

Clouds and the Earth's Radiant Energy System (CERES)

Data Management System

Software Requirements Document

Time Interpolation for Single and Multiple Satellites
(Subsystem 7.1)

Release 1
Version 1

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Preface

The Clouds and the Earth's Radiant Energy System (CERES) Data Management System supports the data processing needs of the CERES Science Team research to increase understanding of the Earth's climate and radiant environment. The CERES Data Management Team works with the CERES Science Team to develop the software necessary to support the science algorithms. This software, being developed to operate at the Langley Distributed Active Archive Center, produces an extensive set of science data products.

The Data Management System consists of 12 subsystems; each subsystem represents a stand-alone executable program. Each subsystem executes when all of its required input data sets are available and produces one or more archival science products.

The documentation for each subsystem describes the software design at various significant milestones and includes items such as Software Requirements Documents, Data Products Catalogs, Software Design Documents, Software Test Plans, and User's Guides.

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1.0 Introduction

The Clouds and the Earth's Radiant Energy System (CERES) is a key component of the Earth Observing System (EOS). The CERES instruments are improved models of the Earth Radiation Budget Experiment (ERBE) scanner instruments, which operated from 1984 through 1990 on the National Aeronautics and Space Administration's (NASA) Earth Radiation Budget Satellite (ERBS) and on the National Oceanic and Atmospheric Administration's (NOAA) operational weather satellites NOAA-9 and NOAA-10. The strategy of flying instruments on Sun-synchronous, polar orbiting satellites, such as NOAA-9 and NOAA-10, simultaneously with instruments on satellites that have precessing orbits in lower inclinations, such as ERBS, was successfully developed in ERBE to reduce time sampling errors. CERES will continue that strategy by flying instruments on the polar orbiting EOS platforms simultaneously with an instrument on the Tropical Rainfall Measuring Mission (TRMM) spacecraft, which has an orbital inclination of 35 degrees. In addition, to reduce the uncertainty in data interpretation, and to improve the consistency between the cloud parameters and the radiation fields, CERES will include cloud imager data and other atmospheric parameters. The first CERES instrument is scheduled to be launched on the TRMM spacecraft in 1997. Additional CERES instruments will fly on the EOS-AM platforms, the first of which is scheduled for launch in 1998, and on the EOS-PM platforms, the first of which is scheduled for launch in 2000.

1.1 Purpose and Objective of Document

Subsystem (7.0) consists of two parts: The Merge Satellites, Time Interpolate, and Compute Fluxes Time Interpolation for Single and Multiple Satellites process (7.1) and the Synoptic Surface and Atmospheric Radiation Budget (SARB) process (7.2). This document is concerned exclusively with the first of these processes.

The purpose of this document is to serve as a basis for the design and to provide a complete set of requirements necessary to guide the development of the Time Interpolation for Single and Multiple Satellites process (7.1). The intended audience consists of the following groups: the Subsystem design team, testers, follow-on subsystems, and science reviewers. Additional information is provided to suggest guidelines for organizing the design efforts.

This document contains the following information related to process 7.1:

- A brief overview of the process
- A description of key concepts
- A description of the requirements approach and any necessary trade-offs
- A description of each external interface
- An explanation of each mode the Subsystem can operate in
- The detailed functional requirements for the Subsystem

- A description of any design goals and constraints
- Identification of resource usage requirements

1.2 System Overview

The time interpolation process (7.1), one of the two key parts of Subsystem 7.0, temporally interpolates CERES data and produces global synoptic maps of top-of-the-atmosphere (TOA) fluxes and cloud properties on a 1.25-degree equal-area grid. Another key part of Subsystem 7.0, the Synoptic SARB, Subsystem 7.2, calculates synoptic maps, Synoptic Radiative Fluxes and Clouds (SYN), of the vertical structure of atmospheric and surface flux using the interpolated data as input and boundary conditions.

The main input to the time interpolation process is the Hourly Gridded Single Satellite Fluxes and Clouds (FSW) product, produced by Atmospheric Gridding and Spatial Averaging, Subsystem 6.0. The gridded shortwave (SW) and longwave (LW) TOA fluxes and cloud information are the key items to be interpolated. The radiative profile will be recalculated in the SARB part of Subsystem 7.0 using the interpolated fluxes as constraints. This process produces the internal product, Time Space Interpolate (TSI), which is the input to Subsystem 7.2.

The time interpolation process produces global maps of TOA total-sky LW and SW flux, TOA clear-sky LW and SW flux, TOA window radiances, and cloud properties at 0, 3, 6, ..., 21 Greenwich mean time (GMT) for every day of the month. The process of producing synoptic maps involves several steps:

1. The FSW data are regionally and temporally sorted and merged.
2. The ancillary geostationary data which are used in the interpolation of TOA fluxes are regridded to the CERES grid system and regionally and temporally sorted and merged.
3. Cloud properties from the CERES times of observation are interpolated to the synoptic times.

The CERES TOA LW and SW fluxes are interpolated to synoptic times using geostationary data to assist in modeling meteorological variations between times of observations.

2.0 Key Concepts

The following key concepts are embodied in the Time Interpolation for Single and Multiple Satellites Subsystem:

Data Organization. The primary input, FSW, consists of 1-hour averages of CERES measurements for each observed region of the 1.25-degree equal-area grid. One month of data will be processed together. In addition, each region will be analyzed independently of all others. Therefore, for a single satellite product, approximately 744 FSW files (31 days x 24 hours) must be input and then sorted by region and time. These data are stored as Regional Time-Sorted Gridded Data.

Merge Data. After being sorted by region and time, if data from different instruments or different satellites are processed for the same month, these data are combined. When data exist for a given hour and region from more than one satellite or instrument, the data are linearly averaged. If data for a given hour and region are only from one satellite or instrument, the data are simply rewritten to the output dataset, Regional Time-Sorted Gridded Data. The relevant parameters from FSW which are used in the averaging process are the total-sky LW and SW TOA fluxes, the clear-sky TOA LW and SW fluxes, and the CERES-derived cloud information.

Shared Functions. In order to eliminate duplication of code and processing, Subsystem 7 will perform two functions which can also be performed by Subsystem 10: process Regrid Geo and Generate Solar Declination Data. If either of these two functions has already been performed by Subsystem 7 or Subsystem 10 and the output data stored, then the last subsystem to run will only access this data.

Geostationary Data. Geostationary data will most likely be the International Satellite Cloud Climatology Project (ISCCP) B3 or DX data. These data are provided at 3-hourly intervals at 0, 3, 6, ..., 21 GMT. These data will be sorted and averaged onto the CERES 1.25-degree equal-area grid. If this regridding has already been done by Subsystem 10 and does not need to be redone, access to the regridded data is all that is needed by the time interpolation process.

Solar Information. The solar declination angle and the distance corrections for the narrowband and broadband solar constants for each day of the year are produced to be used in the interpolation process. If this information has already been produced by Subsystem 10 and does not need to be recreated, access to this information is all that is needed by the time interpolation process.

Time Interpolation. Time interpolation is the main function of Subsystem 7.1. Details of interpolation methods for LW and SW fluxes, window fluxes, cloud data, and surface-only parameters can be found in Sections 5.2.1.6.2.3.1 - 5.2.1.6.2.3.6.

Metadata and Error Handling. Metadata and error handling will conform to the Earth Observing System Data and Information System (EOSDIS) operating environment requirements, which are currently being defined. Details regarding metadata and error handling have been deferred until more information on the operating environment is available.

Data Quality. All bad data are expected to have been eliminated from the input data products by the time that TSI processing takes place. Several validation studies are planned by the Science Team to determine the uncertainties in the interpolated cloud properties and surface and TOA fluxes. These efforts will be used to quantify the errors introduced into the time interpolation process and to develop improved techniques.

Data Output. At the close of processing, 248 synoptic maps (TSI), eight for each day, will be output to Subsystem 7.2.

3.0 Requirements Approach and Trade-offs

The purpose of this Section is to examine the overall approach in gathering, analyzing, and synthesizing requirements and the trade-off processes used to arrive at the software requirements for this Subsystem.

The following issues were identified from the Algorithm Theoretical Basis Document for this Subsystem ([Reference 1](#)):

1. Geostationary data and polar-orbiting satellite radiance data are used for interpolation of fluxes and window radiances.

Rationale: This type of data provides enhanced temporal resolution. The measurements also provide information regarding variations in meteorology and cloudiness occurring between the times of the CERES observations. Several simulations have been performed which show that these data enhance the accuracy of time interpolation of broadband observations by decreasing root mean square error ([Reference 1](#)). Other advantages found from using the narrowband data in the above simulations were that the sampling effects were minimized and that it increased the accuracy of filling in the flux values for times between the CERES measurements.

2. The total-sky LW and SW interpolation involves two methods.

Rationale: Method 1 used in the interpolation is the one found in the ERBE-like Averaging to Monthly TOA and Surface Fluxes Subsystem ([Reference 2](#)). Method 2 involves the inclusion of the geostationary data since it provides a more accurate picture of the shape of the curve that is fit to the CERES observations. For Release 1, Method 2 is used whenever possible; however, when geostationary data are not available or there are gaps in the geostationary data ([Reference 1](#)), the ERBE-like methodology will be used for interpolation of the data.

3. The clear-sky SW and LW interpolation is the same as the Method 1 of the total-sky interpolation.

Rationale: Since the CERES Project is geared towards studying the effects of clouds, there will be a significant improvement in the quality of clear-sky data. Therefore, the misclassifications of clear-sky scenes which occurred in the ERBE data should no longer be a problem and, hence, for Release 1, the idealized ERBE half-sine model will be used for interpolation of clear-sky LW over land regions.

4. The number of cloud properties interpolated varies depending on the cloud conditions of the two observed points between which the interpolation is performed.

