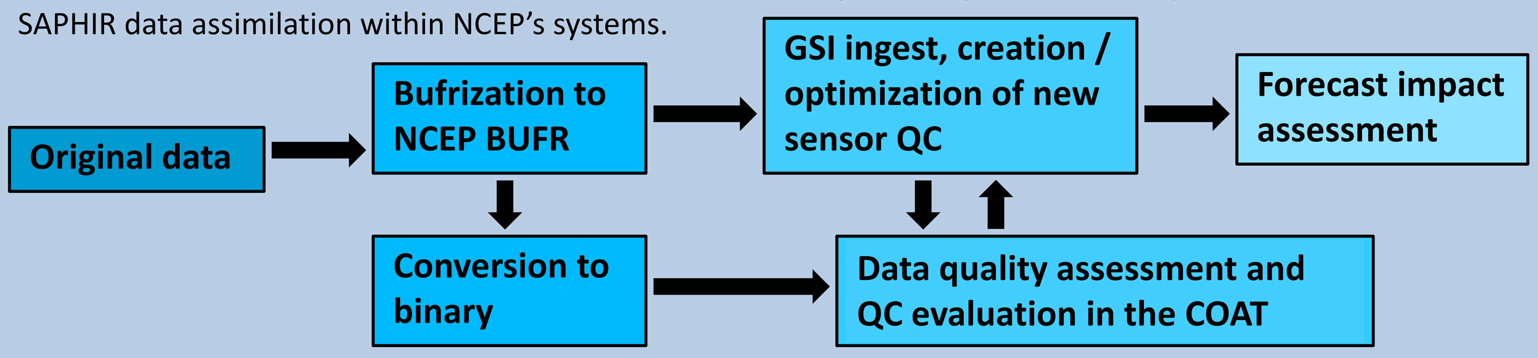
The Assimilation of AMSR2, GMI, and SAPHIR Data the NCEP GDAS

Erin Jones[1], Kevin Garrett[1], Eric Maddy[1], and Sid Boukabara[2]

1. Riverside Technology, Inc., JCSDA 2. NOAA/NESDIS/STAR, JCSDA

Introduction

The Global Precipitation Measurement (GPM) Microwave Imager (GMI), Global Change Observation Mission-Water 1 (GCOM-W1) Advanced Microwave Scanning Radiometer 2 (AMSR2), and Megha-Tropiques Sondeur Atmosphérique du Profil d'Humidité Intertropicale par Radiométrie (SAPHIR) instruments are currently providing surface and atmosphere radiance data across multiple channels in near-real-time, but these data are not presently being used operationally in the National Center for Environmental Prediction's (NCEP) Global Data Assimilation System (GDAS), which uses the Community Gridpoint Statistical Interpolation system (GSI). In an effort to take advantage of the observations being provided by these satellites in a numerical weather prediction context, NOAA's Center for Satellite Applications and Research (STAR), in support of the Joint Center for Satellite Data Assimilation (JCSDA), has endeavored to begin testing and optimizing GMI, AMSR2, and SAPHIR data assimilation within NCEP's systems.



The process taken to add new observations to NCEP's systems. STAR, in support of the JCSDA, uses the Community Observation Assessment Tool (COAT) to independently assess observations and to evaluate QC.

Methods

GMI, AMSR2, and SAPHIR BUFR data were converted to a binary format for assessment in the COAT. Since the COAT provides a channel-by-channel assessment of satellite-observed brightness temperatures with respect to co-located simulated brightness temperatures from NWP backgrounds in all sky conditions over all surface types, the results can be used to assess the quality of the observations being ingested into the GDAS, and to test filtering of cloud and precipitation-contaminated observations.

Observation errors for GMI, AMSR2, and SAPHIR observations used in the GDAS are taken from COAT results, or from OmAs generated by the GDAS. Coefficients used in cloud, precipitation, and emissivity retrievals for filtering of the data over ocean were derived from a multi-linear regression. Additional quality control measures for GMI and AMSR2 data will be implemented to remove observations that have been contaminated by radio frequency interference (RFI) and sun glint.

