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Hans-Ertel-Zentrum für Wetterforschung
Deutscher Wetterdienst

Assimilating 3D radar reflectivity with an Ensemble Kalman Filter on a convection-permitting scale

COSMO User Seminar 2015

Theresa Bick[1,*],
Roland Potthast[2], Clemens Simmer[1], Klaus Stephan[2], Silke Trömel[1], Kathrin Wapler[2]

[1]Meteorological Institute, University of Bonn, Germany
[2]Deutscher Wetterdienst, Offenbach, Germany

[*]thbick@uni-bonn.de

Special thanks to U. Blahak (DWD), H. Reich (DWD), C. Schraff (DWD), Y. Zeng (LMU)

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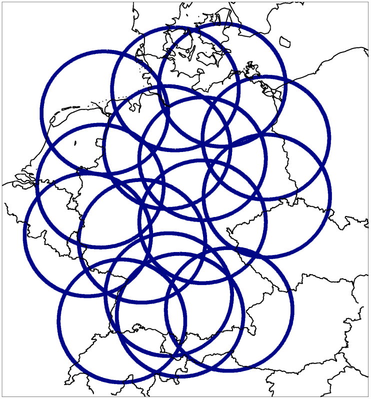
Motivation

Goal

- Improve short-term model forecasts of convective events

Radar data

- High resolution in both space + time, dense coverage
- 3D information
- Here: only radar reflectivity. Radial winds: Y. Zeng (LMU), M. Würsch (LMU) → poster

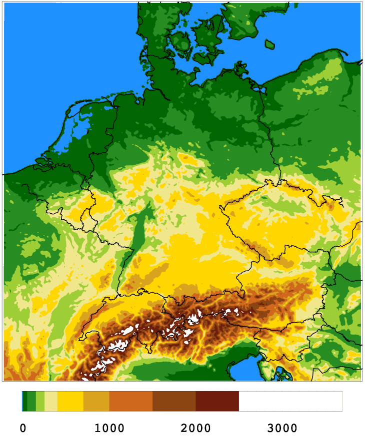


COSMO-DE and LETKF

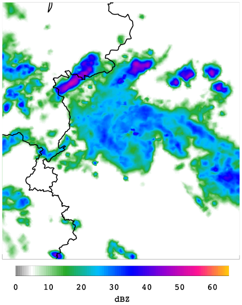
- **KENDA:** Local Ensemble Transform Kalman Filter (**LETKF**) for COSMO-DE (developed at DWD, following Hunt et al., 2007)

- Propagate non-linear model equations
- Estimate flow-dependent covariances

- 40 ensemble members + 1 deterministic run



Radar forward operator



Simulate synthetic 3D radar scan based on COSMO-DE model fields (EMRADSCOPE, developed at DWD/KIT)

- **No-reflectivity:** set all values below 5 dBZ to 5 dBZ
- **Superobbing:** achieve relatively homogeneous horizontal data distribution
  - Reduce computational costs
  - Relax necessity of direct match between model and obs (double penalty problem)

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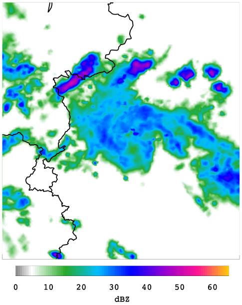

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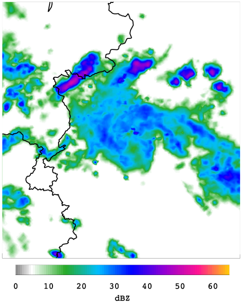
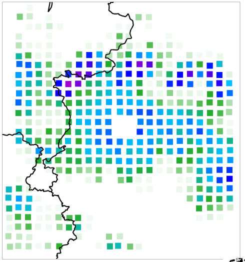




Cycling study

Case study: May 26th 2014

- Spinup from 0-12 UTC (no data assimilation)
- 3h cycling (12-15 UTC) followed by 6h free forecast (15-21 UTC)

CONV

Assimilated obs:
conventional (synop, temp, airep)

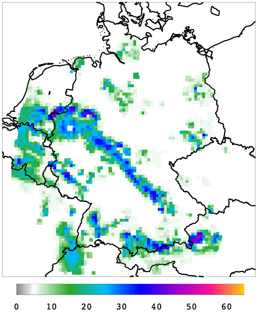
RADAR+CONV

Assimilated obs:
reflectivity, no-reflectivity, conventional

- Study influence of update frequencies: **5, 15, 30, 60 minutes**
- Consider all available data since last analysis

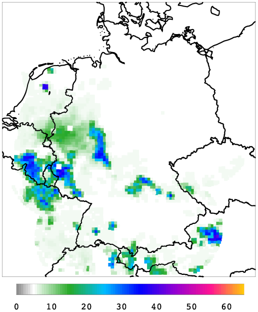
Det run 15min update: Analysis cycle (Reflectivity)

