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# GEWEX Cloud Assessment: a review

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Clouds cover about 70 % of the Earth's surface and play a dominant role in the energy and water cycle of our planet. Only satellite observations provide a continuous survey of the state of the atmosphere over the whole globe, at space-time scales at which cloud processes occur. Satellite cloud data records now exceed more than 25 years in length. The International Satellite Cloud Climatology Project (ISCCP) is a project of GEWEX. To resolve the diurnal cycle of clouds, ISCCP is using 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. To be relevant for climate studies and for evaluation of general circulation models, the accuracy and error sources of these cloud products must be determined. Cloud properties under study include cloud amount, cloud height (in terms of pressure, temperature or altitude), cloud radiative properties (visible optical depth or infrared (IR) emissivity), cloud thermodynamic phase and bulk microphysical properties. Twelve cloud datasets participated in the assessment. A common L3 database (gridded, monthly statistics) facilitates further assessments and climate studies. It is available at the GEWEX Cloud Assessment website: http://climserv.ipsl.polytechnique.fr/gewexca/.

The participating datasets made use of different types of satellite instruments retrieve cloud properties: multi-spectral imagers (measuring at discrete wavelengths from solar to IR spectrum), multi-spectral multi-angle imagers (often only measuring the solar spectrum), IR sounders (measuring at discrete wavelengths sounding along the $CO_2$ absorption band) as well as active lidar.

The NOAA PATMOS-x project has reanalyzed the Advanced Very High Resolution Radiometer (AVHRR) data onboard the NOAA polar orbiting satellites. Two other cloud datasets (HIRS-NOAA and TOVS Path-B) use TIROS-N Operational Vertical Sounder (TOVS) observations onboard the same satellites. The NASA Earth Observing System, with the satellites Terra and Aqua, includes the second generation instruments MODIS (Moderate Resolution Imaging Spectroradiometer) and AIRS (Atmospheric Infrared Sounder). Methods to retrieve cloud properties from MODIS observations have been developed by the MODIS Science Team and by the CERES Science Team. Complementary cloud information by the active lidar aboard the A-Train is provided by the CALIPSO Science Team and by CALIPSO-GOCCP (GCM-Oriented CALIPSO Cloud Product), inferring cloud properties as in a GCM simulator, using a reduced vertical resolution. The POLDER (Polarization and Directionality of the Earth's Reflectances) instrument gives insight on the phase of clouds. Whereas passive remote sensing essentially provides information on the uppermost cloud layer, the comparison with cloud amount and top height determined from MISR (Multi-angle Imaging SpectroRadiometer) observations leads to some estimation of the clouds underneath. The recently developed cloud data record of the ATSR (Along-Track-Scanning Radiometer) - GRAPE project has also participated in the assessment.

Climatological averages of cloud properties, their regional, seasonal and diurnal variations as well as time series will be presented. One outcome of this study was, that the different datasets compared better when high-level, mid-level and low-level cloud amount were scaled by total cloud amount. This approach might also be useful for comparisons with climate models. About 40% of all clouds are high-level clouds (pressure smaller than 440 hPa) and about 40% of all clouds are single-layer low-level clouds (pressure larger than 680 hPa). Differences can be mostly understood by different instrument sensitivities to thin cirrus: the active lidar of the CALIPSO mission is the most sensitive instrument to very thin cirrus (50%). The relatively high spectral resolution of IR sounders (HIRS/TOVS and AIRS) makes them the passive instruments most sensitive to cirrus (40%), but already the use of IR spectral radiance differences can increase the sensibility to thin cirrus, as demonstrated by PATMOS-x and MODIS. Even if the absolute values of high cloud amount differ, geographical distribution patterns and seasonal cycle agree quite well between the different datasets.