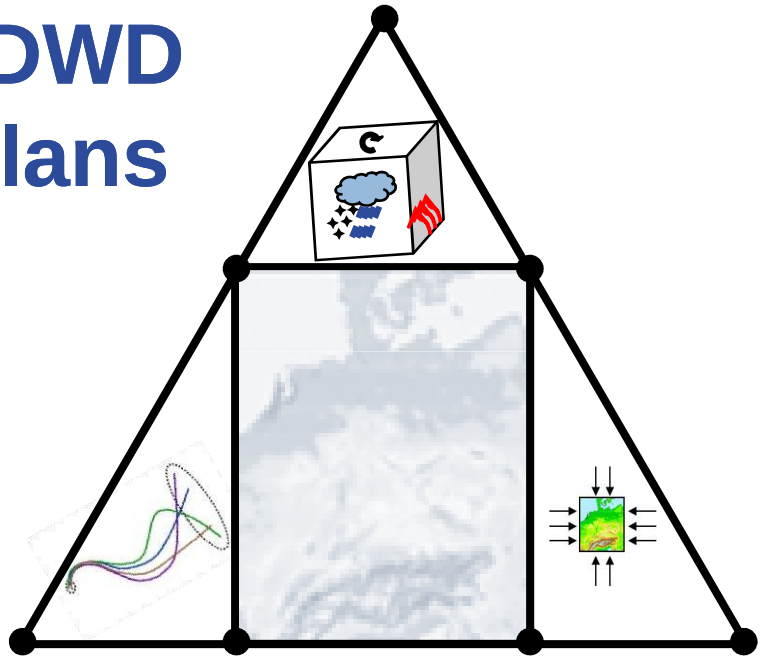
Convective-scale EPS at DWD
status, developments & plans



C. Gebhardt, S. Theis, R. Kohlhepp, E. Machulskaya, M. Buchhold

developers of KENDA, ICON-EPS, ICON-EDA, COSMO-D2, verification

Outline

- new operational set-up *(since 21st March 2017)*
- verification results *(„new vs. old“, general characteristics in 2017)*
- COSMO-D2-EPS
- EM-Scheme – model for the model error
- future plans

Operational set up of COSMO-DE-EPS *(since 21st March 2017)*

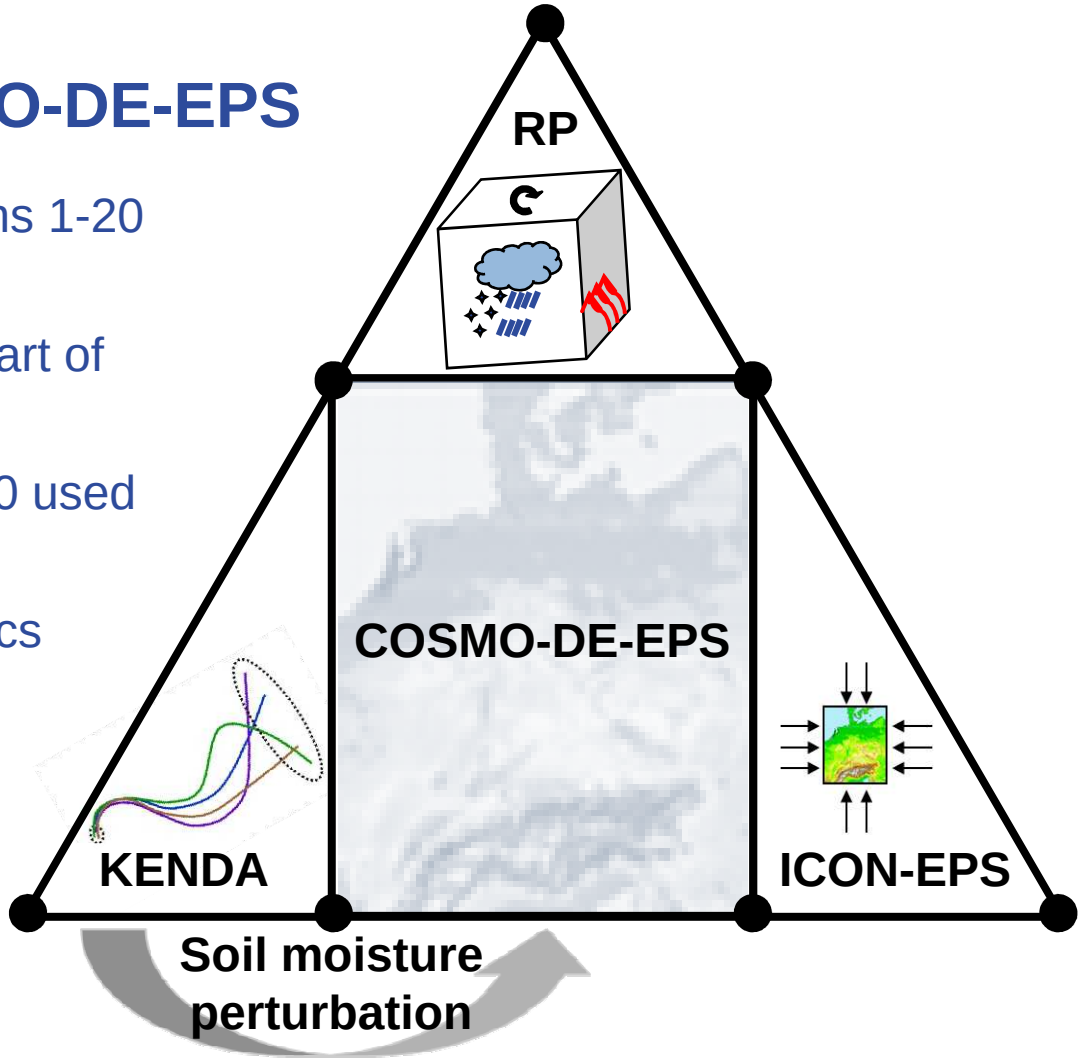
- improved quantification of **initial state uncertainty** by a "Local ensemble transform Kalman filter" as a statistical-dynamical sound method ("**KENDA**") (including stochastic, scale-dependent perturbation of **soil moisture**, soil temperature, and SST)
  Members 1-20 of 40 KENDA members

- ICON-EPS provides **boundary conditions** for COSMO-DE-EPS based on a state-of-the-art model with high quality
  Use of ICON-EPS is technically more feasible (data transfer, robustness)
  Members 1-20 of 40 ICON-EPS members

- new randomized selection of **physics perturbations** improves forecast quality and is more flexible (e.g. perturb more parameters)

Improvements in COSMO-DE-EPS

- ➔ KENDA as EPS initial conditions 1-20 of 40 members
- ➔ Soil moisture perturbation as part of KENDA
- ➔ ICON-EPS members 1-20 of 40 used as boundary conditions
- ➔ Randomised selection of physics parameter perturbations (RP)

