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SUMMARY REPORT OF INTERNATIONAL CLOUDS WORKING GROUP (ICWG) ACTIVITY

This working paper presents a summary report of ICWG activities in the past year and recommendations to CGMS from its topical groups. In response to A42.02, ICWG co-chairs drafted white paper to define common cloud parameters to be discussed at ICWG-1. These parameters include: cloud mask (CM), cloud top temperature (CTT), cloud emissivity, effective radius (Re), and cloud optical thickness (COT). These cloud parameter retrievals are increasingly used for near-term (now-casting), short-term; weather forecasting), medium-term (regional monitoring), and decadal (climate monitoring), as well for potential improvements in the cloud and convection parameterizations adopted in weather and climate models. Six topical groups TGs were convened in the ICWG-1 meeting. In response to R43.14, a new TG titled “Assessment of level-2 Passive Imager Cloud Parameter Retrievals” was established, to assess the differences in cloud parameter retrievals over the Asian region. CMA, EUMETSAT, JMA, KMA, NASA-GSFC, NASA-LaRC and NOAA participated in this intercomparison study, applying existing retrieval algorithms to Himawari-8 measurements on 19 August 2015 (as the golden day for intercomparison). In addition, the reports and recommendations from other TGs (Severe Weather, Cloud Models for Remote Sensing, Cloud Climate Data Record, and Uncertainties) are included in this paper. ICWG interactions with other CGMS groups are discussed. Andrew Heidinger will replace Bryan Baum as a new co-chair of ICGW.

SUMMARY REPORT OF INTERNATIONAL CLOUDS WORKING GROUP (ICWG) ACTIVITY

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ICWG Co-Chairs: Rob Roebeling (EUMETSAT) and Bryan Baum (U. Wisc, SSEC)

This is a summary paper to CGMS-44 in Biot, France in June 2016. The International Cloud Working Group (ICWG), formally known as the Cloud Retrieval Evaluation Workshop (CREW) group, was created and endorsed during the CGMS-42.

The CGMS-ICWG intends to provide 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 research community. The ICWG plans to serve as a forum to exchange and enhance knowledge on state-of-art cloud parameter retrievals algorithms, to stimulate support for training on cloud parameters, and to encourage space agencies and the cloud research community to use and share commonality algorithms. The ICWG plans to prepare recommendations to guide the direction of future research, for example on observing severe weather events or on process studies, and to influence relevant programs of WMO, WCRP, GCOS and the space agencies.

The 1st biennial workshop of the ICWG, or ICWG-1, was held in Lille, France from 17 to 20 May 2016, with ~85 attendees. The workshop covered a wide range of topics concerning cloud parameter retrievals, its applications and related issues. ICWG has several active topical groups (TG) and group leads in parenthesis, as listed below:

- Cloud masks (Karl-Göran Karlsson)
- Calibration of passive imagers (Dave Doelling)
- Use of combined sensors for cloud retrievals (Bryan Baum)
- Cloud modelling for remote sensing (Phil Watts)
- Cloud height for wind applications (Andy Heidinger)
- Cloud retrievals over snow and ice surfaces (Andi Walther and Adam Dybbroe)
- Severe weather applications (Mike Pavolonis)
- Validation sources and strategies (Pat Minnis)
- Assessment of level-2 passive imager cloud parameter retrievals (Yong-Sang Choi)
- Assessment of retrieval uncertainties (Caroline Poulsen)
- Aggregation methods for climate applications (Nadia Smith)
- Assessment of cloud parameter data records for climate studies (Martin Stengel, Mike Foster)

Six TGs (underlined) were convened in ICWG-1.

A) RECALLING PREVIOUS ACTIONS AND RECOMMENDATIONS

CMA, EUM, JMA, NASA, NOAA, WMO	WGII/3	A42.02	The new task team on calibration events logging to identify a common set of parameters to be monitored as part of the calibration events logging and sensor performance monitoring.

In Nov 2015 Co-chair R Roebling drafted white paper to be circulated within ICWG. The common cloud parameters discussed at ICWG-1 include: cloud mask (CM), cloud top temperature (CTT), cloud emissivity, effective radius (Re), and cloud optical thickness (COT).

ICWG	WGII/8	R43.14	ICWG should put focus on investigating data from the new-generations instruments on Himawari-8 and if available GOES-R for the retrieval of cloud parameters.

