CRTM Support to GMAO, Validation and Coefficient Generation

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Thanks to Louis Kouvaris (GSFC) for running SARTA!

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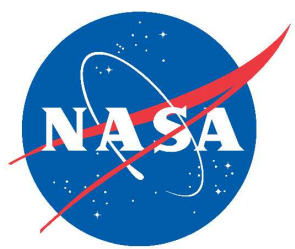


Table of Content

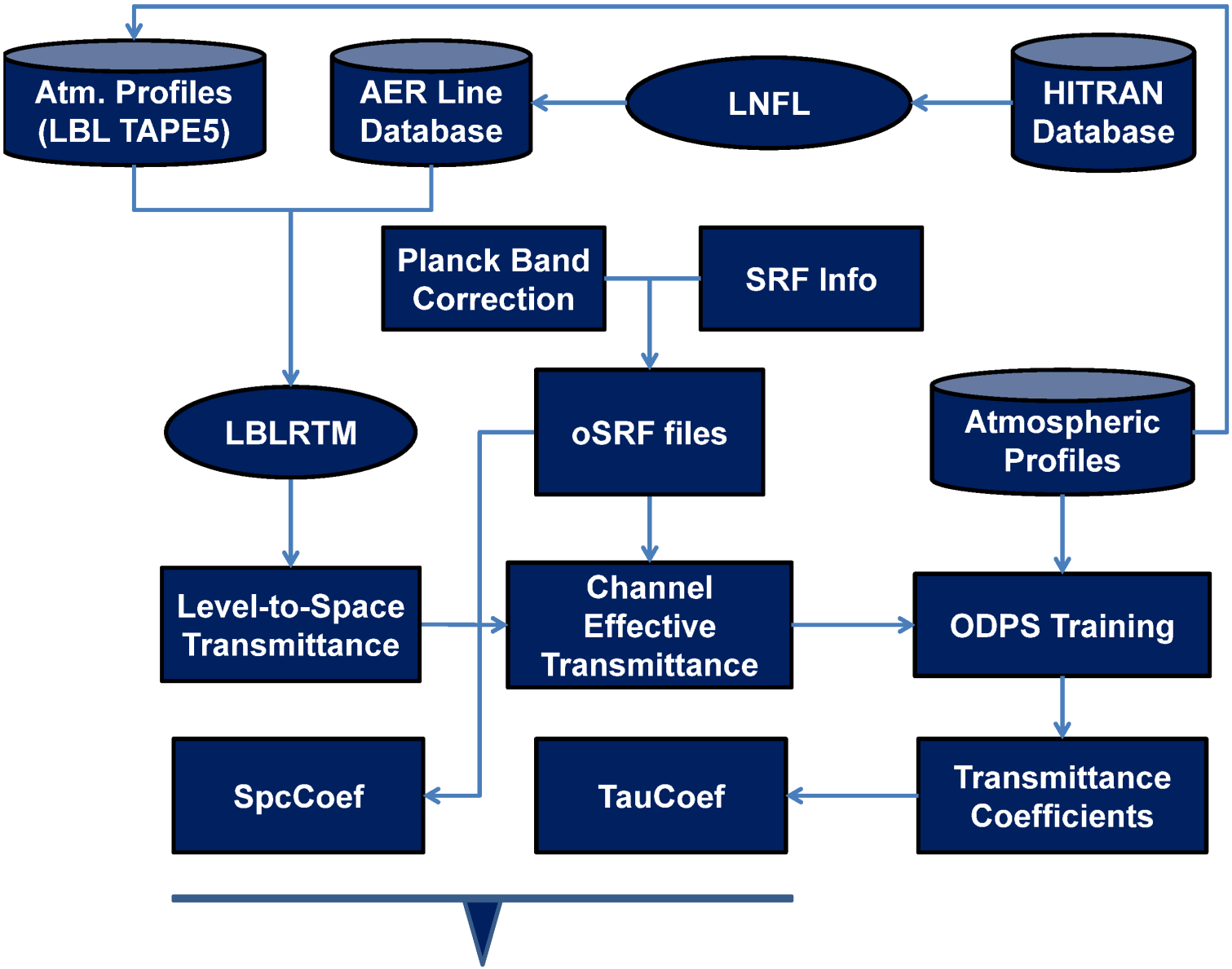
CRTM Coefficient Generation An ongoing activity to develop a simple system for generating CRTM coefficients. We initially started with IR instruments but are planning to extend it to other instruments in the future.

Clear-sky CRTM/SARTA Comparison Evaluating CRTM vs. a well validated RT model for AIRS observations

CRTM vs. MISTiC Observations Comparing CRTM and observations for clear-sky conditions. The observations for a planned NASA instrument (MISTiC) were generated from high resolution IASI data.

CRTM all-weather performance AIRS all-weather radiances simulated using CRTM and a few other RT models were compared with the AIRS observations.