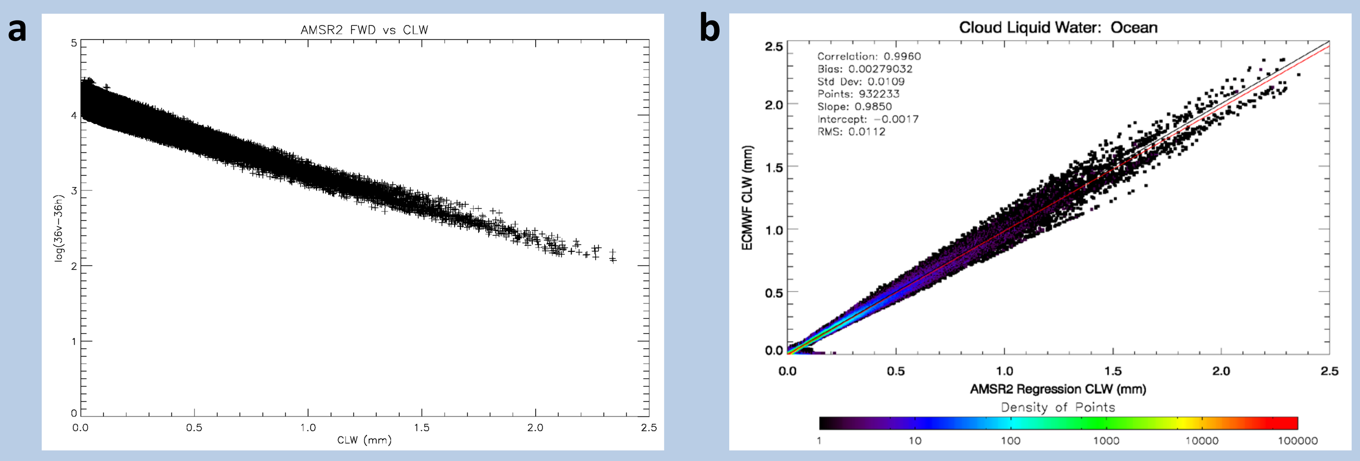


Figure 1. Training a CLW regression for AMSR2. ***a:*** Analysis CLW compared against the log difference of AMSR2 channel 11 and 12 (36.5 GHz V and H) simulated brightness temperatures (a predictor for the CLW regression). ***b:*** Density scatter plot of CLW retrieved (in mm) over ocean from simulated AMSR2 brightness temperature observations versus CLW from ECMWF analyses.

Assimilation of GPM GMI Observations

GMI L1C-R brightness temperatures are being used in our experimentation on GMI data assimilation to enable us to ingest all 13 GMI channels into the GSI in a single step, and to use all available channels for quality control and filtering. In the assimilation results shown:

- The data have been thinned to 45km, only data over ocean are used.
- Cloud and precipitation retrievals tailored to GMI have been implemented in the GSI.
- An emissivity filter is being tested to remove observations with surface misclassifications or that have been missed by cloud /precipitation checks. The filter is based upon the differences between multi-channel and single channel emissivity regressions for GMI channels 2, 4, and 7.

