Validation and Impact Assessment of ADM-AEOLUS Observations in the DWD Modelling System

Alexander Cress Deutscher Wetterdienst
Martin Weissman Hans Ertel Centre for weather research
Roland Potthast Deutscher Wetterdienst

ADM-Aeolus CAL/VAL Rehearsal Workshop, Toulouse, France, 28-30 March 2017

Proposal objectives

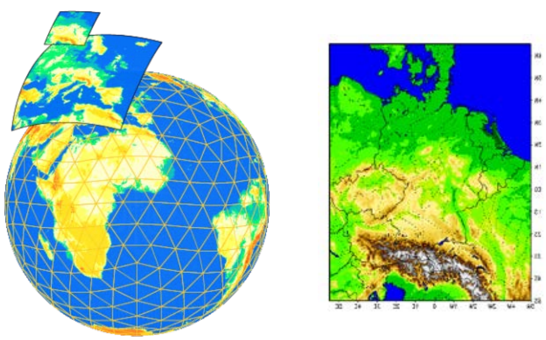
- Estimation of representativity errors for the assimilation of ADM-Aeolus
- Assessment of systematic and random errors of ADM-Aeolus
- Assessment of the impact of ADM-Aeolus observations using the global and regional modelling system of DWD

Description of CAL/VAL techniques applied

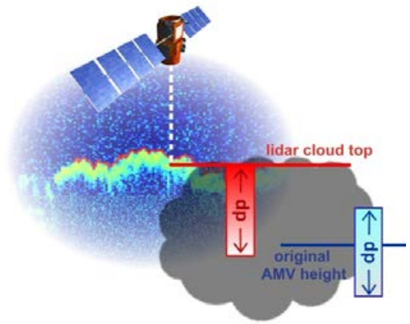
Validation and impact assessment of ADM-Aeolus observations in the DWD modelling system

Martin Weissmann (LMU Munich), Alexander Cress (DWD), Roland Potthast (DWD)

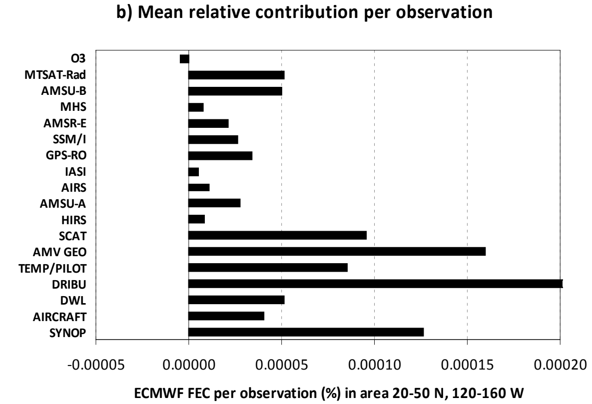
Estimation of representativity errors for the assimilation/validation of ADM-Aeolus observations through high-resolution (500 / 1000 m) simulation



Error assessment in DWD modelling system and optimization of assimilation (assigned errors, volume operator)



Impact assesment through data denial experiments and ensemble-based estimates (FSO)



