Ensemble activity in Europe: present status and plans

(review talk on Ensemble and Predictability)

Chiara Marsigli for the ET-EPS, with contributions from many people!

Aim of this talk

- make the point of the present status of the LAM ensemble in Europe
  - last SRNWP-EPS WS: “There are more questions than answers” … BUT … there are some answers!
- recognise the recent answers which have been given to some of the questions we asked ourselves some years ago
- underline the still open questions
- optimising the share of the work between the LAM Consortia
  - remind that the investigations carried out at an institution can provide useful hints to all the community, permitting to save time and resources for other investigations!

EPS and Predictability

- This review deals with EPS systems only, not directly with predictability studies
- Nevertheless, predictability is embedded!
  - how to develop an ensemble system depends on the spatio-temporal scales of interest
  - the predictability of the phenomena relevant for those scales is taken into account in the system design

Topics

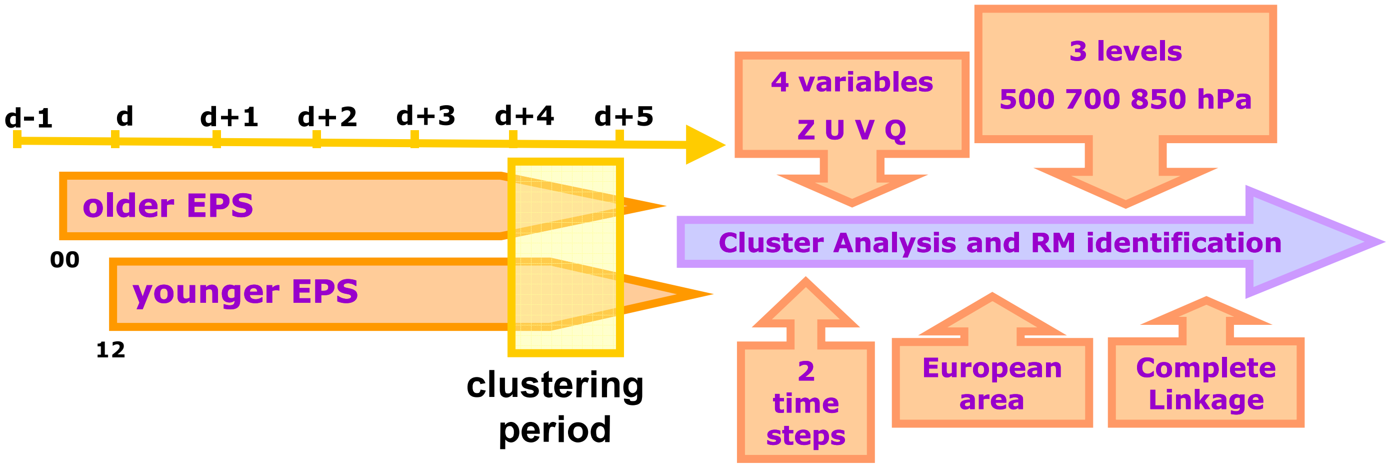
- Downscaling
  - added value
- Perturbations of the initial conditions:
  - ETKF
  - SVs
  - Breeding
  - Compatibility between IC and BC perturbations
- Perturbations in the model:
  - Schemes/parameters
  - SKEB
  - Soil
- Spatial resolution
- Ensemble size
- Multi-model
- Collaborations
- Convection-permitting ensembles
- Calibration
- Quality of the ensemble forecasting

Downscaling from global

Global EPS has an important impact on the LAM performance
(W. Tennant, SRNWP-EPS WS 2009, Exeter)

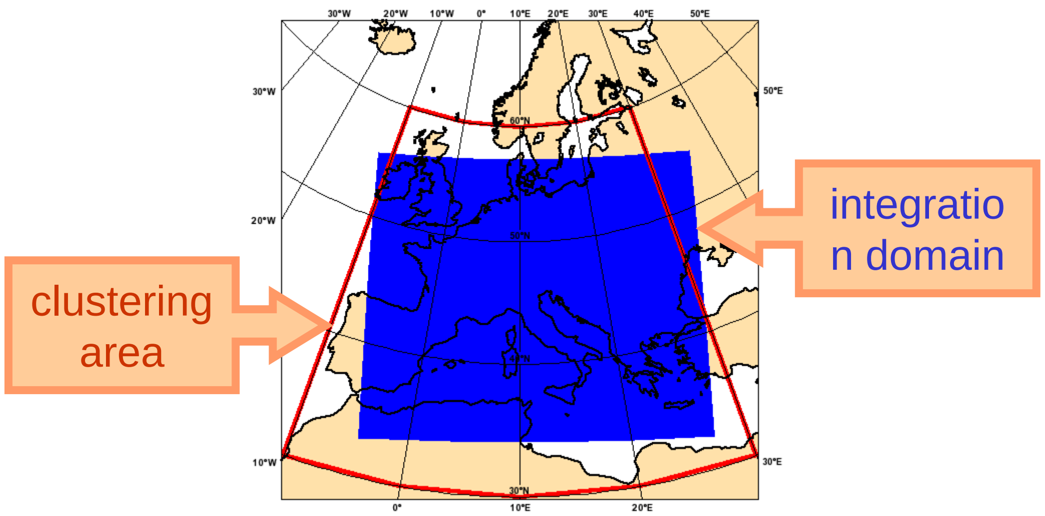
- Downscaling + LAM perturbations
  - COSMO-LEPS (new: multi-ensemble downscaling)
- Downscaling only
  - ALADIN HMS
- Downscaling + (planned) mesoscale IC perturbations
  - ALADIN-LAEF
- Downscaling + hybrid
  - NORLAMEPS

COSMO-LEPS



16 Representative Members driving the 16 COSMO model integrations

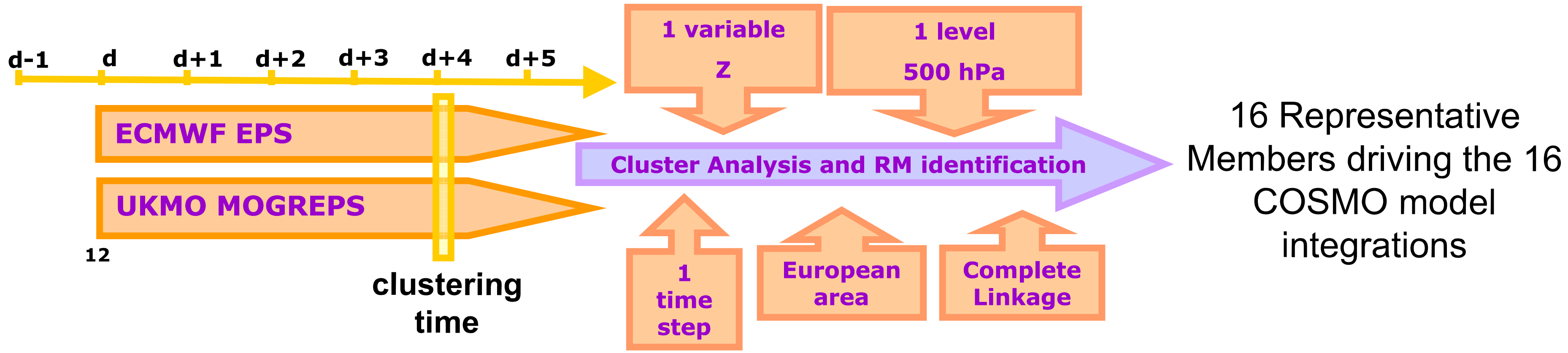
physics perturbations: Tiedtke or Kain-Fritsch convection scheme + 2 turbulence parameters



10 km 40 levels +132h

- “time-critical application” at ECMWF, managed by ARPA-SIMC
- computer time provided by the COSMO partners which are ECMWF member states

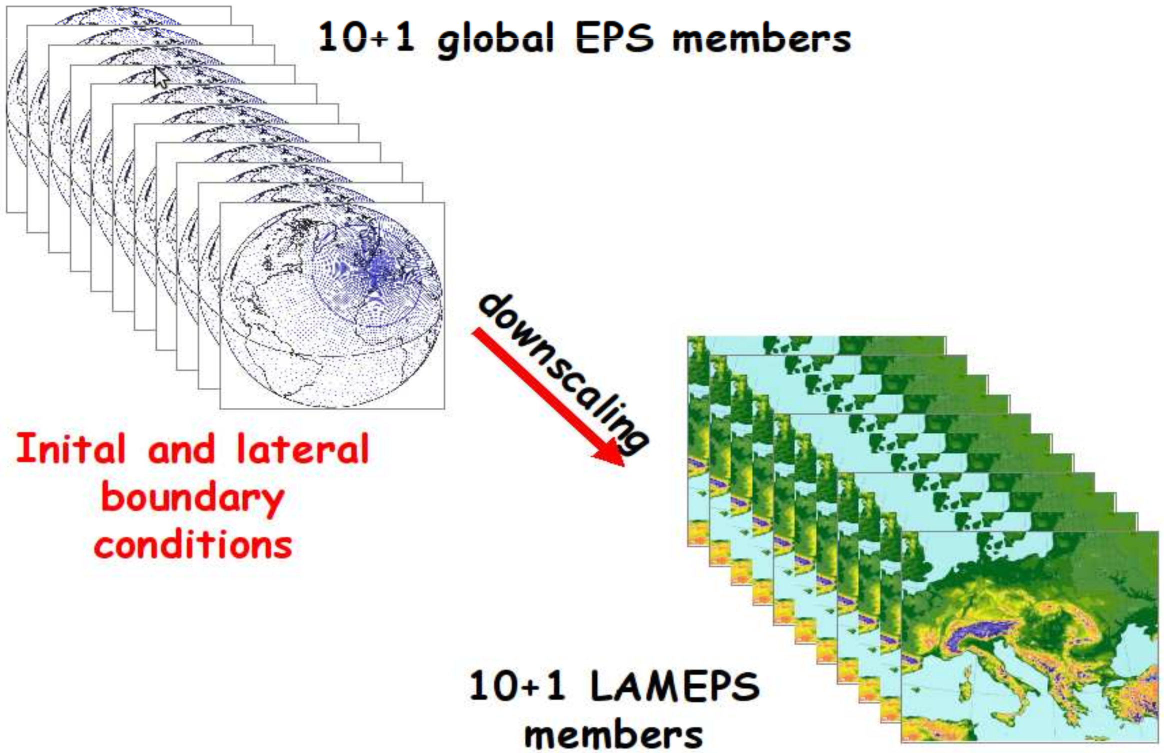
Multi-model clustering: first approach



- data from TIGGE-PORTAL (GRIB2)
- first tests using Z500 at fc+96h as clustering variable
- for verifying analysis:
  - "consensus analysis" (average of UKMO and ECMWF high-res analyses)
  - independent analysis (e.g. from NCEP)

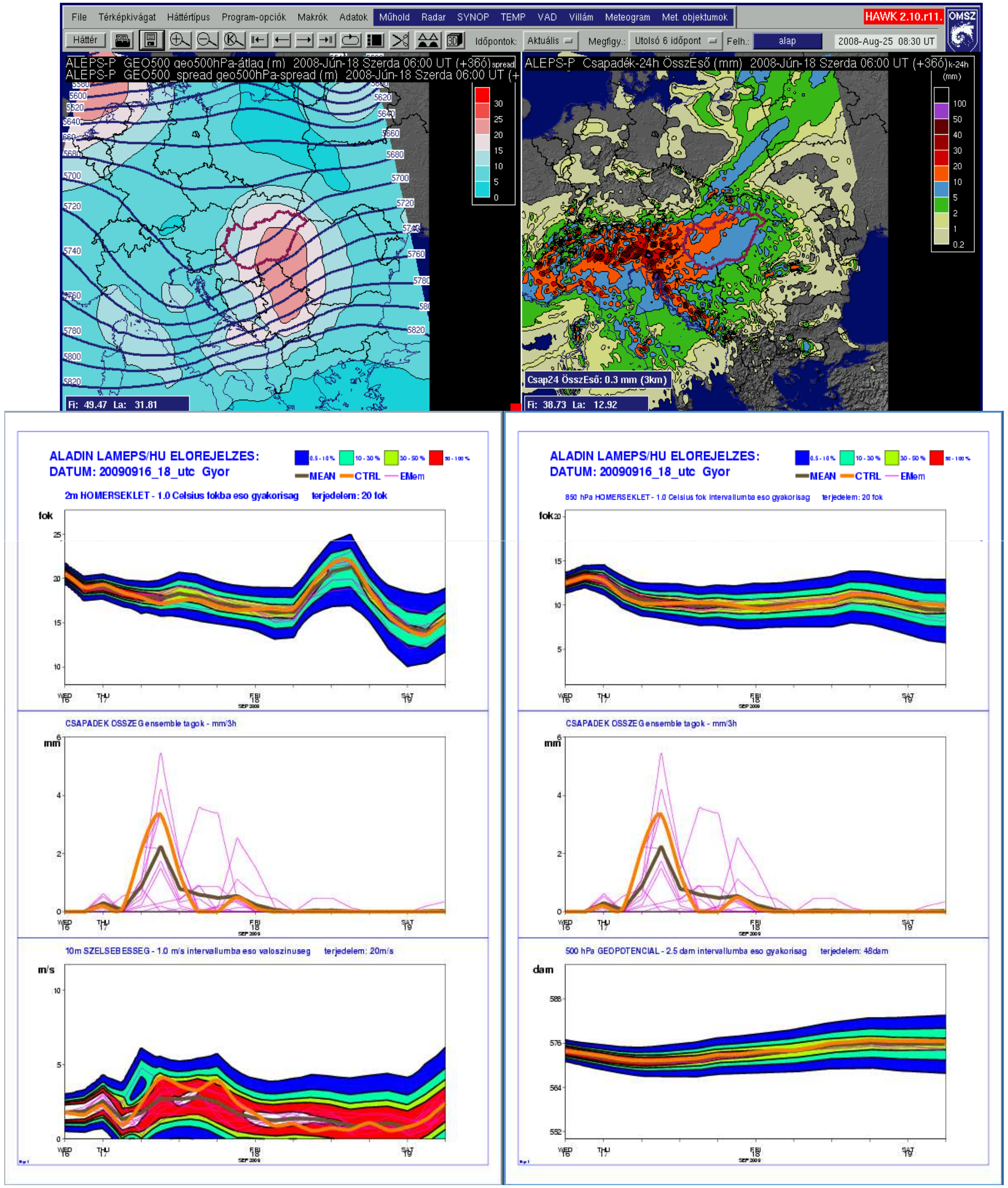
The ARPEGE/ALADIN LAMEPS system of the Hungarian Met Service

- Operational since December 2008
- Initial and boundary conditions are provided by the PEARP system of Météo-France
- 11 ALADIN members up to 60 h every day at 18UTC
- 12 km horizontal resolution, 46 vertical levels

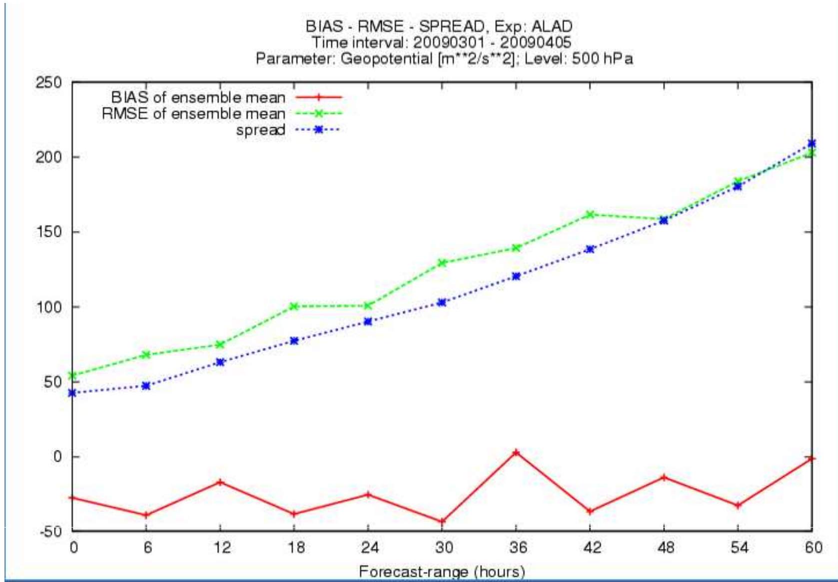


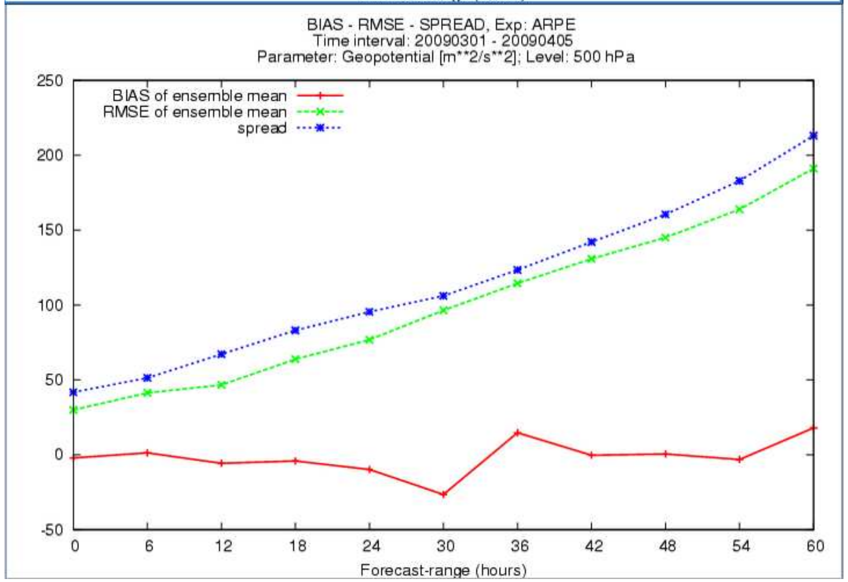
Visualisation and post-processing

- Post-processed products NetCDF and Grib files
- Prognostical parameters in 7 pressure level, surface parameters (MSLP, 2mTEMP, 10m WIND, GUST, PREC)
- Probability products (mean, spread, probability maps), Individual members (spaghetti maps)



Verification: Compare ARPEGE/PEARP and ALADIN/LAMEPS





- Upper level parameters against ECMWF analyses. The scores are similar (PEARP a little bit closer the ECMWF analysis).
- Surface level parameters against observations (not shown). LAMEPS skill better.

Further plans

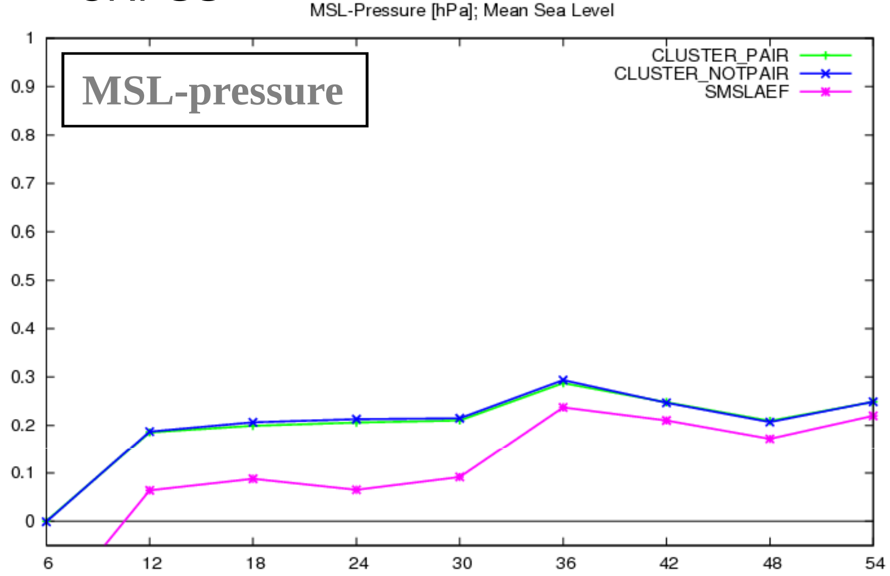
- Computation of ALADIN SVs and their combination into the initial conditions of the ALADIN EPS
- Tests with the downscaling of ECMWF/EPS
- New coupling files: GLAMEPS domain

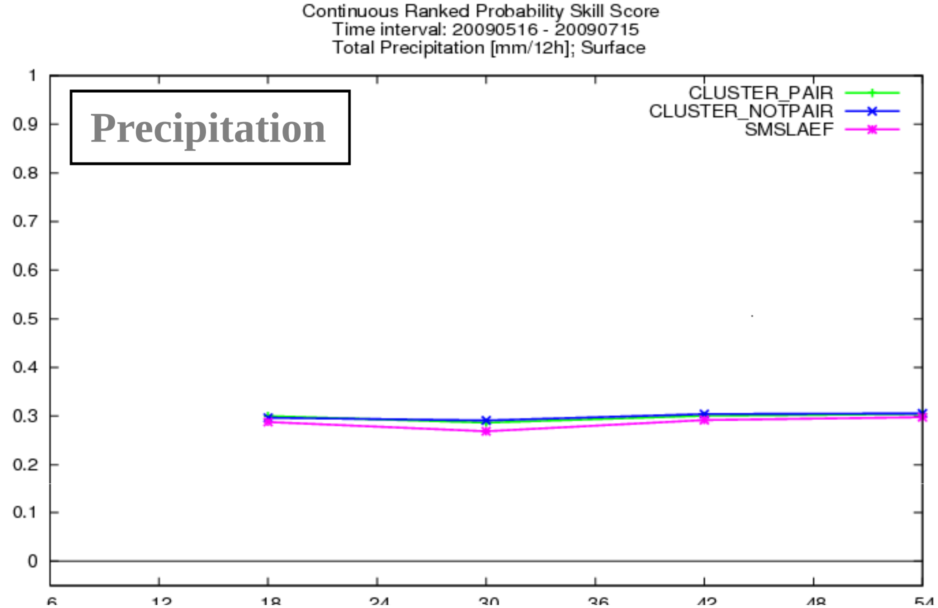
The ALADIN-LAEF system

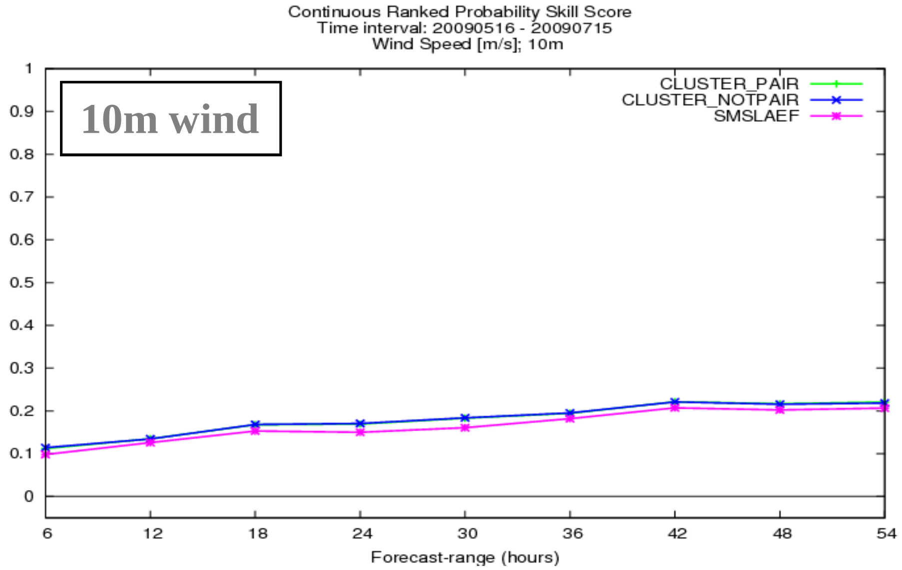
- 16 members, 18 km hor. res.
- available on MARS at ECMWF
- Ope: first 16 members of the 50 ECMWF-EPS member are chosen as coupling fields
- Exp: running ALADIN-LAEF with Representative Members as initial and boundary conditions:
  - definition of 8 clusters and their representative members, where the associated pair member from Singular Vector method is also considered
  - definition of 16 clusters and selection of the representative member as coupling field for ALADIN-LAEF

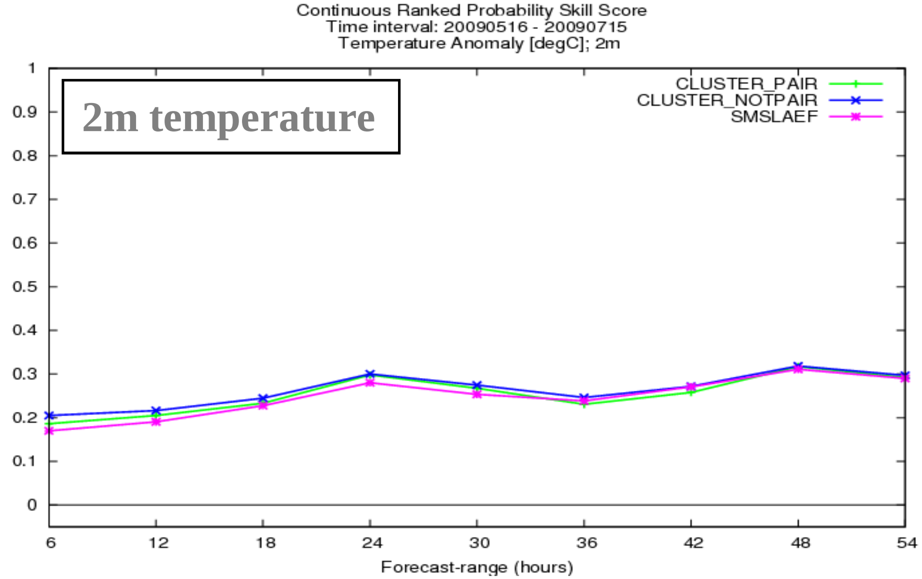
Clustering:
15.05 –15.07.09 and 4 case studies