Ch7 OmB vs. Emissivity **Ch 7 Obs vs. Sim Tb**

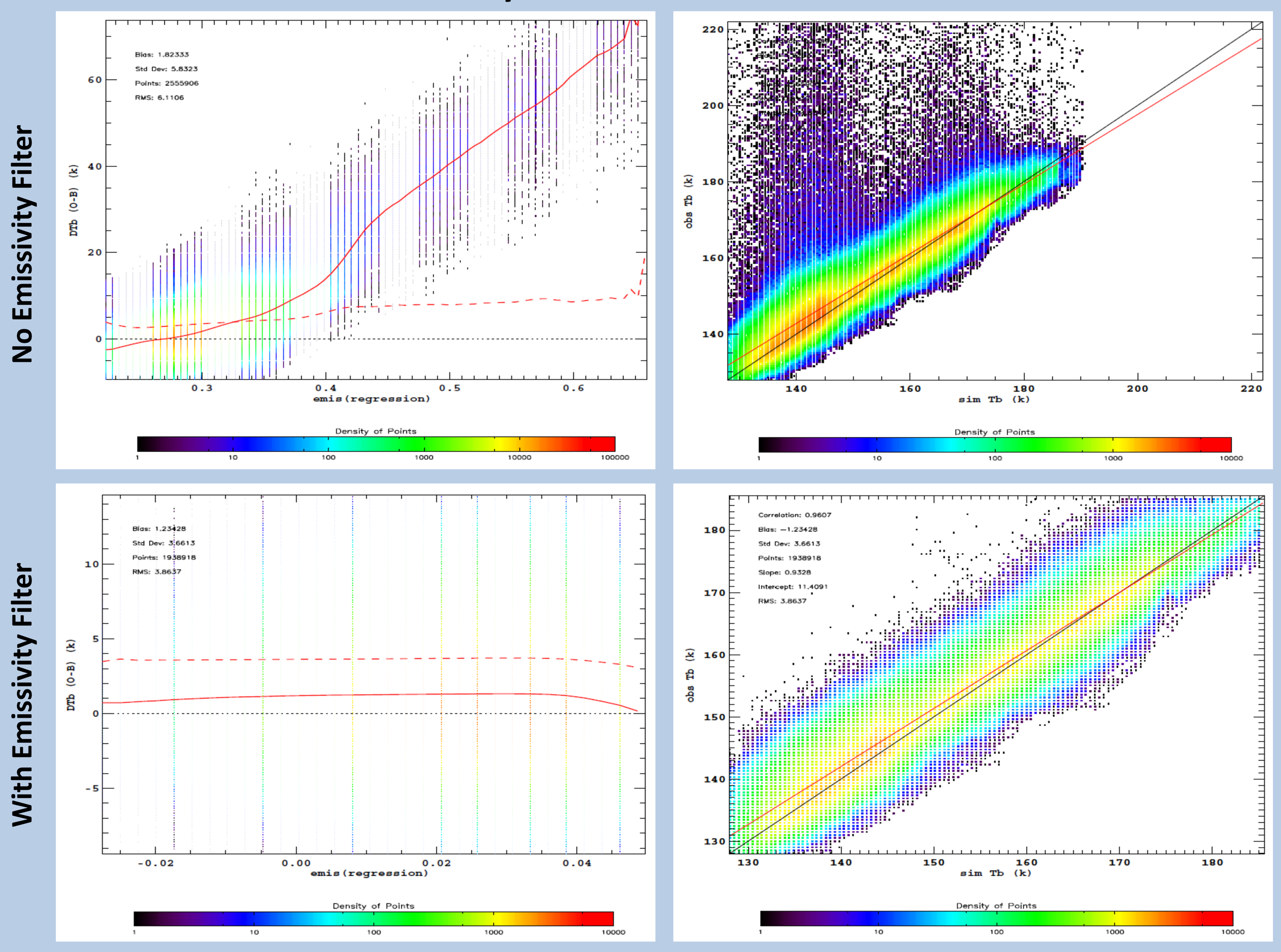


Figure 2. COAT results for GMI channel 7 (36.5 GHz) for 20140810. ***Top row:*** OmB vs. retrieved emissivity (left) and observed vs. simulated brightness temperatures when filters are only applied for cloud and precipitation (right). ***Bottom row:*** OmB vs. the difference of multi-channel and single channel retrieved emissivity (left) and observed vs. simulated brightness temperatures when filters are applied for cloud, precipitation, and emissivity (right).

At present, only data points where observations from channels 1 to 9 can be co-registered with observations from channels 10 to 13 are used in the assimilation. Separate retrieval and filtering procedures need to be developed for data at the first swath edge, where low frequency data have no corresponding high frequency observations. For simplicity, differences in the incidence angles of the first and second swaths (52.821 and 49.495 degrees, respectively) have been ignored. The angle difference can be considered a systematic bias, and removed during bias correction.

