New developments for the use of microphysical variables for the assimilation of IASI radiances in convective scale models

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2: CMS, Lannion

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Contents

Introduction

State of the art of the assimilation of cloud-affected infrared radiances.

Evaluation of the radiative transfer model prior to the assimilation

- Use of the AVHRR cluster for the selection of homogeneously covered scenes.
- Evaluation of the radiative transfer model RTTOV CLD

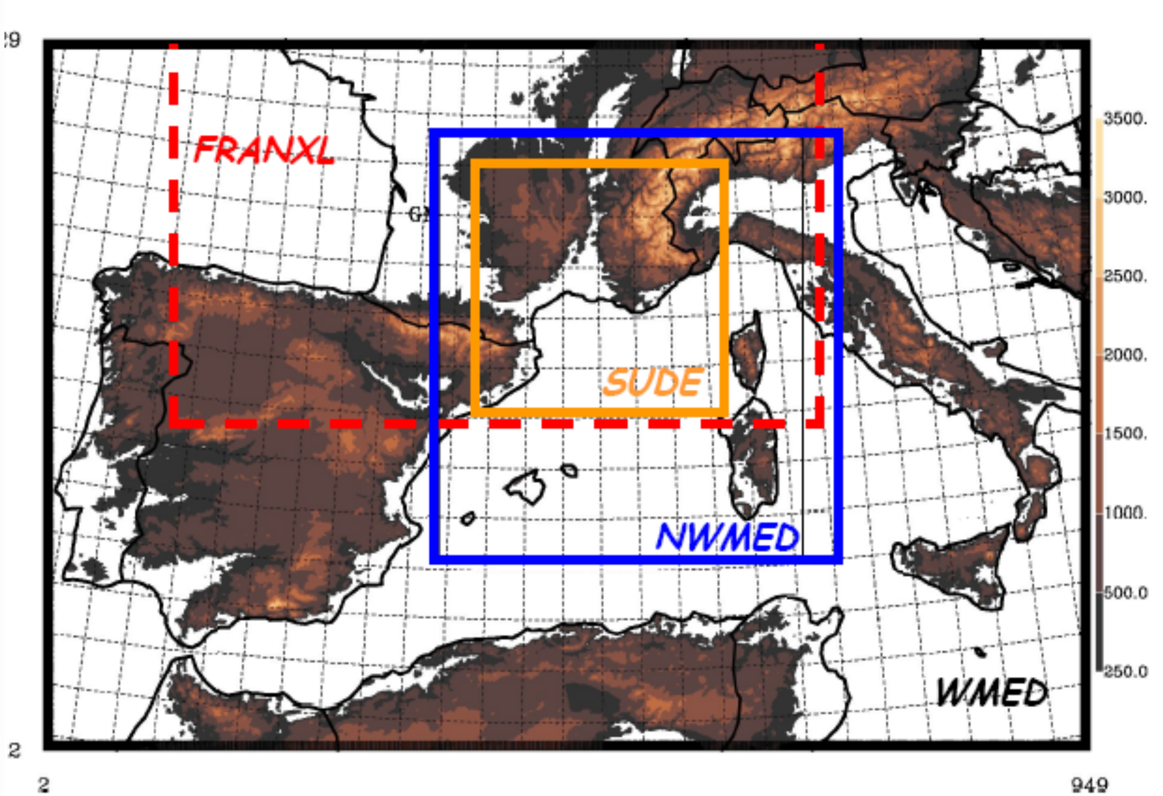
1DVAR with simulated observations

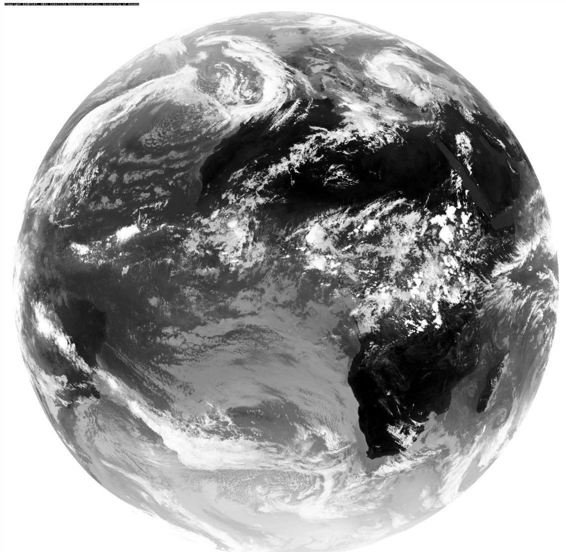
- Observing System Simulation Experiments (OSSE)
- Retrieval of microphysical variables (liquid water content, ice water content) simultaneously with temperature and humidity.

Context of the study

- Experimental campaign **HyMeX [1]**.: hydrological cycle over the Mediterranean, heavy precipitation events.
- Special Observation Periods: 2012/2013

•Convective scale model AROME W MED: 2.5 km grid.





• Cloud-affected radiances from the hyperspectral infrared sounder **IASI** (8461 channels).

1: Hydrological cycle in Mediterranean EXperiment

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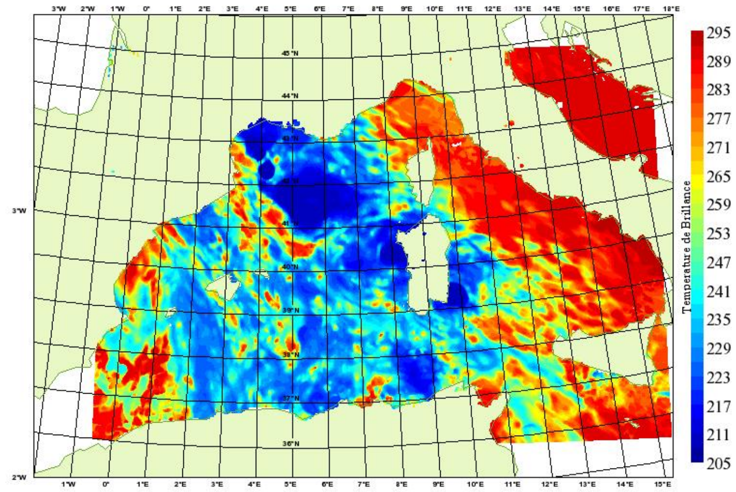
Main issues of cloud-affected IR radiances

• **Cloud mislocation** between the model and the observation: non gaussian distribution of background errors

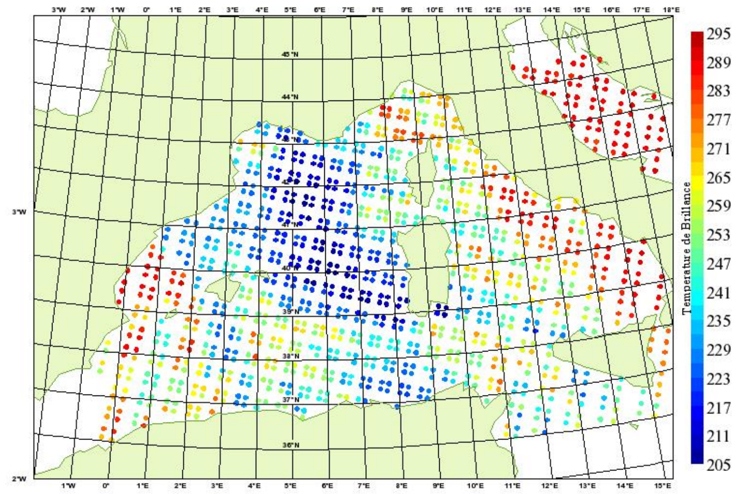
• **Deficiencies of cloud modelling**:
NWP models, radiative transfer model

