Assimilation of cloudy radiances in global numerical weather prediction model.

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Overview

- 1. Introduction: in operations
  - 1.a Operational configuration for AIRS and IASI in the global model
  - 1.b Assimilation of AIRS cloudy radiances
- 2. A step further: IASI cloud-affected radiances assimilation
  - 2.a First trials of cloudy radiance assimilation
  - 2.b Cloud parameters retrievals
  - 2.c Simulation of cloudy radiances
- 3.Conclusions and future work

1.a Current operational configuration

IASI operationally assimilated in :

- "long wave" temperature channels are assimilated and water vapour,
- **clear condition** (1 flag/channel, McNally & Watts, 2003):

	operations	Pre-operational
Open sea	**64**	**77** channels
Land	**50**	**59** channels
Sea ice	**32**	**41** channels

AIRS operationally assimilated in :

- "long wave" temperature channels are assimilated,
- Clear and cloudy conditions
- **Over open sea**

	Number of assimilated channels
Clear	**54** channels
Cloudy	**54** channels

1.b Assimilation of AIRS cloudy radiances

- **Method used for the assimilation of AIRS cloudy radiances affected by mid- to low-level clouds**

Cloud parameters determined with CO2slicing (120 channels)

Minimisation of $F_{k,p}$

$$F_{k,p} = \frac{(R^{k}_{clr} - R^{k}_{obs})}{(R^{K_{ref}}_{clr} - R^{K_{ref}}_{obs})} - \frac{(R^{k}_{clr} - R^{k,p}_{cld})}{(R^{K_{ref}}_{clr} - R^{k_{ref},p}_{cld})}$$

Robs: observed radiance
Rclr: clear radiance simulated from the model
Rcld: radiance with opaque cloud at pressure level p
k= channel of the C02 band
Ref= reference channel (surface)
= 917.31 cm-1 (AIRS)

Cloud top pressure:

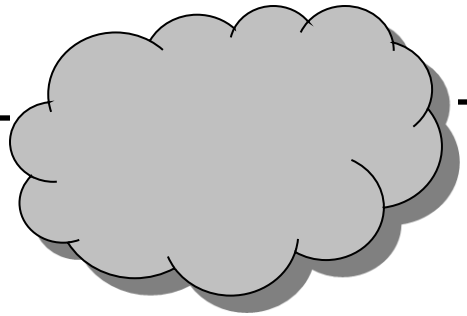
$$p_c = \frac{\sum p_{c,k} w_k^2}{\sum w_k^2}$$

$P_{c,k}$: pressure level minimizing $F_{k,p}$
W_k: derivative of $F_{k,p}$ wrt pressure

Effective cloud emissivity

$$N_\varepsilon = \frac{(R^{k_{ref}}_{clr} - R^{k_{ref}}_{obs})}{R^{k_{ref}}_{clr} - R^{k_{ref}}_{cld}}$$

1.b Method for the assimilation of cloudy radiances



CO2-Slicing

Cloud parameters retrieval (CTP et Ne)

Use of CTP and Ne into RTTOV

Simulation of cloudy radiance

Cloud-Detect

(Mc Nally and Watts, 2003)

Flag cloudy channels

Assimilation of cloudy channels

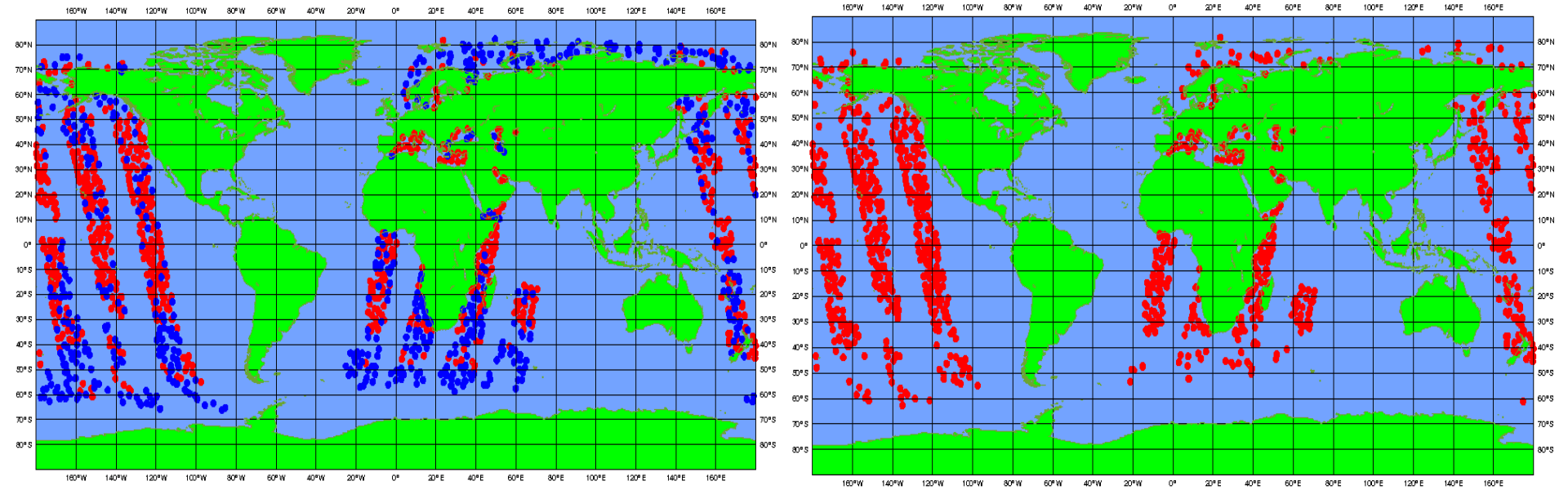
- **600hPa<CTP<950hPa**
- **AIRS: sigma_o(cloudy) = sigma_o(clear) = 1K**

