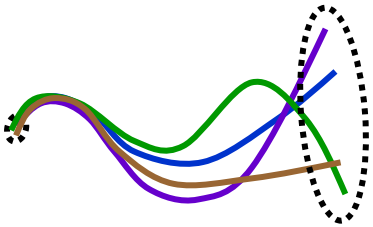
Deutscher Wetterdienst
Wetter und Klima aus einer Hand

COSMO-DE-EPS

operational status

and

developments



**Christoph Gebhardt, Susanne Theis,
Zied Ben Bouallègue, Michael Buchhold,
Andreas Röpnack, Nina Schuhen**

Deutscher Wetterdienst, DWD

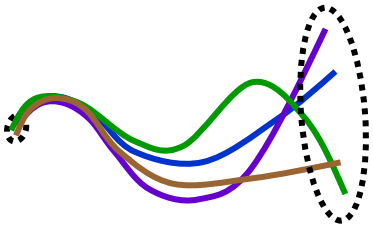
Deutscher Wetterdienst
Wetter und Klima aus einer Hand

COSMO-DE-EPS

operational status since May 22nd 2012

and

developments



**Christoph Gebhardt, Susanne Theis,
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Deutscher Wetterdienst, DWD

Outline

- ➔ operational set-up and member generation of COSMO-DE-EPS
- ➔ basic verification results of the first operational months (more details in plenary session)
- ➔ current developments
  - upgrade to 40 members, redesign (BC, physics, soil moisture)
  - statistical post-processing
  - LAF

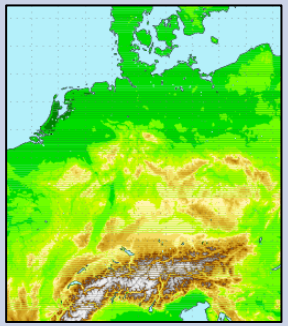
Operational set-up of COSMO-DE-EPS

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)

