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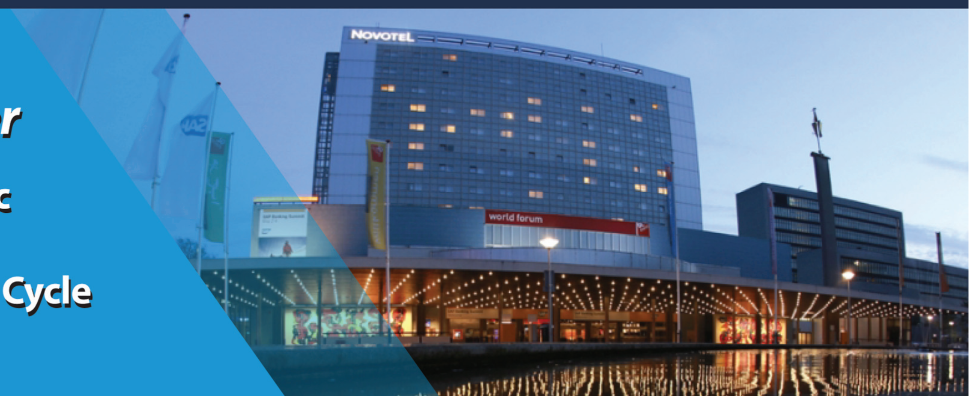
CALL FOR ABSTRACTS



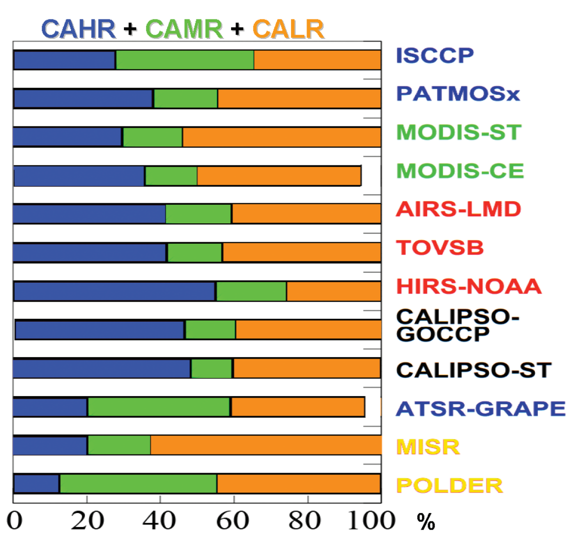
Trending Now: Water

7th International Scientific Conference on the Global Water and Energy Cycle

14-17 July 2014 — World Forum, The Hague, The Netherlands

See Conference Details on Page 15

First Coordinated Intercomparison of Cloud Products (see page 7)



Global averages of fraction of high-level, mid-level, and low-level cloud amount relative to total cloud amount (CAHR + CAMR + CALR = 100 percent). Statistics are averaged over daytime measurements (1:30–3:00 PM LT, except MISR and ATSR-GRAPE at 10:30 AM LT). About 42 percent of all clouds are high-level clouds with optical depth greater than 0.1. About 16 percent of all clouds correspond to mid-level clouds with no other clouds above. According to the majority of data sets, about 42 percent of all clouds are single-layer low-level clouds.

Newsletter Contents

GEWEX is a component of the World Climate Research Programme (WCRP) and its sponsors.
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Results from the GEWEX Cloud Assessment

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Cloud properties derived from space observations are immensely valuable for climate studies and model evaluation. This assessment has highlighted those that are well determined and has revealed how the statistics of others may be affected by instrument capabilities and/or retrieval methodology.

The GEWEX Cloud Assessment provides the first coordinated intercomparison of publicly available, Level-3 (L3) global cloud products with gridded and monthly statistics from spaceborne multi-spectral imagers, infrared (IR) sounders, and lidar. The Assessment was initiated in 2005 by the GEWEX Radiation Panel (now the GEWEX Data and Assessments Panel). Four workshops were held for investigating cloud property retrievals and eventually led to the creation of the GEWEX Cloud Assessment L3 database (*http://climserv.ipsl.polytechnique.fr/gewexca/*). Extending the self-assessments conducted by the different teams, analyses using this database have shown how cloud properties are perceived by instruments measuring different parts of the electromagnetic spectrum, and how cloud property averages and distributions are affected by instrument choice as well as some methodological decisions. These satellite cloud products are very valuable for climate studies and model evaluation. Even if absolute values, especially those of high-level cloud statistics, depend upon instrument (or retrieval) capability to detect and/or identify thin cirrus, relative geographical and seasonal variations, the cloud properties agree very well (with only a few exceptions, such as deserts and snow-covered regions). Probability density functions of radiative and bulk microphysical properties also agree well, when one considers retrieval filtering or possible biases due to partly cloudy pixels and to ice-water misidentification.

