COSMO ensemble activities

Chiara Marsigli

former: **Arpae SIMC, Bologna, Italy**

present: **Deutscher Wetterdienst, Germany**

Outline

- Priority Project SPRED:
  - study and improve the spread/skill relation
  - Model perturbation
  - Lower-boundary perturbation
  - Post-processing (-> SRNWP-EPS II)
  - Initial condition selection
- COSMO-LEPS
- Future plans

Priority Project SPRED: some conclusions

- The spread/skill relation of the ensembles has been assessed extensively
- New methodologies were implemented/applied in the COSMO countries (maps of spread/error, new methods for spread computation, observational error)
- Model perturbations have been further tested or developed, also leading to reformulation of plans due to unsatisfactory performances
- Post-processing has been applied to the ensemble, probabilistic products for selected phenomena have been tested -> need for verification

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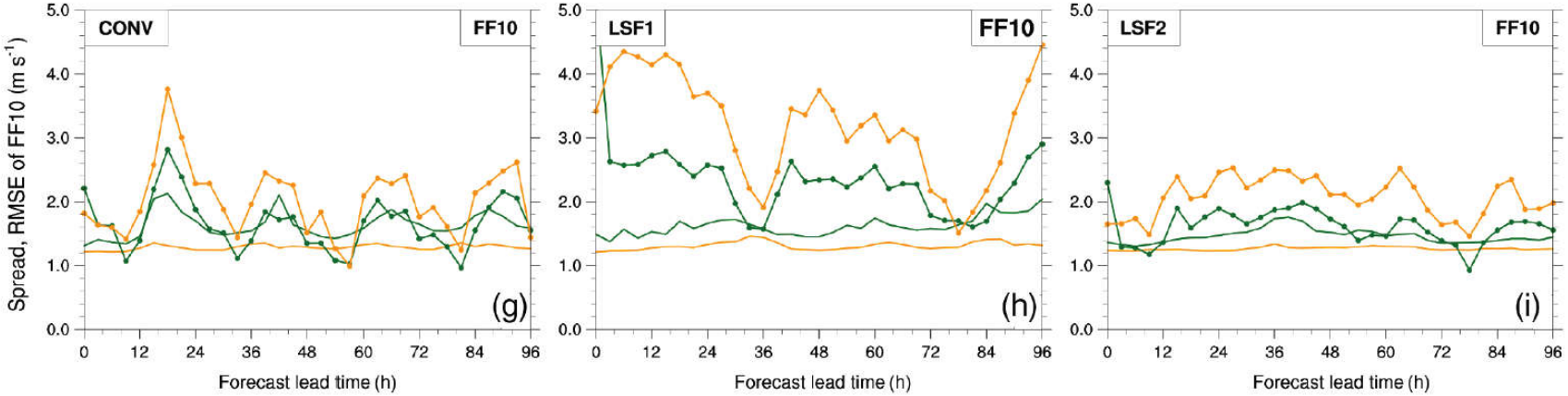
Task 1:
Study of the spread/skill relation in the ensembles

COSMO-E vs ENS for FF@10m
Case studies

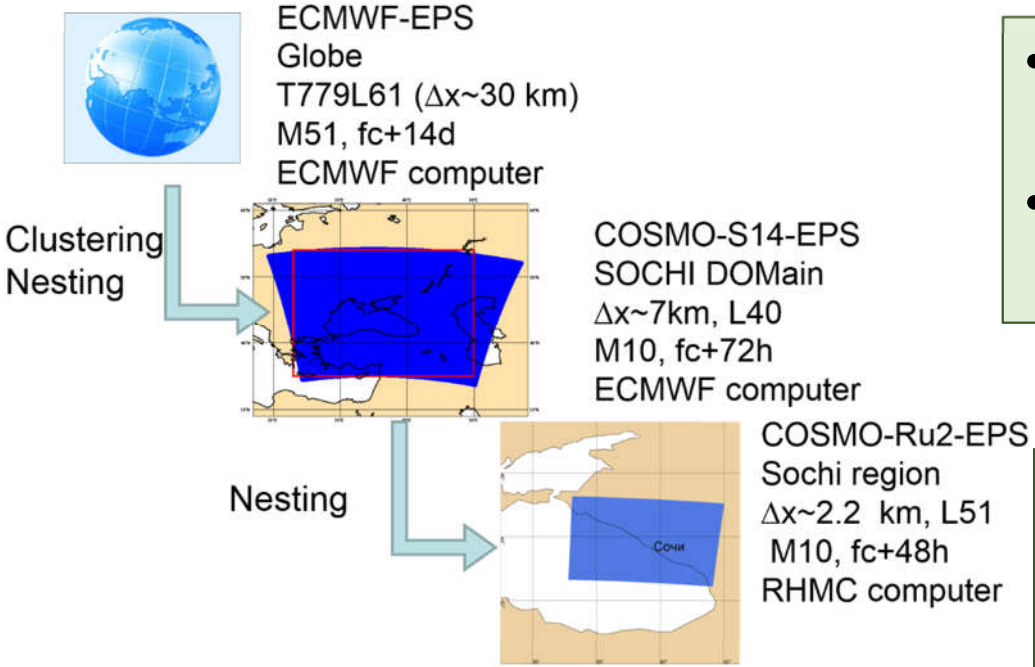


- convective (CONV) & 2 large-scale flow (LSF1/LSF2) cases
- COSMO-E shows smaller error and larger spread than ENS
- ENS misses the diurnal cycle of the spread for CONV

