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

# Data Management System

Software Requirements Document

Compute Regional, Zonal, and Global Averages
(Subsystem 8.0)

Release 1
Version 1

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**January 1995**

# 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.

Acknowledgement is given to David F. Young, of Lockheed Engineering and Sciences Company, for his technical guidance and tireless support.

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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

The purpose of this document is to serve as a basis for designing the Monthly Regional, Zonal, and Global Radiation Fluxes and Cloud Properties Subsystem.  The intended audience for this document consists of the following groups: the Subsystem design team, testers, and science reviewers.

The objective of this document is to provide a complete set of requirements necessary to guide the development of this Subsystem.  Additional information is provided to suggest guidelines for organizing the design efforts.

This document contains the following information:

- Brief overview of this Subsystem
- Description of key concepts
- Description of the requirements approach and any necessary trade-offs
- External Interface Requirements
- Explanation of the operating mode for this Subsystem
- Detailed functional requirements for the Subsystem
- Description of any design goals and constraints
- Identification of resource usage requirements
- References, Abbreviations, Acronyms, and Symbols

## 1.2  System Overview

The Monthly Regional, Zonal, and Global Radiation Fluxes and Cloud Properties Subsystem produces regional, zonal and global monthly and monthly-hourly means of shortwave (SW) and longwave (LW) fluxes and cloud conditions.  These means are calculated from 1-month of synoptic maps on a regional basis and then combined to produce zonal and global averages.

The main input to this Subsystem is the Synoptic Radiative Fluxes and Clouds (SYN) product produced by the Time Interpolation and Synoptic Flux Computation for Single and Multiple Satellites Subsystem (Subsystem 7.0).  This product contains 1-month of 3-hourly synoptic maps of top-of-atmosphere (TOA) LW and SW fluxes, TOA window radiances, upwelling and downwelling SW and LW flux at each standard CERES pressure level, and numerous cloud parameters for each region of the CERES global 1.25-degree equal-area grid.  The flux parameters include both total-sky and clear-sky.

The two archival products output from this Subsystem are the Monthly Regional Radiative Fluxes and Clouds (AVG) product which contains regional monthly and monthly-hourly means of fluxes and cloud parameters and the Monthly Zonal and Global Radiative Fluxes and Clouds (ZAVG) product which contains the same parameters but averaged on zonal and global scales.

The main steps involved in the averaging process are:

- Reading the synoptically ordered data.

- Averaging the LW and SW flux data to produce monthly and monthly-hourly means.

- Averaging the cloud properties using the specified weighting schemes.

- Averaging the regional means to produce zonal and global means.

## 2.0 Key Concepts

The following key concepts are embodied in the Monthly Regional, Zonal, and Global Radiation Fluxes and Cloud Properties Subsystem.

*Data Organization.* The input data are organized as files that contain synoptic maps of the vertical structure of flux and cloud properties. A separate data file exists for maps at 0, 3, 6, ...., 21 Greenwich mean time (GMT) for each day of the month. Each file contains data organized regionally on the CERES equal-area grid. Sums of data values are maintained for each region and parameter simultaneously.

*Usage of ERBE Subroutines.* In this Subsystem, ERBE Monthly Time/Space Averaging (MTSA) and ERBE S-4 subroutines will be modified to fit the needs of the CERES project when deemed desirable. The routine names that are found in the process specifications can be located in the ERBE Data Management System Reference Manual Volume VI - Daily Data Base and Monthly Time/Space Averaging (Reference 1) and the ERBE Data Management System Reference Manual, Volume VII - Output Products (Reference 2).

*Averaging of LW fluxes.* Since the temporal interpolation necessary for calculating the monthly means has already been performed in Subsystem 7.0 (Reference 3) and since the fluxes have also been calculated at the levels at which they are averaged in Subsystem 7, the monthly means of LW fluxes are computed by averaging the month of synoptic data.

*Averaging of SW fluxes.* For SW fluxes, constantly changing solar conditions and the change of albedo as a function of the solar zenith angle have to be considered. All SW averages use the same techniques described in the ERBE-like Averaging to Monthly TOA and Surface Fluxes Subsystem, Subsystem 3.0, (Reference 4) to correct mean fluxes.

*Averaging of Cloud Parameters.* Data from the synoptic grids for the cloud category properties and the cloud overlap statistics are linearly averaged. Monthly means for the Angular Model Scene Class data are compiled using data from times of CERES observations. Column-weighted cloud properties are averaged using the weighting schemes as described in the Grid Single Satellite Fluxes and Clouds Subsystem, Subsystem 6.0, (Reference 5).

*Output Products.* Since input data are only from 0, 3, 6,...,21 GMT, monthly-hourly means are produced for each parameter for only these times. Once regional means are computed for all parameters and all regions, they are accumulated and formatted to form AVG, one of the archival products produced by this Subsystem. The regional means are then combined into zonal and global means. Area weighting factors are used to correct for the slight variation of grid box size with latitude. These means are then accumulated and formatted to form the second archival product, ZAVG.

*Metadata and Error Handling.* Metadata and error handling will conform to the EOSDIS operating environments, 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 processing takes place for this Subsystem.

## 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 process 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 6).

1.  Temporal and vertical interpolation of TOA LW flux is not needed.

    Rationale:  This process, which is necessary for calculating monthly means, has already been done in Subsystem 7.0 (Reference 3).  This provides a complete data set with uniform time sampling.  The fluxes have been calculated at the levels at which they are averaged; hence, no vertical interpolation is required (Reference 3).

2.  SW averaging is performed using the methods in the ERBE-like Averaging to Monthly TOA and Surface Fluxes Subsystem (Reference 4).

    Rationale:  Consideration needs to be given for the constantly changing solar conditions and the change of albedo as a function of the solar zenith angle.  The ERBE-like method of averaging the SW fluxes corrects the mean fluxes to more accurately account for the contribution of the total integrated incident solar flux.