CRPSS

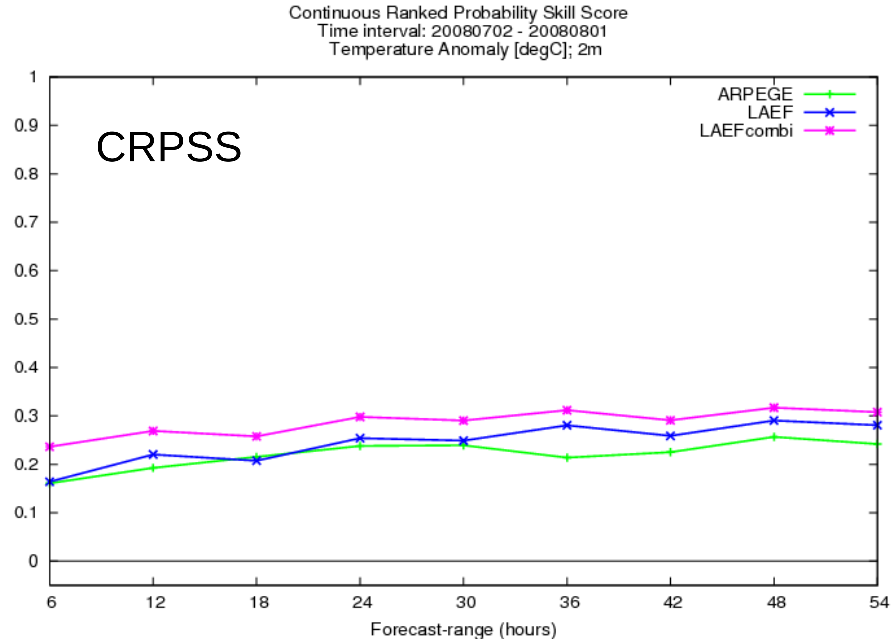


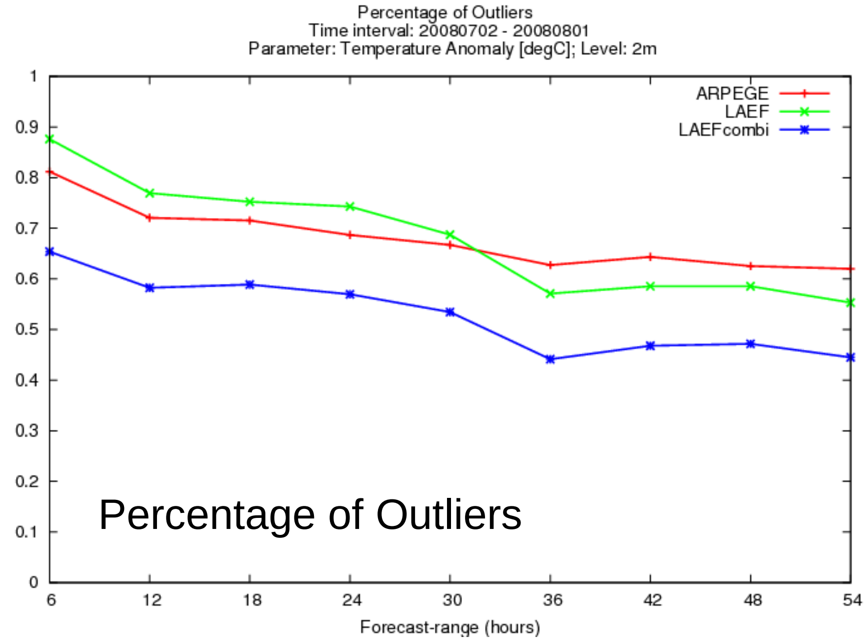


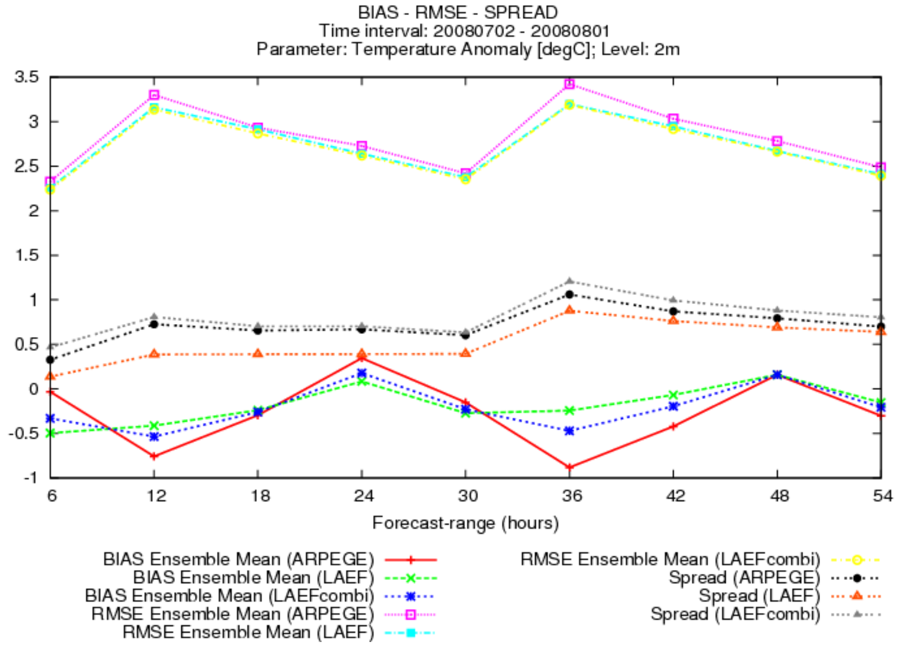




Combination: LAEF/ECMWF + LAEF/PEARP







More spread, better outlier
better skill, small error

One month test 02.07-01.08.2009

LACE
nwp central europe

Ensemble prediction systems at met.no

Trygve Aspelien, Dag Bjørge, Inger-Lise Frogner, Trond Iversen, Marit Helene Jensen, Jørn Krisitiansen, Silje Lund-Sørland, Ole Vignes

- NORLAMEPS=Combination of TEPS & LAMEPS
  - A simple "multi" model, multi initial condition ensemble
  - Targeted EPS = TEPS (~50km)
  - Limited Area Model (HIRLAM) EPS = LAMEPS
    - 12 km resolution, 60 vertical levels
    - alternating between STRACO & KF (even/odd members)
  - 42 ensemble members [2 times (20+control)]

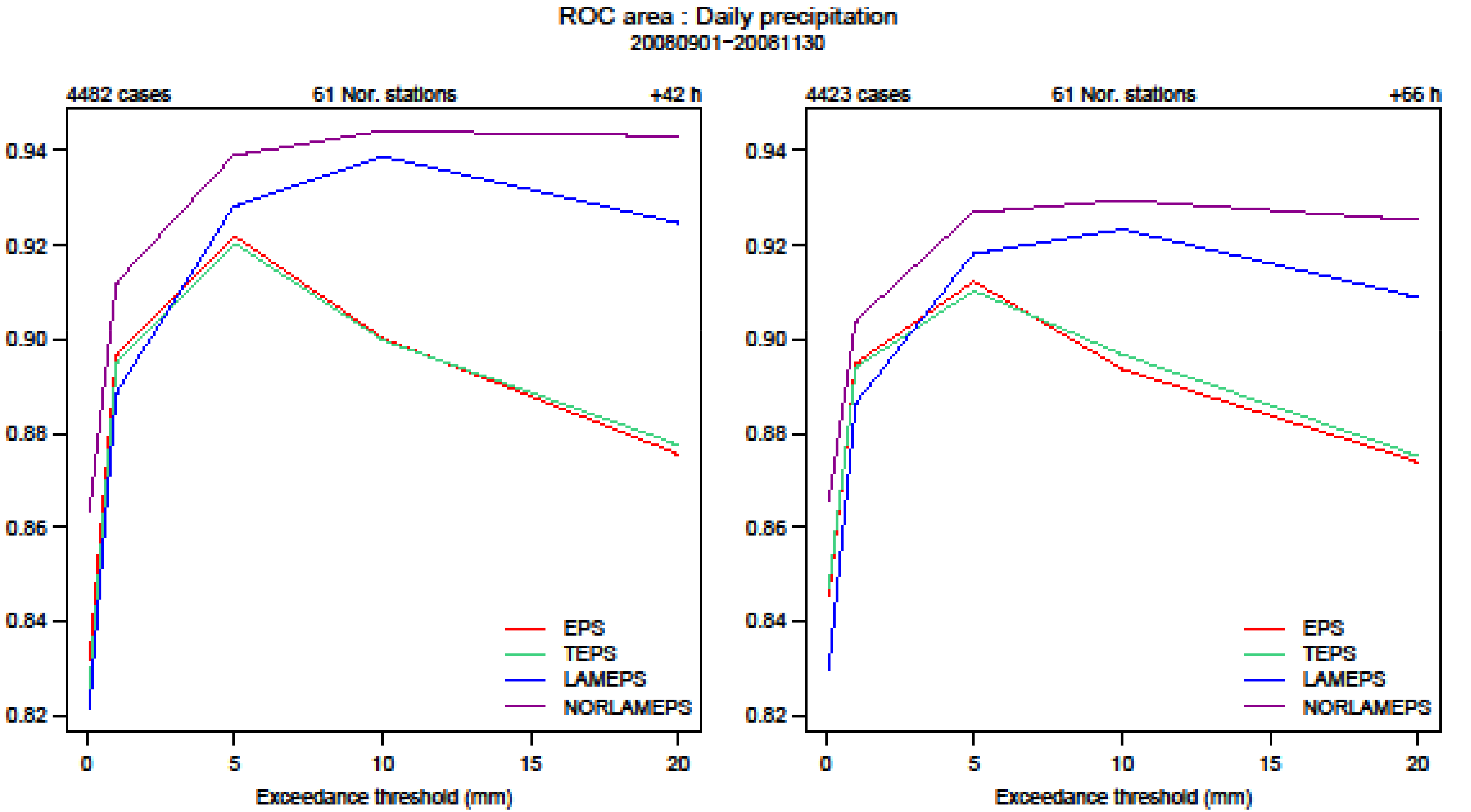
Downscaling from global – added value

QUESTION:

Is there any added value in the LAM ensemble with respect to the driving global ensemble?

ANSWER: YES!

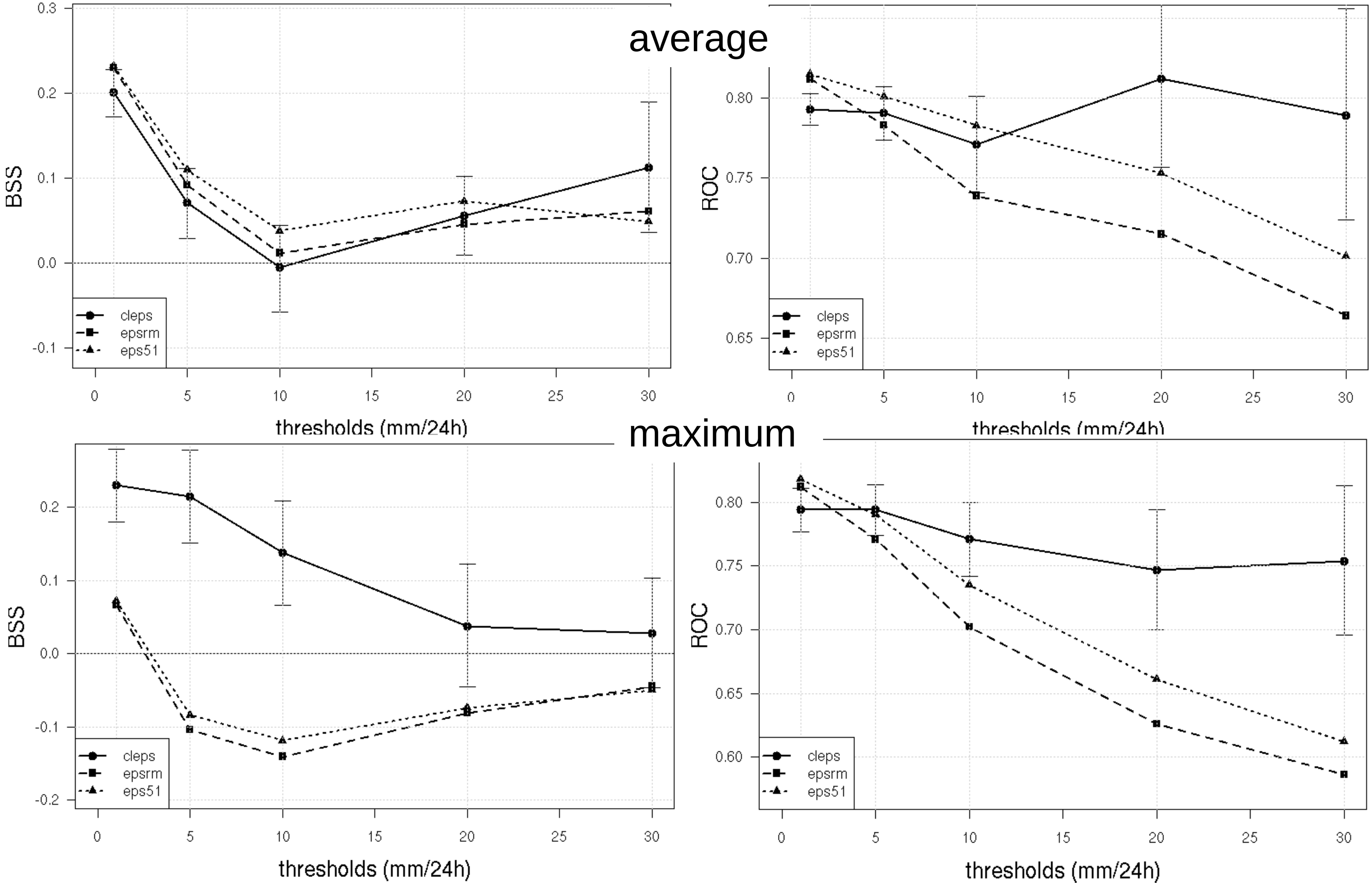
NORLAMEPS vs TEPS and EPS
PRECIPITATION



Courtesy of Inger-Lise Frogner

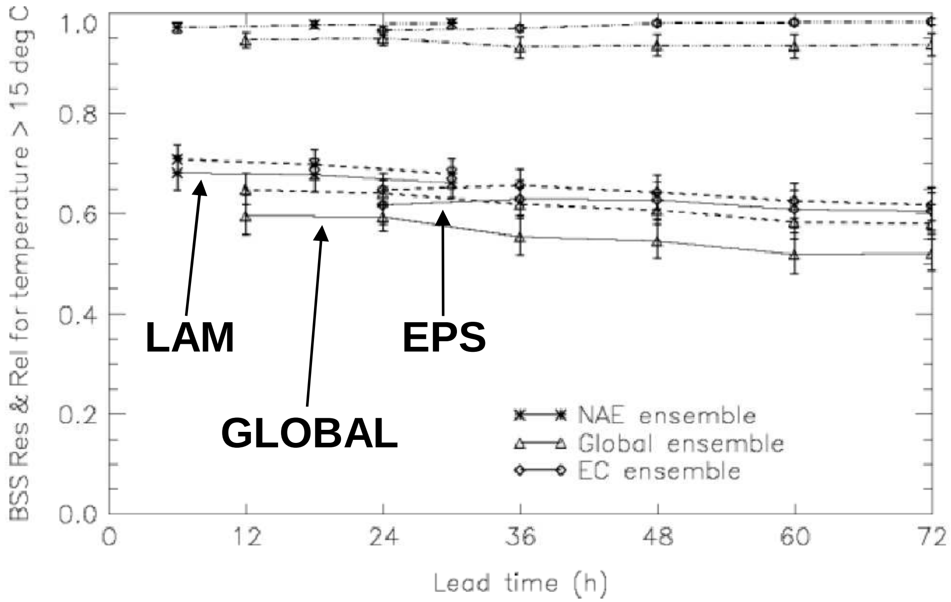
66-90 h

COSMO-LEPS vs EPS

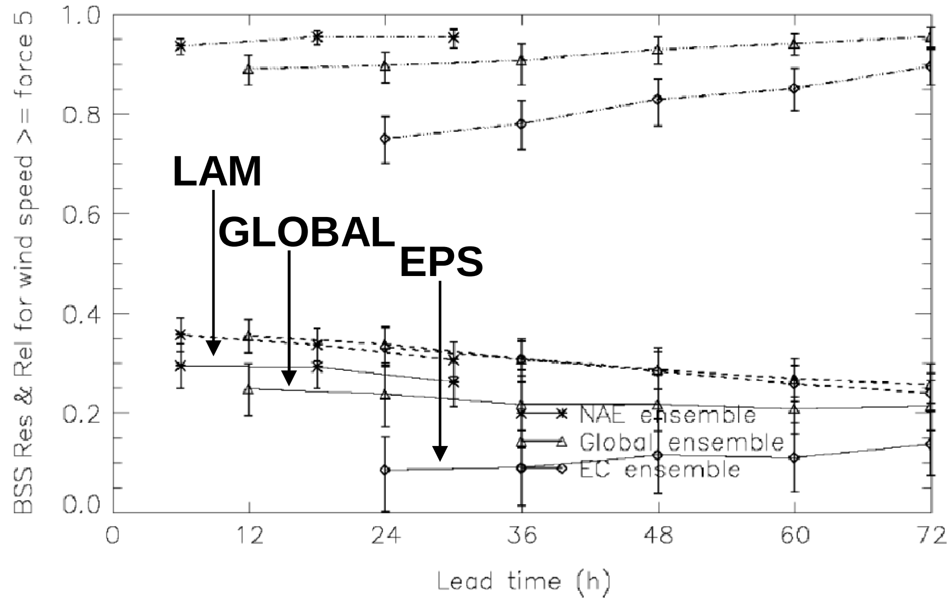


Marsigli et al. (2008): A spatial verification method applied to the evaluation of high-resolution ensemble forecasts. *Meteorol. Appl.* **15**: 125–143

MOGREPS LAM vs GLOBAL and EPS



screen temperature > 15℃



wind speeds of at least fo rce 5

Bowler et al. (2008): The MOGREPS short-range ensemble prediction system.
Q. J. R. Meteorol. Soc. **134**: 703–722

Perturbations of the initial conditions: EDA and ETKF

PRESENT STATUS

- MOGREPS
- HIRLAM for GLAMEPS

- PEARP – Combine Ensemble Data Assimilation with SVs
- KENDA at DWD (COSMO Priority Project)
- LETKF for HRM - Italy
- ECMWF SV+EDA

J. Bojarova, N. Gustafsson, O. Vignes, Å. Johansson

ETKF rescaling scheme for HIRLAM

- Development of an ETKF rescaling scheme for HIRLAM to be used as a means of providing alternative IC perturbations to GLAMEPS
- Presently, TEPS is used to provide both initial and boundary conditions to GLAMEPS
- One advantage is that the new perturbations are produced within the LAM itself and they have explicit dependence on observation density and accuracy
  - Real observational network is used to construct the rescaling matrix: TEMP, PILOT, AIREP,SYNOP, SHIP, DRIBU (satellite observations are not used in the construction of T_T at present)

J. Bojarova, N. Gustafsson, O. Vignes, Å. Johansson

SKILL and SPREAD

Dependence on # Observations

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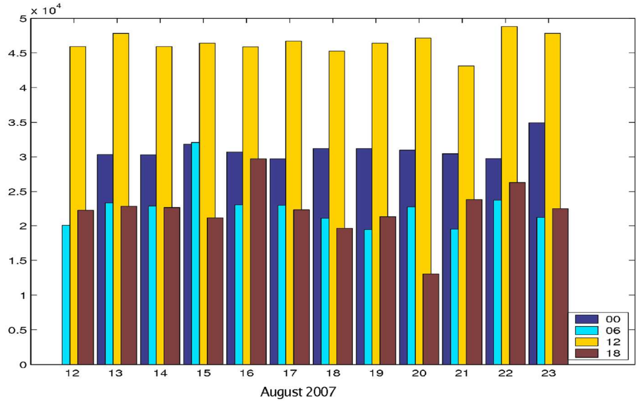
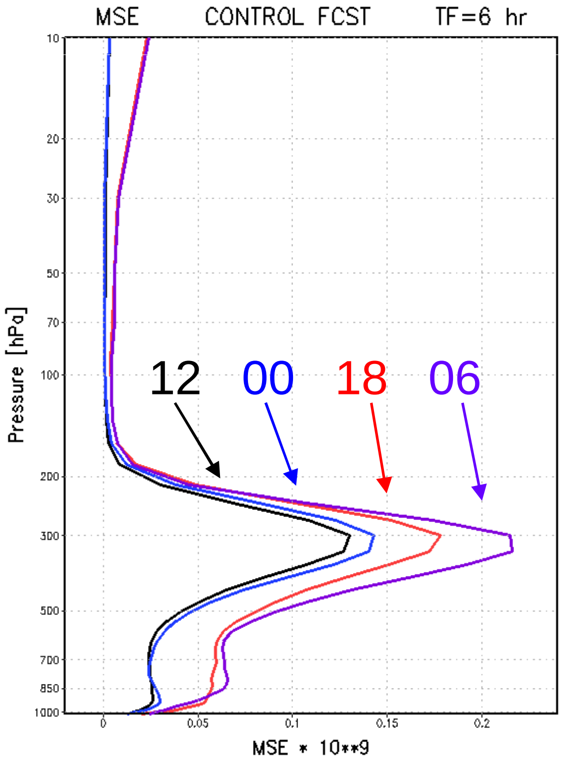
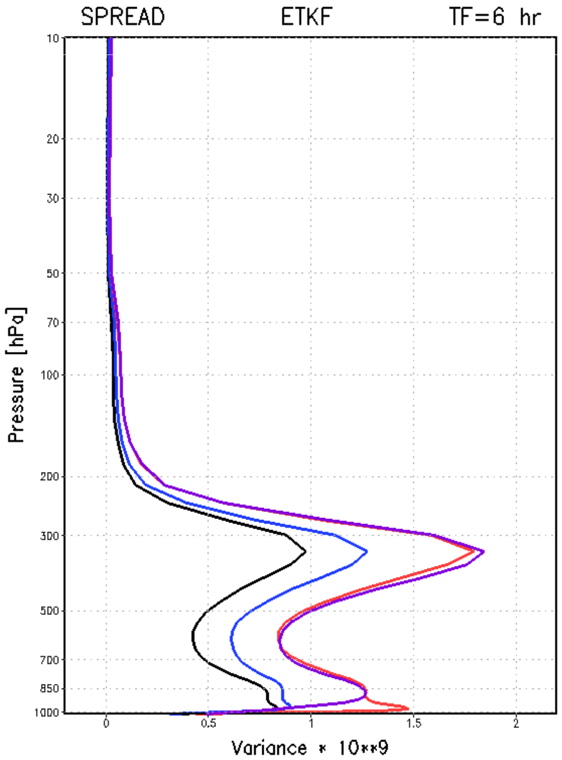
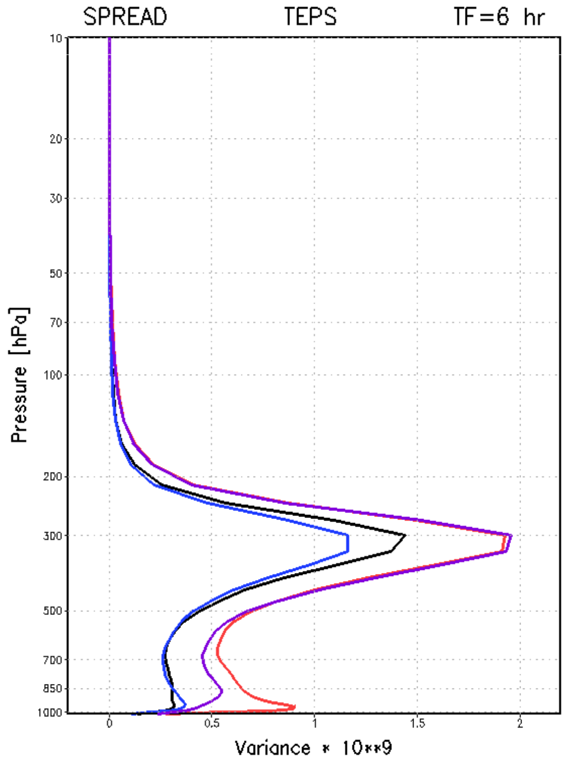


