Assimilating GCOM-W AMSR2 Radiance Data in Future GEOS Reanalyses

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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 and sea surface temperature analyses.
- 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.

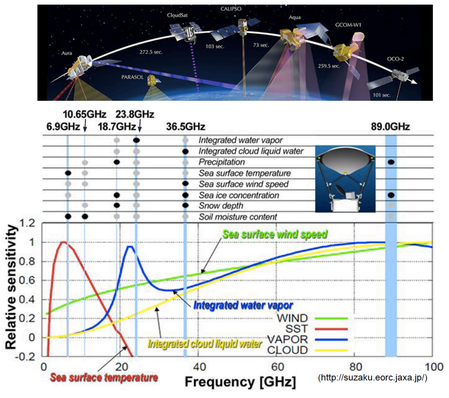
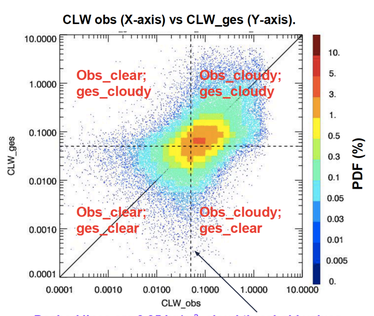


Fig. 1: AMSR2 channel information.

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), 11 (36.5V GHz), and 12 (36.5H GHz).



Dashed lines are 0.05 kg/m², cloud threshold values for cloudy conditions.

Fig 2: (Right) A scattering comparison of CLW_obs and CLW_ges.

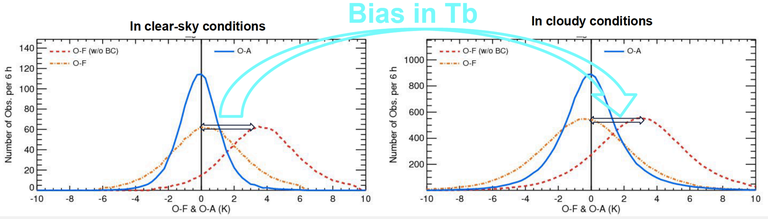


Fig 3: Example probability distribution functions (PDF) of observed (O) Tb minus first-guess (F) Tb (O-F), with and without bias correction (BC), and observed Tb minus analyzed (A) Tb (O-A). The first-guess Tb is calculated using forecasted atmospheric profiles and the analyzed Tb is calculated using 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.**

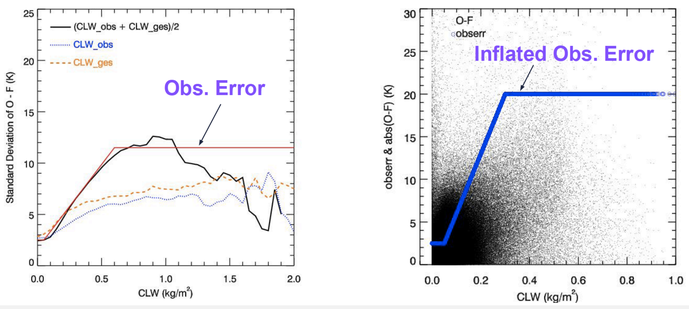


Fig 4: (Left) Standard deviations as functions of cloud contents. Observation error is set as a function of mean cloud content (clw_obs + clw_ges)/2. (right) Observational errors, however, have to be largely inflated because of large inter-channel correlations between observational error covariances (not shown).

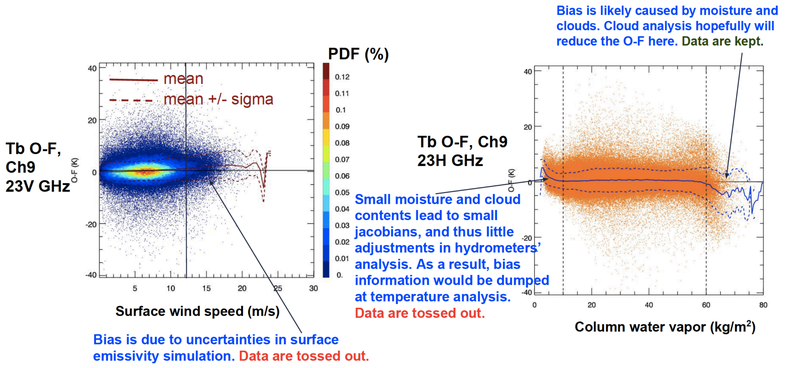


Fig 5: Examples of AMSR2 observation data quality control procedure using (left) surface wind (right) total column water vapor (TCWV).

