Predictability and EPS review

Chiara Marsigli for the ET-EPS
twinned with the TIGGE-LAM review, T. Paccagnella

contributions by:
I.-L. Frogner, Y. Wang, A. Montani, K. Mylne, N. Bowler, C. Fisher, J. Bojarova, N. Gustafsson, A. Johansson, M. Mile, T. Iversen, N. Roberts, O. Nuissier, S. Theis, J. A. Garcia-Moya, J.-F. Caron, A. Joly, A. Horanyi

Outline

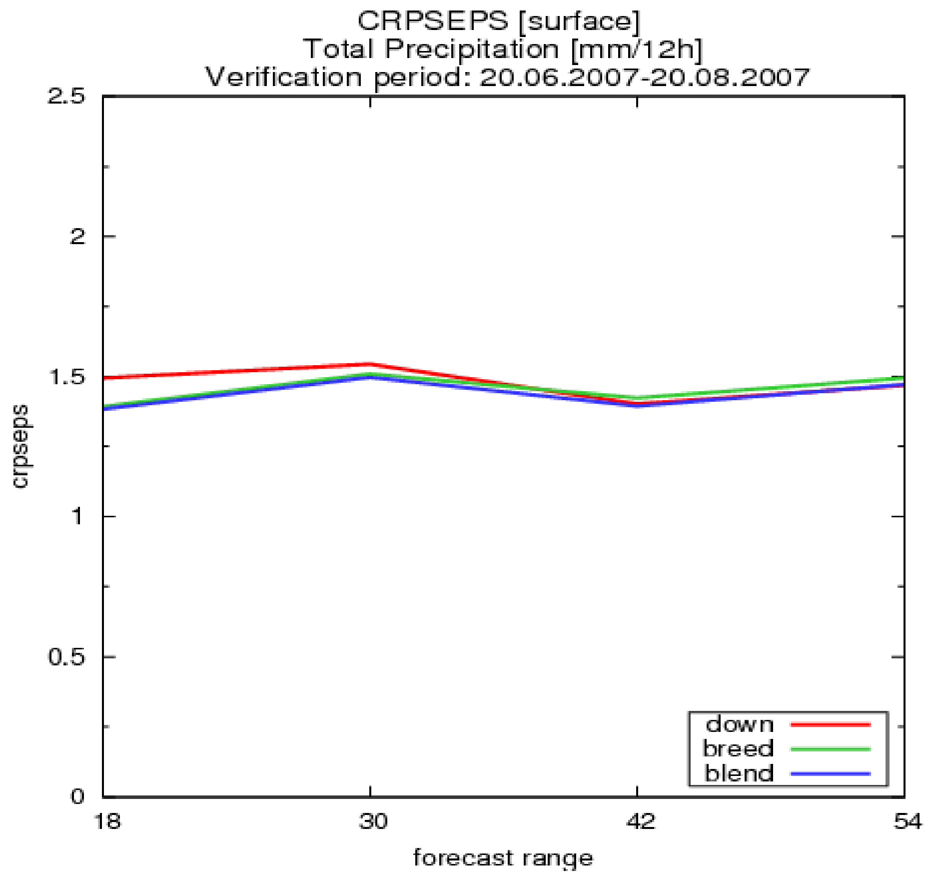
- Recent developments in LAM/short-range EPS in Europe
- Main research topics
- Convection-permitting EPS: present status and some predictability issues
- Issues which require coordination

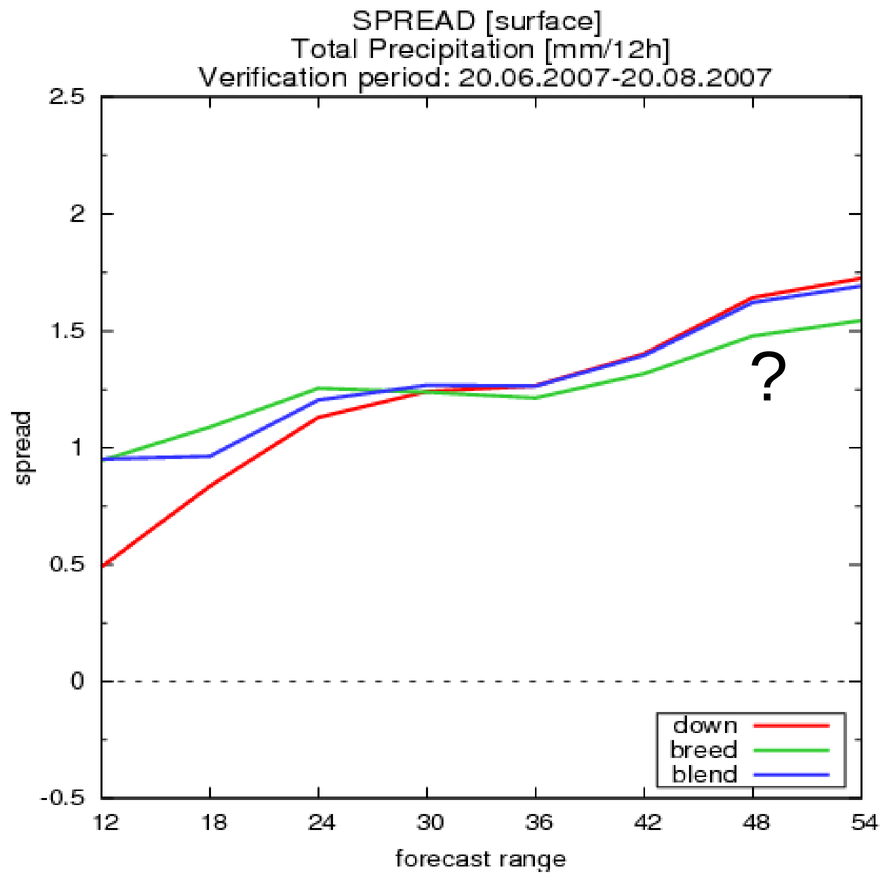
IC perturbations - blending

- ALADIN-LAEF: ECMWF EPS perturbations + ALADIN breeding perturbations
- PEARP: targeted Singular Vector + breeding

ALADIN-LAEF

Blending of larger scale perturbations from global ensemble (ECMWF EPS) and local scale perturbations from LAM (ALADIN breeding), using a **scale selective** procedure





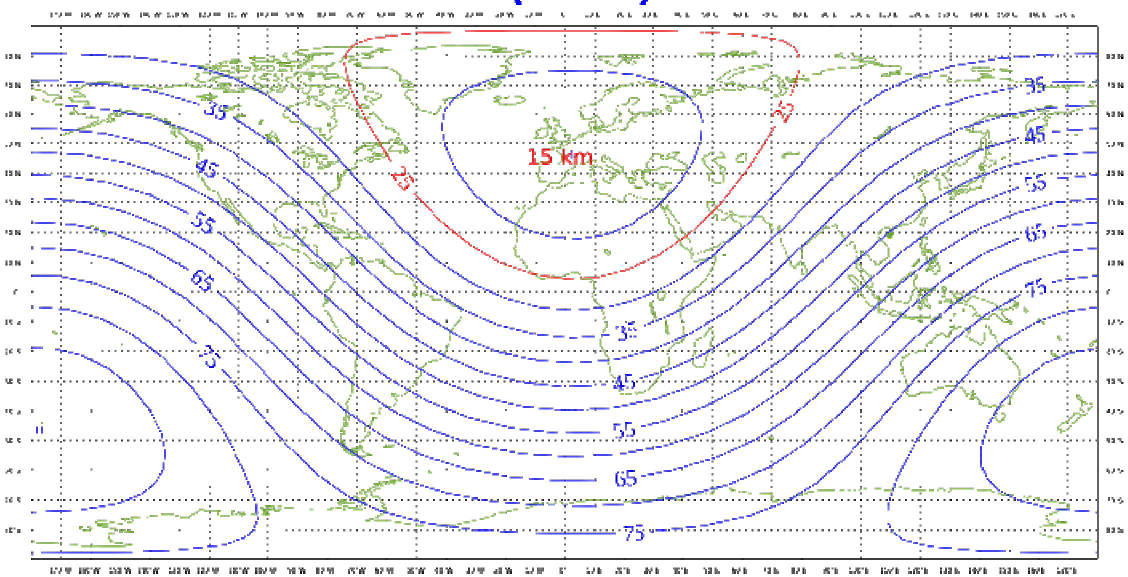
METEO FRANCE
Toujours un temps d'avance

PEARP

Blending of:
• 56 dry TE SVs on 4 areas
+
• breeding, using the 6 analyses computed by AEARP (Assimilation Ensemble ARPege)
• scaled to an amplitude size using error variances background of the day consistent with 4D-Var assimilation cycle

