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

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- Channel selection for cloud parameter
- 1D-Var retrieval
- Impact on a 1D forecast of cloud parameter initialisation

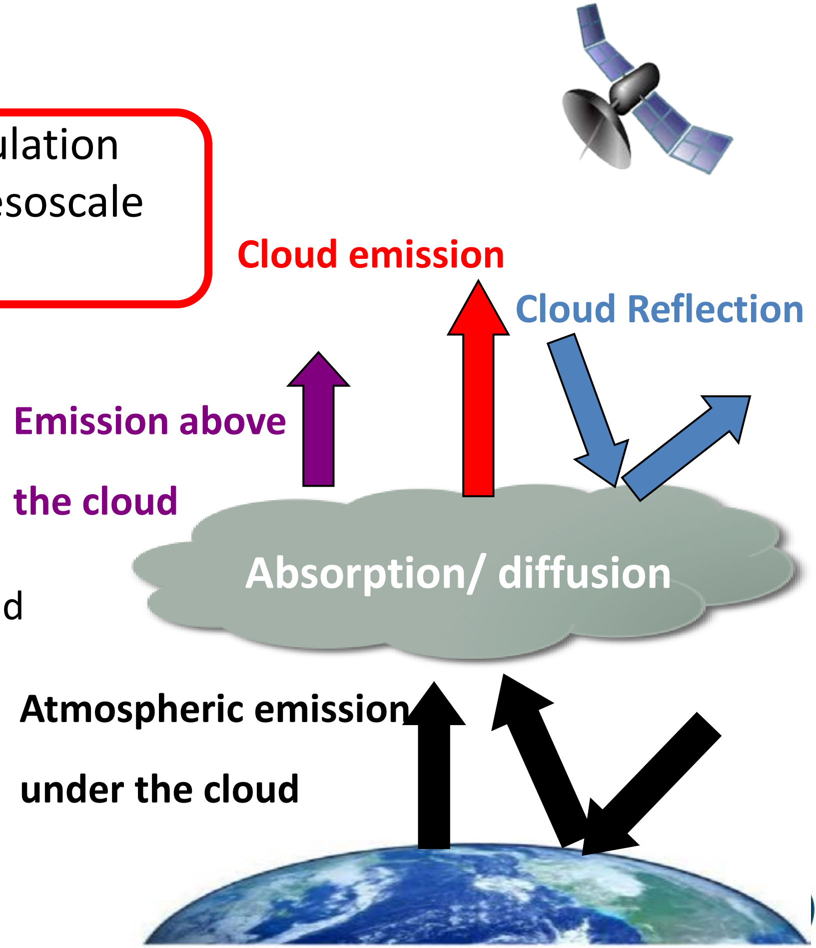
The assimilation of cloudy IR radiances

-**Under-exploitation** of satellite data (only 10 to 15% of the total volume), about **80%** of the data being covered (at least partially) by **clouds**

<u>Currently:</u> Use of two cloud parameters: cloud top pressure (**PTOP**) and effective cloud fraction (**Ne**) for cloudy radiance simulation.

Main goal of this study

Use of cloud **microphysical** variables for a better simulation and assimilation of cloud-affected IASI data in our mesoscale model (2.5 km)



• **RTTOV-CLD:** Mixed phase, multi-layer clouds, cloud scattering (Hocking 2010).

Selected approach

Inclusion of cloud variables (ql, qi, cfrac) in the control vector of the assimilation

