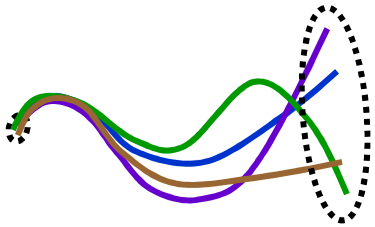
# KENDA
# and
# physics perturbations / model error
# in experimental COSMO-DE-EPS

## -- WG 7 parallel session --



**Richard Keane, Ekaterina Machulskaya,
Regina Kohlhepp, Christoph Gebhardt**

**Deutscher Wetterdienst, DWD**

# Outline

➔ operational set up & changes since last COSMO GM

➔ TIGGE-LAM (including COSMO-DE-EPS)

➔ KENDA in COSMO-DE-EPS

➔ model uncertainty in COSMO-DE-EPS

***experimental***

➔ other research topics

➔ upcoming changes

# COSMO-DE-EPS operational set-up & changes since last COSMO GM

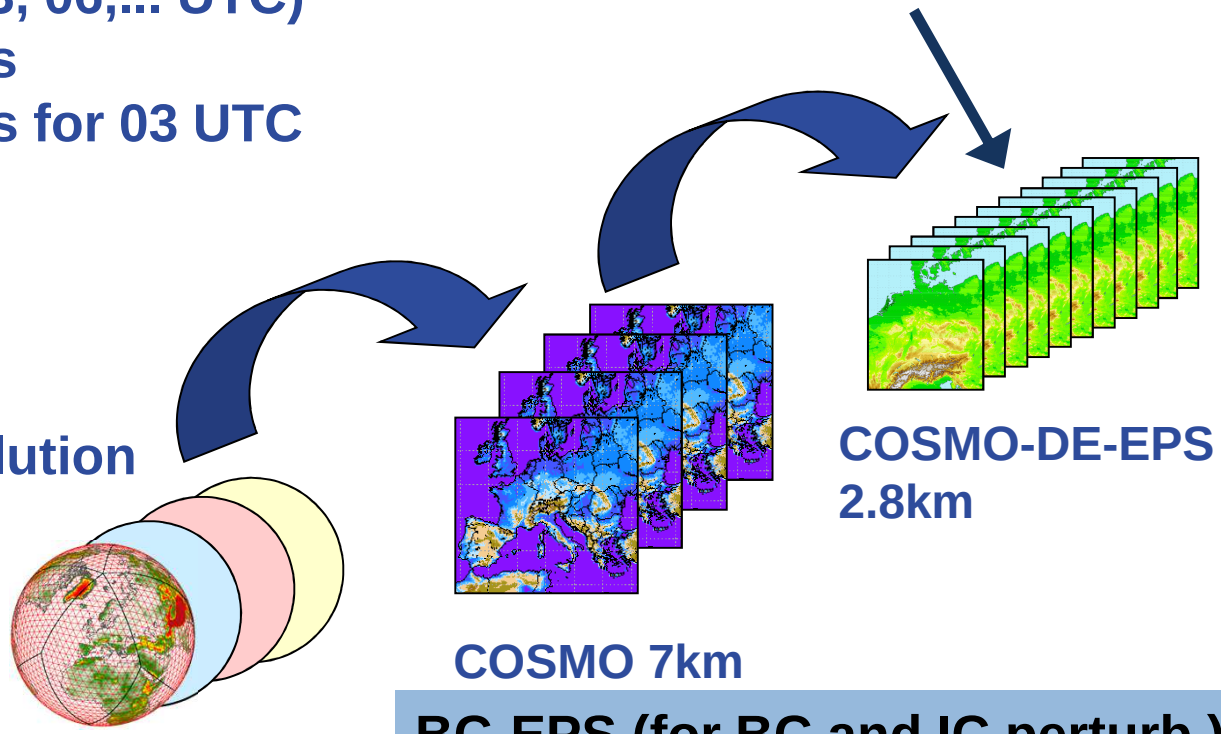
➔ 20 members, grid size: 2.8 km

➔ 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



COSMO-DE-EPS 2.8km

COSMO 7km

ICON, IFS, GFS, GSM

BC-EPS (for BC and IC perturb.)

# 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

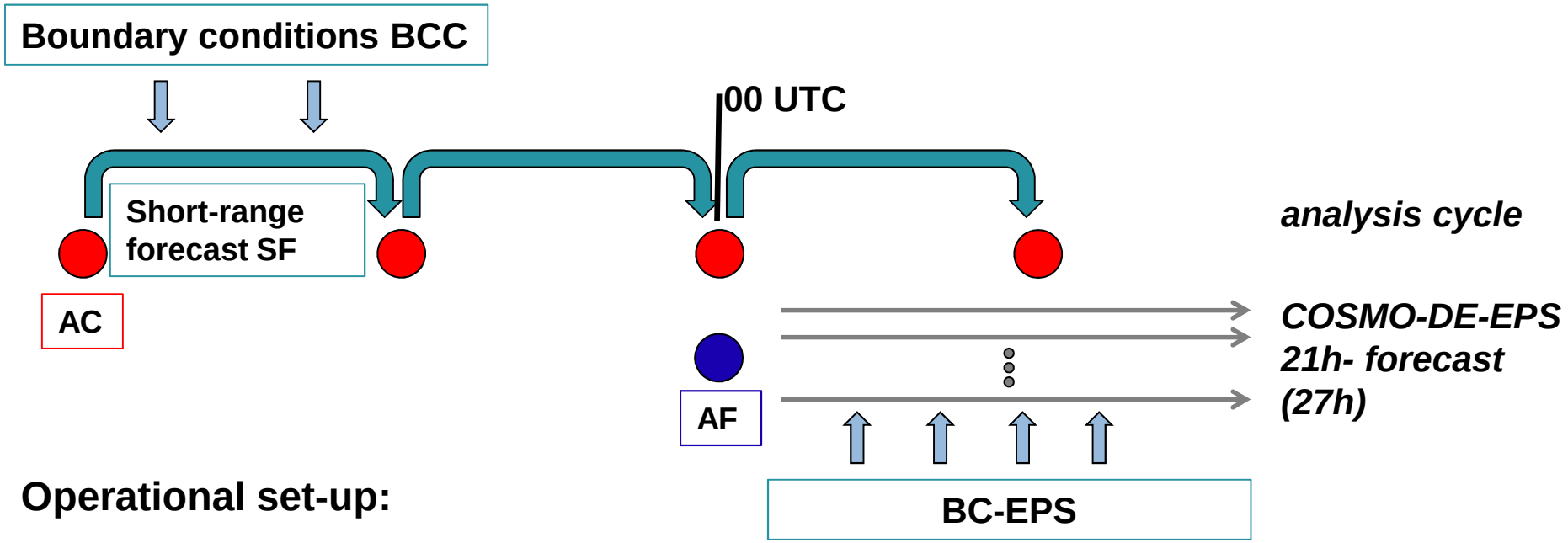
➔ including COSMO-LEPS and LAM-EPS versions of

