FIFTH WORKSHOP OF THE INTERNATIONAL PRECIPITATION WORKING GROUP

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BACKGROUND. It is a tremendous challenge to estimate the global record of precipitation at the finescales and long records that are needed. At present, precipitation estimates from satellite-based sensors constitute the key input for this vital information. In 2001, the Coordination Group for Meteorological Satellites (CGMS) established the International Precipitation Working Group (IPWG) with cosponsorship of the World Meteorological Organization (WMO) to provide a forum for the international precipitation research and operations communities to exchange information, establish common goals, and recommend future activities, primarily related to satellite-based precipitation work. Since that time the IPWG has pursued its goals by holding biennial workshops, organizing specialty workshops, and pursuing long-term cooperative projects among participants. IPWG5 is the latest in the series of biennial workshops and builds on the results and recommendations of the fourth workshop (IPWG4), held in Beijing, China, in October 2008 (Kidd et al. 2010). Two and a half days of presentations and posters set the stage for a day and a half of breakout sessions for three working groups: Applications, Research/New Technology, and Validation. All conference materials, presentations, posters, and proceedings papers are available online (see www.isac.cnr.it/~ipwg/meetings/hamburg-2010/Hamburg2010.html).
To summarize, a few space-based radars are now taking data (on Tropical Rainfall Measuring Mission (TRMM) and CloudSat), but the best generally available sensors are passive microwave (PMW) instruments whose data have a relatively strong relation to hydrometeors (rain and snow). However, technological issues limit these sensors to low Earth orbit (LEO) satellites, so their coverage is relatively sparse. Infrared (IR) sensors provide lower-quality information, but the data are available frequently because IR sensors are standard equipment on geosynchronous Earth orbit (GEO) meteorological satellites. Algorithms have been developed to collect various combinations of these individual sensors to create multisatellite products with uniform coverage at finescales and reasonable quality that are not available from any single sensor type. Some multisatellite products also include additional satellite sensors to address difficult situations and employ global analyses of precipitation gauge data to tie the satellite estimates more closely to “ground truth” data. One key development since the start of IPWG is that precipitation datasets are computed at a variety of delays (or “latencies”) from the time of observation. Short-latency data allow the rapid use of the estimates, but at the price of less precise estimates. Long-latency datasets permit the use of additional data, including monthly analyses of precipitation gauge data.

**HIGHLIGHTS.** One key topic in the presentations and posters was the status and plans for the various operational and experimental precipitation products that are currently available or planned. A large number of precipitation datasets are freely available, and they are new enough that it is still challenging to enumerate them and track their status. As a result of IPWG5, it was agreed to establish a master list on the IPWG Web site (see www.isac.cnr.it/~ipwg/data/datasets.html) to facilitate this process. Furthermore, it was a major concern at IPWG5 that these datasets must be properly maintained. Specifically, the responsible agencies and research groups should seek to use the best calibration standards for the satellite radiances, and as new calibrations or algorithm versions are introduced for a particular dataset, it is imperative that the entire dataset is reprocessed with the new approach.

Several promising new approaches were discussed for retrievals from individual sensors, including one-dimensional variational retrievals and microwave-calibrated multichannel GEO data estimates using neural networks. Other algorithm research is focused on situations considered “difficult” in current PMW retrievals. One such problem situation is retrieval over complex terrain. Over land the useable PMW channels only sense the ice hydrometeors, yet a great deal of enhanced tropical and warm-season rainfall in complex terrain results from liquid-phase “warm rain” processes. As well, this enhancement tends to occur at scales that are smaller than the footprint of many PMW sensors. The solution to this is to develop a simple model that incorporates ancillary data on atmospheric moisture profiles and the component of the wind blowing upslope against the local terrain. Another important “challenging” topic is the quantitative detection of snowfall, or even liquid precipitation over icy surfaces. The current approach is to use PMW channels that do not “see” the surface, although research shows that there is a delicate balance between avoiding the surface and additionally missing the lowest layers of the atmosphere where the precipitation is located. In support of this work, IPWG sponsored the Third International Workshop on Space-Based Snowfall Measurement, held 30 March–2 April 2011 in Gränaub, Germany. Turning to multisatellite studies, two groups are working to use Kalman filtering to improve the time sequence of maps at finescales, and one study showed promising results from a novel scheme for using daily precipitation gauge data to recalculate the distribution of satellite precipitation estimates, as opposed to the monthly gauge analyses that are currently used.

The presentations covered new satellite systems, specifically the Global Precipitation Measurement (GPM) mission, which is a joint U.S.–Japan project that follows the highly successful TRMM, another joint U.S.–Japan project that has marked 14 yr of operation and features the first precipitation radar to fly in space. As well, the joint French–Indian Megha-Tropiques satellite was recently launched in a very low inclination orbit (20°, versus 35° for TRMM, 65° for GPM, and polar for most other PMW sensors) to maximize data collection in the deep tropics. The
Japanese are preparing yet another LEO mission, the Global Change Observation Mission 1—Water (GCOM-W1) satellite, which has a capable PMW sensor. Algorithm developers were urged to exploit the new generation of GEO sensors, which provides both numerous channels (10+) and lightning mappers.

