4th INTERNATIONAL PRECIPITATION WORKING GROUP WORKSHOP

13-17 October 2008, Beijing, China

National Satellite Meteorological Center
Chinese Meteorological Administration
Fourth Workshop of the
International Precipitation Working Group
13-17 October 2008

Program Committee
Ralph Ferraro, NOAA/NESDIS, USA
Chris Kidd, The Univ. of Birmingham, UK
Joe Turk, NRL-Monterey, USA
Beth Ebert, BMRC, Australia
Song Yang, NOAA/NESDIS, USA
Fuzong Weng, NOAA/NESDIS, USA

Local Organizing Committee
Naimeng Lu, NSMC, China
Wang Yun, NSMC, China
Ran You, NSMC, China

IPWG Co-Chairs
Ralph Ferraro, NOAA/NESDIS and the Cooperative Institute for Climate Studies
Univ. of Maryland Research Park (M-Sq)
5825 University Research Court, Suite 4001
College Park, MD 20740-3823 USA
Ralph.R.Ferraro@noaa.gov

Chris Kidd, The University of Birmingham
School of Geography
Earth & Environmental Sciences
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Birmingham B15 2TT, United Kingdom
C.Kidd@bham.ac.uk
FOREWARD

It is with great pleasure to welcome you to the fourth meeting of the International Precipitation Working Group (IPWG) and to Beijing, China. The number of abstracts submitted was near 80, with approximately 70 attendees from nearly 20 nations registered for the meeting; this makes it the largest IPWG workshop to date.

As you recall, the purpose of the IPWG is, in the area of quantitative precipitation measurement, to foster the development of better measurements, and improvement of their utilization; improvement of scientific understanding, and development of international partnerships. In following these goals, three successful bi-annual workshops have been held beginning with Madrid, Spain (2002), followed by Monterey, California, USA (2004) and Melbourne, Australia (2006). Additionally, specialty workshops have been held on snowfall measurement and modelling (2005 and 2008) and the evaluation on high resolution precipitation products (2007).

The goals of this fourth workshop include:

- To learn about the status of current and future satellite missions focused on precipitation retrieval.
- To update the current status of operational and quasi–operational satellite-based estimates of precipitation for weather, hydrometeorological and climate applications.
- To analyze the open issues underlying precipitation retrievals, such as retrievals over complex terrain, light precipitation, and snowfall.
- To analyze the statistical performance of current satellite techniques over various seasons, rainfall regimes, and space-time scales.
- To develop strategies within IPWG in the areas of community consensus algorithms, radiative transfer, and cloud resolving models, as well as satellite calibration and inter-calibration.
- To report on the results of two recent IPWG sponsored workshops – the Pilot Evaluation of High Resolution Precipitation Products (PEHRPP) and the 2nd Workshop on Space-based Snowfall Measurement – and plan for follow on efforts.
- To develop key recommendations for short and long term activities for the CGMS agencies and the IPWG.

The meeting will include both oral and poster sessions on various topical issues, and two sessions of working groups to track action items established in Melbourne and to develop key recommendations on future issues. The working group areas include research, applications, validation and new technology/techniques.

We finally want to extend thanks to our hosts at the National Satellite Meteorological Center of China for their generosity and hospitality in addition to EUMETSAT and the World Meteorological Organization for funding and in-kind support to make this workshop possible.

Ralph Ferraro
Chris Kidd
Co-Chairs, IPWG
Agenda

Monday, October 13

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<td>930-950</td>
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<td>950-1010</td>
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<td>1030-1050</td>
<td>Maintaining the Operational use of Satellite Precipitation Data and Products - Challenges and Opportunities</td>
<td>W. Grabs</td>
<td>WMO/Switzerland</td>
<td>Fusang Wang</td>
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<td>1050-1110</td>
<td>The GPM Mission - Overview and Status</td>
<td>A. Hou</td>
<td>NASA/USA</td>
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<td>1110-1135</td>
<td>China's Microwave Sensor Developments</td>
<td>H. Yang</td>
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<td>1135-1200</td>
<td>Update on the status of precipitation products in the Eumetsat satellite application facility on hydrology and water management (H-SAF)</td>
<td>B. Bizzani</td>
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<td>1200-1230</td>
<td>LUNCH</td>
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<td>Vincenzo Levizzani</td>
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<td>1230-1345</td>
<td>Considerations for the blending of multiple precipitation data sets for hydrological applications</td>
<td>L. Ranzulli</td>
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<td>1345-1400</td>
<td>GMSnP Passive microwave precipitation retrieval algorithm: description and validation</td>
<td>K. Aomashi</td>
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<td>1415-1430</td>
<td>PEHRPP Workshop Summary and Results</td>
<td>M. Sapiano</td>
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<td>1430-1445</td>
<td>Charge to WG, logistics, etc</td>
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<td>1500-1700</td>
<td>Working Group Session 1 - Old Business &amp; Group Plenary</td>
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<td>1830</td>
<td>Reception at Hotel Nikko New Century</td>
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Fourth Workshop of the International Precipitation Working Group
13-17 October 2008

Agenda, Tuesday October

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<td>Quality indicators in an operational precipitation product</td>
<td>T. Henebrenna</td>
<td>EUMETSAT/Germany</td>
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<td>09:45-11:00</td>
<td>Improvement of cold season land precipitation rivaltices through the use of field campaign data and high frequency microwave radiative transfer model</td>
<td>N. Wang</td>
<td>Univ. of Maryland/USA</td>
<td>R. Ferraro</td>
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<td>11:00-12:15</td>
<td>An SSM/I - SSM/I Application for Climate Research - The extension of Hydrological Products Climate Records</td>
<td>D. Vila</td>
<td>Univ. of Maryland/USA</td>
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<td>12:15-13:30</td>
<td>A Kalman filter approach to blend various satellite rainfall estimates in CMORPH</td>
<td>R. Joyce</td>
<td>NOAA/USA</td>
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<td>13:30-14:45</td>
<td>Evaluating the utility of multi-spectral information for delineating the areal extent and intensity of precipitation</td>
<td>A. Beherangi</td>
<td>Univ. of California-Irvine/USA</td>
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<td>14:45-15:00</td>
<td>Observing precipitation with AMSU-B opaque channels: the 153-WL algorithm</td>
<td>V. Leuzzani</td>
<td>ISAC-CNR/Italy</td>
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<td>15:00-16:00</td>
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<td></td>
<td>16:00-17:30</td>
<td>Evaluating the impact of aerosols on the onset and microphysical properties of rainfall on the coast of China</td>
<td>W. Bieg</td>
<td>Colorado State Univ./USA</td>
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<td>17:30-19:00</td>
<td>Characteristics of precipitating and non-precipitating clouds in typhoon Ranan as viewed by TRMM combined measurements</td>
<td>Y. Fu</td>
<td>NSMC/China</td>
<td>Wolfgang Grabo</td>
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<td>19:00-21:00</td>
<td>Characteristic comparison of precipitation between TRUM PR measurements and rain gauge observations in mainland China</td>
<td>P. Liu</td>
<td>NSMC/China</td>
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<td></td>
<td>21:00-22:30</td>
<td>The role of remote sensing satellite data for rainfall forecasting in Indonesia</td>
<td>A. Sudradjo</td>
<td>Univ. of Maryland/USA; IT/Indonesia</td>
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<td>22:30-24:00</td>
<td>Validation and analysis of precipitation extremes in IMPA</td>
<td>G. Huffman</td>
<td>NASA/USA</td>
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<td>24:00-01:30</td>
<td>Operational estimation of accumulated precipitation using satellite observation by Eumetsat H-SAF</td>
<td>A. D. Diodato</td>
<td>IMAA-CNR/Italy</td>
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Session 2B - Poster Session

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<td>15:15-17:00</td>
<td>12:00-13:30</td>
<td>Evaluating the impact of aerosols on the onset and microphysical properties of rainfall on the coast of China</td>
<td>W. Bieg</td>
<td>A novel algorithm for rain rate retrieval using AMSU-B observations</td>
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<td>15:15-17:00</td>
<td>13:30-14:45</td>
<td>Characteristics of precipitating and non-precipitating clouds in typhoon Ranan as viewed by TRMM combined measurements</td>
<td>Y. Fu</td>
<td>On the statistical relationship between the optical and microphysical characteristics or warm topped clouds from AVHRR and the rainfall intensity derived from AMSU-B</td>
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<td>15:15-17:00</td>
<td>14:45-15:15</td>
<td>Characteristics of precipitating and non-precipitating clouds in typhoon Ranan as viewed by TRMM combined measurements</td>
<td>P. Liu</td>
<td>Finding breakpoints in precipitation series</td>
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<td>15:15-17:00</td>
<td>15:15-17:00</td>
<td>The role of remote sensing satellite data for rainfall forecasting in Indonesia</td>
<td>A. Sudradjo</td>
<td>Applicability of a correction method for real time flood forecasting based on satellite-based rainfall information</td>
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<td>15:15-17:00</td>
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<td>Validation and analysis of precipitation extremes in IMPA</td>
<td>G. Huffman</td>
<td>Environmental data records from SSM/I</td>
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<td>15:15-17:00</td>
<td>17:30-19:00</td>
<td>Operational estimation of accumulated precipitation using satellite observation by Eumetsat H-SAF</td>
<td>A. D. Diodato</td>
<td>Merging gauge observations and satellite estimates of daily precipitation over China</td>
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<td>15:15-17:00</td>
<td>19:00-21:00</td>
<td>The status of operational satellite precipitation products at NOAA/NESSIE</td>
<td>M. Zhao</td>
<td>The status of operational satellite precipitation products at NOAA/NESSIE</td>
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<td>15:15-17:00</td>
<td>21:00-23:00</td>
<td>Operational quantitative precipitation estimation using radar, gauge and satellite for hydro-meteorological applications in Southern Brazil</td>
<td>M. Caliceti</td>
<td>Operational quantitative precipitation estimation using radar, gauge and satellite for hydro-meteorological applications in Southern Brazil</td>
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<td>08:30 - 09:00</td>
<td>First results of validation and hydrological impact studies for Eumetstar H-SAF satellite precipitation products</td>
<td>B. Lapeta</td>
<td>IMWM/Poland</td>
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<td>09:00 - 09:30</td>
<td>Characteristics of High Resolution Precipitation Products over China in Summer</td>
<td>Y. Shen</td>
<td>CMA/China</td>
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<td>Session 3A - Validation</td>
<td>09:30 - 10:00</td>
<td>Intercomparison of CMORPH rainfall estimation with rain gauges over South America</td>
<td>A. Pereira</td>
<td>Univ. San Paolo/Brazil</td>
<td>Matt Sapiano</td>
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<td>10:00 - 10:30</td>
<td>Very high resolution precipitation frequency and rainfall estimates from TRMM applications and uncertainties</td>
<td>S. Neebet</td>
<td>Univ. of Illinois/USA</td>
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<td>10:30 - 11:00</td>
<td>Validation of satellite rainfall estimation in the summer monsoon dominated area of the Hindu Kush Himalayan region</td>
<td>S. Bajracharya</td>
<td>INGO/Nepal</td>
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<td>11:00 - 12:00</td>
<td>Validation of daily satellite rainfall estimates over South America</td>
<td>T. Dinku</td>
<td>IR/USA</td>
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<td>12:00 - 12:30</td>
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<td>Session 3B - Poster Session</td>
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<td>Song Yang</td>
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<td>13:15 - 13:30</td>
<td>Satellite data assimilation in cloudy and precipitation conditions</td>
<td>F. Weng</td>
<td>NOAA/USA</td>
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<td>13:30 - 14:00</td>
<td>Assimilation of rain and cloud affected microwave radiances at ECMWF</td>
<td>A. Geer</td>
<td>ECMWF/UK</td>
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<td>14:00 - 14:30</td>
<td>Testing of Cloud Microphysics Scheme with Snow Events</td>
<td>W. Tao</td>
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<td>14:30 - 15:00</td>
<td>Global precipitation analyses and reanalyses</td>
<td>P. Arkin</td>
<td>Univ. of Maryland/USA</td>
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<td>Session 3C - New Applications, Modeling and Topical Issues</td>
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<td>Song Yang</td>
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<td>Application of high-resolution multi-satellite precipitation real-time estimates for global hydrological disaster monitoring and prediction</td>
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<td>16:30 - 17:00</td>
<td>Working Group Session 2 - New Business</td>
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<td>Eito</td>
<td>The verification of the hydrometeor properties simulated by a cloud resolving model using passive microwave satellite and ground-based radar observations for rainfall systems associated with the Baiu front</td>
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<td>Fuchs</td>
<td>The Global Precipitation Climatology Centre (GPCC) - A contribution to climate monitoring and research in context of GCOS and WCRP</td>
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<td>Klepp</td>
<td>The HOAPS climatology on rain and snowfall validation over the oceans</td>
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<td>Knuth</td>
<td>Measuring precipitation in Antarctica</td>
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<td>Kubota</td>
<td>GMSaP validation activities of high resolution satellite-based precipitation products around Japan</td>
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<td>Kucera</td>
<td>Application of MEI for the validation of precipitation estimates</td>
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<td>Lu</td>
<td>A weighted fuzzy verification model</td>
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<td>Mech</td>
<td>General observation period 2007</td>
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<td>Nekhalivhe</td>
<td>Verification of 24-hour satellite-based rainfall estimates over South Africa</td>
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<td>Via</td>
<td>The South American Land Data Assimilation System (SALDAS): The rainfall retrieval methodology</td>
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<td>1045 - 1100</td>
<td>Summary of the Second International Workshop on Space-based Snowfall Measurement (WSSM)</td>
<td>G. Tripoli</td>
<td>Univ. of Wisconsin/USA</td>
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<td>1100 - 1115</td>
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<td>Applications of CloudSat light precipitation products</td>
<td>T. L'Ecuyer</td>
<td>Colorado State Univ/USA</td>
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<td>1115 - 1130</td>
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<td>HAMP - the microwave package on the upcoming high altitude and Long range aircraft HALO</td>
<td>M. Mech</td>
<td>Germany</td>
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<td>1130 - 1200</td>
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<td>Current scientific progress and future scientific prospects enabled by spaceborne precipitation measurements</td>
<td>E. Smith</td>
<td>NASA/USA</td>
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<tr>
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<td>Passive and active microwave remote sensing of cold-cloud precipitation</td>
<td>B. Johnson</td>
<td>NASA/USA</td>
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<td>SSM/I intersensor calibration and impact on precipitation trend</td>
<td>S. Yang</td>
<td>NOAA/USA</td>
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<td>Working Group Reports &amp; Discussion</td>
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<td>Kidd/Tonizzo</td>
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<td>1500-1700</td>
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<td>Final Plenary/Discuss/Wrap Up</td>
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### Friday, October 17

Outings to Forbidden City or Great wall with continued discussions on IPWG topics!
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<td>Adesi</td>
<td>Use of Satellite Precipitation data in Nigeria</td>
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ABSTRACTS WITH CONTACT INFORMATION
USE OF SATELLITE PRECIPITATION DATA IN NIGERIA

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ABSTRACT

The use of satellite precipitation data for forecast in Nigeria is greatly advancing, this is due to the availability of satellite imagery and measured real time rainfall data that can be used to validating the estimated amount of rainfall been derived from imagery captured by satellite of an area.

Rainfall data from rain gauge measurements have been used to validate the data of the Tropical Rainfall Measuring Mission Precipitation Radar (TRMM PR) and the data of two other satellite algorithms namely 3B43 and TMPI for 36 months (Jan1998-Dec2000) at 1.00x1.00 latitude/longitude grid boxes over Nigeria.

Between 1998 and 2000 we studied the interconnection between precipitation imageries captured over Nigeria and the amount of Rainfall measured. We noted that there is critical connection between the Thermodynamic properties over the surface, the estimated amount of rainfall from a particular captured imagery and measured rainfall data. Therefore proper understanding of the satellite precipitation imagery will enable forecasters in Nigeria to forecast the amount of precipitation from a particular type of imagery for flood and disaster monitoring. More practical issues will be presented.

Flood disaster related event has claimed million of lives, make thousand homeless and devastated more million arable land in Africa.
This paper describes the Global Satellite Mapping of Precipitation project (GSMaP) passive microwave precipitation retrieval algorithm using the precipitation-related variable models and the retrieval methods based on the TRMM observation studies. This paper also reports its validation results using precipitation retrievals from the TRMM Microwave Imager (TMI) brightness temperatures (TBs) and the Precipitation Radar (PR) precipitation rates.

Our algorithm employs Polarization Corrected Temperature (PCT) at 37 and 85 GHz (PCT37, PCT85) over land and coast, TBs with vertical polarization at 10, 19, and 37 GHz (TB10v, TB19V, and TB37v) in addition to PCT37 and PCT85 over ocean. In the forward calculation to calculate look-up tables (LUTs) between TBs and precipitation rates, we adopted the following convective and stratiform precipitation models for the precipitation-related variables:

a) TRMM PR precipitation profiles averaged for the statistically classified precipitation types (Takayabu 2006);

b) The gamma distribution for rain particle size distribution (Kozu et al. 2006);

c) The particle size distribution and refractivity parameterization for mixed-phase stratiform precipitation (Nishituji et al. 1983).

The forward calculation part incorporated the above models into the Radiative Transfer Model (RTM) of Liu (1998) to obtain convective and stratiform LUTs for various inhomogeneities. The weighted averages of the convective and stratiform LUTs were used in the retrieval part of our algorithm. The retrieval part consists of the following procedures:

a) Detection of precipitating areas over land (Seto et al. 2005), coast (Kubota et al. 2007), and ocean (Kida et al. 2008);

b) Estimation of precipitation inhomogeneity using PCT85 (Kubota et al. 2008);

c) Precipitation retrieval using the scattering signals of PCT37 and PCT85;

d) Precipitation retrieval using the emission signals of TB10v, TB19v and TB37v over ocean.

In order to validate our algorithm, we compared its retrievals from TMI with the PR precipitation rates for some Baiu cases and global precipitation distribution in 1998. The results show:

1) The over-land and over-coast retrievals agreed better with PR than the retrievals only using PCT85, while the correlation degraded for precipitation heavier than 10 mm hr⁻¹. The over-land and over-coast retrievals underestimated PR precipitation rates for precipitation heavier than 10 mm hr⁻¹. These errors were caused by the problems in the forward calculation of scattering signals at the high frequencies. In order to alleviate this, we need to improve the precipitation-related variable models and RTM program for frozen precipitation.

2) The over-ocean retrievals agreed well with PR, in spite of slight overestimation of precipitation weaker than 10 mm hr⁻¹. This can be due to the neglect of the slant-path effect.