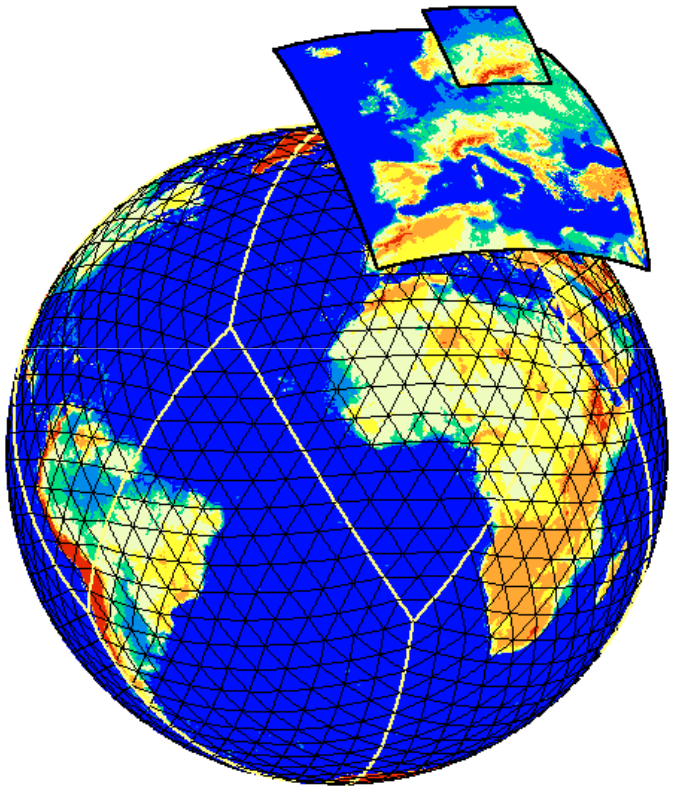


Folie: T. Tröndle

KENDA & COSMO-DE-EPS (initial conditions)

- 4D-LETKF (Local Ensemble Transform Kalman Filter)
- Observations:
  - SYNOP, TEMP, aircraft, wind profiler
  - radar derived precipitation rate via Latent Heat Nudging (LHN)
- "deterministic analysis": Initial Conditions for COSMO-DE
- "analysis ensemble":
  - observation uncertainties & error inflation
  - variations in soil moisture, soil temperature and SST
- first 20 (of 40) analysis members as initial conditions for COSMO-DE-EPS

ICON-EPS & COSMO-DE-EPS (boundary conditions)



COSMO-DE-EPS: 2.8 km

↑

ICON-EU-EPS nest: 20 km
(two-way nesting)

↑

ICON-EPS: 40 km

Pre-operational ensemble prediction system

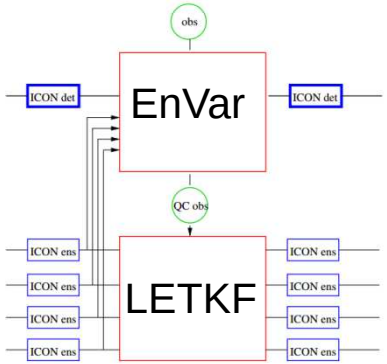
Currently operational:

- ICON Ensemble Data Assimilation
- Boundary conditions for COSMO-DE-EPS

ICON Ensemble Data Assimilation

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

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



Global ensemble prediction
ICON-EPS
40 members
40 / 20 km (Europe)

ICON-EPS

- LETKF (Localized Ensemble Transform Kalman Filter)
- Covariance Inflation
  - adaptive multiplicative factor
  - additive Inflation + 0,25B_{3dVar} (NMC Method)
  - „relaxation to the prior“
  - SST 1K random perturbations with spatial correlations of 100km/1000km and correlations in time of 1 day
- En-Var using flow dependent background error covariance from the LETKF (-> 13 km)

Andreas Rhodin, Harald Anlauf, Ana Fernandez del Rio, Alexander Cress, Roland Potthast

Randomized physics perturbations in COSMO-DE-EPS

- 2-3 different values for each of 12 parameters
- each parameter is perturbed in 50% of the members of each ensemble run
- **random selection** of members with perturbed parameter at each forecast start (done for each parameter seperately)
- parameter values stay fixed over the forecast range

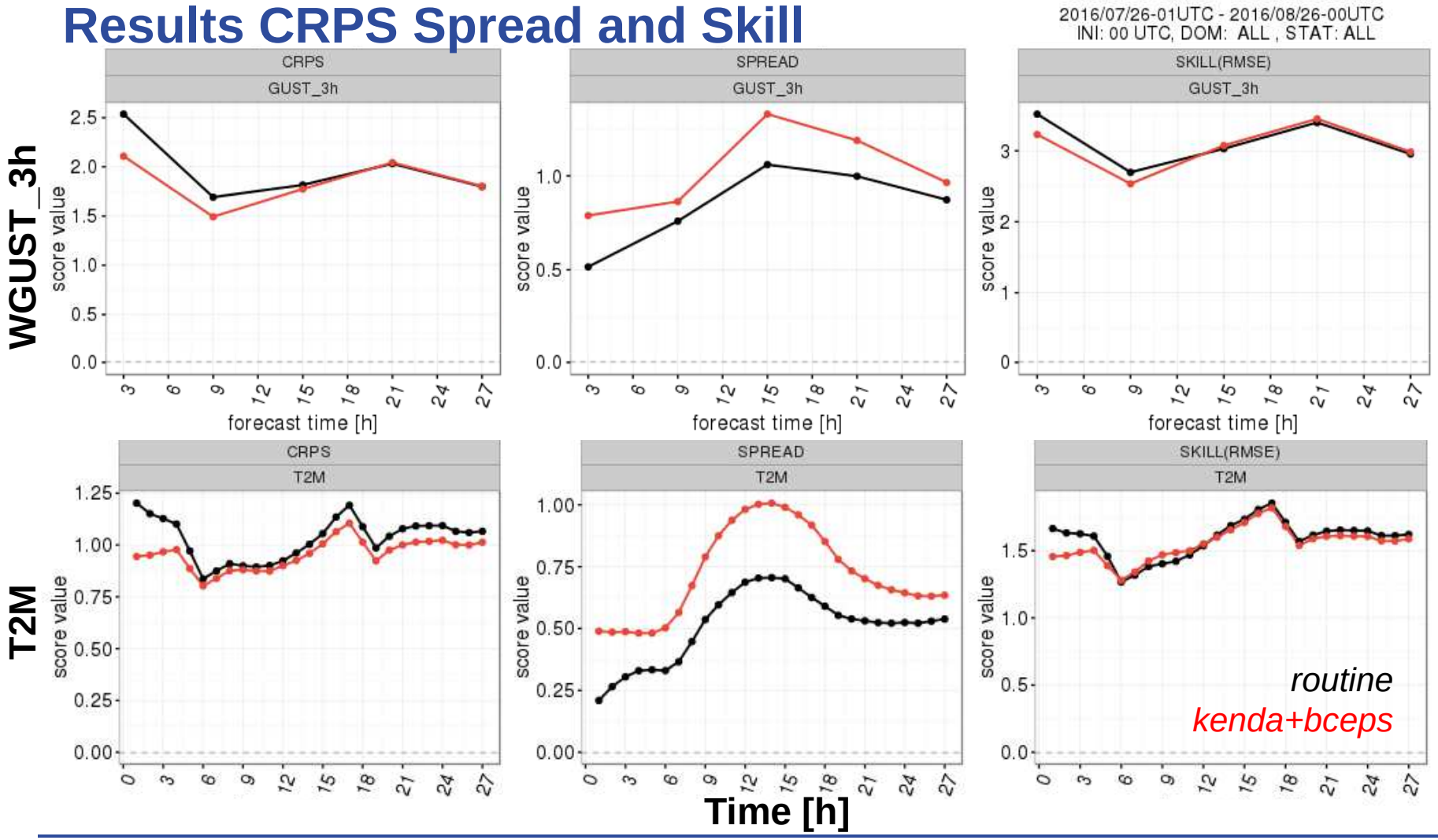
New perturbations (easier to implement with the RP)

a_stab	c_diff	radqi_ fact	radqc_ Fact	thick_ sc	rlam_ heat	entr_sc	q_crit	tur_len	tkh min	tkm min	lhn_coef
0	0.2	0.5	0.5	25000	1	0.0003	1.6	150	0.4	0.4	1
1	0.1	0.9	0.9	10000	10	0.002	4	500	0.7	0.7	0.5
	10			30000	0.1				0.2	0.2	