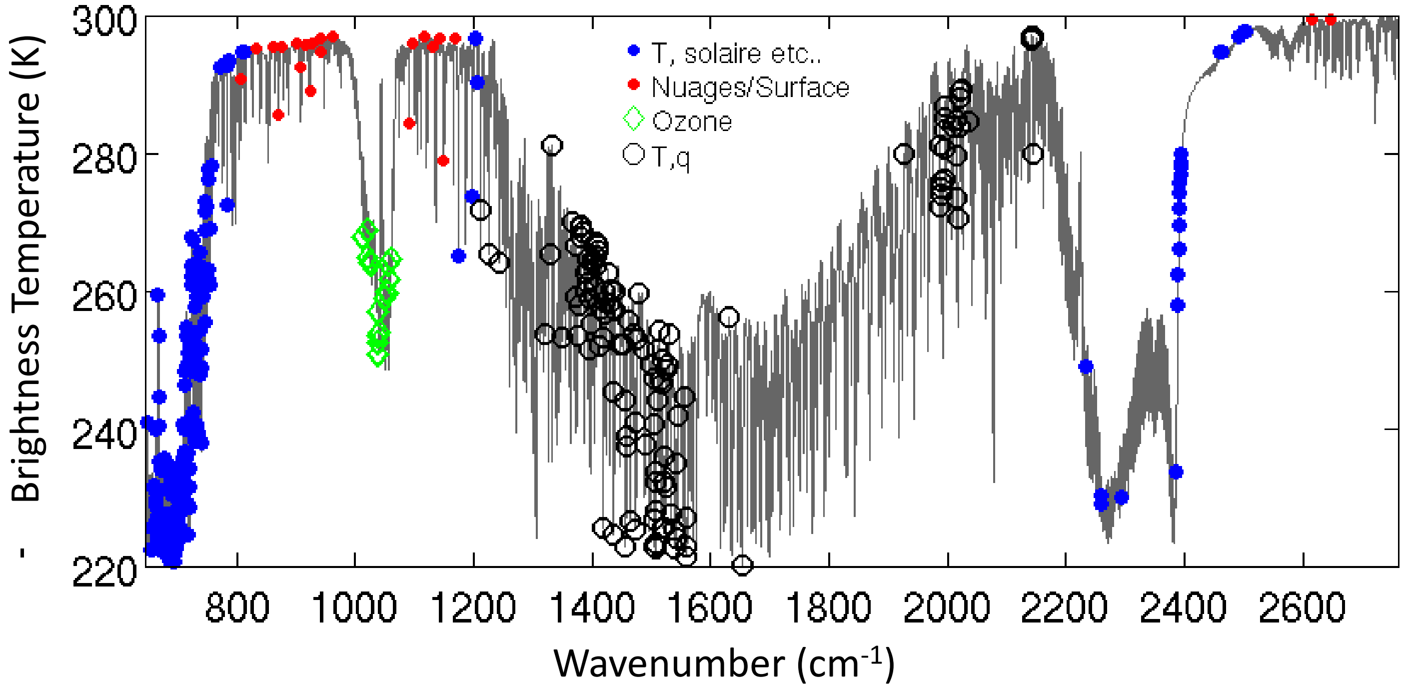
Channel selection for cloud variables

<u>Current status (for clear sky profiles) :</u>

•366 IASI channels were already selected on clear atmospheric profiles at ECMWF (Collard and McNally 2009)

• Channels essentially sensitive to temperature, humidity and ozone.

• Only 20 channels were manually added for their sensitivity to cloud and surface properties.

