Comparing different cloud representations in variational retrievals using the HT-FRTC code on IASI data

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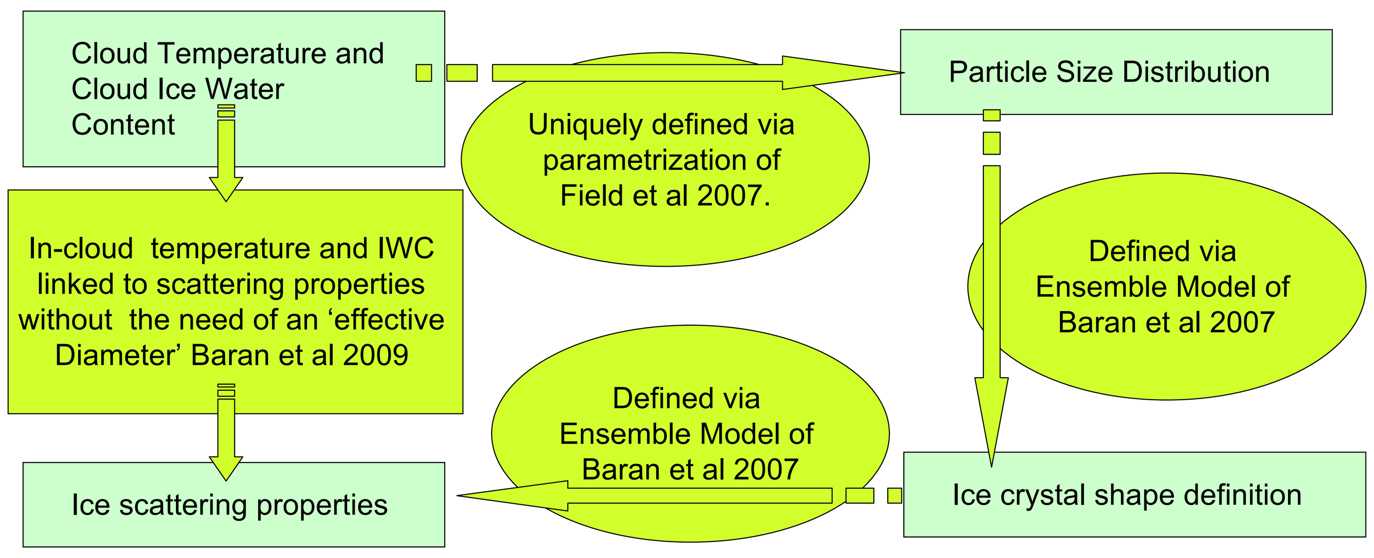
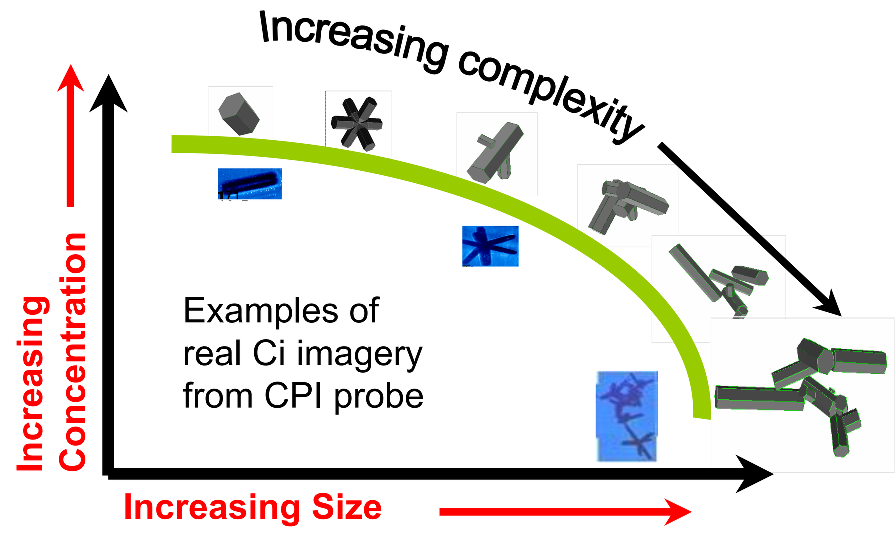
The Havemann-Taylor Fast Radiative Transfer Code allows fast and exact radiance calculation for the simulation of hyperspectral instruments across the electromagnetic spectrum. The radiance spectra are represented by one hundred principal components. For the training of the HT-FRTC with a diverse set of atmosphere and surface conditions the recent spectroscopy of LBLRTM 11.7 is used. The HT-FRTC does now incorporate various cloud and aerosol properties. The scattering problem is treated exactly with a spherical harmonics code very similiar to the Edwards-Slingo radiation code, which has been included into the HT-FRTC. The HT-FRTC serves as the fast forward model within a 1D-Var code, which also represents the radiance observations in principal components. This reduces the size of the inverse problem considerably whilst conserving the information content of the measurements. Vertical profiles of temperature, humidity and ozone as well as surface temperature and surface emissivity can be retrieved. Ice and water cloud parameters can be retrieved. The new description of the cirrus optical properties (volume extinction coefficient, single-scattering albedo and the moments of the phase functions) parametrizes these in terms ice water content and ice cloud temperature. In addition to the ice water content, the ice cloud retrieval parameters include cloud fraction, cloud height and thickness. The list of water cloud parameters is similiar, but only cloud fraction and height tend to be relevant in this case. The retrievals with these cloud representations are compared with retrievals obtained with a simple grey cloud approximation, where the emission is spectrally uniform and the only parameters are a cloud height and an effective cloud fraction. The performance of the different cloud models and their effect on the retrieval of temperature and humidity are investigated. Results are presented where the Facility for Airborne Atmospheric Measurements BAe146-301 Atmospheric Research Aircraft under-flew an IASI overpass and characterised the structure of the atmosphere including the microphysics of the cirrus that was prevalent that day.

