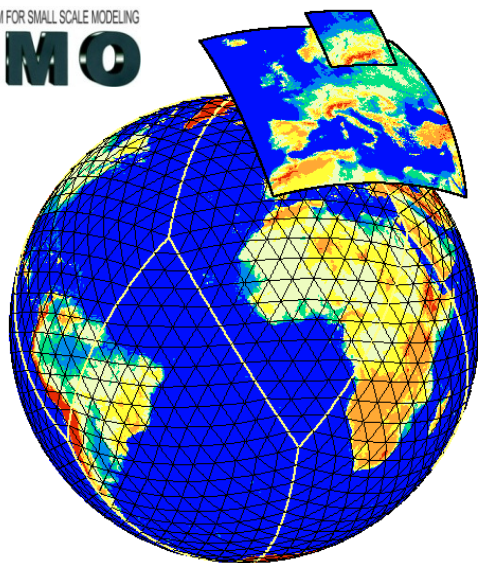# Ensemble activities in COSMO
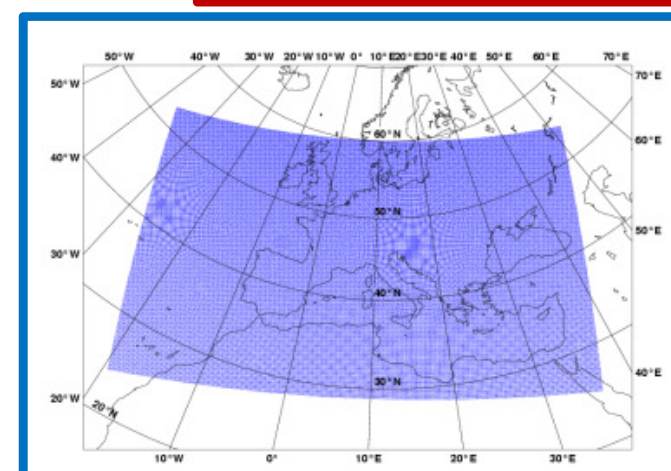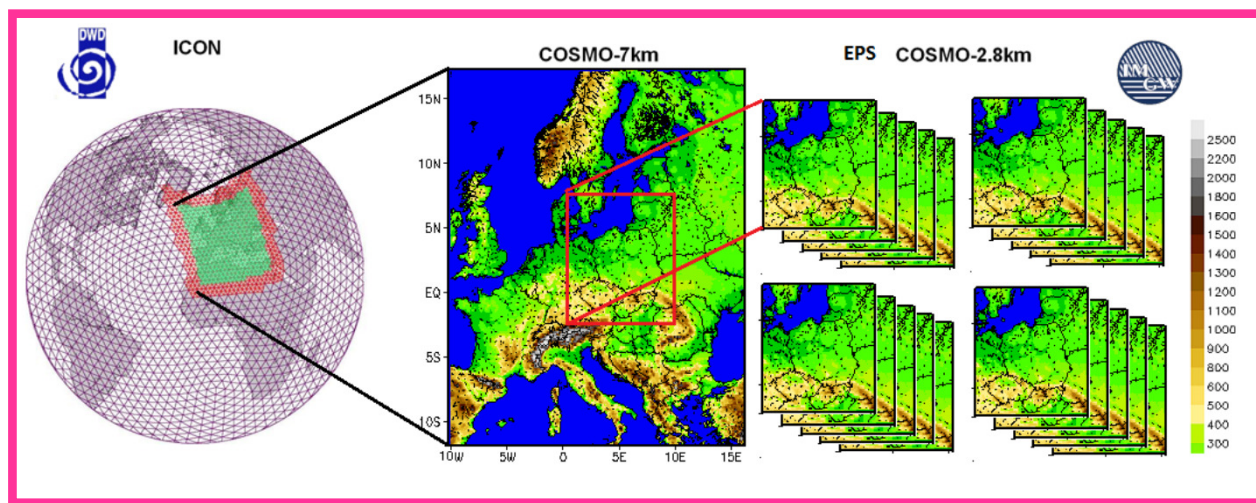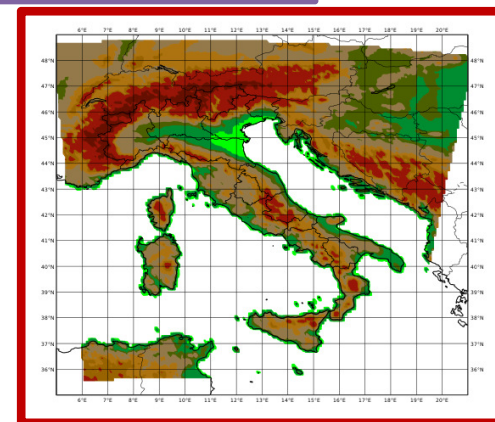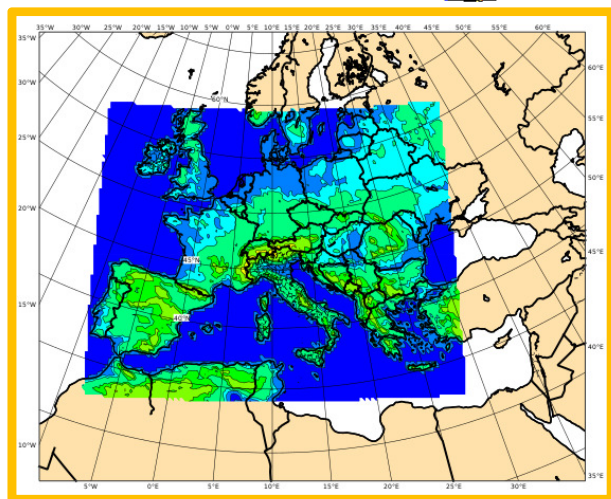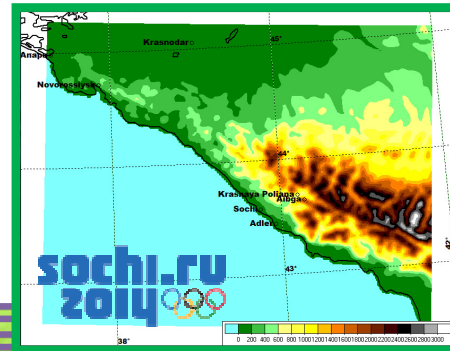
Chiara Marsigli

Arpae SIMC, Bologna, Italy

COSMO WG on Predictability and EPS

Ensemble systems

- **COSMO-DE-EPS**
- **COSMO-E**
- **TLE-MVE**
- **COSMO-IT-EPS**
- **COSMO-Ru2-EPS**
- **COSMO-LEPS**
- **COSMO-ME-EPS**

Improvements in COSMO-DE-EPS

➔ KENDA as EPS initial conditions 1-20 of 40 members

➔ Soil moisture perturbation as part of KENDA

➔ ICON-EPS members 1-20 of 40 used as boundary conditions

➔ Randomised selection of physics parameter perturbations (RP)

RP

COSMO-DE-EPS

KENDA

ICON-EPS

Soil moisture perturbation

Folie: T. Tröndle
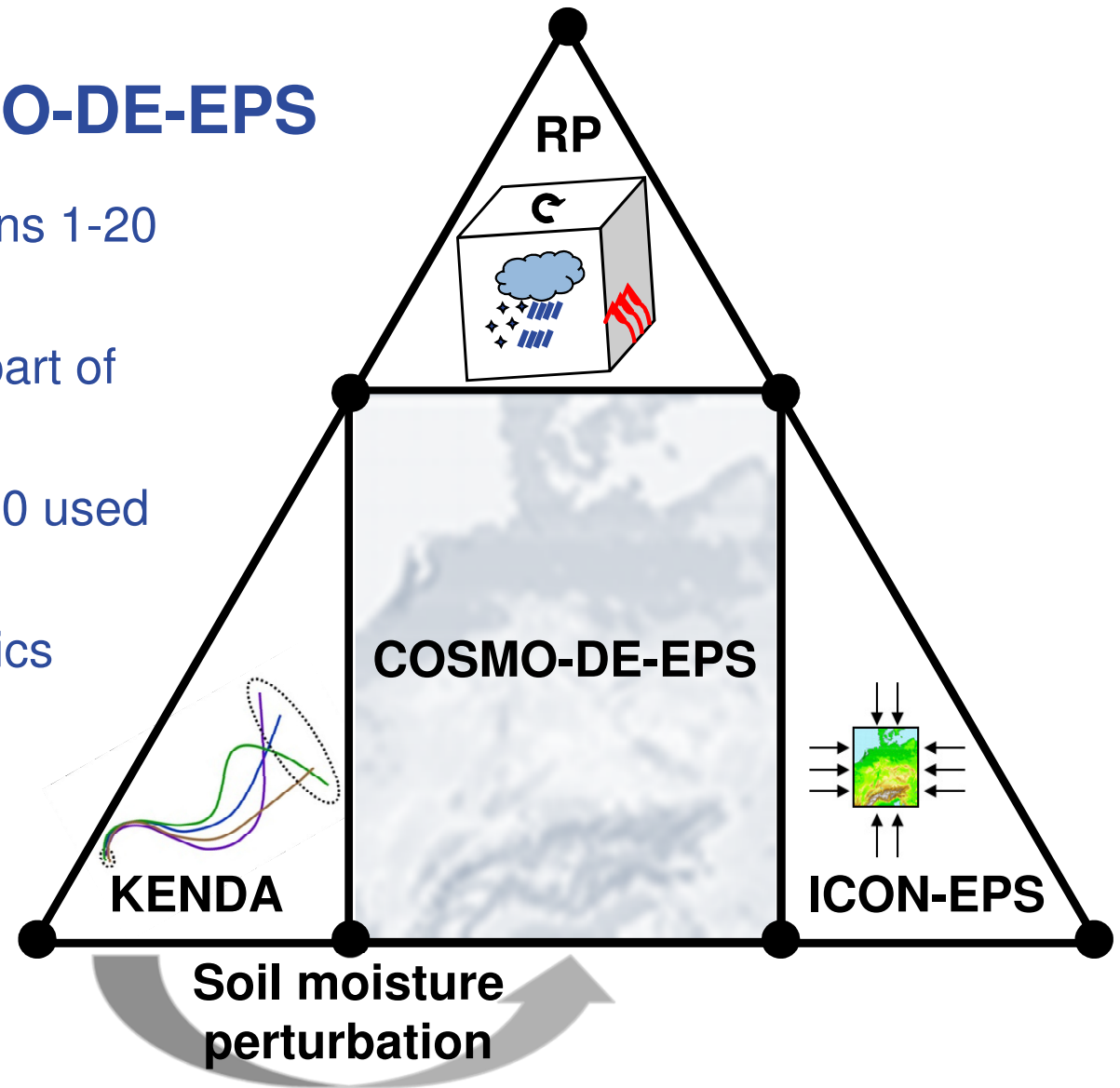
Randomized physics perturbations in COSMO-DE-EPS

