

3. DATA PRODUCT DESCRIPTION

3.1. GRIDDED PRODUCTS ANALYSIS (STAGE D1 AND D2)

The Stage D1 product is produced by summarizing the pixel-level results (Stage DX data, see Section 3.2) every 3 hours on an equal-area map grid with 280 km resolution and merging the results from separate satellites with the atmospheric (TV) and ice/snow (IS) datasets to produce global coverage at each time. The Stage D2 data product is produced by averaging the Stage D1 data over each month, first at each of the eight 3 hr time slots and then over all time slots.

3.1.1. MAP GRID DEFINITIONS

Two related map grids are used for the ISCCP D1 and D2 datasets, an EQUAL-AREA grid and an EQUAL-ANGLE (square) grid. These grids are identical at the equator. Collection of statistics from the pixel-level satellite analysis (DX data), which produces global information at about 30 km resolution, is performed using an EQUAL-AREA map to maintain a nearly constant statistical weight for results at all locations (Rossow and Garder 1984). For economy of data storage, the results are also recorded in the same EQUAL-AREA grid. However, since data manipulation on computers and in image displays is more convenient using rectangular arrays, the D1READ and D2READ programs provided with the data contain optional subroutines that will re-map the data into an EQUAL-ANGLE map grid of 2.5° resolution. The data are transformed to the EQUAL-ANGLE grid by replication, which preserves all of the original statistics (Rossow and Garder 1984), since the grid cells of the EQUAL-ANGLE grid at higher latitudes represent higher resolution (in the longitudinal direction) than in the original dataset. If a user wishes to re-map the data to some other projection, the EQUAL-AREA form of the data is most convenient to use as a starting point, since the area-weights are all equal.

Both map grids are indexed in order from the south pole to the north pole, latitudes ranging from -90° to 90° . In each latitude zone, all longitudes are indexed in order from the Greenwich meridian, eastward (longitudes are given in the range $0 - 360^\circ$), before going to the next latitude zone.

Equal-Area Grid for Data Storage

The EQUAL-AREA map (Figure 3.1) is defined by the area of a 2.5° latitude \times 2.5° longitude cell at the equator; the intersection of the Greenwich meridian and the equator is a cell corner. There are 6596 cells in this map grid. All map cells are determined by a constant 2.5° increment in latitude and a variable longitude increment. The longitude increment is selected to provide an integer number of cells in a latitude zone and to give a cell area as close to that of the equatorial cell as possible. See Table 2.5.11 for definition of index values and longitude increments as a function of latitude.

Equal-Angle Grid for Data Display

The D1READ and D2READ programs, provided to read the data files, contain optional subroutines that replicate the data from the 6596 EQUAL-AREA cells to an EQUAL-ANGLE map grid. This map grid has equal 2.5° increments in latitude and longitude; there are 10368 cells in this grid (72 latitude zones and 144 longitude intervals). The intersection of the Greenwich meridian and equator is a cell corner; coordinates are given as latitudes from -90° to 90° and longitudes from 0° to 360° (positive eastward).

