{a} \frac{\partial \pi}{\partial \phi}\right) + \frac{\pi Q}{C_p}$$

COMP1: HA:

$$\frac{\partial \Pi T_{ijk}}{\partial t} = \{4*[(U^*_{ijk}+U^*_{i-1jk})(T_{ijk}+T_{i-1jk})-(U^*_{ijk}+U^*_{i+1jk})(T_{ijk}+T_{i+1jk})$$

$$-.5*[(U^*_{ijk}+U^*_{i-2jk})(T_{ijk}+T_{i-2jk}) - (U^*_{ijk}+U^*_{i+2jk})(T_{ijk}+T_{i+2jk})$$

$$+4* [(V^*_{ijk}+V^*_{ij-1k})(T_{ijk}+T_{ij-1k}) - (V^*_{ijk}+V^*_{ij+1k})(T_{ijk}+T_{ij+1k})$$

$$-.5*[(V^*_{ijk}+V^*_{ij-2k}) (T_{ijk}+T_{ij+2k}) - (V^*_{ijk}+V^*_{ij+2k})(T_{ijk}+T_{ij+2k})]$$

VA:

$$+.5p^k_{ijk}[\dot{S}_{ijk-1}\left(\frac{T_{ijk}}{p^k_{ijk}} + \frac{T_{ijk-1}}{p^k_{ijk-1}}\right) - \dot{S}_{ijk} \left(\frac{T_{ijk}}{p^k_{ijk}} + \frac{T_{ijk+1}}{p^k_{ijk+1}}\right)]/\Delta\sigma_k \}$$

COMP2:

$$\left(+ \frac{\sigma_k KT_{ijk}}{p_{ijk}} [\pi_{ij} \frac{\partial \pi}{\partial t} + U^*_{ijk}\{8.*[\pi_{i+1j}-\pi_{i-1j}]+\pi_{i-2j}-\pi_{i+2j} \}\right.$$

$$\left. + V^*_{ijk}\{8.*[\pi_{ij+1}-\pi_{ij-1}]+\pi_{ij-2}-\pi_{ij+2}\}]\right)$$

COMP3:

$$+\left(\frac{\pi Q_{ijk}}{Cp}\right)$$

THE MOISTURE EQUATION

$$\frac{\partial \pi q}{\partial t} = - \frac{1}{a\cos\phi} \left[\frac{\partial \pi U \cdot q}{\partial \lambda} + \frac{\partial \pi V\cos\phi \cdot q}{\partial \phi}\right] - \frac{\partial \pi \dot{\sigma} q}{\pi\sigma} + \pi(E-C)$$

COMP1: HA

$$\frac{\partial \Pi q_{ijk}}{\partial t} = \{4.*[(U^{*}_{ijk}+U^{*}_{i-1jk})(q_{ijk}+q_{i-1jk})-(U^{*}_{ijk}+U^{*}_{i+1jk})(q_{ijk}+q_{i+1jk})]$$

$$-.5*[(U^{*}_{ijk}+U^{*}_{i+2jk})(q_{ijk}+q_{i-2jk})-(U^{*}_{ijk}+U^{*}_{i+2jk})(q_{ijk}+q_{i+2jk})]$$

$$+4.*[(V^{*}_{ijk}+V^{*}_{ij-1k})(q_{ijk}+q_{ij-1k})-(V^{*}_{ijk}+V^{*}_{ij+1k})(q_{ijk}+q_{ij+1k})]$$

$$-.5*[(V^{*}_{ijk}+V^{*}_{ij-2k})\ (q_{ijk}+q_{ij-2k})-(V^{*}_{ijk}+V^{*}_{ij+2k})(q_{ijk}+q_{ij+2k})]$$

$$+.5*[\dot{S}_{ijk-1}(q_{ijk}+q_{ijk-1})-\dot{S}_{ijk}(q_{ijk}+q_{ijk+1})]/\Delta\sigma_{k}\}$$

COMP3:

$$+\Pi(E_{ijk}-C_{ijk})$$

Note: The current transport scheme for the moisture field is being modified.

THE PRESSURE-TENDENCY EQUATION

$$\frac{\partial \pi}{\partial t} = - \sum_{\ell=1}^{L} \frac{(\Delta\sigma)_\ell}{a\cos\phi} \left[\frac{\partial \pi u}{\partial \lambda} + \frac{\partial \pi v\cos\phi}{\partial \phi}\right]$$

COMP1:

$$\mathrm{CONV}_{i\ell j} = \Delta\sigma_\ell \{8.*(U^*_{i-1j\ell} - U^*_{i+1j\ell}) + U^*_{i+2j\ell} - U^*_{i-2j\ell}$$
$$+ 8.*(V^*_{ij-1\ell} - V^*_{ij+1\ell}) + V^*_{ij+2\ell} - V^*_{ij-2\ell}\}$$

COMP1:

$$\frac{\partial \Pi_{ij}}{\partial t} = \left(\sum_{\ell=1}^{L} \mathrm{CONV}_{i\ell j} \right)$$

THE VERTICAL VELOCITY EQUATION

$$\frac{\partial \pi}{\partial t} = - \frac{1}{a\cos\phi} \left[\frac{\partial \pi U}{\partial \lambda} + \frac{\partial \pi V\cos\phi}{\partial \phi}\right] - \frac{\partial}{\partial \sigma} (\pi \dot{\sigma})$$

Thus

$$\Delta\sigma_k \frac{\partial \Pi}{\partial t} = \mathrm{CONV}_{ikj} - \Delta\dot{S}_{ijk}$$

giving:

COMP1:

$$\dot{S}_{ijk} = \{\dot{S}_{ijk-1} + \mathrm{CONV}_{ikj} - \Delta\sigma_k \frac{\partial \Pi}{\partial T}\}$$

VI. The Forecast Equations at the Poles

The fourth order band model uses a spherical cap at the poles, and the finite difference approximations to the equations of motion must be derived for this spherical region. Stereographic projection is used to give us a well-defined velocity vector at the poles.

From trigonometry, (Fig. VIa) if the vector (U,V) in X-Y coordinates is represented by (U',V') in X'-Y' coordinates where the prime coordinate axes are rotated by an angle λ then,

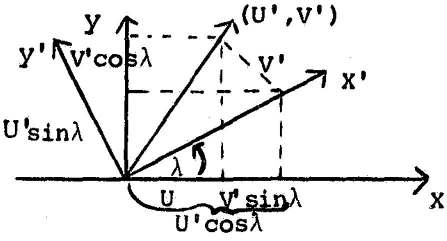


Fig. VIa

$$(1) \quad U = U'\cos\lambda - V'\sin\lambda$$

$$(2) \quad V = U'\sin\lambda - V'\cos\lambda$$

We want to interpret "polar stereographic" velocities (U_{NP}, V_{NP}) also as "spherical" velocities $(U,V)_\lambda$, as we approach the North Pole along a meridian of longitude λ. From Fig. VIb, which shows a unit vector in both coordinate systems, we see that, at the North Pole, spherical coordinates are rotated by an angle $(\frac{\pi}{2}+\lambda)$ with respect to the polar stereographic coordinates. Therefore,

$$U_{NP} = U\cos(\lambda+\tfrac{\pi}{2}) - V\sin(\lambda+\tfrac{\pi}{2})$$

$$V_{NP} = U\sin(\lambda+\tfrac{\pi}{2}) + V\cos(\lambda+\tfrac{\pi}{2})$$

or

$$(3) \quad \boxed{\begin{aligned} U_{NP} &= -U\sin\lambda - V\cos\lambda \\ V_{NP} &= U\cos\lambda - V\sin\lambda \end{aligned}}$$

Similarly, for the South Pole:

$$(4) \quad \boxed{\begin{aligned} U_{SP} &= -U\sin\lambda + V\cos\lambda \\ V_{SP} &= -U\cos\lambda - V\sin\lambda \end{aligned}}$$

also,

$$(5) \quad \boxed{\begin{aligned} U &= -U_{NP}\sin\lambda + V_{NP}\cos\lambda \\ V &= -U_{NP}\cos\lambda - V_{NP}\sin\lambda \end{aligned}}$$

$$(6) \quad \boxed{\begin{aligned} U &= -U_{SP}\sin\lambda - V_{SP}\cos\lambda \\ V &= U_{SP}\cos\lambda - V_{SP}\sin\lambda \end{aligned}}$$

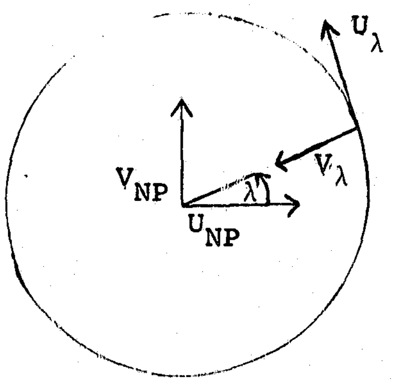


Fig. VIb

The initial values for U_{NPk} , V_{NPk} , U_{SPk} , V_{SPk} are obtained from equations 3 and 4 by averaging in the zonal direction on the line of latitude j=45 for the north pole and j=2 for the south pole. In the forecast stereographic velocities are advected and transformed back into spherical velocities after each time step by equations 5 and 6.

In the following equation we will denote the polar velocities by $VP_{k,m}$, $VP_{k,m}$ and the temperature and other variables in a similar way, $TP_{k,m}$, $\pi P_{k,m}$, ... where m=1 for the south pole and m=2 for the north pole. The following constants are used,

$COEF1=(-1)^{m}$ $\quad$ $COEF2=-COEF1$ $\quad$ $RADIM=3\cdot a\cdot IM$

$CON1=4COT(.5\Delta\phi)/RADIM$

$CON2=-COT(\Delta\phi)/RADIM$

$CON3=4DT/(RADIM*SIN(.5\Delta\phi)$

$CON4=DT/(RADIM*SIN(\Delta\phi))$

$JPOL(K,M)=\begin{pmatrix}2 & JM\\ 3 & JM-1\end{pmatrix}$

r=JPOL(1,m)=first interior value of j (2 for the S. Pole, JM for the N. Pole)

s=JPOL(2,m)=second interior value of j(3 for the S. Pole, JM-1 for the N. Pole).

ZONAL (U) MOMENTUM EQUATION (POLES)

COMP1:

$$\frac{\partial \pi UP}{\partial t}_{k,m} = \{COEF1*[CON1* \sum_{i=1}^{IM} -\pi_{ir}V_{irk}(U_{irk}Sin\lambda_i + COEF1*V_{irk}COS\lambda_i)$$

$$+CON2* \sum_{i=1}^{IM} -\pi_{is}V_{isk}(U_{isk}Sin\lambda_i + COEF1*V_{isk}COS\lambda_i)]$$

$$+.5[\dot{S}P_{k-1}(UP_k+UP_{k-1}) - \dot{S}P_k(UP_k+UP_{k+1})]/\Delta\sigma_k\}$$

COMP2:

$$+\ \pi P_m[-\frac{CON3}{DT} * \sum_{i=1}^{IM} (\phi'_{irk} + \frac{\sigma_k RTP'_k}{pP_k}\ \pi_{ir})COS\lambda_i$$

$$+\frac{CON4}{DT} * \sum_{i=1}^{IM} (\phi'_{isk} + \frac{\sigma_k RTP'_k}{pP_k}\ \pi_{is})COS\lambda_i]$$

COMP3:

$$+\ f_m \pi P_m \cdot VP_{k,m})\ +\ (\pi P_m \cdot FP_{k,m}$$

MERIDIONAL (V) MOMENTUM EQUATION (POLES)

COMP1:

$$\frac{\partial \pi VP}{\partial t}_{k,m} = \{COEF1*[CON1* \sum_{i=1}^{IM} -\pi_{ir}V_{irk}(COEF2*U_{irk}*COS\lambda_i + V_{irk}Sin\lambda_i)$$

$$+CON2* \sum_{i=1}^{IM} -\pi_{is}V_{isk}(COEF2*U_{isk}*COS\lambda_i + V_{isk}Sin\lambda_i)]$$

$$+.5[\dot{S}P_{k-1}(VP_k+VP_{k-1}) - \dot{S}P_k(VP_k+VP_{k+1})]/\Delta\sigma_k\}$$

COMP2:

$$+\pi P_m \cdot [-\frac{CON3}{DT} * \sum_{i=1}^{IM} (\phi'_{irk} + \frac{\sigma_k RTP_k}{pP_k}\pi_{ir})Sin\lambda_i$$

$$+\frac{CON4}{DT} * \sum_{i=1}^{IM} (\phi'_{isk} + \frac{\sigma_k RTP_k}{pP_k}\pi_{is})Sin\lambda_i]$$

COMP3:

$$-\ f_m \pi P_m \cdot UP_{k,m}\ +\ (\pi P_m \cdot SP_{k,m})$$

THE THERMODYNAMICS ENERGY EQUATION (POLES)

COMP1:

$$\frac{\partial \pi TP_{k,m}}{\partial t} = \{COEF1*(CON1*\sum_{i=1}^{IM} \pi_{ir}V_{irk}T_{irk}+CON2*\sum_{i=1}^{IM} \pi_{is}V_{isk}T_{isk})$$

$$+.5pP^{k}_{k,m}*[\dot{S}P_{k-1,m}(\frac{TP_{k,m}}{pP^{k}_{k,m}} + \frac{TP_{k-1,m}}{pP^{k}_{k-1,m}})$$

$$-\dot{S}P_{k,m}(\frac{TP_{k,m}}{pP^{k}_{k,m}} + \frac{TP_{k+1,m}}{pP^{k}_{k+1,m}})]/\Delta\sigma_{k}\}$$

COMP2:

$$+(\frac{\pi P_{m}\sigma_{k}KTP_{k,m}}{pP_{k,m}}\{\frac{\partial \pi P_{m}}{\partial t} + CON5*\sum_{i=1}^{IM}[(COEF1*UP_{k,m}COS\lambda_{i}+VP_{k,m}SIN\lambda_{i})*(8\pi_{ir}-\pi_{is})]\})$$

COMP3:

$$+(\frac{\pi P_{m}}{Cp} QP_{k})$$

THE MOISTURE BALANCE EQUATION (POLES)

COMP1:

$$\frac{\partial \pi qP_{k,m}}{\partial t} = \{COEF1*(CON1*\sum_{i=1}^{IM} \pi_{ir}V_{irk}q_{irk}+CON2*\sum_{i=1}^{IM} \pi_{is}V_{isk}q_{isk})$$

$$+.5[\dot{S}P_{k-1,m}(qP_{k,m}+qP_{k-1,m})-\dot{S}P_{k,m}(qP_{k,m}+qP_{k+1,m})]/\Delta\sigma_{k}\}$$

COMP3:

$$+(\pi P_{m}*EP_{k})$$

THE PRESSURE TENDENCY EQUATION (POLES)

$$CONVPL_{k,m}=COEF1*(CON1*\sum_{i=1}^{IM}\pi_{ir}V_{irk}+CON2*\sum_{i=1}^{IM}\pi_{is}V_{isk})\Delta\sigma_k$$

$$\frac{\partial \pi P_m}{\partial t} = \sum_{k=1}^{NLAY} CONVPL_{k,m}$$

THE VERTICAL VELOCITY EQUATION (POLES)

$$\dot{S}P_{k,m} = \dot{S}P_{k-1,m} + CONVPL_k - \Delta\sigma_k \frac{\partial \pi P_m}{\partial t}$$

VII. Diagnostic Equations ($\phi,\dot{\sigma},p$)

Once the updated values of πU, πV, πT, πq are found we unscale:

$$U^{n+1}_{ijk} = \pi U^{n+1}_{ijk}/\pi^{n+1}_{ij} \qquad \text{for all } i,j,k.$$

Similarly for V,T,q. We also filter the fields near the poles to prevent linear instability (see subroutine AVRX). $\dot{\sigma}$ is obtained from $\dot{S}$ by unscaling also.

We determine from π^{n+1}_{ij} and σ_k, p^{n+1}_{ijk}

$$p^{n+1}_{ijk} = \sigma_k \pi^{n+1}_{ij} + p_{TOP} \qquad p_{TOP}=\text{constant.}$$

ϕ_S is the surface geopotential (a function only of latitude and longitude)

For the Phillips geopotential we define $(p)^k$ at the center of the layer in the following way:

$$(p)^k_{ijk} = \frac{p^{k+1}_{ijk+1'} - p^{k+1}_{ijk'}}{(k+1)(p_{ijk'+1}-p_{ijk'})} \qquad \left(p^k = \frac{1}{k+1}\,\frac{\partial p^{k+1}}{\partial p}\right)$$

$k=1,2,\ldots,NLAY$

where

$$p^{k+1}_{ijk'} = (SIGE(k)*\pi_{ij}+p_{TOP})^{k+1} \qquad (SIGE(k)=\sigma'_k), \text{ i.e.}$$

p^{k+1} is obtained by exponentiation and $(p)^k$ by differences.

The following equations represent the geopotential calculations used in the old fourth order model.

Let

$$C_{ijk} = \frac{\pi_{ij}\sigma_k R\Delta\sigma_k}{p_{ijk}} - \frac{C_p}{2}\left[\sigma_{k'}\left(\frac{p^k_{ijk+1}}{p^k_{ijk}} - 1\right) + \sigma_{k'-1}\left(1-\frac{p^k_{ijk-1}}{p^k_{ijk}}\right)\right]$$

for $k=1,\ldots,NLAY$

with

$$p^k_{ij0} = p^k_{ij1} \text{ and } p^k_{ijNLAY+1} = p^k_{ijNLAY}$$

An optimized version of C_{ijk} is:

$$C_{ijk} = \frac{\pi_{ij}\sigma_k R\Delta\sigma_k}{p_{ijk}} - \frac{.5Cp}{p^k_{ijk}}\left\{\Delta\sigma_{k'}(p^k_{ijk+1}-p^k_{ijk})+\sigma'_{k-1}(p^k_{ijk+1}-p^k_{ijk-1})\right\}$$

Rather than compute ϕ and then subtract $\overline{\phi}$ we do everything at once:

(1) $$\phi'_{ijNLAY} = \phi'_S - CPTH*(PSKAPA - p^k_{ijNLAY}) + \sum_{\ell=1}^{NLAY} C_{ij\ell}T_{ij\ell}$$

(2) $$\phi'_{ij\ell} = \phi'_{ij\ell+1} + \frac{Cp}{2}*(p^k_{ij\ell+1}-p^k_{ijk})\left(\left(\frac{T_{ijk}}{p^k_{ijk}} + \frac{T_{ijk+1}}{p^k_{ijk+1}}\right) - 2\overline{\theta}\right)$$

where

$CPTH = C_p \cdot \overline{\theta}$ $PSKAPA = 1000^k = p_s^k$.

VIII. The Time Differencing Scheme

The fourth order band model has the option of using the Matsuno time scheme or the smooth leapfrog scheme (see MWR-Vol 100 (487-490) R. Asselin).

Let Q^n represent a typical variable that is to be updated to time n+1, and let $D(Q^n)$ represent the nonlinear space differences. The Matsuno (Euler-backward) scheme is as follows:

$$\tilde{Q} = Q^n + \Delta t D(Q^n)$$

$$Q^{n+1} = Q^n + \Delta t D(\tilde{Q})$$

The standard leapfrog scheme is given by

$$\frac{Q^{n+1} - Q^{n-1}}{2\Delta t} = D(Q^n) \tag{1}$$

For the smooth leapfrog scheme we replace Q^{n-1} by $\bar{Q}^{n-1}$

$$Q^{n+1} = \bar{Q}^{n-1} + 2\Delta t D(Q^n) \tag{2}$$

with

$$\bar{Q}^n = (1-\nu)Q^n + .5\nu(\bar{Q}^{n-1} + Q^{n+1}) \tag{3}$$

Equation (3) represents a simple time filter except $\bar{Q}^{n-1}$ is used instead of Q^{n-1} in order to save core storage. The above equations (2) and (3) represent the order in which the smooth leapfrog scheme is evaluated. For n=1 we define $\bar{Q}^0 = Q^0$ then we update in equation (2) followed by the filtering in equation (3) which is needed for the next time step.

The smoothing step introduces dissipation with respect to time, controlled explicitly by the parameter ν, as compared to the implicit dissipation in the Matsuno scheme. The amplification factor can be found in the paper by Asselin.

A further modification must be made to the smooth leapfrog scheme when source terms are included. Essentially the idea is that we must include the source term effect over two steps rather than one. If we do not do this, then the source effects (COMP3) are included only in every other step which will introduce large discretization errors. (For details see the attached report, Appendix B.)

If the source terms are called every NCOMP3 steps, then for step n=NCOMP3

$$Q_*^n = \bar{Q}^{n-2} + 2\Delta t D(Q^{n-1})$$

$$\bar{Q}_*^{n-1} = (1-\nu) \quad Q^{n-1} + .5\nu(\bar{Q}^{n-2} + Q^n)$$

Then compute the source terms S^n and include in both steps n and n-1,

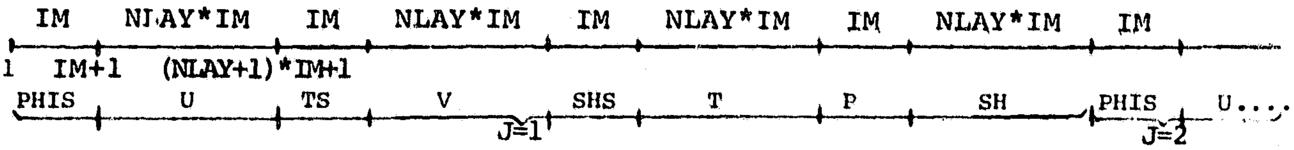
$$Q^n = Q_*^n + \text{NCOMP3}\cdot\Delta t S^n$$

$$\bar{Q}^{n-1} = \bar{Q}_*^{n-1} + \text{NCOMP3}\cdot\Delta t S^n$$

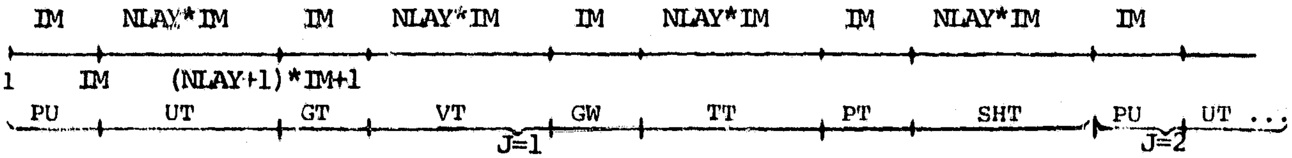
The actual code is complicated by the fact that we actually use scaled and unscaled variables, but the generalization is straightforward.

IX. Documentation of the Code (Preliminary)

The band fourth model uses special equivalences and nonstandard dimensions in order to have the variables P,U,V,T,SH stored in contiguous locations for each line of latitude. Thus, we desire to have the variables stored as follows.



The scaled variables PT, UT, VT, TT, SHT are to be stored as follows:



The above storage designation is accomplished by dimensioning PHIS(4*(NLAY+1)*IM,JNP) instead of PHIS(IM,JNP) (for a fine grid we have PHIS(2880,46), for ultrafine we have PHIS(4800,72)). Then we equivalence NLAY*IM locations of the first line of latitude of U with PHIS(IM+1,1) to PHIS((NLAY+1)*IM,1) (the first IM locations of PHIS are used for the quantity PHIS itself).

Similarly, we equivalence TS(1,1) to TS(IM,1) with PHIS((NLAY+1)*IM+1,1) to PHIS((NLAY+2)*IM,1) and so forth. (See the enclosed computer codes for the exact values in the fine and ultrafine versions.)

In order to have the successive lines of latitude arranged properly in storage we dimension our variables to achieve this purpose. Thus, we have U(IM,4*(NLAY+1),1) instead of U(IM,NLAY,JM), similarly for V,T,SH,UT,VT,TT, and SHT. For P we have P(4*(NLAY+1)*IM,1) instead of P(IM,JNP) and similarly for TS, SHS,GT,GW, and PT. Note that the variables U,UT,... are only computed at IM*NLAY*JNP points, the special dimensions are needed to properly align the variables in storage. It is important to recall that we are using two properties of the FORTRAN Compiler:

First, by equivalencing two elements of two different arrays we implicitly equivalence the other elements of the arrays. Second, that last array dimension can be left as 1 as long as it is dimensioned properly in the calling routine or it is equivalenced to a properly dimensioned array. Note we could have dimensioned U as U(IM,4*(NLAY+1),JNP) we would use the same amount of storage. It is crucial to have the IM*(NLAY+1) dimension because it would cause the computations on U for the successive lines of latitude to be shifted IM*(NLAY+1) locations where the next line of latitude of U are stored. For clarity and simplicity in programming we use the standard equivalence of U,V,T,SH with Q(I,L,N,J) with U equivalent to Q(I,L,1,J) and so forth. Since we want P,U,V,T, and SH in contiguous storage locations and the equivalence of Q with U,V,T, and SH, then we must dimension Q as Q(IM,NLAY+1,4,1) instead of Q(IM,NLAY,4,1). We fill in the extra locations by including PHIS,TS,SH, and P.

COMP0 Description

This subroutine contains the time schemes and controls the calling sequences of the routines COMP1, COMP2, COMP3, and the polar filtering routine AVRX.

The logic of this subroutine involves three considerations. First, it permits one to choose either the Matsuno or the smooth leapfrog time scheme. Second, the latter scheme involves the use of storage arrays PSM and QSM. Third, the unscaling, smoothing of the updated variables QT and the call of subroutine COMP3 occur at the value JS2=J-2 when J is the value of the current line of latitude which is being computed. The routine COMP1 and COMP2 require the values of U,V,... at JS2 in order to compute the updated values at J because fourth order differences are used in the meridional (J) direction. Only after the COMP1 and COMP2 are called for value J can we unscale, smooth, and finish processing the variables at JS2.

The code for the poles is identical in format with the code for the other J values except the variables are scaled by the pressure PPOL only.

The main program contains two calls to COMP0 which cannot be treated independently because of the calling sequence: COMP0(Q,QT), COMP0 (QT,Q). If the first call is a leapfrog step (LF), the second one must be also LF. If the first call is Matsuno predictor (MP), the second one must be Matsuno corrector (MC). This is represented symbolically by LF→LF, or MP→MC. The second call can be followed by either MP or LF. Each of these combinations requires different transfers.

Description of the Time Step Sequence Parameters

NSTEP:	Counts the time steps. Starts and restarts both begin with NSTEP=0.
NSEQ:	The number of steps (combined matsuno and leapfrog) in each (repeated) sequence of time steps.
MLF(I):	MLF(I)=0 or 1 according to whether the Ith step in the sequence is Leapfrog or Matsuno, respectively. First step is always Matsuno (MLF(1)=1).
ISMTH, NSM1:	Smoothing routine (SMSHAP) is called MOD(NSTEP-NSM1, ISMTH); if ISMTH=0, there is no smoothing.
NCOMP3, NCM1:	Physics routine (COMP3) is called MOD (NSTEP-NCM1, NCOMP3).

Sample Runs

Matsuno only:

NSEQ=1, MLF(1)=1, MATSUN=1, DT=750., NSM1=0, NCM1=0
BCINO3=4, ISMTH=8

Leapfrog only:

NSEQ=1, MLF(1)=1, MATSUN=0, DT=600., NSM1=0, NCM1=0
NCOMP3=5, ISMTH=10

1 Matsuno, 4 Leap-Frog:

NSEQ=5, MLF=(1,0,0,0,0), MATSUN=not needed, NSM1=0,
NCM1=0, DT=600., NCOMP3=5, ISMTH=10

COMP1 Description

The COMP1 subroutine contains the horizontal and vertical advection differences. The DO loops over I are arranged to make use of the periodicity of the variables in the zonal (I) direction. For example, suppose we are to compute D(I)=Q(I+1)-Q(I) for I=1,...,IM. Then the corresponding code is

```
          I=IM
          DO 10 IP1=1,IM
          D(I)=Q(IP1)-Q(I)
          I=IP1
       10 CONTINUE
```

Where we used the periodicity Q(IM+1)=Q(1).

In the meridional (J) direction we compute our difference approximations in stages in order to make maximum use of each line of latitude of a typical variable when it is in core. The fourth order difference approximation to $\frac{\partial Q}{\partial \phi}$ $(i\ell j\Delta\phi)=D(i,\ell,j)$

$$\frac{4}{3}\left(\frac{Q_{i\ell j+1}-Q_{i\ell j-1}}{2\Delta\phi}\right) - \frac{1}{3}\left(\frac{Q_{i\ell j+2}-Q_{i\ell j-2}}{4\Delta\phi}\right) \tag{1}$$

Thus we see that $Q_{i\ell j}$ will be needed in the difference approximations to $\frac{\partial Q}{\partial \phi}$ for j-2, j-1, j+1, and j+2. The corresponding code is

```
          DO 20    I = 1,IM
          QFLUX1=  4*(Q(I,L,JP1)+Q(I,L,J))
          QFLUX2=-.5*(Q(I,L,JP2)+Q(I,L,J))
     D(I,L,JP2)=  D(I,L,JP2)-QFLUX2
     D(I,L,JP1)=  D(I,L,JP1)-QFLUX1
     D(I,L,J)  =  D(I,L,J)+QFLUX1+QFLUX2
  20 CONTINUE
```

For simplicity the array D is inititalized to zero and Q is scaled so that (1) contains no divisions.

At the poles (j=1 or J=JNP=46) we use the values given in section IV on boundary conditions. We have special code for these cases denoted J=2 or J=JM corrections.

COMP2 Description

This routine contains the Coriolis force term, the geopotential calculation (which should be made into a separate subroutine), and the pressure gradient and energy term calculations.

The geopotential PHI is dimensioned PHI(72,9,5) since we only need at most five storage locations for any computation. We use modular arithmetic (MOD5) to compute the indices JMOD, JP1MOD, JP2MOD which correspond to the standard index values of J,J+1, and J+2. Thus PHI(I,L,6) is stored in PHI (I,L,1), and we avoid shifting array values by using the JMOD index as a pointer.

For the south pole calculation we need geopotential values at J=2 and 3, thus, for J=1 we compute PHI for J=1,2, and 3. For successive values of J we need only compute PHI at JP2 which is needed in the pressure gradient calcualtion at J. Therefore, the calculation of PHI and the associated array PK are coded for calculation at JP2. Except for the first J value we are only computing the geopotential at one latitude value for each pressure gradient calculation.

X: Flow Charts

COMPO (Q,QT)

```
                    JS1=1
                    JS2=1

                    ((MAIN LOOP))
                    DO 10 J=1,JM

                    ((COMPUTE ALL J-PARAMETERS))

     IF(JP2>JM)                                        GO TO 25

     IF(J>1)                                           GO TO 18

                    JP2=JP2MOD=2
                    ((SAVE QTPOL(M) IN QSMPOL(M),M=1,2))

18                  ((SAVE QJ(JP2) IN QSM(JP2MOD)))

     IF(JP2>2)                                         GO TO 25
                    ((INCREMENT JP2,JP2MOD))           GO TO 18

25                  CALL COMP1(Q,QT,J)
                    CALL COMP2(Q,QT,J)

                    ((ELIMINATE NEGATIVE HUMIDITIES)

     IF(PT∉(400,1100.))                                STOP

     IF(J<3)                                           GO TO 200

     IF(J=3)                                           GO TO 70

29                  ((UNSCALE QT(JS2)))
                    CALL AVRX(QT,JS2)

                    ((LEAP FROG, MATSUNO AS RELATED TO THE
                    SEQUENCE OF 2 CALLS TO COMPO:
                    1st CALL ⇒ LF ⇒ LF or MP ⇒ MC,
                    2nd CALL ⇒ LF ⇒ LF or LF ⇒ MP or MC ⇒ MP)

     IF(LF→LF)                                         GO TO 45

     IF(LF→MP.OR.MC→MP)                                GO TO 58

                    ((STATUS: MP→MC OR MC→LF))
                    ((P(I,JS2)←PSM(I,JS2MOD),Q←QSM))

     IF(MC→LF)                                         GO TO 63

                    (STATUS: MP→MC))
```

(contin.)

```
                         COMPJ (Q,QT)

58                ((P(I,JS2)←PT(I,JS2),Q←QT*DXYP*PT))    GO TO 64

45                ((P(I,JS2)← *P(I,JS2)+α*(PSM+PT),
                  Q←β*DXYP*P*Q+α*(QSM+QT*DXYP*PT)))

63                CONTINUE
                  ((SOURCE TERM CORRECTION FOR LEAP FROG))

      IF(NOT COMP3 CALL)                                 GO TO 67

                  ((Q←Q-QT*DXYP*PT))

64    IF(NOT COMP3 CALL)                                 GO TO 67

      IF(MATSUNO PREDICTOR STEP)                         GO TO 67

                  CALL COMP3(QT,JS2)
                  ((COMPLETE SOURCE TERM CORRECTION,
                  Q←Q+QT*DXYP*PT))

67    IF(J<JM)                                           GO TO 200

                  ((INCREMENT JS2,JS2MOD))

      IF(JS2≤JM)                                         GO TO 29

70                ((POLES))

200               JS2=JS1
                  JS1=J

10                CONTINUE

                  ((END OF J LOOP))

                  RETURN
```

COMP1 (Q,QT,J)

```
                  ((COMPUTE JP2-JS2MOD))

      IF(J>2)                                            GO TO 2150

                  JS1=JS2-JS1MOD=JS2MOD=1
```

(contin.)

COMP1 (Q,QT,J)

```
2150   IF (J=JM)                                              GO TO 2158
                     ((COMPUTE $PV_1,PV_2 = V^*_j + V^*_{j+2}$))
       ----------------------------●----------------------------
       IF(J=1)                                                GO TO 2225

2158                 ((COMPUTE $PU_1$, $PU_2 = U^*_i + U^*_{i+2}$))

                     ((COMPUTE HORIZ.ADVEC.-IN LONG. DIREC.))
       IF (J = JM)                                            GO TO 2237

2225                 ((COMPUTE HORIZ.ADV.-IN LAT. DIREC.))
       IF (J>1)                                               GO TO 2290
                     ((J=2 CORREC. TO HORIZ. ADVEC & CONV.))
                     ((CONV. CALC. FOR CONT. EQ.))
2290   IF (J<JM)                                              GO TO 2405

2237                 ((J=JM CORREC. TO HORIZ. ADVEC. & CONV.))
       ----------------------------●----------------------------
2405                 ((CONV + CONV * DSIG(L)))
       IF (L≤NLAY)                                            GO TO 2150

       IF (J=1)                                               GO TO 2600
                     ((COMPUTE SIGDOT,PT))
                     ((COMPUTE VERTICAL ADVEC.))

       IF (J<JM)                                              RETURN

2600                 ((POLES,  M=1 or 2))
                     ((HORIZ. ADVEC.))
                     ((CONT. E.Q.))
                     ((SIGDOT PL, PTPOL))
                     ((VERT. ADVEC.))
                                                              RETURN

                     END OF COMP1
```

Alternative code from ———●——— to ———●———

```
                     ----●----
     IF(J.EQ.1)                                             GO TO 2222
                       ((COMPUTE $PU_1$, $PU_2$))
                       ((COMPUTE HA(I)         ))
                                                            GO TO 2235

2222                   ((J=2 CORREC          ))

2235 IF (J<JM)                                              GO TO 2225
                       ((J=JM CORREC))
                                                            GO TO 2405

2225                   ((HORIZ ADVEC(J)          ))
                       ((CONV.CALC.FORCONT.EQ.))

2405                   ((CONV CONV*DSIG(L)))
                     ----●----
```

COMP2 (Q,QT,J)

```
                     ((COMPUTE JP2=...   ))

    IF(J>1)                                           GO TO 3001
                     ((JP2=JP2MOD=JPKP2=1))            :3005

3001                 ((CORIOLIS          ))

    IF(J≥JM)                                          GO TO 3032

                     ((FIRST MAIN LOOP IN L))

3005                 ((DO 3030 LX=1,NLAY ))
                     ((COMPUTE ENERGY TERM IN
                       THERMODYNAMIC EQN ))
                     ((L=NLAY+1-LX       ))
    IF(L<NLAY)                                        GO TO 3055

3007                 ((COMPUTE PK(I,LL,JPKP2)FORLL=1,NLAY))
                     ((COMPUTE PHI'(I,NLAY,JP2MOD))    :3065

3055                 ((COMPUTE PHI' AT JP2MOD FOR L<NLAY))

3065 IF(JP2=1 or JP2=JNP)                             GO TO 3030
                     ((COMPUTE W(JP2MOD)))

3030                 ((INCREMENT LX     ))
                     ((IF J=1 GO TO 3005 AND COMPUTE PHI(2),W(2)))


                    (( 2nd MAIN LOOP IN L))

3032                ((DO 3031 LX=1, NLAY))
      IF(J=1)                                           GO TO 3111 ( POLES)

      IF (J > 2)                                        GO TO 3085
                    ((J=2:  VT,TT CORREC.))

3085                (((P) FOR U EQ.))
      IF (J=2orJM)                                      GO TO 3135

                    (((P) FOR V EQ.))


3135  IF (J < JM)                                       GO TO 3031
                    (( CORREC. TO (P) J=JM))
3111                ((POLES))

3031                ((CONTINUE))
                    ((RETURN))
                      END
```

A FOURTH-ORDER FORECASTING MODEL*

(E. Kalnay-Rivas, D. Hoitsma, and P. Anolick)

The GISS fourth-order model (Kalnay-Rivas, et al., 1977), which is a fourth-order, energy-conserving GCM on an unstaggered grid, had shown promising capabilities. It produced forecasts that showed an improvement over the second-order GISS forecasts with the same fine grid (4° x 5°) resolution, but that were somewhat inferior to the "ultrafine" forecasts. However, the first version of the model required excessive amounts of computer memory and time for execution.

The model has been reprogrammed into the "fourth-order band model." The new program solves the primitive equations one latitude band at a time. The arrays are stored in an interlaced way, with all arrays being updated at the same latitude stored contiguously, and similarly for all arrays used in the computation of the time derivatives. This design of the program makes effective use of the virtual memory capability of the Modeling and Simulation Facility's IBM 370/165 or Amdahl computers. The virtual memory facility permits the execution of programs whose core size is larger than the one available, by placing the excess on disk and reading in those pages of information needed in the current calculations. The band fourth-order data structure and computations were constructed to optimize this virtual I/O process; a possible improvement may be to interlace also the arrays being updated with those used to compute the time derivatives. The use of the virtual memory facility avoids the explicit I/O used in the current Kern model, and yields a simpler program. (The band structure was suggested by G. Russell.)

The band fourth-order model computations have been optimized so that each time step is computed in the Amdahl in half the time required by the old model. The array structure has also been designed to reduce the amount of overall storage and high-speed memory by a factor of two (see Table 1).

Table 1. Comparison of Fourth-Order Model Computing Requirements.

	Original 4th-Order Model	Band 4th-Order Model
Core (bytes)	3500K	1500K
CPU time per step (COMP1, COMP2)	34 sec	17 sec

---

*Reprint from Atmospheric and Oceanographic Research Review-1978, GSAS, NASA Technical Memorandum 80253.

The model has been programmed so that it can use both the Matsuno and the leapfrog time schemes, the latter with the Robert time smoother. If Q^n and $D(Q^n)$ denote the fields at time $n\Delta t$ and the corresponding time derivative computed from the space differences, the smoothed leapfrog scheme is

$$Q^{n+1} = \bar{Q}^{n-1} + 2\Delta t\, D(Q^n)$$

$$\overline{Q^n} = Q^n + .5\nu(Q^{n-1} + Q^{n+1} - 2Q^n)$$

with $\bar{Q}^o = Q^o$. The use of a smoothing coefficient requires a slightly smaller time step. For example, with $\nu = .1$, the model is marginally stable with $\Delta t = 288$ sec., compared to $\Delta t = 300$ sec. for the Matsuno and leapfrog schemes.

The smoothed leapfrog scheme is further modified to include the subgrid "physics" terms, and scaling and spatial smoothing procedures. Since the "physics" is called every few time steps, unless the leapfrog scheme is restarted after every call to the "physics," only one of the two consecutive fields will be affected. The restarting procedure is time-consuming, so it has been replaced by the following algorithm

$$Q^{n-1} = Q^{n-1} - Q^n$$

$$\tilde{Q}^n = Q^n + S^n$$

$$Q^{n-1} = Q^{n-1} + \tilde{Q}^n$$

where S^n corresponds to the "physics" terms. This procedure, which ensures that the physics is applied to two consecutive time steps, has been tested with good results.

The model can be extended into an "ultrafine" version in a straightforward way.

Preliminary Results. The first numerical integrations performed with the new band fourth-order model show dramatic improvements over forecasts made with the GLAS model with the same resolution ("fine grid" or 4° latitude by 5° longitude). The quality of the forecasts is now comparable with those produced with the "ultrafine" (2.5° latitude by 3° longitude) version of the model. Results from a 3-day numerical integration are presented in Figure 1. During an extended 8-day integration of the new fourth-order model, the atmospheric systems remained remarkably smooth, exhibiting a realistic behavior both with respect to position and intensities.

References

Kalnay-Rivas, E., A. Bayliss, and J. Storch, 1977: The fourth-order GISS model of the global atmosphere. Contributions to Atmos. Phys., 20, pp. 299-311.

The 4th Order GISS Model of the Global Atmosphere*

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Abstract: The new GISS 4th order model of the global atmosphere is described. It is based on 4th order quadratically conserving differences with the periodic application of a 16th order filter on the sea level pressure and potential temperature equations, a combination which is approximately enstrophy conserving. Several short range forecasts indicate a significant improvement over 2nd order forecasts with the same resolution (~ 400 km). However the 4th order forecasts are somewhat inferior to 2nd order forecasts with double resolution. This is probably due to the presence of short waves in the range between 1000 km and 2000 km, which are computed more accurately by the 2nd order high resolution model. An operation count of the schemes indicates that with similar code optimization, the 4th order model will require approximately the same amount of computer time as the 2nd order model with the same resolution.

It is estimated that the 4th order model with a grid size of 200 km provides enough accuracy to make horizontal truncation errors negligible over a period of a week for all synoptic scales (waves longer than 1000 km).

1. Introduction

It is generally accepted that the use of 4th order finite differences is more efficient in reducing space truncation errors than the use of higher resolution on a 2nd order model (KREISS and OLIGER, 1972). Linear analyses and shallow water type of experiments give *an upper limit* of the improvement that can be expected from the reduction of errors in the horizontal differences. For example, Table 1 corresponds to a linear wave equation with phase speed $c = 11\ \mathrm{ms}^{-1}$, typical of atmospheric motions. It provides a measure of the "computational predictability period" after which the errors introduced by horizontal truncation alone become very serious. The table suggests that for waves longer than 2000 km a 4th order – 400 km grid model is preferable to a 2nd order – 200 grid model. Waves shorter than 2000 km are forecast more accurately by a 2nd order – 200 km grid model. In order to insure that horizontal truncation errors are small in the 1–3 week period of atmospheric predictability for all synoptic scale waves it is necessary to use either 4th order differences with a grid resolution of the order of 200 km or 2nd order differences with a grid of the order of 100 km. Numerical experiments with simple nonlinear models (WILLIAMSON and BROWNING, 1973, KALNAY-RIVAS 1976a, from now on I) also indicate dramatic reduction of errors by the use of 4th order differences.

All these studies indicate that a considerable improvement in forecasting skill is to be expected from the use of 4th order differences *if a substantial portion of the forecasting errors is due to horizontal truncation errors.* In actual numerical forecasts there are several are several other important sources of errors: vertical truncation errors, errors in the initial conditions, and poor "physics" (i.e. parameterization of physical processes like radiation, dissipation, subgrid transports, cumulus convection, boundary layers, etc.)

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* (Paper presented during the DMG-AMS Meeting, Hamburg 1976; see Preface to Issue 1 – 2/1977)

Beiträge zur Physik der Atmosphäre, 50. Band, 1977, Seite 299–311

■ Table 1. Elapsed time T after which a wave of wavelength L moving with a phase speed $c = 11\ ms^{-1}$ lags by more than 100 km due to space truncation errors.

	$\Delta x = 400$ km	$\Delta x = 200$ km
2nd order differences	L = 2000 km, T = 0.4 days L = 4000 km, T = 1.6 days	L = 2000 km, T = 1.6 days L = 4000 km, T = 6.4 days
4th order differences	L = 2000 km, T = 1.5 days L = 4000 km, T = 21 days	L = 2000 km, T = 21 days L = 4000 km, T = 328 days

At the Goddard Institute for Space Studies (GISS), New York, we have developed a 4th order general circulation model (GCM) with the expectation that it will yield more accurate short range forecasts, and probably more realistic climate simulations, but with the improvement limited by the other sources of errors. The model is described in Section 2. The results of several experimental short range forecasts are discussed in Section 3. A sample 36-hour forecast is presented and compared with forecasts by the standard 2nd order GISS model, which has the same resolution as the 4th order model, and by the "ultrafine" 2nd order GISS model, which has twice the horizontal resolution. Section 4 contains the conclusions and a discussion of future work.

2. Description of the model

The 4th order GISS global atmospheric model is a primitive equation model using longitude (λ), latitude (ϕ) and sigma (σ) coordinates. The basic equations and the parameterizations of physical processes are the same as those of the standard 2nd order GISS global model (Somerville et al, 1974). The finite difference scheme is quite different and is described in the following subsections.

2.1. Finite-difference scheme

The horizontal grid is uniform (constant $\Delta\lambda$ and $\Delta\phi$) and non-staggered. There are two ways to define such a grid, depending on whether variables are defined at the poles, as done by WILLIAMSON and BROWNING (1973), or half a grid size away from the poles (HOLLOWAY et al, 1973). We chose the former method because in the absence of smoothing near the poles it allows a time step twice as large as the latter. The singularity that sherical coordinates have at the poles is explicitly avoided by the use of a polar cell where "stereographic" velocities are used.

In the vertical direction we use a staggered grid with $\dot{\sigma}$, the vertical velocity, defined at the boundaries of each layer, and all other variables in the center of the layer. The vertical grid can be non uniform although experiments have been made so far with constant $\Delta\sigma$. Experiments reported in I indicated that no significant improvement in accuracy was obtained when a 4th order staggered conservative scheme was used in the vertical direction. Therefore the model has 2nd order vertical differences. The computation of the geopotential Φ is performed as indicated by ARAKAWA (1972), with a modification suggested by PHILLIPS (1974).

a) Forecast equation away from the poles

Several systems of horizontal difference werl tested as reported in I. The scheme chosen for the basis of these experiments consists of the simplest possible quadratically conservative 4th order differences.

We define the finite difference horizontal divergence operator at the vertical level k as

$$D_k(g) = \frac{1}{a\cos\phi}\left[\frac{4}{3}\delta_\lambda(\Pi u^{\lambda}\overline{g}^{\lambda}) - \frac{1}{3}\delta_{2\lambda}(\Pi u^{2\lambda}\overline{g}^{2\lambda}) + \frac{4}{3}\delta_\phi(\Pi v\cos\phi^{\phi}\overline{g}^{\phi}) - \frac{1}{3}\delta_{2\lambda}(\Pi v\cos\phi^{2\phi}\overline{g}^{2\phi})\right]_k \tag{2.1}$$

and the finite difference gradient operator as

$$\nabla g = \frac{\mathbf{i}}{a\cos\phi}\left[\frac{4}{3}\delta_\lambda\overline{g}^{\lambda} - \frac{1}{3}\delta_{2\lambda}\overline{g}^{2\lambda}\right] + \frac{\mathbf{j}}{a}\left[\frac{4}{3}\delta_\phi\overline{g}^{\phi} - \frac{1}{3}\delta_{2\phi}\overline{g}^{2\phi}\right] \tag{2.2}$$

Here $\Pi = p_S - p_T$ is the difference between the pressure at the surface and the constant pressure at the top of the model, a is the radius of the earth, $\mathbf{v} = u\mathbf{i} + v\mathbf{j}$ is the horizontal velocity vector in spherical coordinates, and we use the finite difference notation

$$\delta_{n\lambda}g = [g(\lambda + n\Delta\lambda/2, \phi, \sigma, t) - g(\lambda - n\Delta\lambda/2, \phi, \sigma, t)]/(n\Delta\lambda),$$
$$\overline{g}^{n\lambda} = [g(\lambda + n\Delta\lambda/2, \phi, \sigma, t) + g(\lambda - n\Delta\lambda/2, \phi, \sigma, t)]/2, \tag{2.3}$$

and similar formulas for the other independent variables. With this notation, the continuity equation away from the poles is

$$\frac{\partial\Pi}{\partial t} = -D_k(1) - \Pi\delta_\sigma\dot{\sigma}_k \tag{2.4a}$$

or, if we integrate it in the vertical and make use of the boundary condition

$\dot{\sigma} = 0$ at $\sigma = 0, 1$,

$$\frac{\partial\Pi}{\partial t} = -\sum_{k=1}^{K}{}' D_k(1)\,\Delta\sigma_k \tag{2.4b}$$

where K is the number of vertical layers. Equation (2.4b) is the forecast equation for Π. The momentum equation is

$$\left(\frac{\partial\Pi\mathbf{v}}{\partial t}\right)_k = -D_k(\mathbf{v}) - \Pi\delta_\sigma(\dot{\sigma}\overline{\mathbf{v}}^{\sigma})_k + \left(f + \frac{u_k\tan\phi}{a}\right)\mathbf{k}\times(\Pi\mathbf{v})_k - \Pi\left[\nabla\Phi' + \frac{\sigma RT'}{p}\nabla\Pi\right]_k + \mathbf{F}_k. \tag{2.5}$$

The first law of thermodynamics is

$$\left(\frac{\partial\Pi T}{\partial t}\right)_k = -D_k(T) - \{p^{\kappa}\Pi\delta_\sigma[\dot{\sigma}\,\overline{(T/p^{\kappa})}^{\sigma}]\}_k + \left\{\frac{\Pi\sigma\kappa T}{p}\left[\frac{\partial\Pi}{\partial t} + \mathbf{v}.\nabla\Pi\right]\right\}_k + \frac{\Pi}{C_p}Q. \tag{2.6}$$

Here T is absolute temperature, **F** is the frictional force, $\kappa = R/C_p$, Q is the diabatic heating per unit mass, p is the pressure and p^κ is computed as indicated in Subsection 2.1c. The moisture equation for the water vapor mixing ratio q is

$$\left(\frac{\partial \Pi q}{\partial t}\right)_k = -D_k(q) - \Pi \delta_\sigma (\dot{\sigma} q^\sigma)_k + \Pi (E - C). \qquad (2.7)$$

E and C are the rates of evaporation and condensation.

In the momentum equation (2.5) we follow a device suggested by PHILLIPS (1974) to alleviate the difficulties of the computation of the pressure gradient in σ-coordinates in the vicinity of orography. We define $T' = T - \bar{T}(p)$, $\Phi' = \Phi - \bar{\Phi}(p)$, where $\bar{T} = \theta p^\kappa$, $\theta = 280\ K/(1000\ mb)^\kappa$, $\bar{\Phi} = \Phi_0 - C_p \theta p^\kappa$ and $\Phi_0 = [(1000\ mb)^\kappa - p_T^\kappa]$. We have simplified PHILLIPS' expression for Φ_0 since its precise value is not important. With this procedure, in the pressure gradient term there is an exact cancellation of the terms $\nabla \Phi + \frac{\sigma R T}{p} \nabla \Pi$, and this implies a significant reduction of truncation errors in regions with steep orography.

b) Forecast equations at the Poles

We have followed the method used by WILLIAMSON and BROWNING (1973) and define a polar cap of radius $a\Delta\varphi$ on which we use "stereographic" (or rather "cartesian") velocity components defined by the transformation

$$\begin{aligned} U_{\pm p} &= -u\sin\lambda \pm v\cos\lambda \\ V_{\pm p} &= \pm u\cos\lambda - v\sin\lambda \end{aligned} \qquad (2.8)$$

with inverse

$$\begin{aligned} u &= -U_{\pm p}\sin\lambda \pm V_{\pm p}\cos\lambda \\ v &= \pm U_{\pm p}\cos\lambda - V_{\pm p}\sin\lambda \end{aligned} \qquad (2.9)$$

where the top and bottom signs correspond to the north and south poles respectively. The positive x-axis of the cartesian coordinates coincides with the meridian of longitude $\lambda = 0$. The difference in signs at the south pole is due to the choice of a right handed system of coordinates with the vertical unit vector pointing outwards. Formulas (2.8) and (2.9) are used to define "spherical" or "cartesian" velocity components wherever they are required in the finite difference equations.

The finite difference horizontal divergence operator at the poles is defined by an average aver all longitudes λ_i:

$$D_{\pm p,k}(g) = \pm \sum_{i=3}^{I+2}{}' \left\{ \frac{4}{3} A_1 (\Pi v g)_{\lambda_i, \pm(\frac{\pi}{2} - \Delta\phi)} - \frac{1}{3} A_2 (\Pi v g)_{\lambda_i, \pm(\frac{\pi}{2} - 2\Delta\phi)} \right\}_k \qquad (2.10)$$

where $\lambda_i = (i-3)\,\Delta\lambda$, $\Delta\lambda = 2\pi/I$, and $A_n = \Delta\lambda\, a \sin(n\Delta\phi)/[2\pi a^2(1 - \cos(n\Delta\phi))]$. The finite difference gradient operator at the poles is also defined by an average over all longitudes:

$$\nabla_{\pm p} g = \frac{2}{I a \Delta\phi} \sum_{i=3}^{I+2}{}' \left\{ \frac{4}{3} g_{\lambda_i, \pm(\frac{\pi}{2} - \Delta\phi)} - \frac{1}{6} g_{\lambda_i, \pm(\frac{\pi}{2} - 2\Delta\phi)} \right\} \cdot \{\cos\lambda_i\, \mathbf{i} \pm \sin\lambda_i\, \mathbf{j}\} \qquad (2.11)$$

Then the continuity equation at the poles is

$$\frac{\partial \Pi_{\pm P}}{\partial t} = \mp \sum_{k=1}^{K}{}' D_{\pm P,k}(1)\,\Delta\sigma_k, \tag{2.12}$$

the momentum equation is

$$\left(\frac{\partial \Pi V}{\partial t}\right)_k = \mp D_{\pm P,k}\,(V) - \Pi_{\pm P}\,\delta_\sigma\left(\dot{\sigma}_{\pm P}\,\overline{V}^{\sigma}_{\pm P}\right)_k + f_{\pm P}\,\mathbf{k}\times(\Pi V)_{\pm P,k}$$

$$- \Pi_{\pm P}\left[\nabla_{\pm P}\,\Phi' + \frac{\sigma R T'}{p}\,\nabla_{\pm P}\,\Pi\right]_k + \mathbb{F}_{\pm P,k} \tag{2.13}$$

where $V_{\pm P} = U_{\pm P}\,\mathbf{i} + V_{\pm P}\,\mathbf{j}$. The thermodynamic equation is

$$\left(\frac{\partial \Pi T}{\partial t}\right)_{\pm P,k} = \mp D_{\pm P,k}(T) - \left\{p^{\kappa}_{\pm P}\,\Pi_{\pm P}\,\delta_\sigma\left[\dot{\sigma}_{\pm P}\,\overline{(T_{\pm P}/p^{\kappa}_{\pm P})}^{\sigma}\right]\right\}_k \tag{2.14}$$

$$+ \left\{\frac{\Pi_{\pm P}\,\sigma\,\kappa\,T_{\pm P}}{p_{\pm P}}\left[\frac{\partial \Pi_{\pm P}}{\partial t} + V_{\pm P}\cdot\nabla_{\pm P}\,\Pi\right]\right\}_k + \frac{\Pi_{\pm P}}{C_p}\,Q_{\pm P}$$

and the moisture equation is similar.

c) Diagnostic equations

In σ-coordinates, the pressure is defined by $p = \sigma\Pi + p_T$. Following a suggestion by PHILLIPS (1974) we define at the center of a layer $p_k^{\kappa} = 1/(\kappa + 1)\,\delta_\sigma p_k^{\kappa+1}/\delta_\sigma p_k$, instead of $p_k^{\kappa} = (\overline{p}_k^{\sigma})^{\kappa}$ as in ARAKAWA (1972). This formula was derived under the assumption that the potential temperature varies in a σ-layer much less than either the temperature of the pressure. PHILLIPS indicated that a more accurate relationship between temperature and geopotential can be expected from this formula.

The geopotential Φ is determined following ARAKAWA (1972): If Φ_S is the surface geopotential, then the geopotential at the center of the lowest layer is

$$\Phi_K = \Phi_S + \sum_{k=1}^{K}{}' C_k\,T_k \tag{2.15}$$

and at other levels

$$\Phi_k = \Phi_{k+1} + C_p\,\Delta\sigma_{k+\frac{1}{2}}\,\delta_\sigma\left(p^{\kappa}_{k+\frac{1}{2}}\right)\left(\overline{\frac{T_{k+1/2}}{p^{\kappa}_{k+1/2}}}^{\sigma}\right) \tag{2.16}$$

The coefficients C_k are determined from

$$C_k = \frac{\Pi\sigma_k\,R\,\Delta\sigma_k}{p_k} - \frac{C_p}{p_k^{\kappa}}\,\overline{\left(\sigma\,\Delta\sigma\,\delta_\sigma\,p^{\kappa}\right)_k}^{\sigma} \tag{2.17}$$

The vertical velocity in σ-coordinate is determined from (2.4a) and (2.4b), and the boundary condition $\dot{\sigma} = 0$ at $\sigma = 0, 1$:

$$\delta_\sigma\,\dot{\sigma}_k = \frac{1}{\Pi}\left\{\sum_{k=1}^{K}{}' D_k(1)\,\Delta\sigma_k - D_k(1)\right\} \tag{2.18}$$

d) Boundary conditions

In the east-west direction we use periodicity: $g(\lambda + 2\pi, \phi) = g(\lambda, \phi)$ for all variables. When the value of a variable is needed "beyond" the poles, we define it by continuation along the same meridian:

$$v\left(\lambda, \pm\left(\frac{\pi}{2} + \Delta\phi\right)\right) = -v\left(\pi + \lambda \pm \left(\frac{\pi}{2} - \Delta\phi\right)\right) \; ; g\left(\lambda, \pm\left(\frac{\pi}{2} + \Delta\phi\right)\right) = g\left(\pi + \lambda, \pm\left(\frac{\pi}{2} - \Delta\sigma\right)\right),$$

where g represents all variables other than the two horizontal velocity components. In the vertical the top and bottom are material surfaces through which there is no flux ($\dot{\sigma} = 0$ at $\sigma = 0, 1$) except for subgrid boundary layer fluxes of momentum and heat included in F and Q.