➢ 2-3 different values for each of 12 parameters

➢ each parameter is perturbed in 50% of the members of each ensemble run

➢ **random selection** of members with perturbed parameter at each forecast start (done for each parameter seperately)

➢ parameter values stay fixed over the forecast range

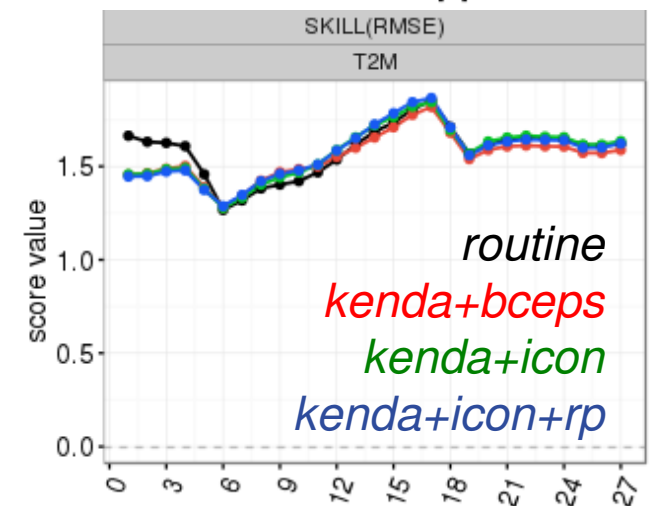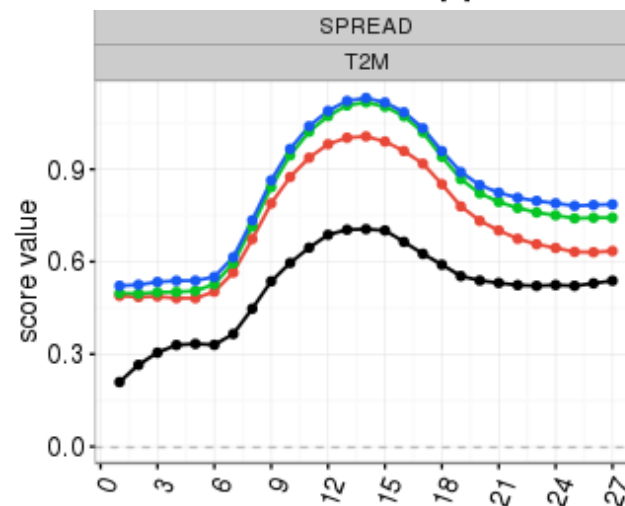**New perturbations (easier to implement with the RP)**

a_stab	c_diff	radqi_fact	radqc_Fact	thick_sc	rlam_heat	entr_sc	q_crit	tur_len	tkh min	tkm min	lhn_coef
0	0.2	0.5	0.5	25000	1	0.0003	1.6	150	0.4	0.4	1
1	0.1	0.9	0.9	10000	10	0.002	4	500	0.7	0.7	0.5
	2			30000	0.1				0.2	0.2	

Results CRPS Spread and Skill
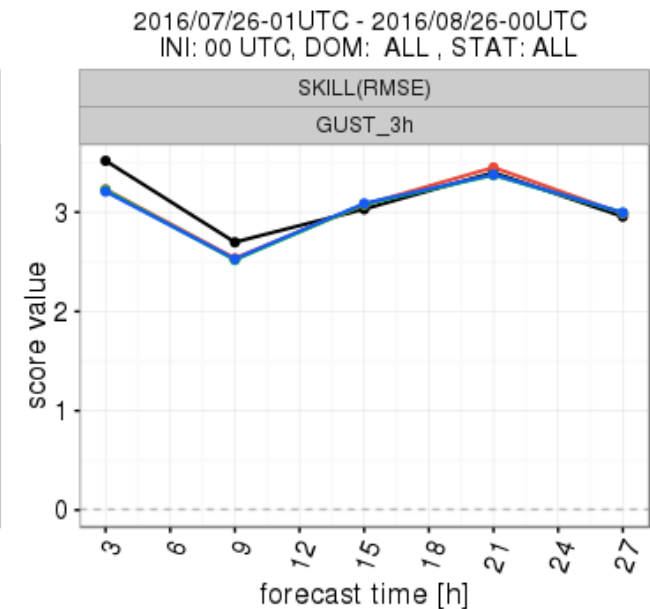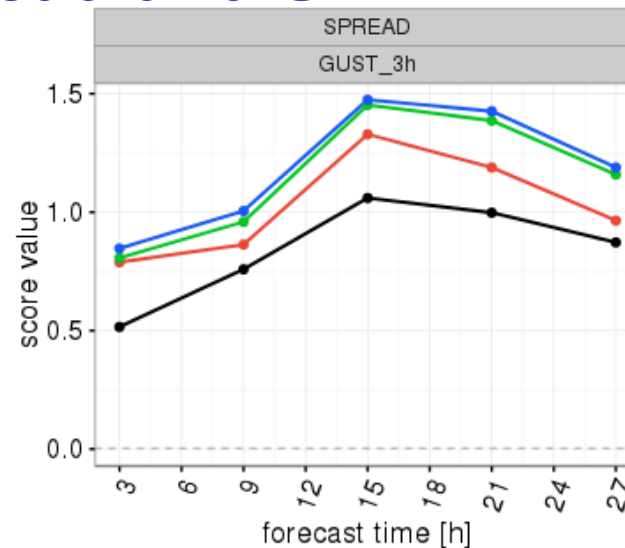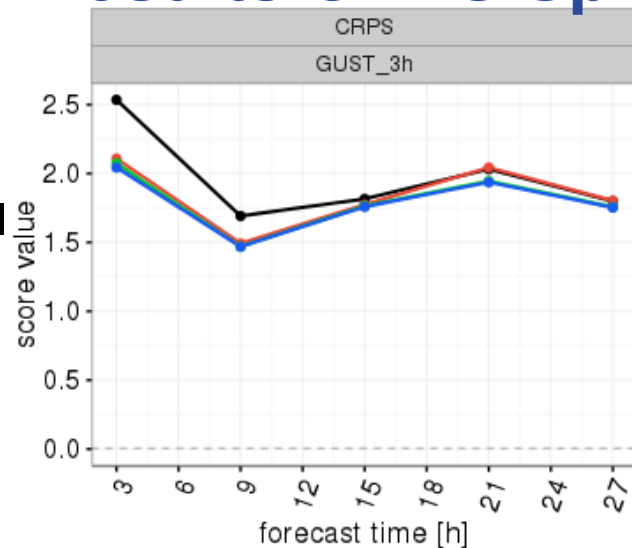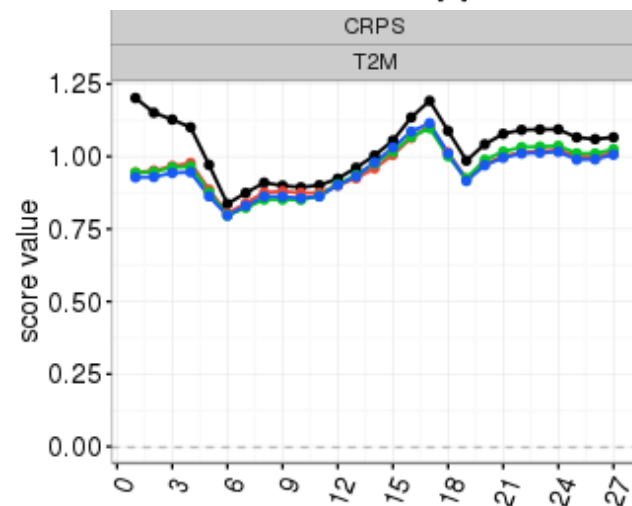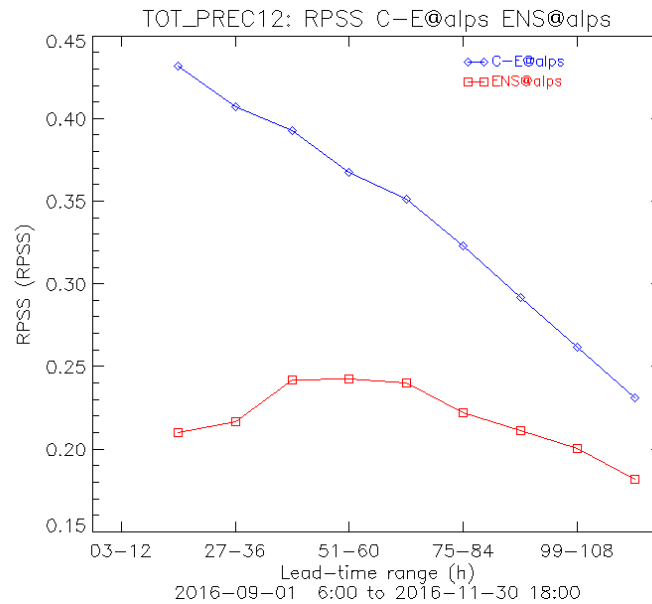
COSMO-E operational setup
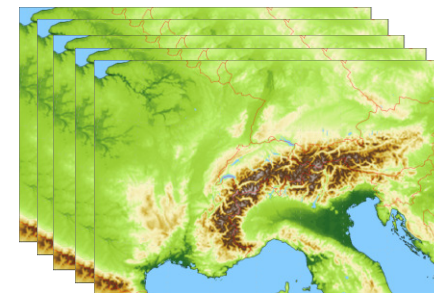
- 21 members (control and 20 perturbed runs)
- 2.2 km horizontal mesh-size, 60 vertical levels
- two forecasts per day (00 and 12 UTC) up to +120h
- initial condition (perturbations): KENDA assimilation cycle
  - KENDA ensemble mean for control
  - KENDA members 1-20 (out of 40)
- lateral boundary condition (perturbations): ECMWF IFS-ENS (18 & 06 UTC, i.e., 6h older LBCs)
  - ENS control for control
  - ENS members 1-20 (out of 50)
- model uncertainty: SPPT
- COSMO version 5.0+/GPU, single precision

