Experiments related to the extension of the ECMWF BC project to EPS LBCs

Chiara Marsigli (ARPA-SIMC), Alfons Callado (AEMET), Inger-Lise Frogner (Met.no), Martin Leutbecher (ECMWF), Andrea Montani (ARPA-SIMC), Mihaly Szűcs (OMSZ), André Walser (MCH)

Aim of this work

- In the framework of C-SRNWP, an activity was initiated to support an extension of the ECMWF BC project to ENS LBCs
- **A first experiment** was organised in 2013, with the help of ECMWF, to test the **impact of high-resolution LBCs** from ENS
- A meeting for presenting and discussing the results was held at ECMWF, 9-10 December 2013
- A proposal for the extension of the BC project was formulated by the Working Group and presented to the TAC Subgroup for the revision of the BC project (Jan 2014)
- **A second experiment** was organised to test the feasibility of the proposal, focussing on **increasing the frequency of the LBCs** (summer 2014)
- Finally, the proposal for the extension was recommended to ECMWF TAC by the TAC Subgroup

Data provided – RES experiment

- ENS experiments were run with two horizontal resolutions:
  - Experiment R: T_L639 (32 km)
  - Experiment H: T_L1279 (16 km)
- 20+1 forecasts twice daily at 00 and 12 UTC, 7-day forecast
- Model physics and perturbation methodologies as in 38r1 ope ENS
- Experiments covered 98 cases in 3 two-week periods:
  a. 23 Oct – 7 Nov 2011
  b. 26 Dec 2011–8 Jan 2012
  c. 10–28 June 2012
- Model levels archived 1-hourly until 48 h and 3-hourly afterwards

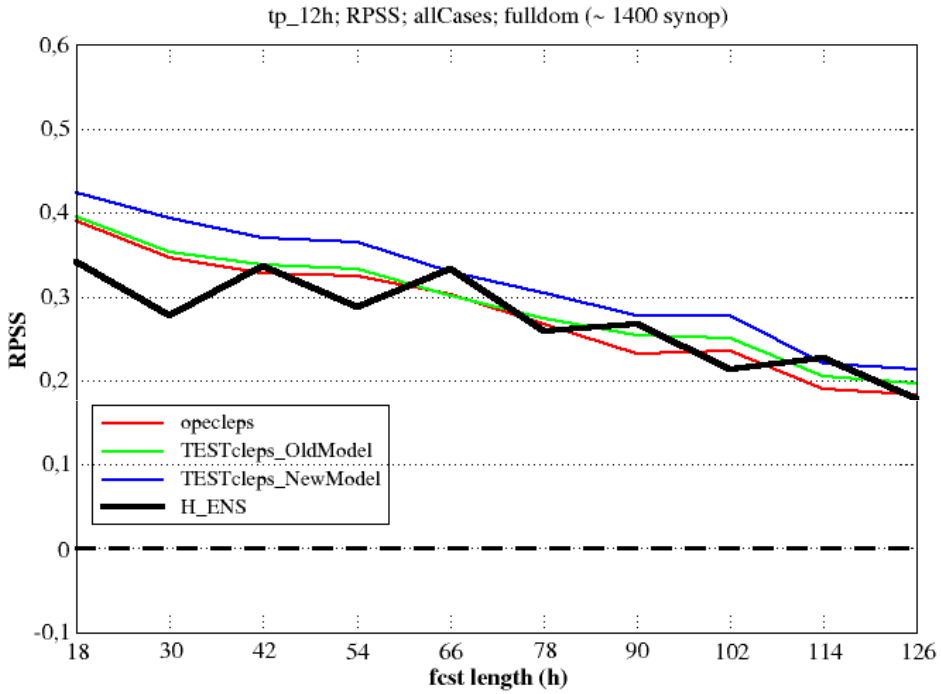
RES experiment – COSMO-LEPS

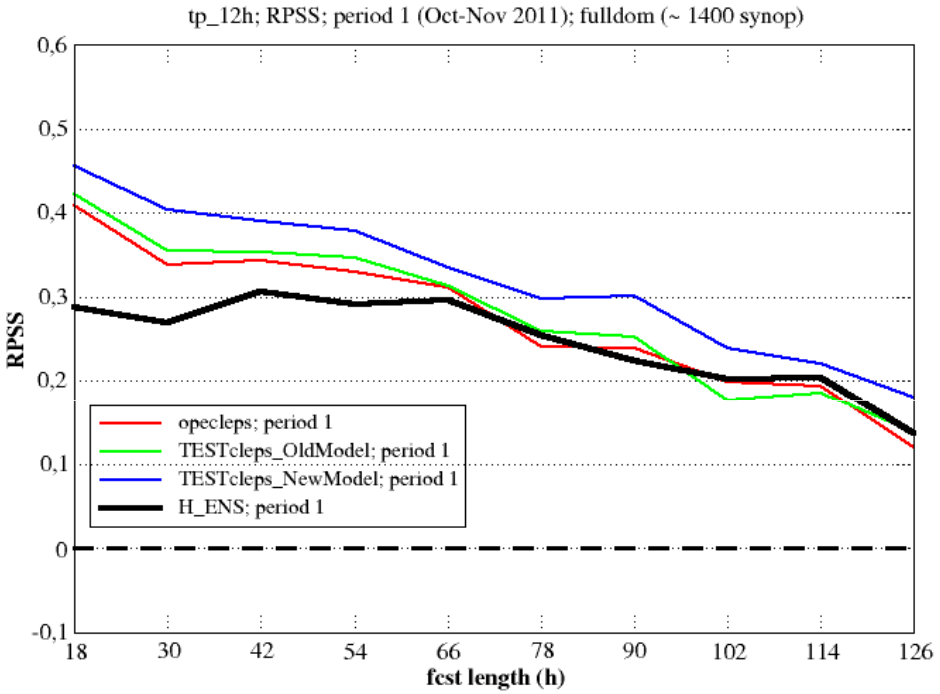
ARPA-SIMC

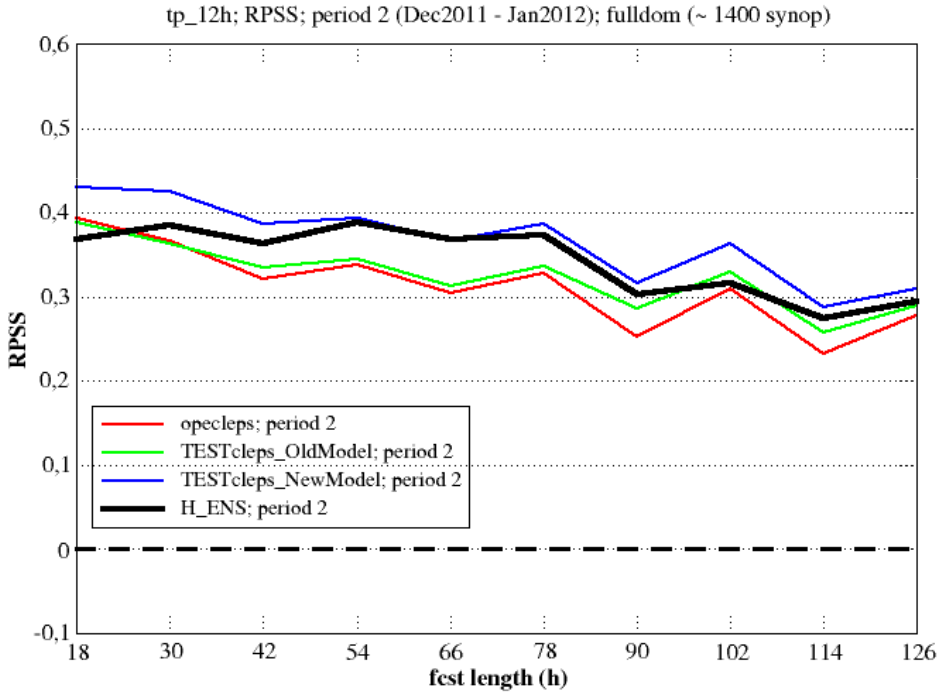
- **16 members, 132h forecast range, 7km**

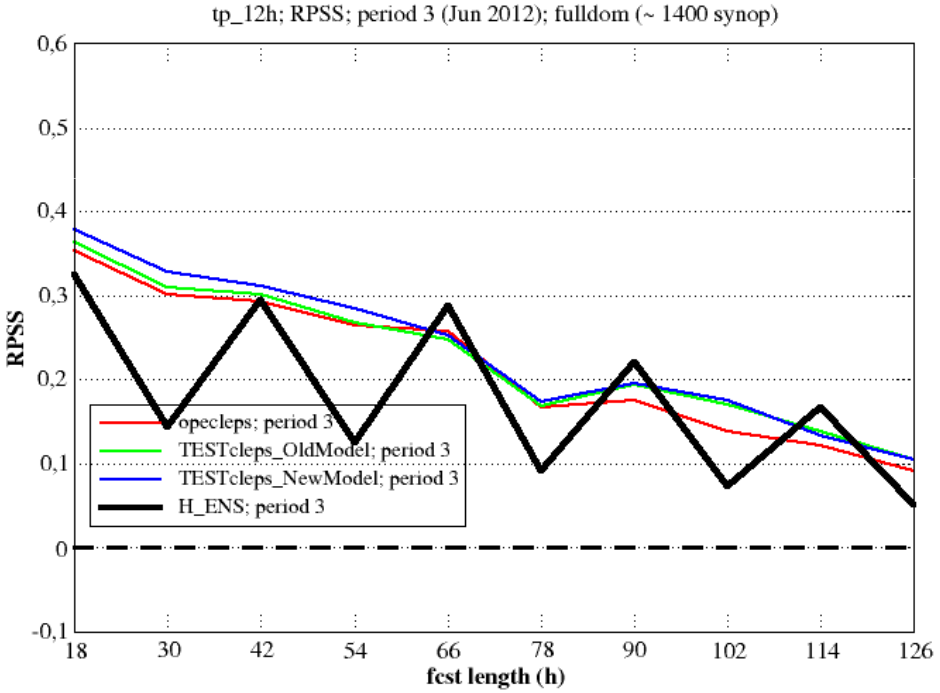
- operational COSMO-LEPS: low-res LBCs (as exp R), old COSMO version
- **high-res LBCs:** high-res LBCs (exp H), old COSMO version
- **high-res LBCs new:** high-res LBCs (exp H), new COSMO version
- **H_ENS:** 21-member high-res global ENS

