# 2016 GSICS User’s Workshop – Proposed Microwave Session

Draft Version – 18 July 2016

1. **Introduction/Overview – 5 min – R. Ferraro**
2. **Investigating Shortcomings of Radiative Transfer Models at Microwave Frequencies – 20 min – W. Berg**
3. **Stability and Interconsistency of Passive Microwave Water Vapor Products for Weather and Climate – 20 min – J. Forsythe**
4. **What Happens to Radiances after They Leave Home: Precipitation – 20 min – G. Huffman**
5. **Toward a Long-Term Climate Change Monitoring in the JPSS Era – 20 min – C-Z. Zou**
6. **Closing/Discussion – 5 min – R. Ferraro**

**Investigating Shortcomings of**

**Radiative Transfer Models at Microwave Frequencies**

Wes Berg, Colorado State University

In recent years there have been notable improvements in the quality and stability of the calibration for several of the current generation satellite microwave imagers and sounders. These improvements have been driven by a focus on calibration that have included a combination of technological developments, design changes to address the source of issues with previous sensors, and the use of on-orbit maneuvers to better characterize calibration-related corrections. With these advances, the accuracy and thus the agreement between observed brightness temperatures (Tb) from microwave imagers such as WindSat and GMI and sounders like ATMS and MHS has started to exceed the capability of current radiative transfer models (RTMs). The use of on-orbit maneuvers to correct for issues such as antenna spillover and cross-track biases that are difficult to measure prior to launch and do not rely on radiative transfer models, provides an opportunity to investigate deficiencies with the models. In other words, instead of using RTMs to characterize and/or improve satellite calibration deficiencies, we are focusing on using high-quality satellite observations to characterize deficiencies in the RTMs.

While a GMI-based 1D variational retrieval algorithm for non-precipitating ocean scenes shows improvement in the Tb residuals with the latest updated calibration, the choice of ocean emissivity models has a much larger impact on the results. There are significant differences in the simulated Tb depending on the ocean emissivity model used for window channel and/or sounding channels that are sensitive to surface emission. This is an issue for both calibration and clear-sky/non-precipitating ocean retrievals as surface emissivity varies dramatically as a function of frequency, surface temperature, surface wind speed and direction, and view angle. Similarly, a workshop in Paris in 2015 and subsequent publication focused on trying to resolve discrepancies between observed and simulated Tb for sounding channels near the 183 GHz water vapor line. Efforts such as these to understand deficiencies and improve the RTMs for both microwave window and sounding channels are important to many GSICS-related activities including instrument intercalibration, relcalibration of archived data, and tying the calibration to a reference standard consistent with RTMs. It is also highly relevant to applications such as data assimilation and the development of long-term multisensor climate data sets. We have begun working to assemble high-quality in-situ observations of ocean surface parameters and atmospheric profiles from ships, buoys, and coastal sites in order to better understand the limitations of current ocean emissivity models. To address issues with both atmospheric and surface models across the full range of imaging and sounding channels, however, will require coordinating such efforts with those like the Paris workshop and related efforts within GSICS.

**What Happens to Radiances after They Leave Home: Precipitation**

**George J. Huffman,** *NASA/GSFC, Greenbelt, MD, USA*

Modern estimates of global precipitation critically depend on passive microwave data from the international constellation of satellites. As a result, the precipitation community is highly dependent on careful radiometric calibration among the various microwave sensors, for the present time, stretching back to the beginning of the “modern” microwave era (starting with DMSP F08), and continuing into the future. However, calibrated radiances are only the first step in the process of creating (quasi-)globally complete gridded precipitation data sets. These global merged multi-satellite precipitation products are also highly dependent on the algorithms that convert calibrated radiances from individual sensors into precipitation estimates that are combined to form the final estimate. Typically, there is an effort to tune the algorithms to compensate for sensor differences (i.e, footprint sizes, channels, etc.) to maintain as much consistency as possible in the resulting precipitation estimates, and then there is another round of intercalibration for these precipitation estimates in the process creating the multi-satellite combinations. In certain situations it is advantageous to use infrared radiance-based precipitation estimates to fill notable gaps in the microwave coverage despite their lower quality. Creating all these individual and combined precipitation products requires detailed insight into the capabilities and (potentially) changing characteristics of the various sensors. Documentation of this information is a key requirement for the long-term viability of the data record in support of current estimates, and subsequent algorithm upgrades and reprocessings.