3) Our algorithm overlooked some weak precipitation areas over sub-tropical oceans. This arose from the forward calculation of emission signals. In order to improve the over-ocean precipitation detection method, we need to give more realistic humidity and CLWC for shallow precipitation regions.
GLOBAL PRECIPITATION ANALYSES AND REANALYSES

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ABSTRACT

Variability in precipitation exhibits large-scale coherence on a broad range of spatial and temporal scales. Adequate understanding of the causes and consequences of these variations on continental to global scales requires consistent descriptions, in the form of time series of values on a regular grid, or analyses, of precipitation over the entire globe, including the oceans. Such analyses are essential to determining future water resource and water supply requirements. Since no single source of information can provide us with the accuracy and coverage required to provide such analyses, we and others have developed methods to combine information from a variety of sources and to construct time series of gridded fields of precipitation for a number of time periods, scales and domains. In this presentation, I will discuss the various sources of information and methods used to create global analyses of precipitation and to extend the analyses to cover the period since 1900. Variability in precipitation on regional and global scales as depicted in these data sets will be discussed.
Valiation of Satellite rainfall estimation in the summer monsoon dominated area of the Hindu Kush Himalayan Region

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Weather events like intensive rainfall causing floods and flash floods result into loss of lives and properties whereas prolong drought can cause decline in agriculture production and loss of vegetation cover. Rainfall affects the lives and economies of majority of people where the populations are dependent on rain water for agriculture. With the existence of large unpopulated rugged terrain with limited number of observation hydro-meteorological stations, accurate rainfall estimation is a challenging task and the spatial distribution of the rain gauge is not sufficient to provide a detail outlook on highly temporal and spatial variable nature of rainfall that may be needed for applied stream flow modeling technique.

In the present paper, the estimated 24 hours rainfall product developed by National Oceanic and Atmospheric Administration (NOAA) in a South Asian domain was validated with the observed rain gauge data on a daily basis for the monsoon period of 2002 to 2004. The result shows maximum negative bias and root mean square error (RMSE) in the heavy rainy days and Satellite Rainfall Estimation (SRE) overestimates the rain before monsoon and in rain shadow area. Qualitatively rainfall events in general match but quantitatively SRE and observed rain gauge product are vast difference. The study provides important input for the improvement of the SRE development algorithms. Further, incorporation of orographic effect in the algorithm is felt necessary before it should be implemented to the stream flow model for flood forecasting.

Key Words: Satellite Rainfall Estimation, flood forecasting, monsoon, validation
Evaluating the Utility of Multi-Spectral Information for Delineating the Areal Extent and Intensity of Precipitation

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Data from Geosynchronous Earth Orbiting (GEO) satellites equipped with visible and Infra-Red (IR) imagers are commonly used for rain retrieval due to the high spatial and temporal resolution of GEO observations, despite the lower quality compared to passive microwave observations from Low Earth Orbiting (LEO) satellites. Although GEO-based precipitation retrieval algorithms have begun to use data from spectral bands other than the longwave IR window, the potential benefit of these additional bands for precipitation retrievals has not yet been fully quantified. Here, we present a Neural Network-based framework to evaluate the utility of multi-spectral information in improving both rain/no-rain detection and rain rate estimation. The proposed algorithm consists of three stages. The first training stage involves feature selection and, if necessary, spectral dimension compression of multi-spectral images using the principal component analysis technique. The second training stage uses a feature classification scheme based on the self-organizing feature map and probability matching method against coincident LEO passive microwave precipitation estimates, resulting in rain probability and intensity estimates for each multi-spectral class. In the final stage, the trained neural network is applied to all of the GEO data to detect the occurrence of rain and estimate rain rate.

Multi-spectral images from the current-generation GOES Imager and the Spinning Enhanced Visible and Infrared Imager (SEVIRI) instrument of Meteosat Second Generation satellites were used for this experiment. Since SEVIRI and future GOES-R Advanced Baseline Imager possess many common spectral channels, the capabilities demonstrated using SEVIRI image channels should be representative of expected GOES-R performance.

Detailed examination of case studies in addition to overall statistics indicates that multi-spectral data are beneficial for screening out no-rain pixels associated with cold thin clouds, and identifying rain areas under warm, but rainy clouds. Both situations are problematic for IR-only algorithms. Overall, the improvement is significant for delineating the areal extent of precipitation (about 50%) and less so for estimating precipitation intensity (about 20%). Thus, multi-spectral data are found to promise improvements for precipitation retrievals from GEO platforms.
Evaluating the impact of aerosols on the onset and microphysical properties of rainfall off the coast of China

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Differences in satellite rainfall estimates from the Tropical Rainfall Measuring Mission’s (TRMM) precipitation radar (PR) and microwave imager (TMI) provide compelling evidence for the large-scale modification of precipitating clouds by aerosols off the coast of China. The role of aerosols in modifying cloud properties over this region is examined using a combination of satellite observations from TRMM and CloudSat along with cloud resolving model (CRM) simulations. Coincident TRMM/CloudSat observations for a case from 3 April 2007 show striking differences in both rain area and rainfall intensity from the TMI, PR, and CloudSat retrievals. Observations from the 94-GHz CloudSat radar, which is highly sensitive to the onset of rain, confirm the presence of widespread light rain/drizzle containing relatively small drops below the ~17 dBZ PR detection threshold. For pixels with reflectivities above the PR detection threshold, large differences are present in the satellite rain intensity estimates, which are consistent with either a decrease in the mean drop size, an increase in ratio of cloud water to rain water, or both. Idealized cloud resolving model (CRM) simulations initialized for the 3 April 2007 case are generally consistent with the observations indicating high aerosol concentrations leading to an overall increase in the ratio of cloud water to rain water for developed systems, as well as a delay in the onset of warm rain. Based on the combination of observations and CRM simulations, it is hypothesized that the observed satellite rainfall differences may be due to an increase in the ratio of cloud water to rain water leading to an overestimate in rain intensity by the CloudSat/TMI retrievals and/or a decrease in the mean drop size leading to an underestimate by the PR retrieval.
UPDATE ON THE STATUS OF PRECIPITATION PRODUCTS IN THE EUMETSAT SATELLITE APPLICATION FACILITY ON HYDROLOGY AND WATER MANAGEMENT (H-SAF).

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ABSTRACT

The “EUMETSAT Satellite Application Facility on support to Operational Hydrology and Water Management” (H-SAF) has been established by the EUMETSAT Council on 3rd July 2005 and started activity at the official date of 1st September 2005. IPWG was kept abreast of the project evolution.

The Project Plan is focused on the generation of products such as:
- precipitation rate and accumulated precipitation, including liquid/solid discrimination;
- soil moisture in the surface layer and possibly in the roots region;
- snow parameters such as effective cover, wet/dry discrimination and water equivalent.

The project implies, in addition to products development and generation, also a products validation programme and a hydrological validation programme. The development programme duration is 5 years, ending on 31 August 2010. If successful, it will be followed by a “Continuous Operations-Development Programme (CDOP)”. In order to provide sufficient time for product validation, and for hydrologists to assess the impact of the products in applied hydrology, a first version of products has been released and made routinely available on the web whereas, in parallel, improved versions are in preparation. As precipitation is concerned, the following 5 products are routinely made available:

- PR-OBS-1 - Precipitation rate at ground by MW conical scanners (with indication of phase)
- PR-OBS-2 - Precipitation rate at ground by MW cross-track scanners (with indication of phase)
- PR-OBS-3 - Precipitation rate at ground by GEO/IR supported by LEO/MW
- PR-OBS-5 - Accumulated precipitation at ground by blended MW and IR
- PR-ASS-1 - Instantaneous and accumulated precipitation at ground computed by a NWP model

and a 6th is being developed:
- PR-OBS-4 - Precipitation rate at ground by LEO/MW supported by GEO/IR (with flag for phase).

Whilst products continue to be developed or improved, major focus is now on product validation. Data are available in a pre-operational fashion, within a delay of few minutes to few hours from observation, depending on satellite data access. Access is limited to beta-users participating to either the product or the hydrological validation activities.

IPWG members are entitled to access H-SAF data for validation purposes.
STATUS OF THE PROPOSAL FOR AN IGEOLAB GEO-MICROWAVE MISSION

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ABSTRACT

The case for frequent observation of precipitation from Space by using millimetre-submillimetre wavelengths from geostationary satellites was discussed since long, i.a. in the framework of IPWG, and was considered as one of the first tests of the concept of an International Geostationary Laboratory (IGeoLab), introduced at CGMS-32 in 2004. Since then, a Focus Group has been working in establishing requirements, analysing technical solutions and making progress with scientific assessment of the basic principles and the utilisation methods. Some progress was also made with collecting experimental evidence, though this remains a gap to be filled.

On the way of implementing a demonstration project, several attempts have been made, but till recently the big R&D space agencies have rather focused on advanced technological developments than on establishing a finalised implementation programme.

The situation has changed when China focused on planning for the development of the next generation of geostationary meteorological satellites, FY-4. The idea is to split the mission over two series, FY-4 “O” for optical observations and FY-4 “M” for microwaves. The target date for the prototype FY-4M is 2015.

The opportunity for implementing the FY-4M mission in the framework of IGeoLab was identified at CGMS-34 in 2006. WMO and CMA were tasked to explore convergence. The 4th meeting of the GEO-Microwave Focus Group was held in Beijing in April 2007, and reviewed requirements, technical solutions and scientific aspects. In the following months the FG faced the basic technological options and provided advise. CGMS-35 in 2007 took note of progress and tasked WMO and CMA to write a Proposal to be presented at CGMS-36 (2-7 November 2008).

The Proposal is undertaking completion. It includes consideration of:
- Requirements for frequent observation of precipitating clouds
- Background on satellite microwave radiometry
- Mission requirements for the geostationary orbit
- Scientific aspects
- Mission concepts
- System requirements
- Identification of mission elements for IGeoLab purposes
- The scientific programme
- Statement of Work for the Phase A study (assumed to start 1st January 2009).

The final meeting of the Focus Group (FG-5) is taking place in association with the 4th IPWG workshop, so as to favour IPWG / IGeoLab cooperation on the scientific issues. If the Proposal is successful with CGMS-36, the leadership of IGeoLab GEO-Microwave will be taken over by China and the Focus Group will be disbanded.
Operational quantitative precipitation estimation using radar, gauge and satellite for hydrometeorological applications at Southern Brazil

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This work shows the development and implementation of improved methodologies to Quantitative Precipitation Estimation (QPE) merging radar, rain gauges and satellite data that has been using at Southern Brazil. The integration of rain estimates has been used for hydrometeorological and agrometeorological applications. First, for flood prediction the integration of QPE was used to supply hydrological models (Sacramento and TopModel) for Iguacu River (Parana State, Brazil), a middle complex terrain basin and São Paulo city, a big urban watershed. Second, we start the using of accumulations of QPF into a system of extreme floods alert for urban areas. In this case, the QPE is used to calculate the effective precipitation (PE) over terrain complex areas. So, the system could automatically decide if the problem is the great accumulation or great intensities of precipitation for each area and would be alert the meteorologist of the floods, landslides and other natural disasters. Also, we validated, for Parana State, the rainfall estimates from CMORPH, NRLB, TRMM, PERSIANN and CST techniques. The best results of rainfall estimates are obtained by CMORPH technique for monthly analysis and CMORPH and TRMM for daily analysis. There is a spatially difference of the error. In eastern areas (land near coasts of Atlantic Ocean) the error is greater than inland regions. The hypothesis of this results is that warm clouds produces great precipitation accumulations due the high efficiency of the precipitation.
Evaluation and Development of Cumulus Parameterization in the GISS GCM using Satellite Precipitation Data

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Abstract

Moist convection remains one of the largest sources of uncertainty in GCM predictions of future climate change. The GISS GCM's tropical atmospheric response to El Niño is found to be too weak compared to observations including TRMM precipitation and diabatic heating anomalies. This is mainly due to the model's lack of upper-level stratiform anvil heating and excessive low-level heating, a consequence of underestimates of stratiform rain fraction and downdraft cooling. Our study suggests that parameterizations of mesoscale updrafts, convective downdrafts and cumulus-scale pressure gradient effects on momentum transport are keys to simulating reasonable tropical interannual variability. The implementation and impacts of such changes are evaluated using TRMM and other satellite data and the WRF model. The precipitation patterns over tropical ocean and land are significantly improved in the new version of the model though the intensity remains too strong. Distributions of deep and shallow convection and the diabatic heating profile are also more realistic. Tropical responses to ENSO are now better simulated in the model in precipitation, stratiform rainfall fraction, diabatic heating, tropospheric temperature and large-scale vertical velocity. Cumulus updraft speed differences in WRF during weak and strong convection are captured by the SCM except at high altitude.
Operational Estimation of Accumulated Precipitation using Satellite Observation, by Eumetsat Satellite Application facility in Support to Hydrology (H-SAF Consortium)


Satellite Application Facilities (SAFs) are specialised development and processing centres of the EUMETSAT Distributed Ground Segment. SAFs process level 1b data from meteorological satellites (geostationary and polar ones) in conjunction with all other relevant sources of data and appropriate models to generate services and level 2 products. Each SAF is a consortium of EUMETSAT European partners lead by a host institute responsible for the management of the complete SAF project. The Meteorological Service of Italian Air Force is the host Institute for the Satellite Application Facility on Support to Operational Hydrology and Water Management (H-SAF). HSAF has the commitment to develop and to provide, operationally after 2010, products regarding precipitation, soil moisture and snow. HSAF is going to provide information on error structure of its products and validation of the products via their impacts into Hydrological models. To that purpose it has been structured a specific subgroups. Accumulated precipitation is computed by temporal integration of the instantaneous rain rate achieved by the blended LEO/MW and GEO/IR precipitation rate products generated by Rapid Update method available every 15 minutes. The algorithm provides four outputs, consisting in accumulated precipitation in 3, 6, 12 and 24 hours, delivered every 3 hours at the synoptic hours. These outputs are our precipitation background fields. Satellite estimates can cover most of the globe, however, they suffer from errors due to lack of a direct relationship between observation parameters and precipitation, the poor sampling and algorithm imperfections. For this reason the 3 hours accumulated precipitation is compared by climatic thresholds got, basically, by the project “Climate Atlas of Europe” led by Meteo France inside the project ECSN (European Climate Support Network) of EUMETNET. To reduce the bias errors introduced by satellite estimates the rain gauge data are used to make an intercalibration with the satellite estimates, using information achieved by GTS network. Precipitation increments are estimated at each observation location from the observation and the interpolated background field. A field of the increments is carried out by standard Kriging method. The final precipitation analysis is achieved by the sum of the increments and the precipitation estimation at each grid points. The next step is to introduce a DEM model during the spatial interpolation in order to take in account the orography and the use of quantitative precipitation forecast (QPF) got by numerical weather prediction model to improve the algorithm where the density of observations is low. Taking advantage of the activity of the HSAF cal/val group (**) some algorithm validation outcomes versus fine ground networks observations and impact evaluation on hydrological model output over selected basins are reported and commented.

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A novel algorithm for rain rate retrieval using AMSU-B observations

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A new algorithm is presented for the detection and estimation of rainfall based on observations made by the US Advanced Microwave Sounding Unit-B (AMSU-B) on the National Oceanic and Atmospheric Administration (NOAA) satellites. The advantages of using satellite-borne passive microwave sensors for rain rate retrieval have been well demonstrated in the literature. Observations at different microwave frequencies, in fact, have proved to provide very useful information on the amount and type of precipitation, as well as on other hydrological parameters. Still, there is a need for a more accurate and faster rainfall retrieval to be used for operational data assimilation and real-time applications. The aim of the present work is to improve the current state of rainfall estimation by proposing a procedure based entirely on AMSU-B radiances. The proposed technique does not require ancillary data nor the integration of additional sensors which could deteriorate the overall spatial and temporal resolution. It exploits both the radiometric observations made at 89 and 150 GHz (window channels) and the ones made in the 183 GHz water vapour band (opaque channels). AMSU-B high frequency channels show a good ability in resolving precipitation signature also in the case of widespread stratiform precipitations. Moreover, opaque channels can sense precipitation over land without strong emissivity effects. In particular, the differences between the measurements of some of the AMSU-B channels are analysed for the estimation of precipitation over both land and water surfaces and are related to rain rate values. The latter is based on the assumption that the radiometric channels respond to precipitation scenes differently than they respond to clear scenes. Furthermore, radiative transfer code simulations are used to fit a regression between brightness temperature differences and rain rates in various scenarios.

Some case studies are presented and validated against land-based radar measurements and on different surface types, including snow cover. Good agreement with the radar observations proves the validity of the new technique, which additionally possesses various positive features: it is fast to operate, does not require the integration of any further instrument than AMSU-B, and provides rain rate estimates with a good spatial and temporal resolution.
Validation of daily satellite rainfall estimates over South America

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ABSTRACT

A dense station network of over 400 gauges over Columbia is used to evaluate six different satellite rainfall estimates at daily time scale and 0.25° spatial resolution. This region of South America has a very complex topography and associated high spatial variability of rainfall. The topography varies from sea level to over 3000 meter, while the mean annual rainfall varies under 500 mm over the northwestern part of the country to over 11000 mm over parts of the southeast. It would be very interesting to see how the different products would perform particularly over the exceptionally wet areas. The availability of relatively dense station network over this region has made this analysis possible. The evaluated satellite rainfall products are TRMM-3B42, TRMM-3B42RT, GSMaP, CMORPH, PERSIANN, and the Naval Research Laboratory’s blended product. Preliminary results show that the correlation coefficients between gauge measurements and the satellite estimates are between 0.36 and 0.48. The probability of detection is about 70% with low false alarm rates. The HSS statistic is relatively high, particularly for TRMM-3B42 (0.47) and TRMM-3B42RT (0.46). These results are encouraging considering the complexity of the terrain and associated high spatial variability of rainfall.
Evaluation of High-Resolution Satellite Rainfall Products
Over Regions Frequented by Desert Locusts

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The Desert Locust Information Service (DLIS) of the UN Food and Agriculture Organization (FAO) provides a decisions support system for monitoring the desert locust. The region of interest covers desert areas from northwestern Africa to East Asia. Rainfall data is one of the main inputs to DLIS. And satellite rainfall estimates are the only source of rainfall information over the remote areas. However, the accuracy of the satellite rainfall estimates over these regions is not well known. The current investigation has been performed with the request of FAO, who has provided the gauge data.

