Developmental Testbed Center | DTC

GOBIERNO DE ESPAÑA

MINISTERIO DE MEDIO AMBIENTE Y MEDIO RURAL Y MARINO

AEMet Agencia Estatal de Meteorología

Implementation and validation of WRF model as ensemble member of a probabilistic prediction system over Europe

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This project has been founded by DTC visitor program.

10th Annual WRF Users' Workshop

23-26 June 2009 in Boulder, CO

DTC VISITOR PROJECT OBJECTIVES

- Analyze the predictability of severe phenomena in the Atlantic area. .
- The inclusion of WRF model as member of the SREPS.
- The quality of each new WRF members will be insure by a deterministic inter comparison with the rest of the models outputs and by means daily verification against observations over the post- processing area.
- The new system will be run twice a day at AEMET operational suite.

DTC VISITOR PROJECT OBJECTIVES

- ***WRF members implementation.***
  1.1. *Installation and compilation of WRF codes.*
  1.2. *Preprocessing adaptations for running with different global models.*
  1.3. *Post processing adaptations for comparison with other models.*
- ***WRF members quality studies.***
  2.1. *Integrations during a test period.*
  2.2. *WRF models benchmark.*
  2.3 *Deterministic inter comparison with the rest of the models in SREPS.*
- ***Verification and calibration of the SREPS.***
  3.1. *Objective verification against observational data.*
  3.2. *Bayesian calibration and bias correction.*
  3.3. *Objective verification of the calibrated SREPS.*
- ***Operational SREPS. Applications.***
  4.1. *New definition of the operational AEMET SREPS.*
  4.2. *Application to severe weather events.*

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

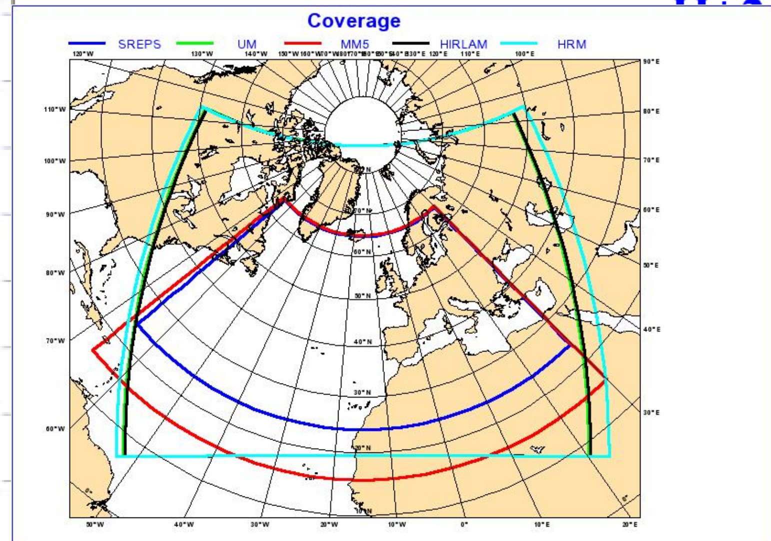
COSMO

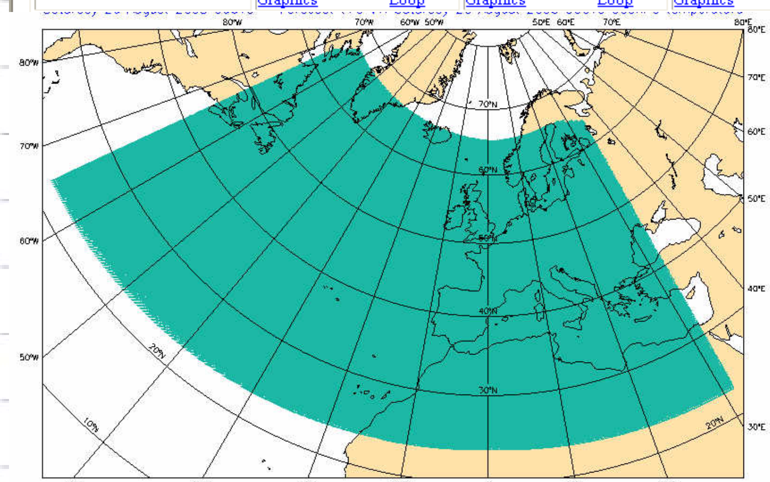
5 LAM

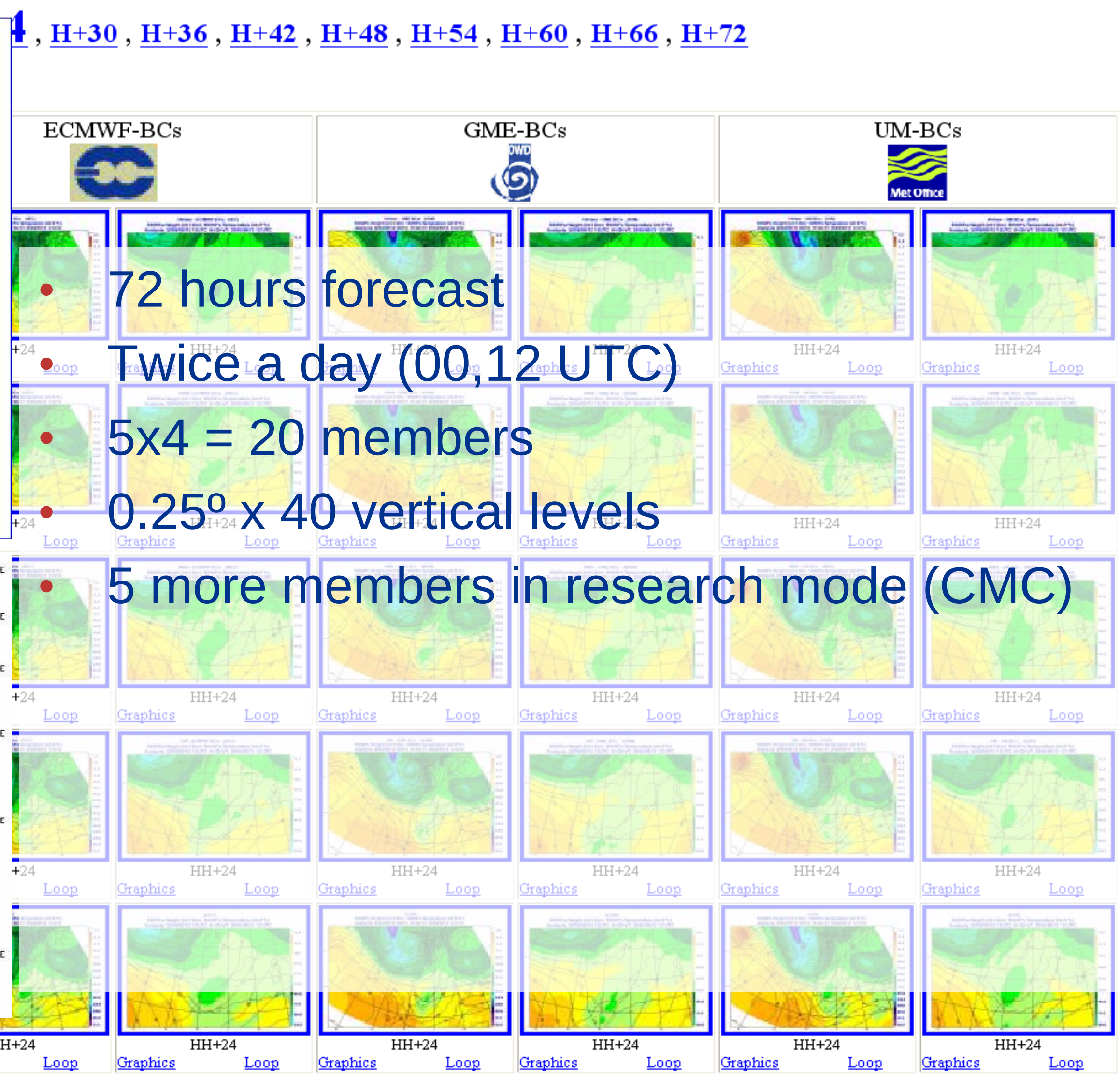
4 IC´s & BC´s from Global models

20 ensemble members

AEMET-SREPS







- 72 hours forecast
- Twice a day (00,12 UTC)
- 5x4 = 20 members
- 0.25º x 40 vertical levels
- 5 more members in research mode (CMC)

AEMET-SREPS

- Daily volume processed:

 - BCs : 63 GB
 - fc files: 2.9 GB in 700 files

- Daily volume permanently stored (SAN):

- fc files: 1.4 GB in 700 files

- Daily volume of graphics generated for fc offices:

- 1GB in 23000 files

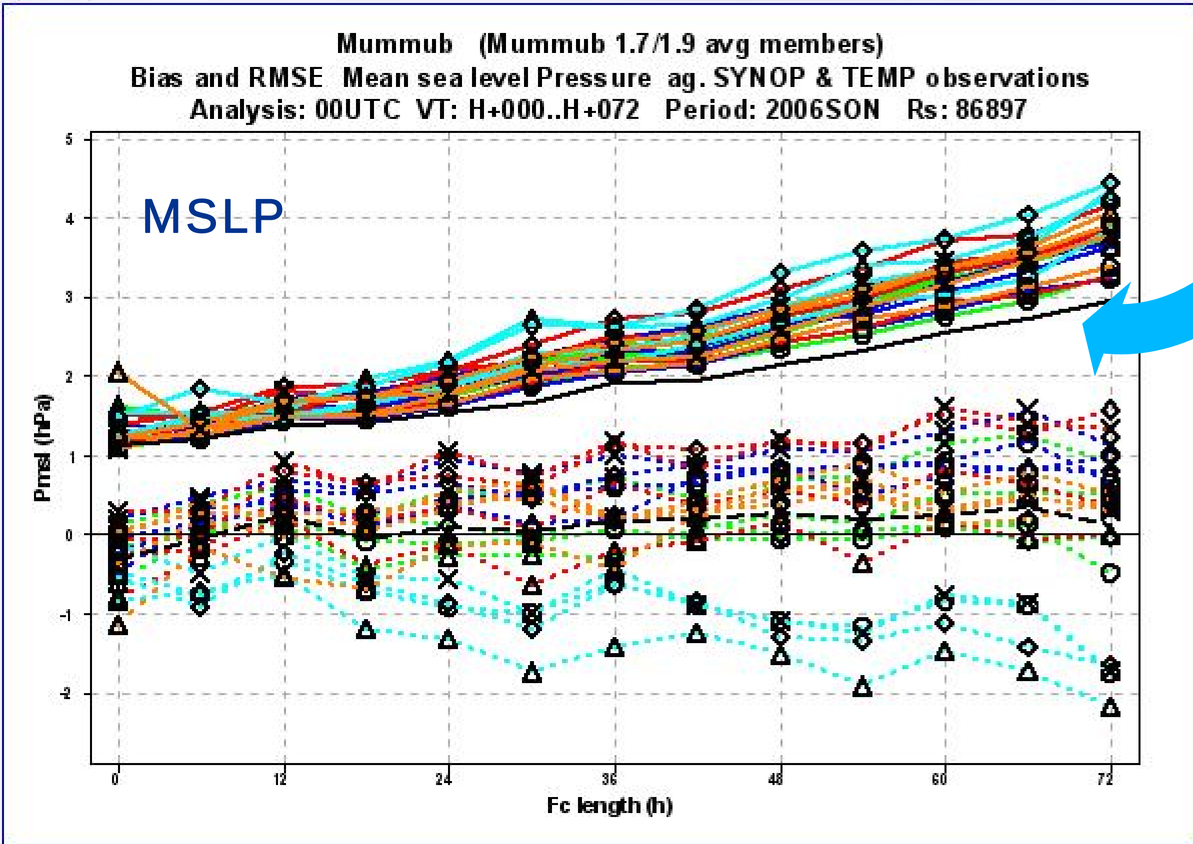
- Daily volume verification:

- ASCII: 70 MB in 18000 files
-GRIB: 4 GB in 120000 files

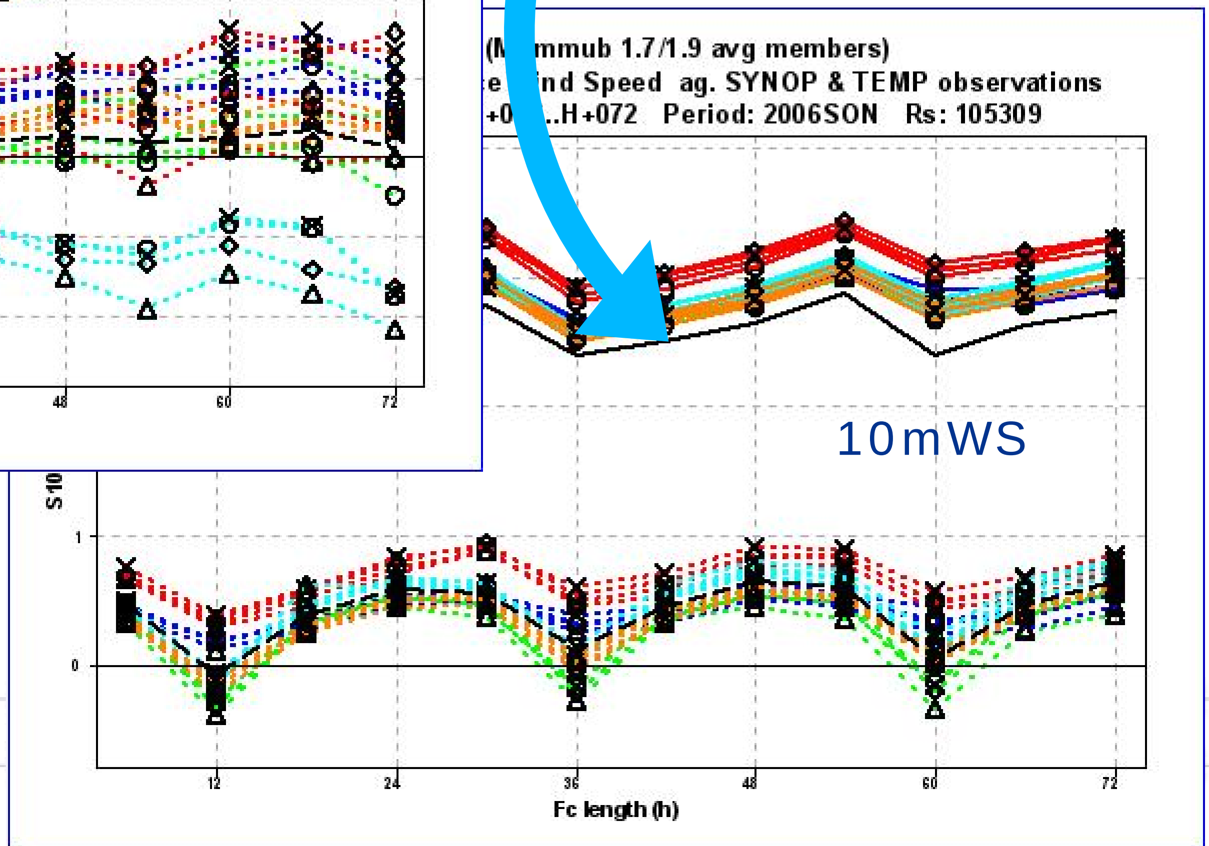
- Timing: 00 UTC run completely ready at 0730 UTC
- Software:

- Horizontal interpolation (Hirlam)
- Vertical interpolation (home-made)
- Post-processing (home-made, ECMWF metview based)
-Verification (home-made, metview based)

