Cloudy infrared radiances: status of assimilation at Météo-France and Intercomparison exercise

Vincent GUIDARD
Météo-France and CNRS / CNRM-GAME

Lydie LAVANANT
Météo-France / CMS

METEO FRANCE
Toujours un temps d'avance

Content

Part 1: Comparison of IASI Cloud Products for cloudy radiances assimilation

Part 2: Status of cloudy IR data assimilation at Météo-France

1. Overview:
assimilation of data from InfraRed Sounders in operations
   - Global model ARPEGE
   - Convective-scale model AROME

2. Comparison of 3 approaches in AROME

Comparison of IASI Cloud Products for cloudy radiances assimilation

International cooperation:

- Météo-France/CMS
- Météo-France/CNRM
- EUMETSAT
- NOAA
- Centre Météorologique Canadien
- UK Met Office
- Japan Meteorological Agency
- Naval Research Laboratory
- Laboratoire de Météorologie Dynamique
- NCEP

Comparison of IASI Cloud Products for cloudy radiances assimilation

Rationale:

- IASI data for temperature and humidity sounding are now assimilated **in clear conditions** at many operational meteorological centres.
- However, a large amount of situations, more than 80% on the whole globe, are covered by clouds.
- The first step is **to detect and characterize the clouds** in the footprint of the sounder.
- One way of investigating the limitations of a particular methodology is to perform a careful intercomparison of the results of different processing schemes for the same observations.

Experimental settings:

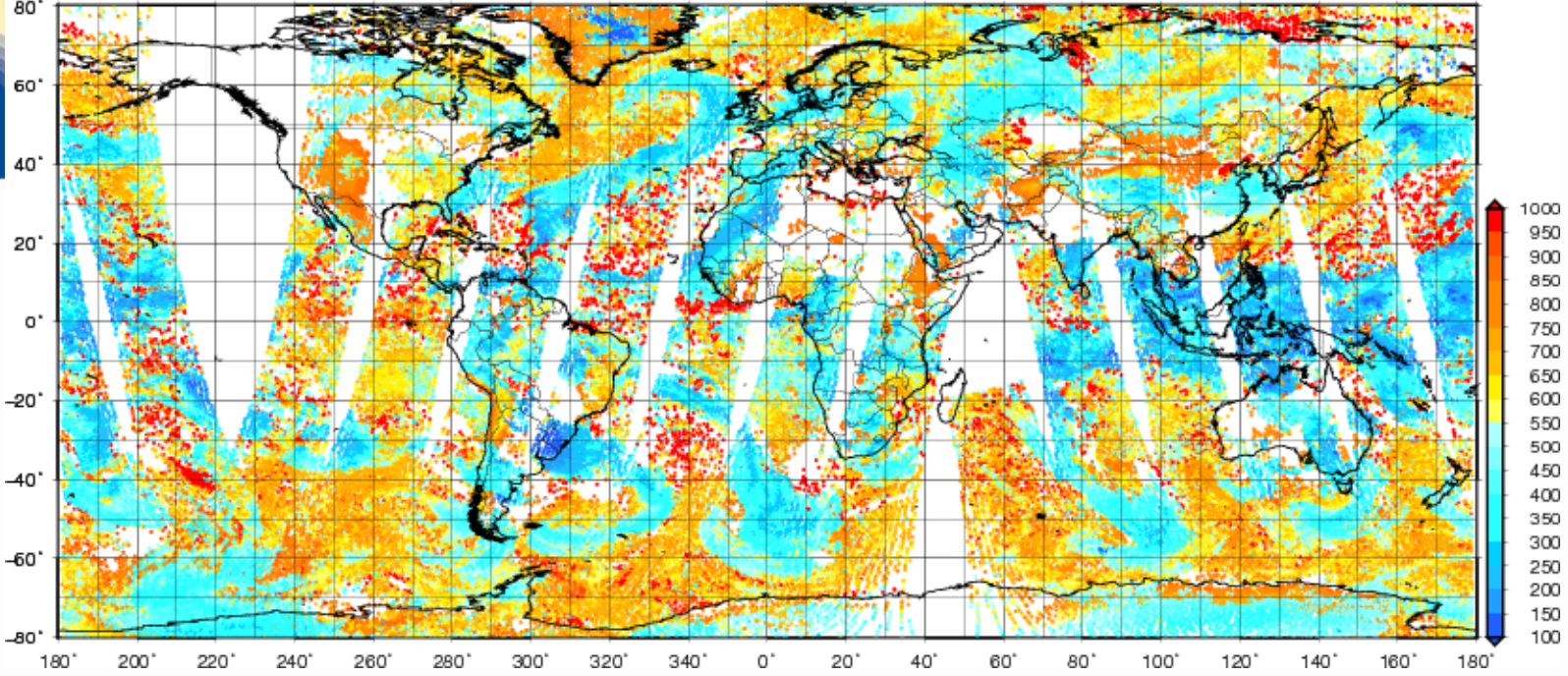
All methods are applied to a 12-h global acquisition on 18 Nov. 2009.

Comparison of IASI Cloud Products for cloudy radiances assimilation

Methods:

