

EVALUATING AND IMPROVING CLOUD PARAMETER RETRIEVALS

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RECOMMENDATIONS FROM THE MEETING

- Increase focus on detection and analysis of multiple-layer clouds;
- Increase the skill of cloud property retrievals from infrared observations;
- Increase understanding of the microphysical properties of ice cloud models that are used to retrieve ice cloud parameters from visible and shortwave infrared observations;
- Coordinate activities to improve traceability and uniformity in data products;
- Accommodate a common approach for generating global gridded (level 3) cloud climatologies;
- Establish working groups on cloud vertical placement, cloud physical properties, and cloud climatologies and, through these, enhance the exchange of information and collaboration on these topics;
- Involve participants from Asia and Australia;
- Plan on biannual meetings.

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THE THIRD CLOUD RETRIEVAL EVALUATION WORKSHOP

WHAT: A joint European/United States workshop gathered about 70 research scientists and students to review existing and new approaches to infer cloud parameters from passive and active satellite observations. The priorities of this workshop were to compare products from different teams, increase traceability of results, and discuss scientific issues common to all teams.
WHEN: 13–17 November 2011
WHERE: Madison, Wisconsin

Clouds strongly modulate the energy balance of Earth and its atmosphere through their interaction with solar and thermal radiation (Cess et al. 1989). However, because cloud properties vary on time scales of seconds to days, and also spatially on scales from meters to thousands of kilometers, clouds are represented in a rudimentary way in climate and weather forecast models and contribute largely to the uncertainty in climate predictions (Solomon et al. 2007). The radiative behavior of clouds depends predominantly on cloud cover and cloud micro- and macrophysical properties, such as cloud height, cloud thermodynamic phase, and cloud ice/water path. Measurements of the global distributions of these properties and their diurnal, seasonal, and interannual variations are critical for improving our understanding of the role of clouds in the weather and climate systems. The Cloud Retrieval Evaluation Workshops (CREWs) provide a forum for international satellite-based cloud retrieval teams to share their experience with state-of-the-art cloud parameter retrievals from

passive imaging satellite observations. CREW provides a path toward optimizing these retrievals for both climate monitoring research and climate and weather model analysis. Besides focusing on instantaneous cloud parameter retrievals, CREW also seeks to observe and understand methods that are used to prepare daily and monthly cloud parameter climatologies. Finally, particular attention is given to increase the traceability and uniformity of different long-term and homogeneous records of cloud parameters.

The CREW in Madison, Wisconsin, was the third workshop held on this topic. In 2006, the first workshop was held in Norrköping, Sweden, and had about 25 participants. The second workshop was held in Locarno, Switzerland, in 2009, and had about 45 participants. The third CREW workshop had about 70 participants from universities, research institutes, and satellite agencies in Europe and the United States. The overarching objectives of CREW are to bring together scientists working on cloud retrievals so as to identify and address research questions related to cloud parameter retrievals; to enhance communication; to develop international partnerships; to provide a comparison and validation platform; and finally to provide retrieval verification and validation statistics. An important component of the workshop is the discussion on the

results of the algorithm and sensor comparisons and validation studies. A topic of great interest at CREW-3 was how each team filtered their global results for detailed analysis and comparison with other products. For CREW-3, a common database was built to organize cloud property retrievals from different algorithms for passive imagers (SEVIRI, MODIS, AVHRR, POLDER, and/or AIRS; see Table 1 for a complete list of acronyms), complemented with cloud measurements that serve as a reference (CALIOP, CPR, AMSU, MISR) for a number of “golden days.” Prior to the workshop, the data in this database were evaluated by a EUMETSAT Fellow and by several workshop participants. It has now become common to compare individual products from passive sensors with the active sensor measurements from the A-Train constellation of seven satellites. In this way more knowledge may be gained as to the behavior of the different retrieval schemes over different cloud conditions.

HIGHLIGHTS. In the session on “Instrument Calibration,” presentations were given on methods to obtain calibrated satellite radiances, stressing the importance of these fundamental climate data records (FCDRs) as input to cloud parameter retrieval algorithms. On a different topic, the session on

TABLE 1. List of acronyms.

