Initial conditions provided by convective-scale ensemble data assimilation in the COSMO-DE model

Florian Harnisch[1],Christian Keil[2]

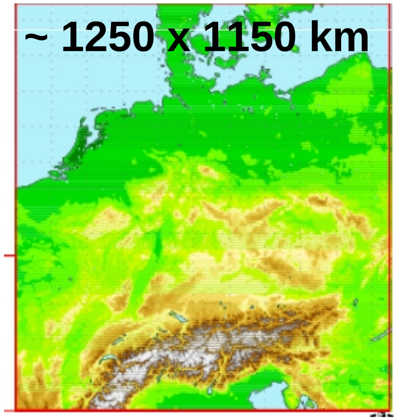
[1]Hans-Ertel-Centre for Weather Research, Data Assimilation, LMU München, Germany
[2]Meteorologisches Institut, LMU München, Germany

Limited Area Model Ensemble Prediction System

COSMO-DE-EPS Δx = 2.8 km (50 levels)

- No parametrization of deep convection
- 20 ensemble member
- 21 hours forecast length, initalized every 3 hours
- Operational since May 2012

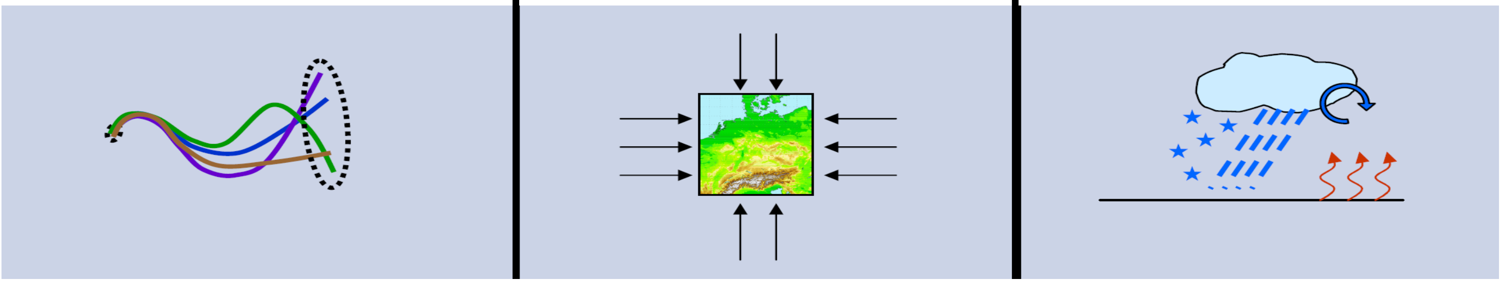
→ Good results for precipitation forecasts
(e.g. Gebhardt et al. 2011, Peralta et al. 2012, Kühnlein et al. 2013)



initial conditions (ICs)

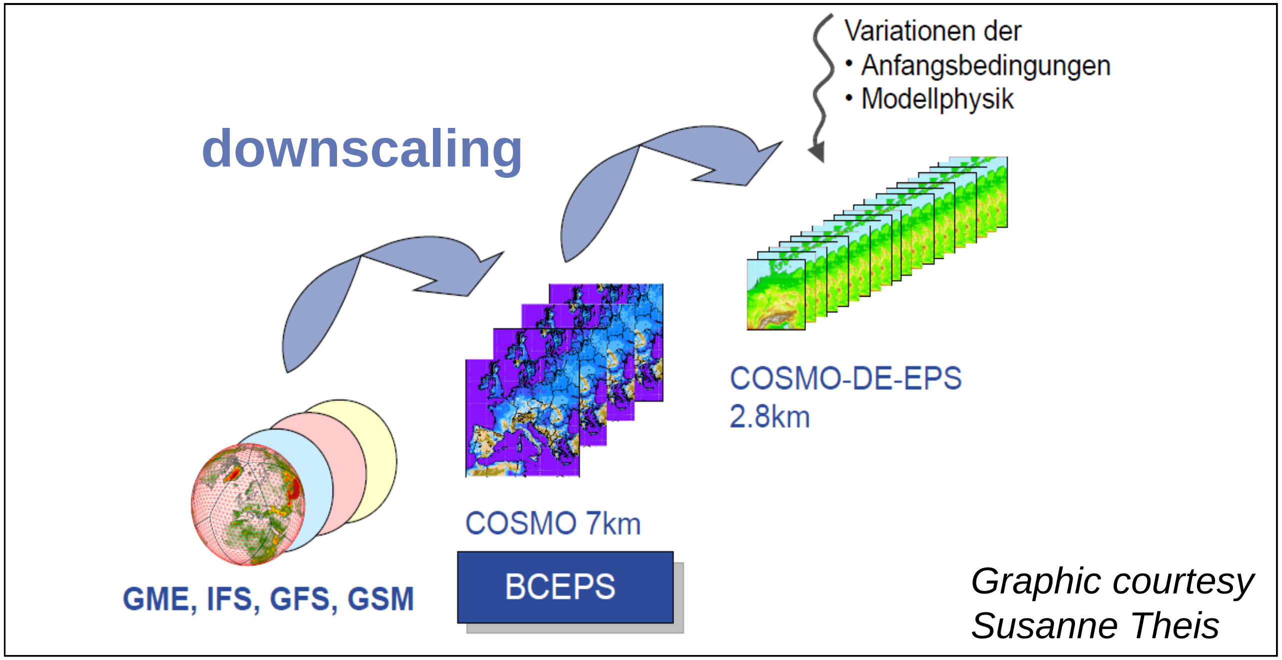
lateral boundary conditions (LBCs)

