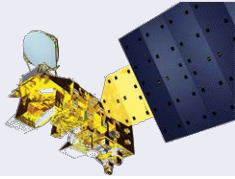

Cloudy RTA Development

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Jet Propulsion Laboratory, California Institute of Technology,

and

Sergio Machado
UMBC

AIRS Team Meeting. Greenbelt, MD
September 14, 2016

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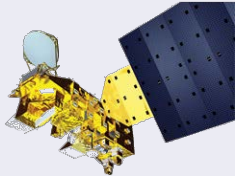
Outline



- Motivation
- AGU 2016 Special Session
- First results for cloudy conditions
- Summary and Conclusions

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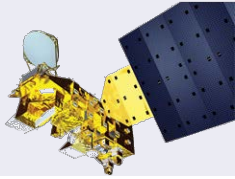
Realistic cloudy spectra will improve weather forecasting and climate models



Clouds are a key component in medium range weather forecasting and climate models.

Medium range forecast and climate models specify clouds, but do not test if the clouds agree with observations.

Clouds are the most prominent feature in infrared observations from space.

For the past 30 years the emphasis in infrared sounder data utilization has been on
- sounding under clear conditions only (1% of the data)
- or eliminating the effect of clouds from the data

Algorithm improvements in scattering RTMs can now create reasonable looking cloudy infrared spectra.

If we can show that a cloudy RTA can produce statistically realistic spectra with acceptable computer resource requirements, the RTA will be used to improve weather forecasting and climate models.

This is the objective of the Cloudy RTA session at the AGU2016.

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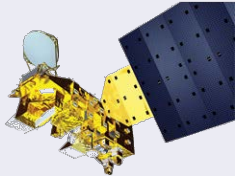
AGU2016 Special Session on Cloudy RTA



We proposed a session on cloudy RTA for the 2016 AGU

The infrared atmospheric remote sensing community was invited to report on advances in how they deal with clouds, the development of fast and accurate RTMs in clear and cloudy, day and night atmospheres for the spectral ranges covered by AIRS, CrIS and IASI, closure between the model clouds and observed clouds, and results from validation campaigns related to clouds and cloudy RTMs.

In support of a comparison of spectra we prepared test set of 7377 globally representative atmospheric states using AIRS and ECMWF data.

11 abstracts were submitted.
8 of the 11 promised to calculate spectra for the 7377 atmospheric states (UMBC, LARC, U.Michigan, UKMetoffice, MeteoFrance, JPL (2) and Caltech.
The calculations will be done with LBLRTM/DISORT, SARTA , PCRTM, RTTOV and some new names.

We set up an anonymous website at thunder.jpl.nasa.gov to exchange data.

The session has been renamed “Advances in Remote Sensing of Cloud” to include microwave active and passive with a total of 27 presentations for one oral session (2 hours = 6 presentations + posters)
For hyperspectral IR there will be the first 3 oral presentations plus 8 posters.

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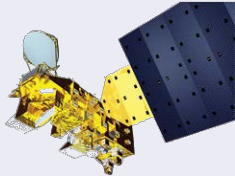
Preliminary Results: Cloudy conditions



There is a one-on-one correspondence between the spectra calculated by different RTAs under cloudy conditions since they all use the same ECMWF data.

Differences will be due to residual unspecified choices of cloud overlap (e.g. MRO), particle size and ice cloud properties (Baum, UW vs. Baran, UKMetoffice)

There is no one-on-one correspondence between the ECMWF atmospheric state specification and AIRS observations at the same location and time. We assume that there is a statistical correlation.

There are various ways to assess which of the algorithms is closest to reality (as defined by AIRS).

We plan to use PDF correlation analysis to determine who of the algorithms is closest to reality.
The simplest analysis compares the PDF of AIRS with the calculated PDF at 1231 and 2616 cm-1

We illustrate this with preliminary results for SARTA_two_stream and PCRTM_MRO compared to AIRS using day and night non-frozen ocean cases.

