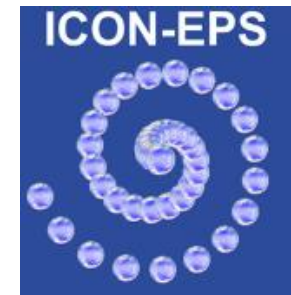


*M. Denhard, A. Rhodin, J. T. Ambadan, H. Anlauf, A. Fernandez del Rio, A. Cress,  
G. Zängl, H. Frank, T. Hanisch, C. Primo,  
F. Fundel, M. Buchhold, R. Potthast*

# ICON-EPS a contribution to TIGGE ?

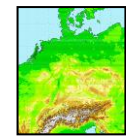
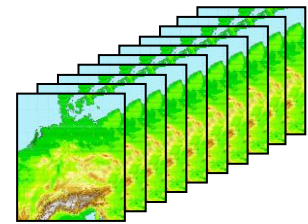
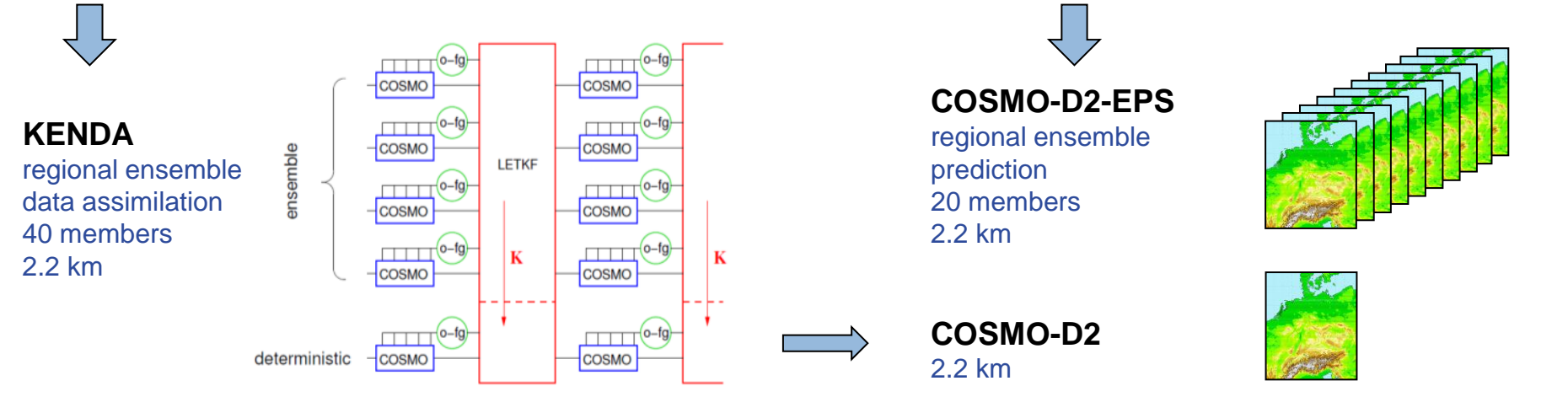
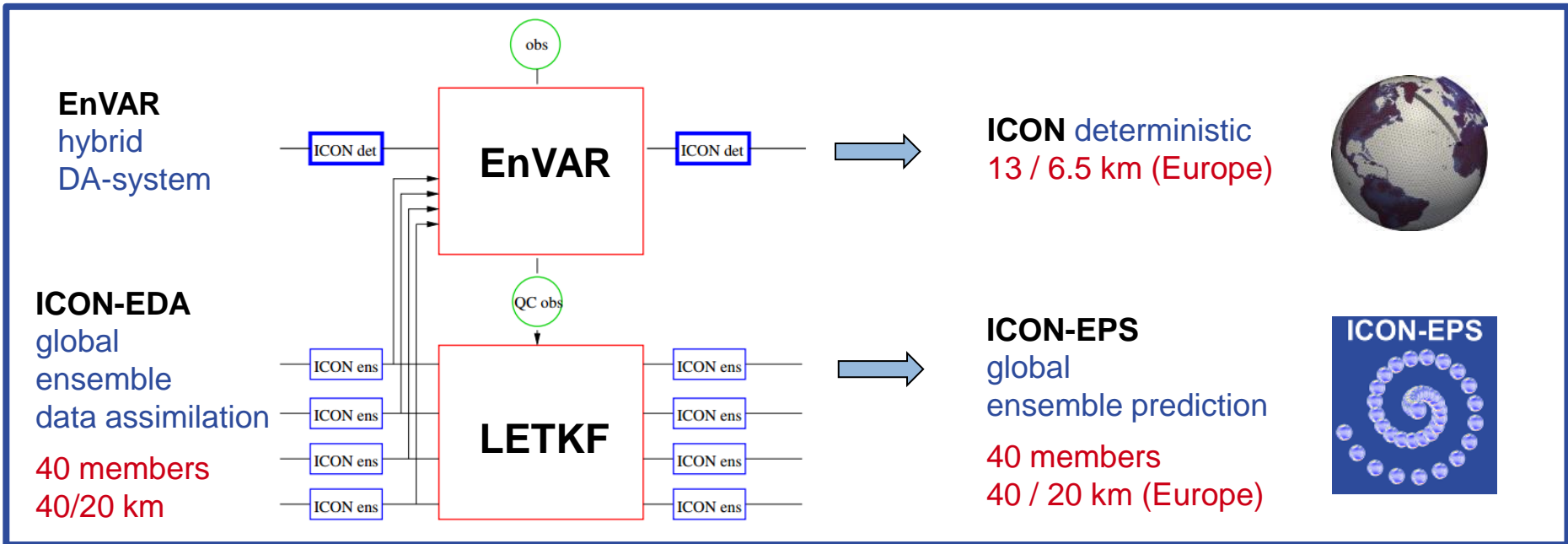
**operational suite** ( since 18<sup>th</sup> January 2018 )

- 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



**Global:** 0,5°

[opendata.dwd.de](https://opendata.dwd.de/weather/wmc/icon-eps) : weather/wmc/icon-eps

