Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Towards the assimilation of radial winds in an ensemble Kalman filter on the convective scale

5 March 2018
ISDA 2018, Munich

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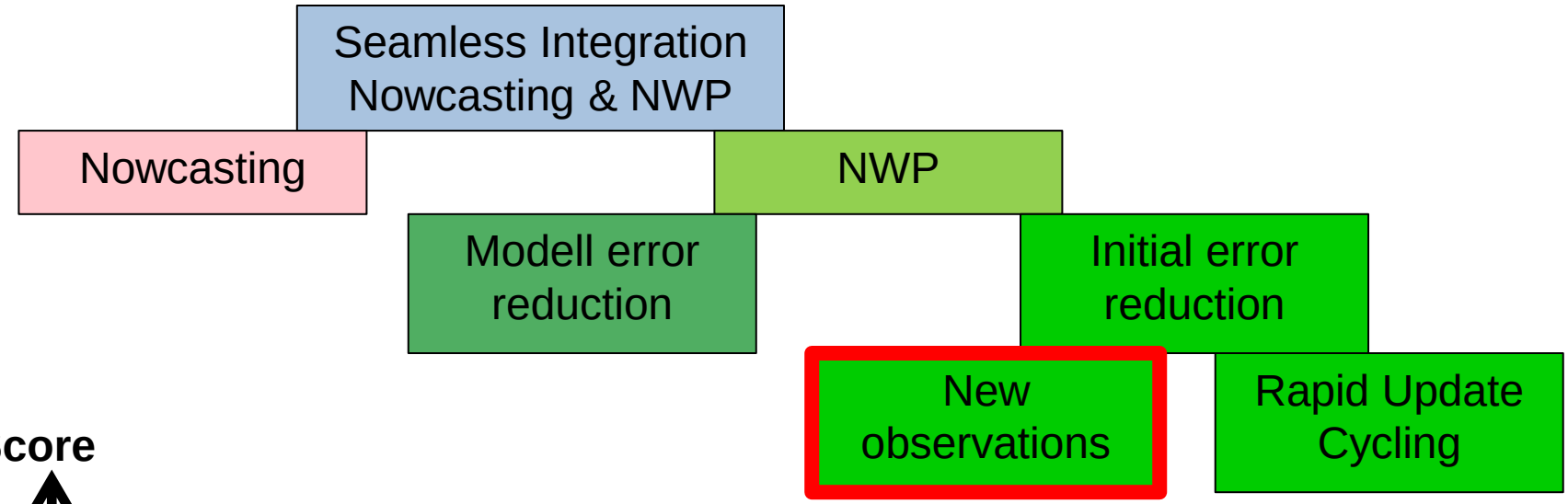
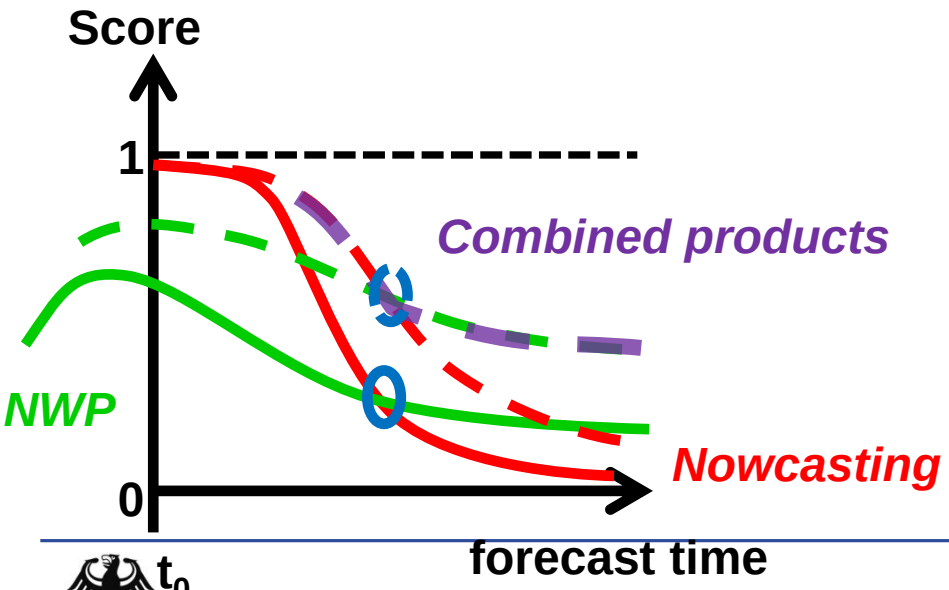
In collaboration with: K. Stephan, U. Blahak, C. Schraff, H. Reich, R. Potthast, …

Outline

- SINFONY project
- Radar data
- Data assimilation
- Experiments and results
- Conclusions

- Improvement and combination of nowcasting and numerical weather prediction





SINFONY
- Talks: A. De Lozar
  L. Bach
- Posters: U. Blahak
  C. Welzbacher

Assimilation of radar data in NWP at DWD

Operational:

- **Latent Heat Nudging** (LHN, uses 2D radar derived precipitation rates)
  [K. Stephan et al., QJRMS 2008]

In **development**:

- Assimilation of **reflectivities** within the COSMO-KENDA system:
  - Theresa Bick [T. Bick et al., QJRMS 2016]
  - Alberto de Lozar, Axel Seifert, Christian Welzbacher, Ulrich Blahak, …

- Assimilation of **radial winds** within the COSMO-KENDA system

3D volume radar data

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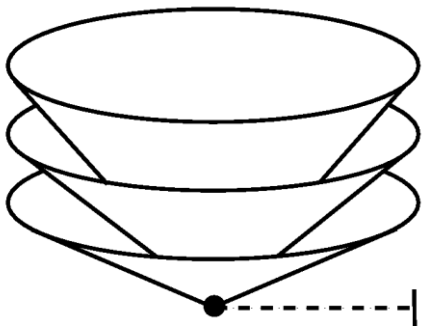
Radar network of DWD:

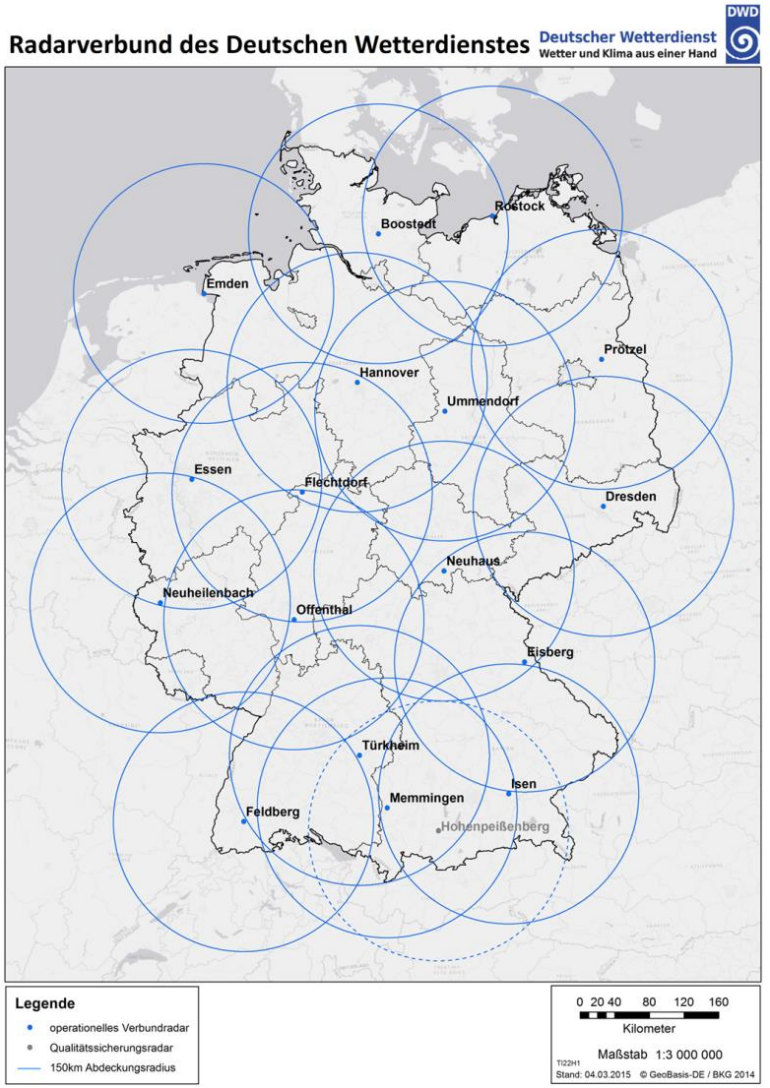
- 17 polarimetric Doppler C-Band radar systems
- **Reflectivities** and **Radial Winds**
- Temporal resolution:

  5 minutes
- Spatial resolution:

  1° x 1 km

  10 elevations (between 0.5° and 25°)



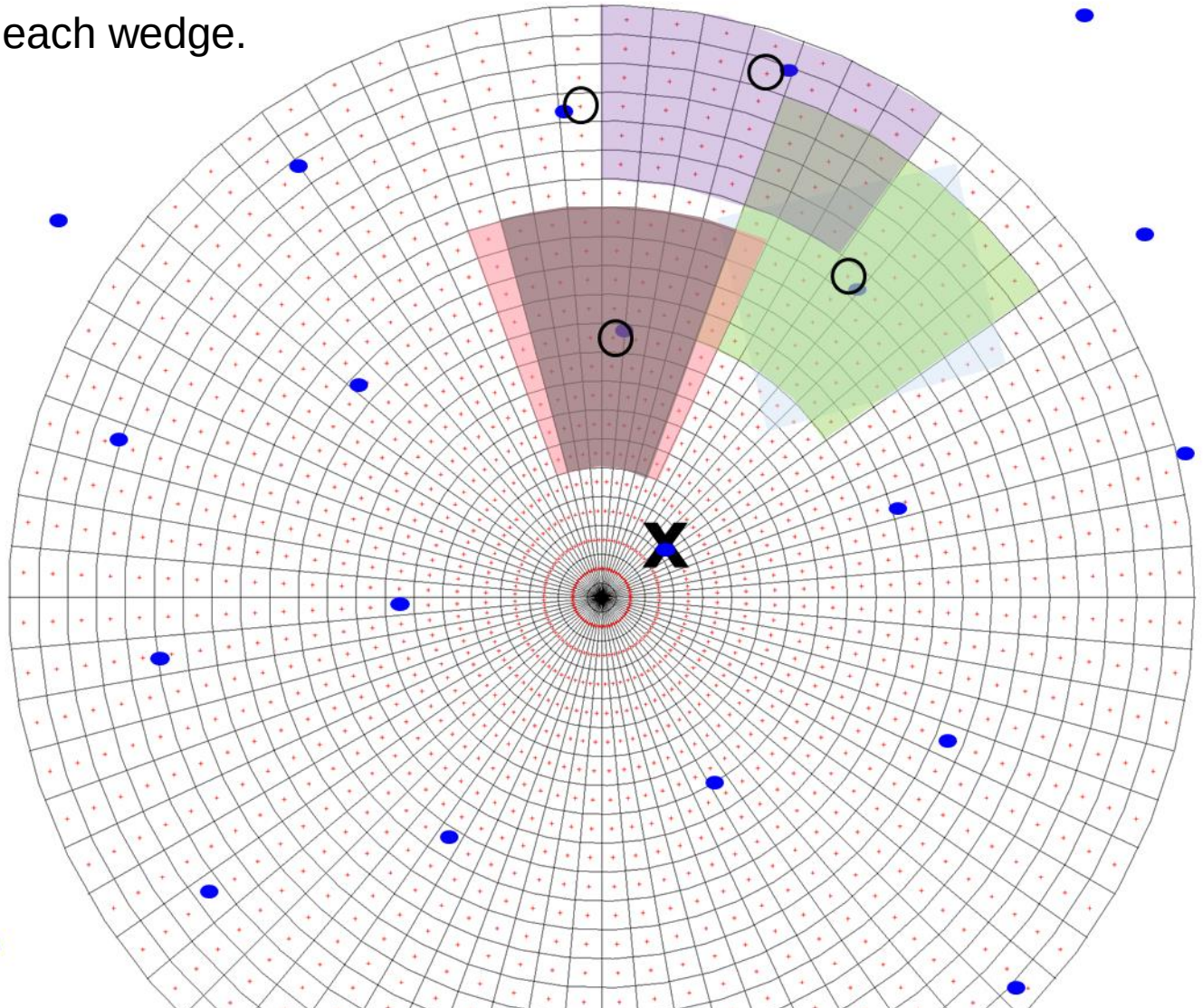


Superobing of radar data

- Superobing for each elevation and radar station.
- Average over each wedge.

