

MEETING SUMMARIES

TOWARD GLOBAL HARMONIZATION OF DERIVED CLOUD PRODUCTS

DONG L. WU, BRYAN A. BAUM, YONG-SANG CHOI, MICHAEL J. FOSTER, KARL-GÖRAN KARLSSON, ANDREW HEIDINGER, CAROLINE POULSEN, MICHAEL PAVOLONIS, JÉRÔME RIEDI, ROBERT ROEBELING, STEVEN SHERWOOD, ANKE THOSS, AND PHILIP WATTS

Formerly known as the Cloud Retrieval Evaluation Workshop (CREW; see the list of acronyms used in this paper below) group (Roebeling et al. 2013, 2015), the International Cloud Working Group (ICWG) was created and endorsed during the 42nd Meeting of CGMS. The CGMS-ICWG provides a forum for space agencies to seek coherent progress in science and applications and also to act as a bridge between space agencies and the cloud remote sensing and applications community. The ICWG plans to serve as a forum to exchange and enhance knowledge on state-of-the-art cloud parameter retrievals algorithms, to stimulate support for training in the use of cloud parameters, and to encourage space agencies and the cloud remote sensing community to share knowledge. The ICWG plans to prepare recommendations to guide the direction of future research—for example,

FIRST WORKSHOP OF THE INTERNATIONAL CLOUD WORKING GROUP (ICWG)

WHAT: The first ICWG workshop, or ICWG-1, drew ~85 attendees (including algorithm/product developers, cloud modelers, weather forecasters, and climate scientists) and covered a wide range of topics concerning the remote sensing of cloud parameters; related applications and issues, specifically in cloud detection, cloud modeling for remote sensing, severe weather applications, level 2 retrievals and uncertainties; and the establishment of a decadal cloud record for climate research with well-defined uncertainties.

WHEN: 17–20 May 2016

WHERE: University of Lille, Villeneuve-d'Ascq, Lille, France

AFFILIATIONS: WU—CRL, NASA Goddard Space Flight Center, Greenbelt, Maryland; BAUM AND FOSTER—SSEC, University of Wisconsin, Madison, Wisconsin; CHOI—DESE, Ewha Womans University, Seoul, South Korea; KARLSSON AND THOSS—Swedish Meteorological and Hydrological Institute (SMHI), Norrköping, Sweden; HEIDINGER AND PAVOLONIS—Center for Satellite Applications and Research, NESDIS, NOAA, Madison, Wisconsin; POULSEN—STFC, Rutherford Appleton Laboratory, Harwell, Oxfordshire, United Kingdom; RIEDI—LOA, University of Lille, Villeneuve d'Ascq, France; ROEBELING AND WATTS—EUMETSAT, Darmstadt, Germany; SHERWOOD—CCRC, University of New South Wales, Sydney, New South Wales, Australia

CORRESPONDING AUTHOR E-MAIL: Dong L. Wu, dong.l.wu@nasa.gov

DOI:10.1175/BAMS-D-16-0234.1

In final form 6 November 2016
©2017 American Meteorological Society

on observing severe weather events or on process studies—and to influence relevant programs of the WMO, WCRP, GCOS, and the space agencies.

The first biennial workshop of the ICWG, or ICWG-1, was held in University of Lille, Villeneuve d'Ascq, Lille, France, and covered a wide range of topics concerning cloud parameter retrievals, their applications, and related issues. ICWG has several topical groups (TGs), six of which, underlined below, were convened during ICWG-1 in the order of their importance on satellite cloud products and applications:

- Cloud Masks,
- Calibration of Passive Imagers,
- Use of Combined Sensors for Cloud Retrievals,
- Cloud Modeling for Remote Sensing,
- Cloud Height for Wind Applications,
- Cloud Retrievals over Snow and Ice Surfaces,

- Severe Weather Applications,
- Validation Sources and Strategies,
- Assessment of L2 Passive Imager Cloud Parameter Retrievals,
- Assessment of Retrieval Uncertainties,
- Aggregation Methods for Climate Applications, and
- Assessment of Cloud Parameter Data Records for Climate Studies.