Rationale: Only cloud amount is linearly interpolated when only one observation has a non-zero cloud amount. All cloud properties are linearly interpolated when both observations have non-zero cloud amounts, with the exception of visible optical depth ([Reference 1,3](#)).

4.0 External Interface Requirements

This Section provides information on the interface requirements which must be satisfied between the system and each of its external input/output entities. These interfaces are depicted graphically in the Context Diagram (Figure 4-1). The subparagraphs following the context diagram provide the detailed requirements for each of the data interfaces represented in the diagram.

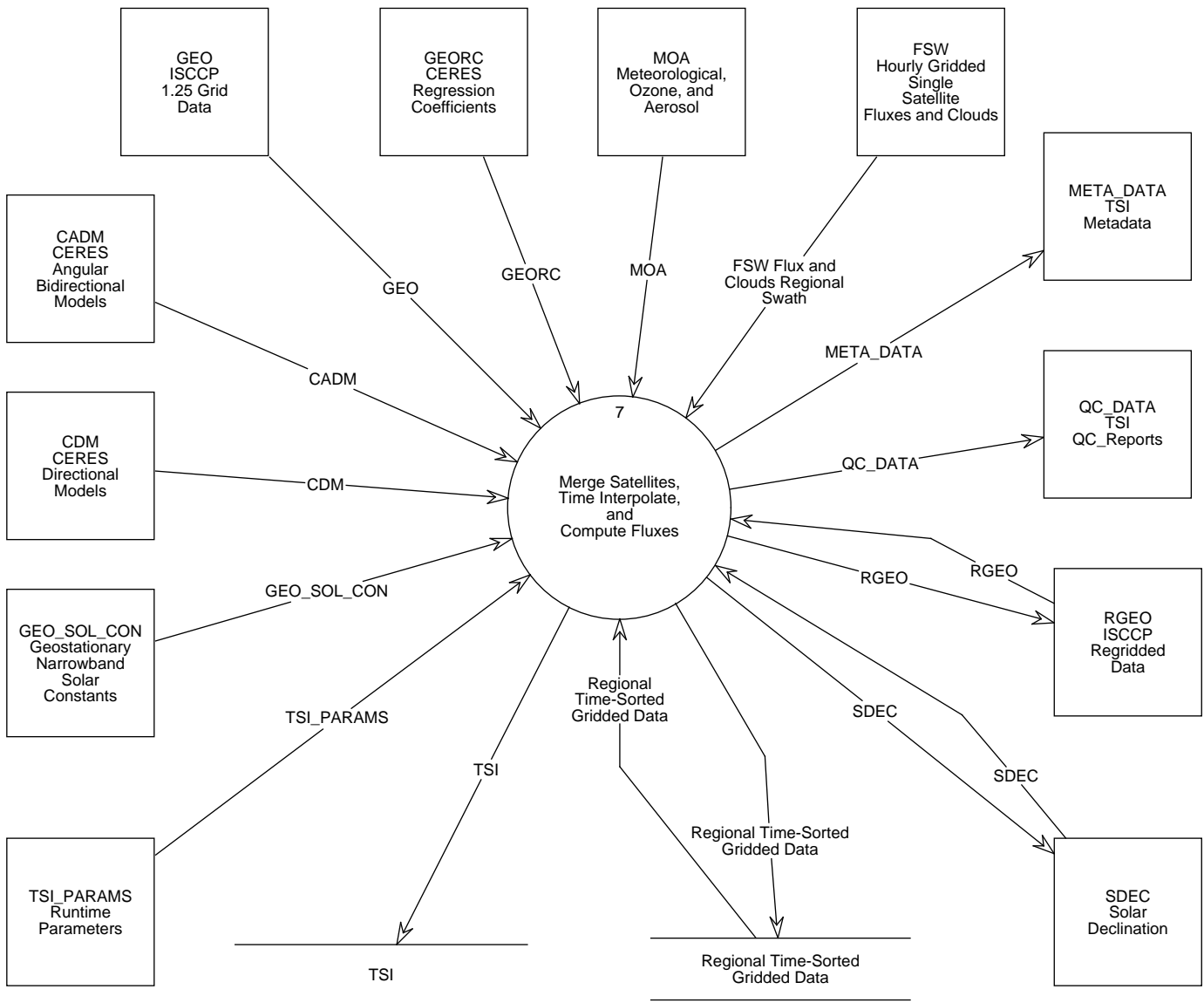


Figure 4-1. Context Diagram

4.1 Input Data Sources

4.1.1 FSW

The Hourly Gridded Single Satellite Fluxes and Clouds (FSW) (formerly Flux and Clouds Regional Swath) archival data product from the Atmospheric Gridding and Spatial Averaging Subsystem is the main input for Subsystem 7.1. This data product contains hourly single satellite flux and cloud parameters averaged over 1.25-degree regional hour boxes. Each FSW covers a single hour swath from a single CERES instrument mounted on one satellite. The product contains a product header and multiple records; each record contains spatially averaged data for an individual regional hour box. Details of the data product can be found in the CERES Data Management System Data Products Catalog ([Reference 5](#)).

The major categories of data output on the FSW are:

- Region parameters
- Total-sky radiative flux parameters at TOA, surface, and atmospheric levels
- Clear-sky radiative flux parameters at TOA, surface, and atmospheric levels
- Cloud overlap conditions
- Cloud category properties
- Column-averaged cloud properties
- Angular model scene type parameters
- Surface-only parameters
- Adjusted parameters.

4.1.2 GEO

ISCCP produces B3 radiances which are used for filling in unsampled portions of the globe during a particular 1-hour interval. The ISCCP B3 radiances are well enough defined that we do not need to make a further composite data structure to reformat them. In addition, these radiances are part of the Langley Research Center's (LaRC) Distributed Active Archive Center (DAAC) archival responsibility.

The ISCCP B3 radiances consist of a window channel radiance (near 10.8 micrometers) and a visible channel radiance (near 0.68 micrometers) obtained from up to five geostationary satellites, as well as some data from the equivalent channels of the Advanced Very High Resolution Radiometer (AVHRR) and High Resolution Infrared Radiation Sounder (HIRS) instruments on the operational satellites. The radiances from each geostationary imager are sampled at about 32 km resolution and every three hours. Where a geostationary (GEO) data source is not available (over India, primarily), the AVHRR data are processed into an equivalent format. Each geostationary satellite has a Sector Processing Center (SPC) that samples and formats the radiances and then

sends the sampled and formatted radiance pairs to the Global Processing Center (GPC), where the radiances are normalized and reformatted into archival form. Because each SPC follows its own schedule, the global radiance sets may not be available on a schedule that is appropriate for CERES operations; the CERES Project will use the ISCCP DX radiance data as an alternate source. The GEO radiances contain two basic kinds of information:

1. Visible (near 0.68 micrometers) and Window (near 10.8 micrometers) Radiances sampled at 32 km spacing
2. Earth Location Information

These radiances have been normalized to a common set of locations on the Earth and corrected for gain drifts, insofar as possible. GEO is an external input data product retrieved from the EOSDIS DAAC at LaRC. Details of the GEO product can be found in the CERES Data Management System Data Products Catalog ([Reference 5](#)).

4.1.3 MOA

The CERES archival product, Meteorological, Ozone, and Aerosol (MOA), formerly named Atmospheric Structures (ASTR), is produced by the CERES Regrid Humidity and Temperature Subsystem. Each MOA file contains meteorological, ozone, and aerosol data for 1 hour, and is used by several of the CERES subsystems. Data on the MOA are derived from several data sources external to the CERES system, such as the National Meteorological Center (NMC), Moderate Resolution Imaging Spectrometer (MODIS), Stratospheric Aerosol and Gas Experiment (SAGE), and various other satellites. These data arrive anywhere from four times daily to once a month, and may have entirely different spatial and temporal resolutions than what the CERES system requires. The Regrid Humidity and Temperature Subsystem interpolates these data temporally, horizontally, and vertically to conform with CERES processing requirements.

The MOA contains

- Surface temperature and pressure
- Vertical profiles for up to 38 internal atmospheric levels of temperature, humidity, and geopotential height as a function of pressure level. The 38 internal atmospheric levels, in hPa, as requested by the CERES Clouds and SARB Working Groups are listed in [Table 4-1](#).
- Column precipitable water
- Vertical ozone profiles at 26 (of the 38) internal atmospheric levels
- Column ozone
- Total column aerosol
- Stratospheric aerosol

Table 4-1. MOA Internal Atmospheric Levels (in hPa)

Floating Levels	1000 to 875	850 to 725	700 to 450	400 to 225	200 to 70	50 to 1
Surface	1000	850	700	400	200	50
Surface - 10	975	825	650	350	175	30
Surface - 20	950	800	600	300	150	10
	925	775	550	275	125	5
	900	750	500	250	100	1
	875	725	450	225	70	

Details of the MOA product can be found in the CERES Data Management System Data Products Catalog ([Reference 5](#)).

4.1.4 GEORC

The Geostationary Regression Coefficients (GEORC) product contains regional narrowband - broadband regression coefficients that will be used with the narrowband data from the GEO data set to convert the narrowband fluxes to broadband fluxes. GEORC will contain two sets of four regression coefficients each, for every CERES grid box. One set of coefficients will be for LW flux while the second set will be for SW flux. Owing to seasonal variations in surface albedos and variations in regional cloud type, both sets of coefficients will need to be updated monthly. For Release 1, GEORC will be produced offline. For Release 2, GEORC will be produced in production when data months are being processed sequentially; 4 days of data from the previous month are used to generate the regression coefficients for the current month being processed. When data months are being processed nonsequentially, GEORC will be produced offline.