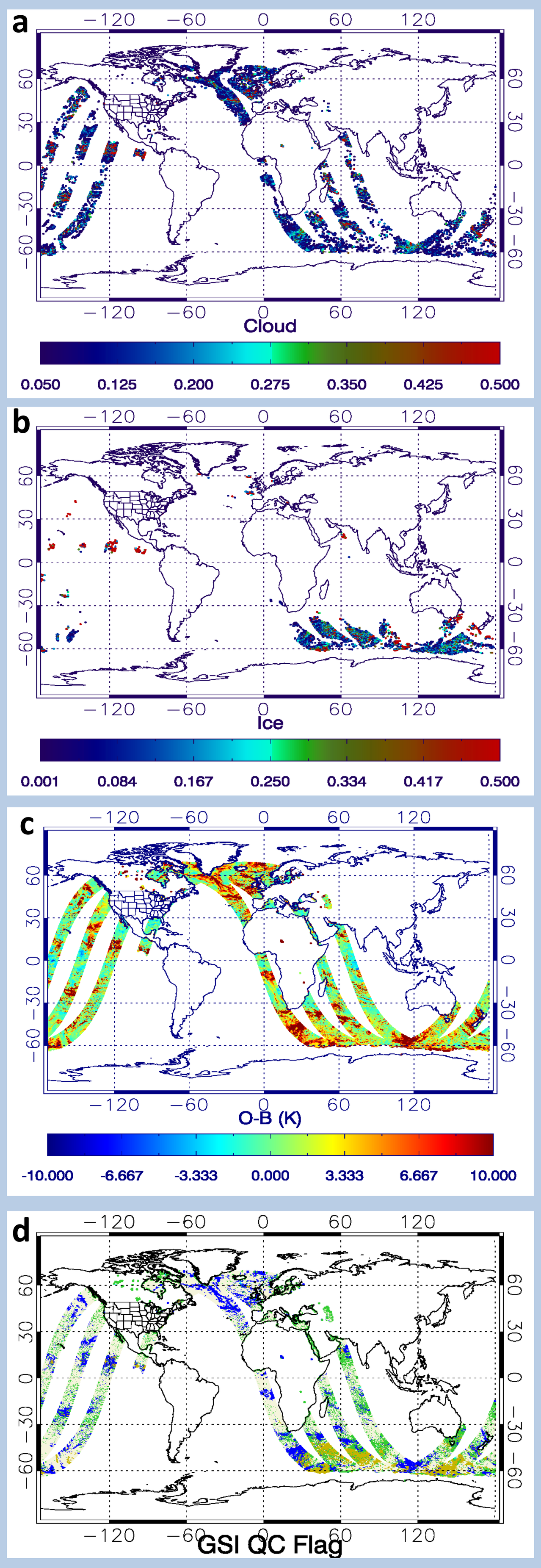


Figure 3. Assimilating GMI data in the GSI for the 2014080106 cycle. ***a:*** CLW retrieved using GMI observations. ***b:*** Ice (GWP) retrieved using GMI observations. ***c:*** GSI OmB (bias corrected) for channel 6 (36.5 GHz) during this cycle. ***d:*** Results for channel 6 after going through GMI QC in the GSI. Teal points fail gross check, **blue** points are flagged for cloud, gold points are flagged for rain, and **green** points fail the emissivity check.

Assimilation of GCOM-W1 AMSR2 Observations

AMSR2 L1B data have been ingested and assimilated into the GSI.

- Channels 1 to 14 are used in the assimilation. Every-other observation is selected from the high resolution channels to allow for the ingest of AMSR2 data into the GSI in one step.
- Channels 15 and 16 are not used.
- Data are thinned to 45 km. Only points over ocean are used.
- A CLW retrieval that has been tailored to AMSR2 has been developed for clear-sky filtering, and is being tweaked (see Methods section for some results from the CLW regression).

The data used here have not yet been reprocessed by JAXA to be in line with their latest L1B data updates (dated April 3, 2015). While updated AMSR2 data are currently being tested, it is believed that these updates will have minimal impact on results.

