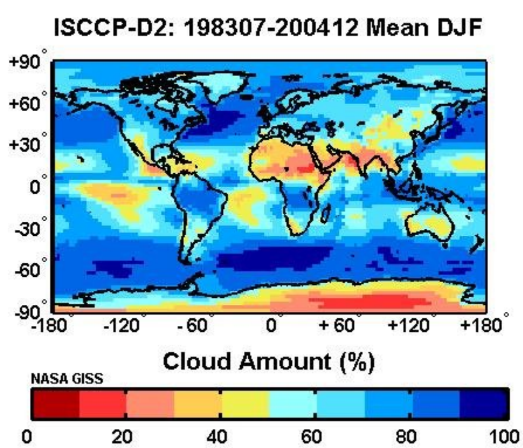
International Satellite Cloud Climatology Project (ISCCP)
Data Products
http://isccp.giss.nasa.gov/index.html

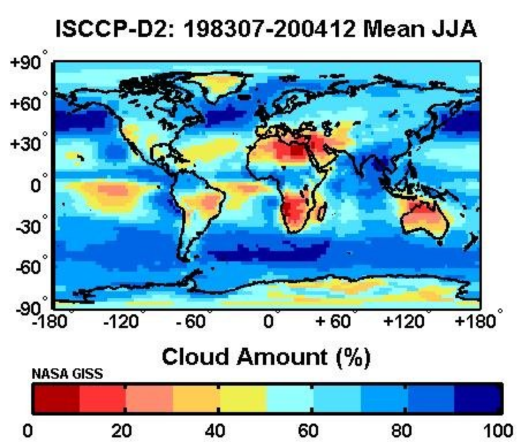
1) Products and Purposes

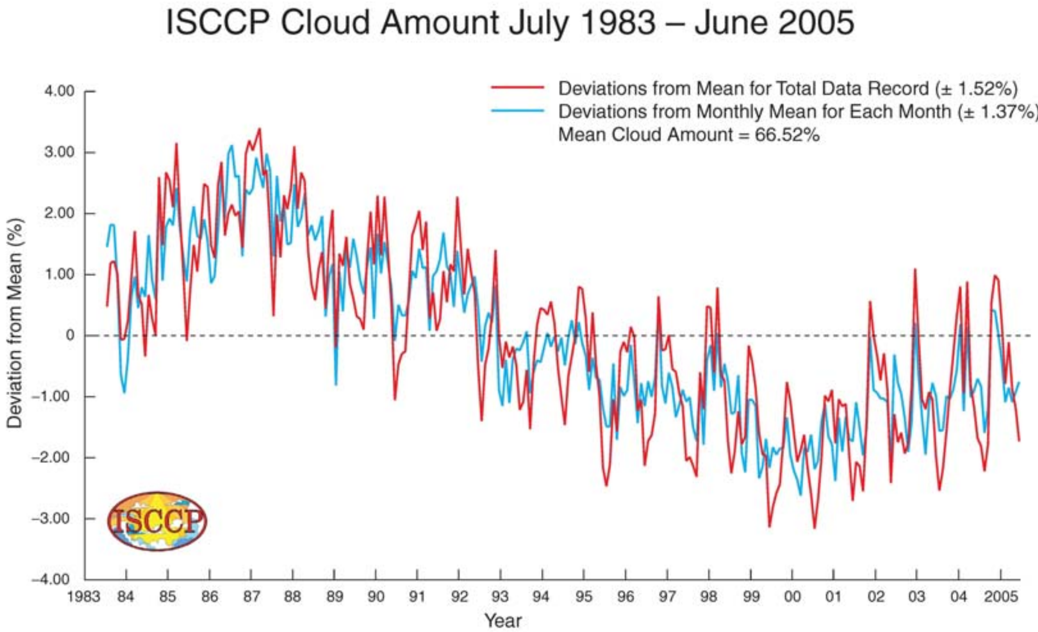
The original impetus for the International Satellite Cloud Climatology Project (ISCCP) within the World Climate Research Program (WCRP) was to obtain more information about how clouds alter the radiation balance of Earth (Schiffer and Rossow 1983). To this end ISCCP has been collecting, since July 1983, the infrared and visible radiances obtained from imaging radiometers carried on the international constellation of weather satellites. After sampling the radiances to reduce data volume, they are calibrated, navigated, and placed in a common format. The first global radiance data set was released in 1984 (Schiffer and Rossow, 1985). These radiance data have been analyzed to characterize the main cloud radiative properties and their variations over the whole globe; the first cloud data products were released in 1988 (Rossow and Schiffer, 1991). Specific accomplishments have been to extend the measured cloud properties beyond total areal cover and low-level cloud-base height, available from surface observations, to include cloud-top temperature and pressure (or height) and cloud optical thickness and to extend the range of observed cloud variations from diurnal and mesoscale to multilayer and global scales.