1.b Cloud-affected radiances: Impact

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

EXP: assim clear + cloudy observations

REF: assim clear observations only



Coverage of assimilated observations for channel 239 (478 hPa:mid-troposphere). 01/09/2006 00UTC

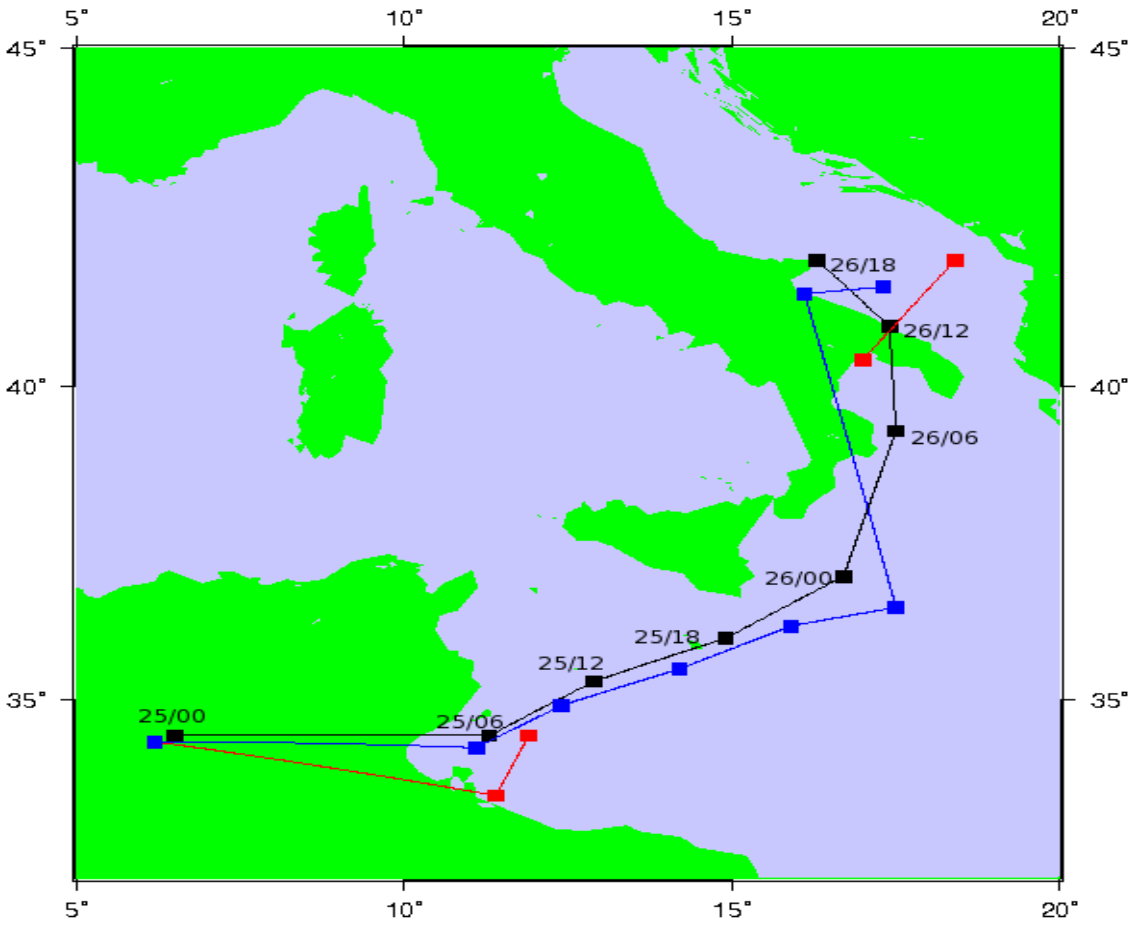
Cloudy obs assimilated

Clear obs assimilated

Small positive impact on forecast scores.

1.b Case study: predictability of the Medicane storm (Pangaud et al, 2009, MWR)

•Medicane: Storm that affected the southeastern part of Italy on the 26th of september 2006.



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

Improvement of :

- **the trajectory of the storm**
- **The intensity**
- **Precipitations**

ECMWF Analyses

EXP (Clear+Cloudy)

REF (Only clear)