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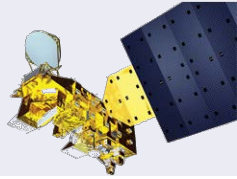
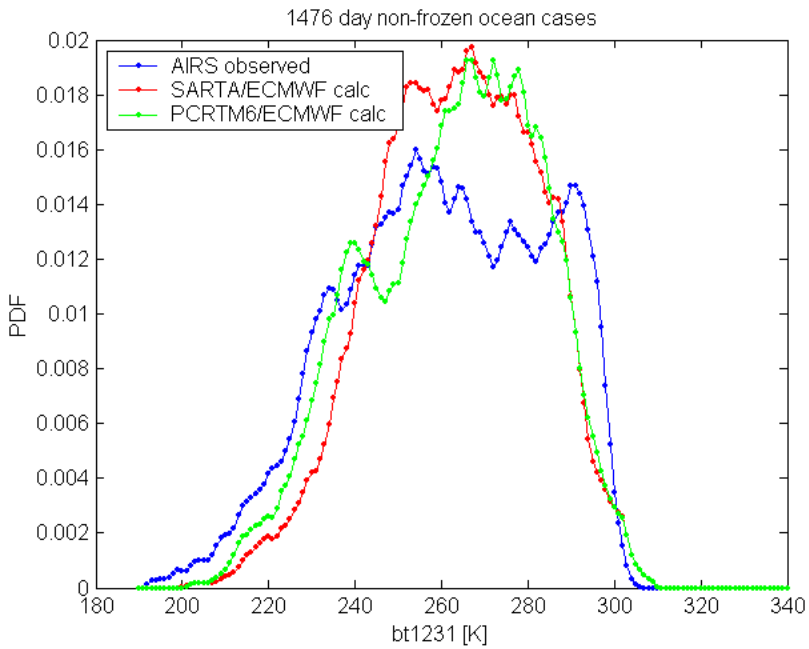
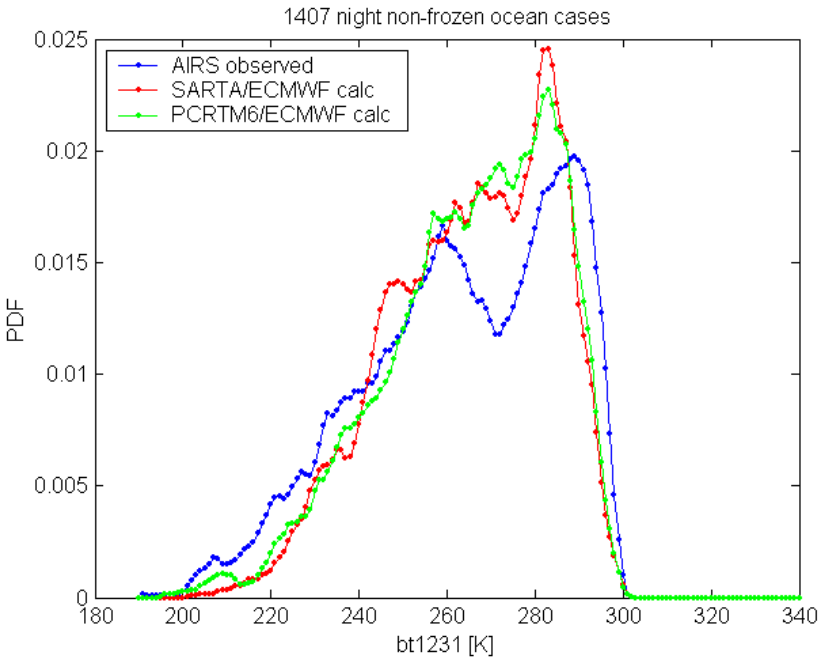
Preliminary Results: 1231 cm-1 PDF
Day compared to night cloudy conditions



Day PDF at 1231 cm-1



Night PDF at 1231 cm-1



During the day bt1231 SARTA and PCRTM agree with each other (r=0.97), but not with AIRS (r=0.81). This could be a problem with the ECMWF state.

At night SARTA and PCRTM agree with each other nearly perfectly at 1231 cm-1 (r=0.98), but not with AIRS (r=0.85). This could be due to a ECMWF/AIRS mismatch