Vorticity







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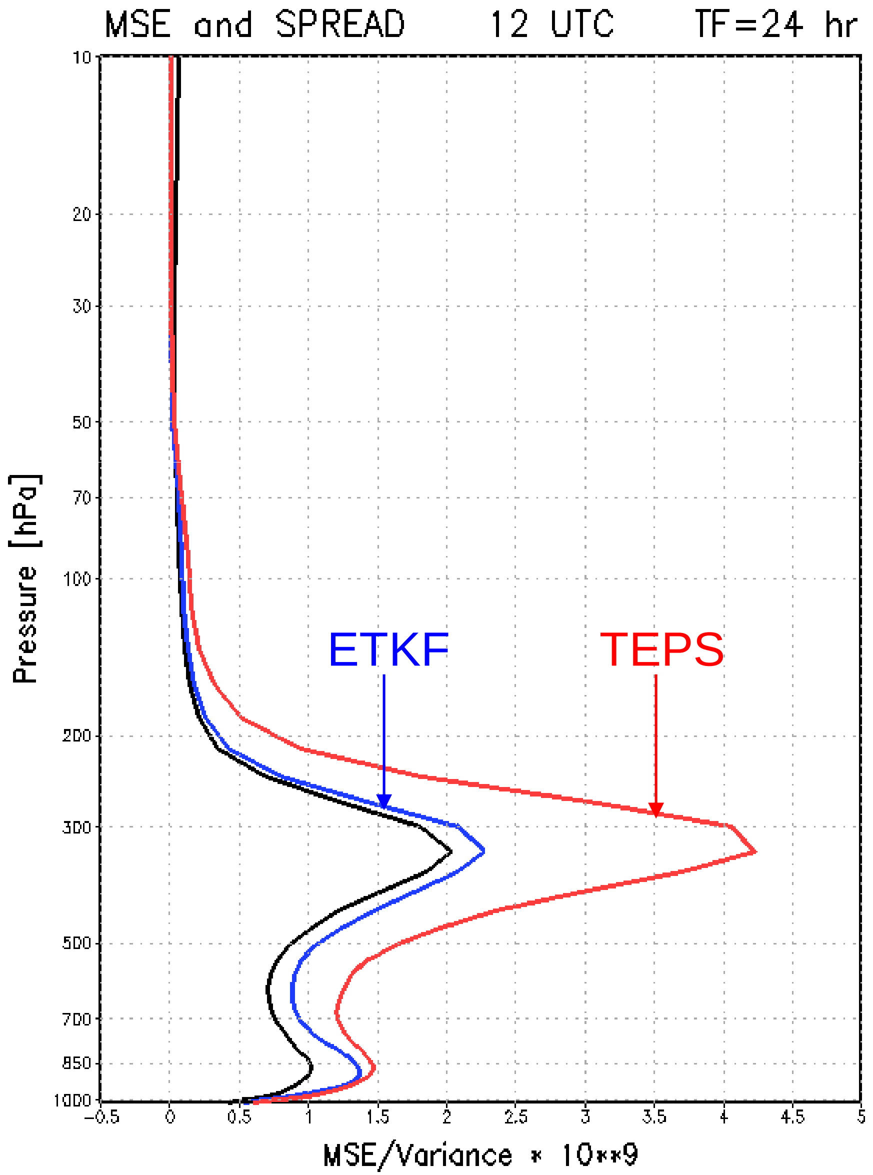
SKILL VS SPREAD



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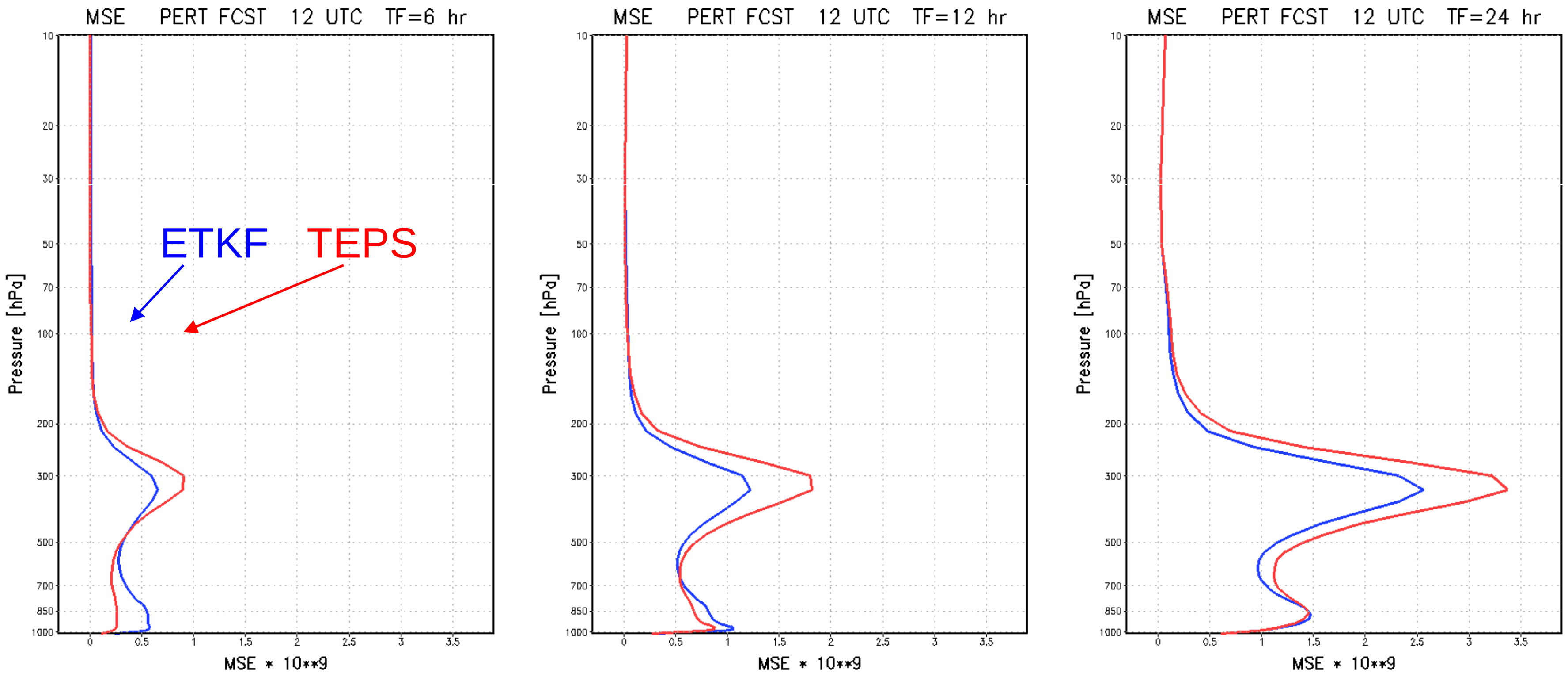
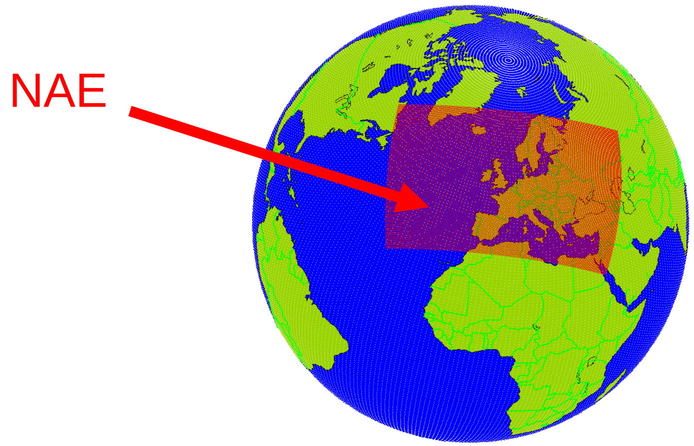
ERROR OF PERTURBED MEMBERS



MOGREPS – The Met Office short-range ensemble

Met Office

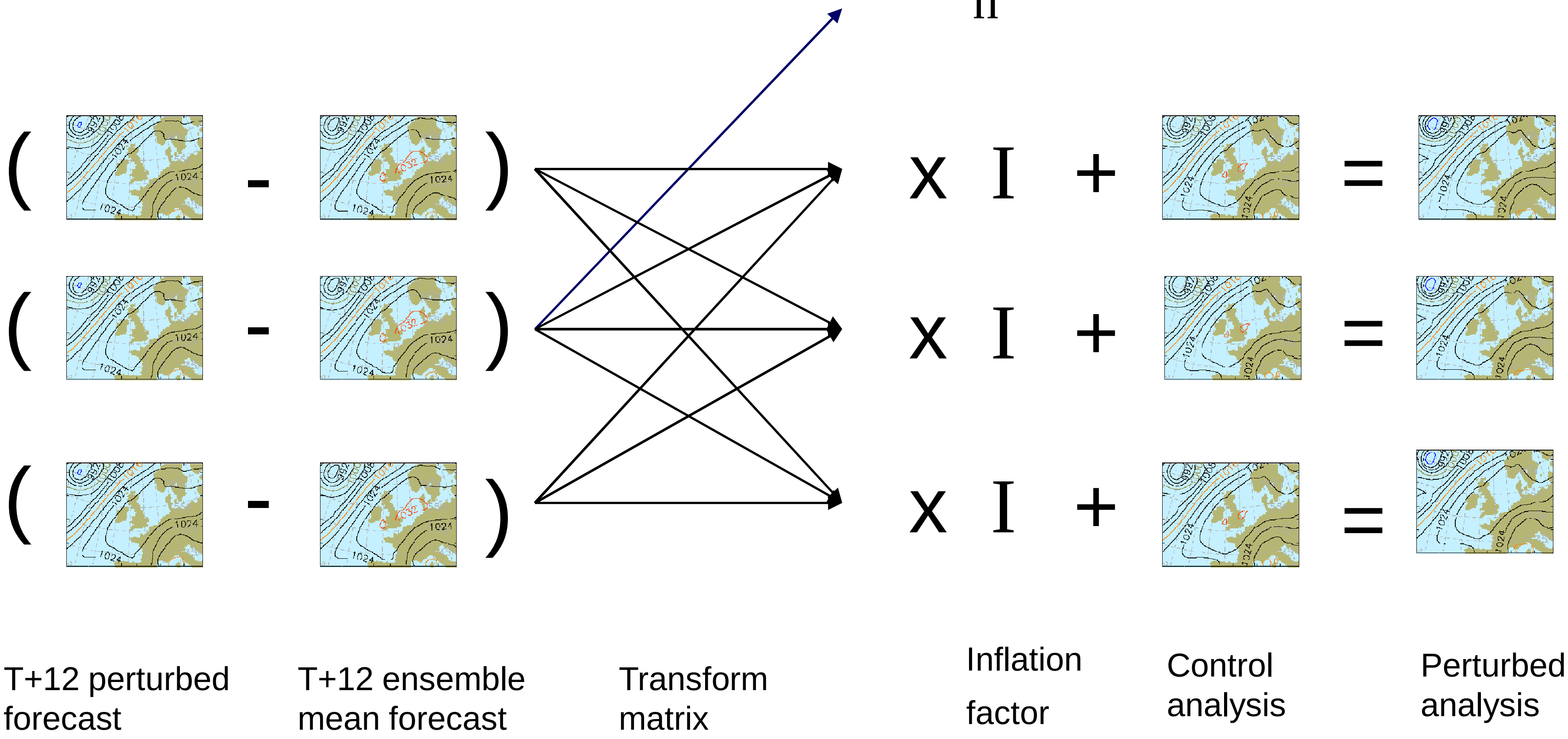
- 24-member ensemble designed for short-range forecasting
  - Regional ensemble over N. Atlantic and Europe (NAE) (24km resolution, 38 levels) to T+54
  - Global ensemble (~90km resolution, 38 levels) to T+72
    - Also runs to 15 days at ECMWF for THORPEX multi-model ensemble research MOGREPS-15
  - ETKF for initial condition perts (global only)
  - Stochastic physics – SKEB (global only) and Random Parameters
  - MOGREPS-G run at 0Z and 12Z: MOGREPS-R run at 6Z & 18Z



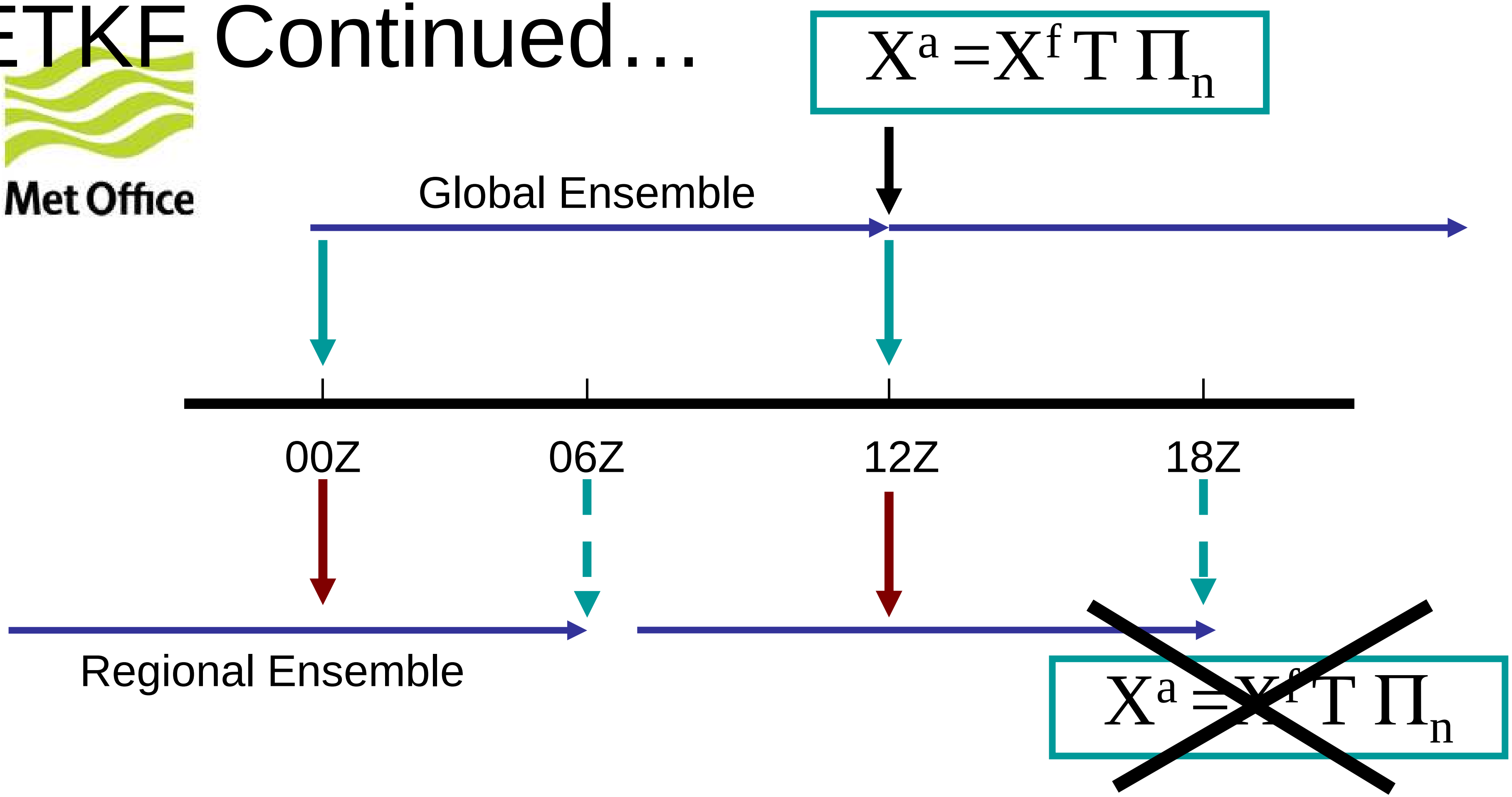
MOGREPS became fully operational in Sep 2008 after 3 years of trials

Ensemble Transform Kalman Filter (ETKF)

$$X^a = X^f T \Pi_n$$



ETKF Continued…

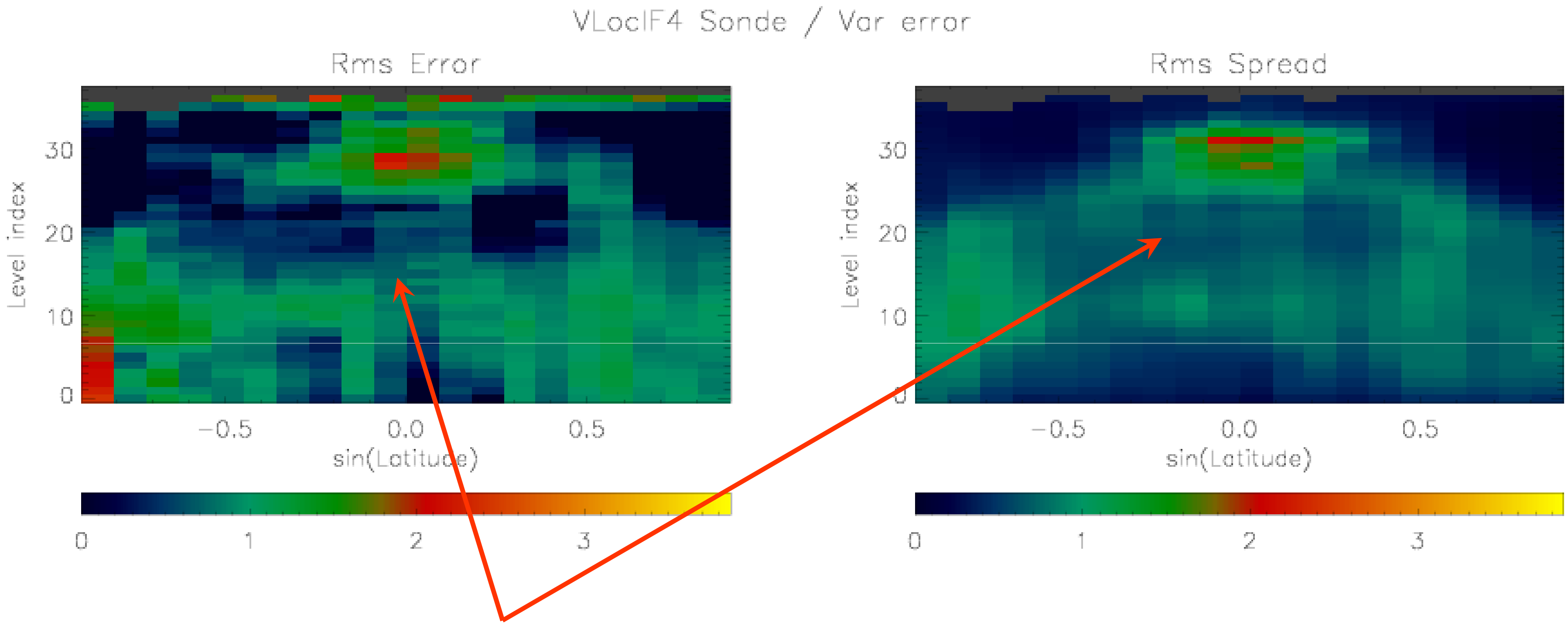


"… one may speculate that this is due to the greater consistency between the lateral boundary perturbations and the initial condition perturbations in this ensemble. This result would suggest that regional ensembles are best implemented as dynamical downscaling ensembles, rather than using initial condition perturbations specifically generated for this type of ensemble."

Bowler and Mylne (2009): Ensemble transform Kalman filter perturbations for a regional ensemble prediction system. *Q. J. R. Meteorol. Soc.* **135**: 757–766

Effect of vertical localisation

New vertical localisation: allow inflation factor to vary in the vertical



Pattern of spread and error (at T+12h) match well at most locations

Perturbation incompatibility

- “in a LAM ensemble, it is not ideal to perturb ICs and BCs independently”
- “in the ideal LAM EPS, initial and boundary conditions for each member come from the same global member”

- Some results:
  - MOGREPS: it is better to downscale the ICs with respect to produce ICs with a LAM ETKF
  - Canada experience: “Piloting the LAM integrations with the Canadian global EPS provides better results than using targeted singular vectors” (Charron (2009), TIGGE-LAM Meeting, Bologna)

Perturbations of the initial conditions: Singular Vectors

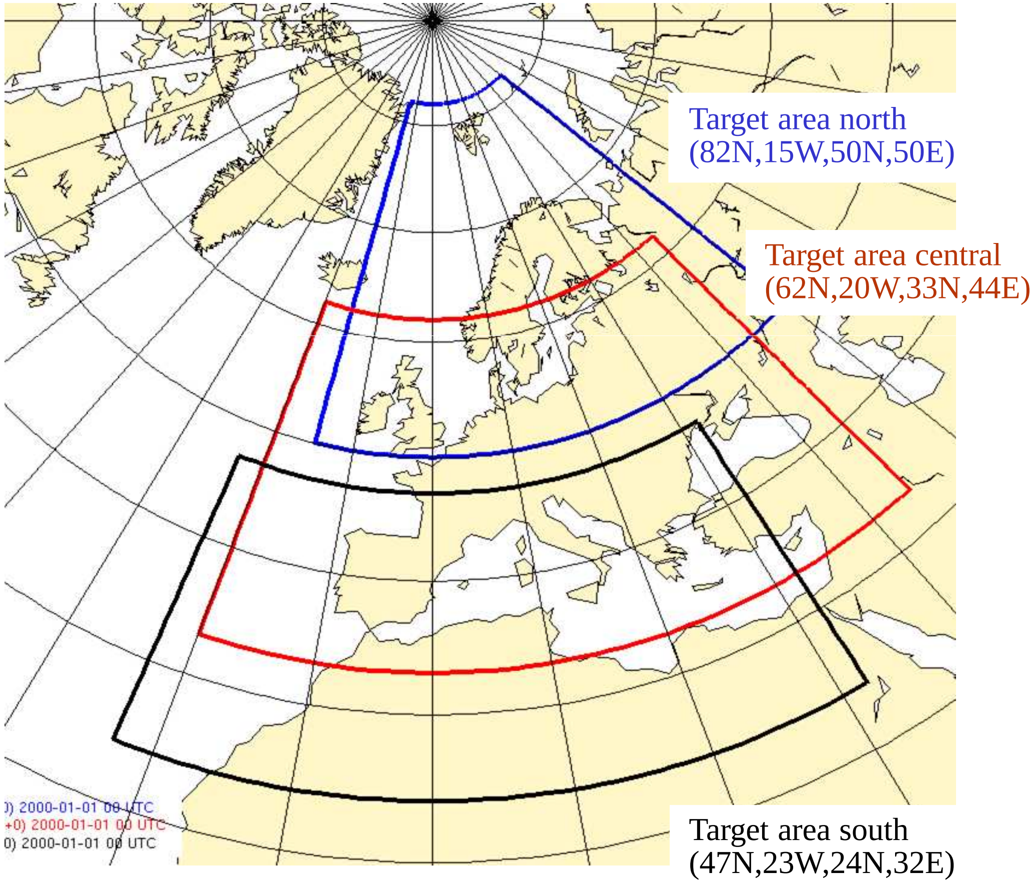
PRESENT STATUS

- Still used mainly in the global ensembles (perturbations for short-range ensemble should be fully developed from the beginning of the integration):
  - PEARP (grid refinement) (poster by O. Riviere)
  - TEPS (Targeted), hence with a focus on LAM
- Inclusion of moist dynamics:
  - ECMWF (TE+HUMID)
  - CAPE SVs at KNMI with HIRLAM (-> poster by G. Burgers)

