CURRENT ACTIVITIES OF THE INTERNATIONAL PRECIPITATION WORKING GROUP (IPWG)

Joe Turk¹ and Peter Bauer² (IPWG Co-Chairpersons)

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http://www.isac.cnr.it/~ipwg
Endorsed during the 52nd session of the WMO Executive Council (June 2000)
WMO encouraged the Coordination Group for Meteorological Satellites (CGMS) to participate in the formation of the IPWG with active participation by WMO and GPCP

Endorsed by the CGMS 29th session (July 2001)

Precipitation “equivalent” of the longstanding ITWG (TOVS Working Group)

First Co-Chairs were Vincenzo Levizzani (CNR) and Arnold Gruber (NESDIS)
IPWG-1: September 2002, INM, Madrid, Spain

- Development of better measurements, and improvement of their utilization
- Improvement of scientific understanding
- Development of international partnerships
IPWG-2004: 25-28 October 2004, Monterey, California

19 countries represented

2 ½ days presentations
1 day working groups

Productive!

Workshop proceedings in press (email me for a copy)
turk@nrlmry.navy.mil
How far have we come?

• 25 Years Ago:
  - Oceanic climatologies; gauge-based analyses over land
  - Qualitative indices of tropical convection

• Now:
  - Time series of global gridded monthly, pentad precipitation ([GPCP](#), [CMAP](#))
  - Powerful new observations (TRMM, SSM/I, AMSR-E, AMSU-B, SSMI/S, high resolution geostationary)
  - New algorithms for high resolution products (CMORPH, PERSIANN, TRMM-RT, NRL, numerous others)
  - Improved gauge-based analyses over land; oceanic reconstruction

See Climate Research Data Center ([CRDC](#)) at CSU

(slide courtesy of Phil Arkin)
IPWG Research: Increasing Refresh and Coverage with Multi-Dataset Techniques

Multiple LEO (Microwave) Satellite Merging

\[ \sum \text{DMSP orbits} + \sum \text{Aqua (AMSR)} + \sum \text{TRMM (TMI+PR)} + \ldots \]

**Characteristics**

- Only a few obs per point per day
- Intermittently spaced in time
- Inter-sensor differences (resolution, calibration, algorithm)
- Open issues: high latitudes, snow, cold/variable surfaces, drizzle

3-hour
6-hour
12-hour
24-hour etc....
At mid-to-high latitudes, snowfall represents a substantial portion of the precipitation.

(Slide courtesy of Ralf Bennartz)

From higher latitudes at least 90% of the precipitation occurs at rates less than 3 mm/hr and 60% at less than 1 mm/h
IPWG/GPM/GRP Workshop on global microwave modeling and retrieval of snowfall

Date: 11-13 October 2005

Venue: Pyle Center
University of Wisconsin – Madison

Workshop Co-Organizers
Ralph Ferraro (NOAA/NESDIS)
Ralf Bennartz (University of Wisconsin)

Objective
The International Precipitation Working Group (IPWG), the GEWEX Radiation Panel (GRP) and NASA’s Global Precipitation Measurement Program (GPM) co-sponsor a workshop on passive microwave modeling and retrieval of snowfall. The aim of this workshop is to review the state of the art in passive microwave modeling and retrieval of falling snow over both land and ocean and to develop future directions and requirements for algorithm development, implementation and validation of applications ranging from short-term weather forecasting to climate data set generation.

Agenda
Draft agenda (posted: 28 April 2005)

Registration
Online registration form. Registration fee will be $200 US dollars.