In Nov 2015 ICWG established a TG titled “Assessment of level-2 Passive Imager Cloud Parameter Retrievals”, to assess the differences in Cloud Parameter Retrievals over the Asian region, applying existing retrieval algorithms to Himawari-8 measurements on 19 August 2015 (as the golden day for intercomparison).

For the golden day inter-comparison, the participants for evaluations of cloud products included CMA, EUMETSAT, JMA, KMA, NASA-GSFC, NASA-LaRC and NOAA, and presented their results at the ICWG-1 meeting. ICARE has been hosting and will continue to host the inter-comparison data sets. Data will be made available to other groups interested in testing operational cloud products for specific applications.

As planned at ICWG-1, GOES-R ABI inter-comparison will also be considered before ICWG-2 meeting. Polar orbiting data will be collected for this golden day for future analysis. ICWG will consider a polar orbiting inter-comparison for the same golden day used for AHI and establish references from these comparisons that can be used as benchmarks to track the cloud product accuracies from CGMS agencies. For example, Taylor Plots using CALIPSO as the reference will be used as one benchmark result for cloud height comparisons.

For cloud intercomparison exercise, ICWG-1 proposed the following action and recommendation to CGMS:

Action item:

CGMS members to submit their data to the ICWG inter-comparison. Full-disk data at 10 minute temporal resolution, 2 km spatial resolution in the native AHI projection is preferred. The data should be submitted by September 1, 2016.

Recommendation:

CGMS members to budget a baseline funding for the intercomparison study, given its importance and impacts on global cloud products. Currently, ICWG helps to facilitate to collect the data (e.g., level-3 climate data record in TG Climate Product, level-2 retrieval assessment in TG Intercomparison), but many teams carried out the efforts on a volunteer basis. Lack of funding has limited the scope and prohibited a definitive analysis of the new HIMAWARI-8 data set.

CGMS-43 assigned two HLPP priorities to ICWG:

3.2.3 Develop best practices for retrieving cloud properties, using the converging capabilities of next-generation geostationary imagers	ICWG

ICWG Topical Groups selected August 19, 2015 as the golden day for inter-comparison and evaluations of cloud products. The results are presented at ICWG-1. GOES-R ABI and polar orbiting data will be included for intercomparison before ICWG-2. ICWG attempts to establish references from these comparisons that can be used as benchmarks to track the cloud product accuracies from CGMS agencies.

3.2.4 Using current and future geostationary imagers and sounders, generate and disseminate consistent basic nowcasting products, initially in pilot areas, as identified in SCOPE-Nowcasting.	ICWG

ICWG Severe Weather Topical Group had active discussions on nowcasting products as well as data collection and effective information generation. A scan strategy is recommended to include full disk imaging at least every 10 minutes when satellite and ground station capabilities allow. The group identified a need for intercomparison studies from various satellite derived thunderstorm properties over the life cycle of several thunderstorms.

B) REPORT FROM ICWG-1 MEETING

Additional reports and highlights from ICWG-1 topical groups (TGs) are summarized in the following.

B.1 TG Severe Weather:

The group put initial focus on mid-latitude convective nowcasting applications over land, and summarized European CWG activities. Satellite data collection recommendations were made for CGMS agencies, including steps towards global harmonization of derived products for severe weather applications, coordination with other ICWG topical groups (e.g. cloud property needs for severe weather applications), and outside-CGMS coordination. Specifically, the group put together the following **recommendations to CGMS**:

- Ensure that convective weather outside of rapid scan areas is sufficiently sampled, geostationary satellite operators from CGMS members should adopt a scan strategy that includes full disk imaging at least every 10 minutes when satellite and ground station capabilities allow.
- When only a subset of spectral channels on a geostationary sensor can be disseminated during rapid scan operations, the channel selection should include at least two infrared window channels (3 where possible) in addition to standard visible (0.65 um) and near-infrared (3.9 um) measurements to allow convective cloud properties to be estimated for nowcasting applications regardless of solar zenith angle.

- In coordination with users, CGMS members to work towards standardizing satellite products (requirements and terminology) that identify rapid developing cumulus clouds and mature cumulonimbus with strong updrafts.
- Initiate coordination with IWWG, ITWG, and IPWG on convective weather.
- Use satellite cloud products in tandem with non-satellite data, specifically ground-based radar and lightning products.

B.2 TG Cloud Models (CMo) for Remote Sensing:

The aim of this group is to btain a collective view on current cloud modelling issues and solutions (both employed and proposed), document to provide a group resource and an encouragement for collaborative endeavour.