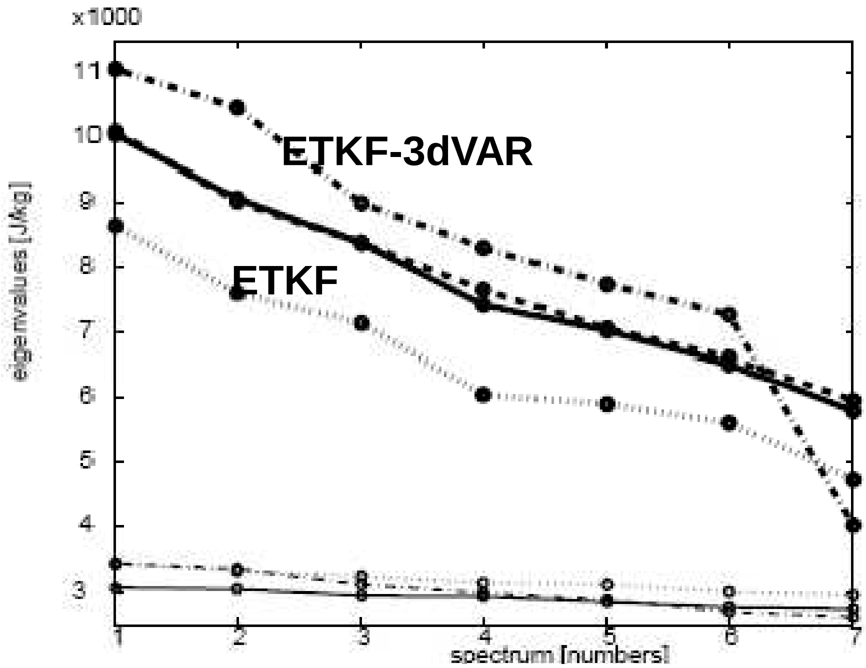
Developments:
more Target Area
+ resolution increase

Resolution locale (en km) en T 538 C 2.4

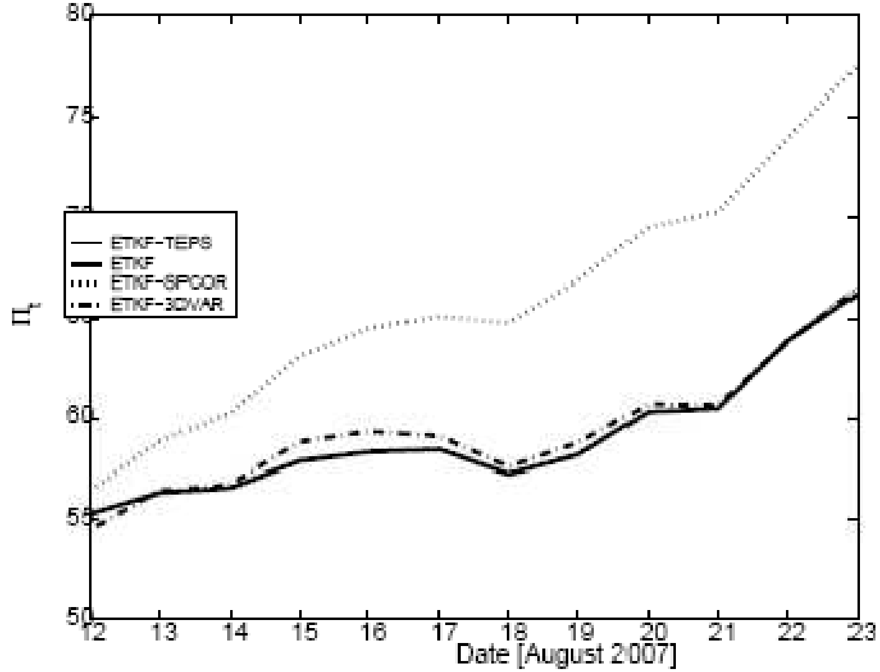


HIRLAM ETKF for GLAMEPS

Development of new inflating methodology with additive term in ETKF. As a result of that, the forecast uncertainty will have larger projection on the leading uncertainty eigenmodes.



The spectra of ETKF perturbations are more realistic than ensemble perturbations based on targeted singular vectors, in particular at analysis time and for short forecast lengths.



Interior of Domain:
ETKF = 20% EuroTEPS + 80% ETKF
EuroTEPS = 100% EuroTEPS
Boundary conditions: EuroTEPS

Jelena Bojarova, Nils Gustafsson, Ake Johansson and Ole Vignes – NMI, SMHI

IC perturbations - ETKF

- MOGREPS
- HIRLAM for GLAMEPS
- UK 1.5km ensemble

Planned by:

- COSMO-DE-EPS (KENDA project)
- AROME ensemble

IC - perturbations applied to an independent basic state

- NORLAMEPS: TEPS perturbations (differences from the control) applied to the HIRLAM control analysis
- COSMO DE EPS: test of COSMO-SREPS perturbations (difference from COSMO-EU) applied to COSMO-DE analysis

Issue: do the perturbations applied to an independent basic state keep their efficiency?

Surface perturbations

Recent development of **surface perturbations**:

- LAMEPS-HU: perturbed observations in CANARI
- ALADIN-LAEF: non-cycling surface breeding
- COSMO-SREPS: soil moisture perturbations with the Sutton and Hamill method (HNMS work)
- MOGREPS: as a future development

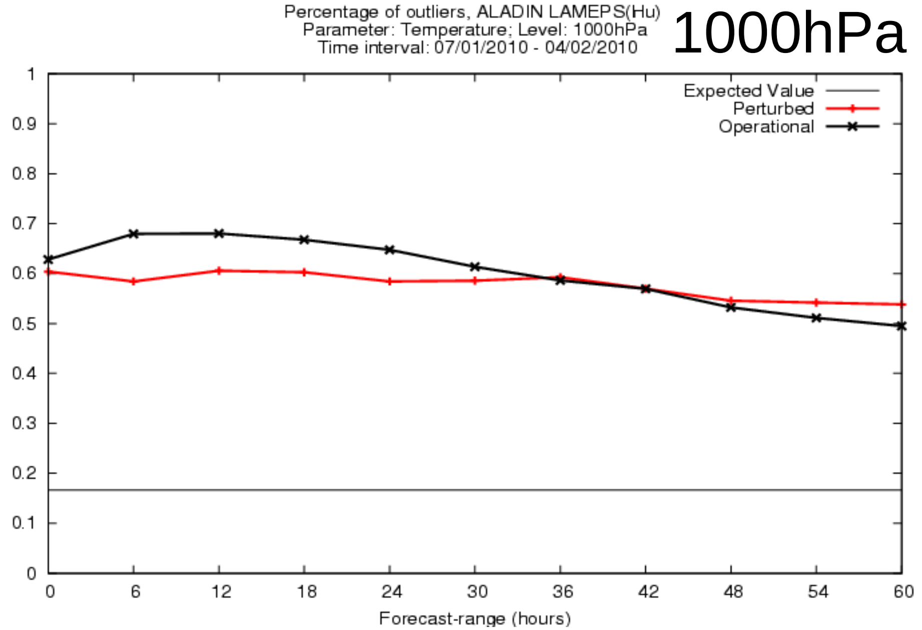
How to perturb the soil of the model?

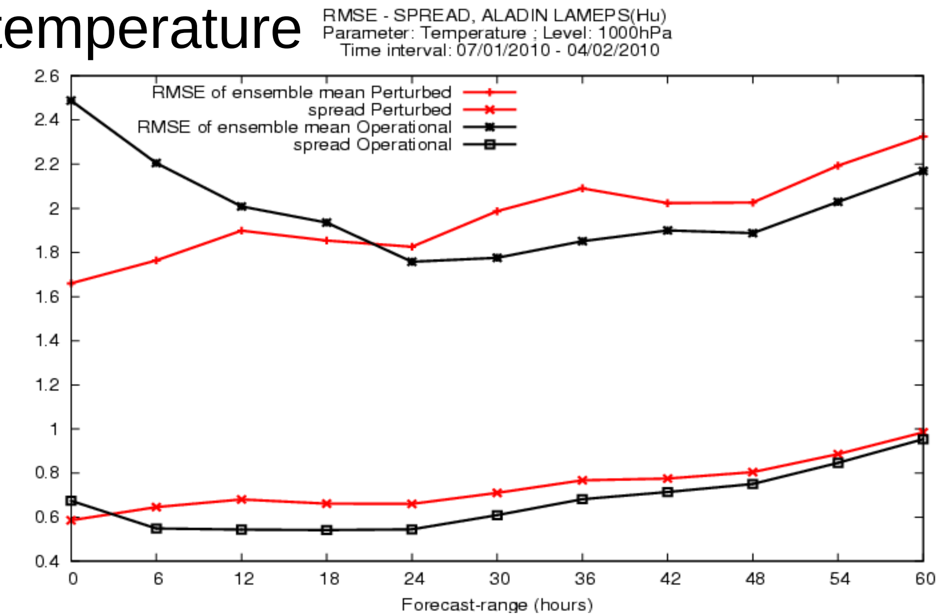
The soil moisture field is often computed as the field which produce the better near surface parameters forecast (Mahfouf 1991, Balsamo et al 2005, Hess at all 2008): can this field be perturbed independently? Can this perturbations be considered representative of the error in the surface fields?