12h precipitation - RPSS





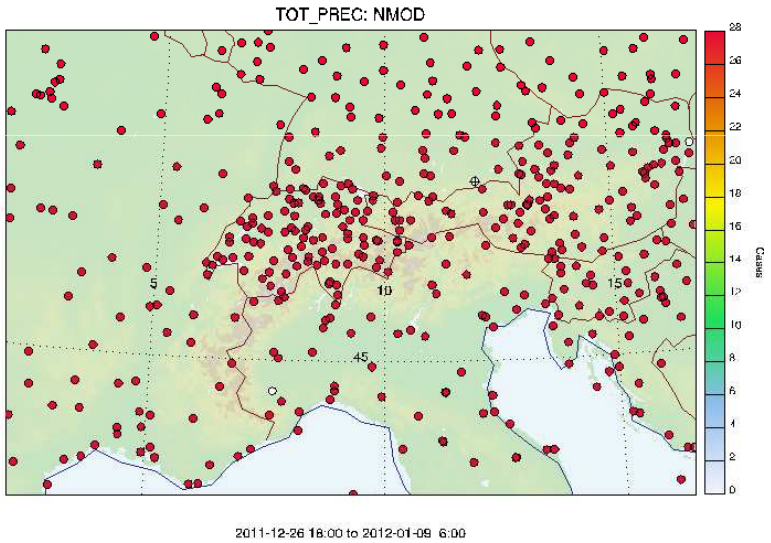




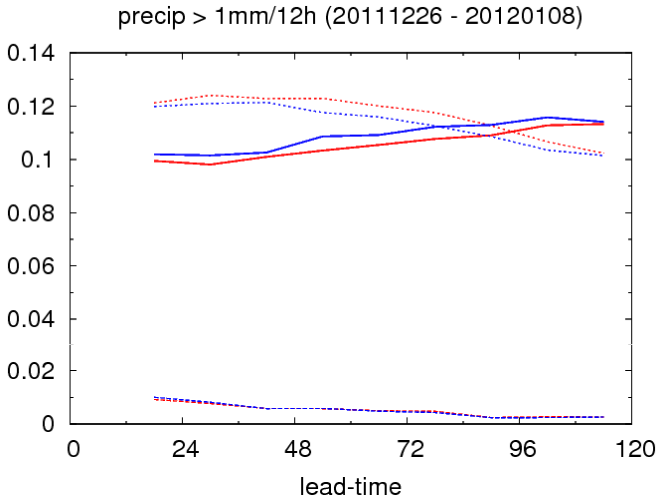
RES experiment - COSMO-E

MeteoSwiss

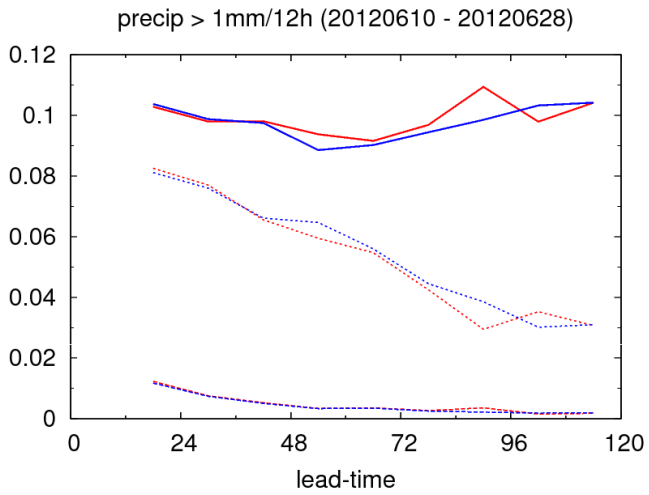
- Experiments with COSMO-E
  - BCR: downscaling 32 km → 2.2 km
  - BCH: downscaling 16 km → 2.2 km
- Analysis: COSMO-2 (2.2 km)
- No IC and model physics perturbations applied
- 120 h forecast range



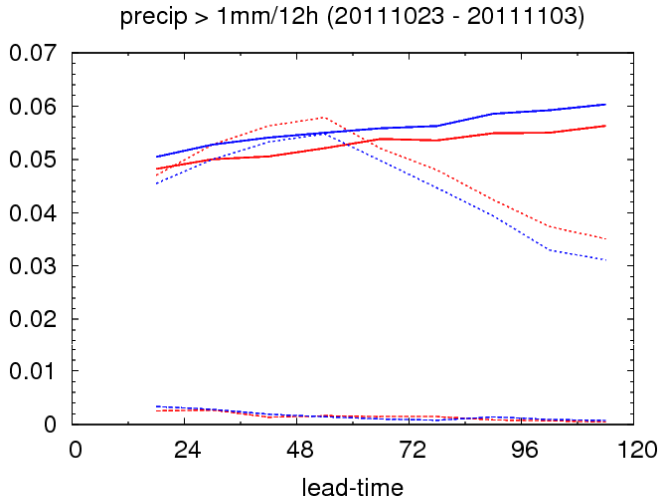
Brier score 12h sum of precipitation – 3 periods



winter period

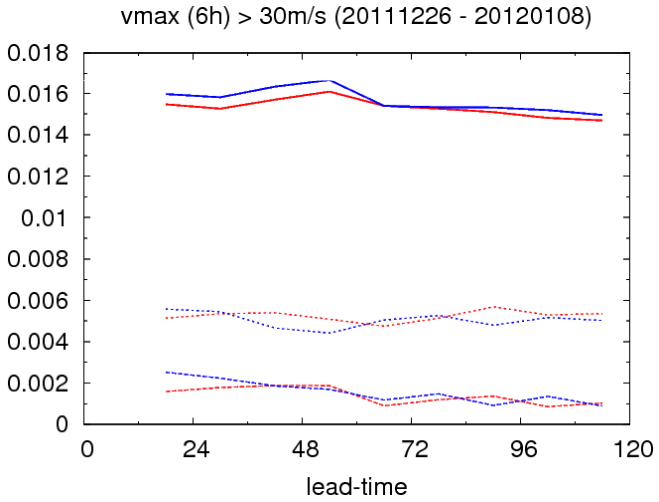


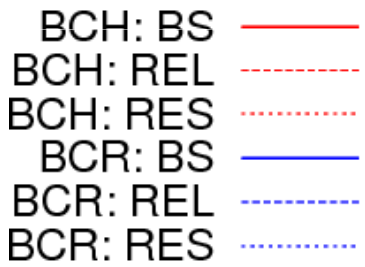
summer period



autumn period

10 m wind gusts - Brier Score





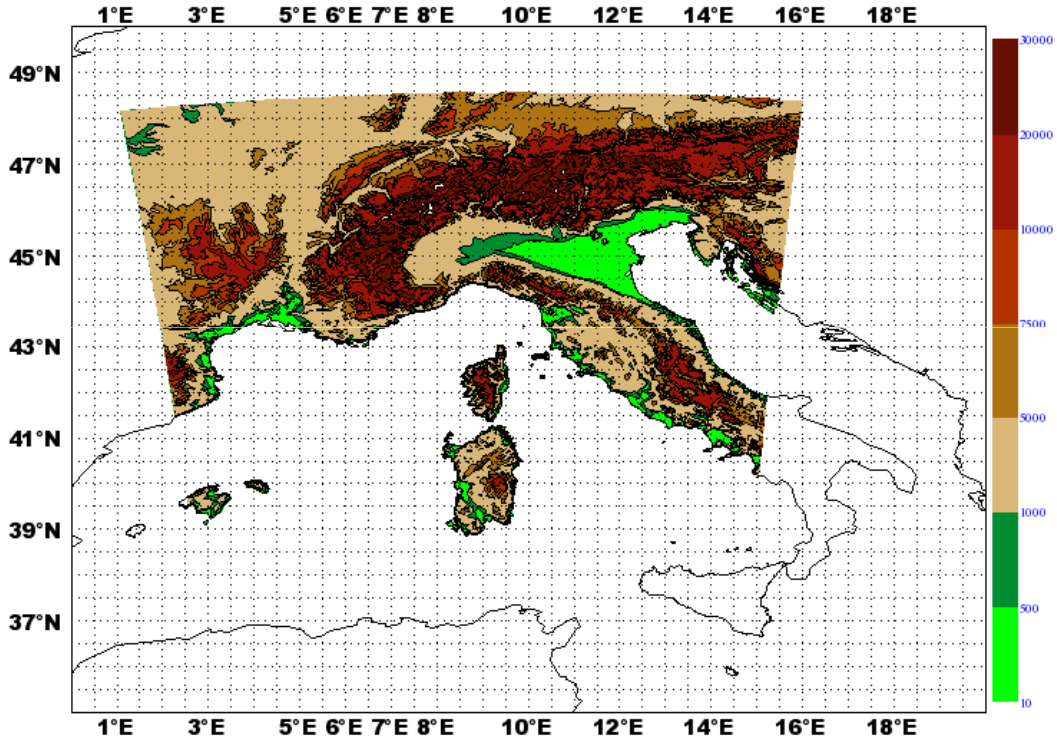
high-res LBCs

low-res LBCs

RES experiment - COSMO-H2-EPS

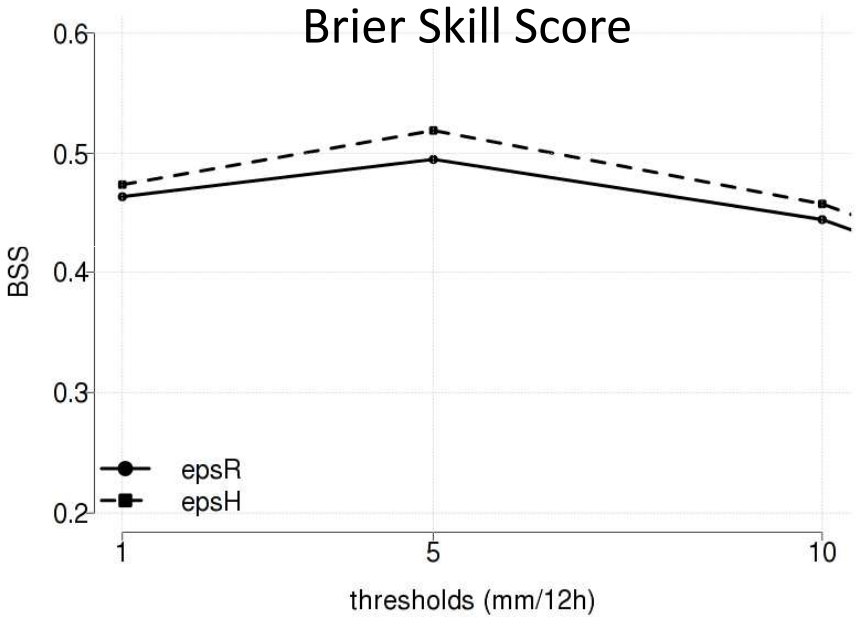
ARPA-SIMC

- IC and BCs from ECMWF ENS, R (T639) or H (T1279)
- 2.8 km, 50 levels
- 20+1 members
- no parameter perturbations
- no data assimilation
- 36h forecast range
- autumn period:
  (23/10 - 7/11 2011)

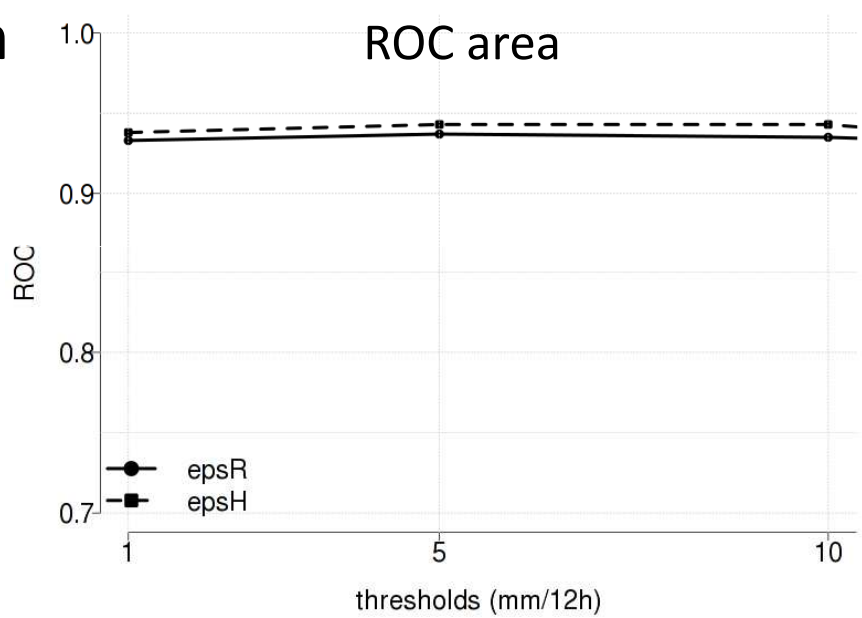


total precipitation over 12h

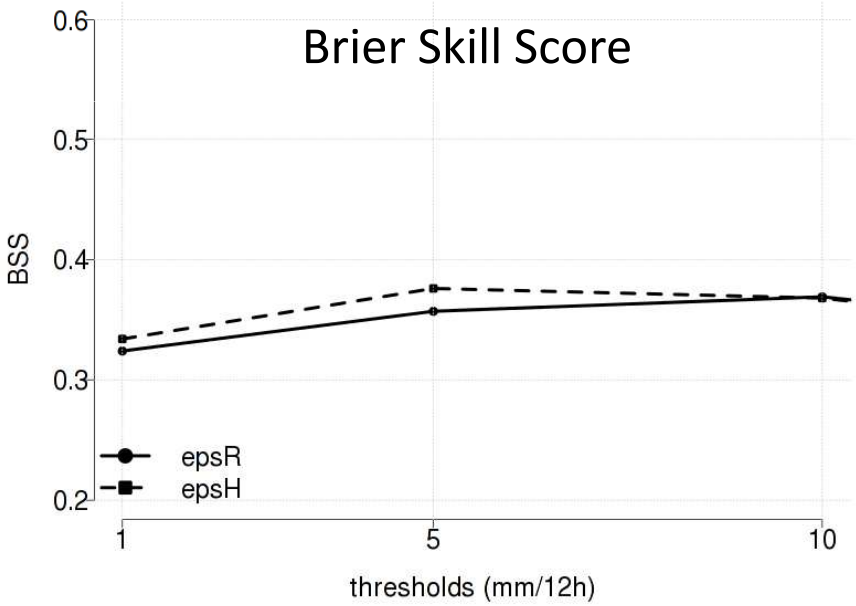
whole domain – synop data – nearest point

