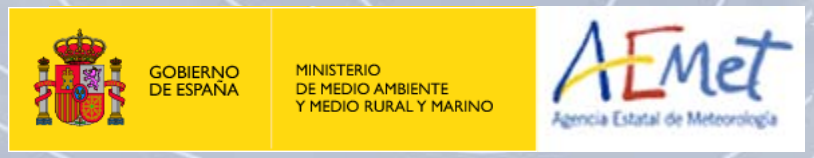


Performance and Calibration of a Short-Range Ensemble Prediction System over Europe

DANIEL SANTOS-MUÑOZ , ALFONS CALLADO, PAU ESCRIBÁ, JOSE A. GARCIA-MOYA, CARLOS SANTOS AND JUAN SIMARRO.

AEMET Predictability Group

The Ninth WRF Users' Workshop

23-27 June 2008 in Boulder, CO

INTRODUCTION

- Multimodel short-range ensemble prediction systems have been tested at NCEP (Hamill and Colucci, 1997, 1998; Stensrud et al., 1999; Du and Tracton, 2001, Wandishin et al., 2001) also by a research community during Storm and Mesoscale Ensemble Experiment (SAMEX, Hou et al., 2001) an also over the Pacific North West (Grimit and Mass, 2002) and over the Northeast (Jones et al., 2007) of the United States

- A combined multimodel multianalisys technique has been part of the operational NCEP´s production suite (Du and Tracton, 2001) and the main idea of the University of Washington SREPS (Grimit and Mass, 2002)

- AEMET is producing probabilistic forecasts by means of a short range multimodel multianalysis ensemble (AEMet-SREPS former INM-SREPS)

AEMet-SREPS

- SREPS is multi-model multi-analysis system
- The system is running twice a day at 00 and 12 UTC with 72-hours forecast lead time

GFS IFS GME UM

HIRLAM

HRM

MM5

UM

COSMO

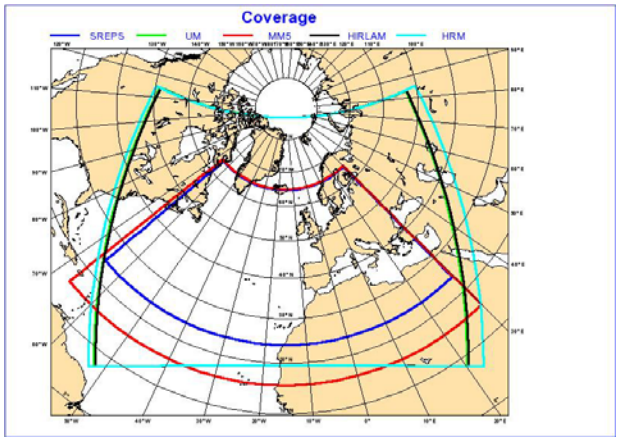
5 LAM

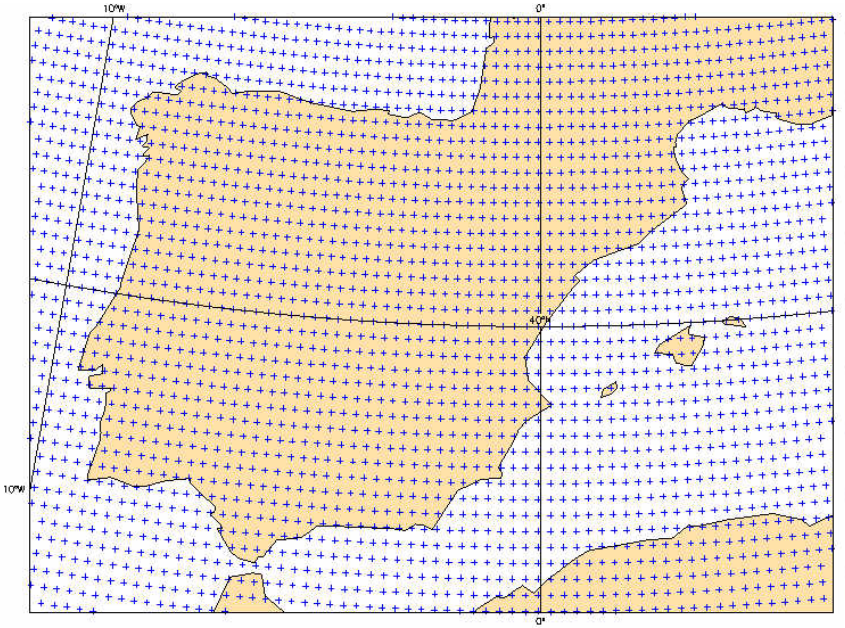
4 IC´s & BC´s from Global models

20 ensemble members

AEMet-SREPS

- 0.25 º horizontal resolution and 40 vertical levels
- Model output is codified in GRIB





SREPS EXPERIMENTAL PRODUCTS

- **Run: D-7, 12UTC , H+00 , H+06 , H+12 , H+18 , H+24 , H+30 , H+36 , H+42 , H+48 , H+54 , H+60 , H+66 , H+72**
  MSL Pressure & 6h Accumulated Precipitation
  Models X Boundaries

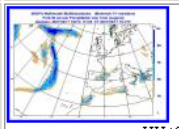
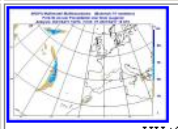
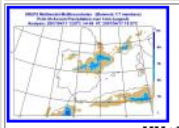
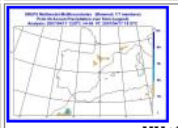
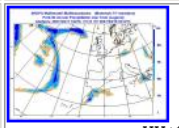
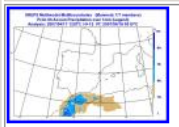
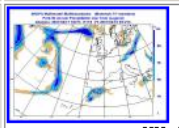
Models / Boundaries	GFS-BCs (NCEP)		ECMWF-BCs		GME-BCs (DWD)		UM-BCs (Met Office)	
Hirlam	HH+24 Graphics Loop	HH+24 Graphics Loop	HH+24 Graphics Loop	HH+24 Graphics Loop	HH+24 Graphics Loop	HH+24 Graphics Loop	HH+24 Graphics Loop	HH+24 Graphics Loop
HRM (DWD)	HH+24 Graphics Loop	HH+24 Graphics Loop	HH+24 Graphics Loop	HH+24 Graphics Loop	HH+24 Graphics Loop	HH+24 Graphics Loop	HH+24 Graphics Loop	HH+24 Graphics Loop
MM5 Community Model	HH+24 Graphics Loop	HH+24 Graphics Loop	HH+24 Graphics Loop	HH+24 Graphics Loop	HH+24 Graphics Loop	HH+24 Graphics Loop	HH+24 Graphics Loop	HH+24 Graphics Loop
UM (Met Office)	HH+24 Graphics Loop	HH+24 Graphics Loop	HH+24 Graphics Loop	HH+24 Graphics Loop	HH+24 Graphics Loop	HH+24 Graphics Loop	HH+24 Graphics Loop	HH+24 Graphics Loop
LM (DWD)	HH+24 Graphics Loop	HH+24 Graphics Loop	HH+24 Graphics Loop	HH+24 Graphics Loop	HH+24 Graphics Loop	HH+24 Graphics Loop	HH+24 Graphics Loop	HH+24 Graphics Loop

SREPS EXPERIMENTAL PRODUCTS

- E

2.

