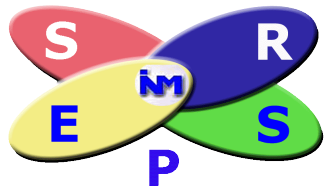


Multi-model Ensemble at INM. Status and verification

J. A. García-Moya, A. Callado, C. Santos, D. Santos, J. Simarro

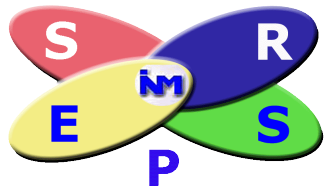
NWP – Spanish Met Service INM

**HIRLAM / ALADIN All Staff Meeting
Met.no – April 2007**



Multi-model

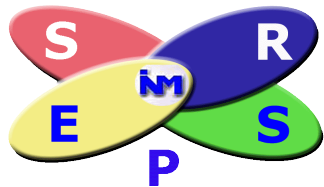
- ☀ Hirlam (<http://hirlam.org>).
- ☀ HRM from DWD (German Weather Service).
- ☀ MM5 (<http://box.mmm.ucar.edu/mm5/>).
- ☀ UM from UKMO (Great Britain Weather Service).
- ☀ LM (COSMO Model) from COSMO consortium (<http://www.cosmo-model.org>).



Multi-Boundaries

From different global deterministic models:

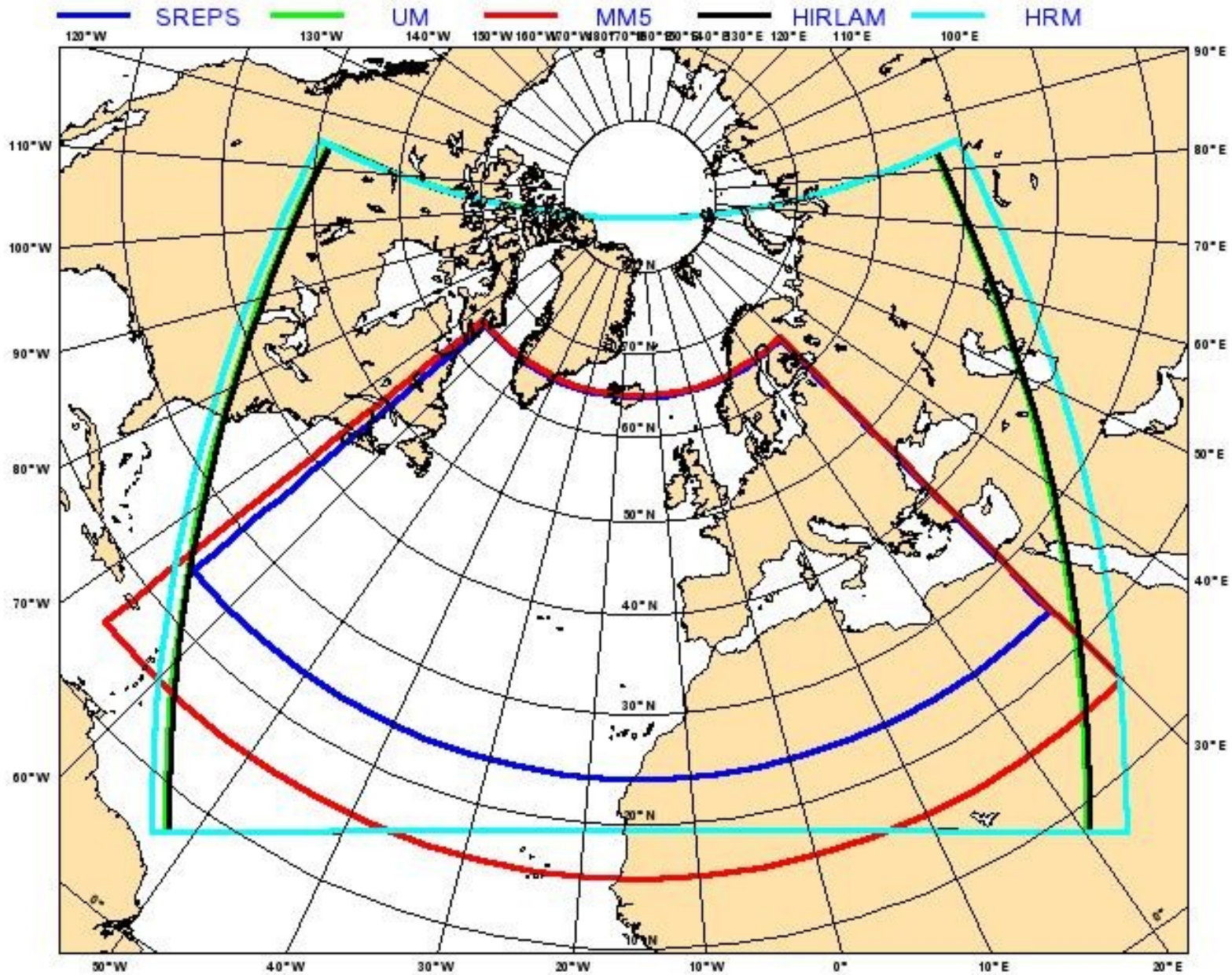
- ✱ ECMWF
- ✱ UM from UKMO (UK Weather Service)
- ✱ GFS from NCEP
- ✱ GME from DWD (German Weather Service)

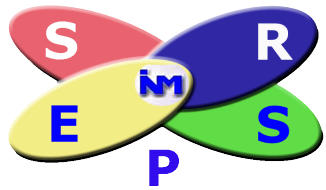


SREPS at INM

- ☀ Mummub: Multi-model Multi-boundaries
- ☀ 72 hours forecast two times a day (00 & 12 UTC).
- ☀ Characteristics:
 - ☀ 5 models.
 - ☀ 4 boundary conditions.
 - ☀ 2 latest ensembles (HH & HH-12).
- ☀ 20 member ensemble every 12 hours
- ☀ Time-lagged Super-Ensemble of 40 members every 12 hours.