Ch 10 Obs vs. Sim Tb: Legacy QC

Ch 10 Obs vs. Sim Tb: Updated QC

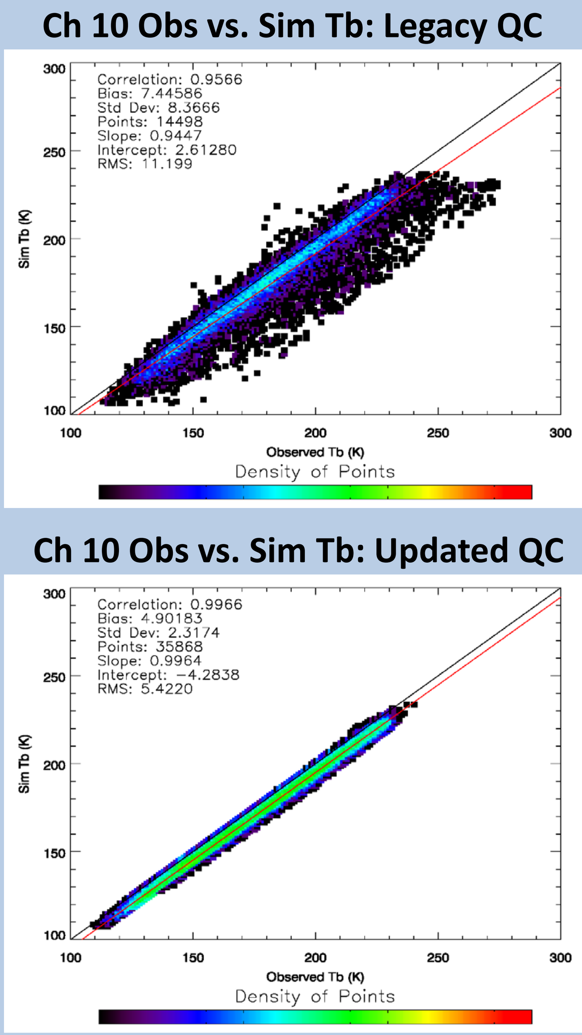
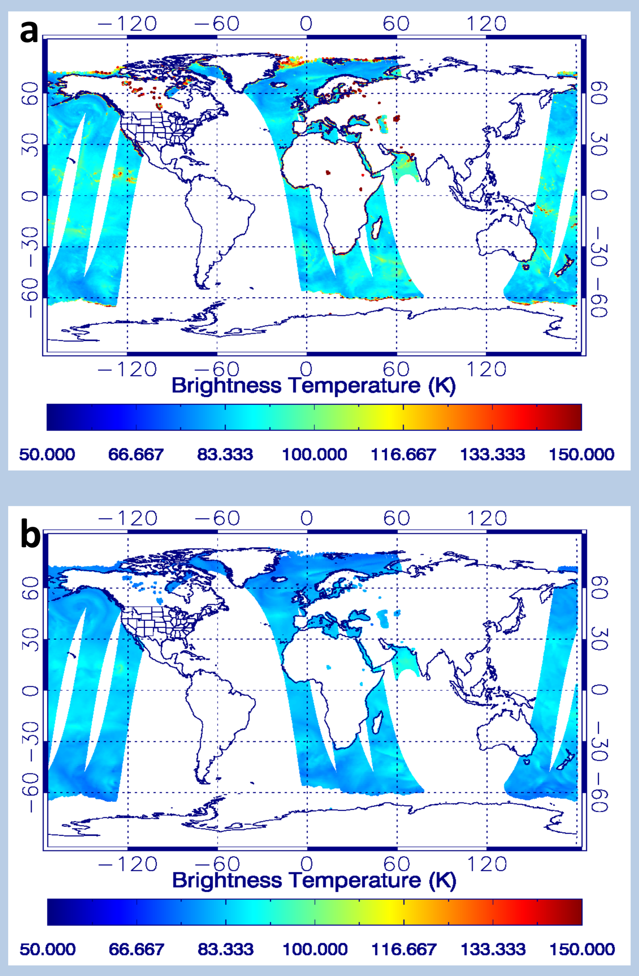