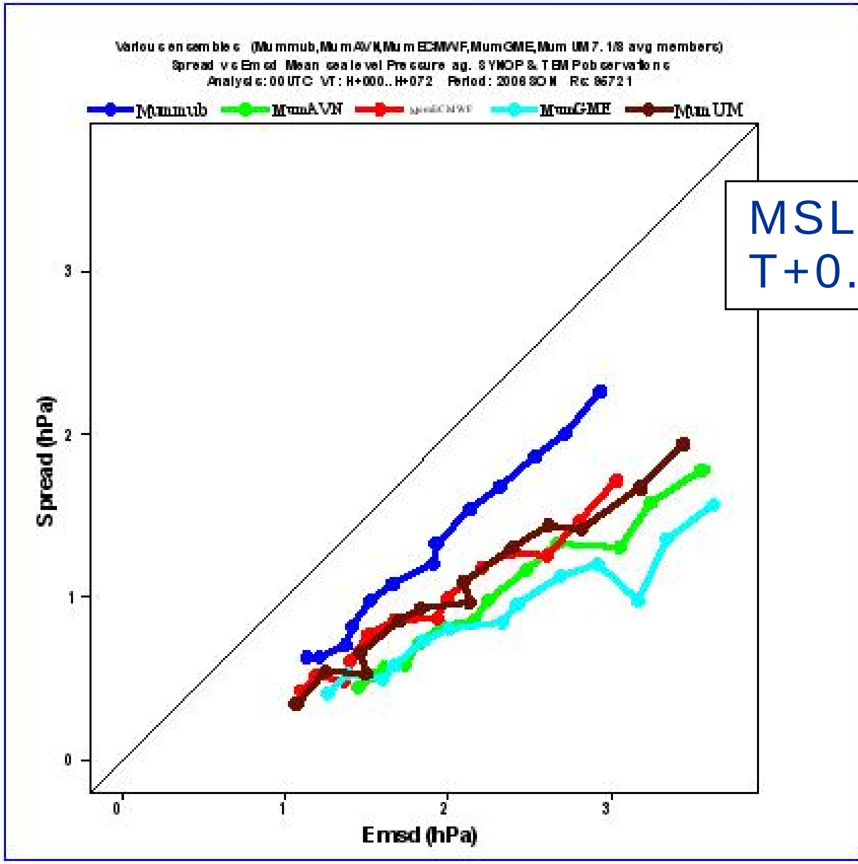
SREPS PERFORMANCE



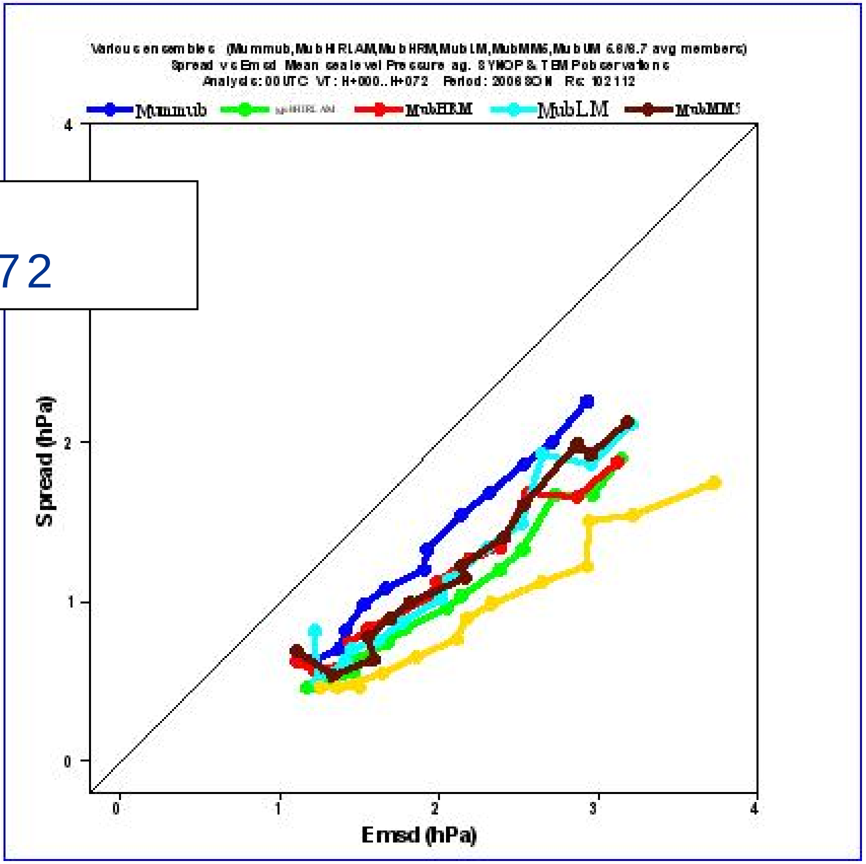
- Ensemble mean (black) performs better than any member



SREPS PERFORMANCE

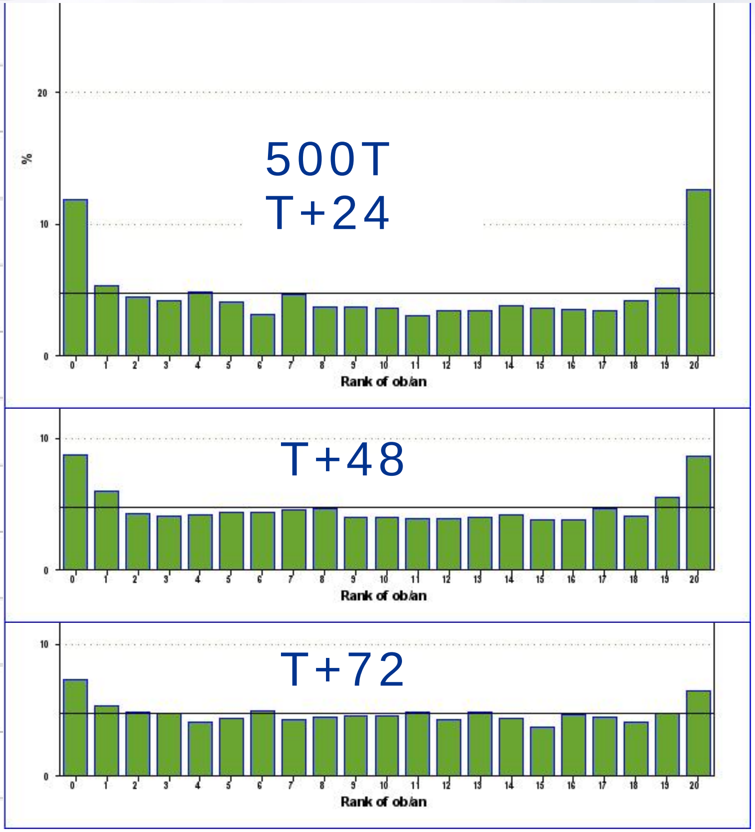


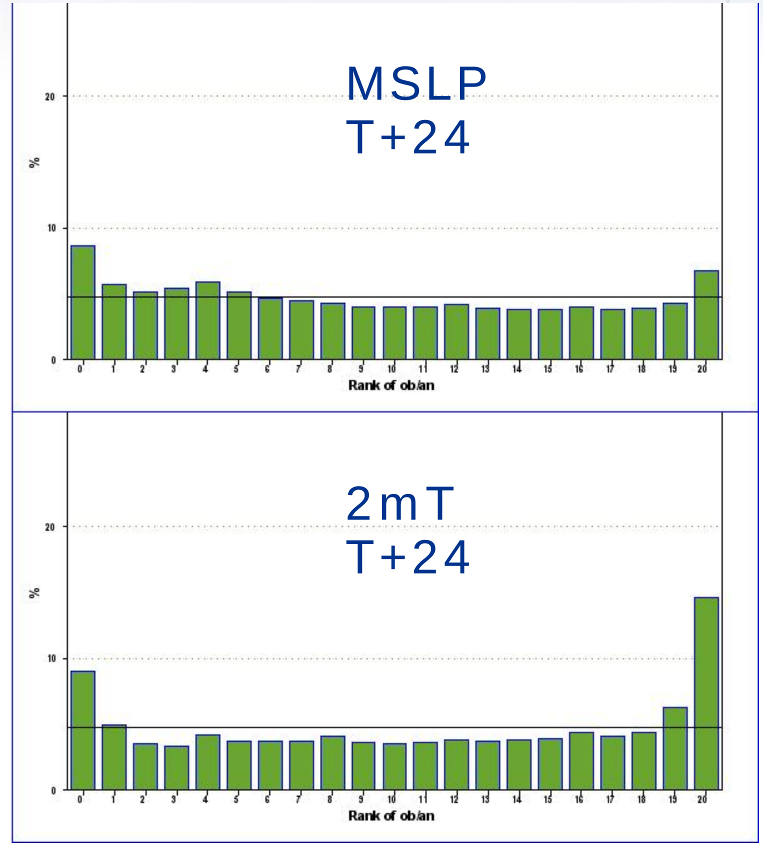
MSLP
T+0...72



- How much spread comes from “multi-model” (left) and how much from “multi-analysis” (right)?

