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ASSIMILATION OF MODE-S EHS AIRCRAFT OBSERVATIONS IN COSMO-KENDA

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OBSERVATIONS AND COSMO-KENDA

The present study aims to assimilate the **Mode-S EHS temperature and wind** (de Haan, 2011) data with the Kilometre-scale Ensemble Data Assimilation (KENDA) system (Schraff et al. 2015). KENDA couples a local ensemble transform Kalman filter (LETKF; as in Bishop et al. 2001; Hunt et al. 2007) with a **40-member ensemble** of the Consortium for Small-Scale Modeling (COSMO; Baldauf et al. 2011) model in the domain over Germany (COSMO-DE). We investigate the effect of the assimilation on one and three hour forecasts (Lange and Janjic 2015).

Experiments:

- **NoDA** the control experiment without data assimilation.
- **Aconv** assimilates all conventional data except radiosondes.
- **MAconvTh10, MAconvTh50** and **MAconv** in addition assimilate Mode-S data randomly thinned to contain 10, 50 and 100 percent of full data set.

All data assimilation experiments assimilate the selected datasets in an **hourly** interval.

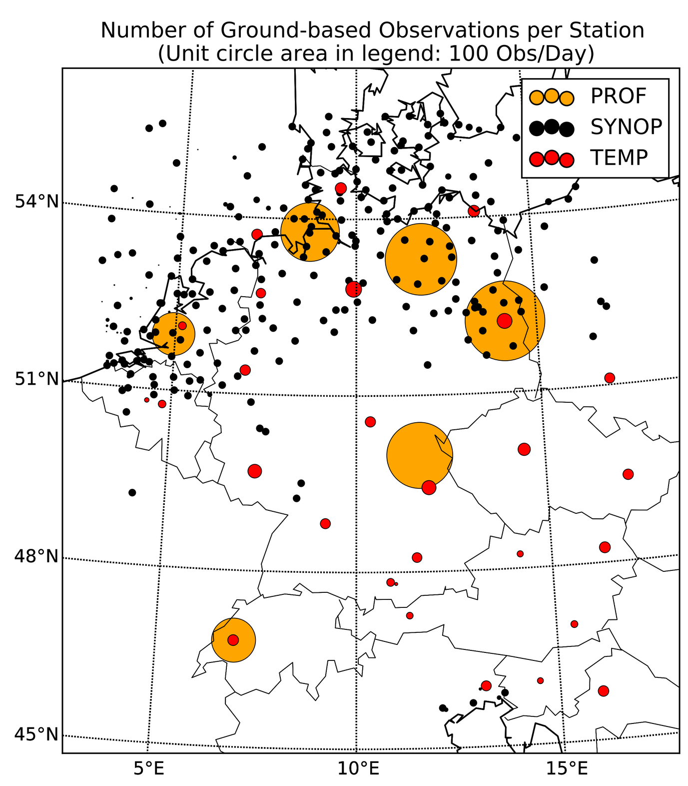


Figure 1: Domain of COSMO-DE model. The circles indicate positions of the surface-based stations. The areas of the circles correspond to the average daily number of single observations of the wind variable per station:11 851 PROF, 5813 SYNOP, and 1571 TEMP.

