Deutscher Wetterdienst
Wetter und Klima aus einer Hand

EnVAR Quality Control and Observation Aggregation for ICON-LAM

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SINFONY

Introduction

The German Weather Service (DWD) operationally runs a LETKF (Localized Ensemble Transform Kalman Filter) for the regional Numerical Weather Prediction (NWP) with the ICON-LAM model. For the global data assimilation, we use an EnVAR+LETKF scheme with the ICON model.

We investigate the potential of a regional EnVAR data assimilation in addition to KENDA (kilometer scale ensemble data assimilation [1]). The deterministic KENDA run serves as a benchmark for the EnVAR run. In order to compare the algorithms, both setups should assimilate (almost) the same observations, thus Quality Control (QC) and Observation Aggregation (OA) should choose a similar set of active observations. As EnVAR and LETKF share only a small portion of the QC and OA code, this is a difficult task.

The EnVAR uses a fully dynamic ensemble error covariance matrix and the observation errors of KENDA. Furthermore, the EnVAR uses the horizontal and vertical localization scales of KENDA, neglecting that a B matrix localization is not equivalent to an R matrix localization, but similar enough for a first setup.

The presented experimental setup is not focused on getting the best forecast (or assimilation) scores, but to have as similar as possible sets of assimilated observations after QC and OA to compare the algorithms and identify problems in a regional EnVAR scheme.

Why do we do Quality Control & Observation Aggregation?

- ➔ Filter incomplete or erroneous observations (QC)
- ➔ Increase observation representativeness (OA) if the observations are spatially denser than the model resolution
- ➔ Reduce (spatial) observation error correlations (OA, in particular thinning)
- ➔ Improve computational efficiency (QC & OA)

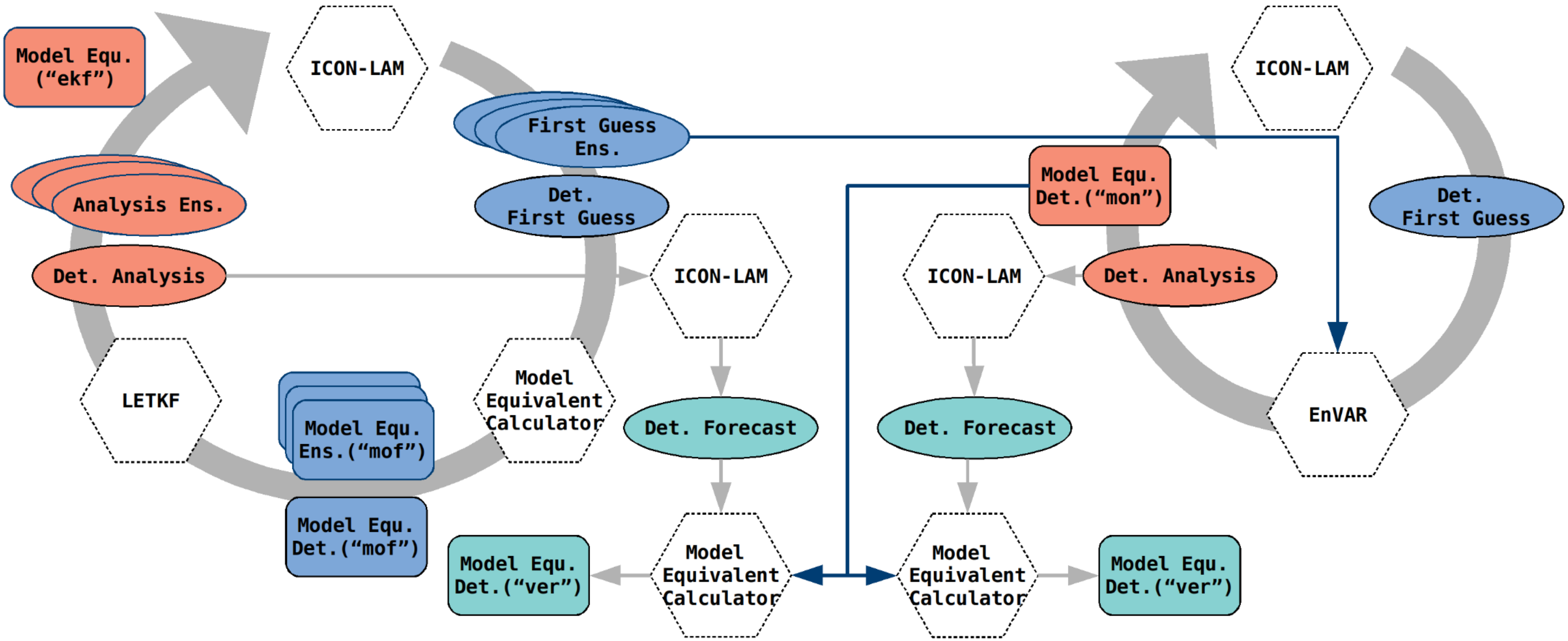
Quality control & Observation Aggregation measures in “DACE”