2D PPI grid

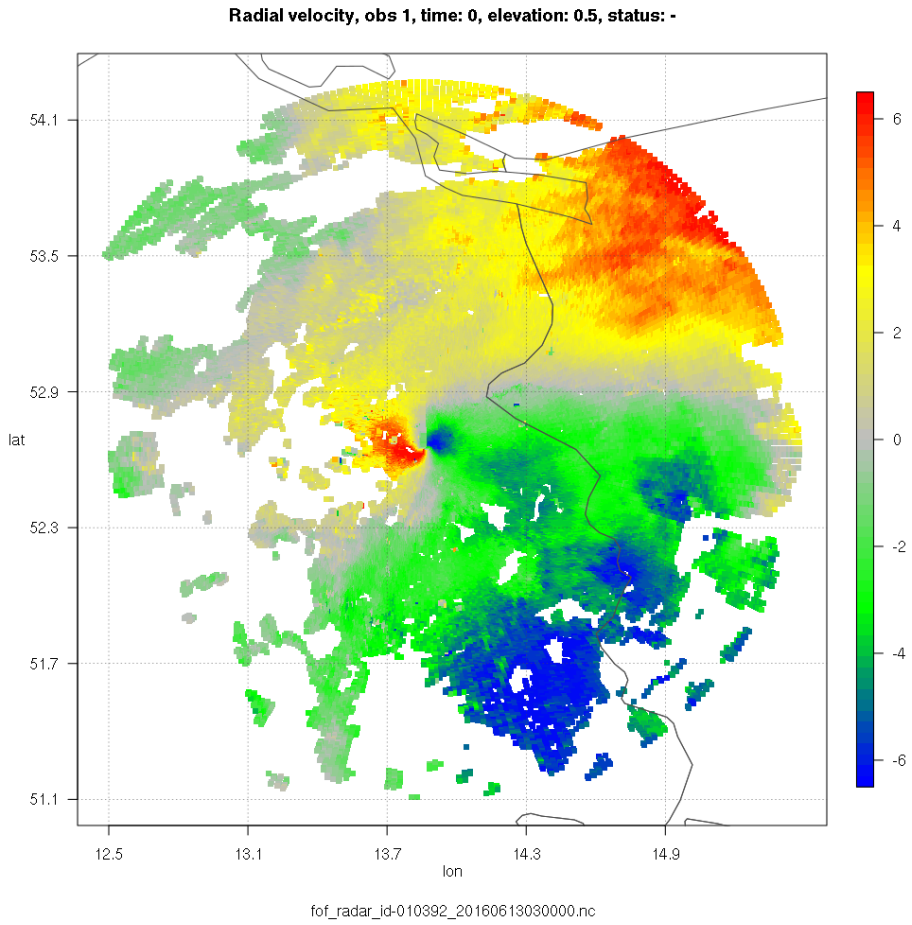
Superobing grid

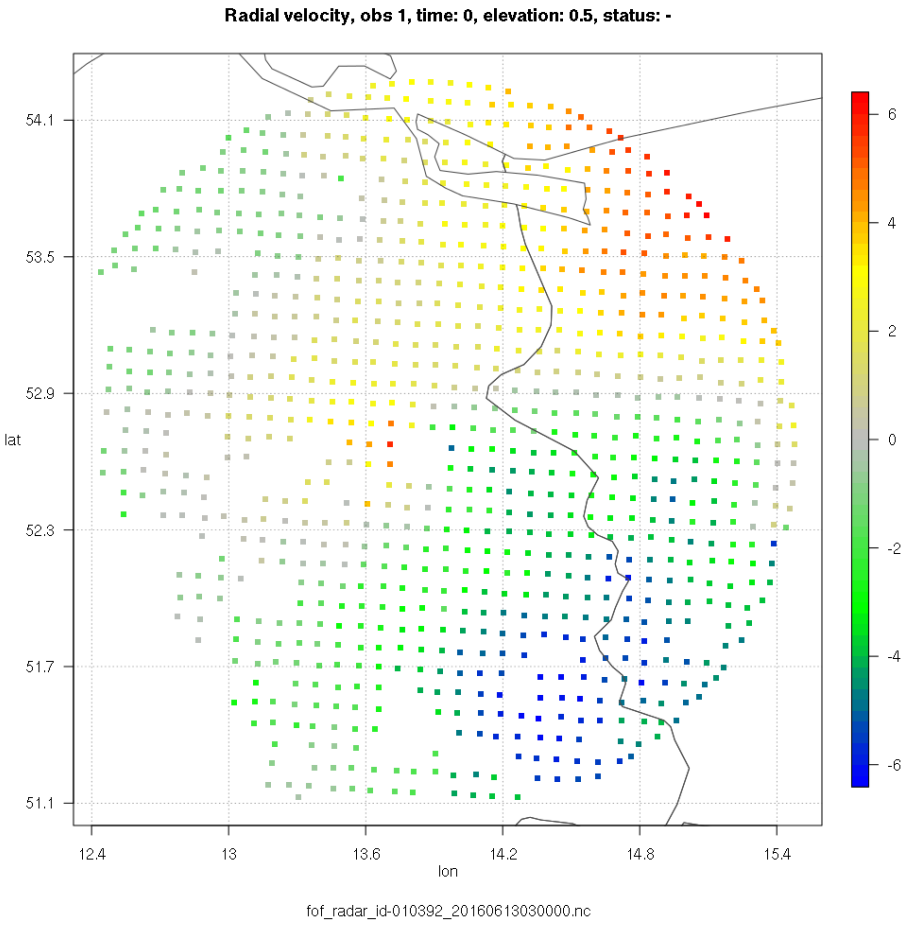


Superobing of radar data

Without superobing

With superobing (here 10 km)





Superobing of radar data

Why superobing?

- **Technical** issues (less memory, less time, …)
- Spatial resolution of superobing data should be coarser or equal to the **effective resolution** of the model.
- A too large number of high resolution data might result in an im**balance between this data and conventional observations** with regard to the influence in the data assimilation process.
- The data assimilation system (LETKF) does **not yet account for correlations of observation errors**.

Experimental setup

- Regional model:

  COSMO-DE (V5.04d; **2.8 km** horizontal grid resolution)

- Data assimilation system:

  KENDA (Kilometer-scale ENsemble Data Assimilation)

  [C. Schraff et al., QJRMS 2016]

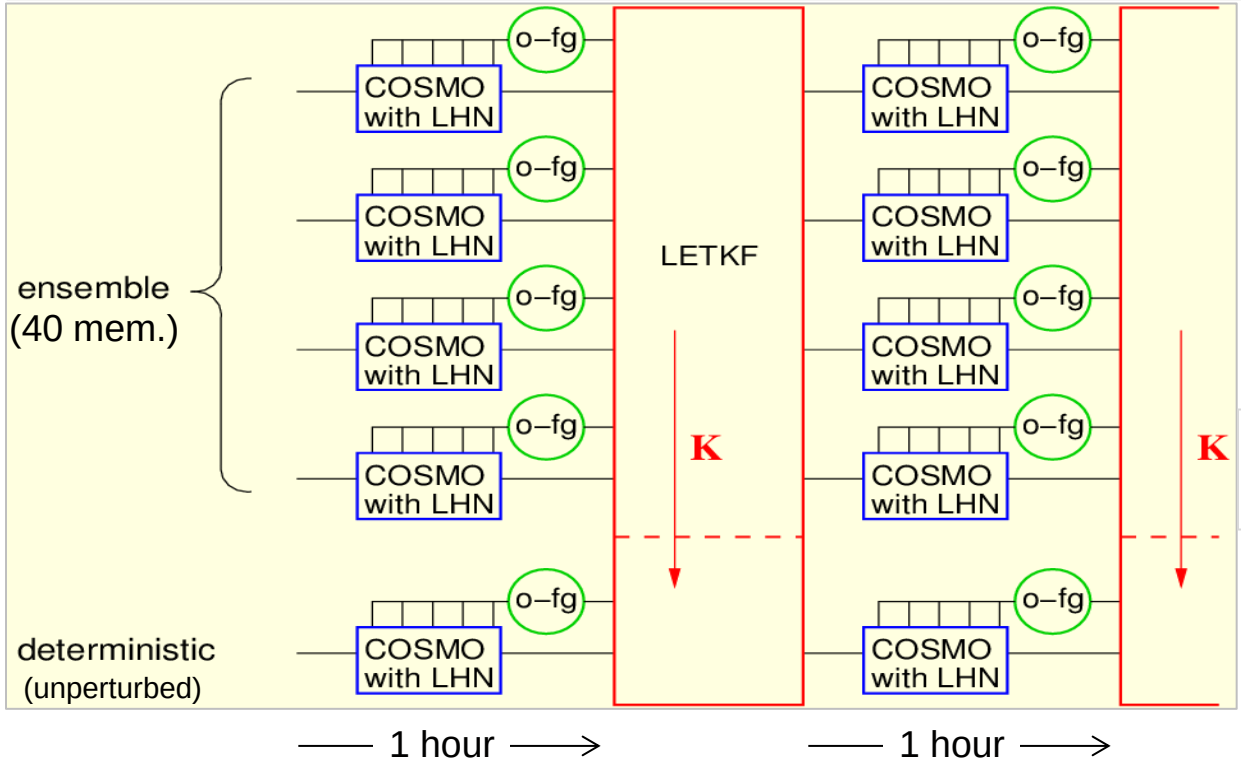
- Radar Observation Operator:

  EMVORADO (Efficient Modular VOlume scanning RADar Operator)

  [Y. Zeng et al., QJRMS 2016]

KENDA-LETKF:

KENDA: 4D-LETKF + LHN (latent heat nudging for assimilation of radar precip)



→ **K**: Kalman Gain for ensemble mean

Modelspace
x

Observation operator

H(x,t)

Obs-space
{o-H(x,t)}

o observations
fg first guess H(x,t)
(model equivalents)

QC: obs – first guess statistics

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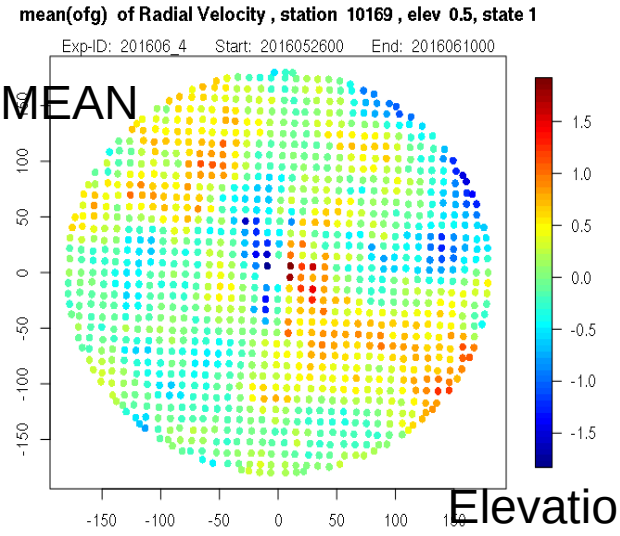
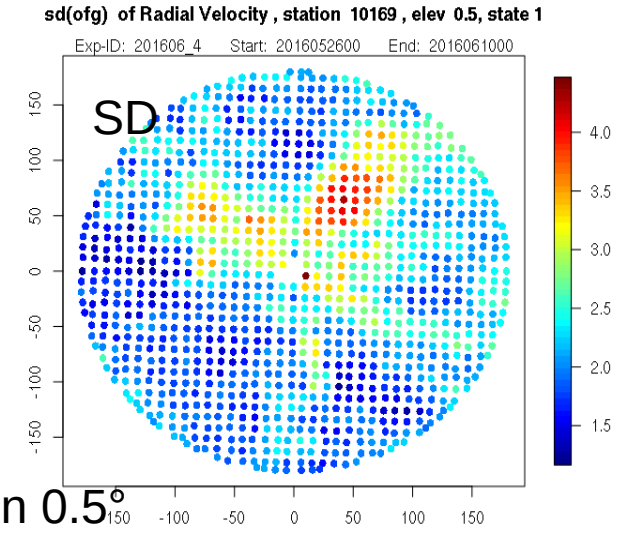
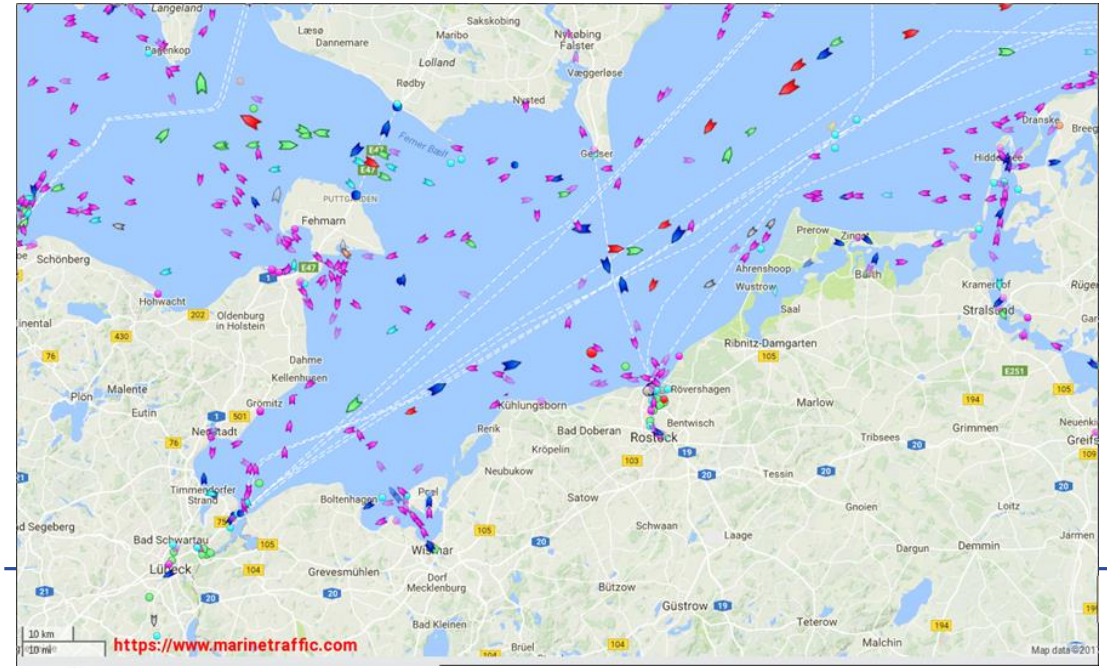
- **Signature of ships**