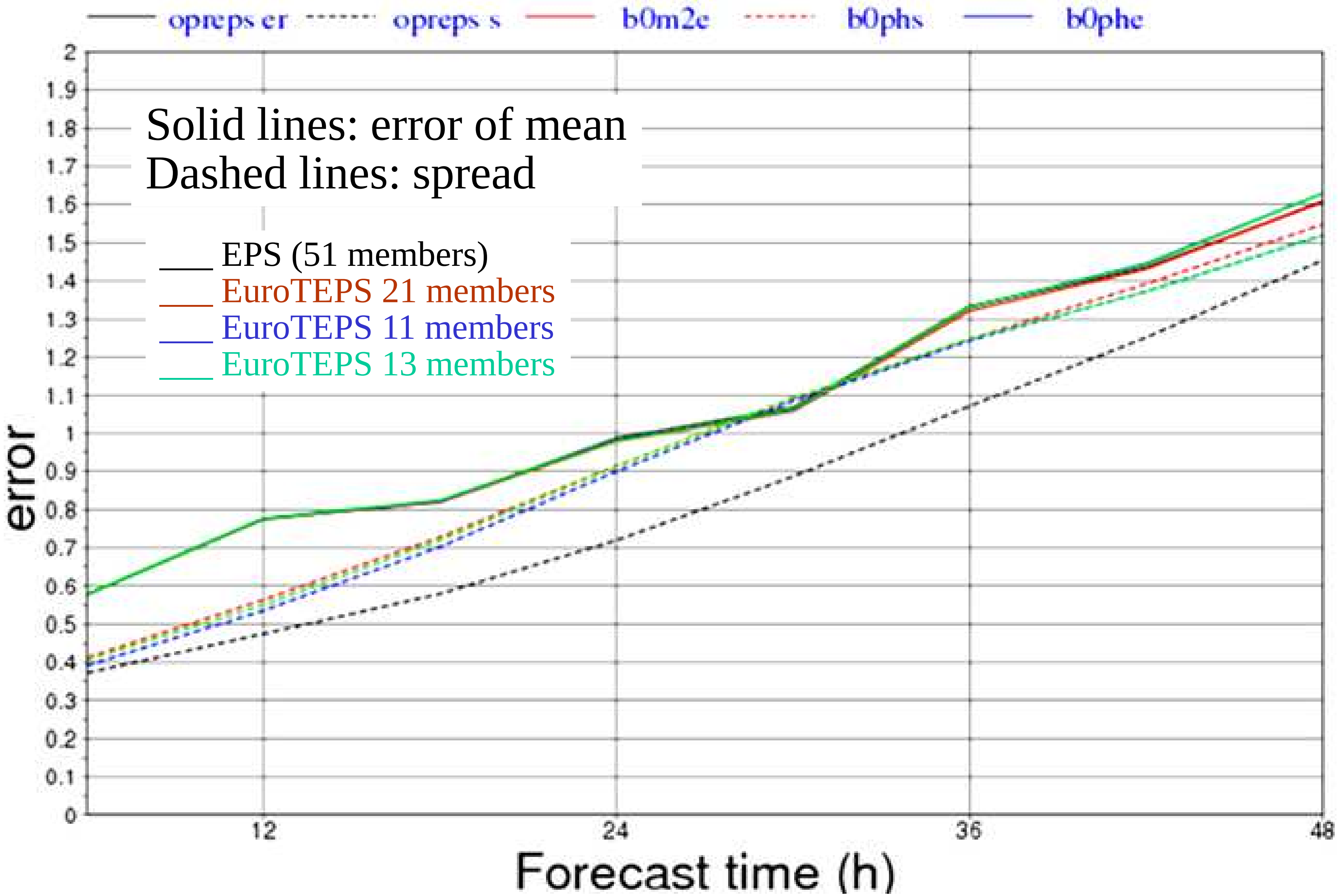
EuroTEPS

Inger-Lise Frogner

- EuroTEPS is as a version of EPS with targeted SVs
  - Target area: Europe
  - The SVs are calculated with higher resolution than in EPS
  - Several sets of SVs are combined to create the perturbations
- EuroTEPS is part of the GLAMEPS-project
- EuroTEPS will provide initial and lateral boundary perturbations for multi-model limited area EPS for the short range for the HIRLAM and ALADIN countries
- It is a special version of ECMWF IFS EPS that is designed to be optimal for Europe in the short range (day 1-3)

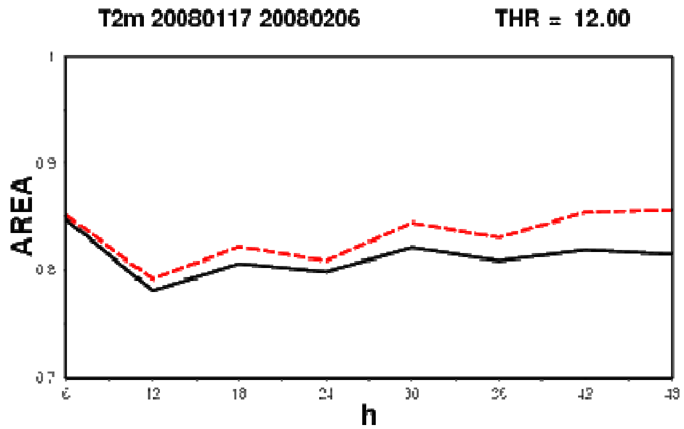


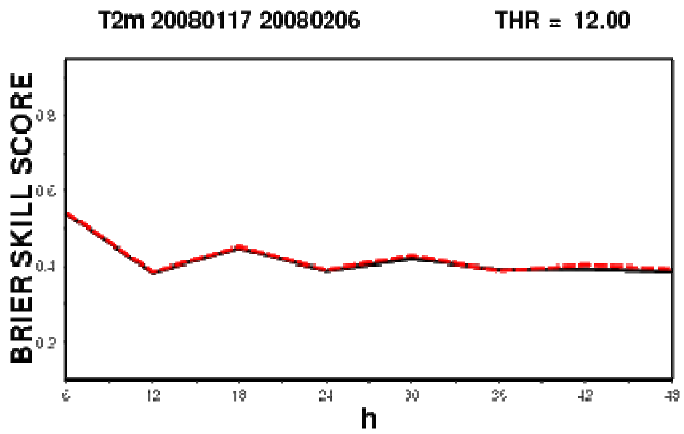
Spread-Skill MSLP 21 cases winter 2008

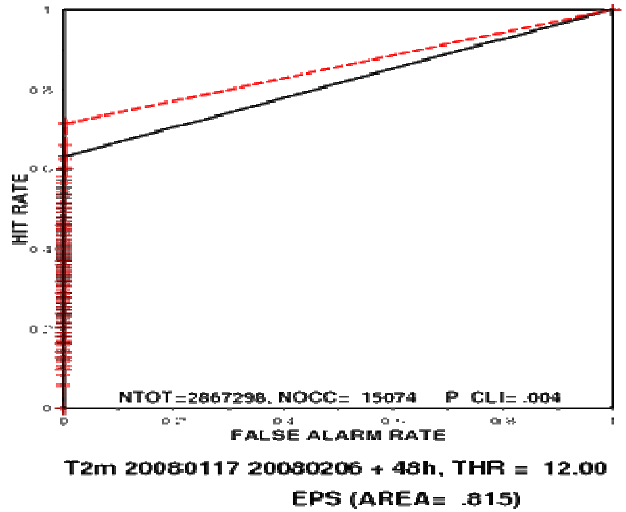


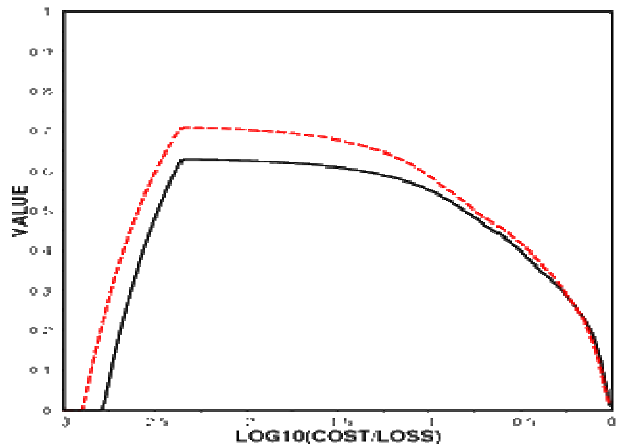
Comparison of EuroTEPS51 and EPS51

_ _ _ EuroTEPS51
____ EPS51









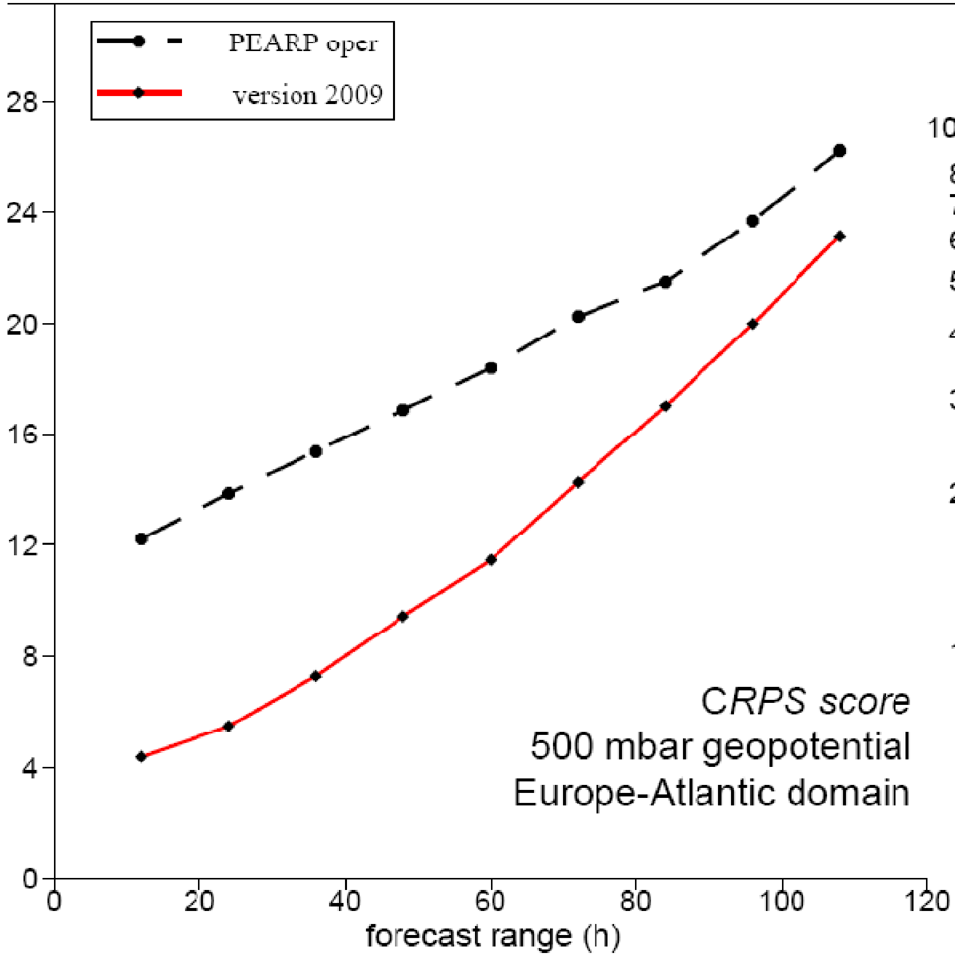
The short-range Ensemble Prediction System at Météo-France (PEARP)

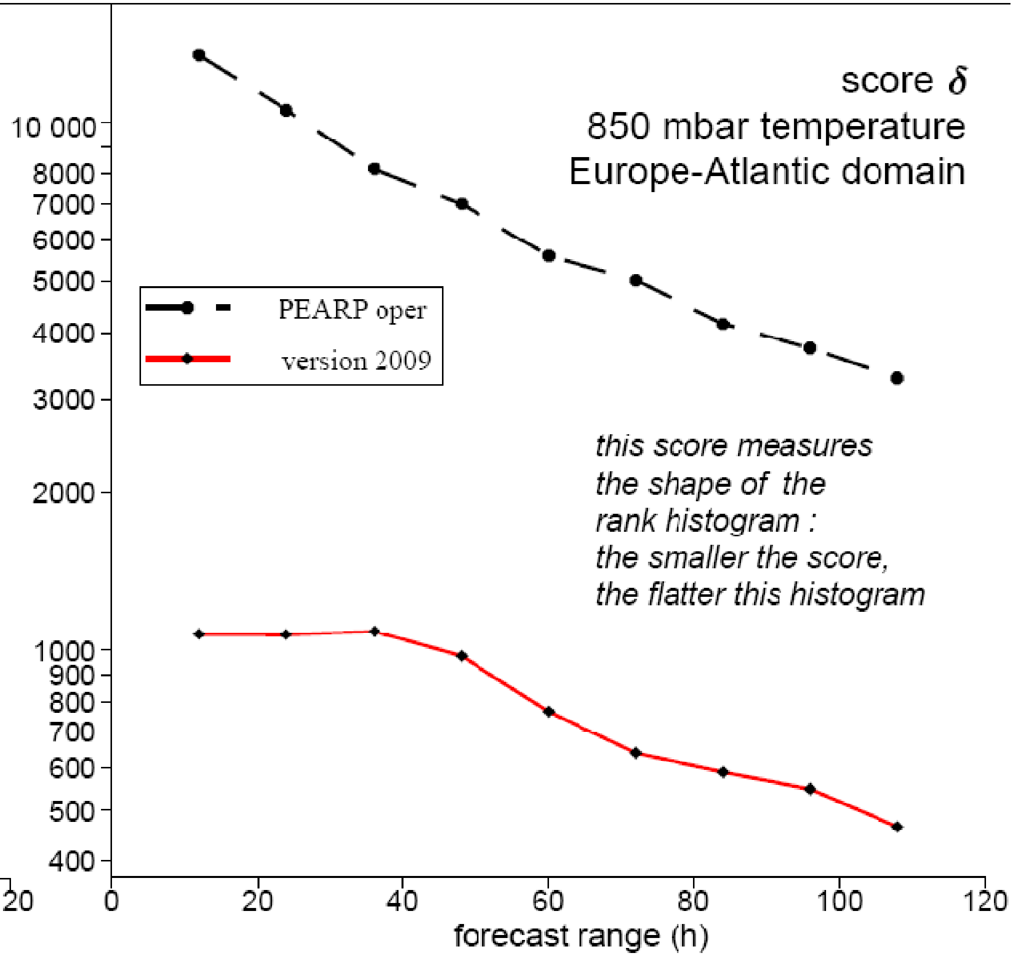
- Inizialization procedure:
  - Blending breeding (24h evolved SVs) + 56 dry TE SVs
  - Perturbation amplitude controlled by analysis error variance "of the day"
- Global, T358c2.4 L55 resolution (grid refinement)
- 10 perturbed members + 1 control
- 3 day forecast range

PEARP
planned upgrades for end of 2009

- Initialization procedure:
  - Combine Ensemble Data Assimilation with SVs
- Simulate model uncertainties using a set of 8 physical packages
- Ensemble size: 34 perturbed members + control
- L65 vertical resolution

PEARP – planned upgrades





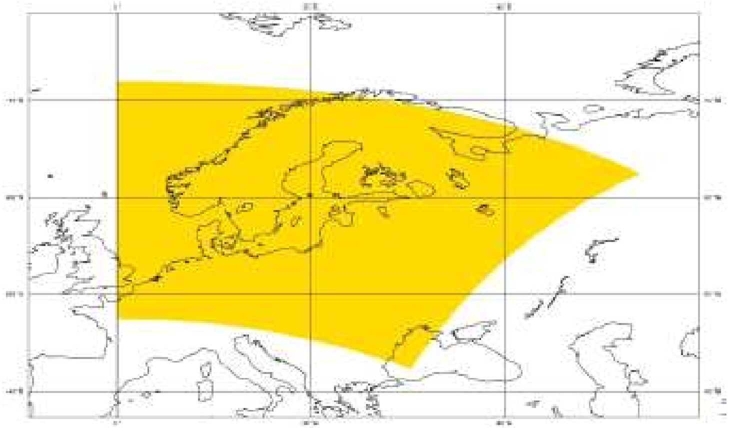
January 2009 - EURAT (Western Europe + Atlantic Ocean)

PEARP

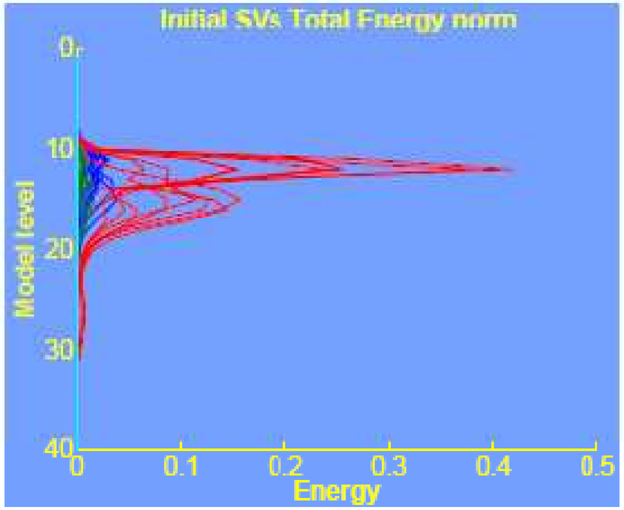
- Important upgrades are planned for next winter: new initialization method, increased ensemble size
- Objective evaluation: use of TIGGE data base
- Other planned improvements:
  - Increased model resolution (end 2010): 10 km over France
  - Develop a reforecast data set
  - Use of methods of calibration

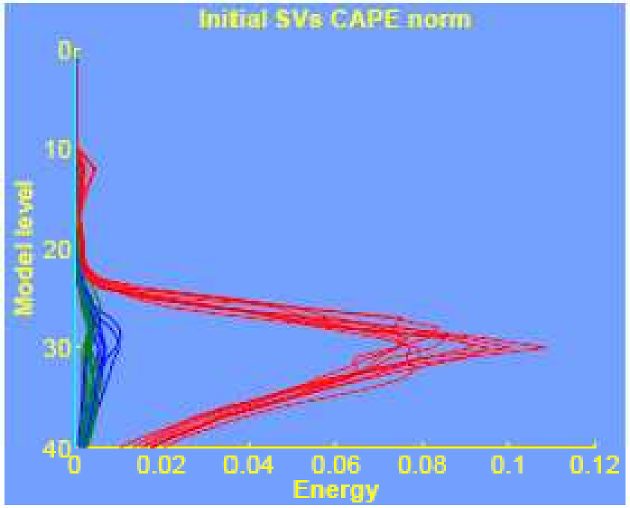
CAPE SVs for HIRLAM

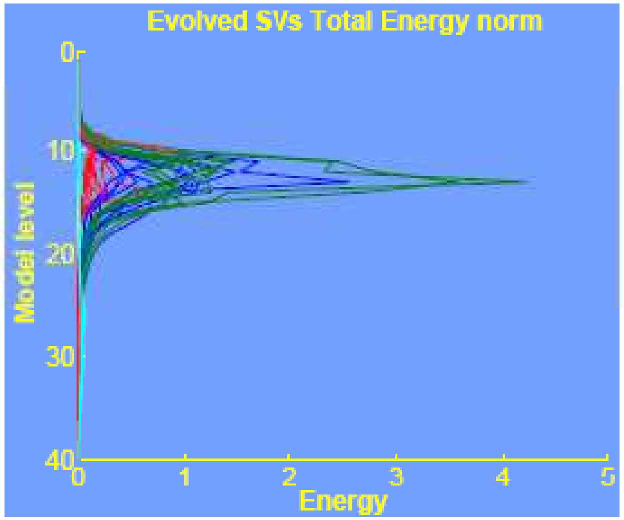
- HIRLAM model
- Resolution: $0.5^\circ \times 0.5^\circ$
- Dry total energy norm at initial time, Cape/TE-norm at final time
- Optimization time: 12 h
- The adjoint model uses Meteo France simplified physics:
  - Vertical diffusion, Convection, Large scale condensation

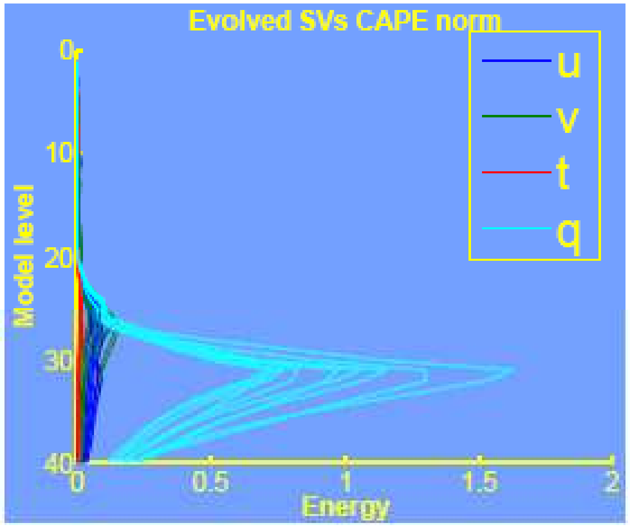


CAPE SVs for HIRLAM





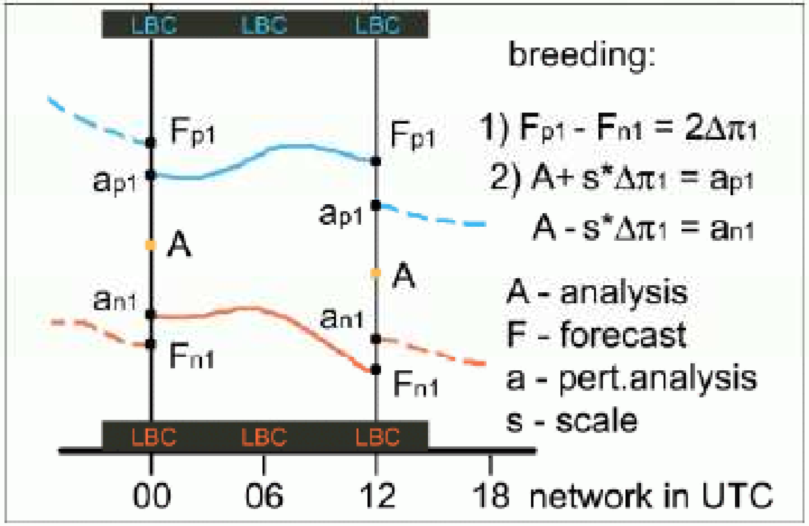




CAPE SVs for HIRLAM

- The TE-SVs in HIRLAM show well known features: most energy in the temperature field at initial time and most energy in the wind-field at final time near the jetstream
- CAPE-SVs are situated much lower in the troposphere and at final time the “energy” is mostly in the specific humidity field. In both cases 12 hour CAPE forecast are most sensitive to the analysis fields at 850 hPa.
- The twin experiments show that the tangent linear approximation using CAPE-SVs as IC perturbations is valid up to 12 hours at 0.5◦ resolution
- Future plans:
  - Modify (MU)CAPE-norm to include CIN
  - Look at integrated water vapor as final time norm
  - How to use (MU)CAPE-SVs as building blocks for EPS members in GLAMEPS?

Perturbations of the initial conditions: Breeding



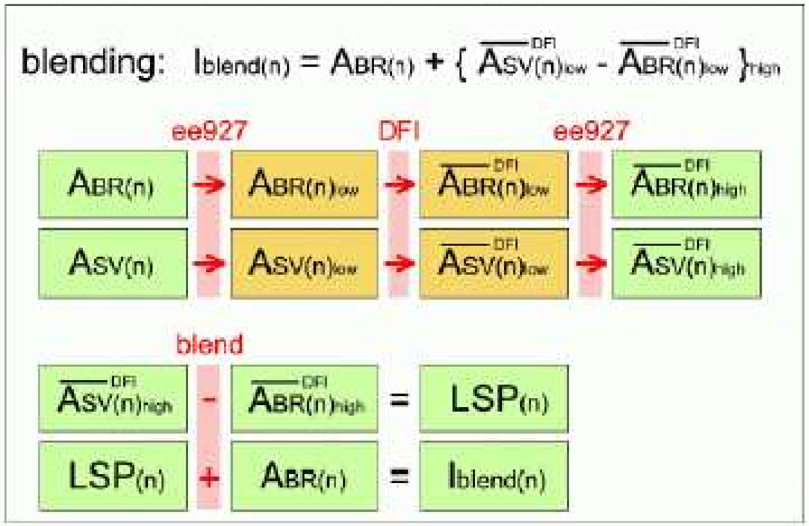
Breeding:

Generation of perturbation on ALADIN-LAEF scale

Pairs of 12h forecasts from previous run are scaled wrt to analysis

Blending:

Combination of small scale perturbations from Breeding with large scale perturbations from ECMWF-EPS



How to account for the model uncertainties?

