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N84-2725	ISA-CR-173511) DEVELOPMENT OF GREAT LAKES
	ORITHMS FOR THE NIMBUS-G COASTAL ZONE OR SCANNER Final Report (Environmental
Unclas	search Inst. of Michigan) 05 -
	search Inst. of Michigan) 95 p A05/MF A01 CSCL 05B

Phase I – Final Technical Report

SEP 1981

DEVELOPMENT OF GREAT LAKES ALGORITHMS FOR THE NIMBUS-G COASTAL ZONE COLOR SCANNER

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JUNE 1981





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1. REPORT NUMBER 150000-11-F	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER		
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		150000-11-F		
7. AUTHOR(S)	:	8. CONTRACT OR GRANT NUMBER (s)		
Fred J. Tanis and David R. Ly	/zenga	NAS3-22442		
9. PERFORMING ORGANIZATION NAME AND AL Environmental Research Instit Applications Division Ann Arbor, ilichigan 48107 11. CONTROLLING OFFICE NAME AND ADDRES	ute of Michigan	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS		
INCONTROLLING OFFICE NAME AND ADDRES	5	12. REPORT DATE June 1981		
Cleveland, Ohio 44135		13. NUMBER OF PAGES		
Technical ionitor: Thom A. Con 14. MONITORING AGENCY NAME AND ADDRES	ney - Hail Stop MS-542	vi + 90		
(if different from Controlling Office)	5	15. SECURITY CLASS. (of this report) Unclassified		
		154 DECLASSIFICATION / DOWNGRADING		
16. DISTRIBUTION STATEMENT (of this Report)		SCHEDULE		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)				
18. SUPPLEMENTARY NOTES				
19 KEY WORDS (Continue on reverse side if necessary and identify by block number) Water Reflectance Models Geometric Polyconic Image Projection Optical Proportion Atmospheric Algorithms				
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The Great Lakes Experimental Team (GLET) has conducted a series of experiments in the Great Lakes designed to evaluate the application of Nimbus-G Coastal Zone Color Scanner (CZCS). Absorption and scattering measurement data were reduced to obtain a preliminary optical model for the Great Lakes. Available optical models were used in turn to calculate subsurface reflectances for expected concentrations of chlorophyll-a pigment and suspended minerals.				

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20. ABSTRACT (Continued)

Hultiple non-linear regression techniques were used to derive CZCS water quality prediction equations from Great Lakes simulation data. An existing atmospheric model was combined with a water model to provide the necessary simulation data for evaluation of preliminary CZCS algorithms.

A CZCS scanner model was developed which accounts for image distorting scanner and satellite motions. This model was used in turn to generate mapping polynomials that define the transformation from the original image to one configured in a polyconic projection.

PREFACE

This final report as issued by the Applications Division of the Environmental Research Institute of Michigan (ERIM) under National Aeronautics and Space Administration (NASA) contract NAS3-22442 for the Lewis Research Center (LeRC) covers the contract period from April 1, 1980 through February 28, 1981. The technical representative for the contract officer was Mr. Thom A. Coney of LeRC. The Principal Investigator was Fred J. Tanis with important contributions to the technical program made by David R. Lyzenga, Glenn Davis, and Robert Dye. This research was conducted by the Applications Division under the direction of Mr. Donald S. Lowe.

This contract involves developing algorithms to map selected constituent concentrations in Great Lakes waters from the Coastal Zone Color Scanner (CZCS). The approach is based upon the inherent optical characteristics of Great Lakes waters.

A number of institutions and universities are involved in the project and are organized as the Great Lakes Experimental Team (GLET). This report covers ERIM's activities in the project during Phase I of an anticipated two phase program.

ERIM

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INTRODUCTION

The Great Lakes Experimental Team (GLET) is conducting a series of experiments in the Great Lakes region designed to evaluate the application of the Nimbus G Coastal Zone Color Scanner (CZCS). Potential uses foreseen include assessment of trophic status, verification and spatial refinement of whole lake models, and observation of temporal and spatial dynamics of phytoplankton. Currently members of the NOAA Nimbus Experimental Team (NET) are developing chlorophyll and sediment algorithms largely to be applied, to the open ocean [1]. Preliminary examination of these algorithms indicates they have limited applicability to the Great Lakes. Concentrations and compositional differences of suspended materials along with atmospheric aerosol variants are expected to exhibit important differences from the marine environment and result in additional complexities. The focus of the present program is the development and testing of atmospheric and water algorithms appropriate to the Great Lakes as well as evaluation of existing algorithms developed for the marine environment.

1.1 STATEMENT OF THE PROBLEM

The quantification of substances in Great Lakes waters by satellite visible radiometry is dependent on a thorough understanding of the radiative transfer processes in the atmosphere, at the waters surface, and in the water column itself. It has been well established that the content of water, be it particulate or dissolved substances affects the apparent color. By sensing color with a high signal to noise ratio in narrow spectral bands CZCS provides a means of looking at the water content which has been heretofore unavailable from satellite data. Since the air and water effects are coupled to the CZCS radiometric data, removal of atmospheric effects becomes critical to the success of

the Great Lakes verification. Once removed the radiance which is scattered upward from beneath the surface can be observed clearly by the Effectively the radiance reaching the satellite from the satellite. lake surface amounts to only five percent of the total radiation and consequently ninety-five percent of the radiation received is from atmospheric backscatter and surface reflectance. Furthermore, the variation in radiance at the satellite due to change in constituent concentration are on the order of one percent while the variation due to atmospheric changes can be considerably higher. The spatially varying atmospheric component is due principally to aerosol scattering. The significance of the atmospheric problem for a water target has been demonstrated by Hovis and Lung [2] and more recently by Quenzel and Kaestner [3] who compared the variability of the atmosphere with the reflected light from phytoplankton suspensions. Thus unless atmospheric effects can be negated resolving quantitative information on water constituents it is considered to be most difficult. Baring elimination of the atmospheric effects the water problem requires understanding how the inherent optical properties relate to the measured quantities of chlorophyll-a pigment, phytoplankton cell count, suspended solids, and dissolved organics. Previous algorithms relied heavily on the availability of extensive surface truth [4,5,6]. For this study algorithms are sought which can be based on optical properties specific to the Great Lakes and which reduce the present requirements for extensive surface truth.

1.2 PROJECT GOALS AND ERIM TASKS

In order to be acceptable to the Great Lakes user community CZCS algorithms must, in our estimation, meet at least two general criteria. First, the algorithms must be able to predict accurately surface concentrations of chlorophyll-a pigments and suspended sediment over widely varying ranges and do so with little or no ancillary measurement data. Second, they must be capable of making predictions over water masses

which exhibit spatial variation in atmospheric haze and surface concentration.

The ERIM participation in the Great Lakes experiments involves two The first covers the period from April 1980 through February phases. 1981 and is the subject of this report. This first phase has involved development of computer software to process CZCS tapes received from the NASA Goddard Space Flight Center (GSFC), collection of surface truth measurement data in connection with CZCS overflights of the Great Lakes, and formulation of preliminary algorithms. The second phase will involve development and testing of specific atmospheric and water computer algorithms for CZCS. The water algorithms will be based upon radiative transfer theory and measured optical properties of Great Lakes Existing atmospheric models will be tested, including some waters. recently developed models, using surface truth and low altitude aircraft measurements made during the 1980 GLET experiments. These models in turn will be utilized in the development of operational algorithms for removing atmospheric effects from CZCS data without the direct use of a large number of in situ measurements of atmospheric optical depth. Our approach is to remove spatially variable components using properties of the data itself. It is anticipated that both the algorithm development by Gordon [7] and that by a group at the Scripps Institute of Oceanography [8] will be tested for their suitability to the Great Lakes atmospheric environment.

1.3 PROJECT BACKGROUND

The scientific objective of CZCS is to determine water constituents quantitatively and to carry out such measurements over large areas which are not possible or practical to be obtained with surface ship investigations. Currently the Nimbus experimental team (CZCS-NET) is investigating CZCS capabilities to quantify material suspended or dissolved in the water. These validation studies are concentrating on the ocean

environment. The present study is similar in design to the NET investigations but the focus is on a freshwater environment. A number of institutions, research centers, and universities plan to participate various aspects of the program. In addition to LeRC, which has led the current effort, participants in the Great Lakes Experiment include ERIM, Canada Center for Inland Waters, NOAA Great Lakes Environmental Research Laboratory, EPA Grosse Ile, University of Minnesota, University of Wisconsin, and others. These participants have a wide variety of backgrounds and capabilities which can be applied to the project. While it is understood that LeRC will not be able to participate fully in subsequent program phases it is anticipated that they will maintain an active interest in the project and promote the continuity of the GLET.

1.4 SUMMER 1980 GREAT LAKES EXPERIMENTS

During 1980 a number of surface truth measurements were made coincident with CZCS overflights of the Great Lakes. Experiments were conducted at three principal locations in the Great Lakes: western Lake Erie, Duluth area of western Lake Superior, and the Grand Haven area in Lake Michigan. All of these experiments were designed to gather necessary validation data and optical properties specific to the Great Lakes waters. Measurements made included the following:

- Aircraft flights were made by NASA LeRC F-106 aircraft fitted with the Ocean Color Scanner at altitudes of 500 and 41,000 feet.
- (2) Water samples were gathered by the University of Michigan GLRD and the NOAA GLERL and subsequently analyzed for chlorophyll pigments and suspended solids.
- (3) NASA LeRC made various surface ship radiometric measurements.

- (4) NASA Langley Research Center deployed a mobile optical laboratory to Cleveland. Optical parameters including absorption, beam attenuation, and scattering were measured on selected water samples.
- (5) The Naval Oceans System Center conducted in-situ submersible radiometer measurements of subsurface downwelling and upwelling irradiance at selected sites in Lake Erie.

A total of twenty separate sites were sampled in the Great Lakes, fourteen of which were made in connection with CZCS overflights. Only a very small portion of the above measurements have been analyzed to date but all analyses are expected to be completed in phase II of the program. 2

DEVELOPMENT OF A GEOMETRIC CORRECTION ALGORITHM FOR CZCS

The objective of this task was the modification of existing software and the development of a new scanner model which together will permit transformation to CZCS line and pixel coordinates into earth latitude and longitude. CZCS scanning geometry including variable tilt angle for Great Lakes viewing was combined with ground control points to derive the appropriate transformation matrix. Landsat geometric processing programs were adapted and modified as necessary to process available CZCS taped data for the Great Lakes. The initial accuracy goal was set to one pixel in each direction. In this task our efforts included investigation of geometric correction based on the 77 tie points per line, development of a CZCS scanner model, generation of mapping polynomials, modification of resampling software, and processing of an example image.

The geometric correction of an image results from two operations. First, mapping polynomials are generated that define the transformation from the raw original image to the corrected image. Second, the corrected image is created from the uncorrected image using these mapping pol-Two fifth-order, twenty-one term polynomials were used in ynomials. this process, one for each dimension of the image. These polynomials define the transformation which makes the corrected image conform to a given map projection as well as adjust for viewing distortions such as satellite position, satellite motion, and earth motion. Two approaches were considered in the present study; a geometric regression analysis approach, and an orbit modelling approach. Both of these approaches are based on extensive experience with Landsat image correction. Thus the basic techniques were extended in the present effort to accommodate the Coastal Zone Color Scanner.

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2.1 INVESTIGATION OF REGRESSION MODEL TECHNIQUES

Regression analysis was undertaken as the first approach to geometric correction. While this approach is considered to be straightforward it has the disadvantage of requiring extensive ground control points which makes it time consuming. In order to get satisfactory results, fifty or more points should be taken for each scene. The first image considered was taken on November 8, 1978. An image analyst selected forty-six ground control points of which forty-one were found to be suitable. A geometric regression analysis of these points produced mapping polynomials which could predict the location of these points with standard errors of 517 meters in the horizontal dimension and 553 meters in the vertical direction. Since the pixel size of the CZCS is nominally 825 by 825 meters, derived mapping polynomials are estimated to be accurate to within one pixel. These results are comparable to those typically obtained with Landsat processing.

Selecting ground control points is a lengthy process so an alternative method was sought to correct the scene. An attempt was made to use the ephemeris data that accompanies each image tape. Specifically, anchor points are included that describe the geographic position at 77 locations on each scan line. A two hundred point sample distributed throughout the scene was selected for testing. Geometric regression of these points showed errors greater than 13,000 meters in both dimensions. A similar set of points selected from a second scene taken on May 8, 1979 produced errors of the same magnitude. Subsequent to this experiment we learned that later versions of the GSFC processing algorithm had improved the accuracy of the anchor points considerably. Fortunately, we were able to obtain a copy of the May 8 scene with the improved anchor point values. However, this image was the only one available under the new version [9] and thus it was used exclusively for purposes of testing the geometric correction algorithms. A geometric regression was performed on a 429 point sample of anchor points which was in turn used to produce a set of mapping polynomials. Using the

mapping polynomials derived from the anchor points the ground control points were predicted with RMS errors of 4068 meters in the horizontal dimension and 4425 meters in the vertical dimension. This five pixel accuracy is within that claimed by GSFC for the anchor point reference system. Geometric regression of a set of sixty-two ground control points taken from the same image showed errors of 557 meters in the horizontal and 893 meters in the vertical.

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An attempt was made to obtain additional scenes with which to verify these results. Two scenes were obtained from the Lewis Research Center for this purpose. The first, April 17, 1979 had extensive cloud cover and it was impossible to obtain an adequate number of ground control points. The second, June 20, 1979 was centered in an area east and south of Lake Erie. Most of the image covered the Atlantic Ocean and again ground control points in the Great Lakes area were insufficient.

2.2 COASTAL ZONE COLOR SCANNER MODEL

The scanner model developed for CZCS is based upon our experience with Landsat and in its present form takes each image control point in turn and projects it to the earth's surface. The line number for each point is used to interpolate for the latitude, longitude, and altitude from the values supplied with the tape reference data for each scene. The point number is used to calculate the mirror scan angle, which together with the reported tilt angle determines the scanner line-ofsight vector in spacecraft coordinates.

A series of rotations through the angles of roll, pitch, heading, latitude, and longitude plus a translation provide the transformation to earth centered coordinates. The intersection of the line-of-sight vector with the surface of the eplisoid is then derived and converted to latitude and longitude. These coordinates are compared with the corresponding values obtained from map data, and the discrepancies minimized by successive refinement of the estimated roll, pitch, and heading. The

present model permits manual intervention with the operator who can supply needed refinements to the latitude and longitude parameters. It is anticipated that future model versions will eliminate the need for operator interaction and model adjustments.

Once unsatisfactory control points have been eliminated the refined attitude and location data are combined with the model. The cartographic projection is then selected and subjected to polynomial regression analysis which yields in turn the coefficients to a pair of twenty-one term, fifth degree polynomials. These polynomials provide an approximating transformation from cartographic coordinates to the original image coordinates.

The uses to which a scanner model of the imaging system for the CZCS are twofold. First, the image control points and their corresponding map control points may be easily evaluated for consistency with other points and any outliers rejected. Second, the coefficients for global mapping polynomials used in the resampling process can be derived by a fit to the model rather than to the points themselves. This feature permits the use of a much smaller number of points than would be needed for simple regression.

2.3 GENERATION OF MAPPING POLYNOMIALS

An arbitrary set of points were selected from the test image and used together with the scanner model to derive a set of mapping polynomials. A number of scanner variables including satellite attitude and position will influence the model results. Values of latitude and longitude are converted to line and pixel location in the resulting image via the equations that define the desired map projection.

The process used to resample a corrected image works in the reverse direction. For each pixel location in the resulting image the program calculates the corresponding location in the original image. This process implies reversing the projection equations in order to derive

the desired latitude and longitude information. However, operation of the scanner model in reverse so as to select original pixel locations which correspond to given location in the corrected image is most difficult and unwieldly. Alternatively, the pair of twenty-one term polynomials is generated to satisfy this mapping requirement. One polynomial describes the east-west position and the other the north-south location. The selected arbitrary image points mentioned above are used to generate coefficients for each term in the polynomial. The complete set of coefficients defines the mapping from the original image to the correct projected image.

Mapping coefficients are generated by step-wise regression in which the correlation matrix is calculated relating each term to its ability to predict the location of the point in the original image. A regression coefficient is calculated for the most influential term. This term is in turn removed from the matrix and the step regression continued until all terms that contribute predictive capability are included in the coefficient matrix. By utilizing points selected throughout the image file derived mapping coefficients are applicable over the entire pixel range in the corrected image. RMS errors are also calculated by the polynomial generation software for predicted locations in the original image. In the resampling process the correct image line and pixel number is translated to a location in the original image. The nearest neighbor pixel is then copied to the corrected image file.

2.4 RESAMPLING OF THE CZCS MAY 8, 1979 IMAGERY

Using the scanner model software fifty-four ground control points of the May 8, 1979 Great Lakes image file were tested for consistency with model parameters. Results indicated north-south RMS errors of 693 meters and east-west errors of 1338 meters respectively. Based upon existing satellite attitude information the scanner model was used to generate latitude and longitude positions from which the appropriate polynomial coefficients could be derived. The polynomial prediction

errors were found to be 55 meters in the north-south direction and 583 meters in the east-west direction. Combining these results leads to an expected total error of 748 meters in the north-south and 1921 meters in the east-west or approximately 1.0 and 2.5 pixels, respectively in the original image. Figure 1 shows the original and resampled images for the Great Lakes portion of the CZCS data file. This area includes all of the lakes except Lake Superior and the upper most portions of Lakes Huron and Michigan which are included in the next CZCS data frame.

Unfortunately portions of Lakes Michigan and Huron are obscured by cloud cover. Lakes Erie and Ontario are essential cloud free with the exception of a thin covering over the western basin of Lake Erie. The resampled image was made using a polyconic projection and an arbitrary pixel size of 500 by 500 meters. So as to verify the accuracy of the corrected image twenty additional ground control points were selected and compared to those predicted by the projection polynomials. Table 1 shows the results of this comparison. The maximum difference occurred for the sixth test point which was found to be 3000 meters in the northsouth direction and 7500 meters in the east-west direction. Test pixels located near the center of the original image and principal meridian showed, on the other hand, minimal errors. For example the second test pixel had a north-south error of 500 meters and an east-west error of The mean error was estimated to be 200 meters in the 2500 meters. north-south direction and 1875 meters in the east-west direction. Α listing of CZCS geometric correction programs developed for the PDP-11/70 computer facility are contained in Appendix A.



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Original and Polyconic Projected CZCS Thermal Band Images of the Great Lakes for May 8, 1979. Figure la.

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Original and Polyconic Projected CZCS Thermal Band Images of the Great Lakes for May 8, 1979. Figure lb.

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TABLE 1

GROUND CONTROL LOCATIONS

	Pre	edicted	Ac	tual	Diff	erence
Location	Row	Column	Row	Column	Row	Column
Toledo, Ohio	1028	1274	1029	1278	1	4
Detroit, Michigan	808	1182	806	1191	-2	9
Detroit, Michigan	843	1122	841	1131	-2	9
Flint, Michigan	692	1381	690	1390	-2	9
Flint, Michigan	688	1163	685	1174	-3	9
Tawas City, Michigan	311	1150	305	1165	-6	15
Cleveland, Ohio	1039	1564	1039	1567	0	3
Erie, Pennsylvania	801	1495	801	1500	0	5
Buffalo, New York	731	1806	731	1808	0	2
Buffalo, New York	865	1827	865	1829	0	2
Toronto, Ontario	646	1788	647	1793	1	5
Toronto, Ontario	658	1895	659	1897	1	2
Toronto, Ontario	563	1804	563	1808	0	4
Elmira, New York	785	2204	786	2203	1	-1
Elmira, New York	715	2308	715	2307	0	-1
Rochester, New York	635	2129	636	2129	1	0
Rochester, New York	462	2290	463	2290	1	0
Kingston, Ontario	438	2103	439	· 2103	1	0
Kingston, Ontario	365	2321	365	2321	0 .	0
Kingston, Ontario	419	2222	419	2221	0	-1

Mean Difference	-0.41	3.75
Standard Deviation	1.79	4.44

3

USE OF OPTICAL MODELS TO DEVELOP CZCS CHLOROPHYLL AND SUSPENDED SEDIMENT ALGORITHMS

A requirement fundamental to the validation of CZCS for the Great Lakes is the development of a working algorithm which can transform the satellite measured radiances into surface concentrations of chlorophyll and suspended sediment. While the ERIM task defined for current study involves development of water algorithms, these algorithms cannot in our estimation be attempted without some examination of and experimentation with atmospheric components. Thus, while we were able to place emphasis on certain water aspects of algorithm development, our approach has considered radiative transfer in the atmosphere. Our efforts to date have involved extensive use of statistical and model simulation techniques. Attempts to test candidate algorithms on real CZCS data have been limited because very few scenes of the Great Lakes were available and no CZCS tapes which correspond to the 1980 summer experiments are expected until mid 1981.

3.1 APPLICABILITY OF EXISTING ALGORITHMS

The removal of atmospheric effects is a necessary prerequisite for all remote sensing applications. Atmospheric effects are especially important in CZCS data for the following reasons.

- The large swath width of the CZCS implies a large atmospheric variability due to simple considerations of scale as well as scan angle variations.
- 2. The inherent radiance of the water is low causing path radiance effects to be relatively more important than over land.
- 3. The CZCS includes wavelengths in the blue region of the spectrum where atmospheric effects predominate.

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The study of atmospheric effects in CZCS data can be broken down First, one can attempt to develop and/or validate into two levels. radiative transfer models by making careful measurements of the relevant atmospheric parameters and of the radiance at the surface, and comparing the radiance measured by the satellite with that calculated from the Studies of this kind have been carried out for aircraft data at model. various altitudes [10] and for CZCS data over the Gulf of Mexico [11]. Aircraft studies have resulted in fairly good agreement between model predictions and measurements, although there is a discrepancy at large angles which is thought to be due to surface reflected skylight [10]. Previous studies with CZCS data have encountered some difficulty in obtaining agreement between model predictions and measurements [11]. One possible explanation for this difficulty is the effect of scattering from adjacent land areas which some studies have indicated to be of the same order of magnitude as the directly scattered path radiance [12]. In its studies ERIM will test existing models with aircraft measurements made during last summer's GLET experiments and with data obtained in the Gulf of Mexico Experiment [11].

A second kind of atmospheric study involves the development of operational algorithms for removing atmospheric effects from CZCS data without the use of an unreasonable number of in situ atmospheric measurements. The primary goal of these studies is to remove the variable component of the atmospheric effect using some property of the data itself to obtain the necessary correction parameters. One such algorithm was developed by Gordon [7] and applied to CZCS data over the Gulf of Mexico [10]. However, the formulation of Gordon's algorithm involves the assumption of zero intrinsic radiance in the 679 mm band which is not met in some parts of the Great Lakes and other coastal areas. Modifications to this algorithm have been made by a group at Scripps Institution of Oceanography for conditions occurring in Pacific coastal waters, but there is some doubt that their assumptions would hold in the Great Lakes. In addition to testing these algorithms, new directions have been pursued in the development of more suitable approaches.

3.2 OPTICAL MODELS AND RADIATIVE TRANSFER THEORY

Most existing algorithms are based upon empirical relationships between constituent concentrations and remotely sensed radiances, and are generally valid for the limited range of environmental conditions under which these relationships were derived. In order to systematically approach the evaluation of existing algorithms or the development of new algorithms, it is necessary to understand the relationships among the observed quantities on a more fundamental level. The study of these relationships is conveniently divided into two phases. The first phase deals with the inherent optical properties of the water aand atmospheric constituents, and the second phase deals with the large-scale radiative transfer processes which relate these inherent optical properties to the radiances measured by the satellite.

3.2.1 OPTICAL MODELS

A full description of the optical properties of a passive (nonemitting) medium include the absorption coefficient and the volume scattering function. For most remote sensing purposes, however, it is not necessary to specify the complete volume scattering function. Commonly two parameters describing the scattering properties are considered: the total scattering coefficient (which is the integral of the volume scattering function over all angles), and the back-scattering coefficient (which is the integral of the volume scattering function over the angular range of 90° to 180° from the incident direction).

It is generally assumed that the inherent optical properties are linear functions of the concentrations of the various constituents of the medium. Thus, for natural bodies of water we can write

$$a = a_{w} + \sum_{i=1}^{N} \hat{a}_{i}C_{i}$$

$$Bb = Bb_{w} + \sum_{i=1}^{N} B\hat{b}_{i}C_{i}$$

$$b = b_{w} + \sum_{i=1}^{N} \hat{b}_{i}C_{i}$$

(1)

where a_w , Bb_w , and b_w are the absorption, backscattering, and total scattering coefficients of pure water; \hat{a}_i , \hat{Bb}_i , and \hat{b}_i are the absorption, backscattering, and total scattering cross sections (i.e., the coefficients for unit concentration) of constituent i, and C_i is the concentration of constituent i. These are clearly approximations, since the actual optical properties may depend upon factors other than the concentrations. The scattering properties of suspended particulates, for example, depends upon the size distribution as well as the mass per unit volume. Some preliminary studies of the effect of size distribution are described in section 3.3.