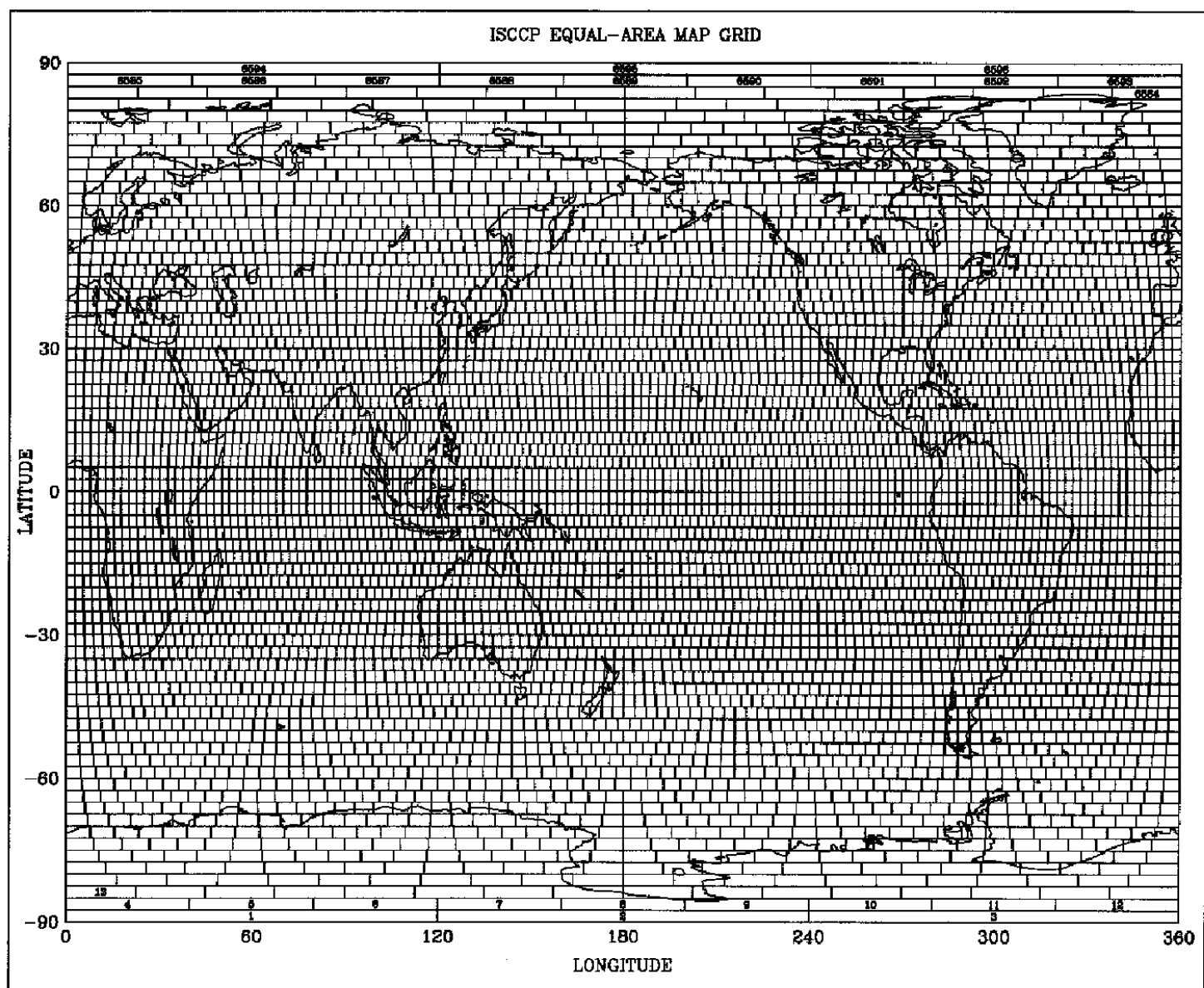


Figure 3.1. Equal-area map grid used for ISCCP data. The first and last thirteen cells are numbered for illustration.

3.1.2. VARIABLE DEFINITIONS

Missing data

The cosine of the satellite zenith angle for any pixel must be ≥ 0.3 (zenith angle $\leq 72.5^\circ$). If there are less than 20 pixels available in a map grid cell, the pixels are discarded and the cell is labeled "missing". In this case all variables except the grid cell indices and the atmospheric (TOVS) information are given the value of 255.

Land/water/coast

Each EQUAL-AREA map grid cell is labeled as either land, water, or coast. If the fraction of the cell covered by land is $\geq 65\%$, the cell is labeled "land". If the fraction covered by land is $\leq 35\%$, the cell is labeled "water". Cells with land fraction $> 35\%$ and $< 65\%$ are labeled "coast".

Day/Night

If more than half of the total number of pixels in a map grid cell are "daytime" pixels (see Section 3.2.3), the cell is labeled "day", otherwise it is labeled "night". In a "day" cell, only daytime pixels (those with both IR and VIS information available) are used to calculate statistics and both IR- and VIS-dependent results are reported. In a "night" cell, all pixels are used to calculate statistics, but only the IR-dependent information is used and reported.

Cloud Amounts

The cloud detection procedure (Section 3.2.4) decides whether each satellite pixel is cloudy or clear and reports the results of the threshold tests for each radiance (IR, VIS, NIR) by codes that indicate the relative relationship between the observed pixel radiances and the clear radiances (Table 2.5.5). For the gridded datasets, where many satellite pixels are included in each map grid cell, cloud amount (CA) is determined by counting the number of cloudy pixels and then dividing by the total number of pixels in that cell. In the D1 dataset, the number of cloudy pixels and the total number of pixels are reported explicitly; cloud amount is calculated in the D1READ program. In the D2 dataset, D1 cloud amounts are averaged over the month and reported to the nearest 0.5%.