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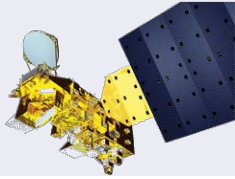
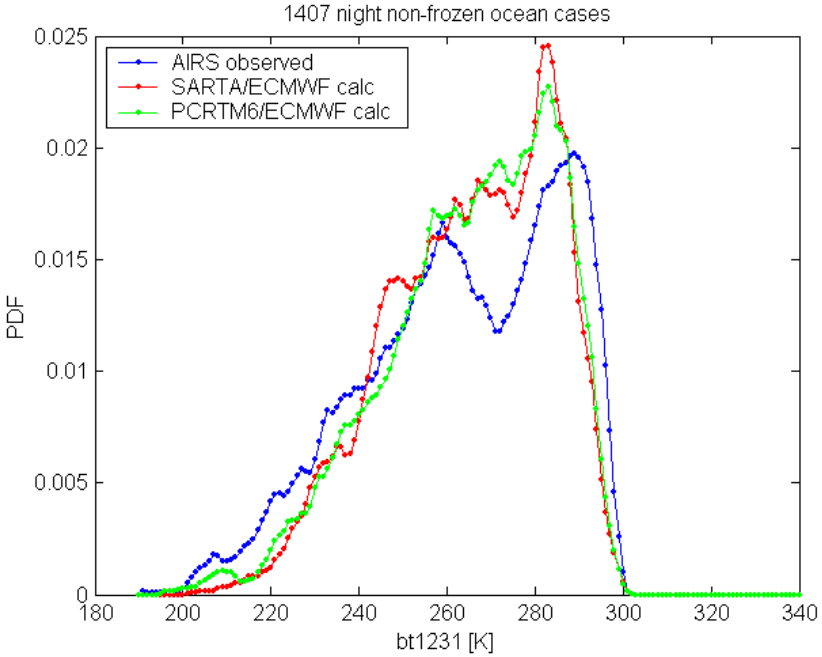
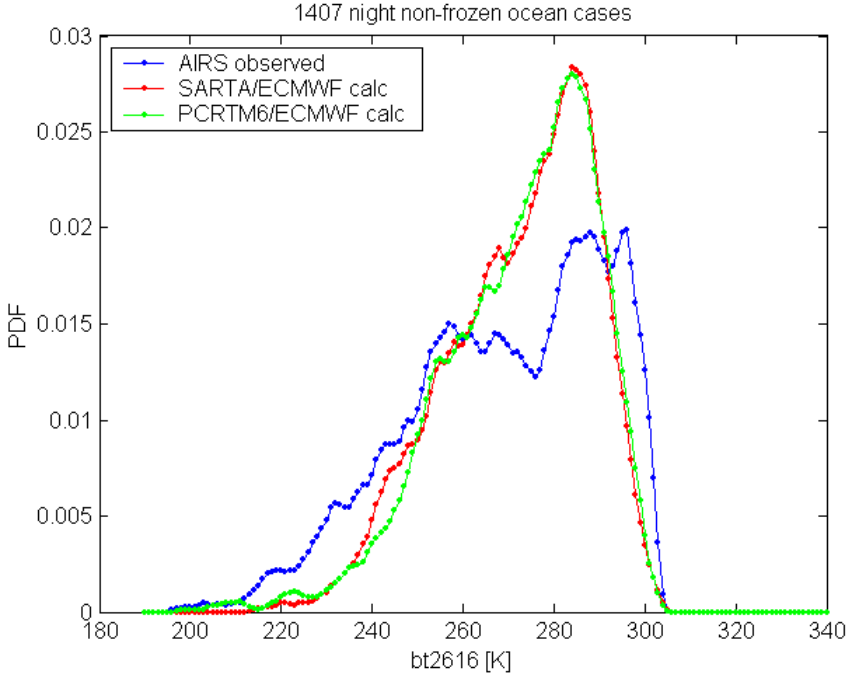
Preliminary Results: The 2616 and 1231 cm-1 PDF agree at night , but not with AIRS



PDF at 1231 cm-1



PDF at 2616 cm-1



At night SARTA and PCRTM agree with each other nearly perfectly at 1231 and 2616 cm-1 (r=0.98), but not with AIRS (r=0.85). This could be due to a ECMWF/AIRS mismatch

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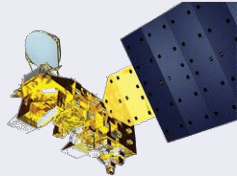
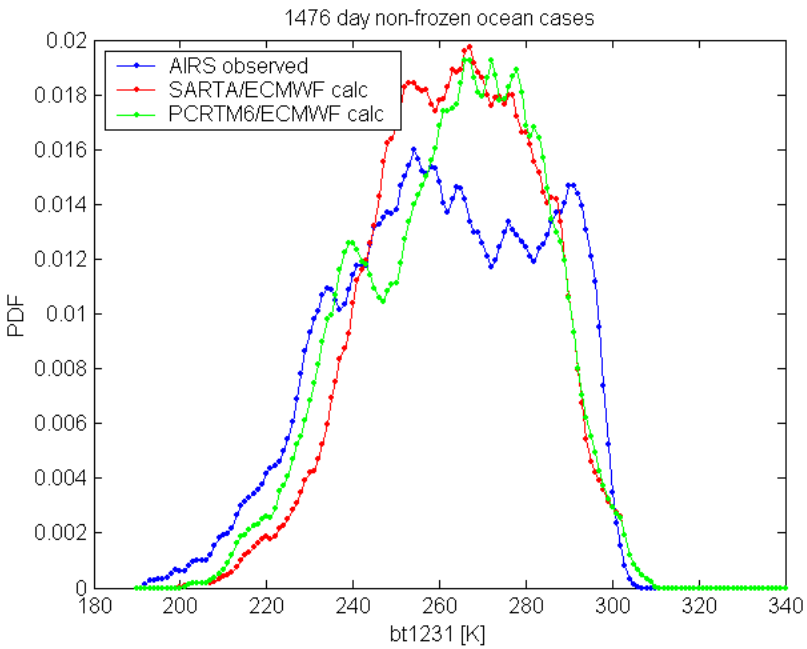
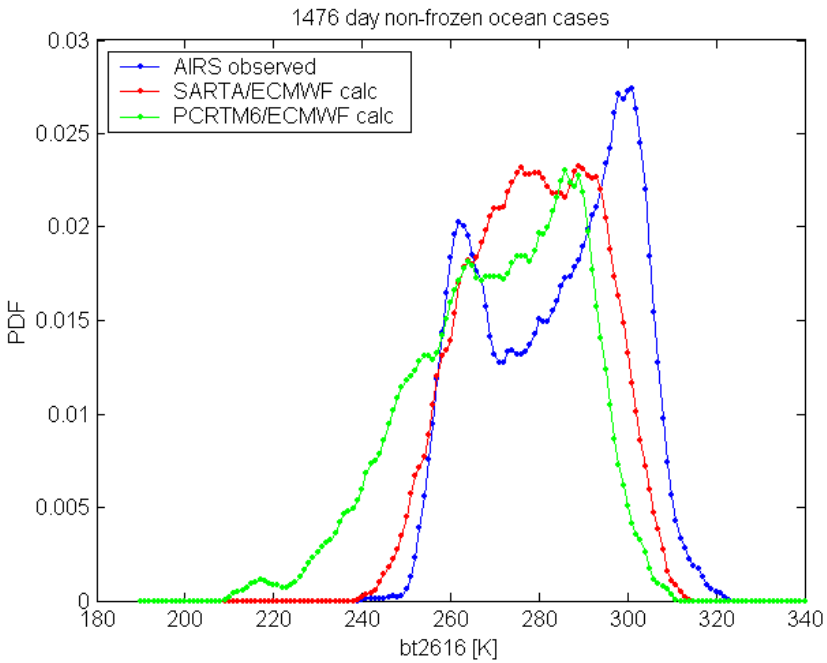
Preliminary Results: Day Cloudy conditions