The study area covers the region between 15°W to 55°E, and 10°N to 35°N. FAO provided data from 1992 to 2006, which are over 30 thousand observations. The current evaluation uses data from 2003 to 2006. Most of the data are removed owing to uncertainties in time/location of some of the observations. Still over 19 thousand observations were used for this analysis. The evaluated satellite rainfall products are the NOAA-CPC African rainfall estimation algorithm (RFE), TRMM-3B42, and the CPC morphing technique (CMORPH). The gauge-satellite comparisons are done for daily accumulations at quarter-degree spatial resolution. The results show that the performance of the satellite products is very poor over most of study region. The main problem is that the satellite estimates significantly overestimate the occurrence of rainfall with false alarm ratio as high as 90%.
The verification of the hydrometeor properties simulated by a cloud resolving model using passive microwave satellite and ground-based radar observations for rainfall systems associated with Baiu front

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Global Precipitation Measurement (GPM) is proposed for passive microwave precipitation retrieval to measure precipitation in the middle and high latitudes. Microwave radiative transfer in precipitation clouds observed in the middle and high latitudes depends on various physical properties of the solid precipitation particles; however, they are not well understood due to lack of their observations. Cloud Resolving Models (CRMs) with complicated cloud microphysical parameterization forecast various cloud microphysical variables with high resolution in time and space; therefore, the information from CRM for physical properties of the solid precipitation particles is probably useful to improve the accuracy of microwave solid precipitation retrieval. However, cloud microphysical validation of CRMs has not sufficiently been carried out.

This paper compares satellite microwave radiometer and ground-based radar observations with the CRM simulations, using the two-moment 3 ice bulk microphysical parameterization, for rainfall systems associated with Baiu front around Okinawa Islands, Japan on 8 June 2004. The CRM used in this study is the Japan Meteorological Agency nonhydrostatic model (JMA-NHM: Saito et al., 2006). The JMA-NHM correctly replicated the shape, location and intensity of precipitation associated with observed rainfall systems. Radar reflectivities and brightness temperatures (TBs) were estimated using outputs derived from the JMA-NHM simulations, which were compared to the timely corresponding the National Institute of Information and Communications Technology (NICT) Okinawa Bistatic Polariometric Radar (COBRA) and the Advanced Microwave Scanning Radiometer for EOS (AMSR-E) observations, respectively. An almost good agreement is obtained between the simulated and observed reflectivities and TBs in the liquid phase under the melting layer; however, the intensity of scattering in the simulations was stronger than that in the observations above the melting layer. This is caused that JMA-NHM overestimated an amount of snow particles thorouhg the large depositional growth. The excessive snow contents were reduced by some microphysical process adjustments of JMA-NHM such as larger snowfall speed and changed riming threshold for snow to graupel conversion. Both adjustments had the positive impact on the reduction of snow amount, resulting in further agreement with the COBRA and AMSR-E observations.
Abstract

The precipitation type of “others” defined by Tropical Rainfall Measuring Mission (TRMM) Precipitation Radar in the product 2A25 has been neglected. So it's unknown what their physical significances are. Based on case analysis and statistics analysis, the precipitation type of “others” in summer Asia of the last ten years was investigated. Results indicate that cumulonimbus incus samples accounts for 70% in the “others”. Statistically, the occurring frequency of cumulonimbus incuses ranges 0.1% ~ 0.4% in summer Asia during last ten years. That is about one-tenth of convective precipitation frequency in summer Asia. Results also show higher frequencies of cumulonimbus incus over land than that over ocean. Generally, the averaged thickness of cumulonimbus incus is about 3~4km, and its bottom is located at 6km altitude.

Key words: TRMM PR, Precipitation profile, Cumulonimbus Incus,
Characteristics of Precipitating and Non-Precipitating Clouds in Typhoon Ranan as Viewed by TRMM Combined Measurements

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Abstract

In this paper, characteristics of infrared temperatures, microwave brightness temperatures, cloud ice/liquid water, rain water and latent heat for precipitating and non-precipitating clouds in Typhoon Ranan occurred in the northwest Pacific Ocean in August 2004 is studied by matching and unifying TRMM PR, TMI and VIRS combining measurements. Statistics shows 79%, 10.6 % and 10.4 % precipitating pixels for higher top (TB_{10.8} \leq 230K), moderate top (250K < TB_{10.8} \leq 270K ) and lower top (295K < TB_{10.8} ) precipitating clouds, respectively, contrary to 34.1 %, 16.7 % and 45.5 % for the three kinds of non-precipitating clouds, respectively. Results indicate much large size cloud droplets existing among precipitating clouds contrary to the wide spectrum of cloud droplet size in non-precipitating clouds based on the relationship of both 10.8\mu m and 12.0\mu m channels. The relationship between TMI 19.4 GHz and 85 GHz shows proportional variations of cloud ice water and cloud liquid water in higher top precipitating clouds, only varies of cloud liquid water in moderate and lower top precipitating clouds. While an inverse proportion between cloud ice water and cloud liquid water is unfolded for the three kinds of non-precipitating clouds. Latent heat profiles display heating proposes occurring above 3km and maximum at 4.5km in higher top precipitating clouds. Investigations also find a jumping increase of cloud ice water, cloud liquid water and rainfall in the center of depression in the moment before the typhoon hatches out, which may imply a latent heat stimulating function in the initial stage of typhoon processes. Analysis on latent heat and ice water profiles shows unreasonable vertical structures of hydrometeor in the moderate and lower top precipitating and non-precipitating clouds possibly caused by no considering cloud top as their profiles retrieved by TMI microwave brightness temperatures in the model.
Characteristics of Convective and Stratiform Precipitation at Seasonal Scale in Asia Based on Measurements by Precipitation Radar Onboard TRMM Satellite

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In this paper, the precipitation frequency, intensity and vertical structure of convective and stratiform precipitation at seasonal scale in Asia are investigated based on measurements by TRMM Precipitation Radar (PR) in the latest ten years from 1998 to 2007. Results indicate the nearly band distribution of seasonal mean precipitation with rain rate no more than 10 mm/d in East Asia around the subtropical anticyclone in the western Pacific Ocean in Spring, Autumn and Winter. However, heavy rain areas of more than 12 mm/d occur in the spread Asian summer monsoon precipitation region from the Bay of Bengal, Southwestern China, Eastern China to Japan during summer. Generally, rain intensity of both convective and stratiform precipitation is weaker over land than over ocean. It is the mountain forcing effect in Asia that produces windward heavy rain bands with a scale about one thousand kilometers while weaker precipitation usually accompanies with the leeward region. It is found that such mountain forcing only generates a large frequency of convective and stratiform precipitation. Results also show a convective precipitation frequency less than 3% distributed in the most parts of Asia. For stratiform precipitation, however, its frequency exceeds 3% with a maximum about 10% in Asia. The distribution of the precipitation frequency for both convective and stratiform precipitation in Asia also displays higher percentages in tropics southward and southwestward away from subtropical anticyclone than in mid-latitude region situated northward and northwestward from subtropical anticyclone. Furthermore, convective precipitation frequencies in spring announce much more convective activities occurring in the Indochina Peninsula, southern China and South China Sea than in the Indian subcontinent, which conforms that the onset of East Asian monsoon is earlier than that of Indian monsoon, while the decay originates from the mainland of China. The seasonal variability of precipitation profiles for both convective and stratiform precipitation is mostly demonstrated by the changes of the storm top height, i.e. the depth variations of precipitating clouds, which shows stronger variability in the extratropical regions than in tropics, stronger over land than over ocean in the same latitude, stronger in the Bay of Bengal than South China Sea. There are almost no such variability in South China Sea and the warm pool in the western Pacific Ocean. Results also expose four and three layers in the vertical direction according to distributions of rain rates for convective and stratiform precipitation, respectively.

Key Words: Convective precipitation, Stratiform precipitation, Precipitation frequency, Precipitation Intensity, Precipitation profile
The Global Precipitation Climatology Centre (GPCC) - A contribution to climate monitoring and research in context of GCOS and WCRP

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Summary
The Global Precipitation Climatology Centre (GPCC) provides global monthly precipitation analyses for monitoring and research of the earth’s climate. The centre is a German contribution to the World Climate Research Programme (WCRP), to the Global Climate Observing System (GCOS), and to the Global Earth Observation System of Systems (GEOSS). Its data base comprises monthly precipitation totals from more than 70 000 different stations in the world. GPCC produces gridded data sets of monthly precipitation on the earth’s land surface derived from raingauge based observation data. Intensive quality control of observation data and station metadata ensures a high analysis quality. The different GPCC products are adjusted to different user needs. GPCC routinely produces 2 near real-time precipitation monitoring products. 2 non real-time GPCC products are updated at irregular time intervals after significant updates of its full database, which is the largest monthly precipitation station database of the world. GPCC recently published a new global precipitation climatology as well as a reanalysis of its full database for all months of the period 1901-2007. It contributes to water resources assessments, flood and drought monitoring, climate variability and trend analyses. All GPCC products can be visualised and accessed free of charge via Internet from http://gpcc.dwd.de.

The GPCC First Guess Product of the monthly precipitation anomaly is based on synoptic weather reports (SYNOP) from about 6,000 stations worldwide received near real-time via the WMO Global Telecommunication System (GTS). The product is available within 5 days after end of an observation month. Main application purpose is near real-time drought monitoring. The product uses since mid 2008 the new GPCC monthly precipitation climatology as analysis background. Spatial product resolution: 1.0° and 2.5°.

The GPCC Monitoring Product of monthly precipitation is based on SYNOP and monthly CLIMAT reports received near real-time via GTS from about 7,500 stations. It is available within about 2 months after end of an observation month. The analyses are based on automatic and manual quality-control (QC) of input data and related station metadata. The GPCC Monitoring Product is the in situ component to the satellite-raingauge combined precipitation analyses of GPCP and CMAP. It also supports regional climate monitoring in context of WMO RA VI and EUMETNET. The product uses since mid 2008 the new GPCC monthly precipitation climatology as analysis background. Spatial product resolution: 1.0° and 2.5°.

The GPCC Full Data Reanalysis Product is of higher accuracy compared to the GPCC near-realtime products mentioned above. Thus its application is recommended for hydrometeorological model verification and water cycle studies. This analysis product is based on all stations, near real-time and non real-time, in GPCC’s data base with precipitation data for the individual month. Since end of September 2008 updated Version 4 of this product is ready based on a significantly enlarged database, which enabled GPCC to extend the analysis period to 1901-2007. The product uses the new GPCC monthly precipitation climatology as analysis background. Spatial product resolution: 0.5°, 1.0° and 2.5°.
The GPCC 50-Year Dataset VASClimO is based on data being selected with respect to a (mostly) complete temporal data coverage and homogeneity of the time-series. These longterm climatological analyses of homogenised area-averaged precipitation time-series are of special interest for GCOS and contributed to the IPCC Fourth Assessment Report. VASClimO Version 2 is planned to be ready by spring 2009 based on a significantly enlarged database, which enables GPCC to extend the product analysis period to 1951-2005. Spatial product resolution: 0.5°, 1.0° and 2.5°.

Since May 2008 a new GPCC global monthly precipitation climatology is available, based on data from more than 50,000 different stations worldwide with at least 10 years of data. Data sources are the normals collected by WMO, normals delivered by the countries to the GPCC, and normals calculated from data time-series available in the GPCC database. The new climatology enabled GPCC to change its analysis method now using the climatology as background for its near real-time and non real-time precipitation analyses. This further improves the representation of orography in areas with poor station density. Spatial product resolution of the climatology: 0.25°, 0.5°, 1.0° and 2.5°.

GPCC activities for the next 1-3 years will comprise continuous updating of its monthly in situ database based on data acquisition activities related to the quality needs of the different GPCC products. Processing and quality control activities are continuously done after reception of additional national data. Based on the enlarged GPCC data base a new version of the VASClimO Climatology (Version 2) is in preparation, planned to be available until spring 2009. The GPCC products are operationally visualised and provided on the GPCC website http://gpcc.dwd.de. This activity will comprise a significant update of the GPCC Visualiser (http://orias.dwd.de/GPCC/GPCC_Visualizer). A GPCC reference publication to be published in a peer reviewed journal is in preparation. This is expected to further enlarge the user community of GPCC products.

Plans for future research activities include testing of the applicability of the GPCC products for operational monitoring of precipitation extremes leading to flooding and drought. This will be done under umbrella of UNESCO FRIEND in joint research activities with the German hosted Global Runoff Data Center (GRDC). Additionally a new global daily precipitation product covering the whole surface of the earth is planned to be developed based on a combination of GPCC in situ based precipitation analyses for the land surface with high quality satellite based microwave precipitation analysis products for the ocean surface from the Hamburg Ocean Atmosphere Parameter System (HOAPS, http://www.hoaps.org), which are operationally processed by the EUMETSAT Climate Monitoring Satellite Application Facility (CM-SAF) hosted at DWD. Further down the road is the climatological exploitation of hourly regional and national precipitation products (like the RADOLAN products of DWD) in 1 km x 1 km spatial resolution using weather radar based quantitative precipitation estimates online adjusted with measurements from automatic weather stations.

GPCC-contribution to IPWG: High quality gridded real-time and non real-time raingauge based precipitation analysis products for earth’s land surface for 1) Validation purposes 2) Adjustment of sat-based products over land 3) Merging with sat-based products. Central European high resolution (1 hour, 1 x 1 km) QPE and QPF products (ground based radar precipitation online adjusted with automatic raingauge data) are in development and will be available for validation, adjustment and merging of sat-based precipitation products. As a first step into this direction, an hourly radar based QPE product in 1 x 1 km resolution for the hydrological catchment area of Germany will be ready at DWD by end of year 2008.
On the Small-scale Variability of Daily Rainfall in Complex Terrain and Tropical Region in Africa: Observational Evidence

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Information on the small-scale scale variability of rainfall is important to validate satellite rainfall products against rain gauge observations. It is widely known that topographic properties exert control on this variability. Yet there is little observational evidence available to quantify this variability, particularly in the tropical regions of Africa characterized by complex topography. The Hydrological Experiment in the Blue Nile (HEXB) field campaign, held in central Ethiopia during July-August 2006, provides a unique opportunity to understand the small-scale variability of rainfall in such a region. During this field campaign, we installed at two contrasting locations 36 non-recording rain gauges in an area of 5-km by 5-km. Based on data collected from these networks of rain gauges, we present the results of the small-scale variability of daily rainfall. We also present the effects of topography in controlling this variability.
Assimilation of rain and cloud affected microwave radiances at ECMWF

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Rain and cloud affected Special Sensor Microwave / Imager (SSM/I) observations have been assimilated operationally at the European Centre for Medium-Range Weather Forecasts (ECMWF) for over two years. In the current system, the four-dimensional variational analysis (4D-Var) assimilates total column water vapour (TCWV) retrieved from the SSM/I radiances using 1D-Var. 1D-Var retrieves not just TCWV, but the vertical profiles of temperature, humidity, cloud and precipitation, and the surface wind. The main shortcoming of the 1D+4D-Var technique is that this information does not get into the 4D-Var analysis. The information is reliable: we show that the retrieved rain water path agrees well, in an instantaneous comparison, with that observed by the precipitation radar on the Tropical Rainfall Measuring Mission. Our implementation is affected by other issues: the simplified moist physics operators currently produce twice the observed amount of rain, and there is a sampling bias caused by using the 1D+4D-Var technique in areas identified by the observations as cloudy or rainy, but not when the first guess is rainy or cloudy and the observations are clear. We will address the shortcomings of 1D+4D-var by moving to a direct 4D-Var assimilation which includes all SSM/I observations, whether clear, cloudy or rainy, in the same stream. Initial results from this new system will be presented.
The weather, climate and water communities have access to almost 30 years of satellite-derived precipitation data since the Global Precipitation Climatology Centre started to provide this information in 1979. Since 1996, 1-degree products are available. On a temporal scale, developments have moved on so that interpolated products are now available down to 3 hours and experimentally down to 1 hour, downscaling on a spatial scale makes local use of satellite precipitation data within reach for (semi)-operational local forecasting purposes. We have now the opportunity and tools at hand to harvest the fruitful results of almost 30 years of research and development activities to make satellite-based precipitation data and products available to national agencies, regions and the entire world to demonstrate the significant value of research, development and observations in improved monitoring, forecasting and climate observations.

A number of products are being used that have direct relevance for operational forecasting of heavy rain, flash floods, and riverine floods. Generally, multi-satellite precipitation observations and land surface characteristics have provided new opportunities to develop global flood and even landslide techniques:

Using Experimental Real-Time TRMM Multi-Satellite Precipitation Analysis (TMPA-RT), providing heavy rain map updates every 3 hours, the Global Hazard System (GHS-Flood) of NASA provides for Hydrological/Flood Model information in real-time experimental mode globally at 0.25° lat./long Resolution. The availability of this data makes it also attractive for use in other global hydrological flood forecasting initiatives such as in the Global Flood Alert System developed by the Infrastructure Development Institute (IDI, Japan) in collaboration with JAXA.

Using CMORPH as a standard satellite precipitation product, NOAA in collaboration with the Hydraulic Research Centre (HRC) and WMO aims to establish a Flash Flood Guidance System with Global Coverage.

Constraints in the operational use of satellite precipitation products can be traced to a few main causes, namely that high resolution precipitation products have uncertainties that are not easily quantifiable, that calibration and validation exercises are carried out largely on an experimental and research base and that there is no single best universal precipitation product. Other constraints relate to the operational continuity of products that are necessary for fully operational purposes with high requirements for service delivery including continuity and accuracy of data streams. At present, various weak points have been identified for example for TMPA-RT data including satellite hardware, satellite guidance or sensor calibration failures, server breakdowns and computing errors, although all of these error sources were detected and corrected.

For forecasting purposes in any National Meteorological and Hydrological Service (NMHS), satellite precipitation data would need to be integrated with ground-based rainfall observations from a conventional network and, on regional basis, needs to be integrated with data streams received through WMO’s Global Telecommunication System (GTS). In addition, and with the goal to further increase warning lead times for forecasting purposes, rainfall forecasts from global numerical weather prediction models could also be included in a multi-platform precipitation forecasting system operated on national basis and integrated into a regional/global framework. Quantitative satellite precipitation products are at present only seldom used in NMHSs especially in the developing world that account for the majority of countries with critical precipitation information requirements for forecasting and water management purposes. Out of a number of reasons for this situation, only two are highlighted:

Firstly, satellite precipitation data is provided and mainly used in support of major Research and Development (R&D) programmes and projects that eventually may lead to semi-operational products, with the expectation by the developers that a mechanism will be found to operationalize the use of such products from these projects, something that is not matching the reality of most NMHSs;
Secondly, most space agencies that initiate and support the satellite precipitation missions and projects do not see it as their task to ensure the continued delivery of satellite information in a form that can be easily used by NMHSs, including archiving of satellite derived data. This leads to the currently observed situation that with the ending of a specific project or, even more critical, with the end of a mission, the data stream is discontinued. Likewise, the development of guidance materials and manuals or front-end products facilitating the operational use of satellite precipitation products is not a priority in most projects which is an effective hindrance of their use under the conditions of an average NMHS and in particular in the developing world.