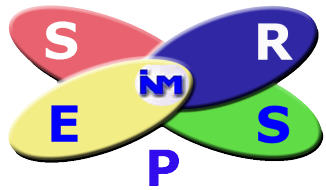
Coverage





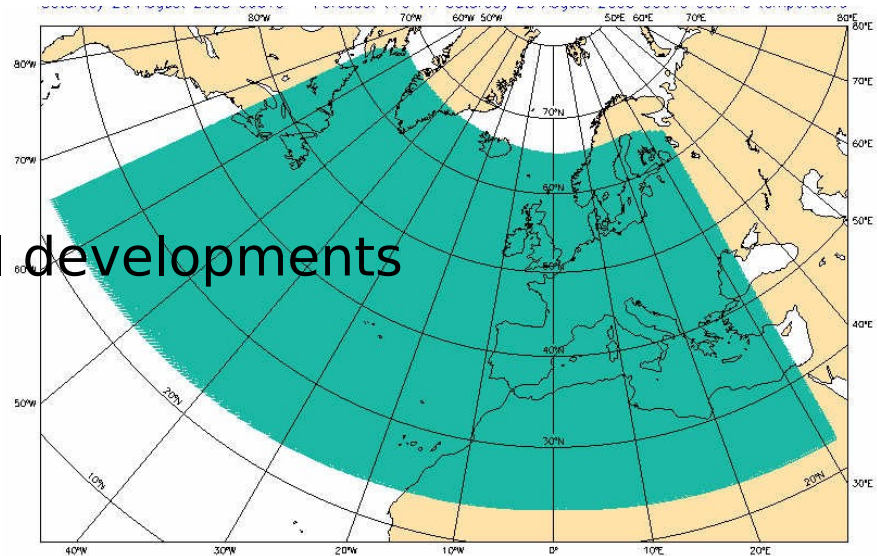
Road Map

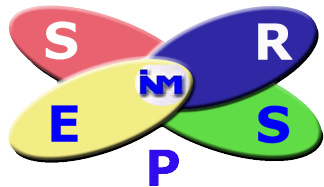
2003-2004	Research to find best ensemble for the Short	
Jun 04 – Jun 05	Building Multimodel System	
Jun 05-Mar 06	Mummub n/20 members	Daily run non-operational Twice a day
September 06	40 member lagged Super-ensemble	Twice a day
Mar 07	Archiving in MARS at ECMWF	Twice a day
Apr 07 (Delay from January)	Daily disseminations of	Twice a day
Jan - June 07	BMA Calibration	
June 07	BMA Calibration in daily run	Twice a day



Post-processing

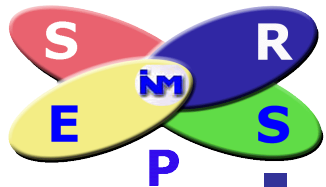
- ☀ Integration areas 0.25 latxlon, 40 levels
- ☀ Interpolation to a common area
 - ☀ ~ North Atlantic + Europe
 - ☀ Grid 380x184, **0.25°**
- ☀ Software
 - ☀ Enhanced PC + Linux
 - ☀ ECMWF Metview + Local developments
- ☀ Outputs
 - ☀ Deterministic
 - ☀ Ensemble probabilistic



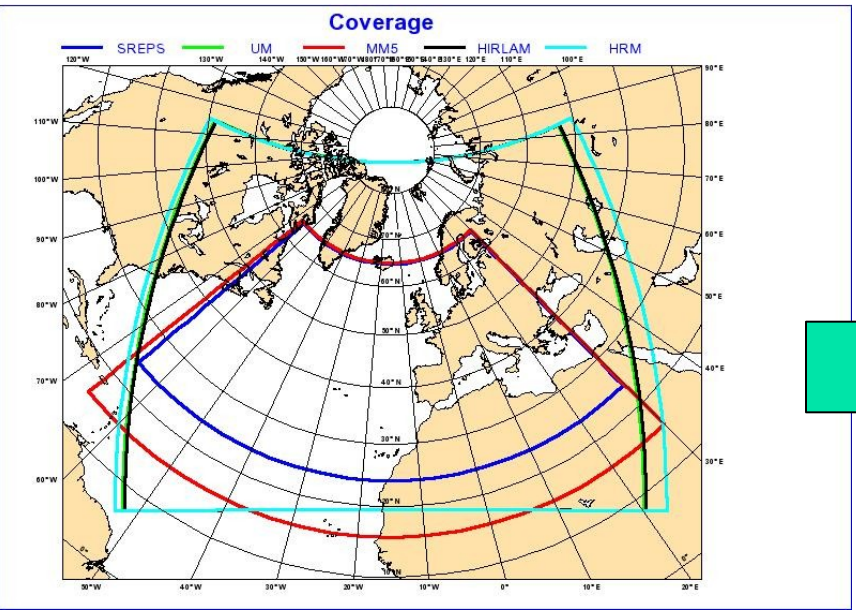
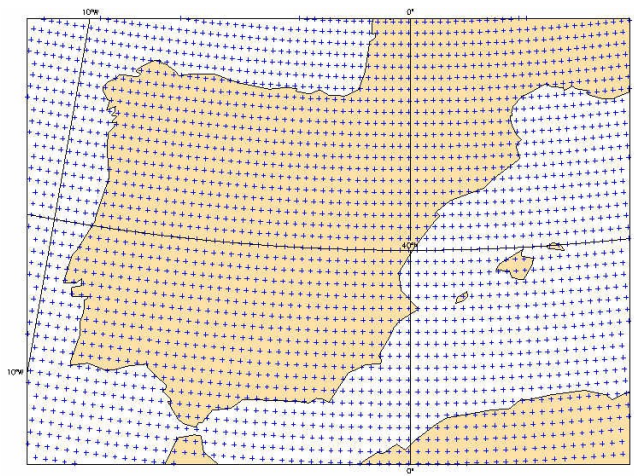
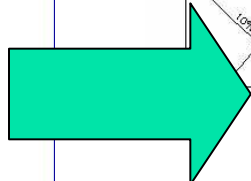
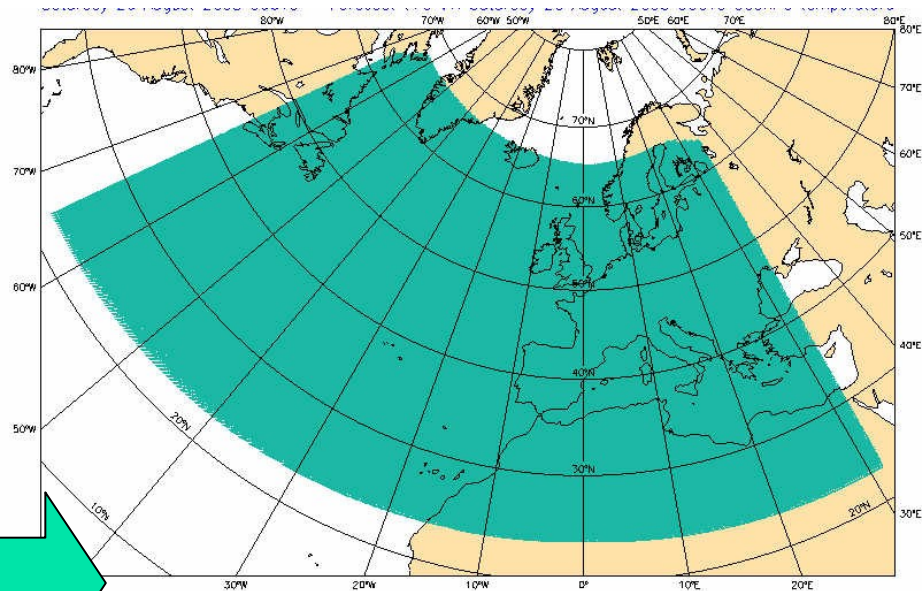
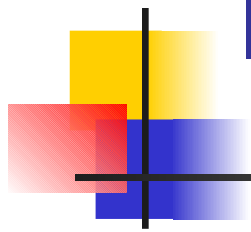