Contact Information
CIMSS
IPWG Research: Increasing Refresh and Coverage with Multi-Dataset Techniques

LEO + GEO (High Refresh VIS/SW/LW) Satellite Merging

- GOES-10/12: 30-min ENH, 3-hr disk
- GOES-9 (MTSAT-1R): 1-hr disk
- MSG-1: 15-min disk (9 thermal bands)
- Meteo-5: 30-min disk

Characteristics
- Quantitative use of GEO
- Sequential use of GEO
- “In Microwave We Trust”
- TMI+PR only non-sun-synch PMW observation

Operational Geostationary Constellation

TRMM (TMI+PR)

Aqua (AMSR)

F-14 SSMI
Other IPWG Research: Data Assimilation

Presentations and Articles from IPWG-2004


Evaluation of RTTOVSCATT at AMSU Frequencies by Comparison to Observation and ARTS (Una O’Keeffe, UKMO)

Radiometer Channel Optimization for Precipitation Remote Sensing (Peter Bauer, Sabatino DiMichele, ECMWF)
IPWG Validation: Satellite Precipitation Algorithm Validation and Intercomparison Project

- Conducted by The International Precipitation Working Group (IPWG)
- Co-sponsored by the Global Precipitation Climatology Project (GPCP)

- Routine daily validation of several satellite precipitation algorithms against daily rain gauge analyses was begun in February 2003 at the Australian Bureau of Meteorology

- The NOAA Climate Prediction Center (CPC) began a similar validation of algorithms over the United States starting in May 2003, followed by a European validation in mid 2004

- Most of the algorithms currently being validated are "operational" or "semi-operational", meaning that they are run routinely in near-real time and their estimates are available to the public via the web or FTP

- Short-term rain forecasts from a small number of numerical weather prediction (NWP) models are also verified for comparison

Example Validation Product from the USA Validation

13Z 23Apr2005 thru 13Z 24Apr2005
Data on 0.25 deg grid (UNITS are mm/day)

<table>
<thead>
<tr>
<th></th>
<th>g-g</th>
<th>g-r</th>
<th>r-r</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of points</td>
<td>13323</td>
<td>13323</td>
<td>13323</td>
</tr>
<tr>
<td># points w/rain</td>
<td>6032</td>
<td>3651</td>
<td>3545</td>
</tr>
<tr>
<td>Mean rain rate</td>
<td>2.83</td>
<td>2.83</td>
<td>1.44</td>
</tr>
<tr>
<td>Caud. rain rate</td>
<td>7.23</td>
<td>5.87</td>
<td>5.51</td>
</tr>
<tr>
<td>Max. rain rate</td>
<td>64.63</td>
<td>51.20</td>
<td>42.23</td>
</tr>
</tbody>
</table>

- Correlation: 0.650, 0.736, 0.460
- Mean Absolute Error: 0.745, 1.092, 2.402
- RMSE (mm/day): 5.54, 4.21, 6.43
- RMSE (normalized): 1.99, 1.56, 4.45
- Probability of Detection: 0.594, 0.621, 0.630
- False Alarm Ratio: 0.247, 0.107, 0.439
- Bias Ratio (rainfall): 0.786, 0.696, 1.122
- Halpin Skill Score: 0.516, 0.622, 0.440
- Hansen-Kuipers Score: 0.486, 0.580, 0.467
- Equitable Threat Score: 0.343, 0.452, 0.289

- | g-g | g-r | r-r |
- | NRMSE | NRMSE |
- | < 1 | > 1 | < 1 | > 1 |
- | 0.39 | 0.39 |
- | < 1.12 | > 1.12 |
- | 1867 | 2863 |
- | > 1823 | 2886 |
Example Validation Product from the **EUROPEAN Validation**

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### Daily fraction by occurrence

<table>
<thead>
<tr>
<th>Est</th>
<th>Obs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Cumulative occurrences (common data)

### Daily fraction of total

<table>
<thead>
<tr>
<th>Est</th>
<th>Obs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Rainfall accumulation by amount

<table>
<thead>
<tr>
<th>Estimated Rain</th>
<th>Estimated &lt;1mm–1mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>3507</td>
<td>406</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Observed Rain</th>
<th>Zero</th>
<th>1mm–1mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>1926</td>
<td>2504</td>
<td></td>
</tr>
</tbody>
</table>

