Current data assimilation systems aim at produce the best possible estimate of the atmospheric state to be used as initial conditions by a forecasting model. This estimate is called the model analysis. In the formalism of the Three-Dimensional Variational Data Assimilation (3D-Var), the analysis should minimize a quadratic cost function that measures the distance between the estimate and the available information, namely the observations and the background (which corresponds to a short range forecast), taking into account their respective precisions. Observation error covariances contain information about errors in the observation process (measurement and representativeness uncertainties). Background error covariances are used to filter and propagate the observational information in a spatial multivariate way. They compose the gain matrix that determines how the analysis increments (that is to say, the analysis corrections to the background) are obtained from the innovations (i.e., the differences between observations and background at the observation locations). However, since the true atmospheric state can not be exactly known, background error covariances (in particular) can only be estimated.

Nowadays, Numerical Weather Prediction (NWP) centers often use an off-line specification of background error covariances. This relies on running an ensemble of perturbed assimilation cycles during a past period, to simulate the error evolution during the successive analysis/forecast steps. Moreover, as the full background error covariance matrix is far too large to be handled explicitly, sparse covariance models are usually employed, and they are calibrated by using ensemble forecast perturbations. These sparse covariance models are often based on simplifications such as horizontal homogeneity and temporal stationarity. This is the case of the ALADIN/France regional system which has been used in this study.

A diagnostic study of actual temporal variations in background error covariances is carried out in the first experimental part of the manuscript. It is shown that seasonal variations are relatively large, with larger variances in the considered summer period than in the winter period, and also sharper horizontal correlations and broader vertical correlations. Daily variations are examined as well, and the contrast between anticyclonic and cyclonic situations is illustrated in particular, reflecting the influence of atmospheric instabilities. Diurnal variations are also found to be particularly significant in summer in the boundary layer.

The impact of seasonal and daily variations are then studied. Results indicate that specifying background error covariances corresponding to a one-day sliding average (preceding each each analysis date) has a positive impact on the short-range forecast quality, compared to the currently operational static covariances. This positive impact arises to a large extent from

the update of the monthly component of covariance variations. The update of the daily component contributes to additional positive impacts, which are however relatively localized and modest during this period. These impacts are illustrated by case studies for humidity during an anticyclonic situation, and for wind during a cyclonic event. These results support the idea to consider an on-line updated specification of background error covariances.

Keywords: limited area model, 3D-Var, ensemble assimilation cycling, time-dependent background error covariance estimates, operational application