-> Performance: 97 min for +120h forecast

COSMO-E
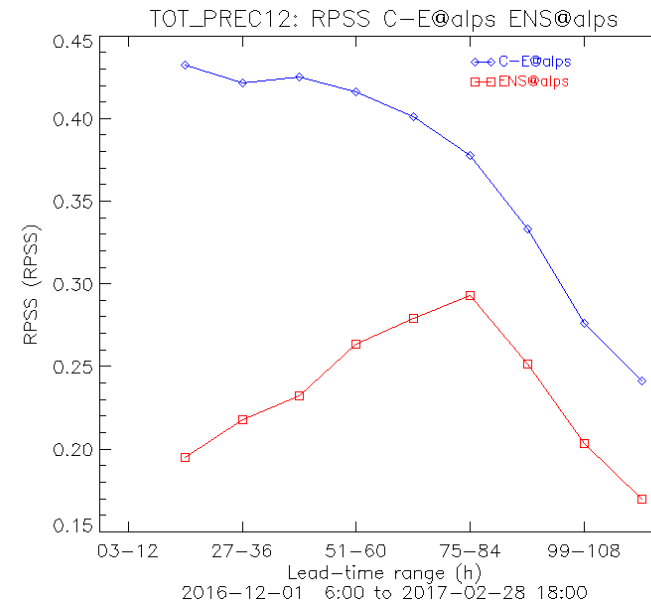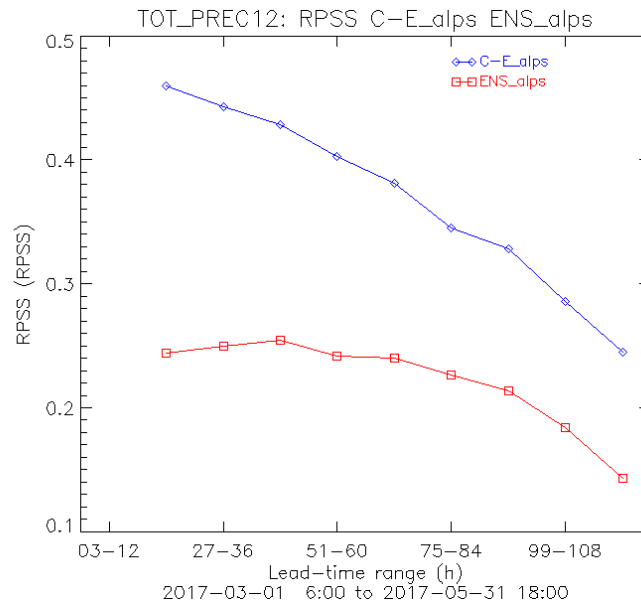# Verification – comparison with ECMWF ENS