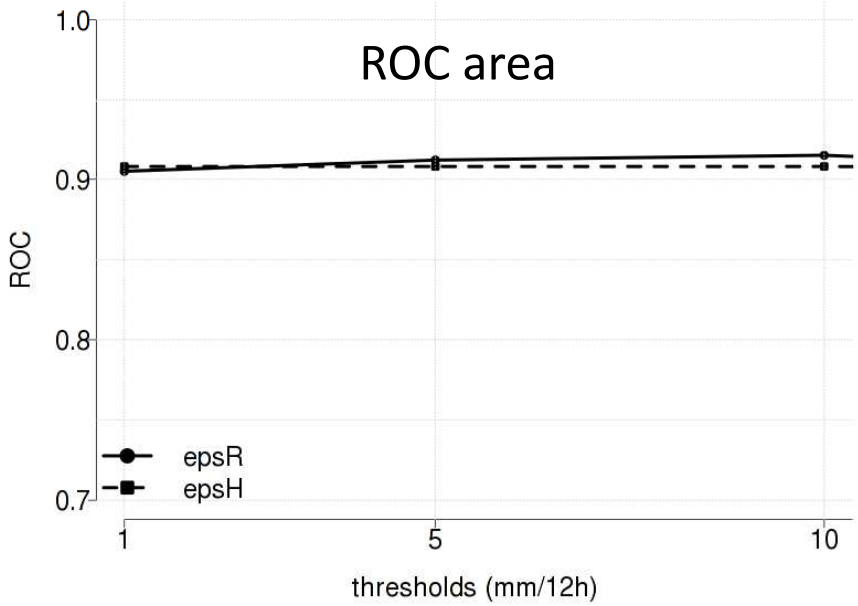


+ 6-18h



+ 18-30h

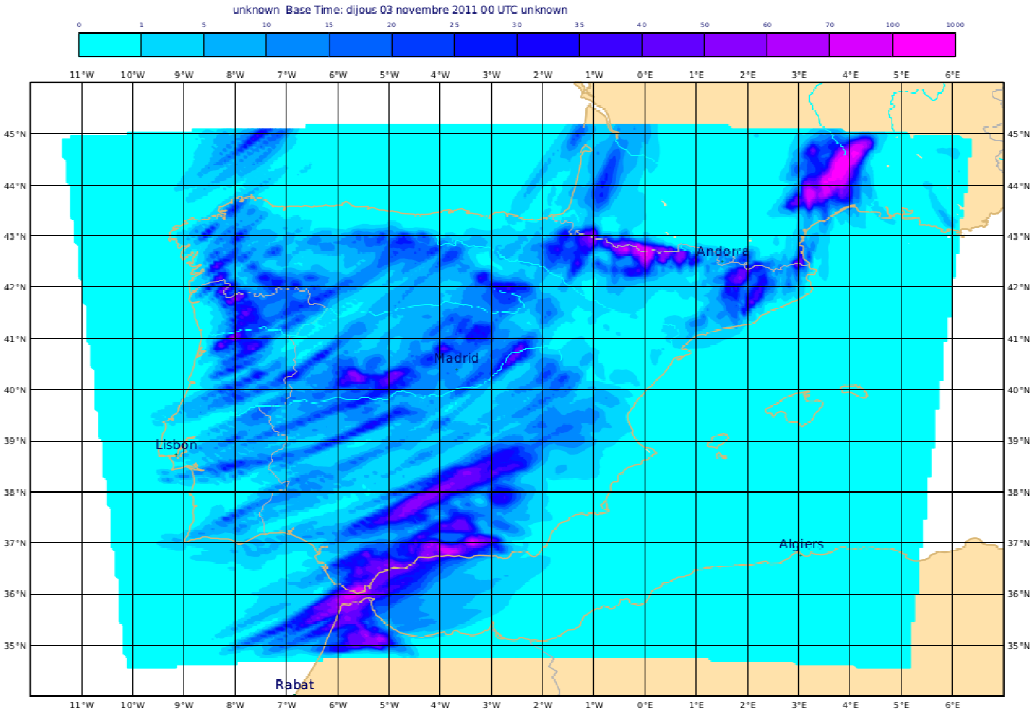




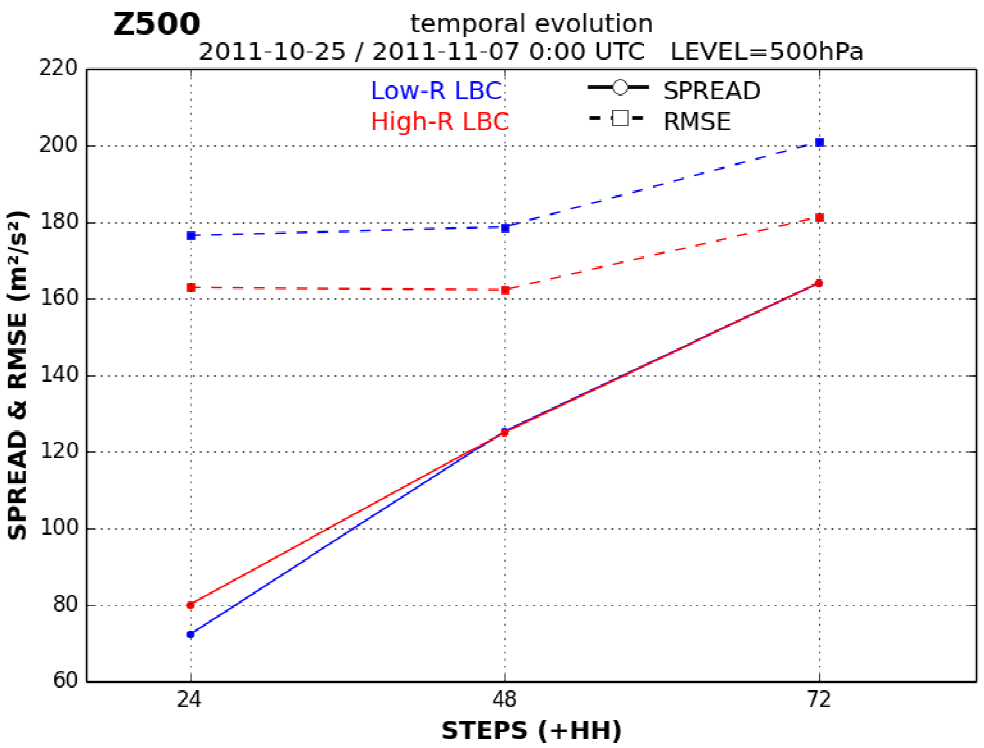
RES experiment - AROME EPS Spain

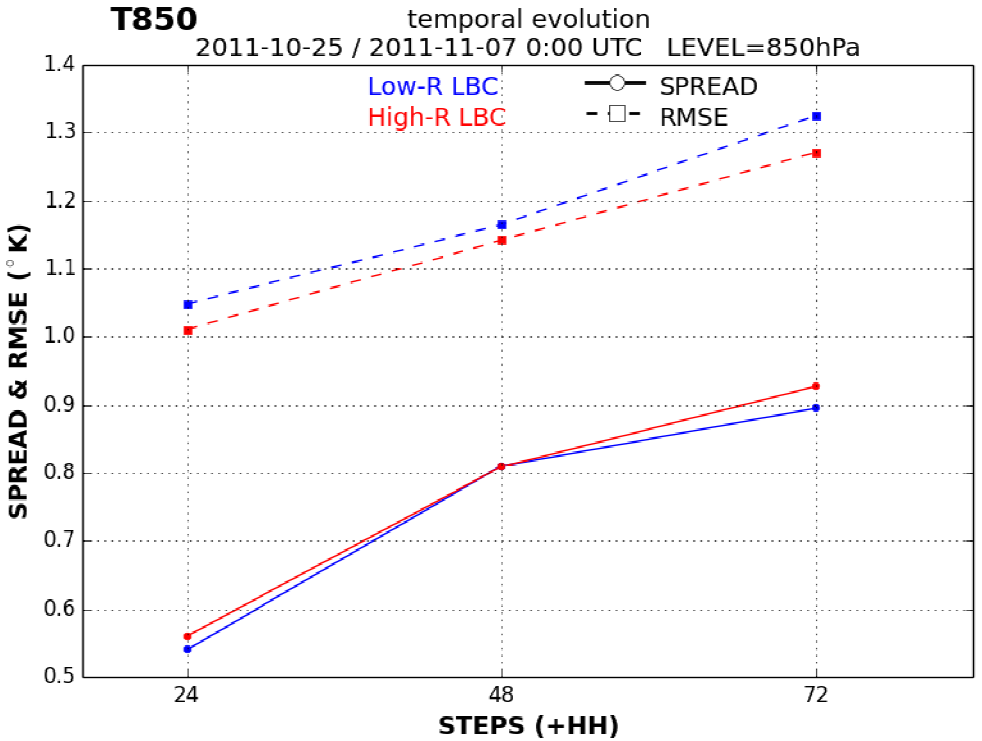
AEMET

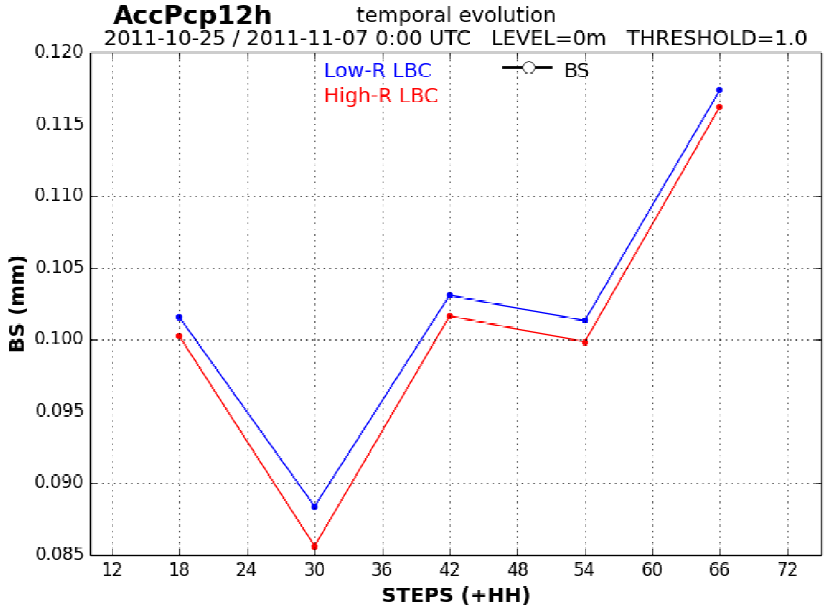
- BCs from ECMWF ENS, R (T639) or H (T1279)
- 2.5 km
- AROME physics
- Assimilation: surface & 3DVAR
- 22 members
- 72h forecast range
- autumn period:
  (23/10 - 7/11 2011)