HERZ Data Assimilation Branch, LMU Munich

The *deterministic* NWP-System of DWD

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Global-Modell ICON

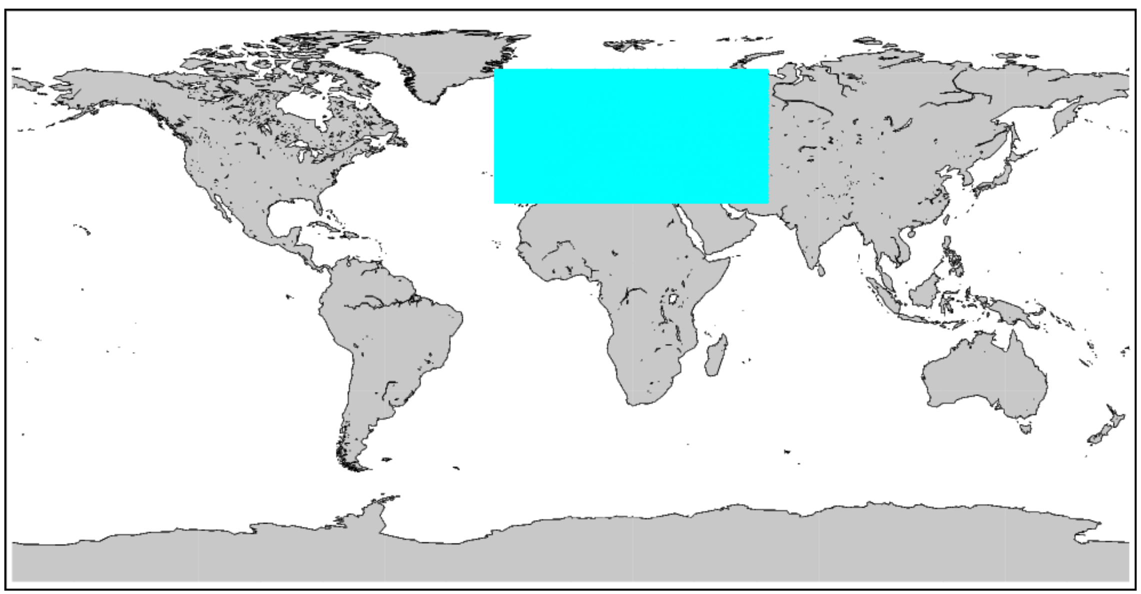
grid size: 13 km
vertical levels: 90
forecasts:
180 h von 00 und 12 UTC
120 h von 06 und 18 UTC
30 h von 03, 09, 15 und 21UTC
Grid area: 173 km^2

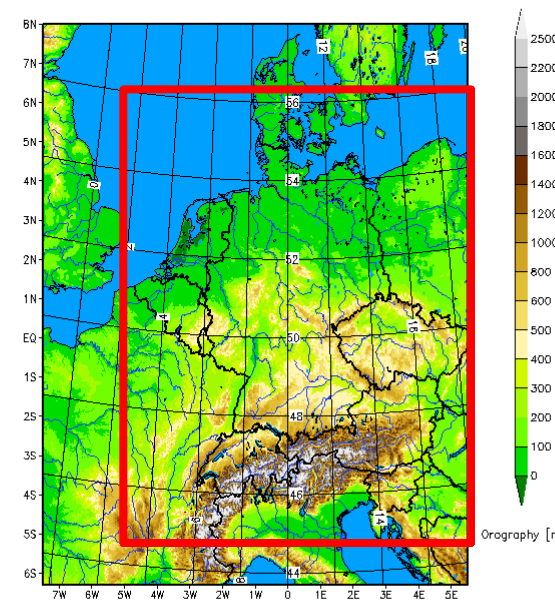
ICON-EU Nest over Europe

grid size: 6.5 km
Vertical levels: 60
forecasts:
120 h von 00, 06, 12 und 18 UTC
30 h von 03, 09, 15 und 21UTC
Grid area: 43 km^2

COSMO-DE (convection resolving)

grid size: 2.8 km
vertical levels: 50
forecasts:
27 h von 00, 03, 06, 09, 12, 15, 18, 21 UTC
421x461 grid size
Girid area: 8 km^2





The *probabilistic* NWP-System of DWD

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

ICON-EPS; M40

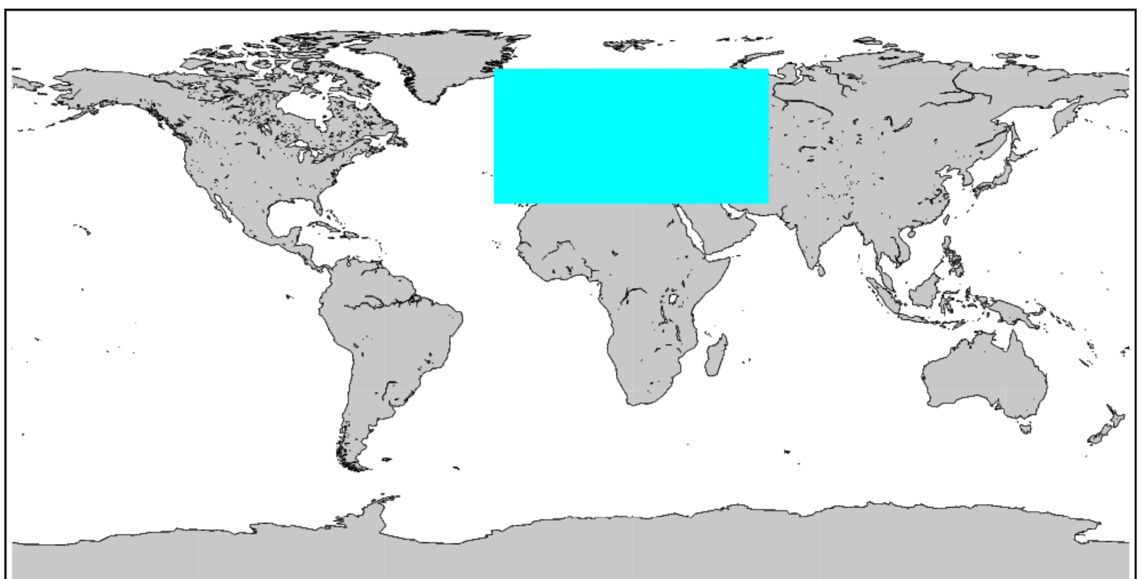
grid size: 40 km
vertical levels: 90
forecasts:
180 h von 00 und 12 UTC
120 h von 06 und 18 UTC
30 h von 03, 09, 15 und 21UTC
grid area: 1638 km^2