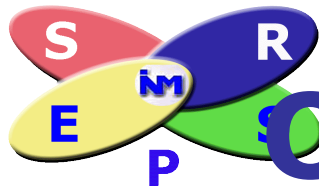
Verification

- ☀ Verification exercise, April-June 2006:
 - ☀ **Calibration:** with synoptic variables Z500, T500, Pmsl
 - ☀ **Response to binary events:** reliability and resolution of surface variables 10m surface wind, 6h and 24h accumulated precipitation



Interpolation





Obs verification - Probabilistic scores

☀ Ensemble calibration:

- ☀ Synoptic variables:

- ☀ Z500, T500, Pmsl

- ☀ Scores:

- ☀ Rank histograms

- ☀ Spread-skill

☀ Response to binary events:

- ☀ Surface variables:

- ☀ 10m surface wind (10,15,20m/s thresholds)

- ☀ 6h accumulated precipitation (1,5,10,20mm thresholds)

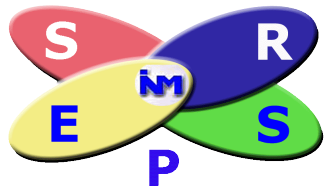
- ☀ 24h accumulated precipitation (1,5,10,20mm thresholds)

- ☀ Scores:

- ☀ Reliability, sharpness (H+24, H+48)

- ☀ ROC, Relative Value (H+24, H+48)

- ☀ BSS, ROCA with forecast length



Synoptic parameters

- Using ECMWF Analysis as reference:

- Pmsl

- Over all FC lengths H+00 .. H+72:

- Spread-skill

- H+72:

- Rank histograms

- Using Synoptic observations as reference:

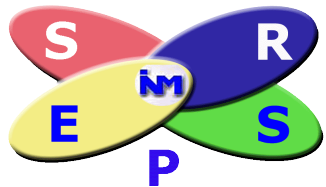
- Pmsl

- Over all FC lengths H+00 .. H+72:

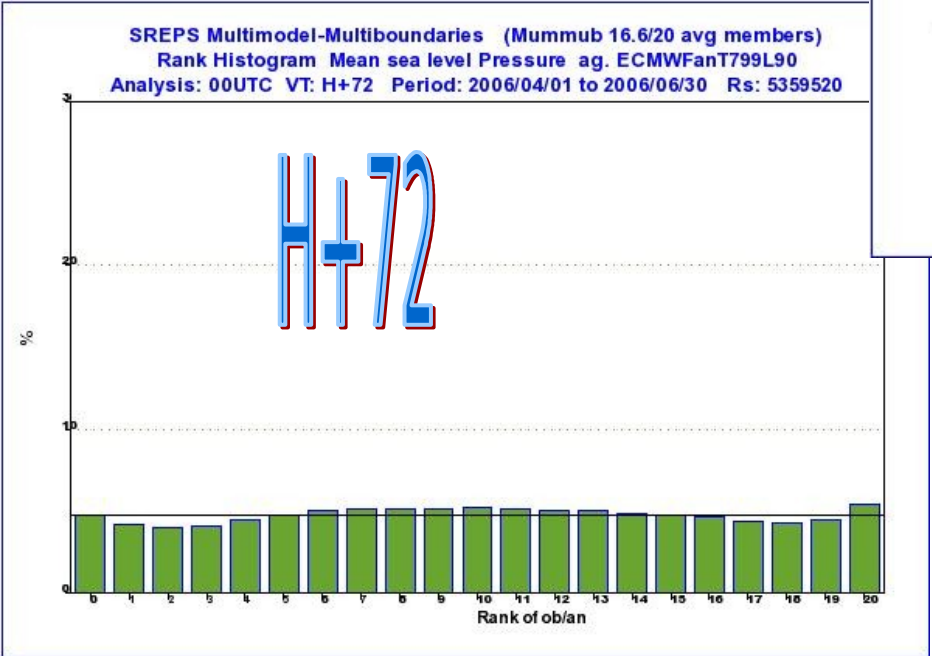
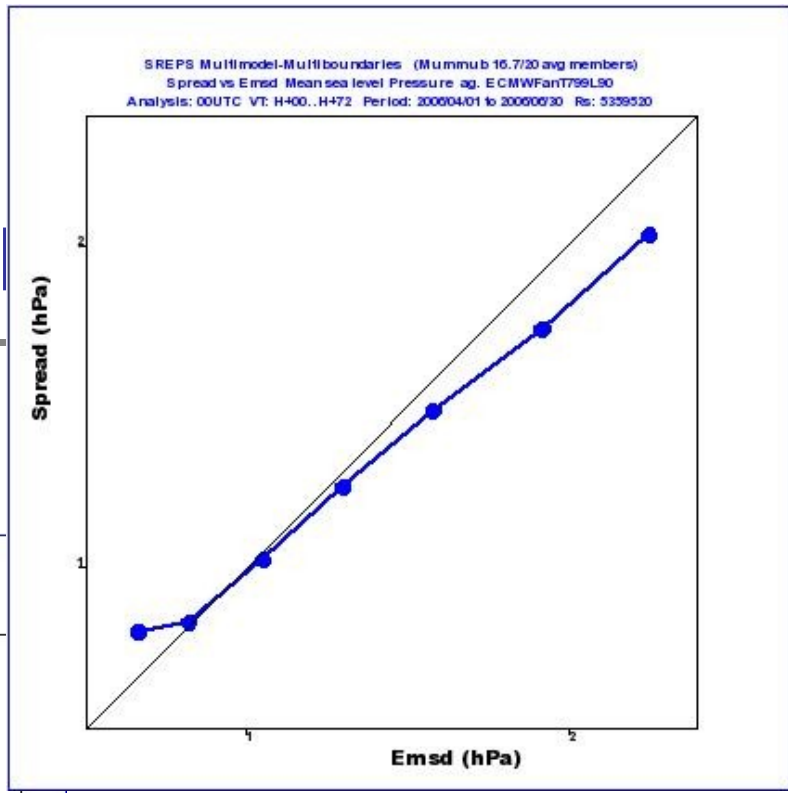
- Spread-skill

