# Assimilation of Precipitation Measurement Missions Microwave Radiance Observations With GEOS-5

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- GPM/GMI was launched in February 2014. It is a microwave radiometer (imager) with a conical view of the Earth, measuring rain, snow and other hydrological variables (**Fig 1**). It has 13 channel at 10 – 183 GHz.
- GMAO has developed the procedure to assimilate GMI and TRMM/TMI level 1 radiance data. GEOS-5 assimilation algorithm (GSI) now has the capability to assimilate GMI and TMI radiance observations.
- We are currently expanding the system to assimilate all-sky GMI radiance data.
- This research presents results from GEOS-5 experiments assimilating GMI and TMI data in clear sky conditions.

## 1. Assimilation Procedure and Quality Control

- In GEOS-5 ADAS, GMI data are thinned before these observations are screened. GEOS-5 only assimilates data over the ocean with skin temperature above 275 K (**Fig 2**). Data are not used if the observations suggest there is rain or thick clouds. These threshold vary by channels. The difference between GMI observations (O) and those model produced (forecasts, F) are adjusted through cloud and other bias correction processes (BC), in GSI (**Fig 3**).
- GMI level 1C-R and TMI 1B radiance data are investigated. However, channels 1 and 2, 10 Ghz, are not actively used in atmospheric data assimilation because of biased background departure (**Fig 4**).

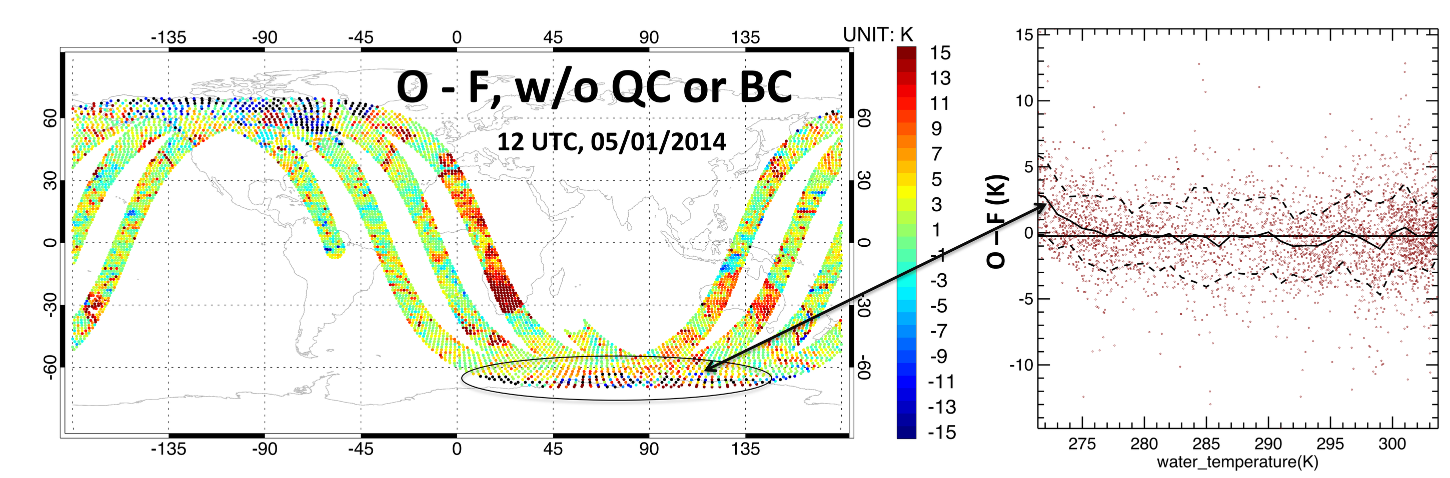


**Fig 2**. Left, map of GMI background departure O – F (before BC and QC ). Right, O – F vs water surface temperature. **This figure demonstrates large O – F above cold water surface.**