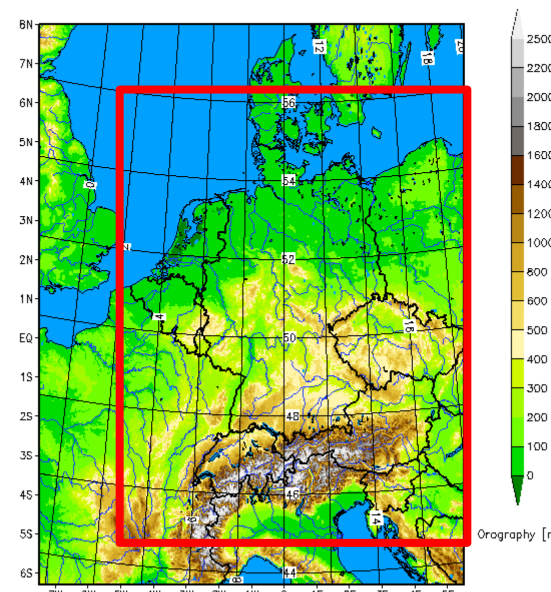
ICON-EU Nest over Europe

grid size: 20 km
vertical levels: 60
forecasts:
120 h von 00, 06, 12 und 18 UTC
30 h von 03, 09, 15 und 21 UTC
grid area: 407 km^2

COSMO-DE-EPS; M20

grid size: 2.8 km
vertical levels: 50
forecasts:
27 h von 00, 03, 06, 09, 12, 15, 18, 21 UTC
421x461 grid points
grid area: 8 km^2





Global
Ensemble Data Assimilation (EDA)

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

- **Implementation following the LETKF method based on Hunt et al. (2007).**
- **VarEnKF. Flow dependent B: $B_{VarEnKF} = \alpha B_{LETKF} + (\alpha-1)B_{3DVAR}$**
- **Boundary conditions for KENDA-COSMO.**
- **Natural initialization for global EPS.**
- **Prior for particle filters.**

Deterministic DA

- 13km/40km 3D-VAR.
- SST, SMA and snow ana.
- Incremental analysis update.

Hybrid DA

- 13km/40km VarEnKF technical tests.

Ensemble DA

- 40 member 40km LETKF.
- Horizontal localization radius 300km.
- Relaxation to prior perturbations (0.75).
- Adaptive inflation (0.9 - 1.5).
- SST perturbations.
- Soil moisture perturbations (experimental)

Kilometer ScaleEnsemble Data Assimilation (KENDA)

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

- **Implementation following the LETKF method based on Hunt et al. (2007)**
  (because of ist relatively low computational costs)
- **Replaced the nudging scheme for COSMO-DE in March 2017**