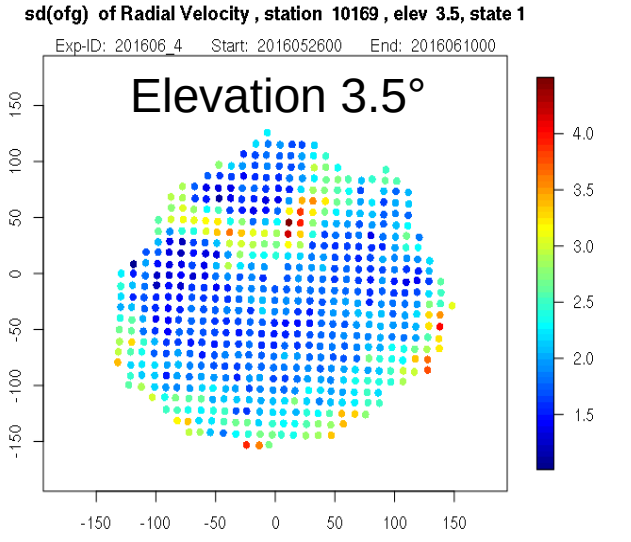
Radar Rostock





Elevation 0.5°

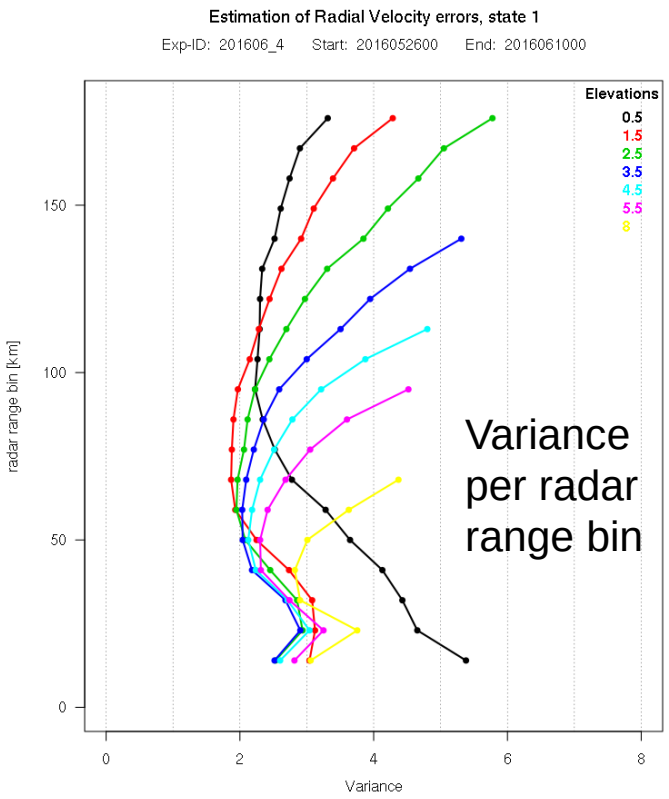


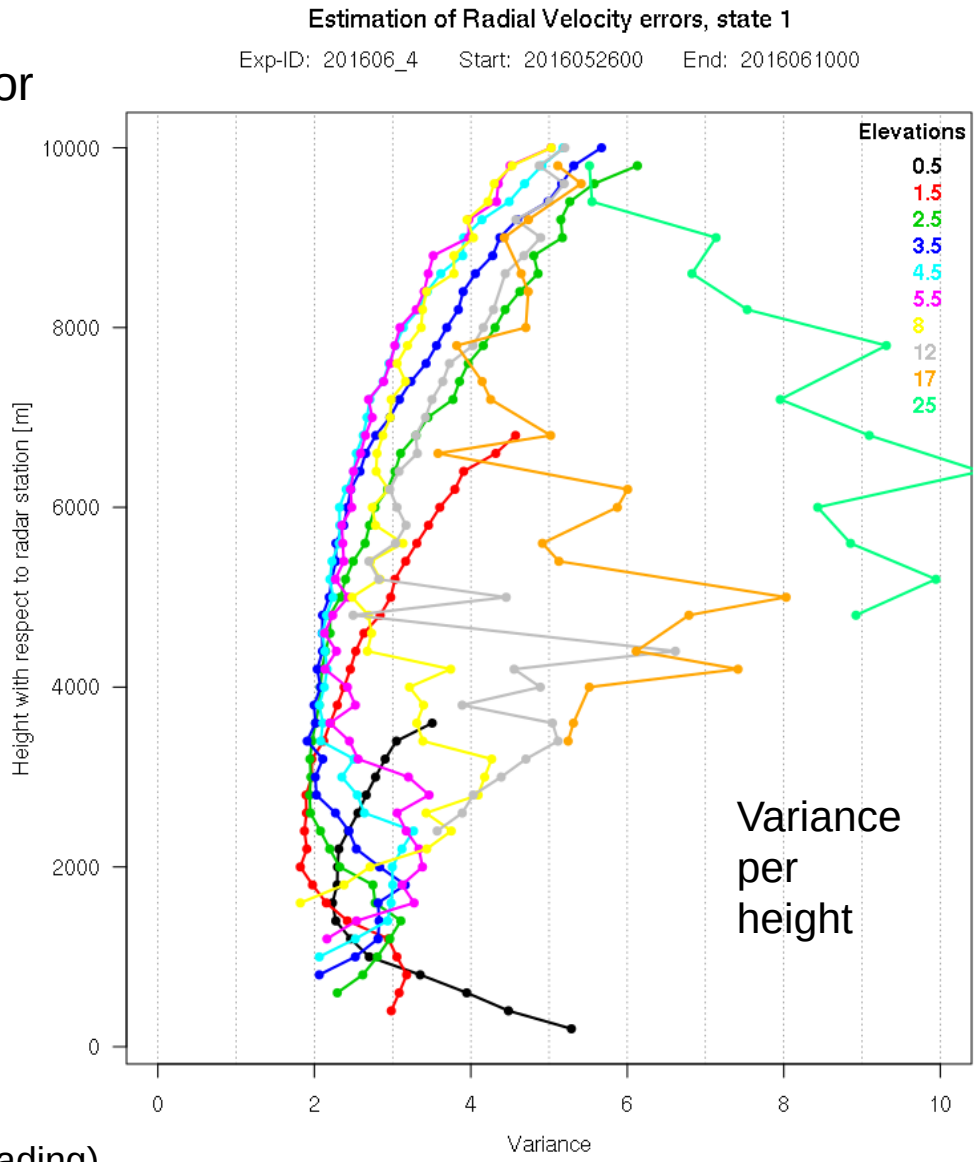


Desroziers-statistics of superobservations

- Estimating the observation error (for R-Matrix in the LETKF)

$$E[(obs - fg)(obs - ana)]$$





(Collaboration with J. Waller, Reading)

Experiments

- Period: 26.05.2016 to 30.06.2016
  (Severe **convective events**)
- Analysis updates: **hourly**
- Forecast every 6 hours (0, 6, 12, 18 UTC)

From previous experiments:

- „**Temporal thinning**:“
  Only radial winds from scans every hour
  (i.e. at analysis time)
- Use of **lower elevations** only


(source: http://strangesounds.org)

Experiments

Setup for the experiments is close to the operational KENDA setup at DWD.