PDF at 1231 cm-1



PDF at 2616 cm-1



During the day bt1231 SARTA and PCRTM agree with each other (r=0.97), but not with AIRS (r=0.81). This could be a problem with the ECMWF state.

During the day bt2616 SARTA and PCRTM disagree with each other and with AIRS. (SARTA/AIRS r=0.85, PCRTM/AIRS r=0.67) PCRTM cold clouds reflect more than SARTA or AIRS. AIRS reflects more from low clouds and clear than SARTA and PCRTM. This may be related to Barran vs. Baum at 2616 cm-1.

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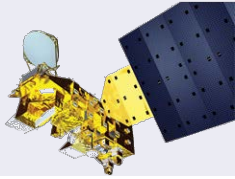
Summary



For the 2016 AGU RTA session we will be have spectra calculated with eight different clear and cloudy RTAs for the 7377 atmospheric states for a one-on-one comparison.

The statistical correlation between the ECMWF atmospheric state specification and AIRS spectra at the same location and time can be used to evaluate the fidelity of the cloudy RTA spectra.

The method looks promising based on preliminary results with SARTA_two_stream and PCRTM_MRO.

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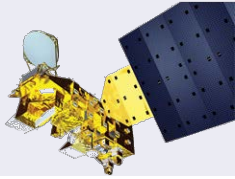

Questions/Comments?

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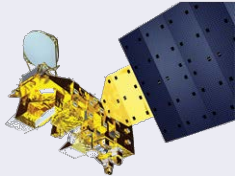

Backup slides for SARTA RTTOV comparison under clear conditions

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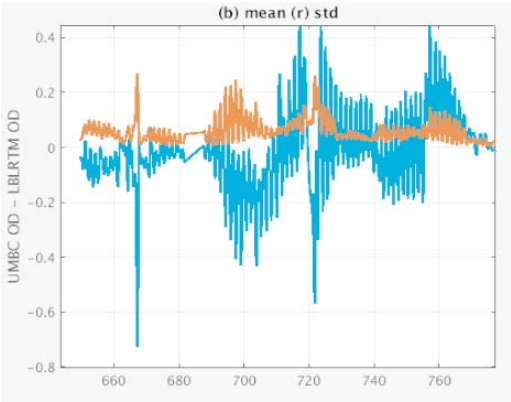
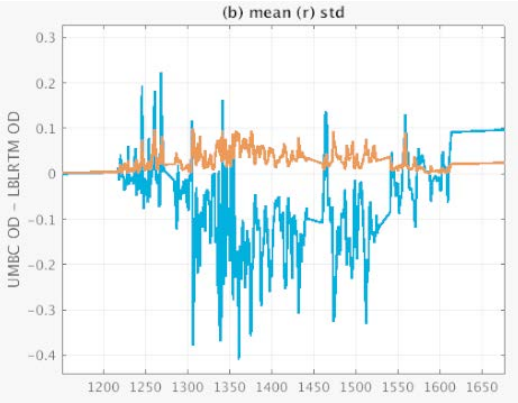
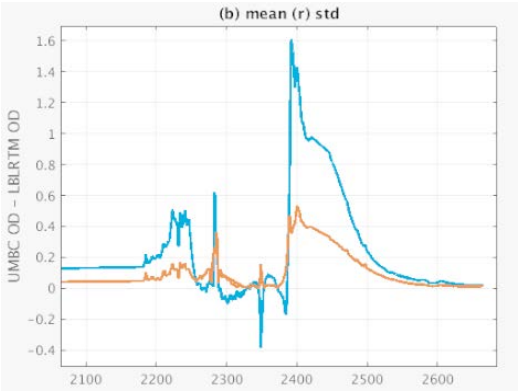
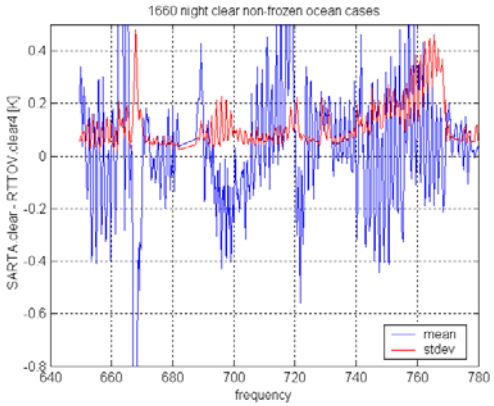
Early Results: Clear conditions

