WORKING GROUP REPORTS

FIRST IPWG WORKSHOP

23-27 SEPTEMBER 2002

MADRID SPAIN

OPERATIONAL APPLICATIONS WORKING GROUP

Chairman:
James F. W. Purdom

Rapporteur:
F. Joseph Turk

Attendees:
Philip A. Arkin , Roderick A. Scofield, Daniel Vila, Jochen Kerkmann, Thomas Heinemann, Piotr Struzik, Jose Miguel Fernandez

List of Acronyms
TOR terms of reference
ST short-term, 0-2 years
MT mid-term, 2-5 years
LT long-term, 5+ years
VIS visible (affected by solar radiation only) spectrum
SW shortwave (affected by solar radiation and thermal emission) spectrum
IR thermal infrared (independent of solar radiation) spectrum
MW microwave spectrum
MS multi-spectral
NWP Numerical Weather Prediction

1. Standard/common procedures

Recommendation 1:
Form a subgroup of the development of instantaneous precipitation estimation ***export algorithms*** for users of geostationary and low Earth-orbiting satellite data

Actions:
- Collect current, operationally-oriented, instantaneous satellite-based precipitation algorithms to be made available to an IPWG website (see Recommendation 2). (ST: *R. Scofield and one other*).
    - Restrict the current (0-2 years) techniques to be single-sensor techniques; specifically, geostationary IR-only and low Earth-orbiting MW-only precipitation estimation techniques.
    - Define algorithm structure (source code, block diagrams, or documents describing the technique and its implementation) for specific satellite platforms and sensors (e.g., GOES I-M, MSG, GMS, SSMI, AMSU-B, etc).
    - For each export algorithm, information on the specific validation statistics (if they are available) need to be made available, especially if the error characteristics are important for the application(s) of the product.

- At a minimum, an ancillary “product quality flag”, which is determined by the provider, and which provides a qualitative indicator of the precipitation estimate, must accompany any export algorithm.
- Training materials describing the basis of the algorithm, its applicability, and its capabilities and limitations also must accompany any export algorithm. The training materials are to be constrained along the lines of the Virtual Laboratory (VL) for Satellite Data Utilization (**www.cira.colostate.edu/RAMM/WMOVL/main.html**). The training materials are to be separated into “basic” and “specialized” skills and made available under the IPWG website and the VL (ST, LT: *J. Purdom, D. Hinsman to coordinate*).

- Provide information on current and research-oriented climatological precipitation techniques, where climatological precipitation datasets can be found, and where they are documented. IPWG group to survey the space/time needs, accuracies needed, data latency time, and temporal coverage. This material is also to be made available on the IPWG website (ST: *P. Arkin*).

Recommendation 2:
Organize and maintain an IPWG website for algorithm download and use by IPWG website-registered users (logon as user/password so we know who is using the algorithms and get their feedback). Website to contain inventory and access to several existing products, as well as links to algorithm description and a further link to online data, if available.

The IPWG website should contain:
- Access to baseline export algorithms through login process
- Information on existing online MW and geo-IR digital datasets (not all users will have satellite direct-capture capabilities)
- Access to existing, maintained precipitation products, with explanations
- Comprehensive datasets for specific meteorological events for case studies
- Training materials and information about coming training activities
- Information on upcoming IPWG-related activities

Actions:
- The website access was recommended to be organized and maintained similar to the existing EURAINSAT project (ST, MT: *V. Levizzani, J. Turk, J. Purdom*).

Recommendation 3:
Coordinate an effort to work with other members of IPWG to coordinate applications with other "non-traditional" applications of precipitation data. Broaden application of satellite precipitation products by co-operation with communities involved to not only meteorology and hydrology but also: snow models, irrigation models, pest and disease models, mud slide and avalanche models, dispersion models, surface pollution models and others.

Actions:
- IPWG group to determine non-traditional applications and requirements as a function of space/time needs, accuracies needed, data latency time (ST: *P. Struzik*).

2. Research

Recommendation 1:
The operational applications group suggested making case study satellite datasets available through the IPWG website, for further algorithm research.