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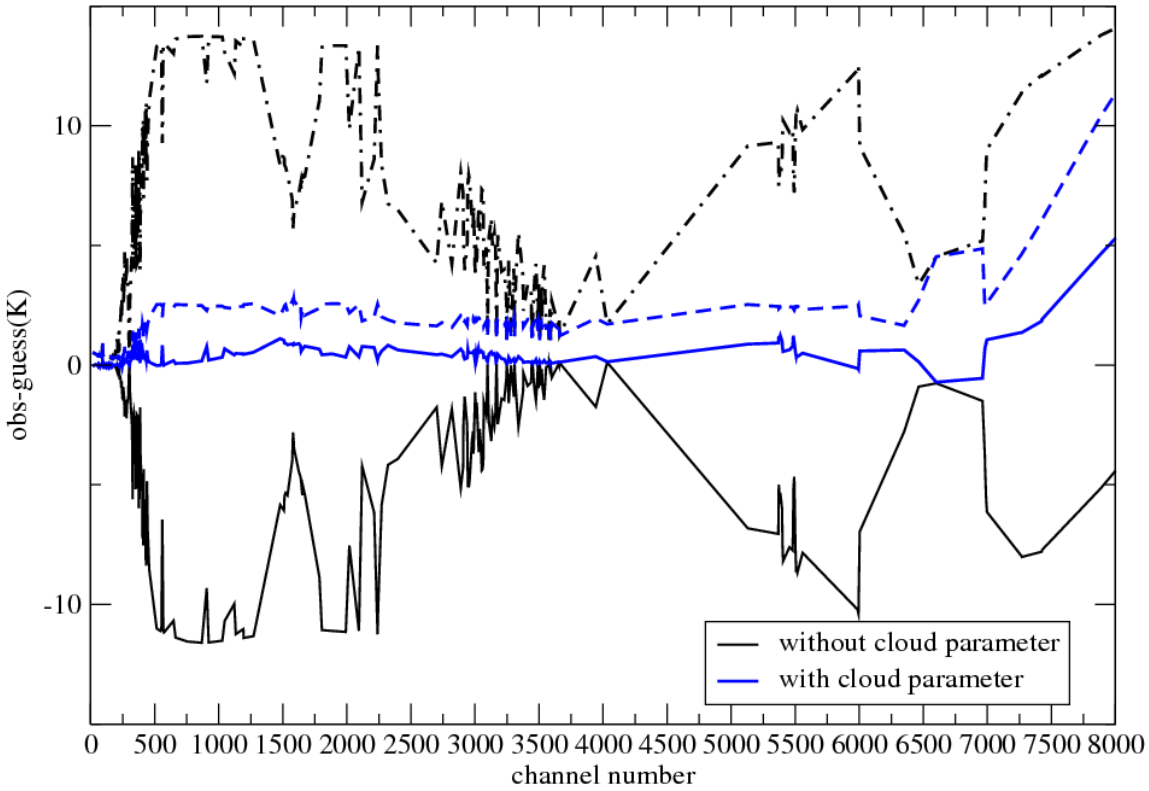
2.IASI cloudy radiances

- Impact of the cloud parameter on the simulation of the IASI observations
- CO2slicing with 34 channels



- Bias and standard deviation of the innovation (obs –simulation) reduced with the cloud parameters.

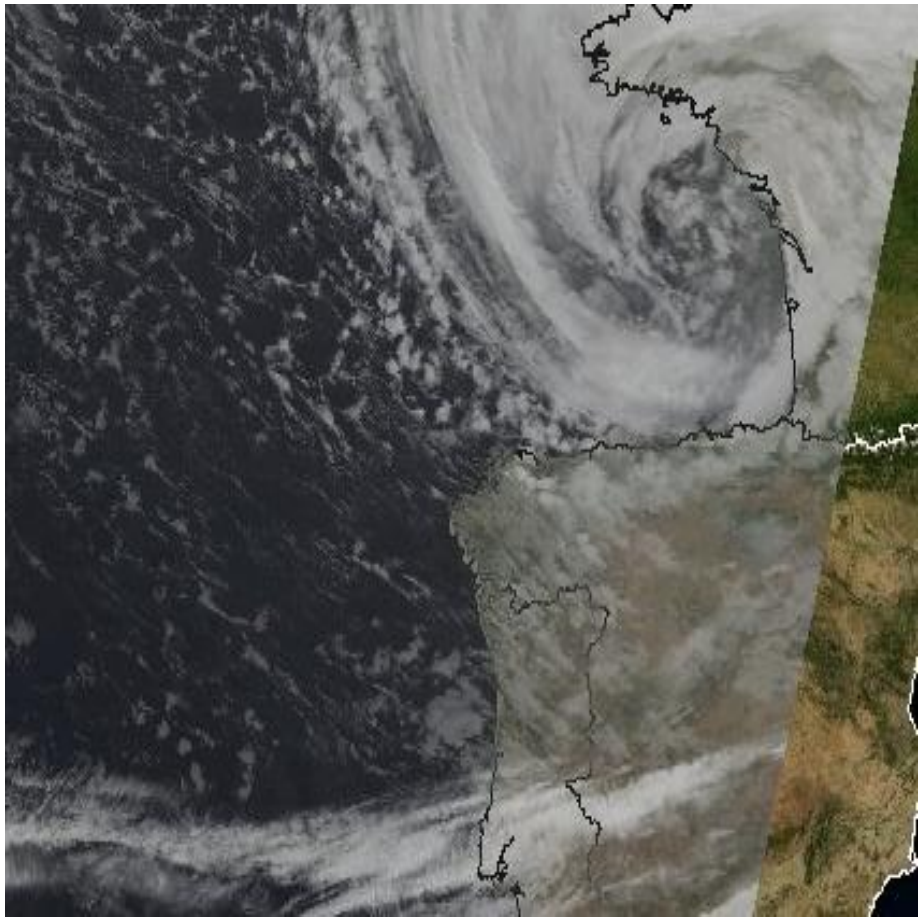
2.a IASI cloudy radiances:Preliminary results
(Pangaud, 2009)

Case study: KLAUS storm

• 22 to 25 January 2009
Most damaging storm in France since 10 years

• **OPER:** all data (including IASI clear radiances and AIRS cloudy radiances)
• **EXP** = OPER + IASI cloudy radiances