# 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.
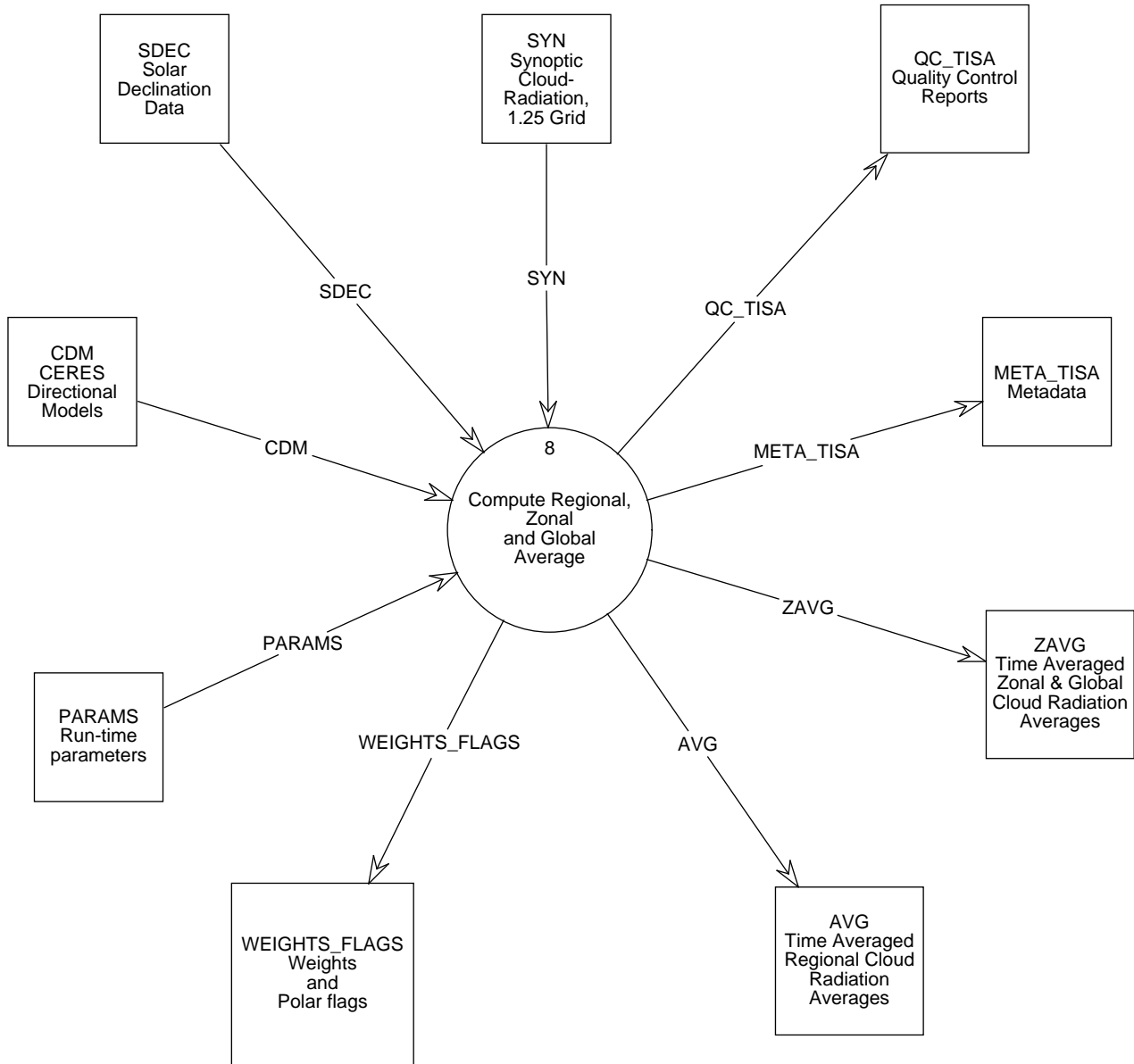
Figure 4-1. Context Diagram

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## 4.1 AVG

The Monthly Regional Radiative Fluxes and Clouds product (AVG) contains a monthly and monthly hourly average of the TOA and surface LW and SW fluxes together with LW and SW fluxes at standard pressure levels in between. This final product also contains observed cloud and clear-sky properties at the standard 1.25-degree horizontal resolution.

AVG is an archival product produced for each instrument and for each combination of instruments. Initially, at the TRMM launch, this product is produced in a validation mode every 3 months; or for 4 months a year. During these 18 months, the CERES Science Team will derive a production quality set of Angular Distribution Models, which are needed to produce the LW and SW instantaneous fluxes. Eighteen months after the TRMM launch, this product is archived and contains LW and SW fluxes at the tropopause and at 500 hPa pressure levels. Thirty-six months after the TRMM launch, this archived product contains LW and SW fluxes at 18 standard pressure levels. The pressure levels are in addition to fluxes at TOA and at the surface. In addition, the cloud and clear-sky properties are averaged between the 18 pressure levels, resulting in 17 vertical instances of the averaged cloud properties.

The major categories of data on the AVG are
- Regional location data.
- Radiative fluxes for both clear-sky and total-sky at TOA.
- Cloud category properties for four (low, lower middle, upper middle, and high) cloud layers.
- Column-averaged cloud properties for five (TOA SW, TOA LW, Surface (SFC) LW, Liquid Water Path (LWP), and Ice Water Path (IWP)) 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 conditions.
- Angular model scene classes.
- Adjustment parameters for four cloud layers.
- Atmospheric flux profile for clear-sky and total-sky.
- Flux adjustments for clear-sky and total-sky.
- Surface-only data.
- Adjustment parameters for clear-skies.

Details of the AVG product can be found in the CERES Data Management System Data Products Catalog (Reference 7).

## 4.2 CDM

The CERES Directional Models (CDM) contain 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. For Release 1, CDM 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.

## 4.3 META TISA

META_TISA consists of all the metadata (TBD) produced by this process for the two archival products, AVG and ZAVG.

## 4.4 PARAMS

The run-time parameters (PARAMS) product is ancillary input to this Subsystem. It consists of run-time parameters needed to identify and process the data. The parameters classified in this product are (but not limited to):

1. The satellite identification.

2. The data month being processed.

3. The number of days in the data month being processed in order to help identify if there are any missing days of data in the data month.

4. The year being processed

This product is classified for this project as internal ancillary and, therefore, will be generated as needed to process this data.

## 4.5 QC TISA

QC_TISA contains two separate files of Quality Control (QC) information for the archival products for this Subsystem, AVG and ZAVG. The QC information consists of echoes of the run-time parameters, error messages, a summary of the hours containing data, statistics for sample regions, global processing summary, and zonal and global averages.

## 4.6 SDEC

The Solar Declination (SDEC) product contains the tabulated values of solar declination angles and distance corrections to the broadband solar constant. 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. The distance corrections to the broadband solar constant are not needed in this Subsystem but are used in the CERES Time Interpolation and Synoptic Flux Computation for Single and Multiple Satellites Subsystem, Subsystem 7.0, and the Monthly Regional TOA and Surface Radiation Budget Subsystem, Subsystem 10.0.

## 4.7  SYN

The CERES archival product, Synoptic Radiative Fluxes and Clouds (SYN), is produced by the CERES Time Interpolation and Synoptic Flux Computation for Single and Multiple Satellites Subsystem.  Each SYN file contains regional longwave and shortwave radiative fluxes for the surface, internal atmosphere, and TOA.  The data are synoptically computed at 3-hour intervals on a 1.25-degree equal area ISCCP-type grid, and are based on measurements from multiple EOS CERES instruments.  In addition to being an archival product, the SYN is used by the Monthly Regional, Zonal, and Global Radiation Fluxes and Cloud Properties Subsystem.

The SYN contains global maps at regular synoptic intervals of :

- Regional data
- Observed CERES TOA data for clear-sky and total-sky
- Cloud category properties for four cloud layers
- Column-averaged cloud properties for five weighting schemes
- Overlap data for 11 cloud overlap conditions
- Angular model scene classes for 12 ERBE scene types
- Atmospheric flux profile for both clear-sky and total-sky at the surface, 500 hPa, tropopause, and TOA
- Flux adjustments (tuned-untuned) for clear-sky and total-sky at the surface and TOA
- Surface-only data
- Adjustment parameters for clear-skies
- Adjustment parameters for L, LM, UM, and H cloud layers.

