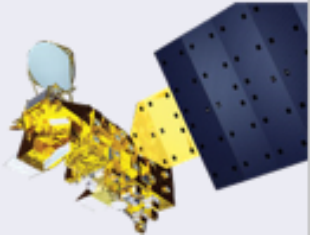

Cloudy Radiative Transfer Model Status Report

H. H. Aumann, Sergio DeSouza-Machado, Xu Liu, Evan Manning, Evan Fishbein, Bill Irion, Mathias Schreier, Chris Wilson

AIRS Science Team Meeting

24 March 2016

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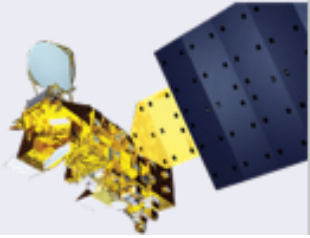

An accurate and fast Radiative Transfer Model (RTM) is the foundation of the accurate interpretation and assimilation of hyperspectral infrared sounder data.

For clear (or cloud-cleared) data we have SARTA for AIRS, CRTM for CrIS.

The interpretation of cloudy spectra, requires an accurate and fast RTM.

In October 2015 the AIRS project started to evaluate cloudy RTMs. Following is a status report.

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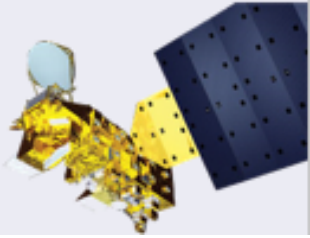

We created a global set of 7377 atmospheric states based on AIRS spectra.

These states were matched up (time and space interpolation) to the nearest ECWMF definition of T(p), q(p) etc in 62 layer, including clouds.

The international community was invited to exchange spectra calculated for AIRS.
Sergio Machado is the interface into the ITOVS community.

As a test of the data set and an analysis methodologies we used the March 2016 versions of SARTA_cloudy (UMBC , Sergio) and PCRTM_cloudy (LARC , Xu Liu).

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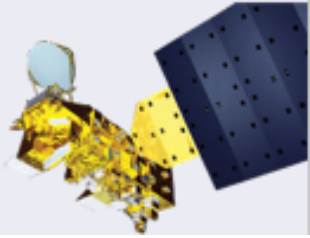

Several methods have been used to validate fast cloudy RTMs.

1) Compare results from different cloudy RTMs.
Assumptions regarding scattering, particle size distribution and cloud overlap largely cancel.

2) Compare the results with spectra calculated with observed spectra from field campaigns.
Not globally representative.

3) Compare the results with spectra calculated using LBLRTM and DISORT.
This is impractical for globally representative conditions and hyperspectral data.
Shared assumptions regarding scattering, particle size distribution and cloud overlap cancel.

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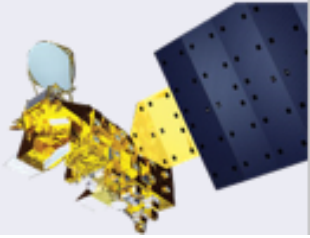

We use a variant of the previously used methods.

We analyzed the mean and stdev of (PCRTM-SARTA) under clear and cloudy conditions

We analyze the mean and stdev of (PCRTM-AIRS) and (SARTA-AIRS) under cloudy conditions.

The 7377 set of conditions is large enough to analyze day/night, global and regional statistics