When comparing climate models, the observation time, the view from above, and retrieval filtering have to be taken into account. This can be achieved either by simple methods or by more sophisticated ones, such as the Cloud Feedback Model Intercomparison Project (CFMIP) Observation Simulator Package that consists of individual simulators, with each corresponding to a specific cloud data set. These simulators try to estimate the observation biases identified by this assessment. The study of long-term variations with these data sets requires consideration of many factors, which have to be carefully investigated before attributing any detected trends to climate change. Due to the systematic variations of cloud properties with geographical location, time of day, and season, any systematic variations in the sampling of these distributions can introduce artifacts in the long-term record.

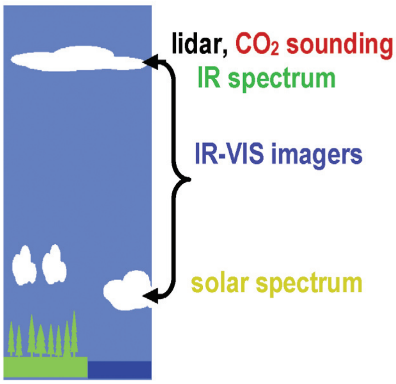
Detailed results and description of the data sets are given in the report, which is available at: *http://www.wcrp-climate.org/documents/GEWEX_Cloud_Assessment_2012.pdf*. Key results are published in the *Bulletin of the American Meteorological Society* (doi:10.1175/BAMS-D-12-00117.1).

Participating Satellite Data Sets

Operational weather satellite sensors have supplied data records extending more than 30 years. Whereas polar-orbiting, cross-track scanning sensors generally only provide daily global coverage at particular local times of day, geostationary satellites are placed at particular longitudes along the equator and permit higher frequency temporal sampling. Multi-spectral imagers are radiometers that make measurements at a few discrete wavelengths, usually from the solar to thermal infrared spectrum. They are the only sensors aboard geostationary weather satellites. The International Satellite Cloud Climatology Project (ISCCP, W.B. Rossow, City College of New York) has been providing GEWEX cloud products since the 1980s (see *GEWEX News*, November 2012). These were designed to characterize essential cloud properties and their variation on all key time scales to elucidate cloud dynamical processes and cloud radiative effects. To achieve the necessary sampling, ISCCP uses multi-spectral imager data from a combination of polar orbiting and geostationary weather satellites.

During the past decade, other global cloud data records have been established from various instruments, mostly onboard polar orbiting satellites, including the Advanced Very High Resolution Radiometer (AVHRR) and the Moderate Resolution Imaging Spectroradiometer (MODIS). The Pathfinder Atmospheres Extended [PATMOS-x, A. Heidinger, National Oceanic and Atmospheric Administration (NOAA)] was developed to take full advantage of all five channels of the AVHRR sensor aboard the polar orbiting platforms of NOAA and of the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT). MODIS data are analyzed by two teams: (1) the MODIS Science Team [MODIS-ST, S. Platnick, National Aeronautics and Space Administration (NASA) Goddard Spaceflight Center (GFSC); S. Ackerman, Cooperative Institute for Meteorological Satellite Studies (CIMSS)]; and (2) the MODIS Clouds and Earth's Radiant Energy System (CERES) Science Team [MODIS-CE, P. Minnis, NASA Langley Research Center (LaRC)]. Multi-angle, multi-spectral imagers make measurements of the same scene with different viewing angles, allowing a stereoscopic retrieval of cloud top height. Together with the use of polarization, the cloud thermodynamic phase can be determined.

The Cloud Assessment database includes data sets derived from the Multi-angle Imaging SpectroRadiometer (MISR, L. Di Girolamo, NASA) and a sensor using Polarization and Directionality of the Earth's Reflectances [POLDER, J. Riedi, Atmospheric Optics Laboratory, both operating only during



Sketch illustrating cloud height interpretation in the case of thin cirrus overlying low-level clouds (less than 20 percent of all cloudy scenes according to CALIPSO) when using different instruments.

