1. Introduction

3DVar Data Assimilation (DA) is operational at GeoSphere Austria; the background error covariances (BEC/B) 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) purely sampled from ensembles, while a weighted combination of B and B 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.
- 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 test case to study.

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: Horizontal cross-section of analysis increment (K) at 0000 UTC on 20220812

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 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.

References


RMSD of analysis departures calculated against non-assimilated observation:

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Description</th>
<th>RMSD (%) against Radiosonde</th>
<th>RMSD (%) against aircraft</th>
</tr>
</thead>
<tbody>
<tr>
<td>3DVAR</td>
<td>Climatological BEC Matrix (B)</td>
<td>+1.13</td>
<td>+1.12</td>
</tr>
<tr>
<td>EnVar-50</td>
<td>Pure Ensemble B</td>
<td>-1.31</td>
<td>-0.30</td>
</tr>
<tr>
<td>HYB0.5-50</td>
<td>50% weight to B</td>
<td>-1.16</td>
<td>-0.32</td>
</tr>
<tr>
<td>VTS0.5-3x16</td>
<td>50% weights to B</td>
<td>-0.94</td>
<td>-0.27</td>
</tr>
<tr>
<td>VTS0.5-3x50</td>
<td>50% weights to B</td>
<td>-0.98</td>
<td>-0.27</td>
</tr>
</tbody>
</table>