Several additional subsets of the total cloud amount are reported in the D1 dataset to indicate the types of clouds present and provide some information on the reliability of the cloud detection procedure (Table 2.5.5). These subsets are defined by different combinations of radiance threshold codes, indicating the degree of separation between the radiances and the clear sky values, and are illustrated in Figure 3.2. A single pixel is labeled cloudy if **any** of the following threshold results is reported: IR code = 4, 5 or VIS code = 4, 5 (or NIR code = 9, 10, 11, 12 and 13). A clear pixel occurs only when all threshold results indicate clear values. VIS = 0 indicates nighttime where no VIS threshold test can be performed. To provide cloud amount information that is consistent over the whole diurnal cycle, the number of pixels indicated as cloudy by IR, regardless of any other threshold codes (called IR-cloudy, last two columns), is reported for all times of day. Two subsets of these pixels, IR-only-cloudy and marginal IR-cloudy are also reported: the first is the number of pixels which are labeled cloudy **only** by the IR tests and the second (M-IR) is the number of pixels with IR code = 4, indicating that these clouds change the IR radiance by an amount only slightly more than the threshold amount. The corresponding VIS-only-cloudy amount is not reported because it can be determined by subtracting the IR-cloudy amount from the total cloud amount (minus the NIR-only-cloudy amount if present). The corresponding marginal VIS/IR-cloudy is defined by pixels with VIS = 4 **and** IR = 4 (M-VIS/M-IR), together with pixels labeled as M-VIS-only and M-IR-only.

VIS THRESHOLD CODE	5	VIS-only	VIS-only	VIS-only	VIS/M-IR	VIS/IR
	4	M-VIS-only	M-VIS-only	M-VIS-only	M-VIS/M-IR	M-VIS/IR
	3	VIS>	VIS> IR>	VIS> IR<	M-IR-only	IR-only
	2	VIS<	VIS< IR>	VIS< IR<	M-IR-only	IR-only
	1	VIS<< IR>>	IR>	IR<	M-IR-only	IR-only
		1	2	3	4	5
IR THRESHOLD CODE						

Figure 3.2. Subset measures of Cloud Amount.

In the polar regions (latitudes polewards of 50°) over sea ice and snow-covered locations, the NIR threshold test is performed, day and night, for polar orbiter data. These results are added to the total cloud amount, but are excluded from the subsets defined above (for consistency with the C-series products). The total number of pixels labeled cloudy by this test (NIR-cloudy) are reported in the D1 dataset, together with the two subsets, NIR-only-cloudy and marginal NIR-cloudy.

An additional quality check on the clear sky radiances is to examine the distribution of the observed radiances labeled clear by the threshold test around the clear sky values. In the D1 dataset, this information is given as the ratio of the number of pixels with IR and VIS radiances just above and below their respective clear sky values (IR>, IR<, VIS>, VIS< in Figure 3.2).

In the D2 dataset, the monthly averages of the total cloud amount and the marginal IR-cloudy amount are calculated for each time UTC and then over all times to produce the monthly mean values. Two adjustments are made to total CA (see Section 3.1.7). In addition to reporting the monthly mean cloud amount, a frequency distribution of individual cloud amounts from the D1 dataset is given.

Temperatures and Pressures

Layer-average atmospheric temperatures (T) in Kelvins are reported at the center of seven tropospheric layers with nominal center pressures (P): 900, 740, 620, 500, 375, 245, 105 mb. The layers have boundary pressures: 1000 or surface pressure (PS), whichever is smaller, 800, 680, 560, 440, 310, 180, and 30 or tropopause pressure (PT), whichever is larger. Seven troposphere layers are always present in the data, but the actual extent of the bottom and top layers in the troposphere is variable, depending on the values of PS and PT. The former depends primarily on surface topography. As examples, if PS = 850 mb and PT = 100 mb, then the first layer will extend from 850 to 800 mb with a center pressure of 825 mb and the last layer will extend from 180 to 100 mb with a center pressure of 140 mb. If PS = 750 mb and PT = 200 mb, then the first and last layers have no reported values (count values set = 255), the second layer will extend from 750 to 680 mb with a center pressure of 715 mb, and the sixth layer will extend from 310 to 200 mb with a center pressure of 255 mb. As illustrated, the temperatures are reported at the center pressures of these variable layers which are calculated in D1READ and D2READ. There are also two stratospheric temperatures reported at 50 and 15 mb, representing the

centers of two layers with fixed extent from 70 to 30 mb and 30 to 0 mb, independent of the location of the tropopause.