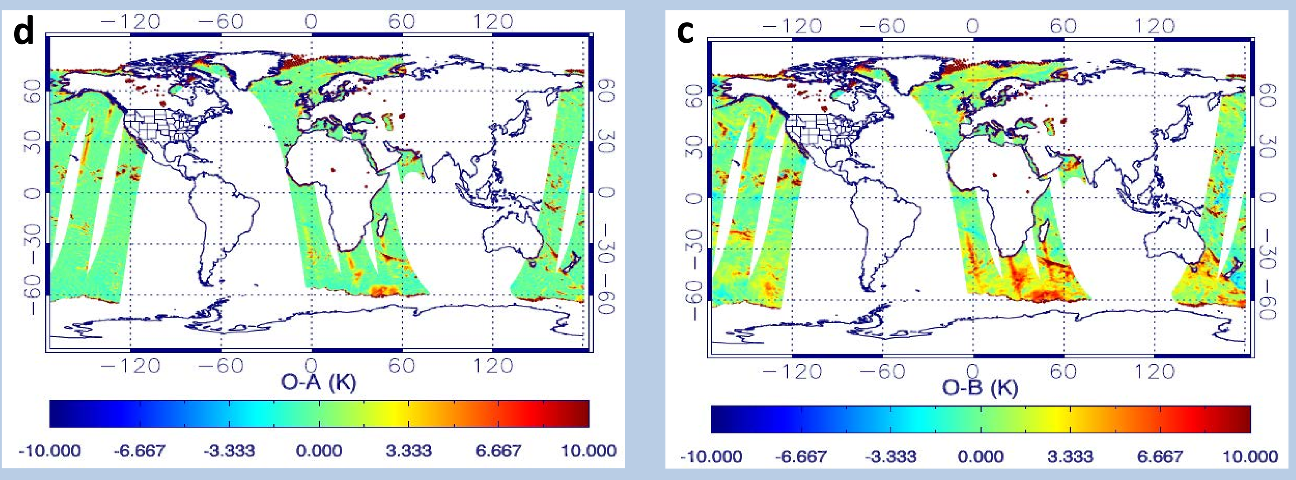
Figure 4. Observed vs. simulated brightness temperatures in the GSI using legacy QC (top) and updated QC (bottom). Thinning and gross check errors are also different between runs.



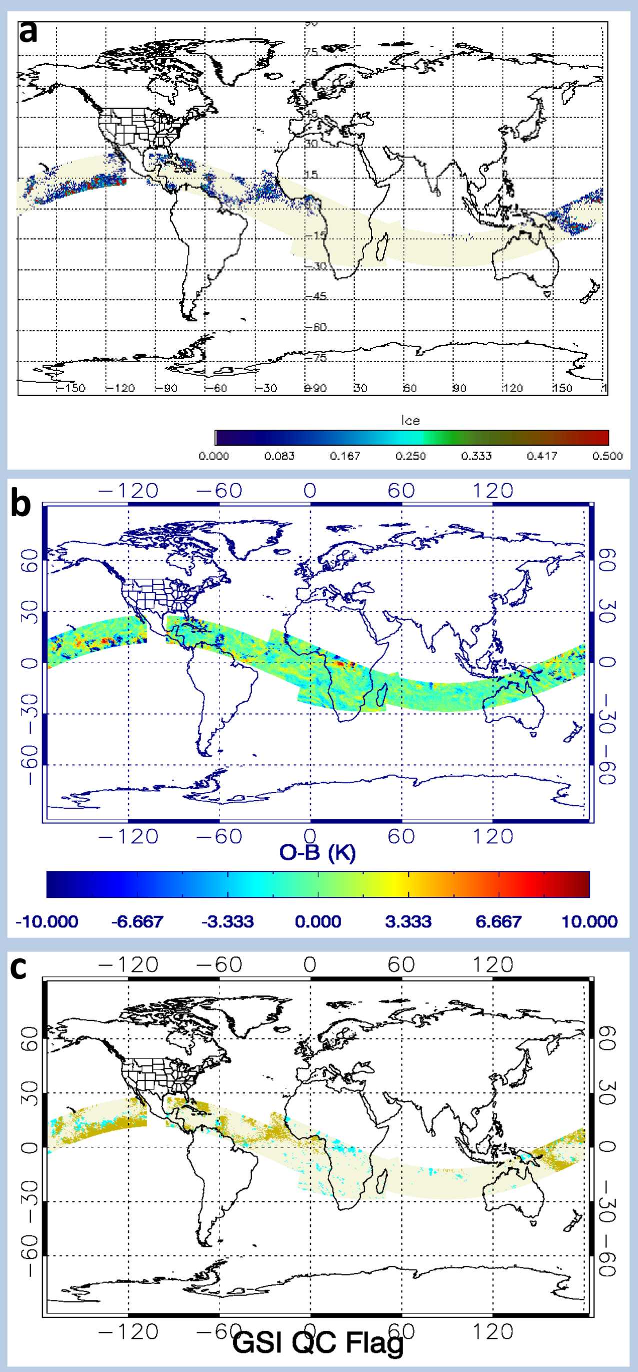
The final assessment of AMSR2 observations and the optimization of AMSR2 QC within the GSI is in progress. A GWP retrieval is being evaluated for efficacy at removing precipitation-contaminated observations, and an emissivity retrieval and check (similar to that done for GMI) are under development. Additionally, a sun glint filter will be added to remove low frequency observations contaminated by sun glint. An example of sun glint can be seen in **Figure 4c-d**.