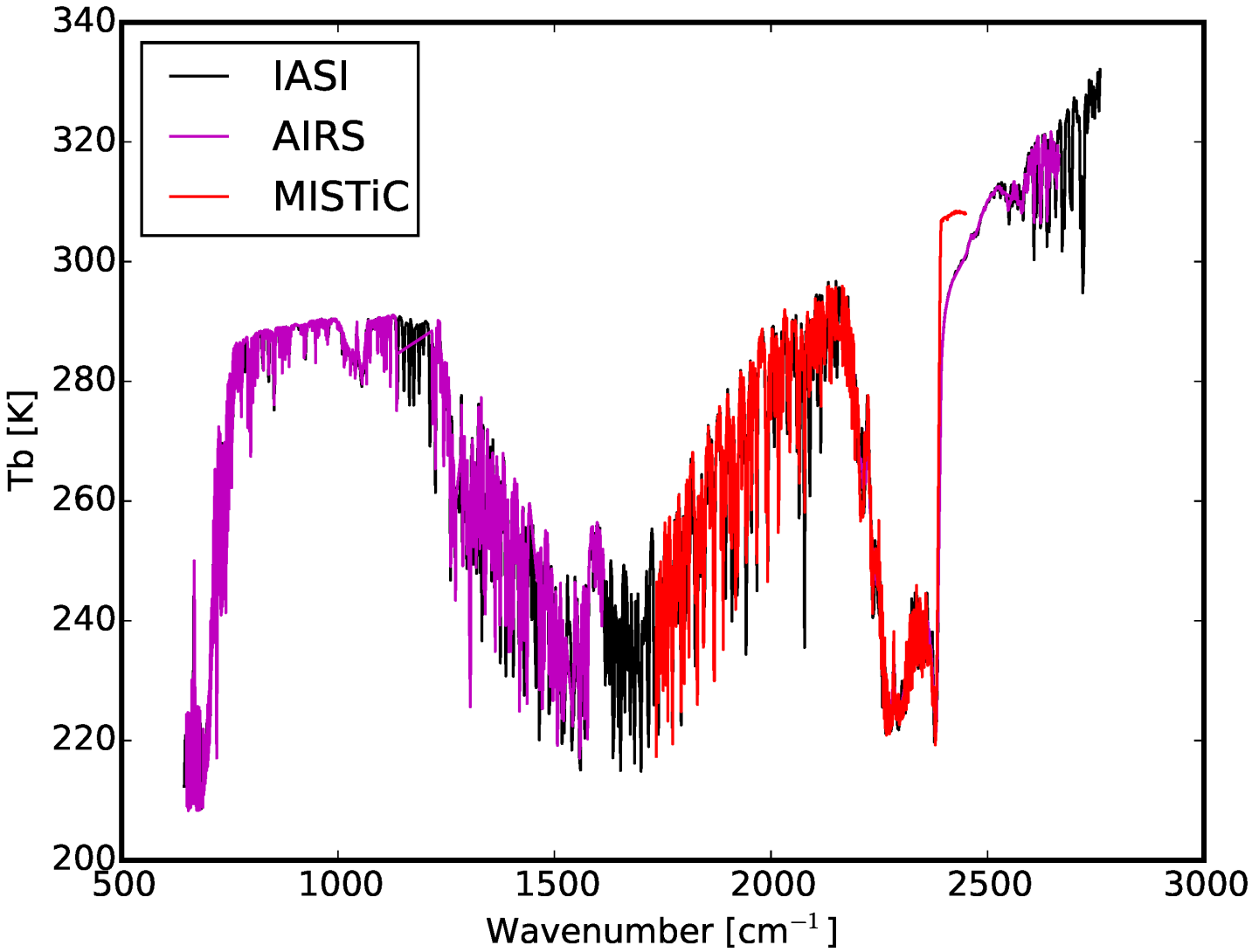
Training CRTM Coefficients



Current Code for Generating CRTM Coefficients

- Outdated and not under sub-version, some pieces of the code have been updated while the rest not so no longer the code works
- It is written in multiple languages and not documented anywhere
- Intermediate data are saved in NetCDF format; the way variables defined (several per channel), all the channels for hyper-spectral IR instruments can not be processed together because of limit for NetCDF variables
- Currently only works with LBLRTM for IR instruments and Rosenkranz for MW instruments; users need to be familiar with LBLRTM and prepare very complicated TAPE inputs
- The coefficients are generated based on statistical fitting but based on a limited number of profiles
- We have updated some part of the code for IR instruments and have submitted a proposal to NASA to completely update the coefficients generation algorithm and code

Generating Coefficients for IR Instruments

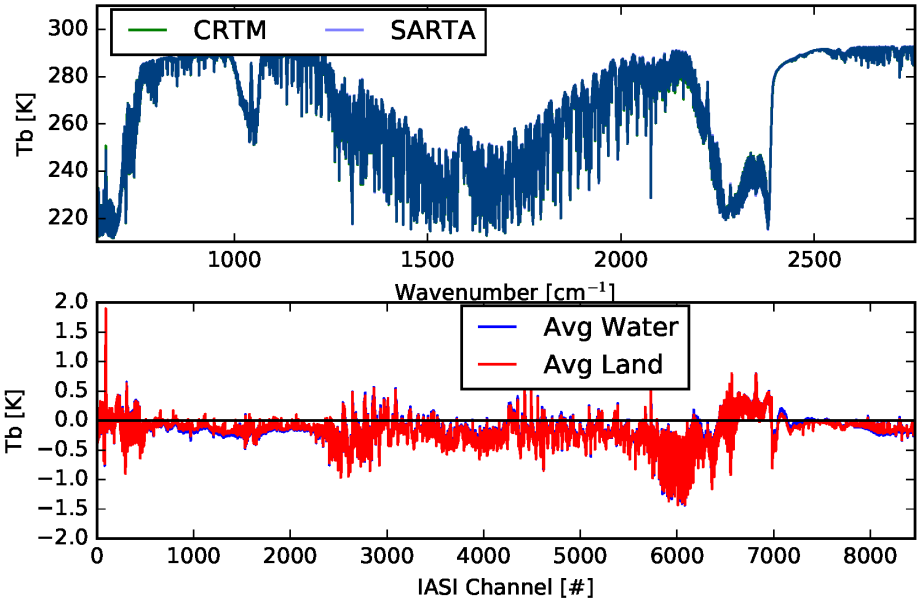


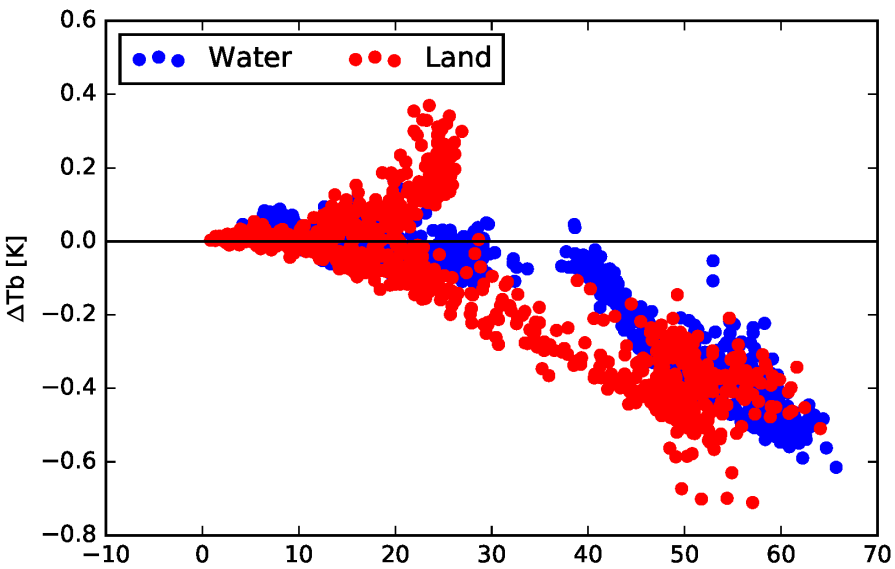
CRTM vs. SARTA in clear-sky

- SARTA is a well-validated model developed by UMBC and currently used as the AIRS radiative transfer model.
- More than 15000 profiles extracted from NASA G5NR
- Simulated IASI radiances using CRTM and SARTA but used emissivity values calculated using CRTM as input to SARTA
- The differences were less than one Kelvin for most channels, but larger differences for water vapor and window channels
- Main issue for comparing the window channels was that SARTA assumes a piece-wise emissivity model and a specular reflectivity model