Cloud top temperatures (TC) are reported in Kelvins; the pressure of the atmosphere at the same temperature is reported as the cloud top pressure (PC) in millibars. The D1READ program also calculates the corresponding cloud top heights from the cloud top temperature using the atmospheric temperature profile; the D2READ program uses the differences of cloud top and surface temperatures to estimate a cloud top height using a fixed temperature lapse rate of 6.5 K km^{-1} .

Surface temperatures (TS) in Kelvins retrieved from satellite IR radiances represent the brightness temperatures of the solid surface "skin" (usually the first millimeter, but the situation is more complicated in vegetation). Two values of TS are reported, one based on the IR clear sky radiances from the 5-day composites and one based on any available clear pixel IR radiances (if cloud cover is 100%, this value will be undefined = 255). In addition a "surface" temperature based on the TV dataset is reported that represents the near-surface air temperature.

Cloud Optical Thicknesses and Water Paths

Cloud optical thicknesses (TAU) are visible ($0.6 \mu\text{m}$ wavelength) values retrieved using two different cloud microphysical models:

- (i) a liquid water droplet model with a water sphere size distribution described by a gamma distribution with effective mean radius = $10 \mu\text{m}$ and effective variance = 0.15, and
- (ii) an ice crystal model with a random fractal crystal shape and a -2 power law size distribution from 20 to $50 \mu\text{m}$, giving an effective radius of $30 \mu\text{m}$ and an effective variance of 0.10.

Optical thickness values from individual pixels are averaged with non-linear weights that preserve the average cloud albedo. Water path values are stored in the D1 and D2 datasets as optical thickness values, but they represent linear averages of individual pixel values of optical thickness proportional to cloud water content. The D1READ and D2READ programs convert these values to g/m^2 by multiplying WP by 6.292 for liquid water clouds and WP by 10.500 for ice clouds.

Ice/Snow cover

Sea ice and snow cover are reported as the fraction of the region, without regard for land or water classification, that is covered by either snow or ice. An absence of data is reported as zero coverage.

3.1.3. CLOUD TYPE DEFINITIONS

Since the actual distributions of the cloud properties are not symmetric in shape, the mean and standard deviation do not represent all of the characteristics of the clouds. Hence the D1 dataset also includes explicit distributions of cloud properties for each map grid cell. For diurnal studies based solely on the IR analysis, the number of IR-cloudy pixels with cloud top pressures located in each of the seven tropospheric layers is reported along with the average cloud top temperature of the pixels in each layer. In daytime when visible radiances are available, the number of VIS/IR cloudy pixels is given for each of 42 categories defined by seven cloud top pressure intervals and six optical thickness intervals.

Table 3.1.1. PC Categories Used to Define Cloud Types.

PRESSURE LAYERS	PRESSURE	APPROXIMATE HEIGHT ABOVE MEAN SEA LEVEL (m)
	1000 (or surface)	100
1	900	1000
	800	2000
2	740	2600
	680	3200
3	620	4000
	560	4700
4	500	5600
	440	6500
5	375	7600
	310	8900
6	245	10500
	180	12500
7	105	15900
	30 (or tropopause)	19600

Table 3.1.2. TAU Categories Used to Define Cloud Types.

TAU INTERVAL	TAU	APPROXIMATE ALBEDO
	0.02	0.005
1	0.05	0.075
	1.27	0.150
2	2.30	0.225
	3.55	0.300
3	6.00	0.400
	9.38	0.500
4	14.50	0.600
	22.63	0.700
5	34.74	0.780
	60.36	0.860
6	109.8	0.915
	378.65	0.970

Original ISCCP plans called for reporting the properties of five cloud types: low, middle, high, cirrus, and deep convective clouds. The latter two types were qualitatively defined to be optically thin and thick high-level clouds, respectively. In the C-series datasets, only the PC and PC-TAU pixel number distributions were reported in the C1 dataset and the average properties of a smaller number of cloud types (low, middle and high from the IR analysis and seven types from the daytime VIS/IR analysis) were estimated in the C2 dataset. Research with these data has shown the value of reporting the average properties of these cloud types more precisely in the D-series datasets. The cloud types for the D1 and

