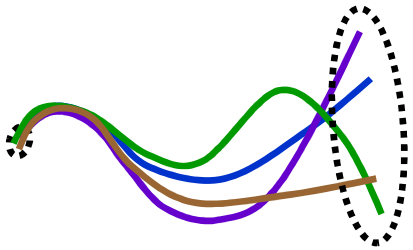
Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Evaluation of the operational convection-permitting COSMO-DE-EPS for the summer of 2012



Detlev Majewski, Susanne Theis, Christoph Gebhardt
Zied Ben Bouallègue, Michael Buchhold, Carlos Peralta

Deutscher Wetterdienst, DWD

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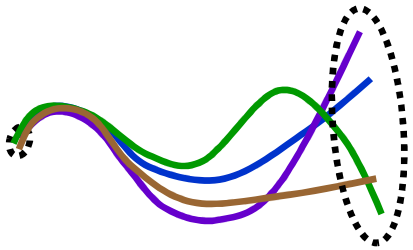

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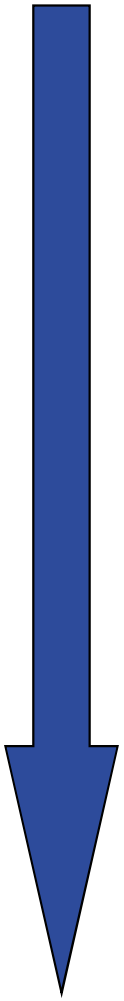
COSMO-DE-EPS status and plans

➔ **start of pre-operational mode (9th Dec 2010)**

➔ **undergoing evaluation by forecasters (EPS quality and visualization by NinJo)**

switch to operational mode (22nd May 2012)

first operational convection-permitting EPS in Europe



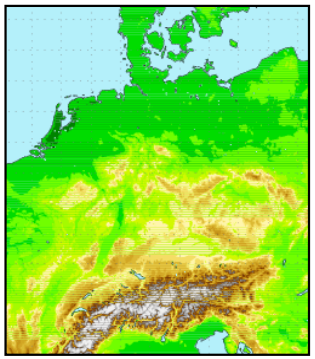
2010

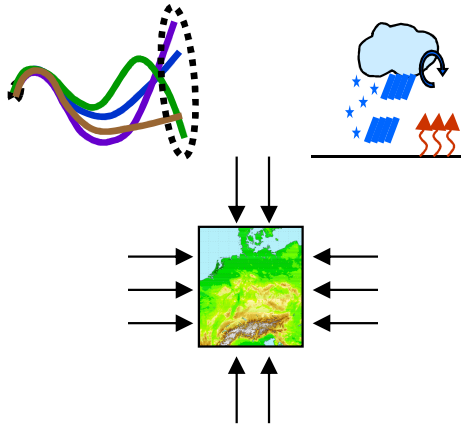
2011

2012

2013 / 14

operational set-up:





- ➔ **20 members**
- ➔ **grid size: 2.8 km**

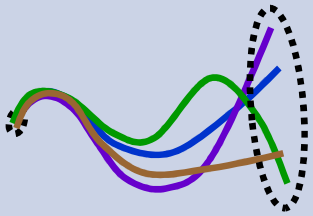
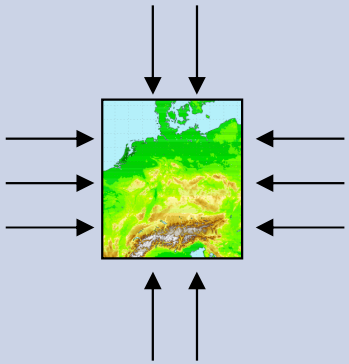
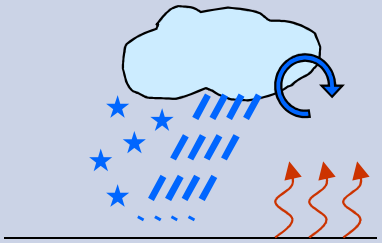
  convection-permitting
- ➔ **lead time: 0-21 hours,**

  8 starts per day (00, 03, 06,... UTC)

- ➔ **includes all features of deterministic COSMO-DE:**
  - **resolution**
  - **assimilation of radar data**
  - **complex microphyscis**
  - **…**