LAMEPS-HU

- Perturbation of near-surface observations (2m temperature and humidity) in the ALADIN OI assimilation cycle.
- This implies a perturbation in the initial soil temperature and moisture

1000hPa temperature





- short test interval
- small improvements in early forecasts and bigger RMSE in extended ranges with local perturbation

ALADIN-LAEF

Non-Cycling Surface Breeding (NCSB):

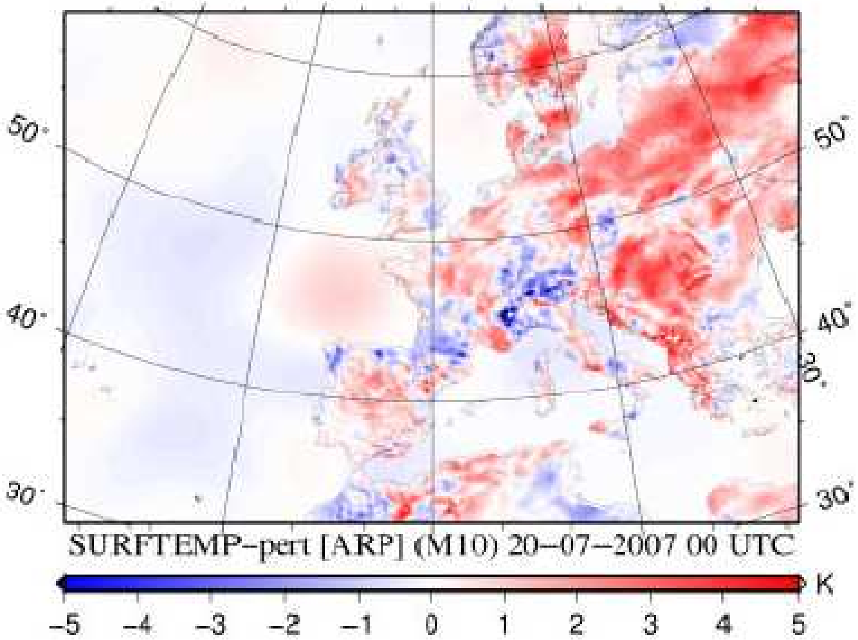
Pseudo-breeding->

• the regional model is integrated up to 6 or 12 hours with perturbed atmospheric ICs and LBCs (from EPS), but with the same surface initial state

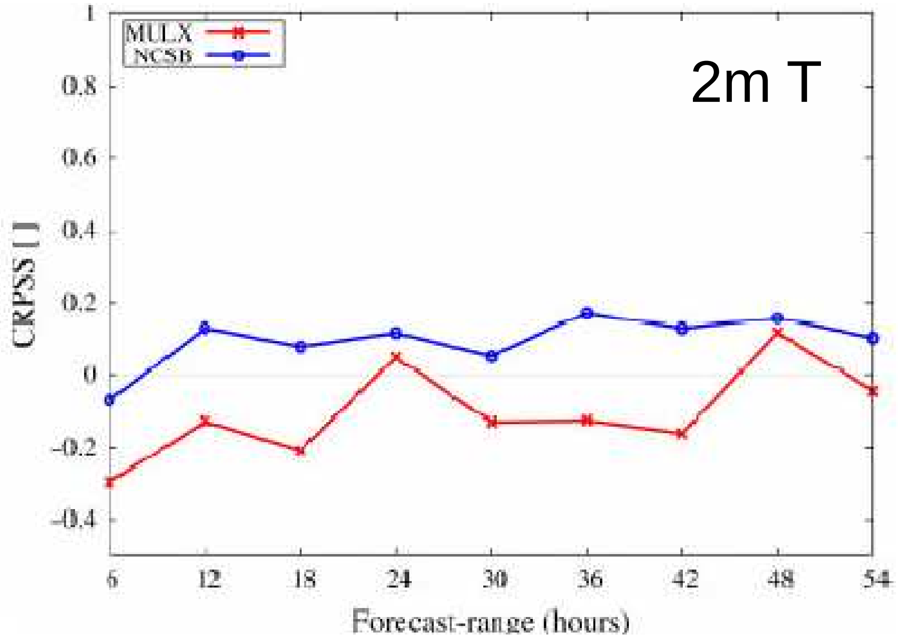
• the difference between the forecasts and the (ARPEGE) new surface analyses is rescaled, and then added to the new surface analysis

• this non-cycling feature (the run is restarted every time with a new perturbation of the atmosphere obtained from the global EPS) ensures that the initial surface perturbation in LAM-EPS is only driven by the atmospheric perturbations from the global EPS.

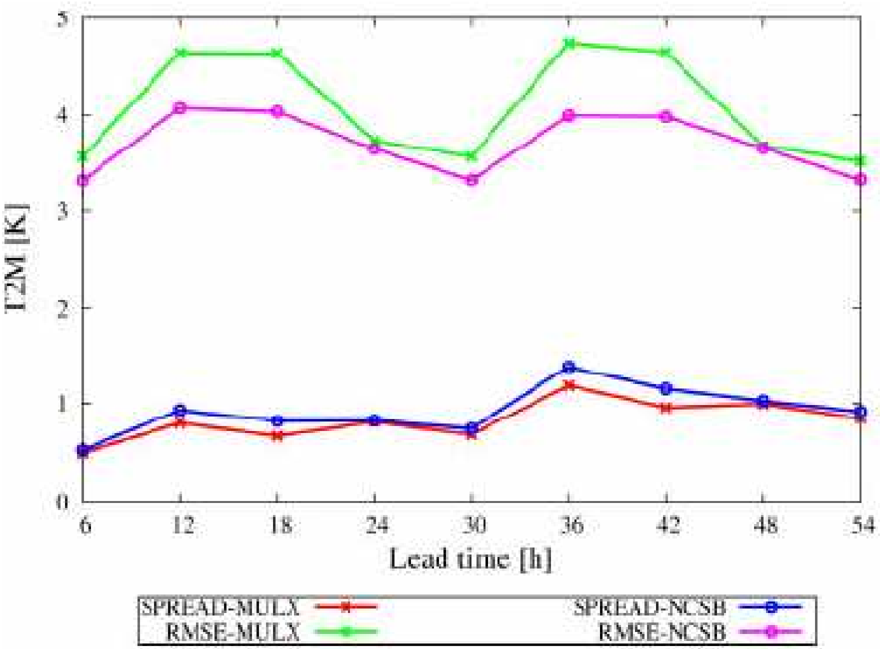
ALADIN LAEF



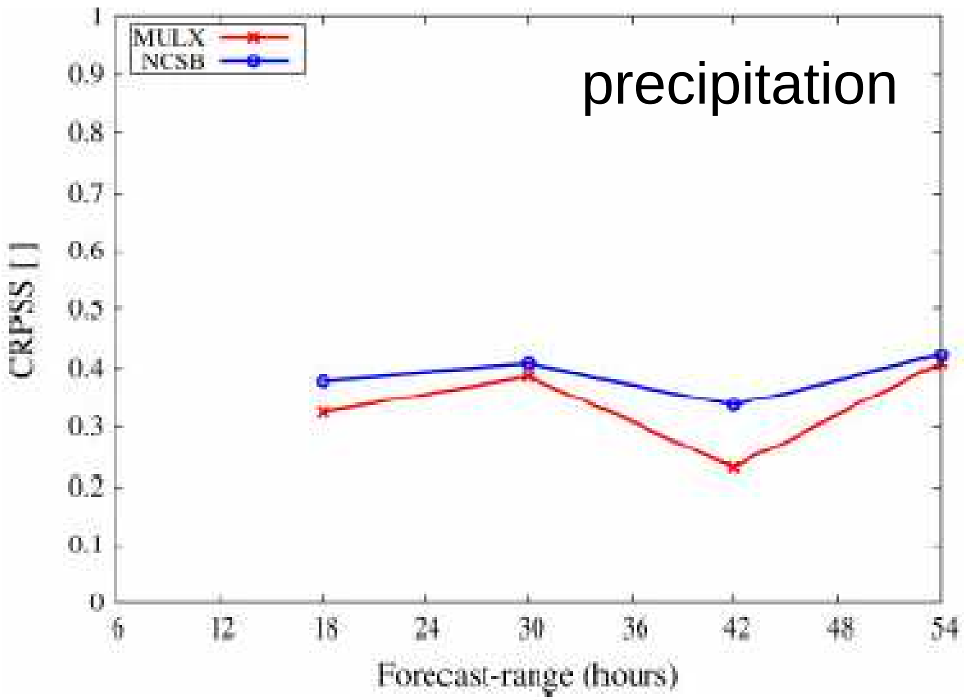
SURFTEMP–pert [ARP] (M10) 20–07–2007 00 UTC
K
–5 –4 –3 –2 –1 0 1 2 3 4 5
50° 40° 30°