spread/error - Z500 / T850





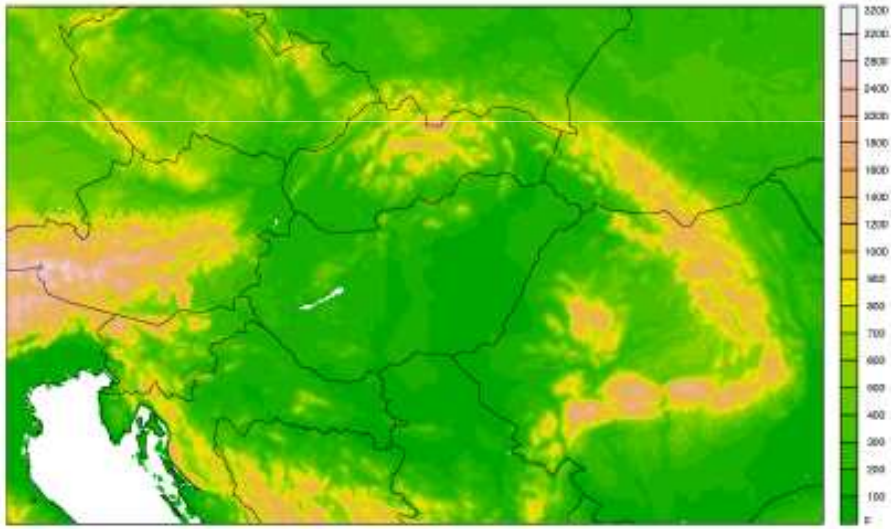


12 h precipitation
Brier Score

RES experiment – AROME-EPS Hungary

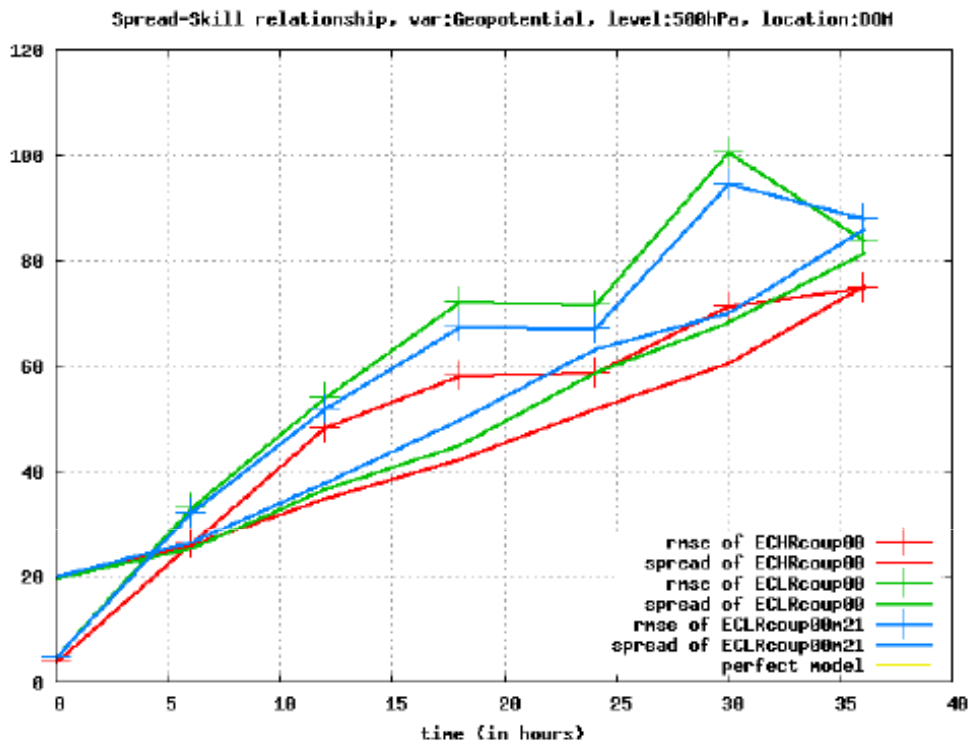
OMSZ

- Resolution: 2.5 km
- Ensemble size: 10-1 or 20+1 members
- Domain: 500*320 grid points
- 2 runs per day (00 and 12 UTC)

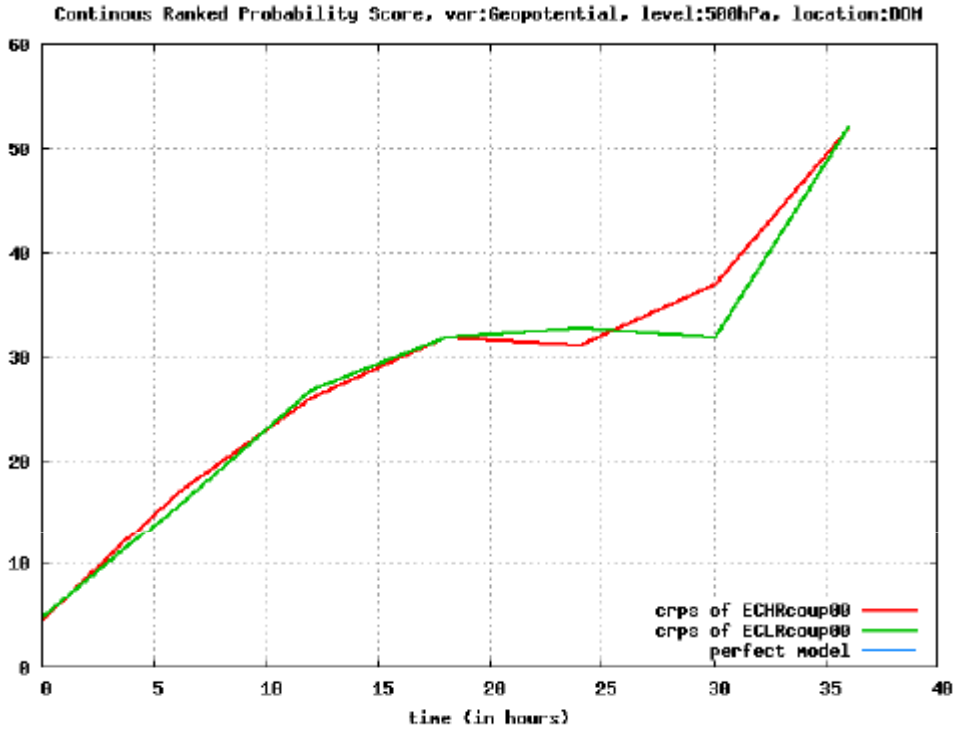


Geopotential height at 500 hPa

Winter period (26.12.2011-08.01.2012)

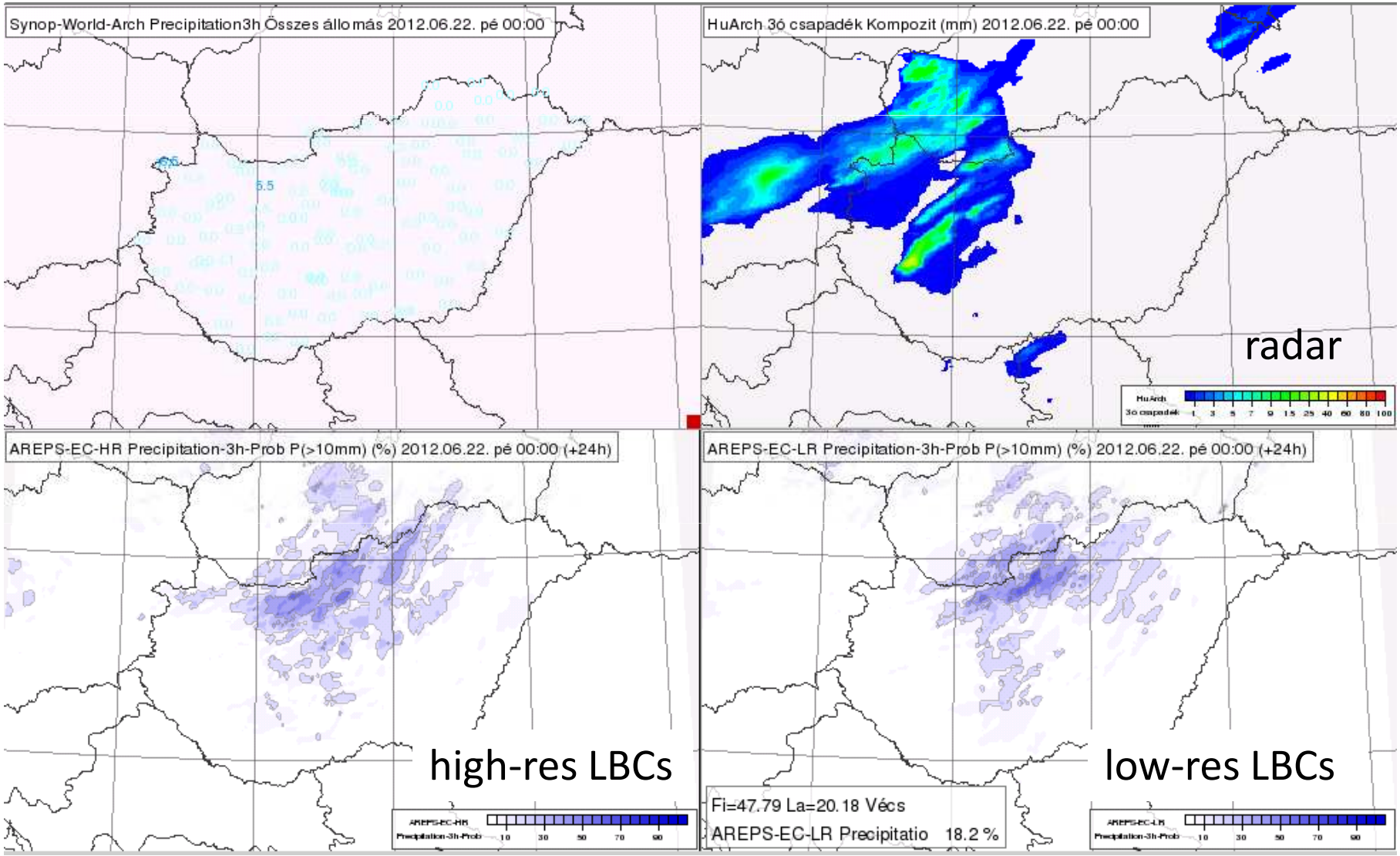


Summer period (10.06.2012-28.06.2012)