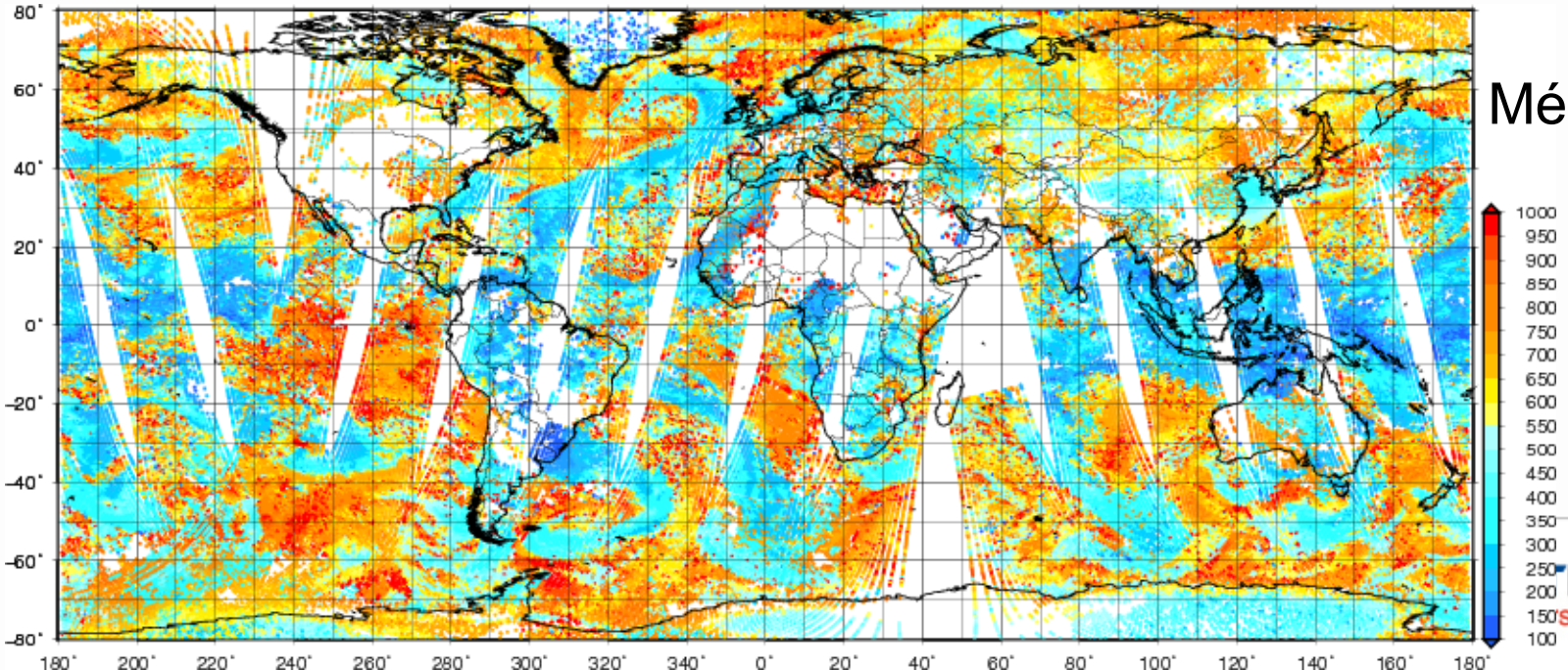
- Mainly CO2-slicing methods
- Settings differ:
  - from 8 channels to ~80 channels
  - 1 reference channel for all channels or couples of channels

- And many other differences
  - use of AVHRR information or not
  - single layer cloud or multiple layer (up to 3) clouds
  - RT models: RTTOV (from 7 to 9.3), SARTA, 4A
- - FOV to which the method is applied

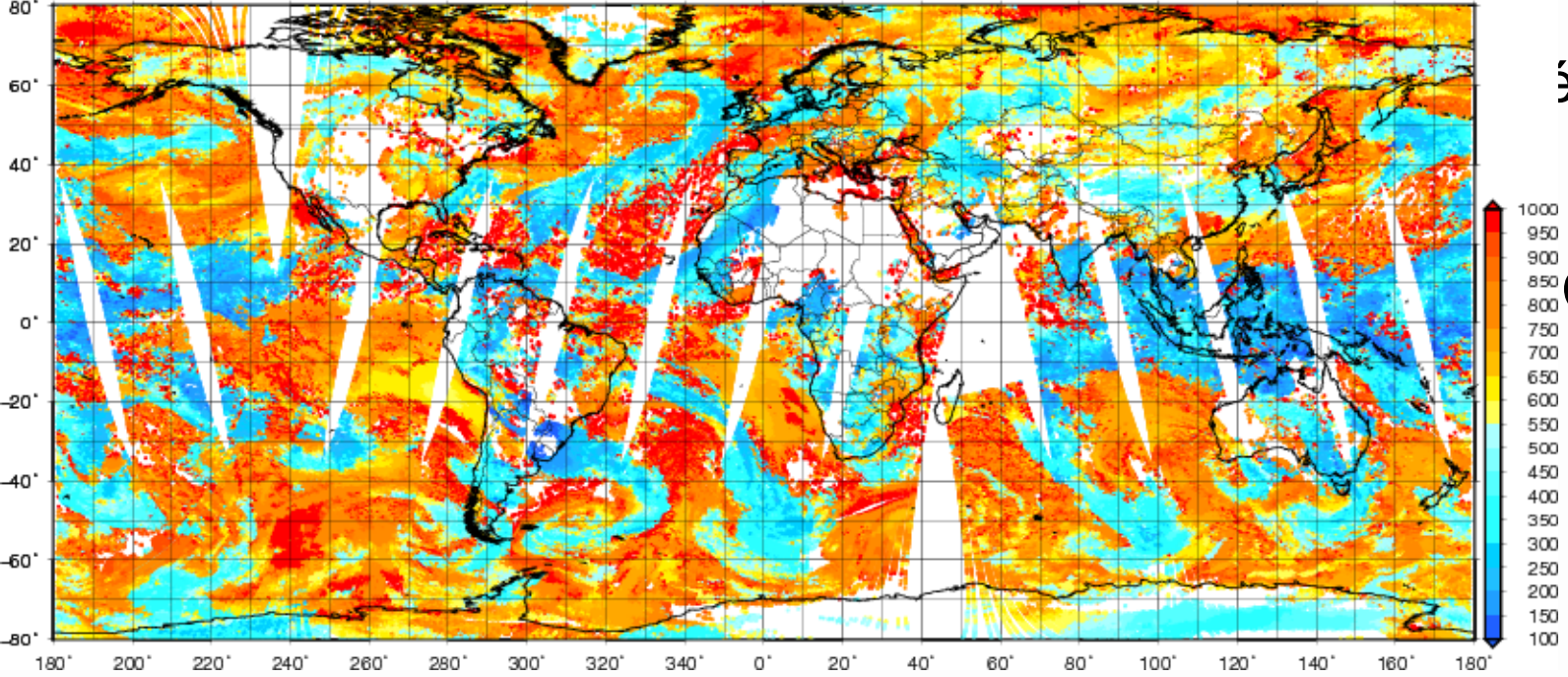


CMC

Retrieved Cloud Top Pressures: comparable results (CO2-Slicing)