HIGHLIGHTS. ICWG selected a focus day (19 August 2015) for intercomparison of cloud observations to assess the differences in cloud parameter retrievals; the participants (CMA, EUMETSAT, JMA, KMA, NASA GSFC, NASA LaRC, and NOAA) applied their retrieval algorithms to the high-resolution *Himawari-8* observations (Fig. 1). The evaluation included the cloud mask (CM), cloud-top

temperature (CTT), cloud emissivity, effective radius (Re), and cloud optical thickness (COT). These cloud parameter retrievals are important for understanding near-term (nowcasting), short-term (weather forecasting), medium-term (regional monitoring), and decadal (climate monitoring) Earth’s system variabilities, as well as for potential improvements in the cloud and convection parameterizations adopted in weather and climate models. The Cloud–Aerosol–Water–Radiation Interactions (ICARE) Data and Services Center website (www.icare.univ-lille.fr) from the University of Lille is hosting and will continue to host various comparison datasets, which are available to other groups interested in testing operational cloud products for specific applications.

ICWG plans to include GOES-R Advanced Baseline Imager (ABI) data in future comparison studies before

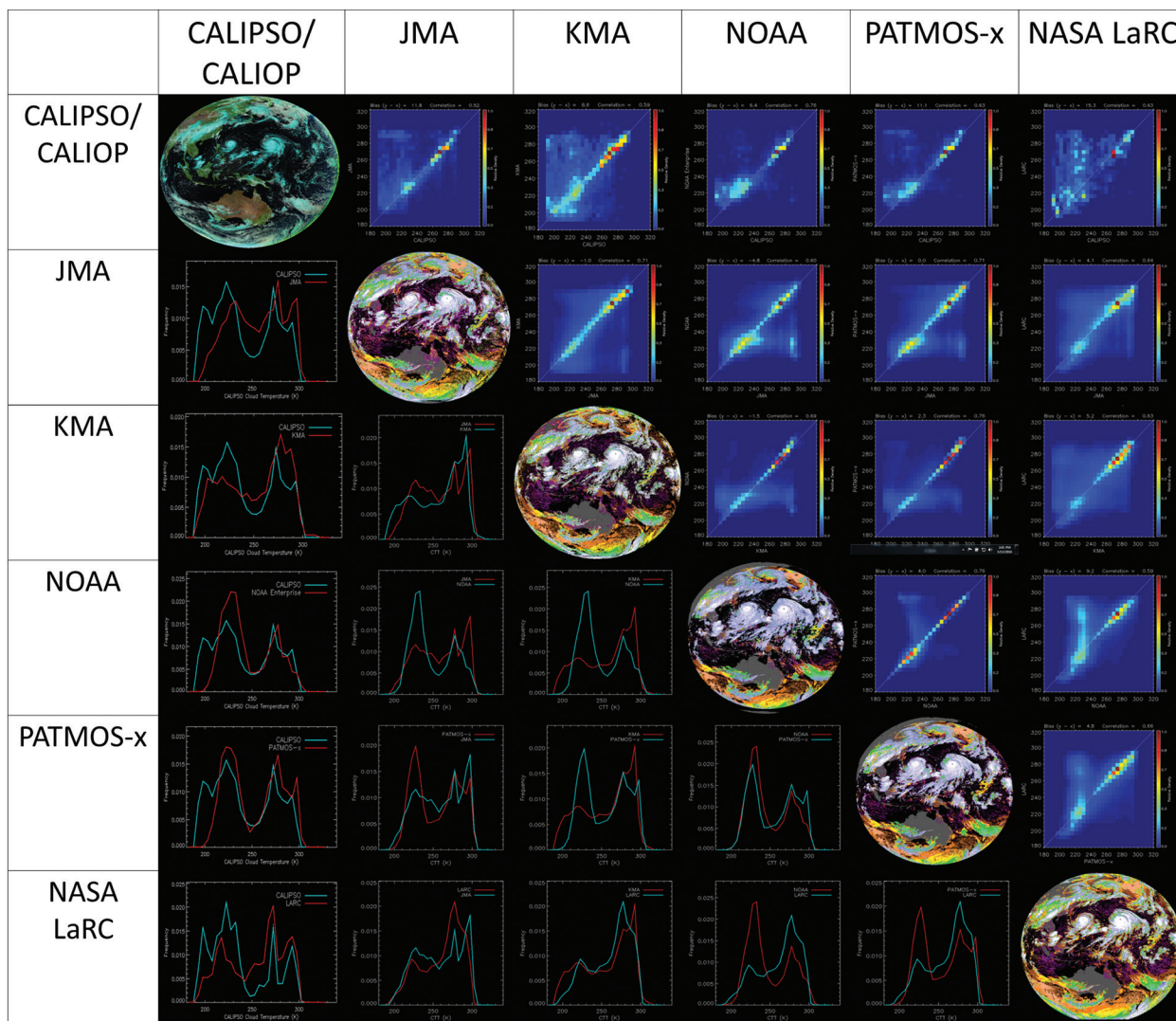


FIG. 1. Intercomparisons of cloud-top temperature (CTT) on the golden day (19 Aug 2015) in terms of 2D histogram (top-right panels) and pdf (bottom panels).

the ICWG-2 meeting. Polar-orbiting data will be added for comparison on new focus day(s) chosen for ICWG-2. These exercises are invaluable for tracking the cloud product improvements over time and assessing the accuracies from different algorithms (e.g., using Taylor plots with *CALIPSO* as the reference).

OUTCOME OF ICWG-1. The Assessment of Cloud Parameter Data Records for Climate Studies and Cloud Masks TGs discussed the value of the GEWEX Cloud Assessment as an archive for global level-3 (L3) cloud climatologies in a standard format. Six of the participants (SatCORPS, PATMOS-x, CLARA-A2, HIRS CMSAF, Cloud_cci, and *CALIPSO*) agreed to either add or extend their data holdings in the GEWEX archive (climserv.ipsl.polytechnique.fr/gewexca). Questions raised regarding the current GEWEX format included whether the current L3 spatial resolution ($1^\circ \times 1^\circ$) would be sufficient for current and future model needs; whether to add or change included variables; based on the steady increase in AVHRR- and HIRS-derived records whether a method to address satellite orbital drift should be