Forecast sensitivity to observations at Météo-France Application to GPS radio-occultation data

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The 4DVAR system used at METEO-FRANCE processes and assimilates a large amount of satellite and ground based observations. Such a large number of observations needs to be monitored to evaluate their impact on forecast skill. In order to improve weather forecasts and assimilations, the capability to compute the forecast sensitivity to observations has been implemented at Météo-France. This technique (Langland and Baker, 2004) is now commonly used as a complement to data denial experiments. The code implemented in our global model ARPEGE has been developed at ECMWF by C. Cardinali and M. Fisher.

To compute the observation impact, we define a cost function J representing the forecast error. Here, J is the three dimension integrated dry total energy of the difference between the 24 hour forecast and a reference state (e. g. verifying analysis) computed over the globe. The forecast sensitivity to observations calculation requires the adjoint of the forecast model and the assimilation system. In practice, the linear estimate of the forecast impact (deltaJ) calls for a second order approximation (Errico, 2007). It is then computed using both trajectories from analysis and background as shown in Fig.1.

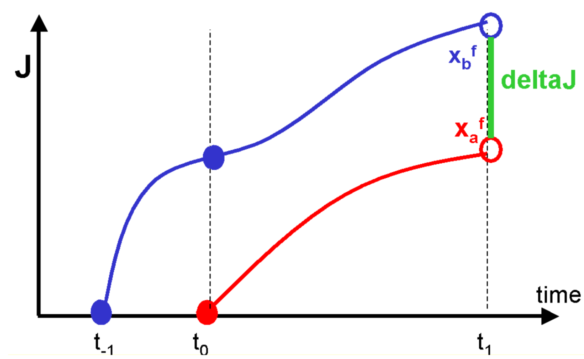

Fig. 1: schematic diagram showing 2 trajectories from background (blue), and analysis (red). deltaJ appears in green.

A forecast impact experiment has been conducted over the period going from December 2010 to mid January 2011. Fig.2a shows the results for observations assimilated in ARPEGE parted by observation group. AMSU-A and IASI have the biggest impact on the forecast error reduction. Computation of the impact of the different channels of IASI shows that the nine water vapour channels reduce the forecast error. Among the other ones, the biggest impact comes from Temperature channel pointing the UTLS. As far as AMSU-A is concerned, channel 7 and 8 in the upper troposphere and channel 13 at the highest level have the biggest influence on the forecast error reduction. These two instruments also bring most observations. If we consider a single source of observation (Fig. 2b), ground observations from buoy and radiosondes are the more informative. Concerning individual satellite observation, the biggest impact comes from Atmospheric Motion Vectors and GPS radio-occultation data.

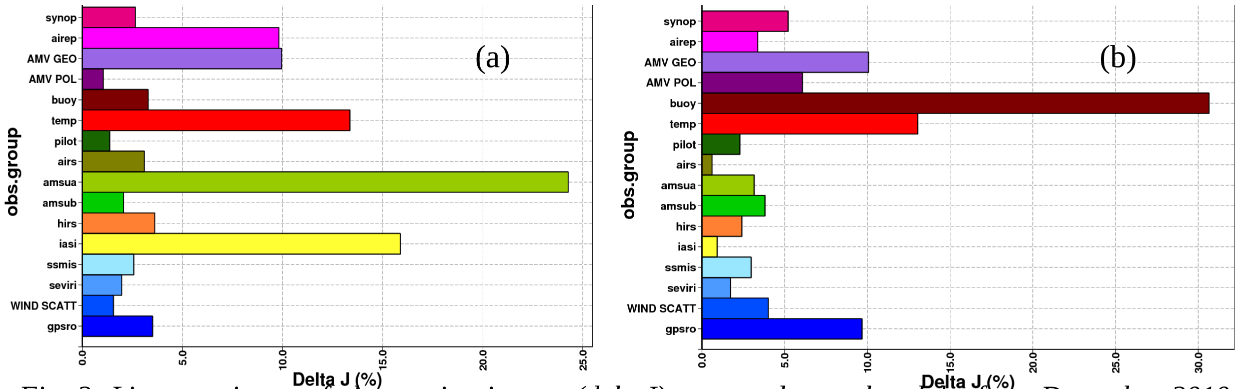

Fig. 2: Linear estimate of observation impact (deltaJ) averaged over the globe from December 2010 to January 2011.(a) separated by observation group and (b) divided by observation number

GPS RO data are assimilated in the global 4DVAR since September 2007. Bending angles are assimilated using 1D operator from GRAS-SAF. Data used in this experiment come from GRACE-A, FORMOSAT-3/COSMIC constellation and GRAS on Metop. Rising and setting occultations are used up to 36 km. A vertical thinning is operated to keep one datum per model vertical layer. These data have a good global coverage but their impact strongly depends on the altitude as shown in Fig.6a. The biggest impact is located in the UTLS and also at the highest assimilated levels. A bad impact is also noticeable at 29 km and 35 km high. Fig.6b show the impact on a grided map of data between 33 and 35 km. Even though the global impact is good, it is unevenly distributed at this height. The good values in the Northern hemisphere compensate for the bad ones over the tropics. This unevenness needs more investigation to know whether it comes from the model, J calculation, the weather regime or anything else.

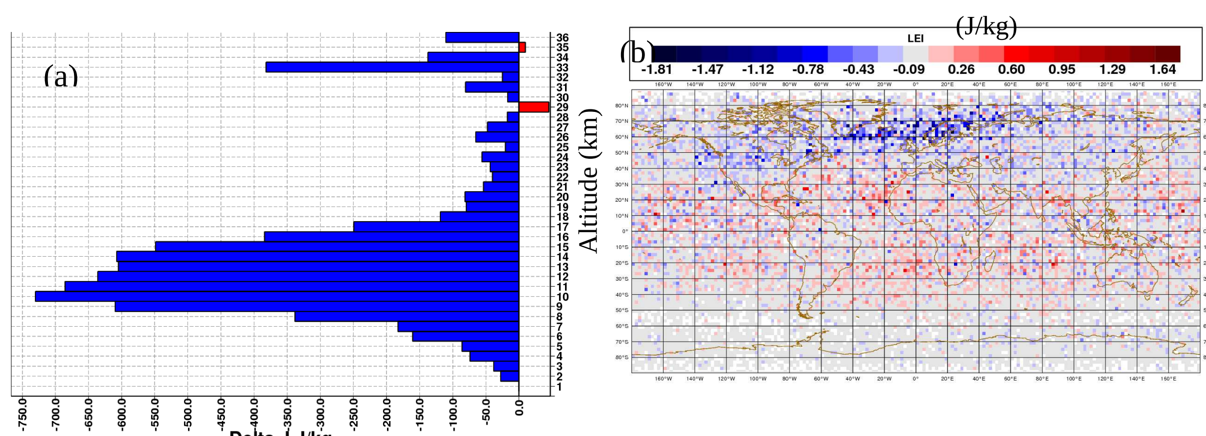

Fig. 3: Impact in J/kg of GPS radio-occultation data averaged over the globe (same period as Fig. 2.) (a) depending on altitude in km and (b) 2°x2° grided averaged values between 33 and 35 km high.

Accounting for the approximation made, the linear estimate can only be used to compute observation impact on a short range forecast, such as 24 hours and must be further investigated, using classical OSEs or on other periods for example.

References:

Errico RM. 2007: Interpretations of an adjoint-derived observational impact measure. *Tellus* **59A**:273-273

Langland RH, Baker NL. 2004: Estimation of observation impact using the NRL atmospheric variational data assimilation adjoint system.*Tellus* **56A:**189-201