SON

DJF

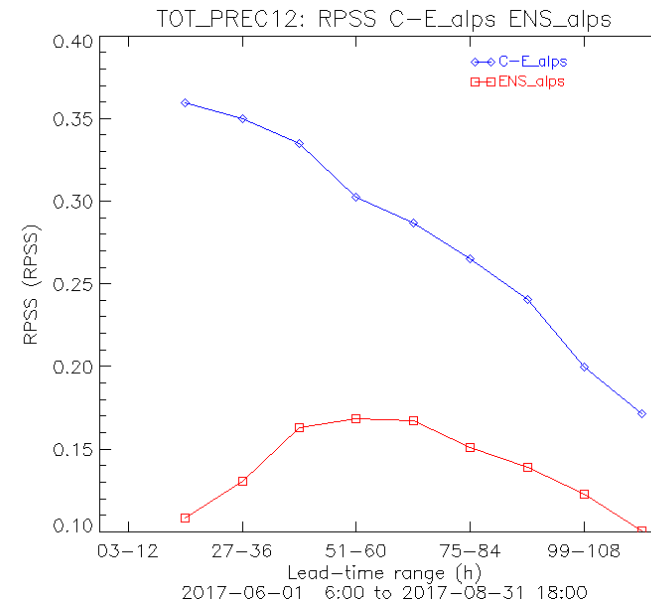**COSMO-E**
ENS

RPSS

MAM

JJA

Thresholds: 0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 30, 50 mm/12h

T 2m

COSMO-E
Verification – comparison with ECMWF ENS

SON

COSMO-E
ENS

MAM
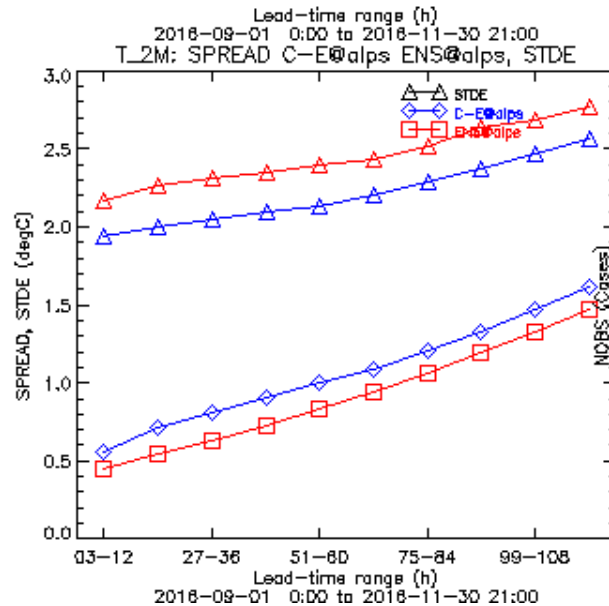
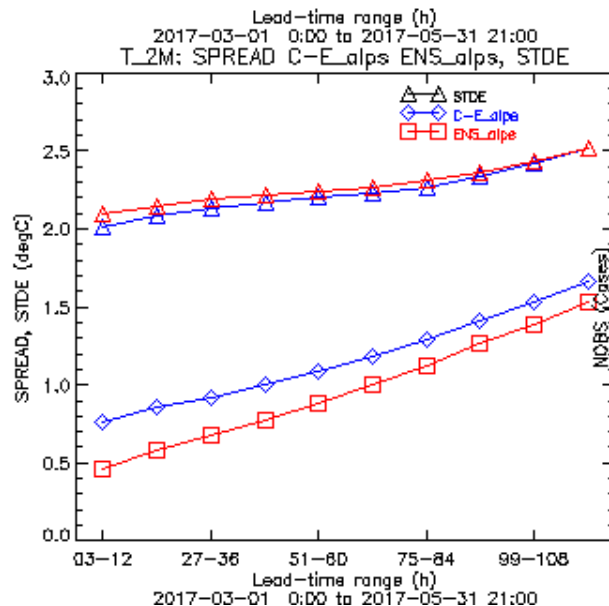**DJF**
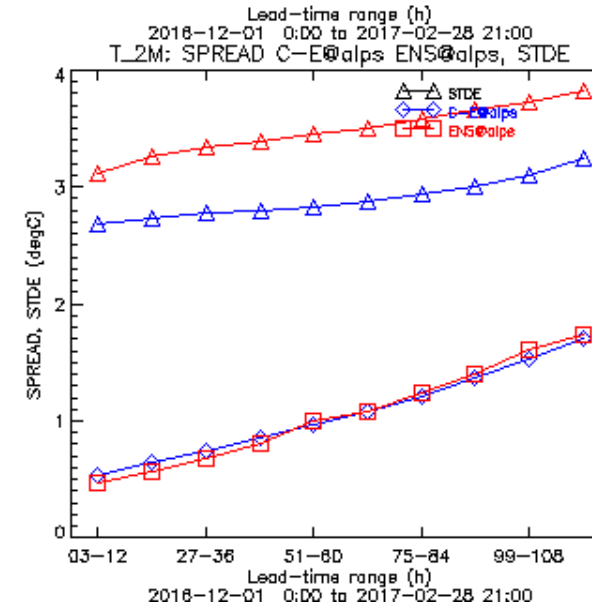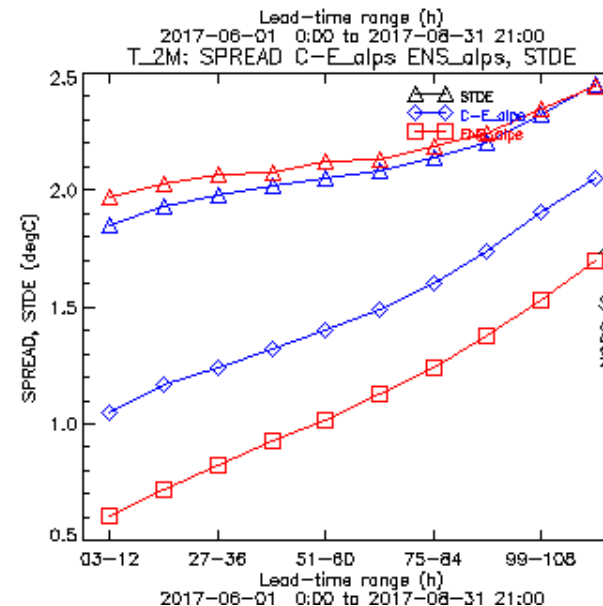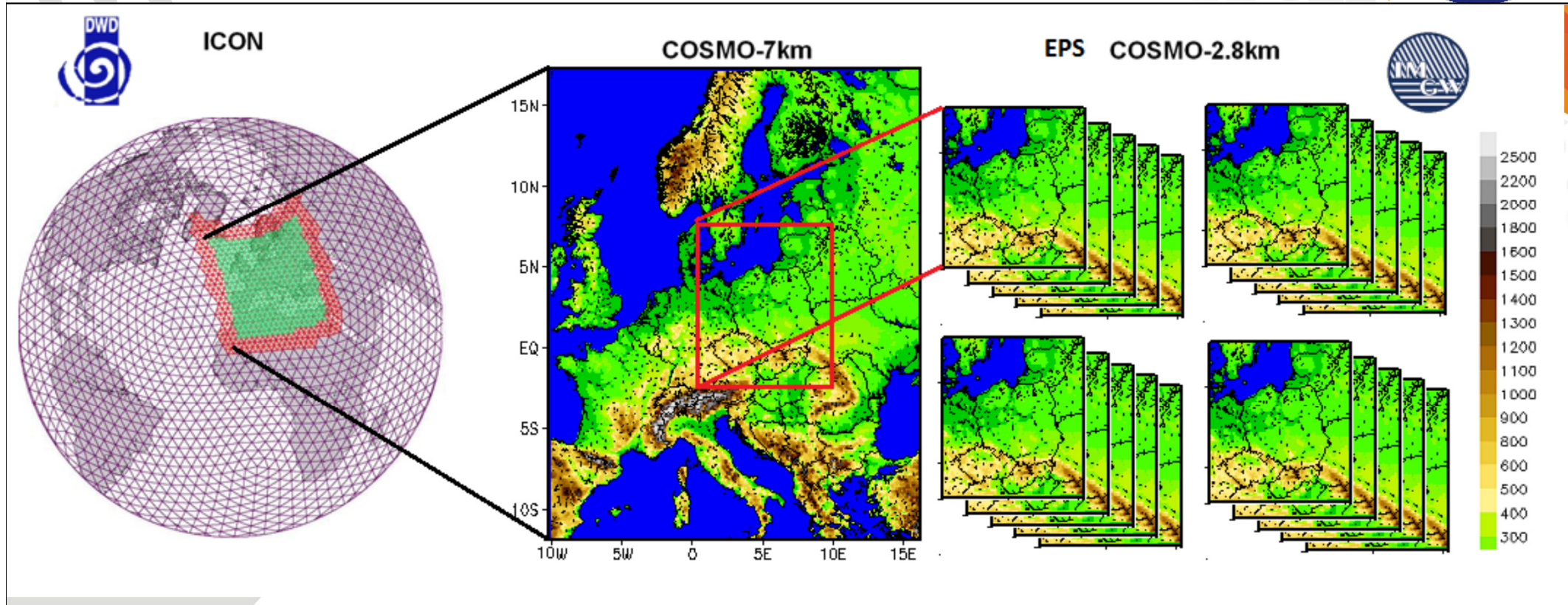
spread &
skill
(STDE)

JJA

TLE-MVE – operational setup and status

- Operational since January, 2016
- 4 runs per day, 36 hours forecasts, 20 members in 4 groups
- Time-lagged, c_soil perturbation

TLE-MVE – Study of the spread/skill relation

Skill-Spread spatial distribution
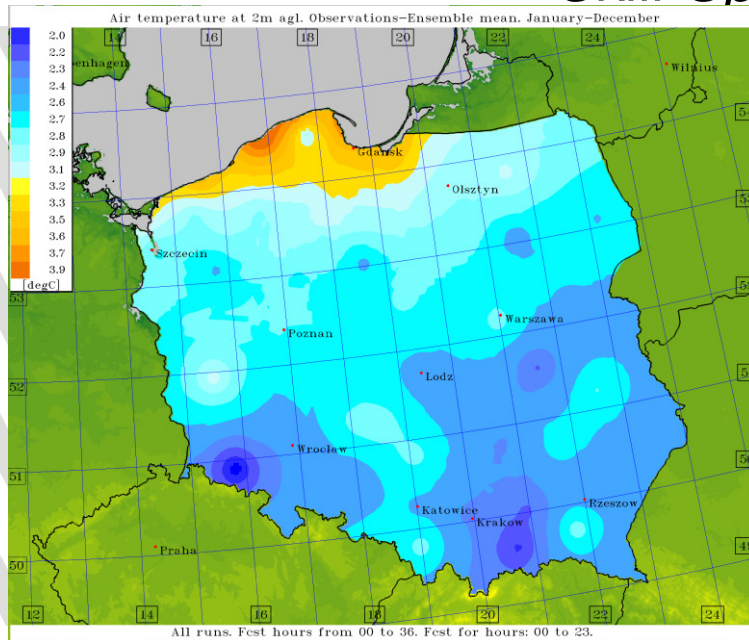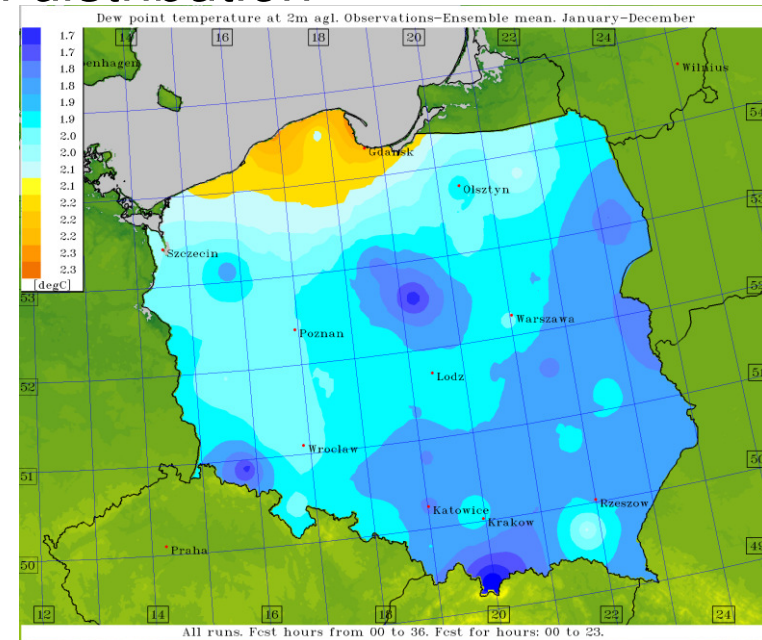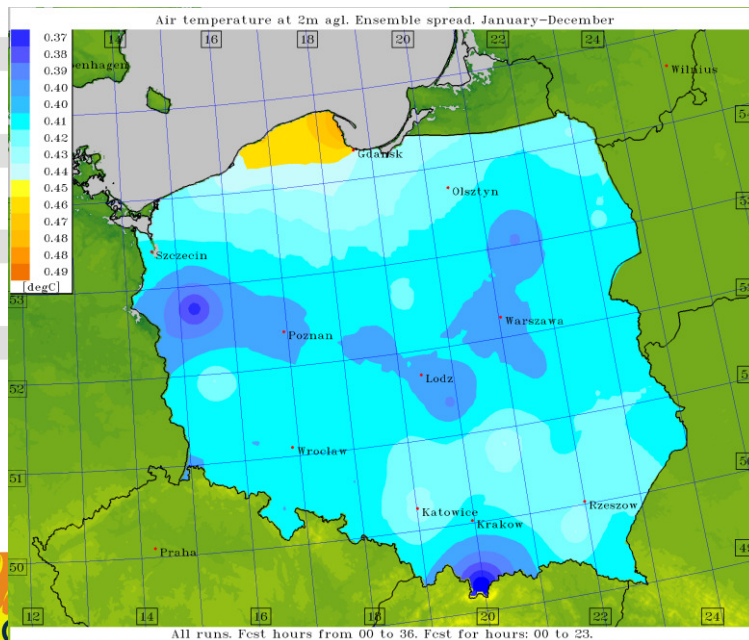
Avg. skill (up)/spread (down); T2M, TD2M (all runs, all fcst hours, Jan-Dec)