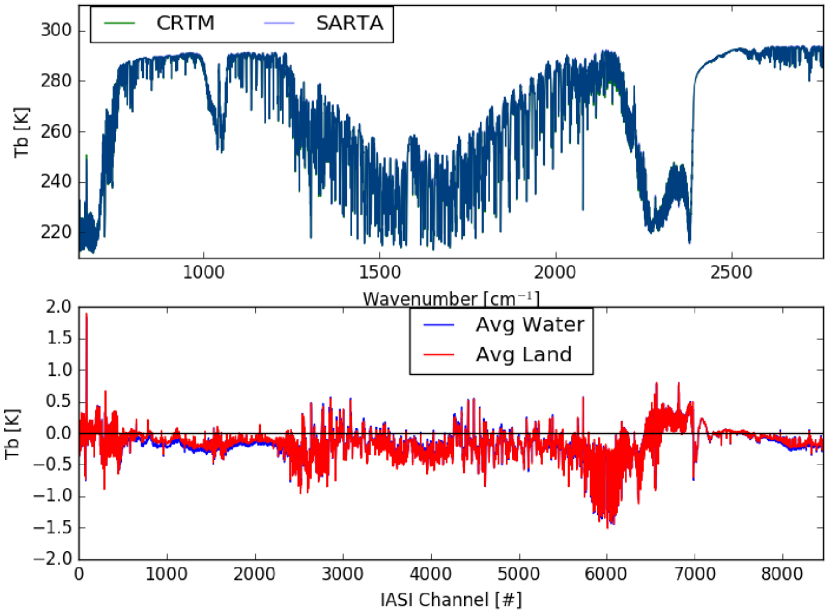
CRTM vs. SARTA

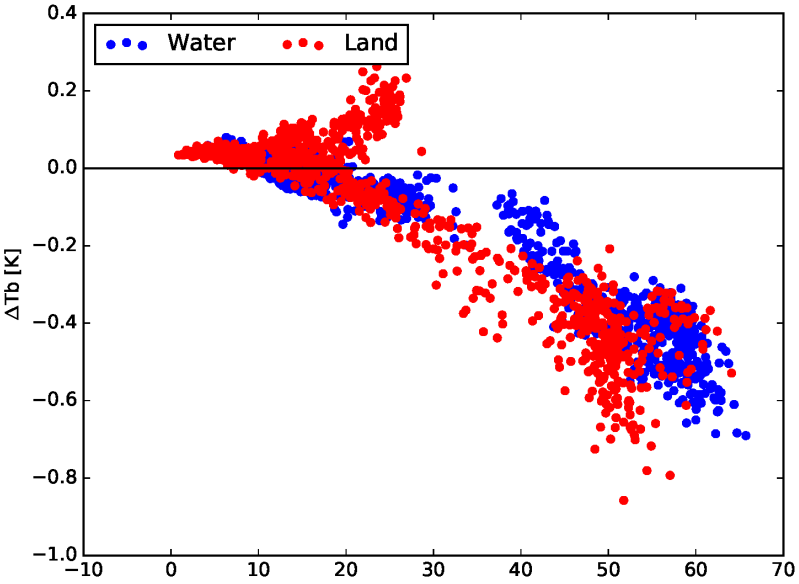
CRTM Emissivity





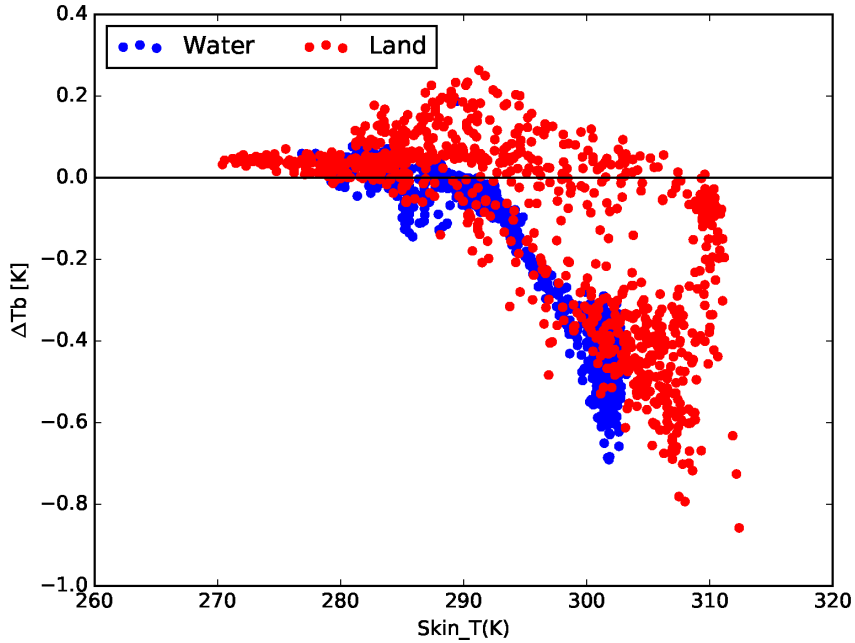
Emissivity = 1.0

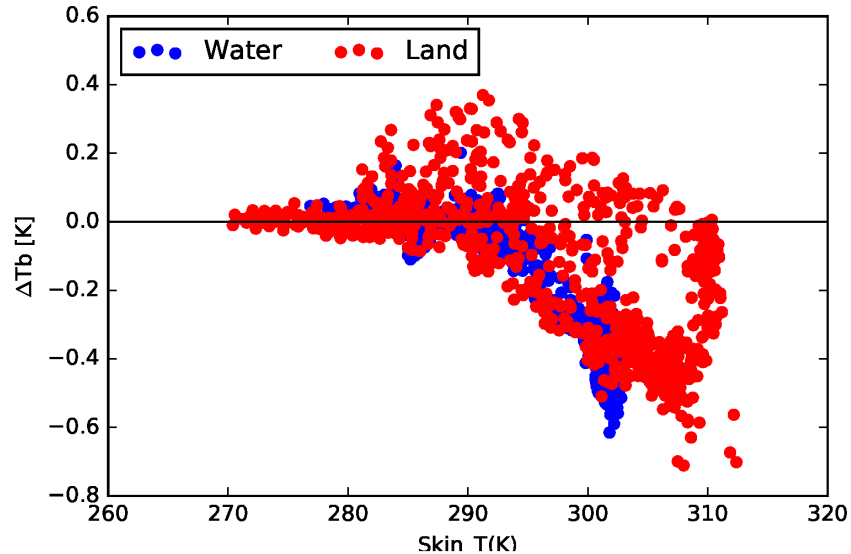




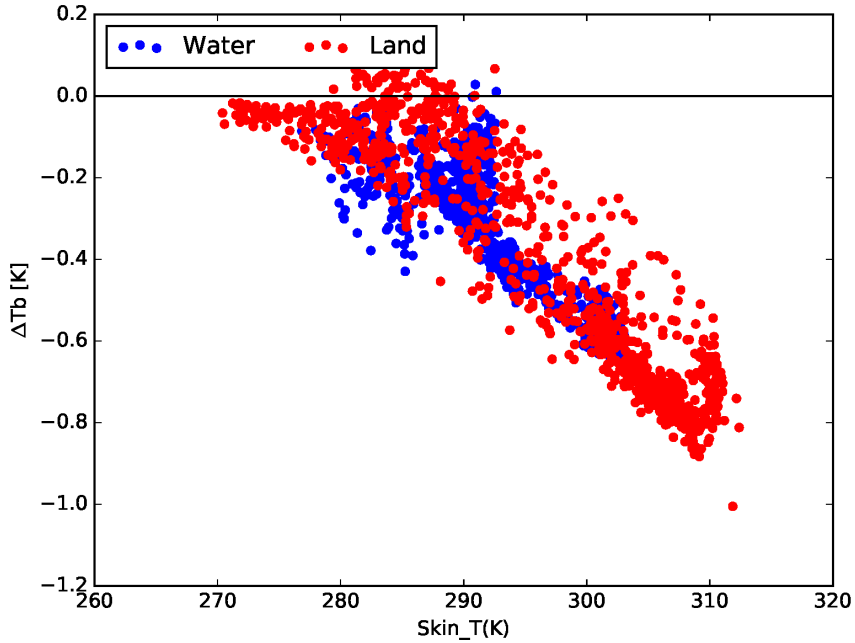
CRTM vs. SARTA

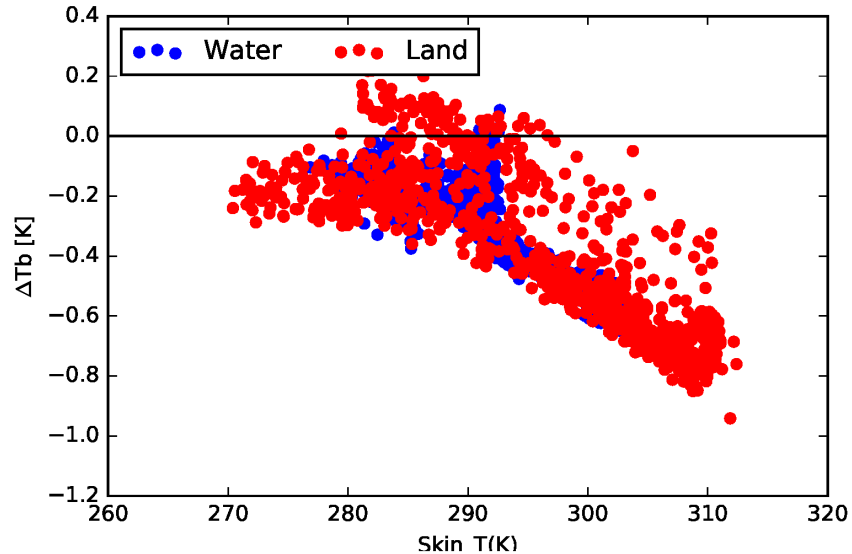