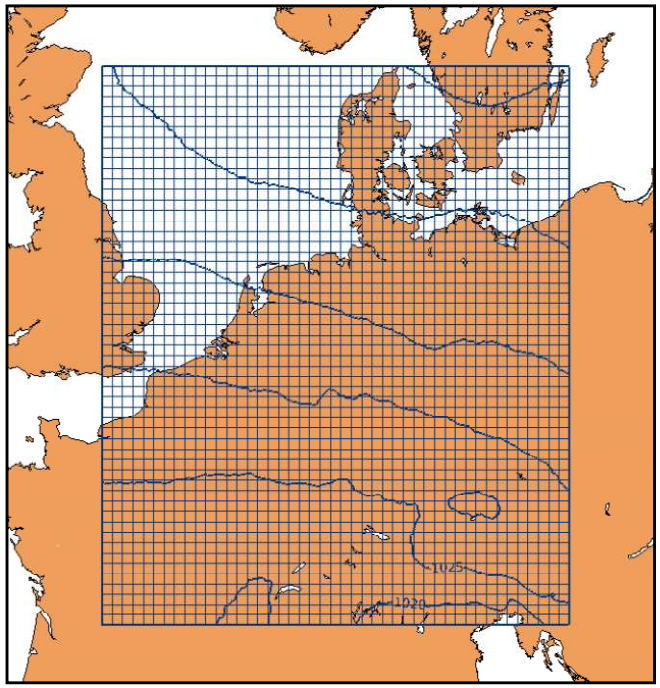
Probability of exceeding 10mm/3h

22.06.2012 00UTC



RES experiment – HarmonEPS

Met.no



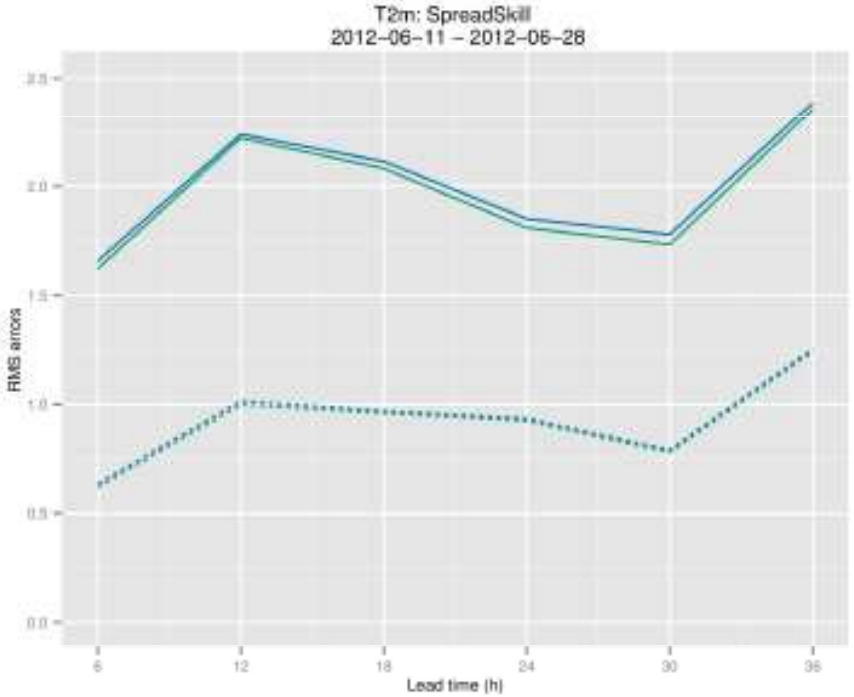
- 2.5 km resolution
- +36 h lead time
- 3h coupling
- Full DA and 6 h cycling for the controls
- Surface assimilation included for every member
- 20 members, 10 with AROME and 10 with ALARO

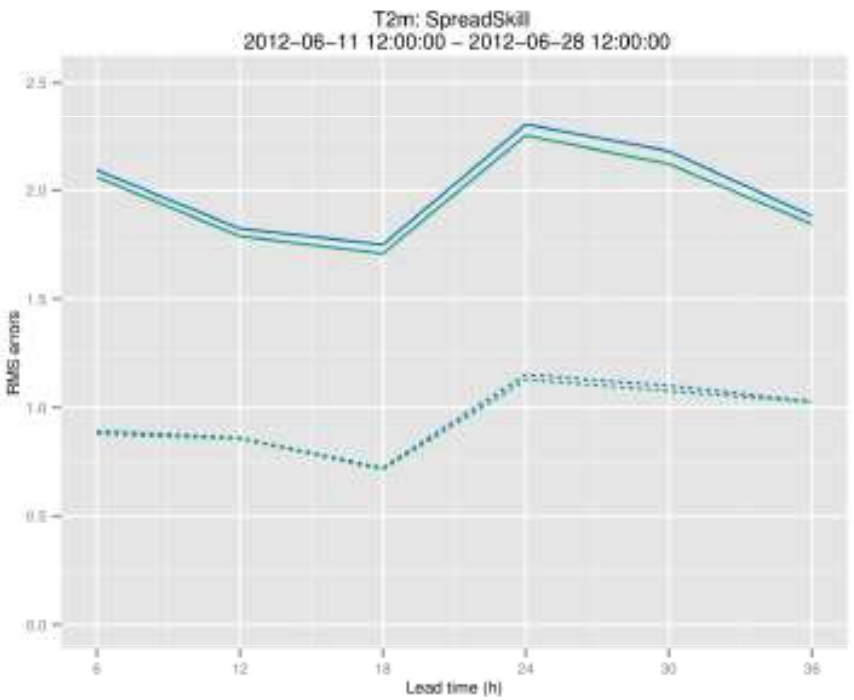
T2m – summer period (June 2012)

00 UTC

Spread -Skill

12 UTC





Members

- HarmonEPS
- HarmonEPS_highres

ScoreType

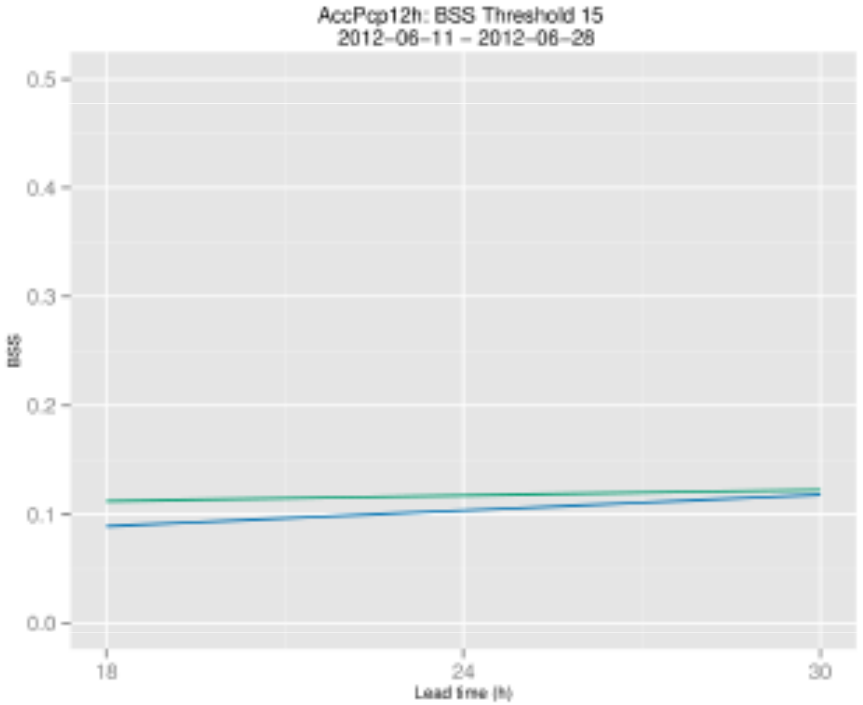
- MEANrmse
- MEANspread

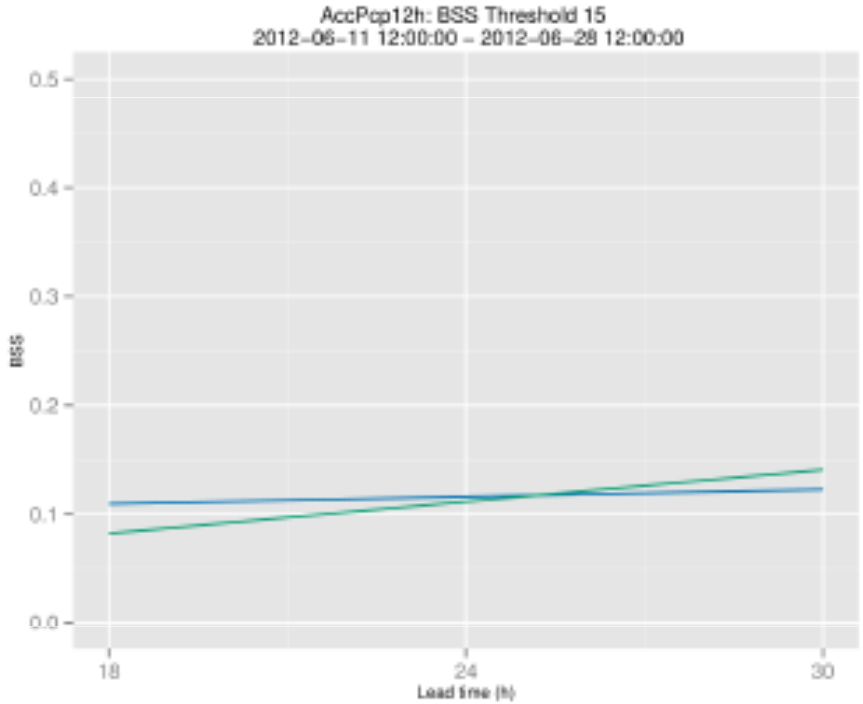
12h precipitation – summer period (June 2012)

00 UTC

BSS
THR 15

12 UTC





Members

HarmonEPS

HarmonEPS_highres

Proposal for the extension

A. **Add 2 runs of ENS at 06 and 18 UTC**
   - present resolution (to be increased as planned in 2015)
   - with a 6-day forecast range
   - with 50+1 members
   - hourly output for all 4 ENS runs (00, 06, 12 and 18 UTC runs) up to day 3 and 3-hourly output after day 3

B. **As in A but with 50+1 members up to day 3, then 20+1 members up to day 6**

Data provided – FREQ experiment

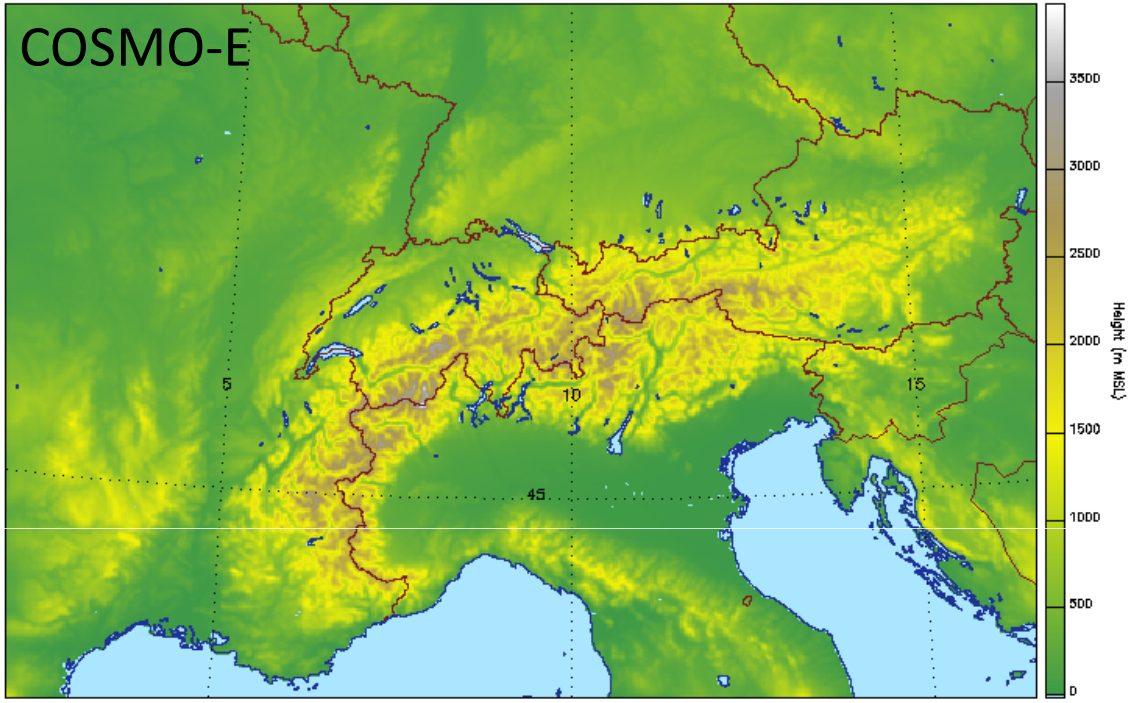
- 4 ENS runs per day (00, 06, 12, 18 UTC)
  - 20130510 to 20130531
- ensemble configuration as operational ENS model cycle 40r1, except for:
  - 20+1 members instead of 50+1 members
  - steps 0/to/144 every 3 hours
  - the 06 and 18 UTC runs use EDA perturbations based on 12-hour forecasts (instead of 6-hour forecasts)