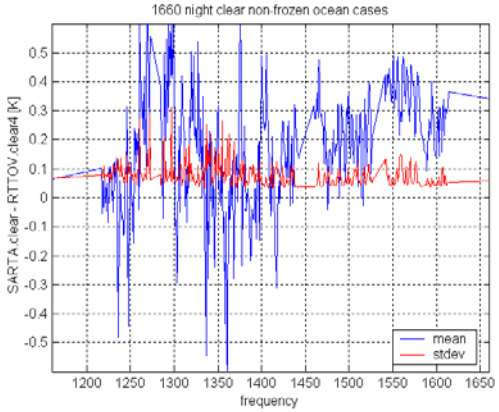
We compare SARTA-kCarta.new for 49 clear night ocean training sets to SARTA-RTTOV for 1660 independent clear non-frozen night ocean cases.

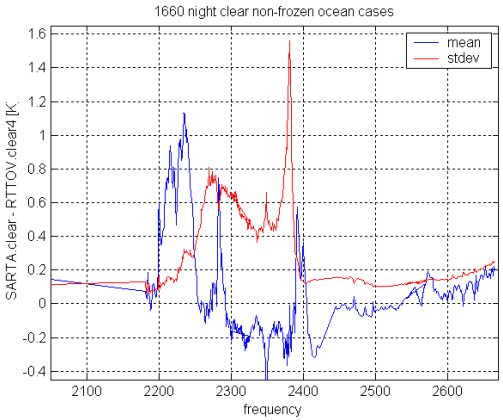












Differences are due to new CO2 and CH4 line mixing, WV lines, WV continuum, and N2 CIA in the 2400-2500 cm-1 region. N20 is at 2220 cm-1

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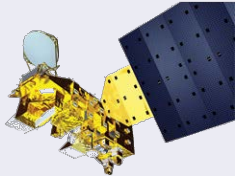
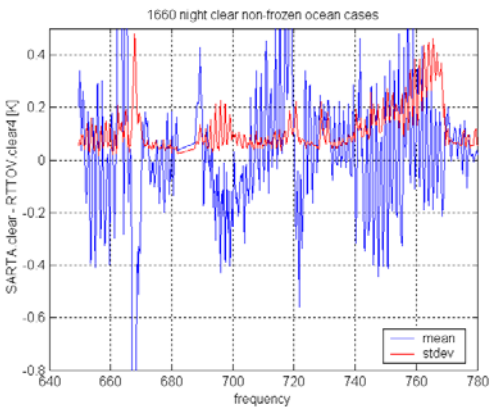
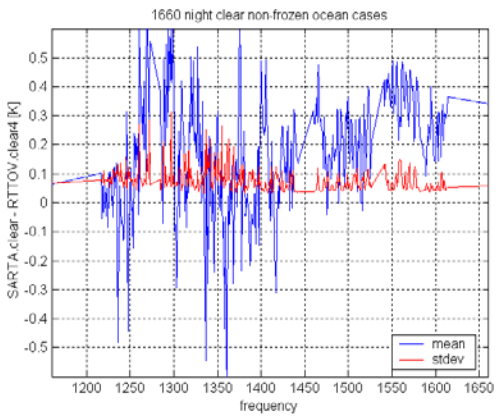
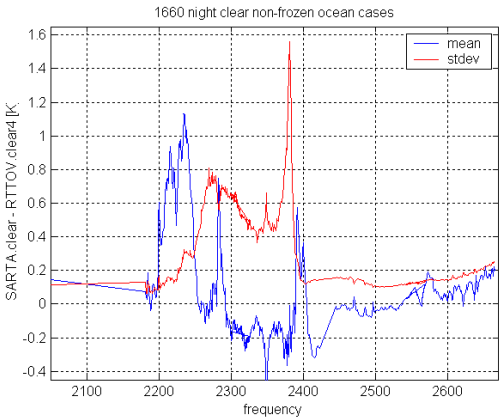
Early Results: Clear conditions

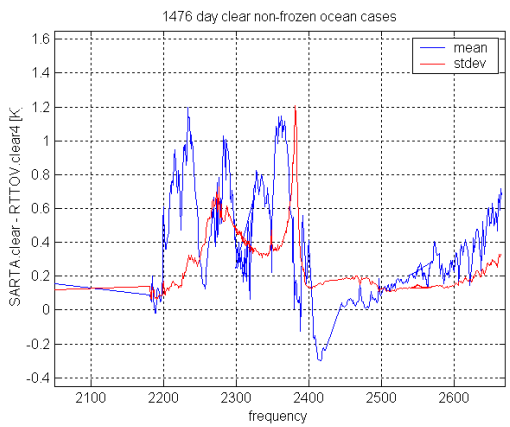


SARTA-RTTOV for 1660 independent clear non-frozen night ocean cases.