D2 datasets are defined by their values of TC, PC and TAU and differ slightly from the definitions used in the C-series. From the IR analysis, three cloud types (same as for C-series data) are defined by the range of PC: low ($PC > 680$ mb), middle ($680 \leq PC < 440$ mb), and high ($PC \leq 440$ mb). In daytime, nine categories are defined by three PC and three TAU intervals; in C2 data low and middle cloud levels were divided into only two TAU intervals and the TAU value dividing cirrus and cirrostratus increased as PC decreased. The major difference for D1 and D2 datasets is that clouds at lower levels may be either ice or liquid water clouds within the same PC-TAU category, while high level clouds are always ice clouds: if $TC < 260$ K, a low or middle cloud is classified as an ice cloud, otherwise it is a liquid water cloud. Fifteen cloud types are defined in Table 2.5.7.

In the D1 dataset, the actual average properties (TC, TAU and WP) of each cloud type are reported in addition to their amounts. The amounts of each type are not reported explicitly, but are calculated from the more detailed PC-TAU distribution of pixels by the D1READ program. Consequently, the monthly mean cloud type properties in the D2 dataset are calculated more precisely than they were in the C2 dataset.

3.1.4. SPATIAL AVERAGING

The distribution of cloud and surface parameter values for the pixels in each map grid cell represents their variations on small spatial scales (from about 5 to 280 km, cf., Sèze and Rossow 1991a,b). Spatially averaged results are reported every three hours for the whole globe in the Stage D1 dataset in the form of a mean value and a standard deviation. The total number of pixels used to calculate both of these statistics is also reported.

Since the primary objective of ISCCP is to determine the statistical properties of the clouds (and surface) that influence the radiation balance of the Earth, a description of the average properties and their variability must assign proper weight to the cloud and surface values according to their contribution to the total radiation. For example, warmer objects contribute more to the total IR flux than colder objects. Additionally, since the basic measurements used to infer these values are radiance measurements themselves, the relative precision of the measurements is linear in energy rather than in the retrieved parameter. To study cloud microphysical and dynamical processes, we need average quantities that give linear weight to the vertical location of the cloud and the amount of water in it. Hence, the averages of some cloud properties are performed in two ways. The first averaging method uses representations of the values that are linear in their equivalent radiative energy amounts: the cloud and surface temperatures are represented in increments that are linear in radiance and the cloud optical thicknesses have linear increments in reflectance. The surface reflectance is already linear in this sense. The second averaging method is represented by averaging cloud top pressures, which is equivalent to the linear average of cloud top temperature, and a linear average of cloud optical thicknesses reported as an average water path. The water path values are coded as optical thicknesses and converted in the READ programs using the expression

$$WP = \frac{4\rho r_e}{3Q_{\text{ext}}} \times \tau \quad \text{g/m}^2 \quad (1)$$

where r_e is the effective particle radius in microns, Q_{ext} is the normalized Mie extinction efficiency at $0.6 \mu\text{m}$ wavelength, and ρ is the mass density of the cloud particle in g/cm^3 . For liquid water clouds, the

cloud particle size distribution gives $r_e = 10 \mu\text{m}$, $Q_{\text{ext}} = 2.119$ and $\rho = 1.0 \text{ g/cm}^2$:

$$\text{WPW} = 6.292 \text{ PAIH } \text{ g/m}^2 \quad (2)$$

For ice clouds, $r_e = 30 \mu\text{m}$, $Q_{\text{ext}} = 2.0$ and $\rho = 0.525 \text{ g/cm}^2$:

$$\text{WPI} = 10.500 \text{ PAIH } \text{ g/m}^2 \quad (3)$$

The density of an ice particle is determined by the bulk density of ice times the ratio of the actual crystal volume to that of a sphere with the same scattering cross-section.

3.1.5. MERGING RESULTS FROM SEVERAL SATELLITES

The D1 data is constructed by combining the analysis results from several satellites, up to five geostationary satellites and two polar orbiting satellites, to obtain complete global coverage every 3 hrs. Since the polar orbiters provide complete global observations twice daily and adjacent geostationary satellites view some overlapping portions of the globe, there are many coincident observations available. Rather than average two or more measurements, usually obtained at somewhat different times within the 3 hr periods and under different viewing geometries, only observations from a specific satellite are used in each map grid cell in each 3 hr period. That is, data from different satellites are merged on a grid cell by grid cell basis, not pixel by pixel.

