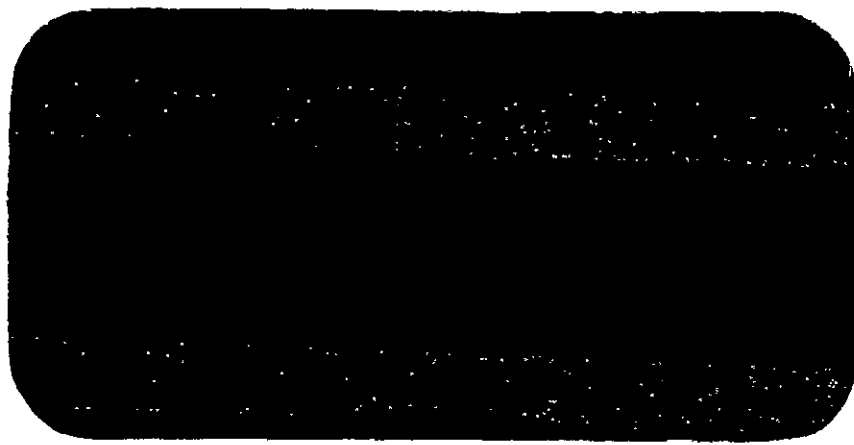


NSG 5075

(NASA-CR-158766) DOCUMENTATION OF A GROUND
 HYDROLOGY PARAMETERIZATION FOR USE IN THE
 GISS ATMOSPHERIC GENERAL CIRCULATION MODEL
 (Connecticut Univ.) 143 p HC A07/ME A01
 N79-27632
 Unclass
 28886
 CSCL 08H G3/43

CIVIL ENGINEERING DEPARTMENT



SCHOOL OF ENGINEERING
THE UNIVERSITY OF CONNECTICUT
STORRS, CONNECTICUT

DOCUMENTATION OF A GROUND HYDROLOGY
PARAMETERIZATION FOR USE IN
THE GISS ATMOSPHERIC GENERAL CIRCULATION MODEL

by

J. D. Lin, J. Alfano and P. Bock*

C. E. 79-126

June 1978

* Associate Professor, Graduate Assistant and Professor, respectively.

This research was sponsored by the NASA-Goddard, Laboratory for Atmospheric Sciences, Modeling and Simulation Facility, Greenbelt, Maryland and was carried out through the Institute of Water Resources in the Civil Engineering Department of the University of Connecticut.

PREFACE

This documentation is prepared for the Goddard Modeling and Simulation Program (and others with some familiarity with general circulation modeling) to provide a detailed description of a ground hydrology parameterization that can be used in the Atmospheric General Circulation Model (GCM). The preparation of this documentation is part of an ongoing program involving hydrologists with atmospheric modelers to develop realistic interaction between the ground hydrology and the atmospheric components in the GCM. In 1973 the GISS-GCM was documented by Tsang and Karn (TK). In this version the ground wetness is kept constant according to the particular monthly climatic surface relative humidity values for the globe. The ground wetness parameterizations were subsequently revised by GISS modelers to account for the effects of a variable ground wetness on the atmosphere. However, we have found a serious lack of information about how the parameterizations were developed. Our documentation is based primarily on the ground wetness and related sections of the computer coding (Subroutine COMP35).

This documentation is not intended to be self-contained. The reader should refer to TK for further details.

We have developed an off-line testing program for diagnostic and sensitivity studies of the ground wetness and ground temperature parameterization. As a result, some revisions and refinements of the Ground Hydrology Model (GHM) were incorporated in an off-line version, labeled as UCNI.

TABLE OF CONTENTS

	Page
Preface	i
Table of Contents	ii

PART I

MODEL DESCRIPTION

I. Introduction	1
II. Formulation	3
2.1 Ground Hydrology	3
Ground Wetness and Soil Parameters	4
Precipitation	7
Evapotranspiration	7
Surface Storage of Snow and Ice	10
Runout	15
2.2 Ground Temperature	22
2.3 Surface Conditions in the Atmosphere	24
Surface Wind and Stability Condition	25
Heat Flux and Surface Temperature	26
Moisture Flux	27
Solar Radiation	28
III. Description of the Computer Program for the GHM	29
Subroutine COMP35	29
Flow Charts	30
COMP35	30
Step 7 of COMP35	36
Step 14 of COMP35	39

TABLE OF CONTENTS (Cont'd)

PART II

MODEL RESULTS & ANALYSIS

IV. Off-Line Model (OLM)	43
Introduction	43
Differences in Hydrologic Parameterizations	48
Experiments	51
Results	51
Soil Moisture	52
Surface and Ground Temperature	52
Potential (ET) and Actual (AET) Evapotranspiration and Their Ratio, β	53
Summary	53
V. Description of the OLM Computer Program	69
OLM Program	69
Flow Chart	70
References	80
Appendix	
A. Symbols and Notations	
B. Code Listings - GHM (COMP35) and Off-Line Model (OLM)	

PART I

MODEL DESCRIPTION

I. Introduction

The ground hydrology portion of the Goddard GCM models the moisture transport processes related to the earth's surface that were considered to be important to the GCM. The evaporative, sensible and ground heat fluxes that are calculated in the ground hydrology are the principal terrestrial output parameters for the GCM. The principal input parameters to the GHM from the GCM are precipitation, either in the form of rain or snow, and net solar radiation. In the hydrologic cycle the net change in ground cell moisture levels and surface water storage are generally small for long-term averages; then precipitation, evaporation and runoff are the major components of the moisture balance in the GHM.

The present GHM parameterizations are conveniently divided into the following parts:

- a) ground wetness and soil parameters,
- b) precipitation,
- c) evapotranspiration,
- d) surface storage of snow and ice, and
- e) runoff (moisture which is unavailable for evaporation and for cell moisture changes).

In this documentation all of the above moisture transfer processes are considered. In addition, the effects of ground wetness on the ground temperature, the surface specific humidity and the surface temperature will be treated separately. The discussion focuses on understanding the computational aspects of the GHM and how they affect the flux estimates. This documentation does not attempt to develop an extensive derivation or statement of assumptions for the parameterizations at this time. Although

an attempt has been made to fully understand the current GHM parameterizations we must point out that the presently available supporting documentation for this report was not completely adequate; therefore we made inferences from the GHM computer code.

Contrary to the traditional hydrology model which is based on the approach of drainage basin system, the development of the GHM parameterizations are designed to capture, in a gross manner, the vertical fluxes for a terrestrial cell 4 degrees latitude by 5 degrees longitude. This type of approach or modeling for hydrologic processes like evapotranspiration, runoff, infiltration, etc. is difficult because of the large size of the cell (which requires arbitrary lumping of hydrologic parameters) and the arbitrary divisions of the latitude and longitude slices that generally cut through drainage basins. The fundamental moisture coupling concept is based on the storage capacity of the soil moisture near the surface to satisfy and therefore regulate the actual evaporative demand. The actual evapotranspiration depends on the characteristics of the ground surface, soil moisture level and the potential atmospheric evaporative demand.

The computer programs and the flow chart for the GHM are described in Sec. III. An off-line ground hydrology model (OLM), devised for diagnostic and sensitivity studies, is discussed in Sec. IV. Some results from numerical experiments are also presented in Sec. IV. The computer program description and flow chart for the OLM can be found in Sec. V. Listings of both programs for the GHM and OLM are in Appendix B with symbols and notations described in Appendix A.

II. Formulation

2.1 Ground Hydrology

The present ground hydrology parameterizations are developed for a ground layer of uniform thickness throughout the globe for each cell following essentially the approach outlined in Arakawa (1972). The fundamental ground moisture concept is based on the availability of moisture in soil to satisfy the evaporative demand of the atmosphere either from bare soil surface or from vegetation canopies. The equation of moisture conservation is given by

$$\rho_w S h \frac{\partial w'}{\partial t} = P - E_s - R_o - \rho_w \frac{\partial S_{si}}{\partial t} \quad (2-1-1a)$$

where w' is the ground wetness in [fraction of saturation];

ρ_w is the density of water in [g cm^{-3}],

S is the porosity of soil,

h is the depth of the ground layer in [cm],

P is precipitation in [$\text{g cm}^{-2} \text{s}^{-1}$],

E_s is evapotranspiration from the ground surface in [$\text{g cm}^{-2} \text{s}^{-1}$],

R_o is "runout" of water from the cell in [$\text{g cm}^{-2} \text{s}^{-1}$],

(This is not the conventional hydrologic definition of runoff (Sec 2.1) Runout))

and S_{si} is the surface storage of snow or ice in [cm].

There are two additional conditions governing the ground wetness:

$$(i) \quad 0 \leq w' \leq 1 \quad (2-1-1b)$$

$$(ii) \quad w' = 1, S_{si} > 0 \quad (2-1-1c)$$

Certain critical remarks concerning the fundamental concept of the parameterization are necessary at this point. The present formulation of the GHM incorporates the following basic hydrologic assumptions:

1. surface water storage other than snow and ice is negligible;
2. the presence or absence of a ground water table is ambiguous;
3. ground water storage or storage in the aerated zone below the bulk layer is neglected;
4. horizontal moisture fluxes between adjacent ground cells - surface runoff, flow in the unsaturated zone, groundwater flow, deep vertical percolation, etc. - can be either lumped or calculated by a term R_0 in (2-1-1a), and
5. the hydrology of individual ground cells are independent of each other, i.e. mass continuity of the horizontal moisture fluxes is not preserved between adjacent cells.

Another major concern of the parameterizations for the GCM is how the actual evapotranspiration, E_s , in (2-1-1a) can be estimated, because E_s also affects the ground temperature and the sensible heat flux (see Sec. 2.2 and 2.3) in addition to the moisture flux balance.

Ground Wetness and Soil Parameters

The ground wetness in the present parameterization is not clearly defined, causing a certain amount of confusion. Inferences had to be made from the specific values assigned to the soil parameters. The depth of the ground layer is not explicitly specified; instead, a maximum amount of water, w_m or WGM, available for actual evapotranspiration is prescribed for two types of soil layer: WGM = 66.4 g for a "composite soil"

and $WGM = 4.0$ g for a "sandy soil." In addition, an impervious surface is identified by a "ROCK" factor. In reference to UCLA's model [Arakawa, 1972], an amount of 10 g available for actual evapotranspiration was used. Therefore, it appears that WGM in this model is closer to the saturation moisture content than the UCLA's maximum available amount. If we interpret the WGM as the saturation moisture content, then the ground wetness, w' (WET), in this model is defined by volumetric moisture content as a fraction of saturation. We have adopted this definition throughout this documentation. Thus, $w_m = \rho_w Sh$ in (2-1-1a). For the "composite soil," $w_m = 66.4$ g which is equivalent to specifying $S = 0.52$ and $h = 1.28$ m. However, the maximum available moisture of 10 g in UCLA's model has been used as the range over which the actual evapotranspiration is scaled from the potential evaporation by a coefficient β . β is defined as the ratio of actual evapotranspiration to potential evaporation. For the "composite soil," the lower limit of this range is set in the neighborhood of the permanent wilting percentage, PWP (USM) at a ground wetness, w' , of 0.1, while the upper limit has a value of 0.25 which is near field capacity, FC. The available amount of moisture for actual evapotranspiration ($0 \leq \beta \leq 1$) is then $ASM = 0.15 \times 66.4 = 10$ g (=FC-PWP) [Salter and Williams, 1965]. The parameterization for evapotranspiration will be discussed later.

For the "sandy soil", $ASM = 0.065944$ g and $USM = 0.024278$ g, which are consistent with the field capacity and permanent wilting percentage for a sandy loam [Salter and William, 1965]. The value of $w_m = 4.0$ g is not consistent with the parameterization outlined in the preceding paragraph. However, if 4.0 g is intended as the maximum available amount of moisture for a desert region, then the layer thickness should be adjusted according to the porosity of the "sandy soil."

Another important aspect of ground wetness in the model concerns the transformation of the initial values of "ground wetness" from the climate data of Schutz and Gates (1972). The ground wetness is first derived from the surface relative humidity data of Schutz and Gates according to

$$GW = \frac{r_s - 15}{85}, \quad 0 \leq GW \leq 1 \quad (2-1-2)$$

where r_s is the surface relative humidity and GW is the initial "ground wetness" input matrix in the GCM. We cannot find the basis for this transformation. This "ground wetness" is coded as WAT, which is used only for computing the surface relative humidity and the criterion temperature (TK, p. 132).

For the ground hydrology, another transformation is carried out according to

$$WET = 0.5*(0.3*GW + 0.4) \quad (2-1-3)$$

which reduces the initial "ground wetness" from the range of (0,1) to (0.2, 0.35). Schutz and Gates' surface relative humidity may be considered as a long-term climatic average value which is proportional to the corresponding quantity near or on the ground surface. It is well known that in moist soil the relative humidity in the soil remains high even if the soil moisture content reaches field capacity [Child, 1969]. This implies that the atmospheric relative humidity near the ground becomes less than unity only when the ground wetness falls below the field capacity. Thus, it is reasonable to scale the range of the surface relative humidity data of Schutz and Gates for the ground wetness between the field capacity and the permanent wilting percentage. Since the ground wetness in this model is considered as depth averaged value, the ground wetness on the ground surface could become less than the permanent wilting percentage during an extended drying cycle. Therefore, the range of the ground wetness scale should be somewhat larger than the interval between the field capacity and the permanent wilting

percentage to realistically accomplish the transformation. The upper limit at WET = 0.35 is not unreasonable, but the lower limit at WET = 0.20 should be reduced to a value at or below the permanent wilting percentage.

Precipitation

The precipitation is the primary moisture input in this GHM in the form of rain or snow. The contribution of rain to the ground wetness is by means of the surface infiltration. There is no surface retention of rain water allowed in the model. The surface runoff and seepage are lumped together as the "runout." Snow is first accumulated on the ground surface as a form of surface storage. Whether it will contribute to ground wetness depends on the ground temperature above or below the freezing temperature. Therefore, the melting of snow will affect both the ground wetness and the ground temperature.

Evapotranspiration

The actual evapotranspiration in the GHM is scaled from the potential evaporation by means of a scaling factor, β . The potential evaporation, E_p (PREVAP) in [mm/hr], is given by

$$E_p = \rho_a C_D W_s (q_g^* - q_s) \quad (2-1-4)$$

where ρ_a is the density of air in [gcm^{-3}],

C_D is the drag coefficient,

W_s is the surface wind speed in (ms^{-1}),

q_s is the surface specific humidity at a reference height above the ground surface, and

q_g^* is the ground saturation specific humidity.

The ground saturation specific humidity is a function of the average ground temperature in the diurnal layer. The actual evapotranspiration, E_s (AET), is scaled down from (2-1-4) according to

$$E_s = \beta E_p, \quad 0 < \beta \leq 1. \quad (2-1-5)$$

For ocean, snow and ice, $\beta = 1$. For land, β is a function of ground wetness, soil characteristics, solar angle and the potential evaporation as the following:

$$\beta = (\beta_{\text{plant}} + \beta_{\text{soil}}) * (1 - \text{ROCK}) \quad (2-1-6)$$

where $\beta_{\text{plant}} = 1. - \exp \{ [-0.1 * \text{VPM} * \exp (16.75 * \text{VPM}) / \text{PREVAP}] * \text{PLANT} \}, \quad (2-1-7)$

$$\beta_{\text{soil}} = 1. - \exp[-0.01 * \text{VSM} * \exp (16.75 * \text{VSM}) / \text{PREVAP}] , \quad (2-1-8)$$

$$\text{VSM} = 2. * \text{WET} * (\text{ASM} + \text{USM}) \quad (2-1-9)$$

and

$$\text{VPM} = 0.1 * \text{VSM} / \text{USM} + 0.2 * \left(\frac{\text{VSM} - \text{USM}}{\text{ASM}} \right) \quad (2-1-10)$$

It has been suggested that the parameterizations of (2-1-7) to (2-1-10) are based on Van Bavel (1966) field study. However we are not able to pin down these relationships quantitatively. Therefore, a study of the range of variation of the above parameters was carried out as follows. The PLANT factor given as a function of solar angle, Z,

$$\text{PLANT} = \min \left(1.0, \frac{\cos(Z)}{0.2588} \right) \quad (2-1-11)$$

is shown in Figure 1. It is interesting to note that for the 32° N Latitude, the ratio of daily maximum solar radiation at the ground between Dec. 21 and June 21 is 0.4 [Koberg, 1962] while the ratio of average PLANT factor derived from Figure 1 is 0.67. Similarly, the ratios for April 21 and August 21 were found to be 0.85 and 0.95, respectively. The comparison indicates that

the PLANT factor based on the solar angle is overestimated based on Koberg. For specified values of E_p and PLANT, the scaling factor β given in (2-1-6) is plotted in Figures 2(a) and (b) for the composite and sandy soil. These figures indicate that β_{plant} dominates the actual evapotranspiration scaling factor. The intent of the specified values of field capacity and permanent wilting percentage in relation to β is not evident from the coded parameterizations. In an attempt to understand the effect of field capacity and permanent wilting percentage values we compared β with the parameterization of agricultural crops and a soil [Monteith, 1975]. This is presented in Figure 3 which shows that the current parameterizations represent a revision of the UCLA values and do not follow conventional agricultural type variations. For $E_p = 0.1$ mm/hr or approximately 1.2 mm/day if transpiration is shut off during the night, β in the current model comes closest to the linear variation of the UCLA scaling factor between FC and PWP explained in Arakawa [1972].

In summary we see that the scaling factor for the calculation of actual evapotranspiration is a function of solar angle, E_p , soil type and moisture content and that in a gross sense the family of curves presented in the examples of Figure 3 is consistent with the previous UCLA formulation. However, there exists an inconsistency for the scaling factor in relation to the field capacity and permanent wilting percentage. If a parameterization embodies pertinent soil characteristics such as field capacity and permanent wilting percentage, the scaling factor should approximate the simple rule: a) once ground wetness has exceeded field capacity the actual evapotranspiration rate should approach the potential rate and b) at or below field capacity the scaling factor, β , should fall below 1 and approach zero as the permanent wilting percentage is reached. The parameterization in this model does not follow this rule, tending to scale down the potential rate excessively. If realistic evaporation

fluxes from the model are to be expected the potential rate would have to be significantly higher to compensate for the lower values of the scaling factor β . On the other hand, the value of β is limited by this potential rate in the exponent of (2-1-7) and (2-1-8). Therefore, it appears that the actual evaporation rate is in general underestimated in this model. This may significantly affect the calculation of moisture fluxes as an input to the GCM. See Section IV for further details.

Surface Storage of Snow and Ice

The surface storage in the GHM is in the form of snow, ice or mixed ice and water. There is no surface storage of rain water on the ground surface during or after a rainfall. Thus the absence of surface storage inherently affects the computed values of ground wetness. The storage affects not only the ground wetness but also the ground temperature through transfer of latent heat. The thickness of snow and ice and the fraction of ice in mixed ice and water are updated every time step. The surface storage in the ground wetness equation (2-1-1) and the latent heat transfer term in the ground temperature equation (see Sec. 2.2) are adjusted simultaneously. Again the "ROCK" factor characterizing the impervious surface is appropriately incorporated in the adjustment of the transfer processes.

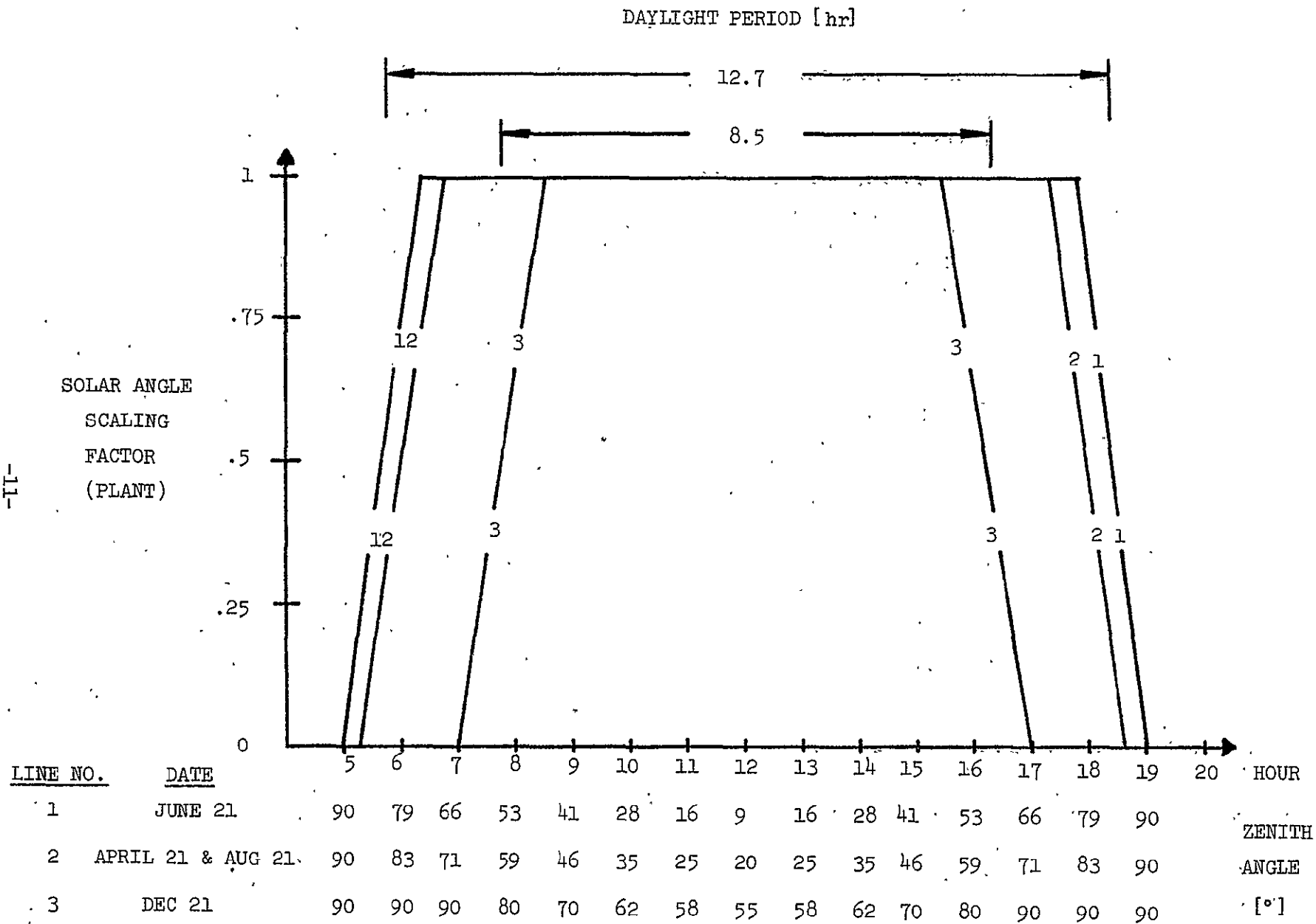


FIGURE 1. SOLAR ANGLE SCALING FACTOR, PLANT, AS A FUNCTION OF SOLAR ZENITH ANGLE AT 32°N

$$E_p = .1 \text{ mm hr}^{-1} = .1 \text{ cal cm}^{-2} \text{ mm}^{-1}$$

$$\text{ROCK} = 0.0$$

$$\text{PLANT} = 1.0$$

$$E_p = 1 \text{ mm, hr}^{-1} = 1 \text{ cal cm}^{-2} \text{ mm}^{-1}$$

$$\text{ROCK} = 0.0$$

$$\text{PLANT} = 1.0$$

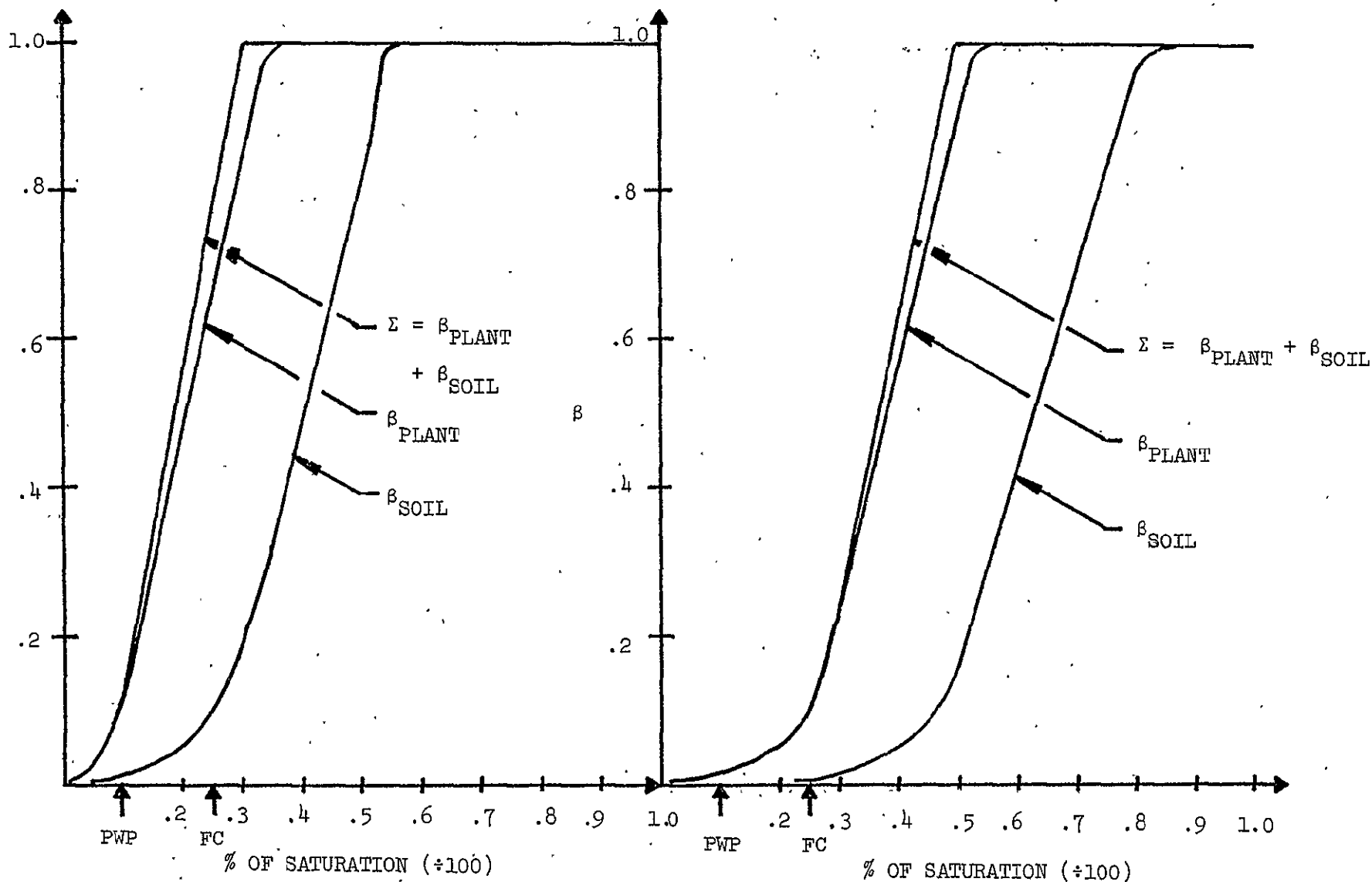


FIGURE 2A. β , EVAPORATION SCALING FACTOR FOR COMPOSITE SOIL

$E_p = .1 \text{ mm hr}^{-1}$
 ROCK = 0.0, PLANT = 1.0

$E_p = 1 \text{ mm hr}^{-1}$
 ROCK = 0.0, PLANT = 1.0

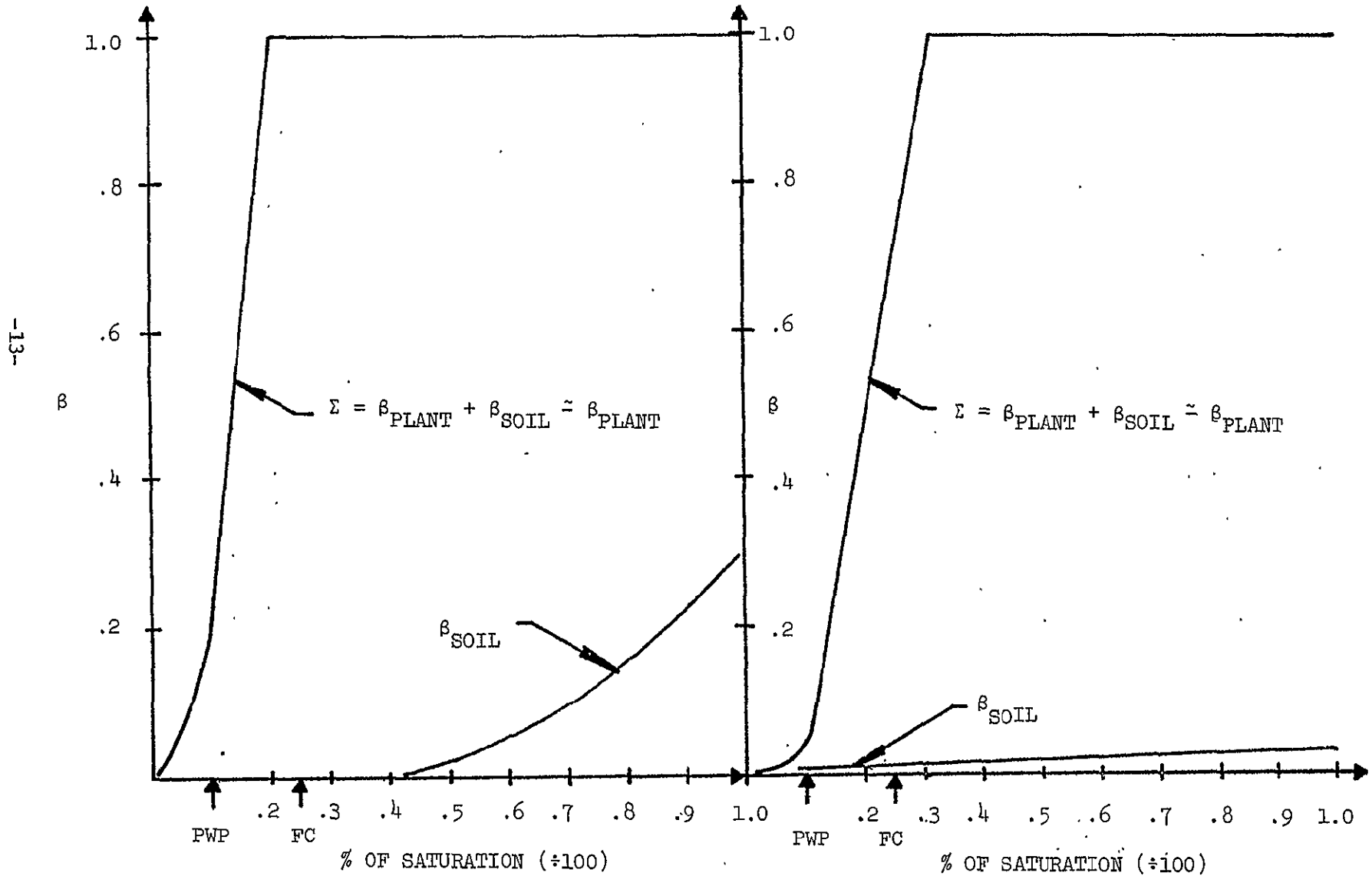


FIGURE 2B. β , EVAPORATION SCALING FACTOR FOR DESERT SOIL

GIVEN FOR A-D & A', D':

PLANT = 1.0

ROCK = 0.0

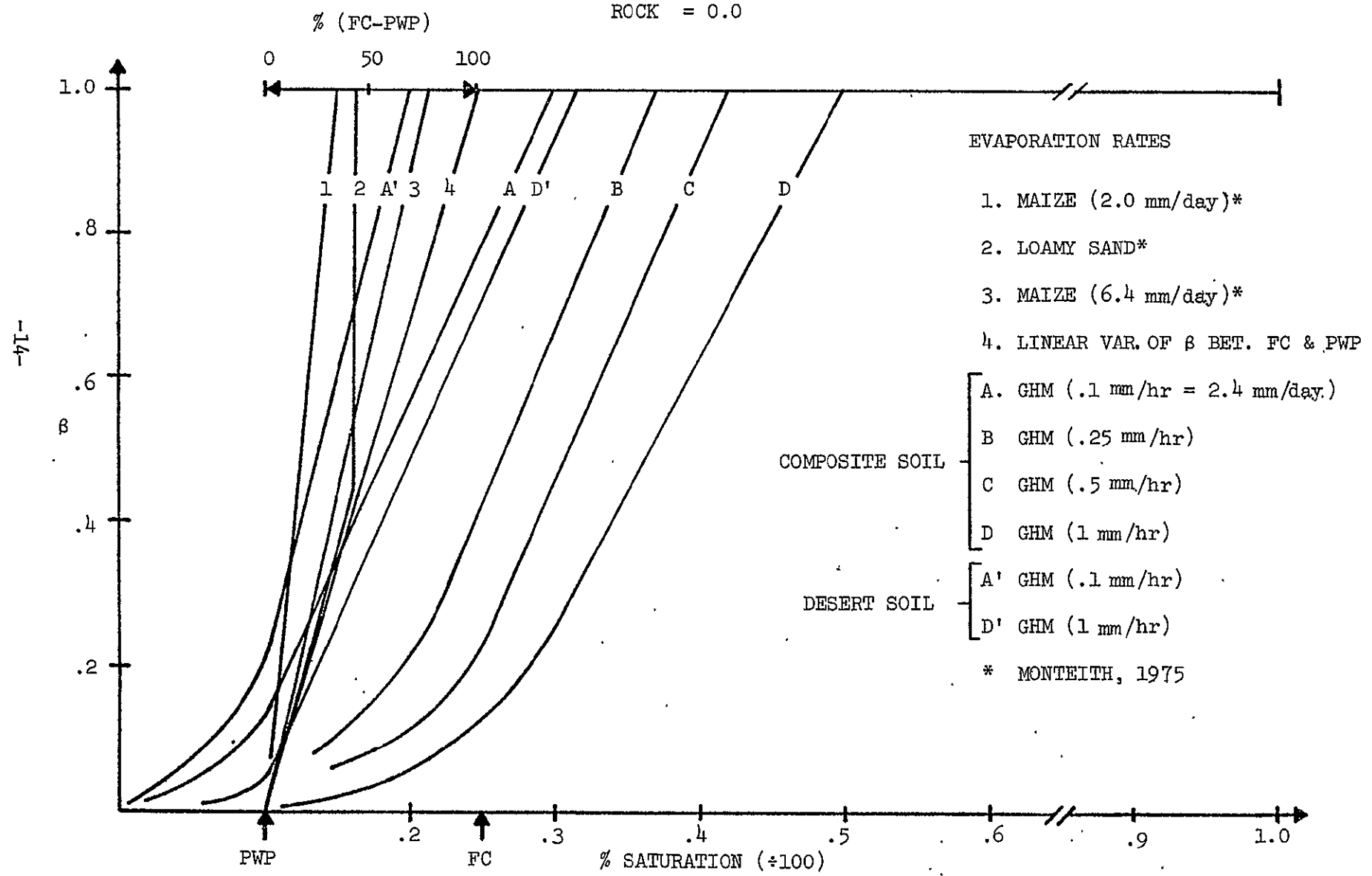


FIGURE 3. EVAPORATION SCALING FACTOR, β , COMPARISONS

Runout

The term, "runout," in the present GHM has a special meaning which is different from the "runoff" conventionally used in hydrology. Runoff is generally considered to be the continuous gravity movement of water on the ground surface and in channels with a characteristic magnitude which should be consistent with the intensity of precipitation, infiltration and topography of the ground surface [Ward, 1975]. The runout in this model is divided into two regimes, depending on the relative magnitude of the rainfall rate and the maximum surface infiltration rate. Runout is defined as, in a gross sense, the sum of all outgoing moisture fluxes other than evapotranspiration from a ground cell. In view of the assumption of hydrologically isolated ground cells, the runout moisture neither enters the surrounding cells nor is being stored in a lower ground layer. Therefore, the amount of runout estimated in the model represents the portion of rain or melting snow which cannot contribute to the ground wetness and evapotranspiration. Runout consists of (a) surface runoff, (b) percolation and (c) any excess of moisture above the capacity of the soil layer ($w' > 1$).

Before calculating the runout, an infiltration rate is first calculated as one half of

$$BBFACT = 2. *FILTF*EXP(-1.75*(ADINF-0.5)) \quad \text{in [cm/hh]} \quad (2-1-12)$$

where

$$FILTF = [1.77.*EXP\{-0.036*(TG - TICE)\} + 0.44562]^{-1} \quad (2-1-13)$$

and

$$ADINF = 1.25*(2.*WET-0.2)-0.5 \quad (2-1-14)$$

where TG and TICE are the ground and freezing temperature. FILTF is a temperature dependent parameter as shown in Figure 4 and ADINF is a function of ground wetness. Both ADINF and BBFACT as a function of ground wetness are shown in Figure 5. However, the physical implications of ADINF and FILTF are not known at this time. When the rainfall rate exceeds twice the maximum surface infiltration rate (MSIR), the excess contributes to the runoff, or

$$\text{RUNOFF} = \text{RAIN} - .5 * \text{BBFACT in [cm/hh]} \quad (2-1-15)$$

When the rainfall rate is less than twice the BBFACT, the runoff is calculated by

$$\text{RUNOFF} = .5 * (\text{RAIN})^2 / \text{BBFACT in [cm/hh]} \quad (2-1-16)$$

These formulas are shown graphically in Figures 6 and 7. Again, the hydrologic basis for (2-1-15) and (2-1-16) is not known to us.

Given the ground temperature and soil moisture values one can first estimate the BBFACT from Figure 5. Then, for a given rain input one can obtain the runoff by using Figure 6. Soil characteristics or vegetal cover effects are not considered in obtaining runoff values. What are the characteristics values of runoff? The following numerical example will help answer this question. Since typical global soil moisture contents are generally less than field capacity, WET = .25 should be a reasonable value for a field capacity or the upper limit of mean soil moisture values. Taking a typical ground temperature, say 20°C, one finds, from Figure 5 a value for the BBFACT of 4.75. In Figure 6 we see the following for BBFACT = 4.75:

RAIN [cm/hh]	RUNOFF [cm/hh]
1.0	.1
2.0	.4
3.0	.8
4.0	1.5

A review of the computer output from the GCM indicates that the rainfall rates rarely exceed 1 [cm/hh]. The above table implies that runoff is generally a small part of rain or that the major portion of rain contributes to cell moisture changes. However, a recent study indicates that, on a global scale, the ratio of runoff (which is a part of runoff in GHM) to rainfall over the continent is 0.36 [Baumgartner, 1975]. Finally, runoff versus soil moisture for a given temperature is plotted for various rain values in Figure 7. In the model, the runoff is adjusted for the percentage of ROCK on the surface. The effect of a nonzero value of ROCK is to increase runoff which reduces the surface infiltration rate.

In order to balance (2-1-1a) the runoff is computed according to (2-1-12) through (2-1-16). Two corrections of runoff from the cell are made by (1) limiting the ground wetness to be less than unity as (2-1-1b) and (2) percolation by reducing the ground wetness in an amount of 5% if the ground wetness exceeds half of its maximum value.