Each satellite operator saves complete datasets for specific days, set of baseline datasets, one day in each season if preferable. Consists of all channels, all data, all satellite data for specific days:

- MODIS (archived and freely available through EOSDIS)
- AMSR-E (no responsibility assigned)
- AIRS (no responsibility assigned)
- AMSU-A/B (no responsibility assigned)
- SSMI (NRL/J. Turk to collect and archive F-13/14/15)
- TMI (available and archived through TSDIS)
- GOES-East/West (NRL/J. Turk to collect and archive GOES-8/10)
- Meteosat/MSG (EUMETSAT/J. Kerkmann to collect and archive Meteosat-5/7)
- GMS (NRL/J. Turk to collect and archive GMS-5)

Actions:

- March 21, 2003 was selected as the first target date. Either simple flat binary or HDF are common formats that would be potentially used. The dataset would be freely available to any IPWG website registered user. As the date approaches, the responsible IPWG member(s) will be reminded (ST: *J. Turk, J. Kerkmann, J. Purdom*).

Recommendation 2:
Encourage continued development, refinement, and validation of the various research-status satellite sensor precipitation estimation techniques**.**

Actions:

- At this time, the group was in agreement that only the single-satellite/single-sensor type algorithms were scientifically ready o be made publicly available and advertised on the IPWG website. However, there is large amount of research currently being devoted to:
  - MS satellite precipitation techniques,
  - Combined or "blended" satellite precipitation techniques (IR+MW),
  - Satellite + NWP precipitation techniques,
  - Improved validation techniques to properly analyze the error characteristics of satellite-derived precipitation estimates at different space and time scales,
  - Assimilation of precipitation information into NWP models at short time scales (instantaneous to 6-hourly) and relatively fine spatial scales (0.25-degree resolution or less),

Therefore, the operational applications group agreed that since all of these topics are in a research and development stage, that they should be further investigated and reported on at the next IPWG meeting (LT: J. Turk and others to report at next IPWG).

The IPWG research group has pointed out the special problems faced by the algorithms such as orographic precipitation, frozen precipitation, light precipitation especially

outside of the tropical regime. As a result, the group discussed the need for a creation of a rainfall climatology that would be stratified as a function of synoptic conditions, but no specific conclusions were reached on this issue (no further actions taken).

Recommendation 3:
Coordinate satellite-based precipitation estimation research with the needs and requirements for climatological applications. While climate models typically analyze precipitation on time scales of one month and space scales of 2.5 degrees, there is an increasing need for daily-scale precipitation estimates and space scales approaching one-degree. These data can be produced with a latency time, but need to have data records extending back over a sufficient number of years in order to be useful for identifying long time scale variabilities.

Actions:
- IPWG to report on status of GPCP daily/1-degree products at the next IPWG meeting (MT: *R. Adler, P. Arkin*).

3. Future sensors

Recommendation 1:
The group discussed the possibility of recommending a geostationary-situated lightning sensor to the CGMS, as a means to improve convective/stratiform delineation. However, the group did not come to any conclusions on this.

Actions:
- We agreed to revisit this issue at the next IPWG (LT: *J. Purdom, B. Bizzarri*).

4. Open items for discussion

Recommendation 1:
Provide a means for to update other members of the IPWG with the current status of action items. This applies to the operational applications, research, and validation sub-groups.

Actions:
- Suggested that members of the IPWG who have specific action items are report back to the IPWG with their results at 6-month intervals.

Recommendation 2:
The group agreed to recommend better temporal coverage of the southern hemisphere (South America). Currently, the GOES-East half-hourly satellite coverage cuts off at 20S latitude and in periods of rapid-scan operations the refresh rate for South America is reduced to three hours.

Actions:

- Recommend to the satellite operators at the next meeting of the CGMS (ST: *D. Vila, D. Hinsman*).

RESEARCH ACTIVITIES WORKING GROUP

Chairman:
Peter Bauer

Rapporteur:
Joerg Schulz

Attendees:
Andrew J. Negri, Augusto Pereira Filho, Bizzarro Bizzarri, Robert F. Adler, Christopher Reudenbach, Francisco J. Tapiador, Kuolin Hsu, Armand Nzeukou , Ralf Bennartz, Ralph R. Ferraro.