[www.dwd.de/DE/leistungen/wmc/wmc.html](http://www.dwd.de/DE/leistungen/wmc/wmc.html)

**EU:** 0,25°

<https://opendata.dwd.de/weather/nwp/icon-eu-eps/>

## RSMC

Regional Specialized  
Meteorological Centre for  
Global Ensemble Numerical  
Weather Prediction

### 24h Probability of Precipitation >10mm 2018-08-28 00:00 UTC +72h

#### 1. Mean and extreme values

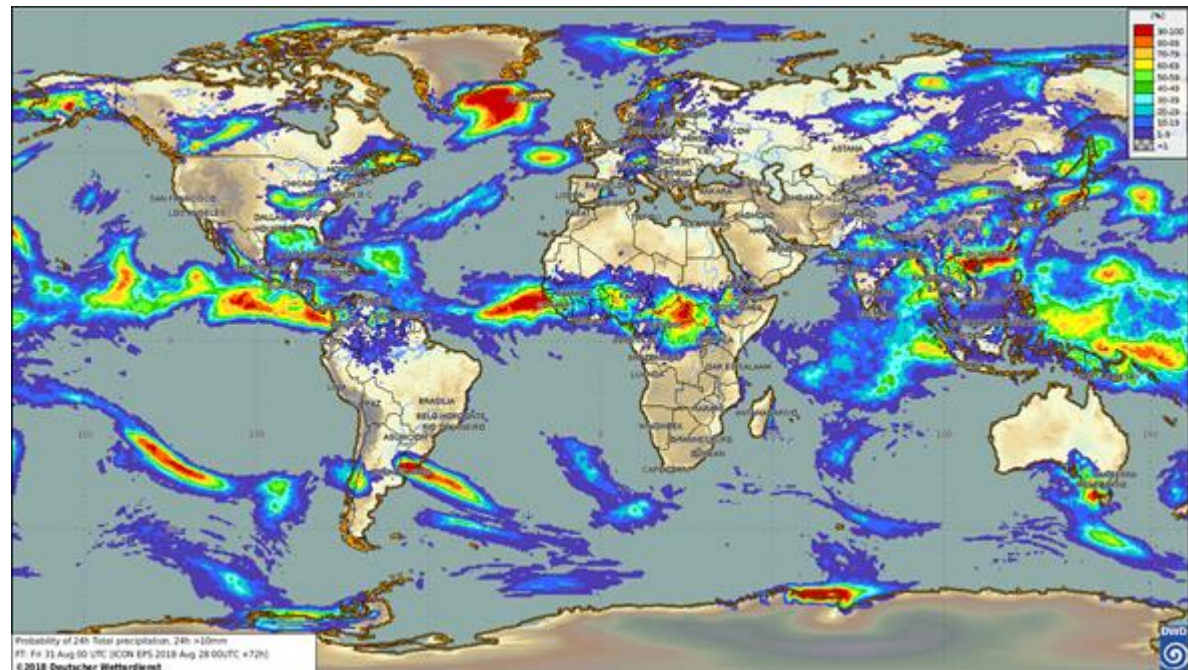
- Unweighted mean of all members
- Spread of all members
- Minimum of all ensemble members
- Maximum of all ensemble members