• **Non linearity** of the observation operator

AROME - 2.5km



IASI - 12 km at Nadir



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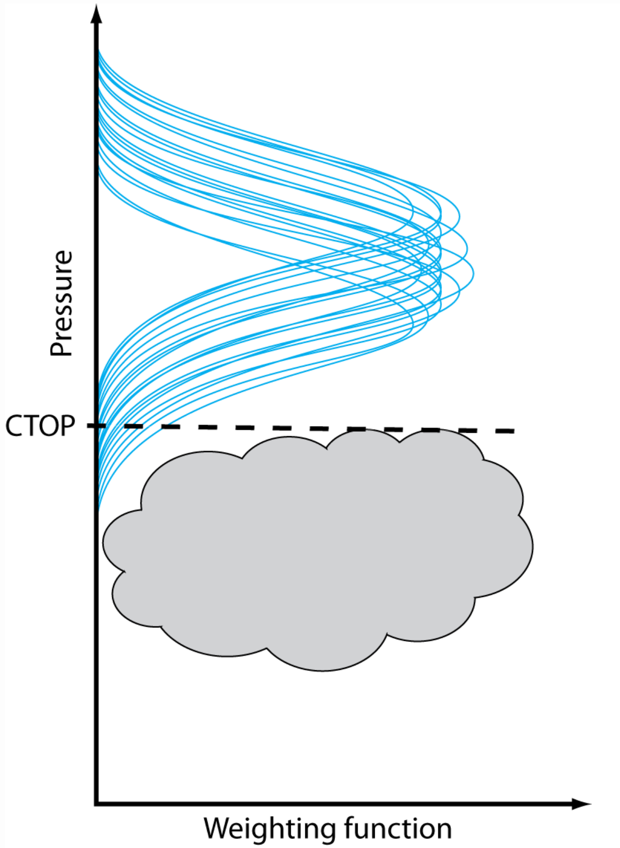
State of the art for the treatment of cloud-affected radiances

- Cloud detection scheme of McNally and Watts (2003) [1].
  + detection of clear channels instead of clear locations
  - Use of data only above cloud tops: highly restricted in the mid to upper troposhere.



1: A.P.McNally and P.D Watts 2003: A cloud detection algorithm for high spectral resolution infrared sounders. Quart.J.Roy.Meteor.Soc,129,3411-3423.
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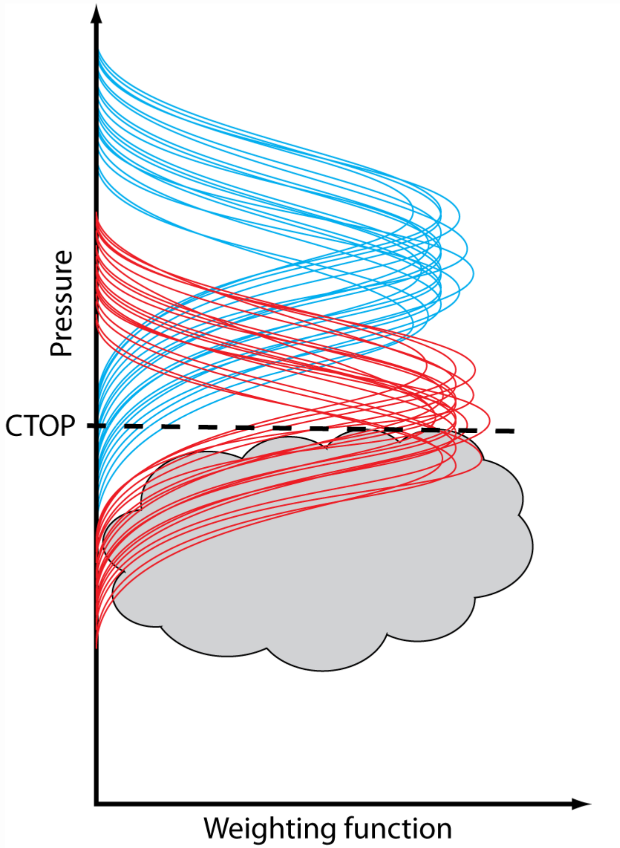
- Use of two cloud parameters: cloud top pressure (**CTOP**) and effective cloud fraction (**Ne**) to constrain the assimilation.[2],[3],[4].

  \+ Use of cloud-affected channels

  \- Problems of detection of low level clouds and thin cirrus clouds, simplified modelling of clouds



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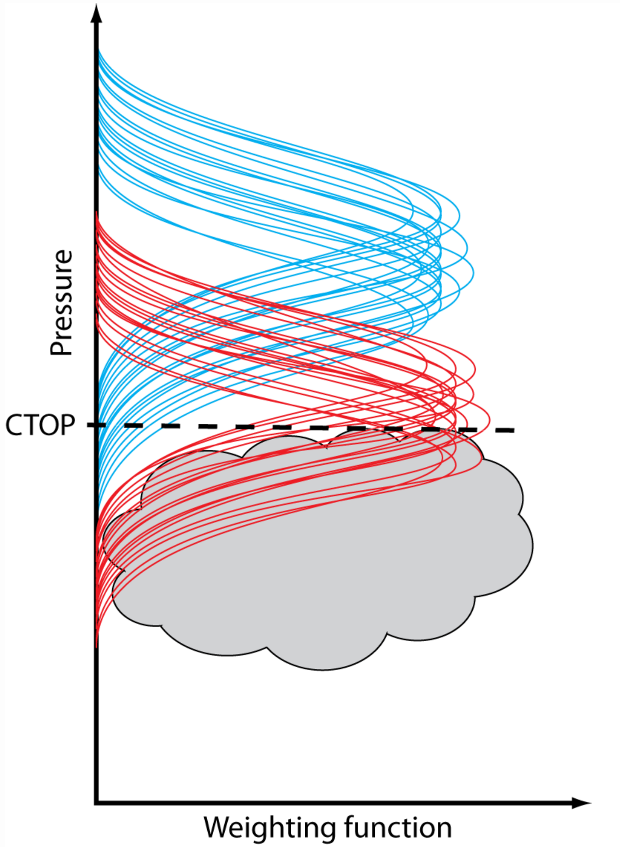
- Development of a new solution: use of microphysical variables for the assimilation.

  + Better modelling of clouds (multi layer, mixed phase).