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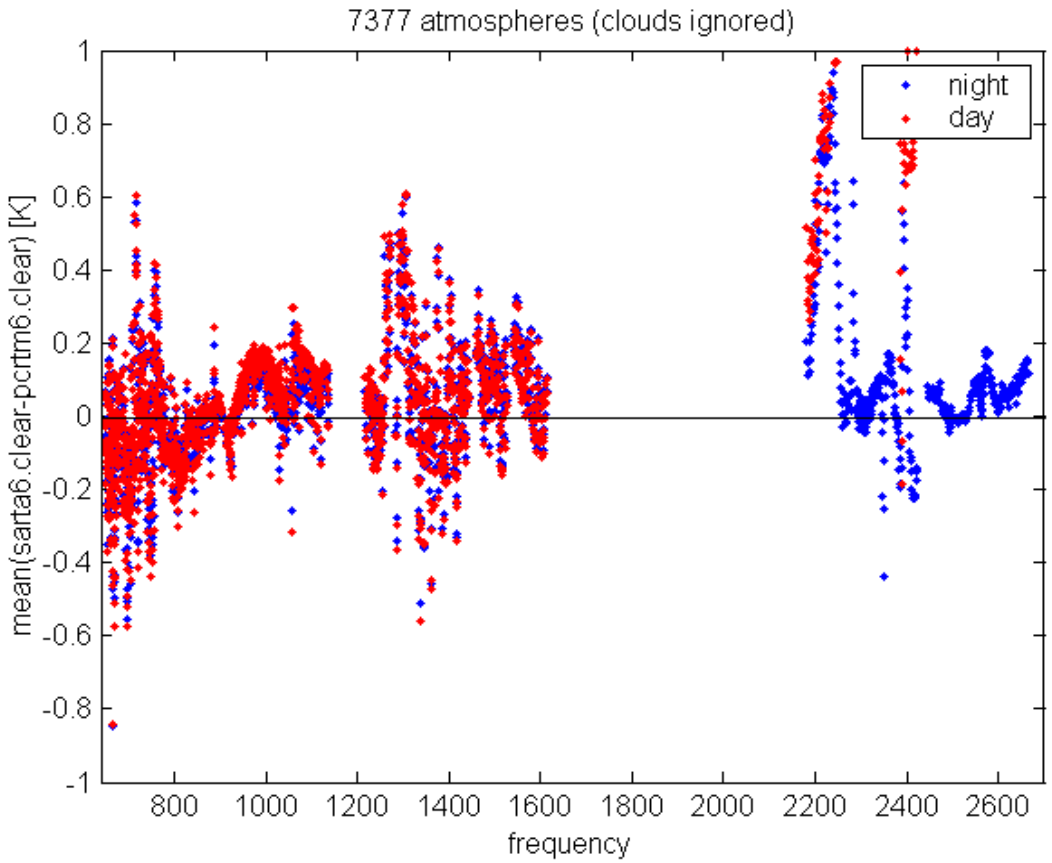
Under clear conditions SARTA and PCRTM agree within 0.1K at night



During the day SARTA and PCRTM agree within 0.1K in the long-wave channels.
The version of PCRTM available for our test did not implement daytime non-LTE.
In the following we focus n the longwave channels.