4.1.5 CADM

CERES Angular Distribution Models (CADMs) are inputs to the CERES radiative flux inversion process and are used to invert CERES unfiltered radiance measurements to SW, LW, and window (WN) fluxes at the TOA. For Release 1, the CADM files will contain ERBE production Angular Distribution Models (ADMs). This file will include LW (limb darkening) models, SW (bidirectional) models, and SW and LW normalization constants. In Release 1 CERES software, the ERBE LW ADMs and LW normalization constants will be used to invert the WN channel unfiltered radiance measurements.

- The ERBE LW models are a function of the LW scene type, viewing zenith angle, the colatitude of the scanner target, and the season of the year.

- The ERBE LW normalization constants for bilinear interpolation are a function of the LW scene type and the colatitude of the scanner target.
- The ERBE SW models are a function of the SW scene type and three angles: viewing zenith, solar zenith, and the relative azimuth between the Sun and the satellite.
- The ERBE SW normalization constants for trilinear interpolation are a function of the SW scene type and the solar zenith angle.

The CERES Inversion Working Group will generate and maintain the CADMs. The CADMs will be updated for Release 3, after analyzing the results from approximately 18 months of CERES processing using data from the CERES Rotating Azimuth Plane Scanner (RAPS) ([Reference 4](#)).

4.1.6 CDM

The CERES Directional Models (CDM) product contains the appropriate directional albedo models used in the modeling of albedo in the monthly averaging process of CERES data. It is derived from the angular bidirectional models. It consists of models for clear-sky scenes over the five geotypes of ocean, land, snow, desert, and land/ocean; partly cloudy and mostly cloudy scenes over the three geotypes of ocean, land, or desert, and land/ocean mix; and an overcast scene.

4.1.7 TSI PARAMS

The TSI_PARAMS product contains runtime parameters for all 7.1 processes; subsets of the parameters below are used by the different processes. It is an ancillary input to the CERES Time Interpolate and Average/Merge Single & Multiple Satellite Subsystem. It consists of parameters needed to identify and process the data. The parameters in this product include but are not limited to:

1. Satellite(s) identification
2. The data month being processed
3. The number of days in the data month being processed, to help identify missing days.
4. The data year being processed
5. Geostationary satellite identifications
6. The number of geostationary data products available

This product is classified, for this project, as internal ancillary data and, therefore, will be generated as needed to process the data. It is not yet clear whether CERES or EOSDIS will produce TSI_PARAMS.

4.1.8 GEO SOL CON

The Geostationary Solar Constant (GEO_SOL_CON) product is an ancillary input to the CERES Time Interpolation for Single and Multiple Satellites Subsystem. It contains a parameter which gives the number of satellites which are being used in the ISCCP data and the narrowband solar constants for each satellite.

This product is classified as internal ancillary. It will change whenever the composition of satellites used in ISCCP data collection changes.

4.2 Output Data Sources

4.2.1 TSI

The Time Space Interpolate product contains a global, synoptic map of TOA fluxes and cloud conditions which is used as input to the computation of synoptic radiation fields by the Synoptic (SARB) Subsystem. It is produced by interpolating observations of these parameters to fixed Universal times of 0, 3, 6, ..., 21 GMT for each day of the month and each 1.25-degree grid region. TSI is an internal product produced by Subsystem 7.1 as an interface with Subsystem 7.2. There will be one produced for each spacecraft and one produced for each combination of spacecraft, a total of eight per spacecraft or combination of spacecraft per day.

The TSI contains:

- Regional data
- Observed CERES TOA data
- Cloud category properties for four (low, lower middle, upper middle and high) cloud layer classes
- Column averaged cloud properties for five (TOA SW, TOA LW, Surface LW, Liquid Water Path, and Ice Water Path) weighting schemes
- Overlap data for eleven (clear, low (L), lower middle (LM), upper middle (UM), high (H), H/UM, H/LM, H/L, UM/LM, UM/L, LM/L) cloud overlap conditions
- Angular model scene types
- Surface-only data

4.2.2 QC DATA

QC_DATA indicates all of the Quality Control (QC) information for 7.1 processes. The QC information for Sort Gridded Data consists of input parameters, error messages, a summary of the regions filled, hours filled, number of records, and a flux histogram. The QC information for Generate Solar Declination consists of the solar declination angles, the distance corrections for the narrowband solar constants, and the distance corrections for the broadband solar constants. The QC information for Regrid Geo is TBD. The QC information for Merge Multi-Satellite Data consists of input parameters, error messages, and statistics for sample regions. The QC information for Process Synoptic Data consists of input parameters, error messages, a summary of the hours containing data, statistics for sample regions, and a global processing summary.

4.2.3 META DATA

META_DATA consists of all the metadata (TBD) produced by 7.1 processes.

4.3 Input/Output Data Sources

4.3.1 RGEO

The regridded geostationary (RGEO) data contains ISCCP geostationary visible and window narrowband radiance data, satellite identification, region number, time information, number of points, solar zenith angle, viewing zenith angle, and azimuth angles. These data are gridded to the CERES 1.25-degree grid and sorted by time.

4.3.2 SDEC

The Solar Declination (SDEC) product contains the tabulated values of solar declination angles, distance corrections to the broadband solar constant, and distance corrections to the narrowband solar constants. These values are required for each day of each year and are always referenced to $0^H 0^M 0^S$ Universal time (UT). A FORTRAN program for generating the solar declination angles and the distance corrections to the broadband solar constant from an analytic Earth Ephemeris already exists from ERBE. This program will be modified to generate the distance corrections to the narrowband solar constants; it will produce a set of distance corrections for each of the ISCCP geostationary satellites.

4.3.3 Regional Time-Sorted Gridded Data

The Regional Time-Sorted Gridded data is a collection of data from all regions and all hours of the month. These data have been sorted by region and by time and will be used as input to the process of interpolating to synoptic times. These sorted data from a given instrument will need to be stored until data from all other instruments which are operational for this month have been processed

through the gridding and the sorting processes and can be merged to produce a multiple satellite product. This multiple satellite product will also be a regional time-sorted gridded dataset which will be used as input to the process of interpolating to synoptic times. The parameters in the Regional Time-Sorted Gridded Data Product are the same as in FSW; details of FSW can be found in the CERES Data Management System Data Products Catalog ([Reference 5](#)).

5.0 Requirements Specification

This Section provides the specification of requirements which must be satisfied by the system. Included are functional requirements, internal data elements, performance requirements, and implementation constraints. In addition, this Section identifies design goals which will be addressed during the design phase and estimates for the processing resources required by the subsystem. The design goals are distinguished from the requirements by the fact that it is not possible to include formal tests for the design goals in the system Test Plan.

5.1 Operating Modes

There will be two normal modes of operation for this process. In both of these modes, Control Process will be executed; it will then determine which operating mode will be used. A description of the operating modes follows:

1. Single instrument mode will be used when data from a single instrument become available. In this mode, processes Sort Gridded Data and Process Synoptic Data will be executed. Processes Regrid Geo and Generate Solar Declination Data will be executed, or the data produced by these processes in previous runs will be accessed.
2. Multiple instrument mode will be used when data from two or more instruments have been processed through single instrument mode and the regional time-sorted gridded data from each of these instruments are available. In this mode, Process Merge Multi-Satellite Data and Process Synoptic Data will be executed. Data produced by the processes Regrid Geo and Generate Solar Declination Data in previous runs will be accessed.

5.2 Functional Requirements

This section identifies the specific functional requirements for the Subsystem, which are depicted graphically in data flow diagrams. A top-level subsystem context diagram was previously depicted in Section 4. The first level decomposition of the Subsystem is shown in the Data Flow Diagram for Level 0 (Figure 5-1). A discussion of the functionality shown in Figure 5-1 can be found in the System Overview (Section 1.2). The subparagraphs following the Data Flow Diagram for Level 0 provide the detailed requirements (process specifications, or "p-specs") for each of the processes shown in the figure. Processes that can be further decomposed into subprocesses are indicated by the inclusion of an "*" in the diagram beside the process number. If there are no further subprocesses, the diagram will include a "p" beside the process number. The process specifications will be used to define the testing requirements for the subsystem and will be documented in a subsystem Test Plan and Procedures document.

