Potential of horizontal line-of-sight winds in a limited area model

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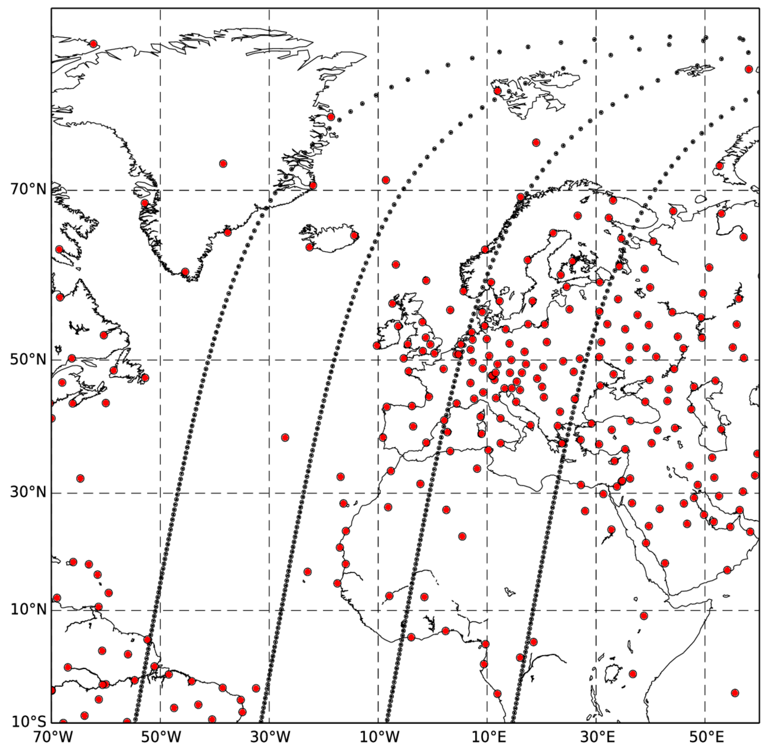
1 Motivation

A large resolution increase in the last decade has not been accompanied by a sufficient increase in a number of observations to initialize the models. In particular, there is a large need for the direct wind observations as well as for the humidity data in order to improve the mesoscale analyses.

What is the potential of ADM-Aeolus wind profiles in a limited area model for Europe?

We presents results of Observing System Simulation Experiments (OSSEs) addressing the value of HLOS winds in a limited-area model in comparison to other data types.



Comparison between the current radiosonde coverage (red dots) with expected ADM-Aeolus observations (black dots) in 6 h over Euro-Atlantic domain. Aeolus profiles are shown for the accumulation length 90 km.

2 Methodology

Numerical model

- ***Weather Research and Forecasting model WRF*** v3.5.1
- WRF is nested in ECMWF ENS on model levels
- Model setup: low-resolution with 30 km and 31 model levels to compare the outputs with the ECMWF analyses
- Domain larger than any LAM domain in use in Europe (Fig. 2.1)

Ensemble Adjustment Kalman Filter (EAKF)

- *Data Assimilation Research Testbed DART*
- 6-hour cycling
- Flow-dependent background-error covariances
- No covariances inflation
- Standard Gaspari-Cohn localization

Observing System Simulation Experiments

- All experiments nested in ECMWF 50 member ensemble (ENS)
- Basic cycling: 00 and 06 steps nested in +12/+18 ENS from 12 UTC earier day, and 12 and 18 UTC steps nested in +12/+18 ENS from 00 UTC run the same day
- Data resolution: interpolated to ~0.25^0 with 91 vertical model levels

Simulation of observations

- Observations simulated from ECMWF analyses (nature run, NR)
- Each simulated observation profiles contains ~50 observations defined
- Observation type: U, V, T and HLOS
- Observation error: white noise added to the NR. Typical obs errors about 1 K and 2 m/s (for U, V and HLOS)

$$HLOS = U\sin(\alpha) + V\cos(\alpha)$$

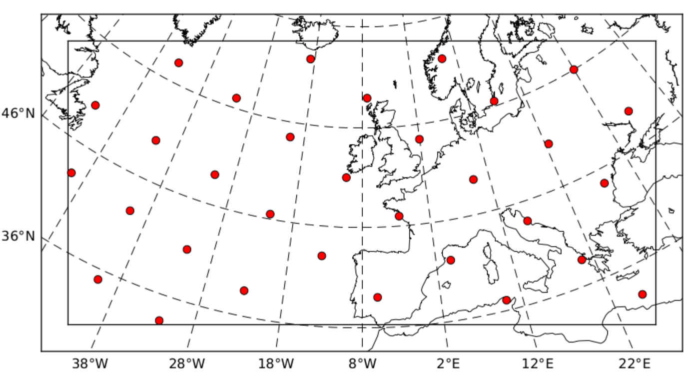


Figure 2.1: LAM domain with the simulated observation point in one of OSSE experiments.