- Reference: **201606_modeS_ref**
  - Latent heat nudging (**LHN**)
  - Assimilation of **conventional observations** (SYNOP, TEMP, AIREP, PILOT)
  - Assimilation of **modeS** data (operationally used since October 2017)
- Experiment: **201606_modeS_el124**
  - Additionally assimilation of **radial wind** data from **elevations 0.5°, 1.5° und 3.5°**, only from **hourly** radar scans.

Precipitation (29.5.2016, 12 UTC + 6h)

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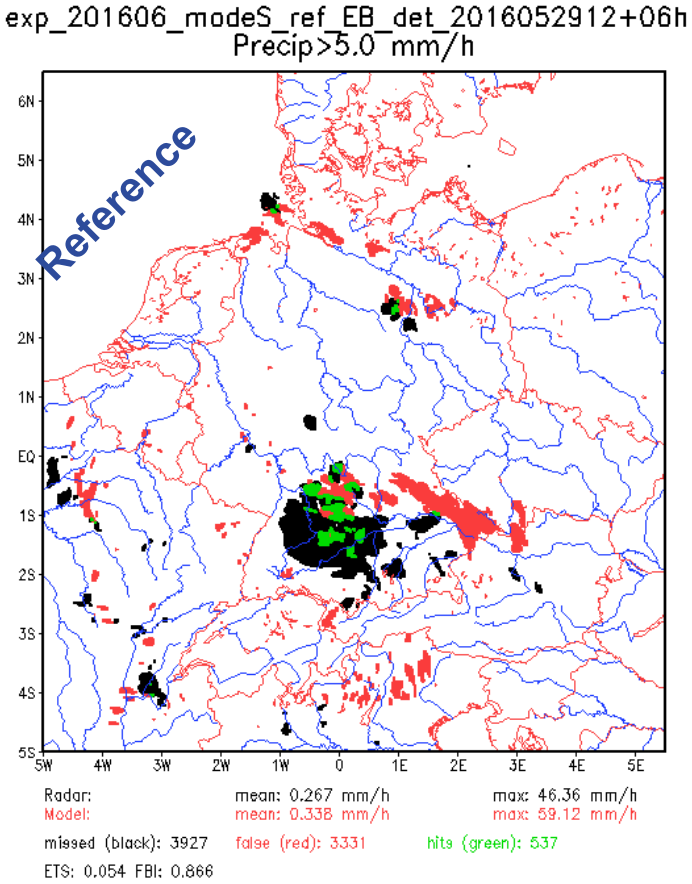
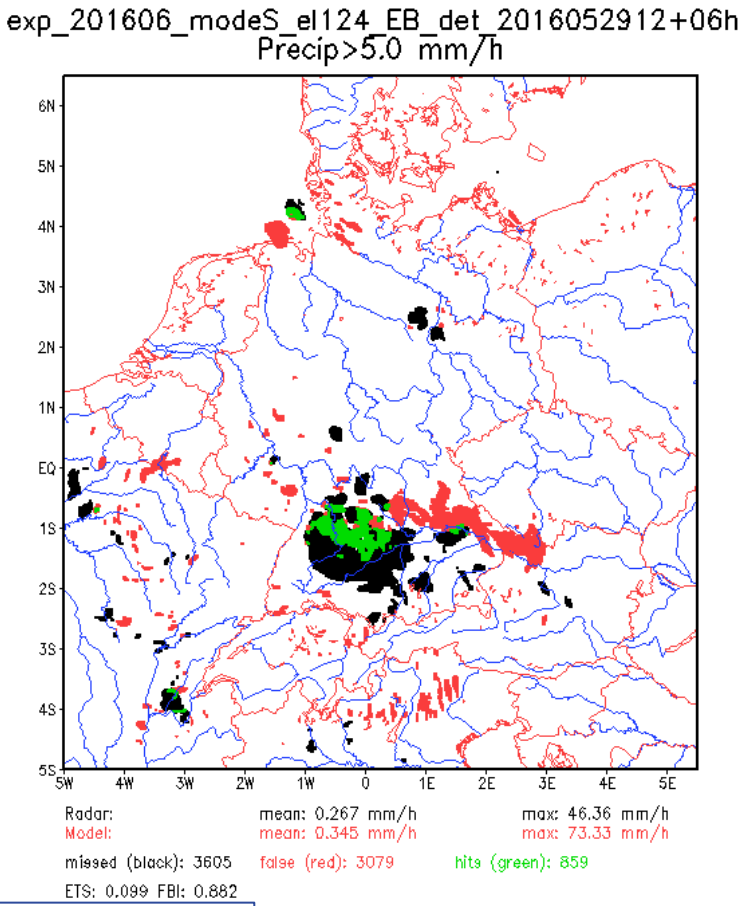
Comparison of precipitation in forecast with radar observations (here threshold **5.0 mm/h**)





ETS: 0.054
FBI: 0.866

black:	**missed**	(obs. yes, model no)
red:	**false alarms**	(obs. no, model yes)
green:	**hits**	(obs. yes, model yes)