Channel 1800





Channel 6000





Generating semi-real obs

$$h(z) = \int f(x)g(z-x)dx \quad (1)$$

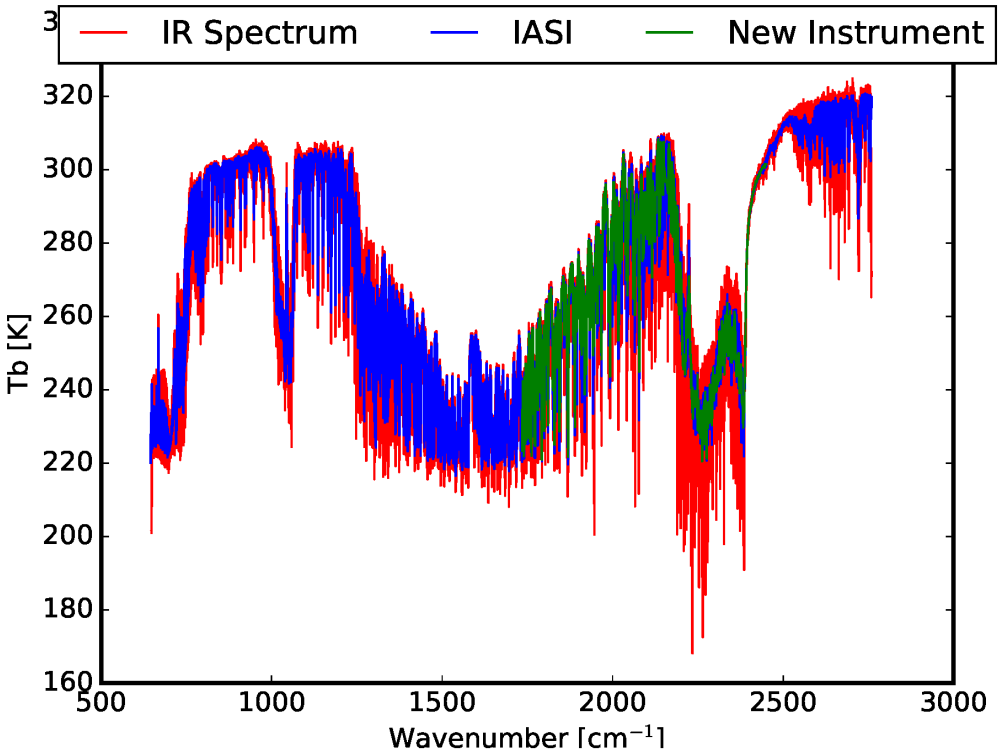
$$F(\nu) = \mathcal{F}(f) = \int f(x)e^{-2\pi i x\nu}dx \quad (2)$$

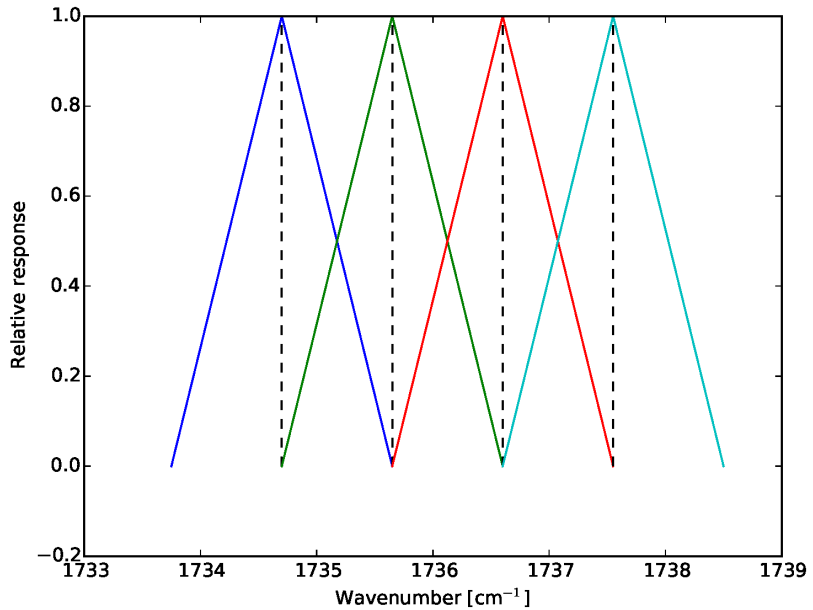
$$G(\nu) = \mathcal{F}(g) = \int g(x)e^{-2\pi i x\nu}dx \quad (3)$$