The ISCCP cloud data sets are now being used to determine cloud effects on Earth's radiation balance. Clouds also play an equally important role in Earth's water cycle as the intermediate stage between the water vapor that evaporates from and cools the surface and the precipitation that heats the atmosphere and returns the water back to the surface. This water cycle is the other major energy exchange process in the climate besides radiation exchanges. Variations in both the radiation and water cycles help drive the circulations of the atmosphere and oceans. Since it is the motions of the atmosphere that transport water vapor and form clouds and precipitation, understanding both the cloud radiation and the cloud water feedbacks on the climate also requires understanding how atmospheric motions determine cloud properties. These topics are now receiving more emphasis. Such considerations call for more information on how cloud systems form, evolve and decay in different meteorological regimes, which requires extending the list of cloud properties that can be measured and organizing the observations in more meaningful terms of the evolution of the dynamics of whole systems, such as the midlatitude cyclones and tropical mesoscale convective complexes. Research is under way to adapt or extend the ISCCP cloud data sets for this purpose.

2) Examples







3) Algorithm

The ISCCP cloud analysis is applied separately to the **B3** radiance data (Schiffer and Rossow, 1985; Rossow et al., 1987) from each satellite, together with the TOVS and ICE/SNOW data sets. The absolute radiometric calibrations of all **B3** radiances have been normalized to that of the NOAA-9 AVHRR. The analysis is composed of two major procedures: the cloud detection procedure divides the **B3** radiances into cloudy and clear groups and the radiative analysis procedure retrieves physical properties of clouds and the surface, respectively. The cloud detection procedure analyzes the radiance data in four steps. The first step uses a series of tests of the space-time variations of the IR and VIS radiances to obtain the first estimate of the radiance values that represent clear conditions at each place and time. The second determines which radiance measurements deviate from the first clear sky values by an amount greater than the uncertainty in the estimated clear radiances (first threshold test). The third step conducts an additional series of tests, based on the results of the first two steps, to remove some infrequent errors in the clear sky radiances that occur under certain circumstances. For polar orbiter data, the third step also obtains an estimate of the daytime clear solar reflectances for the near-infrared channel. Together these results are the refined clear-sky radiances. The fourth step is the final threshold test using the refined clear sky radiances and, in the case of polar orbiter data, an additional threshold test for near-infrared radiances over ice and snow-covered surfaces. Cloudy conditions are defined by those radiances that are sufficiently different from the clear values in any spectral channel.

The radiation analysis procedure first retrieves the properties of the surface from the clear sky composite radiances and the atmospheric data for each pixel (ranging from 4 to 7 km in size). These surface properties are then used, along with the same atmospheric properties, to analyze individual pixel radiances. For each individual pixel, *either* surface properties or cloud properties are retrieved from the pixel radiances depending on whether the threshold tests indicate clear or cloudy conditions. When only IR data are available, all clouds are assumed to be completely opaque to IR radiation. When both VIS and IR data are available (daytime only), the IR retrieval is adjusted to account for the effects of variable cloud optical thickness on the radiances. Both the unadjusted (IR only) and VIS-adjusted results are reported in daytime. The analysis uses two models: a liquid water cloud model and an ice crystal microphysical model. In daytime conditions in the polar regions over snow or sea ice, NIR reflectances are used to aid in the retrieval of cloud optical thicknesses. This creates the **DX** product.

The **D1** product is produced by summarizing the pixel-level results (**DX** data) 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) data sets to produce global coverage at each time. The **D2** data product is produced by averaging the Stage **D1** data over each month, first at each of the eight 3 hour time slots and then over all time slots; thus, nine files are included in the **D2** data set.

4) Details, Contents, Resolution

Satellite Radiance Data Sets

Reduced Resolution Radiance Data (B3)
Resolution: 30 km pixel, 3hr, individual satellites
Volume: 1.1GB per data month, for global coverage
Contents: Radiances with calibration and navigation appended. Uniform format for all satellites.
See data set version table at http://isccp.giss.nasa.gov/docs/dataverB3.html.