SREPS PERFORMANCE

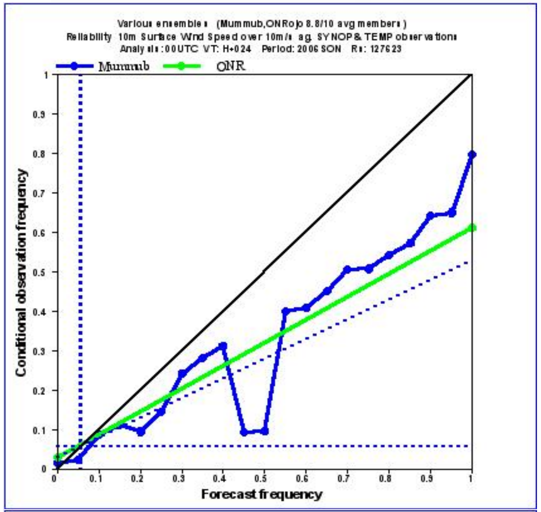


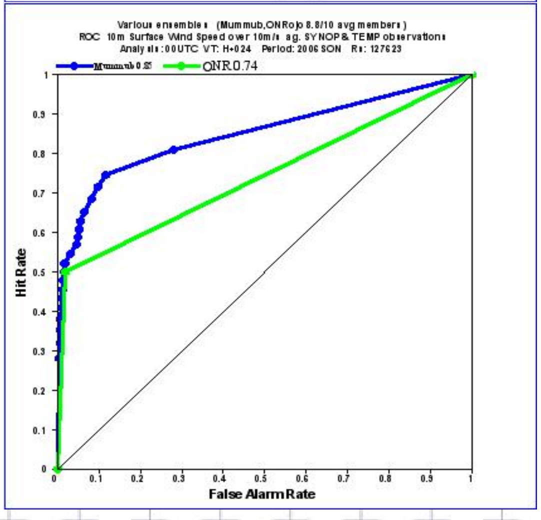


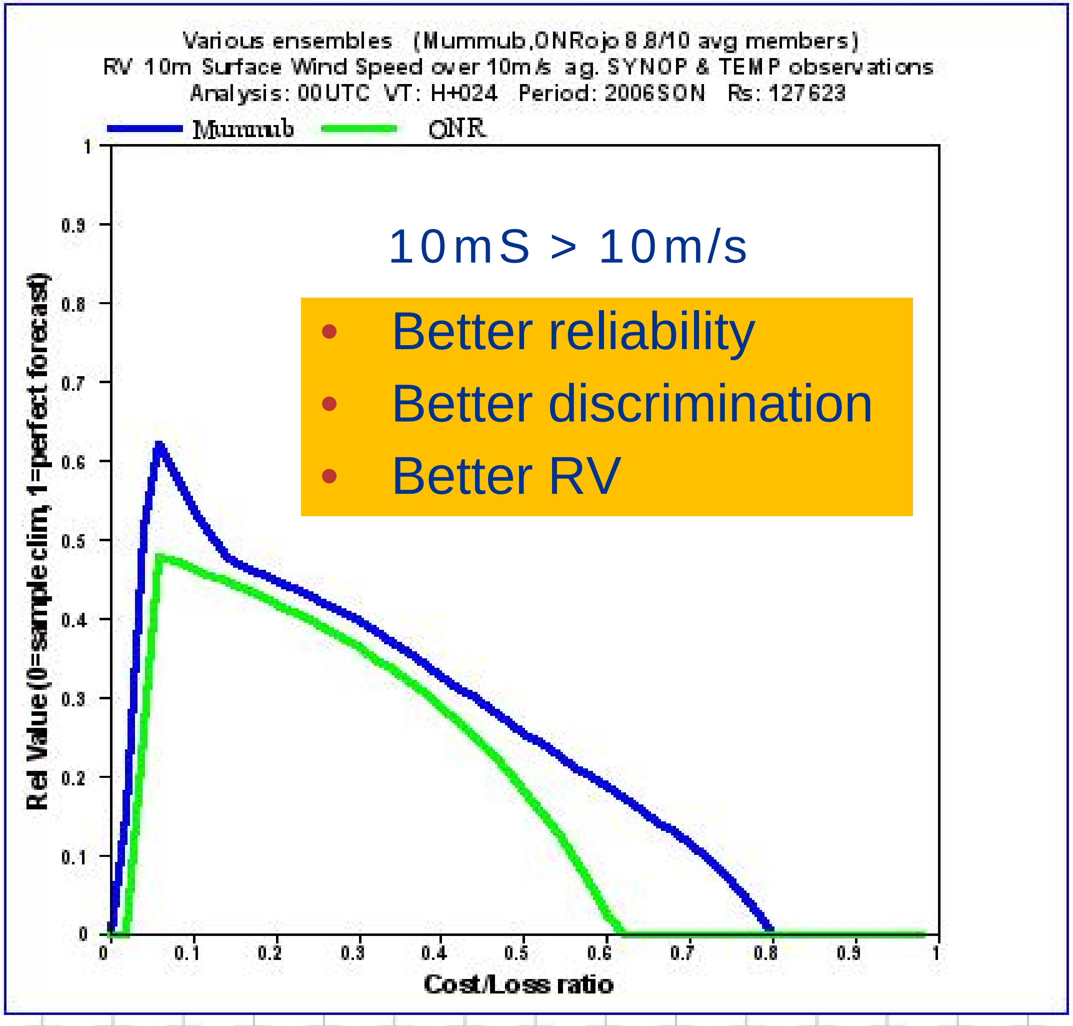
- 500T under-dispersive T+24
- Becoming flat T+72

- MSLP near flat
- 2mT under-dispersive & cold bias

SREPS PERFORMANCE

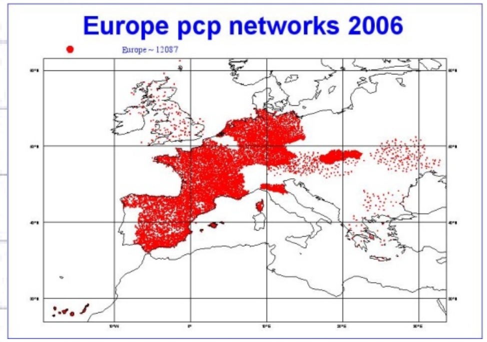






- Better reliability
- Better discrimination
- Better RV

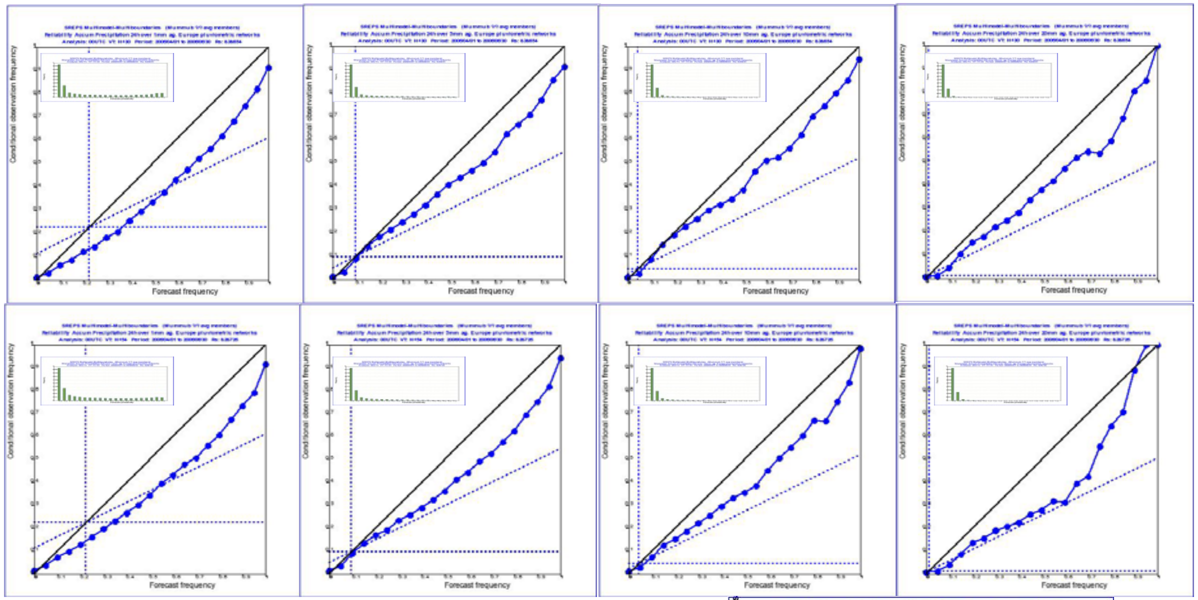
SREPS PERFORMANCE

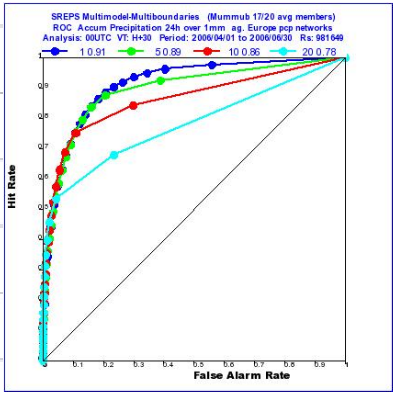


HH+30

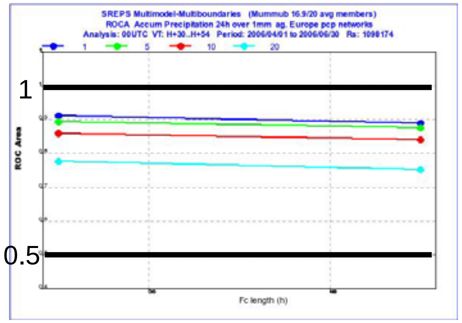
HH+54

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

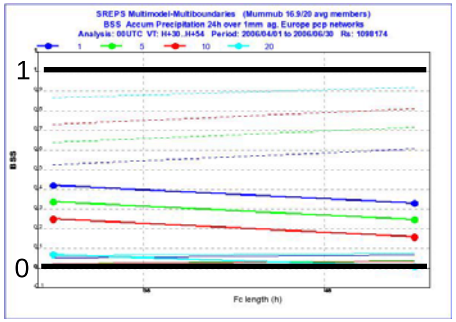




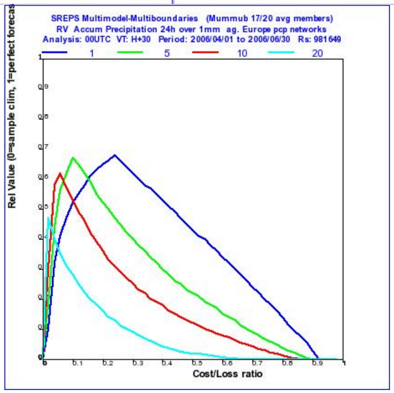
ROC



ROCA



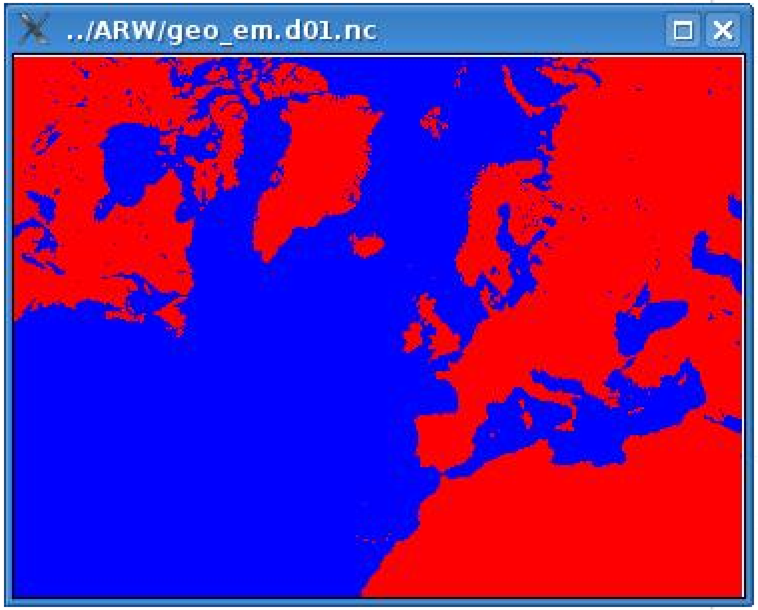
BSS



Relative Value

DTC VISITOR PROJECT STATUS

- Due to extension of the area that covers Northern latitudes, the members should run on rotated latitude longitude areas.
- Obtain the outputs on regular latitude-longitude areas written on GRIB format to verify the WRF models with the same tools that we ordinary manage to verify the SREPS.