Definition of Satellite Hierarchy

To maintain as much continuity and uniformity as possible, a hierarchy of satellites is specified for each map grid cell, indicating the order of preference when several observations are available. This hierarchy is defined by two general rules: geostationary data are preferred over polar orbiter data equatorward of 55° and preference is given to the best viewing geometry (smallest satellite zenith angle). The transition between geostationary and polar regimes at high latitudes is selected as a compromise between the rapidly increasing satellite zenith angles of the geostationary observations and obtaining sufficient orbit overlap to provide complete diurnal coverage with polar orbiter observations.

Since the preferred satellite data may not always be available, each map grid cell has a specified hierarchy of preference for any other satellites that may observe that location.

Global Coverage

Figure 3.3 shows the global coverage provided by the primary satellites (first preference level of the hierarchy) and indicates the next level of the hierarchy of other satellites at each location. At low latitudes, the two polar orbiters do not actually observe the same location at the same time. The figure assumes no INSAT data are available as only one year of data have been obtained to date. The "morning" polar orbiter is used to supplement the "afternoon" polar orbiter coverage. If no data are available from any satellite at a particular location and time, only the map indices and the TV data are reported. No form of interpolation or "bogusing" is used.

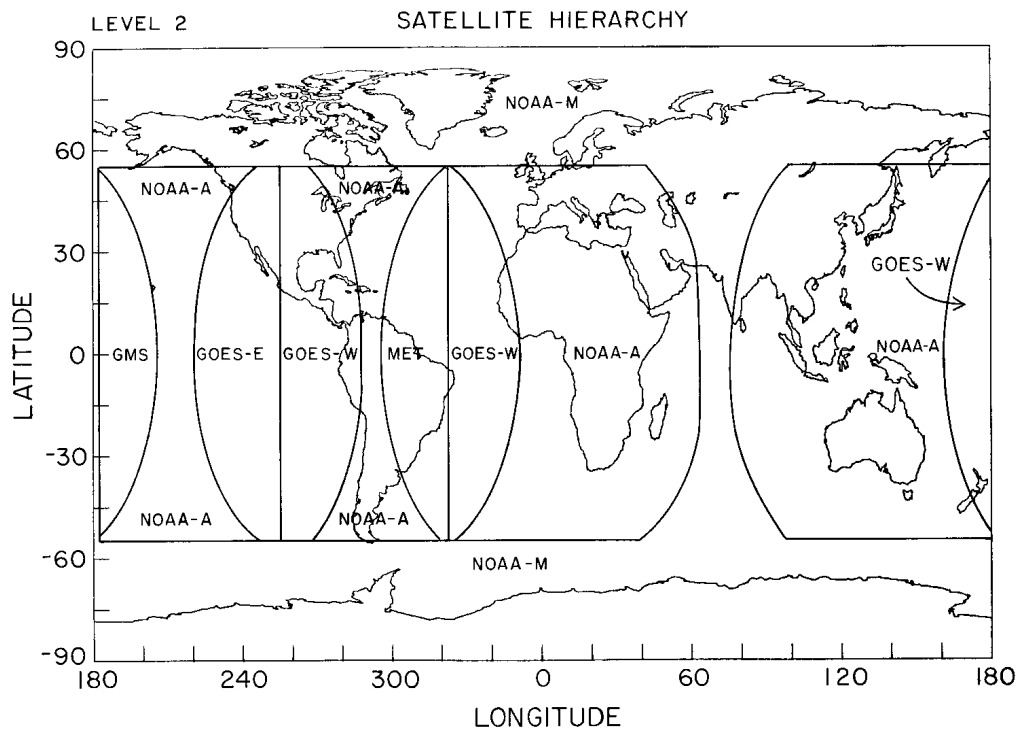
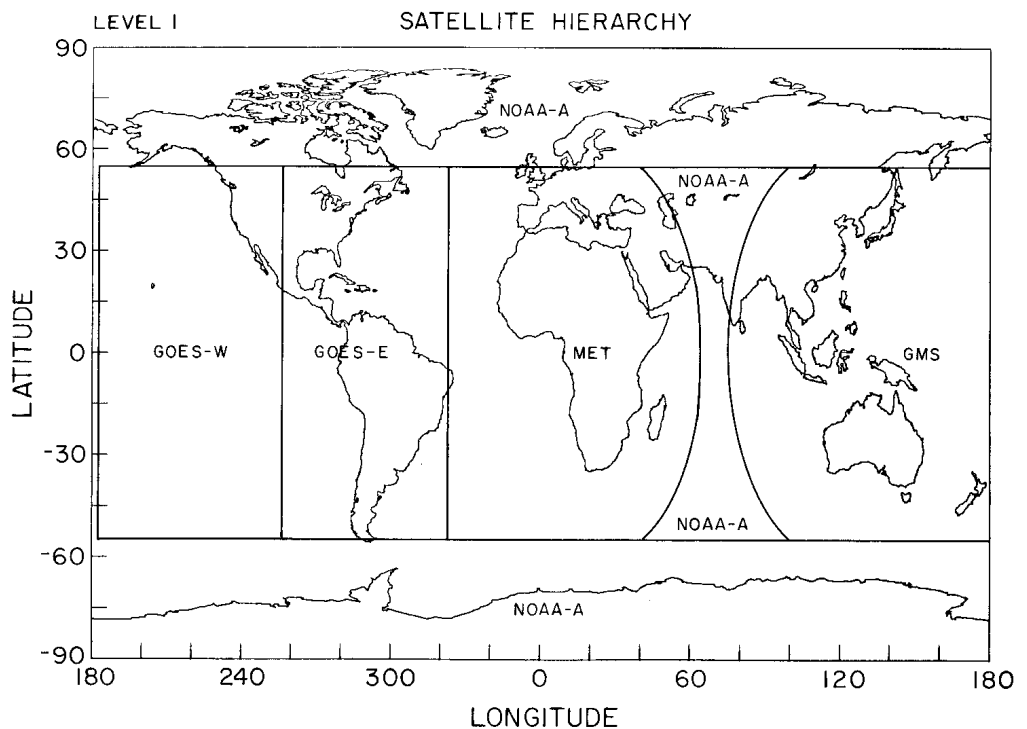