$$H(\nu) = \mathcal{F}(h) \quad (4)$$

$$H(\nu) = F(\nu) * G(\nu) \quad (5)$$

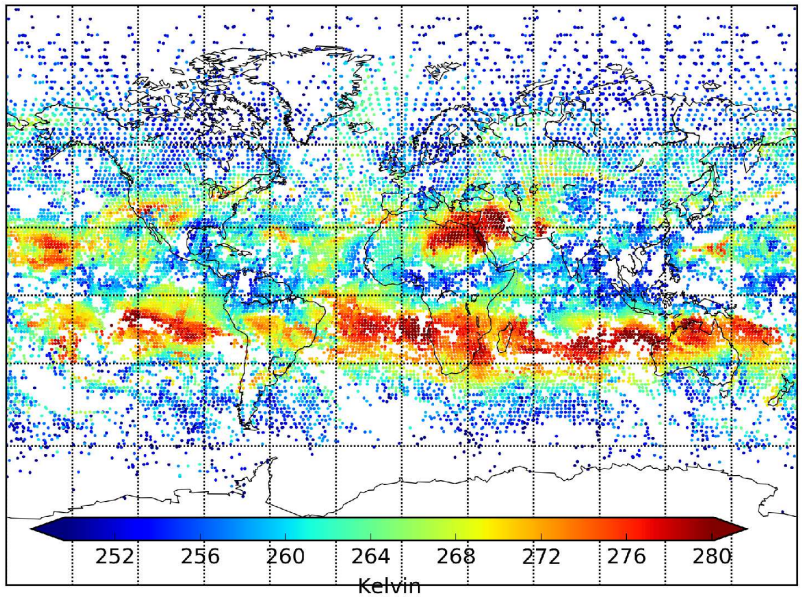
$$h(z) = \mathcal{F}^{-1}(H) \quad (6)$$