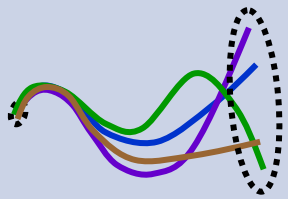


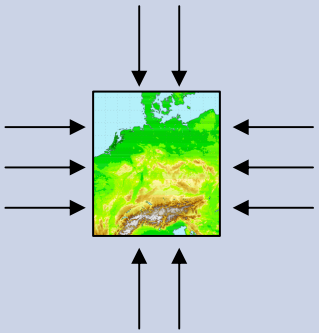
model domain

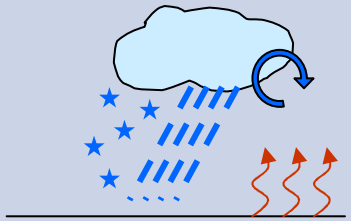
Generation of EPS members

representing uncertainty in

initial conditions	boundary conditions	model physics



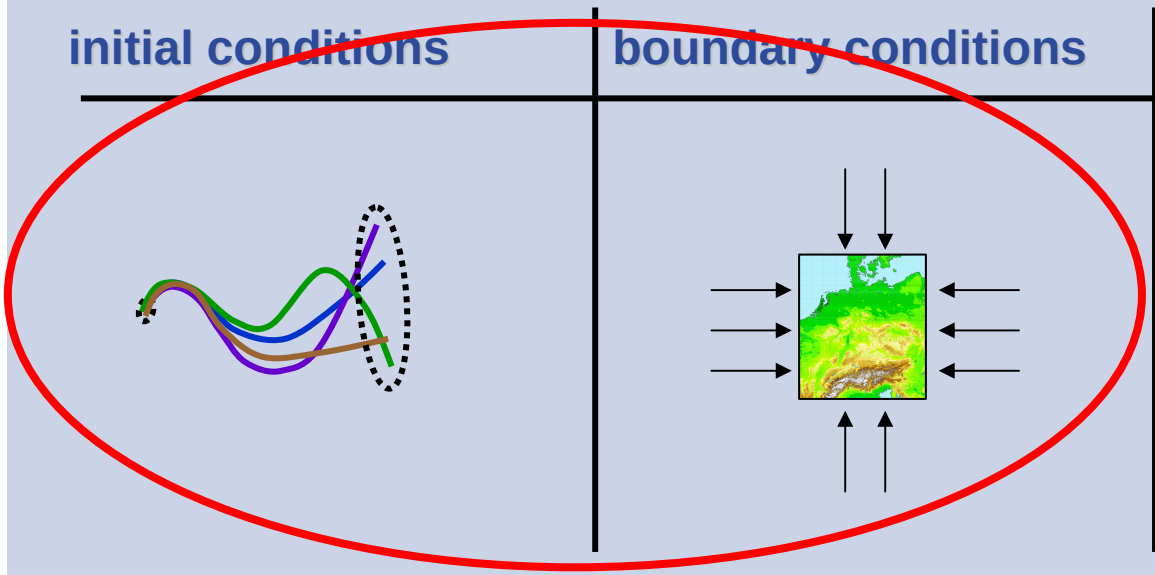




Generation of EPS members

representing uncertainty in

initial conditions | boundary conditions | model physics



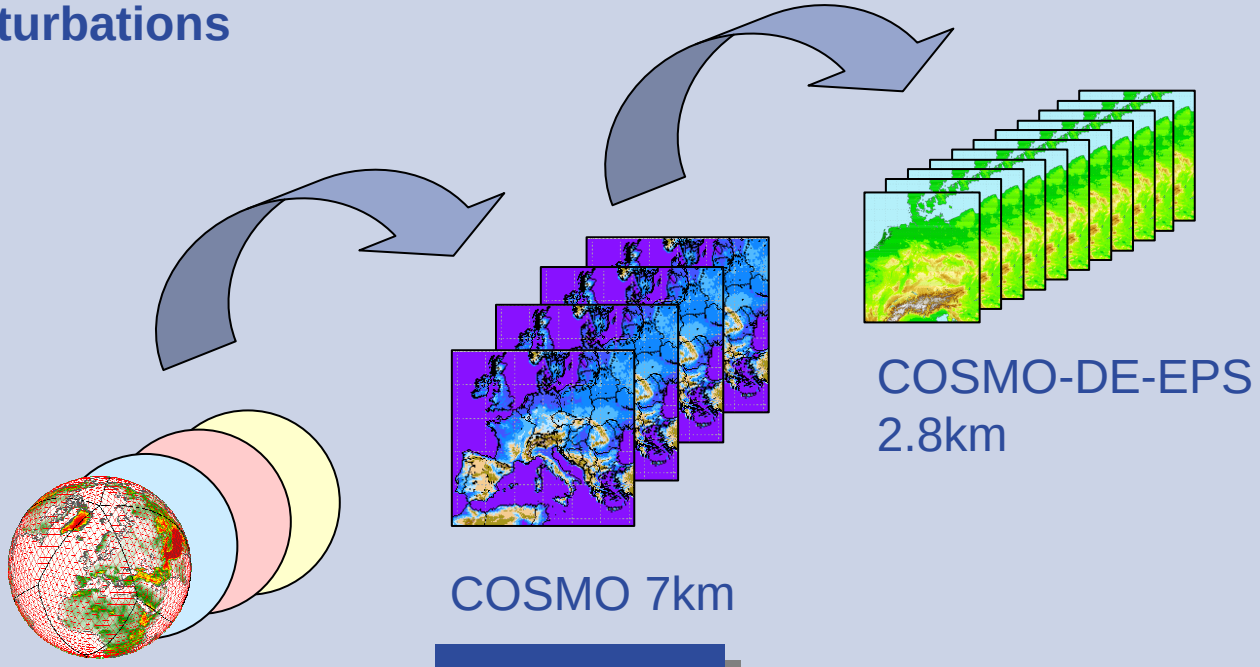
perturbed parameters

„multi-model“

non-stochastic

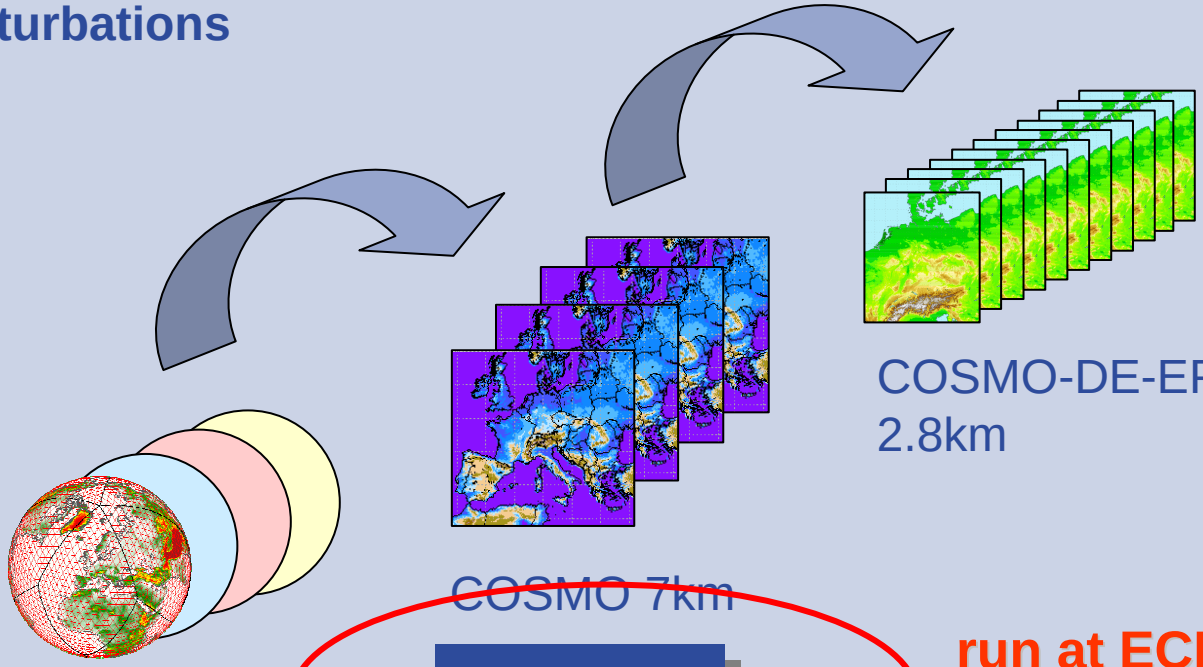
Generation of EPS members

BC-EPS for boundary and initial perturbations



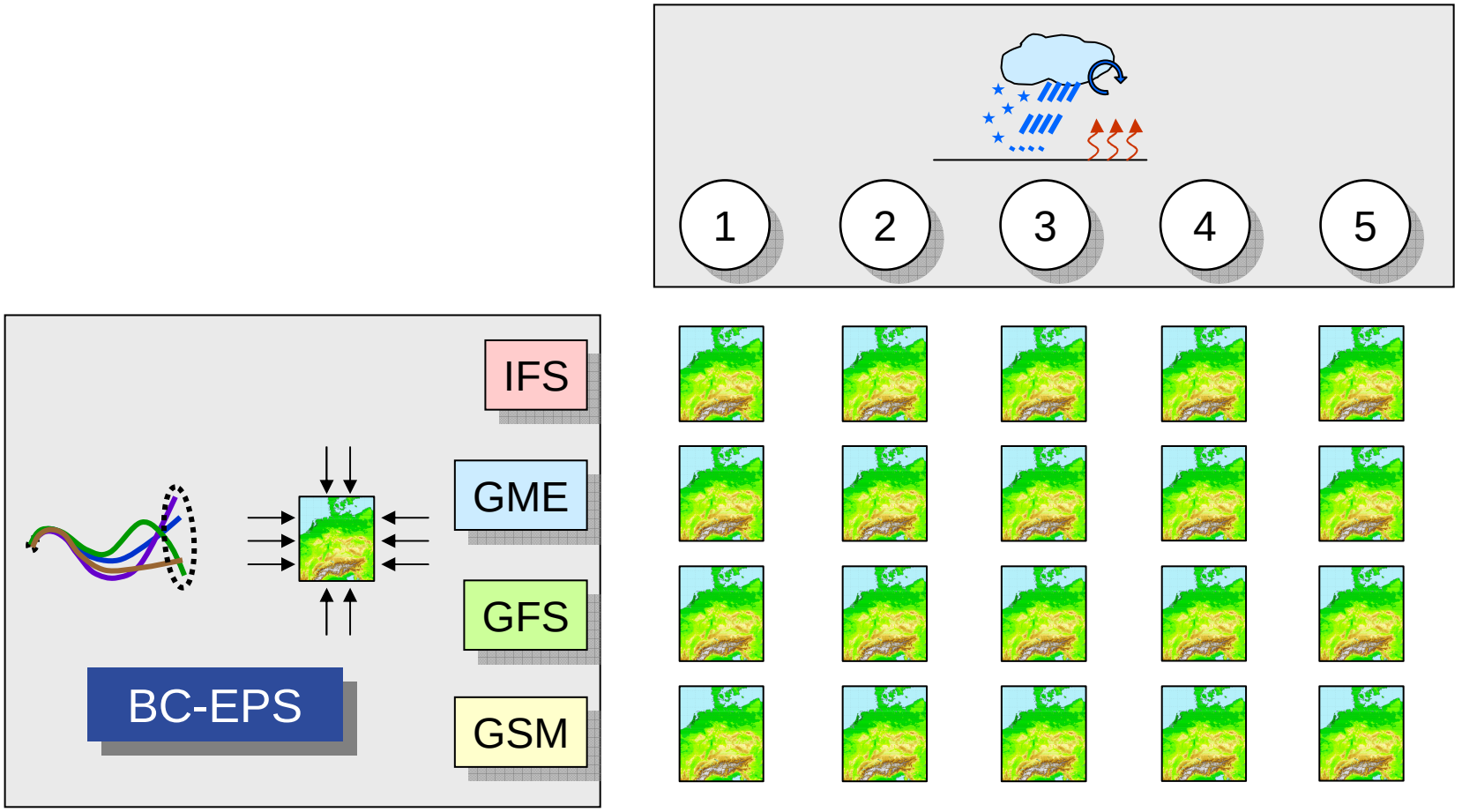
Generation of EPS members

BC-EPS for boundary and initial perturbations



run at ECMWF as time critical application

The 20 members of COSMO-DE-EPS



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)*

Peralta, C. and M. Buchhold, 2011: **Initial condition perturbations** for the COSMO-DE-EPS, COSMO Newsletter 11, 115–123.

COSMO-DE-EPS Overview COSMO GM 2011

- start of pre-operational phase / evaluation — December 2010
  - 20 members → probabilities, quantiles, etc
  - runs at 00 UTC, 03 UTC, 06 UTC,…
- start of pre-operational phase with **40 ensemble** members — Q1 2012
- reach operational status — End of 2012
- … — 2013

COSMO-DE-EPS Overview COSMO GM 2011

- start of pre-operational phase / evaluation
  - 20 members → probabilities, quantiles, etc
  - runs at 00 UTC, 03 UTC, 06 UTC,…
- start of pre-operational phase with **40 ensemble** members
- reach operational status
- …

December 2010

Q2 2012

End of 2012

2013

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**
  - ➔ **drawback: 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)**

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  - 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)

modify time schedule to benefit from EPS in summer 2012

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VERIFICATION OF COSMO-DE-EPS