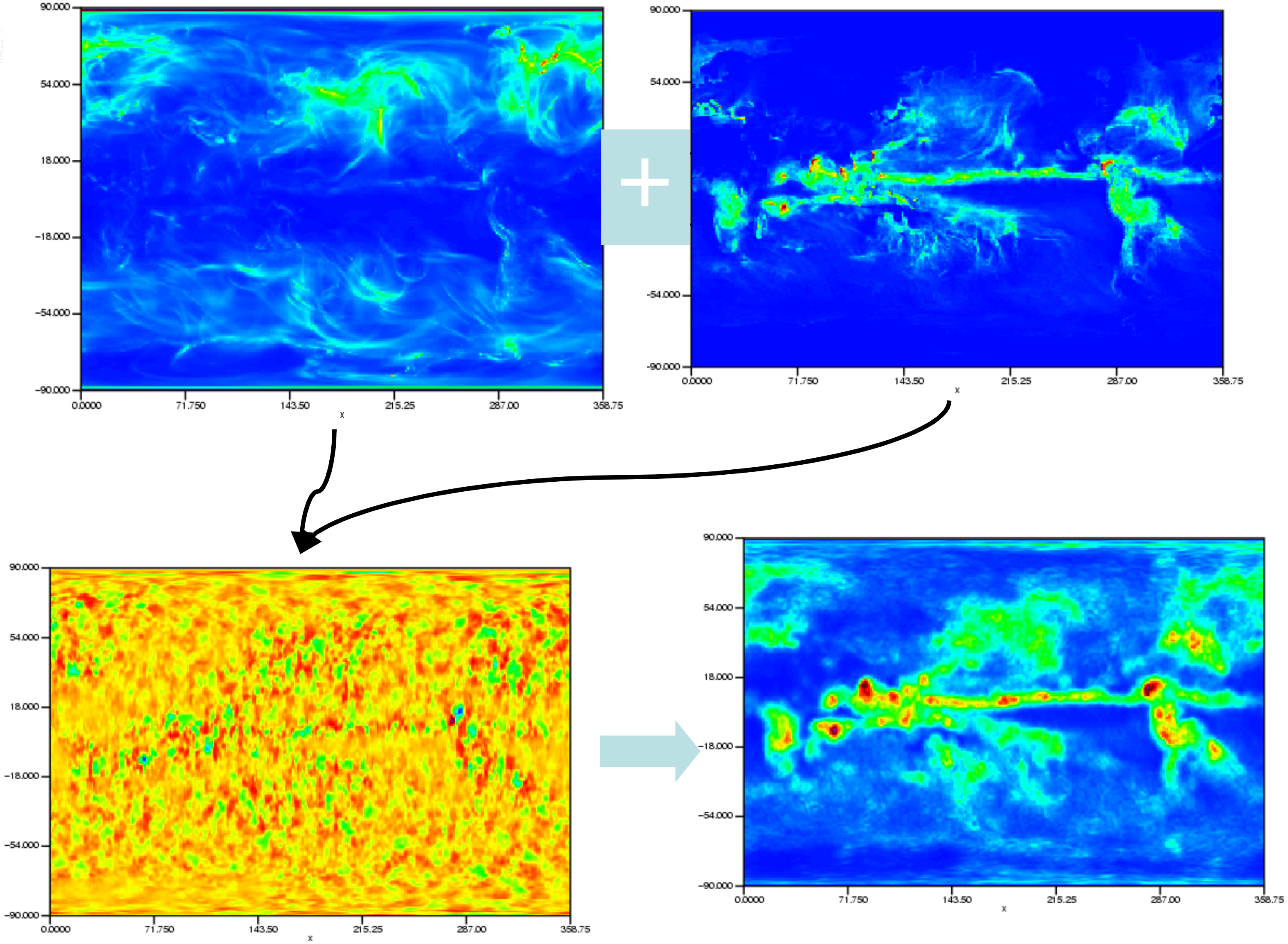
PRESENT STATUS

- multi-scheme multi-parameter (but are the different model configurations of the same quality?)
  - MOGREPS
  - COSMO-DE-EPS
  - COSMO-LEPS / COSMO-SREPS
  - PEARP
  - NORLAMEPS (convection)
- SKEB: MOGREPS
- A look outside Europe: “Both the multi-physics ensemble and the ensemble with simplified stochastic backscatter scheme improve the AWFA ensemble system over the ensemble with control physics.” (Hacker 2009, SRNWP-EPS WS, Exeter)
- Surface perturbations:
  - MOGREPS, poster by W.Tennant
  - COSMO-SREPS

Stochastic Physics: SKEB2

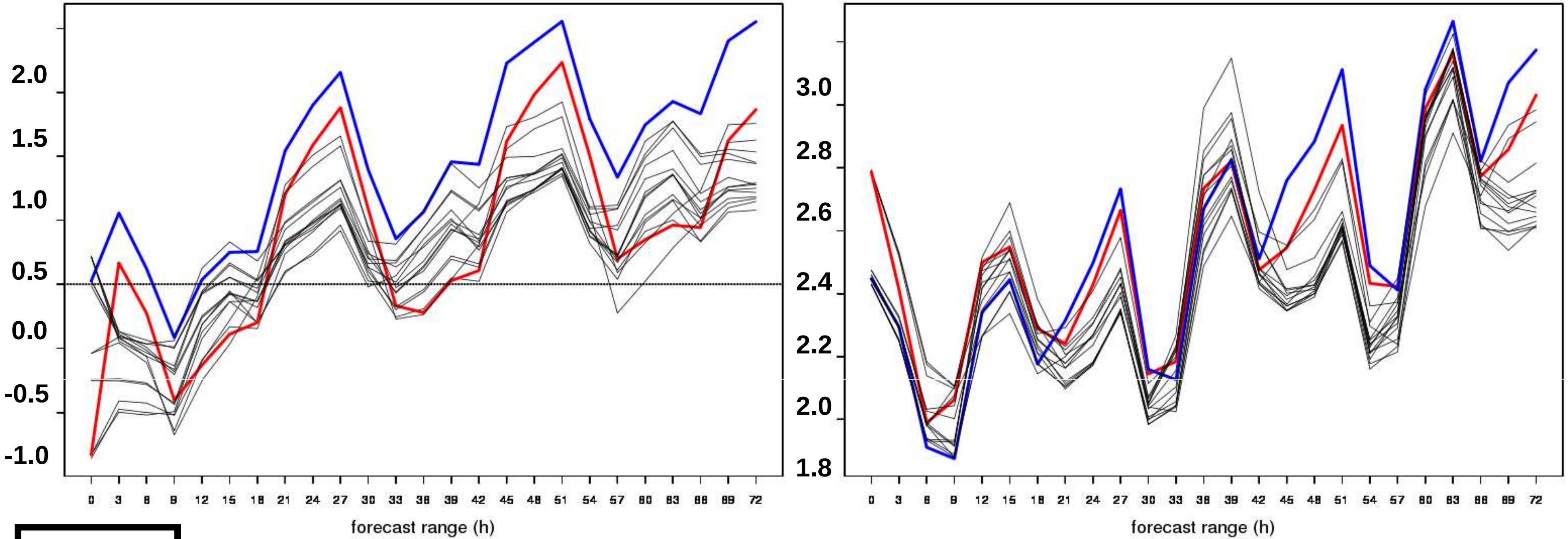
- SKEB2 = Stochastic Kinetic Energy Backscatter version 2
- A randomly initialised stream-function forcing field (Ψ) is created with specified spatial and temporal characteristics
- Calculate energy dissipation as a result of:
  - Numerical schemes: Smagorinsky-Lilly
  - Convection buoyancy: Mass-flux change * CAPE
- Modulate the random Ψ-field with the energy dissipation
- Calculate wind components from the Ψ-field and add to other wind increments from model physics at each time-step

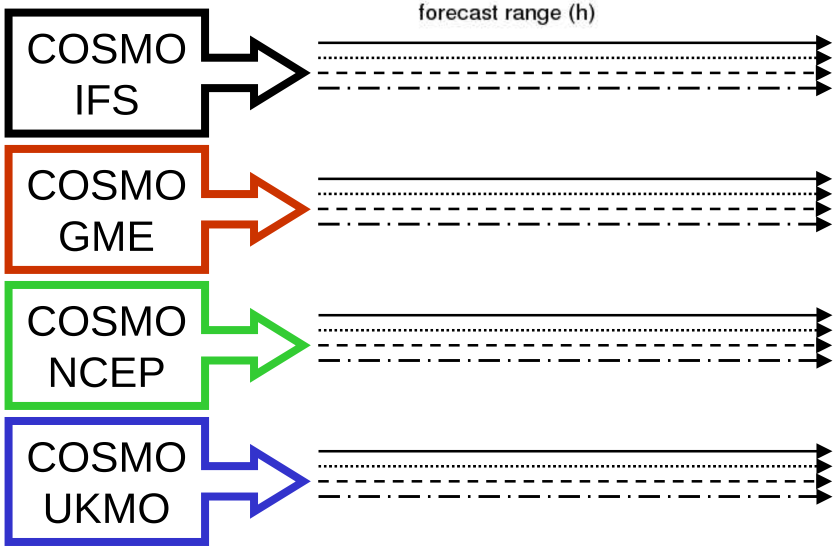
SKEB2: 15-day average



COSMO-SREPS

BIAS **T 2m** **MAE** **JJA09**





pat_len=10000 – ecmwf KF

pat_len=10000 – gme T

SYNOP Alpine - npo

Model perturbations:

Developing soil perturbations for COSMO-SREPS

Aim

Implement a technique for perturbing soil moisture conditions and explore its impacts

Reasoning

The lack of spread is typically worse near the surface rather than higher in the troposphere. Also, soil moisture is of primary importance in determining the partition of energy between surface heat fluxes, thus affecting surface temperature forecasts

Soil Perturbation method

Based on the method proposed by Sutton and Hamill (2004)

- Select a period that provides variability in soil moisture e.g. spring
- Use of data from a land–surface model analysis for the defined period for a few years in order to create some "climatology" (DWD SMA)
- Apply the EOF (Empirical Orthogonal Function – Principal Component Analysis) to the soil moisture analysis in order to generate a perturbed field with a spatial consistency
- Test the perturbed soil moisture field in COSMO-SREPS

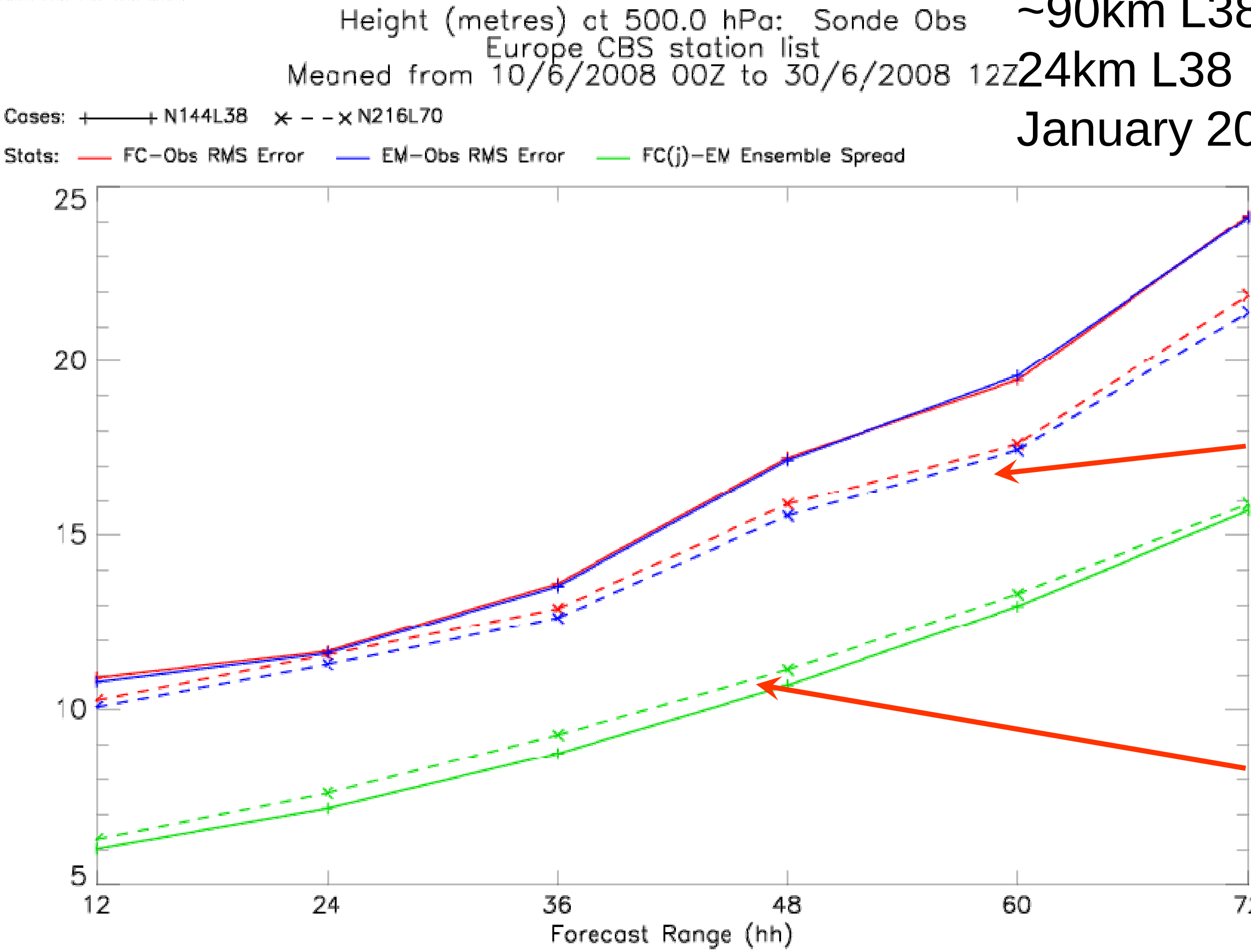
Model grid resolution

It is better to increase the number of members or the model resolution?

- Several centres are increasing the LAM ensemble resolution:
  - NORWAY: UMEPS 4km
  - MOGREPS from 24 to 18 km
  - PEARP from 25 to 10 km over France
  - COSMO-LEPS from 10 to 7 km (poster by A. Montani)
- +
  - NORLAMEPS 12km
  - ALADIN-LEAF 18km
  - ALADIN-LAMEPS Hungary 18 km

Resolution upgrade in global

Resolution upgrade
~90km L38 -> ~60km L70
24km L38 -> 18km L70
January 2010

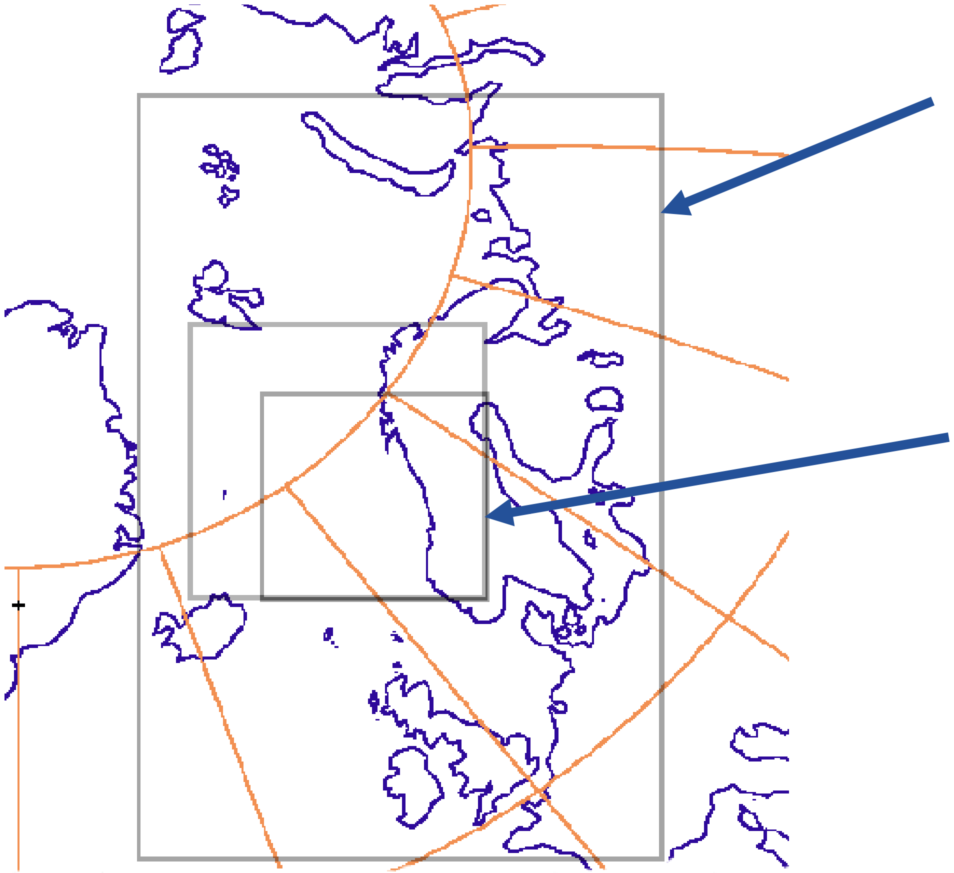


On resolution upgrade:

- decreased error in control and ensemble mean
- increased spread

Example UMEPS – IPY Thorpex

Legacy: Better forecasts of polar lows and extreme weather events in the Arctic



NORLAMEPS: 42 members, 12km

UMEPS: 21 members, 4 km

UMEPS

- UMEPS is a new system under development at met.no with 4km grid resolution (or finer), using the non-hydrostatic UKMO Unified Model to downscale the HIRLAM-based members in NORLAMEPS
- UMEPS with 4km has been tested on several integration domains for selected cases. It works technically with promising forecast results, but with large sensitivity w.r.t. choice of integration domain

Multi-model

Pros:

– Good sampling of analysis and model uncertainty

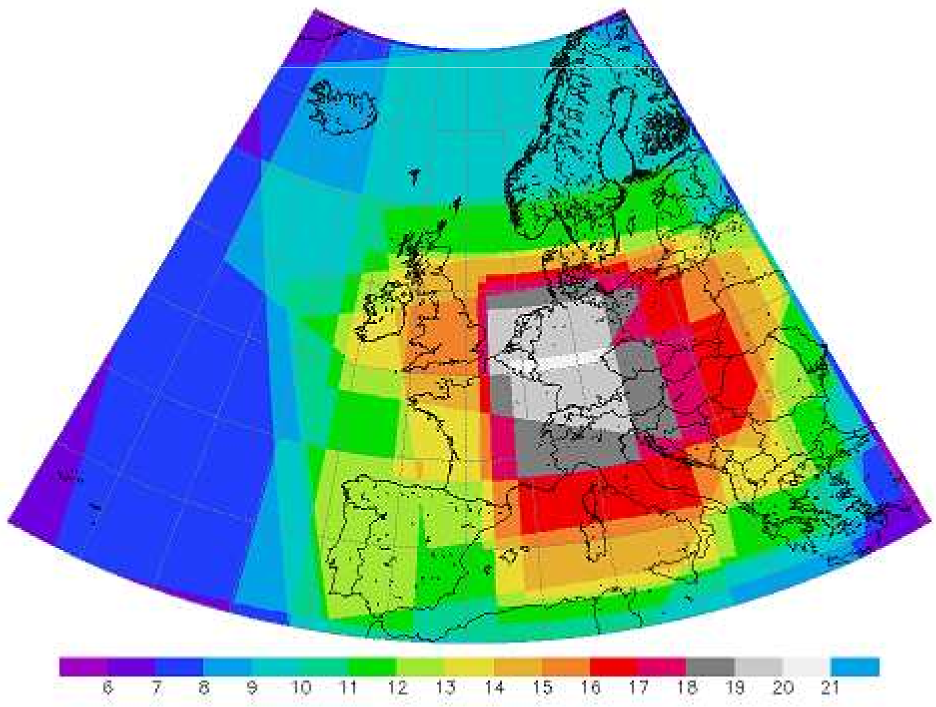
– “Implicit” bias correction

PRESENT STATUS

- PEPS
- AEMET-SREPS
- COSMO-SREPS short-range, high-res
- PREVIEW
- COSMO-LEPS multi-clustering
- Used in convection-permitting ensemble
  - COSMO-DE-EPS
  - University of Oklahoma

SRNWP PEPS

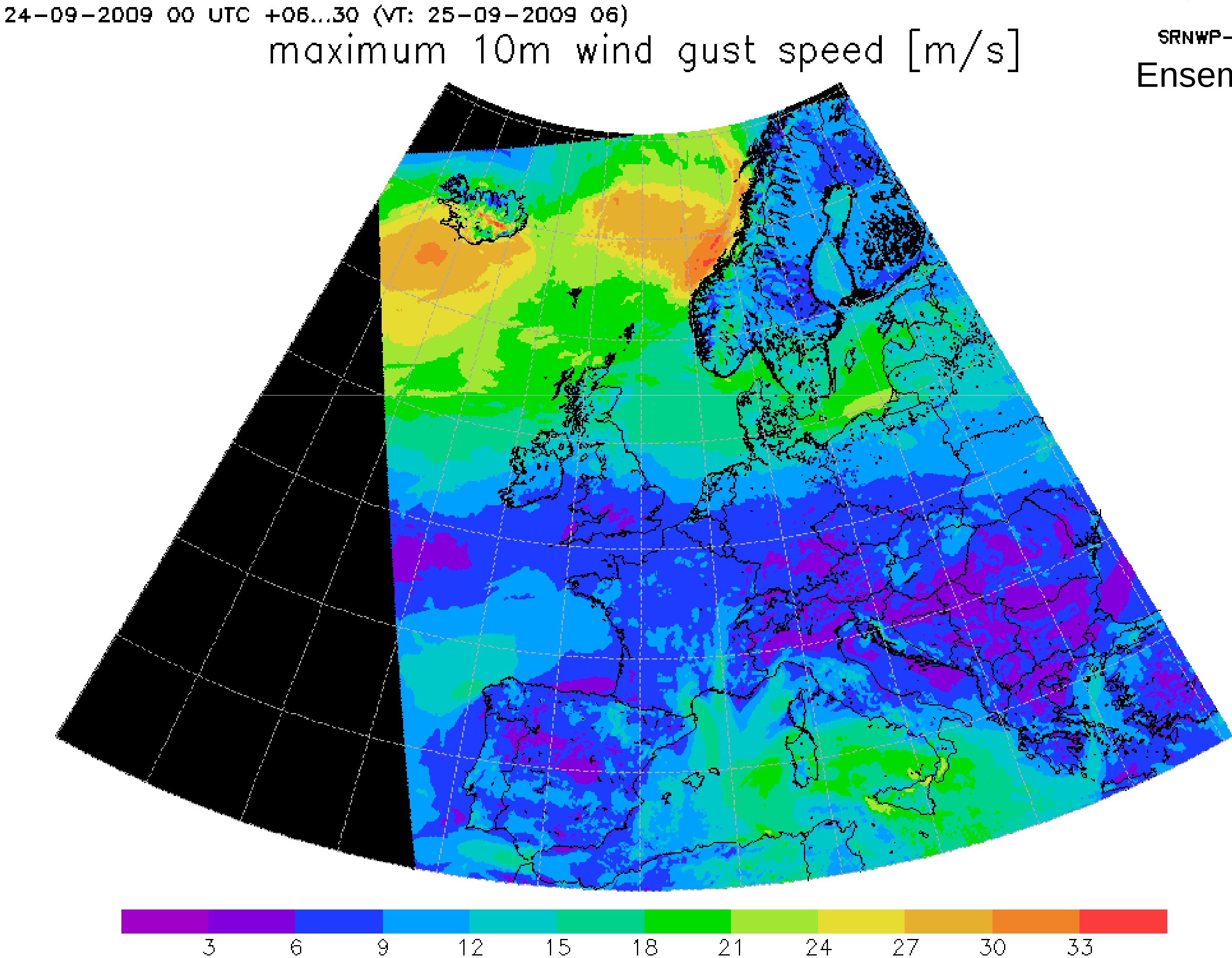
- collection of European operational LAM runs
- “poor-man” ensemble
- 24 members
- variable resolution (from 7 to 22 km)