In summary, the runoff parameterizations are a function of rain, cell moisture content and temperature. This represents a change over the previous UCLA model which used a linear scaling factor of the cell moisture to obtain a value of runoff. From the numerical example presented above it has been shown that runoff is a small part of rainfall rate and hence plays a minor role in the calculation of cell moisture changes in this model. However,

FILTF

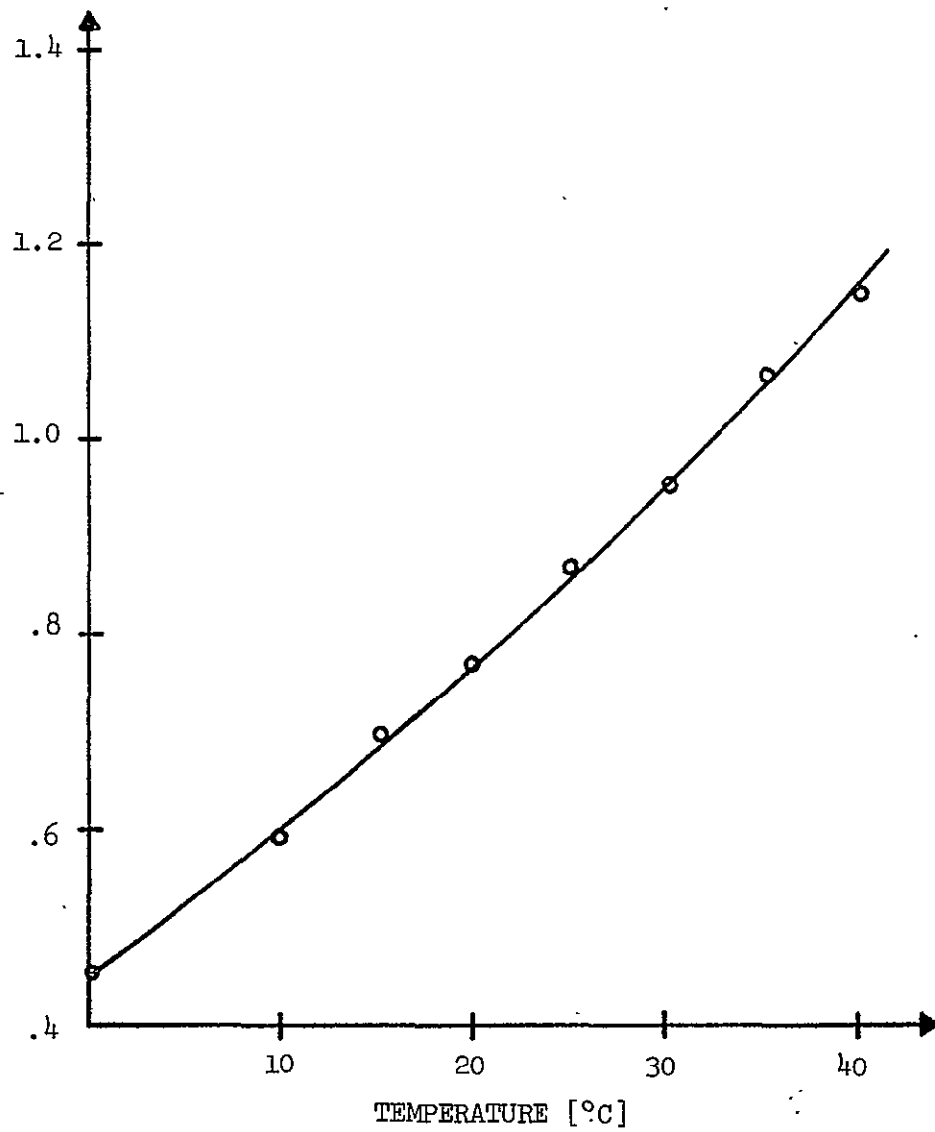
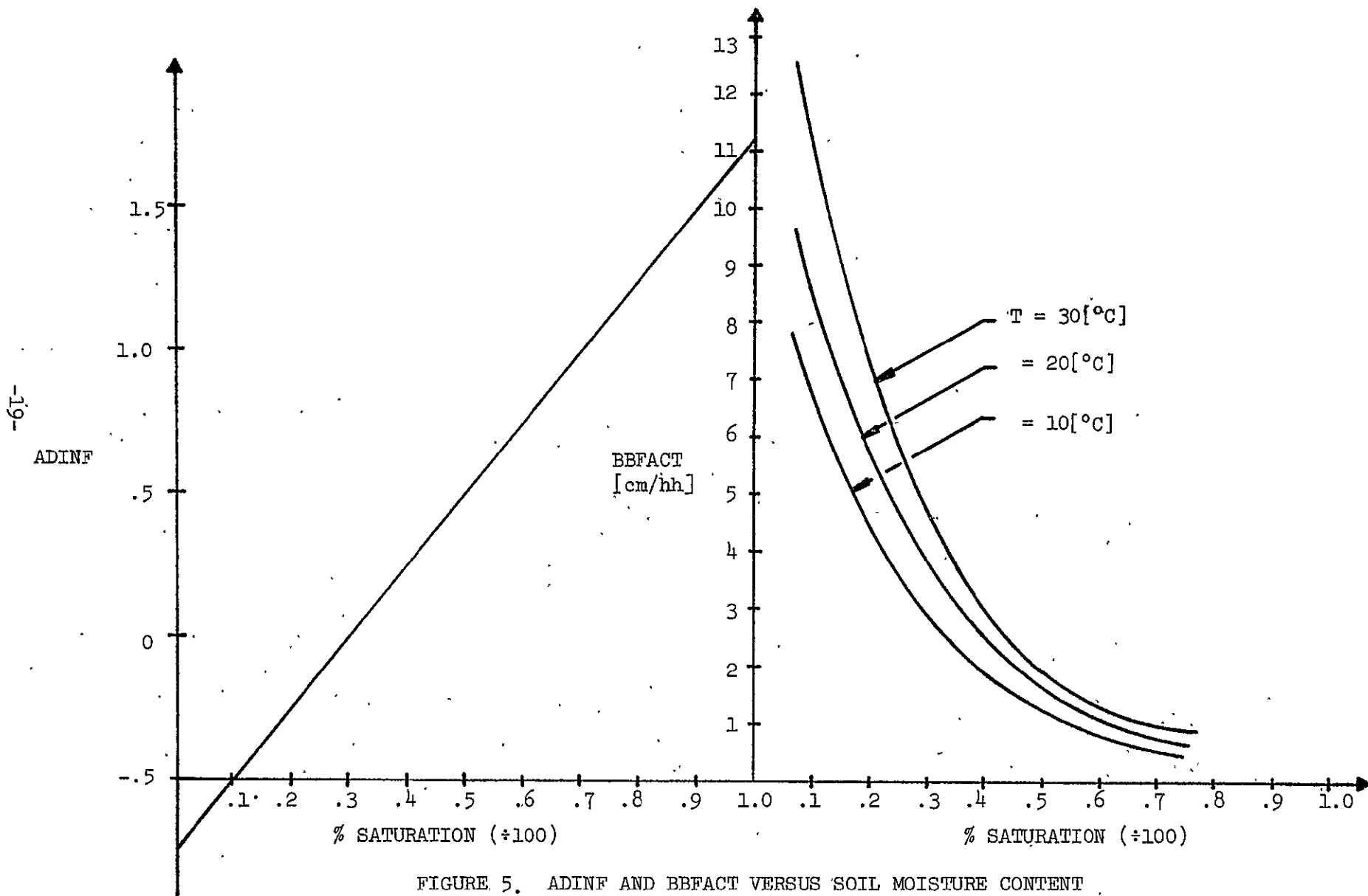


FIGURE 4. FILTF VERSUS TEMPERATURE



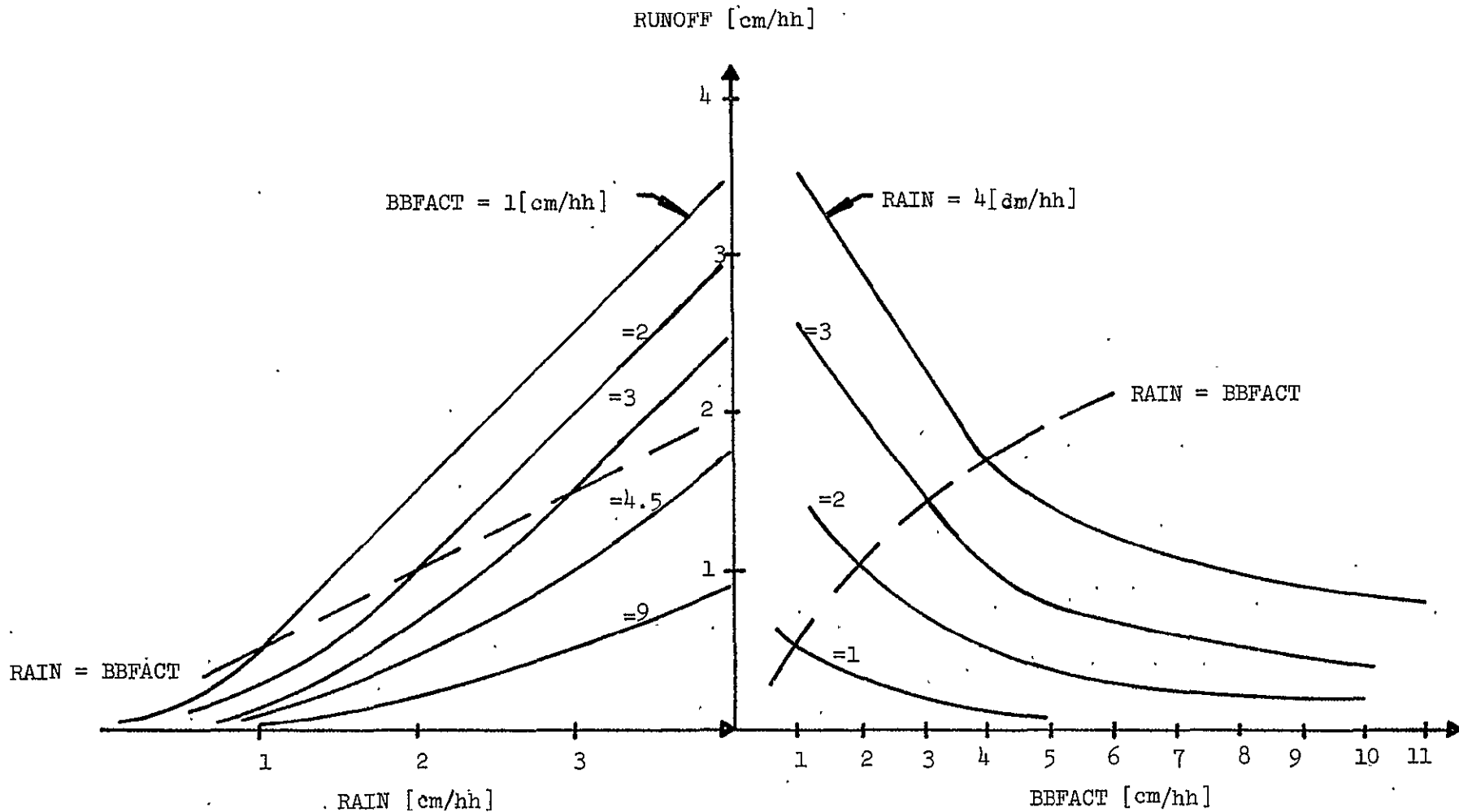


FIGURE 6: RUNOFF VERSUS RAIN FOR VARIOUS VALUES OF BBFACT AND
RUNOFF VERSUS BBFACT FOR VARIOUS VALUES OF RAIN

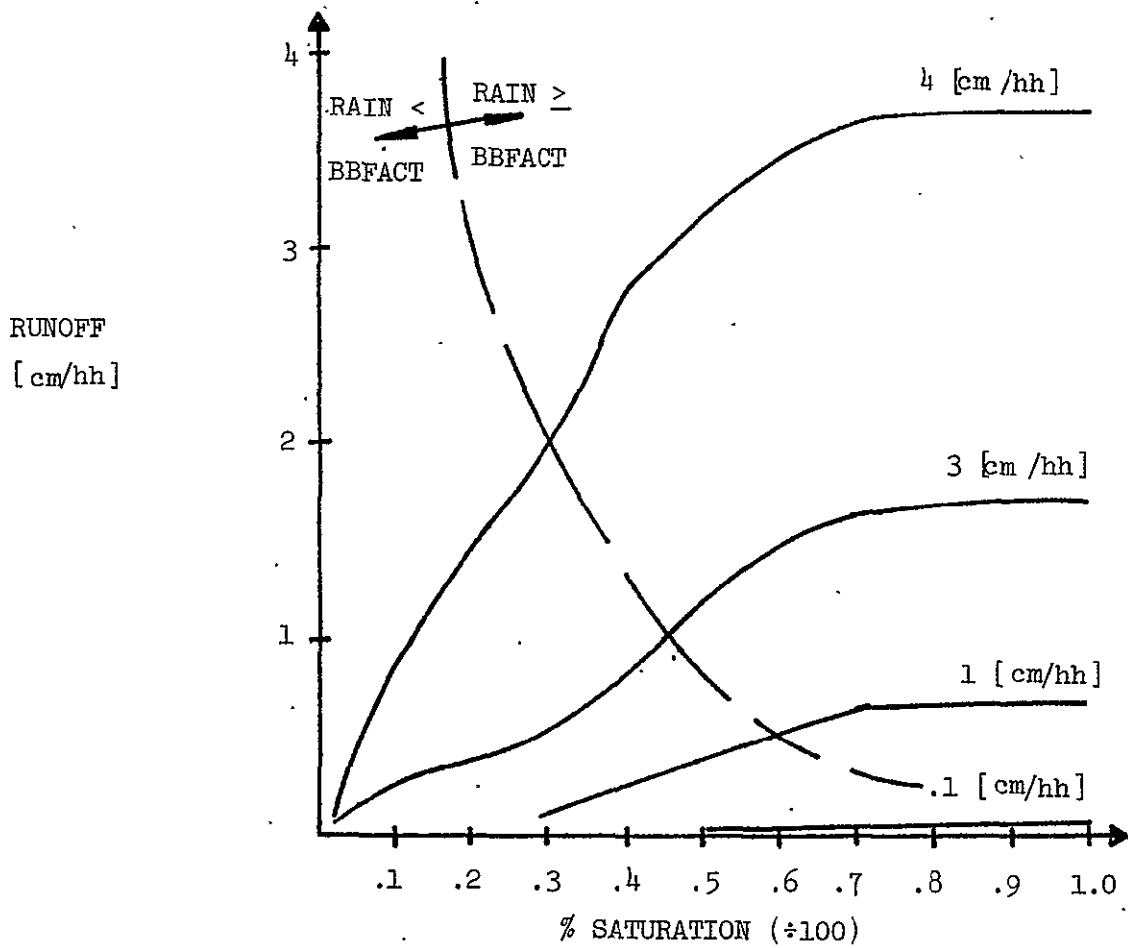


FIGURE 7. RUNOFF VERSUS SOIL MOISTURE FOR VARIOUS VALUES OF RAIN

Baumgartner has shown that runoff, which is less than runout, is not negligible; hence the GCM calculations of cell moisture are questionable.

2.2 Ground Temperature

The ground temperature in the GCM has been documented in TK. As the ground temperature is intrinsically coupled with the ground wetness, we intend to discuss only the terms in the ground temperature equation involving the ground wetness. The ground temperature is given by

$$C \frac{\partial T_g}{\partial t} = R_N - F_s - LE_s + Q_m + S_i \quad (2-2-1)$$

where T_g is the ground temperature in the diurnal ground layer [Arakawa and Mintz, 1974] in [$^{\circ}$ K],

C is the total heat capacity in [$\text{cal cm}^{-2} \text{deg}^{-1}$],

R_N is the net radiation flux at the ground surface positive downward in [ly day^{-1}],

F_s is the upward flux of sensible heat in [ly day^{-1}],

LE_s is the upward flux of latent heat in [ly day^{-1}],

Q_m is the heating or cooling due to conduction through sea ice from the ocean below in [ly day^{-1}], and

S_i is the transfer of latent heat due to melting of ice or snow or due to freezing of water in [ly day^{-1}].

The ground temperature equation is discretized with respect to time by an implicit scheme and is updated in the time step before updating the ground wetness. The finite difference equation is given in TK without the term, S_i , as the following:

$$T_g^{n+1} = T_g^n + \frac{\eta_3 \Delta t [R_N - F_s - LE_s + Q_m + S_i]^n}{C + \left[\frac{\partial R_N}{\partial T_g} + \frac{\partial F_s}{\partial T_g} + L \frac{\partial LE_s}{\partial T_g} - \frac{\partial Q_m}{\partial T_g} \right]^n} \quad (2-2-2)$$

where the superscripts $n+1$ and n indicate the time step and $n_3 \Delta t$ is the time interval used in the subroutine.

In Equation (2-2-2), the terms, F_s , LE_s , $\frac{\partial F_s}{\partial T_g}$, $L \frac{\partial E_s}{\partial T_g}$, S_i and C , involve ground wetness. The latent heat flux, LE_s , or the actual evapotranspiration, E_s , has been discussed in Sec. 2.1. The sensible heat flux, F_s , will be discussed in Sec. 2.3, because both the ground temperature and the surface temperature are affected by ground wetness. The total heat capacity is defined as

$$C = \left(\frac{c\lambda}{\omega}\right)^{1/2} \text{ in } [\text{cal cm}^{-2} \text{ deg}^{-1}] \quad (2-2-3)$$

where c is the specific heat capacity in $[\text{cal cm}^{-3} \text{ deg}^{-1}]$,

λ is the thermal conductivity in $[\text{cal cm}^{-1} \text{ s}^{-1} \text{ deg}^{-1}]$, and

ω is the diurnal frequency in $[\text{s}^{-1}]$.

The values of C are given as the following:

$$\text{for ocean } C = \infty \quad (2-2-4a)$$

$$\text{for snow, } C = 2.3 \quad (2-2-4b)$$

$$\text{for ice, } C = 5.1 \quad (2-2-4c)$$

for frost,

$$C = [(0.331 + 0.075w') (2 + 2.5w') * 0.001 * \frac{24 \times 3600}{2\pi}]^{1/2} \quad (2-2-4d)$$

for mixed water and ice,

$$C = [(0.276 + (0.11 + 0.15w')(w' - 0.5w_i)) (1 + w' - 0.25w_i) * .002 * \frac{24 \times 3600}{2\pi}]^{1/2} \quad (2-2-4e)$$

where w_i = the portion of ice in $w' = (WET)$.

For soil, the original UCLA formula, (2-2-4e), with $w_i = 0$ is replaced in the present model by

$$C = \left[(.3 + VSM) * (1 + 10. * VSM) * 0.001 * \frac{24 * 3600}{2\pi} \right]^{1/2} \quad (2-2-4f)$$

where $VSM = 2.0 * WET * (ASM + USM)$, (2-1-9)

ASM = available soil moisture in [% of saturation ÷ 100], and

USM = unavailable soil moisture in [% of saturation ÷ 100].

The proper use of (2-2-4f) requires an appropriate definition of WET. This has been discussed in Sec. 2.1. Therefore, WET in (2-2-4f) is the ground wetness defined in this model despite the fact that the maximum available amount of moisture used in this model is different from UCLA's value.

The transfer of latent heat, S_i , due to melting of ice or snow or due to freezing of water is updated at each time step according to the ground temperature below or above the freezing temperature.

2.3 Surface Conditions in the Atmosphere

The formulation of the atmosphere-ground hydrology interaction depends on parameterization of both the planetary boundary layer (PBL) and ground hydrology. In TK, the boundary layer is taken to be the bottom half of the ninth layer in the GCM and the location of the "surface," the bottom of the ninth layer, with respect to the ground surface is not specified. We shall follow the same approach in this documentation. The atmospheric conditions that are coupled with the ground hydrology are related to the source terms in the governing equations of the GCM (see TK, pp. 7-13); namely,

- (1) the surface wind and stability conditions
- (2) the heat flux
- (3) the moisture flux, and
- (4) the solar radiation.

Most of the discussions in the following paragraphs can be referred to TK (Chapter XI, pp. 109-191).

Surface Wind and Stability Conditions

Since the lower surface of the GCM or PBL is not explicitly specified, we assume that the "surface" is located at the level of anemometer height, say, 8 m from the ground surface. The surface wind components are extrapolated from the values at the n-th and n-1 th layers with respect to their σ coordinates by

$$\frac{u_n - u_{n-1}}{\sigma_n - \sigma_{n-1}} = \frac{u_s - u_n}{\sigma_s - \sigma_n} \quad (2-3-1)$$

where the subscripts n and s refer the quantities to the center of the nth layer and to the "surface" and u is the x-component of wind velocity. The y-component of velocity, v_s , is computed in a similar manner. The magnitude of the surface wind velocity is then

$$W_s = (u_s^2 + v_s^2)^{1/2} \text{ in } [m \text{ s}^{-1}] \quad (2-3-2)$$

Special provisions are made for computing wind speeds at the north and south poles. The surface wind affects not only the surface skin friction but also the moisture and heat fluxes on the ground surface. These fluxes depend also on the drag coefficient, C_D . For a neutrally stable atmosphere when the surface temperature, T_s , and ground temperature, T_g , are equal,

$$C_D \equiv C_{D_0} = \min[(1.0 + 0.07 W_s^2)/1000., 0.0025], \text{ for ocean} \quad (2-3-2a)$$

$$= 0.002 + 0.006(Z_s/5000), \text{ for not ocean} \quad (2-3-2b)$$

where Z_s is the ground surface elevation in [m].

In general,

$$C_D = C_{D_0} / [1 - 7.0(T_g - T_s) / W_s^2] , T_g < T_s \quad (2-3-3a)$$

$$= C_{D_0} [1 + \sqrt{(T_g - T_s) / W_s^2}] , T_g \geq T_s \quad (2-3-3b)$$

These coefficients will be used in the moisture and heat flux computations.

Heat Flux and Surface Temperature

The sensible heat flux on the ground surface is computed according to

$$F_s = C_p \rho_a C_D |W_s| (T_g - T_s) \text{ in } [1y \text{ day}^{-1}] \quad (2-3-4)$$

which is coupled to the heat flux in the PBL by the turbulent diffusion equation

$$F_h = -C_p \rho_a K \left. \frac{\partial T}{\partial z} \right|_{PBL} \quad (2-3-5)$$

where ρ_a is the air density in $[g \text{ cm}^{-3}]$,

C_p is the specific heat at constant temperature in $[\text{cal g}^{-1} \text{ deg}^{-1}]$, and

K is the vertical eddy diffusivity in $[m^2 \text{ s}^{-1}]$.

The horizontal convergence in the boundary layer and geopotential difference between its top and bottom are neglected, then the surface temperature, T_s , can be computed by equating the above two equations as described in detail in TK. However, we would like to point out one computation directly involving the ground wetness for the temperature gradient, $\left. \frac{\partial T}{\partial z} \right|_{PBL}$, in (2-3-5).

The temperature gradient is given by

$$\left. \frac{\partial T}{\partial z} \right|_{PBL} = \frac{(T_{TB} - T_s) - (T_{TB} - T_s)_{crit}}{(\Delta z)_{PBL}} \quad (2-3-6)$$

$$\text{and } (T_{TB} - T_s)_{crit} = (1 - r_s)(T_{TB} - T_s)_{d.a.} + r_s(T_{TB} - T_s)_{m.a.} \quad (2-3-7)$$

where $(\Delta z)_{PBL}$ is the thickness of the PBL and the subscripts, T_B, s, (d.a.) and (m.a.) refer to the top of PBL, the "surface" or the bottom of PBL, dry adiabatic and moist adiabatic, respectively. The relative humidity on the "surface", r_s , is derived from

$$r_s = \frac{2w' r_n}{w' + r_n}, \text{ and } w' = WET \quad (2-3-8)$$

where w' is the ground wetness (see TK, p. 132). It appears that the ground wetness is treated like the relative humidity on the ground surface in (2-3-8). The relation between the ground wetness and the relative humidity in a soil layer has been discussed in Sec. 2.1. In order to use (2-3-8), the following transformations are made:

$$WAT = 2. * (1.66667 * 2. * WET - 0.66667) \quad (2-3-9a)$$

for the "composite soil", and

$$WAT = 0.2 * (2. * WET - 0.26909) \quad (2-3-9b)$$

for the "sandy soil." WAT is used as w' in (2-3-8) instead of WET. In a way, it is an inverse transformation of (2-1-3), which changes the ground wetness back to the "initial ground wetness" (Schutz and Gates' surface relative humidity).

On the other hand, the surface specific humidity is computed by another method using (2-3-10) as discussed in the following section.

Moisture Flux

The moisture flux from the ground is equal to the actual evapotranspiration given by (2-1-4) and (2-1-5). In these equations, the surface specific humidity, q_s , is derived by equating the flux in the PBL to the flux from the surface as the following:

$$q_s = \frac{EVACO \cdot q_g + EDV \cdot q_n}{EVACO + EDV} \quad (2-3-10)$$

where q_g^* and q_n are the saturation specific humidity at the ground surface and the specific humidity at the 9th level in the GCM. $EVACO = \beta C_D W_s$, an evapotranspiration coefficient in (2-1-4) and (2-1-5). $EDV = K/(\Delta z)_{PBL}$, a surface layer eddy coefficient. Physically, (2-3-10) implies a constant moisture flux through the PBL similar to the assumption used in deriving the surface temperature. However, in case of supersaturation, the surface temperature and specific humidity are adjusted to account for the heating effect of condensation and the releasing of moisture (see TK, pp. 135-136).

Solar Radiation

The radiation model in the GCM has not been documented at this time; therefore, it must be referred to the forthcoming documentation. In running the GHM on-line with the GCM or off-line alone, the radiation terms in the ground temperature equation (2-2-1) are treated either as the version given in TK or as input quantities from the GCM output.

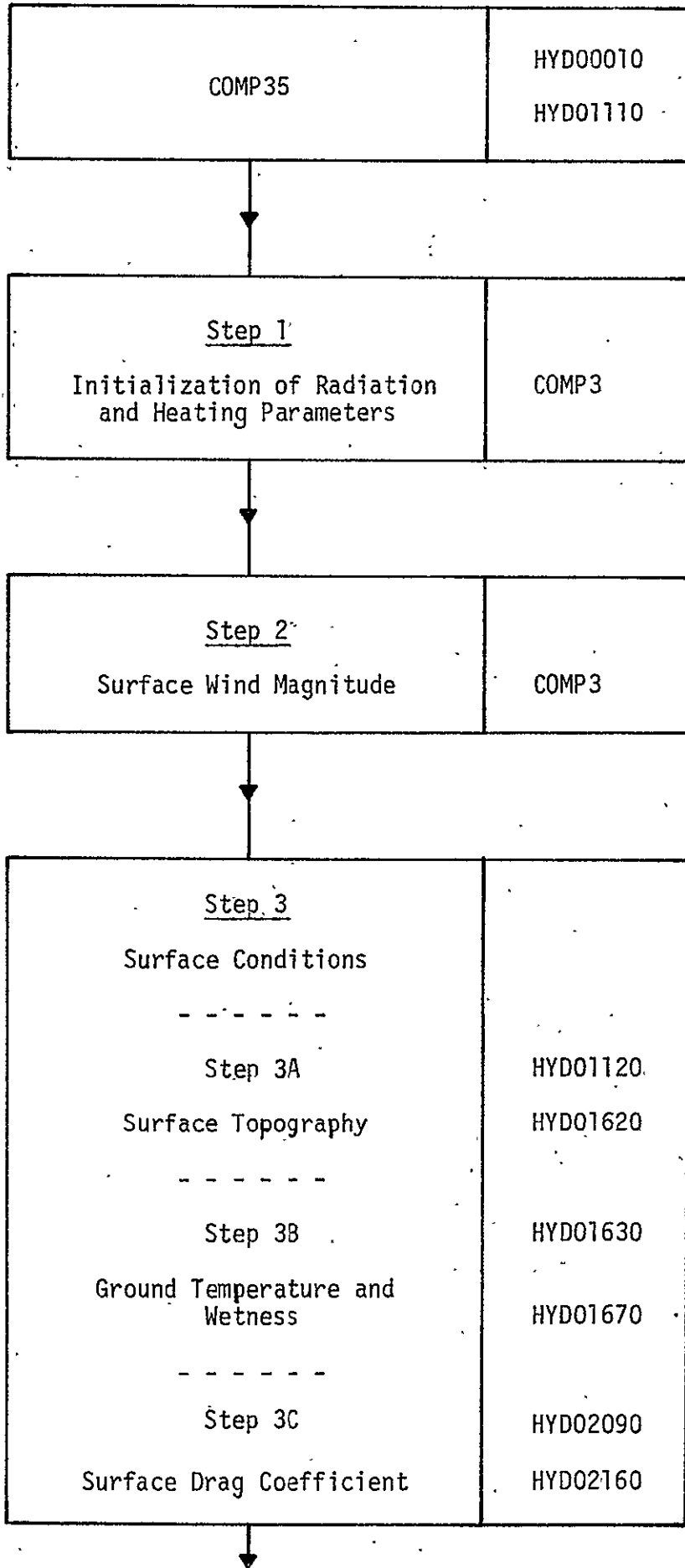
III. Description of the Computer Program for the GHM

Subroutine COMP35

The ground hydrology model resides in subroutine COMP35 in the GCM computer program. The function of COMP35 is to evaluate the hydrology related source terms in the governing equations and their effects on the atmospheric motion. It should be noted that COMP35 is different from COMP3 in TK in that the ground hydrology parameterizations were later added. There are 16 steps in COMP35 as in COMP3 as illustrated in the flow chart. Steps 1, 2, 3, 6 and 12 interact directly with the GIM. The major ground hydrology parameterizations are incorporated in Steps 7 and 14. Step 7 deals with the coupled effects of the ground hydrology and the atmosphere on the "surface" temperature and humidity as discussed in Sec. 2.3 and the parameterizations of evapotranspiration for the latent heat flux. In Step 14, the ground temperature is first updated according to the scheme outlined in Sec. 2.2 and then ground wetness change is calculated on the basis of (2-1-1).

FLOW CHARTS

COMP35:



↓

<u>Step 4</u> Set Up Vertical Arrays for Some Variables ----- Step 4A Pressures ----- Step 4B Temperature & Convective Adjustment ----- Step 4C Moisture Variables	HYD01680 HYD01770 HYD01780 HYD01930 HYD01940 HYD02000
---	--

↓

<u>Step 5</u> Vertical Diffusion of Heat & Moisture	HYD02170 HYD02420
--	----------------------

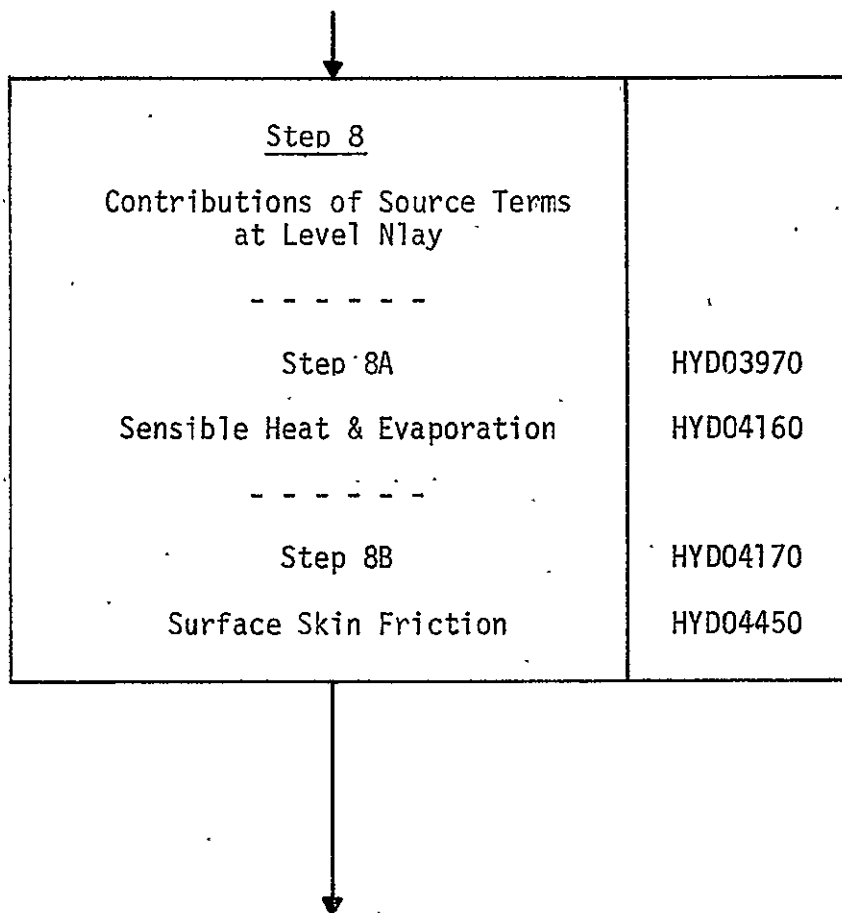
↓

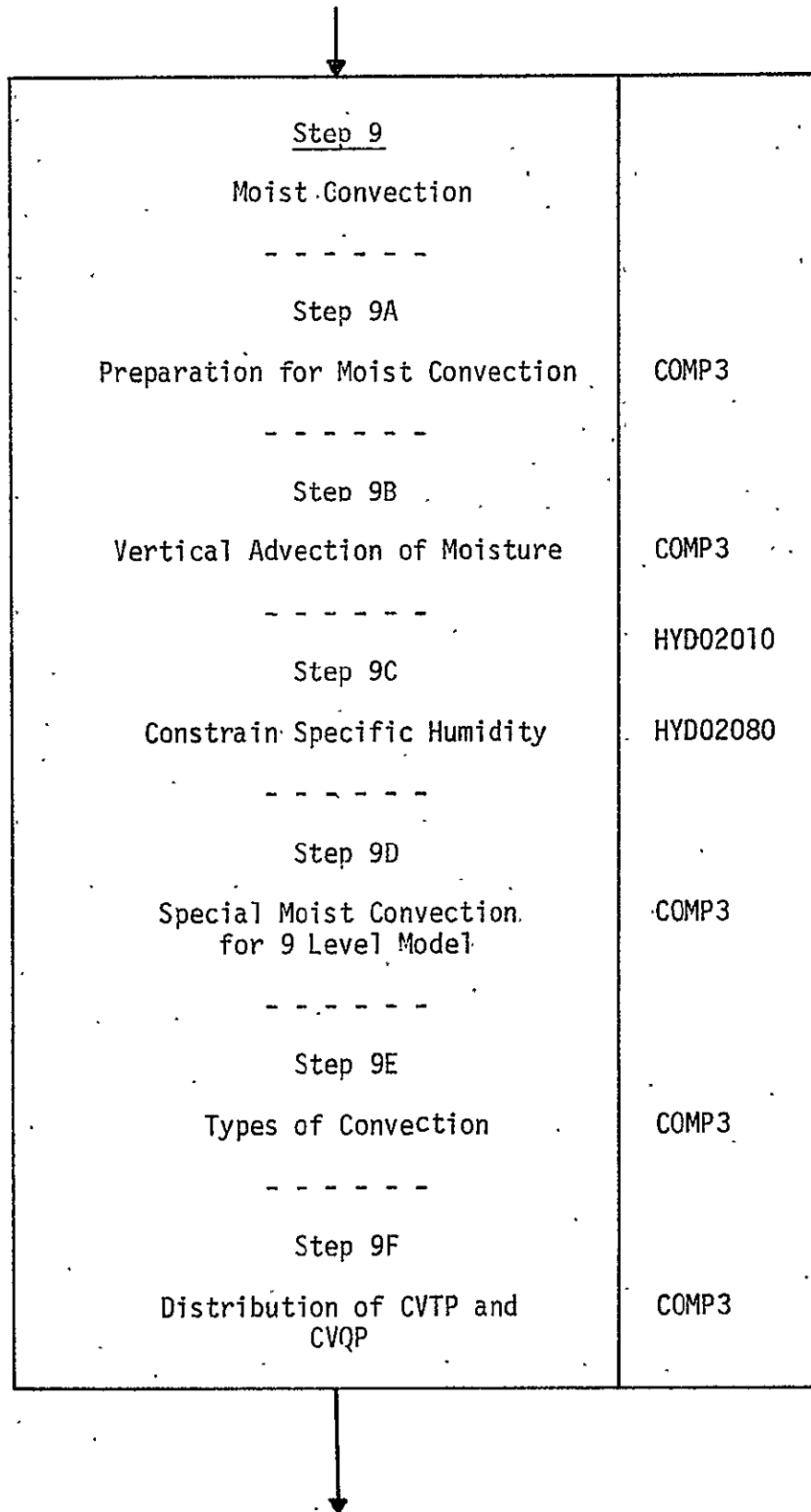
<u>Step 6</u> Saturation Specific Humidity and Specific Humidity	HYD02430 HYD02480
--	----------------------

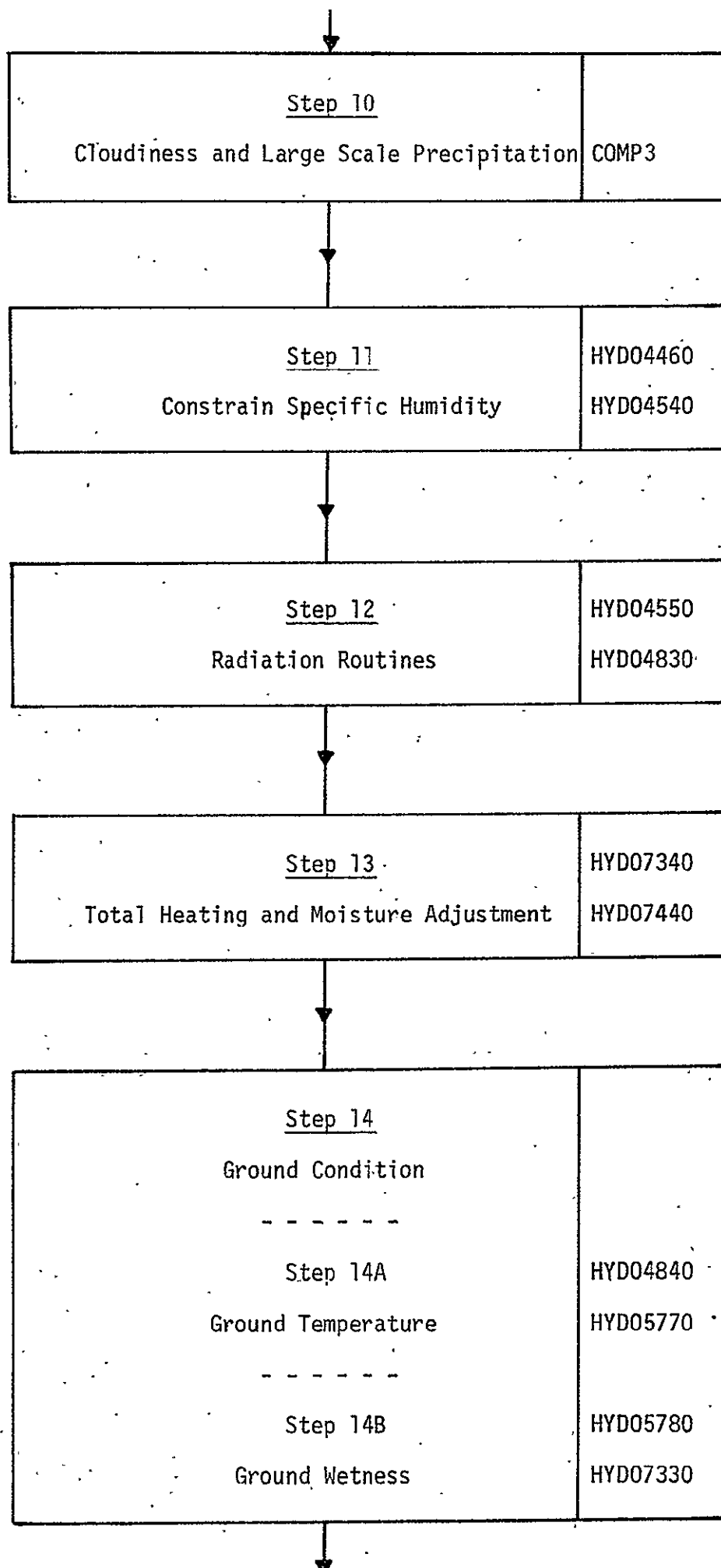
↓

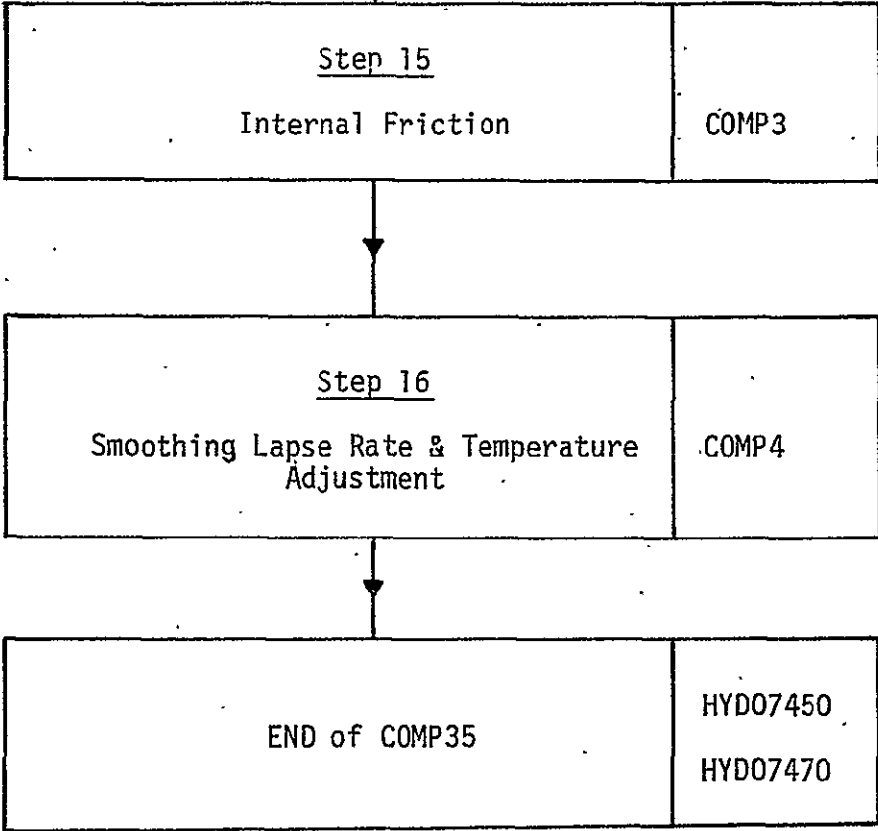
<u>Step 7</u> Determination of Surface Temperature and Specific Humidity	HYD02490 HYD03960
---	----------------------