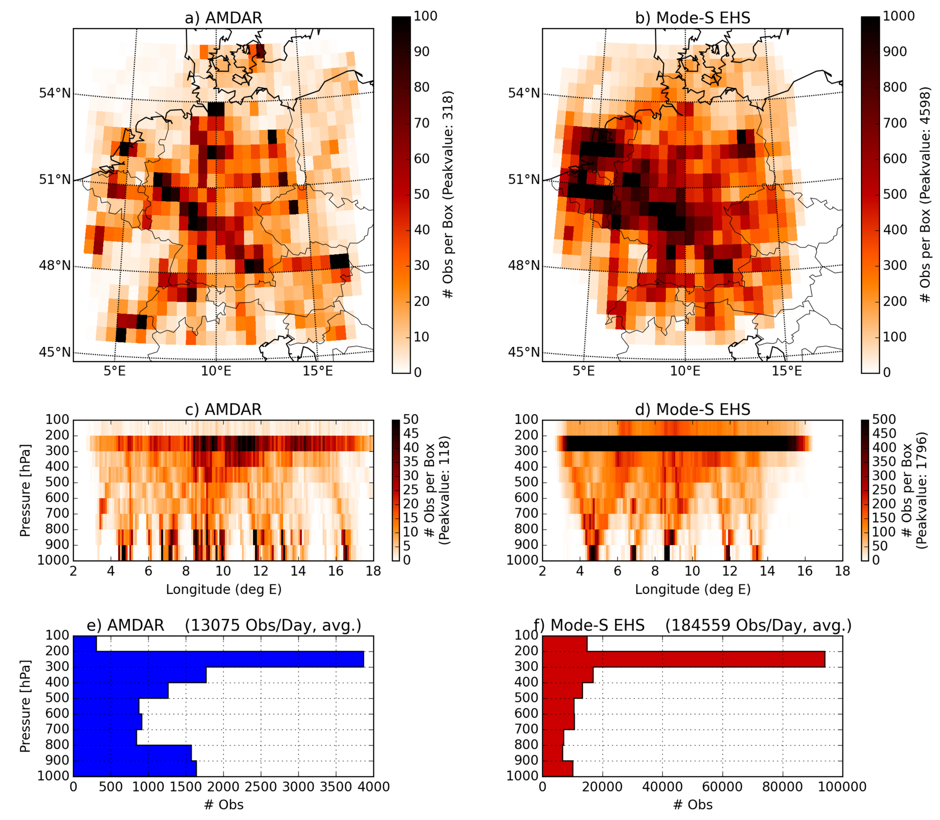


Figure 2: The horizontal density of assimilated aircraft observations of **AMDAR** (left) and the full **Mode-S EHS** (right) set per average day (top panels). The vertical density against longitude. Differences in the low-level distributions are due to highly frequented airports (middle panels). The overall vertical density (bottom panels).

Accounting for model and sampling error in KENDA

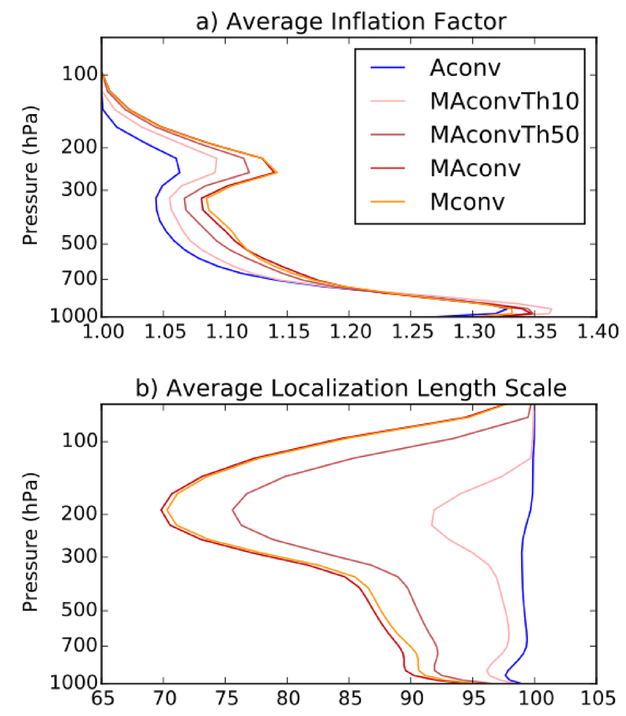


Figure 3: Adaptive covariance inflation factor (top), averaged over the experimental period on the pressure levels of the analysis grid. **Adaptive localization** length scale (bottom). In addition **RTPP** scheme of Zhang et al. 2004 is used with 0.75.

RESULTS OF THE 3-HOUR ENSEMBLE FORECASTS

Inclusion of the Mode-S data improves the accuracy compared to assimilation of AMDAR in both one hour (not shown) and three hour forecasts.