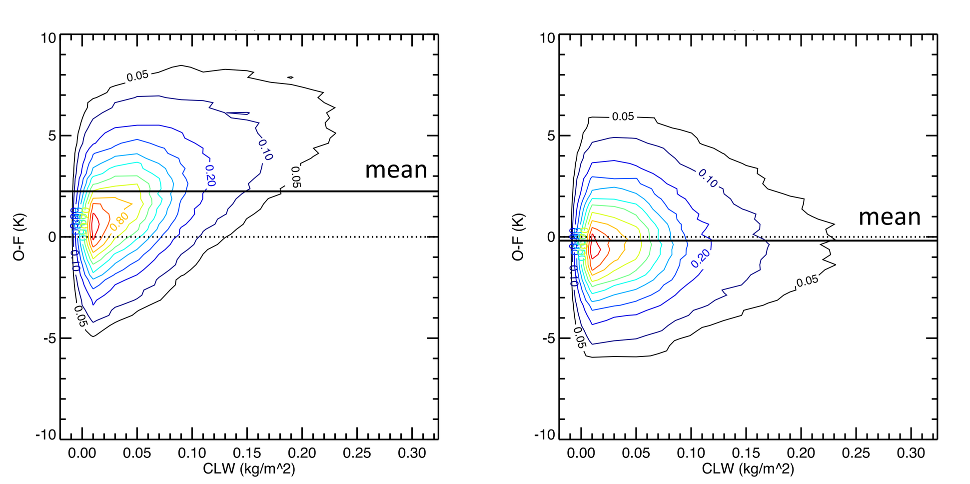


**Fig 3**. Probability Density Function (PDF, %) of GMI channel 5 background departures (left, before BC; right after BC) versus Cloud liquid water (CLW) path in May 2014. **BC makes the background departures have a Gaussian distribution.**

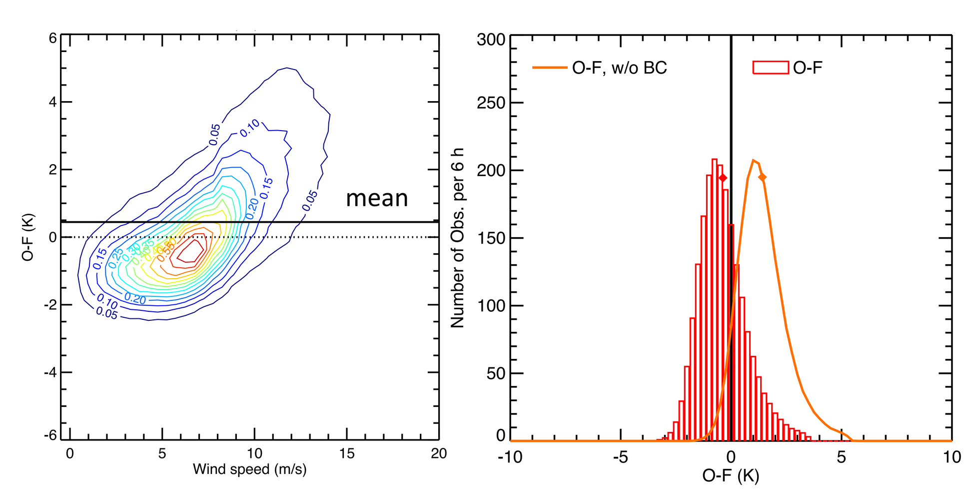


**Fig 4**. PDF of GMI channel 1 background departure (after BC) versus surface wind speed in May 2014. **Channel 1 (and channel 2) data are not assimilated with GEOS-5 because of biases in O – F as shown in the right panel.**