↓

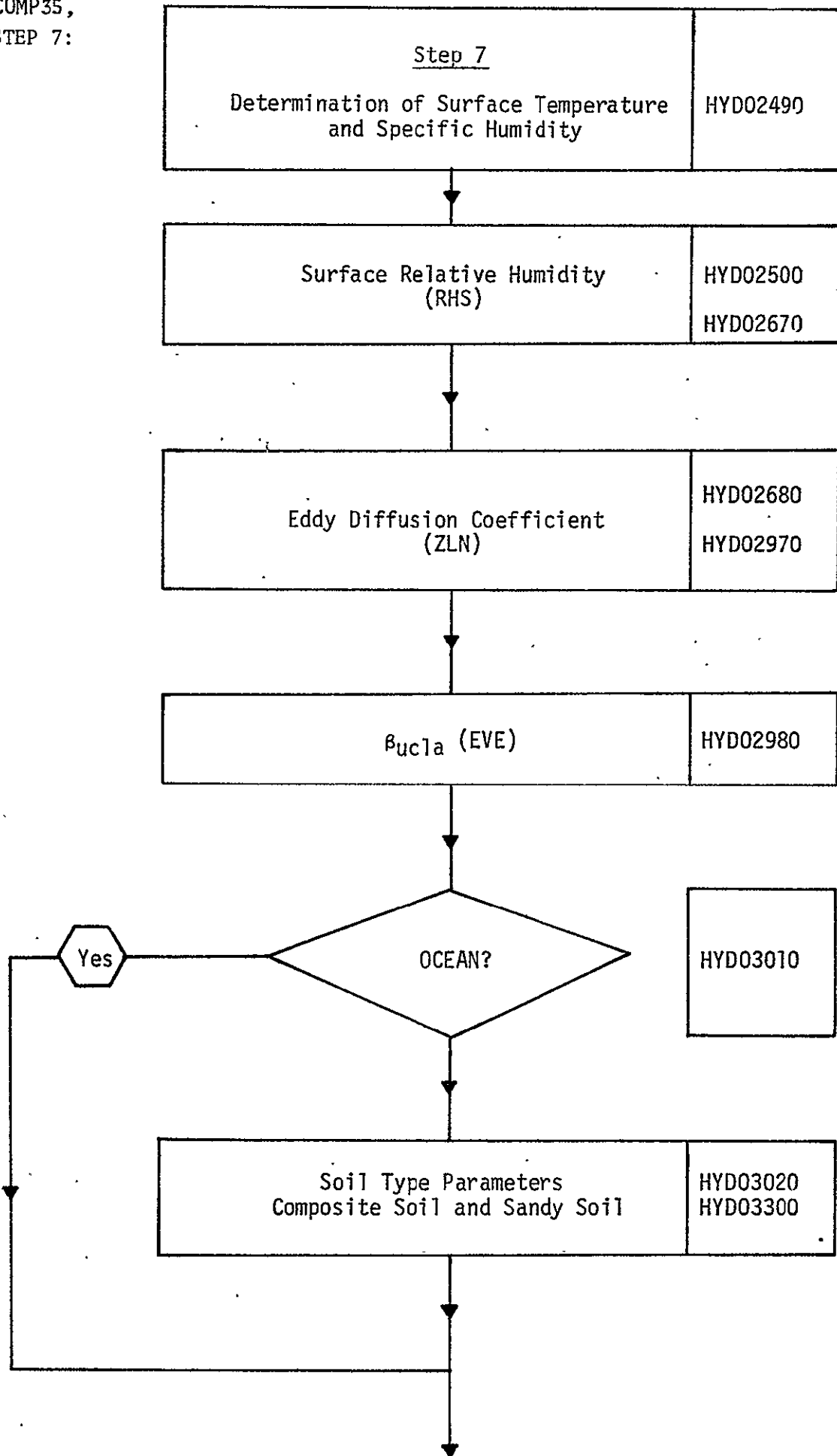


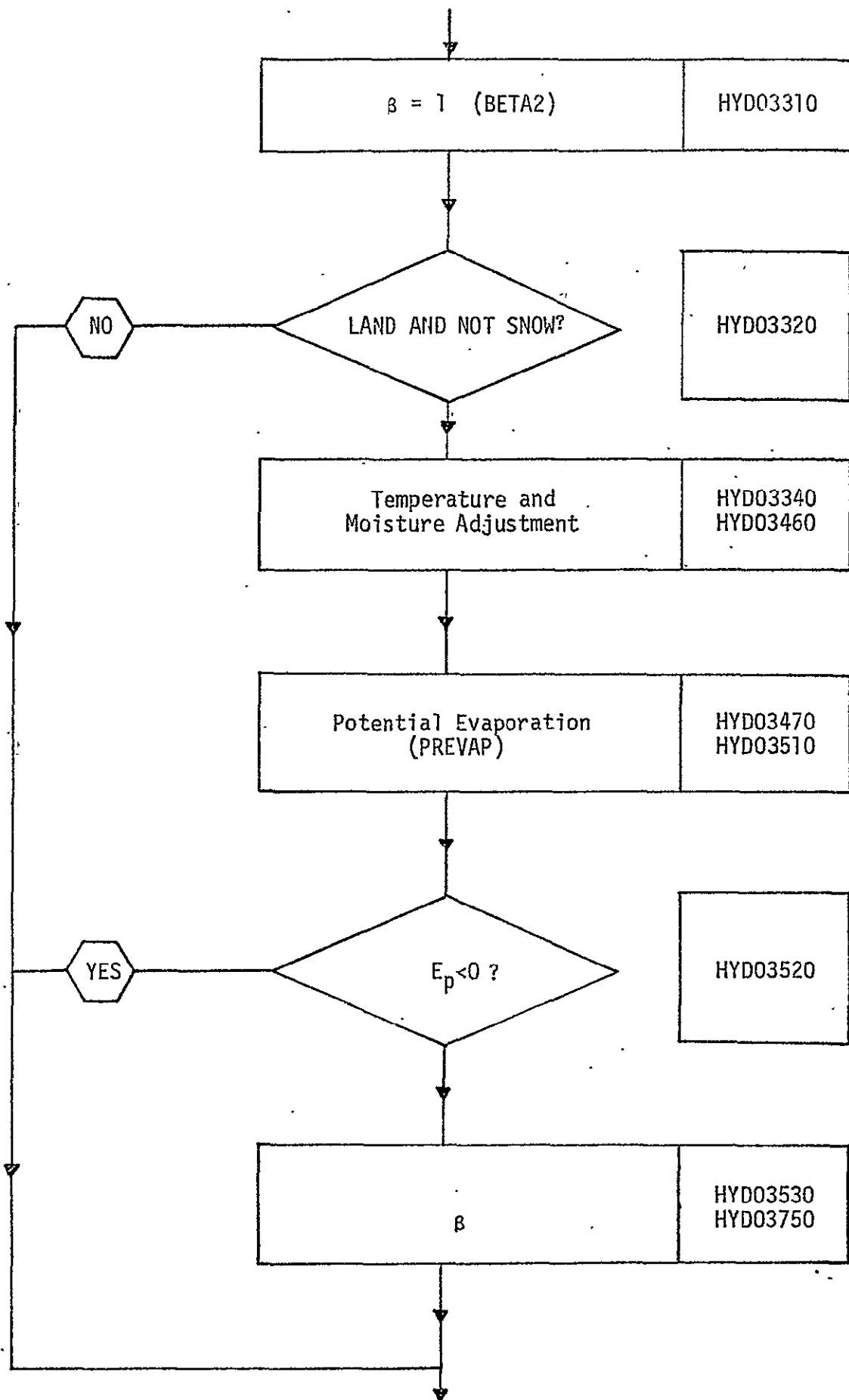


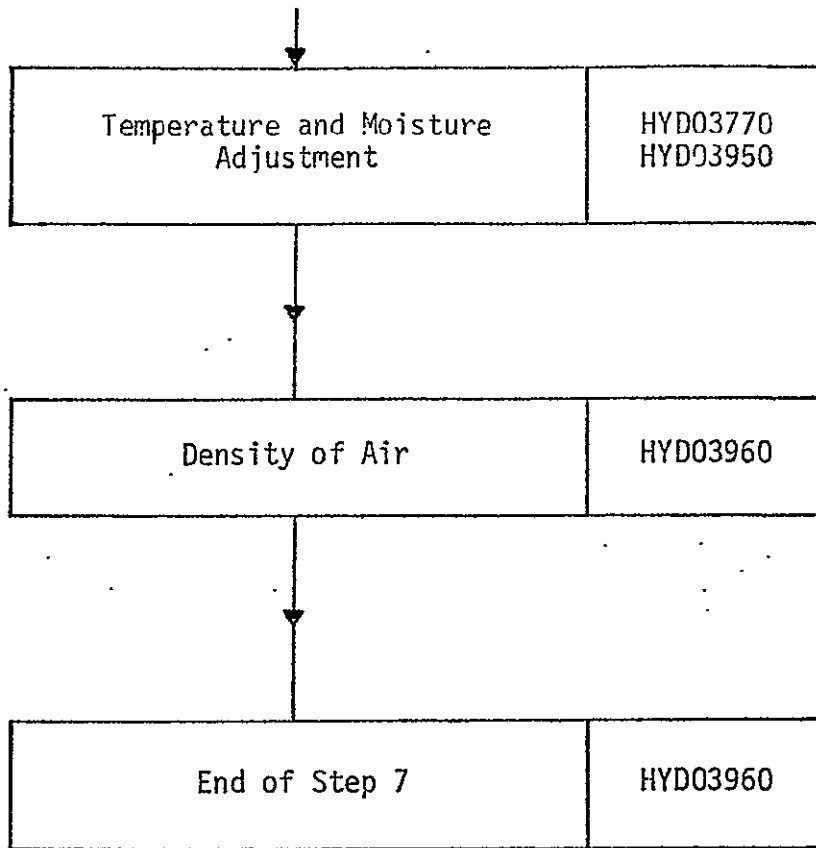




COMP35,
STEP 7:

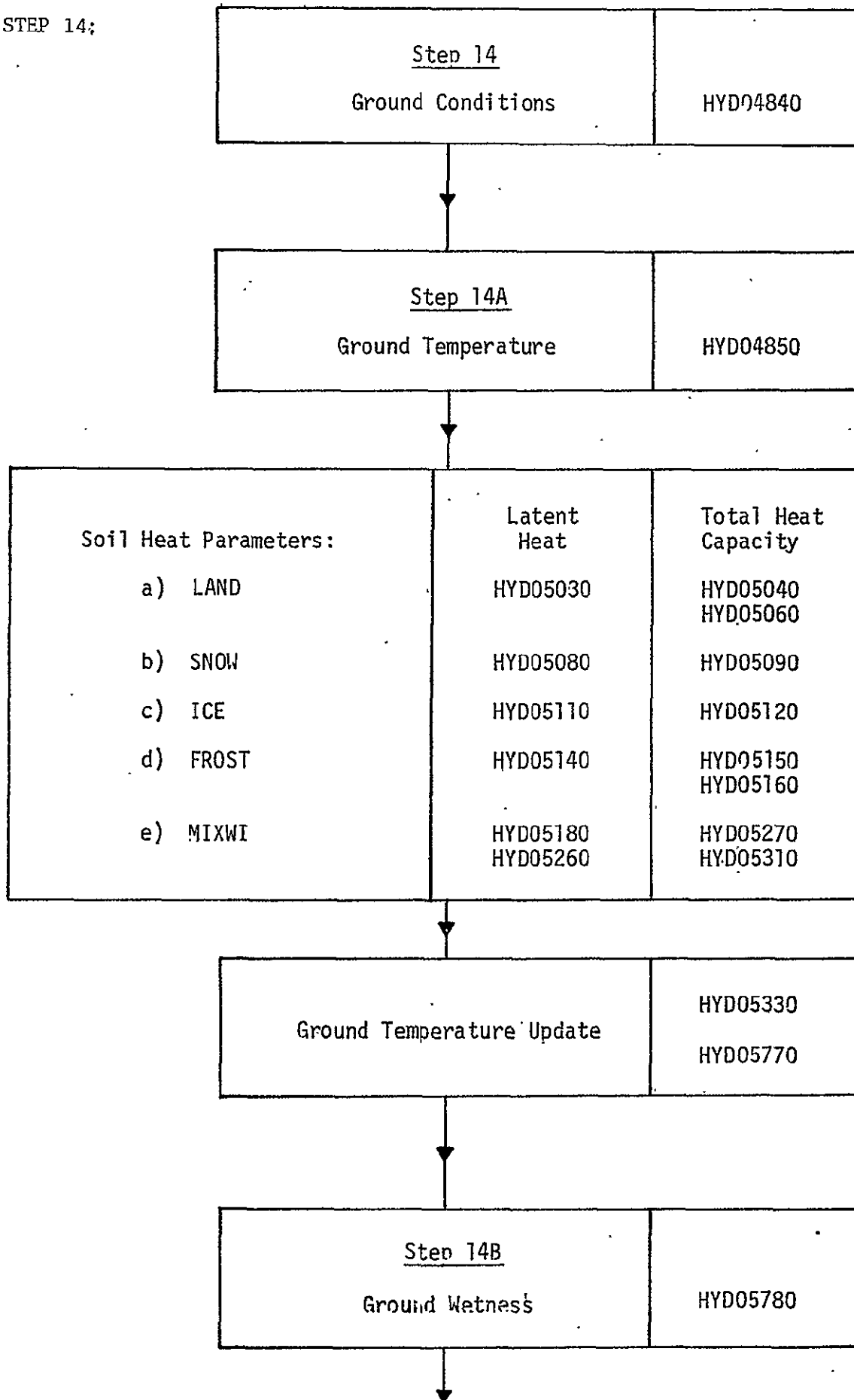


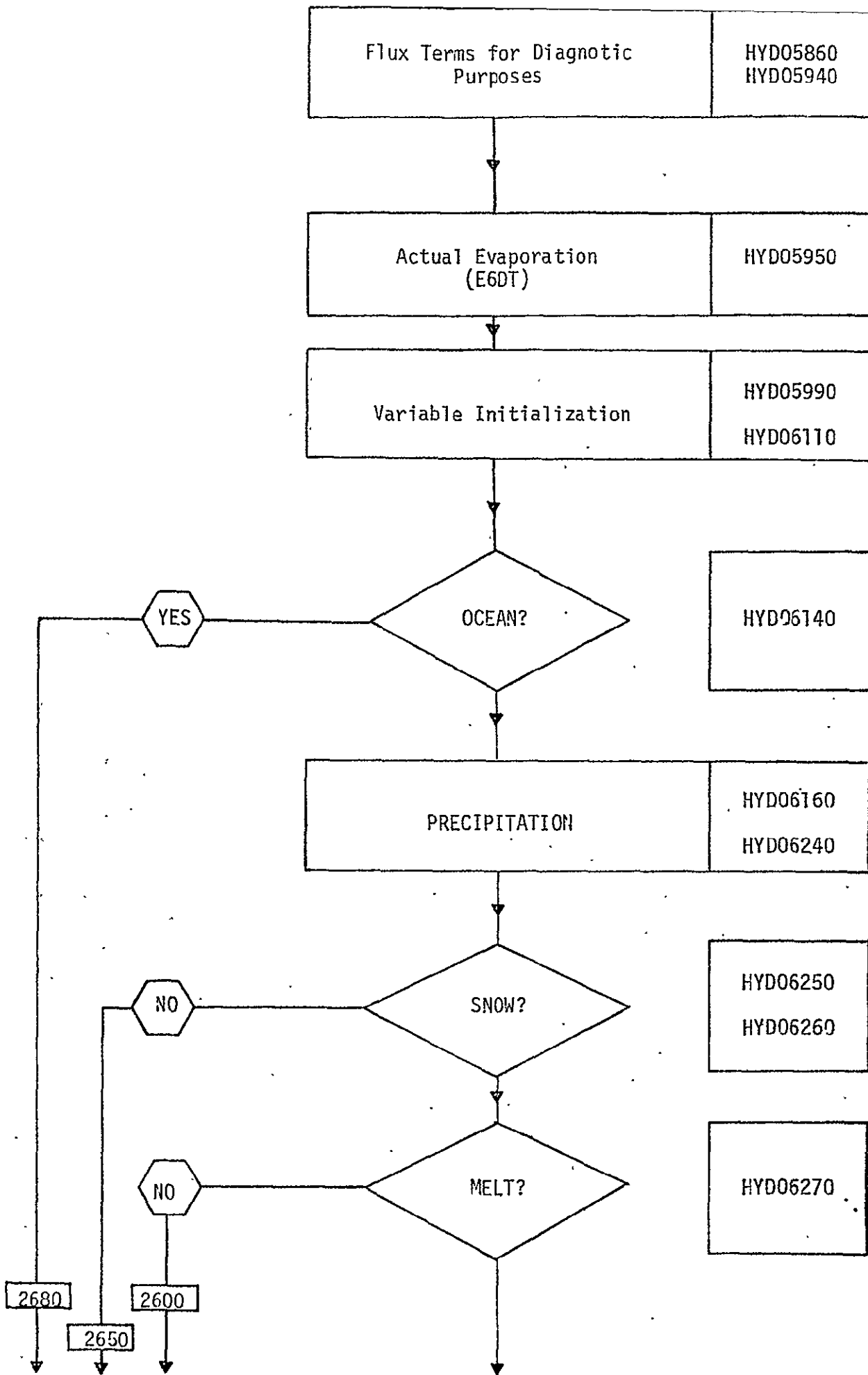


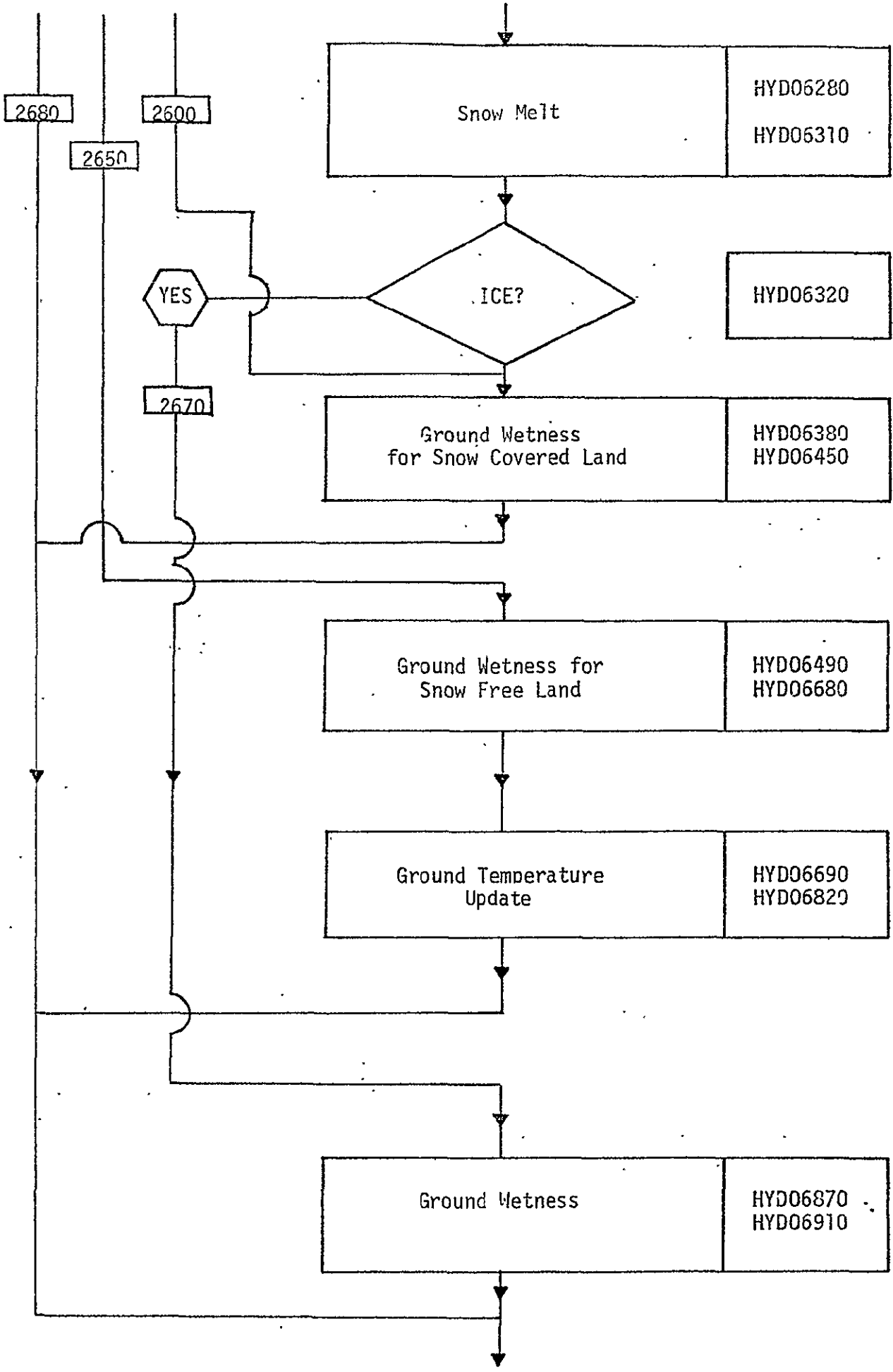


COMP 35,

STEP 14:







↓

Ground Wetness Packing	HYD06920 HYD06960
------------------------	----------------------

↓

End of Step 14	HYD06970 HYD07330
----------------	----------------------

PART II.

MODEL RESULTS & ANALYSIS

IV. Off Line Model (OLM)

Introduction

The OLM provides a simple and efficient way to test various hydrologic parameterizations without the need for extensive simulation time. The hydrologic parameterizations are assembled in a parallel manner in the OLM and given the following identification:

1. UCNI - a first revision by the University of Connecticut,
2. UCLA - the UCLA Model (Arakawa, 1972; Arakawa & Mintz, 1974),
3. GISSJK - Jack Kornfield's work previously referred to as GHM, and discussed in this text.

UCNI was developed because we felt that a hydrologically consistent model using only simple and well-defined parameterizations was needed for evaluating the existing GHM. UCNI represents our first step in developing a physically realistic multi-layered model. Specifically, the following ideas were incorporated into UCNI:

- a) soil moisture is defined in fraction of saturation;
- b) cell moisture changes are calculated from (2-1-1a) with respect to the amount of water at saturation;
- c) saturation moisture content is a function of given layer depth and porosity of soil type;
- d) the initial soil moisture range is linearly scaled between field capacity (FC) if the surface relative humidity (r_s) equals 100% to permanent wilting point if r_s equals 0;
- e) available soil moisture is the difference between FC and PWP;
- f) evaporation scaling factor, β , varies from unity at FC to 0 near PWP, with plant factor (2-1-11) kept constant at unity regardless of solar angle; and

g) vegetation and soil type may change effective soil layer thickness.

The OLM reads an output or data tape from a previously run GCM experiment with a certain known ground hydrology model. The ground hydrology parameterization generally used in GCM experiments to develop the data tape has been described in TK. Recalling these parameterizations we see the following:

1. $\beta = \text{Min}(1, 2w')$,
2. $0 \leq w' \leq 1$,
3. $WGM = 10 \text{ g}$, and
4. $w' = \text{initial } w' \text{ for all time} = \text{WET}$.

The data set the OLM reads every half hour from the GCM data tape is:

1. TAU, the model time in [hr];
2. PC, the surface pressure in [mb];
3. TSC, the surface temperature in [$^{\circ}\text{K}$];
4. SHSC, surface specific humidity [g/g] for first time step the net radiation in [ly/day] for 2 through n time steps;
5. GTC, the ground temperature in [$^{\circ}\text{K}$];
6. GWC, the ground wetness in [% saturation \div 100];
7. UC, the x component of velocity in [m/sec] for levels 7, 8, 9;
8. VC, the y component of velocity in [m/sec] for levels 7, 8, 9;
9. TC, the temperature of air in [$^{\circ}\text{K}$] for levels 7, 8, 9 ; and
10. SHC, the specific humidity in [g] of water vapor/[g] of air for levels 7, 8, 9 .

The ground hydrology model being evaluated calculates the following diagnostic parameters:

1. GW, the ground wetness in [% saturation \div 100];
2. TS, the surface temperature in [$^{\circ}$ K];
3. GT, the ground temperature in [$^{\circ}$ K]; and
4. AET, (formerly E6DT) the evapotranspiration flux in [cm/hh].

With the GCM data tape and subroutines SDET (Solar angle calculation), SURFWD (Surface wind calculation), and RITE (Diagnostic parameters) the OLM simulates an on-line run and calculates the diagnostic variables. At the end of the experiment comparisons between GW, GWC, TS, TSC, GT, GTC and AET, AETC (from UCLA) were made and will be discussed in a later section.

The OLM-UCLA1 and OLM-UCLA2 were incorporated in OLM to calculate the AET flux (actual evapotranspiration, missing on data tape) for the case of variable ground wetness (GW \neq K, OLM - UCLA1) and constant ground wetness (GW=K, OLM - UCLA2). The recalculation of AETC was also necessary because of the different eddy diffusivity parameterizations used in developing the GCM data tape versus OLM. The TK eddy diffusivity parameterization was used in off-line experiments because it required a substantially smaller data set.

In figure 4-1 a schematic is presented of the parallel hydrology parameterizations in the OLM. The accuracy of the OLM in simulating an on-line calculation can be evaluated by comparing UCLA(GW = K) with OLM-UCLA1 or OLM-UCLA2. Close agreement between UCLA and OLM-UCLA2 was always found. In particular, Table 4-1 outlines how diagnostic variable comparisons are made for the different hydrologic parameterizations.

GCM with UCLA Formulation and NCAR Eddy Diffusivity (EDNS)

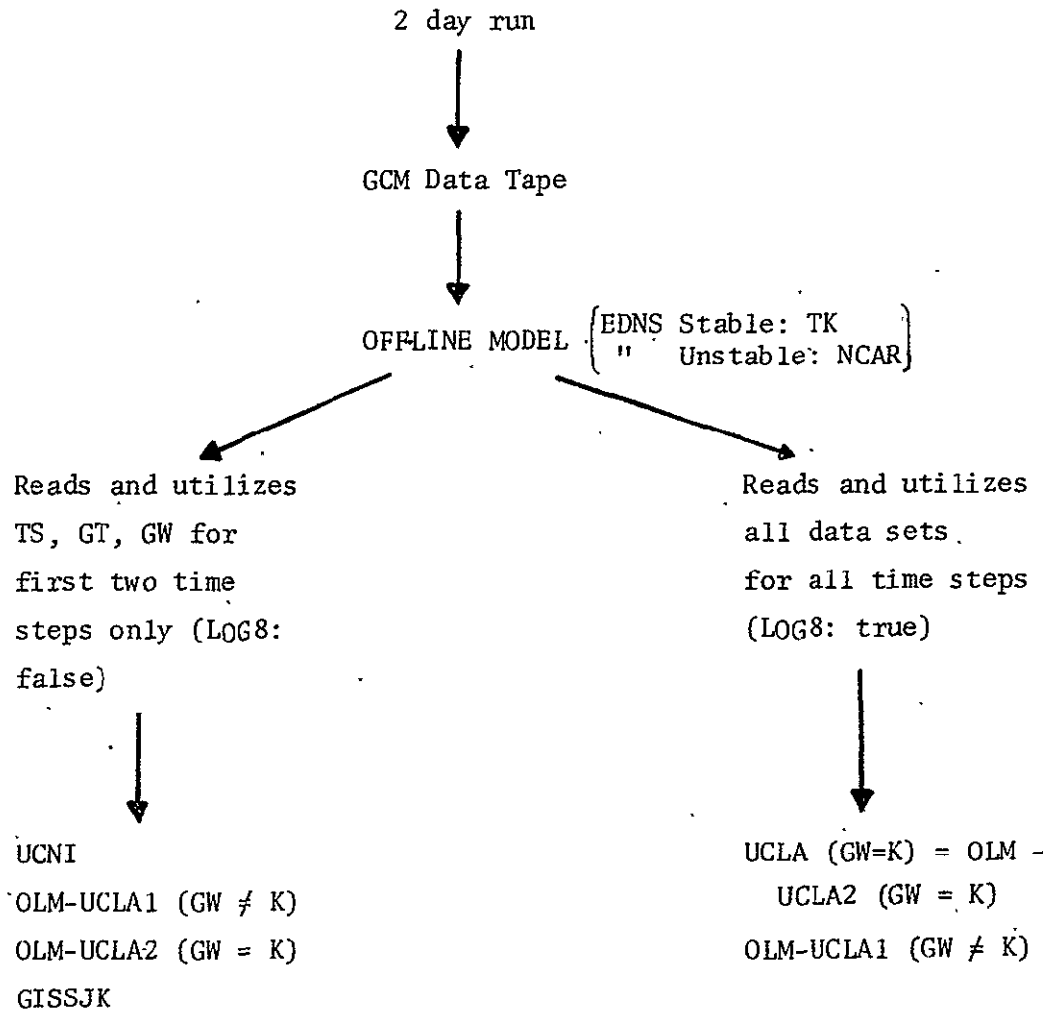


FIGURE 4-1 Schematic of Parallel Model in OLM

TABLE 4-1

Model Diagnostic Parameter Read and Calculation Scheme

GCM Data Tape Variables	TSC	TS	GTC	GT	GWC	GW	AETC	AET
OLM Models								
UCNI	R	C		C		C		C
OLM-UCLA1: UCLA w/GW Variable								
LOG8:F	R	C		C		C		C
LOG8:T	R	C	R	C	R	C	C	
OLM-UCLA2: UCLA w/GW Constant								
LOG8:F	R	C		C		C		C
LOG8:T	R	C	R		R	C	C	
GISSJK	R	C		C		C		C
UCLA: GCM Data Tape (LOG8:T) Values w/GW Constant	R		R		R		C	

R: Model reads data tape variable every time step

C: Model calculation of this variable will be used for diagnostic purposes

It should be noted that the surface and ground temperature are calculated by the following different schemes:

$$TSC^N \rightarrow TS^{N+1}, TSC^{N+1} \rightarrow TS^{N+2} \dots \text{etc.}$$

$$GTC^N \rightarrow GT^{N+1} \rightarrow GT^{N+2} \rightarrow GT^{N+3} \dots \text{etc.}$$

Thus, TS differences reflect variations during a time step while GT differences represent cumulative effects since second data tape read.

Differences in Hydrologic Parameterizations

In order to understand the significance of the comparisons discussed later we will highlight their differences in this section. First, the UCNI differs from the UCLA parameterizations in the following areas:

- a) initialization of GW,
- b) approach taken in scaling β as a function of GW,
- c) soil water content at saturation, and
- d) definitions of GW and how it changes.

Secondly, the GISSJK parameterization differs from UCNI in the same areas, a) through d) plus the following:

- e) plant factor (effect of solar radiation on β),
- f) volumetric heat capacity, and
- g) runoff.

Among these differences, the principal factors that lead to significant variations in the estimation of the evaporative flux were β and different definitions of changes in GW. Table 4-2 summarizes the differences between these hydrologic parameterizations (UCNI, UCLA, GISSJK).

TABLE 4-2 Comparisons of UCNI, UCLA and GISSJK Parameterization

		UCNI	UCLA	GISSJK
1. Layer Depth	CS	100 cm	100 cm	4 ft (?)
	SS	50 cm	100 cm	4 ft (?)
2. Porosity	CS	.5	?	?
	SS	.5	?	?
3. Field Capacity [% Saturation/100]	CS	.25	?	.25
	SS	.09	?	.09
4. PWP [% Saturation/100]	CS	.10	?	.10
	SS	.025	?	.024
5. Soil Water Content at Saturation [g/cm ²]	CS	50	66.6	66.4
	SS	25	66.6	4
6. Available Water [g/cm ²]	CS	7.5	10.0	10.0
	SS	1.6	10.0	.2
7. GW Initialization	CS	$\frac{SRH (FC-PWP) + PWP}{100}$	$\frac{SRH - 15}{85}$	$.5 \left(\left(\frac{SRH-15}{85} \right) .3 + .4 \right)$
	SS	"	--	$\left(\frac{SRH-15}{85} \right) 5.0 + .27$
		[% Saturation/100]	[% Available/100]	[% Saturation/100]
8. Plant (<1)	CS/SS	--	--	Cos z/.2588
9. $\beta (<1) \times$ (Plant = 1)	CS/SS	$\frac{WET-PWP}{FC-PWP}$	2 x GW	Double exponential (see text)
10. C [cal cm ⁻² deg ⁻¹] (GW=0) (GW=1) (GW=1)	CS	C1	C1	$C1/\sqrt{2(.386/.3)}$
	CS	C2	C2	$C2 \times \sqrt{2}$
	SS	C2	C2	$C2/\sqrt{3/2}$

TABLE 4-2 Comparisons of UCNI, UCLA and GISSJK Parameterization (cont'd)

	UCNI	UCLA	GISSJK
11. Runoff [g/cm ²]	Rain(.1 + .9(GW) ^{1.5})	Rain(.1 + .9(GW) ^{1.5})	See Text
Examples:			
Rain = .1 [cm/hh]	GW=0 .01	.01	0
	GW=.5 .042	.042	.05
	GW=1.0 .1	.1	.1
Rain = 1.0 [cm/hh]	GW=0 .1	.1	0
	GW=.5 .42	.42	.45
	GW=1.0 1.0	1.0	.9
12. EDV [m sec ⁻¹]	TK (1973)	NCAR	TK (1973)

Notations: CS: composite soil; SS: sandy soil
 SRH: surface relative humidity
 EDV: surface layer eddy coefficient

Experiments

To conduct the OLM experiments a 2 day GCM run (DSNAMES: I719/VRM0, VRH0, VRP0, VRR0, 11/76) was executed from which the input GCM data tape variables, discussed in the introduction, were extracted for the general US surface and neighboring ocean cells for levels 7, 8, 9 of the GCM. The ground surface and ocean cells are shown in Fig. 4-2. This compacted or condensed GCM tape information was then read by the OLM for the following cases:

		US	Globe	Area
Cell Types	1. Dry	(J,I) (4,4)	(J,I) (33,15)	Dry Southwest
	2. Average	(3,6)	(32,17)	Southern Great Plains
	3. Wet	(7,12)	(36,23)	Canada/New England

in combination with the following ground hydrology parameterizations:

UCNI
OLM-UCLA1 (GW≠K constant)
OLM-UCLA2 (GW=K constant)
UCLA (GW=K constant)
GISSJK

These experiments took about 1 minute on IBM 360-50 at the University of Connecticut Research Computer Center while the Amdahl at GSFC took about half this time to execute.

Results

The OLM provided a simple comparison of the various ground hydrology parameterizations that were reviewed in this section. In particular, the following parameters are discussed and summarized:

Soil moisture

Surface and ground temperature

Potential & actual evapotranspiration and their ratio, β .

Soil Moisture

The following comparisons were made about soil moisture levels and variations for various cell cases (see Fig. 4-3 to 4-5):

1. GISSJK moisture levels were significantly higher for all three moisture cases;
2. UCNI and UCLA moisture levels were close in all three moisture cases;
3. OLM-UCLA1 (GW#K) moisture levels changed significantly for typical ET and rain fluxes; and
4. In general the change of moisture levels was not significant during two day test period. (Therefore longer OLM runs of duration greater than 2 days should be made.)

Surface and Ground Temperature

For temperature comparisons the following assessments were made (see Fig. 4-6 to 4-11):

1. The ground and surface temperature calculations for the UCLA model and UCNI were consistent for all cases with better surface temperature agreement during daylight hours;
2. Temperature predictions were generally in phase for most models and cell types with the exception of GISSJK;
3. The ground and surface temperature were generally higher for GISSJK, sometimes as much as 10°C higher for the different cell types; and

4. The ground temperature for GISSJK demonstrated a phase shift of about 3 hours with a gradual upward drift in magnitude from those of other models.

Potential (ET) and Actual (AET) Evapotranspiration and Their Ratio, β .

The OLM provided the following results related to evaporation rates for the three parameterizations (UCNI, UCLA, GISSJK) (see Fig. 4-12 to 4-14 and Table 4-3):

1. Potential evaporation rates were generally highest for GISSJK for all cell types;
2. The potential evaporation scaling factor, β , was lowest for GISSJK and highest for UCLA for all cell types;
3. The actual evaporation rate was lowest for GISSJK for all cell types; and
4. The UCNI generally predicted values of PE and β that appear reasonable when compared with GISSJK and UCLA models.

Summary

The major findings discussed in previous sections individually will now be summarized collectively:

Different definitions of soil moisture, although significant between models, did not cause major differences in the calculation of AET. This suggests a certain consistency within each model.

Surface and ground temperature results are similar for all models for the range of moisture levels tested with the exception of GISSJK.

Ground temperature difference of +10°C between GISSJK and other models is believed to be due to the underestimation of AET by a factor of 2

or more.

Surface temperature variation of 10°C between time steps had appeared to be due to separate (stable, unstable) parameterizations for the surface layer eddy coefficient. The variations had a deleterious effect on AET when they occurred. When the OLM used the eddy diffusivity in TK, the oscillations were greatly reduced.

Peak AET seems to occur when surface and ground temperatures peak at mid-day.

β as a function of PET&GW in GISSJK led to a "flat" - fairly constant AET for most of the daylight hours. β as a function of GW in UCNI & UCLA produced significant variations of AET during daylight hours. In OLM-UCLA1 with variable ground wetness noticeable changes in β occurred during significant evaporation or precipitation periods.

AET estimates for three different soil moisture levels, wet, average and dry case, were remarkably similar in magnitude for the 2 days. This is due to the compensating factors of a large PET when β is small for the dry case or vice versa for the wet case.

Small negative evaporation rates generally occur during evening hours.

UCNI appears to be a reasonable revision of currently available ground hydrology models.

In conclusion the OLM has provided an efficient way to compare three different hydrology parameterizations. The effects of the differences between these parameterizations on soil moisture and temperature, although not interactive with the GCM, can be readily evaluated. The long-term calculations (greater than 2 days) although not attempted at this time should be conducted later as soon as major revisions are completed and a data tape is available.