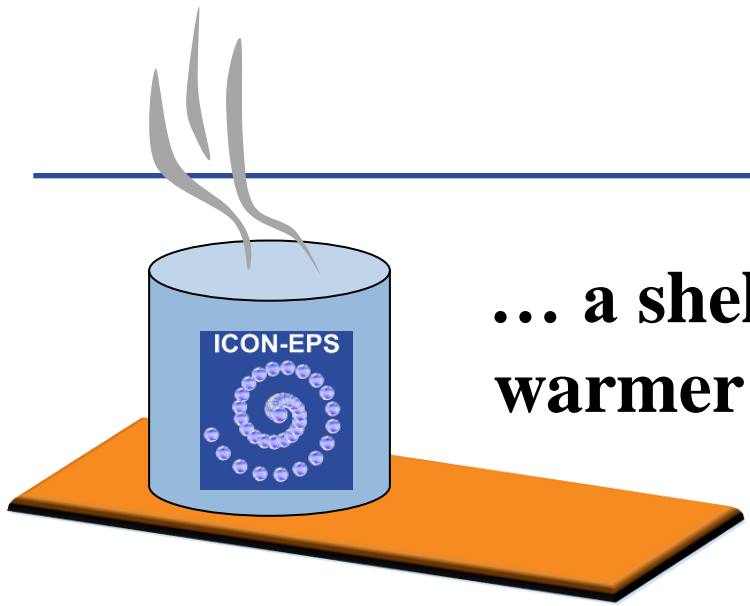
#### 2. Percentiles

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





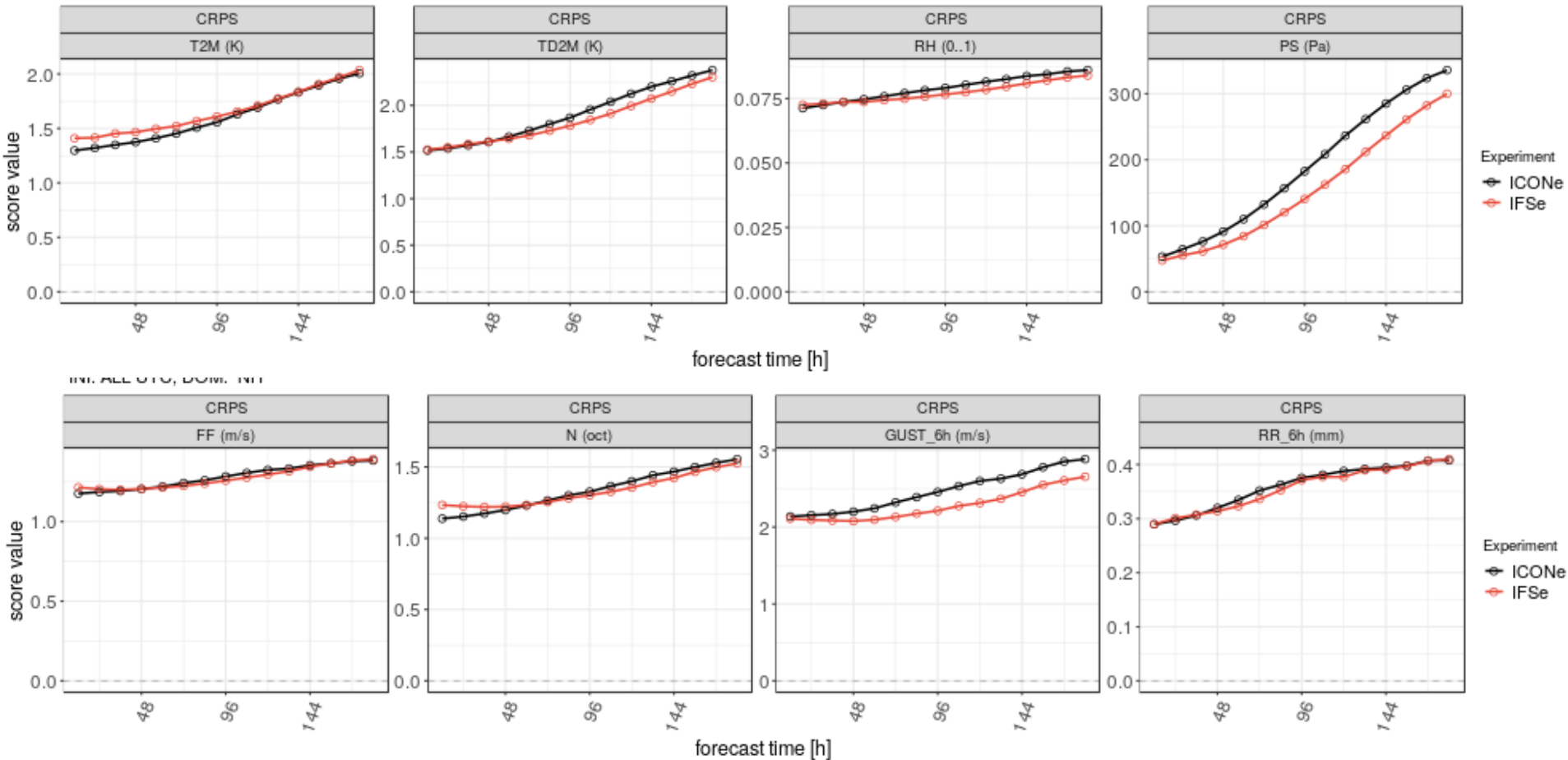
... a shelf  
warmer ?



# March 2019, NH, Synop, CRPS

— ECMWF-EPS  
— ICON-EPS

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



# Evaluation of ICON-EPS by the forecasters of DWD

... keep in mind that they rely on ECMWF-EPS

## Wind gusts (6h)

Summer 2017

**0-48h**

479 cases %

Added Value	yes	285	<b>59,5</b>
	some	117	<b>24,4</b>
	no	73	<b>15,1</b>
		4	<b>0,8</b>
Comparison	ECMWF	68	<b>14,2</b>
	ICON	91	<b>19,0</b>
	similar	299	<b>62,4</b>
		23	<b>4,8</b>

**60-108h**

604 cases %

Added Value	yes	297	<b>49,2</b>
	some	174	<b>28,8</b>
	no	132	<b>21,9</b>
		1	<b>0,2</b>
Comparison	ECMWF	98	<b>16,2</b>
	ICON	61	<b>10,1</b>
	similar	429	<b>71,0</b>
		16	<b>2,6</b>



## precipitation (12h)

**0-48h**

61 cases      %

Added value	yes	23	<b>37,7</b>
	some	13	<b>21,3</b>
	no	23	<b>37,7</b>
		2	<b>3,3</b>
Comparison	ECMWF	8	<b>13,1</b>
	ICON	7	<b>11,5</b>
	similar	39	<b>63,9</b>
		4	<b>6,6</b>

**60-108h**

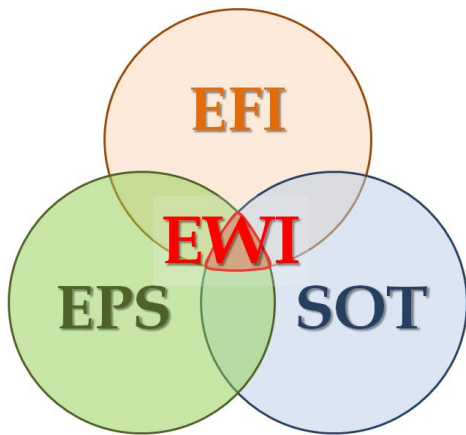
91 cases      %

Added value	yes	20	<b>22,0</b>
	some	17	<b>18,7</b>
	no	54	<b>59,3</b>
		0	<b>0,0</b>
Comparison	ECMWF	13	<b>14,3</b>
	ICON	12	<b>13,2</b>
	similar	62	<b>68,1</b>
		4	<b>4,4</b>

