KENDA and physics perturbations / model error in experimental COSMO-DE-EPS

-- WG 7 parallel session --

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Outline

- operational set up & changes since last COSMO GM
- TIGGE-LAM (including COSMO-DE-EPS)
- KENDA in COSMO-DE-EPS \textit{experimental}
- model uncertainty in COSMO-DE-EPS
- other research topics
- upcoming changes
COSMO-DE-EPS operational set-up & changes since last COSMO GM

- 20 members, grid size: 2.8 km
- 8 starts per day (00, 03, 06,... UTC)
  lead time: 0 - 27 hours
  0 - 45 hours for 03 UTC

- ICON replaced GME (Jan. 2015)
- GFS with higher resolution (Jan. 2015)

perturbation of model physics (non-stochastic) and soil moisture
Contribution to TIGGE-LAM data set

→ COSMO-DE-EPS available since 1st Jan 2014

→ 00, 06, 12, 18 UTC

→ selected variables of all members with 27h forecast range

→ including COSMO-LEPS and LAM-EPS versions of

ALADIN     HIRLAM     MOGREPS     PEARP

https://software.ecmwf.int/wiki/display/TIGL/Home
(TIGGE-LAM info)

http://apps.ecmwf.int/datasets/data/tigge_lam/
(TIGGE-LAM data portal)
KENDA in COSMO-DE-EPS

**Boundary conditions BCC**

**Short-range forecast SF**

**00 UTC**

**analysis cycle**

**COSMO-DE-EPS**

**21h- forecast**

**(27h)**

**Operational set-up:**

- **AC** = Nudging
- **SF** = COSMO-DE
- **BCC** = COSMO-EU
- **AF** = Nudging + BC-EPS perturbations

**BC-EPS**
KENDA in COSMO-DE-EPS

Reference set-up:

AC  = Nudging
SF   = COSMO-DE
BCC  = ICON 80km
AF   = Nudging + BC-EPS perturbations
KENDA in COSMO-DE-EPS

KENDA set-up:

AC = KENDA
SF = 20 members on 2.8km
BCC = ICON+LETKF 80km (20 members)
AF = Ensemble Kalman filter
KENDA in COSMO-DE-EPS

KENDA + BC-EPS set-up:

AC  = KENDA
SF  = 15 members + „KENDA deterministic“
BCC = ICON+LETKF 80km
AF  = Ensemble Kalman filter + BC-EPS perturb.
KENDA in COSMO-DE-EPS

2m temperature

operational
reference 80km
KENDA
KENDA + BCEPS

18/05-15/06 2014

Brier Skill Score

BSS with respect to
reference 80km

deg. K
KENDA in COSMO-DE-EPS

2m temperature

operational reference 80km
KENDA
KENDA + BCEPS

threshold 293.15K

BSS with respect to reference 80km

Richard Keane
KENDA in COSMO-DE-EPS

hourly precipitation

Spread Skill

operational reference 80km
KENDA
KENDA + BCEPS

Brier Skill Score

threshold 5mm/h

BSS with respect to reference 80km

lead time [h]

lead time [h]
KENDA in COSMO-DE-EPS

10m wind gusts

operational reference 80km
KENDA
KENDA + BCEPS

threshold 18m/s

BSS with respect to reference 80km

lead time [h]

Brier Skill Score
Model error / physics perturbations

- EM-scheme – a model for the model error

- SPPT

- randomly perturbed parameters

- combined parameter perturbations + randomization
EM-scheme – a model for the model error (E. Machulskaya)

\[
\frac{\partial \psi}{\partial t} = \left[ \frac{\partial \psi}{\partial t} \right]_{\text{det}} + \eta(t) \quad \frac{\partial \eta}{\partial t} = -\gamma \eta + \gamma \lambda^2 \nabla^2 \eta + \sigma \xi(t)
\]

\( \psi \): prognostic variables (T, QV, U, V)

\( \eta(t) \): noise field / model error, correlated in time and space

\( \xi(t) \): Gaussian noise

\( \gamma, \lambda, \sigma \): standard deviation and spatial and temporal correlation

\( \gamma, \lambda \) and \( \sigma \) are weather-dependent and are derived from past data.

Potential predictors are \( \left| \frac{d \mathbf{r}}{dt} \right|, |U|, \text{cl.cover}, \left| \frac{dq}{dt} \right| \)

for different model levels („offline“ training).
SPPT

\[
\frac{\partial \psi}{\partial t} = \left[ \frac{\partial \psi}{\partial t} \right]_{\text{det}} + \eta(t) \ast \left[ \frac{\partial \psi}{\partial t} \right]_{\text{det}}
\]

\(\psi: \text{prognostic variables}\)

**noise field \(\eta(t)\)**

- random number field on a coarse grid
  interpolated onto the COSMO grid
- spatial correlation scale: 5.0 degrees
- temporal correlation scale: 6 hours
- standard deviation: 1.0
Randomly perturbed parameters

- operational COSMO-DE-EPS: fixed parameter perturbations

- modification:
  randomly select either the default value or the fixed perturbed value (each with 50% chance)

- done for each forecast start, not changed during forecast
Model error / physics perturbations

2m temperature

Operational setup
Random parameters
SPPT
EM scheme

Spread Skill

Brier Skill Score

BSS with respect to operational

lead time [h]

deg. K

10/01-24/01 2014
Model error / physics perturbations

Operational setup
Random parameters
SPPT
EM scheme

hourly precipitation

Brier Skill Score

Spread Skill

lead time [h]

0 1 2 3 4 5

−0.01 0.00 0.01 0.02 0.03

0 1 2 3 4 5

BSS with respect to operational

Thresholds
Model error / physics perturbations

10m wind gusts

Operational setup
Random parameters
SPPT
EM scheme

Brier Skill Score with respect to operational
Combined parameter perturbations + randomization

- more parameter perturbations
  (focus on renewable energy applications: radiation, wind at hub heights:
   radqx_fact, thick_sc, c_diff, a_stab)
  optimized combination of perturbations (criterion: CRPS)
  red line in following plot

- randomly select a combination of all parameters and additionally apply the random value approach
  (done for each forecast start, not changed during forecast)
  dark yellow line in following plot
Model error / physics perturbations

ORKA project
Regina Kohlhepp

2m temperature
operational setup
additional param.
ransomed

01/08-31/08
2013

10m wind gusts

CRPS

Brier Skill Score

lead time [h]
m/s
Other research topics

- extension of COSMO-DE-EPS to 40 members
  BC perturbations as combination of multi-model/single-model EPS

  \[ \text{BC-EPS} \pm \text{COSMO-LEPS anomalies} \]

- parameter perturbations
  e.g. rlam\_heat \times rat\_sea = \text{const.}
  for consistency of T\_2M spread over land and sea

- dependence of minimum diffusion (tkh\_min) on stability and the effect on COSMO-DE-EPS
Upcoming changes

→ KENDA operational (second half of 2016)

→ COSMO-D2-EPS
  with 2.2km, 65 levels, westward extension of model domain
  (second half of 2016)

→ 40 members (2016/17)

→ ICON-EPS as BC for COSMO-DE-EPS (not before 2017)