Cloud Data Sets

Pixel Level Cloud Product - (DX)
Resolution: 30 km mapped pixel, 3 hr, individual satellites
Volume: 5GB per data month
Contents: Calibrated radiances, cloud detection results, cloud and surface properties from radiative analysis. See list of variables at ftp://isccp.giss.nasa.gov/pub/documents/dx.titles and definitions at http://isccp.giss.nasa.gov/cloudtypes.html.

DX Contents

Provided every 3 hours at approximately 30-km intervals for individual satellites:

Pixel identification information
- Flags indicating day-night, land-water, near shore, high topography, snow/ice
- Viewing geometry (satellite zenith, solar zenith, relative azimuth angles, sun glint flag)

Original radiances (IR, VIS, NIR reflectivity, any others)
Clear sky radiances (IR, VIS, NIR reflectivity)
Cloud detection algorithm test results
- Time and space tests
- Clear sky composite tests
- Radiance threshold results (IR, VIS, NIR)

Radiative retrieval quality codes
Surface temperature, pressure and reflectance from clear sky composite radiances
Surface temperature, pressure and reflectance for clear pixels
Blackbody cloud model results: top temperature and pressure
Liquid cloud model results: top temperature, top pressure and optical thickness
Ice cloud model results: top temperature, top pressure and optical thickness

Gridded Cloud Product - (D1)
Resolution: 280km equal-area grid, 3hr, global
Volume: 320Mb per data month
Contents: Spatial averages of DX quantities and statistical summaries, including properties of cloud types. Satellites are merged into a global grid. Atmosphere and surface properties from TOVS appended. See list of variables at ftp://isccp.giss.nasa.gov/pub/documents/d1.titles and definitions at http://isccp.giss.nasa.gov/cloudtypes.html.

D1 Contents

Contents of the ISCCP D1 data set provided every 3 h for each 280-km grid cell over the globe. Some variables are defined only for local daytime and are undefined at night. Additional variables are calculated in the provided D1-READ program: cloud amounts, cloud top height in meters, total IR radiance, total VIS radiance, and layer mid-point pressures.

Cloud amount and distribution information

- Total number of pixels
- Total number of cloudy pixels
- Number of cloudy pixels and marginally cloudy pixels for various channel combinations
- Number of cloudy pixels in seven PC categories (IR only)
- Number of cloudy pixels in 42 PC/cloud optical thickness categories
- Number of ice clouds in low- and middle-level categories

Total cloud properties

- Cloud-top pressure (PC) for various channel combinations
- Cloud-top pressure for marginally cloudy pixels
- Spatial standard deviation of PC
- Cloud-top temperature (TC) for various channel combinations
- Cloud-top temperature for marginally cloudy pixels
- Spatial standard deviation of TC
- Cloud optical thickness (TAU) for various channel combinations
- Cloud optical thickness for marginally cloudy pixels
- Spatial standard deviation of TAU
- Cloud water path (WP) for various channel combinations
- Cloud water path for marginally cloudy pixels
- Spatial standard deviation of WP

Cloud-type information

- Average cloud-top temperatures for seven PC categories (IR only)
- Average TC, TAU, and WP for cumulus, stratocumulus, and stratus clouds (liquid and ice)
- Average TC, TAU, and WP for altocumulus, altostratus, and nimbostratus clouds (liquid and ice)
- Average TC, TAU, and WP for cirrus, cirrostratus, and deep convective clouds (ice)

Surface properties

- Surface pressure (PS) and skin temperature (TS)
- Spatial standard deviation of TS
- Surface visible reflectance (RS)
- Spatial standard deviation of RS
- Surface near-IR reflectance (RNIR)
- Snow/sea ice cover fraction
- Topography and land-water flag

Radiances

- Average IR radiance for cloudy pixels
- Spatial standard deviation of cloudy IR radiances
- Average IR radiance from clear-sky composite
- Average IR radiance for clear pixels
- Spatial standard deviation of clear IR radiances
- Average VIS radiance for cloudy pixels

Spatial standard deviation of cloudy VIS radiances
Average VIS radiance from clear sky composite
Average VIS radiance for clear pixels
Spatial standard deviation of clear VIS radiances
Viewing geometry and day-night flag
Satellite identification

Atmospheric Properties

Near-surface air temperature (TSA)
Temperature for nine pressure levels
Tropopause temperature and pressure
Precipitable water amounts for five layers
Ozone column abundance
Source of atmospheric data

Climatological Summary Product - (D2)

Resolution: 280 km equal-area grid, monthly, global
Volume: 7.5MB per data month
Contents: Monthly average of D1 quantities including mean diurnal cycle. Distribution and properties of total cloudiness and cloud types. See list of variables at ftp://isccp.giss.nasa.gov/pub/documents/d2.titles and definitions at http://isccp.giss.nasa.gov/cloudtypes.html.

