Correction of non-additive errors in the HIRLAM hybrid ensemble variational DA using image registration approach

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Tomas Landelius, Magnus Lindskog, Nils Gustafsson (SMHI)

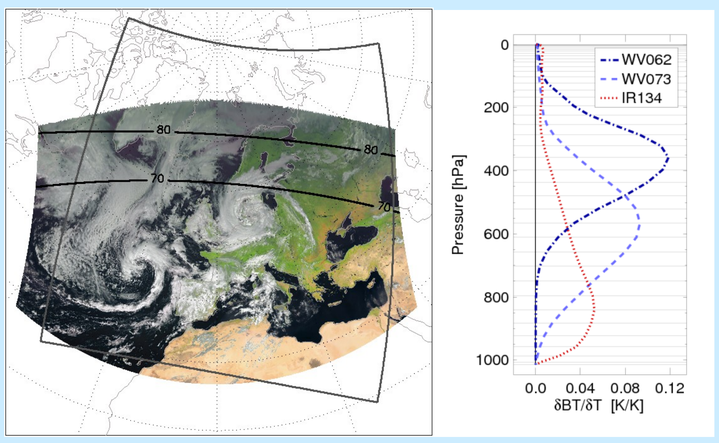
and Jelena Bojarova (met.no)

Image registration using SEVIRI WV73

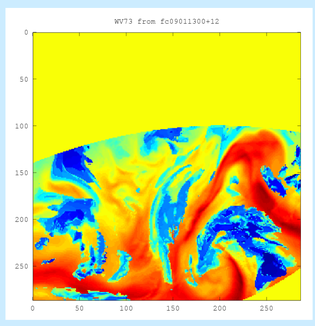
Total error is generally non-Gaussian (Lawson and Hansen 2005)

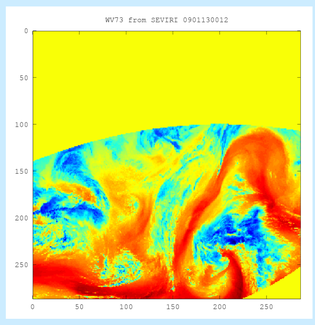
$\varepsilon_t(s) = x_t(s) - x_b(s)$

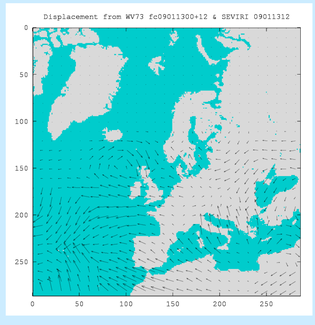
$x_b(s+\varepsilon_p(s)) - x_b(s) + \varepsilon_a(s)$



Computation of the displacement field with image registration method

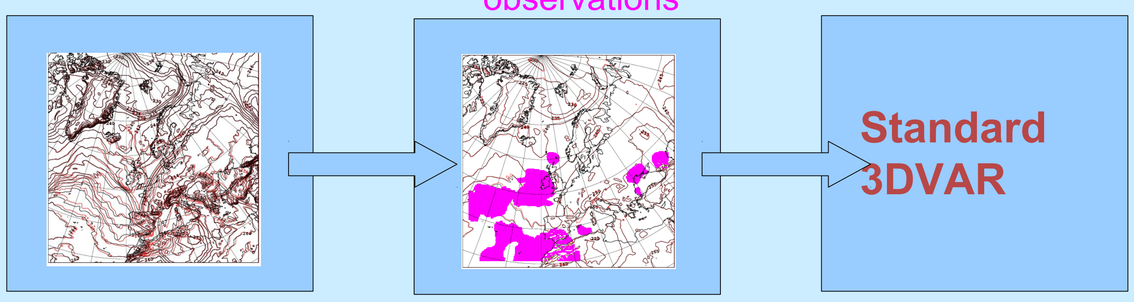






Balances: A two step data assimilation

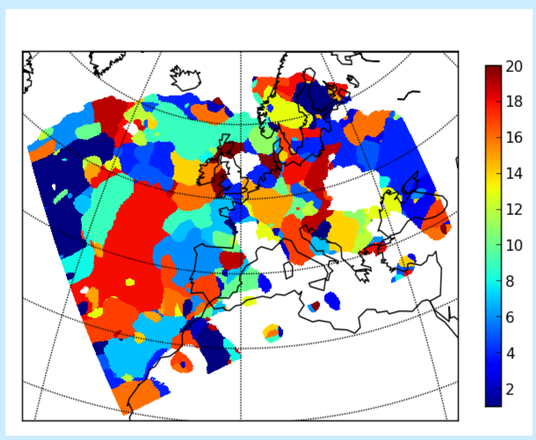
Step 0: Warp first-guess field and calculate displacement norm
Step 1: Generate pseudo-observation (T,q,u,v) from the warped field where displacement field is large enough and assimilate these pseudo-observations using 3DVAR to obtain phase-error corrected background
Step 2: Perform standard 3DVAR on the phase-error corrected background to minimize additive error assimilation real observations

