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SATELLITE DATA DERIVED ESTIMATES OF EROSION PARAMETERS
FOR REENTRY VEHICLES

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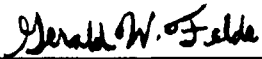
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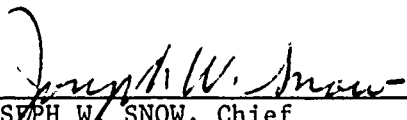
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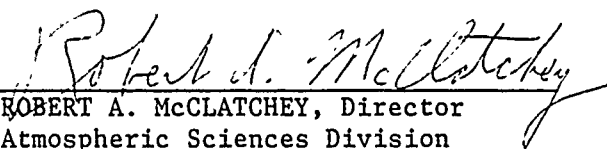
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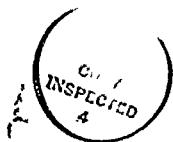
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13. ABSTRACT (Maximum 200 words) This pilot study investigates derivation of reentry vehicle erosion parameter estimates based on the inference of rain rate and hydrometeor liquid water content from microwave imagery data from the Defense Meteorological Satellite Program (DMSP) sensors. Specifically, this research focuses on the evaluation of Special Sensor Microwave/Imager (SSM/I) brightness temperature data to obtain a climatology of intense precipitation at selected relevant land based sites for a four month summer period. An integral element of the study is the identification of convective cloud models to support the analysis of hydrometeor liquid water content from the inferred surface rainfall rates. The study consisted of four tasks: (1) development of SSM/I rain rate climatology, (2) development of hydrometeor liquid water content parameterization, (3) application of liquid water parameterization, and (4) documentation. Software was implemented to (a) read the SSM/I TDRs from the acquired SSM/I data tapes, (b) calibrate and antenna pattern correct the data to obtain brightness temperatures, (c) bin the data according to the location of each desired site by latitude and longitude, (d) apply the rain rate retrieval algorithm to the data, and (e) evaluate relevant climatologies. The latter included four month summer time series of average rainfall rate, spatial standard deviation, and hydrometeor integrated liquid water content for eleven Eurasian sites.				
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1. INTRODUCTION

Reentry vehicle erosion is an adverse environmental impact on weapons delivery systems with potential significance. This phenomenon which directly affects the accuracy of reentry trajectories is attributable to mechanical ablation of vehicle aerodynamic surfaces during reentry due to interaction with atmospheric ice clouds and solid or liquid hydrometeors (i.e. precipitation). Assessment of existing or prediction of future erosion severity potential requires an understanding of the temporal and spatial distribution (i.e. climatology) of contributing meteorological conditions. These include both high altitude cirrus cloud and convective activity at lower altitudes. Thus, appropriate analyses and observation techniques are necessary to characterize cloud and hydrometeors. This report focuses on the latter issue. In particular, due to the site specific nature of the erosion problem, analyses are required at specific land based locations.

Significant effort has been devoted to the development of analysis techniques based on time/altitude cross section analyses to identify regions of likely convective activity (Feteris et al., 1976; Hardy, 1979). These approaches supported by radiosonde and surface station data were labor intensive and subject to the sparsity of available surface and upper air data. For the latter reason, for example, questions of spatial representativeness are always present (Bunting and Touart, 1980). Due to the level of effort involved in implementing these approaches, they are unsuitable for application to large scale climatological studies.

Both cloud and hydrometeors can be observed globally using satellite based sensors (Isaacs et al., 1986). Previous application of visible and infrared satellite imagery data to the cloud problem is discussed by Conover and Bunting (1977). The advent of remotely sensed microwave imagery such as that from the Defense Meteorological Satellite Program (DMSP) Special Sensor Microwave/Imager (SSM/I) provides the capability to directly sense hydrometeor liquid water content (Savage et al., 1987). Due to the radiative transfer physics relevant to the remote sensing of precipitation, the phenomenology of rain rate retrieval is different over land and oceans. This is due to the inherent differences in land type and ocean surface emissivities (Isaacs et al., 1989). Retrieval techniques have been identified to provide quantitative measurements of rainfall rates over the ocean based on microwave imager data (Wilheit et al., 1977) and oceanic climatologies have been developed (NASA, 1976).

Due to the spatial variation of emissivities over land and temporal features such as snow (which have signatures similar to precipitation), there are caveats related to the retrieval of rain rate over land. However, in optically thick situations when surface contributions to measured brightness temperatures are small, precipitation can be inferred. Such optically thick cases are those which characterize intense convection and these can be mapped over land (Spencer and Sautek, 1985). The recently completed SSM/I calibration/validation study provides further confidence in the validity of seeking quantitative inferences of rain rate over both ocean and land. The specific analysis tool available in this regard is the rain rate retrieval algorithm developed by the University of Wisconsin research group (Olson et al., 1988).

While rainfall rate brightness temperature relationships have been validated based on the MJCS 154-86 requirements for precipitation measurements, the physics of the reentry erosion phenomenon indicates that a knowledge of the liquid water content profile is necessary. This can be achieved by adoption of a suitable model of the vertical distribution of liquid water content resulting in the desired surface rainfall rate. The selection of the meteorologically appropriate liquid water content vertical distribution model is important due to the relationship between liquid water content and radiometric signature through the drops size distribution (Falcone et al., 1979). For example, many investigators commonly use the Marshall Palmer (1948) relationship which was derived for stratiform rain. Erosion severity is a function of precipitation severity and, therefore, convective situations are of greater potential interest. For these cases, other relationships are likely valid (Ulbrich, 1983; Willis and Tattleman, 1989).

This research study applies SSM/I based precipitation remote sensing technology to the characterization of reentry vehicle erosion environments over selected sites. Three complementary areas of investigation were identified in our study proposal: (a) data acquisition and application of the SSM/I rain rate retrieval algorithm to the development of a four month summer climatology of rain rate over selected sites with an emphasis on the identification and analysis of heavy rain rate situations, (b) identification and assessment of appropriate convective cloud models to establish a parameterization of the relationship between surface rainfall rate and the vertical profile of hydrometeor liquid water content, and (c) testing of the parameterization of hydrometeor liquid water content on the determination of liquid water content profiles for selected cases with emphasis on intense convection. These issues are explored in the following sections.

2. BACKGROUND

2.1 Rain Rate Retrieval Concepts

At microwave wavelengths, precipitation sized droplets provide a source of atmospheric attenuation analogous to the effect of cloud droplets in the infrared spectrum (Savage, 1978; Falcone et al., 1979). This attenuation mechanism suggests a direct causal relationship between rainfall and microwave atmospheric emission which has been exploited to infer rainfall rate (Weinman and Wilheit, 1981). Furthermore, the presence of precipitation within the field of view of microwave sensors is itself of considerable interest since the quality of resultant retrievals of other quantities is most certainly degraded (Liou et al., 1981). For example, microwave sounding brightness temperatures such as those from the SSM/T must be corrected for rain in much the same way as infrared radiances are for cloud. To provide a theoretical microwave brightness temperature/rainfall rate relationship applicable to rain rate retrieval, models of both the rain layer (including a rain layer height and thickness) and of rain microphysics are required. These models determine the vertical distribution of hydrometeor liquid water content. Both of these factors, of course, vary synoptically introducing some uncertainty into the retrieval process.

Collectively, these factors determine the atmosphere's scattering and absorption contribution to total satellite incident brightness temperature which is evaluated as a multiple scattering calculation assuming that the rain layer fills the field of view. Microwave radiative transfer theory accounting for multiple scattering has been extensively applied to the study of atmospheric precipitation and clouds (Weinman and Guetter, 1977; Wilheit et al., 1977; Tsang and Kong, 1977; Jin and Isaacs, 1985). The surface background against which the rain is modeled consists of surface emission and surface reflected atmospheric contributions, which must be included.

Over the ocean, surface emissivity is low and relatively uniform, providing good contrast for the quantification of precipitation. This approach was applied over the ocean by Wilheit et al. (1977) to data from the NIMBUS 5 Electronically Scanning Microwave Spectrometer (ESMR) operating at 19.35 GHz. Accuracies of 2 mm/h and a dynamic range up to about 20 mm/h were achieved using ground based radar for validation. Results based on retrievals obtained using the Seasat and Nimbus 7 SMMR instruments, for example, indicate that the retrieved rainfall rates generally underestimate those measured at the surface with rain gages (cf. Gloerson et al., 1984). Lipes (1982) found that the Seasat SMMR failed to detect showery precipitation associated with convective cloud in midlatitudes and underestimated rain rates for heavy precipitation. This behavior was attributed to both loss of incremental sensitivity to precipitation at higher rainfall rates and insufficient sensor resolution (about 30 km at 37 GHz) in convective situations. Sensor resolution plays a role since intense precipitating cells with horizontal scales of a few kilometers will not fill the microwave radiometer's field of view. Similar results were obtained in midlatitudes by Alishouse (1983).

Theoretical calculations suggest that over land, higher frequency, dual polarized measurements can distinguish atmospheric scattering due to rain from surface contributions (Savage and Weinman, 1975; Weinman and Guetter, 1977; Huang and Liou, 1983).

However, in practice the dynamic range of measurable rainfall rates is so much reduced at 37 GHz that these measurements are virtually useless and considerable ambiguity of surface and atmospheric contributions still exists. In addition to the problems of specifying appropriate rain models and obtaining measurements over land, another problem arises because the typical horizontal scale of precipitating cloud elements is generally much less than the field of view of the ESMR instrument (50 km). Integration over a large field of view creates a negative bias which underestimates instantaneous rainfall rates. In spite of these difficulties, areas of intense precipitation can be identified (Spencer and Santeck, 1985). Based upon the above discussion, there will be some difficulties in providing accurate rain rates in intense convective situations from microwave data alone. The rainfall rates in the higher ranges of the desired domain will almost always be due to energetic convective cells with spatial scales on the order of a few kilometers which cannot be fully resolved with the 25 km FOVs of the SSM/I instrument. In such cases it has been noted that high rain rates are always associated with minima in the equivalent blackbody temperature (EBBT) field observed from infrared imagers (Negri and Adler, 1987a,b). The converse of this is not true, however, i.e., low EBBTs can be due to other than precipitation, therefore, it is advantageous to exploit both microwave (for lower rain rates and to identify the presence of intense convective precipitation) and infrared (at higher rain rates) data. At the higher rain rates (and to help in the determination of beam filling at lower rates), OLS infrared imager data can be used. The specific approach adopted could be based on that described by Adler and Negri, 1988. They used GOES imager data to delineate convective rain areas by searching for minima in the EBBT field and then assigned rain rates based on the results from a one dimensional cloud model which provided the relationship between convective development (cloud top height) and the resulting rain rate. Stratiform rain rates were delineated based on EBBT threshold criteria. Due to level of effort constraints, however, this study will focus on the use of SSM/I data alone to derive convective rainfall climatology.

2.2 SSM/I Data Characteristics

The Defense Meteorological Satellite Program (DMSP) Special Sensor Microwave/Imager (SSM/I), launched on 19 June 1987, is a passive microwave radiometer which provides brightness temperature data of particular relevance to the monitoring of global precipitation properties. The SSM/I sensor antenna observes seven microwave channels (three dual polarized frequencies: 19.35, 37.0, and 85.5 GHz and a vertically polarized channel at 22.235 GHz) and scans conically with an angle of incidence on the surface of the earth of 53.1 degrees (Savage et al., 1987). Using a single antenna to span this frequency range results in a sensor field-of-view (FOV) which varies with frequency: about 50 km at the two lowest frequencies, 25 km at 37 GHz, and 13 km at 85.5 GHz.

The exact spatial resolution of each FOV depends on the definition used and the antenna response pattern. Based on the polar orbiting DMSP satellite, SSM/I data potentially provides global coverage daily, with twice daily coverage possible at northern latitudes due to orbital overlap. SSM/I data are archived through the DoD-NOAA Shared Metsat Processing agreement by NOAA/NESDIS through the Cryospheric Data Management System (CDMS) at the National Snow and Ice Data Center (see Weaver et al., 1987). These data consist of both satellite data records (SDRs, i.e. the calibrated brightness temperatures) and environmental data records (EDRs, i.e. the retrieved parameters). Table 1 illustrates the sensitivity of SSM/I microwave imager channels to a variety of desired geophysical parameters (the DMSP assigned priorities for these parameters are in brackets).

The retrieval of precipitation from SSM/I data follows the statistical method outlined in Lo (1983) and used in simulation for SSM/I data sets in Jin and Isaacs (1987). While simulation retrieval results suggest that the required accuracies of a few mm/h are possible at the lower rain rates a number of important factors are often neglected. These include the degree of beamfilling, the vertical extent of the precipitation, the rain drop size distribution,

Table 1. Microwave Imager Channel Applications

<i>Sensor Parameters</i>				
Frequency (GHz)	19.35	22.235	37	85.5
Spatial resolution (km)	50	50	25	12.5
Sensitivity (K)	0.6	0.8	0.8	1.0
<i>Geophysical Parameters, [Priority]</i>				
Precipitation (land) [5]	0		•	•
Precipitation (ocean) [5]	•	0	x	x
Snow cover [10]	•		0	x
Sea ice (extent, type) [18]	•		•	•
Sea surface temperature [8]	0	0	x	
Wind speed (ocean) [4]	0	x	x	x
Atmospheric water (total) [3]	•	•	0	
Soil Moisture [9]	0			
Vegetation (e.g. Albedo) [1]	x	0	x	x
Cloud Liquid Water [7]	x	x	x	•

Channels which are important for determining each parameter are indicated using the following code:

• = Critical; 0 = Important; x = Helpful.

the temperature profile through the precipitating layer, and the presence of glaciated precipitation which can significantly alter the brightness temperature signature. These factors are often kept constant in simulations whereas they vary in the natural atmosphere. Uncertainties associated with these factors certainly impact the accuracy of rainfall rate determination, and it is perhaps more reasonable to expect that a few broad rainfall rate categories are retrievable from the SSM/I. Retrievals of precipitation (both liquid and glaciated) and surface emissivity from simulated SSM/I data were discussed in a journal article by Jin and Isaacs (1987) which also described a specially developed multiple scattering model which was designed to simulate dual polarized brightness temperatures in the presence of inhomogeneous, nonisothermal distributions of atmospheric precipitation.

The capability to simulate inhomogeneous (i.e., those varying with height) distributions of precipitation is necessary to treat the realistic variation of rain rate with altitude within developing frontal systems and the phase change (from water to ice) occurring in convective situations. In that paper brightness temperature simulations specifically applicable to the SSM/I were shown. Figure 1, for example, illustrates the dependence of simulated dual polarized 85.5 GHz brightness temperature on rain rate and the presence of an upper layer of frozen precipitation. The figure inset illustrates a model of the simulated atmosphere with a 5 km rain layer over the ocean surface and either a 3 km ice layer or another 3 km rain layer above. It can be seen from these results that due to enhanced multiple scattering at this frequency, the brightness temperature is significantly lowered by the ice layer. At lower frequencies such as 19.35 GHz, the ice layer has little or no effect and, therefore, using the multispectral SSM/I data, the phase of the upper levels of precipitation can be identified in the retrieval/analysis procedure in addition to the rain rate. This provides a method to probe the vertical structure of the precipitation.

A significant calibration/validation effort (Olson et al., 1988) has focused on the SSM/I precipitation retrieval algorithm. The resulting investigation provides simple formulae to obtain rainfall rates over ocean and land and addresses the loss of the 85.5V channel data. The latter issue is of significance for the inference of rain rate over land. We propose to employ the most recent land regression coefficients obtained from the University of Wisconsin group. The steps in the retrieval are essentially: (1) antenna pattern correct, (2) apply existing SSM/I precipitation screening logic, and (3) apply

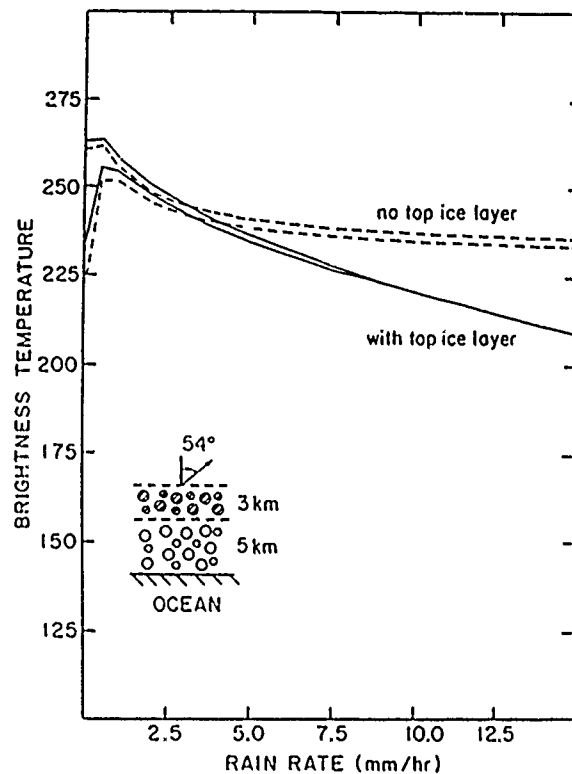


Figure 1. SSM/I dual polarized 85.5 GHz brightness temperature vs. rain rate (mm/hr) with and without top layer of glaciated precipitation

regression formulae for rain rate. Step (1) is part of the coding available with the compacted SSM/I data from Remote Sensing System, Inc. (F. Wentz, personal communication). The coding for steps 2 and 3 will be obtained via GL from the University of Wisconsin. We note that due to the additional computational load imposed by the antenna pattern correction step, it might be prudent to develop a prescreening algorithm to identify precipitating situations directly from the antenna temperatures themselves. If this is possible, only those cases identified need be antenna pattern corrected.

2.3 Convective Cloud Models

As discussed in the previous section, the SSM/I retrieval algorithm provides rain rate as an output parameter although the radiative transfer physics indicates that radiometer brightness temperatures are fundamentally sensitive to hydrometeor liquid water content (LWC). Assessment of reentry vehicle erosion indices require determination of a hydrometeor liquid water content vertical profile. The required interface between surface rainfall rate and LWC profile is a model of the vertical distribution of hydrometeors appropriate to the observed synoptic situation. Previous studies such as Peirce et al. (1975) have focused on the applicability of specific hydrometeor LWC models for this purpose. Notably, Falcone et al. (1979) have specified climatological cloud and hydrometeor liquid water content models applicable to the simulation of microwave and millimeter wave data sets which provide strawman cloud model candidates as functions of precipitation intensity categories (i.e. light, moderate, heavy). Since the application driven climatological emphasis will be on the delineation of convective precipitation, our focus will be on convective cloud models.

Table 2 provides a list of candidate models which characterize a range of synoptic situations, including: frontal rain, thunderstorms, tropical squall lines, and cumulus towers. For example, a simple one-dimensional convective cloud model is that based on the work of Cotton (1972a,b) and Simpson and Wiggert (1969). The model dynamics are

Table 2. Candidate Convective Cloud Models

<i>Synoptic Situation</i>	<i>Reference</i>
Thunderstorm	Helmsfield and Fulton, 1988
Frontal Rainband	Rutledge and Hobbs, 1984
Cumulus Tower	Simpson and Wiggert, 1969
Tropical Squall Line	Tao and Simpson, 1989
Tropical Storm	Wilheit et al., 1982
Convective Cloud	Cotton, 1972a,b

based on the conservation of vertical momentum including the buoyancy effects of perturbation temperature and liquid water loading. Physical processes included in this simple model are the latent heating by condensation, entrainment of environmental air, conversion of cloud liquid water to rain (and its fallout), and the freezing of condensate. The microphysical parameterizations are kept intentionally simple, both in the interests of run time and because of the likely uncertainties in the input data. In Section 5, we discuss the hydrometeor cloud model in greater detail and identify parameterization for stratiform and convective precipitation.

3. TECHNICAL APPROACH

3.1 Rain Rate Estimation Procedure

A functional flow diagram of the project analysis approach is shown in Figure 2. The essential steps are: (a) reading of the SSM/I TDRs from the acquired SSM/I data tapes, (b) calibration and antenna pattern corrections applied to the data to obtain brightness

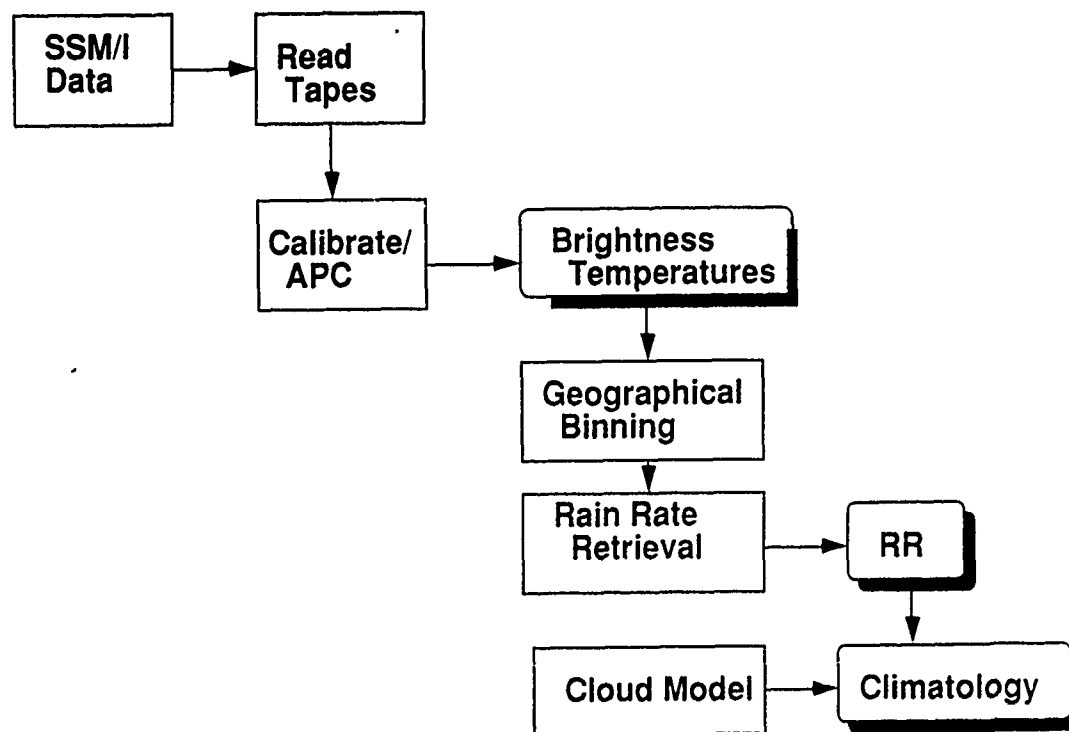


Figure 2. Functional flow diagram for SSM/I data based erosion parameter estimation procedure

temperatures, (c) geographical binning of the data according to the location or each desired site by latitude and longitude, (d) application of the rain rate retrieval algorithm to the data, and (e) evaluation of relevant climatologies. The last step includes calculation of time series for the four month period for the rain rate and integrated liquid water content of precipitation. The latter time series required adoption of appropriate hydrometeor cloud models which are described in Section 5.

The software for reading the SSM/I tapes was implemented on the Air Force Geophysics Laboratory Interactive Meteorological System (AIMS) cluster (Gustafson and Felde, 1988). The unmodified software was run and its performance verified. Certain modifications of the software were made to enhance this project's performance. The first aspect of the software modification concerned the performance time of the entire package. In its unmodified form, the tape reading package took about 8 hours to read an entire SSM/I data tape. Since there are 32 tapes, at best a minimum of 32 tape reads will have to be performed, which would translate into over 6 weeks of work just to extract the data necessary for this project. After closely examining the individual modules and command/data flow design of the software, we optimized the performance time such that it now takes slightly more than 1 hour to read a data tape. The data extracted by the modified software has been verified and validated compared to data extracted by the unmodified package. Software was developed that: (a) loaded the site locations into the program, and (b) filtered the input data stream from any SSM/I data tape such that it would determine "local" data points relevant for each site, and group them into respective data sets. The data is binned using the exact latitude/longitude coordinates of each site such that a region defined by a square, whose center is the point in question, is generated. Any data points which fall within this defined region are considered associated with the point in question. Upon completion of this filtering, a file for each region is written, containing the data observed by the SSM/I for the time period in question. Software to read the SSM/I tapes and do the geographical binning by site is contained in Appendix A. A sample output from the tape reading algorithm is contained in Appendix B. Output are the time (number of seconds since the SSM/I sensor was first turned on), latitude, longitude and brightness temperatures for 19.35 v,h, 22.235, and 37 v,h GHz. The 85.5 GHz channel is read in a second pass due to the different sampling.

A data display software package was also prepared that utilizes NCAR and GKS routines to project the user's choice of either an orthographic, or cylindrically equidistant projection of the earth, and then superimposes either the data observed for a specific site, or the surface scan track for the SSM/I sensor during the periods in question. This software is given in Appendix C. Sample map output illustrating the data density as a function of site at various scales is shown in Appendix D.

Software was also written to evaluate the desired climatologies. These elements include: (a) the calculation of average rain rates and spatial standard deviations within each site region, and (b) the evaluation of liquid water content and integrated liquid water content time series based on the adopted hydrometeor cloud parameterization. This software is also provided in Appendix A.

3.2 SSM/I Data Set

A list of the SSM/I data used in this study is given in Appendix E. Provided are: (a) the tape number, (b) the beginning and end time of data set, and (c) the number of files.

The data files were acquired as part of this study and are available for further analysis. The software capabilities assembled and developed during the course of this pilot study, i.e. data reading, data categorization, data plotting, and data analysis, should be generally applicable to the analysis of this SSM/I data set.

While no comprehensive examination of the data set was made for purposes other than those of this study, it should be noted that this global data set should be extremely useful for a variety of other study purposes.

4. SSM/I RAIN RATE CLIMATOLOGIES

4.1 Eurasian Sites

The study focused on eleven USSR stations of the Environmental Definition Program. Data on these sites was obtained from GL. The eleven sites are: (a) Aktyubinsk, (b) Blagoveschensk, (c) Chita, (d) Kiev, (e) Leningrad, (f) Moscow, (g) Murmansk, (h) Perm, (i) Semipalatinsk, (j) Simferopol, and (k) Tashkent. The latitude and longitude coordinates for these sites used in the study can be found in subroutine "estreg" in Appendix A.

Of these sites, Murmansk is the northernmost and Tashkent is the southernmost. Blagoveschensk and Chita are in the far east bordering China. Leningrad, Moscow, and Kiev are the most western sites. Murmansk is the only coastal site. For the purposes of this study all of the sites were treated as land based.

This study did not call for the collection or investigation of conventional data sources such as surface and upper air data which might be available for these locations or for the comparison of the SSM/I derived rainfall rate climatologies with these data. In retrospect, this is an important consideration. Essentially, the subsequent analysis assumes that the statistical relationship between rain rate and brightness temperature inherent in the SSM/I algorithm regression coefficients (which were validated over the United States and the United Kingdom), are equally valid over the set of Eurasian sites.

4.2 Site Specific Rain Rate Climatologies

Referring to the data flow diagram presented in Figure 2, the next step in the data processing is the coding and application of the University of Wisconsin SSM/I rain rate retrieval algorithm to the four month data set. This has been accomplished. Data for each of the eleven sites was binned according to lat/long and time tag and rain rate retrievals were performed as a function of field-of-view within 400 km boxes centered at each site. This bin size was selected somewhat arbitrarily, however, consideration was given to capturing precipitation events of synoptic scale which passed in the vicinity of the site as well as mesoscale/convective activity. Considerations of time-space sampling for area-averaged precipitation (WMO, 1985) were considered in formulating our approach, however, there was insufficient time to fully explore these issues.

In addition to the spectral information available in the SSM/I brightness temperature data used to derive the surface rainfall rates, it was recognized that the spatial distribution of rain within the binned area could be used for the purpose of helping to characterize the meteorological properties of the situation. This information is particularly useful to aid in the selection of an appropriate parameterization of precipitation liquid water content (both vertical distribution and integrated) based on the SSM/I derived surface rain rates. It is the liquid water content which can be related to reentry vehicle erosion.

For this reason, both the average daily rain rate (defined as the simple arithmetic average of the individual SSM/I derived rain rates falling within the site specific bin) and the spatial standard deviation (SD) within the bin were evaluated to analyze the spatial coherence of the rain rate field. These data were plotted as time series to produce rain rate climatologies for each site for the four month period. Climatologies for each site are illustrated in Figures 3-13. Illustrated are average rain rate (Figs 3a-13a) and standard deviation (Figs. 3b-13b), respectively. The time series are labelled in days from 1 June 1989, the beginning of the four month data set. All time series plots have been put on a common scale (truncated at 2.5 mm/h) so that intercomparisons can be made.

Examining Figure 7a for Leningrad, it can be seen that there are obvious high (in a relative sense averaged over 400 km squares) rain rate situations (e.g. days 60-65) and low rain rate days (e.g. 35-45). The standard deviations are also illustrative (Fig. 7b). For days 60-65, the high rain rates are accompanied by a large spatial standard deviation (also days 27-30, 75, and 82). This might be indicative of cellular convection. Moderate rain rates with smaller standard deviations might indicate more uniform precipitation. The Leningrad data set does not show this behavior.

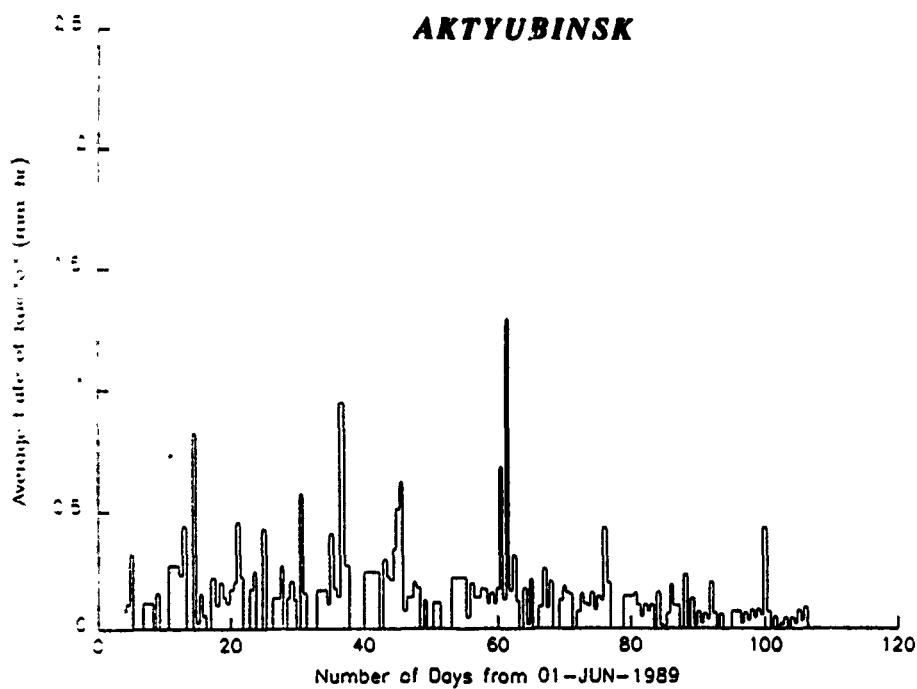


Figure 3a. Sample time series of SSM/I derived rain rate: average rain rate.

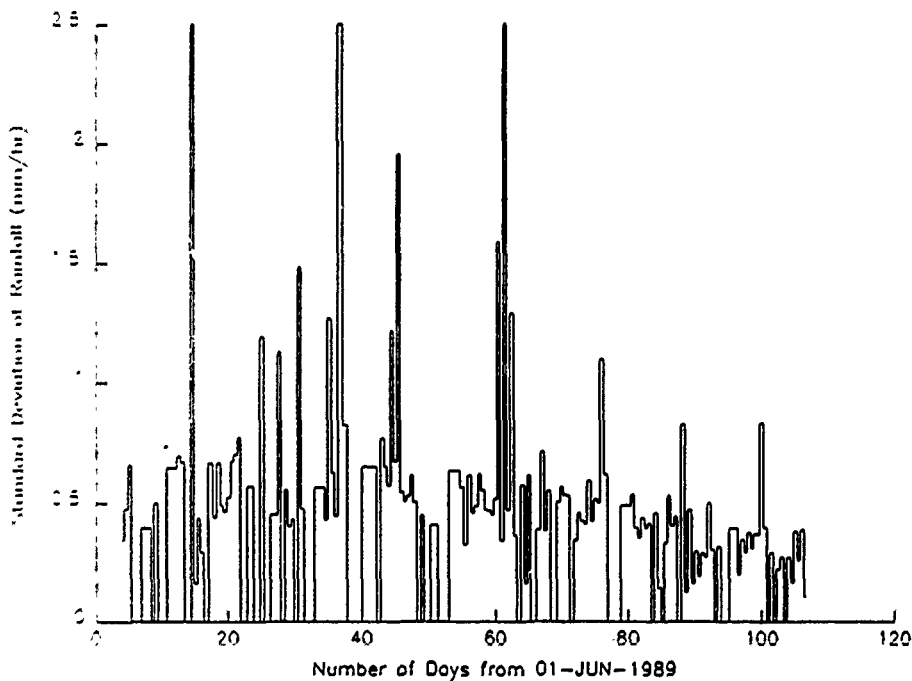


Figure 3b. Sample time series of SSM/I derived rain rate: standard deviation.

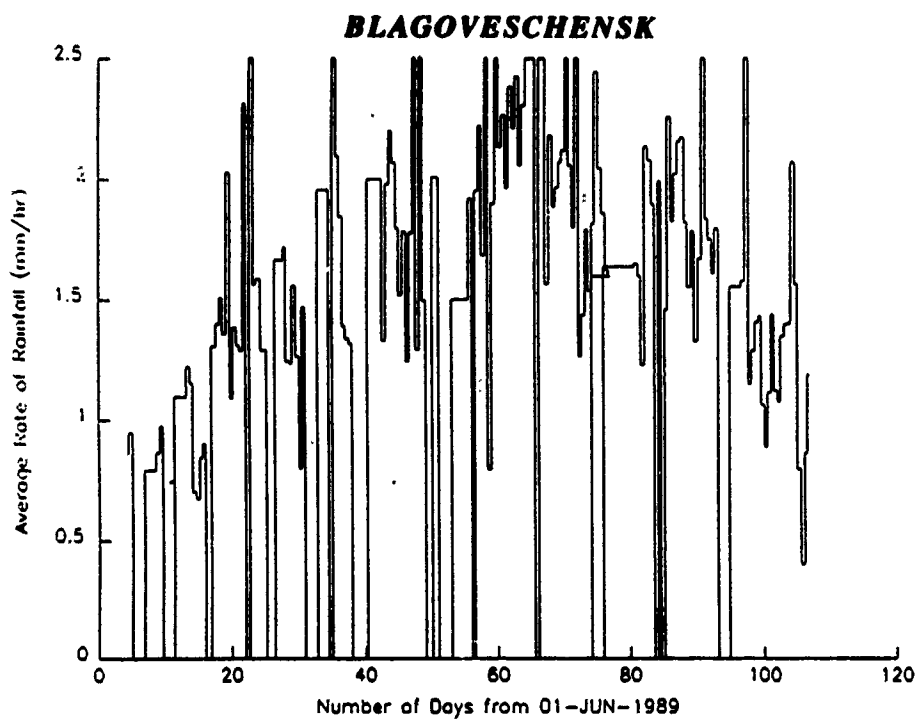


Figure 4a. Sample time series of SSM/I derived rain rate: average rain rate.

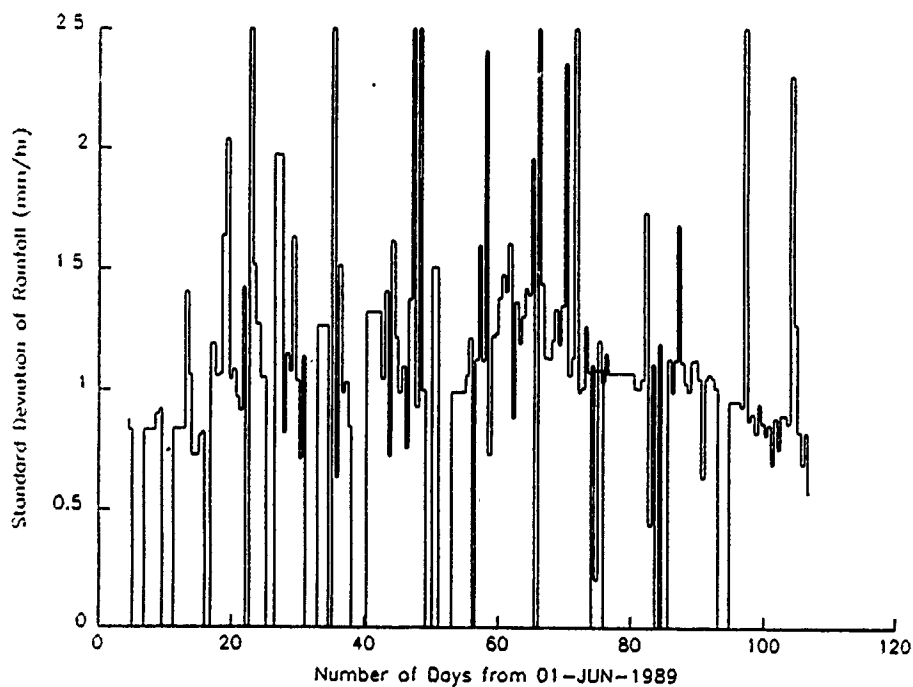


Figure 4b. Sample time series of SSM/I derived rain rate: standard deviation.

CHITA

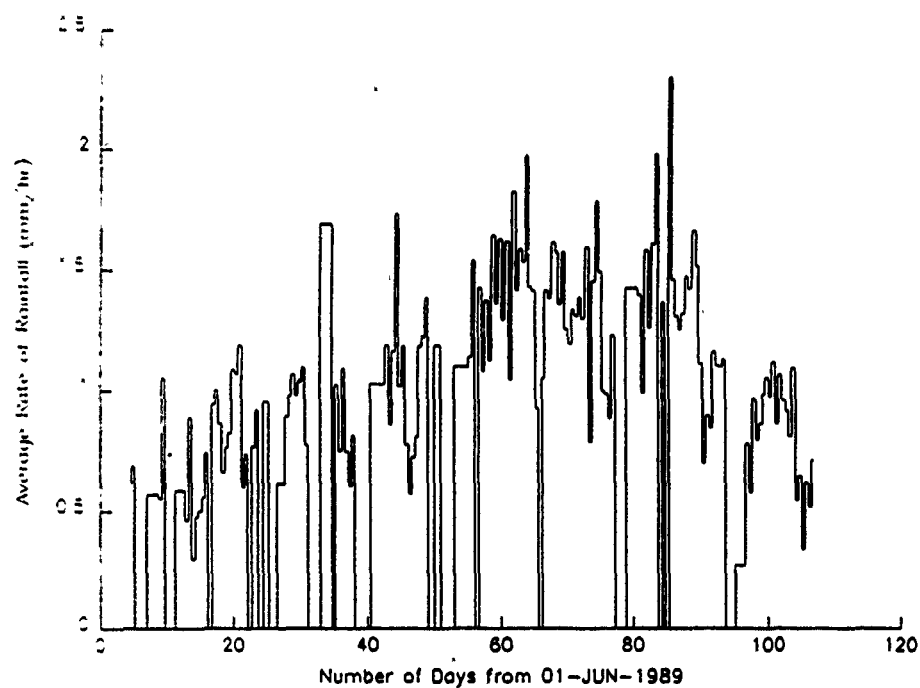


Figure 5a. Sample time series of SSM/I derived rain rate: average rain rate.

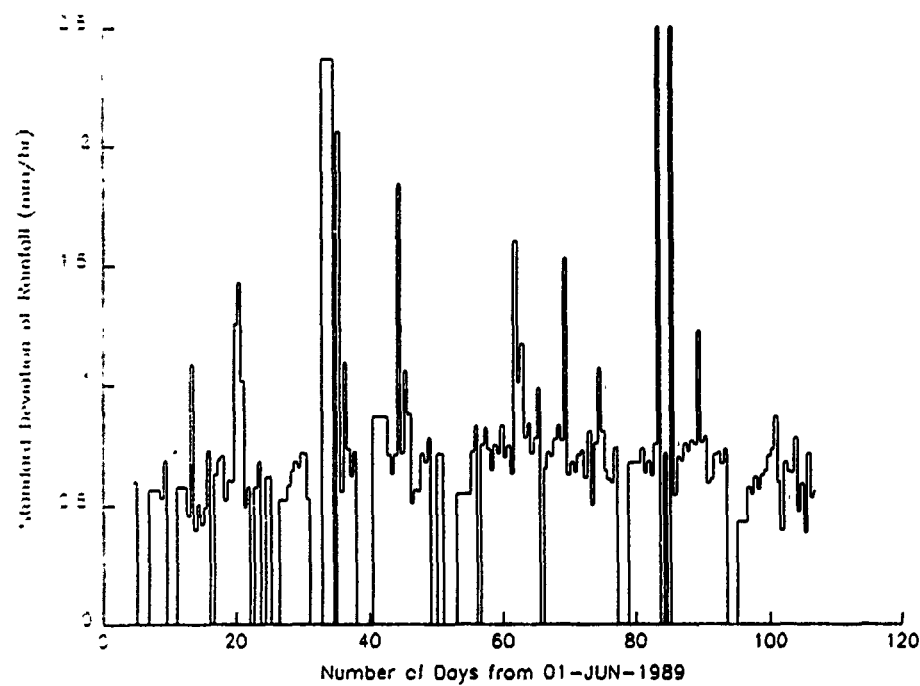


Figure 5b. Sample time series of SSM/I derived rain rate: standard deviation.

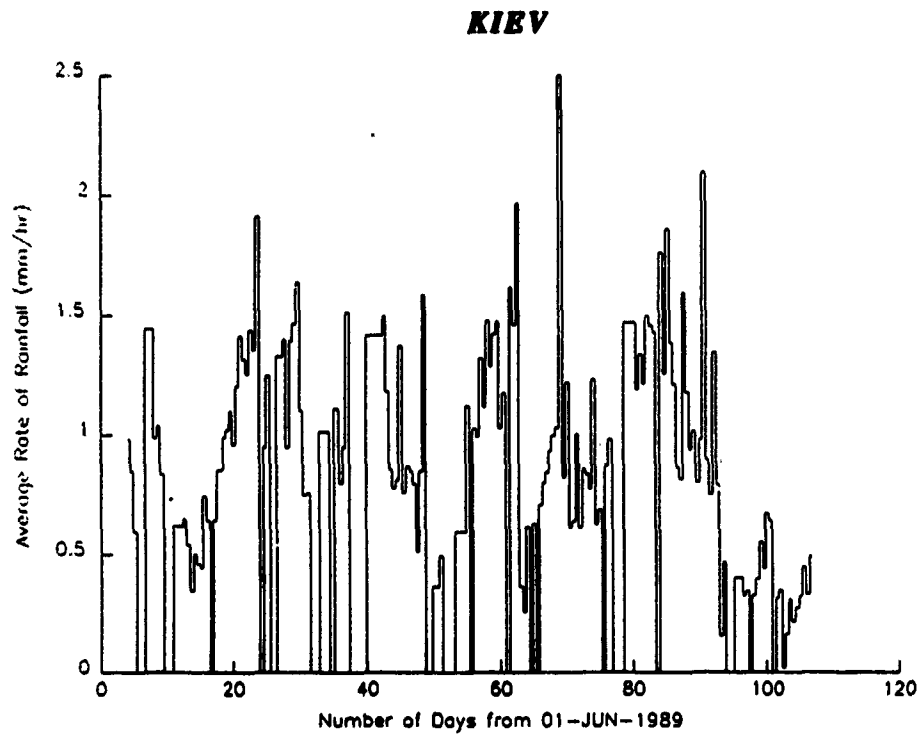


Figure 6a. Sample time series of SSM/I derived rain rate: average rain rate.

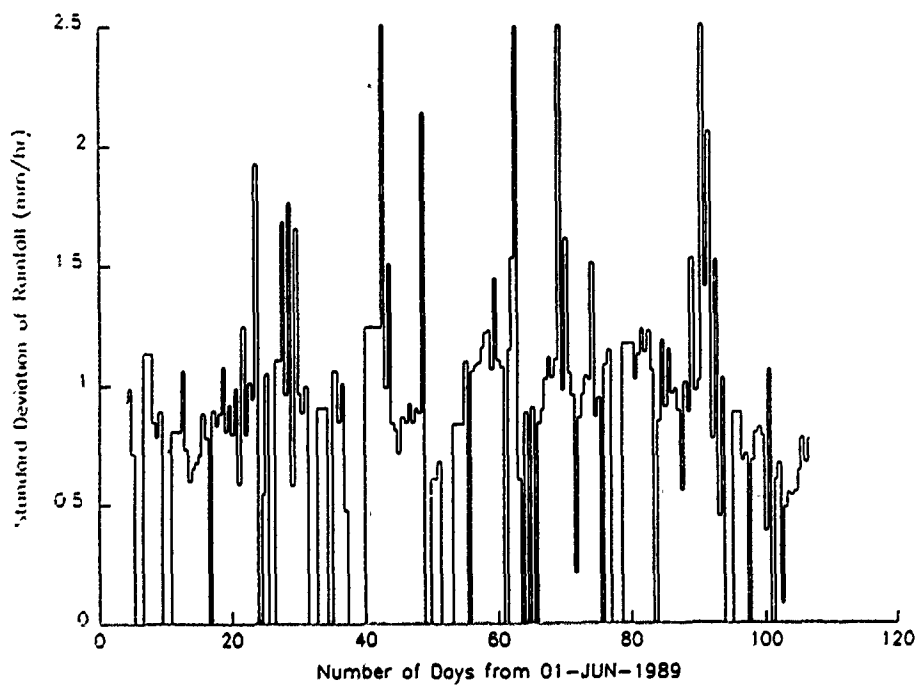


Figure 6b. Sample time series of SSM/I derived rain rate: standard deviation.

LENINGRAD

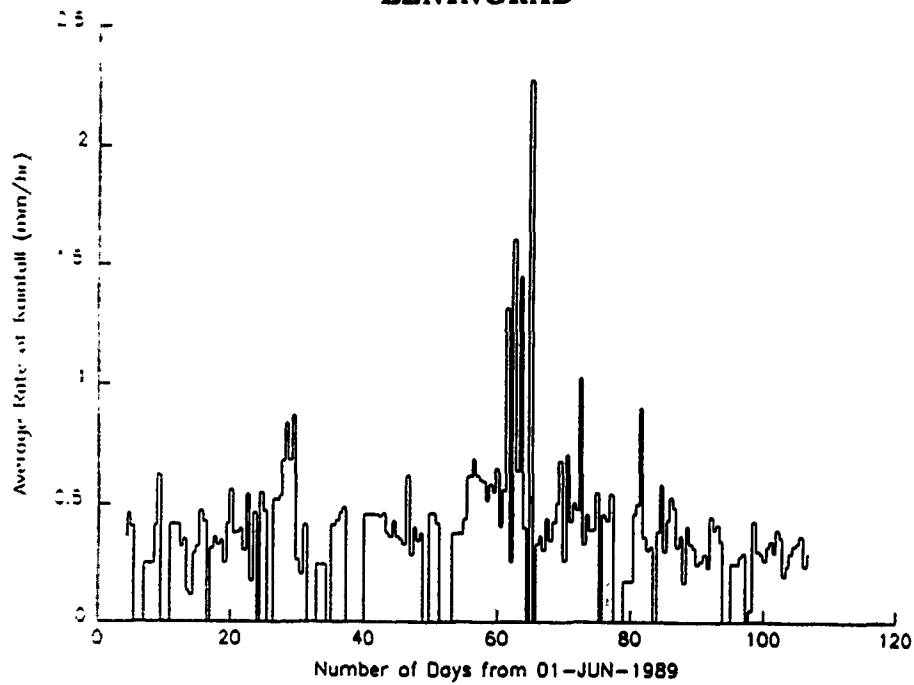


Figure 7a. Sample time series of SSM/I derived rain rate: average rain rate.