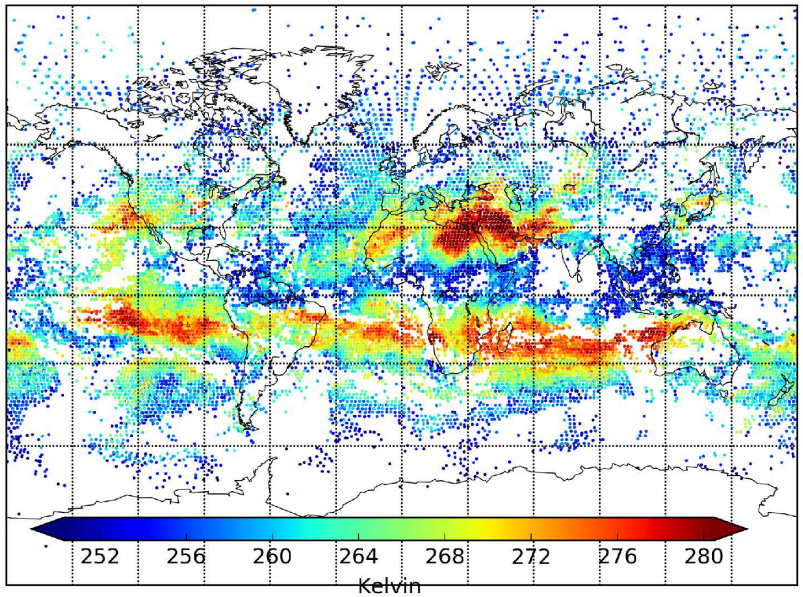


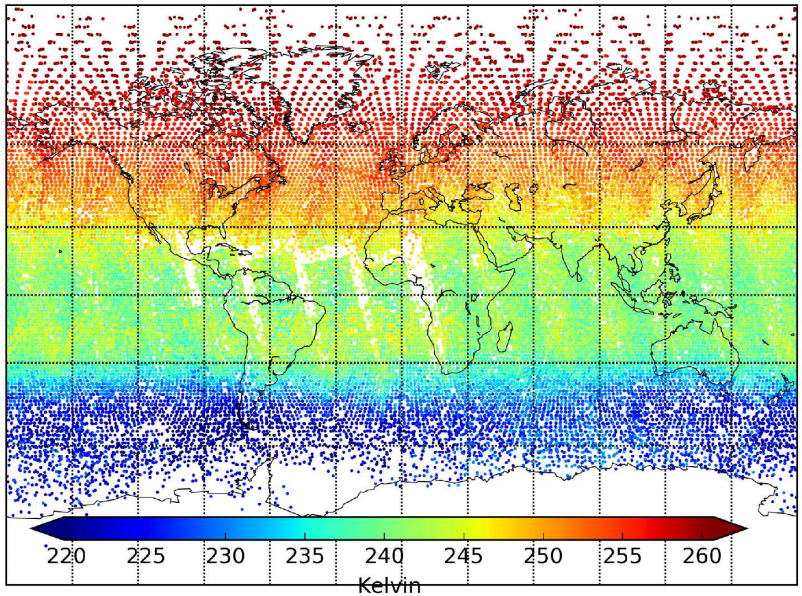
CRTM Simulated vs. Observations

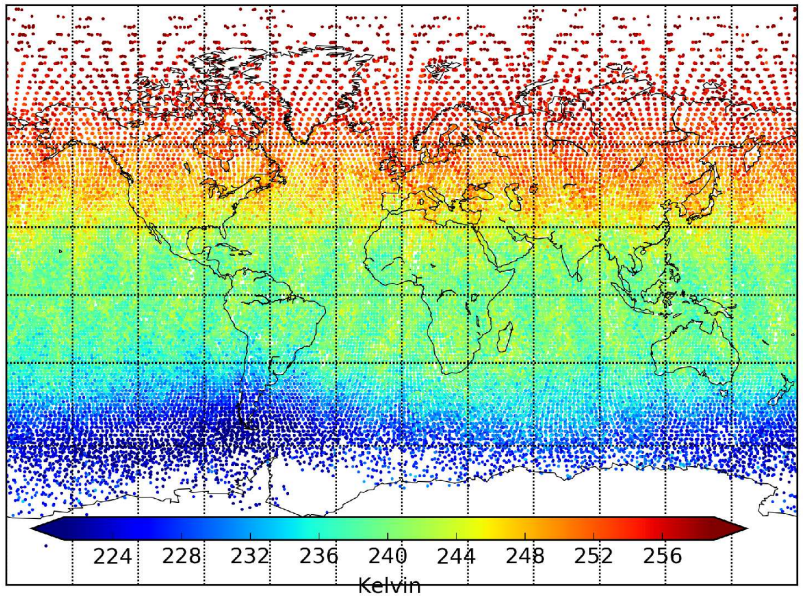
MISTiC observations



Simulated observations

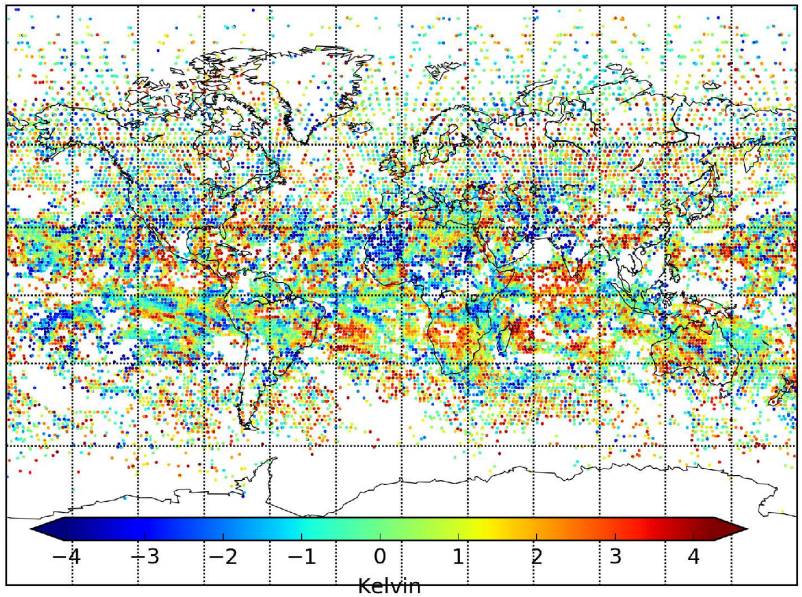


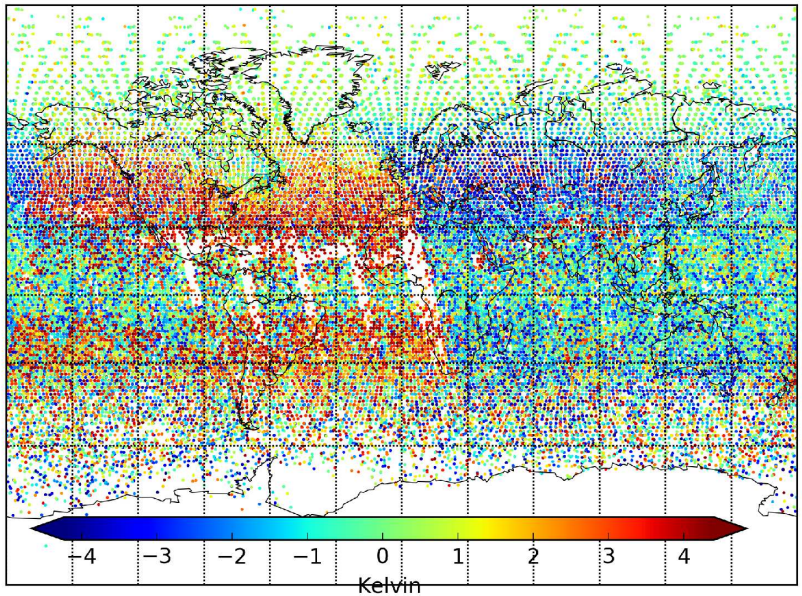




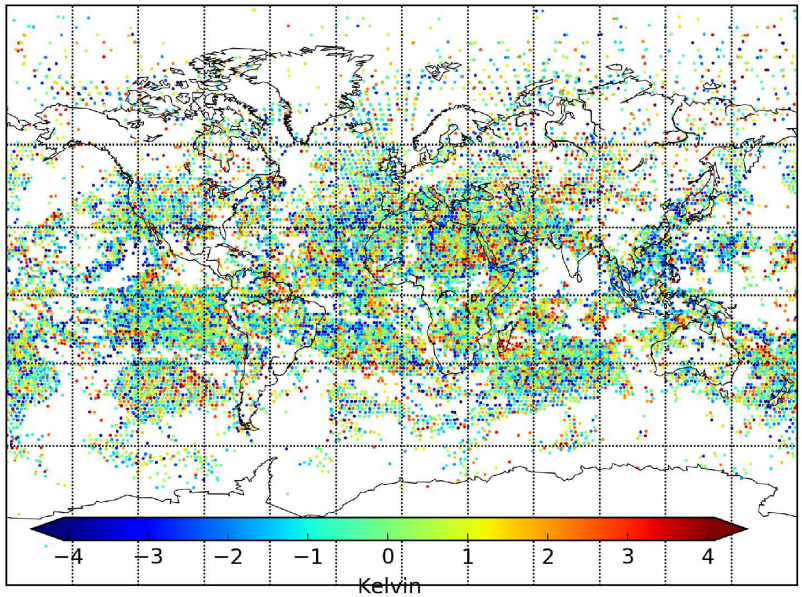
OmF for Simulated and Real Obs

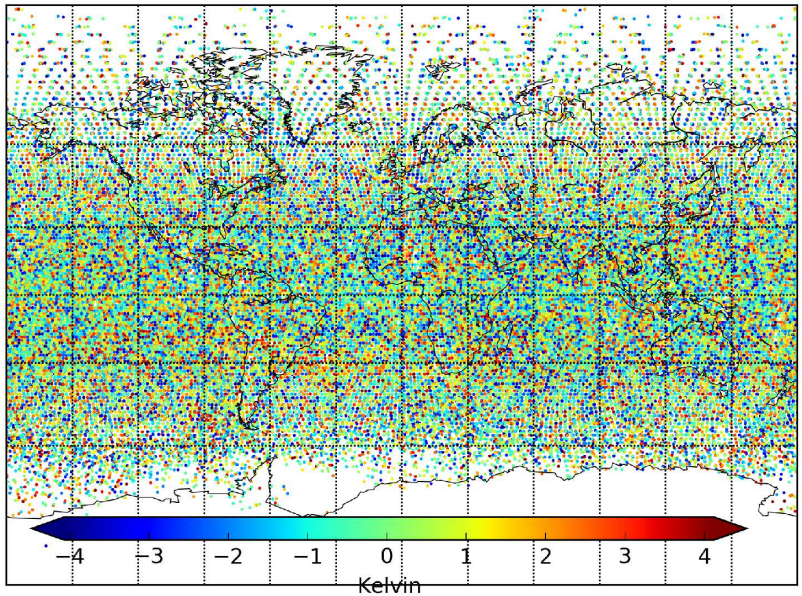
Real observations





Simulated observations





Collocated Era-Interim and AIRS dataset

- Collocated Era-Interim and 3 million lat/lon sample points of AIRS radiances
- Dataset includes profiles (91 level) of temperature, humidity, ozone, cloud amount, and cloud cover, as well as the surface temperatures and total cloud cover.
- A set of default profiles for CO2, CH4, CO, and N2O were added to the profiles.
- The dataset was pare down to about 8000 representative set of atmospheric states by stratification based on lat/ocean/day/night, the surface temperature from ECMWF and the brightness temperature of the 1231 cm^{-1} window channel from AIRS.