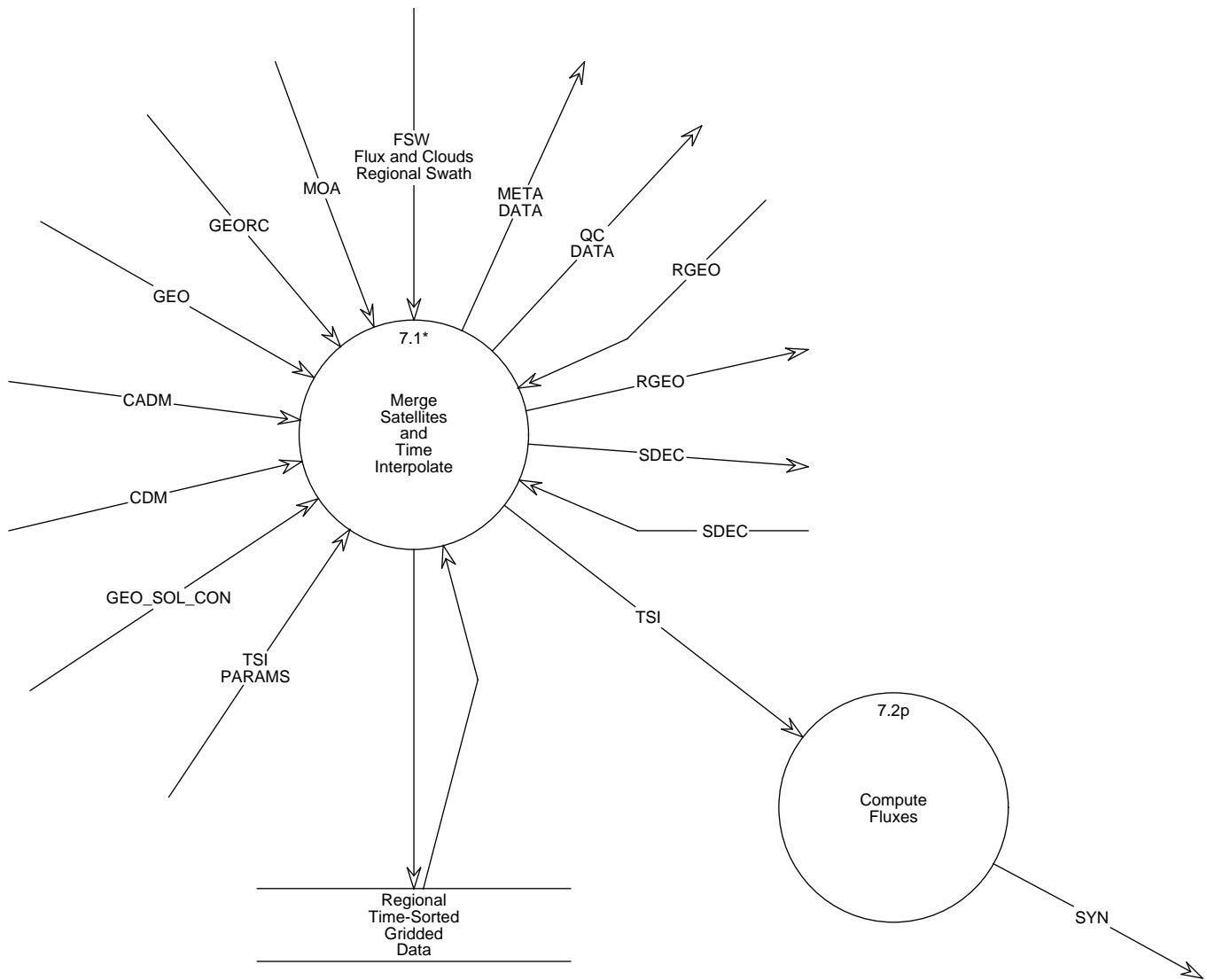


Figure 5-1. Data Flow Diagram for Level 0

5.2.1 Merge Satellites and Time Interpolate - Process 7.1

Input Data Flows

- CADM
- CDM
- FSW
- GEO
- GEORC

GEO SOL CON
MOA
TSI PARAMS

Output Data Flows

META DATA
QC DATA
RGEO
Regional Time-Sorted Gridded Data
SDEC
TSI

Process Description (Figure 5-1):

This process will perform the following subprocesses:

1. Regrid Geo
2. Generate Solar Declination Data
3. Control the processing of data:
 - a) If the data are from a single instrument, execute the Sort Gridded Data Process.
 - b) If the data are from multiple instruments, execute the Merge Multi-Satellite Data Process.
4. Process the synoptic data

The decomposition for this function is shown in Figure 5-2.

5.2.1.1 Control Process - Process 7.1.1

Input Data Flows

SYNOP PARAMS

Output Data Flows

SYNOP PARAMS

Process Specification (Figure 5-2):

This process shall:

1. Check for the existence of regrided geostationary data; if not there, initiate execution of Regrid Geo.
2. Check for the existence of solar declination data. If these data do not exist, initiate execution of Generate Solar Declination Data.

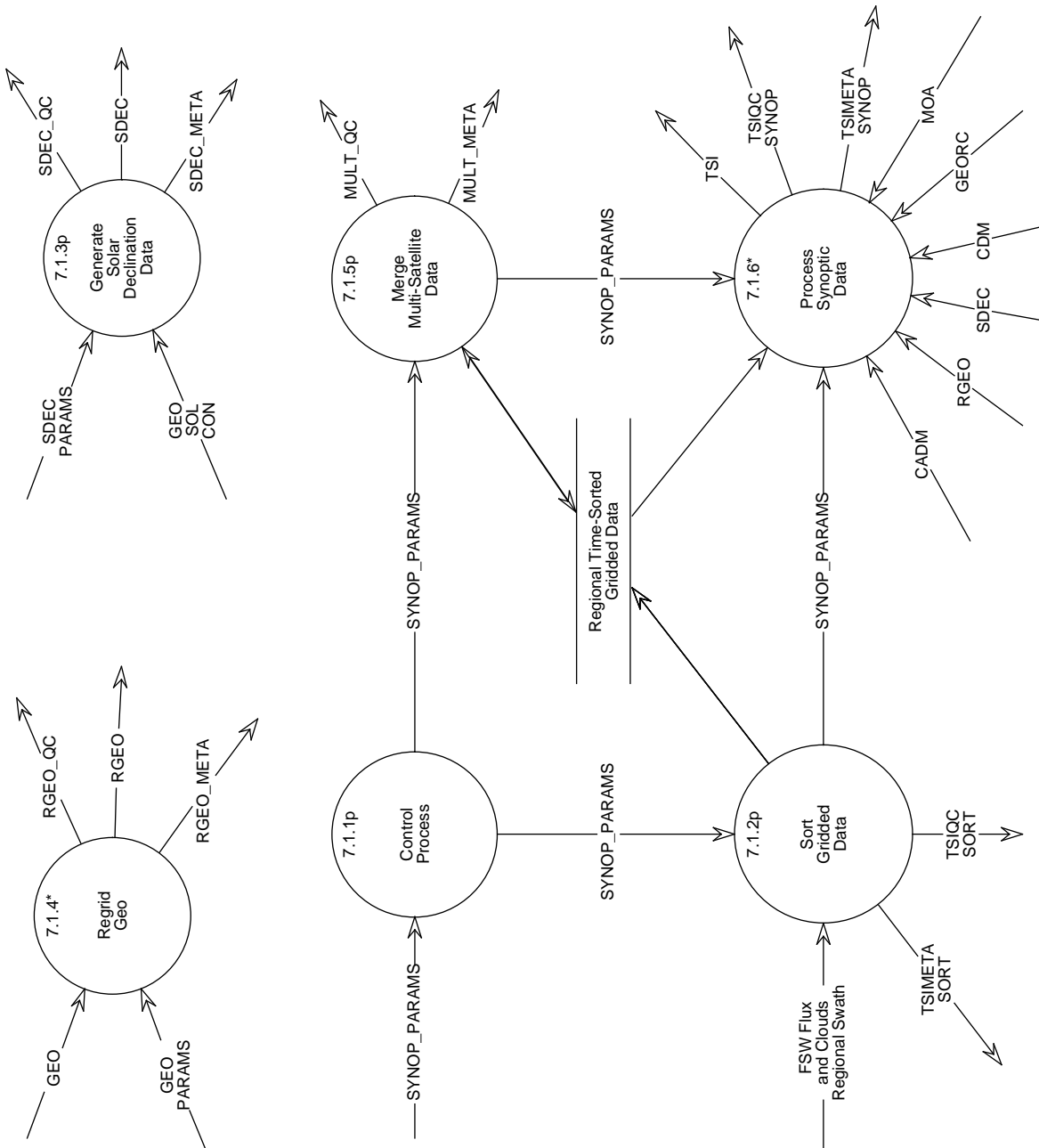


Figure 5-2. Data Flow Diagram for Merge Satellites and Time Interpolate

3. Examine satellite identification:
 - a) If satellite id indicates only a single instrument, then initialize and execute the Sort Gridded Data Process.
 - b) If satellite id indicates multiple instruments, then initialize and execute the Merge Multi-Satellite Data Process.

5.2.1.2 Sort Gridded Data - Process 7.1.2

Input Data Flows

FSW
SYNOP PARAMS

Output Data Flows

Regional Time-Sorted Gridded Data
SYNOP PARAMS
TSIMETA SORT
TSIQC SORT

Process Specification (Figure 5-2):

This process shall:

1. Check the availability of the FSW products. If not available, then write an error message in the QC report and quit the process.
2. If the product is available, read in 1 month of data, a maximum of 744 FSW 1-hour gridded products and check the headers.
3. Retain total-sky LW and SW TOA fluxes, clear-sky LW and SW TOA fluxes, window fluxes, surface-only fluxes, and CERES-derived cloud information for interpolation.
4. Sort the data by region and by time.
5. Write the data sorted by time and region to Regional Time-Sorted Gridded Data.
6. Keep statistics which include but are not necessarily limited to the following:
 - a) the number of records processed per region
 - b) the number of regions with data
 - c) the number of hours with data
 - d) a flux histogram
7. Write a Quality Control report.
8. Write meta data.

5.2.1.3 Generate Solar Declination Data - Process 7.1.3

Input Data Flows

GEO SOL CON
SDEC PARAMS

Output Data Flows

SDEC
SDEC META
SDEC QC

Process Specification (Figure 5-2):

This process shall:

1. Input date in calendar format.
2. Convert calendar date to Julian format.
3. For every day of a given year:
 - a) Calculate the solar declination angle
 - b) Calculate the distance corrections to the broadband solar constant
4. Create product SDEC.
5. Write solar declination angles and distance corrections to QC report.
6. Write metadata (TBD).

5.2.1.4 Regrid Geo - Process 7.1.4

Input Data Flows

GEO
GEO PARAMS

Output Data Flows

RGEO
RGEO META
RGEO QC

Process Description (Figure 5-2):

This process will perform the following subprocesses:

1. Check the availability of ISCCP data via the GEO_PARAMS file, if not available then write an error message in the RGEO QC report and quit the process.
2. If data are available, read in the ISCCP geostationary narrowband data.

3. Sort the 3 hourly, 32 kilometer resolution geo radiance pixel data, and regrid data to the CERES 1.25-degree equal area grid.
4. Create the regrided geostationary product (RGEO) and output the RGEO quality control report and metadata.

The decomposition for this function is shown in [Figure 5-3](#).