2.2. Filtering near the poles and high order filtering

The CFL computational stability condition requires a very small time step unless linearly unstable short waves are filtered out near the poles. For this purpose several alternative procedures have been tried but so far the method found to give most satisfactory results is the fourier filtering of the prognostic variables u, v, T and *the indirect smoothing of* H *through the filtering of the sea level pressure (SLP) field.*

The fourier filtering is performed polewards of 66° latitude. The amplitudes of the fourier components of zonal wavenumber n are multiplied by a transfer function which is 1 for $n \leqslant N$ and decreases linearly to zero between $n = N$ and $n = N + 5$. The number of retained modes is defined by $N(\phi)$ = integer part of $(90 \cos\phi)$. We have tried filtering the stereographic velocities U, V instead of u, v but no improvement was obtained.

Since both the surface geopotential and the surface pressure fields contain large amplitude short wave components due to the presence of orography, an artifical smoothing of these fields represents a distortion of the real geometry of the boundary. On the other hand, the SLP is an instrinsically smooth field, and its high wavenumber components more closely represent *atmospheric* waves. Therefore in our model *the SLP is filtered near the poles and* H *is recovered by solving the transcendental equation used to relate them.*

It was found that the 4th order model forecasts were less smooth than those of the 2nd order GISS model, especially in regions with steep orography. Based on the same considerations we have introduced a periodic application of a high (16th) order filter (SHAPIRO, 1970) on the SLP and potential temperature fields, which are not very affected by orography.

The filter is of the form $\tilde{g} = \{1 - (F_\phi^2)^8\}\{1 - (F_\lambda^2)^8\}g$, where $F_\lambda^2(g_{ij}) = (g_{i+1j} - 2g_{ij} + g_{i-1j})/4$ and has a response $F_\lambda^2 [\exp(ik\lambda)] = -\sin^2(k\Delta\lambda/2)\exp(ik\lambda)$. This filter eliminates waves shorter than $4\Delta\lambda$ and even after hundreds of applications has negligible damping effect on waves longer than $4\Delta\lambda$.

In the meridional direction there are three simple alternative forms for F_ϕ^2:

$$F_{\phi I}^2(g_{ij}) = (g_{ij+1} - 2g_{ij} + g_{ij-1})/4$$

$$F_{\phi II}^2(g_{ij}) = [(g_{ij+1} - g_{ij})\cos\phi_{j+1/2} - (g_{ij} - g_{ij-1})\cos\phi_{j-1/2}]/(4\cos\phi_j)$$

and

$$F_{\phi III}^2(g_{ij}) = [F_{\phi I}^2(g_{ij}\cos\phi_j)]/\cos\phi_j$$

FRANCIS (1975) used $F_{\phi II}^2$, which is the only one that conserves the area weighted average of g. However,we have found that the three meridional filters produced virtually identical results. This could be expected because the waves affected by the filter are too short to be strongly influenced by the convergence of the meridians. Since $F^2_{\phi I}$ and $F^2_{\phi II}$ can be programmed as efficiently as F^2_λ we find them preferable. In the model we use $F^2_{\phi I}$, with g continued "beyond" the poles as indicated in Subsection 2.1d. At the poles $\bar{g}_{\pm P}$ is defined as the average over all longitudes λ_i of the filtered values $\bar{g}_{i,\pm P}$. At the present we are applying the high order filter to the SLP and potential temperature fields once every two hours.

2.3. Enstrophy constraint

BAYLISS and ISAACSON (1975) have developed a simple method to make any finite difference scheme conservative with respect to any quantity. The method has been tested in our model by forcing conservation of enstrophy on the dry adiabatic version of the model, although in such a model it is potential enstrophy that is conserved. The procedure is the following: Let the vectors U and V represent the values of the velocity components discretized over the grid and let the functional G(U, V) denote the consistent 4th order approximation of the mean square vorticity. At each time step a correction U', V' is added to the predicted values $\bar{U}$, $\bar{V}$ such that $G(\bar{U} + U', \bar{V} + V') = G(U_0, V_0)$ where U_0, V_0 denote the velocities at time t = 0. Since this equation cannot be solved explicitly, it is linearized about the predicted values $\bar{U}$, $\bar{V}$:

$$\left(\frac{\partial G}{\partial U}\right)_{\bar{U},\bar{V}} \cdot U' + \left(\frac{\partial G}{\partial V}\right)_{\bar{U},\bar{V}} \cdot V' = G(U_0, V_0) - G(\bar{U}, \bar{V}) \tag{2.19}$$

If we assume

$$(U', V') = \alpha \left(\frac{\partial G}{\partial U}, \frac{\partial G}{\partial V}\right)_{\bar{U},\bar{V}} \tag{2.20}$$

then α can be determined from (2.19):

$$\alpha = \frac{G(U_0, V_0) - G(\bar{U}, \bar{V})}{\left|\frac{\partial G}{\partial U}\right|^2 + \left|\frac{\partial G}{\partial V}\right|^2} \tag{2.21}$$

It may be easily shown that the choice (2.20) minimizes $\| U' \| + \| V' \|$, the norm of the correction vector. It has been found that this procedure improves the forecasting skill of the model. However, when it is used in combination with the periodic application of the high order filter the improvement is marginal. Therefore this option is not included in the standard version of our model.

2.4. Summary of the properties of the model

The finite differences of the model have the following properties:

a) Horizontal differences are performed on a nonstaggered grid and have 4th order truncation errors.
b) Vertical differences are performed on a staggered grid and have 2nd order truncation errors.
c) The differences are conservative in the sense that in the absence of diabatic and dissipation, mass and energy are conserved except for marginal terms at the poles. Non-conservative differences similar to those used by WILLIAMSON and BROWNING (1973), *starting from real data,* proved to be nonlinearly unstable after less than one day of integration.
d) Unlike the "box method", the horizontal differences remain 4th order near the poles (KALNAY-RIVAS, 1976b)

e) The model contains *no horizontal diffusion* expect for the possible use of a dissipative time scheme and for the periodic application of the high order filter. It has been shown in I that the combination of a 4th order quadratically conservative scheme with the *periodic* application of a high order filter *replaces successfully the use of an enstrophy-conserving scheme.* This is because waves shorter than four times the grid size are the ones subject to aliasing and to large truncation errors, and they are removed by the filter *before they attain finite amplitude.* Waves longer than four times the grid size are accurately computed by the 4th order scheme and are not affected by the filter.

3. Numerical forecasts

3.1. Analytical initial conditions

The model was tested using 3 dimensional extensions of both the nontrivial steady state solution and the Rossby-Haurwitz wave initial conditions used in I. The forecasts remained smooth during the several days of interation. Errors in the steady state case were an order of magnitude larger than in I because of the use of single precision arithmetic on the IBM/360-95 computer. However, it was found necessary to use double precision for the longitudinally averaged pressure gradient at the poles in order to avoid excessive local error growth.

3.1. Forecasts with real initial data

As mentioned before, the parameterization of physical processes included in the terms **F**, Q, C and E of Equations (2.5) - (2.7) has been adapted from the standard 2nd order GISS model (SOMERVILLE et al, 1974). The only change that has been introduced is the reduction by a factor of 2 of the surface drag coefficient. This was found to be necessary in order to avoid an excessive damping of the pressure systems after one or two day forecasts. We believe that the fact that in the staggered grid the surface winds are obtained by a horizontal average reduces the relative effect of friction in the standard model.
At the present time (November 1976), we have performed 5 experimental short range forecasts. Since they have been made with slightly different versions of the 4th order model, we don't yet have a reliable measure of the model's forecasting skill. The initial data so far has been available in the staggered grid used by the standard model so that winds have been linearly interpolated to the nonstaggered grid. This is a source of error which may have adversely affected the 4th order forecasts.
We have performed a single 4-day forecast which indicated that the model remains very stable and that synoptic systems show no tendency to become unrealistically weak.
All the numerical 4th order forecasts show a significant improvement over the 2nd order forecasts performed with the same resolution. This improvement appears as a better estimation of the changes in position and intensity of several pressure systems. This in an encouraging result, especially in view of the study made by BAUMHEFNER and DOWNEY (1976) which indicates that the standard 2nd order GISS model forecasts compare favorably with those made by the NMC and NCAR models with similar resolution.
On the other hand, and contrary to our expectations, the forecasts made with the 2nd order GISS model with double horizontal resolution were found to be either similar or superior to the 4th order forecasts. This is more true in the sea level pressure than in the 500 mb forecasts. We consider that there are several possible reasons for this result. One is the extra errors introduced in the 4th order model initial

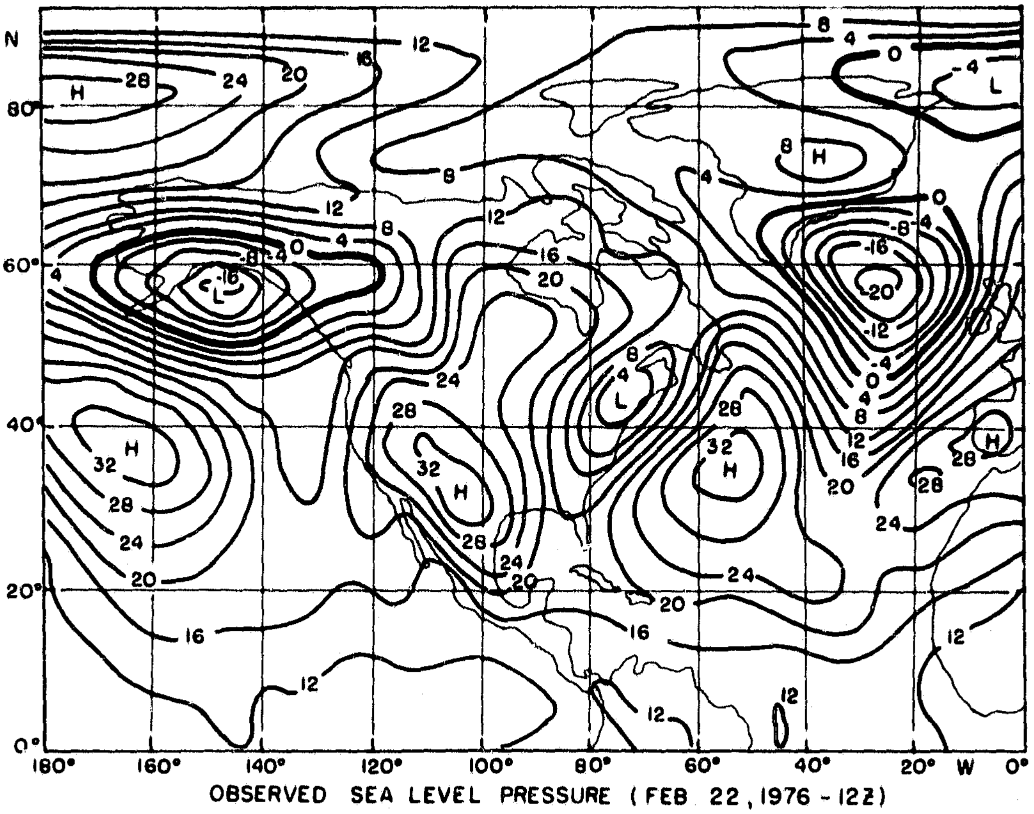
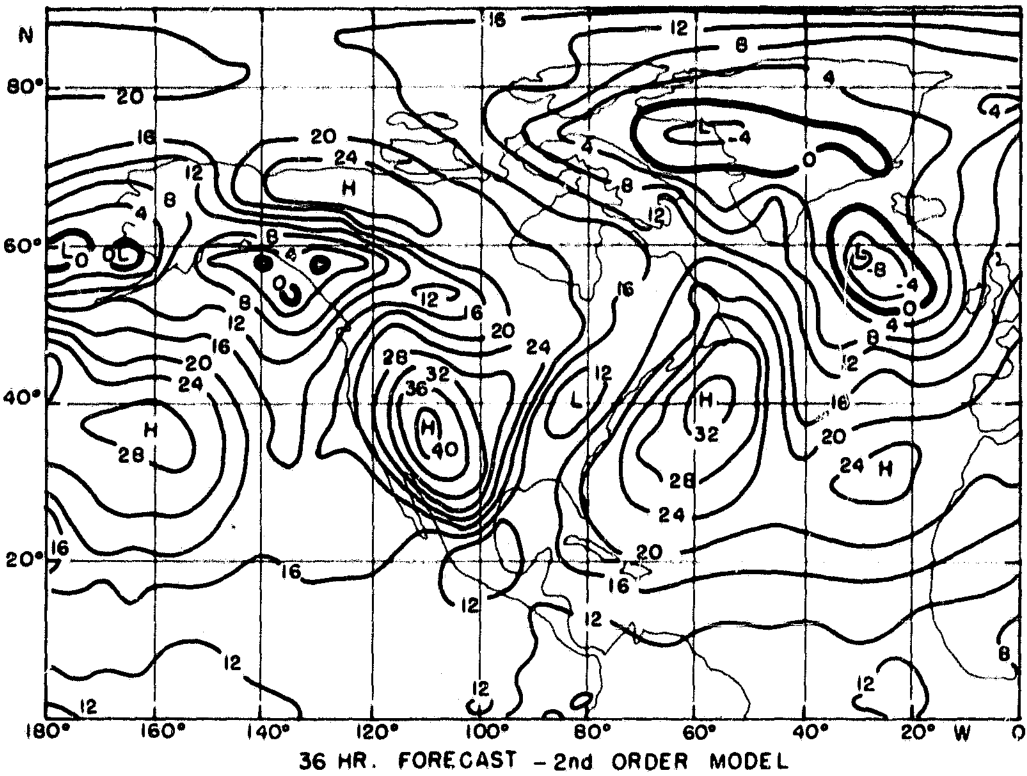


Figure 1. Observed 36 hr. sea level pressure at 0000 GMT, 22 February 1976

data by the averaging of the winds. A second reason (and probably the most important one) is the existence of waves with significant amplitudes and wavelengths between 1000 and 2000 km. These short waves are better detected in the initial data and more accurately forecast by the 2nd order model with double resolution. The nonlinear interaction of these short waves with longer synoptic waves which according to linear theory are better forecasted by the 4th order model is clearly very important. A third important reason is the fact that errors introduced by the parameterization of subgrid processes become less important as the grid size is reduced.

We present an example of a 36 hour forecast of the sea level pressure corresponding to February 22, 1976, 12Z. Figure 1 is the verification sea level pressure map. Figure 2 is the forecast computed with the standard 2nd order GISS model, which has a resolution $\Delta\lambda = 5^\circ$, $\Delta\phi = 4^\circ$, $\Delta\sigma = 1/9$. Figure 3 is the 4th order forecast computed with the same resolution, and Figure 4 is the forecast obtained using the "ultrafine" 2nd order GISS model which has a resolution $\Delta\lambda = 2.5^\circ$, $\Delta\phi = 2^\circ$, $\Delta\sigma = 1/9$.

The most striking improvement showed by the 4th order forecast is in the position and intensity of the low in the eastern portion of North America. In fact, this low and the high over the Atlantic Ocean have been forecasted better by the 4th order model than by the 2nd order model with double resolution. On the other hand the developing cold high in central Canada and the intense low pressure center south of Greenland have been predicted better by the double resolution 2nd order model. As usual in this

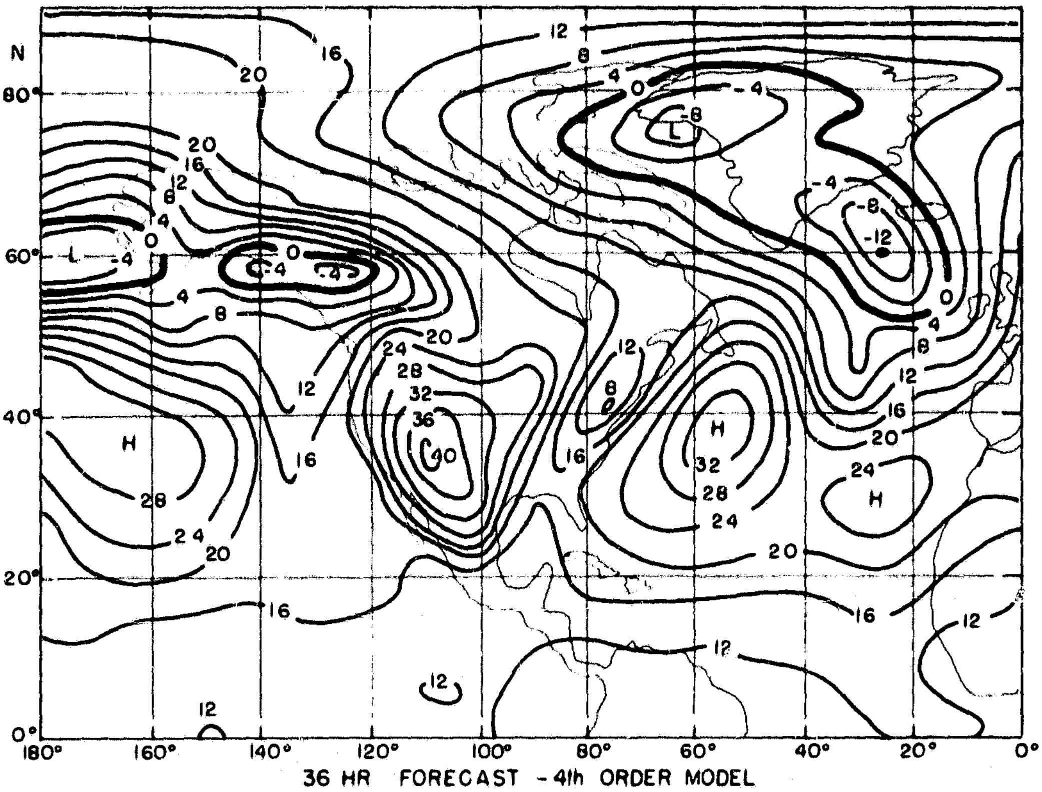


● Figure 2. 36 hr. horecast using the standard 2nd order GISS model

type of comparison, the three forecasts share several important deficiencies. For example the intensity of the high over southwest USA has been overpredicted by the three models, probably because of difficulties introduced by the orography. The low south of Alaska has been erroneously split by the three models. This splitting, which is slightly less pronounced in the 4th order forecast, may be due to both errors in the initial data and orographic and coastal problems.

4. Summary and conclusions

We have described the characteristics of the 4th order GISS model of the global atmosphere. It is based on a quadratically conservative scheme with the periodic application of a 16th order filter on the sea level pressure and potential temperature fields. As shown in I this combination is approximately enstrophy-conserving. An operation count of the numerical schemes indicates that with similar code optimization the 4th order model will require approximately the same amount of computer time as the 2nd order enstrophy-conserving GISS model with the same resolution. We also plan to introduce a simplified semi-implicit scheme, and to study the possibility of using the combination of a nonstaggered vertical grid with the Kreiss 4th order method described in I.

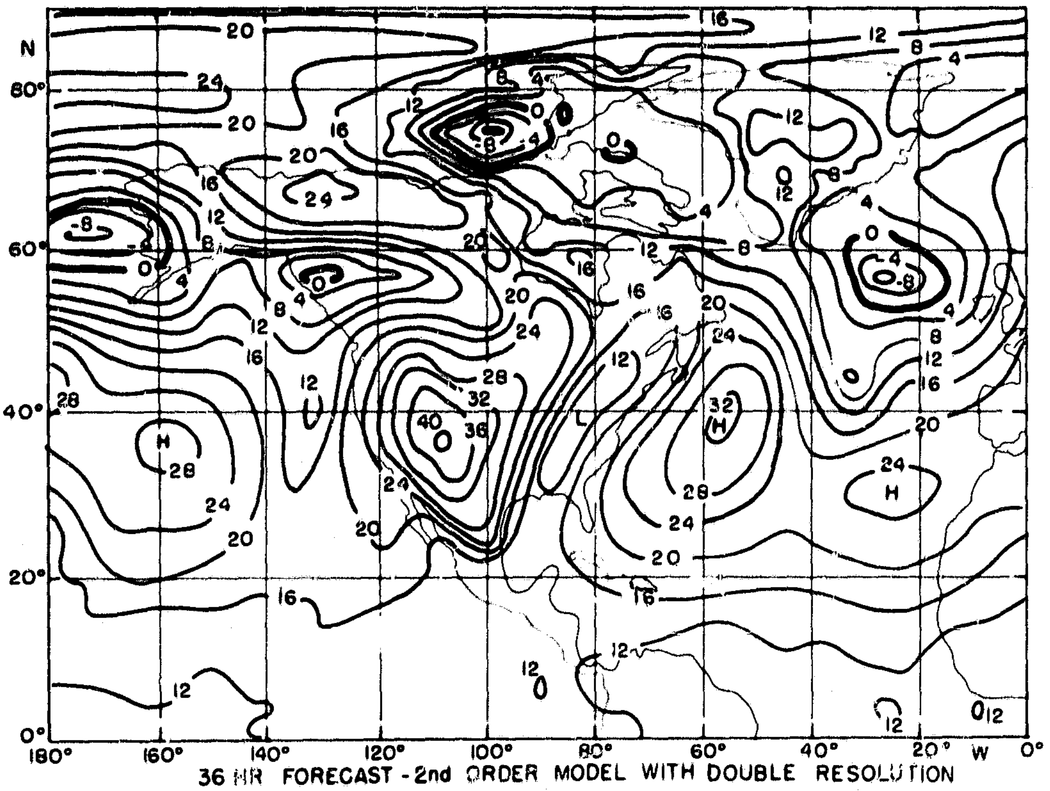


- **Figure 3.** 36 hr. forecast using the 4th order GISS model with the same resolution as in Figure 2

The results of several short range forecasts indicate a significant improvement over the 2nd order forecast with the same resolution. This improvement is shown in the estimations of changes in position and intensity of several pressure systems. We plan to study the impact that the greater accuracy of 4th order differences has on the forecasting skill of variables of more practical importance, such as temperature and precipitation.

It has been found that the 4th order forecasts are somewhat inferior to the forecasts made with a 2nd order model with double horizontal resolution. We consider that one of the most important reasons for this result are the presence of waves in the range between 1000 km and 2000 km which are computed more accurately by the high resolution 2nd order model than by the 4th order model. Another important reason is that errors introduced by the parameterization of subgrid processes become smaller as the size is reduced.

It is estimated that the 4th order model with a grid size of 200 km provides enough accuracy to make horizontal truncation errors negligible over a period of a week for all synoptic scales (waves longer than 1000 km).



- **Figure 4.** 36 hr. using the "ultrafine" 2nd order GISS model with double horizontal resolution

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THE EFFECT OF ACCURACY, CONSERVATION AND FILTERING ON NUMERICAL WEATHER FORECASTING

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1. INTRODUCTION

The design of a numerical model for atmospheric simulation is not a straight-forward procedure. Both in the areas of mathematical and numerical analysis, and in the parameterization of physical processes not explicitly resolved, the modeler faces several difficult choices between equally reasonable methods, and sometimes between similarly unsatisfactory methods.

In this paper we discuss the considerations leading to the numerical design of the GLAS Fourth-Order Global Atmospheric Model. This model, which was briefly described in Kalnay-Rivas et al., [1977], has been restructured, and several minor changes were introduced. *The computation time and memory requirements for the 4th order model are now similar to those of the present second order GLAS model with the same 4° latitude, 5° longitude and 9 vertical-level resolution [Sommerville et al., 1974]. However, the fourth-order model forecast skill is significantly better than that of the current GLAS model, and after 3 days it is comparable or better than that obtained with the 2.5° by 3° version of the GLAS model.*

A discussion of several of the basic characteristics of the model design is contained in section 2. For each of them we present some of the possible alternatives, their advantages and disadvantages, and the reason for our choice. In section 3, we discuss the effect on numerical forecasts of changes in the accuracy, resolution and conservation properties of the models.(1) Section 4 contains some final remarks.

2. DISCUSSION OF THE DESIGN OF THE MODEL

Different numerical analysts and atmospheric modelers often take different approaches in the design of a numerical model for weather prediction. Sometimes they even have different basic philosophies. For example Arakawa [1966, 1972], has been a pioneer in the development and use of numerical schemes that reproduce as closely as possible the conservation properties of the continous equations of fluid dynamics that determine the motion of the atmosphere. On the other extreme, Kreiss and Oliger [1972, 1973] have advocated the use of more accurate schemes even when they don't formally satisfy any conservation properties.

The current GLAS model is based on Arakawa's [1972] second order scheme using a staggered grid B. The scheme is energy conserving and approximately enstrophy conserving for non-divergent flow. In this section we isolate the areas in which the Fourth-Order model is different from the GLAS model, discuss some of the alternatives, and the justification of our choice.

2.1 Accuracy

There is a consensus among modelers that for finite difference models with second-order accuracy, horizontal resolution of about 400 km, and about 10 vertical levels, horizontal truncation errors are the most important source of errors. The truncation errors can be reduced by any of the following methods:

a. Increased horizontal resolution, retaining second-order differences. Advantages: If the horizontal grid size is reduced by a factor of 2, truncation errors are reduced by a factor of 4. A comparison of the effect of truncation errors on the computational phase speed and group velocity of a linear wave is presented in Fig. 1. Another advantage is that increasing

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(1) As of this writing, several of the numerical experiments are not complete.

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the resolution allows smaller but possibly important scales to be explicitly included in the model.
Disadvantages: The reduction of error is slow, and the computation time is increased by a factor of 8.

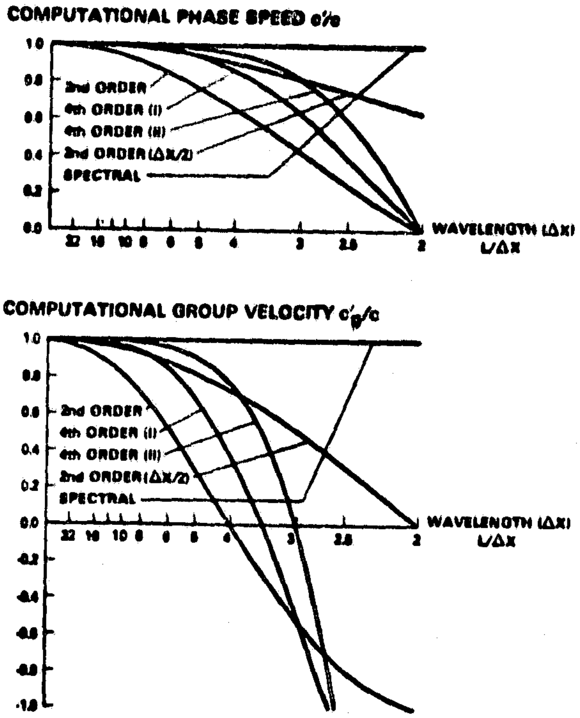

Fig. 1 Computational phase speed and group velocity fot a linear wave of constant phase speed c, for different numerical schemes as a function of wavelength L.

b. Fourth order schemes of the first kind. We include in this group the common 5-point explicit fourth order schemes [Kreiss and Oliger, 1972].
Advantages: Phase speed errors are much smaller, especially for long waves (Fig. 1). Waves longer than 5Δx have smaller errors in their phase speed with fourth order differences than with second order differences with twice the resolution. If we consider the computational group velocity, the crossover occurs at about 7Δx. The computational time is only increased by a factor between 2 and 3.
Disadvantages: Waves in the range of 2Δx to 4Δx are still grossly misrepresented.

c. Fourth order schemes of the second kind. In this group we include linear finite elements, cubic splines and the "compact" or Pade type 3-point 4th order differences introduced by Kreiss [Orszag & Israeli, 1972], all of which have the same fourth order accuracy.
Advantages: These fourth-order differences are considerably more accurate than the fourth-order differences of the first kind (Fig. 1). The crossover with double-resolution second-order differences in the phase speed error occurs at 3Δx, and in the group velocity error at about 4Δx.
Disadvantages: In the simplest case, Kreiss' fourth order differences require the solution of tri-diagonal matrices. Finite element schemes require the solution of at least block tri-diagonal matrices. Even though there are efficient methods to perform these inversions, they are still computationally expensive. The extra accuracy can be compensated with 4th order differences of the first kind by increasing the resolution, which has other advantages, as we mentioned earlier. These schemes, as well as in higher order finite difference schemes, waves in the range of 2Δx to 4Δx are still grossly misrepresented.

d. Spectral schemes.
Advantages: *If the basis of the spectral expansion are the eigenfunctions of the wave equation,* spectral schemes have no phase speed errors. Because of this they require less resolution than finite difference schemes.
Disadvantages: Because of the large number of computations required for the nonlinear terms, spectral schemes are competitive with finite difference schemes only in combination with the use of less resolution and semi-implicit time schemes.

Our choice: We chose to use fourth order finite differences of the first kind because they are computationally efficient and have small truncation errors except in the range of waves with wavelengths between 2Δx and 4Δx.

2.2 Type of Grid

Both staggered and unstaggered grids have been widely used by atmospheric modelers.

a. Unstaggered grid: The advantage of this grid is its simplicity. Higher order schemes are easily developed with this grid. Its disadvantage is that all centered differences have to be computed over a distance of 2Δx.

b. Staggered grids: Several staggered grid configurations are possible as reviewed by Arakawa [1972]. The one he called scheme C, which is the most commonly used, has the pressure defined at the center of a grid cell, and the velocity components u and v defined at their corresponding normal walls. This grid has the advantage that the pressure gradient and velocity divergence terms are computed over a distance of only 1Δx, so that *inertia gravity waves are computed with double resolution.* Therefore, as pointed out by Arakawa, geostrophic adjustment is best represented in this grid. On the other hand, advection terms are computed with no more accuracy than in the unstaggered grid, and in the Coriolis' acceleration term, it is necessary to take horizontal averages of the velocities. The higher resolution of inertia gravity waves *reduces the maximum time step for explicit time schemes by a factor of two.* Full fourth order schemes can be developed with staggered schemes but they are very involved [Kalnay-Rivas, 1976]. To date, modelers using staggered grids have introduced fourth order differences *only* in the advection terms.

Our choice: During extended range forecasts, second order errors in the non-advective terms may become important. For this reason we chose to use an unstaggered grid that allows the use of a simple, full fourth-order scheme.

2.3 Conservation Properties and the Use of Horizontal Diffusion

With respect to conservation properties, there are basically 3 types of finite difference schemes for the primitive equations: a) Nonconservative schemes, the simplest of which is the one based on the advective form of the equations; b) quadratically or energy conserving schemes; and c) enstrophy conserving schemes. Advective and quadratically conservative schemes can be easily developed using staggered or unstaggered grids [Lilly, 1965; Bryan, 1966]. Enstrophy conserving schemes for the primitive equations have been developed on a grid C by Grammeltvedt [1969] and Arakawa and Mintz [1974]. Sadourny [1965a, b] constructed a potential enstrophy conserving scheme on grid C, and Arakawa [1978] has recently developed a potential enstrophy and energy conserving scheme also on grid C.

Nonconservative schemes require a procedure to damp waves shorter than $4\Delta x$, which otherwise grow spuriously causing catastrophic nonlinear instability [Phillips, 1959]. This has usually been done by means of linear or nonlinear horizontal diffusion, or by using dissipative numerical schemes such as the Lax-Wendroff, or schemes that contain explicit horizontal averaging.

Quadratically conservative schemes avoid the unbounded growth of the solutions associated with catastrophic nonlinear instability. However, as Arakawa [1972] and Sadourny [1975a, b] have pointed out, in the course of long integrations, there is still a spurious build up of energy in the shortest waves, which appears as an *unbounded growth of the total enstrophy.* In the absence of horizontal diffusion, this type of *slow nonlinear instability* will completely distort the solution. Enstrophy conserving schemes, on the other hand, impose a stronger constraint on the growth of the smallest scales present in the model. For this reason, the UCLA and the GLAS models, which use enstrophy conserving schemes, *do not need to include horizontal diffusion.*

It should be emphasized that conservation of enstrophy does not necessarily imply a more accurate or realistic simulation. In the real atmosphere, the constraint of quasi-geostrophic motion implies that very little of the energy generated in the baroclinically unstable scales can reach the smallest scales and be eventually dissipated [Charney, 1972]. In a numerical model, *the finite resolution imposes an artificial "wall" at the short end of the spectrum,* inducing an excessive accumulation of energy in the shortest waves. This problem is worst in nonconservative schemes, but it appears even in alias-free, energy- and enstrophy-conserving spectral models. This justifies using some parameterization of the unresolved subgrid eddies to withdraw energy from the smallest resolved scales.

For this purpose, Leith [1972] suggested the use of nonlinear horizontal diffusion in which the eddy diffusion coefficient is proportional to the local gradient of vorticity. This formulation is consistent with the transfer of energy to subgrid scales in two-dimensional turbulence. In another widely used formulation, suggested by Smagorinsky [1963] and based on a three-dimensional turbulent cascade theory, the diffusion coefficient is proportional to the deformation tensor. These formulations are better than the use of linear diffusion, but they both share the following problems: a) the diffusion coefficient is computed inaccurately for the shortest waves, and, more importantly, b) when the diffusion coefficient is large enough to avoid the spurious growth of the smallest scales, it produces excessive damping of the larger scales [Merilees, 1975; Williamson, 1978]. Furthermore, at the short end of the spectrum (scales of the order of 100 km), neither quasi-geostrophic nor 3-dimensional isotropic turbulence theories are really justified. Williamson [1978] generalized a higher order diffusion of the form $\nabla^2\kappa\nabla^2$, suggested by Kreiss and Oliger [1972], still using the deformation type of diffusion coefficient. This formulation has the advantage that, because it is more scale dependent, there is less damping of the longer waves.

In our model, we have taken an approach closer to Fourier filtering the shortest waves, as suggested by Phillips [1959]. Our "subgrid parameterization" is based on the following argument: The 4th order scheme is adequate accurate for waves longer than $4\Delta x$, but grossly inaccurate for waves between $2\Delta x$ and $3\Delta x$. Since the shortest waves *cannot provide any useful information in a finite difference scheme,* we filter them out of the system while their amplitude is still small. Even though they are filtered out, the shortest waves still play an important role in the model: they act as a buffer or "sponge layer" in the spectrum domain, allowing energy to trickle down from longer waves and avoiding the accumulation of energy that would otherwise occur at the short wave cutoff.

The elimination of the short waves is performed in the model with the periodic use of a 16th order Shapiro [1970] filter, first introduced in GCMs by Francis [1975]. Figure 2 indicates the response of Shapiro filters of order 4, 8 and 16. It can be observed that in the case of a 16th order filter waves longer than 4 are scarcely affected at all even after 128 applications, which in our model correspond to a 10 day integration. Waves shorter than 4 are virtually eliminated. Lower order filters introduce too much decay at long scales.

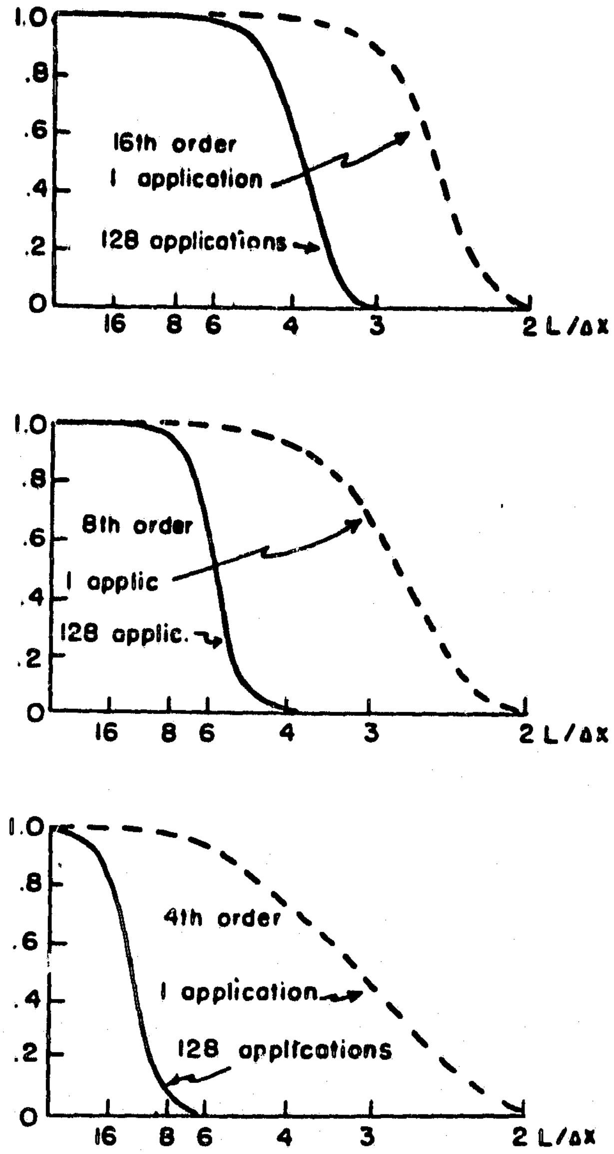

Fig. 2 Response of Shapiro filters after 1 and after 128 applications.

In order to explore the effect of filtering short waves we performed a series of 20 day forecasts with a simple shallow water equation model [Kalnay-Rivas, 1976], using different combinations of schemes, smoothing operators and frequency of application as indicated on Table 1.

A1:	4th order,	non-conservative,	no smoothing.
A2:	" ,	"	,linear diffusion, $\nu = 10^{5} m^{2}/s$
A3:	" ,	"	,16th order filter/4 hrs.
A4:	" ,	" ,	" /time step.
B1:	" ,	quadrat. conserv.,	no smoothing.
B2:	" ,	"	,16th order filter/4 hrs.
B3:	" ,	"	, 8th " " "
B4:	" ,	"	, 4th " " "
C:	2nd order,	"	, no smoothing

TABLE 1: Characteristics of the different runs in Fig. 3.

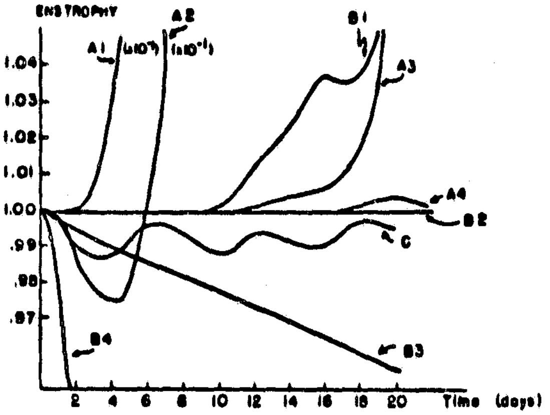

Fig. 3 Variations of total enstrophy during numerical integrations as indicated in Table 1. The scale corresponding to experiments A1 and A2 is multiplied by 10^{-1}.

We found that all stable runs conserved total energy with a high degree of accuracy. Fig. 3 shows the variation in time of the total potential enstrophy, which is conserved exactly in the continuous equations. The results indicate that when the 16th order filter is applied every time step (10 minutes) even a formally nonconservative scheme conserves both total energy and total potential enstrophy during a long integration (Run A4). The quadratically conservative scheme controls better the amount of energy going into the smallest scales, so that in Run B2 it was enough to apply the filter every 4 hours to conserve potential enstrophy within 0.05%, even though such conservation is not formally guaranteed in the scheme.

It may be questioned whether the application of a high order filter eliminates small scale features like frontal zones or the effects of orographic or cumulus convection forcing on small scales. Fig. 4 indicates that this is true for lower order filters. However a 16th order filter eliminates only those components which are not resolved anyway, and still allows for the formation of sharp gradient zones and strong local maxima.

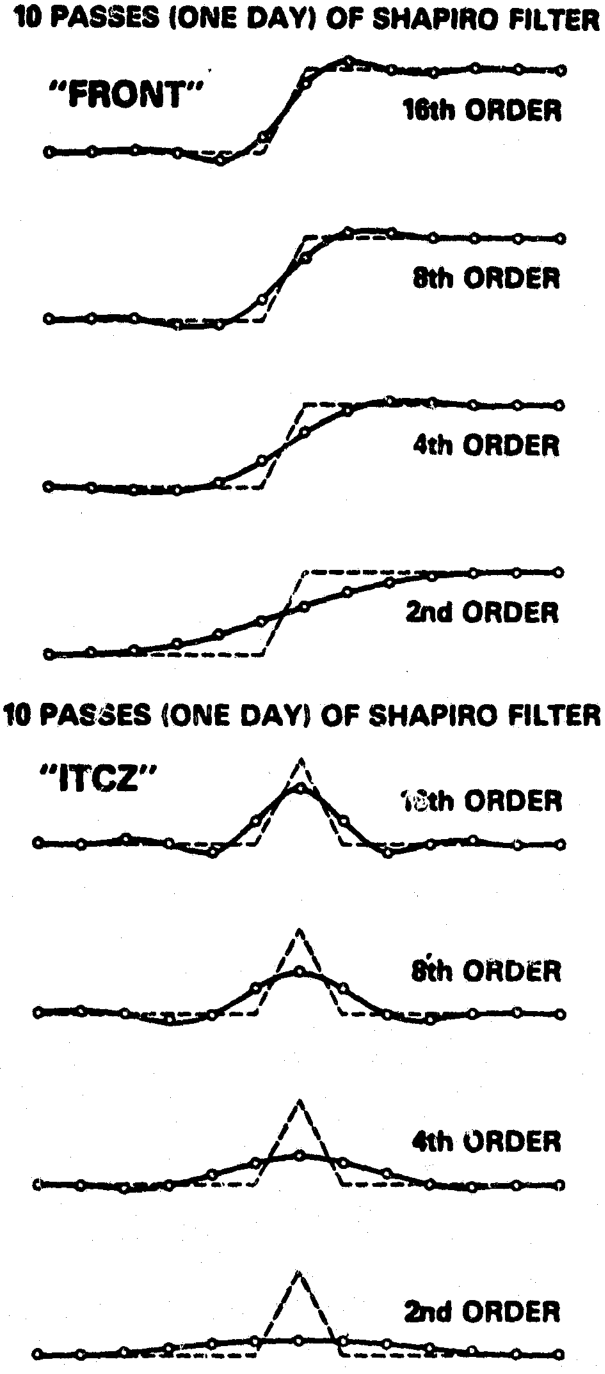

Fig. 4 Effect of 10 applications of a 16th order Shapiro filter on a) a step function b) a spike.

Our choice: We chose to use a quadratically (energy) conserving scheme because it is only slightly less efficient than an advective scheme and it requires the application of a high-order filter only every few hours to avoid the effect of slow nonlinear instability associated with a spurious growth of enstrophy. We apply the filter to the *sea level pressure and potential temperature fields* in order to compensate for the effect of topography.(3)

3. EXPERIMENTAL FORECASTS: PRELIMINARY RESULTS

We plan to perform an extensive series of forecasts to study the effect of using different schemes and varying resolution on the quality of actual weather forecasts. In this section we present some preliminary results.

We tested the Fourth Order model by making 3-day forecasts from several initial conditions. In every case the model performed much better than the GLAS model with the same 4° by 5° resolution. After 3 days the forecasts were comparable to the 2.5° by 3° version of the GLAS model in the sea level pressure maps, and had slightly less phase errors in the 500 mb maps.

Fig. 5a shows the verification sea level pressure map corresponding to a 3-day forecast with February 19, 1976, 0Z (a case that has been studied in detail by Atlas et al., 1979). Fig. 5b is the 3-day forecast with the Fourth Order 4° by 5° model verifying on the same date. The excessive gradients, especially at high latitudes are due to a faulty computation of the ground temperature by the radiation routine used in that run. Figs. 5c and 5d are the forecasts generated by the GLAS models with 4° by 5° and 2.5° by 3° resolution respectively. Fig. 6 displays the corresponding 500 mb maps.

In Fig. 7a, we present the verification sea level pressure map corresponding to a 3-day forecast with February 1, 1976, 0Z initial conditions. The results of six different 3-day forecasts are shown in Figs. 7b to 7g. The forecast in Fig. 7b was computed with the new full Fourth-Order model, using the same resolution and parameterization of physical processes (except for the long-wave radiation routine) as in the 4° by 5° GLAS model (Fig. 7c). In Fig. 7d, the model was the same as in 7b, but full Second-Order accuracy was used. If we compare these three made with the same resolution, we see that the fourth order model did considerably better, especially in forecasting the development and motion of the cyclone southwest of Greenland. The two second-order forecasts are close to each other.

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(3) The idea of filtering these fields is due to Dr. A. Bayliss.

Fig. 7 shows the forecast made with the 2.5° by 3° GLAS model starting from the NASA initial conditions with assimilation of satellite data [Atlas et al., 1979]. All other forecasts were made from NMC's Global Analysis initial conditions. The cyclogenesis forecast was poorer than with the fourth order model, but over continental North America the forecast was better. This may be due to the higher resolution or, possibly, improved initial conditions. Fig. 7f presents the forecast made with NMC's 6-layer, 380 km resolution, which has resolution comparable to our 4° by 5° grid. For these initial conditions, NMC's forecast was better than the GLAS second order forecast, although it shared some of its errors (such as a spurious anticyclogenesis over the Great Lakes).

Fig. 7g shows a forecast made with a slightly different version of the fourth order model. The differences were as follows: In the 7g forecast we used a Matsuno time step, a surface drag that was .75 of that of the standard model, the Shapiro was applied every two hours, and a slightly different scheme for the vertical advection of moisture was used. In the 7b forecast we used a combined Matsuno-leap-frog scheme, the surface drag was the same as in the standard model and the filter was applied every hour. The two forecasts are quite similar, but from other experiments it seems that the positions of the oceanic lows west of Spain and south of Alaska were somewhat affected by the change in frequency of the Shapiro filter.

4. FINAL REMARKS

Although these are preliminary results, the new Fourth-Order model seems to have very good forecasting skill. Similar excellent results with fourth order schemes were reported by Campana [1978, 1979], and by Williamson (1978). Campana found that most of the improvement over the second order model was obtained just by introducing fourth order accuracy on the horizontal averages performed on the Shuman-Hovermale model. Campana also obtained that for 2-day forecasts, fourth order differences were importent in the advection terms but not in the pressure and continuity terms. We made shallow water equation experiments that showed some deterioration of the solution after about 8 days when only the advection terms were written with fourth order accuracy. Since baroclinic models are much more unstable than the SWE, Campana's results may not hold during extended forecasts. We are performing experiments to study this possibility in our model. We are also repeating some of the forecasts using a vector invariant form of the momentum equations. The NMC 6-layer PE model used in Fig. 7f is based on such a formulation, and we want to determine if it affects the solution.

We are performing integrations with a 2.5° by 3° version of the Fourth-Order model. From linear theory, this should make horizontal truncation errors negligible for most synoptic scales for periods of a week or longer. Still, narrow atmospheric features like those due to sharp orographic forcing on the ITCZ will remain poorly resolved.

We have found the fourth order model to be extremely sensitive to the parameterization of physical processes. For example, it became unstable through excessive cooling near the surface, apparently due to a flaw in the radiation routine. None of the second order models was sensitive to this problem.

In this paper we have discussed the use of formally nonconservative schemes coupled with periodic filtering of the shortest waves as an alternative to the use of conservative schemes. It is clear from the experimental results that formal enstrophy conservation has had no beneficial impact on the quality of the forecast (Figs. 7c and 7d). Conservation of potential enstrophy [Arakawa, 1978] might have a more positive effect.

We think that the use of nonconservative schemes with high order periodic filtering is also justified in climate simulations as long as the rates of energy or enstrophy loss due to filtering remain much smaller than the observed rates of generation and dissipation.

Acknowledgements: Dr. A. Bayliss' contribution was crucial in the development of the model. The authors have benefitted from stimulating discussions with Profs. M. Cane, E. Isaacson and D. Randall. The authors are grateful to Dr. M. Halem for his patience, encouragement and many useful suggestions. Dr. N. Rushfield and Mr. W. Connelly were extremely helpful in the development of the program. Dr. M. Wu provided us with her accurate radiation routine.

Fig. 5 Sea level pressure maps corresponding to 3-day forecasts with February 19, 1976, 0Z initial conditions.

Fig. 6 Same as Fig. 5 but 500 mb geopotential heighte.

Fig. 7 Same as Fig. 5 but for February 1, 1976, 0Z initial conditions.