Probability Maps
6h Accumulated Precipitation
Forecast range (HH+06..HH+72) X Thresholds (1,5,10,20)

Last run forecast length	Thresholds: 1	5	10	20
06	 HH+06 Graphics Loop	 HH+06 Graphics Loop	 HH+06 Graphics Loop	 HH+06 Graphics Loop
	 HH+06 Graphics Loop	 HH+06 Graphics Loop	 HH+06 Graphics Loop	 HH+06 Graphics Loop
12	 HH+12 Graphics Loop	 HH+12 Graphics Loop	 HH+12 Graphics Loop	 HH+12 Graphics Loop
	 HH+12 Graphics Loop	 HH+12 Graphics Loop	 HH+12 Graphics Loop	 HH+12 Graphics Loop
18	 HH+18 Graphics Loop	 HH+18 Graphics Loop	 HH+18 Graphics Loop	 HH+18 Graphics Loop

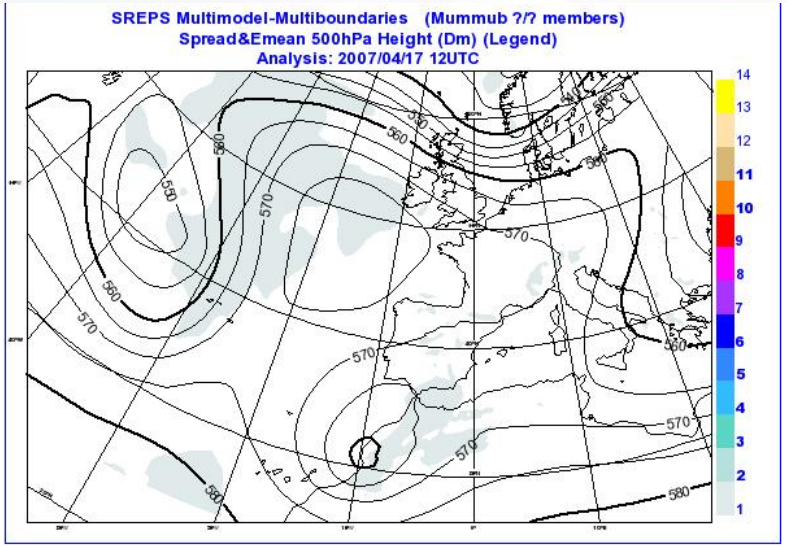
SREPS EXPERIMENTAL PRODUCTS

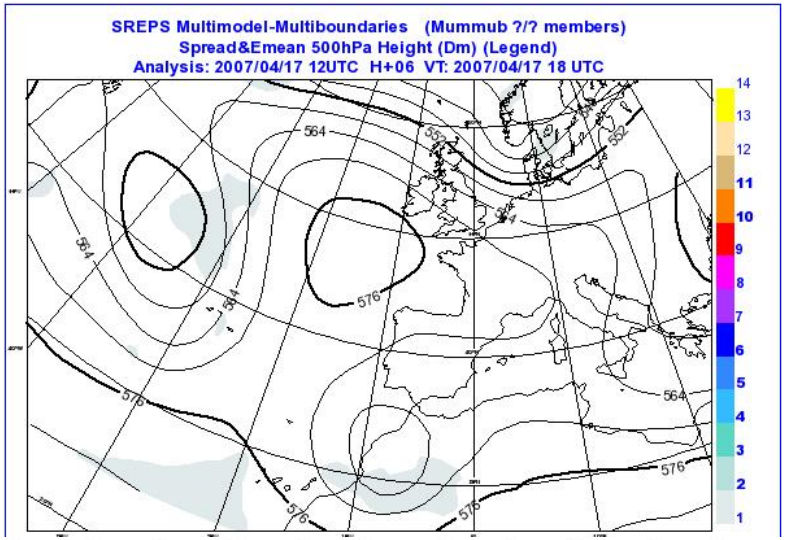
- EXPERIMEN ntranet):

3. Spread & E

- 500 hPa

- MSL Pr



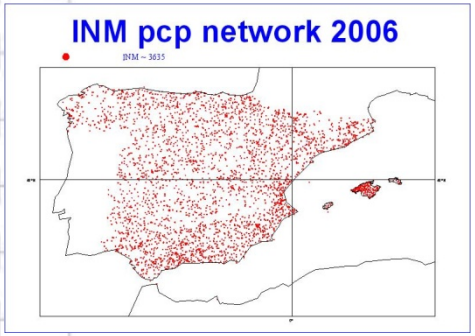


SREPS PERFORMANCE

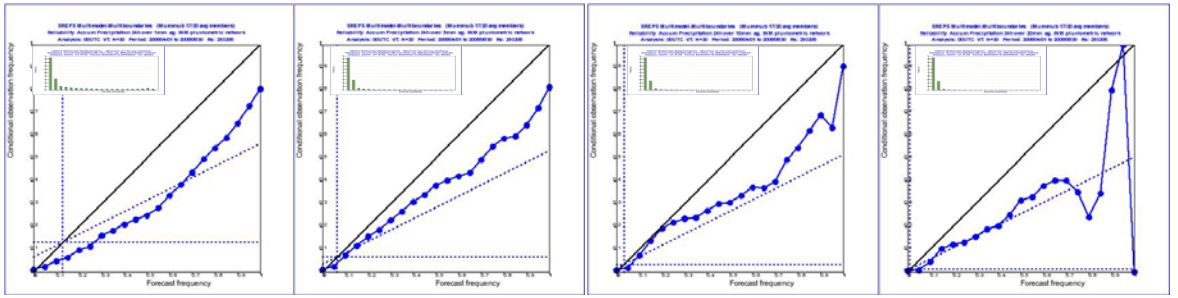
- 24h accumulated precipitation forecast 06UTC-06UTC against observed 07UTC-07UTC
  - Checked in HH+030 and HH+054
  - 90 days (Apr1 to Jun30 2006)
  - References:
  - INM network
  - European network
- Verification method
  - Interpolation to observation points
- Verification software
  - ~ ECMWF Metview + Local developments
- Performance scores
  - ECMWF recommendations