1. Cloud in the HT-FRTC

The HT-FRTC includes a full treatment of scattering using spherical harmonics. Within the 1d-Var retrieval the control vector is as follows: Temperature (z), Log(Q (z)), Log(Ozone (z)), T* (surface temperature), Surface Emissivity (represented as 15 Principal Components), For clouds: Log(Cloud liquid / ice water content), cloud height, fraction and thickness. Alternatively, grey cloud height and effective grey cloud fraction.





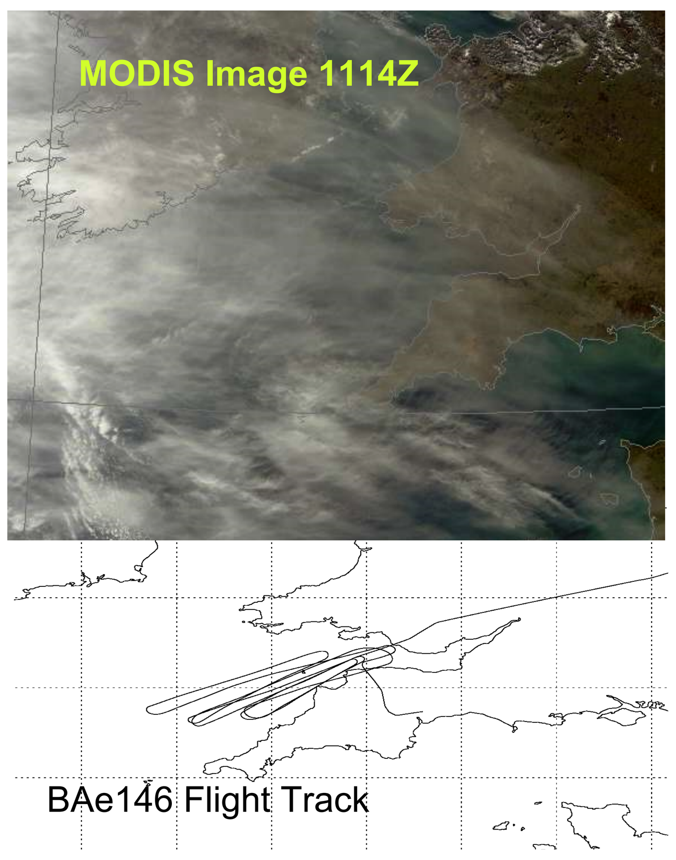
References

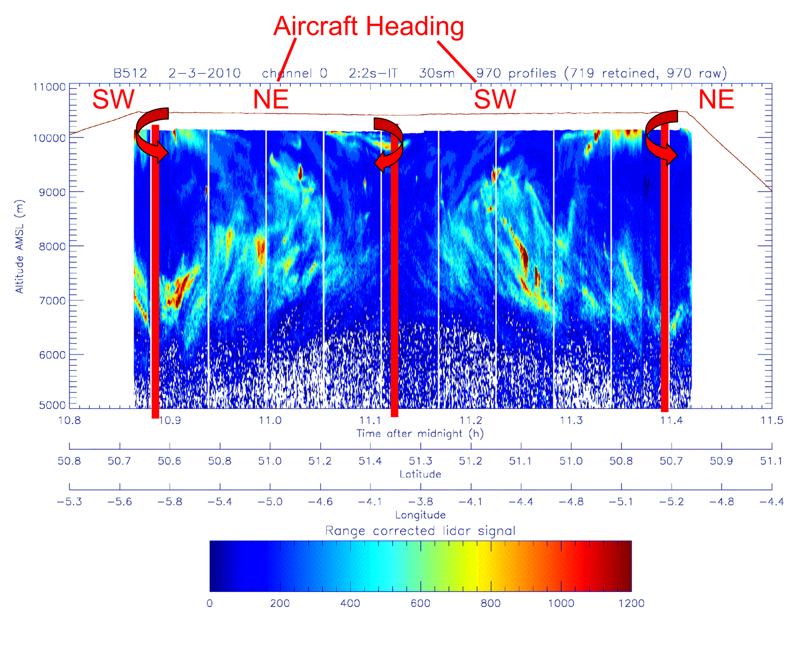