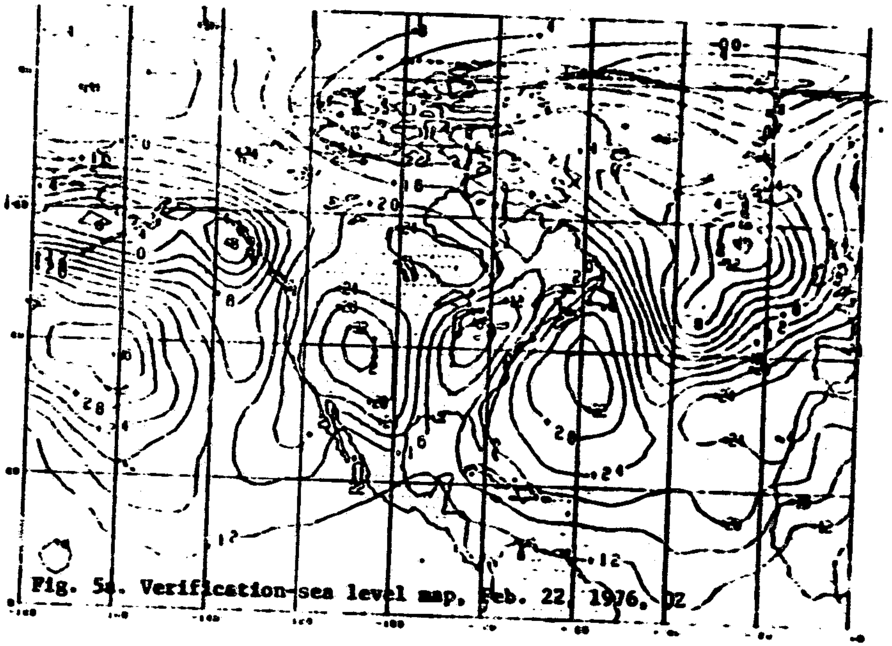

Fig. 5a. Verification-sea level map, Feb. 22, 1976, 02

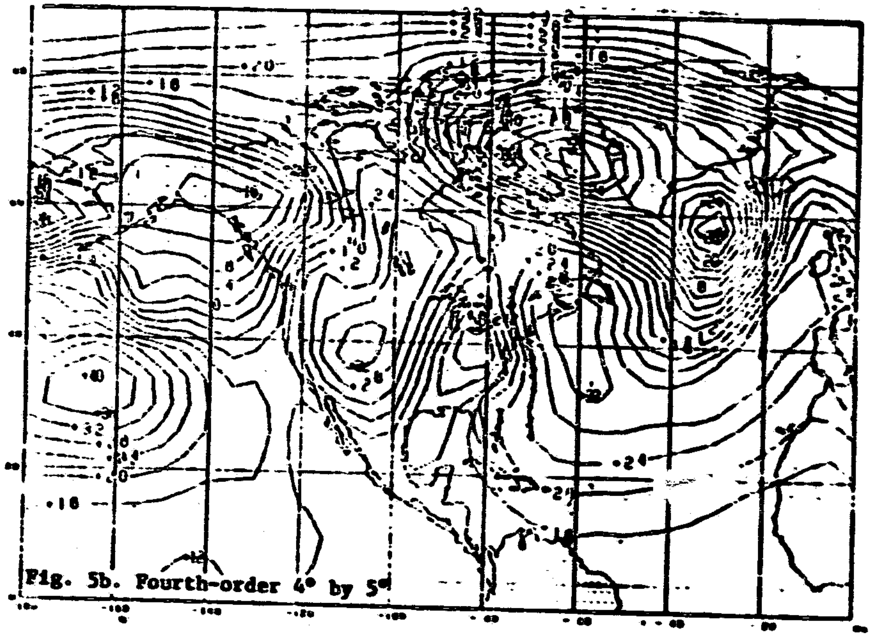

Fig. 5b. Fourth-order 4° by 5°

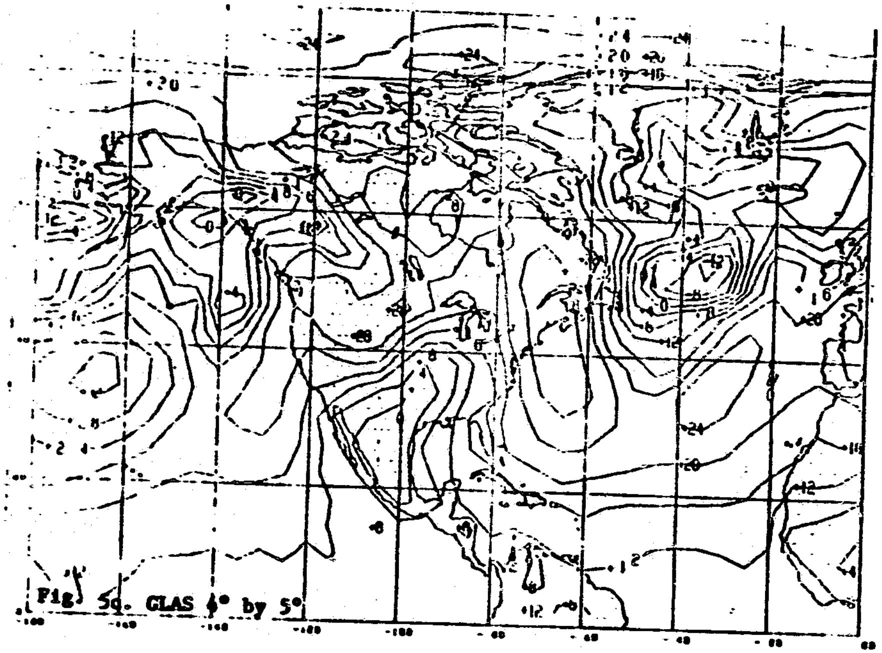

Fig. 5c. GLAS 4° by 5°

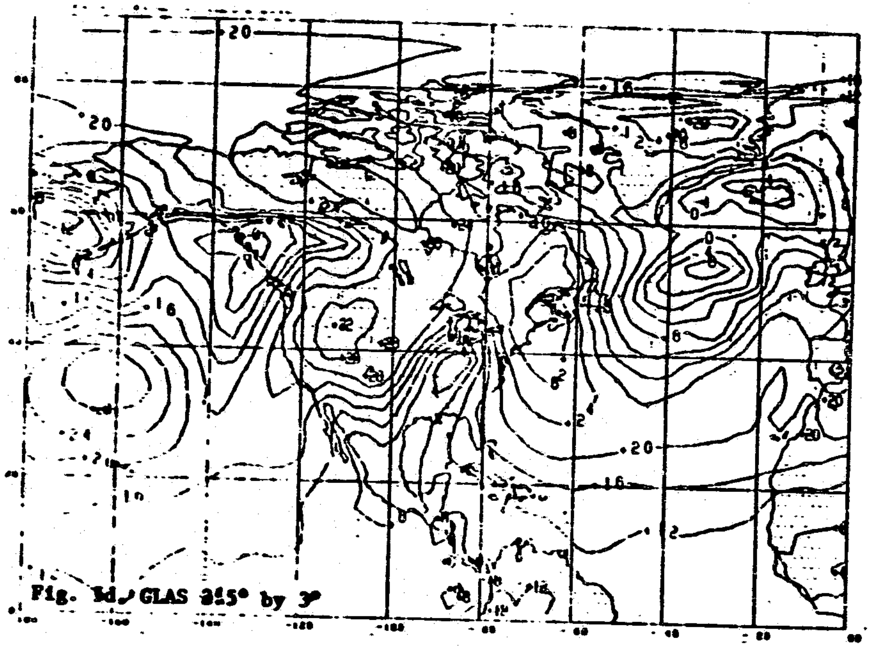

Fig. 5d. GLAS 2.5° by 3°

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OF POOR QUAL

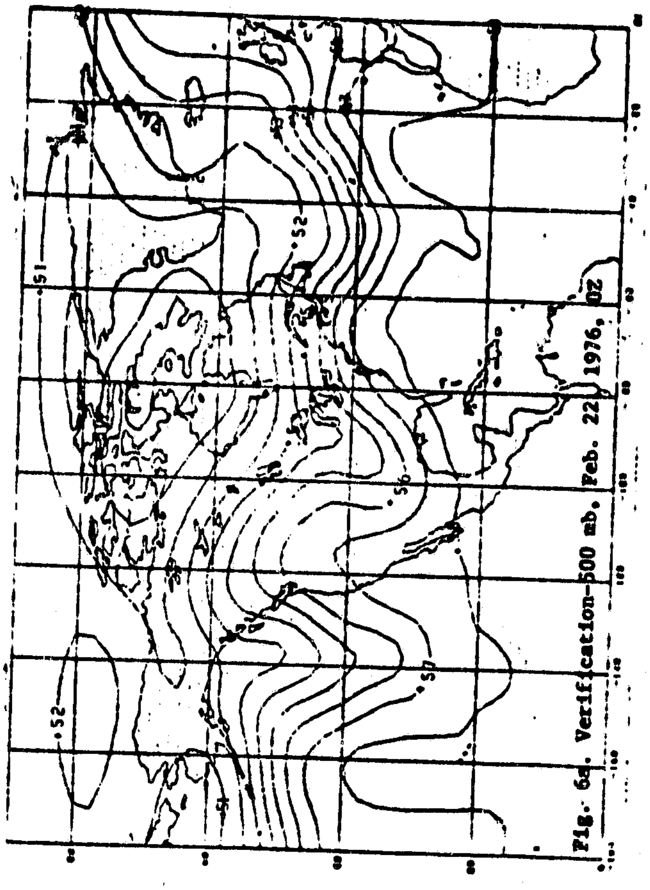

Fig. 6a. Verification-500 mb, Feb. 22, 1976, 0Z

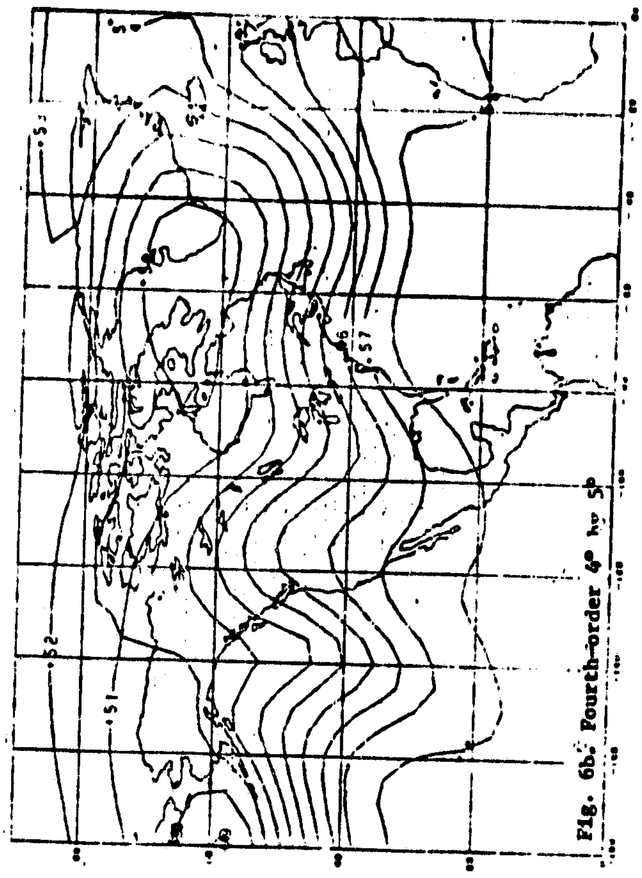

Fig. 6b. Fourth-order 4° by 5°

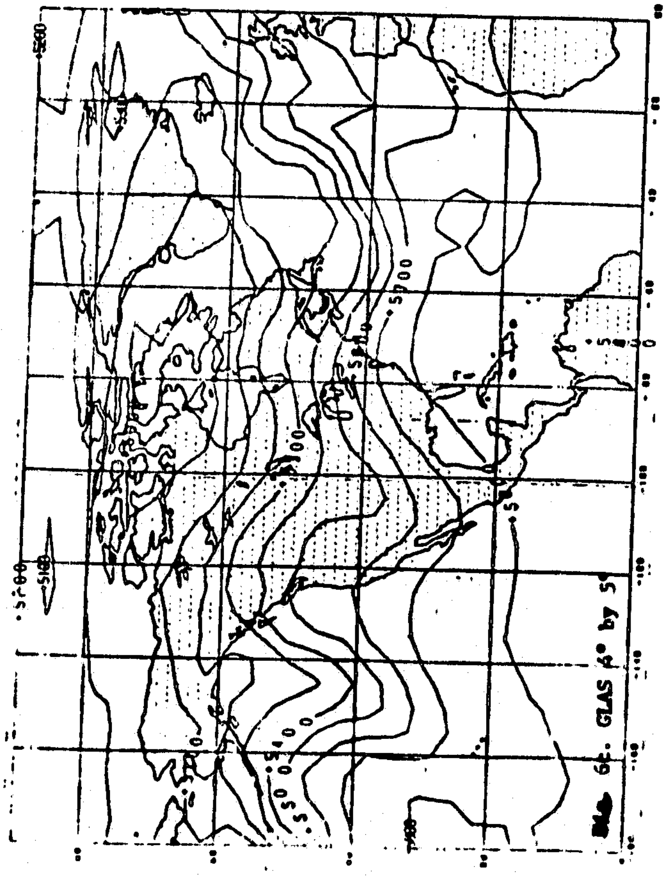

Fig. 6c. GLAS 4° by 5°

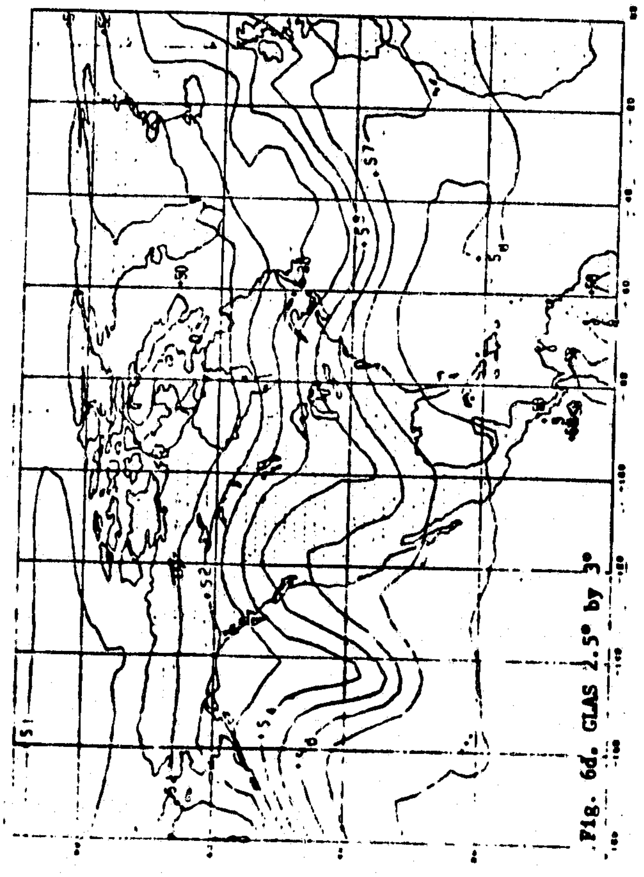

Fig. 6d. GLAS 2.5° by 3°

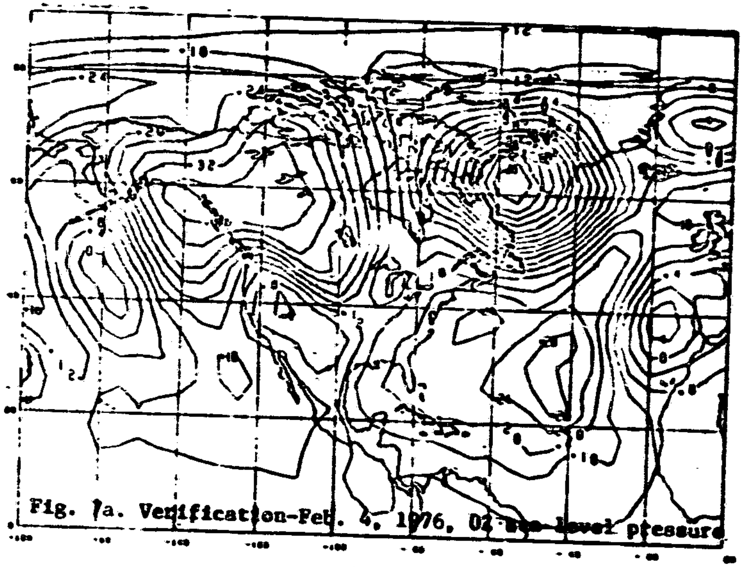

Fig. 7a. Verification-Feb. 4, 1976, 0Z sea-level pressure

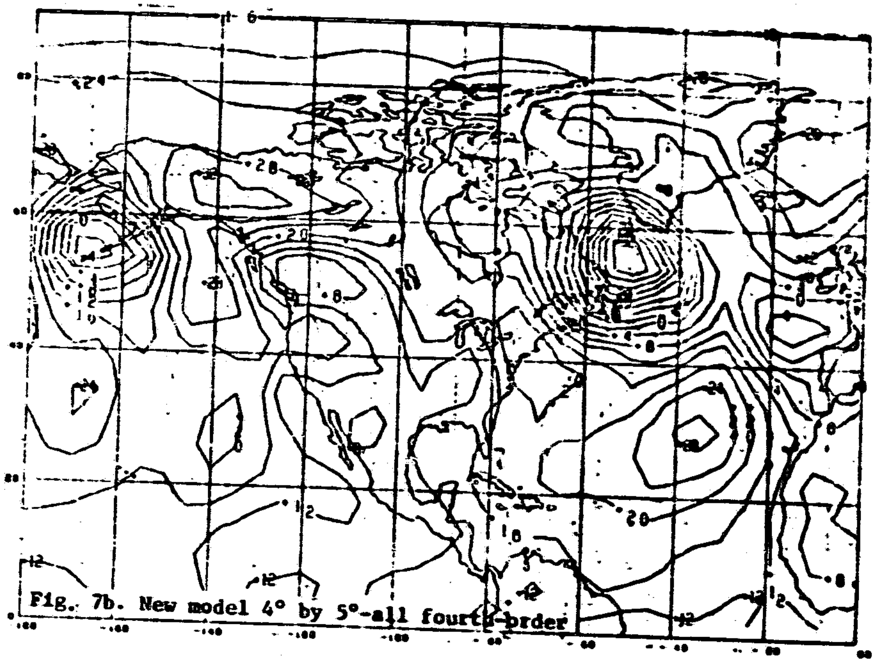

Fig. 7b. New model 4° by 5°-all fourth-order

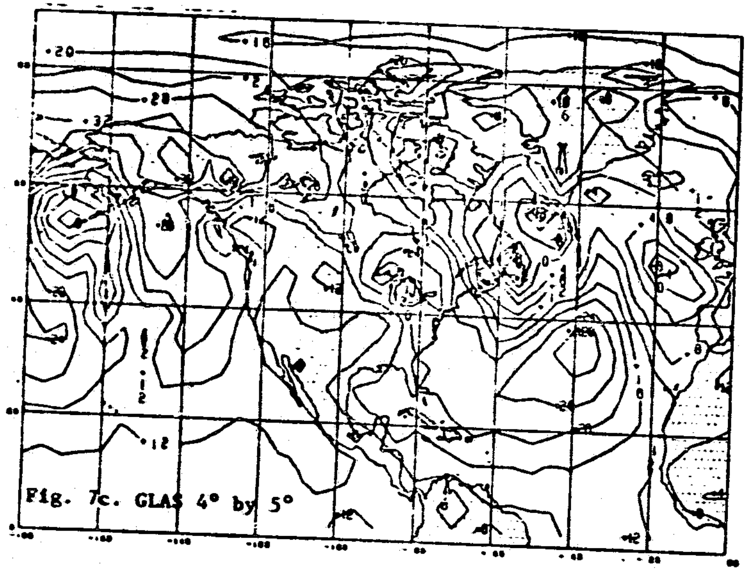

Fig. 7c. GLAS 4° by 5°

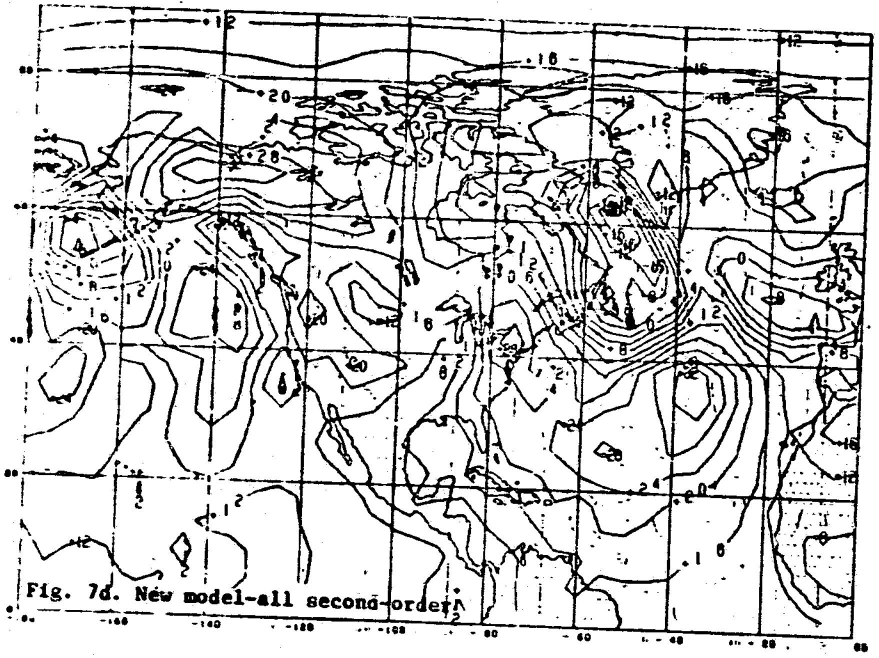

Fig. 7d. New model-all second-order

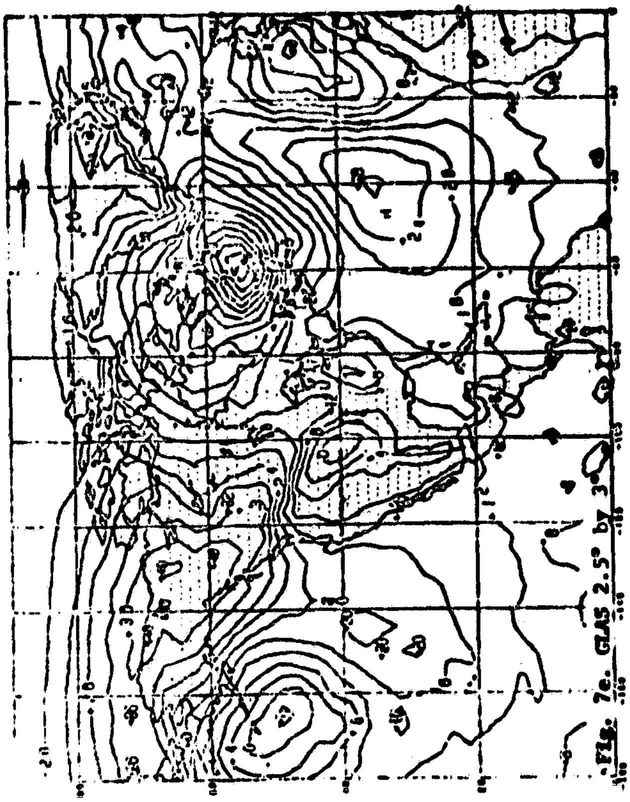

Fig. 7e. GLAS 2.5° by 3°

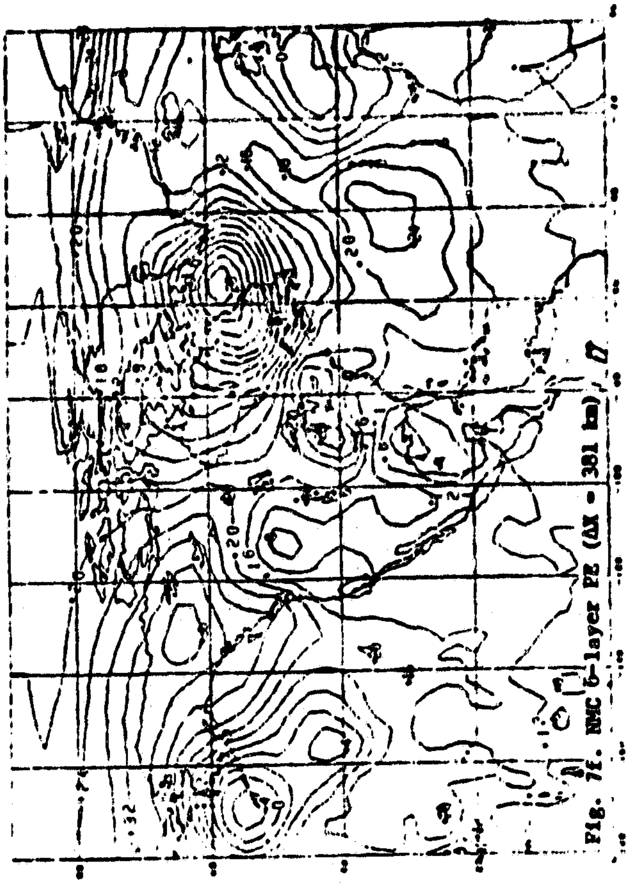

Fig. 7f. NMC 6-layer PE (ΔX = 381 km)

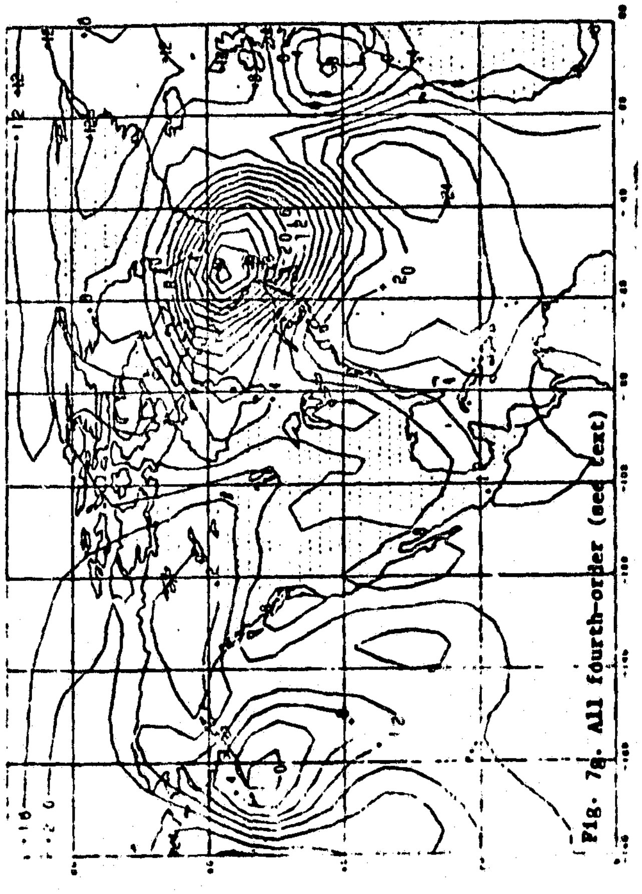

Fig. 7g. All fourth-order (see text)