To overcome this situation, the objective of a dedicated initiative would be to make full use of the potential that satellite-derived precipitation observations provide to a multitude of routine applications in hydrological and meteorological forecasting and water resources management and to enhance justification of the resources allocated to the planning, implementation and R&D undertaken in precipitation missions.

To achieve this objective, we need to plan and implement future projects pro-actively by including operational requirements from the beginning of the projects, and involve experts from service providing organizations such as NMHSs to shorten the transition time from research and development to operational services. This will help demonstrate the benefits of observations and research to the end users in a more timely and efficient manner. For the implementation of this concept, the following steps are proposed:

(a) Most importantly, a mechanism needs to be established that allows the migration of (semi)-operational satellite precipitation products to organizations who will ensure long-term availability of satellite precipitation products. This is most important in all those cases, where space agencies that move on to next generation satellite missions and research find themselves resource-constrained to up-keep routine data management and dissemination of data and products from still operational satellites;

(b) Formation of a “Community of Practice” that serves as a dialogue platform comprising of satellite operators, researchers, and practitioners including staff from National Meteorological and Hydrological Services (NMHSs) mainly with the objective to facilitate the requirements-driven operational use of satellite precipitation observation products for routine forecasting services;

(c) Development of guiding materials, manuals, front-end software etc to familiarize staff of NMHSs in the access and use of satellite precipitation products. Along this line, standard operational procedures and common software for deriving precipitation measurements from satellites need to be promoted;

(d) Initiate tailored calibration and validation campaigns for regions identified by NMHSs as priority for forecasting purposes; provide estimates of probable errors in satellite observations and model errors;

(e) Develop course materials for trainers-of-trainers in the use of satellite precipitation products;

(f) Provide intercomparison results from different satellite precipitation products for different applications and regions; this should guide users towards the selection of the probably best suitable product for specific applications and regions. In this line,

(g) Provide information on limits of use and uncertainties of different products.

These suggestions could be further developed as an initiative to mainstream the operational use of satellite precipitation observations and products for forecasting and climate monitoring purposes. The collaborative framework to further develop and implement the initiative could consist of WMO together with the World Climate Research Programme (WCRP), the Committee on Earth Observation Satellites (CEOS) and including the Coordination Group for Meteorological Satellites (CGMS) together with members of the International Precipitation Working Group (IPWG), all with specific areas of expertise and mandates.

The planning and implementation of such a new and innovative initiative requires a well-coordinated, concerted effort that is research-based and requirements-driven in particular for the forecasting, climate observations and prediction communities. This requires resources that should be perceived by space agencies and development partners as a future-oriented investment rather than a liability.
Quality indicators in an operational precipitation product

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Algorithms for the retrieval of precipitation parameters from satellite data are becoming increasingly complex. In many ways the product quality depends not only on the underlying satellite data but also on the retrieval scheme and its specific application. For many users, especially in operational environments, the information on data quality is crucial for the application of the data. Therefore, this information should be passed to the users in the form of appropriate quality indicators (QIs). The functionality of QIs will be demonstrated using the newly-introduced quality indicators for the EUMETSAT Multi sensor Precipitation Estimate (MPE) as an example. MPE is a real-time instantaneous rain rate product in original METEOSAT-pixel resolution, delivered to the users every 15 minutes via internet or satellite dissemination (EUMETCAST/GEONETCAST). The algorithm is based on a blending technique using rain-rates derived from microwave sensors on polar-orbiting satellites to continuously re-calibrate the retrieval scheme for the geo-stationary IR satellite data. The basic assumption of the IR retrieval is a monotonic relation between measured brightness temperature and rain-rate at the surface. This assumption is only valid for specific weather situations, like strong convection, and limits the suitability of the derived rain rate data. In order to identify the suitable regions for the application of the algorithm, two QIs were defined on the basis of the difference between the co-located original microwave rain rates and the final IR retrievals. This information is added to the operational MPE product and distributed to the users. Case studies show how the QIs can be used to identify regions and time periods when the algorithm is likely to deliver good results. In addition, a statistical analysis is used to describe the validity of the product in different weather situations.
Application of High-resolution Multi-satellite Precipitation Real-time Estimates for Global Hydrological-disaster (Flood/Landslide) Monitoring and Prediction

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Abstract

With the availability of satellite rainfall analyses at fine time and space resolution, a trial version of Global Hazard System (GHS-Flood/Landslide) is now running in real-time using multi-satellite rainfall analysis in combination with hydrological models and landslide susceptibility zoning maps. This information is used to estimate key flood and landslide parameters in an effort to offer a practical cost-effective solution to the ultimate challenge of building natural disaster early warning systems for the data-sparse regions of the world. The system also uses satellite-based land surface information such as digital elevation models from the NASA SRTM (Shuttle Radar Terrain Mission) and vegetation information from MODIS in the model and algorithm calculations.

Key components of the GHS-Flood framework are: (a) a fine resolution precipitation acquisition system derived from multi-satellites; (b) a characterization of land surface including topographic variables, topography-derived hydrologic parameters such as flow direction, flow accumulation, basin, and river network, etc.; (c) a hydrological model to infiltrate rainfall and route overland runoff; and (d) an implementation interface to relay the input data to the models and display the flood inundation results to potential users. The GHS-Landslide system integrates satellite rainfall information with a global landslide susceptibility map, derived from a combination of global surface characteristics (digital elevation topography, slope, soil types, soil texture, and land cover classification, etc.) using a weighted linear combination approach. In those areas identified as “susceptible” (based on the weighted combination of surface characteristics), the time and location of potential landslide condition areas are forecasted where and when a rainfall intensity/duration threshold is exceeded.

This talk will present the progress and prospect in using the TRMM Multi-satellite Precipitation Analysis (TMPA) and future GPM data as input to these flood and landslide forecasts. Case studies and additional validation from flood and landslide events will provide further information to update the algorithm. Validation analysis indicates good results for flood detection and evolution, but with limitations in the current routing calculations. Occasional flood events are missed due to limitations in the satellite rain estimations. The landslide validation results indicate over-prediction due mainly to the limitations in the initial susceptibility map and challenges in resolving rainfall in mountainous regions.

Keyword: Flood, Landslide, Remote Sensing Precipitation, TRMM, and GPM
The Global Precipitation Measurement (GPM) Mission: Overview and Status

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Abstract

The Global Precipitation Measurement (GPM) Mission is an international satellite mission to unify and advance global precipitation measurements from a constellation of dedicated and operational microwave sensors. The GPM concept centers on the deployment of a Core Spacecraft in a non-Sun-synchronous orbit at 65° inclination carrying a dual-frequency precipitation radar (DPR) and a multi-frequency passive microwave radiometer (GMI) with high-frequency capabilities to serve as a precipitation physics observatory and calibration standard for the constellation radiometers. The baseline GPM constellation is envisioned to comprise conical-scanning microwave imagers (e.g., GMI, SSMIS, AMSR, MIS, MADRAS, GPM-Brazil) augmented with cross-track microwave temperature/humidity sounders (e.g., MHS, ATMS) over land. In addition to the Core Satellite, the GPM Mission will contribute a second GMI to be flown in a low-inclination (~40°) non-Sun-synchronous orbit to improve near real-time monitoring of hurricanes.

GPM is a science mission with integrated applications goals aimed at (1) advancing the knowledge of the global water/energy cycle variability and freshwater availability and (2) improving weather, climate, and hydrological prediction capabilities through more accurate and frequent measurements of global precipitation. The GPM Mission is currently a partnership between NASA and the Japan Aerospace Exploration Agency (JAXA), with opportunities for additional partners in satellite constellation and ground validation activities. Within the framework of the inter-governmental Group ob Earth Observations (GEO) and Global Earth Observation System of Systems (GEOSS), GPM has been identified as a cornerstone for the Precipitation Constellation (PC) being developed under the auspices of Committee of Earth Observation Satellites (CEOS).

The GPM Core Observatory is scheduled for launch in 2013, followed by the launch of the GPM Low-Inclination Observatory in 2014. An overview of the GPM mission status, instrument capabilities, ground validation plans, and anticipated scientific and societal benefits will be presented.
VALIDATION AND ANALYSIS OF PRECIPITATION EXTREMES IN THE TMPA

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ABSTRACT

The TRMM Multi-satellite Precipitation Analysis (TMPA) provides three-hourly, 0.25°x0.25° gridded precipitation estimates based on intercalibrated passive microwave estimates, microwave-calibrated infrared estimates, and monthly raingauge analyses for 1998-present over the latitude band 50°N-50°S. The uniform, fine-scale coverage is appealing to a wide range of users, but we continue to work to summarize the dataset in useful ways and compare these results to surface-based data to validate the dataset as possible.

In this presentation we address a suite of measures of “extreme” precipitation events developed by the joint CCl/CLIVAR/JCOMM Expert Team (ET) on Climate Change Detection and Indices (ETCCDI). These include annual precipitation, annual precipitation for days exceeding the 95th percentile threshold, and runs of consecutive dry days. Up to now these indices have been computed from station data, but clearly are amenable to quasi-global study using the TMPA, although its period of record is too short to yield truly climatological values. Particularly in light of the point-to-area conversion problem for precipitation, it is important to compare the index values against existing station data to determine how faithfully the TMPA-based results reflect the station-based results. This is done both by pooling all years for all stations and by looking at the interannual variation at individual stations. The comparison is done for all ETCCDI stations in the latitude belt 40°N-S that have data for each of the years 1998-2003. The annual precipitation tends to compare the best between the two data sets, with >95th percentile rain next. Consecutive dry days, on the other hand, is more sensitive to the occurrence of isolated rain events and shows less of a relationship between the two data sets. In the analysis, we see general consistency among the various indices, but the shifts in relationships give important information on the regimes that dominate various regions.
Global distribution of tropical cyclone rainfall and its contribution to total precipitation from 9 years of TRMM 2A25 and 3B42 data

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Based on the University of Utah TRMM Precipitation Feature (PF) database, Tropical Cyclone related PFs (TCPFs) are identified for 770 storms that reached tropical storm intensity level or above around the globe during 1998-2006. Six basins are considered: Atlantic (ATL), east+central Pacific (EPA), northwest Pacific (NWP), north Indian Ocean (NIO), south Indian Ocean (SIO), and south Pacific (SPA). Best track data are obtained from NHC and JTWC. TRMM 2A25 and 3B42 derived rainfall amounts are used to assess the impact of tropical cyclone rainfall in altering the regional, seasonal, and interannual distribution of the global total rainfall during tropical cyclone seasons in the six basins. The geographical, seasonal and interannual variations of the monthly rainfall inside TCPFs are presented. The fractional rainfall contributions by TCPFs are compared in different basins.

Preliminary results show that tropical cyclones contribute, respectively, 8%, 7%, 11%, 2%, 7%, 3% of the rainfall to the entire domain of ATL, EPA, NWP, NIO, and SPA basins. Similar to the results of Rodgers et al. (2000 and 2001), the maximum of tropical cyclone rainfall is poleward of the maximum non-tropical cyclone rainfall for both northern and southern hemisphere. The shift is the most for the ATL basin (about 20 degrees), while it is the least for the NIO (less than 2 degrees). Regionally, the maximum percentage contribution of tropical cyclone rainfall is located in the EPA basin near the Baja California (Mexico) coast (about 60%), the SIO close to the Australia coast (about 50%), and the NWP near Taiwan (about 40%). Seasonally, the maximum percentage contribution of tropical cyclone rainfall is, respectively, in September for the ATL basin, August and September for EPA, August for NWP, November for NIO, March for SIO, and January for SPA. The percentage of rainfall contributed by tropical cyclones is higher during El-Nino years than La-Nina years for the EPA, NWP, and SPA basins. But the trend is the reverse for ATL and NIO, and nearly neutral for SIO.
Precipitating clouds, over both land and ocean, are critically important to local and global climate, energy balance, and hydrologic cycles. However, our understanding of cold-cloud precipitation, dominant in the middle and high latitudes, remains lacking in several areas. Microwave remote sensing techniques, both active and passive, exploit relationships between ice/water and particle sizes/shapes to both separate frozen and melted precipitation and to infer geophysical properties of interest. The process is complicated by the fact that observations are often an "integrated" response within a finite field of view, which may include a range of temperatures, humidity, cloud, and a variety of precipitation particles -- all of which can significantly influence observations.

The research to be presented describes an amalgamation of methods by which one can attempt to untangle the relationship between the observation and the geophysical properties of cold-cloud precipitation, such as particle size distribution properties, precipitation rate, particle density, attenuation, etc. A case study is also presented to illustrate the retrieval capabilities, deficiencies, and sensitivities to assumptions and input parameters. Using aircraft-based radar and radiometer data obtained during the 2003 Wakasa Bay winter field campaign over the Sea of Japan, several rain and snow events were observed. The PR-2 active radar operated at microwave frequencies of 13.4 and 35.6 GHz, and the MIR radiometer made passive observations of brightness temperature (TB) at 89, 150, 220, near 183, 220 and 340 GHz. A radar retrieval method based on the dual wavelength ratio technique (Meneghini et. al., 1997) is used to infer particle size distribution properties. With suitable assumptions about particle density, forward model simulated TBs are compared to observed TBs to further constrain the radar retrievals. Key model features include a 1-D microphysical model based on Petty, 2001; Mie-based 1-D radar reflectivity profiles with attenuation; and TB simulation via RT4 (Evans, 1995). New features incorporated into the models include: an explicit melting layer model; a symmetric three-component dielectric-mixing formulation using the effective medium approximation; an empirically calibrated ocean surface-wind speed model; and several other enhancements.

This research provides a straightforward physical basis for precipitation retrieval in precipitating clouds where both dual frequency radar and passive microwave observations are present. Given suitable knowledge of the particle properties, the retrieval provides a fairly well constrained set of solutions. For a given set of observations, the retrievals consist of a set of retrieved particle size distributions, particle density, and cloud liquid water content; all of which are consistent with simulation and observation. Extension to regions where radiometer-only observations are present is currently being explored.

The techniques are being developed with an eye toward the Global Precipitation Measurement Mission (GPM: http://gpm.gsfc.nasa.gov/).
A Kalman Filter Approach to Blend Various Satellite Rainfall Estimates in CMORPH

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The various sources of satellite passive microwave (PMW) rainfall estimation input incorporated in the CPC Morphing (CMORPH) blended satellite rainfall product differ in: microwave channels availability/selection, earth coverage of the retrieval, sampling frequency and orbital crossing time. Currently geostationary satellite IR is only used for the determination of cloud motion vectors utilized for PMW rainfall propagation in CMORPH. The CMORPH-IR variant of CMORPH currently uses an elementary either/or decision for selection of a PMW derived rainfall estimate versus an IR derived counterpart. Questions arise as to which PMW estimate (or possibly combination thereof) should be used for determination of a forward time PMW rainfall propagation component when both a higher and lower sensor-quality estimate are available, or if IR should also contribute to the estimate, especially for cases when the “age” of the higher quality estimate is relatively older.

In order to produce an estimate of the desired variable in such a manner that the error/skill is minimized/maximized statistically, each input parameter must initially be determined from a “truth”. Geostationary satellite IR rainfall and PMW rainfall estimates from both forward and backward in time CMORPH propagations are averaged up to hourly 0.25 degrees latitude/longitude and compared with NEXRAD rainfall over the United States for JJAS 2007. Using radar rainfall as “truth”, various statistical properties of geostationary satellite IR and propagated PMW derived rainfall are determined, the PMW statistics stratified by sensor-type, temporal propagation direction, and temporal distance from scan time. The CMORPH rainfall estimates are reconstructed using the statistical parameter(s) determined to best weight estimates from various satellite sources and validated against both radar and gauge analyses from the IPWG U.S. model and satellite rainfall validation site.
This presentation provides an overview of current validation activities of the International Precipitation Working Group. The primary validation sites, Australia, Europe and US, were established in 2002 to provide information on the performance of satellite and model precipitation products to the algorithms developers and the wider user community. A degree of standardisation was devised across the validation sites to provide common statistical analysis and graphical display of the products in near real-time. Products are compared at a nominal resolution of daily, 0.25 degree, although the starting/ending times of the days vary according to the individual sites. Additional validation sites have been added, with validation over South America now available in near real-time, together with a number of sites where validation is available for specific periods. The results of these studies are available through numerous publications and presentations. The main results have shown that the satellite products perform better in the warm seasons where they out perform modelled forecast products, and vice versa in cold seasons. The presentation will conclude with suggestions for the future direction of the validation efforts, including continuing availability of near real-time results, temporal/spatial resolution of validation comparisons and breadth of available climatologically-diverse sites across the globe.
The HOAPS climatology
On Rain and Snowfall Validation over the Oceans

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ABSTRACT

The HOAPS (Hamburg Ocean Atmosphere Parameters and Fluxes from Satellite Data) climatology contains fields of precipitation, evaporation and the resulting freshwater flux along with 12 additional atmospheric parameters over the global ice-free ocean between 1987 and 2005. Precipitation fields are available until 2008. Except for the NOAA Pathfinder SST, all basic state variables are calculated from SSM/I passive microwave radiometer measurements. HOAPS contains three main data subsets that originate from one common pixel-level data source. Gridded 0.5 degree monthly, pentad and twice daily data products are freely available from www.hoaps.org. Especially for North Atlantic mid-latitude mix-phase precipitation, the HOAPS precipitation retrieval has been investigated in some depth. This analysis revealed that the HOAPS retrieval qualitatively well represents cyclonic and intense mesoscale precipitation, while GPCP, ECMWF forecast, ERA-40 and regional model data miss mesoscale precipitation substantially.