Advantages against nudging

1. provide **perturbed initial conditions for COSMO-DE EPS**

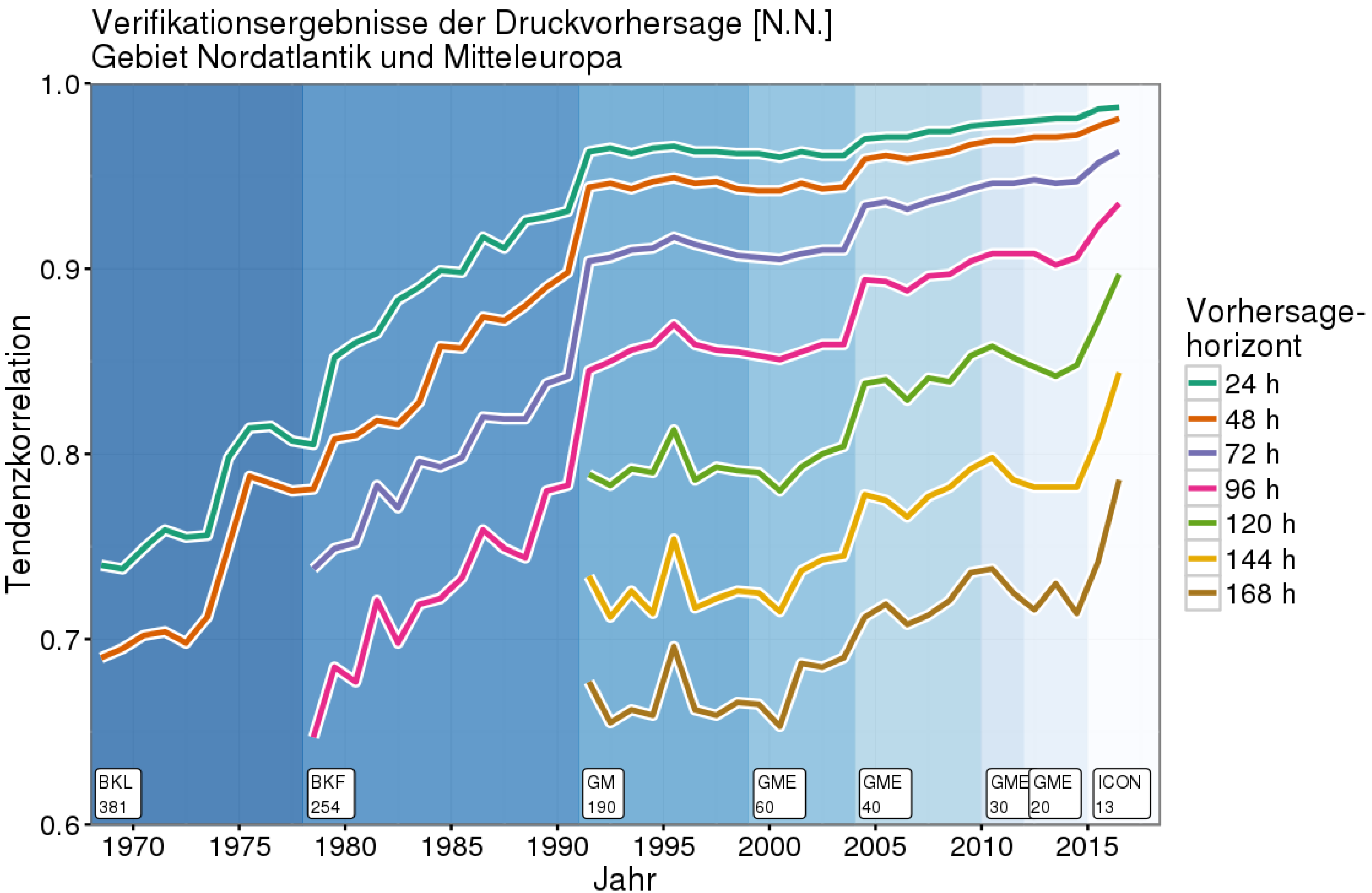
2. improved analysis / forecast quality by use of
   multi-variate, flow-dependent error covariances

3. better suitable than current operational nudging scheme for use of
   indirect observations (**satellite**, **radar**, etc.):
   - nudging requires retrievals (e.g. T-, q- profiles from satellite radiances)
   - EnKF: apply forward observation operator (→ simulated radiances)

Full System with conventional data including LHN is running
(operational since March 2017)