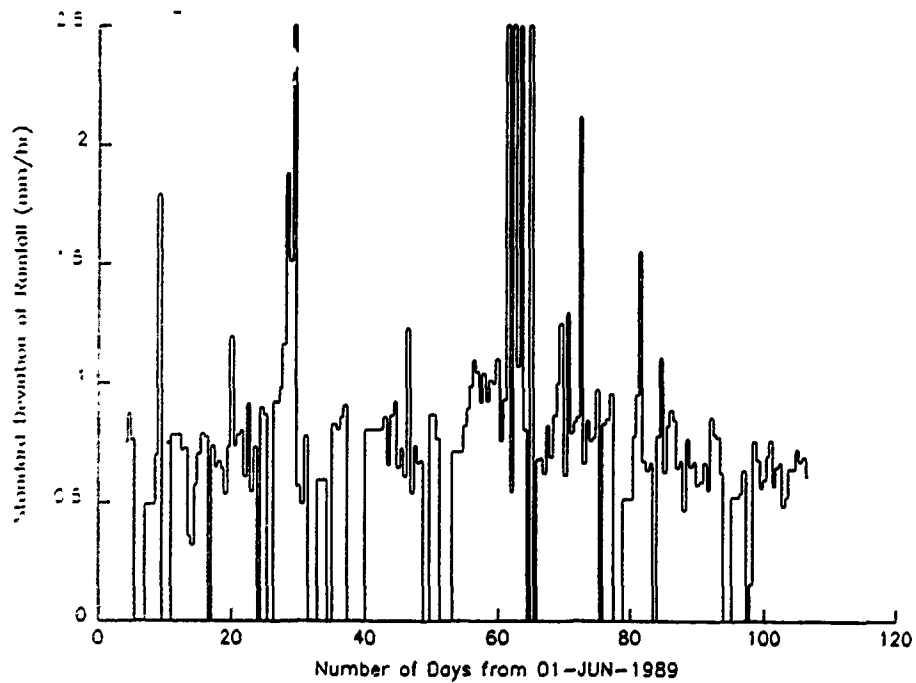


Figure 7b. Sample time series of SSM/I derived rain rate: standard deviation.

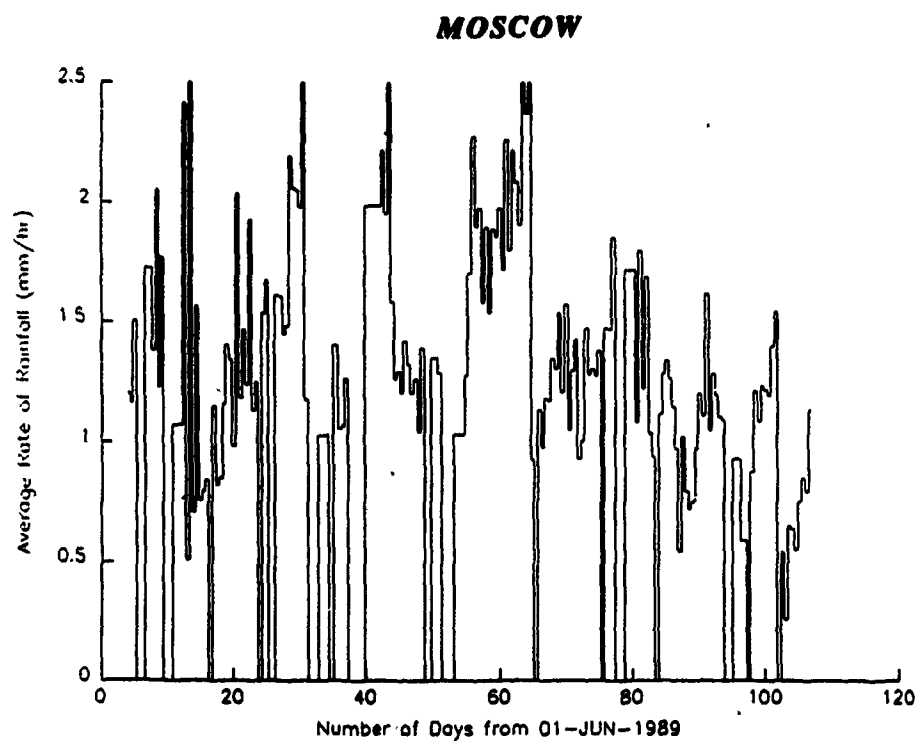


Figure 8a. Sample time series of SSM/I derived rain rate: average rain rate.

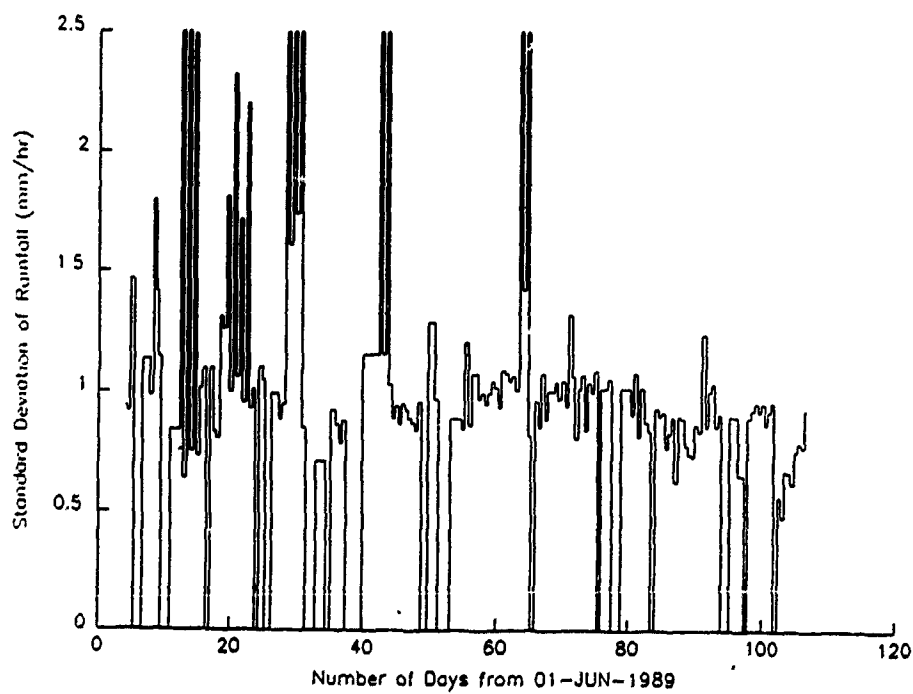


Figure 8b. Sample time series of SSM/I derived rain rate: standard deviation.

MURMANSK

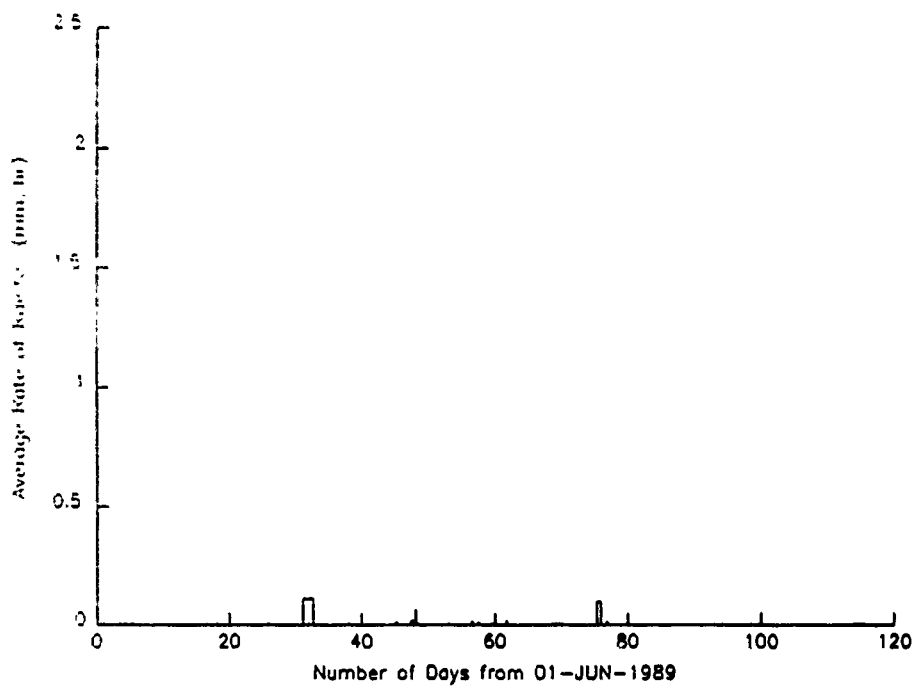


Figure 9a. Sample time series of SSM/I derived rain rate: average rain rate.

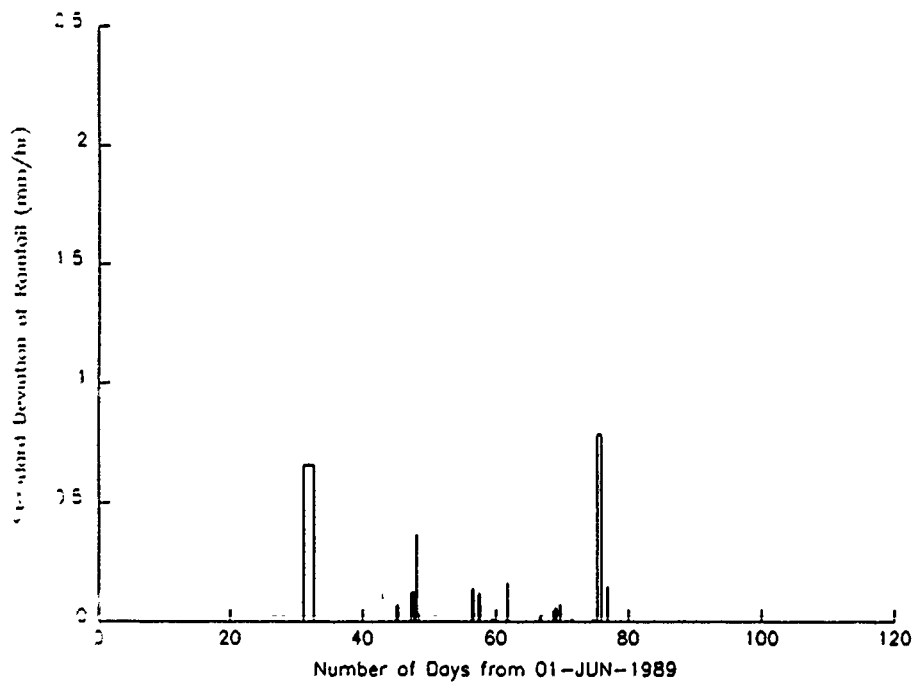


Figure 9b. Sample time series of SSM/I derived rain rate: standard deviation.

PERM

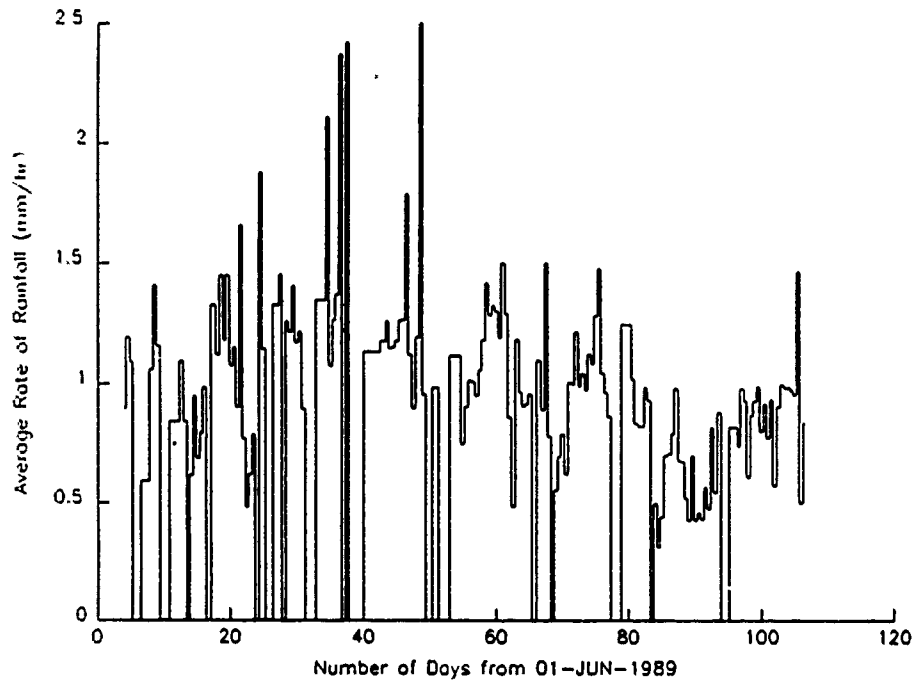


Figure 10a. Sample time series of SSM/I derived rain rate: average rain rate.

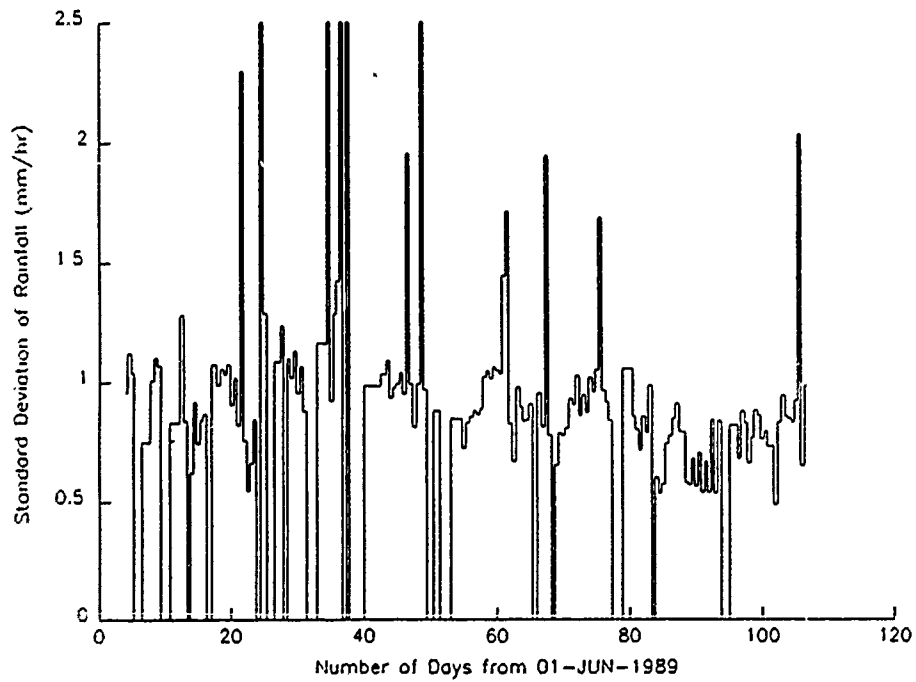


Figure 10b. Sample time series of SSM/I derived rain rate: standard deviation.

SEMIPALATINSK

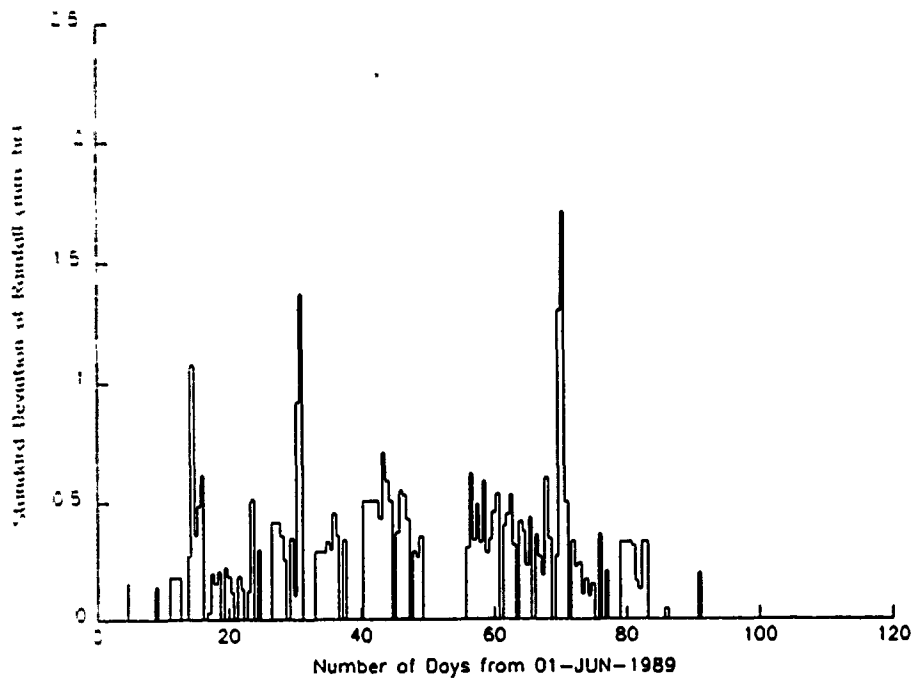


Figure 11a. Sample time series of SSM/I derived rain rate: average rain rate.

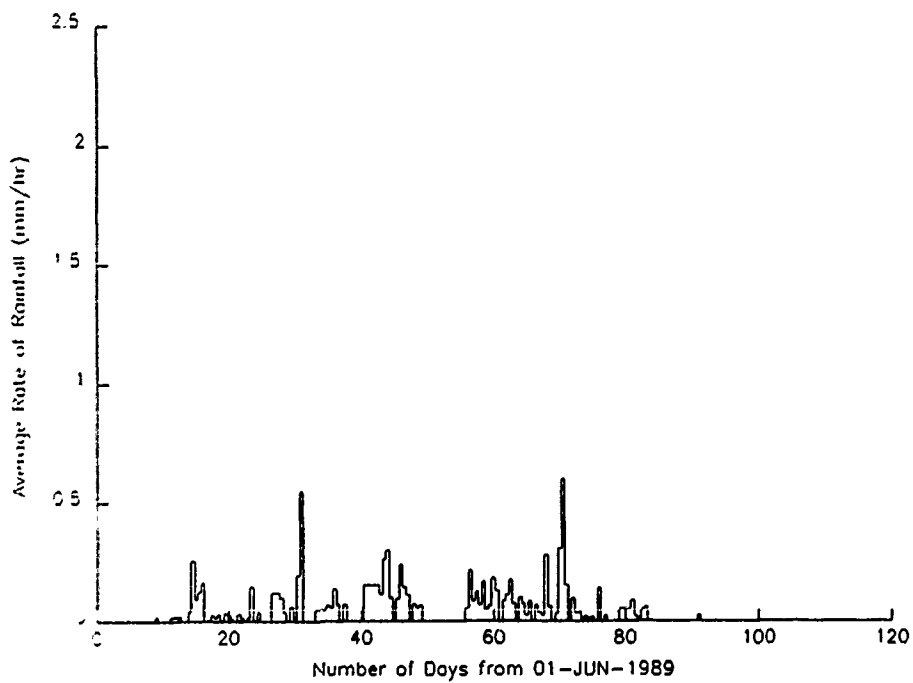


Figure 11b. Sample time series of SSM/I derived rain rate: standard deviation.

SIMFEROPOL

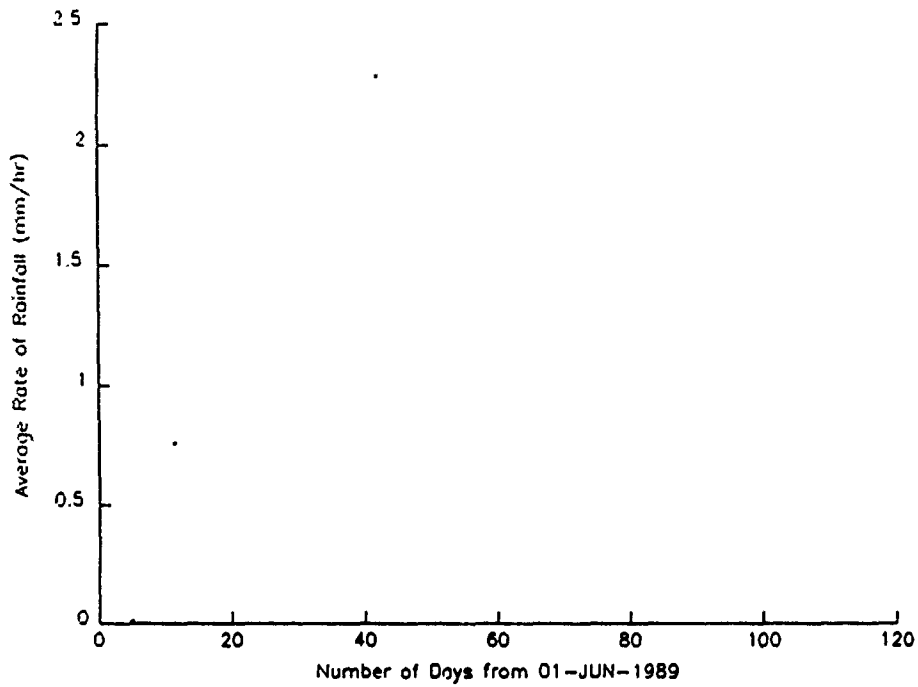


Figure 12a. Sample time series of SSM/I derived rain rate: average rain rate.

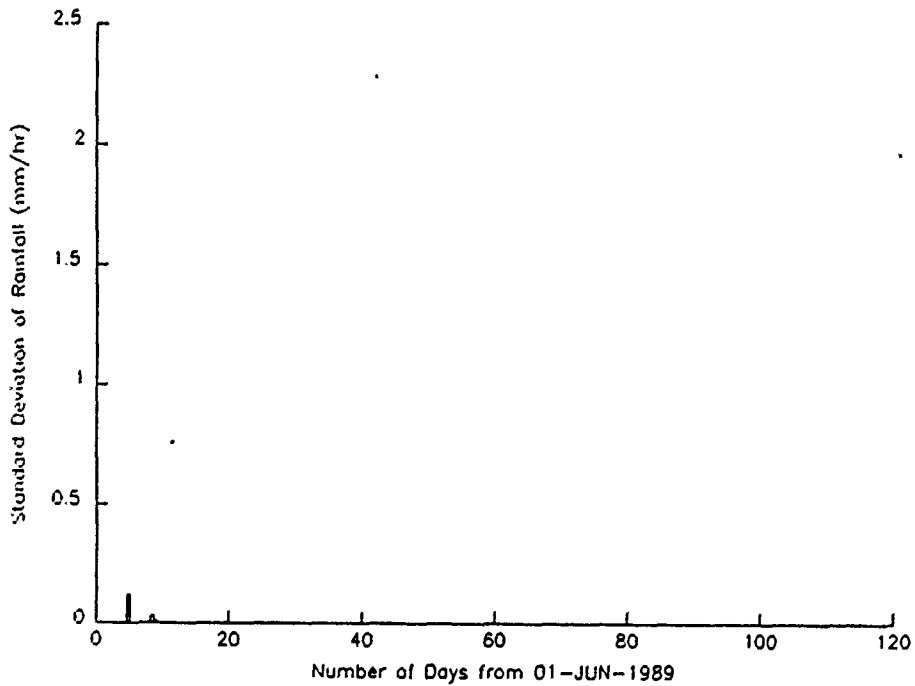


Figure 12b. Sample time series of SSM/I derived rain rate: standard deviation.

TASHKENT

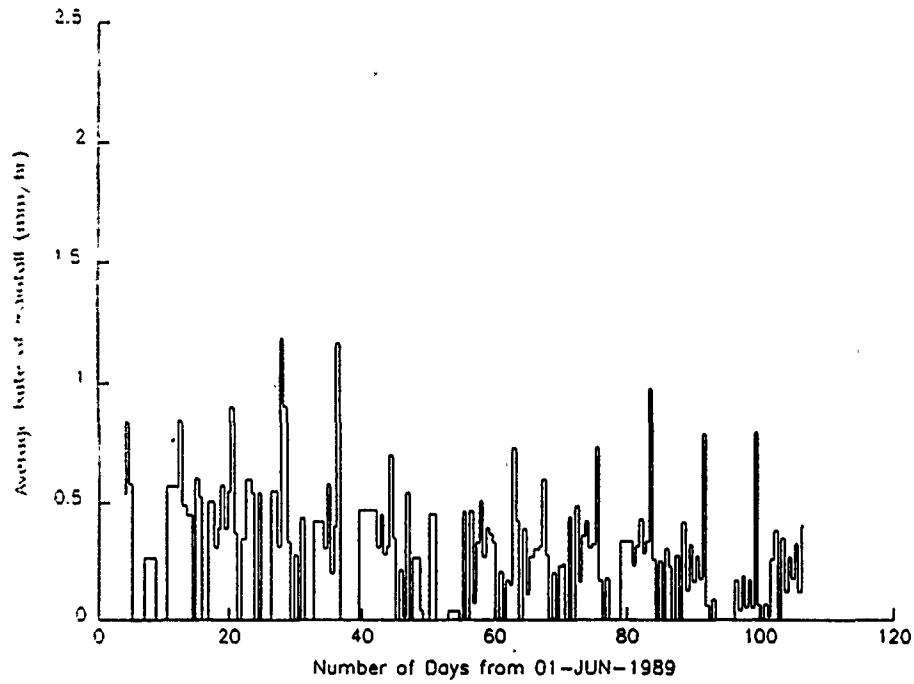


Figure 13a. Sample time series of SSM/I derived rain rate: average rain rate.

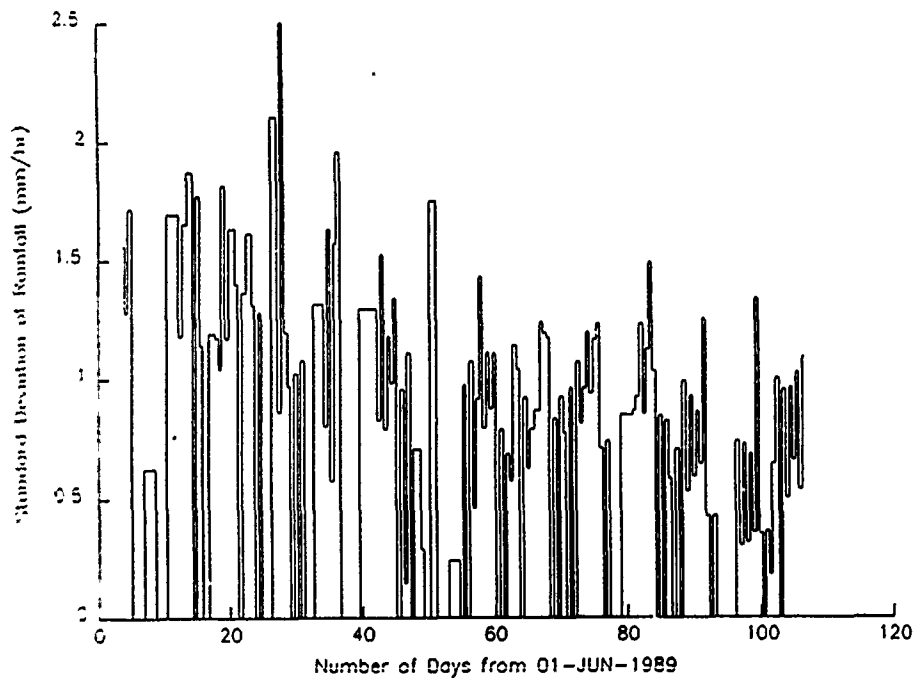


Figure 13b. Sample time series of SSM/I derived rain rate: standard deviation.

In addition to the time series, we can look at the contoured daily SSM/I derived rain rates for given sites. This gives the opportunity to study the structure of the precipitation for a desired day at the resolution of the SSM/I footprints. An example is shown in Figure 14 for Moscow. Based on the time series data given in Figures 8a,b, the figure illustrates: (a) a low rain, high SD case (day 15, [4]), (b) a high rain, high SD case (day 44, [0.4]), (c) a high rain, low SD case (day 61, [0.2]), and (d) a low rain, low SD case (day 95, [0.1]). The numbers in brackets are the contour intervals on each plot in mm/h. A heavy convective cell can be seen in Figure 14a, but there is little precipitation elsewhere resulting in a very low average rate for the region. Cells of moderate intensity can be seen in Figures 14b,c also. In these cases most of the region is active resulting in high average rainfall rates. In Figure 14d by comparison, there is light rain throughout the region (note the contour interval changes). The importance of examining both the average rainfall rate and the spatial standard deviation in characterizing an event is obvious.

4.3 Discussion

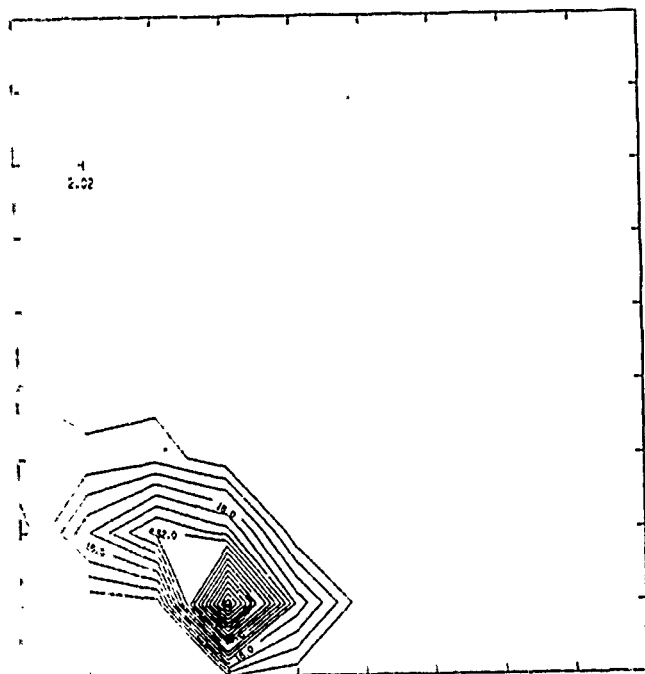
The type of meteorological event resulting in precipitation is likely to be related to the distribution of hydrometeor signatures within the region examined. High standard deviation indicates that the precipitation is scattered over the area of the view box, e.g. convective type precipitation, and the low standard deviation means the rainfall is uniform over the area of the view box, e.g. stratiform type precipitation. If high rainfall rate is associated with high standard deviation, it might be precipitation from individual thunderstorms. The passage of a frontal rainband, on the other hand, could be characterized by high rainfall rate associated with low standard deviation. The association of low rainfall rate with low standard deviation could mean the passage of a warm front, and/or precipitation from stratiform cloud. If low rainfall rate associates with high standard deviation, it could mean that the weather system which causes precipitation passes through only part of the view box. The other possibilities of low rainfall rate with high standard deviation could indicate that the weather system is too weak to produce a sufficient amount of precipitation and/or the environment is too dry, thus only part of the rainfall could be detected at the surface when the weather system passes through the view box.

Regions of convective and stratiform precipitation are hard to define, because several well-developed and decaying convective cells might still overhang into the stratiform region (Tao and Simpson, 1989). Therefore, it is hard to use the rain rate to clearly define the type of precipitation. From the data, we can see that the two stations located at the eastern part of the USSR have higher rainfall rate and higher standard deviation. The difference between these two stations might be that individual thunderstorms occur in Blagoveschensk more than Chita. Although both data show that the frontal rainfall occurs very often at both sites. It might be that the Blagoveschensk site is much closer to the ocean. Other sites have less rainfall rate and show the situation of steady precipitation occurs more frequently in these locations, despite the fact that some individual thunderstorms (maybe afternoon thunderstorms) occurred in the period.

We employ these spatial coherence concepts to the application of our precipitation cloud models (Section 5) to the determination of integrated hydrometeor liquid water content in Section 7.

5. CONVECTIVE CLOUD MODEL PARAMETERIZATIONS

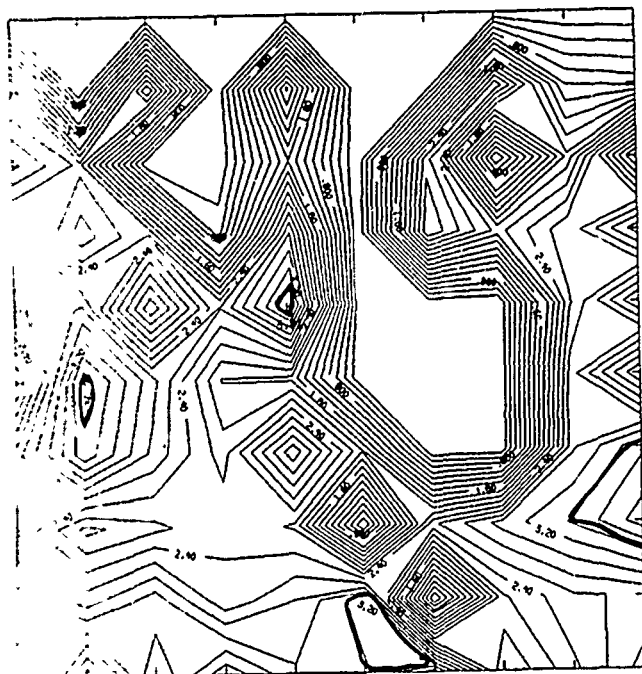
Task 2 required definition of cloud models to relate SSM/I derived surface rain rates to precipitation liquid water content. We have completed this task by defining parameterizations of liquid water content vertical distribution and total integrated liquid water content of precipitation for stratiform and convective rain with the capability to decide between the two using the spatial coherence data derived from the SSM/I rain rate fields.



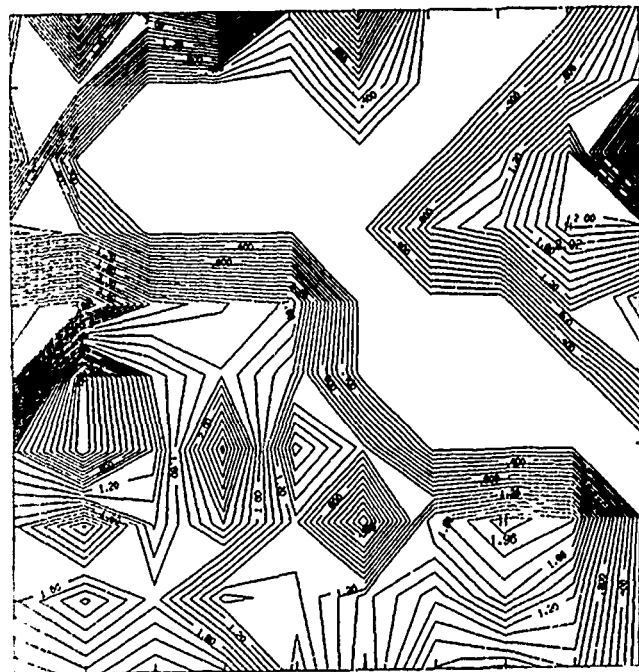
a



b



c



d

Figure 14. Sample contour map of SSM/I derived rain rate.

5.1 Cloud Process Overview

The formation of raindrops or ice crystals involves complicated microphysical and dynamical processes. The thermodynamical effects from the phase changes of water in turn affect the evolution of the weather system in which those processes are embedded. Several papers have studied the dependence of the formation of precipitation on microphysical and dynamical processes. The results show that both the microphysical and the dynamical processes are important. For example, the growth and fallout of rain can interact with the updraft, or can evaporate in the subsaturated downdraft region, which in turn, affects formation of the hydrometeors. Since measurement of the microphysical processes is difficult, the only way to simulate these processes is to parameterize them with respect to the large scale dynamical motion. Due to recent theoretical developments and laboratory experiments, several models have been proposed to treat these processes and some of the results have been compared with the measurements from the field experiments.

In this study we conducted a survey of different hydrometeor cloud models focusing on those which can be used to simulate the vertical distribution of liquid water content based on the surface precipitation rate. A simple parameterized relationship based on climatological statistics is derived and the vertical distribution of the liquid water content is expressed as a function of height and surface rainfall rate.

5.2 Review of Cloud Vertical Distribution Models

5.2.1 Simulation Studies

A high correlation between cloud top height and rainfall rate has been shown by Zawadzki and Ro (1978) and Dennis et al. (1975). Adler and Mack (1984) used a one dimensional cloud model to study the relationship of the thunderstorm cloud height-rainfall rate and the cloud height-volume rainfall rate with satellite infrared data. The variation of the vertical velocity and precipitation efficiency γ has been shown to dominate both the slopes and the difference of the two curves which represent the relation between the cloud top height and the rainfall rate. Information on the convection from numerical model output is needed to derive the cloud-rain relationship, and the vertical shear is considered to be the important parameter to estimate the volume rainfall rate.

Larger scale factors such as the synoptic environment, topographical situation, and the location of the station with respect to the thunderstorm or frontal rainband are important in determining the desired relationship. Therefore, empirical rain estimation techniques developed in one area cannot be applied directly to other areas. Simple adjustments may be inadequate because of differences in slopes of rainfall rate-height in different locations. To determine convective rain rate and the volume rain rate, the moisture source, the vertical velocity, and the rain efficiency are important. Additionally, the updraft area is important in determining the volume rain rate. Ideally all of these data should be used to adjust the value of the input parameters to get a more representative profile. Thus, full use of a numerical cloud model with the inclusion of the adequate dynamical processes is necessary.

Kessler (1959, 1961, 1963) devised parameterized equations for microphysical processes (cloud water and rain) with an assumed vertical motion profile and water generation function. Simpson and Wiggert (1969) used a one dimensional cloud model with the Kessler (1965) type of parameterization to study the precipitation in tropical cumulus clouds. The microphysical processes include the autoconversion from cloud water to precipitation water, collection and coalescence, terminal velocity, and fallout of the precipitation with the evaporation due to entrainment of drier air in a downdraft. The initial conditions include the information from the sounding data: the saturation at cloud base or lifting condensation level at environment temperature, the excess of the temperature at cloud base, and the vertical velocity at the cloud base. The assumptions made with the above model rule out the feedback between the microphysical and dynamical processes in the

model. The new model corrects this problem and the results are more reasonable. However, the treatment of the ice phase is insufficient and, therefore, the parameterization needs to be updated in order to include the ice phase change effect. The results from this study reveal that more complicated microphysical processes should be introduced and the interaction with dynamical effects should be included. The amount of the rain which reaches the ground as precipitation cannot be calculated in the context of this study and, therefore, we cannot use the information of the surface rainfall rate to derive the vertical distribution of the liquid water content.

Cotton (1972a, 1972b) studied precipitation processes within the supercooled cumuli environment, and the interaction between the microphysical process and cloud dynamics. Precipitation formation in warm clouds (1972a) and a model which includes the ice phase (1972b) have been studied. A more complicated parameterization to simulate the microphysical processes in midlatitudes, which includes the processes of phase change between cloud ice, snow and graupel, cloud water and rain water has been developed by Lin et al. (1983). This parameterization is used in the study by Rutledge and Hobbs to investigate the precipitation within warm clouds (1983) and seeded ice phase (1984) environments. Three different precipitation zones categorized according to the surface precipitation rate are described in the study. Their results are in a good agreement with those from field experiments.

Tao and Simpson (1989) use the Kessler type of microphysical (cloud water and rain water) and Lin et al. (1983) parameterizations (cloud water, rain, cloud ice, snow and graupel) to study the structure of tropical squall-type convective lines. Two-dimensional models and three dimensional models have been used. The role of the ice-phase and the mesoscale ascent in middle and high-levels has also been investigated. The model output of the ice runs have been compared with that of the ice-free runs. The results show that the ice-phase microphysical processes are crucial for a realistic stratiform structure and its precipitation statistics. Also, their results show that the mesoscale ascent in the middle level was the main mechanism responsible for the extended region of the stratiform precipitation at the rear of the squall line, which has been suggested by Rutledge (1986).

5.2.2 Measurement Studies

Wei et al. (1989) use five different methods to estimate path-integrated (columnar) cloud liquid water. The methods include one-channel (31.65 GHz) and two-channel (20.6 GHz and 31.65 GHz) physical retrievals, the standard method of linear statistical inversion using two channels, and two statistical methods that proceed from an initial determination of several empirical regressions between measured and computed quantities. With brightness temperature data and/or the absorption coefficients (for oxygen, the water vapor and the cloud), the optical thickness of the clear air and the cloud water can be calculated. The calculation of cloud water content with microwave radiometer data is encouraging, however, their results lack comparison with independent observations, e.g. radar.

During the period of interest, there is no precipitation occurring in the study of Wei et al. (1989), thus they only estimate the cloud water content without estimating the precipitation amount. The study needs sounding data (vertical distribution of pressure, temperature, humidity, and cloud water content), and knowledge of the absorption coefficients to resolve the answer. Also, a hypothetical liquid water profile from an archival sounding needs to be specified in order to calculate the radiative transfer. These conditions require almost the same effort of running a more sophisticated dynamical cloud model.

Heymsfield and Fulton (1988) studied the measurement of precipitation in thunderstorms from high altitude remote aircraft. In their studies, the comparisons between the microwave data at 92 GHz and 183 GHz with the data from radar, lidar or GOES IR data reveal that using 92 GHz microwave data to detect the rainfall area is advantageous. The liquid water content (LWC) or ice water content (IWC) can be calculated based on the

convective area, IWC for the snow aggregates in the convective region and IWC in nonprecipitating anvil region. The relation of the rainfall rate with the vertical liquid and/or ice structure is unclear in this study.

Wilheit et al. (1982) used the 19.35 GHz and 183 GHz data from a microwave radiometer to study the precipitation in a tropical storm. The tendency of the rainfall rate can be matched by the tendency of the brightness temperature at 92 GHz, and the 183 GHz providing some information on the vertical extent of the frozen hydrometeors. This is a more direct way to determine the vertical distribution of the liquid water, and it is worth further study.

5.3 Discussion

Simpson and Wiggert (1969), Cotton (1972a,b), Rutledge and Hobbs (1983, 1984) and Tao and Simpson (1989) used cloud models to simulate the spatial distribution of the liquid water distribution. Since the vertical distribution of liquid water depends on the stage of evolution, the position away from the core of the updraft and the type of the system, the dynamical processes are as important as the microphysical process. Forvell and Ogura (1988) found that the addition of ice was responsible for the achievement of more realistic scale features in the convective region of the simulated squall line. More complex microphysical process which included the ice-phase parameterization have been simulated by Lin et al. (1983). Rutledge and Hobbs (1984) and Tao and Simpson (1989) show that the model output is in good agreement with the field experiment data. The two-dimensional cloud model of Tao and Simpson (1989) is capable of simulating stratiform precipitation and the areal coverage of the stratiform region. Therefore, if a numerical approach is desired, it is recommended to use this cloud model for the stratiform precipitation cases.

The model of the Rutledge and Hobbs (1984) is good in the situation of frontal rain bands and convective precipitation. In order to obtain the vertical structure of the liquid water from model output, several initial conditions are needed. Using this model requires the specification of additional sources of information. Since the liquid water field from model output is specified at each grid point, a simple relationship between the vertical distribution of liquid water field and surface rain fall rate is unnecessary. If we have more specific description of the liquid water field, the snow field and the cloud water field, the total liquid water content in a column can be obtained by integrating vertically. Also, the rainfall rate is determined by the conditions of the environment, such as the relative humidity, the wind shear and updraft. Therefore, it is hard to find a simple relationship which will satisfy all of the dynamical conditions in determining the vertical distribution of liquid water depending on the surface rainfall rate alone.

An alternative approach to derive a simple relation between the surface rainfall rate and the vertical distribution of liquid water content is using the climatological record. From the result of Adler and Mack (1984), the height-rainfall rate relation is different from place to place. For example, high rainfall rate for moderate and small storms occurs in the coastal regimes, while fairly deep convection in Midwest thunderstorms produces only moderate rain rate (Adler and Mack, 1984). Therefore, our derivation of the relationships between the surface rainfall rate and the vertical distribution of the liquid water content based on the climatological data depend on the geographical distribution too.

In the study of Adler and Mac (1984), the statistical retrievals of columnar liquid water and water vapor are found to be more accurate than physical retrievals. Therefore, we will use the climatological data to derive the simple relationship based on the vertical distribution of the liquid water content from Falcone et al. (1979). The important features of these distributions are (see Figure 15):

- (1) A maximum liquid water content is located between the cloud top and the surface (Rutledge and Hobbs, 1983, 1984; Tao and Simpson, 1989). From the model output, the height of the maximum liquid water content is strongly influenced by the

vertical velocity, therefore, the maximum height of the cumulus convection is normally higher than the stratiform precipitation, and

(2) The amount of the liquid water content is nearly uniform below the cloud base, or the liquid water content below the freezing level in the convective region is almost constant with height (Tao and Simpson, 1989).

5.4 Liquid Water Content/Rainrate Relationships

Based on the results from the diagnostic studies, a statistical polynomial fit like the one used in Wei et al. (1989) is used to simulate the climatological profiles for the four precipitation models given in Falcone et al. (1979). Models I-IV (pp. 46-47) correspond to two stratiform (I, II) and two convective (III, IV) models, respectively. The following conditions are used to derive the coefficients of the polynomial fits:

- the liquid water content reaching the surface, M_s , is derived from the rain rate retrieved from the SSM/I microwave,
- the maximum liquid water content is M_m and is at height Z_m ,
- the liquid water content at the cloud top (Z_t) is zero,
- the first derivation of the polynomial at the height (Z_m) equals zero, and
- the first derivative of the polynomial at the surface equals zero.

These values are read from Figures 14-17 in Falcone et al. (1979), see Table 3.

The relationship between the rainfall rate and the liquid water content can be found in Falcone et al. (1979) and Simpson and Wiggert (1969). We use the relationship of Falcone et al. (1979)

$$M = 0.07 * RR^{**0.83},$$

where M is the liquid water content (g/m^3) and RR is the rainfall rate (mm/h), and apply it at the surface and use M_s to denote the liquid water content here.

A fourth order polynomial fit is used to simulate convective precipitation (models III and IV). The result, as shown in Fig. 15a, shows the simulation of the vertical distribution of the liquid water content with the polynomial equation and the input values of Z_t , Z_m , M_m , M_s corresponding to the four precipitation categories from Falcone et al. (1979) (Models I-IV, pp 46-47), given in Table 3. The cloud top of curve 2 is lower than that specified by Falcone et al. (1979) in their Fig. 15. If we look at the curves carefully, we can find that the slope is nearly the same above and below the maximum height. In steady rain cases like stratiform precipitation, most of the cloud water and the precipitation is located in the lower troposphere. The maximum liquid water accumulation is near 1 to 2 km, the height of the maximum liquid water field is lower. Thus, if the slopes above and below the maximum height are the same, the liquid water content will vanish at a height below the specified cloud top. For this reason, only curves 3 and 4 are used to model convective rain.