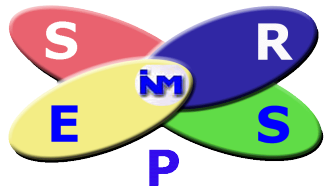
- H+72:

- Rank histograms

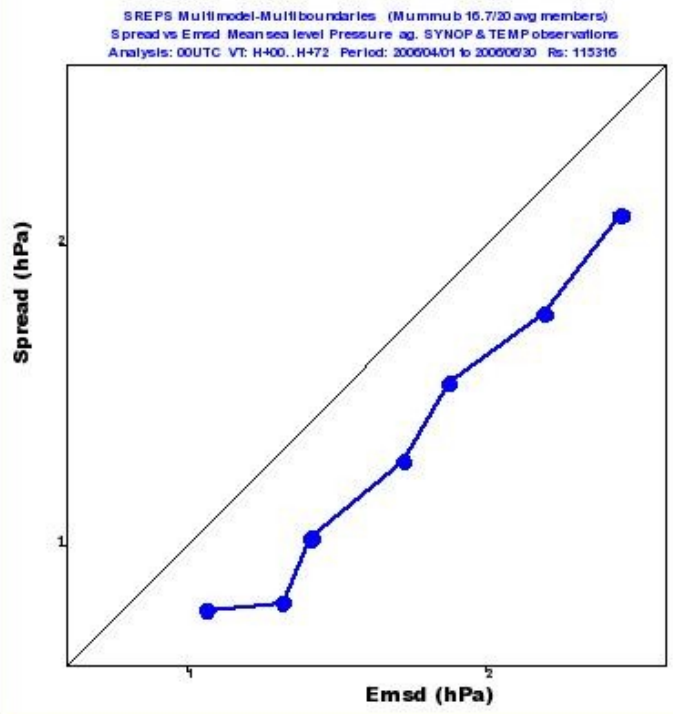


Pmsl- ECMW

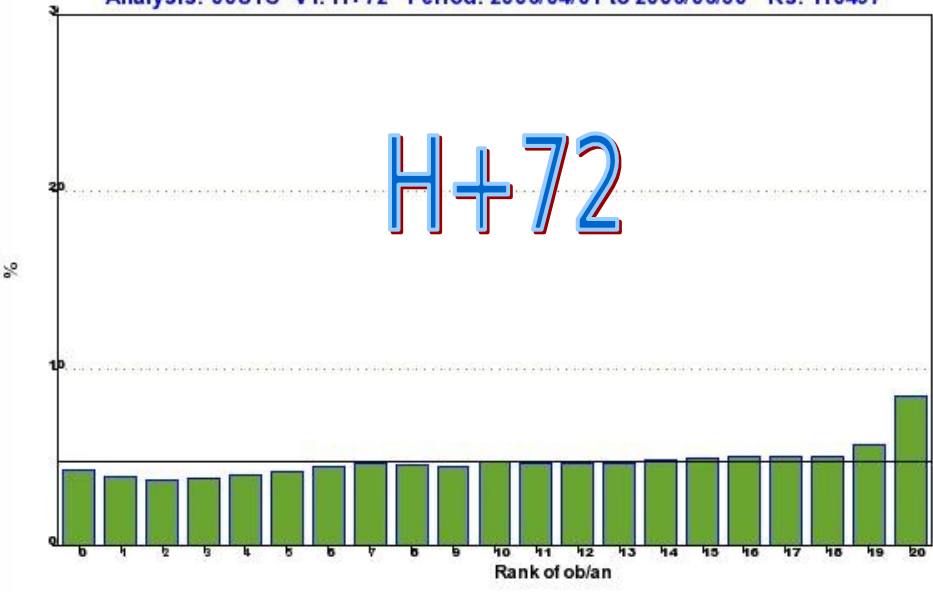


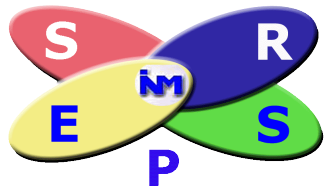


Pmsl- Obs



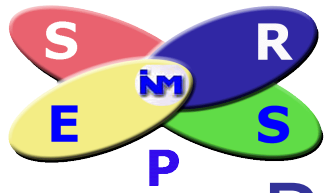
SREPS Multimodel-Multiboundaries (Mummub 16.6/20 avg members)
 Rank Histogram Mean sea level Pressure ag. SYNOP & TEMP observation
 Analysis: 00UTC VT: H+72 Period: 2006/04/01 to 2006/06/30 Rs: 110497





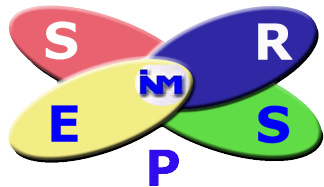
Binary events

- ☀ Binary events $X = \{0,1\}$ at every point
- ☀ Accumulated precipitation in 24 hours $\geq 5\text{mm}$
- ☀ Useful to decompose the forecast in thresholds
- ☀ Performance computed using contingency tables (CT's)