SREPS PERFORMANCE

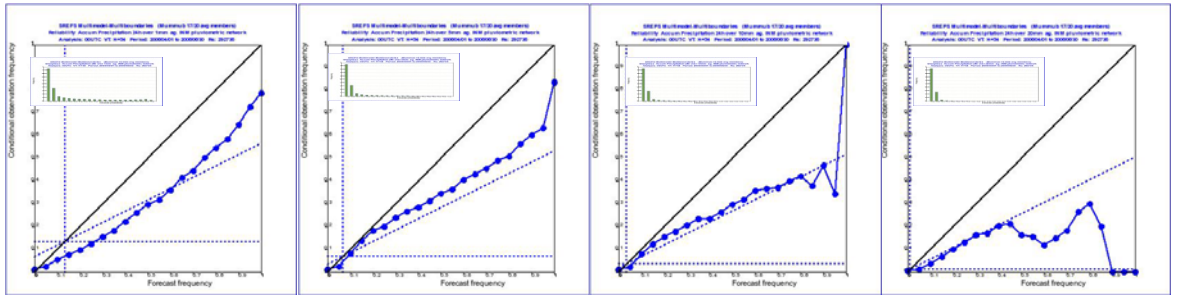
>=1mm >=5mm >=10mm >=20mm

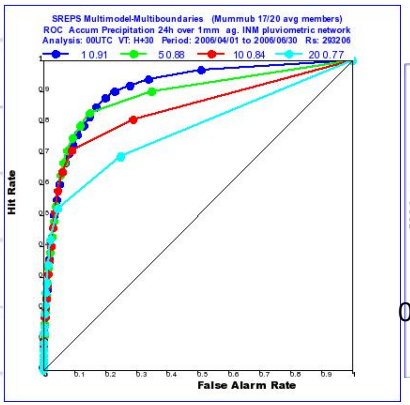


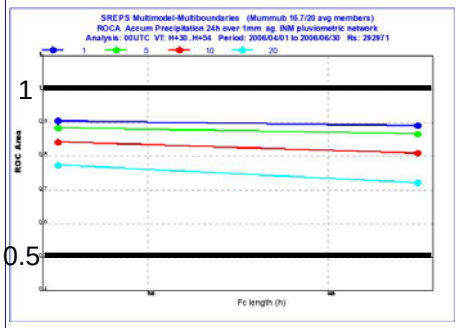
HH+30

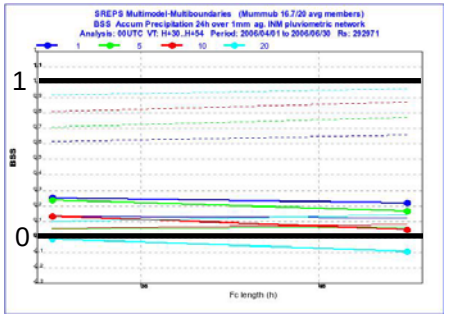


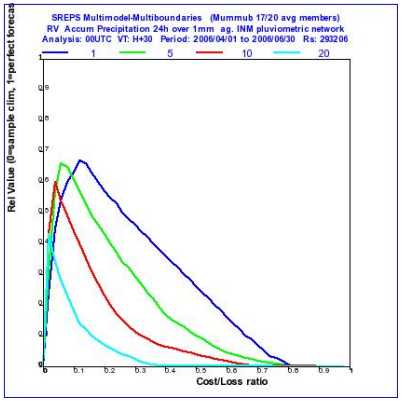
HH+54





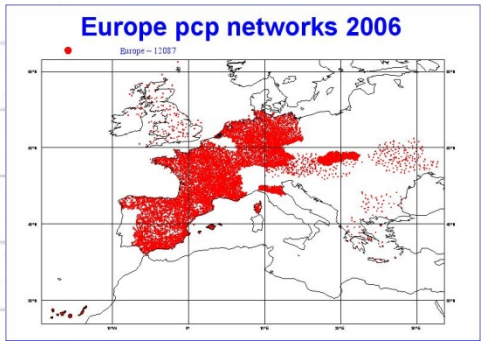






ROC ROCA BSS Relative Value

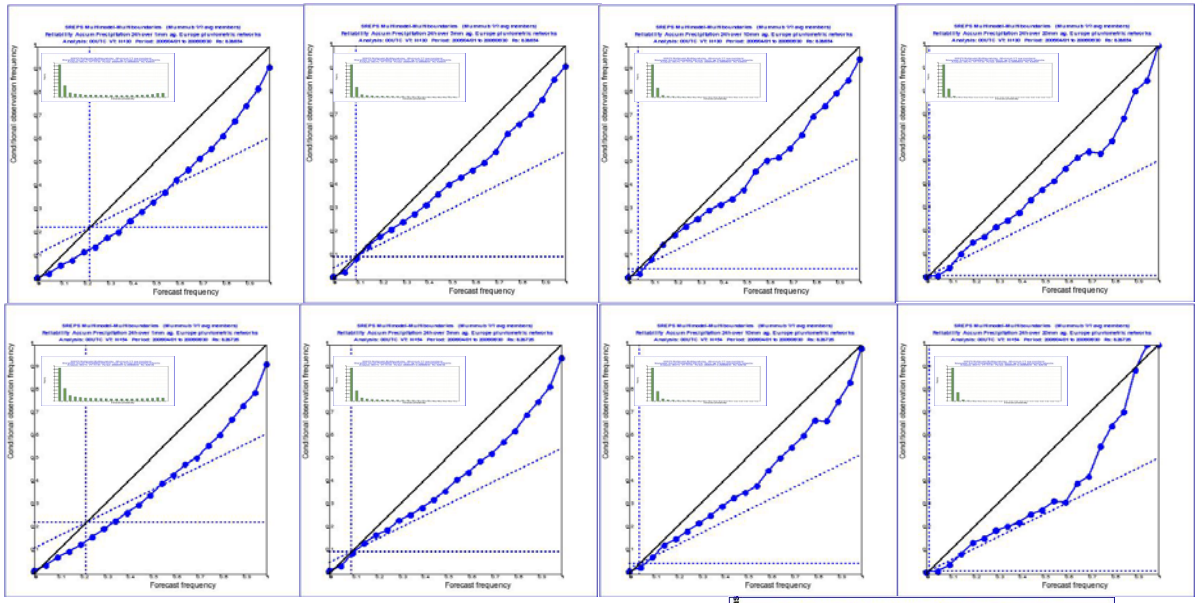
SREPS PERFORMANCE

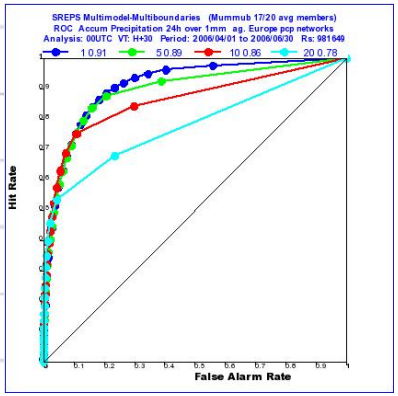


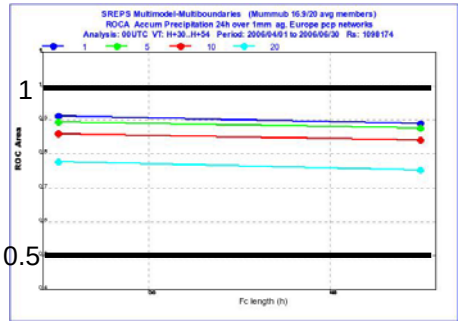
HH+30

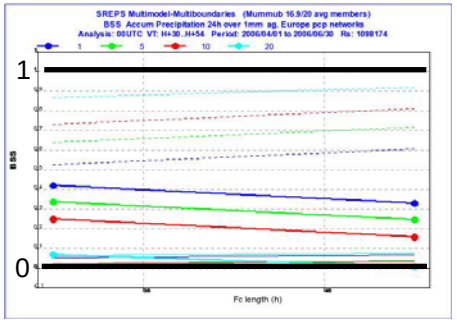
HH+54

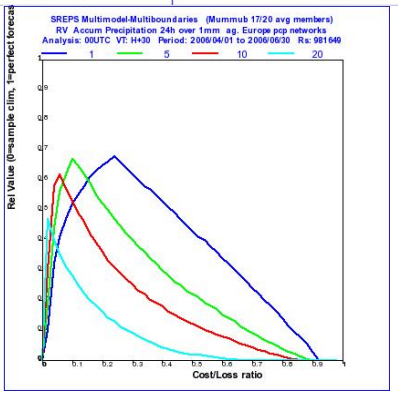
>=1mm >=5mm >=10mm >=20mm







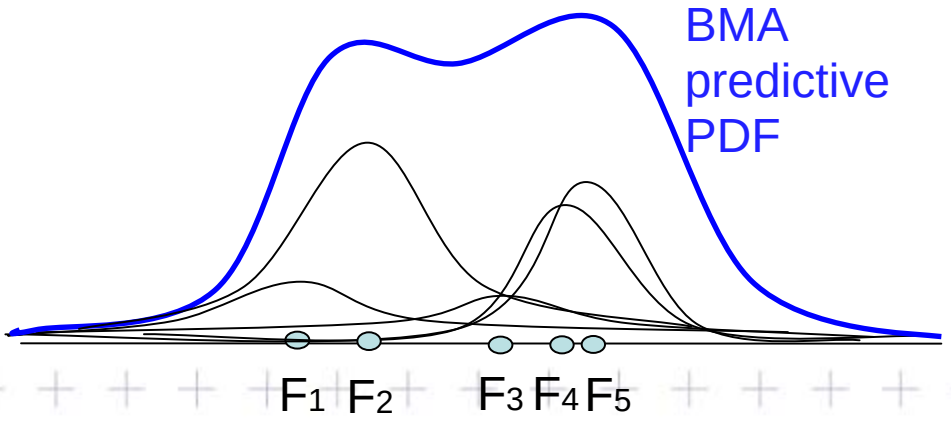




ROC ROCA BSS Relative Value

SREPS CALIBRATION

- Bayesian Model Averaging technique has been tested trying to improve the SREPS performance.
- The BMA predictive PDF of any quantity of interest is a weighted average of PDFs centered on the individual bias-corrected forecasts, where the weights are equal to posterior probabilities of the models generating the forecasts and reflect the models' relative contributions to predictive skill over the training period (Raftery et al, 2005).



BMA CALIBRATION EXERCISE

- BMA calibration:
  500 hPa Temperature (T500)
  500 hPa Geopotencial (Z500)

  - 3, 5 and 10 days of training period
  - 3 months of calibration (April, May and June of 2006)
  - 24, 48 and 72 hours forecast

  10m Wind speed (S10m)

  - 3, 5, 10 and 25 days of training period
  - 1 month for S10m (April 2006)
  - 24, 48 and 72 hours forecast