A third order polynomial equation is used to simulate the stratiform precipitation. Three tests have been run with the equations satisfying four out of the five given

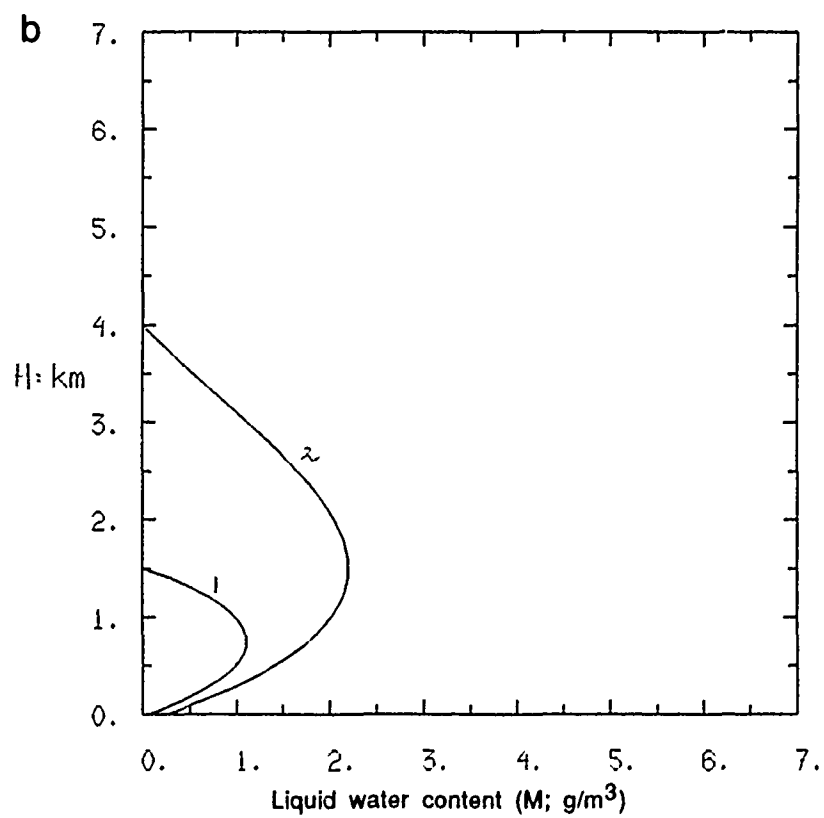
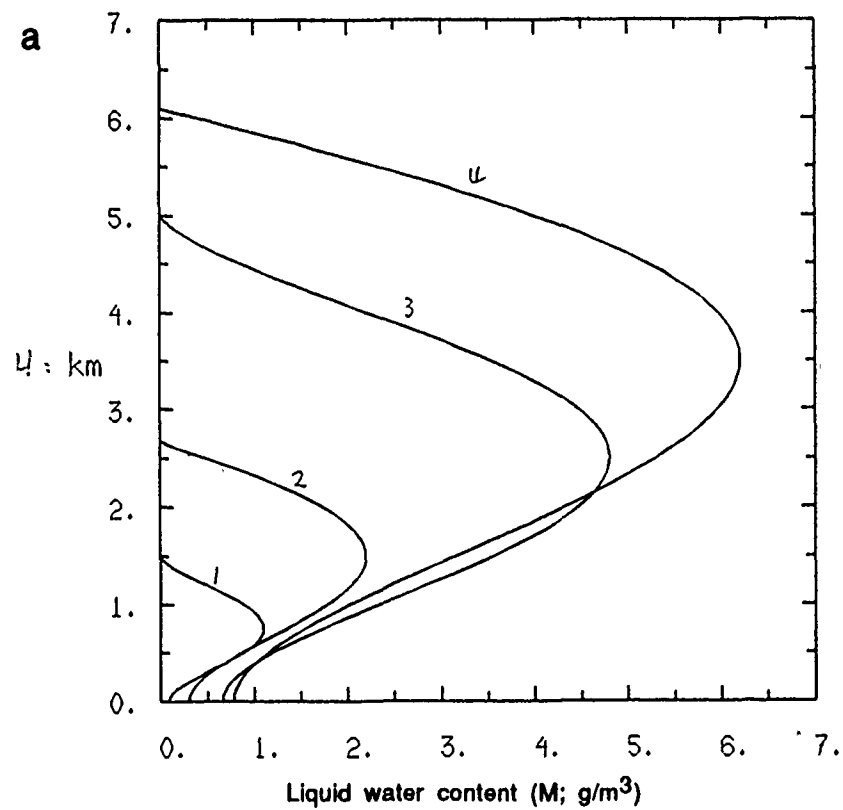


Figure 15. Simulation of the vertical distribution of the liquid water content with polynomial equations (see text).

Table 3. Polynomial Fit Data

Curve	RR (m/h)	Z _t (km)	Z _m (km)	M _m (g/m ³)
1	1.25	1.5	0.75	1.1
2	5.00	4.0	1.50	2.2
3	12.50	5.0	2.50	4.8
4	15.00	6.1	3.50	6.2

conditions. Test one satisfies the conditions 1, 3, 4, 5, test two satisfies the condition 1, 2, 3, 4 and test three satisfies conditions 1, 2, 3, 5. The test two results (Figure 15b) are the best fit for the simulation of stratiform precipitation.

The equation for the vertical distribution for the convective type of precipitation (e.g. Falcone models III and IV), is:

$$LWC = a * z^4 + b * z^3 + c * z^2 + d ,$$

where

$$a = \frac{1}{z_m^5 z_t^2 - 2z_m^4 z_t^3 + z_m^3 z_t^4} \left[(3z_m z_t^2 - 2z_t^3 - z_m^3) m_s - (3z_m z_t^2 - 2z_t^3) m_m \right]$$

$$b = \frac{-1}{z_m^5 z_t^2 - 2z_m^4 z_t^3 + z_m^3 z_t^4} \left[(4z_m^2 z_t^2 - 2z_t^4 - 2z_m^4) m_s - (4z_m^2 z_t^2 - 2z_t^4) m_m \right]$$

$$c = \frac{-1}{z_m^4 z_t^2 - 2z_m^3 z_t^3 + z_m^2 z_t^4} \left[(z_m^4 - 4z_m z_t^3 + 3z_t^4) m_s + (4z_m z_t^3 - 3z_t^4) m_m \right]$$

$$d = m_s$$

Curves 3 and 4 in Figure 15a provide the vertical distribution for convective situations.

The equation for the stratiform type of precipitation (e.g. Falcone models I and II) is:

$$LWC = e * z^3 + f * z^2 + g * z + h ,$$

where

$$e = \frac{-1}{z_m^2 z_i (z_i - z_m)^2} \left[(z_i - z_m)^2 m_i + z_i (2z_m - z_i) m_m \right]$$

$$f = \frac{-1}{z_m^2 z_i (z_i - z_m)^2} \left[(3z_m^2 z_i - z_i^3 - 2z_m^3) m_i - (3z_m^2 z_i - z_i^3) m_m \right]$$

$$g = \frac{-1}{z_m z_i (z_i - z_m)^2} \left[(z_m^3 - 3z_m z_i^2 + 2z_i^3) m_i + (3z_m z_i^2 - 2z_i^3) m_m \right]$$

$$h = m_i$$

Curves 1 and 2 in Figure 15b provide the vertical distribution for stratiform situations for different input parameters.

The vertical integrated liquid water content is:

$$\text{ILWC} = a/5 * Z_t^5 + b/4 * Z_t^4 + c/3 * Z_t^3 + e * Z_t + M_s$$

for the convective precipitation, and

$$\text{ILWC} = e/4 * Z_t^4 + f/3 * Z_t^3 + g/2 * Z_t^2 + h * Z_t + M_s$$

for the stratiform precipitation.

Some studies show that the height of the cloud top and the surface rainfall rate are closely related (Dennis et al., 1975). Thus we can derive the statistics of the relationship for different sites, and rewrite the cloud top as a function of the surface rainfall rate to derive a more precise vertical distribution of the liquid water field.

5.5 Summary

These studies reveal that the formation and evolution of hydrometers have close relationships with both microphysical and the dynamical processes. The inclusion of the ice-phase parameterization is important in simulating these processes.

Since the vertical distribution of the liquid and/or ice content is highly dependent on the type of the precipitation, the evolution stage of the thunderstorm, and the distance away from the core of the thunderstorm (in the area near the convection core or in the anvil area), a simple relationship between the surface rainfall rate and vertical liquid water distribution is quite site and time specific. A climatological record of the different sites should be collected and used to derive the simulation equation. The instant observation afforded by the satellite can be used to adjust some input parameters, e.g. cloud top and surface rainfall rate, which allow the simulation to be as close as possible to the real situation.

The specific simulated liquid water field can be obtained from the results of a numerical cloud model, however, this requires a significant amount of additional data. For this reason, we have adopted vertical profile models based on climatological models requiring a minimum of input data. The relationships provide a parameterization of vertical

hydrometeor liquid water content with surface rain rate and other input such as the height of the cloud and location and magnitude of the maximum. The latter are also provided by the Falcone et al. (1979) model classes.

6. CLOUD LIQUID WATER

Recognizing the difficulties associated with low correlations between SSM/I brightness temperatures and cloud liquid water content over land (and snow), the SSM/I calibration validation team recommended that retrievals of cloud liquid water not be attempted over land (Alishouse et al., 1988). In this study we have specifically undertaken to explore the parameterization of hydrometeor liquid water content vertical distribution and integrated amount for the purpose of characterizing intense convective activity. In the absence of other data sources (e.g. visible and infrared satellite data), some correlation can be inferred between precipitation events and cloud presence. To that extent, climatological cloud models can be applied in an attempt to characterize the cloud liquid water content based on SSM/I determination of the hydrometeor properties.

To this end we have adopted the cloud models proposed by Falcone et al. (1979) which accompany his respective precipitation event vertical profiles. A relationship between rainfall rate and cloud liquid water of the form:

$$M = 0.05 * RR ,$$

is proposed to provide a climatological cloud liquid water adjunct to the hydrometeor liquid water content discussed in the previous section. Following Falcone et al (1979), the vertical distribution of the cloud is assumed to have the same vertical dependence as the rain, except that its magnitude is scaled by the above relationship. Results for two sites, Tashkent and Perm are illustrated in figures 16 and 17.

7. APPLICATION TO SELECTED PRECIPITATION EVENTS

In order to apply the liquid water content parameterizations for convective and stratiform situations defined in the previous sections, criteria had to be developed based on the mean areal rainfall rates and spatial standard deviation data available in the time series. This was accomplished by examining the ensemble properties of these two parameters for the four month study period using a simple clustering approach. The mean areal rainfall rates and spatial standard deviation for each site were plotted against one another. Results are given in Figures 18-28. These figures were plotted on the same scale so that comparisons can be made among the sites. Note that area averaging reduces local values considerably. Based on these cluster diagrams an approach was developed to differentiate between stratiform and convective precipitation regimes.

Notably there is a general similarity in the behavior of the cluster diagrams. Two regions are definable from the data. In the first region, there is a systematic increase of areal standard deviation with average rain rate. For some sites this increase is gradual and near linear (see Chita, Figure 20), while for other sites it is rapid and nonlinear (see Leningrad, Figure 22). The first region occupies the lower left quadrant of the available data. The second region occurs at higher rain rates and standard deviations than the first region, occupying more of the upper right quadrant of the data. The break points defining the transitions from region one to region two vary with site. Based on our examination of daily contours, we have defined region one to consist largely of stratiform events and region two to consist largely of convective events. There was not sufficient time in the study to provide detailed analyses to support this hypothesis. This should be explored using conventional data sources.

The implications of the categorization defined above based on examination of the cluster diagrams, is to provide criteria based on the rain rates and standard deviations to define membership in one of the clusters (i.e. either stratiform or convective) and then use

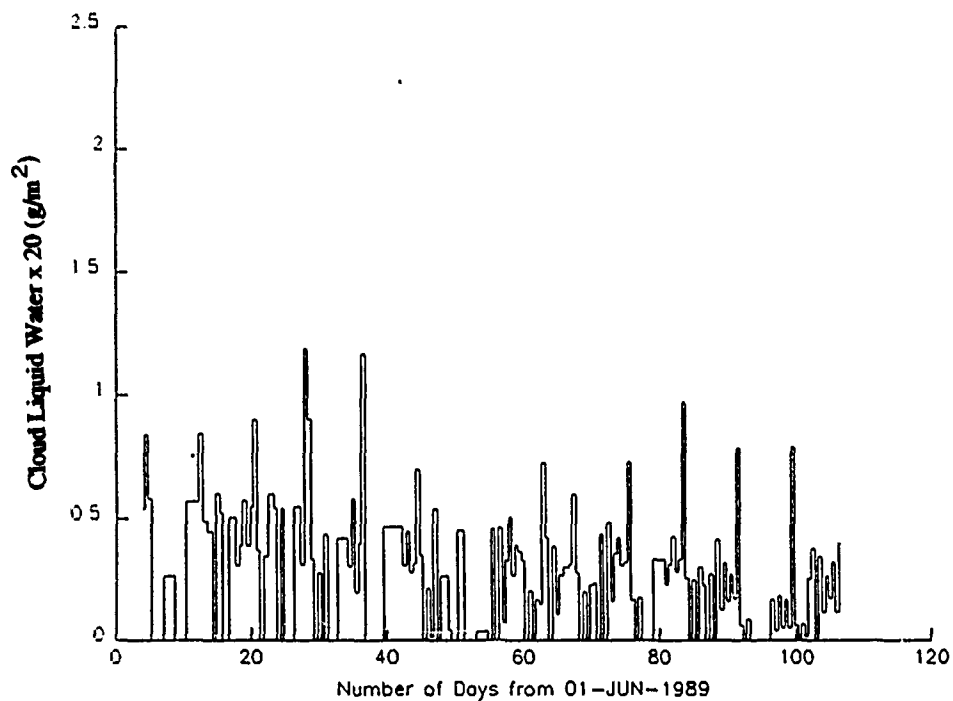


Figure 16. Cloud liquid water time series for Tashkent.

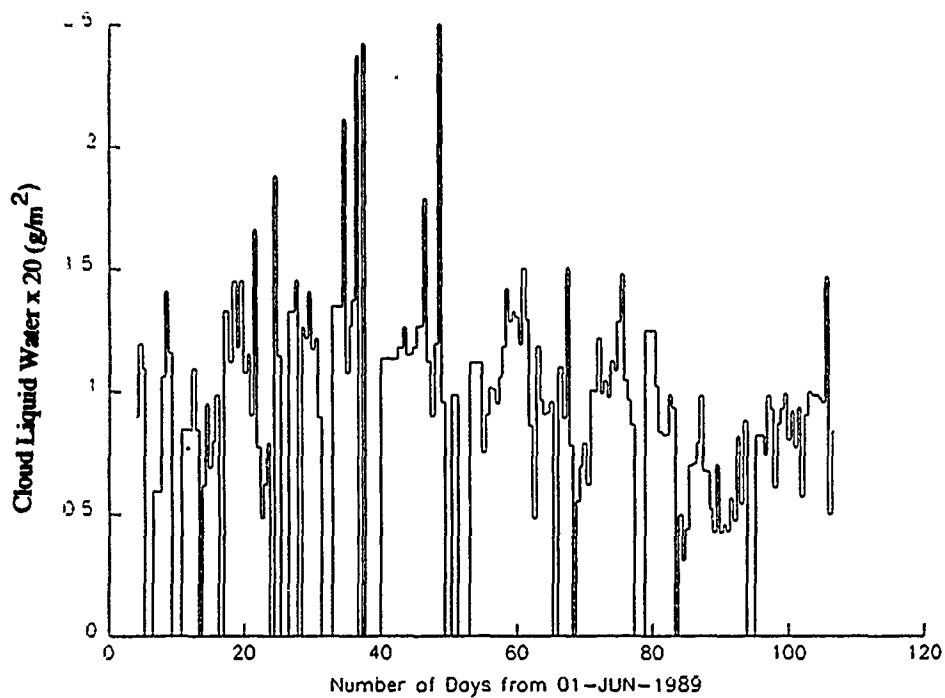


Figure 17. Cloud liquid water time series for Perm.

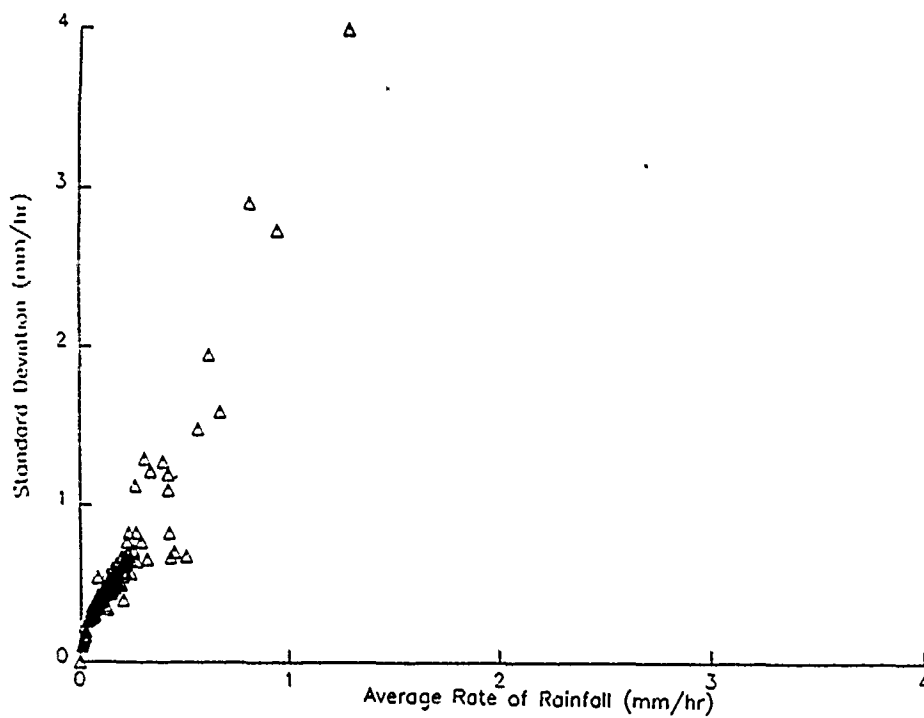


Figure 18. Cluster diagram for Aktyubinsk

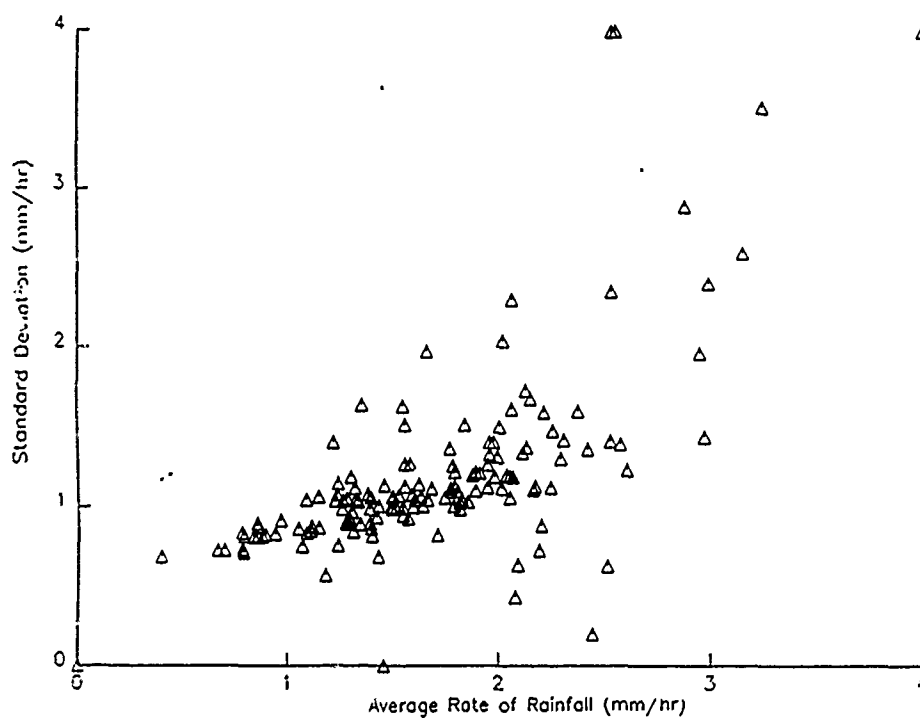


Figure 19. Cluster diagram for Blagoveschensk

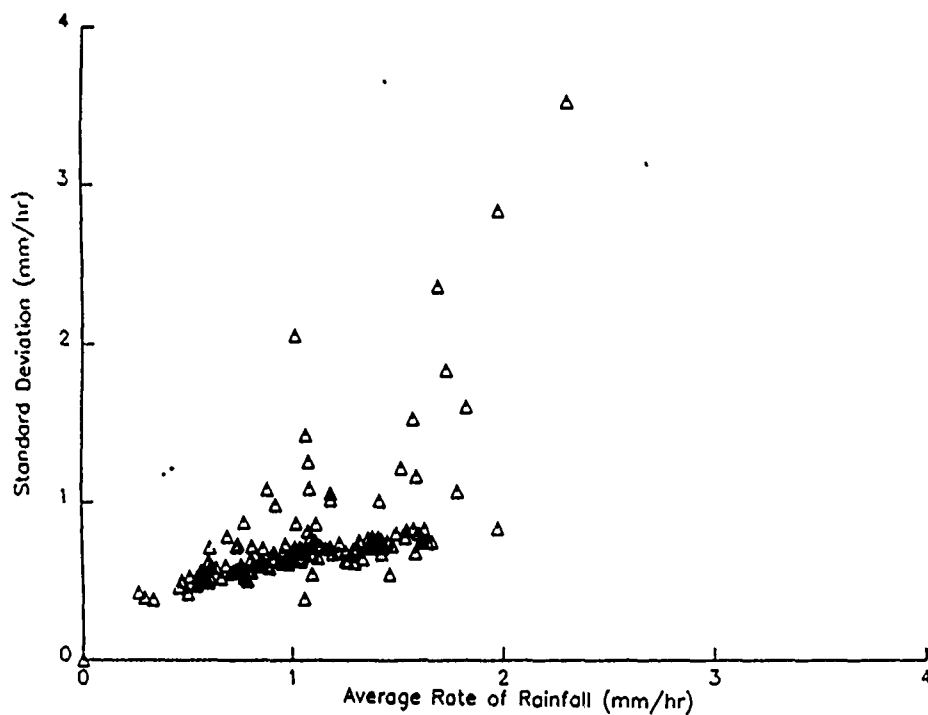


Figure 20. Cluster diagram for Chita

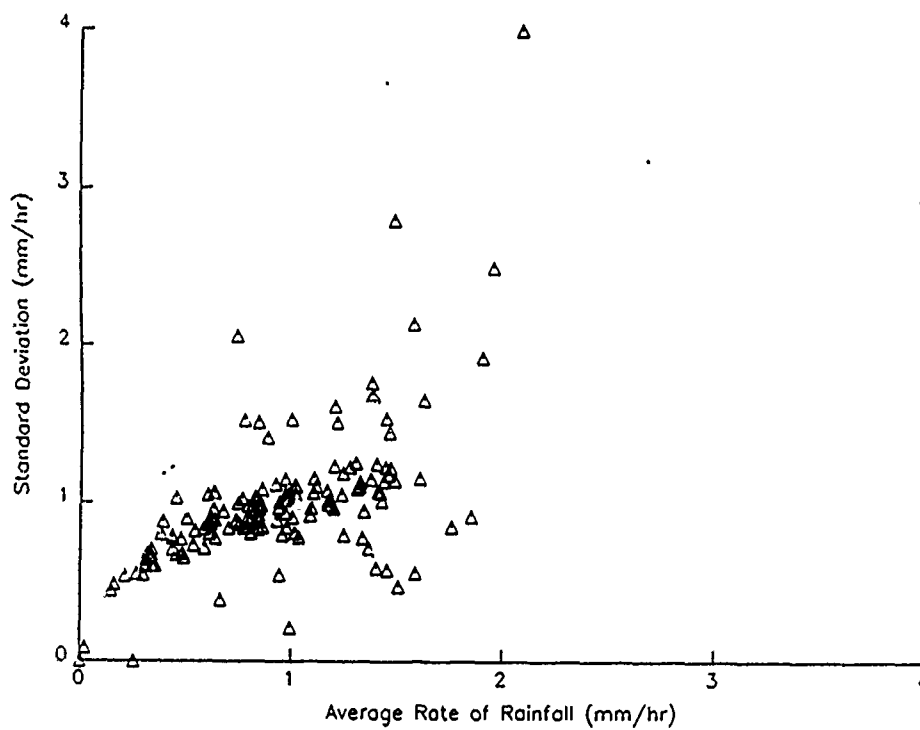


Figure 21. Cluster diagram for Kiev

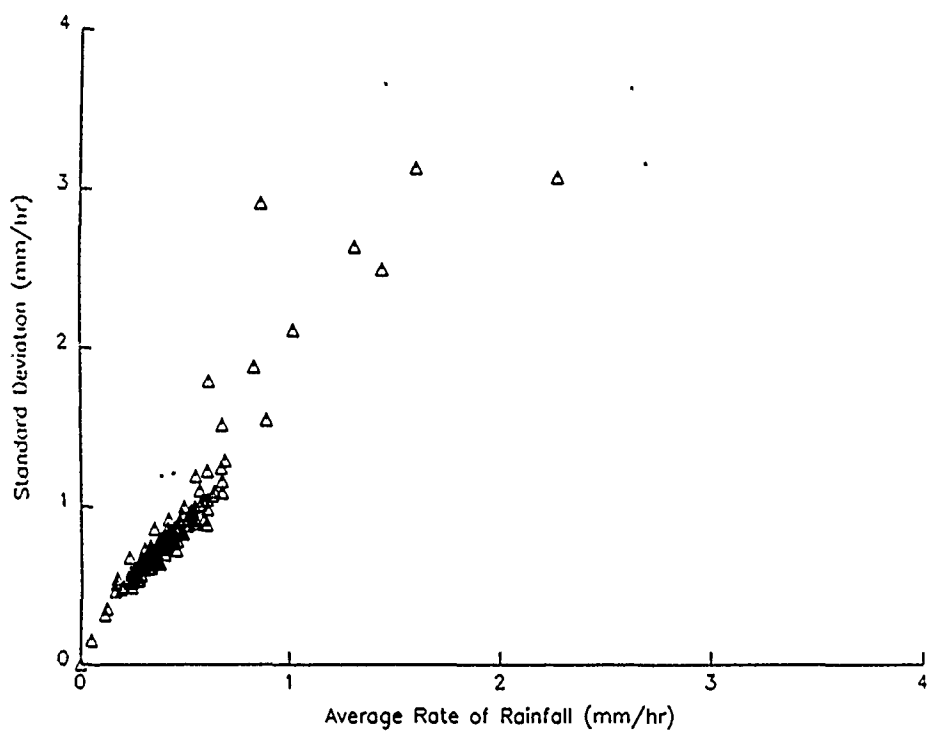


Figure 22. Cluster diagram for Leningrad

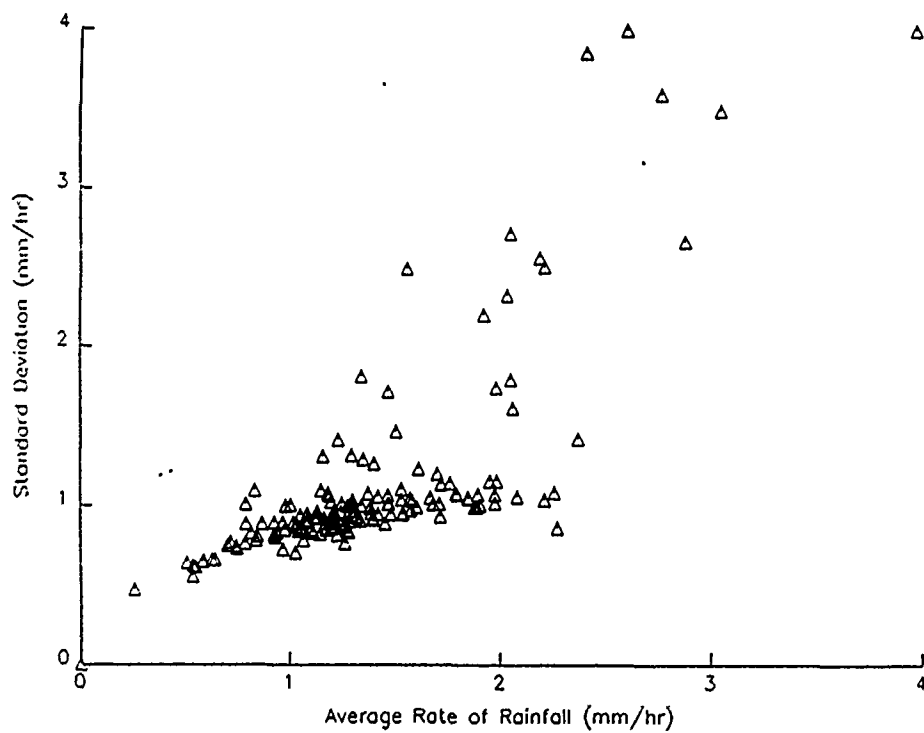


Figure 23. Cluster diagram for Moscow

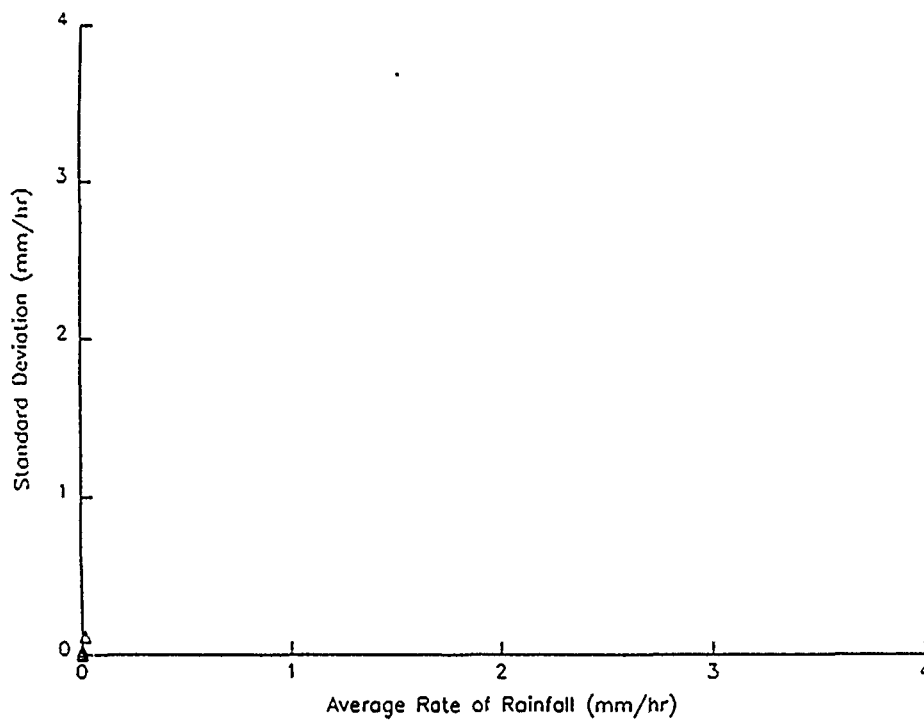


Figure 24. Cluster diagram for Murmansk

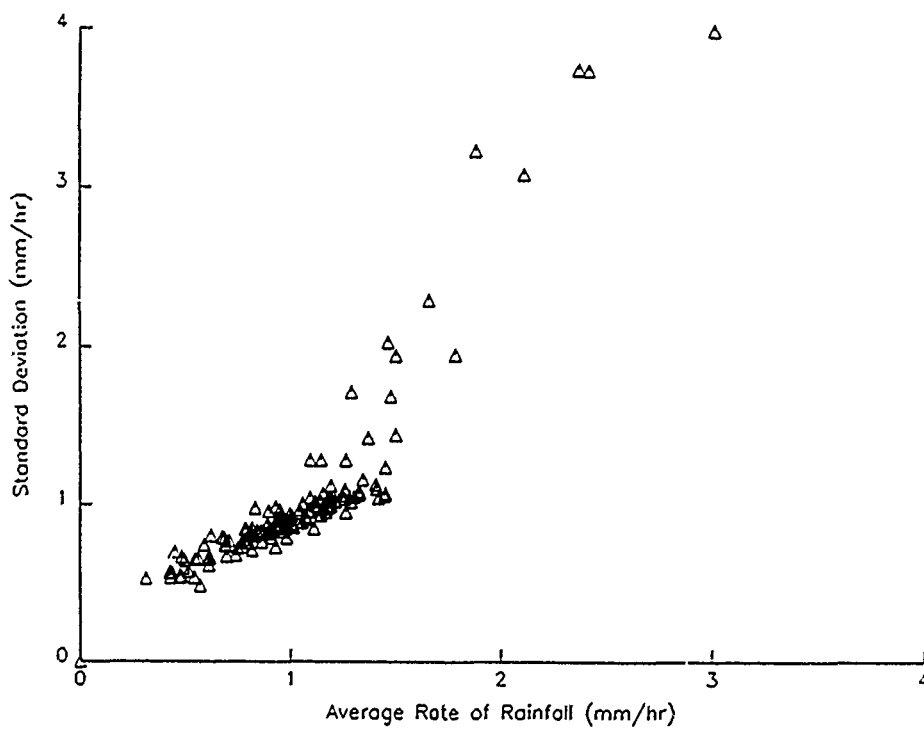


Figure 25. Cluster diagram for Perm

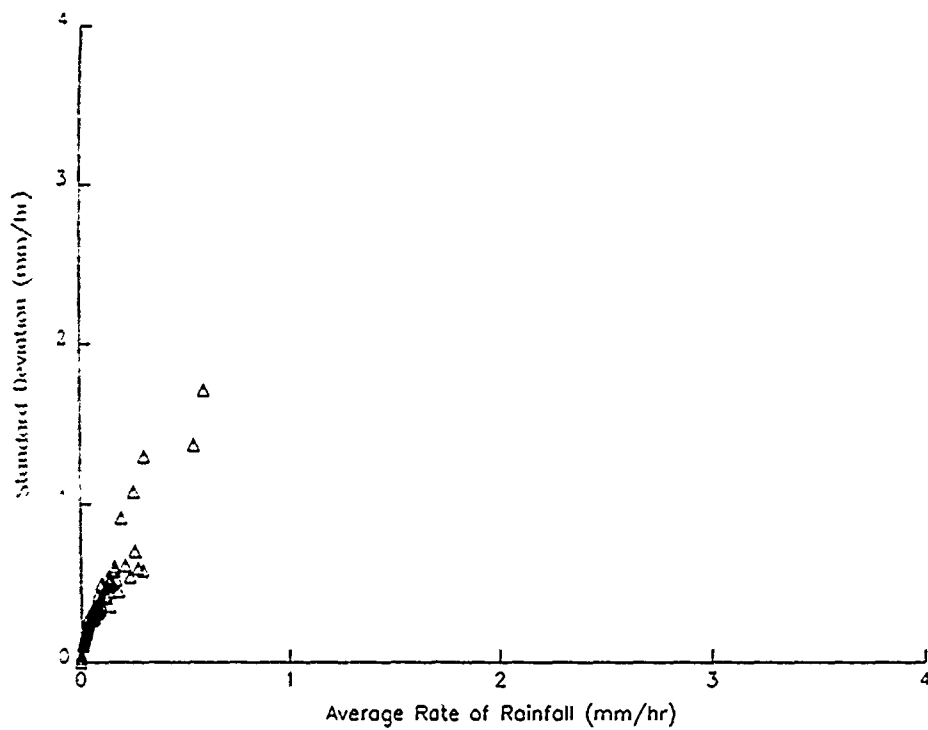


Figure 26. Cluster diagram for Semipalatinsk

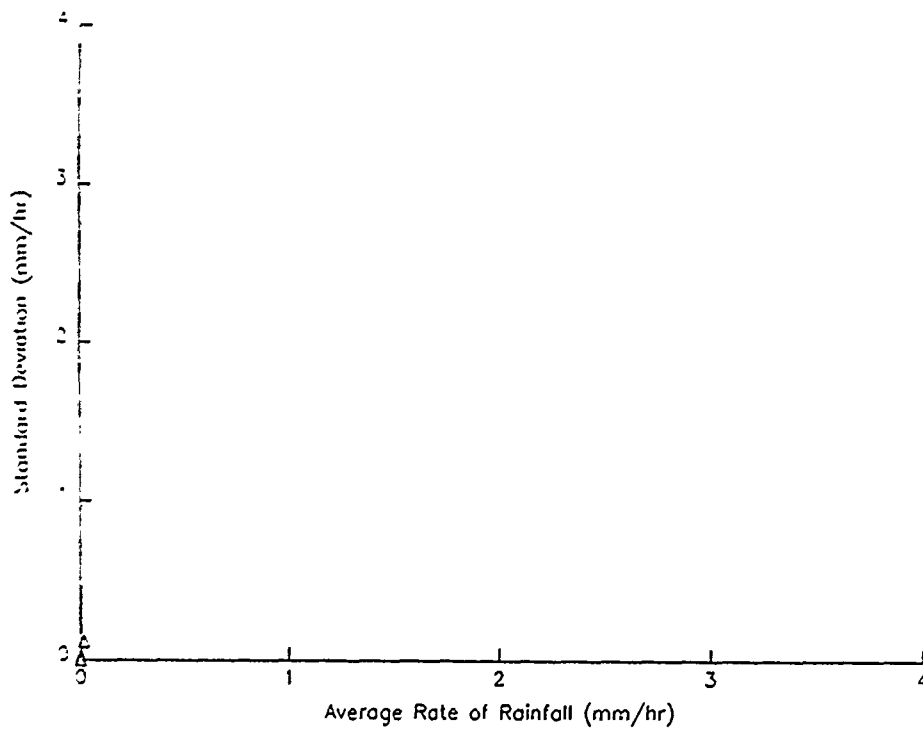


Figure 27. Cluster diagram for Simferopol

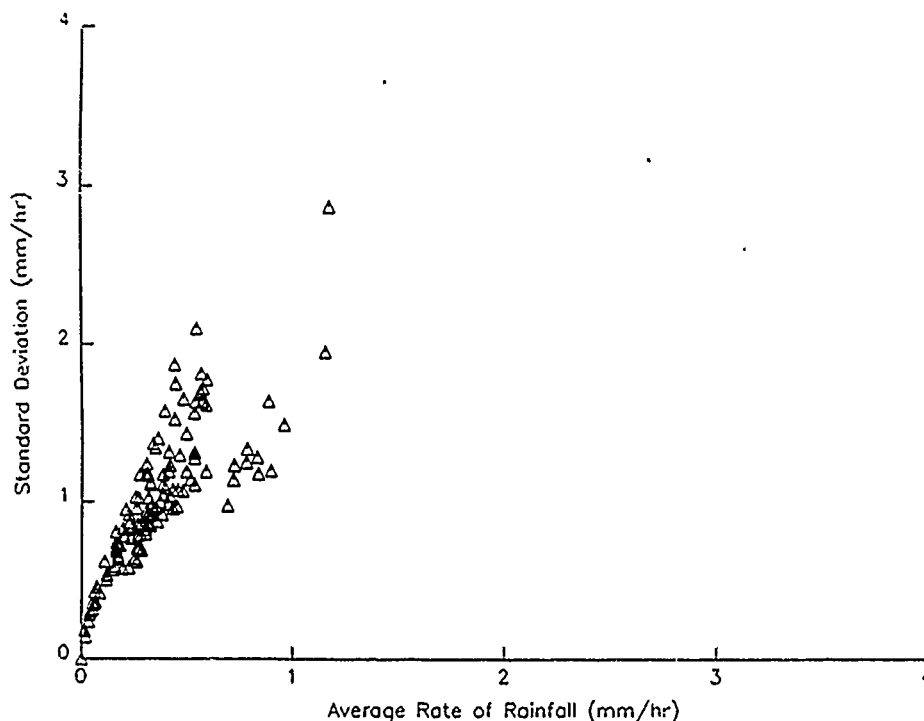


Figure 28. Cluster diagram for Tashkent

the appropriate liquid water content relationship developed in Section 5 to evaluate time series of this and related quantities for each site.

We have applied this approach to the data for Moscow displayed in Figure 23. The Moscow cluster diagram shows a region of low standard deviation days ($SD < \sim 1.3$) with increasing rain rate (region 1) bounded by high SD days. The highest SD days are those for which the rain rates are the highest. We have defined this latter cluster as region 2 in the context of the previous discussion. Therefore, the criteria adopted for this site is that days for which the SD is less than 1.3 are defined as stratiform and others are convective. The time series corresponding to application of this criterion for Moscow is shown in Figure 29a. For comparison, Figures 29b and 29c show the same time series when it is assumed that all precipitation events are stratiform or convective, respectively.

It should be noted that this criteria applies only to the Moscow time series and that a more general criteria for other sites has not been developed. Our approach would be to develop the generalized criteria based on normalized values using the mean average rainfall rate (i.e. the mean of the time series of areal averages) and mean standard deviation (i.e. the mean of the time series of spatial standard deviations).

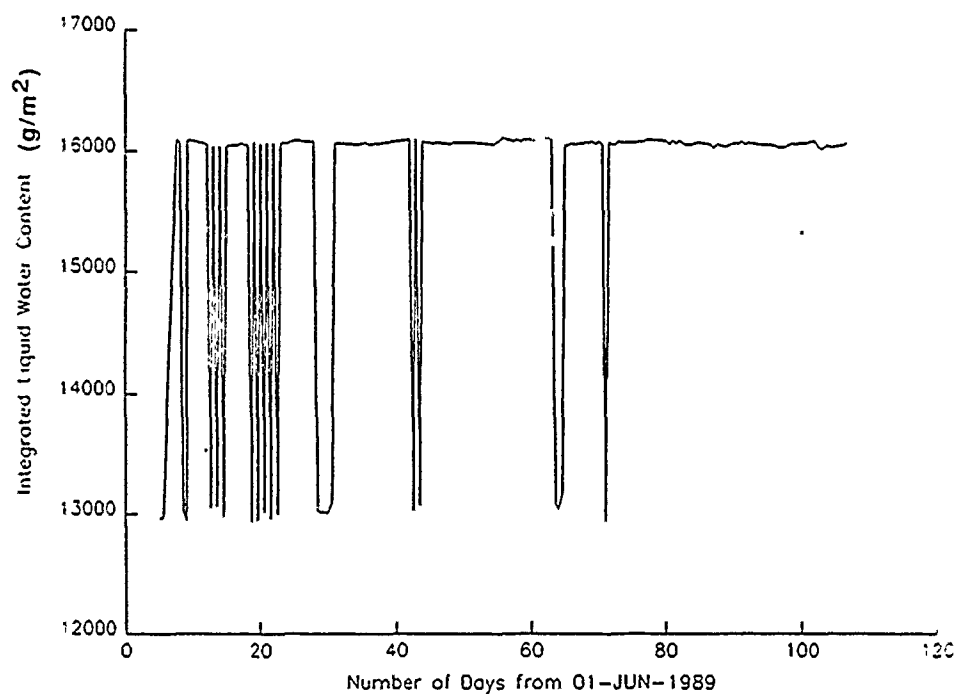


Figure 29a. Time series of ILWC for Moscow employing two region criteria

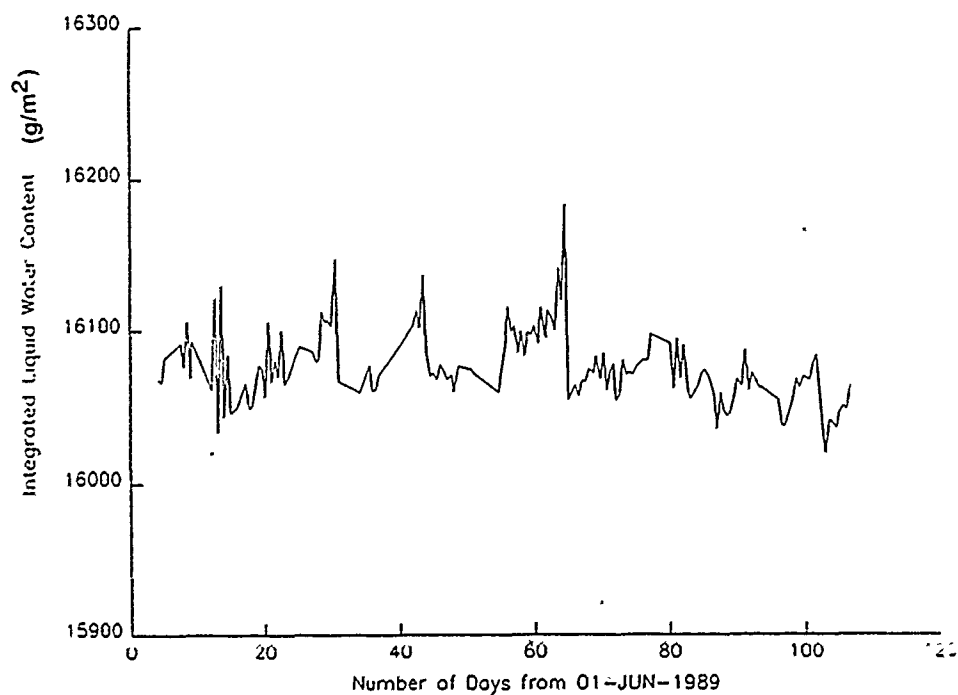


Figure 29b. Time series of ILWC for Moscow assuming stratiform only

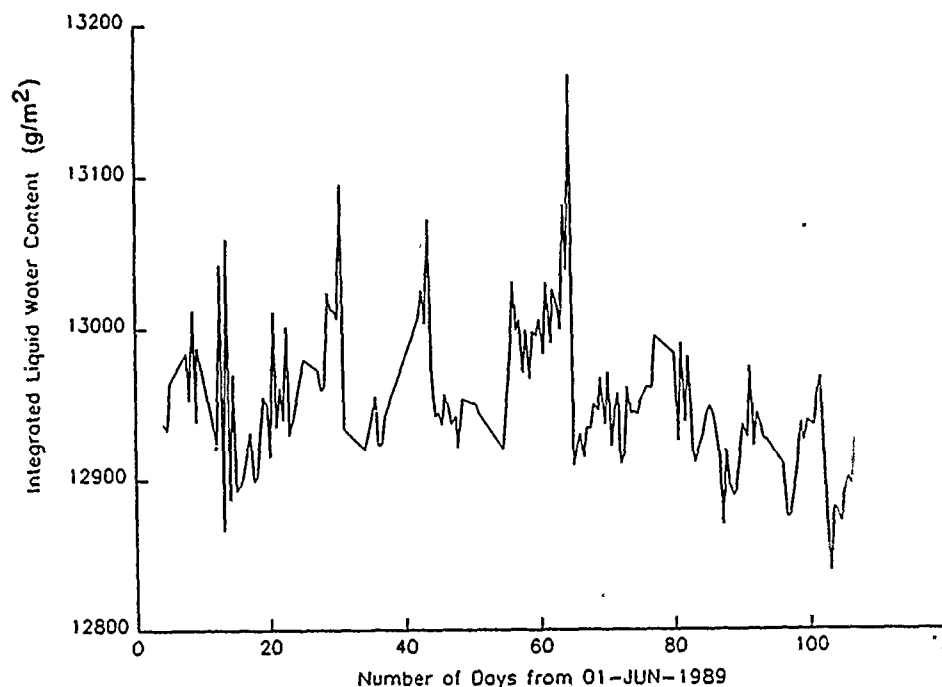


Figure 29c. Time series of ILWC for Moscow assuming convective only

To illustrate application of this approach to two additional sites the cluster diagrams were examined and Blagoveschensk and Leningrad (Figures 19 and 22, respectively) were selected. The cluster structure for Blagoveschensk is much more diffuse than for Moscow. There is a much greater variation in standard deviation which is qualitatively manifested in a much less organized stratiform arch. In this case we have based the definition of convective events on high average rainfall rate ($> 1.5 \text{ mm/h}$) rather than on standard deviation as was done in the Moscow case. The results of applying this criterion for the determination of ILWC for the Blagoveschensk time series data are shown in Figures 30a-30c.