As the differences between the investigated data sets are already large under mix-phase precipitation conditions, further work is carried out on snowfall validation during the cold season at high-latitudes. A Norwegian Sea field campaign in winter 2005 was carried out using an optical disdrometer capable of measuring quantitative amounts of snowfall over the ocean. Results show that collocated HOAPS data compares well to the in-situ data. As a successor campaign, the disdrometer was operated on a Norwegian coast guard ship in March 2008 during an IPY/THORPEX cruise. Data from the SAMOS (Shipboard Automated Meteorological and Oceanographic System) initiative can be used to validate ITCZ and Southern Ocean precipitation. Additionally, precipitation estimates using the Cloudsat radar reveal further insight on the precipitation structure and intensity.
Measuring Precipitation in Antarctica

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Measuring precipitation in Antarctica is an arduous task with unique challenges not found elsewhere on the globe. Traditional measurement techniques employable over the tropics or mid-latitudes are not available or not achievable in Antarctica due to challenges with blowing snow, distinguishing snow at the surface from falling snow by satellite, the logistics of transportation across a vast and unforgiving continent, and low snowfall rates. Tracking the real-time and accumulated amount of precipitation on the continent remains important, however, as influences from climate change, changes in the mass balance of ice sheets, and forecasting for logistical purposes requires knowledge of the amount of precipitation on the continent.

Beginning in 2003, over ten acoustic depth gauges (ADGs) have been placed in several remote areas of Antarctica, including the Ross Ice Shelf, East Antarctica, and on several icebergs, with the primary purpose being to measure snow accumulation at each location. The acoustic depth gauges have been installed on automatic weather stations (AWS) as part of the NSF sponsored Antarctic Automatic Weather Stations project (AAWS), which currently has over 65 stations located across the continent. The AWS take measurements of temperature, pressure, wind speed and direction, and relative humidity with the data available in near real time via the Argos System on board the NOAA polar-orbiting satellites. While data from the ADGs cannot uniquely determine the causes of accumulation, these measurements, coupled with measurements from the AWS, as well as satellite data and model output, can give a clearer understanding of the causes of snow depth change at each location. In particular, the AWS data allows a partitioning of the ADG data into three known causes of changes in snow depth at the surface: accumulation caused by blowing snow, precipitation, or a combination of the two. This field campaign provides data widely available in both time and space of both snow depth change and its causes, with a particular focus on precipitation. This presentation will discuss the methodology used in determining this classification system and discuss accumulation trends across the Antarctic, as well as provide an overview of precipitation measurement methods across the Antarctic.
GSMaP validation activities of high resolution satellite-based precipitation products around Japan

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The Global Satellite Mapping of Precipitation (GSMaP) Project (Okamoto et al. 2005, Ushio et al. 2007) has contributed to Program to Evaluate High Resolution Precipitation Products (PEHRPP) activities by verifying satellite data around Japan using gauge-calibrated ground radar data provided by the Japan Meteorological Agency (JMA Radar-AMeDAS precipitation analysis; hereafter, RA dataset). Validation results for daily satellite estimates during 2004-2005 from various centers and universities are indicated using the RA dataset in the GSMaP web site (http://www.radar.aero.osakafu-u.ac.jp/~gsmap/IPWG/dailyval.html). We are developing a near-real-time validation system for daily satellite estimates using the RA datasets. This system will be open in September-October 2008.

We analyzed six high resolution satellite rainfall estimates around Japan with reference to the RA datasets during the period from January to December 2004. Ten record-breaking tropical storms and typhoons made landfall in Japan between June and October 2004. Passive MW sensors and a GEO IR radiometer around Japan were fixed during 2004. RA validation results for all products tend to be better during the boreal summer and worse during the boreal winter. The correlation coefficients (root mean square errors) of the products with temporal interpolation based upon the morphed technique using GEO IR information are higher (smaller) than those of other products. Performances of satellite estimates are worse for light rainfalls during the warm season and for very heavy rainfalls.
Application of MET for the Validation of Satellite Precipitation Estimates

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The goal of this study is to demonstrate the usefulness of the NCAR Model Evaluation Tools (MET) applied to the validation of high-resolution satellite rainfall estimates. MET was originally developed to support the Developmental Testbed Center (DTC) at NCAR and has been integrated into the Weather Research and Forecasting (WRF) system primarily for forecast verification applications. However, MET provides grid-to-point, grid-to-grid, and advanced spatial validation techniques in one unified, modular toolkit that can be applied to a variety of spatial fields (e.g., satellite precipitation estimates). Most validation studies rely on the use of standard validation measures (mean error, bias, mean absolute error, and root mean squared error, etc.) to quantify the quality of the precipitation estimates. Often these measures indicate poorer performance because, among other things, they are unable to account for small-scale variability or discriminate types of errors such as displacement in time and/or space (location, intensity, and orientation errors, etc.) in the precipitation estimates. This issue has motivated recent research and development of many new techniques such as, but not limited to, scale decomposition, fuzzy neighborhood, and object orientated methods for evaluating spatial precipitation estimates. This study will compute statistics for high resolution satellite estimates of precipitation using standard validation measures for the comparison with object orientated measures using the MET built-in Method for Object-based Diagnostic Evaluation (MODE) algorithm using the radar-rainfall estimates as the reference.

Tentatively, the study will attempt to validate all or a subset of the satellite rainfall estimates generated by the TRMM Multi-satellite precipitation analysis (TMPA), CPC Morphing technique (CMORPH), Hydro-Estimator (HE), Precipitation Estimation from Remotely Sensed Information using Artificial Neural Networks (PERSIANN), and PMIR at 0.25° spatial and 3-h temporal resolution. Satellite precipitation estimates will be compared to radar-derived rainfall products generated over the United States using NEXRAD observations for several regions and a variety of example cases. The presentation will give a summary of MET tool along with an overview the results of applying MET to satellite precipitation estimates.
Intercomparison and Selection of Rainfall Estimation and Nowcasting Algorithms by the GOES-R Algorithm Working Group

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GOES-R will be the first of the next generation of NOAA’s operational geostationary meteorological satellites, and will include a 16-band Advanced Baseline Imager (ABI) and a Geostationary Lightning Mapper (GLM). The GOES-R Algorithm Working Group (AWG) has been tasked with providing recommended, demonstrated, and validated algorithms for processing GOES-R data into user-required products. This work has been divided among 15 Algorithm Teams (AT’s), including the Hydrology AT which is responsible for algorithms for retrieving current instantaneous rainfall rate, probability of rainfall during the next 3 hours, and quantitative forecast of rainfall during the next 3 hours.

The Hydrology AT has evaluated 6 rainfall rate algorithms and 6 radiance nowcasting algorithms (including variants) in order to select which ones would form the basis for GOES-R rainfall estimation and nowcasting products. The results of this intercomparison will be presented, along with plans for additional improvements to the algorithms which were selected for operational implementation.
FIRST RESULTS OF VALIDATION AND HYDROLOGICAL IMPACT STUDIES FOR/OF EUMETSAT H-SAF SATELLITE PRECIPITATION PRODUCTS

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ABSTRACT

The key factor in the operational hydrology is proper modelling of processes of hydrological cycle that requires actual and detailed information about precipitation, soil moisture and snow cover. Mainly, these data come from the hydro-meteorological network but the satellite data are also crucial source of the information about the atmosphere and ground surface that can be used for feeding hydrological models.

The main goal of EUMETSAT Satellite Application Facility in Support to Operational Hydrology and Water Management (H-SAF) is to provide satellite products for operational hydrology. Products of H-SAF concerns are precipitation, soil moisture and snow cover parameters. Among them, the first H-SAF precipitation products based on both passive microwave sensors (conical and cross track scanning) and IR sensors calibrated by MW have been available since 2007 for cooperating teams for detailed validation before release of operational products.

Problem in validation of developed satellite precipitation products is their high variability in space and time causing difficulties in proper validation using conventional ground measurements and observations. As a result, two ways of validation were used in H-SAF activities: conventional technique using ground meteorological networks (both automatic and manned) and with the use of operational hydrological models. This second solution is part of H-SAF Cluster 4 activity, coordinated by Poland and involving 8 European countries.

The six month time series of H-SAF precipitation products was used for validation. The quality of the rain rate and accumulated precipitation estimates were analyzed both using the standard ground measurements from Polish hydro-meteorological network and the hydrological model MIKE 11. While the conventional validation was performed for the selected meteorological situations that referred to convection and stratiform rainfalls, hydrological validation was done using whole data set. The methodology applied for validation and the obtained results will be presented in the paper.
Observing precipitation with AMSU-B opaque channels: the 183-WSL algorithm

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The retrieval of precipitation rates by passive microwave sensors exploits the difference in sensitivity correlated to the absorption and scattering from the hydrometeors. Within window channels rainfall is revealed by the signal perturbations due to the ice crystals at cloud top, which scatter the incoming radiation giving a cooling effect into the satellite field of view. This effect is adopted by the algorithms based on a scattering index approach. On the other hand, emission-based methods derive surface rain rates from the thermal emission of raindrops within strong absorption bands.

An approach to precipitation retrieval can be done using water vapor absorption theory by exploring the extinction of radiation due to the absorption mechanism correlated to the formation of liquid and solid precipitation hydrometeors based both on the collision-coalescence process and the ice crystal formation. In this work we propose a new algorithm to infer rainrates by exploiting the perturbation into the 183 GHz water vapor absorption bands. Since, these frequencies are highly sensitive to the variation of condensed water vapor and humidity profiles, specific thresholds are calculated to remove non-rainy pixels surrounding precipitating areas and to possibly reduce the scattering effect due to the snow cover on mountain tops. The 183-WSL retrieval scheme classifies precipitation types using thresholds based on the difference of AMSU-B window channels at 89 GHz and 150 GHz. Typically, the brightness temperature differences for a convective system is > 10 K, whereas it drops down to about 3 K for light stratiform systems. The robustness of the algorithm is being validating with co-located radar data assumed as ground truth and a numerical forecast model.
The problem of accurately identifying and estimating the intensity of light precipitation on the global scale remains a challenge for almost all conventional precipitation sensors. Large discrepancies remain, for example, in current estimates of the global distribution of light rainfall and its importance in the global hydrologic cycle and our understanding of the processes that govern the onset of precipitation remain uncertain. With a growing number of precipitation cross-sections in its quicklook archive and the recent development of a suite of new precipitation retrieval algorithms, the ability of CloudSat’s millimeter wavelength Cloud Profiling Radar (CPR) to detect and quantify the intensity of light rainfall has now been established. This presentation will review the primary applications that have benefited from new CloudSat precipitation products including preliminary analyses of global rainfall incidence, early comparisons with climate rainfall datasets, and new evidence that hints at possible modification of precipitation by aerosols. The results underscore the anticipated role of CloudSat rainfall products for improving current estimates of global rainfall frequency, particularly at higher latitudes, and ultimately quantifying the contribution of light rainfall to the global energy and water cycle.
Characteristic Comparison of Precipitation between TRMM PR Measurements and Rain Gauge observation in the Mainland China

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Abstract

The TRMM PR monthly rainfall data and the monthly rainfall records observed by 580 raingauges in the mainland of Southern China are used to analyze similarities and differences of the precipitations in Southern China in the period from January 1998 to December 2005. Results expose significantly consistent rainfall distributions, between the both datasets in multiyear mean, multiyear seasonal mean. Departures of monthly rainfall rates of the two datasets also show a high correlation with a correlation coefficient of over 0.75. Analysis indicates that differences of both datasets are small in spring, autumn, and winter, as well as in the density region of raingauges compared with sparsity region on the contrary to relative large in summer. Generally, the TRMM PR has an underestimating trend in rainfall rates. Based on the above relationships of the two datasets, the TRMM PR data are used to investigate distributions and variations of precipitation in the Tibetan Plateau. Results show that the Tibetan Plateau is a dry area, because of the special terrain, it forms a large zone of precipitation along the south of the Tibetan Plateau.

Key words: TRMM PR, Raingauge, Rain rate, Tibetan Plateau
A weighted fuzzy verification method

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Abstract

This talk will introduce a weighted fuzzy method for the precipitation verification. A space-time neighborhood is used for both the observation and forecast. The weights assigned to the grid points within the neighborhood are defined as a function of distance from the grid point to the point of interest, the threshold, and the spatial scale. This method is applied to daily precipitation totals in Arkansas-Red River Basin.
Finding Breakpoints in Precipitation Series

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Abstract

This talk introduces a method to estimate the number and times of multiple changepoints in a precipitation series. A penalized likelihood is used with a minimum description length principle to estimate the number of breakpoints and their times of occurrence. A genetic algorithm is used to search (optimize) the penalized likelihood over the huge number of possible changepoint configurations. The methods can be used with or without a reference series. An application to annual precipitations from New Bedford, Massachusetts, is given.
General Observation Period 2007

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In the year 2007 a General Observation Period (GOP) has been performed within the German Priority Program on Quantitative Precipitation Forecasting (PQP). By optimizing the use of existing instrumentation a large data set of in-situ and remote sensing instruments with special focus on water cycle variables was gathered over the full year cycle. The area of interest covered central Europe with increasing focus towards the Black Forest where the Convective and Orographically-induced Precipitation Study (COPS) took place from June to August 2007. Thus the GOP includes a variety of precipitation systems in order to relate the COPS results to a larger spatial scale. For a timely use of the data, forecasts of the numerical weather prediction models COSMO-EU and COSMO-DE of the German Meteorological Service were tailored to match the observations and perform model evaluation in a near real-time environment. The ultimate goal is to identify and distinguish between different kinds of model deficits and to improve process understanding.
New cloud observation techniques are needed to improve our understanding of the impact of clouds on the earth's water cycle and radiation budget, which represents still one of the largest uncertainties in global and regional climate modeling. To provide an airborne platform for such observation techniques is one of the purposes of the new German research aircraft HALO (High Altitude Long Range). It will be commissioned in 2009, and will open a new dimension for climate and atmospheric research. By HALO it will be possible to survey the atmosphere on continental scales but with much higher resolution and with more powerful instrumentation than feasible on space borne platforms. An advanced set of microwave remote cloud sensing instruments (HAMP - HALO Microwave Package) will be operated on board of HALO. It consists of a cloud radar and a suite of passive radiometers in different frequency bands. The radar MIRA-36 operates at 36.5 GHz. Although this is an unusual low frequency it benefits from the wider range of applications due to less signal attenuation in deep clouds and rain, compared to the 94 GHz (operated on CloudSat). The frequencies for the passive microwave radiometers were selected in allusion to the AMSU-A and -B sounder. Thereby the 150 GHz channel of AMSU-B has been replaced by frequencies in the 118 GHz oxygen band that together with the 60 GHz oxygen complex can be used for precipitation retrieval after Bauer and Mugnai (2003). Furthermore by including channels in the water vapor lines at 22.235 GHz and 183.31 GHz and higher microwave channels sensitive to scattering in the ice phase, various precipitation retrieval algorithms can be compared by measurements with HAMP.

This presentation introduces the microwave package on HALO. It further shows the potential of the observations by presenting first results of a simulation study for the selected microwave frequencies and the cloud radar. The potential of the selected frequencies for hydrometeor observations and their retrieval has been investigated by developing simple algorithms based on a data set of brightness temperatures and concurrent hydrometeor contents and profiles. These were achieved by cloud resolving model simulations and forward radiative transfer calculations for a set of mid-latitude precipitation events. Good retrieval capabilities for frozen hydrometeors over both surfaces (land/ocean) and for rain over ocean surfaces are found. Bauer, P., and A. Mugnai (2003), Precipitation profile retrievals using temperature sounding microwave observations, J. Geophys. Res., p. 4730.
The African continent has always been vulnerable to natural hazards such as drought and flooding, which normally have a substantial influence on the economy due to it being largely dependent on agricultural sectors. The vast land area of the continent is home to only a few precipitation-measuring ground networks which are also sparsely situated. This creates a great need for some sort of reliable data source, especially concerning those regions with inadequate ground measurements. Remotely-sensed rainfall has often proven to play an imperative role in many African countries’ rainfall studies, specifically since the launch of the Meteosat Second Generation (MSG) satellites. Various satellite rainfall algorithms have been developed at research centers across the world and there are many efforts aimed at the validation of these data sets. The South African Weather Service (SAWS) in conjunction with EUMETSAT installed the Hydro-estimator on local computer systems at SAWS in September 2007. This estimation technique utilizes NWP output from the Unified Model (UM), also locally installed at SAWS, which covers most of the Southern Hemisphere. Many South African Development Community (SADC) countries now have access to rainfall maps of accumulated Hydro-estimator data, however very little verification of this data has been done. SAWS has previously been involved with the verification of satellite rainfall estimates through the efforts of the International Precipitation Working Group (IPWG) after which the results were presented at the 3rd IPWG Workshop in Melbourne, Australia in 2006. This year these efforts have been revived along with the addition of Hydro-estimator rainfall estimates.

In the study presented here, the authors performed a verification analysis of five individual 0.25 degree resolution satellite rainfall products, namely CMORPH, PERSIANN, 3B42, NRLB and the Hydro-estimator, with the use of IDL software developed by the IPWG. The authors mainly aim to validate the performance of the Hydro-estimator technique, although results from the remaining products are equally valuable to other members of the IPWG. Daily satellite rainfall accumulations from the previous austral summer season ranging from October 2007 to March 2008 were validated against rain gauge measurements from the South African gauge network. Statistical results are presented in terms of various skill scores in order to portray the performance of each product.
Very High Resolution Precipitation Frequency and Rainfall Estimates from the Tropical Rainfall Measurement Mission: Applications and Uncertainties

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We will present the 10-year high-resolution precipitation climatology from the TRMM precipitation radar (PR) and TRMM microwave imager (TMI) at resolutions as high as the 5 km scale. We will examine these depictions in comparison with existing high-resolution products such as the TRMM Multi-satellite Precipitation Analysis (TMPA), which has 0.25° resolution. We will examine climatological high-resolution precipitation variations in rainfall frequency, accumulation, and PR echo structure along topographic features, and across variations in land surface type where topography is more homogeneous. Over terrain, we will examine the along- and across-barrier distributions of precipitation characteristics, and compare observed high-resolution precipitation distributions with simple linear predictive models of precipitation. We will examine the uncertainty in these high resolution depictions of precipitation both statistically by developing a model to describe sampling uncertainties using the statistical properties of the observed rain distribution, as well as by comparing these high resolution climatologies to existing high resolution rain gauge networks in complex terrain.
Dynamical Downscaling Using Satellite-Gauge Based Precipitation Analyses

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Abstract

Recent studies have shown that the use of a regional model to downscale the large-scale analyses marginally improves simulated precipitation fields. Using satellite-based products as input, a regional spectral model carried out extended and short-term simulations of the South American summertime circulations. The authors seek to recover the precipitation patterns during January of 2004, when precipitation analyses are available from a daily, high-resolution, satellite-gauge based analysis over the continental South America. In this study, precipitation assimilation is only effectuated in the same time scale as the rainfall analysis. The regional model solutions using a combined satellite-gauge scheme are encouraging, especially in comparison to the global reanalyses. As will be shown, rain rate assimilation not only increases the regional model precipitation simulation skill but also provides improvements in other fields influenced by the precipitation. This positive impact on regional simulations is enough to prove that the precipitation assimilation here proposed does not provide unbalanced initial fields to the regional model predictions. Due to the potential impact on land surface variables, improvements in monthly to seasonal predictions are expected as well.
INTERCOMPARISON OF CMORPH RAINFALL ESTIMATION WITH RAINGAUGES OVER SOUTH AMERICA

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Abstract

Satellite rainfall estimates over South America between 0S to 40S and 80W to 25W obtained with CMORPH rainfall estimates are compared to raingauge rainfall measurements. The CMORPH rainfall estimation accuracy is analyzed as a function of the accumulation time (hourly to annual), geographic region (continental/coastal) and weather type (convective/stratiform). Common performance metrics such as CSI are used. Results indicate time and space dependencies on the rainfall accuracy obtained with the CMORPH technique.
Precipitation is arguably the most important forcing variable in hydrology and hydrometeorology. Requirements of the hydrological modelling community may be summarised in two ways: first there is a need for near real-time precipitation data for improved initialisation of stream flow forecasts, including flood early warning; and secondly there is a need for accurate historical records for water accounting and climate studies. In Australia ground-based radars and the rain gauge network, for example, are concentrated on the more populous regions of the country, and there is an increasing need to extend these observations to regions of hydrological significance such as headwater catchments. Satellite-based precipitation data or quantitative precipitation forecasts certainly have the desired geographic coverage, but lack the resolution in space and time for most hydrological applications. Furthermore, limitations of individual data sets in terms of spatial coverage, measurement frequency, as well as absolute accuracy, necessitate the merging of multiple source of precipitation information.