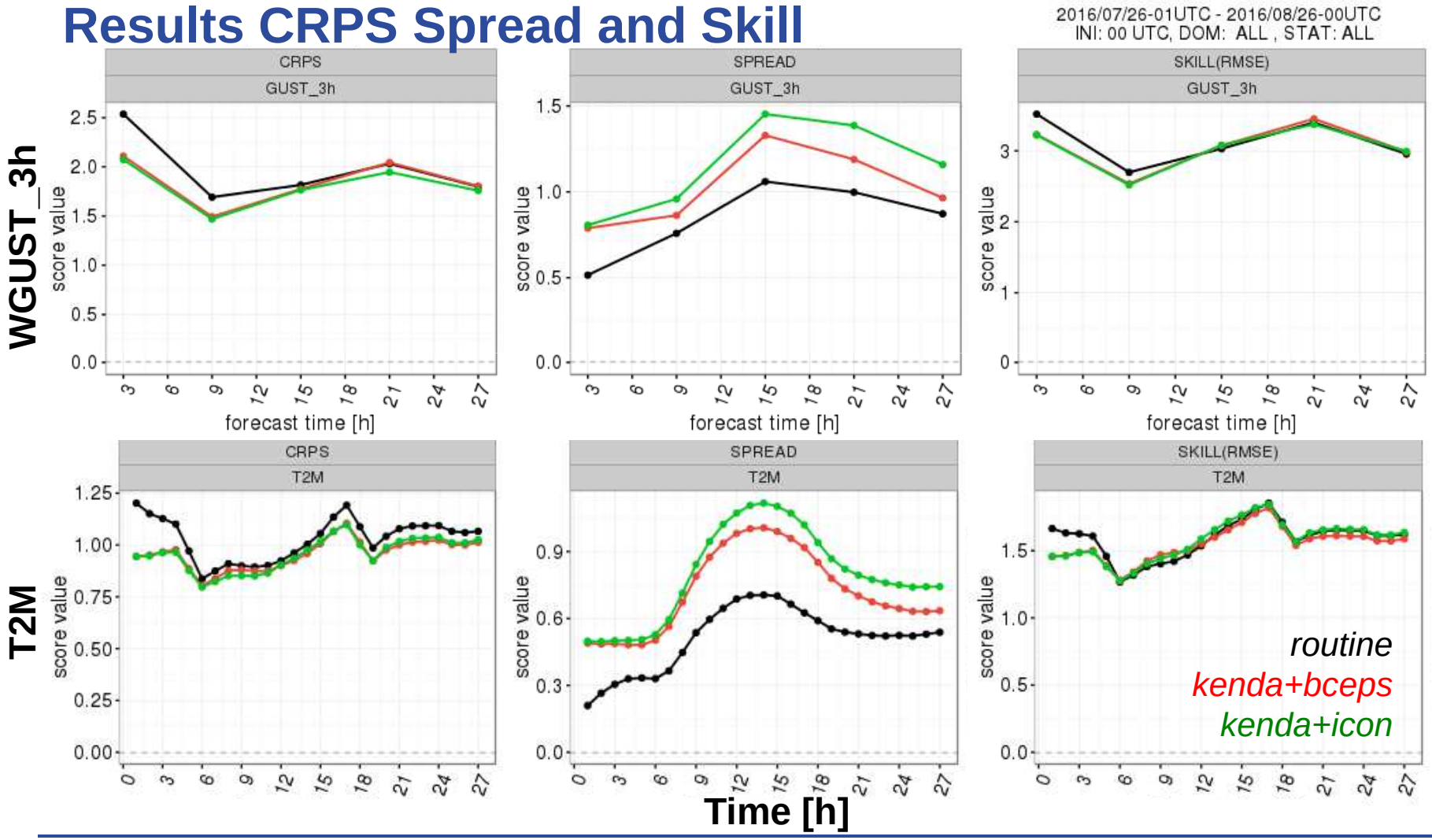
Verification results *(„new vs. old“)*

- 26th July – 25th August 2016
- 00 and 12 UTC (not shown) runs with 27 hours forecast range
- hourly precipitation vs radar (rain gauge adjusted)
- 3-hourly 10m gusts vs SYNOP
- 2m temperature vs SYNOP