COSMO-IT-EPS: pre-operational set-up

LETKF (COMET)

10 km
going to 7
soon KENDA

COSMO-ME-EPS (COMET)

10 km (going to 7)

2.2 km
explicit convection
COSMO-IT-EPS (Arpae)
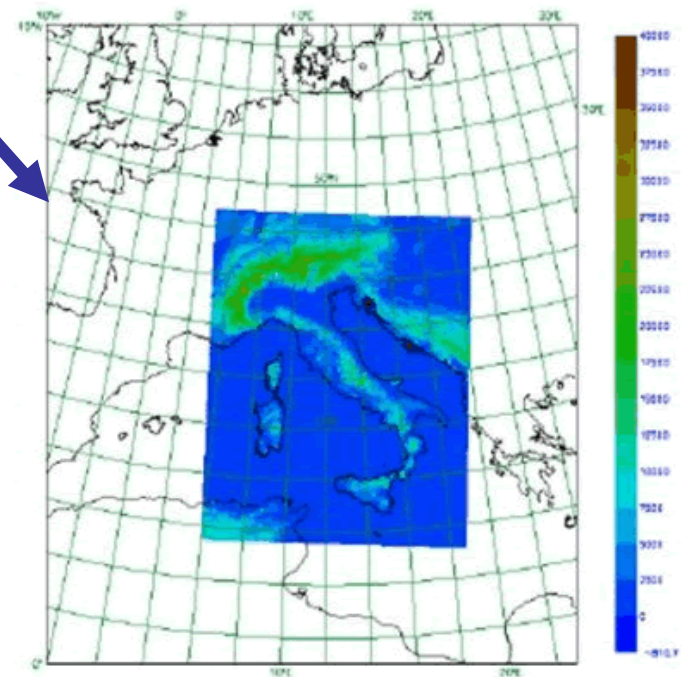
KENDA Initial Conditions

CTRL

CTRL + IC from LETKF

CASE STUDY: 10/10/2015
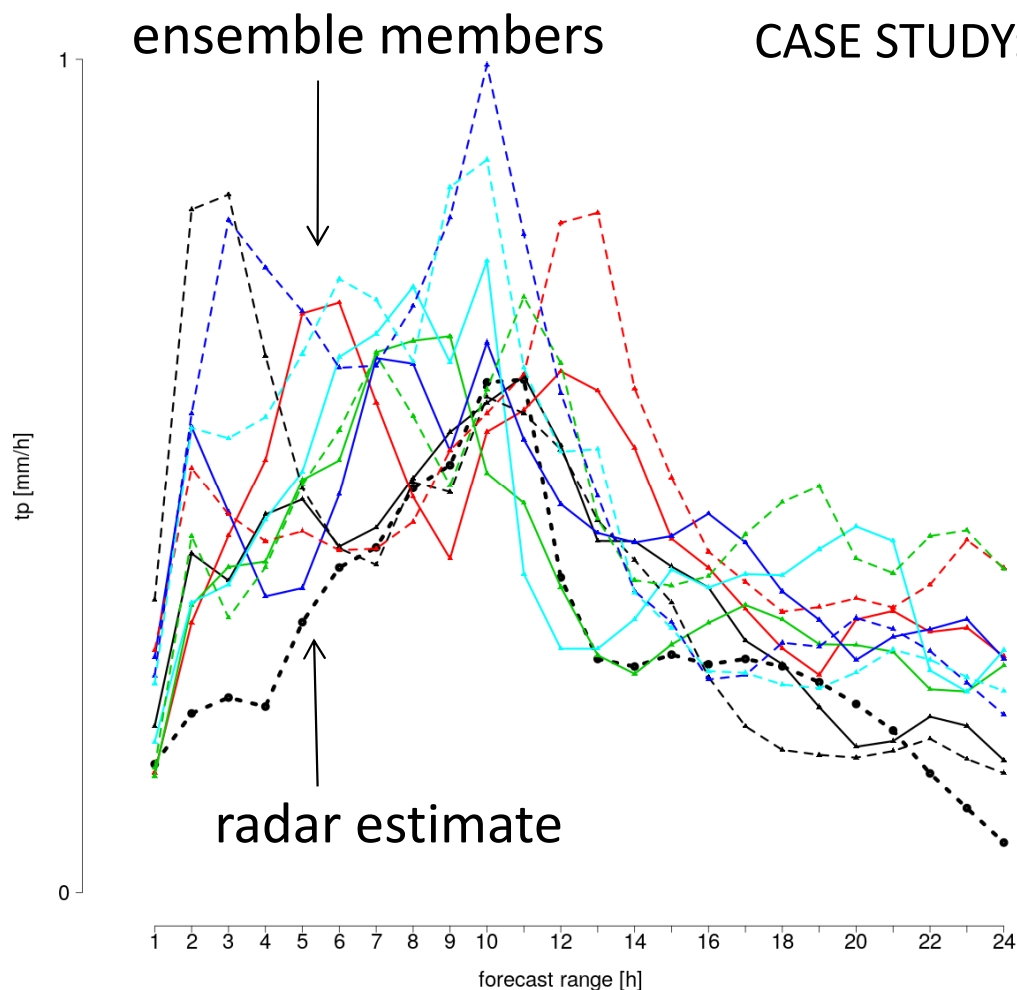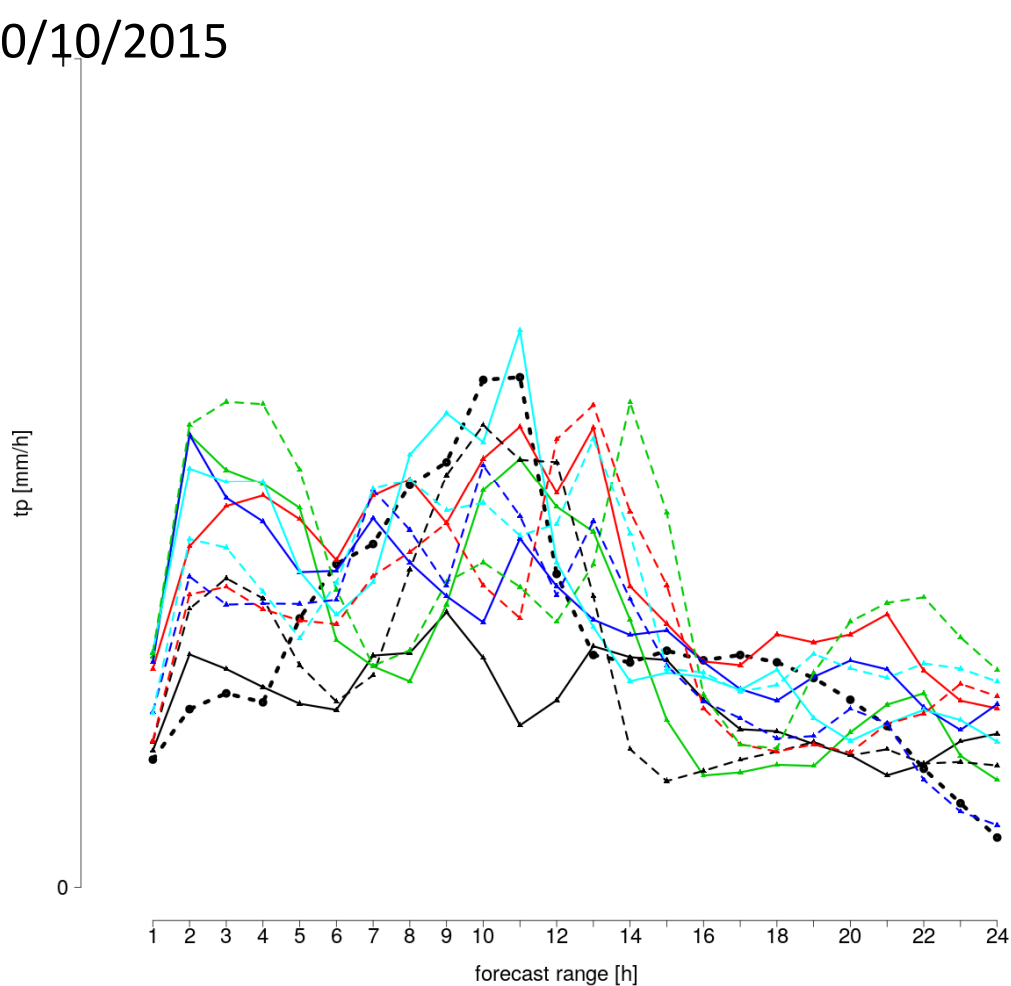
Hourly precipitation, area average (land only)