- ➔ Meta data check: time, location, completeness, quality flags
- ➔ Physical plausibility: variable specific prescribed physical bounds
- ➔ White/Blacklisting: previous knowledge about good/bad observations (typically by station or instrument)
- ➔ Observation operator applicability: check restrictions, e.g. limitation to clear-sky cases
- ➔ First Guess check: prescribe bounds for e.g. expected error, ratio of observation value and observation error
- ➔ Variational QC (EnVAR only): reduce observation impact on the analysis if there is a bad agreement with the current best analysis estimate (in minimization)

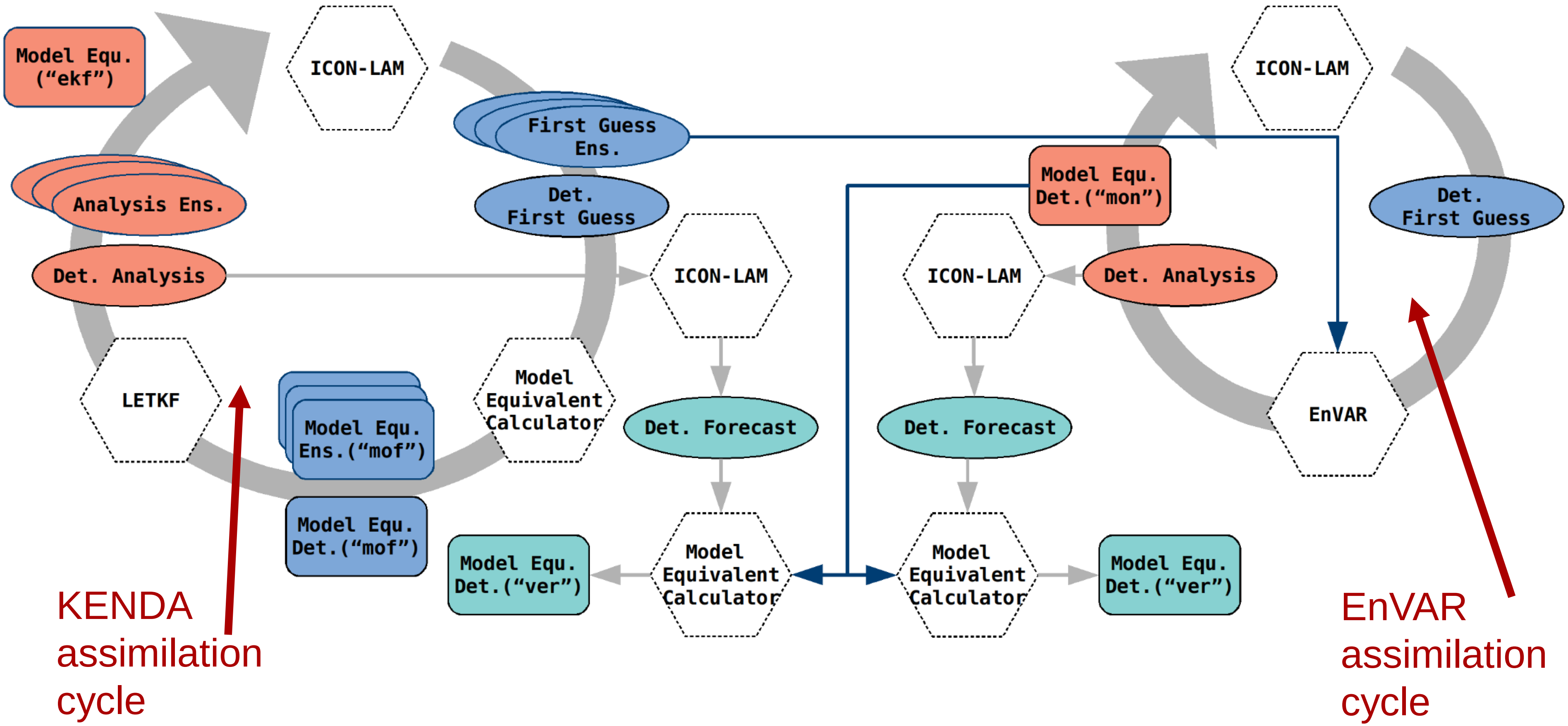
Experiment Design

- ➔ 2 weeks in June 2021
- ➔ Forecasts: every 6 hours initialization, lead time up to 24 hours
- ➔ Observation choice
  - Active: aircraft temperature and wind observations
  - Passive: high-resolution super-obbed Radiosondes, Synop
- ➔ Observation choice
  - Active: aircraft temperature and wind observations (Observation Operator for aircraft observations is simple, basically just a spatial interpolation)
  - Passive: high-resolution super-obbed Radiosondes, Synop
- ➔ Algorithm LETKF (differences to KENDA routine setup)
  - Dace Operators (-> Routine production since March 2022)
  - No adaptive localization
  - “3D-LETKF”: no temporal slicing in the assimilation window