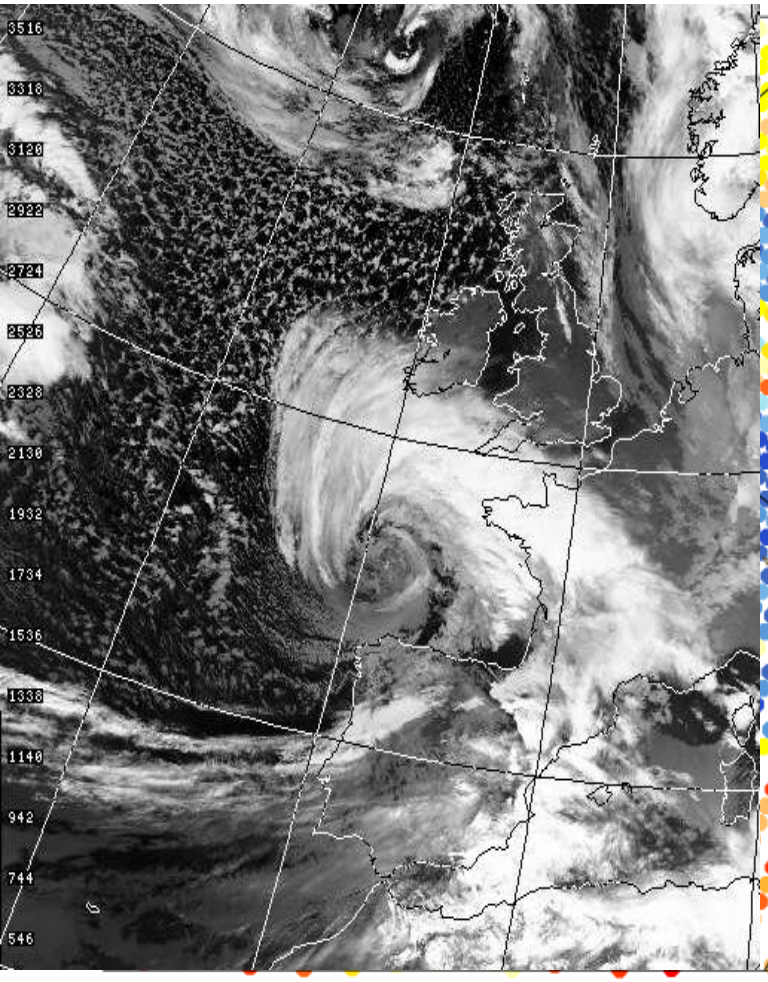
• **Verifying data**: ECMWF analysis
Validity time: 24 january 2009 at 06UTC
Forecast range : 102h (runs from 20 January at 00UTC)