Observation:



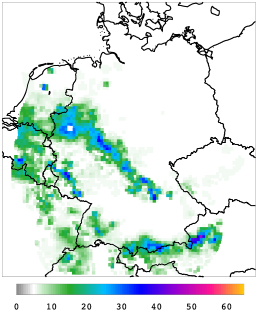
radar reflectivity (obs) 20140526121500
ppi at elevation 0.5deg

CONV:



sim. radar reflectivity (ana_det) 20140526121500
ppi at elev. 0.5deg

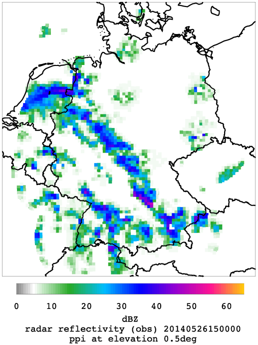
RAD+CONV:



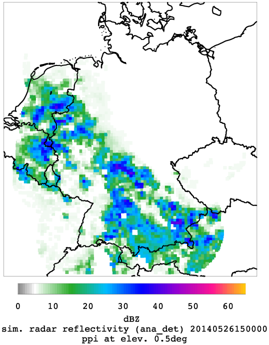
sim. radar reflectivity (ana_det) 20140526121500
ppi at elev. 0.5deg

Det run 15min update: Forecast window (Reflectivity)

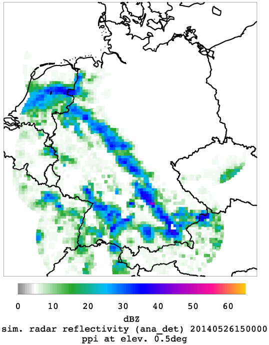
Observation:



CONV:

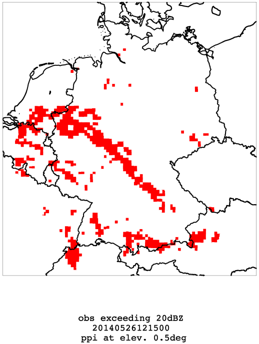


RAD+CONV:

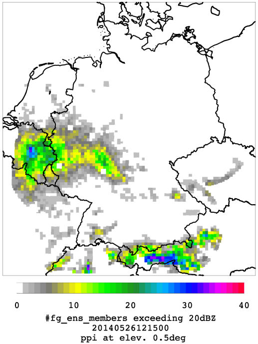


FG ensemble 15min update: Analysis cycle (#ens members > 20dBZ)

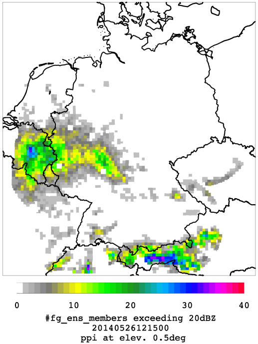
Obs (> 20dBZ):



CONV:

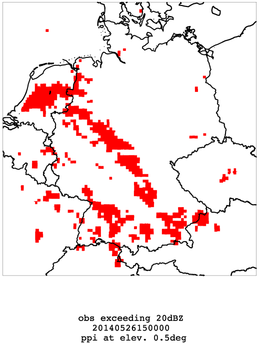


RAD+CONV:



FG ensemble 15min update: Forecast window (#ens members > 20dBZ)

Obs (> 20dBZ):



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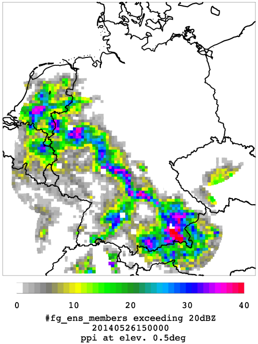

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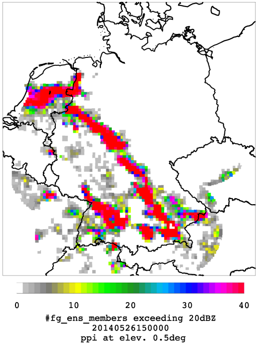


First verification

In observation space: Fraction Skill Score

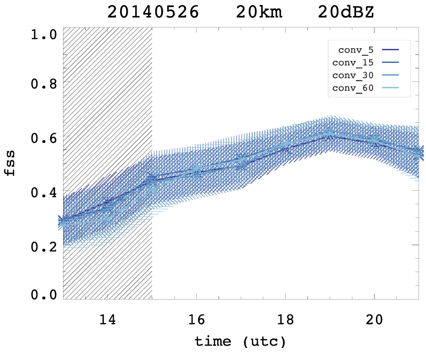
- compares model and observation based on exceedance of a dBZ threshold
- ranges from 0 to 1, perfect score 1