model formulation



Graphic courtesy Christoph Gebhardt

Setup of operational COSMO-DE-EPS



4 x 5 = 20 ensemble members

(1) ensemble of 4 LBCs (multi-model)

(2) ensemble of 4 ICs (multi-model)

(BCEPS perturbations + deterministic COSMO-DE nudging analysis; vertical filter)

(3) 5 perturbations of model physics parametrization

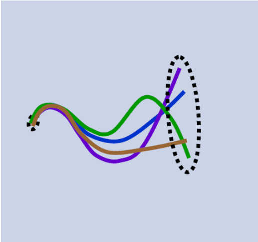
Ensemble data assimilation for COSMO-DE-EPS

- So far: no data assimilation component in COSMO-DE-EPS

KENDA: Kilometer-Scale Ensemble Data Assimilation
→ Lokal Ensemble Transform Kalman Filter (**LETKF**) *(Hunt el al. 2007)*

- Experimental setup for data assimilation of conventional observations
- LETKF yields an analysis ensemble (+ optional deterministic analysis)
  → Provides initial conditions for COSMO-DE-EPS forecasts
  → Improved representation of IC uncertainty in COSMO-DE-EPS

→ **What effect do different initial conditions have on ensemble forecasts?**



Overview of experiments

Period of interest: 12 UTC 10 June – 00 UTC 12 June 2012

KENDA:
- 3-hourly LETKF data assimilation of conventional data (TEMP, AIREP, PILOT and SYNOP)
- 3-hourly analysis ensemble with **20** ensemble members
- 20 member ECMWF EPS boundary conditions (Δx =16 km)
- No physics parametrization perturbations (PPP)
- 21 h forecasts at 00 UTC 11 / 12 June 2012

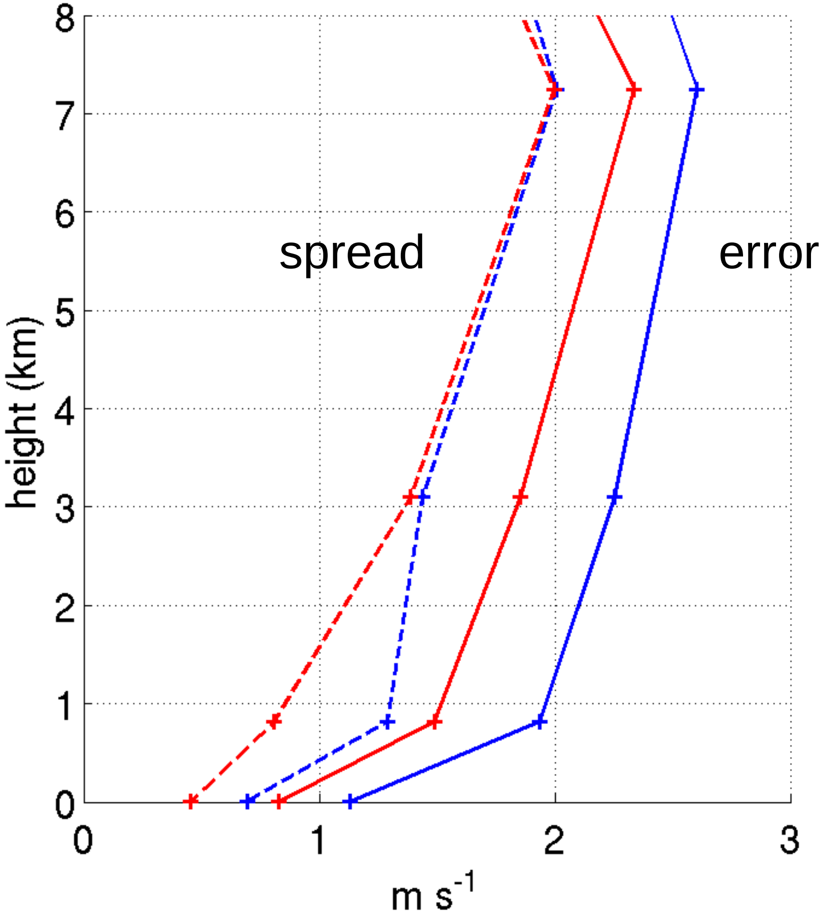
OPER:
- COSMO-DE-EPS (boundary conditions: BCEPS)
- ICPs from downscaled BCEPS + nudging analysis, vertical filter
- 5 model physics parametrization perturbations