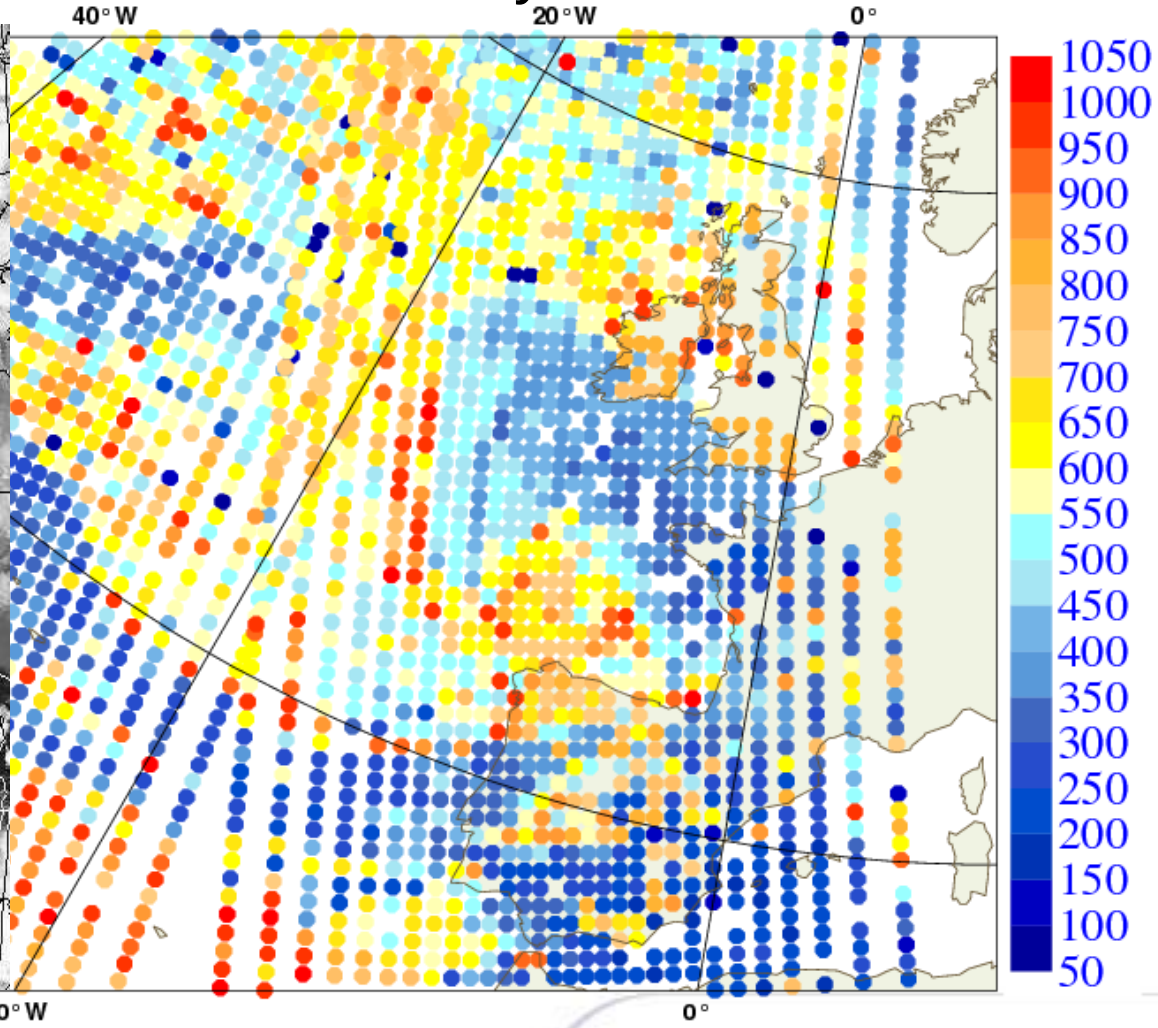


Satellite view from NOAA 18 of Klaus at 3h30UTC the 24th of january 2009

2.a IASI cloudy radiances :Preliminary results

KLAUS: Cloud top pressure for 24 January 2009, 00 UTC





AVHRR channel 5, 23 january 2009
21H41UTC

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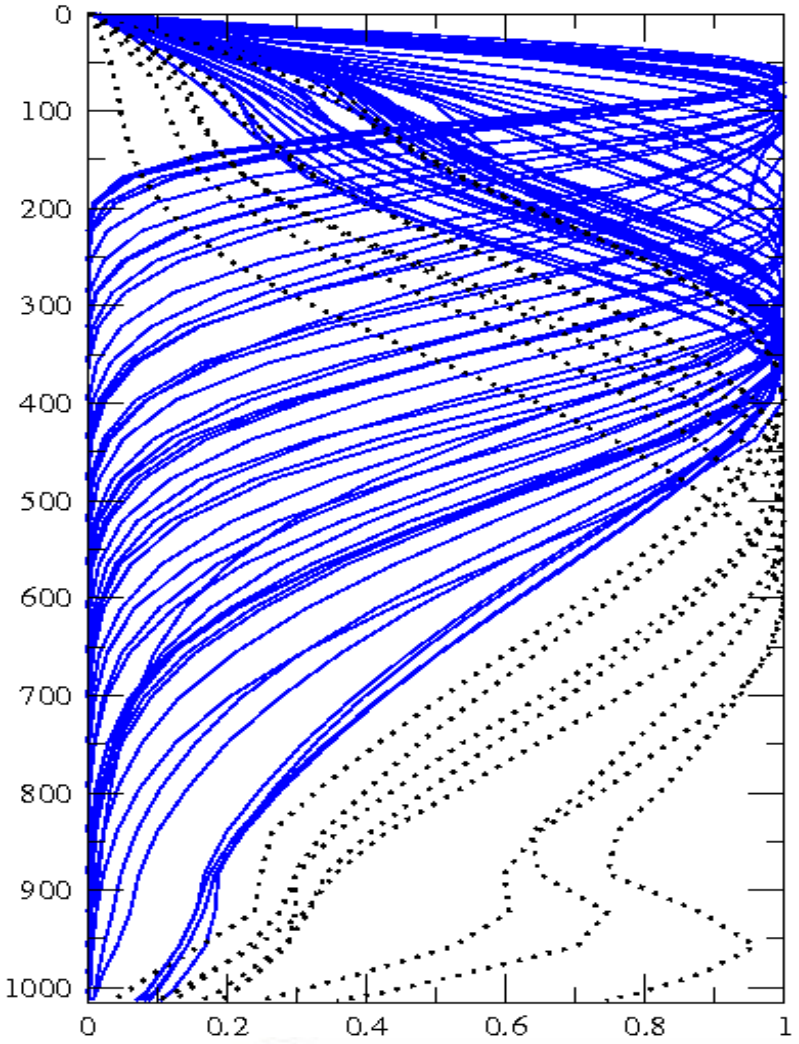
2.a IASI cloudy radiances:Preliminary results

(Pangaud, 2009)

Settings:

- **RTTOV 8**
- **Assimilation only over open sea**
- **Obs error(cloudy) = 1K**
  (obs error(clear) = 0.5K)
- **56 channels used (64 channels used Over open sea – 8 lower channels)**

