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NOAA PI PMM Annual Report:

A Physical Rainfall Rate Algorithm for All Surfaces: Applicability to All Microwave Sensors Including TRMM & GPM

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Project Objectives

Extend algorithm to TRMM and GPM sensors

The project will extend the development of an existing physically-based rainfall rate retrieval algorithm, applicable to all microwave passive sensors, to include the capability to process TRMM and GPM constellation sensors. This algorithm is valid over land and ocean. The design of the algorithm is based on the generic One-Dimensional Variational (1DVAR) approach where the solution starts from a first guess and converges to the final estimate based on a forward model and its Jacobian. The final solution found is guaranteed to at least fit the brightness temperatures measurements. The algorithm we build on is called the Microwave Integrated Retrieval System (MiRS). The MiRS algorithm uses a comprehensive approach to sensing geophysical parameters from space. It retrieves all parameters that have an impact on the measurements, simultaneously. It therefore retrieves soundings of temperature and moisture, along with surface emissivity, skin temperature and hydrometeors parameters, all at the same time, ensuring that the final solution is totally consistent with the measurements. This feature allows it for instance to account for emissivity variations when obtaining rain estimates which is critical for rain retrieval over land using low frequency channels. The MiRS algorithm has been applied successfully in the past, and its modular design allows for a timely and efficient extension to the TRMM and GPM sensors. MiRS has been running operationally for the AMSU and MHS sensors onboard NOAA-18, 19 and Metop-A as well as for SSMI/S onboard DMSP F16, running experimentally using AMSR-E data, and has been applied routinely to ATMS proxy data in preparation for the NPP launch in 2011. The rainfall rate algorithm over both ocean and land has been operational since 2008.

Validate algorithm and its products.

We will validate this expanded algorithm by using real data from TRMM and Megha-Tropiques (planned for 2010). We will leverage an internal validation testbed used for polar-orbiting satellites (NOAA-18, 19, Metop-A and DMSP-F16 SSMIS) as well as leverage NASA GPM ground validation (GV) activities – current and planned in the Science Implementation Plan SIP-. We will use the Canadian CloudSat/CALIPSO Validation Program, C^3VP and other field campaigns such as the planned Mid-Latitude Convective Clouds Experiment, MC^3E, which will be held at the DOE CART ARM facility in Oklahoma, in order to validate model microphysics parameterizations. We will use these analyses to interpret and validate MiRS rain and snow retrievals from various satellites including TRMM and GPM sensors during C^3VP and MC^3E, as well as polar-orbiting satellites with AMSU/MHS onboard.

Progress Report:

Improvements to the MiRS TMI retrievals and the routine validation of the retrieved products have been made this year. MIRS TRMM is being processed on a daily basis at 9 km resolution near the Southeast US and Gulf of Mexico region and globally at 70 km resolution. The MiRS retrieved parameters include atmospheric temperature and water vapor profiles, rainfall rate, cloud liquid water, ice water path, rain water path, total precipitable water, land surface temperature, surface emissivity spectrum. Direct assessments of MiRS TMI rain rates and indirect assessments by way of surface emissivity, total precipitable water, and skin temperature show good agreement. GPM GMI simulated data are being generated using European Centre for Medium-Range Weather Forecasts (ECMWF) fields collocated with the TRMM TMI, and used to produced MIRS GMI products daily over same region and resolution.

Improvements to the MiRS algorithm

Improvements have been made to science components of the algorithm. The MiRS algorithm is based on the generic One-Dimensional Variational (1DVAR) approach where the solution starts from a first guess and converges to the final estimate based on a forward model and its Jacobian. Convergence tests are adjusted to account for each sensor's characteristics. For TRMM TMI, model uncertainties at high frequencies were reduced in the first attempt to detect more rain, and relaxed in the second attempt (where hydrometeors are assumed to be present). Also, Channel 2 (10.65 GHz) was turned off because its large footprint was found to be contaminated by land in coastal areas. The changes have increased the rain detection in both light and heavy conditions, and made the rain rates in coastal transitions smoother.

Evaluation of MiRS TMI rainfall rate

Direct assessment of rain rates use comparisons against TRMM 2A12, NWP Stage IV radar data, and CPC analysis are made daily. Figure 1 shows rainfall rates from MiRS using TMI data and TRMM 2A12 data. Each point of the TRMM 2A12 data is matched to a corresponding MiRS TMI point so that histograms, scatter plots, and statistics of their differences are also generated.

