Assimilating GCOM-W1 AMSR2 and TRMM TMI Radiance Data in GEOS Analysis and Reanalysis

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1, Introduction

- **Advanced Microwave Scanning Radiometer 2 (AMSR2) is aboard the Global Change Observation Mission 1st - Water (GCOM-W1) satellite which was launched in 2012 and is a part of A-Train satellite constellation**
- **GMAO is going to assimilate its brightness temperature (Tb) for atmospheric profiles in all-sky conditions. Cloud control variables are used for atmospheric analysis in current GEOS all-sky GPM/GMI microwave radiance data assimilation framework. However, cloud analysis increments are not fed back to GEOS model's forecasts.**
- **GMAO is also testing all-sky assimilation of the Tropical Rainfall Measurement Mission's Microwave Imager(TRMM/TMI) radiance data for future GEOS reanalysis.**

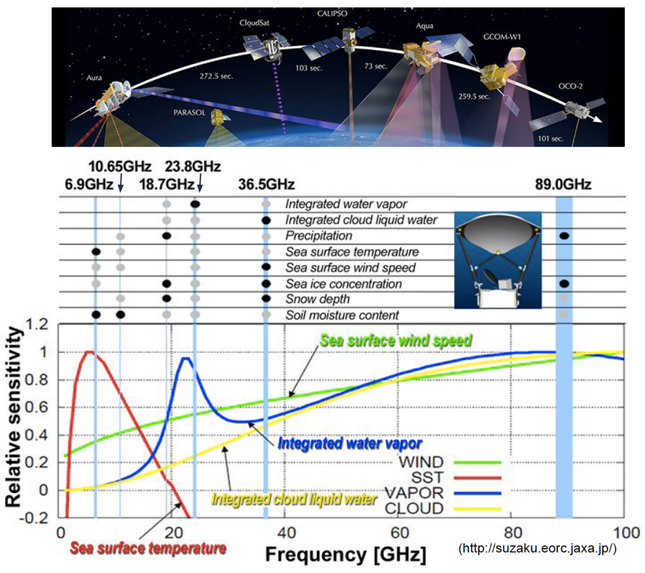
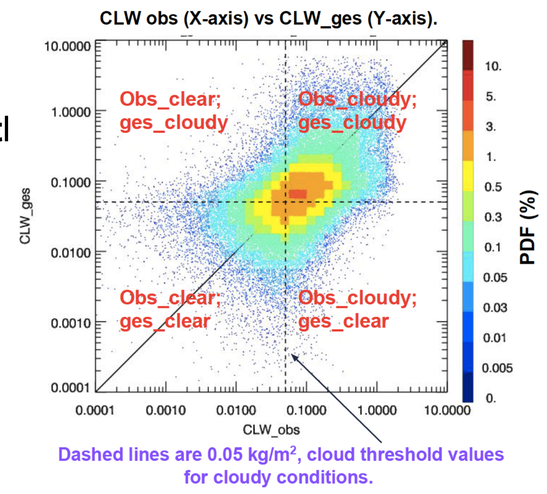


Fig. 1, Relative sensitivity of AMSR2 channels.

2, Procedures of Assimilating AMSR2 Tb

- **Clouds are identified in observations and in forecast (model) during assimilation even though cloud contents are not assimilated.**
- **Observed clouds (CLW_obs) are retrieved from observed brightness temperature (Tb) data, using the retrieval algorithm developed by K. Garrett for AMSR2.**
- **Guess clouds (CLW_ges) are retrieved from forecasted Tb by a radiative transfer model (CRTM) with inputs from GEOS profiles including clouds.**
- **Current test is conducted with Tb data at channels 9 (23.8V GHz) and 11 (36.5V GHz) .**

Fig. 2 (right), A scattering comparison of CLW_obs and CLW_ges.



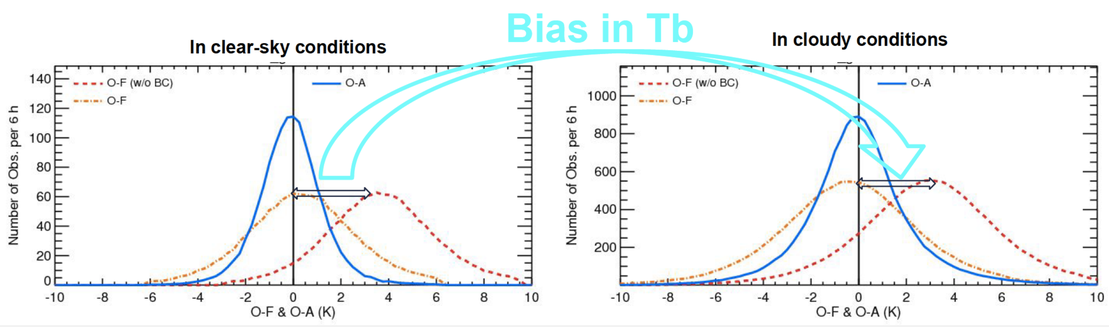


Fig. 3, Examples of probability distribution functions (PDF) of observed (O) Tb minus first-guess (F) Tb (O-F), with and without bias correction (BC), and observed Tb minus analyzed (A) Tb (O-A). The first-guess Tb is calculated using forecasted atmospheric profiles and the analyzed Tb is calculated using analyzed atmospheric profiles. This figure demonstrates that bias correction information in clear-sky conditions is used to correct data in both clear-sky and cloudy conditions.