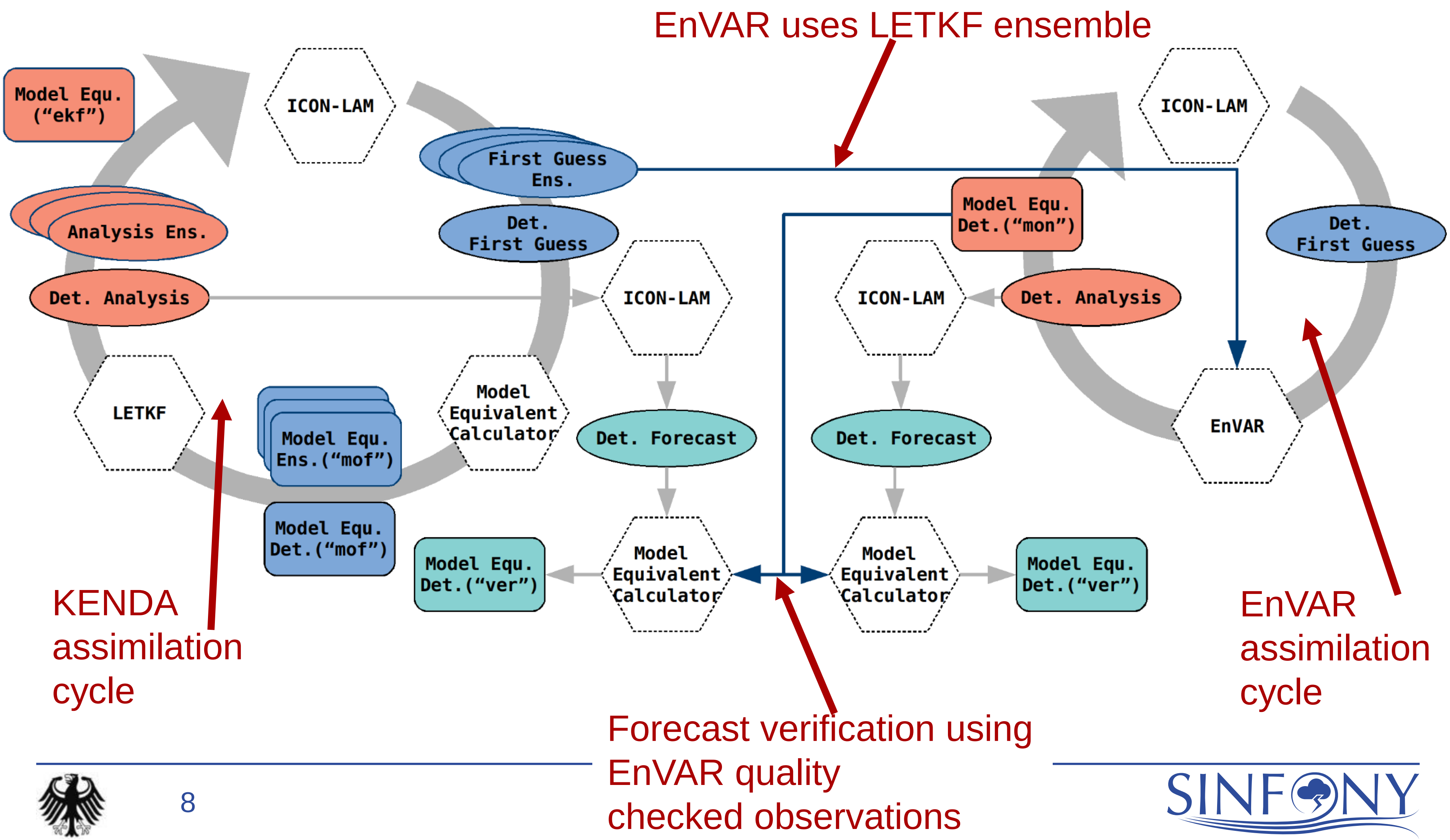
Experiment Design



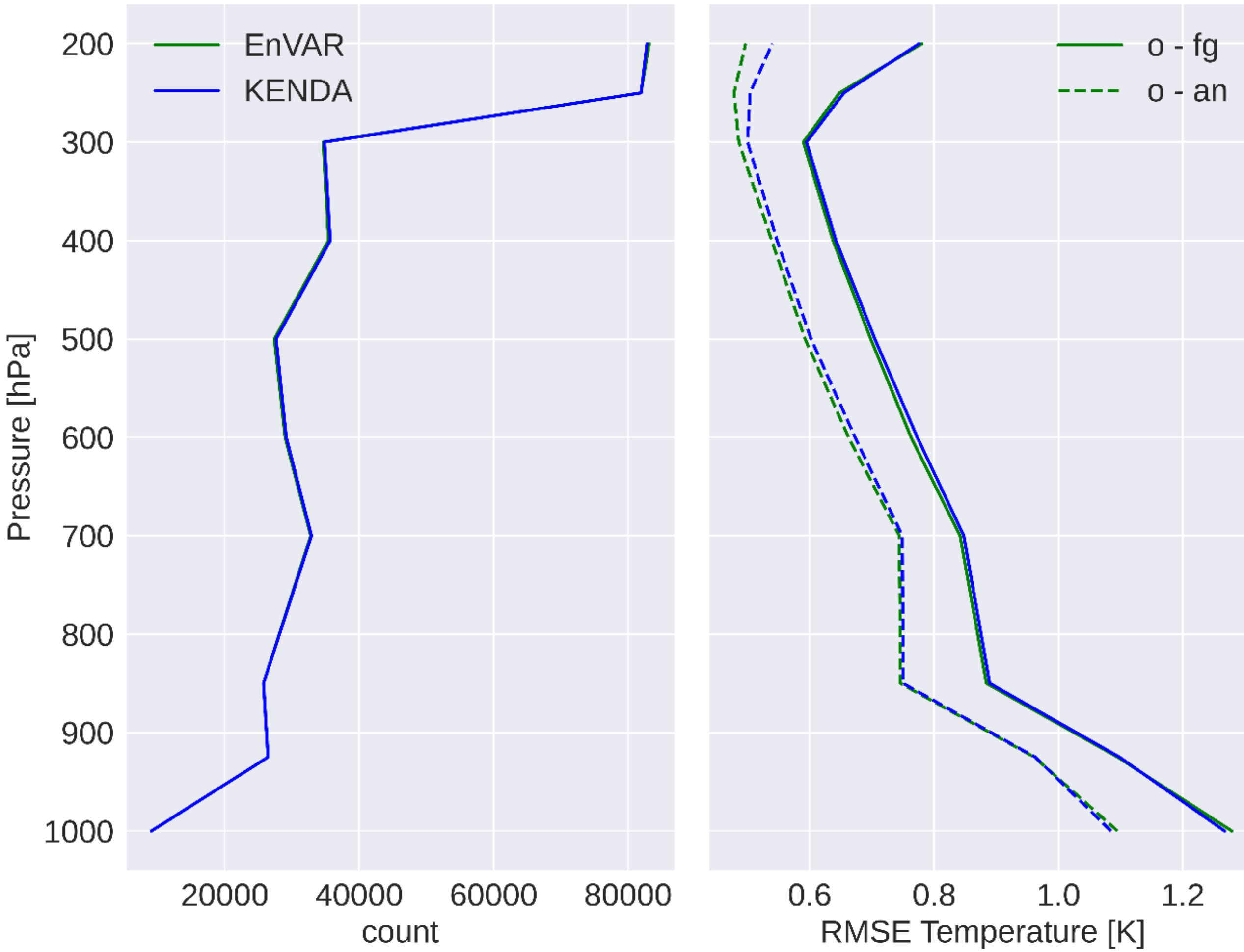
Experiment Design



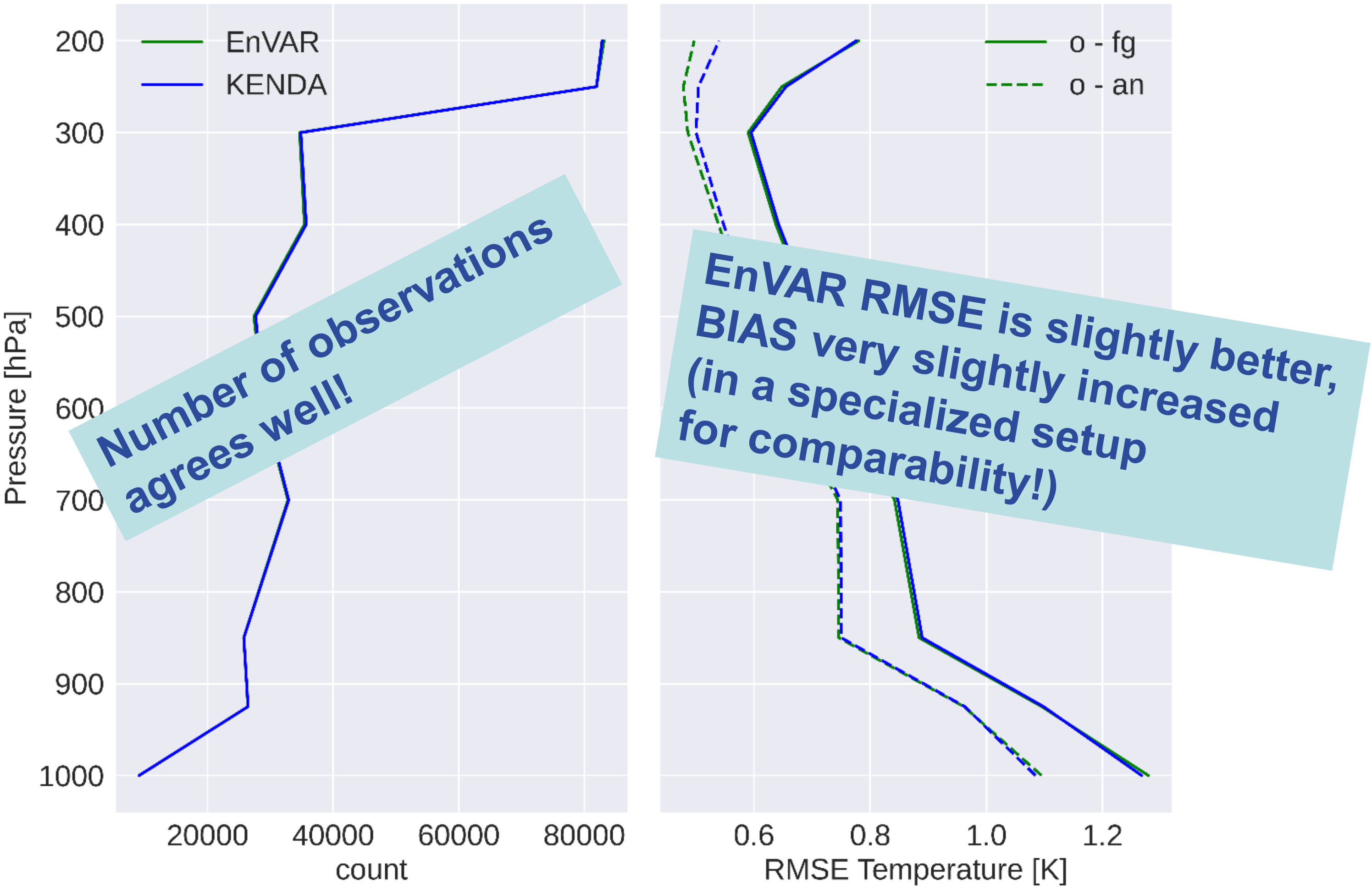
Experiment Design



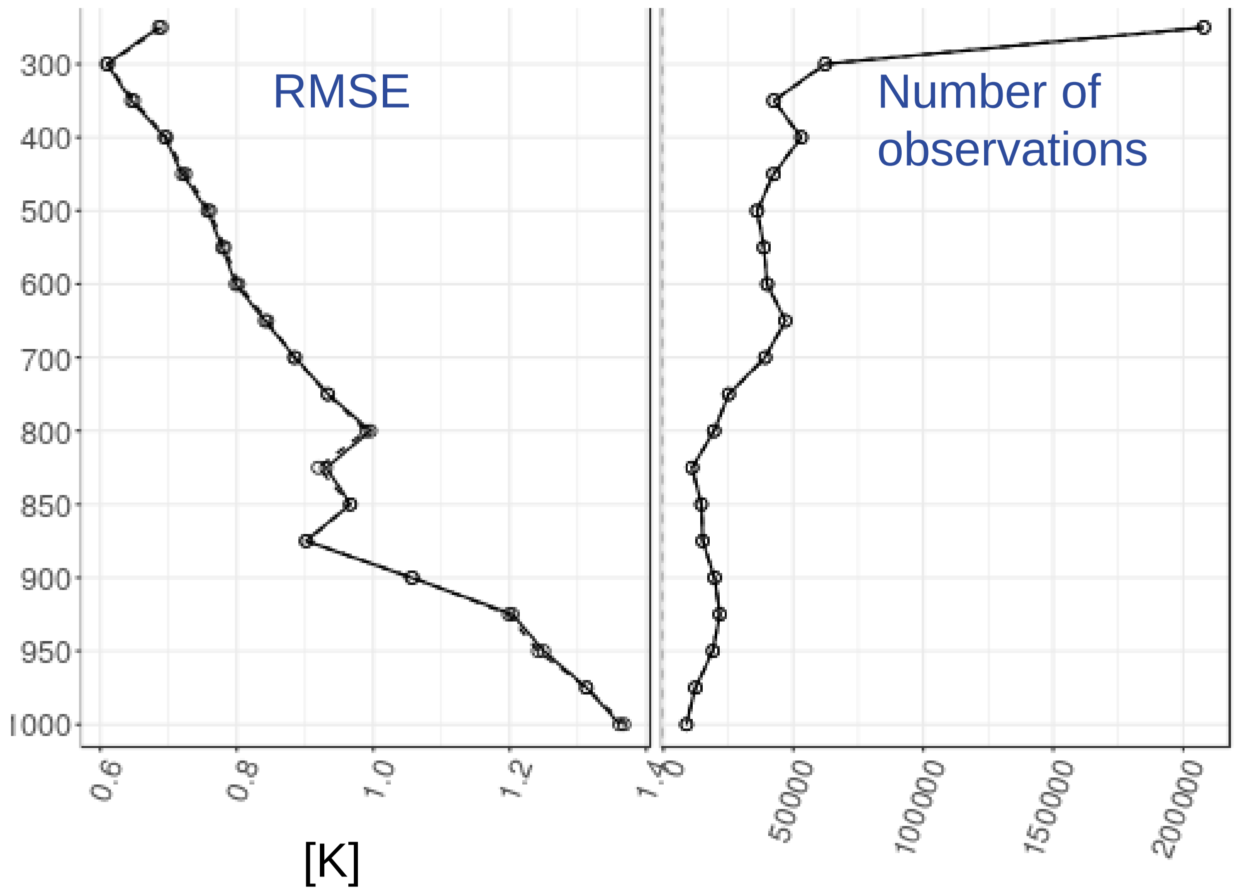
Results: Analysis



Results: Analysis

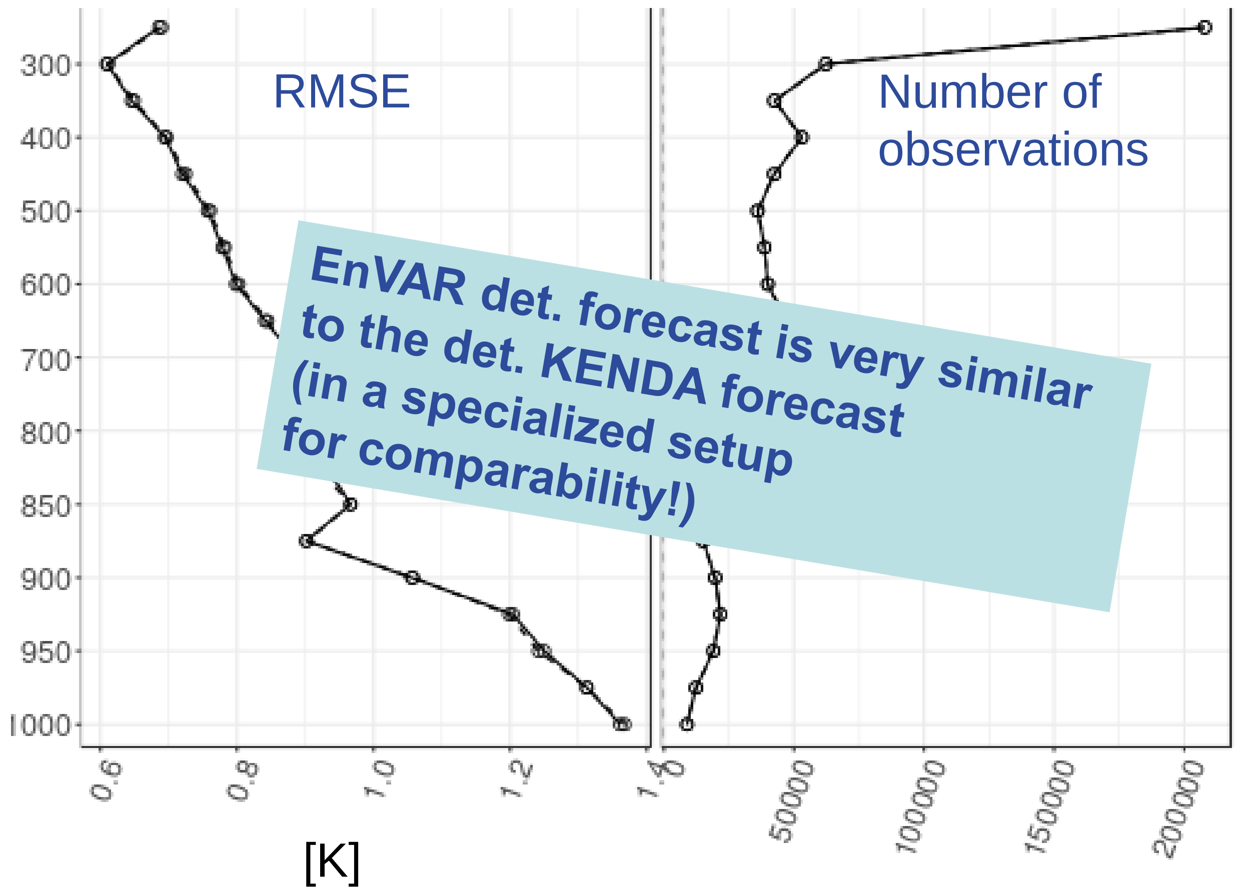


Results: Forecast (Aircraft Temperature, all lead times)



Solid: EnVAR
Dashed: KENDA

