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Assimilation of surface observations in KENDA and observation impact on the convection-permitting scale

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ASSIMILATION OF SURFACE OBSERVATIONS

INTRODUCTION

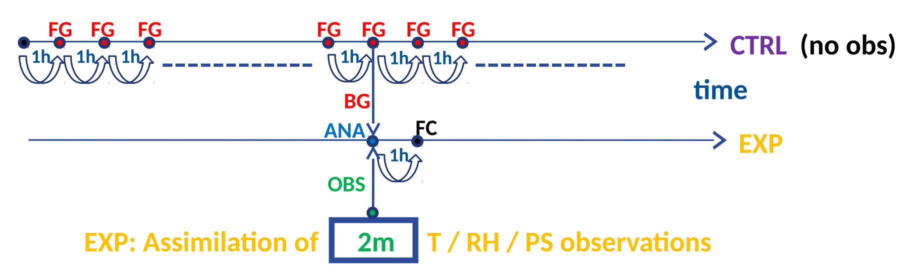
- The Km-scale ENsemble Data Assimilation (KENDA) system within COSMO does not make sufficient use of surface observations.
- An accurate representation of near-surface variables influences the characterization of the planetary boundary layer and can have a significant impact on e.g. the initiation of convection or the simulation of fog or foehn.

GOALS

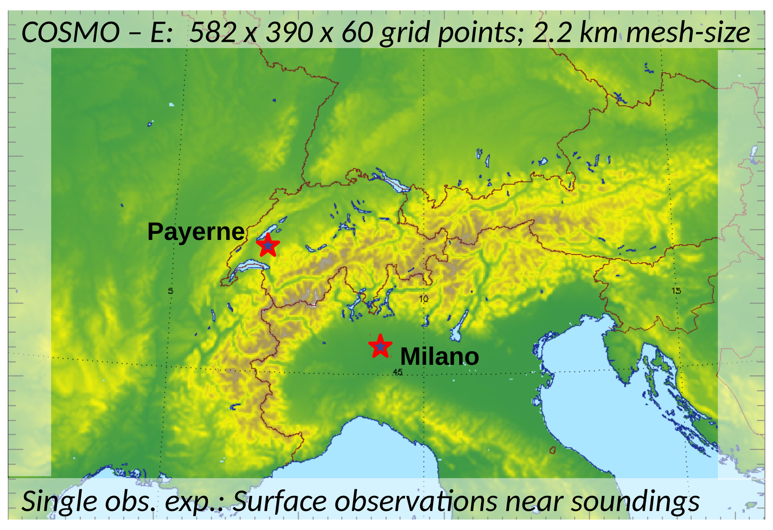
- Improve the COSMO near-surface analysis by making better use of screen height observations in the KENDA system.
- Analyze the influence of screen height observations on the analysis and its sensitivity to various settings, such as the horizontal and vertical localization lengths in different meteorological situations.

EXPERIMENTAL SETUP

- MeteoSwiss COSMO-LETKF system.
- 10. - 15. April 2015 with one day spin up.
- Single observation and full system experiments.