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)*

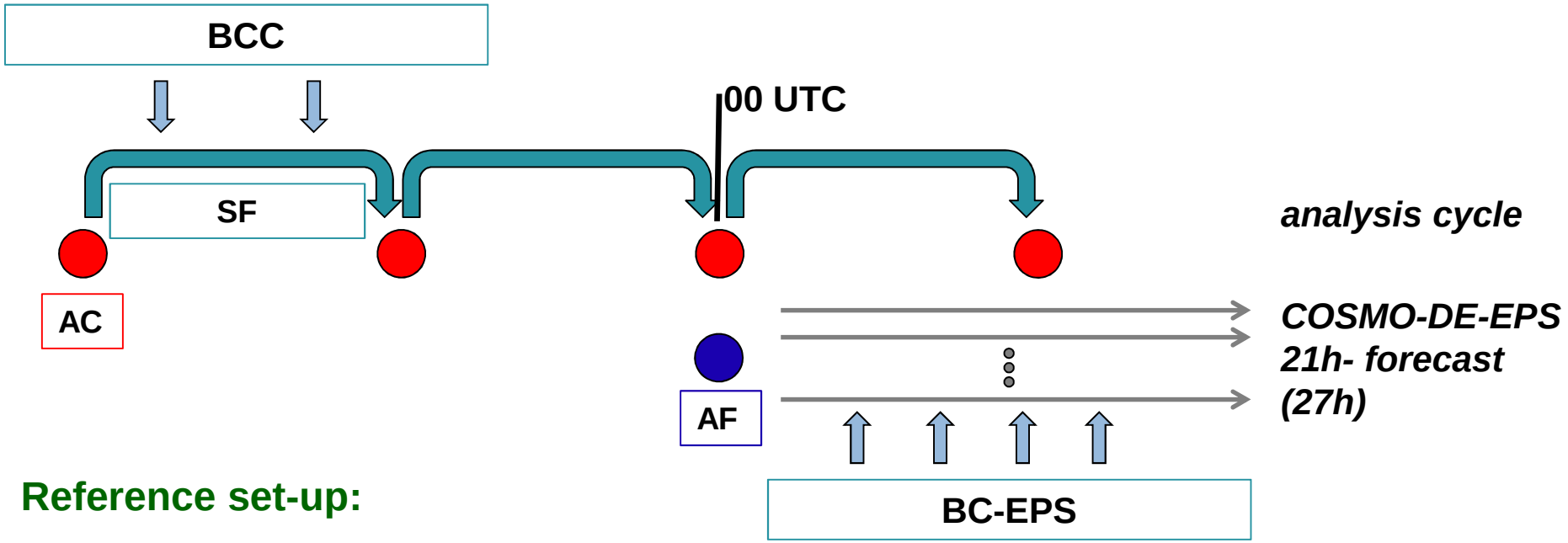
# KENDA in COSMO-DE-EPS




**Operational set-up:**

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

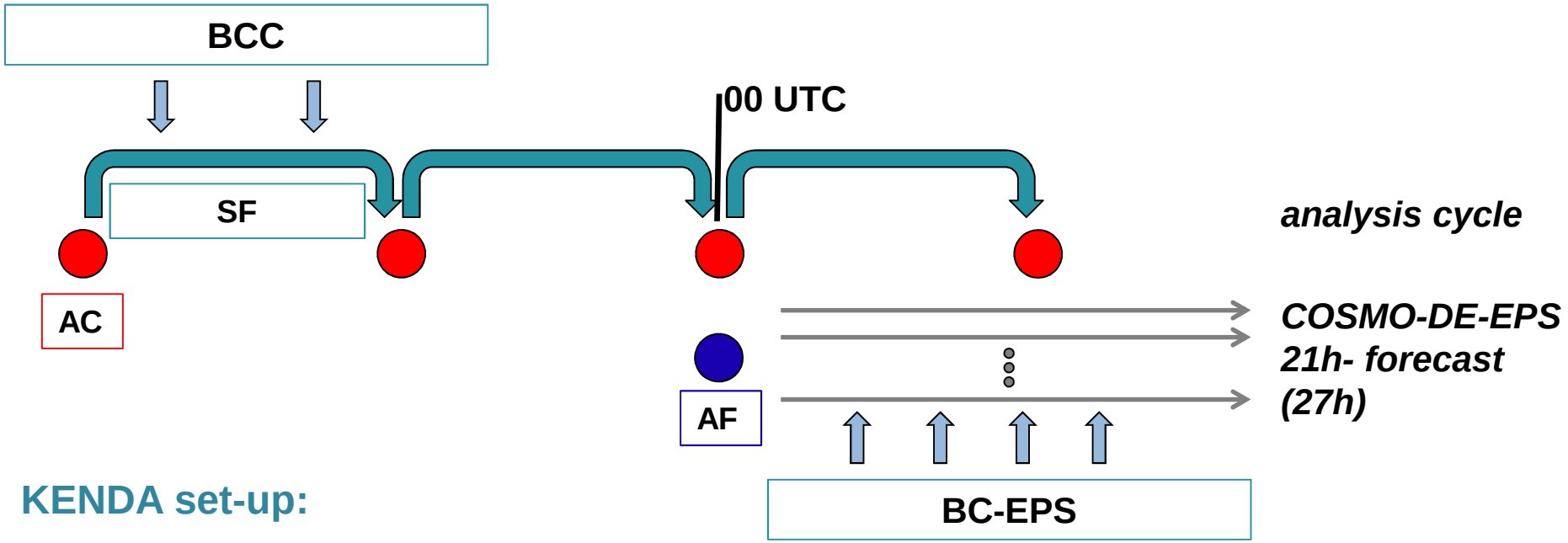
# KENDA in COSMO-DE-EPS




**Reference set-up:**

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