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  ISN 0030               INTFX(XTAU)=INT(XTAU*XINT+.5)                                       B4N00680
```

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ISN 0031          EVENT(XTAU)=MOD(ITAU.INTFX(XTAU)).LT.IDTHR                     B4M00690
ISN 0032          CALL SUPUND                                                     B4M00700
ISN 0033          CALL DATE(ADATE)                                                B4M00710
ISN 0034          CALL TIME(ATIME)                                                B4M00720
ISN 0035          CALL CLOCKS(ITM)                                                B4M00730
ISN 0036          NDS=1                                                           B4M00740
ISN 0037          ITIME=ITM                                                       B4M00750
ISN 0038          LNTM=ITM                                                        B4M00760
ISN 0039          CALL INPUT                                                      B4M00770
ISN 0040          CALL INPUT4                                                     B4M00780
ISN 0041          DTSAVE = DT                                                     B4M00790
ISN 0042          DTS2=2.*DT                                                      B4M00800
            C     NPC=0  FOR PREDICTOR STEP                                       B4M00810
            C     NPC=1  FOR CORRECTOR STEP                                       B4M00820
ISN 0043          TAUO=TAUI+12.                                                   B4M00830
ISN 0044          DTHR=DT/3600.                                                   B4M00840
ISN 0045          IDTHR=INTFX(DTHR)                                               B4M00850
ISN 0046          I24=INTFX(24.)                                                  B4M00860
ISN 0047          NSTP=.5+TAU/DTHR                                                B4M00870
ISN 0048          NSTEPC=.5+(TAU-TAUI)/DTHR                                       B4M00880
ISN 0049          WRITE(3.26)NSTEPC                                               B4M00890
ISN 0050       26 FORMAT(//30X.'FIRST NSTEP='.I5//)                               B4M00900
ISN 0051          NSTEP=0                                                         B4M00910
ISN 0052          IF(NSEQ.EQ.1)MLF(2)=MATSUN                                      B4M00920
ISN 0054          MATSNX=MLF(1)                                                   B4M00930
ISN 0055          ITAU=NSTP*IDTHR                                                 B4M00940
ISN 0056          TAU = FLOAT(ITAU)/XINT                                          B4M00950
ISN 0057          IDAY=ITAU/I24                                                   B4M00960
ISN 0058          TOFDAY=FLOAT(ITAU-IDAY*I24)/XINT                                B4M00970
ISN 0059          CALL DAILY0                                                     B4M00980
ISN 0060          IF(IALTER.GT.0) CALL ALTER                                      B4M00990
ISN 0062          WRITE (3.OUPUTZ)                                                B4M01000
ISN 0063          TAUST=TAU                                                       B4M01010
ISN 0064          TAPNUM=XLABEL(20)                                               B4M01020
ISN 0065          WRITE (3.901) TAPNUM.TAUST.TAU.TAUT.XLABEL                      B4M01030
ISN 0066          WCODE=BLANK                                                     B4M01040
ISN 0067          WRITE(3.24)                                                     B4M01050
ISN 0068       24 FORMAT(////50X.'NEW FOURTH ORDER'//)                            B4M01060
ISN 0069          IF(ISTART.LE.4) GO TO 45                                        B4M01070
            C**** MAIN LOOP                                                       B4M01080
ISN 0071       40 WCODE=BLANK                                                     B4M01090
ISN 0072          IF(IALTER.GT.0) CALL ALTER2                                     B4M01100
ISN 0074       45 CONTINUE                                                        B4M01110
ISN 0075          NSTEPT=NSTEP+NSTEPC                                             B4M01120
ISN 0076          COMG = .FALSE.                                                  B4M01130
ISN 0077          IF(.NOT.EVENT(TAUT)) GO TO 50                                   B4M01140
ISN 0079          COMG = .TRUE.                                                   B4M01150
            C                                                                     B4M01160
            C     REPLACE DT WITH MATSUNO TIME-STEP SIZE SINCE                    B4M01170
            C     ANY RESTART NEEDS TO BEGIN WITH A MATSUNO STEP                  B4M01180
            C                                                                     B4M01190
ISN 0080          TEMP = DT                                                       B4M01200
ISN 0081          DT = DTSAVE                                                     B4M01210
            C                                                                     B4M01220
ISN 0082          CALL CLOCKS(NTM)                                                B4M01230
ISN 0083          WCODE=ONTAPE                                                    B4M01240
ISN 0084          CALL TWRITE                                                     B4M01250
            C   INITIALIZE PRECIPITATION ARRAY.                                   B4M01260
ISN 0085          ITAU1 = TAU + 0.01                                              B4M01270
ISN 0086          IF (MOD(ITAU1. 12) .NE. 0) GO TO 47                             B4M01280
ISN 0088          DO 46 J = 1. JNP                                                B4M01290
ISN 0089          DO 46 I = 1. IM                                                 B4M01300
ISN 0090          SDOT(I. J. 3) = 0.                                              B4M01310
ISN 0091          SDOT(I. J. 4) = 0.                                              B4M01320
ISN 0092       46 CONTINUE                                                        B4M01330
ISN 0093       47 CONTINUE                                                        B4M01340
            C                                                                     B4M01350
            C     REPLACE DT WITH CURRENT STEP-SIZE                               B4M01360
            C                                                                     B4M01370
ISN 0094          DT = TEMP                                                       B4M01380
            C                                                                     B4M01390
ISN 0095       50 CALL CLOCKS(NTM)                                                B4M01400
ISN 0096          TOTM=FLOAT(ITM-NTM)/100.                                        B4M01410
ISN 0097          STM=FLOAT(LNTM-NTM)/100.                                        B4M01420
ISN 0098          LNTM=NTM                                                        B4M01430
ISN 0099          WRITE(3.902)NSTEPT.IDAY.TOFDAY.JDATE.JMONTH.STM.TOTM.TAU        B4M01440
                1   .XLABEL(20).WCODE                                             B4M01450
ISN 0100          CALL SSWTCH(4.ISS4)                                             B4M01460
ISN 0101          IF (ISS4.EQ.1) WRITE (15.906)TAU.IDAY.TOFDAY.TAUST.TAUE         B4M01470
ISN 0103          IF (ISS4.EQ.1) CALL SSOFF                                       B4M01480
ISN 0105          CALL SSWTCH (6.KSS6)                                            B4M01490
ISN 0106          IF(KSS6.EQ.1)WRITE(3.27)NSTEP                                   B4M01500
ISN 0108       27 FORMAT(//30X.'LAST  NSTEP='.I5//)                               B4M01510
ISN 0109          IF(KSS6.EQ.1)GOTO 87                                            B4M01520
ISN 0111          IF(TAU+.01 .GT. TAUE)GOTO 88                                    B4M01530
ISN 0113          IF(NSTEPT.NE.0)GO TO 86                                         B4M01540
ISN 0115          DO 60 J=1.JNP                                                   B4M01550
ISN 0116       60 CALL COMP3(U.V.T.SH.P.Q.UPOL.VPOL.TPOL.SHPOL.PPOL.QPOL.J)       B4M01560
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ORIGINAL PAGE IS
OF POOR QUALITY

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ISN 0117          86 ITAU=ITAU + IDTHR                                                  B4M01570
ISN 0118             NPC=0                                                              B4M01580
ISN 0119             TAU=FLOAT(ITAU)/XINT                                               B4M01590
                C * * *                                                                 B4M01600
ISN 0120             IDAY=ITAU/I24                                                      B4M01610
ISN 0121             TOFDAY=FLOAT(ITAU-IDAY*I24)/XINT                                   B4M01620
ISN 0122             NSTEP=NSTEP+1                                                      B4M01630
ISN 0123             IF(NSEQ.GT.1)GO TO 12                                              B4M01640
ISN 0125             MATSUN=MATSNX                                                      B4M01650
ISN 0126             MATSNX=MLF(2)                                                      B4M01660
ISN 0127             GO TO 11                                                           B4M01670
ISN 0128          12 NTH=MOD(NSTEP-1,NSEQ)+1                                            B4M01680
ISN 0129             NEXT=MOD(NSTEP,NSEQ)+1                                             B4M01690
ISN 0130             MATSUN=MLF(NTH)                                                    B4M01700
ISN 0131             MATSNX=MLF(NEXT)                                                   B4M01710
ISN 0132          11 CONTINUE                                                           B4M01720
ISN 0133             DT=DTSAVE                                                          B4M01730
ISN 0134             IF(MATSUN.EQ.0)DT=DTS2                                             B4M01740
ISN 0136             CALL COMPO(U,V,T,SH,P,Q,UPOL,VPOL,TPOL,SHPOL,PPOL,QPOL,UT,VT,TT,   B4M01750
                    $     SHT,PT,QT,UTPOL,VTPOL,TTPOL,SHTPOL,PTPOL,QTPOL)               B4M01760
ISN 0137             IF(ISMTH.EQ.0)GO TO 14                                             B4M01770
ISN 0139             IF(NDS.EQ.0)GO TO 14                                               B4M01780
ISN 0141             MSM=MOD(NSTEP-NSM1,ISMTH)                                          B4M01790
ISN 0142             IF(MATSUN.EQ.1)GO TO 14                                            B4M01800
ISN 0144             IF(MSM.GT.1)GO TO 14                                               B4M01810
ISN 0146             CALL SMSHAP(TT,PT,QT,TTPOL,PTPOL,QTPOL,P,Q,PPOL,QPOL)              B4M01820
ISN 0147          14 CONTINUE                                                           B4M01830
ISN 0148             NDS=1                                                              B4M01840
                C *** IF(MATSUNO.OR FIRST LEAP FROG STEP)                               B4M01850
ISN 0149             NPC=1                                                              B4M01860
ISN 0150             IF((MATSUN.EQ.1).OR.(NSTEP.EQ.1))GO TO 84                          B4M01870
ISN 0152             NSTEP=NSTEP+1                                                      B4M01880
ISN 0153             IF(NSEQ.GT.1)GO TO 15                                              B4M01890
ISN 0155             MATSUN=MATSNX                                                      B4M01900
ISN 0156             MATSNX=MLF(2)                                                      B4M01910
ISN 0157             GO TO 18                                                           B4M01920
ISN 0158          15 NTH=MOD(NSTEP-1,NSEQ)+1                                            B4M01930
ISN 0159             NEXT=MOD(NSTEP,NSEQ)+1                                             B4M01940
ISN 0160             MATSUN=MLF(NTH)                                                    B4M01950
ISN 0161             MATSNX=MLF(NEXT)                                                   B4M01960
ISN 0162          18 CONTINUE                                                           B4M01970
ISN 0163             ITAU=ITAU + IDTHR                                                  B4M01980
ISN 0164             TAU=FLOAT(ITAU)/XINT                                               B4M01990
ISN 0165             IDAY=ITAU/I24                                                      B4M02000
ISN 0166             TOFDAY=FLOAT(ITAU-IDAY*I24)/XINT                                   B4M02010
ISN 0167        84   CALL COMPO(UT,VT,TT,SHT,PT,QT,UTPOL,VTPOL,TTPOL,SHTPOL,PTPOL,      B4M02020
                    $     QTPOL,U,V,T,SH,P,Q,UPOL,VPOL,TPOL,SHPOL,PPOL,QPOL)            B4M02030
ISN 0168             IF(ISMTH.EQ.0)GO TO 17                                             B4M02040
ISN 0170             MSM=MOD(NSTEP-NSM1,ISMTH)                                          B4M02050
ISN 0171             IF(MSM.GT.1)GO TO 17                                               B4M02060
ISN 0173             IF(MATSUN*MSM.EQ.1)GO TO 17                                        B4M02070
ISN 0175             CALL SMSHAP(T,P,Q,TPOL,PPOL,QPOL,PT,QT,PTPOL,QTPOL)                B4M02080
ISN 0176          17 CONTINUE                                                           B4M02090
ISN 0177             IF(MATSUN.EQ.1)NDS=0                                               B4M02100
ISN 0179             IF(EVENT(24.)) CALL DAILY                                          B4M02110
ISN 0181             GOTO 40                                                            B4M02120
                C**** END OF MAIN LOOP                                                  B4M02130
ISN 0182          87 WRITE(3,905)                                                       B4M02140
ISN 0183             WRITE (15,905)                                                     B4M02150
ISN 0184          88 CONTINUE                                                           B4M02160
ISN 0185             WRITE (3,904) IDAY,TOFDAY                                          B4M02170
ISN 0186             STOP                                                               B4M02180
ISN 0187        901  FORMAT('0TAPE ',A4,'  TAUS',2F10.3,F8.3,5X,20A4,/,                 B4M02190
                    1  '     WCODE=',2A4)                                               B4M02200
ISN 0188         902 FORMAT(5X,'STEP'I4,5X,'SIMU. TIME IS DAY' I4,7X,'HOUR'F7.3,I5,1X2A4,B4M02210
                    12F7.2,6X,'TAU=',F9.3,' TAPE='A4,' WCODE=',2A4)                     B4M02220
ISN 0189         904 FORMAT ('0PROGRAM HAS TERMINATED AT DAY',I4,' HOUR',F7.3)          B4M02230
ISN 0190         905 FORMAT(' SENSE SWITCH 6 ON')                                       B4M02240
ISN 0191         906 FORMAT(' SS4 ON. TAU='F8.2,2X'DAY'I4,2X'HOUR'F6.2/                 B4M02250
                    *  ' RUN START'F8.2,2X'WILL END'F6.2)                               B4M02260
ISN 0192             END                                                                B4M02270

                                       /     MAIN /     SIZE OF PROGRAM 00116C HEXADECIMAL BYTES

NAME TAG TYPE ADD.    |= ===    % NAME TAG TYPE ADD.    |= ===    % NAME TAG TYPE ADD.    |= ===    % NAME TAG TYPE ADD.    |= ===    %
      C      CE  R*4  000000           F         C  R*4    N.R.            I SF           I*4  000388           J SFA          I*4  0003BC
      P SFA  CE  R*4  002F10           Q SFA    CE  R*4  000E70            R         C    R*4    N.R.            T SFA   CE   R*4  0024F0
      U SFA  CE  R*4  000E70           V SFA    CE  R*4  0019B0            W         C    R*4    N.R.           CP         C   R*4    N.R.
     DT SF    C  R*4  00006C          ED         C  R*4  00012C           GT        CE    R*4  000840           GW        CE   R*4  001680
     IN  F    C  I*4  000008          JM         C  I*4  000030           JA         C    I*4  00002C           KN         C   I*4  000034
     NR       C  I*4  00004C          PI         C  R*4    N.R.           PK         C    R*4    N.R.           PT SFA    CE   R*4  0021C0
     PU      CE  R*4  000000          QT SFA    CE  R*4  000120           SH SFA    CE    R*4  003030           TS        CE   R*4  001890
     TT SFA  CE  R*4  0017A0          UT SFA    CE  R*4  000120           VT SFA    CE    R*4  000C60          CDX         C   R*4  000144
    DXP       C  R*4    N.R.         DXU         C  R*4    N.R.          DYP         C    R*4    N.R.          DYU         C   R*4    N.R.
    FIN       C  R*4    N.R.         FMU         C  R*4  000124          INC         C    I*4    N.R.          ITN SFA       I*4  0003C0
    I24 SFA      I*4  0003C4         JNB         C  I*4  0000BC          JNP  F      C    I*4  000004          JP1         C   I*4    N.R.
    JP2       C  I*4    N.R.         JSB         C  I*4  0000AC          JSP        CE    I*4  000000          LAT         C   R*4    N.R.
    MLF SF    C  I*4  000004         MSM S          I*4  0003C8          NDS S            I*4  0003CC          NPC S       C   I*4  000004
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    NTH SF        I*4  0003D0       NTM SFA       I*4  0003D4       PSF      C    R*4  00012C       PSL      C    R*4  00011C
    PSM      C    R*4    N.R.       QSM      C    R*4    N.R.       RAD      C    R*4    N.R.       SHS      CE   R*4  0023D0
    S4T SFA  CE   R*4  0022E0       SIG      C    R*4  00037C       SLP      C    R*4    N.R.       STM SF        R*4  000308
    SUM      C    R*4    N.R.       TAU SF   C    R*4  0000CC       TMP      C    R*4    N.R.      BETA      C    R*4    N.R.
   CATA      C    R*4    N.R.      CONG S    C    L*4  0389A4      CON1      C    R*4    N.R.      CON2      C    R*4    N.R.
   CON3      C    R*4    N.R.      CON4      C    R*4    N.R.      CONS      C    R*4    N.R.      COSD      C    R*4    N.R.
   COSL      C    R*4    N.R.      CPD2      C    R*4    N.R.      CPTH      C    R*4    N.R.      DATA      C    R*4    N.R.
   DATE SF   XF   R*4  000000      DIFF      C    R*4    N.R.      DLAT      C    R*4  000084      DLON      C    R*4  000088
   DSIG      C    R*4  0003C0      DTHR SFA       R*4  0003DC      DTS2 SF        R*4  0003E0      DXYP      C    R*4    N.R.
   FAST      C    L*4  00000C      GRAV      C    R*4    N.R.      IDAY SFA  C    I*4  0000CC      IND2      C    I*4    N.R.
   INCS      C    I*4    N.R.      IROT      C    I*4  00003C      ISS4 SFA       I*4  0003E4      ITAU SFA  C    I*4  0000C4
   JAYS      C    I*4    N.R.      JDAY      C    I*4    N.R.      JEND      C    I*4    N.R.      JMAX      C    I*4    N.R.
   JMIN      C    I*4    N.R.      JMPS      C    I*4    N.R.      JMS1      C    I*4    N.R.      JMS2      C    I*4    N.R.
   JMUS      C    I*4    N.R.      JPOL      C    I*4    N.R.      JSUM      C    I*4    N.R.      J1P5      C    I*4    N.R.
   J1US      C    I*4    N.R.      KAPA      C    R*4    N.R.      KNBS      C    I*4    N.R.      KSBS      C    I*4    N.R.
   KSS6 SFA       I*4  0003E8      LNTM SFA       I*4  0003EC      MRCH      C    I*4    N.R.      MROT      C    I*4  000040
   NCM1      C    I*4    N.R.      NEXT SF        I*4  0003FC      NFLW      C    I*4  000128      NLAY      C    I*4  00000C
   NOC3      C    L*4  000004      NSEQ FA   C    I*4  00000C      NSM1 FA   C    I*4  000030      NSTP SF        I*4  0003F4
   PHIS      CE   R*4  000D50      PPOL SFA  CE   R*4  000654      PTOP      C    R*4  000010      QPOL SFA  CE   R*4  000414
   RADT      C    I*2    N.R.      RGAS      C    R*4    N.R.      SDCT S    CE   R*4  000000      SIGE      C    R*4    N.R.
   SINC      C    R*4    N.R.      SINL      C    R*4    N.R.      SMTH      C    R*4    N.R.      TAUE F    C    R*4  000100
   TAUI F    C    R*4  0000FC      TAUG S    C    R*4  000104      TAUP      C    R*4  0000F8      TAJT FA   C    R*4  000038
   TEMP SF        R*4  0003F8      TIME SF   XF   R*4  00000C      TOTM SF        R*4  0003FC      TPOL SFA  CE   R*4  00045C
   UPOL SFA  CE   R*4  000414      VPOL SFA  CE   R*4  000438      XINT FA   C    R*4  0000C8     ADATE SFA       R*8  000420
  ADLDP      C    R*4    N.R.     ALPHA      C    R*4    N.R.     ALTER SF   XF   R*4  000000     ATIME SFA       R*8  000428
  BLANK F         R*8  000430     COMPO SF   XF   R*4  00000C     COMP3 SF   XF   R*4  000000     C3WRT      C    L*4  000000
  DAILY SF   XF   R*4  00[illegible]0     DSIGO      C    R*4    N.R.     DUMMY      C    R*4    N.R.     EVENT S    ASF  L*4  000000
  IDTHR SF        I*4  000400     INDEX      C    I*4    N.R.     INPUT SF   XF   I*4  000000     INTFX S    AASF I*4  000300
  ISDOT      CE   I*2  00CF00     ISMTH FA   C    I*4  00000C     ITAU1 S    A    I*4  000404     ITEST      C    I*4  000048
  ITIME S         I*4  000408     JDATE F    C    I*4  0000D8     JNEXT      C    I*4    N.R.     JNPM1      C    I*4    N.R.
  JPMOD      C    I*4    N.R.     JSPP1      C    I*4    N.R.     JTEST      C    I*4  000044     JYEAR      C    I*4    N.R.
  MODPK      C    I*4    N.R.     NSTEP SFA  C    I*4  0000E8     OMEGA      C    I*2    N.R.     POLES      CE   R*4  000414
  PSIGN      C    R*4    N.R.     PTPOL SFA  CE   R*4  00065C     QTPOL SFA  CE   R*4  000534     RADIM      C    R*4    N.R.
  RHMAX      C    R*4    N.R.     SDPOL      C    R*4    N.R.     SHPOL SFA  CE   R*4  000480     SSOFF SF   XF   R*4  000300
  TAUST SF        R*4  00040C     THBAR      C    R*4    N.R.     TOPOG      C    R*4    N.R.     TTPOL SFA  CE   R*4  00057C
  UTPOL SFA  CE   R*4  000534     VTPOL SFA  CE   R*4  000558     WCODE SF        R*8  000438     WORKX      C    R*4    N.R.
 ADPCLD      C    L*4  000018    ALBEDO      C    I*2    N.R.    ALTER2 SF   XF   R*4  000000    CLOCKS SF   XF   R*4  000000
 CONVPL      C    R*4    N.R.    COSLON      C    R*4    N.R.    DAILY0 SF   XF   R*4  000000    DTMULT      C    R*4  000108
 DTSAVE SF        R*4  000410    DUMMYA      C    R*4    N.R.    DUMMYC      C    R*4    N.R.    FORML# F    XF   R*4  000000
 IALTER      C    I*4  000190    IBCOM# F    XF   R*4  00000C    IND2P1      C    I*4    N.R.    INPUT4 SF   XF   I*4  000000
 ISTART      C    I*4  000014    ISWTCH      C    I*4  00000C    JMONTH F    C    I*4  0000DC    MATSNX SF   C    I*4  00002C
 MATSUN SF   C    I*4  000058    MNMXTS      C    I*4    N.R.    NCOMP3      C    I*4  0000F0    NCYCLE      C    I*4  0000EC
 NHOGAN      C    I*4  0000F4    NLAYM1      C    I*4    N.R.    NLAYP1      C    I*4    N.R.    NSTART      C    I*4    N.R.
 NSTEPC SF        I*4  000414    NSTEPT SF        I*4  000418    ONTAPE F         R*8  000440    OUPUTZ F              000001
 PHISPL      C    R*4    N.R.    PITPOL           R*4    N.R.    PSKAPA      C    R*4    N.R.    PSMPOL      C    R*4    N.R.
 QSMPOL      C    R*4    N.R.    RSDIST      C    R*4    N.R.    SHSMOO      C    L*4  000008    SHTPOL SFA  CE   R*4  0005A0
 SINLON      C    R*4    N.R.    SMAFTA      C    L*4  000014    SMSHAP SF   XF   R*4  000000    SSWTCH SF   XF   R*4  000000
 SUPUND SF   XF   R*4  000000    TAPNUM SF        R*4  00041C    TOFDAY SF   C    R*4  000004    TWRITE SF   XF   R*4  000000
 XLABEL F    C    R*4  000320

                                 *****   COMMON INFORMATION   *****

   NAME OF COMMON BLOCK * F;U#.ZE OF BLOCKCOMMON      005E24 HEXADECIMAL BYTES

 VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE
      CON1     R*4     N.R.          CON2     R*4     N.R.          CON3     R*4     N.R.          CON4     R*4     N.R.
      CONS     R*4     N.R.         THBAR     R*4     N.R.         ALPHA     R*4     N.R.          BETA     R*4     N.R.
    IND2P1     I*4     N.R.         ADLDP     R*4     N.R.          JMS2     I*4     N.R.          JMS1     I*4     N.R.
      CPTH     R*4     N.R.        PSKAPA     R*4     N.R.             R     R*4     N.R.           RAD     R*4     N.R.
        CP     R*4     N.R.           INC     I*4     N.R.        NSTART     I*4     N.R.          CPD2     R*4     N.R.
      IND2     I*4     N.R.         RADIM     R*4     N.R.          JEND     I*4     N.R.           JP1     I*4     N.R.
       JP2     I*4     N.R.        MATSUN     I*4   000068         JNEXT     I*4     N.R.         MODPK     I*4     N.R.
      JPOL     I*4     N.R.         JPMOD     I*4     N.R.        SINLON     R*4     N.R.        COSLON     R*4     N.R.
     INDEX     I*4     N.R.         PSIGN     R*4     N.R.         POLES     R*4   000414             W     R*4     N.R.
        PK     R*4     N.R.          DISF     R*4     N.R.        CONVPL     R*4     N.R.         SDPOL     R*4     N.R.
    PHISPL     R*4     N.R.           SUM     R*4     N.R.
 EQUIVALENCED VARIABLES WITHIN THIS COMMON GROUP
   VARIABLE OFFSETE               VARIABLE OFFSETE               VARIABLE OFFSETE               VARIABLE OFFSETE
      QPOL     000414                QTPOL     000534                 UPOL     000414                 VPOL     000438
      TPOL     00045C                SHPCL     000480                UTPOL     000534                VTPOL     000558
     TTPCL     00057C               SHTPOL     0005AC                 PPOL     000654                P7POL     00065C


   NAME OF COMMON BLOCK *  =M..ZE OF BLOCKCOMMON      000148 HEXADECIMAL BYTES

 VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE
       QSM     R*4     N.R.           PSM     R*4     N.R.        QSMPOL     R*4     N.R.        PSMPOL     R*4     N.R.

   NAME OF COMMON BLOCK *  =M6.ZE OF BLOCKCOMMON      003E70 HEXADECIMAL BYTES

 VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE
      DATA     R*4     N.R.          CATA     R*4     N.R.           SLP     R*4     N.R.
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  NAME OF COMMON BLOCK *  )HWR.E OF BLOCKCOMMON      000C1C HEXADECIMAL BYTES

VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE
   C3WRT    L*4   000000           NOC3     L*4   000004         SHSMOO    L*4   000008          FAST     L*4   00300C
     TMP    R*4     N.R.         SMAFTA     L*4   000014         ADPCLD    L*4   000018

  NAME CF CCMMON BLOCK * S*OT*9E OF ELOCKCOMMON      038SA8 HEXADECIMAL BYTES

VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE
    SDOT    R*4   000000          OMEGA     I*2     N.R.         MNMXTS    I*4     N.R.          RADT     I*2     N.R.
    COMG    L*4   0389A4

EQUIVALENCED VARIABLES WITHIN THIS CCMMON GROUP
  VARIABLE CFFSETE             VARIABLE OFFSETE               VARIABLE OFFSETE               VARIABLE OFFSETE
   ISDOT    00CF00

  NAME OF CCMMON BLOCK *  -NTR#E OF ELOCKCOMMON      083C30 HEXADECIMAL BYTES

VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE
     JSP    I*4   000000            JNP     I*4   000004             IM    I*4   000008          NLAY     I*4   00000C
    PTOP    R*4   000010         ISTART     I*4   000014          JSPP1    I*4     N.R.         JNPM1     I*4     N.R.
     FIM    R*4     N.R.         NLAYM1     I*4     N.R.         NLAYP1    I*4     N.R.            J1     I*4   00002C
      JM    I*4   000030             KM     I*4   000034           TAUT    R*4   000038          IROT     I*4   00003C
    MROT    I*4   000040          JTEST     I*4   000044          ITEST    I*4   000048            NR     I*4   00004C
    JAYS    I*4     N.R.           INCS     I*4     N.R.            JSB    I*4   0000AC           JNB     I*4   0000B0
    DLAT    R*4   0000B4           DLON     R*4   0000B8             DT    R*4   0000BC           TAU     R*4   0000C0
    ITAU    I*4   0000C4           XINT     R*4   0000C8           IDAY    I*4   0000CC          JDAY     I*4     N.R.
  TOFDAY    R*4   0000D4          JDATE     I*4   0000D8         JMONTH    I*4   0000DC         JYEAR     I*4     N.R.
   NSTEP    I*4   0000E8         NCYCLE     I*4   0000EC         NCOMP3    I*4   0000F0        NHOGAN     I*4   0000F4
    TAUP    R*4   0000F8           TAUI     R*4   0000FC           TAUE    R*4   000100          TAUO     R*4   000104
  DTMULT    R*4   000108             PI     R*4     N.R.           GRAV    R*4     N.R.          RGAS     R*4     N.R.
    KAPA    R*4     N.R.            PSL     R*4   00011C             ED    R*4   000120           FMU     R*4   000124
    NFLW    I*4   000128            PSF     R*4   00012C           MRCH    I*4     N.R.        RSDIST     R*4     N.R.
    SIND    R*4     N.R.           COSD     R*4     N.R.          RHMAX    R*4     N.R.           CDX     R*4   000144
  DUMMYC    R*4     N.R.         IALTER     I*4   000198         DUMMYA    R*4     N.R.        XLABEL     R*4   000320
     SIG    R*4   000370           DSIG     R*4   0003C0           SIGE    R*4     N.R.         DSIGO     R*4     N.R.
    J1PS    I*4     N.R.           JMPS     I*4     N.R.           J1US    I*4     N.R.          JMUS     I*4     N.R.
    KSBS    I*4     N.R.           KNBS     I*4     N.R.            LAT    R*4     N.R.           DXU     R*4     N.R.
     DXP    R*4     N.R.            DYU     R*4     N.R.            DYP    R*4     N.R.          DXYP     R*4     N.R.
       F    R*4     N.R.           SINL     R*4     N.R.           COSL    R*4     N.R.         DUMMY     R*4     N.R.
    PHIS    R*4   000050         ALBEDG     I*2     N.R.

EQUIVALENCED VARIABLES WITHIN THIS COMMON GROUP
  VARIABLE OFFSETE             VARIABLE OFFSETE               VARIABLE OFFSETE               VARIABLE OFFSETE
       Q    000E70                    U   000E70                   TS   001890                    V   001980
     SHS    0023D0                    T   0024F0                    P   002F10                   SH   003030
       C    000000

  NAME CF CCMMON BLOCK *  *W6R#E OF BLOCKCOMMON      01D1C0 HEXADECIMAL BYTES

VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE
   WORKX    R*4     N.R.

  NAME CF CCMMON BLOCK *  =O#S#E OF ELOCKCOMMON      081C00 HEXADECIMAL BYTES

VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE
      PU    R*4   000000

EQUIVALENCED VARIABLES WITHIN THIS COMMON GROUP
  VARIABLE CFFSETE             VARIABLE OFFSETE               VARIABLE OFFSETE               VARIABLE OFFSETE
      QT    000120                   UT   00012C                   GT   000840                   VT   000C60
      GW    001680                   TT   0017A0                   PT   0021C0                  SHT   0022E0

  NAME OF COMMON BLOCK *  *S6-"E OF BLOCKCOMMON      000C08 HEXADECIMAL BYTES

VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE
   ISMTH    I*4   000000            NPC     I*4   000004

  NAME OF COMMON BLOCK *  * T-?E OF BLOCKCOMMON      0033C0 HEXADECIMAL BYTES

VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE RE_. ADDR.HE
   TOPOG    R*4     N.R.

  NAME CF CCMMON BLOCK *  *DS_7E OF BLOCKCOMMON      000C04 HEXADECIMAL BYTES

VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE
  ISWTCH    I*4   000000

  NAME CF CCMMON BLOCK *  * SI.E OF ELOCKCOMMON      000SE0 HEXADECIMAL BYTES
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VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE
    JMIN    I*4      N.R.            JMAX    I*4      N.R.            JSUM    I*4      N.R.            SMTH    R*4      N.R.

  NAME OF COMMON BLOCK *  *M3|.E OF BLOCKCOMMON     000C38 HEXADECIMAL BYTES

VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE
    NSEQ    I*4    000000            MLF     I*4    000004            MATSNX  I*4    00002C            NSM1    I*4    000030
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     LABEL   ADDR              LABEL   ADDR              LABEL   ADDR              LABEL   ADDR
       40   000A44               45   000A62               46   000B7A               47   000B82
       50   000B9A               60   000D66               86   000D86               12   000E4A
       11   000E8A               14   000F0A               15   000F6E               18   000FAE
       84   001032               17   00108E               87   0010F2               88   00111C

*OPTIONS IN EFFECT*       NAME=  MAIN,OPT=02,LINECNT=55,SIZE=1000K,

*OPTIONS IN EFFECT*       SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,NOXREF

*STATISTICS*      SOURCE STATEMENTS =      191   PROGRAM SIZE=       4460

*STATISTICS*  NO  DIAGNOSTICS GENERATED

****** END OF COMPILATION ******                                     852K BYTES OF CORE NOT USED

 LEVEL 19.6-APR 71                            OS/360 FORTRAN H AT GISS                          DATE 12/12/79-0783.03

        COMPILER OPTIONS -   NAME=  MAIN,OPT=02,LINECNT=55,SIZE=1000K,
                             SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,NOXREF
  ISN 0002              SUBROUTINE DAILY                                                B4M02280
                  C**** FINE NINE LAYER GLOBAL CDE BLOCK FOR VM MODEL, FEBRUARY 1976    B4M02290
  ISN 0003              INTEGER*2 ALBEDO                                                B4M02300
  ISN 0004              REAL*4 KAPA,LAT                                                 B4M02310
                  C     REAL*8 SINLON,COSLON,SUM                                        B4M02320
  ISN 0005              COMMON/FOURTH/CON1,CON2,CON3,CON4,CONS,TFBAR,ALPHA,BETA,IMD2P1, B4M02330
                     $     ADLDP,JMS2,JMS1,CPTH,PSKAPA,R,RAD,CP, INC,NSTART,CPD2,       B4M02340
                     $     IMD2,RADIM,JEND(2),JP1,JP2,MATSUN,JNEXT(2),MODPK(2,2),       B4M02350
                     $     JPOL(2,2),JPMOD(2,2),SINLON(72),COSLON(72),INDEX(72),        B4M02360
                     $     PSIGN(4),POLES(148),W(72,9,5),PK(72,9,3),DIFF(9),            B4M02370
                     $     CONVPL(9),SDPOL(9,2),PHISPL(2),SUM(2,5)                      B4M02380
  ISN 0006              EQUIVALENCE (QPOL(1,1,1),POLES(1)),(QTPOL(1,1,1),POLES(73)),    B4M02390
                     $     (UPOL(1,1),POLES(1)),(VPOL(1,1),POLES(10)),(TPOL(1,1),       B4M02400
                     $     POLES(19)),(SHPOL(1,1),POLES(28)),(UTPOL(1,1),POLES(73)),    B4M02410
                     $     (VTPOL(1,1),POLES(82)),(TTPOL(1,1),POLES(91)),(SHTPOL(1,1),  B4M02420
                     $     POLES(100)),(PPOL(1),POLES(145)),(PTPOL(1),POLES(147))       B4M02430
  ISN 0007              DIMENSION PPOL(2),PITPOL(2),UPOL(36,1),VPOL(36,1),TPOL(36,1),   B4M02440
                     $     SHPOL(36,1),QPOL(9,4,2),Q(72,10,4,1)                         B4M02450
  ISN 0008              DIMENSION PTPOL(2),UTPOL(36,1),VTPOL(36,1),TTPOL(36,1),         B4M02460
                     $     SHTPOL(36,1),QTPOL(9,4,2),QT(72,10,4,1)                      B4M02470
  ISN 0009              COMMON /CNTRL/                                                  B4M02480
                     *  JSP,JNP,IM,NLAY,PTOP,ISTART,JSFP1,JNPM1,FIM,NLAYM1,NLAYP1,      B4M02490
                     *  J1,JM,KM,TAUT,IROT,MROT,JTEST,ITEST,                            B4M02500
                     *  NR,JAYS(12),INCS(11),JSB,JNB,DLAT,DLON,                         B4M02510
                     *  DT,TAU,ITAU,XINT,IDAY,JDAY,TOFDAY,JDATE,JMONTH(2),JYEAR,NSTEP,  B4M02520
                     *  NCYCLE,NCOMP3,NHOGAN,TAUP,TAUI,TAUE,TAUO,DTMULT,                B4M02530
                     *  PI,GRAV,RGAS,KAPA,PSL,ED,FMU,NFLB,PSF,RCH,RSDIST,SIND,COSD,     B4M02540
                     *  RHMAX,CDX,DUMMYC(18),IALTER,DUMMYA(99),                         B4M02550
                     *  XLABEL(20),SIG(20),DSIG(20),SIGE(21),DSIGO(19),                 B4M02560
                     *  J1PS(11),JMPS(11),J1US(11),JMUS(11),KSES(11),KNBS(11),          B4M02570
                     *LAT(46),DXU(46),DXP(46),DYU(46),DYP(46),DXYP(46),F(46),SINL(46),  B4M02580
                     *COSL(46),DUMMY(72),PHIS(2880,46),ALBEDO(72,46)                    B4M02590
  ISN 0010              DIMENSION U(72,40,1),V(72,40,1),T(72,40,1),SH(72,46,1),         B4M02600
                     *P(2880,1),TS(2880,1),SHS(2880,1),GT(2880,1),GW(2880,1),C(300)     B4M02610
  ISN 0011              EQUIVALENCE (U(1,1,1),PHIS(73,1)),(TS(1,1),PHIS(721,1)),        B4M02620
                     $     (V(1,1,1),PHIS(793,1)),(SHS(1,1),PHIS(1441,1)),              B4M02630
                     $     (T(1,1,1),PHIS(1513,1)),(P(1,1),PHIS(2161,1)),               B4M02640
                     $     (SH(1,1,1),PHIS(2233,1)),(GT(1,1),PU(721,1)),(GW(1,1),       B4M02650
                     $      PU(1441,1)),(C(1),JSP)                                      B4M02660
  ISN 0012              COMMON /WORK2/PU(2880,46)                                       B4M02670
  ISN 0013              INTEGER AMONTH,DAYSPM,DAYSPY                                    B4M02680
  ISN 0014              DIMENSION AMONTH(2,12),DAYSPM(12)                               B4M02690
  ISN 0015              DATA AMONTH/'JANU','ARY ','FEBR','UARY','MARC','H   ','APRI',   B4M02700
                     $     'L   ','MAY ','    ','JUNE','    ','JULY','    ','AUGU',       B4M02710
                     $     'ST  ','SEPT','EMBR','OCTO','BER ','NOVE','MBER','DECE',     B4M02720
                     $     'MBER'/                                                      B4M02730
  ISN 0016              DATA DAYSPM/31,28,31,30,31,30,31,31,30,31,30,31/                B4M02740
  ISN 0017              DATA IDAY0/302/,DAYSPY/365/                                     B4M02750
  ISN 0018              DATA SOLS,APHEL,ECCN/173.,183.,.0178/                           B4M02760
  ISN 0019              IFIRST=0                                                        B4M02770
                  C**** CALCULATE GLOBAL MEAN SURFACE PRESSURE                          B4M02780
                  C * * *                                                               B4M02790
  ISN 0020            5 SAREA=0.                                                        B4M02800
  ISN 0021              SMASS=0.                                                        B4M02810
  ISN 0022              INC=1                                                           B4M02820
  ISN 0023              FINC=INC                                                        B4M02830
  ISN 0024              DO 20 J=2,JM                                                    B4M02840
  ISN 0025              SPRESS=0.                                                       B4M02850
  ISN 0026              DO 10 I=INC,IM,INC                                              B4M02860
  ISN 0027           10 SPRESS=SPRESS+P(I,J)                                            B4M02870
  ISN 0028              SAREA=SAREA+DXYP(J)*FIM                                         B4M02880
  ISN 0029           20 SMASS=SMASS+SPRESS*DXYP(J)                                      B4M02890
  ISN 0030              DAP = 4. * PI * SIN(.5*DLAT) ** 2                               B4M02900
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ISN 0031          SAREA = SAREA + 2. * DAP                                      B4M02910
ISN 0032          SMASS = SMASS + DAP * (PPOL(1) + PPOL(2))                     B4M02920
ISN 0033          PBAR=SMASS/SAREA+PTOP                                         B4M02930
ISN 0034          IF(IFIRST.NE.1) GO TO 30                                      B4M02940
ISN 0036          PSF=PBAR                                                      B4M02950
ISN 0037          GO TO 50                                                      B4M02960
ISN 0038       30 DELTAP=PSF-PBAR                                               B4M02970
ISN 0039          DO 40 I=1,IM                                                  B4M02980
ISN 0040          DO 40 J=1,JNP                                                 B4M02990
ISN 0041       40 P(I,J)=P(I,J)+DELTAP                                          B4M03000
ISN 0042          WRITE (3,901) DELTAP                                          B4M03010
             C**** CALCULATE CALENDAR                                           B4M03020
ISN 0043       50 JYEAR=1+(IDAY+IDAY0-1)/DAYSPY                                 B4M03030
ISN 0044          JDAY=IDAY+IDAY0-DAYSPY*(JYEAR-1)                              B4M03040
ISN 0045          J=0                                                           B4M03050
ISN 0046          DO 60 MONTH=1,12                                              B4M03060
ISN 0047          J=J+DAYSPM(MONTH)                                             B4M03070
ISN 0048          IF(JDAY.LE.J) GO TO 70                                        B4M03080
ISN 0050       60 CONTINUE                                                      B4M03090
ISN 0051          WRITE (3,902) JDAY                                            B4M03100
ISN 0052       70 JDATE=JDAY-(J-DAYSPM(MONTH))                                  B4M03110
ISN 0053          JMONTH(1)=AMONTH(1,MONTH)                                     B4M03120
ISN 0054          JMONTH(2)=AMONTH(2,MONTH)                                     B4M03130
             C**** CALCULATE ORBIT POSITICN                                     B4M03140
ISN 0055          FDAY=JDAY                                                     B4M03150
ISN 0056          SEASON=(FDAY-SOLS)/DAYSPY                                     B4M03160
ISN 0057          DIST=(FDAY-APHEL)/DAYSPY                                      B4M03170
ISN 0058          DECMAX=PI*(23.5/180.)                                         B4M03180
ISN 0059          DEC=DECMAX*COS(2.*PI*SEASON)                                  B4M03190
ISN 0050          RSDIST=(1.+ECCN*COS(2.*PI*DIST))**2                           B4M03200
ISN 0061          SIND=SIN(DEC)                                                 B4M03210
ISN 0062          COSD=COS(DEC)                                                 B4M03220
ISN 0063          CALL NEWDAY(JDAY)                                             B4M03230
ISN 0064          RETURN                                                        B4M03240
ISN 0065          ENTRY DAILY0                                                  B4M03250
ISN 0066          IF(ISTART.LE.4) GO TO 50                                      B4M03260
ISN 0068          IFIRST=1                                                      B4M03270
ISN 0069          GO TO 5                                                       B4M03280
ISN 0070      901 FORMAT (' PRESSURE ADDED IN GMP IS',F10.6)                    B4M03290
ISN 0071      902 FORMAT ('0JDAY=',I4)                                          B4M03300
ISN 0072          END                                                           B4M03310

                                     /   DAILY /      SIZE OF PROGRAM 00067C HEXADECIMAL BYTES

NAME TAG TYPE ADD.  |* ***   % NAME TAG TYPE ADD.  |* ***   % NAME TAG TYPE ADD.  |* ***   % NAME TAG TYPE ADD.  |* ***   %
      C      CE   R*4  000005        F       C   R*4    N.R.         I SF          I*4  000120         J SF          I*4  000124
      P SF   CE   R*4  002F10        Q           R*4    N.R.         R         C   R*4    N.R.         T        CE   R*4  0024F0
      U      CE   R*4  000E70        V      CE   R*4  00198C         W         C   R*4    N.R.        CP         C   R*4    N.R.
     DT       C   R*4    N.R.       ED       C   R*4    N.R.        GT        CE   R*4  000840        GW        CE   R*4  001680
     IM  F    C   I*4  000008       JN  F    C   I*4  00003C        J1         C   I*4    N.R.        KM         C   I*4    N.R.
     NR       C   I*4    N.R.       PI  FA   C   R*4  00010C        PK         C   R*4    N.R.        PU        CE   R*4  000000
     OT           R*4    N.R.       SH      CE   R*4  00303C        TS        CE   R*4  001890       CDX         C   R*4    N.R.
    DAP SF        R*4  000128      DEC SFA       R*4  00012C       DXP         C   R*4    N.R.       DXU         C   R*4    N.R.
    DYP       C   R*4    N.R.      DYU       C   R*4    N.R.       FIM  F      C   R*4  000020       FRU         C   R*4    N.R.
    INC SF    C   I*4  000044      JNB       C   I*4    N.R.       JNP  F      C   I*4  000004       JP1         C   I*4    N.R.
    JP2       C   I*4    N.R.      JSB       C   I*4    N.R.       JSP        CE   I*4  000090       LAT         C   R*4    N.R.
    PSF SF    C   R*4  00012C      PSL       C   R*4    N.R.       RAD         C   R*4    N.R.       SHS        CE   R*4  0023D0
    SIG       C   R*4    N.R.      SUM       C   R*4    N.R.       TAU         C   R*4    N.R.      BETA         C   R*4    N.R.
   CON1       C   R*4    N.R.     CON2       C   R*4    N.R.      CON3         C   R*4    N.R.      CON4         C   R*4    N.R.
   CON5       C   R*4    N.R.     COSD S     C   R*4  00013C      COSL         C   R*4    N.R.      CPD2         C   R*4    N.R.
   CPTH       C   R*4    N.R.     DIFF       C   R*4    N.R.      DIST SFA         R*4  000130      DLAT  FA     C   R*4  000084
   DLON       C   R*4    N.R.     DSIG       C   R*4    N.R.      DXYP  F      C   R*4  000950      ECCN  F          R*4  000134
   FDAY SF        R*4  000138     FINC S         R*4  00013C      GRAV         C   R*4    N.R.      IDAY  F      C   I*4  0000CC
   IMD2       C   I*4    N.R.     INCS       C   I*4    N.R.      IROT         C   I*4    N.R.      ITAU         C   I*4    N.R.
   JAYS       C   I*4    N.R.     JDAY SFA   C   I*4  0000D0      JEND         C   I*4    N.R.      JMPS         C   I*4    N.R.
   JMS1       C   I*4    N.R.     JMS2       C   I*4    N.R.      JMUS         C   I*4    N.R.      JPOL         C   I*4    N.R.
   J1PS       C   I*4    N.R.     J1US       C   I*4    N.R.      KAPA         C   R*4    N.R.      KNBS         C   I*4    N.R.
   KSBS       C   I*4    N.R.     MRCH       C   I*4    N.R.      MROT         C   I*4    N.R.      NFLW         C   I*4    N.R.
   NLAY       C   I*4    N.R.     PBAR SF        R*4  00014C      PHIS        CE   R*4  000050      PPOL  F     CE   R*4  000654
   PTOP  F    C   R*4  000010     QPOL      CE   R*4  000414      RGAS         C   R*4    N.R.      SIGE         C   R*4    N.R.
   SIND S     C   R*4  000138     SINL       C   R*4    N.R.      SOLS  F          R*4  000144      TAUE         C   R*4    N.R.
   TAUI       C   R*4    N.R.     TAUQ       C   R*4    N.R.      TAUP         C   R*4    N.R.      TAUT         C   R*4    N.R.
   TPOL      CE   R*4  00045C     UPOL      CE   R*4  000414      VPOL        CE   R*4  000438      XINT         C   R*4    N.R.
  ADLOP       C   R*4    N.R.    ALPHA       C   R*4    N.R.     APHEL  F          R*4  000148     DAILY             R*4  00014C
  DSIGO       C   R*4    N.R.    DUMMY       C   R*4    N.R.     IDAY0  F          I*4  000150     INDEX         C   I*4    N.R.
  ITEST       C   I*4    N.R.    JDATE S     C   I*4  0000DE     JNEXT         C   I*4    N.R.     JNPM1         C   I*4    N.R.
  JPMOD       C   I*4    N.R.    JSPP1       C   I*4    N.R.     JTEST         C   I*4    N.R.     JYEAR SF      C   I*4  0000E4
  MODPK       C   I*4    N.R.    MONTH SF        I*4  000154     NSTEP         C   I*4    N.R.     POLES        CE   R*4  000414
  PSIGN       C   R*4    N.R.    PTPOL      CE   R*4  00065C     QTPOL        CE   R*4  000534     RADIR         C   R*4    N.R.
  RHMAX       C   R*4    N.R.    SAREA SF        R*4  00015E     SDPOL         C   R*4    N.R.     SHPOL        CE   R*4  000480
  SMASS SF        R*4  00015C    THBAR       C   R*4    N.R.     TTPOL        CE   R*4  00057C     UTPOL        CE   R*4  000534
  VTPOL      CE   R*4  000558      COS      XF   R*4  00000C       SIN        XF   R*4  000000    ALBEDO         C   I*2    N.R.
 AMONTH  F        I*4  00017C   CONVPL       C   R*4    N.R.    COSLON         C   R*4    N.R.    DAILY0             R*4  000160
 DAYSPM  F        I*4  0001DC   DAYSPY  F        I*4  000164    DECMAX SF          R*4  000168    DELTAP SF          R*4  00016C
 DTMULT       C   R*4    N.R.   DUMMYA       C   R*4    N.R.    DUMMYC         C   R*4    N.R.    IALTER         C   I*4    N.R.
 IBCOM#  F   XF   R*4  000000   IFIRST S         I*4  00017C    IND2PI         C   I*4    N.R.    ISTART         C   I*4  000014
 JMONTH S     C   I*4  0000DC   MATSUN       C   I*4    N.R.    NCOMP3         C   I*4    N.R.    NCYCLE         C   I*4    N.R.
 NEWDAY SF   XF   I*4  000000   NHOGAN       C   I*4    N.R.    NLAYM1         C   I*4    N.R.    NLAYP1         C   I*4    N.R.
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NSTART        C  I*4     N.R.      PHISPL        C  R*4     N.R.      PITPOL           R*4     N.R.      PSKAPA        C  R*4     N.R.
RSDIST S      C  R*4   000134      SEASON SFA       R*4   000174      SHTPOL        CE R*4   0005A0      SINLON        C  R*4     N.R.
SPRESS SF        R*4   000178      TOFDAY        C  R*4     N.R.      XLABEL        C  R*4     N.R.
                                         *****  COMMON INFORMATION  *****

   NAME OF COMMON BLOCK * F:U#.ZE OF BLOCKCOMMON     005E24 HEXADECIMAL BYTES

 VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE
      CON1   R*4     N.R.            CON2   R*4     N.R.            CON3   R*4     N.R.            CON4   R*4     N.R.
      CONS   R*4     N.R.           THBAR   R*4     N.R.           ALPHA   R*4     N.R.            BETA   R*4     N.R.
    IMD2P1   I*4     N.R.           ADLDP   R*4     N.R.            JMS2   I*4     N.R.            JMS1   I*4     N.R.
      CPTH   R*4     N.R.          PSKAFA   R*4     N.R.               R   R*4     N.R.             RAD   R*4     N.R.
        CP   R*4     N.R.             INC   I*4   000044          NSTART   I*4     N.R.            CPD2   R*4     N.R.
      IMD2   I*4     N.R.           RADIN   R*4     N.R.            JEND   I*4     N.R.             JP1   I*4     N.R.
       JP2   I*4     N.R.          KATSUN   I*4     N.R.           JNEXT   I*4     N.R.           MODPK   I*4     N.R.
      JPOL   I*4     N.R.           JPMOD   I*4     N.R.          SINLON   R*4     N.R.          COSLON   R*4     N.R.
     INDEX   I*4     N.R.           PSIGN   R*4     N.R.           POLES   R*4   000414               B   R*4     N.R.
        PK   R*4     N.R.            DIFF   R*4     N.R.          CONVPL   R*4     N.R.           SOPOL   R*4     N.R.
    PHISPL   R*4     N.R.             SUM   R*4     N.R.
EQUIVALENCED VARIABLES WITHIN THIS COMMON GROUP
  VARIABLE OFFSETE              VARIABLE OFFSETE              VARIABLE OFFSETE              VARIABLE OFFSETE
    QPOL    000414                 QTPCL    000534               UPOL    000414                VPOL    000438
    TPOL    00045C                 SHPOL    00048C              UTPOL    000534               VTPOL    000558
   TTPOL    00057C                SHTPCL    0005A0               PPOL    000654               PTPOL    00065C

  NAME OF COMMON BLOCK *  -NTR#E OF BLOCKCOMMON     083C30 HEXADECIMAL BYTES

VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE
      JSP   I*4   000005             JNP   I*4   000004              IM   I*4   000008            NLAY   I*4     N.R.
     PTOP   R*4   000010          ISTART   I*4   000014          JSPP1   I*4     N.R.           JNPM1   I*4     N.R.
      FIM   R*4   000020          NLAYM1   I*4     N.R.          NLAYP1   I*4     N.R.              J1   I*4     N.R.
       JM   I*4   000030              KM   I*4     N.R.            TAUT   R*4     N.R.            IROT   I*4     N.R.
     MROT   I*4     N.R.           JTEST   I*4     N.R.           ITEST   I*4     N.R.              NR   I*4     N.R.
     JAYS   I*4     N.R.            INCS   I*4     N.R.             JSB   I*4     N.R.             JNB   I*4     N.R.
     DLAT   R*4   000084            DLON   R*4     N.R.              DT   R*4     N.R.             TAU   R*4     N.R.
     ITAU   I*4     N.R.            XINT   R*4     N.R.            IDAY   I*4   0000CC            JDAY   I*4   0000D0
   TOFDAY   R*4     N.R.           JDATE   I*4   000008          JMONTH   I*4   0000DC           JYEAR   I*4   0000E4
    NSTEP   I*4     N.R.          NCYCLE   I*4     N.R.          NCOMP3   I*4     N.R.          NHOGAN   I*4     N.R.
     TAUP   R*4     N.R.            TAUI   R*4     N.R.            TAUE   R*4     N.R.            TAUO   R*4     N.R.
   DTMULT   R*4     N.R.              PI   R*4   00010C            GRAV   R*4     N.R.            RGAS   R*4     N.R.
     KAPA   R*4     N.R.             PSL   R*4     N.R.              ED   R*4     N.R.             FMU   R*4     N.R.
     NFLW   I*4     N.R.             PSF   R*4   00012C            MRCH   I*4     N.R.          RSDIST   R*4   000134
     SIND   R*4   000138            COSD   R*4   00013C           RHMAX   R*4     N.R.             CDX   R*4     N.R.
   DUMMYC   R*4     N.R.          IALTER   I*4     N.R.          DUMMYA   R*4     N.R.          XLABEL   R*4     N.R.
      SIG   R*4     N.R.            DSIG   R*4     N.R.            SIGE   R*4     N.R.           DSIGO   R*4     N.R.
     J1PS   I*4     N.R.            JMFS   I*4     N.R.            J1US   I*4     N.R.            JMUS   I*4     N.R.
     KSBS   I*4     N.R.            KNBS   I*4     N.R.             LAT   R*4     N.R.             DXU   R*4     N.R.
      DXP   R*4     N.R.             DYU   R*4     N.R.             DYP   R*4     N.R.            DXYP   R*4   000950
        F   R*4     N.R.            SINL   R*4     N.R.            COSL   R*4     N.R.           DUMMY   R*4     N.R.
     PHIS   R*4   000D50          ALBECO   I*2     N.R.
EQUIVALENCED VARIABLES WITHIN THIS COMMON GROUP
  VARIABLE OFFSETE              VARIABLE OFFSETE              VARIABLE OFFSETE              VARIABLE OFFSETE
       U    000E70                    TS    00189C                  V    001980                 SHS    0023D0
       T    0024F0                     P    002F10                 SH    003030                   C    000000

  NAME OF COMMON BLOCK *  =O#S#E OF BLOCKCOMMON     081E00 HEXADECIMAL BYTES

VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE
       PU   R*4   000000

EQUIVALENCED VARIABLES WITHIN THIS COMMON GROUP
  VARIABLE OFFSETE              VARIABLE OFFSETE              VARIABLE OFFSETE              VARIABLE OFFSETE
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     LABEL   ADDR                 LABEL   ADDR                 LAEEL   ADDR                 LABEL   ADDR
        5   000298                   10   0002F4                  20   000314                  30   000384
       40   0003FE                   50   000430                  60   00049A                  70   0004C4

*OPTIONS IN EFFECT*       NAME=  MAIN.OPT=02.LINECNT=55.SIZE=1000K.

*OPTIONS IN EFFECT*       SOURCE.EBCDIC.NOLIST.NODECK.LOAD.MAP.NOEDIT.ID.NOXREF

*STATISTICS*     SOURCE STATEMENTS =      71   PROGRAM SIZE=       1660

*STATISTICS*  NO  DIAGNOSTICS GENERATED

****** END OF COMPILATION ******                                          868K BYTES OF CORE NOT USED

 LEVEL 19.6-APR 71                          OS/360 FORTRAN H AT GISS                                  DATE 12/12/79-0783.04

         COMPILER OPTIONS -   NAME=  MAIN.OPT=02.LINECNT=55.SIZE=1000K.
                              SOURCE.EBCDIC.NOLIST.NODECK.LOAD.MAP.NOEDIT.ID.NOXREF
   ISN 0002                SUBROUTINE INPUT                                                        B4M03320
   ISN 0003                LOGICAL FLAGS                                                           B4M03330
   ISN 0004                COMMON/LID/FLAGS(5)                                                     B4M03340
   ISN 0005                COMMON/FOURTH/CON1.CON2.CON3.CON4.CON5.TPBAR.ALPHA.BETA.IND2P1.        B4M03350
                          $   ADLDP.JMS2.JMS1.CPTH.PSKAPA.R.RAD.CP.INC.NSTART.CPD2.               B4M03360
                          $   IND2.RADIN.JEND(2).JP1.JP2.MATSUN.JNEXT(2).MODPK(2.2).              B4M03370
                          $   JPOL(2.2).JPMOD(2.2).SINLON(72).COSLON(72).INDEX(72).               B4M03380
                          $   PSIGN(4).POLES(148).W(72.9.5).PK(72.9.3).DIFF(9).                   B4M03390
                          $   CONVPL(9).SDPOL(9.2).PHISPL(2).SUM(2.5)                             B4M03400
   ISN 0006                EQUIVALENCE (QPOL(1.1.1).POLES(1)).(QTPOL(1.1.1).POLES(73)).           B4M03410
                          $   (UPOL(1.1).POLES(1)).(VPOL(1.1).POLES(10)).(TPOL(1.1).              B4M03420
                          $   POLES(19)).(SHPOL(1.1).POLES(28)).(UTPOL(1.1).POLES(73)).           B4M03430
                          $   (VTPOL(1.1).POLES(82)).(TTPOL(1.1).POLES(91)).(SHTPOL(1.1).         B4M03440
                          $   POLES(100)).(PPOL(1).POLES(145)).(PTPOL(1).POLES(147))             B4M03450
   ISN 0007                DIMENSION PPOL(2).PTTPOL(2).UPOL(36.1).VPOL(36.1).TPOL(36.1).          B4M03460
                          $   SHPOL(36.1).QPOL(9.4.2).Q(72.10.4.1)                                B4M03470
   ISN 0008                DIMENSION PTPOL(2).UTPOL(36.1).VTPOL(36.1).TTPOL(36.1).                B4M03480
                          $   SHTPOL(36.1).QTPOL(9.4.2).QT(72.10.4.1)                             B4M03490
   ISN 0009                INTEGER*2 ALBEDO                                                        B4M03500
   ISN 0010                REAL*4 KAPA.LAT                                                         B4M03510
                  C        REAL*8 SINLON.COSLON.SUM                                                B4M03520
   ISN 0011                REAL*8 ALONG.TWOPI                                                      B4M03530
   ISN 0012                COMMON/INSMSH/F5D6.F17.F98                                              B4M03540
   ISN 0013                COMMON/WORK2/PU(2880.46)                                                B4M03550
   ISN 0014                COMMON/SMITH/QSM(72.9.4.5).PSM(72.5).QSMPOL(9.4.2).PSMPOL(2)           B4M03560
                  C                                                                                B4M03570
   ISN 0015                COMMON/SDOT48/SDOT(72.46.8).OMEGA(72.46.5).MNMXTS.RADT(72.46.10)       B4M03580
                          + .COMG                                                                  B4M03590
   ISN 0016                LOGICAL COMG                                                            B4M03600
                  C                                                                                B4M03610
   ISN 0017                INTEGER*2 RADT.OMEGA                                                    B4M03620
   ISN 0018                INTEGER*2 ISDOT(72.46.8)                                                B4M03630
                  C                                                                                B4M03640
   ISN 0019                EQUIVALENCE (SDOT(1.1.5).ISDOT(1.1.1))                                  B4M03650
                  C                                                                                B4M03660
   ISN 0020                COMMON /CNTRL/                                                          B4M03670
                          *   JSP.JNP.IM.NLAY.PTOP.ISTART.JSFP1.JNPM1.FIM.NLAYM1.NLAYP1.         B4M03680
                          *   J1.JM.KM.TAUT.IROT.MROT.JTEST.ITEST.                                B4M03690
                          *   NR.JAYS(12).INCS(11).JSB.JNB.DLAT.DLON.                             B4M03700
                          *   DT.TAU.ITAU.XINT.IDAY.JDAY.TOFDAY.JDATE.JMONTH(2).JYEAR.NSTEP.     B4M03710
                          *   NCYCLE.NCOMP3.NHOGAN.TAUP.TAUI.TAUE.TAUD.DTMULT.                    B4M03720
                          *   PI.GRAV.RGAS.KAPA.PSL.ED.FMU.NFLB.PSF.ARCH.RSDIST.SIND.COSD.       B4M03730
                          *   RHMAX.CDX.DUMMYC(18).IALTER.DUMMYA(99).                             B4M03740
                          *   XLABEL(20).SIG(20).DSIG(20).SIGE(21).DSIGO(19).                     B4M03750
                          *   J1PS(11).JMPS(11).J1US(11).JMUS(11).KSES(11).KNBS(11).             B4M03760
                          *LAT(46).DXU(46).DXP(46).DYU(46).DYP(46).DXYP(46).F(46).SINL(46).      B4M03770
                          *COSL(46).DUMMY(72).PHIS(2880.46).ALBEDO(72.46)                         B4M03780
   ISN 0021                DIMENSION U(72.40.1).V(72.40.1).T(72.40.1).SH(72.40.1).                B4M03790
                          *P(2880.1).    TS(2880.1).SHS(2880.1).GT(2880.1).GW(2880.1).C(300)      B4M03800
   ISN 0022                DIMENSION UT(72.40.1).VT(72.40.1).TT(72.40.1).SHT(72.40.1).            B4M03810
                          *PT(2880.1)                                                              B4M03820
   ISN 0023                COMMON/S/JMIN.JMAX.JSUM.SMTH(37.17)                                     B4M03830
   ISN 0024                COMMON/MLFS/NSEQ.MLF(10).MATSNX.NSM1.NCM1                               B4M03840
   ISN 0025                EQUIVALENCE                                                             B4M03850
                          $   (Q(1.1.1.1).U(1.1.1).PHIS(73.1)).(TS(1.1).PHIS(721.1)).             B4M03860
                          $   (V(1.1.1).PHIS(793.1)).(SHS(1.1).PHIS(1441.1)).                    B4M03870
                          $   (T(1.1.1).PHIS(1513.1)).(P(1.1).PHIS(2161.1)).                     B4M03880
                          $   (SH(1.1.1).PHIS(2233.1)).(QT(1.1.1.1).UT(1.1.1).PU(73.1)).         B4M03890
                          $   (GT(1.1).PU(721.1)).(VT(1.1.1).PU(793.1)).                          B4M03900
                          $   (GW(1.1).PU(1441.1)).(TT(1.1.1).PU(1513.1)).                       B4M03910
                          $   (PT(1.1).PU(2161.1)).(SHT(1.1.1).PU(2233.1)).(C(1).JSP)            B4M03920
   ISN 0026                DIMENSION C1(300)                                                       B4M03930
   ISN 0027                DIMENSION INCP(46).INCU(46)                                             B4M03940
   ISN 0028                REAL*8 RECORD.ANDEND.DPI                                                B4M03950
   ISN 0029                DIMENSION RECORD(10)                                                    B4M03960
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ISN 0030          DATA ANDEND/' &END    '/                                            B4M03970
ISN 0031          COMMON/RMWRT/ C3WRT,NOC3,SHSMOD,FAST,TMP,SMAFTA,ADPCLD              B4M03980
ISN 0032          COMMON /DBUG/ISWTCH                                                 B4M03990
ISN 0033          COMMON /LIC35/ITC,GSW                                               B4M04000
ISN 0034          COMMON/SMOO/ISMTH,NPC                                               B4M04010
ISN 0035          COMMON/TPG/TOPOG(72,46)                                             B4M04020
ISN 0036          LOGICAL   C3WRT,NOC3,SHSMOD,FAST,SMAFTA,ADPCLD                      B4M04030
ISN 0037          NAMELIST/INPUTZ/ISTART,IM,NLAY,NR,JAYS,INCS,PAWZE,IALTER,DSIG,      B4M04040
                 *  DT,NCOMP3,NHOGAN,DTMULT,TAUP,TAUI,TAUE,TAUO,                      B4M04050
                 *  TAUT,MROT,J1,JM,KM,JTEST,ITEST,                                   B4M04060
                 *  PTOP,PSL,ED,FMU,COX,NFLW,PSF,RHMAX,                               B4M04070
                 * XINT,C3WRT,NOC3,SHSMOD,FAST,SMAFTA,ALPHA,ISMTH,MATSUN,ISWTCH       B4M04080
                 1,NSEQ,MLF,NSM1,NCM1,ITC,GSW                                         B4M04090
ISN 0038          DATA DISK/'DISK'/                                                   B4M04100
ISN 0039          FAC=60.                                                             B4M04110
ISN 0040          ALPHA = .05                                                         B4M04120
ISN 0041          ISMTH = 6                                                           B4M04130
ISN 0042          MATSUN = 0                                                          B4M04140
            C * * MATSUNO   : NSEQ=1,MLF(1)=1,MATSUN=1                                B4M04150
ISN 0043          NSEQ=1                                                              B4M04160
ISN 0044          NSM1=1                                                              B4M04170
ISN 0045          NCM1=1                                                              B4M04180
ISN 0046          MLF(1)=1                                                            B4M04190
            C * * LEAP FROG: NSEQ=1,MLF(1)=1,MATSUN=0                                 B4M04200
            C * * NSM1 IS STEP IN SEQ. WHERE SMSHAF MAY BE CALLED                     B4M04210
            C * * NCM1 IS STEP IN SEQ. WHERE COMP3  MAY BE CALLED                     B4M04220
            C * * ISMTH  MUST BE MULTIPLE OF NSEQ                                     B4M04230
            C * * NCOMP3 MUST BE MULTIPLE OF NSEQ                                     B4M04240
            C * *                                                                     B4M04250
            C * * NSM1   .NE.  NSEQ OR NSEQ-1                                         B4M04260
            C * * NCM1   .NE.  NSEQ                                                   B4M04270
            C * *                                                                     B4M04280
ISN 0047          IU = [illegible]                                                    B4M04290
ISN 0048          DPI=3.141592654                                                     B4M04300
ISN 0049          PI = DPI                                                            B4M04310
ISN 0050          J1=1                                                                B4M04320
ISN 0051          JM=45                                                               B4M04330
ISN 0052          IM=72                                                               B4M04340
ISN 0053          NLAY=9                                                              B4M04350
ISN 0054          KM=4*NLAY+5                                                         B4M04360
ISN 0055          KMM4=KM-4                                                           B4M04370
ISN 0056          IM4=IM*4                                                            B4M04380
ISN 0057          IMP1 = IM + 1                                                       B4M04390
ISN 0058          IM2 = 2 * IM                                                        B4M04400
ISN 0059          IM2P1 = IM2 + 1                                                     B4M04410
ISN 0060          IM3 = 3 * IM                                                        B4M04420
ISN 0061          IM3P1 =  IM3 + 1                                                    B4M04430
ISN 0062          C3WRT = .FALSE.                                                     B4M04440
ISN 0063          NOC3 = .FALSE.                                                      B4M04450
ISN 0064          SHSMOD = .TRUE.                                                     B4M04460
ISN 0065          FAST = .FALSE.                                                      B4M04470
ISN 0066          TMP = 12.                                                           B4M04480
ISN 0067          SMAFTA = .FALSE.                                                    B4M04490
ISN 0068          JSP=1                                                               B4M04500
ISN 0069          JNP=46                                                              B4M04510
ISN 0070          PTOP=10.                                                            B4M04520
ISN 0071          ISTART=7                                                            B4M04530
ISN 0072          JTEST=33                                                            B4M04540
ISN 0073          ITEST=16                                                            B4M04550
ISN 0074          GRAV=9.81                                                           B4M04560
ISN 0075          RGAS=287.                                                           B4M04570
ISN 0076          KAPA=.286                                                           B4M04580
ISN 0077          PSL=1000.                                                           B4M04590
ISN 0078          ED=0.5                                                              B4M04600
ISN 0079          FMU=0.00067                                                         B4M04610
ISN 0080          NFLW=5                                                              B4M04620
ISN 0081          COX=1.                                                              B4M04630
ISN 0082          XINT=600.                                                           B4M04640
ISN 0083          DT=60.                                                              B4M04650
ISN 0084          NCOMP3=6                                                            B4M04660
ISN 0085          NCYCLE=1000000                                                      B4M04670
ISN 0086          DTMULT=1.                                                           B4M04680
ISN 0087          NHOGAN=4                                                            B4M04690
ISN 0088          RHMAX=1.                                                            B4M04700
ISN 0089          TAUP=-1.                                                            B4M04710
ISN 0090          TAUI=-1.                                                            B4M04720
ISN 0091          TAUE=24000.                                                         B4M04730
ISN 0092          TAUO=24000.                                                         B4M04740
ISN 0093          TAUT=4.0                                                            B4M04750
ISN 0094          IROT=0                                                              B4M04760
ISN 0095          MROT=49                                                             B4M04770
ISN 0096          PAWZE=1.                                                            B4M04780
ISN 0097          RAD=6375000.                                                        B4M04790
ISN 0098          SDAY=86400.                                                         B4M04800
ISN 0099          ROTPER=24.                                                          B4M04810
ISN 0100          IALTER=0                                                            B4M04820
ISN 0101          NR=1                                                                B4M04830
            C**** BEGIN TITLE PAGE                                                    B4M04840
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ORIGINAL PAGE IS
OF POOR QUALITY

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ISN 0102          WRITE (6,901) IVER                                                B4M04850
ISN 0103          READ (5,902) XLABEL                                               B4M04860
ISN 0104          WRITE (3,903) XLABEL                                              B4M04870
            C**** COPY INPUTZ NAMELIST CNTG CORE TAPE AND TITLE PAGE                B4M04880
ISN 0105       20 READ (5,904) RECORD                                               B4M04890
ISN 0106          WRITE (11,904) RECORD                                             B4M04900
ISN 0107          WRITE (3,905) RECORD                                              B4M04910
ISN 0108          IF(RECORD(1).NE.ANDEND) GO TO 20                                  B4M04920
ISN 0110          REWIND 11                                                         B4M04930