Accepting the linear model for the optical properties described above, there are several possible approaches to the determination of the absorption and scattering cross sections for each constituent. One approach would be to attempt to isolate each constituent and measure the optical properties for different concentrations of that constituent. Isolation can obviously be accomplished more easily with some types of constituents than with others. The danger of this approach is that by artificially changing the sample, the measured conditions might not be representative of naturally occurring waters.

A second approach for determining the optical cross sections is to measure the optical properties and the constituent concentrations of a large number of diverse natural samples, and performing a statistical analysis (i.e., a multiple linear regression) of the results. This approach avoids the possibility of encountering unrealistic conditions, but is subject to biases introduced by natural correlations between various constituents, for example between phytoplankton and sediments

associated with phytoplankton nutrients. Examples of this approach include the work of Bukata et al [13] and the preliminary analysis presented in section 3.3 of this report.

It should be pointed out that some of the optical properties, i.e., the scattering cross sections, can be calculated from electromagnetic theory if the size distribution, shapes, and indices of refraction of the particles are known. Although it is instructive to make such calculations in order to determine the sensitivity of the cross sections to the size distribution, for example, there is no particular advantage to the exclusive use of this method since it requires measurements which are at least as difficult as the direct measurement of the optical properties.

3.2.2 RADIATIVE TRANSFER THEORY

The radiance at any point in the ocean/atmospheric system is provided, in principle, by the solution of the radiative transfer equation with the proper boundary conditions and the proper optical properties specified at each point. Unfortunately, an exact solution of this equation is not obtainable in closed form for even the simplest geometry. Two general types of approach are, therefore, possible. The first approach is to develop approximate solutions which give reasonably accurate results over the range of conditions encountered. The advantage of this approach is that results can be obtained at a relatively low cost, and that considerable insight can be gained by merely examining the functional form of the solutions.

The alternative approach is to develop exact numerical solutions of the radiative transfer equation. Several types of numerical solutions exist, perhaps the most prominent for this application being the Matrix Operator and Monte Carlo methods. The Monte Carlo method is especially powerful because of its ability to incorporate complex boundary conditions (e.g., at the water surface) and spatially variable optical properties. The advantage of the numerical approach is, of course, the

accuracy of the results. The disadvantages are the cost of obtaining these results and the fact that insight can be gained into the nature of the solutions only by examining a large number of cases with different input parameters.

The preliminary modeling work done on this project has involved a combination of the approaches described above. For the purpose of formulating candidate algorithms it has been useful to consider a simplified model in which the water radiance is calculated using Gordon's Power Series Approximation, and the atmospheric effects are described by a model which assumes constant transmittance and a path radiance which is a linear function of the aerosol optical depth. According to this model, the radiance at the satellite is given by

$$L = L_{p}(\tau_{a}) + TE_{\rho_{w}}(x)$$
(2)

where

 $L_p(\tau_a)$ = path radiance (assumed to be a linear function of the aerosol optical depth τ_a)

T = atmospheric transmittance (assumed constant)

E = irradiance at water surface (assumed constant)

$$\rho_{W}(x) = \frac{T_{W1} T_{W2} x}{2\pi n^{2} (\mu + \mu_{0})}$$

$$x = \frac{B b}{a + Bb} \quad (c.f. \text{ previous definitions of a and b in text})$$

$$T_{W1}, T_{W2} = \text{water surface transmittance for incoming and outgoing}$$

$$light$$

 μ_0 , μ = cosine of solar zenith angle and observation angle, respectively

n = index of refraction of water

The algorithms developed using this model are described in sections 3.4 of this report. For the purpose of evaluating these and other algorithms, a more comprehensive simulation model was also developed. This model incorporates the Monte Carlo calculations of the subsurface water reflectance using the following power series expansion [14]

$$\rho_{W}(x) = \frac{T_{W1} T_{W2}}{\pi n^{2}} [.0001 + .3244x + .1425x^{2} + .1308x^{3}]$$

where x is defined as previously. Atmospheric effects are calculated using the QSS model for the path radiance, and the double-delta model [11] for the irradiance and sky radiance. The surface-reflected sky radiance is included, assuming a nominal surface reflectance of 2.0 percent. The atmospheric state is described in terms of the horizontal visibility using the relationships developed by Elterman [15] to calculate the optical depth. The results of this simulation model are presented in section 3.5 of this report.

3.3 PRELIMINARY ANALYSIS OF OPTICAL PROPERTIES FOR THE GREAT LAKES

During late July 1980 twenty-one individual samples gathered by LeRC were analyzed by the NASA/Langley research Center (LaRC) portable laboratory stationed at the LeRC flight facility. Samples were flown in on the same day as collection and usually received by the LaRC staff within four hours for analysis. Underwater optical properties were measured in vitro with identical spectral range (400-800 nm) and intervals (50 nm). These properties included absorption, beam attenuation, and volume scattering. Three separate instruments were used to measure these parameters, (1) a combination beam attenuation and small angle scattering meter (SASM, $\Theta = 0.379$, 0.751, 1.49°) developed by LaRC and patterned after the Scripps Institution of Oceanography ALSCAT instrument; (2) a Brice Phoenix (BP) scattering meter modified to accommodate large angle measurements ($25^{\circ} \leq \Theta \leq 155^{\circ}$); and (3) the LaRC spectral absorption coefficient instrument (SPACI) [16]. Standard errors for these

instruments are reported to be as follows: (1) for the SASM less than 5% α , and less than 12% $\beta(\theta)$; and (3) for the SPACI less than 10% a.

The optical measurements made by LaRC during the 1980 summer experiments were for lake samples. In this case the measured optical properties pertain to the particular mix of constituents in the lake sample. If sufficient number of measurements are made in this manner and if the principal constituents present are known then multiple regression techniques can be used to derive the optical cross sections for a common constituent. While the present data are considered limited for this purpose a preliminary set of optical properties were derived for the Great Lakes.

Of the twenty-one optical data sets taken, three Lake Erie samples contained sufficient quantities of sediment to saturate the optical measurement instruments. Samples collected from Green Bay in Lake Michigan and from Western Lake Superior were found to have distinctive local optical properties. Four of the six samples collected from the Grand Haven area were essentially sediment-free and the presence of very low concentrations of phytoplankton made absorption measurements difficult. Attempts to include these samples in the regression analysis have so far not been productive.

The best regression results were obtained when nine samples from Lake Erie were combined with two samples from Lake Michigan. Several regression models were formulated and tested against the above selected optical measurement sets. These models were based upon the available surface truth sampling data which included Secchi depth, surface temperature, chlorophyll-a pigment, phaeophytins, and residue (total, ashed, and volatile) [17]. Of these parameters chlorophyll-a, chlorophyll-a plus phaeophytins, total residue and ashed residue were selected for regression. Each of the candidate models contained two components and a constant which includes absorption or scattering for pure water. Models involving ashed residue produced generally better statistics than

those with total residue. Each regression model consists of four equations pertaining to the backscatter cross section. In each case the four equations correspond to four CZCS wavelengths (443, 520, 550, 670 nm). The optical model considered for these analyses describes the surface water mass to be a combination of pure water (w), unique organics as represented by chlorophyll-a (chl) and phaeophytin (pp) concentration and unique inorganics as represented by the measurement of suspended minerals (sm). The two component model equations are written as

 $a(\lambda) = a_w(\lambda) + xa_{chl}(\lambda) + ya_{sm}(\lambda) + constant a(\lambda)$

$$Bb(\lambda) = Bb_{w}(\lambda) + xBb_{CHL}(\lambda) + yBb_{sm}(\lambda) + constant Bb(\lambda)$$

where x and y are the concentrations of chlorophyll a and suspended minerals (ashed weight) respectively, and a and Bb are the absorption and backscatter cross sections.

Optical cross sections as derived from these regression analyses are given in Table 2. These optical cross sections are the only such data available, to our knowledge for the Great Lakes. Note that the a or Bb, are included in the constant term given for each analysis. As shown in Table 2, two preliminary optical models were derived based upon chlorophyll-a and chlorophyll + phaeophytin concentrations, respectivelv. Also shown for comparison are values of four and five component Lake Ontario models [18] which were derived indirectly from apparent rather than inherent optical measurements. The four component model included chlorophyll, suspended sediment, pure water, and dissolved The five component model has an additional term for non organics. living organics which includes detritus. The dissolved organics term accounts for the presence of yellow substance which was found in the Ontario study to be about 2 mg/e and fairly constant throughout the

.

TABLE 2

OPTICAL CROSS SECTIONS FOR GREAT LAKES WATER QUALITY MODELS

(1) Great Lakes 1980 Preliminary Models

Model la	Wavelength (nm)	a _{CHL} (m ² /mg)	a _{sm} (m ² /g)	Constants	Multiple Regression Coefficient
	443 520 550 670	.01620 .00836 .00529 .00450	.0764 .0636 .0577 .0556	.3088 .2484 .3034 .3897	•961 •952 •945 •942
		Bb _{CHL} (m ² /mg)	Bb _{sm} (m²∕g)		
	443 520 550 670	.000152 .000372 .000469 .000428	.0312 .0284 .0287 .0250	.0424 .0370 .0232 .0197	.900 .911 .911 .913
Model 1b		^a CHL+pp ^{(m²/mg}	g)a _{sm} (m ² /g)		
	443 520 550 670	.01142 .00599 .00384 .00323	.07290 .06178 .05658 .05468	.3794 .2813 .3220 .4072	•970 •963 •954 •947
		Bb _{CHL+pp} (m ² /n	ng) a _{sm} (m ² /g))	
2	443 520 550 670	.000043 .000213 .000273 .000254	.03117 .02832 .02856 .02490	.04590 .0408 .0277 .0237	.890 .910 .910 .912
	(2) Lak	e Ontario Five	•		
		a _{CHL} (m ² /mg)	a _{sm} (m ² /g)	Constant	
	443	.0354	.0557	.020	

.0240

.0173

.0100

.0281

.0185

.0225

.028

.037

.370

520

550

670

.

.

	Bb _{CHL} (m ² /mg)	Bb _{sm} (m ² ∕g)	Constant
443	.00199	.0328	0
520	.00182	.0474	0
550	.00241	.0525	0
670	.00175	.0333	0

(3) Lake Ontario Four Component Model

	a _{CHL} (m ² /mg)	a _{sm} (m ² /g)	Constant
443 520 550 670	.0343 .0232 .0173 .0105	.0557 .0281 .0185 .0225	.185 .119 .122 .388
070	Bb _{CHL} (m ² /mg)		
443 520	.00163	.0328	.0010

lake. Since for the present study no effort was made to analyze the samples for a non-living organics or dissolved organics term they were not included in our preliminary model except as part of the constant term.

The absorption cross sections as derived from the 1980 optical measurement sets are for chlorophyll, about half of those derived for the Lake Ontario models. Derived chlorophyll backscatter coefficients were found to be only one tenth of those obtained by the Lake Ontario study. Chlorophyll absorption and scattering cross sections as obtained by regression are considerably less than those reported elsewhere in the literature [17]. On the other hand, derived optical cross sections for the suspended sediment are comparable to the Lake Ontario values.

All of the above models have utilized phaeophytin free chlorophyll determinations. Since chlorophyll and phaeophytins have similar absorption properties they cannot be readily distinguished by CZCS. Therefore, it seemed appropriate to combine these determinations in the above regression analyses and determine cross sections for chlorophyll plus phaeophytin. The resulting cross sections as given in Table 2 model 1b are smaller for the chlorophyll term and larger for the constant term than in the phaeophytin free analysis of model 1a. Since the direction of these changes are opposite to our expectations, additional investigation into the optical properties of phaeophytins is warranted.

In addition to the statistical analyses of the collected samples described above a brief investigation was made of an indirect technique for measuring scattering and absorption properties of suspended sediment in Lake Erie. The approach involved making a series of physical and optical measurements on a single turbid water sample at various time intervals. A portion of the suspended sediment was allowed to settle out between each measurement. Optical parameters measured by the LaRC portable laboratory included the beam attenuation coefficient and the volume scattering function at 90°. Both of these measurements were made

at a single wavelength of 550 nm. Physical measurements included the particle size distribution (using a Coultor counter) and the total suspended solids concentration. There were two objectives to these measurements. First the change in suspended solids concentration could be related to the corresponding change in the optical properties from which optical cross sections could be obtained. Second, Mie particle scattering theory could be used to calculate the same optical properties based upon the change in particle size distribution. Unfortunately, the total suspended solids measurements were found to be unreliable, either because of sampling or measurement errors, and were not included in the analysis. The optical measurements are summarized in Table 3, and the particle size measurements are shown in Figure 2 (panel a). It should be noted that Coulter counter measurements are difficult and subject to considerable error in the particle size range necessary for studies of this kind.

Because of the unreliability of the total suspended solids measurements, it was not possible to derive the optical cross sections directly from this set of measurements. Instead, the data set was used to test the feasibility of the approach of calculating the optical properties with Mie scattering theory. Of course, these calculations also requires a knowledge of the index of refraction of the particles. Since no measurements of the index of refraction were made, an average value of 1.1 was assumed. The extinction efficiency was calculated from the Mie theory using J.V. Dave's algorithm [19] for particle diameters between The portion of the total extinction coefficient 1.0 and 25.4 um. arising from this particle size range was then obtained for each sample by multiplying by the size distribution function and integrating (summing) over this range. For particle diameters less than 1 micron, the extinction efficiency was calculated using Van de Hulst's approximation [20].

$$Q_{ext} = 2 - \frac{4}{\rho} \sin \rho + \frac{4}{\rho^2} (1 - \cos \rho)$$
 (6)

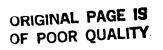


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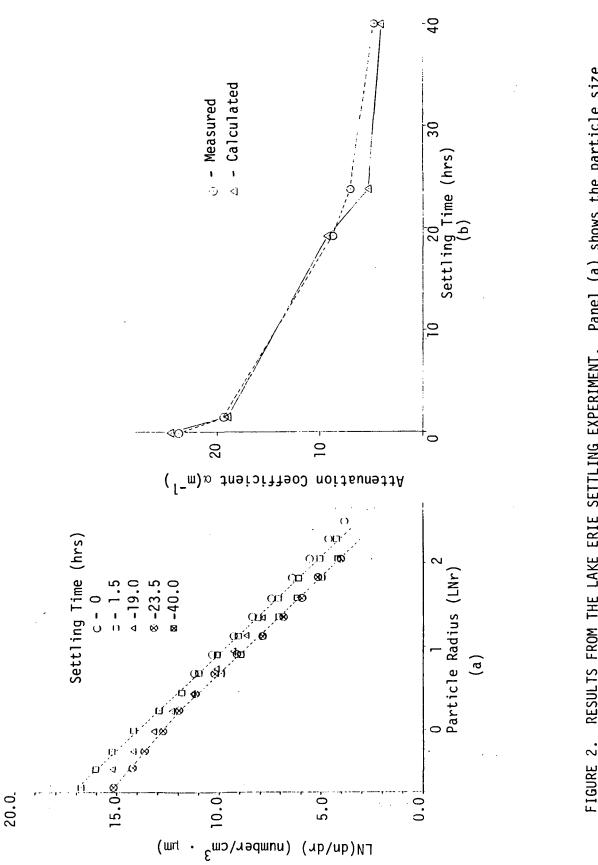
TABLE	3
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OPTICAL MEASUREMENTS MADE DURING SETTLING EXPERIMENT

Sample	Settling Time (hrs)	α(550 nm)	β(90°, 550 nm)
1	0	23.7 m ⁻¹	$0.1380 \text{ m}^{-1} \text{ sr}^{-1}$
2	1.5	19.3 m ⁻¹	
3	19.0	$8.7 m^{-1}$	$0.0685 \text{ m}^{-1} \text{ sr}^{-1}$
4	23.5	7.0 m^{-1}	$0.0617 \text{ m}^{-1} \text{ sr}^{-1}$
5.	40.0	$4.5 m^{-1}$	$0.0319 \text{ m}^{-1} \text{ sr}^{-1}$







Panel (a) shows the particle size attenuation coefficient with that calculated from the particle size distribution distribution measured at selected time intervals. Panel (b) compares measured RESULTS FROM THE LAKE ERIE SETTLING EXPERIMENT. based upon Mie scattering theory. where

$$\rho = \frac{4\pi(n-1)r}{\lambda}$$

(n is the index of refraction and λ is the wavelength). The contribution to the total extinction coefficient from particles less than 1 micron in diameter is than given by

$$\sigma'_{\text{ext}} = \int \pi r^2 \, Q_{\text{ext}}(\frac{\mathrm{d}n}{\mathrm{d}r}) \, \mathrm{d}r \tag{7}$$

For this particle size range, the size distribution was assumed to have the form

$$\frac{dn}{dr} = cr^{-4}$$
 (8)

where c is chosen to fit the measurement of $r = 0.5 \ \mu m$. The extinction coefficients calculated from this procedure are shown in Table 4, and are compared with the measured extinction coefficients in Figure 2 (panel b). In view of all the uncertainties and assumption required to make these calculations the agreement shown is surprisingly good. While these results are obviously insufficient to validate the approach they do suggest that further controlled studies of this type would be beneficial. If a technique could be derived for universal Coulter Counter measurements instead of the present elaborate and not readily available optical measurements the overall benefits of the present program would be substantial.

3.4 DISCUSSION OF ATMOSPHERIC EFFECTS AND CORRECTIONS

A necessary preliminary step before attempting to extract any information about the water itself is to remove the effects of atmospheric variations from the measured radiances. Atmospheric effects are



TABLE 4

EXTINCTION COEFFICIENTS CALCULATED FROM MIE SCATTERING THEORY

Contribution From r < 0.5 μm	Contribution From r > 0.5 μm	Total ext ^(m⁻¹)
7.2	18.3	25.5
4.8	14.1	18.9
2.5	6.7	9.2
1.0	4.3	5.3
0.7	3.2	3.9
	r < 0.5 μm 7.2 4.8 2.5 1.0	$r < 0.5 \ \mu m$ $r > 0.5 \ \mu m$ 7.218.34.814.12.56.71.04.30.73.2

particularly important in CZCS data because of the large swath width and the band placement. The development of radiative transfer models for the atmosphere is an important step in understanding this problem, but ultimately the goal must be to remove the atmospheric effects on a point-by-point basis with the aid of only a very limited number of external measurements.

The first attempt to formulate such an atmospheric correction algorithm for CZCS data was made by Gordon [7]. This algorithm is based upon the assumption that the total radiance in a suitable wavelength band may be interpreted as an index of the atmospheric state (i.e., the aerosol optical depth) and thus used to correct the atmospheric effects in the other bands. In this formulation it is assumed that the water radiance in the 670 nm band is zero or negligible compared to the path radiance, an assumption which is valid in clear ocean waters but is frequently violated in more turbid coastal waters, including the Great Lakes. In fact, our modeling study has shown the 670 nm band displays the greatest sensitivity to sediment concentration. Therefore, although the algorithm gives apparently good results in ocean areas [1] it cannot be applied directly to the Great Lakes.

The assumptions about the atmosphere in Gordon's algorithm seem to be valid for a reasonably wide range of atmospheric variations. These assumptions are essentially the same as those listed for the simplified model described in section 3.2, namely: (1) the path radiances in the various wavelength bands are linearly related to each other, and (2) the atmospheric transmittance changes relatively slowly and may be assumed constant. Under these assumptions one can define a large class of linear combinations.

$$X_{i} = \sum_{j=1}^{N} A_{ij}L_{j}$$
(9)

which are independent of atmospheric variations. Gordon's algorithm is one member of this class, but is not necessarily the optimum one. The condition for the X_i 's to be independent of atmospheric variations can be written as

$$\sum_{j=1}^{N} A_{ij} \frac{\partial L_{pj}}{\partial \tau_{a}} = \sum_{j=1}^{N} A_{ij} A_{j}' = 0$$
(10)

where i=1...N-1, L_{pj} is the path radiance in band j and τ_a is the aerosol optical depth. The coefficients A_{ij} may be interpreted as components of the vector \vec{A}_i , and the above condition viewed as the requirement that these vectors be perpendicular to the vector

$$A_{N} = (A_{1}, A_{2}, \dots, A_{N})$$
 (11)

If we require in addition that the vectors $\vec{A}_1 \dots \vec{A}_{N-1}$ be orthonormal, i.e.,

$$\vec{A}_{i} \cdot \vec{A}_{j} = \begin{pmatrix} 0, i \neq j \\ 0 \end{pmatrix}$$

$$(12)$$

then the transformation (9) has the properties of a projection onto a hyperplane perpendicular to \vec{A}_N , and the projected variables are linearly independent of each other. Although this would seem to be a desirable condition, the actual benefits of this procedure, as opposed to Gordon's procedure for example (which does not satisfy equation (12), have not yet been demonstrated. Work has begun on the evaluation of this procedure using the simulation model described in section 3.2, but a full comparison with Gordon's algorithm has not yet been completed.

It should be noted that the direction of the vector A_N can be determined empirically from the CZCS data itself, if an area of variable haze over a uniform water background can be located in the image. The

direction cosines are obtained readily by a principal components analysis of the radiances observed over such an area.

As discussed previously in section 3.2 the signal variants due to spatial changes in the aerosol content (haze) are linear. As discussed by Gordon in his correction method the aerosol contribution at one wavelength is approximately proportional to the other wavelengths. In CZCS four channel signal space, atmospheric variation is visualized as a vector oriented by these proportions and offset from the origin by the presence of water constituents and atmospheric transmittance effects. By comparison the water variants represent separate orientations for each constituent and generally much smaller than the atmospheric haze vector. Thus for open clear waters of the Great Lakes the observed variations are due essentially to atmospheric haze and system noise.

In order to explore the haze phenomenon several segments from two available CZCS images were examined. Each segment (200-1000 pixels) was first scaled to radiance and then analyzed for principal components. Two available CZCS scenes were selected for analysis: Great Lakes May 8, 1979 and Gulf of Mexico, November 9, 1978. Results of these analyses are shown in Table 5. Also shown is the principal component for atmospheric variation as derived from simulations using the preliminary atmospheric model discussed in section 3.2. Atmospheric vectors derived by this analysis show strong similarity in orientation. Differences in orientation are likely due to cloud effects and variations in water Radiometric changes due to scan angle effect may also constituents. account for some of the observed differences. Excellent agreement (1.1°) was found between the combination of Lake Huron data sets and the theoretical orientation of the haze vector. In general, the orientation of the haze vector for the Gulf of Mexico data sets were similar to those for Lake Huron but with less consistency and lower accounting of the percent of total variance. Clouds and variation of chlorophyll and suspended materials could possibly account for the observed variability in principal components.

TABLE 5

FIRST PRINCIPAL COMPONENTS DERIVED FROM CZCS SATELLITE MEASURED RADIANCES

Sample Location	First Principal Component	Percent of Total Variance
Georgian Bay, Lake Huron (1)	(.563, .539, .543, .313)	94.8%
Georgian Bay, Lake Huron (2)	(.440, .499, .565, .488)	94.2
Southern Lake Huron	(.435, .577, .594, .355)	95.4
Combination Set, Lake Huron	(.426, .5520, .547, .500)	95.5
Gulf of Mexico (2)	(.596, .580, .467, .298)	98.3
Gulf of Mexico (3)	(.487, .548, .538, .416)	94.8 ⁻
Gulf of Mexico (4)	(.559, .597, .465, .339)	91.7
Gulf of Mexico (5)	(.604, .679, .330, .256)	85.1
Combination Set, Gulf of Mexico	(.521, .579, .518, .353)	87.4
Atmospheric Model	(.426, .510, .524, .533)	100.0
	CZCS Imagery	

Lake Huron: May 8, 1979 Orbit 2715

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Gulf of Mexico: November 9, 1978 Orbit 227

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An analysis was made to observe if the haze vector was present and significant in apparent low haze area. Several samples were selected in the May 8 image from a test area south of Nova Scotia in the open ocean and at least 160 kilometers from the US mainland. The image appeared to be free of haze. Nevertheless the haze vector appeared as the principal component in each sample and subsample and with as few as fifteen pixels. These analyses further demonstrate the need to account for the atmospheric variants even under the clearest of conditions.

3.5 PRELIMINARY CZCS WATER ALGORITHMS

The atmospheric, interface, and subsurface water reflectance models discussed in section 3.2 were used to calculate expected satellite radiances for a variety of water masses at each of the CZCS wavelengths. The primary input for these calculations were the optical cross section data as described per the three optical models in section 3.3. Different water masses were simulated by varying the concentrations of chlorophyll and suspended mineral concentrations. In the case of the Lake Ontario five component model the level of non-living detrital material was taken as 2.0 mg/ ϵ and dissolved organics at 2.5 mg/ ϵ . These levels are similar to those measured in the Lake Ontario study [13]. Presently we have no measurement data to support the representativeness of these values to Lakes Erie or Michigan.