Ensemble mean error and ensemble spread

- Average over 11 cycles
- Verification against COSMO-DE analysis
- OPER has smaller error:
  → choice of verification

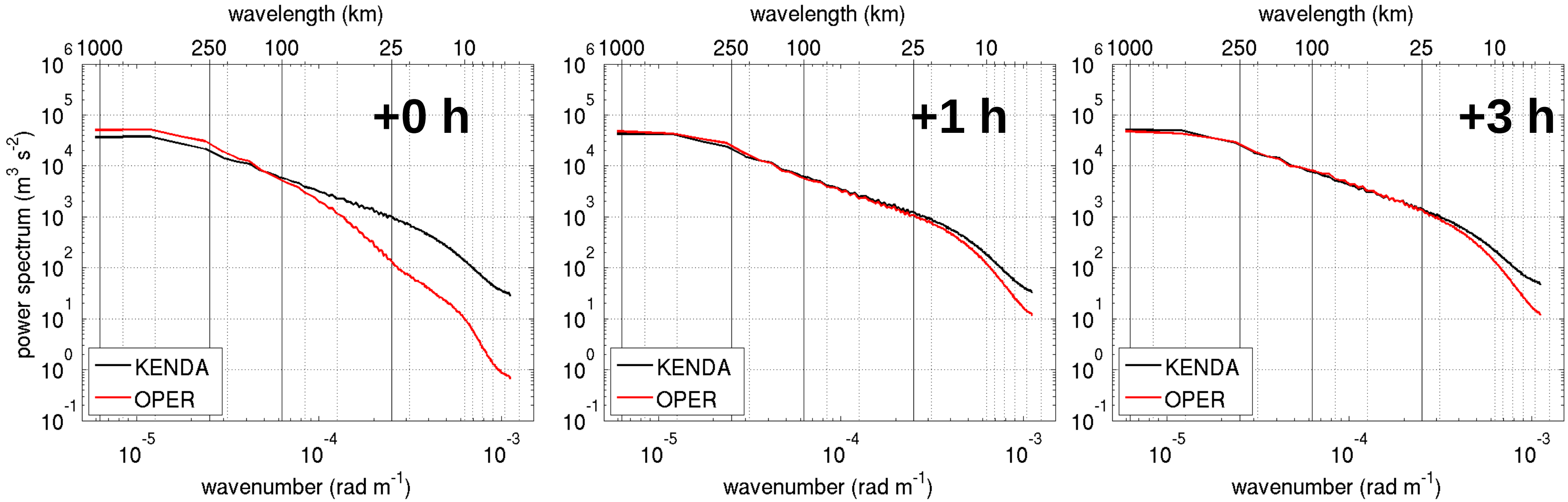
  → initial ensemble constructed around COSMO-DE analysis
- Both experiments are under dispersive