List of Acronyms:
TOR terms of reference
ST short-term, 0-2 years
MT mid-term, 2-5 years
LT long-term, 5+ years

1. Standard/common procedures

Background:
The working group identified the need for generally available information on algorithms, satellite and validation data under quality criteria generally accepted by the community. IPWG represents an excellent forum for providing this platform through a web-based and dynamically updated information database. Many research activities, in particular in the transition from experimental to routine applications, lack critical information on both algorithms and data. On a very short term, information on those experimental missions which were considered crucial for near-future algorithm development and the improvement of products (AMSR etc.) has to be requested.

The structures proposed in recommendation no. 3 will represent transparent and modular (plug and play) environments which allow retrieval/validation/data blending at the best available scientific level. Their modular organisation allows an isolated improvement of individual components by researchers to adjust the techniques to their needs. The structures will be equipped with functioning day-one modules. Examples: GPM combined sensor retrieval development efforts; NRL blending technique. Another advantage will be the utilization of fairly complex algorithms by a large community.

Recommendation 1:
Provide a generally accessible platform on data and algorithms for the research community.

Actions:

- Define elements of algorithm transition required for general applications. (QPE, bias/error estimate, limits of applicability, documentation, comprehensive bibliography, compliance with user requirements as defined by WMO, EUMETSAT, NASA-DAO, ESA, others - compile user requirements w.r.t. to precipitation on the IPWG web site). (ST: *P. Bauer, R. Adler, IPWG-O*)
    - Define criteria of satellite data (including meta-data) access for research applications including data availability (schedules), sensor specifications, calibration/validation activities, data formats, data accessibility (cost). (ST: *R. Ferraro, R. Bennartz, IPWG-O*). In the short term, the responsible agencies have to be approached for providing information on the following sensors which will be used for experimental/operational applications (*J. Purdom, CGMS*):
    - SSMIS (DOD/NOAA)
    - AMSR-E (NASA/NASDA)
    - AMSR-J (NASA/NASDA)
    - MSMR
    - VIS/IR sensors ???
- Set up an inventory of field campaign data, co-located satellite data. (ST: *IPWG-V*).

Recommendation 2:
Enable co-operation and training through software libraries.

Action:
- Provision of radiative transfer codes, algorithm codes, footprint matching codes (e.g. to be used with direct read out raw data, especially for developing countries) with corresponding training tools and documentation. (ST-MT: *J. Schulz, R. Bennartz, IPWG-O*)

Recommendation 3:
Develop new strategies on flexible and global structures for physical algorithm development, validation, and data fusion.

Actions:
- Establishing a framework for
    - (physical) algorithm development (global and regional). (ST-LT: *GPM, V. Levizzani*)
    - a testbed for algorithm validation (comparison data sets etc.). (ST-LT: *IPWG-V, IPWG-R*)
    - product merging and blending. (ST-LT: *IPWG-O, R. Adler, P. Arkin, J. Turk*).

2. Research

Background:
The group feels that with the current quality of observational data and retrieval methods the accuracy limits of precipitation retrieval from satellite data are in reach. Significant improvements on retrieval accuracy will only be possible through the employment of more complex analyses that is by constraining the satellite data analysis with additional

information from other sources (additional data and/or simplified dynamical physical models as used in NWP analyses).

Due to the limited accuracy and proper representation of ground-validation, alternative methods for the uncertainty estimation of satellite data retrievals have to be investigated. Physical algorithms which are based on the simulation of cloud environment - cloud microphysics – radiative transfer – satellite observation capabilities should be used to calculate error propagation through the physical models. This would provide an independent uncertainty estimate at the same level of consistency as the algorithms themselves.

Recommendation 1:
The principal problem of under-constrained precipitation retrievals requires a different type of analysis/retrieval approach.

Methodology and information:

- more complex analysis methodologies;
- multiple sensors, multiple satellites, new instrument developments (e.g. geo-microwave, lightning sensors, dual-frequency radars);
- climatological information;
- simplified dynamical physical models.

The usefulness and complexity of the needed methodology and information depends on the application. Only by stronger constraints on algorithms special retrieval problems such as:

- orographic precipitation;
- light precipitation;
- frozen precipitation;
- resolution enhancement [spatial (vertical/horizontal) and temporal]; can be solved.