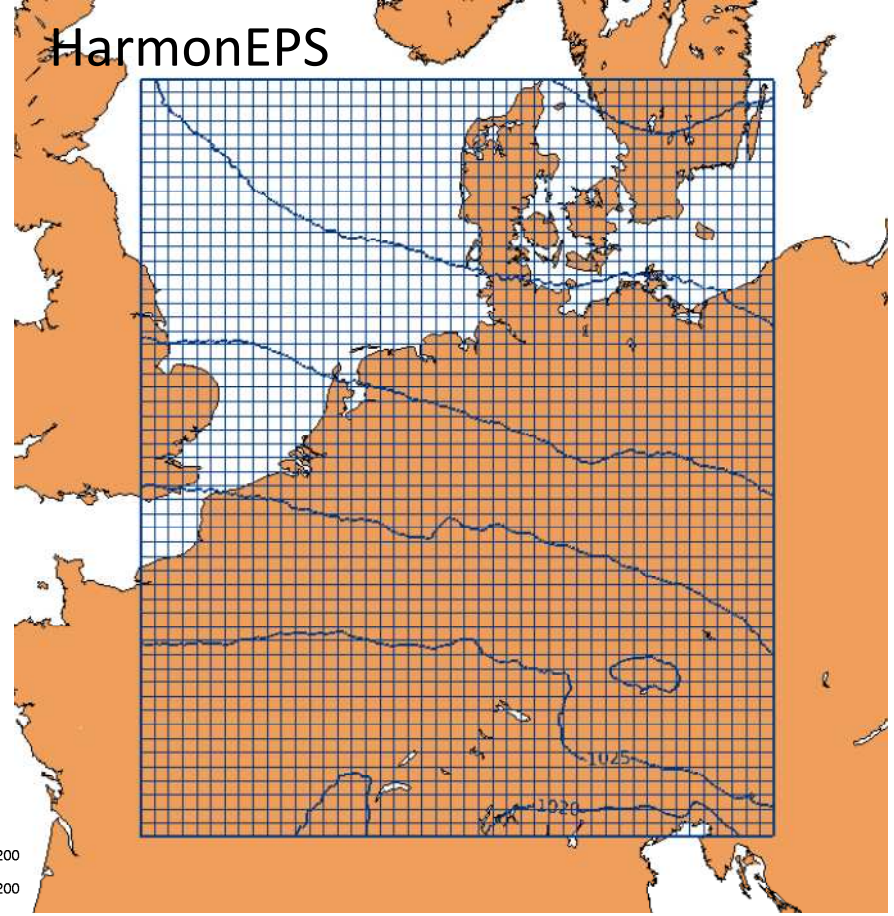
Purpose of the tests

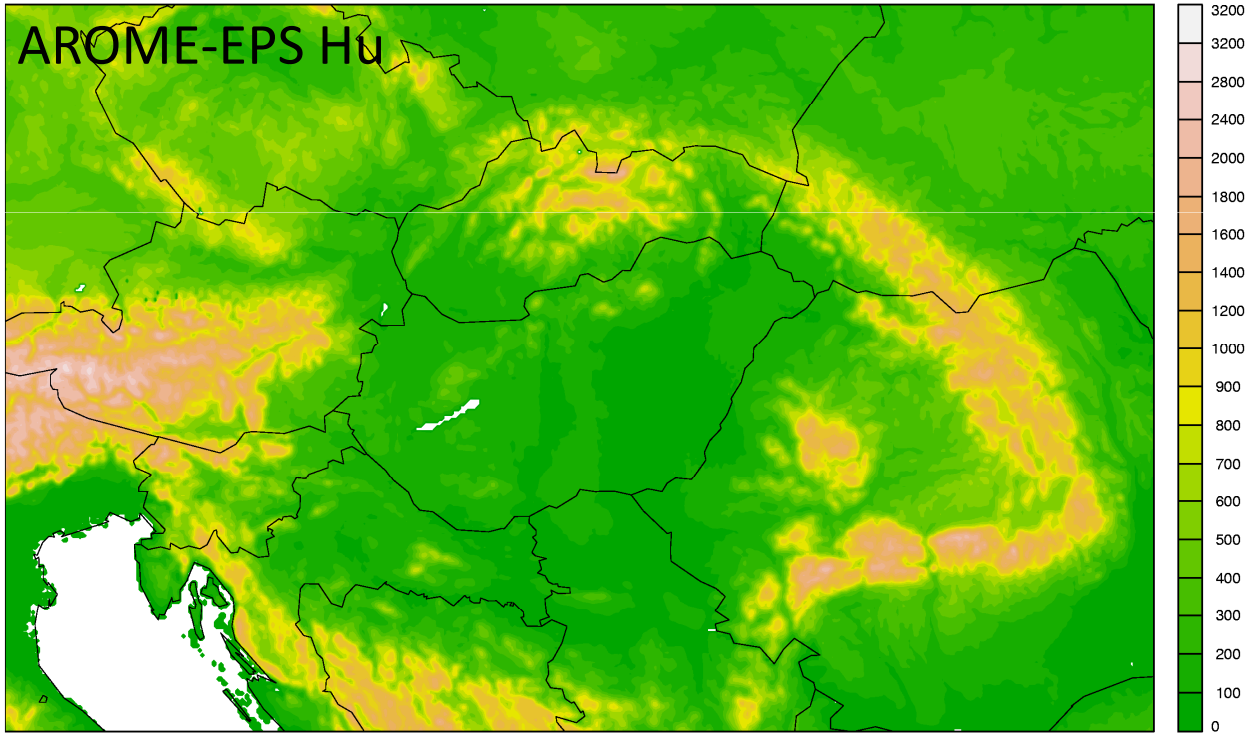
- The purpose of the test was mainly focused on answering those questions:
  - is the spread/error relation of the LAM-EPSs driven by the 06/18 and 00/12 UTC ENS runs comparable?
  - does the additional 06/18 UTC ENS runs bring benefit on top of the already available 00/12 UTC ENS runs when used to drive LAM-EPS applications?
  - what is the benefit of having additional ENS forecast data four times a day?

LAM-EPS test set-up

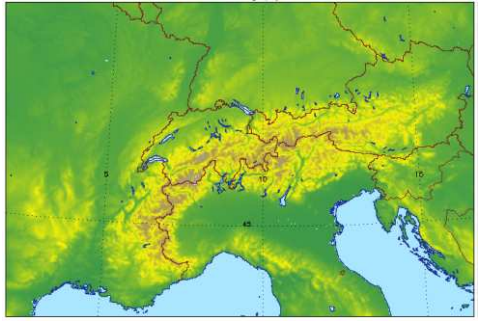
- The tests have been carried out by:
  - Met.no and SMHI for HIRLAM
    - HarmonEPS, 2.5 km resolution, 65 levels
    - 20+2 members, 36h forecast length
  - Hungarian Meteorological Service for LACE
    - AROME-EPS Hu at 2.5 km resolution
    - 10+1 members, 36h forecast length
  - MeteoSwiss for COSMO ensemble (ARPA-SIMC contributed to verification)
    - COSMO-E, 2.2 km resolution, 60 levels
    - 21 members, 120h forecast length







Model domains

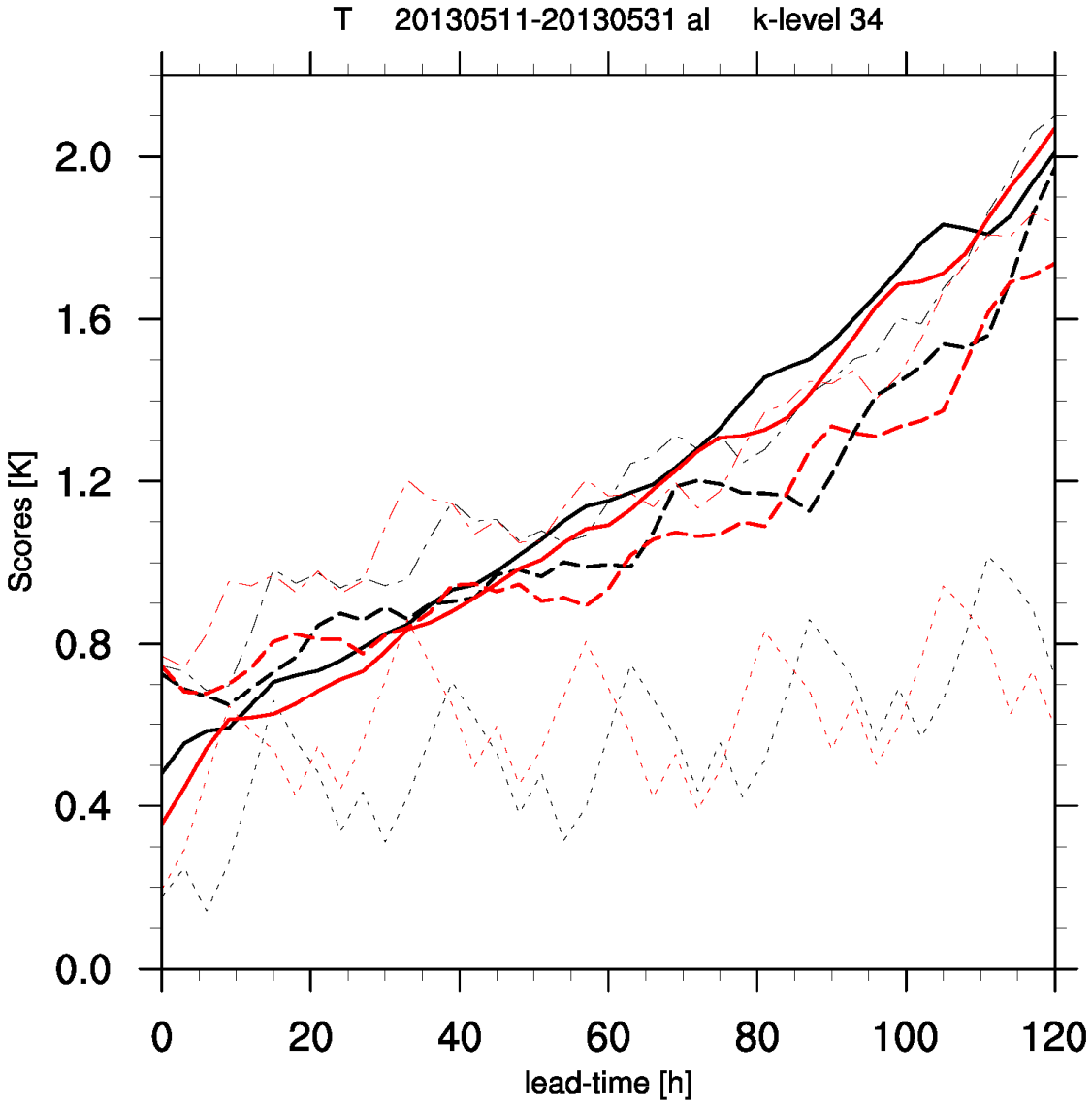


Results: spread/skill relation

COSMO-E

COSMO-E exp1 (test):
Initial time 00 UTC
IC and BC ENS 18 UTC (+6h)

