- Third International IASI Conference, Hyères, France, 4-8 February 2013 -

A new ice cloud optical properties database in RTTOV for IASI

METEO FRANCE – Toujours un temps d'avance

Jérôme Vidot[1,*], Pascal Brunel[1] and Anthony Baran[2]
[1]Centre de Météorologie Spatiale, DP/Météo-France, Lannion, France
[2]MetOffice, Exeter, UK
*jerome.vidot@meteo.fr

Met Office NWP SAF

Introduction

A new database of optical properties of ice cloud particles in the thermal infrared (1) have been parameterized for RTTOV. As compared with the current ice cloud optical properties of RTTOV (2), this new database offers two new features: It allows a direct parameterization of the optical properties from the RTTOV inputs for ice cloud (the cloud temperature T_C and the ice water content *IWC*) without the need of estimating the effective size of ice cloud particle through four different empirical parameterizations, and the optical properties of the Baran database where simulated for an ensemble of different ice cloud particle shapes which is expected to be more realistic than the two current RTTOV ice particles shapes (hexagonal or aggregates). With this new database, users will not be requested to choose among the eight different ice cloud options (2 shapes times 4 effective size of ice cloud particle parameterizations).

The Baran database and the RTTOV parameterization

• based of 20662 PSDs (Particles Size Distribution) that were assembled from different cloud temperature (T_C) and ice water content (*IWC*) (see Figure 1).

• provide for each PSD: simulated volumetric extinction coefficient β_e (in m^{-1}), volumetric scattering coefficient β_s (in m^{-1}), single scattering albedo ω_0 and asymmetry parameter *g* at 57 wavelengths between 3 and 18 microns. Figure 2 shows the mean absorption coefficient and the standard deviation of the absorption coefficient versus the wavelength (in red) and of the scattering coefficient (in blue) calculated as extinction minus absorption. The phase function *P* is an analytical formulation of g.

In RTTOV, the scattering scheme in IR is simplified through the effective extinction (Eq. 1), where *b* is the fraction of backscattered radiation (Eq. 2).

$$\tilde{\beta}_e = \beta_a + b\beta_s \quad (1) \qquad b = \frac{1}{2}\int_0^1 d\mu \int_{-1}^{0} \overline{P(\mu,\mu')} d\mu' \quad (2)$$

We parameterize the RTTOV ice cloud optical properties through the following relationships for absorption and scattering coefficients (Eq. 3), and for b and g (Eq. 4):

$$\log10[\beta_a(\lambda)] = r_{a,0}(\lambda) + r_{a,1}(\lambda)T_c + r_{a,2}(\lambda)\log10(IWC) \quad (3) \qquad b(\lambda) = r_{b,0}(\lambda) + r_{b,1}(\lambda)T_c + r_{b,2}(\lambda)\log10(IWC) \quad (4)$$