In this paper, we describe planned research activities under the newly formed Water Information Research and Development Alliance between the CSIRO and the Bureau of Meteorology directed at blending multiple precipitation data sets for water resources assessment and water availability forecasting in Australia. Some of the deficiencies in the currently available data sets will be highlighted in the context of flood early warning and hydrological model calibration, and preliminary results of some blending strategies will be presented.
An Update of PEHRPP Activities

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Beginning in 2004, the International Precipitation Working Group (IPWG) began a satellite precipitation algorithm validation/intercomparison project over three domains (continental United States, Australia, and northern Europe) covered by quality-controlled surface networks. Its aim is to provide information to users on the daily-scale performance metrics (bias, RMSE, skill score, etc) relative to ground networks, and give algorithm developers a better understanding of the strengths and weaknesses of different algorithmic approaches and satellite data blends. A secondary aim is to investigate when and where satellite rainfall estimates generally perform better or worse than short-term rainfall predictions from NWP models. These validation activities were motivated by expanding requirements in climate modeling, data assimilation, nowcasting, and hydrological applications.

The development of high resolution precipitation products (HRPP; typically blends of low Earth orbiting passive microwave radiometric (PMW) and geostationary-based imagers) has also proceeded to the point where a more thorough analysis of their performance is required. The goal of the expanded Program to Evaluate High Resolution Precipitation Products (PEHRPP) is to characterize as clearly as possible the errors in various HRPP on many spatial and temporal scales, over variable background surfaces, and across seasons and climate regimes. Furthermore, errors of and differences between HRPP are meaningful in that they can be systematically related to precipitation characteristics and/or algorithm methodology, thereby potentially improving HRPPs by combining products or methods based on the observed errors and differences. In this presentation we will provide an overview of the validation strategies and summarize validation results to date.
A New Merged Analysis of Precipitation Utilizing Satellite and Reanalysis Data

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Many merged multi-source global analyses of precipitation exist, including the Global Precipitation Climatology Project (GPCP) analysis and the CPC Merged Analysis of Precipitation (CMAP). The multi-source nature of these datasets allows them to use the most accurate type of inputs available to produce the best estimate of precipitation for any given place and time. However, studies have shown that the oceanic satellite estimates used in these datasets are less accurate at high latitudes when compared to reanalysis data. I will describe the Multi-Source Analysis of Precipitation (MSAP) a new 2.5° gridded global analysis of precipitation from 1987-2002 using Optimum Interpolation (OI). This is the first version of MSAP which is based on the Defense Meteorological Satellite Program (DMSP) Special Sensor Microwave/Imager (SSM/I) and the forecast precipitation from the ERA-40 reanalysis. An advantage of the OI methodology is that it optimally merges the inputs based on pre-defined weights and errors associated with the analysis are estimated from the technique. Validation against other gridded datasets as well as tropical ocean and high-latitude land gauges show that MSAP performs particularly well at high latitudes when compared to the satellite-only part of GPCP. However, it contains negative biases in parts of the Northern Hemisphere due to the ERA-40 data and large positive biases over tropical land areas due to issues with the SSM/I estimates. In the future, this new approach can be applied using precipitation estimates from the next generation reanalysis systems such as the JRA-25, NASA’s MERRA and the ERA Interim reanalysis.
Precipitation and Crop Yield: A Statistical Model

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We develop a statistical model, using multivariate time series models, to predict crop yield over a broad agricultural area in Canada. The major input variable to the model is precipitation, but other relevant covariates such as daily average and monthly average temperatures are included in the model. Of particular interest in the model are the functional relationships between the covariates.
Characteristics of High-Resolution Satellite Precipitation Products in Spring and Summer over China

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Abstract:
An analysis of hourly precipitation is constructed on a 0.25°lat/lon grid over China for a 3-year period from 2005 – 2007 by interpolating gauge observations at over 2,000 stations. The gauge-based precipitation analysis is then applied to examine the performance of six selected high-resolution satellite precipitation estimates including the CMORPH, the TRMM 3B42RT and 3B42_Version 6, the NRL blended product, the PERSIANN and the COMB (only Microwave-based products) satellite estimates which are all integrated into fields of 0.25°lat/lon and 3-hourly resolution. Our preliminary results showed that all the satellite products are capable of capturing the overall spatial distribution and temporal variations of precipitation reasonably well over China. But the performance of the satellite presents varies for different regions and different seasons, with better comparison statistics observed over wet regions and for warm seasons. Moreover, all satellite products present seasonally and regionally dependent biases. All the satellite products can represent the PDF well with the best performance given by NRL. The diurnal cycle research of different satellite-based estimates is under way.
A CLSMAS using FY2C precipitation and AMSR-E soil moisture data based on CLM3 and EnKF

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Soil moisture plays a vital role in land-atmosphere interactions. The purpose of this paper is to develop a CLSMAS (China Land Soil Moisture Assimilation System) which could assimilate soil moisture from satellite remote sensing data, and then to obtain high temporal and spatial distribution of soil moisture in China.

The CLSMAS includes three modules, one module is the cumulative precipitation time downscaling method based on geostationary satellite data using cloud precipitation probability as weight and the estimation of spatial and temporal distribution of incident solar radiation applied to estimate atmosphere forcing data of land surface model, another is soil moisture assimilation module based on CLM3 and EnKF, the other is a data analysis module of soil moisture observation.

In this paper, the FY2C precipitation and surface incident solar radiation data set with the one hour time resolution and 10km spatial resolution from 2005 to 2007 are developed as the atmosphere forcing of land surface model. These data sets are validated using surface observation data. It shows the FY2C precipitation and surface incident solar radiation data set is reasonable. The compare indicated that there are large deviations between the retrieved soil moisture between NASA/AMSR-E soil moisture operational product and the gauge observation in China. It indicates the soil moisture retrieval from microwave satellite sensing could be improved. Then several assimilation experiments have been tried using the atmosphere forcing data sets generated by the assimilation system in this paper and CLSMAS and the soil moisture sets retrieved from AMSR-E. The result of an assimilation experiment from June to September in 2006 indicates that the simulation of land surface model and the assimilation could both represent the spatial and temporal distribution of soil moisture well. And the distribution of assimilated soil moisture corresponds well to summer drought in Chongqing and Sichuan in August in 2006 which is the worst since 1949. It also has a good relationship with the drought in September in east of Hubei and south of Guangxi and so on.

Keywords: Land data assimilation, soil moisture, FY2C satellite, high resolution precipitation and surface Incident solar radiation
Applicability of a correction method for real time flood forecasting based on satellite-based rainfall information

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In this paper, a proposal is made to apply corrections to satellite rainfall data so that they can be used effectively. Rainfall is the basic information that is needed for flood forecasting, and in many developing countries, measurements are not often carried out in a systematic way. Satellite-based rainfall data has the advantage that they can be obtained world-wide in near real-time. Therefore, satellite-based rainfall information has the potential to be utilized for flood forecasting and warning in developing countries. The satellite-based rainfall product used in this study is GSMaP(JAXA). The characteristics of these products were studied in the Yoshino river basin in Japan. They were compared with the ground observed rainfall data, and it was found that the products underestimated the ground observed data.

In this study, “the movement of rainfall area of satellite-based rainfall product” is studied and regarded as one of its characteristics. If the movement of rainfall area can be evaluated, it is possible to establish a correction method to reduce the error margin with ground observation data. “The movement of rainfall area of satellite-based rainfall product” is expressed from a time change in the mapping pattern of satellite-based rainfall product. As a result, the error margin rate has improved from 68% to 21%. The detailed results will be described in the full paper.
Current Scientific Progress & Future Scientific Prospects Enabled By Spaceborne Precipitation Radar Measurements

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First, we examine current scientific progress and understanding that have been possible through use of spaceborne precipitation radar measurements being provided by the TRMM and CloudSat satellites. Second, we look across a future 20-year time frame to assess how and why anticipated improvements in space radar systems will further advance scientific progress into topic areas once considered beyond the realm of space-based remote sensing. JAXA’s 13.8 GHz Ku-band cross-track scanning Precipitation Radar (PR) developed for flight on NASA’s non-sun-synchronous, diurnally-precessing TRMM satellite, was the first Earth radar flown in space that was designed specifically for precipitation measurement. Its proven accuracy in measuring global rainfall in the tropics and sub-tropics and its unanticipated longevity in continuing these measurements beyond a full decade have established the standards against which all follow-up and future space radars will be evaluated. In regards to the current PR measurement time series, we will discuss a selection of major scientific discoveries and impacts which have set the stage for future radar measuring systems. In fact, the 2nd contemporary space radar applicable for terrestrial precipitation measurement, i.e., JPL-CSA’s 94 GHz nadir-staring Cloud Profiling Radar (CPR) flown on NASA’s sun-synchronous CloudSat satellite, although designed primarily for measurement of non-precipitating cloud hydrometeors and aerosols, has also unquestionably advanced precipitation measurement because CPR’s higher frequency and greatly increased sensitivity (~30 dBZ) has enabled global observations of light rain rate spectrum processes (i.e., rain rates below 0.05 mm hr⁻¹) and of precipitation processes in the high troposphere (particularly ice phase processes). These processes are beyond reach of the TRMM radar because the PR sensitivity limit is ~17 dBZ which means its lower rain rate cutoff is around 0.3 mm hr⁻¹ and its vertical profiling acuity is greatly limited above the melting layer. Thus, the newer CPR measurements have become important for a variety of scientific reasons that will be highlighted and assessed.

In considering scientific progress likely to stem from future precipitation radar systems, we will specifically examine possible scientific impacts from three anticipated missions for which NASA and various of its space agency partners are expected to lead the way. These three missions are: (1) the near-term Global Precipitation Measuring (GPM) Mission; (2) the decadal timeline Aerosol and Cloud Experiment (ACE) Mission; and the post-decadal timeline NEXRAD in Space (NIS) Mission. The observational capabilities of the planned radar systems for each of these three satellite missions are distinct from each other and each provides progressive improvements in precipitation measuring and scientific research capabilities relative to where we are now -- insofar as TRMM PR and the CloudSat CPR capabilities. The potential innovations in scientific research will be discussed in a framework of likely synergisms between next-generation radar capabilities and accessible dynamical and microphysical properties that have heretofore evaded detection.
Precipitation regime changes in GPCP?

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The availability of the Global Precipitation Climatology Project (GPCP) pentad precipitation analysis makes possible higher temporal precipitation variability analyses. However, it should be cautioned that the dataset is still average values of five days precipitation. Hence, analyses on intensity, duration and frequency of precipitation that require higher temporal dataset should not be done with the dataset. Here we present changes in global precipitation regimes (regions with significant seasonality) during the period between 1979 and 2007 shown in the dataset. Two “seasons” are used in order to show the changes: MAMJJA and SONDJF. By using the two seasons, we can show the regions where there are no seasonality in total precipitation within the year indicating that two precipitation systems maintain the precipitation in the regions. The regions also implicitly show the borders between the precipitation systems. Results show that changes in precipitation regimes are especially noticeable in the regions where land-water interactions exist, such as the monsoon regions. Further analyses are still needed in order to statistically and physically explain the causes of the changes.
Testing of Cloud Microphysics Scheme with Snow Events

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Abstract

One of the grand challenges of the Global Precipitation Measurement (GPM) mission is to improve precipitation measurements in mid- and high-latitudes during cold seasons through the use of high-frequency passive microwave radiometry. For this, the Weather Research Forecast (WRF) model with the Goddard microphysics scheme is coupled with the Satellite Data Simulation Unit (WRF-SDSU) that has been developed to facilitate the over- snowfall retrieval algorithm by providing virtual cloud library and microwave brightness temperature (Tb) measurements consistent to the GPM Microwave Imager (GMI). This study tested the Goddard cloud microphysics scheme in WRF in snowstorm events (January 20-22, 2007) over the Canadian CloudSat/CALIPSO Validation Project (C3VP) site up in Ontario, Canada.

In this meeting, we will present the performance of the Goddard cloud microphysics scheme both with 2ice (ice and snow) and 3ice (ice, snow and graupel) as well as other WRF microphysics schemes. We will also examine the microphysical processes that generate the liquid and ice phase. Results will be compared with the King Radar data. We will also use the WRF model outputs to drive the Goddard SDSU to calculate radiances and backscattering signals consistent to satellite direct observations. The simulated radiances are evaluated against the measurement from A-Train satellites.
Report on the Second International Workshop on Space-based Snowfall Measurement

Gregory J. Tripoli¹, Ralf Bennartz¹, Ralph Ferraro²

As recommended by the Third International Workshop of the International Precipitation Working Group (IPWG) held in Melbourne, Australia (October 2006), the 2nd International Workshop on Space Based Snow Measurement (IWSSM) was held on 31 March – 4 April 2008 at the Steamboat Ski Village in Steamboat, Colorado. The workshop was a follow on to the October 2005 meeting held in Madison Wisconsin.

The workshop focused on 5 topic areas which included: (1) Applications, (2) Global and Regional Detection, (3) Modeling, (4) New Technology and (5) Validation. Based on plenary sessions in each topic area, 9 high priority recommendations were made which included:

1) Encourage the generation of community CRM/NWP model profile databases that represent natural variability.
2) Use “modeling chains” as a basic research tool to develop an understanding of the relationship between snowfall and radiative transfer.
3) Recognize “Data Assimilation” as a necessary component of snow analysis from space-based measurements.
4) Continuing community efforts to study and development of high-latitude surface emissivity products (10-200 GHz) including error estimates are strongly recommended.
5) The use of combined active and passive satellite data for snowfall detection/retrieval should be further encouraged.
6) Future space borne measurement platforms must have high sensitivity and be able to detect reflectivity down to within 100-200 m of the surface and with a sensitivity of -20 to -30 dBz.
7) New passive microwave instruments and new channel combinations need to be studied.
8) High level coordination of international GV programs for snowfall (e.g., through GPM, GEWEX, IPWG) should be enhanced to advance the current state of snowfall retrievals.
9) Dedicated validation: MW transmission links with parallel particle probing, inter-sensor validation in radiance/reflectivity space, and statistically robust datasets for (frozen) cloud processes are needed.

Further explanation of and the background behind these recommendations will be given at the oral presentation.

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An SSM/I - SSMI/S Application for Climate Research: the Extension of Hydrological Products Climate Records

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Global monthly rainfall estimates and other hydrological products like integrated Cloud Liquid Water (CLW) and Total Precipitable Water (TPW) have been produced from 1987 to present using measurements from the Defense Meteorological Satellite Program (DMSP) series of Special Sensor Microwave Imager (SSM/I). The aim of this paper is to present recent efforts that are necessary to extend the 21-year climate records of these valuable products. Since the DMSP F16 and F17 satellites was successfully launched carrying onboard the Special Sensor Microwave Imager/Sounder (SSMI/S), the first objective of this paper is focused on the application of SSMI/S channels to evaluate the performance of several hydrological products using the heritage of existing algorithms for SSMI. The second objective is related to the beacon interference in DMSP F15 22V occurred in August 2006. A proposed correction scheme will be tested in order to evaluate the performance of the aforementioned products on a monthly basis when compared with other satellite retrievals (F13 and F14).