Having made these assumptions the subsurface irradiance reflectance can be readily calculated for each CZCS band (443, 520, 550, 670 nm) as a function of the concentration of chlorophyll and suspended minerals. The spectral characteristics of the irradiance reflectance function can be depicted with iso-concentration curves for each pair of wavelengths. Figures 3, 4, and 5 show calculated subsurface reflectance for each of the two Lake Ontario models and the preliminary 1980 optical model, respectively. Each of the four panels of each figure has nine curves of increasing suspended mineral concentration and constant value of chlorophyll pigment concentration (0.0, 1.0, 2.0, 5.0 10.0, 20.0, 50.0,

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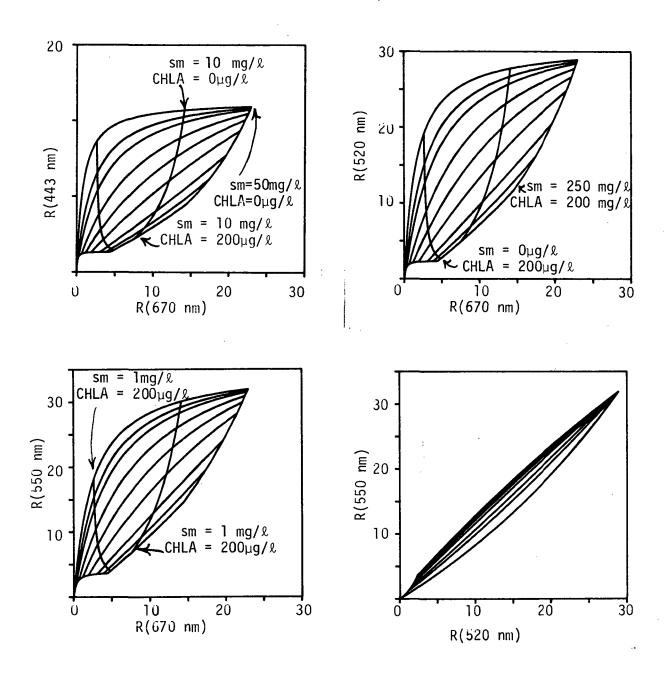


Figure 3. Subsurface reflectance (percent) at CZCS wavelengths (443 nm, 520 nm, 550 nm, 670 nm) as predicted by the Lake Ontario 5-component model [18]. Each figure has nine parametric curves of increasing suspended mineral concentration $(0.0-50.0 \text{ mg/}\ell)$ with constant values of chlorophyll pigment concentration $(0.0, 1.0, 2.0, 5.0, 10.0, 20.0, 50.0, 100, 200 \mu g/\ell)$. Each figure also contains four parametric curves of increasing chlorophyll a $(0.0-200.0 \mu g/\ell)$ at constant values of suspended mineral concentration $(0.0, 1.0, 10.0, 50.0 \mu g/\ell)$.

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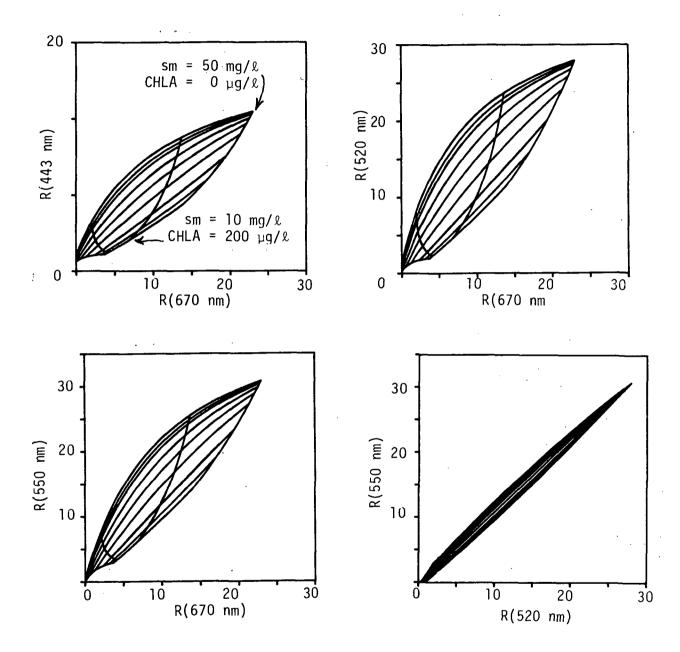


Figure 4. Subsurface reflectance (percent) at CZCS wavelengths (443 nm, 520 nm, 550 nm, 670 nm) as predicted by the Lake Ontario 4-component model [18]. Each figure has nine parametric curves of increasing suspended mineral concentration (0.0-50.0 mg/l) with constant values of chlorophyll pigment concentration $(0.0, 1.0, 2.0, 5.0, 10.0, 20,0, 50.0, 100, 200 \mu g/l)$. Each figure also contains four parametric curves of increasing chlorophyll a $(0.0-200.0 \mu g/l)$ at constant values of suspended mineral concentration $(0.0, 1.0, 10.0, 50.0 \mu g/l)$.

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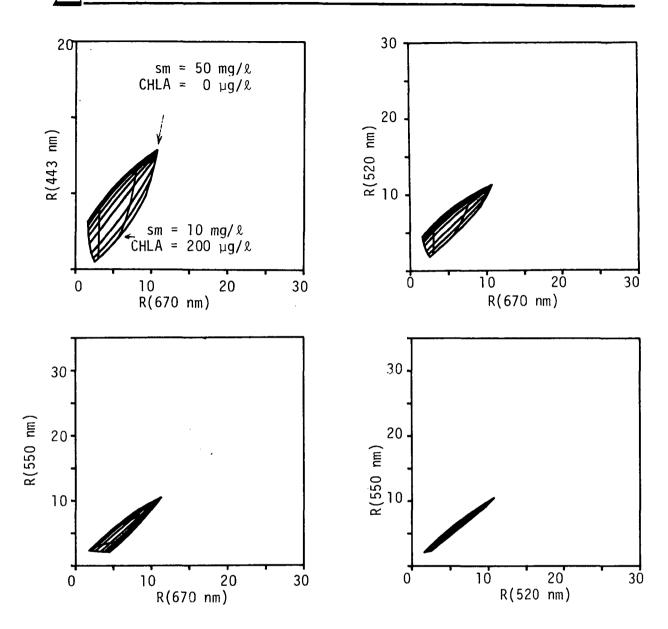


Figure 5. Subsurface reflectance (percent) at CZCS wavelengths (443 nm, 520 nm, 550 nm, 670 nm) as predicted by the Preliminary 1980 Optical Model. Each figure has nine parametric curves of increasing suspended mineral concentration (0.0-50.0 mg/ℓ) with constant values of chlorophyll pigment concentration (0.0, 1.0, 2.0, 5.0, 10.0, 20.0, 50.0, 100, 200 µg/ℓ). Each figure also contains four parametric curves of increasing chlorophyll a (0.0-200.0 µg/ℓ) at constant values of suspended mineral concentration (0.0, 1.0, 10.0, 50.0 mg/ℓ).

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100, and 200 μ g/ ℓ). These curves tend to converge to a point beyond the calculated range. One could refer to this ideal point as the "point of all sediment". Each figure also contains four curves of increasing chlorophyll with constant values of sediment (0.0, 1.0, 10.0, and 50.0 mg/ ℓ). These latter iso-concentration curves tend to converge in several of the panels to a point on the 670 nm axis. This ideal could be referred to as the "point of all chlorophyll". Each panel of these figures is a projection and together suggest the reflectance space is a three dimensional hyperplane and nearly perpendicular to the R(550)/R(520) plane.

For the five component Lake Ontario model the constant optical cross sections are very small relative to those for chlorophyll and sediment. As a result the sensitivity of reflectance to changes in concentration is large. By comparison the Lake Ontario four component model has slightly smaller cross sections and a larger constant term. Consequently the panel figures are slightly smaller. The effect of the relatively small optical cross sections of the preliminary 1980 optical model with a large constant term is shown by the small magnitudes of change in each panel of Figure 5. The difficulties of using this latter optical model to predict concentrations is apparent. The above figures also show generally that reflectance is more sensitive to changes in sediment (as mg/ℓ) than chlorophyll (as $\mu g/\ell$) which is consistent with their relative optical cross sections.

As discussed in the previous section, the spectral changes observed in CZCS data due to chlorophyll and sediment will be influenced by the presence of atmospheric variants. A principal component analysis of pure chlorophyll and sediment data indicated spectral orientation with angular separations from the pure atmospheric vector of 26.1° and 18.7°, respectively. Thus it seems apparent that the atmospheric variants are indeed coupled to those we wish to determine in the water. Unless there is some way to separate the atmospheric and water components by spatial filtering it seems appropriate to remove this influence by projecting

these reflectance data along the atmospheric vector. This projection reduces the four dimensional reflectance space to one of three dimensions which is free of any atmospheric influence. Figure 6 shows the projected space for each of the three optical models under consideration. The panel figures on the right are nearly a planer view of the depicted leaf like projected structure. Thus corresponding projected axis hold promise for decifering the water components. Since there are an infinite set of transformations which will project the four dimensional reflectance space into three dimensions the panel figures shown can be rotated to any orientation. This feature may provide a means to later optimize candidate algorithms.

Thus far our efforts to obtain chlorophyll and sediment algorithms have utilized the above projection technique. Using non-linear regression techniques algorithm prediction equations were derived as third order, second degree polynomials with nine terms. These equations have the following form:

$$f(conc) = C_1(R_1)^2 + C_2(R_2)^2 + C_3(R_3)^2 + C_4(R_1, R_2) + C_5(R_1, R_3) + C_6(R_2, R_3) + C_7(R_1 + C_8(R_2 + C_9(R_3 + C_{10})))$$
(13)

where the R's refer to the three axis of projection and the C's are the multiple regression coefficients.

Using the model described in section 3.2 and the optical properties of Table 2 data sets of simulated CZCS radiances were generated for water quality conditions similar to those that exist in the Great Lakes. Several simulation data sets were generated for each model. These included each of the following types:

 Variable chlorophyll, fixed sediment, fixed haze, zero system noise; original page is of poor quality

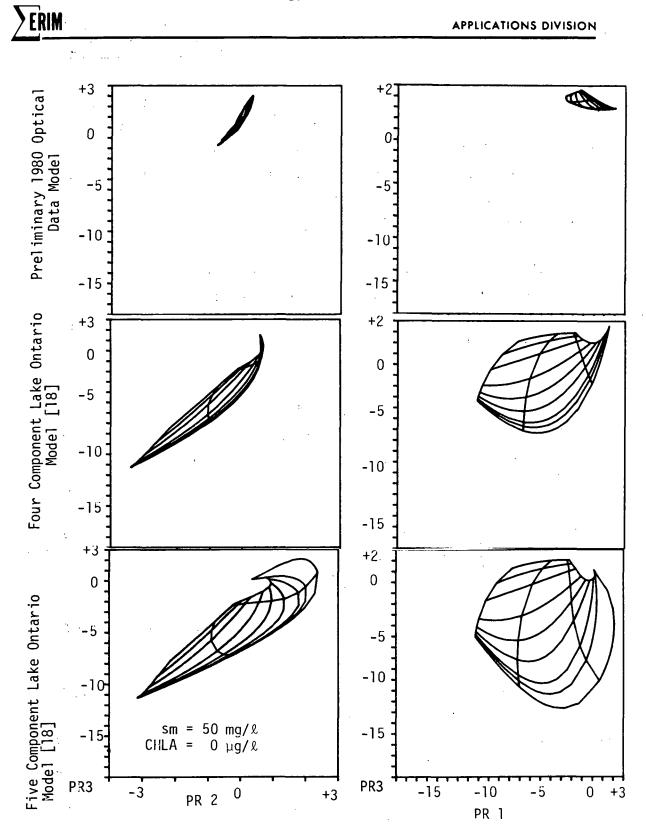


Figure 6. Projected subsurface reflectances (percent) as predicted by each of the above reflectance models. Projected variables are linear combinations of the corresponding predicted CZCS reflectances as shown in Figures 3, 4, and 5.

- (2) Fixed chlorophyll, variable sediment, fixed haze, zero system noise;
- (3) Variable chlorophyll, variable sediment, variable haze condition, standard system noise level.

The simulations included the effects of system noise by adding a normally distributed random variable with standard deviation equal to the mean radiance divided by the signal-to-noise ratio. The signal-tonoise ratio used were those reported by Gordon for CZCS [1]. The preliminary algorithms derived from these simulation data sets use as a first step the atmospheric projection procedure described in section 3.4. The orientation of the atmospheric vector was that given in Table 5. Data set (1) as described above was then used to derive a prediction function of the form given in equation (13). Similarly data set (2) was used to derive a corresponding equation for sediment. The third type of data sets (3) were used subsequently to test performance of the derived prediction equations.

Results of these analyses are summarized as follows:

- Sediment equations for the Lake Ontario models were able to predict sediment concentrations under conditions of variable haze and system noise to within approximately 50% over wide ranges of concentrations (1 to 20 mg/L) and to within 30% over narrow ranges (1 to 5 mg/L).
- The sediment equation for the preliminary 1980 optical model were able to predict sediment concentration to less than 50% only after the signal-to-noise ratio was doubled.
- 3. None of the regression equations for chlorophyll were capable of predicting chlorophyll to within 50% under standard system noise conditions. When the noise was reduced by four times the

Lake Ontario optical model predictions fell within the 50% error range. The presence of sediment, as might be expected, was found to have a deteriorating effect on the prediction algorithms for chlorophyll.

4. Satisfactory results were obtained with the preliminary 1980 optical model only when the presence of sediment was reduced to very small quantities (<< 1 mg/2) and the system noise was virtually eliminated.</p>

While we are encouraged by these simulation results additional investigations of this type will be needed under Phase II in order to produce satisfactory algorithms. The simulation techniques developed in the present study will become a powerful analytical tool for investigating and evaluating the applicability of Phase II CZCS algorithms to the Great Lakes.

Attempts to apply derived chlorophyll and sediment algorithms to Great Lakes CZCS data sets were not viable because of the lack of surface truth. However, some preliminary analysis was performed on the May 8, 1979 scene. The derived atmospheric vector compared well with that obtained from the atmospheric model as discussed in the previous section.

The processing portions of the final algorithm is anticipated to be able to classify the image and separate it into a land and water file. The water file, which will contain the surface area of the Great Lakes, will be then radiometrically calibrated in the first four bands. In turn, the water file will be transformed to one suitable for constituent determinations by projecting the data along the atmospheric vector. Applying the sediment and chlorophyll prediction equations to the projected file will produce the desired pixel by pixel concentrations maps. These concentration data files would then be recombined in the computer with the land mass file to produce a final map product.

A first attempt at performing some of these manipulations was made for the May 8, 1979 scene. While complete processing was beyond the scope of the present program phase we were able to separate the image into land and water files, color slice the water file, and recombine the separated image as shown in Figure 7.



depicting sediment concentration. The land area is shown as continuous grey tone image of band 5 (750 nm). It should be noted that the original image was GREAT LAKES CZCS IMAGE FOR MAY 8, 1979 RECONSTRUCTED FROM WATER AND LAND FILES In this image the water is represented by a CZCS band 4 (670 nm) level slice color coded and, therefore, the dark areas of the lakes as seen above do not accurately represent the quantity of sediment present. FIGURE 7.

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SUMMARY AND CONCLUSIONS

Much of the work accomplished to date is preliminary to the validation of CZCS in the Great Lakes. During the first phase of an anticipated two phase program, efforts were initiated and directed toward development of the necessary algorithms and supporting processing software which will allow the transformation of CZCS images of the Great Lakes into maps depicting concentrations of chlorophyll-a and sediment. The second phase will involve analyses of the CZCS imagery and surface truth measurements collected during the 1980 summer experiments.

Preliminary examination of existing CZCS atmospheric correction algorithms developed by NOAA for the open ocean indicates that the assumptions required are not valid for much of the Great Lakes area. Work has begun on the development of new atmospheric correction algorithms which are appropriate to the Great Lakes. While these algorithms appear to be promising, they have not as yet been thoroughly tested with actual CZCS data.

A preliminary optical model was derived from the LaRC optical measurements made for Great Lakes waters. Derived chlorophyll-a cross sections were found to be less than those reported with the Lake Ontario models [18] and elsewhere in the literature.

Efforts to derive chlorophyll and suspended sediment algorithms were based upon simulations of the preliminary optical model and the Lake Ontario models. Simulations included system noise and atmospheric variants as calculated using existing models. Multiple non-linear regression techniques were used to derive water quality prediction equations from Great Lakes CZCS simulation data. While results produced are encouraging they are thus far incomplete because of the lack of sufficient optical data and appropriate CZCS images. Suspended sediment algorithms were found to be able to predict sediment concentrations with

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single pixel accuracy to within 50% of the true value over the range (1-20 mg/s) for all optical models under consideration. Chlorophyll on the other hand was found to be more difficult to predict because of its smaller optical cross section. A 50% prediction accuracy could only be obtained after substantial reduction was made to the system signal to noise ratios. Furthermore this improvement was only realized with the Lake Ontario optical models. Satisfactory chlorophyll predictions could not be obtained using the preliminary optical model for the Great Lakes. This result was anticipated in part since the derived chlorophyll optical cross sections were much smaller than expected.

A second activity of the current work involved development of a geometric correction algorithm for CZCS. A scanner model specific to CZCS was developed which accounts for image distorting scanner and satellite motions. This model was used in turn to generate mapping polynomials that define the transformation from the original image to one configured in a polyconic projection.

Actually two approaches were investigated in the present study to obtain these mapping polynomials; geometric regression and orbit modeling. Based on a single available CZCS scene for the Great Lakes a geometric regression of anchor points produced mapping polynomials which predicted the location of ground control points with RMS errors of approximately five pixels in both the horizontal and vertical directions. By comparison the scanner model produced RMS errors of less than one pixel in the horizontal and 1.5 pixels in the vertical directions. Thus the scanner model approach is presently considered to be superior to exclusive use of image anchor points.

While some minor modifications to the scanner model are anticipated as additional imagery is acquired the software package to provide CZCS geometric correction is essentially complete.

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APPENDIX A

CZCS GEOMETRIC CORRECTION SOFTWARE

This appendix contains FORTRAN IV listings of four programs as developed for the PDP-11/70 computer system under the present contract. These programs form the basis of ERIM's present capability to transform NASA/GSFC CZCS image files into an image with desired metric qualities. The four programs include: (1) the CZCS Scanner Model, (2) CZCS Image Ground Control Program, (3) the Mapping Projection Polynomial Generation Program, and (4) an adapted Nearest Neighbor Resampling Program. These programs do not constitute a stand alone capability but instead require selected supporting software from ERIM's Earth Resources Data Center (ERDC) operating system. Available documentation and operating instruction can be obtained by request from ERDC.



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APPLICATIONS DIVISION

COASTAL ZONE COLOR SCANNER MODEL

8E 0	CZCSMHG,FTN 26-FEH-81 12144107 PAGE 1
10	PROGRAM CZCSMP
50	C COASTAL ZUNE COLOR SCANNER MERGE "CZCSMRG"
30	
4.2	C C
52	r
62	C MODIFIED FROM EDIPSMRG ON AUGUST 27, 1980 BY GLENN DAVIS
7 14	C THIS PROGRAM WILL READ A COASTAL ZONE COLOR SCANNER DATA TAPE
6 8 7 T	C AS DESCRIBED IN "NIMBUS G, NIMBUS OBSERVATION PROCESSING SYSTEM
97	C (NDES) TAPE SPECIFICATION T744041 CZCS CRT TAPE, 4/19/79".
100	C. THE HEADER INFORMATION IS EXTRACTED AND COPIED TO THE HEADER FILE.
110	C THE DATA CHANNELS ARE INTERLEAVED AND COPIED TO THE IMAGE FILE.
120	c
130	C OPTIONALLY THE ANCHOR POINTS ARE COPIED TO A FILE
142	c
150	PARAMETER EDF=1, BERIMG#861, BEGANC=P37, ANCLEN#616, ENDANC=852
160	PARAMETER ANCREC=154, BEGILT = 1549, OFFDAY = 7, OFFSEC = 9
177	PARAMETER GRPSZ = 405, SUBATT=21, PREATT=69, BEGATT= 1705
180	PARAMETER NLONS2=33, NLATSZ=36, NALTSZ=39, POSSZ = 45
193	PARAMETER GMTSZ # 18, SECGRP=16, GMTINC=1702
5.55	PARAMETER PITOFF = 0, YAWOFF = 3, ROLOFF = 6
217	c
223	INTEGER START, DEGREE, FRAC1, FRAC2, FRAC3, END, WHCANC
230	INTEGER OFFSET, GMTD12, WHCGRP, WHCSEC
2410	INTERFRAD NADALT(4), NADTIM(4)
259	TNTEGEN + 4 MESULT, SECNDS, IMGSZ, GMTSEC, LDMIN, HIMIN, WHCMIN
262	INTEGER#4 WORK, FRAC, TWO16, TWO8, NADENT, SPAN, IMGEDG, MINMRK, IMGBEG
510	TNTERER UNIT, DEN, RECNBR, YEAR, DAY, LATLON (2)
242	INTEGER OBUFP(5974), TILTID, TILT, TILTSV, ANS
203	С
200	t
319	RFAL LT, LN, GDAY12, GSEC
3-29	REAL GEO, TWC22, POINTS (154), OPMR, GTBASE, RTIME
7.36	REAL NADLAT (47, NADLON (4)
349	C PEAL SUMPOL, SUMPIT, SUMYAW, PITRAT, ROLRAT, YAWRAT
359	PEAL + R NORK
360	<u>c</u>
47.4	. c
3671	LOGICAL+1 LHF(12780), HFN(18), ST(10), OBUF(11808)
".	LOGICALA1 SID(12), HT(30), CODRUS(4), SWAP, LOAD
40.2	RYTE ANCHOP, SEC(4)
410	EQUIVALENCE (YEAR, LBF(17)), (SECNDS, LBF(21)), (DAY, LBF(19))
429	EQUIVALENCE (TILT,LBE(17)),(TILTID,LBE(19))
430	EQUIVALENCE (DBUF, OBUF?), (IMGSZ, LBF(251), (GMTSEC, SEC(1))
407	EDHIVALENCE (LBE(1), REGNBR)
450	EDUIVALENCE (LATLON, COURDS), (RESULT, COORDS)
460	
479	C
4 8 21	c
400	C OPEN FILES, SET CONSTANTS
5 % M	C
510	49216N 99497 TO 149400
527	60 10 99400
530	99402 CONTINUE
549	C C
550	C GET FIRST NADIR VALUES
560	c