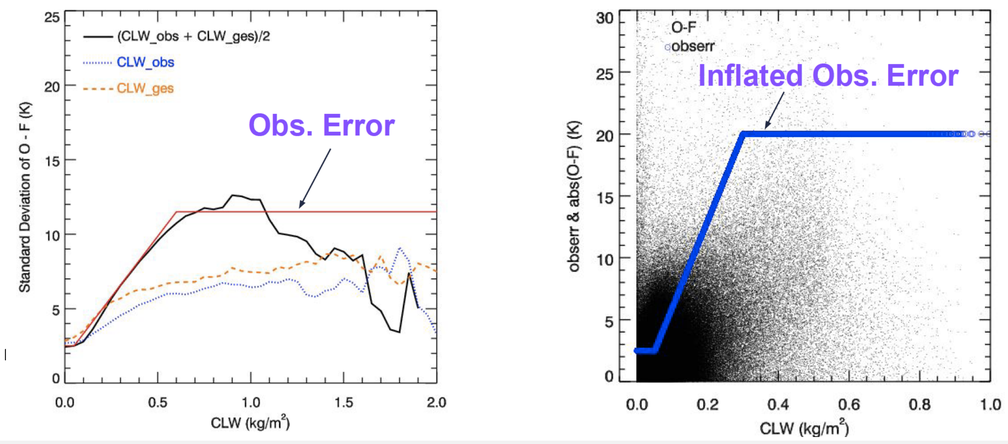


Fig. 4, (left) Standard deviations as functions of cloud contents. Observation error is set as a function of mean cloud content (clw_obs + clw_ges)/2. (right) Observational errors, however, have to be largely inflated because of large inter-channel correlations between observational error covariances (not shown). Observational errors are set as 3 K for ch. 9 and 5 K for ch. 11 in clear-sky conditions and 20 K for ch.9 and 30 K for ch. 11 in cloudy conditions.

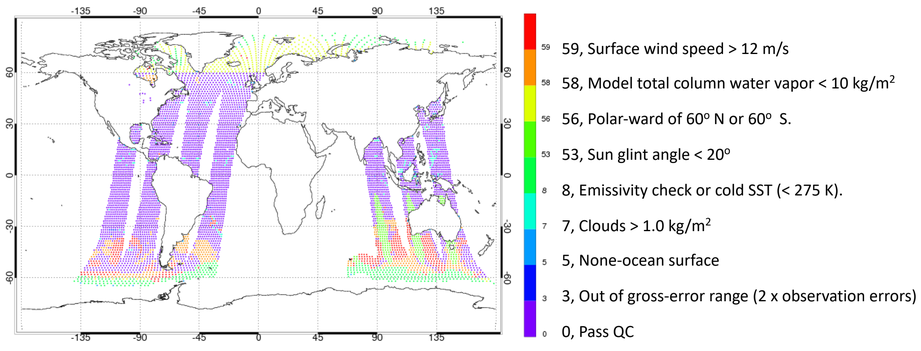


Fig. 5, An example of data screening criteria. Data over land, ice or snow surfaces are not processed.

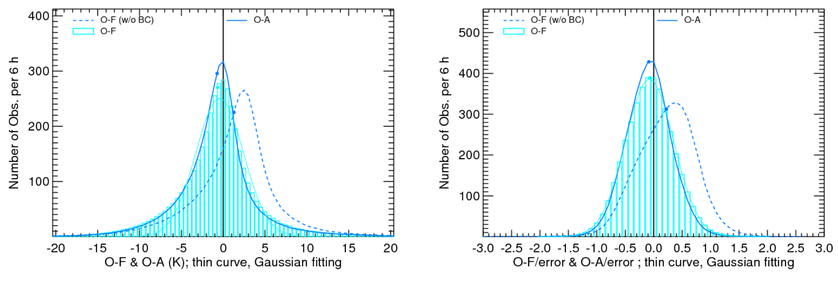


Fig 6. (Left) Probability density functions (PDFs) of O-F, O-F without bias correction (BC) and after BC, and O-A of Tb during July-August 2018. (Right) PDFs of O-F (w/o BC), O-F, and O-A of Tb normalized by observational errors.