D2 Contents

Contents of the ISCCP D2 data set provided every month for each 280-km grid cell over the globe; monthly average information is also provided at each of eight times of day. Cloud-top heights (in meters) are calculated in the provided D2-READ program.

Cloud amount information

Total cloud amount (CA)
Marginal IR cloud amount
Frequency distribution of cloud amounts

Average total cloud properties

Cloud top pressure (PC)
Time mean spatial standard deviation of PC
Temporal standard deviation of spatial mean of PC
Cloud top temperature (TC)
Time mean spatial standard deviation of TC
Temporal standard deviation of spatial mean of TC
Cloud optical thickness (TAU)
Time mean spatial standard deviation of TAU
Temporal standard deviation of spatial mean of TAU
Cloud water path (WP)
Time mean spatial standard deviation of WP
Temporal standard deviation of spatial mean of WP

Average properties for cloud types (CA, PC, TC, TAU, WP)

Low, middle and high clouds (CA, PC and TC from IR only)
Cumulus, stratocumulus and stratus clouds (liquid and ice)
Altocumulus, altostratus and nimbostratus clouds (liquid and ice)
Cirrus, cirrostratus and deep convective clouds (ice)

Average surface properties

Surface skin temperature (TS)
Standard deviation of TS
Surface visible reflectance (RS)
Snow/sea ice cover fraction

Average atmospheric properties

Surface pressure (PS)
Near-surface air temperature (TSA)
Temperature at 740 mb (T740), 500 mb (T500) and 375 mb (T375)
Tropopause pressure (PT) and temperature (TT)
Stratosphere temperature at 50 mb, ST50
Precipitable water for 1000-680 mb (PWL)
Precipitable water for 680-310 mb (PWU)
Ozone column abundance (O3)

ADDITIONAL DATA SETS

Calibration Table Data Set (BT)
Resolution: 3hr, individual satellites
Contents: Updates of calibration tables for B3 data set.

Ice/Snow Data Set (IS)
Resolution: 150km equal-area grid, 5-days, global
Contents: 5-day averages of snow and sea ice fractional coverage deduced from ship/shore station reports and satellite visible, infrared, and microwave imagery data.

TOVS Data Set (TV)
Resolution: 280km equal-area grid, daily, global
Contents: Atmosphere and surface data including temperature structure, water, and ozone abundances obtained from the TIROS Operational Vertical Sounding Product and supplemented by two climatologies.

Radiative Flux Data Sets

A number of radiative flux data sets are available (280 km equal-area grid, 3hr, global):

FD-TOA
Contents: All the radiative flux components at TOA. Total of 20 output parameters.
FD-TOA is available via anonymous ftp through our website.

FD-SRF
Contents: All the radiative flux components at SRF. Total of 25 output parameters.
FD-SRF is available via anonymous ftp through our website.

FD-PRF
Contents: All the radiative flux components for PRF (TOA and SRF inclusive). Total of 81 output parameters.
FD-PRF is available by request via anonymous ftp through our website.

FD-INP - Input flux data
Contents: Complete input variables used in flux calculation
FD-INP is available by request via anonymous ftp through our website.

Also:

FD-MPF - Climatological Summary Product
Resolution: 280km equal-area grid, monthly, global
Contents: Radiatively linearly averaged monthly-mean FD-PRF. Total of 81 output parameters.
FD-MPF is available via anonymous ftp through our website.

5) Frequency of New Product Releases

Not applicable

6) Lag Time

Typical lag time between observation and data production is 6-12 months.

7) Necessary Metadata

The ISCCP READ programs are provided with the data and are also available for download from the web site. These programs are mostly self-contained. Lists of variables are included in the program listing. One ancillary data set exists containing information for the D1 and D2 grid cells. It is available from both the archives and the ISCCP website. Complete documentation of these data sets is also available from the ISCCP website.