5.2.1.4.1 Read Geo Data - Process 7.1.4.1

Input Data Flows

GEO
GEO PARAMS

Output Data Flows

Geo Radiance Data

Process Specification ([Figure 5-3](#)):

This process shall:

1. Check the availability of the geostationary data and obtain other necessary processing parameters via the GEO PARAMS file.
2. Read in 1 month of geostationary data, which are measured every 3 hours (0,3,6, ..., 21 GMT).
3. Validate the data headers as well as each image id.
4. Obtain and store necessary information (TBD) from each image id, such as the number of radiance data records.
5. Output the Geo Radiance Data (shortwave radiances and longwave (window) radiances, satellite identification, number of points, and angle information) to process Sort/Regrid Geo Data.

5.2.1.4.2 Sort/Regrid Geo Data - Process 7.1.4.2

Input Data Flows

Geo Radiance Data

Output Data Flows

Regridded Radiance Data

Process Specification ([Figure 5-3](#)):

This process shall:

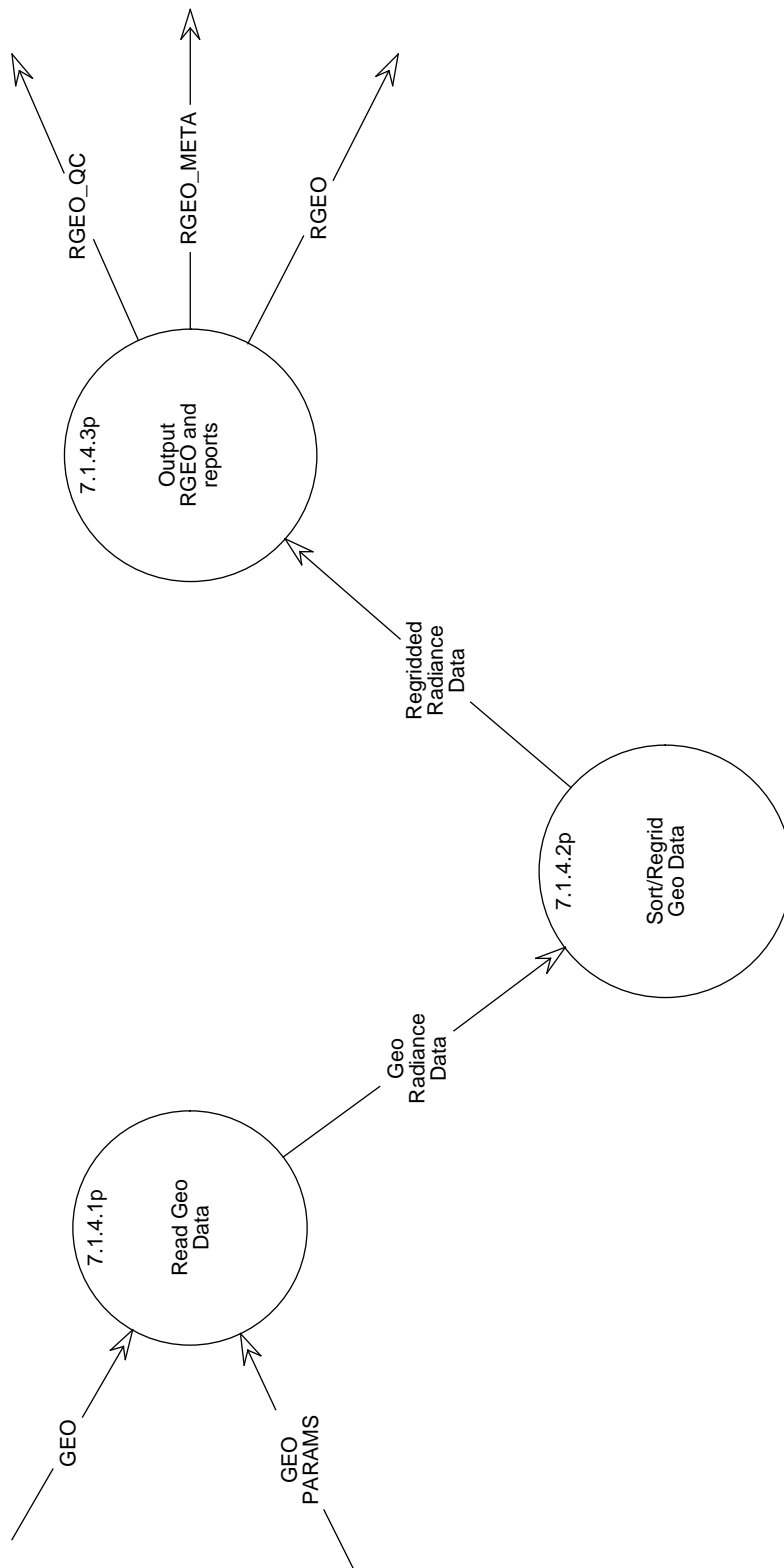


Figure 5-3. Data Flow Diagram for Regrid Geo

1. Access the Geo Radiance Data
2. Regrid the Geo Radiance Data to the CERES 1.25-degree equal area grid
3. Sort the 3-hourly, 32-kilometer resolution radiance pixel data for the entire month by region and time.

5.2.1.4.3 Output RGEO and reports - Process 7.1.4.3

Input Data Flows

Regridded Radiance Data

Output Data Flows

RGEO
 RGEO META
 RGEO QC

Process Specification (Figure 5-3):

This process shall:

1. Create header information for RGEO.
2. Output the header information and the Regridded Radiance Data to a file (RGEO) for use in Process Synoptic Data.
3. Output QC report with TBD information.
4. Output metadata.

5.2.1.5 Merge Multi-Satellite Data - Process 7.1.5

Input Data Flows

Regional Time-Sorted Gridded Data
 SYNOP PARAMS

Output Data Flows

MULT META
 MULT QC
 Regional Time-Sorted Gridded Data
 SYNOP PARAMS

Process Specification (Figure 5-2):

This process shall:

1. Read input parameters for merging process.
2. Read Regional Time-Sorted Gridded data files for each instrument.

3. Merge data from different instruments; i.e., when data exist for a given hour and region from more than one instrument, average the data.
4. Output merged data.
5. Output Quality Control information.
6. Output metadata.

5.2.1.6 Process Synoptic Data - Process 7.1.6

Input Data Flows

CADM
CDM
GEORC
MOA
RGeo
Regional Time-Sorted Gridded Data
SDEC
SYNOP PARAMS

Output Data Flows

TSI
TSIMETA SYNOP
TSIQC SYNOP

Process Description ([Figure 5-2](#)):

This process will perform the following subprocesses:

1. Input hourly gridded data.
2. Perform interpolation of fluxes and cloud properties by latitude band.
3. Produce the output product, TSI.
4. Produce quality control reports and metadata.

The decomposition for this function is shown in [Figure 5-4](#).

5.2.1.6.1 Input Hourly Gridded Data - Process 7.1.6.1

Input Data Flows

Regional Time-Sorted Gridded Data
SYNOP PARAMS

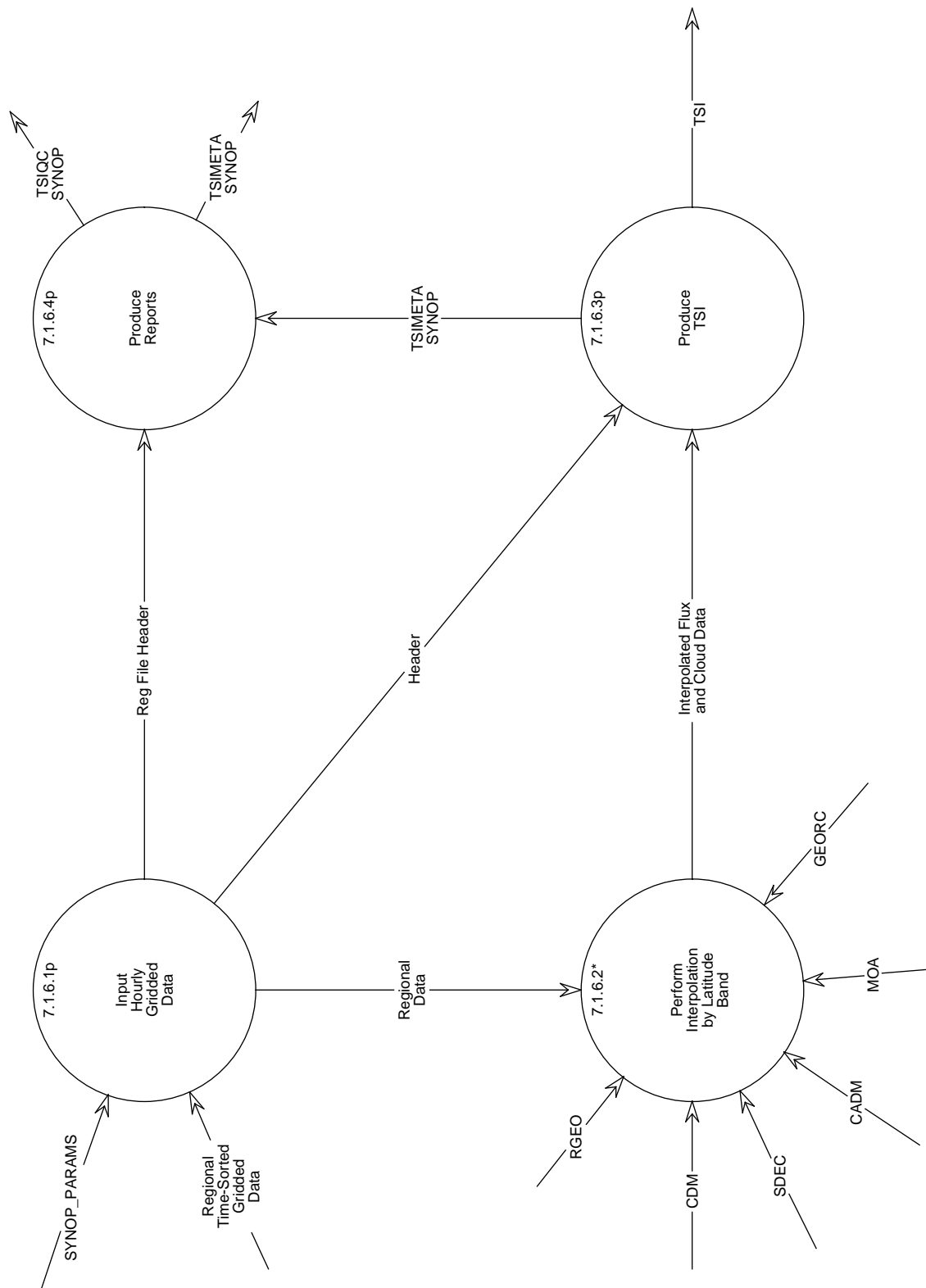


Figure 5-4. Data Flow Diagram for Process Synoptic Data

Output Data Flows

Header
Reg File Header
Regional Data

Process Specification (Figure 5-4):

This process shall:

1. Verify that the input headers indicate the sorted gridded data for the desired month, year, and satellite.
2. Output the input headers to the process Produce Reports.
3. Generate headers for the output product TSI using month, year, and instrument, and output these headers to process Produce TSI.
4. Output Regional Data to process Perform Interpolation by Latitude Band.

