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Ice cloud properties, an information content analysis from high spectral resolution measurements in the thermal infrared: Application to IASI, IASI-NG and FORUM

Laurent Labonnote (1), Anthony J. Baran (2,3), Jérôme Vidot (4), Hervé Herbin (1), and Luca Palchetti (5)

(1) University of Lille - LOA Bvd Langevin, cité scientifique, 59655 Villeneuve d'ascq, France, (2) MetOffice Exeter, United Kingdom, (3) University of Hertfordshire School of Physics, Astronomy and Mathematics, Hatfield, United Kingdom, (4) Centre de Météorologie Spatiale (CMS) Lannion, France, (5) INO-CNR, Sesto Fiorentino Florence, Italy

Numerous retrieval methods nowadays help us in reaching a better understanding of climate processes by providing information on ice or liquid cloud columns, and profile properties from passive and active measurements, respectively. If the information provided by the latter is completeness, it suffers from spatial coverage compared to passive measurements. It is therefore important to better characterize cloud properties from passive measurements by using for example, high resolution spectral instruments.
Besides their strong contribution to weather forecast improvement, through data assimilation in clear-sky conditions, thermal infrared sounders on board polar orbiting platforms are now playing a key role in monitoring changes in atmospheric composition. However, it is notoriously known that clear sky observations are only a small part of the entire set of measurements, the remaining part being unused as they are contaminated by either aerosol and/or cloud.
The present study aims in quantifying the potential of retrieving ice cloud properties, and more specifically, the ice water content (IWC) profile, or column ice water path (IWP), together with layer position, from thermal infrared sounders such as IASI (and the future IASI-NG) or the recently selected FORUM mission. The method used here is based on the Shannon information content analysis (ICA). We ran this ICA for different ice cloud opacities, by taking into account the Signal-to-Noise ratio of each specific instrument and the inherent non-retrieved atmospheric and surface parameter errors. The synthetic measurements have been simulated by a line-by-line model developed at the Laboratoire d'Optique Atmosphérique (LOA), and the multiple scattering by the open source radiative transfer code LIDORT (Spurr et al., 2008). The ice cloud microphysics has been simulated by the ensemble model developed by Baran and Labonnote (2007), and its size distribution parameterization, as a function of IWC and the in cloud temperature, by Baran et al. (2009). Results show that this observing system provides little information on IWC unless we introduce a Twomey-Thikonov smoothness constraint in the retrieval framework. The IWP as well as layer position should, on the contrary, be well retrieved with expected errors that decrease with cloud opacity until the signal saturation is reached. Despite its coarser spectral resolution, the FORUM instrument (which makes measurement in the far infrared region (100 to 1600 cm-1)) is expected to bring more information on IWP and the cloud layer position in comparison to IASI or IASI-NG.