Validation of the Community Radiative Transfer Model

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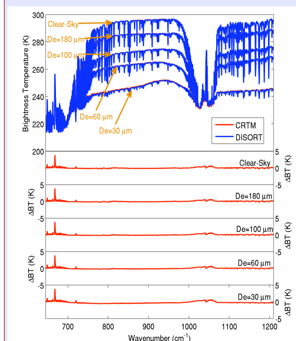
Introduction

Accurate simulation of radiation at the top of the atmosphere is extremely important for improving the quality of the assimilation of radiance data under all weather conditions, aimed ultimately at enhancing the capability of numerical weather prediction (NWP). This study is a follow up of our previous efforts (Ding et al., 2009).

- In support of the Community Radiative Transfer Model (CRTM), we have developed the bulk-scattering properties datasets for ice clouds. To validate the CRTM products, we have set up a rigorous model based on a combination of the discrete ordinate radiative transfer (DISORT) model and the line-by-line radiative transfer (LBLRTM) model.
- In this study, we compared IASI band 1 brightness temperatures (BT) computed from the CRTM with those from the LBLRTM+DISORT model for clear-sky and ice cloudy cases. In addition, we compared the computational efficiency of two models.
- We also compared the radiances simulated from the CRTM using the MODIS cloud products and AIRS atmospheric profile in conjunction with the AIRS level 1B radiance data.

Validation of the CRTM (1)

To validate the CRTM, we compared IASI band brightness temperatures (BTs) simulated from the CRTM model with those from LBLRTM+DISORT model for clear-sky and ice cloudy cases.



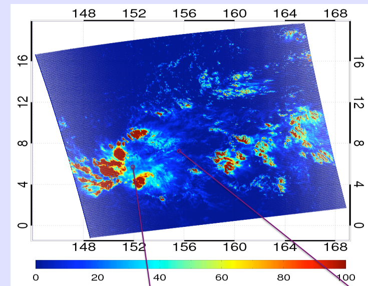
The diagram on the left shows the comparison of IASI band 1 BTs simulated from the CRTM forward model and LBL+DIRSORT model for clear-sky and cloudy cases.

- The ice cloud water path for ice cloud layers is assumed to be 0.01 kg/m² while the effective particle sizes are 30, 60, 100 and 180 μm. The surface and cloud top temperatures are 300.0 and 232.0 K, respectively.
- The comparisons against the LBLRTM+DISORT model indicate that the CRTM is quite accurate for both clear sky and ice cloudy radiance simulations.
- The RMS values of each spectral ΔBT are listed in the left table. The errors decrease with the increase of ice particle effective size. The largest error, 0.349 K, occurs when D_e=30 μm, but is still less than 0.5 K.

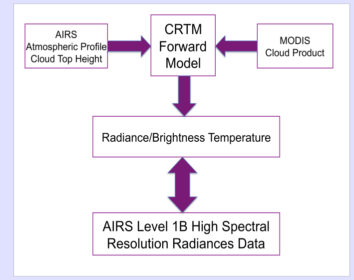
	De=30 μm	De=60 μm	De=100 μm	De=180 μm	Clear sky
RMS of ΔBT (K)	0.3490	0.1816	0.1668	0.1660	0.1619

Case study

In the study, the measurements by the Aqua MODIS and AIRS at 0300 UTC on October 27, 2007 are collocated. The figure below shows the ice cloud optical thickness of the granule observed by MODIS.



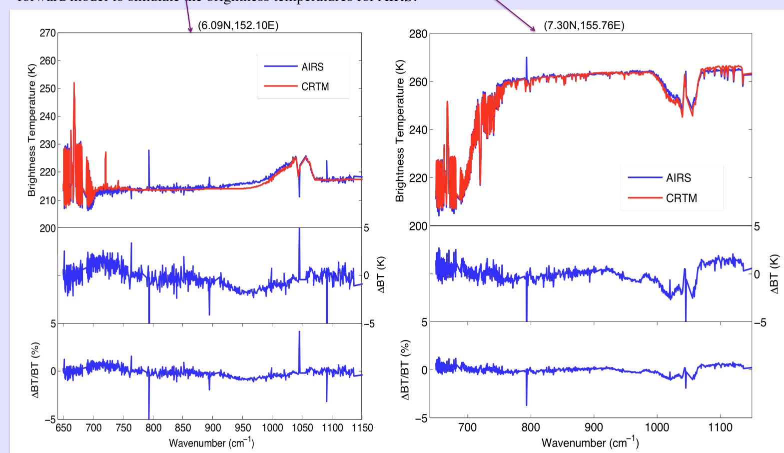
Flowchart



A simple flowchart showing the validation process for the CRTM using MODIS cloud products and AIRS atmospheric profiles and radiances data.