COSMO-Ru2-EPS

Ensemble experiments
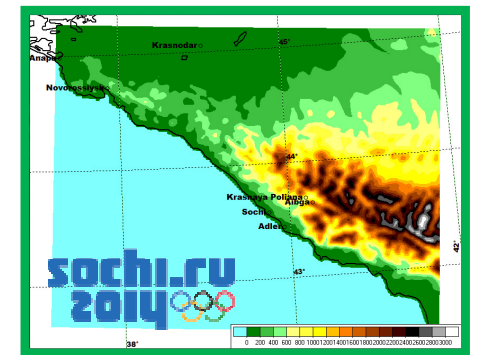
Technical details

Period: 1- 4 February 2014, 8 forecasts (00 UTC and 12 UTC)
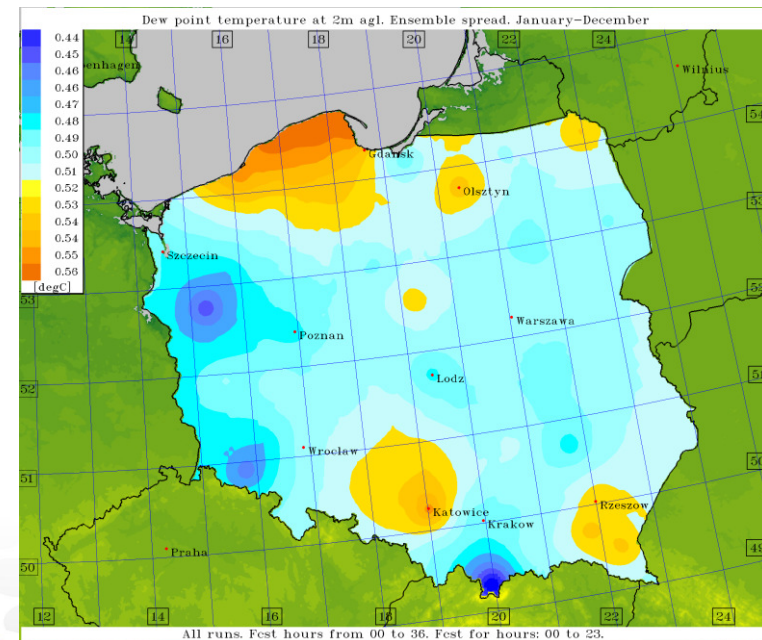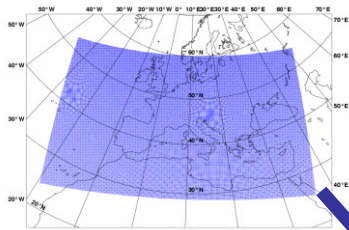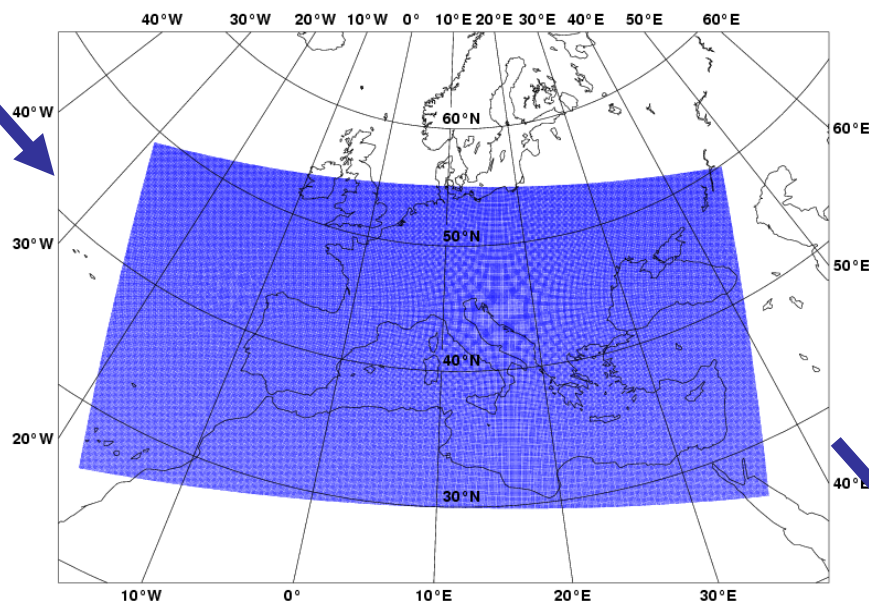
COSMO-Ru2-EPS, Sochi region, $\Delta x \approx 2.2 km$

3 configurations:

1. **no SPPT** - no model perturbations

2. **SPPTtest** - stochastic perturbation of physical tendencies. Gaussian distribution, no interpolation, water vapour perturbation.

3. **SPG** - stochastic pattern generator in additive mode. Gaussian distribution. The perturbed fields are: U, V, T, p, no humidity perturbation.

D. Gayfulin, M. Tsyrulnikov, E. Astakhov

COSMO-Ru2-EPS – SPG test

SPG

SPPTtest

F0+12h
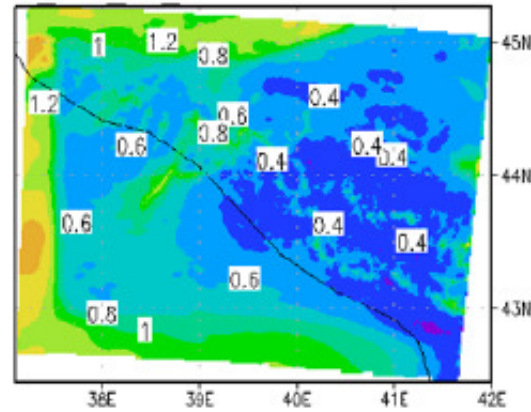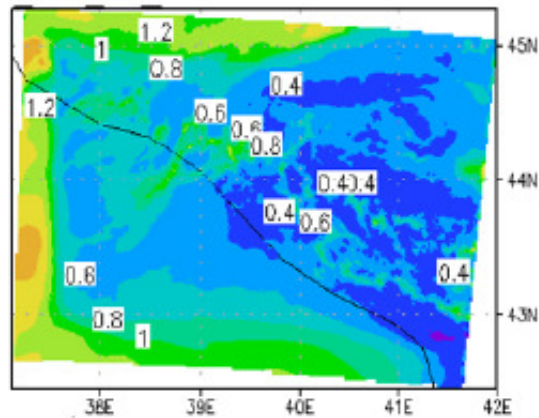
F0+48h

T2m Spread. COSMO-Ru2-EPS. Sochi area. Febr 1-4.2014. UTC 00 and 12.

D. Gayfulin, M. Tsyrulnikov, E. Astakhov

COSMO-ME EPS

Ensemble Data Assimilation:
Operational since June 2011

LETKF
(40+1 members)

7 km
49 v.l.

Ensemble Analysis

7 km
45 v.l.

Ensemble Prediction System:

COSMO-ME EPS
00-12 UTC up to 72h

CNMCA 28 Aprile 2009 00UTC Forecast T+39 VT: 29 Aprile 2009 15UTC
Altezza onda significativa (metri) + direzione media

NETTUNO-EPS 3'
00 UTC up to 72h

Operational products (Fieldextra)

2 x standard deviation 2m temperature
2 x standard deviation 10m wind
6h integrated total precipitation > 0.2 mm
6h integrated total precipitation > 10 mm
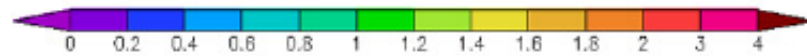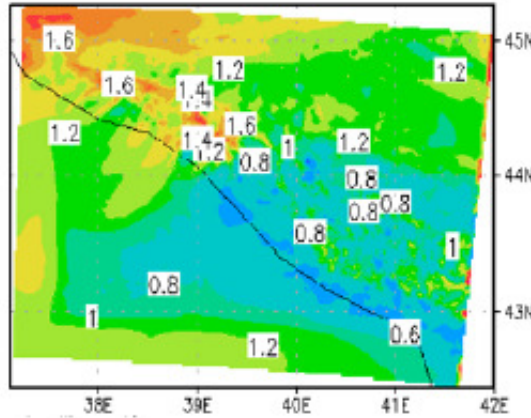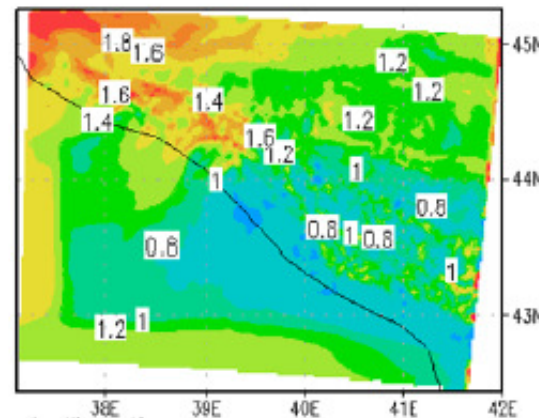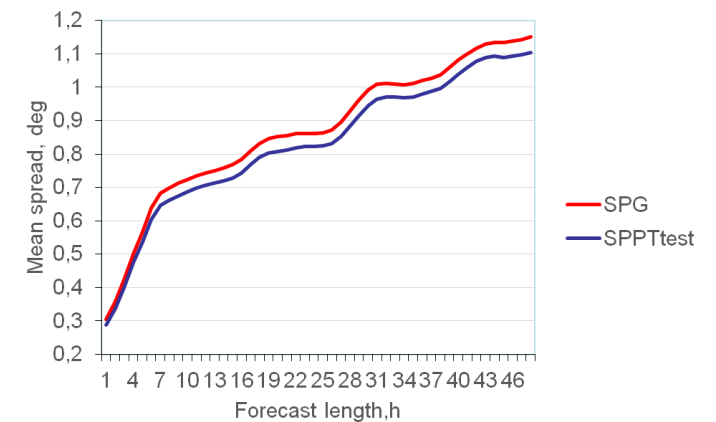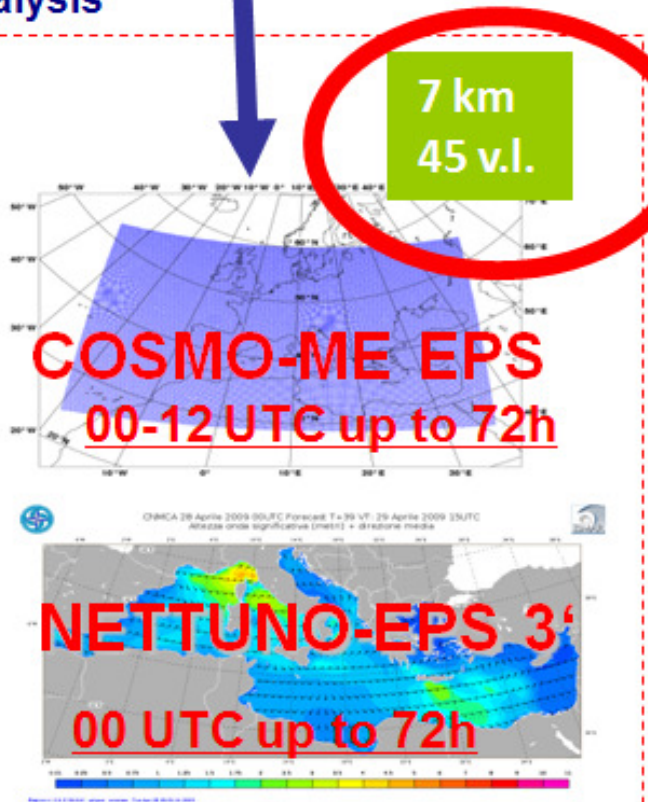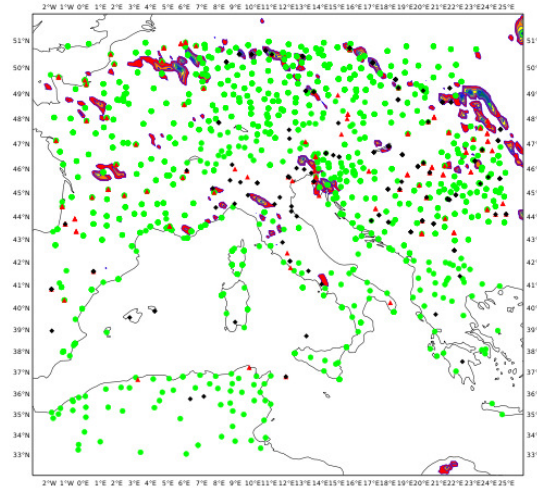6h integrated total precipitation > 20 mm
6h integrated total precipitation > 30 mm
6h integrated total precipitation > 40 mm
24h integrated total precipitation > 100 mm
24h integrated total precipitation > 20 mm
24h integrated total precipitation > 40 mm
6h integrated total snow precipitation > 0.2 cm
6h integrated total snow precipitation > 10 cm
6h integrated total snow precipitation > 20 cm
6h integrated total snow precipitation > 5 cm
24h integrated total snow precipitation > 10 cm
24h integrated total snow precipitation > 20 cm
24h integrated total snow precipitation > 40 cm
Max 2m temperature > 32 ℃
Max 2m temperature > 35 ℃
Max 2m temperature > 38 ℃
Min 2m temperature < 5 ℃
Min 2m temperature < 0 ℃
Min 2m temperature < -5 ℃
Min 2m temperature < -10 ℃
Wind gust > 21 kt
Wind gust > 33 kt
Wind gust > 55 kt
Sea wave height prob > 2.5 m
Sea wave height prob > 4 m
Sea wave height prob > 5 m