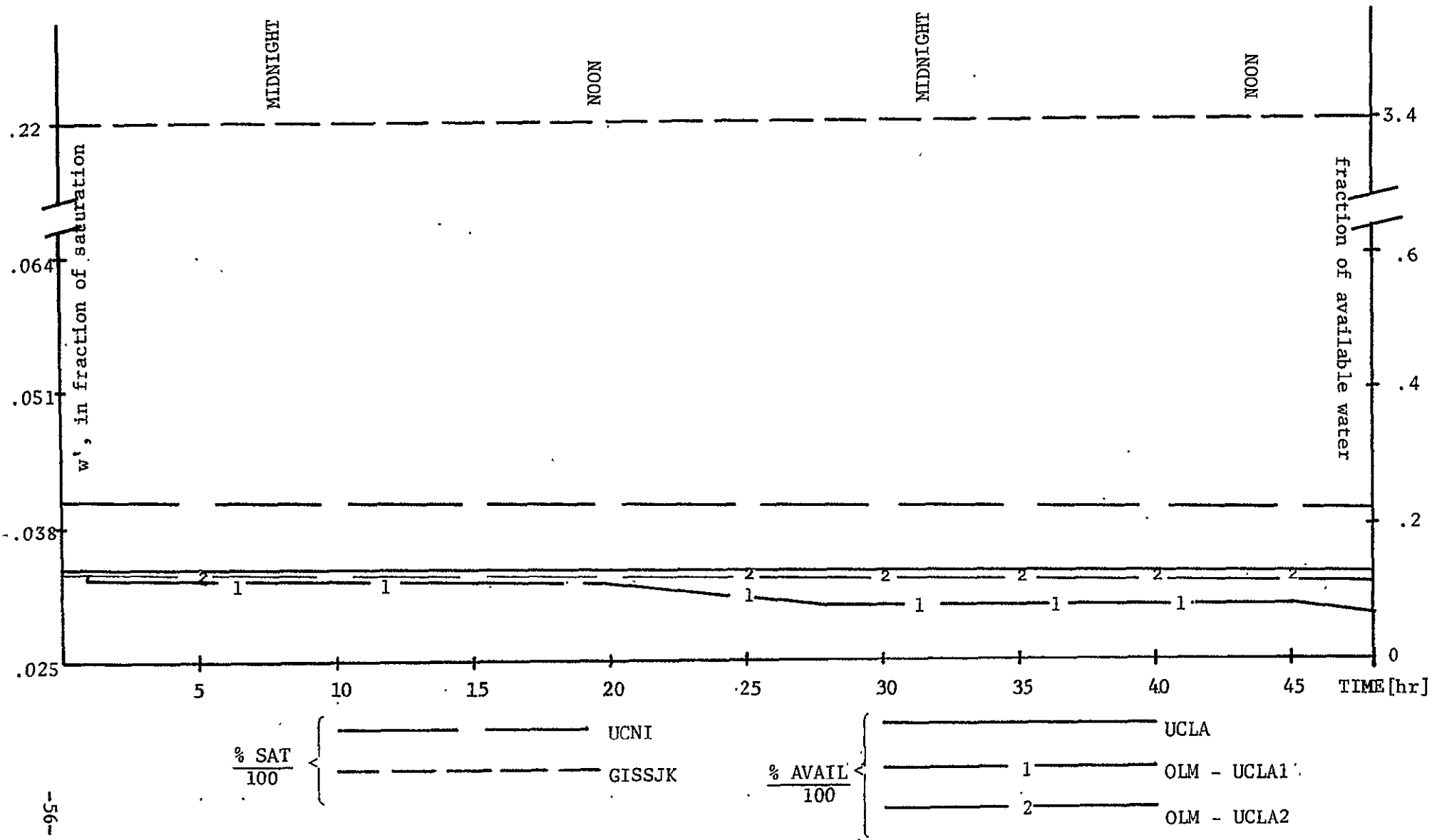


FIGURE 4-3 SOIL MOISTURE CONTENT FOR DRY CELL

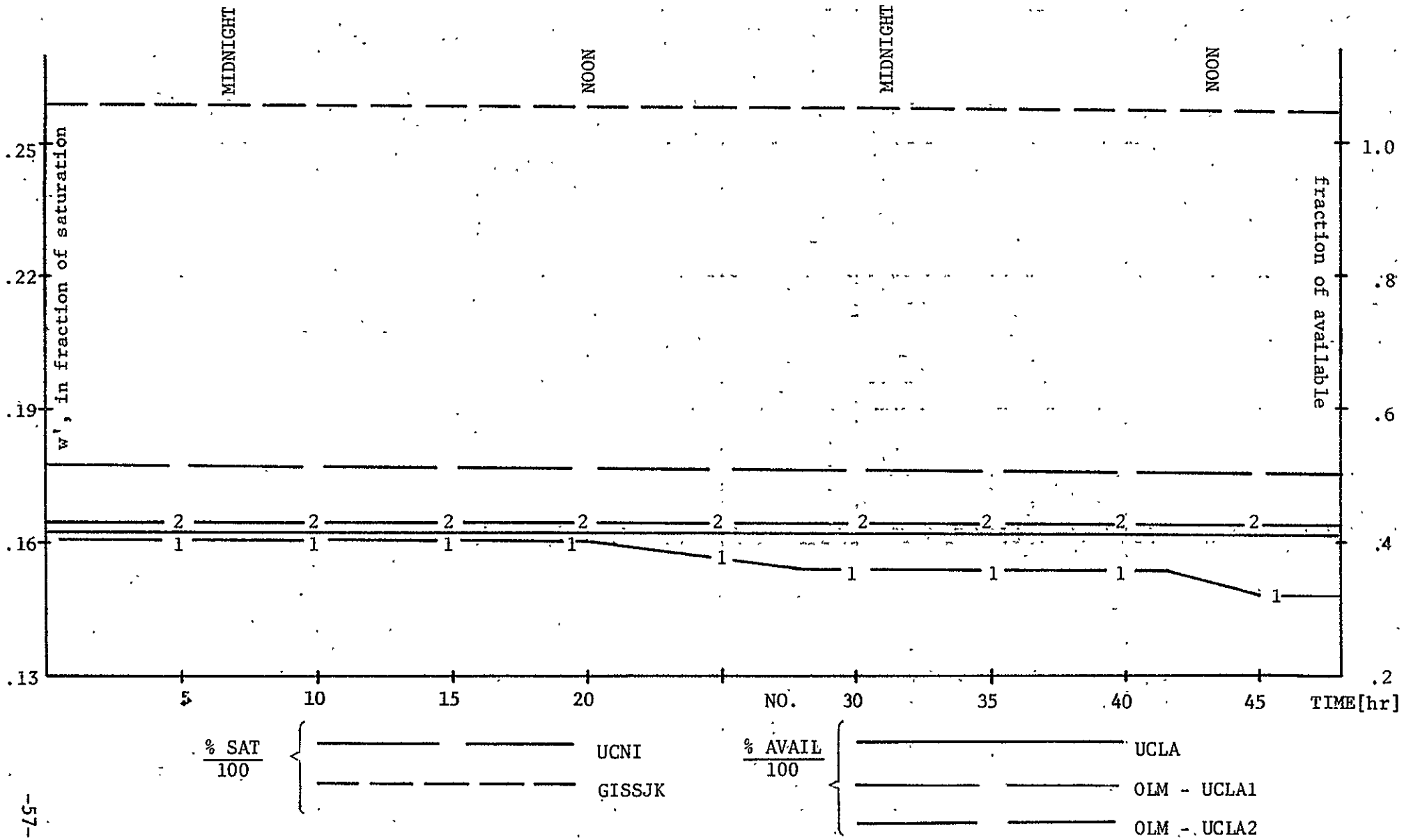


FIGURE 4-4 SOIL MOISTURE CONTENT FOR AVERAGE CELL

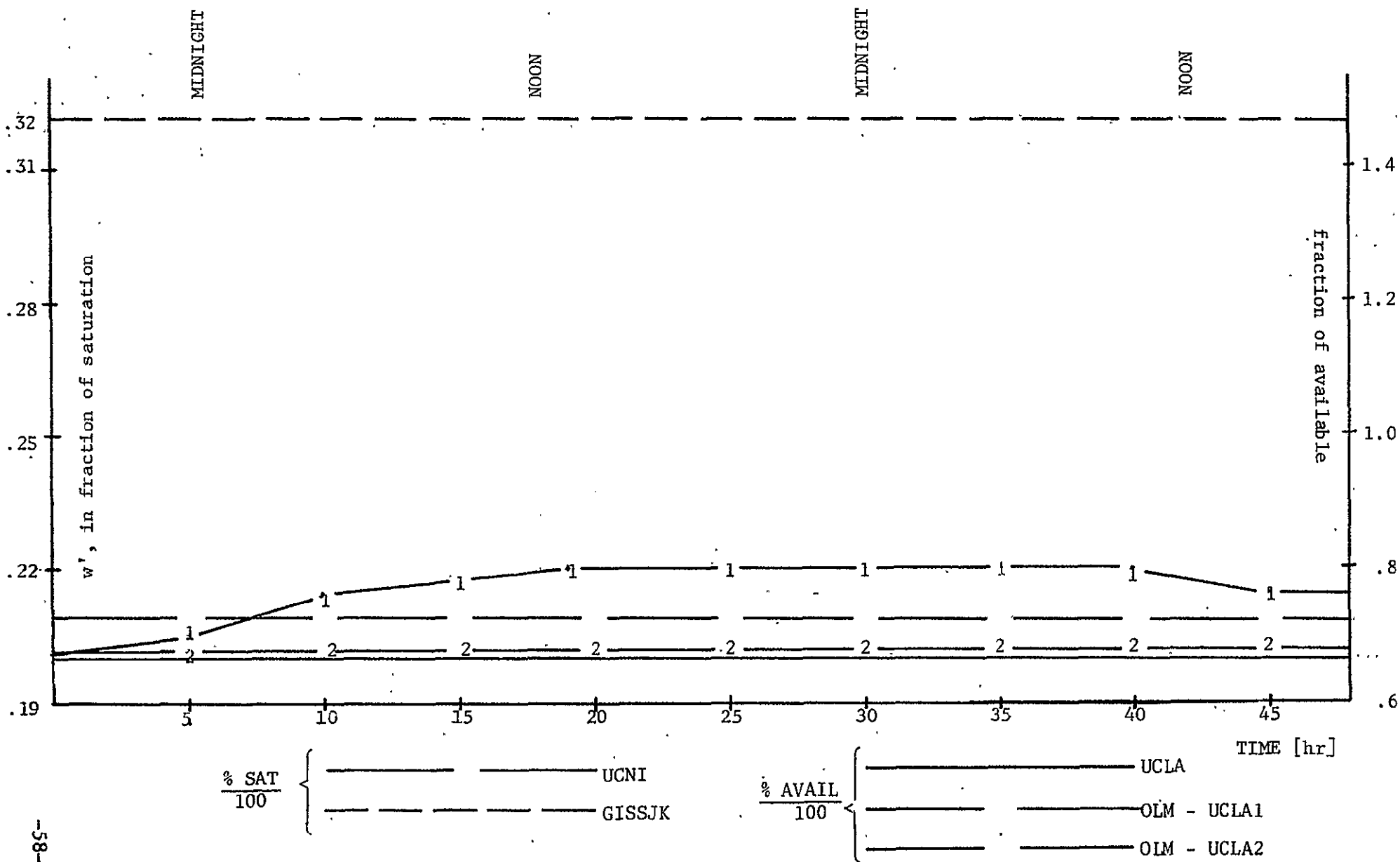


FIGURE 4-5. SOIL MOISTURE CONTENT FOR WET CELL

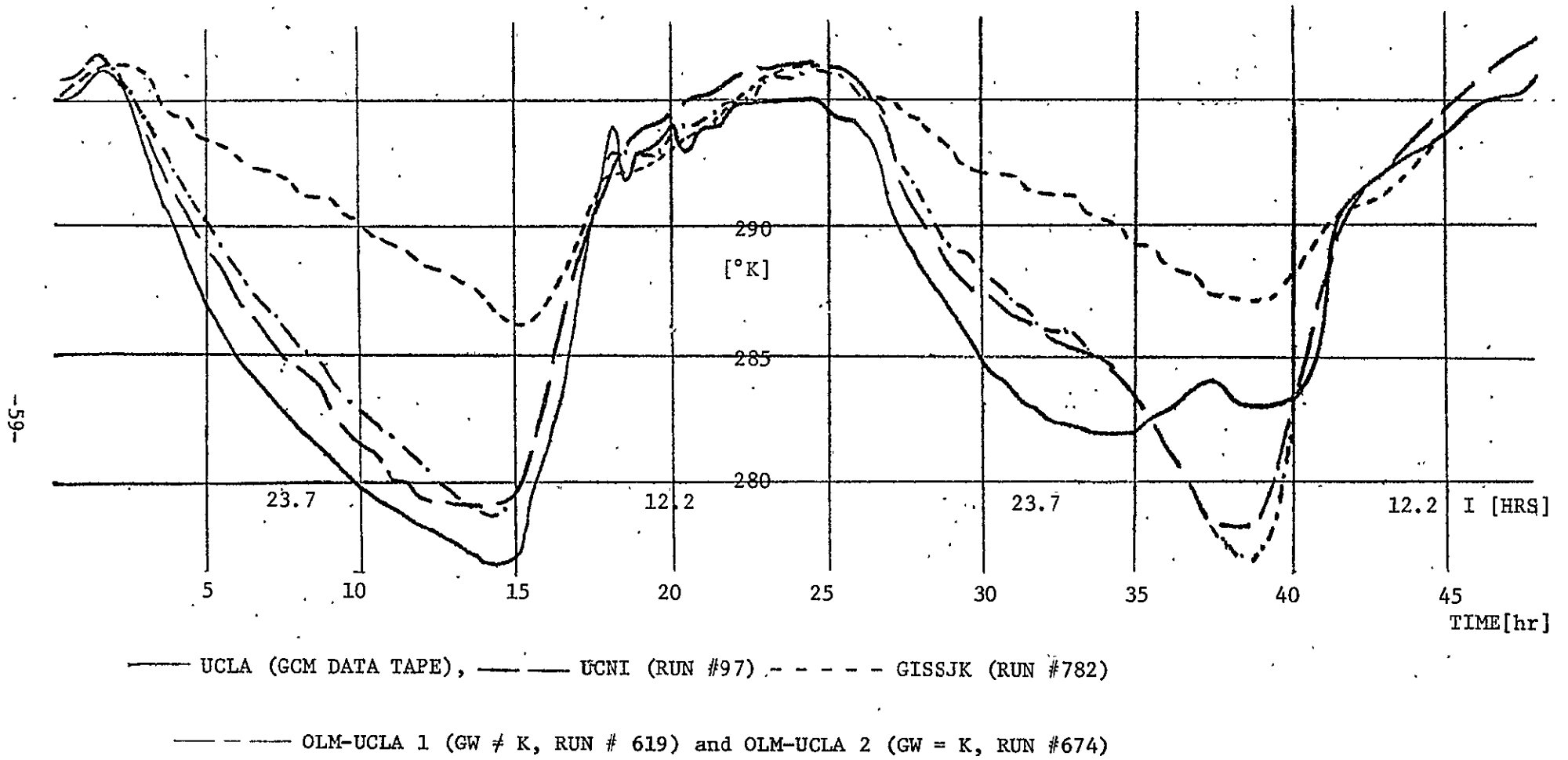


FIG. 4-6 SURFACE AIR TEMPERATURES (TS) FOR DRY CELL

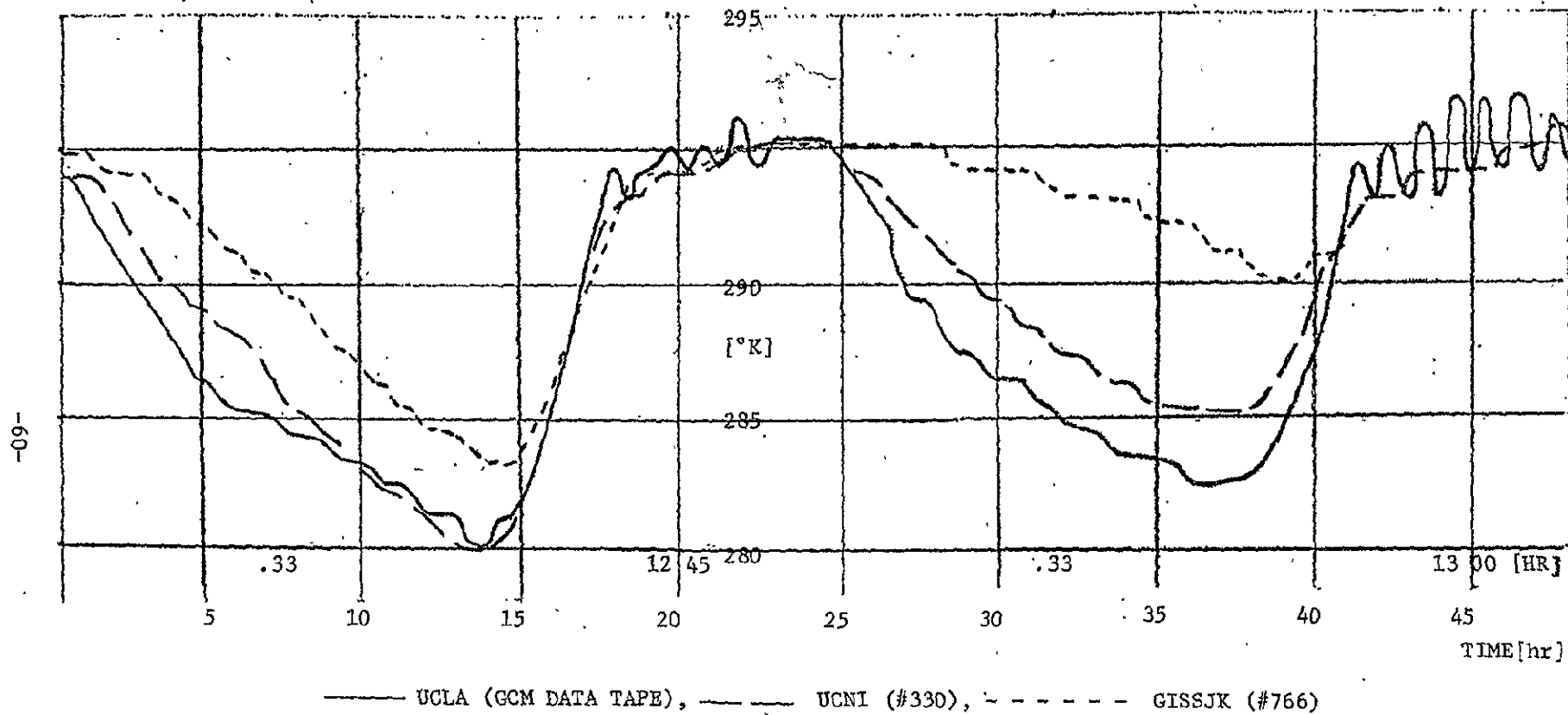
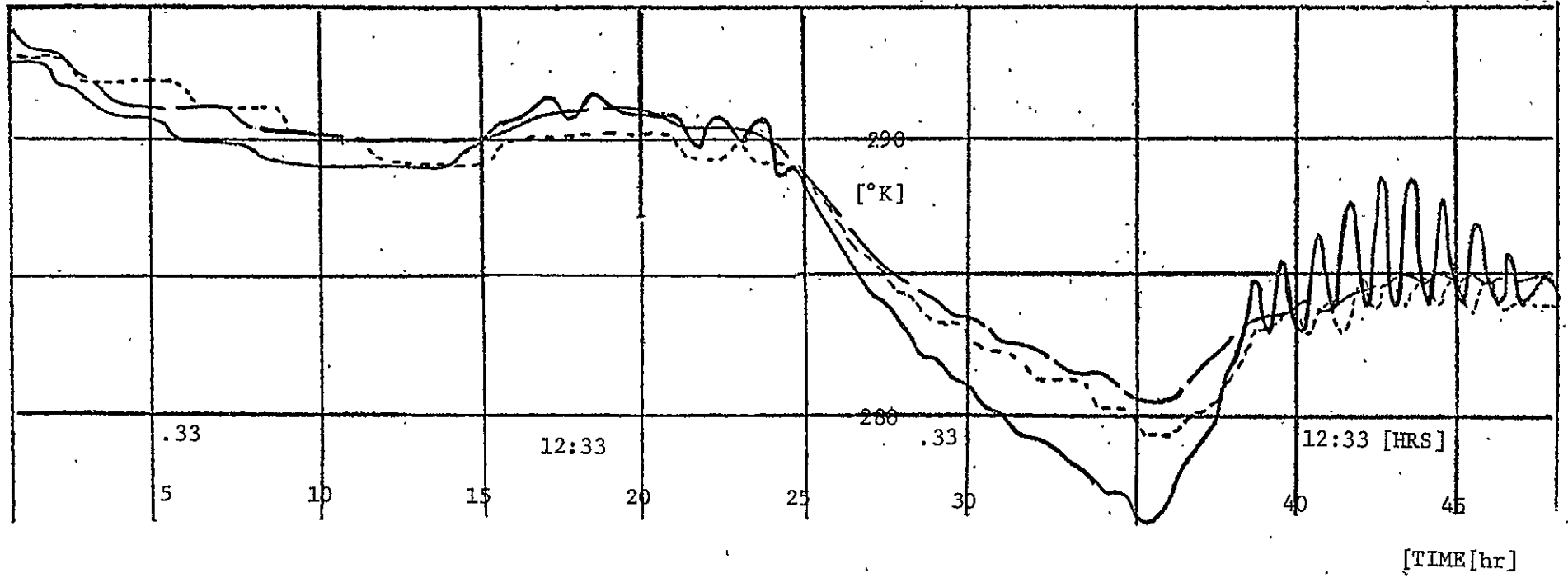


FIG. 4-7 SURFACE TEMPERATURE (TS) FOR AVERAGE CELL



— UCLA (GCM DATA TAPE), — UCNI (#218), - - - - GISSJK (#468)

FIG. 4-8 SURFACE AIR TEMPERATURE (TS) FOR WET CASE

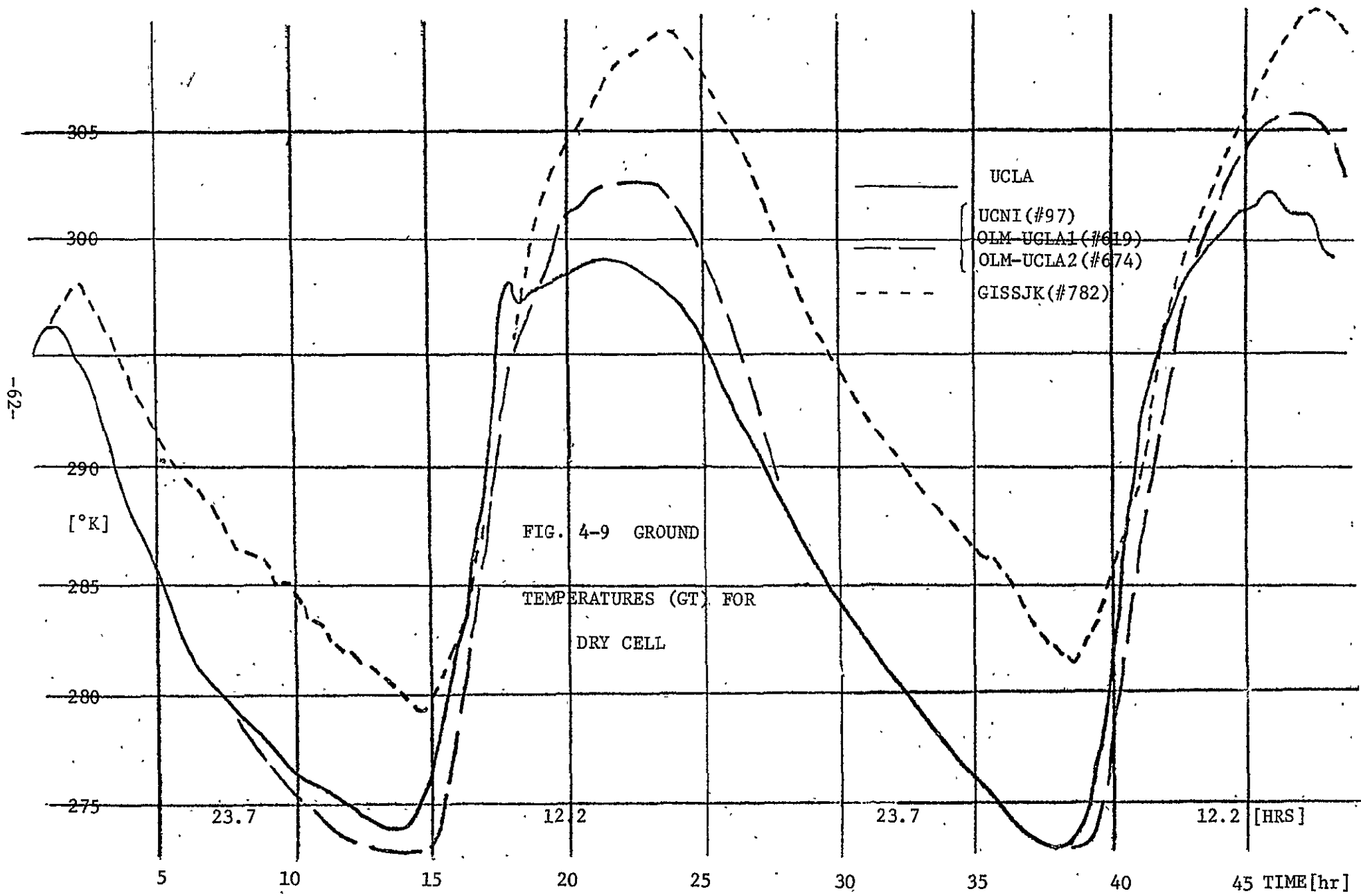
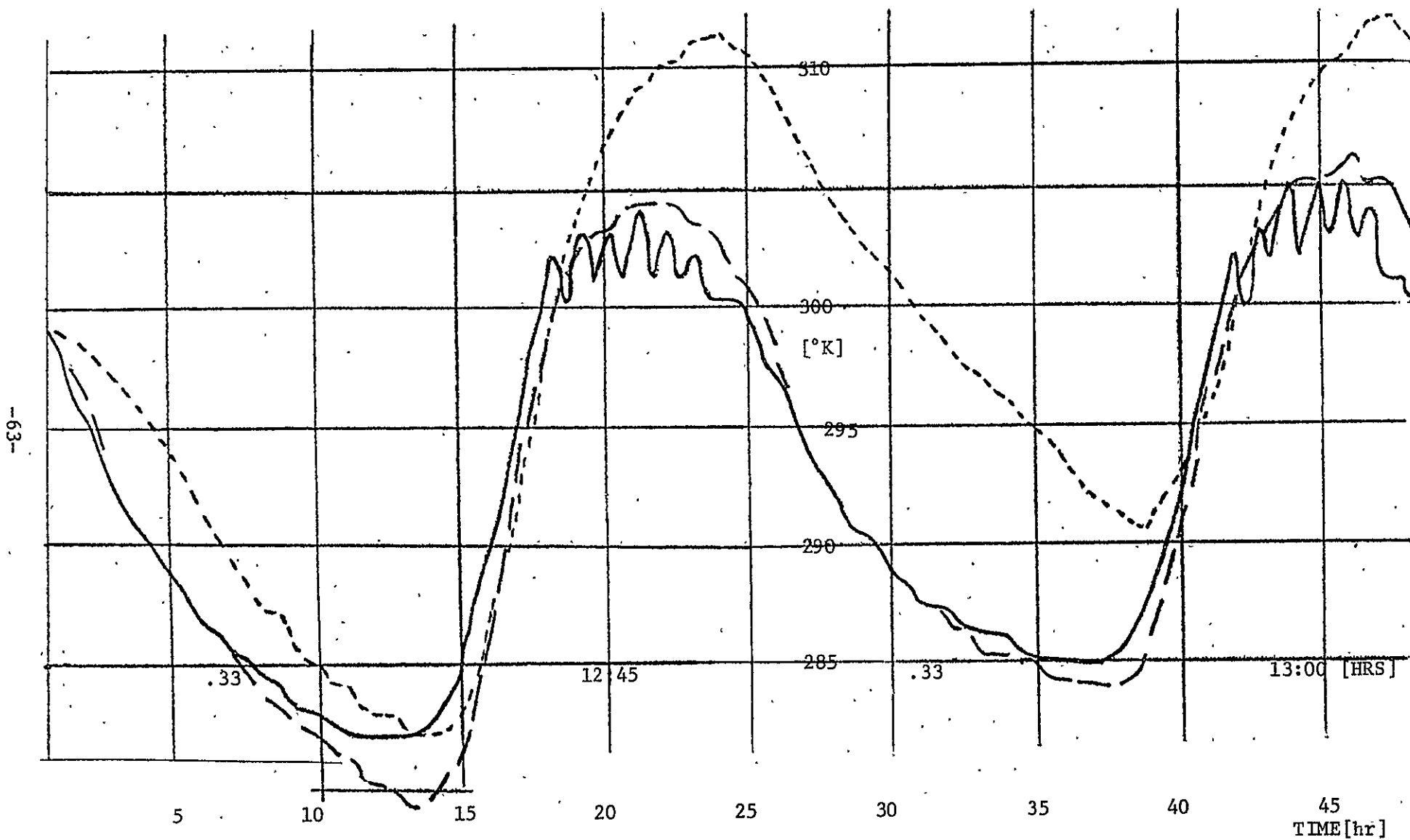


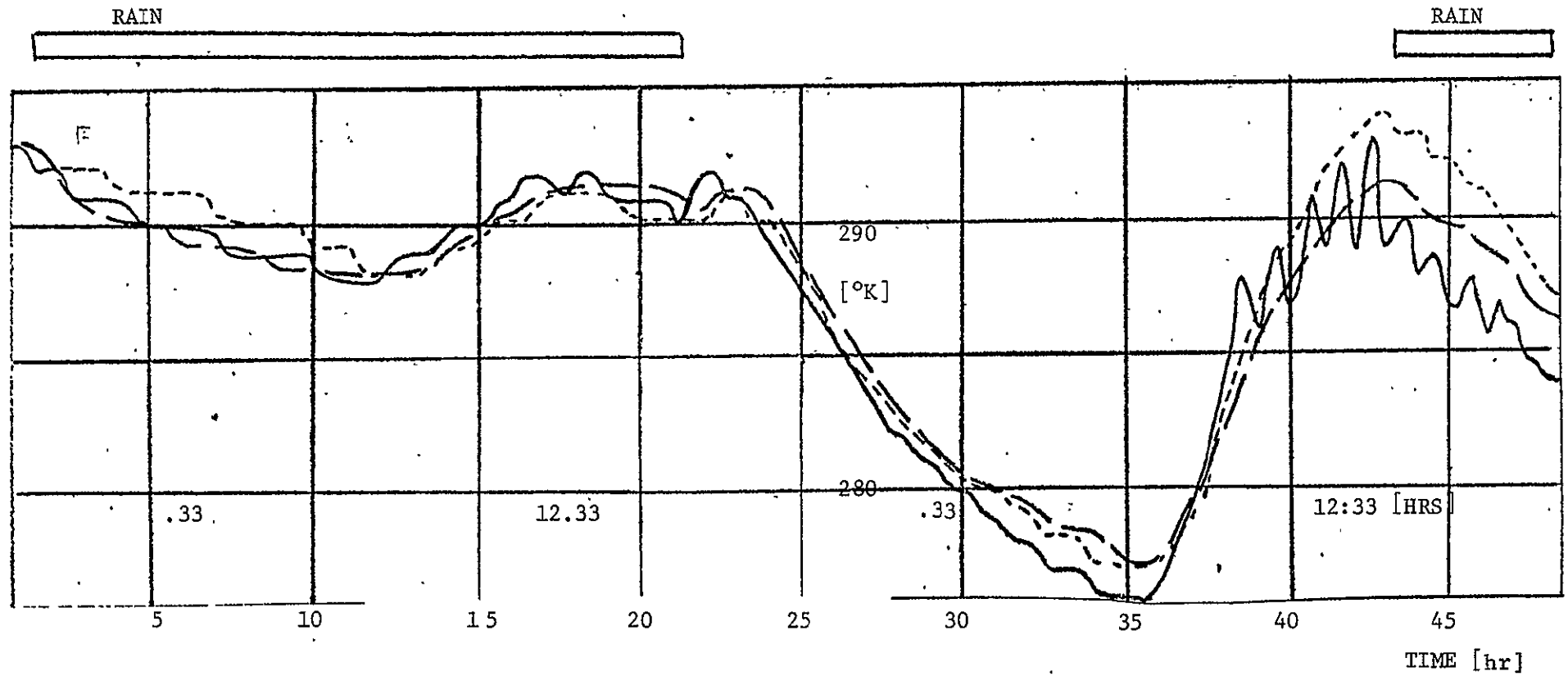
FIG. 4-9 GROUND
TEMPERATURES (GT) FOR
DRY CELL

-62-



— UCLA (GCM DATA TAPE), — UCNI (#330), - - - - GISSJK (K766)

FIG. 4-10 GROUND TEMPERATURE (GT) FOR AVERAGE CELL



—— UCLA (GCM DATA TAPE), — — — UCNI (#218), - - - - - GISSJK (#468)

FIG. 4-11 GROUND TEMPERATURE (GT) FOR WET CASE

—— UCLA (#322), — UCNI (#97), - - - - - GISSJK (#468), — 1 — OLM-UCLA 1 (#619), — 2 — OLM-UCLA 2 (#674)

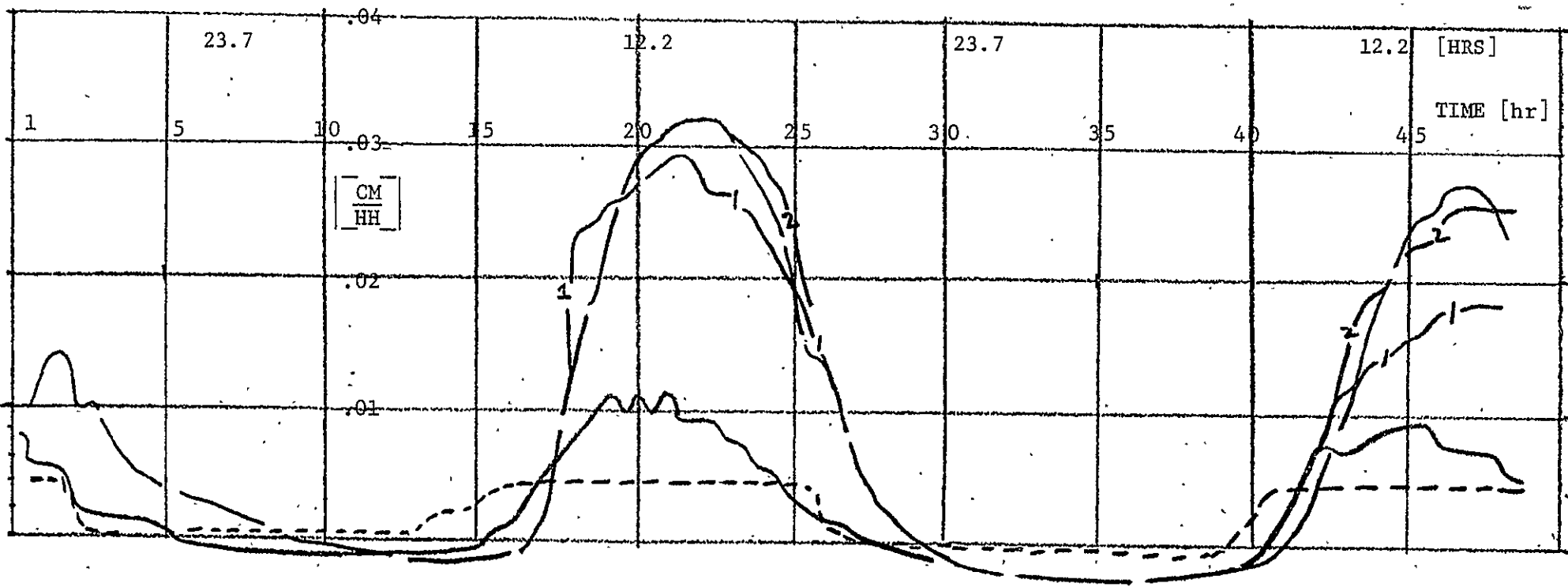


FIG. 4-12 EVAPOTRANSPIRATION FOR DRY CELL

— UCLA (#364), — UCNI (#330), - - - - - GISSJK (#766), — 1 — OLM-UCLA 1 (#751), — 2 — OLM-UCLA 2 (#672)

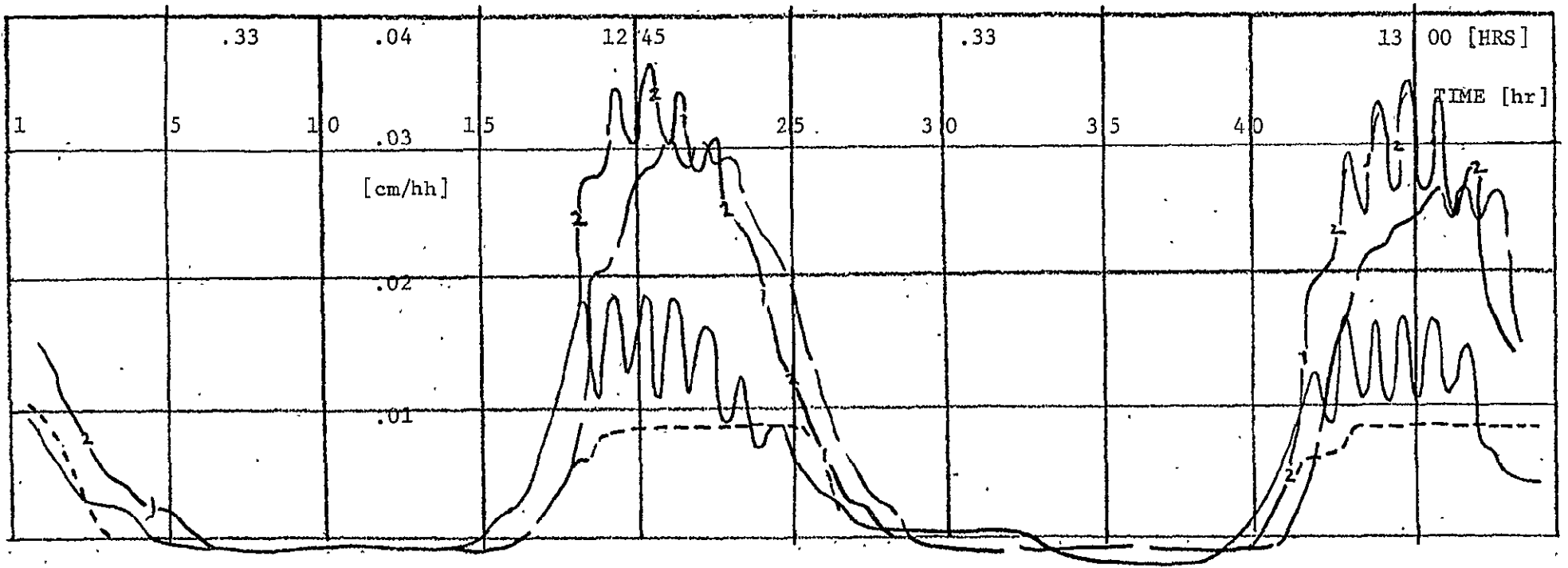


FIG. 4-13 EVAPOTRANSPIRATION FOR AVERAGE CELL

— UCLA (#356), — UCNI (#218), - - - - - GISSJK (#782), — 1 — OLM-UCLA 1 (#668), — 2 — OLM-UCLA 2 (#731)

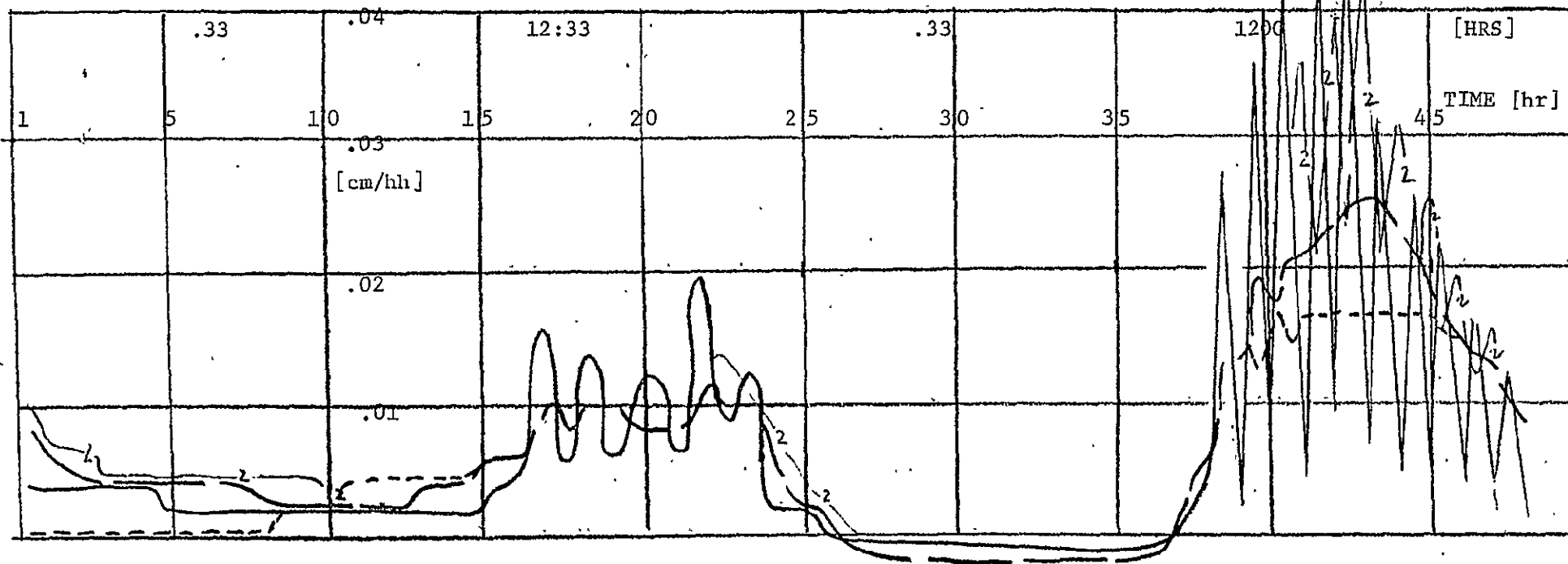


FIG. 4-14 EVAPOTRANSPIRATION FOR WET CELL

CELL	RUN #	MODEL	LOG	$\overline{\text{PET}} \sim \frac{2}{3} \text{PE}_{\text{max}}$		$\overline{\text{GW}}$		$\bar{\beta}$		$\overline{\text{AET}} \sim \frac{2}{3} \text{AET}_{\text{max}}$	
				$\overline{\text{PET}}$ [cm/hh]		[1] % sat/100	[2] % avail/100	Day 1	Day 2	Day 1	Day 2
DRY	97	UCNI	F	.08	.075	.04[1]	.04[1]	.27	.27	.021	.019
	619	OLM-UCLA1	F	.095	.095	.11[2]	.07[2]	.21	.14	.017	.012
	674	OLM-UCLA2	F	.085	.075	.14[2]	.14[2]	.27	.27	.023	.019
	322	UCLA	T	.06	.047	.14[2]	.14[2]	.27	.27	.017	.013
	332	OLM-UCLA2	T	.06	.047	.14[2]	.14[2]	.27	.27	.017	.013
	782	GISSJK	F	.14	.12	.22[1]	.22[1]	.02	.02	.003	.003
	AV	330	UCNI	F	.041	.033	.176[1]	.176[1]	.5	.5	.02
751		OLM-UCLA1	F	.028	.028	.41[2]	.36[2]	.78	.75	.024	.023
672		OLM-UCLA2	F	.027	.027	.42[2]	.42[2]	.83	.83	.024	.024
364		UCLA	T	.037	.033	.42[2]	.42[2]	.83	.83	.03	.027
766		GISSJK	F	.095	.08	.26[1]	.26[1]	.08	.08	.008	.008
WET	218	UCNI	F	.0125	.025	.21[1]	.21[1]	.71	.71	.009	.018
	668	OLM-UCLA1	F	.01	.027	.65[2]	.75[2]	1	1	.01	.027
	731	OLM-UCLA2	F	.01	.02	.65[2]	.65[2]	1	1	.01	.02
	356	UCLA	T	.0125	.025	.65[2]	.65[2]	1	1	.0125	.025
	468	GISSJK	F	.01	.0375	.32[1]	.32[1]	.6	.4	.006	.012

NOTE: % sat/100 = (% avail/100) x (FC-PWP) + PWP

TABLE 4 - 3

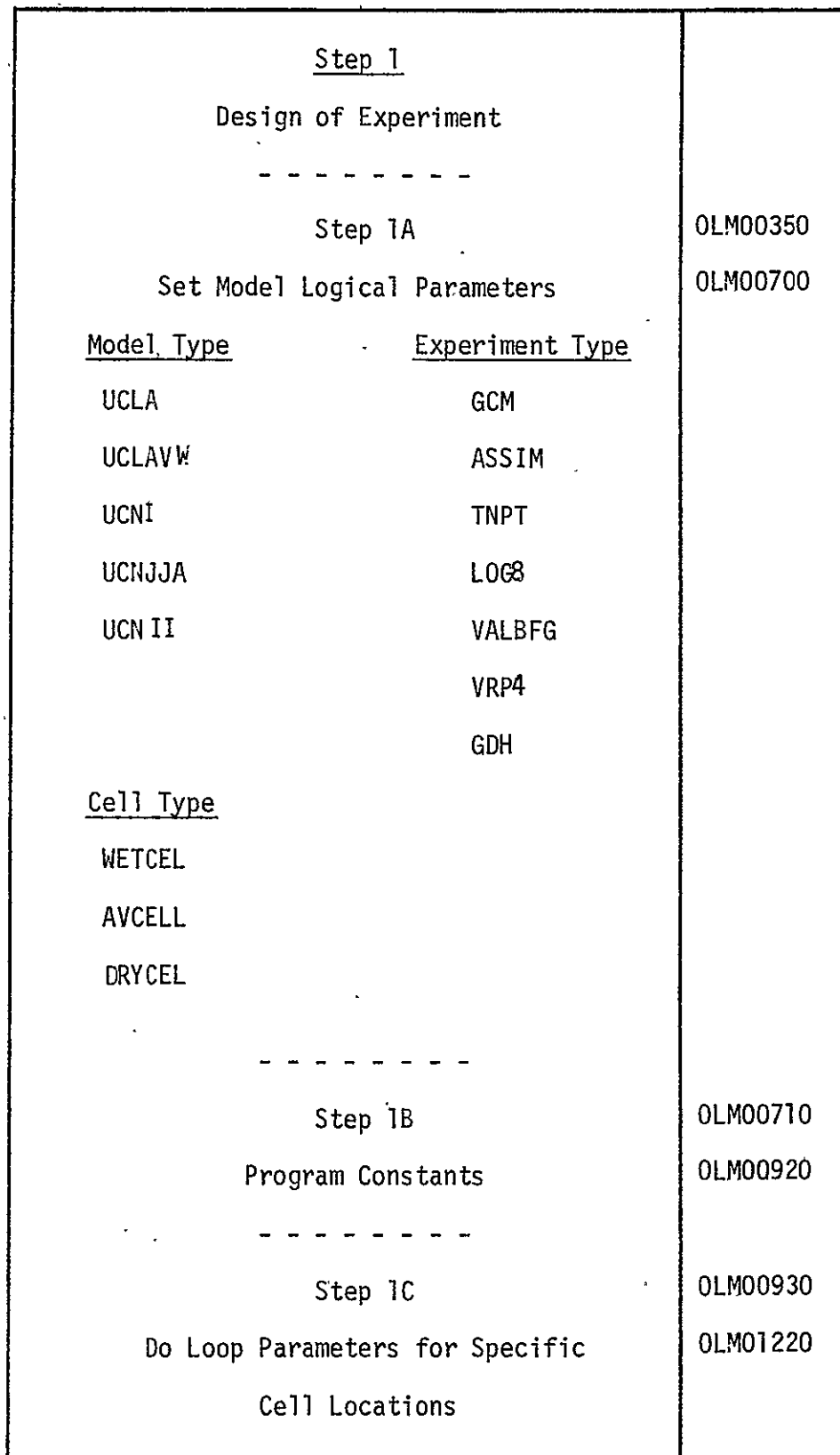
DAYTIME AVERAGES OF PE, GW, β AND AET VERSUS DRY, AVERAGE AND WET CELL CONDITIONS