### POD, FAR, HSS scores

- **POD 0.565**
- **FAR 0.139**
- **HSS 0.293**

### Observed vs estimate metrics

- **Numbers of points:** 7199, 7199
- **Raining points:** 4432, 2907
- **Raining pts > 1mm:** 3219, 1938
- **Mean rain total:** 4.07, 2.26
- **Conditional rain total:** 6.61, 5.61
- **Maximum rain total:** 101.60, 74.20

### Performance metrics

- **Bias:** -1.81
- **Ratio:** 0.556
- **RMSE:** 8.2
- **Correlation:** 0.873
- **n:** 7199

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**3B40 vs radar 20050425**
Example Validation Product from the AUSTRALIAN Validation

CMORPH estimates for 20040930

Daily gauge analysis (land only) for 20040930

Verification statistics for 20040930  n=9835  Verif. grid=0.25°  Units=mm/d

<table>
<thead>
<tr>
<th></th>
<th>Analysed</th>
<th>CMORPH</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;1</td>
<td>6947</td>
<td>385</td>
</tr>
<tr>
<td>≥1</td>
<td>516</td>
<td>1987</td>
</tr>
</tbody>
</table>

- Mean abs error = 2.0
- RMS error = 5.5
- Correlation coeff = 0.724
- Frequency bias = 0.948
- Probability of detection = 0.794
- False alarm ratio = 0.182
- Harsen & Kulbers score = 0.741
- Equitable threat score = 0.608
The IPWG Satellite Precipitation Archive

Updated daily with 24-hour rainfall estimates from 16 operational and semi operational algorithms, as well as some NWP model forecasts, gauge and radar analyses

Encourage the validation and intercomparison of satellite precipitation estimates in additional regions of the globe using high quality and/or national rainfall reference data

IPWG is interested in the evaluation of these satellite precipitation estimates as input to weather, climate, hydrological, and agricultural models and other applications

Located at the Cooperative Institute for Climate Studies (CICS) at the University of Maryland (updated daily):
ftp://cics.umd.edu/pub/DATA/Validation

See also the IPWG Satellite Precipitation Archive web site:
Continental Australia including Tasmania
All Latitude Regimes    Jan 2003-Sept 2004

**Daily Correlation between Gauge Analysis and Estimates**

- **15 Satellite Algorithms**
  (blended PMW-IR, PMW-only, Multi-Precip, IR-only)

- **4 NWP Models**
  (AVN, ECMWF, NOGAPS, mesoLAPS)

- Wide variety in performance of satellite techniques
- NWP model performance is superior for winter season
- Similar performance in summer season
Continental Australia including Tasmania  
All Latitude Regimes  
Jan 2003-Sept 2004  

**Bias Score** between Gauge Analysis and Estimates

15 Satellite Algorithms  
(blended PMW-IR, PMW-only, Multi-Precip, IR-only)

4 NWP Models  
(AVN, ECMWF, NOGAPS, mesoLAPS)

Bias Score = (hits + false alarms)/(hits + misses)  
Range = 0 to infinity  
Indicates whether the system has a tendency to underforecast (**bias < 1**) or overforecast (**bias > 1**)
IPWG Validation Results So Far (Still Ongoing….)

No Ocean Validation

Microwave algorithms are expected to have better performance over ocean because emission signal is used.

Therefore microwave+IR algorithms should also perform better over ocean.

NWP QPFs perform better over land than over ocean since more observations used in model initialization.

Upcoming Snowfall Workshop!