Generation of EPS members

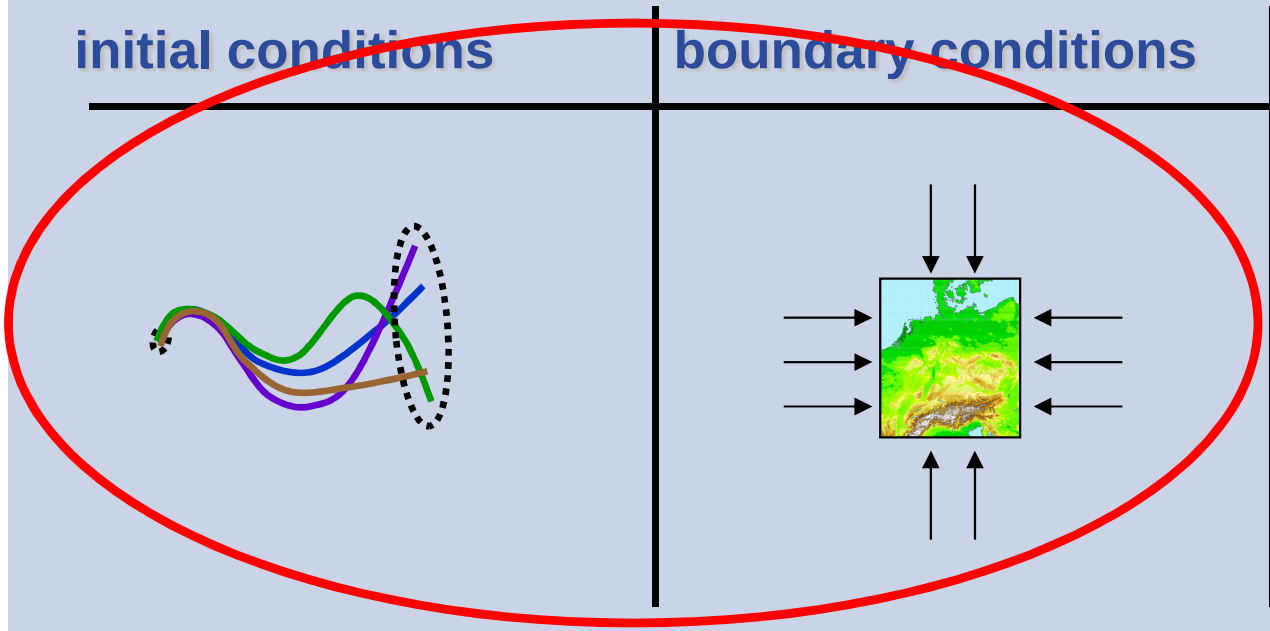
representing uncertainty in

initial conditions	boundary conditions	model physics
		

Generation of EPS members

representing uncertainty in

initial conditions | boundary conditions | model physics



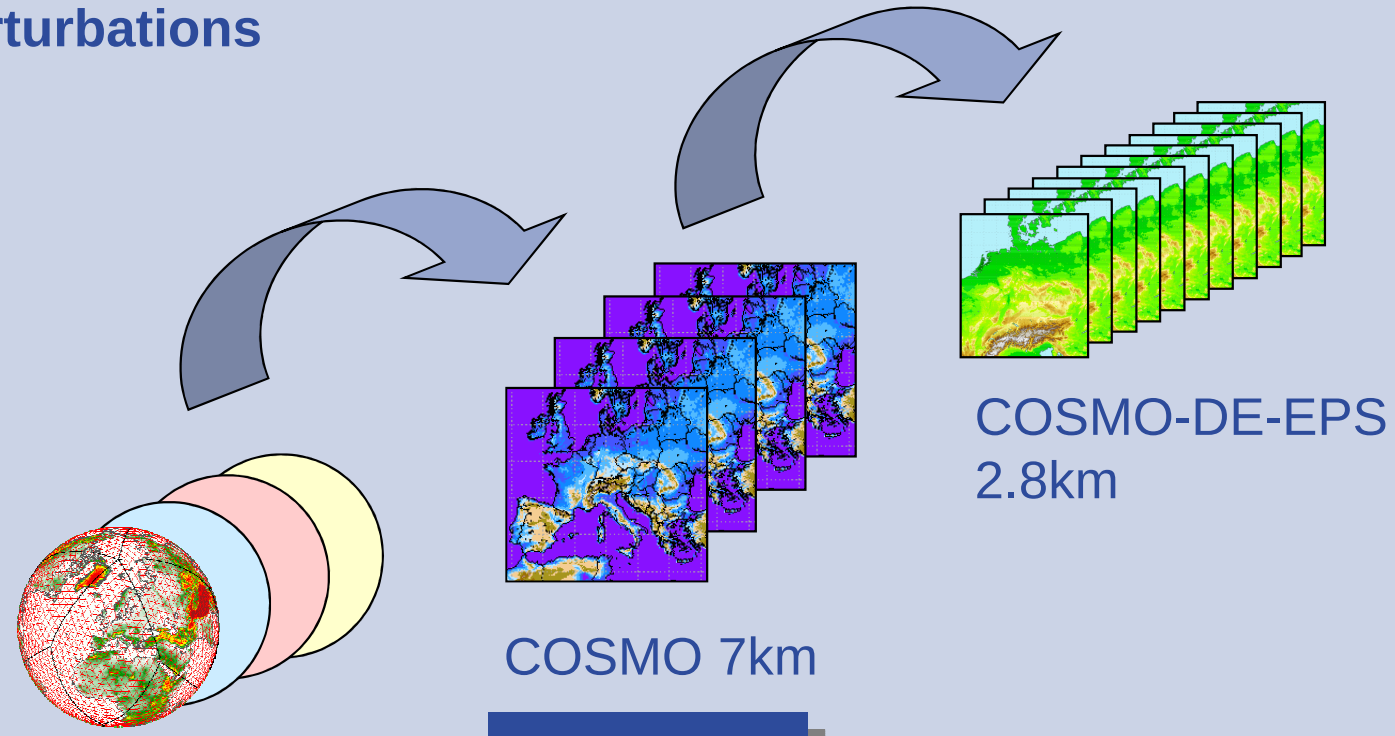
perturbed parameters

„multi-model“

non-stochastic

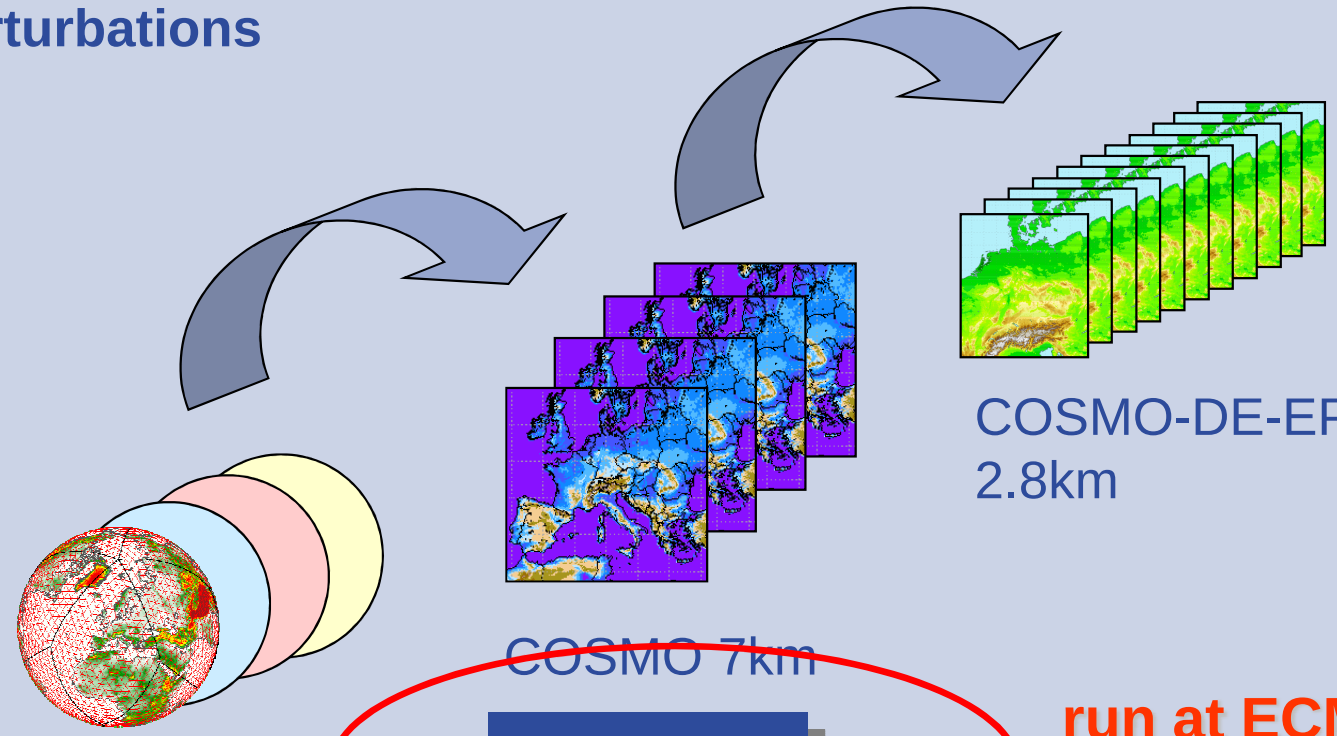
Generation of EPS members

BC-EPS for boundary and initial perturbations



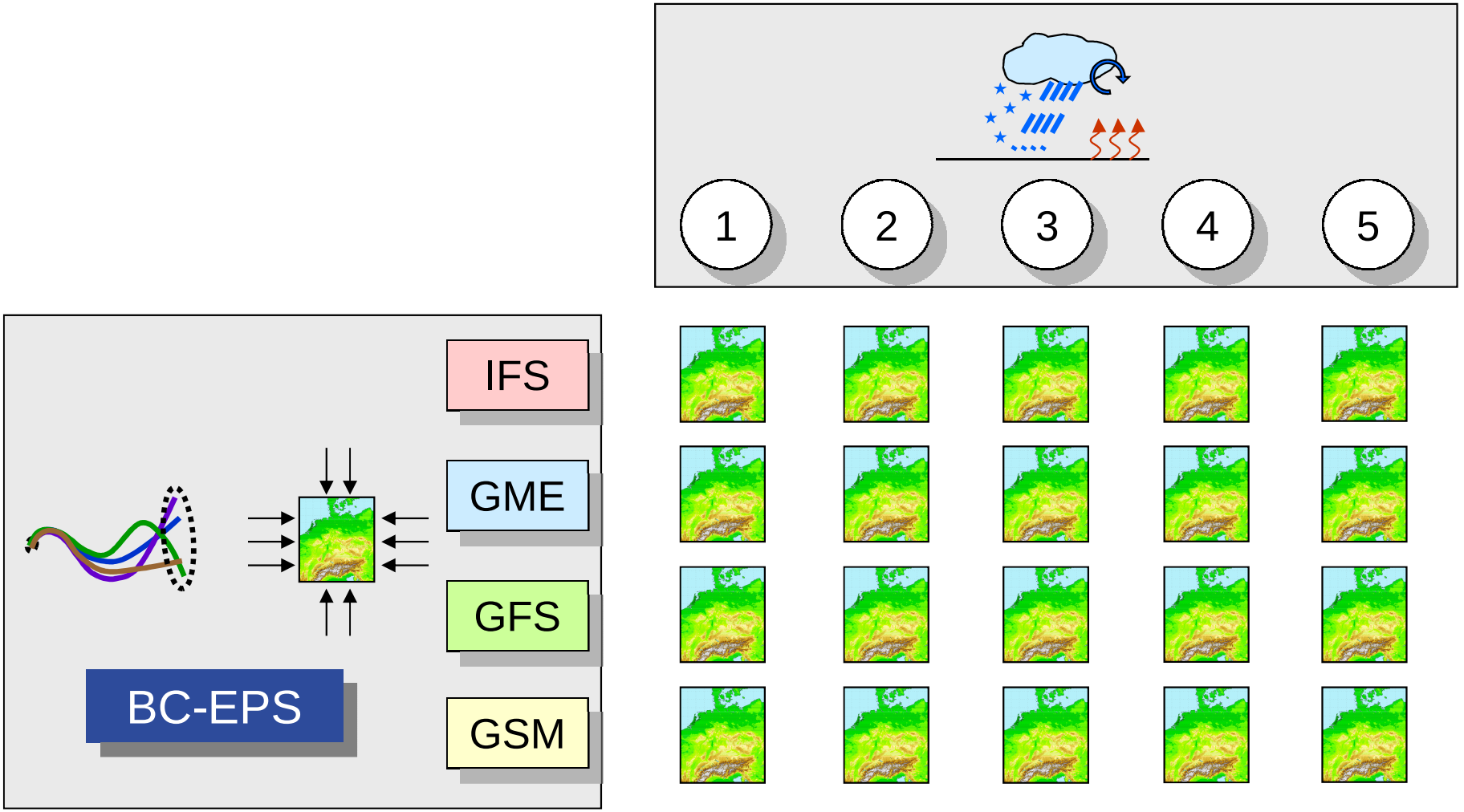
Generation of EPS members

BC-EPS for boundary and initial perturbations



run at ECMWF as time critical application

The 20 members of COSMO-DE-EPS

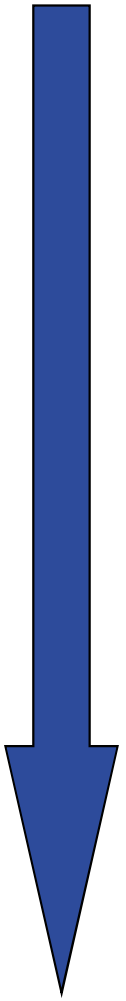


COSMO-DE-EPS status and plans

➔ **start of pre-operational mode (9th Dec 2010)**

➔ **undergoing evaluation by forecasters (EPS quality and visualization by NinJo)**

switch to operational mode (22nd May 2012)



2010

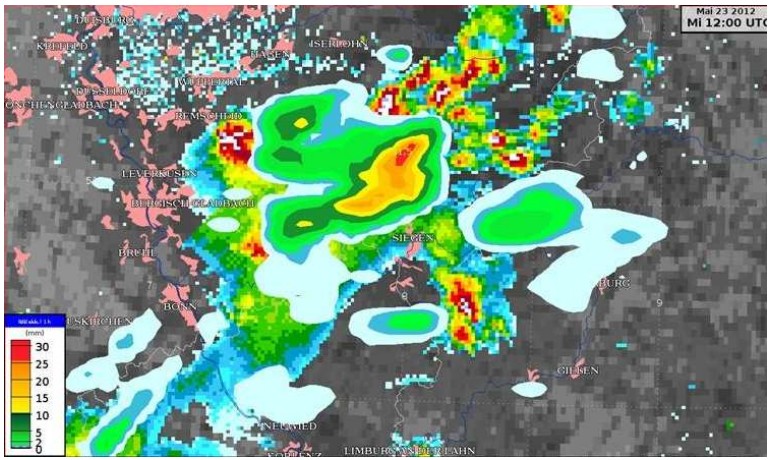
2011

2012

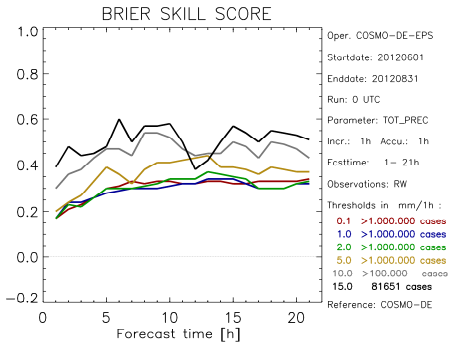
2013 / 14

Main results from pre-operational phase (20 members)

➔ **evaluation by forecasters (case studies):**



➔ **probabilistic verification (for periods of several months)**



Case study of 23rd May 2012, 12UTC (just to welcome the COSMO-DE-EPS ☺)

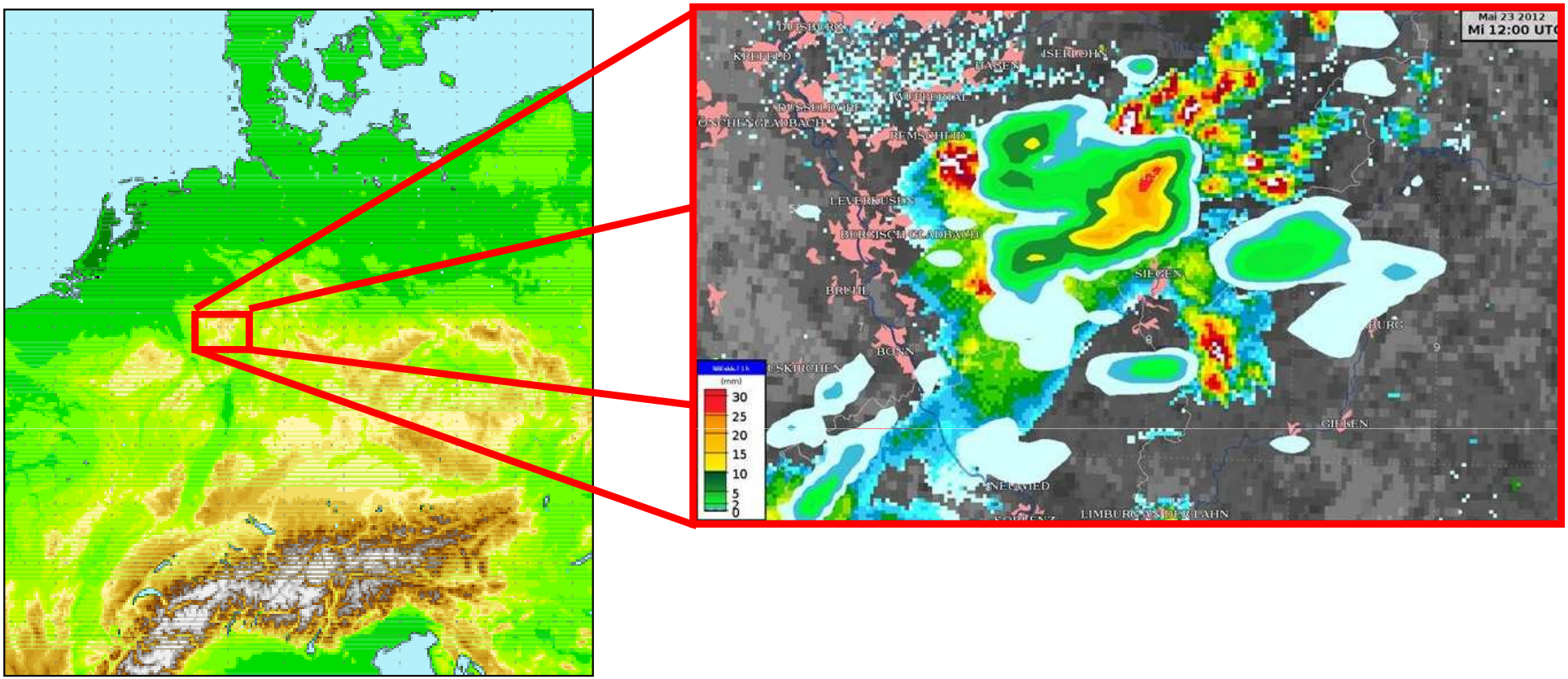
- ➔ severe precipitation event in Germany (North Rhine-Westphalia & Hesse)
- ➔ hourly precipitation up to 40 mm/h
- ➔ hail, thunderstorm, minor flooding and landslides

pictures:

Bernd Brandt / wetteronline.de

wirsiegen.de

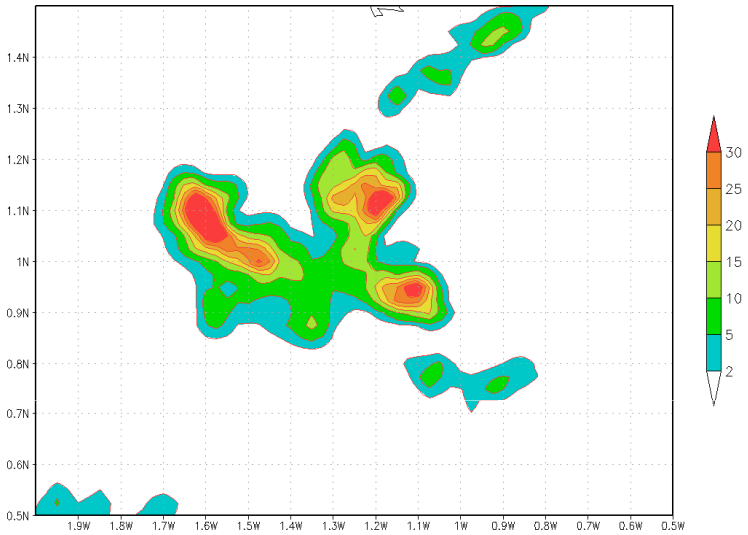
Case study of 23rd May 2012, 12 UTC



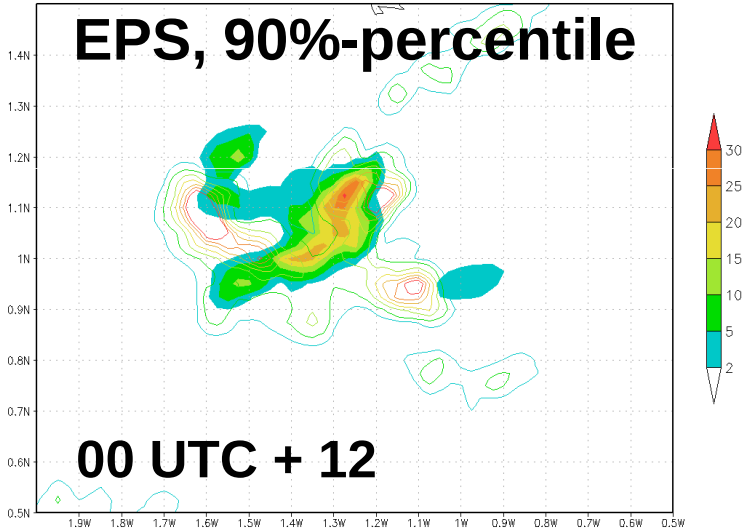
Case study of 23rd May 2012

hourly precipitation 11-12UTC

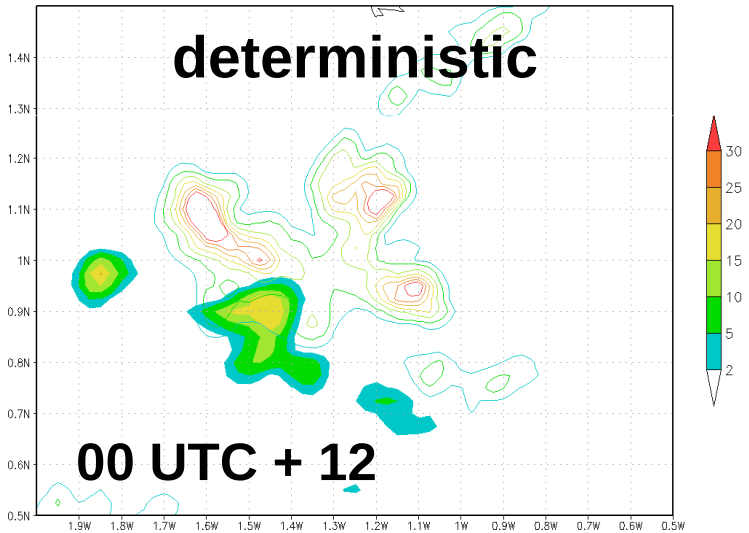
rain-gauge adjusted radar



EPS, 90%-percentile



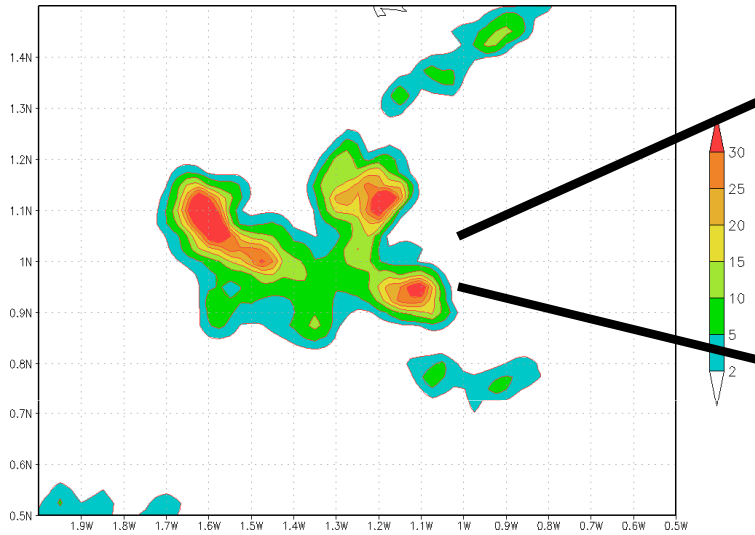
deterministic

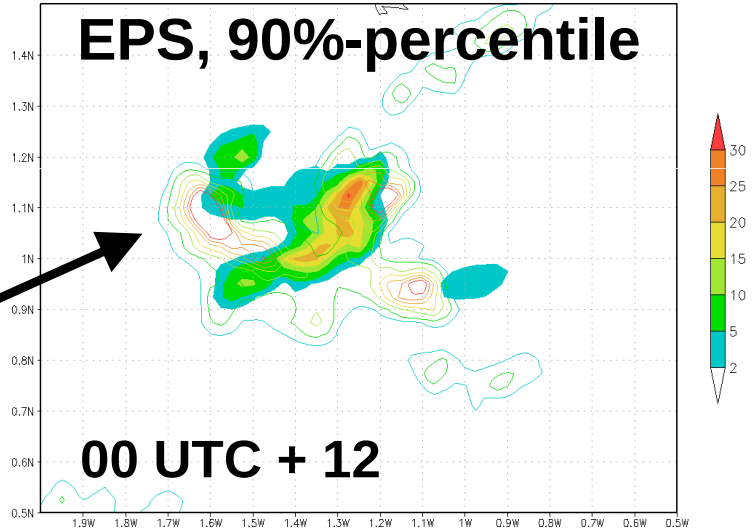


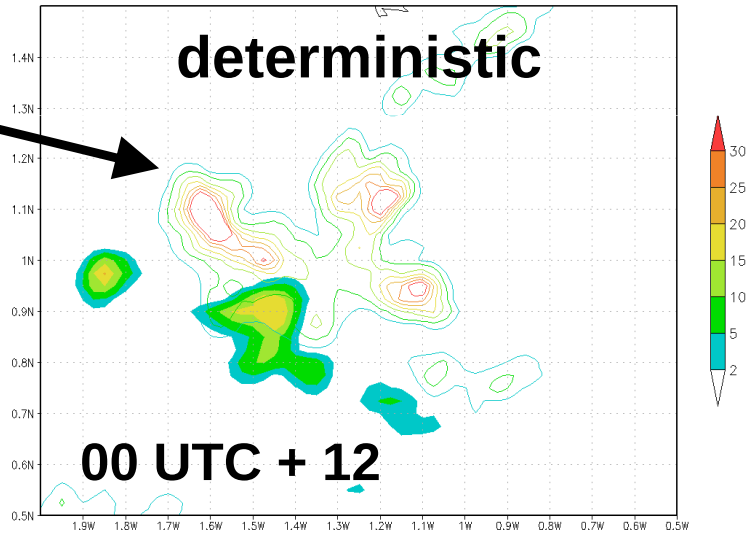
Case study of 23rd May 2012

hourly precipitation 11-12UTC

rain-gauge adjusted radar



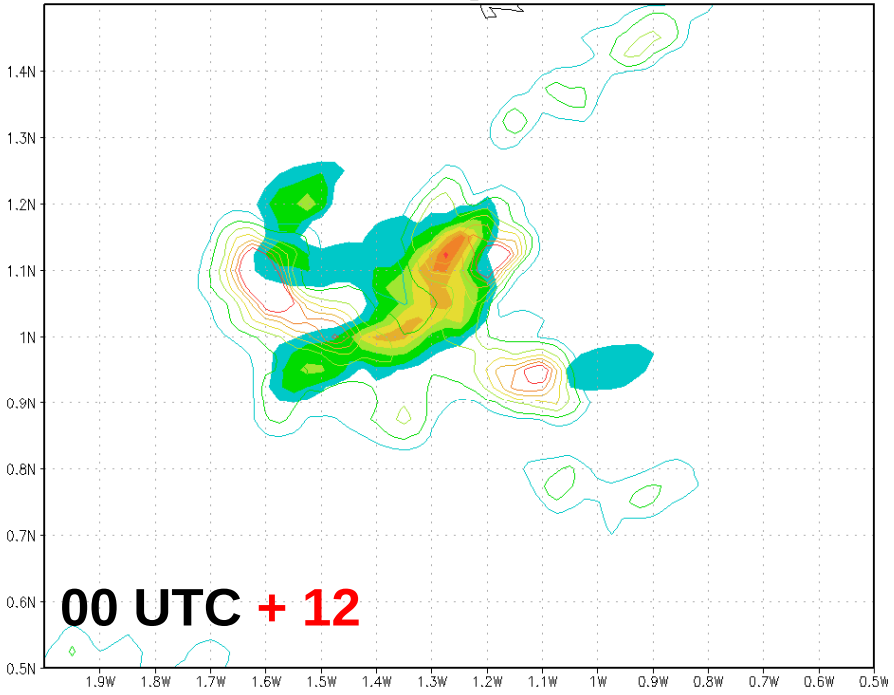


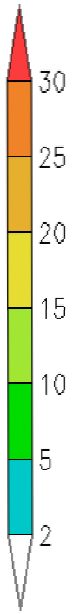


Case study of 23rd May 2012

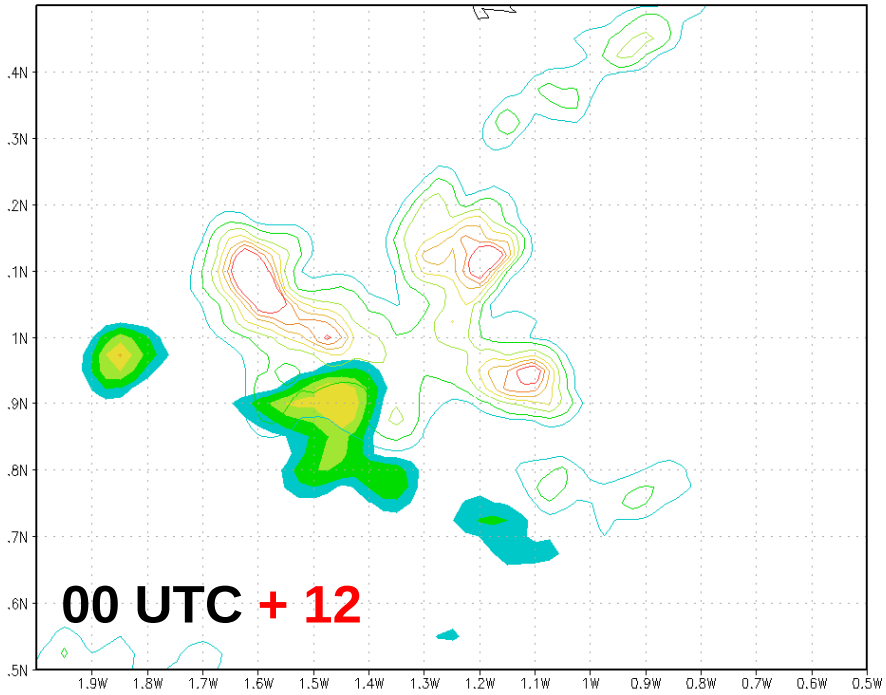
hourly precipitation 11-12UTC

EPS, 90%-percentile





deterministic



Case study of 23rd May 2012

hourly precipitation 11-12UTC

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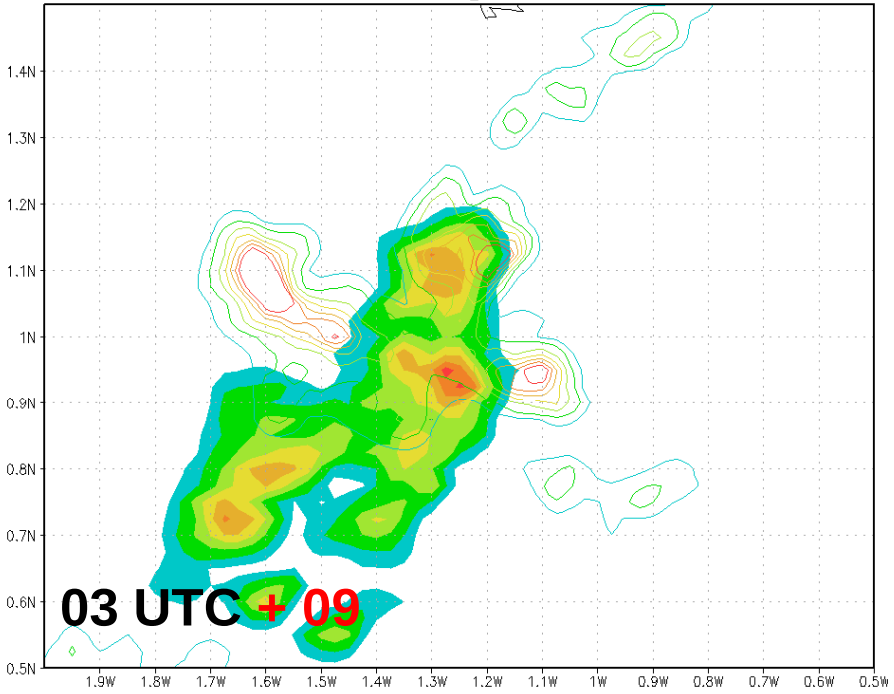
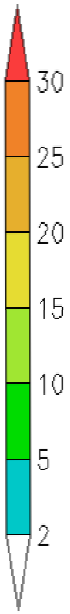
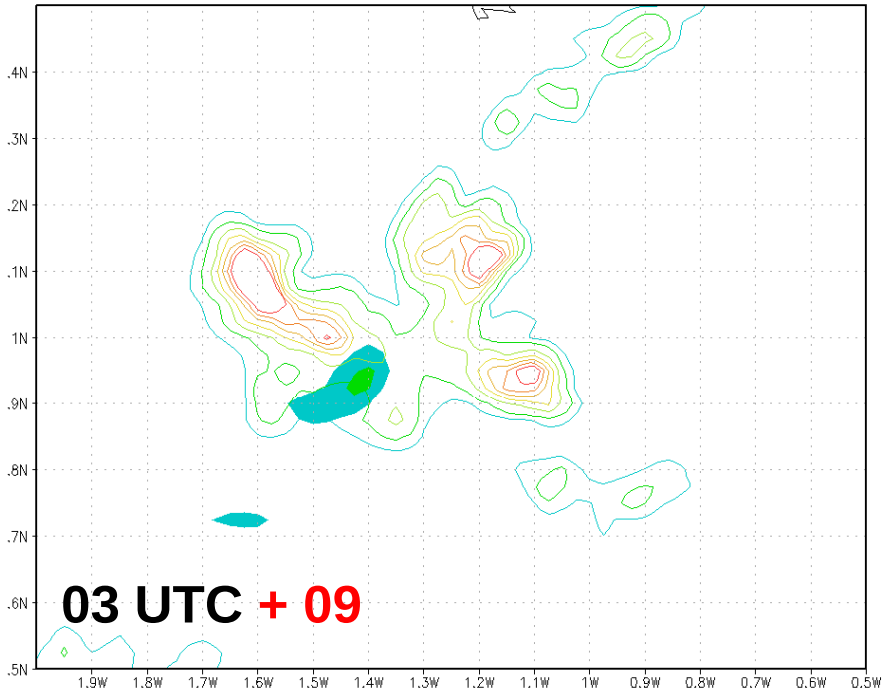