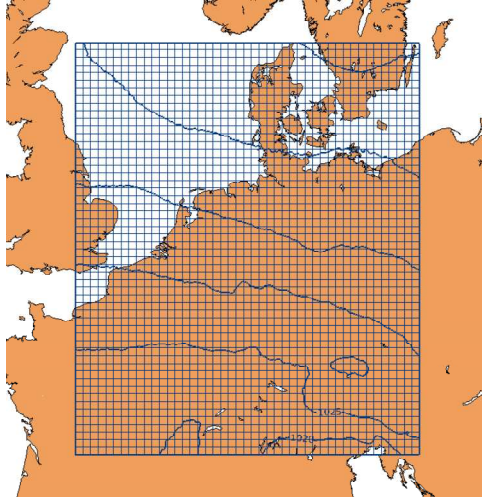
COSMO-E exp2 (ope):
Initial time 06 UTC
IC and BC ENS 00 UTC (+6h)

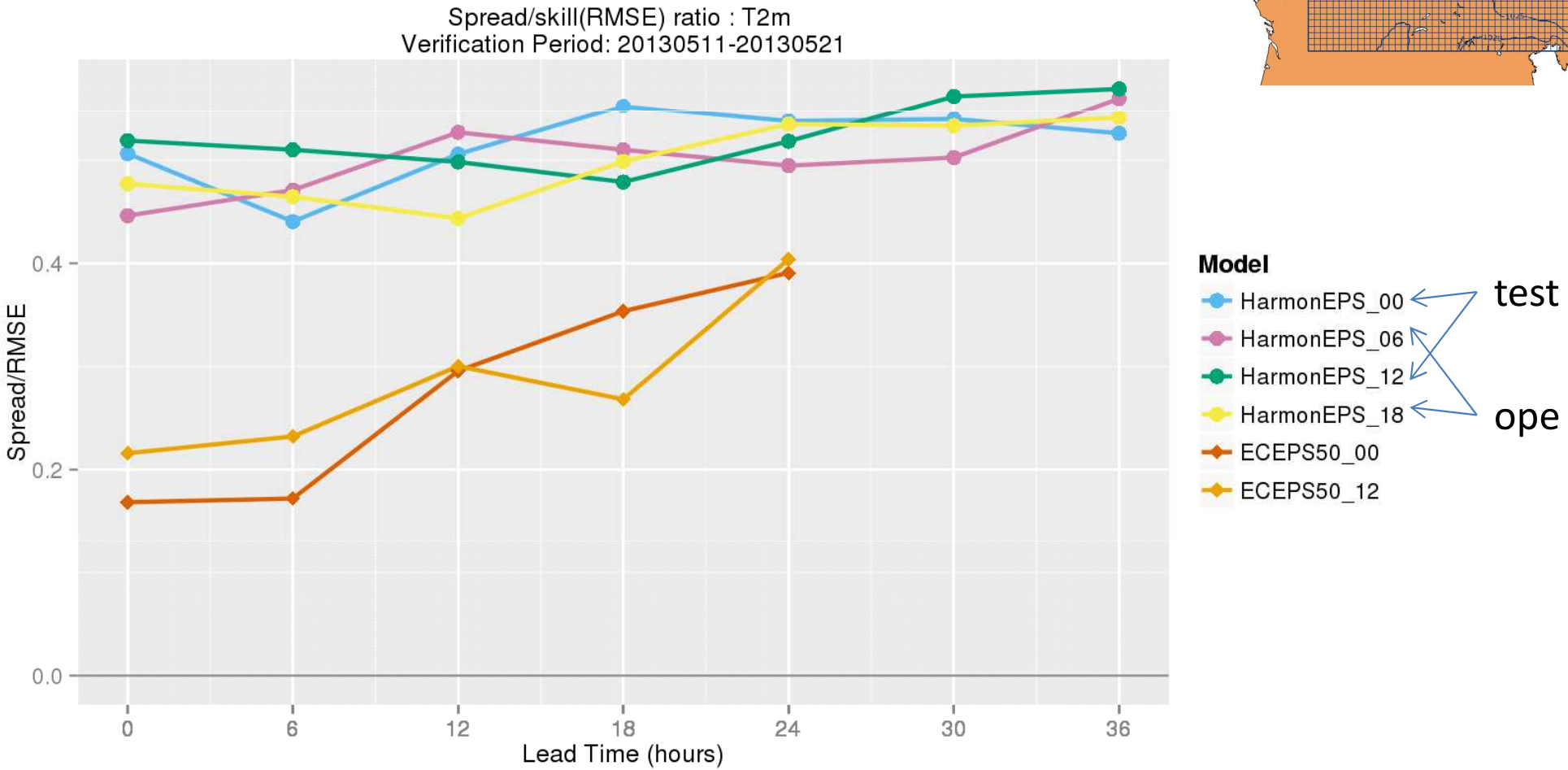


error: dashed spread: solid

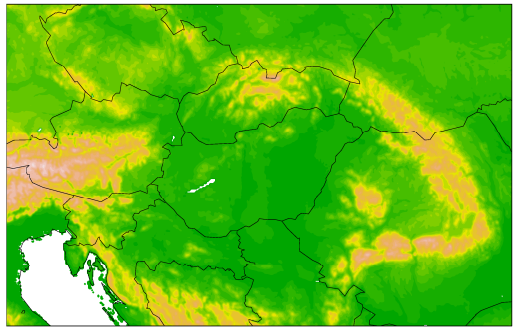
Results: spread/error relation

HarmonEPS





spread/RMSE ratio

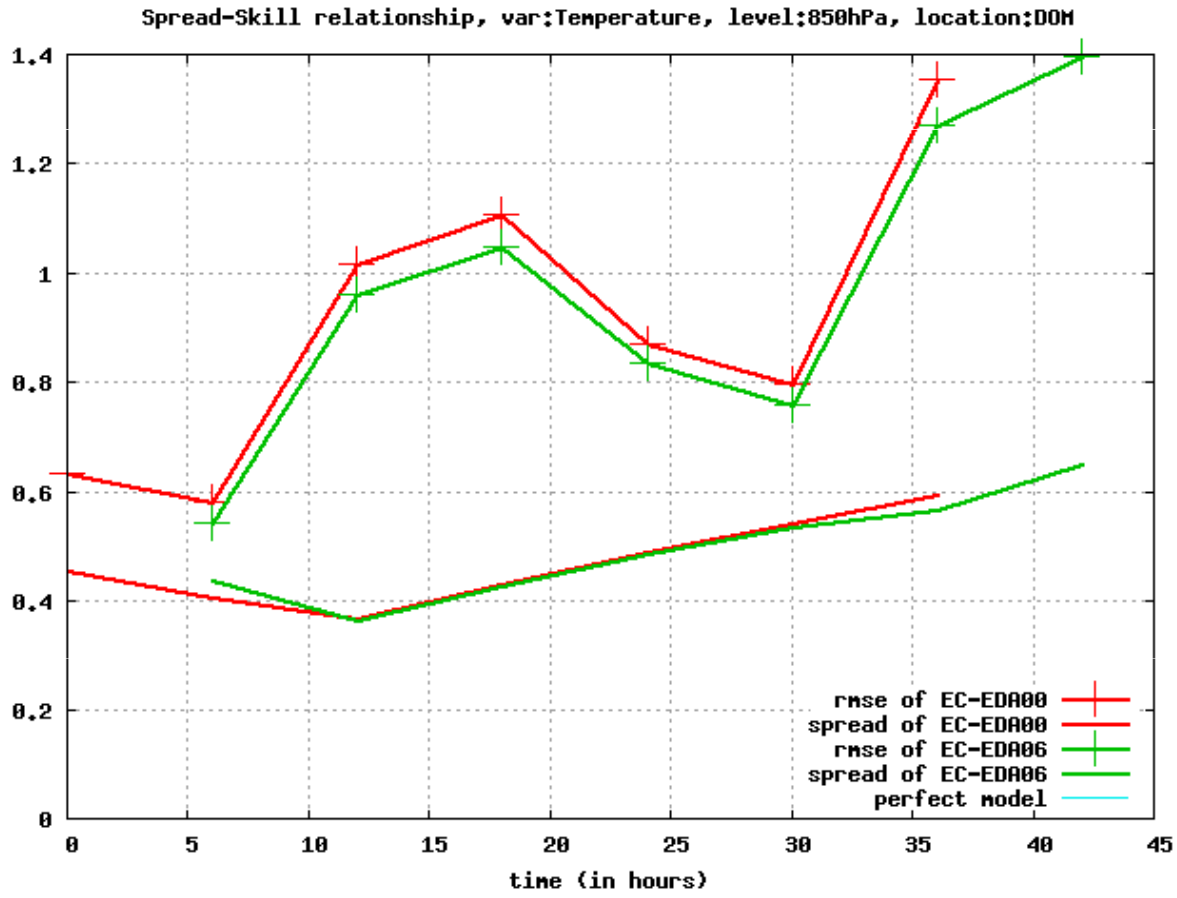


Results: spread/skill relation

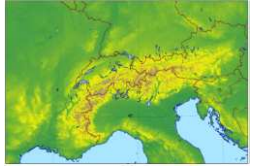
AROME-EPS

AROME-EPS EC-EDA00 (test):
Initial time 00 UTC
BC ENS 18 UTC (+6h)

AROME-EPS EC-EDA06 (ope):
Initial time 06 UTC
BC ENS 00 UTC (+6h)