Evaluation and intercomparison

- The pairwise comparison of the observed AIRS spectra with the calculated spectra: collocation error, lack of input variables (e.g., particles size distribution)
- Characterization of the radiometric effect of clouds using histograms of (stemp-bt): In the lack of solar reflected component for window channels, (stemp-bt) increases from near zero under clear conditions to 100 K with increasing cloudiness.
- The pairwise comparison of results from different RTMs: Not vulnerable to biases in ECMWF data or collocation errors but cannot tell much about absolute error.

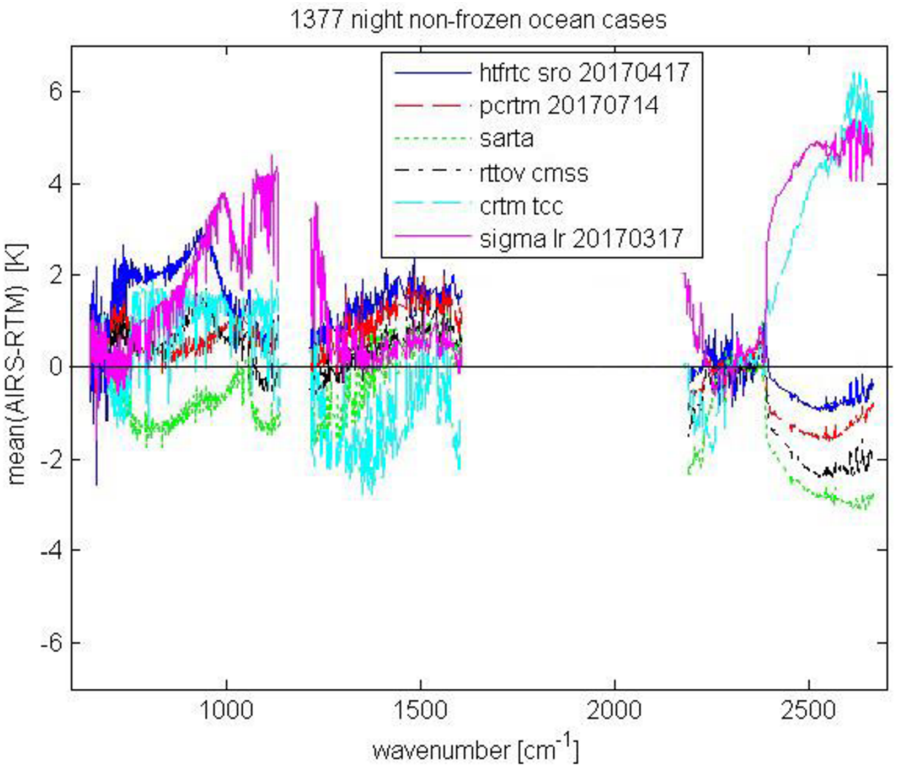
RTM Evaluation

- Six RTMs were used: (1) SARTA, (2) RTTOV, (3) HT-FRTC, (4) PCRTM, (5) CRTM, and (6) σ-IASI
- All RTMs calculated cloudy radiances using a linear combination of clear sky calculations and scattering calculations for one or more cloud columns.
- The results of the clear sky column calculations from all these RTMs were nearly identical
- There are several variations of cloud overlap assumptions including Maximum Overlap, and Maximum Random Overlap

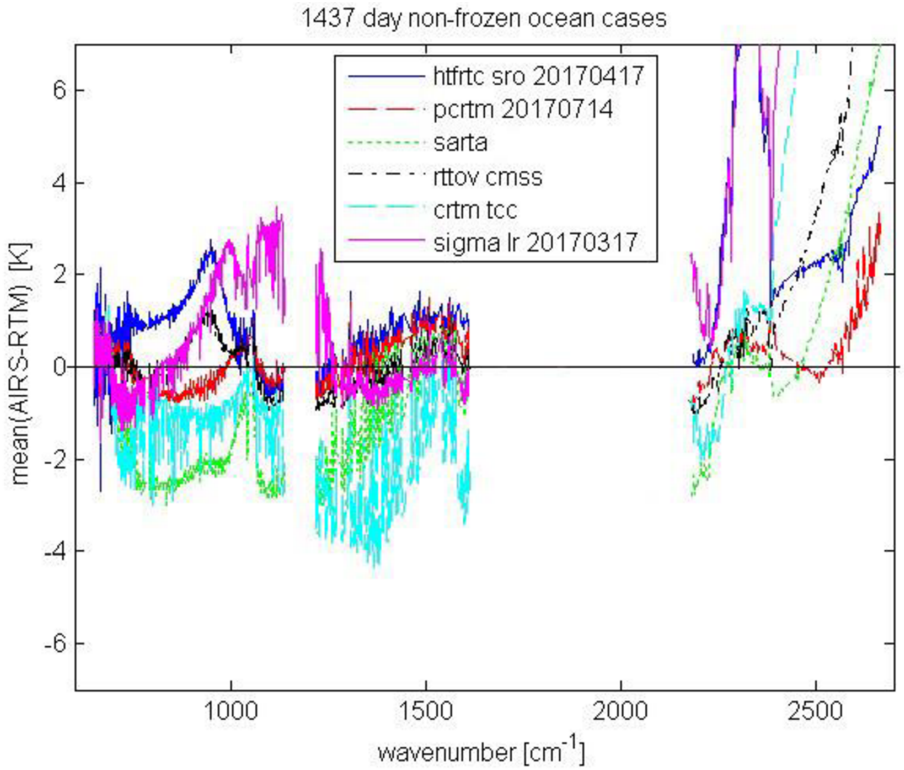
Participants

RTM name	Base Model Spectroscopy	Participant	Organization
SARTA	HITRAN2008	DeSouza-Machado Strow	UMBC
RTTOV	HITRAN2008	Vidot Matricardi	NWPSAF (France) ECMWF (EU)
HT-FRTC	HITRAN2008	Havemann	U.K. Met Office
PCRTM	HITRAN2008	Xianglei Huang Xu Liu	U. Michigan LARC
CRTM	HITRAN2008	Moradi, Wilson	NASA GMAO NASA JPL
σ-IASI-as	HITRAN2012	Liuzzi Masiello	U. Basilicata, Italy