Details of this product can be found in CERES Data Management System Data Products Catalog (Reference 7).

## 4.8  WEIGHTS FLAGS

WEIGHTS_FLAGS contains the polar flags and the area weighting factors.  The polar flags are day-night indicators needed in this Subsystems to identify those regions within approximately 23.5 degrees of the poles that experience continuous darkness or continuous light at certain times of the year.  These regions are treated differently from those which always experience day-night cycles when calculating zonal and global averages.  The polar flags vary monthly and are calculated for an entire year.

The area weighting factors are values needed in this Subsystem to account for the small differences in the areas of regions in different latitude zones.  Only one weighting factor is needed for each latitudinal band.  The area weighting factors do not change; they may be calculated once and used repeatedly.

A FORTRAN program already exists to calculate the polar flags and area weighting factors.

## 4.9 ZAVG

The Monthly Zonal and Global Radiative Fluxes and Clouds (ZAVG) product is a summary of the zonal and global averages of the radiative fluxes and cloud properties, probably most suitable for inclusion in the Earth Observing System Data and Information System (EOSDIS) Information Management System (IMS) as a browse product. This product is the CERES equivalent to the zonal averages and global averages in the ERBE S-4 product.

ZAVG is an archival product produced by the TISA Subsystem for each instrument and for each combination of instruments. Initially at the TRMM launch, this product is produced in a validation mode every 3 months, or for 4 months a year. During the first 18 months, the CERES Science Team will derive a production quality set of Angular Distribution Models, which are needed to produce the LW and SW instantaneous fluxes. Eighteen months after the TRMM launch, this product is archived and contains LW and SW fluxes at the tropopause, and at 500 hPa pressure levels. Thirty-six months after the TRMM launch, this archived product will contain LW and SW fluxes at 18 standard pressure levels. The pressure levels are in addition to fluxes at TOA and at the surface. In addition, the cloud and clear-sky properties are averaged between the 18 pressure levels, resulting in 17 vertical instances of the averaged cloud properties. ZAVG contains one record of monthly and monthly hourly averages for each of the 144 latitudinal zones and one record of global averages.

The major categories of data on the ZAVG are

- Regional location data
- Radiative fluxes for both clear-sky and total-sky at TOA
- Cloud category properties for four cloud layers
- Column-averaged cloud properties for five weighting schemes
- Overlap data for eleven cloud conditions
- Angular model scene classes
- Adjustment parameters for four cloud layers
- Atmospheric profile for clear-sky and total-sky
- Flux adjustments for clear-sky and total-sky
- Surface-only data
- Adjustment parameters for clear-skies

Details of this product can be found in the CERES Data Management System Data Products Catalog (Reference 7).

# 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 one normal mode of operation for this Subsystem. A description of this mode follows:

When a months worth of SYN product is passed as input to this Subsystem, process Compute Regional Averages, which averages the parameters passed on a regional basis, is invoked.  The output of this process, AVG, is then input to the process Compute Zonal and Global Averages to compute the output product, ZAVG, which contains averages of the parameters on a zonal and global basis.  Process Generate Weights and Flags will be executed, or the data produced by this process 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 4.0.  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.

### 5.2.1  Compute Regional Averages - Process 8.1

**Input Data Flows**
>      CDM
>      REGPARAM
>      SDEC
>      SYN

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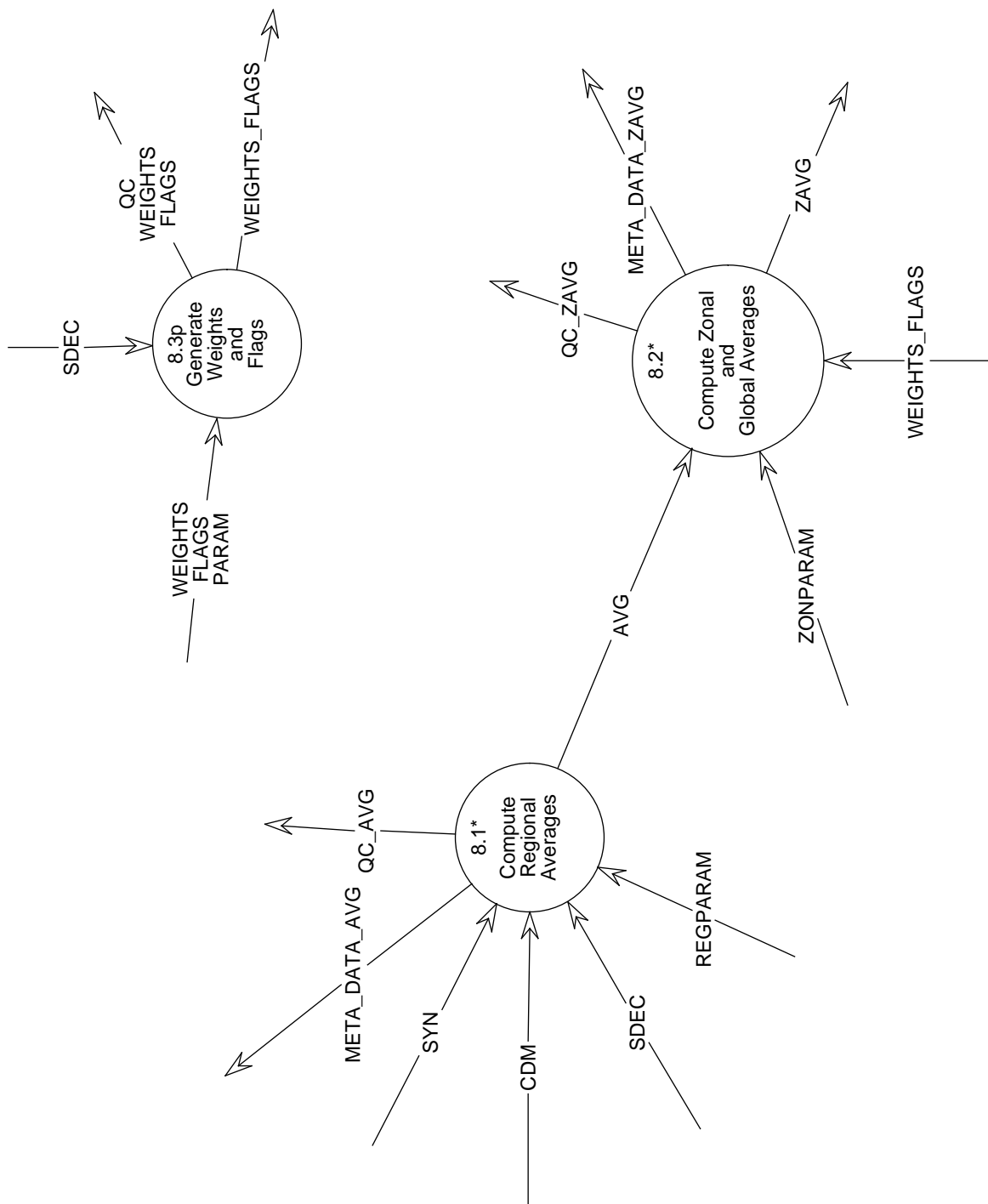
Figure 5-1.  Data Flow Diagram for Level 0

**Output Data Flows**
     AVG
     META DATA AVG
     QC AVG

**Process Description** (Figure 5-1):

This process will consist of the following subprocesses:

1.   Input and sort synoptic and auxiliary data.

2. Process by latitude band.

3. Produce the output product, AVG.

4. Produce QC and metadata information.

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

### 5.2.1.1  Input Sorted Synoptic and Auxiliary Data - Process 8.1.1

**Input Data Flows**
     CDM
     REGPARAM
     SDEC
     SYN

**Output Data Flows**
     CDM
     Header
     SDEC
     SYN

**Process Specification** (Figure 5-2):

This process shall:

1. Read the input data, SYN, strip the header from the input data, validate it, and output it to processes Produce Reports and Produce AVG Product.

