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

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Abstract: The present study aims in quantifying the potential of retrieving ice cloud properties, and more specifically, the Ice Water Path (IWP) and layer altitude, from thermal infrared sounders IASI and the future IASI-NG. The method is based on the Shannon information content analysis (ICA). We applied this ICA to different ice cloud profiles coming from a global database originate from the NWP (ECMWF IFS NWP model) by taking into account the Signal-to-Noise ratio of the instruments and the inherent non-retrieved atmospheric and surface parameters errors. The forward model used is the fast radiative transfer model RTTOV (Saunders et al. (1999), Matricardi et al. (2004)) with ice cloud microphysics from the ensemble model developed by Baran and Labonnote (2007) and size distribution parametrization by Baran et al. (2009).

ICE CLOUD MICROPHYSICS MODEL

The ensemble model is composed of six individual ice particles with increasing complexity as a function of size. Concentration of each individual particle depends on their surface roughness as well as spherical air bubble inclusions (Baran and Labonnote (2007)).

The scattering phase matrix and optical properties are integrated over the PSD obtained from Field et al. (2006) and Field et al. (2007). Optical properties are parametrized, from integrating them over 20662 parametrized PSDs, as a function of IWC and incloud temperature (Baran et al. (2009)).

Variation of the ensemble model optical properties for two different IWC on the IASI spectrum:

FORWARD MODEL / SENSITIVITY STUDY

The fast radiative transfer code RTTOV (Saunders et al. (1999), Matricardi (2004)) including Baran parametrization (Vidot et al. (2015)) with Cloud approximation (1999) is used for this study. Jaccobians and radiances are compared with the radiative transfer model LIDORT which computes exact multiple scattering in ice clouds. Results show a good agreement between the two models.

State vector:
- Ice Water Path : $h(IWP)$
- Top and bottom altitudes $h(\text{top})$, $h(\text{bot})$

Non-retrieved parameters / associated errors:
- Surface/atmospheric profile temperature : $1K$ and surface emissivity $5\%$
- Atmospheric $\text{H}_2\text{O}/\text{O}_3$ profile concentration : $10\%$
- Liquid Water Path and layer altitude : $50\%$

REFERENCES

Saunders et al., QJRMS, 125(556):1407–1425, 1999
Baran, JQSRT, 110(14-16):1239–1260, 2009
Vidot et al., JQSRT, 68, 2003
Field et al., JQSRT, 29:1377-1397, 2004
Field et al., JQSRT, 44:346-405, 2007

Forward model / Sensitivity Study

CHANNEL SELECTION

Information brought by the observation system is assumed to be given by the averaging kernel ($A$) and posterior covariance ($\Sigma_p$) matrices as:

1. The diagonal elements of $A=\sum K$ provides an information on the ability of the observing system to capture any variation of the real state vector $\Sigma_x=\sum K \Sigma_y$, with $K$ the gain matrix and $\Sigma_y$ the covariance of the errors on the state vector components.

2. $\Sigma_p=\sum K \Sigma_y K^T$ contains the expected (or posterior) errors on the state vector components.

ICA ON MIXED AND ICE CLOUDS

Conclusion and perspectives: Results show that IASI and IASI-NG would provide information on IWP as well as layer position, and should therefore be well retrieved with expected errors that decrease with cloud opacity until the signal saturation is reached. The study of mix clouds show that the information is sometimes greater because of the presence of the liquid cloud that reduces the influence of the surface. The main perspective is now to develop an algorithm based on an optimal estimation approach in order to retrieve ice cloud properties (e.g. IWP, $Z_{\text{top}}$, $Z_{\text{bot}}$) by taking into account a rigorous forward model error. This algorithm will also take advantage of the channel selection from this present study. We will also investigate the potentiality of IASI/IASI-NG to retrieve the column/profile of water vapour content in presence of ice cloud.