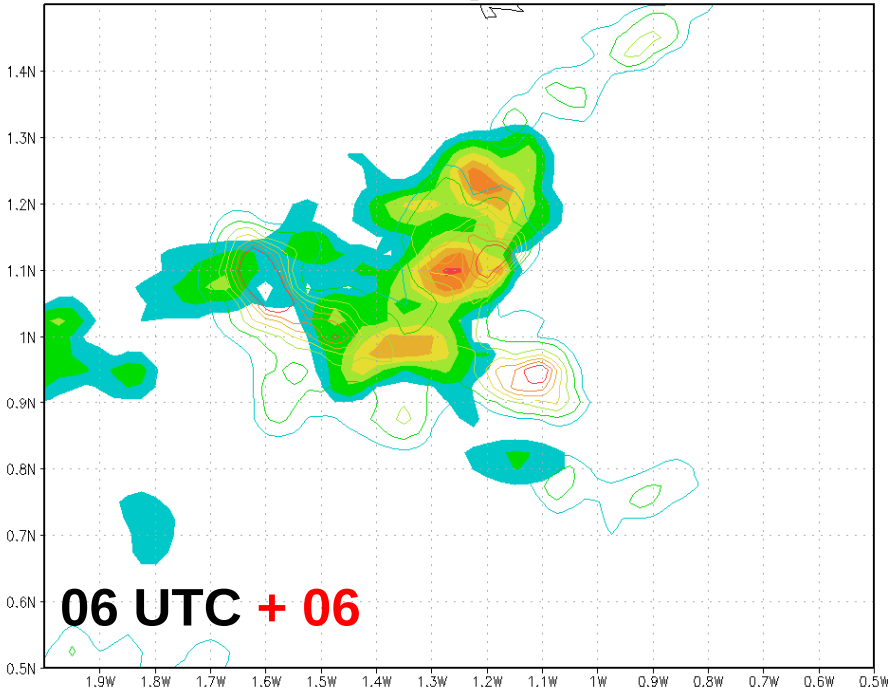
deterministic

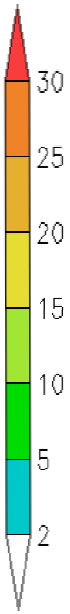


Case study of 23rd May 2012

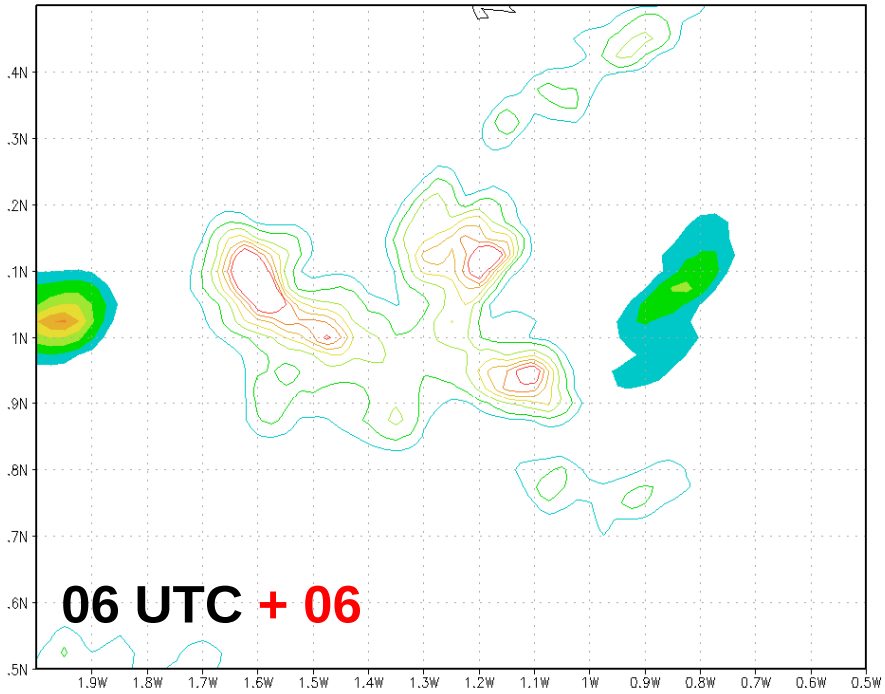
hourly precipitation 11-12UTC

EPS, 90%-percentile





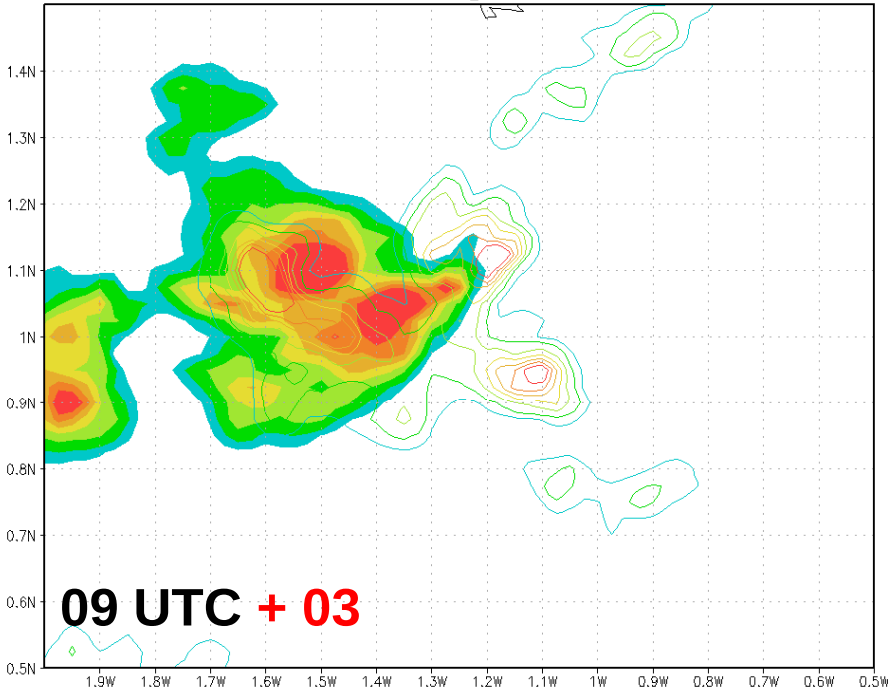
deterministic

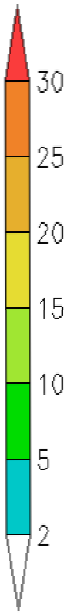


Case study of 23rd May 2012

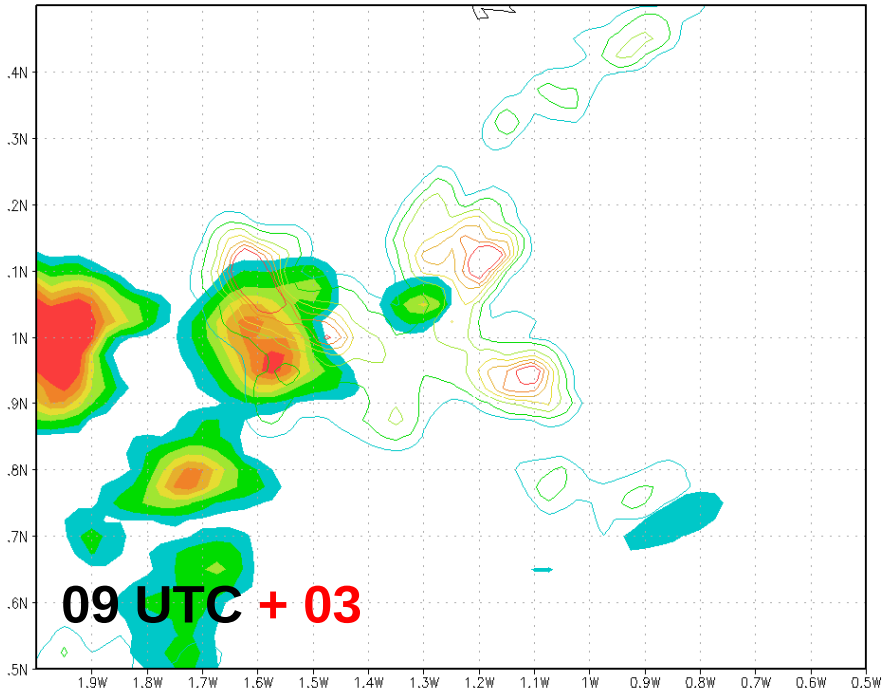
hourly precipitation 11-12UTC

EPS, 90%-percentile





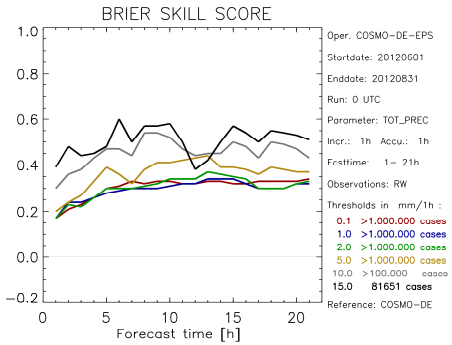
deterministic



Main results from pre-operational phase (20 members)

- ➔ **evaluation** by forecasters (case studies):
  - ➔ additional benefit for **precipitation** forecasts
  - ➔ provides **early signals for severe weather**
  - ➔ most beneficial for **convective precipitation** in summer
  - ➔ reduced jumpiness between consecutive runs

- ➔ **probabilistic** verification (for periods of several months)