2. Read in the directional models.

3. Read in the solar declination data.

Figure 5-2.  Data Flow Diagram for Compute Regional Averages

4. Read in the run-time parameters.

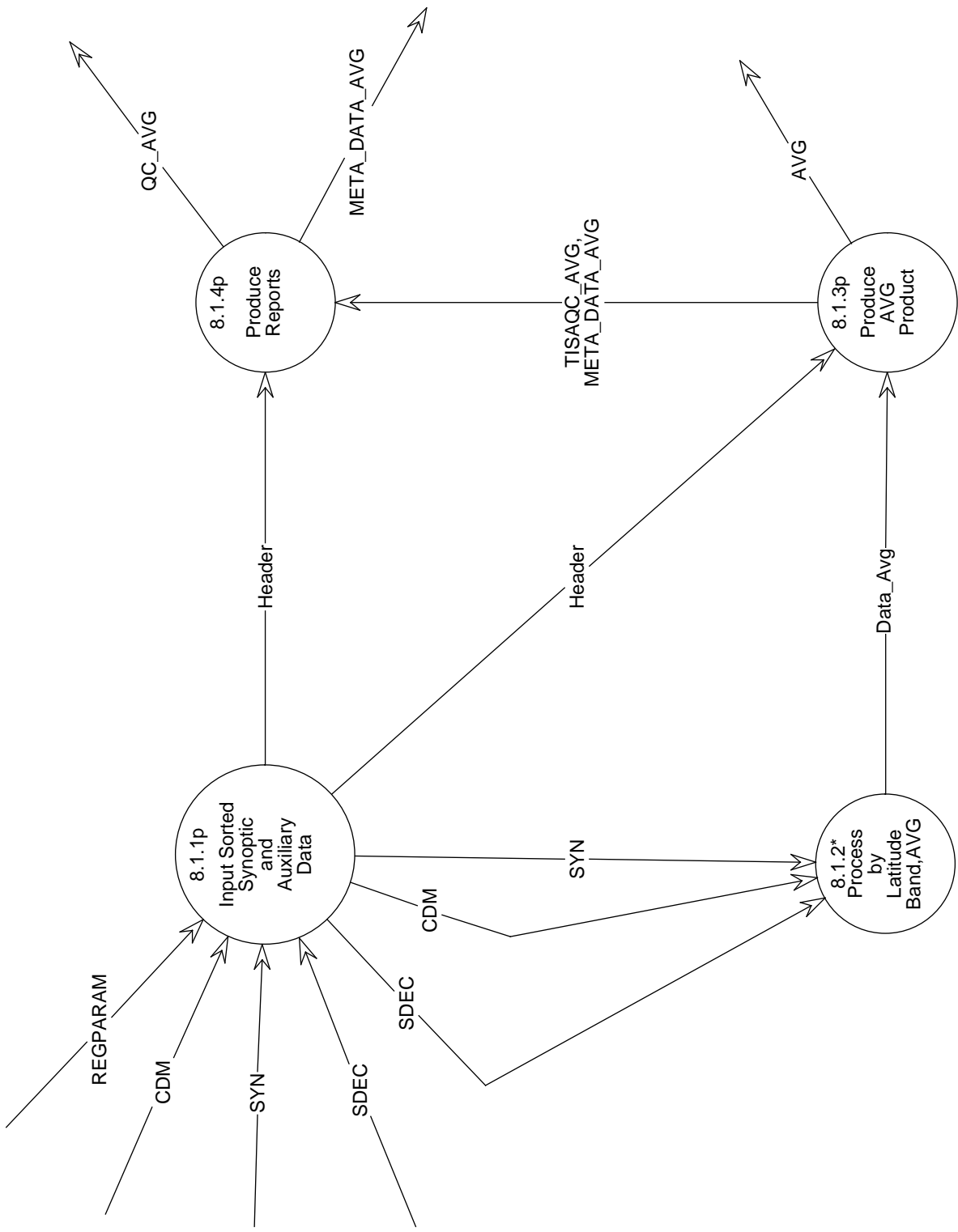5. Output the synoptic data, the solar declination data, and the CERES directional models to Process by Latitude Band.

6. If errors occur in reading the above data, output the error message to produce a report and abort operations.

This process performs similar functions as the subroutines, INITSC and LDTABLS, found in the ERBE code; algorithms may be modified to suit the CERES Project.

### 5.2.1.2  Process by Latitude Band,AVG - Process 8.1.2

**Input Data Flows**
      CDM
      SDEC
      SYN

**Output Data Flows**
      Data Avg

**Process Description** (Figure 5-2):

For each latitude band, this process will consist of the following subprocesses:

1. Process the solar information.

2. Calculate the SW diurnal model.

3. Process by region number.

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

The decomposition for this function is shown in Figure 5-3.