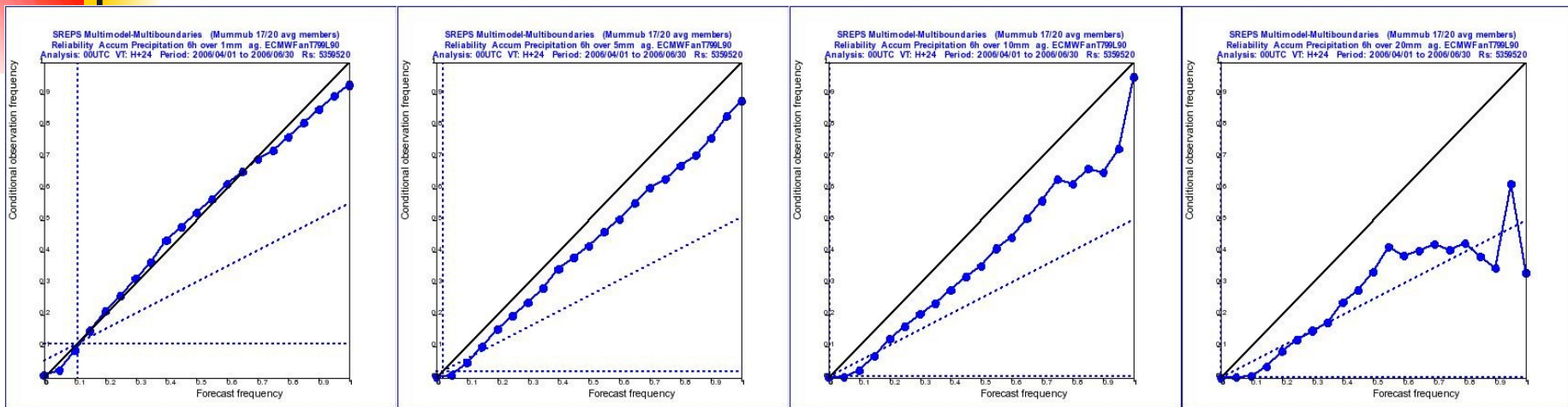


Precipitation

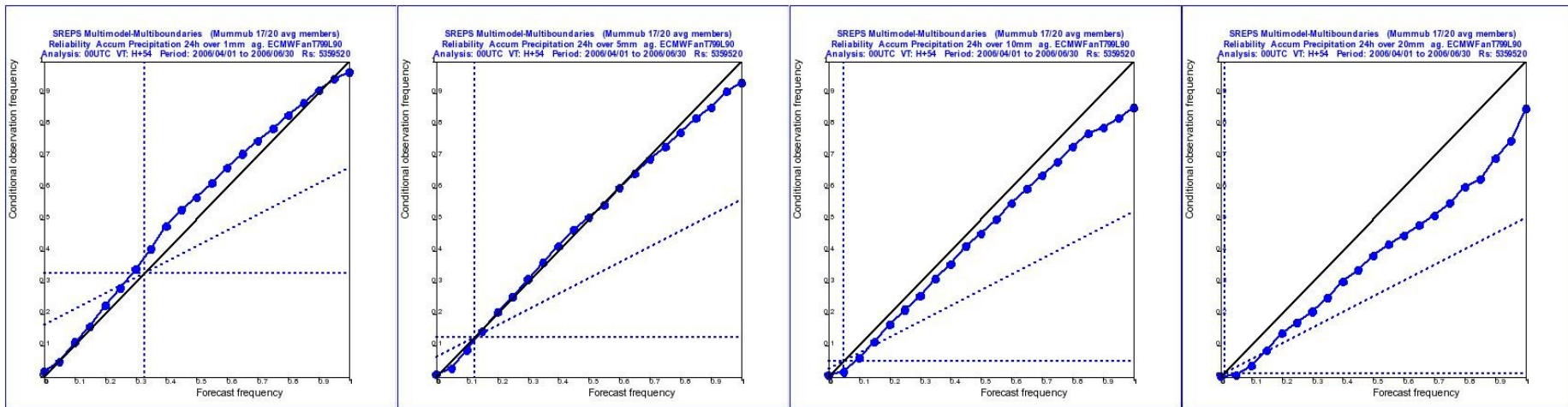
- Using ECMWF Deterministic Model as reference:
 - 6 hours accumulation – 24 hours forecast length
 - 24 hours accumulation – 54 hours forecast length
 - Thresholds 1, 5, 10 y 20 mm
- Using Synoptic observations as reference:
 - 6 hours accumulation – 24 hours forecast length
 - 24 hours accumulation – 54 hours forecast length
 - Thresholds 1, 5, 10 y 20 mm