ETS: 0.099
FBI: 0.882

Verification of precipitation

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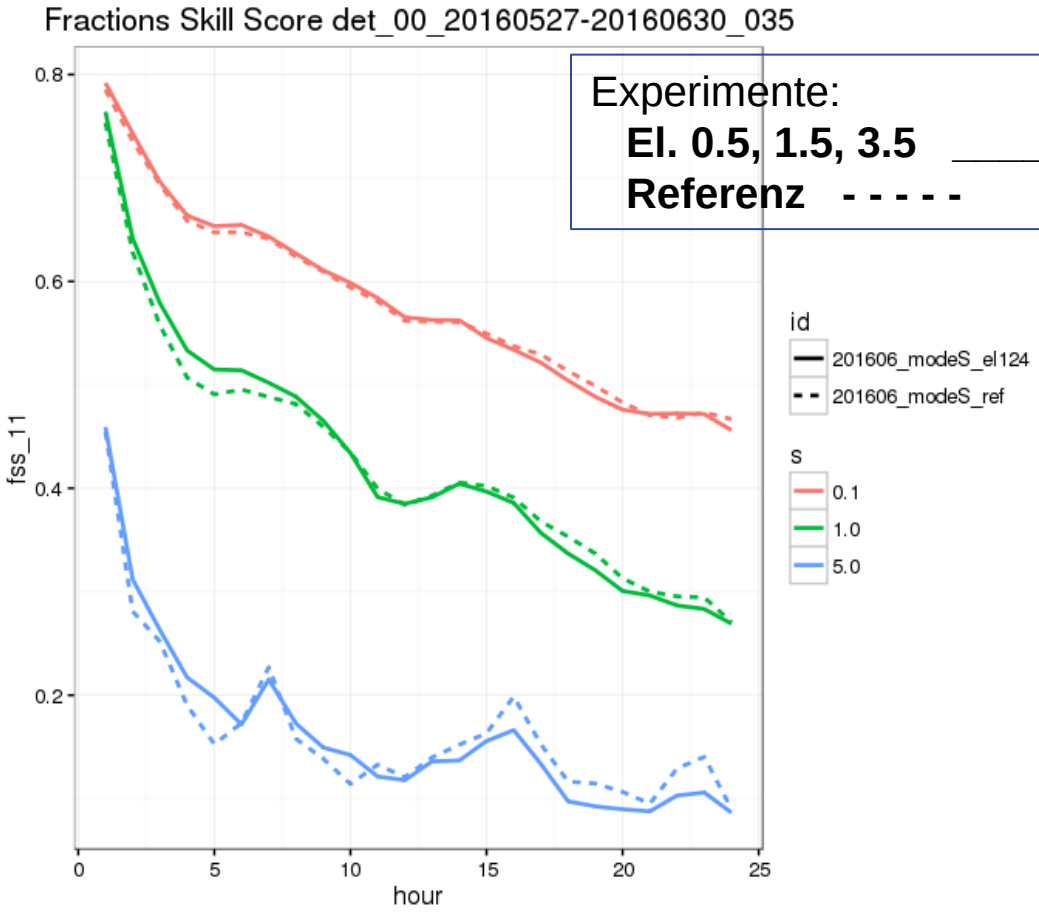
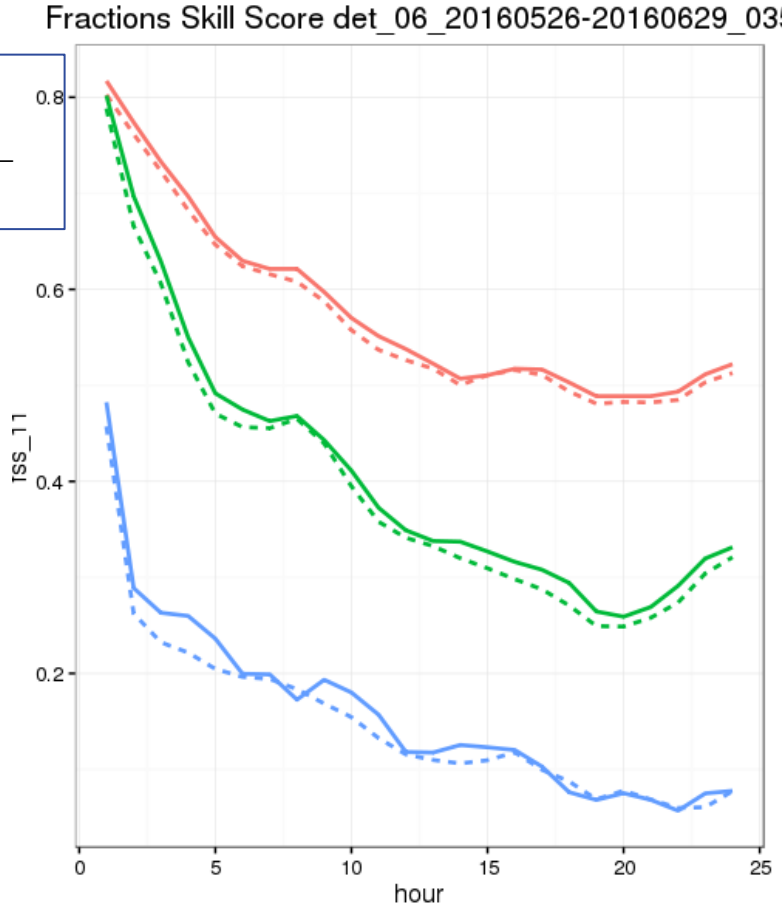
0 UTC - Forecasts