- BMA calibration using TEMP and SYNOP observations over whole area

SREPS CALIBRATION

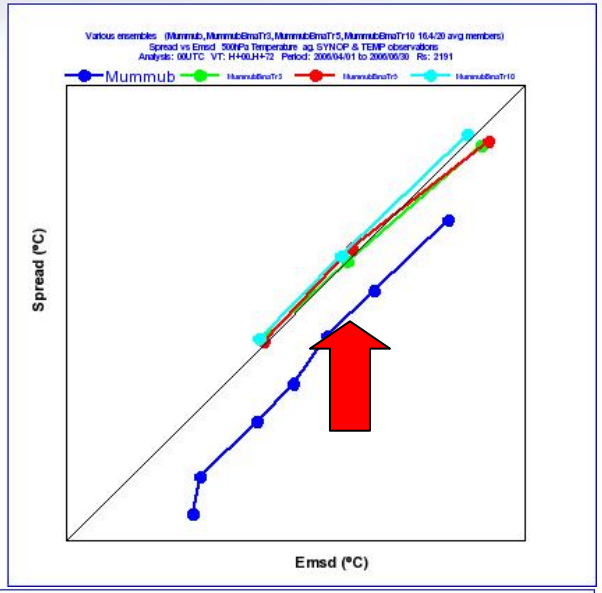
- T500

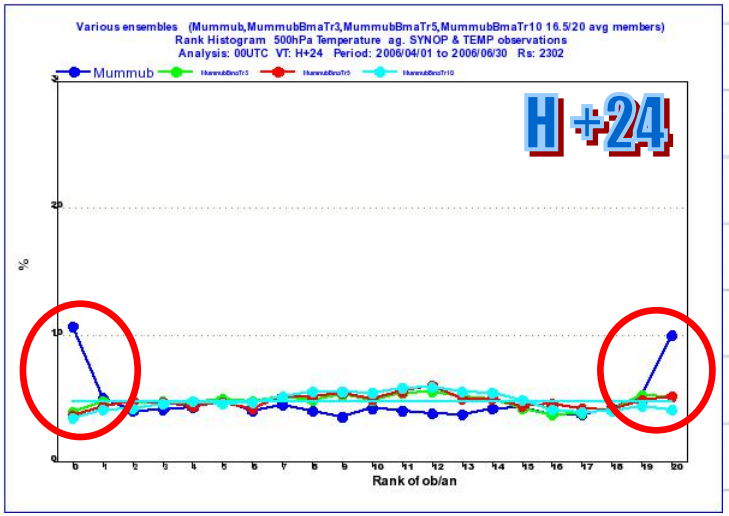
MULTIMODEL

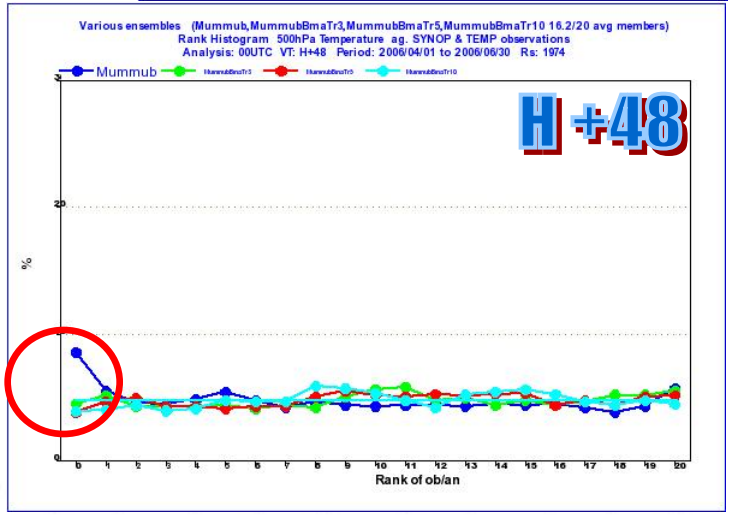
BMA 3 T. DAYS

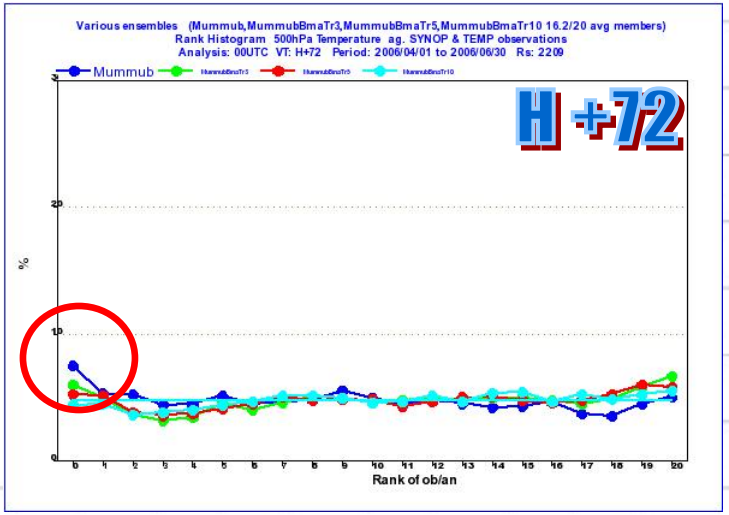
BMA 5 T. DAYS

BMA 10 T. DAYS









SREPS CALIBRATION

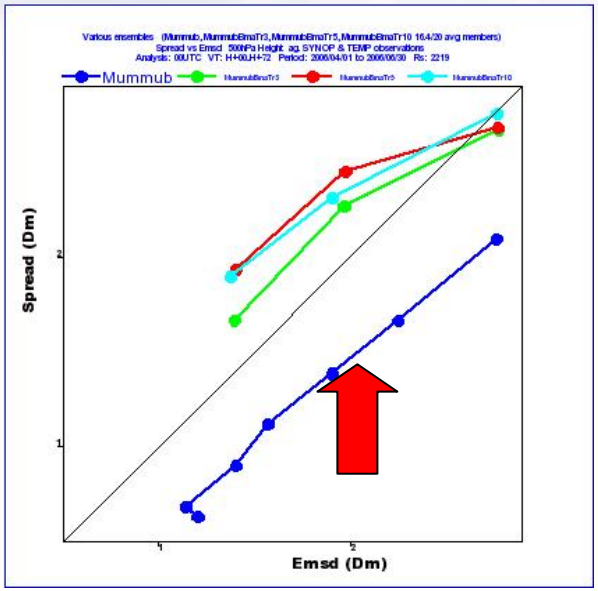
- Z500

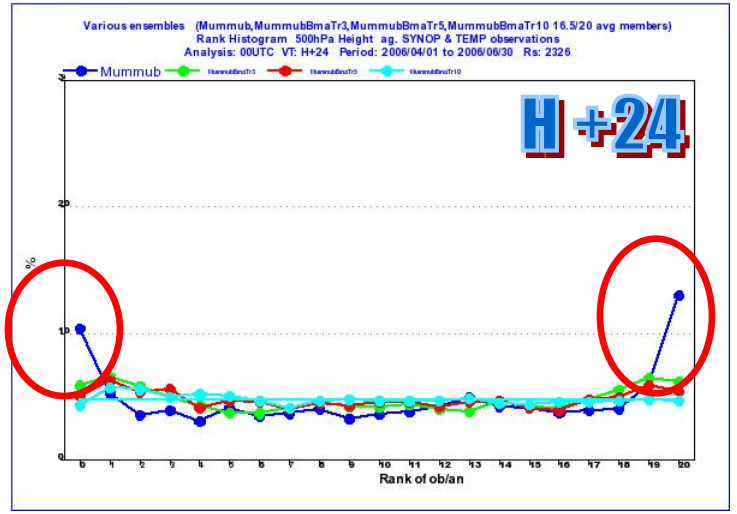
MULTIMODEL

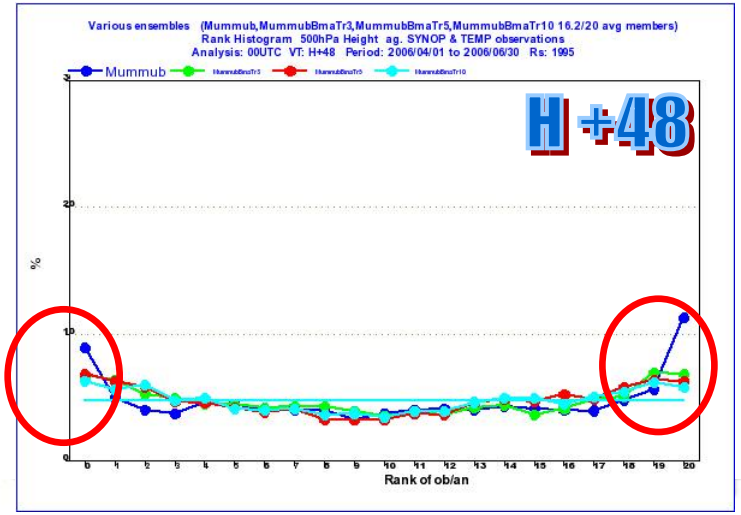
BMA 3 T. DAYS

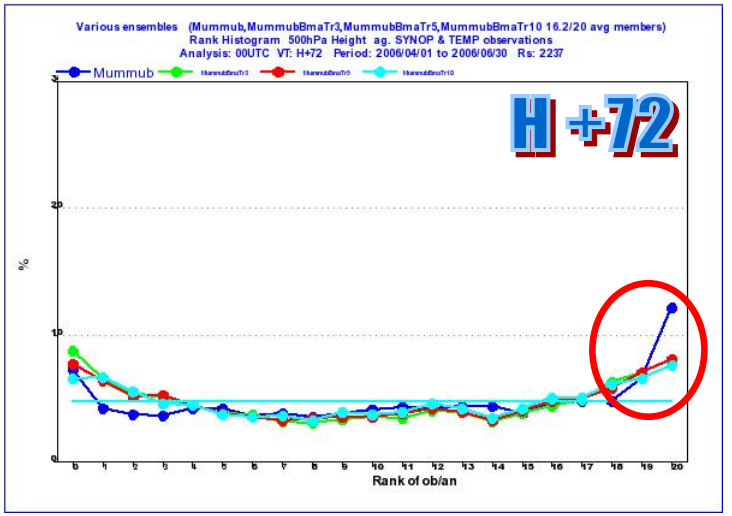
BMA 5 T. DAYS

BMA 10 T. DAYS









SREPS CALIBRATION

- 10m Wind Speed

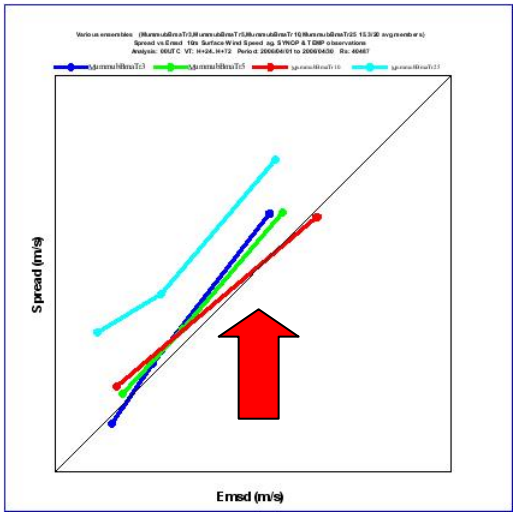
MULTIMODEL

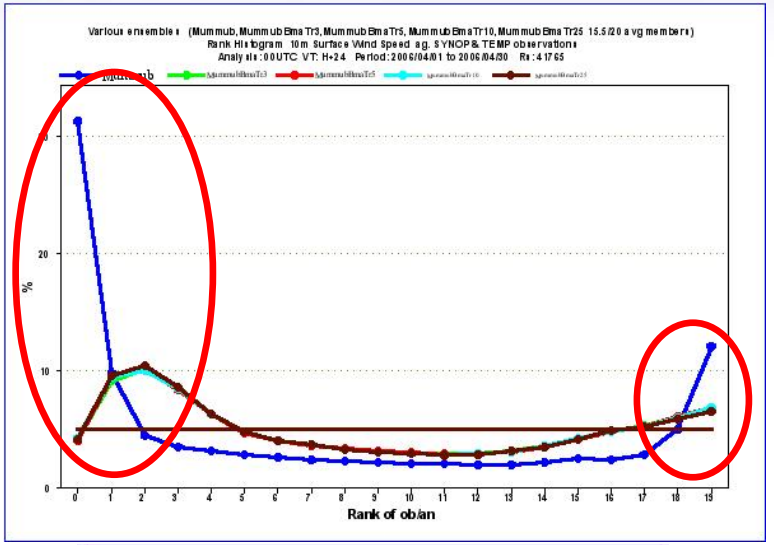
BMA 3 T. DAYS

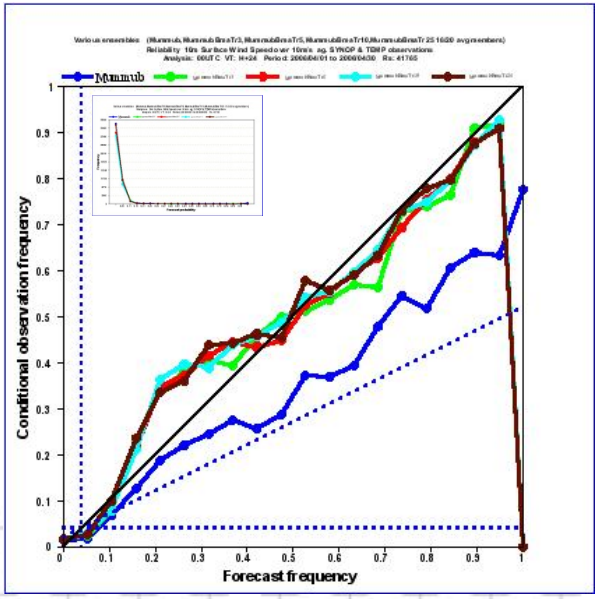
BMA 5 T. DAYS

BMA 10 T. DAYS

BMA 25 T. DAYS



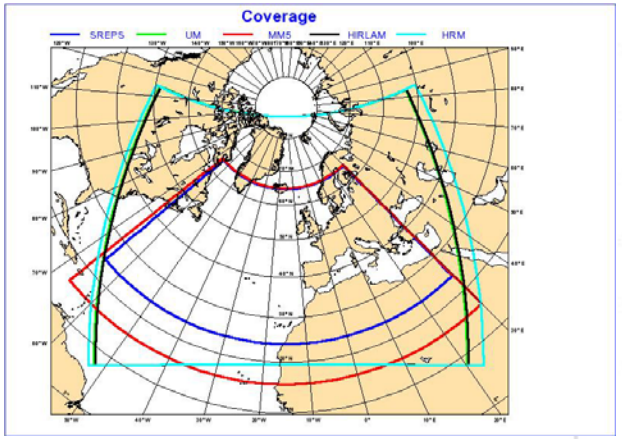


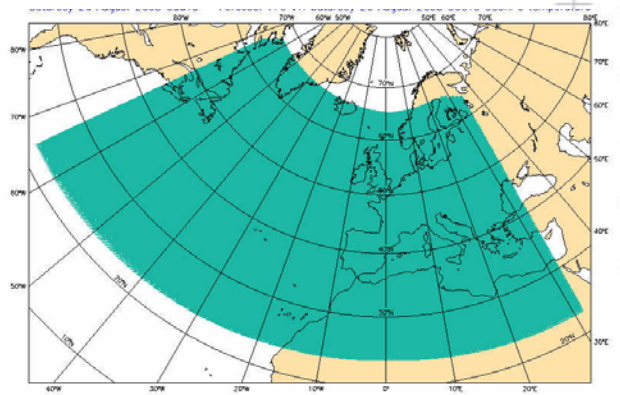


>=10m/s

WRF AT AEMet SREPS

- Reasons to include WRF at the AEMET Short-Range EPS:
  1. MM5 is phase-out
  2. Increase common post-processing area
  3. Obtain a better performance than MM5 model on our vector machine CRAY X1E.





- First selection WRF-NMM

  Advantages:

  Operational at NCEP

  Rotated grid

  Results WRF-NMM v 2.1.2:

  Area: 320x435x40levels 25 km

  Stable time step 60 sec.!!!

  Resources: 8MSPs or 32 SSPs

  Benchmark : 72 hours forecast in about 36 hours clock time !!!!

  Conclusion: Unviable in operations

WRF AT AEMet SREPS

- Second selection WRF-ARW v3.0

Advantages:

Lat Lon grid (rotated?)