WGNE bluebook 2018

<http://wgne.meteoinfo.ru/publications/wgne-blue-book/>





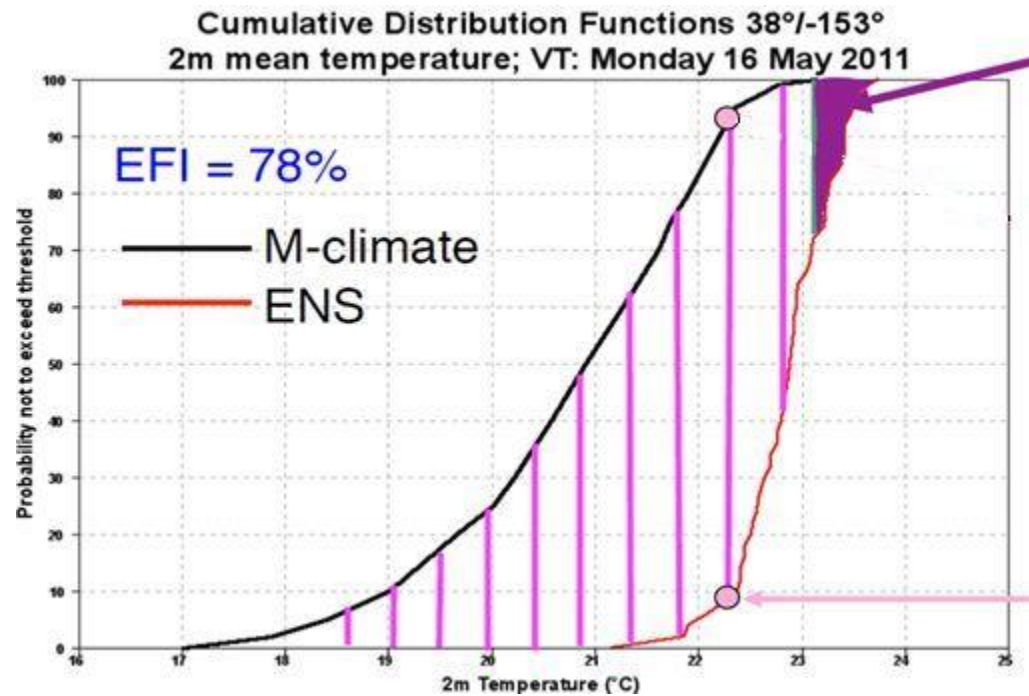
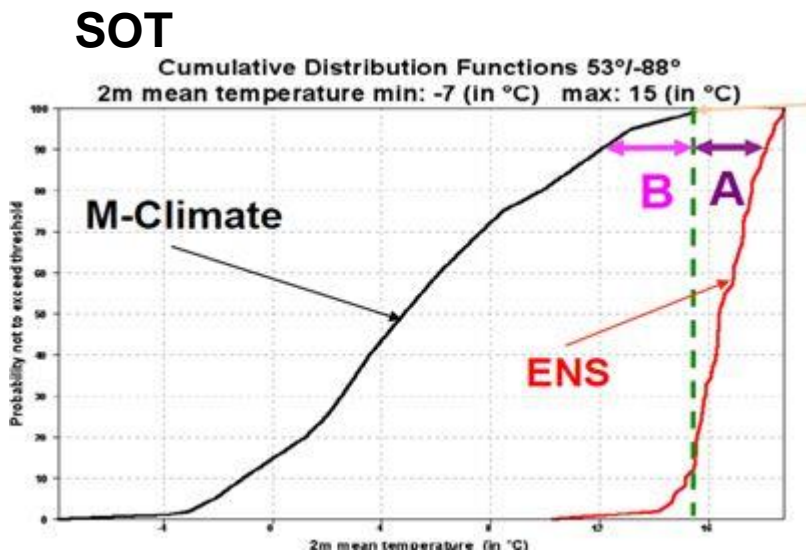
## Shift of Tails (SOT)

### Extreme Forecast Index (EFI)

EPS Quantiles of the actual forecast distribution (90%)