COSMO – E: 582 x 390 x 60 grid points; 2.2 km mesh-size

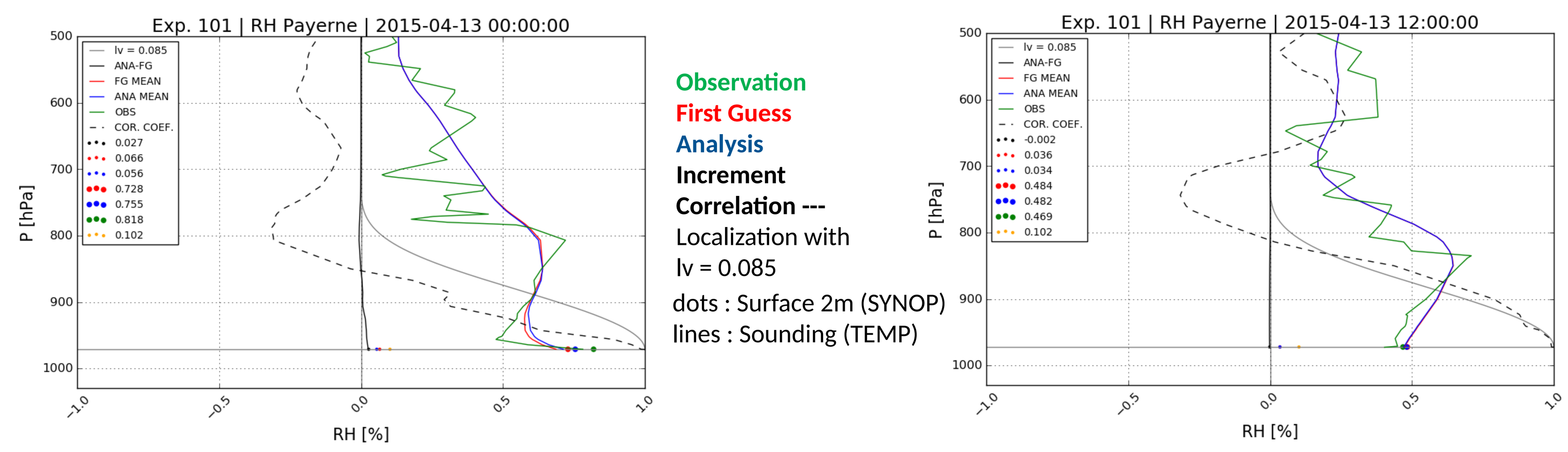


Single obs. exp.: Surface observations near soundings

REPRESENTATIVENESS

- The limited representativeness of surface observations is a central issue.
- The correlation of 2m humidity with the humidity profile (in the first guess ensemble) captures to some extent the meteorological situation (e.g. stable or well-mixed sounding).
- A smaller localization seems to be needed for a successful assimilation of surface observations.

Payerne - 00 UTC : stable PBL (inversion) | **Payerne - 12 UTC : well-mixed PBL**

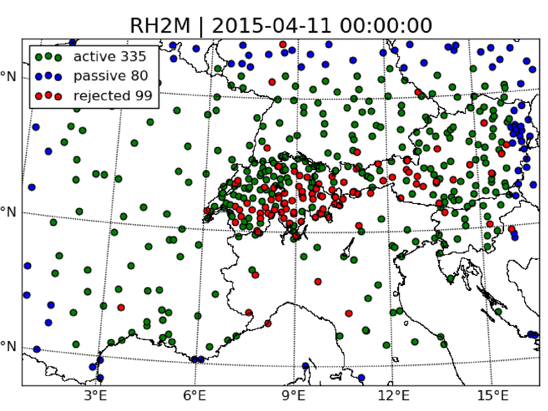


Vertical profile of RH at Payerne for the single observation experiment, 13.04.2015. RH values at 2m height are displayed as large dots, upper-air RH with solid lines: analysis minus first guess (black), observation (green), ensemble first guess mean (red) and ensemble analysis mean (blue). The small dots show first guess spread (red), analysis spread (blue) and observation error (yellow), respectively. Furthermore, the correlation of RH(p) to RH2M (dashed, black line) and the Gaspari Cohn function at the surface (thin, solid, grey line) are shown.