Last week 1st cross-compiled version on CRAY X1E
Available configure.wrf modifications asking dsantos@inm.es or Peter Johnsen pjj@cray.com from Cray.

On-going work:

Testing meteorological performance and benchmarking

SUMMARY

- The AEMET Short-Range EPS is a useful tool to characterize low predictability areas on severe weather events.
- The system exhibit a good performance according to the different probabilistic scores using PCP observations.
- The calibration results exhibit a good spread-skill relationship, reduction of outliers in rank histograms, better reliability diagrams and brier skill scores than multimodel.
- After testing 25 days training period seems there is not an improvement in verification scores. The shortest training period seems to be suitable for calibration of short range forecasts if the sample size of calibration data base is enough large. In that sense, the rapid changes in meteorological patterns are better represented with BMA.

SUMMARY

- Work on going to replace MM5 members by WRF-NMM or WRF-ARW or both adding 4 new members.
- Our proposal: “Implementation and validation of WRF model as ensemble member of probabilistic prediction system over Europe” will be founded by the 2008-2009 DTC visitor program.

Objectives:

- Analyze the predictability of severe phenomena in the Atlantic area. Special attention will be paid to the Spanish area.
- Adaptations of WRF pre and post processing codes to obtain model integrations twice a day.
- Insure the quality of WRF members by a deterministic inter comparison with the rest of the models outputs and by means a daily verification against observations over the post-processing area.
- Perform benchmark studies and the BMA calibration of the resulting system.

INTERNATIONAL COLLABORATIONS

- MAP-Dphase (European Project)
- COSMO-SREPS (Italy) and COSMO-DE (Germany)
- PEPS(Germany)

- All data available under request on:

ftp.inm.es

Real time for Met services and 24-hours delayed for research

e-mail: dsantos@inm.es, png@inm.es


THANK YOU
MUCHAS GRACIAS

REFERENCES

- Cullen, M. (1993). The unified forecast/climate model. *Meteor. Mag. , 122*, 81-94.
- Doms, G., and Schälter, U. (1997). *The nonhydrostatic limited-area model LM (Lokal-Modell) of DWD. Part I: Scientific Documentation Deutscher Wetterdienst.* Offenbach, Germany.
- Du, J., and Tracton, M. (2001). Implementation of a real-time short range ensemble forecasting system at NCEP: An update. *Preprints, Ninth Conf. on Mesoscale Processes* (págs. 355-360). Ft. Laurderdale, FL: Amer. Met. Soc.
- DWD. (1995). *Documentation des EM/DM Systems.* DWD 06/1995.
- Epstein, E. S. (1969). Stochastic dynamic predictions. *Tellus , 21*, 739-759.
- Fleming, R. (1971a). On stochastic dynamic prediction. I.The energetics of uncertainty and the question of closure. *Mon.Wea.Rev. , 99*, 851-872.
- Fleming, R. (1971b). On stochastic dynamic prediction. II. Predictability and utility. *Mon. Wea. Rev. , 99*, 927-938.
- Gleeson, T. A. (1970). Statistical-dynamical predictions. *J. Appl.Meteorol , 9*, 333-334.