The cluster data for Leningrad exhibits yet another form of behavior. Rather than being diffuse as in the previous case, there is a very tight cluster of low rain rate/ low standard deviation near the origin with some outlying points of higher rain rate and standard deviation. We have defined the former class as stratiform events and the latter as convective. The results of applying these criteria for the determination of ILWC for the Leningrad time series data are shown in Figures 31a-31c.

8. CONCLUSIONS

This study has established the feasibility of establishing climatologies of stratiform and convective precipitation events for site specific regions of interests based on the use of SSM/I microwave imager brightness temperature data. The application of SSM/I microwave imager brightness temperature data to the determination of precipitation climatologies for eleven selected sites has been investigated. The SSM/I precipitation retrieval algorithm has been applied to the determination of surface rainfall rates within a 400 km region surrounding each site and additionally algorithms have been developed to provide areal averaged rain rates and spatial standard deviations. A novel application of the spatial standard deviations provides information on spatial inhomogeneities of the retrieved rain rates in addition to exploiting the spectral information content of the microwave brightness temperature data.

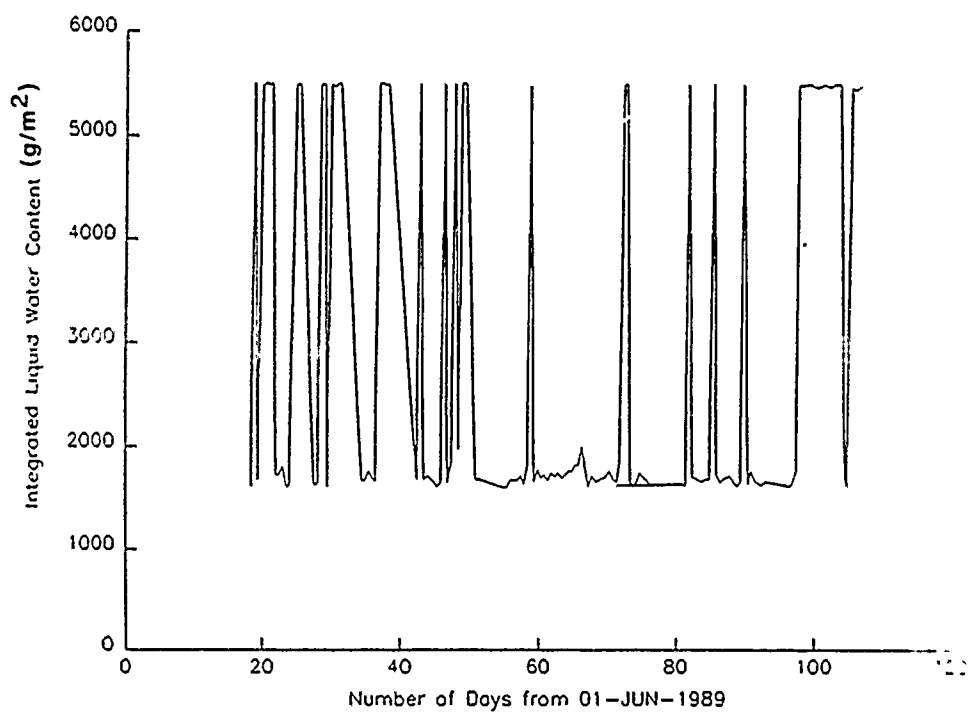


Figure 30a. Time series of ILWC for Blagoveschensk employing two region criteria

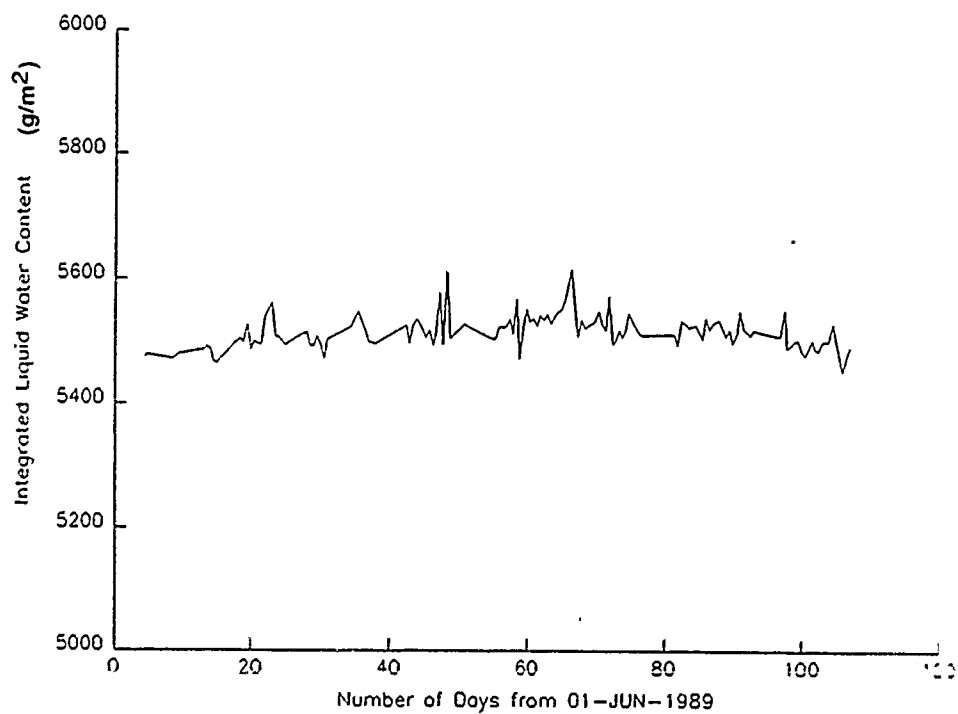


Figure 30b. Time series of ILWC for Blagoveschensk assuming stratiform only

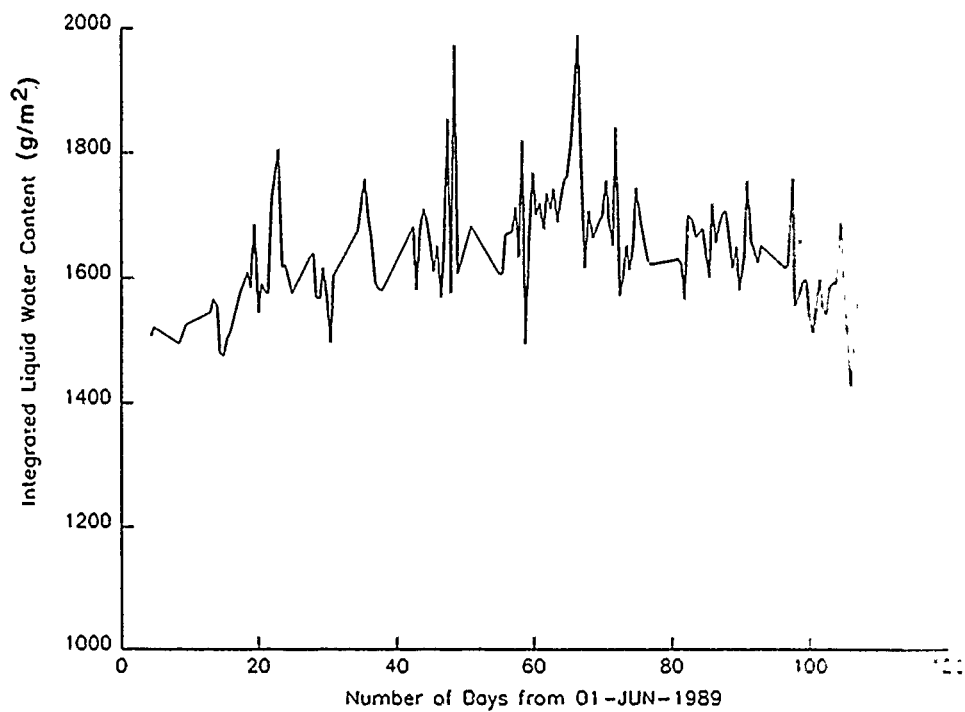


Figure 30c. Time series of ILWC for Blagoveschensk assuming convective only

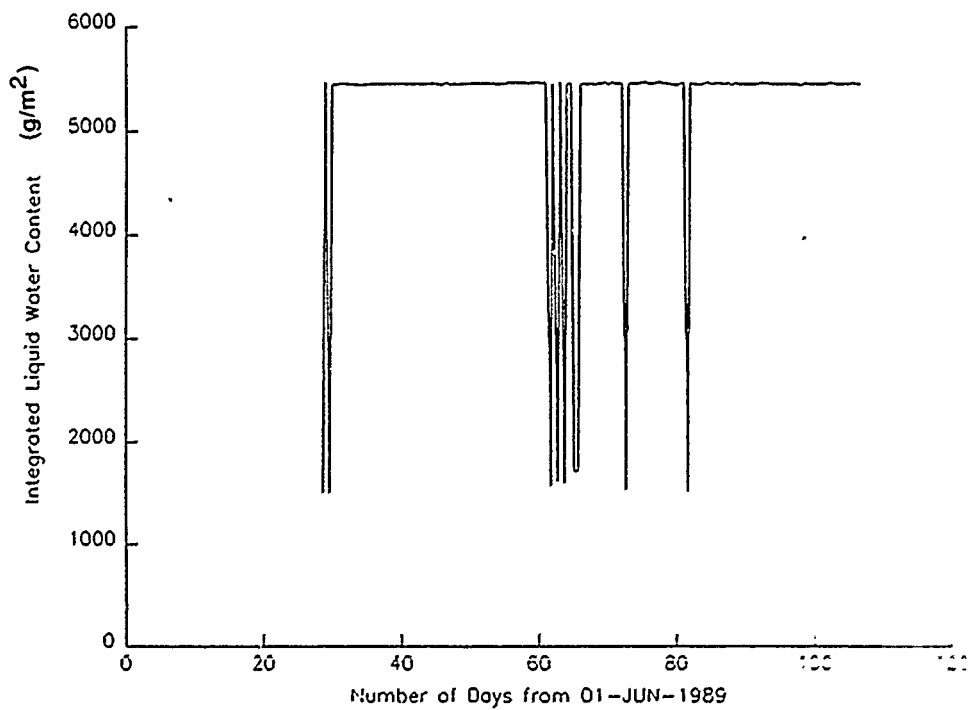


Figure 31a. Time series of ILWC for Leningrad employing two region criteria

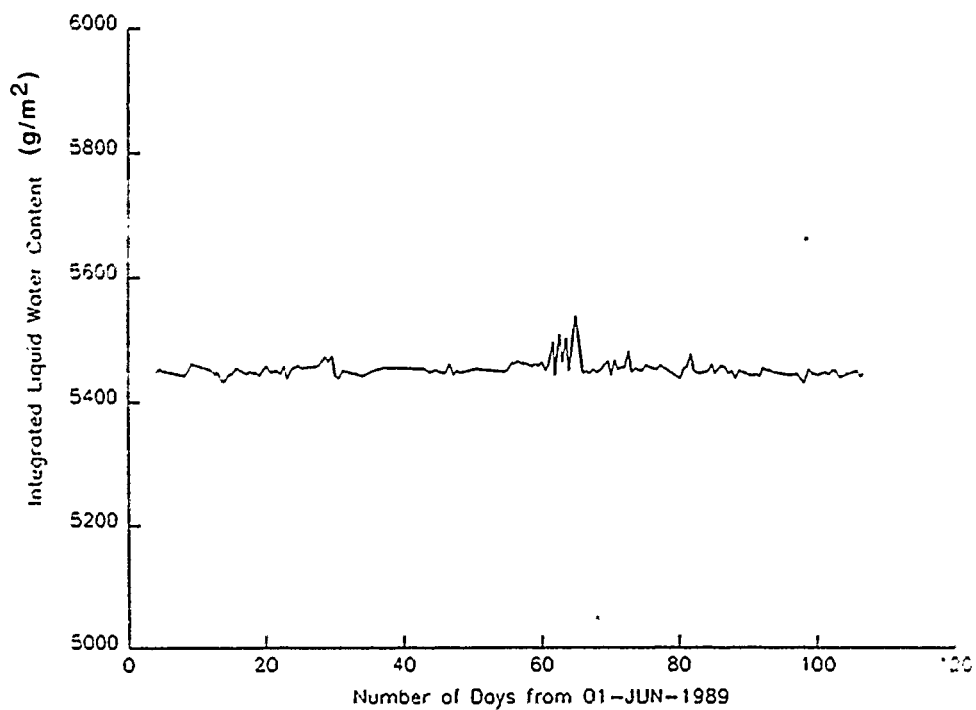


Figure 31b. Time series of ILWC for Leningrad assuming stratiform only

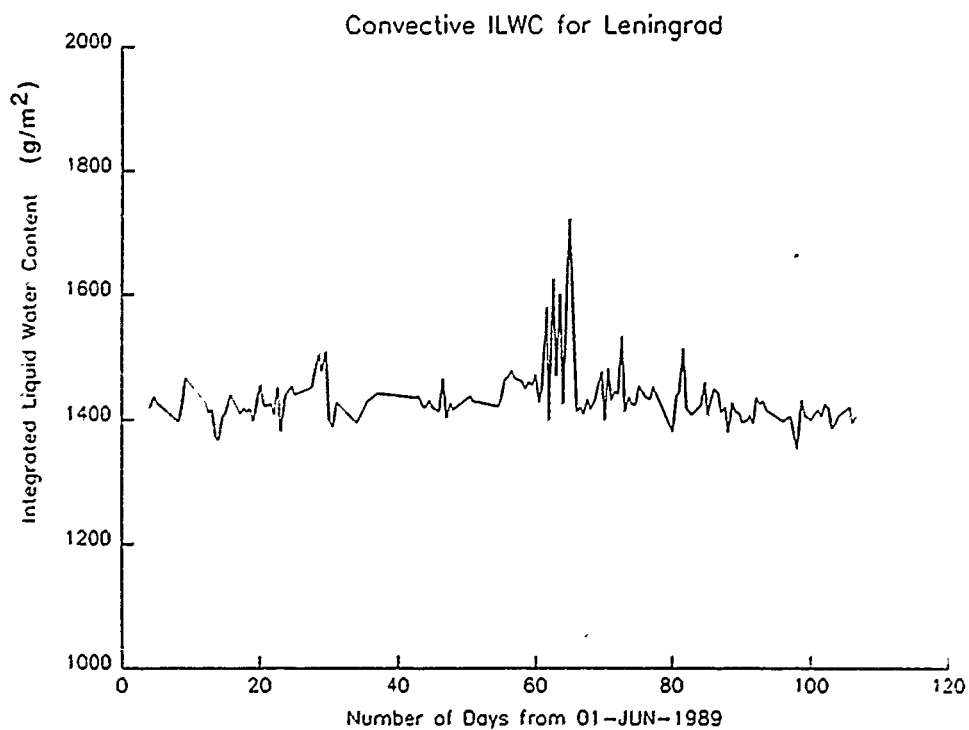


Figure 31c. Time series of ILWC for Leningrad assuming convective only

Time series of the areal averaged rain rates and spatial standard deviations have been calculated for a four month summer period for each of the sites. This climatology of precipitation events can be used to provide an indication of intense convective activity which is of interest in the determination of reentry vehicle erosion. In order to distinguish convective precipitation events, the areal averaged rainfall rates and standard deviations for each site have been displayed in cluster diagrams for the entire four month period. Based on these cluster diagrams, a set of preliminary criteria has been discussed to distinguish between stratiform and convective situations. Parameterizations of the vertical distributions of hydrometeor liquid water content for both stratiform and convective situations have been developed based on climatological precipitation cloud models. These parameterizations were developed after review of the relevant dynamical cloud model literature. Furthermore these vertical profiles of hydrometeor liquid water content have been integrated to provide functional relationships between SSM/I retrieved surface rain rates and total hydrometeor liquid water content. Time series of the total hydrometeor liquid water content have also been provided for selected sites.

It is recognized that cloud liquid water content profiles are also desired to calculate reentry vehicle erosion parameters. While cloud liquid water content is not directly retrievable over land based on the use of the SSM/I brightness temperature data, model based and climatological correlations between the vertical distribution of hydrometeor liquid water content and that of cloud liquid water content allows for a rudimentary characterization of cloud liquid water. A simple approach correlating hydrometeor and cloud liquid water vertical distributions has been explored based on climatological models available from the microwave attenuation literature. These models assume that the cloud liquid water content is proportional to the rainfall rate and that the shape of the vertical distribution of cloud liquid water is similar to that of the precipitation. Using this approach, time series of total cloud liquid water content is also provided for selected sites.

9. RECOMMENDATIONS

As proposed this study has focused exclusively on the use of SSM/I microwave imager brightness temperature data to develop rain rate climatologies. Precipitation events are indicative of meteorological situations which are inherently problematic with respect to reentry vehicle erosion. A novel aspect of the investigation is the application of spatial coherence concepts to the characterization of precipitation regimes such as stratiform and convective which determine the vertical distribution of hydrometeor liquid water content. Rain also acts as a surrogate for the presence of cloud which is not easily measured over land with microwave sensors.

A number of avenues of additional study are recommended based on the results reported here:

- More work should be done to exploit the identification of convective precipitation using the spatial information content of the microwave data. The examination of the spatial coherence properties of each site for the study period should be augmented with conventional observations to help in stratifying the observed arches and clusters according to the nature of the precipitation event. For example, surface and upper air data should be available from ETAC to be used in the analysis;
- As noted in Section 5 it is possible to identify numerical models of precipitation dynamics to support parameterization of rain rate/liquid water content relationships. In this study we resorted to climatological relationships for expediency. A fully interactive mesoscale model could be used as a vehicle for satellite data fusion and retrieval purposes;
- The algorithms developed here can be readily applied to the examination of alternate sites and changes in the statistical computations such as the time period and spatial

averaging field. Additionally, although bandpass limited by the inherent instantaneous fields-of-view of the SSM/I data, the spatial power spectrum of precipitation events could be determined. This would provide additional degrees of freedom beyond the simple measure provided by the spatial standard deviation;

- The clustering of rain rate and spatial standard deviations can be extended to use surface observations to further stratify the precipitation regime characterization. For example, frontal and various thunderstorm categories could be added along with their respective vertical distribution models. Available surface observations should also be employed to verify and validate the SSM/I time series. This was not investigated here;
- Data fusion with sensor data sources colocated aboard the DMSP spacecraft (OLS, SSM/T, SSM/T-2) should be investigated. Visible and infrared imagery provide a means to specify the presence of cloud, cloud cover, cloud type, and cloud top height. The evolution of multispectral imagery will provide the capability to identify high, middle, and low cloud in conjunction with nephelometry techniques (d'Entremont, 1986). The use of microwave and millimeter wave sounder channels provides a means to sense the vertical distribution of liquid water content for precipitation analogous to the "slicing" approach for clouds employed using infrared sounder channels. The SSM/T microwave temperature sounder provides a signature in each channel which is proportional to the presence of precipitation elements at altitudes characteristic of its weighting function. Grasiewski and Staelin (1989) have suggested utilizing the impact of precipitation on microwave oxygen band (60GHz) and line (118GHz) absorption to obtain precipitation vertical structure information. An application of these concepts to the profiling of hydrometeor liquid water from DMSP SSM/T data could be fruitful in this regard. This would give a direct measurement which frees one from the climatological precipitation vertical distribution models employed in this study. The vertical distribution of cloud liquid water can then be obtained using the simple climatological based correlations suggested in this study;
- The SSM/T-2 moisture sounder is also sensitive to precipitation, however, due to its shorter wavelength response, it also provides a cloud liquid water signature (Isaacs and Deblonde, 1987). Although the number of available channels (five) is not as extensive as that potentially available from an infrared sounder, the millimeter wave channels respond to cloud liquid water content which can be directly related to cloud vertical structure and erosion parameter indices. The problem of high, variable surface emissivity inherent in the use of the SSM/I imager data is mitigated by the use of the SSM/T-2 sounder data. This is due to the vertical resolution properties of the sounding weighting functions which selectively sense the middle and upper tropospheric cloud liquid water (for increasingly absorbing channels of the sounder);
- Finally, it is recommended that the use of data available from civilian satellites including both the Tiros polar orbiters and the GOES geosynchronous platforms be investigated. Use of multispectral cloud imagery from the Tiros Advanced Very High Resolution Radiometer (AVHRR) can be used for multispectral nephelometry. High resolution Infrared Sounder (HIRS) data can be used for applying the CO₂ slicing method. The GOES VAS (VISSR Atmospheric sounder) provides visible and infrared imagery and infrared sounder data. GOES infrared data could be particularly useful. The specific approach adopted could be modeled on that described by Adler and Negri, (1988). They used GOES imager data to delineate convective rain areas by searching for minima in the equivalent black body brightness temperature (EBBT) field and then assigned rain rates based on the results from a one dimensional cloud model which provided the relationship between convective development (cloud top height) and the resulting rain rate. Stratiform rain rates were delineated based on EBBT threshold criteria.

10. ACKNOWLEDGEMENT

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11. REFERENCES

- Adler, R. F. and R. A. Mack, 1984: Thunderstorm cloud height-rainfall rate relations for use with satellite rainfall estimation techniques. J. Climate Appl. Meteor., **23**, 280-296.
- Adler, R. F. and A. J. Negri, 1988: A Satellite Infrared Technique to Estimate Tropical Convective and Stratiform Rainfall. A. Appl. Met., **27**, 30-51.
- Alishouse, J.C., 1983: Total precipitable water and rainfall determination from the SEASAT scanning multichannel microwave radiometer, J. Geophys. Res., **88**(C3), 1929-1935.
- Alishouse, J.C, S. Snyder, J. Vongsathorn, and R. Ferraro (1988): Water vapor and cloud water validation in DMSP special sensor microwave/imager calibration/validation. J. Hollinger (ed.). Naval Research Laboratory (Draft).
- Atlas, D. and O. Thiele (eds) , 1981: Precipitation measurements from space, Workshop report, Goddard Space Flight Center, Greenbelt, MD.
- Bunting, J.T., and C.N. Touart, 1980: Horizontal scale variations in satellite estimates of weather erosion parameters for reentry systems. AFGL-TR-80-0209. ADA092447
- Conover, J.H., and J.T. Bunting, 1977: Estimates from satellites of weather erosion parameters for reentry systems. AFGL-TR-77-0260. ADA053654
- Cotton, W.R., 1972a: Numerical simulation of precipitation development in supercooled cumuli, 1. Monthly Weather Rev., **100**, 757-764.
- Cotton, W.R., 1972b: Numerical simulation of precipitation development in supercooled cumuli, 2. Monthly Weather Rev., **100**, 764-784.
- Dennis, A. S., A. Koscielski, D. E. Cain, J. H. Hirsch and P. L. Smith, 1975: Analysis of radar observations of a randomized cloud seeding experiment. J. Appl. Meteor., **14**, 897-908.
- d'Entremont, R.P., 1986: Low- and midlevel cloud analysis using nighttime multispectral imagery. J. Clim. Appl. Met., **25**, 1853-1869.
- Falcone, V.J., L. V. Abreu, and E.P. Shettle, 1979: Atmospheric attenuation of millimeter and submillimeter waves: Models and computer code, AFGL-TR-79-0253. [NTIS AD A084485]
- Feteris, P.J., A.S. Lisa, and A.J. Bussey, 1976: Environmental definition program cross sectional analysis: Summary of data and analysis techniques. AFCRL-TR-76-0002. ADA021908
- Forvell, R. G., and Y. Ogura, 1988: Numerical simulation of a midlatitude squall line in two dimensions. J. Atmos. Sci., **45**, 3846-3879.

- Gloerson, P., D.J. Cavalieri, A.T.C. Chang, T.T. Wilheit, W.J. Campbell, O.M. Johannessen, K.B. Katsaros, K.F. Kunzi, D.B. Ross, D. Staelin, E.P.L. Windsor, F.Y. Barath, P. Gudmandsen, E. Langham, and R.O. Ramseier, 1984: A summary of results from the first NIMBUS 7 SMMR observations, J. Geophys. Res., **89**(D4), 5335-5344.
- Grasiewski, A.J. and D.H. Staelin (1989): Numerical modeling of passive microwave O₂ observations over precipitation. Submitted to Radio Science.
- Gustafson, G.B. and G.W. Felde, 1988: Interactive satellite image processing applied to cloud detection. Preprints: 4th conference on Interactive Information Processing Systems, AMS, Boston, MA.
- Hardy, K.R., 1979: Meteorological data analysis in support of the ABRES program. AFGL-TR-79-0084. ADA070946
- Heymsfield, G.M. and R. Fulton, 1988: Comparison of high-altitude remote aircraft measurements with the radar structure of an Oklahoma thunder-storm: Implications for precipitation estimation from space. Mo. Wea. Rev., **116**, 1157.
- Huang, R., and K.N. Liou, 1983: Polarized microwave radiation transfer in precipitating cloudy atmospheres: Applications to window frequencies, J. Geophys. Res., **88**(C6), 3885-3893.
- Isaacs, R. G. and G. Deblonde, 1987: Millimeter wave moisture sounding: the effect of clouds. Radio Science, **22**, 3, 367-377.
- Isaacs, R.G., 1989: A unified retrieval methodology for the DMSP meteorological sensors, in RSRM '87: Advances in Remote Sensing Retrieval Methods, A. Deepak, H.E. Fleming, and J.S. Theon (eds.). A. Deepak Publishing, pp. 203-214.
- Isaacs, R.G., Y.-Q. Jin, R.D. Worsham, G. Deblonde, and V.J. Falcone, Jr. (1989): The RADTRAN microwave surface emission models, IEEE Transactions on Geoscience and Remote Sensing, **27**, 4, pp.433-440.
- Isaacs, R.G., R.N. Hoffman, and L.D. Kaplan (1986): Satellite remote sensing of meteorological parameters for global numerical weather prediction, Reviews of Geophysics, **24**, 4, pp. 701-743.
- Jin, Y.Q. and Isaacs, R.G., 1985: Thermal radiative transfer for inhomogeneous nonisothermal atmospheric precipitation and statistical retrieval of related parameters. In Remote Sensing Instrumentation: Technology for Science and Applications. Proceedings of the 1985 International Geoscience and Remote Sensing Symposium (IGARSS'85), Amherst, MA, 7-9 October, 1985. Univ. Massachusetts, IEEE.
- Jin, Y.Q. and R.G. Isaacs, 1987: Simulation and Statistical Retrieval for Inhomogeneous Non-isothermal Atmospheric Precipitation. J. Quantitative Spectroscopy and Radiative Transfer, **37**, 5, 461-469.
- Kessler, E., 1959: Kinematic relations between wind and precipitation distributions, I. J. Meteor., **16**, 630-637.

- Kessler, E., 1961: Kinematic relations between wind and precipitation distributions, II. J. Meteor., 18, 510-525.
- Kessler, E., 1963: Elementary theory of associations between atmospheric motions and distributions of water content. Mon. Wea. Rev., 91, 13-27.
- Kessler, E., 1965: Microphysical parameters in relation to tropical cloud and precipitation distributions and their modification. Geofisica International, 5, 79-88.
- Kessler, E., 1969: On the distribution and continuity of water substance in atmospheric circulation. Meteor. Monogr., 32, Amer. Meteor. Soc., 84 pp.
- Lin, Y. -L., R. D. Farley and H. D. Orville, 1983: Bulk parameterization of the snow field in a cloud model. J. Climate Appl. Meteor., 22, 1065-1092.
- Liou, K.N., G.C. Aufderhaar, and P.T. Nipko, 1981: Some examples of the effects of clouds and precipitation on the temperature profile retrieval for DMSP SSM/T microwave sounders, J. Appl. Meteorol., 20, 821-825.
- Lipes, R.G., 1982: Description of SEASAT radiometer status and results. J. Geophys. Res., 87(C5), 3385-3396.
- Lo, R. C., 1983: A Comprehensive Description of the Mission Sensor Microwave Imager (SSM/I) Environmental Parameter Extraction Algorithm, NRL Memorandum Report 5199, Naval Research Laboratory, 52 pp.
- Marshall, J.S. and W.M. Palmer, 1948: The distribution of raindrops with size. J. Meteor., 5, 165-166.
- NASA, 1976: Satellite derive global oceanic rainfall atlas, NASA SP-410.
- Negri, A.J. and R.F. Adler, 1987a: Infrared and Visible Satellite Rain Estimation. Part I: A Grid Cell Approach. J. Clim. and Appl. Met., 26, 1565-1576.
- Negri, A.J. and R.F. Adler, 1987b: Infrared and Visible Satellite Rain Estimation. Part II: A Cloud Definition Approach. J. Clim. and Appl. Opt., 26, 1565-1576.
- Olson, W.S., F.J. LaFontaine, W.L. Smith, R.T. Merrill, B.A. Roth, and T. Achtor, (1988): Recommended algorithms for the retrieval of rainfall rates at midlatitudes using the SSM/I (DMSP-8). In DMSP special sensor microwave/imager calibration/validation. J. Hollinger (ed.) Naval Research Laboratory (Draft).
- Peirce, R.M., R.W. Lenhard and B.D. Weiss, 1975: Comparison study of models used to prescribe hydrometeor water content values. AFCRL-TR-75-0470. ADA019633
- Rutledge, S. A. and P. V. Hobbs, 1983: The mesoscale and microscale structure and organization of clouds and precipitation in midlatitude cyclones. VIII: A model for the "seeder-feeder" process in warm-frontal rainbands. J. Atmos. Sci., 40, 1185-1206.
- Rutledge, S.A., and P.V. Hobbs, 1984: The mesoscale and microscale structure and organization of clouds and precipitation in mid-latitude cyclones. XII: A diagnostic modeling study of precipitation development in narrower frontal rainbands. J. Atmos. Sci., 41, 2949-2972.

- Rutledge, S. A., 1986: A diagnostic modeling study of the stratiform region associated with a tropical squall line. J. Atmos. Sci., 43, 1356-1377.
- Savage, R. C., 1981: The DMSP Microwave Imager (SSM/I): Unfinished Plans. In Precipitation Measurements from Space, D. Atlas and O. Theile, (eds). pp 246-252.
- Savage, R.C. and J.A. and Weinman, 1975: Preliminary calculations of the upwelling radiance from rain clouds at 37.0 and 19.35 GHz. Bulletin of the American Meteorological Society, 56, 1272-1274.
- Savage, R. C., L. A. Burgess, and B. W. Shipley, 1987: The Defense Meteorological Satellite Program (DMSP) Microwave Imager (SSM/I) in Passive Microwave Observing from Environmental Satellites. J. C. Fisher (ed.). NOAA Technical Report NESDIS 35. pp. 186-202.
- Simpson, J., and V. Wiggert, 1969: Models of precipitating cumulus towers. Monthly Weather Rev., 97, 471-489.
- Simpson, J., R. H. Simpson, D. A. Andrews and M. A. Eaton, 1965: Experimental cumulus dynamics. Reviews of Geophysics, 3, 387-431.
- Spencer, R.W. and D.A. Santek, 1985: Measuring the global distribution of intense convection over land with passive microwave radiometry, J. Cli. Met., 24, 860.
- Tao, W.-K., and J. Simpson, 1989: Modeling study of a tropical squall-type convective line. J. Atmos. Sci., 46, 177-202.
- Tsang, L., and J.A. Kong, 1977: Theory for thermal microwave emission from a bounded medium containing spherical scatterers. J. Appl. Physics, 48, 3593-3599.
- Ulbrich, C.W., 1983: Natural variations in the analytical form of the raindrop size distribution. J. Appl. Meteorol., 22, 1764-1775.
- Weaver, R., C. Morris, R. G. Barry, 1987: Passive Microwave Data for Snow and Ice Research: Planned Products from the DMSP SSM/I System, EOS, 29 September, p. 769.
- Wei, Leighton, and Rogers, 1989: A comparison of several radiometric methods of reducing path integrated cloud liquid water. JAOT, 6, 1001-1012.
- Weinman, J.A., and P.J. Guetter, 1977: Determination of rainfall distribution from microwave radiation measured by the NIMBUS 6 ESMR, J. Appl. Meteorol., 16, 437-442.
- Weinman, J.A., and T.T. Wilheit, 1981: A survey of passive microwave and hybrid remote sensing of precipitation, in Precipitation Measurements from Space Workshop Report, edited by D. Atlas and O.W. Thiele, GSFC, pp. D-173-D-175.
- Wilheit, T.T., A.T.C. Chang, M.S. V. Rao, E.B. Rodgers, and J.S. Theon, 1977: Satellite technique for quantitatively mapping rainfall rates over the oceans, J. Appl. Meteorol., 16, 551-560.
- Wilheit, T.T., A.T.C. Chang, M.S.V. Rao, E.B. Rodgers, R.A. Nieman, B.M. Krupp, A.S. Milman, J.S. Stratigos and H. Siddalingaiah, 1982: Microwave radiometric

observations near 19.35, 92, and 183 GHz of Precipitation in Tropical Storm Cora. J. Appl. Met., 21, 1137.

Willis, P.T., and P. Tattleman, 1989: Drop-size distributions associated with intense rainfall. J. Appl. Meteor., 28, 3-15.

WMO, 1985: Review of requirements for area averaged precipitation data, etc. WCP-100, WMO/TD-N0.115, World Meteorological Organization.

Zawadzki, I. I., and C. V. Ro, 1978: Correlations between maximum rate of precipitation and mesoscale parameters. J. Appl. Meteor., 17, 1327-1344.

Appendix A SSM/I Data Extraction Software

3-DEC-1990 09:41:33
19-APR-1990 15:16:57

```

0001 C PROGRAM NAME: RDSSMI.FOR          LAST UPDATE: 28FEB90
0002 C A USER FRIENDLY, GENERALIZED PROGRAM FOR READING FROM THE
0003 C WENTZ COMPRESSED SSM/I TAPES.
0004 C BEFORE RUNNING THE PROGRAM ISSUE THE FOLLOWING VAX COMMAND:
0005 C
0006 C ALLOCATE HSCISMA0: FOR001:
0007 C MOUNT/FOREIGN/DENSITY=6250/BLOCKSIZE=28544/RECORDSIZE=1784
0008 C FOR001:/COMMENT="TAPE XXXX"
0009 C
0010 C QUESTIONS ABOUT THE PROGRAM? CONTACT:
0011 C Mark Goodberlet
0012 C 13 Marcus Hall
0013 C University of Massachusetts
0014 C Amherst, MA 01003
0015 C (413) 545-4675
0016 C
0017 C program rdssmi
0018 C
0019 C CHARACTER CSEL*1, IDUM
0020 C
0021 C *****
0022 C SPECIFY COMMON /INDATA/ *
0023 C *****
0024 C
0025 C CHARACTER*1 LREC(1784)
0026 C INTEGER*4 KBT,IBYT,IFLAG
0027 C COMMON/INDATA/LREC,KBT,IBYT,IFLAG
0028 C
0029 C DATA KBT/1/      !Program set to work on VAX computer
0030 C
0031 C 10 CONTINUE
0032 C KFLAG=0
0033 C
0034 C WRITE(6,1000)
0035 C 1000 FORMAT('1'/23X,32(' ')/
0036 C 125X,'SSM/I DATA RETRIEVAL PROGRAM'/34X,
0037 C 1'MAIN MENU'/23X,32(' ')/23X,
0038 C 1'C = EXTRACT SENSOR HEALTH DATA'/23X,
0039 C 1'B = EXTRACT TB AND WSP SWATH DATA'/23X,
0040 C 1'H = EXTRACT ALL 85GHZ TA DATA'/23X,
0041 C 1'Q = QUIT'/27X,'ENTER SELECTION <CR>: ', $)
0042 C
0043 C READ(5,1100)CSEL
0044 C 1100 FORMAT(A1)
0045 C IF(CSEL.EQ. 'C'.OR. CSEL.EQ. 'C')CALL CALDAT(KFLAG)
0046 C IF(CSEL.EQ. 'B'.OR. CSEL.EQ. 'B')CALL SWATH(1,KFLAG)
0047 C IF(CSEL.EQ. 'H'.OR. CSEL.EQ. 'H')CALL SWATH(2,KFLAG)
0048 C IF(CSEL.EQ. 'Q'.OR. CSEL.EQ. 'Q')GO TO 999
0049 C
0050 C *****
0051 C VARIABLE KFLAG INTERPRETATIONS *****
0052 C KFLAG=0 => INVALID OPTION SELECTED BY USER
0053 C KFLAG=1 => SUCCESSFUL COMPLETION OF A USER SELECTED OPTION
0054 C KFLAG=2 => USER SELECTED A VALID OPTION NOT AVAILABLE AT THIS TIME
0055 C KFLAG=3 => VALID OPTION SELECTED BUT EXECUTION ERROR ENCOUNTERED
0056 C *****
0057

```

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RDSSMI

```

0058 IF(KFLAG.EQ. 0)WRITE(6,2100)
0059 IF(KFLAG.EQ. 2 .OR. KFLAG.EQ. 0)GO TO 10
0060 WRITE(6,2200)
0061 IF(KFLAG.EQ. 3) WRITE(6,2400)
0062 2100 FORMAT(////////21X,'INVALID SELECTION - PLEASE TRY AGAIN'//)
0063 2200 FORMAT(////////18X,'REWIND THE TAPE BEFORE RERUNNING THE PROGRAM'//
0064 19X,' USE==> SET MAGTAPE/REWIND FOR001: ',//)
0065 2400 FORMAT(/23X,'PROGRAM TERMINATED DUE TO ERRORS'.)
0066 999 STOP
0067 END

```

PROGRAM SECTIONS

Name	Bytes	Attributes
0 \$CODE	242	PIC CON REL LCL SHR EXE RD NOWRT QUAD
1 \$PDATA	431	PIC CON REL LCL SHR NOEXE RD NOWRT QUAD
2 \$LOCAL	48	PIC CON REL LCL NOSHR NOEXE RD WRT QUAD
3 \$INDATA	1796	PIC OVR REL GBL SHR NOEXE RD WRT QUAD
Total Space Allocated	2517	

ENTRY POINTS

Address	Type	Name
0-00000000		RDSSMI

VARIABLES

Address	Type	Name	Address	Type	Name
2-00000000	CHAR CSEL		2-00000001	CHAR IDUM	
3-000000F8	I*4 KET		3-00000700	I*4 IFLAG	

ARRAYS

Address	Type	Name	Bytes	Dimensions
3-00000000	CHAR LREC		1784	(1784)

LABELS

Address	Label	Address	Label	Address	Label
0-00000009	10	0-000000EB	999	1-00000008	1000'
1-00000187	2400,			1-000000E8	1100'
				1-000000EB	2100'
				1-0000011B	2200'

ROSSMI
01

FUNCTIONS AND SUBROUTINES REFERENCED

Type	Name	Type	Name
	CALDAT		SWATH

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0001
0002

COMMAND QUALIFIERS

```
FORTRAN/NOOPT/DEBUG/LIST/NOOBJ MAIN
/CHECK=(NOBOUNDS,OVER"LOW,NOUNDERFLOW)
/DEBUG=(SYMBOLS,TRACEBACK)
/DESIGN=(NOCOMMENTS,NOPLACEHOLDERS)
/SHOW=(NO DICTIONARY,NO INCLUDE,MAP,NO PREPROCESSOR,SINGLE)
/STANDARD=(NO SEMANTIC,NOSOURCE FORM,NOSYNTAX)
/WARNINGS=(NO DECLARATIONS,GENERAL,NOULTRIX,NOVAXELN)
/CONTINUATIONS=19 /NOCROSS REFERENCE /NOD LINES /NOEXTEND SOURCE
/F77 /NOG FLOATING /I4 /NOMACHINE_CODE /NOOPTIMIZE /NOPARALLEL
/NOANALYSIS DATA
/NO DIAGNOSTICS
/LIST=USER$DISK_26:(BELFIORE.SSMI.SRC.RDSSMI)MAIN.LIS:1
/NOOBJECT
```

COMPILATION STATISTICS

Run Time:	0.54 seconds
Elapsed Time:	0.98 seconds
Page Faults:	497
Dynamic Memory:	344 pages

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```

0001 SUBROUTINE CALDAT(KFLAG)
0002
0003 C .....
0004 C PROGRAM USED TO STRIP SENSOR HEALTH DATA FROM THE WENTZ SSMI TAPES
0005 C
0006 C NOTE: * ONLY A-SCAN CALIBRATION COUNTS ARE OUTPUTTED
0007 C
0008 C * OTHER SENSOR HEALTH ITEMS AVAILABLE ARE:
0009 C (1) AGC SETTINGS
0010 C (2) REF VOLTAGES 1 & 2
0011 C (3) CALIB SLOPE VALUES
0012 C (4) CALIB OFFSET VALUES
0013 C (5) B-SCAN HOT AND COLD LOAD COUNTS
0014 C
0015 C .....
0016
0017 INTEGER ITRF(7),ITNOW(7)
0018 INTEGER JULIAN(12,2),STIME,ETIME,HH,MM
0019 CHARACTER FRAME*10
0020
0021 C .....
0022 C SPECIFY COMMON /INDATA/ *
0023 C .....
0024
0025 CHARACTER*1 LREC(1784)
0026 INTEGER*4 KBT,IBYT,IFLAG
0027 COMMON/INDATA/LREC,KBT,IBYT,IFLAG
0028
0029 C .....
0030 C SPECIFY COMMON /OUTDAT/ *
0031 C .....
0032
0033 REAL*8 REV
0034 INTEGER*4 ITIME,ITIMSC,IVOLT,IAGC,ICOLDA,IHOTA,ICOLDB,IHOTB,ISPARI
0035 INTEGER*4 ITOIL,ISPAR2
0036 REAL*4 XLATSC,XLONSC,ALTSC,HLTEMP,RTTEMP,FRTEMP,CALSLP,CALOFF
0037 REAL*4 ALAT,ALON,BLAT,BLON,TALO,TAHI
0038
0039 COMMON/OUTDAT/ REV,ITIME,ITIMSC,XLATSC,XLONSC,ALTSC,
0040 1 HLTEMP(3),IVOLT(2),RTTEMP,FRTEMP,IAGC(6),CALSLP(7),CALOFF(7),
0041 2 ICOLDA(5,7),IHOTA(5,7),ICOLDB(5,2),IHOTB(5,2),ISPARI,
0042 3 ALAT(128),ALON(128),BLAT(128),BLON(128),
0043 4 TALO(5,64),TAHI(8,64),ITOL(4,64),ISPAR2(64)
0044
0045 DATA ITRF/87,1,1,0,0,0,1/
0046 DATA JULIAN/1,32,60,91,121,152,182,213,244,274,305,335,
0047 1,32,61,92,122,153,183,214,245,275,306,336/
0048
0049 OPEN(1,STATUS='OLD',BLOCKSIZE=28544,RECL=1784,
0050 1 RECORDTYPE='FIXED',FORM='FORMATTED')
0051
0052 C .....
0053 C READ PAST THE TAPE HEADERS *
0054 C .....
0055
0056 CALL READHD
0057 WRITE(6,1000)

```

CALDAT

```

0058      FORMAT(1X,' ENTER START DATE (YR MM DD)(e.g. 88 1 25): ', $)
0059      READ(5,*)ITNOW(1),ITNOW(2),ITNOW(3)
0060      WRITE(6,1100)
0061      1100 FORMAT(1X,' ENTER START TIME (HH MM SS)(e.g. 0 0 0): ', $)
0062      READ(5,*)ITNOW(4),ITNOW(5),ITNOW(6)
0063      CALL QTIME(ITREF,ITNOW,ITIME,IERR,1)
0064      STIME=ITIME
0065      WRITE(6,1200)
0066      1200 FORMAT(1X,' ENTER END DATE (YR MM DD): ', $)
0067      READ(5,*)ITNOW(1),ITNOW(2),ITNOW(3)
0068      WRITE(6,1300)
0069      1300 FORMAT(1X,' ENTER END TIME (HH MM SS): ', $)
0070      READ(5,*)ITNOW(4),ITNOW(5),ITNOW(6)
0071      CALL QTIME(ITREF,ITNOW,ITIME,IERR,1)
0072      ETIME=ITIME
0073      WRITE(6,1400)
0074      1400 FORMAT(1X,' ENTER OUTPUT FILE NAME: ', $)
0075      READ(5,1500)FNAME
0076      1500 FORMAT(A10)
0077      OPEN(UNIT=2,STATUS='NEW',NAME=FNAME)
0078
0079      C*****
0080      C WRITE HEADERS TO THE OUTPUT FILE *
0081      C*****
0082
0083      WRITE(2,1600)
0084      1600 FORMAT(' OUTPUT LINE #1==> SCAN TIME, 3 HOT LOAD TEMPS,',
0085      &' RF MIXER TEMP, AND FWD RADIATOR TEMP,',
0086      &' OUTPUT LINE #2==> FIVE COLD LOAD AND HOT LOAD COUNTS FOR 19V',
0087      &' OUTPUT LINE #3==> FIVE COLD LOAD AND HOT LOAD COUNTS FOR 19H',
0088      &' OUTPUT LINE #4==> FIVE COLD LOAD AND HOT LOAD COUNTS FOR 37V',
0089      &' OUTPUT LINE #5==> FIVE COLD LOAD AND HOT LOAD COUNTS FOR 37H',
0090      &' OUTPUT LINE #6==> FIVE COLD LOAD AND HOT LOAD COUNTS FOR 22V',
0091      &' OUTPUT LINE #7==> FIVE COLD LOAD AND HOT LOAD COUNTS FOR 85V',
0092      &' OUTPUT LINE #8==> FIVE COLD LOAD AND HOT LOAD COUNTS FOR 85H')
0093      IREC=0
0094      IREC2=0
0095      WRITE(6,1800)
0096      1800 FORMAT(///, REC NO')
0097      10 IEOF=0
0098      11 READ(1,2000,END=12)IREC
0099      2000 FORMAT(1784A1)
0100      GO TO 14
0101      12 IEOF=IEOF+1
0102      WRITE(6,2001)IEOF
0103      2001 FORMAT(' IEOF= ',I2)
0104
0105      C*****
0106      C DOUBLE END-OF-FILE MEANS END-OF-TAPE *
0107      C*****
0108
0109      IF(IEOF.EQ.2)GO TO 999
0110      GO TO 11
0111      14 CONTINUE
0112      IREC=IREC+1
0113      IREC2=IREC2+1
0114      IF(IREC.EQ.25)WRITE(6,*)IREC2

```

CALDAT