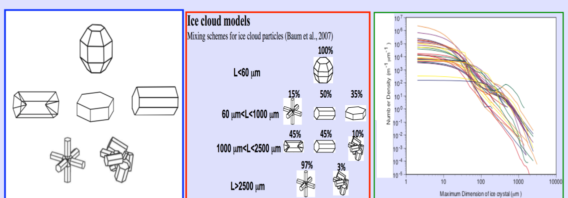
Validation of the CRTM (2)

In this study, cloud parameters of two MODIS pixels in the presence of ice clouds, one for optically thick cloud (τ=27.8) and the other for optically thin cloud (τ=4.86), with well-chosen AIRS atmospheric profile data are used as inputs to the CRTM forward model to simulate the brightness temperatures for AIRS.

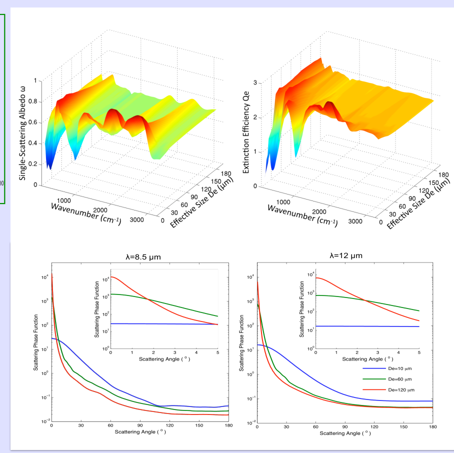


The above figures show the comparisons between the high spectral resolution BTs simulated from the CRTM and those observed by AIRS for the two selected MODIS pixels of optically thick (left) and thin (right) cloud. The cloud geometrical thickness is determined by the minimization method. The brightness temperature differences between observations and simulations are also shown.

Spectral bulk scattering properties of ice cloud



$$\bar{P}(\Theta,\nu)=\frac{\int_{D_{min}}^{D_{max}}\left[\sum_{h=1}^{M}P_h(\Theta,D,\nu)\sigma_{sca,h}(D,\nu)f_h(D)\right]n(D)dD}{\int_{D_{min}}^{D_{max}}\left[\sum_{h=1}^{M}\sigma_{sca,h}(D,\nu)f_h(D)\right]n(D)dD}$$



(Baum et al., 2007)

References

[1] Ding, S., Y. Xie, P. Yang, F. Weng, Q. Liu, B. Baum, and Y. X. Hu, 2009: Estimate of radiation over clouds and dust aerosols: optimized number of terms in phase function expansion, J. Quant. Spectroc. Radiat. Transfer. 110, 1190–1198.
[2] Baum, B. A., P. Yang, S. Nasiri, A. K. Heidinger, A. J. Heymsfield, and J. Li, 2007, Bulk Scattering Properties for the Remote Sensing of Ice Clouds. III: High resolution spectral models from 100 to 3250 cm-1 *J. Appl. Meteor. Clim*. 46, 423-434.

Comparison of CPU time for the two models on a dual 2.6 GHz 64-bit AMD Operation System

	Clear Sky	Cloudy
CRTM	1.66 s	3.95 s
DISORT	375.62 s	542.70 s

Summary and conclusions

- The ability of the CRTM to accurately simulate the IASI band 1 brightness temperature has been tested in terms of model-to-model comparisons for both clear-sky and ice cloudy conditions.
- Using well-chosen AIRS atmospheric profiles and MODIS ice cloud properties as input to the CRTM, we simulated the high spectral resolution brightness temperatures for optically thick and thin ice clouds. On the basis of the comparisons between simulated and observed brightness temperatures for AIRS, we have validated the ice cloud scattering model.