Acronym	Meaning
AIRS	Atmospheric Infrared Sounder
AMSU	Advanced Microwave Sounding Unit
AVHRR	Advanced Very High Resolution Radiometer
CALIOP	Cloud–Aerosol Lidar with Orthogonal Polarization
CALIPSO	Cloud–Aerosol Lidar and Infrared Pathfinder Satellite Observations
CPR	Cloud Profiling Radar
CREW	Cloud Retrieval Evaluation Workshop
EUMETSAT	The European Organization for the Exploitation of Meteorological Satellites
FCDR	Fundamental Climate Data Record
GEWEX	Global Energy and Water Cycle Experiment
IR	Infrared
MISR	Multi-Angle Imaging Spectroradiometer
MODIS	Moderate Resolution Imaging Spectroradiometer
POLDER	Polarization and Directionality of the Earth’s Reflectances
SCOPE-CM	Sustained, Co-Ordinated Processing of Environmental Satellite Data for Climate Monitoring
SEVIRI	Spinning Enhanced Visible and Infrared Imager
SWIR	Shortwave Infrared
TCDR	Thematic Climate Data Record
VIS	Visible

“Cloud Reference Observations” included several presentations on the capabilities of recent active satellite instruments, such as *CloudSat*, *CALIPSO*, and the passive microwave instrument AMSR, for the observation of cloud parameters. Besides the value of these observations for cloud research in general, they are also an important source of information for the validation of passive imager retrievals. Comparison of passive to active cloud properties is increasingly important in the framework of CREW. In the sessions on “Cloud Detection,” “Cloud Properties Retrievals,” and “Intercomparison and Validation,” many talks were given regarding the physical fundamentals of cloud remote sensing, with results provided from comparison and validation studies. Example comparison results are shown in Fig. 1. Finally, in the session on “Cloud Climatologies,” presentations were given on conditions and requirements that need to be satisfied for the generation of well-understood cloud parameter data records, and on the use of these thematic climate data records (TCDRs) in several climate monitoring and climate model evaluation studies.

OUTCOME OF CREW-3. A more focused analysis of cloud retrieval principles and the validation of cloud parameters was made within

three parallel breakout sessions. The topics of these sessions were 1) cloud vertical placement, 2) cloud physical properties, and 3) cloud climatologies. All working groups stressed the necessity of long-term, well-calibrated, and homogenized (i.e., common grid and format) datasets of satellite products. These datasets are needed to ensure the quality of instantaneous cloud parameter retrievals, whereas they are inevitable for developing TCDRs that are suitable for detecting climate trends. They also expressed the intent to actively contribute to CREW’s cloud parameter assessment, aiming to quantify the sensitivities of cloud parameter retrievals to different sources of error and to increase our scientific understanding of the different physical (assumptions) and philosophical approaches adopted by the retrieval teams. More specifically, the Working Group on Cloud Vertical Placement suggested complementing the cloud height and temperature retrievals with information on the cloud type (i.e., opaque, semi-transparent, or multiple-layer clouds). In addition, this group strongly supported the recent developments towards better detection of multiple-layer clouds in an atmospheric column. The Working Group on Cloud Physical Properties discussed in detail the differences