```

0115 IF(IREC.EQ.25)IREC=0
0116 ITIME=INT44(KBT,LREC(1),LREC(2),LREC(3),LREC(4))
0117 CALL QTIME(ITREF,ITNOW,ITIME,IERR,2)
0118 JDAY=JULIAN(ITNOW(2),ITNOW(7))+ITNOW(3)-1
0119 HH=ITNOW(4)
0120 MM=ITNOW(5)
0121 REV=1.D-4*INT44(XBT,LREC(5),LREC(6),LREC(7),LREC(8))
0122 IF(ITIME.LT.STIME)GO TO 10
0123 IF(ITIME.GT.STIME)GO TO 999
0124 CALL FDCAL
0125 WRITE(2,2100)JDAY,HH,MM,(HLEMP(I),I=1,3),RFTMP,FRTEMP
0126 DO 50 JCH=1,7
0127   WRITE(2,2200)(ICOLDA(I,JCH),I=1,5),(IHOTA(I,JCH),I=1,5)
0128   50 CONTINUE
0129   2100 FORMAT(' ',I3,X,I2,X,I2,5(X,F7.2))
0130   2200 FORMAT(' ',5(I5,X),5X,5(I5,X))
0131   GO TO 10
0132   999 KFLAG=1
0133   RETURN
0134   END
    
```

PROGRAM SECTIONS

Name	Bytes	Attributes
0 \$CODE	906	PIC CON REL LCL SHR EXE RD NOWRT QUAD
1 \$PDATA	834	PIC CON REL LCL SHR NOEXE RD NOWRT QUAD
2 \$LOCAL	488	PIC CON REL LCL NOSHR NOEXE RD WRT QUAD
3 \$INDATA	1796	PIC OVR REL GBL SHR NOEXE RD WRT QUAD
4 \$OUTDAT	7156	PIC OVR REL GBL SHR NOEXE RD WRT QUAD
Total Space Allocated	11180	

ENTRY POINTS

Address	Type	Name
0-00000000		CALDAT

VARIABLES

Address	Type	Name	Address	Type	Name
4-00000018	R*4	ALTS	2-00000098	CHAR	FNAME
2-000000AC	I*4	HH	3-000000FC	I*4	IBYT
2-000000B4	I*4	IERR	2-000000B8	I*4	IIRC
4-000001F0	I*4	ISPAR1	4-0000000C	I*4	ITIMSC
2-000000C4	I*4	JDAY	AP-00000004	I*4	KFLAG
4-00000000	R*8	REV	2-000000A4	I*4	STIME
4-00000014	R*4	XLONSC	4-00000010	R*4	XLATSC
			4-00000034	R*4	FRTEMP
			2-000000C0	I*4	IEOF
			2-000000B0	I*4	IIRC2
			2-00000000	I*4	JCH
			2-00000080	I*4	MM

CALDAT
01

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ARRAYS

Address	Type	Name	Bytes	Dimensions
4-000001F4	R*4	ALAT	512	(128)
4-000003F4	R*4	ALON	512	(128)
4-000005F4	R*4	BLAT	512	(128)
4-000007F4	R*4	BLOH	512	(128)
4-0000006C	R*4	CALOFF	28	(7)
4-00000050	R*4	CALSLEP	28	(7)
4-0000001C	R*4	HLTEMP	12	(3)
4-00000038	I*4	IAGC	24	(6)
4-00000088	I*4	ICOLDA	140	(5, 7)
4-000001A0	I*4	ICOLDB	40	(5, 2)
4-000003114	I*4	IHOTA	140	(5, 7)
4-0000031C8	I*4	IHOTB	40	(5, 2)
4-00001AF4	I*4	ISPAR2	256	(64)
2-0000001C	I*4	ITNOW	28	(7)
4-000016F4	I*4	ITDIL	1024	(4, 64)
2-00000300	I*4	ITREF	28	(7)
4-00000028	I*4	IVOLT	8	(2)
2-00000038	I*4	JULIAN	96	(12, 2)
3-00000000	CHAR	LREC	1784	(1784)
4-00000EF4	R*4	TAHI	2048	(8, 64)
4-000009F4	R*4	TALO	1280	(5, 64)

LABELS

Address	Label	Address	Label	Address	Label	Address	Label
0-000001BD	10	0-000001C0	11	0-000001E7	12	0-00000215	14
1-00000008	1000,	1-0000003B	1100,	1-0000006C	1200,	1-0000008F	1300,
1-0000000D5	1600,	1-0000002EE	1800,	1-000000300	2000,	1-000000306	2001,
						0-0000037D	50
						1-000000B2	1400,
						1-00000312	2100,
						0-00000385	999
						1-000000D2	1500,
						1-0000032A	2200,

FUNCTIONS AND SUBROUTINES REFERENCED

Type	Name	Type	Name	Type	Name
FDAL	FOR\$OPEN	I*4	INT44	QTIME	READHD

0001 C*****
 0002
 0003

COMMAND QUALIFIERS

```

FORTRAN/NOOPT/DEBUG/LIST/NOOBJ CALDAT
/CHECK=(ROBOUNDS,OVERFLOW,UNDERFLOW)
/DEBUG=(SYMBOLS,TRACEBACK)
/DESIGN=(NOCOMMENTS,NOPLACEHOLDERS)
/SHOW=(NODICTIONARY,NOINCLUDE,MAP,NOPREPROCESSOR,SINGLE)
/STANDARD=(NOSEMANTIC,NOSOURCE FORM,NOSYNTAX)
/WARNINGS=(NODECLARATIONS,GENERAL,NOULTRIX,NOVAXELN)
/CONTINUATIONS=19 /NOCROSSREFERENCE /NO LINES /NOEXTEND SOURCE
/F77 /NOG FLOATING /14 /NOMACHINE_CODE /NOOPTIMIZE /NOPARALLEL
/NOANALYSIS DATA
/NO DIAGNOSTICS
/LIST=USER$DISK_26:(BELFIORE.SSMI.SRC.RDSSMI)CALDAT.LIS:1
/NOOBJECT
  
```

COMPILATION STATISTICS

```

Run Time:      1.35 seconds
Elapsed Time:  4.32 seconds
Page Faults:   293
Dynamic Memory: 400 pages
  
```

```

0001      subroutine estreg (regions)
0002      .....
0003      Subroutine ESTREG establishes the coordinates of 11 Eurasian sites
0004      in a 2-D array. This is a specific example. This routine can be
0005      easily modified to accept user-defined locations.
0006      .....
0007      The first dimension of the 2-D array refers to the location in
0008      question. The ordering is as follows: (east longitudes!)
0009      .....
0010      1 = Leningrad
0011      2 = Kiev
0012      3 = Simferopol
0013      4 = Moscow
0014      5 = Murmansk
0015      6 = Perm
0016      7 = Aktyubinsk
0017      8 = Tashkent
0018      9 = Semipalatinsk
0019      10 = Chita
0020      11 = Blagoveshensk
0021      .....
0022      .....
0023      .....
0024      real regions(11,4), box(4)
0025      .....
0026      .....
0027      C Leningrad *
0028      .....
0029      call geobox (59.96, 30.30, 200.00, box)
0030      regions(1,1) = box(1)
0031      regions(1,2) = box(2)
0032      regions(1,3) = box(3)
0033      regions(1,4) = box(4)
0034      .....
0035      .....
0036      C Kiev *
0037      .....
0038      call geobox (50.40, 30.45, 200.00, box)
0039      regions(2,1) = box(1)
0040      regions(2,2) = box(2)
0041      regions(2,3) = box(3)
0042      regions(2,4) = box(4)
0043      .....
0044      .....
0045      C Simferopol *
0046      .....
0047      call geobox (45.01, 33.98, 200.00, box)
0048      regions(3,1) = box(1)
0049      regions(3,2) = box(2)
0050      regions(3,3) = box(3)
0051      regions(3,4) = box(4)
0052      .....
0053      .....
0054      C Moscow *
0055      .....
0056      call geobox (55.96, 37.41, 200.00, box)
0057      regions(4,1) = box(1)

```

ESTREG

```

0058      regions(4,2) = box(2)
0059      regions(4,3) = box(3)
0060      regions(4,4) = box(4)
0061
0062      C*****
0063      C Murmansk
0064      C*****
0065      call geobox (68.96, 33.05, 200.00, box)
0066      regions(5,1) = box(1)
0067      regions(5,2) = box(2)
0068      regions(5,3) = box(3)
0069      regions(5,4) = box(4)
0070
0071      C*****
0072      C Perm
0073      C*****
0074      call geobox (58.01, 56.30, 200.00, box)
0075      regions(6,1) = box(1)
0076      regions(6,2) = box(2)
0077      regions(6,3) = box(3)
0078      regions(6,4) = box(4)
0079
0080      C*****
0081      C Aktyubinsk
0082      C*****
0083      call geobox (50.28, 57.15, 200.00, box)
0084      regions(7,1) = box(1)
0085      regions(7,2) = box(2)
0086      regions(7,3) = box(3)
0087      regions(7,4) = box(4)
0088
0089      C*****
0090      C Tashkent
0091      C*****
0092      call geobox (41.26, 69.26, 200.00, box)
0093      regions(8,1) = box(1)
0094      regions(8,2) = box(2)
0095      regions(8,3) = box(3)
0096      regions(8,4) = box(4)
0097
0098      C*****
0099      C Semipalatinsk
0100      C*****
0101      call geobox (50.35, 80.25, 200.00, box)
0102      regions(9,1) = box(1)
0103      regions(9,2) = box(2)
0104      regions(9,3) = box(3)
0105      regions(9,4) = box(4)
0106
0107      C*****
0108      C Chita
0109      C*****
0110      call geobox (52.01, 113.33, 200.00, box)
0111      regions(10,1) = box(1)
0112      regions(10,2) = box(2)
0113      regions(10,3) = box(3)
0114      regions(10,4) = box(4)

```

ESTREG

```

0115 C*****
0116 C BlagovosChensk *
0117 C*****
0118 C*****
0119 call geobox (50.26, 127.50, 200.00, box)
0120 regions(11,1) = box(1)
0121 regions(11,2) = box(2)
0122 regions(11,3) = box(3)
0123 regions(11,4) = box(4)
0124 return
0125 end
0126
  
```

PROGRAM SECTIONS

Name	Bytes	Attributes
0 \$CODE	511	PIC CON REL LCL SHR EXE RD NOWRT QUAD
1 \$PDATA	92	PIC CON REL LCL SHR NOEXE RD NOWRT QUAD
2 \$LOCAL	280	PIC CON REL LCL NOSHR NOEXE RD WRT QUAD
Total Space Allocated	883	

ENTRY POINTS

Address	Type	Name
0-00000000		ESTREG

ARRAYS

Address	Type	Name	Bytes	Dimensions
2-00000000	R*4	BOX	16	(4)
AP-00000004Q	R*4	REGIONS	176	(11, 4)

FUNCTIONS AND SUBROUTINES REFERENCED

Type	Name
	GEOBOX

ESTREG
01

COMMAND QUALIFIERS

3-Dec-1990 09:38:51
26-Apr-1990 12:03:21

VAX FORTRAN V5.5-98
{BELFIORE.SSMI.SRC.RDSSMI}ESTREG.FOR;1

Page 4

```
FORTRAN/NOOPT/DEBUG/LIST/NOOBJ ESTREG
/CHECK=(NOBOUNDS,OVERFLOW,NOUNDERFLOW)
/DEBUG=(SYMBOLS,TRACEBACK)
/DESIGN=(NOCOMMENTS,NOPLACEHOLDERS)
/SHOW=(INODICTIONARY,NOINCLUDE,MAP,NOPREPROCESSOR,SINGLE)
/STANDARD=(NOSEMANTIC,NOSOURCE FORM,NOSYNTAX)
/WARNINGS=(NODECLARATIONS,GENERAL,NOULTRIX,NOVAXELN)
/CONTINUATIONS=19 /NOCROSS_REFERENCE /NOD_LINES /NOEXTEND_SOURCE
/F77 /NOG_FLOATING /I4 /NOMACHINE_CODE /NOOPTIMIZE /NOPARALLEL
/NOANALYSIS DATA
/NO DIAGNOSTICS
/LIST=USERSDISK_26:{BELFIORE.SSMI.SRC.RDSSMI}ESTREG.LIS;1
/NOOBJECT
```

COMPILATION STATISTICS

Run Time:	1.08 seconds
Elapsed Time:	1.55 seconds
Page Faults:	514
Dynamic Memory:	392 pages

```

0001 SUBROUTINE FDCAL
0002
0003 INTEGER*4 IBH,IBC
0004 REAL*4 SCALE1(10)
0005
0006 C*****
0007 C SPECIFY COMMON /INDATA/
0008 C*****
0009
0010 CHARACTER*1 LREC(1784)
0011 INTEGER*4 KBT,IBYT,IFLAG
0012 COMMON/INDATA/LREC,KBT,IBYT,IFLAG
0013
0014 C*****
0015 C SPECIFY COMMON /OUTDAT/
0016 C*****
0017
0018 REAL*8 REV
0019 INTEGER*4 ITIME,ITIMSC,IVOLT,IAGC,ICOLDA,IHOTA,ICOLDB,IHOTB,ISPARI
0020 INTEGER*4 ITOIL,ISPAR2
0021 REAL*4 XLATSC,XLONSC,ALTSC,HITEMP,FRTEMP,CALSLP,CALOFF
0022 REAL*4 ALAT,ALON,BLAT,BLON,TALO,TAHI
0023
0024 COMMON/OUTDAT/ REV,ITIME,ITIMSC,XLATSC,XLONSC,ALTSC,
0025 1 HITEMP(3),IVOLT(2),FRTEMP,FRTEMP,IAGC(6),CALSLP(7),CALOFF(7),
0026 2 ICOLDA(5,7),IHOTA(5,7),ICOLDB(5,2),IHOTB(5,2),ISPARI,
0027 3 ALAT(128),ALON(128),BLAT(128),BLON(128),
0028 4 TALO(5,64),TAHI(8,64),ITOIL(4,64),ISPAR2(64)
0029
0030 C*****
0031 C DATA INITIALIZATION
0032 C*****
0033
0034 DATA SCALE1/3*1.E-2,2*1.,2*1.E-2,3*1./
0035
0036 C*****
0037 C BEGIN EXECUTION
0038 C*****
0039
0040 ITIME=INT44(KBT,LREC(1),LREC(2),LREC(3),LREC(4))
0041 REV=1.D-4*INT44(KBT,LREC(5),LREC(6),LREC(7),LREC(8))
0042 ITIMSC=INT44(KBT,LREC(9),LREC(10),LREC(11),LREC(12))
0043 XLATSC=1.D-6*INT44(KBT,LREC(13),LREC(14),LREC(15),LREC(16))-90.
0044 XLONSC=1.D-6*INT44(KBT,LREC(17),LREC(18),LREC(19),LREC(20))
0045 ALTSC=1.D-6*INT44(KBT,LREC(21),LREC(22),LREC(23),LREC(24))
0046 ALTSC=1.D-3*INT44(KBT,LREC(25),LREC(26),LREC(27),LREC(28))
0047 IBYT=29
0048
0049 DO 100 IP=1,3
0050 HITEMP(4-IP)=0.01*INT24(KBT,LREC(IBYT),LREC(IBYT+1))
0051 IBYT=IBYT+2
0052 100 CONTINUE
0053
0054 IVOLT(2)=INT24(KBT,LREC(35),LREC(36))
0055 IVOLT(1)=INT24(KBT,LREC(37),LREC(38))
0056 FRTEMP=0.01*INT24(KBT,LREC(39),LREC(40))
0057 FRTEMP=0.01*INT24(KBT,LREC(41),LREC(42))

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```

0058      IBYT = 43
0059
0060      DO 200 IP=8,10
0061          IAGC(11-IP)=INT24(KBT,LREC(IBYT),LREC(IBYT+1))
0062          IBYT=IBYT+2
0063      200 CONTINUE
0064
0065      DO 300 ICH=1,7
0066          CALSLP(ICH)=1.E-5*INT24(KBT,LREC(IBYT),LREC(IBYT+1))
0067          CALOFF(ICH)=2.E-2*INT24(KBT,LREC(IBYT+2),LREC(IBYT+3))
0068          IBYT=IBYT+4
0069      300 CONTINUE
0070
0071      IBC=IBYT
0072      IBH=IBYT+70
0073      DO 400 ICH=1,7
0074          DO 400 IP=1,5
0075              ICOLDA(IP,ICH)=INT24(KBT,LREC(IBC),LREC(IBC+1))
0076              IHOTA(IP,ICH)=INT24(KBT,LREC(IBH),LREC(IBH+1))
0077              IBC=IBC+2
0078              IBH=IBH+2
0079      400 CONTINUE
0080      IBYT=IBH
0081
0082      DO 500 IP=1,3
0083          IAGC(7-IP)=INT24(KBT,LREC(IBYT),LREC(IBYT+1))
0084          IBYT=IBYT+2
0085      500 CONTINUE
0086      IBC=IBYT
0087      IBH=IBYT+20
0088
0089      DO 600 ICH=1,2
0090          DO 600 IP=1,5
0091              ICOLDB(IP,ICH)=INT24(KBT,LREC(IBC),LREC(IBC+1))
0092              IHOTB(IP,ICH)=INT24(KBT,LREC(IBH),LREC(IBH+1))
0093              IBC=IBC+2
0094              IBH=IBH+2
0095      600 CONTINUE
0096      IBYT=IBH
0097
0098      RETURN
0099      END

```

PROGRAM SECTIONS

Name	Bytes	Attributes
0 \$CODE	956	PIC CON REL LCL SHR EXE RD NOWRT QUAD
2 \$LOCAL	864	PIC CON REL LCL NOSHR NOEXE RD WRT QUAD
3 \$INDATA	1796	PIC OVR REL GBL SHR NOEXE RD WRT QUAD
4 \$OUTDAT	7156	PIC OVR REL GBL SHR NOEXE RD WRT QUAD
Total Space Allocated	10772	

ENTRY POINTS

Address	Type	Name
0-00000000		FDCAL

VARIABLES

Address	Type	Name	Address	Type	Name
4-00000018	R*4	ALTSC	2-00000028	I*4	IBH
3-0000006FC	I*4	IBYT	2-00000030	I*4	IP
4-0000001F0	I*4	ISPARI	3-0000006F8	I*4	KBT
4-000000000	R*8	REV	4-000000014	R*4	XLONSC

ARRAYS

Address	Type	Name	Bytes	Dim	'ns
4-0000001F4	R*4	ALAT	512	(128)	
4-0000003F4	R*4	ALON	512	(128)	
4-0000005F4	R*4	BLAT	512	(128)	
4-0000007F4	R*4	BLON	512	(128)	
4-00000006C	R*4	CALOFF	28	(7)	
4-000000050	R*4	CALSLP	28	(7)	
4-00000001C	R*4	HLTEMP	12	(3)	
4-000000038	I*4	IAGC	24	(6)	
4-000000038	I*4	ICOLDA	140	(5, 7)	
4-0000001A0	I*4	ICOLDB	40	(5, 2)	
4-000000114	I*4	IHOTA	140	(5, 7)	
4-0000001C8	I*4	IHOTB	40	(5, 2)	
4-0000001AF4	I*4	ISPAR2	256	(64)	
4-00000016F4	I*4	ITOIL	1024	(4, 64)	
4-000000028	I*4	IVOLT	8	(2)	
3-000000000	CHAR	LREC	1784	(1784)	
2-000000000	R*4	SCALE1	40	(10)	
4-000000EF4	R*4	TAHI	2048	(8, 64)	
4-0000009F4	R*4	TALO	1280	(5, 64)	

LABELS

Address	Label	Address	Label	Address	Label	Address	Label
0-00000109	200	0-000001A7	200	0-00000235	300	0-000002C9	400
						0-0000031C	500
						0-000003AA	600

FUNCTIONS AND SUBROUTINES REFERENCED

Type	Name
I*4	INT24
I*4	INT44

0001 C.....

0002
 0003

COMMAND QUALIFIERS

```

FORTRAN/NOOPT/DEBUG/LIST/NOOBJ FDCAL
/CHECK=(NOBOUNDS,OVERFLOW,NOUNDERFLOW)
/DEBUG=(SYMBOLS,TRACEBACK)
/DESIGN=(NOCOMMENTS,NOPPLACEHOLDERS)
/SHOW=(NODICTIONARY,NOINCLUDE,MAP,NOPREPROCESSOR,SINGLE)
/STANDARD=(NOSEMANTIC,NOSOURCE FORM,NOSYNTAX)
/WARNINGS=(NODECLARATIONS,GENERAL,NOULTRIX,NOVAXELN)
/CONTINUATIONS=19 /NOCROSS REFERENCE /NOD LINES /NOEXTEND SOURCE
/F77 /NOG FLOATING /I4 /NOMACHINE_CODE /NOOPTIMIZE /NOPARALLEL
/NOANALYSIS DATA
/NO DIAGNOSTICS
/LIST=USER$DISK_26:[BELFIORE.SSMI.SRC.RDSSMI]FDCAL.LIS;1
/NOOBJECT

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COMPILATION STATISTICS

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Run Time:      1.33 seconds
Elapsed Time:  1.92 seconds
Page Faults:   590
Dynamic Memory: 440 pages

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3-DEC-1990 09:39:57
19-APR-1990 15:25:14

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0001 SUBROUTINE FDLTLEN(IISCAN)
0002
0003 C.....
0004 C ISCAN = 1 ==> *ODD # PIXEL* LAT/LON FROM "A" SCAN ARE DECODED *
0005 C ISCAN = 2 ==> ALL LAT/LON FROM "A" AND "B" SCAN ARE DECODED *
0006 C.....
0007
0008 INTEGER*4 INDEX(19), JINDEX(3,109), IBLT, IBLN, IB2D, ISCAN
0009
0010 C.....
0011 C SPECIFY COMMON /INDATA/ *
0012 C.....
0013
0014 CHARACTER*1 LREC(I784)
0015 INTEGER*4 KBT, IBYT, IFLAG
0016 COMMON/INDATA/LREC,KBT,IBYT,IFLAG
0017
0018 C.....
0019 C SPECIFY COMMON /OUTDAT/ *
0020 C.....
0021
0022 REAL*8 REV
0023 INTEGER*4 ITIME, ITMSC, IVOLT, IAGC, ICOLDA, IHOTA, ICOLDR, IHOTB, ISPAR1
0024 INTEGER*4 ITOIL, ISPAR2
0025 REAL*4 XLATSC, XLONSC, ALTSC, HLTEMP, RFTEMP, FRTEMP, CALSLP, CALOFF
0026 REAL*4 ALAT, ALON, BLAT, BLON, TALO, TAHI
0027
0028 COMMON/OUTDAT/ REV, ITIME, ITMSC, XLATSC, XLONSC, ALTSC,
0029 1 HLTEMP(3), IVOLT(2), RFTEMP, FRTEMP, IAGC(6), CALSLP(7), CALOFF(7),
0030 2 ICOLDA(5,7), IHOTA(5,7), ICOLDR(5,2), IHOTB(5,2), ISPAR1,
0031 3 ALAT(128), ALON(128), BLAT(128), BLON(128),
0032 4 TALO(5,64), TAHI(8,64), ITOIL(4,64), ISPAR2(64)
0033
0034 C.....
0035 C DATA INITIALIZATION *
0036 C.....
0037
0038 DATA RAD/0.017453293/
0039 DATA INDEX/1,9,17,25,33,41,49,57,65,73,81,89,97,105,113,121,123,
0040 1 127,128/
0041 DATA JINDEX/
0042 1 5, 1, 9, 13, 17, 21, 25, 29, 33, 37, 41,
0043 1 45, 41, 49, 53, 49, 57, 61, 57, 65, 69, 65, 73, 77, 81,
0044 1 85, 81, 89, 93, 89, 97, 101, 97, 105, 109, 105, 113, 117, 113, 121,
0045 1 3, 1, 5, 7, 5, 9, 11, 9, 13, 15, 13, 17, 19, 17, 21,
0046 1 23, 21, 25, 27, 25, 29, 31, 29, 33, 35, 33, 37, 39, 37, 41,
0047 1 43, 41, 45, 47, 45, 49, 51, 49, 53, 55, 53, 57, 59, 57, 61,
0048 1 63, 61, 65, 67, 65, 69, 71, 69, 73, 75, 73, 77, 79, 77, 81,
0049 1 83, 81, 85, 87, 85, 89, 91, 89, 93, 95, 93, 97, 99, 97, 101,
0050 1 103, 101, 105, 107, 105, 109, 111, 109, 113, 115, 113, 117, 119, 117, 121,
0051 1 125, 123, 127, 2, 1, 3, 4, 3, 5, 6, 5, 7, 8, 7, 9,
0052 1 10, 9, 11, 12, 11, 13, 14, 13, 15, 16, 15, 17, 18, 17, 19,
0053 1 20, 19, 21, 22, 21, 23, 24, 23, 25, 26, 25, 27, 28, 27, 29,
0054 1 30, 29, 31, 32, 31, 33, 34, 33, 35, 36, 35, 37, 38, 37, 39,
0055 1 40, 39, 41, 42, 41, 43, 44, 43, 45, 46, 45, 47, 48, 47, 49,
0056 1 50, 49, 51, 52, 51, 53, 54, 53, 55, 56, 55, 57, 58, 57, 59,
0057 1 60, 59, 61, 62, 61, 63, 64, 63, 65, 66, 65, 67, 68, 67, 69,

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FDLTLN

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0058      1 70, 69, 71, 72, 71, 73, 74, 73, 75, 76, 75, 77, 78, 77, 79,
0059      1 80, 79, 81, 82, 81, 83, 84, 83, 85, 86, 85, 87, 88, 87, 89,
0060      1 90, 89, 91, 92, 91, 93, 94, 93, 95, 96, 95, 97, 98, 97, 99,
0061      1 100, 99, 101, 102, 101, 103, 104, 103, 105, 106, 105, 107, 108, 107, 109,
0062      1 110, 109, 111, 112, 111, 113, 114, 113, 115, 116, 115, 117, 118, 117, 119,
0063      1 120, 119, 121, 122, 121, 123, 124, 123, 125, 126, 125, 127/
0064
0065      C*****
0066      C BEGIN EXECUTION
0067      C
0068      C SET TABLE LAT/LON FOR A-SCAN
0069      C
0070      C*****
0071      IBYT=263
0072      IBLT=IBYT
0073      IBLN=IBYT+38
0074
0075
0076      DO 100 JCEL=1,19
0077          ICEL=INDEX(JCEL)
0078      C*****
0079      C NOTE THAT ALAT CHARS ARE READ AS SIGNED 2-BYTE INTEGER *
0080      C*****
0081      ALAT(ICEL)=0.01*(INT24(KBT,LREC(IBLT),LREC(IBLT+1))-9000)
0082      ALON(ICEL)=0.01*INT24(KBT,LREC(IBLN),LREC(IBLN+1))
0083      IF(ALON(ICEL).LT.0.) ALON(ICEL)=ALON(ICEL)+360.
0084      IF(ALON(ICEL).GE.360.) ALON(ICEL)=ALON(ICEL)-360.
0085      IBLT=IBLT+2
0086      IBLN=IBLN+2
0087
0088      100 CONTINUE
0089
0090      C*****
0091      C SET MID-POINTS FOR A-SCAN
0092      C*****
0093
0094      NCEL=46
0095      IF(ISCAN.EQ.2) NCEL=109
0096      DO 200 JCEL=1,NCEL
0097          ICEL=JNDEX(1,JCEL)
0098          I1=JNDEX(2,JCEL)
0099          I2=JNDEX(3,JCEL)
0100          DIFLAT=ALAT(I2)-ALAT(I1)
0101          AVGLAT=0.5*(ALAT(I1)+ALAT(I2))
0102          DIFLON=ALON(I2)-ALON(I1)
0103          IF(DIFLON.GT.180.) DIFLON=DIFLON-360.
0104          IF(DIFLON.LT.-180.) DIFLON=DIFLON+360.
0105          AVGLON=ALON(I1)+0.5*DIFLON
0106          XSQ=(2.*RAD*AVGLAT)**2
0107          XFAC=1.-.16627142*XSQ+.00807934*XSQ*XSQ-.000151880*XSQ*XSQ*XSQ
0108          ALAT(ICEL)=AVGLAT*(1.+0.125*(RAD*DIFLON)**2*XFAC)
0109          X=RAD*(90.-ABS(AVGLAT))
0110          TANLAT=1./(X*X*X/X/3.)
0111          IF(AVGLAT.LT.0.) TANLAT=-TANLAT
0112          ALON(ICEL)=AVGLON-0.2500*RAD*DIFLAT*DIFLON*TANLAT
0113          IF(ALON(ICEL).LT.0.) ALON(ICEL)=ALON(ICEL)+360.
0114          IF(ALON(ICEL).GE.360.) ALON(ICEL)=ALON(ICEL)-360.

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FDLTN

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0115      200 CONTINUE
0116
0117      IF(ISCAN.NE.2) RETURN
0118
0119      C*****
0120      C  SET TABLE LAT/LON FOR B-SCAN
0121      C*****
0122
0123      IBLT=IBYT
0124      IBLN=IBYT+38
0125      IBZD=IBYT+76
0126
0127      C*****
0128      C  NOTE THAT IDEL AND BLAT CHARS ARE READ AS SIGNED 2-BYTE INTEGERS
0129      C*****
0130
0131      DO 300 JCEL=1,19
0132      ICEL=INDEX(JCEL)
0133      IDEL=INT24S(KBT,LREC(IBZD),LREC(IBZD+1))
0134      LATDEL=(IDEL+30000)/1000-30
0135      LONDEL=IDEL+29100-1000*(LATDEL+30)
0136      BLAT(ICEL)=.01*(INT24S(KBT,LREC(IBLT),LREC(IBLT+1))
0137      +LATDEL-9000)
0138      BLON(ICEL)=.01*(INT24(KBT,LREC(IBLN),LREC(IBLN+1))+LONDEL)
0139      IF(BLON(ICEL).LT.0.) BLON(ICEL)=BLON(ICEL)+360.
0140      IF(BLON(ICEL).GE.360.) BLON(ICEL)=BLON(ICEL)-360.
0141      IBLT=IBLT+2
0142      IBLN=IBLN+2
0143      IBZD=IBZD+2
0144
0145      300 CONTINUE
0146
0147      IBYT=IBZD
0148
0149      C*****
0150      C  SET MID-POINTS FOR B-SCAN
0151      C*****
0152
0153      DO 400 JCEL=1,109
0154      ICEL=JINDEX(1,JCEL)
0155      I1=JINDEX(2,JCEL)
0156      I2=JINDEX(3,JCEL)
0157      DIFLAT=BLAT(I2)-BLAT(I1)
0158      AVGLAT=0.5*(BLAT(I1)+BLAT(I2))
0159      DIFLON=BLON(I2)-BLON(I1)
0160      IF(DIFLON.GT.180.) DIFLON=DIFLON-360.
0161      IF(DIFLON.LT.-180.) DIFLON=DIFLON+360.
0162      AVGLON=BLON(I1)+0.5*DIFLON
0163      XPAC=1.-.16627142*XSQ+.00807934*XSQ*XSQ-.000151880*XSQ*XSQ*XSQ
0164      BLAT(ICEL)=AVGLAT*(1.+0.125*(RAD*DIFLON)).*2*XPAC
0165      X=RAD*(90.-ABS(AVGLAT))
0166      TANLAT=1./(X*X*X/3.)
0167      IF(AVGLAT.LT.0.) TANLAT=-TANLAT
0168      BLON(ICEL)=AVGLON-0.2500*RAD*DIFLAT*DIFLON*TANLAT
0169      IF(BLON(ICEL).LT.0.) BLON(ICEL)=BLON(ICEL)+360.
0170      IF(BLON(ICEL).GE.360.) BLON(ICEL)=BLON(ICEL)-360.
0171
0172      400 CONTINUE

```

0172 RETURN
 0173 END

PROGRAM SECTIONS

Name	Bytes	Attributes
0 \$CODE	1490	PIC CON REL LCL SHR EXE RD NOWRT QUAD
2 \$LOCAL	1628	PIC CON REL LCL NOSHR NOEXE RD WRT QUAD
3 \$INDATA	1796	PIC OVR REL GBL SHR NOEXE RD WRT QUAD
4 \$OUTDAT	7156	PIC OVR REL GBL SHR NOEXE RD WRT QUAD
Total Space Allocated	12070	

ENTRY POINTS

Address	Type	Name
0-00000000		FOLTLN

VARIABLES

Address	Type	Name	Address	Type	Name
4-00000018	R*4	ALATSC	2-00000594	R*4	AVGLAT
2-00000588	R*4	DIFLON	4-00000034	R*4	FRTEMP
2-0000058C	I*4	IBLN	2-00000568	I*4	IBLT
2-0000057C	I*4	ICEL	2-00000580	I*4	IDEL
4-000001F0	I*4	ISPAR1	4-00000008	I*4	ITIME
3-000006F8	I*4	KBT	2-00000584	I*4	LATDEL
2-00000574	R*4	RAD	4-00000000	R*8	REV
2-00000528	R*4	X	2-000005A4	R*4	XFAC
2-000005A0	R*4	XSQ			
			2-0000059C	R*4	AVGLON
			2-00000588	I*4	IL
			3-000006FC	I*4	IBYT
			3-00000700	I*4	IFLAG
			4-0000000C	I*4	ITMNC
			2-00000588	I*4	LONDEL
			4-00000030	R*4	RFTMP
			4-00000010	R*4	XLATSC
			2-00000590	R*4	DIFLAT
			2-0000058C	I*4	I2
			2-00000579	I*4	IB2D
			AP-00000004e	I*4	ISCAN
			2-00000578	I*4	JCEL
			2-00000580	I*4	NCEL
			2-000005AC	R*4	TANLAT
			4-00000014	R*4	XLONSC

ARRAYS

Address	Type	Name	Bytes	Dimensions
4-000001F4	R*4	ALAT	512	(128)
4-000003F4	R*4	ALON	512	(128)
4-000005F4	R*4	BLAT	512	(128)
4-000007F4	R*4	BLON	512	(128)
4-0000006C	R*4	CALOFF	28	(7)
4-00000050	R*4	CALSPL	28	(7)
4-0000001C	R*4	HTEMP	12	(3)
4-00000038	I*4	IACC	24	(6)
4-00000088	I*4	ICOLDA	140	(5, 7)
4-000001A0	I*4	ICOLDB	40	(5, 2)
4-00000114	I*4	IHOTA	140	(5, 7)
4-000001C8	I*4	IHOTB	40	(5, 2)
2-00000000	I*4	INDEX	76	(19)

3-Dec-1990 09:39:57
19-Apr-1990 15:25:14

4-00001AF4	I*4	ISPAR2	256	(64)
4-000015F4	I*4	ITAIL	1024	(4, 64)
4-00000028	I*4	IVOLT	8	(2)
2-00000034C	I*4	JNDEX	1308	(3, 109)
3-000000000	CHAR	LREC	1784	(1784)
4-000000EF4	R*4	TAHI	2048	(8, 64)
4-0000009F4	R*4	TALO	1280	(5, 64)

LABELS

Address	Label	Address	Label	Address	Label
0-000000EA	100	0-000002B4	200	0-00000410	300
				0-000005C6	400

FUNCTIONS AND SUBROUTINES REFERENCED

Type	Name	Type	Name
I*4	INT24	I*4	INT24S

3-Dec-1990 09:39:57
19-Apr-1990 15:25:14

VAX FORTRAN V5.5-98
(BELFIORE.SSMI.SRC.RDSSMI)FDTLN.FOR;1

Page 6

0001 C.....
0002
0003

COMMAND QUALIFIERS

FORTRAN/NOOPT/DEBUG/LIST/NO:DJ FDTLN
/CHECK=(NOBOUNDS,OVERFLOW,NUMBERFLOW)
/DEBUG=(SYMBOLS,TRACEBACK)
/DESIGN=(NOCOMMENTS,NOPLACEHOLDERS)
/SHOW=(NODICTIONARY,NOINCLUDE,MAP,NOPREPROCESSOR,SINGLE)
/STANDARD=(NOSEMANANTIC,NOSOURCE_FORM,NOSYNTAX)
/WARNINGS=(NODECLARATIONS,GENERAL,NOUTRIX,NOVAXELN)
/CONTINUATIONS=19 /NOCROSS_REFERENCE /NOD_LINES /NOEXTEND_SOURCE
/F77 /NOG_FLOATING /I4 /NONACHINE_CODE /NOOPTIMIZE /NOPARALLEL
/NOANALYSIS DATA
/NODIAGNOSTICS
/LIST=USER\$DISK_26:(BELFIORE.SSMI.SRC.RDSSMI)FDTLN.LIS;1
/NOOBJECT

COMPILATION STATISTICS

Run Time:	2.01 seconds
Elapsed Time:	2.72 seconds
Page Faults:	638
Dynamic Memory:	476 pages

3-Dec-1990 09:40:20
19-Apr-1990 15:26:35

```

0001 SUBROUTINE FDTA(ISCAN)
0002
0003 C*****
0004 C ISCAN=1 ==> DOES TA'S FOR A-SCAN, ODD-NUMBERED PIXELS ONLY.
0005 C CHANNELS FOR THESE PIXELS ARE 19, 22, 37, AND 85GHZ
0006 C ISCAN=2 ==> DOES ALL OF ISCAN=1 PLUS 85GHZ TA'S FOR ALL OTHER A-SCAN
0007 C AND B-SCAN PIXELS
0008 C*****
0009
0010 INTEGER*4 IWORK4, IBL, IBH, ISCAN
0011
0012 C*****
0013 C SPECIFY COMMON /INDATA/
0014 C*****
0015
0016 CHARACTER*1 LREC(1784)
0017 INTEGER*4 KBT, IBYT, IFLAG
0018 COMMON/INDATA/LREC, KBT, IBYT, IFLAG
0019
0020 C*****
0021 C SPECIFY COMMON /OUTDAT/
0022 C*****
0023
0024 REAL*8 REV
0025 INTEGER*4 ITIME, ITIMSC, IVOLT, IAGC, ICOLDA, IHOTA, ICOLDB, IHOTB, ISPAR1
0026 INTEGER*4 ITOIL, ISPAR2
0027 REAL*4 XLATSC, XLONSC, ALTSC, HLTEMP, RFTEMP, FRTEMP, CALSLP, CALOFF
0028 REAL*4 ALAT, ALON, SLAT, BLON, TALO, TAHI
0029
0030 COMMON/OUTDAT/ REV, ITIME, ITIMSC, XLATSC, XLONSC, ALTSC,
0031 1 HLTEMP(3), IVOLT(2), RFTEMP, FRTEMP, IAGC(6), CALSLP(7), CALOFF(7),
0032 2 ICOLDA(5,7), IHOTA(5,7), ICOLDB(5,2), IHOTB(5,2), ISPAR1,
0033 3 ALAT(128), ALON(128), SLAT(128), BLON(128),
0034 4 TALO(5,64), TAHI(8,64), ITOIL(4,64), ISPAR2(64)
0035
0036 C*****
0037 C BEGIN EXECUTION
0038 C*****
0039
0040 I3YT = 377
0041 IBL = IBYT
0042 IBH = IBYT+640
0043
0044 DO 100 ICEL=1,64
0045
0046 C*****
0047 C FIND THE TA'S FOR THE 3 LOWER FREQUENCIES
0048 C*****
0049
0050 DO 50 ICH=1,5,2
0051 IWORK4=INT34(KBT,LREC(IBL),LREC(IBL+1),LREC(IBL+2))
0052 IBL = IBL+3
0053 ITAV=INT(IWORK4/4096)
0054 TALO(ICH,ICEL)=0.1*ITAV
0055 IF(ITAV.GT.3800) TALO(ICH,ICEL)=ITAV-3420
0056 ITAH=IWORK4-4096*ITAV
0057 IF(ICH.EQ.5) GO TO 60

```

```

FDTA
0038      TALO(ICH+1,ICEL)=0.*ITAH
0039      IF(ITAH.GT.3800) T=2*(ICH+1,ICEL)=ITAH-3420
0040      CONTINUE
0041      SO
0042      CONTINUE
0043      4SPAR2(ICEL)=INT14(KBT,LREC(IBL))
0044      IBL = IBL+1
0045      C*****
0046      C FIND THE TOIL FLAGS *
0047      C*****
0048      ITOIL1=INT(ITAH/512)
0049      IRES=ITAH-ITOIL1*512
0050      ITOIL2=IRES/64
0051      IRES=IRES-ITOIL2*64
0052      ITOIL3=IRES/8
0053      IRES=IRES-ITOIL3*8
0054      ITOIL4=IRES-ITOIL3*8
0055      ITOIL(1,ICEL)=ITOIL1
0056      ITOIL(2,ICEL)=ITOIL2
0057      ITOIL(3,ICEL)=ITOIL3
0058      ITOIL(4,ICEL)=ITOIL4
0059      C*****
0060      C FIND $5 GHZ TA'S FOR ODD # PIXELS IN THE A-SCAN *
0061      C*****
0062      ICH = 1
0063      IWORK4=INT14(KBT,LREC(IBH),LREC(IBH+1),LREC(IBH+2))
0064      IBH = ISH+12
0065      ITAV=INT(IWORK4/4096)
0066      TAHI(ICH,ICEL)=0.1*ITAV
0067      IF(ITAV.GT.3800) TAHI(ICH,ICEL)=ITAV-3420
0068      ITAH=IWORK4-4096*ITAV
0069      TAHI(ICH+1,ICEL)=0.1*ITAH
0070      IF(ITAH.GT.3800) TAHI(ICH+1,ICEL)=ITAH-3420
0071      100 CONTINUE
0072      IF(ISCAN .NE. 2)RETURN
0073      IBH=IBYT+640
0074      C*****
0075      C FIND THE 85GHZ TA'S FOR ALL OTHER PIXELS *
0076      C*****
0077      DO 200 ICEL=1,64
0078      IBH=IBH+3
0079      DO 150 ICH=3,7,2
0080      IWORK4=INT14(KBT,LREC(IBH),LREC(IBH+1),LREC(IBH+2))
0081      IBH = IBH+3
0082      ITAV=INT(IWORK4/4096)
0083      TAHI(ICH,ICEL)=0.1*ITAV
0084      IF(ITAV.GT.3800) TAHI(ICH,ICEL)=ITAV-3420
0085      ITAH=IWORK4-4096*ITAV
0086      TAHI(ICH+1,ICEL)=0.1*ITAH
0087      IF(ITAH.GT.3800) TAHI(ICH+1,ICEL)=ITAH-3420
0088      150 CONTINUE
0089      200 CONTINUE
0090      IF(ITAH.GT.3800) TAHI(ICH+1,ICEL)=ITAH-3420
0091      IF(ITAH.GT.3800) TAHI(ICH+1,ICEL)=ITAH-3420
0092      IF(ITAH.GT.3800) TAHI(ICH+1,ICEL)=ITAH-3420
0093      IF(ITAH.GT.3800) TAHI(ICH+1,ICEL)=ITAH-3420
0094      IF(ITAH.GT.3800) TAHI(ICH+1,ICEL)=ITAH-3420
0095      IF(ITAH.GT.3800) TAHI(ICH+1,ICEL)=ITAH-3420
0096      IF(ITAH.GT.3800) TAHI(ICH+1,ICEL)=ITAH-3420
0097      IF(ITAH.GT.3800) TAHI(ICH+1,ICEL)=ITAH-3420
0098      IF(ITAH.GT.3800) TAHI(ICH+1,ICEL)=ITAH-3420
0099      IF(ITAH.GT.3800) TAHI(ICH+1,ICEL)=ITAH-3420
0100      IF(ITAH.GT.3800) TAHI(ICH+1,ICEL)=ITAH-3420
0101      IF(ITAH.GT.3800) TAHI(ICH+1,ICEL)=ITAH-3420
0102      IF(ITAH.GT.3800) TAHI(ICH+1,ICEL)=ITAH-3420
0103      IF(ITAH.GT.3800) TAHI(ICH+1,ICEL)=ITAH-3420
0104      IF(ITAH.GT.3800) TAHI(ICH+1,ICEL)=ITAH-3420
0105      IF(ITAH.GT.3800) TAHI(ICH+1,ICEL)=ITAH-3420
0106      IF(ITAH.GT.3800) TAHI(ICH+1,ICEL)=ITAH-3420
0107      IF(ITAH.GT.3800) TAHI(ICH+1,ICEL)=ITAH-3420
0108      IF(ITAH.GT.3800) TAHI(ICH+1,ICEL)=ITAH-3420
0109      IF(ITAH.GT.3800) TAHI(ICH+1,ICEL)=ITAH-3420
0110      IF(ITAH.GT.3800) TAHI(ICH+1,ICEL)=ITAH-3420
0111      IF(ITAH.GT.3800) TAHI(ICH+1,ICEL)=ITAH-3420
0112      IF(ITAH.GT.3800) TAHI(ICH+1,ICEL)=ITAH-3420
0113      IF(ITAH.GT.3800) TAHI(ICH+1,ICEL)=ITAH-3420
0114      IF(ITAH.GT.3800) TAHI(ICH+1,ICEL)=ITAH-3420
    
```

FDTA

```

0115      150      CONTINUE
0116      200      CONTINUE
0117      RETURN
0118      END
    
```

PROGRAM SECTIONS

Name	Bytes	Attributes
0 \$CODE	872	PIC CON REL LCL SHR EXE RD NOWRT QUAD
2 \$LOCAL	200	PIC CON REL LCL NOSHR NOEXE RD WRT QUAD
3 \$INDATA	1796	PIC OVR REL GBL SHR NOEXE RD WRT QUAD
4 \$OUTDAT	7156	PIC OVR REL GBL SHR NOEXE RD WRT QUAD
Total Space Allocated	10024	

ENTRY POINTS

Address	Type	Name
0-00000000		FDTA

VARIABLES

Address	Type	Name	Address	Type	Name
4-00000018	R*4	ALTSC	2-00000004	I*4	IBL
3-000000FC	I*4	IBYT	3-00000700	I*4	IFLAG
2-00000020	I*4	IRES	2-00000018	I*4	ITAH
2-00000014	I*4	ITAV	2-0000001C	I*4	ITOIL1
2-00000024	I*4	ITOIL2	2-00000000	I*4	IWORK4
3-0000006F8	I*4	KBT	4-00000010	R*4	XLATSC
4-00000014	R*4	XLONSC			

ARRAYS

Address	Type	Name	Bytes	Dimensions
4-000001F4	R*4	ALAT	512	(128)
4-000003F4	R*4	ALON	512	(128)
4-000005F4	R*4	BLAT	512	(128)
4-000007F4	R*4	BLON	512	(128)
4-0000006C	R*4	CALOFF	28	(7)
4-00000050	R*4	CALSFP	28	(7)
4-0000001C	R*4	HLTEMP	12	(3)
4-00000038	I*4	IAGC	24	(6)
4-00000088	I*4	ICOLDA	140	(5, 7)
4-000001A0	I*4	ICOLDB	40	(5, 2)
4-00000114	I*4	IHOTA	140	(5, 7)
4-000001C8	I*4	IHOTB	40	(5, 2)
4-00001AF4	I*4	ISPAR2	256	(64)

4-000016F4	I*4	ITOIL	1024	(4, 64)
4-00000028	I*4	IVOLT	8	(2)
3-00000000	CHAR	LREC	1784	(1784)
4-000000F4	R*4	TAHI	2048	(8, 64)
4-000009F4	R*4	TALO	1280	(5, 64)

LABELS

Address	Label	Address	Label	Address	Label	Address	Label
0-C00C00FA	50	0-00000101	60	0-00000261	100	0-00000355	150
						0-0000035C	200

FUNCTIONS AND SUBROUTINES REFERENCED

Type	Name	Type	Name
I*4	INT14	I*4	INT34

0001 C*****

0002

0003

COMMAND QUALIFIERS

FORTAN/NOOPT/DEBUG/LIST/NOOBJ FDTA