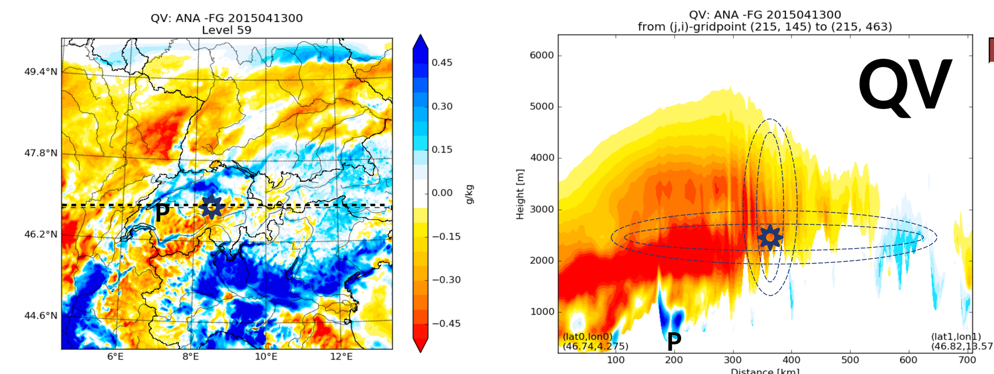
LETKF GRID & LOCALIZATION

- More than 400 surface observations per hour available.
- The vertical localization is a function of the pressure and increases with decreasing pressure.
- LETKF grid is a factor 3 coarser and non-terrain following. For this reason, increments form surface observations in the Alps can spread horizontally into the free atmosphere.

Available RH2M surface observations

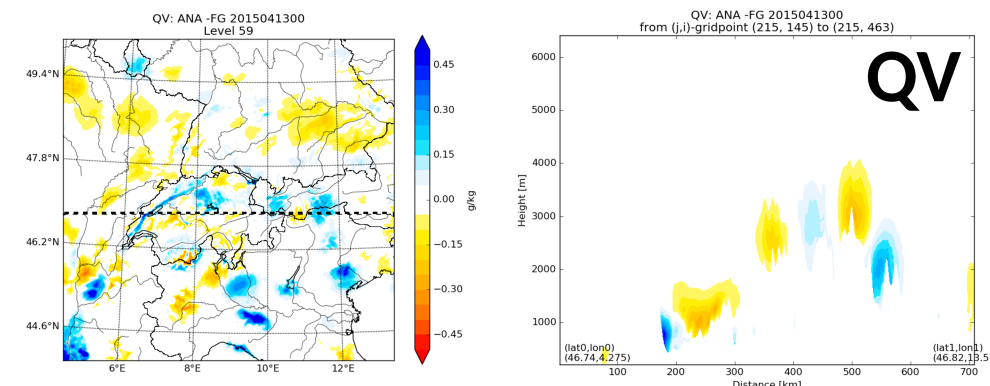


Horizontal slice at lowest model level | *Vertical slice along dashed line*



*Analysis minus First Guess Increments of specific humidity (QV) at 13.04.2015 **00UTC**. Assimilation of T2M, RH2M and PS only. Localization similar to the operational setup.*

lh: horizontal localization
lv_srf: localization at sea surface pressure
nzr: vertical levels of the LETKF grid



Experiment with reduced horizontal and vertical localization. To ensure that the localization is larger than the grid spacing, the number of vertical levels (coarse LETKF grid) is increased from 30 to 40 levels.

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CONSORTIUM FOR SMALL SCALE MODELING COSMO

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OBSERVATION IMPACT

INTRODUCTION

- Knowledge about the impact of observations is crucial to refine and optimize the observing and data assimilation system.
- An adjoint model is not available for the DWD COSMO-DE system, but idealized studies show that ensemble methods can estimate such an impact at a very low computational cost (when the ensemble itself is computed anyway).

GOALS

- Estimate the impact of observations (i.e. contribution to the reduction of forecast error) in the future regional LETKF data assimilation system of DWD (COSMO-KENDA).
- Use verification with (independent) observations instead of analysis in model space.
- Verification with COSMO observations, radar-derived precipitation and GPS humidity.