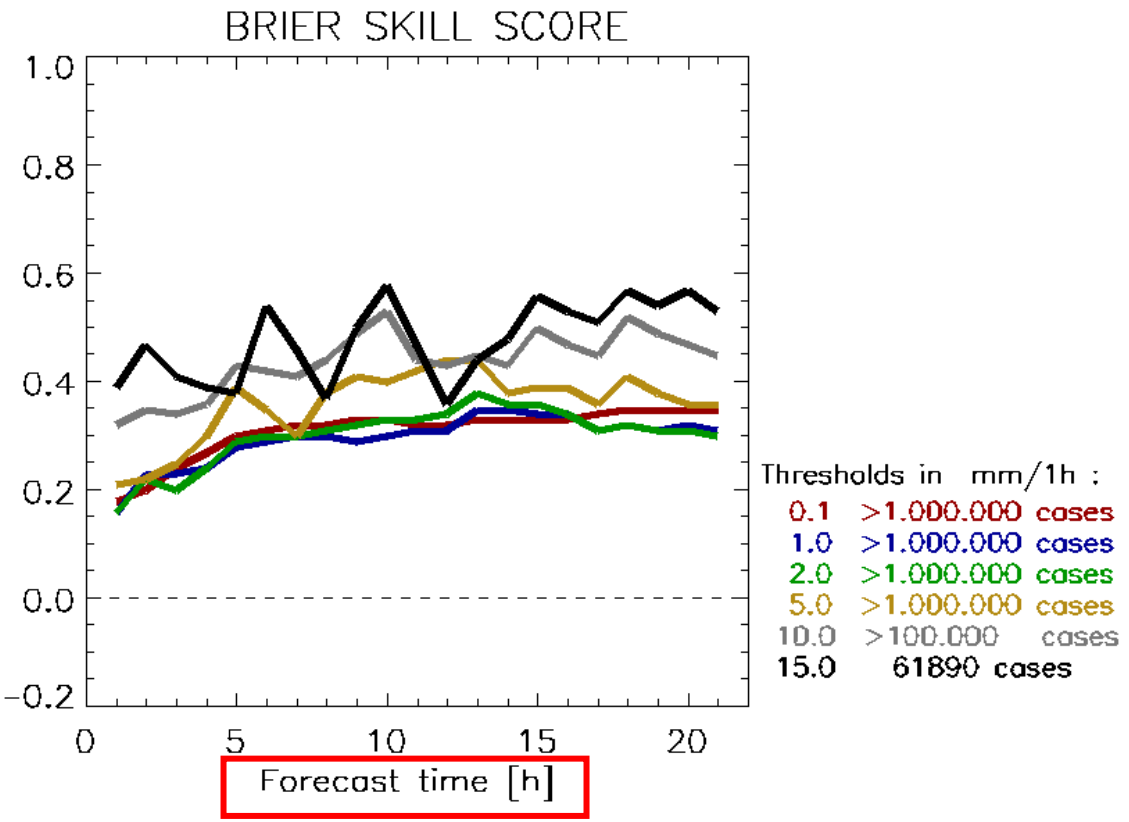
all results for hourly precipitation

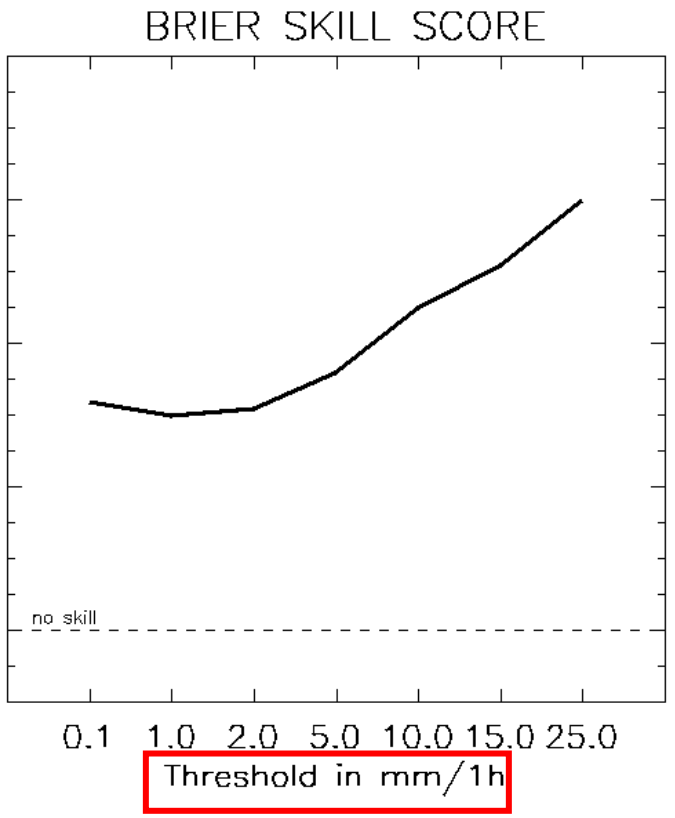
in June / July 2012

EPS not calibrated or post-processed

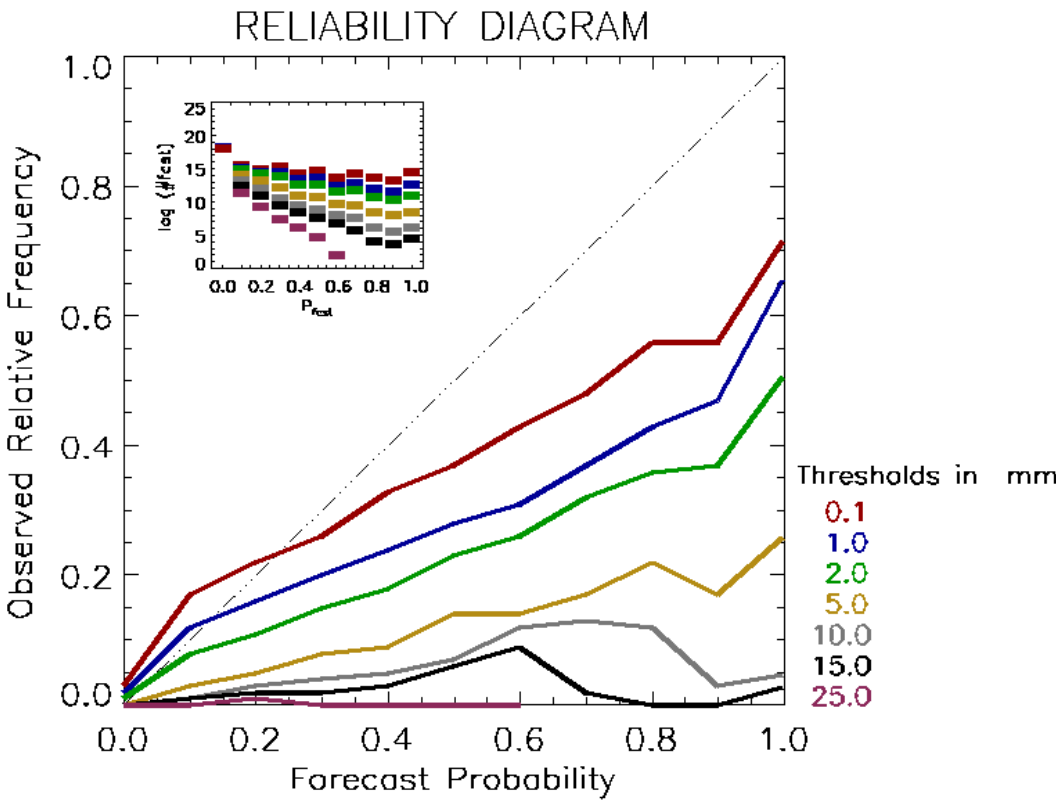
observations: rain-gauge adjusted radar

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

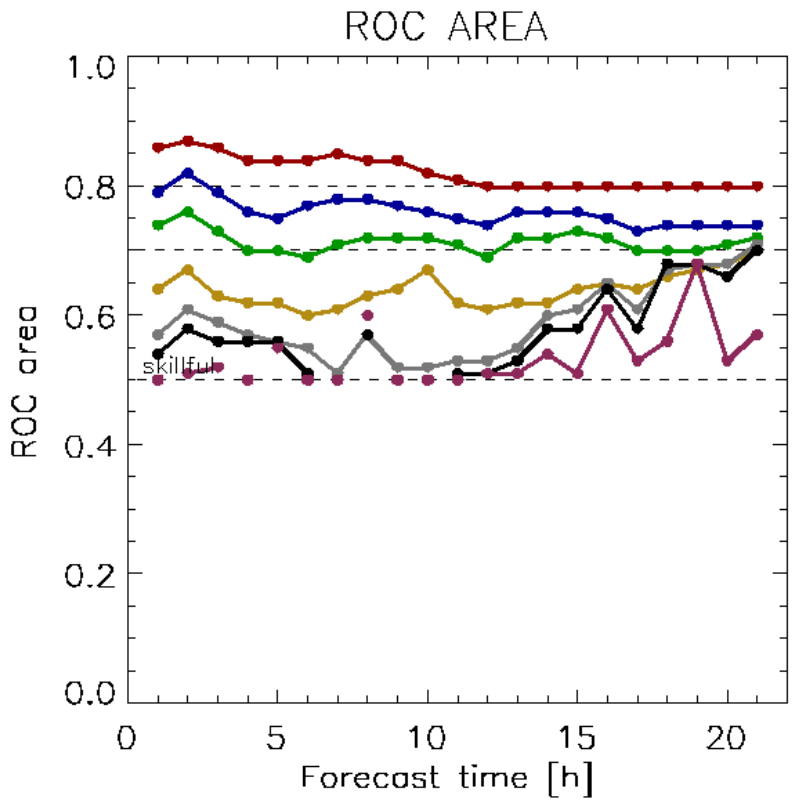




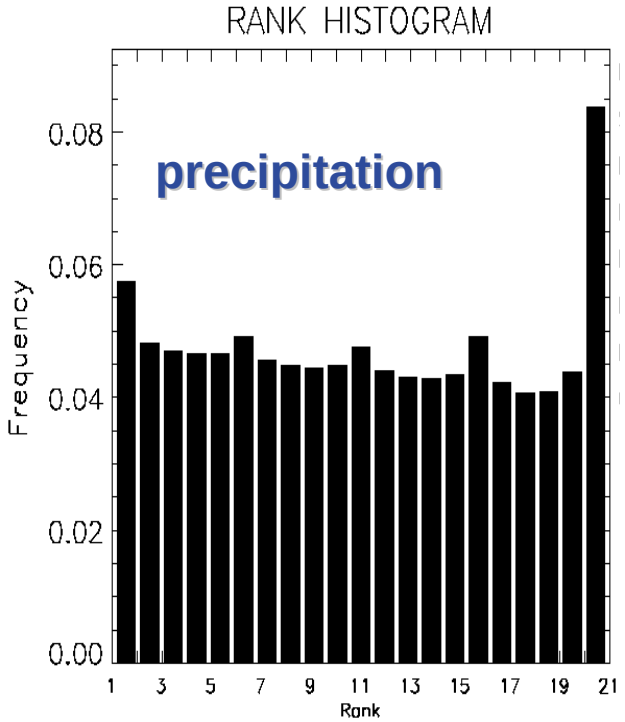
Reliability diagram



ROC area



Rank histogram



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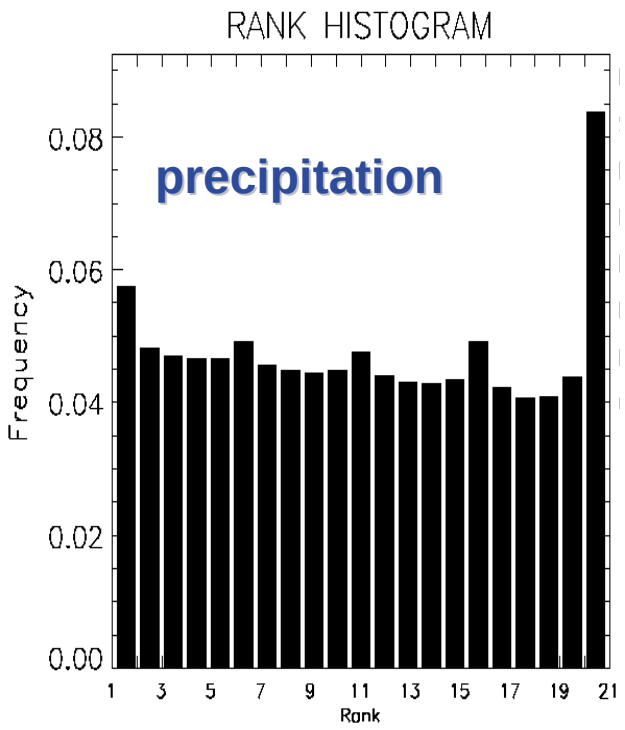
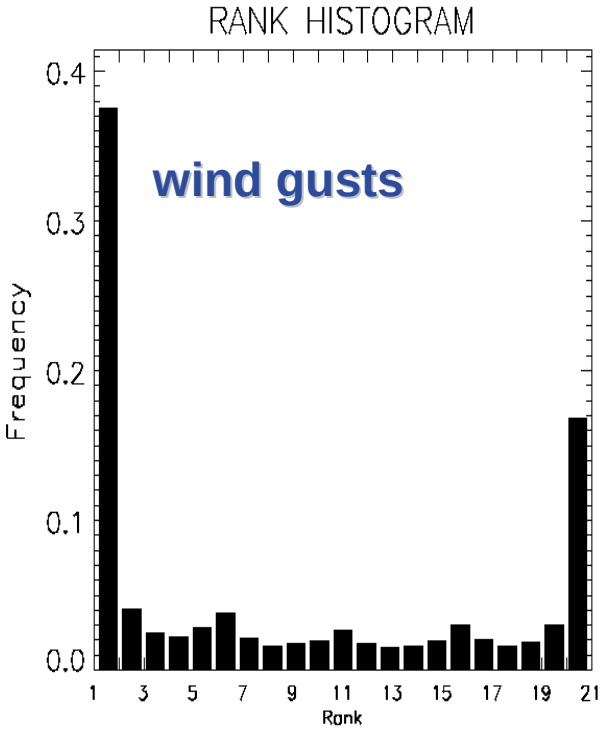
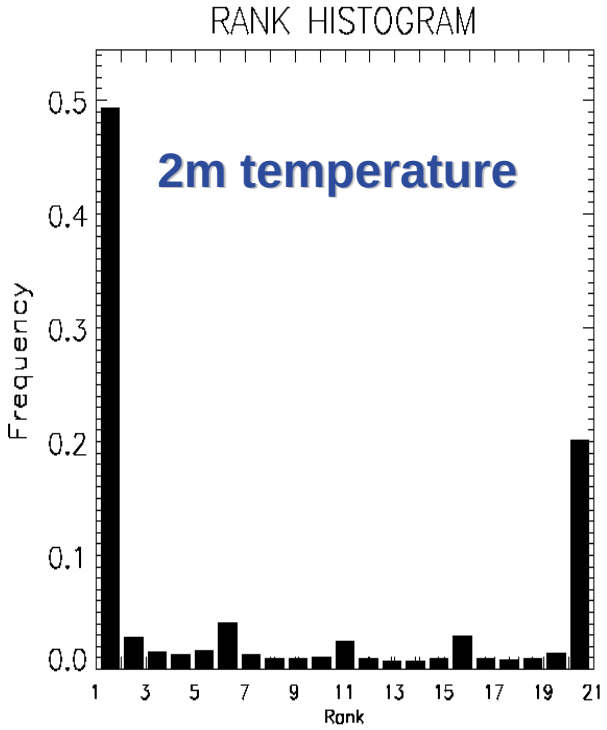






COSMO-DE-EPS status and plans