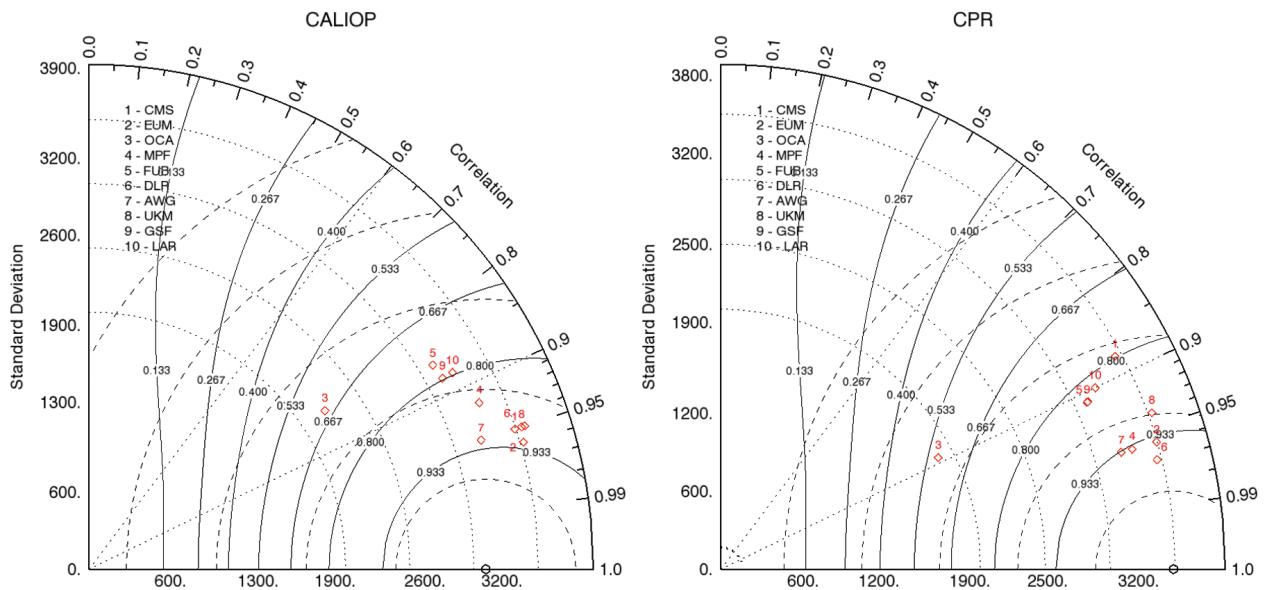


FIG. 1. Example of a Taylor plot (Taylor 2001) showing the relationship of 10 SEVIRI cloud-top height retrievals relative to (left) CALIOP and (right) CPR reference observations. The radial distance from the origin represents the standard deviations; the correlation is given by the azimuthal lines with values between 0 and 1, while the root-mean-square difference between the reference and the validation data (test) is plotted as the dashed lines centered around the reference point. The solid isolines represent the skill scores with values between 0 (least skillful) and 1 (most skillful). The standard deviation of the reference observation is represented by the black circle on the x axis, while the red points represent the 10 different cloud-top retrievals. Note that the presented results are based on cloud-top height retrievals provided in 2007, and the current versions of the retrieval algorithms may produce different results.

between cloud property retrievals from infrared (IR) observations and the microphysical properties of ice cloud models that should be used to retrieve ice cloud parameters from visible (VIS) and short-wave infrared (SWIR) observations. They concluded that IR-only cloud optical thickness retrievals appear to have better skill than VIS/SWIR techniques for clouds with optical thicknesses smaller than 3. Based on comparisons between active sensor (CALIOP), VIS/SWIR, polarized measurements from POLDER, and IR-only retrievals of optical thickness, the retrievals for ice cloud seem to match best with nature when roughened particles are assumed. Finally, the Working Group on Cloud Climatologies discussed ways forward to accommodate a common approach for generating global gridded (level 3) cloud climatologies with respect to methods used for spatial sampling and methods for calculating uncertainty information. Moreover, the need was stressed for uniformity among the cloud parameter datasets.

The collaboration initiated at the CREW workshop will be continued. The attending scientists strongly support the proposal to establish working groups on the three research topics of the breakout sessions (cloud vertical placement, cloud physical properties, and cloud climatologies) and, through these, enhance the exchange of information and collaboration on these topics in the future. In support of the GEWEX Cloud Assessment, the Working Group on Cloud Climatologies will seek to advance the aggregation methods used to derive level-3 cloud parameters from level-2 instantaneous retrievals, and help to produce climate data records with sufficient quality and error characterization for studying trends on seasonal, interannual, and decadal time scales.

The attending scientists acknowledged the need to preserve their data in formats that are widely

accessible, and to increase the use of their data by adopting common data formats. The goal of working toward traceability and uniformity in data products includes discussions on data quality, analytical standards, and strategies for data interpretation. To work toward these goals, it was suggested that CREW establish connections with international programs that coordinate these types of activities, such as the SCOPE-CM program.

MORE INFORMATION. More detailed information on the CREW workshops can be found on the CREW website (www.icare.univ-lille.fr/crew/). The passive imager retrievals and the reference data in the common database are available via our FTP site, and can be downloaded after registering at the following site: www.icare.univ-lille.fr/register/register.php. When asked for a “short description of your project,” please state that you want to have an account created for the Cloud Retrieval Evaluation Workshop (CREW).

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