Baran, A.J. , P.J. Connolly, and C.Lee: Testing an ensemble model of cirrus ice crystals using midlatitude in situ estimates of ice water content, volume extinction coefficient and the total solar optical depth, Journal of Quantitative Spectroscopy & Radiative Transfer, 110, (2009), 1579-1588.

Baran A.J, and L.C. Labonnote, QJRMS, 2007.

Field, P. R., A. J., Heymsfield, and A. Bansemer: Snow size distribution parameterization for midlatitude and tropical ice cloud. J. Atmos. Sci. (2007);64; 4346-65.

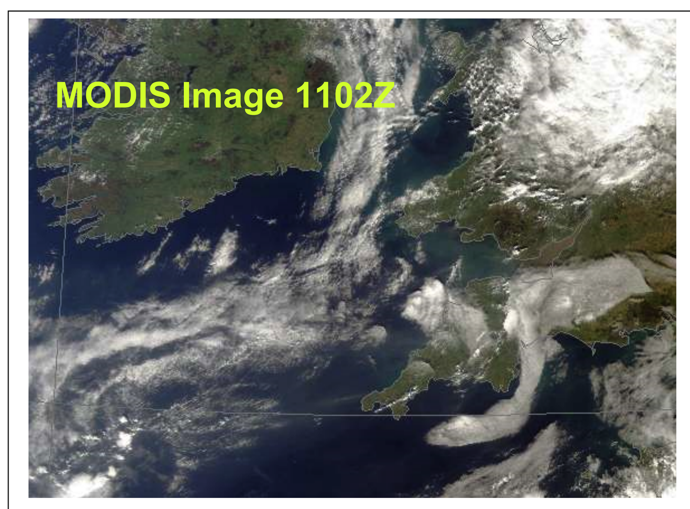
2. Case Study ONE Flight B512 2nd March 2010, IASI overpass 1102Z