  - Linearity



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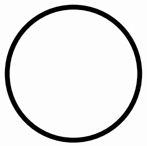
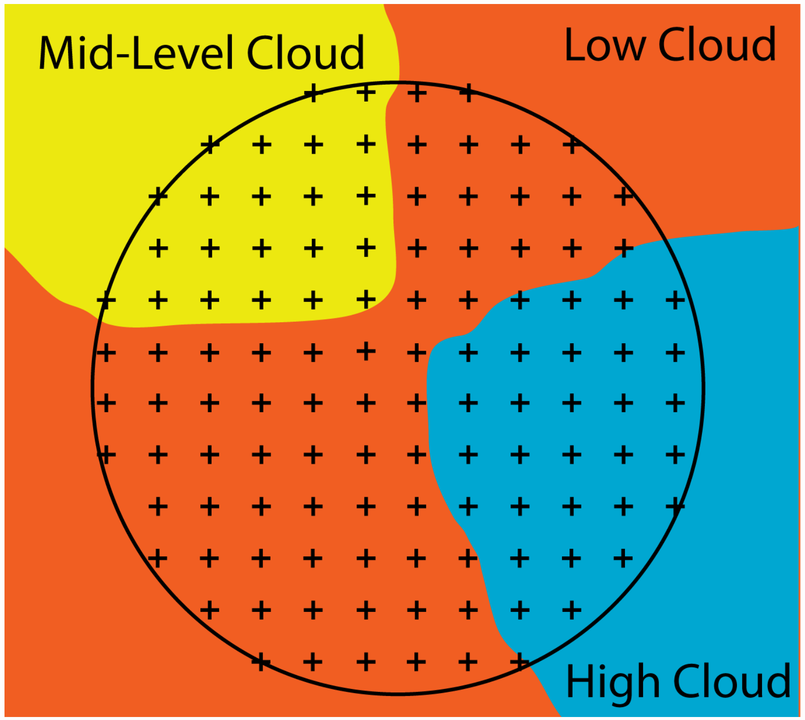
Selection of homogeneously covered scenes: AVHRR cluster

- **AVHRR cluster** provided by EUMETSAT.
- **Aggregation** of AVHRR pixels in classes with a K-means clustering based on the 5 radiances when available.
- Restriction to overcast data: all the AVHRR pixels within the IASI FOV are cloudy.



IASI FOV

+ AVHRR pixels



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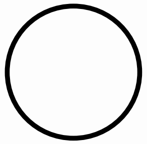 IASI FOV

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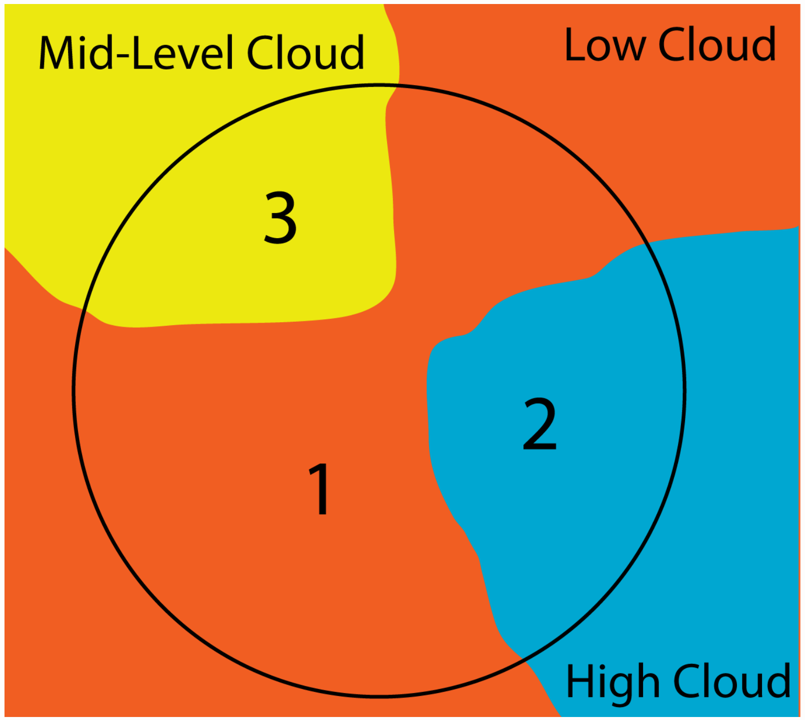

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Evaluation of the radiative transfer model RTTOV CLD.

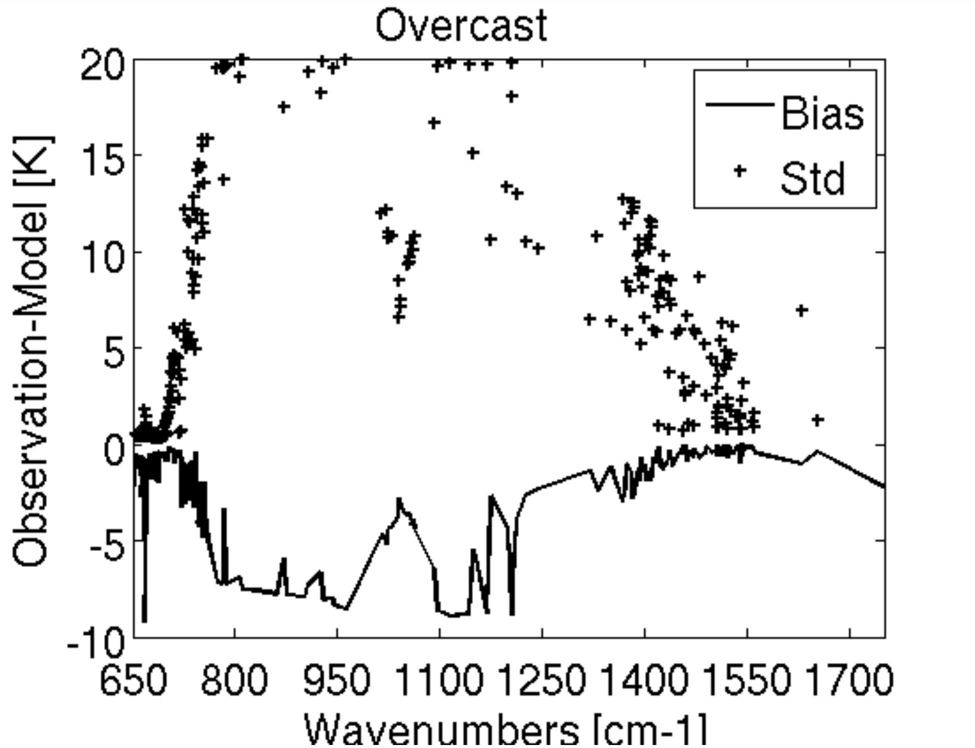
Temperature (T)
Humidity (q)

RTTOV CLD

Simulated radiance

Liquid Water Content (ql)
Ice water content (qi)