COSMO-ME EPS
Visibility from asymptotic approach

Probability of fog

Probability of mist

RH ≥ 95 %
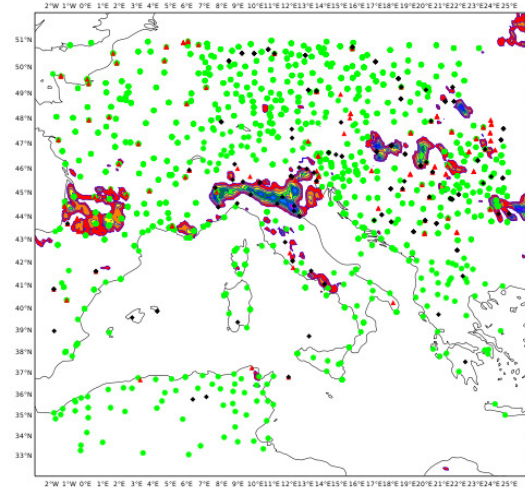
RH ≥ 93 %

Probability (%):

10-20	20-30	30-40
40-50	50-60	60-70
70-80	80-90	90-100

Observations:

◆ $Vis < 1\ km$ (Fog)

▲ $1\ km < Vis \leq 5\ km$ (Mist)

● $Vis > 5km$

Aeronautica Militare
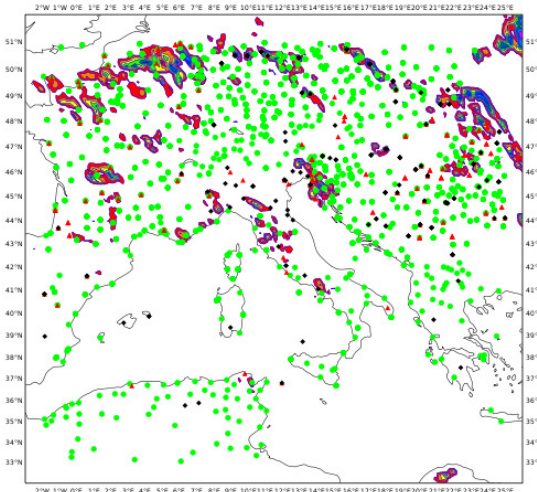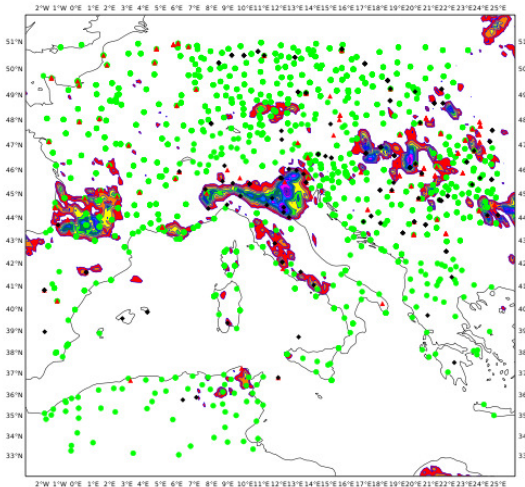
COSMO-ME EPS
Visibility from UPS approach

Probability of fog

Probability of mist
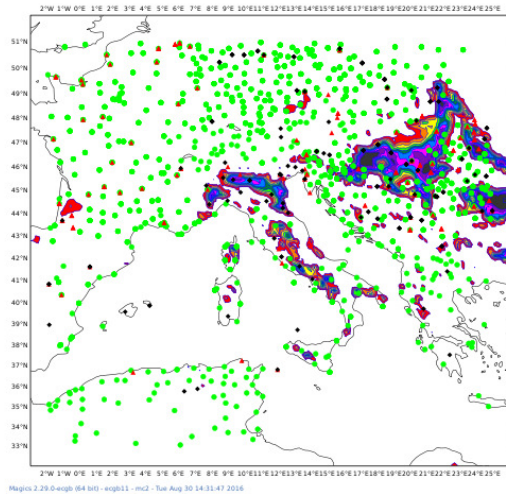
Without MRI control

With MRI control

Probability (%):
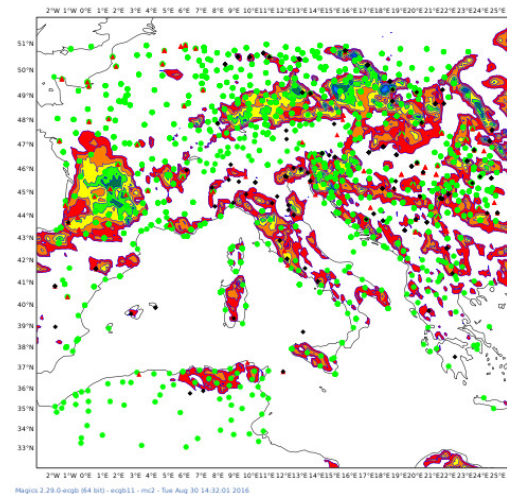
10-20	20-30	30-40
40-50	50-60	60-70
70-80	80-90	90-100

Observations:

♦ $Vis < 1\ km$ (Fog)

▲ $1\ km < Vis \leq 5\ km$ (Mist)

● $Vis > 5km$

COSMO-LEPS

RPSS

RPSS; 6M running mean; 12h cumulated precipitation; FULLDOM

Legend:
- fcst 30-42h
- fcst 54-66h
- fcst 78-90h
- fcst 102-114h

Y-axis: Ranked Probability Skill Score

X-axis: forecast month

Developments:

• COSMO Priority Task CIAO: test of the IFS Becthold convection scheme as physics perturbation (alternative to the Tiedtke scheme)