METHOD

J : Observation Impact

Y_a^d : Analysis ensemble

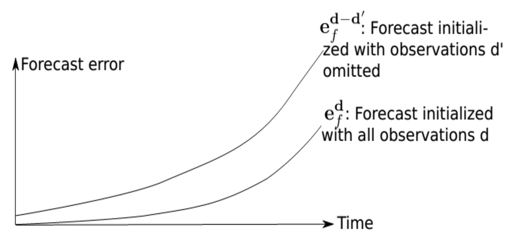
Y_f^d : Forecast ensemble in obs . space

R : Obs. error cov. matrix

$$J(d') \approx \frac{2}{N_e - 1}\, e_f^d \cdot Y_f^d \left(Y_a^d\right)^T R^{-1} d'$$

Super-script "d": set of observations used in analysis

Sub-script "f": forecast



N_e: Number of ensemble member

d' : Innovation vector of subset of observation

$$d = y_o - y_b$$

e_f^d : Forecast error

$$e_f^d = \overline{H_{veri}(x_f^d)} - y_{veri}$$

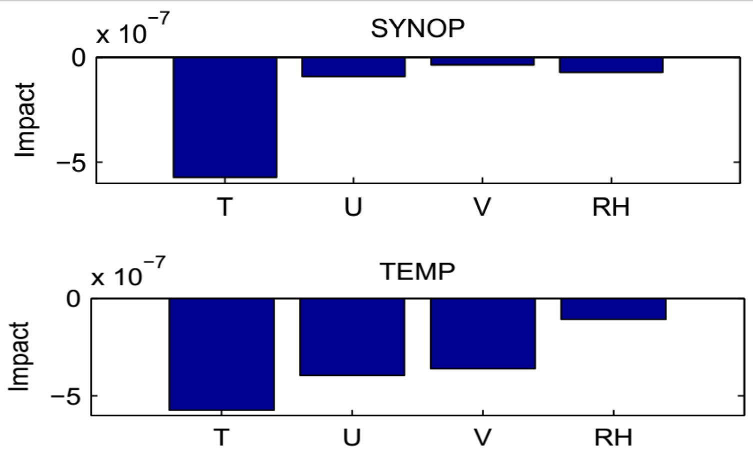
Overbar: Ensemble mean

y_{veri} : Observation used for verification → ***NEW: Precipitation***

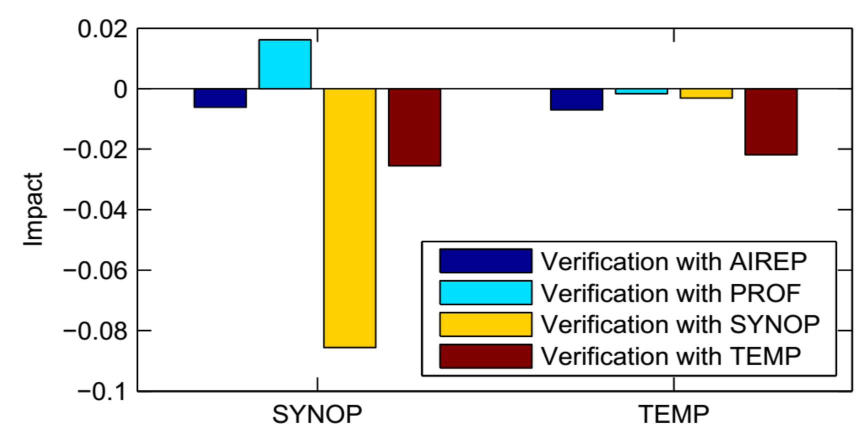
H_{veri} : observation operator into verification space