Differences between SARTA (2010 vintage) and RTTOV (2015 v11.3 vintage) are due to

- new CO2 and CH4 line mixing**,
- WV lines, WV continuum**,
- N2 CIA between 2400-2500 cm-1
- N20 between 2200 and 2250 cm-1**,
- nonLTE between 2350 and 2380 cm-1

** RTTOV 11.3 implements the latest line parameters, to be implemented in a new release of SARTA

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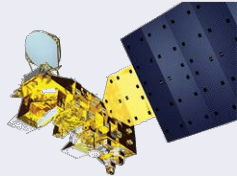
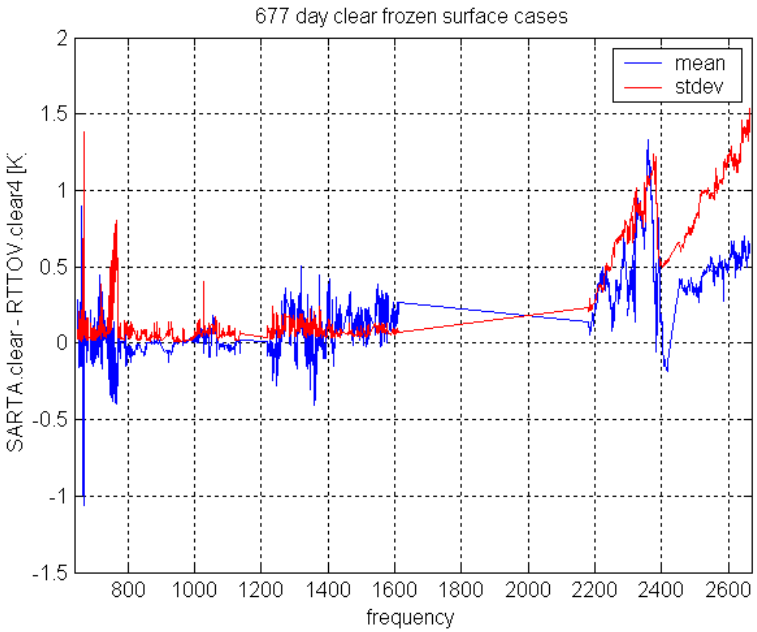
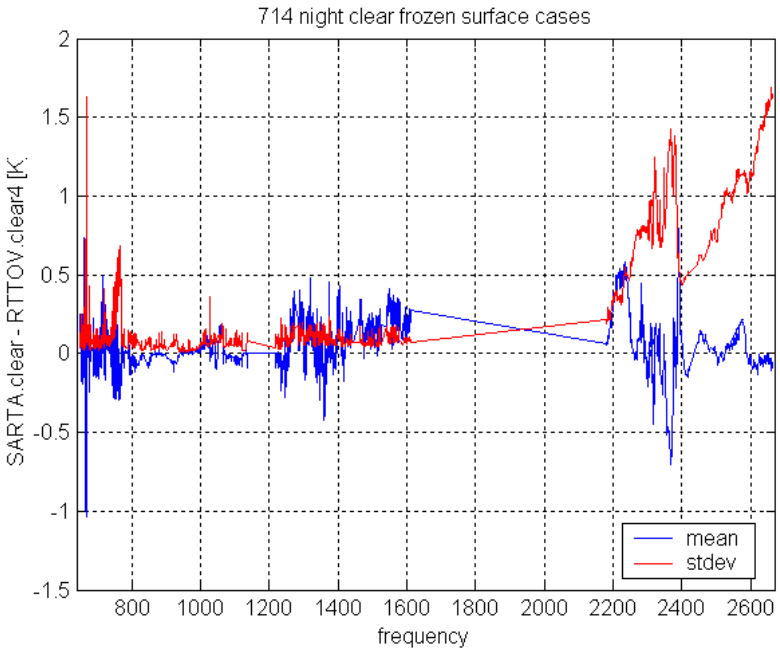
Early Results: Clear conditions



SARTA-RTTOV for 677 independent clear frozen day, ocean cases.





Under cold conditions the stdev(SARTA-RTTOV) in the 4.2 micron sounding channels exceeds 1K, with 0.5K bias.