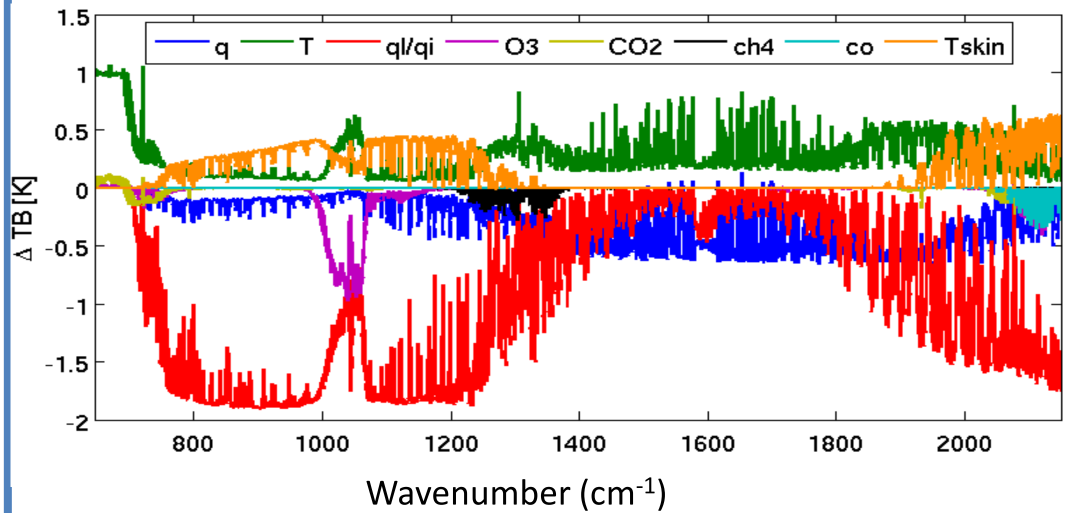


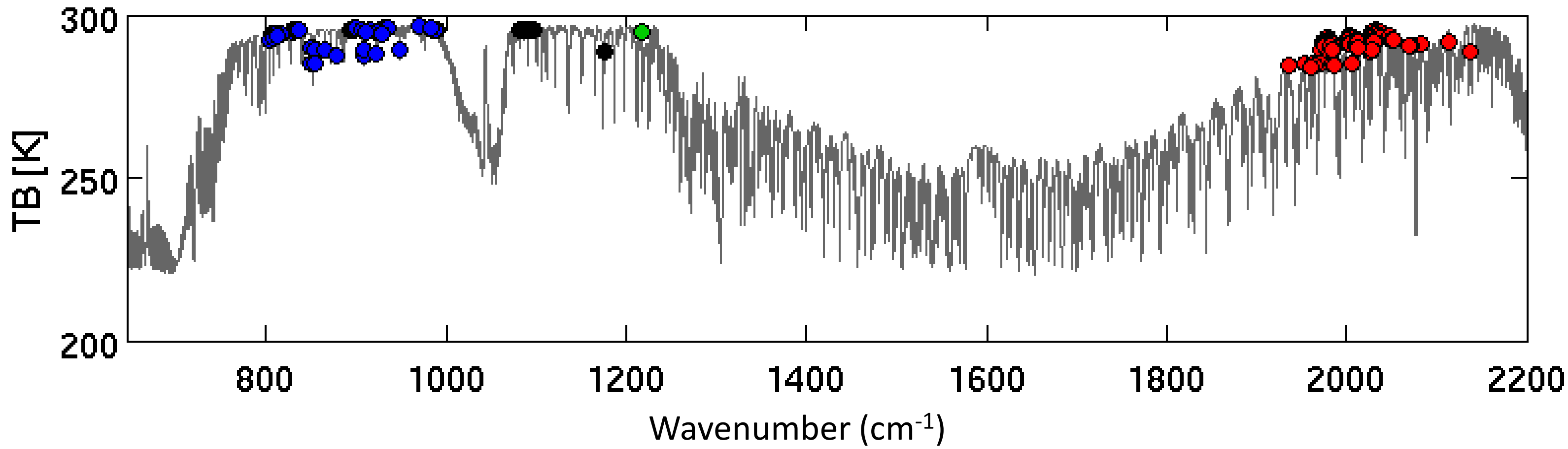
Channel selection for cloud variables

Physically-based channel selection

$$\Delta BT = BT(x+\delta x) - BT(x)$$

- Brightness temperature response to the perturbation of each atmospheric constituent (Gambacorta and Barnet 2012)
- Selection of the channels with the highest sensitivity to ql/qi and the lowest sensitivity to interfering species.
- 134 channels added