Klasa et at. (2017)

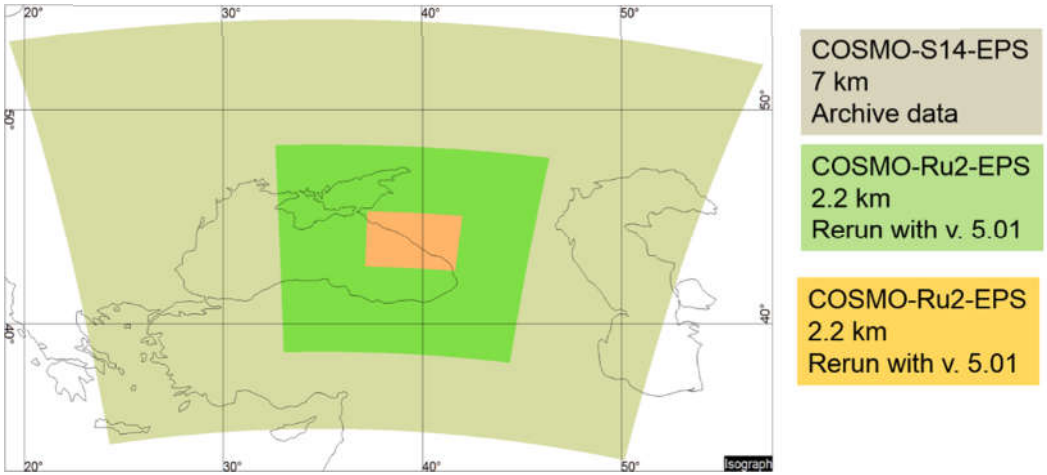
For a month period for the Sochi area the ensemble T2m spread was compared for systems

A) with different resolutions: COSMO-S14-EPS 7km, COSMO-Ru2-EPS 2.2km



- In many cases the T2m spread was higher for the coarser-resolution EPS.
- The monthly-averaged spread was also larger for the 7-km EPS.

B) with different domain sizes



- The forecast results (both ensemble mean and spread patterns) depend on the size of the integration domain.
- The effect is related to weather situation and is most pronounced in lower layers, in regions with complex topography, and near the lateral boundaries.