In order to define what is meant by a cloud modelling 'issue', i.e. a discrepency between reality and models, it was agreed that a baseline model definition is useful to have. Although there is no single baseline model that applies to all methods and/or measurement systems, it was agreed to use the definition "Single layer, plane parallel, and homogeneous in microphysics and temperature". It is described by the parameters phase, optical thickness, effective particle size and altitude. This model is ubiquitous in VIS/NIR remote sensing and therefore the definition is perhaps here entirely appropriate; in many IR methods, this model is not literally used but instead the "single layer, effective emissivity, cloud top" model which we may consider to be an analogue of the defined baseline.

The group considered what characteristics of the modelling issue and potential solutions would be useful to collect and document. These are:

- Overview and perceived deficiencies arising in products,
- Mitigation strategies,
- Potential modelling solutions,
- Whether extra parameters of the modelling improvement can be retrieved,

Eight issues were highlighted and discussed at the meeting, and they are:

ICWG CMo Issue 1 – Multi-Layer Cloud
ICWG CMo Issue 2 – Horizontal Inhomogeneity
ICWG CMo Issue 3 – Vertical Inhomogeneity
ICWG CMo Issue 4 – Ice scattering parameters
ICWG CMo Issue 5 – Aerosol (with cloud, over, in or below)
ICWG CMo Issue 6 – Fractional Cover (n<1)
ICWG CMo Issue 7 – index of refraction
ICWG CMo Issue 8 – Effective variance

The group also recommended that ICWG should open a discussion / dialogue with cloud product users, especially the AMV user community through the IWWG, so that they are informed about, and can contribute to, the effectiveness and consequences of the cloud models employed.

B.3 TG Cloud Climate Data Record (CDR):

The group discussed prominent issues facing those groups developing climate data sets (CDRs) from heritage sensors like HIRS and AVHRR. In recent years the number of cloud climate records developed from these sensor has steadily grown. Three issues identified as being priorities for this group include: 1) inter-calibration; 2) reliance on reanalysis products as ancillary data; 3) Aliasing effects caused by orbital drift. These are issues that specifically affect stability of these records over time, limiting their usefulness for certain climate applications such as trend detection. The group discussed issues in terms of GEWEX cloud assessment, long-term lidar cloud record from CALIPSO/EarthCARE, uncertainty in cloud CDR, and reprocessing satellite data for climate quality.

For GEWEX cloud assessment, the group discussed its value as an archive for level3 cloud climatologies in a shared format. To this end six of the participants present agreed to either add or extend their data holdings in the GEWEX archive (climserv.ipsl.polytechnique.fr/gewexca/): SATCorps, PATMOS-x, CLARA-A2, HIRS CMSAT, Cloud_CCI, CALIPSO. Questions were raised regarding the current GEWEX format included whether:

- The current level3 spatial resolution (1°x1°) would be sufficient for current and future model needs (perhaps add 0.5°x0.5° when possible)
- We need to add or change included variables (CDNC, radiative properties)
- Given the increase in AVHRR- and HIRS-derived records a method to address satellite drift should be included;
- Averaging standards should be developed to account for visible saturation for optical retrievals
- Uncertainty estimates should be integrated into the averaging process.

The group expressed interest in extending and expanding GEWEX cloud assessment activities in the ICWG framework.

For spaceborne lidar cloud data, the group pointed out the importance of CALIPSO and the upcoming EarthCare mission for validation of satellite cloud properties. The availability of satellite-derived lidar cloud measurements is essential for validation of long-term cloud records. It is **recommended** that satellite lidar data providers provide/reserve sufficient funding for future missions to ensure long-term global lidar record of atmospheric variables from space.

For cloud CDR uncertainty, the group discussed prominent issues facing the CDR developers from heritage sensors like HIRS and AVHRR, as the number of cloud climate records developed from these sensors has steadily grown in recent years. Issues identified as being priorities include:

- Calibration
- Reliance on reanalysis products as ancillary data
- Aliasing effects caused by orbital drift

These are issues that specifically affect stability of these records over time, limiting their usefulness for certain climate applications such as trend detection. The group came up a **Recommendation to CGMS CDR developers**

- CDR development groups to use heritage sensors and collaborate to better characterize error associated with calibration, dependence on ancillary data, and satellite drift, with the goal of developing robust methods for minimizing

uncertainty paying specific attention to improving the long-term stability of the record via addressing biases on season, annual and multi-decadal timescales.