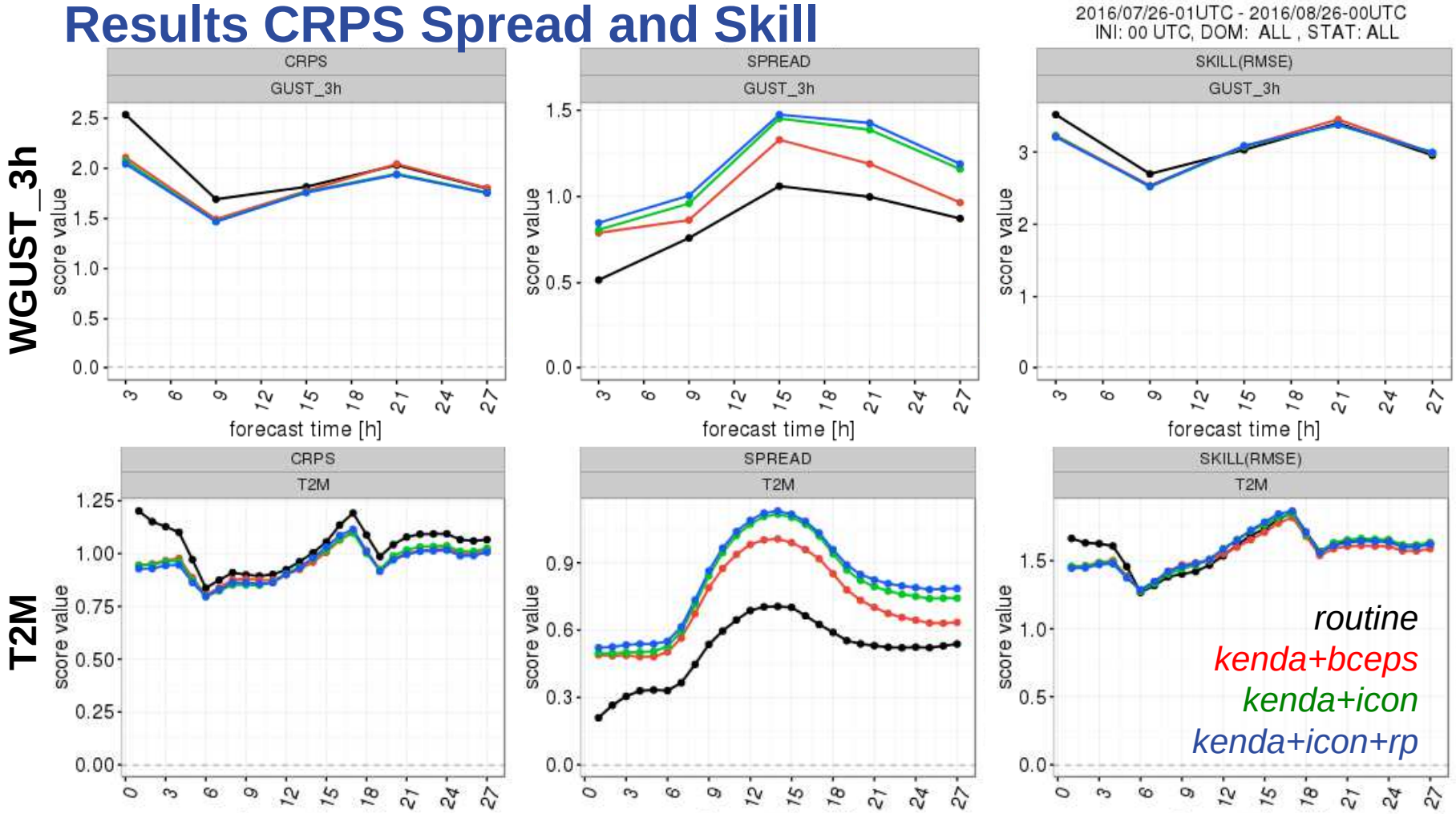
Results CRPS Spread and Skill



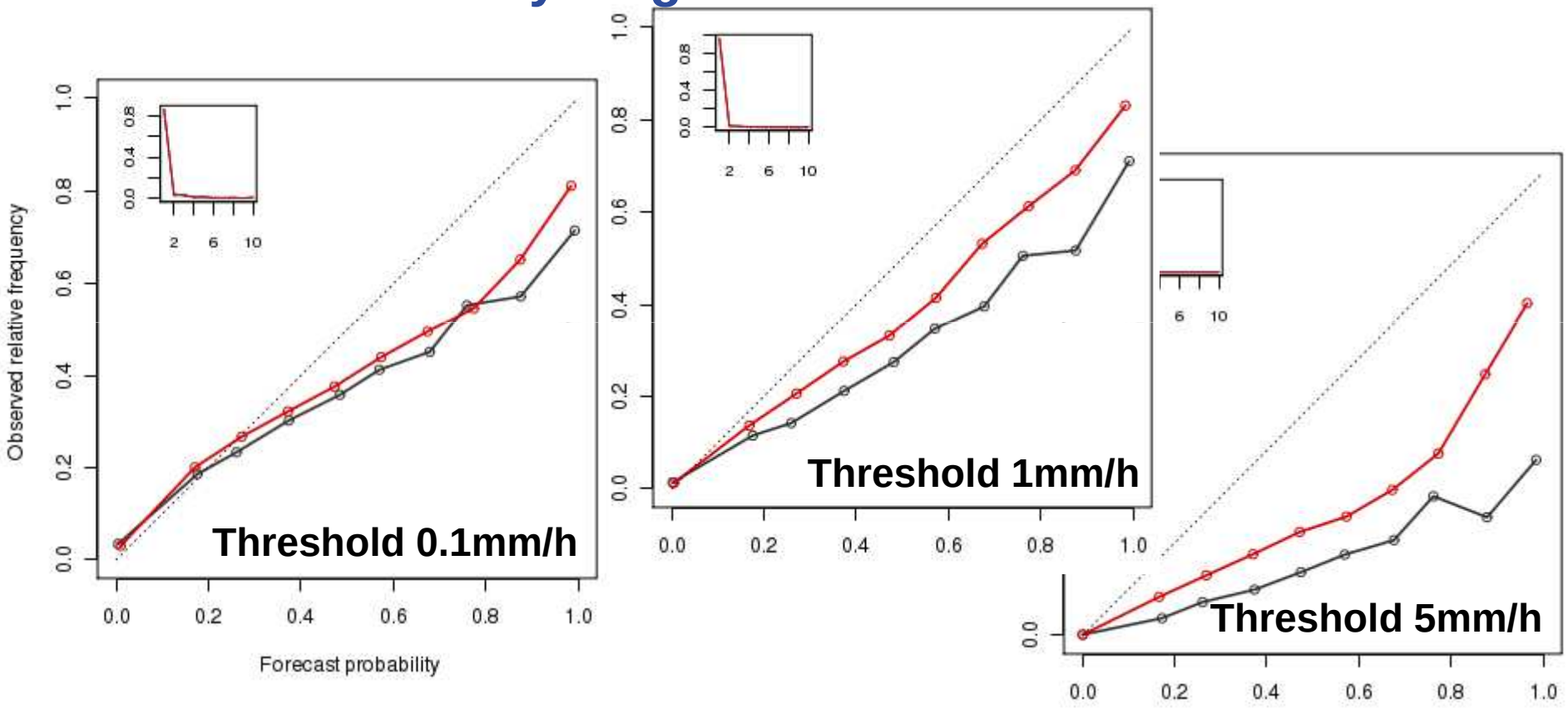
Results CRPS Spread and Skill



Results CRPS Spread and Skill



Results – Reliability diagram



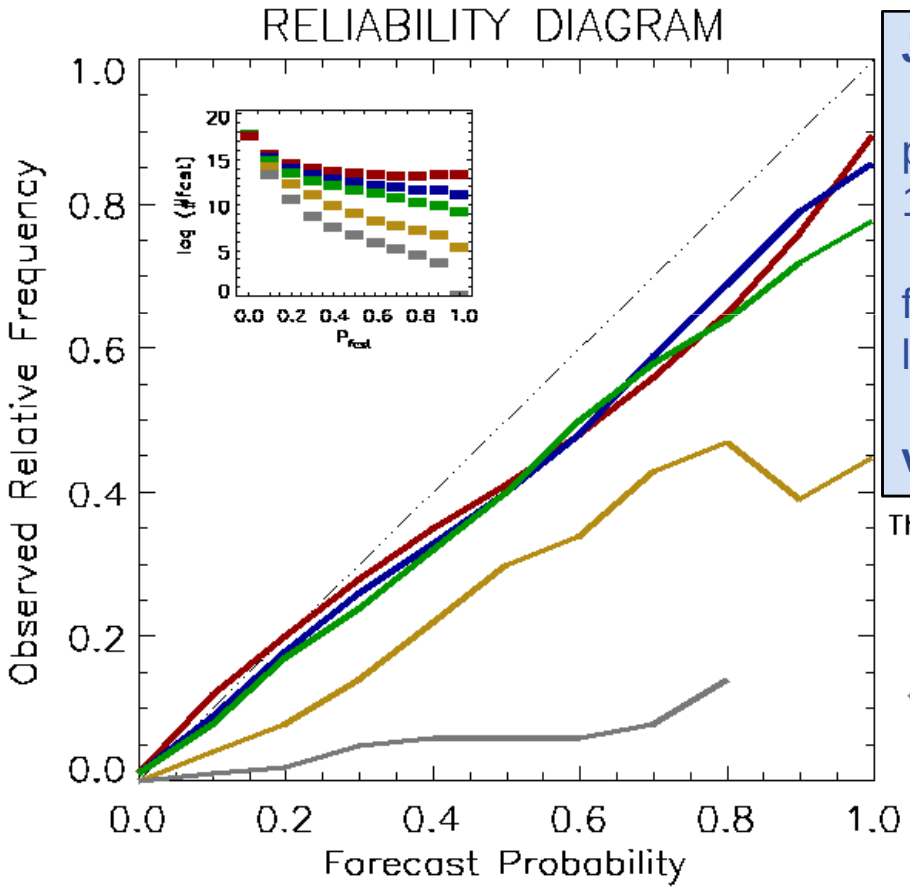
PREC routine (black) and kenda+icon+rp (red) from 26.07.-25.08.2016
as 00 UTC run for the threshold values 0.1, 1 and 5mm/h