+3 h forecast of U-Wind: KENDA OPER



Power spectrum of ensemble perturbations

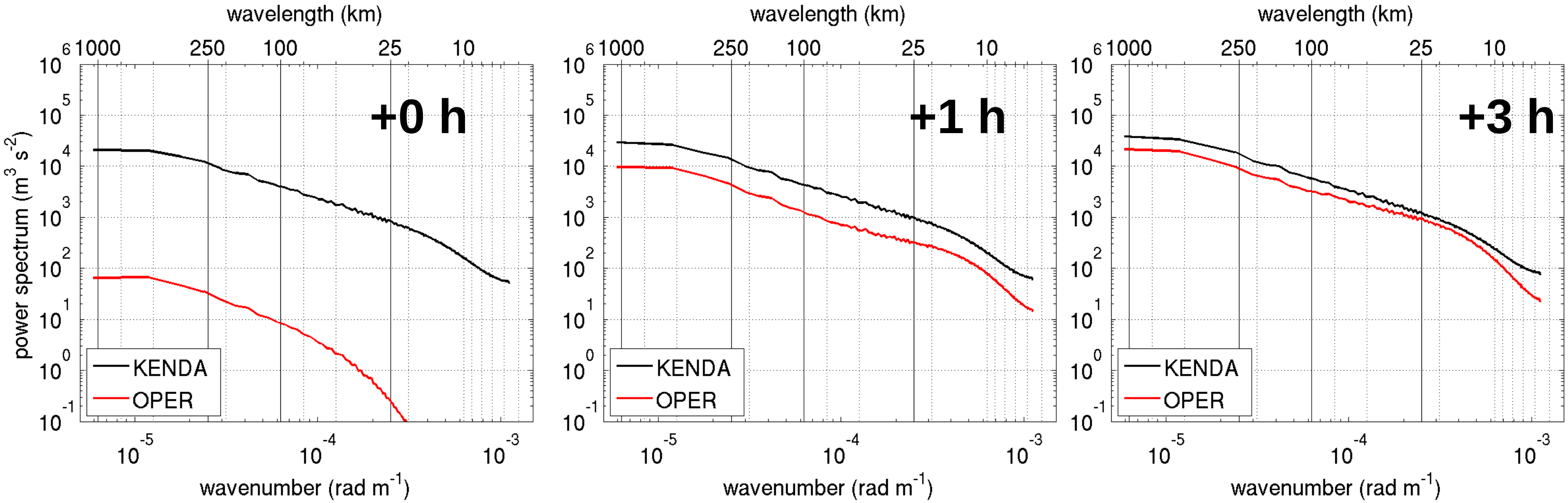
Horizontal wind, model level 30 (~3.1 km)



- Variance at small scales (<100 km) is reduced OPER
- Most of the missing variance at small scales developes within 1 hour

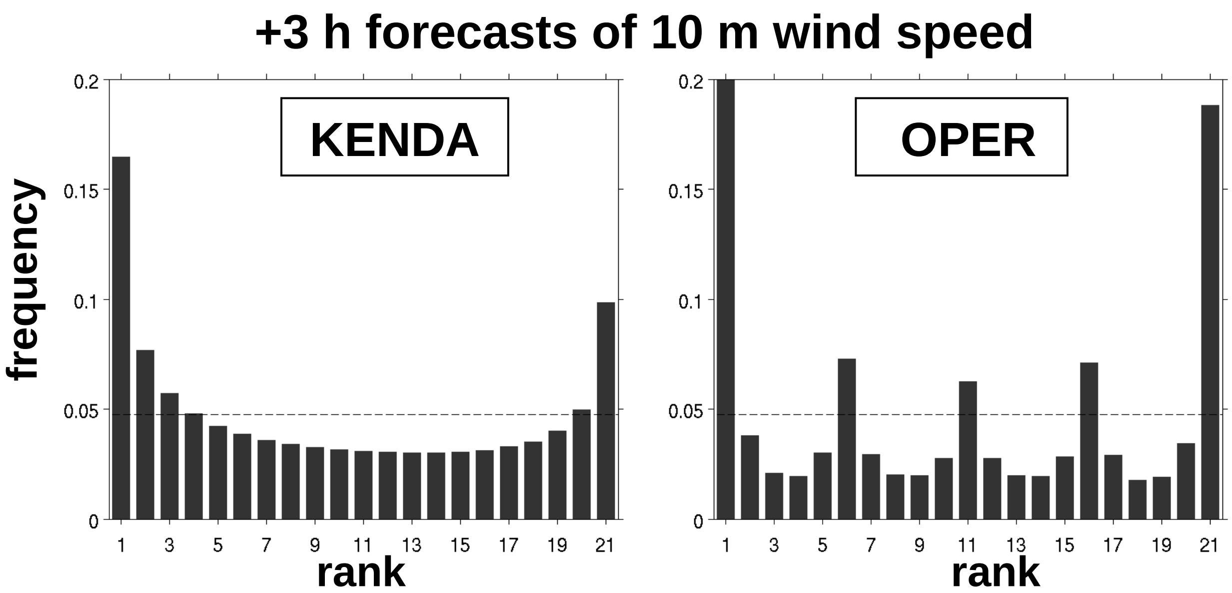
Power spectrum of ensemble perturbations