3, Impact of Assimilating AMSR2 Data

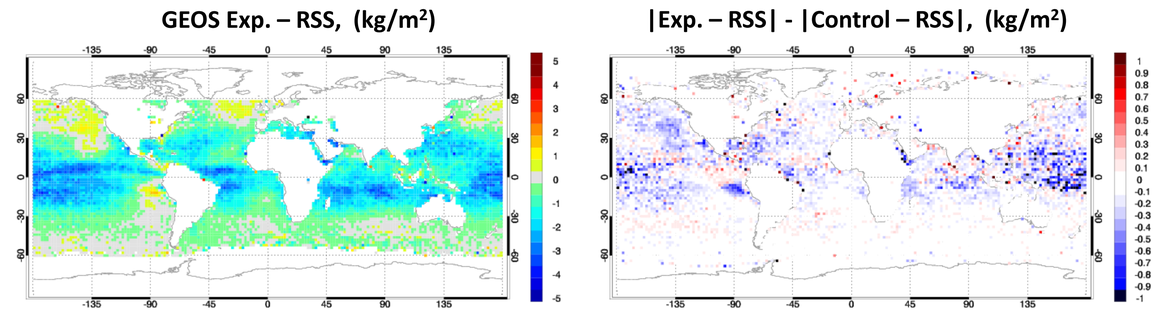


Fig. 7, Total column water vapor in GEOS analysis is generally smaller after assimilating AMSR2 Tb than retrievals made by Remote Sensing Systems, Inc. (RSS) from AMSR2 data, as demonstrated by their difference during July-August 2018 (shown in the left panel). However, it brings the GEOS analysis closer to the retrievals to assimilate ASMR2 radiance data as suggested by the right panel.

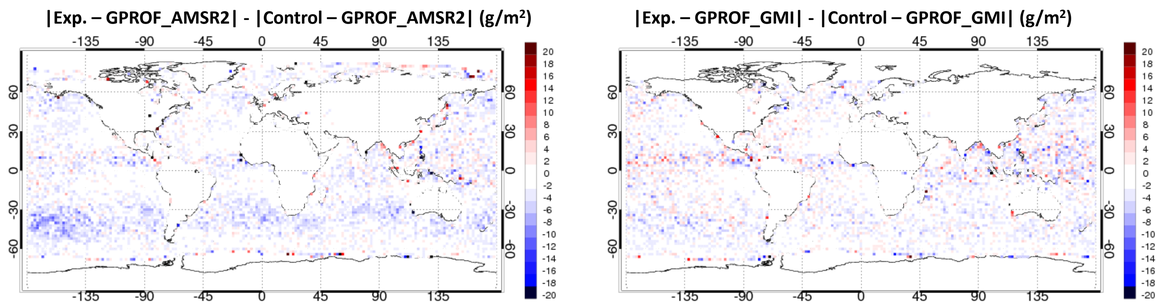


Fig. 8, Assimilating AMSR2 data makes GEOS liquid cloud (ql) analysis closer to GPROF retrievals made from AMSR2 data during July-August 2018 as shown in the left. However, there is no noticeable improvements in analyzed ql at GPM/GMI locations when the analyzed ql is evaluated with GPROF GMI retrievals (shown in the right panel), probably because GMI radiance data are also assimilated in the control experiment in all-sky conditions.

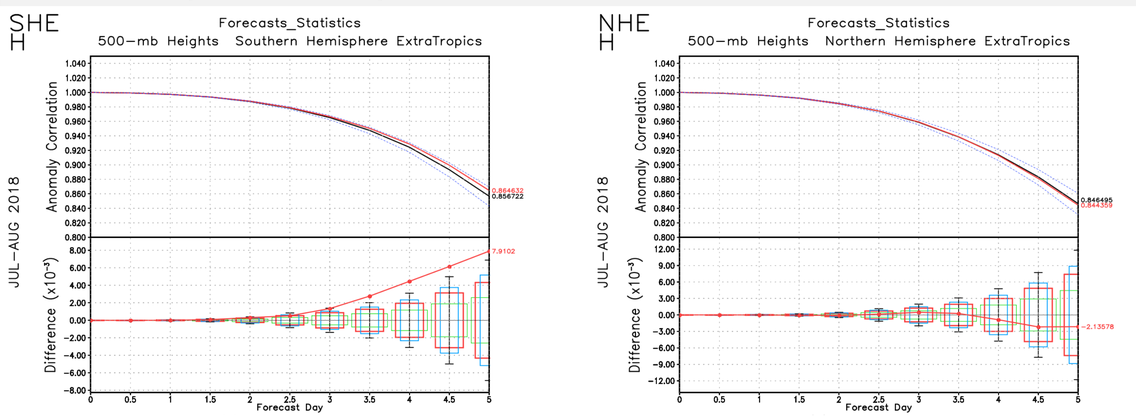


Fig. 9, Assimilating AMSR2 data improves GEOS forecasts in the southern hemisphere during July-August 2018 as shown in the left panel, but it has a neutral impact in the forecasts in the northern hemisphere as shown in the right panel.