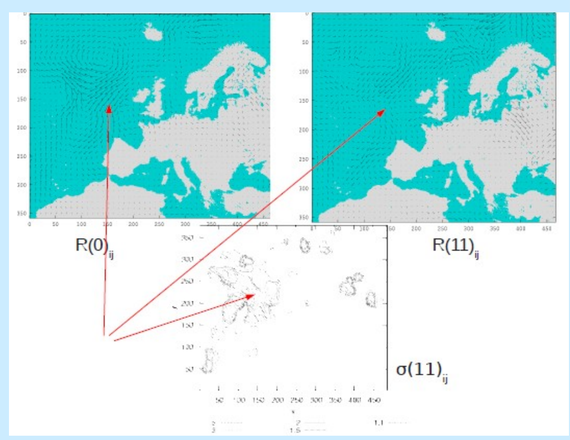


Selection of locally best ensemble member

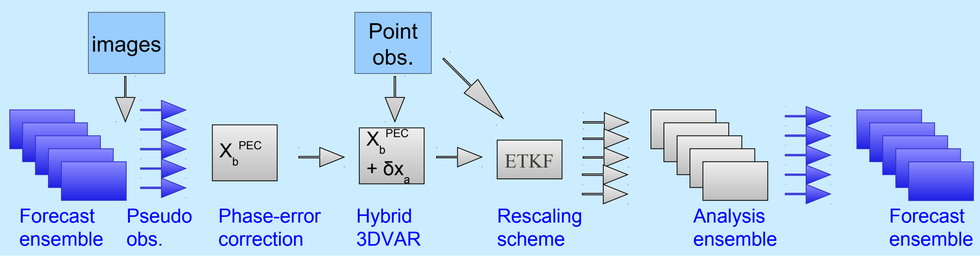
- Use integrated water vapour ensemble forecasts and compare these to the SEVIRI image (or other "truth")
- Calculate horizontal displacement $R(m)_{ij}$ for each ensemble member m including control ($m=0$) in each grid-point (i,j)
- For each grid-point with a "large" displacement error ($|R(0)_{i,j}| > \delta$) in the control forecast assign an ad-hoc ensemble member weight

$\sigma(m)_{ij} = max\{min([R(0)_{ij}/R(m)_{ij}],8),1\}/nmembers$





Step 0: Select locally "best" ensemble member m^* - ensemble member with the largest $\sigma(m)_{ij}$ <=> the largest displacement in control $R(0)_{ij}$ and the smallest displacement error in this member $R(m^*)_{ij}$
Step 1: Generate pseudo-observations from the locally best ensemble members and assimilate these pseudo-observation using the hybrid ensemble variational technique in order to obtain phase-error corrected background utilizing flow-dependent balances.
Step 2: Perform the hybrid ensemble variational data assimilation using the phase-error corrected background and the "usual" observations preserving introduced structures.

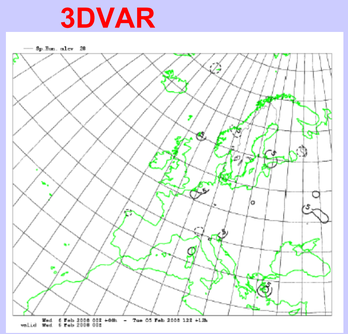


Assimilation of structures (SEVIRI images)

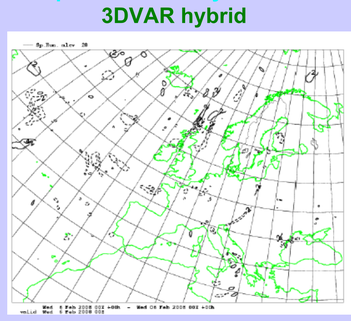
Specific humidity increment

3DVAR

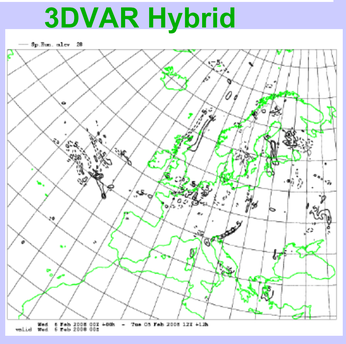
2step sev 3DVAR Hybrid Tune - 3DVAR hybrid