3 Value of HLOS winds relative to other observation types

Sensitivity experiments

<u>Reference experiment</u>

TUV → *temperature, zonal and meridional wind*

<u>Single wind component experiments</u>

THLOS → *temperature and HLOS*

TU → *temperature and zonal wind*

TV → *temperature and meridional wind*

<u>Mass and wind experiments</u>

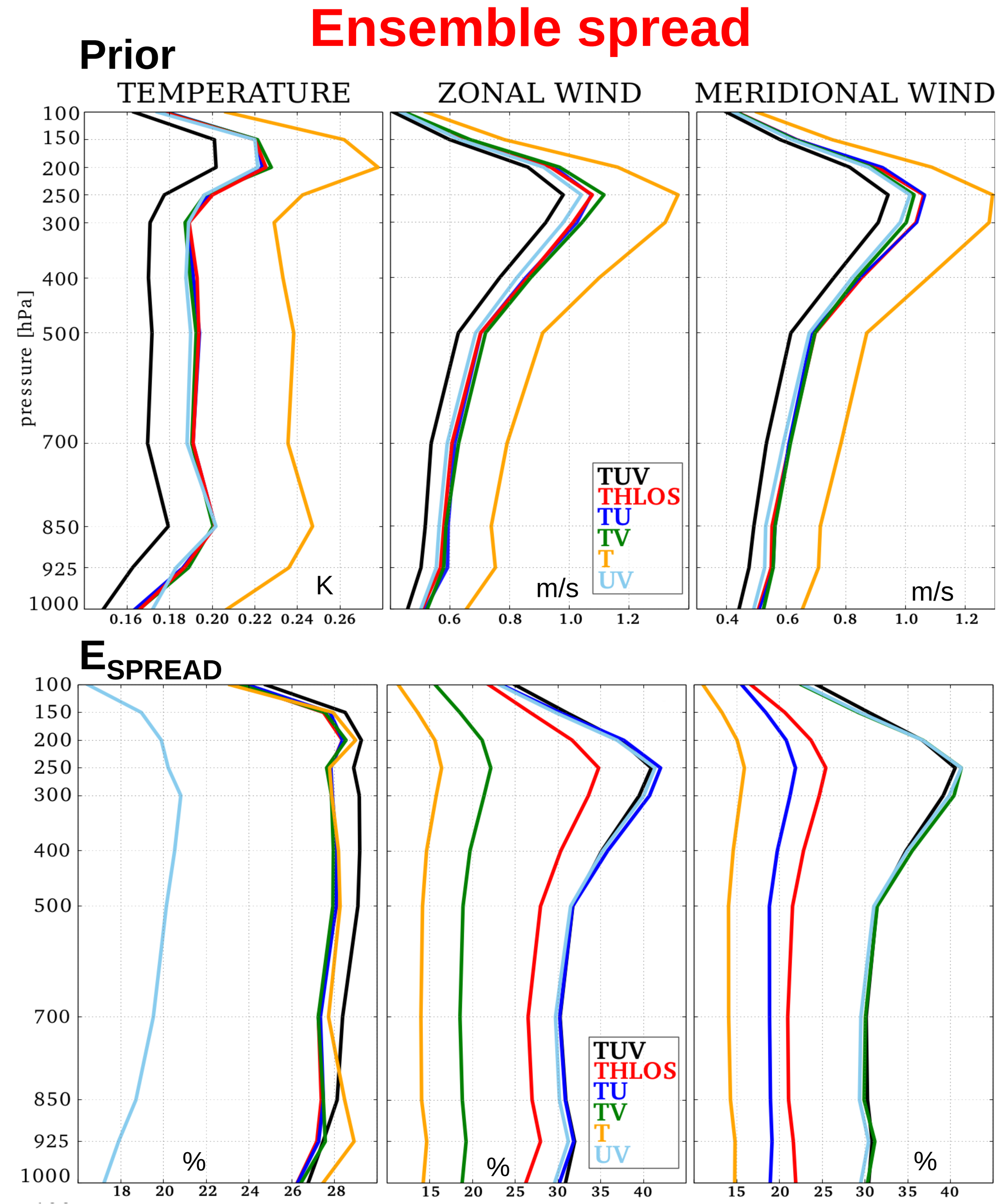
T → *temperature*

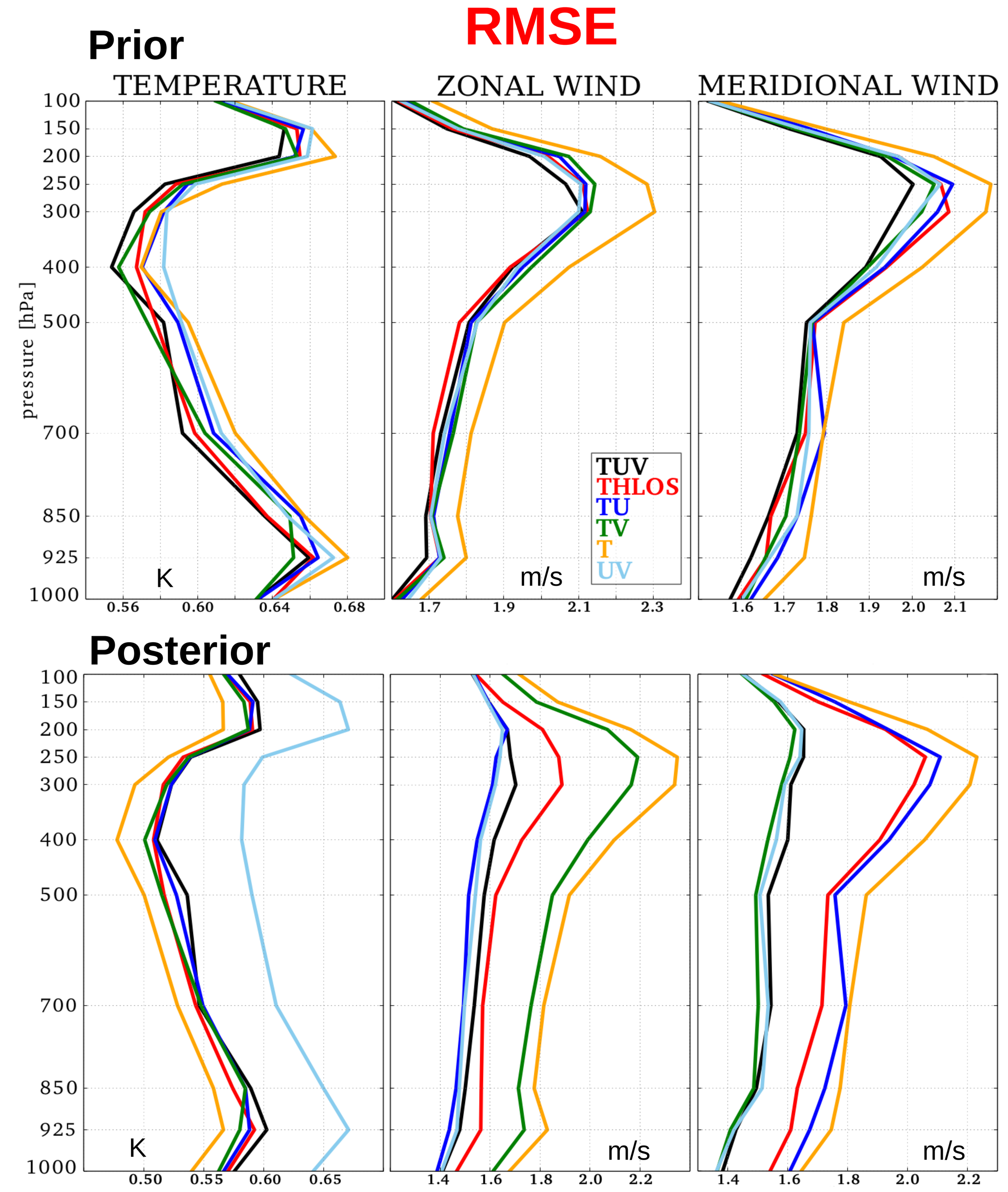
UV → *total wind*

- The assimilation reduces the prior ensemble spread for the assimilation variable for around 30%.
- Adding a single wind component to temperature observations does not further reduce the prior ensemble spread of the temperature field. Similar for the case when the meridional wind is added to TU or zonal to TV.
- THLOS is ~5 % (~10 %) less successful than TUV in reducing prior ensemble spread in zonal (meridional) wind component. Such difference is expected given the applied α=60^0 (clockwise from N).