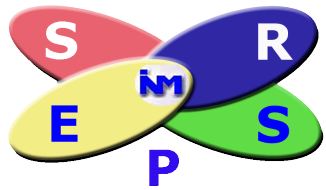


Reliab. - 6 h Acc. Precip H+24 (1,5,10,20) mm



Reliab. - 24 h Acc. Precip H+54 (1,5,10,20) mm

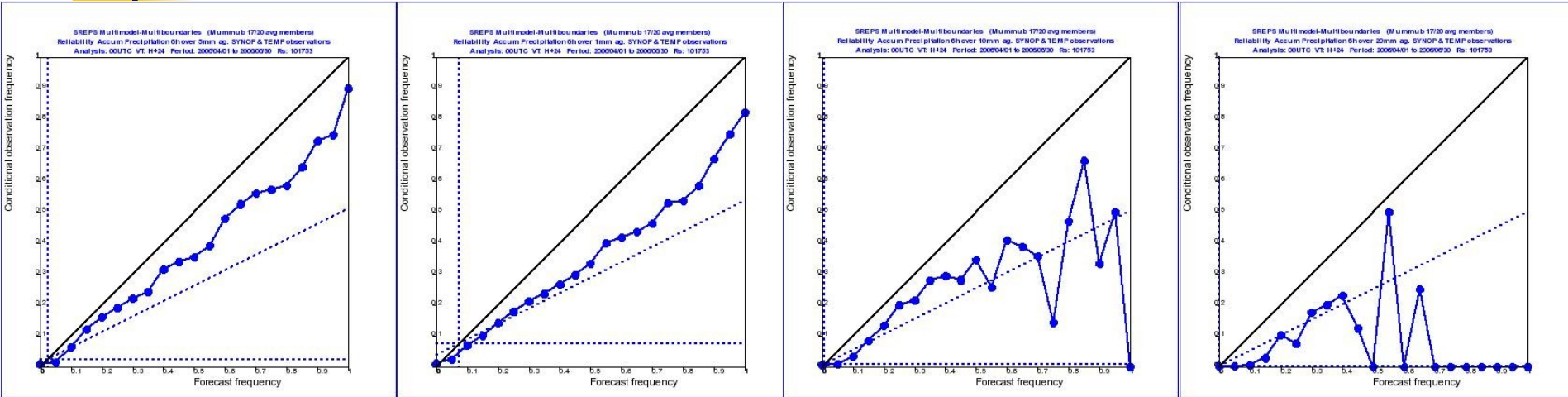




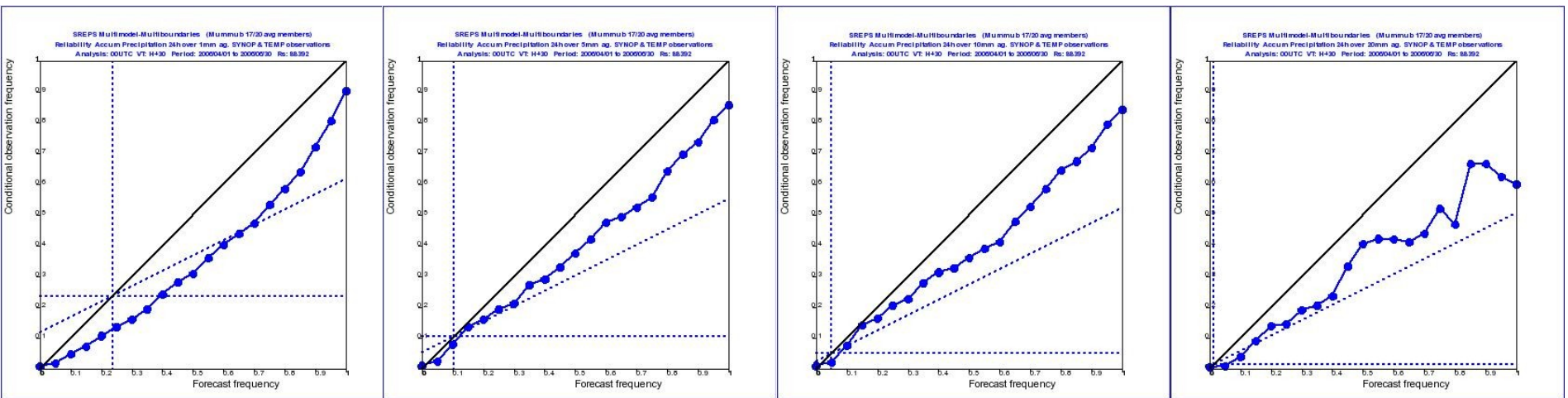
Observations

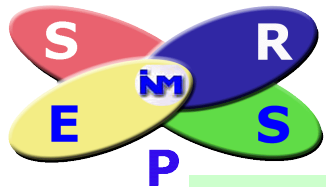


Reliab. - 6 h Acc. Precip H+24 (1,5,10,20) mm



Reliab. - 24 h Acc. Precip H+54 (1,5,10,20) mm



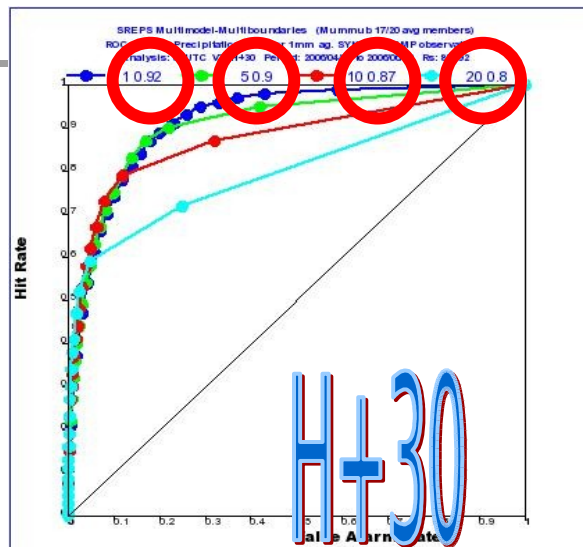
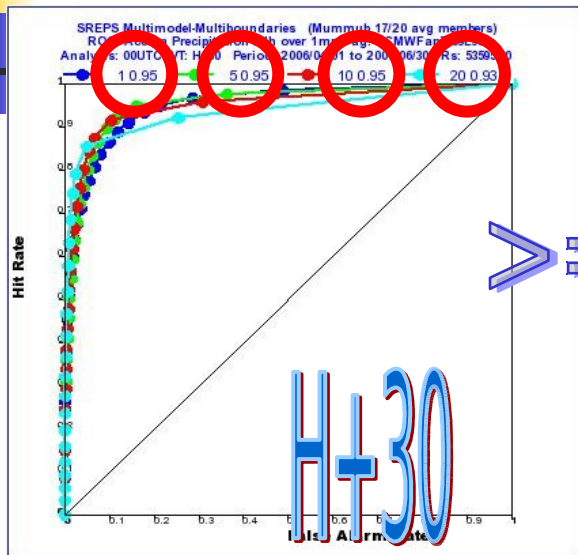


ROC curves – 24 h Acc Precip (1, 5, 10 & 20 mm)

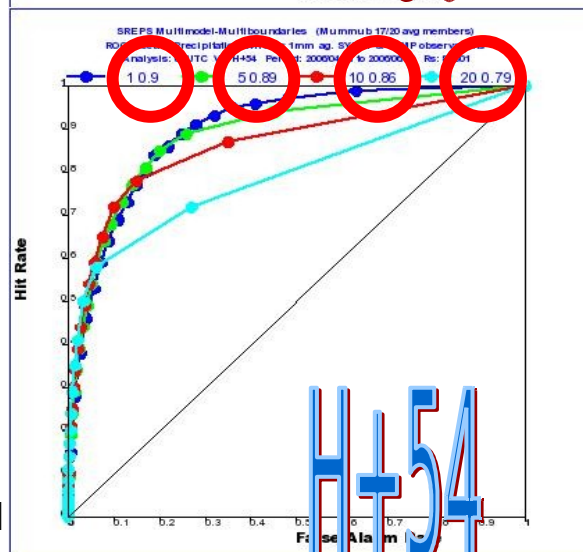
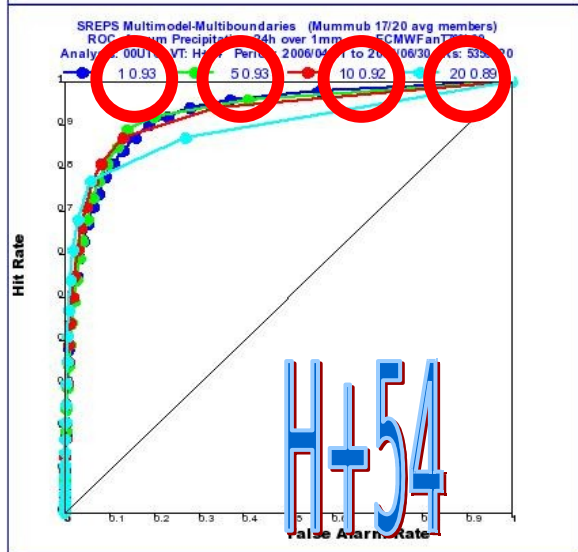