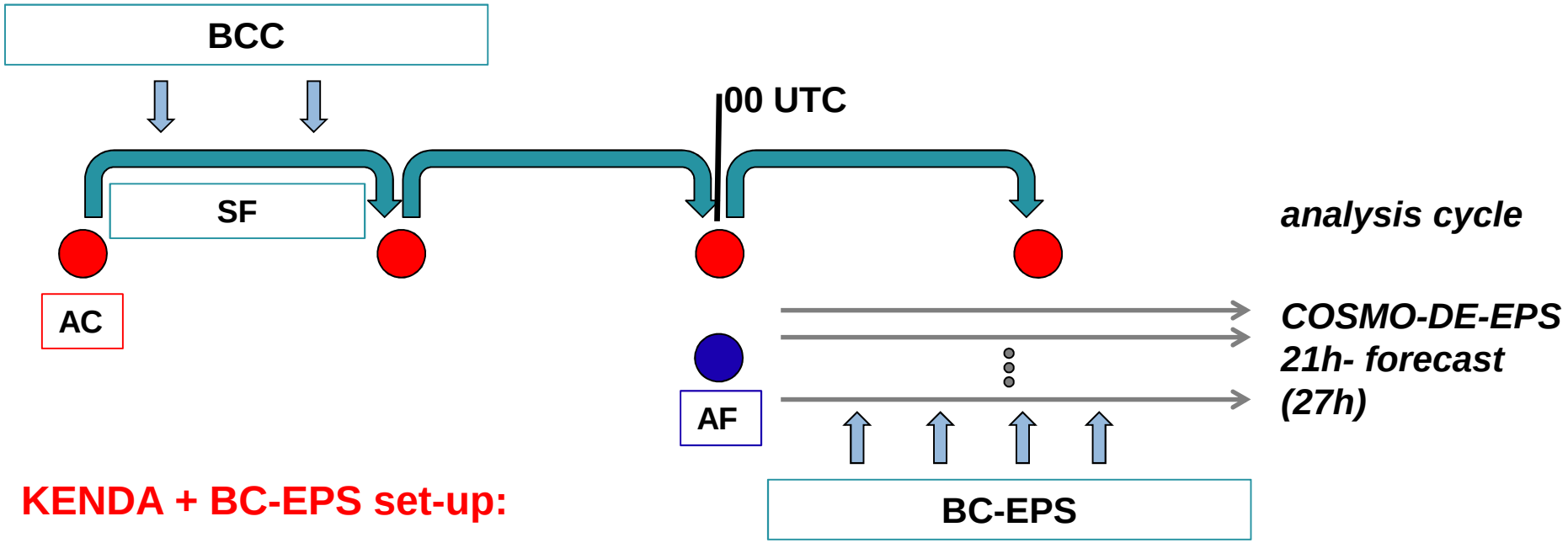
# KENDA in COSMO-DE-EPS




**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.**

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Richard Keane

# KENDA in COSMO-DE-EPS

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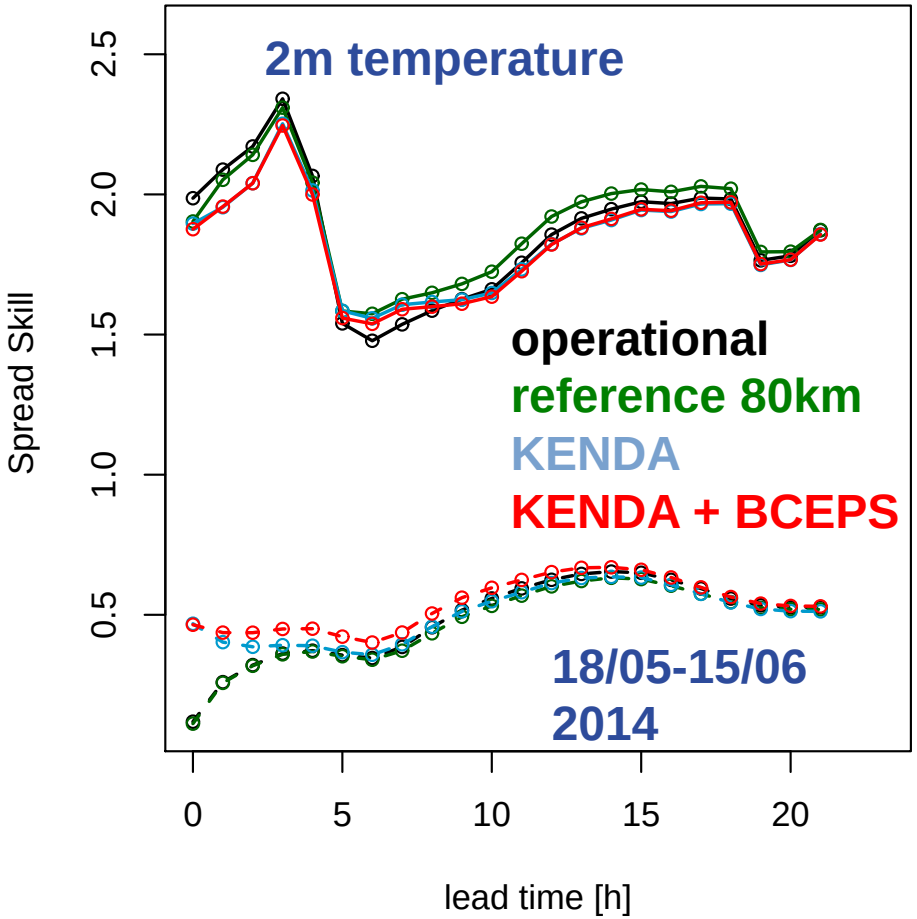