• evaluation of the upgrade to 5 km horizontal resolution
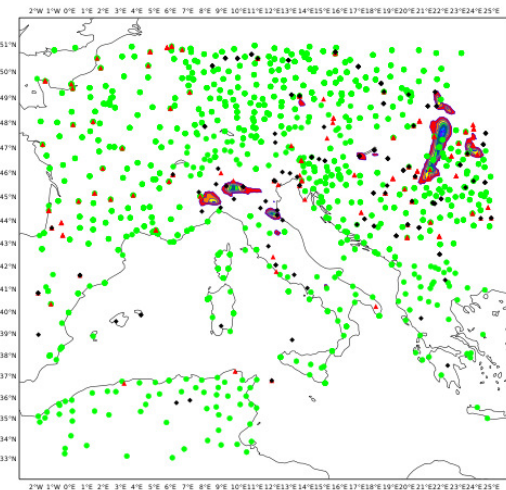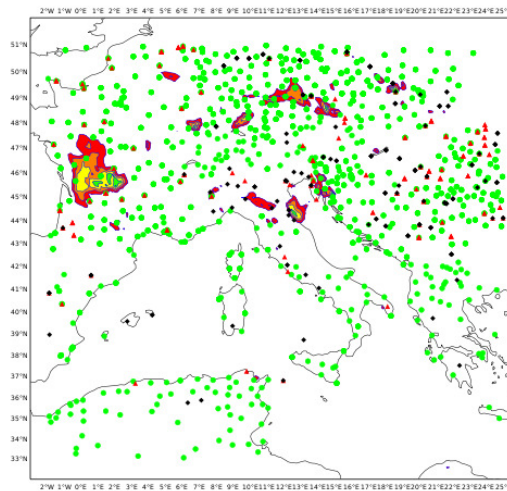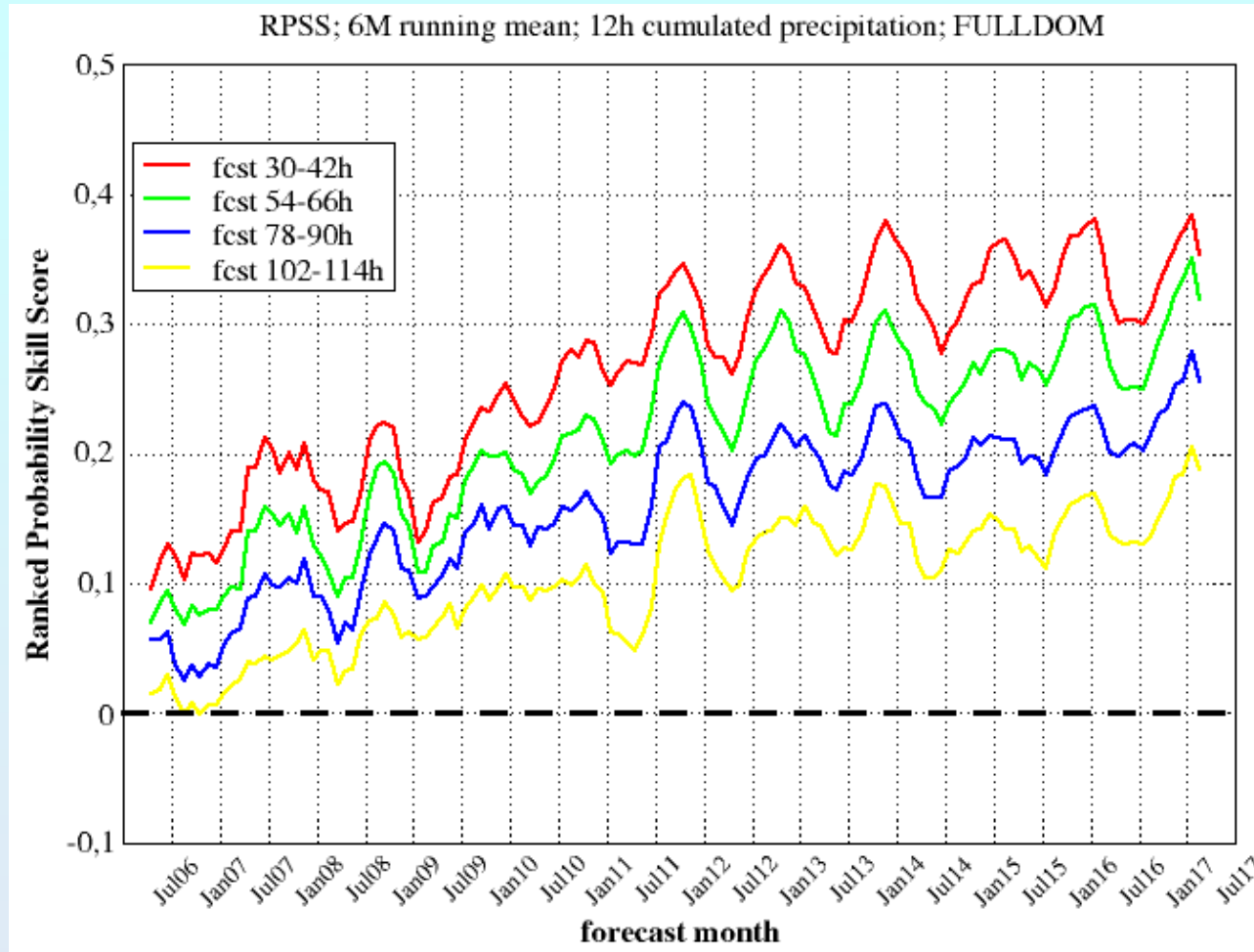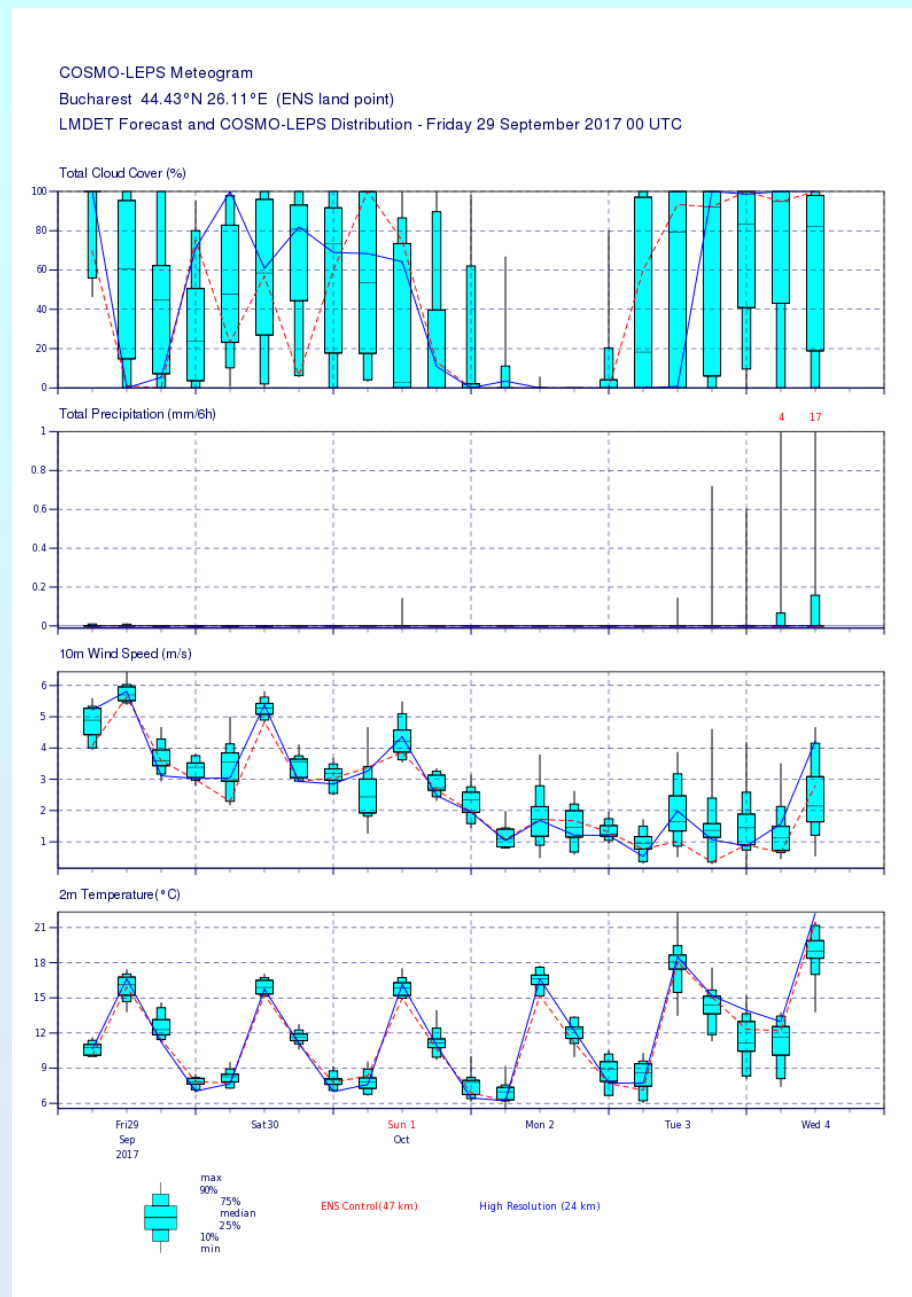
Monthly-based verification performed over the full integration domain (~1400 synop reports; NGP)

COSMO-LEPS to web

Disseminate from ECMWF to COSMO web-site some static maps with few "basic" COSMO-LEPS products:

- meteograms of COSMO-LEPS over some fixed locations,

- ensemble mean of mean-sea-level-pressure overlapped with probability of total precipitation to exceed some threshold

- ...

First prototype, with many thanks to Paul Dando

COSMO-LEPS Meteogram
Bucharest 44.43°N 26.11°E (ENS land point)
LMDET Forecast and COSMO-LEPS Distribution - Friday 29 September 2017 00 UTC

Future plans

- test new methods for model perturbation (Stochastic Pattern Generator, PBL perturbations, model for the model error) and review the parameter perturbation,

- lower boundary perturbation: SPG, combination of pert

- calibration and new products for high-impact weather -> verification oriented to the products (spatial methods, object oriented, "new" observations) -> link with verification and interpretation WGs

- work on member selection from KENDA, inflation of BC perturbations

- transition to ICON-LAM ensembles