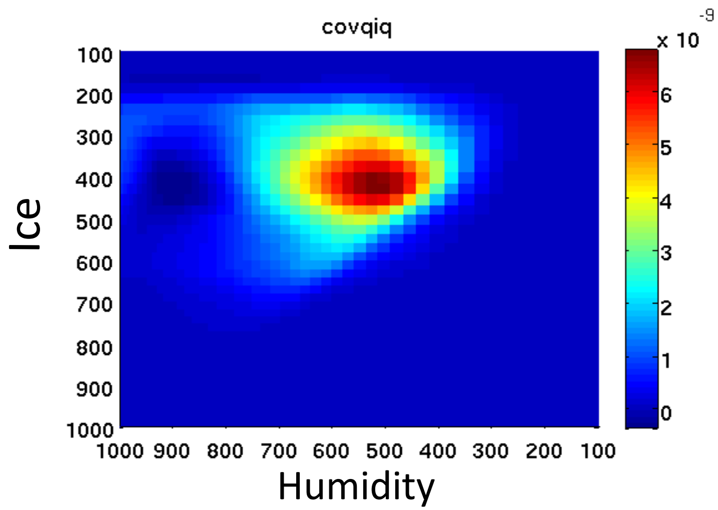


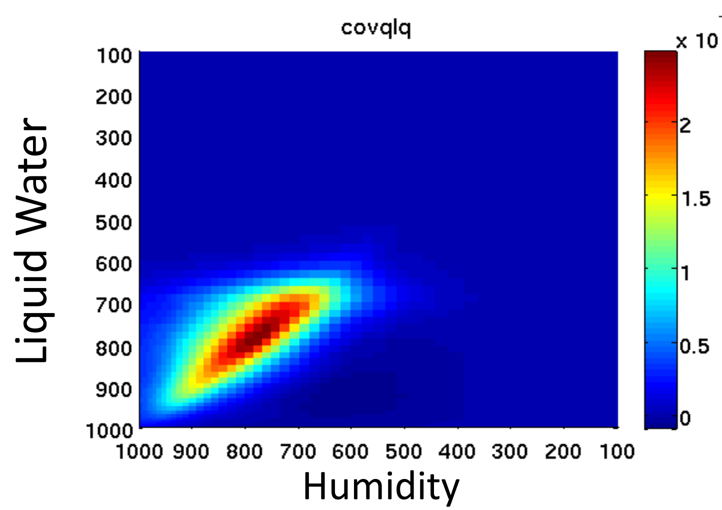
Martinet et al 2014: Evaluation of a revised IASI channel selection for cloudy retrievals with a focus on the Mediterranean basin, QJRMS, in press.

Analysis of cloud variables : B matrix definition

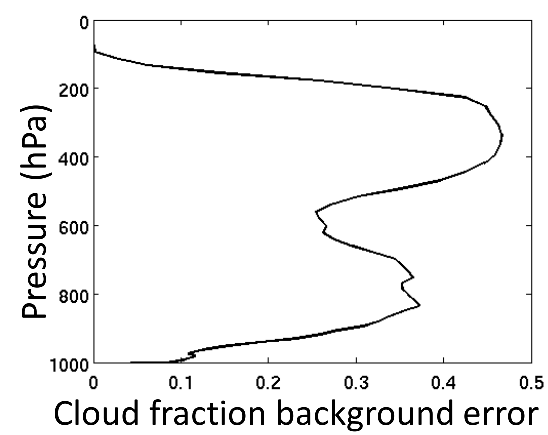
Cloud liquid and ice water contents

- Computed from an AROME ensemble assimilation (Montmerle and Berre 2010, Michel et al 2011) over 18 convective cases observed during July, August and September 2009.
- Use of a geographical cloud mask to separate clear and cloud areas.

