Observation Impact in a Convective-Scale Localized Ensemble Transform Kalman Filter

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Background

- Knowledge about the impact of observations is crucial to refine and optimize the observing and data assimilation system.
- The computational cost of the direct approach to observation impact with data denial experiments is however prohibitively high.
- This motivated the development of the Adjoint Forecast Sensitivity to Observation (FSO) tools, which is now implemented at several weather centers.
- An adjoint model is not available for the DWD COSMO-DE system, but idealized studies show that ensemble methods can estimate such an impact at a very low computational cost (when the ensemble itself is computed anyway).

Method

- **Goal**
  - Estimate the impact of observations (i.e., contribution to the reduction of forecast error) in the future regional ensemble data assimilation system of DWD (KENDA-COSMO).
  - Demonstrate the feasibility of the ensemble observation impact estimate in a full NWP system, evaluate the accuracy and investigate limitations.
  - Perform sensitivity experiments in order to optimize efficiency and accuracy.

- **References**: Liu and Kalnay (QJRMS, 2008), Li et al. (QJRMS, 2010), Kalnay et al. (Tellus A, 2012), Sommer and Weissmann (submitted to QJRMS, 2013).

- **Observation innovation**
  - Error of forecast initialized at \( t_0 \)
  - Error of forecast initialized at \( t_1 \)
  - Forecast ensemble
  - Background ensemble in observation space
  - \( K_{ij} \) Weight matrix at grid point \( j \)
  - \( R(j) \) Observation error covariance matrix

- **Observation error covariance matrix**

- **Error of forecast initialized at \( t_0 \)**

- **Error of forecast initialized at \( t_1 \)**

- **Forecast ensemble**

- **Background ensemble in observation space**

- **Weight matrix at grid point \( j \)**

- **Observation error covariance matrix**

- **Data denial impact**

- **Approximated impact**

- **Difference Data denial - Approximation**

- **Sensitivity to observation perturbations**

- **Experiment with perturbed v-wind observations**

- **Impact reduction by perturbations in data denial**

- **Effect of perturbations correctly reproduced in approximation**

- **Approximation allows for an efficient breakdown of total observation impact**

- **Disadvantageous contribution of v-wind component observation correctly attributed by approximation method**

- **Experiment with unrealistically small observation error (50%)**

- **Data denial (solid lines) shows reduced impact**

- **Suboptimal use correctly detected by approximation (dashed lines)**

- **… reduced impact in experiment with modified observation error, in agreement with data denial results**

- **Histogram of individual observation impact values shows increased spread but...**

- **... reduced impact in experiment with modified observation error, in agreement with data denial results**

- **Sensitivity to assumed observation error**

- **Sensitivity to localization**

- **Varying horizontal localization**

- **Varying vertical localization**

- **Status and outlook**

- **The method of Kalnay et al. 2012 was applied to a experimental convective-scale data assimilation and forecasting system**

- **Data denial and sensitivity experiments with 10-6-hourly forecast and assimilation cycles were performed**

- **In a comparison to data denial experiments, it is demonstrated that the approximation method can efficiently estimate the impact of different conventional observations on a 6h-forecast when averaged over 10 cycles**

- **The observed differences between approximation and data denial were not statistically significant**

- **The method was sensitive to perturbations in observation subgroups and suboptimal use of observations**

- **Best results were achieved with the localization length scale taken equal to the one used in computing the analysis**

- **In future studies, more extended periods and more complex observation types shall be investigated**

- **Spatial distribution of impact at forecast time 6 hours**

- **Beneficial observations**

- **Disadvantageous observations**

- **Difference Data denial - Approximation**

- **P-values of observed difference**