



## **The implementation of the hybrid ETKF-Variational data assimilation scheme in the HIRLAM forecasting system**

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The Hybrid Variational-ETKF data assimilation scheme has been implemented into the HIRLAM forecasting system. The structures of the static forecast error covariance are merged with the flow-dependent structures of the HIRLAM ETKF perturbations, reflecting the density of the observational network as well. The flow-dependent structures are incorporated into the existing HIRLAM Variational data assimilation scheme by the extended control variable method. The produced analysis increment is a weighted average of the full-rank variational increment and the local in space linear combination of the rank-deficient ETKF perturbations. A number of real observation experiments (conventional observations only) and observing system simulation experiments (single observation experiments) were conducted in order to understand properties of the hybrid scheme. We investigated the sensitivity of the hybrid scheme to the various tuning parameters, such as the assumptions on smoothness and variability of the local linear weights. In general, the hybrid scheme assigns smaller weights to mass observations in comparison to those produced by the purely variational data assimilation scheme. The hybrid variational-ETKF data assimilation scheme, in its optimal settings, outperforms (slightly) the 3DVAR Variational Data assimilation scheme, on RMSE measure averaged over forecast lengths (the standard verification tool in the HIRLAM forecasting system). The improvement is the largest for the relative humidity and temperature fields.