Figure 3.3. Regional coverage provided by satellites used for ISCCP: Level 1 of hierarchy indicates the preferred satellite for each location while Level 2 indicates the second choice used if the preferred satellite is not available. There are 4 levels available as indicated in the Ancillary Data Table. The actual satellite used in each map grid cell is reported in the D1 dataset. NOAA-A is “afternoon” and NOAA-M is “morning” orbiter.

Overlapping Results

The overlap of observations from different satellites provides an opportunity to check the cloud detection algorithm and radiative retrieval model, since the analysis of each dataset is performed independently. Studies of the earlier versions of these data have shown that the cloud amount increases, cloud top pressure decreases, and optical thickness decreases systematically as satellite zenith angle increases (Rossow and Garder 1993b, Zhang *et al.* 1995). In the C1 data, the difference between the cloud amounts and satellite zenith angles was reported whenever two observations were available. Since these differences are relatively small (generally $< 10\%$) and since the DX dataset is now archived, this overlap information is not reported in the D1 dataset. However, the overlapping observations are used in the production stream to check for small residual differences in satellite radiance calibration (see Section 3.1.7).

3.1.6. TIME AVERAGING

A basic objective of the analysis is to summarize the cloud analysis results on a monthly time scale. To preserve information about diurnal variability, the results are first averaged over the calendar month, separately for each time of day, 00, 03, 06, 09, 12, 15, 18 and 21 UTC. These eight datasets are the hour-monthly means. The number of days of observations contributing to the average value is also recorded in each map grid cell. Then, the hour-monthly mean values are averaged to obtain the monthly mean values. Hour-monthly mean values that consist of less than three daily observations are excluded from the monthly mean. Some adjustments are made to the hour-monthly mean datasets before averaging over time-of-day and a small diurnal-sampling adjustment is made to the monthly mean (see Section 3.1.7).

In the D2 datasets the time averages of the spatial standard deviation values from the D1 dataset and the standard deviations over time of the spatial mean values are reported. The number of days contributing to these statistics are also reported.

