OSSE on geostationary hyperspectral infrared sounders: Radiance simulation, validation and impacts on hurricane forecast

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1. Introduction

a. LEO hyperspectral IR sounder
- AIRS/IASI/CrIS
- Great success in global forecast

b. GEO hyperspectral IR sounder
- EUMETSAT: IRS/MTG (2020)
- China: FY4 (2017)
- High temporal resolution
- High vertical resolution
- Ideal for regional weather forecast

c. Observing System Simulation Experiment (OSSE)
- Study the value added impacts compared to existing instruments
- Simulate observations for existing and future instruments
- Validate the simulations
  -- Radiative transfer (RT) calculation validation
  -- Nature run validation
- Quick OSSE on Hurricane Sandy

2. Radiative transfer model determination

a. Different RT models in simulation and assimilation

b. CRTM/GSI

c. Difference between CRTM and the chosen RT model should be:
- Reasonably different (radiance accuracy or bias)
- Reasonably close (radiance precision)

d. The University of Wisconsin – Madison (UW) radiative transfer model (UWRTM)
- SARTA (Strow et al., 2003)
- The cloud model by Wei et al., (2004)

Figure 1 shows comparison between SARTA and CRTM in clear sky.

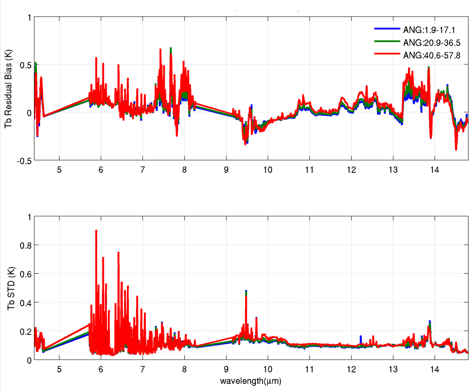

Figure 1. The clear sky radiative transfer model (RTM) comparison (bias in upper panel, StdDev in lower panel) between SARTA and CRTM with different satellite viewing angle zone (1.9 – 17.1; 20.9 – 36.5 and 40.6 – 57.8 degree).

3. Validation of synthetic observations

a. A major difficulty: the nature run is different from real atmosphere.

b. Real observation may not directly validate simulations.

c. Two steps in validation of synthetic observations
- identifying and characterizing clouds
- validating radiance indirectly using real observations

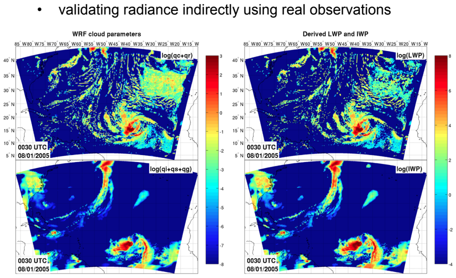

Figure 2. Comparison of hydrometers in WRF nature run (left, upper for water, and lower for ice) with the derived liquid water path (upper right) and ice water path (lower right).

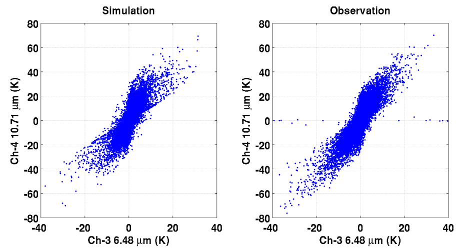

Figure 3. The temporal variation of GOES-12 Imager channel 3 and 4 from the simulation (left) and the observation (right).

4. Examples of synthetic observations

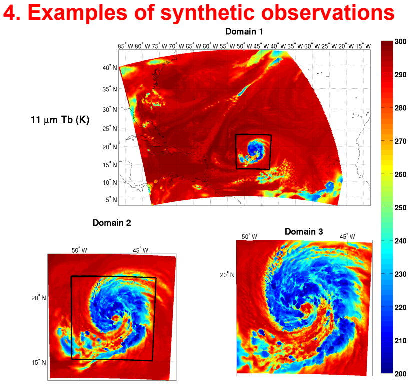

Figure 4. The simulated GEO AIRS Tb at 11 micron at 0430 UTC on August 3 2005 for Domain 1 (upper), 2 (lower left) and 3 (lower right). Simulated from AOML/NOAA WRF nature run.