Verification results *(general characteristics in 2017)*

- June 2017
- 00 and 12 UTC (not shown) runs with 27 hours forecast range
- hourly precipitation vs radar (rain gauge adjusted)
- hourly 10m gusts vs SYNOP
- no 2m temperature shown

slide by S. Theis

Reliability Diagram *precipitation*



June 2017

precipitation
1h-accumulations

forecast start: 00 UTC
lead times: 1-21 hours

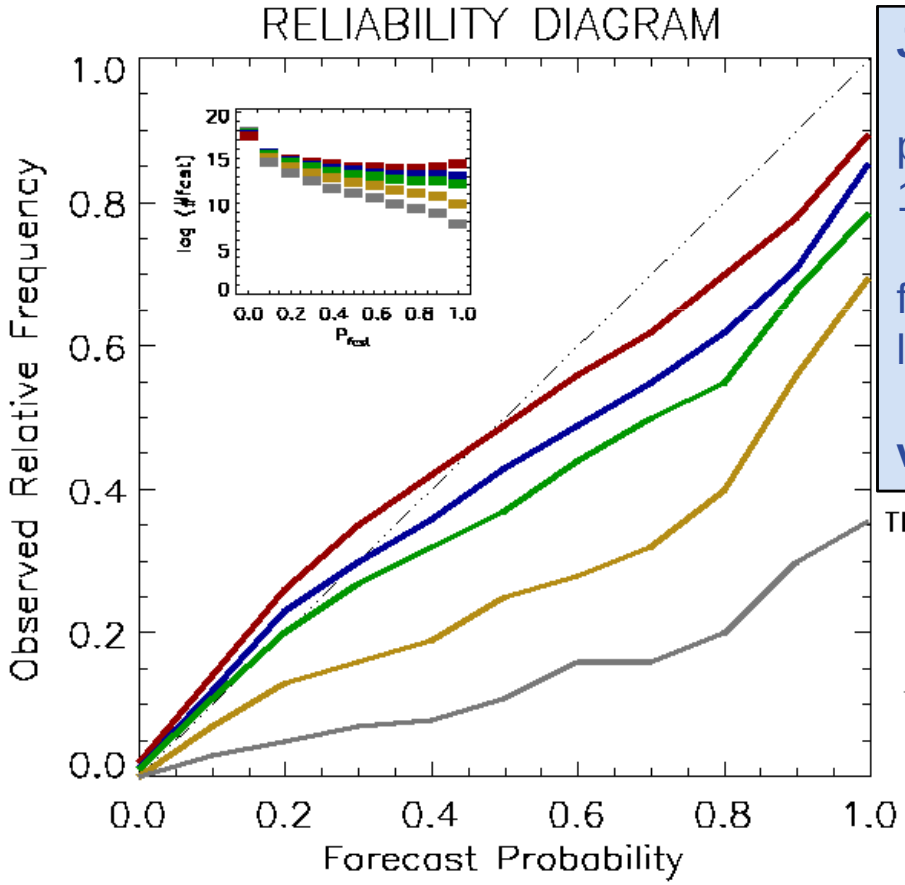
verified against radar (RW)

Thresholds in mm/1h :

0.1	>1.000.000 cases
1.0	>1.000.000 cases
2.0	>1.000.000 cases
5.0	>100.000 cases
10.0	72162 cases

slide by S. Theis

Reliability Diagram *precipitation*



June 2017

precipitation **„upscaled 28km“**
1h-accumulations

forecast start: 00 UTC
lead times: 1-21 hours

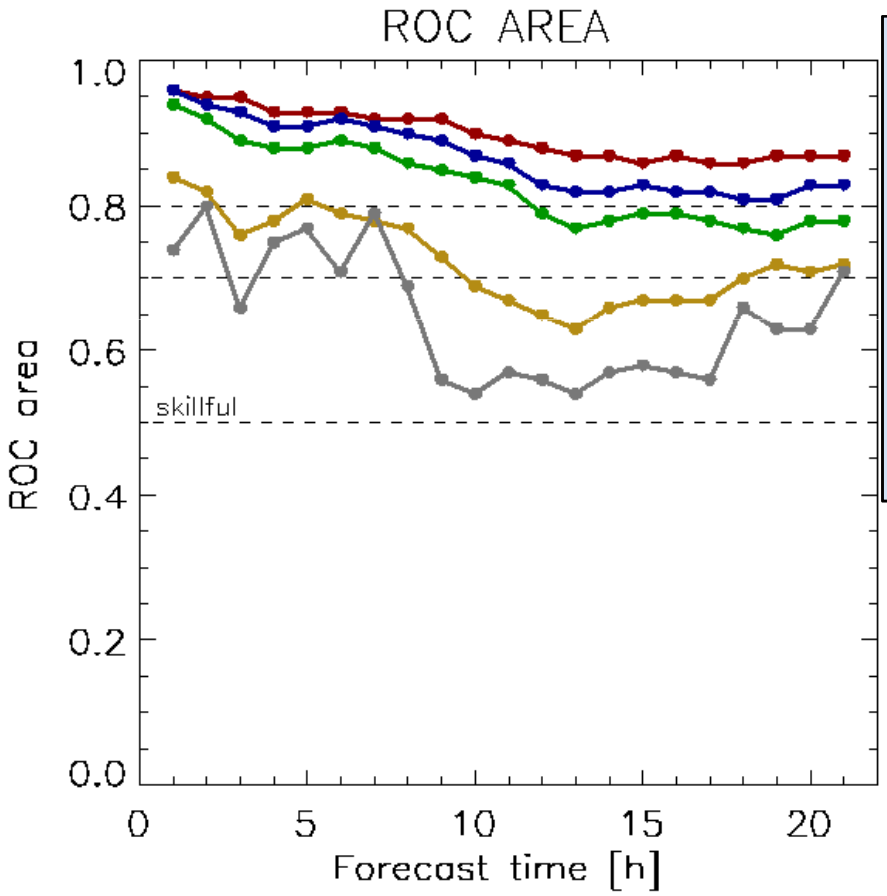
verified against radar (RW)

Thresholds in mm/1h :