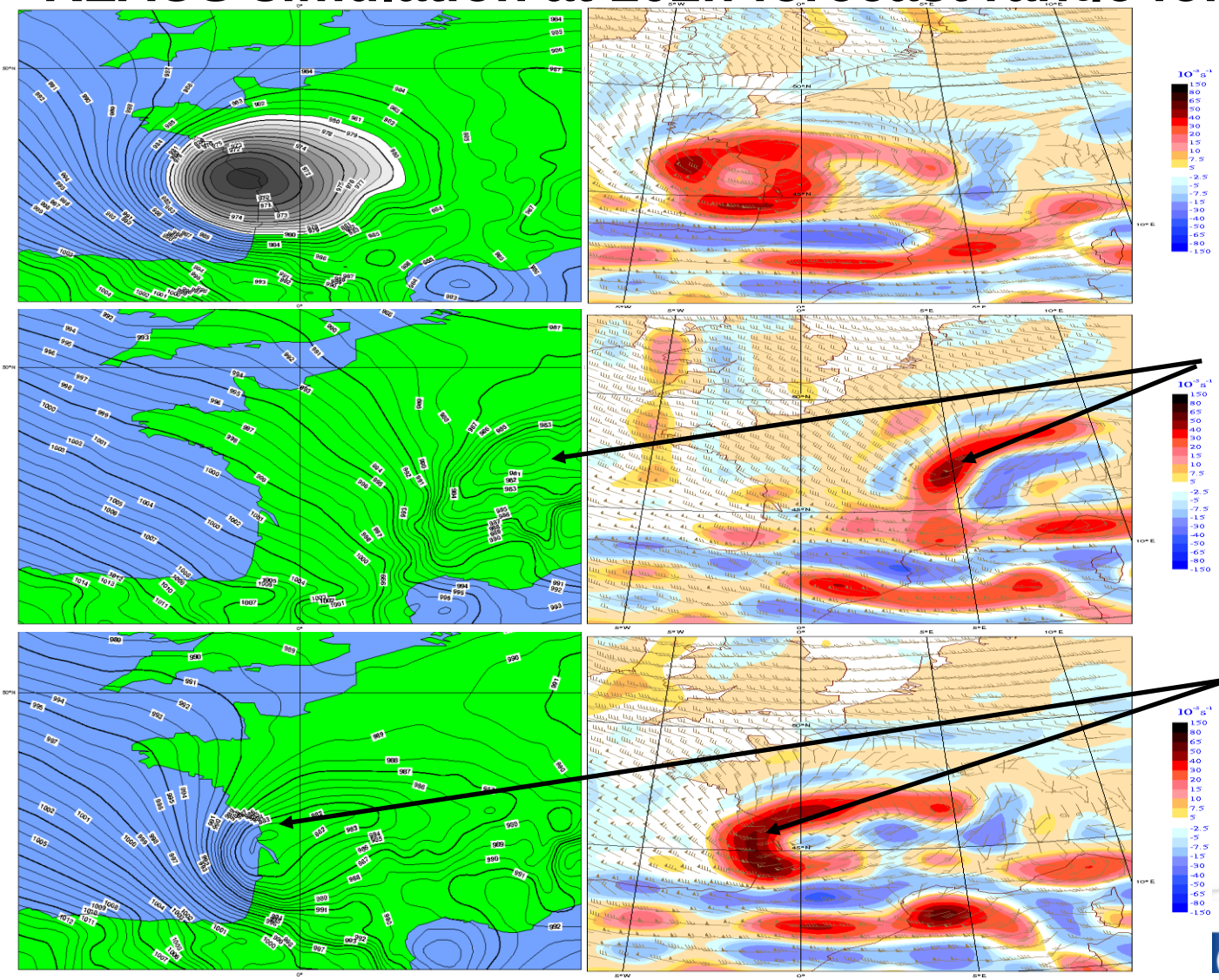
3 week experiment.
Impact on global forecasts:
Mixed impact and not statistically significant



2.IASI cloudy radiances : Preliminary results

(Pangaud, 2009)

KLAUS simulation at 102h forecast range for 24/01/2009 06UTC



ECMWF analysis

REF 102h forecast range

Distance from ECMWF analysis : **630 km**

EXP 102h forecast range

Distance from ECMWF analysis : **50 km**

Atmospheric pression reduced to sea level

Relative vorticity and wind at 850hPa

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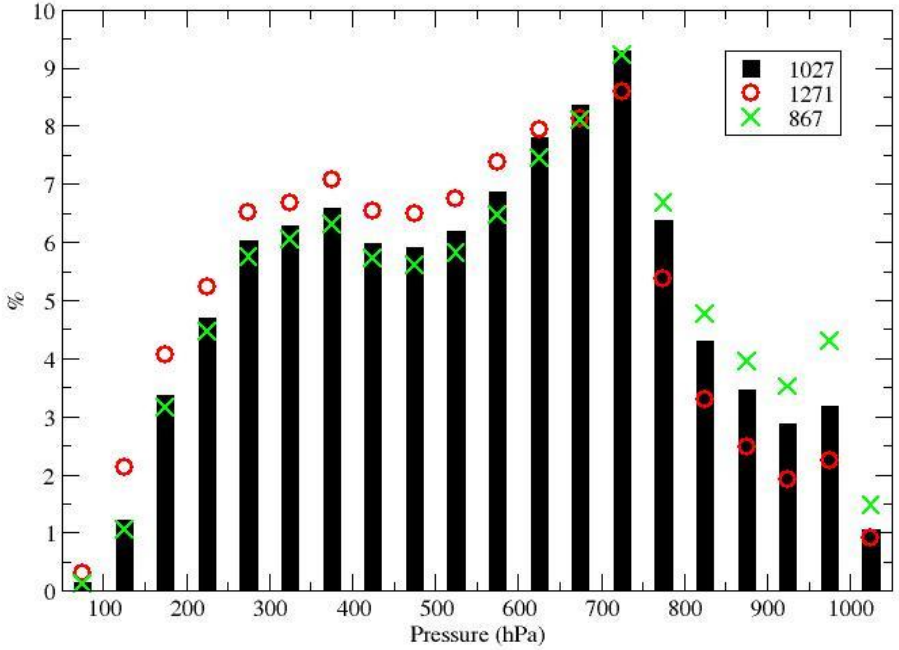
2.b IASI cloudy radiances : evaluation of the cloud parameters