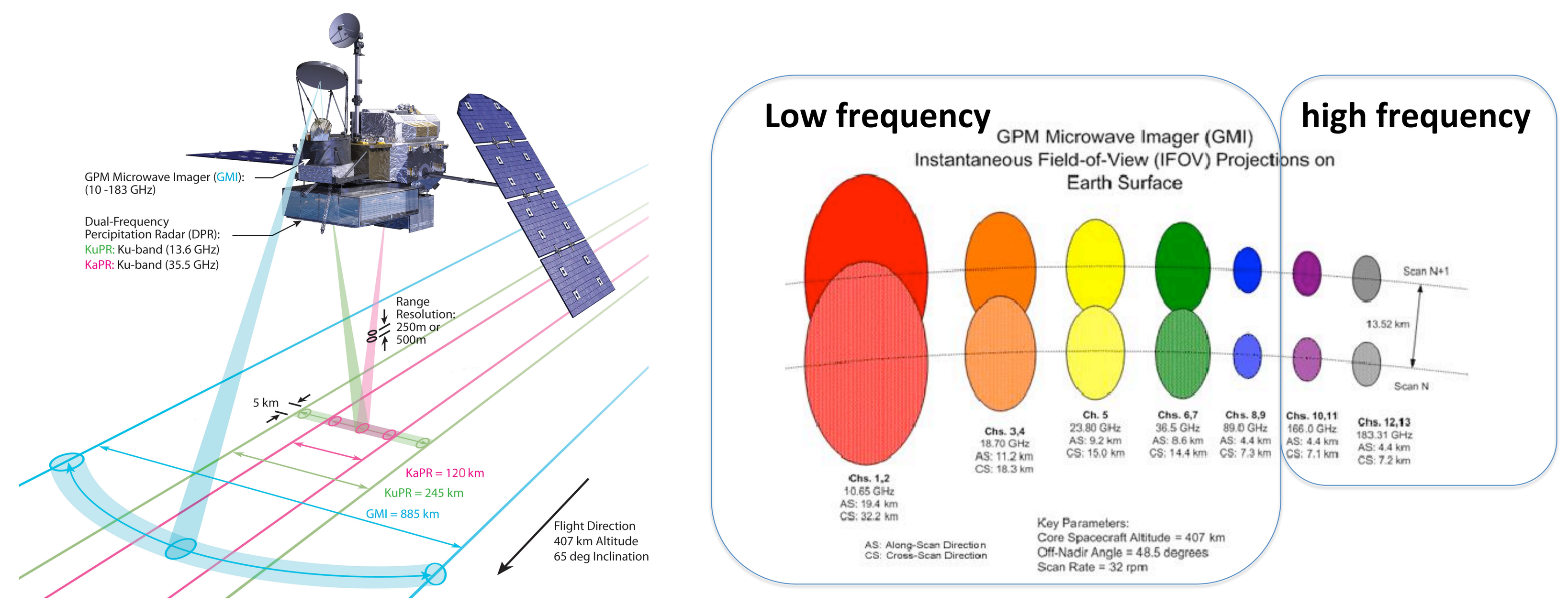


**Fig 1**. Left, GPM GMI and DPR scan patterns and swaths. Right, GMI channel frequencies and IFOV.

## 2. Assimilate GMI Radiance Observations With GEOS-5

The experiments are conducted with 0.5° x 0.5° (latitude by longitude) grid resolution. The **control experiment** is conducted with the full observation data set used for GEOS-5 operational processing. GMI data are added in the **Experiment.** Both experiments are conducted between mid-April and May 2014.

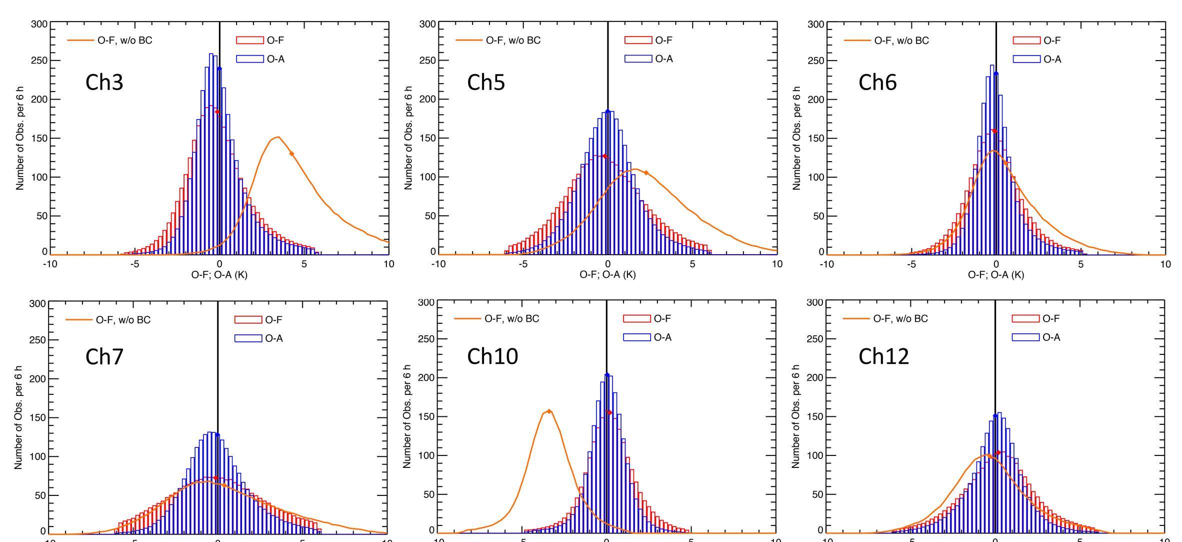


**Fig 5**. Histograms of GMI observations departures (O – F) and analysis departures (O – A) in the GMI experiment result in May 2014. Orange curves demonstrate O – F before BC.