- Status of WRF-ARW members:
  - 72 hours forecast 366 x 272 x 40
    dx=dy 27794.37 Δt= 180 s.
  - Forecast outputs are written on netCDF format for each 6-hours
  - 180 minutes using 8 Bluefire processors.

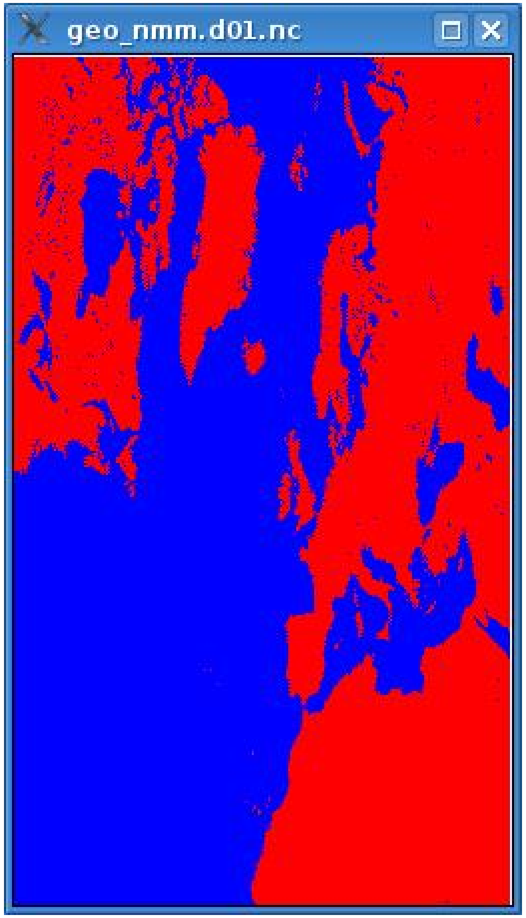
DTC VISITOR PROJECT STATUS

- Status of WRF-ARW members:

  - 72 hours forecast 250 x 426 x 40

    dx = 0.191683,dy = 0.162951 Δt= 60 s.
  - Forecast outputs are written on netCDF format for each 6 hours
  - 80 minutes using 8 Bluefire processors

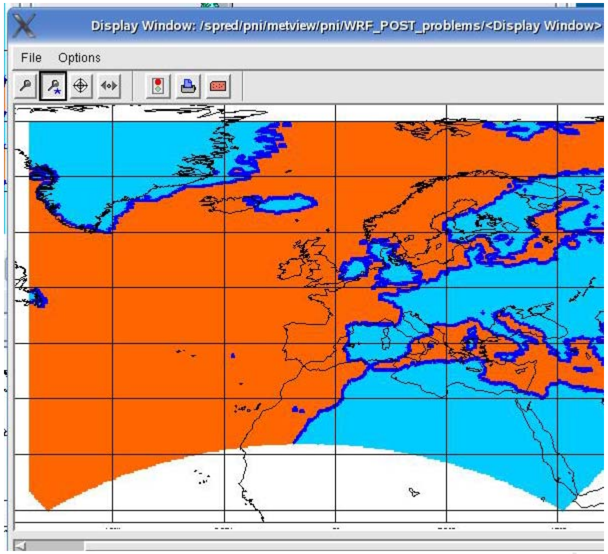
.



DTC VISITOR PROJECT STATUS

- Dificulties of WRF-ARW members:
  - How to configure the model to run on rotated lat lon areas
  - The WPP can not postprocess the rotated ARW outputs .
  - Write direct outputs on GRIB or GRIB2 does not work.
  - Tool to convert directly the rotated netCDF to GRIB under test.

- Dificulties of WRF-NMM members:
  - The WPP had problems to postprocess the big outputs generating a shifting of the fields. Thanks Jamie Wolff and Hui-Ya Chuang that had made some changes on INITPOST_NMM.f
  - Some of the models can not be integrate yet due to initialization problems.



DTC VISITOR PROJECT STATUS

- The WRF-NMM models using GFS data (WNAV) and ECMWF data (WNEC) have been verified during February 2009
  - Deterministic verification: S10m, T2m, Pmsl and T850

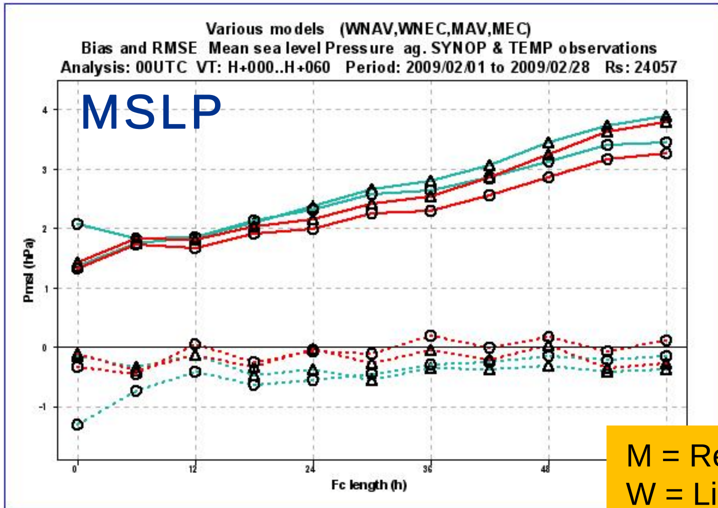
    RMSE & BIAS MEC vs WNEC MAV vs WNAV
  - Ensemble verification:

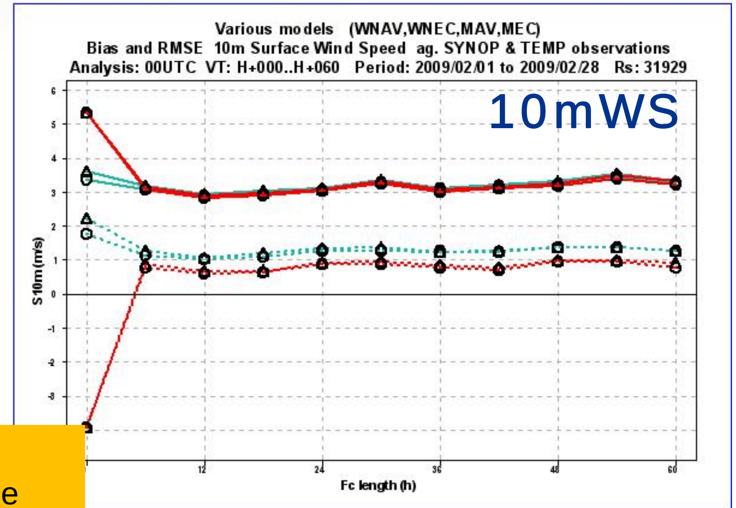
    EnsWLarge= { H,I,L, WN, U}x {AV,EC,GM,UK} = 18 members
    EnsMLarge = {H,I,L ,M,U} x{AV,EC,GM,UK} = 18 members

    with out WNGM, WNUK, MGM & MUK

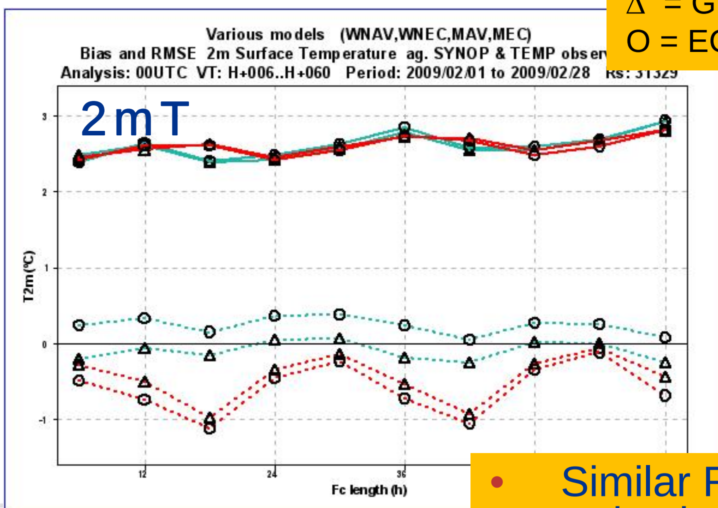
    EnsWShort = {H,I,L,WN,U} x {AV,EC} = 10 members
    EnsMShort = {H,I,L,M,U} x {AV,EC} = 10 members