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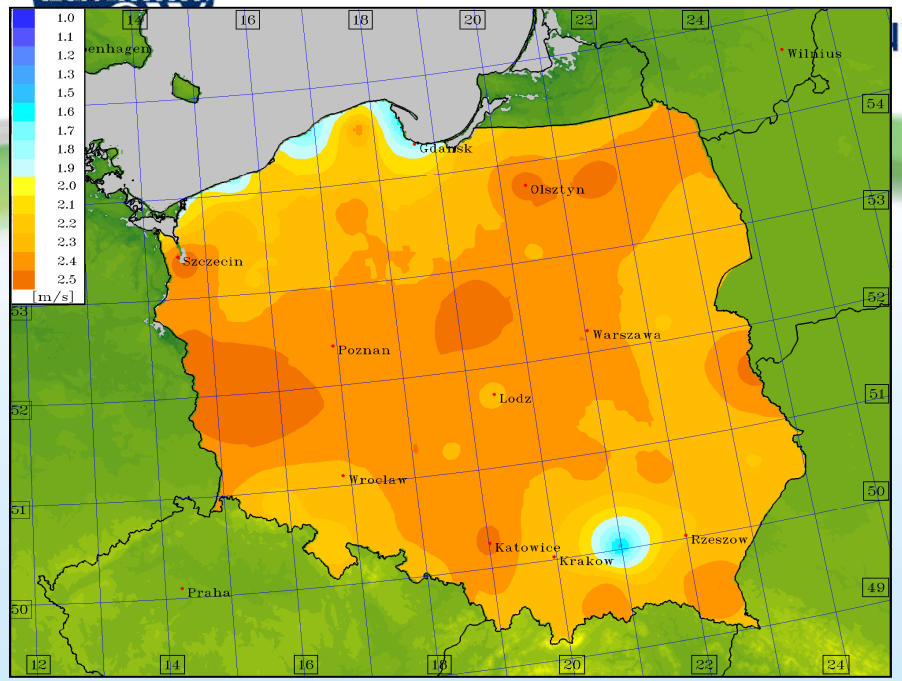
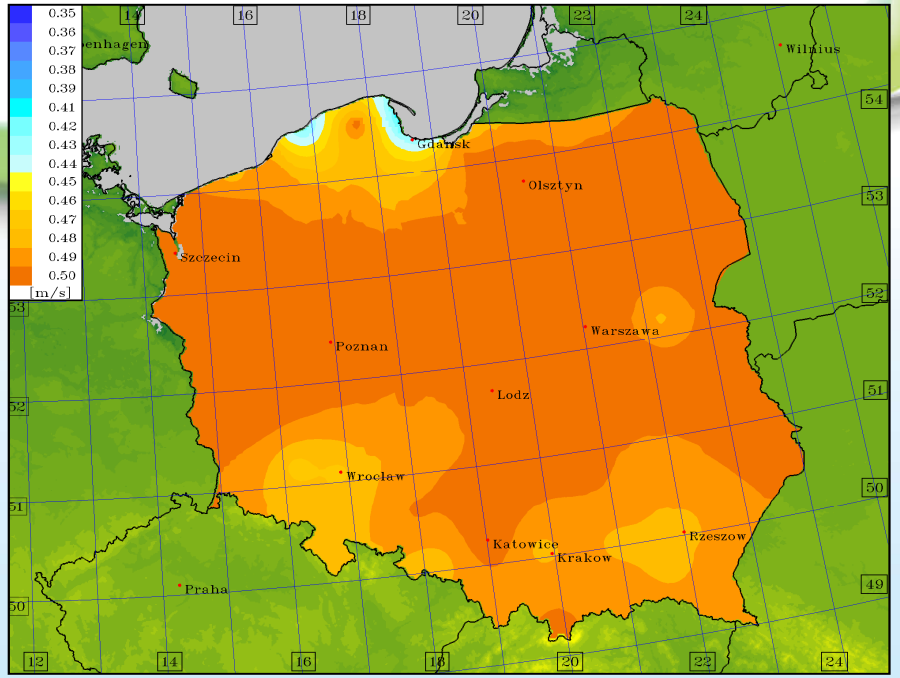
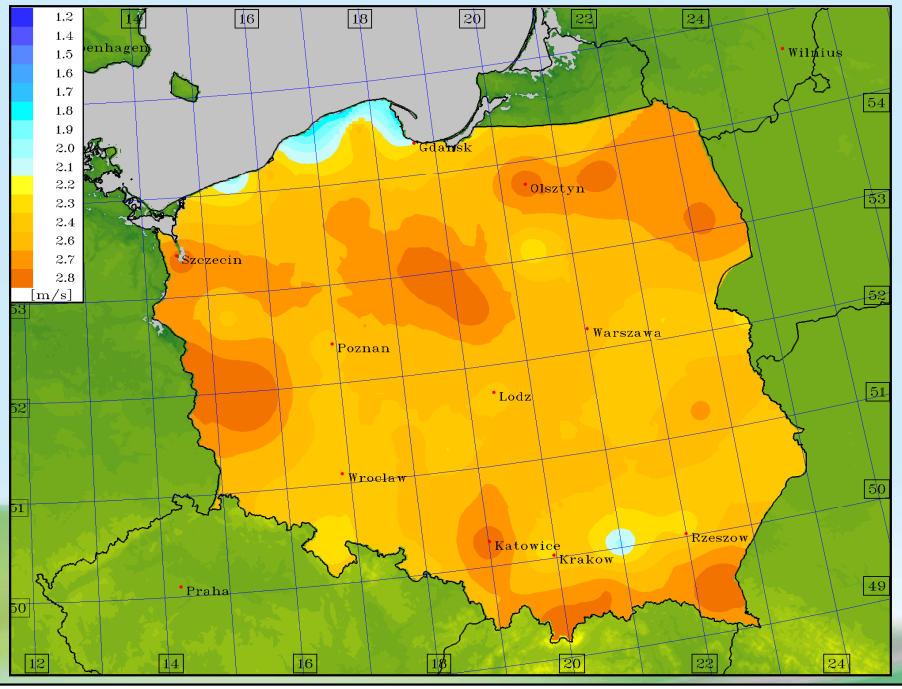
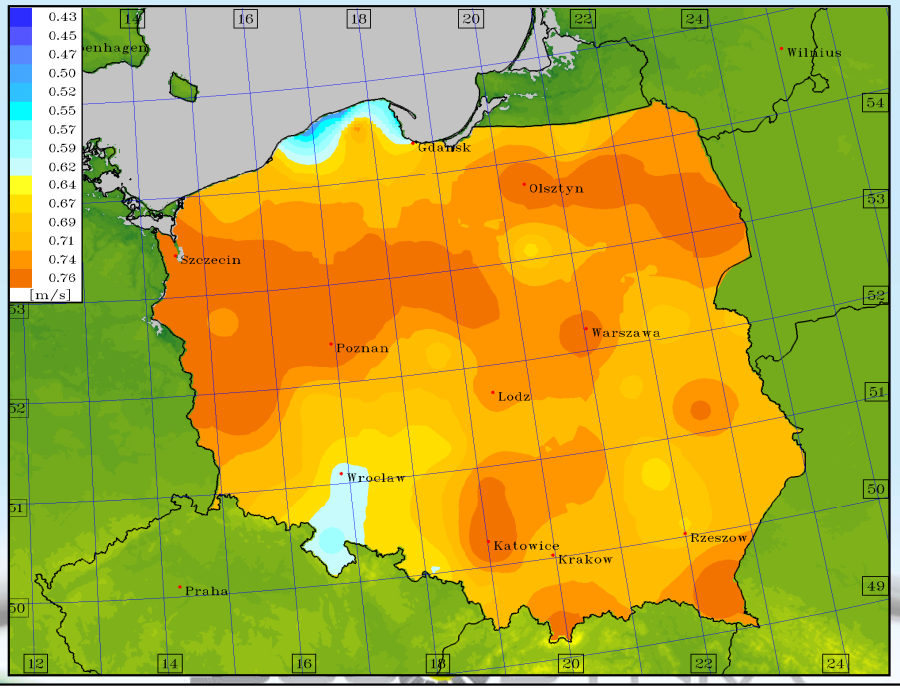