### 5.2.1.2.1  Process Solar Information - Process 8.1.2.1

**Input Data Flows**
      SDEC

**Output Data Flows**
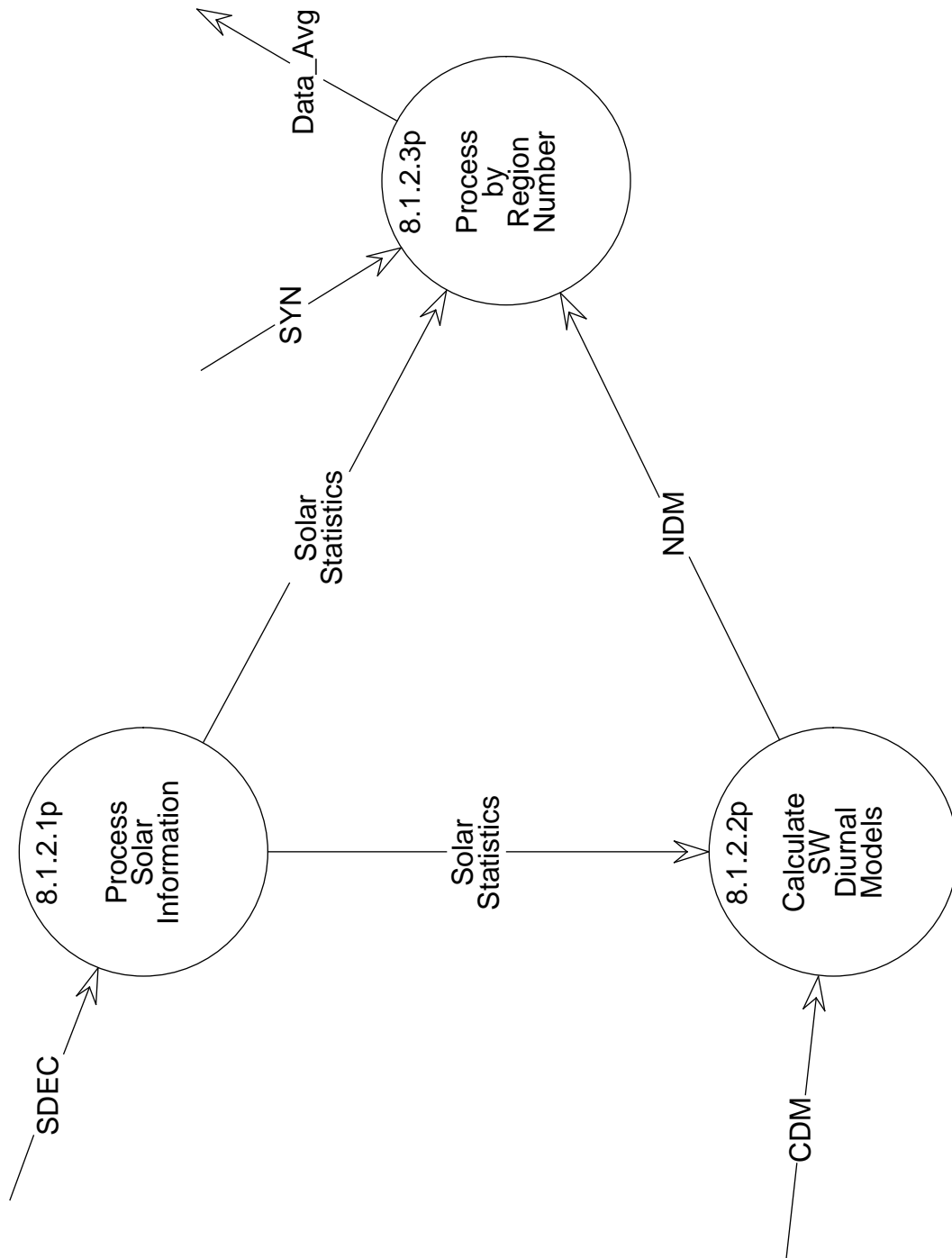      Solar Statistics

Figure 5-3. Data Flow Diagram for Process by Latitude Band, AVG

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**Process Specification** (Figure 5-3):

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 hour for the local half hour.

      2) Sum the cosine of the solar zenith angle up 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.

      4) Determine if the Sun came out that day, i.e., summed cosine of the solar zenith angle is greater than 0.0000001.

      5) Compute the half day length as the half-sine fit for clear-sky longwave will not be used if half day length is less than 1 hour.

      6) Calculate the first and last daylight hours for the month using the half day length.

      7) Compute the integrated solar incidence for the day.

      8) Output the solar statistics to processes Calculate SW diurnal models and 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.

### 5.2.1.2.2 Calculate SW Diurnal Models - Process 8.1.2.2

**Input Data Flows**
    CDM
    Solar Statistics

**Output Data Flows**
    NDM

**Process Specification** (Figure 5-3):

This process shall:

1. For each hour of the month, calculate the SW normalized directional model values for each scene type associated with the cosine of the solar zenith angle on a latitude band basis:

   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 an 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.

### 5.2.1.2.3 Process by Region Number - Process 8.1.2.3

**Input Data Flows**
> NDM
> SYN
> Solar Statistics

**Output Data Flows**
> Data Avg

**Process Specification** (Figure 5-3):

For monthly and monthly hourly averages, this process shall:

1. Compute the means of LW fluxes by averaging the month of synoptic data.

2. Compute the SW averages. This is done by using the same techniques described in the Total-Sky and Clear-Sky TOA SW Flux Section of Subsystem 3.0 (Reference 4).   The mean fluxes are corrected to more accurately account for the contribution of the total integrated incident solar flux.

3. Compute the linear averages of the cloud category properties and the cloud overlap statistics using the data from the synoptic input data.

4. Compute the averages of the Angular Model Scene Class by using only the data from the clock times of the CERES observations.

5. Compute the averages of the column-weighted cloud properties.  This is done using the proper weighting schemes described in the Spatial Averaging Algorithm Subsection of Subsystem 6.0 (Reference 5).

### 5.2.1.3  Produce AVG Product - Process 8.1.3

**Input Data Flows**
> Data Avg
> Header

**Output Data Flows**
> AVG
> META DATA AVG
> TISAQC AVG

**Process Specification** (Figure 5-2):

This process shall:

1. Write header to the output product, AVG.

2. Format processed data in Hierarchical Data Format (HDF) as required by the science community.

3. Output data product, AVG, to process Compute Zonal and Global Averages only if there were no failure error messages.

4. Provide necessary quality control and metadata information for the data product to process Produce Reports.

### 5.2.1.4  Produce Reports - Process 8.1.4

**Input Data Flows**
> Header
> META DATA AVG
> TISAQC AVG

**Output Data Flows**
> META DATA AVG
> QC AVG

**Process Specification** (Figure 5-2):

This process shall:

1.  Write metadata (TBD).

2.  Write an error message report to the quality control (QC) report.

3.  Write a global processing summary to the QC report.

4.  Write a summary of hours with data to the QC report.

5.  Write a statistics summary to the QC report.

### 5.2.2  Compute Zonal and Global Averages - Process 8.2

**Input Data Flows**
> AVG
> WEIGHTS FLAGS
> ZONPARAM

**Output Data Flows**
> META DATA ZAVG
> QC ZAVG
> ZAVG

**Process Description** (Figure 5-1):

This process will perform the following subprocesses:

1.  Input the regional synoptic data, AVG.

2.  Calculate the zonal averages.

3. Calculate the global averages.

4. Produce the output product, ZAVG.

5. Produce the QC and metadata reports.

The decomposition for this function is shown in Figure 5-4.


### 5.2.2.1  Input Regional Synoptic Data - Process 8.2.1

**Input Data Flows**
      AVG
      WEIGHTS FLAGS
      ZONPARAM

**Output Data Flows**
      AVG
      Header
      WEIGHTS FLAGS

**Process Specification** (Figure 5-4):

This process shall:

1. Read the regional synoptic data, validate the header, and output the header to processes Produce QC and Produce ZAVG.

2. Read the polar flags and area weighting factors, and validate the header.

3. Read the run-time parameters.

The process performs similar functions as the subroutines, FILINT, INITL, and FILDRV, found in the ERBE code; algorithms may be modified to suit the CERES Project.

