ICON-EPS

**operational suite (since 18th January 2018)**

- 40 Member
- Global, 40 km / ICON-EU Nest, 20 km
- 00/12 UTC $\rightarrow$ +180h / 06/18UTC $\rightarrow$ +120h
- 03/09/15/21 UTC $\rightarrow$ +30h  Boundary Conditions for COSMO-DE-EPS
- Perturbing physics tuning parameters  (fixed during the forecast)
- Initial condition perturbations by global EDA (LETKF)

EDA at DWD  Spread Skill relation  Outlook
• LETKF (Localized Ensemble Transform Kalman Filter, Hunt et.al. 2007)
• 40 Members (-> extend to 80 Members)
• 3h Assimilation Cycle
• 40 km (20 km Europa)

• Covariance Inflation
  – multiplicative factor (0.9 to 1.5)
    Houtekamer et al. (2005): online estimate of spread and ensemble mean RMSE in observation space
  – additive Inflation + \(0,25B_{3dVar}\) length scales 300 km , 150km (RH)
  – „relaxation to the prior“ (0.75) Zhang et al. (2004)
  – SST random perturbations 1°K, correlations of 100km/1000km and 1 day

How do these perturbations grow during the forecasts?
Verification against analysis, 1.5° lat/lon

**NH 500hPa [20171101; 20180225]**

**GEOP**

*rmse & spread*

**Lead Time**

**Winter**

**run**

00

**verification type**

- **ice** = ICON-EPS
- **ece** = ECMWF-EPS
- **icR** = ICON hres Routine analysis
- **ec** = IFS hres analysis
Spread-Skill Reliability

Leutbecher, M., 2009: Diagnosis of Ensemble Forecasting Systems, ECMWF

Linear Regression Model

Barker (1991)
Scherrer et al. (2004)
Grimit and Mass (2007)
Eckel et al. (2012)
vан Schaevbroeck and Vannitsem (2016)
Spread-Skill Reliability

Improve the Spread-Skill Reliability in the short range

\[ \text{ice} = \text{ICON-EPS} \quad \text{icR} = \text{ICON hres Routine analysis} \]
\[ \text{ece} = \text{ECMWF-EPS} \quad \text{ec} = \text{IFS hres analysis} \]
Spread-Skill Reliability

ECMWF-EPS

ICON-EPS

GEOP, NH, run-00UTC [20171101; 20180228]

lead times
- 12
- 24
- 36
- 48
- 60
- 72
- 84
- 96
- 108
- 120
- 132
- 144
- 156
- 168
- 180

atmospheric Levels

[ hPa ]

seGrad

ece-ec

ice-icR
spread error bias

\[ \text{spread error bias} = \frac{1}{N} \sum_{i}^{N} \frac{|e_i|}{MAD_i} - 1 \]

- **Spread** = MAD
- **Error divided by spread**
- **centred error**
  - e.g. Talagrand et al. (1999)
  - Candille et al. (2007)
Spread = MAD
$$seBias = \frac{1}{N} \sum_{i}^{N} \frac{|e_i|}{MAD_i} - 1$$
conditional on spread

\[ seBias = \frac{1}{N} \sum_{i}^{N} \frac{|e_i|}{MAD_i} - 1 \]
dseBias.ssp  dseBias.lsp

ECMWF-EPS
GEOP, NH, run-00UTC  [20171101; 20180225]

ICON-EPS

250 hPa → 250 hPa

small
Spreads

250 hPa

large
Spreads

250 hPa ← 250 hPa
Mean initial perturbation

Zonal average of total perturbation energy

Figure 2. Magnusson, Leutbecher and Källén. 2008 (MWR)
Perturbation methods  Lorenz-63

Initial point

by Linus Magnusson

- Random pert.
- 1st SV
- 2nd SV
- BV

After 1 time unit
random Initial Perturbations
from the tangent linear subspace of growing perturbations

\[ A \times Q = Q \times H + \varepsilon \]

Krylov subspace computed by Arnoldi Algorithm

Growth rates of the 1st SV during Arnoldi updates in a shallow water model of dimension 1587

Tangent Linear Operator

Singular Vectors of

model for
Spread Skill Relation is not reliable during the first days of the forecast

- Singular Vector perturbations for the short range using Arnoldi Iteration

ICON-EPS is operational since 18\textsuperscript{th} January 2017

International Contributions

- WMO – Verification
- TIGGE (Thorpex Interactive Grand Global Ensemble)

Documentation

The spread skill properties of the global ICON Ensemble


in preparation