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570 580		ASSIGN 99802 TO 199800 GO TO 99800
590	99802	CONTINUE
600	C	
610	C C	
620	Ç	
630	C	GET FIRST GROUP OF ATTITUDE VALUES
640	C	
650	С	ASSIGN 99302 TO 199300
662	C	GO TO 99300
670	C9930	CONTINUE
682	C	
690		TMGHEG = IMGEDG
700	C	
719	C	
720	900	CALL READIUNIT, LRF, 12780, NAP, IC)
732		IF (NAR, NE. 12780) GO TO 950
740	C	
750 -		IF (,NDT,(LOAD,OR,ANCHOR)) GO TO 900
769	C	
770		SWAP = LEF(1)
789		LAF(1) = LAF(2)
790		LBF(2) = SWAP
8.6%		
810	D	TYPE 910, HECNBR, RECNBR
854	0910	FORMAT(15,06)
937	C	
AUA		RECNBR = 971 - (RECNBR/16) + 1
853 853		1 ADO ONE TO MAKE VALUE ONE RELATIVE 1 subtract from 971 to invert image
870		1 DIVIDE BY 16 TO SHIFT RIGHT 4 BITS
- 58¢	<u>с</u>	
H90	<u>.</u>	TYPE 910, HECNBP, RECNBR
900		TIUTID = MOD(TILIID,256)
910		IF (TILTID, NE.2) GO TU 660
920		SWAP . LRF(17)
930		LAF(17) = LBF(18)
949	•	LRF(18) = SWAP
950	C	
969		TF (TILT, FQ, TILTSV) GO TO 680
970		
960	C	DIVIDE BY 255 TO USE LEFT HALF OF WORD WHICH IS THE WHOLE PART
047	C	OF THE NUMBER
009		RWORK = FLOAT(TILT / 256)
919		TLTVAL = HWOPK * 367 + 29.87
020	Ď	WPITE(S, AHP) RWORK, TLTVAL, RECNOR
010		FORMATI' TILT = ', F5.0, ' TILT (DEG) + ', F8.4, ' AT RECORD ', I5)
642	680	CONTINUE
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ወትወ	C	
070		JF (NOT ANCHOP) GD. TO 684
OB0	C	
000	C	GFT LINE OF ANCHOR POINTS
100	C	ASSIGN 99902 TO 199900
110	C	GO TO 99407
150	C 9 9 9 9	P CONTINUE
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170		AND . 1 , NOVL
180	START #	REGIMG + (BAND + 1) + NE
190	690 CALL MOV	E(LBF(START), 1, ORUF (RAND), NOVL, NE, 0)
2011	C C CALL HEY	CICER (START) TIUPUP (BANDIINUVLINE, 0)
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549	C	
550		,LOAD) GO TO 310
560	C	
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1690	
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1720	C99901 GO TD 199900, (99902)
1739	
1740	99801 GO TO 199800, (99802, 99803)
1750	
1769	C99701 G0 TB 199700, (99702, 99706, 99707, 99708, 99709)
1770	99701 GO TO 199700, (99706, 99707, 99708)
1780	
1795	99601 GD TO 199600, (99602)
Han	C.
1819	C99501 GD TO 199500, (99502,99503,99504,99505)
1820	C ·
1537	99401 60 10 199400, (99402)
1840	C
1850	C99301 GO TU 199307, (99302)
1 460	C
1A70	C99201 GC TO 199200, (99202)
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1890	C99181 GD TO 199188, (99182, 99183, 99184)
1920	c
1910	99401 GO TO 199000, (99002)
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1950	GET ANCHOR POINTS
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2040 2050 2050 2050 2050 2050 2050 2050	C AIT 31 REPPFSENTS THE SIGN C BITS 30-22 REPRESENT THE WHOLE DEGREES PORTION OF THE NUMPER. C BITS 21-0 REPRESENT THE SEVEN-DIGIT DECIMAL FRACTION OF DEGREES. C SINE = LEF (WHCANC) .AND. "200 I SIGN IS ALWAYS POSITI C SINE = ISIGN(1, SINE) C WHCPNT = 0 C DO 982 WHCANC = BEGANC, ENDANC, 4 C DO 982 WHCANC = BEGANC, ENDANC, 4 C DEGREE = LEF (WHCANC) .AND. "177 C DEGREE = ISHFT(DEGREE, 2) C WORK = WORK / 64 C DEGREE = DEGREE + WORK C DEGREE = DEGREE + WORK
2040 2050 2050 2050 2050 2050 2050 2050	C AIT 31 REPPFSENTS THE SIGN C BITS 30-22 REPRESENT THE WHOLE DEGREES PORTION OF THE NUMPER. C BITS 21-0 REPRESENT THE SEVEN-DIGIT DECIMAL FRACTION OF DEGREES. C SINE = LEF (WHCANC) .AND. "200 I SIGN IS ALWAYS POSITI C SINE = ISIGN(1, SINE) C WHCPNT = 0 C DO 982 WHCANC = BEGANC, ENDANC, 4 C DO 982 WHCANC = BEGANC, ENDANC, 4 C DEGREE = LEF (WHCANC) .AND. "177 C DEGREE = ISHFT(DEGREE, 2) C WORK = WORK / 64 C DEGREE = DEGREE + WORK C DEGREE = DEGREE + WORK
2040 2050 2050 2050 2050 2050 2050 2150 215	C AIT 31 REPPFSENTS THE SIGN C BITS 30-22 REPRESENT THE WHOLE DEGREES PORTION OF THE NUMPER. C HITS 21-0 REPRESENT THE SEVEN-DIGIT DECIMAL FRACTION OF DEGREES. C SINE = LBF (WHCANC) .AND. "200 I SIGN IS ALWAYS POSITI C SINE = ISIGN(1, SINE) C UNCPNT = 0 C DO 982 WHCANC = BEGANC, ENDANC, 4 C DO 982 WHCANC = BEGANC, ENDANC, 4 C DEGREE = LBF (WHCANC) .AND. "177 C DEGREE = ISHFT(DEGREE, 2) C WORK = UBF (WHCANC + 1) .AND. "300 C WORK = WORK / 64 C SINE = ISHFT (SINE + 1) .AND. "300 C WORK = WORK / 64 C SINE = ISHFT (SINE + 1) .AND. "300 C WORK = WORK / 64 C SINE = ISHFT (SINE + 1) .AND. "300 C WORK = WORK / 64 C SINE = ISHFT (SINE + 1) .AND. "300 C WORK = WORK / 64 C SINE = ISHFT (SINE + 1) .AND. "300 C WORK = WORK / 64 C SINE = ISHFT (SINE + 1) .AND. "300 C WORK = WORK / 64 C SINE = ISHFT (SINE + 1) .AND. "300 C WORK = WORK / 64 C SINE = ISHFT (SINE + 1) .AND. "300 C WORK = WORK / 64 C SINE = ISHFT (SINE + 1) .AND. "300 C WORK = WORK / 64 C SINE = ISHFT (SINE + 1) .AND. "300 C WORK = WORK / 64 C SINE = ISHFT (SINE + 1) .AND. "300 C WORK = WORK / 64 C SINE = ISHFT (SINE + 1) .AND. "300 C WORK = WORK / 64 C SINE = ISHFT (SINE + 1) .AND. "300 C WORK = WORK / 64 C SINE = ISHFT (SINE + 1) .AND. "300 C WORK = WORK / 64 C SINE = ISHFT (SINE + 1) .AND. "300 C WORK = WORK / 64 C SINE = ISHFT (SINE + 1) .AND. "300 C WORK = WORK / 64 C SINE = ISHFT (SINE + 1) .AND. "300 C WORK = WORK / 64 C SINE = ISHFT (SINE + 1) .AND. "300 C SINE = ISHFT (SINE + 1) .AND. "300 C SINE = ISHFT (SINE + 1) .AND. "300 C SINE = ISHFT (SINE + 1) .AND. "300 C SINE = ISHFT (SINE + 1) .AND. "300 C SINE = ISHFT (SINE + 1) .AND. "300 C SINE = ISHFT (SINE + 1) .AND. "300 C SINE = ISHFT (SINE + 1) .AND. "300 C SINE = ISHFT (SINE + 1) .AND. "300 C SINE = ISHFT (SINE + 1) .AND. "300 C SINE = ISHFT (SINE + 1) .AND. "300 C SINE = ISHFT (SINE + 1) .AND. "300 C SINE = ISHFT (SINE + 1) .AND. "300 C SINE = ISHFT (SINE + 1) .AND. "300 C SINE
2040 2050 2050 2050 2050 2050 2050 2100 210	C AIT 31 REPPFSENTS THE SIGN C BITS 30-22 REPRESENT THE WHOLE DEGREES PORTION OF THE NUMPER. C BITS 21-0 REPRESENT THE SEVEN-DIGIT DECIMAL FRACTION OF DEGREES. C SINE = LEF (WHCANC) .AND. "200 I SIGN IS ALWAYS POSITI C SINE = ISIGN(1, SINE) C WHCPNT = 0 C DO 982 WHCANC = BEGANC, ENDANC, 4 C DO 982 WHCANC = BEGANC, ENDANC, 4 C DEGREE = LEF (WHCANC) .AND. "177 C DEGREE = ISHFT(DEGREE, 2) C WORK = WORK / 64 C DEGREE = DEGREE + WORK C DEGREE = DEGREE + WORK
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SEN	CZCSMRG FTN	26-FEH-81 12144107 PAGE 5
3364		
2250 2250	C FRACE HLBF	(WHCANC + 2) .AND. "377
2279	C FRAC3 #LRF	
2280		(WHCANC + 3) AND #377
2294	C END . WHCAN	n an
2303	C	
2310	D TYPE 931.WH	CANC, (LEF(I), T=WHCANC, END), (LEF(I), I=WHCANC, END)
2320	D951 FORMAT(P	OINT ', I5, 2X, ' DEC: ', 4(16, 1X)
2333	D + ./.14X.* D	CT: 1,4(D6,1X))
2340	С	
2750	C FRAC # FRAC	1 + TWO16 + FRAC2 + TWOR + FRAC3
2367	C	
2379	C RHORK = FLO	AT (FRAC) / (TW022)
> < 8.0	C	
2109	C GEO = FLOA	T(DEGREE) + RWORK
2400	C	
P410	C IF (GED,GT,	1AD) GEO = - (360, - GEO)
2420	C · ·	
430	D TYPE 930, DE	GHEF, FRACI, FRACZ, FRACJ, FRAC, RWORK, TWO22
24413	C930 FURMAT(411	6,1X1,110,F15,12,F10,21
2450	<u>C</u>	
Р46И	D TYPE 932, G	
9470	C932 FORMAT(1X,	F12,8)
2480	C	
9499	C WHCPNT = WH	· · · · · · · · · · · · · · · · · · ·
522	C POINTS (WHCP	NT] = GEO
510	C CONTINUE	
2520 2520	and a statement of the state statement	
2530	<u>C</u>	
2540	C WRITEI3'REC	NRR) (POINTS(K),K#1,WHCPNT)
2569		WHCPNT > F9.4 3
570	C	
	C	
590	C	
600	C GO TO 99901	
617	C+++++++++++++++++++++++++++++++++++++	*************
620	c	
539	C PROCEDURE T	D EXTRACT NADIR INFORMATION
642	С	· · · · · · · · · · · · · · · · · · ·
550	C	
2660	99800 CONTINUE	
570	<u>c</u>	
1589	C	LAC CAPE ITUAPARA INA I PRASU AP THINK ADDIN
2692	· · · · · · · · · · · · · · · · · · ·	AGE EDGE (IMGEDG) AND LENGTH OF IMAGE (SPAN)
2700		SE AND WOONS TO MATCH DEC CONVENTIONS
2712	A 19 YE REAL PROPERTY AND A 19 YO REAL PROPE	'ES AND WORDS TO MATCH DEC CONVENTIONS
2720	C DO 90 WORK	* 21.25.4
2730	00 70 WOME	
2740	SWAP = 1.	RETWORK
2750		K) = LBF (WORK + 3)
2769 2779		K + 3) = SWAP
2770 2780	COT L NON	
2790	SWAP = 1	BF (WORK + 1)
2603	LBF (WOR	
. 997	Los C wor	
		an ann an ann an a



SEO	CZCSMRG.FTN	26-FEB-81 12144107 PAGE 6
2010	1	
2810 2820	SU CONTINUE	+ 2) = SWAP
2930	C C CONTINUE	and a second provide an age and second construction of the second barran second s
2940	č	
2850	IMGEDG = SECN	Ins
2860	SPAN = IMGSZ	
2870	C IMSEDG = IMGE	
2982	D TYPE *, *IMGER	DG ", IMGEDG, " SPAN ", SPAN
2400	C	
2900	C VALUE GIVEN C	IN TAPE FOR SPAN DOESN'T APPEAR TO BE RELIANLE
2420	C SO A UCFAULT	SIZE OF 128 SECONUS IS USED.
2930	SPAN = 128000	
2240	с	
2950	C	сторани и поста и поста и пострана и пострана и пострании и пострании и статица, <u>пострани и пострани и постран</u> и с Пострани
2967	C	
2970	C EXTRACT TIME	OF GMT MINUTE MARK (MINMRK)
5980	C UNSCRAMHLE GM	17 1/12 DAY
2997	OFFSET = HEGI	(LT + DFFDAY
3100	GMISEC = 0	
3010	SEC(2) = LHF(
3030	GMTD12 = GMTS	(OFFSET + 1)
3040		HEFORE CURRENT DAY
3050	WORK = MOD (G	
3968	C CUNVERT TO MI	
3070	WORK = WORK	
3089	C	
5090	C	
3102		T MILLISECONDS OF 1/12 DAY
3110	OFFSET # BEGI	LT + OFFSEC
3120	GMTSEC = 0	
31.50	SEC (3) * L	
3140	<u> </u>	.8F (0FFSET + 1) .8F (0FFSET + 2)
3150	C	or (urraci + c)
1 3170		INDS OF THIS TWO HOUR SEGMENT
3180-	MINMRK . GMTS	
3190.	D TYPE +, . HOR	R ', WURK, ' GMTSEC ', GMTSEC, MINMRK ', MINMRK
3560	C	n na
3210	C	
3250	C	
3230		MARK INVEXES
3240		(MINMRK / 60030) - 1.
3260		(GTHASE, RTIME)
3279	D TYPE +, GTE	
3280-	. C	
1 3200	c	
3320	C	
3310	C	
3354	C	· · · · · · · · · · · · · · · · · · ·
3330	C	
3340	C GET NADIR VAL	UES
3359	DU SOU MHCHIN	V # 1,2
3360	C	
L		
f		ана на коро су дошно су арило би улих и и ранског колистик и каки и и и и и и и и и и и и и и и
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r ·		
· .		And a construction of the

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SEQ	CZCSHRG,FTN 26-FEB-81 12144107 PAGE 7
3370	NADENT = NADENT + 1
3360	START # BEGILT + GMTSZ + (HHCMIN = 1) + POSSZ
3390	UFFSET . NLONSZ + START
3400	C
3410	C GET LIN VALUE
3420	ASSIGN 99706 TO 199700
3430	GO TO 99700
3447	99706 CONTINUE
3452	C
3450	NADLON (NADCNT) = FLUAT (RESULT) + DPMR
3470	C
3480	OFFSET . NLATSZ + START
3440	C GET LAT VALUE
3500	ASSIGN 99707 TO 199700
3510	GO 10 99700
3520	99707 CONTINUE
	C
3530 3540	
···· .	NADLAT(NADCNT) = FLOAT(RESULT) + DPMR
3550	
3560 1570 -	UFFSET # NALTSZ + START C get alt value
3570 - 3580 -	C GET ALT VALUE ASSIGN 99708 TO 199700
5590 m	GO TO 99700
3600	9970A CONTINUE
3619	
3520	NADALT(NADENT) = RESULT
3630	C
3649	NADTIM(NADCNT) = (MINMRK + ((WHCMIN - 1) + 60000))
3650	+ / 60000
3660	
3670	O TYPE ., " NADIR LAT, LON, TIM, ALT ", NADLAT (NADCNT),
5680	D + NADLDN(NADCNT), NADTIM(NADCNT), NADALT(NADCNT)
3697	
3700	200 CONTINUE
3710	<u></u>
3720	
3730	<u>C</u>
3740	<u>60 TO 99801</u>
3750 -	
3750	C
3770	
3729	C OPEN FILES, SET CONSTANTS
3790	C
3800	
3810	99490 CONTINUE
3820	PI = 3,1415927
3832	DPHH = 1,t-6 + 180 / PI 1 DEGREES PER MILLIRADIAN
RA40	TW022 = 2. ** 22
\$850	TW016 # 2 ** 16
1860	
5870	NERATT • Ø
3880	NADENT # P
5890 🗍	GTBASE # 999999
3900	e
3410	
\$920	K8=5



SEQ	CZCSMRG,FTN 26-FEB-81 12144107 PAGE 8
3930	- + • • • • • • • • • • • • • • • • • •
	IDR=1 DRIVE 1
3947	
3950	WRITE (N9,20)
1960	20 FURMAT (" CZCS DATA TAPE MERGE VER 1.0",/)
3970	
3980	WRITE (KB,30)
3990	30 FORMAT ("SINPUT UNIT AND DENSITY? ").
<u>"</u> 46%9 "	· c
~4010 [~]	C THIS STATEMENT READS & DIAGNOSTIC CONTROL VARIABLE
4659	C AND & & LOAUS HOTH IMAGE AND ANCHOR POINT FILES
4030	C ANS . 1 LOADS ONLY IMAGE FILE
4040	C ANS . 2 LUADS ONLY ANCHOR POINT FILE
4050	READ (KB, 40) UNIT, DEN, ANS
4060	40 FORMAT (2110)
4070	C
<u>4080</u>	CALL INIT (UNIT, DEN, 2)
4090	CALL REWIND (UNIT)
4110	IF (ANS, NE, 0, AND, ANS, NE, 1) GO TO 72
4120	LOAD # TRUE.
4137	WRITE (KB, 50)
4140	50 FORMAT ('SSCENE TITLE ? ')
4157	REAU (KB, 50) ST
4160	50 FORMAT (12041)
4170	C
4180	WRITE (KR,65)
4197	65 FORMAT ('SDRIVE NUMBER? ')
4200	READ (KR, 40) IDR
4210	
4220	WRITE (KB,70)
4237	70 FORMAT ("SHEADER TITLE? ")
-	
4590	READ (KH,60) HT
4250	
4289	15 CONTINUE
4270	Č
4289	C ANCHOR . FALSE.
4299	C IF (ANS NE . 0. AND . NE . 2) 60 TO 74
4300	C ANCHOR . TRIJE
"4310"	OPEN (UNIT # 3, NAME # "ANCHOR DAT", TYPE "NEW"
	L UPEN (UNIT = 3) PARC - ANGRUN(UNITER NUN
4320	C + ,ACCESS='DIRECT',FORM='UNFORMATTED',RECORDSTZE=ANCRE
" 4330	CC + ,INITIALSIZE=1940
4340	C + , MAXREC = 970, ASSOCIATEVARIABLE = INDX)
4350	C
4360	C
4370	C SKIP TO SECOND FILE
4350	C 517 10 366040 1166
4390	C 74 CONTINUE
4400	CALL SKIP (UNIT, 2, 1C)
4410	C
4420	CALL SKIP (UNIT, 1, IC)
4430	IF (IC, NE, EOF) STOP "EXPECTED END OF FILE
4449	
4450	
4450	CALL READ (UNIT, LBF, 5328, NAR, IC)
4479	
- 1480	1F (NAR, NE, 5328) STOP 'UNKNOWN FORMAT'
· · · · · · · · · · · · · · · · · · ·	



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SEQ	CZCSMRG,FTN	26-FEB-81 12144107 PAGE 9
4490	C	***************************************
4500	C CONSTANTS	FOR HEADER FILE
4510	C	
4520	NE=1968	I NUMBER OF OUTPUT ELEMENTS
4530	NL=970	I NUMBER OF OUTPUT LINES
4540	NHP=6	I NUMBER OF BYTES/PIXEL
4550	TPN=5	1 PROJECTION NUMBER
4560	NPP=0	I NUMBER OF PROJECTION PARAMETERS
4570	IEC=0	I ELEMENT OFFSET
4580	ILO≥0	LINE OFFSET
4590	NOVL=6	I NUMBER OF OVERLAYS
4620	0x=425,	I SAMPLING INTERVAL (METERS) ACROSS TRACK
4610	04+825.	I SAMPLING INTERVAL (METERS) ALONG TRACK
4659	C	
4630	NBBNEANBP)
4540	C	
4650	IF (LOAD)	CALL IMOPEN(1, ST,, IDR, NB, NL, 'M')
4660	OPFN (UN	IT = 4, NAME = "CSP.DAT", TYPE="NEW")
4679	<u> </u>	
4689	GO TO 994	01
4640 4700	C	
	• • • • • • • • • • • • • •	***************************************
4710	С С	
4729		
4730	C LOAD HEAD	CK TILL
4740 4750 -	C 99600 CONTINUE	
4760		
4770	CALL GHEN	
4780		GN (1,HFN)
4790	C C C C	
4800	Ċ	
4810		(LBF(33).1.CODRDS(1).1.4.0)
4820	C	
4950	C	
4840	SWAP # CO	10RDS(2)
4850		# COOKDS(1)
4860 -	COORDS(1)	
4979	C	
4888	SWAP = CO	DHD\$(4)
4899	COORDS(4)	■ CODHOS(3) ■ SWAP
4900	CONROS(3)	= SWAP
4918	C	
4929	C	
4930		= LATLON(1) - 9000
4949		N(2), GT, 18000) LATLON(2) = - (36000 - LATLON(2))
4950		T(LATLON(1)) /100
4960	and president and Transmiss and Transmission	T(LATLON(2)) / 100
4970	<u>.</u>	
4980	C	
4990		50) YEAR, DAY HT
5049		,14,':',13,2×,30×1,7×)
5010	<u> </u>	
5924	C	
50.30		160) NE, NL, NBP, IPN, NPP, IEO, ILO, NOVL
5240	160 FORMAT (8	15,40x)
		······································
·····	· · · · · · · · · · · · · · · · · · ·	



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SEQ	CZCSMRG,FTN 26-FEB-81 12144107 PAGE 10
150	C
160	C
170	WRITE (1,170) DX, DY, LT, LN
80	170 FORMAT (4F12.6, 32X)
190	C
00	ć
10	WRITE (1,170) TH,2,2,2
29	C
37	C
40	WRITE (1,180) (1,1,1=1,NOVL)
50	180 FORMAT (1615)
69	
70	CALL CLOSE (1)
80	
90	GO TO 99601
80	
10 -	· · · · · · · · · · · · · · · · · · ·
20	
30	
47	C LOAD NADIN FILE
50	
69	99000 CONTINUE
79	c
P, (A	c
40 1	SWAP = LBF(17)
00	LBF(17) = LBF(18) LBF(18) = SWAP
10	LBF(18) - SWAP
59	C
30	SWAP = LRF(19)
49	LBF(19) • LBF(20)
50	LBF (20) . SWAP
60	e
70	WRITE(4, 150) YEAR, DAY, HT
80	RTIME . FLOAT (IMBBEG) / 60000 GTBASE UNITS . MINUTE
90	RWORK * RTIME + (FLUAT(SPAN) / 60000.) 1 END OF IMAGE
ae -	WATTE (4, 925) RTIME, RWORK TIME IMAGE STARTS, ENDS
10	D() 920 WHCGRP # 1, 4
20 -	C CALCULATE TIME OF MINUTE MARK RELATIVE TO GTBASE, UNITS . MIN
38	RTIME + FLOAT (NADTIM(WHCGRP)) - GTBASE
40	
50	
	925 FORMATE 2F 12.6 , 112 , F12.6)
60	
70	WRITE (4,927) TLIVAL
80	927 FORMAT(F12,6)
90	<u>C</u>
30	C
10	GD TO 99001
20	c
30	C+++++++++++++++++++++++++++++++++++++
40	с
50	C.
60	C EXTRACT THREE HYTES AND FLIP TO CONFORM TO DEC CONVENTIONS
70	C
80	99700 CONTINUE
90	
29	COORD'S (4)

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SED	CZCSMRG FTN	26=FE8=81	12144107	PAGE	11
5610	COORDS(3)	+ LBF (OFFSE	÷• • • • • • • • • • • • • • • • • • •	********	
5620	C00805(2)	# LBF (OFFSE	1)		
5630		= LBF(OFFSE			
5640	C TEST FOR	- LDF (UFFSC	<u></u>		
		NEGATIVE SIGN			
5659	WUNK # LB	F(OFFSET) .A	ND. "200		
5560	IF (WORK,	NE.0) COORDS	(4) = "377		
5670	<u> </u>		•		
5680	GO TO 99701				
5590	<u>C</u>				
5760	С				
5719	C				
5720	C***************	**********	*********	******	
5730	C INCLUDE CZC	SMRG, INC"			
5740	C+++++++++++++++++++++++++++++++++++++	*********	*********	******	
5750	C .		10120200000		
5760	Ċ				
5770	END				
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APPLICATIONS DIVISION

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COASTAL ZONE COLOR SCANNER GROUND CONTROL PROGRAM

	C.FTN	26-FE8-81 12:47:11 PAGE 1
10	<u>с</u> С	COLOTAL TONE COLOR CONNER COOLUND CONTROL - CTCO
20	Ċ	COASTAL ZONE COLOR SCANNER GROUND CONTROL - CZGC
40	Č	ANAPTED ON OCTOBER 8, 1980 BY GLENN DAVIS FROM LGC.
50	<u>č</u>	REV 2.0 R DVE 30 OCT 80 TO INCOMPORATE CONICAL SCAN
60	Ċ	REV 2,1 R DYE 11 DEC 80 TO USE LAGRANGE INTERPOLATION
70		
80	C	
90	C	
100	Ċ	
110-	Ċ	
120	C	
130	C	**** WARNINGI CHANGES IN MODEL SHOULD ALSO BE MADE IN CZMP.FTN
140	C	
150 -		REAL&4 LT, LN, LTLP, UNLP, LTD, LND, LTSH, LNSH, SID (4)
167		DIMENSION IX(100), IY(100), PLT(100), PLN(100), EN(100), EE(100)
170		DIMENSION TALF(4), PALF(4,100), JUL(390), PALT(100)
180 -		DIMENSION A(10), X(4), X8(4), SDY(4), R(4) DIMENSION A(15), Y(5), Y8(5), SDY(5), P(5)
190		DIMENSION A(15), Y(5), YA(5), SOY(5), P(5)
560		DIMENSION TT(4), TLT(4), TLN(4), TALT(4)
210		TNTEGER+2 1PT(100), 1W(100), 1GN(100).
550	****	INTEGER + 2 AN, AE, AY, RPF, ONE
230		LOGICAL + 1 TM (8), DA (9)
249		DATA RE, RP, DPR/6378200., 6356800,, 57, 2957795/
250		NATA AN, AE, AV/ N *, *E * , * * *
5.90		CATA SF/1000000./
510		DATA REV/2.1/
580		LF(1P,NIP,T,J)=J=I+NIP+1=((IP=I+1)*(IP=I+2))/2
290		ONE = 10
	C	
310		WRITE (5,20) REV
350	50	FORMAT ("OCOASTAL ZONE COLOR SCANNER GROUND CONTROL REV
330		• ,Fs,1,//)
340	30	FDRMAT (2F10,0)
350		RFS#Rt#RF
360		EC#RE/RP
370		
380		CALL ASSIGN 16, "DRICZCG,LST")
390		LP15
490	C	
410 420		IALL = 1968 LLD = JALL / 2
430		
4 5 M	<u>C</u>	CALL ASSIGN(4, "CSP, DAT")
450		READ (4,40) SID
460	40	FORMAT(444)
479		WRITE (5, 40) STO
480		READ (4,50) TO
490	50	FORMAT (2F12.6, F12.6)
500-		UO 60 1=1,4
510		READ(4,50)TLT(1),TLN(1),TALT(1),TT(1)
520 -	- 60	WRITE(5,50)TLT(1),TLN(1),TALT(1),TT(1)
530		READ (4,50) TILT
540		CALL CLOSE (4)
550-		TSENINT(TILT)/(2.*DPR)
560	····· · · · · · · · · ·	FF=45./DPR