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Rainfall is a very important variable in a Land Data Assimilation Systems (LDAS). An important challenge when implementing LDAS is the scarcity of comprehensive land-surface data at the spatial and temporal resolutions at which they operate. Providing adequate observations of precipitation is particularly problematic because precipitation is so spatially variable and often only point sample data from well-separated rain gauges are available. This satellite-gauge merging approach is based on a multi-satellite technique (TRMM Multi-satellite Precipitation Analysis – TMPA) and a combination of additive and multiplicative bias correction schemes in order to get the lowest bias when compared with the observed values. Inter-comparisons and cross-validations tests have been carried out for the control algorithm (TMPA real-time algorithm) and the proposed merging scheme for several regions in South American continent.
Improvement of Cold Season Land Precipitation Retrievals through the use of Field Campaign Data and High Frequency Microwave Radiative Transfer Model

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As we move from the TRMM to GPM era, more emphasis will be placed on a larger regime of precipitation in mid- and high-latitudes, including light rain, mixed-phase precipitation and snowfall. In these areas, a large and highly variable portion of the total annual precipitation is snow. The remote sensing of snowfall is especially challenging because of several factors (1) the lack of liquid precipitation in the snowfall limits the passive microwave retrieval to the scattering signals at the high frequency, which is indirectly associated with surface precipitation (2) The optical properties of frozen hydrometeor is more variable and less well known than those of rain (3) The surface emissivity of snow is highly variable in time and space, which further hampers the uses of the window channels. There is a wealth of observational evidence of brightness temperature depression from frozen hydrometeor scattering at the high frequency from aircraft and spacecraft microwave instruments. Research on the development of snowfall retrieval over land has become increasing important in the last few years (Chen and Staelin, 2003; Kongoli et al., 2004; Skofronick-Jackson et al., 2004). However, there is still a considerable amount of work that needs to be done to develop global snowfall detection and retrieval algorithms. This paper describes the development and testing of snowfall models and retrieval algorithms using pre-launch GPM field campaign data (e.g., CV3P) and high frequency radiative transfer models.
Satellite Data Assimilation in Cloudy and Precipitation Conditions

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In the past two decades, much progress has been made in utilization of satellite data in numerical weather prediction (NWP) models and is attributed to the improvement in satellite instrumentation, continued increase in the computational power and related improvements in the numerical models and data assimilation techniques. Direct satellite radiance assimilation into NWP models has resulted in steady increases in the global medium range forecast skills at all major NWP centers. Today, satellites provide over 90% of the data ingested by NWP models, although the utilized satellite data is only a small fraction of that available. Many data are excluded by a thinning process that attempts to make the numbers more manageable for timely processing and to remove possibly horizontally correlated errors. Others are excluded because they are suspected of being cloud- or rain-affected, which renders their quantitative interpretations (e.g., retrievals of atmospheric temperature profiles) more prone to error. These latter observations naturally contain some information about the clouds and precipitation present. Better use of their content in general requires estimating some properties of any clouds and precipitation affecting the local radiative transfer and characterization of the errors in their radiances and products. At the US Joint Center for Satellite Data Assimilation, we are making some progresses toward uses of cloudy radiances in NCEP GFS through the advancement in the community radiative transfer model and improvement to NCEP GSI. Preliminary results will be demonstrated at the workshop.
Environmental Data Records from Special Sensor Microwave Imager and Sounder (SSMIS)

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Abstract: The Special Sensor Microwave Imager/Sounder (SSMIS) provides simultaneous information on atmospheric sounding up to 100 km and environmental parameters from its conical scanning mode. The first two DMSP satellites (F-16 and F-17) carry SSMIS on board and have been successfully launched in 2003 and 2007, respectively. The F-18 will be launched in 2008. The entire DMSP mission from F-16 to F-20 will last at least into the next decade.

In the past 20 years, NOAA has accumulated great experiences from operational uses of satellite microwave measurements. Since 1990s, we provided continual supports to the DMSP program through participating in SSM/I calibration and validation (Cal/Val) and delivered several versions of SSM/I algorithms to the Fleet Numerical Meteorology and Oceanography Center (FNMOC) for operational implementation. At National Environmental Satellites, Data, and Information Service (NESDIS), we are routinely producing monthly SSM/I products from 1987 to today and have being archived the data at National Climate Data Center (NCDC). These activities will be continued and expanded to include the end-to-end responsibility from radiance calibration, product developments and data assimilation into weather and climate models. NESDIS is responsible for developing enhanced products from operational satellites to meet the requirements of NOAA users as well as international community. This overview will summarize the recent SSMIS research and development activities at NOAA/NESDIS and Joint Center for Satellite Data Assimilation (JCSDA).

Currently, SSMIS products are generated through the algorithms inherited from its predecessor: SSM/I. SSM/I-like products include cloud liquid water, total precipitable water, precipitation, sea ice cover, snow concentration, and surface wind speed, surface emissivity at window frequencies (from 19 to 91 GHz). In addition, a new cloud ice water algorithm is also developed using SSMIS 91 and 150 GHz channels with the two-stream radiative transfer appreciation. The algorithms are also developed to demonstrate the temperature and water vapor profiles which have quality comparable to AMSU. Several experiments were also conducted at the Joint Center for Satellite Data Assimilation (JCSDA) and illustrated the impacts of direct assimilation of SSMIS radiances on hurricane and global weather forecasts skills. It is shown that the hurricane warm core at the upper troposphere and improved temperature and wind fields at surface are dramatically improved after SSMIS radiances are assimilated.
The Role of Remote Sensing Satellite Data for Rainfall Forecasting in Indonesia

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ABSTRACT

Indonesian area stretches in the equatorial area between Asia and Australian continents, and Pacific and Indian Oceans, as well as consisted of thousands of island that forms Indonesian archipelago with wide range of characteristics, orographic structure and island shapes. Consequently, the rainfall in Indonesia varies depending on place and season. Depending on the influence of wind, generally, the rainfall in Indonesia can be divided into three patterns, they are Monsoon, Equatorial and Local types. Based on these types therefore rainfall can occur in different type of cloud and at limited area. Since remote sensing satellite technology had become an efficient tool for many purposes of object or phenomenon analysis on the Earth surface, now this technology is also used to analyze weather phenomenon such as rainfall forecasting. This paper describes the use of remote sensing satellite data for rainfall forecasting in Indonesia. Brief methodology in satellite image processing based on characteristics of satellite images and its validation is also discussed.

Keywords: remote sensing satellite data, rainfall, forecasting, radar, optic
Merging Gauge Observations and Satellite Estimates of Daily Precipitation over China

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A new technique has been developed to create high-resolution, high-quality precipitation analyses on a 0.25°lat/lon grid over land by merging gauge-based analysis and satellite estimates. The gauge-based analysis used here (Shen et al. 2008) is created operationally on a real-time basis at CMA National Meteorological Information Center (NMIC) by interpolating reports of daily precipitation from over 2,400 stations over mainland China using the algorithm of Xie et al. (2006) which takes into account orographic effects on precipitation. The satellite estimates are those generated by the CPC Morphing technique (CMORPH, Joyce et al. 2004) which defines high-resolution precipitation estimates over the globe by morphing the instantaneous precipitation fields (estimated from all available PMW satellite observations) propagated by the advection vectors derived from consecutive IR images.

A two-step strategy is applied to remove the bias inherent in the CMORPH satellite precipitation estimates and to combine the bias-corrected satellite estimates with the gauge analysis, respectively. First, bias correction is performed for the CMORPH estimates by matching the probability density function (PDF) of the satellite data with that of the gauge analysis. Matching pairs of the gauge and satellite data are collected over grid boxes with at least one gauge over a spatial domain of 10°lat/lon centering at the target grid box and over a time period of 30-days ending at the target date. Cumulative PDF functions are then defined for the satellite and gauge data, respectively. Bias in the satellite estimates is finally identified and removed by matching the cumulative PDF of the satellite estimates with that of the gauge analysis.

The bias corrected CMORPH satellite estimates are then combined with the gauge analysis through the optimal interpolation (OI) technique, in which the bias-corrected CMORPH is used as the first guess while the gauge data is used as the observations. Error statistics are computed for the input gauge and satellite data to maximize the performance of the high-resolution merged analysis of daily precipitation.

An automated system is constructed to create merged analysis of daily precipitation on a 0.25°lat/lon grid over China on a real-time basis using the algorithm described above. Preliminary inspection of the new analysis showed substantial improvements in the quantitative quality compared to its original inputs. A comprehensive examination is underway. Detailed results will be reported at the conference.
Active and passive microwave sensor are very important for atmospheric and surface parameters monitoring. In past decades, microwave sensors like SSM/I, AMSR-E and PR have got great achievements in measuring global temperature profile and Precipitation, as well as surface parameters like soil moisture and snow water equivalent.

FY series satellite is the meteorological satellites of China. Its main objective is to provide data needed for meteorological application. In next generation FY series satellites, we plan to develop our own active and passive microwave sensor, both in polar orbit and in Geostationary orbit.

FY3 is the next generation polar orbit meteorological satellite of China. The first series satellites, FY3-01, is planed to be launched in 2007. There is total of 11 different remote sensing sensor onboard it, design to get the geophysical parameters of atmosphere, land, and ocean surfaces at the same time all day and night and in all weather conditions. There are three passive microwave sensors onboard the satellite: MWRI, which is a 10-channel five-frequency linearly polarized, passive microwave radiometer imager system, designed to measure atmospheric, ocean, and terrain microwave brightness temperatures at 10.65, 18.7, 22.3, 36.5, and 89 GHz; MWTS is one channel microwave sensor designed to obtain atmospheric temperature profile at 50-57GHz frequencies; MWHS is a two channel sensor designed to obtain atmospheric water vapor profile at 150-183GHz.

Active microwave sensor is also planed in FY3-02 series satellites, which is planed to be launched in 2012. In FY3-02 series, the Ku and Ka band precipitation radar, together with other two sensors, are to be setting in a low altitude orbit satellite, together with other two mid-altitude satellites, consists the whole FY3-02 series meteorological satellite constellation. The main target of the active microwave sensor is to monitor the precipitation and disaster weather in global scale.

Keywords: Microwave sensor, FY3, Meteorological Satellite, China
Special Sensor Microwave Imager (SSM/I) Intersensor Calibration and Impact on Precipitation Trend

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The Defense Meteorological Satellite Program (DMSP) Special Sensor Microwave Imager (SSM/I) series provide the longest time series of satellite microwave measurements from July 1987 to present. These observations are being followed with a nearly identical sensor, the Special Sensor Microwave Imager/Sounder (SSMIS), which will continue to operate for at least the next decade. The long records of consistent measurements from multi-sensors are extremely important in generating the climate data records (CDRs). However, because of instrumental differences existed among multiple SSM/I platforms, these different sensors should be calibrated to a reference satellite in order to produce a consistent and high quality CDRs for climate analysis and reanalysis.

This presentation will focus on a simultaneous conical overpass (SCO) technique developed at NOAA/DESDIS in calibration of SSM/I measurements. SCO will match SSM/I measurements from two sensors located near Arctic and Antarctic regions. The collocated measurements then allow for linear and nonlinear calibration corrections. F13 is selected as the reference satellite and only linear calibration is discussed here. Results indicate a clear scan position-dependent antenna temperature data record (TDR) bias of up to -2.5K, while the intersensor bias ranging from -0.92K to 0.83K varies with different channels, platforms, and surface types. A significant deduction of systematic TDR biases among all SSM/I measurements is clearly demonstrated with the calibration. In addition, the calibration shows a significant impact on the TDR trend. Preliminary analysis also indicates a prominent impact of the TDR calibration on environmental data record (EDR). For example, the monthly mean oceanic surface rainrate is consistently weaker with the calibrated TDR than with the uncalibrated TDR. The overall deduction of monthly mean oceanic surface rainrate is about 3.1%. The detailed SCO technique and its impacts on TDR and EDR climate trends will be presented and discussed at the workshop.
The Status of Operational Satellite Precipitation Products at NOAA/NESDIS

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NOAA/NESDIS has been providing user community operational precipitation products for many years from both polar and geo-stationary satellites. These products have been instrumental in supporting NOAA’s role in protecting life and property. In this paper, the current status of the NOAA/NESDIS operational precipitation products and their applications are summarized, and recent developments and future plans on the operational precipitation products are discussed as NOAA enters into the MetOp, NPP, NPOESS and GOES-R era. In addition, the standard procedures on the transition of the scientific algorithms from research to operation at NOAA/NESDIS are briefly outlined.
PRELIMINARY WORKING GROUP REPORTS
22 OCTOBER 2008
A. Introduction
The first validation working group session focused on reviewing old business. We discussed the recommendations from the previous working group meeting and determined if the recommendations had been addressed and if so, to what level. The group determined that several of the recommendations were not addressed since the last meeting and were brought forward to the second group meeting. The agenda for the second meeting was to develop a new set of recommendations to bring forward to IPWG. We also determined a subset that we recommended be brought forward to CGMS. A list of recommendations from the IPWG Validation Working group is presented below.

B. IPWG Validation Working Group Recommendations

**Recommendation 1:** The committee recommends the creation of a subcommittee on validation for PEHRPP.

Discussion: The goal of the new committee is to carry forward the recommendations of the IPWG and PEHRPP Validation Working Group. We suggest that the group would have a fixed membership and 2 co-chairs. The committee suggested that IPWG select members that represent algorithm, application, and validation developers. The members should be involved in PEHRRP. The committee recommended Beth Ebert and Chris Kidd as the first co-chairs because of the experience and involvement in PEHRPP.

Action Items: We suggested that the members of the committee be selected within the next three months.

**Recommendation 2:** The committee recommends an inter-comparison project (similar to PIP, AIP) for the evaluation of HRPP.
Discussion: For the intercomparison, the products should aim for a standard of three hourly, 0.25° resolution with quasi-global coverage, with validation done at a regional scale. The focus should be on the validation of both the level 3 products and the components (level 2). The intercomparison should focus on how errors at high resolution propagate through the products. Details of the inter-comparison (locations (high latitude to tropics), case studies, temporal scale, etc.) will be determined by the new PEHRPP Working Group. The committee should coordinate with the GPM ground validation working group to maximize the impact of such a comparison. If possible, the intercomparison should be conducted in the next 12 to 18 months with a workshop to be held at the end of the intercomparison.

Action Items: PEHRPP Working Group should organize the intercomparison study within the next six months.

**Recommendation 3:** The committee recommends the support of the proposal for Joint Precipitation Intercomparison Activities between International Precipitation Working Group (IPWG) and the Working Group on Numerical Experimentation (WGNE).

Discussion: The goal of the proposal is to expand PEHRPP to include short-range QPF from NWP model forecasts, assimilations and reanalysis. The IPWG is requesting assistance and collaboration with WGNE in these activities.

Action Items: Matt Sapiano will forward any feedback on the proposal to the IPWG and WGNE.

**Recommendation 4:** The committee recommends the development of a list with links on the IPWG web page of existing high quality reference data to enable improved validation of satellite rainfall estimates.

Discussion: The group discussed that it was very important for improved validation activities in different geographical regions that the reference data website be developed. This activity should focus on the determination of the locations and availability of rain gauge networks, disdrometer data, and radar data from national networks, international experiments, the Global Precipitation Climatology Center (GPCC), experimental test sites, TRMM validation sites, and other unique surface precipitation datasets. One issue is data sharing for many countries. In these cases, IPWG should encourage participation of other countries to use the HRPP satellite products and provide feedback to the product developers.

Action Items: Paul Kucera will take the lead on organizing the web link database. **The committee recommends that CGMS pursues the activity of the generation and providing access to a global unified gridded rain gauge database from all nations on a daily scale for validation, hydrology, and other applications to help address this issue.**

**Recommendation 5:** The committee encourages providers of validation observations to provide some type of quality index (e.g., 1 = poor, 10 = excellent).
Discussion: The quality index could be assigned based on if it has been corrected, interpolated, or flagged as suspicious. It was discussed during the working group presentations that this was a good idea. It was brought forward that the definitions of the quality index should be determined in formal workshop supported by CGMS. It was suggested that this should be a recommendation to CGMS.

Action Items: The committee recommends that this should also be an item for CGMS (Note: this was not one of the original CGMS recommendations, but was added after the working group presentations).

**Recommendation 6:** The committee recommends that a feedback website be developed.

Discussion: The goal of this activity would allow users of validation data to provide feedback on the usefulness of the validation products and provide a mechanism to suggest what products/data that would improve the development of HRPP.

Action items: Matt Sapiano will take the lead developing the website. It could include a feedback form and/or an interactive page such as a wiki to provide the necessary feedback to the validation product developers.

**Recommendation 7:** The committee encourages the production/availability of quantitative precipitation estimates (QPE) products from new sensors (e.g., SSMIS, FY-03) for validation purposes.

Discussion: This activity would provide case study analysis for periods beyond SSM/I. Also it would help prolong climate data records beyond SSM/I.

Action Items: The committee recommends that this should be an item for CGMS.

**Recommendation 8:** Recommend the use of existing HRPP in hydrological impact studies, such as the EUMETSAT H-SAF and HydroMet test beds in the US, to assess the usefulness of the HRPP products in hydrological models.

Discussion: The group thought that these types of applications were essential to understand the usefulness of the products and would also provide good feedback to the algorithm developers.

Action Items: The PEHRPP validation committee should coordinate with institutions (e.g., H-SAF, NOAA, etc.) to explore this activity.

**Recommendation 9:** The committee recommends that the meteorological modeling community actively (make available) provides model outputs (e.g. precipitation fields, 700mb winds) to the satellite precipitation development and validation communities.
Discussion: None

Action Items: The PEHRPP validation committee should coordinate with the modeling community (e.g., WGNE) to explore this activity.

**Recommendation 10:** The committee recommends that investigators should evaluate the usefulness of other validation tools and encourage the development of methods to address the issue of validation in regions of sparse surface data.

Discussion: There was a good, extended discussion that this must be done. However, it was pointed out that previous papers have been published on this topic, but those studies have not provided tools or applications that could be used easily by the validation community. The group emphasized that any new techniques should also include the development of a “toolbox” that could be used by the diverse user community. During the general discussion in the working group presentations, this was also highlighted as an important activity for IPWG.

Action Items: Robert Lund and Mekonnen Gebremichael volunteered to develop a white paper to present new statistical methods (e.g., extreme value statistics, PDF of the errors, etc.). Before any new method(s) is supported by the group, the white paper will be circulated for comments and feedback. The PEHRPP validation committee should follow up on this activity in 3-6 months to determine the progress in the development of the white paper.

**Recommendation 11:** The committee recommends that guidelines are established for the standardization of product formats and filename conventions (grid format, units, etc) with the goal of making the data more easily usable among the validation community.

Discussion: This was a topic of extensive discussion during the working group meeting. The discussion pointed out this was a very important activity to make the products more usable by the application community. However, it would be very difficult to impossible to standardize all the formats. Some of the developers would likely not put effort in reformatting their products. One suggestion is that simple reader programs (e.g. convert to standard formats such as ArcGIS) be developed in an effort to resolve this issue. Everyone agreed that at minimum, detailed documentation should be required for all the HRPP to make the products more usable.

Action Item: The PEHRPP Working Group will develop guidelines for data format specifications and documentation.

**Recommendation 12:** The committee recommends that a discussion at a higher level, maybe WMO, concerning the distribution of HRPP through networks such as GEONETCast, should be made to maximize the utility of such products.

Discussion: None
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International Precipitation Working Group  
13-17 October 2008

Action Items: The committee recommends that this should also be a recommendation to CGMS.

**Recommendation 13:** The committee recommends that we include and/or encourage the development of high-latitude validation sites such as the BALTEX, LOFZY follow up 5 years Nordic Seas, high latitude maritime radar sites, Alaskan WSR-88D radars, and/or the Canadian sites.

Discussion: This activity should be coordinated with GPM GV to maximize both efforts in high latitude validation. There was discussion during the IPWG working group summary that this should be a high-priority because the amount of precipitation in the high-latitude regions is often unknown. During the discussion, it was also pointed out that many other regions (e.g., Rocky Mountains) also needed improved validation observations.