included; whether averaging standards should be developed to account for VIS channel saturation for optical thickness retrievals; and whether uncertainty estimates should be integrated into the averaging process. The number of cloud climate data records (CDRs) developed from AVHRR and HIRS has steadily grown in recent years. Therefore, the TG identified three prominent issues in developing CDRs from heritage sensors like these: 1) intercalibration, 2) reliance on reanalysis products as ancillary meteorological data, and 3) aliasing effects caused by orbital drift. These are issues that specifically affect the stability of these records over time that limit their usefulness for certain climate applications such as trend detection. (See the sidebar for a list of recommendations from the meeting.) Further community input and discussion are anticipated during the ICWG-2 meeting.

The Severe Weather Applications TG put initial focus on midlatitude convective nowcasting applications over land, made several recommendations on data collection for GEO satellite agencies, and summarized European CWG activities. The TG outlined steps toward harmonizing derived cloud products for severe weather applications globally, coordinating their activities with other ICWG topical groups (e.g., cloud property needs for severe weather applications), and coordinating their activities with groups outside of CGMS.

The Cloud Modeling for Remote Sensing TG discussed current cloud modeling issues and solutions (both employed and proposed) and exchanged documents to provide a group resource and

encouragement for collaboration. It was agreed to use as a baseline model clouds that are “single layer, plane parallel, and homogeneous in microphysics and temperature.” The clouds are described by the parameters thermodynamic phase, optical thickness, effective particle size, and altitude. This model is ubiquitous in solar-wavelength-based remote sensing, but in many IR methods the model clouds are rather defined by “single layer, effective emissivity, and cloud top.” From the baseline, models can be further improved with better treatment for multilayer clouds, horizontal inhomogeneity, vertical inhomogeneity, ice scattering parameters, aerosol (within cloud, above, or below), fractional cover, index of refraction, and effective variance of particles size.

The Assessment of Retrieval Uncertainties TG discussed key sources of uncertainty, current techniques for estimating and evaluating uncertainty,

RECOMMENDATIONS FROM THE MEETING (CGMS 2016)