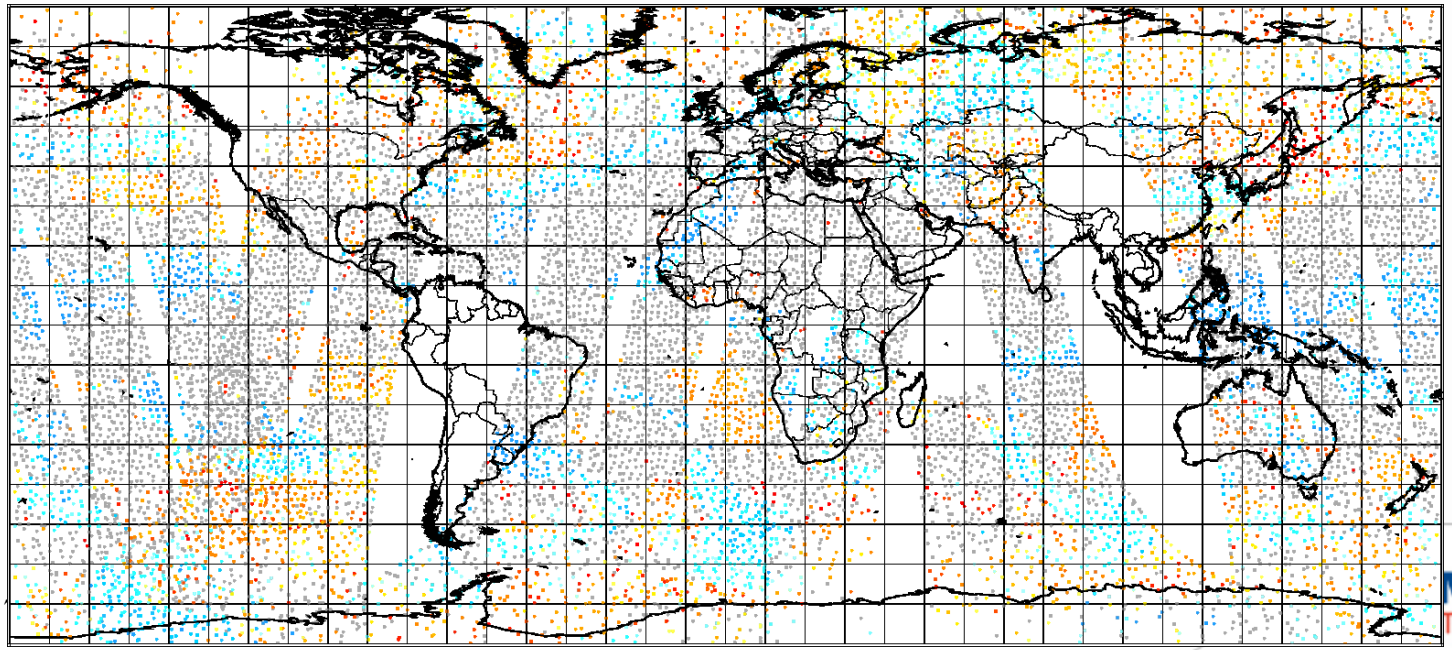


Météo-France
CNRM



éteo-France
CMS
AVHRR +
CO2-slicing

Retrieved Cloud Top Pressures: more different results

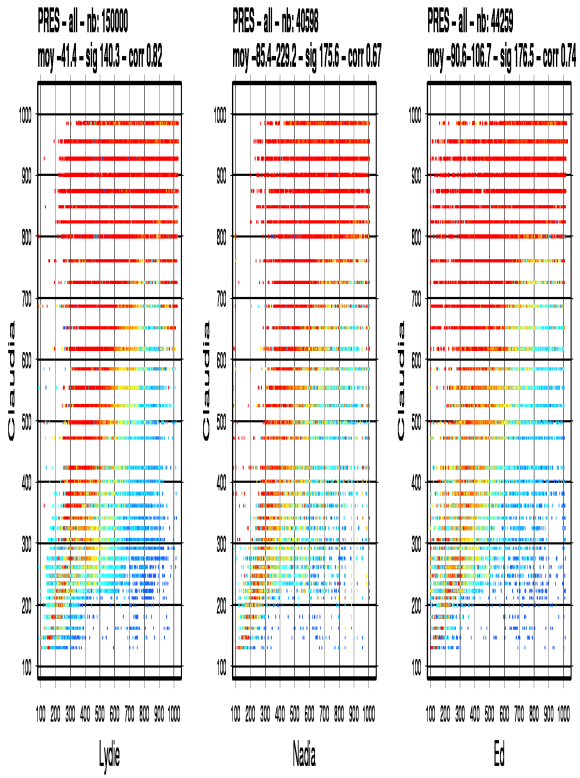


NCEP

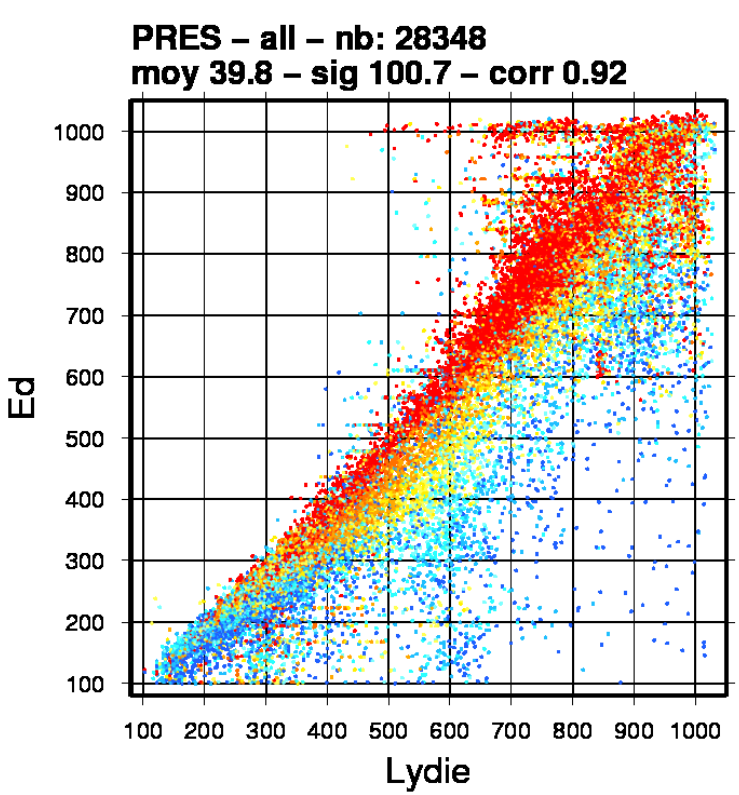
METEO FRANCE
Toujours un temps d'avance

Retrieved Cloud Top Pressures: scatterplots

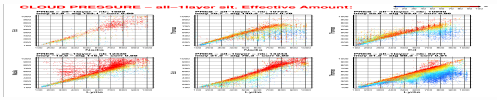
LMD
versus
Météo-France / CMS



UK Met Office
versus
Météo-France / CMS



Cloud fraction



METEO FRANCE
Toujours un temps d'avance

Comparison of IASI Cloud Products for cloudy radiances assimilation

Conclusions:

- The main meteorological structures have been retrieved by all the schemes but the cloud heights can be very different.
- Similar methods lead to similar results (e.g. CMC and Météo-France / CNRM) ; reversely, larger differences come from different methods (e.g. CO2-slicing and weighted χ^2 method).