Participants



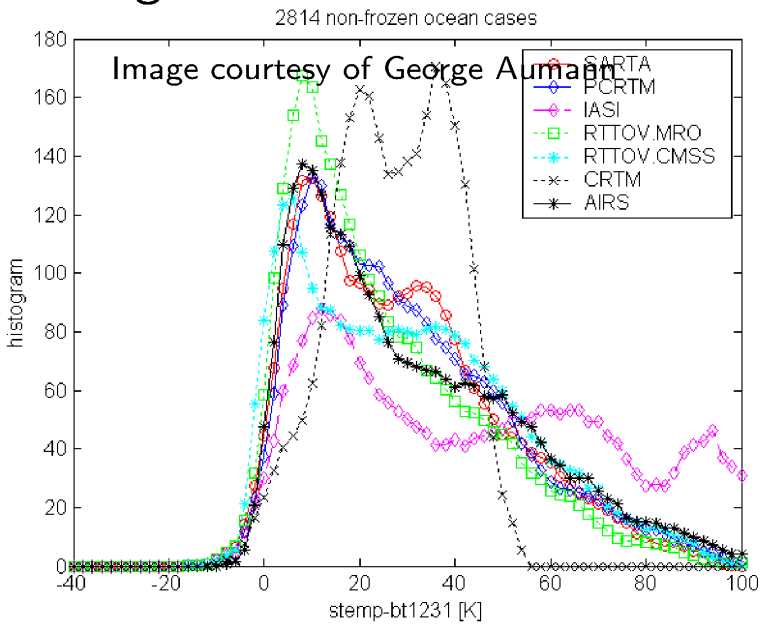
a) Night

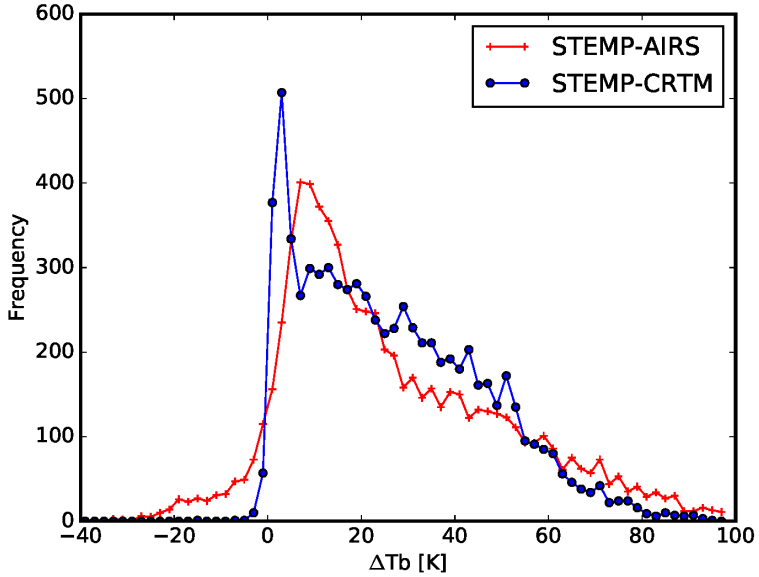


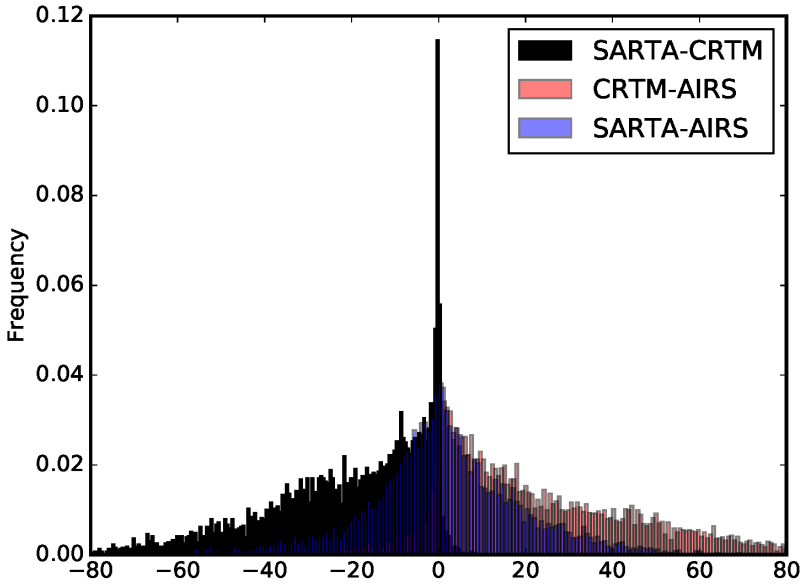
b) Day

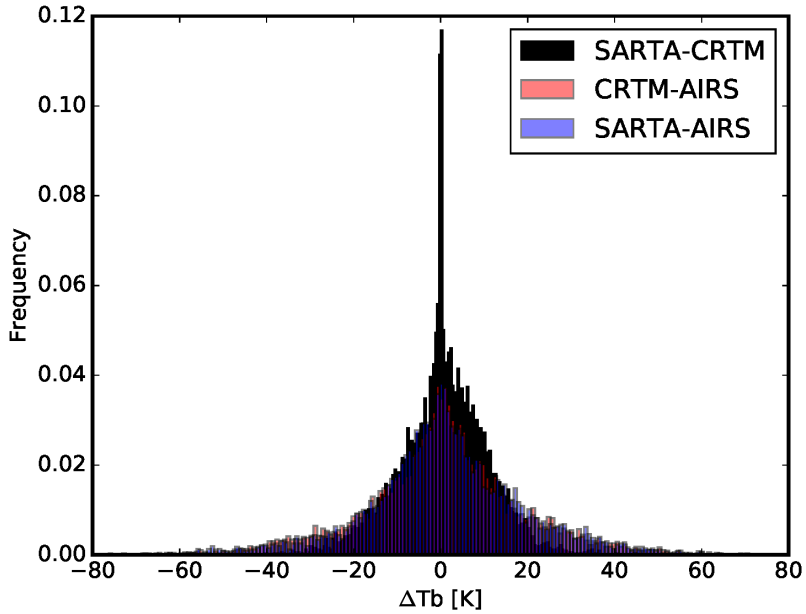
CRTM vs. SARTA

Original IWC Profiles Skin T - Tb1231 Scaled IWC by 0.3









Conclusions

- An ongoing activity to prepare a package for generating CRTM coefficients
- Clear-sky comparison between CRTM and SARTA shows somewhat large differences for the WV channels
- Evaluation of CRTM vs. several other models as well as AIRS radiances shows significant biases in the CRTM cloudy simulations

Thank you for your attention!