More generally, IPWG5 strongly supported the continued launch and exploitation of multichannel, dual-polarization, conically scanning PMW imagers with resolutions of 5–10 km, given their significant technical advantages for retrieving finescale precipitation estimates. As well, these sensors support numerous other retrievals, such as ocean surface winds and soil moisture, particularly when channels at 10 GHz or lower are included. IPWG5 also highlighted the significant contribution that the TRMM and CloudSat radars are making to research and calibration for precipitation, making it clear that agencies should be developing plans for the ongoing provision of space-based precipitation-capable radars.

Turning to a climate-scale perspective, for the first time at an IPWG meeting there were presentations on the concept of Climate Data Record (CDR) datasets. The CDR concept is to provide carefully intercalibrated, long-term datasets that might omit recent innovations in order to preserve relative homogeneity over as long a period as possible. For satellite precipitation estimates, this starts with careful examination of each sensor’s record, and then extends to intercalibration at both the radiometric and precipitation algorithmic levels between satellites. One particular concern raised in the meeting is that the calibrations used in the CDR datasets should be carried over into the short- and medium-latency precipitation datasets, even while it is clear that residual differences are inevitable at the months-to-years range.

The calibration issues raised in CDR’s were specifically focused in a special session on the Special Sensor Microwave Imager Sounder (SSMIS). Although these sensors are currently flying on Defense Meteorological Satellite Program satellites provided by the U.S. Department of Defense, they have suffered several calibration issues that have effectively prevented their use by the precipitation community. The data assimilation community developed the Universal Preprocessor code system to address these deficiencies from their own perspective, and this code is now being reworked to address additional issues for precipitation estimation.

Another major topic at IPWG5 was the validation of the various precipitation estimates. On the one hand, vigorous validation programs are being carried out at various institutions to support the choice and use of precipitation datasets for particular projects, as discussed above. On the other hand, IPWG has pursued a long-term project to provide large-region validation using precipitation gauge and radar analyses at the daily 0.25° × 0.25° scale for routinely produced precipitation datasets. Multiyear results now include Australia, the continental United States, western Europe, parts of South America, and Japan. One exciting development, first proposed at IPWG4 and still being implemented, is to include estimates of precipitation from major numerical models in the IPWG validation exercises in cooperation with members of the Working Group on Numerical Experimentation (WGNE). Once the numerical model estimates are incorporated, it is planned to pursue an analysis phase, with the target being presentation-quality results that are available at the time of the next IPWG meeting in

**Fig. 1.** The international constellation of precipitation-relevant satellites has disparate platforms, sensors, orbits, and periods of record. It is a major challenge for satellite-based precipitation studies, such as those the IPWG promotes, to best exploit these data, emphasizing the strengths and minimizing the weaknesses of the various resulting precipitation estimates. Most applications need merged estimates, illustrated at the bottom of the figure. (Images courtesy of the GPM project.)
2012. It is considered key to refine the metrics used in the validation, compared to the wide-ranging list that is currently computed at the IPWG sites.

One ongoing matter of concern to the IPWG is the lack of availability of quality-controlled precipitation gauge datasets in near-real time for use by the precipitation research and operations communities. As noted above, such gauge data are critical to providing the best datasets for many applications. Another long-term issue on which IPWG is urging more attention is the provision of surface validation data in oceanic areas. Precipitation studies would benefit greatly from increased attention and systematic dataset preparation for collections of island stations, buoy-based gauges, and innovative ship-based instruments.

Interaction with data users was a point of emphasis at IPWG5. As the various precipitation datasets mature and become better known, there is an increasing need to inform users at all levels of scientific expertise about the various choices and their attributes. Some users are working toward application systems that turn precipitation estimates into guidance on crop growth, drought, flooding, or landslide probability. Such applications require a steady supply of short-latency precipitation estimates whose errors are characterized as well as possible. Other groups of “power users” are researchers that are either seeking to close the global and regional water and energy budgets or attempting to quantify global changes in precipitation. In addition, there is an increasing need for tailored products that meet the needs of various researchers in related fields, many of whom do not have the extensive computer programming background that the power users have. In order to improve services to users, IPWG5 agreed to improvements to the IPWG web site, and planned to develop a summary of user needs for precipitation products.

The IPWG realizes that one important group of users is the personnel working in the hydrometeorological services in developing countries. Accordingly, IPWG partnered with the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) to develop a Hydrology and Precipitation Training Workshop that was held concurrently with IPWG5 during 12–14 October 2010. The 16 attendees came from 15 different countries, and 11 of the 16 lecturers were scientists also attending IPWG5. Topics ranged from background on precipitation algorithms to exercises on accessing precipitation data across the web. The IPWG will seek to hold such training workshops more frequently in the future.

OTHER NOTES. The IPWG serves as the leader of the Group for Earth Observations (GEO) precipitation subtask (WA-08-01d in the current work plan). This activity is part of the water theme under the Integrated Products for Water Resource Management work plan task and was reported during IPWG5. As well, the cochairs serve 2-yr terms, and new cochairs were nominated (and subsequently confirmed by CGMS): Paul Kucera (National Center for Atmospheric Research) and Bozena Lapeta (Institute of Meteorology and Water Management National Research Institute, Satellite Remote Sensing Centre). Finally, the next workshop of the IPWG is planned for 2012, potentially in Brazil.

REFERENCES