### 5.2.2.2  Calculate Zonal Averages - Process 8.2.2

**Input Data Flows**
      AVG
      WEIGHTS FLAGS

**Output Data Flows**
      Monthly Zonal and Global Data
      QC ZAVG
      WEIGHTS FLAGS

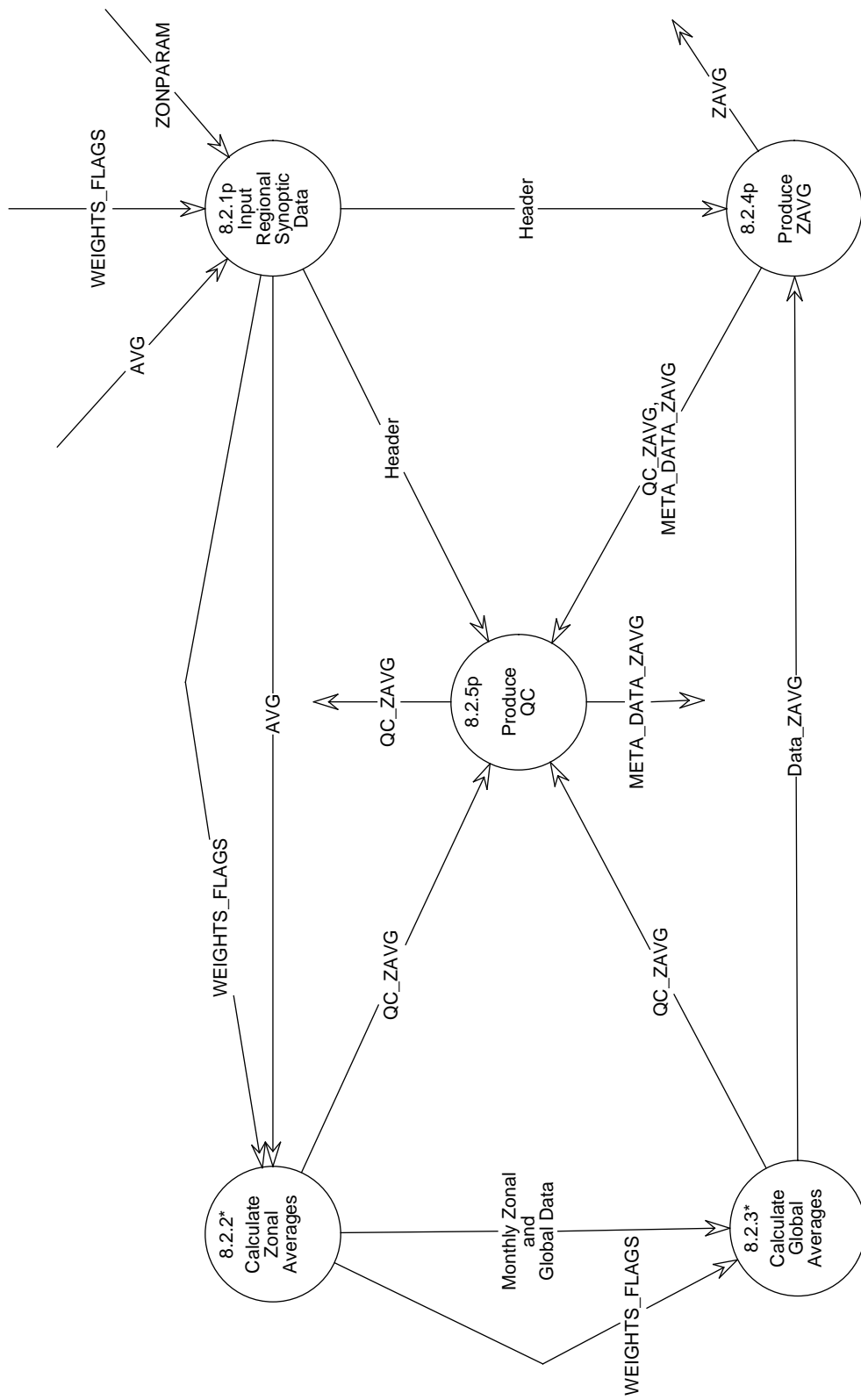Figure 5-4. Data Flow Diagram for Compute Zonal and Global Averages

**Process Description** (Figure 5-4):

This process will consist of the following subprocesses:
1. Initialize zonal processing.

2. Apply the zonal nonpolar algorithm.

3. Apply the zonal polar algorithm.

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

**5.2.2.2.1  Initialize Zonal Processing - Process 8.2.2.1**

**Input Data Flows**
> AVG
> WEIGHTS FLAGS

**Output Data Flows**
> Monthly Data
> Monthly Hourly Data
> WEIGHTS FLAGS

**Process Specification** (Figure 5-5):

This process shall:

1. Determine the number of regions per latitude.

2. Determine if the colatitude is a polar colatitude.

3. Apply the polar or nonpolar algorithm.

4. Calculate the zonal averages for the specified spatial resolution.

This process performs similar functions as the subroutine, ZONE, found in the ERBE code; functions may be modified to suit the CERES Project.
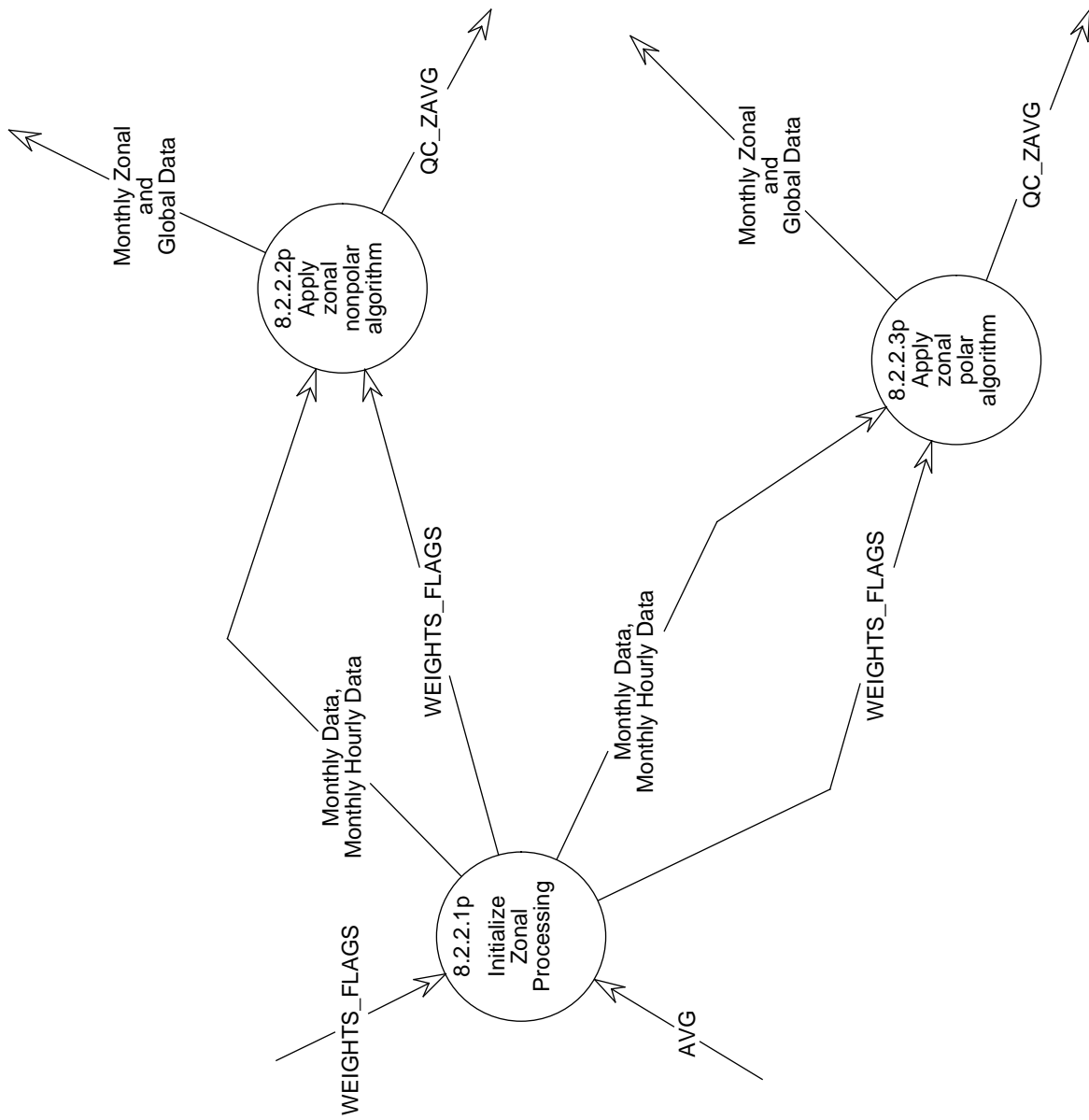
Figure 5-5.  Data Flow Diagram for Calculate Zonal Averages