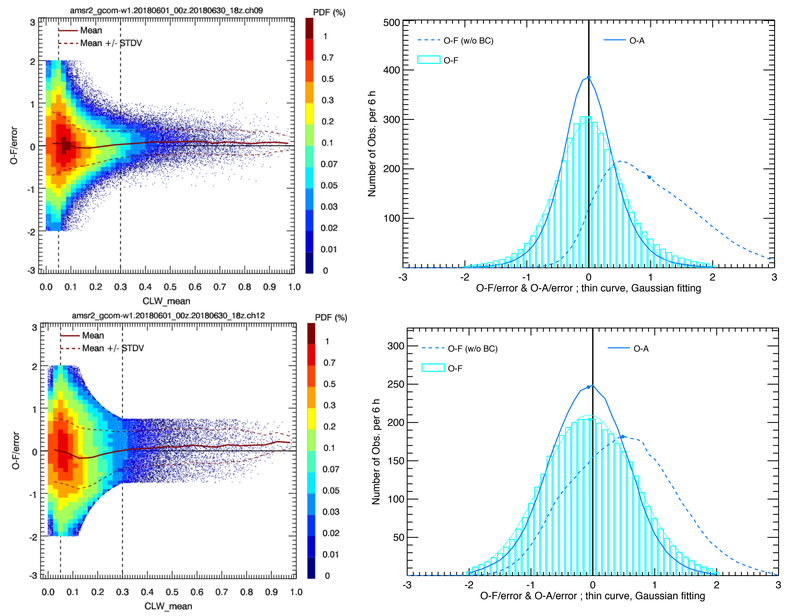


Fig 6: (Left) Scatter distribution of channels (top) 9 and (bottom) 12 O-F Tb differences normalized by observation errors versus mean clouds (clw_mean) in June 2018 after quality control. (Right) Curves and histograms show PDF of channels 9 and 12 normalized O-F (w/o BC), O-F, and O-A Tb differences and the dots demonstrate mean values of these O-F and O-A values.

3. Impacts of AMSR2 Data

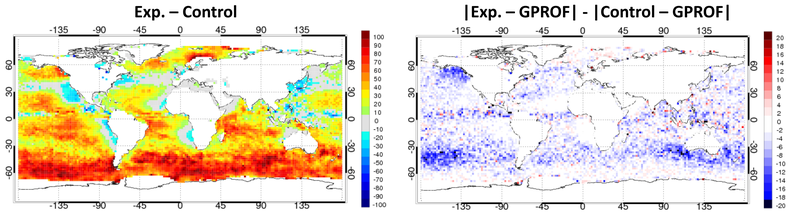


Fig 7: (Left) Total column liquid (tql, kg/m²) cloud difference in GEOS experiments (control) before and (Exp.) after AMSR2 data are assimilated in June 2018. (Right) Closeness comparison of tql in GEOS experiments with GPROF AMSR2 products (Red, control is closer to GPROF; blue, experiment (control+amsr2) is closer to GPROF). Note, GPM/GMI brightness temperature data are being assimilation in the control experiment and current GEOS operational analysis in all-sky conditions. **GEOS liquid clouds are made closer to GPROF retrievals after AMSR2 data are assimilated in all-sky conditions.**

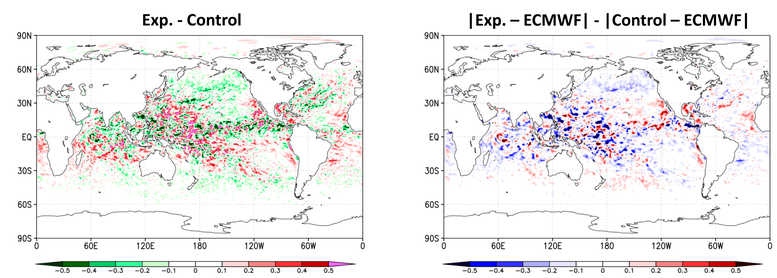


Fig 8: (Left) Total column water vapor (tqv, kg/m²) difference in GEOS experiments (control) before and (Exp.) after AMSR2 data are assimilated in June 2018. (Right) Closeness comparison of tqv in GEOS experiments with ECMWF operational analysis (Red, control is closer to ECMWF; blue, experiment (control+amsr2) is closer to ECMWF). **It overall slightly improves GEOS tqv to assimilating AMSR2 in all-sky conditions though it has a mixed impact in GEOS tqv in lower latitudes.**

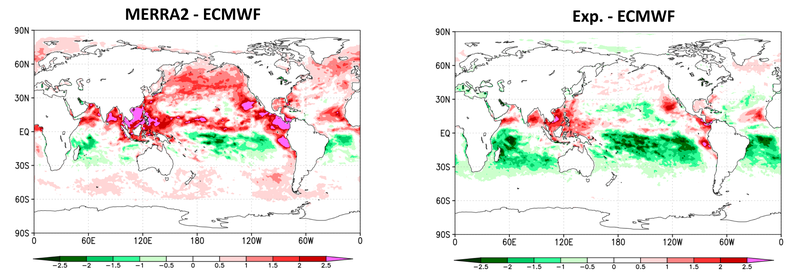


Fig 9: (Left) Total column water vapor (tqv, kg/m²) difference between MERAA-2 reanalysis and ECMWF analysis in June 2018. (Right), tqv difference between this GEOS experiment and ECMWF analysis in June 2018. **Future GEOS reanalysis will have smaller positive bias against ECMWF data. The negative bias will be further investigated.**

4. Future Development And Summary

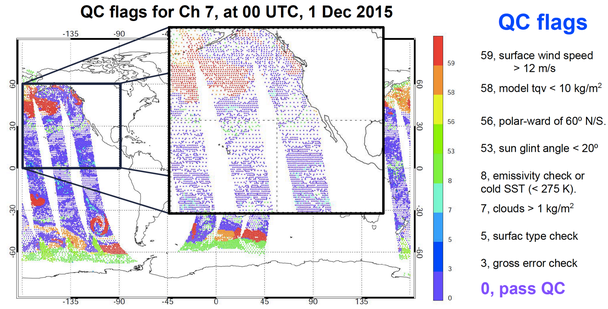


Fig 10: Example of a new variational satellite data thinning method that is developed in order to assimilate more data in cloudy regions. This figure shows quality control (QC) flags at 00 UTC, 1 Dec 2015.

Summary

- AMSR2/GCOM-W1 brightness temperature data can be assimilated with GEOS in all-sky conditions. GEOS analyzed moisture and clouds are improved after assimilating these observations.
- A new "variational" thinning method is developed in order to assimilate more observations in cloudy conditions.
- Other radiance data made by microwave imagers such as TRMM TMI will be tested for the production of future GEOS reanalysis.

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