- The occurrence of complex situations with multi-cloud layers is about 30% in this study. The NOAA scheme is able to detect and characterize very high thin clouds above lower clouds.

Future work:

- Make use of the A-Train data
- Further intercomparison exercise with in-situ observations from future campaigns (e.g. the ConcordIasi campaign) or/and using a collocated dataset of radiosonde and IASI data.

InfraRed Sounder assimilation in operations

In global model ARPEGE & in convective scale model AROME

- IASI: **only clear channels**, flagged clear by McNally & Watts (2003) algorigthm

- AIRS:
  - McNally & Watts: assimilation of **all clear channels**
  - CO2-slicing: assimilation of **cloudy data** when cloud top pressure $\in$ [600 ; 950 hPa]

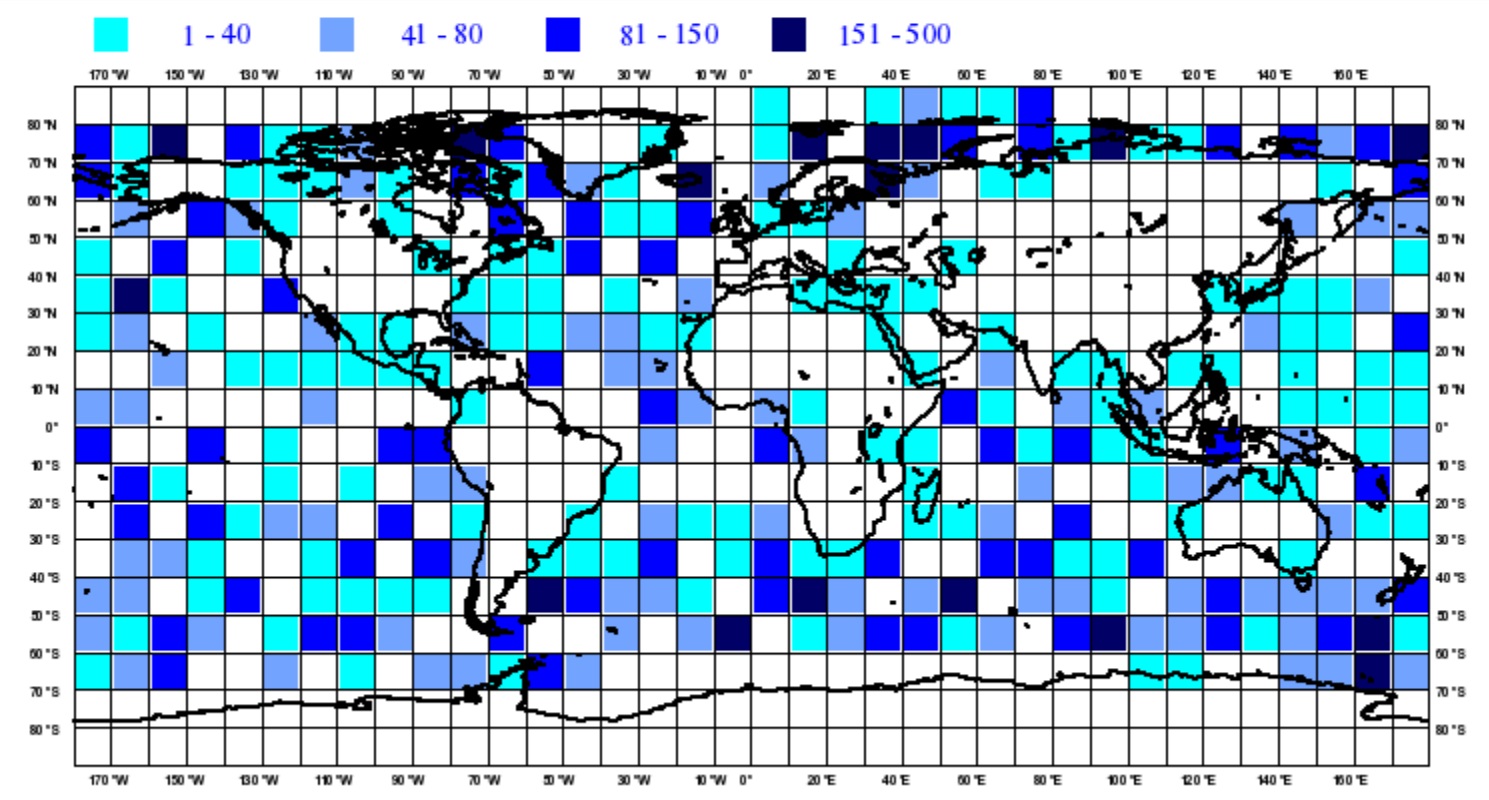
- SEVIRI:
  - **Clear Sky Radiances** (CSR) in ARPEGE
  - **Only clear channels** in AROME, selection using Cloud Type product provided by Météo-France / CMS in Lannion