5.2.1.6.2 Perform Interpolation by Latitude Band - Process 7.1.6.2

Input Data Flows

CADM
CDM
GEORC
MOA
RGEO
Regional Data
SDEC

Output Data Flows

Interpolated Flux and Cloud Data

Process Description (Figure 5-4):

This process will perform the following subprocesses:

1. Process the solar information
2. Calculate SW diurnal models
3. Process by region number

The decomposition for this function is shown in [Figure 5-5](#).

5.2.1.6.2.1 Process Solar Information - Process 7.1.6.2.1

Input Data Flows

SDEC

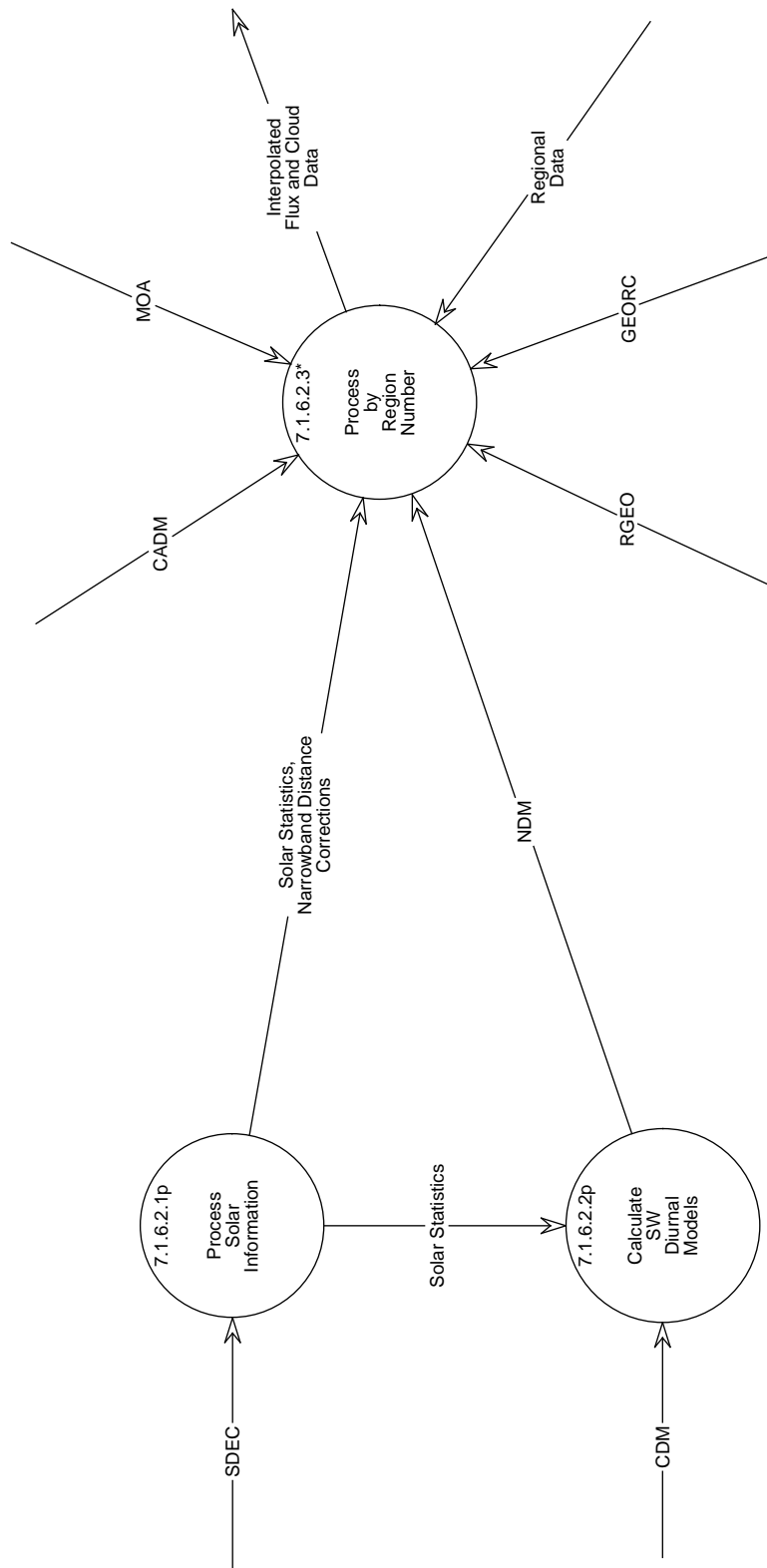


Figure 5-5. Data Flow Diagram for Perform Interpolation by Latitude Band

Output Data Flows
Solar Statistics

Process Specification (Figure 5-5):

This process shall:

1. Compute sine and cosine of latitude band.
2. For each day in the month:
 - a) Compute the sine and cosine of the solar declination angle
 - b) For each hour in the day:
 - 1) Compute the cosine of the solar zenith angle at the local solar half hour for the local half hour
 - 2) Sum the cosine of the solar zenith angle for the day.
 - 3) Compute the solar incidence value for the hour box by multiplying the cosine of the solar zenith angle for the half hour by the distance corrected broadband solar constant
 - c) Determine if the sun came up for the day, i.e., summed cosine of solar zenith angle for day is greater than 0.0000001
 - d) Compute the half day length since the half-sine fit for clear-sky longwave will not be used if the half day length is less than 1 hour.
 - e) Calculate the first and last daylight hours for the month using the half day length
 - f) Compute the integrated solar incidence for the day
3. Output the solar statistics to Process by Region Number.

This process performs similar functions as the subroutine, COSZSC, found in the ERBE code; algorithms may be modified to suit the CERES Project.

5.2.1.6.2.2 Calculate SW Diurnal Models - Process 7.1.6.2.2

Input Data Flows
CDM
Solar Statistics

Output Data Flows
NDM

Process Specification (Figure 5-5):

This process shall:

1. For each hour of the month:

- a) Determine if the cosine of the solar zenith angle is less than or equal to zero; if so, set the modeled directional values to zero
 - b) If the cosine is greater than zero and less than 0.05, set the modeled directional values to those values corresponding to a cosine of 0.05
 - c) If the cosine is greater than or equal to 0.95, set the modeled directional values to those values corresponding to a cosine of 0.95
 - d) Compute the indices which point to the nearest high and low modeled directional model values read from CDM
 - e) Compute the interpolation factor
 - f) Interpolate between high and low modeled values to compute the modeled directional values for each scene type
2. Output the normalized diurnal model (NDM) to Process by Region Number.

This process performs similar functions as subroutine, DIMODS, found in the ERBE code; algorithms may be modified to suit the CERES project.

5.2.1.6.2.3 Process by Region Number - Process 7.1.6.2.3

Input Data Flows

CADM
 GEORC
 MOA
 NDM
 Narrowband Distance Corrections
 RGEO
 Regional Data
 Solar Statistics

Output Data Flows

Interpolated Flux and Cloud Data

Process Description (Figure 5-5):

This process will perform the following subprocesses:

1. Read in data for a region.
2. Interpolate the cloud properties.
3. Interpolate the LW flux data for both total-sky and clear-sky.
4. Interpolate the SW flux data for both total-sky and clear-sky.
5. Interpolate the window fluxes.
6. Interpolate the surface-only parameters.

7. Gather all the above data and pass them on to process Produce TSI.

The decomposition for this function is shown in [Figure 5-6](#).

5.2.1.6.2.3.1 Interpolate Cloud Data Structures - Process 7.1.6.2.3.1

Input Data Flows

Cloud Data Sort

Output Data Flows

Angular Model Scene Class

Cloud Information TSI

Process Specification ([Figure 5-6](#)):

This process shall:

1. Linearly interpolate the four cloud data structures (Cloud Overlap Conditions, Cloud Category Properties, Column-Averaged Cloud Properties, and Angular Model Scene Class) using the following strategy:
 - a) If both the observation times contain a non-zero cloud amount for a given cloud pressure category, the means and standard deviations of all the cloud properties are linearly interpolated with respect to time with the exception of visible optical depth.
 - b) The visible optical depth is recalculated using the interpolated values of liquid (or ice) water path and particle size using the relationships described in [Reference 3](#).
 - c) If only one of the two observation times contains a non-zero cloud amount for the cloud category, then only the cloud amount is linearly interpolated. The remaining properties are assumed to be constant throughout the time period.