All **overcast** data



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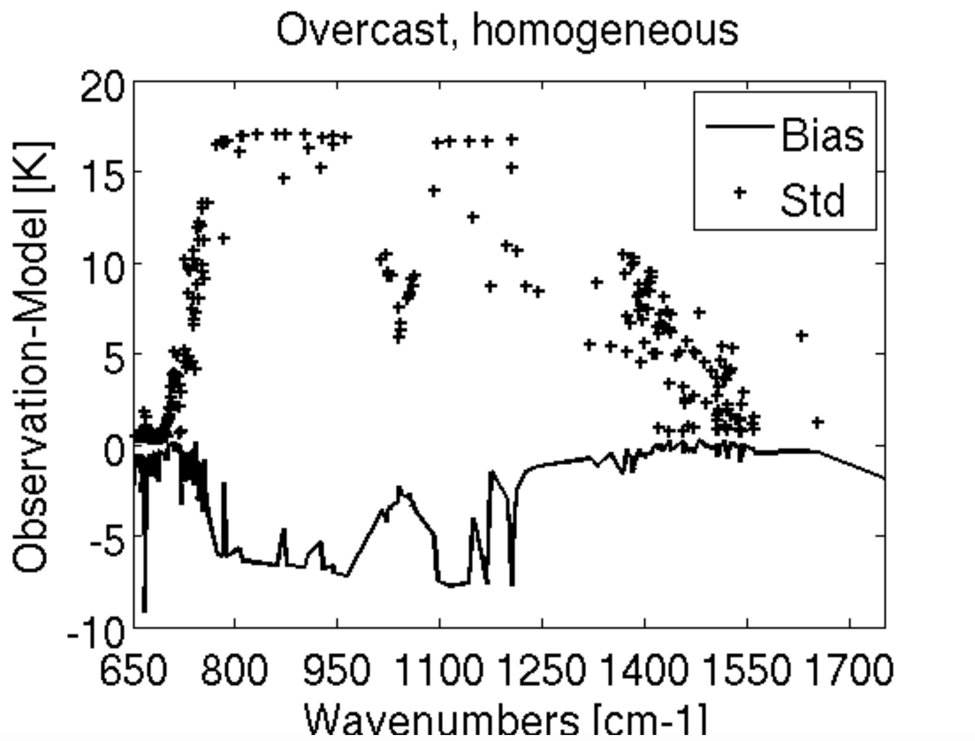
All **overcast** data

All **homogeneous overcast** data



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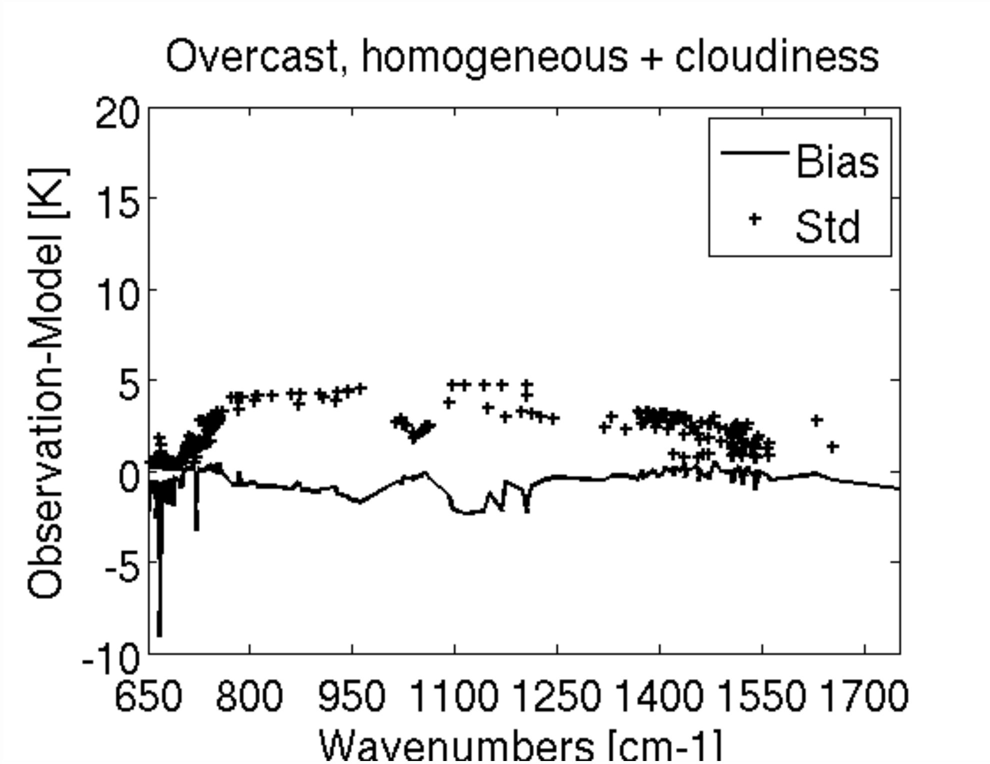
→ **RTTOV CLD** → Simulated radiance

All **overcast** data

All **homogeneous overcast** data

All **homogeneous overcast** data with a constraint on the **cloudiness** in AROME and IASI.
ΔBT_AVHRR<7 K= Observed AVHRR – Simulated AVHRR

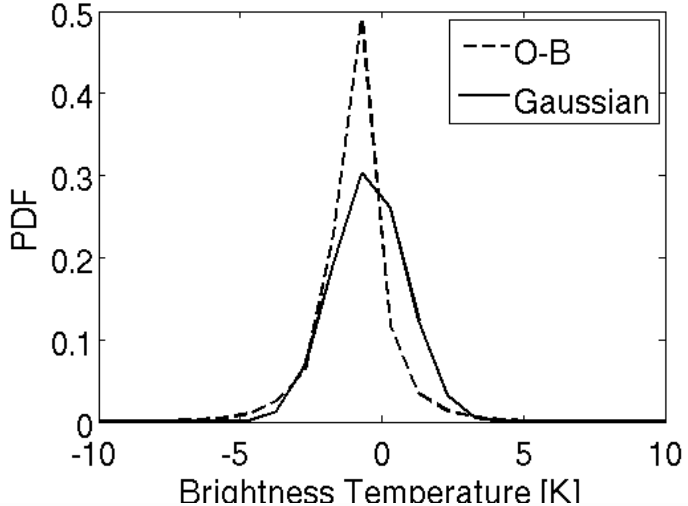


Evaluation of the radiative transfer model RTTOV CLD.

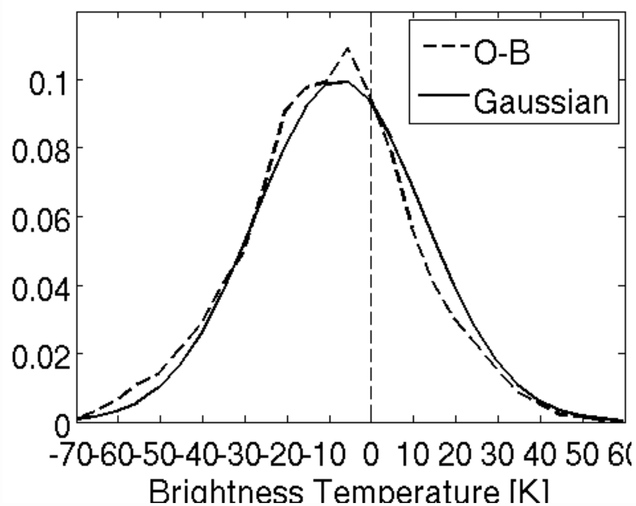
Frequency distribution of the observation minus simulation innovations.

All **overcast** data

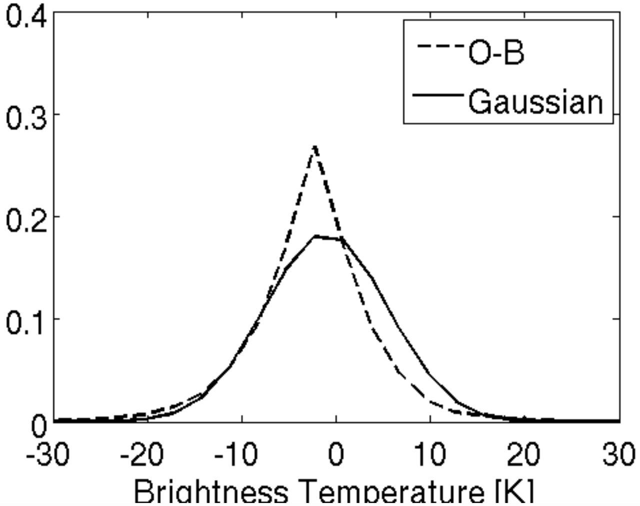
CO2 band: 700 cm^{-1}



Window channel : 812 cm^{-1}



Water Vapor channel : 812 cm^{-1}



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All **homogeneous overcast** data with a constraint on the cloudiness in AROME and IASI.