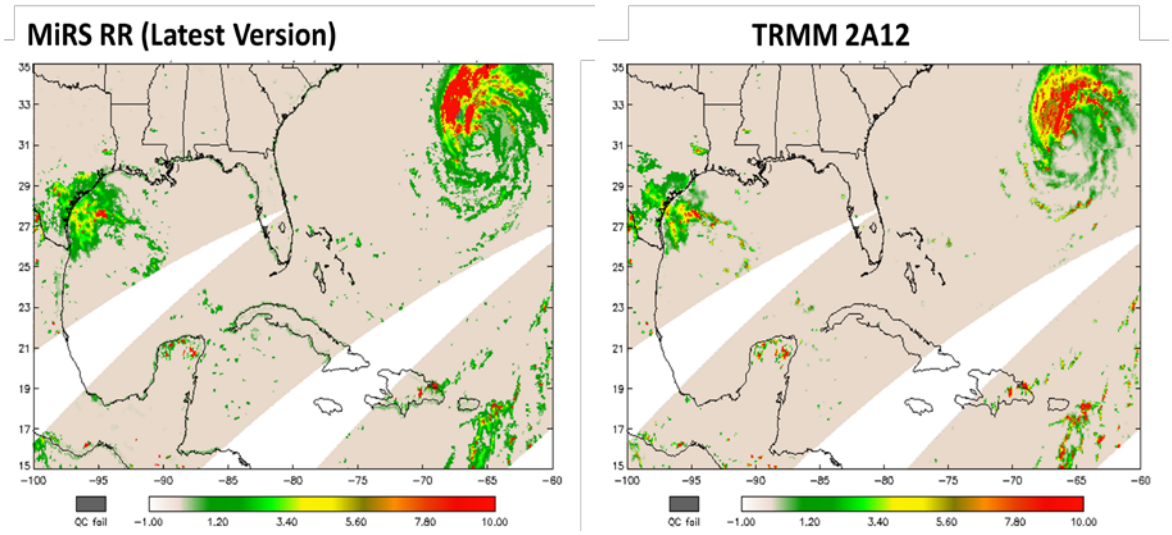


Figure 1. Example of retrieved rainfall rate from MiRS on TMI data (left) compared to TRMM 2A12 data (right) for 2010-07-25.

Support to the Passive Algorithm Working Group (Surface Emissivity Under Rainy Conditions)

MiRS is able to provide surface emissivity which are radiometrically consistent with all retrieval parameters, even under rainy conditions. Figure 2 shows how the changes in surface emissivity as a storm system moved across the US is captured. The averaged retrieved surface emissivities over a region in northern Texas, western Oklahoma drop as the region experiences a rain event, and slowly begins to recover. We support the Passive Algorithm Working Group in a number of ways such as providing dynamically estimated emissivity or using MiRS emissivity retrievals to build an emissivity covariance matrices in rainy conditions.

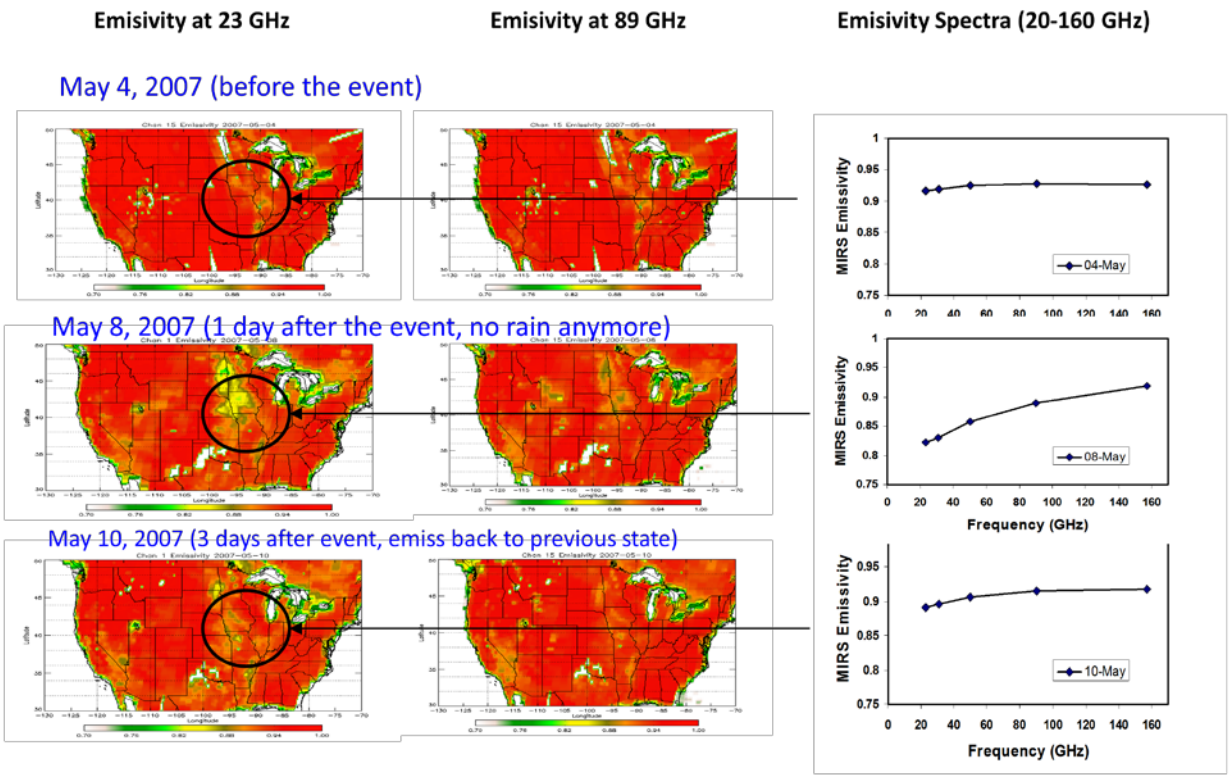
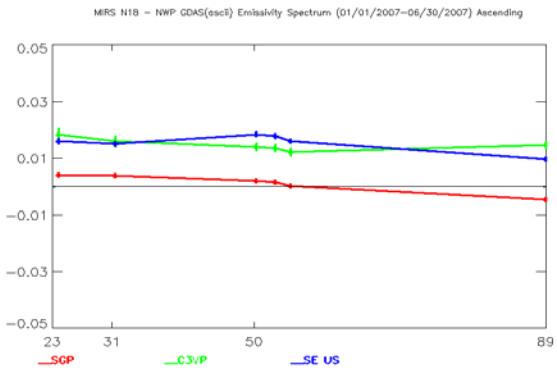