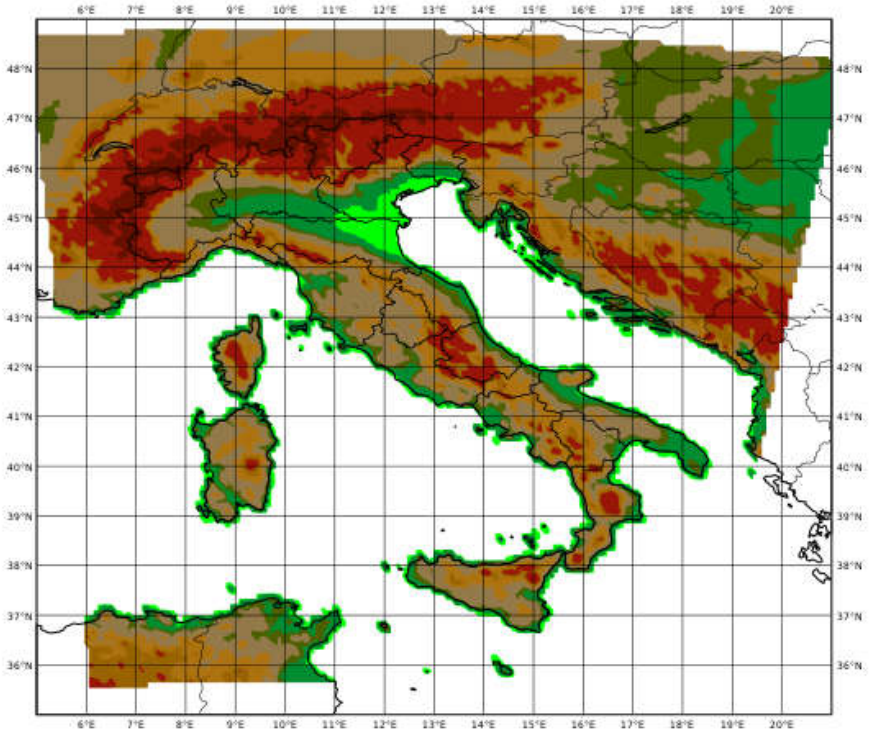


Skill (left) and spread (right) for U10M (upper – 2016; lower – 2017)

COSMO-IT-EPS - Evaluation of ensemble spread

- 2.8 km
- 10 members

- 3 set-up:
  - no physics perturbation
  - SPPT
  - SPPT + Perturbed Parameters



- **Aim**: assess the impact of physics perturbations on precipitation: do they increase the spread?
- **Compute dFSS (FSS between all pairs of ensemble members)**
- **Compute SAL between all pairs of ensemble members**