VERIFICATION OF COSMO-DE-EPS

all results for hourly precipitation

summer 2012

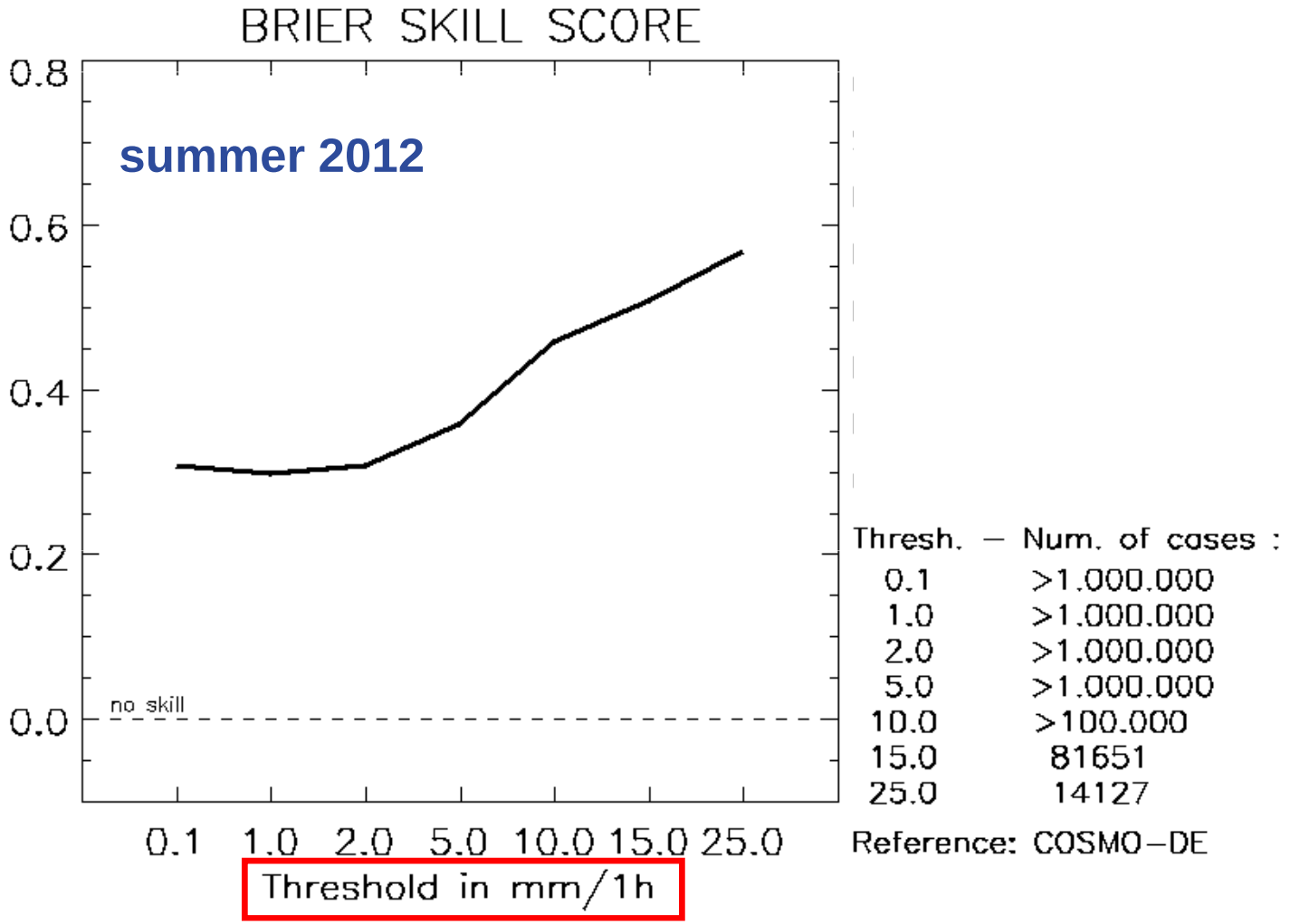
winter 2011/12

00 UTC run

EPS not calibrated or post-processed

observations: rain-gauge adjusted radar (upscaled to COSMO-DE grid)

Brier Skill Score (reference: deterministic run of COSMO-DE)



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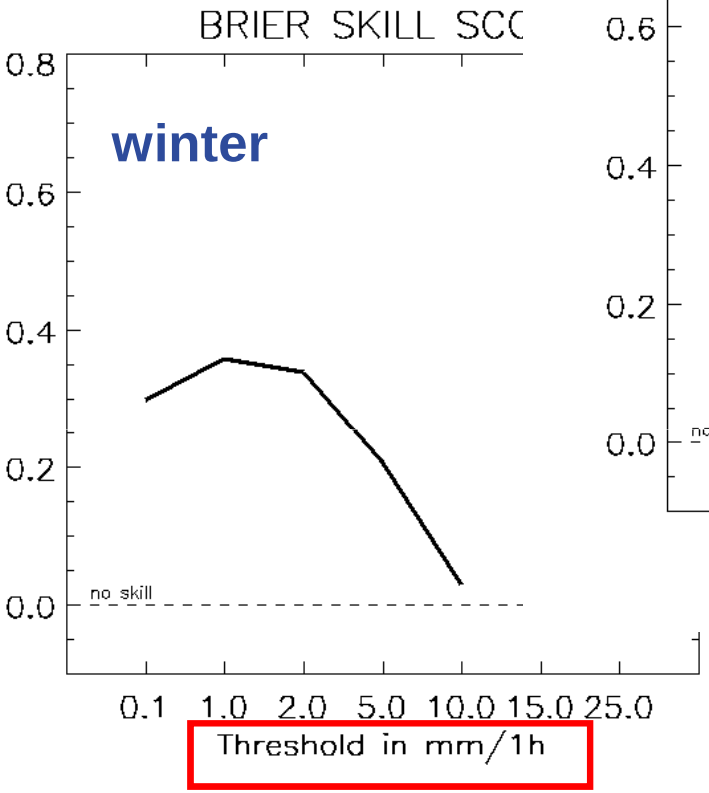
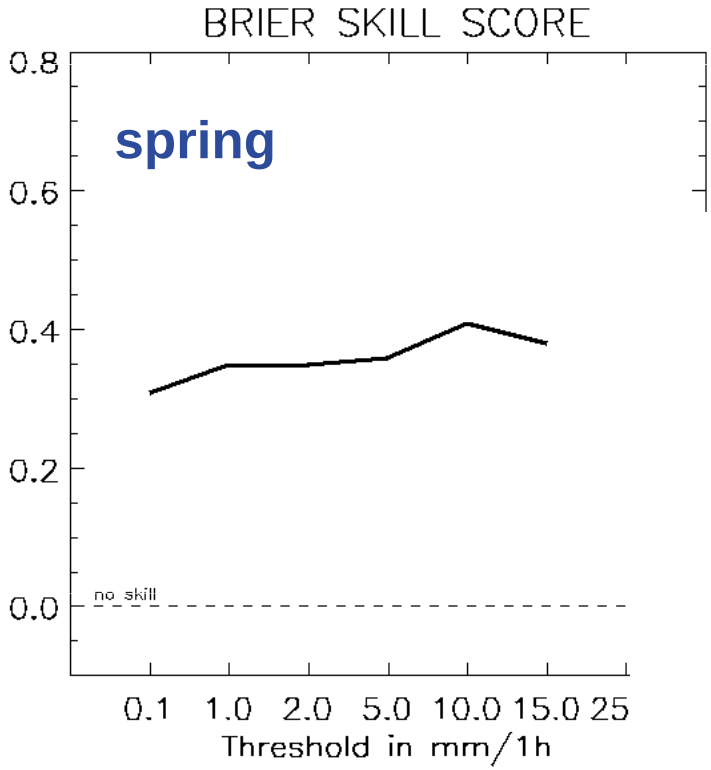
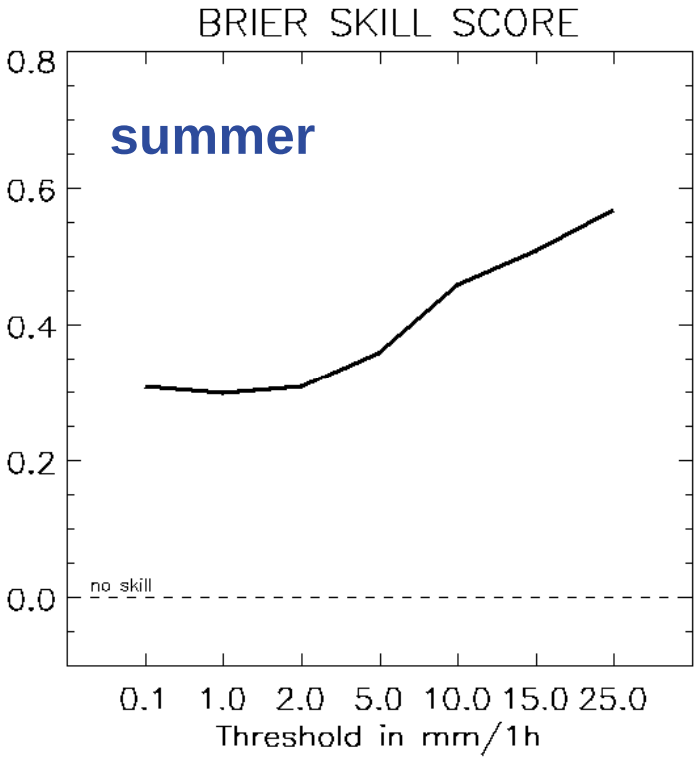
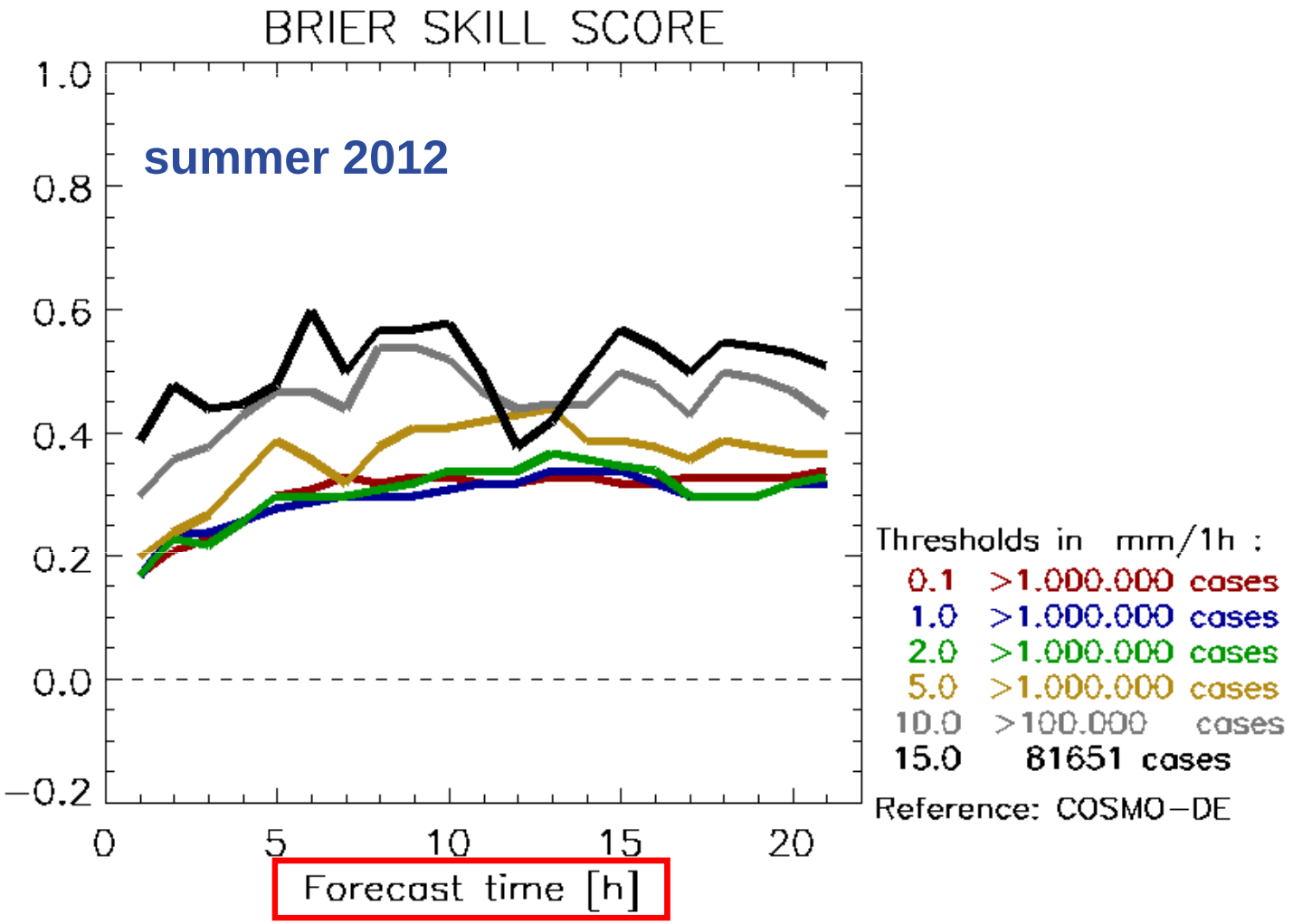