Improvement of forecast quality 1968 - 2016

Deutscher Wetterdienst
Wetter und Klima aus einer Hand



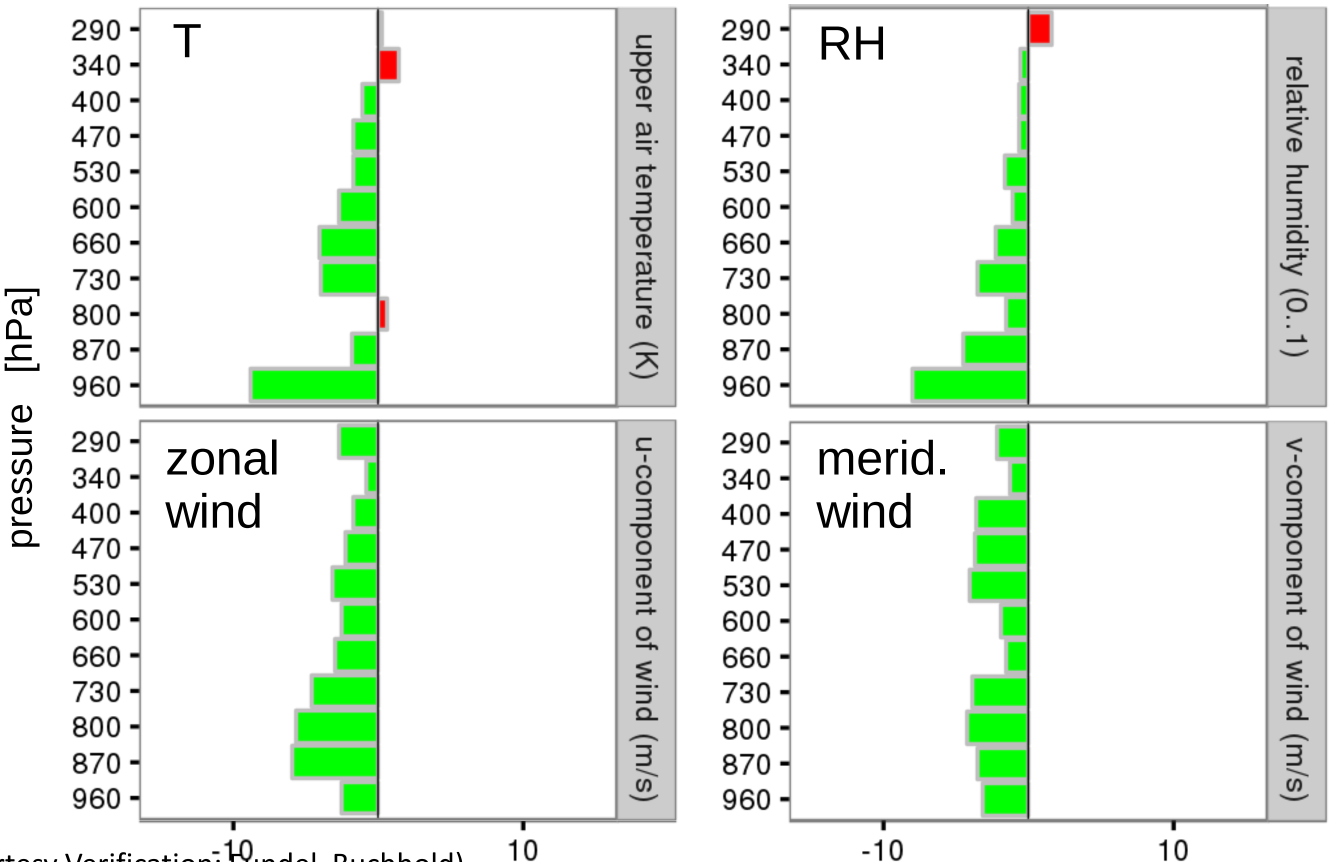
http://141.38.40.96:1111/users/ffundel/veri1968/

Verification COSMO-DE EDA

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Upper Air Ensemble Verification

KENDA-LETKF vs. nudg./multi-model



CRPS
(averaged over lead times & initial times)

better
worse

Expert Evaluation:

✓ KENDA: much better CRPS

(Courtesy Verification: Fundel, Buchhold)

(Courtesy KENDA: C. Schraff and H. Reich)