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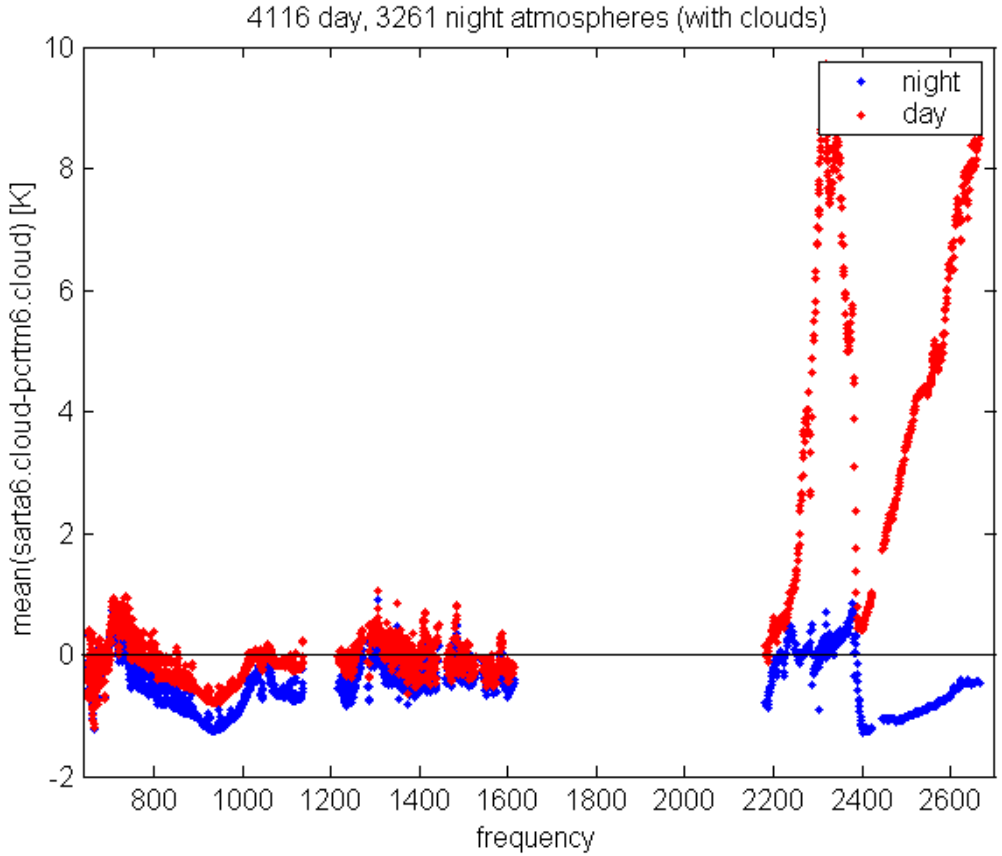
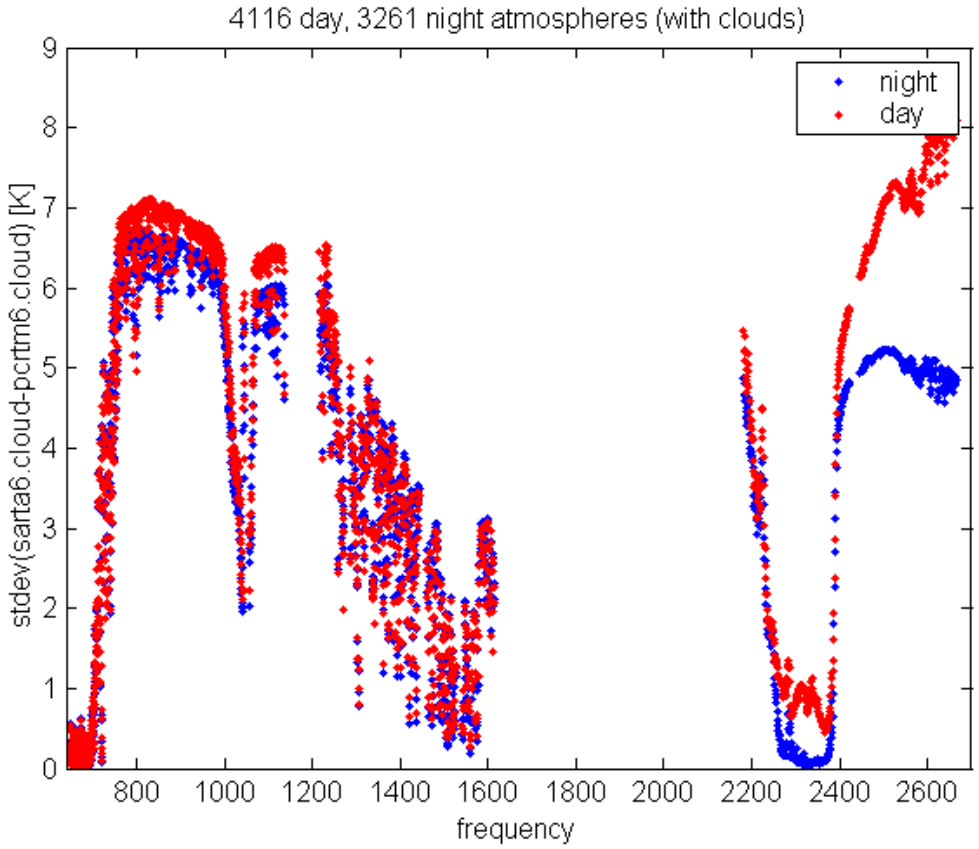
Under cloudy conditions SARTA and PCRTM agree within 1K in the mean, but stdev(SART-PCRTM) is 7K in the 11um window area.





SARTA and PCRTM start with identical ECMWF prescriptions for clouds, both use the same surface emissivity, but differ in the details of how scattering and cloud overlap are handled.

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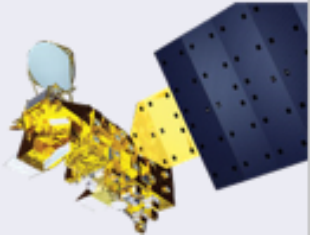
We use AIRS spectra to determine if SARTA or PCRTM is closer to the truth.