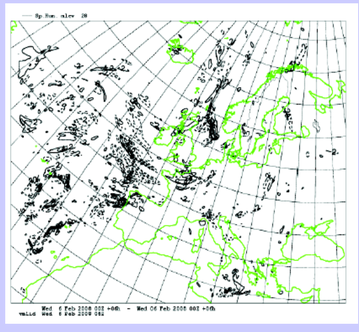
+00h



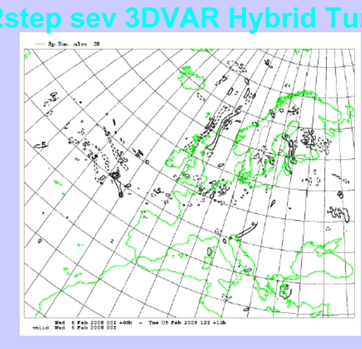
3DVAR Hybrid



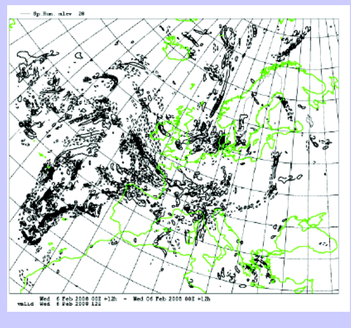
+06h



2step sev 3DVAR Hybrid Tune

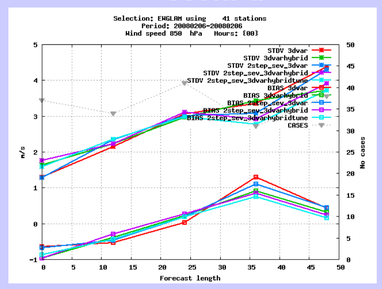


+12h

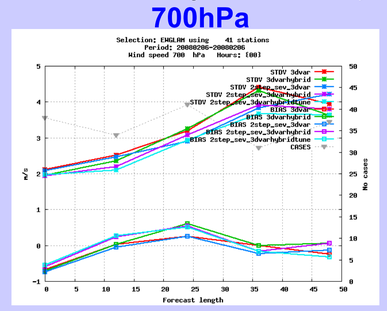


Verification (very preliminary results) : one case study

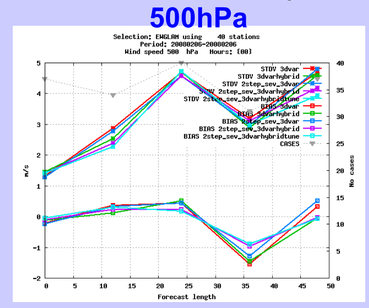
850hPa



700hPa

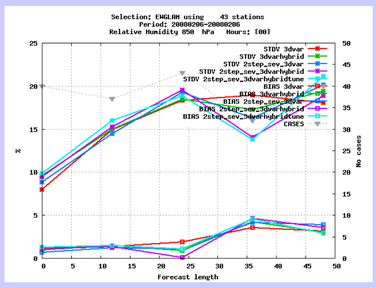


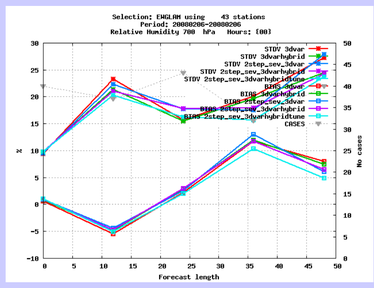
500hPa

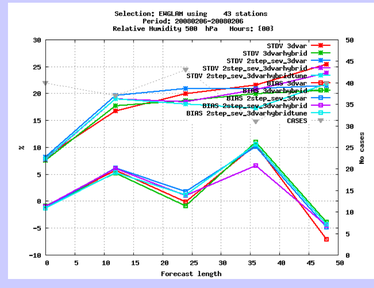


Wind speed

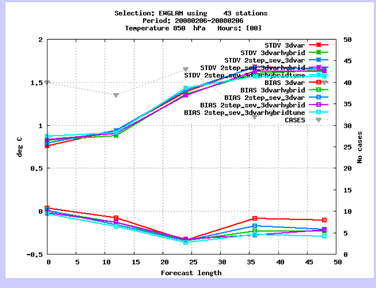
Relative humidity

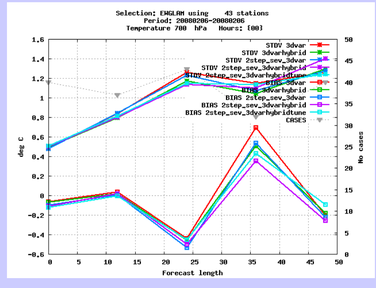


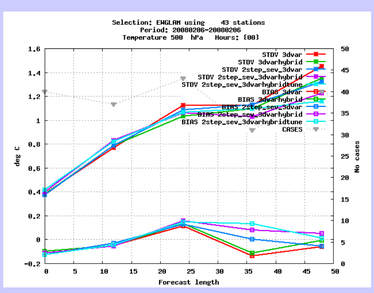




Temperature







- Future work
- Image registration with uncertainties (clouds)
- Other remote sensing images
- Transfer experience to HARMONIE

References

Sun, D.; Roth, S & Black M,J"Secrets of Optical Flow Estimation and Their Principles" IEEE Int. Conf. on Comp. Vision & Pattern Recognition, 2010.