4, Future Development and Summary

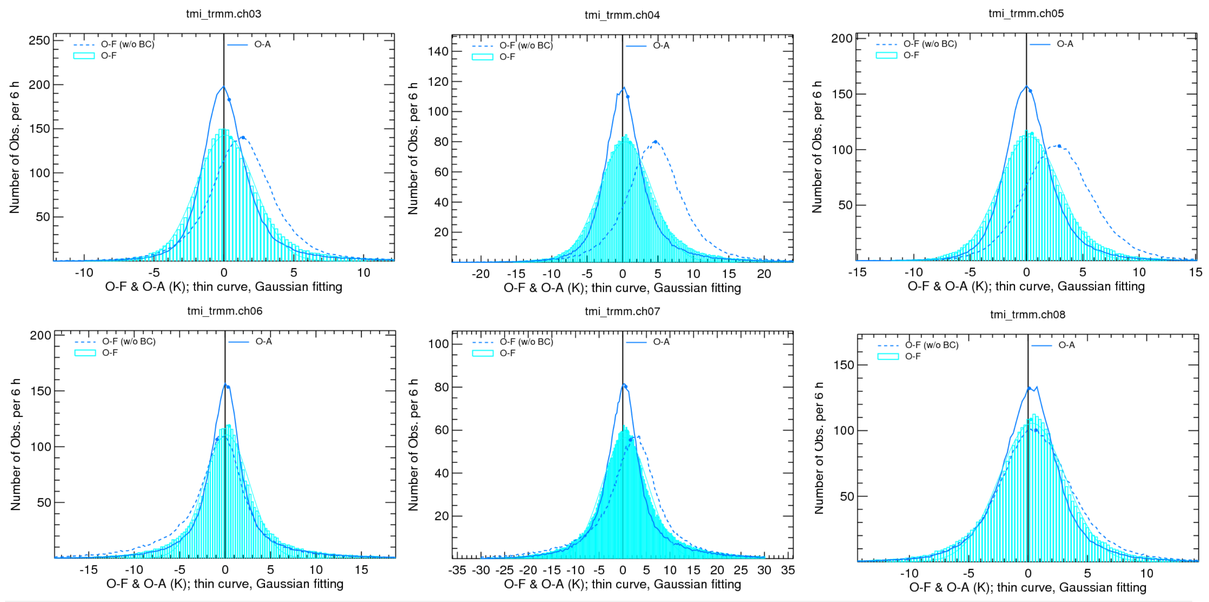


Fig 10. TRMM/TMI O-F without BC and after BC and O-A of Tb at channels 3-8 between 1-15 Dec 2004. There are large O-F Tb values for the horizontal polarization channels 4 and 7. GMAO is testing all-sky assimilation of TMI Tb for future GEOS reanalysis.

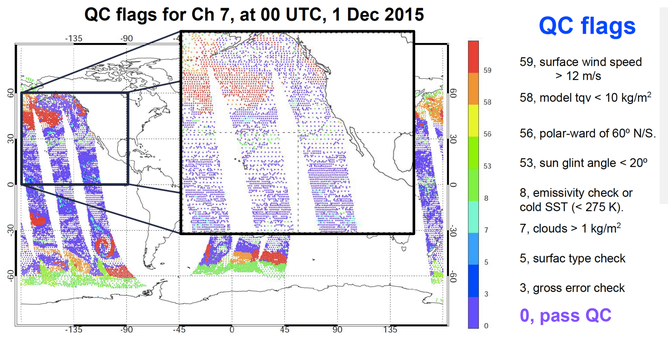


Fig 11, Example of a new variational satellite data thinning method that is developed in order to assimilate more data in cloudy regions. This figure shows AMSR2 quality control (QC) flags at 00 UTC, 1 Dec 2015.

Summary:

- **GCOM-W1 AMSR2 brightness temperature data can be assimilated with GEOS in all-sky conditions. GEOS analyzed moisture and clouds are improved after assimilating these observations.**
- **Other radiance data made by microwave imagers such as TRMM/TMI are being tested for future GEOS reanalysis. Brightness temperature data made by the Advanced Microwave Scanning Radiometer for EOS (AMSR-E) aboard the Aqua satellite will also be tested within the all-sky microwave data assimilation framework.**
- **A new "variational" thinning method will be investigated in order to assimilate more observations in cloudy conditions.**

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