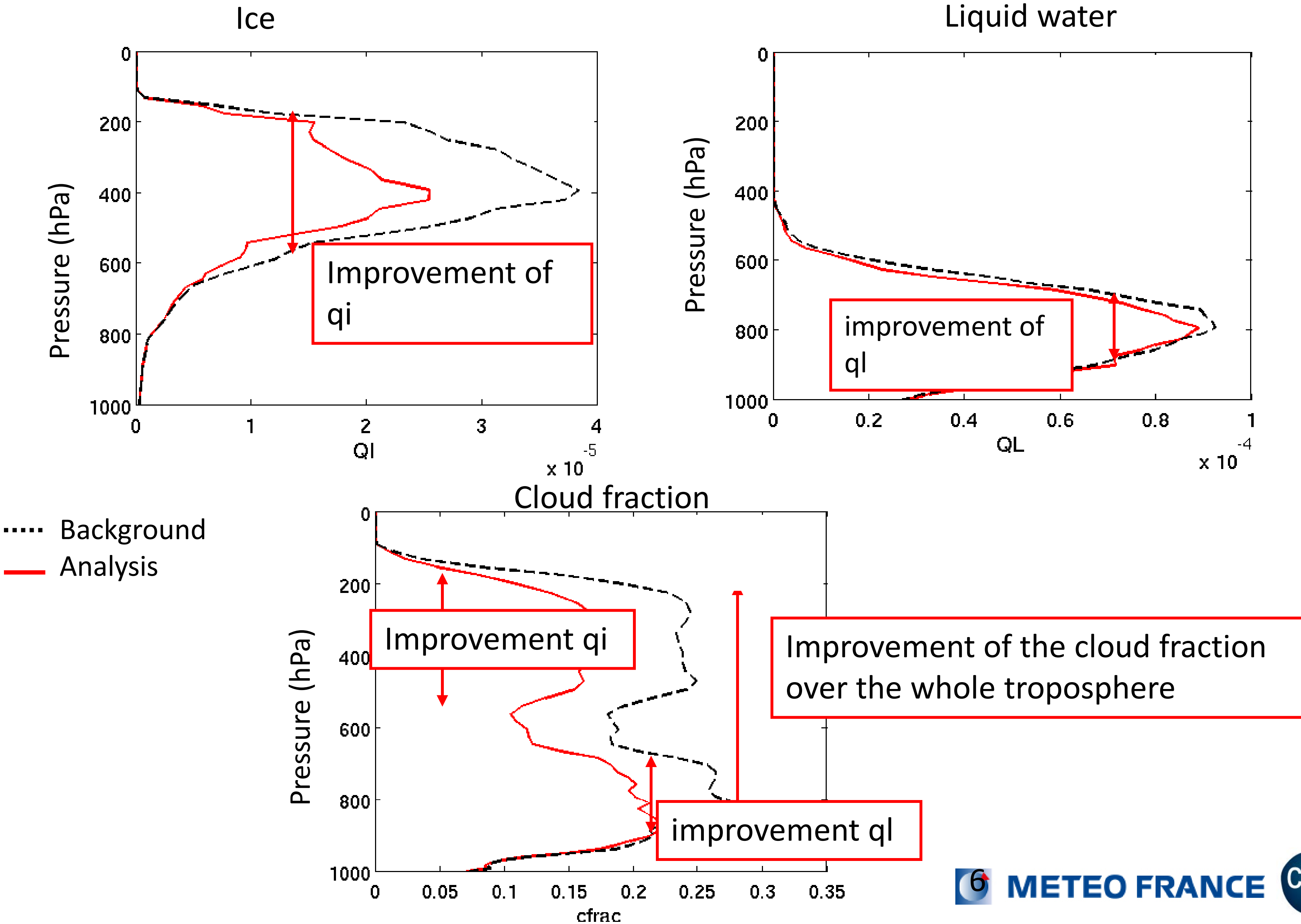




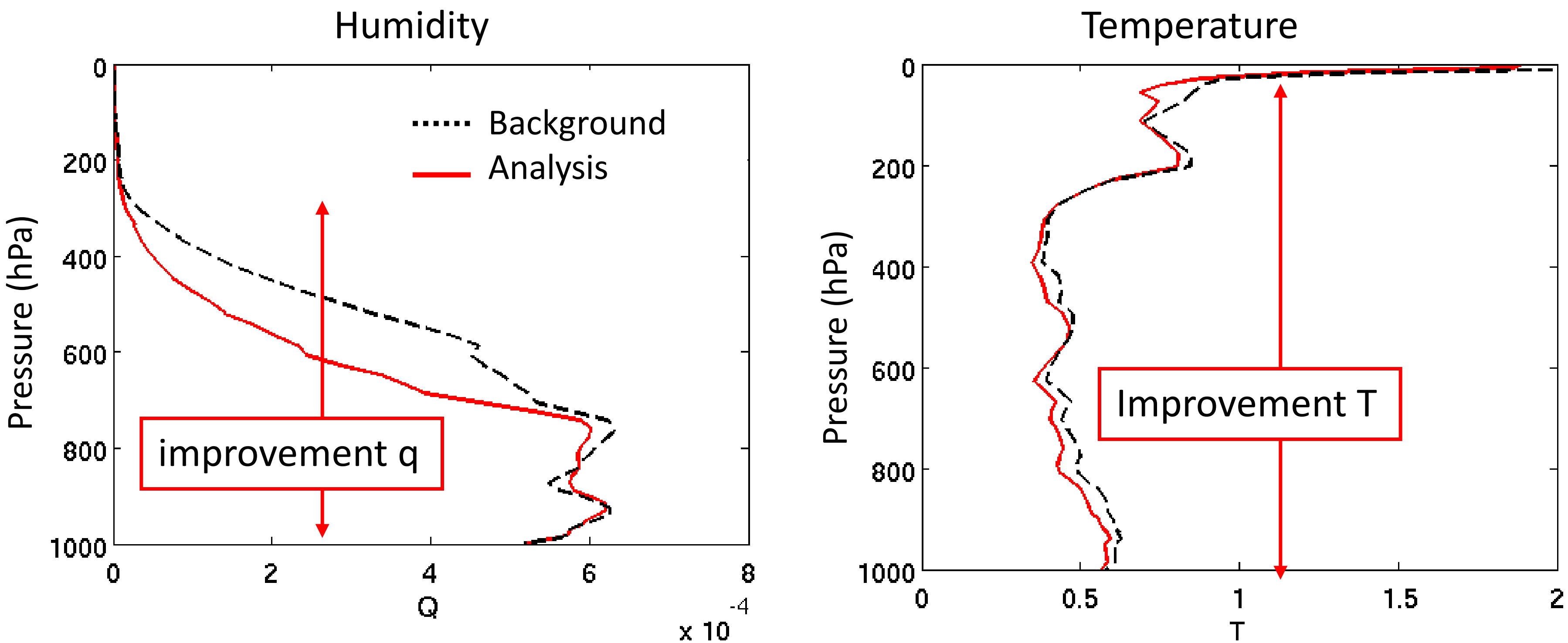
- Cloud fraction.
  - Correlation of 0.1 between cloud fraction and ql/qi.
  - Cloud fraction added to the control variable in the 1D-Var
- 1D-Var assimilation experiment (OSSE)