OBSERVATION IMPACT

Negative impact - Observation helpful

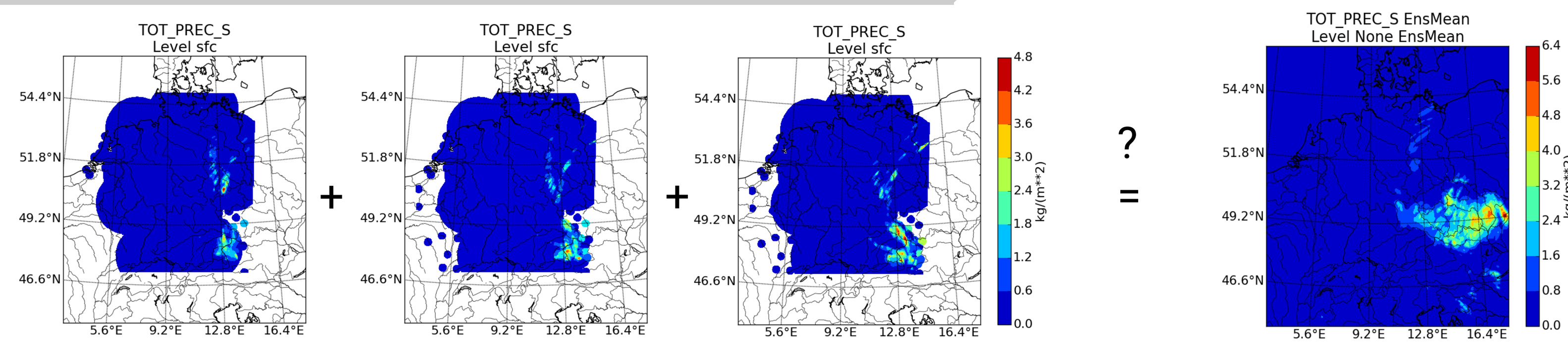


Temporally averaged observation impact per observed variable

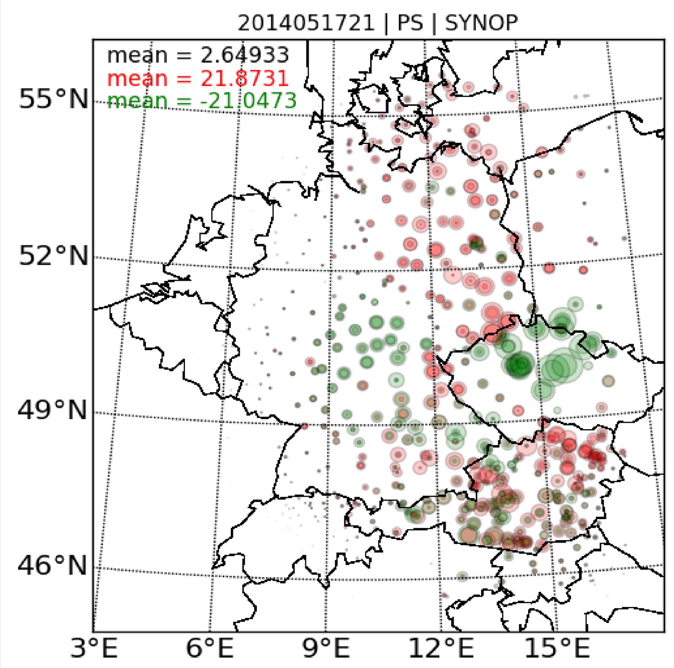


Impact for different verification metrics

VERIFICATION WITH PRECIPITATION



*1h accumulated **observed** radar derived precipitation rates* | *3h accumulated precipitation **model** forecast*



Why radar-derived precipitation?
- Precipitation is a quantity of interest for many costumers
- Indirect verification with radar data (spatial coverage)

Spatial impact distribution of SYNOP surface pressure (PS) observations verified with radar derived precipitation (RW product)

ooo Negative impact: Observation helpful
ooo Positive impact: Observation harmful
17.05.2014 , 21UTC

****** Preliminary *** Prove of concept *** Only 5 member *****

REFERENCES

Sommer, M. and M. Weissmann, 2014: Observation Impact in a Convective-Scale Localized Ensemble Transform Kalman Filter, *Q. J. R. Meteorol. Soc.*, 140, 2672–2679.

Sommer, M. and M. Weissmann, 2015: Ensemble-based approximation of observation impact using an observation-based verification metric. *Tellus*, in preparation.