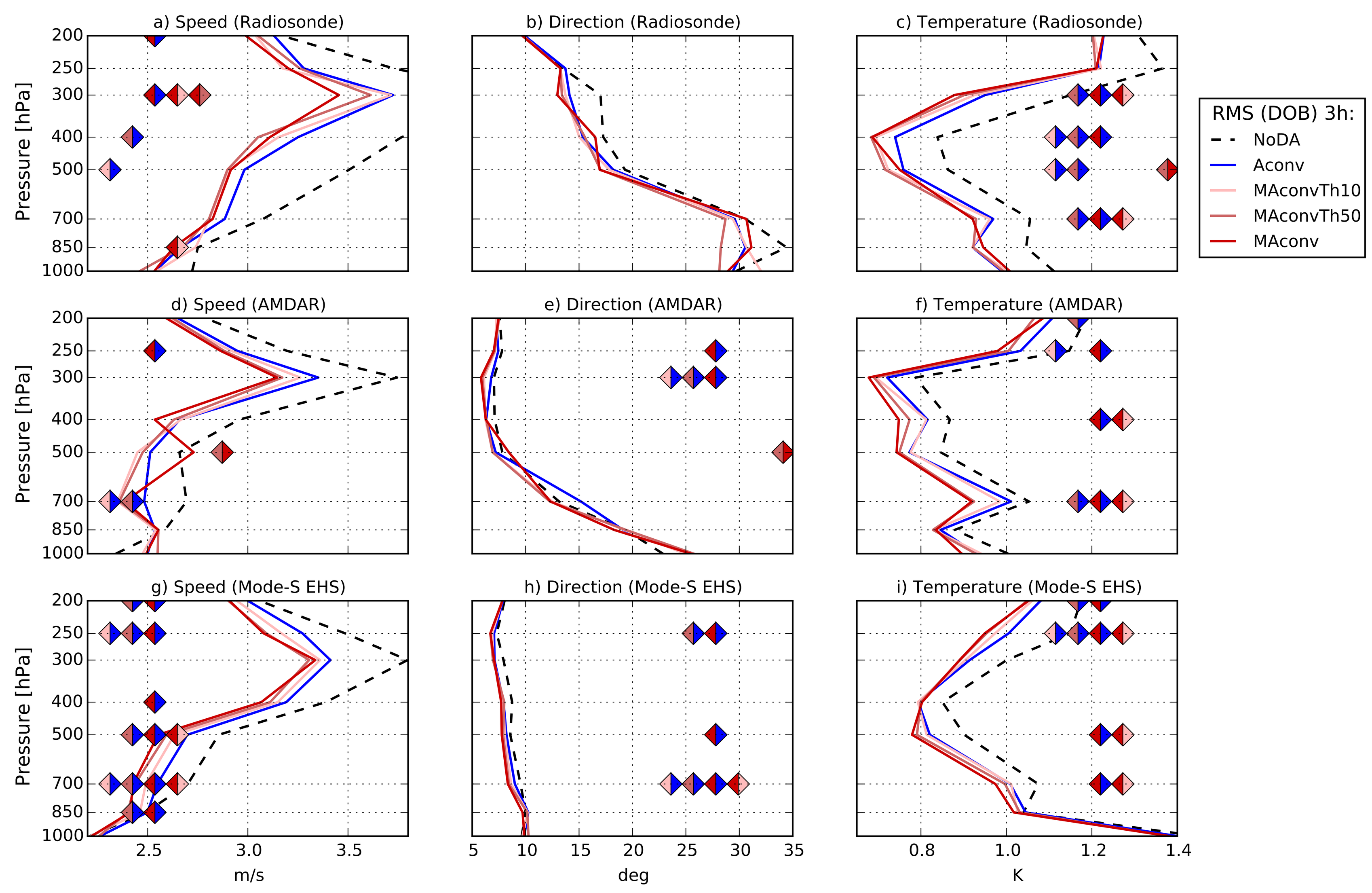


Figure 4: RMS of 3-hour forecast: Forecast RMS of the Mode-S thinning experiments and Aconv, evaluated during the last hour of 3-hour forecast windows from 9 to 12 UTC and 21 to 00 UTC (also for NoDA). A two-colored diamond on a level means that the RMSs of the left experiment are significantly smaller than of the right experiment.

The improvement compared to AMDAR is primarily for pressure levels above 850 hPa (Fig. 4).

The wind field of the ensemble was saved **every 15 min** throughout the 3-h forecasts and the corresponding one-dimensional kinetic energy spectra were calculated on flight levels. To enhance the relative differences, the energy of the difference wind field from the NoDA experiment is scaled by the absolute kinetic energy spectrum of NoDA.