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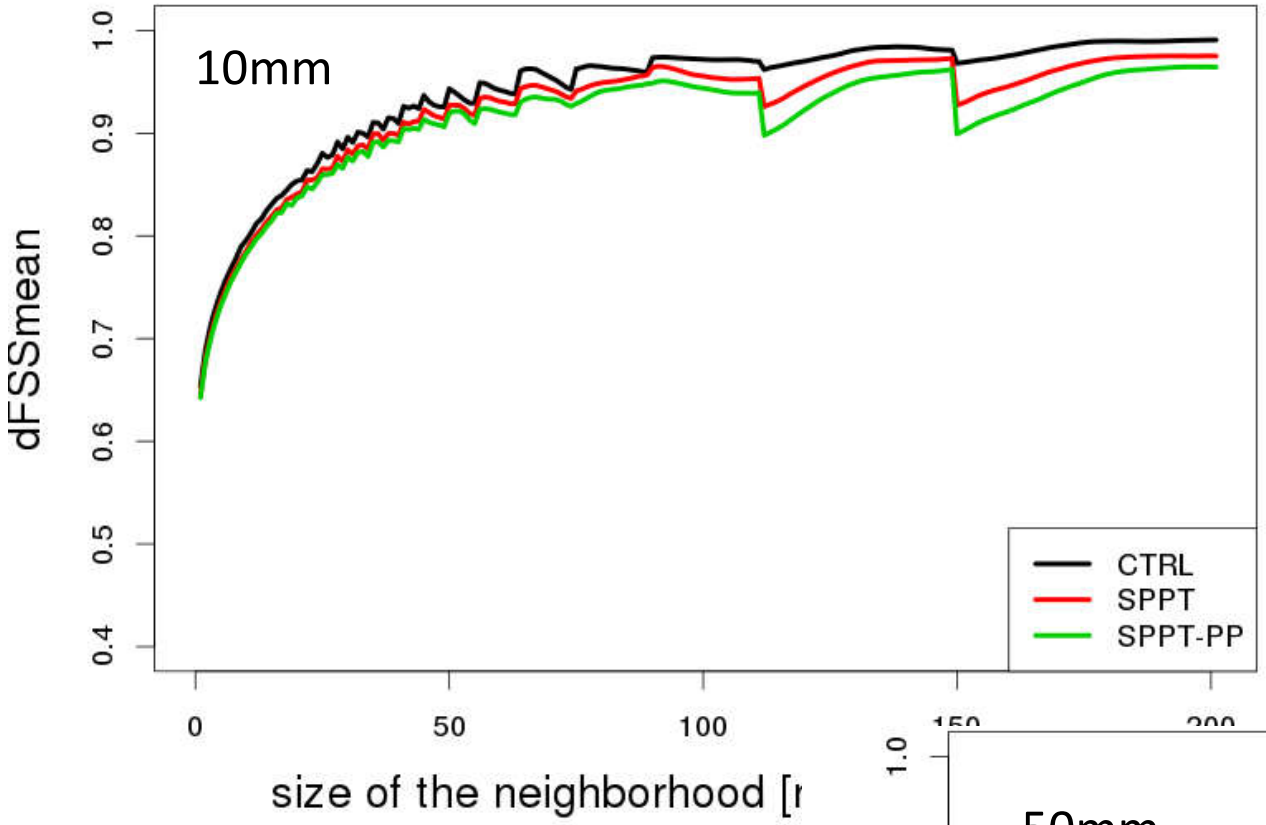
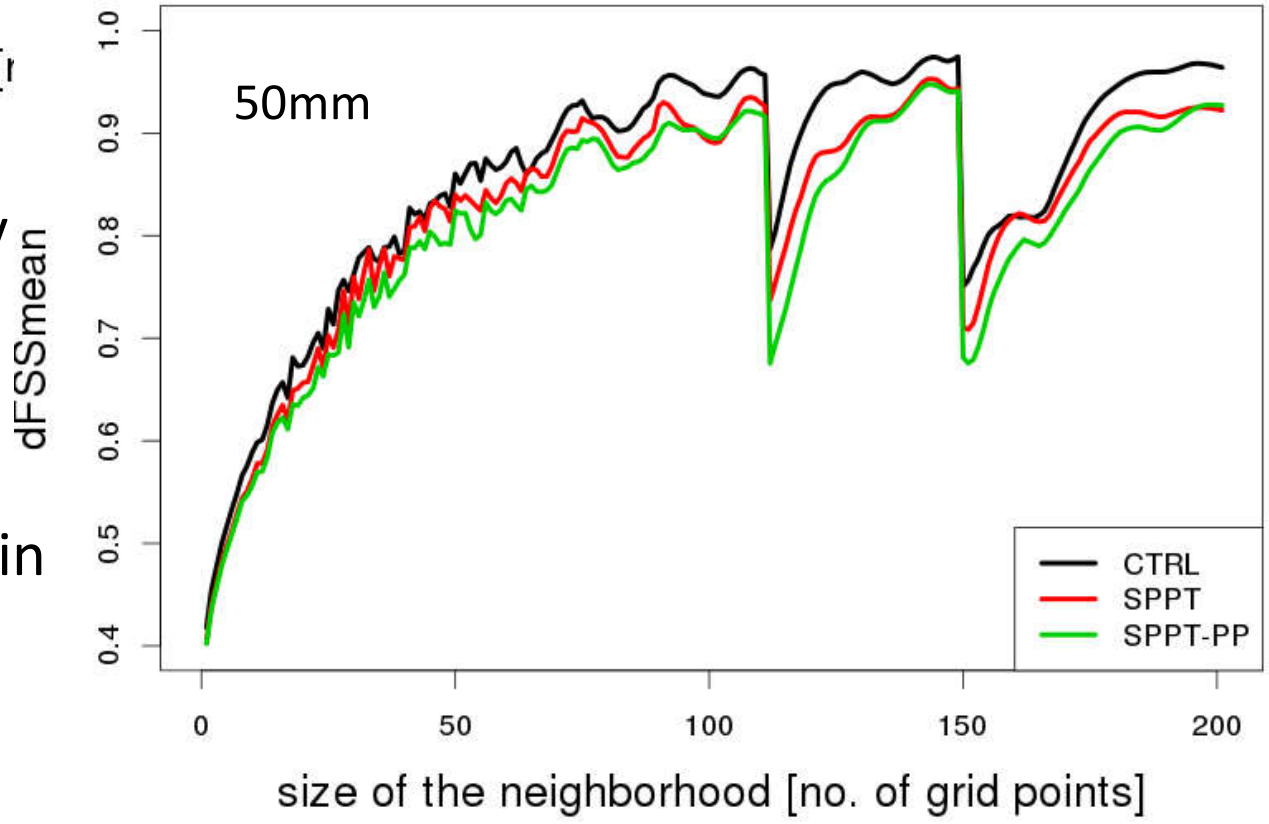
dFSS: dispersion Fraction Skill Score