Figure 5. Assimilating AMSR2 data in the GSI for the 2014080112 cycle. ***a:*** Observed brightness temperatures for channel 4 (7.3 GHz), and ***b:*** Simulated brightness temperatures for channel 4.

Figure 5 (cont). ***c:*** GSI OmB (bias corrected, all points) for channel 4 (7.3 GHz), and ***d:*** corresponding OmA (bias corrected, all points).



Assimilation of Megha-Tropiques SAPHIR Observations



To test the assimilation of SAPHIR data, SAPHIR L1A2 brightness temperatures are being used. The data have been thinned to 45 km in the assimilation results shown, and observations over all surfaces are present, though the current intent is to assimilate only those observations over ocean. A GWP regression has been trained to SAPHIR, and is used to filter out precipitation-contaminated observations.

An assessment of SAPHIR data is ongoing, as are the optimization of SAPHIR QC and errors, and an assessment of the impacts that assimilating SAPHIR data will have on a GFS forecast.

MT SAPHIR All Clear-Sky Cases (Ocean Only)

Chan	Freq, [GHz]	Bias, [K]	Std. Dev., [K]	RMSE, [K]	Corr.	No of Cases
1	183.	1.21	1.75	2.13	0.97457	2853388
2	183.	-0.10	1.41	1.42	0.98318	2853354
3	183.	-0.72	1.24	1.43	0.98340	2853388
4	183.	-1.24	1.13	1.68	0.98054	2853388
5	183.	-1.28	1.07	1.67	0.97172	2853388
6	183.	-1.92	1.01	2.17	0.95650	2853388

Table 1. Statistics from the COAT for a day's worth of SAPHIR data (20140920) over ocean, after a filter is applied to the data based upon a GWP retrieval.

Figure 6. Assimilating SAPHIR data in the GSI for the 2014080118 cycle. ***a:*** Ice retrieved using SAPHIR observations. ***b:*** GSI OmB (bias corrected) for channel 3 (183.31 +/- 2.8 GHz) for this cycle. ***c:*** Results for channel 3 for this cycle, after going through SAPHIR QC in the GSI. Flags are as described in **Figure 3**.