```

/CHECK=(NOBOUNDS,OVERFLOW,NOUNDERFLOW)
/DEBUG=(SYMBOLS,TRACERACK)
/DESIGN=(NOCOMMENTS,NOPLACEHOLDERS)
/SHOW=(NODICTIONARY,NOINCLUDE,MAP,NOPREPROCESSOR,SINGLE)
/STANDARD=(NOSEMANANTIC,NOSOURCE FORM,NOSYNTAX)
/WARNINGS=(NODECLARATIONS,GENERAL,NOULTRIX,NOVAXELN)
/CONTINUATIONS=19 /NOCROSS_REFERENCE /NOD_LINES /NOEXTEND_SOURCE
/F77 /NOG_FLOATING /I4 /NOMACHINE_CODE /NOOPTIMIZE /NOPARALLEL
/NOANALYSIS DATA
/NO DIAGNOSTICS
/LIST=USER$DISK_26:[BELFIORE.SSMI.SRC.RDSSMI]FDTA.LIS;1
/NOOBJECT

```

COMPILATION STATISTICS

```

Run Time:      1.20 seconds
Elapsed Time:  1.87 seconds
Page Faults:   555
Dynamic Memory: 396 pages

```

```

0001      subroutine geobox (lat, lon, dplc, box)
0002
0003      C.....
0004      C Subroutine GEOBOX defines the 'corners' of a box on the earth's
0005      C surface given its center, and an arbitrary surface displacement
0006      C from said center. The boundary values of this box are stored in
0007      C an array for later use.
0008      C.....
0009
0010      real lat, lon, dplc, box(4), rad2deg
0011      real e_rad, dplc_angle
0012
0013      C.....
0014      C Earth Radius (polar orbit: kilometers) *
0015      C.....
0016      e_rad = 6356.913
0017
0018      C.....
0019      C Compute (infer) the 'corners' of a box with the given lat/lon
0020      C coordinates as its center. Return the min/max latitude and
0021      C longitudes in the 4-element 1-D array "box()", the contents of
0022      C which are:
0023      C   box(1) = minimum latitude
0024      C   box(2) = maximum latitude
0025      C   box(3) = minimum longitude
0026      C   box(4) = maximum longitude
0027      C.....
0028      rad2deg = 180.0 / 3.14159265
0029      dplc_angle = asin(dplc/e_rad) * rad2deg
0030      box(1) = lat - dplc_angle
0031      box(2) = lat + dplc_angle
0032      box(3) = lon - dplc_angle
0033      box(4) = lon + dplc_angle
0034
0035      return
0036      end

```

PROGRAM SECTIONS

Name	Bytes	Attributes
0 \$CODE	97	PIC CON REL LCL SHR EXE RD NOWRT QUAD
2 \$LOCAL	44	PIC CON REL LCL NOSHR NOEXE RD WRT QUAD
Total Space Allocated	141	

ENTRY POINTS

Address	Type	Name
0-00000000		GEOBOX

VARIABLES

Address	Type	Name	Address	Type	Name
AP-00000000	R*4	DPLC	2-00000008	R*4	DPLC_ANGLE
AP-00000000	R*4	LOX	2-00000000	R*4	RAD2DEG
			2-00000004	R*4	E_RAD
			AP-00000004	R*4	LAT

ARRAYS

Address	Type	Name	Bytes	Dimensions
AP-00000010	R*4	BOX	16	(4)

FUNCTIONS AND SUBROUTINES REFERENCED

Type	Name
R*4	WTH\$ASIN

COMMAND QUALIFIERS

```

FORTRAN,NOOPT/DEBUG/LIST/NOOBJ GEOBOX
/CHECK=(NOSOUNDS,OVERFLOW,NOUNDERFLOW)
/DEBUG=(SYMBOLS,TRACEBACK)
/DESIGN=(NOCOMMENTS,NOPLACEHOLDERS)
/SHOW=(NODICTIONARY,NINCLUDE,MAP,NOPREPROCESSOR,SINGLE)
/STANDARD=(NOSEMANANTIC,NOSOURCE FORM,NOSYNTEX)
/WARNINGS=(NODECLARATIONS,GENERAL,NOULTRIX,NOVAXELN)
/CONTINUATIONS=19 /NOCROSS_REFERENCE /NOD_LINES /NOEXTEND_SOURCE
/F77 /NOG_FLOATING /14 /NOMACHINE_CODE /NOOPTIMIZE /NOPARALLEL
/NOANALYSIS DATA
/NO DIAGNOSTICS
/LIST=USERS$DISK_26:[BELFIORE.SSMI.SRC.RDSSMI]GEOBOX.LIS:1
/NOOBJECT
  
```

GEOBOX
01

COMPILATION STATISTICS

Run Time: 0.34 seconds
Elapsed Time: 0.83 seconds
Page Faults: 448
Dynamic Memory: 332 pages

3-Dec-1990 09:40:33
19-Apr-1990 12:44:23

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[BELFIORE.SMI.SRC.RDSSMI]GEOBOX.FOR;1 Page 3

```

0001 SUBROUTINE GTLAT(GTL)
0002
0003 C*****
0004 C CALCULATES LATITUDE OF GROUND TRACK POINT FROM REGRESSION *
0005 C ON SCAN PIXELS 3,63 AND 125 (IE. 2,32,63 IN 64 PIX SCAN) *
0006 C*****
0007
0008 REAL CF(4)
0009
0010 C*****
0011 C SPECIFY COMMON /OUTDAT/ *
0012 C*****
0013
0014 REAL*8 REV
0015 INTEGER*4 ITIME,ITIMSC,IVOLT,IAGC,ICOLDA,IHOTA,ICOLDB,IHOTB,ISPAR1
0016 INTEGER*4 ITOIL,ISPAR2
0017 REAL*4 XLATSC,XLONSC,ALTSC,HLTEMP,RTTEMP,FRTEMP,CALSLP,CALOFF
0018 REAL*4 ALAT,ALON,BLAT,BLON,TALO,TAHI
0019
0020 COMMON/OUTDAT/ REV,ITIME,ITIMSC,XLATSC,XLONSC,ALTSC,
0021 1 HLTEMP(3),IVOLT(2),RTTEMP,FRTEMP,IAGC(6),CALSLP(7),CALOFF(7),
0022 2 ICOLDA(5,7),IHOTA(5,7),ICOLDB(5,2),IHOTB(5,2),ISPAR1,
0023 3 ALAT(128),ALON(128),BLAT(128),BLON(128),
0024 4 TALO(5,64),TAHI(8,64),ITOIL(4,64),ISPAR2(64)
0025
0026 DATA CF/-0.129,1.533,-1.928,1.411/
0027
0028 GTL = CF(1)+CF(2)*ALAT(3)+CF(3)*ALAT(63)+CF(4)*ALAT(125)
0029 RETURN
0030 END

```

GTLAT
 01

PROGRAM SECTIONS

Name	Bytes	Attributes
0 \$CODE	49	FIC CON REL LCL SHR EXE RD NOWRT QUAD
2 \$LOCAL	16	FIC CON REL LCL NOSHR NOEXE RD WRT QUAD
3 OUTDAT	7156	PIC OVR REL GBL SHR NOEXE RD WRT QUAD
TOTAL Space Allocated	7221	

ENTRY POINTS

Address	Type	Name
0-00000000		GTLAT

VARIABLES

Address	Type	Name
3-00000018	R*4	ALTSC
3-00000008	I*4	ITIME
3-00000010	R*4	XLATSC

ARRAYS

Address	Type	Name	Bytes	Dimensions
3-00000014	R*4	ALAT	512	(128)
3-00000034	R*4	ALON	512	(128)
3-00000054	R*4	BLAT	512	(128)
3-00000074	R*4	BLON	512	(128)
3-0000006C	R*4	CALOFF	28	(7)
3-00000050	R*4	CALSIC	28	(7)
2-00000000	R*4	CF	16	(4)
3-0000001C	R*4	HLTEMP	12	(3)
3-00000038	I*4	IAGC	24	(6)
3-00000080	I*4	ICOLDA	140	(5, 7)
3-000001A0	I*4	ICOLDB	40	(5, 2)
3-00000114	I*4	IHTA	140	(5, 7)
3-000001C8	I*4	IHTB	40	(5, 2)
3-00001AF4	I*4	ISPAR2	256	(64)
3-000016F4	I*4	ITAIL	1024	(4, 64)
3-00000028	I*4	IVOLT	8	(2)
3-000000EF4	R*4	TAHI	2048	(8, 54)
3-0000009F4	R*4	TALO	1280	(5, 64)

Address	Type	Name
3-0000001F0	I*4	ISPAR1
3-000000030	R*4	RFTMP

Address	Type	Name
AP-000000040	R*4	GTL
3-000000000	R*8	REV

3-DEC-1990 09:40:49
19-APR-1990 15:21:28

0001 C.....
0002
0003

COMMAND QUALIFIERS

```

FORTRAN/NOOPT/DEBUG/LIST/NOOBJ GTLAT
/CHECK=(NOBOUNDS,OVERFLOW,NOUNDERFLOW)
/DEBUG=(SYMBOLS,TRACEBACK)
/DESIGN=(NOCOMMENTS,NOPLACEHOLDERS)
/SHOW=(MODIFICATION,NINCLUDE,MAP,NOPREPROCESSOR,SINGLE)
/STANDARD=(NOSEMANTIC,NOSOURCE FORM,NOSYNTAX)
/WARNINGS=(NODECLARATIONS,GENERAL,NOULTRIX,NOVAXELN)
/CONTINUATIONS=19 /NOCROSS REFERENCE /MOD LINES /NOEXTEND SOURCE
/F77 /NOG FLOATING /I4 /NOMACHINE_CODE /NOOPTIMIZE /NOPARALLEL
/NOANALYSIS DATA
/NO DIAGNOSTICS
/LIST=USER$DISK_26:[BELFIORE.SSMI.SRC.RDSSMI]GTLAT.LIS:1
/NOOBJECT

```

COMPILATION STATISTICS

Run Time:	0.39 seconds
Elapsed Time:	0.83 seconds
Page Faults:	425
Dynamic Memory:	200 pages

3-Dec-1990 09:41:05
19-Apr-1990 15:29:11

VAX FORTRAN V5.5-98
[BELFIORE.SSHI.SRC.RDSSMI]INTFUNC.FOR;1

Page 1

```

0001 FUNCTION INT24(KBT,BYT1,BYT2)
0002
0003
0004 C *****
0005 C THIS ROUTINE CONVERTS A 2-BYTE ARRAY INTO A 4-BYTE POSITIVE INTEGER
0006 C *** USE FUNCTION INT24S IF DECODING A 2-BYTE SIGNED INTEGER ***
0007 C KBT=1 ==> VAX, KBT=2 ==> IBM OR HP
0008 C *****
0009
0010 INTEGER*4 NUM,KBT
0011 INTEGER*2 ISWP(2,2)
0012 CHARACTER*1 BAR(4),BYT1,BYT2
0013 EQUIVALENCE (BAR(1),NUM)
0014 DATA ISWP/2,1,3,4/
0015 NUM = 0
0016 BAR(ISWP(1,KBT)) = BYT1
0017 BAR(ISWP(2,KBT)) = BYT2
0018 INT24 = NUM
0019 RETURN
0020 END

```

PROGRAM SECTIONS

Name	Bytes	Attributes
0 \$CODE	70	PIC CON REL LCL SHR EXE RD NOWRT QUAD
2 \$LOCAL	32	PIC CON REL LCL NOSHR NOEXE RD WRT QUAD
Total Space Allocated	102	

ENTRY POINTS

Address	Type	Name
0-00000000	I*4	INT24

VARIABLES

Address	Type	Name	Address	Type	Name
AP-00000008	CHAR	BYT1	AP-00000004	I*4	KBT
			AP-00000000	I*4	NUM

ARRAYS

Address	Type	Name	Bytes	Dimensions
2-00000000	CHAR	BAR	4	(4)
2-00000004	I*2	ISWP	8	(2, 2)

```

0001 C*****
0002
0003
0004
0005
0006
0007
0008 FUNCTION INT24S(KBT,BYT1,BYT2)
0009
0010 C *****
0011 C THIS ROUTINE CONVERTS A 2-BYTE ARRAY INTO A 4-BYTE INTEGER
0012 C KBT=1 ==> VAX, KBT=2 ==> IBM OR HP
0013 C *** THIS PROGRAM WILL WORK IF THE 2-BYTE ARRAY IS INTENDED TO
0014 C *** REPRESENT A SIGNED 2-BYTE INTEGER.
0015 C *** NOTE THAT WE CANNOT DIRECTLY PUT THE BYTES INTO A 4-BYTE INTEGER
0016 C *** BUFFER OTHERWISE WE WILL NOT RECOVER THE SIGN BIT.
0017 C *****
0018
0019 INTEGER*4 KBT
0020 INTEGER*2 ISWP(2,2),NUM
0021 CHARACTER*1 BAR(2),BYT1,BYT2
0022 EQUIVALENCE (BAR(1),NUM)
0023 DATA ISWP/2,1,1,2/
0024 BAR(ISWP(1,KBT)) = BYT1
0025 BAR(ISWP(2,KBT)) = BYT2
0026 INT24S = NUM
0027 RETURN
0028 END

```

PROGRAM SECTIONS

Name	Bytes	Attributes
0 \$CODE	67	PIC CON REL LCL SHR EXE RD NOWRT QUAD
2 \$LOCAL	32	PIC CON REL LCL NOSHR NOEXE RD WRT QUAD
Total Space Allocated	99	

ENTRY POINTS

Address	Type	Name
0-00000070	1*4	INT24S

VARIABLES

Address	Type	Name
AP-000000080	CHAR	BYT1
AP-0000000C0	CHAR	BYT2
AP-000000040	1*4	KBT
2-000000000	1*2	NUM

INT74S
 01

ARRAYS

Address	Type	Name	Bytes	Dimensions
2-00000000	CHAR	BAR	2	(2)
2-00000002	I*2	ISNP	8	(2, 2)

```

0001 C *****
0002
0003
0004
0005
0006
0007
0008
0009 C THIS ROUTINE CONVERTS A 4-BYTE ARRAY INTO A 4-BYTE INTEGER
0010 C KBT=1 ==> VAX, KBT=2 ==> IBM OR HP
0011 C *** THIS PROGRAM WILL WORK IF THE 4-BYTE ARRAY IS INTENDED ***
0012 C *** TO REPRESENT A NEGATIVE INTEGER. (I.E. SIGN BIT USED) ***
0013 C *****
0014
0015
0016
0017
0018
0019
0020
0021
0022
0023
0024
0025
    
```

```

      FUNCTION INT4(KBT,BYT1,BYT2,BYT3,BYT4)
      *****
      C THIS ROUTINE CONVERTS A 4-BYTE ARRAY INTO A 4-BYTE INTEGER
      C KBT=1 ==> VAX, KBT=2 ==> IBM OR HP
      C *** THIS PROGRAM WILL WORK IF THE 4-BYTE ARRAY IS INTENDED ***
      C *** TO REPRESENT A NEGATIVE INTEGER. (I.E. SIGN BIT USED) ***
      C *****
      INTEGER*4 NUM,KBT
      INTEGER*2 ISWP(4,2)
      CHARACTER*1 BAR(4),BYT1,BYT2,BYT3,BYT4
      EQUIVALENCE (BAR(1),NUM)
      DATA ISWP/4,3,2,1,1,2,3,4/
      NUM = 0
      BAR(1)SWP(1,KBT)) = BYT1
      BAR(1)SWP(2,KBT)) = BYT2
      BAR(1)SWP(3,KBT)) = BYT3
      BAR(1)SWP(4,KBT)) = BYT4
      INT4 = NUM
      RETURN
      END
    
```

PROGRAM SECTIONS

Name	Bytes	Attributes
0 \$CODE	118	PIC CON REL LCL SHR EXE RD NOWRT QUAD
2 \$LOCAL	56	PIC CON REL LCL MOSHR NOEXE RD WRT QUAD
Total Space Allocated	174	

ENTRY POINTS

Address	Type	Name
0-00000000	I=4	INT44

VARIABLES

Address	Type	Name	Address	Type	Name
AP-00000000	CHAR	BYT1	AP-00000000	CHAR	BYT2
AP-00000000	I=4	KBT	AP-00000000	CHAR	BYT3
			AP-00000000	CHAR	BYT4

ARRAYS

Address	Type	Name	Bytes	Dimensions
2-000000000	CHAR	BAR	4	(4)
2-000000004	I*2	ISWP	16	(4, 2)

```

0001 C*****
0002
0003
0004
0005
0006
0007 FUNCTION INT34(KBT,BYT1,BYT2,BYT3)
0008
0009 C THIS ROUTINE CONVERTS A 3-BYTE ARRAY INTO A 4-BYTE POSITIVE INTEGER
0010 C KBT=1 ==> VAX, KBT=2 ==> IBM OR HP
0011 C *** THIS PROGRAM WILL PRODUCE ONLY POSITIVE INTEGER OUTPUTS ***
0012 C*****
0013
0014
0015
0016
0017
0018
0019
0020
0021
0022
0023
  
```

PROGRAM SECTIONS

Name	Bytes	Attributes
0 \$CODE	94	PIC CON REL LCL SHR EXE RD NOWRT QUAD
2 \$LOCAL	44	PIC CON REL LCL NOSHR NOEXE RD WRT QUAD
Total Space Allocated	138	

ENTRY POINTS

Address	Type	Name
0-00000000	I*4	INT34

VARIABLES

Address	Type	Name	Address	Type	Name
AP-00000008	CHAR	BYT1	AP-00000010	CHAR	BYT2
2-00000000	I*4	NUM	AP-00000004	I*4	KBT

INT34
01

ARRAYS

Address	Type	Name	Bytes	Dimensions
2-00000000	CHAR	BAR	4	(4)
2-00000004	I*2	ISWP	12	(3, 2)

1-DEC-1990 09:41:05
19-APR-1990 15:29:11

VAX FORTRAN V5.5-98
[BELFIORE.SSMI.SRC.ROSSMI]INTFUNC.FOR.1

7

```

0001 C*****
0002
0003
0004
0005 FUNCTION INT14(KBT,BYT1)
0006
0007 C*****
0008 C THIS ROUTINE CONVERTS A 1-BYTE ARRAY INTO A 4-BYTE POSITIVE INTEGER *****
0009 C KBT=1 ==> VAX, KBT=2 ==> IBM OR HP *****
0010 C *** THIS PROGRAM WILL PRODUCE ONLY POSITIVE INTEGER OUTPUTS *****
0011 C*****
0012
0013 INTEGER*4 NUM,KBT
0014 INTEGER*2 ISWP(2)
0015 CHARACTER*1 BAR(4),BYT1
0016 EQUIVALENCE (BAR(1),NUM)
0017 DATA ISWP/1,4/
0018 NUM = 0
0019 BAR(ISWP(KBT)) = BYT1
0020 INT14 = NUM
0021 RETURN
0022 END

```

PROGRAM SECTIONS

Name	Bytes	Attributes						
0 \$CODE	45	PIC CON REL	LCL	SHR	EXE		RD	NO'VRT QUAD
2 \$LOCAL	20	PIC CON REL	LCL	NOSHR	NOEXE		RD	WRT QUAD
Total Space Allocated	65							

ENTRY POINTS

Address	Type	Name
00000000	I+I	INT14

VARIABLES

Address	Type	Name	Address	Type	Name
AP-00000009	CHAR	BYT1	AP-00000004	I*4	KBT
			2-00000000	I*4	KUH

ARRAYS

Address	Type	Name	Bytes	Dimensions
00000000	CHAR	BAR	4	(4)
00000004	I-2	ISWP	4	(2)

3-Dec-1990 09:41:05
19-Apr-1990 15:29:11

VAX FORTRAN V5.5-98
[BELFIORE.SMI.SRC.RDSSMI]INTFUNC.FOR:1

9

0001 C*****

0002

0003

COMMAND QUALIFIERS

```
FORTRAN/NOOPT/DEB/DEB/LIST/NOOBJ INTFUNC
/CHECK={NOBOUNDS,OVERFLOW,NOUNDERFLOW}
/DEB={SYMBOLS,TRACEBACK}
/DESIGN={NOCOMMENTS,NOPLACEHOLDERS}
/SHOW={NODICTIONARY,NOINCLUDE,MAP,NOPREPROCESSOR,SINGLE}
/STANDARD={NOSEMANTIC,NOSOURCE,FORM,NOSYNTEX}
/WARNINGS={NODECLARATIONS,GENERAL,NOULTRIX,NOVAXELN}
/CONTINUATIONS=19 /HOCROSS REFERENCE /NOD_LINES /NOEXTEND SOURCE
/F77 /NOG FLOATING /I4 /NOMACHINE_CODE /NCOPTIMIZE /NOPARALLEL
/NOANALYSIS DATA
/NOAGNOSTICS
/LIST=USER$DISK_26:[BELFIORE.SMI.SRC.RDSSMI]INTFUNC.LIS:1
/NOOBJECT
```

COMPILATION STATISTICS

Run Time:	0.92 seconds
Elapsed Time:	1.66 seconds
Page Faults:	443
Dynamic Memory:	328 pages

3-Dec-1990 09:41:48
25-Apr-1990 15:16:37

```

0001      subroutine openreg ( )
0002      C.....
0003      C Subroutine OPENREG simply opens the output files necessary to keep
0004      C track of the regional microwave data processed from the SSM/I data
0005      C tape in question.
0006      C.....
0007
0008      open (11, status='unknown', file='lenigrad.dat')
0009      open (12, status='unknown', file='kiev.dat')
0010      open (13, status='unknown', file='simferopol.dat')
0011      open (14, status='unknown', file='moscow.dat')
0012      open (15, status='unknown', file='murmansk.dat')
0013      open (16, status='unknown', file='perm.dat')
0014      open (17, status='unknown', file='aktyubinsk.dat')
0015      open (18, status='unknown', file='tashkent.dat')
0016      open (19, status='unknown', file='semipalatinsk.dat')
0017      open (20, status='unknown', file='chita.dat')
0018      open (21, status='unknown', file='blagoveshensk.dat')
0019
0020      return
0021      end

```

PROGRAM SECTIONS

Name	Bytes	Attributes
0 \$CODE	105	PIC CON REL LCL SHR EXE RD NOWRT QUAD
1 \$PDATA	145	PIC CON REL LCL SHR NOEXE RD NOWRT QUAD
2 \$LOCAL	352	PIC CON REL LCL NOSHR NOEXE RD WRT QUAD
Total Space Allocated	602	

ENTRY POINTS

Address	Type	Name
0-00000000		OPENREG

FUNCTIONS AND SUBROUTINES REFERENCED

Type	Name
	FOR\$OPEN

3-Dec-1990 09:41:48
25-Apr-1990 15:16:37

OPENREG
01

COMMAND QUALIFIERS

```

FORTRAN/NOOPT/DEBUG/LIST/NOOBJ OPENREG
/CHECK=(NOBOUNDS,OVERFLOW,NOUNDERFLOW)
/DEBUG=(SYMBOLS,TRACEBACK)
/DESIGN=(NOCOMMENTS,NOLACHECKERS)
/SHOW=(NODICTIONARY,NOLACHECK,MAP,NOPREPROCESSOR,SINGLE)
/STANDARD=(NOSEMANTIC,NOSOURCEFORM,NOSYNTAX)
/WARNINGS=(NODECLARATIONS,GENERAL,NOLACHECK,NOLACHECK)
/CONTINUATIONS=19 /NOCROSS REFERENCE /NOD LINES /NOEXTEND SOURCE
/F77 /NOG FLOATING /I4 /NOMACHINE_CODE /NOOPTIMIZE /NOPARALLEL
/NOANALYSIS_DATA
/NOAGNOSTICS
/LIST=USER$DISK_26:[BELFIORE.SSMI.SRC.RDSSMI]OPENREG.LIS;1
/NOOBJECT

```

COMPILATION STATISTICS

```

Run Time:      0.37 seconds
Elapsed Time:   0.86 seconds
Page Faults:    372
Dynamic Memory: 200 pages

```

3-DEC-1990 09:41:59
19-APR-1990 15:30:28

```

0001 SUBROUTINE QTIME(ITREF,ITNOW,ITIME,IERR,IFUNCT)
0002
0003 *****
0004 SUBROUTINE CREATED: 11 JULY 1988
0005
0006 USE THIS SUBROUTINE TO CONVERT A (YEAR,MONTH,DAY,HR,MIN,SEC)"NOW"
0007 TIME GROUP INTO A TIME, ITIME,(IN SECONDS) WHICH IS COUNTED FROM THE
0008 (YEAR,MONTH,DAY,HR,MIN,SEC)"REF" TIME GROUP. OR-- GIVEN A "REF"
0009 TIME GROUP AND "ITIME", THE PROGRAM WILL CALCULATE THE "NOW" TIME GROUP.
0010
0011 *****
0012 SUBROUTINE QTIME(ITREF,ITNOW,ITIME,IERR,IFUNCT)
0013
0014 *****
0015 VARIABLE INDICATING WHAT IS TO BE CALCULATED
0016 IFUNCT - VARIABLE INDICATING WHAT IS TO BE CALCULATED
0017 1 ==> GIVEN ITREF AND ITNOW CALCULATE ITIME
0018 2 ==> GIVEN ITREF AND ITIME CALCULATE ITNOW
0019 7 ELEMENT ARRAY CONTAINING REFERENCE TIME GROUP
0020
0021 ITREF(1) = YEAR, RANGE = (40,99)
0022 ITREF(2) = MONTH, RANGE = (1,12)
0023 ITREF(3) = DAY, RANGE = (1,31)
0024 ITREF(4) = HOUR, RANGE = (0,23)
0025 ITREF(5) = MINUTE, RANGE = (0,59)
0026 ITREF(6) = SECOND, RANGE = (0,59)
0027 ITREF(7) = LEAP YEAR INDICATOR, 1=NORMAL YR, 2=LEAP YR
0028
0029 ITIME - DIFFERENCE IN SECONDS BETWEEN REF TIME AND NOW TIME
0030 IERR - ERROR FLAG
0031 0 ==> NO ERRORS
0032 1 ==> ITNOW(I) OR ITREF(I) IS OUT OF RANGE
0033 1 ==> NORMAL YEAR
0034 2 ==> LEAP YEAR
0035
0036 JULIAN(I,J) - ARRAY CONTAINING THE JULIAN DAY CORRESPONDING TO
0037 THE START OF EACH MONTH "I".
0038 J=1 ==> NORMAL YEAR
0039 J=2 ==> LEAP YEAR
0040
0041 IYEAR(.) - ARRAY CONTAINING NUMBER OF SECONDS IN NORMAL YEAR
0042 AND IN A LEAP-YEAR
0043
0044 *****
0045
0046 INTEGER ITREF(7),ITNOW(7),JULIAN(12,2),IYEAR(2),LY(60)
0047
0048 INTEGER IRANGE(6,2)
0049 DATA IYEAR/31536000,31622400/
0050 DATA JULIAN/1,32,60,91,121,152,182,213,244,274,305,335,
0051 1,32,61,92,122,153,183,214,245,275,306,336/
0052 DATA IRANGE/40,1,1,0,0,0,
0053 99,12,31,23,59,59/
0054
0055 IERR=0
0056 DO 5 I=1,6
0057 IF(ITREF(I).LT.IRANGE(I,1).OR.ITREF(I).GT.IRANGE(I,2))IERR=I
0058 IF(IFUNCT.EQ.2)GO TO 5
0059 IF(ITNOW(I).LT.IRANGE(I,1).OR.ITNOW(I).GT.IRANGE(I,2))IERR=I
0060
0061 5 CONTINUE
0062 IF(IERR.NE.0)RETURN
0063 C FILL LEAP-YEAR INDICATOR ARRAY
0064 I1=1
0065 DO 10 I=1,15
0066 LY(I1)=2
0067 I1=I1+1

```

QTIME

```

0058 LY(I1)=1
0059 I1=I1+1
0060 LY(I1)=1
0061 I1=I1+1
0062 LY(I1)=1
0063 I1=I1+1
0064 10 CONTINUE
0065 C CALCULATE "REF" TIME IN SECONDS FROM BEGINNING OF REF YEAR
0066     Y1=ITREF(1)-39
0067     IL1=LY(IY1)
0068     ISTART=(JULIAN(ITREF(2),IL1)+ITREF(3)-2)*86400
0069     ISTART=ISTART+ITREF(4)*3600+ITREF(5)*60+ITREF(6)
0070     IF(IFUNCT.EQ.2)GO TO 100
0071
0072 C ** IFUNCT=1 MODULE FOLLOWS
0073 C
0074 C CALCULATE "NOW" TIME IN SECONDS FROM BEGINNING OF "NOW" YEAR
0075     IY2=ITNOW(1)-39
0076     IL2=LY(IY2)
0077     ITNOW(7)=IL2
0078     IEND=(JULIAN(ITNOW(2),IL2)+ITNOW(3)-2)*86400
0079     IEND=IEND+ITNOW(4)*3600+ITNOW(5)*60+ITNOW(6)
0080     ITIME=IEND-ISTART
0081     IERR=0
0082     I2=IY2-1
0083     DO 20 I=IY1,I2
0084         IL=LY(I)
0085         ITIME=ITIME+YEAR(IL)
0086
0087 20 CONTINUE
0088     RETURN
0089
0090 C ** IFUNCT=2 MODULE FOLLOWS
0091 C
0092 100 CONTINUE
0093     IY2=IY1
0094     ISUM=IYEAR(LY(IY2))-ISTART
0095 110 CONTINUE
0096     IF(ISUM.GT.ITIME)GO TO 120
0097     IY2=IY2+1
0098     ISUM=ISUM+IYEAR(LY(IY2))
0099     GO TO 110
0100 120 IEND=ITIME-ISUM+IYEAR(LY(IY2))
0101     IL2=LY(IY2)
0102     ITNOW(7)=IL2
0103     JDAY=IEND/86400+1
0104     IEND=IEND-(JDAY-1)*86400
0105     ITNOW(4)=IEND/3600
0106     IEND=IEND-ITNOW(4)*3600
0107     ITNOW(5)=IEND/60
0108     ITNOW(6)=IEND-ITNOW(5)*60
0109     IM=1
0110 130 CONTINUE
0111     IF(JDAY.LT.JULIAN(IM,IL2))GO TO 140
0112     IM=IM+1
0113     GO TO 130
0114 140 IM=IM-1
0115     ITNOW(2)=IM

```

```

QTIME
0115 ITNOW(3)=JDAY-JULIAN(IM,IL2)+1
0116 ITNOW(1)=IY2+39
0117 RETURN
0118 END
    
```

PROGRAM SECTIONS

Name	Bytes	Attributes
0 \$CODE	719	PIC CON REL LCL SHR EXE RD NOWRT QUAD
2 \$LOCAL	512	PIC CON REL LCL NOSHR NOEXE RD WRT QUAD
Total Space Allocated	1231	

ENTRY POINTS

Address	Type	Name
0-00000000	QTIME	

VARIABLES

Address	Type	Name	Address	Type	Name
2-00000188	I*4	I	2-0000018C	I*4	IL
AP-00000010E	I*4	IERR	AP-00000014E	I*4	IFUNCT
2-000001A0	I*4	IL2	2-000001BC	I*4	IM
AP-00000000C	I*4	ITIME	2-00000190	I*4	IY1
			2-000001A8	I*4	I2
			2-000001B0	I*4	IL
			2-000001A8	I*4	ISTART
			2-0000019C	I*4	IY2
			2-000001B8	I*4	JDAY
			2-000001A4	I*4	IEND
			2-00000194	I*4	IL1
			2-000001B4	I*4	ISUM
			2-000001B8	I*4	JDAY

ARRAYS

Address	Type	Name	Bytes	Dimensions
2-00000158	I*4	IRANGE	48	(6, 2)
AP-00000008E	I*4	ITNOW	28	(7)
AP-00000004E	I*4	ITREF	28	(7)
2-00000060	I*4	IYEAR	8	(2)
2-00000000	I*4	JULIAN	96	(12, 2)
2-00000068	I*4	LY	240	(60)

LABELS

Address	Label	Address	Label	Address	Label
0-0000006F	5	0-000000B4	10	0-000001E0	110
0-00000287	130	0-0000029E	140	0-000001C8	100
				0-000001FD	120

QTIME
 01

COMMAND QUI -IFIERS

```

FORTRAN/NOOPT/DEBUG/LIST/NOOBJ QTIME
/CHECK=(NOBOUNDS,OVERFLOW,NOUNDERFLOW)
/DEBUG=(SYMBOLS,TRACEBACK)
/DESIGN=(NOCOMMENTS,NOPLACEHOLDERS)
/SHOW=(NODICTIONARY,NOINCLUDE,MAP,NOPREPROCESSOR,SINGLE)
/STANDARDS=(NOSEMANTIC,NOSOURCE FORM,NOSYNTAX)
/WARNINGS=(NODECLARATIONS,GENERAL,NOULTRIX,NOVAXELN)
/CONTINUATIONS=19 /NOCROSS REFERENCE /NOD LINES /NOEXTEND SOURCE
/F77 /NOG FLOATING /I4 /NOMACHINE_CODE /NOOPTIMIZE /NOPARALLEL
/NOANALYSIS DATA
/NO DIAGNOSTICS
/LIST=USER$DISK_26:[BELFIORE.SSMI.SRC.RDSSMI]QTIME.LIS;1
/NOOBJECT
  
```

COMPILATION STATISTICS

Run Time:	1.21 seconds
Elapsed Time:	2.00 seconds
Page Faults:	523
Dynamic Memory:	392 pages

3-DEC-1990 09:42:11
3-JUN-1990 10:41:00

TAX FORTRAN V5.5-92
INTELFIORE.SSMI.SRC.RDSSMI1SWATH.FOR:4 Page 1

```

0001 SUBROUTINE SWATH(ISCAN,KFLAG)
0002
0003 C *****
0004 C PROGRAM USED TO STRIP SWATH DATA FROM THE WENTZ SSMI TAPES
0005 C **THIS LATEST VERSION(19FEB88) ALLOWS USER TO STRIP MORE THAN**
0006 C **ONE SWATH AT A TIME**
0007 C ISCAN=1 => OUTPUT A-SCAN, ODD-PIXEL, TB'S AND WSP
0008 C ISCAN=2 => OUTPUT ONLY 85GHZ TA DATA FOR ALL A&B SCAN PIXELS
0009 C
0010 C Severe modifications made for AFGL/LYS by James S. Belfiore, Jr.
0011 C (30-APR-1990) and AER, Inc.
0012 C *****
0013
0014 INTEGER JULIAN(12,2),STIME(10),ETIME(10),RAINF(64)
0015 INTEGER ITRF(7),ITNOW(7)
0016 CHARACTER FNAME(10)*10, SC*1,DECIS*1
0017 REAL*4 WIND(64),TB(7,64)
0018
0019 real regions(11,4)
0020 logical res_flg
0021
0022 C *****
0023 C SPECIFY COMMON /INDATA/
0024 C *****
0025
0026 CHARACTER*1 LREC(1784)
0027 INTEGER*4 KBT,IBYT,IFLAG
0028 COMMON/INDATA/LREC,KBT,IBYT,IFLAG
0029
0030 C *****
0031 C SPECIFY COMMON /OUTDAT/
0032 C *****
0033
0034 REAL*8 REV
0035 INTEGER*4 ITIME,ITMSC,IVOLT,IAGC,ICOLDA,IHOTA,ICOLDB,IHOTB,ISPAR1
0036 INTEGER*4 ITOIL,ISPAR2
0037 REAL*4 XLATSC,XLONSC,ALTSC,HLTEMP,RTTEMP,FTTEMP,CALSLP,CALOFF
0038 REAL*4 ALAT,ALON,BLAT,BLON,TALO,TANI
0039
0040 COMMON/OUTDAT/ REV,ITIME,ITMSC,XLATSC,XLONSC,ALTSC,
0041 1 HLTEMP(3),IVOLT(2),RTTEMP,FTTEMP,IAGC(6),CALSLP(7),CALOFF(7),
0042 2 ICOLDA(5,7),IHOTA(5,7),ICOLDB(5,2),IHOTB(5,2),ISPAR1,
0043 3 ALAT(128),ALON(128),BLAT(128),BLON(128),
0044 4 TALO(5,64),TANI(8,64),ITOI(4,64),ISPAR2(64)
0045
0046 DATA ITRF/87,1,1,0,0,0,1/
0047 DATA JULIAN/1,32,60,91,121,152,182,213,244,274,305,335,
0048 1,32,61,92,122,153,183,214,245,275,306,336/
0049
0050 OPEN(1,STATUS='OLD',BLOCKSIZE=28544,RECL=1784,
0051 1 RECORDTYPE='FIXED',FORM='FORMATTED')
0052
0053 C *****
0054 C READ PAST THE TAPE HEADERS
0055 C *****
0056
0057 CALL READND

```

SWATH

```

0058 WRITE(6,1010)
0059 1010 FORMAT(' THIS OPTION ALLOWS THE USER TO STRIP SWATH DATA FROM'
0060 ' THE TAPE. MORE THAN ONE SWATH CAN BE EXTRACTED AT A'
0061 ' TIME HOWEVER, THE SWATH TIMES MUST BE ENTERED IN'
0062 ' **ASCENDING** ORDER.')
0063
0064 IFILE=0
0065 1 IFILE=IFILE+1
0066 WRITE(6,1000)
0067 1000 FORMAT(' FOR THE SWATH DATA TO BE EXTRACTED ENTER,'//
0068 ' START DATE (YR MM DD)(e.g. 87 1 25): ', $)
0069 READ(5,' )ITNOW(1),ITNOW(2),ITNOW(3)
0070 WRITE(6,1100)
0071 1100 FORMAT(' START TIME (HH MM SS)(e.g. 0 0 0): ', $)
0072 READ(5,' )ITNOW(4),ITNOW(5),ITNOW(6)
0073 CALL QTIME(ITREF,ITNOW,ITIME,IERR,1)
0074 STIME(IFILE)=ITIME
0075 WRITE(6,1200)
0076 1200 FORMAT(' END DATE (YR MM DD): ', $)
0077 READ(5,' )ITNOW(1),ITNOW(2),ITNOW(3)
0078 WRITE(6,1300)
0079 1300 FORMAT(' END TIME (HH MM SS): ', $)
0080 READ(5,' )ITNOW(4),ITNOW(5),ITNOW(6)
0081 CALL QTIME(ITREF,ITNOW,ITIME,IERR,1)
0082 ETIME(IFILE)=ITIME
0083 WRITE(6,1400)
0084 1400 FORMAT(' OUTPUT FILE NAME: ' $)
0085 READ(5,1500)FNAME(IFILE)
0086 1500 FORMAT(A20)
0087 WRITE(6,1550)
0088 1550 FORMAT(' WOULD YOU LIKE TO EXTRACT OTHER SWATH DATA FROM',
0089 ' THIS TAPE? (Y/N): ', $)
0090 READ(5,1560)DECIS
0091 1560 FORMAT(A1)
0092 IF(DECIS.EQ.'Y'.OR.DECIS.EQ.'Y')GO TO 1
0093
0094 DUM=0.0
0095 IREC=0
0096 IREC2=0
0097 WRITE(6,1800)
0098 1800 FORMAT(' REC NO')
0099
0100 DO 990 IF=1,IFILE
0101 call openreg (
0102 open (2, status='new', name=fname(if))
0103
0104 C*****
0105 C WRITE HEADERS TO THE OUTPUT FILE *
0106 C*****
0107
0108 IF(ISCAN.EQ. 1) WRITE(2,1600)
0109 IF(ISCAN.EQ. 2) WRITE(2,1700)
0110
0111 format (' time lat lon tb19v tb19h',
0112 ' tb22v tb37v tb37h')
0113 format (' time lat lon ta85v ta85h')
0114

```

```

0115 C*****
0116 C Establish target regions *
0117 C*****
0118 call estreg (regions)
0119
0120 I0 IEOF=0
0121 reg_flg = .false.
0122 11 READ(1,2000,END=12)LREC
0123 2000 FORMAT(1784A1)
0124
0125 GO TO 14
0126 12 IEOF=IEOF+1
0127 WRITE(6,2001)IEOF
0128 2001 FORMAT(' IEOF= ',I2)
0129
0130 C*****
0131 C DOUBLE END-OF-FILE MEANS END-OF-TAPE *
0132 C*****
0133 IF(IEOF .EQ. 2)GO TO 999
0134 GO TO 11
0135 CONTINUE
0136 14 IREC=IREC+1
0137 IREC2=IREC2+1
0138
0139
0140 IF(IREC.EQ.25)WRITE(6,2010)IREC2,IF
0141 2010 FORMAT(' RECS READ=',I10,' SEARCHING FOR SWATH ',I2)
0142
0143 IF(IREC.EQ.25)IREC=0
0144 ITIME=INT44(KBT,LREC(1),LREC(2),LREC(3),LREC(4))
0145 REV=1.D-4*INT44(KBT,LREC(5),LREC(6),LREC(7),LREC(8))
0146
0147 IF(ITIME.LT.STIME(IF))GO TO 10
0148 IF(ITIME.GT.STIME(IF))GO TO 980
0149
0150 CALL FDLTLN(ISCAN)
0151
0152 C*****
0153 C Scan (array platform) filter *
0154 C*****
0155 do 42 i=2,63
0156 ii = i*2-1
0157 call testreg (alat(ii), alon(ii), regions, reg_flg)
0158
0159 C*****
0160 C If any of the elements are in the right spot, skip to output section *
0161 C*****
0162 if (reg_flg) then i = 63
0163 42 continue
0164
0165 CALL FDLTA(ISCAN)
0166 IF(ISCAN .EQ. 2) GO TO 30
0167
0168 CALL WINDMX(WIND,TB,RAINF) :Calculate ground track point latitude
0169 CALL GLAT(GTL)
0170 DO 20 I=2,63
0171

```

SWATH

```

0172      II=I*2-1
0173      DO 101 J=1,11
0174      IF ((ALAT(II) .GT. REGIONS(J,1)) .AND.
0175      (ALAT(II) .LT. REGIONS(J,2)) .AND.
0176      (ALON(II) .GT. REGIONS(J,3)) .AND.
0177      (ALON(II) .LT. REGIONS(J,4)))
0178      WRITE (J+10, 2101) ITIME, ALAT(II), ALON(II), TB(1,I),
0179      TB(2,I), TB(3,I), TB(4,I),
0180      TB(5,I), TB(6,I)
0181      CONTINUE
0182      FORMAT (1X, 1I8, 2X, 1F6.2, 3X, 1F6.2, 3X, 5(2X,F6.2))
0183      CONTINUE
0184      GO TO 10
0185      CONTINUE
0186
0187      C*****
0188      C PRINT OUT THE 85GHZ DATA --> A-SCAN THEN B-SCAN *
0189      C*****
0190
0191      SC = 'A'
0192      II=1
0193
0194      DO 40 I=1,64
0195      WRITE(2,2200)ALAT(II),ALON(II),TAHI(1,I),TAHI(2,I),
0196      II,SC,ITAIL(1,I)
0197      II=II+1
0198      WRITE(2,2200)ALAT(II),ALON(II),TAHI(5,I),TAHI(6,I),
0199      II,SC,ITAIL(2,I)
0200      II=II+1
0201      CONTINUE
0202      SC='B'
0203      II=1
0204
0205      DO 50 I=1,64
0206      WRITE(2,2200)BLAT(II),BLON(II),TAHI(3,I),TAHI(4,I),
0207      II,SC,ITAIL(3,I)
0208      II=II+1
0209      WRITE(2,2200)BLAT(II),BLON(II),TAHI(7,I),TAHI(8,I),
0210      II,SC,ITAIL(4,I)
0211      II=II+1
0212      CONTINUE
0213
0214      FORMAT(4(X,F6.2),X,I3,A1,X,I2)
0215      GO TO 10
0216      CLOSE(2)
0217      CONTINUE
0218      KFLAG=1
0219      RETURN
0220      END

```

PROGRAM SECTIONS

Name	Bytes	Attributes
0 \$CODE	1945	PIC CON REL LCL SHR EXE RD NOWRT QUAD
1 \$PDATA	745	PIC CON REL LCL SHR NOEXE RD NOWRT QUAD
2 \$LOCAL	3236	PIC CON REL LCL NOSHR NOEXE RD WRT QUAD
3 \$INDATA	1796	PIC OVR REL GBL SHR NOEXE RD WRT QUAD
4 \$OUTDAT	7156	PIC OVR REL GBL SHR NOEXE RD WRT QUAD
Total Space Allocated	14878	

ENTRY POINTS

Address	Type	Name
0-00000000		SWATH

VARIABLES

Address	Type	Name	Address	Type	Name
4-00000018	R*4	ALTSC	2-000000B0C	R*4	DUM
2-000000B30	R*4	GTL	3-0000006FC	I*4	IBYT
2-000000B08	I*4	IERR	2-000000B04	I*4	IFILE
2-000000B28	I*4	II	2-000000B14	I*4	IREC2
4-000001F0	I*4	ISPAR1	4-0000000C	I*4	ITINSC
3-000006F8	I*4	KBT	2-000000B00	L*4	REG_FLG
4-00000030	R*4	RFTENP	2-000000B2C	R*4	THENI
4-00000014	R*4	XLONSC	4-000000034	R*4	PREMP
			2-000000B20	I*4	IEOF
			3-000000700	I*4	IFLAG
			AP-0000000048	I*4	ISCAN
			2-000000B34	I*4	J
			4-000000000	R*8	REV
			4-000000010	R*4	XLATSC

ARRAYS

Address	Type	Name	Bytes	Dimensions
4-000001F4	R*4	ALAT	512	(128)
4-000003F4	R*4	ALON	512	(128)
4-000005F4	R*4	BLAT	512	(128)
4-000007F4	R*4	BLOH	512	(128)
4-0000006C	R*4	CALOFF	28	(7)
4-00000050	R*4	CALSLP	28	(7)
2-00000008	I*4	ETINE	40	(10)
2-000000A98	CHAR	FNAME	100	(10)
4-0000001C	R*4	HLTEMP	12	(3)
4-00000038	I*4	IAGC	24	(6)
4-00000008	I*4	ICOLDA	140	(5, 7)
4-000001A0	I*4	ICOLDB	40	(5, 2)
4-00000114	I*4	IHOTA	140	(5, 7)
4-000001C8	I*4	IHOTB	40	(5, 2)
4-000001A14	I*4	ISPAR2	256	(64)
2-000001CC	I*4	ITNOW	28	(7)
4-0000016F4	I*4	ITOL	1024	(4, 64)
2-000001H0	I*4	ITREF	28	(7)
4-00000028	I*4	IVOLT	8	(2)

I-4	JULIAN	96	(12, 2)
I-4	CHAR	1784	(1784)
I-4	RAINF	256	(64)
I-4	REGIONS	176	(11, 4)
I-4	STINE	40	(10)
R-4	TAHI	2048	(8, 64)
R-4	TALO	1280	(5, 64)
R-4	TB	1792	(7, 64)
R-4	WIND	256	(64)

[illegible]

Type	Name	Type	Name	Type	Name	Type	Name
I*4	ESTREG		FDLTLN		FOR\$CLOSE		FOR\$OPEN
	INT44		OPENREG		QTIME		TESTREG
					READHD		WINDMX