2m T
MULX
NCSB
CRPSS [ ]
Forecast-range (hours)



T2M [K]
Lead time [h]
SPREAD-MULX
RMSE-MULX
SPREAD-NCSB
RMSE-NCSB



precipitation
MULX
NCSB
CRPSS [ ]
Forecast-range (hours)

Model perturbations

On-going developments in **perturbed tendencies**:

• MOGREPS: enhanced stochastic physics – perturbed tendencies similar to ECMWF SPPT

• COSMO: test EPS perturbed tendencies in COSMO EPS 7 km

• AROME ensemble

Multi Model

- AEMET SREPS: multi-model multi-boundary (MUMMUB)
- NORLAMEPS: TEPS < LAM-EPS < NORLAMEPS
- GLAMEPS: multi-model w.r.t. single model
- COSMO-SREPS: combination of IFS and GME driven members better than both IFS only and GME only, even if of different qualities

Usually proved to be beneficial.

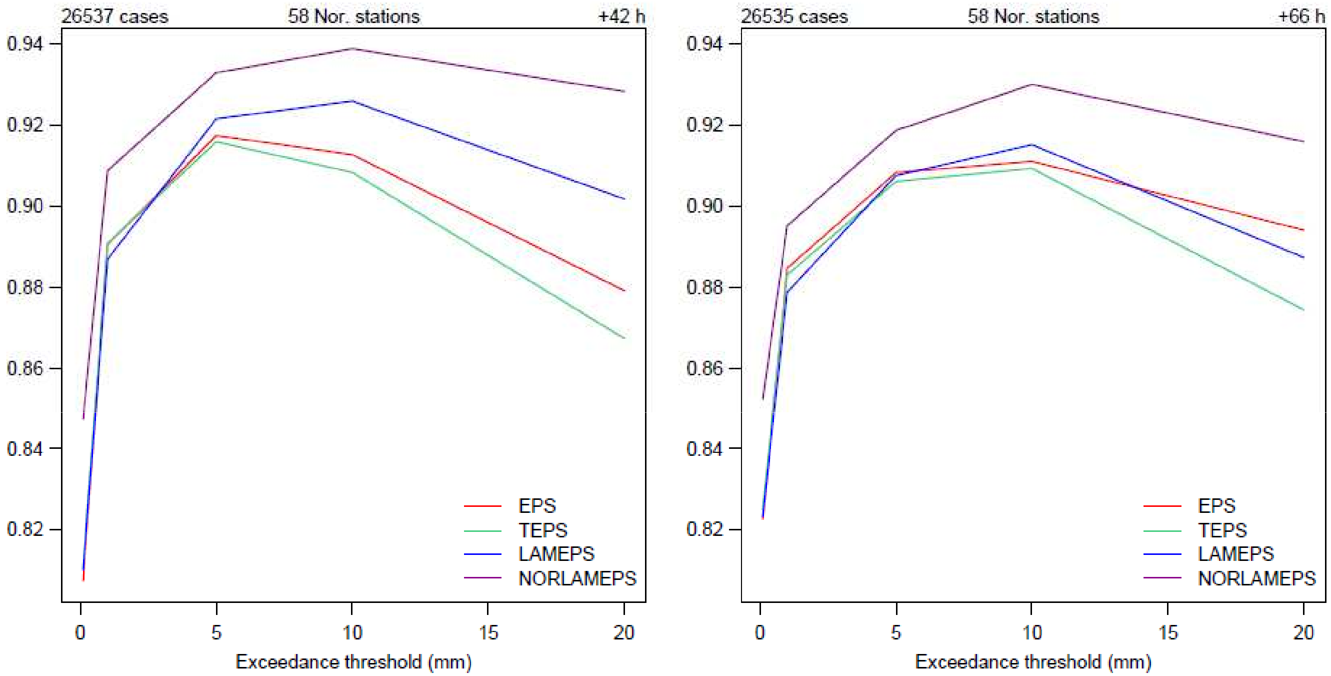
Different model biases are adding value by compensating each other deficiencies in spanning the pdf? (pragmatic approach)

GOBIERNO DE ESPAÑA MINISTERIO DE MEDIO AMBIENTE Y MEDIO RURAL Y MARINO AEMet Agencia Estatal de Meteorología

SREPS

- 25 members :
  - Global models: ECWMF, DWD, UKMO, NCEP & CMC (Canada, new!)
  - LAMs: Hirlam, MM5, HRM, COSMO & UM + WRF work in progress
- Daily runs at 00 and 12 UTC
- Forecast length: 72 hours
- Resolution: 25 Km y 40 vertical levels

ROC area daily precipitation +42h (left) and +66h (right) as a function of threshold

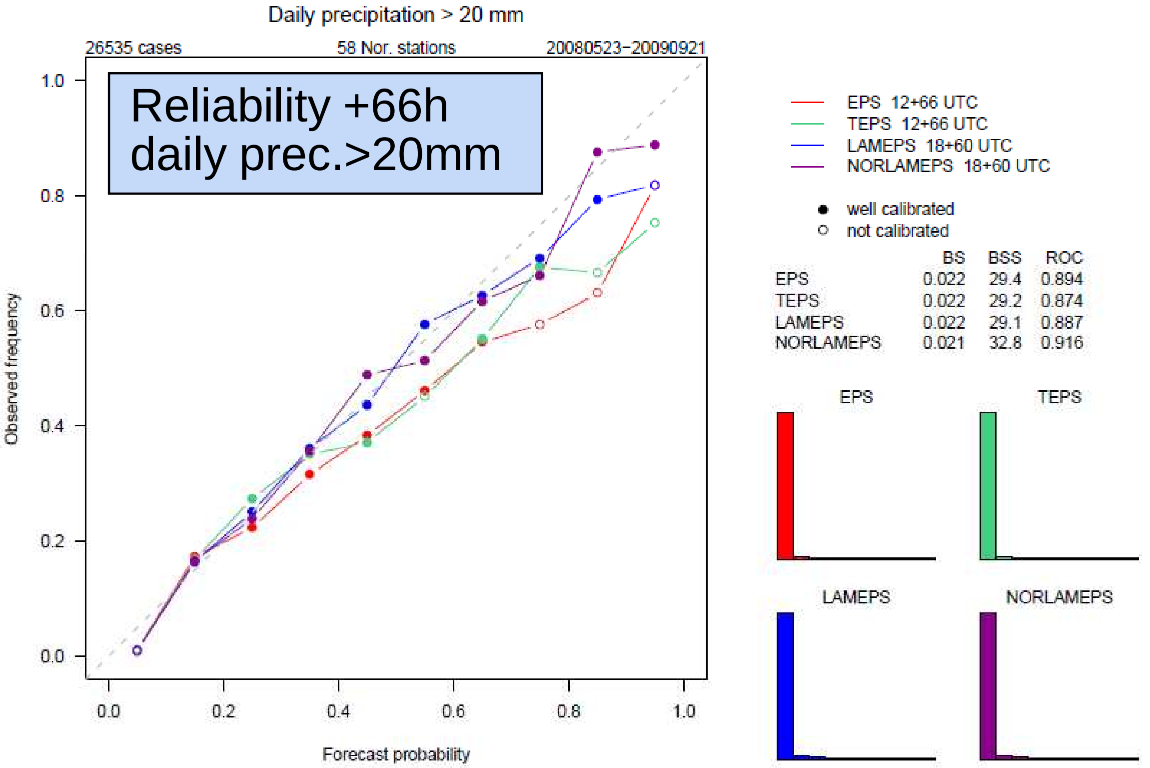


NORLAMEPS

Long time verification (20080523-20090920)