0.1	>1.000.000 cases
1.0	>1.000.000 cases
2.0	>100.000 cases
5.0	>100.000 cases
10.0	67230 cases

slide by S. Theis

„ROC area“ *precipitation*



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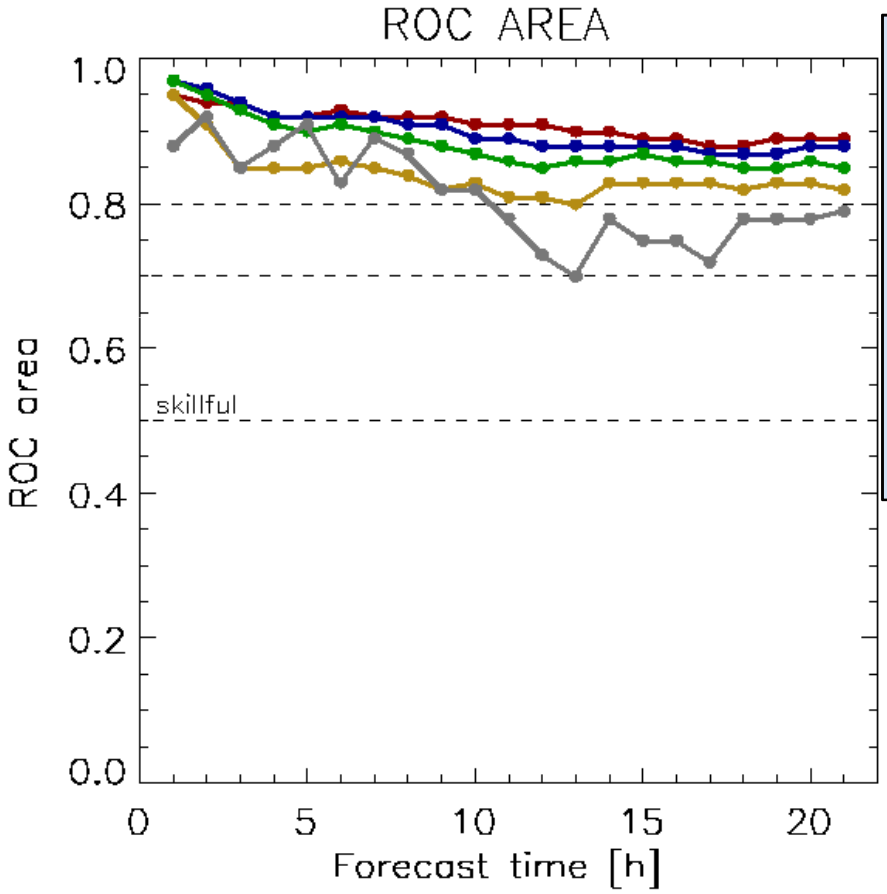
slide by S. Theis

„ROC area“ *precipitation*



June 2017

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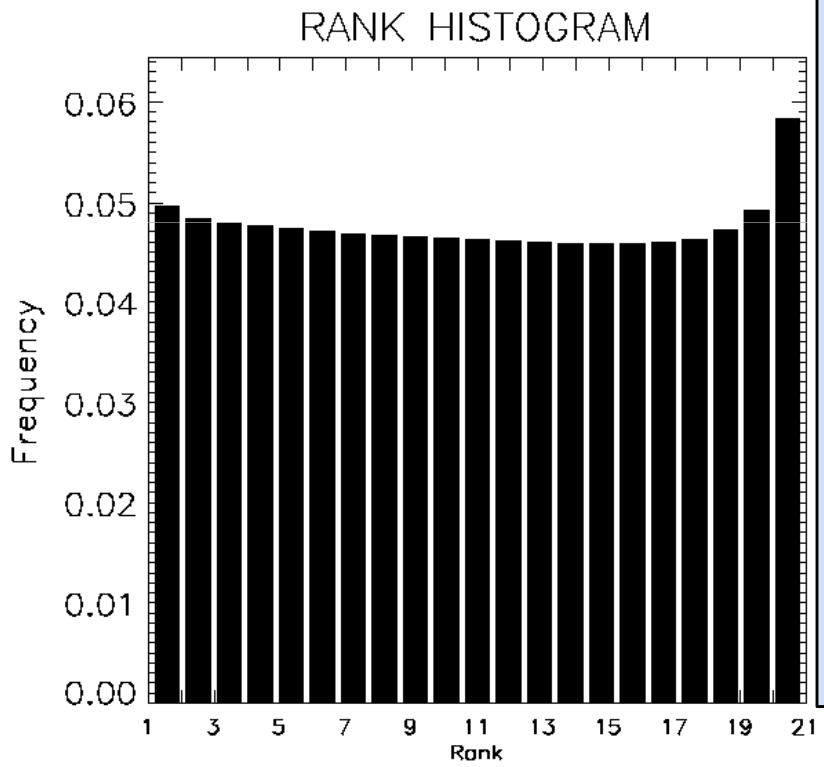
5.0	>100.000	cases
10.0	67230	cases

slide by S. Theis

Rank histogram precipitation



June 2017

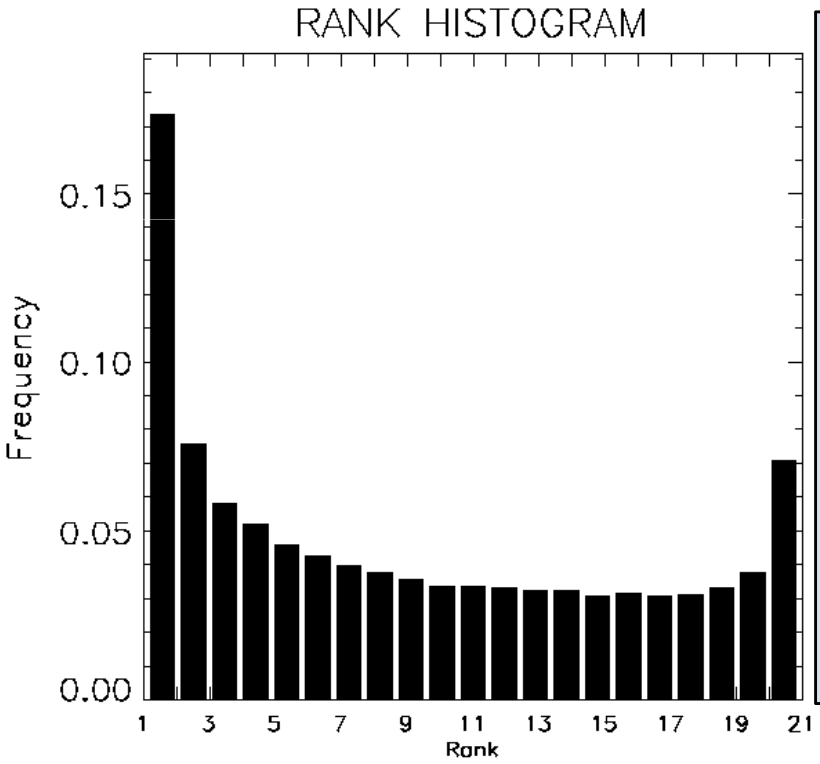
precipitation
1h-accumulations

forecast start: 00 UTC
lead times: 1-21 hours

verified against radar (RW)