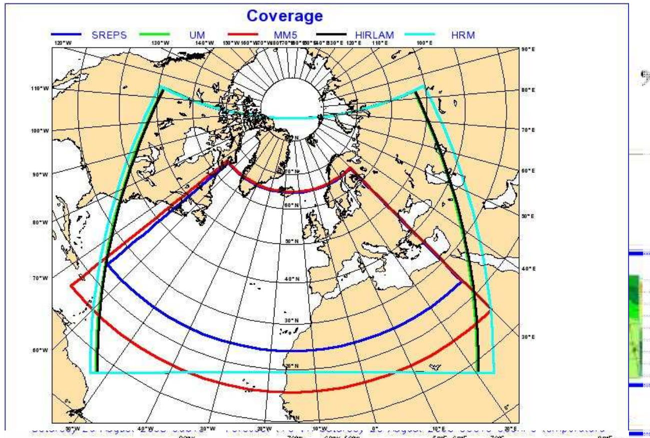
PEPS

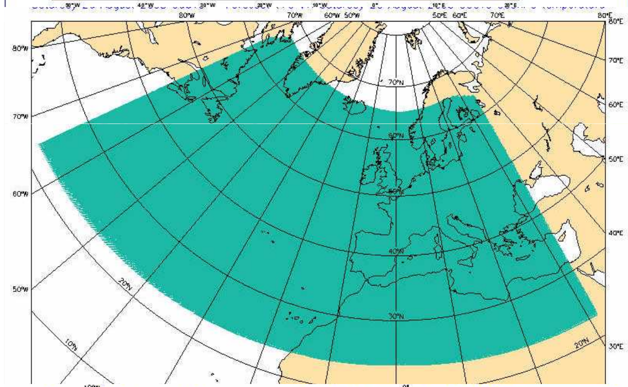
DWD
SRNWP-PEPS

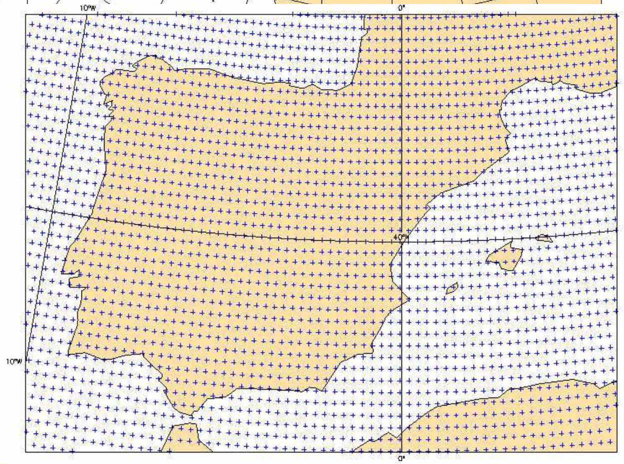
Ensemble mean

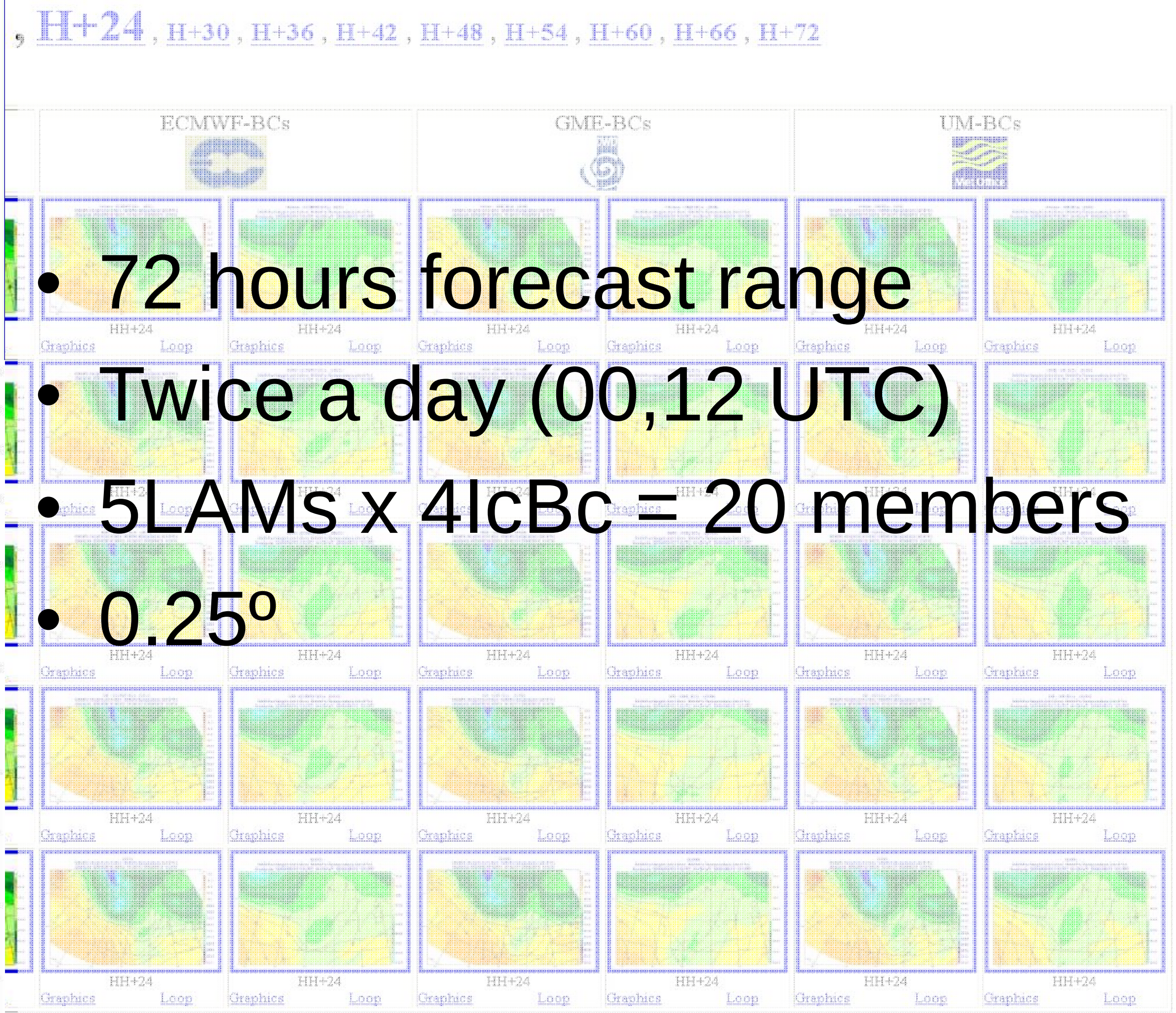


AEMET Multi-model LAM SREPS





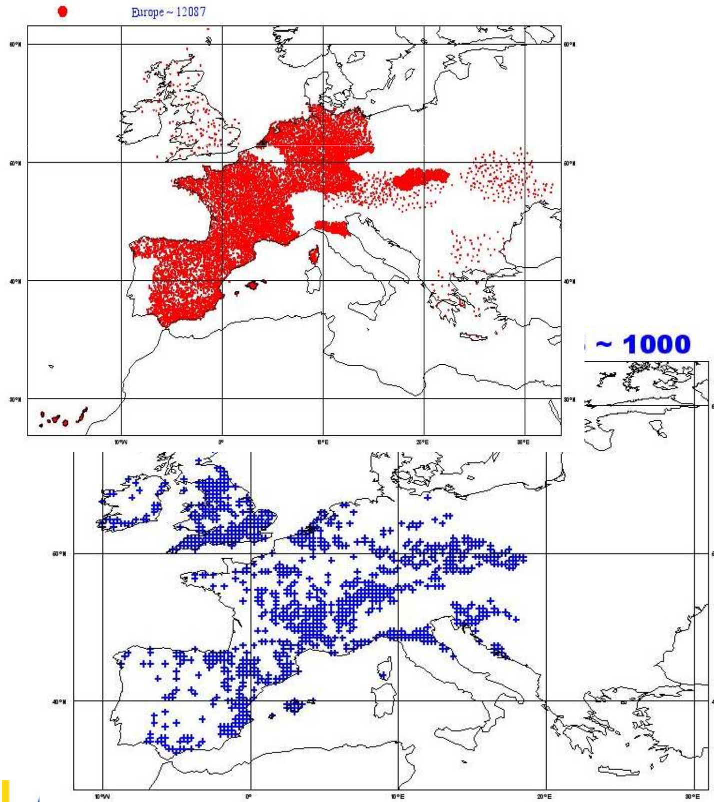


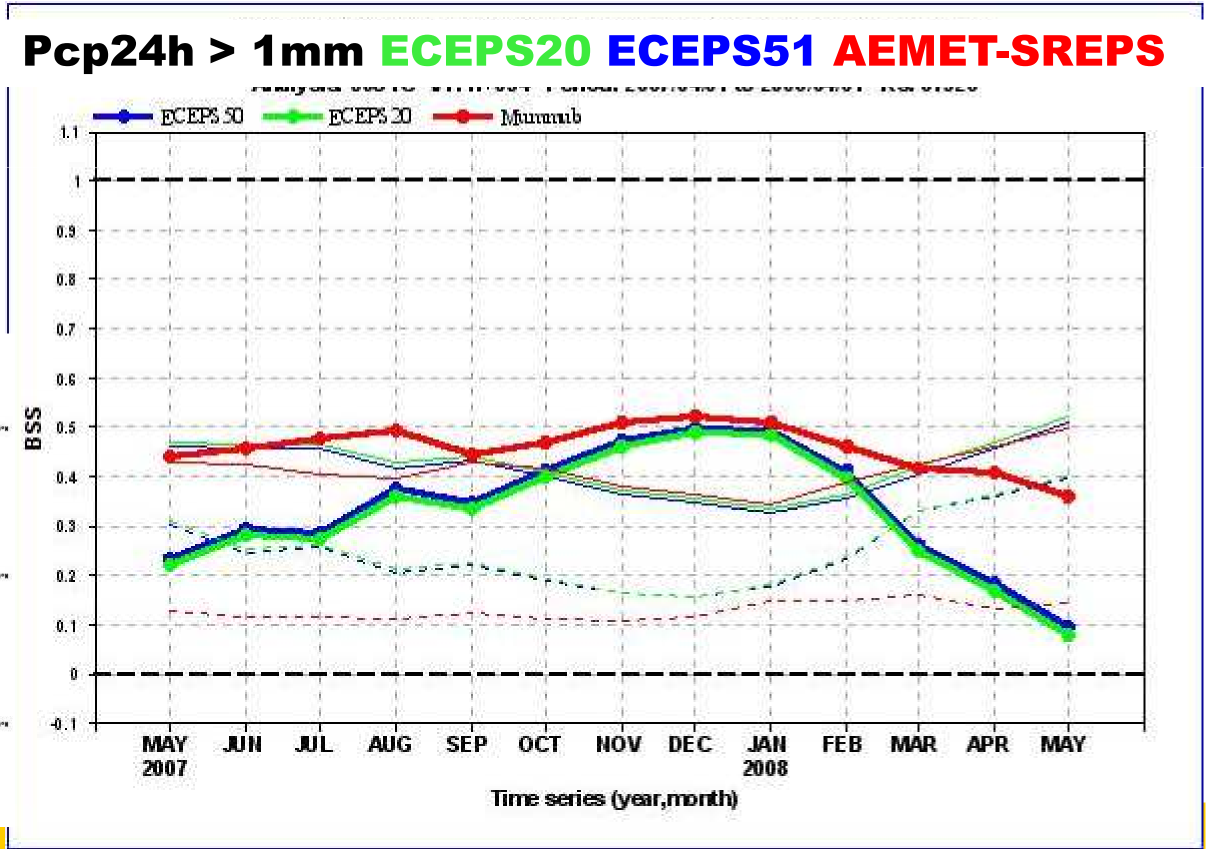


- 72 hours forecast range
- Twice a day (00,12 UTC)
- 5LAMs x 4IcBc = 20 members
- 0.25º

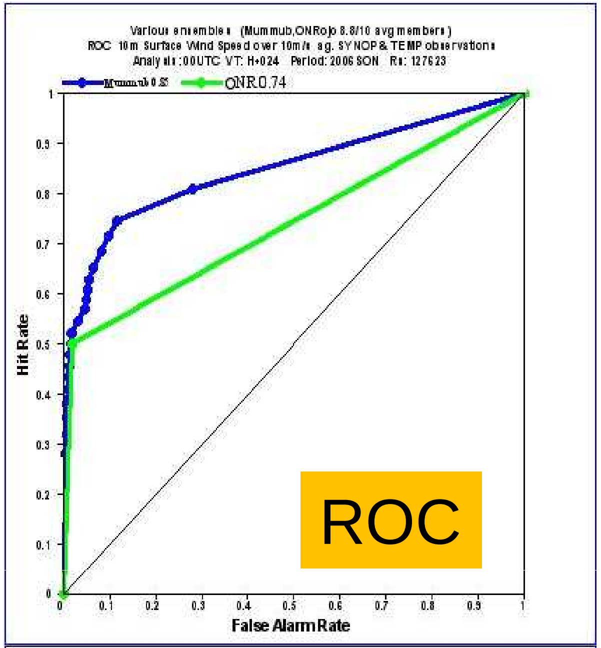
Added value w.r.t. ECMWF EPS

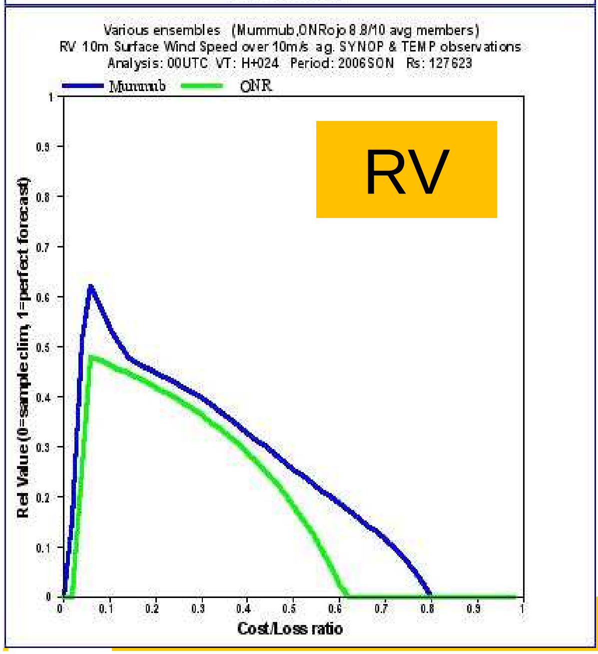
- SREPS covers the **SHORT RANGE**
- **Better performance** due to resolution and ensemble features: using pcp up-scaling over Europe and observational uncertainty method, SREPS shows better reliability, discrimination, etc.



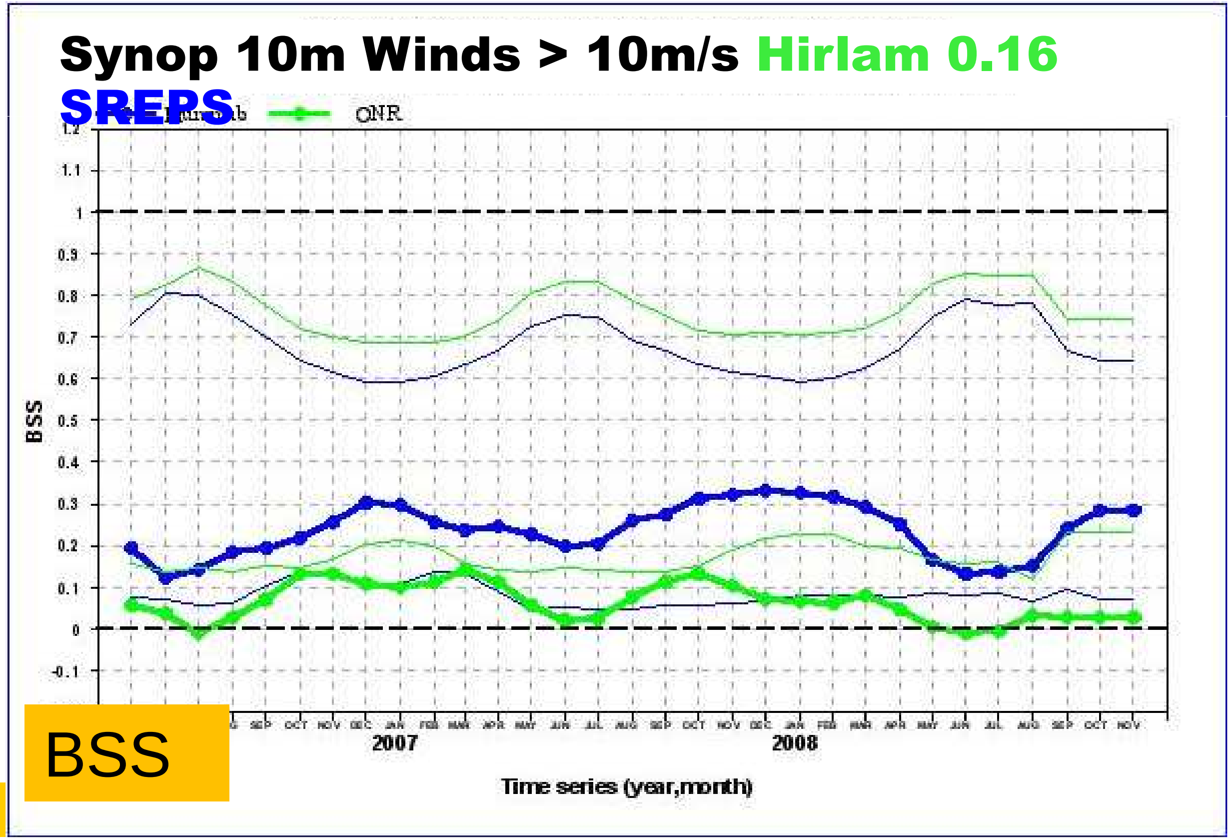


Added value w.r.t det. Hirlam





- Added value w.r.t. our deterministic model?
- SREPS purpose: **probabilistic forecasts**
- Better performance measures:
  - Better reliability & Resolution (BSS)
  - Better discrimination (ROC)
  - Higher relative Value (RV)



Collaboration

PRESENT STATUS

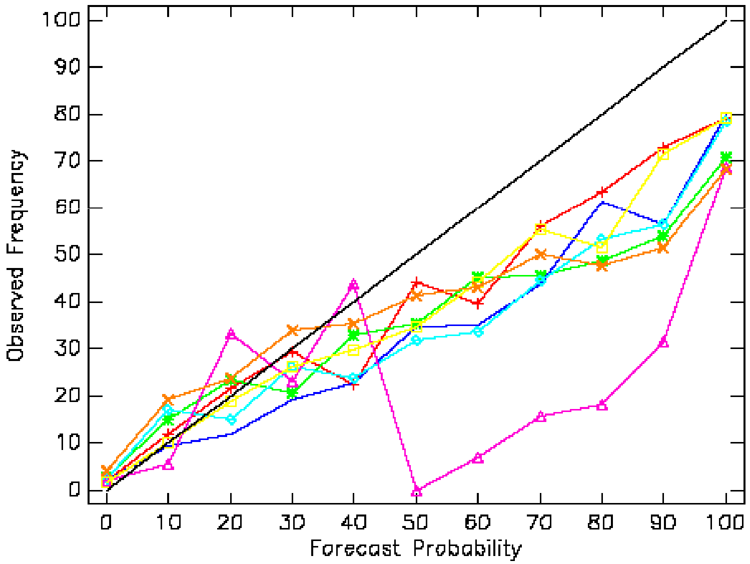
- Intercomparisons:
  - Preview
  - B08RDP
  - MAP D-PHASE
  - EurEPS (not started)
- Collaborations:
  - GLAMEPS (talk by T. Iversen)
  - AEMET-SREPS + COSMO
  - TIGGE-LAM!
- Review

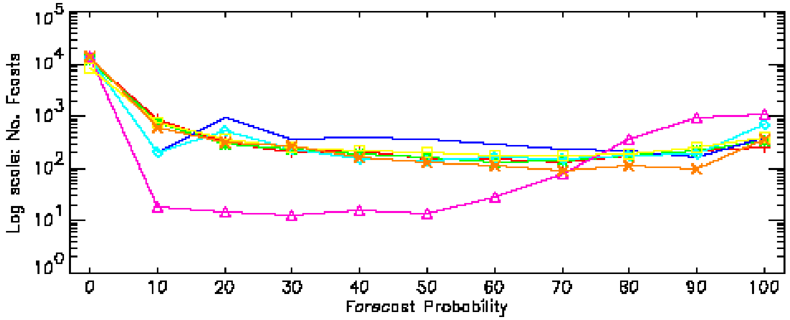
PREVIEW - Windstorm

Wind speed > 10m/s   +30-48h

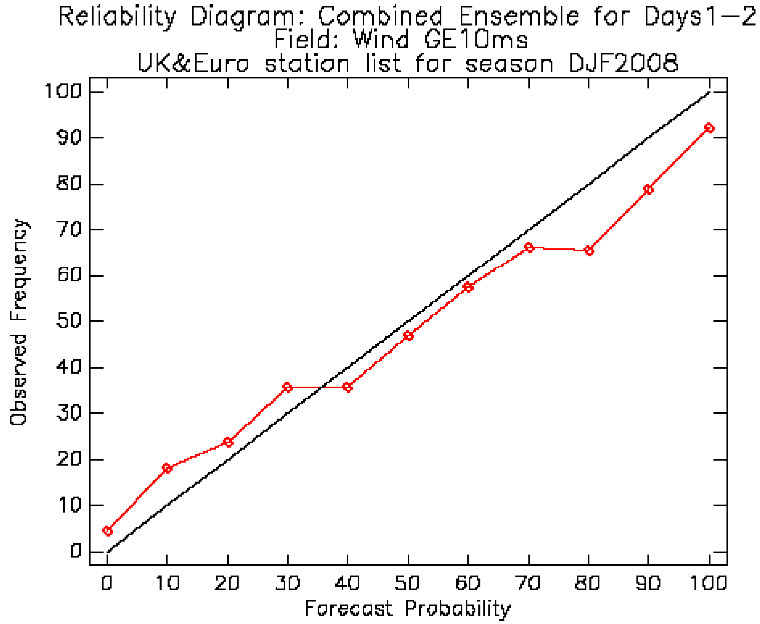
verifying at 1800UTC   DJF08

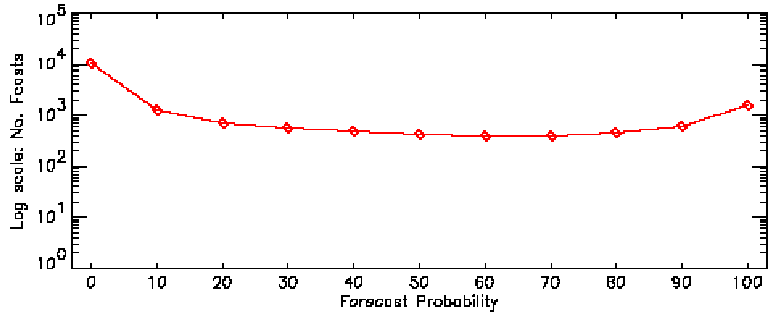
Fcast type			Reliability Score
EU	T+	36	0.00305275
GL	T+	30	0.00710127
FR	T+	48	0.00674122
IT	T+	30	0.00673237
GE	T+	30	0.0368281
NO	T+	48	0.00524987
EC	T+	30	0.00594657





Fcast type	Reliability Score
RAW	0.00360582

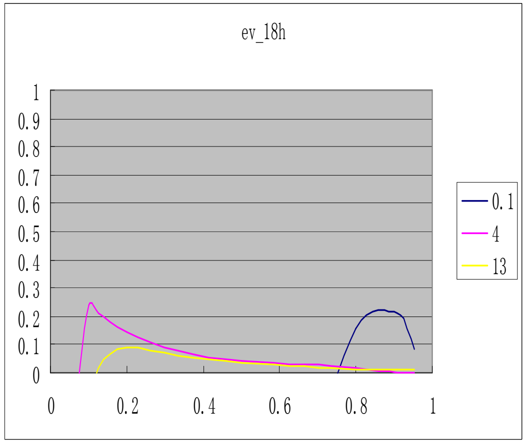




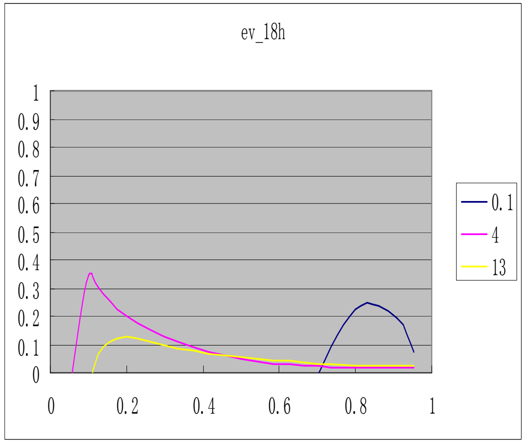
B08RDP

Economic Value For rainfall at 18h Forecasting (2008.7.1-2008.8.24)