EPS 51 members
TEPS 21 members
LAMEPS 21 members
NORLAMEPS 42 members

Reliability +66h
daily prec.>20mm



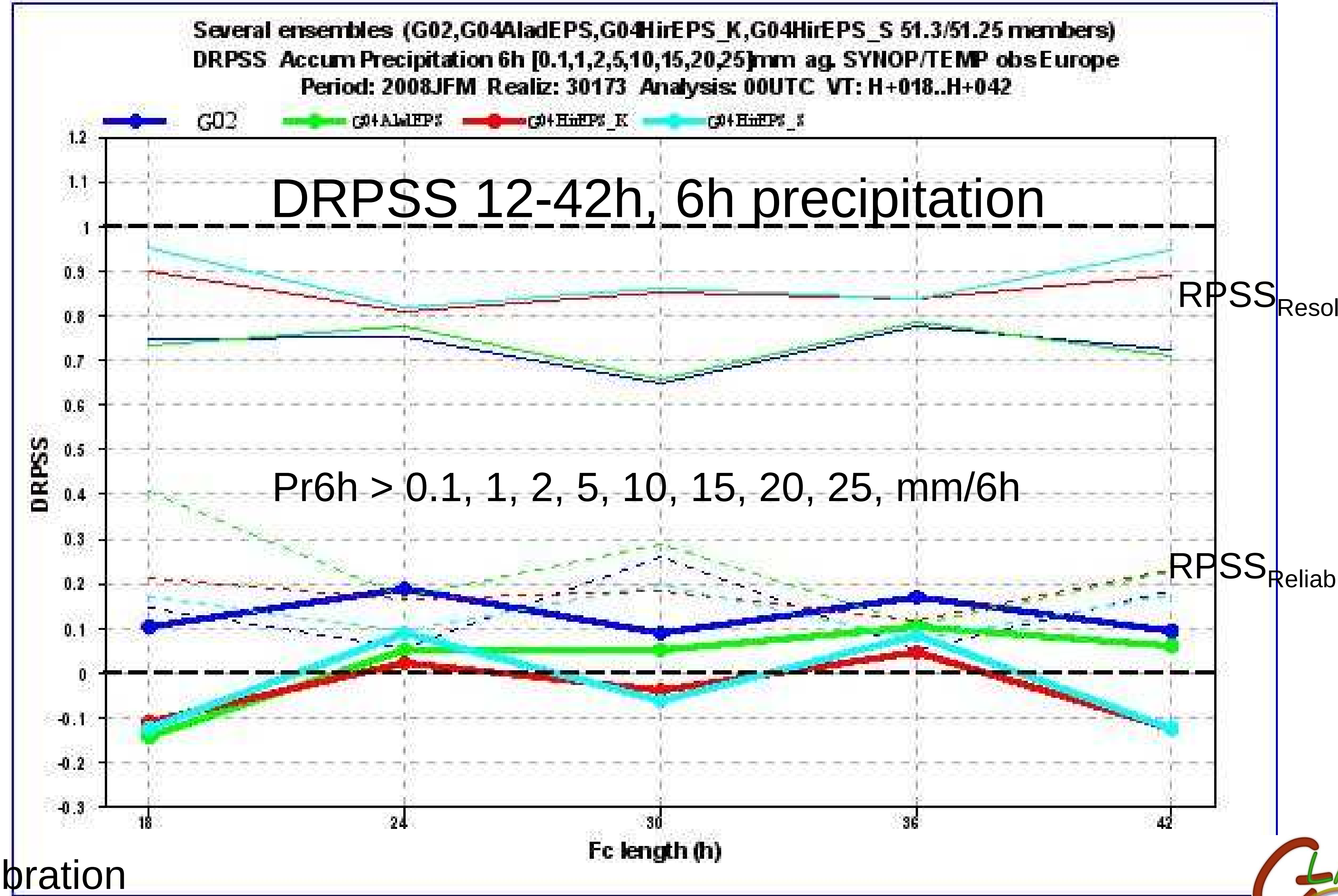
Conclusions:

NORLAMEPS is able to beat EC EPS for most thresholds, scores and parameters.

GLAMEPS will probably replace NORLAMEPS later

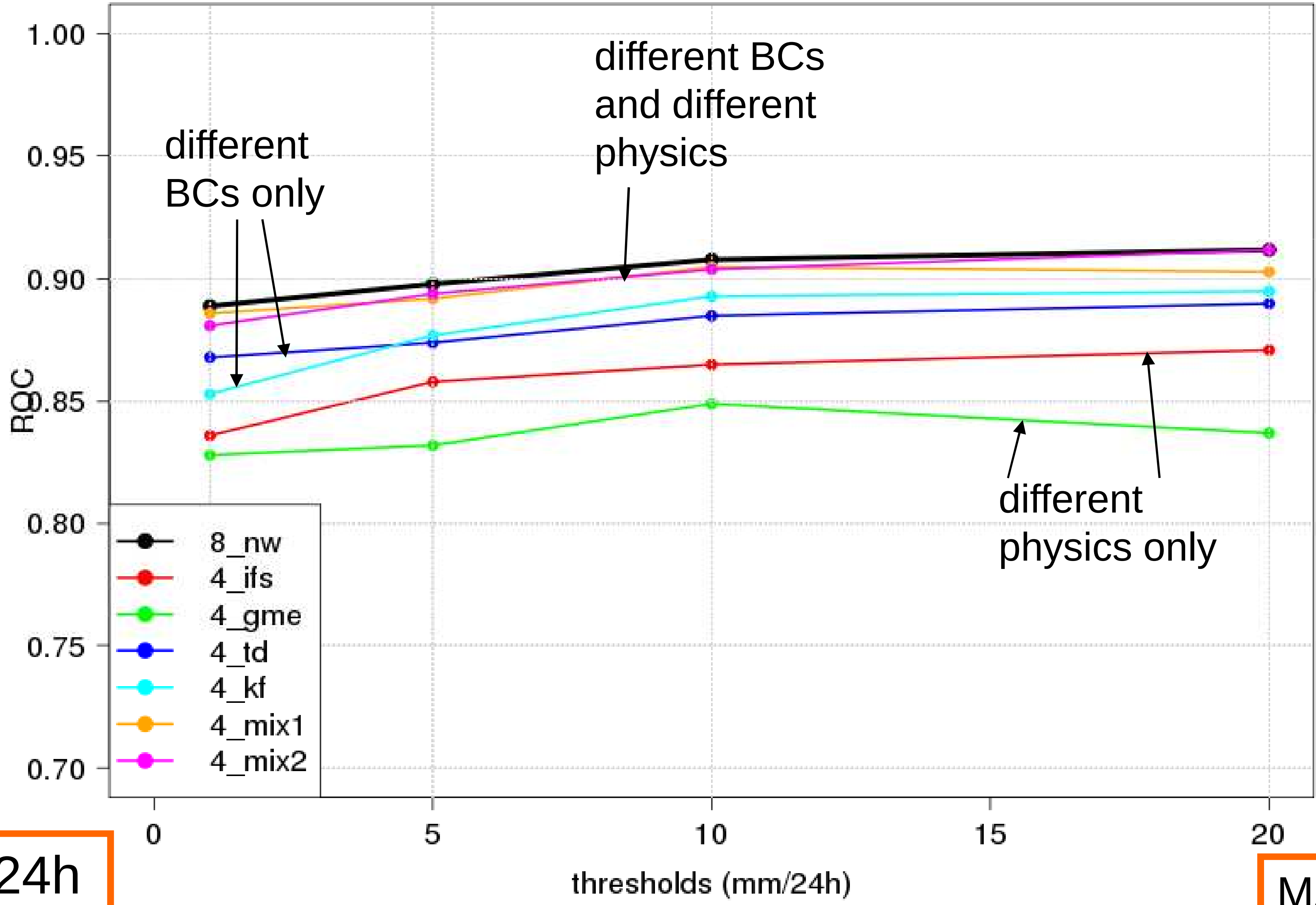
GLAMEPS - Multi-model vs.single model EPS