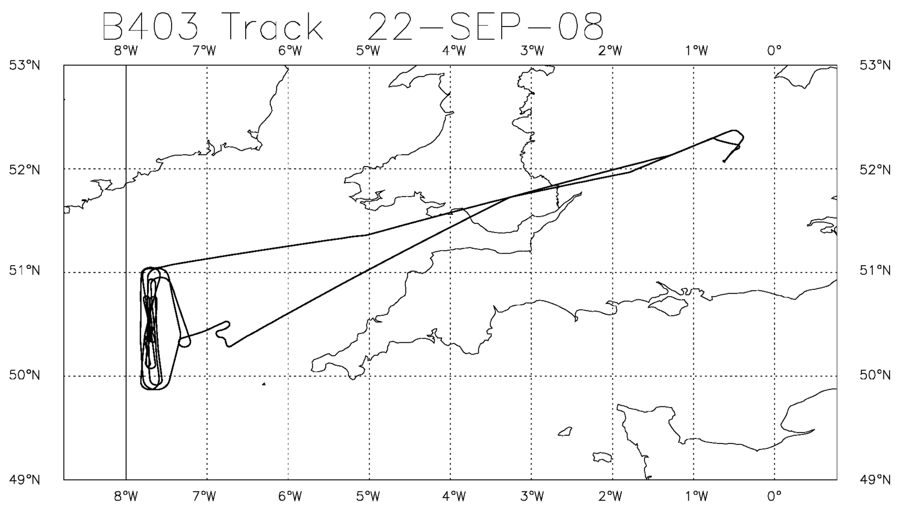




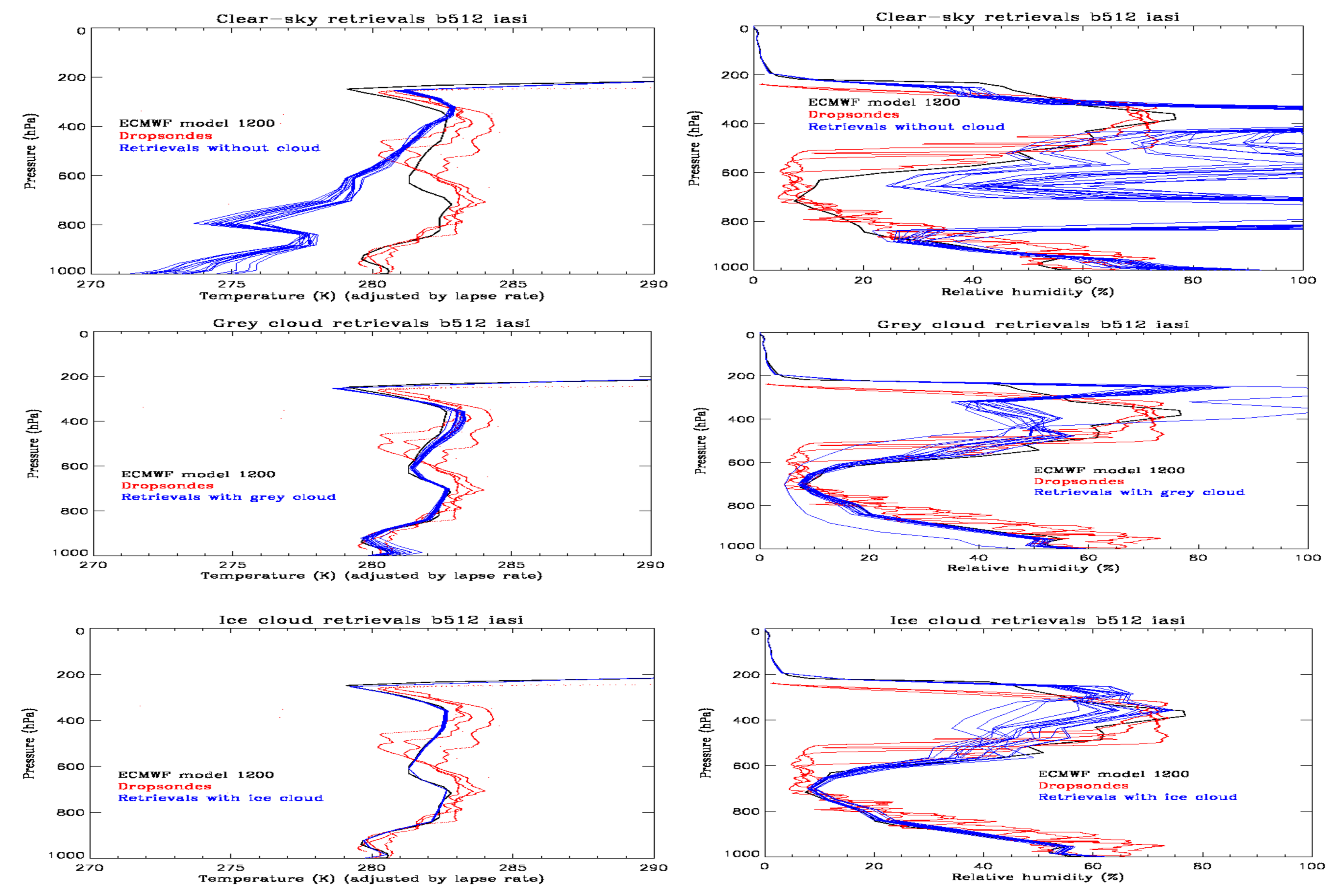
Lidar Return on-board BAe146

2. Case Study TWO Flight B403 22nd Sept 2008, IASI overpass 1045Z



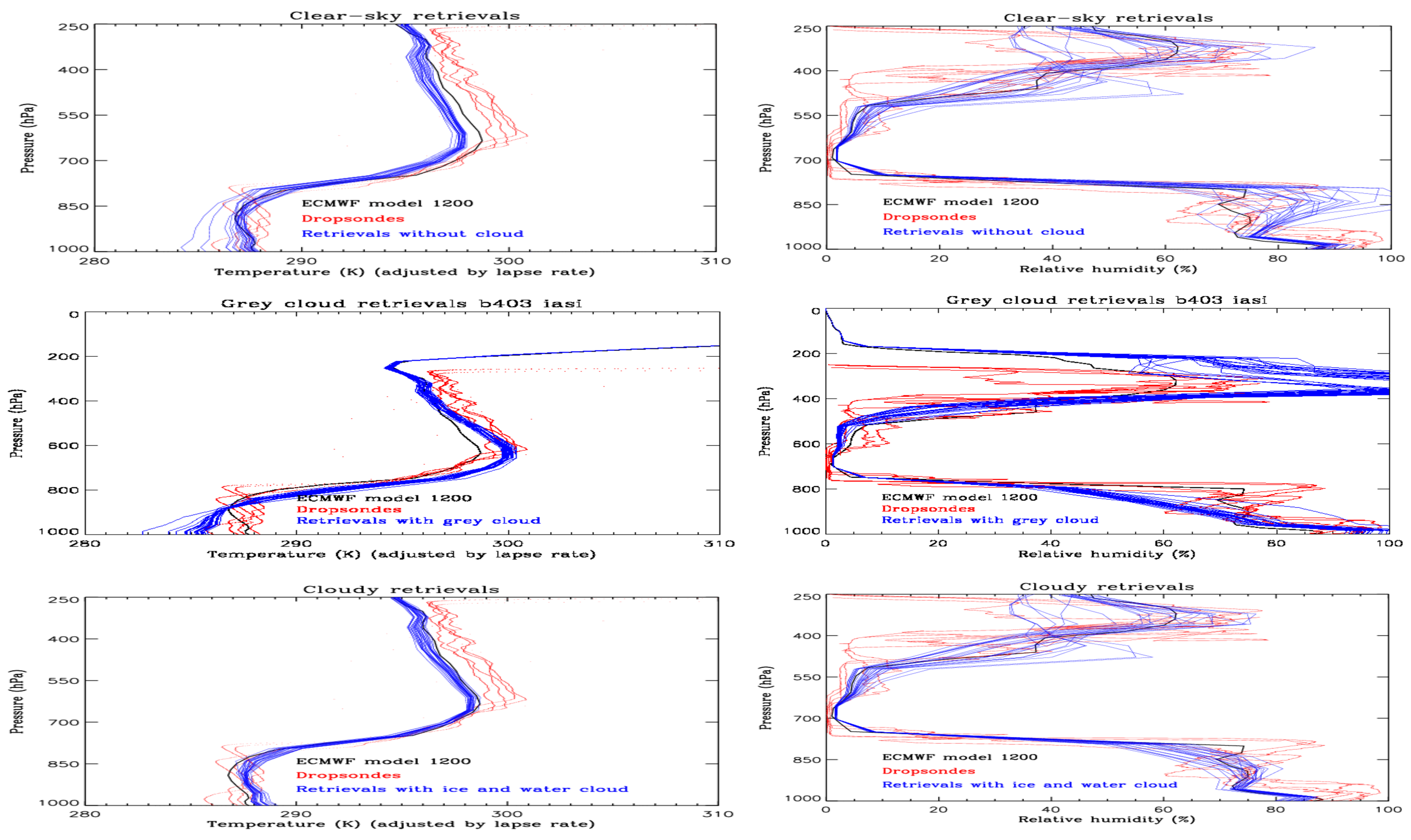


3. IASI 1d-Var Retrieval Results from Case Study ONE



Cirrus cloud (275 to 475 hPa): Retrieved ice water content is 171.0±64.4 mgm^{-3} and cloud fraction is 0.47±0.04.

4. IASI 1d-Var Retrieval Results from Case Study TWO



Cirrus cloud (275 to 325 hPa): Retrieved ice water content 34.4±19.3 mgm^{-3} and cloud fraction 0.72±0.22. Water cloud (850 to 900 hPa): Retrieved liquid water content 1.04±0.09 gm^{-3} and cloud fraction 0.17±0.13.

5. Conclusions

The case studies demonstrate that the skill of temperature and humidity retrievals in the presence of cloud is increased if cloud parameters are part of the retrieval state vector. In the current retrievals, one (in case study ONE) or two (in case study TWO) homogeneous cloud layers were assumed. Ice clouds are not well represented by the grey cloud approximation with its spectrally uniform emission.

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