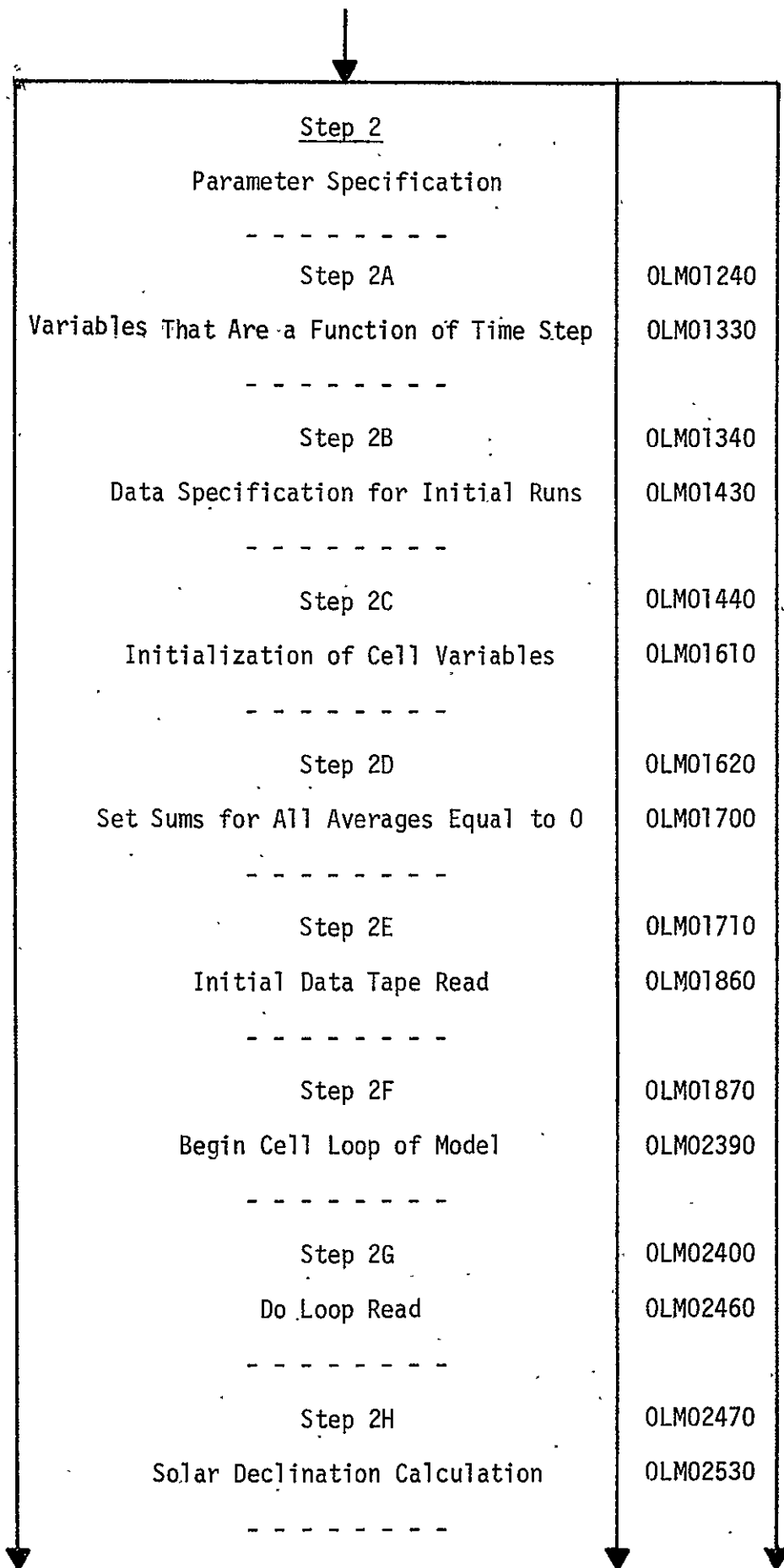
V. Description of the OLM Computer Program

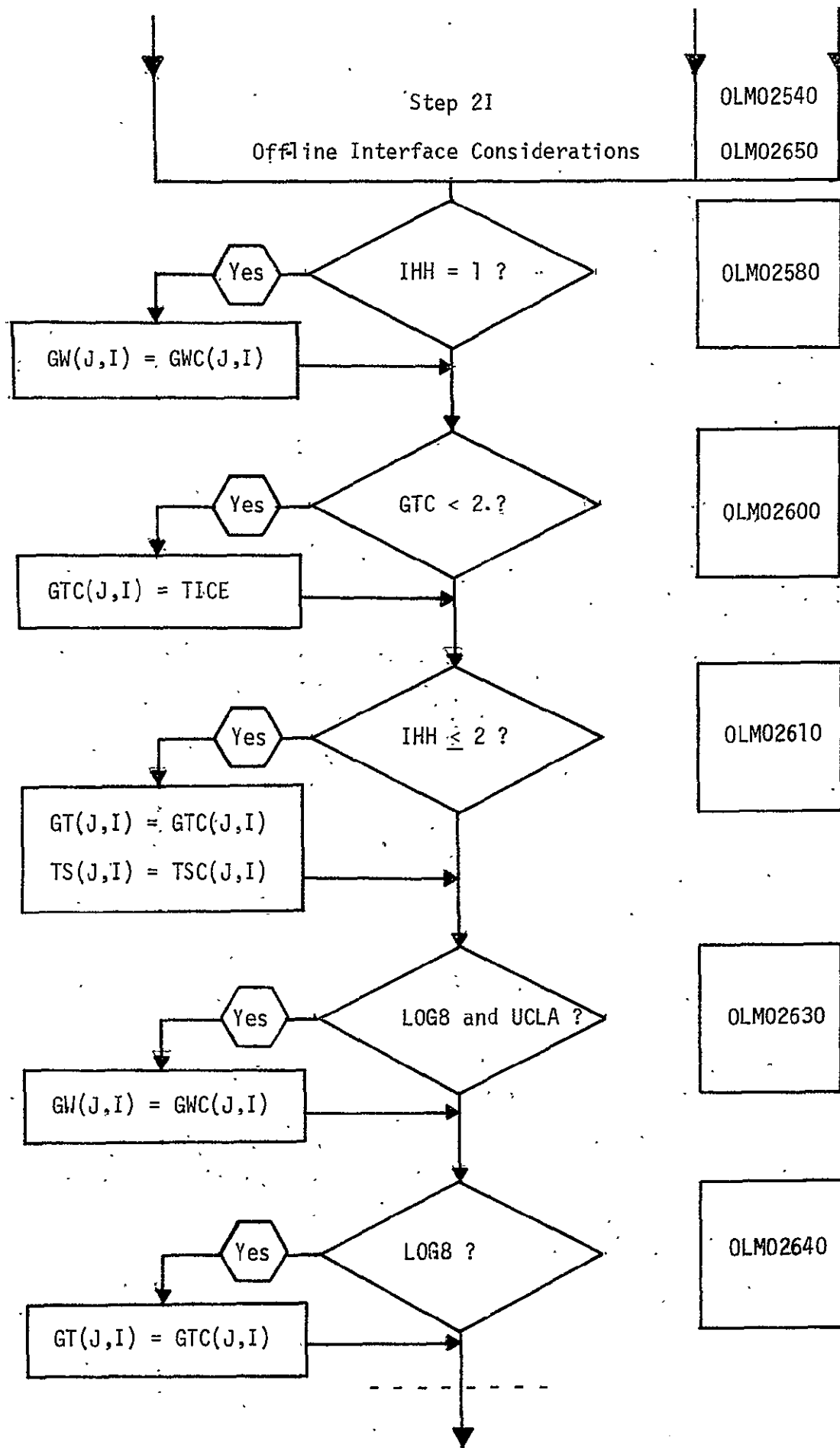
OLM Program

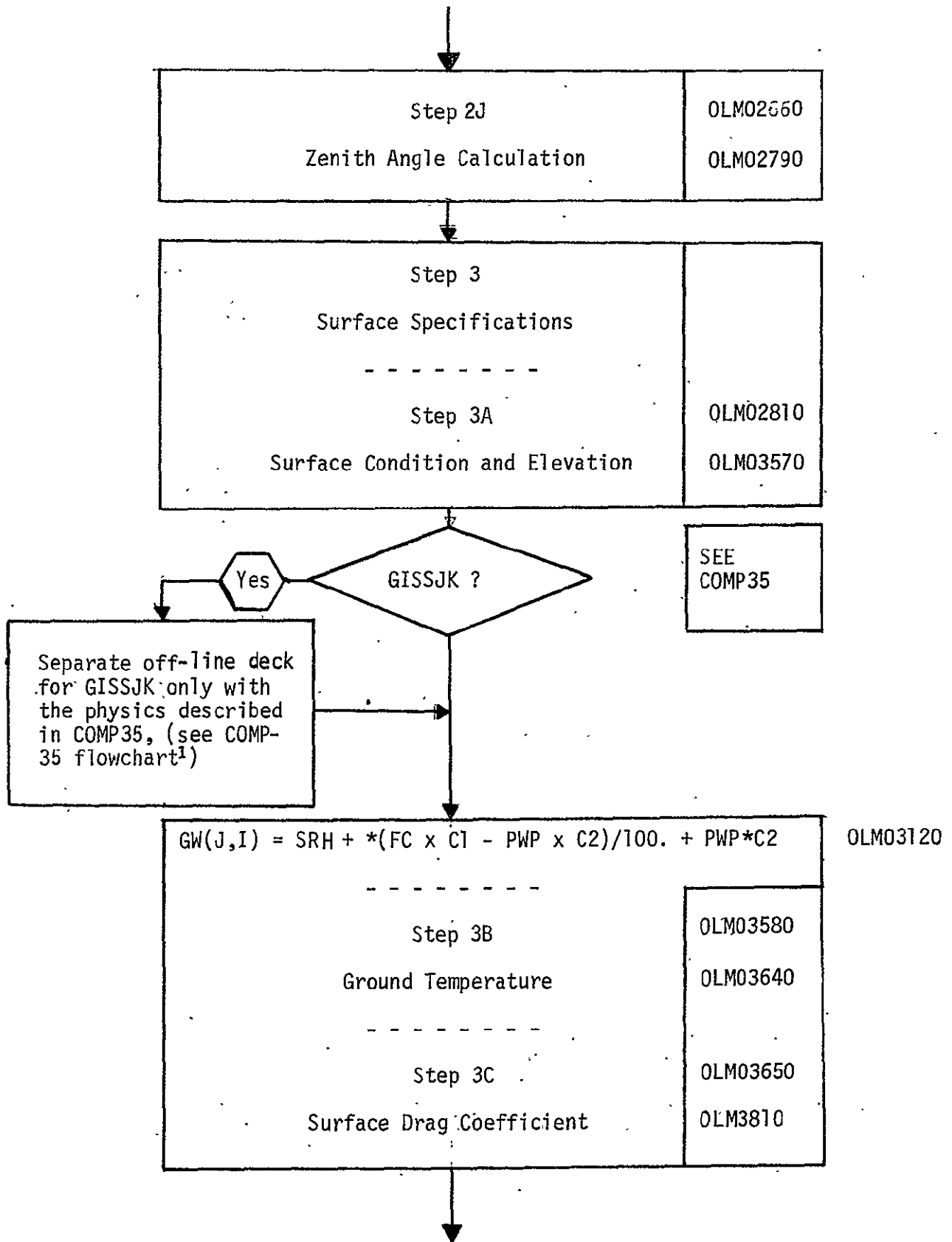
The OLM program contains a main section where parallel hydrologic parameterizations are evaluated. The first two subroutines, SDET and SURFWD provide needed information to the main hydrologic section that would normally be available in a GCM run. The third subroutine, RITE contains the bulk of Fortran statements needed for parameter evaluation.

There is a total of 9 steps in the OLM as illustrated in the flow chart. Through step 2, Parameter Specification, the OLM receives the necessary data to simulate an on-line GCM run. The major ground hydrology parameterizations are incorporated in steps 3A, 7 and 14. Steps 7 & 14 are similar to those in COMP35 and discussed in Section III, while step 3A was added to parameterize different soil characteristics.

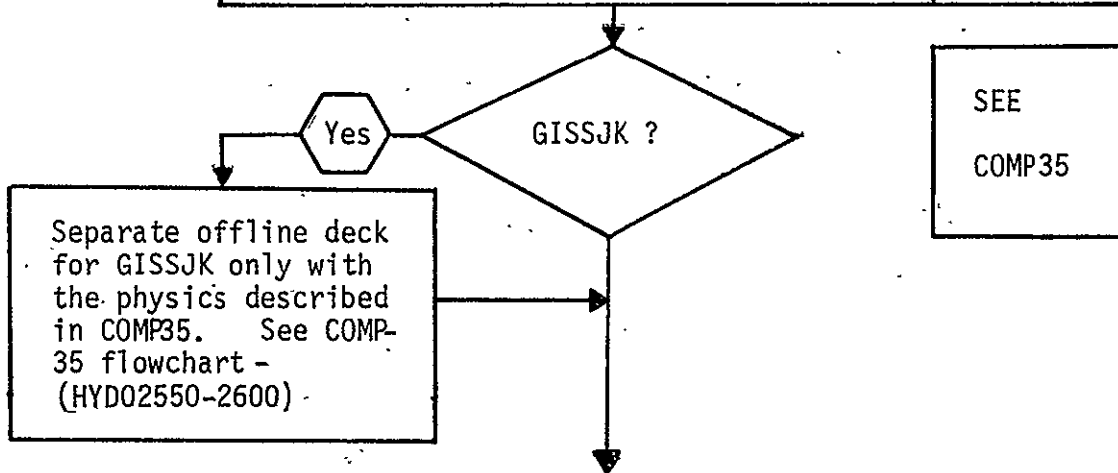
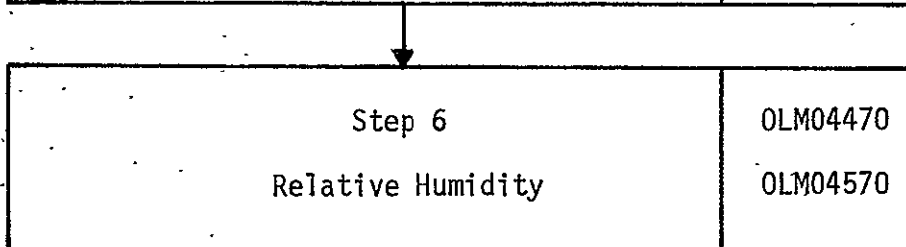
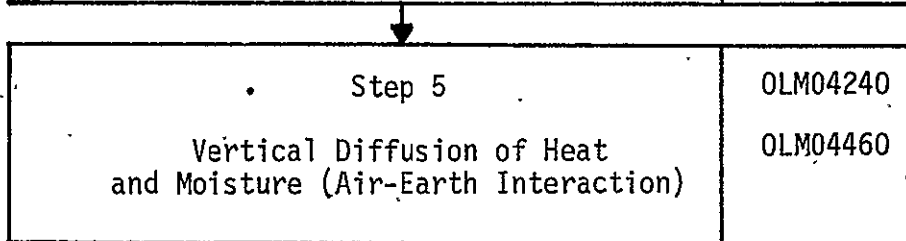
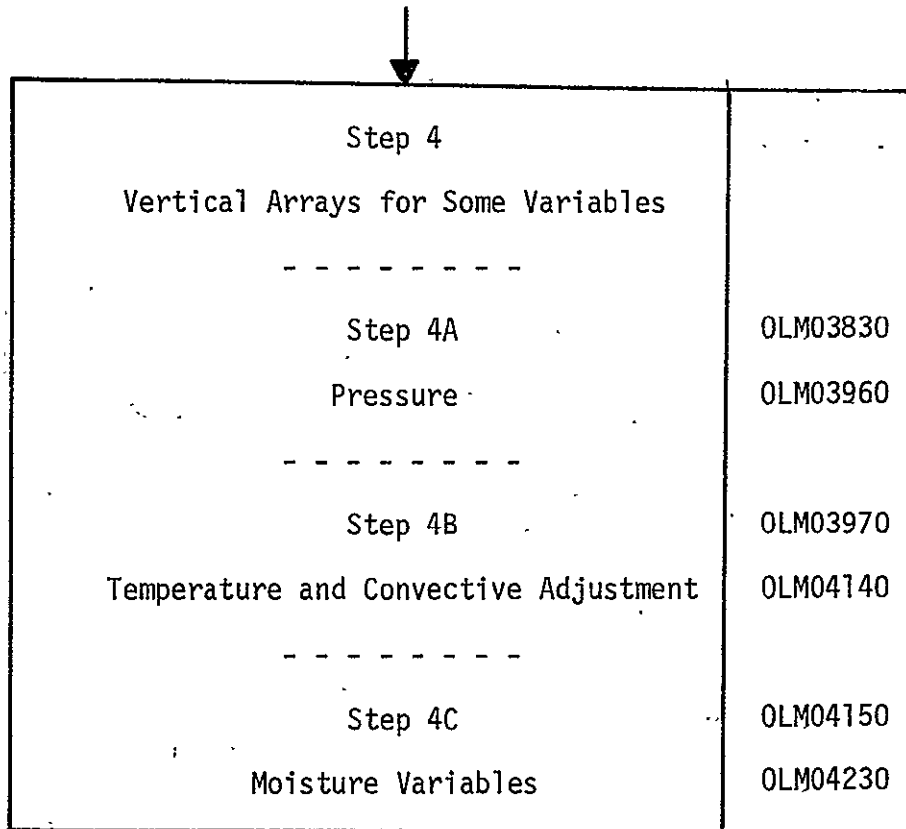








HYD01240 - 1260
HYD03000 - 3740





Step 7	
Determination of Surface Temperature	

Step 7A	OLM04580
Initialization	OLM04660
TLE (NLAYP1) = TS(J,I)	OLM04620

Step 7B	OLM04670
Relative Humidity Scale	OLM04700

Step 7C	OLM04710
Bulk Aerodynamic Coeff	OLM04760

Step 7D	OLM04770
Surface Diffusion Coefficient	OLM04810

Step 7E	OLM04820
Eddy Diffusivity (see TK and NCAR)	OLM05080

T&K:

$$EDNS = AMIN1(100., ED \times EXP (.32 * DTS / WMAGN \times x2))$$

$$EORIG = EDNS$$

$$ZLN = ZLNCO \times TLE (NLAYPI) \times SP/PS$$

New EDNS formulation

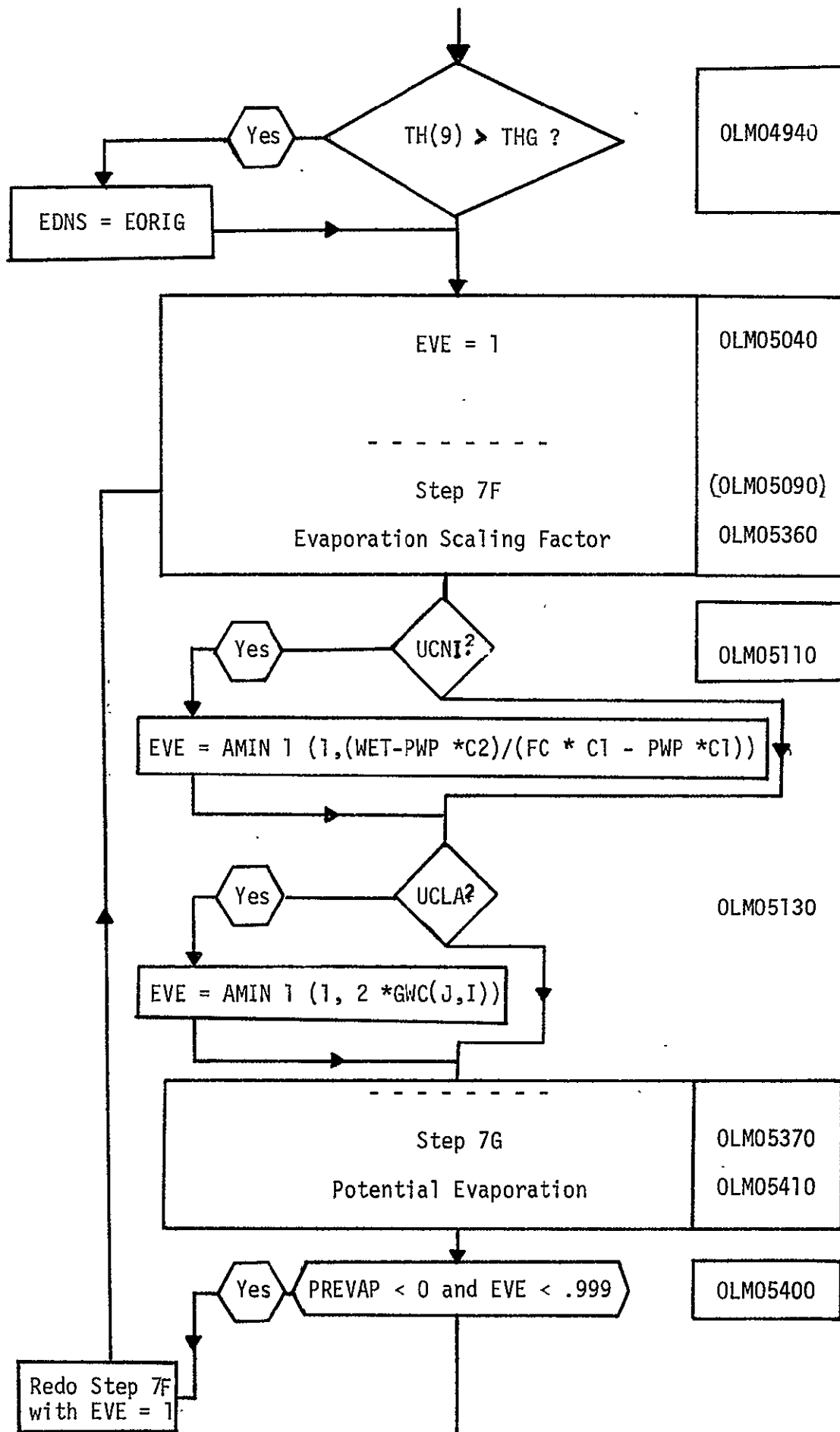
NCAR w/no countergradient (Used in GCM Data Tape Creation)

NCAR:

$$EDNS = 10. + 100. * (1 - EXP (1200. * ((TH(NLAY) - THG) / ZLN)))$$

Can't use above calculation for TH(9) > THG. Best that can be done offline with data from levels 7, 8 & 9.





OLM04940

EVE = 1

Step 7F
Evaporation Scaling Factor

OLM05110

EVE = AMIN 1 (1, (WET-PWP * C2) / (FC * C1 - PWP * C1))

OLM05130

EVE = AMIN 1 (1, 2 * GWC(J, I))

Step 7G
Potential Evaporation

OLM05400

Redo Step 7F
with EVE = 1

Step 7H

Potential Evaporation Using LOG8 Input

OLM05420

OLM05550

Note:

Potential Evaporation Calculation Differences

Offline (Step 7G)

Wet from UCNI or UCLA

Eve from UCNI or UCLA

Step 7F adjust SHLE (10)

where SHLE = f(EDV,)

SHG = QSAT (TG,PS)

for LOG8 False:

TG from previous calculation

for LOG8 true:

TG from GCM tape

UCLA (GCM Data Run - Step 7H)

Wet from Data Tape

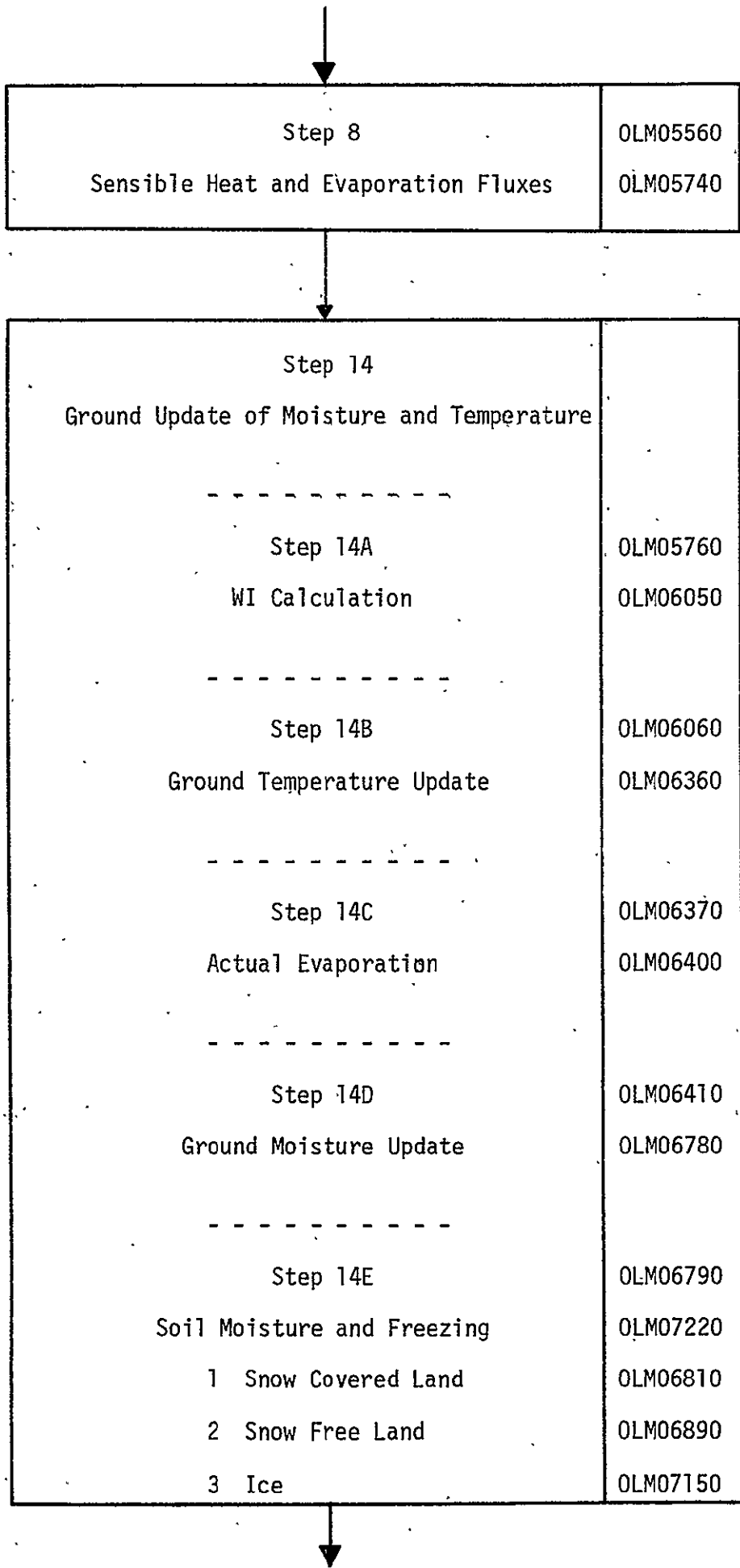
Eve from UCLA

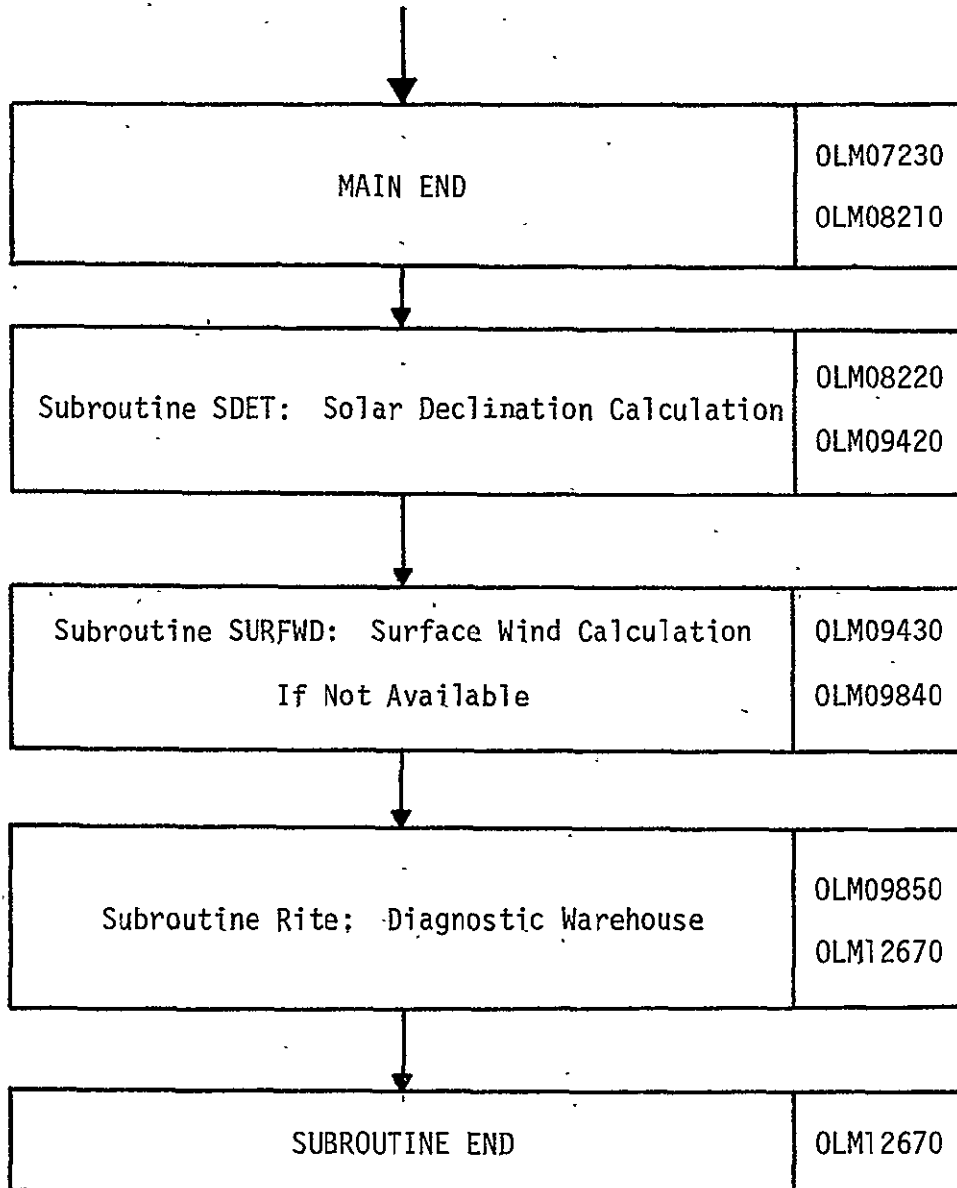
Step 7F adjust SHLE (10)

where SHLE = f(EDV,)

SHG = QSAT(TG,PS)

TG always from GCM data tape





References

1. Arakawa, A. 1972. Design of the UCLA General Circulation Model. Numerical Simulation of Weather and Climate Tech. Rep. No. 7, Dept. of Meteorology, University of California, Los Angeles.
2. Arakawa, A. and Y. Mintz. The UCLA Atmospheric General Circulation Model. Unpublished notes distributed at UCLA Workshop, 25 March to 4 April, 1974.
3. Baumgartner, A. and E. Richard. The World Water Balance. Elsevier Scientific Publishing Company, N. Y. 1975. (Table 12, p 66)
4. Child, E. C. 1969. An Introduction to the Physical Basis of Soil Water Phenomena. John Wiley & Sons Ltd.
5. Koberg, G. E. Methods to Compute Long Wave Radiation from the Atmosphere and Reflected Solar Radiation from a Water Surface, USGS Professional Paper, 1962.
6. Monteith, J. L. Ed. Vegetation and the Atmosphere. Vol. 1, Academic Press, N.Y., 1975.
7. Salter, P. J. and J. B. Williams. 1965. The Influence of Texture on the Moisture Characteristics of Soils. Journal of Soil Sci., 16:1-15 and 16:310-317.
8. Schutz, C. and W. L. Gates. Global Climatic Data for Surface, 800 mb, 400 mb: January. Rand Rept. R-915-ARPA, November 1971 and July, Rand Rept. R-1029-ARPA, November 1972.
9. Tsang, L. C. and R. Karp. 1973. A Documentation of the GISS Nine-Level Atmospheric General Circulation Model. Computer Sciences Corporation.
10. Van Bavel, C. H. M. et al. Atmospheric and Soil-Plant-Water Relations Studies. Research Report No. 388, U.S. Water Conservation Service, Phoenix, Arizona. July 1966.
11. Ward, R. C. Principles of Hydrology. 2nd ed., McGraw-Hill, N. Y., 1975.

Appendix A

Symbols and Notations

FORTRAN SYMBOL	MEANING	UNITS	PROGRAM LOCATION
ADINF	antecedent soil moisture indicator		HYD 06560
ADDW	water which may enter the soil to be evaporated	cm/hh	HYD 06610 06620
ASM	available soil moisture .15 - composite soil .066 - sandy soil (desert)	% sat	HYD 03040 03090
BBFACT	effective infiltration rate	cm/ $\Delta T=30$ min	HYD 06570
BETA2	scaling factor for bare soil evapotranspiration rate (β)		HYD 03310 03660 03730
BETA2P	scaling factor for plant influence on transpiration		HYD 03640
BTA	= BETA2 + BETA2P ($0 \leq BTA \leq 1$)		HYD 03670 03680 03720
BTA2	argument of BETA2 coefficient		HYD 03540
BT2P	argument of BETA2P coefficient for transpiration		HYD 03560 03620
CD	surface drag coefficient		HYD 02140 02150 02160
CZH	$(\frac{\lambda c}{\omega})^{1/2}$, bulk heat capacity	cal/cm ² -deg	HYD 05040 05050 05060
	where λ = thermal conductivity c = specific heat ω = diurnal angular frequency	cal/cm-sec-deg cal/cm ³ -deg 1/sec	05090 05120 05150 05160 05270

FORTRAN SYMBOL	MEANING	UNITS	PROGRAM LOCATION
DENOM	storage variable used in ground temp. eq.	ly/day-cm ² -day	HYD05540
DRAW	C W surface wind drag parameter D S	m/sec	HYD02690 02700 04000 04010
DRNG	water which is unavailable for ET due to field capacity being exceeded loss of water through percolation when WETR >.5		HYD06090 06670
DRRN	see DRAW		HYD03490 03500
DSHS	$\Delta q_G = q_g^* - q_g$ saturation specific humidity at the ground minus specific humidity at the ground		HYD03990
DTRBET	$\partial/\partial T_g$ of (evapotranspiration)		HYD03700 03710 05420 05430 05440 05460
DTSI	difference between ground temperature	°C	HYD03480
DTS	$T_G - T_S = \Delta T_g$ = difference between ground and surface air temperature	°C	HYD02680
DU	temporary storage variable		HYD02810 02860 02890
DV	temporary storage variable		HYD02830 02870 02910
ECAR	= E6DT/(1-ROCK) (Note: EVE in E6DT is equal to (1-ROCK)·EVE so ROCK affect cancels out in evaporation calculation)		HYD06630

FORTRAN SYMBOL	MEANING	UNITS	PROGRAM LOCATION
EGDT	evaporation rate from soil at grid pt	$\frac{g(H_2O)}{cm^2} \cdot /\Delta T=30$	HYD05950
ETFLX	evaporation flux for diagnostic purposes		HYD05900 05910 05920
EVACO	=EVE·DRAW		HYD03780 03790
EVAL	= 600 , latent heat coeff land 680 " " - snow, frost = 680 + 80WI, FOR MIXWI CONDITION	$\frac{cal}{g(H_2O)}$	HYD05030 05080 00110 00140 00180 00260
EVE	soil surface wetness coeff		HYD02980 03740 03770 03830
EXPTI	argument of evapotranspiration coeff		HYD03530 03550
EXDTR	storage variable		HYD03690
EXPTP	does not permit BT2P to become too large		HYD03630
EXPTS	keeps BTA2 from becoming too large		HYD03650
FILTF	infiltration rate derived from viscosity relation -f(t) only not soil type or antecedent precipitation	cm/ $\Delta T=30$ min	HYD03220 03270
FREEZ	amt of water that freezes or melts (%)		HYD06050 06770 06810
FLDRK			HYD06080
FXTRN	not used		HYD03020 03450

FORTRAN SYMBOL	MEANING	UNITS	PROGRAM LOCATION
GAMCN	$r_s \frac{q}{C_p} (\Delta Z)_{bdy} \frac{1 + \frac{L}{G K T_s} \frac{q^*_s}{P}}{1 + 5418 \frac{L}{C_p} \frac{q^*_s}{T_s^2}}$		HYD03360
GAMCN	see GAMC		HYD03360
GAMSN	same as GAMS		HYD03410
GDH	logical variable, if true CD=.5CD		INPUT
GNFLX	variable for diag. purposes		HYD05940
GSW	how often (in hrs) print out will occur		
GT	ground temperature	°K	HYD05570 06920
GW	ground wetness (% sat.) =FLOAT(ISNR) *.5 WETR		HYD01210 01230 01260 01270 01280 01290 01300 01330 01350 01420 01430 01440 01450 01460 06960
IGVET	=13 =21 - dry land, GW = 0 =23 =24 - snow thickness - function of albedo		INPUT
ISNR	integer storage		HYD06200 06950

FORTRAN SYMBOL	MEANING	UNITS	PROGRAM LOCATION
ITC	print variable - allows a portion of J & I cells to be printed when GSW occurs		
IALB	storage for I		HYD01090
PLANT	a variable which decreases transpiration from plants when the solar zenith is greater than 75°		HYD03570 03080 03600
POTALP	precipitation	cm/time step	HYD07080
PREVAP	potential evapotranspiration	$\frac{\text{mm-g(H}_2\text{O)}}{\text{cm}^3\text{-hr}}$	HYD03210 03510
QSAT	saturation specific humidity function	g/g	HYD00890
RADTRM	net radiation term	ly/day	HYD05560 05880
RAIN		cm/hh	HYD06030 06190 06540
RHS	surface relative humidity		HYD02530 02550 02580 02650 02660
RNIT	=RADTRM(6.9×10^{-4}) for diagnostic		HYD05890
ROCK	areal fraction devoid of soil, impervious soil	%	HYD03030
ROK(J ₁ I)	same as ROCK		INPUT
RSURF	decimal value for albedo		HYD01520 01550 01560 01570
RSURFF	variable that determines soil type from albedo array		HYD03060 3070

FORTRAM SYMBOL	MEANING	UNITS	PROGRAM LOCATION
RUNOFF	water that does not infiltrate soil col.	$\frac{\text{cm water}}{\Delta T=30 \text{ min}}$	HYD06060 06440 06580 06590 06660
RUNOVV	water that runs off impervious area and is unavailable for evapotranspiration		HYD06100 06650
RICH	Richardson No.		HYD02930
SATI	saturation specific humidity		HYD03290 03390
SHG	saturation specific humidity at the ground	g/g	HYD03190
SHLE	sat. specific humidity $f(\text{DRAW})$ " $f(\text{BETA2})$ " $f(\text{EVACO})$	g/g	HYD03750 03880 03950
SHSATs	sat. specific humidity at the surface air temperature	g/g	HYD03800
SLBEDO	albedo 7 = ocean 14 = land 35 = desert 39 = 40 = snow 50 = snow 70 = snow	.5 cm 1.0 cm 2.0 cm	HYD01500 01490 01510
SMELT	snowmelt	cm/hh	HYD06070 06280 06290
SNFAL	snow fall	cm/hh	HYD06040 06180
SNFLX	sensible heat flux		HYD05860 05870 05930
SNOTEM	storage location		HYD01540

FORTRAN SYMBOL	MEANING	UNITS	PROGRAM LOCATION
SNR	thickness of snow or change	cm or cm/hh	HYD06000 06210 06220 06240 06310 06940 06510
SNR1	snow thickness	cm or cm/hh	HYD06230
TERM1	short wave radiation	ly day ⁻¹	HYD05470
TERM2	sensible heat	cal cm ⁻² day ⁻¹	HYD05480 05490
TERM3	evaporation flux	"	05500 05510
TERM4	sea ice heat flux from ocean	"	05520
TERM5	long wave radiation	"	05530
TGM	=WAT, used for printout of WAT		HYD02640 07040
TGN	used for printout of WAT		HYD07030 07050
TGR	ground temperature	°K	HYD06020 06160 06300 06720 06820 06900
THG	potential temp of air		
TOTALP	model predicted precipitation	m/hh	HYD06170
TPMN	print variable		
UGTC	storage variable		HYD03240

FORTRAN SYMBOL	MEANING	UNITS	PROGRAM LOCATION
USM	unavailable soil moisture (%) .025 sand soil (desert) .1 composite soil Ref. Salter & Williams '64, Table I, p. 312		HYD03050 03100
VALBFG	model control variable		
VIGT	viscosity correction factor		HYD03250 03260
VGTC	centigrade temp. of ground	deg	HYD03230
VPM	composite soil moisture		HYD03180
VP1	% of available soil moisture (temp.stor)		HYD03150 03160 03170
VP2	% of unavailable soil moisture ()		
VSM	total soil moisture	% sat	HYD03140
WAT	soil moisture available for evaporation scaled up	% sat	HYD02590 02600 02610 02620 02630
WET	ground wetness	% sat	HYD01580 01670 04900 04910 05340
WETIT	water available same as WAT	% sat	HYD04880 04890
WETR	amount of water	% sat	HYD05990 06430 06450 06640 06680 06700 06710 06910
WGM	max water holding capacity or sul moist cont at saturation = 2 sandy soil = 2.16.6 composite soil	g/foot soil g/foot soil	HYD03000 03110 03130

FORTRAN SYMBOL	MEANING	UNITS	PROGRAM LOCATION
WI	% of ice in mixed ice and water	%WET	HYD05190 05210 05220 05230 05240 05250 05350 05730 05740
WIR	"	"	HYD06010 06780 06790 06800
WMAG	W_s wind speed at ground	m/sec	HYD02100 02120 02130
WMAGN	"	"	HYD02710 02720
WTER	% of saturation for ground in desert regions	% sat	HYD01240 01250
WTSTO	stores WET	% sat	HYD04870
XRS	used for point out of RHS		HYD03200 07070

Appendix B

Code Listing - GHM & Off-Line Models (OLM)

GHM:

FILE I635TEST SSSDSN A *** GCDARD SPACE FLIGHT CENTER ***

```

SUBROUTINE CCMP35(J,JCEN,JUP,KCN,KCEN1,KLP)
C
C THIS SUBROUTINE WAS ADDED TO PREVENT CCMP3 FROM EXCEEDING THE
C COMPILER LIMIT FOR OPTIMIZATION (CPT=2). IT COMPRISES THE INNER
C LOOP OF CCMP3.
C**** THIS IS COMMON BLOCK CMS1 CREATED MAY 8 74
LOGICAL*4 FLAGS,SFINUP,GDF
REAL*4 KAPA,LAT
DIMENSION LAT(46),DXU(46),DXP(46),DYL(46),DYP(46),SINL(46),
1 COSL(46),DXYP(46),F(46),C(300),C1(300),CLMXY(72)
DIMENSION PHIS(46,72),MAP(46,2),F2(46,72)
DIMENSION Q(72,9,11,4)
DIMENSION QT(72,9,11,4)
DIMENSION U(72,9,11),V(72,9,11),T(72,9,11),SH(72,9,11)
DIMENSION UT(72,9,11),VT(72,9,11),TT(72,9,11),SHT(72,9,11)
DIMENSION P(72,11),PT(72,11)
DIMENSION PU(72,9,2),PV(72,9,2),PVLP(72,9,2),FUCLD(72,9,2)
DIMENSION CONV(72,9),SD(72,9),PIT(72),SC1(9),CCNSP(9)
DIMENSION NMSAVE(46),ALFSAV(46)
DIMENSION PHI(72,9,2),PHICLD(72,9,2),SPA(72,9,2),SFACLD(72,9,2)
DIMENSION PU2(72,9,2),PU2CLD(72,9,2)
DIMENSION PU3(72,9)
DIMENSION US(72,2),VS(72,2),QS(72,2,2),WINDSG(72,2)
DIMENSION UFIL(72,9),VFIL(72,9),TFIL(72,9),SHFIL(72,9),FFIL(72)
DIMENSION GRUP(46,72,4)
DIMENSION SHS(46,72),GT(46,72),GW(46,72),TOFLC(46,72),TS(46,72)
C D M M C N
* JSP,JNP,IM,NLAY,PTROP,I START,JSPF1,JNFM1,FIM,NLAYM1,NLAYP1,
* J1,JM,KM,TAUT,IROT,MROT,TALHT,MCFTH1,
* NR,JAYS(12),INCS(11),JSB,JNB,DLAT,DLON,JTEST,I1TEST,
* DT,TAU,ITAU,XINT,IDAY,JDAY,TCFDAY,JCATE,JMCNTI(2),JYEAR,NSTEP,
* NCYCLE,NCOMP3,NFOGAN,TAUP,TAUI,TALE,TALC,
* PI,GRAV,RGAS,KAPA,PSL,FD,FMU,NFLW,FSF,MACH,RSDIS1,SIND,CCSD,
* NC3T,NRC3T,LC3T,PRCJAR,TOTAPS,SCX,ISPACE,SOMULT,CUMMY1(5),
* IVER,CDI,RHMAX,FCU,SPINLP,MACHIN,
* IALTER,NNIME,FTE,PTE2,NIMPTS,SETNIM,MINJ,MAXJ,IRANC,IRTYFF,ISS,
* SS,IDIAG,PERIOD,ALPHA(4),BETA,GAMMA(4),TIMEO(4),KTFB,RINFLU,
* MODELT,LRAD(16),NMCT,NRAD(16),KTPA,JTAFE,CDX,FLAGS(10),
* MINI,MAXI,CLF,CLMXY2(20),TINT,
* XLABEL(20),SIG(20),DSIG(20),SIGE(21),DSIGC(19),
* J1PS(11),J1MPS(11),J1US(11),JMUS(11),J1F,JMP,J1U,JMU,J1FV,JMPV,
* INC,J1PY,J1PM1,JMPY,JMPF1,JMPF1X,J1U,J1UM1,J1UM1X,JMUX,FINC,
* INC2,INCH,
* LAT,DXU,DXP,DYU,DYP,SINL,COSL,DXYP,F,CLMXY,NTAE,PHIS,MAP,F2,
* P,Q,PU,PV,FUCLD,PVLP,CONV,PIT,PHI,PHICLD,SPA,SFACLD,PU2,
* PU2CLD,PU3,PITSF,SC1,NMSAVE,ALFSAV
EQUIVALENCE (JSF,C(1))
EQUIVALENCE (P(1,1),C1(1))
EQUIVALENCE (P(1,1),PT(1,1))
EQUIVALENCE (QT(1,1,1,1),C(1,1,1,1))
EQUIVALENCE (Q(1,1,1,1),U(1,1,1),UT(1,1,1))
EQUIVALENCE (Q(1,1,1,2),V(1,1,1),VT(1,1,1))
EQUIVALENCE (Q(1,1,1,3),T(1,1,1),TT(1,1,1))
EQUIVALENCE (C(1,1,1,4),SH(1,1,1),SHT(1,1,1))
HYD00010
HYD00020
HYD00030
HYD00040
HYD00050
HYD00060
HYD00070
HYD00080
HYD00090
HYD00100
HYD00110
HYD00120
HYD00130
HYD00140
HYD00150
HYD00160
HYD00170
HYD00180
HYD00190
HYD00200
HYD00210
HYD00220
HYD00230
HYD00240
HYD00250
HYD00260
HYD00270
HYD00280
HYD00290
HYD00300
HYD00310
HYD00320
HYD00330
HYD00340
HYD00350
HYD00360
HYD00370
HYD00380
HYD00390
HYD00400
HYD00410
HYD00420
HYD00430
HYD00440
HYD00450
HYD00460
HYD00470
HYD00480
HYD00490
HYD00500
HYD00510
HYD00520
HYD00530
HYD00540
HYD00550

```

ON-LINE LISTING (GHM)

B-1

ORIGINAL PAGE OF POOR QUALITY

```

EQUIVALENCE (SD(1,1),CONV(1,1)) HYD00560
EQUIVALENCE (SD1(1),CONSP(1)) HYD00570
EQUIVALENCE (QS(1,1,1),US(1,1),PU(1,1,1)),(VS(1,1),GS(1,1,2),
1 FU(1,3,1)) HYD00580
EQUIVALENCE (WINDSQ(1,1),PU(1,3,1)) HYD00590
EQUIVALENCE (UFIL(1,1),U(1,1,1)),(VFIL(1,1),V(1,1,1)),
1 (TFIL(1,1),T(1,1,1)),(SHFIL(1,1),SP(1,1,1)),(PFIL(1),P(1,1)) HYD00610
EQUIVALENCE (GRUP(1,1,1),SHS(1,1)),(GRUP(1,1,2),GT(1,1)),
1 (GRUP(1,1,3),GW(1,1)),(GRUP(1,1,4),TCFCG(1,1)) HYD00620
EQUIVALENCE (GRUP(1,1,1),PU(1,7,1)),(TS(1,1),U(1,3,6)) HYD00630
C**** ARRAYS FOR SPLIT GRID HYD00640
LOGICAL JIPL(46),JIUL(46),JMPL(46),JMLL(46) HYD00650
INTEGER INCP(46),INCU(46) HYD00660
COMMON/SPLIT/ JIPL,JIUL,JMPL,JMLL,INCP,INCU HYD00670
C HYD00680
LOGICAL LAND,OCEAN,ICE,SNOW,MIXWI,FRCST,FREC HYD00690
COMMON/FACCON/AS(15),RE(16),PL(16),FLE(16),PLK(15),PLKE(16),TL(15) HYD00700
* ,TLE(16),TG,TH(15),SHL(15),SHLF(16),SFC,CLOUD(15),CCSZ,SO,SG,CXL, HYD00710
* OCEAN,ICE,SNOW,SFSAT(15),GAM(15),RF(15),SSS(15),SSSF(15),FH(15), HYD00720
* HMF(16),HHS(15),CVI(15),CVQ(15),CXDE(15),PREC(15),EXL(15), HYD00730
* COE(15) HYD00740
COMMON/COMP3CM/TWCFI,DTCE,SDAY,ZLNCG,TICE,FM,CTI,CTIC,FICE,
* GAMFAC,COEF,COEFS,RSGIN,ROT,PILED,SNOWN,SNOWS,CCEF1,COEF2, HYD00750
* WMAGSP,WMAGNP,M1,M2,M3,NCL,LCL1,LCL2,STEO,CP HYD00760
COMMON/GRHYC/ICVET,ITC,GSW,CCN1,CCN2,CCN3,CCN4,CCN5,CCN6,CCN7 HYD00770
COMMON /ALBCCM/ RSURF,SLBEDD(46,72),VALBFG,JALB,IALB HYD00780
COMMON /SDOT46/ SEOT(46,72,8),MMNXTS HYD00790
DIMENSION ROK(46,72) HYD00800
COMMON/ROKK/ROK HYD00810
INTEGER*2 SLEEDC HYD00820
LOGICAL VALBFG HYD00830
LOGICAL*4 GWSWCH HYD00840
C**** LOGICAL FHAJ HYD00850
QSAT(X,Y)=.622*(10.**((9.4051-2353./X)))/Y HYD00860
GWSWCH = .FALSE. HYD00870
GWSWCH = AMCD((TAU-TAUI+GSW)/GSW,1.).LT..CC01 HYD00880
IF(J.GE.34)GWSWCH=.FALSE. HYD00890
IF(J.LE.16)GWSWCH=.FALSE. HYD00900
IF (GWSWCH,AND,(J-1+ITC)/ITC*ITC.EQ.J+ITC-1) WRITE(3,2555) HYD00910
IMINC=IM HYD00920
DC 809 I=1,IM HYD00930
C SET THESE QUANTITIES TO ZERO FOR USE IN PREPARING COMP3 TAPE HYD00940
C WITH SPLIT GRID HYD00950
T(I,1,M2) = 0. HYD00960
T(I,2,M2) = 0. HYD00970
C SET THESE QUANTITIES TO ZERO FOR USE IN PREPARING COMP3 TAPE HYD00980
C SURFACE FRICTION TERMS HYD00990
P(I,M2) = U(I,1,M3) HYD01000
P(I,M3) = U(I,2,M3) HYD01010
U(I,1,M3) = 0. HYD01020
U(I,2,M3) = 0. HYD01030
809 JALB=J HYD01040
DO 810 I=INC,IM,INC HYD01050
IALB=I HYD01060
HACOS=CCSF*CCS(ROT+(I-1)*DLON) HYD01070
HYD01080
HYD01090
HYD01100

```

```

COSZ=SINL(J)*SINC+CCSL(J)*HACOS
C**** SURFACE CONDITION
OCEAN=TCPCG(J,I),GT,1,
ICE=TOPCC(J,I),LT,-9.9E5
LAND=.NCT.(ICE,CR,OCEAN)
C**** FRAJ=.NCT.OCEAN,AND.(IGVET,EQ,17) *****
IF(GW(4E,72)-1C,) 2554;2554,2553
2552 SNOW = LAND,AND,CW(J,I),GT,1.00
IF(IGVET,EQ,24) GO TO 2552
SNOW = LAND,AND,(CW(J,I),CT,1,C,CR,SLEEDC(J,I),GE,40)
IF(SNOW)GW(J,I) = AMAX1(10,S , GW(J,I))
GC TO 2552
2554 IF(GW(J,I),LT,(-0.1))GW(J,I) = 1.0
WTER=GW(J,I)*5.C0+.2690917958
WTER=.5*WTER
IF(LAND) CW(J,I)=.5*(GW(J,I)*.3+.4)
IF(SLBEDC(J,I),EQ,35 )GW(J,I)=AMIN1(1.,WTER )
GW(J,I) = CW(J,I)/2.
IF(LAND,AND,IGVET,EQ,21)GW(J,I) = C.C
IF(OCEAN) GW(J,I) = 0.50
IF(IGVET,EQ,24) GO TO 25521
IF(OCEAN) GO TO 2552
IF (LAT(J),GE,SNOWN)GW(J,I)=GW(J,I)+INT ((LAT(J)-SNOWN)/(LAT(JMP)-
* SNOWN) *3.E4)
IF(LAT(J),LE,SNOWS) GW(J,I) = GW(J,I) + INT((LAT(J)-SNOWS)/(LAT(1)
* -SNOWS) *3.E4 )
GC TO 2552
25521 IF(SLBEDC(J,I),LE,39) GO TO 2552
C**** SNOW THICKNESS IN CMS.=0.5,1.0,2.0 FOR ALBEDO=40,50,,70 PERCENT.
C**** BESIDES HAVING THICKNESS OF 30CMS AT SOUTH POLE AND PERMANENT ICE.
C**** WITH MAXM ALBEDO OF 80 PERCENT.
GW(J,I) = 2.00E03 +0.5
IF(SLBEDC(J,I),LT,50) GW(J,I) = C.E00E03+ 0.5
IF(SLBEDC(J,I),LT,70) GW(J,I) = 1.0E03 + 0.5
IF(ICE)CW(J,I) = 30.0E03+C.5
IF(J,LE,9,AND,LAND) GW(J,I)=30.0E03+C.5
SNOW = LAND,AND,CW(J,I),GT,1.01
2552 IF(VALBFG) GC TO 2556
SLREDO(J,I) = 14
IF(OCEAN)SLBEDC(J,I) = 7
IF(SNOW,CR,ICE) SLBEDC(J,I) = 7C
2556 PSURF = 0.01*SLEEDC(J,I)
IF(IGVET,NE,24,CR,GW(J,I),LT,1.01) GC TO 25566
SNCTEM = SORTI((GW(J,I)-0.5)/1000.)
RSURF = 0.50*SNCTEM
IF(SNOTEM,LT,1.)RSURF = RSURF+0.01*SLEEDC(J,I)*(1.-SNCTEM)
RSURF = AMIN1(RSURF,0.80)
25566 WET = AMIN1(1.,(AMOD(GW(J,I),1.)*2))
LAND=LAND,AND,.NOT,SNOW
MIXWI = GT(J,I) .LE. 1.1 .AND. (LAND,OR,SNOW)
FROST=LAND,AND,(GT(J,I),LE,TICE).AND,.NOT,MIXWI
IF(.NOT,OCEAN) Z=PHIS(J,I)/GRAV
C**** GROUND TEMPERATURE AND WETNESS
IF(OCEAN) TG=TCPCG(J,I)
IF(.NCT,OCEAN) TG=GT(J,I)

```

HYD01110
HYD01120
HYD01130
HYD01140
HYD01150
HYD01160
HYD01170
HYD01180
HYD01190
HYD01200
HYD01210
HYD01220
HYD01230
HYD01240
HYD01250
HYD01260
HYD01270
HYD01280
HYD01290
HYD01300
HYD01310
HYD01320
HYD01330
HYD01340
HYD01350
HYD01360
HYD01370
HYD01380
HYD01390
HYD01400
HYD01410
HYD01420
HYD01430
HYD01440
HYD01450
HYD01460
HYD01470
HYD01480
HYD01490
HYD01500
HYD01510
HYD01520
HYD01530
HYD01540
HYD01550
HYD01560
HYD01570
HYD01580
HYD01590
HYD01600
HYD01610
HYD01620
HYD01630
HYD01640
HYD01650

B-3

ORIGINAL PAGE IS
OF POOR QUALITY

```

IF(MIXWI).TG=TICE
IF(.NCT.L/AND) WET=1.0
C
C
C**** PRESSURES
SP = P(I,KCENT)
CCLMR=PM/SP
DC 30 L=1,NLAY
PL(L)=SIC(L)*SP+PTROP
PLE(L)=SICE(L)*SP+PTRCP
70 PLK(L)=EXPBYK(PL(L))
PLE(NLAY+1)=SP+PTRCP
C**** TEMPERATURES AND ADIABATIC ADJUSTMENT
DC 35 L=1,NLAY
35 TL(L) = T(I,L,KCENT)
DC 40 N=1,3
DC 40 L=2,NLAY
LM1=L-1
IF(TL(L-1)/PLK(L-1).GE.TL(L)/PLK(L)) CC TC 40
THETA=(TL(LM1)*DSIG(LM1)+TL(L)*DSIG(L))/(PLK(LM1)*DSIG(LM1)+
* PLK(L)*DSIG(L))
TL(L-1)=THETA*PLK(L-1)
TL(L)=THETA*PLK(L)
40 TH(L-1)=TL(L-1)/PLK(L-1)
TH(NLAY)=TL(NLAY)/PLK(NLAY)
C SAVE CHANGE IN TEMPERATURE CAUSED BY ADIABATIC ADJUSTMENT HEATING
DC 45 L = 1,NLAY
45 U(I,L,M1) = TL(L)-T(I,L,KCENT)
C**** MOISTURE VARIABLES
DC 50 L=1,NLAY
50 SHL(L) = SH(I,L,KCENT)
CLOUD(L)=0,
CLOUD(NLAY+1)=0,
CLOUD(NLAY+2)=0,
CLOUD(NLAY+3)=0,
C**** ELIMINATE NEGATIVE SPECIFIC HUMIDITY
DC 202 L=2,NLAY
LM1=L-1
IF(SHL(LM1).CF.C.) GO TO 202
SHL(L)=SHL(L)+SHL(LM1)*DSIG(LM1)/DSIG(L)
SHL(LM1)=0,
202 CONTINUE
IF(SHL(NLAY).LT.0.) SHL(NLAY)=0.
C**** DRAG COEFFICIENT
IF (J.GT.JSP.AND.J.LT.JNP) WMAG = .5*SQRT(WINDSQ(I,JCENT) +
1 WINDSQ(IMINC,JCENT)+WINDSQ(I,JLP)+%INCSG(IMINC,JLP))
IF(J.EQ.JSP) WMAG=WMAGSP
IF(J.EQ.JNP) WMAG=WMAGNP
IF(OCEAN) CD=AMIN1((1+.07*WMAG)*.001,.0025)
IF(.NCT.OCEAN) CD=.002+.006*Z/SCCG.
IF(GDH) CD=C.5*CD
C**** VERTICAL DIFFUSION OF HEAT AND MOISTURE
70 LM1 = 2
C CHANGE THIS FROM *LM1 = NLAYM1*
DC 75 L = 1,NLAY

```

HYD01660
HYD01670
HYD01680
HYD01690
HYD01700
HYD01710
HYD01720
HYD01730
HYD01740
HYD01750
HYD01760
HYD01770
HYD01780
HYD01790
HYD01800
HYD01810
HYD01820
HYD01830
HYD01840
HYD01850
HYD01860
HYD01870
HYD01880
HYD01890
HYD01900
HYD01910
HYD01920
HYD01930
HYD01940
HYD01950
HYD01960
HYD01970
HYD01980
HYD01990
HYD02000
HYD02010
HYD02020
HYD02030
HYD02040
HYD02050
HYD02060
HYD02070
HYD02080
HYD02090
HYD02100
HYD02110
HYD02120
HYD02130
HYD02140
HYD02150
HYD02160
HYD02170
HYD02180
HYD02190
HYD02200

ORIGINAL PAGE IS
OF POOR QUALITY

B-4

C-2

```

C IF THE VERTICAL DIFFUSION HEATING TERMS TO BE SAVED ON THE COMP3 TAPE
C ARE NOT COMPLETED IN THE CODE THEY WILL DEFAULT TO ZERO
75 U(I,L,M2) = 0.
DC 80 L=LMIN,NLAY
LM1=L-1
DTETA=(TH(LM1)-TH(L))*(PLK(LM1)+PLK(L))*E
DZUP=SP*DSIG(LM1)*RGAS*TL(LM1)/(FL(LM1)*GRAV)
DZDN=SP*DSIG(L)*RGAS*TL(L)/(PL(L)*GRAV)
FDLE=.2*FC
TEMP=DTCE*(DSIG(LM1)+DSIG(L))/(DZUP+DZDN)**2
FLE=-2.*FDLE*DTETA*TEMP
TL(LM1)=TL(LM1)+FLE/DSIG(LM1)
TL(L)=TL(L)-FLE/DSIG(L)
U(I,LM1,M2) = U(I,LM1,M2)+FLE/DSIG(LM1)
C SAVE VERTICAL DIFFUSION HEATING TERMS
U(I,L,M2) = -FLE/DSIG(L)
TH(LM1)=TL(LM1)/PLK(LM1)
TH(L)=TL(L)/PLK(L)
DSH=SHL(LM1)-SHL(L)
ELE=-2.*FDLE*DSH*TEMP
SHL(LM1)=SHL(LM1)+ELE/DSIG(LM1)
8) SHL(L)=SHL(L)-ELE/DSIG(L)
C+*** SATURATION SPECIFIC HUMIDITY
DC 100 L=1,NLAY
SFSAT(L)=GSAT(TL(L),PL(L))
GAM(L)=GAMFAC*SFSAT(L)/TL(L)**2
RH(L)=SHL(L)/SFSAT(L)
100 CONTINUE
C*** DETERMINATION OF SURFACE TEMPERATURE
PS=PLE(NLAY+1)
PSK=EXPBYK(PS)
TLE(NLAYP1)=TS(J,I)
RFS=0.
THG = TS(J,I)/FSK
IF(WET+RH(NLAY).NE.0.) RHS=2.*WET*RH(NLAY)/(WET+RH(NLAY))
C RH SCALE
IF(.NOT.LAND)CC TC 101
RFS=0.
WAT=2.*(1.666666666*2.*WET-.666666666)
IF(SLBECC(J,I).EQ.35) WAT=.2*(2.*WET-.2690917558)
IF(WAT.GT.1.) WAT=1.
IF(WAT.LT.0.) WAT=0.
WAT=WAT*(1.-FOK(J,I))
TCM=WAT
IF(WAT+RH(NLAY).GT.0) RHS=WAT*RH(NLAY)/(WAT+RH(NLAY))
RFS=2.*RFS
101 CONTINUE
DTS=TG-TLE(NLAYP1)
IF(DTS.GE.0.) DRAW=CD*(WMAG+SQRT(DTS))
IF(DTS.LT.0.) DRAW=CD*WMAG*(WMAG*WMAC)/((WMAG*WMAC)-7.*DTS)
WMAGN=1.
IF(DTS.LT.0.) WMAGN=.2*(WMAG+.01)
ZLN=ZLNCC*TL(NLAYP1)*SP/PS
IF(TH(NLAY).GT.THG) GO TC 110
EDNS = 10.+100.*(1.-EXP(1200.*((TH(NLAY)-THG)/ZLN)))

```

```

HYD02210
HYD02220
HYD02230
HYD02240
HYD02250
HYD02260
HYD02270
HYD02280
HYD02290
HYD02300
HYDC2310
HYD02320
HYDC2330
HYDC2340
HYD02350
HYD02360
HYD02370
HYD02380
HYD02390
HYD02400
HYD02410
HYD02420
HYD02430
HYD02440
HYD02450
HYD02460
HYD02470
HYDC2480
HYD02490
HYD02500
HYD02510
HYD02520
HYD02530
HYD02540
HYD02550
HYD02560
HYD02570
HYD02580
HYD02590
HYD02600
HYD02610
HYD02620
HYD02630
HYD02640
HYD02650
HYD02660
HYD02670
HYD02680
HYD02690
HYD02700
HYD02710
HYD02720
HYD02730
HYD02740
HYD02750

```

```

GC TO 112 HYD02760
C COMPUTATION OF DIFFUSION COEFFICIENT BETWEEN SURFACE AND LAYER HYD02770
C 'NLAY' WITH NCAR FORMULATION BUT NO COUNTERGRADIENT HYD02780
110 IF (J.EG.JSP) GC TO 113 HYD02790
    IF (J.EG.JNP) GC TO 114 HYD02800
    DU = .25*(U(IMINC,NLAY,KUP)-US(IMINC,JLF)+U(I,NLAY,KUP)-US(I,JUP)+HYD02810
1 U(IMINC,NLAY,KCENT)-US(IMINC,JCENT)+U(I,NLAY,KCENT)-US(I,JCENT)) HYD02820
    DV = .25*(V(IMINC,NLAY,KUP)-VS(IMINC,JLF)+V(I,NLAY,KLP)-VS(I,JUP)+HYD02830
1 V(IMINC,NLAY,KCENT)-VS(IMINC,JCENT)+V(I,NLAY,KCENT)-VS(I,JCENT)) HYD02840
    GC TO 112 HYD02850
113 DU = .5*(U(IMINC,NLAY,KUP)-US(IMINC,JLF)+U(I,NLAY,KLP)-US(I,JUF)) HYD02860
    DV = .5*(V(IMINC,NLAY,KUP)-VS(IMINC,JLF)+V(I,NLAY,KLP)-VS(I,JUF)) HYD02870
    GC TO 112 HYD02880
114 DU = .5*(U(IMINC,NLAY,KCENT)-US(IMINC,JCENT)+U(I,NLAY,KCENT)-
1 US(I,JCENT)) HYD02890
    DV = .5*(V(IMINC,NLAY,KCENT)-VS(IMINC,JCENT)+V(I,NLAY,KCENT)-
1 VS(I,JCENT)) HYD02910
118 RICH = GRAV*((TH(NLAY)-THC)/ZLN)/(TG*((DL/ZLN)**2+(DV/ZLN)**2+
1 1.E-12)) HYD02920
    EDNS = 17./(1.+40.*RICH)+2. HYD02930
112 CONTINUE HYD02940
    EDV=EDNS/ZLN HYD02950
    EVE=AMIN1(1.,2.*WET) HYD02960
C*** ***** NEW BETA FOR GR. EVAPORATION ***** HYD02970
    WGM=2.*16.66666 HYD02980
    IF(SLBEDC(J,I).LT.10) GO TO 102 HYD02990
    FXTPN=1 HYD03000
    ROCK=ROK(J,I) HYD03010
    ASM=.15 HYD03020
    USM=.10 HYD03030
    RSURFF=(SLBEDC(J,I)*.01-.35) HYD03040
    RSUPFF=ABS(RSURFF) HYD03050
    IF(ABS(RSURFF).GT.01) GO TO 6415 HYD03060
    ASM=.065644 HYD03070
    USM=.024272 HYD03080
    WGM=2. HYD03090
6415 CCNTINUE HYD03100
    WGM=WGM*2. HYD03110
    VSM=2*WET*(ASM+USM) HYD03120
    VP1=AMAX1(0.,(2.*WET*(ASM+USM)-USM)/ASM) HYD03130
    VP2=AMIN1(1.,2.*WET*(ASM+USM)/USM) HYD03140
    VF2=AMAX1(0.,VF2) HYD03150
    VPM=.1*VP2+.2*VF1 HYD03160
    SHG=QSAT(TG,FS) HYD03170
    XRS=0. HYD03180
    PREVAP=0. HYD03190
    FILTF=1 HYD03200
    VCTC=GT(J,I)-TICE HYD03210
    UGTC=1.7625*EXP(-.036*VGTC)+.44562 HYD03220
    VIGT=1./UCTC HYD03230
    IF(VGTC.LT.0) VIGT= 1.0E-21 HYD03240
    FILTF=FILTF*VIGT HYD03250
    SHLE(NLAYP1)=(DRAW*SHG+EDV*SHL(NLAY))/(DRAW+EDV) HYD03260
    SATI=QSAT(TLE(NLAYP1),PS) HYD03270
102 CCNTINUE HYD03280
    HYD03290
    HYD03300

```

B-6


```

PETA2=1
IF(LAND,AND,.NCT,SNCW)GO TO 1234
GC TC 1235
1234 CONTINUE
TEMP=SATI/TLE(NLAYP1)
GAMCN=ZLN*RHS*9.8*(1.-(1.+CLH*TEMP/KAPA)/(1.+GAMFAC*TEMP/
TLE(NLAYP1)))*KAPA/RGAS
TNEH=(DRAW*TG+ECV*(TH(NLAY)*PSK-GAMCN))/(DRAW+ECV)
SATI=CSAT(TNEH,FS)
IF(SHLE(NLAYF1),LE,SATI) GO TO 6120
GAMSN=GAMFAC*SATI/TNEH**2
TEMP=(SHLE(NLAYF1)-SATI)/(1.+GAMSN)
TNEH=TNEH+TEMP*CLH
SHLE(NLAYF1)=SHLE(NLAYF1)-TEMP
FXTRN=1./EETA2
6120 CCNTINUE
RHQS=FS/(FGAS*TNEH)
DTSI=.5*(DTS+TG-TNEH)
IF(DTSI,GE,0.) DRRN=CC*(WMAG+SGRT(DTSI))
IF(DTSI,LT,0.) DRRN=CD*WMAG*(WMAG*WMAG)/((WMAG*WMAG)-7.*DTSI)
PREVAP=DRRN*RHQS*100.*(QSAT(TG,FS)-SHLE(NLAYF1))*3600.
IF(PREVAP,LE,0.) GO TO 1235
EXPTI=AMIN1(170.,16.75*VSM)
ETA2=.01*VSM*EXP(EXPTI)/PREVAP
EXPTI=AMIN1(170.,16.75*VPM)
BT2P=.10*VPM*EXP(EXPTI)/PREVAP
PLANT=AMIN1(1.,CCSZ/.2588)
IF(COSZ,LT,0) PLANT=0.
IF(RSURFF,GT,.01) GO TO 4000
PLANT=1.
4000 CCNTINUE
BT2P=PLANT*BT2P
EXPTP=-AMIN1(170.,BT2P)
PETA2P=1.-EXP(EXPTP)
EXPTS=-AMIN1(170.,BT2P)
PETA2=1.-EXP(EXPTS)
BTA=BETA2+BETA2P
IF(BTA,GT,1.) ETA=1.
EXTDR=(EXPTS*EXP(EXPTS)+EXPTP*EXP(EXPTP))
DTRBET=(1.-ROCK)*EXTDR
IF(BTA,GT,.9999)DTRBET=0.
BTA=(1.-ROCK)*ETA
PETA2=BTA
EVE=BETA2
SHLE(NLAYF1)=SHL(NLAY)-BETA2*(SHL(NLAY)-SHLE(NLAYF1))*FXTRN
1235 CCNTINUE
EVE=1.
EVACO=EVE*DRAK
EVACO=AMAX1(EVACO,1,E-40)
SHSATS=CSAT(TLE(NLAYP1),FS)
SHG=QSAT(TG,FS)
NEW BETA CONTINUED
EVE=BETA2
TEMP=SHSATS/TLE(NLAYP1)
GAMC=ZLN*RHS*9.8*(1.-(1.+CLH*TEMP/KAPA)/(1.+GAMFAC*TEMP/

```

HYD03310
HYD03320
HYD03330
HYD03340
HYD03350
HYD03360
HYD03370
HYD03380
HYD03390
HYD03400
HYD03410
HYD03420
HYD03430
HYD03440
HYD03450
HYD03460
HYD03470
HYD03480
HYD03490
HYD03500
HYD03510
HYD03520
HYD03530
HYD03540
HYD03550
HYD03560
HYD03570
HYD03580
HYD03590
HYD03600
HYD03610
HYD03620
HYD03630
HYD03640
HYD03650
HYD03660
HYD03670
HYD03680
HYD03690
HYD03700
HYD03710
HYD03720
HYD03730
HYD03740
HYD03750
HYD03760
HYD03770
HYD03780
HYD03790
HYD03800
HYD03810
HYD03820
HYD03830
HYD03840
HYD03850

B-7

C

```

* TLE(NLAYP1)))*KAPA/RGAS
TLE(NLAYP1)=(DRAW*TG+EDV*(TH(NLAY)*FSK-GAMC))/(DRAW+EDV)
SHLF(NLAYP1)=(EVACO*SHFG+EDV*SHL(NLAY))/(EVACC+EDV)
SHSATS=GSAT(TLE(NLAYP1),PS)
IF(SHLE(NLAYP1).LE.SHSATS) GO TO 120
GAMS=GAMFAC*SHSATS/TLE(NLAYP1)**2
TEMP=(SHLE(NLAYP1)-SHSATS)/(1.+GAMS)
TLE(NLAYP1)=TLE(NLAYP1)+TEMP*CLH
C**** IF(FHAJ)TLE(NLAYP1)=TLE(NLAYP1)-.75*TEMP*CLH *****
SHLF(NLAYP1)=SHLE(NLAYP1)-TEMP
120 RHOS=PS/(FGAS*TLE(NLAYP1))
C**** SENSIBLE HEAT (LY/DAY) AND EVAPORATION (CM/CM**2/SEC)
DTS=.5*(DTS+TG-TLE(NLAYP1))
DSHS=SHFG-SHLE(NLAYP1)
IF(DTS.CE.0.) DRAW=CD*(WMAG+SQRT(DTS))
IF(DTS.LT.0.) DRAW=CD*WMAG*(WMAG*WMAG)/((WMAG*WMAG)-7.*DTS)
FSURF=CCEFS*RHOS*DRAW/SP
TL(NLAY)=TL(NLAY)+FSURF*DTS
C****
CCN1 = TH(NLAY)*PSK-GAMC
CCN2 = DRAW*TG
IF(IGVET.EQ.13) TL(NLAY) = TL(NLAY) + FSURF*DTS*.5
C SAVE CHANGE IN TEMPERATURE IN LAYER 'NLAY' CAUSED BY SURFACE
C INTERACTION HEATING
V(I,9,M2) = FSURF*DTS
IF(IGVET.EQ.13) V(I,9,M2) = V(I,9,M2) + FSURF*DTS*.5
C SAVE EVAPORATION IN MM H2O
P(I,M1) = FSURF*EVE*DSHS*100.*DSIC(NLAY)*SP/GRAV
C**** IF(FHAJ)P(I,M1)=.25*P(I,M1) *****
TH(NLAY)=TL(NLAY)/PLK(NLAY)
SHL(NLAY)=SHL(NLAY)+FSURF*EVE*DSHS
C**** IF(FHAJ)SHL(NLAY)=SHL(NLAY)-.75*FSURF*EVE*DSHS *****
IF(SHL(NLAY).LT.0.) SHL(NLAY)=0.
C SAVE EVAPORATION AND SENSIBLE HEAT FLUX FOR OCEAN(LY/DAY)
IF(.NCT.OCEAN) GO TO 122
EVAL =600.
TEMP=10.*DRAW*RTDS*SDAY
V(I,3,M3)=EVAL*EVE*TEMP*DSHS
V(I,4,M3)=CF*TEMP*DTS
C SAVE PRECIPITABLE WATER VAPOR(G/CM**2)
122 PRECWX=0.
DO 123 L=1,NLAY
123 PRECWX=PRECWX+SHL(L)*DSIC(L)
V(I,1,M3)=SP*PRECWX*10./GRAV
FSURFQ=.25*FSURF
DO 140 K=1,2
IF(J.EQ.JSP) GO TO 135
Q(I,NLAY,KCENT,K) = Q(I,NLAY,KCENT,K)-FSURFQ*QS(I,JCENT,K)
P(I,M1+K) = P(I,M1+K) + FSURFQ*QS(I,JCENT,K)
Q(IMINC,NLAY,KCENT,K) = Q(IMINC,NLAY,KCENT,K) - FSURFQ*
1 QS(IMINC,JCENT,K)
P(IMINC,M1+K) = P(IMINC,M1+K) + FSURFQ*QS(IMINC,JCENT,K)
135 CONTINUE
IF(J.EQ.JNP) GO TO 140
Q(I,NLAY,KUP,K) = Q(I,NLAY,KUP,K)-FSURFQ*QS(I,JUP,K)

```

HYD03860
HYD03870
HYD03880
HYD03890
HYD03900
HYD03910
HYD03920
HYD03930
HYD03940
HYD03950
HYD03960
HYD03970
HYD03980
HYD03990
HYD04000
HYD04010
HYD04020
HYD04030
HYD04040
HYD04050
HYD04060
HYD04070
HYD04080
HYD04090
HYD04100
HYD04110
HYD04120
HYD04130
HYD04140
HYD04150
HYD04160
HYD04170
HYD04180
HYD04190
HYD04200
HYD04210
HYD04220
HYD04230
HYD04240
HYD04250
HYD04260
HYD04270
HYD04280
HYD04290
HYD04300
HYD04310
HYD04320
HYD04330
HYD04340
HYD04350
HYD04360
HYD04370
HYD04380
HYD04390
HYD04400

B-8

ORIGINAL PAGE IS
OF POOR
QUALITY

```

      U(I,K,M3) = U(I,K,M3) + FSURFC*GS(I,JUP,K)
      Q(IMINC,NLAY,KUP,K) = Q(IMINC,NLAY,KUP,K) - FSURFC*GS(IMINC,JUP,K)
      U(IMINC,K,M3) = U(IMINC,K,M3) + FSURFC*GS(IMINC,JUP,K)
140  CONTINUE
      SDOT(J,I,3) = TOTALP + SDOT(J,I,3)
C**** ELIMINATE NEGATIVE SPECIFIC HUMIDITY
      DO 410 L=2,NLAY
      LM1=L-1
      IF(SHL(LM1),GE,0.) GO TO 410
      SHL(L) = SHL(L) + SHL(LM1)*DSIG(LM1)/DSIG(L)
      SHL(LM1) = 0.
410  CONTINUE
      IF(SHL(NLAY),LT,0.) SHL(NLAY) = 0.
      IF(SHLE(NLAYPI),LT,0.) SHLE(NLAYPI) = 0.
C**** RADIATION SUBROUTINES
      IF(NFLW,EC,0) GO TO 420
      IF(.NOT.FLAGS(1)) GO TO 420
      XDAY = FLCAT(JDAY+62)
      XLAT = (J-.5*(JSP+JNP))*DLAT*180./PI
      LATD = XLAT + .5
      CALL SOLAR1 (NLAY,XDAY,XLAT)
      DSAREA = DXYP(J)*RSOIN
      IF(COSZ,GT,.01) PROJAR = PROJAR + DSAREA*CCSZ
      TDSABS = SG
      DO 412 L = 1,NLAY
412  TDSABS = TDSABS + AS(L)
      TOTABS = TOTABS + TDSABS*DSAREA
      CALL LINKFO (NLAY,NFLW,JDAY,LATD)
C   SAVE SOLAR RADIATION INCIDENT ON TOP OF ATMOSPHERE(LY/DAY)
C**** V(I,5,M3) = SOX*CCSZ *****CLC CARD REPLACED*****
      V(I,5,M3) = ANAXI(0.,SOX*CCSZ)
C   SAVE SOLAR RADIATION ABSORBED BY ATMOSPHERE(LY/DAY)
      V(I,6,M3) = TCSAES - SG
C   SAVE SOLAR RADIATION ABSORBED BY GROUND(LY/DAY)
      V(I,7,M3) = SG
C   SAVE NET LONG-WAVE RADIATION AT TOP OF MODEL ATMOSPHERE(LY/DAY)
      V(I,8,M3) = RE(1)
C   SAVE NET LONG-WAVE RADIATION AT GROUND(LY/DAY)
      V(I,9,M3) = RE(NLAYPI)
      SFS(J,I) = SG - RE(NLAYPI)
C   *   *   SAVE WIND MAGNITUDE
      V(I,9,11) = WMAG
C
C**** PREDICTION OF GROUND CONDITION
420  CONTINUE
C   NEW
      WTSTO = WET
      WETIT = WET*3.333333333333 - .6666666666
      WETIT = 2.*WETIT
      WET = AVIN1(1.,WETIT)
      IF(WET,LT,0.) WET = 0.
C SET DEFAULTS FOR COMP3 TAPE
      V(I,5,M2) = 0.
      V(I,6,M2) = 0.
      V(I,7,M2) = 0.