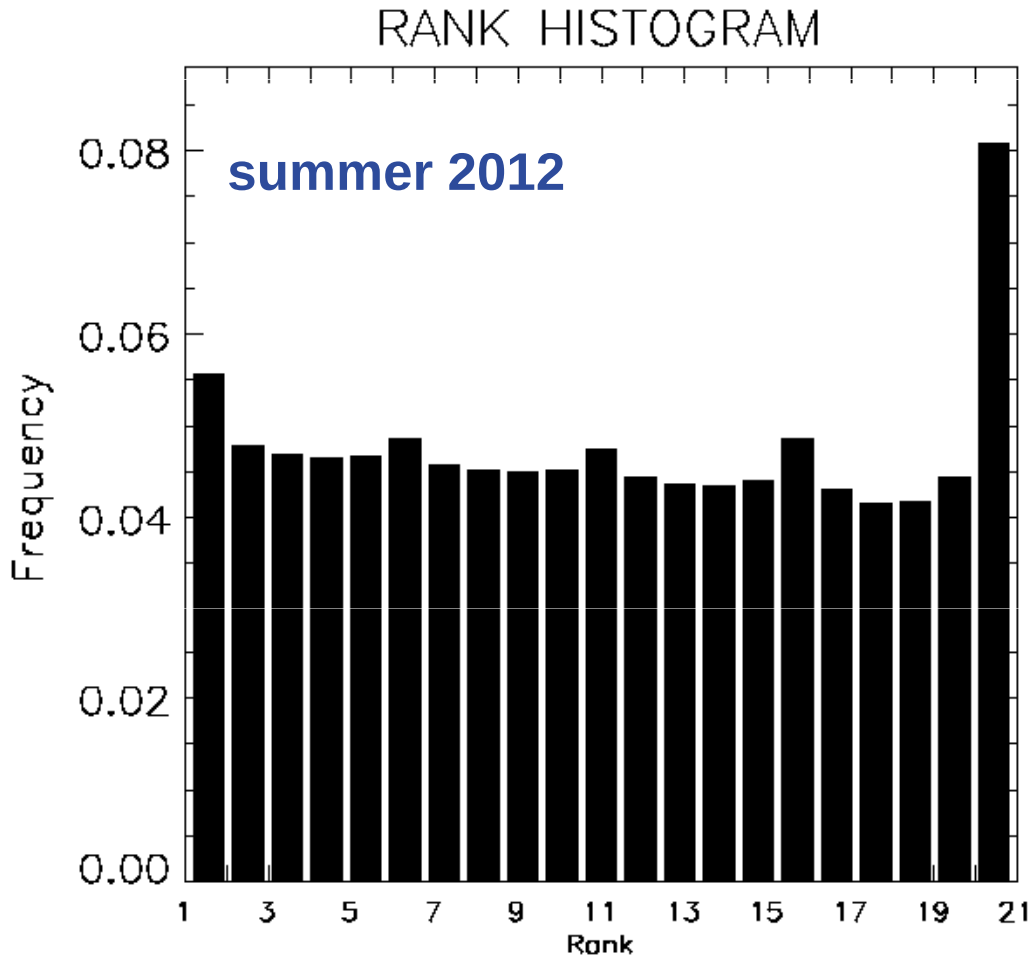




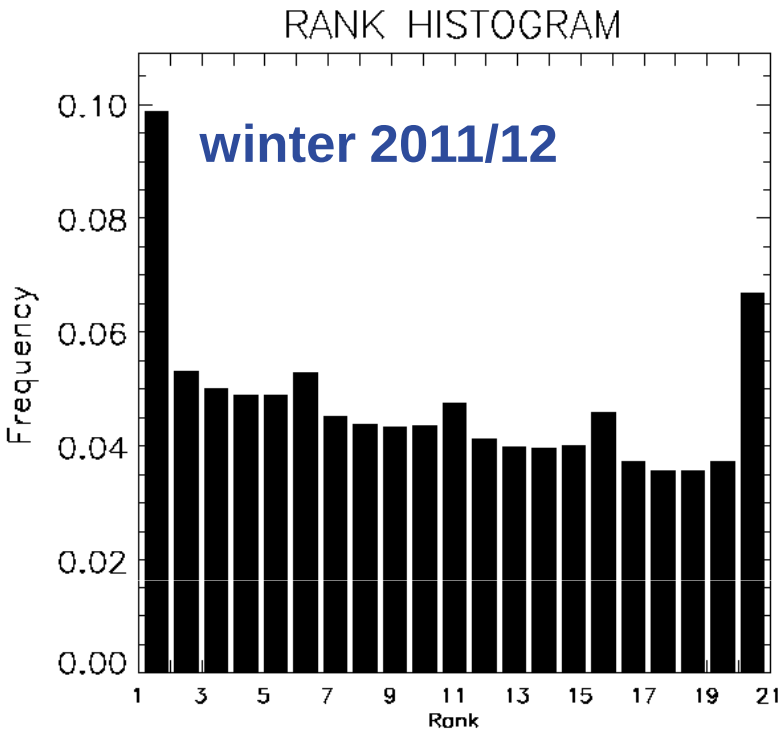
Brier Skill Score (reference: deterministic run of COSMO-DE)

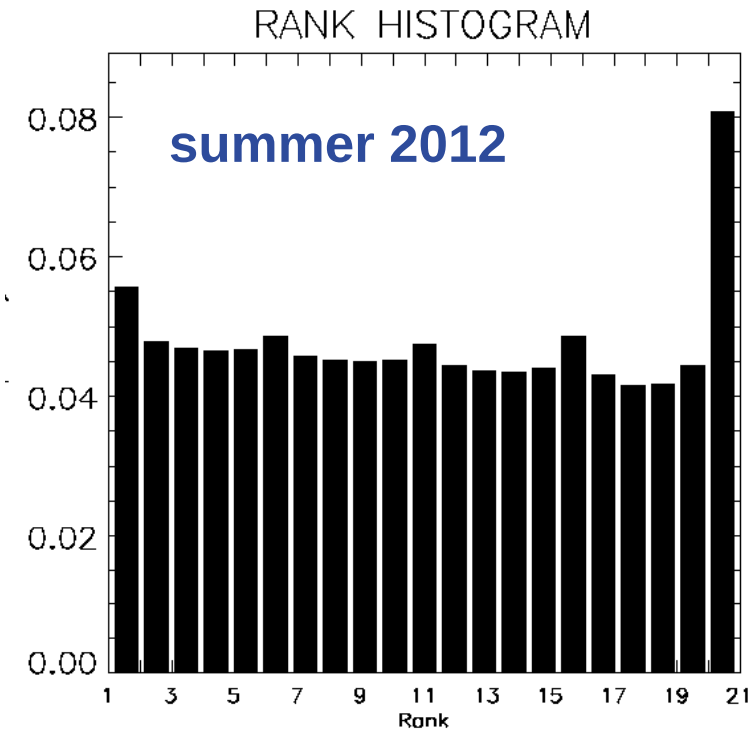


Rank histogram

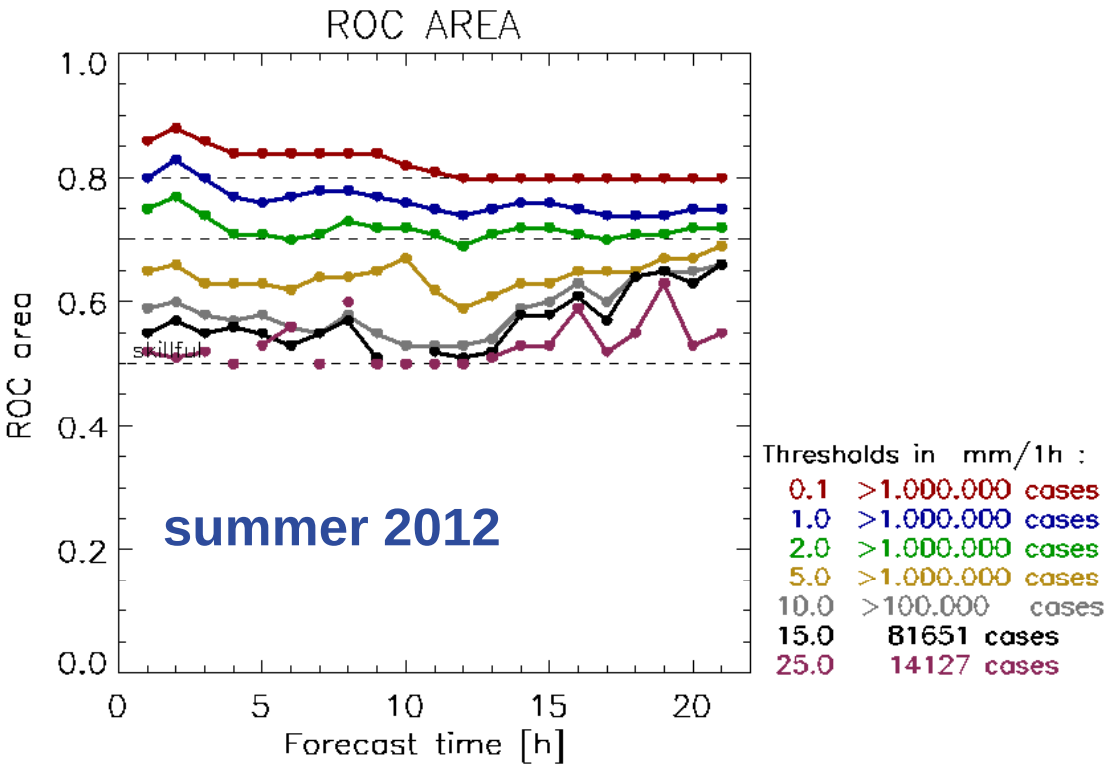


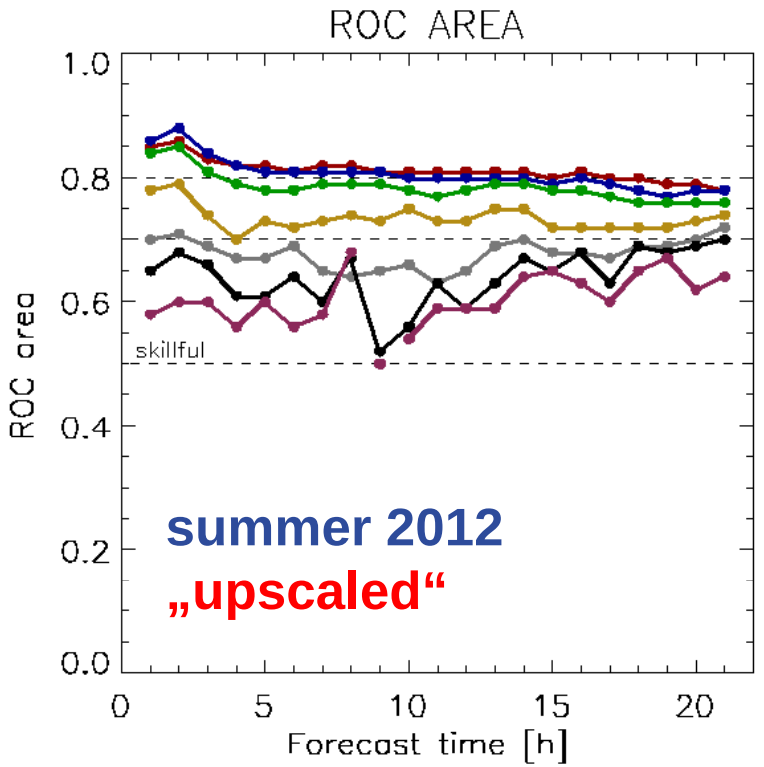
Rank histogram





ROC area

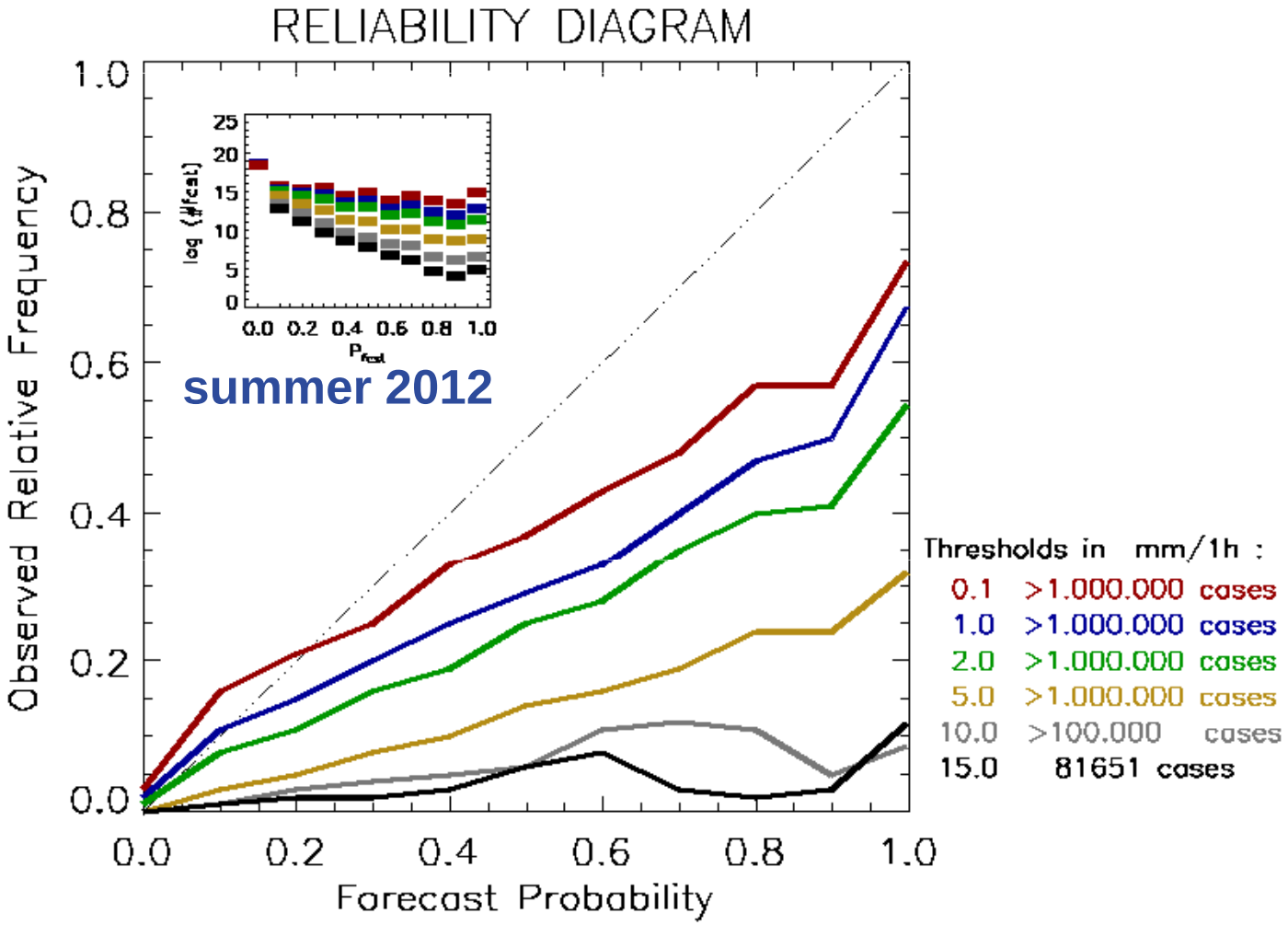




spatially “upscaled“ means:

event somewhere within a 10x10 grid points environment

reliability diagram



Deutscher Wetterdienst
Wetter und Klima aus einer Hand

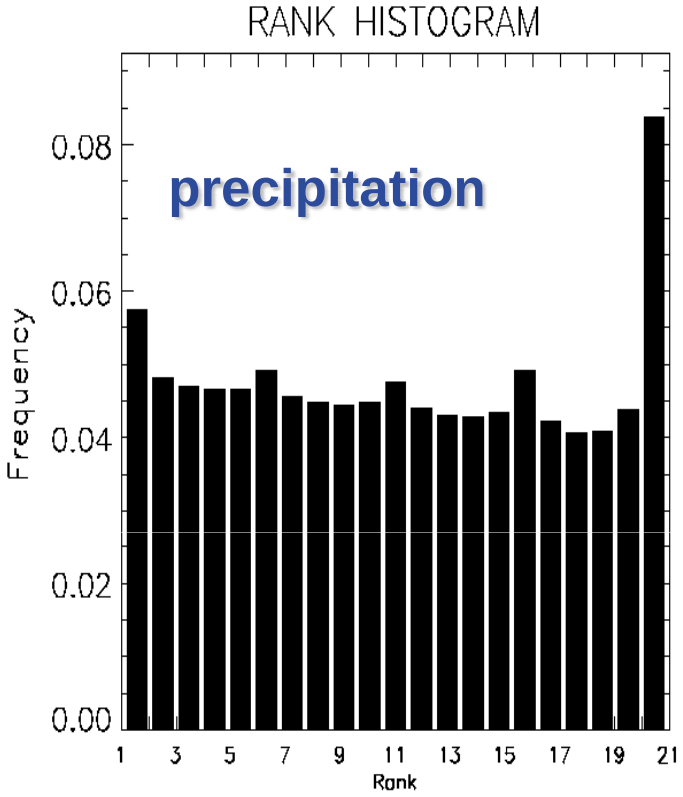
VERIFICATION OF COSMO-DE-EPS

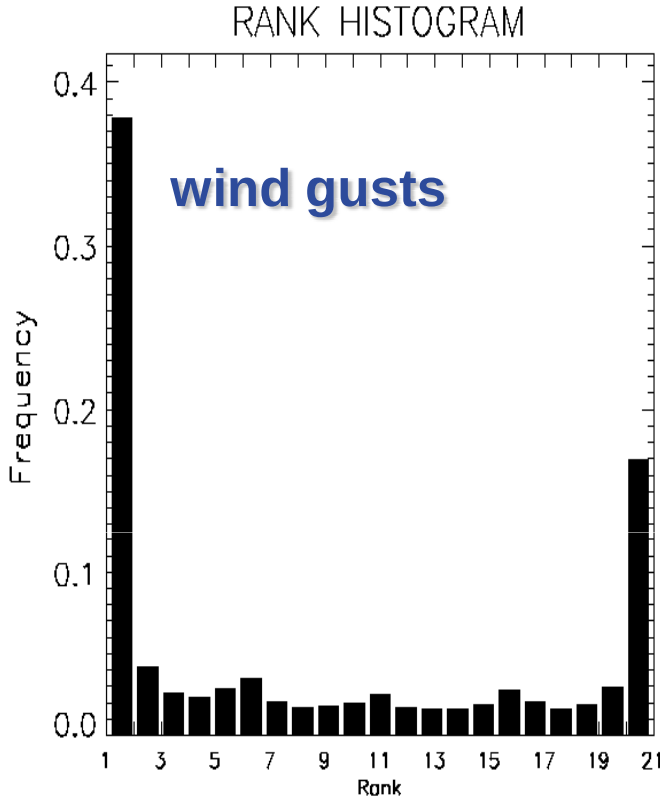
other variables

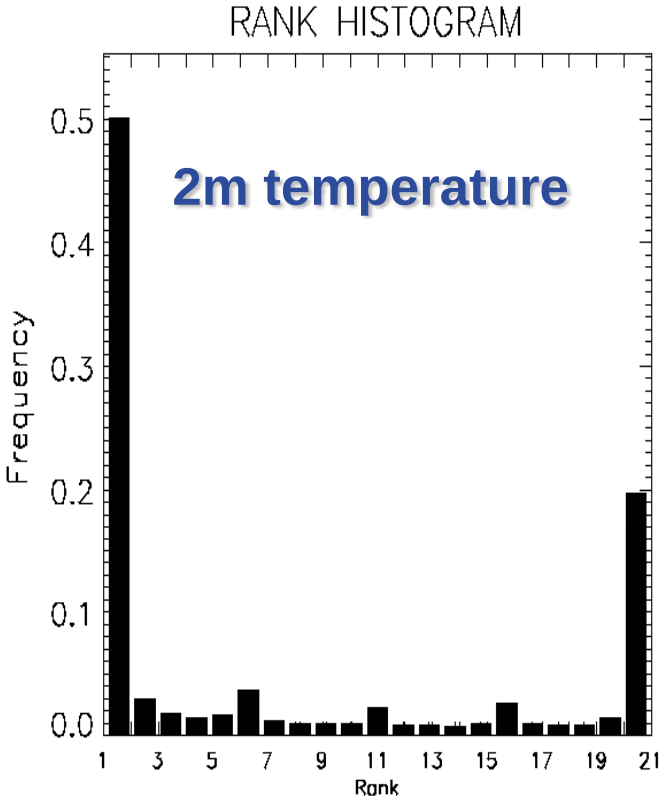
summer 2012

observations: SYNOP

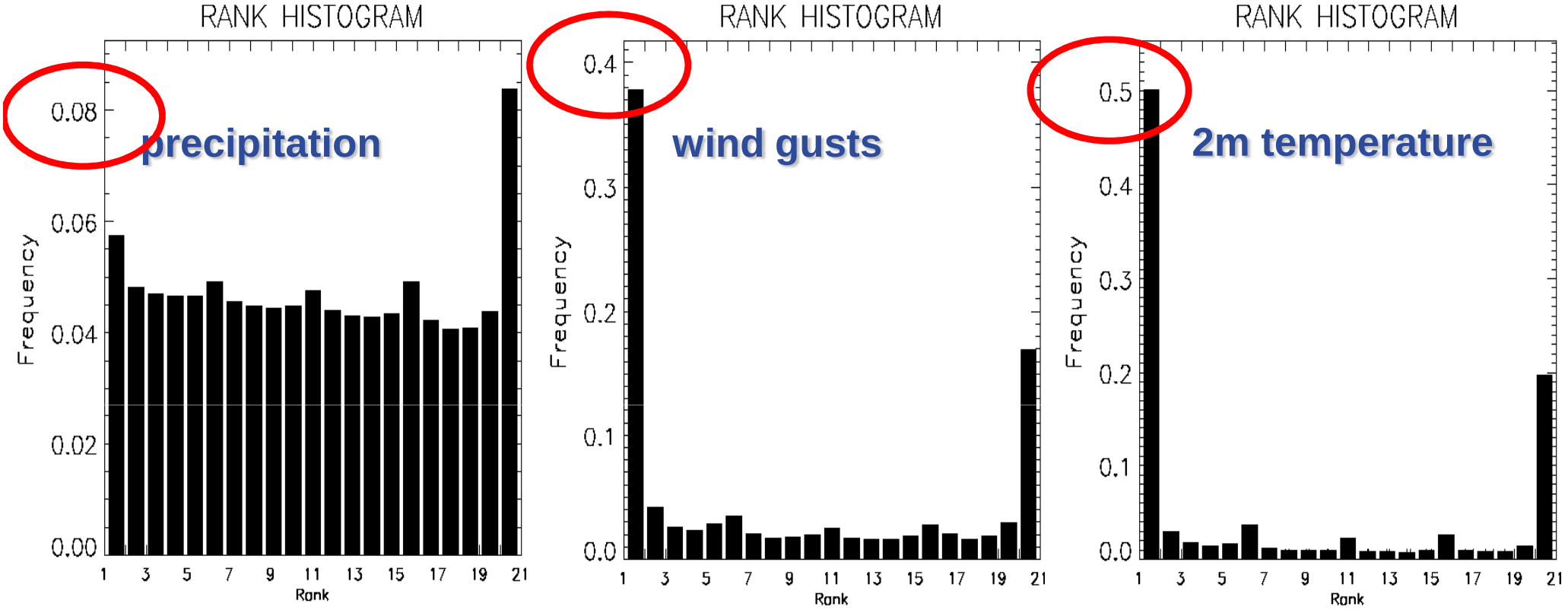
Rank histogram







Rank histogram



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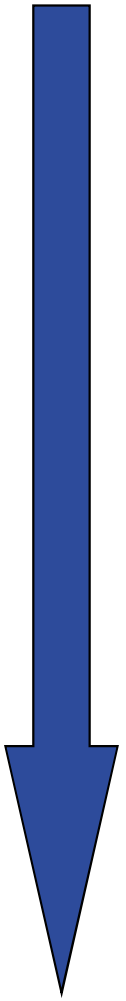
- evaluation by forecasters (case studies):
  - additional benefit for precipitation forecasts
  - provides early signals for severe weather
  - most beneficial for convective precipitation in summer
  - reduced jumpiness between consecutive runs

- probabilistic verification (for periods of several months)
  - probabilities perform better than deterministic “yes/no”
  - particularly for high precipitation thresholds
  - particularly for longer lead times
  - drawback: underdispersiveness (esp. for wind gusts and T_2M)

COSMO-DE-EPS status and plans

- ➔ start of pre-operational mode (9th Dec 2010)
- ➔ undergoing evaluation by forecasters
  (EPS quality and visualization by NinJo)
- switch to operational mode
  (22nd May 2012)
- ➔ upgrade to 40 members, redesign



2010

2011

2012

2013 / 14

upgrade to 40 members

- ➔ quantify more sources of forecast uncertainty
- ➔ use of COSMO-LEPS members as boundary conditions (COSMO-LEPS is driven by IFS EPS of ECMWF)
- ➔ additional physics perturbations (diffusion, roughness length)
- ➔ perturbation of soil moisture

COSMO-DE-EPS status and plans

- start of pre-operational mode (9th Dec 2010) — 2010
- undergoing evaluation by forecasters (EPS quality and visualization by NinJo) — 2011
- switch to operational mode (22nd May 2012) — 2012
- upgrade to 40 members, redesign
- statistical postprocessing — 2013 / 14