The comparison of spectra calculated using the ECMWF prescription with co-located AIRS spectra introduces three errors:

1. **The interpolation error. The ECMWF prescription is from a ¼ degree grid every 3 hours. This error should be zero mean, but may create a large stdev.**

2. **The calculation error. This error could create a bias and a large stdev.**

3. **The ECMWF error. This error could create a bias and contribute to the stdev.**

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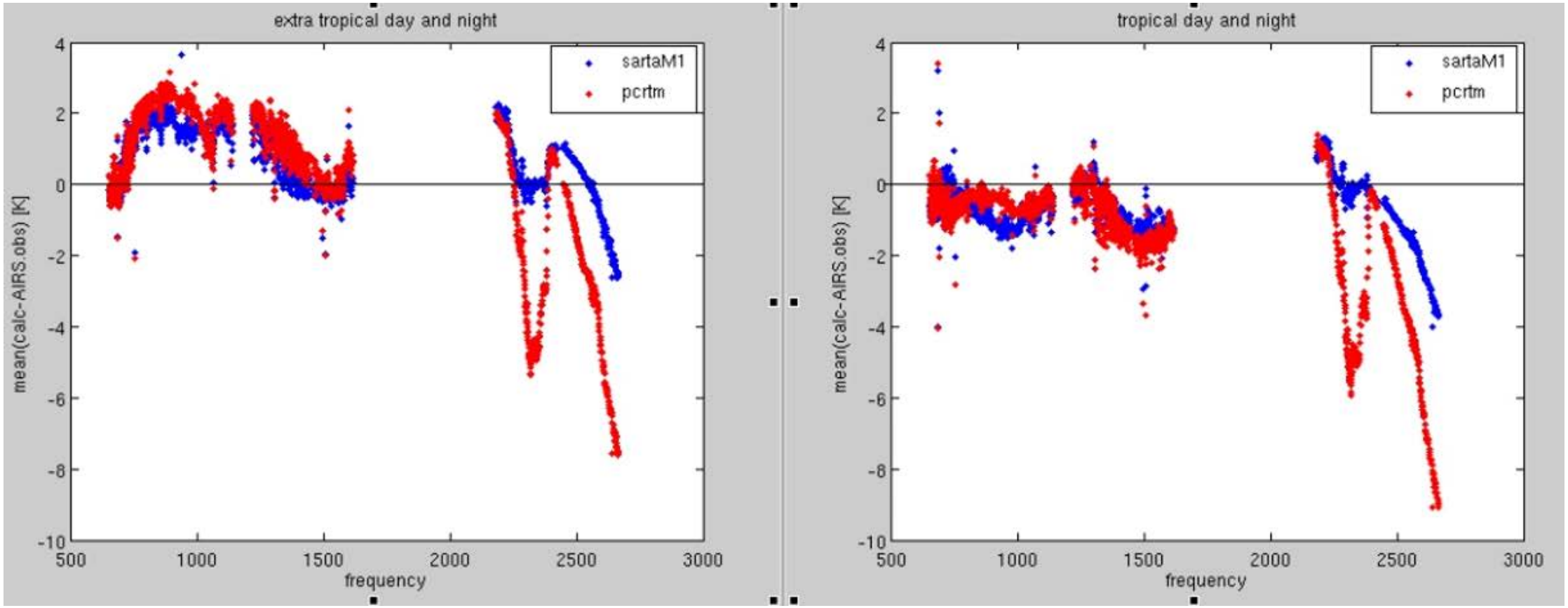
The bias of SARTA and PCRTM relative to AIRS could be an ECMWF prescription issue: Clouds are too thin or too few in the extra-tropical zone.



In the extra-tropical zone AIRS is about 2K colder then SARTA and PCRTM.
In the tropical zone AIRS is 1K warmer than SARTA and PCRTM