Experimente:
El. 0.5, 1.5, 3.5 _____
Referenz - - - - -

id
201606_modeS_el124
201606_modeS_ref
s
0.1
1.0
5.0

06 UTC - Forecasts

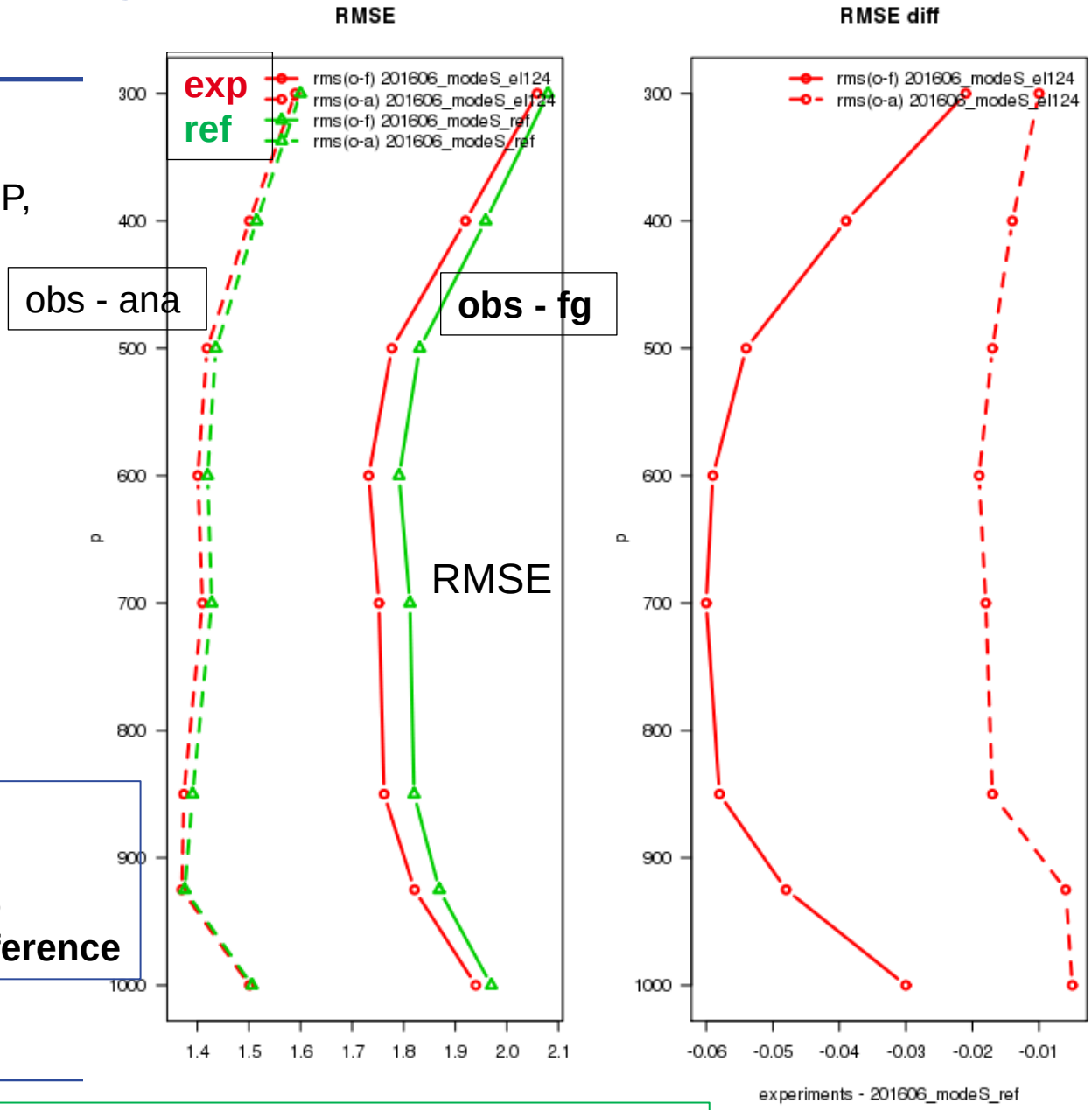


FSS: **Fraction skill score** (perfect: 1)
Threshold: **0.1**, **1.0** und **5.0** mm/h

Slight **positive impact** in 06 UTC forecasts, **neutral** in 0, 12 and 18 UTC forecasts.

Evaluation: Cycling

Wind statistics with observations from AIREP, TEMP and PILOT

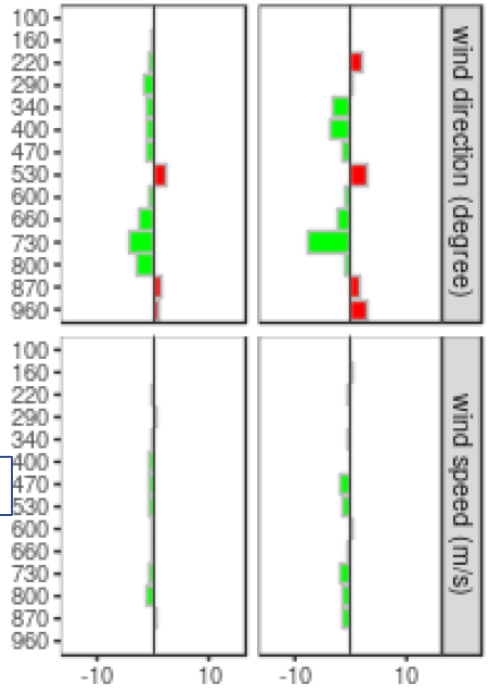


Experiments:
201606_modeS_el124:
El. 0.5, 1.5, 3.5
201606_modeS_ref: **Reference**

➢ **Positive impact** in RMSE (obs-fg).

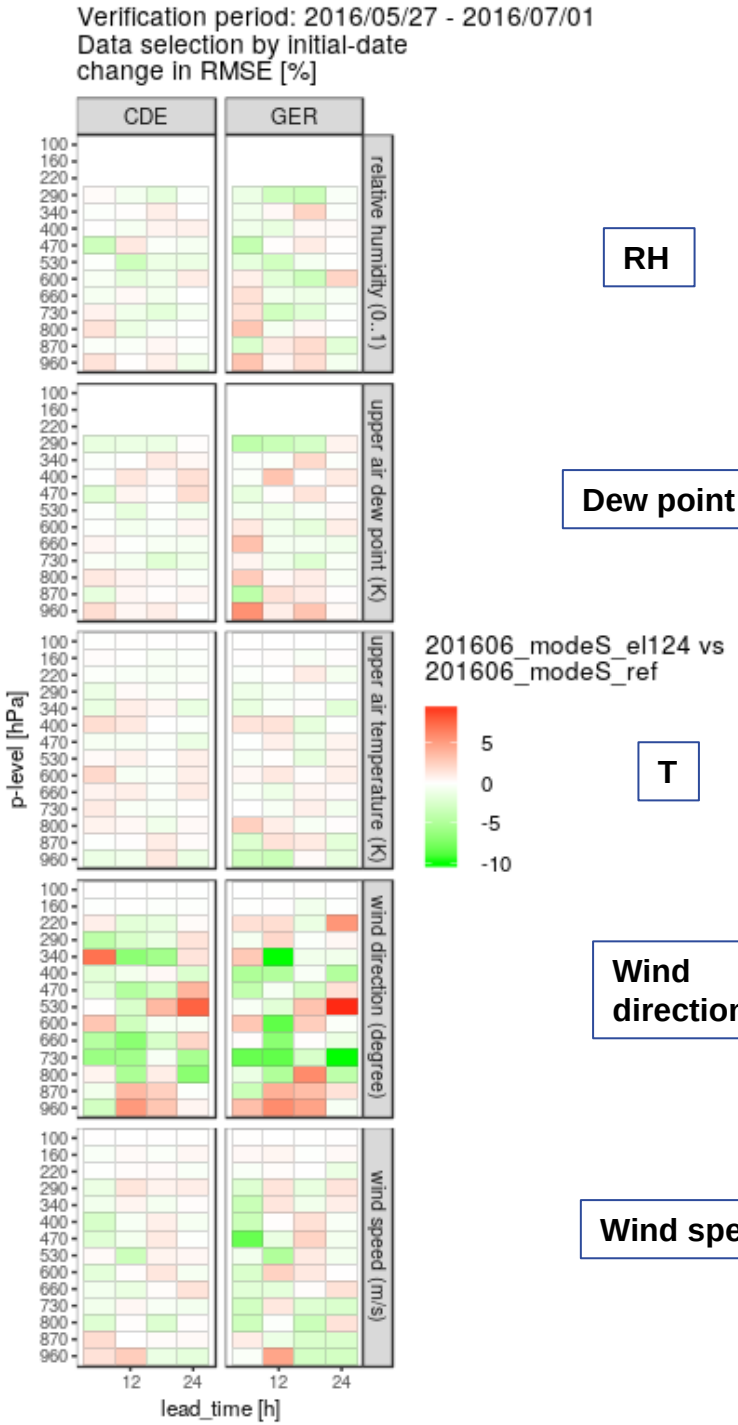
Evaluation: Forecasts

- **Upper air verification** with radio sondes
- Experiments with radial winds from el. 0.5, 1.5, 3.5 versus reference



Wind direction

Wind speed



RH

Dew point

T

Wind direction

Wind speed

Conclusion

- The assimilation of radial winds in the KENDA+LHN system at DWD shows **positive impact** and is going **towards operational use**.
- **Temporal thinning** of radial wind data is currently useful.
- Data of different elevations show different behaviour in observation error statistics: Choose **subset of elevations**.
- Only **slight positive impact in the precipitation verification**; Comparison to experiments without modeS data show that the impact of modeS data on precipitation has been very positive in May/June 2016 and can hardly be outperformed by the radial winds.
- **Positive impact** in the wind variables of the upper air verification, especially in the **first forecast hours**.
- Evaluation of **winter experiments**.
- Challenge: Check the radial wind **data quality**; use parameters depending on elevation, range, …

Thank you for your attention!

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