IPWG/GPM/GRP Workshop on global microwave modeling and retrieval of snowfall 11-13 October 2005, UW-Madison (Organized by Ralf Bennartz)
Program for the Evaluation of High Resolution Precipitation Products (PEHRPP)

- Recommended by IPWG (Working Group of CGMS)

Process:
- Recruit participants; identify/collection necessary data
- Compare with dense gauge networks via Ebert, Janowiak, Kidd efforts
- Use CEOP time series to extend spatial coverage
- Apply coordinated diagnoses with other datasets, circulation data

Outcomes:
- Reach consensus on necessary development steps
- Recommend algorithm(s) to be used for IGWCP IPP
- Recommend actions by space agencies to provide data sets necessary to extend products back to early 1990s

Timeline:
- Initial discussions ongoing; side meeting during GEWEX Conference possible (25 June 2005 planning meeting at UC-Irvine)
- Data collection and analysis efforts: Jan 2005 – June 2006
- Concluding workshop: June or July 2006 during IPWG-2006
IPWG Validation Results So Far (Still Ongoing....)

1. Merging PMW & IR estimates (i.e., GEO and LEO satellites) provides more accurate estimates of precipitation than the separate components can.

2. Two major systematic biases are apparent in the satellite estimates:
   a. OVER-estimation over snow-covered regions
   b. OVER-estimation in semi-arid regions during the warm season

3. When merging PMW & IR data, more accurate results obtained when using IR to transport & morph precipitation than to use IR to estimate precipitation directly.

4. NWP forecasts generally outperform satellite estimates and radar during the winter season over the U.S.

5. Satellite estimates compare better with radar than gauge: point estimates vs. less-direct / spatially complete

   *gauges*  *radar*
Current (10-Satellite) LEO Satellite Constellation

Revisit Time

Color Codes:
SSMI
DMSP F-13/14/15
AMSR-E
Aqua
AMSU-B
NOAA-15/16/17
TMI
TRMM
Coriolis
Windsat
SSMIS
F-16

Revisit Scale: White = 0 hours  Black = 6+ hours (shaded boxes represent 15-minute coverage)
IPWG Research: Increasing Refresh and Coverage with Multi-Dataset Techniques

**LEO + GEO Satellite Merging - Examples**

**CMORPH (R. Joyce, J. Janowiak, P. Arkin)**

GEO-IR data are used as a means to *transport* the microwave-derived precipitation features during periods when microwave data are not available at a location. Propagation vector matrices are produced by computing spatial lag correlations on successive images of geostationary satellite IR which are then used to propagate the microwave derived precipitation estimates.

![CMORPH Precipitation Estimates](http://www.cpc.ncep.noaa.gov/products/janowiak/MW-precip_index.html)
NASA 3B42RT or MPA (George Huffman, Robert Adler)
This algorithm provides a combination of the TRMM real-time merged passive microwave (HQ; 3B40RT) and microwave-calibrated IR (VAR; 3B41RT). The current scheme is simple replacement - for each gridbox the HQ value is used if available, and otherwise the VAR value is used.

http://trmm.gsfc.nasa.gov (images and animations)
ftp://aeolus.nascom.nasa.gov/pub/merged/mergeIRMicro (data)
IPWG Research: Increasing Refresh and Coverage with Multi-Dataset Techniques

**LEO + GEO Satellite Merging - Examples**

**PERSIANN** *(Precipitation Estimation from Remotely Sensed Information using Artificial Neural Networks)* (Kuo-Lin Hsu)

This system uses neural network function classification/approximation procedures to compute an estimate of rainfall rate at each 0.25° x 0.25° pixel of the infrared brightness temperature image provided by geostationary satellites. An adaptive training feature facilitates updating of the network parameters whenever independent estimates of rainfall are available.

[Image of PERSIANN map]

IPWG Research: Increasing Refresh and Coverage with Multi-Dataset Techniques

**LEO + GEO Satellite Merging - Examples**

**NRL-Blend (Joe Turk)**
The NRL blended satellite technique is based upon area-dependent statistical relationships derived from a precise, near realtime ensemble of colocated passive microwave (PMW) and infrared (IR) pixels from any or all low Earth-orbiting (LEO) and geostationary satellites, respectively, as their individual orbits and sensor scan patterns continuously intersect in space and observation time.


**Orographic Adjustments and No-Rain Screening**

Final Blended Analysis  +  Global NWP  →  adjust upslope and downslope rain

identify moist low-level flow