GLAMEPS_52 AladEPS_51
HirEPS_K_51 HirEPS_S_51



no calibration

COSMO-SREPS



+ 0-24h

MAM10

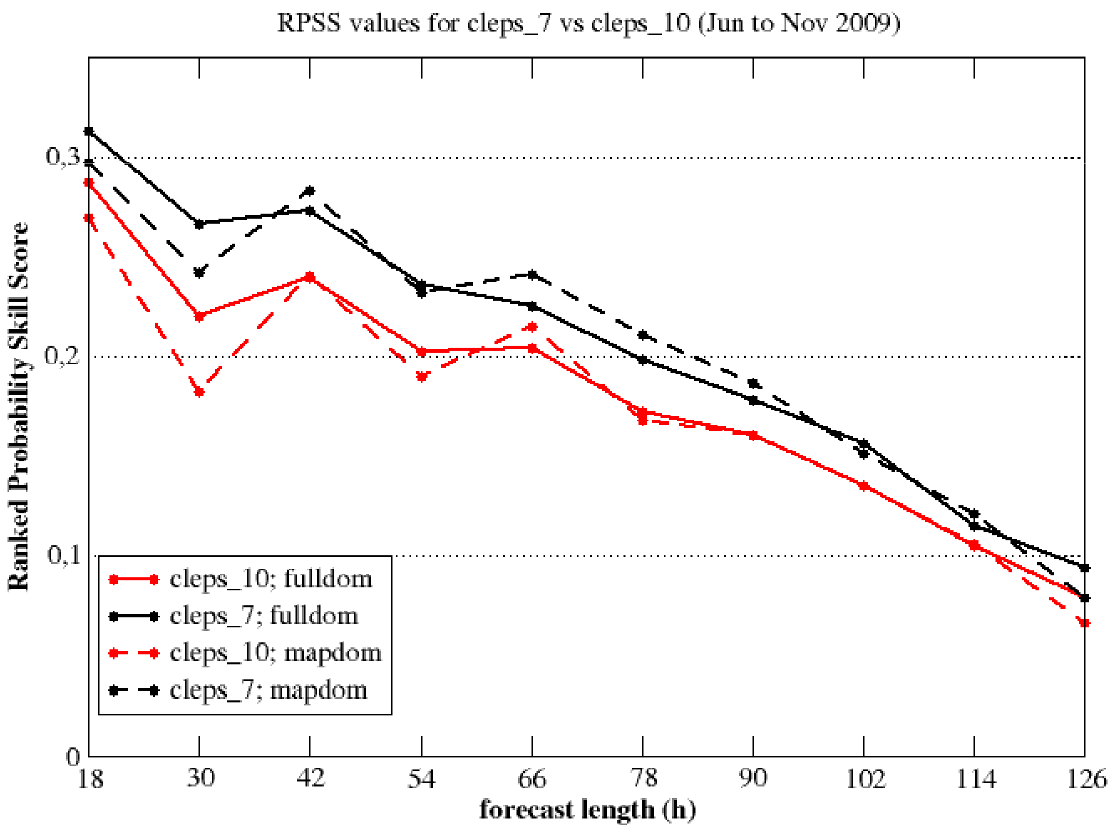
24h prec. - Northern Italy network – average over 0.5 x 0.5 deg boxes

Increase of resolution

- ECMWF EPS: from about 50 to about 30 km
- MOGREPS: from 24 km 38 levels to 18 km 70 levels (planned: up to 12 km by 2012, 100 levels)
- COSMO-LEPS & COSMO-SREPS: from 10 to 7 km
- PEARP: from 23 km to 15 km over France, planned

COSMO-LEPS

12 h total precipitation - Jun-Nov 2009



- Observations: SYNOP reports over either MAP D-PHASE region (450 reports/day) or the FULL-DOMAIN (1400 reports/day)
- Method: nearest grid point; no-weighted forecasts

COSMO-LEPS_7 implemented operationally on 1 December 2009

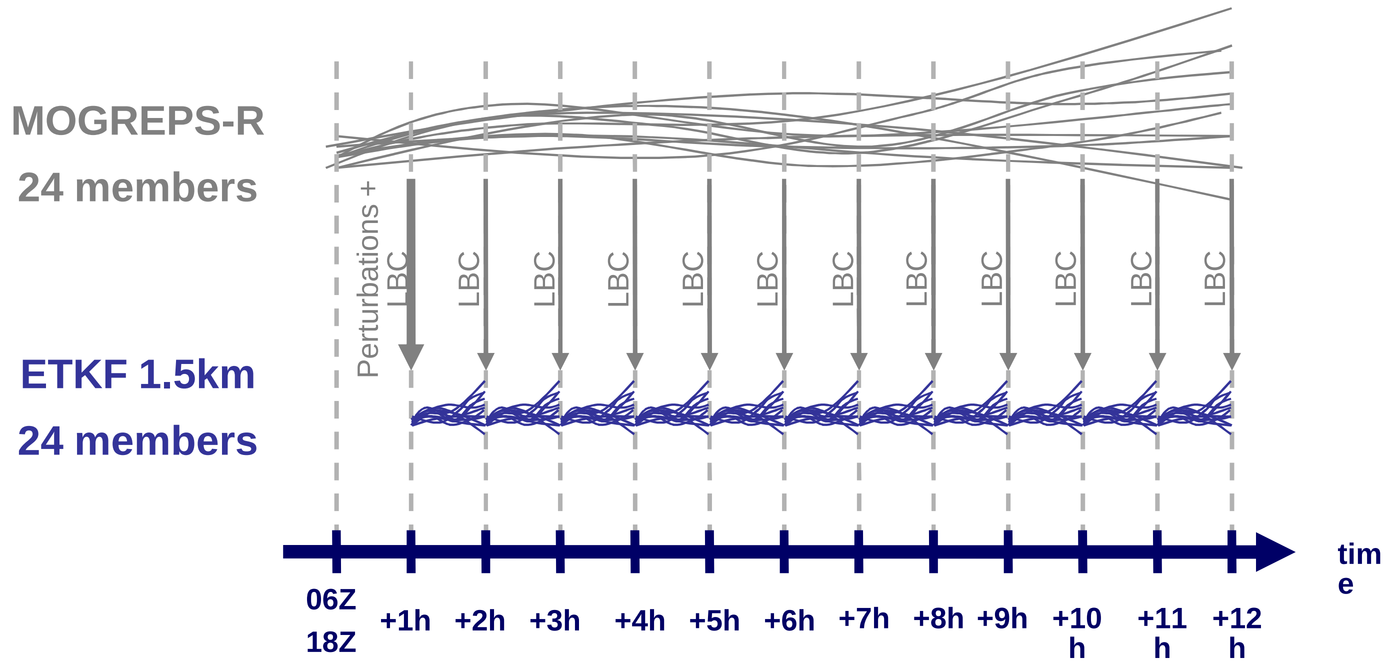
Convection-permitting EPS

- AROME: MDA with pert. obs.
- COSMO-DE-EPS: KENDA
- UK: ETKF 1.5km

Strong emphasis on the **development of combined DA and ensemble forecasting systems for the local scale**, more than in the previous generation of mesoscale ensembles

What about the predictability?

ETKF 1.5km



- Control analysis from 3DVAR SUK 1.5km 1-h cycle with cloud and latent heat nudging and UK4 LBC
- ETKF uses +1h forecast perturbations in observation space for:
  - Surface obs, Aircrafts
  - Radio-sondes
  - GPS, radiances
  - + Radar derived surface rain rate

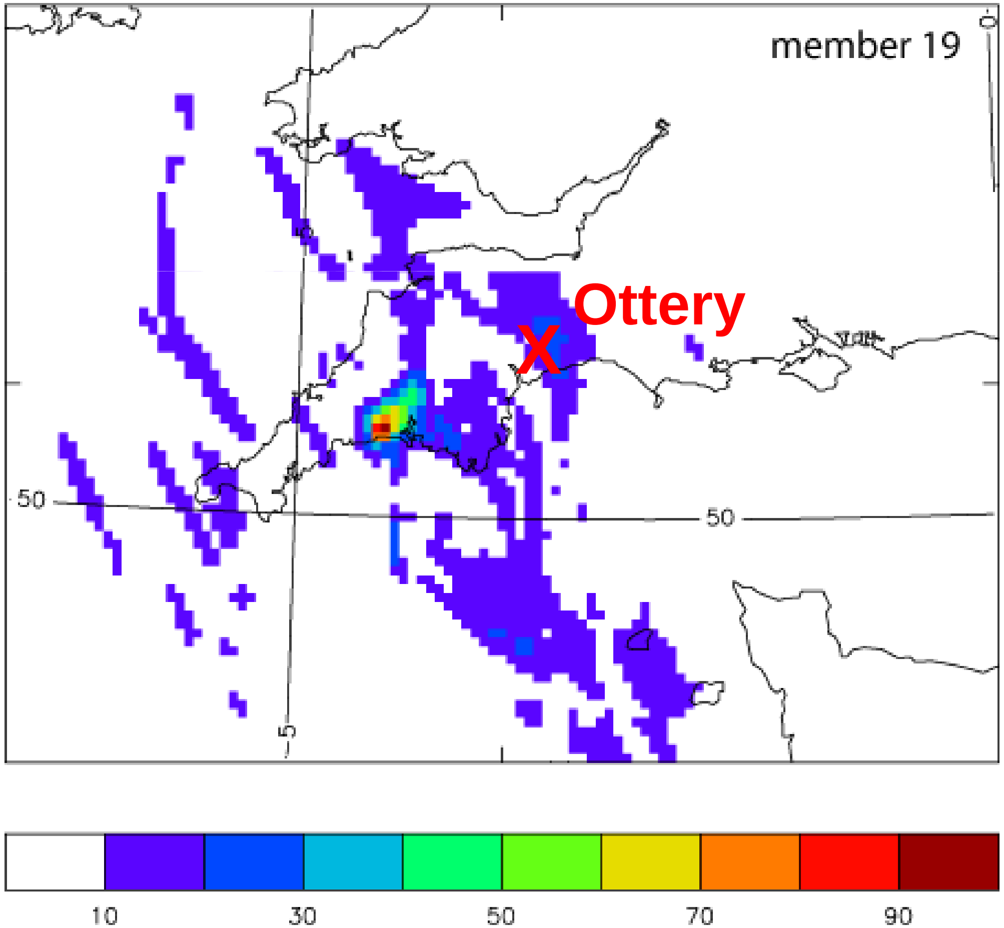
Jean-François Caron†, Sue Ballard†, Ross Bannister* and Stefano Migliorini*