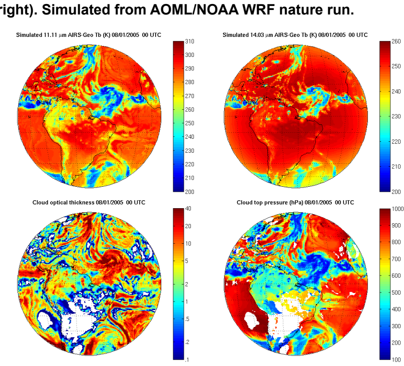

Figure 5. The simulated GEO AIRS Tb at 11.11 micron (top left) and 14.03 micron (top right) at 0000 UTC on August 1 2005. Cloud optical thickness (lower left) and cloud top pressure (lower right) are also shown. Simulated from ECMWF nature run (T511).

5. Clear FOV VS clear channel

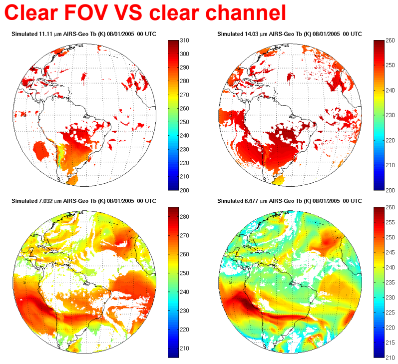

Figure 6. The simulated GEO AIRS Tb at 11.11 micron (top left), 14.03 micron (top right), 7.032 micron (lower left) and 6.677 micron (lower right) at 0000 UTC on August 1 2005. Clear Channels only. Simulated from ECMWF nature run (T511).

For 10 days of WRF nature run, using clear channels instead of clear pixels significantly increases the usability of the simulated synthetic observations from 42.4% to 75.3%.

6. Quick OSSE on Hurricane Sandy

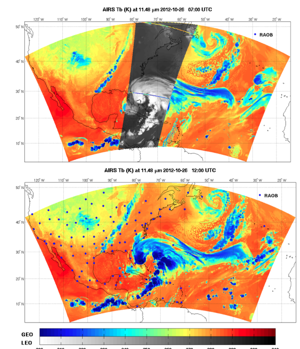

Figure 7. Synthetic observations (RAOBs, LEO AIRS, GEO AIRS) simulated from WRF nature run for Hurricane Sandy at 07 UTC (upper) and 12 UTC (lower) on Oct 26 2012.

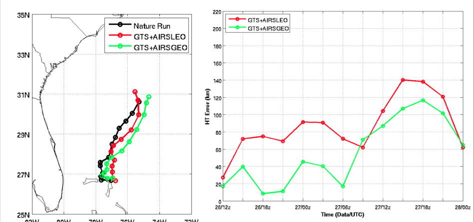

Figure 8. Validation of track forecasts for Hurricane Sandy. (left) the forecast and nature run tracks and (right) the track error. The red lines represent experiments assimilating RAOB (GTS) and LEO AIRS radiances, and the green lines represent experiments assimilating RAOB (GTS) and GEO AIRS radiances.

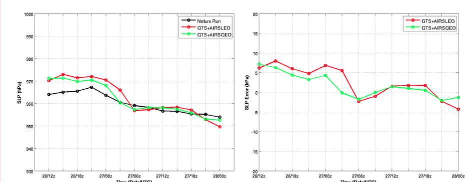

Figure 9. Validation of minimum sea level pressure for Hurricane Sandy. (left) the forecast and nature run tracks and (right) the track error. The red lines represent experiments assimilating RAOB (GTS) and LEO AIRS radiances, and the green lines represent experiments assimilating RAOB (GTS) and GEO AIRS radiances.

7. Summary

- Finished simulating synthetic GEO AIRS radiance observations from both ECMWF and WRF nature runs
- Encoded radiance observations to BUFR format and delivered to AOML and JCSDA
- Assist AOML and JCSDA in assimilating the radiances
- Preliminary quick OSSE experiments on Hurricane Sandy

8. Acknowledgement

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9. Reference

Strow, L. L., S. E. Hannon, S. De Souza-Machado, H. E. Motteler, and D. Tobin (2003), An overview of the AIRS radiative transfer model, IEEE Trans. Geosci. Remote Sens., 41, 303–313.

Wei, H., P. Yang, J. Li, B. B. Baum, H.-L. Huang, S. Platnick, Y. Hu, and L. Strow (2004), Retrieval of semitransparent ice cloud optical thickness from Atmospheric Infrared Sounder (AIRS) measurements, IEEE Trans. Geosci. Remote Sens., 42, 2254– 2267.