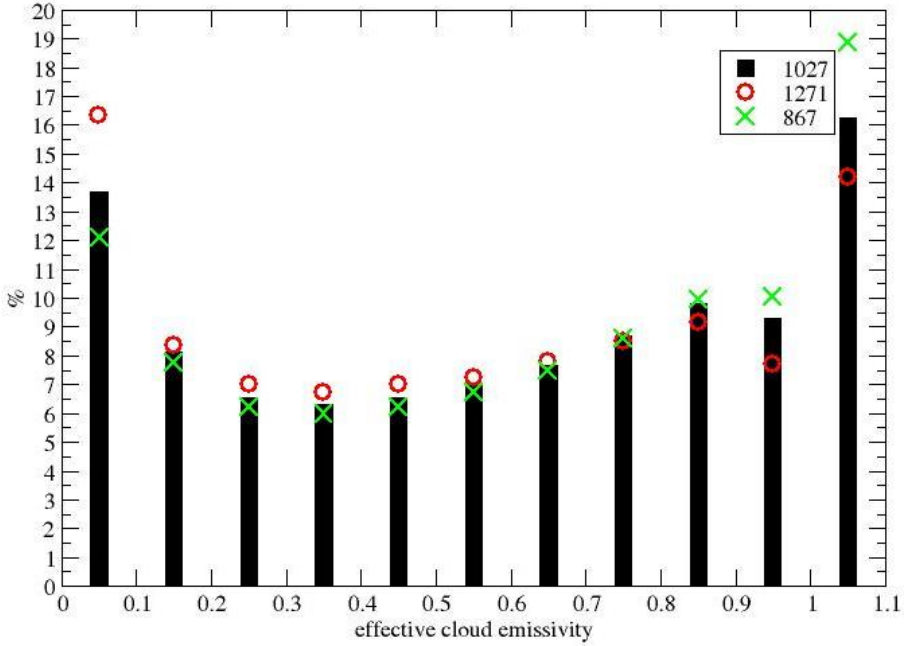
- Validation in current pre-operational configuration: RTTOV version 9, enhanced horizontal and vertical resolution of the global atmospheric model.
- Impact study on the reference channel.