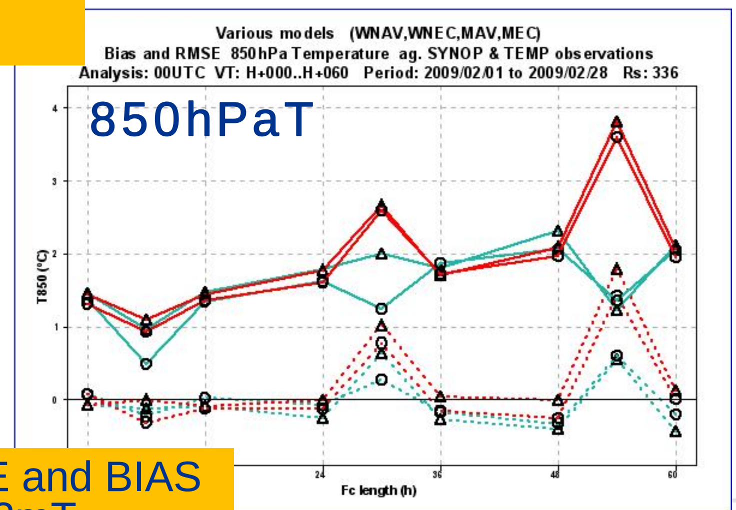
DETERMINISTIC VERIF





M = Red
W = Light Blue
Δ = GFS
O = ECMWF

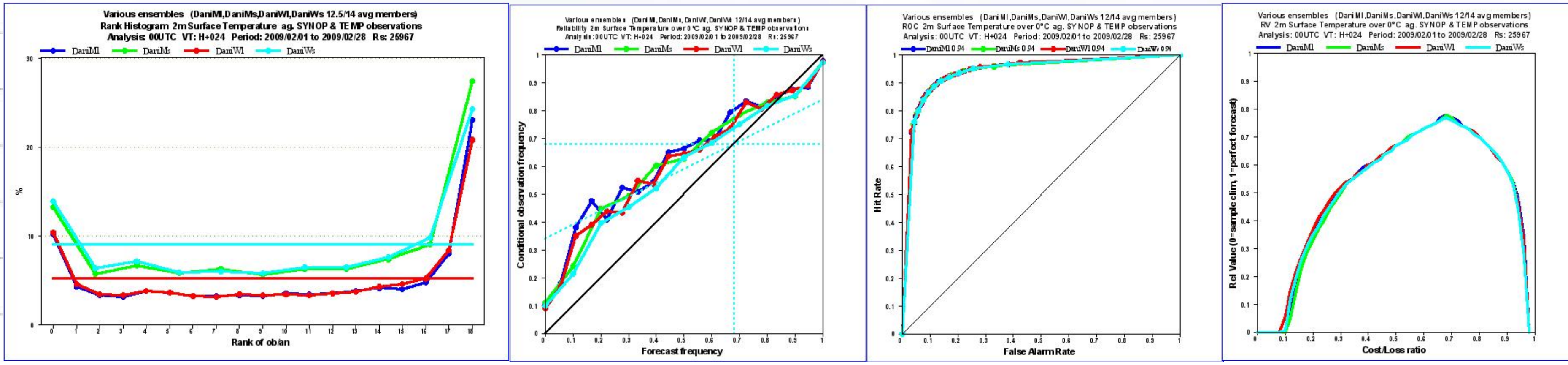




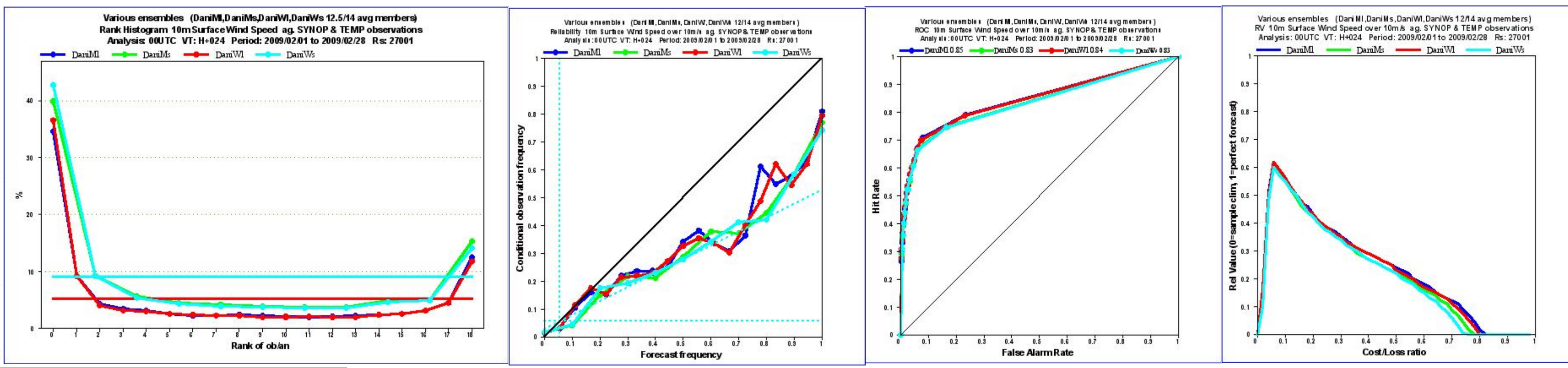
- Similar RMSE and BIAS reduction on 2mT

PROBABILISTIC VERIF

2mT > 0º HH+24



10mWS > 10 ms-1 HH+24



EnsW Large = Red
EnsM Large = Blue
EnsW Short = Light Blue
EnsM Short = Green

- Similar performance of all Ensembles

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 WRF models implementation on the system is not yet completed due to
    1. ARW postprocessing and initialization problems
    2. NMM initialization problems
- The determistic verification shows a clear bias reduction on 2mT and similar RMSE on WRF MM5 comparisons.
- The four ensembles created shows a similar performance and a undersampling on some thresholds (Not showed)

SUMMARY

- On going work:
  1. Solve the initialization problems on NMMs
  2. Solve the postprocessing problems on ARWs.

- Future work:
  1. Complete the 8 ensemble members
  2. Verify the full system
  3. Increase the verification period to avoid undersampling effects.
- The difficulty to transfer huge amounts of data from AEMET to DTC generates delays on the tests and on the results.

ACKNOWLEDGEMENTS

- Thanks for the support of DTC people Laurie Carson and John Halley Gotway.
- Thanks Hui-Ya Chuang from NCEP for solving WPP problems.
- Thanks to the rest of the colleges of AEMET Predictability Group: A. Callado, J. Simarro and P. Escriba

- Thank to all the people who has been helping us to develop AEMET-SREPS

  Eugenia Kalnay (Univ. Of Maryland), Ken Mylne, Jorge Bornemann(MetOffice) Detlev Majewski, Michael Gertz, Michael Denhard (DWD) Metview Team Martin Leutbecher (ECMWF) Chiara Marsigli, Ulrich Schättler (COSMO) Olivier Talagrand (LMD)

- We also like to thank many Met. Services for making their climate network precipitation observations available to us for verification (some of them not yet included): Arpa-Sim (Italy), DWD (Germany), EARS (Slovenia), HNMS (Greece), HMS (Hungary), KNMI (Netherlands), Lombardia (Italy), Météo-France (France), NIMH (Bulgaria), NMAP (Romania), SHMU (Slovakia), UKMO (UK), ZAMG (Austria).