One application of this entire end-to-end process is the Global Precipitation Climatology Project (GPCP). It uses two generations of DMSP sensors (SSMI, SSMIS) that provide the 6 a.m./6 p.m. observations from F08, F11, F13, and now F17, to calibrate the GPCP monthly satellite-gauge combined product, which adheres to Climate Data Record standards. Despite the current long record, the precipitation community is concerned about how coverage for this critical orbit slot will continue past the end of the DMSP program. Other multi-satellite algorithms create near-real-time products, including the Integrated Multi-satellitE Retrievals for Global Precipitation Measurement mission (IMERG). These products require timely notice and resolution of anomalies, such as the DMSP F17 37V channel this spring, to ensure a steady stream of high-quality output to support important societal benefit areas, including flood and drought analyses.

It is interesting to consider what roles GSICS and the other major international organizations should take in supporting the precipitation community’s needs across the international constellation of satellites for calibrations between sensors and satellite metadata repositories (including operational information) covering the entire instrumental record, for timely attention to new satellite and instrument anomalies, and for continuation of the constellation.

**Toward a Long-Term Climate Change Monitoring in the JPSS Era**

***Cheng-Zhi Zou,*** NOAA/NESDIS/Center for Satellite Applications and Research, College Park, USA

Climate change monitoring requires high quality climate data records (CDR) on both global as well as regional scales. In contrast to limited spatial coverage in conventional observations, satellite observations from microwave and infrared sounders provide valuable atmospheric temperature observations with global coverage and fine resolutions for global and regional climate change monitoring. Over the last ten years, NOAA/STAR developed high quality CDRs from sounding observations onboard historical and currently operating NOAA polar-orbiting satellites for long-term change monitoring and variability studies in upper-air temperatures. Innovative inter-calibration approaches were developed to achieve consistency between satellites. A group of CDR products, including 37 years of layer temperature dataset from lower-troposphere to the upper-stratosphere were developed by merging MSU, SSU and AMSU-A together. The products are updated monthly and they are widely used by the climate community for climate change investigation and monitoring. All POES satellites from TIROS-N to NOAA-18, MetOp, and EOS AQUA were used to ensure continuity of CDR products.

ATMS is a new generation microwave sounder equipped on the current Suomi NPP and to be flown on the future JPSS. ATMS is a successor to AMSU with the same channel frequency for most channels and with higher scanning resolution and measurement accuracy. JPSS will also carry a hyperspectral sounder, the Cross-track Infrared Sounder (CrIS), for atmospheric temperature measurements with thousands of channels. CrIS channels can be convolved with the other hyperspectral sounder--AIRS, which had 5 years of overlaps with the earlier infrared sounder, the SSU. With the overlap, it is possible to merge the SSU CDR with AIRS which is then to extend further to CrIS.

The JPSS program will include 4 more ATMS sensors beyond SNPP. Each JPSS satellite is designed in stable afternoon orbits (13:30) for a life cycle of 7 years, launched every 5 years, providing at least 2 years of overlap with the previous satellite. The series of ATMS sensors as well as CrIS will continue at least until 2038, providing eventually a record of nearly 60 years with extensions from the MSU/ASMU-A/SSU. The temperature record from SNPP and JPSS is expected to be of exceptionally stable because of the stable orbits and the more advance design of the sensors. Merging of ATMS and CrIS with the existing MSU/AMSU-A/SSU CDRs will extend the upper-air temperature time series into the future for sustained climate services to both the scientific and public societies.

This presentation will review the current NOAA/STAR MSU/AMSU/SSU CDR products. We will discuss the inter-calibration approach within the GSICS framework. We will discuss bias correction methodologies and challenges in merging the JPSS ATMS/CrIS with POES MSU/SSU/AMSU-A for CDR development. Finally, a perspective for the application of the merged MSU/SSU/AMSU/ATMS/CrIS in climate change monitoring is provided.