### 5.2.2.2.2  Apply zonal nonpolar algorithm - Process 8.2.2.2

**Input Data Flows**
Monthly Data
Monthly Hourly Data
WEIGHTS FLAGS

**Output Data Flows**
Monthly Zonal and Global Data
QC ZAVG

**Process Specification** (Figure 5-5):

This process shall :

1. Apply weighting factors and sum the grand monthly and the monthly hourly longwave, shortwave, solar incidence values, and cloud properties.

2. Sum the number of hours that contain data.

3. Output QC information.

This process performs similar functions as the subroutines, NPOLAR and ZONREP, found in the ERBE code; functions may be modified to suit the CERES Project.

### 5.2.2.2.3  Apply zonal polar algorithm - Process 8.2.2.3

**Input Data Flows**
Monthly Data
Monthly Hourly Data
WEIGHTS FLAGS

**Output Data Flows**
Monthly Zonal and Global Data
QC ZAVG

**Process Specification** (Figure 5-5):

This process shall:

1. Apply weighting factors and sum the grand monthly and monthly hourly solar incidence, flux values, and cloud properties.

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2. Sum the number of hours that contain data.

3. Output QC information.

This process performs similar functions as the subroutines, POLAR and ZONREP, found in the ERBE code; functions may be modified to suit the CERES project.

### 5.2.2.3 Calculate Global Averages - Process 8.2.3

**Input Data Flows**
  Monthly Zonal and Global Data
  WEIGHTS FLAGS

**Output Data Flows**
  Data ZAVG
  QC ZAVG

**Process Description** (Figure 5-4):

This process will consist of the following subprocesses:

1. Initialize global processing.

2. Apply the global nonpolar algorithm.

3. Apply the global polar algorithm.

The decomposition for this function is shown in Figure 5-6.

### 5.2.2.3.1 Initialize Global Processing - Process 8.2.3.1

**Input Data Flows**
  Monthly Zonal and Global Data
  WEIGHTS FLAGS

**Output Data Flows**
  Monthly Zonal and Global Data
  WEIGHTS FLAGS

**Process Specification** (Figure 5-6):

This process shall:

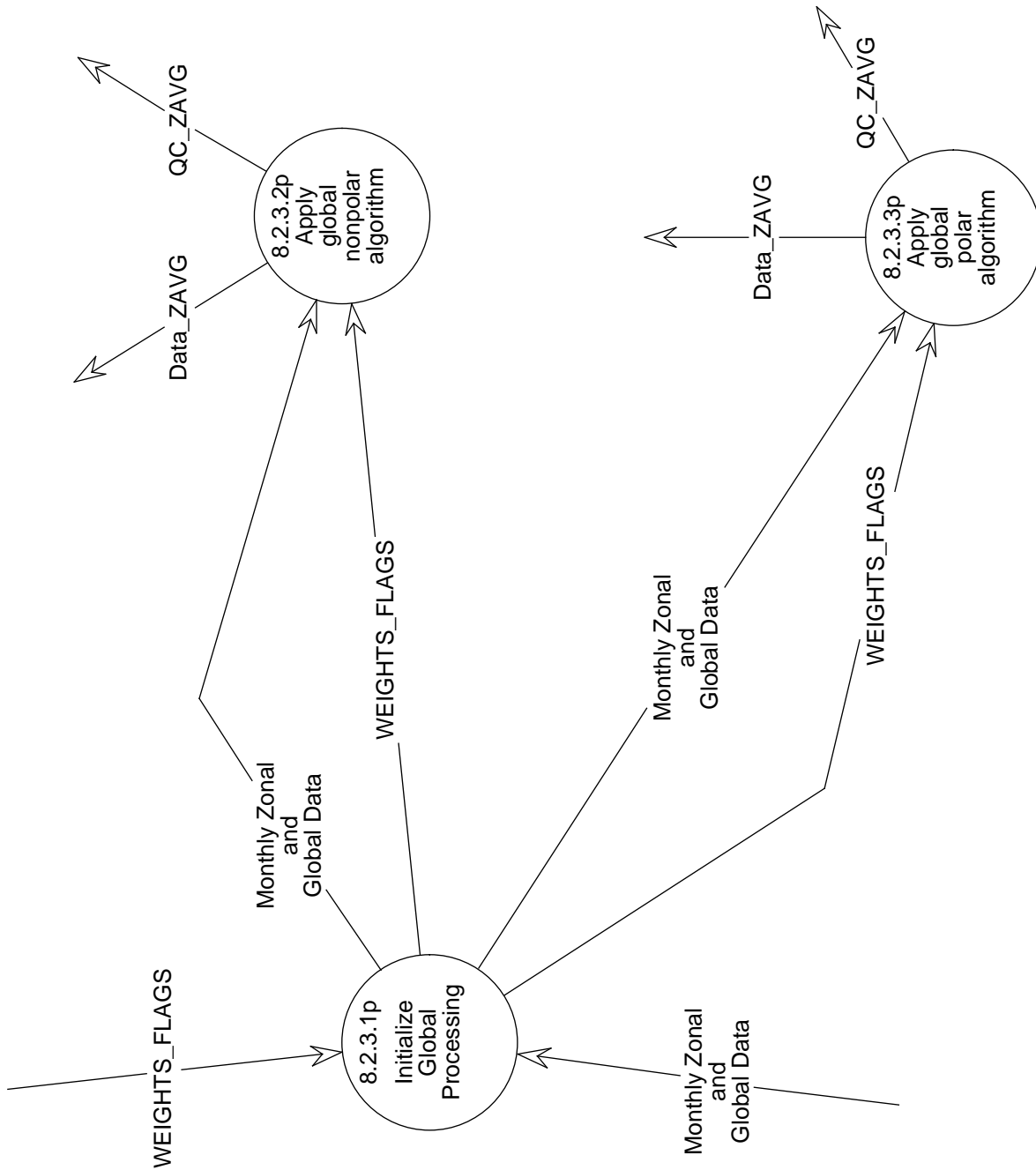1. Apply the global polar or nonpolar algorithm.