The group discussed the challenges of re-processing modern satellites for CDR purposes as the amount of data produced by these satellites rapidly increases. The amount of data produced by Suomi NPP, Himawari and others and future launches (e.g. GOES-R series) is large enough to make it difficult to re-process. The group **recommended to Satellite Data Processors** to develop sub-sampled versions (perhaps ~5km) of level1b files including statistical information (i.e standard deviation) so as to reduce the size of satellite data and facilitate re-processing for CDR development.

For cloud CDR, the group proposed the following action and recommendation to CGMS:

Action items:

- CDR developers submit their records to the GEWEX Cloud Assessment archive.
- CDR developers produce diurnally corrected products based on intended local overpass time of the satellite series at launch (e.g. afternoon or morning).

Recommendation:

- Satellite Data Providers generate subsampled versions of level1B products for recent and future launches to facilitate CDR reprocessing, for example, MODIS MYD02SSH data.

B.4 TG Uncertainties:

The Cloud Uncertainties Group was initiated at ICWG-1 in Lille April 2016. Its aim was to discuss the current advances in modelling uncertainty and to decide a way forward for the community to collaborate. At the meeting considerable interest in uncertainties was expressed by the winds and data assimilation communities as it enables the cloud parameters to be used with more confidence and impact. There is also considerable interest in the climate community. There was broad agreement on the definitions of uncertainty and the types of uncertainty that exist when retrieving cloud properties. The status of these issues within the community was explored to the extent possible within the very short time available. A number of groups have already shown good progress in representing and understanding the uncertainty. There were 3 recommendations coming out of the meeting for CGMS. The first was a recommendation for all operational producers to include an associated uncertainty on retrieved and derived cloud variables. The second, which was reiterated in many other fora, was to include uncertainty evaluation in future ICWG coordinated comparison campaigns. The third was to liase closely on this topic with IWWG. An internal action was agreed that a document collating the existing techniques and experience would be useful starting point for future discussions within the community. This will be set up on the ICWG WiKi page. The aims of the group can be summarised as follows to

1. Understand the needs of the user community
2. Share information on what uncertainties are important
3. Discuss techniques to characterise and estimate uncertainty

4. Define steps to validate uncertainty

At ICWG-1, the group discussed key sources of uncertainty, current techniques for estimating and evaluating uncertainty, and collaboration with other CGMS working groups. The group provided the following **recommendations to CGMS**:

- Operational cloud producers are encouraged to provide uncertainty estimates and associated quality indicators at the pixel (L2) level for each retrieved or derived cloud property.
- Uncertainty evaluation needs to be included in the next rounds of cloud intercomparison studies.
- ICWG should liase with IWWG to better understand uncertainty requirements.

C) ICWG LINKS TO OTHER CGMS WORKING GROUPS

The ICWG has close links with other CGMS working groups, especially, the International Winds Working Group (IWWG) and the International Precipitation Working Group (IPWG). It was recommended in CGMS-43 for ICWG to liaise with these groups to facilitate collaborations on global cloud observations and modelling. Updates on the group interactions are provided below.

ICWG, IWWG	WGII/6 and WGII/8	R43.11	ICWG and IWWG to liaise as appropriate on the provision of further information characterising the AMV derivation for enhanced QC and error characterisation.

ICWG-IWWG interactions:
Andy Heidinger from ICWG will be the liaison to IWWG. He and Dong Wu will participate in IWW-13 to be held in Monterey, CA, in June 2016. Regis Borde from IWWG attended ICWG-1 in Lille, France, in May 2016.

ICWG-IPWG interactions:
Cloud-precipitation connection is also recognized in ICWG-1 and highlighted in a number of presentation papers. Rémy Roca and Ralf Bennartz, who plan to attend IPWG-8 meeting in October 2016 in Bologna, Italy, will help to facilitate further cooperation between the two groups.

D) CHANGES AND UPDATES IN ICWG

Following the resignation submitted by co-chair Bryan Baum, Andy Heidinger (NOAA/NESDIS) will replace Bryan Baum as a new ICWG co-chair.

As part of the ICWG efforts to foster development of cloud retrieval algorithms and the generation data records for meteorological and climatologic applications, the ICWG members are encouraged to exchange data and code efficiently via web-based or open-source developing environments. At ICWG-1 discussions were devoted to consider open source community validation software such as python based library with Pytroll (http://www.pytroll.org).

E) NEXT ICWG MEETING

The ICWG meeting, or ICWG-2, will be held in spring 2018 in Korea (hosted by KMA) or in USA (hosted by a US ICWG member).