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	C,FTN	26-FEB-81 12147111 PAGE 2
570	1	!
580 580		
590	<u> </u>	CALL ASSIGN (2, "OBIDSL, 001")
600		DEFINE FILE 2(100,18,U,INDX)
610		CALL ASSIGN (3, 'DRIMCP, NAT')
620		nie z de Terre e de la herre de Terre e a fin in ella de de de den ner ner proprie consense managemente en commune de commune de la fin de la de
630		Mel
640		
45Ø	<u>C</u>	-
660	<u> </u>	
570 <u>-</u> 580 -		NEØ
590	160	CONTINUE
700		I=N+1 READ (3,170,END=200) M,PLT(I),PLN(I),ALT,(PALF(J,I),J=1,4)
710	170	FORMAT (13,1%,2F12,6,F12,1,1%,4A4)
729		1F (M,EQ,0) GO TO 160
730		I=N+)
140		READ (2'M) IG, ND, IX(I), IY(I)
750		1F (JG,E0,0) GO TO 160
161		N=N+1
779		1PT (N) #M
7 H Ø 7 9 9		
800		IGN(N)=1G+1
B10	C	
A20	<u> </u>	GO TO 160
A 3 Ø	C	
R40	200	CALL CLOSE (3)
850		WRITE (5,210)
360	210	FORMAT ("SPITCH AND ROLL DEGREE ? ")
870		READ (5,220) TOG
88 <u>0</u> 890	550	FORMAT (15,2F10,0)
900		IF (106,LT.1.0R.106,GT.3) 106=1
910	C	
050	230	CONTINUE
9.50		kRJTE(5,251)
940	251	FURMAT('\$LNSH,LTSH,VM,TILT ? ')
950		READ (5,252)LNSH, LTSH, VM, TS
960	225	FORMAT(4F19,0)
970	·	TS=TS/DPR
98 <u>0</u> 990		DU 440 JI=1,10 K=1
799		N 240 I #1,4
710		¥B(I)≠0.
050		IF (JI, EQ, 1) R(1)=0.
3 3 9		DD 240 J=I,4
740		A(K)=0,
150	240	K#K+1
760		Ks]
770		DO 250 I=1,5
780 790		YR(I)=0,
100		DO 250 J=1,5
19	- ***	B(K)=0,
150	250	KsK+1



APPLICATIONS DIVISION

130	SSN#A,	
140	\$\$E=0. \$\u00e4=0.	
150		
170	CTEW=0, CTEW2=0,	
180	CINSER,	
200 210	00 260 ICP=1,N St = Fluat (IV(ICP)) - 485,	NORMALIZE ALONG TRACK DIMENSI
55%	ST = ST /485.	I NORMALIZE ALONG TRACK DIMENSI I Normalize Along Track Dimensi
249	T=(970,-IY(ICP))+128,/(970,+60,)+10
250	CALL LGR(TT, TLT, T, LTD)	
260 270	CALL LGR(TT;TLN,T,LND)	
	CALL LGR(TT,TALT,T,ALT) C WRITE(5,50)LTD,LND,ALT,FLOAT(IY	(100)
298 1		
300	LT = LTD / DPR	
319	LN = LND / DPR	
320	LNELNELNSH	
330	LT#LT+LTSH SLT=SIN(LT)	
350		
360	SH=,15839/CLT	
370	CH=+SOFT(1,=SH+SH)	
380	HD=ATANP(SH,CH)	
390	HDEHD+YW)
400	HDDSHDSDPR	
419 (429	ALEATAN (SLT/(EC+CLT))	
430	RAL = RE + COS (AL) + ALT + CLT	
440	X0=HAL+COS(LN)	
450	YOBRAL +SIN(LN)	
460	ZØBHP+SIN(AL)+ALT+SLT	
470	C=PAL=#AL,+Z0+Z0+ECS=RES GCLT=ATAN(Z0/RAL)	
490 1		
510	RL= .00	
520	RL=RL+(((R(4)+ST+P(3))+ST+R(2))+S	T+R(1))/ALT
530		* - D / 1 / / 1 *
540	PT#PT+(((P(5)*ST+P(4))*ST+P(3))*S HD#HD=P(2)	177(1)]/ALT
550 560 1	R0+R0+F(2)	
570	PNsIX(ICP)+LLD	
560	TH=PN+VM/1000000.	
590	X1=0.	
600	V1=0.	
610	71=ALT CALL SAP(V1 71 TS V2.72)	
620	CALL SAR (x1, Z1, T5, x2, Z2) Y2=Y1	
640	CALL SAR(Y2, X2, -TH, Y3, X3)	· · · · · · · · · · · · · · · · · · ·
650	73=22	
660 -	CALL SAR (X3, 23, FF, X4, 24)	
67 7	¥4=¥3	
682	Y4=-X4 IMIRROR REFLECT	ION
	-	·



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SEQ	C.FTN	26-FEB-81 12147111 PAGE 4	• •
1690	CALL	L SAR(X4,Z4,#Ff,X5,Z5)	*****
1700	¥5=1	ΥΔ	
1710		SAR (Y5, X5, TH, Y6, X6)	
1720	75=2		
1750		SAR(146,76,-TS,17,27)	,
1740	¥7=1		
1750	CALL 22=2	SAR(X7, Y7, -RL, X2, Y2)	
1770		SAR (72, ¥2, P¥, Z3, ¥3)	
1780		SAR (Y2,Z3,HD,Y4,Z4)	
1790	CALLS	SAR (24, x3, GCLT, 25, x5)	
1800		SAR (Y4, X5, LN, Y6, X6)	
1810	C	a na maine a tana " E Marina in tar anina mana mana manana manana ana manana manana ana	
1824	AGETS	**6+Y6*Y6+Z5*Z5*ECS	
1830	80=5	+ (x6+x0+Y6+Y0+Z5+Z0+ECS)/AQ	
1840	and the second sec	(-BQ-SQRT(BQ+BQ-4, +C/AQ))	
1850	XE=X6	· · · · · · · · · · · · · · · · · · ·	<u></u>
1860	YE=Y61		
1870	ZE=25+	A CONTRACTOR OF A DESCRIPTION OF A DESCR	
1890 1890		ATAN (ZE+ECS/SQRT (XE+XE+YE+YE)))PR+ATAN2 (YE, XE)	
1900		DPRALTLP	
1910		TLP-PLT(ICP)	
1920		NLP-PLN(ICP)	
1930	WT#IW	· · · · · · · · · · · · · · · · · · ·	
1940	ENT=EL	TARE/DPR	
1950	EE I = EL	N*RE*CLT/OPR	
1960	CALL S	SAR (ENI, ELI, HD, PTE, RLE)	
1970		RLE+COS(TH)	
1980	X(1)#H		
1990 <u>-</u> 2000	X (2) = S X (3) = S	a a construction of the second se	
2010		5T+ST	
2020	K=1		
2030	· _ · _ · · · · · · · · · · · · · · · ·	8 [2],4	
2040		= X B (I) + X (I) + W T	
2050	00 566	n J=1,4	
2060		A (K) + X (I) + X (J) + WT	
2070	500 K#K+1		
2040	<u>C</u>		
2090	Y())==		
2100 2110	¥(3)=5 ¥(4)=5		
2120		STASTAST	
2130	T=(5)Y		
2140	C		
2150	K=1		
2160		7 [=1,5	
2170		*YB(1)+Y(1)+WT	
2180		7 J=1,5	
5190		3(K)+Y(I)+Y(J)+WR	
5500	270 K=K+1		
2210	SWESWE		
5550			
2230	<u>+96=53</u> EN(ICF	SE+FE1+EE1+WT	
2240	ENILL		
			······

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SEQ	C.FTN	26-FEB-81 12147111 PAGE 5	
2250		EE(ICP)#EEI	
5560		CTEW+CTEW+TH+RLE	
2270	• • • • • • • • • • • • • • • • • • •	CTEW2=CTEW2+TH+TH+RLE	
2280	380	CTNS=CTNS+THaTHaPTE	
2290		CONTINUE	
2300	C		
2310 2320			
2340		CTEW=CTEW/SW CTEW2=CTEW2/SW	
2340		CTNS+CTNS/SW	
2350°``		K=1	
2360		no 290 1=1,4	
2370 "		DO 290 J = 1,4	
2340		A(K) + A(K) - XB(1) + XB(J) / SW	
2340	290	K*K+1	
2400 "		K=1	
2410		00 300 1*1,4	
5450	و معرف من معمد و مار بلد	XH(I)*XB(I)/SW	
2430		DO 300 J+1,4	
2440		A(K)#A(K)/(SW+1,)	
2450		K = K + j	
2460		00 310 1=1,4	<u>.</u>
2470		SDX(1)=SONT(A(LF(4,10,1,1)))	
2480		K = 1	
2490		NO 320 I=1,4	
2500		NO 320 Jal,4	· · · · · · · · · · · · · · · · · · ·
2519		A(K)#A(K)/(SDX(1)*SDX(J))	
2520 -		K=K+j	
2530		00 330 J=2,1+10G	
2540 ~~	· · · · · · · · · · · · · · · · · · ·	1F (A(LF(4,10,1,1)).LT.1.E-5) GO TO 740	
2550		CALL STEP (A, 10, 4, 1)	
2560	C		
2570		Y(1)=X8(1)	
2580 -		00 340 1=2,1+10G	
2540		x(1)=SDx(1)+A(LF(4,10,1,1))/SDX(1)	
2640		X(j)=X(j)=X(1)+X8(1)	
2610		DO 550 I=1,1+10G	
5650	350	R(I)=R(I)+X(I)	
5630	C		
2540		Kel	
2550		NO 360 1+1,5	
5960		DN 360 J=1,5	
2670		R(K)=R(K)-YR(])+YB(J)/SW	
2680		K*K+j	
2690		K=1	
2700		00 370 I+1,5	<u></u>
2710		YA(1)=YB(1)/SW	
2720		DO 370 J=1,5	
2730	Contraction of the second second	B(K)=H(K)/(SW-1.)	
2740			
2750		00 340 1=1,5	
2760		SDY(])=SQRT(B(LF(5,15,1,1)))	
2770			
2780		D(390 1=1,5	
2790		DO 390 J=1,5	
2800		R(K) ± R(K)/(SDY(I) + SDY(J))	···· ··· ···
		, • •	
	• ••• • •••••		

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	C.FTN 1	26-FEB-81 12147111 PAGE 6
810	390 K=	K+1
820	00	400 I=2,2+10G
830	IF	(A(LF(5,15,1,1)),LT,1,E-5) GO TO 740
940		LL STEP (8,15,5,1)
850	<u>C</u>	
863		1)=Y8(1)
870	00	410 1•2,2+10G
880		1) + SDY(1) + B(LF(5,15,1,1))/SDY(1)
890 900	410 Y(1)*v(1)+v(1)*v0(1)
910		420 T=1,2+TDG I)=P(I)+Y(I)
950		1)\$P(1)\$T(1) N#SSN/SW
930		E = SSE / SW
940		«->>=>>> N≠SQRT(\$\$N):
950	en	F ACAUT/CCES
960		WRITE(5,430)50N, SDE
970	430	FURMAT (4F15,1)
980	440 CO	NTINUE
990	C	
900		WRITE(5,441)CTEW,CTEW2,CTNS
010	441	FURMAT (3E15,5)
020	C	
030	445 CA	LL DATE (DA)
040		LL TIME (TM)
950	WR	1 [E (LP, 450) REV, DA, TM
060	450 FO	RMAT ("1 COASTAL ZONE GROUND CONTROL POINTS REV ", F3, 1, 5x, 9A1, 2x
979	1,8	A1,//)
980	WR	1 FF (LP, 460) SID
090		RMAT (* SCENE 10 *,444,/)
100		NWITE(LP,465)LNSH,VM,TS#OPR
110	465	FORMAT (3F12,5)
120	WR	11E (LP, 470) SDE, SDN
130	474 FO	PMAT (" RMS ERRORS EAST ", F7.1." NORTH ", F7.1." (METERS)")
140	WR	1 TE (LP, 48%) P(1), P(3), P(4), P(5)
150		RMAT ('0PITCH:',4F10,1)
160	WR	11E (LP, 490) R
170	490 FO	HAT (* RULL 1*,4410,1)
180	WR	ITE (LP, 540) P(2)+1, E6
190		RMAT (* YAW \$*F10,1)
200	WR	ITE (LP,510) RMAT (//* POINT FILE WEIGHT EAST NORTH*,/)
210	510 FO	RMAT (//* POINT FILE WEIGHT EAST NORTH*,/) 530 I=1,N
250		
230		DE=NINT(EE(I)/SDE) DN=NINT(EN(I)/SDN)
250	םו <u>ק</u> או מוק	ITE (LP, 520) IPT(I), IGN(I), IW(I), EE(I), NSDE, EN(I), NSDN, (PALF(J, I
590 -		J=1,4)
210		RMAT (14, 15, 16, F14, 1, 14, F12, 1, 14, 4X, 4A4)
280		NTINUE
249		1F(LP, E0, 6)60 TO 610
300		WF=0
310		ITE (5,540)
120	549 FO	RMAT ('SALTER POINT WEIGHT ? ')
330	550 RE	AU (5,560) 1P,1TW,FFF
340		RMAT (2110,F10,0)
350		(IP.EQ.0) GO TO 590
360		W#TAHS(ITW)
· · · · · · · · · · · · · · · · · · ·		а у бали и ба кули бали и на сели и на сели сели сели и на нако сели сели и на нако сели и на сели и на сели и Па
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3E Q	C.FTN	26-FEB-01 12147111 PAGE 7
370	•••••	••••••••••••••••••••••••••••••••••••••
3380		DD 570 I=1,N
1490		IF (1P,EG, [PT(I)) IW(I)=ITW
5400	570	CONTINUE
1410		IPWF=1
1420 -		WRITE (5,580)
5430	580	FORMAT ("SANOTHER ? ")
5440		GO TO 550
1450	590	1F (1PWF, NE, 0) GO TO 230
3460	-	WRITE (5,600)
5470	600	FORMAT ('S DUTPUT ON LINE PRINTER ? *)
480		READ (5,605) LPA
5490	605	FORMAT(A1)
1500		IF (LPA.NE.AY) GO TO 610
3510		LP=6
1250		GO TO 445
5530	610	WHITE (5,620)
3540	620	FORMAT (SPRINTER PLOTS ? ")
3550		READ (5,605) LPA 7F (LPA,NE,AY) GO TO 720
560 570	C	
5580	·····	WRITE (5,630)
1590	630	FORMAT ('SMETERS PER DIVISION ? ")
5600	0 3 10	HEAD (5,30) PPS
5610		1F (PPS.EQ.0.) PPS=200.
1650		PP\$F*PP\$/10.
\$630	· · · · · · · · · · · · · · · · · · ·	WRITE (6,640) PPS
3640	640	FORMAT ('1PIXEL V.S. ERRORS', T28, 'EAST', T88, 'NORTH', F10.0, 'METERS/
5650		
3660		00 670 I=1,60
3670 -		LL+(1-1)+33
3680	<u></u>	LU=I+33
3690		D0 660 J=1,N
5720		1F (1W(J), EQ.0) GO TO 660
5710		17 (1x(J), LE, LL) GO TO 660
5720 🗂		1F" (1x(J),GT,LU) GD TO 660
5730	•••••	1EE = EE (J) / PPSF + 30,
3740		IEN=EN(J)/PPSF+90.
3750 **		IF (IEE,LT,2) IEE+2
3760 🗂		1F (1EE.GT.60) IEE.60
\$770		JF ([EN.1.T.6]) IEN=61
5789		IF (IEN.GT.120) IEN=120
5790	·····	WR] TE (6,650) 1PT(J), 1PT(J)
1800	650	FORMAT ("+", T<1EE>, 17, T<1EN>, 12)
5810	660	CONTINUE
8820	670	WRITE (6,680)
3830	680	FORMAT (5(9x, *1*), 10x, 5(9x, *1*))
5940		WHITE (6,690)
3850	690	FORMAT ('ILINE V, S, ERRORS', T28, 'EAST', T88, 'NORTH'/)
5860		DN 710 I=1,60
3870		
588Ø		
3890		DO 700 J=1,N
5900		1F (1W(J),EQ.0) GO TO 700
3910		1F (IY(J), LE, LL) GO TO 700
3920		1F (IY(J),GT,LU) GO TO 700
	·	

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SEG	C.FTN 26-FEB-81 12147111 PAGE 8
10	
3930	18E=EE(J)/PP\$F+30
<u> </u>	IEN=EN(J)/PPSF+90, IF (IEE_L1,2) IEE=2
3960	IF (IEE, GT, 60) IEE=60
3970	IF (1EN,LT,61) 1EN=61
3980	IF (IEN, GT, 120) IEN=120
3940	WRITE (6,650) IPT(J), IPT(J)
4444	700 CONTINUE
4010	710 WRITE (6,680)
0920	720 WRITE (4,730) P(1),P(3),P(4),P(5)
4030	WRITE (4,730) R
4000	WRITE (4,730) P(2)+1,E6
4050	730 FURMAT (6F10, 5)
4050	CLOSE (UNIT+6, DISPOSE= PRINT)
4070	STOP
4040	740 WRITE (5,750)
4090	750 FURMAT (" GCP DATA NOT SUITABLE FOR DEGREE SELECTED")
4100	\$10P
4110	END
4120	SUBROUTINE LGR(V , FV , XI , XREBLT)
4130	<u>c</u>
4140	C
4150	C
4160	C FNVALI -
4170	C I FNVAL3 -
4180	C I XRESLT - I FNVALA -
4192	C I FNVAL2 • I I
4200	
4210	C 1
4220	C VAL1 - XINTRP - VAL2 - VAL3 - VAL4 -
4230	
4250	C GIVEN FOUR VALUES (VAL1 => 4 OR ARRAY V) AND
4260	C GIVEN FOUR CORRESPONDING VALUES (FNVAL1 -> 4 OR ARRAY FV) THAT
4270	C ARE A FUNCTION OF THE FORMER VALUES,
4280	C AND GIVEN A VALUE XINTRP (XI) THAT IS ADJACENT TO VAL1 -> 4
4290	C THEN THIS HOUTINE RETURNS A VALUE, XRESLT, THAT IS THE LAGRANGE
4300	C INTERPOLATION OF XINTRP ABOUT FNVAL1 -> 4.
4310	C
4320	C
4330	
4340	REAL V(4) , FV(4) , XRESLT , XI, PART(4)
4350	REAL A, B, C, D
4360	C
4370	A = XI - V(1)
4380	A = 11 • V(2)
4390	C = XI = V(3)
4400	D = XI = V(4)
4410	0
4420	D TYPE 500, A, B, C, D
4450	D 500 FDRMAT(4F12,6
4440	D TYPE 500, V
4457	D TYPE SAD, FV
4460	D TYPE 500, XI
4470	
4480	PART(1) = (B + C + D)
	3
	3



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4490	•	/((V(1) - V(2)) + (V(1) - V(3)) + (V(1) - V(4)))
4500	с	+ FV (1)
4520		2) = (A + C + D)
4530		/ ((v(2) • v(1)) • (v(2) • v(3)) • (v(2) • v(4)))
4540	•	+ FV (2)
4550	C	· · · · · · · · · · · · · · · · · · ·
4560	PART (3) * (A ± B ± D)
4570	•	/((V(3) - V(1)) + (V(3) - V(2)) + (V(3) - V(4)))
4580	+	+ FV (3)
4590 4600	C	4) = (A * B * C)
4610		/ ((V(4) - V(1)) + (V(4) - V(2)) + (V(4) - V(3)))
4620	•	* FV (4)
4630	XRESL	T = PART(1) + PART(2) + PART(3) + PART(4)
4649	C	n ann ann a na 316 anna a canna 77 an ann an 1971. 'S feannach a falaich Éannach an ann an ann an ann an ann an
4650	D TYPE	500, PART
4660	D TYPE	500, XRESLT
4679	C	
4697	RETUR	
4700	END	
4710		UTINE STEP (A,NIP, IP, KAY)
4720		SION A(15)
4730		,JX)=JX=IX+NIP+1=((IP=IX+1)*(IP=IX+2))/2
4740		F (KAY,KAY)
4759	M = ?	
4760		1 1=1,7P
4770		Jel, 1P
4780	MEM+1	-KAY) 10,70,20
4800	10 LIK#L	F(1,KAY)
4810	01 00	
4420		F(FAY,1)
4850	30 IF (J	+KAY) 40,70,50
4840		F(J,KAY)
4850	GO TO	
4860	50 LKJ#L	F (KAY, J)
4870	60 A(M) = 70 Conti	A (M) + A (L TK) + A (LKJ) / A (LKK)
4890		0 I=1, IP
4900	IF (1	-KAY) 80,110,90
4912		F(1,KAY)
4920	GO TO	100
4930	90 L1K#L	F (KAY, 1)
4940) #A (L [K) /A (LKK)
4950	110 CONTI	NIE) == 1 , / A (LKK)
4950	RETUR	
4980	END	
	·	
	·	



APPLICATIONS DIVISION

MAPPING PROJECTION POLYNOMIAL GENERATION PROGRAM

	1	P.FTN 26-FEB-81 12144128 PAGE 1
10	C	COASTAL ZONE SCANNER MAPPING POLYNOMIALS
56	C	ADAPTED FROM HMP BY GLENN DAVIS ON JANUARY 13, 1981
30	C	
40		LOGICAL ADVFL
50		DOUBLE PRECISION X,XN,A
60		DOUBLE PRECISION XMEAN, STORY, POSD
70		DIMENSION ¥(40), A(840), C(40), F(40), FE(40)
80		DIMENSION XMEAN(40), STDEV(40), B(40), D(40), TOLEV(40), R(40),
90	· · · _ - · · · · · · · · · · · · · · · · · · 	1EN(40), INEN(40)
100		DIMENSION $TT(4)$, $TLT(4)$, $TLN(4)$, $TALT(4)$
110		INTEGER SID(S), AY, PPF
150		LOGICAL 1 IT(10), HFN(18), TH(8), DA(9)
130		REAL LT, LN, LTLP, LNLP, LTSC, LNSC, PT, RL, LTSH, LNSH, SF
140		REAL LTD, LND
150		DIMENSION PS(2), PITCH(5), ROLL(4), DELTA(2)
160		CUMMON_X, XN, A, C, F, FE, L, NTGC, IP, NIP, FINC, FOUT, KAY, FLAG, KOEP, OF, TO
170		DATA RE, RP, DPR, SF/6378200, , 6356800, , 57, 2957795, 1000000,/
180		DATA RMVE/4HRMVE/,ENTR/4HENTR/
190		DATA AY/*Y*/
564		LF(1x, Jx)=Jx=Ix+N1P+1=((IP=Ix+1)+(IP=Ix+2))/2
510		ADVFL . TRUE
550		KB#5
230		LP=3
240		CALL ASSIGN(3, CZSMP,LST')
250		WRITE (KH, 20)
260	20	FORMAT (""COASTAL ZONE SCANNER MAPPING POLYNOMIALS REV 1.0"/
510		1'SPROJECTION NUMBER ? ')
280		READ (KR, 30) IPN, LR
201	30	FORMAT (2110)
500		RFS=RE+RE
310		ECERE/RP
320		ECS=EC+EC
330	C	
340		IALL # 1968
\$59		LLD = IALL / 2
360	С	
378		WRITE (KP, 37)
380	37	FORMAT (*STMAGE TITLE ? *)
390		READ (KB, 31) IT
400	31	FOPMAT (10A1)
419		CALL GHEN (1T, HEN)
950		CALL ASSTGN (2, HFN)
439		READ (2,32) SIN
440	35	FORMAT (1×,5A2)
450		READ (2,33) NIE,NIL,NHP,IIP,NIPP,IEO,ILO
460	33	FARMAT (715)
470		PEAN (2,34) NELTA(1), DELTA(2), LTSC, LNSC
480	34	FORMAT (4F12,6)
490		CALL CLOSE (2)
500		CALL GT(LTSC,LNSC, IPN/U0, V0)
510	C	1
520		CALL ASSIGN(4, CSP, DAT")
530		PEAD (4,40) SID
540	40	FORMAT(5A2)
558		WRJ1E(5,401810
560		READ (4,50) TO

74

.