```

HYD04410
 HYD04420
 HYD04430
 HYD04440
 HYD04450
 HYD04460
 HYD04470
 HYD04480
 HYD04490
 HYD04500
 HYD04510
 HYD04520
 HYD04530
 HYD04540
 HYD04550
 HYD04560
 HYD04570
 HYD04580
 HYD04590
 HYD04600
 HYD04610
 HYD04620
 HYD04630
 HYD04640
 HYD04650
 HYD04660
 HYD04670
 HYD04680
 HYD04690
 HYD04700
 HYD04710
 HYD04720
 HYD04730
 HYD04740
 HYD04750
 HYD04760
 HYD04770
 HYD04780
 HYD04790
 HYD04800
 HYD04810
 HYD04820
 HYD04830
 HYD04840
 HYD04850
 HYD04860
 HYD04870
 HYD04880
 HYD04890
 HYD04900
 HYD04910
 HYD04920
 HYD04930
 HYD04940
 HYD04950

B-9


```

RUNOFF=0.
SMELT=0.
FLDRK=0.
DFNG=0.
RLNOVV=0.
NEW
NEW
IF(OCEAN)GO TO 2680
TGR=GT(J,I)
IF(TCTALP.LT.0)TOTALP=0.
IF(TLE(NLAYP1).LE.TICE)SNFAL=TGTALP *1CC.
IF(TLE(NLAYP1).GT.TICE) RAIN=TCTALP *1CC.
ISNR = IFIX(CW(J,I))
SNR=FLOAT(ISNR)/1000.0
IF(SNR.LT.0.001) SNR=0.
SNR1=SNF+SNFAL
SNR=SNR1-E6DT
IF(SNR1.LE.0.) CC TO 2650
IF(SNR.LE.0.) CO TO 2650
IF(TGR.LE.TICE)CC TO 2600
SMELT=CZH*(TCR-TICE)/80.
SMELT=AMIN1(SMELT,SNR)
TGR=TGR-90.*SMELT/CZH
SNR=SNR-SMELT
IF(ICE) GO TO 2670
SOIL MOISTURE AND FREEZING
SNOW COVERED LAND
NEW
-----
2600 CONTINUE
WETR=WET+(RAIN+SMELT)/WGM
RUNOFF=AMAX1(0.0,WETR-1.)
WETR=WETR-RUNOFF
GO TO 2680
NEW
SNOW FREE LAND
2650 SNR=0.
IF(ICE)GO TO 2670
NEW
IF(RAIN.LT.0.)RAIN=0.0
IF(RAIN.LE.1.E-60)GO TO 5140
ADINF=1.25*(2.*WET-.2)-.5
BEFACT=2.*FILTF*EXP(-1.75*(ADINF-.5))
IF(RAIN.GT.BEFACT)RUNOFF=RAIN-.5*BEFACT
IF(RAIN.LT.BEFACT)RUNOFF=.5*RAIN*RAIN/BEFACT
5140 CONTINUE

```

```

HYD06060
HYD06070
HYD06080
HYD06090
HYD06100
HYD06110
HYD06120
HYD06130
HYD06140
HYD06150
HYD06160
HYD06170
HYD06180
HYD06190
HYD06200
HYD06210
HYD06220
HYD06230
HYD06240
HYD06250
HYD06260
HYD06270
HYD06280
HYD06290
HYD06300
HYD06310
HYD06320
HYD06330
HYD06340
HYD06350
HYD06360
HYD06370
HYD06380
HYD06390
HYD06400
HYD06410
HYD06420
HYD06430
HYD06440
HYD06450
HYD06460
HYD06470
HYD06480
HYD06490
HYD06500
HYD06510
HYD06520
HYD06530
HYD06540
HYD06550
HYD06560
HYD06570
HYD06580
HYD06590
HYD06600

```

B-12

```

ADDW=RAIN-RUNOFF
ADDW=ADCW*(1.-RCCK)
ECAR=E6DT/(1.-RCCK)
WETR=WET+(ADCW-ECAR)/WGM
RUNOVV=RCCK*RAIN
RUNOFF=FUNOVV+(1-ROCK)*RUNCFF
DRNG=0,05*AMAX1(0,0,WETR-.5)
WETR=WETR-DRNG
C
NEW
IF(WETR.GT.1.)WETR=1.
IF(WETR.LT.0.)WETR=0.
IF(FRCST)TGR=TGR+60.*ADDW/CZH
IF(.NOT.MIXWI)WI=0.
IF(FRCST)WI=WETR
IF(.NOT.(MIXWI.OR.(FROST.AND.TGR.GT.TICE).OR.(TG.GT.TICE.AND.
1 TGR.LT.TICE)))GO TC 268C
FREEZ=CZH*(TICE-TGR)/80./WGM
WIR=WI+FREEZ
IF(WIR.GT.WETR)WIR=WETR
IF(WIR.LT.0.)WIR=0.
FREEZ=WIR-WI
TGP=TGR+30.*FREEZ*WGM/CZH
C
ICE
C
ICE
C
C
GC TO 268C
2670 TGR=AMIN1(TGR,TICE)
WETR=1.
268C IF(IGVET.GE.10)GT(J,I)=TGR
IF(WIR.GT.0.AND.WIR.LT.WETR)GT(J,I)=WIR
SNR=AMIN1(SNR,30,0)
ISNR=IFIX(AVAX1(0.,SNR)*1000.)
IF(IGVET.GE.20)GW(J,I)=FLCAT(ISNR)+C.50*WETR
C*****SAVE GROUND WETNESS,RUNOFF,SMELT
T(I,1,M3)=GW(J,I)
T(I,2,M3)=SMELT
T(I,3,M3)=RUNCFF
T(I,4,M3)=CT(J,I)
T(I,5,M3)=TCTALF*100.
TGN=GT(J,I)-TICE
IF(RSURFF.LT..C1)TGM=TGM+6
IF(TGN.LT.-270.)TGN=GT(J,I)
TFMN=4.*GW(J,I)
XRS=RHS
PCTALP=RAIN
GWSWCH=AMOD((TAL-TAUI+GSW)/GSW.1.),LT..CCC1
IF(OCFAN)GWSWCH=.FALSE.
IF(J.LE.16)GWSWCH=.FALSE.
IF(J.GE.37)GWSWCH=.FALSE.
IF(I.GE.48)GWSWCH=.FALSE.
IF(GWSWCH.AND.(I/ITC*ITC.EQ.I.AND.(J-1+ITC)/ITC*ITC.EQ.J+ITC-1))
1 GO TC 8365

```

HYD06610
HYD06620
HYD06630
HYD06640
HYD06650
HYD06660
HYD06670
HYD06680
HYD06690
HYD06700
HYD06710
HYD06720
HYD06730
HYD06740
HYD06750
HYD06760
HYD06770
HYD06780
HYD06790
HYD06800
HYD06810
HYD06820
HYD06830
HYD06840
HYD06850
HYD06860
HYD06870
HYD06880
HYD06890
HYD06900
HYD06910
HYD06920
HYD06930
HYD06940
HYD06950
HYD06960
HYD06970
HYD06980
HYD06990
HYD07000
HYD07010
HYD07020
HYD07030
HYD07040
HYD07050
HYD07060
HYD07070
HYD07080
HYD07090
HYD07100
HYD07110
HYD07120
HYD07130
HYD07140
HYD07150

B-13

ORIGINAL PAGE IS
OF POOR
QUALITY

FILE I635TEST SSSDSN A *** GODDARD SPACE FLIGHT CENTER ***

```
IF(TAU.EQ.TAUI.AND.I.GE.13.AND.I.LE.22.AND.J.GE.31.AND.J.LE.36) HYD07160
1 GC TC 8055 HYD07170
GC TC 8065 HYD07180
8055 CONTINUE HYD07190
C CHANGED UNITS OF PREVAP(MM/HOUR TO CM/ HALF HOUR BY DIVD BY 20 10/1)HYD07200
PREVAP=PREVAP/20. HYD07210
WRITE(6,2551) J,I,GW(J,I),GT(J,I),FCTALF,FUNCOFF,FREVAP,BETA2, HYD07220
1ECAR,FILTF,BEFACT,RHOS,DRRN,QSSH,DRAW,DSFS,PLANT ,RCK,ROFIGW,DTSIHYD07230
2551 FORMAT(1X,2I3,2X,9(E11.4,2X),/,10X,9(E11.4,2X)) HYD07240
2555 FORMAT(///,3X,'J I WETNESS/RHOS CFTEMP/DRRN FCTALF/GSSH FUNCFHYD07250
1/DRAW PREVAP/DSFS BETA2/FLT ECAR/RCK FILTF/ROFIGW BEFACTHYD07260
2/DTSI!,///) HYD07270
8065 CONTINUE HYD07280
C HYD07290
C *****
C ***** GROUND WETNESS SECTION-ENDS ***** HYD07300
C *****
C *****
C *****
C ***** TOTAL HEATING AND MOISTURE ADJUSTMENT HYD07340
DC 520 L=1,NLAY HYD07350
SH(I,L,KCENT) = SH(L) HYD07360
C SAVE CHANGE IN TEMPERATURE FROM SOLAR RADIATION HEATING HYD07370
T(I,L,M1) = AS(L)*COE(L) HYD07380
C SAVE CHANGE IN TEMPERATURE FROM LONG-WAVE RADIATION HEATING HYD07390
SH(I,L,M1) = (FE(L+1)-RE(L))*CCE(L) HYD07400
520 T(I,L,KCENT) = TL(L)+(AS(L)+RE(L+1)-RE(L))*CCE(L) HYD07410
TS(J,I)=TLE(NLAYP1) HYD07420
SDOT(J,I,1) = AMIN1(SDOT(J,I,1),TS(J,I)) HYD07430
SDOT(J,I,2) = AMAX1(SDOT(J,I,2),TS(J,I)) HYD07440
810 IMINC=I HYD07450
RETURN HYD07460
END HYD07470
```

B-14

OLM:

OFF-LINE MODEL (OLM)

B-15

DIMENSION	LAT(46), FLUXC(8,14,12)	OLM00010
COMMON	PHIS(08,14), FD(08,14), TOPOG(08,14), SINL(46), COSL(46)	OLM00020
COMMON		OLM00030
\$	PC(8,14), TSC(8,14), SHSC(8,14), GTC(8,14), GWC(8,14),	OLM00040
\$	UC(8,14,3), VC(8,14,3), TC(8,14,3), SHC(8,14,3), PLK(10),	OLM00050
\$	SGC(8,14), US(08,14), VS(08,14)	OLM00060
COMMON		OLM00070
*	PLE(10), TLF(10), RH(10), TH(10), DSIG(10), SHL(10),	OLM00080
*	SHLE(10), RE(10), SH(8,14,3), PL(10),	OLM00090
*	GT(08,14), SHS(08,14), TL(10),	OLM00100
*	SLBEDO(08,14), TS(08,14), GW(08,14), ROK(08,14),	OLM00110
*	IWR(10), SIGE(10), SIG(10)	OLM00120
COMMON		OLM00130
*	RHS, DTS, CD, EDV, ZLN, DRAW, PREVAP, PLANT, EVE, E6DT,	OLM00140
*RHOS, CZH, DTRBET, TERM1, TERM2, TERM3, TERM4, TERM5, DENOM, RADTRM,		OLM00150
*	SNFAL, RAIN, OVER, WETR, WET, TAU, WMAG, ELE	OLM00160
DIMENSION	PLTGT(200), PLTGT(200), PLTGWC(200), PLTGW(200),	OLM00170
1	PLTSHL(200), PLSHE(200), PLTX(200), PLTTS(200),	OLM00180
2	PLTPE(200), PLTAE(200), PLTEVE(200), PLIRGS(200),	OLM00190
3	PLEGCM(200), PLT9TG(200), PAEGO(200)	OLM00200
LOGICAL*1	STAR/'*'/, PLUS/'+'/, POUND/'#'/, CROSS/'X'/, PERIOD/'.'/	OLM00210
LOGICAL	OCEAN, SNOW, ICE, LAND, MIXWI, FROST, GCM	OLM00220
LOGICAL	UCLA, UCNI, UCNII, UCNJJA, ASSIM, TINPT, VALBFG	OLM00230
LOGICAL	WETCEL, AVCELL, DRYCEL, LOG8, UCLAVW, VRP4, GDH	OLM00240
REAL*4	KAPA	OLM00250
INTEGER*2	SLBEDO	OLM00260
QSAT(X, Y)	= .622*(10.** (9.4051-2353./X))/Y	OLM00270
C		OLM00280
C	REVISED MODEL STARTED 1/78	OLM00290
C	E CMS HYDRO NEW AT GSFC	OLM00300
C		OLM00310
C	DATE CORRECTIONS	OLM00320
C		OLM00330
C	STEP 1: DESIGN OF EXPERIMENT	OLM00340
C		OLM00350
C	A SET MODEL LOGICAL PARAMETERS	OLM00360
	GCM=.TRUE.	OLM00370
	GCM=.FALSE.	OLM00380

C	UCLA=.FALSE.	OLM00390
	UCLA=.TRUE.	OLM00400
	UCLAVW=.FALSE.	OLM00410
	UCLAVW=.TRUE.	OLM00420
	UCNI=.TRUE.	OLM00430
	UCNI=.FALSE.	OLM00440
	UCNJJA=.FALSE.	OLM00450
	UCNII=.TRUE.	OLM00460
	UCNII=.FALSE.	OLM00470
	ASSIM=.FALSE.	OLM00480
C	TINPT: TRUE IF SURFACE WD SPEED INFO IS AVAILABLE	OLM00490
C	ON INPUT DATA TAPE	OLM00500
	TINPT=.FALSE.	OLM00510
	LOG8=.FALSE.	OLM00520
	LOG8=.TRUE.	OLM00530
C	LOG8 TRUE, OLM WILL READ AND USE TAPE VARIABLES,	OLM00540
C	GWC,GTC, EVERY TIME STEP	OLM00550
	VALBPG=.TRUE.	OLM00560
C		OLM00570
	WETCEL=.FALSE.	OLM00580
	WETCEL=.TRUE.	OLM00590
	AVCELL=.TRUE.	OLM00600
	AVCELL=.FALSE.	OLM00610
	DRYCEL=.TRUE.	OLM00620
	DPYCEL=.FALSE.	OLM00630
	VRP4=.TRUE.	OLM00640
	VRP4=.FALSE.	OLM00650
	GDH=.TRUE.	OLM00660
	GDH=.FALSE.	OLM00670
C		OLM00680
C		OLM00690
C	B PROGRAM CONSTANTS	OLM00700
C		OLM00710
	NLAY = 9	OLM00720
	NLAYP1 = NLAY + 1	OLM00730
	JMIN=1	OLM00740
	JMAX=8	OLM00750
	IMAX=14	OLM00760
		OLM00770

OLM00780
OLM00790
OLM00800
OLM00810
OLM00820
OLM00830
OLM00840
OLM00850
OLM00860
OLM00870
OLM00880
OLM00890
OLM00900
OLM00910
OLM00920
OLM00930
OLM00940
OLM00950
OLM00960
OLM00970
OLM00980
OLM00990
OLM01000
OLM01010
OLM01020
OLM01030
OLM01040
OLM01050
OLM01060
OLM01070
OLM01080
OLM01090
OLM01100
OLM01110
OLM01120
OLM01130
OLM01140
OLM01150
OLM01160

```
C      TMIN=1
-----
C      JMINUS=30
-----
      JMAXUS=37
-----
      TMINUS=12
-----
      TMAXUS=25
-----
C
-----
      NLAYM1=NLAY-1
-----
      JMP=JMAX-1
-----
      INC=TMIN
-----
      JNC=1
-----
      IM=IMAX
-----
      J1P=JMIN+1
-----
      JMPP1=JMP+1
-----
C
-----
C      C DO LOOP PARAMETERS FOR SPECIFIC CELL LOCATIONS
-----
C
-----
      I1 = TMIN+1
-----
      I2 = TMAX
-----
      I3 = INC
-----
      J1 = JMIN
-----
      J2 = JMAX-1
-----
      J3 = JNC
-----
C
-----
      SIGE(1)=0.
-----
      DO 70 L=1,NLAY
-----
      DSIG(L)=.11111111
-----
      SIGE(L+1)=SIGE(L)+DSIG(L)
-----
70  SIG(L)=.5*(SIGE(L)+SIGE(L+1))
-----
C
-----
      RGAS=287.
-----
      KAPA=.286
-----
      GRAV = 9.8
-----
      TTCE = 273.16
-----
      SDAY= 86.4E+3
-----
      TWOPI = 2.*3.1416
-----
      PI=3.141592654
-----
      DPI=PI
-----
      CTTD = 432.
-----
```

ORIGINAL PAGE IS
OF POOR QUALITY

B-17

HICE = 300.

STBO = 1.17E-7

CP = .24

CLH=600./ .24

GAMPAC = 5418*CLH

C

C

C

C

C

DTC3 = 1800.

NHOGAN=1

IF(ASSIM) DTC3=60.*60.*3.

IF(ASSIM) NHOGAN=1

C

ASSIM HAS A 3 HOUR TIME INTERVAL

COEFS=GRAV*DTC3/DSIG(NLAY)

C

C

C

C

TOTALP = 0.

MONTH=8

IGVET=15

IGVET=25

IGVET=23

PTROP=10.

FD=10.

C

C

C

C

ROK=1: OCEAN, 2: LOAMY SOIL, 3: SANDY SOIL

READ(5,145) ((ROK(J,I),J=1,8),I=1,14)

C

SLBEDO FOR JULY I527ALBD BUT GCM TAPE USED 14 FOR LANOLM01480

READ(5,146) ((SLBEDO(J,I),J=1,8),I=1,14)

C

BUT FOR THREE TEST CELLS IT READS THIS ARRAY

C

SEE TOPOG PRINT OUT

READ(5,145) ((PHIS(J,I),J=1,8),I=1,14)

DO 148 I=8,MONTH

DO 148 I=1,14

READ(5,147) M, (TOPOG(J,I),J=1,8)

OLM01170

OLM01180

OLM01190

OLM01200

OLM01210

OLM01220

OLM01230

OLM01240

OLM01250

OLM01260

OLM01270

OLM01280

OLM01290

OLM01300

OLM01310

OLM01320

OLM01330

OLM01340

OLM01350

OLM01360

OLM01370

OLM01380

OLM01390

OLM01400

OLM01410

OLM01420

OLM01430

OLM01440

OLM01450

OLM01460

OLM01470

OLM01480

OLM01490

OLM01500

OLM01510

OLM01520

OLM01530

OLM01540

OLM01550

	148 CONTINUE	OLM01560
	145 FORMAT(8(F10.5))	OLM01570
	146 FORMAT(8(I2))	OLM01580
	147 FORMAT(I8,8(F9.3))	OLM01590
C	READ(20) SLBEDO,PHIS,TOPOG	OLM01600
C		OLM01610
C	D SET SUMS FOR ALL AVERAGES = TO 0.	OLM01620
	AVGT=0.	OLM01630
	SUMAV=0.	OLM01640
	AVTS=0.	OLM01650
	AVGW=0.	OLM01660
	AVGTC=0.	OLM01670
	AVTSC=0.	OLM01680
	AVGWC=0.	OLM01690
C		OLM01700
C	E INITIAL DATA TAPE READ	OLM01710
C		OLM01720
	READ(08,95) TAU,PC,TSC,SHSC,GTC,GWC,UC,VC,TC,SHC,FLUXC	OLM01730
	95 FORMAT(226(255A4))	OLM01740
C		OLM01750
C		OLM01760
	HOUR = TAU	OLM01770
	NHH=10	OLM01780
	NHH=96	OLM01790
	TINC=.5	OLM01800
	IF(ASSIM) TINC=3.0	OLM01810
C		OLM01820
	DO 200 IHH = 1,NHH	OLM01830
	HOUR= HOUR+TINC	OLM01840
C		OLM01850
C		OLM01860
C	F BEGIN CELL LOOP OF MODEL	OLM01870
C	VARIABLE LOCATION	OLM01880
C		OLM01890
C		OLM01900
C		OLM01910
C		OLM01920
C		OLM01930
C		OLM01940

-TL,T(LAYER 9)

B-20

OLD	NEW	EQUIVALENT	SOURCE	NAME	
					TS, TLE, PLF OLM01950
					OLM01960
*****					GT, P, TS, SHS, OLM01970
					OLM01980
					OLM01990
					OLM02000
*****					OLM02010
					OLM02020
NOTE 1	NOTE 1	PC(8,14)	TAPE	P(J,I) = PI = PS-	POLM02030
TS(10,10)	TS(8,14)	TSC(8,14)	TAPE	SURFACE TEMPERATURE	OLM02040
SHS(10,1)	SHS(10,10)	SHSC(8,14)	TAPE	NET RADIATION(LY/DOLM	02050
GT(10,10)	GT(8,14)	GTC(8,14)	TAPE	GROUND TEMPERATURE	OLM02060
GW(10,10)	GW(8,14)	GWC(8,14)	TAPE	GROUND WETNESS	OLM02070
	UC(8,14,3)	UC(8,14,3)	TAPE	X VEL COMPONENT(M/OLM	02080
	VC(8,14,3)	VC(8,14,3)	TAPE	Y VEL COMPONENT(M/OLM	02090
NOTE 2	NOTE 2	TC(8,14,3)	TAPE	LAYER TEMPERATURE	OLM02100
SH(10)	SH(8,14,3)	SHC(8,14,3)	TAPE	SPEC HUM OF LAYER	OLM02110
TLE(10)	TLE(10)		STEP 7	T(L) OF INTER L-1,	OLM02120
RH(10)	RH		STEP 6	RELATIVE HUMIDITY	OLM02130
PLF(10)	PLF(10)		STEP 4A	PR OF INTER FACE,	LOLM02140
TH(10)	TH(10)		STEP 7	POTENTIAL TEMPERATOLM	02150
DSIG(10)	DSIG(10)		PROG CONST.=1/NLAY=.111111		OLM02160
SLBEDO(10,10)	SLBEDO(8,14)			SPECIFIED EARTH ALBEDO FROM	OLM02170
					OLM02180
				NOTE 1: PL & PLF ARE SPECIFIED IN STEP 4A FROM PC	OLM02190
				NOTE 2 TL IS SPECIFIED IN STEP 4B IF GCM INPUT NOT AVAILABOLM	02200
					OLM02210
				DO ONE CFLL FOR NOW 10/22/77	OLM02220
				IF(WETCEL) I1C=12	OLM02230
				IF(WETCEL) J1C=7	OLM02240
				IF(AVCELL) I1C=6	OLM02250
				IF(AVCELL) J1C=3	OLM02260
				IF(DRYCEL) I1C=4	OLM02270
				IF(DRYCEL) J1C=4	OLM02280
				J3C=1	OLM02290
				I3C=1	OLM02300
				I2C=I1C	OLM02310
				J2C=J1C	OLM02320
				NCFL=0	OLM02330

ORIGINAL PAGE IS OF POOR QUALITY

C	DO 300 I=I1C,I2C,I3C	OLM02340
	DO 300 J=J1C,J2C,J3C	OLM02350
C	NCPLL=NCPLL+1	OLM02360
C		OLM02370
C	G DO LOOP READ	OLM02380
C	IF(IHH.GT.1) READ(08,95) TAU,PC,TSC,SHSC,GFC,GWC,UC,VC,TC,SHC	OLM02390
	*,FLUXC	OLM02400
C		OLM02410
	IF(NCELL.EQ.1)	OLM02420
	1CALL SUBFWD(NLAY,NLAYM1,JMP,INC,IM,J1P,JMPP1,TINPT,ASSIM)	OLM02430
C		OLM02440
C	H SOLAR DECLINATION CALCULATION	OLM02450
C		OLM02460
C	IF(NCELL.EQ.1)	OLM02470
	1CALL SDET(PI,DPI,COSD,SIND,ROT,DLON,ASSIM,IHH,LAT,JDAY,NCELL,	OLM02480
	2TCTDAY)	OLM02490
C		OLM02500
C		OLM02510
C		OLM02520
C	I OFFLINE INTERFACE CONSIDERATIONS	OLM02530
C		OLM02540
C	INITIALIZE GW(J,I) WITH GWC(J,I) VALUES	OLM02550
C		OLM02560
	IF(IHH.EQ.1) GW(J,I)=GWC(J,I)	OLM02570
C	GTC READ TWICE BECAUSE NET RADIATION NOT AVAILABLE	OLM02580
	IF(GTC(J,I).LT.2.) GTC(J,I)=TICE	OLM02590
	IF(IHH.LE.2) GT(J,I)=GTC(J,I)	OLM02600
	TS(J,I)=TSC(J,I)	OLM02610
	IF(LOG8.AND.UCLA) GW(J,I)=GWC(J,I)	OLM02620
	IF(LOG8) GT(J,I)=GTC(J,I)	OLM02630
C		OLM02640
C	J ZENITH ANGLE CALCULATION	OLM02650
C		OLM02660
	IUS=IMINUS+I-1	OLM02670
	JUS=JMINUS+J-1	OLM02680
	HACOS=COSD*COS(ROT+(IUS-1)*DLON)	OLM02690
	COSZ=SINL(JUS)*SIND+COSL(JUS)*HACOS	OLM02700
	Z =ARCOS(COSZ)	OLM02710
		OLM02720

```

SINA=COSD*SIN (POT+(TUS-1)*DLON)/SIN(Z) OLM02730
CHOUR=TOPDAY-(37.-IUS)*24./72. OLM02740
IF(CHOUR.LE.0.) CHCUR=CHOUR*24. OLM02750
IF(NCELL.EQ.1) WRITE(6,152) COSZ,SINA,CHOUR OLM02760
152 FORMAT(10X,'SOLAR ZENITH ANGLE, COSZ =',F12.4,5X,'AZIMUTH ANGLE(+W OLM02770
1,-E OF S), SINA = ',F12.4,07X,'LOCAL CELL HOUR = ',F6.2) OLM02780
C OLM02790
C STEP 3: SURFACE SPECIFICATIONS OLM02800
C OLM02810
C 3A SURFACE CONDITION OLM02820
C OLM02830
OCEAN=TOPOG(J,I).GT.1. OLM02840
ICE=TOPOG(J,I).LT.-9.9E5 OLM02850
LAND=.NOT.(ICE.OR.OCEAN) OLM02860
IF(IHH.EQ.1) GO TO 54 OLM02870
53 SNOW=LAND.AND.GW(J,I).GT.1.00 OLM02880
IF(IGVET.EQ.24) GO TO 52 OLM02890
SNOW = LAND.AND.(GW(J,I).GT.1.0.OR.SLBEDO(J,I).GT.40) OLM02900
IF(SNOW) GW(J,I)=AMAX1(10.5,GW(J,I)) OLM02910
GO TO 52 OLM02920
54 SRH=85.*GW(J,I) +15. OLM02930
IF(ROK(J,I).EQ.1.) GO TO 55 OLM02940
IF(ROK(J,I).EQ.2.) GO TO 44 OLM02950
IF(ROK(J,I).EQ.3.) GO TO 42 OLM02960
44 FC=.25 OLM02970
PWP=.10 OLM02980
C1=1.0 OLM02990
C2=1.0 OLM03000
PORE=.5 OLM03010
SOILLR=100. OLM03020
WCAS=PORE*SOILLR OLM03030
GO TO 49 OLM03040
42 FC=.09 OLM03050
PWP=.025 OLM03060
C1=1.0 OLM03070
C2=1.0 OLM03080
PORE=.5 OLM03090
SOILLR=050. OLM03100
WCAS=PORE*SOILLR OLM03110

```

B-22


```

49 GW(J,I)=SEH*(FC*C1-PWP*C2)/100. +PWP*C2 OLM03120
55 GW(J,I)=GW(J,I)/2. OLM03130
   IF(OCEAN) GW(J,I) =.5 OLM03140
   IF(IGVET.EQ.24) GO TO 21 OLM03150
   IF(OCEAN) GO TO 52 OLM03160
C OLM03170
C REF T&K CMP12980 OLM03180
   PT180 = PT/180. OLM03190
   SNOWN=(60.-15.*COS(.9863*(JDAY-24.668)*PI180))*PI180 OLM03200
   SNOWS=SNOWN-2.*PI/3. OLM03210
   JNP=46 OLM03220
C IF(LAT(JUS).GE.SNOWN) GW(J,I)=GW(J,I)+INT((LAT(JUS)-SNOWN)/(LAT(JNP OLM03230
C *)-SNOWN)*3.E4) OLM03240
C IF(LAT(JUS).LE.SNOWS) GW(J,I)=GW(J,I)+INT((LAT(JUS)-SNOWS)/(LAT(1) OLM03250
C *-SNOWS)*3.E4) OLM03260
   GO TO 52 OLM03270
21 IF(SLBEDO(J,I).LE.39) GO TO 52 OLM03280
   GW(J,I)=2.00E03+.5 OLM03290
   IF(SLBEDO(J,I).LT.70.) GW(J,I)=1.0E03+.5 OLM03300
   IF(SLBEDO(J,I).LT.50) GW(J,I)=.5E03+.5 OLM03310
   IF(ICE) GW(J,I) = 30.E03+.5 OLM03320
   IF(JUS.LE.9.AND.LAND) GW(J,I)=30.0E03+.5 OLM03330
   SNOW = LAND.AND.GW(J,I).GT.1.01 OLM03340
52 IF(VALBFG) GO TO 56 OLM03350
   SLBEDO(J,I)=14 OLM03360
   IF(OCEAN) SLBEDO(J,I)=7. OLM03370
   SNOW = LAND.AND.(GW(J,I).GT.1.0.OR.SLBEDO(J,I).GE.40) OLM03380
   IF(SNOW.OR.ICE) SLBEDO(J,I) = 70. OLM03390
56 RSURF=.01*SLBEDO(J,I) OLM03400
   IF(IGVET.NE.24.OR.GW(J,I).LT.1.01) GO TO 66 OLM03410
   SNOTEM=SQRT((GW(J,I)-.5)/1000.) OLM03420
   RSURF=.5*SNOTEM OLM03430
   IF(SNOTEM.LT.1.) RSURF=RSURF+.01*SLBEDO(J,I)*(1.-SNOTEM) OLM03440
   RSURF = AMIN1(RSURF,.8) OLM03450
66 WET=AMIN1(1.,(AMOD(GW(J,I),1.)*2)) OLM03460
C IF VALBFG IS T MUST HAVE FOLLOWING CARD 11/2/77 OLM03470
   SNOW = LAND.AND.(GW(J,I).GT.1.0.OR.SLBEDO(J,I).GE.40) OLM03480
   LAND=LAND.AND..NOT.SNOW OLM03490
   MIXWI=GT(J,I).LE.1.1.AND.(LAND.OR.SNOW) OLM03500

```

B-23

C	FROST=LAND.AND. (GT (J,I) .IF.TICE) .AND..NOT.MIXWI	OLM03510
C	-----	OLM03520
C	SURFACE ELEVATION	OLM03530
C	-----	OLM03540
C	IF(OCEAN.AND. (PHIS (J,I) .EQ.0.)) Z=0.	OLM03550
C	IF(.NOT.OCEAN) Z=PHIS (J,I)/GRAV	OLM03560
C	-----	OLM03570
C	3B SURFACE TEMPERATURE	OLM03580
C	-----	OLM03590
C	IF(OCEAN) TG=TOPOG (J,I)	OLM03600
C	IF(.NOT.OCEAN) TG=GT (J,I)	OLM03610
C	IF(MIXWI) TG=TICE	OLM03620
C	IF(.NOT.LAND) WET=1.0	OLM03630
C	-----	OLM03640
C	3C SURFACE DRAG COEFFICIENT	OLM03650
C	-----	OLM03660
C	IMINC=I-1	OLM03670
C	WMAG=.5*SQRT (FD (J,I) +FD (J,IMINC) +FD (J+1,I) +FD (J+1,IMINC))	OLM03680
C	IF(OCEAN) CD=AMIN1 ((1.+07*WMAG)*.001,.0025)	OLM03690
C	IF(.NOT.OCEAN) CD= .002+.006*Z/5000.	OLM03700
C	-----	OLM03710
C	IF(IGVET.EQ.15) GO TO 71	OLM03720
C	IF(GDH.AND.OCEAN) CD=CD*.5	OLM03730
C	IF(GDH.AND..NOT.OCEAN) CD=CD*2.0	OLM03740
C	GO TO 72	OLM03750
C	71 CD=.0032*(1.+3.*Z/5000.)	OLM03760
C	IF(OCEAN) CD=.10/(ALOG (1.0F06/(5.56/AMAX1 (1.,WMAG)-.984+	OLM03770
C	1 .00687*WMAG*WMAG))) **2	OLM03780
C	72 CONTINUE	OLM03790
C	-----	OLM03800
C	STEP 4: VEET. ARRAYS FOR SOME VARIABLES	OLM03810
C	-----	OLM03820
C	4A PRESSURES	OLM03830
C	-----	OLM03840
C	SP=PC (J,I)	OLM03850
C	PC (J,I) =PS-PTPOP=PI=P (J,I) =SP	OLM03860
C	P (J,I) =PTROP+SIG (NLAY) *PT	OLM03870
C	PS=PTROP+SIG (10) * (PS-PTROP)=PS	OLM03880
C	-----	OLM03890

C	PS=SP+PTROP=PLE(NLAY+1)	OLM03900
	DO 30 L=1,NLAY	OLM03910
	PL(L)=SIG(L)*SP+PTROP	OLM03920
	PLE(L)=SIGE(L)*SP+PTROP	OLM03930
30	PLK(L)=PL(L)**KAPA	OLM03940
	PLE(NLAY+1)=SP+PTROP	OLM03950
C		OLM03960
C	4B TEMPERATURES AND CONVECTIVE ADJUSTMENT	OLM03970
C		OLM03980
	DO 35 L=1,NLAY	OLM03990
	NC=L-6	OLM04000
	IF(L.LE.6) TL(L)=TC(J,I,1)-(TC(J,I,2)-TC(J,I,1))*(NLAY-2-L)	OLM04010
35	IF(L.GE.7) TL(L)=TC(J,I,NC)	OLM04020
	IF(GCM) GO TO 41	OLM04030
	DO 40 N=1,3	OLM04040
	DO 40 L=2,NLAY	OLM04050
	LM1=L-1	OLM04060
	IF(TL(L-1)/PLK(L-1).GE.TL(L)/PLK(L)) GO TO 40	OLM04070
	THETA=(TL(LM1)*DSIG(LM1)+TL(L)*DSIG(L))/(PLK(LM1)*DSIG(LM1)+	OLM04080
	*PLK(L)*DSIG(L))	OLM04090
	TL(L-1)=THETA*PLK(L-1)	OLM04100
	TL(L)=THETA*PLK(L)	OLM04110
40	TH(L-1)=TL(L-1)/PLK(L-1)	OLM04120
41	TH(NLAY)=TL(NLAY)/PLK(NLAY)	OLM04130
C		OLM04140
C	4C MOISTURE VARIABLES	OLM04150
	DO 50 L=1,NLAY	OLM04160
	NC=L-6	OLM04170
	IF(L.LE.6) SHL(L)=SHC(J,I,1)-(SHC(J,I,2)-SHC(J,I,1))*(NLAY-2-L)	OLM04180
	IF(L.GE.7) SHL(L)=SHC(J,I,NC)	OLM04190
	IF(SHL(L).LE.0.) SHL(L)=0.	OLM04200
50	CONTINUE	OLM04210
	IF(GCM) GO TO 175	OLM04220
C		OLM04230
C	STEP 5	OLM04240
C	VERTICAL DIFFUSION OF HEAT AND MOISTURE(AIR-EARTH	OLM04250
C	INTERACTION	OLM04260
C		OLM04270
	65 LMIN=NLAYM1	OLM04280

B-26

DO 80 L=LMIN,NLAY	OLM04290
LM1=L-1	OLM04300
DTETA=(TH(LM1)-TH(L))* (PLK(LM1)+PLK(L)) *.5	OLM04310
DZUP=SP*DSIG(LM1)*RGAS*TL(LM1)/(PL(LM1)*GRAV)	OLM04320
DZDN=SP*DSIG(L)*RGAS*TL(L)/(PL(L)*GRAV)	OLM04330
EDLE=.2*ED	OLM04340
TEMP=DTC3*((DSIG(LM1)+DSIG(L))/((DZUP+DZDN)*(DZUP+DZDN)))	OLM04350
FLE=-2.*EDLE*DTETA*TEMP	OLM04360
TL(LM1)=TL(LM1)+FLE/DSIG(LM1)	OLM04370
TL(L)=TL(L)-FLE/DSIG(L)	OLM04380
TH(LM1)=TL(LM1)/PLK(LM1)	OLM04390
TH(L)=TL(L)/PLK(L)	OLM04400
DSH=SHL(LM1)-SHL(L)	OLM04410
ELE=-2.*EDLE*DSH*TEMP	OLM04420
SHL(LM1)=SHL(LM1)+ELE/DSIG(LM1)	OLM04430
8) SHL(L)=SHL(L)-ELE/DSIG(L)	OLM04440
175 CONTINUE	OLM04450
C	OLM04460
C	OLM04470
C	OLM04480
DO 90 L=7,NLAY	OLM04490
TEMP=QSAT(TL(L),PL(L))	OLM04500
9) RH(L)=SHL(L)/TEMP	OLM04510
C	OLM04520
IPR=1	OLM04530
IF(NCELL.EQ.1.AND.IHH.EQ.1)	OLM04540
* CALL RITE(IWRS,I,J,IHH, HOUR, IPR,	OLM04550
*UCLA,UCNI,UCNJJA,UCNII,I2C,J2C,IMAX,JMAX,IMINUS,JMINUS,MONTH)	OLM04560
C	OLM04570
C	OLM04580
C	OLM04590
C	OLM04600
C	OLM04610
TLE(NLAYP1)=TS(J,I)	OLM04620
PS=PLE(NLAY+1)	OLM04630
PSK=PS**KAPA	OLM04640
THG=TS(J,I)/PSK	OLM04650
C	OLM04660
C	OLM04670
B RH SCALE	OLM04670

	RHS=0.	OLM04680
	IF (WET+RH (NLAY) .NE.0) RHS=2.*WET*RH (NLAY) / (WET+RH (NLAY))	OLM04690
C		OLM04700
C	C BULK AERODYNAMIC COEFF.	OLM04710
C		OLM04720
	DTS=TC-TLE (NLAYP1)	OLM04730
	IF (DTS.GE.0.) DRAW=CD*(WMAG+SQRT (DTS))	OLM04740
	IF (DTS.LT.0.) DRAW=CD*WMAG*(WMAG*WMAG) / ((WMAG*WMAG) -7.*DTS)	OLM04750
C		OLM04760
C	D SURFACE DIFFUSION COEFF	OLM04770
C		OLM04780
	ZLNCO = .5*DSIG (NLAY) *RGAS/GRAV	OLM04790
	SP= (PLE (10) -PL (9)) / (1.-17./18.)	OLM04800
C		OLM04810
C	E ORIGINAL FORMULATION FROM TSANG & KARN	OLM04820
C		OLM04830
	WMAGN=1	OLM04840
	IF (DTS.LT.0.) WMAGN = .2*(WMAG+.01)	OLM04850
	EDNS=AMIN1 (100.,ED*EXP (.32*DTS/WMAGN*WMAGN))	OLM04860
	FORIG=EDNS	OLM04870
	ZLN = ZLNCO*TLE (NLAYP1) *SP/PS	OLM04880
C	NEW EDNS FORMULATION (1/30/78)	OLM04890
C	NCAR W/NO COUNTERGRADIENT	OLM04900
C		OLM04910
	EDNS=10.+100.*(1.-EXP (1200.*((TH (NLAY) -THG) /ZLN))	OLM04920
C	TH (9) GT THG THE FOLLOWING EDNS PREDICTION IS BA	OLM04930
	IF (TH (9) .GT. THG) EDNS=FORIG	OLM04940
C		OLM04950
	EDV=EDNS/ZLN	OLM04960
C		OLM04970
C	WRITE (6,7123)	OLM04980
	C7123 FORMAT (10X,'EORIG',6X,'EDNS',8X,'TH (9)',8X,'THG')	OLM04990
C	WRITE (6,7119) EORIG,EDNS, TH (9),THG	OLM05000
	C7119 FORMAT (5X,4 (E12.4))	OLM05010
C		OLM05020
C		OLM05030
	EVE=1.	OLM05040
	IF (LAND.AND..NOT.SNOW) GO TO 7034	OLM05050
	GO TO 7235	OLM05060

B-28

7034	CONTINUE	OLM05070
C		OLM05080
C	F EVAPORATION SCALING FACTOR	OLM05090
C		OLM05100
	IF(UCNI) EVE=AMIN1(1.,(WET-PWP*C2)/(FC*C1-PWP*C1))	OLM05110
	TEMP=2.*GWC(J,I)	OLM05120
	IF(UCLA) EVE=AMIN1(1.,2.*TEMP)	OLM05130
	PLANT=AMIN1(1.,COSZ/.2588)	OLM05140
	IF(COSZ.LT.0) PLANT=0.	OLM05150
C		OLM05160
7235	CONTINUE	OLM05170
	GO TO 7236	OLM05180
7237	EVE=1.0	OLM05190
7236	EVACO=EVE*DRAW	OLM05200
	EVACO=AMAX1(EVACO,1.E-40)	OLM05210
	SHSATS=QSAT(TLE(NLAYP1),PS)	OLM05220
	SHG=QSAT(TG,PS)	OLM05230
	TEMP=SHSATS/TLE(NLAYP1)	OLM05240
	GAMC=ZLN*RHS*9.8*(1.-(1.+CLH*TEMP/KAPA)/(1.+GAMFAC*TEMP/	OLM05250
	* TLE(NLAYP1)))*KAPA/RGAS	OLM05260
	TLE(NLAYP1)=(DRAW*TG+EDV*(TH(NLAY)*PSK-GAMC))/(DRAW+EDV)	OLM05270
	SHLE(NLAYP1)=(EVACO*SHG+EDV*SHL(NLAY))/(EVACO+EDV)	OLM05280
	SHSATS=QSAT(TLE(NLAYP1),PS)	OLM05290
	IF(SHLE(NLAYP1).LE.SHSATS) GO TO 7121	OLM05300
	GAMS=GAMFAC*SHSATS/TLE(NLAYP1)**2	OLM05310
	TEMP=(SHLE(NLAYP1)-SHSATS)/(1+GAMS)	OLM05320
	TLE(NLAYP1)=TLE(NLAYP1)+TEMP*CLH	OLM05330
	SHLE(NLAYP1)=SHLE(NLAYP1)-TEMP	OLM05340
7121	RHOS=PS/(RGAS*TLE(NLAYP1))	OLM05350
C		OLM05360
C	G POTENTIAL EVAPORATION(MM/HR)	OLM05370
C		OLM05380
	PREVAP=DRAW*RHOS*100.*(QSAT(TG,PS)-SHLE(NLAYP1))*3600.	OLM05390
	IF(PREVAP.LE.0..AND.EVE.LT..999) GO TO 7237	OLM05400
C		OLM05410
C	H POT EVAP USING LOG8 INPUT(MM/HR)	OLM05420
C		OLM05430
	T=GTC(J,I)	OLM05440
	DGCM=GTC(J,I)-TSC(J,I)	OLM05450

	WETGCM=GWC (J, I) *2.	OLM05460
	EVCN=AMIN1 (1., 2.*WETGCM)	OLM05470
	SGCM=QSAT (T, PS)	OLM05480
	IF (DGCM.GE.0.) DRCM=CD* (WMAG+SQRT (DGCM))	OLM05490
	IF (DGCM.LT.0.) DRCM=CD*WMAG* (WMAG*WMAG) / ((WMAG*WMAG)-7.*DGCM)	OLM05500
	EVACOG=EVCN*DRCM	OLM05510
	SH10 = (EVACOG*SGCM+EDV*SHL (9)) / (EVACOG+EDV)	OLM05520
	DGCMSH=SGCM-SH10	OLM05530
	EGCM=DGCMSH*EVCN*DTC3*DRCM*RHOS*10.	OLM05540
C		OLM05550
C	STEP 8A:	OLM05560
C	SENSIBLE HEAT (LY/DAY) & EVAPORATION (GR/CM**2/SEC)	OLM05570
C		OLM05580
	DTS=.5* (DTS+TG-TLE (NLAYP1))	OLM05590
	DSHS=SHG-SHLE (NLAYP1)	OLM05600
	IF (DTS.GE.0.) DRAW=CD* (WMAG+SQRT (DTS))	OLM05610
	IF (DTS.LT.0.) DRAW=CD* (WMAG**3) / (WMAG**2-7.*DTS)	OLM05620
	FSURF=COEFS*RHOS*DRAW/SP	OLM05630
	TL (NLAY)=TL (NLAY)+FSURF*DTS	OLM05640
	TH (NLAY)=TL (NLAY)/PLK (NLAY)	OLM05650
	SAVSHL=SHL (NLAY)	OLM05660
	SHL (NLAY)=SHL (NLAY)+FSURF*EVE*DSHS	OLM05670
C	SAVSHL=SAVSHL/SHL (NLAY)	OLM05680
	IF (SHL (NLAY).LT.0.) SHL (NLAY)=0.	OLM05690
C		OLM05700
	IPP=2	OLM05710
	CALL RITE (IWRS, I, J, IHH, HOUR, IPP,	OLM05720
	*UCLA, UCNI, UCNJJA, UCNII, I2C, J2C, IMAX, JMAX, IMINUS, JMINUS, MONTH)	OLM05730
C		OLM05740
C	STFP 14: GROUND UPDATE OF MOISTURE AND TEMP	OLM05750
C		OLM05760
	WTSTO=WET	OLM05770
	1405 IF (OCEAN) GO TO 1490	OLM05780
	IF (SNOW) GO TO 1410	OLM05790
	IF (ICE) GO TO 1420	OLM05800
	IF (PROST) GO TO 1430	OLM05810
	IF (MIXWI) GO TO 1440	OLM05820
	EVAL=600.	OLM05830
	IF (UCLA) CZH= ((.386+.15*WET) * (1.+WET) *2.E-3*SDAY/TWOPI) **.5	OLM05840

	GO TO 1450	OLM05850
1410	EVAL=680.	OLM05860
	CZH=2.3	OLM05870
	GO TO 1450	OLM05880
1420	EVAL=680.	OLM05890
	CZH=5.1	OLM05900
	GO TO 1450	OLM05910
1430	EVAL=680.	OLM05920
	CZH=SQRT((.331+.075*WET)*(2.+2.5*WET)*1.E-3*SDAY/TWOPI)	OLM05930
	GO TO 1450	OLM05940
1440	EVAL=680.	OLM05950
C		OLM05960
C	A WI CALCULATION	OLM05970
C		OLM05980
	WI=GT(J,I)	OLM05990
1445	CZH=SQRT((.276+(.11+.15*WET)*(WET-.5*WI))*(1.+WET-WI+1.25*WI)* * 2.E-3*SDAY/TWOPI)	OLM06000
1450	TEM=0.	OLM06020
	WET=WTSTO	OLM06030
	WI=GT(J,I)	OLM06040
C		OLM06050
C	B GROUND TEMPERATURE UPDATE	OLM06060
C		OLM06070
	IF(ICE.AND.Z.LT..1) TEM=CTID/HICE	OLM06080
	TGSQ=TG*TG	OLM06090
	DRAD=4.*STBO*TGSQ*TG	OLM06100
	DSQG=5418.*SHG/TGSQ	OLM06110
	TEMP=10.*DRAW*RHOS*SDAY	OLM06120
C		OLM06130
C		OLM06140
C	TERM1 = SG*NHOGAN	OLM06150
	TERM2 = -CP*TEMP*DTS	OLM06160
	TERM3 = -EVAL*EVE*TEMP*DSHS	OLM06170
	TERM4 = TEM*(TICE-TG)	OLM06180
C		OLM06190
C	RMIS=.9	OLM06200
C	RE(NLAYP1) = (1.17E-7*TG**4)*RMIS	OLM06210
C	TERM5 = -RE(NLAYP1)*NHOGAN	OLM06220
	DENOM = SDAY*CZH/DTC3 + DRAD + TEM + TEMP*EDV*(CP/DRAW+EDV) +	OLM06230