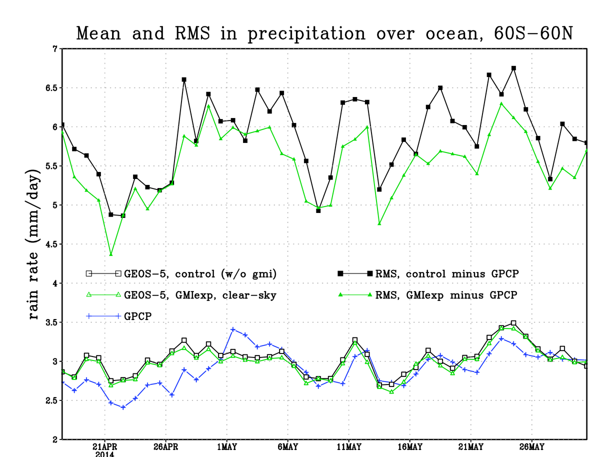


**Fig 6**. Daily mean rain rate from GPCP, the GEOS-5 control and the GMI experiment above ocean and the root mean square (RMS) differences between GEOS-5 results and the GPCP dataset. **This figure shows GMI data pull the modeled precipitation slightly towards GPCP dataset even though global mean rain rate is nearly unchanged.**

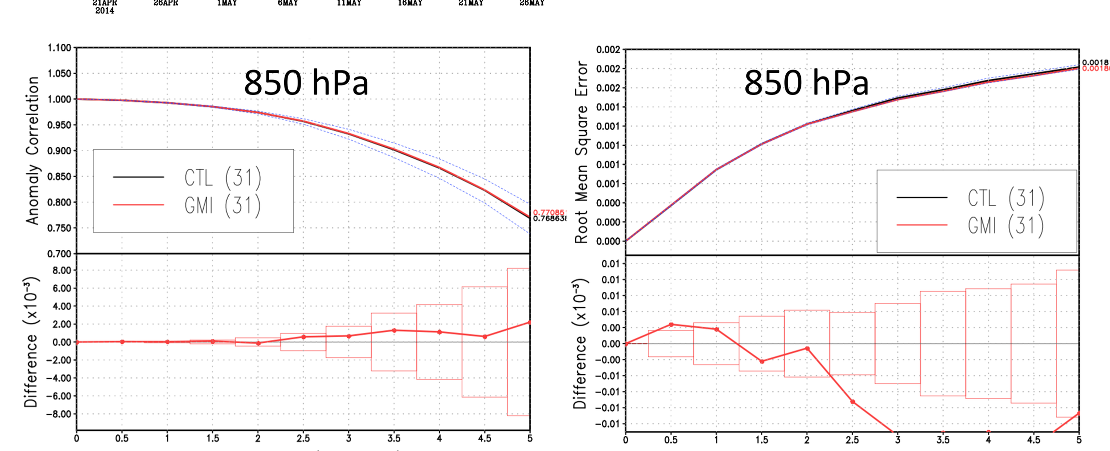


**Fig 7**. (Left) Forecast scores of global correlations of geo-potential height anomalies in forecasts and in GEOS-5 analysis at 850 hPa. The forecasts are performed using GEOS-5 analyses with (GMI experiment) and without (control) GMI data. (Right) Forecast scores of root mean square error in moisture distributions at 850 hPa. **The forecast scores' improvement is neutral in geo-potential heights, and is slightly significant in moisture field after 3 days.**

## 3. Assimilate TMI Observations – Bridge the Microwave Image Data Gap in GEOS-5 Reanalysis

- In GEOS-5 reanalysis, there is a microwave imager radiance data gap between November 2009 – April 2014 after SSMI (F13) data set was lost and before GMI observation started.
- Experiment period: mid Nov 2004 – Jan 2005 when there was no major observation system change in GEOS-5 reanalysis.