daylight conditions. Results from the Global Retrieval of Along Track Scanning Radiometer (ASTR) Cloud Parameters and Evaluation [ATSR-GRAPE, C. Poulsen, Rutherford Appleton Laboratory] are provided only for daylight, but a stereoscopic retrieval has not yet been developed. IR sounders [e.g., the operational High resolution Infrared Radiation Sounder (HIRS) and the Atmospheric Infrared Sounder (AIRS)], originally designed for the retrieval of atmospheric temperature and humidity profiles, use IR channels in absorption bands of carbon dioxide and water vapor. The data have been analyzed by using two retrieval approaches: HIRS-NOAA (P. Menzel, NOAA), as well as TOVS Path B and AIRS-LMD (C. Stubenrauch, LMD/IPSL). The good spectral resolution of these IR sounding instruments allows a reliable identification of cirrus (semi-transparent ice clouds) both day and night. Several MODIS channels are similar to those of HIRS. Active sensors extend the measurements of passive radiometers to cloud vertical profiles. The lidar is highly sensitive and can detect subvisible cirrus, but its beam only reaches cloud base for clouds with an optical depth less than three. The Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) Science Team (D. Winker, NASA/ LaRC) determines cloud top height from VIS backscatter and identifies cloud ice from depolarization. Noise is reduced by horizontal averaging. The General Circulation Model-Oriented CALIPSO Cloud Products (CALIPSO Cloud Product, GOCCP, H. Chepfer, LMD/ IPSL) reduce noise by vertical averaging.

Selected Results: Total Cloud Amount

Total global cloud amount (fractional cloud cover) is about 0.68 (±0.03), when considering clouds with optical depth greater than 0.1. The value increases to 0.74 when considering clouds with optical depth greater than 0.01 (e.g., CALIPSO) and decreases to about 0.56 when clouds with optical depth less than two are considered (e.g., POLDER). According to most data sets, there is about 0.10–0.15 more cloudiness over ocean than over land.

Cloud Height

Cloud top height can be accurately determined with lidar (e.g., CALIPSO). Apart from the MISR stereoscopic height retrieval for optically thick clouds, passive remote sensing provides a "radiative height." The "radiative cloud height" may lie as much as a few kilometers below the "physical height" of the cloud top, depending on the cloud extinction profile and vertical extent. High-level clouds in the tropics especially have such "diffuse" cloud tops for which retrieved cloud top temperature may be up to 10°K larger than cloud top temperature. In general, the "radiative height" lies near the middle between cloud top and "apparent" cloud base (for optically thick clouds, height at which the cloud reaches an optical depth of three). When cloud height is determined via oxygen absorption (e.g., POLDER), it corresponds to a location even deeper inside the cloud.

Long-Term Variability

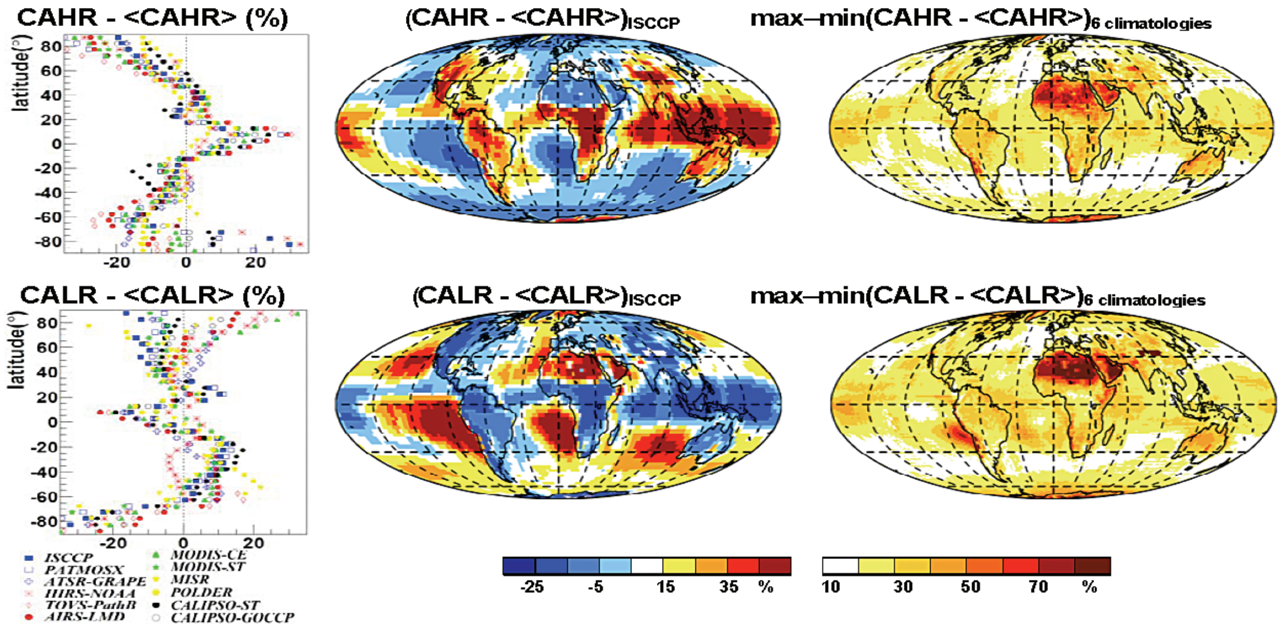
Global cloud amount and cloud temperature seem to be stable within the global mean interannual variability (0.03 and 2°K, respectively).