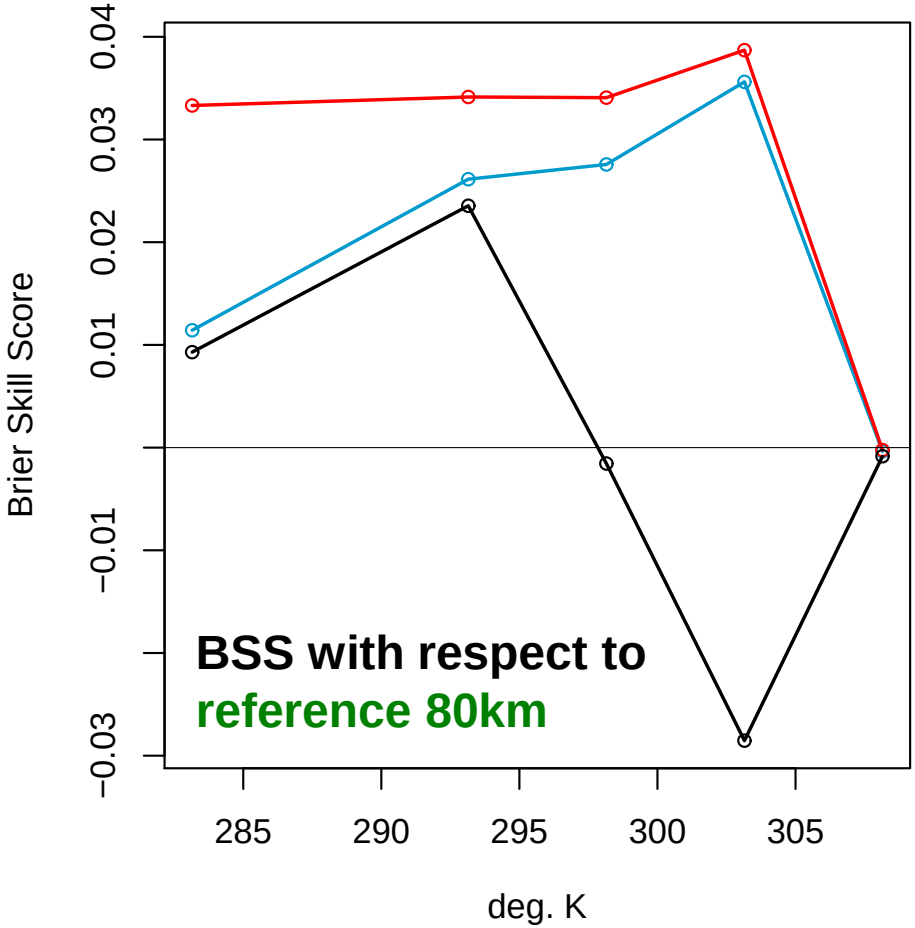

# KENDA in COSMO-DE-EPS

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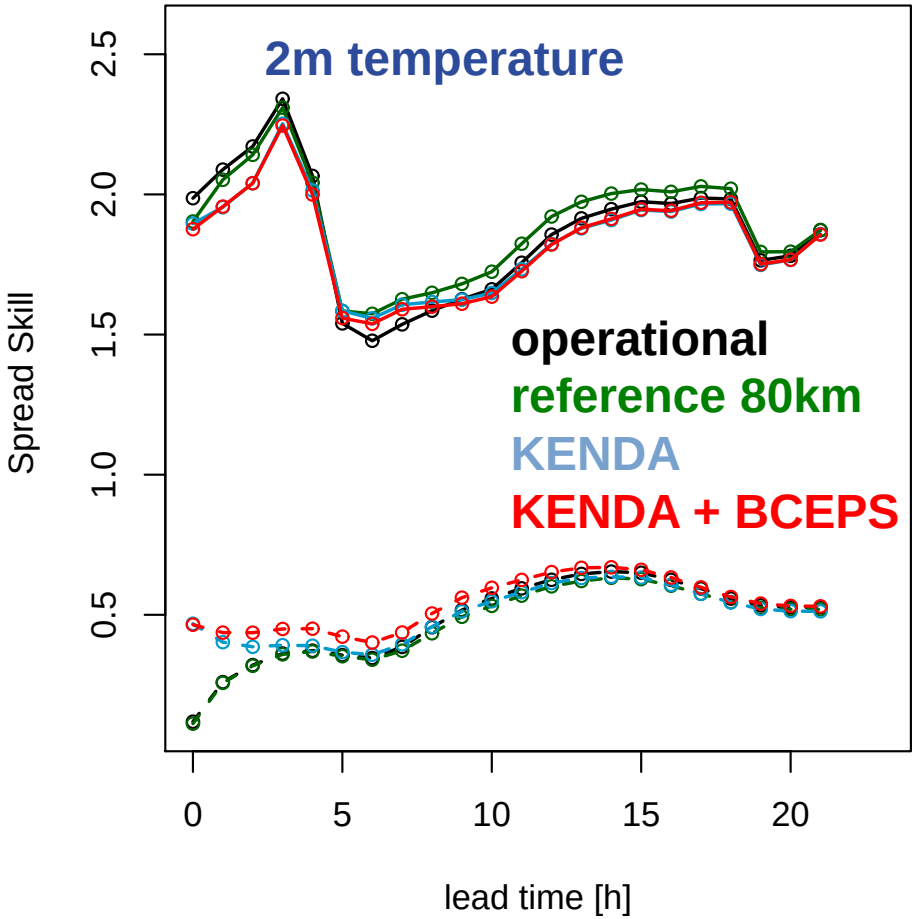


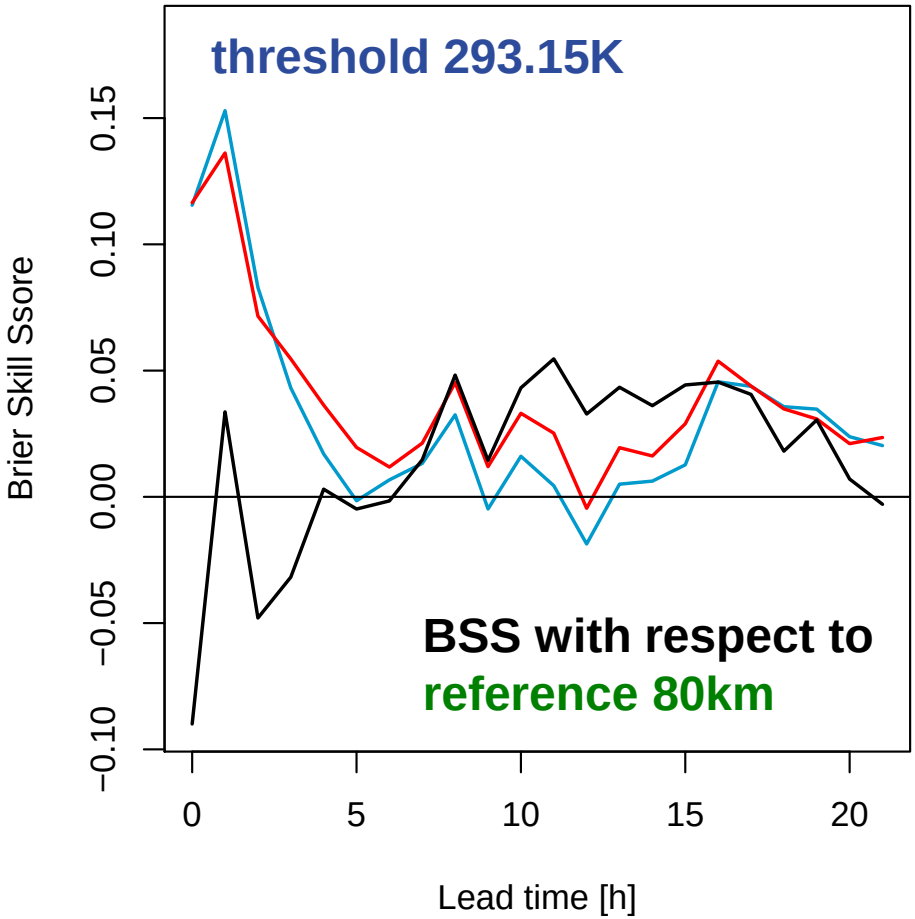

# KENDA in COSMO-DE-EPS

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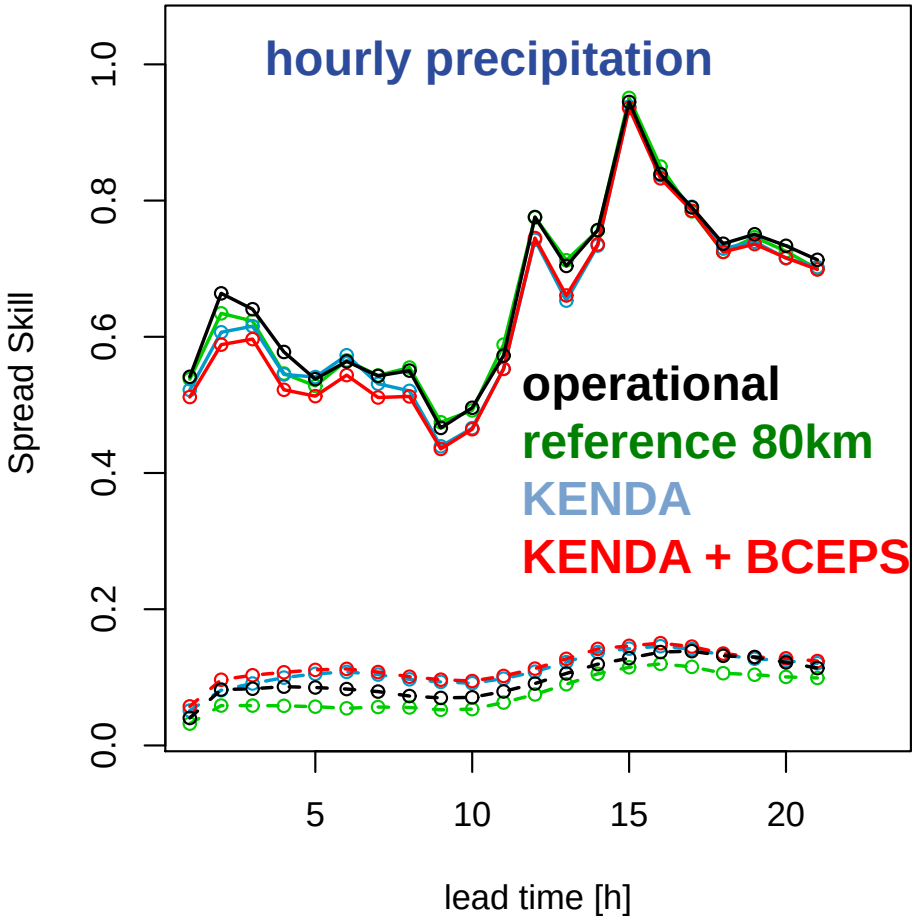