### Investigation 1: TMI data's impact during the SSMI/TMI overlap period 1998-2009.

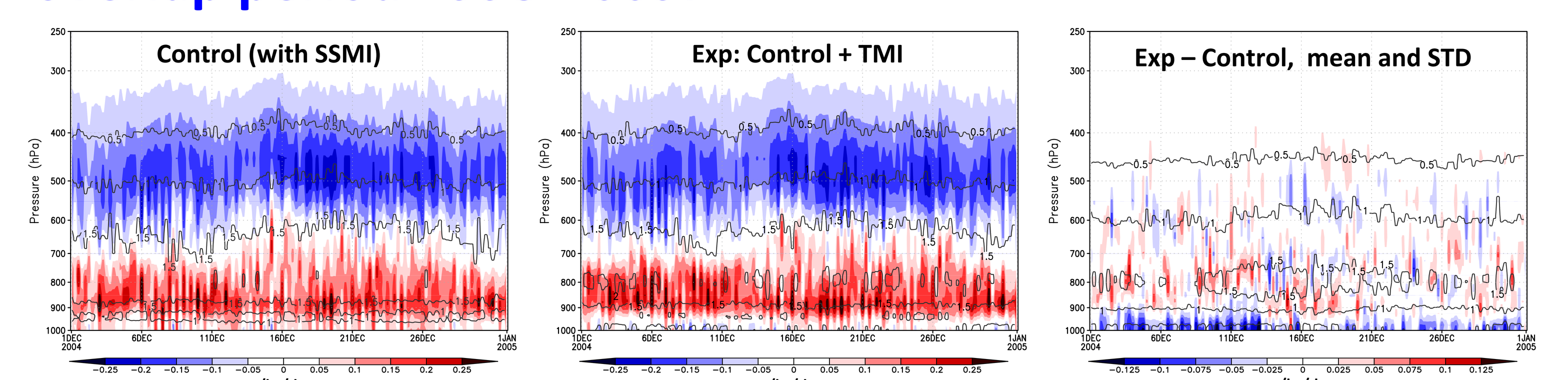


**Fig 8**. Tropical (30 °S – 30 °N) mean (shaded) and standard deviation (STD, contour) of **analysis specific humidity tendencies** in (left) control and (middle) TMI experiments and (right) their difference. **The figure shows that TMI data dehydrate the surface atmosphere and hydrate the lower troposphere with a large variance.**

### Investigation 2: The potential impact of TMI data in the next analysis during the period 2009 – 2014.

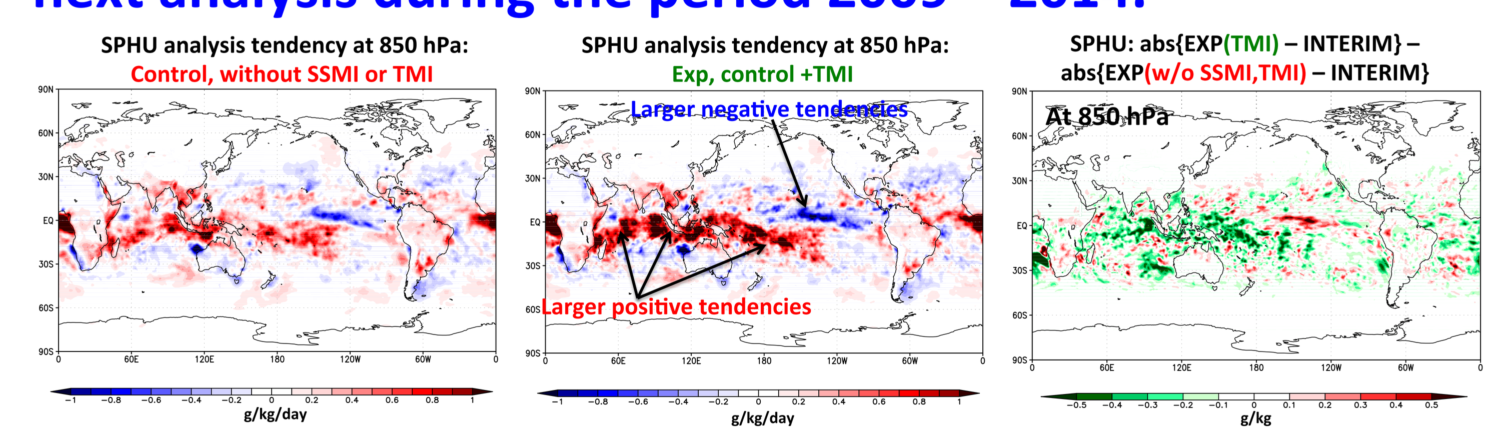


**Fig 9**. **Specific humidity tendencies** in (left) control experiment and (middle) TMI experiment at 850 hPa in January 2005. Right panel shows a comparison of the absolute specific humidity differences between GEOS-5 analyses and ECMWF Interim data set. Red and green colors suggest control and TMI experiments are close to Interim data set, respectively. The right panel demonstrates **TMI observations make GEOS-5 specific analysis closer to ECMWF Interim data set.**

## 4. Summary and ongoing work

- Improvement in GEOS-5 forecasts is neutral after GMI data are assimilated in clear-sky conditions. We are testing all-sky microwave radiance data assimilation framework using these data.
- TMI observations can bridge the microwave imager data gap between 2009 – 2014 in GEOS-5 reanalysis.
- GMAO is also developing a sea surface temperature assimilation methodology using buoy observations and space-borne infrared data. TMI and GMI 10.6 GHz radiance data are being investigated for this purpose.