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

2010

2011

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

2012

switch to operational mode (22nd May 2012)

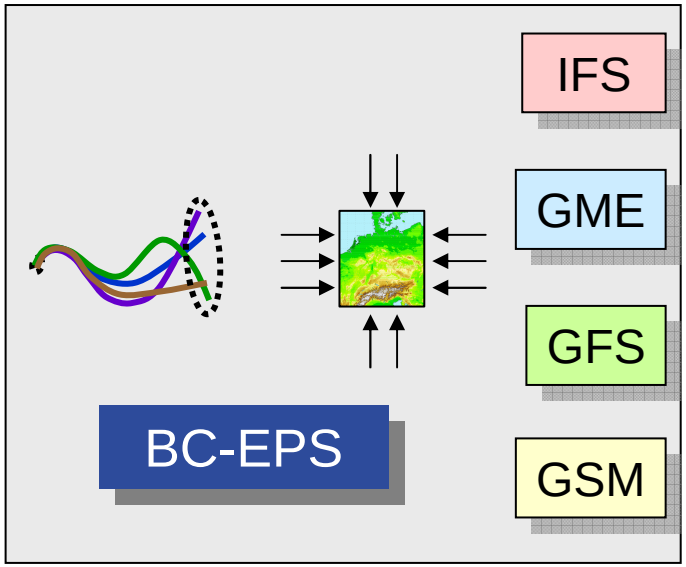
➔ **upgrade to 40 members, redesign**

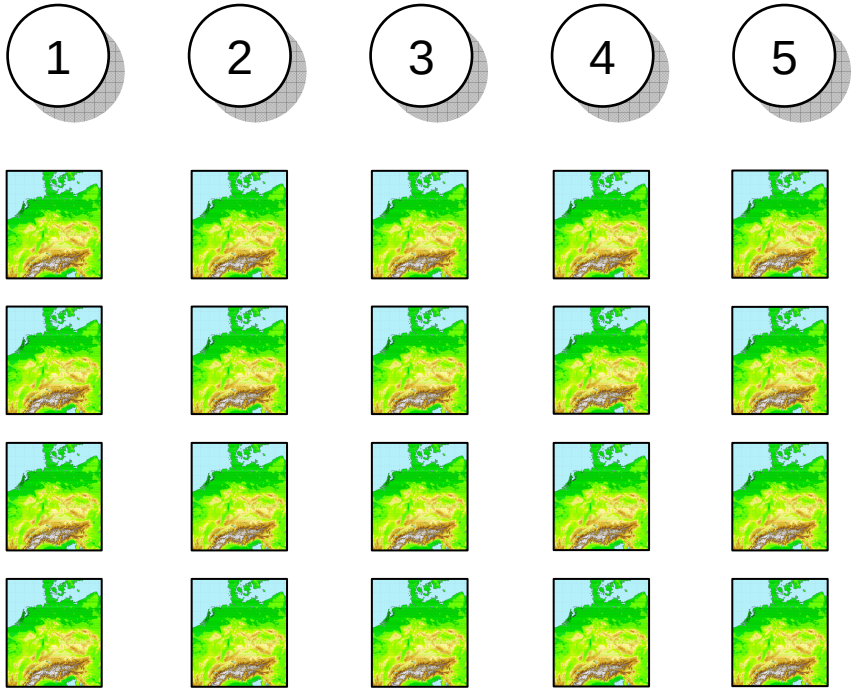
2013 / 14

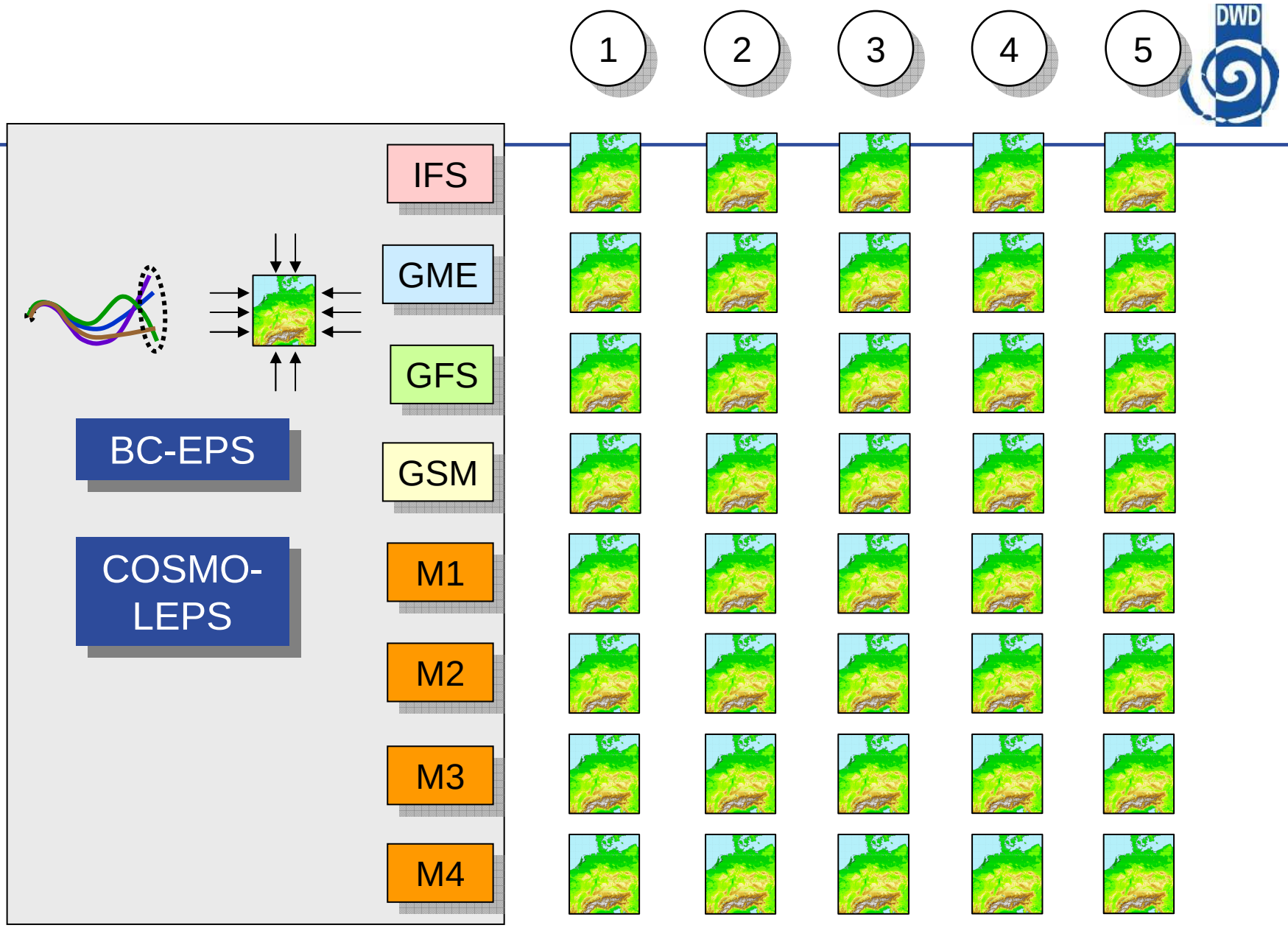
upgrade to 40 members

- ➔ 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

The ~~20~~ 40 members of COSMO-DE-EPS






1
2
3
4
5
IFS
GME
GFS
BC-EPS
GSM
COSMO-
LEPS
M1
M2
M3
M4

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VERIFICATION

20 members / 40 members

winter 2011/12 (1 month)