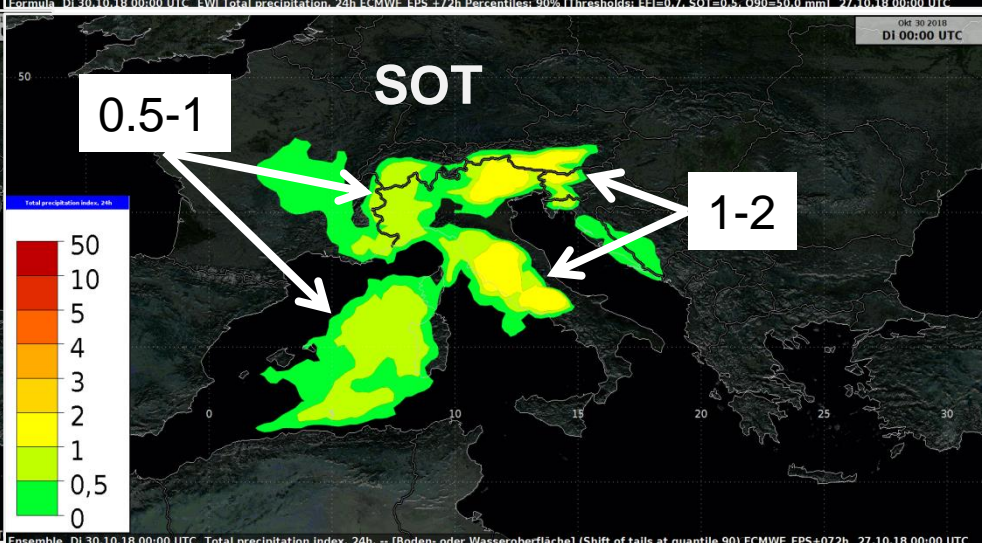
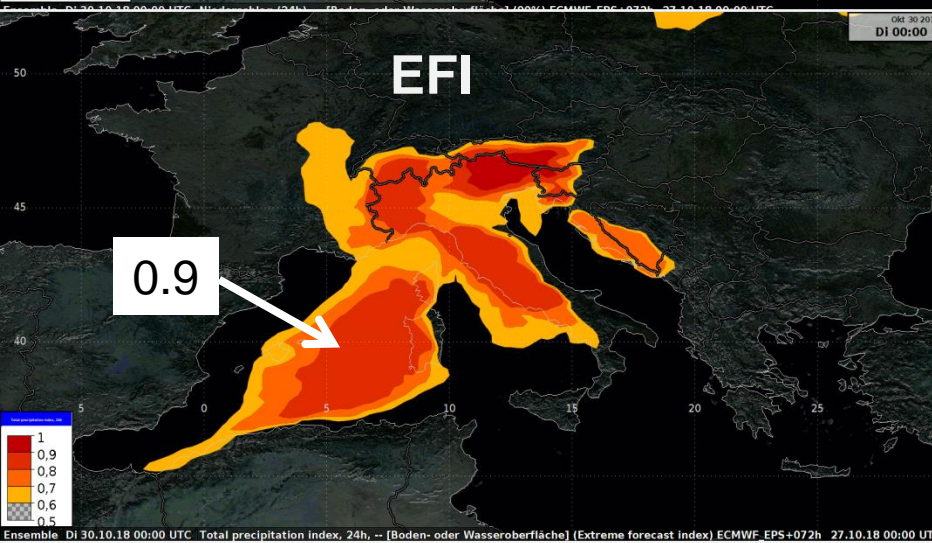
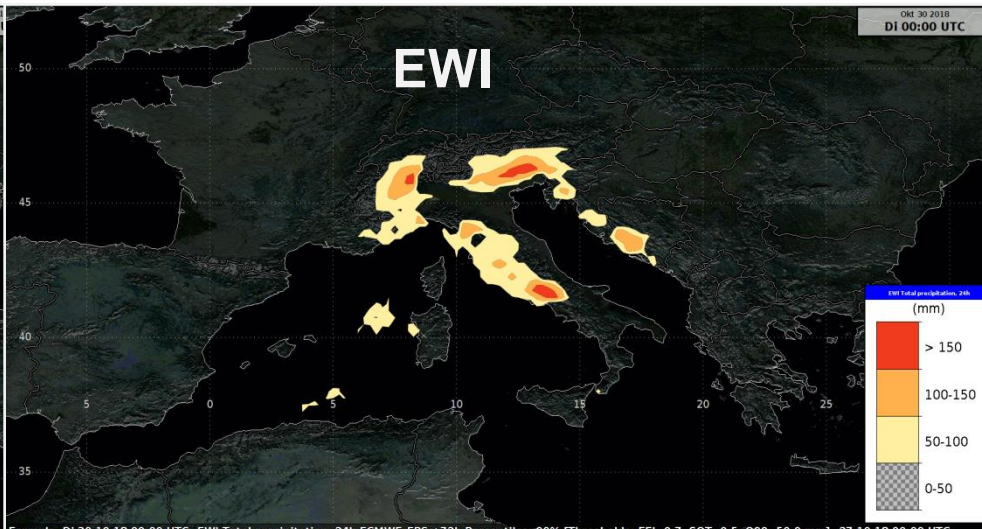
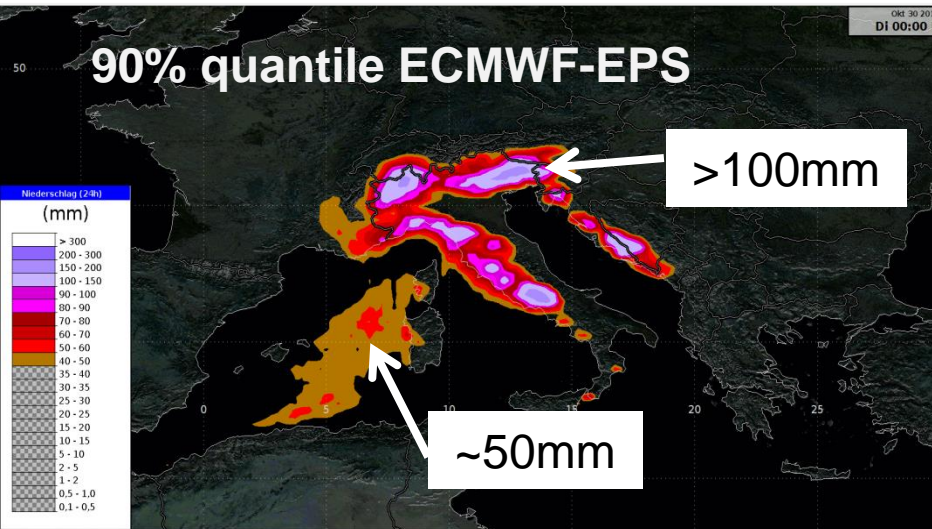