- HIRS: **only clear channels**, selection using detection with CO2 channels

CO2-slicing on AIRS data: more data to assimilate

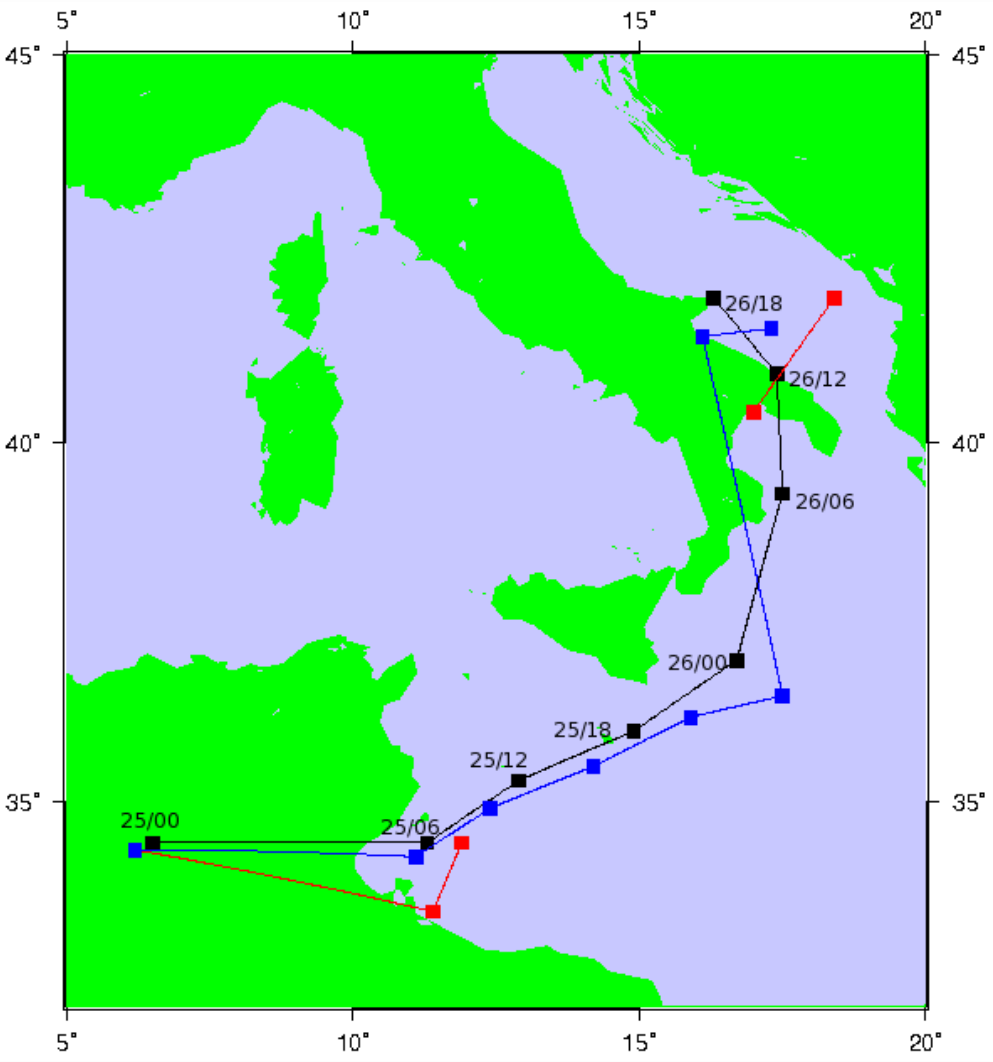
More observations are assimilated, particularly for tropospheric channels (potentially more contaminated by clouds).

Average additional assimilated AIRS channels for 30 September 2006 when assimilating cloud affected radiance



METEO FRANCE
Toujours un temps d'avance

CO2-slicing on AIRS data: impact on forecasts



Case study: Medicane Storm that affected the south-eastern part of Italy on 26 September 2006.

Assimilation of cloud-affected AIRS radiances improved:

← trajectory of the storm

Intensity of the storm
Precipition forecast

Forecast from **23/09/06 00UTC**

cf. Pangaud et al. MWR 2009

Analyses **Clear+Cloudy** **Only clear**

METEO FRANCE
Toujours un temps d'avance

Possible Approaches in AROME

Clear sky assimilation

- IASI: **only clear channels**, flagged clear by McNally & Watts (2003) algorigthm