slide by S. Theis

Rank histogram wind gusts



June 2017

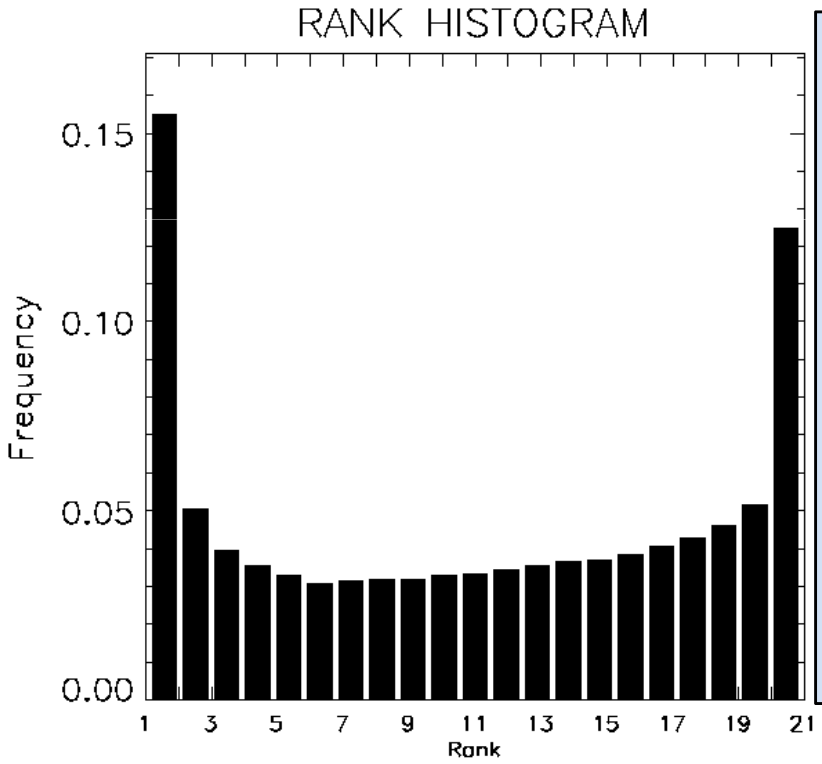
wind gusts

forecast start: 00 UTC
lead times: 1-21 hours

verified against SYNOP

slide by S. Theis

Rank histogram 2m temperature



June 2017

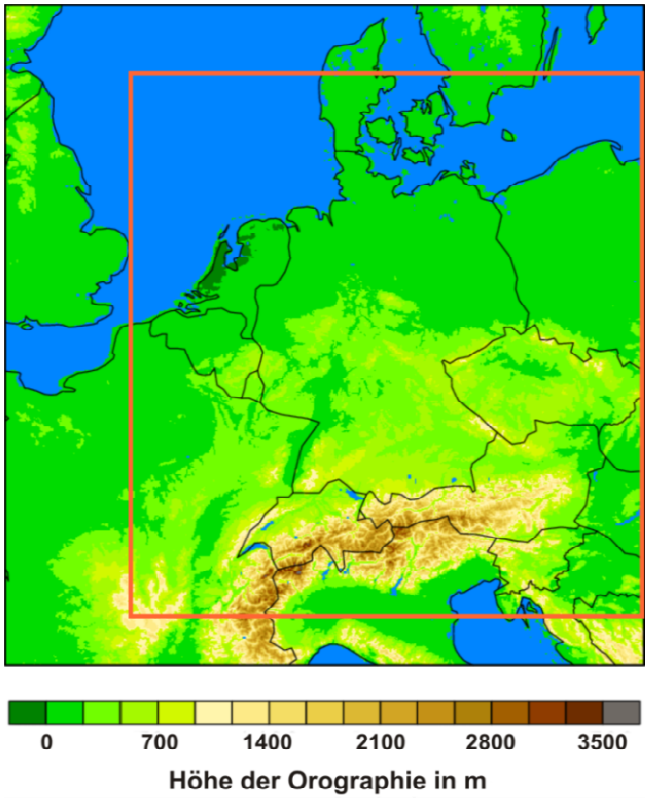
2m-temperature

forecast start: 00 UTC
lead times: 1-21 hours

verified against SYNOP

COSMO-D2 & COSMO-D2-EPS

- increased resolution
  - 2.2 km horizontal grid
  - 65 vertical levels
  - 651 x 716 grid points
- larger domain (mainly to the west)
- common physics with ICON
- operational in 2018



EM-scheme *model for the model error (E. Machulskaya)*

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

ψ : prognostic variables (T, QV, U, V)

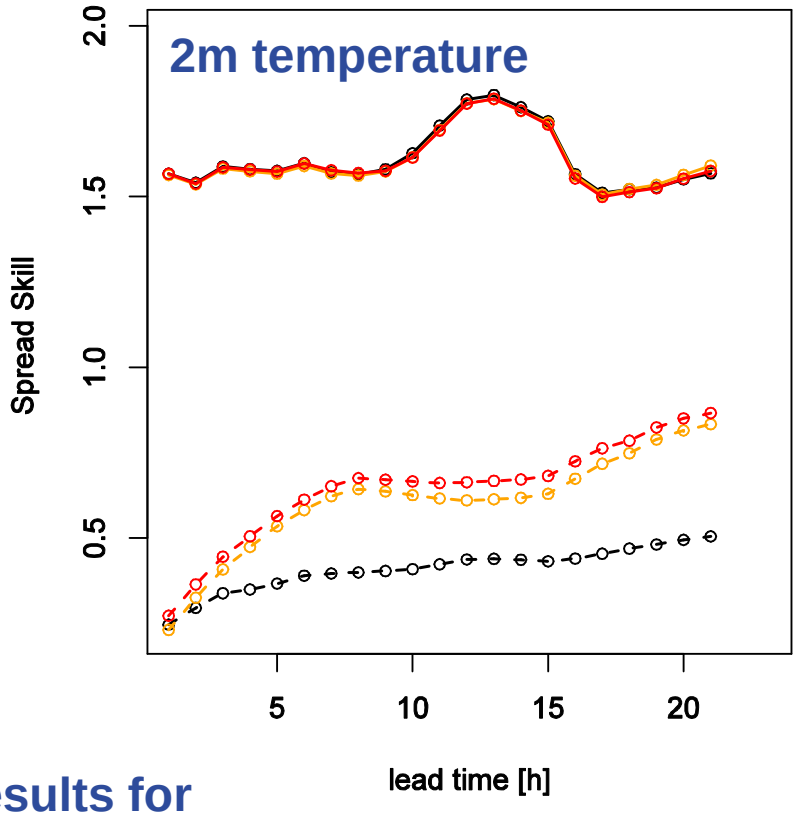
$\eta(t)$: noise field / model error, correlated in time and space

$\xi(t)$: Gaussian noise

σ, γ, λ: standard deviation and spatial and temporal correlation

γ, λ and σ are weather-dependent and are derived from past data

Potential predictors are $\left|\frac{dT}{dt}\right|$, $|U|$, cl.cover, $\left|\frac{dq}{dt}\right|$