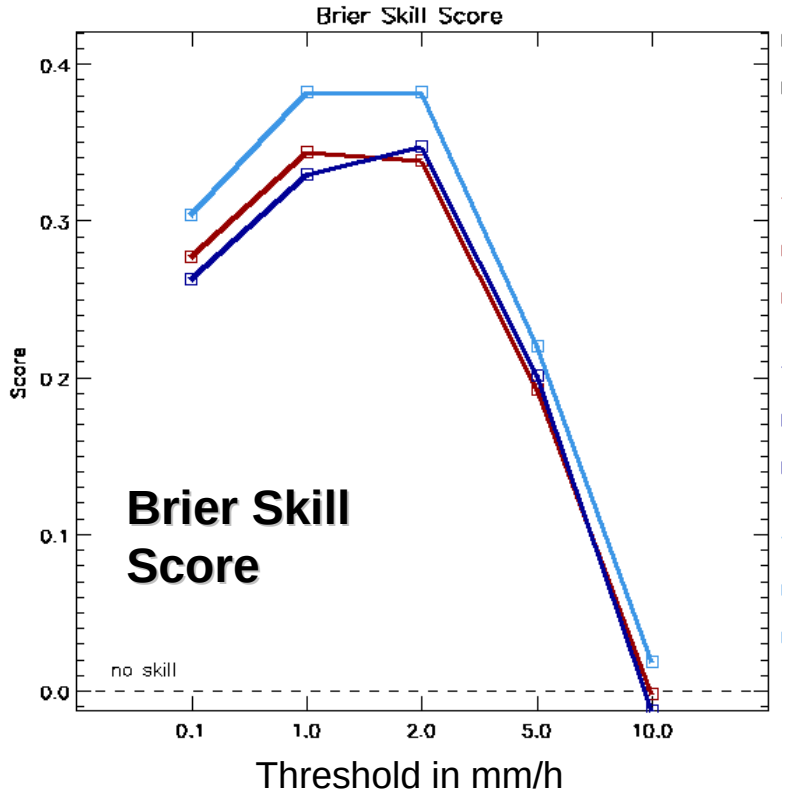
work by Andreas Röpnack

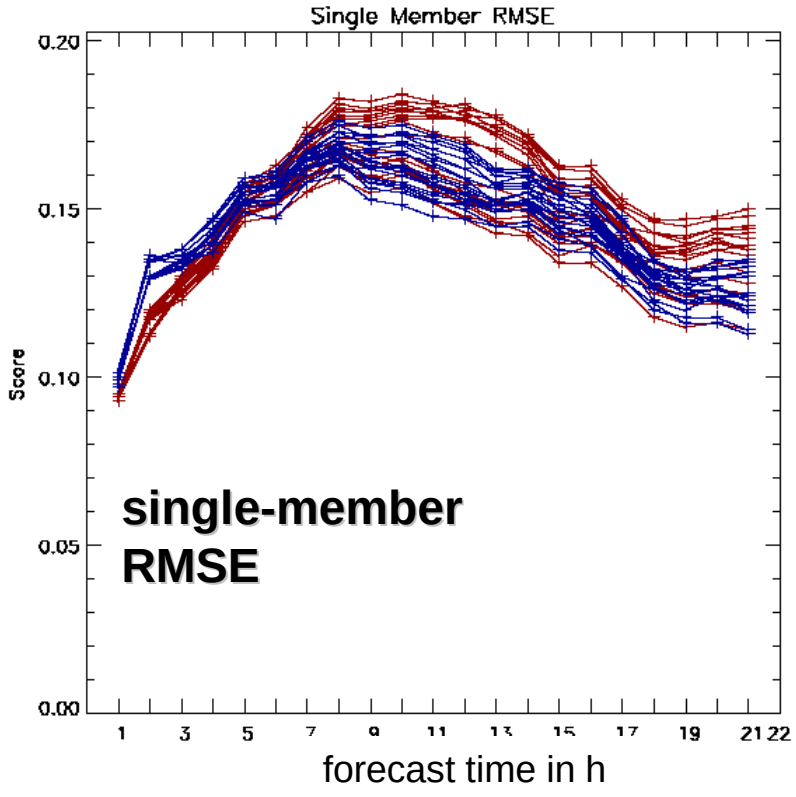
1-hourly precipitation

40 members

BC-EPS driven members (1-20)

LEPS driven members (21-40)



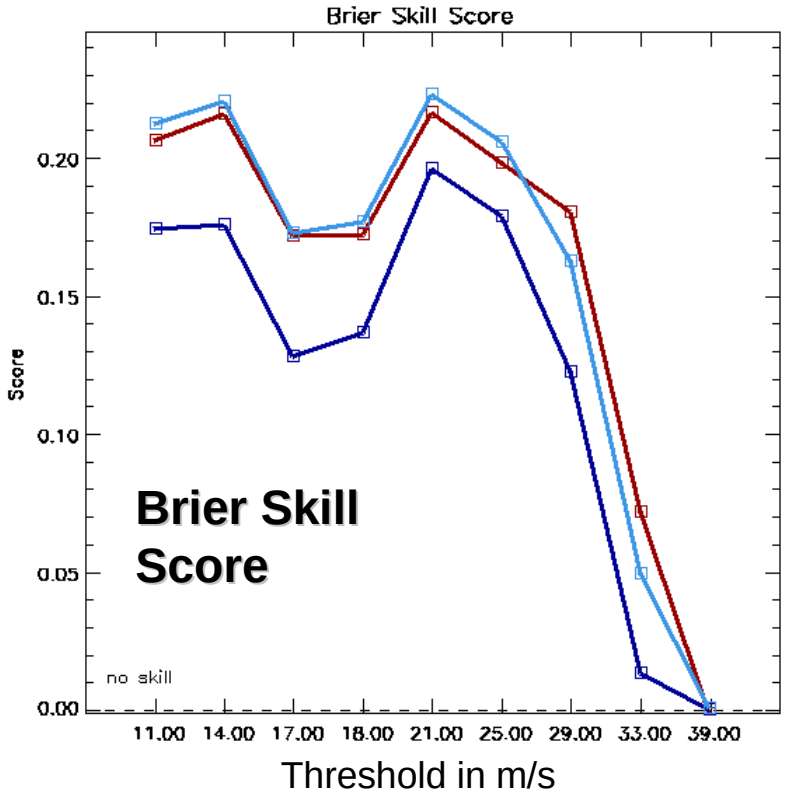


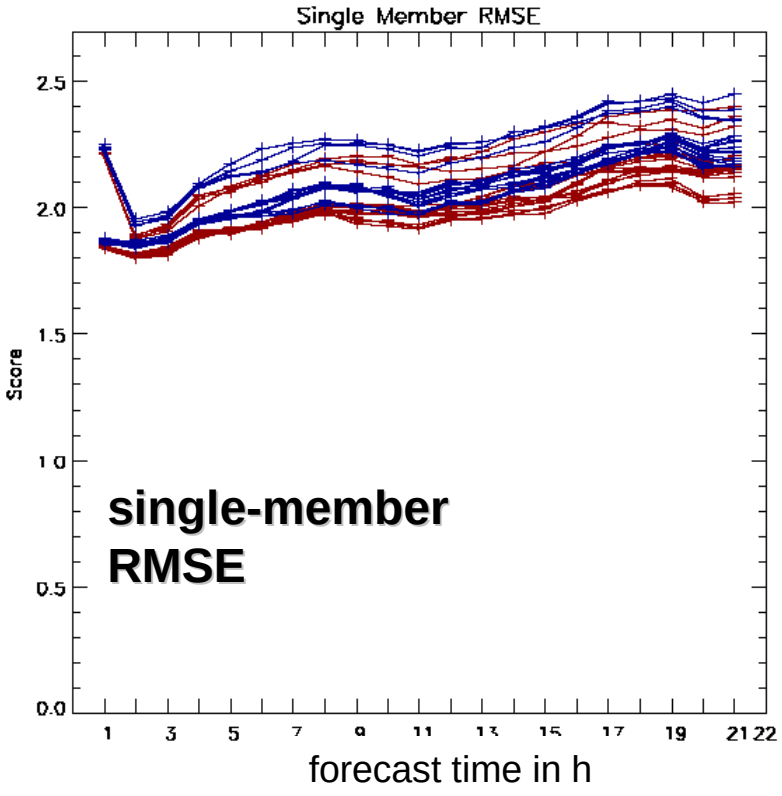
wind gusts

40 members

BC-EPS driven members (1-20)