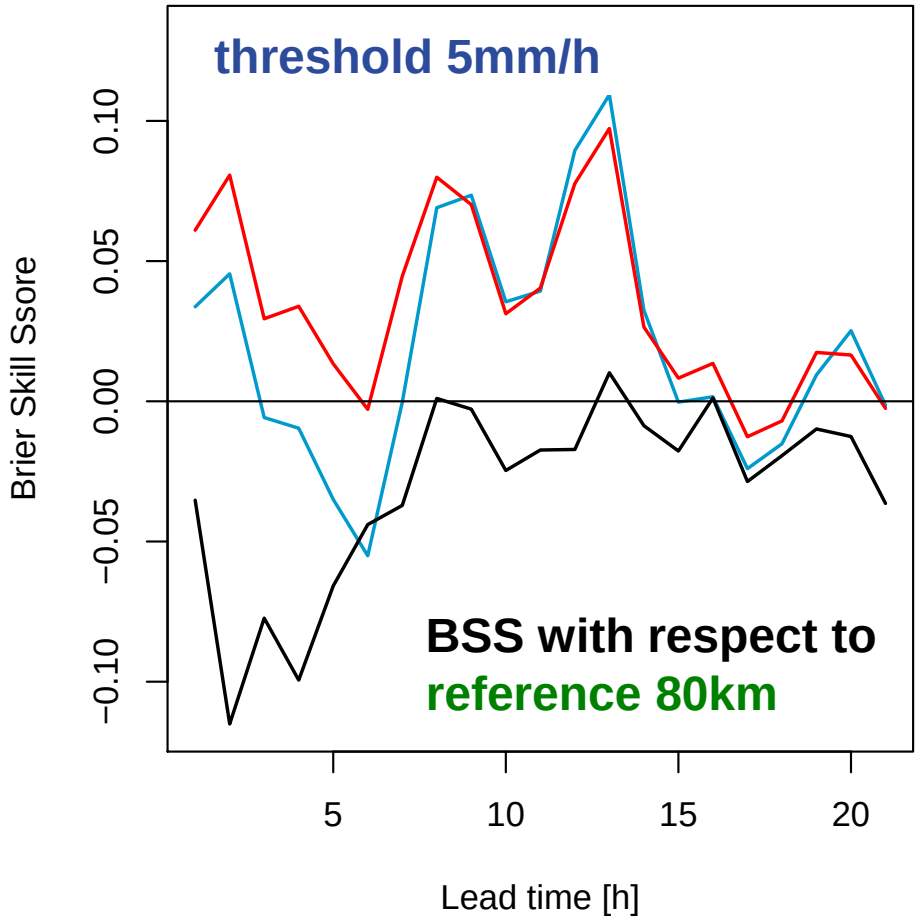

# KENDA in COSMO-DE-EPS

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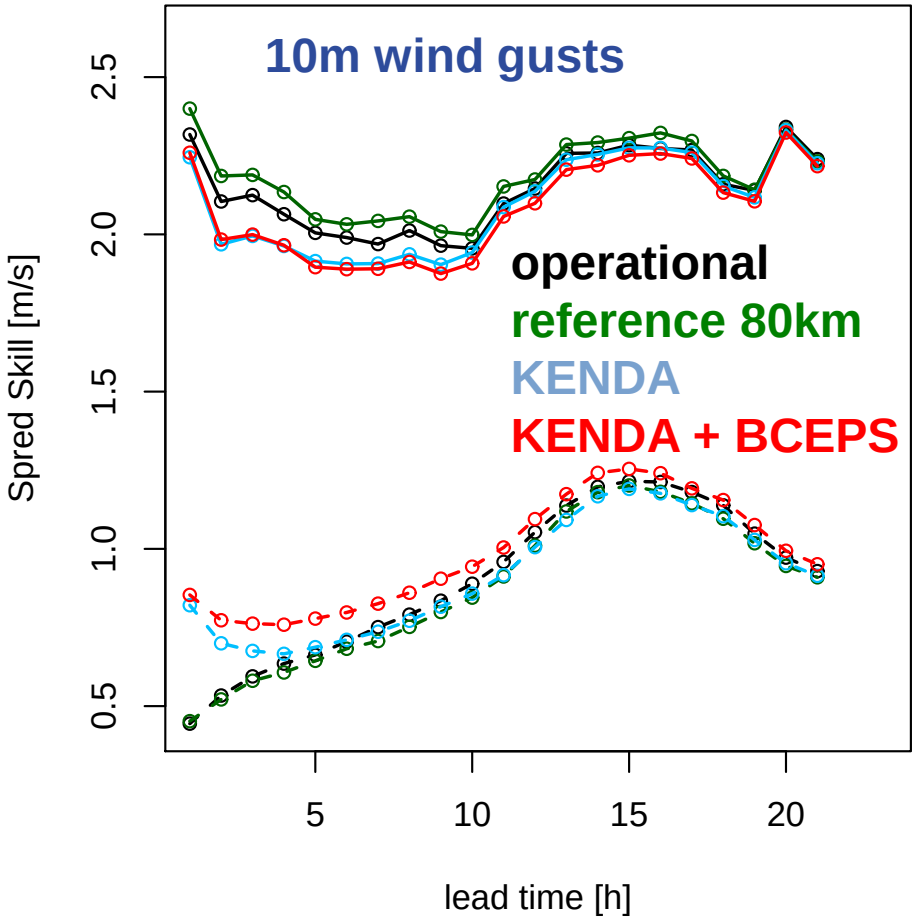


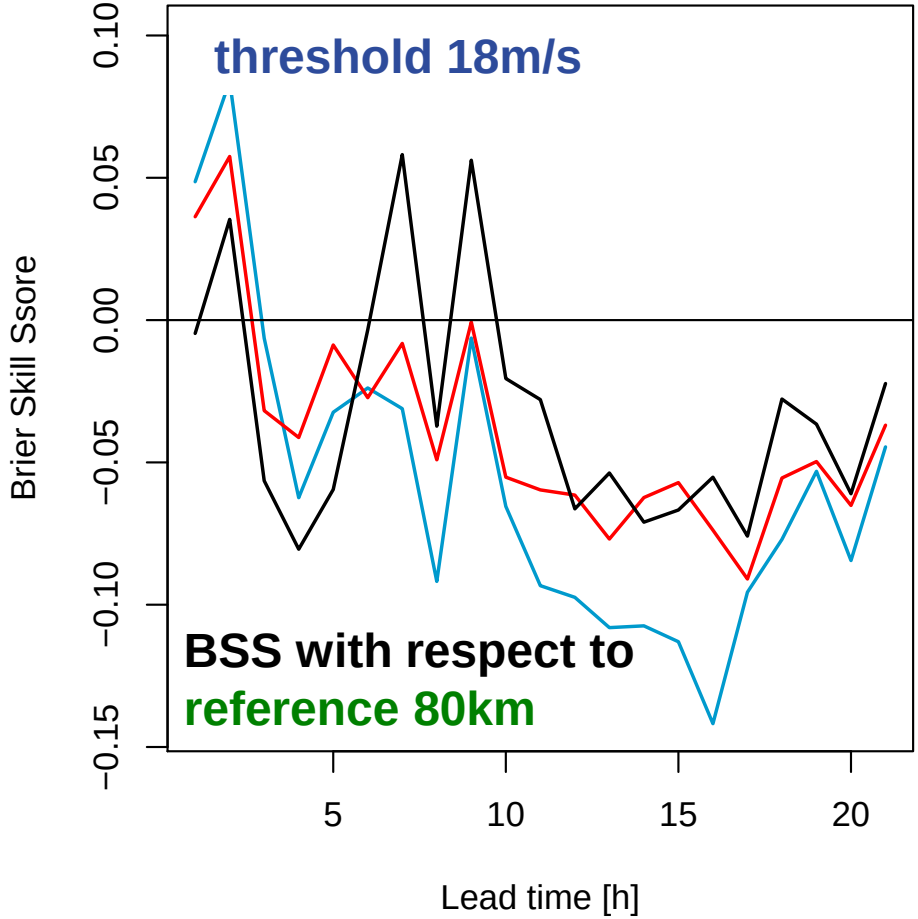

# Model error / physics perturbations

➔ 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)

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

$\psi$ : 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 $\left|\frac{dT}{dt}\right|$, $|U|$, cl.cover, $\left|\frac{dq}{dt}\right|$)

for different model levels („offline“ training).