=> **Extreme Weather Index (EWI)**

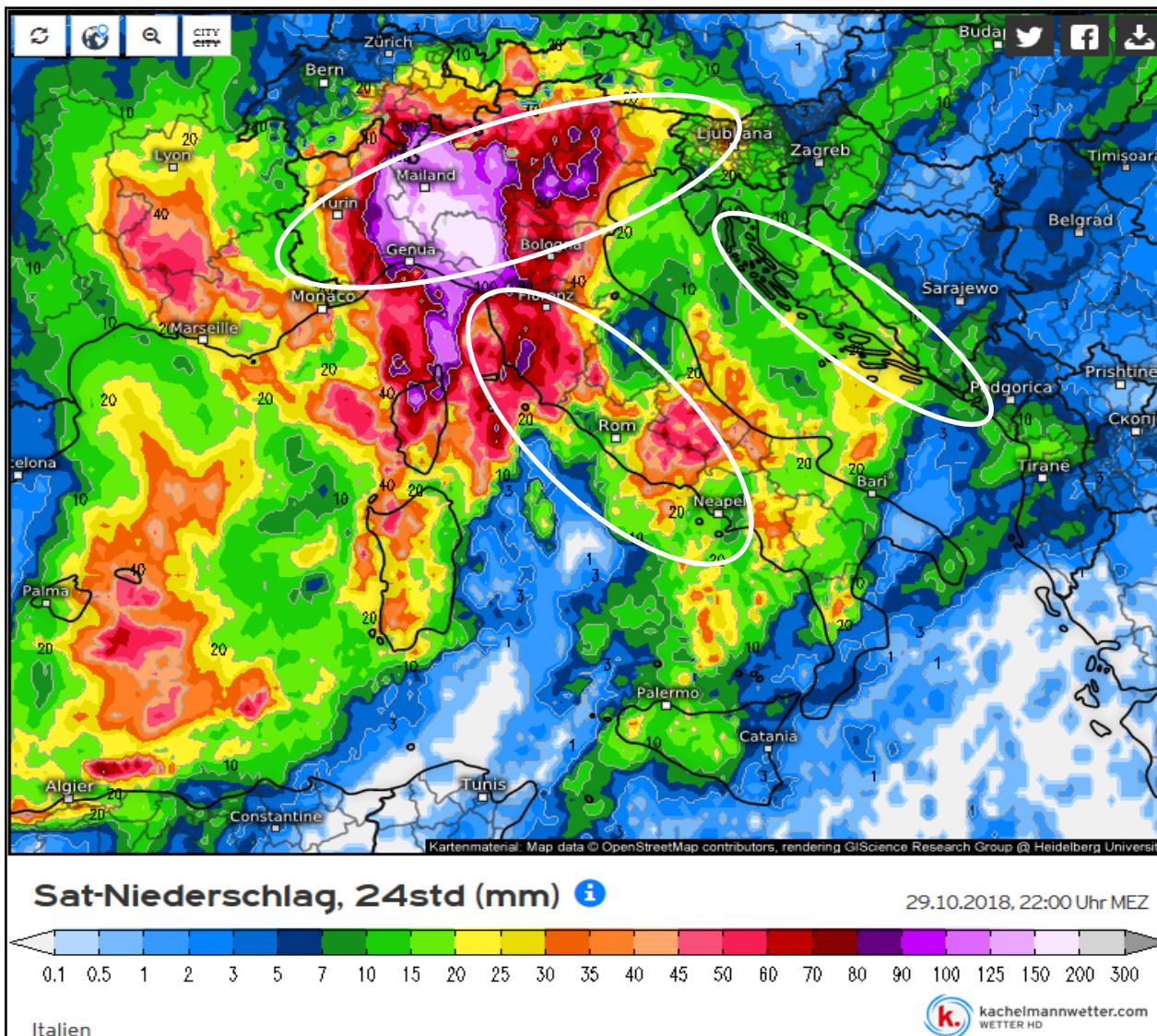
EWI has 3 alert level (yellow, orange, red)