Multivariate aspects

- Assimilation has little effect on unobserved variables
- In THLOS, both U and V variables are affected proportionally to the azimuth angle of HLOS wind: for the applied setup, THLOS has about 50% of the impact of TUV on U and about 20% of the TUV impact on V.





Evaluation was carried out in observation space comparing analysis and background (6-hr forecast, or prior) with observations.

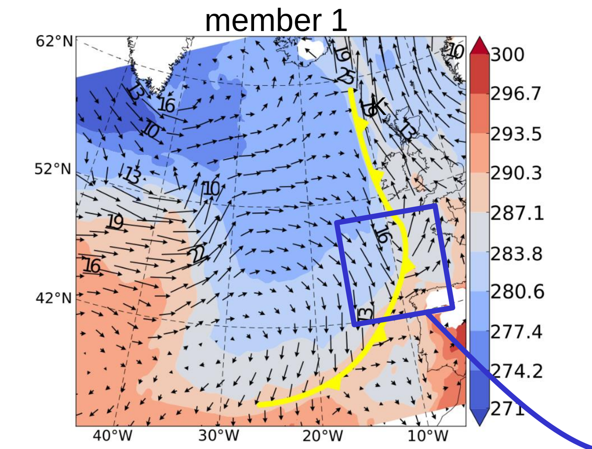
Reduction of ensemble spread: $E_{SPREAD} = 1 - \left\langle \frac{\sqrt{v(x)_{posterior}}}{\sqrt{v(x)_{prior}}} \right\rangle$

X stands for any of (T, U or V), v is ensemble variance at observation location and <> represents averaging over all observation lcoations in 20 day cycle.

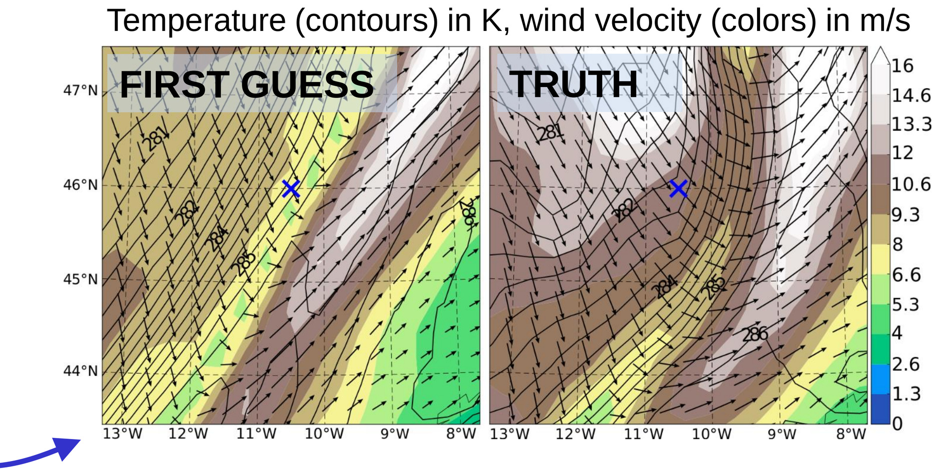
4 Case study of the baroclinic development in north Atlantic

EnKF provides flow-dependent covariances to maximize the impact of HLOS winds along the fronts in the northern Atlantic.