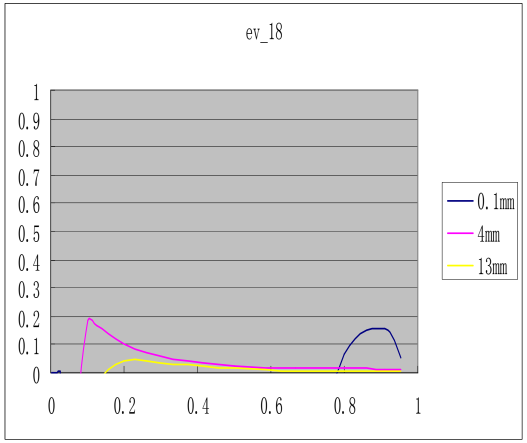
MRI/JMA



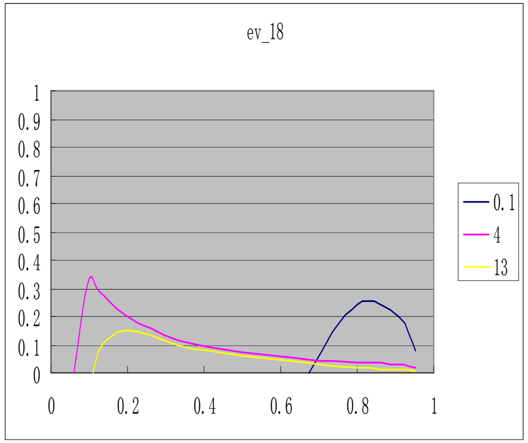
NMC



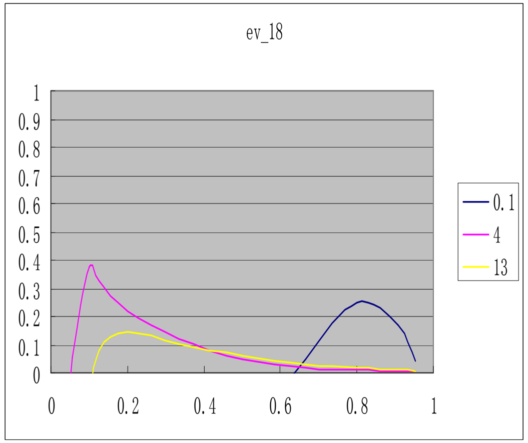
CAMS



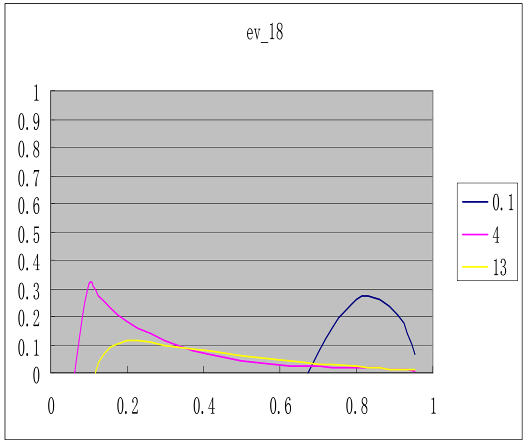
MSC



ZAMG

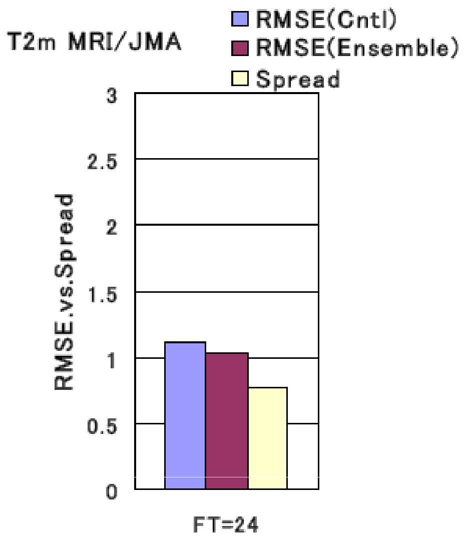


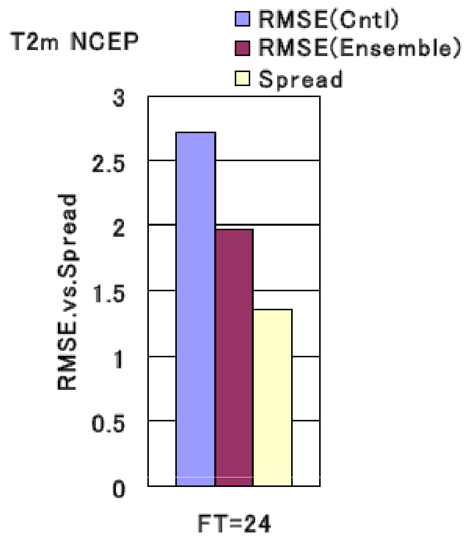
NCEP

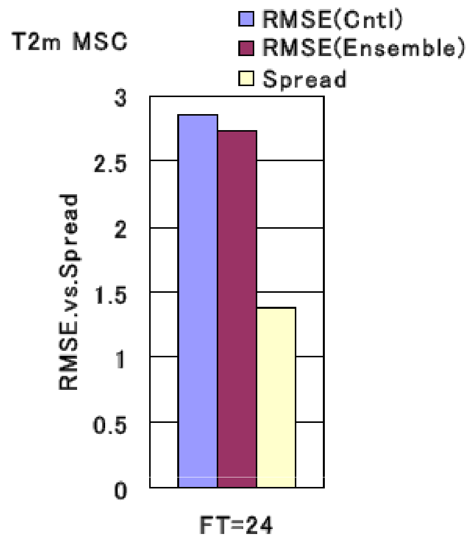


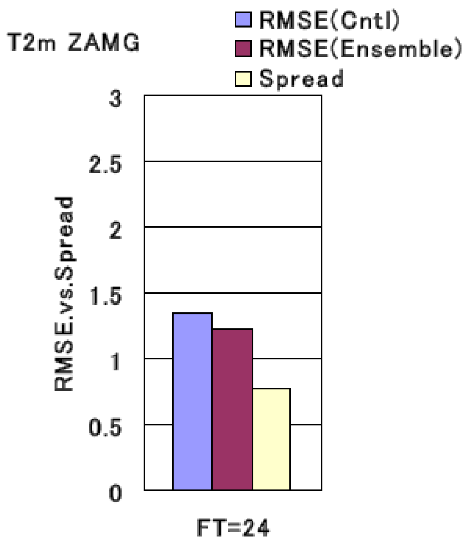
Rain rate: 0.1, 4, 13 mm

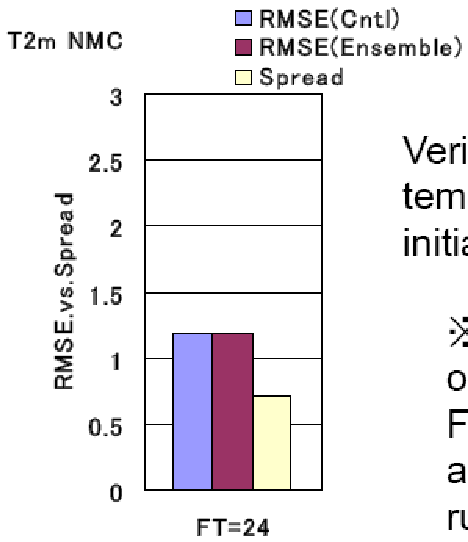
B08RDP







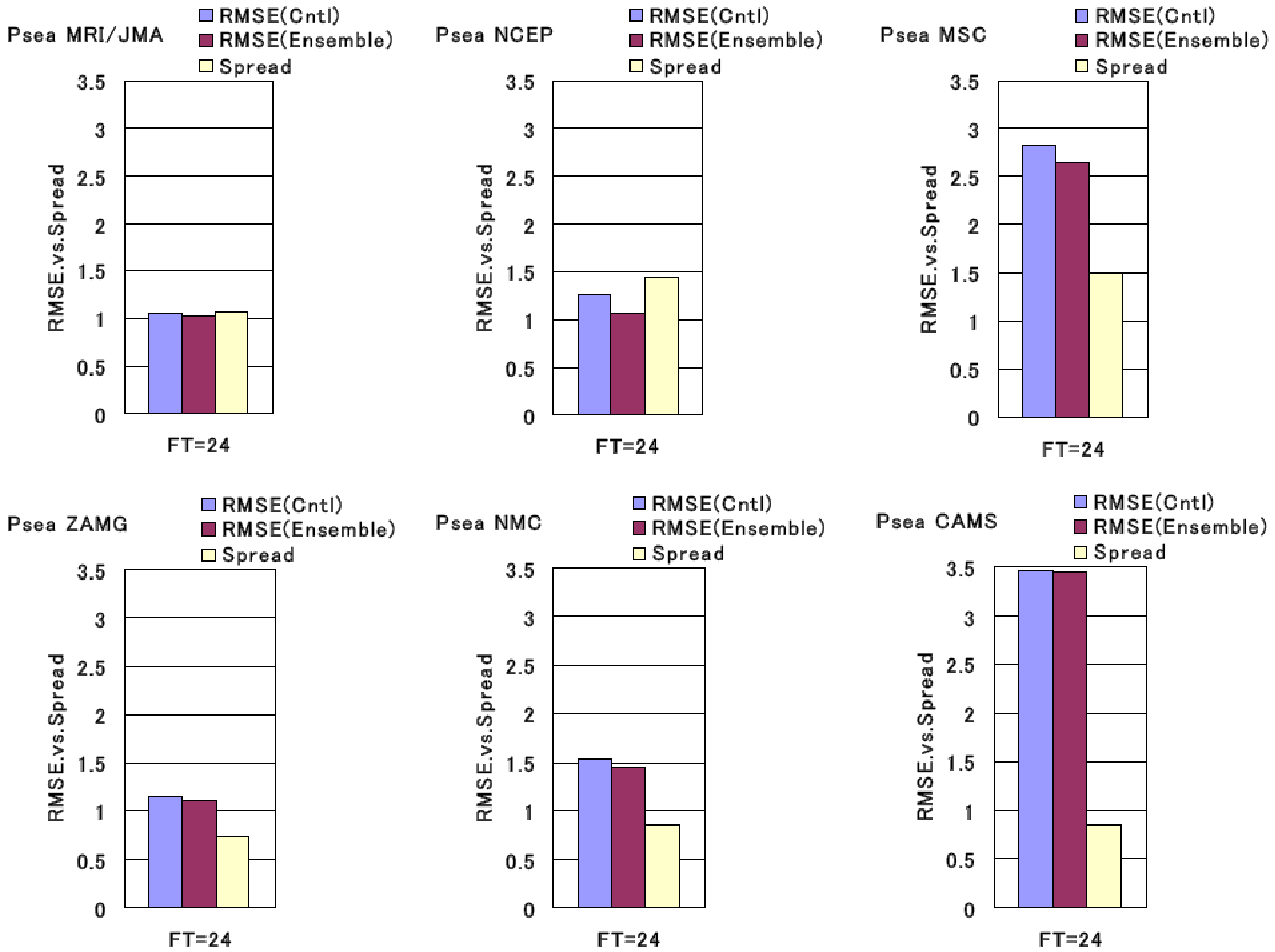




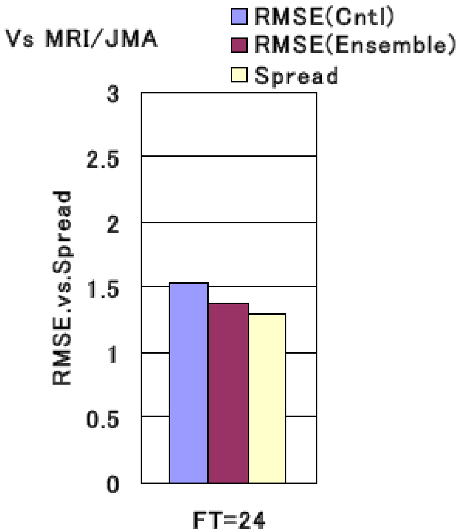
Verification of surface temperatures (T2m) against initial condition

※No FT=0 data in CAMS output
For MSC, member 21 was assumed as the control run

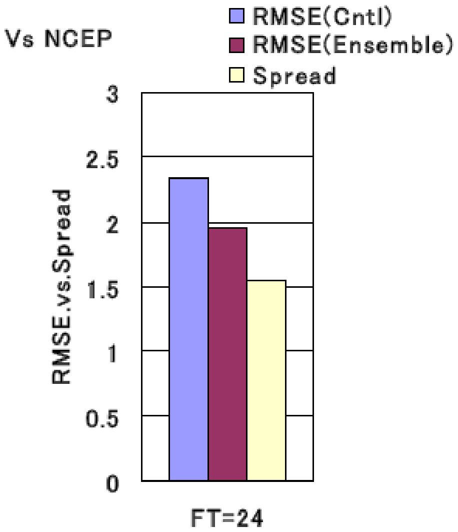
B08RDP


Psea MRI/JMA
RMSE(Cntl)
RMSE(Ensemble)
Spread
RMSE.vs.Spread
3.5
3
2.5
2
1.5
1
0.5
0
FT=24
Psea NCEP
RMSE(Cntl)
RMSE(Ensemble)
Spread
RMSE.vs.Spread
FT=24
Psea MSC
RMSE(Cntl)
RMSE(Ensemble)
Spread
RMSE.vs.Spread
FT=24
Psea ZAMG
RMSE(Cntl)
RMSE(Ensemble)
Spread
RMSE.vs.Spread
FT=24
Psea NMC
RMSE(Cntl)
RMSE(Ensemble)
Spread
RMSE.vs.Spread
FT=24
Psea CAMS
RMSE(Cntl)
RMSE(Ensemble)
Spread
RMSE.vs.Spread
FT=24

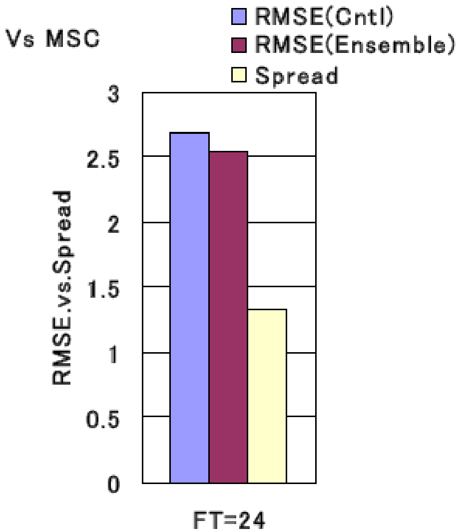
B08RDP



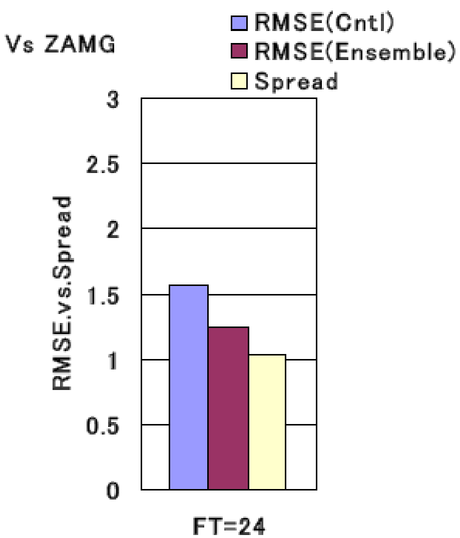
Vs MRI/JMA
RMSE(Cntl)
RMSE(Ensemble)
Spread
3
2.5
2
1.5
1
0.5
0
RMSE.vs.Spread
FT=24



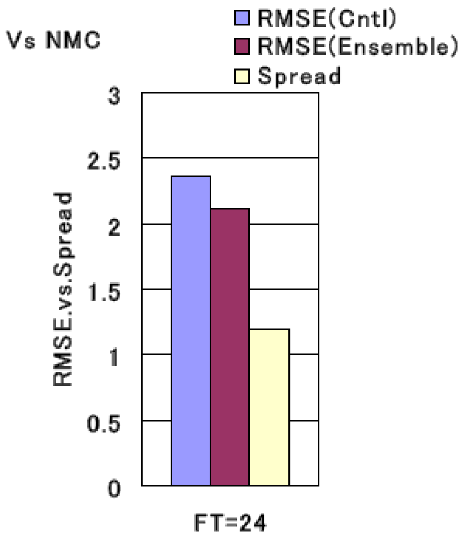
Vs NCEP
RMSE(Cntl)
RMSE(Ensemble)
Spread
3
2.5
2
1.5
1
0.5
0
RMSE.vs.Spread
FT=24



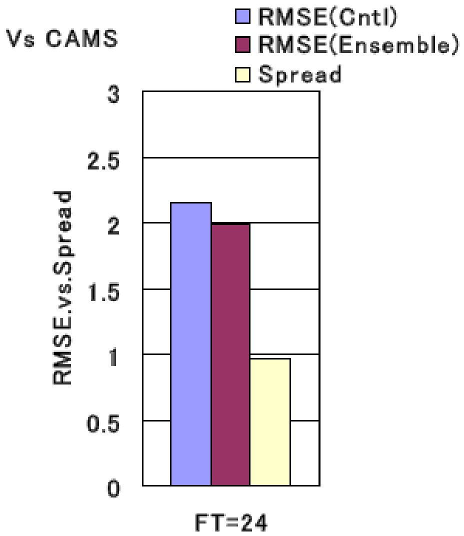
Vs MSC
RMSE(Cntl)
RMSE(Ensemble)
Spread
3
2.5
2
1.5
1
0.5
0
RMSE.vs.Spread
FT=24



Vs ZAMG
RMSE(Cntl)
RMSE(Ensemble)
Spread
3
2.5
2
1.5
1
0.5
0
RMSE.vs.Spread
FT=24



Vs NMC
RMSE(Cntl)
RMSE(Ensemble)
Spread
3
2.5
2
1.5
1
0.5
0
RMSE.vs.Spread
FT=24



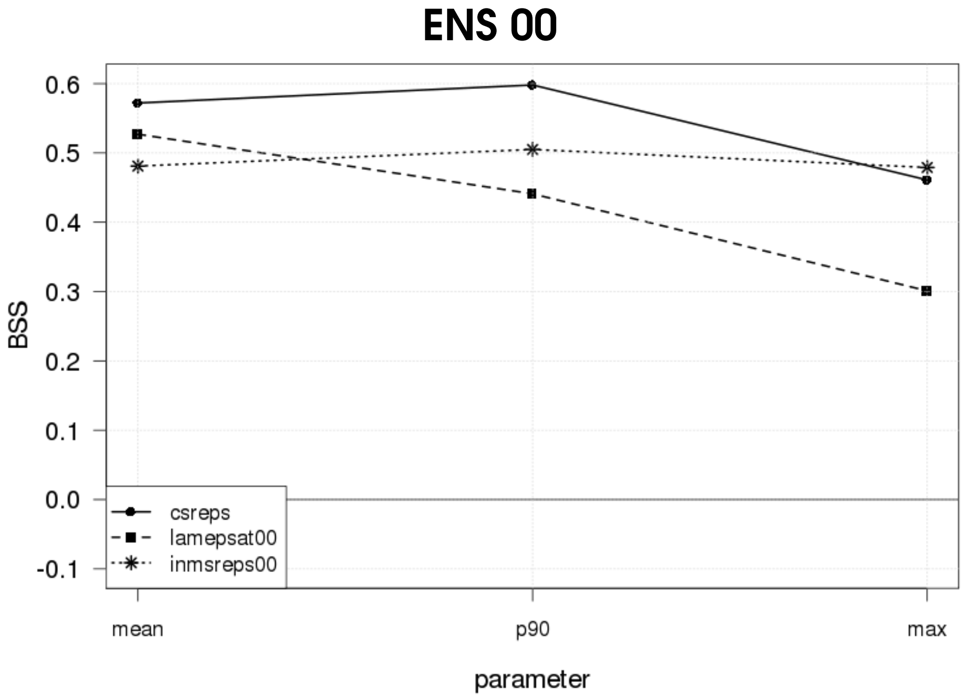
Vs CAMS
RMSE(Cntl)
RMSE(Ensemble)
Spread
3
2.5
2
1.5
1
0.5
0
RMSE.vs.Spread
FT=24

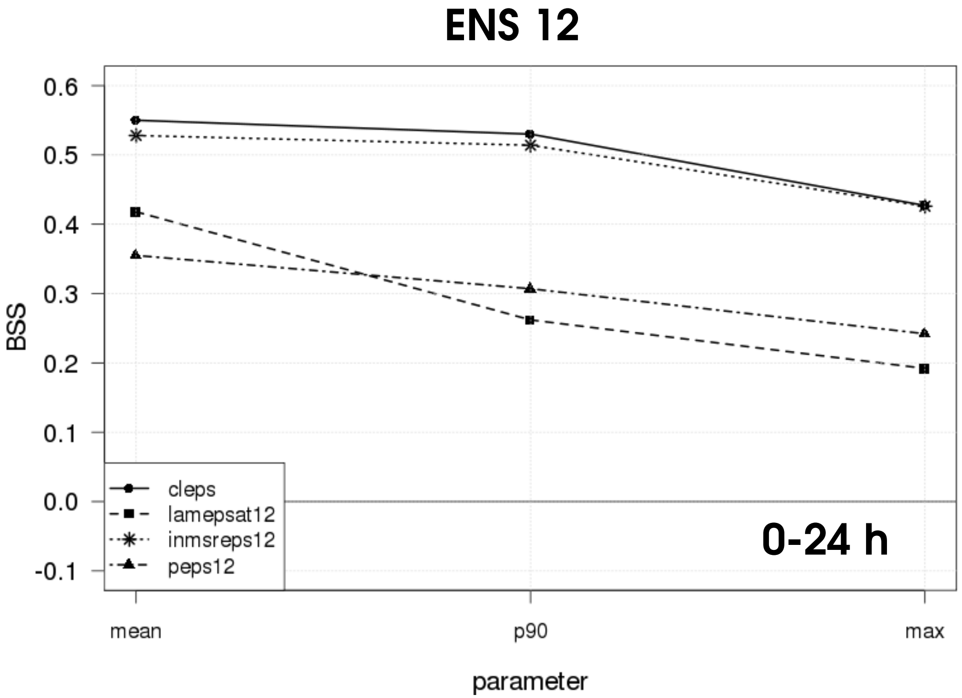
MAP D-PHASE ensemble intercomparison

- some LAM ensembles took part to the project
- data available for June-November 2007 (DOP)

BSS

boxes 1.0 – thr=5mm/24h





Connection with THORPEX-TIGGE

PRESENT STATUS

- TIGGE: used!
  - Meteo-France - PEARP
  - COSMO-LEPS multi-clustering
- TIGGE-LAM:
  - Starting the archive at ECMWF in 2 weeks
  - Proposal to have a common “gridded field” for precipitation (with SRNWP?)
  - Relocation of European systems
  - Strong link with SRNWP-I for IC and BC
  - Take advantage of the European intense activity on LAM ensemble to give answer to the scientific questions related to TIGGE-LAM
  - Scientific report about present status to provide some answers/hints/conclusions as a European contribution to TIGGE-LAM

AMARANTH

A paradigm of African resiliency to climate and weather extremes built through a multidisciplinary network and enhanced research capacity

LAM EPS for Africa

Submission of the AMARANTH proposal to the ACP Science & Technology Programme.

Applicant:

ARPA-SIMC Italy

Partners and Associates

Partner 1. Senegal Meteorological Agency: **ANAMS**
Partner 2. GAD Climate Predictions And Applications Centre:**ICPAC - Kenya**
Partner 3. African Centre for Meteorological Applications for Development :**ACMAD** Niger
Partner 4**.** Cameroon National meteorological Service:**NMS**
Partner 5 South African Weather Service: **SAWS**
Partner 6 Direction de la Météorologie Burkina Faso: **METEOBURKINA**
Partner 7 National meteorological Service of Guinea: **METEOGUINEA**
Partner 8 National Institute of Meteorology and Geophysics of Capeverde: **INMG**
Partner 9 Department of Water Resources of GAMBIA: **DWR**
Partner 10 National Meteorology Directorate of MALI**: METEOMALI**
Partner 11 World Meteorological Organization **WMO**
Partner 12 International Centre for Theoretical Physics **ICTP** Italy
Partner 13 Dipartimento di Ingegneria Civile e Ambientale, Università degli Studi di Firenze **DICEA- UNIFI -** Italy
Partner 14. Zentralanstalt fur Meteorologie und Geodynamic **ZAMG -** Austria
Partner 15 Niger river Basin Authority **NBA**
Associate 1 Centre for Australian Weather and Climate Research (CAWCR), Bureau of Meteorology **BOM** Australia
Associate 2 National Center for Atmospheric Research **NCAR** USA
Associate 3 National Center for Environmental Prediction **NCEP** USA

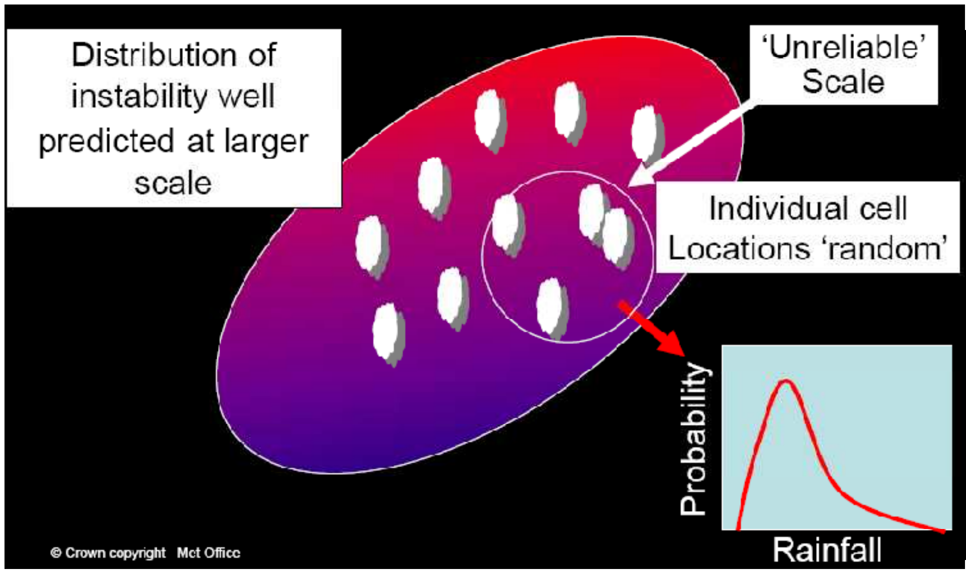
Convection-permitting

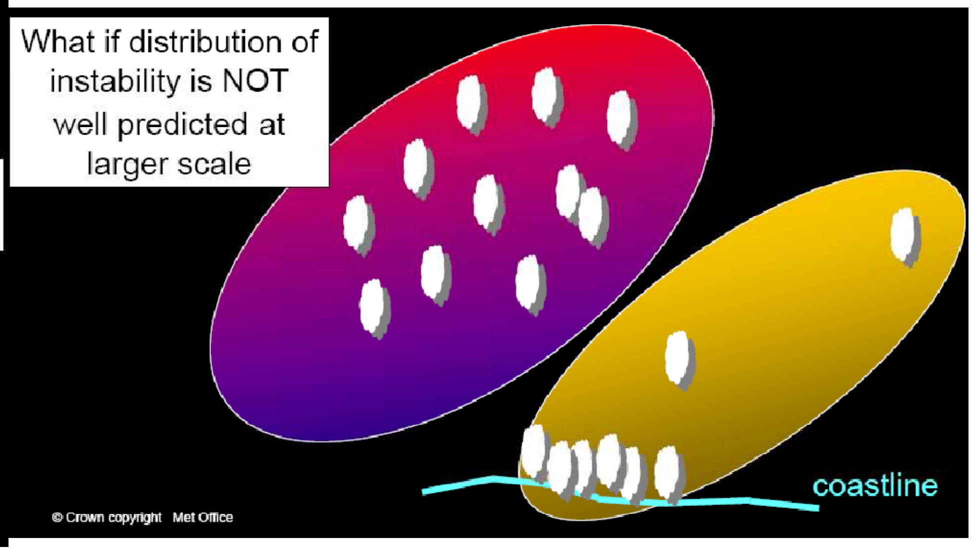
PRESENT STATUS

- COSMO-DE-EPS (talk by S. Theis)
- UKMO (1.5)
- Météo-France
- A look outside Europe: University of Oklahoma

Convection-permitting – UK 1.5km

- Develop a 1.5 km ‘downscale’ ensemble system
- Embed UKV forecasts in selected MOGREPS members
- Based on evidence that mesoscale uncertainty has the greatest impact on the accuracy of local weather forecasts
- Target: ~12 to 36 hours ahead
- Why? We should not believe high resolution at face value!