Horizontal wind, model level 40 (~0.8 km)



- Variance at small scales (<100 km) is reduced OPER
- Most of the missing variance at small scales developes within 1 hour
- Vertical filter: dampening at lowest levels exists for more than 3 hours

Ensemble rank histogram

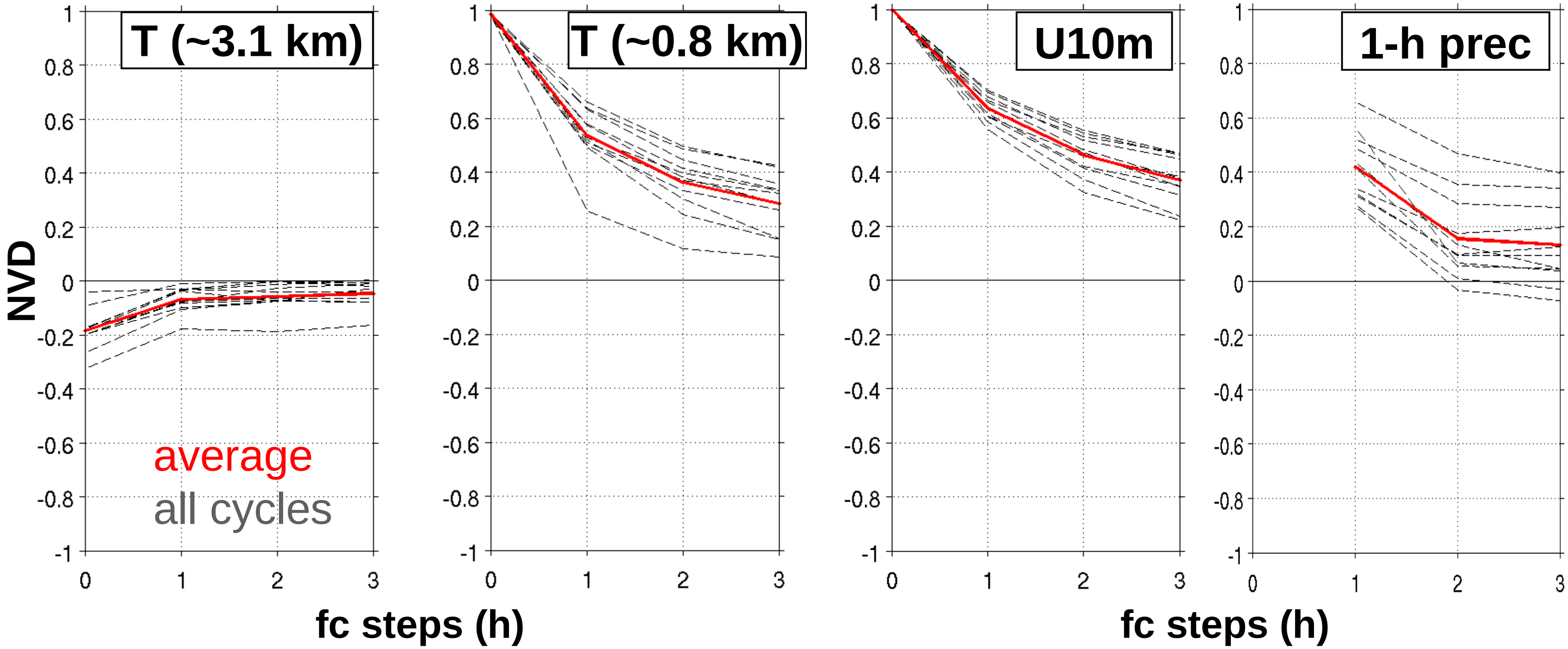


- Verification against COSMO-DE analysis (similar results against obs)
- All ensemble forecasts are under dispersive
- Signal of 4 global models dominate in OPER