Results for low clouds: RMSE for cloud parameters



Results for clouds: RMSE for specific humidity and temperature



•Cloudy IASI observations allow to extract information on cloud fraction and cloud parameters.

Adding cloud fraction to the control variable allows to create cloud layers where no cloud were present in the background (not shown).

Martinet, P., Bell W., Pavelin, E. and Eyre, J. (2013), Evaluation of control variables for the assimilation of cloud-affected radiances, NWPSAF-MO-VS-048: http://research.metoffice.gov.uk/research/interproj/nwpsaf/vs.html

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Validation of short-range 1D forecasts in the context of OSSE.

Set-up of the study

xt: 'true' profile → AROME 1D → 3-h forecast « truth »

xb: perturbed profile → AROME 1D → 3-h forecast « background »

xa: analysis → AROME 1D → 3-h forecast « analysis »

-Output every 15 minutes.

-Evolution of the integrated cloud content during 3-hour.

Study of the importance of the initialisation of cloud variables

Forecast error reduction

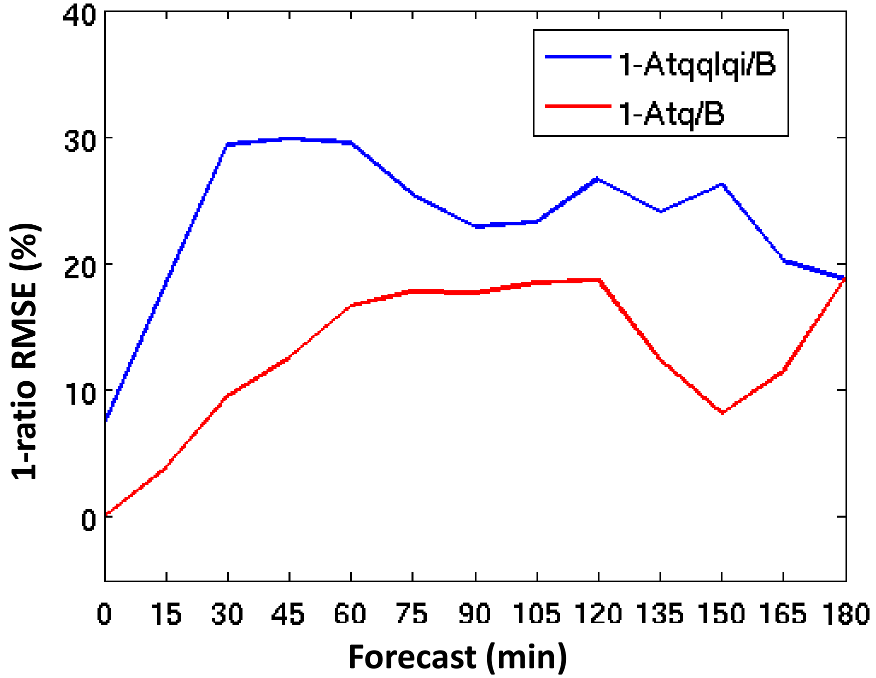
$ER=1- RMSE_{analysis}/ RMSE_{background}$