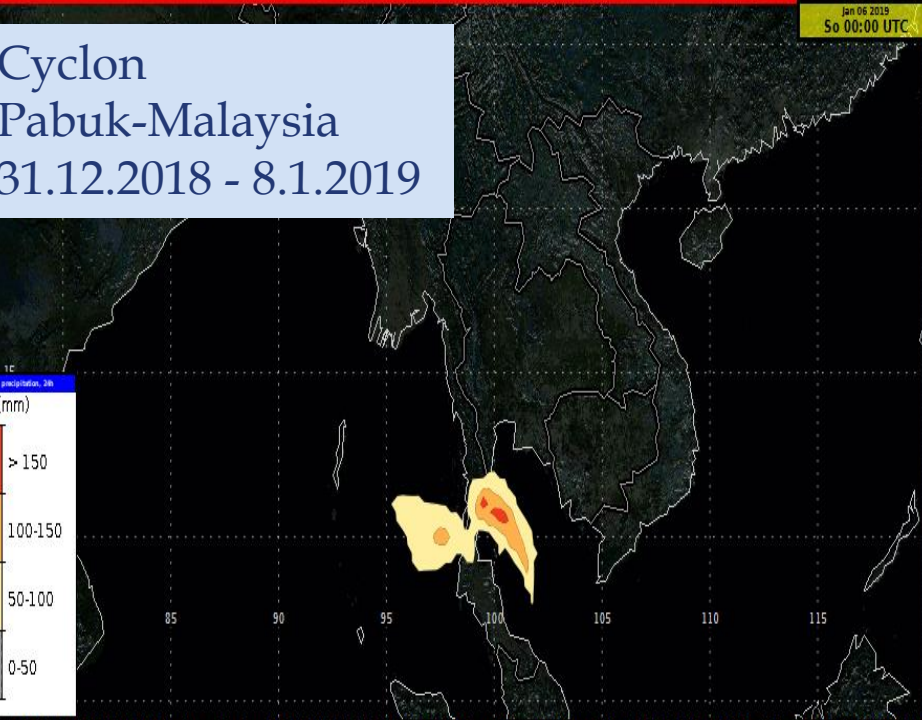


init 27.10.18, 00UTC+72h

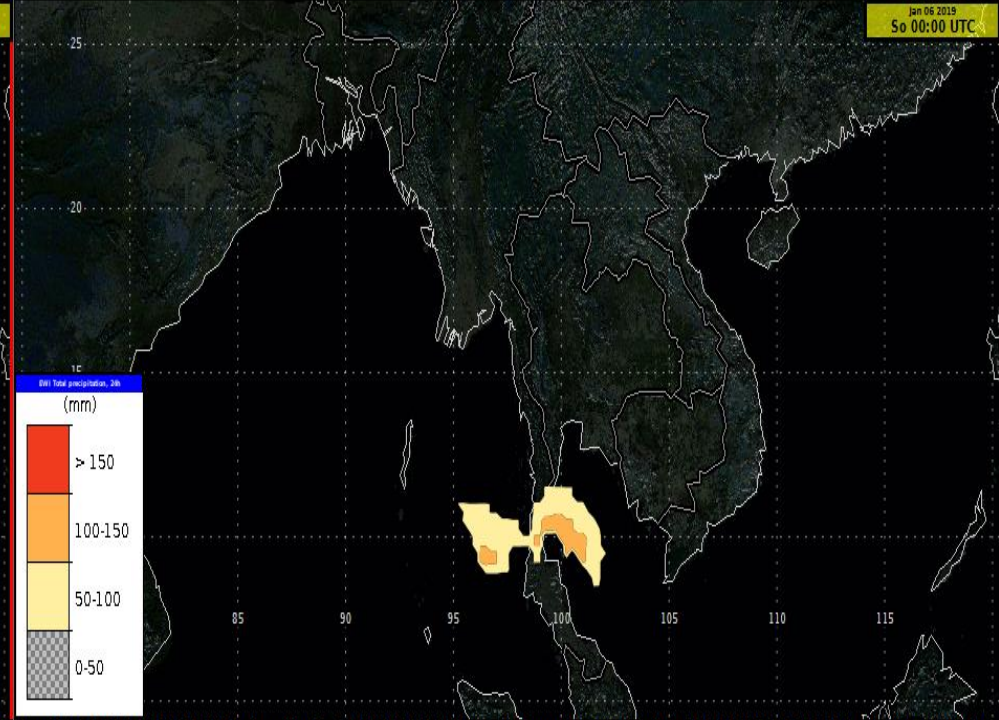




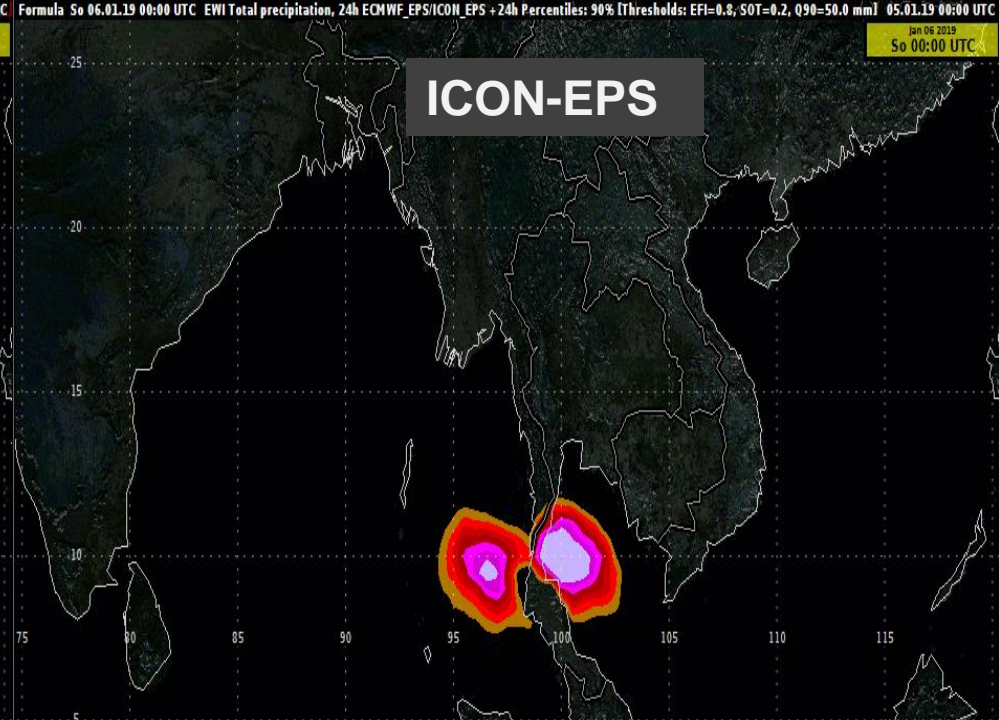
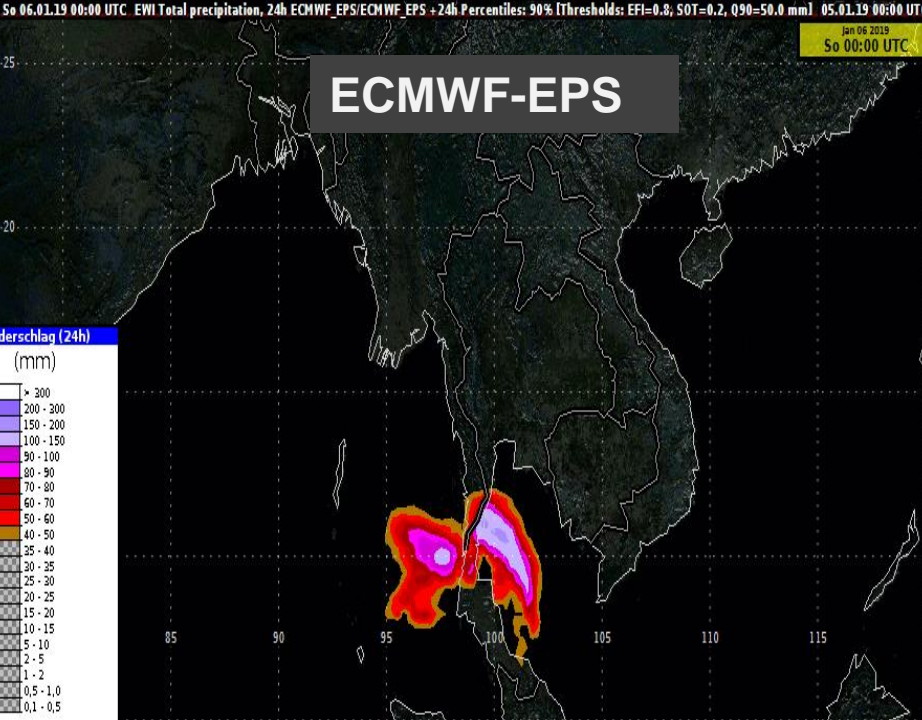
# Cyclon Pabuk-Malaysia 31.12.2018 - 8.1.2019