31 October 2016
Calabria
24h precipitation

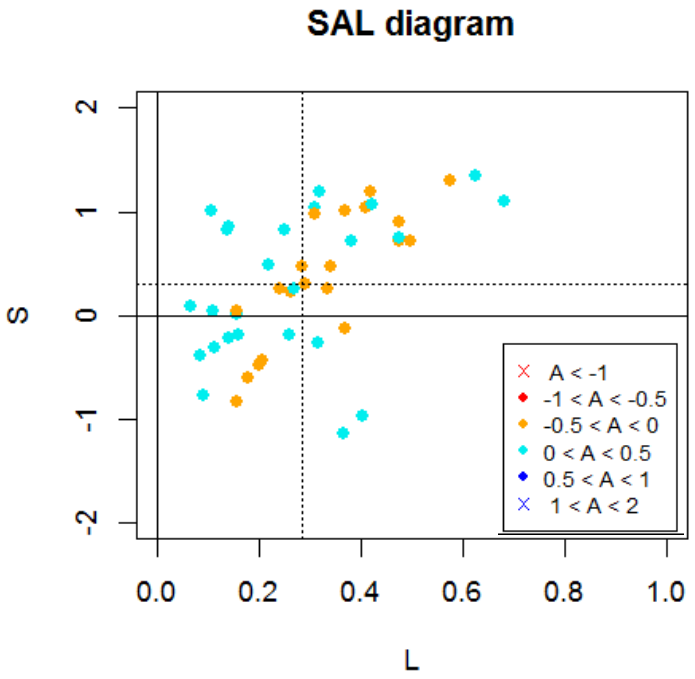
- dFSS uses the FSS to express the (dis)similarity of all the pairs of ensemble members
- dFSSmean indicates the “spatial” agreement within the ensemble for a given neighbourhood size