Verification COSMO-DE EDA

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Precipitation Verification

28 days
18.05. –
15.06.
2014

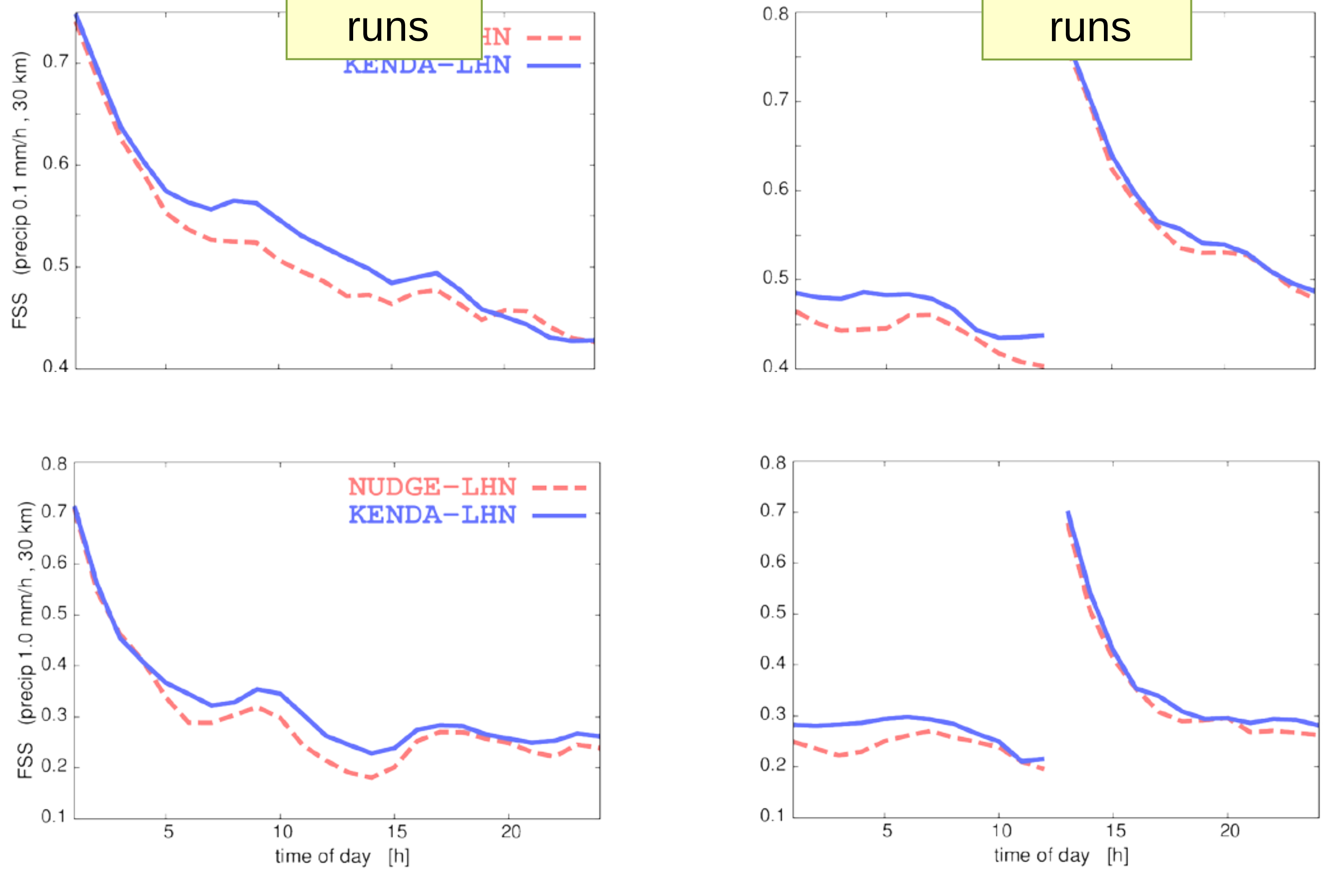
0.1
mm/h

1-hrly
precip
FSS
(30 km)

1 mm/h

0-UTC runs

12-UTC runs



Expert Evaluation:

✓ **with LHN: small difference in first 4 hours due to dominating influence of LHN, thereafter, advantage of KENDA over nudging tends to be larger than without LHN**

Basic Cycling Environment (BACY)

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

- **Cycling is crucial in DA for NWP!**
  Observations are used to correct the forecasted state successively at every analysis time step.
  Model/analysis biases, feedback interactions between both.

- The Basic Cycling (BACY) environment is a collection of scripts, binaries, templates and configurations that allows us to cycle a full DA system in a quasi-operational setup.

- BACY is file based avoiding the access to data base systems which makes BACY much faster.

- Works for deterministic and ensemble systems

- Ideal for monitoring and testing new observation systems

Status of manpower, tools and funding

- DWD NWP analysis and forecast system easy usable (BACY System)
- One PHD student position over three years has been applied for (Located at the Hans Ertel Centre LMU Munich)
- Personal at Deutscher Wetterdienst including computer resources