Ice cloud properties, an information content analysis from high spectral resolution measurements in the infrared: IASI and IASING

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Weather forecast: cloud coverage = more than 80% (Lavanant 2010) of satellite data remains unused.
Introduction: context

→ **Weather forecast**: cloud cover = more than 80% (Lavanant 2010) of satellite data remains unused

→ **Radiative balance**: numerous thin clouds - strong radiative impact → need to test the microphysical models in the IR with high spectral measurements

(Hong and Liu 2015/2016)
Introduction: context

→ Weather forecast:

> Weather forecast: cloud cover more than 80% remains unused.

→ Radiative balance:

> Radiative balance: 50% → IWP < 20 g/m², T < 0.06 (vis).

→ Need to test microphysical models in the IR with high spectral measurements (Hong et Liu 2015/2016).

IR is sensitive to the presence of ice clouds → possibility of using IASI to retrieve ice cloud properties.
Use ice cloud contaminated IASI/IASING measurements to obtain information about:

- Ice Water Path (IWP)
- Cloud Top Height (CTH)
- Cloud Geometrical Thickness (CGT)
**Microphysical model**

*Field et al.* (2005/2007) → **parametrization** of ice crystal **size distribution** giving only **temperature** and **IWC**
Microphysical model

*Field et al.* (2005/2007) → parametrization of ice crystal size distribution giving only temperature and IWC

*Baran et Labonnote* (2007) → ice crystal optical properties from a 6 shape ensemble model
Microphysical model

*Field et al.* (2005/2007) → **parametrization** of ice crystal **size distribution** giving only temperature and **IWC**

*Baran et Labonnote* (2007) → ice crystal **optical properties** from a 6 shape ensemble model

*Vidot et al.* (2015) → **parametrization** for **RTTOV**
Methods

→ **Forward model** : RTTOV (fast radiative transfer code)

→ **Optimal estimate** as inverse method (Rodgers 2000)

→ **Information content** and **channel selection** from information theory (Shannon 1949)
Methods

→ ECMWF profiles database: representative profiles of normal conditions, variability and extreme conditions of the atmosphere over a year (Eresmaa and McNally 2014)
Information content analysis

→ Mono-layer case

- **IWP (g/m²)**
- **CTH (km)**
- **CGT (km)**
Information content analysis

→ Mono-layer case

IWP > 1 g/m²

IWP (g/m²)       CTH (km)       CGT (km)
Information content analysis

→ Multi-layer case: separated

Expected error on cloud IWP

Expected error on cloud top altitude

Expected error on cloud geometrical thickness

IWP (g/m²)

CTH (km)

CGT (km)
Information content analysis

→ Multi-layer case : mixed

Expected error on cloud IWP

Expected error on cloud top altitude

Expected error on cloud geometrical thickness

IWP (g/m²)  CTH (km)  CGT (km)
Channel selection

→ **Information content analysis** with all the IASI and IASING channels
→ calculation cost too important

→ Channel selection to remove redundant information
Channel selection

→ IASI

Mono-layer case

Non-retrieved parameters errors:
- gas profiles concentration (H2O, O3) → 10 %
- temperature profile → 1K
- emissivity → 5 %
- surface temperature → 1K

→ 905 selected channels
Channel selection

→ IASI

Mono-layer case

Multi-layer case : separated

→ similar regions for IASING

→ 905 / 872 selected channels
Ice cloud properties retrieval

Retrieval algorithm test on IASI and IASING synthetic measurements generated from the profile database:

→ synthetic radiances calculation with radiometric noise added following a gaussian distribution

→ non-retrieved parameter errors

→ $pdf$ maximum $\rightarrow$ minimisation with Levenberg-Marquardt
Ice cloud properties retrieval

IASI
Ice cloud properties retrieval

IASI

Ice
Ice cloud properties retrieval

→ Mono-layer case

IASI

116 succeed over 117

\[
\text{IWP}_{\text{retrieved}} (\text{g m}^{-2}) = \begin{cases} 
10^{-1} & \text{for } \text{IWP}_{\text{truth}} (\text{g m}^{-2}) \\
10^1 & \text{for } \text{IWP}_{\text{truth}} (\text{g m}^{-2}) \end{cases}
\]

\[
\text{Surface - Cloud top temperature (K)} = \begin{cases} 
10^{-1} & \text{for } \text{CTH}_{\text{truth}} (\text{Km}) \\
10^1 & \text{for } \text{CTH}_{\text{truth}} (\text{Km}) \end{cases}
\]

\[
\text{Surface - Cloud bottom temperature (K)} = \begin{cases} 
10^{-1} & \text{for } \text{CBH}_{\text{truth}} (\text{Km}) \\
10^1 & \text{for } \text{CBH}_{\text{truth}} (\text{Km}) \end{cases}
\]

IWP > 1 g/m²

OSCAR Goal = objectives from WMO

Cloud Bottom Height = CTH - CGT
Ice cloud properties retrieval

→ Mono-layer case

IASING

IWP > 1 g/m²

IWP

OSCAR Goal = objectives from WMO

CTH

Cloud Bottom Height = CTH - CGT

CBH
Conclusion and outlooks

→ high spectral resolution measurements such as *IASI/IASI-NG* can potentially be used to retrieve ice cloud properties with a *channel selection* to decrease calculation time

→ **Outlooks:**
  - retrieval on real *IASI measurements*
  - *water vapour* retrieval in the presence of clouds
Thank you for your attention