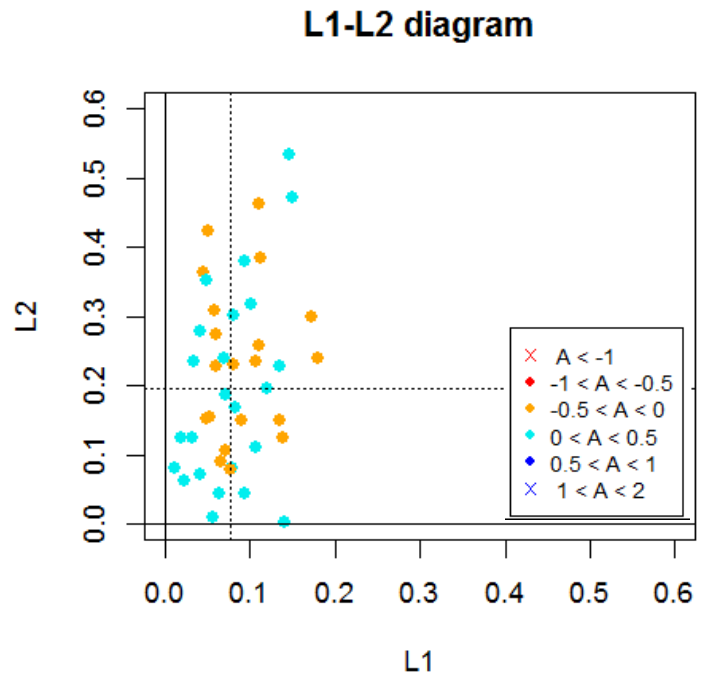


10/10/15 - 100mm – 125x163

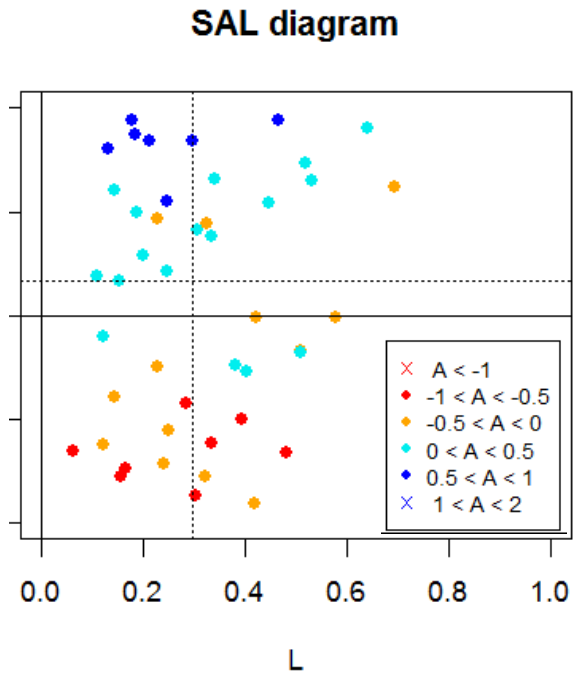
SAL Spread

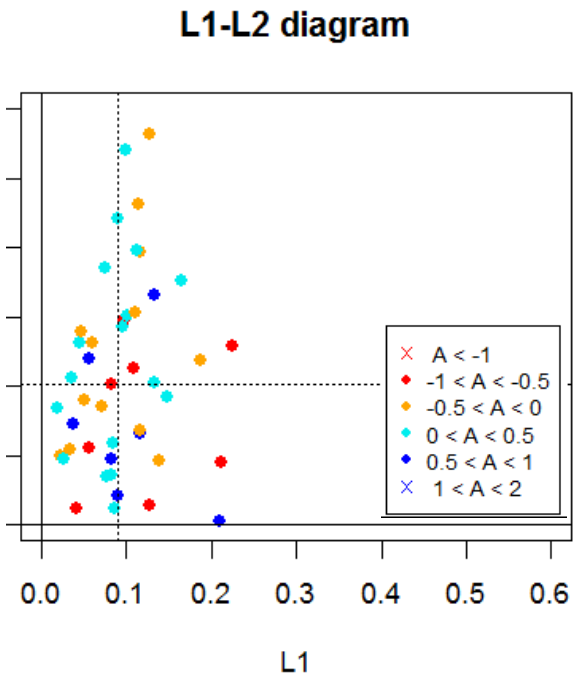
no physics pert



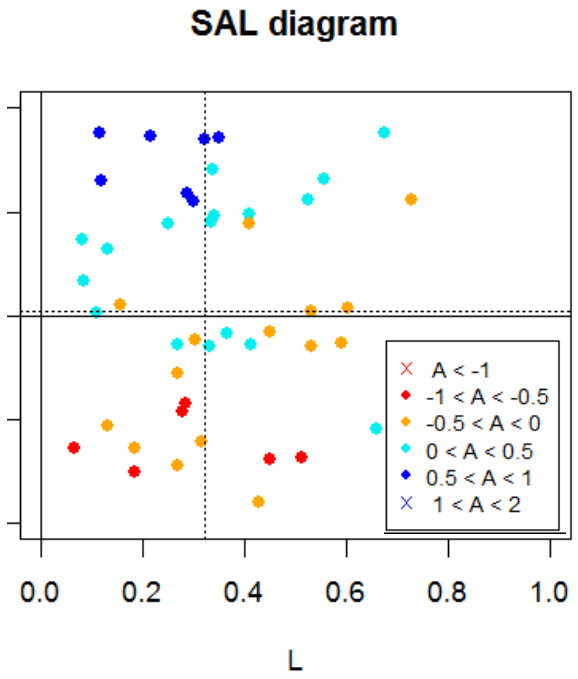


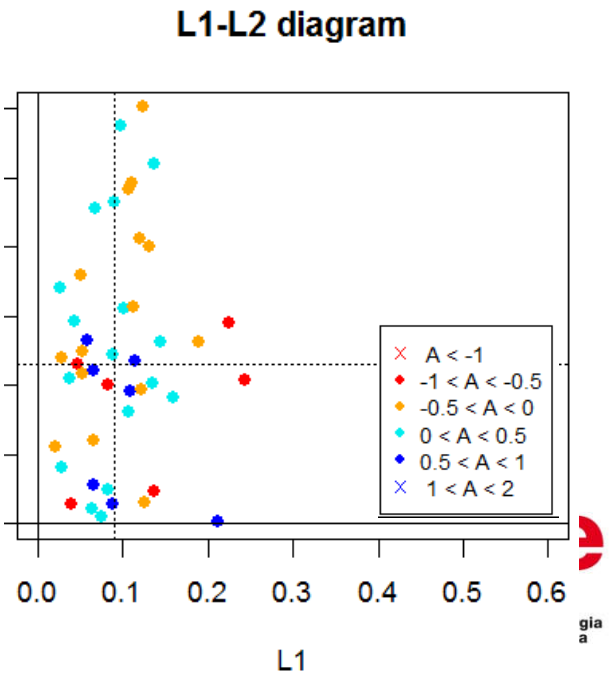
SPPT





SPPT + PP





Summary of problems of the ensemble spread/skill

- in order for the ensemble to be reliable for the desired variable/phenomenon, the ensemble spread should match the forecast error
- the observational error should also be taken into account, but do we have a good estimate of it?
- the model bias hinders the estimate of the spread/skill relation, ideally should be removed (e.g. skill computed against analysis)
- what is a good measure of spread for the precipitation? Or the cloud cover, or the fog?
- how to combine spatial approach / user oriented and spread estimate?

Task 2:
Model perturbation

Learnings from SPPT in COSMO-E

- Sum of parameterization tendencies for T and QV is largest in summer and dominated by those from the turbulence scheme
- Hence, SPPT is able to significantly increase spread in T/QV near surface in summer, but hardly in winter
- SPPT has only significant impact with large correlation lengths in space and time in the random pattern (we thus use 5deg and 6h)