	*EVAL*EVE*DSQG/(EVACO+EDV)	OLM06240
	SHS(J,I) = SHSC(J,I) * NHOGAN	OLM06250
C	SHS(J,I) = SG-RE(NLAYP1)	OLM06260
	RADTRM=SHS(J,I)	OLM06270
	GT(J,I) = TG + (RADTRM + TERM2 + TERM3 + TERM4) / DENOM	OLM06280
1490	CONTINUE	OLM06290
1475	CONTINUE	OLM06300
C		OLM06310
	IPR=4	OLM06320
C		OLM06330
	CALL RITE(IWRS,I,J,IHH, HOUR, IPR,	OLM06340
	*UCLA,UCNI,UCNJJA,UCNII,I2C,J2C,IMAX,JMAX,IMINUS,JMINUS,MONTH)	OLM06350
C		OLM06360
C	C ACTUAL EVAPORATION (CM/HH)	OLM06370
C		OLM06380
	E6DT=DSHS*EVE*DTC3*DRAW*RHOS*10.0	OLM06390
C		OLM06400
C	D GROUND MOISTURE UPDATE	OLM06410
C		OLM06420
	WETR=WET	OLM06430
	SNR=0.	OLM06440
	WIR=0.	OLM06450
	TGR=TG	OLM06460
1851	RAIN=0.	OLM06470
	SNFAL=0.	OLM06480
	FREEZ=0.	OLM06490
	OVER=0.	OLM06500
	SMELT=0.	OLM06510
	FLDRK=0.	OLM06520
	DRNG=0.	OLM06530
	BUNOVV=0.	OLM06540
C		OLM06550
C		OLM06560
	IF(OCEAN) GO TO 1880	OLM06570
	TGR=GT(J,I)	OLM06580
	TOTALP=FLUXC(J,I,3)	OLM06590
C	THEN RAIN INPUT WOULD BE IN CM/SAMPLE TIME	OLM06600
C	ASSUMES FLC(J,I,3), PRECIP IN MM/SAMPLE TIME	OLM06610
	IF(TOTALP.LT..0) TOTALP=0.	OLM06620

B-31

IF (TLE (NLAYP1) .LE. TICE) SNFAL=TOTALP *100.	OLM06630
IF (TLE (NLAYP1) .GT. TICE) RAIN=TOTALP *100.	OLM06640
ISNR = IFIX (GW (J, I))	OLM06650
SNR=FLOAT (ISNR) /1000.0	OLM06660
IF (SNR.LT..001) SNR=0.	OLM06670
SNR1=SNR+SNFAL	OLM06680
SNR=SNR1-E6DT	OLM06690
IF (SNR1.LE.0.) GO TO 1850	OLM06700
IF (SNR.LE.0.) GO TO 1850	OLM06710
IF (TGR.LE.TICE) GO TO 1800	OLM06720
SMELT=CZH*(TGR-TICE)/80.	OLM06730
SMELT=AMIN1 (SMELT, SNR)	OLM06740
TGR=TGR-80.*SMELT/CZH	OLM06750
SNR=SNR-SMELT	OLM06760
IF (ICE) GO TO 1870	OLM06770
C	OLM06780
C E SOIL MOISTURE AND FREEZING	OLM06790
C	OLM06800
C 1 SNOW COVERED LAND	OLM06810
C	OLM06820
1800 CONTINUE	OLM06830
WETR=WET+ (RAIN+SMELT) /WCAS	OLM06840
RUNOFF=AMAX1 (0.0, WETR-1.)	OLM06850
WETR=WETR-RUNOFF	OLM06860
GO TO 1880	OLM06870
C	OLM06880
C 2 SNOW FREE LAND	OLM06890
C	OLM06900
1850 SNR=0.	OLM06910
IF (ICE) GO TO 1870	OLM06920
RAIN=FLUXC (J, I, 3) *100.	OLM06930
1892 E6DT=DSHS*EVE*DTC3*DRAW*RHOS*10.0	OLM06940
WETR=WET	OLM06950
IF (RAIN.GT.0.) OVER=RAIN*(.1+.9*WET**1.5)	OLM06960
C MOISTURE CONTINUITY EQUATION	OLM06970
IF (UCLAVW) WETR=WET + (RAIN-E6DT - OVER) /WCAS	OLM06980
IF (WETR.GT.1.) WETR=1.	OLM06990
IF (WETR.LT.0.) WETR=0.	OLM07000
ADDW= (RAIN-E6DT-OVER) /WCAS	OLM07010

ORIGINAL PAGE IS
OF POOR QUALITY

B-32

	IF (FROST) TGR=TGR+80.*ADDW/CZH	OLM07020
	IF (.NOT.MIXWI) WI=0.	OLM07030
	IF (FROST) WI=WETR	OLM07040
	IF (.NOT. (MIXWI.OR. (FROST.AND.TGR.GT.TICE) .OR. (TG.GT.TICE.AND.	OLM07050
	1 TGR.LT.TICE))) GO TO 1880	OLM07060
	FREEZ=CZH*(TICE-TGR)/80./WCAS	OLM07070
	WIR=WI+FREEZ	OLM07080
	IF (WIR.GT.WETR) WIR=WETR	OLM07090
	IF (WIR.LT.0.) WIR=0.	OLM07100
	FREEZ=WIR-WI	OLM07110
	TGR=TGR+80.*FREEZ*WCAS/CZH	OLM07120
	GO TO 1880	OLM07130
C		OLM07140
C	3 ICE	OLM07150
C		OLM07160
	1870 TGR=AMIN1 (TGR,TICE)	OLM07170
	WETR=1.	OLM07180
	1880 IF (IGVET.GE.10) GT(J,I) = TGR	OLM07190
	IF (WIR.GT..0.AND.WIR.LT.WETR) GT(J,I) = WIR	OLM07200
	SNR = AMIN1 (SNR,30.0)	OLM07210
	ISNR = IFIX (AMAX1 (0.,SNR)*1000.)	OLM07220
	IF (.NOT.LAND) GO TO 300	OLM07230
	IPR=5	OLM07240
C		OLM07250
	CALL RITE (IWRS,I,J,IHH, HOUR, IPR,	OLM07260
	*UCLA,UCNI,UCNJJA,UCNII,I2C,J2C,IMAX,JMAX,IMINUS,JMINUS,MONTH)	OLM07270
C		OLM07280
	SUMAV=SUMAV+1	OLM07290
	AVGTC=AVGTC+GTC (J,I)	OLM07300
	AVTSC=AVTSC+TSC (J,I)	OLM07310
	AVGWC=AVGWC+GWC (J,I)	OLM07320
	AVGT = AVGT+GT (J,I)	OLM07330
	AVTS=AVTS+TLE (10)	OLM07340
	AVGW=AVGW+GW (J,I)	OLM07350
C	PLOT DATA	OLM07360
C	GOOD FOR SINGLE CELL ANALYSIS ONLY	OLM07370
	IH2=IHH	OLM07380
	2553 CONTINUE	OLM07390
	PLTGTC (IH2) =GTC (J,I)	OLM07400

ORIGINAL PAGE IS OF POOR QUALITY

B-33

	PLTTS (IH2) =TS (J,I)	OLM07410
	PLTGT (IH2) =TG	OLM07420
	PLTGWC (IH2) =SHLE (NLAYP1)	OLM07430
	PLTGW (IH2) =SHL (9)	OLM07440
	PLTSHL (IH2) =EORIG	OLM07450
	PLSHE (IH2) =EDNS	OLM07460
	PLT9TG (IH2) =TH (9) /THG	OLM07470
	PLTX (IH2) =IH2	OLM07480
	IF (UCLA) PREVAP = (E6DT/EVE) *20.	OLM07490
	PLTPE (IH2) =PREVAP/20.	OLM07500
	PLTAE (IH2) =E6DT	OLM07510
	PLTEVE (IH2) =EVE	OLM07520
	PLEGCM (IH2) =EGCM	OLM07530
	PLIRGS (IH2) =TLE (10)	OLM07540
	PAEGO (IH2) =PLEGCM (IH2) /PLTAE (IH2)	OLM07550
	IF (IH2.GT.95.AND.IH2.LT.101) IH2=IH2+1	OLM07560
	IF (IH2.GT.95.AND.IH2.LT.101) GO TO 2553	OLM07570
300	CONTINUE	OLM07580
200	CONTINUE	OLM07590
	TEMP =SUMAV	OLM07600
	AVGWC =AVGWC/TEMP	OLM07610
	AVTSC =AVTSC/TEMP	OLM07620
	AVGTC =AVGTC/TEMP	OLM07630
	AVGW =AVGW/TEMP	OLM07640
	AVTS =AVTS/TEMP	OLM07650
	AVGT =AVGT/TEMP	OLM07660
C		OLM07670
	WRITE (6,2571)	OLM07680
2571	FORMAT (6X, 'TIME STEP', 1X, 'TGC', 6X, 'TG', 7X, 'TSC', 3X, 'TS (N+1)', 2X,	OLM07690
	* 'SHLE (10)', 4X, 'SHL (9)',	OLM07700
	* 4X, 'EORIG', 3X, 'EDNS', 6X, 'PE', 8X, 'AE', 7X, 'EVE', 6X, 'AE-GCM',	OLM07710
	* 2X, 'EG/EO')	OLM07720
	DO 2574 I=1, NHH	OLM07730
	WRITE (6,2572) I, PLTGTC (I), PLTGT (I), PLTTS (I), PLIRGS (I), PLTGWC (I),	OLM07740
	* PLTGW (I), PLTSHL (I), PLSHE (I), PLTPE (I), PLTAE (I), PLTEVE (I), PLEGCM (I)	OLM07750
	*, PAEGO (I)	OLM07760
2574	CONTINUE	OLM07770
2572	FORMAT (8X, I3, 2X, 4 (F7.2, 2X), 2 (F9.7, 2X), 2 (F5.1, 2X), 4 (F8.5, 2X), F5.2)	OLM07780
	NHH =IH2-1	OLM07790

	RNHH=NHH/1.	OLM07800
	VBOT=(AVGT+AVGTC+AVTS)/3.-25.	OLM07810
	VBOT=265.	OLM07820
	VTOP=VBOT+50.	OLM07830
	WRITE(6,2564) AVGT,AVTS,AVGW,AVGTC,AVTSC,AVGWC	OLM07840
2564	FORMAT(/,13X,'AV GR TEMP = ',E10.4,14X,'AV SURFACE TEMP = ',E10.4,	OLM07850
	115X,'AV GR WETNESS = ',E10.4,/,3X,'ASSIMILATION GR TEMP = ',E10.4,	OLM07860
	24X,'ASSIMILATION SURFACE TEMP = ',E10.4,5X,'ASSIMILATION GR WETNES	OLM07870
	3S = ',E10.4)	OLM07880
		OLM07890
	C	
	CALL GRDPLT(NHH,0.,RNHH,VBOT,VTOP,PLTX,PLTGTC,PERIOD,1,0)	OLM07900
	CALL GRDPLT(NHH,0.,RNHH,VBOT,VTOP,PLTX,PLTGT,STAR,0,1)	OLM07910
	WRITE(6,2580)	OLM07920
2580	FORMAT(20X,'PERIOD = INPUT GT',5X,'STAR = CAL GT',////)	OLM07930
	CALL GRDPLT(NHH,0.,RNHH,VBOT,VTOP,PLTX,PLTTS,POUND,1,0)	OLM07940
	CALL GRDPLT(NHH,0.,RNHH,VBOT,VTOP,PLTX,PLIRGS,PLUS,0,1)	OLM07950
	WRITE(6,2595)	OLM07960
2595	FORMAT(20X,'POUND = INPUT TS',5X,'PLUS = CALCULATED TS')	OLM07970
	CALL GRDPLT(NHH,0.,RNHH,.000,250.,PLTX,PLTSHL,STAR,1,0)	OLM07980
	CALL GRDPLT(NHH,0.,RNHH,.900,1.10,PLTX,PLT9TG,POUND,0,0)	OLM07990
	CALL GRDPLT(NHH,0.,RNHH,.000,250.,PLTX,PLSHE,PLUS,0,1)	OLM08000
	WRITE(6,2585)	OLM08010
2585	FORMAT(18X,'PLUS = T & K EDNS',5X,'STARS = NCAR EDNS WHEN	OLM08020
	*TH(9)/THG IS LESS THAN 1.0, UNSTABLE CASE',////)	OLM08030
	CALL GRDPLT(NHH,0.,RNHH,-.05,0.20,PLTX,PIEGCM,PERIOD,1,0)	OLM08040
	CALL GRDPLT(NHH,0.,RNHH,-.05,0.20,PLTX,PLTPE,PLUS,0,0)	OLM08050
	CALL GRDPLT(NHH,0.,RNHH,-.05,0.20,PLTX,PLTAE,STAR,0,1)	OLM08060
	WRITE(6,2590)	OLM08070
2590	FORMAT(20X,'STARS = ACTUAL EVAP	OLM08080
	*(CM/HH) ',5X,'PLUS = POTENTIAL EVAP(CM/HH) ',/,20X,'PERIOD = ACTUA	OLM08090
	*L EVAPORATION FROM INPUT TAPE(CM/HH) ',////)	OLM08100
	CALL GRDPLT(NHH,0.,RNHH,.000,1.00,PLTX,PLTEVE,POUND,1,0)	OLM08110
	CALL GRDPLT(NHH,0.,RNHH,0.,2.5,PLTX,PAEGO,PERIOD,0,1)	OLM08120
	WRITE(6,2609)	OLM08130
2609	FORMAT(20X,'POUND = EVAP SCALING FACTOR',5X,'PERIOD = AEGCM/AEOLM'	OLM08140
	*,////)	OLM08150
	CALL GRDPLT(NHH,0.,RNHH,0.,.05,PLTX,PLTGWC,STAR,1,0)	OLM08160
	CALL GRDPLT(NHH,0.,RNHH,0.,.05,PLTX,PLTGW,PLUS,0,1)	OLM08170
	WRITE(6,2605)	OLM08180

2605	FORMAT(20X,'STAR = SHLR(10) :TK',5X,'PLUS = SHL(9)',///)	OLM08190
	STOP	OLM08200
	END	OLM08210
	SUBROUTINE SDET(PI,DPI,COSD,SIND,ROT,DLON,ASSIM,IHH,LAT,JDAY,	OLM08220
	INCELL,TOFDAY)	OLM08230
	DIMENSION LAT(46),DAYSPM(12),JMONTH(12),AMONTH(2,12)	OLM08240
	COMMON PHIS(08,14),FD(08,14),TOPOG(08,14),SINL(46),COSL(46)	OLM08250
	COMMON	OLM08260
	\$ PC(8,14),TSC(8,14),SHSC(8,14),GTC(8,14),GWC(8,14),	OLM08270
	\$ UC(8,14,3),VC(8,14,3),TC(8,14,3),SHC(8,14,3),PLK(10),	OLM08280
	\$ SGC(8,14),US(08,14),VS(08,14)	OLM08290
	COMMON	OLM08300
	* PLE(10),TLE(10),RH(10),TH(10),DSIG(10),SHL(10),	OLM08310
	* SHLE(10),RR(10),SH(8,14,3),PL(10),	OLM08320
	* GT(08,14),SHS(08,14),TL(10),	OLM08330
	* SLBEDO(08,14),TS(08,14),GW(08,14),ROK(08,14),	OLM08340
	* IWR(10),STGE(10),SIG(10)	OLM08350
	COMMON	OLM08360
	* RHS,DTS,CD,EDV,ZLN,DRAW,PREVAP,PLANT,EVE,E6DT,	OLM08370
	*RHOS,CZH,DTRBET,TERM1,TERM2,TERM3,TERM4,TERM5, DENOM,RADTRM,	OLM08380
	* SNFAL,RAIN,OVER,WETR,WET,TAU,WMAG,ELE	OLM08390
	LOGICAL OCEAN,SNOW,ICF,LAND,MIXWI,FROST	OLM08400
	LOGICAL GISSJK,UCLA,UCNI,UCNII,UCNJJA,ASSIM,TINPT	OLM08410
C		OLM08420
	INTEGER AMONTH,DAYSPM,DAYSPLY	OLM08430
C	DATA AMONTH/'JANUARY FEBRUARY MARCH APRIL MAY JUNE JULY	OLM08440
C	* AUGUST SEPTEMBER OCTOBER NOVEMBER DECEMBER' /	OLM08450
C	JJA PUT COMMENTS ON AMONTH 10/22/77	OLM08460
	DATA AMONTH/ 1,2,3,4,5,6,7,8,9,10,11,12, 1,2,3,4,5,6,7,8, 9,10,	OLM08470
	111,12/	OLM08480
	DATA DAYSPM/31,28,31,30,31,30,31,31,30,31,30,31/	OLM08490
	DATA IDAY0/302/,DAYSPLY/365/,LASTM/0/	OLM08500
	INTEGER*2 SLBEDO	OLM08510
	REAL*4 LAT	OLM08520
C		OLM08530
	INTFX(XTAU)=INT(XTAU*XINT+.5)	OLM08540
	XINT=600.	OLM08550
C		OLM08560
C		OLM08570

	JSP=1	OLM08580
	JSB=1	OLM08590
	JNP=46	OLM08600
	JNB=46	OLM08610
	IF(IHH.GT.1) GO TO 211	OLM08620
C		OLM08630
	FJFQ=.5*(JSP+JNP)	OLM08640
	DLAT=180/(JNP-JSP)	OLM08650
	DLAT=DLAT*PI/180.	OLM08660
	DO 200 J=JSB,JNB	OLM08670
200	LAT(J)=DLAT*(J-FJFQ)	OLM08680
	LAT(JSP)=-.5*DPI	OLM08690
	LAT(JNP)=-LAT(JSP)	OLM08700
	DO 210 J=JSB,JNB	OLM08710
	TEMP=LAT(J)	OLM08720
	SINL(J)=SIN(TEMP)	OLM08730
	COSL(J)=COS(TEMP)	OLM08740
C	WRITE(6,30) J,LAT(J),SINL(J),COSL(J)	OLM08750
C 30	FORMAT(2X,'FOR J =',I4,5X,'LAT(J) = ',E12.4,5X,	OLM08760
C	1 'SINL(J) = ',E12.4,5X,'COSL(J) = ',E12.4)	OLM08770
	210 CONTINUE	OLM08780
C		OLM08790
C		OLM08800
211	DT=300.	OLM08810
	IF(ASSIM) DT=60.*60.*3.	OLM08820
	DTHR=DT/3600.	OLM08830
	IDTHR=INTFX(DTHR)	OLM08840
	I24=INTFX(24.)	OLM08850
	NSTEP=.5+TAU/DTHR	OLM08860
	ITAU=NSTEP*IDTHR	OLM08870
	TAU=FLOAT(ITAU)/XINT	OLM08880
	IDAY=ITAU/I24	OLM08890
	TOFDAY=FLOAT(ITAU-IDAY*I24)/XINT	OLM08900
	ROT=2*PI*TOFDAY/24.	OLM08910
	IM=72	OLM08920
	DLON =2.*PI/IM	OLM08930
C		OLM08940
	WRITE(6,212) DTHR,IDTHR,NSTEP,ITAU,TAU,IDAY,TOFDAY,ROT,DLON,IHH	OLM08950
212	FORMAT(/,10X,'DTHR = ',E12.4,5X,'IDTHR = ',I6,5X,'NSTEP = ',	OLM08960

	1I6,5X,'ITAU = ',I10,5X,'TAU = ',F12.3,5X,'IDAY = ',I6,/'	OLM08970
	210X,'TOFDAY(Z HRS) = ',E12.4,5X,'ROT = ',F12.4,5X,'DLON = ',E12.4,	OLM08980
	3 32X,'STEP = ',I5)	OLM08990
C		OLM09000
C		OLM09010
	SOLS=173.	OLM09020
	APHEL=183.	OLM09030
	DECMAX=PI*(23.5/180)	OLM09040
	ECCN=.0178	OLM09050
C		OLM09060
C	CALCULATE CALENDAR	OLM09070
C		OLM09080
	JYFAR=1+(IDAY+IDAY0-1)/DAYSPY	OLM09090
	JDAY=IDAY+IDAY0-DAYSPY*(JYEAR-1)	OLM09100
	J=0	OLM09110
	DO 10 MONTH=1,12	OLM09120
	J=J+DAYSPM(MONTH)	OLM09130
	IF(JDAY.LE.J) GO TO 20	OLM09140
	10 CONTINUE	OLM09150
	20 JDATE=JDAY-(J-DAYSPM(MONTH))	OLM09160
	JMONTH(1)=AMONTH(1,MONTH)	OLM09170
	JMONTH(2)=AMONTH(2,MONTH)	OLM09180
C		OLM09190
	WRITE(6,213) JDAY,JDATE	OLM09200
	213 FORMAT(10X,'JDAY = ',I6,5X,'JDATE = ',I6)	OLM09210
C		OLM09220
C	CALCULATE ORBIT POSITION	OLM09230
C		OLM09240
	FDAY=JDAY	OLM09250
	SEASON=(FDAY-SOLS)/DAYSPY	OLM09260
	DIST=(FDAY-APHEL)/DAYSPY	OLM09270
	DEC=DECMAX*COS(2.*PI*SEASON)	OLM09280
	RSDIST=(1.+ECCN*COS(2.*PI*DIST))**2	OLM09290
	SIND=SIN(DEC)	OLM09300
	COSD=COS(DEC)	OLM09310
	IF(IHH.EQ.1) WRITE(6,25) SIND,COSD	OLM09320
	25 FORMAT(/,5X,'SIND = ',E12.4,5X,'COSD = ',E12.4)	OLM09330
C		OLM09340
C	READ IN TOPOG(J,I) AND CALCULATE PHIS(J,I)	OLM09350

C	SEE TSANG AND KARN CODE LISTING PAGE A-23	OLM09360
C	----- LINES MAI27100 TO MAI27290	OLM09370
C	DID NOT INPUT INTO MODEL AT THIS TIME 10/29/77	OLM09380
C	-----	OLM09390
C	-----	OLM09400
	RETURN	OLM09410
	END	OLM09420
	SUBROUTINE SURFWD(NLAY,NLAYM1,JMP,INC,IM,J1P,JMPP1,TINPT,ASSIM)	OLM09430
	DIMENSION ZM(08,14)	OLM09440
	COMMON PHS(08,14),PD(08,14),TOPOG(08,14),SINL(46),COSL(46)	OLM09450
	COMMON	OLM09460
	\$ PC(8,14),TSC(8,14),SHSC(8,14),GTC(8,14),GWC(8,14),	OLM09470
	\$ UC(8,14,3),VC(8,14,3),TC(8,14,3),SHC(8,14,3),PLK(10),	OLM09480
	\$ SGC(8,14),US(08,14),VS(08,14)	OLM09490
	COMMON	OLM09500
	* PLE(10),TLE(10),RH(10),TH(10),DSIG(10),SHL(10),	OLM09510
	* SHLE(10),RE(10),SH(8,14,3),PL(10),	OLM09520
	* GT(08,14),SHS(08,14),TL(10),	OLM09530
	* SLBEDO(08,14),TS(08,14),GW(08,14),ROK(08,14),	OLM09540
	* IWR(10),SIGE(10),SIG(10)	OLM09550
	COMMON	OLM09560
	* RHS,DTS,CD,EDV,ZLN,DRAW,PREVAP,PLANT,EVE,E6DT,	OLM09570
	*RHOS,CZH,DTRBET,TERM1,TERM2,TERM3,TERM4,TERM5,DENOM,RADTRM,	OLM09580
	* SNFAL,BAIN,OVER,WETR,WET,TAU,WMAG,ELE	OLM09590
	LOGICAL OCEAN,SNOW,ICF,LAND,MIXWI,FROST	OLM09600
	LOGICAL GISSJK,UCLA,UCNT,UCNTI,UCNJJA,ASSIM,TINPT	OLM09610
	INTEGER*2 SLBEDO	OLM09620
C	-----	OLM09630
C	SURFACE WIND MAGNITUDE	OLM09640
C	-----	OLM09650
C	CMS: E SUB WIND	OLM09660
C	-----	OLM09670
C	NOTE FD(J,I) MUST BE CALCULATED AT ALL CELLS FOR	OLM09680
C	WMAG CALCULATION	OLM09690
	IMIN=INC	OLM09700
	IMAX=IM	OLM09710
	JMIN=J1P-1	OLM09720
	JMAX=JMPP1	OLM09730
C	-----	OLM09740

	COEF1=(1.-SIG(NLAYM1))/(SIG(NLAY)-SIG(NLAYM1))	OLM09750
	COEF2=(SIG(NLAY)-1)/(SIG(NLAY)-SIG(NLAYM1))	OLM09760
	DO 10 I=IMIN,IMAX	OLM09770
	DO 10 J=JMIN,JMAX	OLM09780
	IF(TINPT) GO TO 10	OLM09790
	US(J,I)=COEF1*UC(J,I,3)+COEF2*UC(J,I,2)	OLM09800
	VS(J,I)=COEF1*VC(J,I,3)+COEF2*VC(J,I,2)	OLM09810
	10 FD(J,I)=US(J,I)**2+VS(J,I)**2	OLM09820
	RETURN	OLM09830
	END	OLM09840
	SUBROUTINE RITE(IWRS,I,J,IHH,HOURL,IPR,	OLM09850
	*UCLA,UCNI,UCNJJA,UCNII,I2C,J2C,IMAX,JMAX,IMINUS,JMINUS,MONTH)	OLM09860
	DIMENSION	OLM09870
	* ZM(08,14),CELL(08,14)	OLM09880
	COMMON PHIS(08,14),FD(08,14),TOPOG(08,14),SINL(46),COSL(46)	OLM09890
	COMMON	OLM09900
	\$ PC(8,14),TSC(8,14),SHSC(8,14),GTC(8,14),GWC(8,14),	OLM09910
	\$ UC(8,14,3),VC(8,14,3),TC(8,14,3),SHC(8,14,3),PLK(10),	OLM09920
	\$ SGC(8,14),US(08,14),VS(08,14)	OLM09930
	COMMON	OLM09940
	* PLE(10),TLE(10),RH(10),TH(10),DSIG(10),SHL(10),	OLM09950
	* SHLE(10),RE(10),SH(8,14,3),PL(10),	OLM09960
	* GT(08,14),SHS(08,14),TL(10),	OLM09970
	* SLBEDO(08,14),TS(08,14),GW(08,14),ROK(08,14),	OLM09980
	* IWR(10),SIGE(10),SIG(10)	OLM09990
	COMMON	OLM10000
	* RHS,DTS,CD,EDV,ZLN,DRAW,PREVAP,PLANT,EVE,E6DT,	OLM10010
	*RHOS,CZH,DTRBFT,TERM1,TERM2,TERM3,TERM4,TERM5, DENOM,RADTRM,	OLM10020
	* SNFAL,RAIN,OVER,WETR,WET,TAU,WMAG,ELE	OLM10030
	LOGICAL OCEAN,SNOW,ICE,LAND,MIXWI,FROST	OLM10040
	LOGICAL UCLA,UCNI,UCNII,UCNJJA,ASSIM,TINPT	OLM10050
	LOGICAL PRIN,PRISMV,PRSURV,PRGRT,PRMCEV	OLM10060
	INTEGER PARM10,PARM11,PARM12,PARM13,PARM50,PARM51,PARM52,PARM53	OLM10070
	INTEGER*2 SLBEDO	OLM10080
C		OLM10090
C	CMS: E SUB PRINT	OLM10100
C		OLM10110
C	LOGICAL PRINT CONTROL VARIABLES	OLM10120
C		OLM10130

	PRIN=.TRUE.	OLM10140
	PRISMV=.TRUE.	OLM10150
	PRSURV=.TRUE.	OLM10160
	PRGRT=.TRUE.	OLM10170
	PRMCEV=.TRUE.	OLM10180
C		OLM10190
C		OLM10200
C	PRINT CONTROL VARIABLES	OLM10210
C		OLM10220
	PARM10=I2C	OLM10230
	PARM11=J2C	OLM10240
	PARM12=IHH	OLM10250
	PARM13=1	OLM10260
	PARM50=I	OLM10270
	PARM51=J	OLM10280
	PARM52=IHH	OLM10290
	PARM53=IPP	OLM10300
C		OLM10310
C	INITIALIZED VARIABLES	OLM10320
C		OLM10330
	IF(IPR.NE.1.OE..NOT.PRIN) GO TO 305	OLM10340
C		OLM10350
C	INDEX FOR CELL	OLM10360
	T1=JMINUS-1.	OLM10370
	DO 1217 J=1,JMAX	OLM10380
	T1=T1+1	OLM10390
	T2=(IMINUS-1)/100.	OLM10400
	DO 1217 I=1,IMAX	OLM10410
	T2=T2+.01	OLM10420
	CELL(J,I)=T1+T2	OLM10430
1217	CONTINUE	OLM10440
C		OLM10450
	WRITE(6,234)	OLM10460
234	FOPMAT(//,45X,'GISS INDEX FOR CELL (J.I)')	OLM10470
	WRITE(6,90) (I,I=1,IMAX)	OLM10480
	J=JMAX+1	OLM10490
	DO 1216 JJ=1,JMAX	OLM10500
	J=J-1	OLM10510
	WRITE(6,233) J,(CELL(J,I),I=1,IMAX)	OLM10520

1216	CONTINUE	OLM10530
C		OLM10540
	WRITE(6,201)	OLM10550
201	FORMAT(5X, //, 38X, 'SURFACE ALBEDO FOR JULY, DSNAME = I527ALBD')	OLM10560
	WRITE(6,91) (I, I=1, IMAX)	OLM10570
	J=JMAX+1	OLM10580
	DO 1203 JJ=1, JMAX	OLM10590
	J=J-1	OLM10600
	WRITE(6,203) J, (SLBEDO(J, I), I=1, IMAX)	OLM10610
1203	CONTINUE	OLM10620
	203 FORMAT(08(2X, I3, 14(4X, I2, 2X)))	OLM10630
C		OLM10640
	WRITE(6,207)	OLM10650
207	FORMAT(//, 40X, 'SURFACE ELEVATION(GEOPOTENTIAL HT) '	OLM10660
	WRITE(6,91) (I, I=1, IMAX)	OLM10670
	J=JMAX+1	OLM10680
	DO 1204 JJ=1, JMAX	OLM10690
	J=J-1	OLM10700
	WRITE(6,218) J, (PHIS(J, I), I=1, IMAX)	OLM10710
1204	CONTINUE	OLM10720
C		OLM10730
	WRITE(6,209) MONTH	OLM10740
209	FORMAT(//, 44X, 'TOPOG ARRAY FOR MONTH = ', I2)	OLM10750
	WRITE(6,91) (I, I=1, IMAX)	OLM10760
	J=JMAX+1	OLM10770
	DO 1206 JJ=1, JMAX	OLM10780
	J=J-1	OLM10790
	WRITE(6,210) J, (TOPOG(J, I), I=1, IMAX)	OLM10800
1206	CONTINUE	OLM10810
	210 FORMAT(08(2X, I3, 1X, 14(F7.0, 1X)))	OLM10820
C		OLM10830
	WRITE(6,212)	OLM10840
212	FORMAT(//, 43X, 'INITIAL SURFACE TEMPERATURE(K) '	OLM10850
	WRITE(6,90) (I, I=1, IMAX)	OLM10860
	J=JMAX+1	OLM10870
	DO 1207 JJ=1, JMAX	OLM10880
	J=J-1	OLM10890
	WRITE(6,233) J, (TSC(J, I), I=1, IMAX)	OLM10900
1207	CONTINUE	OLM10910

ORIGINAL PAGE IS OF POOR QUALITY

B-42

	C		OLM10920
		WRITE (6,214)	OLM10930
214		FORMAT(//,43X,'INITIAL GROUND TEMPERATURE (K)')	OLM10940
		WRITE(6,90) (I,I=1,IMAX)	OLM10950
		J=JMAX+1	OLM10960
		DO 1208 JJ=1,JMAX	OLM10970
		J=J-1	OLM10980
		WRITE(6,233) J,(GTC(J,I),I=1,IMAX)	OLM10990
1208		CONTINUE	OLM11000
	C		OLM11010
		WRITE(6,216)	OLM11020
216		FORMAT(//,43X,'INITIAL SURFACE PRESSURE (MB)')	OLM11030
		WRITE(6,91) (I,I=1,IMAX)	OLM11040
		J=JMAX+1	OLM11050
		DO 1209 JJ=1,JMAX	OLM11060
		J=J-1	OLM11070
		WRITE(6,218) J,(PC(J,I),I=1,IMAX)	OLM11080
1209		CONTINUE	OLM11090
218		FORMAT(8(2X,I3,1X,14(F7.1,1X)))	OLM11100
	C		OLM11110
		WRITE(6,205)	OLM11120
205		FORMAT(/,2X,38X,'INITIAL GROUND WETNESS MATRIX (GWC)')	OLM11130
		WRITE(6,91) (I,I=1,IMAX)	OLM11140
90		FORMAT(/,3X,'J I' ,14(I3,5X))	OLM11150
91		FORMAT(/,3X,' J/I' ,14(I3,5X))	OLM11160
		J=JMAX+1	OLM11170
		DO 1210 JJ=1,JMAX	OLM11180
		J=J-1	OLM11190
		WRITE(6,200) J,(GWC(J,I),I=1,IMAX)	OLM11200
1210		CONTINUE	OLM11210
200		FORMAT(08(2X,I3,14(F7.4,1X)))	OLM11220
	C		OLM11230
		WRITE(6,237)	OLM11240
237		FORMAT(//,45X,'SURFACE SPECIFICATION',/,10X,'1: OCEAN, ',3X,	OLM11250
		'2: LOAMY SOIL, ',3X,'3: SANDY SOIL, ',4X,'4: ')	OLM11260
		WRITE(6,91) (I,I=1,IMAX)	OLM11270
		J=JMAX+1	OLM11280
		DO 1222 JJ=1,JMAX	OLM11290
		J=J-1	OLM11300

	WRITE (6,233) J, (ROK (J,I) ,I=1,IMAX)	OLM11310
1222	CONTINUE	OLM11320
C		OLM11330
	WRITE (6,236)	OLM11340
236	FORMAT (//, 34X, 'TRANSFORMED GROUND WETNESS MATRIX (GW, 0-.5 SCALE)')	OLM11350
	WRITE (6,91) (I, I=1,IMAX)	OLM11360
	J=JMAX+1	OLM11370
	DO 1220 JJ=1, JMAX	OLM11380
	J=J-1	OLM11390
	WRITE (6,200) J, (GW (J,I) ,I=1,IMAX)	OLM11400
1220	CONTINUE	OLM11410
C		OLM11420
	WRITE (6,235)	OLM11430
235	FORMAT (//, 45X, 'WMAG COMPONENT : FD (J,I)')	OLM11440
	WRITE (6,90) (I, I=1,IMAX)	OLM11450
	J=JMAX+1	OLM11460
	DO 1221 JJ=1, JMAX	OLM11470
	J=J-1	OLM11480
	WRITE (6,233) J, (FD (J,I) ,I=1,IMAX)	OLM11490
1221	CONTINUE	OLM11500
C		OLM11510
	IF (IHH.EQ.1) WRITE (6,240)	OLM11520
	IF (IHH.GT.1) WRITE (6,221)	OLM11530
240	FORMAT (//, 45X, 'SURFACE SPECIFIC HUMIDITY')	OLM11540
221	FORMAT (//, 47X, 'NET RADIATION (LY/DAY)')	OLM11550
	WRITE (6,91) (I, I=1,IMAX)	OLM11560
	J=JMAX+1	OLM11570
	DO 1211 JJ=1, JMAX	OLM11580
	J=J-1	OLM11590
	IF (IHH.EQ.1) WRITE (6,223) J, (SHSC (J,I) ,I=1,IMAX)	OLM11600
	IF (IHH.GT.1) WRITE (6,218) J, (SHSC (J,I) ,I=1,IMAX)	OLM11610
1211	CONTINUE	OLM11620
	LL=0	OLM11630
	DO 229 L=1, 3	OLM11640
	LL=L+6	OLM11650
C		OLM11660
	WRITE (6,222) LL	OLM11670
222	FORMAT (//, 45X, 'X COMP OF VEL AT LEVEL', I2)	OLM11680
	WRITE (6,90) (I, I=1,IMAX)	OLM11690

B-45

	J=JMAX+1	OLM11700
	DO 1212 JJ=1,JMAX	OLM11710
	J=J-1	OLM11720
	WRITE(6,233) J, (UC(J,I,L), I=1,IMAX)	OLM11730
1212	CONTINUE	OLM11740
233	FORMAT(08(1X,I3,1X, 14(F7.2,1X)))	OLM11750
C		OLM11760
	WRITE(6,224) LL	OLM11770
224	FORMAT(//,45X,'Y COMP OF VEL AT LEVEL' , I2)	OLM11780
	WRITE(6,90) (I,I=1,IMAX)	OLM11790
	J=JMAX+1	OLM11800
	DO 1213 JJ=1,JMAX	OLM11810
	J=J-1	OLM11820
	WRITE(6,233) J, (VC(J,I,L), I=1,IMAX)	OLM11830
1213	CONTINUE	OLM11840
C		OLM11850
	WRITE(6,225) LL	OLM11860
225	FORMAT(//,43X,'TEMPERATURE OF AIR AT LEVEL', I2)	OLM11870
	WRITE(6,90) (I,I=1,IMAX)	OLM11880
	J=JMAX+1	OLM11890
	DO 1214 JJ=1,JMAX	OLM11900
	J=J-1	OLM11910
	WRITE(6,233) J, (TC(J,I,L), I=1,IMAX)	OLM11920
1214	CONTINUE	OLM11930
C		OLM11940
	WRITE(6,226) LL	OLM11950
226	FORMAT(//,45X,'SPEC HUMIDITY AT LEVEL', I2)	OLM11960
	WRITE(6,90) (I,I=1,IMAX)	OLM11970
	J=JMAX+1	OLM11980
	DO 1215 JJ=1,JMAX	OLM11990
	J=J-1	OLM12000
	WRITE(6,223) J, (SHC(J,I,L), I=1,IMAX)	OLM12010
1215	CONTINUE	OLM12020
223	FORMAT(08(1X,I3,1X, 14(F7.4,1X)))	OLM12030
229	CONTINUE	OLM12040
C		OLM12050
305	CONTINUE	OLM12060
C		OLM12070
C	SURFACE VARIABLES	OLM12080

C		OLM12090
	IF (IPR.NE.2.OR..NOT.PRISMV) GO TO 395	OLM12100
	396 PARM13=2	OLM12110
	IF (PARM10.EQ.PARM50.AND.PARM11.EQ.PARM51.AND.PARM12.EQ.PARM52	OLM12120
	*.AND.PARM13.EQ.PARM53)	OLM12130
	*GO TO 320	OLM12140
	GO TO 395	OLM12150
	320 CONTINUE	OLM12160
	WRITE (6,490)	OLM12170
	490 FORMAT (/ ,04X, 'RHS', 07X, 'DTS', 07X, 'ELE', 08X, 'EDV', 07X, 'ZLN',	OLM12180
	*05X, 'SHLE (10)', 03X, 'SHL (9)', 04X, 'DRAW', 05X, 'TLE (10)')	OLM12190
	WRITE (6,500) RHS, DTS, ELE, EDV, ZLN, SHLE (10), SHL (9), DRAW, TLE (10)	OLM12200
	500 FORMAT (2X, 09 (F8.4, 2X))	OLM12210
	395 CONTINUE	OLM12220
		OLM12230
C		OLM12240
C	GROUND TEMPERATURE CALCULATION VARIABLES	OLM12250
C		OLM12260
	IF (IPR.NE.4.OR..NOT.PRGRT) GO TO 605	OLM12270
	604 PARM13=4	OLM12280
	IF (PARM10.EQ.PARM50.AND.PARM11.EQ.PARM51.AND.PARM12.EQ.PARM52	OLM12290
	*.AND.PARM13.EQ.PARM53)	OLM12300
	*GO TO 510	OLM12310
	GO TO 605	OLM12320
	510 CONTINUE	OLM12330
	WRITE (6,595)	OLM12340
	595 FORMAT (6X, 'RHOS', 07X, 'DTS', 08X, 'CZH', 07X,	OLM12350
	*'WMAG', 06X, 'TERM2', 05X, 'TERM3', 06X, 'TERM4', 06X, 'TL (9)')	OLM12360
	* ,06X, 'DENOM', 06X, 'RADTRM', 06X, 'GT')	OLM12370
	WRITE (6,600) RHOS, DTS, CZH, WMAG, TERM2, TERM3, TERM4,	OLM12380
	*TL (9), DENOM, RADTRM, GT (J, I)	OLM12390
	600 FORMAT (1X, 11 (F10.3, 1X))	OLM12400
	605 CONTINUE	OLM12410
		OLM12420
C		OLM12430
C	MOISTURE CONTINUITY EQ. VARIABLES	OLM12440
C		OLM12450
	IF (IPR.NE.5.OR..NOT.PRMCEV) GO TO 695	OLM12460
	696 PARM13=5	OLM12470
	IF (PARM10.EQ.PARM50.AND.PARM11.EQ.PARM51.AND.PARM12.EQ.PARM52	OLM12480
	*.AND.PARM13.EQ.PARM53)	OLM12490

B-46

ORIGINAL PAGE IS
OF POOR QUALITY

B-47

	*GO TO 610	OLM12480
	GO TO 695	OLM12490
	610 CONTINUE	OLM12500
	WRITE(6,690)	OLM12510
	690 FORMAT(5X,'SNFAL',05X,'RAIN',06X,'OVER',06X,'PLANT',	OLM12520
	*04X,'PGT-E',04X,'ACTUAL-E',04X,'WETR',06X,'WET',	OLM12530
	*7X,'RH(9)',6X,'PL(9)',6X,'SHL(9)')	OLM12540
	WRITE(6,700) SNFAL,RAIN,OVER,PLANT,PREVAP,E6DT,WETR,WET,	OLM12550
	*RH(9),PL(9),SHL(9)	OLM12560
	700 FORMAT(2X,11(F9.4,1X),//)	OLM12570
	695 CONTINUE	OLM12580
C	//EXEC LDR	OLM12590
C	/DD 008 DSNAME=DJJA	OLM12600
C	/EXEC *	OLM12610
C		OLM12620
	I=PARM50	OLM12630
	J=PARM51	OLM12640
C		OLM12650
	RETURN	OLM12660
	END	OLM12670