In model space:
Equitable Threat Score, Frequency Bias

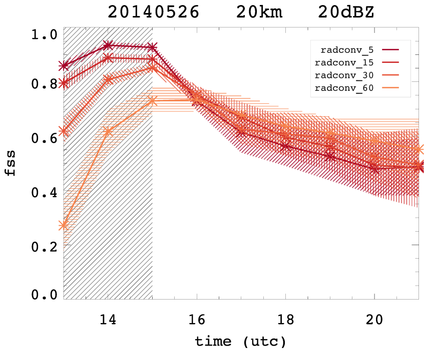
- compares precipitation rate from the model against radar derived precipitation rate (mm/h)
- ETS ranges from -1/3 to 1, perfect score 1
- FBI ranges from 0 to ∞, perfect score 1

Fraction Skill Score

CONV:

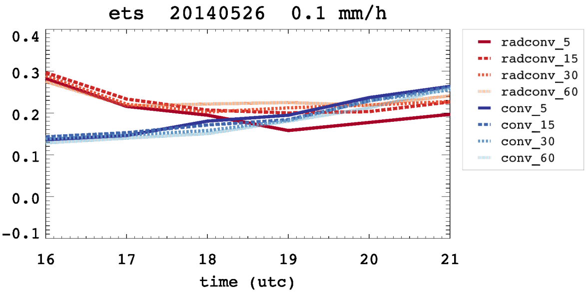


RADAR+CONV:

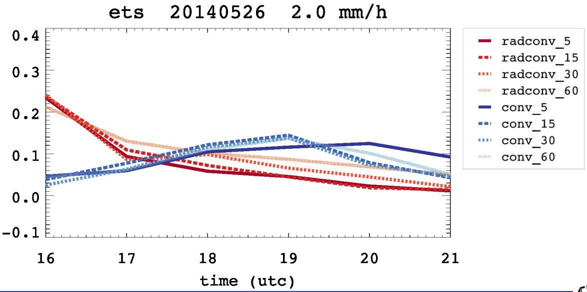


Equitable threat score

0.1 mm/h:



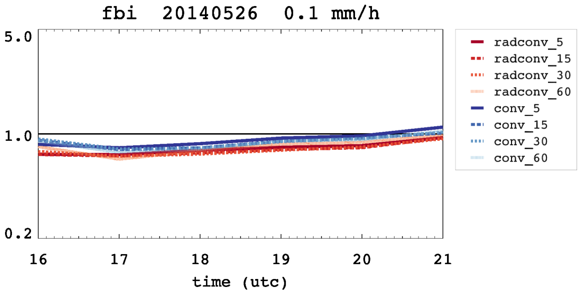
2.0 mm/h:



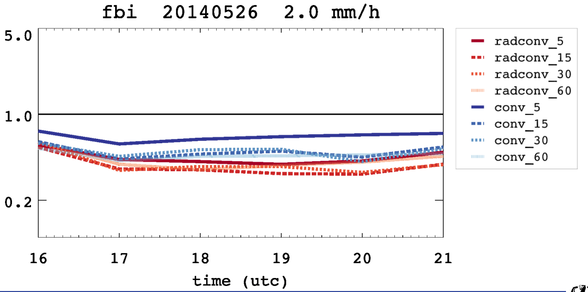
(Forecast initialized at 15 UTC)

Frequency bias

0.1 mm/h:



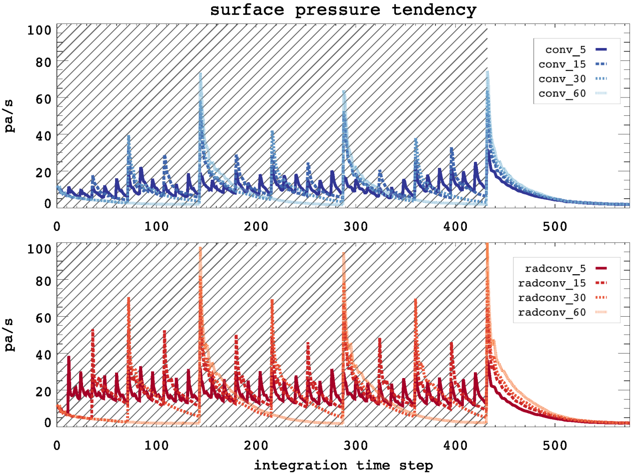
2.0 mm/h:



(Forecast initialized at 15 UTC)

Surface pressure tendency during assimilation

A measure of noise in a model:



Summary: Radar reflectivity assimilation in KENDA

- So far we investigated only 1 case study

- In terms of FSS, assimilating radar reflectivity yields very good agreement between analysis and observation
- Forecast impact is visible during first 2-4 hours in both FSS and ETS
- Underestimation of precipitation intensity in all experiments
- Less precipitation in RADAR experiment - different treatment of no-rain obs necessary?

- After 1h forecast, 60 min update seems superior to 5 min update
- Rapid updates do not allow the model to adjust from changes introduced by data assimilation

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