# SPPT

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

$\psi$ : **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

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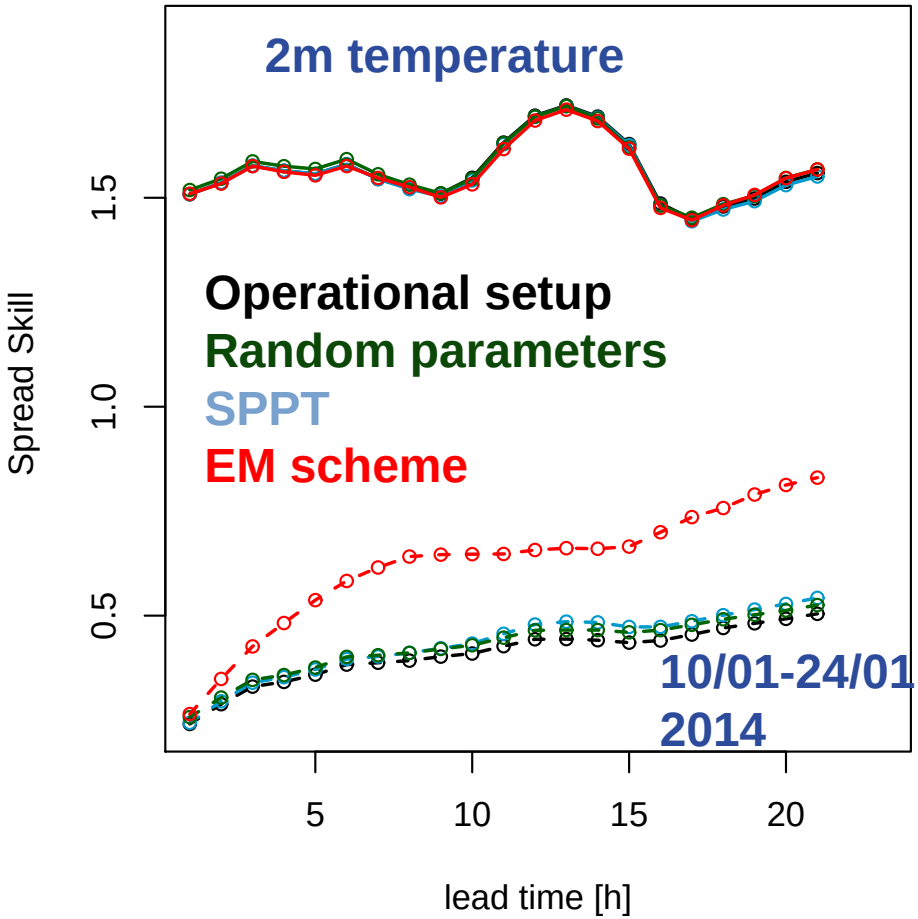
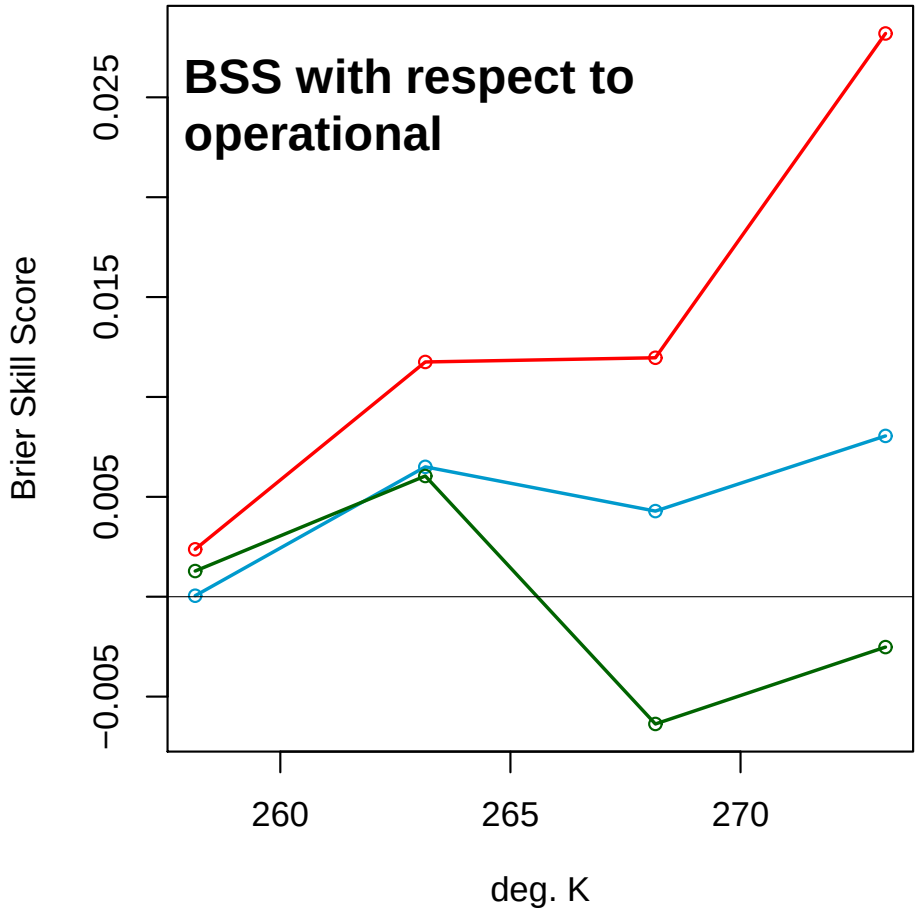
# Model error / physics perturbations