From N. Robert, IV SRNWP EPS WS (2009), Exeter (UK)

Convection-permitting – UK 1.5km

Met Office

- We must have a model that can explicitly represent convection
- Area of convective activity typically controlled by mesoscale dynamics and instability (PV anomalies, fronts, dry filaments etc)
- Local organisation (e.g. convergence due to topography) is predictable if mesoscale dynamics sufficiently correct
- Strong correlation between nested resolutions => capturing uncertainty in the mesoscale dynamics is crucial
- Selection required because it will only be possible to run a few members at 1.5 km. How to choose members?
- Demonstration system by 2012

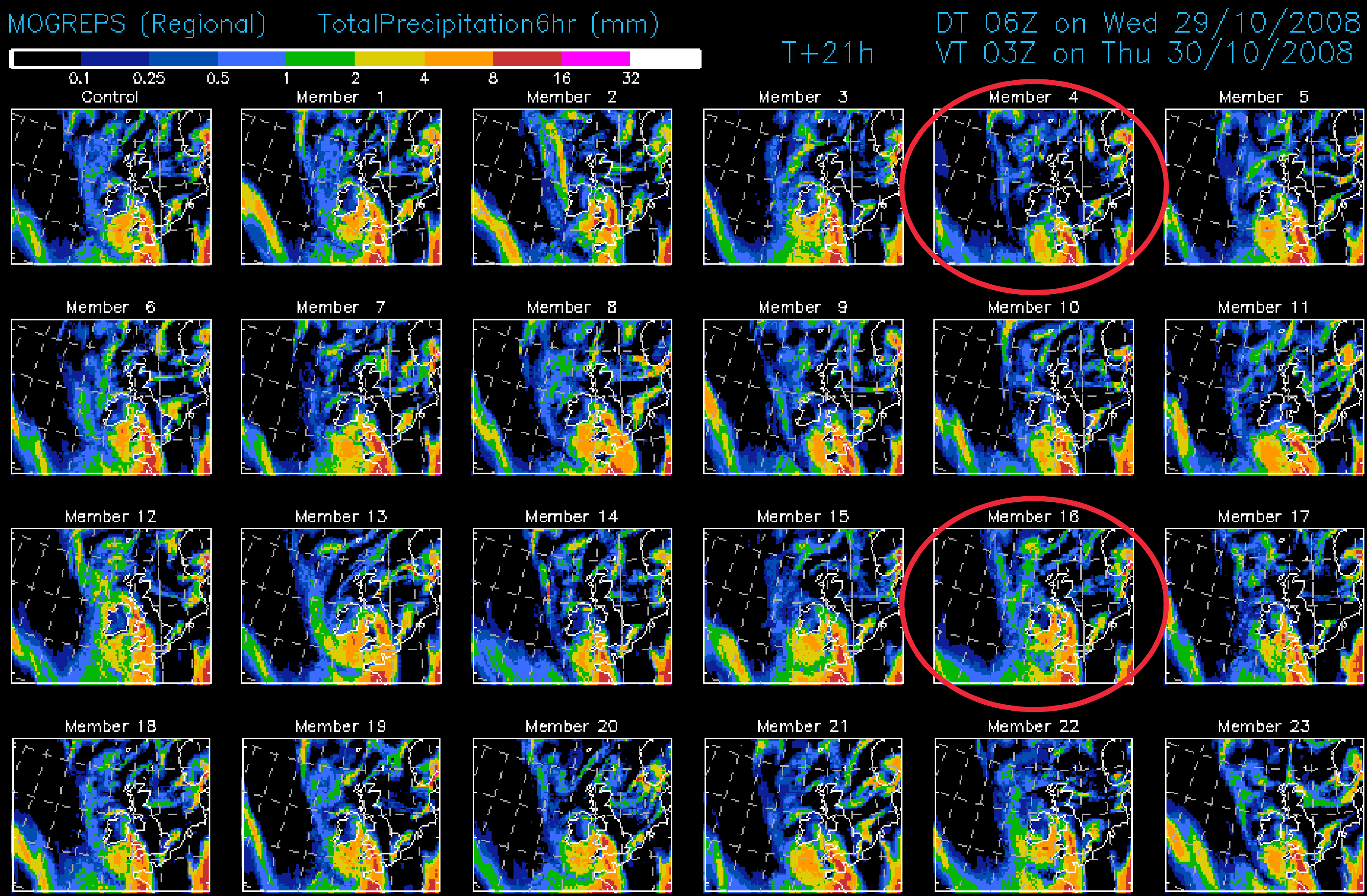
From N. Robert, IV SRNWP EPS WS (2009), Exeter (UK)

Met Office

MOGREPS (24km) 21-hour forecasts – Ottery case

Note variability in mesoscale rainfall patterns (e.g. difference between members 4 and 16)

NO ‘extreme’ rainfall amounts were predicted at this resolution

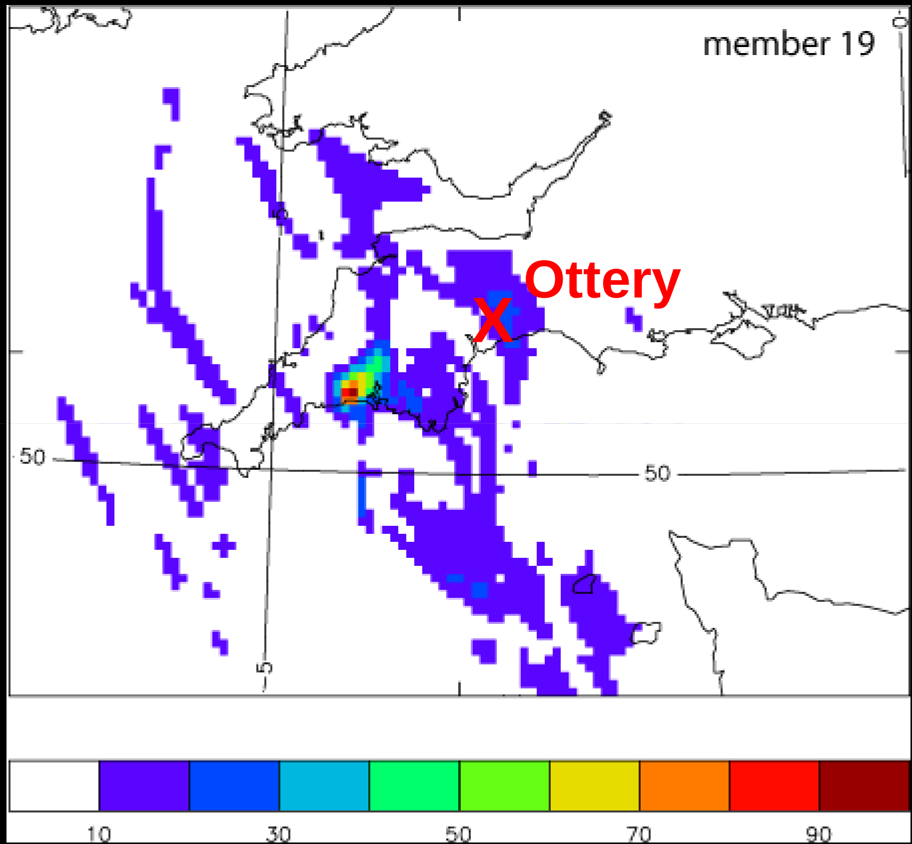


Courtesy of Caroline Jones

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



10 30 50 70 90 mm

Information presented here on 4.5 km grid

Calibration

PRESENT STATUS

- Calibration of high resolution ensembles, focus on precipitation
- COSMO-LEPS
  - F. Fundel (MeteoSwiss)
  - V. Stauch (MeteoSwiss)
  - T. Diomede (ARPA-SIMC)
- NORLAMEPS
- AEMET-SREPS (BMA)
- PEARP: reforecast + calibration planned

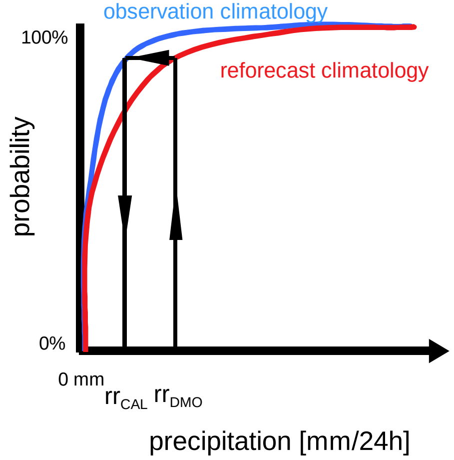
COSMO-LEPS calibration at MeteoSwiss

» CDF mapping with 30 years of reforecasts

precipitation

2m temperature

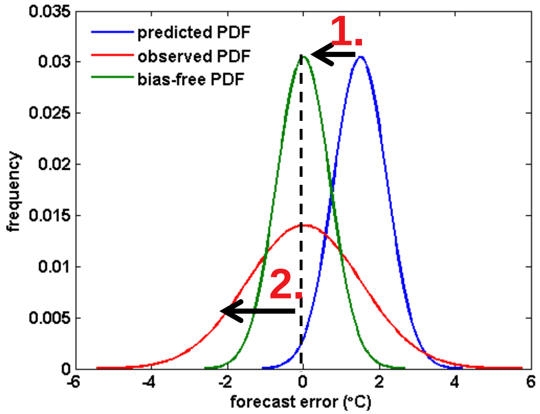
wind gusts



» combined Kalman filter for bias (1.) and spread (2.) calibration

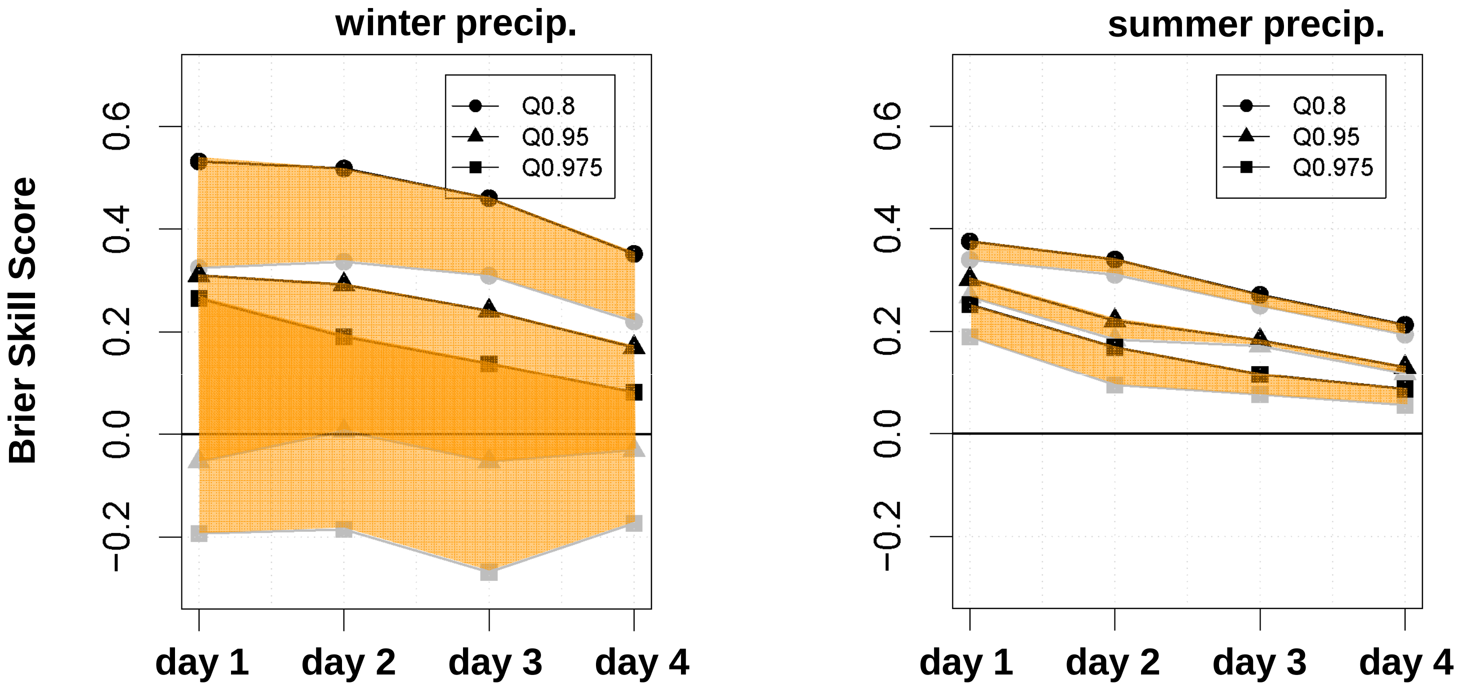
2m temperature

10 m wind speed



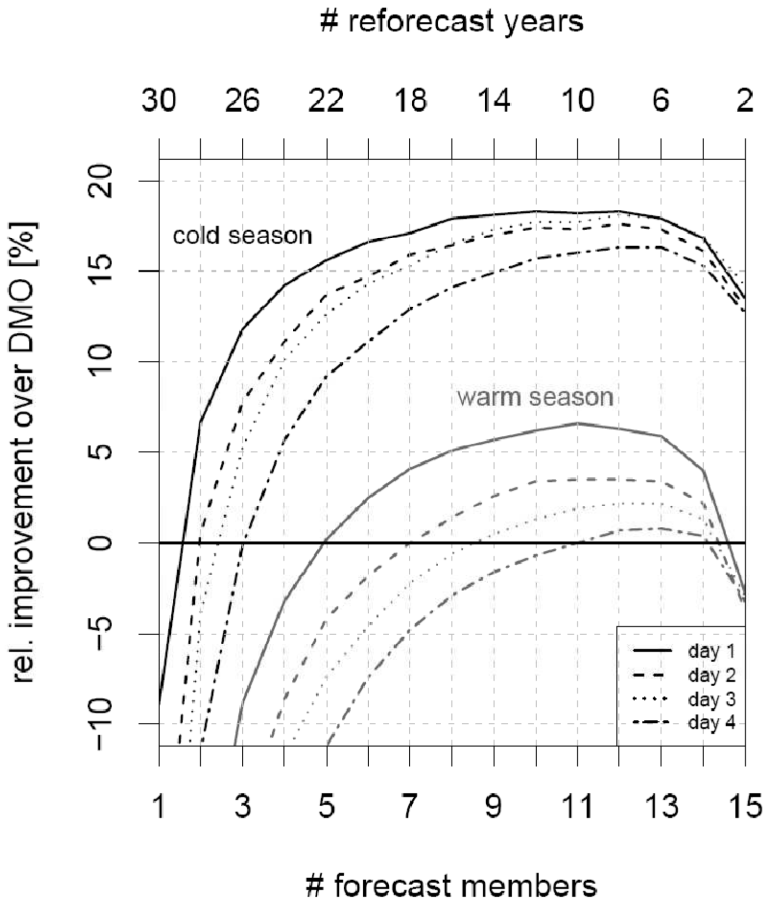
Calibration using reforecast

24h total precipitation over Switzerland



strong improvements in reliability by calibration with reforecasts
smaller improvements in summer (stochastic error)
but, reforecasts are expensive…

… without additional CPU costs



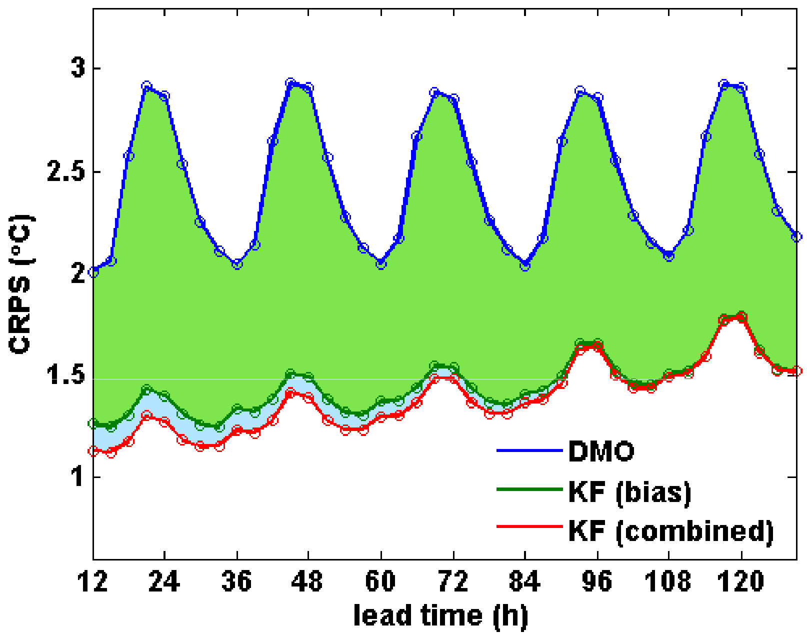
- RPS improvement compared to CLEPS DMO
- 24h total precipitation
- Switzerland
- Dec 2007 – Nov 2008

Strategy:
1. Reduce No. of ensemble members
2. Use free CPU time to calculate reforecasts
3. Calibrate with reforecast

Here:
Cost of 1 forecast member = Cost of 2 reforecasts

Also works for temperature forecasts!

Calibration with combined Kalman filter



verification with continuous ranked probability score (CRPS)

calibration of the bias has biggest impact

calibration of the spread further improves forecast by 5-10% in the first 3 forecast days

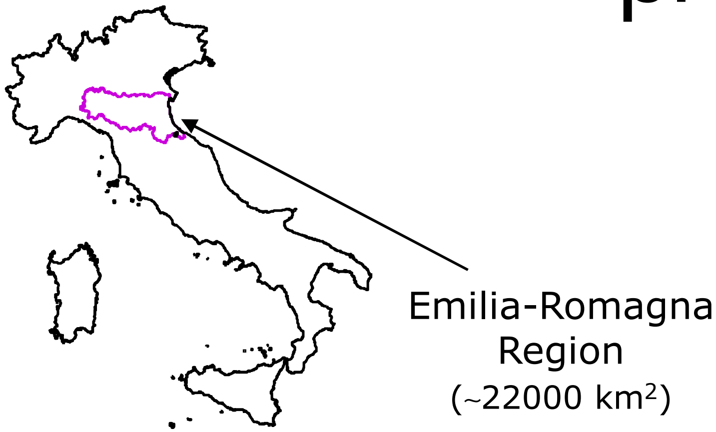
bias correction

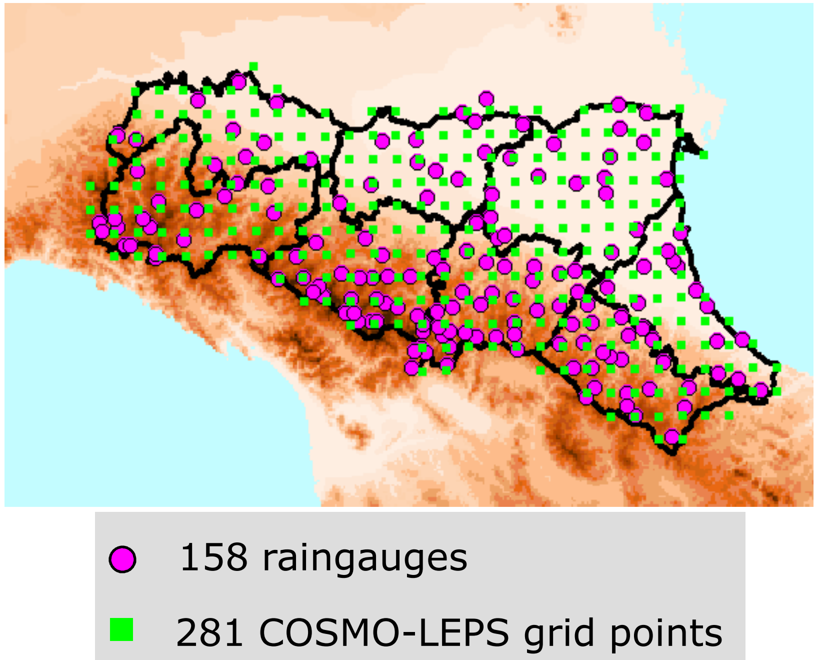
spread correction

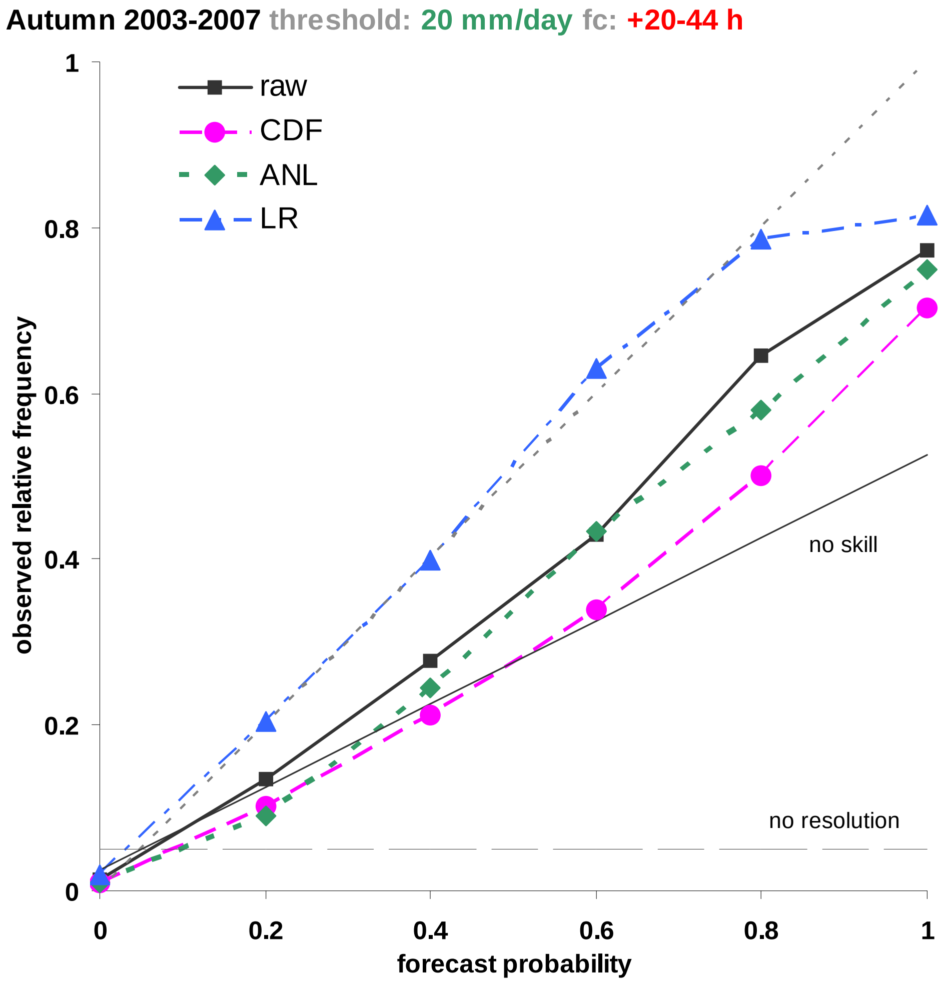
Calibration of COSMO-LEPS precipitation

- develop a methodology which enable a calibration of 24-h QPFs, not only of the probabilities of exceeding a threshold
- selected methods:
  - Cumulative Distribution Function (CDF) based
  - Linear Regression
  - Analogues: based on the similarity of forecast precipitation or circulation fields (30 years reforecast)

Calibration of COSMO-LEPS precipitation







threshold: 20 mm/24 h

Quality of (probabilistic) forecasts

A LONG-LASTING DISCUSSION …

- "It is an illusion to think that we could make good probabilistic forecasts with bad analyses and bad models!" (SRNWP WS 2005)
- This is easily recognised by the ensemble community, so much that sometimes it is not even mentioned! And we may give the wrong impression to think that "the more the perturbations, the better", regardless of the quality of the analysis/model and of the perturbations itself
- Indeed, representing the uncertainty means that we want to describe/include the stochastic part of the error, not the systematic part, which should be tackled by model development or, in the meanwhile, by post-processing (calibration)
- On the other hand, the need for parametrisation will not ease with increasing resolution, there will always be sub-grid processes and unresolved scales