Results: Forecast (Aircraft Temperature, all lead times)



EnVAR det. forecast is very similar to the det. KENDA forecast (in a specialized setup for comparability!)

Solid: EnVAR
Dashed: KENDA

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Summary

In a particular setup for EnVAR and KENDA aiming at the assimilation of (almost) the same observations and the best algorithm correspondence, EnVAR can produce deterministic forecasts of a quality similar to the KENDA system.

EnVAR and KENDA were algorithmically tuned to work as similar as possible. For operational Numerical Weather Prediction, none of these setups is suited well. Both systems have different options to produce better analyses. E.g. “4D-LETKF” (KENDA) or variational quality control (EnVAR).

Outlook

- ➔ Understand more observation systems (radiosondes, synop, pilot)
  - Control EnVAR observation processing such that it is similar to KENDA
- ➔ use of available satellite operators from the global data assimilation

- ➔ “cEnVAR” (coarse EnVAR)
  - Use an existing ensemble forecast of a coarser resolution (e.g. ICON global forecast or ICON-EU forecast) instead of KENDA ensemble
  - Produce EnVAR regional deterministic forecasts anywhere in the world
  - At a lower computational cost than regional LETKF experiments
  - Currently under development

References

[1] Schraff, C., Reich, H., Rhodin, A., Schomburg, A., Stephan, K., Periáñez, A. and Potthast, R., 2016. Kilometre-scale ensemble data assimilation for the COSMO model (KENDA). Quarterly Journal of the Royal Meteorological Society, 142(696), pp.1453-1472