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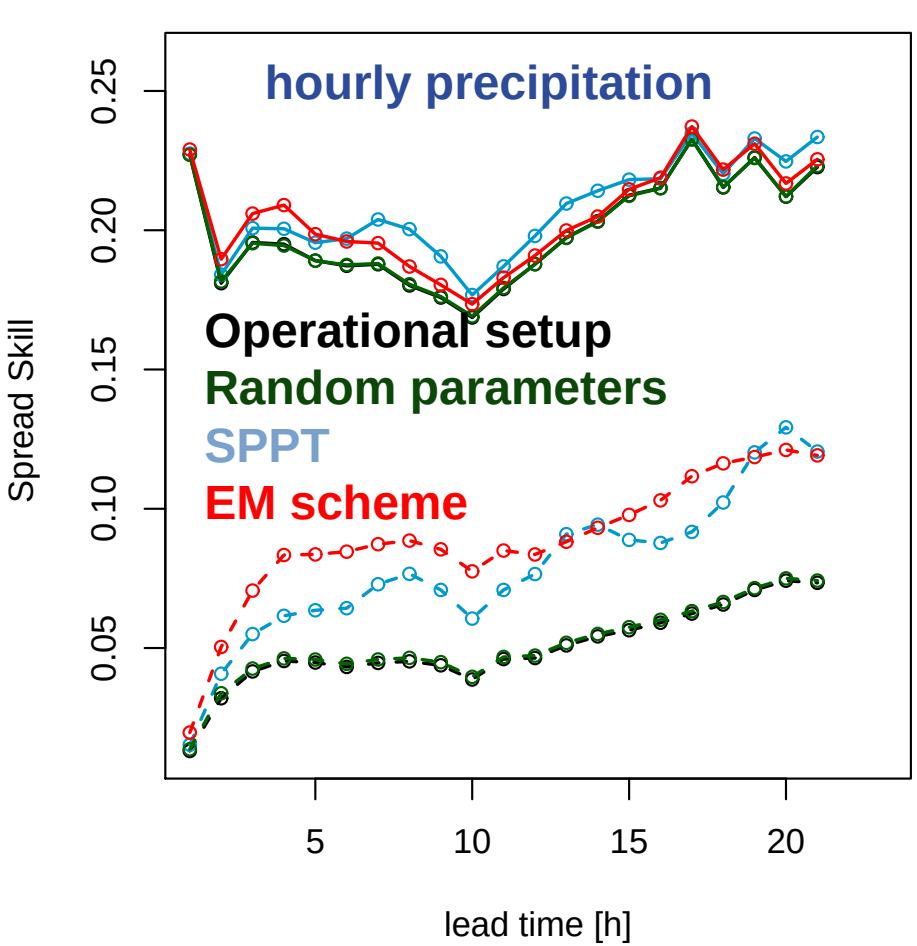
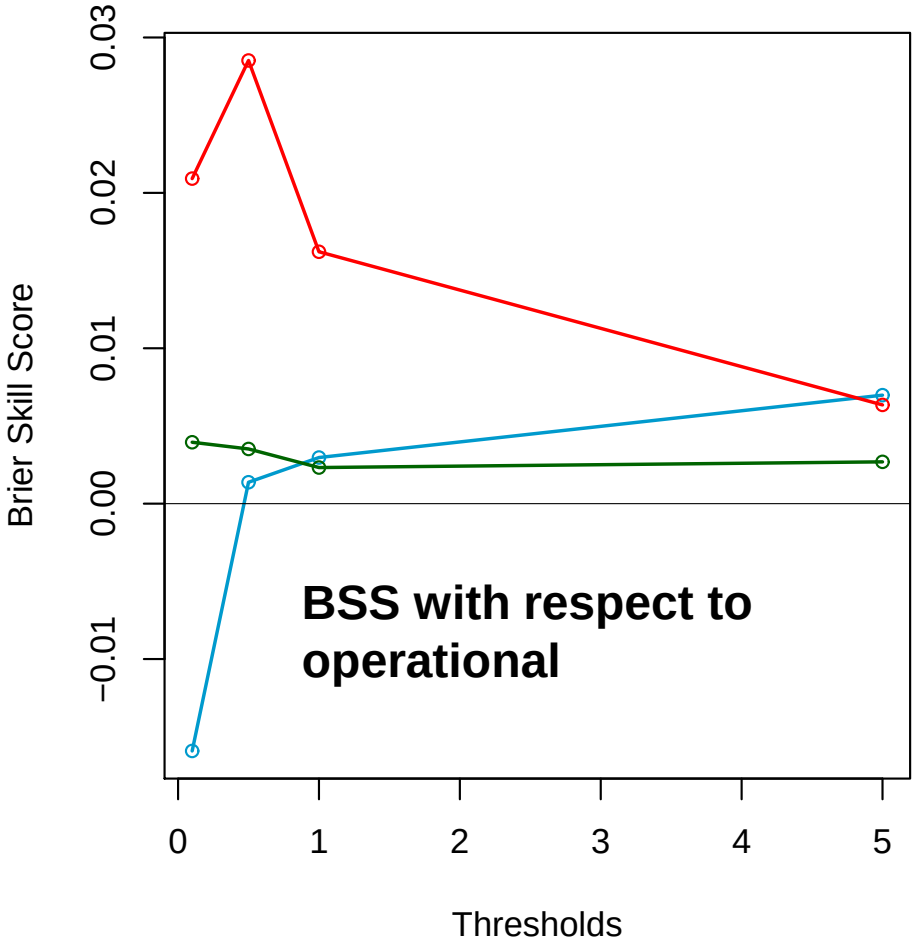
# Model error / physics perturbations



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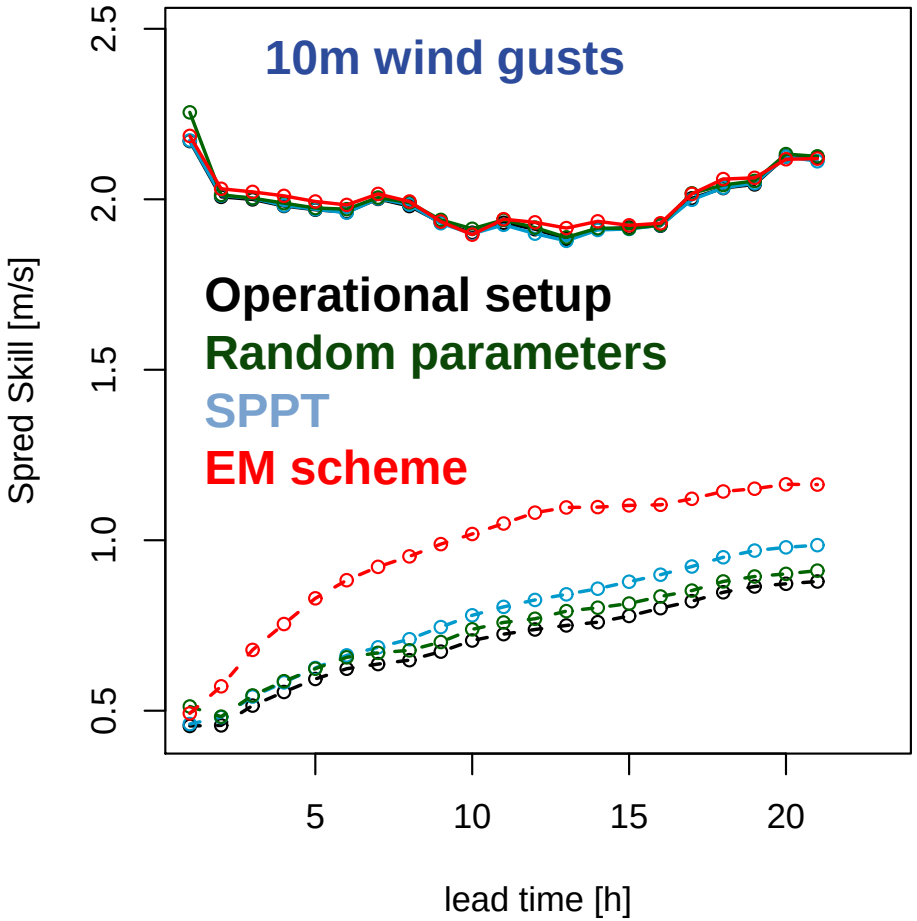
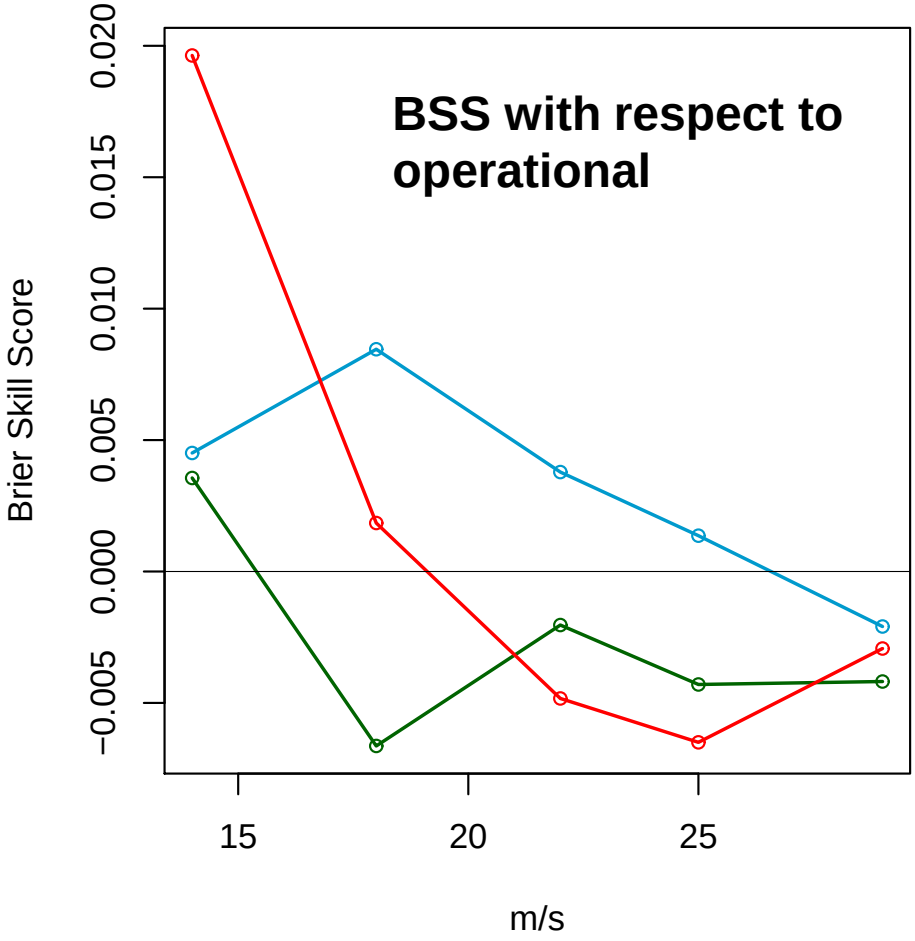
# Model error / physics perturbations