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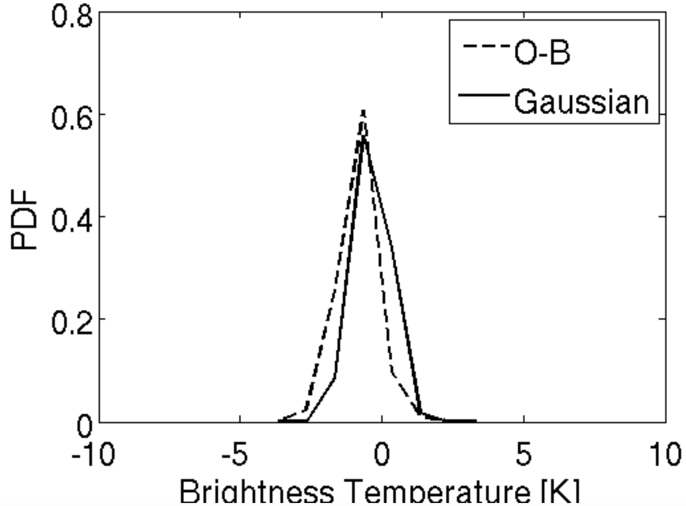

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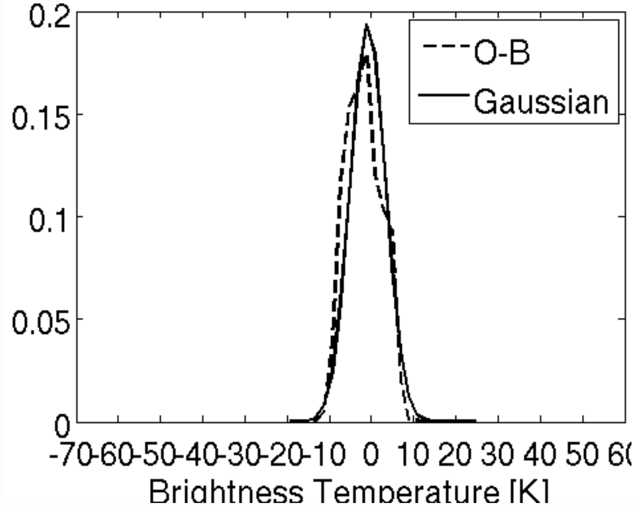

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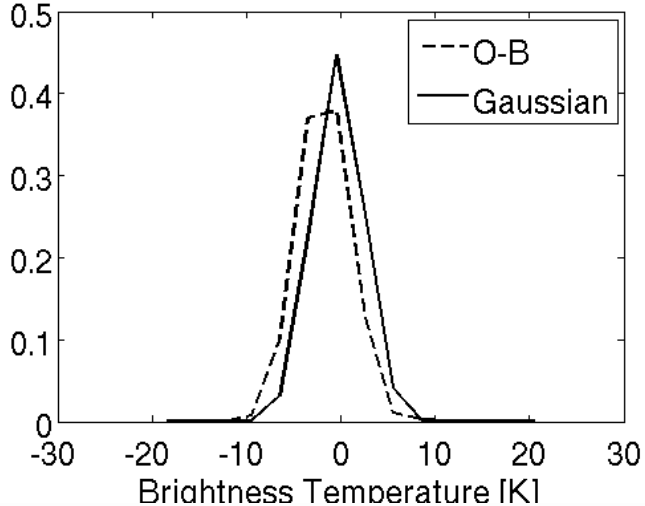


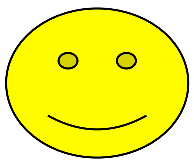
Mid-presentation conclusion

Selection of cloudy scenes prior to the assimilation

- Useful information can be derived from the AVHRR cluster.

- Importance of the cloud mislocation between AROME and IASI: we have to set a constraint on the cloudiness of AROME.

- After the screening procedure, gaussian background errors and biases of the innovations close to zero: we are ready for the assimilation



1DVAR Retrievals: OSSE experiments (Observing System Simulation Experiments)

- Use of AROME profiles within homogeneous overcast observations perturbed with a Gaussian noise proportional to the **B matrix**:

$$x=x_{true}+\varepsilon_b \mathbf{B}^{1/2}$$

- Simulation of IASI radiances with RTTOV CLD. Perturbation with the IASI instrument noise provided by CNES and radiative transfer model errors.

$$y=H(x_{true})+\varepsilon_o \mathbf{R}^{1/2}$$

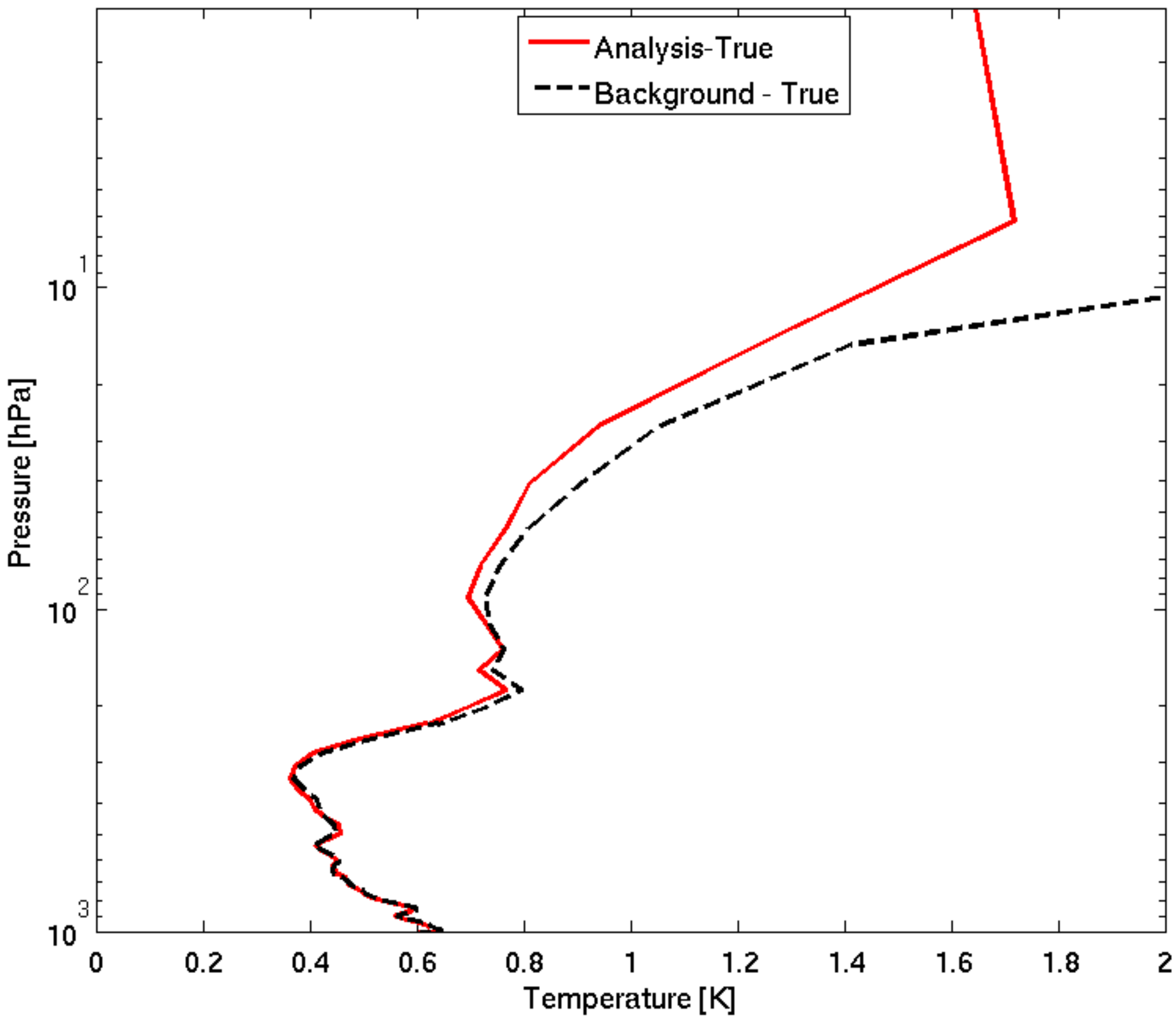
- Use of a background error **B** matrix computed from a 6 member AROME ensemble on **convective cases** **(Thibaut Montmerle [1])**.