ISN 0111          READ (11,INPUTZ)                                                  B4M04940
ISN 0112          IF(ISTART.EQ.7) WRITE (3,938) ISTART                              B4M04950
ISN 0114          IF(ISTART.EQ.7.AND.PAWZE.NE.0.) WRITE (15,938) ISTART             B4M04960
            C**** READ IN VARIABLE ALBEDO                                           B4M04970
ISN 0116          READ (40)((ALBEDO(I,J),J=J1,JNP),I=1,IM)                          B4M04980
            C**** READ IN SURFACE GEOPOTENTIAL                                      B4M04990
ISN 0117          READ (17)((PHIS(I,J),J=J1,JNP),I=1,IM)                            B4M05000
ISN 0118          READ (46)((TOPOG(I,J),J=J1,JNP),I=1,IM)                           B4M05010
ISN 0119          WRITE(6,1900)(J,(PHIS(I,J),I=1,IM),J=1,JNP)                       B4M05020
ISN 0120     1900 FORMAT(1X,46(' J=',I3,' PHIS(I,J)='/9(1X,8E13.6/)/))              B4M05030
ISN 0121          WRITE(6,1941)(J,(ALBEDO(I,J),I=1,IM),J=1,JNP)                     B4M05040
ISN 0122     1941 FORMAT(1X,46(' J=',I3,' ALBEDO(I,J)='/2(1X,36I3/)/))              B4M05050
ISN 0123          MNMXTS = TAUT + XINT + .01                                        B4M05060
ISN 0124          IF(PAWZE.EQ.1.) PAUSE ' MOUNT TAPES'                              B4M05070
ISN 0126          CALL SSWTCH (5,KSSW5)                                             B4M05080
ISN 0127          IF(KSSW5.EQ.1) ISTART=8                                           B4M05090
ISN 0129          KTR=8                                                             B4M05100
            C                                                                     * B4M05110
            C * * * ON INITIAL START ENDFILE MODEL OUTPUT TAPE                     * B4M05120
            C                                                                     * B4M05130
ISN 0130          IF(ISTART.GE.5.AND.ISTART.LE.7) ENDFILE KTR                       B4M05140
ISN 0132          GO TO (30,120,120,40,110,110,40,90,90),ISTART                     B4M05150
ISN 0133       30 STOP                                                              B4M05160
            C**** SET DEPENDENT QUANTITIES                                          B4M05170
ISN 0134       40 DLON=2.*DPI/IM                                                    B4M05180
ISN 0135          DLAT=DPI/JM                                                       B4M05190
ISN 0136          FIM=IM                                                            B4M05200
ISN 0137          KM=4*NLAY+5                                                       B4M05210
ISN 0138          KMM4=KM-4                                                         B4M05220
ISN 0139          IM4=IM*4                                                          B4M05230
ISN 0140          JSPP1=JSP+1                                                       B4M05240
ISN 0141          JNPM1=JNP-1                                                       B4M05250
ISN 0142          JNPP1 = JNP + 1                                                   B4M05260
ISN 0143          JMP1D2 = (JM + 1) / 2                                             B4M05270
ISN 0144          JSB=1                                                             B4M05280
ISN 0145          JSBP1 = JSB + 1                                                   B4M05290
ISN 0146          JNB=JM                                                            B4M05300
ISN 0147          JNBM1=JNB-1                                                       B4M05310
ISN 0148          NLAYM1=NLAY-1                                                     B4M05320
ISN 0149          NLAYP1=NLAY+1                                                     B4M05330
            C *---IF(DSIG(1).NE.0.) GO TO 60                                        B4M05340
ISN 0150          DO 50 L=1,NLAY                                                    B4M05350
ISN 0151       50 DSIG(L)=1./NLAY                                                   B4M05360
ISN 0152       60 SIGE(1)=0.                                                        B4M05370
ISN 0153          DO 70 L=1,NLAY                                                    B4M05380
ISN 0154          SIGE(L+1)=SIGE(L)+DSIG(L)                                         B4M05390
ISN 0155       70 SIG(L)=.5*(SIGE(L)+SIGE(L+1))                                     B4M05400
ISN 0156          DO 80 L=1,NLAYM1                                                  B4M05410
ISN 0157       80 DSIGO(L)=SIG(L+1)-SIG(L)                                          B4M05420
ISN 0158          IF(ISTART.EQ.4) GO TO 120                                         B4M05430
ISN 0160          IF(ISTART.EQ.7) GO TO 110                                         B4M05440
            C**** MACHINE CHECK RESTART, ISTART = 8 OR 9                            B4M05450
ISN 0162       90 IF(KSSW5.NE.1) GO TO 100                                          B4M05460
ISN 0164          WRITE (15,906)                                                    B4M05470
ISN 0165          READ (15,907) TAUP                                                B4M05480
ISN 0166      100 TAUP=TAUP-AMOD(TAUP,TAUT)                                         B4M05490
ISN 0167          WRITE (3,908) TAUP                                                B4M05500
ISN 0168          GO TO 120                                                         B4M05510
            C**** INITIAL CONDITIONS FROM UNIT 12, ISTART= 5, 6, OR 7               B4M05520
ISN 0169      110 KTR=12                                                            B4M05530
ISN 0170          IROT=1                                                            B4M05540
ISN 0171          TAU=TAUI                                                          B4M05550
ISN 0172          IF(TAUP.LT.0.) TAUP=TAUI                                          B4M05560
ISN 0174          TAPNUM=DISK                                                       B4M05570
ISN 0175          IF(PAWZE.EQ.0.) GO TO 120                                         B4M05580
ISN 0177          WRITE (15,909)                                                    B4M05590
ISN 0178          READ (15,902) TAPNUM                                              B4M05600
ISN 0179          WRITE (3,910) TAPNUM                                              B4M05610
            C     READ TAPE ON UNIT KTR                                             B4M05620
            C                                                                       B4M05630
ISN 0180      120 READ(KTR,ERR=800,END=130)TAUX,C1,((PI(I,J),J=1,JNP),I=1,IM),      B4M05640
                 $    ((TS(I,J),J=1,JNP),I=1,IM),((SHS(I,J),J=1,JNP),I=1,IM),      B4M05650
                 $    ((GT(I,J),J=1,JNP),I=1,IM),((GW(I,J),J=1,JNP),I=1,IM)        B4M05660
ISN 0181          CALL RDTAPE(KTR)                                                  B4M05670
ISN 0182          IF (ISTART.LE.4) GO TO 120                                        B4M05680
ISN 0184          IF (TAUX.LT.TAUP-.01) GO TO 120                                   B4M05690
ISN 0186          IF (TAUX.LE.TAUP+.01) GO TO 140                                   B4M05700
ISN 0188    121   CONTINUE                                                          B4M05710
ISN 0189          WRITE (6,912) TAUP                                                B4M05720
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ISN 0190            CALL EXIT                                                 B4M05730
              C                                                               B4M05740
ISN 0191        130 IF(ISTART.GE.5)GOTO 830                                   B4M05750
ISN 0193            BACKSPACE KTR                                             B4M05760
ISN 0194            TAUI=TAUX                                                 B4M05770
ISN 0195        140 TAU=TAUI                                                  B4M05780
ISN 0196            TAUP=TAUX                                                 B4M05790
ISN 0197            DO 145 J=J1.JM                                            B4M05800
ISN 0198        145 BACKSPACE KTR                                             B4M05810
ISN 0199            BACKSPACE KTR                                             B4M05820
ISN 0200            IROT=IROT-1                                               B4M05830
ISN 0201            IF(ISTART.EQ.4.OR.ISTART.EQ.7) GC TO 160                  B4M05840
              C**** COPY C ARRAY FROM C1 ARRAY                                B4M05850
ISN 0203            C1(6)=C(6)                                                B4M05860
ISN 0204            DO 150 K=1.300                                            B4M05870
ISN 0205        150 C(K)=C1(K)                                                B4M05880
ISN 0206            IF(ISTART.EQ.2.OR.ISTART.EQ.5) GC TO 160                  B4M05890
ISN 0208            REWIND 11                                                 B4M05900
ISN 0209            READ (11.INPUTZ)                                          B4M05910
ISN 0210        160 IF(KTR.EQ.8) C(16)=C1(16)                                 B4M05920
ISN 0212            IF(KTR.EQ.8) XLABEL(20)=C1(220)                           B4M05930
ISN 0214            IF(KTR.EQ.12) XLABEL(20)=TAPNUM                           B4M05940
              C**** CALCULATE DISTANCE PROJECTION ARRAYS                      B4M05950
ISN 0216        190 FJEQ=.5*(JSP+JNP)                                         B4M05960
ISN 0217            DO 200 J=1.JNP                                            B4M05970
ISN 0218        200 LAT(J)=DLAT*(J-FJEQ)                                      B4M05980
ISN 0219            DO 210 J=1.JNP                                            B4M05990
ISN 0220            SINL(J)=SIN(LAT(J))                                       B4M06000
ISN 0221        210 COSL(J)=COS(LAT(J))                                       B4M06010
ISN 0222            DO 220 J=1.JM                                             B4M06020
ISN 0223        220 DXP(J)=RAD*DLON*COSL(J)                                   B4M06030
ISN 0224            DO 230 J=2.JM                                             B4M06040
ISN 0225            DYU(J) = RAD * DLAT                                       B4M06050
              C     DYU(J)=RAD*(LAT(J)-LAT(J-1))                              B4M06060
ISN 0226        230                             CONTINUE                      B4M06070
ISN 0227            JMP1D2 = (JM + 1)/2                                       B4M06080
ISN 0228            JNPP1 = JNP + 1                                           B4M06090
ISN 0229            DO 240 J = 2.JMP1D2                                       B4M06100
ISN 0230            DXYP(J) = 12. * DXP(J) * DYU(J)                           B4M06110
ISN 0231        240 DXYP(JNPP1-J) = DXYP(J)                                   B4M06120
ISN 0232            DXYP(1) = 0.                                              B4M06130
ISN 0233            DXYP(JNP) = 0.                                            B4M06140
ISN 0234            WRITE(3.2200)(DXYP(J).J=1.JNP)                            B4M06150
ISN 0235       2200 FORMAT(1X.' DXYP='/(1X.8E16.8))                           B4M06160
ISN 0236            RETURN                                                    B4M06170
              C                                                             * B4M06180
              C * * * AUG 23 1977 ADDITIONS HERE TILL RETURN                * B4M06190
              C                                                             * B4M06200
ISN 0237                                        ENTRY INPUT4                  B4M06210
ISN 0238            INC = 1                                                   B4M06220
ISN 0239            BETA = 1. - 2. * ALPHA                                    B4M06230
ISN 0240            F5D6 = 5. / 6.                                            B4M06240
ISN 0241            F17 = 17. / 18.                                           B4M06250
ISN 0242            F98 = .325 / 981.                                         B4M06260
ISN 0243            R = RGAS                                                  B4M06270
ISN 0244            RADIM = 3 * RAD * IM                                      B4M06280
ISN 0245            CON1 = 4. * COTAN(.5*DLAT) / RADIM                        B4M06290
ISN 0246            CON2 = -COTAN(DLAT) / RADIM                               B4M06300
ISN 0247            CON5 = 1. / (RADIM * DLAT)                                B4M06310
ISN 0248            INC = 1                                                   B4M06320
ISN 0249            JPOL(1.1) = 2                                             B4M06330
ISN 0250            JPOL(2.1) = 3                                             B4M06340
ISN 0251            JPOL(1.2) = JM                                            B4M06350
ISN 0252            JPOL(2.2) = JM - 1                                        B4M06360
ISN 0253            JPMOD(1.1) = 2                                            B4M06370
ISN 0254            JPMOD(2.1) = 3                                            B4M06380
ISN 0255            JPMOD(1.2) = MOD(JM-1.5) + 1                              B4M06390
ISN 0256            JPMOD(2.2) = MOD(JM-2.5) + 1                              B4M06400
ISN 0257            MODPK(1.1) = 2                                            B4M06410
ISN 0258            MODPK(2.1) = 3                                            B4M06420
ISN 0259            MODPK(1.2) = MOD(JM-1.3) + 1                              B4M06430
ISN 0260            MODPK(2.2) = MOD(JM-2.3) + 1                              B4M06440
ISN 0261            JNP=JM+1                                                  B4M06450
ISN 0262            JEND(1) = 1                                               B4M06460
ISN 0263            JEND(2) = JNP                                             B4M06470
ISN 0264            JNEXT(1) = 2                                              B4M06480
ISN 0265            JNEXT(2) = JM                                             B4M06490
ISN 0266            ADLDP = 12. * RAD * DLAT * DLON                           B4M06500
ISN 0267            IMD2=IM/2                                                 B4M06510
ISN 0268            IMD2P1 = IMD2 + 1                                         B4M06520
ISN 0269            JMS1 = JM - 1                                             B4M06530
ISN 0270            JMS2 = JM - 2                                             B4M06540
ISN 0271            JSMT=6                                                    B4M06550
ISN 0272            JMIN = 2 + JSMT                                           B4M06560
ISN 0273            JMAX = JM - JSMT                                          B4M06570
ISN 0274            JSUM = JMAX + JMIN                                        B4M06580
ISN 0275            TWOJM = 2. * JM                                           B4M06590
ISN 0276            JLIM = JMIN - 1                                           B4M06600
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ISN 0277           DO 301 J = 1.JLIM                                                            B4M06610
ISN 0278           JDH = J + 1                                                                  B4M06620
              C    IF(J.GE.JMIN)                  JDH= JMAX + . - JMIN                          B4M06630
ISN 0279           IMAX=INT(FAC*COSL(JDH))                                                      B4M06640
ISN 0280           IMAXM1 = IMAX - 1                                                            B4M06650
ISN 0281           IMAXP3=IMAX+4                                                                B4M06660
              C                                                                                 B4M06670
ISN 0282              DO 310 I = 1.IMD2                                                         B4M06680
ISN 0283           SMTH(I.J) = 1.                                                               B4M06690
ISN 0284           IF((I.GE.IMAX).AND.(I.LE.IMAXP3))SMTH(I.J)=1.-FLOAT(I-IMAXM1)/6.             B4M06700
ISN 0286           IF(I.GT.IMAXP3)                SMTH(I.J) = 0.                                B4M06710
ISN 0288       310                                CONTINUE                                      B4M06720
ISN 0289       301                                CONTINUE                                      B4M06730
ISN 0290           P1KAPA = KAPA + 1                                                            B4M06740
ISN 0291              DO 320 L = 1.NLAY                                                         B4M06750
ISN 0292           DIFF(L) = P1KAPA * DSIG(L)                                                   B4M06760
ISN 0293       320                                CONTINUE                                      B4M06770
ISN 0294           PSKAPA = EXPBYK(1000.)                                                       B4M06780
ISN 0295           THBAR = 280. / PSKAPA                                                        B4M06790
ISN 0296           CP = RGAS / KAPA                                                             B4M06800
ISN 0297           CPD2=.5 * CP                                                                 B4M06810
ISN 0298           CPTH = CP * THBAR                                                            B4M06820
ISN 0299           WRITE(6.9778)PSKAPA.THBAR.RGAS.KAPA.CP.CPTH                                  B4M06830
ISN 0300      9778 FORMAT(1X.' PSKAPA.THBAR.RGAS.KAPA.CP.CPTH(IN INPUT)='/1X.6E15.8)            B4M06840
ISN 0301           PHISPL(1) = PHIS(1.1)                                                        B4M06850
ISN 0302           PHISPL(2) = PHIS(1.JNP)                                                      B4M06860
ISN 0303           IMD2 = IM / 2                                                                B4M06870
ISN 0304           TWOPI=2.*PI                                                                  B4M06880
ISN 0305           TWOPI = 6.283185307175587                                                    B4M06890
ISN 0306           DO 1000 I = 1.IMD2                                                           B4M06900
ISN 0307           ALONG = FLOAT(I-1) * TWOPI / FLOAT(IM)                                       B4M06910
              C                                                                             *   B4M06920
              C * * * ALONG =  FLOAT(I-1) * TWOPI / FLOAT(IM) - PI                          *   B4M06930
              C                                                                             *   B4M06940
ISN 0308           SINLON(I) = -DSIN(ALONG)                                                     B4M06950
ISN 0309           COSLON(I) = -DCOS(ALONG)                                                     B4M06960
ISN 0310           SINLON(IMD2+I) = -SINLON(I)                                                  B4M06970
ISN 0311           COSLON(IMD2+I) = -COSLON(I)                                                  B4M06980
ISN 0312           INDEX(I) = I + IMD2                                                          B4M06990
ISN 0313           INDEX(IMD2+I) = I                                                            B4M07000
ISN 0314      1000                                CONTINUE                                      B4M07010
ISN 0315           OHM2=2.*TWOPI/SDAY                                                           B4M07020
ISN 0316           DO 1010 J=1.JM                                                               B4M07030
ISN 0317           F(J)=OHM2*SINL(J)                                                            B4M07040
ISN 0318      1010                                CONTINUE                                      B4M07050
ISN 0319           F(JNP)=OHM2                                                                  B4M07060
ISN 0320           PSIGN(1) = -1.                                                               B4M07070
ISN 0321           PSIGN(2) = -1.                                                               B4M07080
ISN 0322           PSIGN(3) = 1.                                                                B4M07090
ISN 0323           PSIGN(4) = 1.                                                                B4M07100
              C                                                                             *   B4M07110
              C * * * INITIAL VELOCITIES GIVEN ON A STAGGERED GRID.                         *   B4M07120
              C * * * INTERPOLATION TO UNSTAGGERED GRID IS USED.                            *   B4M07130
              C * * * MAKE USE OF EQUIVALENCING AND OVERLAPPING THE U ARRAY.                *   B4M07140
              C                                                                             *   B4M07150
ISN 0324           DO 1015 M=1.2                                                                B4M07160
ISN 0325           DO 1018 N=3.4                                                                B4M07170
ISN 0326           NM2=N-2                                                                      B4M07180
ISN 0327           DO 1018 L=1.NLAY                                                             B4M07190
ISN 0328           DO 1018 I=1.IM                                                               B4M07200
ISN 0329           IF(ISTART.EQ.7)GO TO 1017                                                    B4M07210
ISN 0331           Q(I.L.NM2.JEND(M))=QT(I.L.NM2.JEND(M))                                       B4M07220
ISN 0332      1017 Q(I.L.N.JEND(M))=QT(I.L.N.JEND(M))                                           B4M07230
ISN 0333      1018 CONTINUE                                                                     B4M07240
ISN 0334           DO 1015 I=1.IM                                                               B4M07250
ISN 0335           P(I.JEND(M))=PT(I.JEND(M))                                                   B4M07260
ISN 0336      1015 CONTINUE                                                                     B4M07270
ISN 0337           DO 1020 J = 2.JM                                                             B4M07280
ISN 0338           JP1 = J + 1                                                                  B4M07290
ISN 0339           DO 1025 N = 1.2                                                              B4M07300
ISN 0340           NP2 = N + 2                                                                  B4M07310
ISN 0341           DO 1025 L = 1.NLAY                                                           B4M07320
ISN 0342           IS1 = IM                                                                     B4M07330
ISN 0343           DO 1025 I = 1.IM                                                             B4M07340
ISN 0344           Q(I.L.NP2.J) = QT(I.L.NP2.J)                                                 B4M07350
ISN 0345           IF(ISTART.NE.7)GO TO 1026                                                    B4M07360
ISN 0347           Q(I.L.N.J) = .25 * (QT(IS1.L.N.J) + QT(I.L.N.J) +                            B4M07370
                  $   QT(IS1.L.N.JP1) + QT(I.L.N.JP1))                                          B4M07380
ISN 0348           IS1 = I                                                                      B4M07390
ISN 0349           GO TO 1025                                                                   B4M07400
ISN 0350      1026 Q(I.L.N.J)=QT(I.L.N.J)                                                       B4M07410
ISN 0351      1025                                CONTINUE                                      B4M07420
ISN 0352           DO 1030 I = 1.IM                                                             B4M07430
ISN 0353           P(I.J) = PT(I.J)                                                             B4M07440
ISN 0354      1030                                CONTINUE                                      B4M07450
              C                                                                             *   B4M07460
              C * * * SCALE UT                                                              *   B4M07470
              C                                                                             *   B4M07480
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ISN 0355         DO 1020 N = 1,4                                                             B4M07490
ISN 0356         DO 1020 L = 1,NLAY                                                          B4M07500
ISN 0357         DO 1020 I = 1,IM                                                            B4M07510
ISN 0358         QT(I,L,N,J) = DXYP(J) * P(I,J) * Q(I,L,N,J)                                 B4M07520
ISN 0359    1020                                   CONTINUE                                  B4M07530
            C                                                                          *     B4M07540
            C * * * COMPUTATION OF STEREOGRAPHIC POLAR VELOCITIES: UPOL(L,M),          *     B4M07550
            C * * * VPOL(L,M), WHERE M=1 CORRESPONDS TO SOUTH POLE                     *     B4M07560
            C                                                                          *     B4M07570
ISN 0360         DO 1040 M = 1,2                                                             B4M07580
ISN 0361         COEF1 = (-1) ** M                                                           B4M07590
ISN 0362         DO 1040 L = 1,NLAY                                                          B4M07600
ISN 0363         IF(ISTART.NE.7) GO TO 1052                                                  B4M07610
ISN 0355         S1 = 0.                                                                     B4M07620
ISN 0366         S2 = 0.                                                                     B4M07630
ISN 0367         DO 1050 I = 1,IM                                                            B4M07640
ISN 0368         S1 = S1 - U(I,L,JNEXT(M)) * SINLON(I) - COEF1 * V(I,L,JNEXT(M))             B4M07650
                $            * COSLON(I)                                                     B4M07660
ISN 0369         S2 =S2+COEF1*U(I,L,JNEXT(M))*COSLON(I)-V(I,L,JNEXT(M))*SINLON(I)            B4M07670
ISN 0370    1050                                   CONTINUE                                  B4M07680
ISN 0371         UPOL(L,M) = S1 / FLOAT(IM)                                                  B4M07690
ISN 0372         VPOL(L,M) = S2 / FLOAT(IM)                                                  B4M07700
ISN 0373         GO TO 1053                                                                  B4M07710
ISN 0374    1052 UPOL(L,M) = -U(I,L,JEND(M))*SINLON(I) -                                     B4M07720
                1                          COEF1*V(I,L,JEND(M))*COSLON(I)                    B4M07730
ISN 0375         VPOL(L,M) = -U(I,L,JEND(M))*COSLON(I) +                                     B4M07740
                1                          COEF1*V(I,L,JEND(M))*SINLON(I)                    B4M07750
ISN 0376    1053 CONTINUE                                                                    B4M07760
ISN 0377         TPOL(L,M) = T(I,L,JEND(M))                                                  B4M07770
ISN 0378         SHPOL(L,M) = SH(I,L,JEND(M))                                                B4M07780
ISN 0379         PPOL(M) = P(I,JEND(M))                                                      B4M07790
ISN 0380         WRITE(6,1968)M,L,PPOL(M),(QPOL(L,N1,M),N1=1,4)                              B4M07800
ISN 0381    1968 FORMAT(1X,' PPOL,QPOL= FOR M=',I2,' L=',I3,5E13.6)                          B4M07810
ISN 0382         PTPOL(M)=PPOL(M)                                                            B4M07820
ISN 0383         DO 1045 N = 1,4                                                             B4M07830
ISN 0384    1045 QTPOL(L,N,M) = QPOL(L,N,M) * PTPOL(M)                                       B4M07840
            C * * * THE QT(I,L,JEND(M)) COMPUTATION BELOW AGREES                       *     B4M07850
            C * * * WITH THE PROCEDURE USED IN COMPO                                   *     B4M07860
ISN 0385         DO 1040 I=1,IM                                                              B4M07870
ISN 0386         IF(ISTART.NE.7) GO TO 1054                                                  B4M07880
ISN 0388         U(I,L,JEND(M))=-UPOL(L,M)*SINLON(I)+COEF1*VPOL(L,M)*COSLON(I)               B4M07890
ISN 0399         V(I,L,JEND(M))=-COEF1*UPOL(L,M)*COSLON(I)-VPOL(L,M)*SINLON(I)               B4M07900
ISN 0390    1054 CONTINUE                                                                    B4M07910
ISN 0391           DO 1040 N = 1,4                                                           B4M07920
ISN 0392         QT(I,L,N,JEND(M)) = Q(I,L,N,JEND(M)) * PTPOL(M)                             B4M07930
ISN 0393    1040                                   CONTINUE                                  B4M07940
ISN 0394                                           RETURN                                    B4M07950
            C**** ERROR ENCOUNTERED READING TAU.C RECORD ON UNIT KTR                         B4M07960
ISN 0395     800 WRITE (3,911)                                                               B4M07970
ISN 0396         CALL EXIT                                                                   B4M07980
            C**** ERROR ENCOUNTERED READING LATITUDE RECORD ON UNIT KTR                      B4M07990
ISN 0397     810 WRITE (3,916) J                                                             B4M08000
ISN 0398         CALL EXIT                                                                   B4M08010
            C**** END-OF-FILE ENCOUNTERED READING LATITUDE RECORD ON UNIT KTR                B4M08020
ISN 0399     820 WRITE (3,917) J                                                             B4M08030
ISN 0400         CALL EXIT                                                                   B4M08040
            C**** LATER PICKUP TAPE NEEDED                                                   B4M08050
ISN 0401     830 WRITE (3,913) TAUP                                                          B4M08060
ISN 0402         CALL EXIT                                                                   B4M08070
ISN 0403         STOP                                                                        B4M08080
ISN 0404     901 FORMAT (//40X,'GISS N LAYER WEATHER MODEL'//100X 'VERSION' I4//)            B4M08090
ISN 0405     902 FORMAT (20A4)                                                               B4M08100
ISN 0406     903 FORMAT (25X,20A4)                                                           B4M08110
ISN 0407     904 FORMAT (10A8)                                                               B4M08120
ISN 0408     905 FORMAT (35X,10A8)                                                           B4M08130
ISN 0409     906 FORMAT (' ENTER THE RESTART VALUE OF TAU AS AN 8 CHARACTER NUMBER           B4M08140
                * E.G. 4026.2 AS 04026.20')                                                  B4M08150
ISN 0410     907 FORMAT (F8.2)                                                               B4M08160
ISN 0411     908 FORMAT ('/MACHINE CHECK RESTART, TAUP=',F9.2/)                              B4M08170
ISN 0412     909 FORMAT (' ENTER THE NUMBER OF THE NEW OUTPUT TAPE AS A FOUR DIGIT           B4M08180
                *NUMBER.')                                                                   B4M08190
ISN 0413     910 FORMAT (//' THE NUMBER OF THE NEW TAPE IS ',A4//)                           B4M08200
ISN 0414     911 FORMAT ('0ERROR ENCOUNTERED READING TAU.C RECORD ON UNIT KTR.')             B4M08210
ISN 0415     912 FORMAT ('0EARLIER PICKUP TAPE NEEDED. TAUP =',F10.2)                        B4M08220
ISN 0416     913 FORMAT ('0LATER PICKUP TAPE NEEDED. TAUF =',F10.2)                          B4M08230
ISN 0417     914 FORMAT (' I.E. READ FROM UNIT',I3,' TAUX=',F9.2,3X,20A4,3X,                 B4M08240
                *  'IROT= ',Z2)                                                              B4M08250
ISN 0418     915 FORMAT ('0',I2,' REGION SPLIT GRID LIMITS   J1P',11I5/31X,'JNP',            B4M08260
                *  11I5/31X,'J1U',11I5/31X,'JNU',11I5/31X,'INC',11I5/31X,'KSB',              B4M08270
                *  11I5/31X,'KNB',11I5/)                                                     B4M08280
ISN 0419     916 FORMAT ('0ERROR ENCOUNTERED READING LATITUDE RECORD ON UNIT KTR.            B4M08290
                *J BEING READ WAS',I4)                                                       B4M08300
ISN 0420     917 FORMAT ('0END-OF-FILE ENCOUNTERED READING LATITUDE RECORD ON UNIT           B4M08310
                *KTR.  J BEING READ WAS',I4)                                                 B4M08320
ISN 0421     938 FORMAT (' ISTART =',I2,' THE DECK IS SET UP AS AN INITIAL START'            B4M08330
                *,/,' IF IT SHOULD BE A RESTART DC JOB NO. AND INSERT AN ISTART=3 C          B4M08340
                *ARD BEFORE &END AND RELOAD.  THANK YOU')                                    B4M08350
ISN 0422         END                                                                         B4M08360
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                                                        /    INPUT /     SIZE OF PROGRAM 003100 HEXADECIMAL BYTES

NAME TAG TYPE ADD.   I* ***    %   NAME TAG TYPE ADD.   I* ***    %   NAME TAG TYPE ADD.   I* ***    %   NAME TAG TYPE ADD.   I* ***    %
     C SF  CE  R*4  000000             F S   C   R*4  000A08             I SFA     I*4  00066C             J SFA     I*4  000670
     K SF      I*4  000674             L SF      I*4  000678             M SF      I*4  00067C             N SF      I*4  000680
     P SF  CE  R*4  002F10             Q SF  CE  R*4  00CE7C             R S   C   R*4  000038             T F   CE  R*4  0024F0
     U SF  CE  R*4  000E70             V SF  CE  R*4  00198C             W     C   R*4    N.R.            CP SF  C   R*4  000040
    CI SF      R*4  000748            DT S   C   R*4  00008C            ED S   C   R*4  000120            GT S   CE  R*4  000840
    GW S   CE  R*4  001680            IM SFA C   I*4  000008            IU S       I*4  000684            JM SFA C   I*4  000030
    J1 SF  C   I*4  00002C            KM SF  C   I*4  000034            NR S   C   I*4  00004C            N1 F       I*4  000688
    PI SF  C   R*4  00010C            PK     C   R*4    N.R.            PT SF  CE  R*4  0021C0            PU     CE  R*4  000000
    QT SF  CE  R*4  000120            SH F   CE  R*4  003030            S1 SF      R*4  00068C            S2 SF      R*4  000690
    TS S   CE  R*4  001890            TT     CE  R*4  0017AC            UT     CE  R*4  000120            VT     CE  R*4  000C60
   CDX S   C   R*4  000144           DPI SF      R*8  000728           DXP SF  C   R*4  000728           DXU     C   R*4    N.R.
   DYP     C   R*4    N.R.           DYU SF  C   R*4  0007EC           FAC SFA     R*4  000694           FIM S   C   R*4  000020
   FMU S   C   R*4  000124           FI7 S   C   R*4  000004           F98 S   C   R*4  000008           GSW     C   R*4  000004
   IN2 SF      I*4  000698           IM3 SF      I*4  00069C           IM4 S       I*4  0006A0           INC S   C   I*4  000044
   IS1 SF      I*4  0006A4           ITC     C   I*4  00000C           JDM SFA     I*4  0006A8           JNB SF  C   I*4  000080
   JNP SF  C   I*4  000004           JP1 SF  C   I*4  00006C           JP2     C   I*4    N.R.           JSB SF  C   I*4  0000AC
   JSP SF  CE  I*4  000000           KIR SFA     I*4  0006AC           LAT SFA C   R*4  0005B8           MLF S   C   I*4  000004
   NM2 SF      I*4  000680           NPC     C   I*4    N.R.           NP2 SF      I*4  000684           PSF     C   R*4  00012C
   PSL S   C   R*4  00011C           PSM     C   R*4    N.R.           QSM     C   R*4    N.R.           RAD SF  C   R*4  00003C
   SHS S   CE  R*4  0023D0           SHT     CE  R*4  0022EC           SIG SF  C   R*4  000370           SUM     C   R*4    N.R.
   TAU S   C   R*4  0000C0           TMP S   C   R*4  000010          BETA S   C   R*4  00001C          CONG     C   L*4  0389A4
  CON1 S   C   R*4  000000          CON2 S   C   R*4  000004          CON3     C   R*4    N.R.          CON4     C   R*4    N.R.
  CON5 S   C   R*4  000010          COSD     C   R*4    N.R.          COSL SFA C   R*4  000B78          CPD2 S   C   R*4  00004C
  CPTH SF  C   R*4  000030          DIFF S   C   R*4  005764          DISK F       R*4  000688          DLAT SFA C   R*4  000084
  DLON SF  C   R*4  000088          DSIG SF  C   R*4  0003CC          DXYP SF  C   R*4  000950          EXIT SF  XF  R*4  000000
  FAST S   C   L*4  00000C          FJEQ SF      R*4  00068C          FSD6 S   C   R*4  000000          GRAV S   C   R*4  000110
  IDAY     C   I*4    N.R.          IMAX SF      I*4  0006CC          IND2 SF  C   I*4  000050          IMP1 S       I*4  0006C4
  INCP         I*4    N.R.          INCS     C   I*4  000080          INCU         I*4    N.R.          IRUT SF  C   I*4  00003C
  ITAU     C   I*4    N.R.          IVER F       I*4  0006C8          JAYS     C   I*4  000050          JDAY     C   I*4    N.R.
  JEND SF  C   I*4  000058          JLIM SF      I*4  0006CC          JMAX SF  C   I*4  000004          JMIN SF  C   I*4  000000
  JMPS     C   I*4    N.R.          JMS1 S   C   I*4  00002C          JMS2 S   C   I*4  000028          JMUS     C   I*4    N.R.
  JPOL S   C   I*4  000084          JSMT SF      I*4  0006DC          JSUM S   C   I*4  000008          JIPS     C   I*4    N.R.
  J1JS     C   I*4    N.R.          KAPA SF  C   R*4  000118          KMM4 S       I*4  0006D4          KNBS     C   I*4    N.R.
  KSBS     C   I*4    N.R.          MRCH     C   I*4    N.R.          MROT S   C   I*4  000040          NCM1 S   C   I*4  000034
  NFLW S   C   I*4  000128          NLAY SF  C   I*4  00003C          NOC3 S   C   L*4  000004          NSEQ S   C   I*4  000000
  NSMI S   C   I*4  000030          OHM2 SF      R*4  0006D8          PHIS SF  CE  R*4  003050          PPOL SF  CE  R*4  000654
  PTOP S   C   R*4  000010          QPOL F   CE  R*4  000414          RADT     C   I*2    N.R.          RGAS SF  C   R*4  000114
  SDAY SF      R*4  0006DC          SDOT     CE  R*4  00000C          SIGE SF  C   R*4  000410          SIND     C   R*4    N.R.
  SINL SF  C   R*4  000AC0          SMTH S   C   R*4  00000C          TAUE S   C   R*4  000100          TAUI SF  C   R*4  0000FC
  TAUO S   C   R*4  000104          TAUP SFA C   R*4  0000F8          TAUT SFA C   R*4  000038          TAUX SF      R*4  0006E0
  TPOL S   CE  R*4  00045C          UPOL SF  CE  R*4  000414          VPOL SF  CE  R*4  000438          XINT SF  C   R*4  0000C8
 ADLDP S   C   R*4  000024         ALONG SFA     R*8  000730         ALPHA SF  C   R*4  000018         COEF1 SF      R*4  0006E4
 C3WRT S   C   L*4  000000         DSIGO S   C   R*4  000464         DUMMY     C   R*4    N.R.         FLAGS     C   L*4  000000
 IM2P1 S       I*4  0006E8         IM3P1 S       I*4  0006EC         INDEX S   C   I*4  0002E4         INPUT         I*4  0006F0
 ISDOT     CE  I*2  00CF00         ISMTH S   C   I*4  00000C         ITEST S   C   I*4  000048         JDATE     C   I*4    N.R.
 JNBM1 S       I*4  0006F4         JNEXT SF  C   I*4  00006C         JNPM1 S   C   I*4  00001C         JNPP1 SF      I*4  0006F8
 JPMOD S   C   I*4  000094         JSBP1 S       I*4  0006FC         JSPP1 S   C   I*4  000018         JTEST S   C   I*4  000044
 JYEAR     C   I*4    N.R.         KSSWS SFA     I*4  000700         MODPK S   C   I*4  000074         NSTEP     C   I*4    N.R.
 OMEGA     C   I*2    N.R.         PAWZE S       R*4  000704         POLES     CE  R*4  003414         PSIGN S   C   R*4  000404
 PTPOL SF  CE  R*4  00065C         QTPOL S   CE  R*4  000534         RADIN SF  C   R*4  000054         RHMAX S   C   R*4  000140
 SDPOL     C   R*4    N.R.         SHPOL S   CE  R*4  000480         THBAR SF  C   R*4  000014         TOPOG S   C   R*4  000000
 TTPOL     CE  R*4  00057C         TWOJM S       R*4  000708         TWOPC SF      R*8  000738         UTPOL     CE  R*4  000534
 VTPOL     CE  R*4  000558        FIXPI#     XF  I*4  00000C          DCOS     XF  R*8  000000          DSIN     XF  R*8  000000
 COTAN     XF  R*4  000000           COS     XF  R*4  00000C           SIN     XF  R*4  000000        ADPCLD     C   L*4  000018
ALBEDO SF  C   I*2  082350        ANDEND         R*8  000740        CONVPL     C   R*4    N.R.        COSLON SF  C   R*4  0001C4
DTMULT S   C   R*4  000108        DUMMYA     C   R*4    N.R.        DUMMYC     C   R*4    N.R.        EXPBYK F   XF  R*4  000000
FRDNL# F   XF  I*4  000000        IALTER S   C   I*4  00019C        IBCOM# F   XF  I*4  000000        INAXM1 SFA     I*4  00070C
INAXP3 S       I*4  000710        IMD2P1 S   C   I*4  000020        INPUTZ F            F57AF7        INPUT4         I*4  000714
ISTART SF  C   I*4  000014        ISWTCH     C   I*4  00000C        JMONTH     C   I*4    N.R.        JMP1D2 SF      I*4  000718
MATSNX     C   I*4    N.R.        MATSUN S   C   I*4  000068        MNMXTS S   C   I*4  0286E0        NCOMP3 S   C   I*4  0000F0
NCYCLE S   C   I*4  0000EC        NHOGAN S   C   I*4  0000F4        NLAYM1 SF  C   I*4  000024        NLAYP1 S   C   I*4  000028
NSTART     C   I*4    N.R.        PHISPL S   C   R*4  0057F4        PITPOL         R*4    N.R.        PSKAPA SF  C   R*4  000034
PSMPOL     C   R*4    N.R.        PIKAPA SF      R*4  00071C        QSMPOL     C   R*4    N.R.        ROTAPE SF  XF  R*4  000000
RECORD SF      R*8  0008F8        ROTPER S       R*4  000720        RSDIST     C   R*4    N.R.        SMSMDO S   C   L*4  000008
SHTPOL     CE  R*4  0005A0        SINLON SF  C   R*4  0000A4        SMAFTA S   C   L*4  000014        SSWTCH SF  XF  R*4  000000
TAPNJM SF      R*4  000724        TUFDAY     C   R*4    N.R.        XLABEL SF  C   R*4  000320

                                  *****   COMMON INFORMATION   *****

   NAME OF COMMON BLOCK *  * 3I_E OF BLCCKCOMMON      000C14 HEXADECIMAL BYTES

 VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE
     FLAGS    L*4    000000

   NAME OF COMMON BLOCK * F:U#.ZE OF BLOCKCOMMON      005E24 HEXADECIMAL BYTES

 VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE
      CON1    R*4    000000          CON2    R*4    000004          CON3    R*4      N.R.          CON4    R*4      N.R.
      CON5    R*4    000010         THBAR    R*4    000014         ALPHA    R*4    000018          BETA    R*4    00001C
    IMD2P1    I*4    000020         ADLDP    R*4    000024          JMS2    I*4    000028          JMS1    I*4    00002C
      CPTH    R*4    000030        PSKAPA    R*4    000034             R    R*4    000038           RAD    R*4    00003C
        CP    R*4    000040           INC    I*4    000044        NSTART    I*4      N.R.          CPD2    R*4    00004C
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OF POOR QUALITY

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     IND2    I*4   000050          RADIN    R*4   000054           JEND    I*4   000058            JP1    I*4   000060
      JP2    I*4     N.R.         MATSUN    I*4   000068          JNEXT    I*4   00006C          MODPK    I*4   000074
     JPOL    I*4   000084          JPMOD    I*4   000094         SINLON    R*4   0000A4         COSLON    R*4   0001C4
    INDEX    I*4   0002E4          PSIGN    R*4   000404          POLES    R*4   000414              W    R*4     N.R.
       PK    R*4     N.R.           DIFF    R*4   005764         CONVPL    R*4     N.R.          SDPOL    R*4     N.R.
   PHISPL    R*4   0057F4            SUM    R*4     N.R.

EQUIVALENCED VARIABLES WITHIN THIS COMMON GROUP
  VARIABLE OFFSETE                VARIABLE OFFSETE                VARIABLE OFFSETE                VARIABLE OFFSETE
     QPOL    000414                  QTPOL    000534                   UPOL    000414                   VPOL    000438
     TPOL    00045C                  SHPOL    000480                  UTPOL    000534                  VTPOL    000558
    TTPOL    00057C                 SHTPOL    0005A0                   PPOL    000654                  PTPOL    00065C


  NAME OF COMMON BLOCK * I)S6.ZE OF ELOCKCOMMON     00000C HEXADECIMAL BYTES

VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE
     F5D6    R*4   000000            F17    R*4   000004            F98    R*4   000008

  NAME OF COMMON BLOCK *  =0#S#E OF ELOCKCOMMON     081600 HEXADECIMAL BYTES

VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE
       PU    R*4   000000

EQUIVALENCED VARIABLES WITHIN THIS COMMON GROUP
  VARIABLE OFFSETE                VARIABLE OFFSETE                VARIABLE OFFSETE                VARIABLE OFFSETE
       QT    000120                     UT    000120                     GT    000840                     VT    000C60
       GW    001680                     TT    0017A0                     PT    0021C0                    SHT    0022E0


  NAME OF COMMON BLOCK *  =M..ZE OF BLOCKCOMMON     00D148 HEXADECIMAL BYTES

VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE
      QSM    R*4     N.R.            PSM    R*4     N.R.         QSMPOL    R*4     N.R.         PSMPOL    R*4     N.R.

  NAME OF COMMON BLOCK * S*OT'9E OF BLOCKCOMMON     038SA8 HEXADECIMAL BYTES

VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE
     SDOT    R*4   000000          OMEGA    I*2     N.R.         MNMXTS    I*4   0286E0           RADT    I*2     N.R.
     CONG    L*4   0389A4

EQUIVALENCED VARIABLES WITHIN THIS COMMON GROUP
  VARIABLE OFFSETE                VARIABLE OFFSETE                VARIABLE OFFSETE                VARIABLE OFFSETE
    ISDOT    00CF00

  NAME OF COMMON BLOCK *  ¬NTR#E OF ELOCKCOMMON     083C30 HEXADECIMAL BYTES

VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE
      JSP    I*4   000000            JNP    I*4   000004             IM    I*4   000008           NLAY    I*4   00000C
     PTOP    R*4   000010         ISTART    I*4   000014          JSPP1    I*4   000018          JNPM1    I*4   00001C
      FIM    R*4   000020         NLAYM1    I*4   000024         NLAYP1    I*4   000028             J1    I*4   00002C
       JM    I*4   000030             KM    I*4   000034           TAUT    R*4   000038           IRQT    I*4   00003C
     MROT    I*4   000040          JTEST    I*4   000044          ITEST    I*4   000048             NR    I*4   00004C
     JAYS    I*4   000050           INCS    I*4   000080            JSB    I*4   0000AC            JNB    I*4   0000B0
     DLAT    R*4   000084           DLON    R*4   000088             DT    R*4   0000BC            TAU    R*4   0000C0
     ITAU    I*4     N.R.           XINT    R*4   0000C8           IDAY    I*4     N.R.           JDAY    I*4     N.R.
   TOFDAY    R*4     N.R.          JDATE    I*4     N.R.         JMONTH    I*4     N.R.          JYEAR    I*4     N.R.
    NSTEP    I*4     N.R.         NCYCLE    I*4   0000EC         NCOMP3    I*4   0000F0         NMOGAN    I*4   0000F4
     TAUP    R*4   0000F8           TAUI    R*4   0000FC           TAUE    R*4   000100           TAUO    R*4   000104
   DTMULT    R*4   000108             PI    R*4   00010C           GRAV    R*4   000110           RGAS    R*4   000114
     KAPA    R*4   000118            PSL    R*4   00011C             ED    R*4   000120            FMU    R*4   000124
     NFLW    I*4   000128            PSS    R*4   00012C           MRCH    I*4     N.R.         RSDIST    R*4     N.R.
     SIND    R*4     N.R.           COSS    R*4     N.R.          RHMAX    R*4   000140            CDX    R*4   000144
   DUMMYC    R*4     N.R.         IALTER    I*4   000190         DUMMYA    R*4     N.R.         XLABEL    R*4   000320
      SIG    R*4   000370           DSIG    R*4   0003C0           SIGE    R*4   000410          DSIGG    R*4   000464
     J1PS    I*4     N.R.           JMPS    I*4     N.R.           J1US    I*4     N.R.           JMUS    I*4     N.R.
     KSBS    I*4     N.R.           KNBS    I*4     N.R.            LAT    R*4   000588            DXU    R*4     N.R.
      DXP    R*4   000728            DYU    R*4   0007E0            DYP    R*4     N.R.           DXYP    R*4   000950
        F    R*4   000A08           SINL    R*4   000AC0           COSL    R*4   000878          DUMMY    R*4     N.R.
     PHIS    R*4   000D50         ALBEDO    I*2   082350

EQUIVALENCED VARIABLES WITHIN THIS COMMON GROUP
  VARIABLE OFFSETE                VARIABLE OFFSETE                VARIABLE OFFSETE                VARIABLE OFFSETE
        Q    000E70                      U    000E70                     TS    001890                      V    001980
      SHS    0023D0                      T    0024F0                      P    002F10                     SH    003030
        C    000000

  NAME OF COMMON BLOCK *  * SI.E OF BLOCKCOMMON     0005E0 HEXADECIMAL BYTES

VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE
     JMIN    I*4   000000           JMAX    I*4   000004           JSUM    I*4   000008           SNTH    R*4   00000C
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   NAME OF COMMON BLOCK *  *N3|.E OF BLOCKCOMMON      000038 HEXADECIMAL BYTES

VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE
   NSEG     I*4    000030
   NCM1     I*4    000034            MLF      I*4    000004          MATSNX     I*4      N.R.            NSM1     I*4    000030

   NAME OF COMMON BLOCK *  IMWR.E OF BLOCKCOMMON      00001C HEXADECIMAL BYTES

VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE
  C3WRT     L*4    000000            NUC3     L*4    000004          SHSMOD     L*4    000008           FAST     L*4    00000C
    TMP     R*4    000010          SMAFTA     L*4    000014          ADPOLD     L*4    000018

   NAME OF COMMON BLOCK *  *DS_7E OF BLOCKCOMMON      000004 HEXADECIMAL BYTES

VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE
 ISWTCH     I*4    000000

   NAME OF COMMON BLOCK *  ¬IT#'E OF BLOCKCOMMON      000008 HEXADECIMAL BYTES

VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE
    ITC     I*4    000000            GSW      R*4    000004

   NAME OF COMMON BLOCK *  *S6¬"E OF BLOCKCOMMON      000008 HEXADECIMAL BYTES

VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE
  ISMTH     I*4    000000            NPC      I*4      N.R.

   NAME OF COMMON BLOCK *  * T¬7E OF BLOCKCOMMON      0033C0 HEXADECIMAL BYTES

VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE
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    LABEL    ADDR                   LABEL    ADDR                    LABEL    ADDR                    LABEL    ADDR
       20  001430                      30  001840                       40  00184E                       50  0019C8
       60  0019D0                      70  0019F6                       80  001A22                       90  001A4A
      100  001A88                     110  001ACC                      120  001B54                      121  001D62
      130  001D8C                     140  001DAC                      145  001DCA                      150  001E24
      160  001E6C                     190  001EAC                      200  001EFA                      210  001F6E
      220  001FBE                     230  001FF6                      240  00204E                      310  0023D2
      301  0023DE                     320  002440                     1000  0025FA                     1010  002644
     1017  00276A                    1018  002776                     1015  0027F0                     1026  002960
     1025  002968                    1030  0029F6                     1020  002A70                     1050  002C6E
     1052  002C98                    1053  002CE2                     1045  002E18                     1054  002F16
     1040  002F30                     800  002FE0                      810  003000 NR                   820  003028 NR
      830  003050

*OPTIONS IN EFFECT*       NAME=  MAIN,OPT=02,LINECNT=55,SIZE=1000K,

*OPTIONS IN EFFECT*       SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,NOXREF

*STATISTICS*      SOURCE STATEMENTS =      421    PROGRAM SIZE=       12544

*STATISTICS*  NO  DIAGNOSTICS GENERATED

****** END OF COMPILATION ******                                                772K BYTES OF CORE NOT USED

 LEVEL 19.6-APR 71                                    OS/360 FORTRAN H AT GISS                                     DATE 12/12/79-0783.20

        COMPILER OPTIONS -     NAME=  MAIN,OPT=02,LINECNT=55,SIZE=1000K,
                               SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,NOXREF
  ISN 0002                SUBROUTINE TWRITE                                                   B4M08370
                     C**** FINE NINE LAYER GLOBAL CDE BLOCK FOR VM MODEL, FEBRUARY 1976          B4M08380
  ISN 0003                INTEGER*2 ALBEDO                                                    B4M08390
  ISN 0004                REAL*4 KAPA,LAT                                                     B4M08400
                     C    REAL*8 SINLON,COSLON,SUM                                            B4M08410
  ISN 0005                COMMON /CNTRL/                                                      B4M08420
                         *  JSP,JNP,IM,NLAY,PTOP,ISTART,JSFP1,JNPM1,FIM,NLAYM1,NLAYP1,        B4M08430
                         *  J1,JM,KM,TAUT,IRGT,MROT,JTEST,ITEST,                              B4M08440
                         *  NR,JAYS(12),INCS(11),JSB,JNB,CLAT,DLON,                           B4M08450
                         *  DT,TAU,ITAU,XINT,IDAY,JDAY,TOFDAY,JDATE,JMONTH(2),JYEAR,NSTEP,    B4M08460
                         *  NCYCLE,NCOMP3,NHOGAN,TAUP,TAUI,TAUE,TALO,DTMULT,                  B4M08470
                         *  PI,GRAV,RGAS,KAPA,PSL,ED,FMU,NFLM,PSF,MRCH,RSDIST,SIND,COSD,      B4M08480
                         *  RHMAX,CDX,DUMMYC(18),IALTER,DUMMYA(99),                           B4M08490
                         *  XLABEL(20),SIG(20),DSIG(20),SIGE(21),DSIGO(19),                   B4M08500
                         *  J1PS(11),JMPS(11),J1US(11),JMUS(11),KSES(11),KNBS(11),            B4M08510
                         *LAT(46),DXU(46),DXP(46),DYU(46),DYP(46),DXYP(46),F(46),SINL(46),    B4M08520
                         *COSL(46),DUMMY(72),PHIS(2880,46),ALBEDO(72,46)                      B4M08530
  ISN 0006                DIMENSION U(72,40,1),V(72,40,1),T(72,40,1),SH(72,40,1),             B4M08540
                         *P(2880,1),    TS(2880,1),SHS(2880,1),GT(2880,1),GW(2880,1),C(300)   B4M08550
  ISN 0007                COMMON/WORK2/PU(2880,46)                                            B4M08560
                     C                                                                        B4M08570
  ISN 0008                COMMON/SDOT48/SDOT(72,46,8),OMEGA(72,46,9),MNMXTS,RADT(72,46,10)    B4M08580
                         + ,COMG                                                              B4M08590
  ISN 0009                LOGICAL COMG                                                        B4M08600
                     C                                                                        B4M08610
  ISN 0010                INTEGER*2 RADT,OMEGA                                                B4M08620
  ISN 0011                INTEGER*2 ISDOT(72,46,8)                                            B4M08630
                     C                                                                        B4M08640
  ISN 0012                EQUIVALENCE (SDOT(1,1,5),(SDOT(1,1,1))                              B4M08650
                     C                                                                        B4M08660
  ISN 0013                DIMENSION SDFIL(72,12),RADFIL(72,10),OMFIL(72,9)                    B4M08670
                     C                                                                        B4M08680
  ISN 0014                EQUIVALENCE                                                         B4M08690
                         $    (U(1,1,1),PHIS(73,1)),(TS(1,1),PHIS(721,1)),                    B4M08700
                         $    (V(1,1,1),PHIS(793,1)),(SHS(1,1),PHIS(1441,1)),                 B4M08710
                         $    (T(1,1,1),PHIS(1513,1)),(P(1,1),PHIS(2161,1)),                  B4M08720
                         $    (SH(1,1,1),PHIS(2233,1)),                                       B4M08730
                         $    (GT(1,1),PU(721,1)),(GW(1,1),PU(1441,1)),(C(1),JSP)             B4M08740
  ISN 0015                COMMON/SMOO/ISMTH,NPC                                               B4M08750
  ISN 0016                EQUIVALENCE(C(100),MACHIN)                                          B4M08760
  ISN 0017                MACHIN = 165                                                        B4M08770
  ISN 0018                IMP1 = IM + 1                                                       B4M08780
  ISN 0019                IM2 = 2 * IM                                                        B4M08790
  ISN 0020                IM2P1 = IM2 + 1                                                     B4M08800
  ISN 0021                IM3 = 3 * IM                                                        B4M08810
  ISN 0022                IM3P1 = IM3 + 1                                                     B4M08820
  ISN 0023                KMM4=KM-4                                                           B4M08830
  ISN 0024                IM4=IM*4                                                            B4M08840
  ISN 0025                TAUR = INT(TAU + .5)                                                B4M08850
  ISN 0026                BACKSPACE 8                                                         B4M08860
                     C                                                                        B4M08870
                     C                                                                        B4M08880
  ISN 0027             70 WRITE (8,END=80,ERR=90)TAUR,C,((P(I,J),J=1,JNP),I=1,IM),            B4M08890
                         $    ((TS(I,J),J=1,JNP),I=1,IM),((SHS(I,J),J=1,JNP),I=1,IM),         B4M08900
                         $    ((GT(I,J),J=1,JNP),I=1,IM),((GW(I,J),J=1,JNP),I=1,IM)           B4M08910
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ISN 0028          DO 75 J = 1,JNP                                                          B4M08920
           CCCC   IF (AMOD((TAU+.0001),TAUT) .LT. .0010) GC TO 76      CCCCCCC             B4M08930
ISN 0029          DO 73 L=1,4                                                              B4M08940
ISN 0030          DO 73 I=1,IM                                                             B4M08950
ISN 0031       73 SDFIL(I,L) = SDOT(I,J,L)                                                 B4M08960
ISN 0032          DO 77 I=1,IM                                                             B4M08970
ISN 0033          DO 76 L=1,8                                                              B4M08980
ISN 0034          OMFIL(I,L) = OMEGA(I,J,L)                                                B4M08990
ISN 0035          RADFIL(I,L) = RADT(I,J,L)                                                B4M09000
ISN 0036       76 SDFIL(I,L+4) = ISDOT(I,J,L)                                              B4M09010
ISN 0037          OMFIL(I,9) = OMEGA(I,J,9)                                                B4M09020
ISN 0038          RADFIL(I,9) = RADT(I,J,9)                                                B4M09030
ISN 0039          RADFIL(I,10) = RADT(I,J,10)                                              B4M09040
ISN 0040       77 CONTINUE                                                                 B4M09050
ISN 0041          WRITE (8,END=80,ERR=90) ((U(I,K,J),I=1,IM),K=1,9),((V(I,K,J),            B4M09060
         $    I=1,IM),K=1,9),((T(I,K,J),I=1,IM),K=1,9),((SH(I,K,J),                        B4M09070
         $    I=1,IM),K=1,9),SDFIL,RADFIL,OMFIL                                            B4M09080
ISN 0042       75 CONTINUE                                                                 B4M09090
ISN 0043          IROT=IROT+1                                                              B4M09100
ISN 0044          ENDFILE 8                                                                B4M09110
ISN 0045          IF(IROT.LE.MROT) RETURN                                                  B4M09120
           C**** BEGIN A NEW OUTPUT TAPE                                                   B4M09130
ISN 0047       80 IROT=0                                                                   B4M09140
ISN 0048          REWIND 3                                                                 B4M09150
ISN 0049          WRITE (15,901)                                                           B4M09160
ISN 0050          READ (15,902) TAPNUM                                                     B4M09170
ISN 0051          WRITE (3,903) TAPNUM,TAUST,TAU,TAUT,XLABEL                               B4M09180
ISN 0052          TAUST=TAU                                                                B4M09190
ISN 0053          XLABEL(20)=TAPNUM                                                        B4M09200
ISN 0054          GO TO 70                                                                 B4M09210
           C**** ERROR OCCURRED WRITING OUTPUT TAPE                                        B4M09220
ISN 0055       90 WRITE (15,904)                                                           B4M09230
ISN 0056          WRITE (3,904)                                                            B4M09240
ISN 0057          GO TO 80                                                                 B4M09250
ISN 0058      901 FORMAT (' MOUNT A NEW OUTPUT TAPE (RING IN) AND ENTER THE TAPE NUMB4M09260
         *BER AS A FOUR DIGIT NUMBER.')                                                    B4M09270
ISN 0059      902 FORMAT (A4)                                                              B4M09280
ISN 0060      903 FORMAT ('0TAPE ',A4,'    TAUS',2F10.3,F8.3,5X,20A4/)                     B4M09290
ISN 0061      904 FORMAT (' ERROR OCCURRED WRITING OUTPUT TAPE. WRITE A NOTE ON SETJB4M09300
         *P TICKET.IF PROGRAM JUST STARTED.CLEAN TAPE DRIVE OR USE ANOTHER'/B4M09310
         $    1X, 'DRIVE AND RESUBMIT THE JCB .')                                          B4M09320
ISN 0062          END                                                                      B4M09330

                                              /   TWRITE /     SIZE OF PROGRAM 002CD8 HEXADECIMAL BYTES

NAME TAG TYPE ADD.  |* ***   % NAME TAG TYPE ADD.  |* ***   % NAME TAG TYPE ADD.  |* ***   % NAME TAG TYPE ADD.  |* ***   %
      C  F  CE  R*4  000000          F      C  R*4    N.R.          I SF        I*4  0001E8          J SF        I*4  0001FC
      K  F      I*4  0001F0          L SF      I*4  0001F4          P  F  CE  R*4  002F10          T  F  CE  R*4  002470
      U  F  CE  R*4  0C0E70          V  F  CE  R*4  001980         DT      C  R*4    N.R.         ED      C  R*4    N.R.
     GT  F  CE  R*4  000840         GW  F  CE  R*4  00168C         IM  F   C  I*4  000008         JM      C  I*4    N.R.
     J1      C  I*4    N.R.         KM  F   C  I*4  000034         NR      C  I*4    N.R.         PT      C  R*4    N.R.
     PU     CE  R*4  000000         SH  F  CE  R*4  00303C         TS  F  CE  R*4  001890        CDX      C  R*4    N.R.
    DXP      C  R*4    N.R.        DXU      C  R*4    N.R.        DYP      C  R*4    N.R.        DYU      C  R*4    N.R.
    FIM      C  R*4    N.R.        FMU      C  R*4    N.R.        IM2 SF       I*4  0001F8        IM3 SF       I*4  0001FC
    IM4 S       I*4  000200        JNB      C  I*4    N.R.        JNP  F   C  I*4  000004        JSB      C  I*4    N.R.
    JSP     CE  I*4  0000C0        LAT      C  R*4    N.R.        NPC      C  I*4    N.R.        PSF      C  R*4    N.R.
    PSL      C  R*4    N.R.        SHS  F  CE  R*4  0023DC        SIG      C  R*4    N.R.        TAU FA   C  R*4  0000C0
   COMG      C  L*4  0389A4       COSD      C  R*4    N.R.       COSL      C  R*4    N.R.       DLAT      C  R*4    N.R.
   DLON      C  R*4    N.R.       DSIG      C  R*4    N.R.       DXYP      C  R*4    N.R.       GRAV      C  R*4    N.R.
   IDAY      C  I*4    N.R.       IMP1 S       I*4  000204       INCS      C  I*4    N.R.       IROT SF   C  I*4  00003C
   ITAU      C  I*4    N.R.       JAYS      C  I*4    N.R.       JDAY      C  I*4    N.R.       JMPS      C  I*4    N.R.
   JMUS      C  I*4    N.R.       J1PS      C  I*4    N.R.       J1US      C  I*4    N.R.       KAPA      C  R*4    N.R.
   KMM4 S       I*4  000208       KNBS      C  I*4    N.R.       KSBS      C  I*4    N.R.       MRCH      C  I*4    N.R.
   MROT      C  I*4  000040       NFLW      C  I*4    N.R.       NLAY      C  I*4    N.R.       PHIS     CE  R*4  000050
   PTOP      C  R*4    N.R.       RADT  F   C  I*2  0286E4       RGAS      C  R*4    N.R.       SDOT  F  CE  R*4  00C000
   SIGE      C  R*4    N.R.       SIND      C  R*4    N.R.       SINL      C  R*4    N.R.       TAUE      C  R*4    N.R.
   TAUI      C  R*4    N.R.       TAUO      C  R*4    N.R.       TAUP      C  R*4    N.R.       TAUR SF      R*4  00020C
   TAUT  F   C  R*4  000038       XINT      C  R*4    N.R.      DSIGO      C  R*4    N.R.      DUMMY      C  R*4    N.R.
  IM2P1 S       I*4  000210      IM3P1 S       I*4  000214      ISDOT  F  CE  I*2  00CF00      ISMTH      C  I*4    N.R.
  ITEST      C  I*4    N.R.      JDATE      C  I*4    N.R.      JNPM1      C  I*4    N.R.      JSPP1      C  I*4    N.R.
  JTEST      C  I*4    N.R.      JYEAR      C  I*4    N.R.      NSTEP      C  I*4    N.R.      OMEGA  F   C  I*2  019E00
  OMFIL SF      R*4  000224      RHMAX      C  R*4    N.R.      SDFIL SF      R*4  000C44      TAUST SF      R*4  000218
 ALBEDO      C  I*2    N.R.     DTMULT      C  R*4    N.R.     DUMMYA      C  R*4    N.R.     DUMMYC      C  R*4    N.R.
 IALTER      C  I*4    N.R.     IBCOM#  F  XF  R*4  00000C     ISTART      C  I*4    N.R.     JMONTH      C  I*4    N.R.
 MACHIN S   CE  I*4  00018C     MNMXTS      C  I*4    N.R.     NCOMP3      C  I*4    N.R.     NCYCLE      C  I*4    N.R.
 NHOGAN      C  I*4    N.R.     NLAYM1      C  I*4    N.R.     NLAYP1      C  I*4    N.R.     RADFIL SF      R*4  0019C4
 RSDIST      C  R*4    N.R.     TAPNUM SF      R*4  00021C     TOFDAY      C  R*4    N.R.     TWRITE         R*4  000220
 XLABEL SF   C  R*4  000320

                                 *****   COMMON INFORMATION   *****

   NAME OF COMMON BLOCK *  ¬NTR#E OF BLOCKCOMMON      083C30 HEXADECIMAL BYTES

VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE
      JSP  I*4   000000              JNP  I*4   000004               IM  I*4   000008             NLAY  I*4    N.R.
     PTOP  R*4    N.R.            ISTART  I*4    N.R.             JSPP1  I*4    N.R.            JNPM1  I*4    N.R.
      FIM  R*4    N.R.            NLAYM1  I*4    N.R.            NLAYP1  I*4    N.R.               J1  I*4    N.R.
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         JM     I*4     N.R.              KM     I*4    000034             TAUT     R*4    000038             IROT     I*4    00003C
       MROT     I*4   000040           JTEST     I*4      N.R.            ITEST     I*4      N.R.               NR     I*4      N.R.
       JAYS     I*4     N.R.            INCS     I*4      N.R.              JSB     I*4      N.R.              JNB     I*4      N.R.
       DLAT     R*4     N.R.            DLCN     R*4      N.R.               DT     R*4      N.R.              TAU     R*4    0000C0
       ITAU     I*8     N.R.            XINT     R*4      N.R.             IDAY     I*4      N.R.             JDAY     I*4      N.R.
     TOFDAY     R*4     N.R.           JDATE     I*4      N.R.           JMONTH     I*4      N.R.            JYEAR     I*4      N.R.
      NSTEP     I*4     N.R.          NCYCLE     I*4      N.R.           NCOMP3     I*4      N.R.           NMDGAN     I*4      N.R.
       TAUP     R*4     N.R.            TAUI     R*4      N.R.             TAUE     R*4      N.R.             TAUO     R*4      N.R.
     DTMULT     R*4     N.R.              PI     R*4      N.R.             GRAV     R*4      N.R.             RGAS     R*4      N.R.
       KAPA     F*4     N.R.             PSL     R*4      N.R.               ED     R*4      N.R.              FMU     R*4      N.R.
       NFLW     I*4     N.R.             PSF     R*4      N.R.             MRCH     I*4      N.R.           RSDIST     R*4      N.R.
       SIND     R*4     N.R.            COSD     R*4      N.R.            RHMAX     R*4      N.R.              CDX     R*4      N.R.
     DUMMYC     R*4     N.R.          IALTER     I*4      N.R.           DUMMYA     R*4      N.R.           XLABEL     R*4    000320
        SIG     R*4     N.R.            DSIG     R*4      N.R.             SIGE     R*4      N.R.            DSIGO     R*4      N.R.
       J1PS     I*4     N.R.            JMPS     I*4      N.R.             J1US     I*4      N.R.             JMUS     I*4      N.R.
       KSBS     I*4     N.R.            KNBS     I*4      N.R.              LAT     R*4      N.R.              DXU     R*4      N.R.
        DXP     R*4     N.R.             DYU     R*4      N.R.              DYP     R*4      N.R.             DXYP     R*4      N.R.
          F     R*4     N.R.            SINL     R*4      N.R.             COSL     R*4      N.R.            DUMMY     R*4      N.R.
       PHIS     R*4   000D50          ALBEDO     I*2      N.R.

EQUIVALENCED VARIABLES WITHIN THIS COMMON GROUP
  VARIABLE OFFSETE                VARIABLE OFFSETE                VARIABLE OFFSETE                VARIABLE OFFSETE
         U   000E70                     TS   001890                      V   001980                    SMS   002300
         T   0024F0                      P   002F1C                     SH   003030                      C   000009
    MACHIN   00018C

  NAME OF COMMON BLOCK *  =0#S#E OF BLOCKCOMMON     081600 HEXADECIMAL BYTES

VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE
     PU    R*4   000000

EQUIVALENCED VARIABLES WITHIN THIS COMMON GROUP
  VARIABLE OFFSETE                VARIABLE OFFSETE                VARIABLE OFFSETE                VARIABLE OFFSETE
        GT   000840                     GW   00168C

  NAME OF COMMON BLOCK * S#OT'9E OF BLOCKCOMMON     0385AE HEXADECIMAL BYTES

VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE
     SDOT    R*4   000300          OMEGA    I*2   019E09          MNMXTS    I*4     N.R.             RADT    I*2   0286E4
     COMG    L*4   0389A4

EQUIVALENCED VARIABLES WITHIN THIS COMMON GROUP
  VARIABLE OFFSETE                VARIABLE OFFSETE                VARIABLE OFFSETE                VARIABLE OFFSETE
     ISDOT   00CF00

  NAME OF COMMON BLOCK *  *S6-"E OF BLOCKCOMMON     000008 HEXADECIMAL BYTES

VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE
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    LABEL    ADDR                    LABEL    ADDR                    LABEL    ADDR                    LABEL    ADDR
       70   002680                      73   002856                      76   00293A                      77   002A22