```

FORTRAN/NOOPT/DEBUG/LIST/NOOBJ SWATH
/CHK= (NOBOUNDS, OVERFLOW, NOUNDERFLOW)
/DEBUG= (SYMBOLS, TRACEBACK)
/DESIGN= (NOCOMMENTS, NOPLACEHOLDERS)
/SHOW= (MODIFICATIONARY, NOINCLUDE, MAP, NOPREPROCESSOR, SINGLE)
/STANDARD= (NOSEMTANTIC, NOSOURCE FORM, NOSYNTAX)
/WARNINGS= (NODECLARATIONS, GENERAL, NOULTRIX, NOVAXELN)
/CONTINUATIONS=19 /NOCROSS REFERENCE /NOD LINES /NOEXTEND SOURCE
/FF77 /NOG FLOATING /I4 /NOMACHINE_CODE /NOOPTIMIZE /NOPARALLEL
/NOANALYSIS DATA
/NO DIAGNOSTICS
/LIST/USERS$DISK_26:[ BELFIORE.SSN1.SRC.RD$SMI]SWATH.LIS;1
/NOOBJECT

```

```
Run Time: 2.10 seconds
Elapsed Time: 2.63 seconds
Page Faults: 692
Dynamic Memory: 484 pages
```

3-Dec-1990 09:42:33
30-May-1990 13:31:12

```

0001      subroutine testreg (lat, lon, regions, reg_flg)
0002      C.....
0003      C Subroutine TESTREG tests a set of lat/lon coordinates to determine
0004      C whether or not said coordinates fall within a specified region. The
0005      C regions in question are pre-defined and passed in via a 2-D array
0006      C for the third input parameter. Since the application of this
0007      C routine is such that it will be called again and again to test
0008      C literally millions of coordinates, it has been tailored to conserve
0009      C cpu usage as much as possible, by implementing a "first pass"
0010      C criterion. That is, the first time the coordinates in question
0011      C passes any of the conditions given in the routine, it assigns a
0012      C positive value to a logical variable and then terminates the
0013      C remaining comparisons.
0014      C.....
0015      real lat, lon, regions(11,4)
0016      logical reg_flg
0017      integer i
0018
0019      reg_flg = .false.
0020      do 10 i=1,11
0021          if ((lat .gt. regions(i,1)) .and.
0022              (lat .lt. regions(i,2)) .and.
0023              (lon .gt. regions(i,3)) .and.
0024              (lon .lt. regions(i,4))) reg_flg = .true.
0025
0026              if (reg_flg) then i = 11
0027      10 continue
0028
0029      return
0030      end

```

PROGRAM SECTIONS

Name	Bytes	Attributes
0 \$CODE	91	PIC CON REL LCL SHR EXE RD NOWRT QUAD
2 \$LOCAL	52	PIC CON REL LCL NOSHR NOEXE RD WRT QUAD
Total Space Allocated	143	

ENTRY POINTS

Address	Type	Name
0-00000000		TESTREG

VARIABLES

Address	Type	Name	Address	Type	Name
2-00000000	I*4	I	AP-000000040	R*4	LAT
2-00000004	R*4	THENI	AP-000000080	R*4	LON
			AP-000000100	L*4	REG_FLG

ARRAYS

Address	Type	Name	Bytes	Dimensions
AP-0000000C0	R*4	REGIONS	176	(11, 4)

LABELS

Address	Label
0-00000056	10

COMMAND QUALIFIERS

```

FORTRAN/NOOPT/DEBUG/LIST/NOOBJ TESTREG
/CHECK=(NOBOUNDS,OVERFLOW,NOUNDERFLOW)
/DEBUG=(SYMBOLS,TRACEBACK)
/DESIGN=(NOCOMMENTS,NOPLACEHOLDERS)
/SHOW=(NODICTIONARY,NOINCLUDE,MAP,NOPREPROCESSOR,SINGLE)
/STANDARD=(NOSEMANATIC,NOSOURCE FORM,NOSYNTAX)
/WARNINGS=(NODECLARATIONS,GENERAL,NOULTRIX,NOVAXELN)
/CONTINUATIONS=19 /NOCROSS REFERENCE /NOD LINES /NOEXTEND SOURCE
/F77 /NOG FLOATING /I4 /NOMACHINE_CODE /NOOPTIMIZE /NOPARALLEL
/NOANALYSIS DATA
/NO DIAGNOSTICS
/LIST=USER$DISK_26:[BELFIORE.SSMI.SRC.RDSSMI]TESTREG.LIS:1
/NOOBJJECT
    
```

TESTREG
01

COMPILATION STATISTICS

Run Time: 0.40 seconds
Elapsed Time: 0.93 seconds
Page Faults: 449
Dynamic Memory: 204 pages

3-Dec-1990 09:42:33
30-May-1990 13:31:12

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{BELFORE.SSMI.SRC.RDSSMI|TESTREG.FOR:2} Page 3

3-Dec-1990 09:42:46
 19-Apr-1990 15:27:35

WINDMX

```

0059 C ..... BEGIN EXECUTION .....
0060 C .....
0061 C .....
0062 C THE FIRST AND LAST PIXELS WE CANNOT COMPUTE TB OR WINDS FOR .....
0063 C .....
0064 DO 90 I=1,7
0065     TB(I,1)=999.99
0066     TB(I,64)=999.99
0067 90 CONTINUE
0068
0069     RAINF(1)=0
0070     RAINF(2)=0
0071     DMXWIN(1)=99.99
0072     DMXWIN(64)=99.99
0073     CALL QTIME(ITREF,ITNOW,ITIME,IERR,2)
0074     JNON=ITNOW(2)
0075
0076 C .....
0077 C LOOP THRU CELLS IN SCAN .....
0078 C .....
0079
0080 DO 300 ICEL=2,63
0081
0082 C .....
0083 C .....
0084 C COMPUTE TB'S, TB() = 19V,19H,37V,37H,21V,85V,85H .....
0085 C .....
0086
0087 DO 200 ICH=1,5
0088     JCH=JCHFX(ICH)
0089     IF(ICH.NE.5) TAXPOL=TALO(JCH,ICEL)
0090     IF(ICH.EQ.5) TAXPOL=OFF22H*SLP22H*TALO(2,ICEL)
0091     TBX=APC(1,ICH)*TALO(ICH,ICEL)-APC(2,ICH)*TAXPOL-
0092     APC(3,ICH)*TALO(ICH,ICEL)-1)*APC(4,ICH)*TALO(ICH,ICEL+1)
0093     TB(ICH,ICEL)=0.1*INT(10.*TBX)
0094 200 CONTINUE
0095
0096 DO 202 ICH=6,7
0097     JCH=JCHFX(ICH)
0098     TAXPOL=TAXI(JCH,ICEL)
0099     I=ICH-5
0100     TBX=APC(1,ICH)*TAXI(I,ICEL)-APC(2,ICH)*TAXPOL-
0101     APC(3,ICH)*TAXI(I,ICEL)-1)*APC(4,ICH)*TAXI(I,ICEL+1)
0102     TB(ICH,ICEL)=0.1*INT(10.*TBX)
0103 202 CONTINUE
0104
0105 C .....
0106 C CHECK TOIL .....
0107 C .....
0108
0109 IF(ITOIL(1,ICEL).GE.4.AND.ITOIL(1,ICEL).LE.5) GO TO 203
0110     DMXWIN(ICEL)=31.
0111     RAINF(ICEL)=0
0112     GO TO 300
0113 203 CONTINUE
0114

```

```

0115 DELTB=TB(3,ICEL)-TB(4,ICEL)
0116
0117 C.....
0118 C IF HEAVY RAIN SET WIND TO 31
0119 C.....
0120
0121 IF(DELTB.GT. 10)GO TO 205
0122 RAINF(ICEL)=2
0123 DMXWIN(ICEL)=31.
0124 GO TO 300
0125
0126
0127
0128
0129 C CHECK FOR ICE
0130 C.....
0131
0132 IF(TB(2,ICEL).GT.140..AND.DELTB.GT.5..AND.DELTB.LT.62)
0133 1 DMXWIN(ICEL)=31.
0134 IF(TB(2,ICEL).GT.140..AND.DELTB.GT.5..AND.DELTB.LT.62)
0135 1 GO TO 300
0136
0137 C.....
0138 C PROCEED TO COMPUTE D-MATRIX WIND
0139 C.....
0140
0141 210 CONTINUE
0142 RAINF(ICEL)=0
0143 JCEL=2*ICEL-1
0144 XLAT=ALAT(JCEL)
0145 ILAT=8
0146 IF(XLAT.GT.-55.) ILAT=7
0147 IF(XLAT.GT.-25.) ILAT=6
0148 IF(XLAT.GT.-20.) ILAT=5
0149 IF(XLAT.GT. 0.) ILAT=4
0150 IF(XLAT.GT. 20.) ILAT=3
0151 IF(XLAT.GT. 25.) ILAT=2
0152 IF(XLAT.GT. 55.) ILAT=1
0153 I=INDEX(JMON,ILAT)
0154 DMXWIN(ICEL)=C0(I)+C1(I)*TB(2,ICEL)+
0155 4 C2(I)*TB(5,ICEL)+C3(I)*TB(3,ICEL)+C4(I)*TB(4,ICEL)
0156 IF(DMXWIN(ICEL).GT.25.) DMXWIN(ICEL)=30.
0157 IF(DMXWIN(ICEL).LE.-2.) DMXWIN(ICEL)=30.
0158 IF(DMXWIN(ICEL).LT.0.) DMXWIN(ICEL)=0.
0159
0160 300 CONTINUE
0161 RETURN
0162 END

```

PROGRAM SECTIONS

Name	Bytes	Attributes
0 \$CODE	1065	PIC CON REL LCL SHR EXE RD NOWRT QUAD
1 \$PDATA	4	PIC CON REL LCL SHR NOEXE RD NOWRT QUAD
2 \$LOCAL	1044	PIC CON REL LCL NOSHR NOEXE RD WRT QUAD
3 \$OUTDAT	7156	PIC OVR REL GBL SHR NOEXE RD WRT QUAD
Total Space Allocated	9269	

ENTRY POINTS

Address	Type	Name
0-00000000		WINDMX

VARIABLES

Address	Type	Name	Address	Type	Name
3-00000018	R*4	ALTSC	3-00000034	R*4	FRTEMP
2-00000036C	I*4	ICEL	2-00000036A	I*4	IERR
3-0000001F0	I*4	ISPAR1	3-00000000C	I*4	ITRSC
2-000000374	I*4	JCH	2-000000368	R*4	OFF22H
3-000000030	R*4	RFTMP	2-000000378	R*4	TAXPOL
2-000000388	R*4	XLAT	3-000000014	R*4	XLONSC

ARRAYS

Address	Type	Name	Bytes	Dimensions
3-0000001F4	R*4	ALAT	512	(128)
3-0000003F4	R*4	ALON	512	(128)
2-0000002E8	R*4	APC	112	(4, 7)
3-0000005F4	R*4	BLAT	512	(128)
3-0000007F4	R*4	BLOH	512	(128)
2-000000000	R*4	C0	36	(9)
2-000000024	R*4	C1	36	(9)
2-000000048	R*4	C2	36	(9)
2-00000006C	R*4	C3	36	(9)
2-000000090	R*4	C4	36	(9)
3-00000006C	R*4	CALOFF	28	(7)
3-000000050	R*4	CALSLP	28	(7)
AP-0000000040	R*4	DMXWIN	256	(64)
3-00000001C	R*4	HLTEMP	12	(3)
3-000000038	I*4	IAGC	24	(6)
3-000000038	I*4	ICOLDA	140	(5, 7)
3-0000001A0	I*4	ICOLDB	40	(5, 2)
3-000000114	I*4	IHOTA	140	(5, 7)
3-0000001C8	I*4	IHOTB	40	(5, 2)
2-0000000B4	I*4	INDEX	384	(12, 8)
3-000001AF4	I*4	ISPAR2	256	(64)
2-0000002CC	I*4	ITNOW	28	(7)

WINDMX
01

3-DEC-1990 09:42:46 VAX FORTRAN V5.5-98 Page 5
19-APR-1990 15:27:35 [SELFIORE.SSMI.SRC.RDSSMI]WINDMX.FOR.1

3-000016F4	I*4	ITAIL	1024	(4, 64)
2-00000250	I*4	ITREF	28	(7)
3-00000028	I*4	IVOLT	8	(2)
2-00000234	I*4	JCHEX	28	(7)
2-0000026C	I*4	JULIAN	96	(12, 2)
AP-0000000C9	I*4	RAINP	256	(64)
3-000000EF4	R*4	TAHI	2048	(8, 64)
3-000009F4	R*4	TALO	1280	(5, 64)
AP-00000008Q	R*4	TB	1792	(7, 64)

LABELS

Address	Label	Address	Label	Address	Label	Address	Label
0-00000050	90	0-00000152	200	0-00000200	202	0-0000023E	203
0-00000421	300					0-00000279	205
						0-000002E0	210

FUNCTIONS AND SUBROUTINES REFERENCED

Type	Name
	QTIME

0001 C*****

0002
 0003

COMMAND QUALIFIERS

```

FORTRAN/NOOPT/DEBUG/LIST/NOOBJ WINDMX
/CHECK=(NOBOUNDS,OVERFLOW,NOUNDERFLOW)
/DEBUG=(SYMBOLS,TRACEBACK)
/DESIGN=(NOCOMMENTS,NOPLACEHOLDERS)
/SHOW=(NODICTIONARY,NOINCLUDE,MAP,NOPREPROCESSOR,SINGLE)
/STANDARD=(NOSEMANTIC,NOSOURCE FORM,NOSYNTAX)
/WARNINGS=(NODECLARATIONS,GENERAL,NOULTRIX,NOVAXELN)
/CONTINUATIONS=19 /NOCROSS REFERENCE /NOD_LINES /NOEXTEND_SOURCE
/F77 /NOG FLOATING /I4 /NOMACHINE_CODE /NOOPTIMIZE /NOPARALLEL
/NOANALYSIS DATA
/NOAGNOSTICS
/LIST=USERS$DISK_26:[BELFIORE.SSMI.SRC.RDSSMI]WINDMX.LIS;1
/NOOBJECT
  
```

COMPILATION STATISTICS

```

Run Time:      1.70 seconds
Elapsed Time:   2.23 seconds
Page Faults:    617
Dynamic Memory: 444 pages
  
```

3-Dec-1990 10:52:12
8-Jun-1990 14:43:51

```

0001      program rainrate
0002      .....
0003      C Program RAINRATE computes the rate of rainfall at a specified location
0004      C given the appropriate microwave imagery data.
0005      C
0006      C Written by: James S. Belfiore, Jr.
0007      C               Atmospheric and Environmental Research, Inc.
0008      C               840 Memorial Drive
0009      C               Cambridge, MA 02139
0010      C               (617)-547-6207
0011      C
0012      C
0013      C
0014      C Program Variables:
0015      C      lat - latitude of point in question
0016      C      lon - longitude of point in question
0017      C      rate - rate of precipitation
0018      C      t19h - 19 Ghz (horizontal) brightness temp
0019      C      t19v - 19 Ghz (vertical) brightness temp
0020      C      t22v - 22 Ghz (vertical) brightness temp
0021      C      t37h - 37 Ghz (horizontal) brightness temp
0022      C      t37v - 37 Ghz (vertical) brightness temp
0023      C      i - counter
0024      C      j - counter
0025      C      ieof - End of file warning flag
0026      C      time - SSM/I data timestamp
0027      C
0028      C
0029      C Functions and
0030      C Subroutines called:
0031      C      openreg - opens regions of interest files
0032      C      openrain - opens rain data files
0033      C      rain_land - computes rain rates over land
0034      C
0035      C
0036      real lat, lon, t19h, t19v, t22v, t37h, t37v, rate
0037      real rain_land
0038      integer i, j, ieof, time
0039      C
0040      C
0041      C Open input and output files
0042      C
0043      call openreg ( )
0044      call openrain ( )
0045      C
0046      C
0047      C Loop through files, and data therein: check and compute rainfall
0048      C
0049      do 10, i=1,21
0050      do 20, j=1,10000
0051      read (i, 100, iostat=ieof) time, lat, lon, t19v,
0052      if (ieof .lt. 0) then
0053      go to 10
0054      endif
0055      if (((t22v - t19v) .le. 4.0) .and.
0056

```

RAINRATE

```

0058      *      *
0059      *      *
0060      *      *
0061      *      *
0062      *      *
0063      *      *
0064      *      *
0065      *      *
0066      *      *
0067      *      *
0068      *      *
0069      *      *
0070      *      *
0071      *      *
0072      *      *
0073      *      *
0074      *      *
0075      *      *
0076      *      *
0077      *      *
0078      *      *
0079      *      *
0080      *      *
0081      *      *
0082      *      *

```

((t19v+t37v)/2) - ((t19h+t37h)/2) -le. 4.0) .and.
 rate = rain_land (t19h, t19v, t22v, t37h, t37v)
 if (rate .lt. 0.0) then
 write (i+11,150) time, lat, lon, 0.0
 else
 write (i+11,150) time, lat, lon, rate
 endif
 else
 write (i+11,150) time, lat, lon, 0.0
 endif
 20 continue
 10 ieof = 0
 continue
 C*****
 C Formats
 C*****
 100 format (1X, 118, 2X, 1F6.2, 3X, 1F6.2, 3X, 5(2X,F6.2))
 150 format (1X, 118, 2X, 1F6.2, 3X, 1F6.2, 3X, 1F10.4)
 end

PROGRAM SECTIONS

Name	Bytes	Attributes
0 \$CODE	455	PIC CON REL LCL SHR EXE RD NOWRT QUAD
1 \$PDATA	51	PIC CON REL LCL SHR NOEXE RD NOWRT QUAD
2 \$LOCAL	92	PIC CON REL LCL NOSHR NOEXE RD WRT QUAD
Total Space Allocated	598	

ENTRY POINTS

Address	Type	Name
0-00000000	R*4	RAINRATE

VARIABLES

Address	Type	Name
2-00000020	I*4	I
2-00000004	R*4	LON
2-00000010	R*4	T22v
2-00000024	I*4	J
2-00000008	R*4	T19H
2-00000018	R*4	T37V
2-00000000	R*4	LAT
2-0000000C	R*4	T19V
2-0000002C	I*4	TIME

LABELS

Address	Label	Address	Label	Address	Label
0-000001B9	10	0-000001AE	20	1-00000004	100'
				1-0000001F	150'

FUNCTIONS AND SUBROUTINES REFERENCED

Type	Name	Type	Name
OPENRAIN		OPENREG	
		R*4	RAIN_LAND

COMMAND QUALIFIERS

FORTRAN/NOOPT/DEBUG/LIST/NOOBJ RAINRATE

```

/CHECK=(NOBOUNDS,OVERFLOW,NOUNDERFLOW)
/DEBUG=(SYMBOLS,TRACEBACK)
/DESIGN=(NOCOMMENTS,NOPINCLUDE,MAP,NOPREPROCESSOR,SINGLE)
/SHOW=(NODICTIONARY,NOCLOSE,FORM,NOSYNTAX)
/STANDARD=(NOSEMANANTIC,NOSOURCE,FORM,NOSYNTAX)
/WARNINGS=(NODECLARATIONS,GENERAL,NOULTRIX,NOVAXELN)
/CONTINUATIONS=19 /NOCROSS_REFERENCE /NOD_LINES /NOEXTEND_SOURCE
/F77 /NOG_FLOATING /I4 /NOMACHINE_CODE /NOOPTIMIZE /NOPARALLEL
/NOANALYSIS DATA
/NO DIAGNOSTICS
/LIST=USER$DISK_26:(BELFIORE.SSMI.SRC.RAINRATE)RAINRATE.LIS:1
/NOOBJECT
  
```

COMPILATION STATISTICS

Run Time: 0.62 seconds
 Elapsed Time: 1.37 seconds
 Page Faults: 494
 Dynamic Memory: 360 pages

3-Dec-1990 10:51:52
 14-Jun-1990 16:15:42

```

0001      subroutine openrain ()
0002      C.....
0003      C Subroutine OPENRAIN opens the output files necessary to keep track *
0004      C of the regional rainfall data processed from the SSM/I data tape in *
0005      C question.
0006      C.....
0007      C.....
0008      open (22, status='unknown', file='Lenigrad_rain.dat')
0009      open (23, status='unknown', file='Kiev_rain.dat')
0010      open (24, status='unknown', file='Simferopol_rain.dat')
0011      open (25, status='unknown', file='Moscow_rain.dat')
0012      open (26, status='unknown', file='Murmansk_rain.dat')
0013      open (27, status='unknown', file='Perm_rain.dat')
0014      open (28, status='unknown', file='Aldyubinsk_rain.dat')
0015      open (29, status='unknown', file='Tashkent_rain.dat')
0016      open (30, status='unknown', file='Semipalatinsk_rain.dat')
0017      open (31, status='unknown', file='Chita_rain.dat')
0018      open (32, status='unknown', file='Blagoveshchensk_rain.dat')
0019
0020      return
0021      end

```

PROGRAM SECTIONS

Name	Bytes	Attributes
0 \$CODE	105	PIC CON REL LCL SHR EXE RD NOWRT QUAD
1 \$PDATA	200	PIC CON REL LCL SHR NOEXE RD NOWRT QUAD
2 \$LOCAL	352	PIC CON REL LCL NOSHR NOEXE RD WRT QUAD
Total Space Allocated	657	

ENTRY POINTS

Address	Type	Name
0-00000000		OPENRAIN

FUNCTIONS AND SUBROUTINES REFERENCED

Type	Name
	FOR\$OPEN

3-Dec-1990 10:51:52
 14-Jun-1990 16:15:42

OPENRAIN
 01

COMMAND QUALIFIERS

```

FORTRAN/NOOPT/DEBUG/LIST/NOOBJ OPENRAIN
/CHECK=(NOBOUNDS,OVERFLOW,NOUNDERFLOW)
/DEBUG=(SYMBOLS,TRACEBACK)
/DESIGN=(NOCOMMENTS,NOPLACEHOLDERS)
/SHOW=(NODICTIONARY,NOINCLUDE,MAP,NOPREPROCESSOR,SINGLE)
/STANDARDS=(NOSEMANTIC,NOSOURCE FORM,NOSYNTEX)
/WARNINGS=(NODECLARATIONS,GENERAL,NOULTRIX,NOVAXELN)
/CONTINUATIONS=19 /NOCROSS REFERENCE /NOD LINES /NOEXTEND SOURCE
/F77 /NOG FLOATING /14 /NOMACHINE_CODE /NOOPTIMIZE /NOPARALLEL
/NOANALYSIS DATA
/NO DIAGNOSTICS
/LIST=USER$DISK_26:(BELFIORE.SSMI.SRC.RAINRATE)OPENRAIN.LIS;1
/NOOBJECT
  
```

COMPILATION STATISTICS

```

Run Time: 0.29 seconds
Elapsed Time: 0.85 seconds
Page Faults: 359
Dynamic Memory: 200 pages
  
```

3-Dec-1990 10:52:30
4-Jun-1990 14:44:44

```

0001      function rain_land (t19v, t19h, t22v, t37v, t37h)
0002      C*****
0003      C Function LANDRAIN determines the rate of rainfall over a land mass
0004      C utilizing the collocated SSM/I brightness temperature measurements.
0005      C This algorithm is taken directly from Olson et al (1990).
0006      C
0007      C Note: This algorithm determines the rate of rainfall, independent
0008      C of the 85 GHz brightness temperatures.
0009      C*****
0010      real t19v, t19h, t22v, t37v, t37h
0011      real exp_term, term1, term2, term3, term4, term5
0012
0013      term1 = 0.08150 * t37v
0014      term2 = 0.01638 * t37h
0015      term3 = 0.03561 * t22v
0016      term4 = 0.05079 * t19v
0017      term5 = 0.01875 * t19h
0018
0019      exp_term = (1.32526 - term1 + term2 + term3 + term4 - term5)
0020
0021      rain_land = (exp (exp_term) - 8.0)
0022
0023      return
0024
0025      end

```

PROGRAM SECTIONS

Name	Bytes	Attributes
0 \$CODE	104	PIC CON REL LCL SHR EXE RD NOWRT QUAD
2 \$LOCAL	28	PIC CON REL LCL NOSHR NOEXE RD WRT QUAD
Total Space Allocated	132	

ENTRY POINTS

Address	Type	Name
0-00000000	R*4	RAIN_LAND

VARIABLES

Address	Type	Name	Address	Type	Name
2-00000004	R*4	EXP_TERM	AP-00000004	R*4	T19V
AP-00000014	R*4	T37H	2-00000008	R*4	TERM1
2-00000010	R*4	TERM3	2-00000018	R*4	TERMS
			AP-0000000C	R*4	T22V
			2-0000000C	R*4	TERM2

3-DEC-1990 10:52:30
4-JUN-1990 14:44:44

RAIN_LAND
01

FUNCTIONS AND SUBROUTINES REFERENCED

Type Name

R*4 HTH\$EXP

COMMAND QUALIFIERS

FORTRAN/NOOPT/DEBUG/LIST/NOOBJ RAIN_LAND

```
/CHECK=(NOBOUNDS,OVERFLOW,NOUNDERFLOW)
/DEBUG=(SYMBOLS,TRACEBACK)
/DESIGN=(NOCOMMENTS,NOLACEHOLDERS)
/SHOW=(NODICTIONARY,NOINCLUDE,MAP,NOPREPROCESSOR,SINGLE)
/STANDARD=(NOSEMANTIC,NOSOURCE FORM,NOSYNTAX)
/WARNINGS=(NODECLARATIONS,GENERAL,NOULTRIX,NOVAXELM)
/CONTINUATIONS=19 /NOCROSS REFERENCE /NOD_LINES /NOEXTEND_SOURCE
/F77 /NOG_FLOATING /I4 /NOMACHINE_CODE /NCOPTIMIZE /NOPARALLEL
/NOANALYSIS_DATA
/NO DIAGNOSTICS
/LIST=USER$DISK_26:[BELFIORE.SSMI.SRC.RAINRATE]RAIN_LAND.LIS:1
/NOOBJECT
```

COMPILATION STATISTICS

Run Time: 0.32 seconds
Elapsed Time: 0.85 seconds
Page Faults: 393
Dynamic Memory: 188 pages

3-Dec-1990 10:55:39
14-Jun-1990 17:02:29

```

0001      program rainavg
0002      .....
0003      C Program RAINAVG takes data generated from the RAINRATE program, and
0004      C determines the following:
0005      C
0006      C      - Spatial average of rainfall (per site, per pass)
0007      C
0008      C .....
0009
0010      integer arrcnt, pntcnt, ieof, time, prevtime
0011      real lat, lon, rainrate, ratearr(500,500)
0012
0013      call openrain ( )
0014      call openavg ( )
0015
0016      do 10, j=1,11
0017      ieof = 0
0018      prevtime = 0
0019      pntcnt = 1
0020      arrcnt = 0
0021      do 15, i=1,5000
0022      read (21+j, 100, iostat=ieof) time, lat, lon, rainrate
0023      if (ieof .lt. 0) then
0024      go to 15
0025      endif
0026
0027      C .....
0028      C Load rainrate and time arrays
0029      C .....
0030      if ((time - prevtime) .lt. 600) then
0031      pntcnt = pntcnt + 1
0032      ratearr(arrcnt,pntcnt) = rainrate
0033      else
0034      if (arrcnt .gt. 0) then
0035      call average (prevtime, ratearr, arrcnt, pntcnt, 32+j)
0036      endif
0037      pntcnt = 1
0038      arrcnt = arrcnt + 1
0039      ratearr(arrcnt,pntcnt) = rainrate
0040      endif
0041      prevtime = time
0042
0043      15 continue
0044      call average (prevtime, ratearr, arrcnt, pntcnt, 32+j)
0045      10 continue
0046
0047      C .....
0048      C Formats
0049      C .....
0050      100 format (1X, I18, 2X, 1F6.2, 3X, 1F6.2, 3X, 1F10.4)
0051
0052      end

```

PROGRAM SECTIONS

Name	Bytes	Attributes
0 \$CODE	268	PIC CON REL LCL SHR EXE RD NOWRT QUAD
1 \$PDATA	20	PIC CON REL LCL SHR NOEXE RD NOWRT QUAD
2 \$LOCAL	1000108	PIC CON REL LCL NOSHR NOEXE RD WRT QUAD
Total Space Allocated	1000396	

ENTRY POINTS

Address	Type	Name
0-00000000		RAINAVG

VARIABLES

Address	Type	Name	Address	Type	Name
2-000F4240	I*4	ARRCNT	2-000F4260	I*4	J
2-000F4254	R*4	LAT	2-000F4250	I*4	PREVTIME
2-000F425C	R*4	RAINRATE			

ARRAYS

Address	Type	Name	Bytes	Dimensions
2-00000000	R*4	RATEARR	1000000	(500, 500)

LABELS

Address	Label	Address	Label
0-00000101	10	0-000000E2	15
		1-00000000	100

FUNCTIONS AND SUBROUTINES REFERENCED

Type	Name	Type	Name
AVERAGE	OPENAVG		OPENRAIN

RAINAVG
01

COMMAND QUALIFIERS

```
FORTRAN/NOOPT/DEBUG/LIST/NOOBJ RAINAVG
/CHECK=(NOBOUNDS,OVERFLOW,NOUNDERFLOW)
/DEBUG=(SYMBOLS,TRACEBACK)
/DESIGN=(NOCOMMENTS,NOPPLACEHOLDERS)
/SHOW=(NODICTIONARY,NOINCLUDE,MAP,NOPREPROCESSOR,SINGLE)
/STANDARDS=(NOSEMANTIC,NOSOURCE FORM,NOSYNTAX)
/WARNINGS=(NODECLARATIONS,GENERAL,NOULTRIX,NOVAXELN)
/CONTINUATIONS=19 /NOCROSS REFERENCE /NOD LINES /NOEXTEND SOURCE
/F77 /NOG FLOATING /I4 /NOMACHINE_CODE /NOOPTIMIZE /NOPARALLEL
/NOANALYSIS DATA
/NO DIAGNOSTICS
/LIST=USER$DISK_26:BELFIORE.SSMI.SRC.RAINAVG]RAINAVG.LIS:1
/NOOBJECT
```

COMPILATION STATISTICS

Run Time:	0.52 seconds
Elapsed Time:	0.95 seconds
Page Faults:	502
Dynamic Memory:	344 pages

3-Dec-1990 10:55:39
14-Jun-1990 17:02:29

VAX FORTRAN V5.5-98
[BELFIORE.SSMI.SRC.RAINAVG]RAINAVG.FOR:11 Page 3

3-Dec-1990 10:53:27
26-Jun-1990 09:06:06

```

0001      subroutine average (time, array2d, ar_index, numpts, filecnt)
0002      *
0003      C Subroutine AVERAGE is an averaging routine customized for the RAINAVG
0004      C program. It takes the two dimensional array 'array2d', and averages
0005      C the values for a given data array of specified array index.
0006      *
0007      C 26-Jun-1990: The subroutine has been modified to determine the
0008      C standard deviation for each average.
0009      *
0010      C integer ar_index, time, numpts, filecnt
0011      C real array2d(500,500), arr_total, arr_avg, days, var_tot
0012      C real variance, std_dev
0013      *
0014      arr_avg = 0.0
0015      arr_total = 0.0
0016      do 10, i=1,numpts
0017          arr_total = arr_total + array2d(ar_index,i)
0018      10 continue
0019      *
0020      C Compute Average
0021      C
0022      arr_avg = arr_total / floatj(numpts)
0023      days = earth_time(time)
0024      *
0025      C
0026      C Compute Variance
0027      C
0028      var_tot = 0.0
0029      do 15, i=1,numpts
0030          var_tot = var_tot + ((array2d(ar_index,i) - arr_avg)**2)
0031      15 continue
0032      variance = 0.0
0033      if (numpts .gt. 1) then
0034          variance = var_tot / (floatj(numpts) - 1)
0035      endif
0036      *
0037      C
0038      C Compute Standard Deviation
0039      C
0040      std_dev = 0.0
0041      if (variance .gt. 0.0) then
0042          std_dev = sqrt(variance)
0043      endif
0044      *
0045      C
0046      C Write our results
0047      C
0048      write (filecnt,100) time, days, arr_avg, std_dev, numpts
0049      *
0050      C
0051      C Formats
0052      C
0053      100 format (1X, 118, 2X, 1F16.8, 2X, 1F10.4, 2X, 1F10.4, 2X, 1I4)
0054      *
0055      return
0056      end
0057

```

Name	Bytes	Attributes
0 \$CODE	261	PIC CON REL LCL SHR EXE RD NOWRT QUAD
1 \$PDATA	24	PIC CON REL LCL SHR NOEXE RD NOWRT QUAD
2 \$LOCAL	88	PIC CON REL LCL NOSHR NOEXE RD WRT QUAD
Total Space Allocated	373	

ENTRY POINTS

Address	Type	Name
0-00000000		AVERAGE

VARIABLES

Address	Type	Name	Address	Type	Name
2-00000004	R*4	ARR_AVG	2-00000000	R*4	ARR_TOTAL
AP-00000014	I*4	FILECNT	2-00000018	I*4	I
AP-00000004	I*4	TIME	2-00000010	R*4	VARIANCE
			AP-0000000C	I*4	AR_INDEX
			AP-00000010	I*4	NUMPTS
			2-0000000C	R*4	VAR_TOT
			2-00000008	R*4	DAYS
			2-00000014	R*4	STD_DEV

ARRAYS

Address	Type	Name	Bytes	Dimensions
AP-00000008	R*4	ARRAY2D	1000000	(500, 500)

LABELS

Address	Label	Address	Label
0-0000003D	10	0-00000089	15
		1-00000000	100

FUNCTIONS AND SUBROUTINES REFERENCED

Type	Name	Type	Name
R*4	EARTH_TIME	R*4	MTHSSQRT

3-DEC-1990 10:53:27
26-JUN-1990 09:06:06

AVERAGE
01

COMMAND QUALIFIERS

```
FORTRAN/NOOPT/DEBUG/LIST/NOOBJ AVERAGE
/CHECK=(NOBOUNDS,OVERFLOW,NOUNDERFLOW)
/DEBUG=(SYMBOLS,TRACEBACK)
/DESIGN=(NOCOMMENTS,NOPPLACEHOLDERS)
/SHOW=(MODICTONARY,NOINCLUDE,MAP,NOPREPROCESSOR,SINGLE)
/STANDARD=(NOSEMANANTIC,NOSOURCE_FORM,NOSYNTEX)
/WARNINGS=(NODECLARATIONS,GENERAL,NOULTRIX,NOVAXELN)
/CONTINUATIONS=19 /NOCROSS REFERENCE /MOD_LINES /NOEXTEND SOURCE
/F77 /NOG FLOATING /I4 /NONACHINE_CODE /NOOPTIMIZE /NOPARALLEL
/NOANALYSIS DATA
/NO DIAGNOSTICS
/LIST=USER$DISK_26:[BELFIORE.SSMI.SRC.RAINAVG]AVERAGE.LIS:1
/NOOBJECT
```

COMPILATION STATISTICS

```
Run Time: 0.54 seconds
Elapsed Time: 0.97 seconds
Page faults: 541
Dynamic Memory: 360 pages
```

3-Dec-1993 10:55:01
14-Jun-1990 15:56:21

```

0001      function earth_time(sat_time)
0002      .....
0003      C Function EARTH_TIME computes the decimal number of days elapsed since
0004      C 01-Jun-1989, 00:00 hours (GMT). The input is the mission elapsed time
0005      C in seconds, from the SSM/I sensor array switch on.
0006      C .....
0007      integer sat_time
0008      real elaps_time
0009
0010      elaps_time = sat_time - 76204800
0011      earth_time = elaps_time / 86400.0
0012
0013      return
0014      end

```

PROGRAM SECTIONS

Name	Bytes	Attributes
0 \$CODE	35	PIC CON REL LCL SHR EXE RD NOWRT QUAD
2 \$LOCAL	8	PIC CON REL LCL NOSHR NOEXE RD WRT QUAD
Total Space Allocated	43	

ENTRY POINTS

Address	Type	Name
0-00000000	R*4	EARTH_TIME

Address	Type	Name
2-00000004	R*4	ELAPS_TIME
AP-00000004	I*4	SAT_TIME

VARIABLES

COMMAND QUALIFIERS

```

FORTRAN/NOOPT/DEBUG/LIST/NOOBJ EARTH_TIME
/CHECK=(NOBOUNDS,OVERFLOW,NOUNDERFLOW)
/DEBUG=(SYMBOLS,TRACEBACK)
/DESIGN=(INCOMMENTS,NOPLACEHOLDERS)
/SHOW=(NODICTIONARY,NOINCLUDE,MAP,NOPREPROCESSOR,SINGLE)
/STANDARD=(NOSEMANANTIC,NOSOURCE FORM,NOSYNTEX)
/WARNINGS=(NODECLARATIONS,GENERAL,NOULTRIX,NOVAXELN)
/CONTINUATIONS=19 /NOCROSS REFERENCE /NOD_LINES /NOEXTEND SOURCE
/F77 /NOG FLOATING /I4 /NOMACHINE_CODE /NOOPTIMIZE /NOPARALLEL
/NOANALYSIS DATA
/NO DIAGNOSTICS
/LIST=USER$DISK_25:[BELFIORE.SSMI.SRC.RAINAVG|EARTH_TIME.LIS:1

```

EARTH_TIME
01

/NOBJECT

COMPIATION STATISTICS

Run Time: 0.22 seconds
Elapsed Time: 0.70 seconds
Page faults: 384
Dynamic Memory: 188 pages

3-Dec-1990 10:55:01
14-Jun-1990 15:56:21

VAX FORTRAN V5.5-98
(BELFIORJ.SSMI.SRC.RAINAVG|EARTH_TIME.FOR:1
Page 2

3-DEC-1990 10:55:23
14-JUN-1990 16:15:44

```

0001      subroutine openavg ( )
0002      C.....
0003      C Subroutine OPENAVG opens the output files necessary to keep track *
0004      C of the regional rainfall averages processed from RAINRATE program *
0005      C data run in question.
0006      C.....
0007      open (33, status='unknown', file='Lenigrad_avg.dat')
0008      open (34, status='unknown', file='Kiev_avg.dat')
0009      open (35, status='unknown', file='Simferopol_avg.dat')
0010      open (36, status='unknown', file='Moscow_avg.dat')
0011      open (37, status='unknown', file='Murmansk_avg.dat')
0012      open (38, status='unknown', file='Perm_avg.dat')
0013      open (39, status='unknown', file='Akyubinsk_avg.dat')
0014      open (40, status='unknown', file='Tashkent_avg.dat')
0015      open (41, status='unknown', file='Semipalatinsk_avg.dat')
0016      open (42, status='unknown', file='Chita_avg.dat')
0017      open (43, status='unknown', file='Blagoveshchensk_avg.dat')
0018
0019      return
0020      end
0021

```

PROGRAM SECTIONS

Name	Bytes	Attributes
0 \$CODE	105	PIC CON REL LCL SHR EXE RD NOWRT QUAD
1 \$PDATA	189	PIC CON REL LCL SHR NOEXE RD NOWRT QUAD
2 \$LOCAL	352	PIC CON REL LCL NOSHR NOEXE RD WRT QUAD
Total Space Allocated	646	

ENTRY POINTS

Address	Type	Name
0-000000c0		OPENAVG

FUNCTIONS AND SUBROUTINES REFERENCED

Type	Name
	FORSOPEN


```

0001 program ilwc_tot
0002
0003 integer i, time, numpts
0004 logical wrif
0005 real avg_rate, days
0006 real std_dev
0007 real*4 ilwc
0008 real*4 mm, zm, zm, zm
0009
0010 write (*,*) ' Enter Cloud Top (m): '
0011 read (*,*) zm
0012 write (*,*) ' Enter Cloud Height of Maximum LWC (m): '
0013 read (*,*) zm
0014 write (*,*) ' Enter Maximum LWC (units): '
0015 read (*,*) mm
0016
0017 open (1, file='.rawdata\blagoveschensk tot.dat',
0018      status='unknown') ! - Tot file
0019 open (2, file='blagoveschensk ilwc.dat',
0020      status='unknown') ! - ilwc file
0021
0022 do 10, i=1,161
0023   read (1,100) time, days, avg_rate, std_dev, numpts
0024   if (abs(avg_rate) .ge. 1.5) then
0025     call ilwc_conv (zm, zm, mm, avg_rate, ilwc, wrif)
0026   else
0027     call ilwc_strat (zm, zm, mm, avg_rate, ilwc, wrif)
0028   endif
0029
0030   if (wrif) then
0031     write (2,110) days, ilwc
0032   endif
0033
0034 10 continue
0035
0036 rewind (1)
0037 open (3, file='blagoveschensk conv.dat', status='unknown')
0038 open (4, file='blagoveschensk strat.dat', status='unknown')
0039
0040 do 15 i=1,161
0041   read (1,100) time, days, avg_rate, std_dev, numpts
0042   call ilwc_conv (zm, zm, mm, avg_rate, ilwc, wrif)
0043   if (wrif) then
0044     write (3,110) days, ilwc
0045   endif
0046   call ilwc_strat (zm, zm, mm, avg_rate, ilwc, wrif)
0047   if (wrif) then
0048     write (4,110) days, ilwc
0049   endif
0050 15 continue
0051
0052 100 format (1X, 118, 2X, 1F16.8, 2X, 1F10.4, 2X, 1F10.4, 2X, 1I4)
0053 110 format (1X, 1F16.8, 2X, 1F16.4)
0054
0055 end

```

PROGRAM SECTIONS

Name	Bytes	Attributes
0 \$CODE	578	PIC CON REL LCL SHR EXE RD NOWRT QUAD
1 \$PDATA	231	PIC CON REL LCL SHR NOEXE RD NOWRT QUAD
2 \$LOCAL	308	PIC CON REL LCL NOSHR NOEXE RD WRT QUAD
Total Space Allocated	1117	

ENTRY POINTS

Address	Type	Name
0-00000000		ILWC_TOT

VARIABLES

Address	Type	Name	Address	Type	Name
2-00000010	R*4	AVG_RATE	2-00000014	R*4	DAYS
2-00000020	R*4	MM	2-00000008	I*4	NUMPTS
2-0000000C	L*4	WRIF	2-00000024	R*4	ZM
			2-00000000	I*4	I
			2-00000018	R*4	STD_DEV
			2-00000028	R*4	ZT
			2-0000001C	R*4	ILWC
			2-00000004	I*4	TIME

LABELS

Address	Label	Address	Label
0-00000156	10	0-00000234	15
		1-000000C4	100'
		1-000000DC	110'

FUNCTIONS AND SUBROUTINES REFERENCED

Type	Name	Type	Name
FOR\$OPEN	ILWC_CONV		ILWC_STRAT

COMMAND QUALIFIERS

```

FORTRAN/NOOPT/DEBUG/LIST/NOOBJ ILWC_TOT
/CHECK=(NOBOUNDS,OVERFLOW,NOUNDERFLOW)
/DEBUG=(SYMBOLS,TRACEBACK)
/DESIGN=(NOCOMMENTS,NOPLACEHOLDERS)
/SHOW=(NODICTIONARY,NOINCLUDE,MAP,NOPREPROCESSOR,SINGLE)
/STANDARD=(NOSEMANATIC,NOSOURCE FORM,NOSYNTAX)
/WARNINGS=(NODECLARATIONS,GENERAL,NOULTRIX,NOVAXELN)
/CONTINUATIONS=19 /NOCROSS REFERENCE /NOD_LINES /NOEXTEND SOURCE
/F77 /NOG FLOATING /I4 /NOMACHINE_CODE /NOOPTIMIZE /NOPARALLEL
/NOANALYSIS DATA
/NO DIAGNOSTICS
/LIST=USER$DISK_26:BELFIORE.SSMI.SRC.ILWC|ILWC_TOT.LIS:1
/NOOBJECT

```

ILWC_TOT
01

COMPILATION STATISTICS

Run Time: 0.71 seconds
Elapsed Time: 1.18 seconds
Page Faults: 497
Dynamic Memory: 360 pages

3-Dec-1990 11:02:40
3-Dec-1990 09:06:11

VAX FORTRAN V5.5-98
(BELFIORE.SSMI.SRC.ILWC)ILWC_TOT.FOR:11 Page 3

3-Dec-1990 11:02:28
2-Nov-1990 14:02:57

```

0001      subroutine ilwc_conv (zm, zt, mm, avg_rate, ilwc, wrif)
0002
0003      logical wrif
0004      real avg_rate
0005      real*4 cst_a, cst_a1, cst_a2, cst_a3, cst_a4
0006      real*4 cst_b, cst_b1, cst_b2, cst_b3, cst_b4
0007      real*4 cst_c, cst_c1, cst_c2, cst_c3, cst_c4
0008      real*4 cst_d
0009      real*4 ilwc
0010      real*4 mm, ms, zm, zt
0011      real*4 term_1, term_2, term_3, term_4, term_5
0012
0013      if (avg_rate .eq. 0.0) then
0014         wrif = .false.
0015         return
0016      endif
0017
0018      wrif = .true.
0019      ms = 0.07 * (avg_rate**0.83)
0020
0021      cst_a1 = 1.0 / ((zm**5)*(zt**2)) - (2.*(zm**4)*(zt**3))
0022      + ((zm**3)*(zt**4))
0023      cst_a2 = ((3.*(zm)*(zt**2)) - (2.*(zt**3)) - (zm**3))*ms
0024      cst_a3 = ((3.*(zm)*(zt**2)) - (2.*(zt**3)))*mm
0025      cst_a4 = cst_a2 - cst_a3
0026      cst_a = cst_a1 * cst_a4
0027
0028      cst_b1 = -1. * cst_a1
0029      cst_b2 = ((4.*(zm**2)*(zt**2)) - (2.*(zt**4)) -
0030      + (2.*(zm**4))*ms
0031      cst_b3 = ((4.*(zm**2)*(zt**2)) - (2.*(zt**4))*mm
0032      cst_b4 = cst_b2 - cst_b3
0033      cst_b = cst_b4 * cst_b1
0034
0035      cst_c1 = -1.0 / ((zm**4)*(zt**2)) - (2.*(zm**3)*(zt**3))
0036      + ((zm**2)*(zt**4))
0037      cst_c2 = ((zm**4) - (4.0*zm*(zt**3)) + (3.0*(zt**4))*ms
0038      cst_c3 = ((4.0*zm*(zt**3)) - (3.0*(zt**4))*mm
0039      cst_c4 = cst_c2 + cst_c3
0040      cst_c = cst_c1 * cst_c4
0041
0042      cst_d = ms
0043
0044      term_1 = (cst_a/5.0) * (zt**5)
0045      term_2 = (cst_b/4.0) * (zt**4)
0046      term_3 = (cst_c/3.0) * (zt**3)
0047      term_4 = (cst_d) * (zt)
0048      term_5 = ms
0049
0050      ilwc = term_1 + term_2 + term_3 + term_4 + term_5
0051
0052      return
0053      end

```

PROGRAM SECTIONS

Name	Bytes	Attributes
0 \$CODE	680	PIC CON REL LCL SHR EXE RD NOWRT QUAD
2 \$LOCAL	88	PIC CON REL LCL NOSHR NOEXE RD WRT QUAD
Total Space Allocated	768	

ENTRY POINTS

Address	Type	Name
0-00000000		ILWC_CONV

VARIABLES

Address	Type	Name	Address	Type	Name	Address	Type	Name
AP-00000010	R*4	AVG_RATE	2-00000000	R*4	CST_A	2-00000008	R*4	CST_A2
2-0000000C	R*4	CST_A3	2-00000010	R*4	CST_A4	2-00000018	R*4	CST_B1
2-0000001C	R*4	CST_B2	2-00000020	R*4	CST_B3	2-00000028	R*4	CST_C
2-0000002C	R*4	CST_C1	2-00000030	R*4	CST_C2	2-00000038	R*4	CST_C4
2-0000003C	R*4	CST_D	AP-00000014	R*4	ILWC	2-00000040	R*4	MS
2-00000044	R*4	TERM_1	2-00000048	R*4	TERM_2	2-00000050	R*4	TERM_4
2-00000054	R*4	TERM_5	AP-00000018	L*4	WRIF	AP-00000058	R*4	ZT
			AP-00000018	L*4	WRIF			

COMMAND QUALIFIERS