†Advanced nowcasting group, DAE, Met Office @ Reading University

*NCEO @ Reading University

UK 1.5km

Precipitation accumulations over 6 hours taken from three of the 1.5 km members



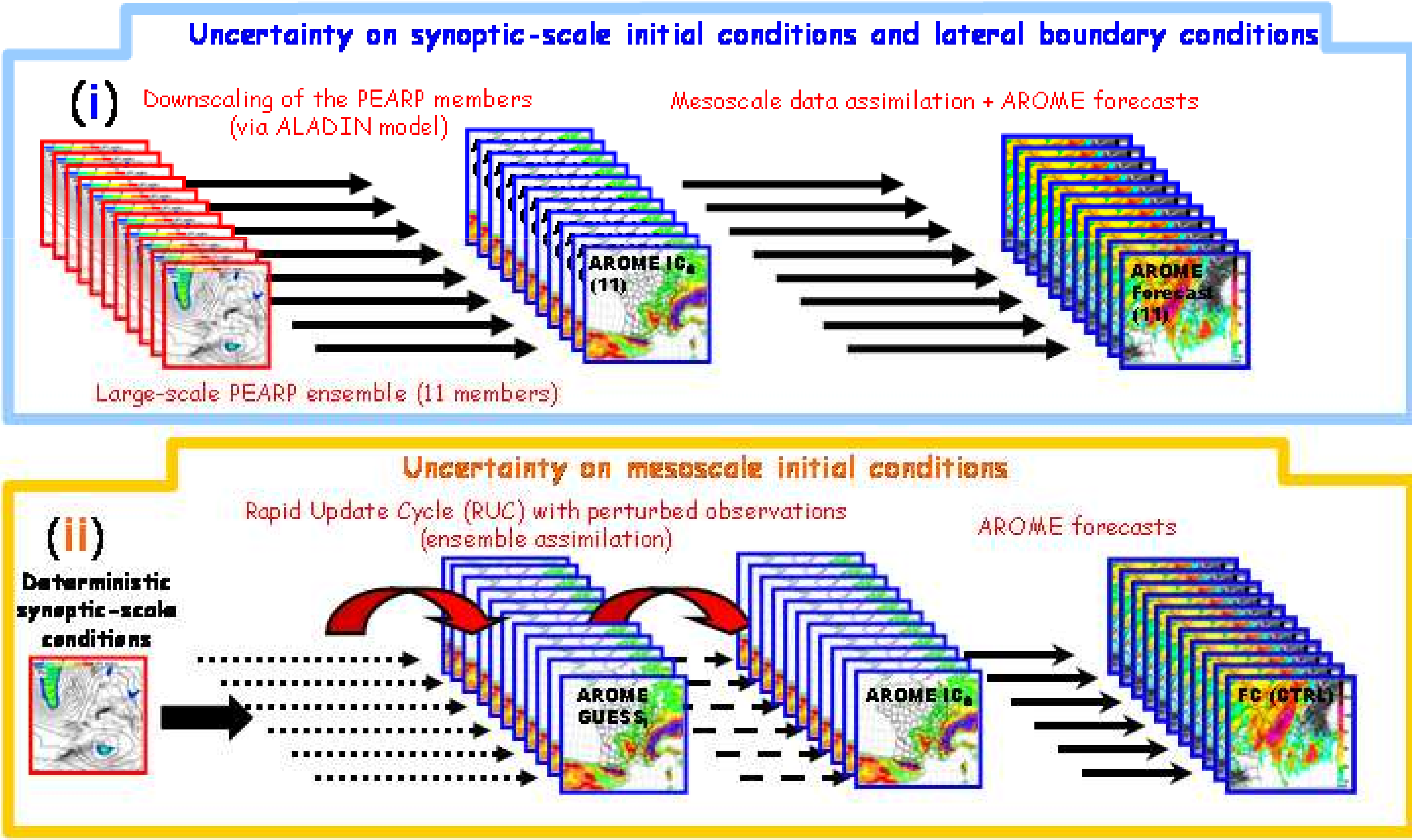
Rainfall amounts exceed critical thresholds for surface water flooding in more than half of the members

Variability in location and amount from member to member

Ensemble reduction by clustering + member selection (similar to COSMO-LEPS)

No positive impact of using cluster population to weight ensemble members: same as for COSMO-LEPS (10 km res.)

Convective scale predictability with AROME

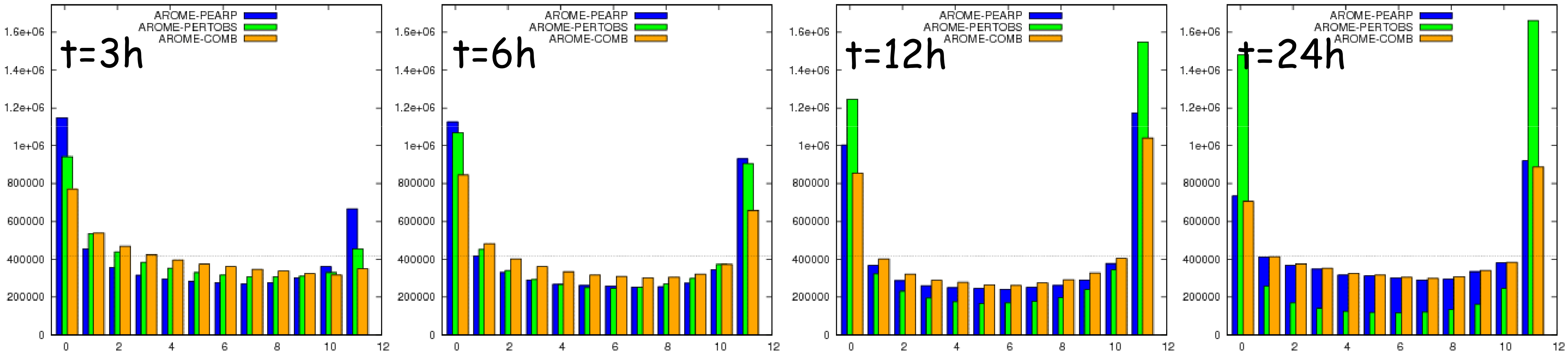


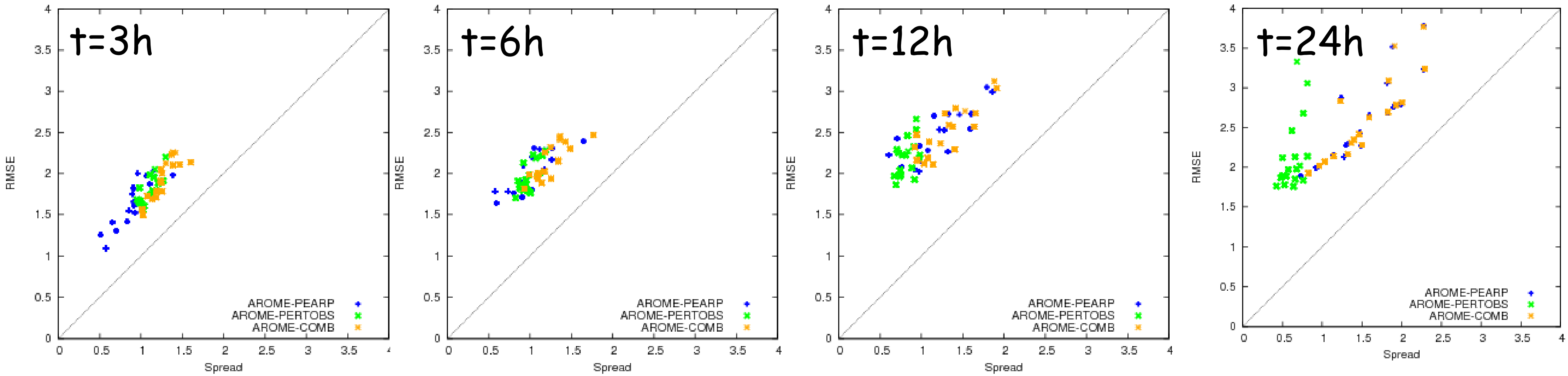
A future plan: select a few relevant global EPS members

METEO FRANCE
Toujours un temps d'avance

Probabilistic evaluation

- Evaluation period: 05/10/2008 → 05/11/2008
- Rank histograms are shown for 925 hPa wind





RMSE vs. Ensemble spread

Results of this study are summarised in Vié *et al.*, 2010 (submitted to Mon. Wea. Rev.)