< 0 → Degradation of the background by the analysis

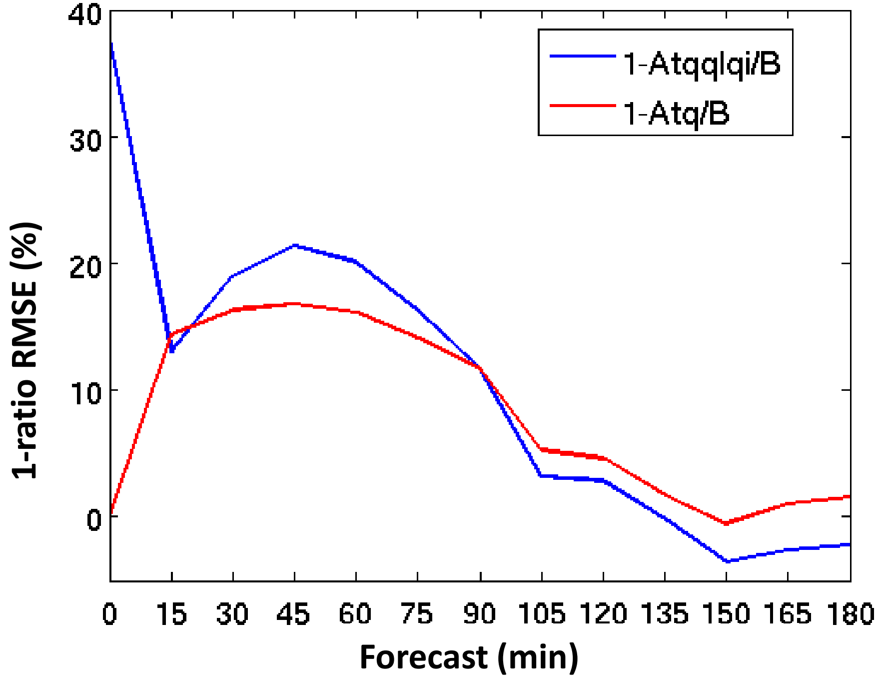
> 0 → Improvement of the background by the analysis

Forecast error reduction: ice water integrated content

qi semi-transparent clouds: 168 cases



qi opaque clouds: 424 cases



- Average forecast error reduction: 20 %.
- Average gain of 10% when ql/qi are initialized.

- Average forecast error reduction: 10 %.
- Average gain of 3% when ql/qi are initialized.

