1. Introduction

3DVar Data Assimilation (DA) is operational at GeoSphere Austria; the background error covariances (BEC/B_s) used are sampled from **climatology** and are **homogeneous, isotropic**, and contain **seasonal variations**.

A common alternative approach is **ensemble-derived** background statistics, bringing errors associated with **short-term weather (flow-dependency)** into assimilation.

Pure Ensemble Variational (EnVar) methods use background covariances (B_e) purely sampled from ensembles, while a **weighted combination** of B_s and B_e is used in Hybrid DA.

Accurate estimation of background and observation error statistics leads to an accurate forecast.

Challenges in the estimation of background statistics :

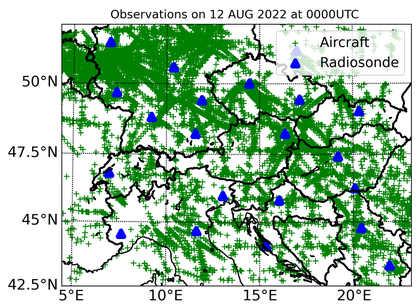
- Local orography and convective-scale non-linearity violate the assumption of hydrostatic and geostrophic balance required for B_s.
- On the other hand, ensemble-derived error statistics suffer from noisy correlations due to small ensemble sizes, limited by computational restrictions.

Research questions:

1. What impact do ensemble-derived background error statistics have on the analysis increment?
2. Is increasing ensemble size by a Valid Time-Shift (VTS) ensemble approach beneficial?

2. Model setup

1. Hybrid-3DEnVar in convective-scale limited-area model AROME with 2.5km horizontal resolution.
2. 50 ensemble members from Convection-permitting Limited-area Ensemble Forecasting (C-LAEF) at 2.5km.
3. Aircraft and radiosonde temperature is assimilated.



Meteorological conditions:

- A locally driven convective summer day with weak pressure gradient force is chosen testcase to study.

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Testing Hybrid-3DEnVar for the Convective-Scale NWP model AROME over Austria

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RMSD of analysis departures calculated against non-assimilated observation:

Experiment	Description	RMSD (%) against Radiosonde	RMSD (%) against aircraft
3DVAR	Climatological BEC Matrix (B_s)	+1.13	+1.12
EnVar-50	Pure Ensemble B_e	-1.31	-0.30
HYB0.5-50	50% weight to B_e	-1.16	-0.32
VTS0.5-3x16	50% weights to B_e	-0.94	-0.27
VTS0.5-3x50	50% weights to B_e	-0.98	-0.27

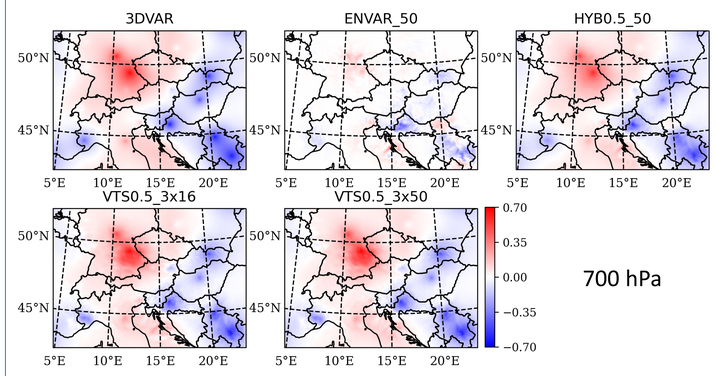
5. Take home messages

1. The first attempt to test Pure 3DEnVar and Hybrid-3DEnVar is successful in Austria.
2. In preliminary results for a single test case, pure 3DEnVar outperforms hybrid DA and operation 3DVar.
3. VTS is an efficient approach to increase ensemble size indirectly. VTS ensembles have a larger spread than baseline ensembles.
4. Performance evaluation of VTS and baseline ensembles based on RMSD of Analysis residuals demonstrate similar behavior.

3. Valid Time-Shift (VTS) ensemble approach

- VTS ensembles are initialized at the same time. These ensemble forecasts have different lengths centered around the next analysis time.
- Rather than directly increasing ensemble size, We use these forecasts of different lengths, treated as they all are valid at analysis time to calculate the background correlations.
- We apply 1-hour time shift to baseline ensembles to prepare VTS ensembles.

4. Temperature Increments (K) from Radiosondes



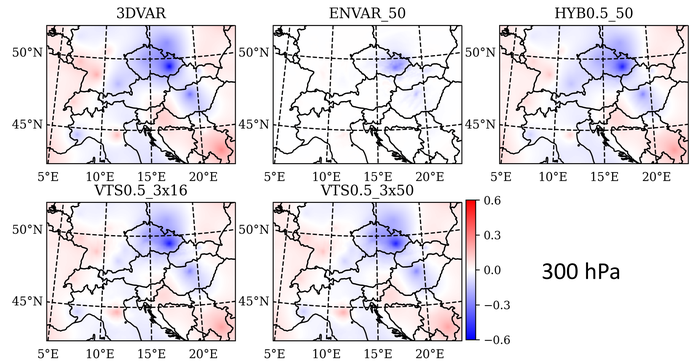


Figure caption: Horizonal cross-section of analysis increment (K) at 0000 UTC on 20220812

References

- Huang, B. and Wang, X., 2018. On the use of cost-effective valid-time-shifting (VTS) method to increase ensemble size in the GFS hybrid 4DEnVar system. *Monthly Weather Review*, *146*(9), pp.2973-2998.
- Montmerle, T., Michel, Y., Arbogast, E., Ménétrier, B. and Brousseau, P., 2018. A 3D ensemble variational data assimilation scheme for the limited-area AROME model: Formulation and preliminary results. *Quarterly Journal of the Royal Meteorological Society*, *144*(716), pp.2196-2215