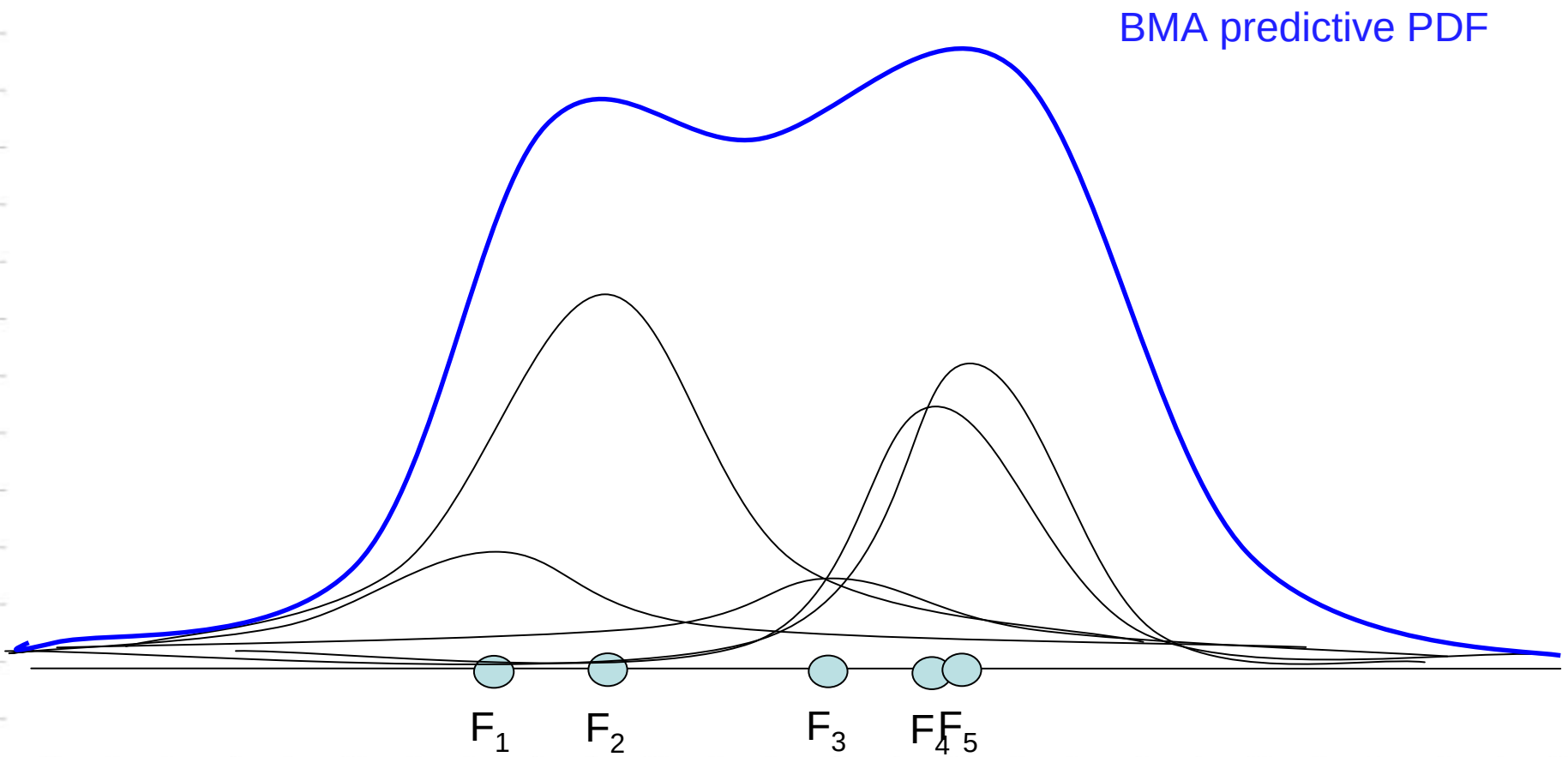
REFERENCES

- Grell, G. D. (1994). *A description of the fifth-generation Penn State/NCAR mesoscale model (MM5).* NCAR/TN-398+STR.
- Grimit, E., and Mass, C. (2002). Initial results of a mesoscale short-range ensemble forescasting system over the Pacific Northwest. *Wea. Forecasting , 17*, 192-205.
- Hamill, T., and Colucci, S. (1998). Evaluation of ETA-RSM probabilistic precipitation forecasts. *Mon. We. Rev. , 126*, 711-724.
- Hamill, T., and Colucci, S. (1997). Verification of ETA-RSM short-range ensemble forecast. *Mon. Wea. Rev. , 125*, 1312-1327.
- HIRLAM. (2002). Scientific documentation. *http://hirlam.knmi.nl* .
- Hou, D., Kalnay, E., and Droegemeier, K. (2001). Objetive verification of the SAMEX'98 ensemble forecast. *Mon. Wea. Rev.* (129), 73-91.
- Houtekamer, P., Lefaivre, L., Derome, J., Ritchie, H., and Mitchel, H. (1996). A system simulation approach to enseble prediction. *Mon. Wea. Rev. , 124*, 1225-1242.
- Jones, M., Colle, B., and Tongue, J. (2007). Evaluation of a mesoscale short-range ensemble forecast system over the Northeast United States. *Wea. Forecasting , 22*, 36-55.

REFERENCES

- Jones, M., Colle, B., and Tongue, J. (2007). Evaluation of a mesoscale short-range ensemble forecast system over the Northeast United States. *Wea. Forecasting , 22*, 36-55.
- Leith, C. E. (1974). Theoretical skill of Monte Carlo forecast. *Mon. Wea. Rev. , 102*, 409-418.
- Molteni, F., Buizza, R., Palmer, T., and Petroliagis, T. (1996). The ECMWF Ensemble Prediction System: Methodology and Validation. *Q.J.R. Meteor. Soc. , 122*, 73-119.
- Raftery, A., Gneiting, T., Balabdaoui, F., and Polakowski, M. (2005). Using bayesian model averaging to calibrate forecast ensembles. *Mon Wea. Rev. , 133*, 1155-1174.
- Stensrud, D., Brooks, H., Du, J., Tracton, M., and Rogers, E. (1999). Using ensembles for short-range forecasting. *Mon. Wea. Rev. , 127*, 433-446.
- Toth, Z., and Kalnay, E. (1993). Ensemble forecasting at NMC: The generation of perturbations. *Bull . Amer. Meteor. Soc. , 74*, 2317-2330.
- Wandishin, M., Mullen, S., Stensrud, D., and Brook, H. (Mon. Wea. Rev.). Evaluation of a short-range multimodel ensemble system. *2001 , 129*, 729-747.

SREPS CALIBRATION



INTRODUCTION

- The theoretical and numerical formulations of a probabilistic approach to weather forecasting have been developed by Epstein (1969), Gleeson (1970), Fleming (1971a,b) and Leith (1974).

- Probabilistic weather predictions by means EPS have been produced on the global scale at NCEP(Toth and Kalnay,1993), at the ECMWF (Molteni et al., 1996) and at the RPN (Houtekamer et al., 1996).

- The successful application of the EPS technique to estimate the time evolution of the PDFs of plausible individual atmospheric states on the global and medium-range scales, has motivated exploration of ensemble forecasting for shorter lead times on the mesoscale.