- Ensure that convective weather outside of rapid scan areas is sufficiently sampled by adopting a scan strategy that includes full-disk imaging at least every 10 min when satellite and ground station capabilities allow.
- Ensure a minimum set of channels during rapid scan operations: two infrared (IR) windows (three where possible), one visible (VIS, $0.65 \mu\text{m}$), and one medium-wave infrared (MWIR, $3.9 \mu\text{m}$).
- Standardize requirements and terminology for cloud products.
- Enhance use of satellite cloud products in tandem with nonsatellite data, specifically with ground-based radar and lightning products.
- Stimulate dialogue with cloud product users, such as the atmospheric motion vector (AMV) community of the IWWG, to integrate their requirements in the cloud retrieval algorithms.
- Use heritage sensors to develop cloud climate data records (CDRs) that better characterize calibration errors, dependence on ancillary data, and orbital drift.
- Generate subsampled versions of level 1 (L1) products from historical, current, and future satellite missions to facilitate CDR reprocessing.
- Include uncertainty estimates and associated quality indicators at pixel level 2 (L2) for each inferred cloud property, and evaluate these in future ICWG assessments.
- Maintain use of current, and plan for future, spaceborne lidar/radar measurements for long-term satellite cloud validation.
- Facilitate L2 cloud assessments for near-real-time applications and L3 cloud assessments for regional and climate applications.

and collaboration with other CGMS working groups. There was broad agreement on the definitions of uncertainty and the types of uncertainty that exist when retrieving cloud properties. Good progress was made in representing and understanding the uncertainty in cloud parameter retrievals.

MORE INFORMATION. More detailed information on the ICWG-1 workshop can be found online at www-loa.univ-lille1.fr/workshops/ICWG2016/. The ICWG encourages the exchange of data and code via web-based or open-source developing environments, in the development of cloud retrieval algorithms, and in the generation of data records for meteorological

and climatologic applications. An example of open-source community software is a Python-based package called Pytroll (www.pytroll.org). The ICWG community aims to successively augment this package with common cloud product validation modules.

ACKNOWLEDGMENTS. The comparison and evaluation of cloud retrievals, done as preparatory work to this workshop, was performed by the Center for Satellite Applications and Research, NOAA/NESDIS, and by Ewha Womans University, Seoul, South Korea, under the Cloud Algorithm Development project funded by KMA. Financial and organizational contributions for this workshop were made by EUMETSAT and the University of Lille.

ACRONYM LIST

AMV	Atmospheric Motion Vector
AVHRR	Advanced Very High Resolution Radiometer
CALIOP	Cloud–Aerosol Lidar with Orthogonal Polarization
CALIPSO	Cloud–Aerosol Lidar and Infrared Pathfinder Satellite Observations
CDR	Climate data record
CGMS	Coordination Group for Meteorological Satellites
CLARA	CMSAF’s cloud, surface albedo, and radiation dataset
Cloud_cci	Cloud Climate Change Initiative
CMA	China Meteorological Administration
CMSAF	Satellite Application Facility on Climate Monitoring
CREW	Cloud Retrieval Evaluation Workshop
EUMETSAT	European Organization for the Exploitation of Meteorological Satellites
GCOS	Global Climate Observing System
GEO	Geostationary
GEWEX	Global Energy and Water Cycle Experiment
GSFC	Goddard Space Flight Center
HIRS	High Resolution Infrared Radiation Sounder
ICWG	International Clouds Working Group
IWWG	International Winds Working Group
JMA	Japan Meteorological Agency
KMA	Korea Meteorological Administration
LaRC	Langley Research Center
MODIS	Moderate Resolution Imaging Spectroradiometer
PATMOS-x	Pathfinder Atmospheres–Extended
SatCORPS	Satellite Cloud Observations and Radiative Property retrieval System
WCRP	World Climate Research Programme
WMO	World Meteorological Organization

REFERENCES

- CGMS, 2016: Summary report of International Clouds Working Group (ICWG) activity. CGMS Working Paper CGMS-44ICWG-WP-01, 9 pp. [Available online at www.eumetsat.int/website/wcm/idc/idcplg?IdcService=GET_FILE&RevisionSelectionMethod=LatestReleased&Rendition=Web&dDocName=CWPT_1746.]
- Roebeling, R., B. Baum, R. Bennartz, U. Hamann, A. Heidinger, A. Thoss, and A. Walther, 2013: Evaluating and improving cloud parameter retrievals. *Bull. Amer. Meteor. Soc.*, **94**, ES41–ES44, doi:10.1175/BAMS-D-12-00041.1.
- , and Coauthors, 2015: Summary of the Fourth Cloud Retrieval Evaluation Workshop. *Bull. Amer. Meteor. Soc.*, **96**, ES71–ES74, doi:10.1175/BAMS-D-14-00184.1.