Cloud characterization

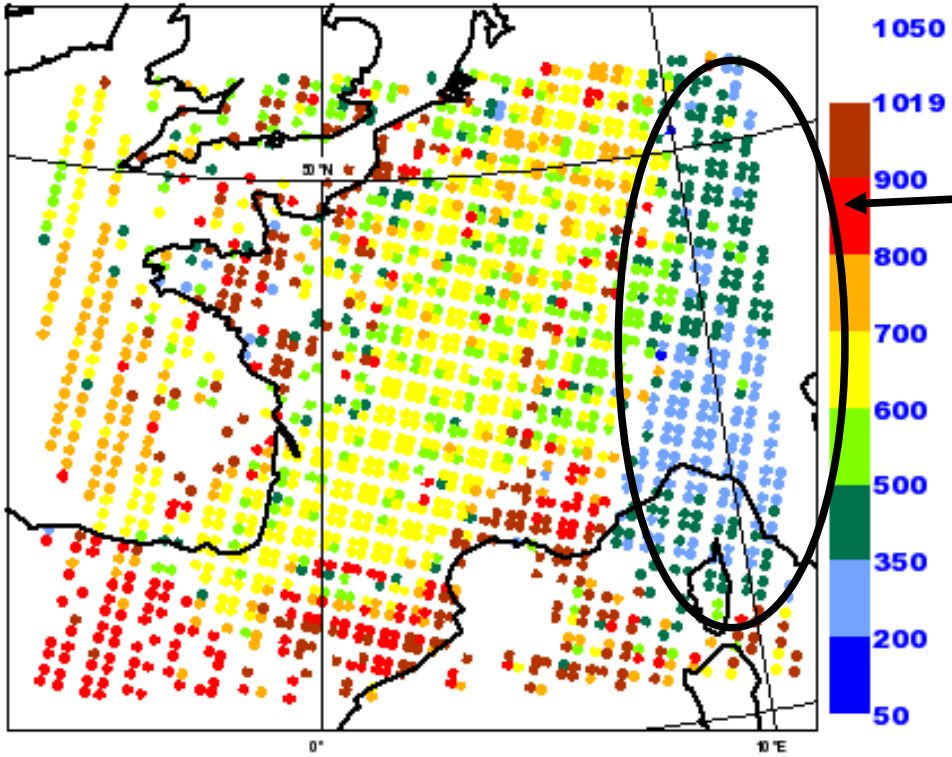
- Assume cloud to be single layer and retrieve cloud top pressure (CTP) and cloud fraction (CFrac)
- CTP and CFrac are provided to RT model and their values are fixed during minimisation

Model microphysics + RTTOV CLOUD

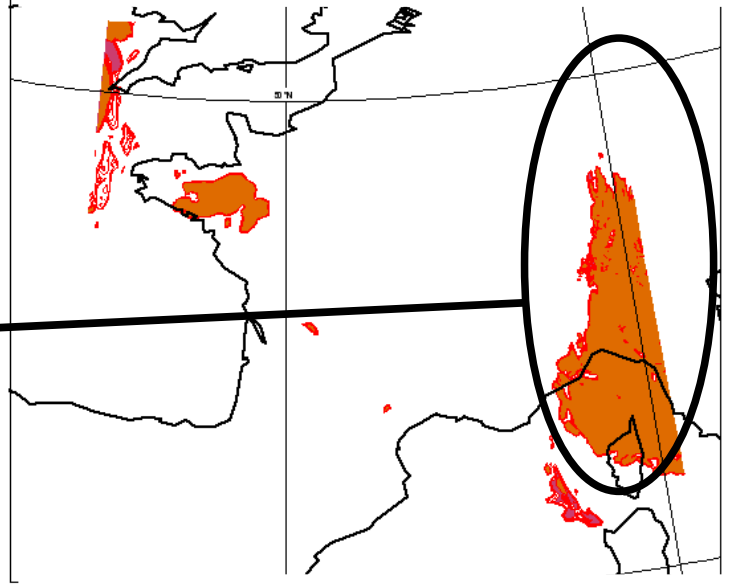
- Use cloud (liquid water + ice water + fraction) from model forecast as inputs to RTTOV CLOUD

Diagnostics comparison

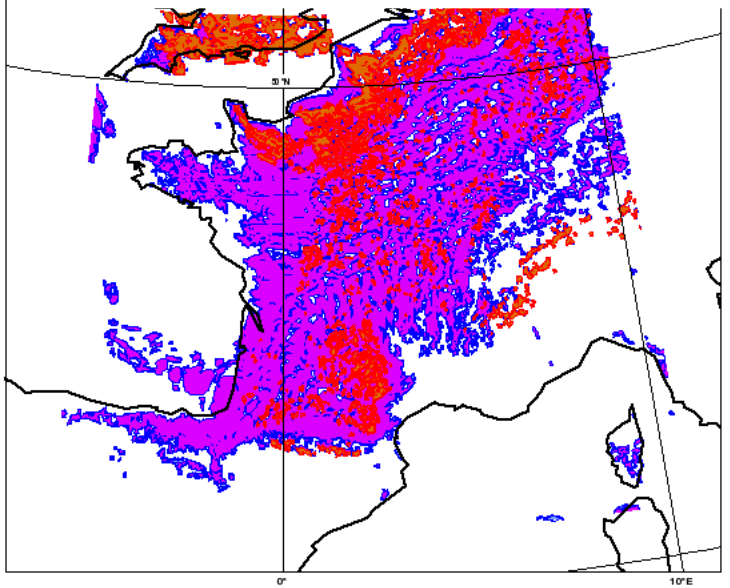
Cloud Top pressure from CO2-slicing on IASI observations