5.2.1.6.2.3.2 Convert Narrowband Radiances to Broadband Fluxes - Process 7.1.6.2.3.2

Input Data Flows

Angular Model Scene Class

CADM

GEORC

MOA

Narrowband Distance Corrections

RGEO

Output Data Flows

Broadband Fluxes

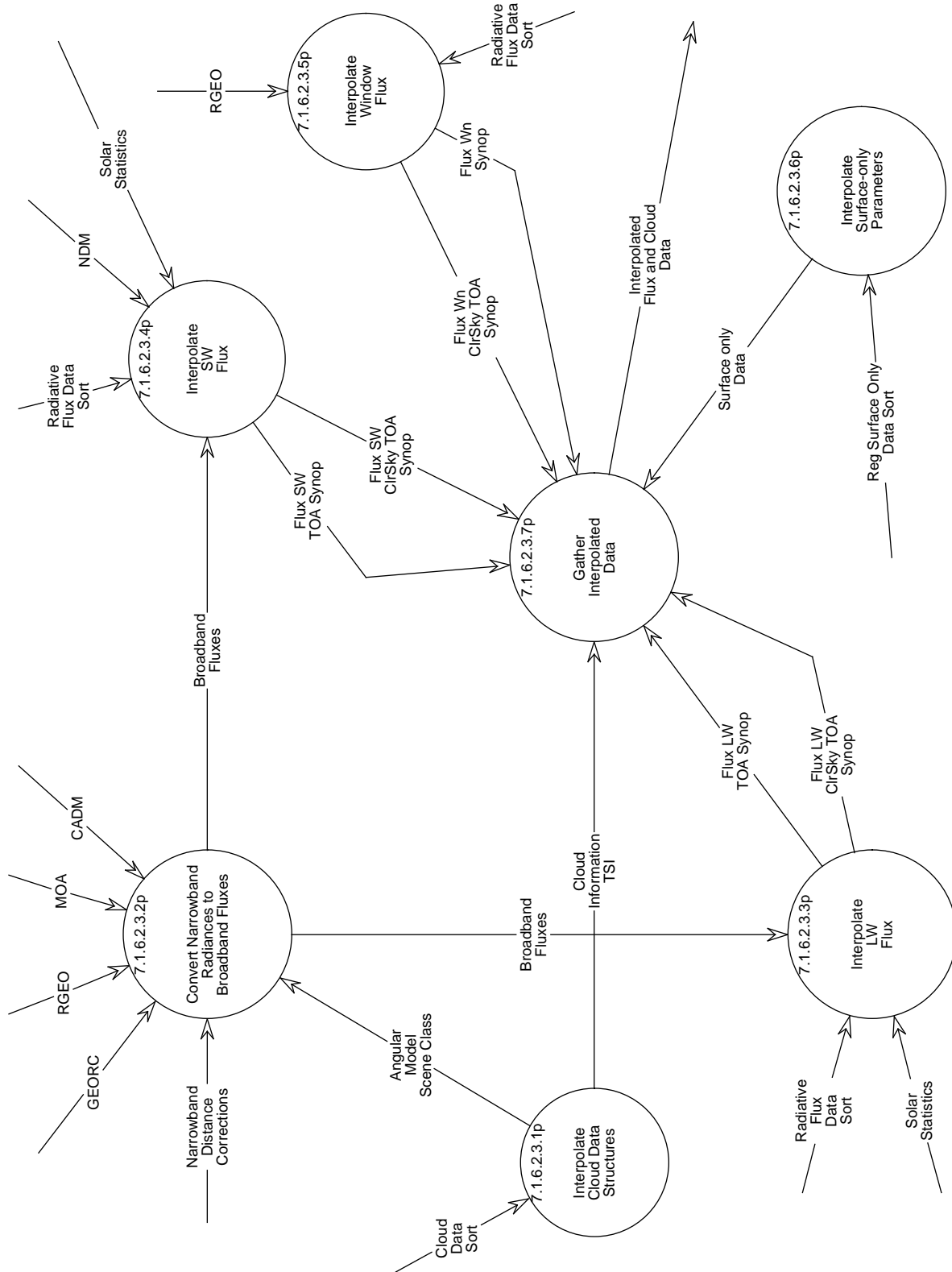


Figure 5-6. Data Flow Diagram for Process by Region Number

Process Specification (Figure 5-6):

This process shall convert narrowband radiances to broadband fluxes based on the following methods:

1. Total-sky Longwave:

- a) When geostationary data are available, the LW narrowband radiance from the geostationary data is converted to narrowband flux by the following equation:

$$F_{nb} = 6.18 \cdot \gamma(\theta)^{-1} \cdot I_{nb} \quad (\text{Reference 1})$$

where I_{nb} is the LW narrowband radiance, $\gamma(\theta)$ is the longwave limb-darkening function at viewing zenith angle θ , and 6.18 represents the product of the limb darkening function integrated over an entire hemisphere and the narrowband spectral interval.

- b) The LW narrowband flux is then converted to LW broadband flux by applying the following regression equation:

$$F_{bb} = a_o + a_1 F_{nb} + a_2 F_{nb}^2 + a_3 F_{nb} \ln(rh) \quad (\text{Reference 1})$$

where F_{bb} is the LW broadband flux, F_{nb} is the narrowband flux, rh is the column averaged relative humidity, and a_i are the derived coefficients.

2. Clear-sky Longwave:

The LW narrowband radiance data will not be used in the interpolation of clear-sky longwave data; therefore, there is no need to convert narrowband radiance data to broadband fluxes.

3. Total-sky Shortwave:

- a) Calculate the narrowband albedo from the narrowband observations using scene fraction and CERES broadband albedo weighted anisotropic factors. The narrowband albedo is calculated in the following equation:

$$\alpha_{nb} = \frac{\left(\frac{\pi I_{nb}}{S_v \cos \theta_o} \right)}{\left[\frac{\sum_{i=1}^{12} R_i \alpha_i f_i}{12} \right]} \quad (\text{Reference 1})$$

where I_{nb} is the mean narrowband SW radiance within the CERES region, S_v is the Earth-Sun distance corrected narrowband solar constant, θ_o is the solar zenith angle at the center of the region at the synoptic time, and α_i , f_i , and R_i are the albedo, scene fraction, and bidirectional anisotropic factor for ADM class i .

- b) The narrowband radiances are then converted to broadband fluxes using the following regression equation:

$$\alpha_{bb} = b_0 + b_1 \alpha_{nb} + b_2 \alpha_{nb}^2 + b_3 \ln(\sec(\theta_0)) \quad (\text{Reference 1})$$

where α_{nb} is the narrowband albedo, α_{bb} is the broadband albedo, and θ_0 is the solar zenith angle at the center of the region at the synoptic time, and b_i are the derived coefficients. Separate regressions are performed for ocean and land regions.

4. Clear-sky Shortwave:

The SW narrowband radiance data will not be used in the interpolation of clear-sky shortwave data; therefore, there is no need to convert narrowband radiance data to broadband fluxes.

5.2.1.6.2.3.3 Interpolate LW Flux - Process 7.1.6.2.3.3

Input Data Flows

Broadband Fluxes
Radiative Flux Data Sort
Solar Statistics

Output Data Flows

Flux LW ClrSky TOA Synop
Flux LW TOA Synop

Process Specification (Figure 5-6):

This process shall:

1. Interpolate the total-sky TOA LW flux in one of the two methods described below:
 - a) Method 1 -- References (2,6)
 - 1) For the ocean, coastal, and snow-covered regions, linear interpolation is used to provide a value for each hour box not observed by CERES. At the beginning of the month, all hours preceding the first observation are filled with the value from the first observed time of the month. This is similar for the end of the month.
 - 2) For land and desert regions, for any day in which an observation is made during the daylight hours and during the preceding and following nights, the LW flux for the remaining hours of the day are modeled by fitting a half-sine curve to the observations. On days that do not have the required observations or if any daylight observations of LW flux are less than the night time values or if the resultant half-sine curve has a negative amplitude, the interpolation performed is linear.

b) Method 2: -- Reference (1)

The simulated broadband measurements (derived LW flux from process Convert Narrowband Radiances to Broadband Fluxes) for the region are normalized to the nearest CERES observation of flux. For points between two CERES measurements, the normalization is linearly scaled inversely by the time difference between the hour in question and the times of the observations.

Method 2 is the algorithm of choice unless geostationary data are not available or are inadequate; in that case Method 1 is used for interpolation.

2. Interpolate the clear-sky TOA LW flux:

Similar to Method 1 of the above algorithms with the exception that clear-sky TOA LW flux is necessary at each synoptic time; in cases where measurements are not available at the particular time, the clear-sky fits from the nearest day with data are used.

5.2.1.6.2.3.4 Interpolate SW Flux - Process 7.1.6.2.3.4

Input Data Flows

Broadband Fluxes
NDM
Radiative Flux Data Sort
Solar Statistics

Output Data Flows

Flux SW ClrSky TOA Synop
Flux SW TOA Synop

Process Specification (Figure 5-6:

This process shall:

1. Interpolate the total-sky TOA SW flux:

a) Method 1:

- 1) For each hour box with an observation, a separate albedo is calculated for each of the cloud classifications.
- 2) Measured values are adjusted to the nearest local solar half hour.
- 3) For a given surface type and cloud cover category, (i.e. scene type for selecting an ADM), the albedos at time t and t' may be specified in terms of a reference value at overhead Sun:

$$\alpha_i(\mu(t)) = \alpha_i(\mu_0 = 1) \cdot \delta_i(\mu(t)) \quad (\text{Reference 2})$$

where μ is the cosine of the solar zenith angle, and δ_i is the normalized ADM function for scene type i . The albedo at any time t' (e.g., at the local solar half hour) can be calculated in terms of known quantities at the time of observation, t_{obs} :

$$\alpha_i(t') = \alpha_i(\mu(t_{obs})) \cdot \frac{\delta_i(\mu(t'))}{\delta_i(\mu(t_{obs}))} \quad (\text{Reference 2})$$

- 4) For days with only one measurement of SW flux, each of the cloud type albedos from the hour of observation is modeled to all daylight hours using equation 3.4 in Reference 2 and the appropriate ADMs. The albedos are then recombined by weighting each cloud type albedo with the appropriate areal coverage fraction to obtain the mean albedo for each hour for the entire region.
 - 5) For days with more than one measurement, all daylight hours preceding the first and following the last measurement assume constant cloud class from the nearest measurement. These hours are modeled as in the single measurement case. For hours between two measurements, the cloud type albedos are calculated from each surrounding measurement and the appropriate ADMs. The total albedo for each hour between the two measurements is calculated by inversely weighting the two estimates by the time from the hour of interest.
 - 6) The SW flux is calculated by multiplying the total albedo by the solar flux for that time.
- b) Method 2: -- Reference (1)
- 1) Read in the converted broadband fluxes.
 - 2) Normalize the time series to the CERES broadband observations
 - 3) Linearly interpolate the measurements using the cloud amounts and albedos in order to select the proper anisotropic factor.
2. Interpolate the clear-sky TOA SW flux:

Interpolate the CERES data using the clear-sky ADMs appropriate to the regional type surface using the Method 1 of total-sky LW interpolation.

