ICON-EPS a contribution to TIGGE?

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

- 40 Member
- Global, 40 km / ICON-EU Nest, 20 km
- 00/12 UTC → +180h / 06/18UTC → +120h
- 03/09/15/21 UTC → +30h Boundary Conditions for COSMO-D2-EPS
- Perturbing physics tuning parameters (fixed during the forecast)
- Initial perturbations by global EDA (LETKF)

→ Products → Evaluation → EWI → Initial Perturbations
The operational NWP system at DWD

EnVAR
- hybrid DA-system
- ICON deterministic
  - 13 / 6.5 km (Europe)

ICON-EDA
- global ensemble data assimilation
  - 40 members
  - 40/20 km

LETKF

KENDA
- regional ensemble data assimilation
  - 40 members
  - 2.2 km

COSMO-D2-EPS
- regional ensemble prediction
  - 20 members
  - 2.2 km

COSMO-D2
- 2.2 km
1. Mean and extreme values
   - Unweighted mean of all members
   - Spread of all members
   - Minimum of all ensemble members
   - Maximum of all ensemble members

2. Percentiles
   i.e. physical values of a forecast parameter (e.g. T_2M, . . . ),
   which define the perc=10,25,50,75,90 [%] parts of the ensemble distribution.

3. Exceedance Probabilities
   - Probability of event above lower limit
   - Probability of event below upper limit

24h Probability of Precipitation >10mm
2018-08-28 00:00 UTC +72h
... a shelf warmer?
March 2019, NH, Synop, CRPS

2019/03/01 00UTC - 2019/03/30 00UTC
INI: ALL UTC, DOM: NH

- ECMWF-EPS
- ICON-EPS
**Evaluation of ICON-EPS by the forecasters of DWD**

… keep in mind that they rely on ECMWF-EPS

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### Wind gusts (6h)

<table>
<thead>
<tr>
<th>Added Value</th>
<th>0-48h</th>
<th></th>
<th>60-108h</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>cases</td>
<td>%</td>
<td>cases</td>
<td>%</td>
</tr>
<tr>
<td>Added Value</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>yes</td>
<td>285</td>
<td>59,5</td>
<td>297</td>
<td>49,2</td>
</tr>
<tr>
<td>some</td>
<td>117</td>
<td>24,4</td>
<td>174</td>
<td>28,8</td>
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<tr>
<td>no</td>
<td>73</td>
<td>15,1</td>
<td>132</td>
<td>21,9</td>
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<td>4</td>
<td>0,8</td>
<td>1</td>
<td>0,2</td>
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<table>
<thead>
<tr>
<th>Comparison</th>
<th>0-48h</th>
<th></th>
<th>60-108h</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>ECMWF</td>
<td>68</td>
<td>14,2</td>
<td>98</td>
<td>16,2</td>
</tr>
<tr>
<td>ICON</td>
<td>91</td>
<td>19,0</td>
<td>61</td>
<td>10,1</td>
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<tr>
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<td>299</td>
<td>62,4</td>
<td>429</td>
<td>71,0</td>
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<td>23</td>
<td>4,8</td>
<td>16</td>
<td>2,6</td>
</tr>
</tbody>
</table>

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### Summer 2017

- **Added Value**
  - yes: 285 cases (59.5%)
  - some: 117 cases (24.4%)
  - no: 73 cases (15.1%)
  - no: 4 cases (0.8%)

- **Comparison**
  - ECMWF: 68 cases (14.2%)
  - ICON: 91 cases (19.0%)
  - similar: 299 cases (62.4%)
  - similar: 23 cases (4.8%)

- **Added Value**
  - yes: 297 cases (49.2%)
  - some: 174 cases (28.8%)
  - no: 132 cases (21.9%)
  - no: 1 cases (0.2%)

- **Comparison**
  - ECMWF: 98 cases (16.2%)
  - ICON: 61 cases (10.1%)
  - similar: 429 cases (71.0%)
  - similar: 16 cases (2.6%)
### Precipitation (12h)

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<tbody>
<tr>
<td></td>
<td>61 cases</td>
<td>%</td>
<td>91 cases</td>
<td>%</td>
</tr>
<tr>
<td><strong>Added value</strong></td>
<td>yes</td>
<td>23</td>
<td>37,7</td>
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<tr>
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<td>some</td>
<td>13</td>
<td>21,3</td>
<td>some</td>
</tr>
<tr>
<td></td>
<td>no</td>
<td>23</td>
<td>37,7</td>
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<tr>
<td></td>
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<td>2</td>
<td>3,3</td>
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</tr>
<tr>
<td><strong>Comparison</strong></td>
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<td>8</td>
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<tr>
<td></td>
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<td>4</td>
<td>6,6</td>
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WGNE bluebook 2018
Shift of Tails (SOT)
Extreme Forecast Index (EFI)
EPS Quantiles of the actual forecast distribution (90%)
=> Extreme Weather Index (EWI)

EWI has 3 alert level (yellow, orange, red)
init 27.10.18, 00UTC+72h

90% quantile ECMWF-EPS

>100mm

~50mm

EFI

0.9

EWI

0.5-1

SOT

1-2

Extreme-Weather-Index „EWI“  lars.kirchhuebel@dwd.de
Cyclon Pabuk-Malaysia

ECMWF-EPS

ICON-EPS
Sat-Niederschlag, 24std (mm)

05.01.2019, 01:00 Uhr MEZ

Thailand

Extreme-Weather-Index „EWI“  lars.kirchhuebel@dwd.de
Andreas Rhodin, Harald Anlauf, Ana Fernandez del Rio, Alexander Cress, Roland Potthast

- LETKF (Localized Ensemble Transform Kalman Filter, Hunt et.al. 2007)
- 40 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 $1^\circ$K, correlations of 100km/1000km and 1 day

Are these perturbations appropriate for the short and very short range?
Initial Perturbations
from the tangent subspace of growing perturbations

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

Tangent Operator

H model for A

Singular Vectors of H

Krylov subspace computed by Arnoldi Algorithm

\[ m << n \]

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

mean exponential growth rate

\[ \text{arn-5.2} \rightarrow m=10 \]

\[ \text{arn-5.1} \rightarrow m=5 \]

\[ \text{arn-5.1} \rightarrow m=5 \]
Summary & Outlook

- **System**
  - center perturbations on high resolution analysis
  - Singular Vector perturbations for the short and very short range
  - Stochastic physics scheme

- **Forecasts**
  - Standard EPS Products on opendata.dwd.de
  - Storm Tracks
  - Contribute to EWI
  - Superensemble ICON-EPS / ECMWF-EPS
  - TIGGE