- Comparison of RMSE of the background and the analysis with respect to the « true » profile. 366 channels monitored at ECMWF + new selection of 200 channels (poster 4.43).

1. Michel et al 2011: Heterogeneous Convective-Scale Background Error Covariances with the inclusion of hydrometeor Variables. Montly Weather Review, 139, 2994-3015.

Opaque clouds (Ne>=0.9)

TEMPERATURE



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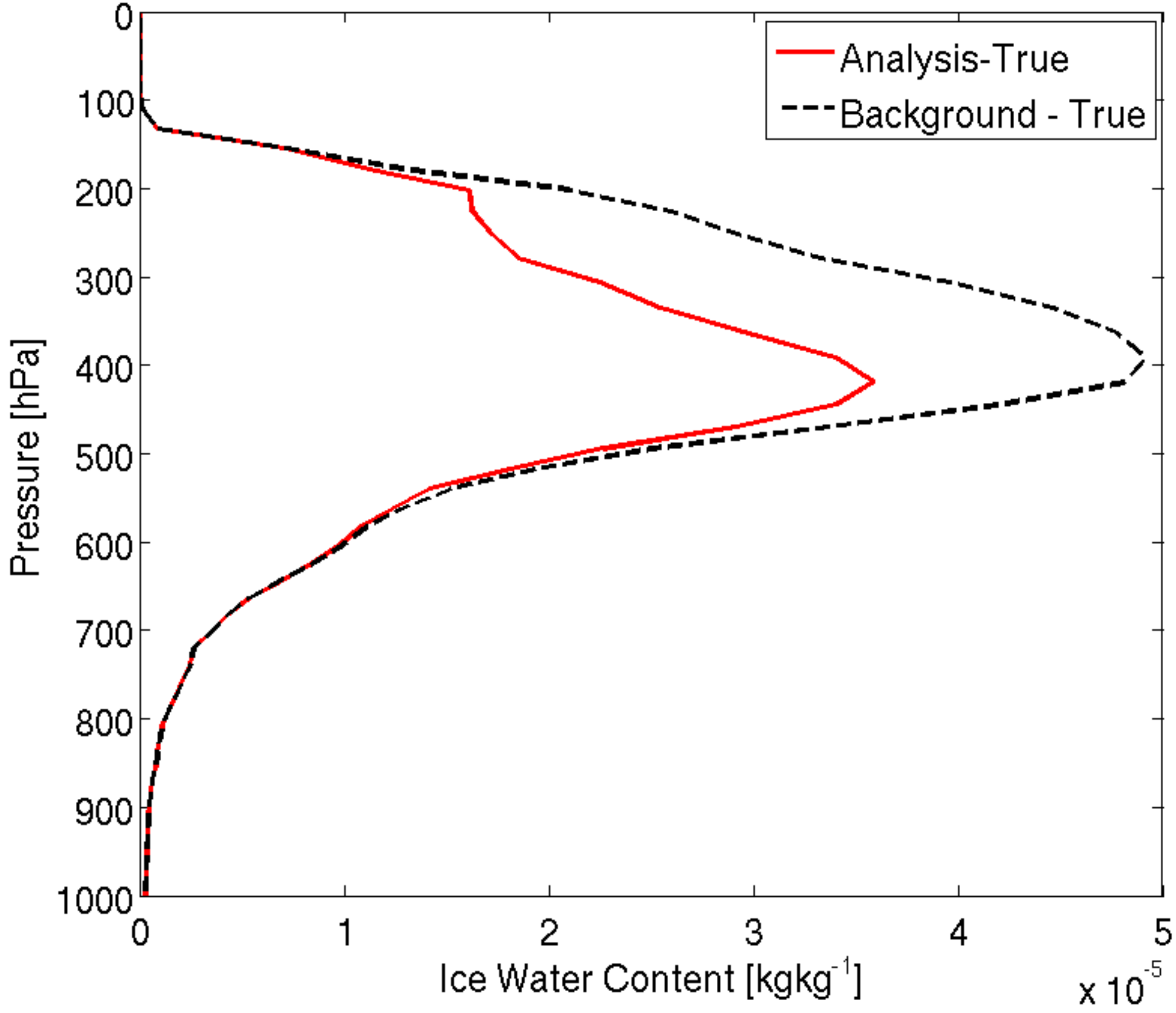
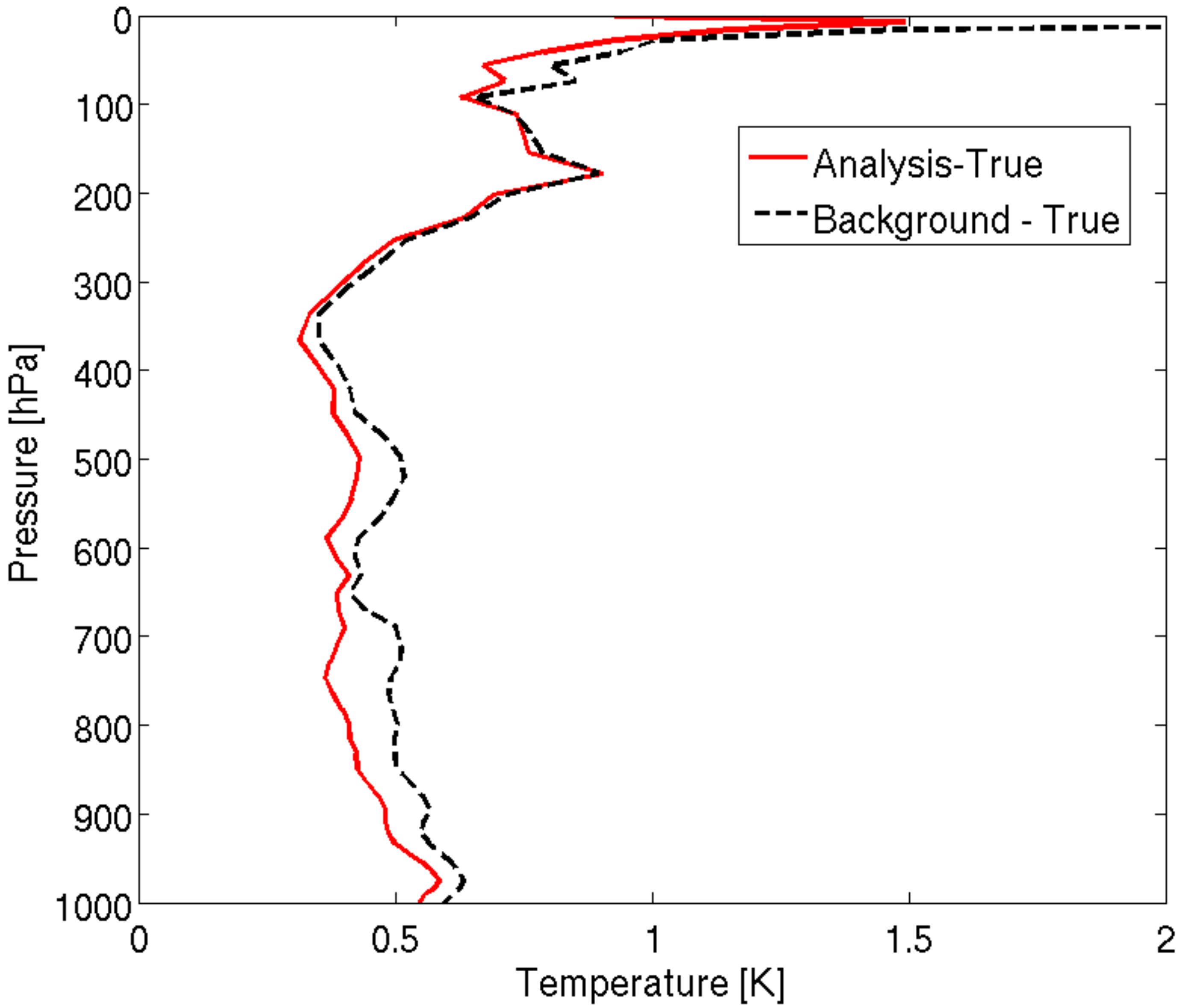
ICE WATER CONTENT