Figure 2. Maps of MiRS F18 rain rates on October 18, 23, 27, 2010 showing a system moving through the southern US (above). A corresponding timeseries of MiRS F18 emissivity (below).

Support to the Surface Characterization Working Group (Surface Emissivity Intercomparisons)

The GPM Land Surface Characterization Working Group (LSWG) is tasked with improving emissivity retrievals for the better development of physically based precipitation retrievals over land. As one of the first steps, they are assessing the current state of land surface emissivity models and retrievals with an intercomparison of emissivity products. In support of the LSWG, we have compared surface emissivities from MiRS NOAA18 AMSU-A/MHS and NCEP Global Data Assimilation System (GDAS) at the prescribed target regions and time period. Figure 3 shows the mean differences between the two emissivities at three regions for the period between January and July 2007 are within two percent.



Plans for the upcoming year:

- Refine the generation of rainy condition surface emissivity covariances for multiple sensors.
- Support the GPM XCal group by using MiRS to translate brightness temperature between the different sensors channels.
- Expand validation of MiRS products with NASA GPM ground validation (GV) activities, the Canadian CloudSat/CALIPSO Validation Program (C^3VP) and other field campaigns, in order to validate model microphysics parameterizations.
- Extend MIRS to Megha-Tropiques SAPHIR/MADRAS once proxy data become available, including MIRS end-to-end codes, surface emissivity covariances, and radiometric bias correction.

Publications and Presentations:

S.-A. Boukabara and K. Garrett, "A Physically-Based Rainfall Rate Algorithm for the Global Precipitation Mission." 5th IPWG Workshop,Oct. 12, 2010, Hamburg, Germany.

S.-A. Boukabara , L. Moy, K. Garrett, F. Iturbide-Sanchez, C. Grassotti, W. Chen, "A Physically-Based Rainfall Rate Algorithm for All Surfaces: Applicable to All Microwave Sensors Including TRMM & GPM." 2010 Precipitation Measurement Mission Science Team Meeting, Seattle, WA, Nov. 1-4, 2010.

S.-A. Boukabara , L. Moy, K. Garrett, F. Iturbide-Sanchez, C. Grassotti, W. Chen, "A Physically-Based Rainfall Rate Algorithm for All Surfaces: Suggestions for Ways to Combine with the Team Algorithm." Algorithm Working Group Team Meeting, Ft. Collins, CO, July 11-12, 2011.

L. Moy, S.-A. Boukabara, K. Garrett, F. Iturbide-Sanchez, C. Grassotti, W. Chen, "MiRS Project Collaboration with GPM X-Cal Activities." Inter-calibration Group Meeting, Ft. Collins, CO, July 13, 2011.

Budget Summary

The project is on budget.