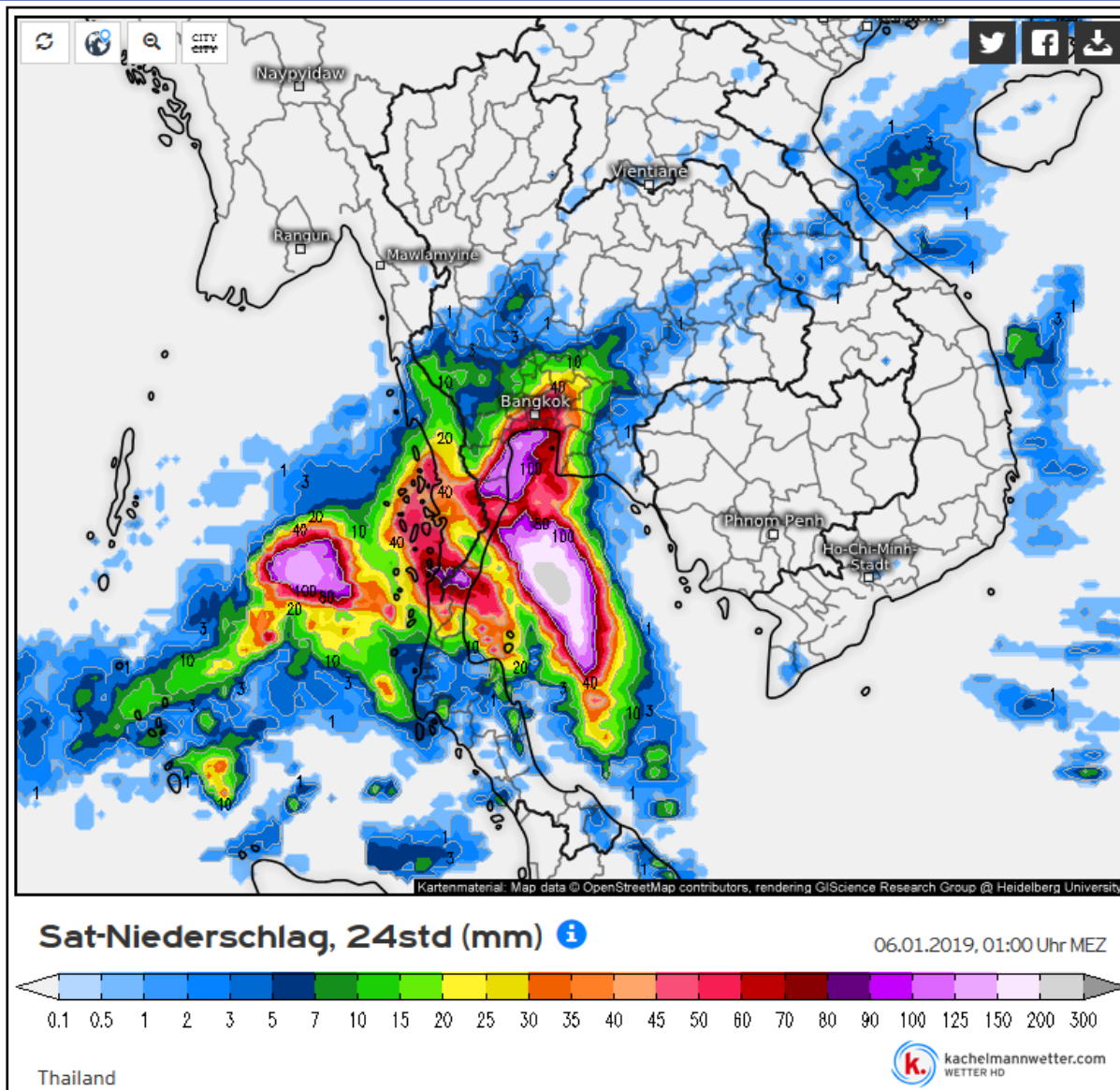


**ECMWF-EPS**



**ICON-EPS**





*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°K, correlations of 100km/1000km and 1 day

**Are these perturbations appropriate for the short and very short range?**



Jens Winkler, Bernhard Schmitt, Michael Denhard

preprint: <http://www.mathematik.uni-marburg.de/~numerik/preprints/?lang=DE>

# Initial Perturbations

from the tangent subspace of growing perturbations

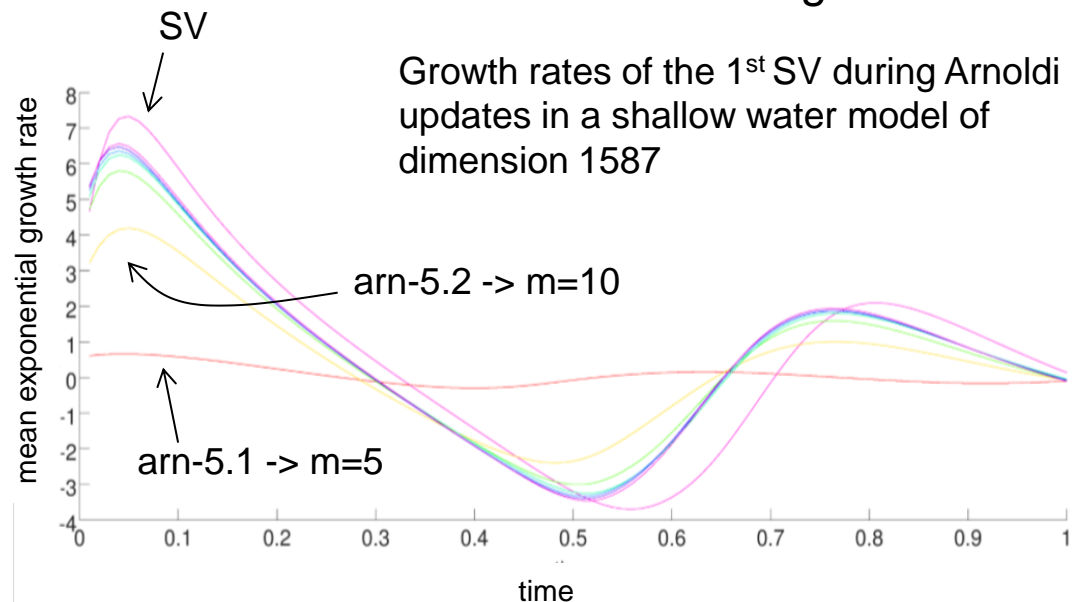
$$\underbrace{\mathbf{A}}_{n \times n} \underbrace{\mathbf{Q}}_{n \times m} = \underbrace{\mathbf{Q}}_{n \times m} \underbrace{\mathbf{H}}_{m \times m} + \boldsymbol{\varepsilon} \quad m \ll n$$

Krylov subspace  
computed by Arnoldi  
Algorithm

Tangent Operator

$\mathbf{H}$  model for  $\mathbf{A}$

Singular Vectors of  
 $\mathbf{H}$



## 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](https://opendata.dwd.de)
- Storm Tracks
- Contribute to EWI
- Superensemble ICON-EPS / ECMWF-EPS
- **TIGGE**

