Evolution of Météo-France global ensemble data assimilation and high resolution regional experimentation of ensemble assimilation

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Since July 2008, a global variational ensemble assimilation system is run operationally at Météo-France with the ARPEGE system. This enables flow-dependent forecast error variances to be produced for the data assimilation system. This ensemble assimilation system is also used to initialize operational ensemble forecasts. However, the evolution of ensemble perturbations relies currently on a perfect model assumption, and resulting error variances are increased a posteriori, to account for contribution of model error to variances.
Studies are being conducted to estimate and represent model error contributions to the perturbation evolution more accurately. Departures between forecasts and observations, which provide total forecast error estimates (sum of evolved initial uncertainties and of model errors), are compared to the evolved ensemble assimilation spread (corresponding to forecast errors due to initial uncertainties). This comparison allows model error variances to be estimated objectively. This information is then used to amplify perturbations after each forecast step (by 10% approximately, every six hours). Compared to the spread obtained when using a perfect model assumption, this inflation technique allows the ensemble spread to be increased by a factor 2.
The effective amplification of perturbations is particularly pronounced in low pressure systems (see Figure 1). Moreover, new variance estimates have a positive impact on the forecast quality, in addition of being more consistent with observation-based estimates. This model error representation in the ensemble assimilation system appears to be also beneficial for the ensemble prediction system, due to the increased realism of ensemble spread in particular. It is thus considered to implement this approach operationally in the near future.

Another important area of ongoing research at Météo-France is the experimentation of ensemble variational assimilation with the high resolution regional model AROME (with a 2.5 km resolution). In the operational version of AROME-France, the flow dependence of background error covariances is currently neglected. In order to relax this static approach, geographically averaged covariances can be calculated daily using an AROME ensemble assimilation, which is coupled to the operational ARPEGE ensemble assimilation based on the same principles.
These statistics depend on the meteorological phenomena encountered. Background error variances are smaller in anticyclonic situations, excepted for temperature and humidity in low troposphere, where the uncertainty due to the fog and low cloud events remains important. In convective situations these variances are larger, representing the uncertainty associated to convective phenomena. Spatial correlation differences are illustrated by single observation experiments (Figure 2) : the analysis increment caused by a given departure between observation and background is more (resp. less) extended horizontally (resp. vertically) in an anticyclonic situation than in a convective one. Under the observation location, the impact on the wind field is also different : the cooling increment has a weak influence in the first case, whereas it generates a strong divergent circulation in the second one.
Studies have shown a positive impact of these covariances of the day on the data assimilation system behaviour and on the forecast quality. These results support the idea to implement an AROME ensemble variational assimilation system operationally.

(a)

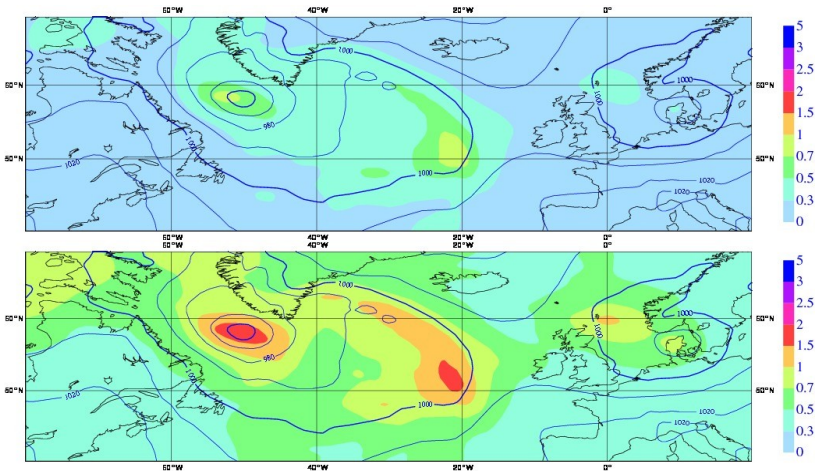

Figure 1 : Amplitude of forecast perturbations for surface pressure (iso-colors, in hPa), derived from the ARPEGE ensemble assimilation system. Top : based on a perfect model assumption. Bottom : including a model error representation in the evolution of perturbations. The mean sea level pressure field is overlaid with blue isolines (iso-contours : 10 hPa).

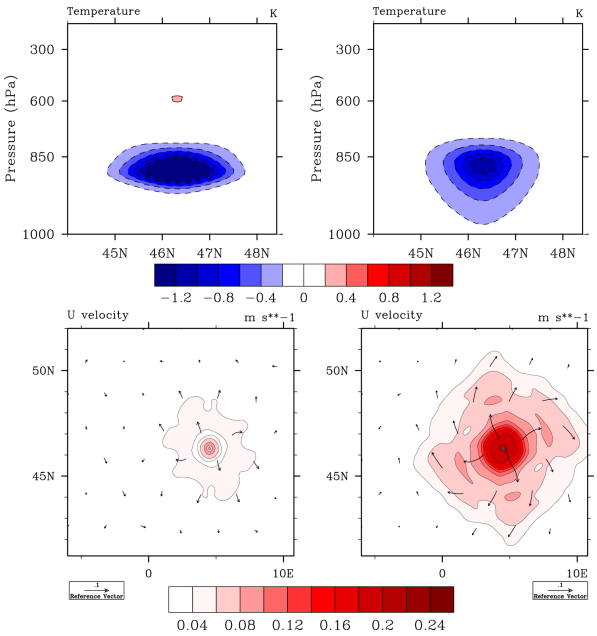

Figure 2 : AROME analysis increment (difference between analysis and background) caused by a given innovation (difference between observation and background) of temperature at 850 hPa using background error covariances calculated for an anticyclonic (left) and a convective (right) situation : vertical cross section of temperature increment (top) and horizontal cross section at 950 hPa of wind increment (bottom).