spread: solid error: solid with crosses

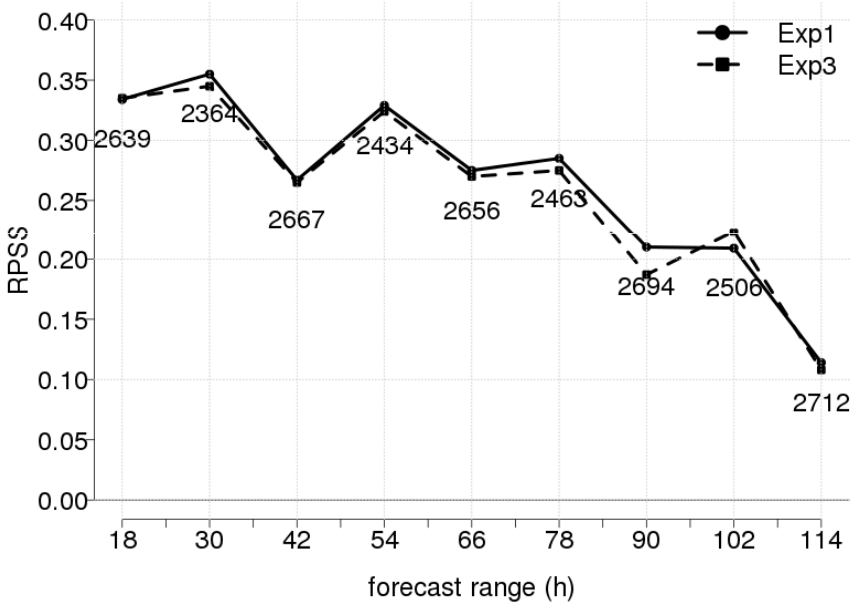


Results: benefit of the 06 and 18 UTC runs

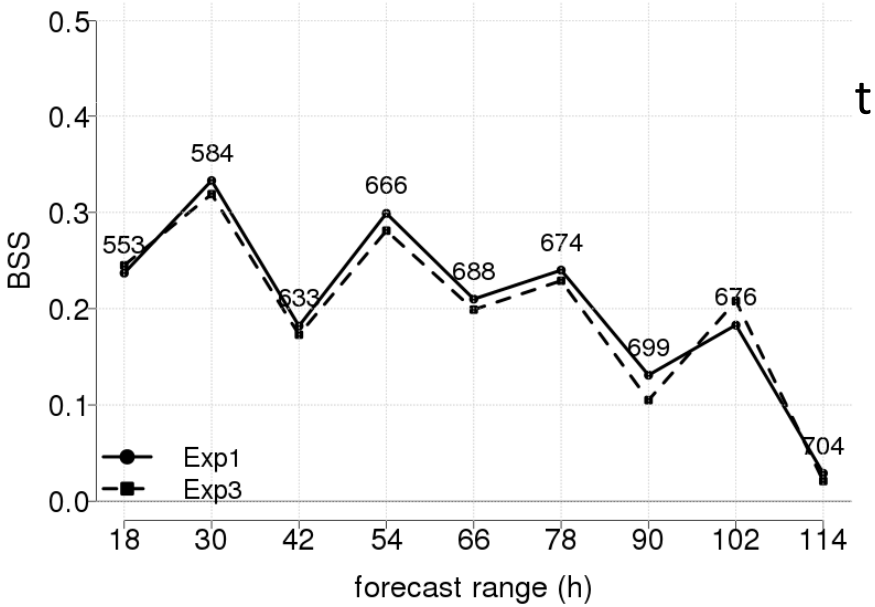
COSMO-E

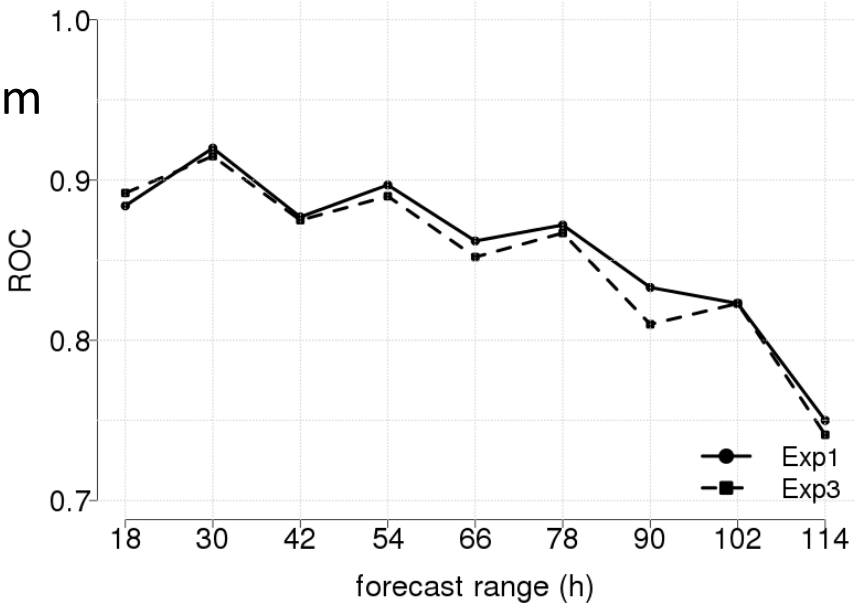
COSMO-E exp1 (test) - solid:
Initial time 00 UTC
IC and BC ENS 18 UTC (+6h)

COSMO-E exp3 (ope) - dashed:
Initial time 00 UTC
IC 18 UTC
BC ENS 12 UTC (+12h)



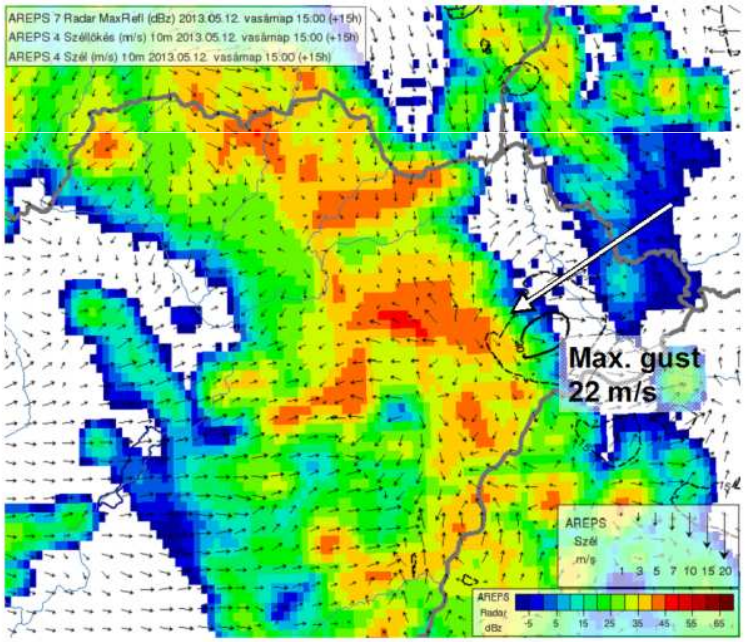
thr: 10mm



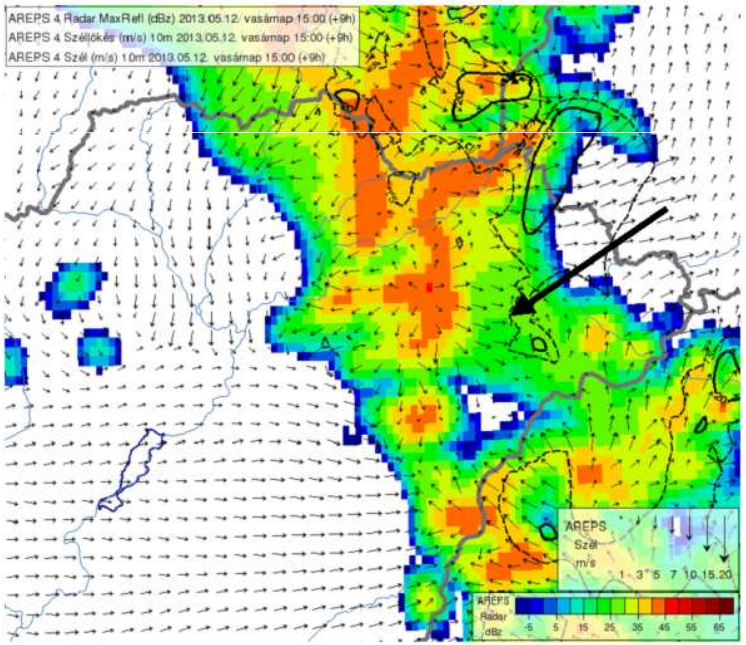


Results: benefit of the 06 and 18 UTC runs

AROME-EPS



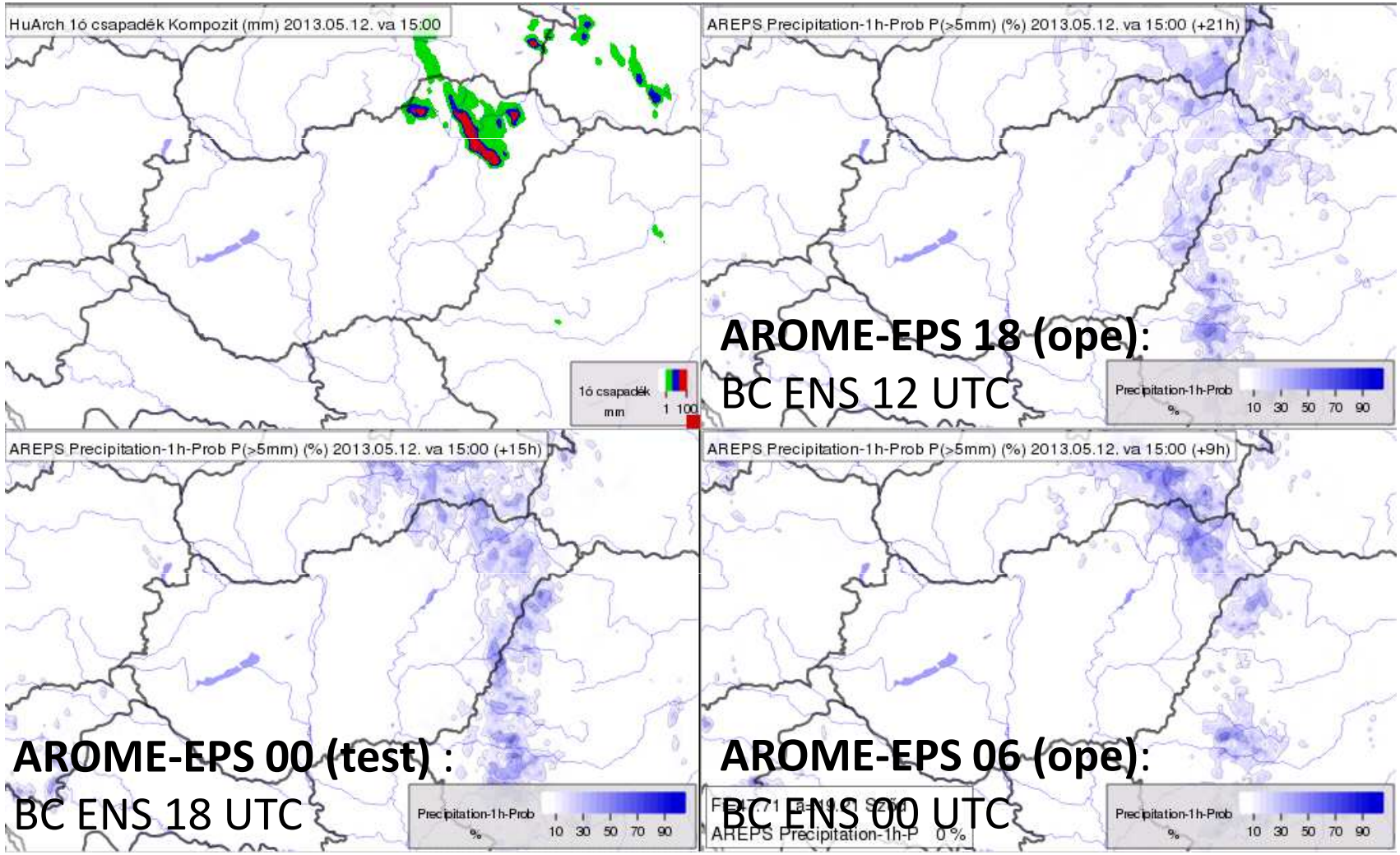
AROME-EPS 00 (test) :
Initial time 00 UTC
BC ENS 18 UTC (+15h)



AROME-EPS 06 (ope):
Initial time 06 UTC
BC ENS 00 UTC (+9h)

Results: benefit of the 06 and 18 UTC runs

AROME-EPS



AROME-EPS 18 (ope):
BC ENS 12 UTC

AROME-EPS 00 (test) :
BC ENS 18 UTC

AROME-EPS 06 (ope):
BC ENS 00 UTC

Summary of the results

The analysis of the results lead to the following conclusions:

- the spread/error relation of the LAM-EPS driven by the 06/18 and 00/12 UTC ENS runs is comparable
- the additional 06/18 UTC ENS runs bring benefit on top of the already available 00/12 UTC ENS runs when used to drive LAM-EPS applications (scores for COSMO-E, case study for AROME-EPS)
- it is found a benefit of having additional ENS forecast data four times a day, given by the possibility to follow the approaching of an event with high-frequency (6 h) information from the ensemble forecast

Conclusions

- High-resolution LBCs impact is positive but not dramatic, also considering the high cost of the high-res ENS
- In 2015 it is planned an upgrade of ENS horizontal resolution to about 20 km
- The test of high-frequency LBCs produced results consistent with the expectations
- Very positive experience of the coordinated testing, good agreement of the results obtained with different ensemble set-up and different models
- Many thanks to ECMWF and to Martin for his help!