Ensemble dispersion

- Normalized variance difference (NVD): $$\frac{\mathrm{var(eps\ 1) - var(eps\ 2)}}{\mathrm{var(eps1) + var(eps\ 2)}}$$

KENDA vs OPER

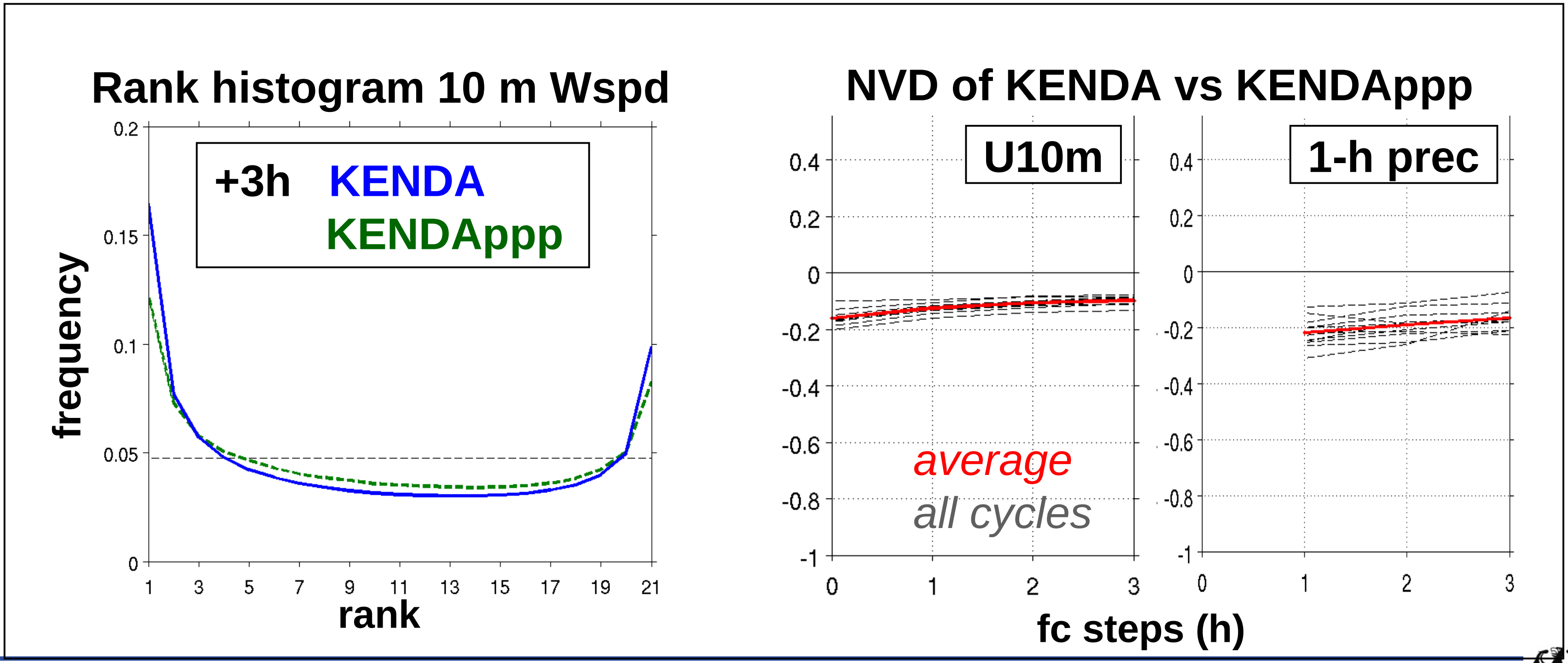


Additional KENDA experiment

- Investigate the effect of model formulation uncertainty:

  KENDAppp: same as **KENDA**, but

  → including 10 physics parametrization perturbations



Summary & Outlook

- Current ICs in COSMO-DE-EPS based on downscaling
- KENDA: km-scale ensemble data assimilation by means of an LETKF for the COSMO model (experimental system)
- KENDA provides consistent ICs for ensemble forecasts

→ ICPs are present at all scales / all levels from the beginning

→ Represent the approximated probability density function (PDF) around the high-resolution deterministic / ensemble mean analysis

(1) Increase KENDA analysis ensemble spread
→ Modify the raw analysis ensemble
(2) Improve representation of model uncertainty
→ Include stochastic boundary layer perturbations

Thanks also to Hendrik Reich, Andreas Rhodin for help with KENDA