       75   0028A0                      80   0028EC                      90   002C88

*OPTIONS IN EFFECT*        NAME=  MAIN.OPT=02.LINECNT=55.SIZE=1000K.

*OPTIONS IN EFFECT*        SOURCE.EBCDIC.NOLIST.NODECK.LOAD.MAP.NOEDIT.ID.NOXREF

*STATISTICS*      SOURCE STATEMENTS =       61   PROGRAM SIZE =      11480

*STATISTICS*   NO  DIAGNOSTICS GENERATED

****** END OF COMPILATION ******                                              864K BYTES OF CORE NOT USED

 LEVEL 19.6-APR 71                               OS/360 FORTRAN H AT GISS                                   DATE 12/12/79-0763.23

        COMPILER OPTIONS -    NAME=  MAIN.OPT=02.LINECNT=55.SIZE=1000K.
                              SOURCE.EBCDIC.NOLIST.NODECK.LOAD.MAP.NOEDIT.ID.NOXREF
   ISN 0002                SUBROUTINE COMPO(J.V.T.SH.P.Q.UPOL.VPOL.TPOL.SHPOL.PPOL.QPOL.         84M09340
                          $   UT.VT.TT.SHT.PT.QT.UTPOL.VTPOL.TTPOL.SHTPOL.PTPOL.QTPOL)           84M09350
   ISN 0003                COMMON/FOURTH/CON1.CON2.CON3.CON4.CONS.TPBAR.ALPHA.BETA.IMD2P1.       84M09360
                          $   ADLOP.JMS2.JMS1.CPTH.PSKAPA.R.RAD.CP. INC.NSTART.CPD2.             84M09370
                          $   IMD2.RADIM.JEND(2).JP1.JP2.MAISUN.JNEXT(2).MODPK(2.2).             84M09380
                          $   JPOL(2.2).JPMOD(2.2).SINLON(72).COSLON(72). INDEX(72).             84M09390
                          $   PSIGN(4).POLES(148).W(72.9.5).PK(72.9.3).DIFF(9).                  84M09400
                          $   CONVPL(9).SDPOL(9.2).PHISPL(2).SUM(2.5)                            84M09410
   ISN 0004                DIMENSION PPOL(2).PITPOL(2).UPOL(36.1).VPOL(36.1).TPOL(36.1).         84M09420
                          $   SHPOL(36.1).QPOL(9.4.2).Q(72.10.4.1)                               84M09430
   ISN 0005                DIMENSION PTPOL(2).UTPOL(36.1).VTPOL(36.1).TTPOL(36.1).               84M09440
                          $   SHTPOL(36.1).QTPOL(9.4.2).QT(72.10.4.1)                            84M09450
   ISN 0006                COMMON/SMITH/QSM(72.9.4.5).PSM(72.5).QSMPOL(9.4.2).PSMPOL(2)          84M09460
   ISN 0007                INTEGER*2 ALBEDO                                                      84M09470
   ISN 0008                REAL*4 KAPA.LAT                                                       84M09480
                  C        REAL*8 SINLON.COSLON.SUM                                              84M09490
   ISN 0009                COMMON /CNTRL/                                                        84M09500
                          *  JSP.JNP.IM.NLAY.PTOP.ISTART.JSPP1.JNPM1.FIM.NLAYM1.NLAYP1.          84M09510
                          *  J1.JM.KM.TAUT.IROT.MROT.JTEST.ITEST.                                84M09520
                          *  NR.JAYS(12).INCS(11).JSB.JNB.DLAT.DLON.                             84M09530
                          *  DT.TAU.ITAU.XINT.IDAY.JDAY.TOFDAY.JDATE.JMONTH(2).JYEAR.NSTEP.      84M09540
                          *  NCYCLE.NCOMP3.NHOGAN.TAUP.TAUI.TAUE.TALO.DTMULT.                    84M09550
                          *  PI.GRAV.RGAS.KAPA.PSL.ED.FMU.NFLW.PSF.PRCH.RSDIST.SIND.COSD.        84M09560
                          *  RHMAX.COX.DUMMYC(18).IALTER.DUMMYA(99).                             84M09570
                          *  XLABEL(20).SIG(20).DSIG(20).SIGE(21).DSIGO(19).                     84M09580
                          *  J1PS(11).JMPS(11).J1US(11).JMUS(11).KSES(11).KNBS(11).              84M09590
                          *LAT(46).DXU(46).DXP(46).DYU(46).DYP(46).DXYP(46).F(46).SINL(46).      84M09600
                          *COSL(46).DUMMY(2).PHIS(2880.46).ALBEDO(72.46)                         84M09610
   ISN 0010                DIMENSION U(72.40.1).V(72.40.1).T(72.40.1).SH(72.40.1).               84M09620
                          *P(2880.1).    TS(2880.1).SHS(2880.1).GT(2880.1).GW(2880.1).C(300)     84M09630
   ISN 0011                EQUIVALENCE (TS(1.1).PHIS(721.1)).(SHS(1.1).PHIS(1441.1)).            84M09640
                          $    (GT(1.1).PU(721.1)).(GW(1.1).PU(1441.1)).(C(1).JSP)               84M09650
   ISN 0012                COMMON /DBUG/ISWTCH                                                   84M09660
                  C                                                                              84M09670
   ISN 0013                COMMON/SDOT48/SDOT(72.46.8).OMEGA(72.46.5).MNMXTS.RADT(72.46.10)      84M09680
                          + .COMG                                                                84M09690
   ISN 0014                LOGICAL COMG                                                          84M09700
                  C                                                                              84M09710
   ISN 0015                INTEGER*2 RADT.OMEGA                                                  84M09720
   ISN 0016                INTEGER*2 ISDOT(72.46.8)                                              84M09730
                  C                                                                              84M09740
   ISN 0017                EQUIVALENCE (SDOT(1.1.5).ISDOT(1.1.1))                                84M09750
                  C                                                                              84M09760
   ISN 0018                COMMON/SMOO/ISMTH.NPC                                                 84M09770
   ISN 0019                COMMON/MLFS/NSEG.MLF(10).MATSNX.NSM1.NCM1                             84M09780
   ISN 0020                COMMON/TPG/TOPOG(72.46)                                               84M09790
   ISN 0021                COMMON/WORK/ FD(648.46)                                               84M09800
   ISN 0022                COMMON/WORK2/PU(2880.46)                                              84M09810
   ISN 0023                DIMENSION UT(72.40.1).VT(72.40.1).TT(72.40.1).SHT(72.40.1).           84M09820
                          *PT(2880.1)                                                            84M09830
                  C                                                                              84M09840
                  C                                                                            * 84M09850
                  C * * *              M A I N   L O O P                                       * 84M09860
                  C                                                                            * 84M09870
   ISN 0024                CON3 = 4. * DT / (RADIM * SIN(.5 * DLAT))                             84M09880
   ISN 0025                CON4 = DT / (RADIM * SIN(DLAT))                                       84M09890
   ISN 0026                JS2 = 1                                                               84M09900
   ISN 0027                JS1 = 1                                                               84M09910
   ISN 0028                K=2                                                                   84M09920
   ISN 0029                DO 10 JJ = 1.JM                                                       84M09930
   ISN 0030                J = JJ                                                                84M09940
   ISN 0031                JP1 = J + 1                                                           84M09950
   ISN 0032                JP2 = J + 2                                                           84M09960
   ISN 0033                JP2MOD = MOD(JP2 - 1.5) + 1                                           84M09970
   ISN 0034                JP1MOD = MOD(JP1 - 1.5) + 1                                           84M09980
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ISN 0035            JMOD = MOD(J - 1,5) + 1                                                      B4M09990
ISN 0036            JS1MOD = MOD(JS1 - 1,5) + 1                                                  B4M10000
ISN 0037            JS2MOD = MOD(JS2 - 1,5) + 1                                                  B4M10010
ISN 0038            IF (JP2 .GT. JM)                 GO TO 25                                    B4M10020
ISN 0040            IF (J .GT. 1)                    GO TC 18                                    B4M10030
ISN 0042            JP2 = 2                                                                      B4M10040
ISN 0043            JP2MOD = 2                                                                   B4M10050
              C                                                                                * B4M10060
              C * * * SAVE QTPOL IN QSMPOL                                                     * B4M10070
              C                                                                                * B4M10080
ISN 0044            DO 15 M = 1,2                                                                B4M10090
ISN 0045            PSMPOL(M) = PTPOL(M)                                                         B4M10100
ISN 0046            DO 15 N = 1,4                                                                B4M10110
ISN 0047            DO 15 L = 1,NLAY                                                             B4M10120
ISN 0048            QSMPOL(L,N,M) = QTPOL(L,N,M)                                                 B4M10130
ISN 0049        15                                   CONTINUE                                    B4M10140
              C                                                                                  B4M10150
              C                                                                                * B4M10160
              C * * * SAVE QT(JP2) IN QSM(JP2MOD)                                                B4M10170
              C                                                                                * B4M10180
ISN 0050        18 DO 22 I = INC,IM,INC                                                          B4M10190
ISN 0051            PSM(I,JP2MOD) = PT(I,JP2)                                                    B4M10200
ISN 0052        22                                   CONTINUE                                    B4M10210
ISN 0053            DO 20 N = 1,4                                                                B4M10220
ISN 0054            DO 20 L = 1,NLAY                                                             B4M10230
ISN 0055            DO 20 I = INC,IM,INC                                                         B4M10240
ISN 0056            QSM(I,L,N,JP2MOD) = QT(I,L,N,JP2)                                            B4M10250
ISN 0057        20                                   CONTINUE                                    B4M10260
ISN 0058            IF (JP2 .GT. 2)                  GO TC 25                                    B4M10270
ISN 0060            JP2 = JP2 + 1                                                                B4M10280
ISN 0061            JP2MOD = JP2MOD + 1                                                          B4M10290
ISN 0062                                             GO TC 18                                    B4M10300
ISN 0063        25 CALL COMP1(U,V,T,SH,P,Q,UPOL,VPOL,TPOL,SHPOL,PPOL,QPOL,UT,VT,TT,             B4M10310
                  $    SHT,PT,QT,UTPOL,VTPOL,TTPOL,SHTPOL,PTPOL,QTPOL,J)                         B4M10320
ISN 0064            CALL COMP2(U,V,T,SH,P,Q,UPOL,VPOL,TPOL,SHPOL,PPOL,QPOL,UT,VT,TT,             B4M10330
                  $    SHT,PT,QT,UTPOL,VTPOL,TTPOL,SHTPOL,PTPOL,QTPOL,J)                         B4M10340
ISN 0065            IF(J.NE.1.AND.J.NE.JNP)GO TO 210                                             B4M10350
ISN 0067            M=1                                                                          B4M10360
ISN 0068            IF(J.EQ.JNP)M=2                                                              B4M10370
ISN 0070            DO 204 L=2,NLAY                                                              B4M10380
ISN 0071            LM1=L-1                                                                      B4M10390
ISN 0072            IF(SHTPOL(LM1,M).GE.0.)GO TO 204                                             B4M10400
ISN 0074            SHTPOL(L,M)=SHTPOL(L,M)+SHTPOL(LM1,M)*DSIG(LM1)/DSIG(L)                      B4M10410
ISN 0075            SHTPOL(LM1,M)=0.                                                             B4M10420
ISN 0076       204 CONTINUE                                                                      B4M10430
ISN 0077            IF(SHTPOL(NLAY,M).LT.0.)SHTPOL(NLAY,M)=0.                                    B4M10440
ISN 0079            GO TO 212                                                                    B4M10450
ISN 0080       210 DO 202 L=2,NLAY                                                               B4M10460
ISN 0081            DO 202 I=1,IM                                                                B4M10470
ISN 0082            LM1=L-1                                                                      B4M10480
ISN 0083            IF(SHT(I,LM1,J).GE.0.)GO TO 202                                              B4M10490
ISN 0085            SHT(I,L,J)=SHT(I,L,J)+SHT(I,LM1,J)*DSIG(LM1)/DSIG(L)                         B4M10500
ISN 0086            SHT(I,LM1,J)=0.                                                              B4M10510
ISN 0087       202 CONTINUE                                                                      B4M10520
ISN 0088            DO 203 I=1,IM                                                                B4M10530
ISN 0089            IF(SHT(I,NLAY,J).LT.0.)SHT(I,NLAY,J)=0.                                      B4M10540
ISN 0091       203 CONTINUE                                                                      B4M10550
ISN 0092       212 CONTINUE                                                                      B4M10560
ISN 0093            DO 27 I = INC,IM,INC                                                         B4M10570
ISN 0094            PST = PT(I,J) + PTOP                                                         B4M10580
ISN 0095            IF((PST.GE.400.).AND.(PST.LE.1100.)) GO TO 27                                B4M10590
ISN 0097            WRITE(3,301)I,J,PT(I,J),P(I,J)                                               B4M10600
ISN 0098            WRITE(3,302)(U(I-INC,L,JP1),L=1,NLAY)                                        B4M10610
ISN 0099            WRITE(3,302)(U(I,L,JP1),L=1,NLAY)                                            B4M10620
ISN 0100            WRITE(3,302)(U(I-INC,L,J),L=1,NLAY)                                          B4M10630
ISN 0101            WRITE(3,302)(U(I,L,J),L=1,NLAY)                                              B4M10640
ISN 0102            WRITE(3,302)(V(I-INC,L,JP1),L=1,NLAY)                                        B4M10650
ISN 0103            WRITE(3,302)(V(I,L,JP1),L=1,NLAY)                                            B4M10660
ISN 0104            WRITE(3,302)(V(I-INC,L,J),L=1,NLAY)                                          B4M10670
ISN 0105            WRITE(3,302)(V(I,L,J),L=1,NLAY)                                              B4M10680
ISN 0106            WRITE(3,302)(T(I,L,J),L=1,NLAY)                                              B4M10690
ISN 0107            WRITE(3,302)(SH(I,L,J),L=1,NLAY)                                             B4M10700
ISN 0108            STOP                                                                         B4M10710
ISN 0109        27                                   CONTINUE                                    B4M10720
ISN 0110            IF (J .LT. 3)                    GO TC 200                                   B4M10730
ISN 0112            IF (J .EQ. 3)                    GO TC 70                                    B4M10740
              C                                                                                * B4M10750
              C * * * UNSCALE                                                                  * B4M10760
              C                                                                                * B4M10770
ISN 0114        29  DO 60 N = 1,4                                                                B4M10780
ISN 0115            DO 60 L = 1,NLAY                                                             B4M10790
ISN 0116            DO 60 I = INC,IM,INC                                                         B4M10800
ISN 0117            QT(I,L,N,JS2) = QT(I,L,N,JS2) / (DXYP(JS2) * PT(I,JS2))                      B4M10810
ISN 0118        60                                   CONTINUE                                    B4M10820
ISN 0119               CALL AVRX(UT,VT,TT,SHT,PT,QT,JS2)                                         B4M10830
              C                                                                                * B4M10840
              C * * * NO TIME SMOOTHING FOR MATSUNO STEP                                        * B4M10850
              C                                                                                * B4M10860
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                C *** IF(LEAP.AND.NEXT STEP IS LEAP)                                            B4M10870
ISN 0120              IF(MATSUN+MATSNX.EQ.0)GO TO 45                                            B4M10880
                C *** IF(NEXT CALL IS TO MATS PRED.)                                            B4M10890
ISN 0122              IF((NPC.EQ.1).AND.(MATSNX.EQ.1))GO TO 58                                  B4M10900
ISN 0124              DO 28 I = INC.IM.INC                                                      B4M10910
ISN 0125              P(I.JS2) = PSM(I.JS2MOD)                                                  B4M10920
ISN 0126           28                                 CONTINUE                                  B4M10930
ISN 0127              DO 30 N = 1.4                                                             B4M10940
ISN 0128              DO 30 L = 1.NLAY                                                          B4M10950
ISN 0129              DO 30 I = INC.IM.INC                                                      B4M10960
ISN 0130              Q(I.L.N.JS2) = QSM(I.L.N.JS2MOD)                                          B4M10970
ISN 0131           30                                 CONTINUE                                  B4M10980
ISN 0132              IF(NPC.EQ.1)GO TO 63                                                      B4M10990
ISN 0134                                              GO TO 67                                  B4M11000
ISN 0135           58 DO 61 I=INC.IM.INC                                                        B4M11010
ISN 0136              P(I.JS2) = PT(I.JS2)                                                      B4M11020
ISN 0137         61                                   CONTINUE                                  B4M11030
ISN 0138              DO 62 N=1.4                                                               B4M11040
ISN 0139              DO 62 L=1.NLAY                                                            B4M11050
ISN 0140              DO 62 I=INC.IM.INC                                                        B4M11060
ISN 0141              Q(I.L.N.JS2) = QT(I.L.N.JS2) * (DXYP(JS2) * PT(I.JS2))                    B4M11070
ISN 0142         62                                   CONTINUE                                  B4M11080
ISN 0143                                              GO TO 64                                  B4M11090
                C                                                                             * B4M11100
                C * * * SMOOTH Q(JS2) FOR SMOOTH LEAPFROG TIME SCHEME                         * B4M11110
                C * * * ALPHA = .5 * NU     BETA = 1 - 2. * ALPHA                             * B4M11120
                C                                                                             * B4M11130
ISN 0144           45 DO 48 I = INC.IM.INC                                                      B4M11140
ISN 0145              P(I.JS2) = BETA * P(I.JS2) + ALPHA * (PSM(I.JS2MOD) + PT(I.JS2))          B4M11150
ISN 0146           48                                 CONTINUE                                  B4M11160
ISN 0147              DO 50 N = 1.4                                                             B4M11170
ISN 0148              DO 50 L = 1.NLAY                                                          B4M11180
ISN 0149              DO 50 I = INC.IM.INC                                                      B4M11190
ISN 0150              Q(I.L.N.JS2) = BETA * DXYP(JS2) * P(I.JS2) * Q(I.L.N.JS2)                 B4M11200
                     $ +ALPHA*(QSM(I.L.N.JS2MOD)+QT(I.L.N.JS2)*DXYP(JS2)*PT(I.JS2))             B4M11210
ISN 0151           50                                 CONTINUE                                  B4M11220
                C                                                                             * B4M11230
ISN 0152           63 CONTINUE                                                                  B4M11240
                C * * * SOURCE TERM CORRECTION DUE TO LEAPFROG TIME SCHEME                     * B4M11250
                C                                                                             * B4M11260
                C *** 12/12/77                                                                  B4M11270
ISN 0153              IF(MOD(NSTEP-NCM1.NCOMP3).NE.0)GO TO 67                                   B4M11280
ISN 0155              DO 57 N = 1.4                                                             B4M11290
ISN 0156              DO 57 L = 1.NLAY                                                          B4M11300
ISN 0157              DO 57 I = INC.IM.INC                                                      B4M11310
ISN 0158              Q(I.L.N.JS2) = Q(I.L.N.JS2) - QT(I.L.N.JS2) *                             B4M11320
                     1DXYP(JS2)*PT(I.JS2)                                                       B4M11330
ISN 0159           57                                 CONTINUE                                  B4M11340
ISN 0160           64 IF(MOD(NSTEP-NCM1.NCOMP3).NE.0)GO TO 67                                   B4M11350
                C     IF(MATSUNO PRED. STEP)                                                    B4M11360
ISN 0162              IF((MATSUN.EQ.1).AND.(NPC.EQ.0))GO TO 67                                  B4M11370
ISN 0164              CALL COMP3(UT.VT.TT.SHT.PT.QT.UTPOL.VTPOL.TTPOL.SHTPOL.PTPOL.             B4M11380
                     $     QTPOL.JS2)                                                           B4M11390
                C *** IF(MATSUNO.OR NOT COMP3 STEP)                                             B4M11400
ISN 0165              IF((MATSNX.NE.0).OR.(MOD(NSTEP-NCM1.NCOMP3).NE.0))GO TO 67                B4M11410
ISN 0167              DO 65 N=1.4                                                               B4M11420
ISN 0168              DO 65 L=1.NLAY                                                            B4M11430
ISN 0169              DO 65 I=INC.IM.INC                                                        B4M11440
ISN 0170              Q(I.L.N.JS2) = Q(I.L.N.JS2) + DXYP(JS2) * PT(I.JS2) *                     B4M11450
                     $    QT(I.L.N.JS2)                                                         B4M11460
ISN 0171        65    CONTINUE                                                                  B4M11470
ISN 0172        67    IF (J .LT. JM)                  GO TO 200                                 B4M11480
ISN 0174              JS2 = JS2 + 1                                                             B4M11490
ISN 0175              JS2MOD = MOD(JS2-1.5) + 1                                                 B4M11500
ISN 0176              IF (JS2 .LE. JM)                GO TO 29                                  B4M11510
                C                                                                             * B4M11520
                C * * * POLES                                                                 * B4M11530
                C                                                                             * B4M11540
ISN 0178           70 M = 1                                                                     B4M11550
ISN 0179              IF (J .EQ. JM)                  M = 2                                     B4M11560
ISN 0181              COEF1 = (-1.) ** M                                                        B4M11570
                C *** IF(LEAP.AND.NEXT STEP IS LEAP)                                            B4M11580
ISN 0182              IF(MATSUN+MATSNX.EQ.0)GO TO 85                                            B4M11590
                C *** IF((MATS PRED.OR.(MATS CORR. AND NEXT STEP IS LEAP))                      B4M11600
ISN 0184              IF((MATSUN.EQ.1).AND.(NPC*MATSNX.EQ.0))GO TO 78                           B4M11610
ISN 0186              PPOL(M) = PTPOL(M)                                                        B4M11620
ISN 0187                  DO 75 N = 1.4                                                         B4M11630
ISN 0188                  DO 75 L = 1.NLAY                                                      B4M11640
ISN 0189              QPOL(L.N.M) = QTPOL(L.N.M)                                                B4M11650
ISN 0190           75                                 CONTINUE                                  B4M11660
ISN 0191                                              GO TO 94                                  B4M11670
ISN 0192           78 PPOL(M) = PSMPOL(M)                                                       B4M11680
ISN 0193              DO 80 N = 1.4                                                             B4M11690
ISN 0194              DO 80 L = 1.NLAY                                                          B4M11700
ISN 0195              QPOL(L.N.M) = QSMPOL(L.N.M)                                               B4M11710
ISN 0196           80                                 CONTINUE                                  B4M11720
ISN 0197              IF(NPC.EQ.1)GO TO 93                                                      B4M11730
ISN 0199                                              GO TO 94                                  B4M11740
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ISN 0200          85 PPOL(M) = BETA * PPOL(M) + ALPHA * (PSMPOL(M) + PTPOL(M))                  B4M11750
ISN 0201             DO 87 N = 1.4                                                              B4M11760
ISN 0202             DO 87 L = 1.NLAY                                                           B4M11770
ISN 0203             QPOL(L.N.M)=BETA*PPOL(M)*QPOL(L.N.M)+ALPHA                                 B4M11780
                    $    * (QSMPOL(L.N.M) + QTPOL(L.N.M))                                       B4M11790
ISN 0204          87                                  CONTINUE                                  B4M11800
               C                                                                              * B4M11810
               C * * * SOURCE TERM CORRECTION DUE TO LEAPFROG TIME SCHEME                     * B4M11820
               C                                                                              * B4M11830
               C *** 12/12/77                                                                   B4M11840
ISN 0205          93 CONTINUE                                                                   B4M11850
ISN 0206             IF(MOD(NSTEP-NCM1.NCOMP3).NE.0)GO TO 94                                    B4M11860
ISN 0208             DO 92 N = 1.4                                                              B4M11870
ISN 0209             DO 92 L = 1.NLAY                                                           B4M11880
ISN 0210             QPOL(L.N.M) = QPOL(L.N.M) - QTPOL(L.N.M)                                   B4M11890
ISN 0211          92                                  CONTINUE                                  B4M11900
               C                                                                              * B4M11910
               C * * * UNSCALE                                                                * B4M11920
               C                                                                              * B4M11930
ISN 0212          94                                  CONTINUE                                  B4M11940
ISN 0213             DO 96 N = 1.4                                                              B4M11950
ISN 0214             DO 96 L = 1.NLAY                                                           B4M11960
ISN 0215             QTPOL(L.N.M) = QTPOL(L.N.M) / PTPOL(M)                                     B4M11970
ISN 0216          96                                  CONTINUE                                  B4M11980
ISN 0217             IF(MOD(NSTEP-NCM1.NCOMP3).NE.0)GO TO 98                                    B4M11990
               C     IF(MATSUNO PRED. STEP)                                                     B4M12000
ISN 0219             IF((MATSUN.EQ.1).AND.(NPC.EQ.0))GO TO 98                                   B4M12010
ISN 0221             CALL COMP3(UT.VT.TT.SHT.PT.QT.UTPOL.VTPOL.TTPOL.SHTPOL.PTPOL.              B4M12020
                    $    QTPOL.JS2)                                                             B4M12030
ISN 0222             IF(MATSNX.NE.0)GO TO 98                                                    B4M12040
ISN 0224             DO 105 N = 1.4                                                             B4M12050
ISN 0225             DO 105 L = 1.NLAY                                                          B4M12060
ISN 0226             QPOL(L.N.M) = QPOL(L.N.M) + PTPOL(M) * QTPOL(L.N.M)                        B4M12070
ISN 0227         105                                  CONTINUE                                  B4M12080
               C                                                                              * B4M12090
               C * * * COPY QTPOL INTO  QT                                                    * B4M12100
               C                                                                              * B4M12110
ISN 0228          98 DO 100 I = INC.IM.INC                                                      B4M12120
ISN 0229             PT(I.JEND(M)) = PTPOL(M)                                                   B4M12130
ISN 0230         100                                  CONTINUE                                  B4M12140
ISN 0231             DO 110 N = 3.4                                                             B4M12150
ISN 0232             DO 110 L = 1.NLAY                                                          B4M12160
ISN 0233             DO 110 I = INC.IM.INC                                                      B4M12170
ISN 0234             QT(I.L.N.JEND(M)) = QTPOL(L.N.M)                                           B4M12180
ISN 0235         110                                  CONTINUE                                  B4M12190
ISN 0236             DO 120 L = 1.NLAY                                                          B4M12200
ISN 0237             DO 120 I = INC.IM.INC                                                      B4M12210
ISN 0238             UT(I.L.JEND(M))=-UTPOL(L.M)*SINLON(I)+COEF1*VTPOL(L.M)*COSLON(I)           B4M12220
ISN 0239             VT(I.L.JEND(M))=-COEF1*UTPOL(L.M)*COSLON(I)-VTPOL(L.M)*SINLON(I)           B4M12230
ISN 0240         120                                  CONTINUE                                  B4M12240
ISN 0241         200 JS2 = JS1                                                                  B4M12250
ISN 0242             JS1 = J                                                                    B4M12260
ISN 0243          10                                  CONTINUE                                  B4M12270
ISN 0244         301 FORMAT(  '0    PRESSURE DIAGNOSTIC.  (.J.PT.P='.2I4.2E15.5)                B4M12280
ISN 0245         302 FORMAT(5X.9E14.4)                                                          B4M12290
ISN 0246                                              RETURN                                    B4M12300
ISN 0247                                              END                                       B4M12310

                                                     /   COMPC /     SIZE OF PROGRAM 002870 HEXADECIMAL BYTES

NAME TAG TYPE ADD.  |= ***    % NAME TAG TYPE ADD.  |= ***    % NAME TAG TYPE ADD.  |= ***    % NAME TAG TYPE ADD.  |= ***    %
    C     CE  R*4  000000            F      C  R*4    N.R.            I SF        I*4  0001CC            J SFA       I*4  000100
    K S       I*4  0001D4            L SF      I*4  0001DE            M SF        I*4  0001DC            N SF        I*4  0001ED
    P SFA XR  R*4  000000            Q SFA XR  R*4  00000C            R       C   R*4    N.R.            T SFA XR    R*4  000000
    U SFA XR  R*4  000000            V SFA XR  R*4  00000C            W       C   R*4    N.R.           CP       C   R*4    N.R.
   DT F    C  R*4  00008C           ED      C  R*4    N.R.           FD       C   R*4    N.R.           GT       CE  R*4  000840
   GM     CE  R*4  001680           IM F    C  I*4  00000E           JJ SF        I*4  0001E4           JM F     C   I*4  000030
   J1      C  I*4    N.R.           KN      C  I*4    N.R.           NR       C   I*4    N.R.           PI       C   R*4    N.R.
   PK      C  R*4    N.R.           PT SFA XR  R*4  00060C           PU       CE  R*4  000000           QT SFA XR    R*4  000000
   SH SFA XR  R*4  000000           TS     CE  R*4  00189C           TT SFA XR    R*4  000000           UT SFA XR    R*4  000000
   VT SFA XR  R*4  000000          CDX      C  R*4    N.R.          DXP       C   R*4    N.R.          DXU       C   R*4    N.R.
  DYP      C  R*4    N.R.          DYU      C  R*4    N.R.          FIM       C   R*4    N.R.          FMU       C   R*4    N.R.
  INC F    C  I*4  000044          JNB      C  I*4    N.R.          JNP       C   I*4  000004          JP1 SFA   C   I*4  000060
  JP2 SFA  C  I*4  000064          JSB      C  I*4    N.R.          JSP       CE  I*4  000000          JS1 SFA       I*4  0001E8
  JS2 SFA     I*4  0001EC          LAT      C  R*4    N.R.          LM1 SF        I*4  0001F0          MLF       C   I*4    N.R.
  NPC      C  I*4  000004          PSF      C  R*4    N.R.          PSL       C   R*4    N.R.          PSM SF    C   R*4  00CA80
  PST S       R*4  0001F4          QSM SF   C  R*4  00000C          RAD       C   R*4    N.R.          SMS       CE  R*4  002300
  SHT SFA XR  R*4  000000          SIG      C  R*4    N.R.          SUM       C   R*4    N.R.          TAU       C   R*4    N.R.
 AVRX SF  XF  R*4  000000         BETA F    C  R*4  00001C         COMG       C   L*4  038[illegible]A4         CON1       C   R*4    N.R.
 CON2      C  R*4    N.R.         CON3 S    C  R*4  00000E         CON4 S     C   R*4  000[illegible]C         CONS       C   R*4    N.R.
 COSD      C  R*4    N.R.         COSL      C  R*4    N.R.         CPD2       C   R*4    N.R.         CPTH       C   R*4    N.R.
 DIFF      C  R*4    N.R.         DLAT FA   C  R*4  0000B4         DLON       C   R*4    N.R.         DSIG F     C   R*4  0003C0
 DXVP F    C  R*4  000950         GRAV      C  R*4    N.R.         IDAY       C   I*4    N.R.         IMD2       C   I*4    N.R.
 INCS      C  I*4    N.R.         IROT      C  I*4    N.R.         ITAU       C   I*4    N.R.         JAYS       C   I*4    N.R.
 JDAY      C  I*4    N.R.         JEND F    C  I*4  00005E         JMOD S         I*4  0001F8         JMPS       C   I*4    N.R.
 JMS1      C  I*4    N.R.         JMS2      C  I*4    N.R.         JMUS       C   I*4    N.R.         JPOL       C   I*4    N.R.
 JIPS      C  I*4    N.R.         JIUS      C  I*4    N.R.         KAPA       C   R*4    N.R.         KNBS       C   I*4    N.R.
 KSBS      C  I*4    N.R.         MRCH      C  I*4    N.R.         MROT       C   I*4    N.R.         NCM1 A     C   I*4  000034
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   NFLW        C  I*4    N.R.       NLAY   F    C  I*4  00000C       NSEQ         C  I*4    N.R.       NSM1         C  I*4    N.R.
   PHIS       CE  R*4  000D50       PPOL   SFA XR  R*4  00000C       PTOP   F     C  R*4  000010       QPOL   SFA XR  R*4  000000
   RADT        C  I*2    N.R.       RGAS        C  R*4    N.R.       SDOT        CE  R*4  000030       SIGE         C  R*4    N.R.
   SIND        C  R*4    N.R.       SINL        C  R*4    N.R.       TAUE         C  R*4    N.R.       TAUI         C  R*4    N.R.
   TAUD        C  R*4    N.R.       TAUP        C  R*4    N.R.       TAUT         C  R*4    N.R.       TPOL   SFA XR  R*4  000000
   UPOL SFA XR    R*4  000000       VPOL   SFA XR  R*4  00000C       XINT         C  R*4    N.R.       ADLDP        C  R*4    N.R.
  ALPHA  F     C  R*4  000018      COEF1   SF      R*4  0001FC      COMP0            R*4  000230       COMP1  SF  XF  R*4  000000
  COMP2 SF    XF  R*4  000000      COMP3   SF  XF  R*4  00000C      DSIGO         C  R*4    N.R.       DUMMY        C  R*4    N.R.
  INDEX        C  I*4    N.R.      ISDOT       CE  I*2  00CF0C      ISMTH         C  I*4    N.R.       ITEST        C  I*4    N.R.
  JDATE        C  I*4    N.R.      JNEXT        C  I*4    N.R.      JNPM1         C  I*4    N.R.       JPMOD        C  I*4    N.R.
  JSPP1        C  I*4    N.R.      JTEST        C  I*4    N.R.      JYEAR         C  I*4    N.R.       MODPK        C  I*4    N.R.
  NSTEP   A    C  I*4  0000E8      OMEGA        C  I*2    N.R.      POLES         C  R*4    N.R.       PSIGN        C  R*4    N.R.
  PTPOL SFA   XR  R*4  000000      QTPOL   SFA XR  R*4  00000C      RADIM  F      C  R*4  000054       RHMAX        C  R*4    N.R.
  SDPOL        C  R*4    N.R.      SHPOL   SFA XR  R*4  00000C      THBAR         C  R*4    N.R.       TOPOG        C  R*4    N.R.
  TTPOL SFA   XR  R*4  000000      UTPOL   SFA XR  R*4  00000C      VTPOL  SFA   XR  R*4  000000      FRXPI#       XF  R*4  000000
    SIN       XF  R*4  000000     ALBEDO        C  I*2    N.R.     CONVPL         C  R*4    N.R.      COSLON  F     C  R*4  0001C4
 DTMULT        C  R*4    N.R.     DUMMYA        C  R*4    N.R.     DUMMYC         C  R*4    N.R.      IALTER        C  I*4    N.R.
 IBCOM#  F    XF  I*4  000000     IMD2P1        C  I*4    N.R.     ISTART         C  I*4    N.R.      ISWTCH        C  I*4    N.R.
 JMONTH        C  I*4    N.R.     JP1MOD   S       I*4  000204     JP2MOD  SF        I*4  000208      JS1MOD  S        I*4  00020C
 JS2MOD SF        I*4  000210     MATSNX        C  I*4  00002C     MATSUN         C  I*4  000068      MNMXTS        C  I*4    N.R.
 NCOMP3   A    C  I*4  0000F0     NCYCLE        C  I*4    N.R.     NHOGAN         C  I*4    N.R.      NLAYM1        C  I*4    N.R.
 NLAYP1        C  I*4    N.R.     NSTART        C  I*4    N.R.     PHISPL         C  R*4    N.R.      PITPOL           R*4    N.R.
 PSKAPA        C  R*4    N.R.     PSMPOL   SF   C  R*4  00D14C     QSMPOL  SF    C  R*4  000020      RSDIST        C  R*4    N.R.
 SHTPOL SFA   XR  R*4  000000     SINLON   F    C  R*4  0000A4     TOFDAY         C  R*4    N.R.      XLABEL        C  R*4    N.R.

                                         *****   COMMON INFORMATION   *****

   NAME OF CCMMON BLOCK * F;U#.ZE OF BLOCKCOMMON      005E24 HEXADECIMAL BYTES

 VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE
      CON1   R*4     N.R.            CON2   R*4     N.R.            CON3   R*4   000008            CON4   R*4   00000C
      CON5   R*4     N.R.           THBAR   R*4     N.R.           ALPHA   R*4   000018            BETA   R*4   00001C
    IMD2P1   I*4     N.R.           ADLDP   R*4     N.R.            JMS2   I*4     N.R.            JMS1   I*4     N.R.
      CPTH   R*4     N.R.          PSKAPA   R*4     N.R.               R   R*4     N.R.             RAD   R*4     N.R.
        CP   R*4     N.R.             INC   I*4   000044          NSTART   I*4     N.R.            CPD2   R*4     N.R.
      IMD2   I*4     N.R.           RADIM   R*4   000054            JEND   I*4   000058             JP1   I*4   000060
       JP2   I*4   000064          MATSUN   I*4   000068           JNEXT   I*4     N.R.           MODPK   I*4     N.R.
      JPOL   I*4     N.R.           JPMOD   I*4     N.R.          SINLON   R*4   0000A4          COSLON   R*4   0001C4
     INDEX   I*4     N.R.           PSIGN   R*4     N.R.           POLES   R*4     N.R.               W   R*4     N.R.
        PK   R*4     N.R.            DIFF   R*4     N.R.          CONVPL   R*4     N.R.           SDPOL   R*4     N.R.
    PHISPL   R*4     N.R.             SUM   R*4     N.R.

   NAME OF COMMON BLOCK *  =M..ZE OF BLOCKCOMMON      00D148 HEXADECIMAL BYTES

 VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE
       QSM   R*4   000000             PSM   R*4   00CA80          QSMPOL   R*4   000020          PSMPOL   R*4   00D140

   NAME OF CCMMON BLOCK *  ¬NTR#E OF BLOCKCOMMON      083C30 HEXADECIMAL BYTES

 VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE
       JSP   I*4   000000             JNP   I*4   000004              IM   I*4   000008            NLAY   I*4   00000C
      PTOP   R*4   000010          ISTART   I*4     N.R.           JSPP1   I*4     N.R.           JNPM1   I*4     N.R.
       FIM   R*4     N.R.          NLAYM1   I*4     N.R.          NLAYP1   I*4     N.R.              J1   I*4     N.R.
        JM   I*4   000030              KM   I*4     N.R.            TAUT   R*4     N.R.            IROT   I*4     N.R.
      MROT   I*4     N.R.           JTEST   I*4     N.R.           ITEST   I*4     N.R.              NR   I*4     N.R.
      JAYS   I*4     N.R.            INCS   I*4     N.R.             JSB   I*4     N.R.             JNB   I*4     N.R.
      DLAT   R*4   000084            DLON   R*4     N.R.              DT   R*4   0000BC             TAU   R*4     N.R.
      ITAU   I*4     N.R.            XINT   R*4     N.R.            IDAY   I*4     N.R.            JDAY   I*4     N.R.
    TOFDAY   R*4     N.R.           JDATE   I*4     N.R.          JMONTH   I*4     N.R.           JYEAR   I*4     N.R.
     NSTEP   I*4   0000E8          NCYCLE   I*4     N.R.          NCOMP3   I*4   0000F0          NHOGAN   I*4     N.R.
      TAUP   R*4     N.R.            TAUI   R*4     N.R.            TAUE   R*4     N.R.            TAUO   R*4     N.R.
    DTMULT   R*4     N.R.              PI   R*4     N.R.            GRAV   R*4     N.R.            RGAS   R*4     N.R.
      KAPA   R*4     N.R.             PSL   R*4     N.R.              ED   R*4     N.R.             FMU   R*4     N.R.
      NFLW   I*4     N.R.             PSF   R*4     N.R.            MRCH   I*4     N.R.          RSDIST   R*4     N.R.
      SIND   R*4     N.R.            COSD   R*4     N.R.           RHMAX   R*4     N.R.             CDX   R*4     N.R.
    DUMMYC   R*4     N.R.          IALTER   I*4     N.R.          DUMMYA   R*4     N.R.          XLABEL   R*4     N.R.
       SIG   R*4     N.R.            DSIG   R*4   0003C0            SIGE   R*4     N.R.           DSIGO   R*4     N.R.
      J1PS   I*4     N.R.            JMPS   I*4     N.R.            J1US   I*4     N.R.            JMUS   I*4     N.R.
      KSBS   I*4     N.R.            KNBS   I*4     N.R.             LAT   R*4     N.R.             DXU   R*4     N.R.
       DXP   R*4     N.R.             DYU   R*4     N.R.             DYP   R*4     N.R.            DXYP   R*4   000950
         F   R*4     N.R.            SINL   R*4     N.R.            COSL   R*4     N.R.           DUMMY   R*4     N.R.
      PHIS   R*4   000D50          ALBEDO   I*2     N.R.
 EQUIVALENCED VARIABLES WITHIN THIS COMMON GROUP
   VARIABLE CFFSETE                VARIABLE OFFSETE               VARIABLE OFFSETE               VARIABLE OFFSETE
       TS   001890                      SHS   0023DC                      C   000000

   NAME OF CCMMON BLOCK *  *DS_?E OF BLOCKCOMMON      000C04 HEXADECIMAL BYTES

 VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE
    ISWTCH   I*4     N.R.
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   NAME OF CCMMON BLOCK * S*OT*9E OF BLOCKCOMMON      038SA8 HEXADECIMAL BYTES

VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE
    SDOT     R*4    000003          OMEGA    I*2     N.R.          MNMXTS    I*4      N.R.           RADT     I*2      N.R.
    CONG     L*4    0389A4

EQUIVALENCED VARIABLES WITHIN THIS COMMON GROUP
  VARIABLE OFFSETE               VARIABLE OFFSETE               VARIABLE OFFSETE               VARIABLE OFFSETE
   ISDCT     00CF00

   NAME CF CCMMCN BLOCK *  *S6-"E OF BLOCKCOMMON      000C0E HEXADECIMAL BYTES

VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE
   ISMTH     I*4      N.R.            NPC     I*4   000004

   NAME OF CCMMON BLOCK *  *M3i.E OF BLOCKCOMMON      000C38 HEXADECIMAL BYTES

VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE
    NSEQ     I*4      N.R.            MLF     I*4     N.R.          MATSNX    I*4    00002C          NSM1     I*4      N.R.
    NCM1     I*4    000034

   NAME CF CCMMON BLOCK *  * T-7E OF BLOCKCOMMON      0033C0 HEXADECIMAL BYTES

VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE
   TOPOG     R*4      N.R.

   NAME CF CCMMON BLOCK *  *W6R*E OF BLOCKCOMMON      010IC0 HEXADECIMAL BYTES

VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE
      FD     R*4      N.R.

   NAME CF CCMMON BLOCK *  =O*S*E OF ELOCKCOMMON      081E00 HEXADECIMAL BYTES

VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE
      PU     R*4    000000

EQUIVALENCED VARIABLES WITHIN THIS COMMON GROUP
  VARIABLE OFFSETE               VARIABLE OFFSETE               VARIABLE OFFSETE               VARIABLE OFFSETE
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LABEL   ADDR              LABEL   ADDR              LAEEL   ADDR              LABEL   ADDR
   15  000B1E                18  000B66                22  000BDE                20  000CC6
   25  000D4A               204  000E2A               210  000E84               202  000F5C
  203  000FCA               212  000FD4                27  00152E                29  00156A
   60  001648                28  001750                30  001834                58  0018A4
   61  0018FA                62  0019EE                45  001A3E                48  001AC2
   50  001C12                63  001C6E                57  001D5E                64  001DB2
   65  001F2E                67  001F72                70  001FB4                75  002098
   78  002004                80  002142                85  00218E                87  002244
   93  002278                92  0022F0                94  002324                96  0023A2
  105  002482                98  0024E6               100  00254C               110  00263E
  120  00278C               200  0027CC                10  0027E4

*OPTIONS IN EFFECT*       NAME=  MAIN.OPT=02.LINECNT=55.SIZE=1000K.

*OPTIONS IN EFFECT*       SOURCE.EBCDIC.NOLIST.NODECK.LCAD.MAP.NCEDIT.ID.NOXREF

*STATISTICS*      SOURCE STATEMENTS =      246  PROGRAM SIZE=      11120

*STATISTICS*  NO  DIAGNOSTICS GENERATED

****** END OF COMPILATION ******                                              780K BYTES OF CORE NOT USED

 LEVEL 19.6-APR 71                                   OS/360 FORTRAN H AT GISS                                     DATE 12/12/79-0783.48

        COMPILER OPTIONS -    NAME=  MAIN.OPT=02.LINECNT=55.SIZE=1000K.
                              SOURCE.EBCDIC.NOLIST.NODECK.LOAD.MAP.NOEDIT.ID.NOXREF
  ISN 0002              SUBROUTINE COMP1(U.V.T.SH.P.C.UPCL.VPCL.TPCL.SHPOL.PPCL.QPOL.        B4M12320
                      $    UT.VT.TT.SHT.PT.QT.UTPOL.VTPOL.TTPOL.SHTPOL.PTPOL.QTPOL.J)       B4M12330
  ISN 0003              COMMON/FOURTH/CON1.CON2.CON3.CON4.CON5.TFBAR.ALPHA.BETA.IMD2P1.      B4M12340
                      $    ADLDP.JMS2.JMS1.CPTM.PSKAPA.R.RAD.CP.INC.NSTART.CPD2.            B4M12350
                      $    IMD2.RADIM.JEND(2).JP1.JP2.MATSUN.JNEXT(2).MODPK(2.2).           B4M12360
                      $    JPOL(2.2).JPMOD(2.2).SINLON(72).COSLON(72).INDEX(72).            B4M12370
                      $    PSIGN(4).POLES(148).W(72.9.5).PK(72.9.3).DIFF(9).                B4M12380
                      $    CONVPL(9).SDPOL(9.2).PHISPL(2).SUM(2.5)                          B4M12390
  ISN 0004              DIMENSION PPOL(2).PITPOL(2).UPOL(36.1).VPOL(36.1).TPOL(36.1).        B4M12400
                      $    SHPOL(36.1).QPOL(9.4.2).Q(72.10.4.1)                             B4M12410
  ISN 0005              DIMENSION PTPOL(2).UTPOL(36.1).VTPOL(36.1).TTPOL(36.1).              B4M12420
                      $    SHTPOL(36.1).QTPOL(9.4.2).CT(72.10.4.1)                          B4M12430
  ISN 0006              COMMON/SMITH/QSM(72.9.4.5).PSM(72.5).QSMPOL(9.4.2).PSMPOL(2)         B4M12440
  ISN 0007              INTEGER*2 ALBEDO                                                     B4M12450
  ISN 0008              REAL*4 KAPA.LAT                                                      B4M12460
                C       REAL*8 SINLON.COSLON.SUM                                             B4M12470
  ISN 0009              COMMON /CNTRL/                                                       B4M12480
                      *  JSP.JNP.IM.NLAY.PTOP.ISTART.JSPP1.JNPM1.FIM.NLAYM1.NLAYP1.          B4M12490
                      *  J1.JM.KM.TAUT.IROT.MROT.JTEST.ITEST.                               B4M12500
                      *  NR.JAYS(12).INCS(11).JSB.JNB.DLAT.DLON.                            B4M12510
                      *  DT.TAU.ITAU.XINT.IDAY.JDAY.TOFDAY.JDATE.JMONTH(2).JYEAR.NSTEP.     B4M12520
                      *  NCYCLE.NCOMP3.NHOGAN.TAUP.TAUI.TAUE.TALO.DTMULT.                   B4M12530
                      *  PI.GRAV.RGAS.KAPA.PSL.ED.FMU.NPLM.PSF.MRCH.RSDIST.SIND.COSD.       B4M12540
                      *  RHMAX.CDX.DUMMYC(18).IALTER.DUMMYA(99).                            B4M12550
                      *  XLABEL(20).SIG(20).DSIG(20).SIGE(21).DSIGO(19).                    B4M12560
                      *  J1PS(11).JMPS(11).J1US(11).JMUS(11).KSBS(11).KNBS(11).             B4M12570
                      *LAT(46).DXU(46).DXP(46).DYU(46).DYP(46).CXYP(46).F(46).SINL(46).     B4M12580
                      *COSL(46).DUMMY(72).PHIS(2880.46).ALBEDO(72.46)                       B4M12590
  ISN 0010              DIMENSION U(72.40.1).V(72.40.1).T(72.40.1).SH(72.40.1).              B4M12600
                      *P(2880.1).   TS(2880.1).SHS(2880.1).GT(2880.1).GW(2880.1).C(300)     B4M12610
  ISN 0011              EQUIVALENCE (TS(1.1).PHIS(721.1)).(SHS(1.1).PHIS(1441.1)).           B4M12620
                      $    (GT(1.1).PU(721.1)).(GW(1.1).PU(1441.1)).(C(1).JSP)              B4M12630
  ISN 0012              COMMON/COMP12/PITPOL                                                 B4M12640
  ISN 0013              COMMON/WORK/ CONV(72.9.46)                                           B4M12650
  ISN 0014              COMMON/WORK2/PU(2880.46)                                             B4M12660
  ISN 0015              DIMENSION UT(72.40.1).VT(72.40.1).TT(72.40.1).SHT(72.40.1).          B4M12670
                      *PT(2880.1).SD(72.9.1).PIT(648.1).PV(72.2)                            B4M12680
  ISN 0016              EQUIVALENCE (SD(1.1.1).CONV(1.1.1)).(        CONV(1.9.1).           B4M12690
                      *  PIT(1.1))                                                          B4M12700
  ISN 0017              COMMON /DBUG/ISWTCH                                                  B4M12710
                C                                                                            B4M12720
  ISN 0018              COMMON/SDOT48/SDOT(72.46.8).OMEGA(72.46.5).MNMXTS.RADT(72.46.10)     B4M12730
                      + .COMG                                                                B4M12740
  ISN 0019              LOGICAL COMG                                                         B4M12750
                C                                                                            B4M12760
  ISN 0020              INTEGER*2 RADT.OMEGA                                                 B4M12770
  ISN 0021              INTEGER*2 ISDOT(72.46.8)                                             B4M12780
                C                                                                            B4M12790
  ISN 0022              EQUIVALENCE (SDOT(1.1.5).ISDOT(1.1.1))                               B4M12800
                C                                                                            B4M12810
  ISN 0023              COMMON/SMOO/ISMTH.NPC                                                B4M12820
  ISN 0024              QSAT(TM.PR) = .622 * EXP(21.65604 - 5417.983 / TM) / PR              B4M12830
  ISN 0025              DATA J2/2/                                                           B4M12840
  ISN 0026              JMS2 = JM - 2                                                        B4M12850
  ISN 0027              F1CO = 4. * DT                                                       B4M12860
  ISN 0028              F2CO = -.5 * DT                                                      B4M12870
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ISN 0029          L = 1                                                                B4M12880
ISN 0030          JP2 = J + 2                                                          B4M12890
ISN 0031          JP1 = J + 1                                                          B4M12900
ISN 0032          JS1 = J - 1                                                          B4M12910
ISN 0033          JS2 = J - 2                                                          B4M12920
ISN 0034          JP2MOD = MOD(JP2-1.5) + 1                                            B4M12930
ISN 0035          JP1MOD = MOD(JP1-1.5) + 1                                            B4M12940
ISN 0036          JMOD = MOD(J-1.5) + 1                                                B4M12950
ISN 0037          JS1MOD = MOD(JS1-1.5) + 1                                            B4M12960
ISN 0038          JS2MOD = MOD(JS2-1.5) + 1                                            B4M12970
ISN 0039          IF (J .GT. 2)                   GO TC 2150                           B4M12980
ISN 0041          JS1 = 1                                                              B4M12990
ISN 0042          JS2 = 1                                                              B4M13000
ISN 0043          JS1MOD = 1                                                           B4M13010
ISN 0044          JS2MOD = 1                                                           B4M13020
            C                                                                        * B4M13030
            C * * * BEGIN OF LAYER LOOP                                              * B4M13040
            C * * * CALC OF PV                                                       * B4M13050
            C                                                                        * B4M13060
ISN 0045     2150 IF (J .EQ. JM)                  GC TC 2158                           B4M13070
ISN 0047          DO 2154 I = INC.IM.INC                                               B4M13080
ISN 0048          PV(I.1) = DXP(J) * P(I.J) * V(I.L.J) + DXP(JP1) * P(I.JP1)           B4M13090
                 $     * V(I.L.JP1)                                                    B4M13100
ISN 0049          PV(I.J2) = DXP(J) * P(I.J) * V(I.L.J) + DXP(JP2) * P(I.JP2)          B4M13110
                 $     * V(I.L.JP2)                                                    B4M13120
ISN 0050     2154                                 CONTINUE                             B4M13130
            C                                                                        * B4M13140
            C * * * PU CALCULATION (OMIT FOR J=1 . SOUTH POLE)                       * B4M13150
            C                                                                        * B4M13160
ISN 0051          IF (J .EQ. 1)                   GO TC 2225                           B4M13170
ISN 0053     2158 IS1 = IM - 1                                                         B4M13180
ISN 0054          I = IM                                                               B4M13190
ISN 0055          PUIS1 = DYU(J) * P(IS1.J) * U(IS1.L.J)                               B4M13200
ISN 0056          PUI = DYU(J) * P(I.J) * U(I.L.J)                                     B4M13210
ISN 0057          DO 2160 IP1 = INC.IM.INC                                             B4M13220
ISN 0058          PUIP1 = DYU(J) * P(IP1.J) * U(IP1.L.J)                               B4M13230
ISN 0059          PU(IS1.1) = PUIS1 + PUI                                              B4M13240
ISN 0060          PU(IS1.2) = PUIS1 + PUIP1                                            B4M13250
ISN 0061          PUIS1 = PUI                                                          B4M13260
ISN 0062          PUI = PUIP1                                                          B4M13270
ISN 0063          IS1 = I                                                              B4M13280
ISN 0064          I = IP1                                                              B4M13290
ISN 0065     2160                                 CONTINUE                             B4M13300
            C                                                                        * B4M13310
            C * * * HORIZONTAL ADVECTION OF MOMENTUM. TEMPERATURE. MOISTURE          * B4M13320
            C * * * COMPUTE FLUXES FIRST IN THE LONGITUDINAL (I) DIRECTION           * B4M13330
            C                                                                        * B4M13340
ISN 0066          IS1 = IM - 1                                                         B4M13350
ISN 0067          I = IM                                                               B4M13360
ISN 0068          DO 2220 IP1 = INC.IM.INC                                             B4M13370
ISN 0069          FLUX1 = F1CO * PU(IS1.1)                                             B4M13380
ISN 0070          FLUX2 = F2CO * PU(IS1.2)                                             B4M13390
ISN 0071          DO 2223 N = 1.4                                                      B4M13400
ISN 0072          QFLUX1 = FLUX1 * (Q(IS1.L.N.J) + Q(I.L.N.J))                         B4M13410
ISN 0073          QFLUX2 = FLUX2 * (Q(IS1.L.N.J) + Q(IP1.L.N.J))                       B4M13420
ISN 0074          IF(N.NE.4)GO TO 100                                                  B4M13430
ISN 0076          IF(Q(IS1.L.4.J).GT.0.)GO TO 110                                      B4M13440
ISN 0078          IF(QFLUX1.GT.0.)QFLUX1=0.                                            B4M13450
ISN 0080          IF(QFLUX2.GT.0.)QFLUX2=0.                                            B4M13460
ISN 0082      110 IF((Q(I.L.N.J).LE.0.).AND.(QFLUX1.LT.0.))QFLUX1=0.                   B4M13470
ISN 0084          IF((Q(IP1.L.N.J).LE.0.).AND.(QFLUX2.LT.0.))QFLUX2=0.                 B4M13480
ISN 0086      100 CONTINUE                                                             B4M13490
ISN 0087          QT(IP1.L.N.J) = QT(IP1.L.N.J) + QFLUX2                               B4M13500
ISN 0088          QT(I.L.N.J) = QT(I.L.N.J) + QFLUX1                                   B4M13510
ISN 0089          QT(IS1.L.N.J) = QT(IS1.L.N.J) - QFLUX1 - QFLUX2                      B4M13520
ISN 0090     2223                                 CONTINUE                             B4M13530
ISN 0091          IS1 = I                                                              B4M13540
ISN 0092          I = IP1                                                              B4M13550
ISN 0093     2220                                 CONTINUE                             B4M13560
ISN 0094          IF (J .EQ. JM)                  GO TC 2237                           B4M13570
            C                                                                        * B4M13580
            C * * * NOW DO FLUX CALCULATION IN THE LATITUDINAL (J) DIRECTION         * B4M13590
            C                                                                        * B4M13600
ISN 0096     2225 DO 2230 I = INC.IM.INC                                               B4M13610
ISN 0097          FLUX1 = F1CO * PV(I.1)                                               B4M13620
ISN 0098          FLUX2 = F2CO * PV(I.J2)                                              B4M13630
ISN 0099          DO 2230 N = 1.4                                                      B4M13640
ISN 0100          QFLUX1 = FLUX1 * (Q(I.L.N.J) + Q(I.L.N.JP1))                         B4M13650
ISN 0101          QFLUX2 = FLUX2 * (Q(I.L.N.J) + Q(I.L.N.JP2))                         B4M13660
ISN 0102          IF(N.NE.4)GO TO 120                                                  B4M13670
ISN 0104          IF(Q(I.L.N.J).GT.0.)GC TC 115                                        B4M13680
ISN 0106          IF(QFLUX1.GT.0.)QFLUX1=0.                                            B4M13690
ISN 0108          IF(QFLUX2.GT.0.)QFLUX2=0.                                            B4M13700
ISN 0110      115 IF((Q(I.L.N.JP1).LE.0.).AND.(QFLUX1.LT.0.))QFLUX1=0.                 B4M13710
ISN 0112          IF((Q(I.L.N.JP2).LE.0.).AND.(QFLUX2.LT.0.))QFLUX2=0.                 B4M13720
ISN 0114      120 CONTINUE                                                             B4M13730
ISN 0115          QT(I.L.N.JP2) = QT(I.L.N.JP2) + QFLUX2                               B4M13740
ISN 0116          QT(I.L.N.JP1) = QT(I.L.N.JP1) + QFLUX1                               B4M13750
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ISN 0117          QT(I.L.N.J) = QT(I.L.N.J) - QFLUX1 - QFLUX2                      B4M13760
ISN 0118     2230                                 CONTINUE                            B4M13770
           C                                                                       *  B4M13780
           C * * * FOLLOWING IS CORRECTION FOR CASE J=2                            *  B4M13790
           C * * * P(I.0) = P(INDEX(I).2)                                          *  B4M13800
           C * * * V(I.L.0) = -V(INDEX(I).L.2)  ETC.                               *  B4M13810
           C * * * PV(I.2) FOR J=0 IS EQUAL TO: -CONV(I.L.2) . . SEE ABOVE         *  B4M13820
           C                                                                       *  B4M13830
ISN 0119          IF(J .GT. 1)                    GO TO 2290                          B4M13840
ISN 0121          DO 2240 I = INC.IM.INC                                              B4M13850
ISN 0122          CONV(I.L.2)=0.                                                      B4M13860
ISN 0123     2240                                 CONTINUE                            B4M13870
           C                                                                       *  B4M13880
           C * * * CONTINUITY EQUATION                                             *  B4M13890
           C * * * DUE TO 1 LINE OF LATITUDE AT A TIME THE DEFINITION OF PV.       *  B4M13900
           C * * * AND 4TH ORDER FORM OF CONV. WE COMPUTE IT AS FOLLOWS:           *  B4M13910
           C                                                                       *  B4M13920
ISN 0124     2290 IS2 = IM - 1                                                        B4M13930
ISN 0125          IS1 = IM                                                            B4M13940
ISN 0126          DO 2400 I    = INC.IM.INC                                           B4M13950
ISN 0127          CONV(I.L.JP2) = - PV(I.J2)                                          B4M13960
ISN 0128          CONV(I.L.JP1) = CONV(I.L.JP1) + 8. * PV(I.1)                        B4M13970
ISN 0129          CONV(I.L.J) = CONV(I.L.J) - 8. * PV(I.1) + PV(I.J2)                 B4M13980
                $    + 8. * (PU(IS1.1) - PU(I.1)) + (PU(I.2) - PU(IS2.2))             B4M13990
ISN 0130          IS2 = IS1                                                           B4M14000
ISN 0131          IS1 = I                                                             B4M14010
ISN 0132     2400                                 CONTINUE                            B4M14020
           C                                                                       *  B4M14030
           C * * * FOLLOWING IS CORRECTION FOR J=JM.                               *  B4M14040
           C * * * U(I.L.JM2) = -U(INDEX(I).L.JM). ETC.                            *  B4M14050
           C                                                                       *  B4M14060
ISN 0133          IF (J .LT. JM)                  GO TO 2405                          B4M14070
ISN 0135     2237 IS2 = IM - 3                                                        B4M14080
ISN 0136          IS1 = IM - 2                                                        B4M14090
ISN 0137          I = IM - 1                                                          B4M14100
ISN 0138          IP1 = IM                                                            B4M14110
ISN 0139          DO 2250 IP2 = INC.IM.INC                                            B4M14120
ISN 0140          PV1JM = DXP(JM) * P(I.JM) * V(I.L.JM)                               B4M14130
ISN 0141          PV2JM=0.                                                            B4M14140
ISN 0142          CONV(I.L.JM) = CONV(I.L.JM) - 8. * PV1JM                            B4M14150
                $    + PV2JM + DYU(JM) * (8. * (P(IS1.JM) * U(IS1.L.JM)               B4M14160
                $    - P(IP1.JM) * U(IP1.L.JM)) + (P(IP2.JM) * U(IP2.L.JM)            B4M14170
                $    - P(IS2.JM) * U(IS2.L.JM)))                                      B4M14180
           C                                                                       *  B4M14190
           C * * * CALCULATION OF THE REMAINDER OF QT(I.L.N.JM)                    *  B4M14200
           C                                                                       *  B4M14210
ISN 0143          FLUX1 = F1CO * PV1JM                                                B4M14220
ISN 0144          FLUX2 = F2CO * PV2JM                                                B4M14230
ISN 0145          DO 2255 N = 1.4                                                     B4M14240
ISN 0146          QFLUX1 = FLUX1 * (Q(I.L.N.JM) + Q(I.L.N.JNP))                       B4M14250
ISN 0147          QFLUX2 = FLUX2 * (Q(I.L.N.JM) + FSIGN(N) * Q(INDEX(I).L.N.JM))      B4M14260
ISN 0148          IF(N.NE.4)GO TO 126                                                 B4M14270
ISN 0150          IF(Q(I.L.N.JM).GT.0.)GO TO 126                                      B4M14280
ISN 0152          IF(QFLUX1.GT.0.)QFLUX1=0.                                           B4M14290
ISN 0154          IF(QFLUX2.GT.0.)QFLUX2=0.                                           B4M14300
ISN 0156      126 IF((Q(I.L.N.JNP).LE.0.).AND.(QFLUX1.LT.0.))QFLUX1=0.                B4M14310
ISN 0158          IF((PSIGN(N)*Q(INDEX(I).L.N.JM).LE.0.).AND.                         B4M14320
                 1(QFLUX2.LT.0.))QFLUX2=0.                                            B4M14330
ISN 0160          QT(I.L.N.JM)=QT(I.L.N.JM)-QFLUX1-QFLUX2                             B4M14340
ISN 0161     2255                                 CONTINUE                            B4M14350
ISN 0162          IS2 = IS1                                                           B4M14360
ISN 0163          IS1 = I                                                             B4M14370
ISN 0164          I = IP1                                                             B4M14380
ISN 0165          IP1 = IP2                                                           B4M14390
ISN 0166     2250                                 CONTINUE                            B4M14400
           C                                                                       *  B4M14410
           C * * * NOTE: MULTIPLY BY DSIG(L) FOR LAT J ONLY.                       *  B4M14420
           C                                                                       *  B4M14430
ISN 0167     2405 DO 2410 I = INC.IM.INC                                              B4M14440
ISN 0168          CONV(I.L.J) = CONV(I.L.J) * DSIG(L)                                 B4M14450
ISN 0169     2410                                 CONTINUE                            B4M14460
ISN 0170          L = L + 1                                                           B4M14470
ISN 0171          IF (L .LE. NLAY)                GO TO 2150                          B4M14480
           C                                                                       *  B4M14490
           C * * *      END OF LAYER LOOP                                          *  B4M14500
           C                                                                       *  B4M14510
           C * * * COMPUTATION OF SIGMA DOT AND NEW SURFACE PRESSURE                *  B4M14520
           C * * * SKIP THIS COMPUTATION IF (J .EQ. 1) (SOUTH POLE)                *  B4M14530
           C * * * PIT(I.J) IS EQUIVALENCED TO CONV(I.9.J)                         *  B4M14540
           C                                                                       *  B4M14550
ISN 0173          IF (J .EQ. 1)                   GO TO 2600                          B4M14560
ISN 0175          DO 2440 I = INC.IM.INC                                              B4M14570
           C * *  PIT(I.J) = CONV(I.9.J)                                              B4M14580
ISN 0176          DO 2420 L = 1.NLAYM1                                                B4M14590
ISN 0177          PIT(I.J) = PIT(I.J) + CONV(I.L.J)                                   B4M14600
ISN 0178     2420                                 CONTINUE                            B4M14610
ISN 0179          SD(I.1.J) = CONV(I.1.J) - DSIG(1) * PIT(I.J)                        B4M14620
ISN 0180          IF(CONG) OMEGA(I.J.1) = SD(I.1.J)/DXYP(J)*1.E6                      B4M14630
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ISN 0182          IF (NLAY .EQ. 2)              GO TC 2440                                   B4M14640
ISN 0184          DO 2430 L = 2.NLAYM1                                                        B4M14650
ISN 0185          SD(I.L.J) = SD(I.L-1.J) + CONV(I.L.J) - CSIG(L) * PIT(I.J)                  B4M14660
ISN 0186          IF(COMG) OMEGA(I.J.L) = SD(I.L.J)/DXYP(J)*1.E6                              B4M14670
ISN 0188     2430                               CONTINUE                                      B4M14680
ISN 0189     2440                               CONTINUE                                      B4M14690
ISN 0190          DO 2450 I = INC.IM.INC                                                      B4M14700
ISN 0191          DELPT = DT * PIT(I.J) / DXYP(J)                                             B4M14710
ISN 0192          I1=I-1                                                                      B4M14720
ISN 0193          IF(I.EQ.1)I1=1                                                              B4M14730
ISN 0195          PT(I.J) = PT(I.J) + DT * PIT(I.J) / DXYP(J)                                 B4M14740
ISN 0196     2450                               CONTINUE                                      B4M14750
ISN 0197          IF(.NOT.COMG)  GO TO 2456                                                   B4M14760