•

579 580	50 FORMAT(2)	<u> </u>
		612 6.612 D.612 A.
5 M M		F12.6.F12.0.F12.6)
1.1.1	00 60 1#1	
590	NEAD (4, 50)TLT(I),TLN(I),TALT(I),TT(I)
600	60 WRITE(5,	50) TLT(1), TLN(1), TALT(1), TT(1)
h10	READ (4,50	
629	RFAD (4,7	30) PITCH(1), PITCH(3), PITCH(4), PITCH(5)
630	READ (4,7	SN) NULL
540		30) PITCH(2)
650	730 FORMATISE	
660	CALL CLOS	
679		1LT)/(2,+0PR)
642	FF=45,/0P	k
690	С	
700	C	
710	1P=21	
150 .	NIP=(IP+f	
730 -	CALL ALTP	R1(,45)
740	°C	
750	CALL ASST	GN (1, *COEF, GEO*)
767		100) SID, IPN
770	100 FORMAT (S	
780	C	
790	CALL DATE	(DA)
800	CALL TIME	
		110) DA, TH
810		
950		X,941,2X,841)
A 30		,120) DA,TM
840		
850	120 FORMAT ("	ICOASTAL ZONE SCANNER MAPPING POLYNOMIALS '941,2X,441//)
860		,130) SID, IPN
870	130 FORMAT ("	SCENE ID ', 5A2, PROJECTION NUMBER', 14)
880	C	
890	WRITE(KB,	
900	251 FORMAT("S	LNSH, LTSH, VM, TILT ? ?)
910	READ (KB, 2	S?) LNSH, LTSH, VH, TS
920	252 FORMAT (4F	19,0)
930	TS = TS /	
940	Ċ	
953 ***	c	
960	C THITTALT7	E ACCUMULATORS AND MATRIX A
970		
980	NO 660 1T	1±1.2
9997	Mag	
999		(. TP
	DO 140 IS	
010	XMEAN (1)=	
020	00 140 J=	111
032	M 2 M + 1	
949	140 A (M) =0.	
050	<u>r</u>	
969	N=0	
070	C	
088T		S = [, 27
197 -	TY = (INS	-14) * 35 + 485
100 -		T (IY) - 485. NORMALIZE ALONG TRACK DIMENSION
110	ST . ST /	
120	· · · · · · · · · · · · · · · · · · ·	
	مربق به مساله الي بالا مسينة الإلميسية ما السينية المالية المسينة المالية المسينة المالية المالية المالية الم التي المالية المالية المالية المالية المسينة المالية المسينة المالية المالية المالية المالية المالية المالية ال	



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	CZSMP.FTN 1	26-FE9-81 12144128 PAGE 3
138	T#(970	-TY)+128./(970.+60.)+TØ
140	CALL L	GR(TT,TLT,T,LTD)
150	CALL L	GR (TT, TLN, T, LND)
160	CALL L	GR(TT,TALT,T,ALT)
179		LT.3) GOTO 142
180	WPITE	(5, 50)LTD, LND, ALT, FLOAT (IY)
190	142 CONTIN	
204	C	
210	LT = L'	TD / DPR
554		NO / DPR
239	LN=LN+	LNSH
240	LT=LT+1	LTSH
250	SL T=SI	N(LT)
260	CL. 7 = CO	S(LT) :
270 -	SH=.15	839/CLT
580		RT(1,-9H+5H)
299	HDEATAI	N2(SH,CH)
300	HD=HD+	
510	HODSHD	
320	C	· · · · · · · · · · · · · · · · · · ·
330	AL = 47 AI	N(SLT/(EC+CLT))
340 -		+COS(AL)+ALT+CLT
350		+COS(LN)
350		+S1N(LN)
370		SIN(AL)+ALT+SLT
380		#RAL+70+20+ECS+HES
390		TAN (ZØ/RAL)
400	C	
010	C	рану и отобу у 1 г. на
420	PL= 0	3
430		(((ROLL(4) + ST+RULL(3)) + ST+ROLL(2)) + ST+ROLL(1)) / ALT
440	PTE 0	
450		(((PITCH(5)+ST+PITCH(4))+ST+PITCH(3))+ST+PITCH(1))/A
460		PITCH(2) / SF
470	C	
480		1FW # 1 , 27
490		1EW-14} + 70 + 984
500		X - LLO
510	THEPN+1	
520	¥1=9.	
530	¥1=9.	
540	21=4LT	
550		AR (X1, Z1, TS, X2, Z2)
560	¥2=¥1	The second s
570		AR (Y2, X2, -TH, Y3, X3)
540	23=22	<u>, , , , , , , , , , , , , , , , , , , </u>
590		AR (X3,73,FF, X4, Z4)
693	¥4=¥3	
610	X4=-X4	IMTRROR REFLECTION
650		AR (X4, 24, +Ff, X5, 25)
630	Y5=Y4	
640		AR (Y5, X5, TH, Y6, \$6)
659	Z6#25	
		AD (V & . 7 &
66 <u>0</u> 670		AR (x6, 26, -TS, x7, 77)
· · · · · · · · · · · · · · · · · · ·	<u> </u>	AD / V7 V7 - 01 V7 V7
680	LALL SA	AR (X7, Y7, +RL, X2, Y2)



SEG	CZ3MP,FTN	26-FEB-81 12144128 PAGE 4
14.00		• • • • • • • • • • • • • • • • • • • •
1690	22#27	0 /73 V3 07 78 V24
1700	PALL SAL	R (22, X2, PT, 23, X3) R (Y2, 23, HD, Y4, 24)
1720		R (24, X3, GCI.T, 75, X5)
1750	CALL SAL	R (Y4, X5, LN, Y6, X6)
1740	C	
1750	AGEX6±X	6+Y4+Y6+Z5+Z5+ECS
1760	BQ#2,*()	x6+x0+Y6+Y0+75+20+ECS)/AQ
1770	T#,5+(=	HQ-SQRT(HQ+HQ-4,+CO/AQ))
1780	XERX6+T	
1790	YF=Y6+T	
1800	7E=25+1	
1810		AN(7E+ECS/SQRT(XE+XE+YE+YE))
1820		N+ATANZ(VE, XE)
1830	LILPOP	
1840		(LTLP, LNLP, IPN, U, V)
1850	U= (U=1)A	· · · · · · · · · · · · · · · · · · ·
1860 1870	V=(V=V0	
1880		GT.2) WRITE(KB,168) LTLP,LNLP,U,V
1890		2F12,3,2F12,6)
1920	C	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
1910	K#1	۲
1920	U1=1.	
1930	00 175	I • 1 , 6
1940	VJ=1.	
1950	DO 170	J=1,6
1969	X(K)a]]	T+VJ
1970	VJ=VJ±V	
1980	17.0 K=K+1	
1990	175 UI#UI+U	
2000	Ć	
2010		,E0,1) X(1)=IX
5050		*E0*5) X(1)+IA
2030	N#N+1	· •
2040	MEØ.	
2050	DO 180	
2060	Do 180) #XMEAN(I) +X(I)
2080	M#M+1	
2290		M)+X(J)+X(J)
2100	180 CONTINU	
2119	XN=N	
2120	XNT=N	
2130	RESOFEX	
2140	M = Ø	
2150	PESDF=X	
2160	NO 190	
2170	D0 190	JEI,IP
2180	MaM+1	
5100	190 A(M)=A(M)=XMEAN(I)+XMEAN(J)/XN
5580	C	יין מרקאים אינער אפריאאין אינעראיין געראאין איז אייייעראיין איייעראיין איייעראיין איייעראיייעראיייעראיייעראיי איייעראייערא
2210		XMEAN WITH MEAN VECTOR, A WITH COVARIANCE MATRIX, A
5550	C COMPUTE	STANDARD DEVIATIONS
2230	L	
2240	MER	



	<u></u>	
2250		
2260	XMEA	N(1) = XMEAN(1)/XN
2270 2230		00 J.I. IP
2290	M=H+	
300		EA(M)/RESDF
310	200 CONT	
2320	<u> </u>	10 I=1, IP
330		LF(1,1) V(1)=DSORT(A(LII))
340	210 CONT	
350	C	INOC
360	<u> </u>	
370	C REPL	ACE UPPER DIAGONAL SECTION OF MATRIX WITH CORRELATION MATRIX
180	<u> </u>	1
390	Mag	
400		50 J=1,TP
410		50 J=1, IP
429	Mame	
430		1-11 220,240,220
447		*STOEV(I)*STOEV(J)
450		PUSD, EQ, 9.0) GO TO 230
460	Ā (H)	\$4 (M) / POSD
470		0 250
480	230 4(M)	
490		0 250
500	249 A(M)	
510	250 CONT	
520	C	**************************************
530		N-1,0
540	C	
550	C	
560	KDEP	s1
570	FINC	
580	FOUT	
590	TOLS	1, E-10
600	MAYS	TP=1P+2
610		60 I=1, IP
620	C(T)	
630 .	260 CONT	
649	LDD=	LF(KDEP,KDEP)
650	C(KD	EP) = 1, 0
660	NVD=	
670	DO 3	00 I=1, 1P
680	IF (1-KDEP) 270,300,280
690	270 LID=	LF(I, KOEP)
700		NVO+1
710	GO 1	0 299
720	280 L10=	LF(KNEP, I)
730		NVO+1
747	290 FEIN	<pre>() = A (LID) + + 2 + XN/() + + ((LID) + + 2)</pre>
750	300 CONT	
760	(1F=9	• P • •
770	L=0	
780	310 L=L+	
790	C CALL	SUBROUTINE TO ENTER VARIABLE, CALCULATE VALUES TO BE PRINTE
800		STEPRG (ADVFL)



APPLICATIONS DIVISION

SEQ	CZSMP	•,	26-FEB-81 12144128 PAGE 6
3819	*****	***********	**************************************
2819	320	ENTERARMV	320,620,330
2820	360	GO TO 340	
2830	110		
2840	339	ENTERSENT	
2450	349	LOCALF (KD	
2860		RESUF=XN=	
2879			(STOEV (KDEP) ++2) +A (LDD)
5998		RESMSERES	
2890			(HESSS/XNT)
59%0		REGOF=DF	
2917			(STDEV (KDEP) ++2) +RESSS
5950		REGMSEREG	
2430		FRATIO	GMS/RESMS
2940		STEHR=SOR	
2950		YMULTR=DS	QRT(1,-A(LDD))
2960		IDF=DF	
2970		INDFERESO	
~2980 ^{~~}		TF (LR.LT	,2) GU TO 370
2990		WPITE (LP	, 350) L, ENTER, KAY, XMULTR, STERR, RSSD
3010	350	FORMAT (1 STEP NUMBER , T35, I3/T5, VARIABLE , A4, D, T35, I3/ 0
3010		T MULTIPLE	R", T35, F8, 47T5, "STD, ERROR OF EST. ", T31, F12, 47T5, "RESID
3920		PAI SAMPLE	RMS DEV, ", T31, F12, 4)
3030	*****		, 360) IDF, HEGSS, REGMS, FRATIO, IRDF, RESSS, RESMS
3040	360	FUDMAT (M ANALYSIS OF VARIANCE //T28, "DF SUM OF SQUARES
3050			AN SQUARE F-RATIO'/T13, REGRESSION', 3X, 14, 3X,
			F14.3,3X,F14,3/T13, 'RESIDUAL', 5X, 14.3X, F16.3, 3X, F14.3)
3060		er 10, 5, 54	1 14931341, 14931131 KEOTOOPE 1341141341, 10631341, 1493
3070			E IS IN THE EQUATION IF C(I) IS LESS THAN OR EQUAL TO D.
3080	C	A VARIAUL	E 15 IN THE EQUATION IF C(1) 15 LESS THAN UN EQUAL TO BE
3090	C	· · · · · · · · · · · · · · · · · · ·	·
3100	370	NV]=0	
3110		NV0=0	
3150		ALPHASYME	
3130		DO 462 1	
3140		L11=(.F(1,	1)
3150		IF (1-KDE	P) 380,460,390
"3160 T	380	LID=LF(I,	, ×DEP)
3170		GO TO 400	
3180	390	LIDELF(KI)EP,1)
3190	400		GT.0.) 50 TO 410
3200	с		
3210	c	COMPLITE N	ULTIPLE REGRESSION EQUATION COEFFICIENTS, STO, ERROR,
3550		AND F TO	HEMOVE, FOR VARIABLES IN THE REGRESSION
3230	č		
3240		NVIENVI+	TDEV (KDEP) +A (LID) /STDEV (I)
3260		してい イントロー	STERR/STDEV(I))+OSORT(-A(LII)/XN)
		UINVVIJ≢(3 	3/KUVY///////////////////////////////////
3270		() ≭((∨⊴) ¶	
3289			PHA-R (NVI) +XMEAN(I)
3290		INENINVI	
3300		GO TO 42	7
3310	C		
3320	C		LE IS OUT OF THE REGRESSION IF C(1) IS GREATER THAN OR
3330	C	EQUAL TO	
3340	C		
3350	C		
3360	<u> </u>	COMPUTE	PARTIAL CORRELATION COEFFICIENTS, TOLERANCE, AND
	······································		
·····	<u> </u>		
· · · · · · · · · · · · · · · · ·			

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SEQ	LISHP	FTN 26-FEB-81 12144128 PAGE 7
3370	·	
3380 3380	c	F TO ENTER FOR VARIABLES OUT OF THE REGRESSION
3390	410	NVD=NVD+1
3400		N1EN(NVO)=1
3410		TOLEV(NVO)=A(LII)
3420		R(NVO) = A(LTD)/DSORT(A(LIT) + A(LDD))
3430		FE (NVO) = (A(LID) ++2+(RESOF-1,))/(A(LIT) +A(LDD)-A(LID)++2)
3440	420	IF (I-KAY) 460,430,460
\$450	430	TF (C(1)) 449,440,450
3460	449	
3470		GO 10 460
3480	450	FKAYSFE (NVO)
5490	469	CONTINUE
3500	C	
3510		7F (LR.LT.P) 60 TO 310
5920	C	WRITE HEADING FOR COEFFICIENTS
5530	C	
1540		WRITE (LP, 470)
3550	470	FORMAT (/57X,1H,/21X,21HVARIABLES IN EQUATION, 15X,1H, 19X,25HVARI
5560		BLES NOT IN EQUATION/57X,1H,/6X,8HVARIABLE,6X.11HCOEFFICTENT,2X.1
570		PHSTD. EPROR, 2X, 13HF TO REMOVE SY, BHVARIABLE, 4X, 13HPARTIAL CORP.
5580		SX, 9HTOLERANCE, 4X, 10HF TO ENTER/57X, 1H.)
590	<u> </u>	
600	С	PRINT THE REGRESSION ANALYSIS TABLE
5610	<u>C</u>	
2050		WRITE (LP, 480) ALPHA
5630	480	FORMAT (57%, 1H. /10%, 9H (CONSTANT, 1%, F11, 5, 2H), 24%, 1H.)
5640		NGO=A
1650	490	IF (NVO) 530,530,500
5660	500	1F (NVI, LE, 9) GO TO 560
1670		LNV=MIN0(NVI,NVO)
5680	<u> </u>	
1690	<u>c</u>	NVO AND NVI BOTH POSITIVE, PRINT BOTH SIDES OF TABLE
5740	<u>C</u>	
3710		D0 520 1=1,LNV
3720	F 1 0	WRITE (LP, 510) INEN(1), B(1), D(1), F(1), NIEN(1), R(1), TOLEV(1), FE(1)
5730 5740	510	FORMAT (8x, 13, 1x, F19, 5, 1x, F11, 5, 1x, F11, 1, 3H ,7x, 13, 1x, F19, 5, 1x,
1750	520	13,8,1¥,F12,4) CUNTINUE
5750 5760	764	NVIINUE
5770		NVO=NVO+LNV
1780	· · · · · · · · · · · · · · · · · · ·	NGOSLAV
1790		GO TO 490
800	C	
610	č	NVO ZERO, PRINT LEFT SIDE ONLY
1820	č	
930	530	IF (NVI, LE, A) GO TO 590
840		00 550 J=1,NVI
850	;	11=1+NGD
860		WRITE (LP,540) INEN(11),B(11),D(11),F(11)
870	540	FORMAT (AX, 13, 12, 19, 5, 1X, F11, 5, 1X, F11, 1, 3H)
880	550	CONTINUE
890		NVI . NVI + LNV ; RESTORE TO NUMBER OF VARS IN REGRESSION
900		GD TO 540
910	C	
920	Ċ	NVI ZERO, PRINT RIGHT SIDE ONLY
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SEQ	CZSMP	
3930	l	! !
3940	560	DO 580 I=1,NVO
3950		11•1+NGO
1446		WRITE (LP, 570) NIEN(II), R(II), TOLEV(II), FE(II)
1972	570	FORMAT (571,1H,,71,13,11,F19,5,11,F13,8,11,F12,4)
1980	580	CONTINUE
1990	590	1F (L-MAYSTP) 310,600,600
4000	610	WHITE (LP, 610) FORMAT (23H SPECIFIED STEP REACHED)
4320	659	RHS*RSSD+DELTA(IIT)
4030		IF (111.EQ.1) WHITE (LP.630) RMS
4040	630	FORMAT (""FAST-WEST FIT", F7, 1, " METERS RMS")
4850		IF (JTT.FO.P) WRITE (LP,640) RMS
anna [640	FORMAT ('ONDRTH-SOUTH FIT', F7, 1, " METERS RMS")
4270		WRITE (LP,650) NVI, ALPHA, (INEN(I), B(I), I#1, NVI)
4089		WRITE (1,650) NVI, ALPHA, (INEN(I), B(I), I*1, NVI)
4000	650	FORMAT (15, F10, 3)
4100 4110 "	660	CONTINUE CLOSE ('UNIT=3, DISP="PRINT")
4120		STOP 'RESULTS IN CZSMP.LST'
4130		
4148		SUBROUTINE STEPRG (ADVFL)
4150		LOGICAL ADVFL
4160		DOUBLE PRECISION X, XN, A
4170.		DIMENSION ¥(40), A(840), C(40), F(40), FE(40)
4180		COMMON X, XN, A, C, F, FE, L, NTGC, IP, NIP, FINC, FOUT, KAY, FLAG, KOEP, DF, TO
4190		LF(1x, Jx)=Jx-Ix+NJP+1-((IP-Ix+1)+(IP+Ix+2))/2
0200		VM1N=1,620
4210 4223		VMAX=-]. Kv]=₽
- 4230 -		KVC*0
- 4747 -		DO 30 K=1, JP
4250		JF (K EO KDEP) GO TO 30
45PG		JF (C(K),GT,0,) GO TO 10
027A		KV]=KV]+j
4280		V=F(KV])+(C(K)+7,)++4
4200		JF (V.GT,VMIN) GO TO 30
4300		
4320		GD TO 30
4330	10	K V D = K v D + j
4340		1F (C(K) .EO.1.) GO TO 30
4358		¥=FE(KVD)+(C(K)-2,)+=4
4368		1F (V.LE. VMAX) GO TO 30
4370		[KK* F(K,K)
4380		IF (A(LKK)-TOL) 30,20,20
1392	56	ΥΜΑΥΕΥ
4000		K MÅY SK
4410	30	
		IF (,NOT,ADVFL) GD TO 100 IF (VMIN-FODT) 40,40,60
	40	JF (L-1) 60,60,50
4450	50	C(KM]V)*C(KMIN)+9.
		KAY±KHIN
4472 -		FLAG:+1,
4480		GO TO 60

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4490	- 6Ø	·1F (V	MAXE	FINC) 90,	10,70	••••							• •
4500	70	CEKMA	x)=C	(KMA		•								
4510		KAY=K	MAX		• • • • • • • • • •									
4520		FLAGE	1.									e. ••		
4530	80	CALL	STEP									· ·		
4540		DF=DF	+FLA	G										
4550		RETUR						•						
4560	90	FLAGE	0.											
4570		RETUR	N											
4580	100	CONTI	NUE											
4590		1F (D	F.GT	.1.)	GD TI	50								
4600		60 10		•										
4610		END								*				
4620		SUBRO	UTIN	ELG	R(V	, FV	, XI	, XRESLT)					
4630	C						- Ferrar							
0600	C													
4650	C	*****								• •=•••				
4660	Ċ	FNVA	L1	•										
4679	C	••••••••••••••••••••••••••••••••••••••			•				Ē	NVAL3		· · · · · · · · · · · · · · · · · · ·		
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1690	C			1		1		ENVAL2 -	••••••		1		1	
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4710-	C 1.					• •••• •• ••• ••		••		ene 241 - 48 se	లి హెక	••••••••••••••••••••••••••••••••••••••	•	
4120	- <u>c</u> '-	*****	****	****	****		*****	********	, 	*****	****		∽≜≛≛≛	**
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4750														
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4780 4790 4800 4800 4800 4800 4800 4800 4850 485	C C C C C C C C C C C C C C C C C C C	ARE A AND G THEN T INTERP REAL REAL A = X B = X D = X TYPE TYPE TYPE TYPE TYPE	FUNC IVEN HIS OLAT V(4) A,H, I I I I 500, T(4F 500, 500, 1) * * 2) *	TION A V ROUT ION C,D V(1) V(2) V(3) V(2) V(3) V(3) V(4) A,B, 12,6 V FV XI C B (C FV	OF TI ALUE Y INE HE OF XII V(4) Y V(4) Y V(4) Y V(4) Y V(1) Y V(1) Y V(2) Y	IE FO (INTR TURN TRP XRE XRE VR VR <td>R MÉ R P (X S A V A ROUT SLT , SLT ,))) *</td> <td>VALUES, I) THAT ALUE, XR FNVAL1 XI, PAR VI, PAR VI, PAR</td> <td>IS / ESLT, -> 4, -> 4, -> 4, -> 4, </td> <td>DJACE THA</td> <td></td> <td>D VAL THE L</td> <td>AGRAN (4)))</td> <td></td>	R MÉ R P (X S A V A ROUT SLT , SLT ,))) *	VALUES, I) THAT ALUE, XR FNVAL1 XI, PAR VI, PAR VI, PAR	IS / ESLT, -> 4, -> 4, -> 4, -> 4, 	DJACE THA		D VAL THE L	AGRAN (4)))	
4780 4790 4800 4800 4800 4800 4850 4850 4850 485	C C C C C C C C C C C C C C C C C C C	ARE A AND G THEN T INTERP REAL REAL A = X B = X D = X TYPE TYPE TYPE TYPE TYPE TYPE TYPE TYPE	FUNC IVEN HIS OLAT V(4) A,H, I I I I 500, T(4F 500, 500, 1) * * 2) *	TION A V ROUT ION V(1) V(2) V(3) V(3) V(3) V(3) V(3) V(3) V(3) V(3	OF TI ALUE Y INE HE OF XII V(4) Y V(4) Y V(4) Y V(4) Y V(1) Y V(1) Y V(2) Y	IE FO (INTR TURN TRP XRE XRE VR VR <td>R MÉ R P (X S A V A ROUT SLT , SLT ,))) *</td> <td>VALUES, I) THAT ALUE, XR FNVAL1 XI, PAR VI, PAR VI, PAR</td> <td>IS / ESLT, -> 4, -> 4, -> 4, -> 4, </td> <td>DJACE THA</td> <td></td> <td>D VAL THE L</td> <td>AGRAN (4)))</td> <td></td>	R MÉ R P (X S A V A ROUT SLT , SLT ,))) *	VALUES, I) THAT ALUE, XR FNVAL1 XI, PAR VI, PAR VI, PAR	IS / ESLT, -> 4, -> 4, -> 4, -> 4, 	DJACE THA		D VAL THE L	AGRAN (4)))	
4780 4790 4800 4800 4800 4820 4820 4850 4850 4850 4850 4850 4850 4900 4910 4920 4950 4950 4950 4950 5010 5020 5020	C C C C C C C C C C C C C C C C C C C	ARE A AND G THEN T INTERP REAL REAL A = X B = X D = X TYPE TYPE TYPE TYPE TYPE TYPE TYPE TYPE	FUNC IVEN HIS OLAT V(4) A,H, I I I I 500, T(4F 500, 500, 1) * * 2) *	TION A V ROUT ION V(1) V(2) V(3) V(3) V(3) V(3) V(3) V(3) V(3) V(3	OF TI ALUE Y INE HE OF XII V(4) Y V(4) Y V(4) Y V(4) Y V(1) Y V(1) Y V(2) Y	IE FO (INTR TURN TRP XRE XRE VR VR <td>R MÉ R P (X S A V A ROUT SLT , SLT ,))) *</td> <td>VALUES, I) THAT ALUE, XR FNVAL1 XI, PAR VI, PAR VI, PAR</td> <td>IS / ESLT, -> 4, -> 4, -> 4, -> 4, </td> <td>DJACE THA</td> <td></td> <td>D VAL THE L</td> <td>AGRAN (4)))</td> <td></td>	R MÉ R P (X S A V A ROUT SLT , SLT ,))) *	VALUES, I) THAT ALUE, XR FNVAL1 XI, PAR VI, PAR VI, PAR	IS / ESLT, -> 4, -> 4, -> 4, -> 4, 	DJACE THA		D VAL THE L	AGRAN (4)))	
$\begin{array}{c} 4780 \\ 4780 \\ 4800 \\ 4800 \\ 4800 \\ 4800 \\ 4800 \\ 4800 \\ 4800 \\ 4800 \\ 4800 \\ 4800 \\ 4800 \\ 4800 \\ 4800 \\ 4900 \\ 4900 \\ 4900 \\ 4900 \\ 4900 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 5000 \\ 50$	C C C C C C C C C C C C C C C C C C C	ARE A AND G THEN T INTERP REAL REAL A = X B = X D = X TYPE TYPE TYPE TYPE TYPE TYPE TYPE TYPE	FUNC IVEN HIS OLAT V(4) A,H, I I I I 500, T(4F 500, 500, 1) * * 2) *	TION A V ROUT ION V(1) V(2) V(3) V(3) V(3) V(3) V(3) V(3) V(3) V(3	OF TI ALUE Y INE HE OF XII V(4) Y V(4) Y V(4) Y V(4) Y V(1) Y V(1) Y V(2) Y	IE FO (INTR TURN TRP XRE XRE VR VR <td>R MÉ R P (X S A V A ROUT SLT , SLT ,))) *</td> <td>VALUES, I) THAT ALUE, XR FNVAL1 XI, PAR VI, PAR VI, PAR</td> <td>IS / ESLT, -> 4, -> 4, -> 4, -> 4, </td> <td>DJACE THA</td> <td></td> <td>D VAL THE L</td> <td>AGRAN (4)))</td> <td></td>	R MÉ R P (X S A V A ROUT SLT , SLT ,))) *	VALUES, I) THAT ALUE, XR FNVAL1 XI, PAR VI, PAR VI, PAR	IS / ESLT, -> 4, -> 4, -> 4, -> 4, 	DJACE THA		D VAL THE L	AGRAN (4)))	