THANK YOU

MUCHAS GRACIAS

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)

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

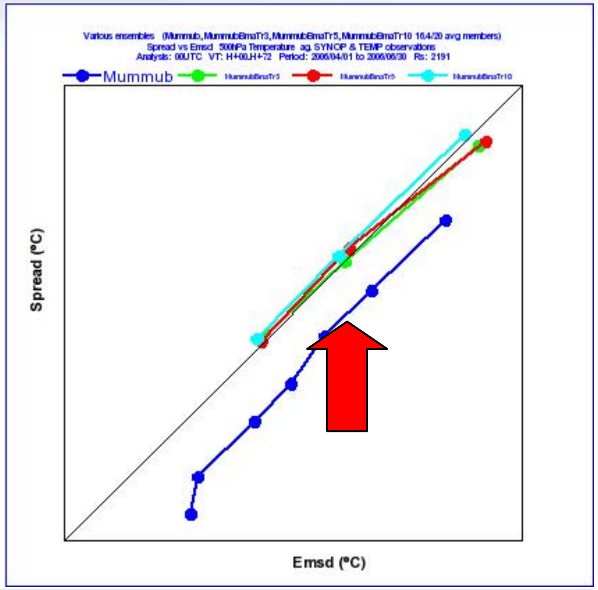
- T500

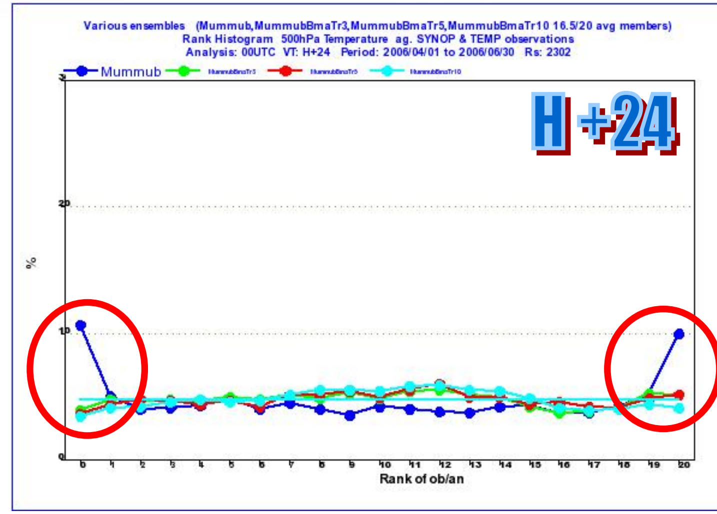
MULTIMODEL

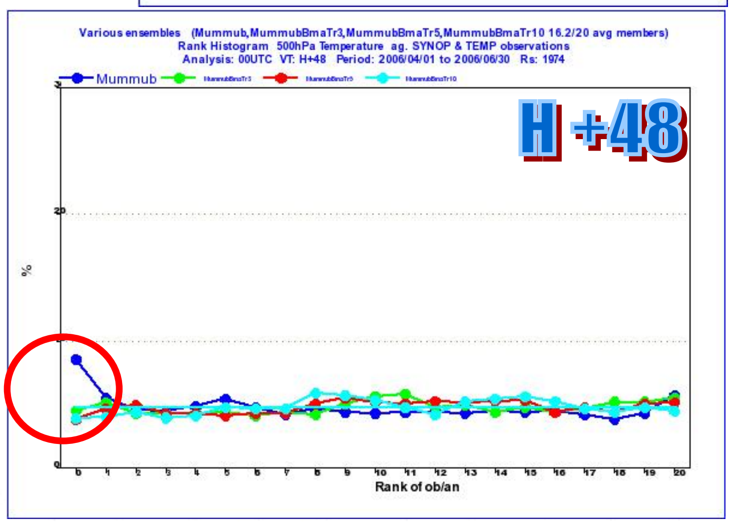
BMA 3 T. DAYS

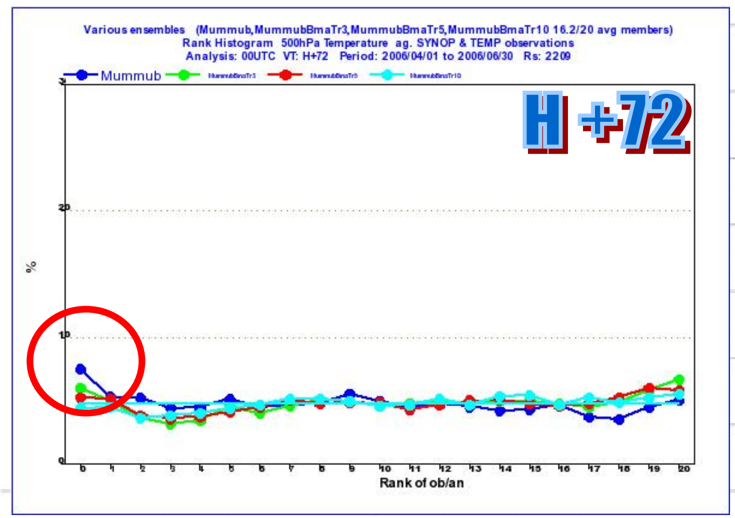
BMA 5 T. DAYS

BMA 10 T. DAYS









SREPS CALIBRATION

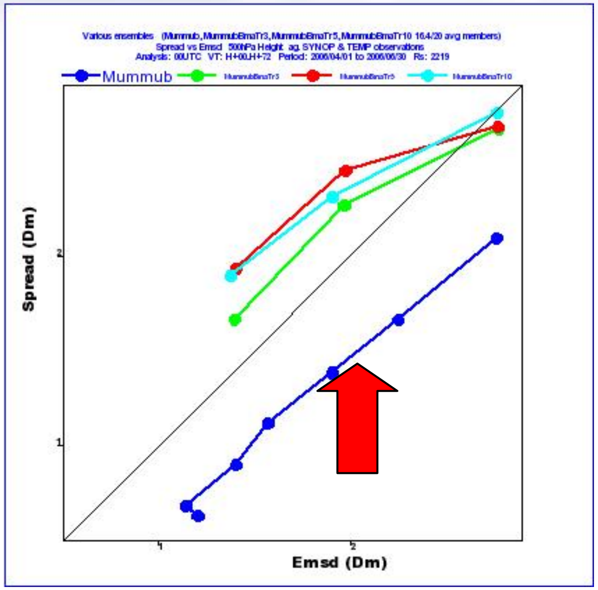
- Z500

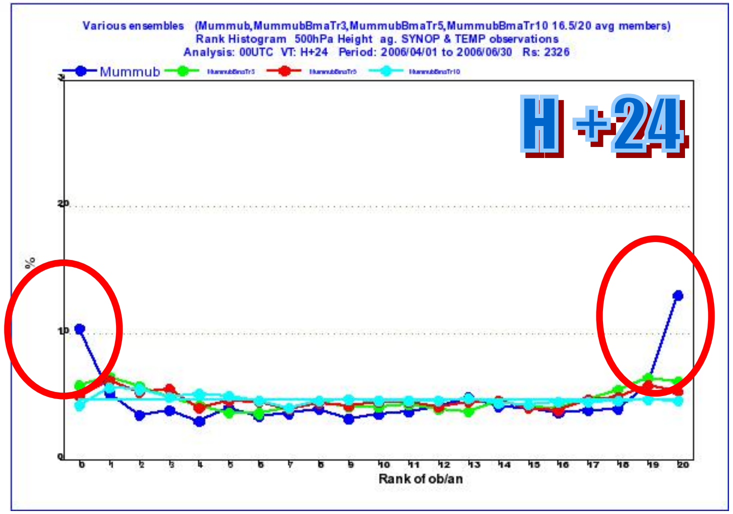
MULTIMODEL

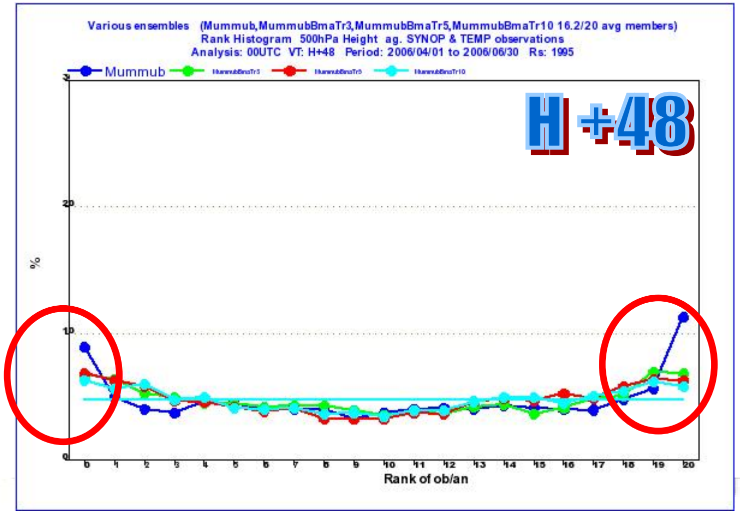
BMA 3 T. DAYS

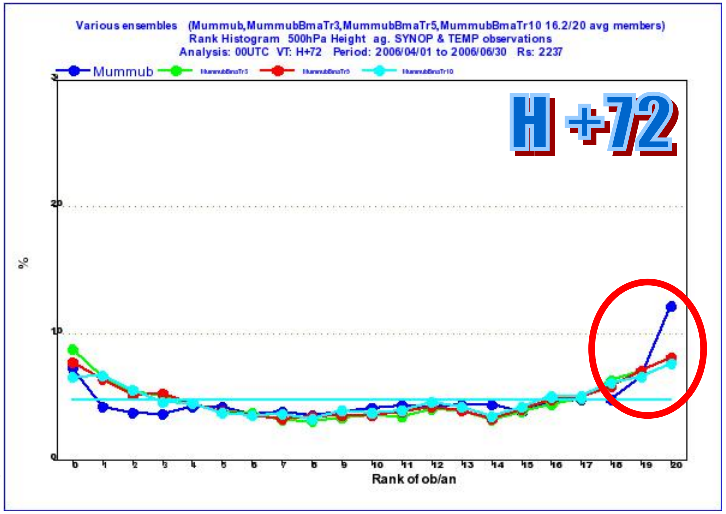