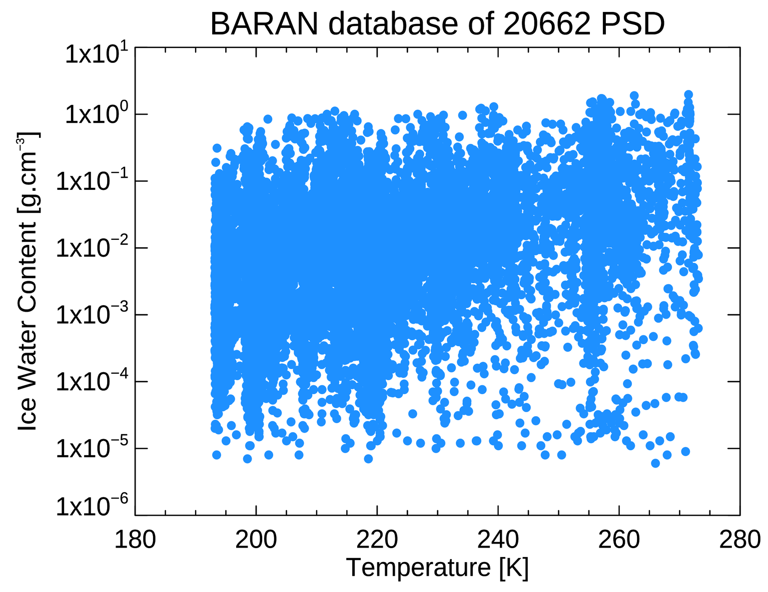

Figure 1. Ice water content versus in cloud temperature of the Baran database

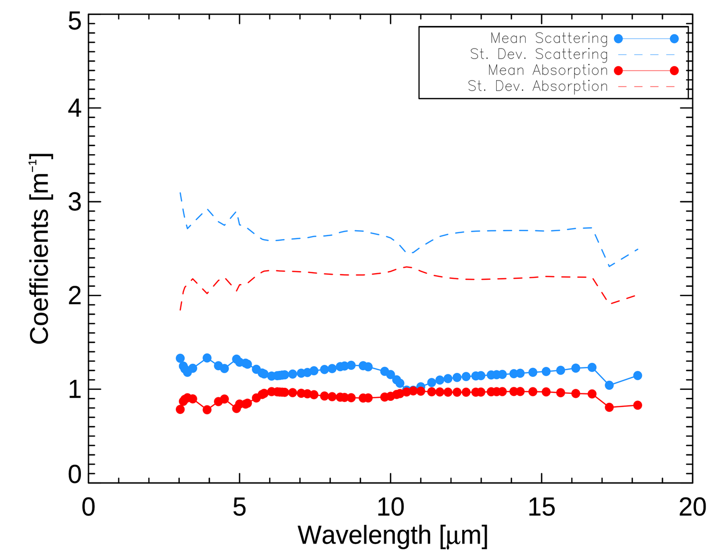

Figure 2. Mean Absorption and scattering coefficients spectra from Baran database

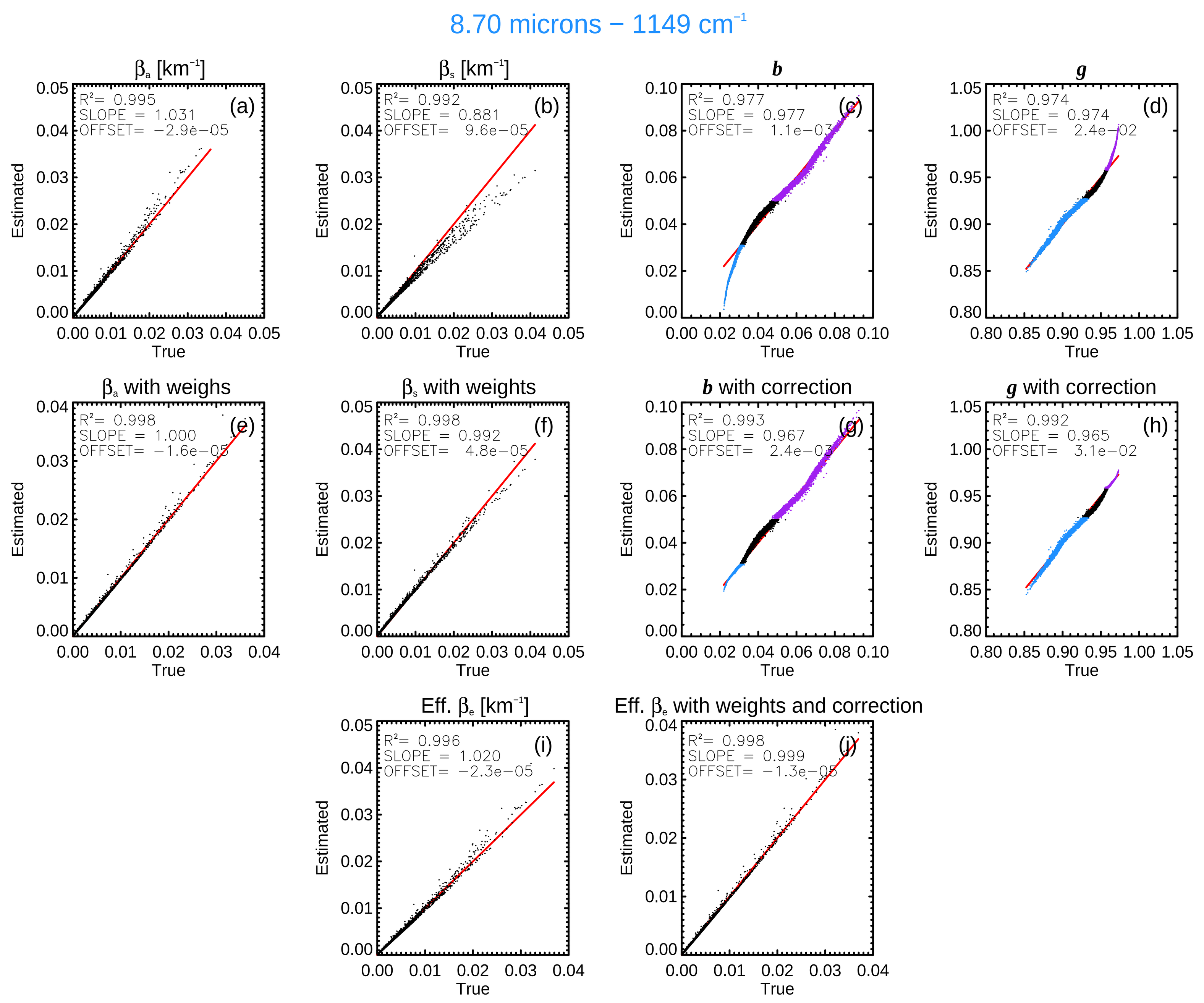

Figure 3. Example of the RTTOV parameterization of the optical properties at 8.7 microns.