```

FORTRAN/NOOPT/DEBUG/LIST/NOOBJ ILWC_CONV
/CHECK=(NOBOUNDS,OVERFLOW,NOUNDERFLOW)
/DEBUG=(SYMBOLS,TRACEBACK)
/DESIGN=(NOCOMMENTS,NOLACHECKERS)
/SHOW=(NODICTIONARY,NOINCLUDE,MAP,NOPREPROCESSOR,SINGLE)
/STANDARD=(NOSEMANANTIC,NOSOURCE FORM,NOSYNTAX)
/WARNINGS=(NODECLARATIONS,GENERAL,NOULTRIX,MOVAXELN)
/CONTINUATIONS=19 /NOCROSS REFERENCE /NOD_LINES /NOEXTEND SOURCE
/F77 /NOG_FLOATING /I4 /NOMACHINE_CODE /NOOPTIMIZE /NOPARALLEL
/NOANALYSIS DATA
/NOAGNOSTICS
/LIST=USERSDISK_26:[BELFIORE.SSMI.SRC.ILWC]ILWC_CONV.LIS:1
/NOOBJECT
  
```

COMPILATION STATISTICS

```

Run Time: 0.88 seconds
Elapsed Time: 1.27 seconds
Page Faults: 454
Dynamic Memory: 360 pages
  
```

```

0001      subroutine ilwc_strat (zm, zt, mm, avg_rate, ilwc)
0002
0003      logical wrif
0004      real avg_rate
0005      real std_dev
0006      real*4 cst_a, cst_a1, cst_a2, cst_a3, cst_a4
0007      real*4 cst_b, cst_b1, cst_b2, cst_b3, cst_b4
0008      real*4 cst_c, cst_c1, cst_c2, cst_c3, cst_c4
0009      real*4 cst_d
0010      real*4 ilwc
0011      real*4 mm, ms, zm, zt
0012      real*4 term_1, term_2, term_3, term_4, term_5
0013
0014      if (avg_rate.eq. 0.0) then
0015         wrif=.false.
0016         return
0017      endif
0018
0019      wrif = .true.
0020      ms = 0.07 * (avg_rate**0.83)
0021
0022      cst_a1 = -1.0/ ( (zm**2) * (zt) * ((zt - zm)**2) )
0023      cst_a2 = ((zt - zm)**2)*ms
0024      cst_a3 = (zt * (2.0 * zm - zt)) * mm
0025      cst_a4 = cst_a2 + cst_a3
0026      cst_a = cst_a1 * cst_a4
0027
0028      cst_b1 = cst_a1
0029      cst_b2 = ((3.0*(zm**2)*zt) - (zt**3) - (2.0*(zm**3)))*ms
0030      cst_b3 = ((3.0*(zm**2)*zt) - (zt**3))*mm
0031      cst_b4 = cst_b2 - cst_b3
0032      cst_b = cst_b4 * cst_b1
0033
0034      cst_c1 = -1.0/((zm*zt) * ((zt - zm)**2))
0035      cst_c2 = ((zm**3) - (3.0*zm*(zt**2)) + (2.0*(zt**3)))*ms
0036      cst_c3 = ((3.0*zm*(zt**2)) - (2.0*(zt**3))*mm
0037      cst_c4 = cst_c2 + cst_c3
0038      cst_c = cst_c1 * cst_c4
0039
0040      cst_d = ms
0041
0042      term_1 = (cst_a/4.0) * (zt**4)
0043      term_2 = (cst_b/3.0) * (zt**3)
0044      term_3 = (cst_c/2.0) * (zt**2)
0045      term_4 = (cst_d) * (zt)
0046      term_5 = ms
0047
0048      ilwc = term_1 + term_2 + term_3 + term_4 + term_5
0049
0050      return
0051      end

```

PROGRAM SECTIONS

Name	Bytes	Attributes
0 \$CODE	464	PIC CON REL LCL SHR EXE RD NOWRT QUAD
2 \$LOCAL	96	PIC CON REL LCL NOSHR NOEXZ RD WRT QUAD
Total Space Allocated	560	

ENTRY POINTS

Address	Type	Name
0-00000000		ILWC_STRAT

VARIABLES

Address	Type	Name	Address	Type	Name	Address	Type	Name
AP-00000010	R*4	AVG_RATE	2-00000008	R*4	CST_A	2-0000000C	R*4	CST_A1
2-00000014	R*4	CST_A3	2-00000018	R*4	CST_A4	2-0000001C	R*4	CST_B1
2-00000024	R*4	CST_B2	2-00000028	R*4	CST_B3	2-0000002C	R*4	CST_B4
2-00000034	R*4	CST_C1	2-00000038	R*4	CST_C2	2-0000003C	R*4	CST_C3
2-00000044	R*4	CST_D	AP-00000014	R*4	ILWC	2-00000040	R*4	CST_C4
2-00000004	R*4	STD_DEV	2-0000004C	R*4	TERM_1	2-00000048	R*4	MS
2-00000058	R*4	TERM_4	2-0000005C	R*4	TERM_5	2-00000054	R*4	TERM_3
AP-00000008	R*4	ZT	2-00000000	L*4	WRIF	2-00000054	R*4	TERM_3
						AP-00000004	R*4	ZM

COMMAND QUALIFIERS

```

FORTRAN/NOOPT/DEBUG/LIST/NOOBJ ILWC_STRAT
/CHECK=(NOBOUNDS,OVERFLOW,NONDERFLOW)
/DEBUG=(SYMBOLS,TRACEBACK)
/DESIGN=(NOCOMMENTS,NOLACEHOLDERS)
/SHOW=(MODIFICATION,NOLCL,MAP,NOPREPROCESSOR,SINGLE)
/STANDARD=(NOSEMANANTIC,NOSOURCEFORM,NOSYNTAX)
/WARNINGS=(NODECLARATIONS,GENERAL,NOULTRIX,NOVAXELM)
/CONTINUATIONS=19 /NOCROSS REFERENCE /NOD LINES /NOEXTEND SOURCE
/F77 /NOG FLOATING /I4 /NOMACHINE_CODE /NOOPTIMIZE /NOPARALLEL
/NOANALYSIS_DATA
/NO DIAGNOSTICS
/LIST=USER$DISK_26:[BELFIORE.SSMI.SRC:ILWC]ILWC_STRAT.LIS:1
/NOOBJECT
  
```

COMPILATION STATISTICS

```

Run Time: 0.70 seconds
Elapsed Time: 1.17 seconds
Page Faults: 425
Dynamic Memory: 216 pages
  
```

Appendix B Sample Output from the Tape Reading Algorithm

Time (Seconds)	Longitude (Degrees)	Latitude (Degrees)	Brightness Temperature (K)				
			19.35v	19.35h	22.235	37v	37h
86543433	55.68	38.46	270.60	266.80	270.40	269.50	265.90
86543433	55.81	38.79	272.40	269.30	271.40	269.70	266.70
86543433	55.93	39.13	272.10	269.30	271.20	270.50	267.60
86543437	55.02	37.48	271.10	268.80	271.60	269.40	266.50
86543437	55.17	37.78	270.80	268.20	270.80	269.30	266.10
86543437	55.31	38.08	270.00	265.10	271.40	268.40	264.30
86543437	55.46	38.39	271.10	264.50	269.30	267.40	263.30
86543437	55.59	38.72	271.60	267.50	270.10	269.60	266.60
86543437	55.71	39.06	271.50	268.60	272.00	269.30	266.00
86543440	54.80	37.42	271.90	268.70	270.60	268.60	265.40
86543440	54.95	37.72	271.90	268.60	271.60	269.30	266.20
86543440	55.09	38.02	271.50	267.60	269.70	268.30	266.00
86543440	55.24	38.33	271.00	264.90	269.10	267.60	264.00
86543440	55.37	38.66	270.50	265.60	270.20	267.90	263.40
86543440	55.49	39.00	271.90	268.60	270.30	269.10	266.00
86543444	54.58	37.36	271.60	268.20	269.10	268.10	264.90
86543444	54.73	37.66	271.20	268.20	269.90	268.50	264.70
86543444	54.87	37.96	271.20	267.70	269.90	268.50	266.10
86543444	55.02	38.26	271.20	265.90	268.10	268.10	264.90
86543444	55.15	38.59	270.60	265.20	269.60	267.80	262.90
86543444	55.27	38.93	270.90	266.80	270.00	268.80	264.90
86543448	54.35	37.30	270.30	266.70	268.70	267.60	264.80
86543448	54.50	37.60	271.10	266.90	267.60	267.90	266.00
86543448	54.65	37.90	271.40	267.80	270.40	268.80	264.80
86543448	54.80	38.20	270.30	267.30	269.90	267.60	264.40
86543448	54.93	38.53	270.00	264.90	268.10	267.10	263.30
86543448	55.05	38.86	270.40	264.70	269.80	266.90	262.80
86543448	55.18	39.19	270.90	266.00	269.30	268.30	265.10
86543452	54.28	37.54	269.80	266.70	268.50	267.20	263.70
86543452	54.43	37.83	270.40	266.20	268.30	268.10	264.90
86543452	54.58	38.13	270.40	267.20	270.40	268.40	264.90
86543452	54.71	38.46	269.70	264.90	268.30	267.20	262.70
86543452	54.83	38.79	268.80	263.60	268.70	266.90	262.00
86543452	54.96	39.12	269.70	263.40	268.50	266.90	261.70
86543456	54.21	37.77	270.10	266.60	268.40	266.40	262.80
86543456	54.36	38.07	270.30	266.30	269.90	267.30	264.40
86543456	54.49	38.39	270.20	265.70	270.10	266.90	264.40
86543456	54.61	38.72	269.10	264.30	268.20	265.60	262.10
86543456	54.74	39.05	269.20	263.80	269.00	266.60	261.80
86543459	54.27	38.33	270.20	265.70	268.80	267.10	263.00
86543459	54.39	38.66	269.30	264.00	268.40	266.80	263.50
86543459	54.52	38.98	269.00	263.70	268.00	266.40	262.50
86543463	54.17	38.59	269.60	264.50	267.40	266.50	262.00
86543463	54.30	38.91	269.70	264.30	267.60	266.30	262.50
86543467	54.20	39.17	269.80	266.00	268.10	267.30	264.20
86720726	57.73	39.10	267.70	264.20	264.90	264.20	262.80
86720730	57.70	38.66	266.20	263.70	267.30	265.60	264.30
86720730	57.52	38.93	267.50	265.20	267.50	265.40	263.20
86720730	57.34	39.18	267.20	264.50	266.80	263.70	261.30
86720733	57.68	38.22	264.70	259.80	264.00	263.80	260.50
86720733	57.50	38.48	267.60	264.50	267.30	266.40	265.20
86720733	57.32	38.75	268.30	265.50	267.30	265.50	264.00
86720733	57.14	39.00	267.80	264.90	266.00	265.10	263.20
86720737	57.63	37.74	263.50	258.70	264.50	261.80	259.70
86720737	57.47	38.04	263.50	258.00	264.90	262.50	257.20
86720737	57.29	38.30	267.50	264.60	265.70	266.80	264.90
86720737	57.11	38.57	268.30	265.20	267.40	266.00	265.10
86720737	56.93	38.82	267.10	263.70	266.50	264.30	261.20

Appendix C Mapping Software

3-Dec-1990 10:32:59
14-Aug-1990 09:03:17

```

0001      program where
0002
0003      C*****
0004      C Program WHERE prompts the user for an elapsed time in the SSM/I data
0005      C mission (zero time defined as 00:07.31 - 01-June-1990), and a time
0006      C "window". It then, via NCAR and GKS, projects a map of the world.
0007      C and superimposes the track of the satellite scanning platform at that
0008      C time.
0009      C*****
0010
0011      include 'sys$library:gksdefs.for'
0012      integer ws_id, linewidth
0013      data ws_id/1/
0014
0015      character*60 fname
0016      real lat, lon, rot, xmax, ymax
0017      real dlat, dlon, d1, d2, d3, d4, d5
0018      real dummies
0019      integer i, time, choice, prevtime
0020      integer ws_type, error, dummyi
0021      common /ws_vars/ ws_id, xmax, ymax, lat, lon
0022
0023      C*****
0024      C Get data file
0025      C*****
0026      write (*,*) 'Enter file name (in quotes): '
0027      read (*,*) fname
0028      open (4, file=fname, status='unknown')
0029      read (4,150) time, lat, lon, d1, d2, d3, d4, d5
0030      rewind (4)
0031
0032      write (*,*) 'Enter (1) for orthographic or (2) for cylindrical
0033      'equidistant projection: '
0034      read (*,*) choice
0035      write (*,*) 'Enter number of lines to be read: '
0036      read (*,*) linewidth
0037
0038      C*****
0039      C Open gks
0040      C*****
0041      call gks$open_gks ('sys$error:','
0042      ' call gks$open_ws (ws_id, gks$gk_conid_default,
0043      ' gks$gk_ws_type_default)
0044      call gks$inq_ws_type (ws_id, error, dummies, ws_type, dummyi)
0045      call gks$inq_max_ds_size (ws_type, error, dummyi, dummyi)
0046      call gks$activate_ws (ws_id)
0047
0048      C*****
0049      C Set color indices
0050      C*****
0051      Call SETUSV('IM',3) : 3 possible colors
0052
0053      Call SETUSV('IR',1) :RED
0054      Call SETUSV('IG',0)
0055      Call SETUSV('IB',0)
0056
0057
0058
0059
0060
0061
0062
0063
0064
0065
0066
0067
0068
0069
0070
0071
0072

```


3-DEC-1990 10:32:59
14-AUG-1990 09:03:17

WHERE

```

1130      prevtime = time
1131      100 continue
1132      150 format (1X, 1I8, 2X, F6.2, 3X, F6.2, 5X, 5(F6.2,2X))
1133
1134      call gks$update_ws (ws_id, gks$ postpone_flag)
1135      call gks$update_ws (ws_id, gks$ postpone_flag)
1136      c      pause
1137
1138      C*****
1139      C      Close GKS *
1140      C*****
1141      call gks$deactivate_ws (ws_id)
1142      call gks$close_ws (ws_id)
1143      call gks$close_gks
1144
1145      END

```

PROGRAM SECTIONS

Name	Bytes	Attributes
C \$CODE	797	PIC CON REL LCL SHR EXE RD NOWRT QUAD
1 \$PDATA	239	PIC CON REL LCL SHR NOEXE RD NOWRT QUAD
2 \$LOCAL	832	PIC CON REL LCL NOSHR NOEXE RD WRT QUAD
3 \$WS_VARS	20	PIC OVR REL GBL SHR NOEXE RD WRT QUAD
Total Space Allocated	1888	

ENTRY POINTS

Address	Type	Name
0-00000000	WHERE	

VARIABLES

Address	Type	Name	Address	Type	Name
2-0000006C	I*4	CHOICE	2-00000050	R*4	D2
2-00000058	R*4	D4	2-00000044	R*4	D3
2-0000007C	I*4	DUMMYI	2-00000048	R*4	DLOW
2-00000064	I*4	I	2-00000000	CHAR	FRAME
3-0000000C	R*4	LAT	2-00000088	I*4	I3
2-00000040	R*4	ROT	2-00000070	I*4	PREVTIME
3-00000004	R*4	XMAX	2-00000074	I*4	WS_TYPE
			3-00000000	I*4	WS_ID
			2-00000054	R*4	D3
			2-00000044	R*4	DLOW
			2-00000078	I*4	ERROR
			2-00000084	I*4	I2
			3-00000010	R*4	LON
			3-00000000	I*4	WS_ID
			2-00000050	R*4	D2
			2-00000044	R*4	D3
			2-00000078	I*4	ERROR
			2-00000084	I*4	I2
			3-00000010	R*4	LON
			3-00000000	I*4	WS_ID
			2-00000054	R*4	D3
			2-00000044	R*4	DLOW
			2-00000078	I*4	ERROR
			2-00000084	I*4	I2
			3-00000010	R*4	LON
			3-00000000	I*4	WS_ID
			2-00000050	R*4	D2
			2-00000044	R*4	D3
			2-00000078	I*4	ERROR
			2-00000084	I*4	I2
			3-00000010	R*4	LON
			3-00000000	I*4	WS_ID
			2-00000054	R*4	D3
			2-00000044	R*4	DLOW
			2-00000078	I*4	ERROR
			2-00000084	I*4	I2
			3-00000010	R*4	LON
			3-00000000	I*4	WS_ID
			2-00000050	R*4	D2
			2-00000044	R*4	D3
			2-00000078	I*4	ERROR
			2-00000084	I*4	I2
			3-00000010	R*4	LON
			3-00000000	I*4	WS_ID
			2-00000054	R*4	D3
			2-00000044	R*4	DLOW
			2-00000078	I*4	ERROR
			2-00000084	I*4	I2
			3-00000010	R*4	LON
			3-00000000	I*4	WS_ID
			2-00000050	R*4	D2
			2-00000044	R*4	D3
			2-00000078	I*4	ERROR
			2-00000084	I*4	I2
			3-00000010	R*4	LON
			3-00000000	I*4	WS_ID
			2-00000054	R*4	D3
			2-00000044	R*4	DLOW
			2-00000078	I*4	ERROR
			2-00000084	I*4	I2
			3-00000010	R*4	LON
			3-00000000	I*4	WS_ID
			2-00000050	R*4	D2
			2-00000044	R*4	D3
			2-00000078	I*4	ERROR
			2-00000084	I*4	I2
			3-00000010	R*4	LON
			3-00000000	I*4	WS_ID
			2-00000054	R*4	D3
			2-00000044	R*4	DLOW
			2-00000078	I*4	ERROR
			2-00000084	I*4	I2
			3-00000010	R*4	LON
			3-00000000	I*4	WS_ID
			2-00000050	R*4	D2
			2-00000044	R*4	D3
			2-00000078	I*4	ERROR
			2-00000084	I*4	I2
			3-00000010	R*4	LON
			3-00000000	I*4	WS_ID
			2-00000054	R*4	D3
			2-00000044	R*4	DLOW
			2-00000078	I*4	ERROR
			2-00000084	I*4	I2
			3-00000010	R*4	LON
			3-00000000	I*4	WS_ID
			2-00000050	R*4	D2
			2-00000044	R*4	D3
			2-00000078	I*4	ERROR
			2-00000084	I*4	I2
			3-00000010	R*4	LON
			3-00000000	I*4	WS_ID
			2-00000054	R*4	D3
			2-00000044	R*4	DLOW
			2-00000078	I*4	ERROR
			2-00000084	I*4	I2
			3-00000010	R*4	LON
			3-00000000	I*4	WS_ID
			2-00000050	R*4	D2
			2-00000044	R*4	D3
			2-00000078	I*4	ERROR
			2-00000084	I*4	I2
			3-00000010	R*4	LON
			3-00000000	I*4	WS_ID
			2-00000054	R*4	D3
			2-00000044	R*4	DLOW
			2-00000078	I*4	ERROR
			2-00000084	I*4	I2
			3-00000010	R*4	LON
			3-00000000	I*4	WS_ID
			2-00000050	R*4	D2
			2-00000044	R*4	D3
			2-00000078	I*4	ERROR
			2-00000084	I*4	I2
			3-00000010	R*4	LON
			3-00000000	I*4	WS_ID
			2-00000054	R*4	D3
			2-00000044	R*4	DLOW
			2-00000078	I*4	ERROR
			2-00000084	I*4	I2
			3-00000010	R*4	LON
			3-00000000	I*4	WS_ID
			2-00000050	R*4	D2
			2-00000044	R*4	D3
			2-00000078	I*4	ERROR
			2-00000084	I*4	I2
			3-00000010	R*4	LON
			3-00000000	I*4	WS_ID
			2-00000054	R*4	D3
			2-00000044	R*4	DLOW
			2-00000078	I*4	ERROR
			2-00000084	I*4	I2
			3-00000010	R*4	LON
			3-00000000	I*4	WS_ID
			2-00000050	R*4	D2
			2-00000044	R*4	D3
			2-00000078	I*4	ERROR
			2-00000084	I*4	I2
			3-00000010	R*4	LON
			3-00000000	I*4	WS_ID
			2-00000054	R*4	D3
			2-00000044	R*4	DLOW
			2-00000078	I*4	ERROR
			2-00000084	I*4	I2
			3-00000010	R*4	LON
			3-00000000	I*4	WS_ID
			2-00000050	R*4	D2
			2-00000044	R*4	D3
			2-00000078	I*4	ERROR
			2-00000084	I*4	I2
			3-00000010	R*4	LON
			3-00000000	I*4	WS_ID
			2-00000054	R*4	D3
			2-00000044	R*4	DLOW
			2-00000078	I*4	ERROR
			2-00000084	I*4	I2
			3-00000010	R*4	LON
			3-00000000	I*4	WS_ID
			2-00000050	R*4	D2
			2-00000044	R*4	D3
			2-00000078	I*4	ERROR
			2-00000084	I*4	I2
			3-00000010	R*4	LON
			3-00000000	I*4	WS_ID
			2-00000054	R*4	D3
			2-00000044	R*4	DLOW
			2-00000078	I*4	ERROR
			2-00000084	I*4	I2
			3-00000010	R*4	LON
			3-00000000	I*4	WS_ID
			2-00000050	R*4	D2
			2-00000044	R*4	D3
			2-00000078	I*4	ERROR
			2-00000084	I*4	I2
			3-00000010	R*4	LON
			3-00000000	I*4	WS_ID
			2-00000054	R*4	D3
			2-00000044	R*4	DLOW
			2-00000078	I*4	ERROR
			2-00000084	I*4	I2
			3-00000010	R*4	LON
			3-00000000	I*4	WS_ID
			2-00000050	R*4	D2
			2-00000044	R*4	D3
			2-00000078	I*4	ERROR
			2-00000084	I*4	I2
			3-00000010	R*4	LON
			3-00000000	I*4	WS_ID
			2-00000054	R*4	D3
			2-00000044	R*4	DLOW
			2-00000078	I*4	ERROR
			2-00000084	I*4	I2
			3-00000010	R*4	LON
			3-00000000	I*4	WS_ID
			2-00000050	R*4	D2
			2-00000044	R*4	D3
			2-00000078	I*4	ERROR
			2-00000084	I*4	I2
			3-00000010	R*4	LON
			3-00000000	I*4	WS_ID
			2-00000054	R*4	D3
			2-00000044	R*4	DLOW
			2-00000078	I*4	ERROR
			2-00000084	I*4	I2
			3-00000010	R*4	LON
			3-00000000	I*4	WS_ID
			2-00000050	R*4	D2
			2-00000044	R*4	D3
			2-00000078	I*4	ERROR
			2-00000084	I*4	I2
			3-00000010	R*4	LON
			3-00000000	I*4	WS_ID
			2-00000054	R*4	D3
			2-00000044	R*4	DLOW
			2-00000078	I*4	ERROR
			2-00000084	I*4	I2
			3-00000010	R*4	LON
			3-00000000	I*4	WS_ID
			2-00000050	R*4	D2
			2-00000044	R*4	D3
			2-00000078	I*4	ERROR
			2-00000084	I*4	I2
			3-00000010	R*4	LON
			3-00000000	I*4	WS_ID
			2-00000054	R*4	D3
			2-00000044	R*4	DLOW
			2-00000078	I*4	ERROR
			2-00000084	I*4	I2
			3-00000010	R*4	LON
			3-00000000	I*4	WS_ID
			2-00000050	R*4	D2
			2-00000044	R*4	D3
			2-00000078	I*4	ERROR
			2-00000084	I*4	I2
			3-00000010	R*4	LON
			3-00000000	I*4	WS_ID
			2-00000054	R*4	D3
			2-00000044	R*4	DLOW
			2-00000078	I*4	ERROR
			2-00000084	I*4	I2
			3-00000010	R*4	LON
			3-00000000	I*4	WS_ID
			2-00000050	R*4	D2
			2-00000044	R*4	D3

LABELS

Address	Label	Address	Label
0-000002E6	100	1-000000D4	150'

FUNCTIONS AND SUBROUTINES REFERENCED

Type	Name	Type	Name
	FOR\$OPEN		GETUSV
	GK\$CLOSE		GK\$CLOSE_WS
	GK\$INO		GK\$INO_WS
	GK\$OPEN_WS_DS_SIZE		GK\$UPDATE_WS
	MAPINT		MAPIT
	MAPLOT		MAPSTC
	SETUSV		

COMMAND QUALIFIERS

```

FORTRAN/NOOPT/DEBUG/LIST/NOOBJ WHERE
/CHECK=(NOBOUNDS,OVERFLOW,NOUNDERFLOW)
/DEBUG=(SYMBOLS,TRACEBACK)
/DESIGN=(NOCOMMENTS,NOLACEHOLDERS)
/SHOW=(NODICTIONARY,NOLCLUE,MAP,NOPREPROCESSOR,SINGLE)
/STANDARD=(NOSEMANANTIC,NOSOURCE,FOM,NOSYNTEX)
/WARNINGS=(NODECLARATIONS,GENERAL,NOLTRIX,NOVAXELN)
/CONTINUATIONS=19 /NOCROSS REFERENCE /NOD LINES /NOEXTEND SOURCE
/F77 /NOG FLOATING /I4 /NOMACHINE_CODE /NOOPTIMIZE /NOPARALLEL
/NOANALYSIS DATA
/NO DIAGNOSTICS
/LIST=USER$DISK_26:{BELFIORE.SSMI.SRC.DISPLAY}WHERE.LIS:1
/NOOBJECT

```

COMPILATION STATISTICS

Run Time:	3.01 seconds
Elapsed Time:	4.74 seconds
Page Faults:	747
Dynamic Memory:	560 pages

```

0001      subroutine ce_map
0002
0003      common /ws_vars/ ws_id, xmax, ymax, lat, lon
0004
0005      call gks$set_ws_viewport (ws_id, 0.0, xmax, 0.0, ymax)
0006      call gks$set_ws_window (ws_id, 0.0, 1.0, 0.25, 0.75)
0007      call gks$update_ws (ws_id, gks$perform_flag)
0008
0009      C.....
0010      C Use cylindrical equidistant projection
0011      C.....
0012      Call MAPROJ('CE',0.0,0.0,0.0)
0013
0014      C.....
0015      C Specify the angular distances to the edges of the map
0016      C.....
0017      call ma set('CO',90.,-180.,-90.,180.)
0018
0019      return
0020      end

```

PROGRAM SECTIONS

Name	Bytes	Attributes
0 \$CODE	50	PIC CON REL LCL SHR EXE RD NOWRT QUAD
1 \$DATA	38	PIC CON REL LCL SHR NOEXE RD NOWRT QUAD
2 \$LOCAL	124	PIC CON REL LCL NOSHR NOEXE RD WRT QUAD
3 \$WS_VARS	20	PIC OVR REL GEL SHR NOEXE RD WRT QUAD
Total Space Allocated	232	

ENTRY POINTS

Address	Type	Name
0-00000000		CE_MAP

VARIABLES

Address	Type	Name
2-00000000	R*4	GK\$K_PERFORM_FLAG
3-00000010	I*4	WS_ID
3-00000000	R*4	WS_ID
3-00000000	R*4	YMAX

FUNCTIONS AND SUBROUTINES REFERENCED

Type Name	Type Name	Type Name
GKSSSET_WS_VIEWPORT MAPROJ	GKSSSET_WS_WINDOW MAPSET	GKSSUPDATE_WS

COMMAND QUALIFIERS

```

FORTRAN/NOOPT/DEBUG/LIST/NOOBJ CE_MAP
/CHECK=(NOBOUNDS,OVERFLOW,NOUNDERFLOW)
/DEBUG=(SYMBOLS,TRACEBACK)
/DESIGN=(NOCOMMENTS,NOPLACEHOLDERS)
/SHOW=(NOdictionary,NOINCLUDE,MAP,NOPREPROCESSOR,SINGLE)
/STANDARD=(NOSEMANTIC,NOSOURCE FORM,NOSYNTAX)
/WARNINGS=(NODECLARATIONS,GENERAL,NOULTRIX,NOVAXELN)
/CONTINUATIONS=19 /NOCROSS REFERENCE /NOD_LINES /NOEXTEND SOURCE
/F77 /NOG FLOATING /I4 /NONACHINE_CODE /NOOPTIMIZE /NOPARALLEL
/NOANALYSIS DATA
/NO DIAGNOSTICS
/LIST=USER$DISK_26:[BELFIORE.SSMI.SRC.DISPLAY]CE_MAP.LIS:1
/NOOBJECT
  
```

COMPILATION STATISTICS

```

Run Time: 0.30 seconds
Elapsed Time: 1.05 seconds
Page Faults: 383
Dynamic Memory: 200 pages
  
```

```

0001      subroutine or_map
0002
0003      real left, right, bottom, top
0004
0005      common /ws_vars/ ws_id, xmax, ymax, lat, lon
0006
0007      call gks$set_ws_viewport (ws_id, 0.0, xmax, 0.0, ymax)
0008      call gks$set_ws_window (ws_id, 0.0, 1.0, 0.0, 1.0)
0009      call gks$update_ws (ws_id, gks$perform_flag)
0010
0011      C*****
0012      C Use a circular perimeter
0013      C*****
0014      C Call MAPSTI ('EL',1)
0015
0016      C*****
0017      C Use orthographic projection
0018      C*****
0019      Call MAPROJ ('OR', lat, lon, 23.0)
0020
0021      write (*,*) ' Enter left, right, bottom, & top offset angles: '
0022      read (*,*) left, right, bottom, top
0023      call MAPSET ('AN', left, right, bottom, top)
0024
0025      return
0026      end

```

PROGRAM SECTIONS

Name	Bytes	Attributes
C \$CODE	133	PIC CON REL LCL SHR EXE RD NOWRT QUAD
1 \$PDATA	67	PIC CON REL LCL SHR NOEXE RD NOWRT QUAD
2 \$LOCAL	148	PIC CON REL LCL NOSHR NOEXE RD WRT QUAD
3 \$WS_VARS	20	PIC OVR REL GBL SHR NOEXE RD WRT QUAD
Total Space Allocated	368	

ENTRY POINTS

Address	Type	Name
0-00000000	OR_MAP	

VARIABLES

Address	Type	Name
2-00000008	R*4	BOTTOM
3-0000000C	I*4	LAT
3-00000010	I*4	LONG
2-00000000	R*4	TOP
2-00000010	R*4	GKSSK_PERFORM_FLAG
2-00000000	R*4	LEFT
2-00000004	R*4	RIGHT
3-00000000	R*4	WS_ID

OR_MAP
01_MAP

3-00000004 R*4 XMAX

3-Dec-1990 10:34:00
8-Aug-1990 14:06:51

VAX FORTRAN V5.5-98

{BELFIORE.SSMI.SRC.DISPLAY}OR_MAP.FOR:2

Page 2

3-00000008 R*4 YMAX

FUNCTIONS AND SUBROUTINES REFERENCED

Type	Name	Type	Name
GKSSSET_WS_VIEWPORT	GKSSSET_WS_WINDOW	GKSSUPDATE_WS	MAPSET

COMMAND QUALIFIERS

FORTRAN/NOOPT/DEBUG/LIST/NOOBJ OR_MAP
/CHECK=(NOBOUNDS,OVERFLOW,NOUNDERFLOW)
/DEBUG=(SYMBOLS,TRACEBACK)
/DESIGN=(NOCOMMENTS,NOPRACEHOLDERS)
/SHOW=(NODICTIONARY,NOINCLUDE,MAP,NOPREPROCESSOR,SINGLE)
/STANDARD=(NOSEMANTIC,NOSOURCE_FORM,NOSYNTAX)
/WARNINGS=(NODECLARATIONS,GENERAL,NOULTRIX,NOVAXELN)
/CONTINUATIONS=19 /NOCROSS REFERENCE /MOD LINES /NOEXTEND_SOURCE
/F77 /NOG FLOATING /I4 /NOMACHINE_CODE /NOOPTIMIZE /NOPARALLEL
/NOANALYSIS DATA
/NODIAGNOSTICS
/LIST=USER\$DISK_26:{BELFIORE.SSMI.SRC.DISPLAY}OR_MAP.LIS:1
/NOOBJECT

COMPILATION STATISTICS

Run Time: 0.37 seconds
Elapsed Time: 1.18 seconds
Page Faults: 431
Dynamic Memory: 200 pages

```

0001      subroutine map_geo (choice)
0002
0003      integer choice
0004
0005      common /ws_vars/ ws_id, xmax, ymax
0006
0007      if (choice .eq. 1) call or_map
0008      if (choice .eq. 2) call ce_map
0009
0010      return
0011      end
  
```

PROGRAM SECTIONS

Name	Bytes	Attributes
0 \$CODE	29	PIC CON REL LCL SHR EXE RD NOWRT QUAD
3 WS_VARS	12	PIC OVR REL GBL SHR NOEXE RD WRT QUAD
Total Space Allocated	41	

ENTRY POINTS

Address	Type	Name
0-00000000		MAP_GEO

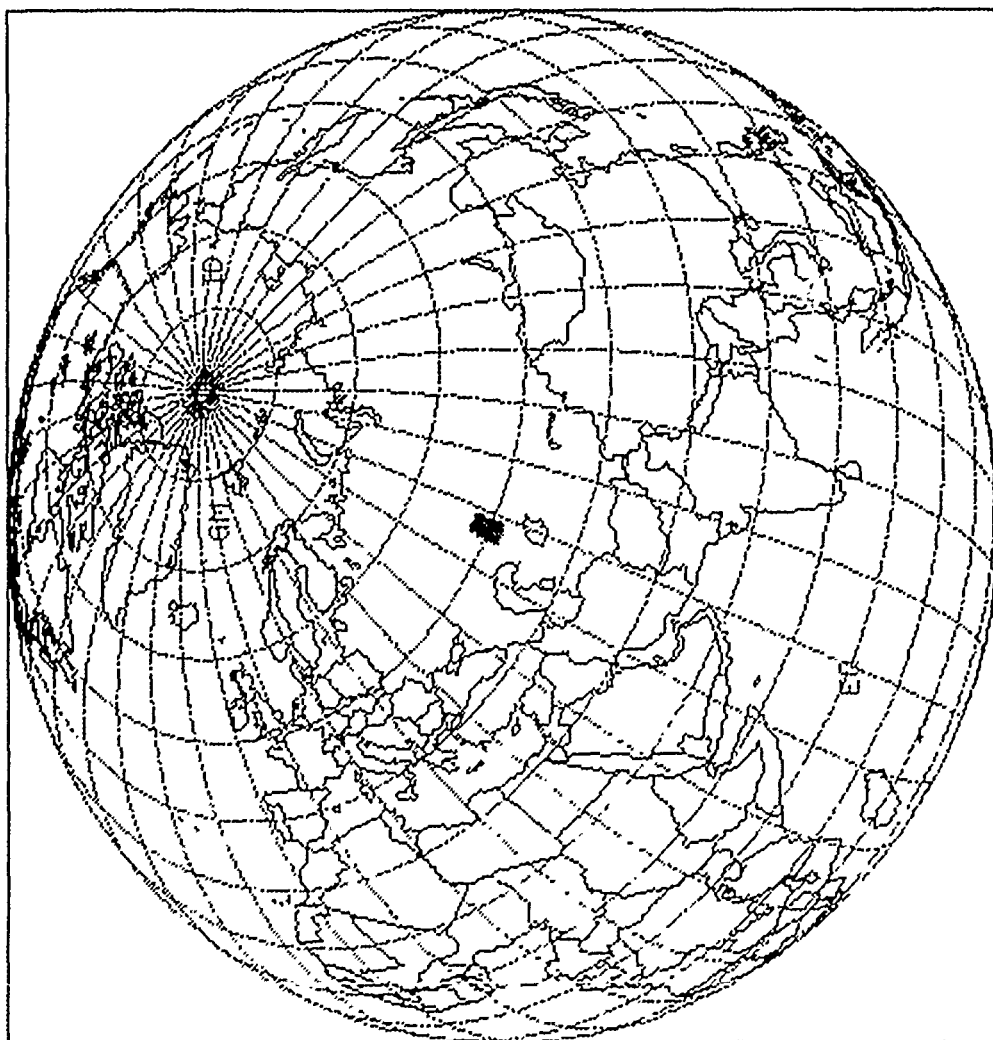
VARIABLES

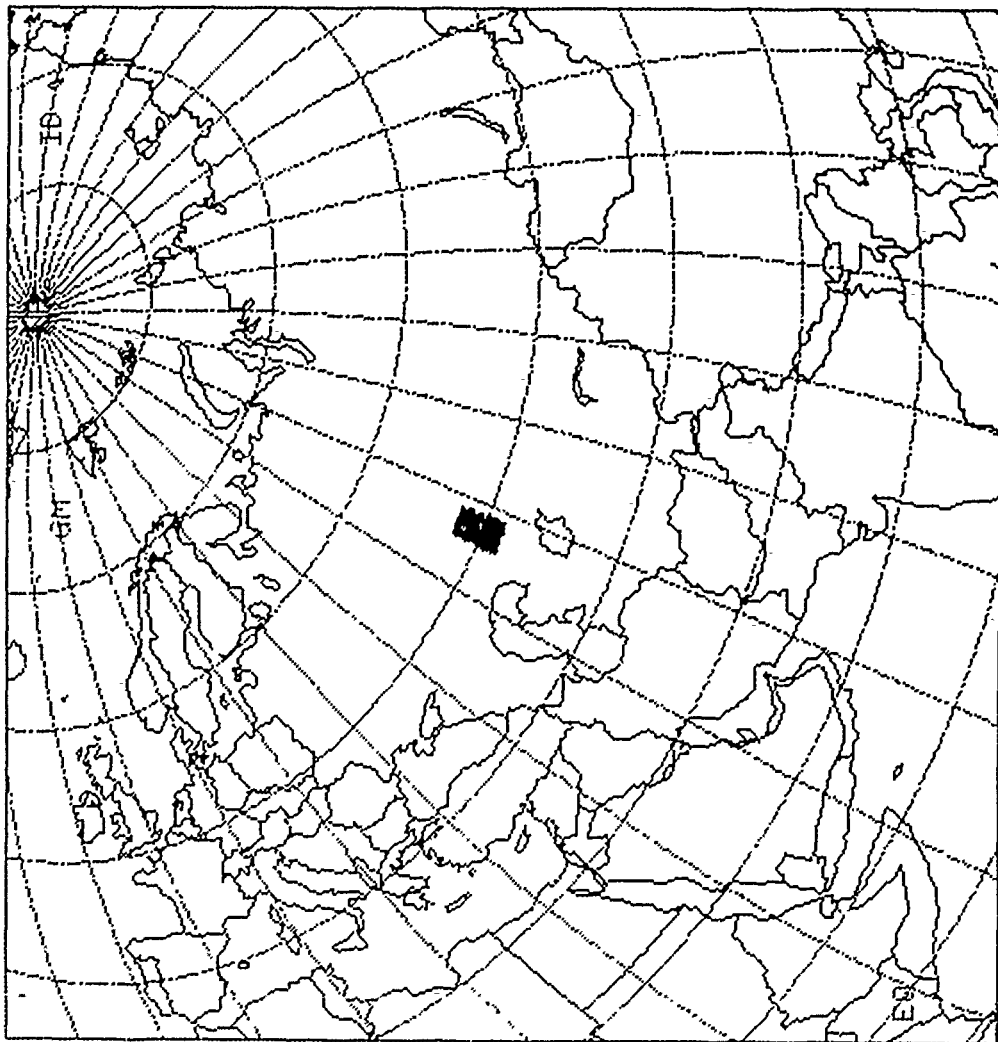
Address	Type	Name	Address	Type	Name
AP-00000040	I*4	CHOICE	3-00000000	R*4	WS_ID
			3-00000004	R*4	XMAX
			3-00000008	R*4	YMAX

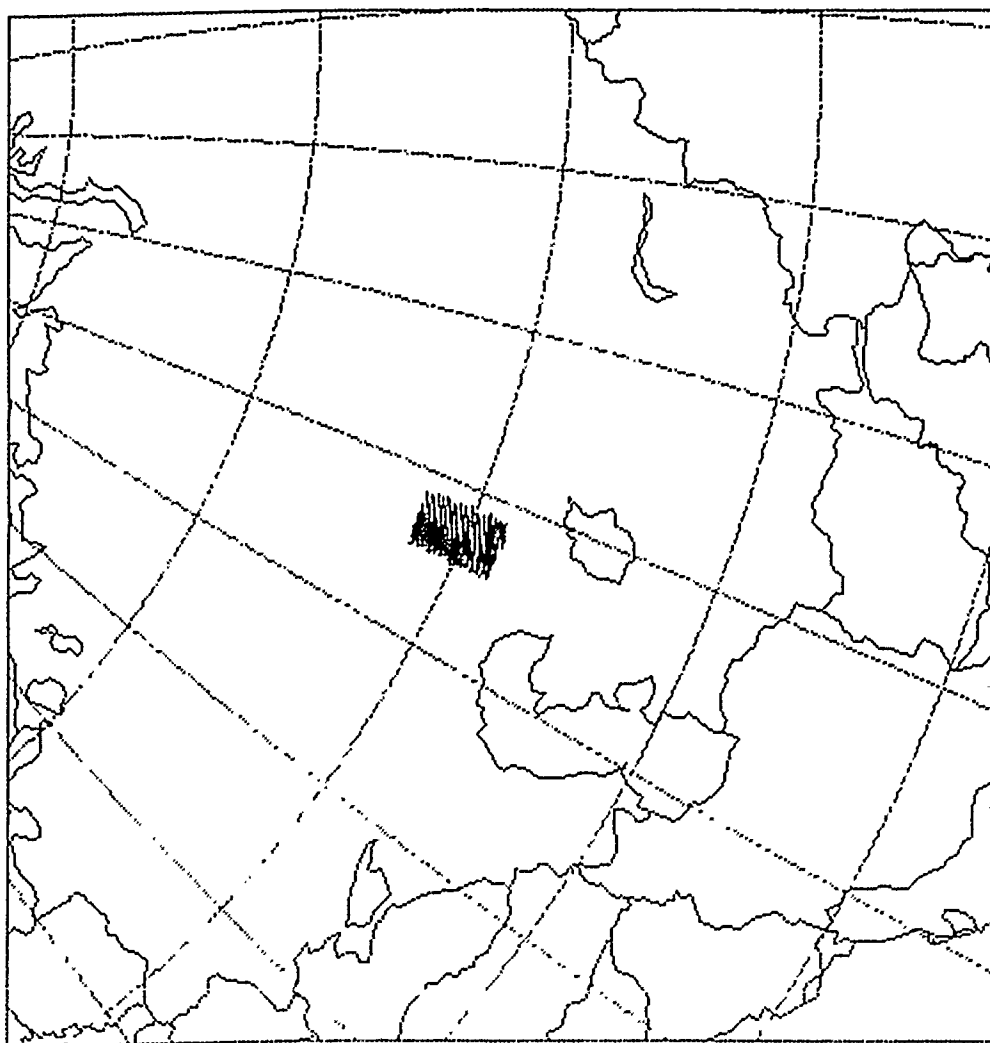
FUNCTIONS AND SUBROUTINES REFERENCED

Type	Name	Type	Name
	CE_MAP		OR_MAP

Appendix D Sample Mapping Software Output







Appendix E SSM/I Data Catalog

SSM/I Data Received

Tape #	Beginning of dataset	End of dataset	# files
01	01-Jun-89:00:07:31	05-Jun-89:00:57:56	56
02	05-Jun-89:00:57:56	09-Jun-89:00:06:24	20
03	09-Jun-89:00:06:24	13-Jun-89:00:56:52	55
04	13-Jun-89:00:56:53	16-Jun-89:00:18:21	42
05	16-Jun-89:00:18:21	20-Jun-89:01:08:51	49
06	20-Jun-89:01:08:51	24-Jun-89:00:17:17	54
07	24-Jun-89:00:17:18	28-Jun-89:01:07:33	49
08	28-Jun-89:01:07:33	01-Jul-89:00:28:44	42
09	01-Jul-89:00:28:55	05-Jul-89:01:18:59	49
10	05-Jul-89:01:18:58	09-Jul-89:00:27:20	53
11	09-Jul-89:00:27:20	13-Jul-89:01:17:35	54
12	13-Jul-89:01:17:35	16-Jul-89:00:38:48	42
13	16-Jul-89:00:38:40	20-Jul-89:01:29:01	57
14	20-Jul-89:01:29:01	24-Jul-89:00:37:17	12
15	24-Jul-89:00:37:17	28-Jul-89:01:27:89	32
16	28-Jul-89:01:27:29	01-Aug-89:00:35:45	56
17	01-Aug-89:00:35:45	05-Aug-89:01:25:54	57
18	05-Aug-89:01:25:54	09-Aug-89:00:34:07	51
19	09-Aug-89:00:34:07	13-Aug-89:01:24:18	57
20	13-Aug-89:01:24:19	16-Aug-89:00:45:28	42
21	16-Aug-89:00:45:28	20-Aug-89:01:35:36	56
22	20-Aug-89:01:35:36	24-Aug-89:00:43:47	53
23	24-Aug-89:00:43:47	28-Aug-89:01:33:51	57
24	28-Aug-89:01:33:51	01-Sep-89:00:41:48	56
25	01-Sep-89:00:41:46	05-Sep-89:01:31:45	55
26	05-Sep-89:01:31:45	09-Sep-89:00:39:47	56
27	09-Sep-89:00:39:47	13-Sep-89:01:29:43	57
28	13-Sep-89:01:29:43	16-Sep-89:00:50:41	42
29	16-Sep-89:00:50:41	20-Sep-89:01:40:33	57
30	20-Sep-89:01:40:33	24-Sep-89:00:48:26	56
31	24-Sep-89:00:48:26	28-Sep-89:01:38:15	57
32	28-Sep-89:01:38:15	01-Oct-89:00:59:09	40

There is no data missing from our requested set.