ISN 0199          DO 2455 L = 1.NLAY                                                          B4M14770
ISN 0200          DO 2455 I = 1.IM                                                            B4M14780
ISN 0201     2455 OMEGA(I.J.L) = OMEGA(I.J.L) + SIG(L)*PIT(I.J)/DXYP(J)                       B4M14790
ISN 0202     2456 CONTINUE                                                                    B4M14800
            C                                                                               * B4M14810
            C * * * VERTICAL ADDVECTION OF MOMENTUM AND TEMPERATURE                             B4M14820
            C                                                                               * B4M14830
ISN 0203          DO 2490 L = 1.NLAYM1                                                        B4M14840
ISN 0204          LP1 = L + 1                                                                 B4M14850
            C                                                                               * B4M14860
            C                                                                                 B4M14870
            C     FIRST DO MOMENTUM                                                           B4M14880
            C                                                                                 B4M14890
ISN 0205          DO 2470 N=1.2                                                               B4M14900
            C                                                                                 B4M14910
ISN 0206          DO 2470 I=INC.IM.INC                                                        B4M14920
            C                                                                                 B4M14930
ISN 0207          SFLUX = F2CO*SD(I.L.J)*(Q(I.L.N.J) + Q(I.LP1.N.J))                          B4M14940
            C                                                                                 B4M14950
ISN 0208          QT(I.LP1.N.J) = QT(I.LP1.N.J) - SFLUX / DSIG(LP1)                           B4M14960
ISN 0209          QT(I.L.N.J) = QT(I.L.N.J) + SFLUX / DSIG(L)                                 B4M14970
ISN 0210     2470                               CONTINUE                                      B4M14980
            C                                                                               * B4M14990
            C * * * VERTICAL ADVECTION OF TEMPERATURE                                       * B4M15000
            C * * * TRYING GISS CODE FOR PK CALC. INSTEAD OF 4TH ORDER CODE                 * B4M15010
            C                                                                               * B4M15020
ISN 0211          DO 2480 I =INC.IM.INC                                                       B4M15030
ISN 0212          PL1 = SIG(L) * P(I.J) + PTOP                                                B4M15040
ISN 0213          PL2 = SIG(LP1) * P(I.J) + PTOP                                              B4M15050
ISN 0214          PK1 = EXPBYK(PL1)                                                           B4M15060
ISN 0215          PK2 = EXPBYK(PL2)                                                           B4M15070
ISN 0216          TFLUX = F2CO * SD(I.L.J) * (T(I.L.J) / PK1 + T(I.LP1.J) / PK2)              B4M15080
ISN 0217          TT(I.LP1.J) = TT(I.LP1.J) - PK2 * TFLUX / DSIG(LP1)                         B4M15090
ISN 0218          TT(I.L.J) = TT(I.L.J) + PK1 * TFLUX / DSIG(L)                               B4M15100
ISN 0219     2480                               CONTINUE                                      B4M15110
ISN 0220     2490                               CONTINUE                                      B4M15120
ISN 0221          IF (J .LT. JM)                RETURN                                        B4M15130
            C                                                                               * B4M15140
            C                                                                               * B4M15150
            C * * * CALCULATIONS AT THE POLES                                               * B4M15160
            C                                                                               * B4M15170
            C                                                                               * B4M15180
            C * * * WHEN (J=1) OR (J=JM) WE DO THE CALCULATIONS AT THE POLES.                * B4M15190
            C * * * MOMENTUM, TEMPERATURE, SPECIFIC HUMIDITY AT SOUTH POLE                  * B4M15200
            C * * * (M = 1)  AND NORTH POLE (M = 2)                                         * B4M15210
            C * * * JPOL(K.M) = (2.3.JM.JM-1)                                               * B4M15220
            C * * * CON1 = DXP(2) / (3 PI * A * A * SIN(DLAT / 2) ** 2)                     * B4M15230
            C * * * CON2 = -DXP(3) / (12 PI * A * A * SIN(LAT) ** 2)                        * B4M15240
            C * * * (K = 1) CORRESPONDS TO THE LATITUDE LINE NEAREST TO THE POLE.           * B4M15250
            C                                                                               * B4M15260
ISN 0223     2600 M = 1                                                                       B4M15270
ISN 0224          IF (J .EQ. JM)                M = 2                                         B4M15280
ISN 0226          PITPOL(M) = 0.                                                              B4M15290
ISN 0227          COEF1 = (-1.) ** M                                                          B4M15300
ISN 0228          COEF2 = -COEF1                                                              B4M15310
ISN 0229          DO 2500 L = 1.NLAY                                                          B4M15320
ISN 0230          DO 2505 N = 1.5                                                             B4M15330
ISN 0231          DO 2505 K = 1.2                                                             B4M15340
ISN 0232          SUM(K.N) = 0.                                                               B4M15350
ISN 0233     2505                               CONTINUE                                      B4M15360
            C                                                                               * B4M15370
            C * * * HORIZ. ADVEC. OF MOMENTUM, TEMPERATURE, SPECIFIC HUMIDITY               * B4M15380
            C * * * AT THE NORTH AND SOUTH POLES.                                           * B4M15390
            C * * * 4/4/78 -PIV TO BE CHANGED TO PIV FOR: -PIE<LONG<PIE                     * B4M15400
            C                                                                               * B4M15410
ISN 0234          DO 2510 I = INC.IM.INC                                                      B4M15420
ISN 0235          DO 2510 K = 1.2                                                             B4M15430
ISN 0236          JKP = 1                                                                     B4M15440
ISN 0237          IF (M.EQ.2) JKP = JNP                                                       B4M15450
ISN 0239          JK = JPOL(K.M)                                                              B4M15460
ISN 0240          PIV = P(I.JK) * V(I.L.JK)                                                   B4M15470
ISN 0241          SUM(K.1) = SUM(K.1) - PIV * (U(I.L.JK) * SINLON(I)                          B4M15480
                $    + COEF1 * V(I.L.JK) * COSLON(I))                                         B4M15490
ISN 0242          SUM(K.2) = SUM(K.2) - PIV * (COEF2 * U(I.L.JK) * COSLON(I)                  B4M15500
                $    + V(I.L.JK) * SINLON(I))                                                 B4M15510
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C-2

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ISN 0243           SUM(K,3) = SUM(K,3) + PIV * T(I,L,JK)                                    B4M15520
ISN 0244           SUM(K,4) = SUM(K,4) + PIV * SH(I,L,JK)                                   B4M15530
             C     DO 2515 N = 3,4                                                          B4M15540
             C2515                             CONTINUE                                     B4M15550
ISN 0245           SUM(K,5) = SUM(K,5) + PIV                                                B4M15560
ISN 0246      2510                             CONTINUE                                     B4M15570
ISN 0247           DO 2520 N = 1,4                                                          B4M15580
ISN 0248           QTPOL(L,N,M) = QTPOL(L,N,M) + COEF1 * DT * (CON1 * SUM(1,N)              B4M15590
                 $    + CON2 * SUM(2,N))                                                    B4M15600
ISN 0249      2520                             CONTINUE                                     B4M15610
             C                                                                         *    B4M15620
             C * * * CONTINUITY EQUATION  AT THE POLES.                                *    B4M15630
             C                                                                         *    B4M15640
ISN 0250           CONVPL(L) = COEF1 * (CON1 * SUM(1,5) + CON2 * SUM(2,5))*DSIG(L)          B4M15650
ISN 0251           PITPOL(M) = PITPOL(M) + CONVPL(L)                                        B4M15560
ISN 0252      2500                             CONTINUE                                     B4M15670
             C                                                                         *    B4M15680
             C * * * COMPUTATION OF SIGMA DOT AND NEW SURFACE PRESSURE AT POLES.      *    B4M15690
             C                                                                         *    B4M15700
ISN 0253           SDPOL(1,M) = CONVPL(1) - DSIG(1) * PITPOL(M)                             B4M15710
ISN 0254           IF(COMG) OMEGA(1,JKP,1) = SDPOL(1,M)*1.E6                                B4M15720
ISN 0256           IF (NLAY .EQ. 2)                GO TO 2538                               B4M15730
ISN 0258           DO 2530 L = 2,NLAYM1                                                     B4M15740
ISN 0259           SDPOL(L,M) = SDPOL(L-1,M) + CONVPL(L) - DSIG(L) * PITPOL(M)              B4M15750
ISN 0260           IF(COMG) OMEGA(1,JKP,L) = SDPOL(L,M)*1.E6                                B4M15760
ISN 0262      2530                             CONTINUE                                     B4M15770
ISN 0263      2538 PTPOL(M) = PTPOL(M) + DT * PITPOL(M)                                     B4M15780
ISN 0264           IF(.NOT.COMG) GO TO 2537                                                 B4M15790
ISN 0266           DO 2539 L = 1,NLAY                                                       B4M15800
ISN 0267      2539 OMEGA(1,JKP,L) = OMEGA(1,JKP,L) + SIG(L) * PITPOL(M)                     B4M15810
ISN 0268      2537 CONTINUE                                                                 B4M15820
             C                                                                         *    B4M15830
             C * * * VERTICAL ADVECTION OF MOMENTUM AND TEMPERATURE AT POLES                B4M15840
             C * * * FIRST DO MOMENTUM                                                      B4M15850
             C                                                                         *    B4M15860
ISN 0269           DO 2540 L = 1,NLAYM1                                                     B4M15870
ISN 0270           LP1 = L + 1                                                              B4M15880
ISN 0271           DO 2550 N=1,2                                                            B4M15890
             C                                                                              B4M15900
ISN 0272           SFLUX = F2CO*SDPOL(L,M)*(QPOL(L,N,M) + QPOL(LP1,N,M))                    B4M15910
             C                                                                              B4M15920
             C                                                                              B4M15930
ISN 0273           QTPOL(LP1,N,M) = QTPOL(LP1,N,M) - SFLUX / DSIG(LP1)                      B4M15940
ISN 0274           QTPOL(L,N,M) = QTPOL(L,N,M) + SFLUX /DSIG(L)                             B4M15950
ISN 0275      2550                             CONTINUE                                     B4M15960
             C                                                                         *    B4M15970
             C * * * VERTICAL ADVECTION OF TEMPERATURE AT THE POLES.                   *    B4M15980
             C                                                                         *    B4M15990
ISN 0276           PL1 = SIG(L) *PPOL(M) + PTOP                                             B4M16000
ISN 0277           PL2 = SIG(LP1) * PPOL(M) + PTOP                                          B4M16010
ISN 0278           PK1 = EXPBYK(PL1)                                                        B4M16020
ISN 0279           PK2 = EXPBYK(PL2)                                                        B4M16030
ISN 0280           TFLUX = F2CO * SDPOL(L,M) * (TPOL(L,M) / PK1 + TPOL(LP1,M) / PK2)        B4M16040
             C                                                                              B4M16050
ISN 0281           TTPOL(LP1,M) = TTPOL(LP1,M) - PK2 * TFLUX / DSIG(LP1)                    B4M16060
ISN 0282           TTPOL(L,M) = TTPOL(L,M) + PK1 * TFLUX / DSIG(L)                          B4M16070
ISN 0283      2540                             CONTINUE                                     B4M16030
ISN 0284                                       RETURN                                       B4M15090
ISN 0285                                       END                                          B4M16100

                                                 /    COMP1 /     SIZE OF PROGRAM 002802 HEXADECIMAL BYTES

NAME TAG TYPE ADD.    |* ***    * NAME TAG TYPE ADD.    |* ***    * NAME TAG TYPE ADD.    |* ***    * NAME TAG TYPE ADD.    |* ***    *
      C       CE  R*4  000000              F        C  R*4    N.R.               I SF        I*4  0000F8               J  FA       I*4  0000FC
      K SF        I*4  000100              L SF        I*4  000104               M SF        I*4  000108               N SF        I*4  00010C
      P  F    XR  R*4  000000              Q  F    XR  R*4  00000C               R        C  R*4    N.R.               T  F    XR  R*4  000000
      U  F    XR  R*4  000000              V  F    XR  R*4  00000C               W        C  R*4    N.R.              CP        C  R*4    N.R.
     DT  F     C  R*4  0000BC             ED        C  R*4    N.R.              GT       CE  R*4  000840              GW       CE  R*4  001680
     IM  F     C  I*4  000008             I1 S         I*4  00011C              JK SF        I*4  000114              JM  F     C  I*4  000030
     J1        C  I*4    N.R.             J2  F        I*4  00011E              KM        C  I*4    N.R.              NR        C  I*4    N.R.
     PI        C  R*4    N.R.             PK        C  R*4    N.R.              PT SF    XR  R*4  000000              PU SF    CE  R*4  000000
     PV SF        R*4  0001A8             QT SF    XR  R*4  00000C              SD SF    CE  R*4  000000              SH  F    XR  R*4  000000
     TS       CE  R*4  001890             TT SF    XR  R*4  00000C              UT       XR  R*4  000000              VT       XR  R*4  000000
    CDX        C  R*4    N.R.            DXP  F     C  R*4  00072E             DXU        C  R*4    N.R.             DYP        C  R*4    N.R.
    DYU  F     C  R*4  0007E0            FIM        C  R*4    N.R.             FMU        C  R*4    N.R.             INC  F     C  I*4  000044
    IP1 SF        I*4  00011C            IP2 SF        I*4  00012C             IS1 SF        I*4  000124             IS2 SF        I*4  000128
    JKP SF        I*4  00012C            JNB        C  I*4    N.R.             JNP  F     C  I*4  000004             JP1 SFA    C  I*4  000060
    JP2 SFA    C  I*4  000064            JSB        C  I*4    N.R.             JSP       CE  I*4  000000             JS1 SFA       I*4  000130
    JS2 SFA       I*4  000134            LAT        C  R*4    N.R.             LP1 SF        I*4  000138             NPC        C  I*4    N.R.
    PIT SF    CE  R*4  000900            PIV SF        R*4  00013C             PK1 SF        R*4  000140             PK2 SF        R*4  000144
    PL1 SFA       R*4  000148            PL2 SFA       R*4  00014C             PSF        C  R*4    N.R.             PSL        C  R*4    N.R.
    PSM        C  R*4    N.R.            PUI SF        R*4  00015C             QSM        C  R*4    N.R.             RAD        C  R*4    N.R.
    SHS       CE  R*4  002300            SHT       XR  R*4  00000C             SIG  F     C  R*4  000370             SUM SF     C  R*4  0057FC
    TAU        C  R*4    N.R.           BETA        C  R*4    N.R.            COMG        C  L*4  0389A4            CONV SF    CE  R*4  000000
   CON1  F     C  R*4  000000           CON2  F     C  R*4  000004            CON3        C  R*4    N.R.            CON4        C  R*4    N.R.
   CON5        C  R*4    N.R.           COSD        C  R*4    N.R.            COSL        C  R*4    N.R.            CPD2        C  R*4    N.R.
   CPTH        C  R*4    N.R.           DIFF        C  R*4    N.R.            DLAT        C  R*4    N.R.            DLON        C  R*4    N.R.
   DSIG  F     C  R*4  0003C0           DXYP  F     C  R*4  00095C            F1CO SF        R*4  000154            F2CO SF        R*4  000158
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   GRAV        C  R*4     N.R.       IDAY        C  I*4    N.R.       IMD2        C  I*4    N.R.       INCS        C  I*4    N.R.
   IROT        C  I*4     N.R.       ITAU        C  I*4    N.R.       JAYS        C  I*4    N.R.       JDAY        C  I*4    N.R.
   JEND        C  I*4     N.R.       JMOD  S        I*4  00015C       JMPS        C  I*4    N.R.       JMS1        C  I*4    N.R.
   JMS2  S     C  I*4   000028       JMUS        C  I*4    N.R.       JPOL   F    C  I*4  000084       J1PS        C  I*4    N.R.
   J1US        C  I*4     N.R.       KAPA        C  R*4    N.R.       KNBS        C  I*4    N.R.       KSBS        C  I*4    N.R.
   MRCH        C  I*4     N.R.       MROT        C  I*4    N.R.       NFLW        C  I*4    N.R.       NLAY   F    C  I*4  00000C
   PHIS       CE  R*4   000D50       PPOL   F   XR  R*4  00000C       PTOP   F    C  R*4  000010       QPOL   F   XR  R*4  000000
   QSAT  S   ASF  R*4   000000       RADT        C  I*2    N.R.       RGAS        C  R*4    N.R.       SDOT       CE  R*4  000000
   SIGE        C  R*4     N.R.       SIND        C  R*4    N.R.       SINL        C  R*4    N.R.       TAUE        C  R*4    N.R.
   TAUI        C  R*4     N.R.       TAUD        C  R*4    N.R.       TAUP        C  R*4    N.R.       TAUT        C  R*4    N.R.
   TPOL   F   XR  R*4   000000       UPOL       XR  R*4  00000C       VPOL       XR  R*4  000000       XINT        C  R*4    N.R.
  ADLDP        C  R*4     N.R.      ALPHA        C  R*4    N.R.      COEF1  SF       R*4  000160      COEF2  SF       R*4  000164
  COMP1           R*4   000168      DELPT  S        R*4  00016C      DSIGO       C  R*4    N.R.      DUMMY       C  R*4    N.R.
  FLUX1  SF       R*4   000170      FLUX2  SF       R*4  000174      INDEX  F    C  I*4  0002E4      ISDOT      CE  I*2  00CF00
  ISMTH        C  I*4     N.R.      ITEST        C  I*4    N.R.      JDATE       C  I*4    N.R.      JNEXT       C  I*4    N.R.
  JNPM1        C  I*4     N.R.      JPMOD        C  I*4    N.R.      JSPP1       C  I*4    N.R.      JTEST       C  I*4    N.R.
  JYEAR        C  I*4     N.R.      MODPK        C  I*4    N.R.      NSTEP       C  I*4    N.R.      OMEGA  SF   C  I*2  019E00
  POLES        C  R*4     N.R.      PSIGN  F     C  R*4  000404      PTPOL  SF  XR  R*4  000000      PUIP1  SF       R*4  000178
  PUIS1  SF       R*4   00017C      PV1JM  SF       R*4  00018C      PV2JM  SF       R*4  000184      QTPOL  SF  XR  R*4  000000
  RADIM        C  R*4     N.R.      RHMAX        C  R*4    N.R.      SDPOL  SF   C  R*4  0057AC      SFLUX  SF       R*4  000188
  SHPOL       XF  R*4   000000      TFLUX  SF       R*4  00018C      THBAR       C  R*4    N.R.      TTPOL  SF  XR  R*4  000000
  UTPOL       XR  R*4   000000      VTPOL       XR  R*4  00000C      FRXPI#     XF  R*4  000000      ALBEDO      C  I*2    N.R.
 CONVPL  SF    C  R*4   005788     COSLON  F     C  R*4  0001C4      DTMULT      C  R*4    N.R.      DUMMYA      C  R*4    N.R.
 DUMMYC        C  R*4     N.R.     EXPBYK  F    XF  R*4  00000C      IALTER      C  I*4    N.R.      IMD2P1      C  I*4    N.R.
 ISTART        C  I*4     N.R.     ISWTCH        C  I*4    N.R.      JMONTH      C  I*4    N.R.      JP1MOD  S       I*4  000190
 JP2MOD  S        I*4   000194     JS1MOD  S        I*4  00019E      JS2MOD  S       I*4  00019C      MISUN       C  I*4    N.R.
 MNMXTS        C  I*4     N.R.     NCOMP3        C  I*4    N.R.      NCYCLE      C  I*4    N.R.      NMOGAN      C  I*4    N.R.
 NLAYM1   F    C  I*4   000024     NLAYP1        C  I*4    N.R.      NSTART      C  I*4    N.R.      PHISPL      C  R*4    N.R.
 PITPOL  SF    C  R*4   000000     PSKAPA        C  R*4    N.R.      PSMPOL      C  R*4    N.R.      QFLUX1  SF      R*4  0001A0
 QFLUX2  SF       R*4   0001A4     QSMPOL        C  R*4    N.R.      RSDIST      C  R*4    N.R.      SHTPOL     XR  R*4  000000
 SINLON   F    C  R*4   0000A4     TOFDAY        C  R*4    N.R.      XLABEL      C  R*4    N.R.

                                   *****  COMMON INFORMATION   *****

    NAME OF CCMMON BLOCK * F:U#.ZE OF BLOCKCOMMON      005E24 HEXADECIMAL BYTES

  VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE
       CON1    R*4   000000           CON2    R*4   000004           CON3    R*4     N.R.           CON4    R*4     N.R.
       CON5    R*4     N.R.          THBAR    R*4     N.R.          ALPHA    R*4     N.R.           BETA    R*4     N.R.
     IMD2P1    I*4     N.R.          ADLDP    R*4     N.R.           JMS2    I*4   000028           JMS1    I*4     N.R.
       CPTH    R*4     N.R.         PSKAPA    R*4     N.R.              R    R*4     N.R.            RAD    R*4     N.R.
         CP    R*4     N.R.            INC    I*4   000044         NSTART    I*4     N.R.           CPD2    R*4     N.R.
       IMD2    I*4     N.R.          RADIM    R*4     N.R.           JEND    I*4     N.R.            JP1    I*4   000060
        JP2    I*4   000064         MATSLN    I*4     N.R.          JNEXT    I*4     N.R.          MODPK    I*4     N.R.
       JPOL    I*4   000084          JPMOD    I*4     N.R.         SINLON    R*4   0000A4         COSLON    R*4   0001C4
      INDEX    I*4   0002E4          PSIGN    R*4   000404          POLES    R*4     N.R.              [illegible]    R*4     N.R.
         PK    R*4     N.R.           DIFF    R*4     N.R.         CONVPL    R*4   005788          SDPOL    R*4   0057AC
     PHISPL    R*4     N.R.            SUM    R*4   0057FC

    NAME OF COMMON BLOCK *  =M..ZE OF BLOCKCOMMON      000146 HEXADECIMAL BYTES

  VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE
        QSM    R*4     N.R.            PSM    R*4     N.R.         QSMPOL    R*4     N.R.         PSMPOL    R*4     N.R.

    NAME OF COMMON BLOCK *  ¬NTR#E OF BLOCKCOMMON      083C30 HEXADECIMAL BYTES

  VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE
        JSP    I*4   000000            JNP    I*4   000004             IM    I*4   000008           NLAY    I*4   00000C
       PTOP    R*4   000010         ISTART    I*4     N.R.          JSPP1    I*4     N.R.          JNPM1    I*4     N.R.
        FIM    R*4     N.R.         NLAYM1    I*4   000024         NLAYP1    I*4     N.R.             J1    I*4     N.R.
         JM    I*4   000030             KM    I*4     N.R.           TAUT    R*4     N.R.           IROT    I*4     N.R.
       MROT    I*4     N.R.          JTEST    I*4     N.R.          ITEST    I*4     N.R.             NR    I*4     N.R.
       JAYS    I*4     N.R.           INCS    I*4     N.R.            JSB    I*4     N.R.            JNB    I*4     N.R.
       DLAT    R*4     N.R.           DLON    R*4     N.R.             DT    R*4   00008C            TAU    R*4     N.R.
       ITAU    I*4     N.R.           XINT    R*4     N.R.           IDAY    I*4     N.R.           JDAY    I*4     N.R.
     TOFDAY    R*4     N.R.          JDATE    I*4     N.R.         JMONTH    I*4     N.R.          JYEAR    I*4     N.R.
      NSTEP    I*4     N.R.         NCYCLE    I*4     N.R.         NCOMP3    I*4     N.R.         NMOGAN    I*4     N.R.
       TAUP    R*4     N.R.           TAUI    R*4     N.R.           TAUE    R*4     N.R.           TAUD    R*4     N.R.
     DTMULT    R*4     N.R.             PI    R*4     N.R.           GRAV    R*4     N.R.           RGAS    R*4     N.R.
       KAPA    R*4     N.R.            PSL    R*4     N.R.             ED    R*4     N.R.            FMU    R*4     N.R.
       NFLW    I*4     N.R.            PSF    R*4     N.R.           MRCH    I*4     N.R.         RSDIST    R*4     N.R.
       SIND    R*4     N.R.           COSD    R*4     N.R.          RHMAX    R*4     N.R.            CDX    R*4     N.R.
     DUMMYC    R*4     N.R.         IALTER    I*4     N.R.         DUMMYA    R*4     N.R.         XLABEL    R*4     N.R.
        SIG    R*4   000370           DSIG    R*4   0003C0           SIGE    R*4     N.R.          DSIGO    R*4     N.R.
       J1PS    I*4     N.R.           JMPS    I*4     N.R.           J1US    I*4     N.R.           JMUS    I*4     N.R.
       KSBS    I*4     N.R.           KNBS    I*4     N.R.            LAT    R*4     N.R.            DXU    R*4     N.R.
        DXP    R*4   000728            DYU    R*4   0007E0            DYP    R*4     N.R.           DXYP    R*4   000950
          F    R*4     N.R.           SINL    R*4     N.R.           COSL    R*4     N.R.          DUMMY    R*4     N.R.
       PHIS    R*4   000D50         ALBEDO    I*2     N.R.

 EQUIVALENCED VARIABLES WITHIN THIS CCMMCN GROUP
   VARIABLE OFFSETE               VARIABLE OFFSETE               VARIABLE OFFSETE               VARIABLE OFFSETE
         TS    001890                  SHS    002300                    C    000000
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  NAME OF CCMMON BLOCK * C;M79*E OF ELOCKCOMMON      000C08 HEXADECIMAL BYTES

VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE
  PITPOL     R*4    000000

  NAME OF CCMMON BLOCK *  *W6R*E OF ELCCKCOMMON      01D1C0 HEXADECIMAL BYTES

VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE
    CONV     R*4    000000

EQUIVALENCED VARIABLES WITHIN THIS CCMMCN GROUP
  VARIABLE OFFSETE             VARIABLE OFFSETE             VARIABLE OFFSETE             VARIABLE OFFSETE
      SD     000000                  PIT    000900

  NAME OF CCMMON BLOCK *  =O*S*E OF ELOCKCOMMON      081600 HEXADECIMAL BYTES

VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE
      PU     R*4    000000

EQUIVALENCED VARIABLES WITHIN THIS COMMON GROUP
  VARIABLE OFFSETE             VARIABLE OFFSETE             VARIABLE OFFSETE             VARIABLE OFFSETE
      GT     000840                  G*     0016EC

  NAME CF CCMMON BLOCK *  *DS_?E OF BLOCKCOMMON      000C04 HEXADECIMAL BYTES

VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE
  ISWTCH     I*4       N.R.

  NAME CF CCMMON BLOCK * S*OT'9E OF ELOCKCOMMON      0385AE HEXADECIMAL BYTES

VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE
    SDOT     R*4    000000         OMEGA   I*2    019E00         MNMXTS    I*4      N.R.          RADT    I*2      N.R.
    COMG     L*4    0389A4

EQUIVALENCED VARIABLES WITHIN THIS CCMMCN GROUP
  VARIABLE OFFSETE             VARIABLE OFFSETE             VARIABLE OFFSETE             VARIABLE OFFSETE
   ISDOT     00CF00

  NAME OF CCMMON BLOCK *  *S6¬"E OF ELCCKCOMMON      000C08 HEXADECIMAL BYTES

VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE
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    LABEL   ADDR            LABEL   ADDR            LABEL   ADDR            LABEL   ADDR
     2150  0009B2            2154  000AD4            2158  000B04            2160  000C28
      110  000D7A             100  000DF6            2223  000E32            2220  000E4C
     2225  000E7C             115  000FC4             120  001034            2230  001084
     2240  001120            2290  001138            2400  00123E            2237  001276
      126  0014AC            2255  001550            2250  001588            2405  0015A0
     2410  001628            2420  00173E            2430  0018A6            2440  0018CC
     2450  00199A            2455  001A58            2456  001B0E            2470  001C4E
     2480  001D92            2490  001D86            2600  001DE6            2505  001E82
     2510  002006            2520  0020A2            2500  002120            2530  00226A
     2538  002284            2539  0022FC            2537  002376            2550  00243E
     2540  002508

*OPTIONS IN EFFECT*      NAME=  MAIN,OPT=02,LINECNT=55,SIZE=1000K,

*OPTIONS IN EFFECT*      SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,NOXREF

*STATISTICS*     SOURCE STATEMENTS =     284  PROGRAM SIZE=     10242

*STATISTICS*  NO  DIAGNOSTICS GENERATED

****** END OF COMPILATION ******                               788K BYTES OF CORE NOT USED

 LEVEL 19.6-APR 71                          OS/360 FORTRAN H AT GISS                              DATE 12/12/79-0783.61

        COMPILER OPTIONS -   NAME=  MAIN,OPT=02,LINECNT=55,SIZE=1000K,
                             SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,NOXREF
   ISN 0002             SUBROUTINE COMP2(J,V,T,SH,P,Q,UPOL,VPOL,TPOL,SHPOL,PPOL,QPOL,        B4M16110
                       $   UT,VT,TT,SHT,PT,QT,UTPOL,VTPOL,TTPOL,SHTPOL,PTPOL,QTPOL,J1)       B4M16120
   ISN 0003             COMMON/FOURTH/CON1,CON2,CON3,CON4,CONS,THBAR,ALPHA,BETA,IMD2P1,     B4M16130
                       $   ADLDP,JMS2,JMS1,CPTH,PSKAPA,R,RAD,CP,INC,NSTART,CPD2,             B4M16140
                       $   IMD2,RADIM,JEND(2),JP1,JP2,MATSUN,JNEXT(2),MODPK(2,2),            B4M16150
                       $   JPOL(2,2),JPMOD(2,2),SINLON(72),COSLON(72),INDEX(72),             B4M16160
                       $   PSIGN(4),POLES(148),W(72,9,5),PK(72,9,3),DIFF(9),                 B4M16170
                       $   CONVPL(9),SDPOL(9,2),PHISPL(2),SUM(2,2)                           B4M16180
   ISN 0004             DIMENSION PPOL(2),PITPOL(2),UPOL(36,1),VPOL(36,1),TPOL(36,1),       B4M16190
                       $   SHPOL(36,1),QPOL(9,4,2),Q(72,10,4,1)                              B4M16200
   ISN 0005             DIMENSION PTPOL(2),UTPOL(36,1),VTPOL(36,1),TTPOL(36,1),             B4M16210
                       $   SHTPOL(36,1),QTPOL(9,4,2),QT(72,10,4,1)                           B4M16220
   ISN 0006             COMMON/SMITH/QSM(72,9,4,5),PSM(72,5),QSMPOL(9,4,2),PSMPOL(2)        B4M16230
   ISN 0007             INTEGER*2 ALBEDO                                                    B4M16240
   ISN 0008             REAL*4 KAPA,LAT                                                     B4M16250
                   C    REAL*8 SINLON,COSLON,SUM                                            B4M16260
   ISN 0009             REAL*8 PL1,PL2,PK1,PK2                                              B4M16270
   ISN 0010             DIMENSION DD(73),EE(73)                                             B4M16280
   ISN 0011             COMMON [illegible]RL/                                               B4M16290
                       *  JSP,JNP,IM,NLAY,PTOP,ISTART,JSPP1,JNPM1,FIM,NLAYM1,NLAYP1,         B4M16300
                       *  J1,JM,KM,TAUT,IROT,NROT,JTEST,ITEST,                               B4M16310
                       *  NR,JAYS(12),INCS(11),JSB,JNB,DLAT,DLON,                            B4M16320
                       *  DT,TAU,ITAU,XINT,IDAY,JDAY,TOFDAY,JDATE,JMONTH(2),JYEAR,NSTEP,     B4M16330
                       *  NCYCLE,NCOMP3,NMOGAN,TAUP,TAUI,TAUE,TAUO,DTMULT,                   B4M16340
                       *  PI,GRAV,RGAS,KAPA,PSL,ED,FMU,NFLW,PSF,ARCH,RSDIST,SIND,COSD,       B4M16350
                       *  RHMAX,CDX,DUMMYC(18),IALTER,DUMMYA(99),                            B4M16360
                       *  XLABEL(20),SIG(20),DSIG(20),SIGE(21),DSIGO(19),                    B4M16370
                       *  JIPS(11),JMPS(11),JIUS(11),JMUS(11),KSES(11),KNBS(11),             B4M16380
                       *LAT(46),DXU(46),DXP(46),DYU(46),DYP(46),DXYP(46),F(46),SINL(46),     B4M16390
                       *COSL(46),DUMMY(72),PHIS(2880,46),ALBEDO(72,46)                       B4M16400
   ISN 0012             DIMENSION U(72,40,1),V(72,40,1),T(72,40,1),SH(72,40,1),             B4M16410
                       *P(2880,1),    TS(2880,1),SHS(2880,1),GT(2880,1),GW(2880,1),C(300)    B4M16420
   ISN 0013             EQUIVALENCE (TS(1,1),PHIS(721,1)),(SHS(1,1),PHIS(1441,1)),          B4M16430
                       $   (GT(1,1),PU(721,1)),(GW(1,1),PU(1441,1)),(C(1),JSP)               B4M16440
   ISN 0014             COMMON/WORK/ CONV(72,9,46)                                          B4M16450
   ISN 0015             COMMON/WORK2/PU(2880,46)                                            B4M16460
   ISN 0016             DIMENSION UT(72,40,1),VT(72,40,1),TT(72,40,1),SHT(72,40,1),         B4M16470
                       *PT(2880,1),PHI(72,9,5),PIT(648,1)                                    B4M16480
   ISN 0017             EQUIVALENCE                                                         B4M16490
                       $   (PIT(1,1),CONV(1,9,1))                                            B4M16500
   ISN 0018             COMMON /DBUG/ISWTCH                                                 B4M16510
                   C                                                                        B4M16520
   ISN 0019             COMMON/SDOT48/SDOT(72,46,8),OMEGA(72,46,5),MNMXTS,RADT(72,46,10)    B4M16530
                       + ,COMG                                                               B4M16540
   ISN 0020             LOGICAL COMG                                                        B4M16550
                   C                                                                        B4M16560
   ISN 0021             INTEGER*2 RADT,OMEGA                                                B4M16570
   ISN 0022             INTEGER*2 ISDOT(72,46,8)                                            B4M16580
                   C                                                                        B4M16590
   ISN 0023             EQUIVALENCE (SDOT(1,1,5),ISDOT(1,1,1))                              B4M16600
                   C                                                                        B4M16610
   ISN 0024             COMMON/SMOO/ISMTH,NPC                                               B4M16620
   ISN 0025             COMMON/COMP12/PITPOL                                                B4M16630
   ISN 0026             TTHBAR = 2.*THBAR                                                   B4M16640
   ISN 0027             JP2 = J + 2                                                         B4M16650
   ISN 0028             JP1 = J + 1                                                         B4M16660
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ISN 0029           JS1 = J - 1                                                              B4M16670
ISN 0030           JS2 = J - 2                                                              B4M16680
ISN 0031           JP2MOD = MOD(JP2-1.5) + 1                                                B4M16690
ISN 0032           JP1MOD = MOD(JP1-1.5) + 1                                                B4M16700
ISN 0033           JMOD = MOD(J-1.5) + 1                                                    B4M16710
ISN 0034           JS1MOD = MOD(JS1-1.5) + 1                                                B4M16720
ISN 0035           JS2MOD = MOD(JS2-1.5) + 1                                                B4M16730
             C * * *                                                                        B4M16740
ISN 0036           JPKP2 = MOD(JP2-1.3) + 1                                                 B4M16750
ISN 0037           JPKP1 = MOD(JP1-1.3)  + 1                                                B4M16760
ISN 0038           JPK = MOD(J-1.3) + 1                                                     B4M16770
ISN 0039           DTKAPA = DT * KAPA                                                       B4M16780
ISN 0040           IF(J.GT.1)                     GO TO 3001                                B4M16790
ISN 0042           JP2 = 1                                                                  B4M16800
ISN 0043           JP2MOD = 1                                                               B4M16810
ISN 0044           JPKP2 = 1                                                                B4M16820
ISN 0045                                          GO TC 3005                                B4M16830
             C                                                                            * B4M16840
             C * * * CORIOLIS FORCE FOR 4TH ORDER DCES NOT FOLLO  GISS                    * B4M16850
             C * * * METHOD OF COMPUTATION                                                * B4M16860
             C * * * ADLOP = (12 * RAD * DLAT * DLON = 12. * DYU(J) * DLON)               * B4M16870
             C                                                                            * B4M16880
             C                                                                              B4M16890
ISN 0046       3001 DO 3000 L = 1.NLAY                                                      B4M16900
ISN 0047           DO 3000 I = INC.IM.INC                                                   B4M16910
ISN 0048           FX = DT * (F(J) * DXYP(J) + ADLOF * SINL(J) * U(I.L.J))                  B4M16920
ISN 0049           UT(I.L.J) = UT(I.L.J) + FX * P(I.J) * V(I.L.J)                           B4M16930
ISN 0050           VT(I.L.J) = VT(I.L.J) - FX * P(I.J) * U(I.L.J)                           B4M16940
ISN 0051       3000                               CONTINUE                                  B4M16950
             C                                                                            * B4M16960
             C * * *              M A I N     L O O P                                     * B4M16970
             C                                                                            * B4M16980
ISN 0052           IF(J.GT.JM) GO TO 3032                                                   B4M16990
             C                                                                              B4M17000
ISN 0054       3005    DO 3030 LX = 1.NLAY                                                  B4M17010
ISN 0055           L = NLAYP1 - LX                                                          B4M17020
ISN 0056           LP1 = L + 1                                                              B4M17030
             C                                                                              B4M17040
ISN 0057           IF(J.EQ.1.OR.J.EQ.JNP) GO TO 3141                                        B4M17050
             C                                                                              B4M17060
             C     COMPUTATION OF THE ENERGY TERM FOR THE THERMODYNAMIC                     B4M17070
             C     EQUATION FOR J=2.3.....JM-1.JM                                           B4M17080
             C                                                                              B4M17090
             C     SET UP CYCLIC I-INDICES                                                  B4M17100
             C                                                                              B4M17110
ISN 0059           IS2 = IM - 3                                                             B4M17120
ISN 0060           IS1 = IM - 2                                                             B4M17130
ISN 0061           I = IM - 1                                                               B4M17140
ISN 0062           IP1 = IM                                                                 B4M17150
             C                                                                              B4M17160
             C     SET UP J-INDICES                                                         B4M17170
             C                                                                              B4M17180
ISN 0063           NDXJP2 = JP2                                                             B4M17190
ISN 0064           IF(J.EQ.JM) NDXJP2 = JM                                                  B4M17200
             C                                                                              B4M17210
ISN 0066           NDXJS2 = JS2                                                             B4M17220
ISN 0067           IF(J.EQ.2) NDXJS2 = 2                                                    B4M17230
             C                                                                              B4M17240
             C     PERFORM CALCULATIONS                                                     B4M17250
             C                                                                              B4M17260
ISN 0069           DO 3140 IP2 = INC, IM, INC                                               B4M17270
             C                                                                              B4M17280
ISN 0070           SKT = DTKAPA*SIG(L)*T(I.L.J)/(PTCP+SIG(L)*P(I.J))                        B4M17290
ISN 0071           PIV = DXP(J)*V(I.L.J)                                                    B4M17300
             C                                                                              B4M17310
             C     SET UP PROPER I-INDEX AND PRESSURE TERMS                                 B4M17320
             C                                                                              B4M17330
ISN 0072           NDXI = I                                                                 B4M17340
ISN 0073           IF(J.EQ.JM) NDXI = INDEX(I)                                              B4M17350
ISN 0075           G1 = P(NDXI.NDXJP2)                                                      B4M17360
             C                                                                              B4M17370
ISN 0076           NDXI = I                                                                 B4M17380
ISN 0077           IF(J.EQ.2) NDXI = INDEX(I)                                               B4M17390
ISN 0079           G2 = P(NDXI.NDXJS2)                                                      B4M17400
             C                                                                              B4M17410
ISN 0080           TT(I.L.J) = TT(I.L.J) + SKT*P(I.J)*(PIT(I.J) + DYU(J) *                  B4M17420
                 1        U(I.L.J)*(8.*(P(IP1.J)-P(IS1.J)) - P(IP2.J) +                     B4M17430
                 1        P(IS2.J)) + PIV*(8.*(P(I.JP1)-P(I.JS1)) - G1 + G2))               B4M17440
             C                                                                              B4M17450
             C     RESET CYCLIC INDICES                                                     B4M17460
             C                                                                              B4M17470
ISN 0081           IS2 = IS1                                                                B4M17480
ISN 0082           IS1 = I                                                                  B4M17490
ISN 0083           I = IP1                                                                  B4M17500
ISN 0084           IP1 = IP2                                                                B4M17510
             C                                                                              B4M17520
ISN 0085     3140  CONTINUE                                                                 B4M17530
             C                                                                              B4M17540
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ISN 0086      3141  CONTINUE                                                       B4M17550
              C                                                                    B4M17560
ISN 0087            IF(J.EQ.JM) GO TO 3030                                         B4M17570
              C                                                                    B4M17580
              C                                                                  * B4M17590
              C * * * COMPUTE PK AT LATITUDE JP2 (USING GISS METHOD)             * B4M17600
              C                                                                  * B4M17610
ISN 0089            IF(L.LT.NLAY)                     GO TC 3055                   B4M17620
              C                                                                    B4M17630
ISN 0091       3C07    DO 3010 I = 1,IM                                            B4M17640
ISN 0092            PL1 = SIGE(1) * P(I,JP2) + PTOP                                B4M17650
ISN 0093            PK1 = PL1 * EXPBYK(PL1)                                        B4M17660
ISN 0094            LL = 1                                                         B4M17670
ISN 0095               DO 3010 LLP1 = 2,NLAYP1                                     B4M17680
ISN 0096            PL2 = SIGE(LLP1) * P(I,JP2) + PTOP                             B4M17690
ISN 0097            PK2 = PL2 * EXPBYK(PL2)                                        B4M17700
ISN 0098            PK(I,LL,JPKP2) = (PK2 - PK1) / (DIFF(LL) * P(I,JP2))          B4M17710
ISN 0099            PK1 = PK2                                                      B4M17720
ISN 0100            LL = LLP1                                                      B4M17730
ISN 0101       3010                                   CONTINUE                     B4M17740
              C                                                                  * B4M17750
              C * * * COMPUTATION OF PHI (GEOPOTENTIAL) AT JP2 FOR L=NLAY,       * B4M17760
              C * * * PSKAPA=1000*K, SIGE(1)=0.                                  * B4M17770
              C * * * HERE PHI IS NORMALIZED,I.E.,EQUALS (STANDARD PHI)-PHIBAR.  * B4M17780
              C                                                                  * B4M17790
ISN 0102            IF (L .LT. NLAY)                  GO TC 3055                   B4M17800
ISN 0104            DO 3050 I = INC,IM,INC                                         B4M17810
ISN 0105            PHI(I,L,JP2MOD) = PHIS(I,JP2) + CPTH*(PK(I,L,JPKP2) - PSKAPA)  B4M17820
              C                                                                    B4M17830
ISN 0106            LLM1 = 1                                                       B4M17840
ISN 0107            DO 3050 LL = 1,NLAY                                            B4M17850
ISN 0108            LLP1 = LL + 1                                                  B4M17860
ISN 0109            IF(LL.EQ.NLAY)  LLP1 = LL                                      B4M17870
              C                                                                    B4M17880
ISN 0111            DUM1 = DSIG(LL)*(PK(I,LLP1,JPKP2) - PK(I,LL,JPKP2))            B4M17890
              C                                                                    B4M17900
ISN 0112            DUM2 = SIGE(LL)*(PK(I,LLP1,JPKP2) - PK(I,LLM1,JPKP2))          B4M17910
              C                                                                    B4M17920
ISN 0113            WL = SIG(LL) * P(I,JP2)                                        B4M17930
ISN 0114            DUM3 = WL * R * DSIG(LL) / (WL + PTOP)                         B4M17940
ISN 0115            LLM1 = LL                                                      B4M17950
              C                                                                    B4M17960
ISN 0116            PHI(I,L,JP2MOD) = PHI(I,L,JP2MOD)+(DUM3-(PD2*                  B4M17970
                   1  (DUM1+DUM2)/PK(I,LL,JPKP2))*T(I,LL,JP2)                      B4M17980
ISN 0117       3050                                   CONTINUE                     B4M17990
ISN 0118                                              GO TC 3065                   B4M18000
              C                                                                  * B4M18010
              C * * * COMPUTATION OF PHI AT JP2                                  * B4M18020
              C                                                                  * B4M18030
ISN 0119       3055 DO 3060 I = INC,IM,INC                                         B4M18040
ISN 0120            PHI(I,L,JP2MOD) = PHI(I,LP1,JP2MOD) + CPD2 * (PK(I,LP1,JPKP2) - B4M18050
                  $    PK(I,L,JPKP2))                                              B4M18060
                  $    * (    (T(I,L,JP2)/PK(I,L,JPKP2)+T(I,LP1,JP2) /             B4M18070
                  $ PK(I,LP1,JPKP2)) - THBAR)                                      B4M18080
ISN 0121       3C60                                   CONTINUE                     B4M18090
              C                                                                  * B4M18100
              C * * * FOR PHI(I,L,0) USE INDEX(I)                                * B4M18110
              C * * * COMPUTE W(I,L,JP2MOD) FOR PRESSURE GRADIENT TERM AND SKT.  * B4M18120
              C * * * PIV FOR ENERGY TERM IN THERMODYNAMICS EQ.                  * B4M18130
              C                                                                  * B4M18140
ISN 0122      3065  IF(JP2.EQ.1.OR.JP2.EQ.JNP) GO TO 3030                          B4M18150
ISN 0124            DO 3070 I = INC,IM,INC                                         B4M18160
ISN 0125            TBAR = THBAR * PK(I,L,JPKP2)                                   B4M18170
ISN 0126            TPRIME = T(I,L,JP2) - TBAR                                     B4M18180
ISN 0127            PRESUR = PTOP + SIG(L) * P(I,JP2)                              B4M18190
ISN 0128            W(I,L,JP2MOD) = SIG(L) * R * TPRIME / PRESUR                   B4M18200
ISN 0129       3070                                   CONTINUE                     B4M18210
ISN 0130                                              GO TO 3030                   B4M18220
              C                                                                  * B4M18230
              C * * * IF (J=1) RETURN AND COMPUTE PHI(I,L,2),W(I,L,2)......      * B4M18240
              C * * * FOR SOUTH POLE CALCULATIONS                                * B4M18250
              C                                                                  * B4M18260
ISN 0131       3030                                   CONTINUE                     B4M18270
ISN 0132            IF(J.GE.JM)                       GO TC 3032                   B4M18280
ISN 0134       3074 IF(JP2.GE.3)                      GO TC 3032                   B4M18290
ISN 0136            JP2 = JP2 + 1                                                  B4M18300
ISN 0137            JP2MOD = JP2MOD + 1                                            B4M18310
ISN 0138            JPKP2 = JPKP2 + 1                                              B4M18320
ISN 0139                                              GO TC 3005                   B4M18330
              C                                                                  * B4M18340
              C     PRESSURE GRADIENT (V EQUATION) FCR J=2                         B4M18350
              C                                                                  * B4M18360
ISN 0140       3032 DO 3031 LX = 1,NLAY                                            B4M18370
ISN 0141            L = NLAYP1 - LX                                                B4M18380
ISN 0142            IF(J.EQ.1) GO TO 3111                                          B4M18390
ISN 0144       3080 IF (J .GT. 2)                     GO TC 3085                   B4M18400
              C                                                                    B4M18410
ISN 0146            DO 3083 I=INC,IM,INC                                           B4M18420
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               C                                                                        B4M18430
ISN 0147             PIV = DXP(J) * V(I,L,J)                                            B4M18440
ISN 0148             F1 = PHI(INDEX(I),L,J)                                             B4M18450
ISN 0149             G1 = P(INDEX(I),J)                                                 B4M18460
ISN 0150             F2 = PHI(I,L,1)                                                    B4M18470
ISN 0151             G2 = P(I,1)                                                        B4M18480
ISN 0152             W1 = W(I,L,J)                                                      B4M18490
ISN 0153             VT(I,L,J) = VT(I,L,J) + DT * DXP(J) * P(I,J) * (8.                B4M18500
                    $   * (F2 - PHI(I,L,JP1MOD) + W1 * (G2 - P(I,JP1)))                 B4M18510
                    $   +(PHI(I,L,JP2MOD) - F1 + W1 * (P(I,JP2) - G1)))                 B4M18520
ISN 0154        3083                               CONTINUE                             B4M18530
               C                                                                      * B4M18540
               C * * * COMPUTATION OF THE PRESSURE GRADIENT FOR ZONAL (U)             * B4M18550
               C * * * MOMENTUM EQ.                                                   * B4M18560
               C                                                                      * B4M18570
ISN 0155        3085 IS2 = IM - 3                                                       B4M18580
ISN 0156             IS1 = IM - 2                                                       B4M18590
ISN 0157             I = IM - 1                                                         B4M18600
ISN 0158             IP1 = IM                                                           B4M18610
ISN 0159             DO 3090 IP2 = INC,IM,INC                                           B4M18620
ISN 0160             W1 = W(I,L,JMOD)                                                   B4M18630
               C * * * NEXT TWO LINES HAVE ADDED (I)'S                                  B4M18640
ISN 0161             UT(I,L,J) = UT(I,L,J) + DT * DYU(J) * P(I,J) * (8.                 B4M18650
                    $   * (PHI(IS1,L,JMOD) - PHI(IP1,L,JMOD) + W1 * (P(IS1,J)            B4M18660
                    $   -P(IP1,J)))+(PHI(IP2,L,JMOD)-PHI(IS2,L,JMOD)+W1                 B4M18670
                    $   *(P(IP2,J)-P(IS2,J))))                                          B4M18680
ISN 0162             IS2 = IS1                                                          B4M18690
ISN 0163             IS1 = I                                                            B4M18700
ISN 0164             I = IP1                                                            B4M18710
ISN 0165             IP1 = IP2                                                          B4M18720
ISN 0166        3090                               CONTINUE                             B4M18730
ISN 0167             IF (J .EQ. 2.OR.J .EQ. JM)    GO TO 3135                           B4M18740
               C                                                                      * B4M18750
               C * * * COMPUTATION OF THE PRESSURE GRADIENT FOR                       * B4M18760
               C * * * MERIDONAL (V) MOMENTUM EQ.                                     * B4M18770
               C                                                                      * B4M18780
ISN 0169             DO 3100 I = INC,IM,INC                                             B4M18790
ISN 0170             W1 = W(I,L,JMOD)                                                   B4M18800
ISN 0171             VT(I,L,J) = VT(I,L,J) + DT * DXP(J) * P(I,J) * (8.                 B4M18810
                    $   * (PHI(I,L,JS1MOD) - PHI(I,L,JP1MOD) + W1 * (P(I,JS1)            B4M18820
                    $   - P(I,JP1))) +(PHI(I,L,JP2MOD) - PHI(I,L,JS2MOD) + W1           B4M18830
                    $   * (P(I,JP2) - P(I,JS2))))                                       B4M18840
ISN 0172        3100                               CONTINUE                             B4M18850
               C                                                                      * B4M18860
ISN 0173        3135 IF(J.LT.JM)                   GO TO 3031                           B4M18870
               C                                                                      * B4M18880
               C     PRESSURE GRADIENT FOR J=JM                                         B4M18890
               C                                                                        B4M18900
ISN 0175             DO 3150 I=INC,IM,INC                                               B4M18910
               C                                                                        B4M18920
ISN 0176             G1 = P(I,JM)                                                       B4M18930
ISN 0177             G2 = P(I,JNP)                                                      B4M18940
ISN 0178             G3 = P(INDEX(I),JM)                                                B4M18950
ISN 0179             W1 = W(I,L,JMOD)                                                   B4M18960
ISN 0180             VT(I,L,JM) = VT(I,L,JM) + DT * DXP(JM) *  G1 * (8.                 B4M18970
                    $   * (PHI(I,L,JS1MOD) - PHI(I,L,JP1MOD) + W1 * (P(I,JS1)            B4M18980
                    $   - G2)) +(PHI(INDEX(I),L,JMOD) - PHI(I,L,JS2MOD) + W1            B4M18990
                    $   * (G3 - P(I,JS2))))                                             B4M19000
ISN 0181        3150                               CONTINUE                             B4M19010
               C                                                                      * B4M19020
               C * * * CALCULATIONS AT THE POLES                                      * B4M19030
               C                                                                      * B4M19040
               C * * * MOMENTUM AND TEMPERATURE AT SOUTH POLE (M = 1) AND AT           * B4M19050
               C * * * NORTH POLE (M = 2).                                            * B4M19060
               C * * * (K = 1) CORRESPONDS TO THE LATITUDE LINE NEAREST THE POLE       * B4M19070
               C * * * JPMOD(K,M)=(2,3,MOD(JM-1,5)+1,MOD((JM-1)-1,5)+1                * B4M19080
               C * * *  CON3 = 4.*DT/(3.*RAD*IM*SIN(.5*DLAT))                         * B4M19090
               C * * *  CON4 = DT/(3.*RAD*IM*SIN(DLAT))                               * B4M19100
               C * * *  CON5 = 1./(3.*RAD*IM*DLAT)                                    * B4M19110
               C                                                                      * B4M19120
ISN 0182        3111 M = 1                                                              B4M19130
ISN 0183             IF (J .EQ. JM)                M = 2                                B4M19140
ISN 0185             JKP = 1                                                            B4M19150
ISN 0186             IF(M.EQ.2) JKP = JNP                                               B4M19160
ISN 0188             JP2 =1                                                             B4M19170
ISN 0189             JP2MOD = 1                                                         B4M19180
ISN 0190             JFKP2 = 1                                                          B4M19190
               C                                                                      * B4M19200
               C * * * CORIOLIS TERM AT THE POLES                                     * B4M19210
               C                                                                      * B4M19220
ISN 0191             F1 = F(JEND(M)) * PPOL(M)                                          B4M19230
ISN 0192             UTPOL(L,M) = UTPOL(L,M) + DT * F1 * VPOL(L,M)                      B4M19240
ISN 0193             VTPOL(L,M) = VTPOL(L,M) - DT * F1 * UPOL(L,M)                      B4M19250
ISN 0194             COEF1 = (-1) ** M                                                  B4M19260
ISN 0195             DO 3200 N = 1,3                                                    B4M19270
ISN 0196             DO 3200 K = 1,2                                                    B4M19280
ISN 0197             SUM(K,N) = 0.                                                      B4M19290
ISN 0198        3200                               CONTINUE                             B4M19300
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                 C  -                                                                     *   B4M19310
                 C * * * 7/31/78 USING PHILLIPS GEOPOTENTIAL AT POLES **                  *   B4M19320
                 C * * * PRESSURE GRADIENT AND ENERGY CONVERSION TERMS FOR                *   B4M19330
                 C * * * MOMENTUM,TEMPERATURE EQUATIONS                                   *   B4M19340
                 C * * * JPMOD(K,M) = (2,3,MOD(JM-1,5)+1),MOD((JM-1)-1,5)+1               *   B4M19350
                 C * * * MODJPK(K,M) = (2,3,MOD(JM-1,3)+1,MOD(JM-2,3)+1                   *   B4M19360
                 C                                                                        *   B4M19370
 ISN 0199              PRPOL = SIG(L) * PPOL(M) + PTOP                                        B4M19380
 ISN 0200              SKTPOL = SIG(L) * KAPA * TPOL(L,M) / PRPOL                             B4M19390
 ISN 0201              WPOL = W(1,L,JP2MOD)                                                   B4M19400
                 C                                                                            B4M19410
                 C     COMPUTE SUMMATION FOR TEMPERATURE EQUATION                             B4M19420
                 C                                                                            B4M19430
 ISN 0202              DO 3211 I=1,IM                                                         B4M19440
 ISN 0203        3211  SUM(1,3) = SUM(1,3) + (COEF1*UPOL(L,M)*COSLON(I)                       B4M19450
                     1  + VPOL(L,M)*SINLON(I))*(8.*P(I,JPOL(1,M))-P(I,JPOL(2,M)))             B4M19460
                 C                                                                            B4M19470
                 C     MODIFY TEMPERATURE AT POLES                                            B4M19480
                 C                                                                            B4M19490
 ISN 0204              TTPOL(L,M) = TTPOL(L,M) + DT*SKTPOL*PPOL(M)*                           B4M19500
                     1     (PITPOL(M) + CON5*SUM(1,3))                                        B4M19510
                 C                                                                            B4M19520
 ISN 0205              DO 3210 I=1,IM                                                         B4M19530
 ISN 0206              DO 3220 K = 1,2                                                        B4M19540
 ISN 0207              JK = JPOL(K,M)                                                         B4M19550
 ISN 0208              JKMOD = JPMOD(K,M)                                                     B4M19560
 ISN 0209              MOD3J = MODPK(K,M)                                                     B4M19570
 ISN 0210              TERM = PHI(I,L,JKMOD) + WPOL*P(I,JK)                                   B4M19580
 ISN 0211              SUM(K,1) = SUM(K,1) + COSLON(I) * TERM                                 B4M19590
 ISN 0212              SUM(K,2) = SUM(K,2) + SINLON(I) * TERM                                 B4M19600
 ISN 0213         3220                          CONTINUE                                      B4M19610
 ISN 0214         3210                          CONTINUE                                      B4M19620
 ISN 0215                 DO 3222 K = 1,2                                                     B4M19630
 ISN 0216              SUM(K,2) = COEF1 * SUM(K,2)                                            B4M19640
 ISN 0217         3222                          CONTINUE                                      B4M19650
 ISN 0218              DO 3225 N = 1,2                                                        B4M19660
                 C     CHANGED SIGN BELOW TO -                                                B4M19670
 ISN 0219              QTPOL(L,N,M)=QTPOL(L,N,M)-PPOL(M)*(-CON3*SUM(1,N)+                     B4M19680
                     $   CON4 * SUM(2,N))                                                     B4M19690
 ISN 0220         3225                          CONTINUE                                      B4M19700
                 C                                                                            B4M19710
 ISN 0221              OMEGA(1,JKP,L) = OMEGA(1,JKP,L)+SIG(L)*(PITPOL(M)+CON5*SUM(1,3))       B4M19720
 ISN 0222         3031                          CONTINUE                                      B4M19730
 ISN 0223                                       RETURN                                        B4M19740
 ISN 0224                                       END                                           B4M19750

                                                       /    COMP2 /     SIZE OF PROGRAM 005398 HEXADECIMAL BYTES

NAME TAG TYPE ADD.   |= ***    % NAME TAG TYPE ADD.   |= ***    % NAME TAG TYPE ADD.   |= ***    % NAME TAG TYPE ADD.   |= ***    %
      C      CE  R*4   000000          F  F    C  R*4   000A08          I SF         I*4   0000DC          J  FA        I*4   0000E0
      K SF       I*4   0000E4          L SF       I*4   0000E8          M SF         I*4   0000EC          N SF         I*4   0000F0
      P  F   XR  R*4   000000          Q       XR R*4   000000          R  F    C    R*4   000038          T  F    XR   R*4   000000
      U  F   XR  R*4   000000          V  F    XR R*4   000000          W SF    C    R*4   000664         CP        C    R*4     N.R.
     DD          R*4     N.R.         DT  F    C  R*4   0000B0         ED       C    R*4     N.R.         EE             R*4     N.R.
     FX SF       R*4   0000F4         F1 SF       R*4   0000F8         F2 SF         R*4   0000FC         GT        CE   R*4   000840
     GW      CE  R*4   001680         G1 SF       R*4   000100         G2 SF         R*4   000104         G3 SF         R*4   000108
     IM  F   C   I*4   000008         JK SF       I*4   00010C         JM  F    C    I*4   000030         J1        C    I*4     N.R.
     KM      C   I*4     N.R.         LL SF       I*4   000110         LX SF         I*4   000114         NR        C    I*4     N.R.
     PI      C   R*4     N.R.         PK SF    C  R*4   003904         PT       XR   R*4   000000         PU        CE   R*4   000000
     QT      XR  R*4   000000         SH       XR R*4   000000         TS       CE   R*4   001890         TT SF     XR   R*4   000000
     UT SF   XR  R*4   000000         VT SF    XR R*4   000000         WL SF         R*4   000118         W1 SF         R*4   00011C
    CDX      C   R*4     N.R.        DXP  F    C  R*4   000728        DXU       C    R*4     N.R.        DYP        C    R*4     N.R.
    DYU  F   C   R*4   0007E0        FIM       C  R*4     N.R.        FMU       C    R*4     N.R.        INC  F     C    I*4   000044
    IP1 SF       I*4   000120        IP2 SF       I*4   000124        IS1 SF         I*4   000128        IS2 SF         I*4   00012C
    JKP SF       I*4   000130        JNB       C  I*4     N.R.        JNP  F    C    I*4   000004        JPK S          I*4   000134
    JP1 SFA  C   I*4   000060        JP2 SFA   C  I*4   000064        JSB       C    I*4     N.R.        JSP       CE   I*4   000000
    JS1 SFA      I*4   000138        JS2 SFA      I*4   00013C        LAT       C    R*4     N.R.        LP1 SF         I*4   000140
    NPC      C   I*4     N.R.        PHI SF       R*4   0001E0        PIT  F   CE    R*4   000900        PIV SF         R*4   000144
    PK1 SF       R*8   0001C0        PK2 SF       R*8   0001C8        PL1 SFA        R*8   0001D0        PL2 SFA        R*8   0001D8
    PSF      C   R*4     N.R.        PSL       C  R*4     N.R.        PSM       C    R*4     N.R.        QSM        C    R*4     N.R.
    RAD      C   R*4     N.R.        SHS      CE  R*4   0023D0        SHT      XR    R*4   000000        SIG  F     C    R*4   000370
    SKT SF       R*4   000148        SUM SF    C  R*4   0057F0        TAU       C    R*4     N.R.       BETA        C    R*4     N.R.
   COMG      C   L*4   0389A4       CONV      CE  R*4   000000       CON1       C    R*4     N.R.       CON2        C    R*4     N.R.
   CON3  F   C   R*4   000008       CON4  F    C  R*4   00000C       CON5  F    C    R*4   000010       COSD        C    R*4     N.R.
   COSL      C   R*4     N.R.       CPD2  F    C  R*4   000040       CPTH  F    C    R*4   000030       DIFF  F     C    R*4   005764
   DLAT      C   R*4     N.R.       DLON       C  R*4     N.R.       DSIG  F    C    R*4   0003C0       DUM1 SF         R*4   00014C
   DUM2 SF       R*4   000150       DUM3 SF       R*4   000154       DXYP  F    C    R*4   000950       GRAV        C    R*4     N.R.
   IDAY      C   I*4     N.R.       IMO2       C  I*4     N.R.       INCS       C    I*4     N.R.       IROT        C    I*4     N.R.
   ITAU      C   I*4     N.R.       JAYS       C  I*4     N.R.       JDAY       C    I*4     N.R.       JEND  F     C    I*4   000058
   JMOD SF       I*4   000158       JMPS       C  I*4     N.R.       JMS1       C    I*4     N.R.       JMS2        C    I*4     N.R.
   JMUS      C   I*4     N.R.       JPOL  F    C  I*4   000084       J1PS       C    I*4     N.R.       J1US        C    I*4     N.R.
   KAPA  F   C   R*4   000118       KNBS       C  I*4     N.R.       KSBS       C    I*4     N.R.       LLM1 SF         I*4   00015C
   LLP1 SF       I*4   000160       MRCH       C  I*4     N.R.       MROT       C    I*4     N.R.       NDX1 SF         I*4   000164
   NFLW      C   I*4     N.R.       NLAS  F    C  I*4   000000       PHIS  F   CE    R*4   000D50       PPOL  F    XR   R*4   000000
   PTOP  F   C   R*4   000010       GPOL      XR  R*4   000000       RADT       C    I*2     N.R.       RGAS        C    R*4     N.R.
   SDOT     CE   R*4   000000       SIGE  F    C  R*4   000410       SIND       C    R*4     N.R.       SINL  F     C    R*4   000AC0
   TAUE      C   R*4     N.R.       TAUI       C  R*4     N.R.       TAUO       C    R*4     N.R.       TAUP        C    R*4     N.R.
   TAUT      C   R*4     N.R.       TBAR SF       R*4   000168       TERM SF         R*4   00016C       TPOL  F    XR   R*4   000000
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   UPOL  F   XR  R*4  000030        VPOL  F   XR  R*4  00000C        WPOL SF        R*4  000170        XINT        C   R*4    N.R.