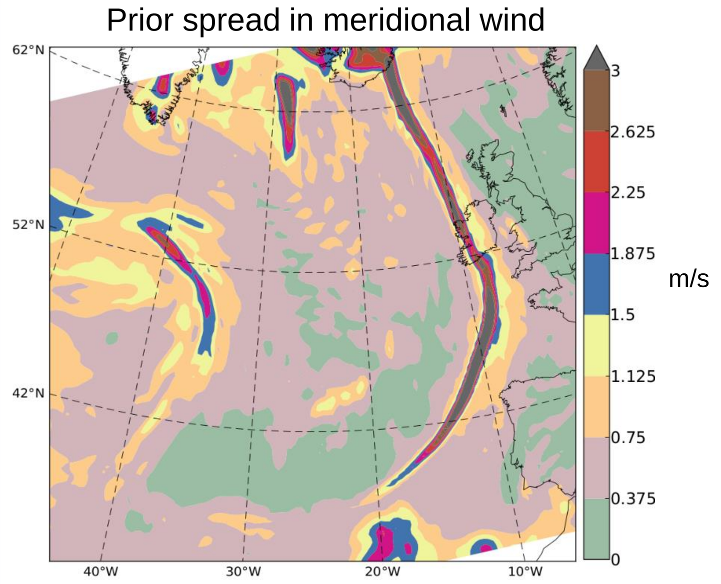
Flow at 925 hPa in member 1



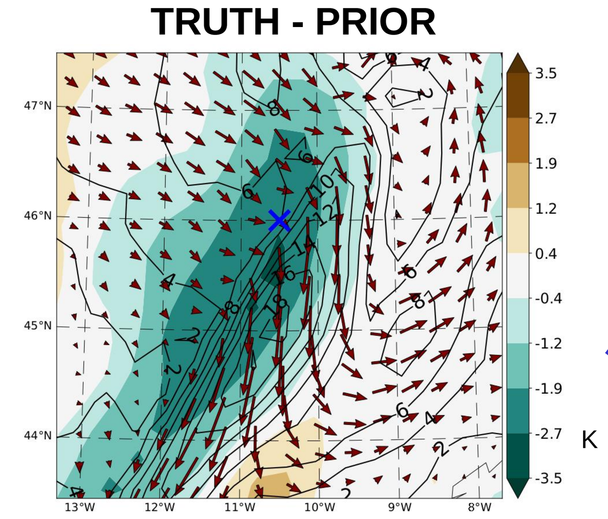
Temperature (contours) in K, wind velocity (colors) in m/s



Prior spread in meridional wind

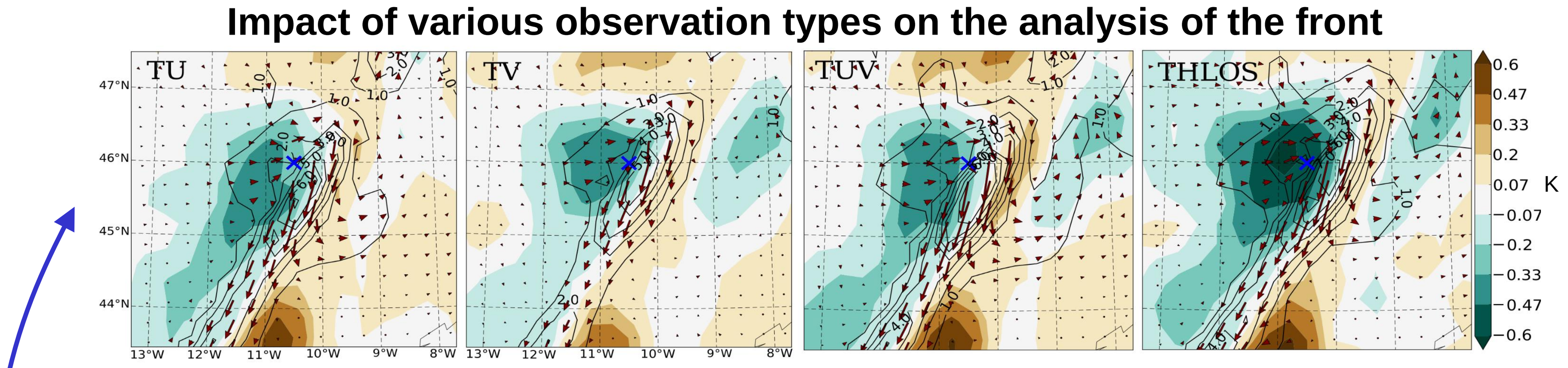


TRUTH - PRIOR



Temperature (colors) in K, wind velocity (contours) in m/s

Impact of various observation types on the analysis of the front



THLOS provides analysis ncrements closest to the truth thanks to the front elongation close to the HLOS azimuth

5 Conclusions

- In the performed OSSEs, the HLOS data with the azimuth of 60 (clockwise from N) provide on average better analyses then individual wind components (U or V).
- Multivariate aspects are small, i.e. the observed variables hardly improve analysis scores for the unobserved quantities. The assimilation of HLOS winds improves analysis of the both wind components.
- In frontal regions in the Atlantic, which often has a SW-NE orientation similar to the line of sight, the HLOS winds may especially beneficial.

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