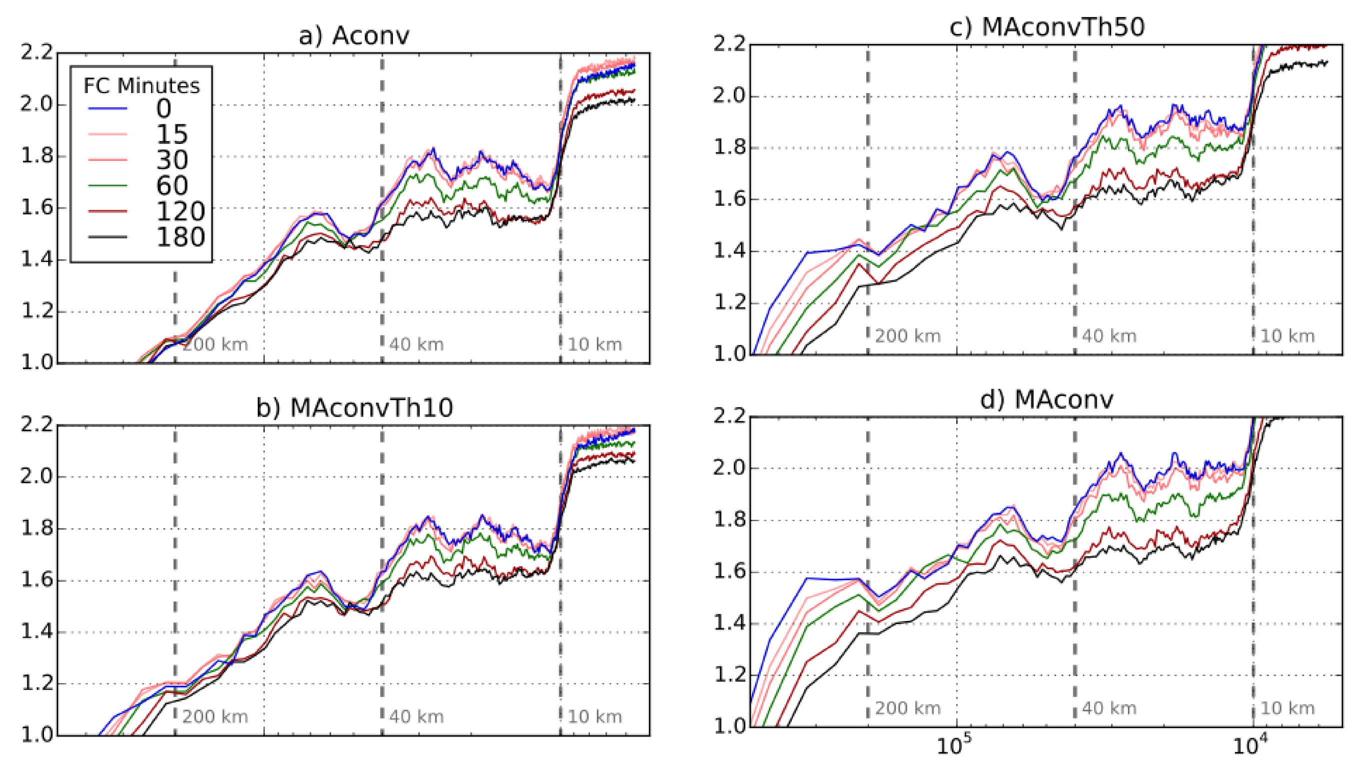
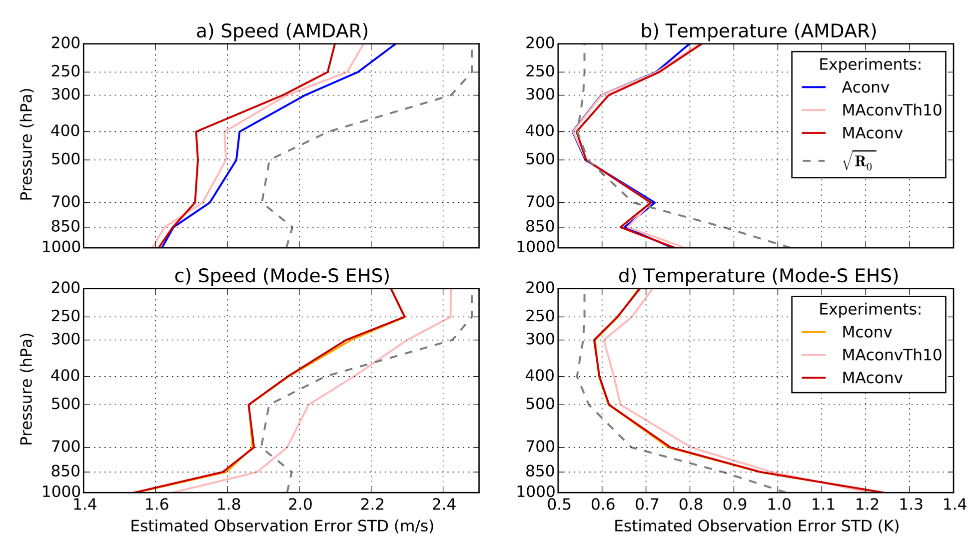


Figure 5: Kinetic energy of the difference wind fields from NoDA, scaled by absolute kinetic energy of the NoDA wind field. Shown are the three hours of ensemble forecast. The upper air spectra are for the experiments Aconv (left top), MAconvTh10 (left bottom), MAconvTh50 (right top) and MAconv (right bottom).

THE OBSERVATION ERROR ESTIMATION

The *a posteriori* diagnostics (Desrozier et al. 2005) indicates that both Mode-S EHS data and AMDAR data are of approximately same accuracy for wind, and that Mode-S is less accurate for temperature. Observation error variance estimates depend on the observational coverage.



SUMMARY

- The amount of Mode-S EHS observations is 15 times larger than of AMDAR, with a similar observation distribution.
- Mode-S EHS data were assimilated in addition to AMDAR, assuming the same observation error.
- Based on both 1-h and 3-h forecasts, a saturation of benefit is seen between using 50% and 100% of Mode-S EHS.
- The observation error standard deviation of Mode-S EHS was estimated to be comparable to AMDAR in the wind variable. For temperature, it was diagnosed to be 50% larger for levels below 700 hPa.
- Spectra of the difference kinetic energy showed that the LETKF data assimilation affects all model scales.

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