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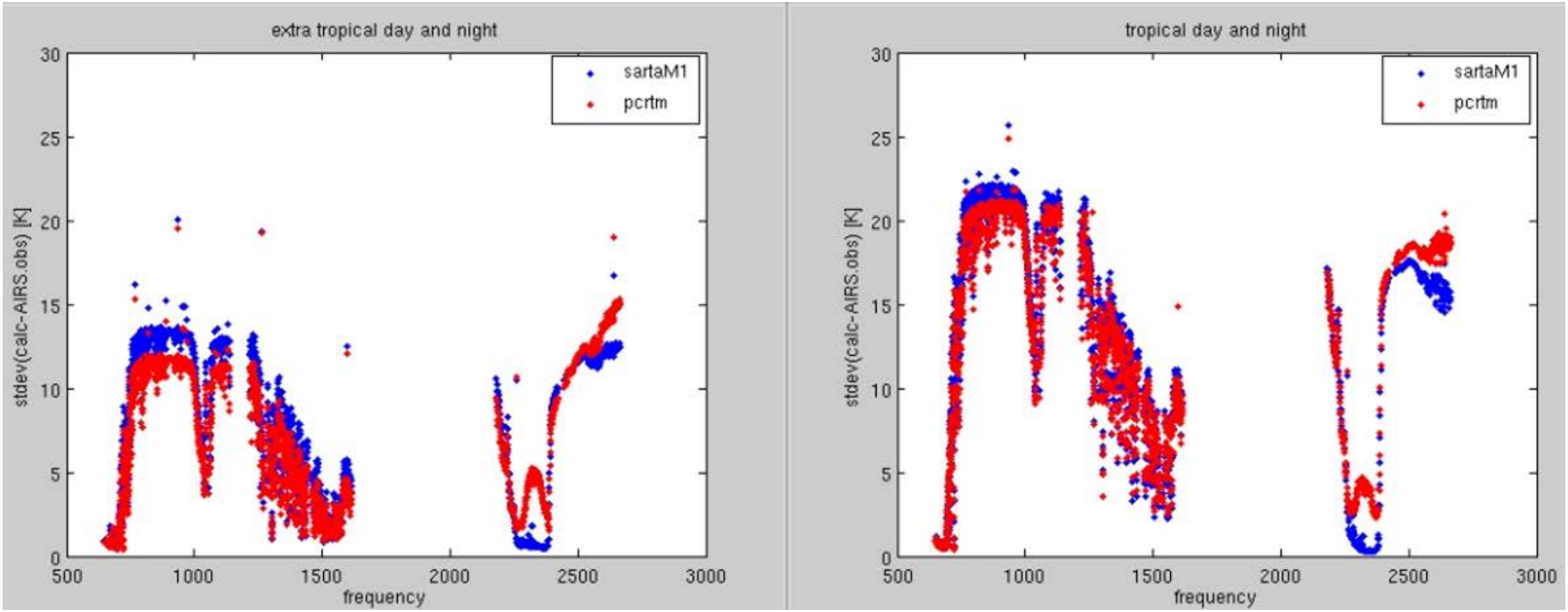
The stdev of SARTA and PCRTM relative to AIRS is due to the combination of interpolation error, calculation error and ECMWF prescription error



Only AIRS channels with nedt250<1K are shown. Some of these are outliers.
The stdev(PCRTM-AIRS) is consistently less than stdev(SARTA_AIRS)
Both are consistently smaller in the extratropical zone than on the tropical zone.

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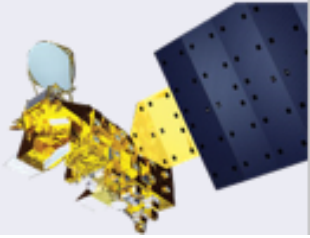
PCRTM matches AIRS better than SARTA



The comparison of spectra calculated using the ECMWF prescription with co-located AIRS spectra is the RSS of the interpolation error, the calculation error, and the ECMWF error.

SARTA and PCRTM have the same interpolation error and ECMWF prescription error.

The finding that stdev(PCRTM-AIRS) is consistently less than stdev(SARTA_AIRS) suggests that PCRTM has a smaller calculation error than SARTA. The details of the PCRTM cloud implementation match reality better then SARTA.

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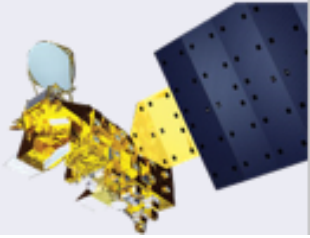
PCRTM matches AIRS better than SARTA



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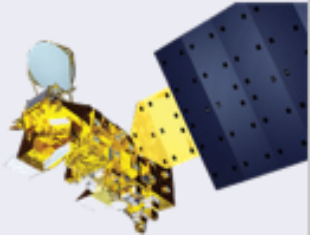

The ITOVS community has expressed interest in the 7377 atmospheric states and cloudy RTM comparisons: UMBC/LARC/NOAA (RTTOVS?)/ AER/UKMetOffice/UW/U.Michigan

At this early state of analysis the 7377 states are good enough. We may be able to create a better evaluation by using AIRS/CloudSat matchups, interpolated to ECMWF state of the atmosphere. This allows us to correlate cloud types and calculations.

Until we see convergence of the mean and the stdev between different algorithms, a better data set and computer resource requirement are a second order issues.

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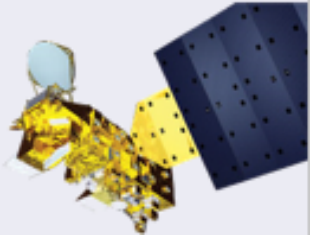

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