METEO FRANCE
Toujours un temps d'avance

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

COSMO-DE-EPS

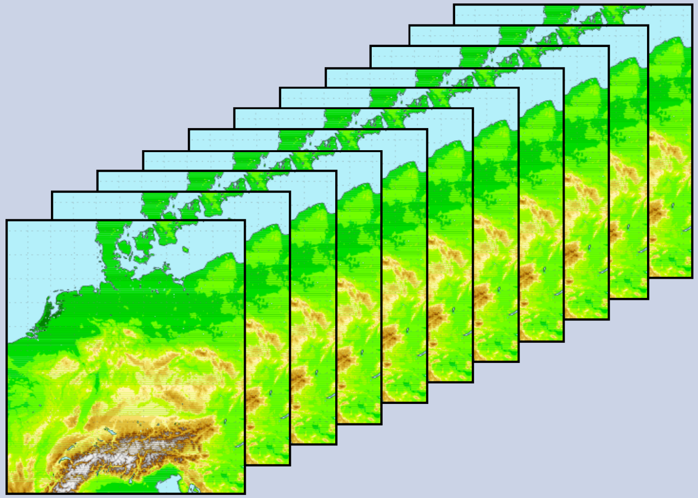
- ➔ based on model COSMO-DE, **convection-permitting**

- ➔ grid size: 2.8 km
- ➔ 20 members
- ➔ lead time: 0-21 hours,

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

- ➔ **start of preoperational phase:**

  within 2010



model domain

COSMO-DE-EPS

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

- **variation of initial conditions and lateral boundary conditions:**

  by different driving models (multi-model)

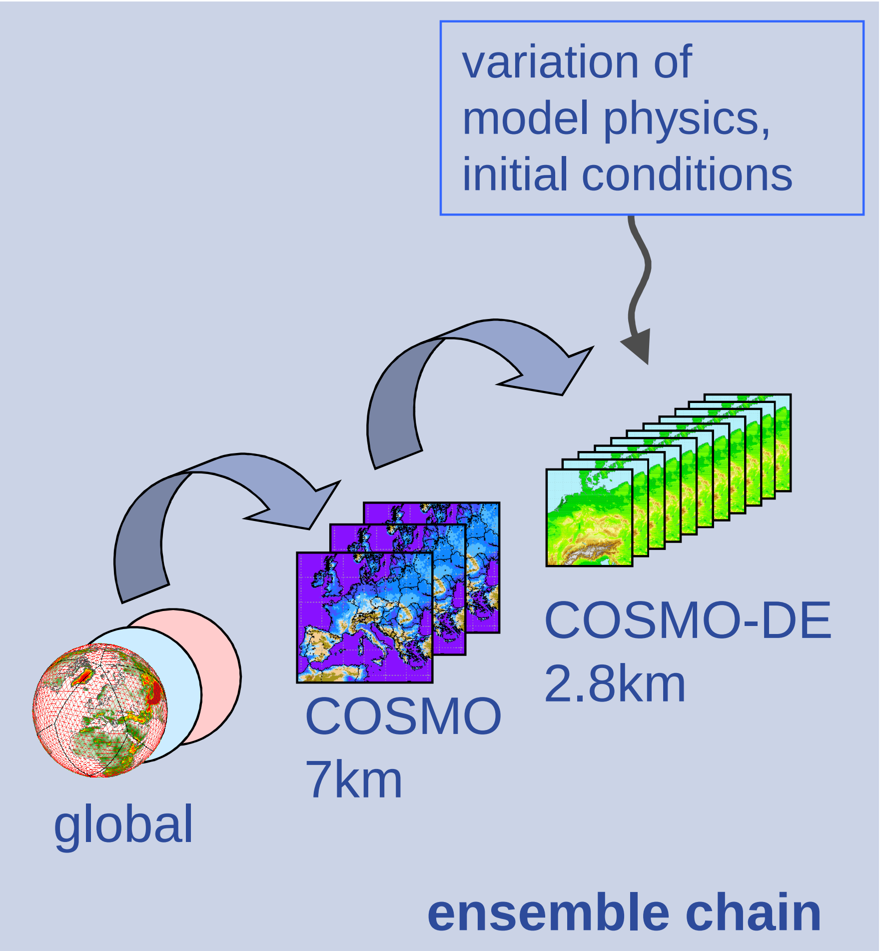
- **variation of model physics:**

  by different configurations of COSMO-DE

  (fixed, non-stochastic)

- **further plans** (2012 and later)**:**

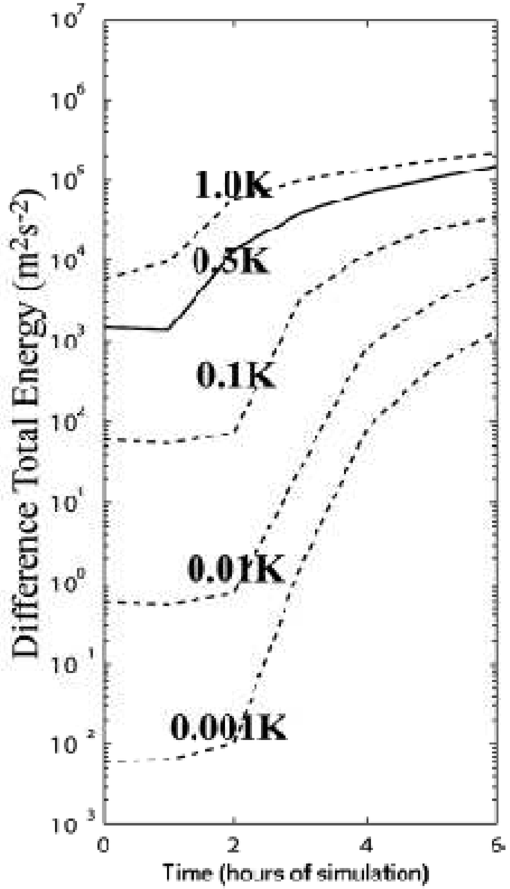
  - upgrade to 40 members
  - start of operational phase (2012)
  - switch to ICON model as driving EPS
  - switch to EnKF for initial condition perturbations



from the talk by O. Nuissier at the ECMWF Seminars:

Convective-scale predictability: scientific issues

- Major results from Hohenegger *et al.*, Zhang, Rotunno, Snyder *et al.*,...
  - small errors grow faster (**non-linear** behaviour).
  - errors amplify faster in high-resolution **convection-resolving simulations.**
  - **moist convection** is the primary mechanism for forecast error growth at small scale.
  - **Mesoscale data assimilation** can lead to improved and more realistic forecasts → however we need to assess the convective-scale predictability
  - **ensemble technique** is well established at synoptic-scale, but suitable for convection-resolving scales?
- Research works and dedicated methods are needed to assess the convective-scale predictability !!
  - Quantify uncertainty sources at convective-scale
  - Initial perturbation generation ?
  - Study the propagation of uncertainties in the hydrometeorological forecasts.



Zhang et al, JAS 2003

from Zhang et al., 2003

“At first glance, the increase of difference growth rates with resolution might seem inconsistent with the result […] that increasing the model resolution provided a better simulation of this case.

Further consideration, however, reveals that there is no contradiction: **at lower resolution, simulations do not diverge as rapidly but that divergence is a poor approximation** to the divergence of the model solution from the atmospheric state.

At higher resolution, the forecast model is more accurate, and this is reflected **both in improvement of the forecast from a given initial condition and in divergence of solutions** that is more rapid and thus more closely approximates the growth of forecast error.”

Issues which require coordination

- EurEPS: EurEPS concept will be possibly part of the EUMETET forecasting strategy (A. Horanyi pres.)
- ECMWF BC for LAMEPS: different priorities from the different Consortia. The discussion will continue, within SRNWP and with ECMWF. It has been proposed to have a dedicated meeting at ECMWF.
- Possibilities for verification/intercomparison/studies:
  - archive: TIGGE-LAM HP parameters still pending due to lack of devoted resources. Hopefully included in a new FP7 proposal
  - high-res analysis of surface fields for verification: many initiatives on-going with some lack of coordination (EUMETGRID, EURO4M, ECMWF precipitation analysis)