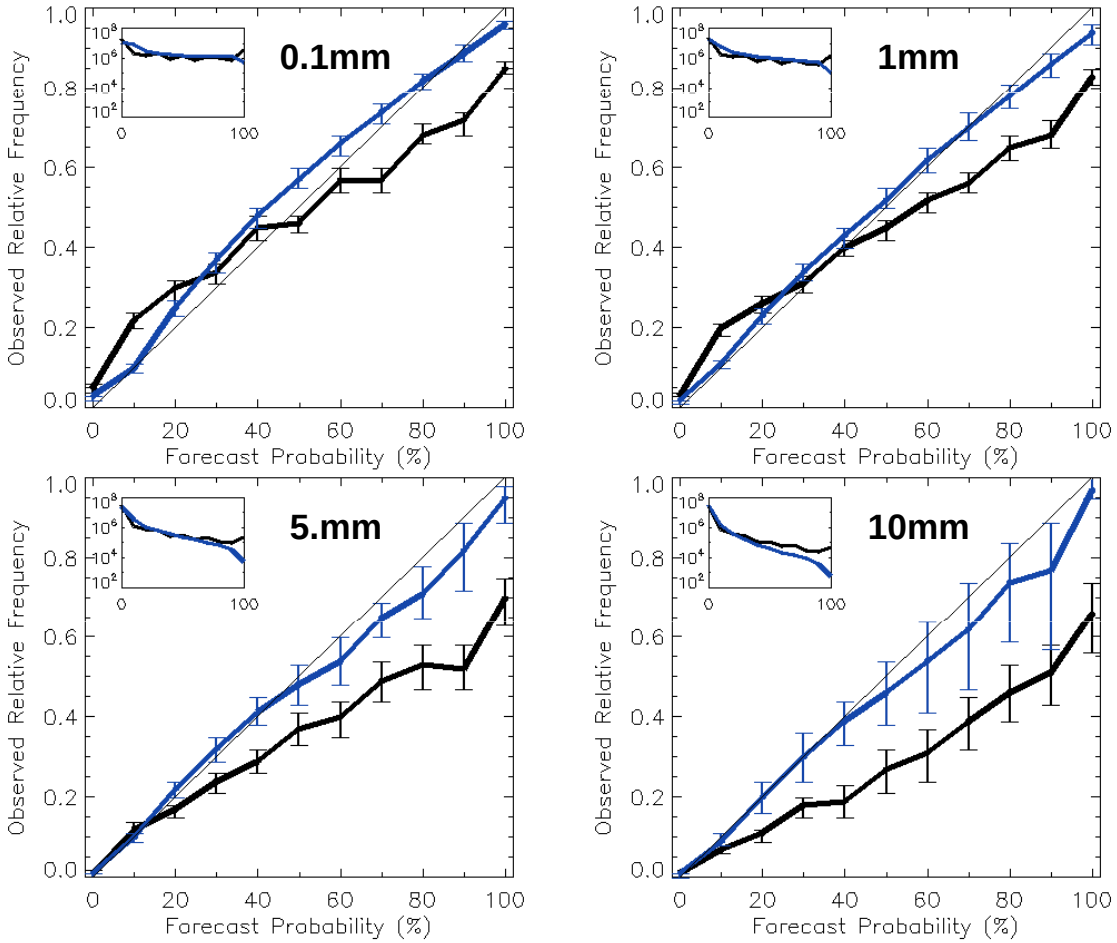
Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Extended Logistic regression with **interaction terms**

Predictor: **ensemble mean**
+ power transformation
+ weighting

Training period: 45 days
Daily update
6-hourly precipitation

Original ensemble forecasts
Calibrated ensemble forecasts



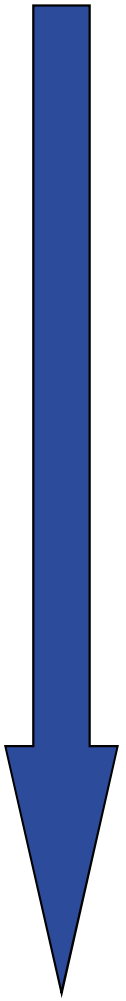
(Ben Bouallègue, 2012)

COSMO-DE-EPS status and plans

- ➔ start of pre-operational mode (9th Dec 2010)
- ➔ undergoing evaluation by forecasters
  (EPS quality and visualization by NinJo)

switch to operational mode
(22nd May 2012)

- ➔ upgrade to 40 members, redesign
- ➔ statistical postprocessing
- ➔ lagged average forecast
- ➔ initial conditions by LETKF (“KENDA”)
- ➔ lateral boundary conditions by ICON EPS



2010

2011

2012

2013 / 14

REFERENCES

Gebhardt, C., Theis, S. E., Paulat, M., Ben Bouallegue, Z., 2011: *Uncertainties in COSMO-DE precipitation forecasts introduced by model perturbations and variation of lateral boundaries*, Atmos. Res.

Peralta, C. , Ben Bouallegue, Z., Theis, S. E., Gebhardt, C. 2012: *Accounting for initial condition uncertainties in COSMO-DE-EPS*, Journal of Geophysical Res.

Wilks, D. S. , 2009: *Extending logistic regression to provide full-probability-distribution MOS forecasts*, Meteo. Appl.

Ben Bouallègue, Z., 2012: *Calibrated short-range ensemble precipitation forecasts using extended logistic regression with interaction terms*, submitted to Wea. Forecasting

Theis, S. E., Hense, A., Damrath, U., 2005: *Probabilistic precipitation forecasts from a deterministic model: a pragmatic approach.* Meteorol. Appl.

extra slides

Generation of Ensemble Members

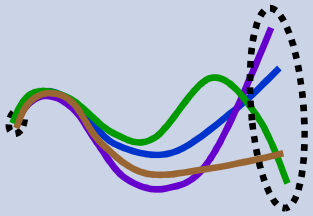
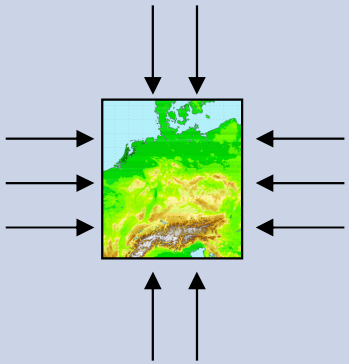
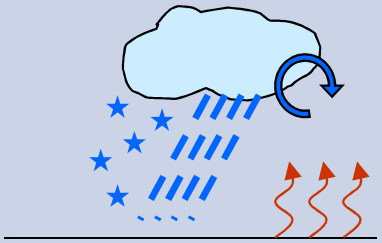
Perturbation Methods

Peralta, C., Ben Bouallègue, Z., Theis, S.E., Gebhardt, C. and M. Buchhold, 2012: Accounting for **initial condition uncertainties** in COSMO-DE-EPS. Journal of Geophysical Research, VOL. 117, D07108, doi:10.1029/2011JD016581, 2012

Gebhardt, C., Theis, S.E., Paulat, M. and Z. Ben Bouallègue, 2011: Uncertainties in COSMO-DE precipitation forecasts introduced by **model perturbations and variation of lateral boundaries**. Atmospheric Research 100, 168-177. *(contains status of 2009)*

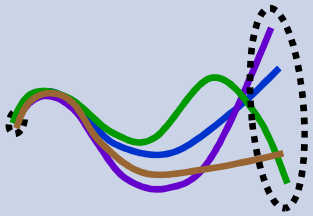
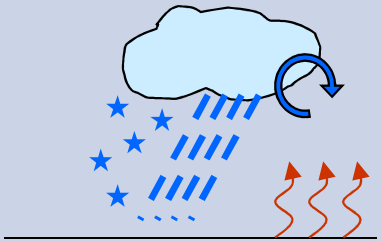
Generation of EPS members

representing uncertainty in

initial conditions	boundary conditions	model physics
		

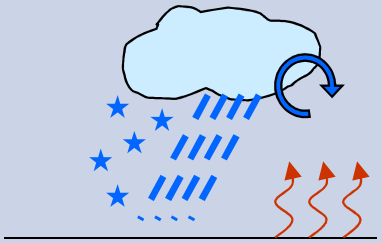
Generation of EPS members

representing uncertainty in

initial conditions	boundary conditions	model physics
	**“multi-model”** driven by different global models	

Generation of EPS members

representing uncertainty in

initial conditions	boundary conditions	model physics
“multi-model” the different global models are used to modify the initial conditions of COSMO-DE	**“multi-model”** driven by different global models	

Generation of EPS members

representing uncertainty in

initial conditions	boundary conditions	model physics
“multi-model” the different global models are used to modify the initial conditions of COSMO-DE	**“multi-model”** driven by different global models	**“multi-configurations”** variation of parameters in model physics (non-stochastic, one fixed perturbation per member)

LOGISTIC REGRESSION

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Benefits from **past error statistics**

Logistic regression approach :

$$z = \beta_0(T) + \beta_1(T)x$$

$$p = \frac{e^z}{1 + e^z}$$

Choice of predictors ***x***. Estimation of the ***β*** over a training period.
Calibrated probabilities ***p*** for a threshold ***T*** directly addressed

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

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Extended Logistic regression including the predictand threshold as predictor provides the **full probability distribution**

$$z = \beta_0 + \beta_1 x \ + \beta_2 T$$

(Wilks 2009)

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Benefits from **past error statistics**

Logistic regression approach :

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Extended Logistic regression including the predictand threshold as predictor provides the **full probability distribution**

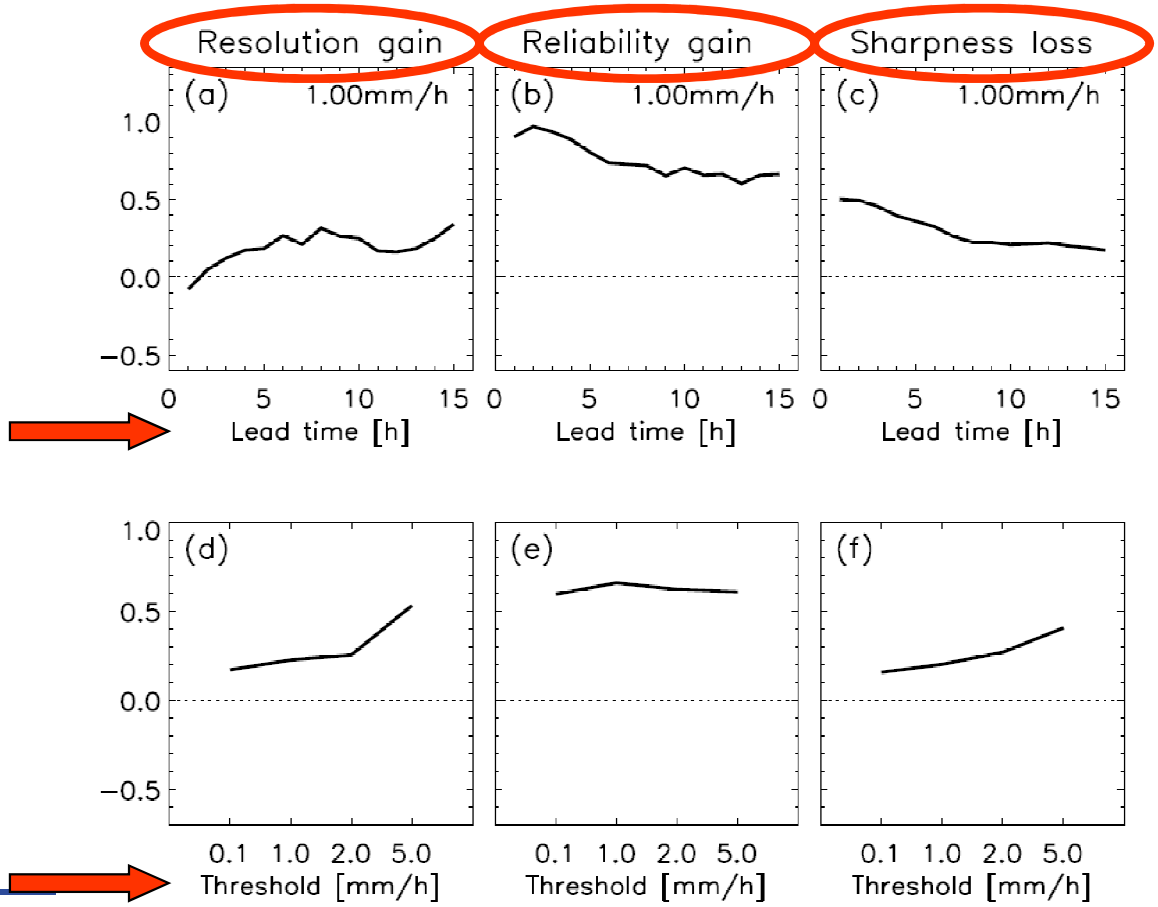
$$z = \beta_0 + \beta_1 x \ + \beta_2 T$$ **(Wilks 2009)**

Extended Logistic regression with **interaction terms** fully describes the influence of *T* on all the original ***β***

$$z = \beta_0 + \beta_1 x + \beta_2 T + \beta_3 T x$$ **(Ben Bouallègue, 2012)**

Lagged average forecast LAF

➔ **combination of members from consecutive COSMO-DE-EPS runs to improve the representation of forecast uncertainty**



LAF (20+20+20 members) compared to COSMO-DE-EPS

hourly precipitation

June 2011