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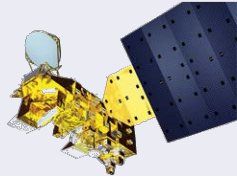
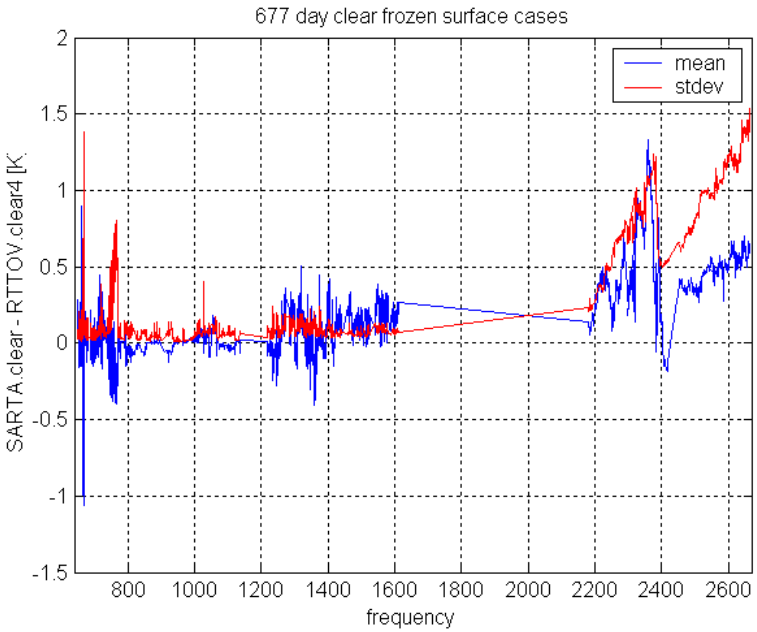
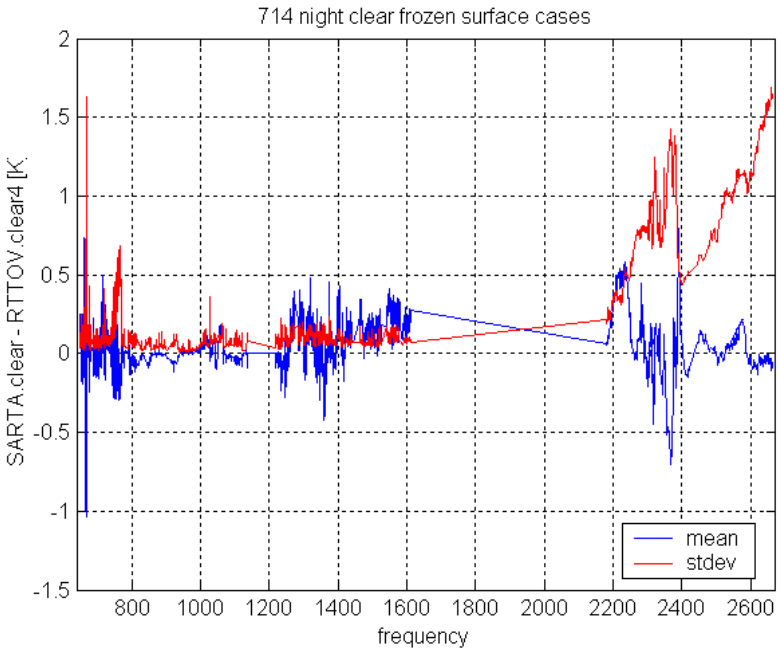
Early Results: Clear conditions



SARTA-RTTOV for 677 independent clear frozen day, ocean cases.





Under cold conditions the stdev(SARTA-RTTOV) in the 4.2 micron sounding channels exceeds 1K, with 0.5K bias.