Cloud ice water @ 300 hPa from 3-h AROME forecast

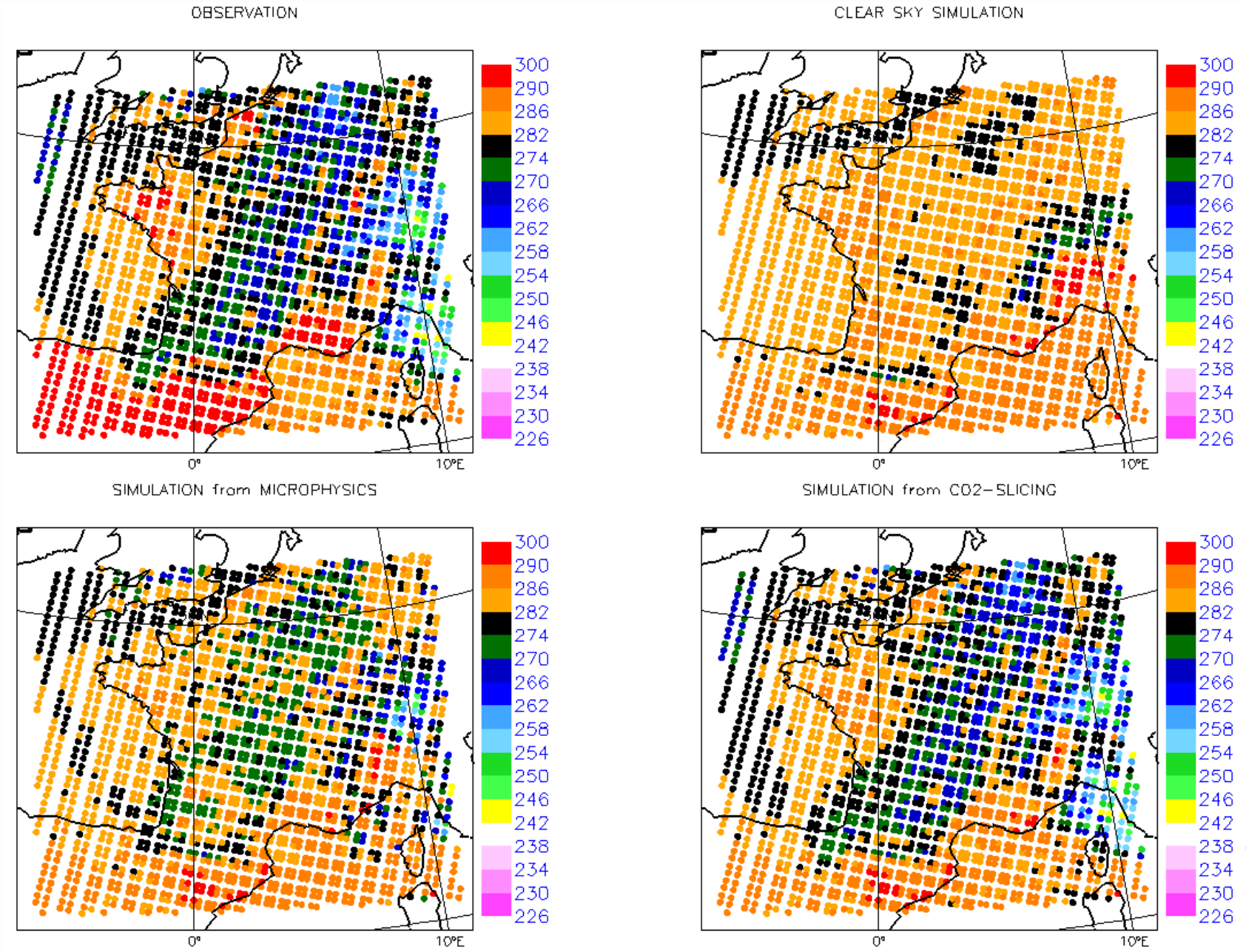


Cloud liquid water @ 850 hPa from 3-h AROME forecast



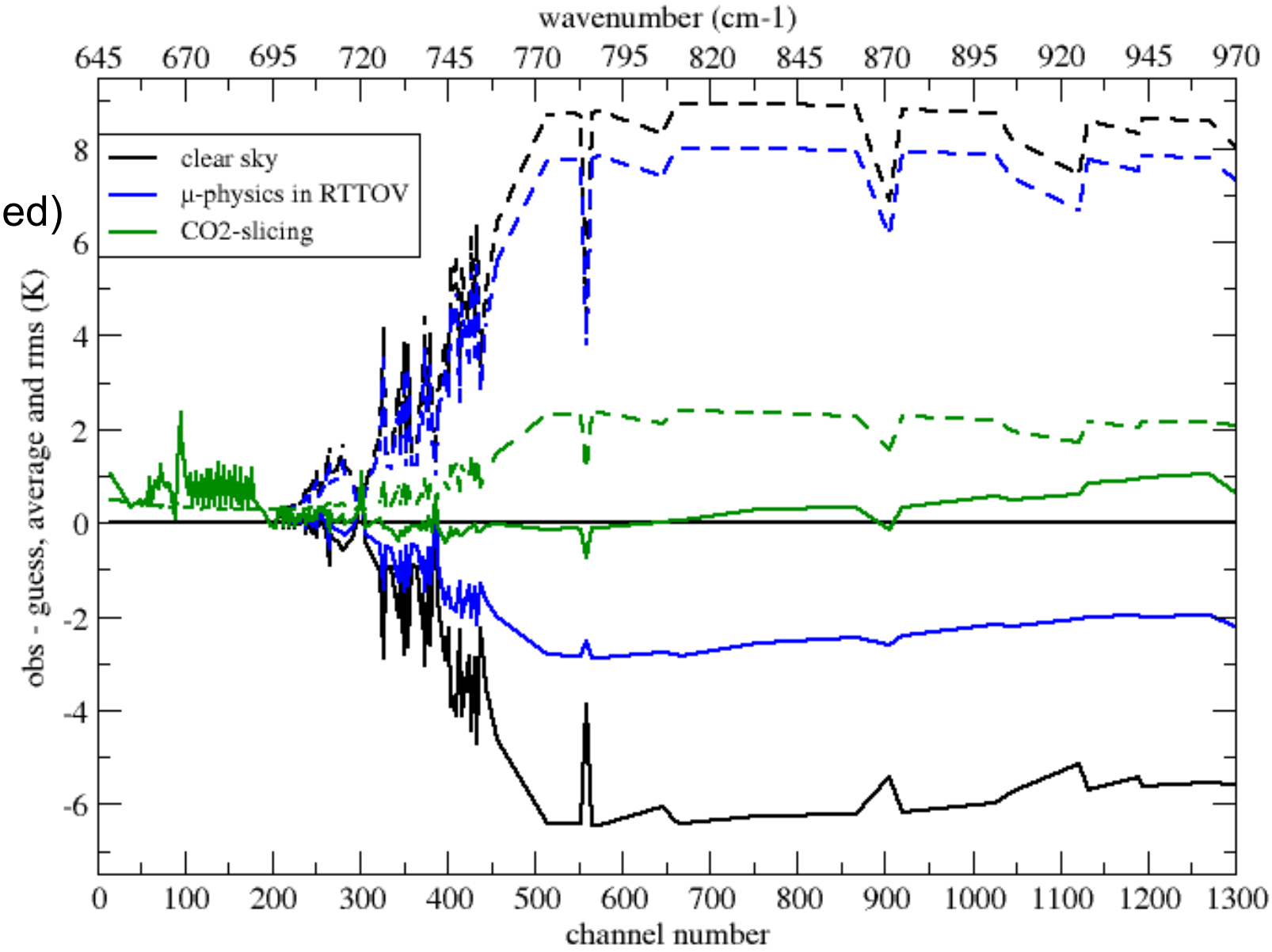
Good agreement between cirrus information
But mid- and low clouds differ in vertical extension and height