APPLICATIONS DIVISION

SEQ	CZSMP,FTN	26-FEB-81 12144128 PAGE 10
		,
5050	С	
5060	PART(3)	
5070	•	/((v(3) - v(1)) + (v(3) - v(2)) + (v(3) - v(4)))
5080	+	• FV (3)
5090	<u>C</u>	
5109	PART(4)	
5110	•	/((V(4) - V(1)) + (V(4) - V(2)) + (V(4) - V(3)))
5120	• ·	• FV (4)
5130		PART(1) + PART(2) + PART(3) + PART(4)
5140	C	
5150	D TYPE 500	7, PARI
5160	D TYPE 500), XRESLT
5170	C	
5190	C	
5190	RETURN	
5200	END	
5210		INE STEP
5220		PRECISION X, XN, A
5230	DIMENSI)N X(40), A(840), C(40), F(40), FE(40)
5240	COMMON	(, XN, A, C, F, FE, L, NTGC, IP, NIP, FINC, FOUT, KAY, FLAG, KDEP, DF, TO
5250	LF(IX,J)	()=JX-IX+NIP+)=((IP+IX+1)+(JP+IX+2))/2
5260	LKK=LF()	(47, KAY)
5270	MEØ	
5280	DO 70 I	n1,1P
5290	00 70 JI	1,1P
5300	M#M+1	
5310	IF (1-K)	AY) 10,70,20
5320	10 LIK+LF(1,KAY)
5330	GO TO 30	
5340	20 LIKELF(I	(AY,])
5350	30 IF (J-K)	AY) 40,70,50
5360	40. LKJELF(],KAY)
5370	GO TO 6	8
5389	50 LKJ=LF((AY,J)
5390	60 A(M)=A(M) = A (LIK) + A (LKJ) / A (LKK)
5400	70 CONTINUE	
5410	00 110	I = 1 , I P
5420	IF (]=K	AY) 80,110,90
5430 -	80 LIK#LF(1,KAY)
5440	GO TO 1	
5450	90 LIKELF(KAY, I)
5460	100 A(LIK) .	A (LÍK) *FLAGZA (LKK)
5470	110 CONTINU	
5480		-1.00/A(LKK)
5490	PETURN	
5500	END	
	<u> </u>	
		و مواد می از این
	مواكا دادة المنصبة بعدر المناه والغام مؤمر ميرمر واستيب	
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APPLICATIONS DIVISION

CZCS NEAREST NEIGHBOR RESAMPLING PROGRAM

SEQ	C75N	R,FTN13 26-FE8-81 12146188 PAGE 1
	1	
10	<u>C</u>	CZCS NEAREST REBAMPLER
50		
		ADAPTED BY GLENN DAVIS ON SEPTEMBER 21, 1980 PROM LNR
50		AUAFTED BY GLENN DAVIS UN BEFIERREN SI, 1400 FRUN LNR
60		
70		
80	<u> </u>	
90	<u> </u>	PARAMETER NSL=34, NBL=620, MAXOLY=16, BYTBYT=0, WRDHPD=2
102		INTEGER+2 WC, WR
110		INTEGER+2 INFF(NSL), ID(5), CVAL, START, FIRST
150		LOGICAL+1 LRF(2048), JBUF(NBL, NSL), ST(10), ST0(10), HFN(18)
130		LOGICAL*1 PRNTJH, PRNTHD
140		LIGICAL+1 DA(10), TH(10)
150		INTEGERAP ORN, IV (MAXOLY), NARMVS, MVTYPE, INSKIP, OUTSKP
		NELTS IS NUMBER OF RLUCKS TO SKIP ON SHORT READ
169	С	DIMENSION DRVAL(6), DCVAL(6), DR(6), DC(6)
180		REAL LTSC, LNSC
190		
290		CALL ASSIGN(4, "CZCS, LST")
210	- <u>č</u>	
850 		CALL DATE (DA)
230		CALL TIME(TM)
242	c	
250	<u>.</u>	WRITE (5,29) DA, TM
	d	WRITE (4.24) DA,TM
270	- 20	FURMAT ("OCZCS NEAREST RESAMPLER V 1.0",4X,10A1,4X,10A1/)
280		NSLMENSLO1
		NWL =NBL/2
300		NBTHaNGL+512
310	c	NOTRENDLADIE
320		
339		JALLEALL
340		WRIIE (5,30)
350	30	FORMAT ('SINPUT IMAGE TITLE ? ')
360		READ (5,40) ST
370	40	FORMAT (10A1)
380		CALL GHEN (ST, HEN)
390		CALL ASSIGN (2, HFN)
400-		READ (2,50) 10
410	- 50	FORMAT (11, 542)
420		READ (2,60) NIE, NIL, NBP, IIP, NIPP, IEO, ILO
430	60	FORMAT (715)
440		READ (2,70) DELP, DELL, LTSC, LNSC
450	70	FORMAT (4F12.6)
460	· · · · · · · · · · · · · · · · · · ·	CLOSE (UNIT : 2)
470		CALL P1 (10, IPN)
480	····· ·	NB1=NIEANBP
490	~	NEL * NBL/NBP
500		TF (11P, NE, 21) GO TO 771
510	77	WRITE (5,80)
520	- 80	FORMAT ('SWHICH DRIVE ? ')
530		READ (5,90) IIOR
540	90	FORMAT (715)
550		
550		WRITE (5,100)

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SEQ	1	FTNIS	26-FEB-81 12146108 PAGE 2	
570	100	FORMAT (BOUTPUT IMAGE TITLE 7 ')	
580		READ 15,40		
590		CALL GHEN	(STO. HEN)	·····
500		CALL ASST	N (2. HFN)	
610		READ (2,40		
620		RFAD (2.60	NE, NL, NBP, IP, NPP	
630			A) DY, FLT, FLN	
649		NLAENSL/2	(1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1	
650		CLOSE (UM		
660	C			
670		IF (MOD (NE	9P,2), EQ.0) GU TO 110	
680		INSKIP		
690		OUTSKP		
799		NERMUS		
710			. BYTRYT	
720		GOTO		
730	C		• No 7. Second on an an ordered over a second question of second questions and a second question of a second question of the second qu	
740	110	INSKTP .	·	
750		OUTSKP .	n	
760		NHRMVS .	NAP / 3	
770		MVTYPE .	WRNWRN	
780	Ċ			
790	120	CONTINUE		
800				
A10		WRITE (5,80	A 1	
A20		READ (5,90		
839		NHO=NE+NBI		
AUD		NBTME 102		
850	C			******
860		HON=DY/2.		
A 7 0 7			FLT, FLN, IP, XFO, YFO)	
AAØ			LTSC, LNSC, IP, XSC, YSC)	
890	C			
970		WRITE (5,	170)	
910	170	FORMAT ("	SBEGINNING RUW AND COLUMN ? ?)	
950 T		PFAD (5.14	BA) IBR, IBC	
930	180	FORMAT (2)		· · · · · · · · · · · · · · · · · · ·
940			E.0) GO TO 200	
952		IBR#1	· · · · · · · · · · · · · · · · · · ·	
969		THC=1		
97 🤊		IERFNL	11. 199 - Angenes 19 - Ander Freiheiten ander ander an angenes ander Ander Angeler ander	
980		IFCC=NE	dr an spanningen sidd file fil effe af de fellen af same og en file af effe af standiske skrindelige og en file Af en spanningen sidd file file effektigt af same af en standiske skrindelige og en file af en standiske af en	
990		WRITE (5.	190) IBR, IBC, IER, IECC	
200	D	WRITE (4,	190) THR, JBC, IER, IECC	
010	190	FORMAT (*	PDEFAULT VALUES: *,415/)	
020 J		60 TO 228		
a sa 🗂	200	WRITE (S,	219)	
949	210	FORMAT ("	SENDING ROW AND COLUMN ? ")	
050-	·······		RA) IER, IECC	
969			T,NL) IER=NL	
070			GT,NE) IECC=NE	·····
080		WRITE (5,		
090 °	D	WRITE (4,		
100	550	NOF=100		
110		INMNE ILO		
120		TRMX: ILD		



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3E 0	CZSNR FTNI3	26-FEB-81	12146108	PAGE 3	
130	ICMN# JEO+	• • • • • • • • • • • • • • •	**********		• • • • • • • • • • • • • • • • • • • •
140	ICMX# IEO+				
150	CALL ALTPH	1(,40)			
160					· · · · · · · · · · · · · · · · · · ·
170	С С				
180	CALL IMOPE	N (1,ST,, IIDR	,NBI,NIL, "R")		· · · · · · · · · · · · · · · · · · ·
190	CALL IMOPH	N (2,5T0,,100	R, NBO, NL, "M")		
500	D CALL ASSIG	N (3, "CZCS3	LST")		
210	C				
250	C				
230		441 XFO, YFO, X			
240	C144 FORMAT(*	XFO	YFO	XSC	YSC ·
250	C + ,/,4F1	5.4 1			
540	C WRITE(4,14	8) INSKIP, OUT	SKP, NARMVS, MVT	PE	
270		INSKIP DUTS	KP NARMVS HV1	YPE ",/,418)	
280	<u>C</u>				
290	C		· · · · · · · · · · · · · · · · · · ·		
300	230 1EC+18C+NO				
110		,IECC) GO TO	240	a daga makatan gugan manakatang ng matika taka Penanggalan a ti kagunanan	
320	TEC=TECC	سميند بالمستحدين ومع			
330	NOESIEC-JH				
340	240 NOL=IER-IB				
350	IECP#IEC+1				·
360	KD=(18C-1)				
370	ND=K0/512	N. NO.			
380 390	TF (NO.LT.O				
	KO=KO-N0+5	10			1
400 410	C THESE VALU	SC ADD TOLITED			
	C INCOC VALU	ES ARE SWATH	L11113		
420 430 7 -	DLX = XFO-				
430	DLY = YFO-				
450		18C-,5)+DX			
460		(NOE-1)+DY			
470		18R+,51+0Y			
4RA	YMINEYMAY-	(NOL-1)+DY			
490	E				
500	C THE 21 TE	RM POLYNOMIAL	STDEFINE BOTH	J AND V ADJUSTHE	NTS.
510	C SINCE THI	S SCHEME WORK	S ALONG A SINGL	E OUTPUT LINE,	THE
520 "				D DNLY WHEN A N	
530				FROM THE POLYNOM	
540			ONTAL ADJUSTMEN		
550	C GnEs,		··· ·· ·······························		···· ····
560	C				
570	-	MIN, YMAX, YMAX	Y DX DY DYIT		
582	-C			••••••••••••••••••••••••••••••••••••••	
590 -	-C WRITE (4,1	40) YMAX, XMIN	, YHAX, YMIN		
600	CI40 FORMAT(/	XMAX	XMIN	YHAX	YMIN
610 🗂	C + ,/,4F1	5,4)			
620	ODTTE //	131 "AV" AV" AITV	,DLY		
630	C142 FORMATE	DX 3	DY	DLX	DLY
640	C142 FORMAT(C + ,/,4F1	5.4)	·····		
650	C WRITE CO.1	46) TH.Y.DY1		······································	
660	CI46 FORMAT.C	TH	¥	DY 1	
670	C + ,/,4F1	5.4)		DY1	
580					



0	
90	0 WRITE (4,60)IEC
í Ø	C
20	C
30	C
40	D KBAND = 6
59	D KMIN # 9999
60	D KTIMEN = 0
70	00 500 J=1,NOL
89	C
90	C P3 CALCULATES THE OTH THROUGH STH DERIVATIVES OF BOTH THE
ดด	C ROW AND THE COLUMN TERMS WHICH GIVE THE CHANGE FROM ONE
10	C EVALUATION OF THE POLYNOMIAL TO THE NEXT. BY ADDING THE
59	C CHANGE TO THE PREVIOUS VALUE OF THE FUNCTION, A LOT OF
30	C CALCULATIONS ARE AVOIDED, THE OTH DERIVATIVE IS THE
40	C FUNCTION ITSELF. THE DERIVATIVES ARE WITH RESPECT TO THE
50	C EASTING OR ALONG ROW DIMENSION STARTING FROM THE RIGHT SIDE
60	C OF THE SWATH,
19	<u>c</u>
80	CALL P3 (Y,RL,CL,DR,DC)
90	DC(1)= DC(1)+1
90	WC= DC(1)
10	WRE DR(1)
53	ICL= CL
30	IHL = RL
49	IF (J,EO,1) ILN#IRL
50	NPN=WC-ICL+1
60	NLNEWR-JRL+1
10	IF (NPN, GT, NEL) STOP 'INSUFFICIENT ELEMENT STORAGE'
80	IF (NLN.GT.NSL) STOP "INSUFFICIENT LINE STORAGE"
97 -	
00	
10	C INVOKE FILL JBUF
20	C ASSIGN 99903 TO 199900
30	C 60 10 99900
40	
60	C PROCEDURE TO FILL JHUF
13	
80	C
90	C99900 CONTINUE
00	250 1F (1RL+NSLM,LE,ILN) GO TO 280
10	
20	YVAL = Y + (ILN = IRL) + DY1
30	CALL P3(YVAL, RLVAL, CLVAL, ORVAL, DCVAL)
40 -	CVAL = DCVAL(1) + 10
50	C ICIVAL = CLVAL
Ø	C
10	C. ICLVAL IS PIXEL CONTAINING LEFT EDGE OF INPUT WINDOW.
80	C SUBTRACT UNE TO SKIP OVER ONLY THOSE THAT ARE TO THE
90	C LEFT OF THE EDGE, SUBTRACT ANOTHER AS A MARGIN OF SAFETY.
ทด	C
19	C ICLVAL = ICLVAL - 2
20	
30	LC=MOD(ILN=1,NSL)+1
40	C
·	



SEQ	CZSNR.FTN13	26-FEB-81 12146108 PAGE	5
259	255 IF (LC.)	· · · · · · · · · · · · · · · · · · ·	*****************
590 520		T,0) GO TO 256	
270	GO TO 255	•	
280	256 CONTINI		
290	<u>C</u>		
300		X(0, CVAL - 1EO - (NBL/NBP))	
310 310	51881 - M	RT +NHP/512	
320		T.O. NHLTS=0	
530	IRN#ILN=I	n	
340	15 (10Å CI	.1.AND.IRN.LE.NIL) GO TO 260	
150		10 0 104 3 1030 3V	
		(0,0,1BF,2,1024,2)	<u> </u>
160) 770' -	GO TO 270		
370	260 CONTINUE		
380		T (1, NBLTS, NBTR)	
140	CALL IMRE	D (1, IRN, LBF)	
407	270 NBYTSE NBI		
410		NHP-NHYTS+1	
454		(L8F(K),1,JBUF(1,LC),1,NBL,0)	
130	С		
40	C THE INPUT	SPACE IS SKEWED IN RELATION TO THE	OUTPUT SPACE.
450	C THE OFFSEI	'S CALCULATED HERE ALLOW THE INPUT S	PACE TO BE STORED
469 -	C AS A RECT	NGULAR AREA. WHEN IT IS INDEXED IN	TO, THE OFFSELS
470	C ARE LISED	O SELECT THE PROPER AREA.	
480 -	C	a sana manna a sa a managa sana na gana a sa kanga ya ka na na ka ka ka sana ang kanganan na kangana na kangana	
490	IOFF(LC)=	START+NBP	
500	TLN#TLN+1		· · · · · · · · · · · · · · · · · · ·
510) KMIN = MIN(START, KMIN)	
520	GO TO 250		
530	C	ann an	من من المركز بين المركز الم المركز المركز
540	280 CONTINUE		
550	с	annan marini baran manan ar ang pangan anan ar ang panga ang bagata, ang banan at Marine na manan ang baran na manan	
560	C GO TO 9990)]	······································
570	C		
580	C99901 GO TO 199	900. (99903)	
590	C	*******************************	***
600	C***********		* * *
510	r		
620	1F (ND+	12+NBTM.GT.NBO)NBTM=NBO=N0+512	
530			
540 -			
550	PALT THELL	T (2,NO,NHTH)	
550 560	CALL INDE	D (2, ORN, LBF)	
		A CENANTELL	
570		TAL SOL IE AL UPTERA ADDA	
580		J-1,50), LE,0) WRITE(4,4098)	U 0
590	04098 FORMAT(*1		WR IRL",
140	······································		
10	U +,180,	1 K WC LC IOFF(LC)	WK*)
150	U WRTTE (4,40	99) J.WC.WR, ICL, IRL, NPN, NLN, START, L	L
739	04099 FORMAT (918		
740	KOUTE KO+	NUE-1) +NBP+1	-
750	D JF (MOD(K)	THEP, NSL) . LT . 1) PRNTJB . TRUE.	
769	D KTIMER .	TIMER + 1	· · · · · · · · · · · · · · · · · · ·
110	C		
180 -	DU 400 I=	,NOE	
790	R= DR(1)		
800	WR. R		
· ·			



APPLICATIONS DIVISION

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		!	
2810		CALL MOVE (0,0	
9829		IF (WR GT IRM)	KOR, WR, LT, IRMN) GO TO 399
2B 4 M	D	IF IWR GE INMA	N, AND, WR, LE, IRMY) GO TO 382
AUA	0	WRITE (4, 380)	I.WR, IRMN, IRMX
850	0380	FORMATC . ROM	VALUE OUT OF BOUNDS & I, WR, IRMN, IRMX 2, 416)
864	D	GC TO 399	
870	C		
887	382	LC=MOD(WR=1,N	N3L)+1
890	C	a El Saran - 2' a nada y cinan são∎ -	
990		C= 0C(1)	
910		WC= C	
920	C	ante Million (Mere es anno anno anno a	
930	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~		a (1997) bat (a 1997)
940		TECHE LT TEM	N; OR, WC, GT, ICMX) GO TO 399
- * # **	··· • • • • • • • • • • • • • • • • • •		
950	<u>'</u> `	1 1 1 4 4 6 6 1 L FI	N. AND, WC.LE. TCMX) GO TO 384
960	<u>D</u>		I,WR,ICMN,ICMX
2970	0383		UMN VALUE OUT OF BOUNDS : I, WC, ICMN, ICMX ',416)
988	0	GO TO 399	
9990	C		
5900	384	K# WC±NBP+IOF	FF (LC) +1
5010			
1050	D375	KDELT . KPREN	· · · · · · · · · · · · · · · · · · ·
5030	C	WRITE (4,4095)) 1,K,WC,LC,IOFF(LC),WR,KDELT
5040	C4095	FORMAT(TA0,71	17)
5050	1)385	KPREV = K	
3060	C		
3070	D	IF (K.LE.NOL.	AND, K GE, 1) GO TO 389
3080	C	KERRCT . KERR	RCT + 1
1040	С	TE (MOD / KEP	RCT, 100) . GT. 10) GO TO 399
100	D	WRITE CA. RAKY	J,I,K,WR,WC,IOFF(LC),LC
5110	0386		JT OF BOUNDSI OUTROW OUTCOL
5124		•, •k ₩R	WC TOFF(LC) LC'
5130		• / 18x,7(16,8	
5140	n	GO 10 399	
5150	C		
3160	<u> </u>	TELK EL NHLY	CN TA 190
	•• - ••••• •• •••••	IF (K, G1, NBL)(
5170		1F(K,LT,1)G0	
51 AU	388		JF(K,LC),INSKIP,IV,OUTSKP,NRRMVS,MVTYPE)
3190 .	-	KBK+NBP	
3200	C		
1210	599	ana in Willing and a second of the second second	, INSKIP, LEF (KOUT), OUTSKP, NBRHVS, MVTYPE)
1220	···· _ ···	KOUT * KOUT-NE	
1520	<u>C</u>		
3240		DO 402 JD=1,5	5
8259		JP= JD+1	
19458		DC(JN)= DC(JI	
3270	402	DR(JU)= DF	R(JD)+DH(JP)
\$250	C		
1290	D	IF (NOT PRNI	TJB) GO TO 400
1300	0	PRNTJH . FAL	
5310	D	PRNTHI) = TRI	JE
1320	0	KMIN # / IOFF	UE, { F(LC) / NAP) • 5 -
5340	0		NSL •1 • NLN
5340	<u> </u>		
5350	n n		
	- <u>ö</u>	CO ANOD KINDS	X = LC - NLN + 1 , JPLUS
5360		KWML = MUU(K)	INDX - 1, NSL) + 1
		-	