ECMWF

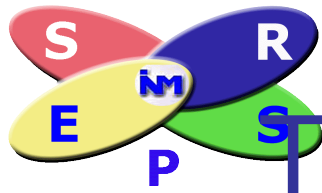
Observations



≥ 0.9

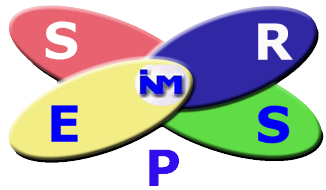


HIRLAM / ALADI



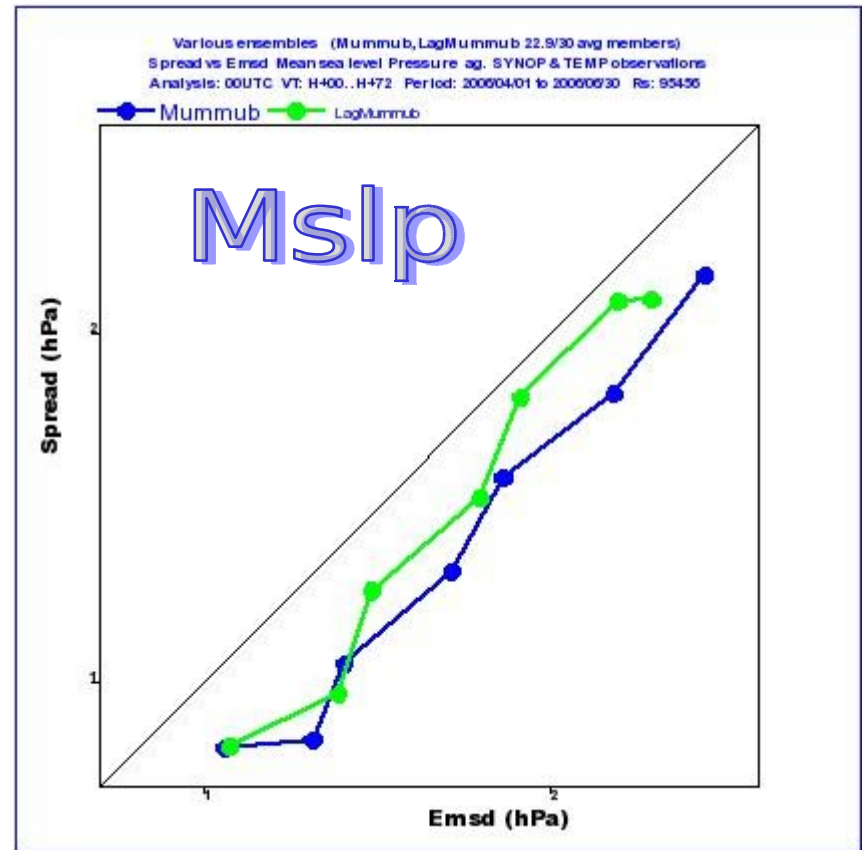
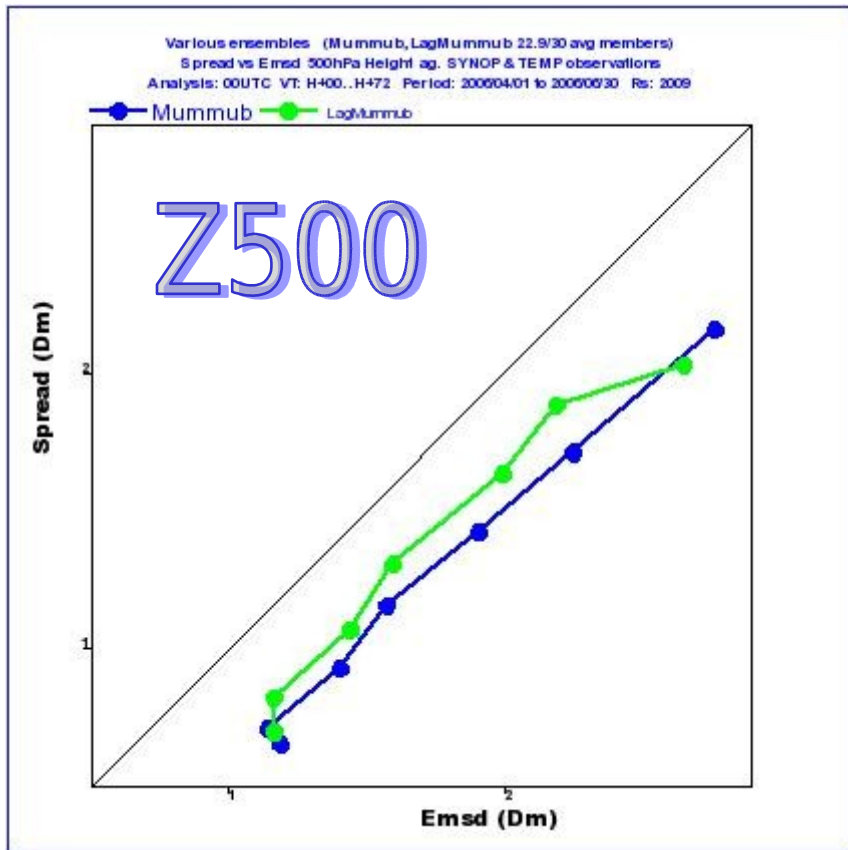
Time-Lagged Super-ensemble

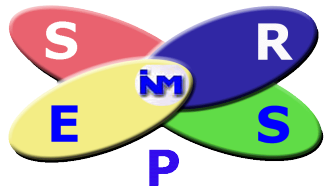
- ✱ How much predictability can be added by a time-lagged super-ensemble?
- ✱ 40 members super-ensemble (SE-SREPS) with the last two runs of SREPS (HH & HH-12).
- ✱ Verifications against observations
- ✱ Cheap in terms of computer resources
- ✱ Just a different post-process



