A Posteriori Diagnostics of the Impact of Observations on the AROME-France Convective-Scale Data-Assimilation System.

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AROME-France is an operational convective-scale Numerical Weather Prediction system that uses a 3D-Var Data Assimilation (DA) scheme in a 3-h continuous assimilation cycle in order to determine its initial conditions at the horizontal resolution of the model (2.5 km). In addition to conventional and satellite observations, regional high-resolution observations are assimilated, such as, screen-level observations, total zenith delays from ground based GPS stations and radar measurements (radial winds and reflectivities).

The impact of the various observation types on AROME-France analyses is assessed using an *a posteriori* diagnostic, the reduction of the estimation error variance. It can be shown that, if observation and background error covariance matrices are well specified in a variational DA system, the analysis error covariance matrix is given by $\mathbf{A} = \mathbf{B} - \mathbf{KHB}$ where **B**, **K** and **H** respectively stand for the assumed background error covariance matrix, the Kalman gain matrix and the linearized observation operator. The total variance reduction provided by the assimilation of the observation $r=\mathrm{Tr}(\mathbf{B})-\mathrm{Tr}(\mathbf{A}) = \mathrm{Tr}(\mathbf{KHB})$ is a measurement of the ability of a DA system to pull the analysis from the background with respect to the observations (Tr stands for the trace of a matrix). A direct estimate of the variance reduction $\mathrm{Tr}(\mathbf{KHB})$ is not possible in practice in an operational variational DA system, since neither **B** nor **K** are explicitly known. Then, the variance reduction which allows one to investigate observation impact depending on the control variable field, model levels, date, analysis time, and spatial scales considered, and the contributions of the different observation types, are estimated in the AROME-France DA system with a randomization method ([1],[2]).

The observations with the largest impact in the AROME-France 3D-Var system are given by aircraft (for temperature and wind fields) and radar (specific humidity and wind fields) observations in the middle and high troposphere, in accordance with the vertical distribution of these observations. Screen-level measurements (2 m temperature, 2 m relative humidity and 10 m wind) are the main contributors at the lowest atmospheric levels. These large impact values are explained by the number of these observations assimilated at each analysis time. On a rainy day, aircraft, radar and screen-level observations account for respectively 22%, 30% and 18% of the total account of assimilated observations. One can note that it is possible to evaluate the impact of an observation of a given physical quantity (resp. at a given model level) on the analyzed field of an other physical quantity (resp. on other levels) through the **B** matrix cross- (resp. vertical) correlations. The total variance and the different observation contributions are also evaluated depending on the spatial scale of the analyzed fields: most of variance reduction concerns length scales above 100 km with a maximum around 500-800 km. Only the radar measurements, with an horizontal density of 15 km, contribute to the variance reduction at scales lower than 100 km.

References

[1] Brousseau et al. "A posteriori diagnostics of the impact of observations on the AROME-France convective-scale data-assimilation system." *Q. J. Roy. Meteor. Soc.*, 2013 *accepted.*

[2] Brousseau et al. "Evaluation of data impact in the mesoscale AROME 3D-Var system at Météo-France". In International Symposium On Data Assimilation, Offenbach, Germany, October 2012 : http://inverseproblems.info/eventsWeb/ISDA2012/talk_6_2_brousseau.pdf