LEPS driven members (21-40)





wind gusts

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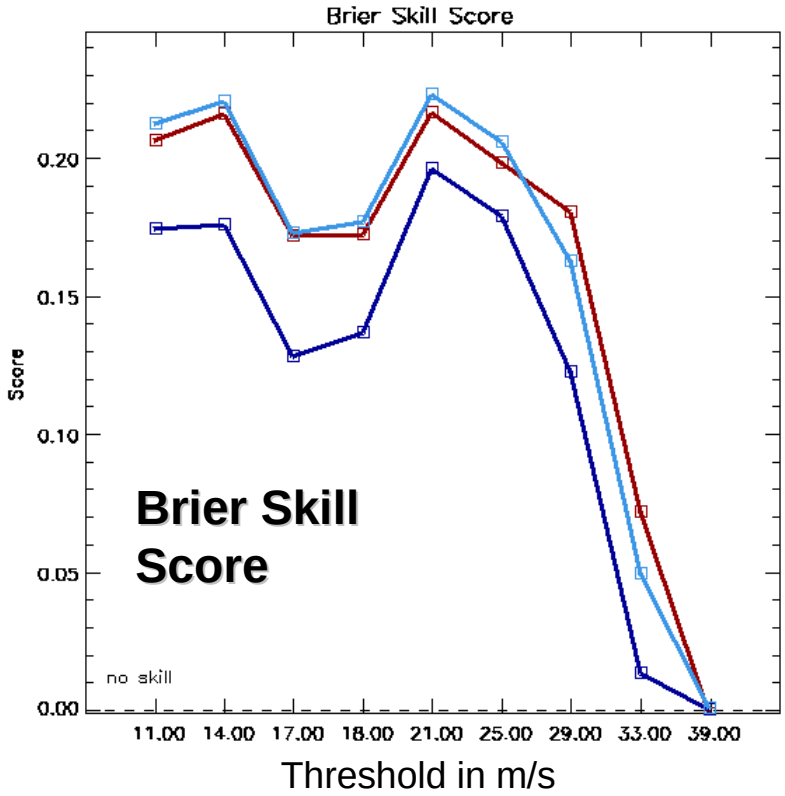
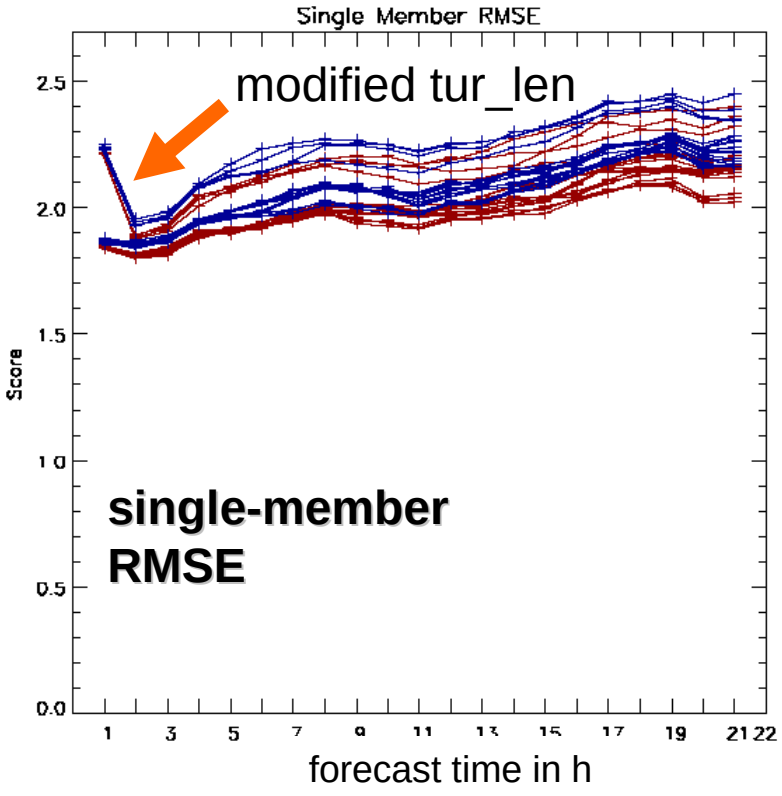


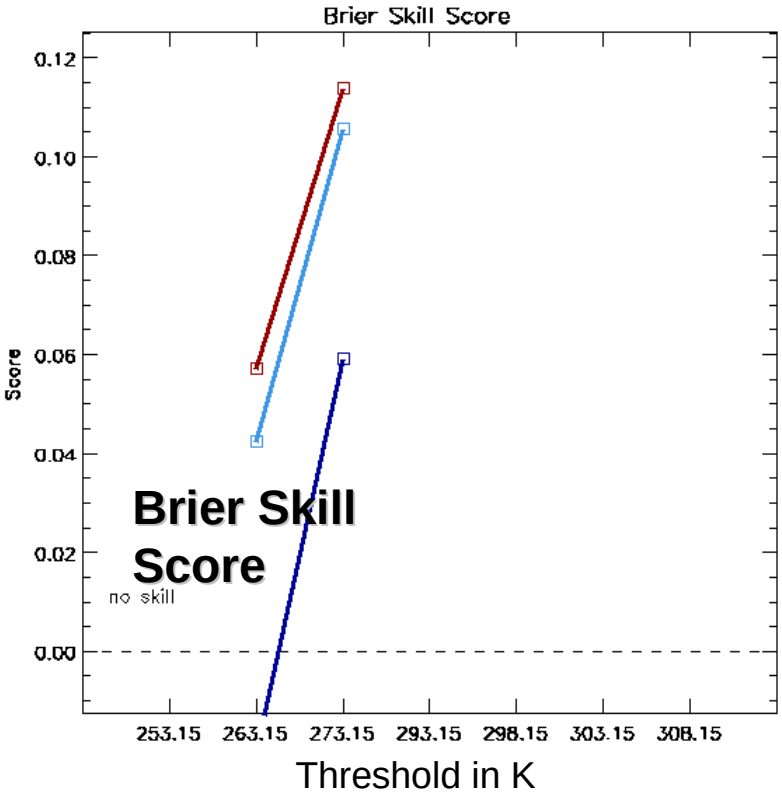


2m temperature

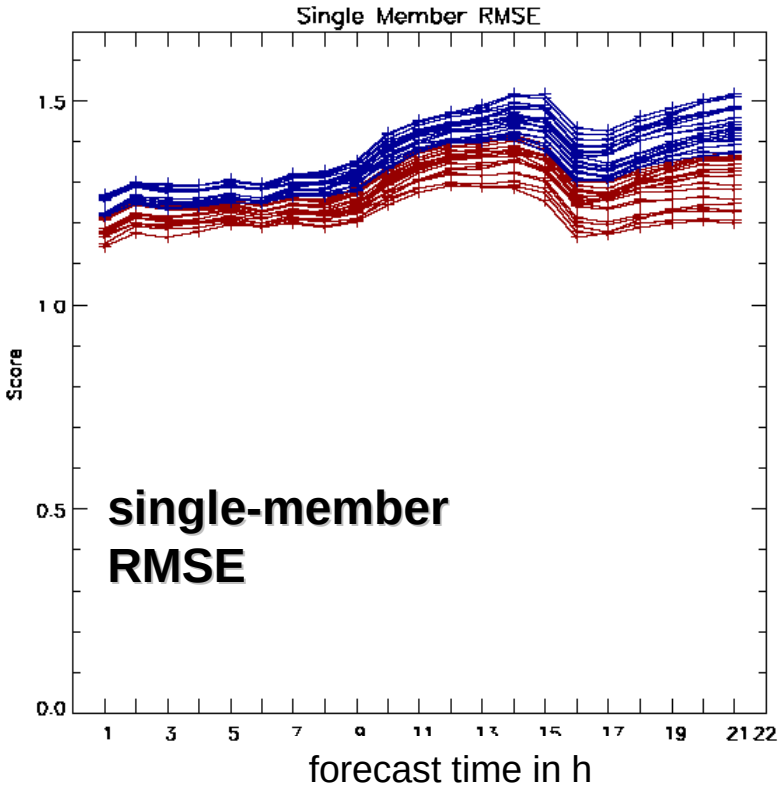
40 members

BC-EPS driven members (1-20)

LEPS driven members (21-40)



Brier Skill Score



single-member RMSE

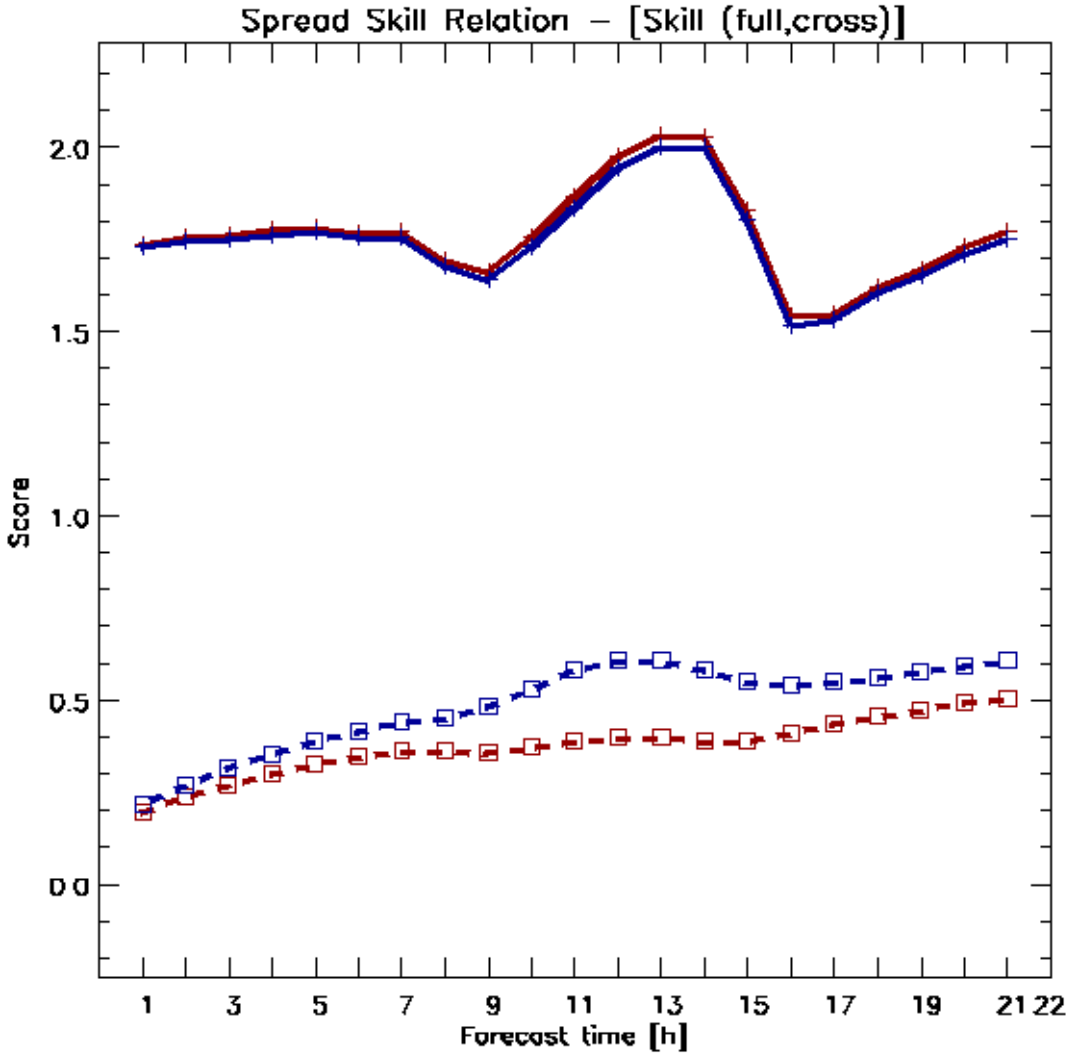
adding 4 LEPS members as BC leads to mixed results:

- **slight improvement for precipitation**
- **neutral for wind gusts**
- **degradation for 2m temperature**
- **separation between BC-EPS and LEPS members obvious**
  ➔ can make calculation and/or interpretation of probabilistic products complex
- **wait for summer results…**

Ensemble experiment with perturbed coefficient for minimum diffusion (heat and momentum *tkhmin, tkmmin*)

- ➔ (modified) operational setup + perturbation of tkhmin, tkmmin
  Range: [0.2 ,0.5, 0.8]
  4 members 0.5, 8 members 0.2, 8 members 0.8 (of 20 members)
- ➔ Test period: November 2011, 00 UTC runs
- ➔ compared with (modified) operational setup
- ➔ "modified" means: 0.5 is the default value

work by Michael Buchhold



Spread-Skill relation

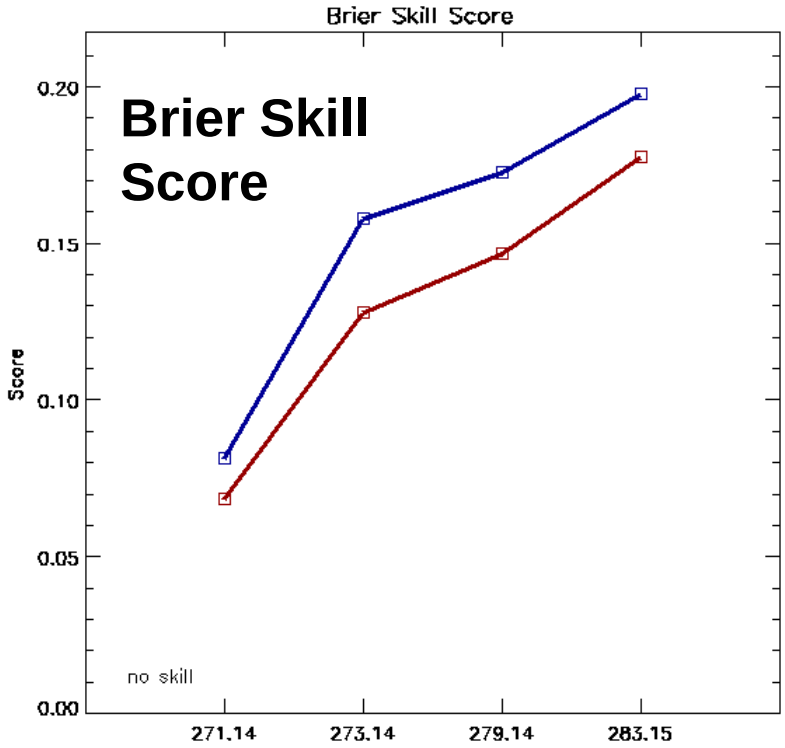
2m temperature

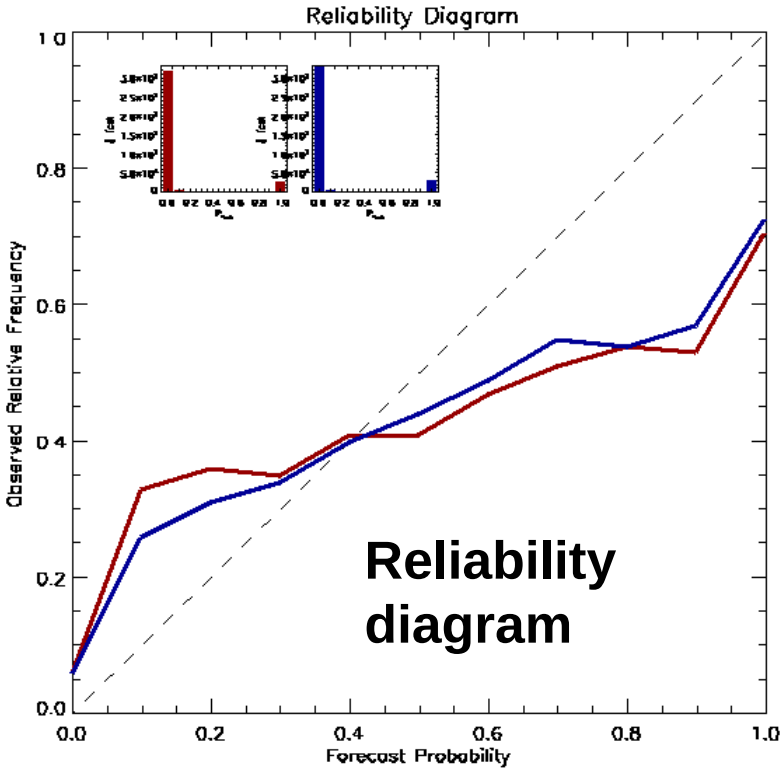
perturbed minimum diffusion

modified operational COSMO-DE-EPS

perturbed minimum diffusion **2m temperature**

modified operational COSMO-DE-EPS





Ensemble experiment with perturbed coefficient for **minimum diffusion** (heat and momentum *tkhmin, tkmmin*)

- ➔ BSS of 2m temperature increases
- ➔ slight improvement of reliability (T_2M below “cold” threshold)
- ➔ spread of 2m temperature increases

Ensemble experiment with perturbed soil moisture

Addition and subtraction of half the difference between C-EU und C-DE soil moisture in all layers but the lowest

m1	m2	m3	m4	m5	m6	...	...	m18	m19	m20
-	+.5*inc	-.5*inc	-	+.5*inc	-.5*inc	…	…	-.5*inc	+.5*inc	-

test period June/July 2012
Reference : operational C-DE-EPS

work by Michael Buchhold

Ensemble experiment with perturbed soil moisture

- ➔ BSS of 2m temperature increases (“warm” thresholds)
- ➔ spread of 2m temperature increases
- ➔ slight (if any) improvement of reliability (T_2M above “hot” thresholds)
- ➔ slightly better results for precipitation

COSMO-DE-EPS status and plans

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

2010

2011

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

2012

switch to operational mode (22nd May 2012)

➔ **upgrade to 40 members, redesign**

➔ **statistical postprocessing**

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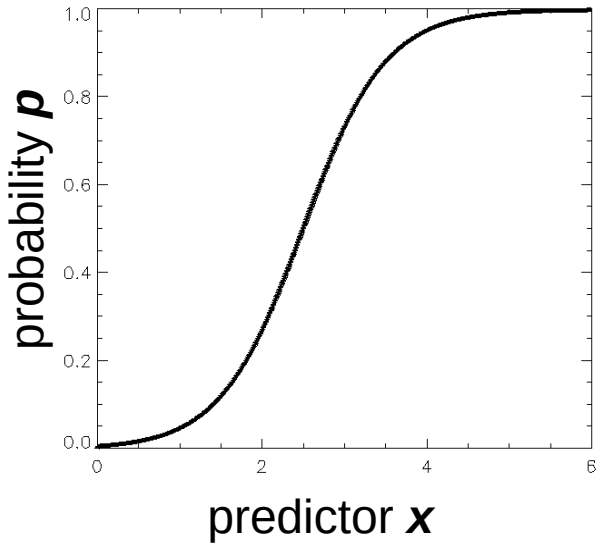
Logistic regression approach :

A standard method with readily understood characteristics
Regression coefficients ***β*** : 'semi' parametric approach
Address directly the probabilities ***p***

$$p = \frac{e^z}{1 + e^z} \qquad z = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_{N_p} x_{N_p}$$



for precipitation

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** **(Wilks 2009)**

Many advantages :

- Coefficients (***β***) **independent of the threshold**
- Probabilities **mutually consistent**.
- Possibility to derive additionally **calibrated quantiles**
- Take advantage of **all the training sample**