Observations & Simulations for IASI channel #0921 (surface)



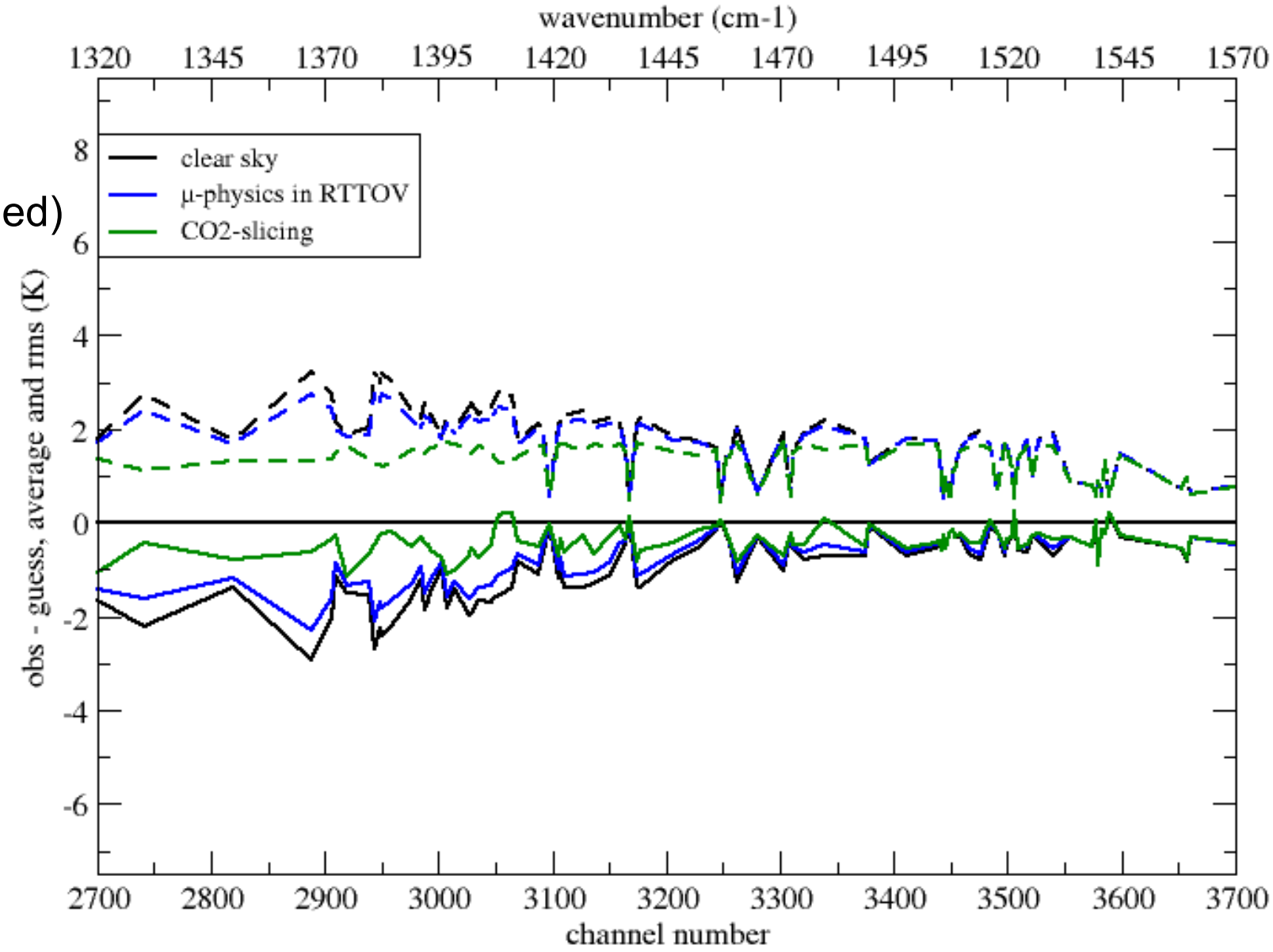
First-guess departures statistics: Long Wave Temperature

Bias (solid)
&
RMS (dashed)



First-guess departures statistics: Water Vapour

Bias (solid)
&
RMS (dashed)



Summary – Near Future

- Cloud characterization as single-layer cloud has proven to be beneficial for AIRS in ARPEGE and AROME in operations
- CO2-slicing for IASI nearly ready and cloud-affected IASI radiances will soon be assimilated in operations
- Similar approach will be studied in AROME for SEVIRI using a cloud characterization done in Météo-France / CMS (Stéphanie Guedj's PhD thesis)

Issues

- Surface temperature and emissivity may not be accurate enough
  --> may "corrupt" cloudy spectra simulations

- Versions of RT model and RT coefficients (and also local tuning of RT model) may have a large impact

- Single-layer cloud approach (CTP retrieved by CO2-slicing eg.) is an easy one but:
  - complex multiple-layer cases exist
  - there is no feedback of the assimilation on cloud water variables

- Horizontal interpolation from model cloud water variable forecasts may be tricky (in forward model, but also in TL and AD)


Thank you for listening !
METEO FRANCE
Toujours un temps d'avance