results for 10.1.-30.1.2014

operational

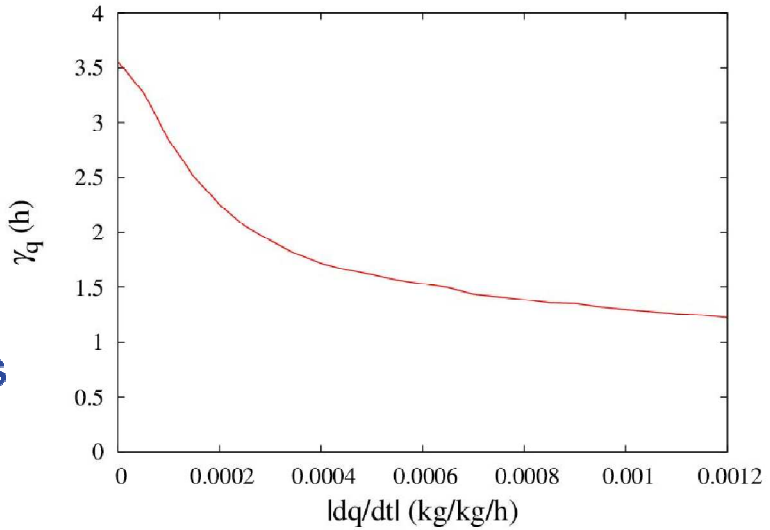
stochastic EM-scheme

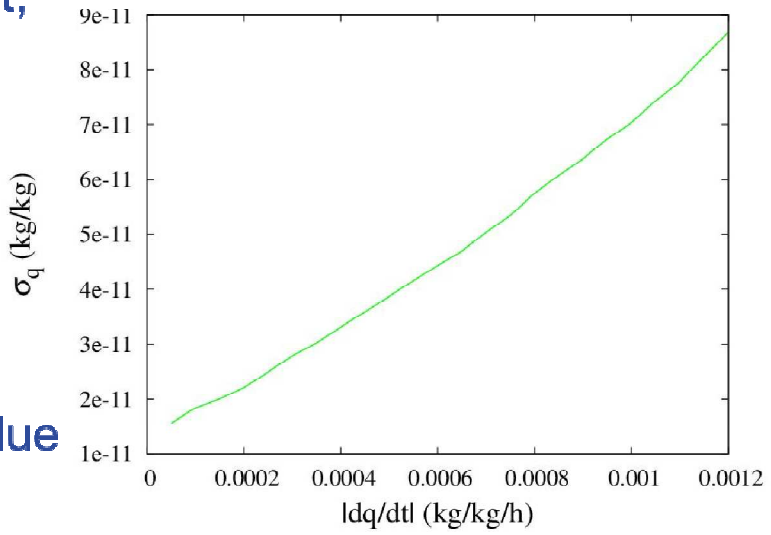
stochastic EM-scheme w/o multi-physics

current status:

- predictors are based on 1-hourly forecast errors (vs. analysis)
- respective tendencies are dominating predictors (e.g. $\left|\frac{dT}{dt}\right|$ for T)
- parameters are defined for 0, 1, and 2 km height, interpolation in-between
- exponential decay in the vertical above 2 km

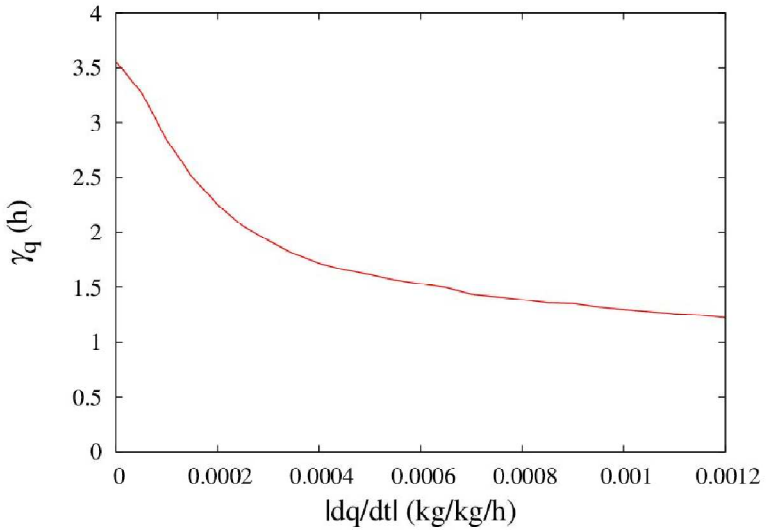
- estimation of γ and σ ist currently based on 1D-approach
- stochastic component is „smoothed“ too much due to diffusion term

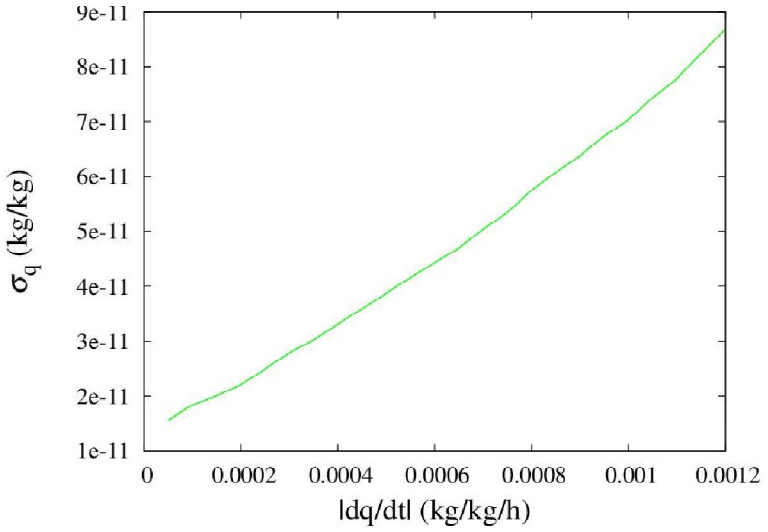




plans:

- Further develop the method for COSMO
- Implement the method in ICON
- Extensive testing and refinement
- Contribute to SPRED 2 with 0.3 FTE/year





future plans

- SINFONY :

  Seamless Integrated Forecasting System for Nowcasting and very short range forecasts

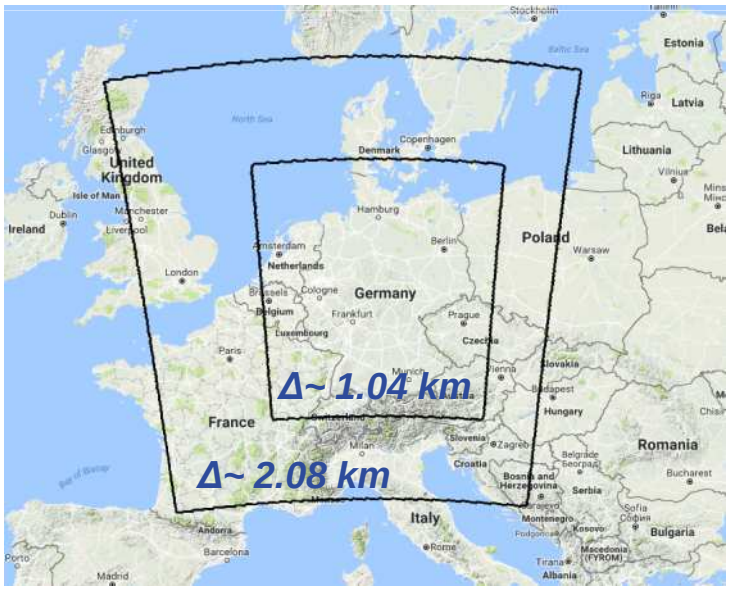
- ICON-LAM(-EPS)…..

slide by D. Majewski

- ***SINFONY* RUC: hourly 12h ensemble forecasts based on very short data cut-off (< 20 min); assimilation of esp. 3D-radar data, satellite (SEVIRI), Mode-S; 40 members for ensemble data assimilation and 40 members for EPS.**

- **ICON-LAM-EPS: every 3 hours ensemble forecasts up to 48h; 40 members for ensemble data assimilation and 30 members**

Model domain of SINFONY RUC / ICON-LAM: 538.000 grid points / layer with a grid spacing of 2.08 km for the full domain and a 2-way nest with 707.000 grid points / layer and a grid spacing of 1.04 km for Germany. 65 layers.



Thank you for your attention!!