Ch 3 Obs vs. Sim Tb: No QC **Ch 3 Obs vs. Sim Tb: With QC**

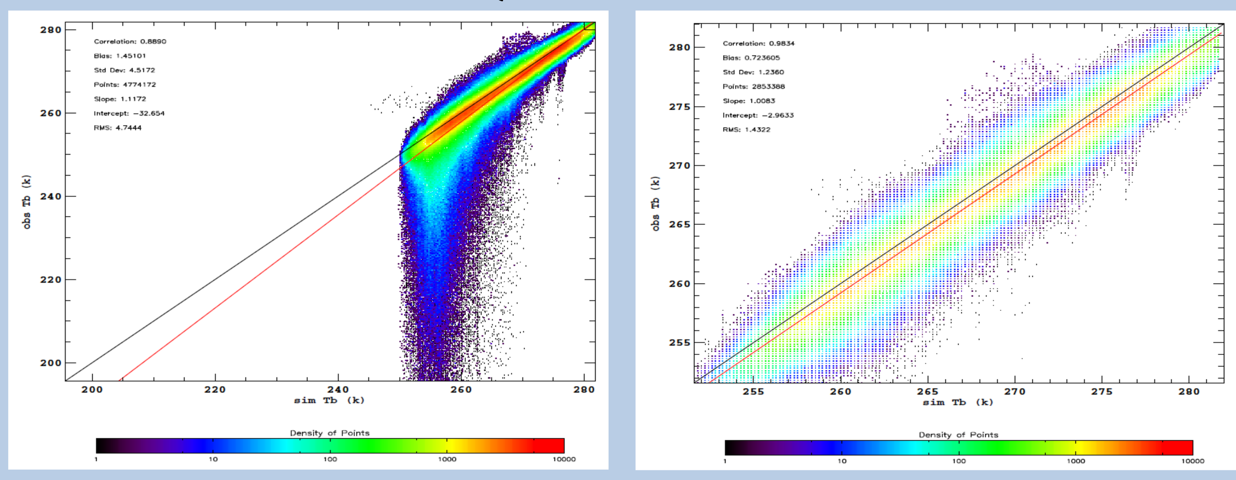


Figure 7. COAT results for SAPHIR channel 3 (183.31 +/- 2.8 GHz) for 20140920. All sky (no QC applied, apart from checking data quality flags) observed vs. simulated brightness temperatures (left), and observed vs. simulated brightness temperatures after a GWP filter has been applied to discard precipitation-contaminated observations.

Conclusions

GCOM-W1 AMSR2, GPM GMI, and Megha-Tropiques SAPHIR brightness temperature data have been ingested into the GDAS. New QC procedures to filter out cloud and precipitation-contaminated observations from these sensors have been developed, and are being tested. The optimization of the assimilation of these data is ongoing, as is the assessment of forecast impacts.

- Preliminary results suggest that newly developed QC procedures have improved the filtering of cloud and precipitation-contaminated points from the assimilation over older and/or legacy filtering schemes.
- Initial experiments in assimilating AMSR2 data suggest that the assimilation of AMSR2, especially at lower frequency channels, could be improved with the implementation of a filtering scheme to discard observations impacted by sun glint.
- Preliminary results (not shown) indicate that the assimilation of GMI, AMSR2, and SAPHIR data has some impact on the forecast. The precise nature of this impact is being investigated for each sensor.

Future Work

- Develop quality control and filtering methods specifically for the low frequency GMI data at swath edges.
- Develop and implement QC procedures to check and filter out AMSR2 observations based on sun glint and emissivity.
- Optimize the errors and thinning of GMI, AMSR2, and SAPHIR data in the GSI.
- Fully extend the Multi-Instrument Inversion and Data Assimilation Preprocessing System (MIIDAPS) pre-processor to GMI, AMSR2, and SAPHIR, and make modifications to the CRTM to account for the differences in incidence angle between the first and second GMI swaths; eventually use MIIDAPS for dynamically generated emissivities.
- Assess the impacts that assimilating GMI, AMSR2, and SAPHIR data will have on GFS and HWRF forecasts and analyses.

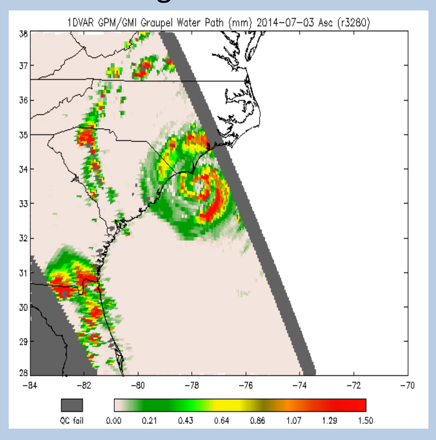


Figure 8. MIIDAPS Ice / GWP GMI retrieval over Hurricane Arthur in July 2014.

Contact info: erin.jones@noaa.gov