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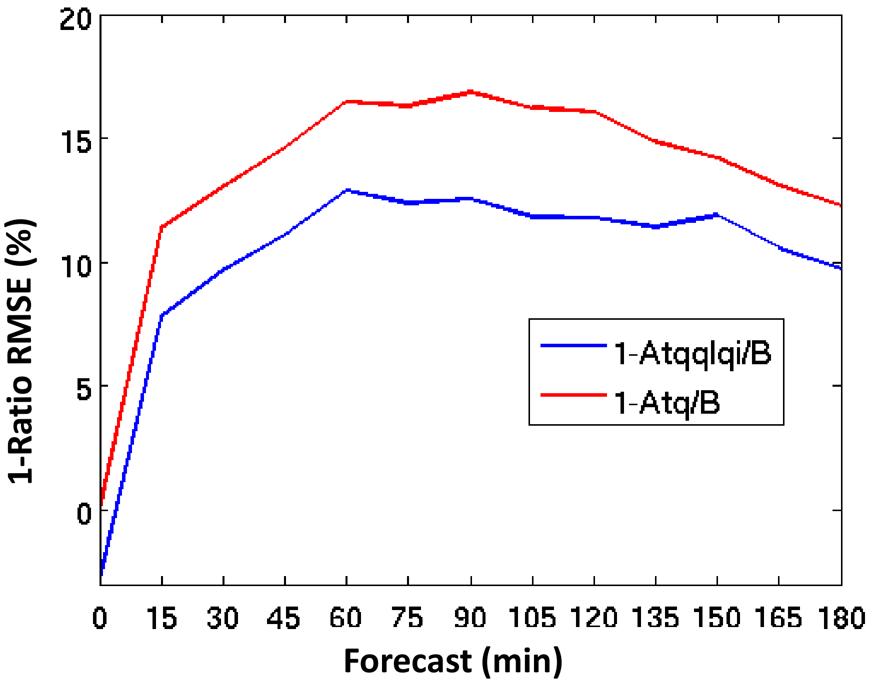
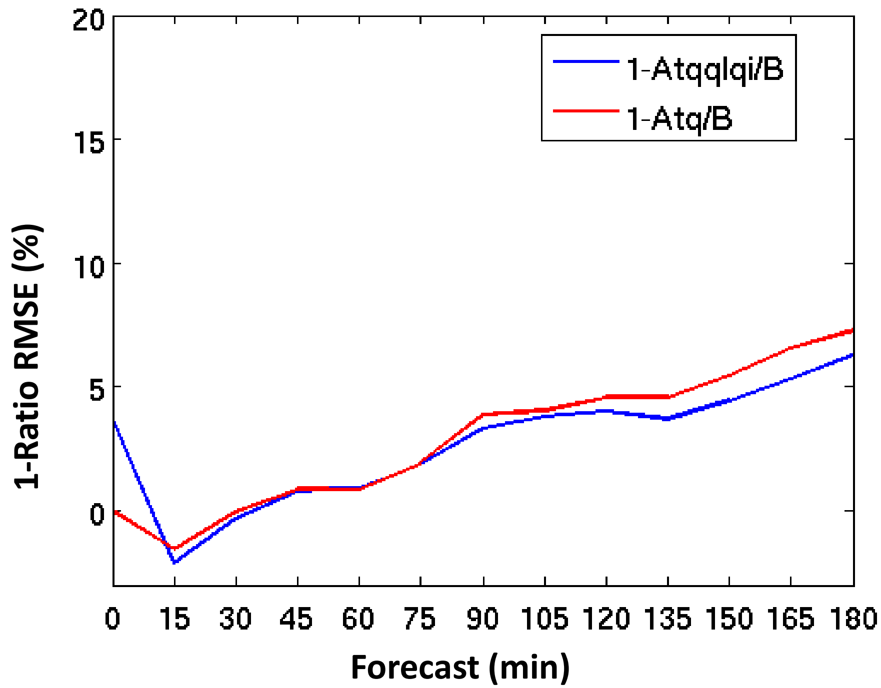
Forecast error reduction: liquid water integrated content

ql semi-transparent clouds: 168 cases



- Average forecast error reduction: 10 %.
- Loss of 3% on the average forecast error reduction when ql/qi are initialized.

ql low clouds: 200 cases



- Average forecast error reduction: 3 %.
- Neutral impact of the initialization of cloud variables.

Conclusions

1D-Var retrievals of cloud variable profiles from IASI radiances.

- Liquid water content, ice water content and cloud fraction have been included in the control vector of a 1D-Var assimilation
- Dedicated IASI channel selection leading to improved retrievals

Impact of cloudy IASI radiances on short-range 1D forecasts (OSSE)

- Maintenance of cloudy information in a 1D column NWP model during 3 hours
- The liquid water content and ice water content forecast errors are well reduced.
- Initialisation of cloud variables improves the forecast of ice water contents

Towards the AROME 3D-Var

- Need for an extension of the control vector (cloud variables to be added) with associated background error covariance matrices

Synergy with other instruments

- Similar developments for SEVIRI and MTG-IRS

Thanks for your attention!

References

Martinet, P., Fourrié, N., Guidard, V., Rabier, F., Montmerle, T. and Brunel, P. (2013), Towards the use of microphysical variables for the assimilation of cloud-affected infrared radiances. Q.J.R. Meteorol. Soc., 139: 1402–1416

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