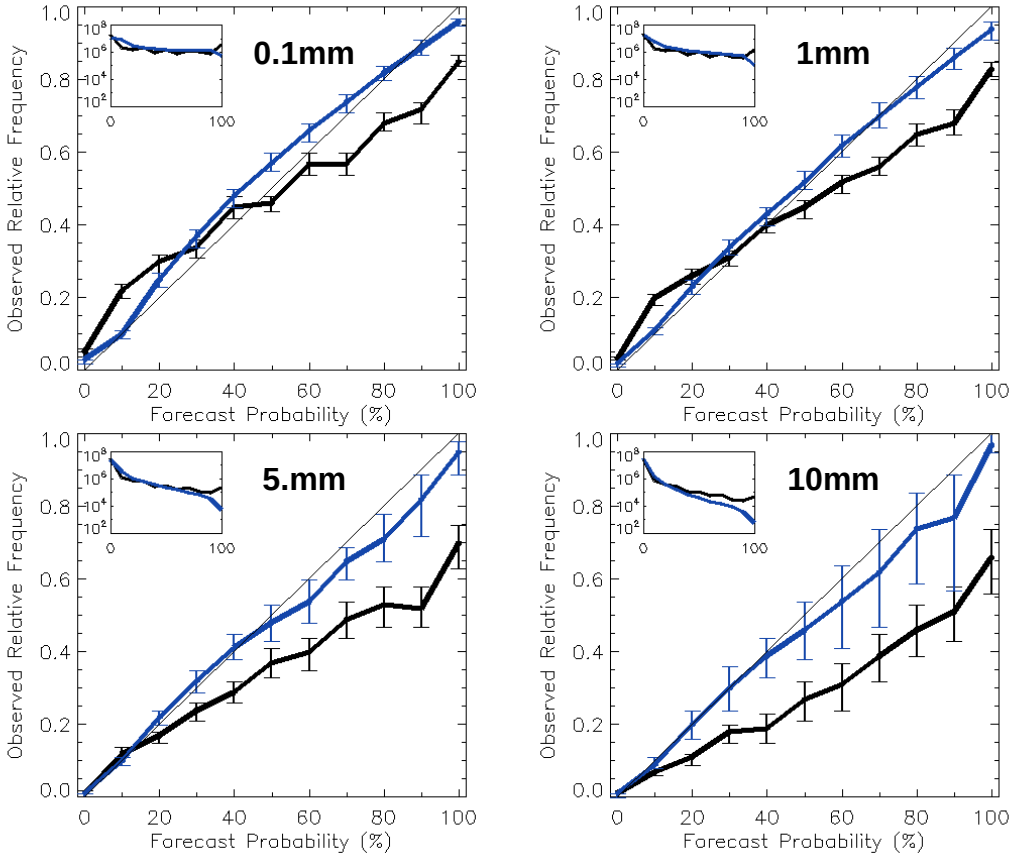
Deutscher Wetterdienst
Wetter und Klima aus einer Hand

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



Deutscher Wetterdienst
Wetter und Klima aus einer Hand

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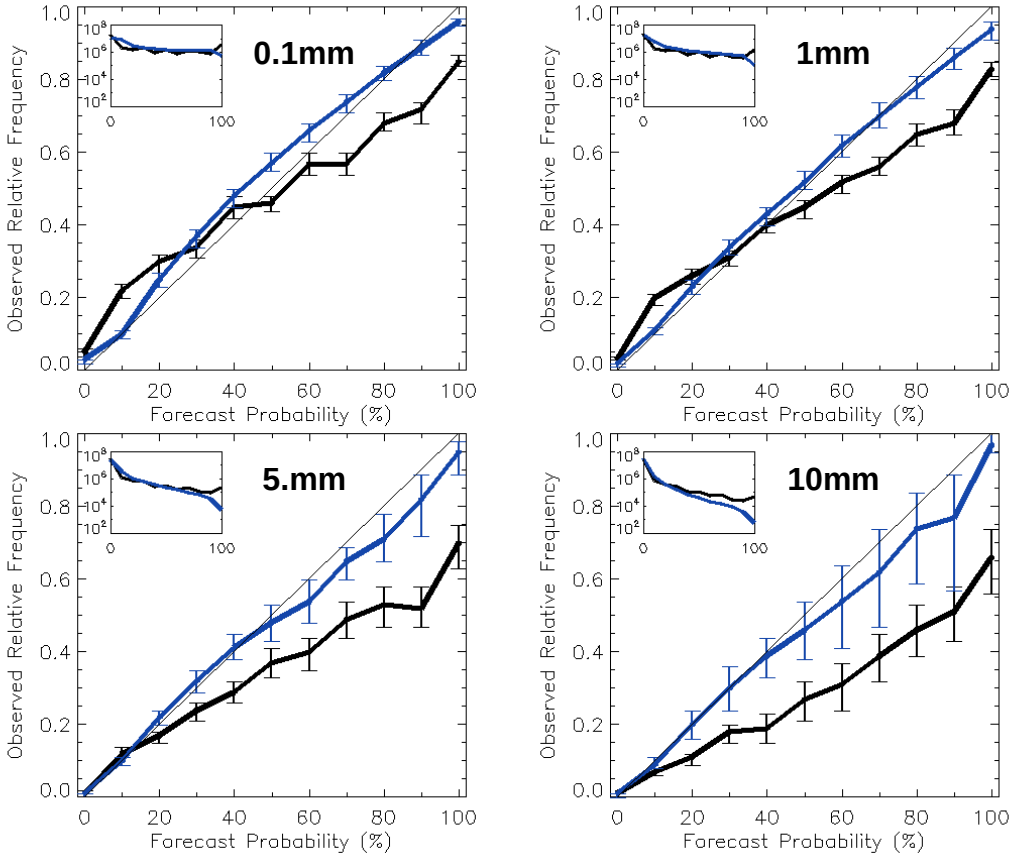
Daily update
6-hourly precipitation

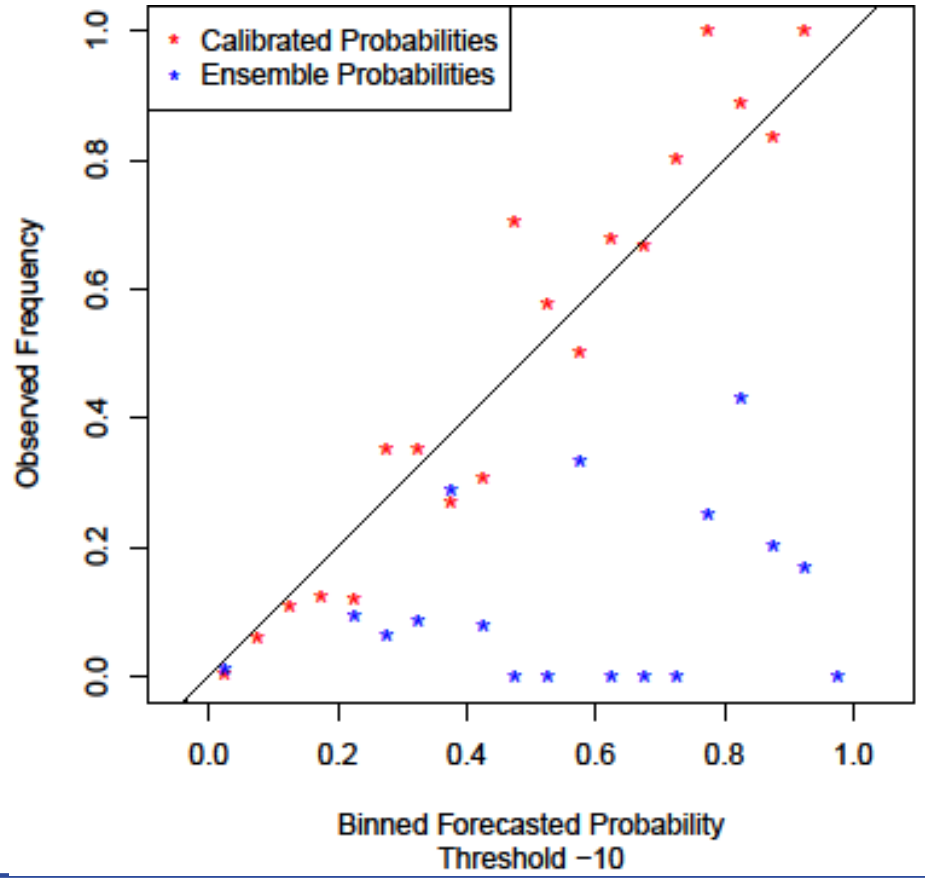
Original ensemble forecasts
Calibrated ensemble forecasts

Ben Bouallègue, Z., 2012:
Calibrated short-range ensemble precipitation forecasts using extended logistic regression with interaction terms.
Submitted to Weather and Forecasting



calibration of wind components probabilities at Frankfurt Airport

(work by Nina Schuhen and Isabel Alberts)



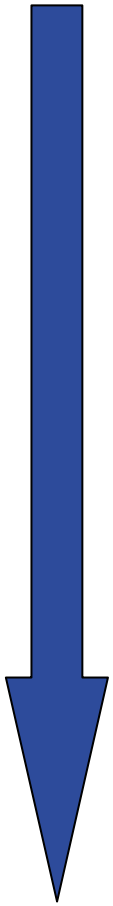
COSMO-DE-EPS status and plans

- ➔ 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



2010

2011

2012

2013 / 14

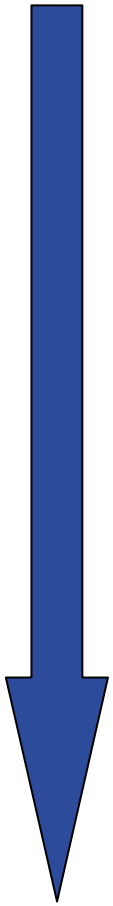
COSMO-DE-EPS status and plans

- ➔ 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

Thank you!