Spread-skill

Green - SE-SREPS
Blue - SREPS

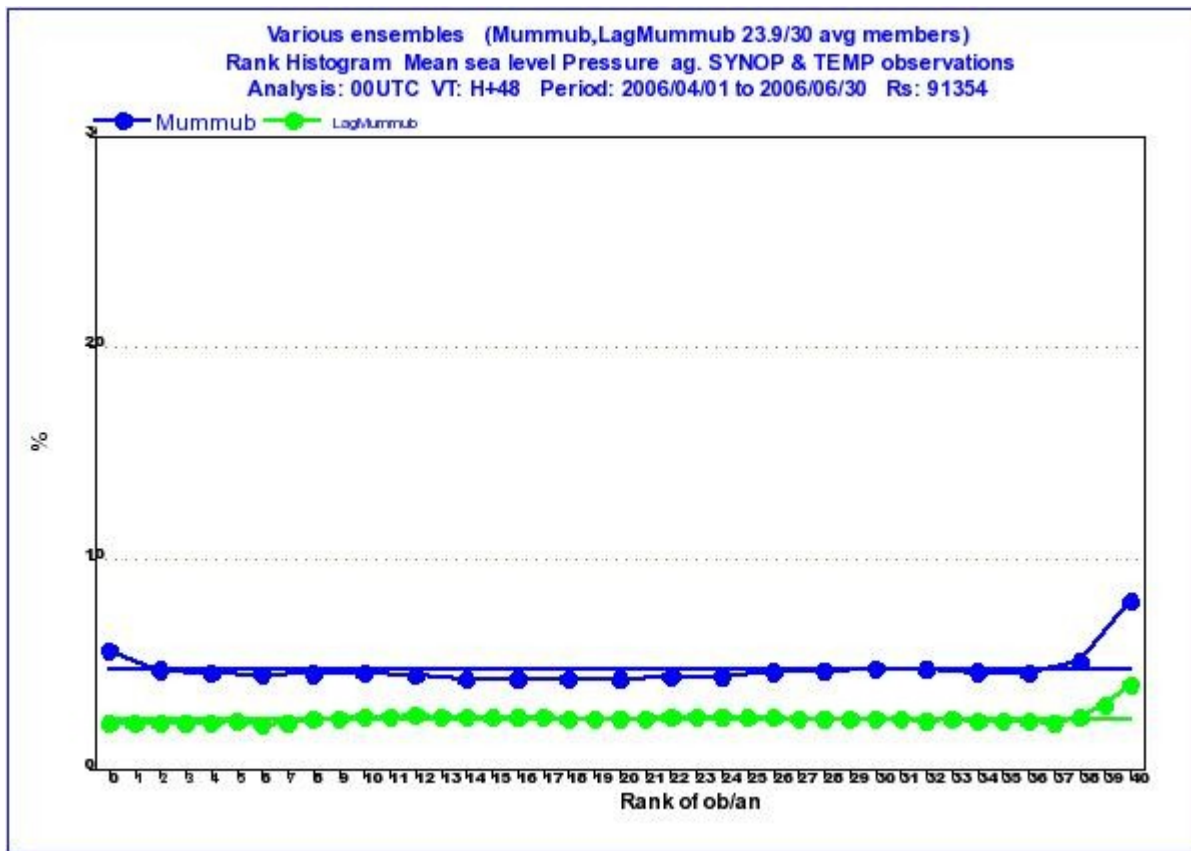


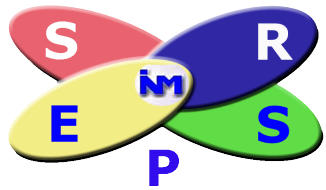


Rank histogram

Green - SE-SREPS
Blue - SREPS

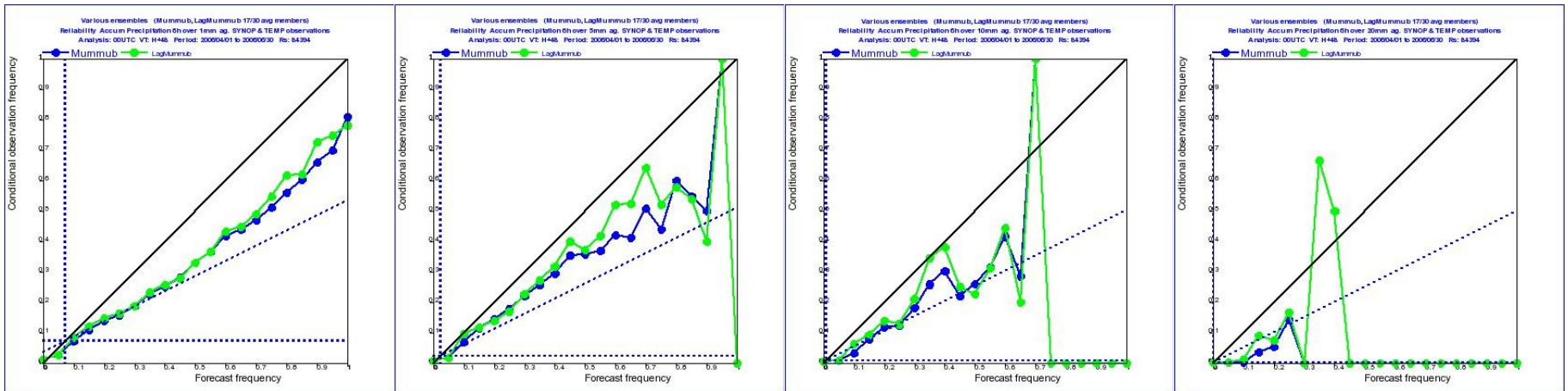
Mslp

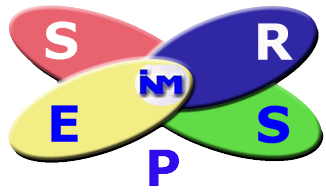




Reliability diagrams Green - SE-SREPS Blue - SREPS

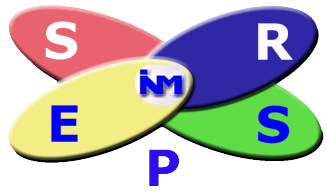
6 h. Acc. Precip. H+48 (1, 5, 10 & 20 mm)





Conclusions I

- ☀ We show here 3 months verification results (April-June 2006), against both synoptic observations and ECMWF analysis and model:
 - ☀ Calibration: Spread-skill diagrams and Rank histograms of precipitation.
 - ☀ Response to binary events: reliability and resolution of surface variables 10m surface wind (not shown), 6h and 24h accumulated precipitation.
- ☀ These first results are very good:
 - ☀ Verification against ECMWF analysis and model shows very good results
 - ☀ Verification against observations shows quite good results
 - ☀ Ensemble is a bit under-dispersive
 - ☀ Good response to binary events.



Conclusions II

- ☀ A Time-Lagged Super-ensemble with 40 members had shown better performance than the Multi-model SREPS alone.
- ☀ Multi-model technique gives much better spread than any other single-model technique (results not shown).
- ☀ **Future:**
 - ☀ Dissemination of probabilistic forecasts in real time.
 - ☀ Archiving individual members and probs in MARS at ECMWF.
 - ☀ Bias correction and calibration through a Bayesian Model Averaging scheme is under development (first results show better performance, see our poster).
 - ☀ BMA for precipitation.