1027 : 901.5cm-1
867 861.5cm-1
1271 963.5cm-1

Cloud top pressure



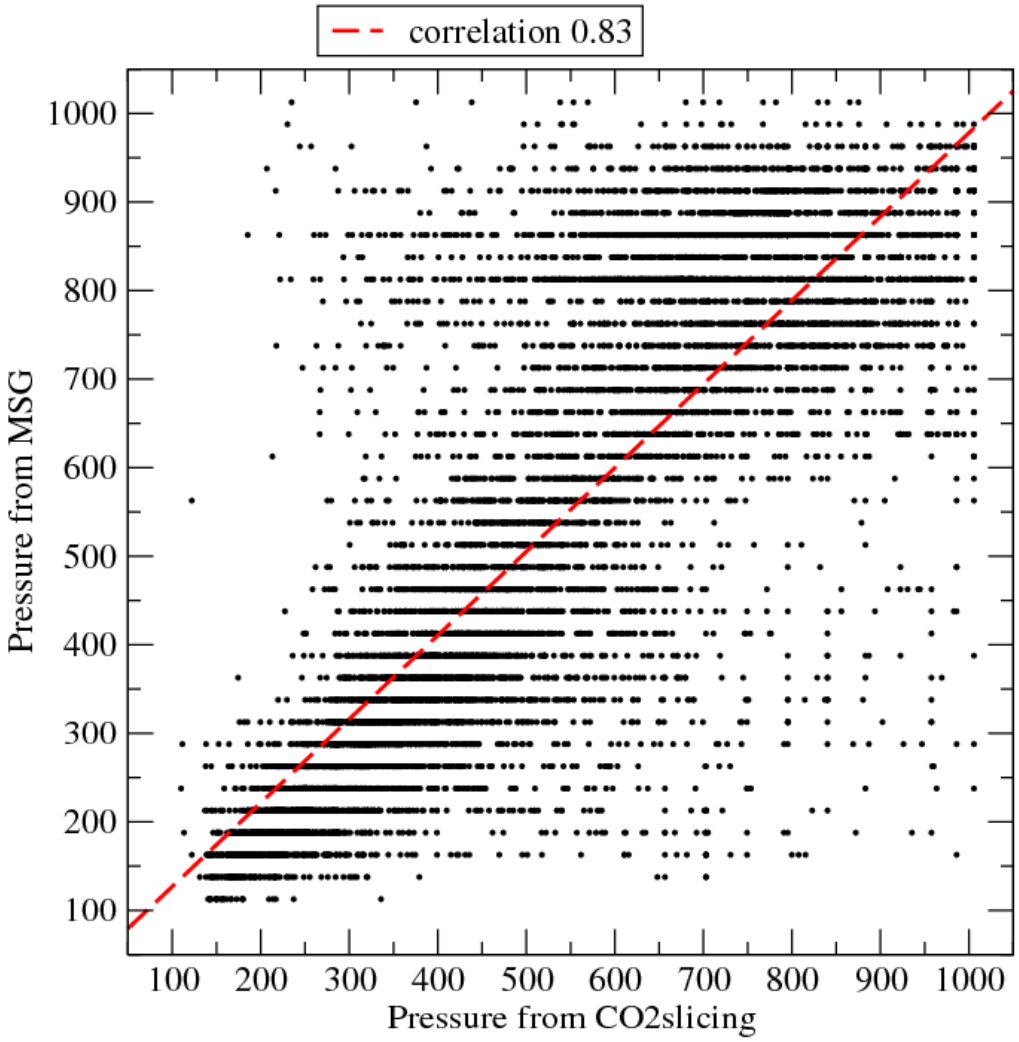
Effective cloud emissivity



29/10/2009-04/11/2009

2.b IASI cloudy radiances: evaluation of the cloud parameters

Preliminary validation against MSG cloud top pressure



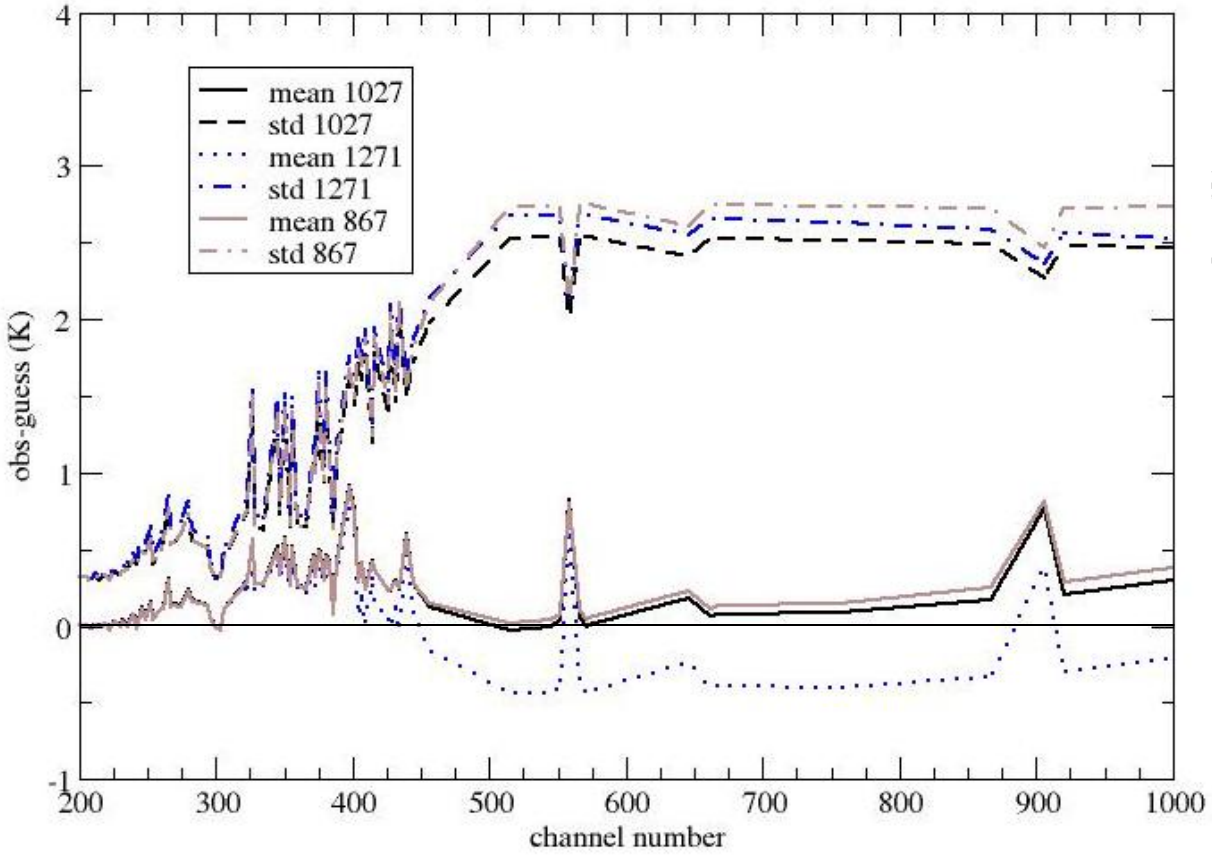
Cloud top pressure from SEVIRI given every 25 hPa

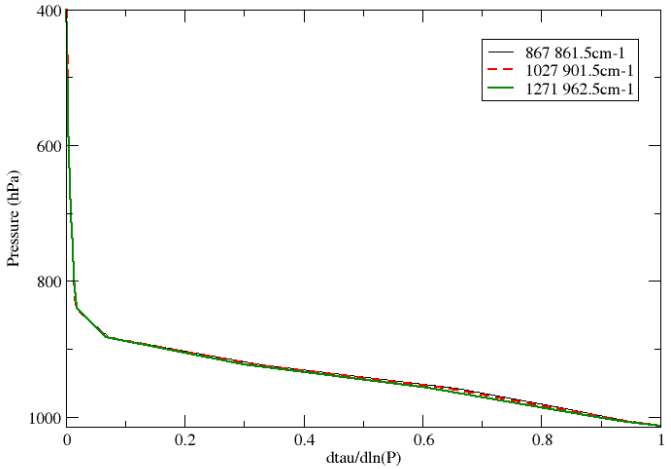
For one day (2009/11/01).

Surface channel	correlation
867 (861.5 cm-1)	0.82
1027 (901.5cm-1)	**0.83**
1271 (962.5cm-1)	0.81

2.c IASI cloudy radiances: impact on the radiance simulation

Statistics for 1/11/2009





Weighting functions of 3 reference channels

Conclusion and future work

- Cloud parameters retrieved with CO2slicing
- Small positive impact of the AIRS cloud-affected radiance assimilation on the forecast skill.

- Same methodology applied for IASI as the one used for AIRS (Pangaud et al, 2009, MWR).
- First results encouraging: simulation of a winter storm with the assimilation of IASI cloud-affected radiances.
- Further validation of the cloud parameter retrieval
  - improve the cloud parameter retrieval by the CO2-Slicing (others set of used channels,choice of the reference surface channel?…)
  - Validation against other sources of cloud parameters (MSG…)
  - Cloud comparison exercice of Lydie Lavanant
  - Investigate the bias correction
- Assimilation of IASI cloud-affected radiances