Example of the results at 8.7 microns (1149 cm^{-1}), see Figure 3:

Figs. 3a to 3d show the estimated versus true absorption and scattering coefficients, *b* and *g*, respectively. Absorption and scattering is overestimated and the parameterization of *b* and *g* is not efficient for lower or higher values.

=> Improvements done

• Improvement for scattering and absorption: we applied a fixed weight of 100 on the 1% higher values from the probability density function. The correlation shown on Figs. 5e and 5f are improved and slopes of linear regressions are closer to unity

• Improvement of the estimation of *b* and *g*: we applied a correction by visually selecting 2 thresholds for *b* and for g to split the values into three parts (represented by different colours in Figs. 5c and 5d). For values above and below each threshold, we calculated a linear regression on these values and corrected the estimated values as for example for *b* (Eq. 5) where $x_{b,0}(\lambda)$ and $x_{b,1}(\lambda)$ are the offset and the slope of the linear regression at a particular wavelength. Results of the correlation after applying the correction is show on Figs. 5g and 5h for *b* and *g*, respectively. In both cases correlation coefficients are increased to better than 0.99.

• The improvement in the estimation of the effective extinction (given by Eq. 1) after applying the weights on absorption and scattering and the correction on *b* is shown by comparing Figs. 5i and 5j. Correlation coefficient is increased from 0.95 to 0.99 and slope of the linear regression is reduced from 1.55 to 1.04.

Simulated IASI spectra with RTTOV ice clouds parameterization

We simulated IASI spectra with all RTTOV ice cloud options (see below) where the ice cloud profile where obtained from the DARDAR product (3) that combined CloudSAT and CALIOP data to retrieve ice cloud profile. In Figure 3 is represented the profile of ice water content (left) and effective diameter (Deff) of ice crystals (rigth) used for the simulation of the IASI spectra (Fig. 5)

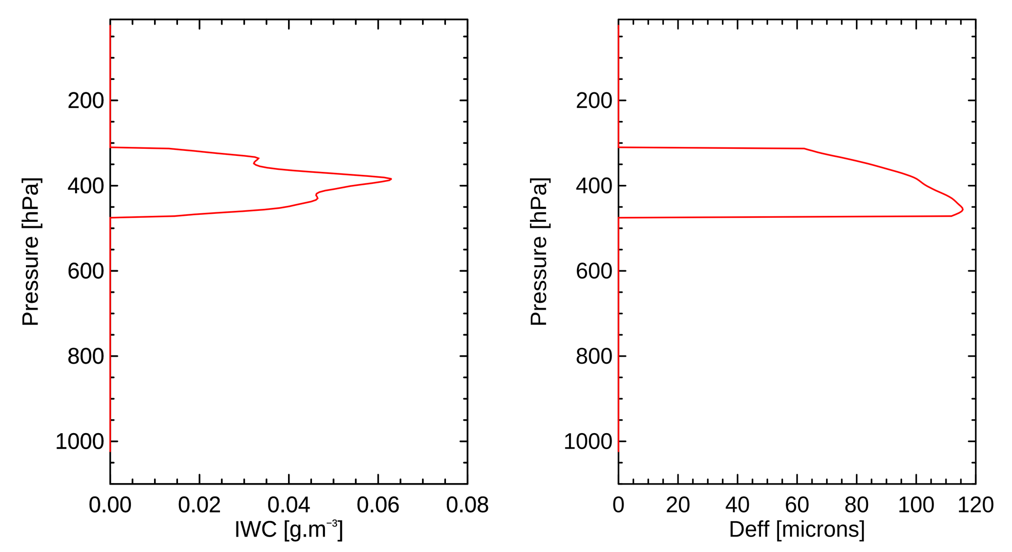

Figure 4. IWC profile (left) and ice crystals Deff (right) from DARDAR.