Low clouds (CTOP>=650 hPa)

TEMPERATURE



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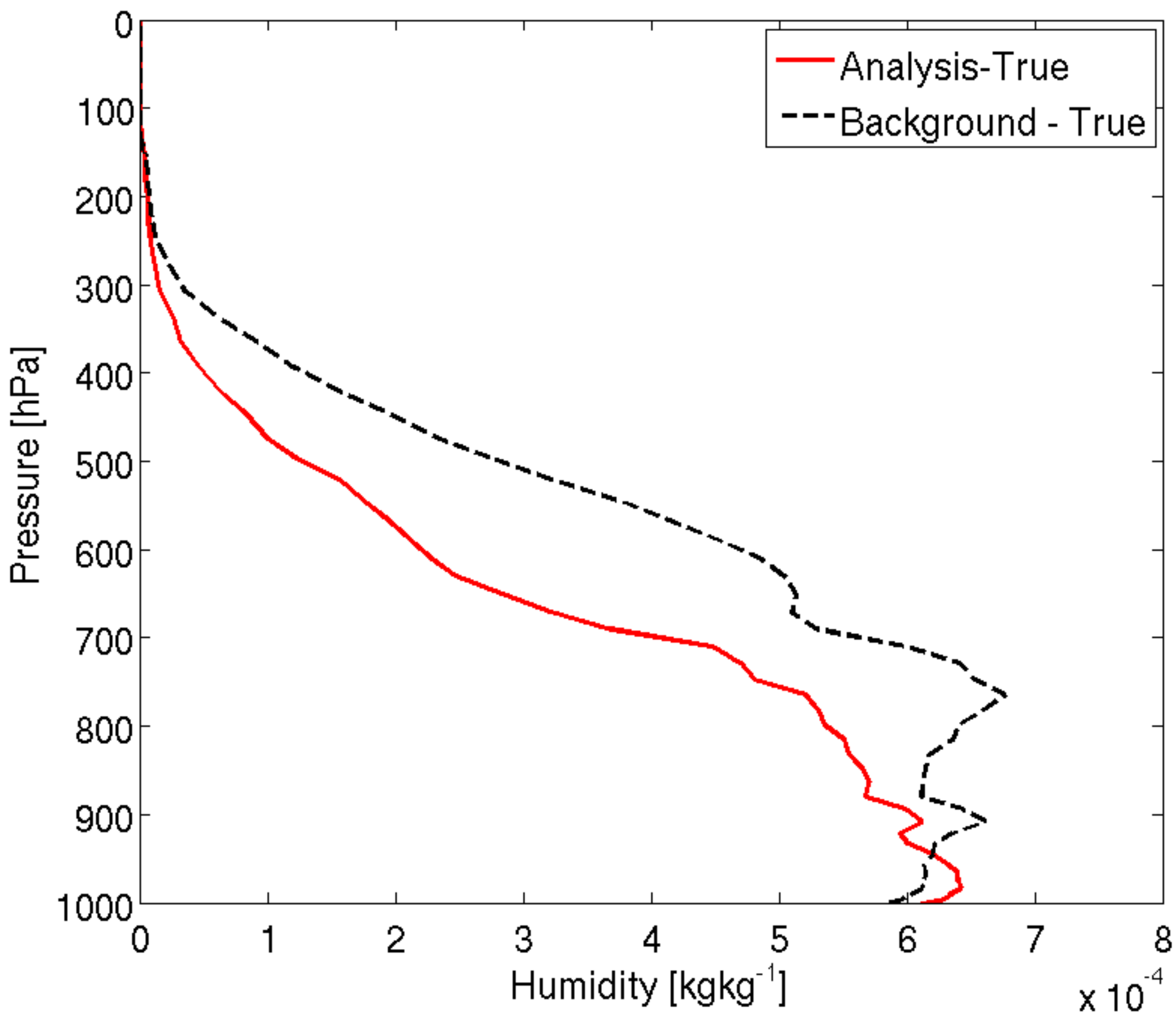
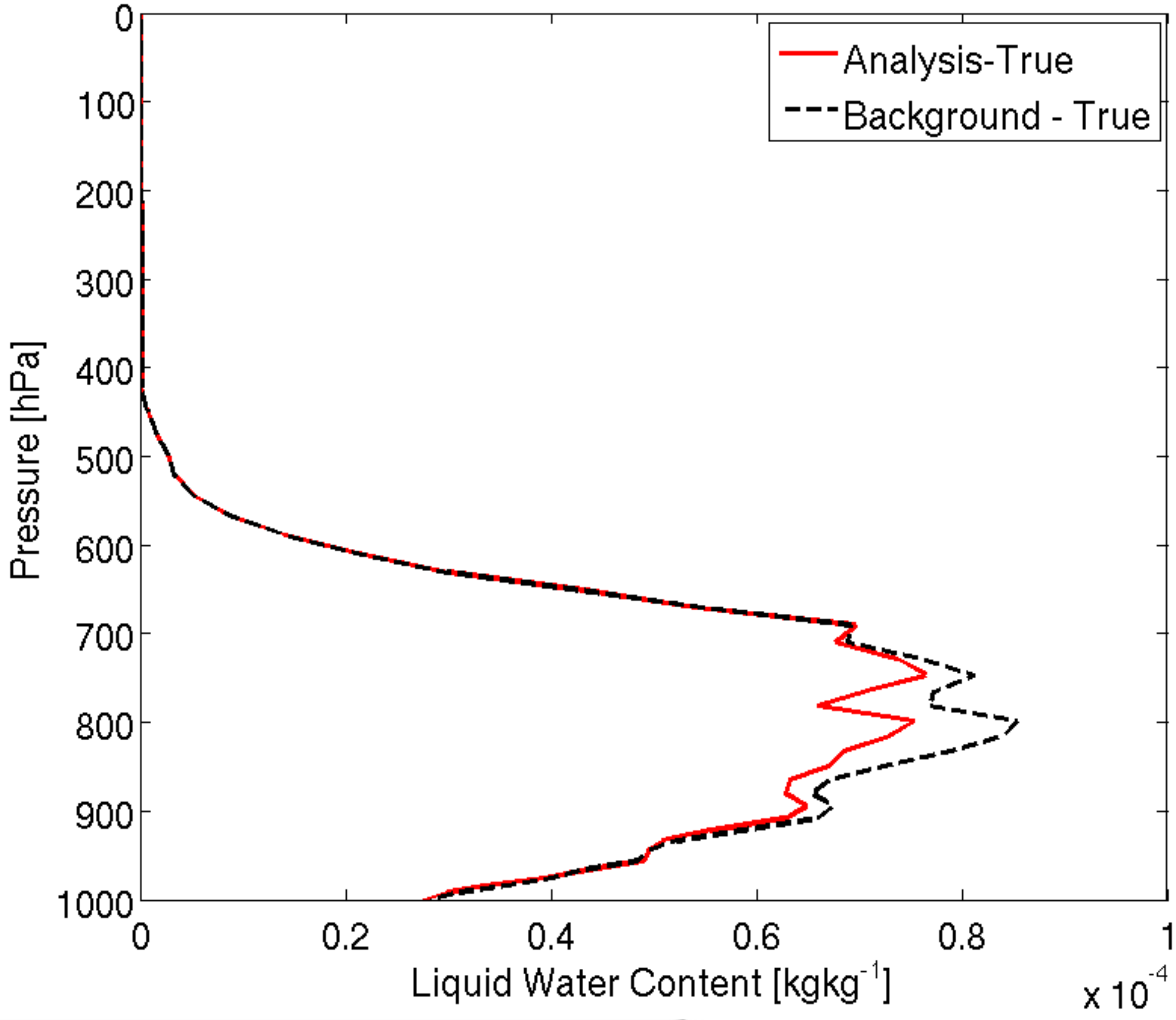
HUMIDITY