# Combined parameter perturbations + randomization

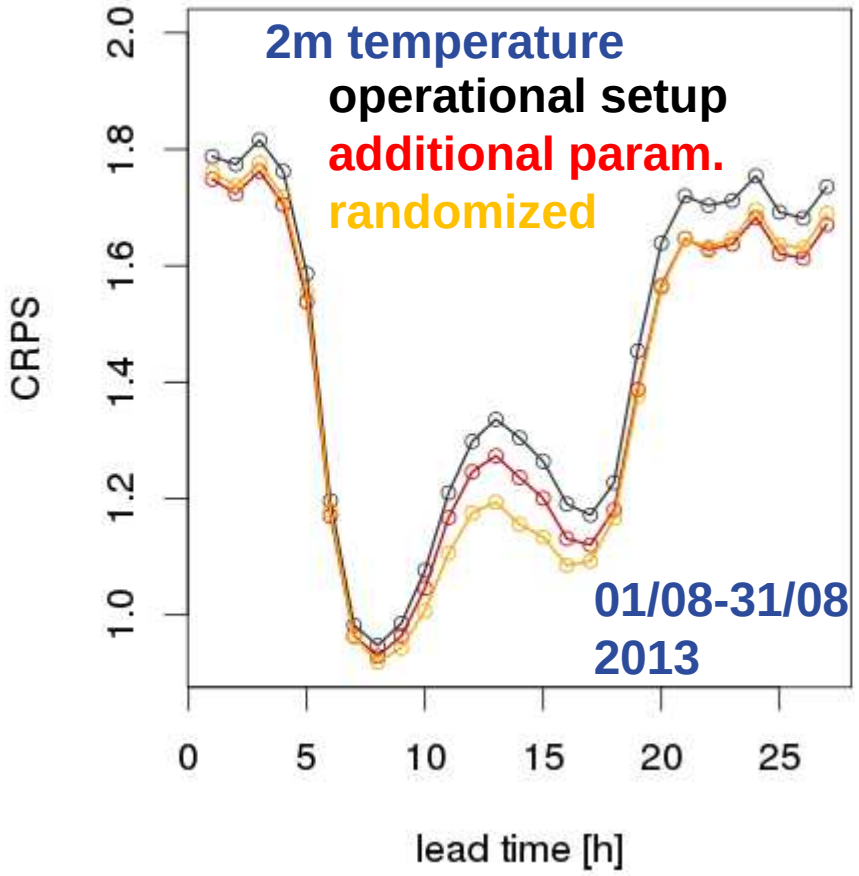
***ORKA project***
**Regina Kohlhepp**

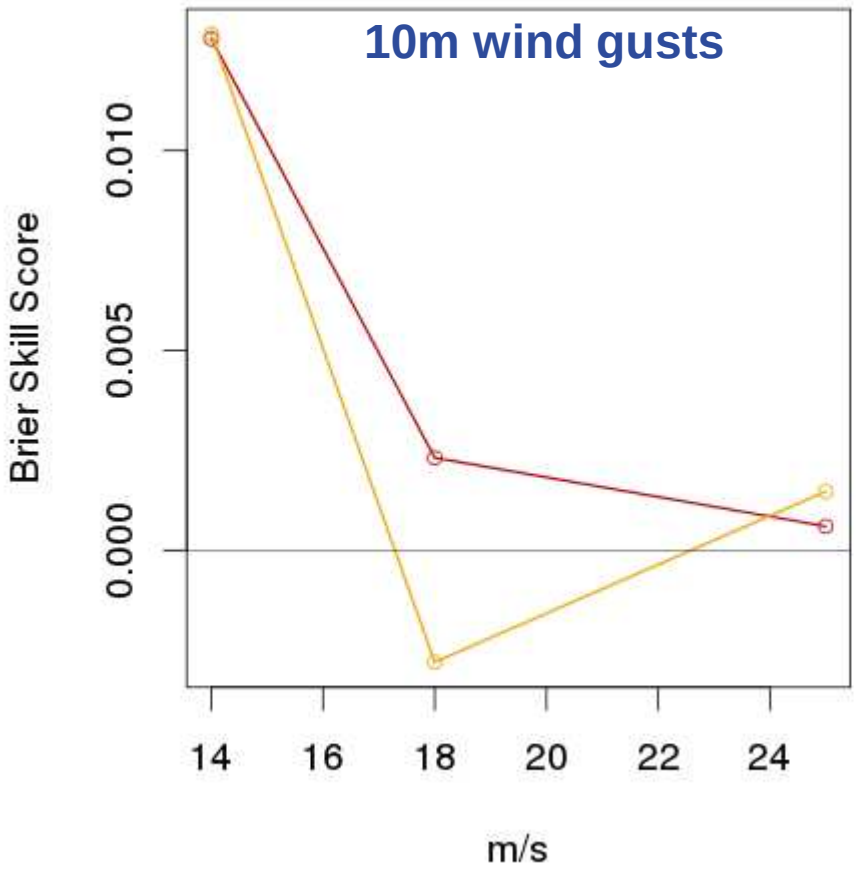
➔ **more parameter perturbations**
**(focus on renewable energy applications: radiation, wind at hub heights:**
*radqx_fact, thick_sc, c_diff, a_stab*)
**optimized combination of perturbations (criterion: CRPS)**
**red line in following plot**

➔ **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**



# Other research topics

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

BC-EPS ± COSMO-LEPS anomalies

➔ parameter perturbations
e.g. rlam_heat × rat_sea = 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)