5.2.1.6.2.3.5 Interpolate Window Flux - Process 7.1.6.2.3.5

Input Data Flows

RGEO
Radiative Flux Data Sort

Output Data Flows

Flux Wn ClrSky TOA Synop
Flux Wn Synop

Process Specification (Figure 5-6):

This process shall:

1. Interpolate the window flux:
 - a) Method 2 of the total-sky TOA LW flux interpolation is used with the difference that the narrowband to broadband regression is not used.
 - b) The geostationary radiances will be normalized to the CERES measurements in order to correct for any differences in the spectral intervals or the calibration of the instruments.

5.2.1.6.2.3.6 Interpolate Surface-only Parameters - Process 7.1.6.2.3.6

Input Data Flows

Reg Surface Only Data Sort

Output Data Flows

Surface only Data

Process Specification (Figure 5-6):

This process shall:

1. Interpolate the surface only parameters using a TBD method

5.2.1.6.2.3.7 Gather Interpolated Data - Process 7.1.6.2.3.7

Input Data Flows

Cloud Information TSI
Flux LW ClrSky TOA Synop
Flux LW TOA Synop
Flux SW ClrSky TOA Synop
Flux SW TOA Synop
Flux Wn ClrSky TOA Synop
Flux Wn Synop
Surface only Data

Output Data Flows

Interpolated Flux and Cloud Data

Process Specification (Figure 5-6):

This process shall:

1. Gather the interpolated TOA total-sky and clear-sky LW flux data.
2. Gather the interpolated TOA total-sky and clear-sky SW flux data.
3. Gather the interpolated cloud data.
4. Gather the interpolated surface only parameters.
5. Gather the interpolated window fluxes.
6. Send above data to process Produce TSI.

5.2.1.6.3 Produce TSI - Process 7.1.6.3

Input Data Flows

Header
Interpolated Flux and Cloud Data

Output Data Flows

TSI
TSIMETA SYNOP

Process Specification (Figure 5-4):

This process shall:

1. Write header to output product TSI.
2. Format processed science data into a 3-hour region-sequenced data file.
3. Output data product TSI only if there were no failure error messages.
4. Provide the necessary metadata information for the data product to process Produce Reports.

5.2.1.6.4 Produce Reports - Process 7.1.6.4

Input Data Flows

Reg File Header
TSIMETA SYNOP

Output Data Flows

TSIMETA SYNOP
TSIQC SYNOP

Process Specification (Figure 5-4):

This process shall:

1. Write metadata (TBD).
2. Write an error message report to the quality control report.

3. Write a global processing summary to the quality control report.
4. Write a summary of the hours with data to the quality control report.
5. Write a statistics summary to the quality control report.
6. If it is necessary to write the output to different files, an output file summary will be written to the quality control report. The output file summary will indicate which region of the globe resides on a given science output data file.

5.2.2 Compute Fluxes - Process 7.2

Input Data Flows

TSI

Output Data Flows

SYN

Process Specification (Figure 5-1):

This process shall:

1. Calculate synoptic maps of the vertical structure of atmospheric and surface flux using the interpolated data as input and boundary conditions.

There exists a separate Software Requirements Document for this process written by the Surface and Atmospheric Radiation Budget Working Group ([Reference 7](#)).

5.3 Design Goals and Constraints

The following are considered to be the design goals for this Subsystem:

1. Flexibility of code so as to be reusable for multiple instrument processing.
2. Inclusion of and modifications to certain routines of the ERBE FORTRAN code in order to minimize coding efforts.
3. Code improvements through lessons learned from the ERBE UNIX conversion ([Reference 8](#)).

The following are considered to be the implementation constraints for this Subsystem:

1. The availability and suitability of geostationary data is a concern for this Subsystem. This is due to the timeliness issue of the ISCCP DX data; there will almost certainly be a delay in obtaining the data since the cloud parameters need to be calculated by ISCCP. The B3 data is more readily available on a near real-time basis, but it does not contain any cloud information.

2. Data gaps in the ISCCP product are also a concern. This is due to the fact that the Indian Satellite (INSAT) data are often not available and the ISCCP products do not include SW data for solar zenith angles over 72.5 degrees, which limits the data being used for the SW interpolation process.
3. Regressions that are to be used to produce the broadband measurements have to be derived monthly. This is due to the seasonal variations in surface albedos and variations in regional cloud type.
4. If the source of the narrowband data is not from ISCCP, then the narrowband radiances may have to be calibrated for each of the geostationary satellites; procedures will have to be developed for this purpose.
5. The EOSDIS Toolkit shall be used for the input/output calling sequences and aid in statistical and graphical calculations. ([Reference 9](#))
6. The archival data products shall be organized using Hierarchical Data Format (HDF).
7. Metadata and handling of such shall be determined by the EOSDIS Toolkit ([Reference 9](#)).

5.4 Resource Use

The TSI product will be produced once for every 3 hours of satellite data or a maximum of 248 times for each satellite month. A separate combined-satellite product will be produced with the same frequency for each data month. The estimated product size for TSI is 25.9 MB or approximately 6420 MB for a month's worth of satellite data.

The CPU processing load has been estimated for a Sun Sparc 2, based on ERBE experience ([Reference 10](#)) to be 20 minutes per product or a maximum of 82 hours for a month's worth of satellite data.

References

The following documents are referenced herein and are directly applicable to this document:

1. Clouds and the Earth's Radiant Energy System (CERES), Algorithm Theoretical Basis Document, Time Interpolation and Synoptic Flux Computation for Single and Multiple Satellites, Release 1.1, April 1994.
2. Clouds and the Earth's Radiant Energy System (CERES), Algorithm Theoretical Basis Document, ERBE-like Averaging to Monthly TOA and Surface Fluxes, Release 1.1, April 1994.
3. Clouds and the Earth's Radiant Energy System (CERES), Algorithm Theoretical Basis Document, Cloud Optical Property Retrieval, Release 1.1, April 1994.
4. Clouds and the Earth's Radiant Energy System (CERES), Algorithm Theoretical Basis Document, CERES Inversion to Instantaneous TOA Fluxes, Release 1.1, April 1994.
5. CERES Data Management System Data Products Catalog, Release 1, July 1994.
6. Earth Radiation Budget Experiment (ERBE), Data Management System Reference Manual, Volume VI - Daily Data Base and Monthly Time/Space Averaging, November, 1986.
7. Synoptic Surface and Atmospheric Radiation Budget (SARB) Software Requirements Document (Subsystem 7.2), CERES Data Management System Software Requirements Document, Release 1, NASA Langley Research Center, August 1994.
8. ERBE-Like Inversion to Instantaneous TOA and Surface Fluxes (Subsystem 2.0), CERES Data Management System Software Requirements Document, Release 1, NASA Langley Research Center, August 1994.
9. PGS Toolkit Users Guide for the ECS Project, Hughes Applied Information Systems, Version 1 Final, May 1994.
10. Clouds and the Earth's Radiant Energy System (CERES), Algorithm Theoretical Basis Document, CERES Data Processing System Objectives and Architecture, Release 1.1, April 1994.

Abbreviations, Acronyms, and Symbols

ADM	Angular Distribution Models
AVHRR	Advanced Very High Resolution Radiometer
CADM	CERES Angular Distribution Models
CDM	CERES Directional Models
CERES	Clouds and the Earth's Radiant Energy System
DAAC	Distributed Active Archive Center
ECS	EOSDIS Core System
EOS	Earth Observing System
EOSDIS	Earth Observing System Data and Information System
ERBE	Earth Radiation Budget Experiment
ERBS	Earth Radiation Budget Satellite
FORTTRAN	FORmula TRANslation
FSW	Hourly Gridded Single Satellite Fluxes and Clouds
GEO	Geostationary data
GEORC	GEO Regression Coefficients
GMT	Greenwich Mean Time
hPa	hectoPascal
ISCCP	International Satellite Cloud Climatology Project
LaRC	Langley Research Center
LW	Longwave
MOA	Meteorological, Ozone, and Aerosol
N/A	Not Applicable
NDM	Normalized Directional Model
NOAA	National Oceanic and Atmospheric Administration
PGS	Product Generation System
QC	Quality Control
RAPS	CERES Rotating Azimuth Plane Scanner
RGEO	Regridded Geostationary data
SARB	Surface and Atmospheric Radiation Budget
SDEC	Solar Declination
SPC	Sector Processing Center
SW	Shortwave
TBD	To Be Determined
TOA	Top-Of-Atmosphere
TRMM	Tropical Rainfall Measuring Mission (joint US-Japan)
TSI	Time Space Interpolation of cloud properties and TOA fluxes
WN	Window

