Using realistic ozone fields for the assimilation of IASI data

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Introduction

Hyperspectral infrared sensors like IASI onboard Metop polar-orbiting European satellites cover a wide range of the infrared spectrum. Parts of this spectrum is sensitive to ozone. During the assimilation process, a priori profiles of temperature, humidity, etc. are mandatory, including ozone profiles. In Météo-France operational system, information on ozone within the numerical weather prediction (NWP) process is a climatological profile, constant in space and in time, coming from RTTOV learning data base (hereafter named **RTTOV**). Other sources of information on ozone are available :

- a climatology based on measurements, which has a monthly and latitudinal variation (Fortuin and Langematz, 1995, hereafter **FL95**);
- an ozone field provided by the French Chemistry Transport Model (CTM) **MOCAGE** (Sic et al, 2015).

This study shows the evaluation of these ozone information with respect to in situ measurements. Then, the impact on the simulation of the infrared sensor IASI is assessed. Finally, realistic ozone fields are input into a cycled assimilation.

IASI channel 1585 (1041cm^{-1}) is used in this poster as an example of ozone-sensitive channel (mostly in the upper troposphere).

1. Evaluation of possible ozone profiles

Ozonesondes from the US network (8 stations covering the poles, the Tropics and northern mid-latitudes) have been used to evaluate the three possible sources of information for ozone. Statistics are computed over the month of August 2014 and are presented on Figure 1.
RTTOV ozone is the worst one according to these statistics. MOCAGE seems better that FL95 (standard deviations) but exhibits a peak in differences, which is located around the tropopause (to be further investigated).

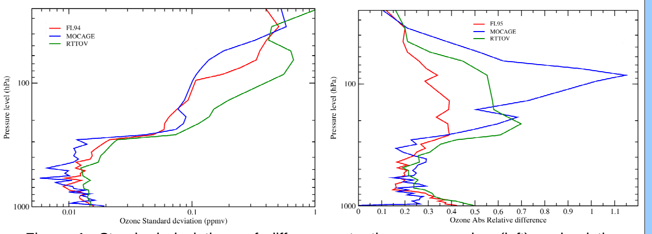

Figure 1. Standard deviations of differences to the ozonesondes (left) and relative absolute differences to the ozonesondes (right) for **RTTOV** (green), **FL95** (red) and **MOCAGE** (blue).

2. Impact on the simulations

The three possible sources of information for ozone have been used in the simulator (RTTOV model) of the French global NWP model ARPEGE. In order to evaluate their accuracy, the simulations are compared to real IASI observations.

An example of a map of differences between observations and simulations is given in Figure 2. Unrealistic large differences exist with RTTOV ozone, which is not the case with FL95 ozone.

Table 1 and Figure 3 present some statistics of the comparison to real observations. As infrared measurement is sensitive to clouds, we will focus on statistics in clear sky condition. FL95 and MOCAGE ozone give similar results, with a slight advantage to FL95.

FL95 has been selected to be used in the assimilation studies.

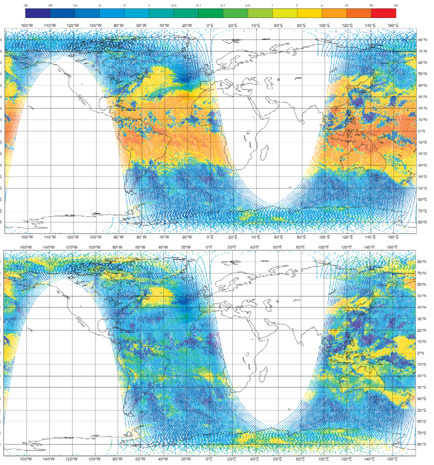

Figure 2. Differences between real observations and simulations for IASI channel 1585 (1041 cm^{-1}), with RTTOV ozone (top) and FL95 ozone (bottom), on the 1st of August 2014 around 00 UTC.

Average / standard deviation	RTTOV	FL95	MOCAGE
All data	-1.32 / 7.1	-3.71 / 5.8	-4.21 / 6.0
Clear data	5.22 / 5.1	-0.08 / 2.2	-0.64 / 2.8

Table 1. Statistics (average / standard deviations in Kelvin) on differences between real observations and simulations for IASI channel 1585, on the 1st of August 2014 00 UTC.

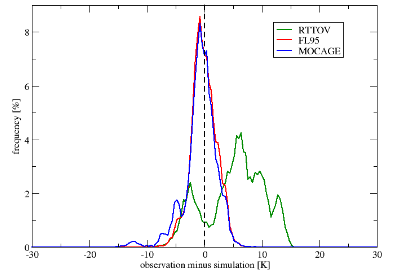

Figure 3. Frequency histogram of differences between real observations and simulations for IASI channel 1585, for clear pixels only, on the 1st of August 2014 00 UTC.

3. Cycled assimilations

Twin assimilation experiments have been carried out over a 1-month period (August 2014). The reference used RTTOV ozone (as for the operations) and the trial used FL95 ozone. Both experiments assimilated the operational set of sensors, including IASI and geostationary infrared sensor SEVIRI. In this setting, only temperature and water vapour infrared channels are assimilated, all ozone sensitive channels are only monitored.
As seen in section 2, innovations have different characteristics. It was important to evaluate the capability of the variational bias correction (VarBC) to take care of it. Figure 4 shows how VarBC adapts in both experiments for IASI channel 1585: the bias estimation in the FL95 experiment adapts much faster and better than in the reference. The quality of bias corrected innovations is good enough to prepare for an assimilation of ozone sensitive channels.
There is no impact on the analyses and on the fit to other observations.

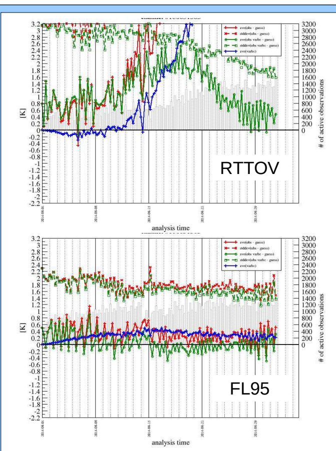

Figure 4. Time series of average (solid) and standard deviation (dashed) of innovations, before bias correction (red) and after (green), and of estimated bias (blue).

Conclusion & Future work

Realistic ozone information, such as the FL95 climatology or the CTM MOCAGE, helps to have much better simulation of ozone-sensive infrared channels. Bias characteristics can easily be properly handled by VarBC with no side-effect on the analysis.

We are now ready to carry out a channel selection among IASI channels sensitive to ozone. We will first focus on 1D-VAR studies and then use the new channel selection in the global model ARPEGE, both for IASI and SEVIRI.
At a longer term, we will evaluate the addition of ozone to the control vector.
Then we will open similar studies with future sensors such as IASI-NG.

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References
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