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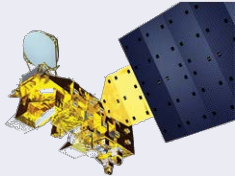
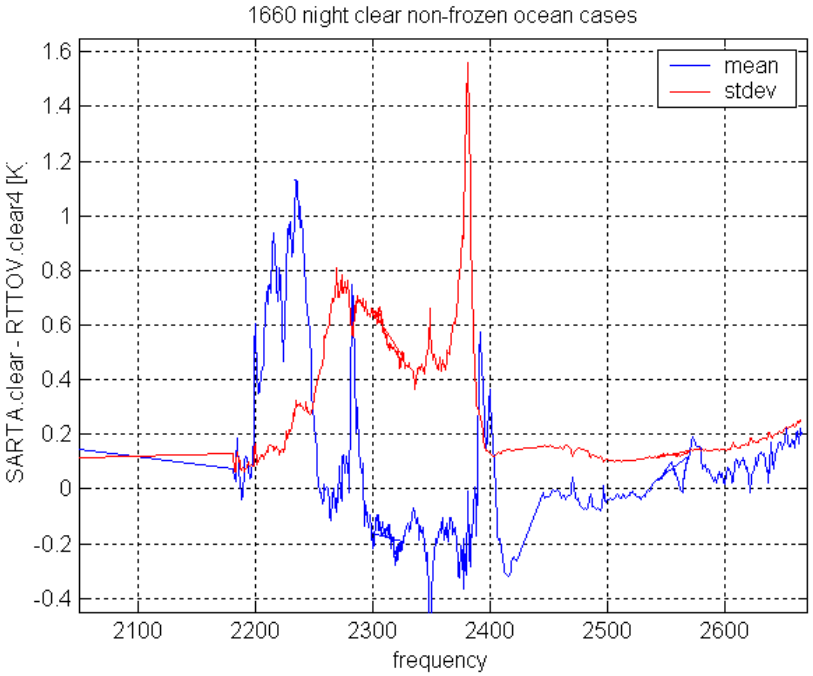
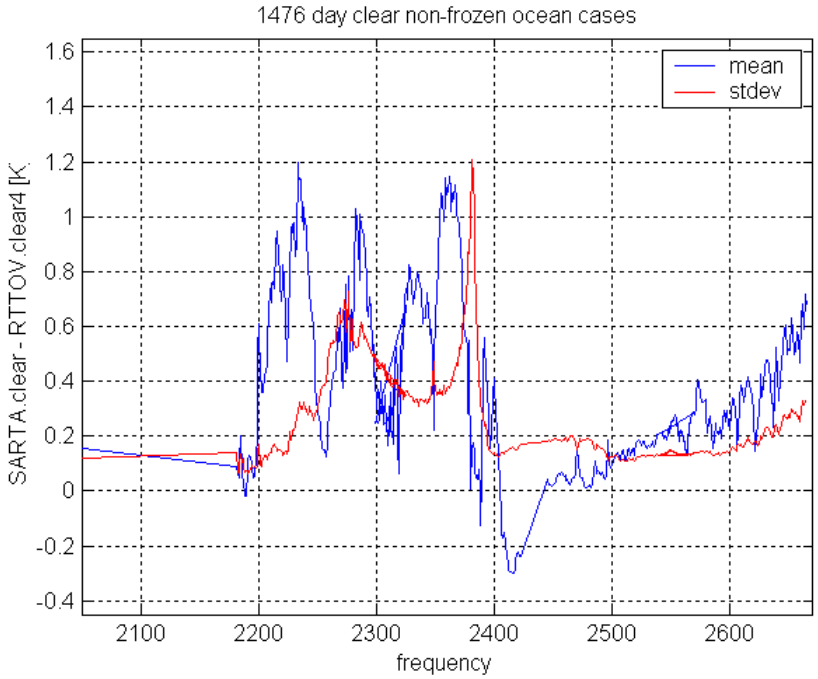
SARTA and RTTOV handle the non-LTE different







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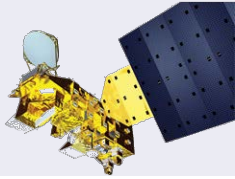
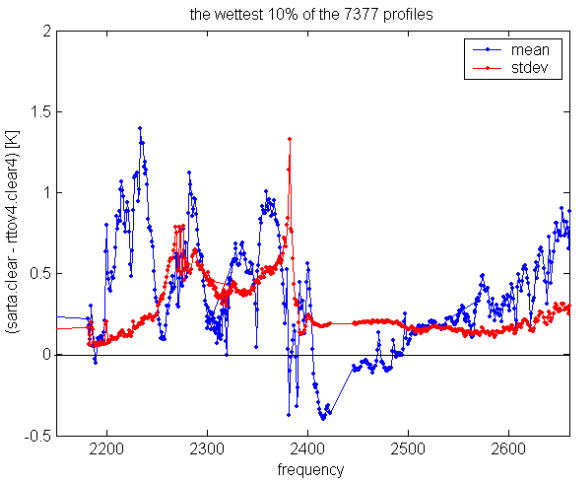
Early Results: Clear conditions

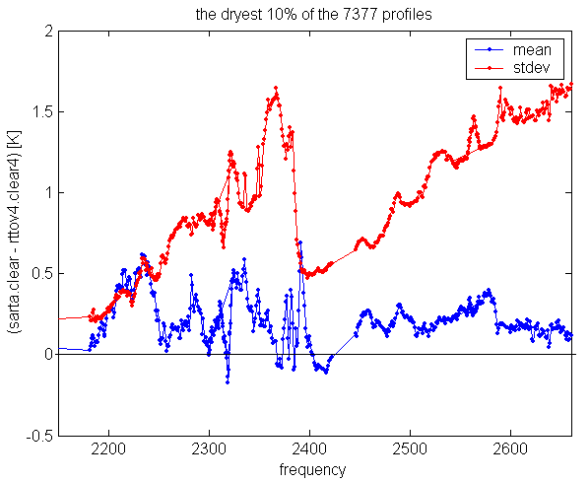


Very little emphasis has been placed on 2200-2600 cm-1 “Midwave” sounding regions

SARTA -RTTOV for the wettest night atmospheric states



SARTA -RTTOV for the driest night atmospheric states



The differences between SARTA and RTTOV are substantial and scene dependent.

Similar differences can be seen in the hottest and coldest night time cases.

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