Recommendation 2:
The physical uncertainty modelling has to be pursued in a similar fashion as physical algorithm development is carried out.

3. Future sensors

Background:
In preparation of future missions and mission constellations a need for means and methodologies for identifying consistent radiometer configurations was identified. On a single sensor basis, this concerns the selection of frequencies (bandwidths, radiometric accuracy), polarization, viewing geometry, spatial resolution etc. These issues require a rather complex simulation environment (cloud environment - cloud microphysics – radiative transfer – satellite observation capabilities) and data from field campaigns with special emphasis on airborne instruments which represent prototype satellite instruments. For the combination of sensors and satellites other issues such as the selection of orbits will be important.

In preparation for the commitment to future radiometer configurations, appropriate steps haven to be taken to protect those frequency bands which can be identified for future

precipitation retrieval applications (183+ GHz). The working group felt that this was a two-step process, i.e. the announcement that studies for the identification of these frequencies are underway and that appropriate measures have to be prepared.

Recommendation 1:
From the work of the group indications for future sensors should emerge based on the identified scientific outstanding areas

Action:
- Generate a framework for the development of a multi-frequency simulator, orbit configurations, required to optimise future sensors w.r.t. to different application areas. (MT-LT: *IPWG-R*).
- Definition and provision of experimental data sets (ST: *Bizzarro Bizzarri*).

Recommendation 2:
In view of future sensor development a long-term strategy for frequency protection has to be developed and integrated in the current ITWG activities. ***(TOR: e)***

Actions:
- Expression of need for frequency protection including approximate frequency bands and their scientific justification w.r.t. future precipitation missions. (very ST: *IPWG*).
- Demonstrate the usefulness of chosen frequencies in order to support the request for protection. (ST-MT: *B. Bizzarri*).

VALIDATION ACTIVITIES WORKING GROUP

Chairman:
Mark L. Morrissey

Rapporteur:
Elizabeth E. Ebert

Attendees
Clemens Simmer, Anke Thoss, Arnold Gruber, Witold F. Krajewski, Eric A. Smith, Angel Luque, Lu Naimeng, Robert F. Adler, Vincenzo Levizzani, Donald E. Hinsman, Wesley Berg

The group first set out to define its understanding of validation. Strictly speaking, we define ***validation*** as *the determination of the error characteristics of the estimates.* This implies that the reference ("truth") dataset is either error-free, or its errors are known and accounted for.

In contrast, ***evaluation*** can be defined as *a qualitative and/or quantitative assessment of the estimates that may not explicitly account for errors in the reference data set*.

In practice, we usually use the word ***validation*** to describe what are actually ***evaluation*** activities. The group felt that it would be virtually impossible to try to enforce a correct usage of the word validation, so we will continue to interpret it loosely.

The remainder of the discussion focussed on two main topics: identification of the validation needs of users of precipitation estimates, and improvement of the reference data used to validate the satellite estimates. Continued communication within the group and with the wider satellite precipitation community was also discussed.

1. Validation needs of users of precipitation estimates

We recognize that different types of users of precipitation products have different needs with regard to the type of validation information required to make best use of the products. We identify the main users of satellite precipitation products as:

Operational nowcasting
Hydrological applications
Climate applications
Numerical weather prediction (data assimilation)
Algorithm developers

While the group felt that it had a reasonable idea of the validation needs of these particular user groups, we also believe that it would be wise to consult more directly with representatives of the groups to better define which validation products are of greatest

interest and usefulness to them. There is clearly also a need for more ongoing and comprehensive validation of the more widely used "operational" satellite precipitation algorithms to benefit both the developers and the users of those algorithms.

We also recognize that direct validation against high quality surface reference data such as rain gauges and radars may not be possible in many regions of the globe, and that alternative approaches such as physical error modelling may be required to characterize the errors in the physical algorithms.

Recommendation 1:
Provide baseline validation standards for satellite precipitation algorithm(s) in terms of the needs of users in NWP data assimilation, nowcasting, hydrology, climate, and algorithm development communities.