Figure 5-6. Data Flow Diagram for Calculate Global Averages

2. Calculate the global average using the zonal averages from the specified spatial resolution.

3. Output QC information.

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

### 5.2.2.3.2 Apply global nonpolar algorithm - Process 8.2.3.2

**Input Data Flows**
> Monthly Zonal and Global Data
> WEIGHTS FLAGS

**Output Data Flows**
> Data ZAVG
> QC ZAVG

**Process Specification** (Figure 5-6):

This process shall:

1. Apply area weighting factors and sum the grand monthly and the monthly hourly LW, SW, incidence values, and cloud properties.

2. Sum the number of hours that contain data.

3. Output QC information.

This process performs similar functions as the subroutines, NPOLAR and GLBREP, of the ERBE code; functions may be modified to suit the CERES Project.

### 5.2.2.3.3 Apply global polar algorithm - Process 8.2.3.3

**Input Data Flows**
> Monthly Zonal and Global Data
> WEIGHTS FLAGS

**Output Data Flows**
> Data ZAVG
> QC ZAVG

**Process Specification** (Figure 5-6):

To accumulate data for records which are in the polar regions, this process shall:

1. Determine from polar flags if the input values are nighttime values.

2. Apply the area weighting factors to the grand monthly and monthly hourly solar incidence values.

3. Sum the daily flux values, monthly hourly flux values, and cloud properties

4. Output QC information.

This process performs similar functions as the subroutines, POLAR and GLBREP, of the ERBE code; functions may be modified to suit the CERES Project.

### 5.2.2.4  Produce ZAVG - Process 8.2.4

**Input Data Flows**
> Data ZAVG
> Header

**Output Data Flows**
> META DATA ZAVG
> QC ZAVG
> ZAVG

**Process Specification** (Figure 5-4):

This process shall:

1. Write header to output product, ZAVG.

2. Format processed science data in HDF as required by the science community.

3. Output data product, ZAVG, only if there were no error messages.

4. Provide the necessary QC and metadata information from the data product to process Produce Reports.

### 5.2.2.5  Produce QC - Process 8.2.5

**Input Data Flows**
> Header
> META DATA ZAVG
> QC ZAVG

**Output Data Flows**
>    META DATA ZAVG
>    QC ZAVG

**Process Specification** (Figure 5-4):

This process shall:

1.  Write metadata (TBD)

2.  Write an error message report to the QC report.

3.  Write a global processing summary to the QC report.

4.  Write a summary of regions with data to the QC report.

5.  Write a summary of zonal and global averages.

6.  Write a statistics summary to the QC report.

Note: If it is necessary to write the output to different files, an output file summary will be written to the QC report.  The output file summary will indicate which region of the globe resides on a given science output data file.

### 5.2.3  Generate Weights and Flags - Process 8.3

**Input Data Flows**
>    SDEC
>    WEIGHTS FLAGS PARAM

**Output Data Flows**
>    QC WEIGHTS FLAGS
>    WEIGHTS FLAGS

**Process Specification** (Figure 5-1):

This process shall:

1.  Generate polar flags which identify the regions which experience continuous sunlight or darkness during certain times of the year.

2.  Generate area weighting factors for each latitude band in order to account for differences in the areas of regions in different latitude zones.

## 5.3  Design Goals and Constraints

The following are considered to be the prime 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.  Additional time interpolation, similar to that used in Subsystem 3.0, may be required for the TOA SW flux estimates for all daylight hours before monthly means can be calculated.

2.  Interpolation to hourly maps may be required once the results of the monthly hourly averages of LW and SW at TOA from this Subsystem and that of Subsystem 10.0 (Reference 9) are compared.

3.  The EOSDIS toolkit shall be used for the input/output calling sequences and aid in statistical and graphical calculations. (Reference 10).

4.  The data shall be organized using HDF.

5.  Metadata and handling of such shall be accomplished using the EOSDIS Toolkit.

## 5.4  Resource Use

The AVG and ZAVG products will be produced once for every month of instrument data.  Separate combined-instrument products will also be produced for each data month. The estimated product size for AVG is 344 MB.  For ZAVG, the estimated product size is 2 MB.

The Central Processing Unit (CPU) processing time has been estimated, based on ERBE experience (Reference 11), to be 60 hours for a months worth of satellite data.

# References

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

1. Earth Radiation Budget Experiment (ERBE), Data Management System Reference Manual, Volume VI - Daily Data Base and Monthly Time/Space Averaging, NASA Langley Research Center, November 1986.

2. Earth Radiation Budget Experiment (ERBE), Data Management System Reference Manual, Volume VII - Output Products - Section 7.2, NASA Langley Research Center, September 1986.

3. 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.

4. 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.

5. Clouds and the Earth's Radiant Energy System (CERES), Algorithm Theoretical Basis Document, Grid Single Satellite Fluxes and Clouds, Compute Spatial Averages, Release 1.1, April 1994.

6. Clouds and the Earth's Radiant Energy System (CERES), Algorithm Theoretical Basis Document, Monthly Regional, Zonal, and Global Radiation Fluxes and Cloud Properties, Release 1.1, April 1994.

7. CERES Data Management System Data Products Catalog, Release 1, Version 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. Clouds and the Earth's Radiant Energy System (CERES), Algorithm Theoretical Basis Document, Monthly Regional TOA and Surface Radiation Budget, Release 1.1, April 1994.

10. PGS Toolkit Users Guide for the ECS Project, Hughes Applied Information Systems, Version 1 Final, May 1994.

11. Clouds and the Earth's Radiant Energy System (CERES), Algorithm Theoretical Basis Document, Data Processing System Objectives and Architecture, Release 1.1, April 1994.

# Abbreviations, Acronyms, and Symbols

| | |
|---|---|
| AVG | Monthly Regional Radiative Fluxes and Clouds |
| CDM | CERES Directional Model |
| CERES | Clouds and Earth's Radiant Energy System |
| DAAC | Distributed Active Archive Center |
| EOS | Earth Observing System |
| EOSDIS | Earth Observing System Data and Information System |
| ERBE | Earth Radiation Budget Experiment |
| GMT | Greenwich Mean Time |
| H | High |
| HDF | Hierarchical Data Format |
| ISCCP | International Satellite Cloud Climatology Project |
| L | Low |
| LM | Lower Middle |
| LW | Longwave |
| MB | Mega Bytes |
| MTSA | Monthly Time/Space Averaging |
| NOAA | National Oceanic and Atmospheric Administration |
| PGS | Product Generation System |
| QC | Quality Control |
| SFC | Surface |
| SPC | Sector Processing Center |
| SW | Shortwave |
| SYN | Synoptic Radiative Fluxes and Clouds |
| TBD | To Be Determined |
| TOA | Top-Of-Atmosphere |
| TRMM | Tropical Rainfall Measuring Mission (joint US-Japan) |
| UM | Upper Middle |
| ZAVG | Monthly Zonal and Global Radiative Fluxes and Clouds |