Low clouds (CTOP>=650 hPa)

LIQUID WATER CONTENT



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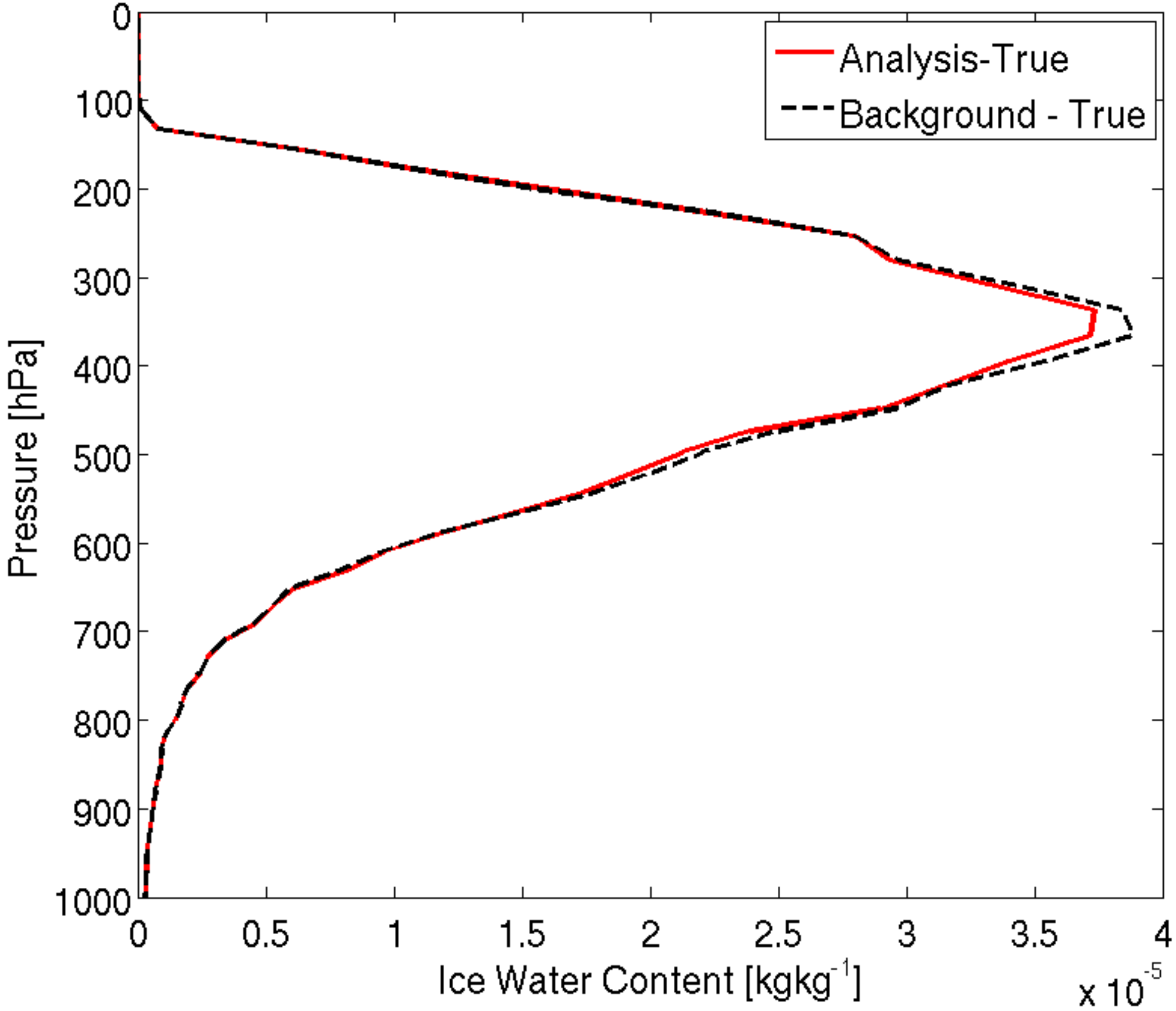

Conclusion and prospects

Past

- A screening procedure of cloud-affected radiances prior to any assimilation is necessary.

- Encouraging results found for the extraction of information about microphysical variables for low clouds and opaque clouds. Some problems remain for semi-transparent clouds (not shown).

Future

- Evaluate the possibility of adding a cloud layer when AROME is clear and IASI cloudy. For that purpose, modification of the cloud fraction during the assimilation.

- Evolution of the 1D-Var increment in a one-dimensional version of AROME to evaluate its capability to keep the cloud information from IASI.

Thanks for your attention.

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