BMA 5 T. DAYS

BMA 10 T. DAYS









SREPS CALIBRATION

- 10m Wind Speed

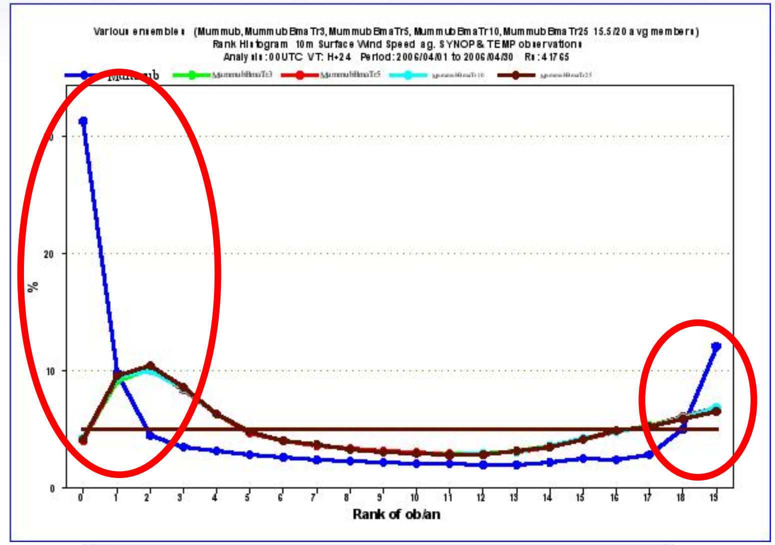
MULTIMODEL

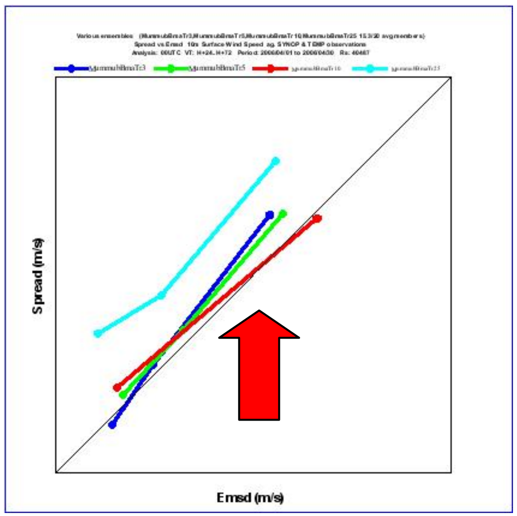
BMA 3 T. DAYS

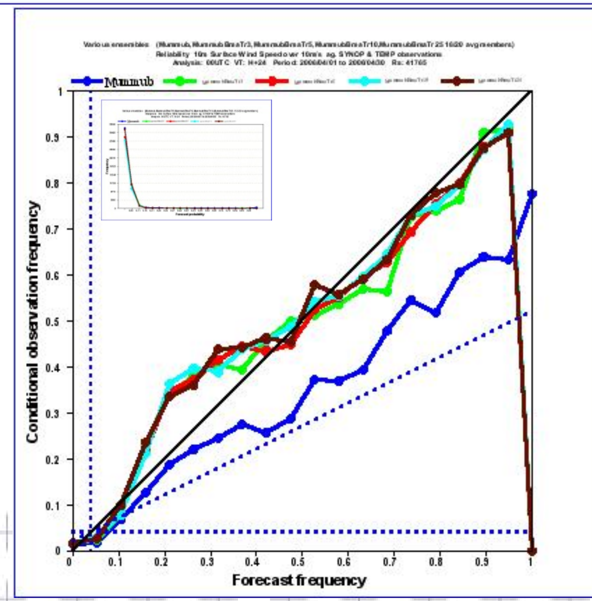
BMA 5 T. DAYS

BMA 10 T. DAYS

BMA 25 T. DAYS



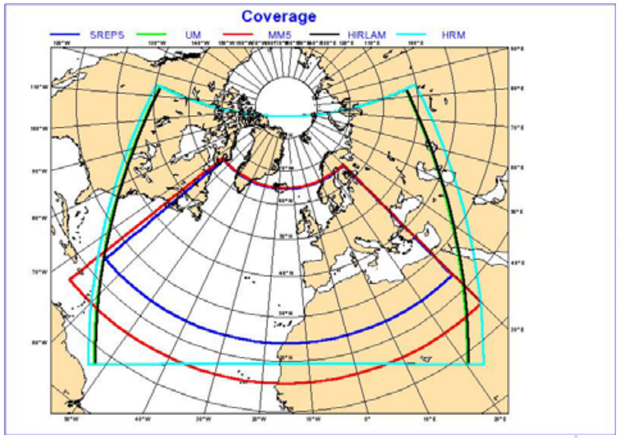


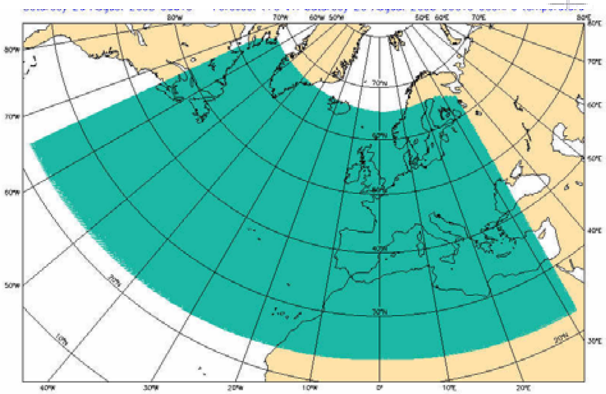


>=10m/s

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

REFERENCES

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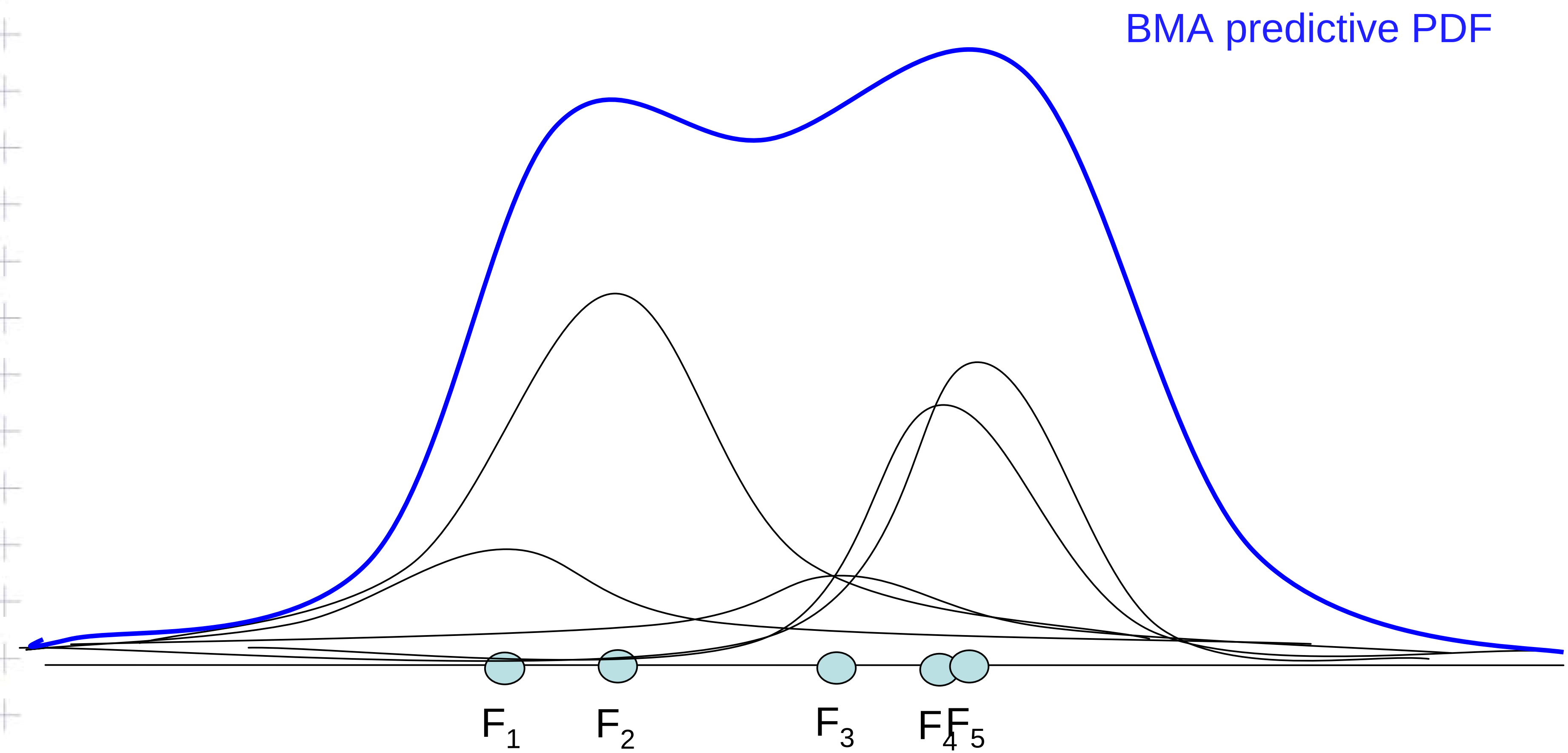
SREPS CALIBRATION



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.