Action Items: The PEHRPP validation subcommittee should determine the best method to make the high-latitude datasets available to IPWG community for validation activities.

**Recommendation 14:** The committee recommends that countries or weather institutions with high-quality ground validation dataset actively participate in IPWG sponsored validation activities.

Discussion: None

Action Items: None

**C. Discussion Topics**

Matt Sapiano and Dan Vila pointed out that the Real-time Cooperative Institute for Climate Studies (CICS) validation database contains daily products that are out-of-date (i.e., TMPA). There is a concern that investigators are using products that can have errors and artifacts known to exist in the older versions. Matt mentioned that he knows of at least one case where an investigator was submitting a paper using the old products. This problem needs to be addressed either with the development of methods to include the re-processed products into the database in a systematic way or the database should be removed from the website. A note to mention is that the latest sub-daily products are available online and investigators could generate the daily products from these files. We brought this up in the summary, but it was not discussed. It could be a topic that is addressed by the PEHRPP validation committee.
Applications working group

Chair: George Huffman
Rapporteur: Thomas Heinemann

Participants: Ali Behrangi, Yonghua Chen, Tufa Dinku, Mekonnen Gebremichael, Wolfgang Grabs, Robert Joyce, Christopher Kidd, Vincenzo Levizzani, Stephen Nesbitt, Yoshiki Shiraishi, Piotr Struzik

1. Global IR data sets

The 4-km Global Merged IR dataset is a global merger of the thermal IR images recorded by the 5 primary geosynchronous satellites, with important adjustments applied for zenith-angle and parallax errors in the original pixels. It provides essentially full resolution on a uniform 4-km-equivalent latitude/longitude grid covering 60°N-S every half hour. This dataset was developed and is being hosted by NOAA/NWS/CPC, with a record that has been extended back to early 2000.

IPWG recommendation to CGMS:
The IPWG requests that CGMS strongly support the continued production, with necessary operational development, of the 4-km Global Merged IR dataset. This dataset is a critical part of most of the current generation of global precipitation estimates that involve IR data.

2. Permanent archives and reprocessing

IPWG recommendation to CGMS:
The IPWG requests that CGMS strongly supports the establishment of permanent active archives for all sensors and operational algorithms that produce precipitation estimates. It is critical that the archives contain complete records of data for both a) the original satellite data (level 1b), and b) precipitation estimates (level 2 and level 3), and that periodic reprocessing be carried out on the entire record as the state of the art in calibration and precipitation retrievals advances.

3. Initiative for mainstreaming satellite precipitation products in operations

IPWG recommendation to CGMS:
The IPWG recommends that CGMS endorse developing a comprehensive initiative to enable users to better exploit the satellite-derived precipitation observations in
operational hydrological and meteorological forecasting and water resources management. This recommendation is consistent with initiatives and programmes like the IFAS International Flood Alert System, the ECMWF assimilation of cloudy radiance data, the development of long-term reanalysis products, and the EUMETSAT’s H-SAF, and should be seen in the context of the R&D to Operations Transition Strategy by WMO. IPWG will take up the task to further develop the concept and necessary actions in collaboration with WMO and other partners, including CGMS.

**Recommendations to IPWG:**
Recognizing the generally inadequate use of available satellite precipitation estimation products by National Meteorological and Hydrological Services (NMHSs), IPWG will work with relevant partners to:

I. Explore options to increase institutional service delivery capacity for the long-term provision of data and product services related to satellite precipitation estimates for operational purposes;

II. Facilitate capacity building to better enable users, and in particular NMHSs, to make use of satellite precipitation products;

III. Promote development of standards and mechanisms to ensure the interoperability of products and services;

IV. Facilitate the building of a “Community of Practice” which will:
   i. define and regularly update user requirements,
   ii. exchange experiences in the use of satellite precipitation products,
   iii. promote and support calibration and validation exercises worldwide and
   iv. promote the use of available data and products for forecasting, assessment and management purposes in particular in developing countries.

**Action (IPWG Co-Chairs):** Define specific actions and recruit interested members to carry out this framework.

4. **Precipitation product contents standard**

For the users of satellite precipitation products the large variety of provided contents in satellite product files is often a problem. Therefore a proposal for a contents standard definition was made at the 2nd IPWG and renewed at the 3rd IPWG. The response to the proposal was unfortunately almost non-existent. The Applications WG still considers this issue to be of high importance but decided not to give a new recommendation separate from the Mainstreaming initiative.
5. **Web-page update**

IPWG recommends that the contents of the IPWG web-pages are updated regularly, but at least revisited yearly. The web-master is responsible to trigger the update process.

**Action (Vincenzo Levizziani):** Contact contents providers of all parts of the IPWG web-page regularly (at least yearly) to check and update their contributions to the web-pages.

6. **Web page visibility**

On the IPWG web-page a feedback section is provided for the users of satellite precipitation products with the intention to facilitate the reporting of feedback or anomalies to the product developers. This mechanism is hardly ever used. The poor visibility of the IPWG web-page to the wider community was identified as one probable reason.

**Action (IPWG members):** The information about the IPWG web-page should be added to the README-files which are provided with the precipitation data created by the various IPWG members. As well, IPWG members are requested to provide appropriate external Web locations that might link to the IPWG pages.

7. **Export algorithms**

On the IPWG Web-pages a section is dedicated to algorithms which can be downloaded and used by everybody. Only two algorithms are provided currently, one each for IR (Tapiador) and passive microwave (Ferraro). It was doubted that many additional of those export algorithms will be posted, because there is usually no funding and no support for it. In addition it is becoming more and more difficult to make more sophisticated algorithms available as export algorithm packages (including documentation). For new users getting the necessary input data may be more difficult than bringing up the export algorithm. Accordingly, each export algorithm’s package should include information on data availability, an introductory tutorial, and a consistent set of test input and output data, together with the algorithm software. The working group agreed that the Web page should continue to be open for the addition of new algorithms. At the same time, state-of-the-art algorithms should be promoted by providing their developers’ contact information.

**Action (Vincenzo Levizziani):** Contact providers of current algorithms to make the data sets complete (add test input/output and tutorial).
8. Training

The best way to provide training to potential users of satellite precipitation products was discussed. Some work has been done by providing relevant information on the IPWG web-page. According to the experience of the working group participants, one effective way of training on satellite products is to provide roving seminars. In this context, the precipitation training should be coordinated with existing training activities (e.g. satellite agencies).

Action (IPWG members): If IPWG members identify a specific need for training, they may contact WMO for organisational or monetary help.

Action (Wolfgang Grabs): Evaluate the opportunities to receive funding from the satellite program of WMO for specific training on the application of precipitation data from satellites.

Action (IPWG Co-Chairs): Contact organisations which already provide training on the use of satellite products, and foster the promotion of satellite precipitation data in their courses.

9. Diverse product goals

Discussion revealed that the various requirements of the user community cannot be satisfied by a single product. In some cases joint observational products delivering the best possible instantaneous result are needed, while for others (e.g. climate applications) it is more important for the products to be consistent over time. In the same sense, the combination of numerical predictions and observational data will provide better information for some application but not for others. Therefore, as a matter of policy it is necessary to provide multiple products.

10. Minimum scales available from satellite observations

Status: Available and near-future satellite technology provide high-quality (i.e., microwave-based) precipitation estimates with a resolution of about 3 hours and 0.1<deg>. Lower-quality (generally IR) precipitation estimates are available from geosynchronous satellites with intervals of about a half hour and 4 km. User requirements for finer scales can only be accommodated by some form of interpolation, extrapolation, or disaggregation.
11. **H-SAF workshop**

**Information:** The EUMETSAT H-SAF 2nd workshop will take place in autumn 2009. The topic is related to hydrological applications of satellite products such as precipitation soil moisture and snow. Detailed information will be provided via IPWG web-page in due time.
New Technologies/Techniques WG

Chair: Fuzhong Weng (NOAA/NESDIS)
Rapporteur: Alan Geer (ECMWF)

Participants: Alan Geer (ECMWF), Eastwood Im (NASA/JPL), Hisaki Eito (JMA), Attilio Di Diodato (Meteocm/Italy), Deborah Hill (Metoffice), Bizzarro Bizzarri (TIN/Italy), Fuzhong Weng (NOAA/NESDIS/JCSDA), Ninghai Sun (NOAA/NESDIS), Adrian Jupp (Metoffice), Ran You (CMA), Wei Han (CMA), Wesley Berg (CSU)

A. New Sensors and Technology

A.1 Microwaves in GEO

Frequent observations from geostationary orbit, at time and space scales consistent with precipitation, constitute a very important technological capability, for several reasons, e.g.:

- more accurate accumulated precipitation for the needs of operational hydrology;
- more frequent information on temperature and water vapour in precipitation conditions;
- driving rapid update assimilation for NWP, with benefit for all other outputs from the NWP model.

The progress of scientific knowledge on the relationships between microwave-millimetre wave radiation and precipitation was noted with great interest, also because these developments are consistent with previous recommendations from IPWG (see proceedings of the 2nd Workshop, in Monterey 2004, and 3rd Workshop, Melbourne 2006).

It was noted that exploiting microwave-submillimeter wavelengths for precipitation measurements will require intensive calibration/validation effort. The opportunity of flying the demonstration mission at a time when the GPM Core observatory is still operational should be exploited.

Recommendation – IPWG considers Geo-MW a continual interest to broader community despite no leadership identified. The cost-effectiveness of various antenna technologies (solid vs. synthetic aperture) should be continued and the results from IPWG technology group will be reported to future CGMS.

Recommendation – IPWG technology working group to perform peer-reviews on GEO-MW proposal presented to CGMS and provide the comments to BIZZ at next IPWG meeting or as soon as possible.

A.2 Frequencies for passive MW radiometers
Progress in passive MW radiometry has been recently achieved with the addition of sounding channels in the 54 GHz band (for temperature) and 183 GHz (water vapour), as well a 150 GHz window channel, to the basic set of SSM/I channels. Further improvements are foreseen with the passive MW radiometer of the GPM Core observatory and the NASA Constellation satellite, with the addition of a 10.8 GHz channel and a sharp improvement of the spatial resolution.

Considering further possible improvements, for instance for the GCOM-W 2 and 3 satellites, the value of the 118 GHz band should be explored. This band was studied in the context of EGPM (European Contribution to the GPM) and it is shown the differential information between corresponding channels 54 GHz and 118 GHz is of significance for precipitation, especially in respect of discriminating liquid from solid.

**Recommendation** – In respect of planning for future passive MW radiometers, IPWG considers that the benefit of the 118 GHz band be explored, either as additional to the couple 54 + 118 GHz, or alternative to the 183 GHz band or the 54 GHz band

Action: IPWG undertakes uses of simulated observations of 54 GHz and 118 GHz for quantitative retrievals of cloud and precipitation, temperature and water vapour as well as NWP applications in storm intensity/track predictions. The benefits of additional 118 GHz in configuration will be assessed relative to the legacy system of 50-60 GHz and 183 GHz. (POC: Fuzhong Weng and BIZZ/Mugnai)

A.3. Long-term continuity of precipitation radars in space

The progress with consolidating the GPM programme was strongly appreciated. As regards the GPM Core observatory, the cooperative NASA-JAXA undertaking seems secured. As regards the GPM Constellation, the inventory of secured and potential contributions is encouraging.

In respect of long-term perspectives, it was noted that many Constellation satellites are in effect part of operational programmes, thus long-term continuity for at least a large fraction of the GPM Constellation is secured. The problem is with the core observatory equipped with dual-frequency precipitation radar. In this context, the plan from China for a series of FY-3 units to carry a dual-frequency precipitation radar (FY-3RM) was much welcome.

**Recommendation** – IPWG considers that precipitation radar in space should continue after the current TRMM and the future GPM Core observatory, and recommends CGMS to endorse the Chinese FY-3RM.

A.4  Improved precipitation radar

Great benefit is expected from the introduction of dual-frequency capability in the GPM Core observatory precipitation radar. Extension of precipitation detection to light precipitation and snowfall is expected. Improved characterisation of cloud microphysics will be possible.
The application of the CloudSat Cloud Radar for precipitation and cloud microphysics observation has been surprisingly effective. Consideration of adding a 94 GHz capability to the basic 14 and 35 GHz should be given although it is understood that a three-band radar complex could become huge, especially if imaging capability at 90 GHz also is requested.

Another potential improvement of great interest would be the Doppler capability. Information on vertical velocity would help precipitation retrieval since it is obviously correlated to precipitation. In addition, it would be an extremely important information for NWP. It is understood that adding Doppler capability, although not as challenging as adding the 94 GHz capability, is still rather challenging for a fast-mobile platform. Trade-off with sensitivity and swath width would arise.

Dual polarisation could help with liquid/solid precipitation discrimination and cloud microphysics characterisation. In this case also, it is understood that challenges would arise in respect of sensitivity (that would need to be substantially improved) and consequently achievable swath.

**Recommendation** – Various possibilities for improving future precipitation radars should be considered, and their cost-effectiveness assessed.

A.5 Lightning mapping

IPWG was pleased to note that lightning mappers are foreseen for a number of future geostationary satellites (at least GOES-R, Meteosat Third Generation, FY-4). This is entirely appropriate since, obviously, convection monitoring requires all-time monitoring and real-time data access. A concern was expressed on the lack of methods to exploit at best lightning information for improving precipitation retrieval and, in general, to make quantitative use of lightning information.

It was noted that no lightning mapper is currently foreseen on the GPM Core observatory to provide continuity to the TRMM LIS. Although the observing cycle from a low-orbiting satellite is not attractive, the synergy with the precipitation radar and the passive MW radiometer could be exploited in a unique environment. To be noted that a lightning mapper in LEO can have much better spatial resolution and sensitivity than in GEO, thus serve as a “calibrator”.

Apart from synergy with radar, lightning mapping could be useful also if simply associated to passive MW radiometry. The planned Brazilian contribution to the GPM Constellation includes a lightning mapper alongside the MW radiometer.

**Recommendation** – Intensify studies aiming at improving quantitative use of lightning information from geostationary satellite with other information, specifically in support of precipitation retrieval.

Action: IPWG encourages an independent study to understand the linkage between lightning information and precipitation
B. Data Assimilation in Precipitation Conditions

B.1. Direct Assimilation of Rain-affected Radiances

Satellites provide over 90% of the data ingested by today’s state of the art NWP models, although the utilized satellite data is only a small fraction of that available. Many data are excluded by a thinning process that attempts to make the numbers more manageable for timely processing and to remove possibly horizontally correlated errors. Others are excluded because they are suspected of being cloud- or rain-affected, which renders their quantitative interpretations (e.g., retrievals of atmospheric temperature profiles) more prone to error. These latter observations naturally contain some information about the clouds and precipitation present. Better use of their content requires estimating some properties of any clouds and precipitation affecting the local radiative transfer.

Recommendation – IPWG encourages studies to intercompare the approaches used at different NWP centers for assimilation of cloudy and rain-affected radiances, and to identify the best practices in areas of radiative transfer modeling, cloud and rain screening procedures, and tangent linear and adjoint schemes of cloud and moisture physics.

Action: Exchange of visitors between JCSDA, Metoffice and ECMWF (POC: Allan Geer and Fuzhong Weng)

B.2 Precipitation Products Assimilation

Precipitation estimated from radar data or derived from IR and MW satellite radiances has been assimilated in some operational or research models for many years. The assimilation techniques began with empirical nudging and more recently have evolved towards optimal estimation theory. Variational techniques, including both 3 and 4 dimensional schemes, are currently employed operationally at a few centers. Success according to some measures has been sufficient to continue the operational practice. Forecast improvements thus far have been generally limited to the first day, and for some systems to only the first 6 hours.

Recommendations: IPWG encourages studies to understand impacts of assimilation of precipitation products in various space and time scales and exchanging information on moisture physics used in variation analysis.

Action: Conduct the 4D-Var assimilation tests in assimilating precipitation products, and report to the next IPWG (POC: JMA ?? Hisaki Eito)

C. Need for Precipitation Climate Data Record Generation

C.1 Microwave Imager Data Preservation
To create high quality climate data records of precipitation and related hydrological fields a well documented and transparent process is necessary starting from the original counts recorded by the sensor to the subsequent calibration of the brightness temperature data (i.e. level 1B) and ultimately to the calculation of geophysical parameters (level 2). As the lesson of the MSU temperature record has previously established, such transparency is critical in order to ensure the highest quality datasets for climate applications. This not only allows the science community to verify and/or identify problems or deficiencies in the aforementioned climate data records, but enables the reprocessing of these records as additional data becomes available and/or improved techniques or algorithms are developed. Based on previous experience with SSM/I in particular, two critical aspects have been identified that need to be addressed. First, it is imperative that the responsible space agencies fully document the characteristics of the instrument and archive the raw counts or equivalent data along with all of the relevant sensor and spacecraft information. This includes, but is not limited to hot and cold load calibration targets, thermister temperature data, spacecraft ephemeris and pointing information etc. Ideally, this would involve orbitized level 1 data granules in a self-describing format containing the original count data along with all of the information necessary to compute the antenna temperature, latitude, longitude, and view angle for each pixel, as well as any other information that might be used for precise calibration of the sensor data. The second aspect involves completely documenting the entire processing stream involved with the computation of the climate data records. This aspect includes, but is not limited to, the calculation of brightness temperatures, geolocation information, corrections to the data to account for issues such as an emissive antenna or intrusions into the feedhorn, intercalibration between sensors, and the algorithms applied to compute geophysical parameters.

Action: 1) Support the timely development of a prototype level 1A dataset from TRMM TMI data as an example for satellite providers. 2) Convey to CGMS the importance for satellite providers to properly document and archive the level 1 data as specified above. This should also be coordinated with ITWG and GCIS. 3) Encourage a level of transparency in the creation of climate data records that allows for future reprocessing incorporating new approaches.

Recommendation – CGMS authorizes IPWG technology group to develop a standard archival procedure for metadata such as antenna pattern correction. Encourage space agencies to follow the archival procedure so as to give a level of transparency in the creation of climate data records that allows for future reprocessing incorporating new approaches.

Action: Maks available TRMM TMI level 1A ATBD to all the space agencies (POC: Wes Berg)

D. Frequency Protection Issues

Recommendation – IPWG coordinate with ITWG on protecting all the needed microwave radiometers. All space agencies designing sensors should strive towards engineering solutions which detect and reduce the effects of radio interference. Where user requirements can be met using protected frequencies, these frequencies should be used. In such cases, bands used should not extend beyond such protected regions of the spectrum.