3.1.7. ADJUSTMENTS

Daytime

At pixel level, the analysis is performed using only IR radiances at all times of day and using VIS and IR radiances in daytime. In the Stage D1 data, two different averages for cloud amount and cloud top temperature/pressure are reported for daytime conditions. One version of cloud amount uses the IR-based analysis as must be done for nighttime conditions; the other version combines cloud detections from both the VIS and IR radiances. Because IR radiances are insensitive to low-level clouds, especially broken ones, the VIS radiance analysis detects more low-level cloudiness than the IR analysis. Thus, the combined VIS/IR analysis is superior to the IR-only analysis. Likewise, one version of the cloud top temperature/pressure is obtained directly from the IR radiances as is done for nighttime conditions and the other version adjusts the values consistent with the value of cloud optical thickness retrieved from the VIS radiances. This adjustment is significant only for optically thin clouds, which transmit IR radiation from below the cloud and, consequently, appear to have a higher temperature than they actually do. Thus, the VIS/IR radiative retrieval is superior to the IR-only version. Stage D2 data contain the VIS/IR versions of cloud amount, cloud top temperature and cloud top pressure for daytime locations.

Nighttime

The mean differences between the VIS/IR and IR-only results during daytime conditions are used to adjust the nighttime results in the hour-monthly mean datasets. Daytime differences between VIS/IR and IR-only values of total cloud amount, mean cloud top pressure and cloud top temperature are linearly interpolated over the nighttime periods between the dusk and dawn values. This interpolated difference is then added to the IR-only value during nighttime. In addition, values of the cloud optical thickness (both TAU and WP) are interpolated over the nighttime period between the dusk and dawn values. The magnitude of the CA, PC and TC corrections is generally $< 10\%$, < 100 mb, and < 5 K, respectively. Larger adjustments occur in near coastal regions, over land and ocean at low latitudes, primarily associated with tropical rainforests and marine stratus regimes. The cloud top pressure and temperature corrections are positive where low clouds predominate, primarily in marine stratus regimes over oceans, and negative where high, thin clouds predominate, primarily over land, especially in desert areas. The adjustments are made only to total cloud properties; cloud type information is not changed.

Calibration Adjustment

Although procedures are applied to normalize the radiances measured by various satellites to the reference polar orbiter (afternoon) measurements (Rossow *et al.* 1987, 1996, Desormeaux *et al.* 1993), the precision of the normalization procedures leaves small residual differences which can be amplified by the retrieval of physical quantities. Collection of monthly comparison statistics during the processing of the C-series datasets provided more statistical weight with which to estimate these residuals. In regions where more than one satellite provides results, the merger process selects the preferred satellite according to a specified hierarchy that favors data continuity and observations made closer to the nadir view. Frequency histograms of the differences in the overlapping measurements between all pairs of satellites are collected and the modal difference value estimated from the average of the mode value and the three nearest values above and below the mode value. These estimated differences for each satellite when compared to the reference polar orbiter are applied to adjust for small residual radiance calibration differences. The quantities in the hour-monthly mean that are corrected are: cloud top and surface temperature, cloud optical thickness and water path, and surface reflectance.

For the production of the D-series datasets, if the monthly correction factors exceed 1.0 K for temperatures and 0.02 for reflectances, then the Stage B3 radiance calibrations are adjusted and the data re-processed to eliminate such large differences (Rossow *et al.* 1995). Any residual difference is still corrected in the Stage D2 datasets, but the magnitudes are below these thresholds: the adjustments for each month are reported in the Header file 5 on D2 tapes.

The spectral response of the METEOSAT "visible" channel covers a larger range of wavelengths than that of the other radiometers used in the ISCCP analysis; normalization of METEOSAT radiances is done using spectrally uniform targets (clouds and clear ocean areas) (Desormeaux *et al.* 1993). However, the spectral response difference means that surface reflectances determined for vegetated land areas are larger for METEOSAT than for the other satellites. This difference in surface reflectances is reduced in the hour-monthly mean datasets by using regression relations that are obtained from the overlapping METEOSAT and NOAA measurements as a function of vegetation type every month. Adjustment factors are reported in Header file 5 on D2 data tapes.

Diurnal Sampling Adjustment

Small corrections to the overall monthly mean are made to account for incomplete sampling of the diurnal variations of cloud and surface properties. For locations with less than 4 hour-monthly observations in the polar regions or less than 8 hour-monthly observations at low and middle latitudes, adjustments are determined using the zonally averaged variations of the quantities in local time for the same surface type. The diurnal average is calculated for the number of samples actually available and compared with the average of eight samples to determine the effect of sub-sampling on the diurnal average. The difference is added to the mean values of total cloud amount, cloud top temperature and pressure, cloud optical thickness and water path, and the surface temperature. These adjustments affect only the monthly mean values and are not applied to the individual hour-monthly means.