***Height-Stratified Cloud Amount (*Figures 1 and 2)**

About 42 percent of all clouds are high-level clouds with optical depth greater than 0.1 (see figure on page 1). The value increases to 50 percent when including subvisible cirrus, and it decreases to 20 percent when considering clouds with optical depth greater than two.

About 16 percent (±5 percent) of all clouds correspond to mid-level clouds with no other clouds above. The values from ISCCP are 27 percent (day: IR and VIS information) and 40 percent (day and night: night only one IR channel), respectively. These biases are due to semi-transparent cirrus overlying low-level clouds during the day and in addition due to semi-transparent cirrus during the night.

Participants of last GEWEX Cloud Assessment meeting, hosted by the Max Planck Institute at the Harnackhaus in Berlin, July 2010.



*Latitudinal variations relative to global annual mean of all cloud data sets (***left panel***), ISCCP regional variations relative to global annual mean (***middle***), as well as relative regional spreads between maximum and minimum within six cloud data sets (ISCCP, PATMOS-x, MODIS-ST, MODIS-CE, AIRS-LMD, and TOVS Path-B) (right), of relative high-level cloud amount (CAHR, top) and relative low-level cloud amount (CALR, bottom). Statistics are averaged over all measurements in the left panel and only over daytime measurements at 1:30–3:00 PM LT for columns 2 and 3.*

According to the majority of data sets, about 42 percent (±5 percent) of all clouds are single-layer low-level clouds. Outliers are HIRS-NOAA with 26 percent (only one IR channel for low-level clouds) and MODIS-ST with 53 percent (misidentification of optically thin cirrus).

Most data sets show similar latitudinal variations in total and height-stratified cloud amount (see figure above). Exceptions are polar latitudes and relative low-level cloud amount from HIRS-NOAA (underestimation of low-level clouds with minimal thermal contrast). Geographical maps show differences in total cloud amount over deserts and land areas, which may be linked to aerosols. Regional anomalies (difference between regional averages and global average cloud properties) agree better between the data sets than regional absolute values. The spread in regional cloud amount anomaly remains below 0.10, and the spread in relative high-level cloud amount anomaly varies between 10 and 20 percent (polar regions and regions with frequent cirrus). Most data sets agree on the seasonal cycle.

Bulk Cloud Microphysical Properties

Remote sensing determines an effective particle size by assuming particle shape and size distribution within the cloud. The height contributions in the retrieval of the effective particle size depend on the absorbing spectral band used; in general, absorption increases with increasing wavelength. However, with increasing cloud optical depth, the retrieved particle size corresponds more and more to particles near the cloud top, which typically leads to overestimates for liquid clouds and underestimates for ice clouds.

Global effective droplet radius of liquid clouds is about 14 µm (±1 µm). Global effective ice crystal radius of high-level ice clouds is about 25 µm (±2 µm). Global cloud water path varies from 30 to 60 gm^2 for liquid clouds and from 60 to 120 gm^2 for clouds with ice tops. Retrieval filtering of ice clouds leads to smaller (25 gm^2 for semi-transparent cirrus) or larger values (225 gm^2 for clouds with optical depth larger than one) of average cloud water path. Differences in probability density functions have been identified due to thermodynamic phase misidentification (leading to larger droplet radii or smaller ice crystal radii, respectively), partly cloudy samples (leading to slightly smaller particle sizes and water path) and retrieval filtering.

Conclusions and Outlook

The GEWEX Cloud Assessment database has provided for the first time ever, a coordinated intercomparison of L3 cloud products from twelve global "state-of-the-art" data sets. The choice of an L3 assessment was driven by the desire to provide an overview of cloud properties retrieved from space observations and by a lack of funding. The GEWEX Cloud Assessment Team recommends that assessments be repeated at regular intervals. The Cloud Assessment database at: *http://climserv.ipsl.polytechnique.fr/gewexca/* can facilitate future assessment activities and also be used for model evaluations, since the multiple data products can be used to give a range of uncertainties on the observations. Participating data sets are encouraged to provide updated versions to the website. Coordinated comparison of satellite-derived cloud properties continues within activities of EUMETSAT (Cloud Retrieval Evaluation Workshop, CREW), which focus on detailed Level 2 data comparisons over limited areas and time periods, and of the European Space Agency, which is establishing long-term data records through its Cloud Climate Change Initiative.