  ADLDP  F    C  R*4  000024       ALPHA       C  R*4    N.R.        COEF1 SF        R*4  000174       COMP2            R*4  000178
  DSIGO       C  R*4    N.R.       DUMMY       C  R*4    N.R.        INDEX  F    C  I*4  0002E4       ISDOT       CE  I*2  00CF00
  ISMTH       C  I*4    N.R.       ITEST       C  I*4    N.R.        JDATE       C  I*4    N.R.       JKMOD  SF       I*4  00017C
  JNEXT       C  I*4    N.R.       JNPM1       C  I*4    N.R.        JPKP1 S         I*4  000180      JPKP2  SF       I*4  000184
  JPMOD  F    C  I*4  000094       JSPP1       C  I*4    N.R.        JTEST       C  I*4    N.R.       JYEAR       C   I*4    N.R.
  MODPK  F    C  I*4  000074       MOD3J S        I*4  00018E        NSTEP       C  I*4    N.R.       OMEGA  SF   C   I*2  019E00
  POLES       C  R*4    N.R.       PRPOL SF       R*4  00018C        PSIGN       C  R*4    N.R.       PTPOL       XR  R*4  000000
  QTPOL SF   XR  R*4  000000       RADIM       C  R*4    N.R.        RHMAX       C  R*4    N.R.       SOPOL       C   R*4    N.R.
  SHPOL      XR  R*4  000000       THBAR  F    C  R*4  000014        TTPOL SF   XR  R*4  000000       UTPOL  SF   XR  R*4  000000
  VTPOL SF   XR  R*4  000000      FIXPI#      XF  I*4  000000       ALBEDO       C  I*2    N.R.      CONVPL       C   R*4    N.R.
 COSLON  F    C  R*4  0001C4      DTKAPA SF       R*4  00019C       DTMULT       C  R*4    N.R.      DUMMYA       C   R*4    N.R.
 DUMMYC       C  R*4    N.R.      EXPDYK  F   XF  R*4  00000C       IALTER       C  I*4    N.R.      IMD2P1       C   I*4    N.R.
 ISTART       C  I*4    N.R.      ISWTCH       C  I*4    N.R.       JMONTH       C  I*4    N.R.      JP1MOD SF        I*4  000194
 JP2MOD SF       I*4  000198      JS1MOD SF       I*4  00019C       JS2MOD SF       I*4  0001A0      MATSUN       C   I*4    N.R.
 MNMXTS       C  I*4    N.R.      NCOMP3       C  I*4    N.R.       NCYCLE       C  I*4    N.R.      NDXJP2 SF        I*4  0001A4
 NDXJS2 SF       I*4  0001A8      NHOGAN       C  I*4    N.R.       NLAYM1       C  I*4    N.R.      NLAYP1  F    C   I*4  000028
 NSTART       C  I*4    N.R.      PHISPL       C  R*4    N.R.       PITPOL  F    C  R*4  000000      PRESUR SF        R*4  0001AC
 PSKAPA  F    C  R*4  000034      PSMPOL       C  R*4    N.R.       QSMPOL       C  R*4    N.R.      RSDIST       C   R*4    N.R.
 SHTPOL      XR  R*4  000000      SINLON  F    C  R*4  0000A4       SKTPOL SF       R*4  000180      TOFDAY       C   R*4    N.R.
 TPRIME SF       R*4  000184      TTHBAR SF       R*4  00018E       XLABEL       C  R*4    N.R.

                                   *****   COMMON INFORMATION   *****

    NAME OF COMMON BLOCK * F:U#.ZE OF BLOCKCOMMON      005E24 HEXADECIMAL BYTES

  VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE
     CON1     R*4     N.R.            CON2     R*4     N.R.            CON3     R*4   000008           CON4     R*4   00000C
     CONS     R*4   000010           THBAR     R*4   000014           ALPHA     R*4     N.R.           BETA     R*4     N.R.
   IMD2P1     I*4     N.R.           ADLDP     R*4   000024            JMS2     I*4     N.R.           JMS1     I*4     N.R.
     CPTH     R*4   000030          PSKAPA     R*4   000034               R     R*4   000038            RAD     R*4     N.R.
       CP     R*4     N.R.             INC     I*4   000044          NSTART     I*4     N.R.           CPD2     R*4   00004C
     IMD2     I*4     N.R.           RADIM     R*4     N.R.            JEND     I*4   000058            JP1     I*4   000060
      JP2     I*4   000064          MATSUN     I*4     N.R.           JNEXT     I*4     N.R.          MODPK     I*4   000074
     JPOL     I*4   000084           JPMOD     I*4   000094          SINLON     R*4   0000A4         COSLON     R*4   0001C4
    INDEX     I*4   0002E4           PSIGN     R*4     N.R.           POLES     R*4     N.R.              W     R*4   000664
       PK     R*4   003904            DIFF     R*4   005764          CONVPL     R*4     N.R.          SOPOL     R*4     N.R.
   PHISPL     R*4     N.R.             SUM     R*4   005 7FC

    NAME OF COMMON BLOCK *  =M..ZE OF BLOCKCOMMON      00D14E HEXADECIMAL BYTES

  VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE
      QSM     R*4     N.R.             PSM     R*4     N.R.          QSMPOL     R*4     N.R.         PSMPOL     R*4     N.R.

    NAME OF COMMON BLOCK *  ¬NTR#E OF BLOCKCOMMON      083C30 HEXADECIMAL BYTES

  VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE
      JSP     I*4   000000             JNP     I*4   000004              IM     I*4   000008           NLAY     I*4   00000C
     PTOP     R*4   000010          ISTART     I*4     N.R.           JSPP1     I*4     N.R.          JNPM1     I*4     N.R.
      FIM     R*4     N.R.          NLAYM1     I*4     N.R.          NLAYP1     I*4   000028             J1     I*4     N.R.
       JM     I*4   000030              KM     I*4     N.R.            TAUT     R*4     N.R.           IROT     I*4     N.R.
     MROT     I*4     N.R.           JTEST     I*4     N.R.           ITEST     I*4     N.R.             NR     I*4     N.R.
     JAYS     I*4     N.R.            INCS     I*4     N.R.             JSB     I*4     N.R.            JNB     I*4     N.R.
     DLAT     R*4     N.R.            ULON     R*4     N.R.              DT     R*4   0000BC            TAU     R*4     N.R.
     ITAU     I*4     N.R.            XINT     R*4     N.R.            IDAY     I*4     N.R.           JDAY     I*4     N.R.
   TOFDAY     R*4     N.R.           JDATE     I*4     N.R.          JMONTH     I*4     N.R.          JYEAR     I*4     N.R.
    NSTEP     I*4     N.R.          NCYCLE     I*4     N.R.          NCOMP3     I*4     N.R.         NHOGAN     I*4     N.R.
     TAUP     R*4     N.R.            TAUI     R*4     N.R.            TAUE     R*4     N.R.           TAUO     R*4     N.R.
   DTMULT     R*4     N.R.              PI     R*4     N.R.            GRAV     R*4     N.R.           RGAS     R*4     N.R.
     KAPA     R*4   000118             PSL     R*4     N.R.              ED     R*4     N.R.            FMU     R*4     N.R.
     NFLW     I*4     N.R.             PSF     R*4     N.R.            MRCH     I*4     N.R.         RSDIST     R*4     N.R.
     SIND     R*4     N.R.            COSD     R*4     N.R.           RHMAX     R*4     N.R.            CDX     R*4     N.R.
   DUMMYC     R*4     N.R.          IALTER     I*4     N.R.          DUMMYA     R*4     N.R.         XLABEL     R*4     N.R.
      SIG     R*4   000370            DSIG     R*4   0003C0            SIGE     R*4   000410          DSIGO     R*4     N.R.
     J1PS     I*4     N.R.            JMPS     I*4     N.R.            J1US     I*4     N.R.           JMUS     I*4     N.R.
     KSBS     I*4     N.R.            KNES     I*4     N.R.             LAT     R*4     N.R.            DXU     R*4     N.R.
      DXP     R*4   000728             DYU     R*4   0007E0             DYP     R*4     N.R.           DXYP     R*4   000950
        F     R*4   000A08            SINL     R*4   000AC0            COSL     R*4     N.R.          DUMMY     R*4     N.R.
     PHIS     R*4   000050          ALBEDO     I*2     N.R.
  EQUIVALENCED VARIABLES WITHIN THIS COMMON GROUP
    VARIABLE OFFSETE               VARIABLE OFFSETE               VARIABLE OFFSETE               VARIABLE OFFSETE
        TS     001890                  SHS     002300                    C     000000

    NAME OF COMMON BLOCK *  #W6R#E OF BLOCKCOMMON      01D1C0 HEXADECIMAL BYTES

  VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE
     CONV     R*4   000000

  EQUIVALENCED VARIABLES WITHIN THIS COMMON GROUP
    VARIABLE OFFSETE               VARIABLE OFFSETE               VARIABLE OFFSETE               VARIABLE OFFSETE
       PIT     000900
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  NAME OF COMMON BLOCK *  =0#S#E OF BLOCKCOMMON     081600 HEXADECIMAL BYTES

VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE
     PU     R*4   000000

EQUIVALENCED VARIABLES WITHIN THIS COMMON GROUP
  VARIABLE OFFSETE              VARIABLE OFFSETE              VARIABLE OFFSETE              VARIABLE OFFSETE
     GT    000B40                     G*    00168C

  NAME OF COMMON BLOCK *  *DS_?E OF BLOCKCOMMON     000004 HEXADECIMAL BYTES

VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE
  ISWTCH     I*4      N.R.

  NAME OF COMMON BLOCK * S*OT'9E OF BLOCKCOMMON     0389A8 HEXADECIMAL BYTES

VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE
    SDOT    R*A   000000           OMEGA    I*2   019E00          MNMXTS     I*4      N.R.           RADT    I*2      N.R.
    CONG    L*4   0389A4

EQUIVALENCED VARIABLES WITHIN THIS COMMON GROUP
  VARIABLE OFFSETE              VARIABLE OFFSETE              VARIABLE OFFSETE              VARIABLE OFFSETE
   ISDOT    00CF00

  NAME OF COMMON BLOCK *  *S6¬"E OF BLOCKCOMMON     000008 HEXADECIMAL BYTES

VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE
   ISMTH     I*6      N.R.             NPC     I*4      N.R.

  NAME OF COMMON BLOCK * C:M79#E OF BLOCKCOMMON     00000E HEXADECIMAL BYTES

VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE
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    LABEL  ADDR          LABEL  ADDR          LABEL  ADDR          LABEL  ADDR
     3001  0039E8         3000  003ABE         3005  003AFA         3140  003E18
     3141  003E34         3007  003E58         3010  003F68         3050  004132
     3055  004176         3060  004258         3065  00427A         3070  00435A
     3030  00437E         3074  0043AE         3032  0043E2         3089  004552
     3083  0046CC         3085  0046F0         3090  004856         3100  0049F4
     3135  004A16         3150  004B76         3111  004B98         3200  004CDA
     3211  004DC6         3220  004F0A         3210  004F2E         3222  004F6C
     3225  004FE6         3031  005058

*OPTIONS IN EFFECT*      NAME=  MAIN,OPT=02,LINECNT=55,SIZE=1000K,
*OPTIONS IN EFFECT*      SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,NOXREF
*STATISTICS*     SOURCE STATEMENTS =     223  PROGRAM SIZE=     21400
*STATISTICS*  NO  DIAGNOSTICS GENERATED
****** END OF COMPILATION ******
LEVEL 19.6-APR 71                                                    808K BYTES OF CORE NOT USED
                                              OS/360 FORTRAN H AT GISS
     COMPILER OPTIONS -   NAME=  MAIN,OPT=02,LINECNT=55,SIZE=1000K,                              DATE 12/12/79-0783
                          SOURCE,EBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,ID,NOXREF
  ISN 0002            SUBROUTINE AVRX(U,V,T,SH,P,Q,J)                                     B4M19760
                C**** FINE NINE LAYER GLOBAL CDE BLOCK FOR VN MODEL, FEBRUARY 1976        B4M19770
  ISN 0003            INTEGER*2 ALBEDO                                                    B4M19780
  ISN 0004            REAL*4 KAPA,LAT                                                     B4M19790
                C     REAL*8 SINLON,COSLON,SUM                                            B4M19800
  ISN 0005            COMMON/FOURTH/CON1,CON2,CON3,CON4,CON5,THBAR,ALPHA,BETA,IND2P1,    B4M19810
                     $   ADLDP,JMS2,JMS1,CPTH,PSKAPA,R,RAD,CP,INC,NSTART,CPD2,            B4M19820
                     $   IND2,RADIN,JEND(2),JP1,JP2,MATSUN,JNEXT(2),MODPK(2,2),           B4M19830
                     $   JPOL(2,2),JPMOD(2,2),SINLON(72),COSLON(72),INDEX(72),            B4M19840
                     $   PSIGN(4),POLES(148),W(72,9,5),PK(72,9,3),DIFF(9),                B4M19850
                     $   CONVPL(9),SDPOL(9,2),PHISPL(2),SUM(2,5)                          B4M19860
  ISN 0006            COMMON /CNTRL/                                                      B4M19870
                     *  JSP,JNP,IM,NLAY,PTOP,ISTART,JSPP1,JNPM1,FIM,NLAYM1,NLAYP1,        B4M19880
                     *  J1,JM,KM,TAUT,IRCT,MFOT,JTEST,ITEST,                              B4M19890
                     *  NR,JAYS(12),INCS(11),JSB,JNB,DLAT,DLON,                           B4M19900
                     *  DT,TAU,ITAU,XINT,IDAY,JDAY,TOFDAY,JDATE,JMONTH(2),JYEAR,NSTEP,    B4M19910
                     *  NCYCLE,NCOMP3,NHOGAN,TAUP,TAUI,TAUE,TALO,DTMUL,                   B4M19920
                     *  PI,GRAV,RGAS,KAPA,PSL,ED,FMU,NFLW,PSF,MRCH,RSDIST,SIND,COSD,      B4M19930
                     *  RHMAX,CDX,DUMMYC(18),IALTER,DUMMYA(99),                           B4M19940
                     *  XLABEL(20),SIG(20),DSIG(20),SIGE(21),DSIGO(19),                   B4M19950
                     *  JIPS(11),JMPS(11),J1US(11),JMUS(11),KSES(11),KNBS(11),            B4M19960
                     *LAT(46),DXU(46),DXP(46),DYU(46),DYP(46),DXYP(46),F(46),SINL(46),    B4M19970
                     *COSL(46),DUMMY(72),PHIS(2880,46),ALBEDO(72,46)                      B4M19980
  ISN 0007            DIMENSION U(72,40,1),V(72,40,1),T(72,40,1),SH(72,40,1),             B4M19990
                     *P(2880,1),TS(2880,1),SHS(2880,1),GT(2880,1),GW(2880,1),C(300)       B4M20000
  ISN 0008            EQUIVALENCE (TS(1,1),PHIS(721,1)),(SHS(1,1),PHIS(1441,1)),          B4M20010
                     $   (GT(1,1),PU(721,1)),(GW(1,1),PU(1441,1)),(C(1),JSP)              B4M20020
  ISN 0009            DIMENSION PPOL(2),PITPOL(2),UPOL(36,1),VPOL(36,1),TPOL(36,1),       B4M20030
                     $   SHPOL(36,1),QPOL(9,4,2),Q(72,10,4,1)                             B4M20040
  ISN 0010            EQUIVALENCE (QPOL(1,1,1),POLES(1)),                                 B4M20050
                     $   (UPOL(1,1),POLES(1)),(VPOL(1,1),POLES(10)),(TPOL(1,1),           B4M20060
                     $   POLES(19)),(SHPOL(1,1),POLES(28)),                               B4M20070
                     $   (PPOL(1),POLES(145))                                             B4M20080
  ISN 0011            COMMON/INSMSH/F5D6,F17,F98                                          B4M20090
  ISN 0012            COMMON /DBUG/ISWTCH                                                 B4M20100
  ISN 0013            COMMON/SMOO/ISMTH,NPC                                               B4M20110
  ISN 0014            COMMON/S/JMIN,JMAX,JSUM,SMTH(37,17)                                 B4M20120
  ISN 0015            COMPLEX TRAN(37)                                                    B4M20130
  ISN 0016            EQUIVALENCE(TRAN(1),DATA(1))                                        B4M20140
  ISN 0017            COMMON/WORK2/PU(2880,46)                                            B4M20150
  ISN 0018            COMMON/SMOTH/DATA(150),CATA(150),SLP(72,46)                         B4M20160
  ISN 0019            SLEXP(PHI,T10) = EXP(PHI / (T10 + F98 * PHI ) / 287.)               B4M20170
  ISN 0020            T10(PP,T8,T9) = (T8 * ALOG((F17 * PP + PTOP) / (PP + PTOP))         B4M20180
                     $   + T9 * ALOG((PP + PTOP) / (F5D6 * PP + PTOP)))                   B4M20190
                     $   / ALOG((F17 * PP + PTOP) / (F5D6 * PP + PTOP))                   B4M20200
  ISN 0021            MISS = 1                                                            B4M20210
  ISN 0022            IF (MISS.EQ.1)                  GO TO 50                            B4M20220
  ISN 0024            INC = 1                                                             B4M20230
  ISN 0025            DRAT=DYU(J)/DXP(J)                                                  B4M20240
  ISN 0026            IF(DRAT.LT.1.) GO TO 40                                             B4M20250
  ISN 0028            ALP=.125*(DRAT-1.)                                                  B4M20260
  ISN 0029            NM=DRAT                                                             B4M20270
  ISN 0030            FNM=NM                                                              B4M20280
  ISN 0031            ALPM=ALP/FNM                                                        B4M20290
  ISN 0032            DO 30 N=1,4                                                         B4M20300
  ISN 0033            DO 30 L = 1,NLAY                                                    B4M20310
  ISN 0034            IMINC=IM-INC                                                        B4M20320
  ISN 0035            I=IM                                                                B4M20330
  ISN 0036            DO 10 IPINC=INC,IM,INC                                              B4M20340
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ISN 0037          DUMMY(I)=Q(I.L.N.J)+ALPH*(Q(IPINC.L.N.J)+Q(IMINC.L.N.J)-                B4M20350
                $     Q(I.L.N.J)-Q(I.L.N.J))                                               B4M20360
ISN 0038          IMINC=I                                                                  B4M20370
ISN 0039       10 I=IPINC                                                                  B4M20380
ISN 0040          DO 20 I=INC.IM.INC                                                       B4M20390
ISN 0041       20 Q(I.L.N.J)=DUMMY(I)                                                      B4M20400
ISN 0042       30 CONTINUE                                                                 B4M20410
ISN 0043          IMINC = IM - INC                                                         B4M20420
ISN 0044          I = IM                                                                   B4M20430
ISN 0045              DO 35 IPINC = INC.IM.INC                                             B4M20440
ISN 0046          DUMMY(I)=P(I.J)+ALPH*(P(IPINC.J)+P(IM[illegible]-P(I.J)-P(I.J))         B4M20450
ISN 0047          IMINC = I                                                                B4M20460
ISN 0048       35 I = IPINC                                                                B4M20470
ISN 0049              DO 40 I = INC.IM.INC                                                 B4M20480
ISN 0050          P(I.J) = DUMMY(I)                                                        B4M20490
ISN 0051       40 CONTINUE                                                                 B4M20500
ISN 0052                                          GO TO 60                                 B4M20510
             C                                                                           * B4M20520
             C * * * FOURIER SMOOTHING NEAR POLES                                        * B4M20530
             C12/12 VERSION 3 SMSHAP ON P AND T.                                         * B4M20540
ISN 0053       50 IF(((J.GT.JMIN).AND.(J.LT.JMAX)).OR. J.EQ.1 .OR. J.EQ.JNP) RETURN        B4M20550
ISN 0055          JSUB = J - 1                                                             B4M20560
ISN 0056          IF(J.GE.JMAX)                           JSUB=JSUM - J - 1                B4M20570
ISN 0058              DO 650 N = 1.4                                                       B4M20580
             C        N = (2**NN) / 2                                                      B4M20590
ISN 0059              DO 650 L = 1.NLAY                                                    B4M20600
ISN 0060              DO 650 I = 1.IM                                                      B4M20610
ISN 0061          DATA(I) = Q(I.L.N.J)                                                     B4M20620
ISN 0062      650                                 CONTINUE                                 B4M20630
ISN 0063                                          CALL FOURT2(CATA.IM.1.-1.0)              B4M20640
ISN 0064              DO 670 I = 1.IMD2P1                                                  B4M20650
ISN 0065          TRAN(I) = SMTH(I.JSUB) * TRAN(I)                                         B4M20660
ISN 0066      670                                 CONTINUE                                 B4M20670
ISN 0067                                          CALL FOURT2(TRAN.IM.1.+1.-1)             B4M20680
ISN 0068              DO 680 I = 1.IM                                                      B4M20690
ISN 0069          Q(I.L.N.J) = DATA(I) / FLOAT(IM)                                         B4M20700
ISN 0070      680                                 CONTINUE                                 B4M20710
ISN 0071      650                                 CONTINUE                                 B4M20720
             C        IF( J.EQ.JM)                CALL SMSHAP                              B4M20730
ISN 0072       60                                 CONTINUE                                 B4M20740
ISN 0073              DO 100 I = 1.IM                                                      B4M20750
ISN 0074          SLP(I.J) = P(I.J)                                                        B4M20760
ISN 0075      100                                 CONTINUE                                 B4M20770
             C                                                                           * B4M20780
             C * * * TRANSFORM TO SEA LEVEL PRESSURE                                     * B4M20790
             C                                                                           * B4M20800
ISN 0076              DO 110 I = 1.IM                                                      B4M20810
ISN 0077          TSURF = T10(SLP(I.J).T(I.NLAYM1.J).T(I.NLAY.J))                          B4M20820
ISN 0078          SLP(I.J) = (SLP(I.J) + PTOP) * SLEXP(PHIS(I.J).TSURF)                    B4M20830
ISN 0079      110                                 CONTINUE                                 B4M20840
ISN 0080          IF(IM.GT.0)GO TO 781                                                     B4M20850
ISN 0082          DO 760 I=1.IM                                                            34M20860
ISN 0083          DATA(I)=SLP(I.J)                                                         B4M20870
ISN 0084      760 CONTINUE                                                                 B4M20880
ISN 0085          CALL FOURT2(DATA.IM.1.-1.0)                                              B4M20890
ISN 0086          DO 770 I=1.IMD2P1                                                        B4M20900
ISN 0087          TRAN(I)=SMTH(I.JSUB)*TRAN(I)                                             B4ME0910
ISN 0088      770 CONTINUE                                                                 B4M20920
ISN 0039          CALL FOURT2(TRAN.IM.1.1.-1)                                              B4M20930
ISN 0090          DO 780 I=1.IM                                                            B4M20940
ISN 0091          SLP(I.J)=DATA(I)/FLOAT(IM)                                               B4M20950
ISN 0092      780 CONTINUE                                                                 B4M20960
ISN 0093      781 CONTINUE                                                                 B4M20970
             C                                                                           * B4M20980
             C * * * SMOOTHING ALONG LONGITUDE (SEE SMSHAP)                              * B4M20990
             C                                                                           * B4M21000
ISN 0094          NSM = 8                                                                  B4M21010
ISN 0095          IF( J.LT.8.OR.J.GT.JM-6)        NSM = 4                                  B4M21020
ISN 0097          IF( J.LT.6.OR.J.GT.JM-4)        NSM = 2                                  B4M21030
ISN 0099          IF( J.LT.4.OR.J.GT.JM-2)        NSM = 1                                  B4M21040
ISN 0101          SGN = (-1) ** NSM                                                        B4M21050
ISN 0102          CX = 4.** NSM                                                            B4M21060
ISN 0103              DO 130 I = 1.IM                                                      B4M21070
ISN 0104          DATA(I) = SLP(I.J)                                                       B4M21080
ISN 0105      130                                 CONTINUE                                 B4M21090
ISN 0106              DO 140 N = 1.NSM                                                     B4M21100
ISN 0107          I = IM                                                                   B4M21110
ISN 0108              DO 145 IP = 1.IM                                                     B4M21120
ISN 0109          CATA(I) = DATA(IP) - DATA(I)                                             B4M21130
ISN 0110          I = IP                                                                   B4M21140
ISN 0111      145                                 CONTINUE                                 B4M21150
ISN 0112          IS = IM                                                                  B4M21160
ISN 0113              DO 150 I = 1.IM                                                      B4M21170
ISN 0114          DATA(I) = CATA(I) - CATA(IS)                                             B4M21180
ISN 0115          IS = I                                                                   B4M21190
ISN 0116      150                                 CONTINUE                                 B4M21200
ISN 0117      140                                 CONTINUE                                 B4M21210
ISN 0118              DO 160 I = 1.IM                                                      B4M21220
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ISN 0119           SLP(I,J) = SLP(I,J) - SGN * CATA(I) / CX                                    B4M21230
ISN 0120       160                                CONTINUE                                     B4M21240
             C                                                                               * B4M21250
             C * * * TRANSFORM BACK TO SURFACE PRESSURE                                      * B4M21260
             C                                                                               * B4M21270
ISN 0121           MAXIT = 50                                                                  B4M21280
ISN 0122              DO 200  I = 1,IM                                                         B4M21290
ISN 0123           PSFC = SLP(I,J) - PTOP                                                      B4M21300
ISN 0124           PHISX = PHIS(I,J)                                                           B4M21310
ISN 0125              DO 210 NITX = 1,MAXIT                                                    B4M21320
ISN 0126           P1 = PSFC                                                                   B4M21330
ISN 0127           TSURF = T10(PSFC,T(I,NLAYM1,J),T(I,NLAY,J))                                 B4M21340
ISN 0128           PSFC = SLP(I,J) / SLEXP(PHISX,TSURF) - PTOP                                 B4M21350
ISN 0129           IF(ABS(PSFC-P1)/1000..LE.1.E-5)GO TO 230                                    B4M21360
ISN 0131       210                                CONTINUE                                     B4M21370
ISN 0132           PRINT 220,MAXIT,I,J                                                         B4M21380
ISN 0133       220 FORMAT(1X,'MORE THAN:',I5,'ITERATIONS FOF J=',I5,' I=',I5)                  B4M21390
ISN 0134       230 P(I,J) = PSFC                                                               B4M21400
ISN 0135       200                                CONTINUE                                     B4M21410
ISN 0136           RETURN                                                                      B4M21420
ISN 0137           END                                                                         B4M21430

                                            /     AVRX /      SIZE OF PROGRAM 00131A HEXADECIMAL BYTES

NAME TAG TYPE ADD.   |= ***    % NAME TAG TYPE ADD.   |= ***    % NAME TAG TYPE ADD.   |= ***    % NAME TAG TYPE ADD.   |= ***    %
      C       CE  R*4  000000          F         C  R*4    N.R.          I SFA        I*4  000198          J SFA        I*4  00019C
      L SF        I*4  0001A0          N SF         I*4  0001A4          P SF    XR   R*4  000000          Q SF    XR   R*4  000000
      R        C  R*4    N.R.          T   FA   XR  R*4  00000C          U       XR   R*4  000000          V       XR   R*4  000000
      W        C  R*4    N.R.         CP         C  R*4    N.R.         CX SF         R*4  0001A8         DT        C   R*4    N.R.
     ED        C  R*4    N.R.         GT        CE  R*4  00084C         GW       CE   R*4  001680         IM SFA    C   I*4  000008
     IP SF        I*4  0001AC         IS SF         I*4  0001B0         JM        C   I*4  000030         J1        C   I*4    N.R.
     KM        C  I*4    N.R.         NM SF         I*4  0001B4         NR        C   I*4    N.R.         PI        C   R*4    N.R.
     PK        C  R*4    N.R.         PU        CE  R*4  00000C         P1 S  A       R*4  0001B8         SM       XR   R*4  000000
     TS       CE  R*4  001890        ALP SF         R*4  0001BC        CDX        C   R*4    N.R.        DXP  F    C   R*4  000728
    DXU        C  R*4    N.R.        DYP         C  R*4    N.R.        DYU  F     C   R*4  0007E0        FIN       C   R*4    N.R.
    FMU        C  R*4    N.R.        FNM SF         R*4  0001C0        F17  FA    C   R*4  000004        F98  FA   C   R*4  000008
    INC SF     C  I*4  000044        JNB         C  I*4    N.R.        JNP        C   I*4  000004        JP1       C   I*4    N.R.
    JP2        C  I*4    N.R.        JSB         C  I*4    N.R.        JSP       CE   I*4  000000        LAT       C   R*4    N.R.
    NPC        C  I*4    N.R.        NSM SF         I*4  0001C4        PSF        C   R*4    N.R.        PSL       C   R*4    N.R.
    RAD        C  R*4    N.R.        SGN SF         R*4  0001C8        SHS       CE   R*4  002300        SIG       C   R*4    N.R.
    SLW SFA    C  R*4  0004B0        SUM         C  R*4    N.R.        TAU        C   R*4    N.R.        T10 S   ASF   R*4  000000
   ALPH SF        R*4  0001CC       AVRX            R*4  0001D0       BETA        C   R*4    N.R.       CATA SF    C   R*4  000258
   CON1        C  R*4    N.R.       CON2         C  R*4    N.R.       CON3        C   R*4    N.R.       CON4       C   R*4    N.R.
   CONS        C  R*4    N.R.       COSD         C  R*4    N.R.       COSL        C   R*4    N.R.       CPD2       C   R*4    N.R.
   CPTH        C  R*4    N.R.       DATA SFA CE     R*4  00000C       DIFF        C   R*4    N.R.       DLAT       C   R*4    N.R.
   DLON        C  R*4    N.R.       DRAT SF         R*4  0001D4       DSIG        C   R*4    N.R.       DXYP       C   R*4    N.R.
   F5D6   FA   C  R*4  000000       GRAV         C  R*4    N.R.       IDAY        C   I*4    N.R.       IMD2       C   I*4    N.R.
   INCS        C  I*4    N.R.       IROT         C  I*4    N.R.       ITAU        C   I*4    N.R.       JAYS       C   I*4    N.R.
   JDAY        C  I*4    N.R.       JEND         C  I*4    N.R.       JMAX        C   I*4  000004       JMIN       C   I*4  000000
   JMPS        C  I*4    N.R.       JMS1         C  I*4    N.R.       JMS2        C   I*4    N.R.       JMUS       C   I*4    N.R.
   JPOL        C  I*4    N.R.       JSUB SF         I*4  0001D8       JSUM  F     C   I*4  000008       J1PS       C   I*4    N.R.
   J1US        C  I*4    N.R.       KAPA         C  R*4    N.R.       KNBS        C   I*4    N.R.       KSBS       C   I*4    N.R.
   MISS S         I*4  0001DC       MRCH         C  I*4    N.R.       MROT        C   I*4    N.R.       NFLW       C   I*4    N.R.
   NITX SF        I*4  0001E0       NLAY   FA    C  I*4  00000C       PHIS  FA CE       R*4  003D50       PPOL      CE   R*4  006654
   PSFC SFA       R*4  0001E4       PTOP   FA    C  R*4  000010       QPOL       CE   R*4  000414       RGAS       C   R*4    N.R.
   SIGE        C  R*4    N.R.       SIND         C  R*4    N.R.       SINL        C   R*4    N.R.       SMTH  F    C   R*4  00000C
   TAUE        C  R*4    N.R.       TAUI         C  R*4    N.R.       TAUO        C   R*4    N.R.       TAUP       C   R*4    N.R.
   TAUT        C  R*4    N.R.       TPOL        CE  R*4  00045C       TRAN SFA   CE   C*8  000000       UPOL      CE   R*4  000414
   VPOL       CE  R*4  000438       XINT         C  R*4    N.R.      ADLDP        C   R*4    N.R.      ALPHA       C   R*4    N.R.
  DSIGO        C  R*4    N.R.      DUMMY SF      C  R*4  000C30      IMINC SF         I*4  0001E8      INDEX       C   I*4    N.R.
  IPINC SF        I*4  0001EC      ISMTH         C  I*4    N.R.      ITEST        C   I*4    N.R.      JDATE       C   I*4    N.R.
  JNEXT        C  I*4    N.R.      JNPM1         C  I*4    N.R.      JPMOD        C   I*4    N.R.      JSPP1       C   I*4    N.R.
  JTEST        C  I*4    N.R.      JYEAR         C  I*4    N.R.      MAXIT SF         I*4  0001F0      MODPK       C   I*4    N.R.
  NSTEP        C  I*4    N.R.      PHISX SFA        R*4  0001F4      POLES       CE   R*4  000414      PSIGN       C   R*4    N.R.
  RADIM        C  R*4    N.R.      RHMAX         C  R*4    N.R.      SDPOL        C   R*4    N.R.      SMPOL      CE   R*4  00048C
  SLEXP S    ASF  R*4  000000      THBAR         C  R*4    N.R.      TSURF SFA        R*4  0001F8     FRXPI#      XF   R*4  000000
 FIXPI#       XF  I*4  000000        EXP        XF  R*4  00000C       ALOG       XF   R*4  000000      CMPY#      XF   C*8  000000
 ALBEDO        C  I*2    N.R.     CONVPL         C  R*4    N.R.     COSLON        C   R*4    N.R.     DTMULT       C   R*4    N.R.
 DUMMYA        C  R*4    N.R.     DUMMYC         C  R*4    N.R.     FOURT2 SF    XF   R*4  000000     IALTER       C   I*4    N.R.
 IBCOM#       XF  I*4  000000     IMD2P1  F      C  I*4  000020     ISTART        C   I*4    N.R.     ISWTCH       C   I*4    N.R.
 JMONTH        C  I*4    N.R.     MATSUN         C  I*4    N.R.     NCOMP3        C   I*4    N.R.     NCYCLE       C   I*4    N.R.
 NMOGAN        C  I*4    N.R.     NLAYM1  FA     C  I*4  000024     NLAYP1        C   I*4    N.R.     NSTART       C   I*4    N.R.
 PHISPL        C  R*4    N.R.     PITPOL            R*4    N.R.     PSKAPA        C   R*4    N.R.     RSDIST       C   R*4    N.R.
 SINLON        C  R*4    N.R.     TOFDAY         C  R*4    N.R.     XLABEL        C   R*4    N.R.

                                  *****  COMMON INFORMATION   *****

    NAME OF COMMON BLOCK * F;U#,ZE OF BLOCKCOMMON      005E24 HEXADECIMAL BYTES

  VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE
       CON1  R*4      N.R.           CON2  R*4      N.R.           CON3  R*4      N.R.           CON4  R*4      N.R.
       CONS  R*4      N.R.          THBAR  R*4      N.R.          ALPHA  R*4      N.R.           BETA  R*4      N.R.
     IMD2P1  I*4    000020          ADLDP  R*4      N.R.           JMS2  I*4      N.R.           JMS1  I*4      N.R.
       CPTH  R*4      N.R.         PSKAPA  R*4      N.R.              R  R*4      N.R.            RAD  R*4      N.R.
         CF  R*4      N.R.            INC  I*4    000044         NSTART  I*4      N.R.           CPD2  R*4      N.R.
       IMD2  I*4      N.R.          RADIM  R*4      N.R.           JEND  I*4      N.R.            JP1  I*4      N.R.
        JP2  I*4      N.R.         MATSUN  I*4      N.R.          JNEXT  I*4      N.R.          MODPK  I*4      N.R.
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     JPOL    I*4     N.R.            JPMCD    I*4     N.R.           SINLUN   R*4   N.R.           CUSLJN   R*4   N.R.
    INDEX    I*4     N.R.            PSIGN    R*4     N.R.            POLES   R*4   003414              W   R*4   N.R.
       PK    R*4     N.R.             DIFF    R*4     N.R.           CONVPL   R*4   N.R.            SDPOL   R*4   N.R.
   PHISPL    R*4     N.R.              SUM    R*4     N.R.

 EQUIVALENCED VARIABLES WITHIN THIS COMMON GROUP
   VARIABLE OFFSETE                 VARIABLE OFFSETE                VARIABLE OFFSETE               VARIABLE OFFSETE
     QPOL    000414                   JPOL    000414                  VPOL    000438                 TPOL    00045C
    SHPOL    000480                   PPOL    000654

    NAME OF COMMON BLOCK *  ¬NTR*E OF BLOCKCOMMON      083C30 HEXADECIMAL BYTES

 VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE
      JSF    I*4    000000            JNP    I*4    000004            IM    I*4    000008           NLAY    I*4    00000C
     PTOP    R*4    000010         ISTART    I*4      N.R.         JSPP1    I*4      N.R.          JNPM1    I*4      N.R.
      FIM    R*4      N.R.         NLAYM1    I*4    000024        NLAYP1    I*4      N.R.             J1    I*4      N.R.
       JM    I*4    000030             KM    I*4      N.R.          TAUT    R*4      N.R.           IROT    I*4      N.R.
     MROT    I*4      N.R.          JTEST    I*4      N.R.         ITEST    I*4      N.R.             NP    I*4      N.R.
     JAYS    I*4      N.R.           INCS    I*4      N.R.           JSB    I*4      N.R.            JNB    I*4      N.R.
     DLAT    R*4      N.R.           DLON    R*4      N.R.            DT    R*4      N.R.            TAU    R*4      N.R.
     ITAU    I*4      N.R.           XINT    R*4      N.R.          IDAY    I*4      N.R.           JDAY    I*4      N.R.
   TOFDAY    R*4      N.R.          JDATE    I*4      N.R.        JMONTH    I*4      N.R.          JYEAR    I*4      N.R.
    NSTEP    I*4      N.R.         NCYCLE    I*4      N.R.        NCOMP3    I*4      N.R.         NMOGAN    I*4      N.R.
     TAUP    R*4      N.R.           TAUI    R*4      N.R.          TAUE    R*4      N.R.           TAUO    R*4      N.R.
   DTMULT    R*4      N.R.             PI    R*4      N.R.          GRAV    R*4      N.R.           RGAS    R*4      N.R.
     KAPA    R*4      N.R.            PSL    R*4      N.R.            SD    R*4      N.R.            FMU    R*4      N.R.
     NFLW    I*4      N.R.            PSF    R*4      N.R.          MRCH    I*4      N.R.         RSDIST    R*4      N.R.
     SIND    R*4      N.R.           COSD    R*4      N.R.         RHMAX    R*4      N.R.            CDX    R*4      N.R.
   DUMMYC    R*4      N.R.         IALTER    I*4      N.R.        DUMMYA    R*4      N.R.         XLABEL    R*4      N.R.
      SIG    R*4      N.R.           DSIG    R*4      N.R.          SIGE    R*4      N.R.          DSIGO    R*4      N.R.
     J1PS    I*4      N.R.           JMPS    I*4      N.R.          J1US    I*4      N.R.           JMUS    I*4      N.R.
     KSBS    I*4      N.R.           KNBS    I*4      N.R.           LAT    R*4      N.R.            DXU    R*4      N.R.
      DXP    R*4    000728            DYU    R*4    0007E0           DYP    R*4      N.R.           DXYP    R*4      N.R.
        F    R*4      N.R.           SINL    R*4      N.R.          COSL    R*4      N.R.          DUMMY    R*4    000C30
     PHIS    R*4    000050         ALBEDO    I*2      N.R.

 EQUIVALENCED VARIABLES WITHIN THIS COMMON GROUP
   VARIABLE OFFSETE                 VARIABLE OFFSETE                VARIABLE OFFSETE               VARIABLE OFFSETE
       TS    001890                    SHS    0023DC                     C    000000

    NAME OF COMMON BLOCK * I)S6.ZE OF BLOCKCOMMON      000C0C HEXADECIMAL BYTES

 VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE
     F5D6    R*4    000000            F17    R*4    000004           F98    R*4    000008

    NAME OF COMMON BLOCK *  *DS_?E OF BLOCKCOMMON      000C04 HEXADECIMAL BYTES

 VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE
   ISWTCH    I*4      N.R.

    NAME OF COMMON BLOCK *  *S6¬"E OF BLOCKCOMMON      000C08 HEXADECIMAL BYTES

 VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE
    ISMTH    I*4      N.R.            NPC    I*4      N.R.

    NAME OF COMMON BLOCK *  * SI.E OF BLOCKCOMMON      000SEC HEXADECIMAL BYTES

 VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE
     JMIN    I*4    000000           JMAX    I*4    000004          JSUM    I*4    000008           SMTH    R*4    00000C

    NAME OF COMMON BLOCK *  =O*S*E OF BLOCKCOMMON      081C00 HEXADECIMAL BYTES

 VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE
       PU    R*4    000000

 EQUIVALENCED VARIABLES WITHIN THIS COMMON GROUP
   VARIABLE OFFSETE                 VARIABLE OFFSETE                VARIABLE OFFSETE               VARIABLE OFFSETE
       GT    000840                     GW    0016EC

    NAME OF COMMON BLOCK *  =M6.ZE OF BLOCKCOMMON      003E70 HEXADECIMAL BYTES

 VAR. NAME TYPE REL. ADDR.HE    VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE   VAR. NAME TYPE REL. ADDR.HE
     DATA    R*4    000000           CATA    R*4    000258           SLP    R*4    000480

 EQUIVALENCED VARIABLES WITHIN THIS COMMON GROUP
   VARIABLE OFFSETE                 VARIABLE OFFSETE                VARIABLE OFFSETE               VARIABLE OFFSETE
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   LABEL   ADDR                LABEL   ADDR                LABEL   ADDR                LABEL   ADDR
      10   000464                 20   0004E6                 30   0004C6                 35   00056E
      40   0005AE                 50   0005CA                660   0006F0                670   000778
     680   0007F4                650   0007FA                 60   000822                100   00088A
     110   0009F6                760   000A38                770   000AE6                780   000B64
     781   000B6A                130   000C6C                145   000CA6                150   000CC6
     140   000CCC                160   000D14                210   000ECA                230   000EFC
     200   000F08

*OPTIONS IN EFFECT*       NAME=  MAIN.OPT=02.LINECNT=55.SIZE=1000K.

*OPTIONS IN EFFECT*       SOURCE.EBCDIC.NOLIST.NODECK.LOAD.MAP.NOEDIT.ID.NOXREF

*STATISTICS*     SOURCE STATEMENTS =      136   PROGRAM SIZE=      4122

*STATISTICS*  NO  DIAGNOSTICS GENERATED

****** END OF COMPILATION ******                                         848K BYTES OF CORE NOT USED

 LEVEL 19.6-APR 71                             OS/360 FORTRAN H AT GISS                              DATE 12/12/79-0783.96

        COMPILER OPTIONS -    NAME=  MAIN.OPT=02.LINECNT=55.SIZE=1000K.
                              SOURCE.EBCDIC.NOLIST.NODECK.LOAD.MAP.NOEDIT.ID.NOXREF
  ISN 0002            SUBROUTINE SMSHAP(T.P.Q.TPOL.PPOL.QPOL.PT.QT.PTPOL.QTPOL)                B4M21440
  ISN 0003            COMMON/WORK/POT(72.46.9)                                                  B4M21450
  ISN 0004            COMMON/FOURTH/CON1.CON2.CON3.CON4.CON5.THBAR.ALPHA.BETA.IMD2P1.           B4M21460
                   $     ADLOP.JMS2.JMS1.CPTH.PSKAPA.R.RAD.CP.INC.NSTART.CPD2.                  B4M21470
                   $     IMD2.RADIN.JEND(2).JP1.JP2.MATSUN.JNEXT(2).MODPK(2.2).                 B4M21480
                   $     JPOL(2.2).JPMOD(2.2).SINLON(72).COSLON(72).INDEX(72).                  B4M21490
                   $     PSIGN(4).POLES(148).W(72.9.5).PK(72.9.3).DIFF(9).                      B4M21500
                   $     CONVPL(9).SDPOL(9.2).PHISPL(2).SUM(2.5)                                B4M21510
  ISN 0005            DIMENSION PPOL(2).PITPOL(2).TPOL(36.1).QPOL(9.4.2).Q(72.10.4.1)           B4M21520
  ISN 0006            DIMENSION PTPOL(2).QTPOL(9.4.2).CT(72.10.4.1)                             B4M21530
  ISN 0007            INTEGER*2 ALBEDO                                                          B4M21540
  ISN 0008            REAL*4 KAPA.LAT                                                           B4M21550
              C       REAL*8 SINLON.COSLON.SUM                                                  B4M21560
  ISN 0009            DIMENSION T(72.40.1).PT(2880.1).                                          B4M21570
                     *P(2880.1).TS(2880.1).SHS(2880.1).GT(2880.1).GW(2880.1).C(300)             B4M21580
  ISN 0010            COMMON/WORK2/PU(2880.46)                                                  B4M21590
  ISN 0011            EQUIVALENCE                                                               B4M21600
                     1(TS(1.1).PHIS(721.1)).(SHS(1.1).PHIS(1441.1))                             B4M21610
                     2.(GT(1.1).PU(721.1)).(GW(1.1).PU(1441.1)).(C(1).JSP)                      B4M21620
  ISN 0012            COMMON /CNTRL/                                                            B4M21630
                   *   JSP.JNP.IM.NLAY.PTOP.ISTART.JSPP1.JNPM1.FIM.NLAYM1.NLAYP1.               B4M21640
                   *   J1.JM.KM.TAUT.IROT.MROT.JTEST.ITEST.                                     B4M21650
                   *   NR.JAYS(12).INCS(11).JSB.JNB.DLAT.DLON.                                  B4M21660
                   *   DT.TAU.ITAU.XINT.IDAY.JDAY.TOFDAY.JDATE.JMONTH(2).JYEAR.NSTEP.           B4M21670
                   *   NCYCLE.NCOMP3.NHOGAN.TAUP.TAUI.TAUE.TALO.DTMULT.                         B4M21680
                   *   PI.GRAV.RGAS.KAPA.PSL.ED.FMU.NFLW.PSF.ARCH.RSDIST.SIND.COSD.             B4M21690
                   *   RHMAX.CDX.DUMMYC(18).IALTER.DUMMYA(99).                                  B4M21700
                   *   XLABEL(20).SIG(20).DSIG(20).SIGE(21).DSIGO(19).                          B4M21710
                   *   J1PS(11).JMPS(11).J1US(11).JMUS(11).KSES(11).KNBS(11).                   B4M21720
                     *LAT(46).DXU(46).DXP(46).DYU(46).DYP(46).DXYP(46).F(46).SINL(46).          B4M21730
                     *COSL(46).DUMMY(72).PHIS(2880.46).ALBEDO(72.46)                            B4M21740
  ISN 0013            COMMON/SMOTH/DATA(150).CATA(150).SLP(72.46)                               B4M21750
  ISN 0014            COMMON/INSMSH/F5D6.F17.F98                                                B4M21760
  ISN 0015            COMMON /DBUG/ISWTCH                                                       B4M21770
  ISN 0016            COMMON/SMOD/ISMTH.NPC                                                     B4M21780
  ISN 0017            COMMON/MLFS/NSEQ.MLF(10).MATSNX.NSM1.NCM1                                 B4M21790
  ISN 0018            DATA J2/2/                                                                B4M21800
              C                                                                             *   B4M21810
              C * * * DEFINITION OF SURFACE TEMPERATURE AND                                 *   B4M21820
              C * * * SEA LEVEL PRESSURE FUNCTIONS                                          *   B4M21830
              C                                                                             *   B4M21840
  ISN 0019            SLEXP(PHI.T10) = EXP(PHI / (T10 + F98 * PHI ) / 287.)                     B4M21850
  ISN 0020            T10(PP.T8.T9) = (T8 * ALOG((F17 * PP + PTOP) / (PP + PTOP))               B4M21860
                   $     + T9 * ALOG((PP + PTOP) / (F5D6 * PP + PTOP)))                         B4M21870
                   $     / ALOG((F17 * PP + PTOP) / (F5D6 * PP + PTOP))                         B4M21880
              C                                                                             *   B4M21890
              C * * * FIRST J LOOP                                                          *   B4M21900
              C * * * GET SURFACE PRESSURE AND TEMPERATURE INCLUDING POLES                  *   B4M21910
              C                                                                             *   B4M21920
  ISN 0021            IF(NSTEP.LE.NSM1)RETURN                                                   B4M21930
  ISN 0023            WRITE(3.999) TAU                                                          B4M21940
  ISN 0024            M=1                                                                       B4M21950
  ISN 0025            DO 200 J = 1.JNP                                                          B4M21960
  ISN 0026            IF (J.NE.1 .AND. J.NE.JNP)   GO TO 120                                    B4M21970
  ISN 0028            DO 130 L = 1.NLAY                                                         B4M21980
              C                                                                                 B4M21990
  ISN 0029            POT(1.J.L) = TPOL(L.M)                                                    B4M22000
  ISN 0030      130                          CONTINUE                                           B4M22010
  ISN 0031            SLP(1.J) = PPOL(M)                                                        B4M22020
  ISN 0032             M=2                                                                      B4M22030
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ISN 0033                                      GO TO 140                                  B4M22040
ISN 0034         120 DO 110 L = 1.NLAY                                                   B4M22050
ISN 0035             DO 110 I = 1.IM                                                     B4M22060
ISN 0036             POT(I.J.L) = T(I.L.J)                                               B4M22070
ISN 0037         110                          CONTINUE                                   B4M22080
ISN 0038             DO 100 I = 1.IM                                                     B4M22090
ISN 0039             SLP(I.J) = P(I.J)                                                   B4M22100
ISN 0040         100                          CONTINUE                                   B4M22110
               C                                                                       * B4M22120
               C * * * TRANSFORM TO SEA LEVEL PRESSURE AND POTENTIAL TEMPERATURE       * B4M22130
               C                                                                       * B4M22140
ISN 0041         140 DO 210 I = 1.IM                                                     B4M22150
ISN 0042             TSURF = T10(SLP(I.J).POT(I.J.8).POT(I.J.5))                         B4M22160
ISN 0043             DO 220 L = 1.NLAY                                                   B4M22170
ISN 0044             PKAPA = EXPBYK(SLP(I.J) * SIG(L) + PTOP)                            B4M22180
ISN 0045             POT(I.J.L) = POT(I.J.L) / PKAPA                                     B4M22190
ISN 0046         220                          CONTINUE                                   B4M22200
ISN 0047             PHISX = PHIS(I.J)                                                   B4M22210
ISN 0048             SLP(I.J) = (SLP(I.J) + PTOP) * SLEXP(PHISX.TSURF)                   B4M22220
ISN 0049             IF (J .EQ. 1.OR.J .EQ. JNP) GO TO 230                               B4M22230
ISN 0051         210                          CONTINUE                                   B4M22240
ISN 0052                                      GO TO 200                                  B4M22250
ISN 0053         230 DO 240 I = 2.IM                                                     B4M22260
ISN 0054             DO 250 L = 1.NLAY                                                   B4M22270
ISN 0055             POT(I.J.L) = POT(1.J.L)                                             B4M22280
ISN 0056         250                          CONTINUE                                   B4M22290
ISN 0057             SLP(I.J) = SLP(1.J)                                                 B4M22300
ISN 0058         240                          CONTINUE                                   B4M22310
ISN 0059         200                          CONTINUE                                   B4M22320
ISN 0060             NF = -1                                                             B4M22330
               C                                                                       * B4M22340
               C * * * SMOOTHING ALONG LONGITUDE                                       * B4M22350
               C * * *                                                                 * B4M22360
               C * * *                                                                 * B4M22370
               C * * *                                                                 * B4M22380
               C * * * 16TH ORDER AT ALL J VALUES.                                     * B4M22390
               C                                                                       * B4M22400
ISN 0061        1000 NF = NF + 1                                                         B4M22410
ISN 0062             DO 1010 J = 2.JM                                                    B4M22420
ISN 0063             NSM = 2                                                             B4M22430
               C     IF (J.LT.8 .OR. J.GT.JM-6)  NSM = 4                                 B4M22440
               C     IF (J.LT.6 .OR. J.GT.JM-4)  NSM = 2                                 B4M22450
               C     IF (J.LT.4 .OR. J.GT.JM-2)  NSM = 1                                 B4M22460
               C     SGN = (-1) ** NSM                                                   B4M22470
ISN 0064             CX = 4. ** NSM                                                      B4M22480
ISN 0065             IF (NF .GT. 0)               GO TO 1024                             B4M22490
ISN 0067             DO 1020 I = 1.IM                                                    B4M22500
ISN 0068             DATA(I) = SLP(I.J)                                                  B4M22510
ISN 0069        1020                          CONTINUE                                   B4M22520
ISN 0070                                      GO TO 1028                                 B4M22530
ISN 0071        1024 DO 1026 I = 1.IM                                                    B4M22540
ISN 0072             DATA(I) = POT(I.J.NF)                                               B4M22550
ISN 0073        1026                          CONTINUE                                   B4M22560
ISN 0074        1028 DO 1030 N = 1.NSM                                                   B4M22570
ISN 0075             I = IM                                                              B4M22580
ISN 0076             DO 1035 IP = 1.IM                                                   B4M22590
ISN 0077             CATA(I) = DATA(IP) - DATA(I)                                        B4M22600
ISN 0078             I = IP                                                              B4M22610
ISN 0079        1035                          CONTINUE                                   B4M22620
ISN 0080             IS = IM                                                             B4M22630
ISN 0081             DO 1040 I = 1.IM                                                    B4M22640
ISN 0082             DATA(I) = CATA(I) - CATA(IS)                                        B4M22650
ISN 0083             IS = I                                                              B4M22660
ISN 0084        1040                          CONTINUE                                   B4M22670
ISN 0085        1030                          CONTINUE                                   B4M22680
ISN 0086             IF (NF .GT. 0)           GO TO 1054                                 B4M22690
ISN 0088             DO 1050 I = 1.IM                                                    B4M22700
ISN 0089             SLP(I.J) = SLP(I.J) -    DATA(I) / CX                               B4M22710
ISN 0090        1050                          CONTINUE                                   B4M22720
ISN 0091                                      GO TO 1010                                 B4M22730
ISN 0092        1054 DO 1056 I = 1.IM                                                    B4M22740
ISN 0093             POT(I.J.NF) = POT(I.J.NF) -       DATA(I) / CX                      B4M22750
ISN 0094        1056                          CONTINUE                                   B4M22760
ISN 0095        1010                          CONTINUE                                   B4M22770
               C                                                                       * B4M22780
               C * * * SMOOTHING ALONG LATITUDE                                        * B4M22790
               C * * * ALSO USE PERIODICITY ALONG COMPLETE MERIDIAN (J=1.2*JM)         * B4M22800
               C                                                                       * B4M22810
ISN 0096             CY=4.**NSM                                                          B4M22820
ISN 0097             IMD2 = IM / 2                                                       B4M22830
ISN 0098             JMT2 = JM * 2                                                       B4M22840
ISN 0099             DO 1110 I = 1.IMD2                                                  B4M22850
ISN 0100             IF (NF .GT. 0)           GO TO 1124                                 B4M22860
ISN 0102             DO 1120 J = 1.JM                                                    B4M22870
ISN 0103             DATA(J) = SLP(I.J)                                                  B4M22880
ISN 0104             DATA(J+JM) = SLP(I+IMD2.JM-J+2)                                     B4M22890
ISN 0105        1120                          CONTINUE                                   B4M22900
ISN 0106                                      GO TO 1128                                 B4M22910
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                C                                                                       *   B4M22920
                C * * * SHOULD PUT (-1) FOR WIND SMOOTHING IN 1126                      *   B4M22930
                C                                                                       *   B4M22940
ISN 0107          1124 DO 1126 J = 1,JM                                                     B4M22950
ISN 0108               DATA(J) = POT(I,J,NF)                                                B4M22960
ISN 0109               DATA(J+JM) = POT(I+IMD2,JM-J+2,NF)                                   B4M22970
ISN 0110          1126                              CONTINUE                                B4M22980
ISN 0111          1128 DO 1130 N=1,NSM                                                      B4M22990
ISN 0112               J = JMT2                                                             B4M23000
ISN 0113               DO 1135 JP = 1,JMT2                                                  B4M23010
ISN 0114               CATA(J) = DATA(JP) - DATA(J)                                         B4M23020
ISN 0115               J = JP                                                               B4M23030
ISN 0116          1135                              CONTINUE                                B4M23040
ISN 0117               JS = JMT2                                                            B4M23050
ISN 0118               DO 1140 J = 1,JMT2                                                   B4M23060
ISN 0119               DATA(J) = CATA(J) - CATA(JS)                                         B4M23070
ISN 0120               JS = J                                                               B4M23080
ISN 0121          1140                              CONTINUE                                B4M23090
ISN 0122          1130                              CONTINUE                                B4M23100
ISN 0123               IF (NF .GT. 0)               GO TO 1154                              B4M23110
ISN 0125               DO 1150 J = 1,JM                                                     B4M23120
ISN 0126               SLP(I,J) = SLP(I,J) - DATA(J) / CY                                   B4M23130
ISN 0127               SLP(I+IMD2,JM-J+2) = SLP(I+IMD2,JM-J+2) - DATA(J+JM) / CY            B4M23140
ISN 0128          1150                              CONTINUE                                B4M23150
ISN 0129                                            GO TO 1110                              B4M23160
ISN 0130          1154 DO 1170 J = 1,JM                                                     B4M23170
ISN 0131               POT(I,J,NF) = POT(I,J,NF) - DATA(J) / CY                             B4M23180
ISN 0132               POT(I+IMD2,JM-J+2,NF)=POT(I+IMD2,JM-J+2,NF) - DATA(J+JM) / CY        B4M23190
ISN 0133          1170                              CONTINUE                                B4M23200
ISN 0134          1110                              CONTINUE                                B4M23210
ISN 0135               IF (NF .GT. 0)               GO TO 1164                              B4M23220
ISN 0137               S1 = 0.                                                              B4M23230
ISN 0138               S2 = 0.                                                              B4M23240
ISN 0139               DO 1160 I = 1,IM                                                     B4M23250
ISN 0140               S1 = S1 + SLP(I,1)                                                   B4M23260
ISN 0141               S2 = S2 + SLP(I,JNP)                                                 B4M23270
ISN 0142          1160                              CONTINUE                                B4M23280
ISN 0143               S1 = S1 / IM                                                         B4M23290
ISN 0144               S2 = S2 / IM                                                         B4M23300
ISN 0145               DO 1165 I = 1,IM                                                     B4M23310
ISN 0146               SLP(I,1) = S1                                                        B4M23320
ISN 0147               SLP(I,JNP) = S2                                                      B4M23330
ISN 0148          1165                              CONTINUE                                B4M23340
ISN 0149                                            GO TO 1180                              B4M23350
ISN 0150          1164 S1 = 0.                                                              B4M23360
ISN 0151               S2 = 0.                                                              B4M23370
ISN 0152               DO 1173 I = 1,IM                                                     B4M23380
ISN 0153               S1 = S1 + POT(I,1,NF)                                                B4M23390
ISN 0154               S2 = S2 + POT(I,JNP,NF)                                              B4M23400
ISN 0155          1173                              CONTINUE                                B4M23410
ISN 0156               S1 = S1 / IM                                                         B4M23420
ISN 0157               S2 = S2 / IM                                                         B4M23430
ISN 0158               DO 1175 I = 1,IM                                                     B4M23440
ISN 0159               POT(I,1,NF) = S1                                                     B4M23450
ISN 0160               POT(I,JNP,NF) = S2                                                   B4M23460
ISN 0161          1175                              CONTINUE                                B4M23470
ISN 0162          1180                              CONTINUE                                B4M23480
ISN 0163               IF (NF .LT. NLAY)            GO TO 1000                              B4M23490
                C                                                                           B4M23500
                C                                                                           B4M23510
                C                                                                       *   B4M23520
                C * * * SECOND MAIN J-LOOP                                              *   B4M23530
                C * * * TRANSFORM BACK TO SURFACE PRESSURE                              *   B4M23540
                C                                                                       *   B4M23550
ISN 0165               MAXIT = 50                                                           B4M23560
ISN 0166               DO 2000 J = 1,JNP                                                    B4M23570
ISN 0167               DO 1320 I = 1,IM                                                     B4M23580
ISN 0168               PHISX = PHIS(I,J)                                                    B4M23590
ISN 0169               PSFC = SLP(I,J) - PTOP                                               B4M23600
ISN 0170               DO 1330 NITX = 1,MAXIT                                               B4M23610
ISN 0171               P1 = PSFC                                                            B4M23620
ISN 0172               T8 = POT(I,J,8) * EXPBYK(PSFC * SIG(8) + PTOP)                       B4M23630
ISN 0173               T9 = POT(I,J,9) * EXPBYK(PSFC * SIG(9) + PTOP)                       B4M23640
ISN 0174               TSURF = T10(PSFC,T8,T9)                                              B4M23650
ISN 0175               PSFC = SLP(I,J) / SLEXP(PHISX,TSURF) - PTOP                          B4M23660
ISN 0176               IF (ABS(PSFC-P1)/1000. .LE. 1.E-5)  GO TO 1340                       B4M23670
ISN 0178          1330                              CONTINUE                                B4M23680
ISN 0179               PRINT 1335,MAXIT                                                     B4M23690
ISN 0180          1335 FORMAT(1X,' MORE THAN',I5,' ITERATIONS.')                            B4M23700
ISN 0181               PRINT 7990,J                                                         B4M23710
ISN 0182               PRINT 7991,I                                                         B4M23720
ISN 0183          7990 FORMAT(1X,' J = ',I5)                                                B4M23730
ISN 0184          7991 FORMAT(1X,' I = ',I5)                                                B4M23740
ISN 0185          1340 SLP(I,J) = PSFC                                                      B4M23750
ISN 0186               IF (J.EQ.1 .OR. J.EQ.JNP)    GO TO 1350                              B4M23760
ISN 0188          1320                              CONTINUE                                B4M23770
ISN 0189                                            GO TO 1310                              B4M23780
ISN 0190          1350 DO 1360 I = 2,IM                                                     B4M23790
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ISN 0191           SLP(I.J) = SLP(1.J)                                                  B4M23800
ISN 0192      1360                                  CONTINUE                            B4M23810
ISN 0193      1310                                  CONTINUE                            B4M23820
            C                                                                         * B4M23830
            C * * * TRANSFORM BACK TO TEMPERATURE                                     * B4M23840
            C                                                                         * B4M23850
ISN 0194           DO 1400 L = 1.NLAY                                                   B4M23860
ISN 0195           DO 1420 I = 1.IM                                                     B4M23870
ISN 0196           PKAPA = EXPBYK(SLP(I.J) * SIG(L) + PTOP)                             B4M23880
ISN 0197           POT(I.J.L) = POT(I.J.L) * PKAPA                                      B4M23890
ISN 0198           IF (J.EQ.1 .OR. J.EQ.JNP)        GO TO 1430                          B4M23900
ISN 0200      1420                                  CONTINUE                            B4M23910
ISN 0201                                            GO TO 1400                          B4M23920
ISN 0202      1430 DO 1440 I = 2.IM                                                     B4M23930
ISN 0203           POT(I.J.L) = POT(1.J.L)                                              B4M23940
ISN 0204      1440                                  CONTINUE                            B4M23950
ISN 0205      1400                                  CONTINUE                            B4M23960
            C                                                                         * B4M23970
            C * * * RETURN SMOOTHED VALUES                                            * B4M23980
            C                                                                         * B4M23990
ISN 0206           DO 1520 L = 1.NLAY                                                   B4M24000
ISN 0207           DO 1520 I = 1.IM                                                     B4M24010
ISN 0208           T(I.L.J) = POT(I.J.L)                                                B4M24020
ISN 0209      1520                                  CONTINUE                            B4M24030
ISN 0210      1525 DO 1530 I = 1.IM                                                     B4M24040
ISN 0211           P(I.J) = SLP(I.J)                                                    B4M24050
ISN 0212      1530                                  CONTINUE                            B4M24060
ISN 0213      2000                                  CONTINUE                            B4M24070
ISN 0214           DO 1550 L = 1.NLAY                                                   B4M24080
ISN 0215           TPOL(L.1) = POT(1.1.L)                                               B4M24090
ISN 0216           TPOL(L.J2) = POT(1.JNP.L)                                            B4M24100
ISN 0217      1550                                  CONTINUE                            B4M24110
ISN 0218           PPOL(1) = SLP(1.1)                                                   B4M24120
ISN 0219           PPOL(2) = SLP(1.JNP)                                                 B4M24130
            C ***  12/14 RUN1 HERE TILL RETURN                                          B4M24140
ISN 0220           IF(KATSNX.EQ.0)RETURN                                                B4M24150
ISN 0222           DO 500 J=2.JM                                                        B4M24160
ISN 0223           DO 500 N=1.4                                                         B4M24170
ISN 0224           DO 500 K=1.NLAY                                                      B4M24180
ISN 0225           DO 500 I=1.IM                                                        B4M24190
ISN 0226           QT(I.K.N.J)=P(I.J)*DXYP(J)*Q(I.K.N.J)                                B4M24200
ISN 0227       500 CONTINUE                                                             B4M24210
ISN 0228           DO 501 J=2.JM                                                        B4M24220
ISN 0229           DO 501 I=1.IM                                                        B4M24230
ISN 0230           PT(I.J)=P(I.J)                                                       B4M24240
ISN 0231       501 CONTINUE                                                             B4M24250
ISN 0232           DO 502 L=1.NLAY                                                      B4M24260
ISN 0233           DO 502 N=1.4                                                         B4M24270
ISN 0234           DO 502 M=1.2                                                         B4M24280
ISN 0235           QTPOL(L.N.M)=PPOL(M)*QPOL(L.N.M)                                     B4M24290
ISN 0236       502 CONTINUE                                                             B4M24300
ISN 0237           PTPOL(1)=PPOL(1)                                                     B4M24310
ISN 0238           PTPOL(2)=PPOL(2)                                                     B4M24320
ISN 0239       599 FORMAT(1X.' NEW SMOOTHER ENTERED.    TAU='.F12.3)                    B4M24330
ISN 0240                                            RETURN                              B4M24340
ISN 0241                                            END                                 B4M24350
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