8) Duration

Data are currently available for the time period from July 1983 through June 2005. Data production is expected to continue until 2010.

9) Error Estimates

For the ISCCP radiance calibrations: a) the total *relative* uncertainties in the radiance calibrations are estimated to be ~ 5% for visible and ~ 2% for infrared; *absolute* uncertainties are < 10%and < 3%, respectively. For cloud cover, determined for regions about 280 km in size, the estimated random error is ~ 10% for instantaneous values and ~ 3% for monthly mean values. Random errors are larger in the polar regions, at least 20-30% for instantaneous values. Systematic errors include underestimates by 5-10% in global mean total cloud cover because of failure to detect very thin (optical thicknesses < 0.3) cirrus clouds, especially in the tropics, and thin and very low level (cloud top heights < 1 km) over sea-ice-covered regions. Retrievals of cloud top temperatures appear to be accurate to within 2-3 K; the main systematic errors are an underestimate of thin (optical thickness < 2) cirrus cloud top heights by 2-4 km when they overlie low-level clouds, which occurs about 10-15% of the time, and an overestimate of top heights by 2-3 km for isolated, very thin (optical thickness < 0.5) cirrus. Retrievals of cloud optical thickness appear to be accurate to about 10-20%, relative, mostly associated with uncertainties in cloud particle sizes and the effects of three-dimensional cloud structure; errors are somewhat larger for ice-phase clouds and for clouds observed at large solar zenith angles. Systematic errors for liquid water clouds associated with uncertainties of droplet size are < 5% and for ice clouds they are < 15%. Errors in retrieved cloud properties are also caused by detection errors but these do not appear to be much larger than the retrieval errors. When a scene is clear, the ISCCP analysis also retrieves surface visible reflectances and skin temperatures. The former appear to be accurate to about 5% with most of the uncertainty associated with unknown aerosol effects. The latter have random errors, mostly due to cloud detection effects of 2-4 K; these values are actually “brightness” temperatures, retrieved assuming a surface infrared emissivity of unity, so they are systematically lower than the actual skin temperatures. For most surfaces (water, vegetated land, ice and snow), the low bias is < 2 K but for grassland and, especially deserts, the bias can be 4-8 K. The radiative fluxes have estimated errors for regional monthly mean values of < 10 Wm^2 for top-of-atmosphere fluxes and < 15 Wm^2 for surface fluxes.

10) Availability and Access

ISCCP data sets are available from the archives:

The official ISCCP archives reside at NOAA/NESDIS/NCDC. Contact the Satellite Services Group at: ncdc.satorder@noaa.gov for information on ordering data sets from NOAA.

The complete ISCCP DX data is now available at NOAA/NESDIS/NCDC via anonymous ftp through: ftp://eclipse.ncdc.noaa.gov/pub/isccp/dx.

ISCCP data is also available through the Langley Research Center (LaRC) EOS DAAC. A catalog of our data may be found there. EOS DAAC ordering procedures for each data product type may be found there: http://eosweb.larc.nasa.gov

Selected D2 variables are available for viewing directly from the ISCCP website at http://isccp.giss.nasa.gov/index.html. These data may be viewed as GIF images or downloaded as IEEE floating point, scaled integer, or ASSCI text in either equal area or square grids.

The complete D2 data product is now available from the ISCCP anonymous ftp site. Read software is available from the website.

The ISCCP Website contains complete documentation, a research bibliography, data read software, data ordering procedures, contact info, sample browse products and climatological analyses of the results and is located at: http://isccp.giss.nasa.gov

11) Other Information

Basic Bibliography (a more complete listing of papers published using ISCCP data can be found on the ISCCP website at http://isccp.giss.nasa.gov/)

Rossow, W.B., and R.A. Schiffer, 1999: Advances in understanding clouds from ISCCP, *Bull. Amer. Meteor. Soc.* **80** 2261-2287.

Rossow, W.B., and R.A. Schiffer, 1991: ISCCP cloud data products. *Bull. Amer. Meteor. Soc.*, **72**, 2-20.

Schiffer, R.A., and W.B. Rossow, 1985: ISCCP global radiance data set: A new resource for climate research. *Bull. Amer. Meteor. Soc.*, **66**, 1498-1505.

Schiffer, R.A., and W.B. Rossow, 1983: The International Satellite Cloud Climatology Project (ISCCP): The first project of the World Climate Research Programme. *Bull. Amer. Meteor. Soc.*, **64**, 779-784.