Actions:
- Define validation metrics for NWP – *E. Smith*
- Define validation metrics for nowcasting – *A. Thoss*
- Define validation metrics for hydrology – *W. Krajewski*
- Define validation metrics for climate – *W. Berg*

Recommendation 2:
Ensure that members of the NWP data assimilation, nowcasting, hydrology, climate communities are represented at future IPWG meetings.

Action:
- Deliver experts from user areas to next IPWG meeting - *V. Levizzani, A. Gruber*

Recommendation 3:
Monitor performance of operational precipitation algorithms on a large scale on a daily basis, preferably in connection with NWP forecast validation.

Action:
- Implement new, and enhance existing, cooperative agreements between agencies providing satellite precipitation estimates and those with surface reference data, to perform ongoing validation of the satellite rainfall products - *IPWG*

Recommendation 4:
Support alternative approaches to error estimation such as physical error modelling and cloud/system classification to obtain global error estimates.

2. Improvement of reference data sets used to validate precipitation estimates

We underline the necessity and importance of high quality reference datasets in being able to measure and characterize errors in the satellite precipitation estimates. Since no reference dataset is perfect, it is also necessary to understand the errors associated with the validation data itself.

For rain gauge networks, the errors include instrument error, undercatch due to wind effects, and sampling and representativeness errors. Radar observations provide indirect measurements of rainfall, and are affected by beamfilling, attenuation, noise, calibration error, anomalous propagation, bright band contamination, and conversion of reflectivity to rain rate. To measure the errors in spatial rain estimates from gauge and radar data it is necessary to compare against an extremely high density gauge network. Studies of this nature are underway and are expected to provide valuable information on the nature of the errors in the reference data.

There exist a number of good and high quality reference data sets, but they may be difficult to obtain in many cases. IPWG can play a role in making these data more widely available. As routine error characterization of some future rainfall missions (GPM in particular) will be based on international partnerships with "supersites", every effort should be made to make these data available to scientists.

Recommendation 1:
Create an inventory of existing high quality reference data.

Actions:
- Determine the location and availability of rain gauge and radar data from national networks, international experiments, the Global Precipitation Climatology Center (GPCC), and experimental test sites such as the Oklahoma Mesonet and TRMM validation sites. It will be necessary in most cases to provide justification, i.e., characterization of errors in satellite precipitation estimates. – *M. Morrissey, C. Simmer, A. Thoss, B. Ebert*
- Publish web links and contact information for obtaining these data on an IPWG web site. – *M. Morrissey*

Recommendation 2:
Encourage sharing of data from Intensive Observation Periods in large-scale experiments with the IPWG community, to enable improved validation of satellite rainfall estimates.

Action:
- IPWG members who are involved in such large-scale experiments as BALTEX, MAP, etc., should encourage the collectors of reference radar and gauge data to make these data available to the wider scientific community. – *IPWG*

Recommendation 3:
Perform and develop new methods for the error characterization of reference datasets.

Action:
- Continue to perform and develop new methods for error characterization of reference datasets - *M. Morrissey, W. Krajewski*

Recommendation 4:
Encourage the use of dual-gauge systems and optimal network design in operational rain gauge networks, to improve the reliability and quality of rainfall observations.

Action:

- Design criteria for improved rain gauge networks to address validation of remotely sensed rainfall estimates - *W. Krajewski*

Recommendation 5:
Investigate the quality and availability of surface reference networks for the validation of difficult (orographic, light, solid) precipitation.

Action:
- Investigate the possibility of obtaining precipitation measurements from Arctic and Antarctic networks - *C. Simmer, B. Ebert*

3. Communication

Good communication among members and working groups of the IPWG is essential to its ability to function effectively and efficiently.

Recommendation 1:
Ensure that good communication among members of the IPWG is developed and maintained.

Actions:
- Create and maintain a list server for IPWG and for the validation group - *D. Hinsman*
- Coordinate the activities of the Validation Group - *M. Morrissey, B. Ebert*
- Instigate a web forum linking groups doing validation - *B. Ebert*

Recommendation 2:
Develop an assessment software package, incorporating both basic and advanced techniques, to facilitate validation of satellite rainfall estimates by algorithm developers and users.

Action:
(This item was seen as a long-term goal for the Validation Group, and no near-term plans were discussed.)