8 RTTOV-10 ice cloud options:

-4 effective diameter parameterizations (OL95, W98, B02, MF03) × 2 ice crystal shapes (Hexagonal or Aggregates)

3 new ice cloud options in RTTOV-11:

- input Deff profile instead of IWC× 2 ice crystal shapes (Hexagonal or Aggregates)

- Baran database parameterization

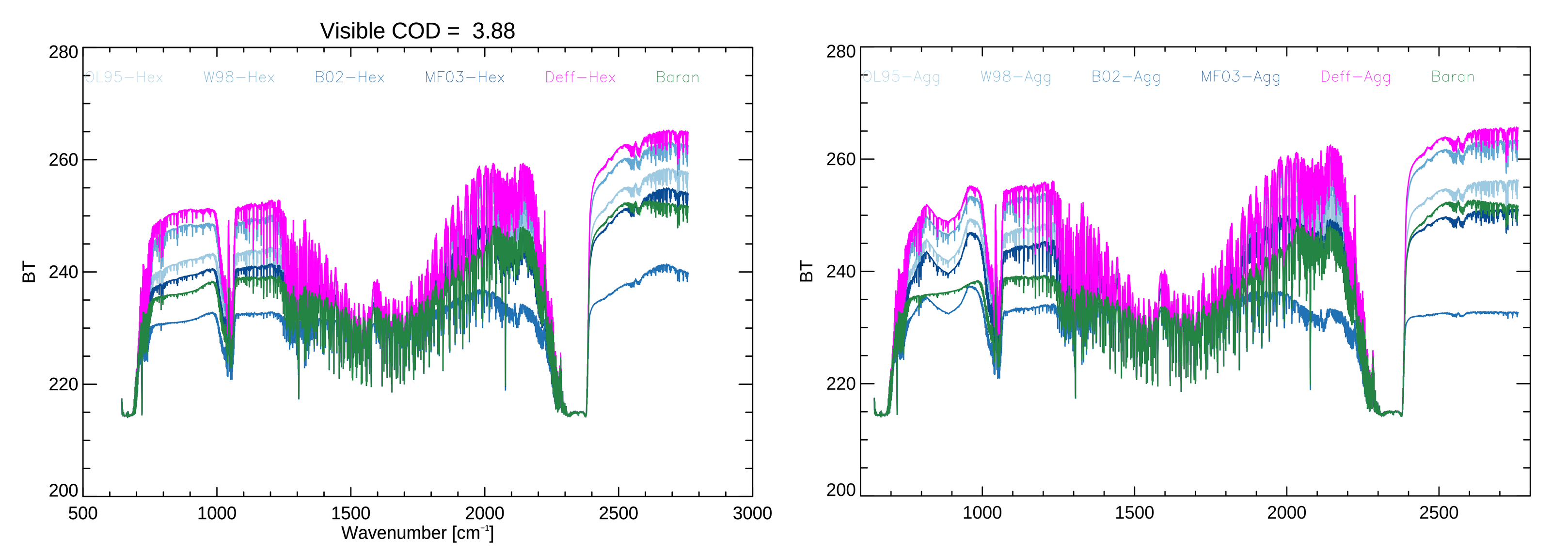

Figure 5. IASI spectra simulated with hexagonal ice crystals (left) and aggregates (right) and new database

Conclusion and perspectives

A new database of ice cloud optical properties in infrared have been parameterized and implemented in RTTOV-11. The new parameterization allow a direct estimation of the cloud optical properties from the IWC and the temperature profiles, avoiding the choice of an effective diameter parameterization and the shape of the ice crystals. By using satellite retrieval of ice cloud properties for comparing all RTTOV ice cloud options, we found that the new database and the new parameterization is able to simulate IASI spectra. However, the parameterization need further improvements and a comparison against real IASI observations is needed but this exercise is very complex because of the uncertainty in the cloud fraction profile within the IASI pixel.

References:

(1) Baran AJ, Connolly PJ, Heymsfield AJ, Bansemer A. 2011. Using *in situ* estimates of ice water content, volume extinction coefficient, and the total solar optical depth obtained during the tropical ACTIVE campaign to test an ensemble model of cirrus ice crystals. Q. J. R. Meteorol. Soc. 137: 199–218.

(2) Matricardi, M., 2005: The inclusion of aerosols and clouds in RTIASI, the ECMWF fast radiative transfer model for the infrared atmospheric sounding interferometer. ECMWF Tech. Memo. 474, 53 pp.

(3) Delanoë, J., and R. J. Hogan, 2010: Combined CloudSat-CALIPSO-MODIS retrievals of the properties of ice clouds. J. Geophys. Res., 115, D00H29, doi:10.1029/2009JD012346.