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3374 0 KEND * 110FF(NAME) / MAP * NAIN 3387 0 KEND * TIM KEND, 25 3397 0 F (AOT, PENTHO) GO TO 8003 3397 0 F (AOT, PENTHO) GO TO 8003 3397 0 F (AOT, PENTHO) GO TO 8003 3497 0 F (AOT, PENTHO) GO TO 8003 3497 0 F (AOT, PENTHO) GO TO 8003 3497 0 F (AOT, PENTHO) GO TO 8003 3498 0 F (AOT, PENTHO) GO TO 8003 3498 0 F (AOT, PENTHO) GO TO 8003 3497 0 F (AOT, PENTHO) GO TO 8003 3498 0 F (AOT, PENTHO) GO TO 8003 3498 0 WHITE (3, 2001 0A, TM OISPLAYED FROM COLUMN ', 10, TO 3540 0 WHITE (3, 2001 0A, TM OISPLAYED FROM COLUMN ', 10, TO 3540 D adm65 FINHARI (1 * KEND 1, IDDX & FINST, 156 * FIRST, NEND Statt, NEND 3540 D ARABE FORMATI (1 * , CONTRUCE Statt, Statt, Statt, NEND Statt, NEND 3540 M KEND * NNE * NBP * NBP Statt, Statt, Statt, Statt, Statt, Statt, Statt, Statt,	SEQ	CZSNR, FTN/3	26-FEB-81 12146108 PAGE 7
3388 D KEND * MIN(KEND,25) 3397 D PRN/HO * ,FALSE, 3497 D PRN/HO * ,FALSE, 3497 D INDF (KMC)/NBP 3497 D FILST * K /NPP * KBAND * 1 3498 D FILST * K /NPP * KBAND * 1 3497 D WITE (3,2001) TRU,1NDX, FIRST 3497 D WITE (3,2001) TRU,1NDX, FIRST 3497 D * 3497 D * 3497 D * 3498 D WITE (3,2001) TRU,1NDX, FIRST 3498 D WITE (3,2001) TRU,1NDX, FIRST 3498 D WITE (3,2001) TRU,1NDX, FIRST 3597 DadmS FIRKHE(3,2002) (JMPK (1DX),KMC),1NDX* FIRST,156 + FIRST,NBP) 3598 DadmS FIRKHE(3,2002) ID 3599 DadmS FIRKHE(3,2002) ID 3590 WHTE (3,2002) ID 3590 KEND * NEF (SUNT * KEND > 1 3590 KEND * NEF (SUNT * KEND > 1 3590 KEND * NEF (SUNT * 10,000) 3590 KEND * NEF (SUNT * 10,000) 3590 KEND * NEF (SUNT * 10,000) <t< td=""><td>3370</td><td></td><td>•••••I••••••I•••••I•••••I•••••I•••••I••••</td></t<>	3370		•••••I••••••I•••••I•••••I•••••I•••••I••••
3399 D MEND = MINI KEND, 50 TO 4883 3400 D FR.M.HD = FALSE. 3420 D INDT = JDPF(KWHC)/NBP 3440 C INDT = STOPF(KWHC)/NBP + KBAND + 1 3440 O FISSI = K /NPP + KBAND + 1 3440 O FISSI = K /NPP + KBAND + 1 3440 O FISSI = K /NPP + KBAND + 1 3440 O HUTE (3,240A1) TEL,INDX, FIRST TOW *,14,* COLUMN *,14, 3447 O * 3448 O WHITE (3,240 DA,TM 3449 DAMAS FORMAT(1 T, *CONT,MUED, INDX * FINST,156 * FIRST,NBP) 5547 DAMAS FORMAT(1 T, *CONT,WUE 5548 C CONTINUE 5549 D KEND * NBP * NBP 5549 D KEND * NBP * NBP 5549 C CONTINUE 5540 CONTINUE C			
1300 N = [, NOT, PENTHO] : (0 TO 4863 3010 PRNIMP : JDF(KWHC)/NBP 13030 INNX : IDF(KWHC)/NBP 13030 WRITE (3, 2081) TPL : INDX, FERST 3040 WRITE (3, 2081) TPL : INDX: FERST, ISC. 3040 WRITE (3, 2081) TPL : INDX: FERST, ISC. 3040 WRITE (3, 2081) CL 3040 WRITE (3, 2083) INC 3040 Mad& FORMAIC (1 < KENO > 3000) 3040 Mad& FORMAIC (1 < KENO > 3000) 3040 WRITE (3, 2080) INC 3040 Mad& FORMAIC (1 < KENO > 3000) 3040 WRITE (3, 2080) INC 3040 KENO * KINC (1 KE, KEND)			
3010 D PANIND * PALSE, 3020 TANX * IDPF(KANC)/NBP * 1 3040 FIRST * K /NBP * KBAND * 1 3040 D FIRST * K /NBP * KBAND * 1 3040 D FIRST * K /NBP * KBAND * 1 3040 D WRITE(1, 4081) TRL, INDX, FIRST 3040 D af01 FOLMAT(* INPUT SPACE STARTS AT ROW *, I4, * COLUNN *, I4, * 3040 D write(1, 4081) TRL, INDX, FIRST 3040 Write(1, 200 Da, TM 3040 Write(1, 4081) TRL, INDX, KEND, IT, * 3040 Write(1, 4081) TRL, 1007, KEND, IT, * 3040 Write(1, 4081) TRL, 1007, KEND, IT, * 3040 Write(1, 4081) TRL, 1007, KEND, IT, * 3040 D af083 FOLMAT(* *, KEND >, 3004) 3040 MRITE(1, * OUTPUT SPACE*/* LINE PIXEL* / 5x, 14) 3040 MRITE(3, 4084) TOH, UTPUT SPACE*/* LINE PIXEL* / 5x, 14) 3040 MRITE(3, 4084) TOH, UTPUT SPACE*/* LINE PIXEL* / 5x, 14) 3040 MRITE(3, 4084) TOH, UTPUT SPACE*/* LINE PIXEL* / 5x, 14) 3040 MRITE(3, 4084) TOH, UTPUT SPACE*/* LINE PIXEL* / 5x, 14) 3040 MRITE(3, 4084) TOH, UTPUT SPACE*/* LINE PIXEL* / 5x, 14) 3040 MRITE(3, 4084) TOH, UTPUT SPACE*/* LINE PIXEL* / 5x			PRNTHU] 60 TO 4083
3220 N INFX = IDPF(KNHC)/NBP 3340 C INFX = K /NAP + KBAND = 1 3440 D #RITE(3,201) TPL, INOX, FIRST 3440 D #WITE(3,201) TPL, INOX, FIRST 3441 T KEND, GI, AB, DA, KEND, LT, AJ, TYPE +, ' KEND = ', KEND 3540 D and S, FIRST, NBP) 3540 D and S, FIRST, NBP) 3540 D and S, FIRST, INON, JUPC + (LO, ' LC ', LC ', LC ', KMIN ', KMIM 3541 D and S, FIRST, INON, JUPC + (LO, ' LC ', LC ', LC ', KMIN ', KMIM 3542 D and S, FIRST, INON, JUPC + (LO, ' LC ', LC ', LC ', KMIN ', KMIM 3543 D and S, FIRST, INON, JUPC + (LO, ' LC ', LC ', LC ', KMIN ', KMIM 3544 D and S, FIRST, INON - JUPC + (LC ', ', LC ', LC ', LC ', SX, IA) 3545 C 3546 C MALL ', MAR + KEND - J + KEND J = NBP 3547 C 3548 C MARC + NIN(140, KEND - J + KEND J = NBP 3549 C MEND * (KEND + J) 3540 C KEND * NINC + (KAND - J + KEND J = NBP	Ma	D PRNTHD	FALSE
1440 0 FIRST * K /NRP + KBAND = 1 1450 DAMBI FOMMAT(1) INC, INDX, FIRST 1460 DAMBI FOMMAT(1) INC, INDX, FIRST, AT ROW *, IA,* 1460 O 1460 WRITE (3, 200) TA, TM 1461 TAKEND, 51, 200 (100 X, WRC), INDX* FINST, 156 + FIRST, NBP) 1462 DAMBA FORMAT(1*, CHEND >, 3000) 1463 THAT (148, KEND) 1464 PMAT(1*,* OUTPUT SPACE*/* LINE PIXEL* / SX, 14) 1550 C 1464 PMAT(148, KEND) 1577 C 15870 KENO * NTNU (148, KEND) 15970 KENO * NTNU (148, KEND) 15970 KENO * NTNU (148, KEND) 15970 KENO * NTNU * KKANO * NOU * NOU * NOU * NOU * NOU * NOU * SALE*/ 15970 KENO * NTH (147, KEND) 15970 KENO * NTH, KEND : NOU * NOU * NOU *	3420	0 INCX # 10	FF(KWHC)/NBP
1050 D WRITE (3,2001) TRL, INDX; FIRST DISPLAYED FROM COLUMN *, TA; 1040 O WRITE (3,201) TA, TM DISPLAYED FROM COLUMN *, TA; 1040 WRITE (3,201) TA, TM DISPLAYED FROM COLUMN *, TA; 1040 WRITE (3,201) TA, TM DISPLAYED FROM COLUMN *, TA; 1040 WRITE (3,201) TA, TM DISPLAYED FROM COLUMN *, TA; 1040 WRITE (3,201) TA, TM DISPLAYED FROM COLUMN *, TA; 1040 WRITE (3,201) TA, TM TYPE *, * KEND * KMIN 10404 PITE (3,201) (JUNT (TOX, KWC), INDX* FINST, 156 + FIRST, NBP) DIANS #THE (3,201) (JUNT (TOX, KWC), INDX* FIRST, NBP) 10507 Danas FIRMAT(1 * KEND , 3004) DISST C 10507 C DANA CONTINUE DISST Stan 10507 C CONTINUE Stan Stan Stan 10507 C KEND * NEP + NEP Stan Stan Stan 10507 C KEND * NEP + NEP Stan Stan Stan Stan 10507 C KEND * NEP + NEP Stan	3450	C INDX # JO	FF(KWHC)/NBP + 1
3478 0 40001 FOMAT(*) INPUT SPACE STARTS AT ROW ', I4, 'COLUMN ', I4, 'DISPLAYED FROM COLUMN ', I4) 3470 WHITE (3,200 TA, TM DISPLAYED FROM COLUMN ', I4) 3470 'F (KEND, GT, R0, DM, KEND, LT, R) TYPE *, 'KEND * 'KEND 3570 'F (ICT'', JUFF(IC]', LC ', LC, 'KHIN ', KHIN 3510 Danks I TE (3,200 S) (JBUF(INDX,KWC), INDX* FINST, IS6 + FIRST, NBP) 3527 Danks I FOMAT('1 ', 'DUFFUT SPACE'/ 'LINE FIXEL' / SX,14) 3538 D WRITE (3,200 S) (JBUF(INDX,KWC), INDX* FINST, IS6 + FIRST, NBP) 3540 DARES FIRMAT(' ', 'A END * NAP 3550 C 3560 WRITE (3,200 S) OUTPUT SPACE'/ 'LINE FIXEL' / SX,14) 3577 C 3560 KENO * NDE * NBP * NAP 3578 C 3579 C 3570 KENO * MIN(168, KEND) 3570 KENO * NIN(168, KEND) 3570 KENO * MIN(168, KEND) 3571 KENO * MIN(168, KEND) 3572 C			
3470 0 * 0 JEPLAYED FROM COLUMN *,14) 3440 IF (KEND, G3, 80, 04, KEND, LT, 8) TYPE *, * KEND *, KEND 3500 C *, IDFF(LC)*, IDFF(C), KEND (C *, LC *, LC *, KEND *, KEND 3510 D4083 WRITE(3, 4085) (JBUF(INDX, KMMC), INDX* FINST, 156 * FIRST, NBP) 3510 D4083 FIRMAT(T * KEND >, 3004)		D WRITE(3,4	081) IRL, INDX, FIRST
3440 0 WHITE (3,20) DA,TM 3400 C TF (KEND,GT, AQ,DW,MENDLLT,G) TYPE +, * KEND * *,KEND 3510 D4083 WRITE (3,4085) (JUPF(IC), * LC *,LC *, KMIN *,KMIN 3510 D4083 WRITE (3,4083) IG 3520 D4083 FIRMAT(T *KEND >, 3004) 3530 D WRITE (3,4083) IG 3540 D4084 FDPMAT('1', * OUTPUT SPACE*/ * LINE PIXEL* / 5%,18) 3550 G 3540 D4084 FDPMAT('1', * OUTPUT SPACE*/ * LINE PIXEL* / 5%,18) 3550 G 3550 G 3560 MEND * NOF * NBP * NBP 3560 MEND * NOF * NBP * NBP 3560 MEND * IC (5,000 + 1 + KEND) = NBP 3560 MEND * IC (5,000 + 1 + KEND) = NBP 3510 MARKARAGI ONN. (LEF (INDX), INDX=KOUT + 5 + NBP,KENO, NEP) 3520 D4404 FORMAT ('*, 14, 3000 +) 3540 C 3540 S60 3540 <td></td> <td></td> <td>INPUT SPACE STARTS AT ROW ', 14, ' COLUMN ', 14,</td>			INPUT SPACE STARTS AT ROW ', 14, ' COLUMN ', 14,
3400 C IF (KEND, 57, 80, 04, KEND, LT, 8) YEEND 3500 C ·, 10FF(LC)', 10F(LC), ', LC (, LC ', KEN', KHEN', ', KHEN', ', KHEN', ', ST, 156 FIRST, 156 3510 D4083 FDIRMAT(T *KEND >, 3004)			/ DISPLAYED FROM COLUMN (,14)
3110 Danas WRITE(3,aus5) (JBUF(1NDX,KWHC),INDX* FINST,156 + FIRST,NBP) 3520 Danas FORMAI(1 * KEND > 3004) 3530 Danas FORMAI(1 * KEND > 2004) 3540 Danas FORMAI(1 * KEND > 2004) 3550 C 3540 Danas KEND * NOC * NBP * NBP 3557 C 3560 KEND * NOC * NBP * NBP 3570 KEND * (180, KEND) 3600 KEND * (180, KEND) 3601 WRITE(3,a00, MEN) 3622 D4000 POMAT(* *, 14, 3004) 3635 C 3640 CALL IMWRIT (2,00N,LBF) 3650 WRITE (5,a00, UN, 18C, IEC, DR (1), DC (1) 3650 S00 3650 S00 3700 IF (IEC,E0, IECC) GO TO S10		D WRITE (3,	20) DA, TM
3110 Danas WRITE(3,aus5) (JBUF(1NDX,KWHC),INDX* FINST,156 + FIRST,NBP) 3520 Danas FORMAI(1 * KEND > 3004) 3530 Danas FORMAI(1 * KEND > 2004) 3540 Danas FORMAI(1 * KEND > 2004) 3550 C 3540 Danas KEND * NOC * NBP * NBP 3557 C 3560 KEND * NOC * NBP * NBP 3570 KEND * (180, KEND) 3600 KEND * (180, KEND) 3601 WRITE(3,a00, MEN) 3622 D4000 POMAT(* *, 14, 3004) 3635 C 3640 CALL IMWRIT (2,00N,LBF) 3650 WRITE (5,a00, UN, 18C, IEC, DR (1), DC (1) 3650 S00 3650 S00 3700 IF (IEC,E0, IECC) GO TO S10		C IF (KEND	GT. AO. OR, KEND. LT. A) TYPE +, KEND = ', KEND
3520 Dan85 FURMAT(T <kend>, 3004) 3530 Dan84 FOPMAT('1', 'OUTPUT SPACE'/ 'LINE PIXEL' / 5X,14) 3550 C 3560 D KEND * NDE * NBP + NBP 3570 C 3570 C KEND * NDE * NBP + NBP 3570 D KEND * NDE * NBP</kend>		C + , IUFF	(LC) ', IUPF(I,C), ' LC ', LC, ' KMIN ', KMIN
3530 D WRITE(3, 404) IBC 3550 DADBA FORMAT(*)*, OUTPUT SPACE*/* (INE PIXEL*/ 5X, Ia) 3550 400 CONTINUE 3570 C 3570 C 3570 C 3570 C 3570 KENO * NOF * NBP * NBP 3570 KENO * KENO * (160, KENO) 3600 KENO * (170, KENO) 3600 KENO * (100, KENO) 3600 C 3600 CALL IMWIT (2,000, LBF) 3600 KAUT (**,315,2F10,11 3600 KAUT (**,315,2F10,11 3600 C 3700 IF (1EC,EQ,1ECC) GO TO 510 3700 G 3700 C 3700 CLOSE (UNIT*4, DISP * 'PRINT*)		04085 WRITE(3,4	(05) (JHUP(INUX,KWHC), INUX# PIKST, 156 + PIRST, NBP)
3540 DADRA FORMAT(*)*, OUTPUT SPACE*/ * LINE PIXEL* / 5X,14) 3550 C 3550 C 3570 C 3570 C 3570 C 3570 D 3570 D 3570 D 3570 D 3670 D 4810 E NDE * NBP * NBP 3590 D 4810 E (S NDE * (NDE * KEND) = NBP 3510 D 4810 E (S NDE * (KEND) = NBP 3510 D 4810 C 3650 C 3750			
3550 C 3500 C 3500 C 3500 C 3500 C 400 C 500 C 50 C 500 C		DUDAN BODMATICA	A P DUTDUT SDAFE A A TALE DIVELA A EV TAS
3560 400 CONTINUE 3570 C 3570 C 3570 D KEND * NOE * NBP + NBP 3500 D KEND * (KUUT + KEND) = NBP 3600 D KEND * (KUUT + KEND) = NBP 3610 D WRITE (S, 400) (LEF (INDXI, INDXIKOUT + 5 + NBP, KEND, NRP) 3620 D 4000 FORMAI (* , 14, 3004) 3630 C 3640 CALL IMWRIT (2, DAN, LBF) 3650 WRITE (S, 440) DNN, IRC, IEC, DR (1), DC (1) 3660 S00 YEVYDY 3660 S00 YEVYDY 3660 S00 YEVYDY 3670 D (LOSE C) GO TO S10 3710 C 3740 S10 CONTINUE 3750 D (LOSE C) UNIT#4, DISP * *PRINT*) 3760 S10P 3740 END 3740 END 3740 END		nadda FORMATC 1	
3570 C 3540 D KEND * NNE * NBP * NBP 3590 O KEND * (KOUT * KEND) 3600 O KEND * (KOUT * KEND) 3610 O KEND * (KOUT * KEND) 3610 O KEND * (ADU * KEND) 3610 O KEND * (ADU * KEND) 3610 O KEND * (ADU * KEND) 3620 D40000 FORMAT (* *, 14, 3004) 3630 C 3640 Call IMWRIT (2, ORN, LBF) 3650 WRITE (5, 4400 OHN, 18C, 1EC, DR (1), DC (1) 3660 GAM*ORN41 3670 GAM*ORN41 3671 If (IEC, EG, IECC) GO TO 510 3740 C 3740 C 3740 CIOSE (UNIT#4, DISP * PRINT*) 3740 C 3740 C 3740 C </td <td></td> <td>AND CONTINUE</td> <td></td>		AND CONTINUE	
3546 0 kEND * NDE * NBP * NBP 35970 0 kEND * KIN(180, KEND) 3600 0 KEND * (KOUT * KEAND -1 * KEND) = NBP 3610 0 WRITE(3,408/0) ORN, (LUF(INOX), INDX*KOUT * 5 * NBP, KEND, NRP) 3620 04080 FORMAT(* *,14, 3004) 3630 C 3640 CALL IMWRIT (2,00N, LBF) 3650 WRITE (5,4090 ONN, IRC, IEC, DR(1), DC(1) 3660 490 FORMAT (**,315,2F10,1) 3660 GRAVE FORMAT (**,315,2F10,1) 3670 IF (IEC,E0,IECC) GO TO 510 3710 IF (IEC,E0,IECC) GO TO 510 3710 GO TO 230 3710 CLOSE (UNIT*4, DISP * *PRINT*) 3770 SIOP 3770 CLOSE (UNIT*3, DISP * *PRINT*) 3770 SIOP 3780 C 3790 SIOP 3800<		C	
3590 0 KEND * MIN(180, KEND) 3600 0 KEND # (KOUT * KHAND -1 * KEND) = NBP 3610 0 WRITE (5,4080) ORN, (LBF(INOX), INDX*KOUT * 5 * NBP, KEND, NBP) 3620 D4080 FORMAT(* *,10, 3004) 3630 C 3640 CALL IMWRIT (2,00N,LBF) 3650 WRITE (5,400) ORN, IRC, IEC, OR(1), DC(1) 3660 400 FORMAT (**,315, 2F10,1) 3670 OKN 00RN41 3680 C 3700 IF (IEC, EQ, IECC) GO TO 510 3710 IKC #IEC+1 3720 GD CANTINUE 3750 C CLOSE (UNIT*4, OISP * *PRINT*) 3760 C CLOSE (UNIT*4, OISP * *PRINT*) 3760 C 3790 END 3790 C 3790 C 3790 C 3790 C 3800 END 2000 END		NOT KEND - NO	E + NBP + NBP
3600 XENU * (KOUT * KHAND * I * KEND) * NBP 3610 WRITE (3, 40A0) OHN, (LBF (INDX), INDX*KOUT * 5 * NBP, KEND, NRP) 3630 C 3630 C 3640 CALL IMWRIT (2, ORN, LBF) 3660 WRITE (5, 440) OHN, IRC, IEC, OR (1), OC (1) 3660 WRITE (5, 440) OHN, IRC, IEC, OR (1), OC (1) 3660 WRITE (5, 440) OHN, IRC, IEC, OR (1), OC (1) 3660 OHMAT (**, 315, 2F10, 1) 3670 OHMAT (**, 315, 2F10, 1) 3680 C 3700 IF (IEC, EQ, IECC) GO TO S10 3710 IF (IEC, EQ, IECC) GO TO S10 3730 C 3740 S10 3750 CLOSE (UNIT*4, DISP * *PRINT*) 3760 CLOSE (UNIT*3, DISP * *PRINT*) 37700 S10P 37700 S10P 37700 S10P 37700 S10P 37700 S10P 3790 C			
3510 0 WFITE(3,40%) GRN, (LUF(INOX), INDX+KOUT + 5 + NBP,KENO,NPP) 3620 D40860 FORMAT(**,14,3004)			
1620 04000 FORMAT(**,14, 3004) 3640 CALL IMWRIT (2,000,LBF) 3640 WRITE (5,440) OHN, IBC, IEC, OR(1), OC(1) 3660 490 FORMAT (**,315,2+10,1) 3670 OHN00000+1 3680 S00 Y*V+DY1 3680 C 3700 IF (1EC,E0,IECC) GO TO 510 3710 IHC41EC+1 3720 GO TO 230 3710 CONTINUE 3750 CLOSE (UNIT#4, DISP = *PRINT*) 3760 CLOSE (UNIT#4, DISP = *PRINT*) 3770 STOP 3780 C 3790 END			
3630 C 3640 CALL IMWRIT (2,0RN,LBF) 3650 WRITE (5,490) ONN,IBC,IEC,OR(1),OC(1) 3660 490 560 GRNACK 3650 GRNACK 3700 IF (IEC, EQ, IECC) GO TO 510 3710 IEC, EQ, IECC) GO TO 510 3710 IEC (IEC) IECC) GO TO 510 3710 GRACK 3720 GO TO 230 3730 C 3740 CLOSE (UNIT=4, DISP = "PRINT") 3740 CLOSE (UNIT=3, DISP = "PRINT") 3740 STOP 3740 END			
3650 WRITE (5,490) DHN, IRC, IEC, DR(1), DC(1) 3660 490 FORMAT (***,315,2F10.1) 3670 OHN+ORN+1 3660 500 Y=V+DY1 1600 C 3700 IF (IEC,EO,IECC) GO TO 510 3710 IHC=IEC+1 3720 GO TO 230 3730 C 3740 S10 S170 CONTINUE 3750 C 3740 S10 S170 CONTINUE 3750 C LOSE (UNIT=4, DISP = *PRINT*) 3760 CLOSE (UNIT=3, DISP = *PRINT*) 3760 C LOSE (UNIT=3, DISP = *PRINT*) 3760 C 3760 C 3760 C 3760 C 3760 C 3760 S10 3760 S10 3760 C 3760 C 3760 C 3760 END	3630	C	and an and a second and and a second and a second a second a second and a second a s
3660 490 FURMAT (***,315,2F10,1) 3650 OWN*ORN+1 3650 S00 3700 IF (IEC,EQ,IECC) GO TO S10 3710 IHC*IEC+1 3720 GO TO 230 3730 C 3740 S10 S700 CONTINUE 3740 S10 3750 CONTINUE 3740 S10 S750 CLOSE (UNIT#4, OISP = *PRINT*) 3760 CLOSE (UNIT#4, OISP = *PRINT*) 3770 STOP 3780 C 3780 C 3780 C 3780 END	3640	CALL IMWR	IT (2,0RN,LBF) .
3670 '' OHNSORN+1 3680 S00 YEVEDY1 1690 C 3700 IF (IEC.EQ.IECC) GO TO S10 3710 G 3710 C 3710 C 3740 S10 CONTINUE 3750 O CLOSE (UNIT#4, DISP * 'PRINT') 3760 C 3770 S10P 3770 S10P 3780 C 3790 C 3800 END	3650	WRITE (5,	490) OKN, IRC, IEC, DR (1), DC (1)
3680 500 Y#Y+DY1 X640 C 3700 IF (IEC,EG,IECC) GO TO SIO 3710 IHC#IEC+1 3720 GO TO 230 3730 C 3740 S10 510 CONTINUE 3750 C LOSE (UNIT#4, DISP * *PRINT*) 3760 C LOSE (UNIT#3, DISP * *PRINT*) 3760 C CONTINUE 3760 C CONTOS CONTINUE 3760 END			
1690 C 3700 IF (IEC,EG,IECC) GO TO 510 3710 IBC#IEC+1 3720 GO TO 230 3730 C 3740 510 3750 CLOSE (UNIT#4, DISP = *PRINT*) 3760 CLOSE (UNIT#3, DISP = *PRINT*) 3760 CLOSE (UNIT#3, DISP = *PRINT*) 3760 C 3800 END	-		
3700 IF (IEC, EQ, IECC) GO TO SIO 3710 ISC IEC+1 3720 GO TO 230 3730 C 3740 SIO CONTINUE 3750 CLOSE (UNIT#4, DISP = *PRINT*) 3760 CLOSE (UNIT#3, DISP = *PRINT*) 3760 CLOSE (UNIT#3, DISP = *PRINT*) 3770 STOP 3780 C 3780 C 3800 END		500 4=++0+1	
3710 IBC#JEC+1 3720 GD IO 230 3730 C 3740 S10 3750 CLOSE (UNIT#4, DISP = *PRINT*) 3760 CLOSE (UNIT#3, DISP = *PRINT*) 3760 CLOSE (UNIT#3, DISP = *PRINT*) 3760 C 3760 END		C	1-1ECCL CA TO CA
3720 GD TO 230 3730 C 3740 510 3750 D 200 CLOSE (UNIT#4, DISP = 'PRINT') 3760 CLOSE (UNIT#3, DISP = 'PRINT') 3760 C 3780 C 3790 C 3800 END			
3730 C 3740 510 CONTINUE 3750 O CLOSE (UNIT#4, DISP = *PRINT*) 3760 O CLOSE (UNIT#3, DISP = *PRINT*) 3760 C STOP 3780 C STOP 3790 STOP STOP 3790 STOP STOP 3790 STOP STOP 3790 STOP STOP			
3740 510 CONTINUE 3750 D CLOSE (UNIT=4, DISP = 'PRINT') 3760 D CLOSE (UNIT=3, DISP = 'PRINT') 3770 STOP 3780 C 3790 C 3790 C 3800 END		A CALL AND AN	
3750 D CLOSE (UNIT#4, DISP = 'PRINT') 3760 D CLOSE (UNIT#3, DISP • 'PRINT') 3770 STOP 3780 C 3790 C 3800 END			
3770 STOP 3780 C 3793 C 3800 END		D CLOSE CU	NIT+4. DISP = "PRINT"
3770 STOP 3780 C 3793 C 3800 END		D CLOSE CU	NITES, DISP . *PRINT*)
	3170	STOP	
		المحمدينية التنبية ومبردة والسابية ويربعا المصيبين مبتوعيان الأمير	
		C	
	3800	END	
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