- higher chance for unphysical temperature anomalies caused by advection scheme when physics tendencies are significantly reduced by SPPT (switched off locally in such cases)
- opr SPPT setup of COSMO-E leads to model crashes in 1.1 km runs

Thoughts about model perturbations

- model perturbations with BLPERT and SPPT have an impact on the physical processes that keep a convective system alive and they can be disruptive
- chance that perturbations are disruptive are particularly high with BLPERT with new random numbers every 10 minutes

- an issue of all our stochastic model perturbations schemes in convection-resolving ensembles (?)
- probably less an issue with parameter perturbations (?)
- process-level uncertainty representation by stochastic perturbed parameterizations (SPP) the long-term goal for our ensembles…?

Randomized physics (RP) in COSMO-DE-EPS

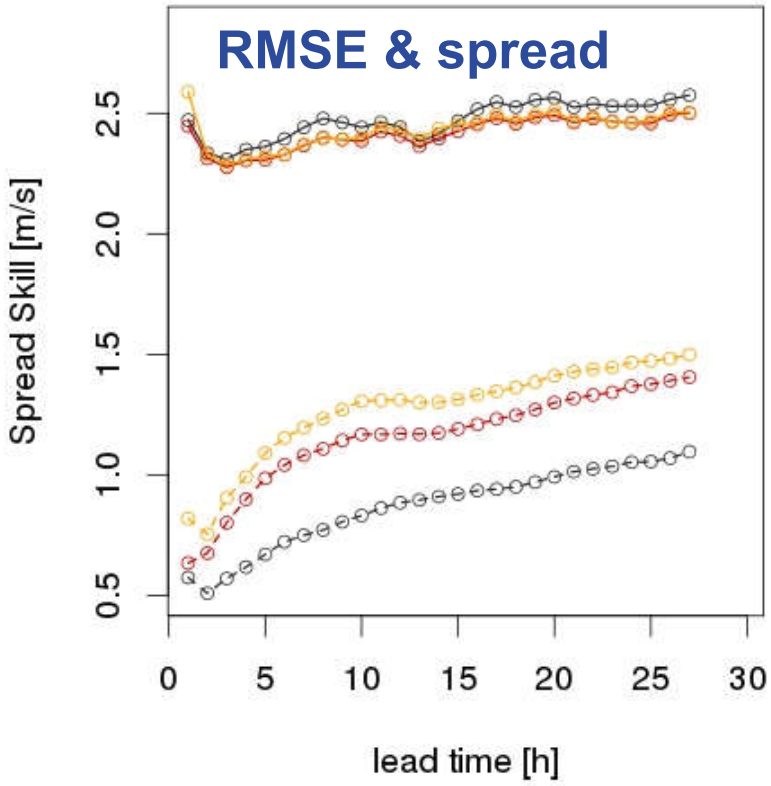
- Randomised selection of the physics parameter perturbation for COSMO-DE-EPS
- The values of the parameters are not random (2-3 different values for each of the 12 parameters) [see table]
- Each parameter gets perturbed for 50% of the members of each ensemble run and stays fixed over the forecast range

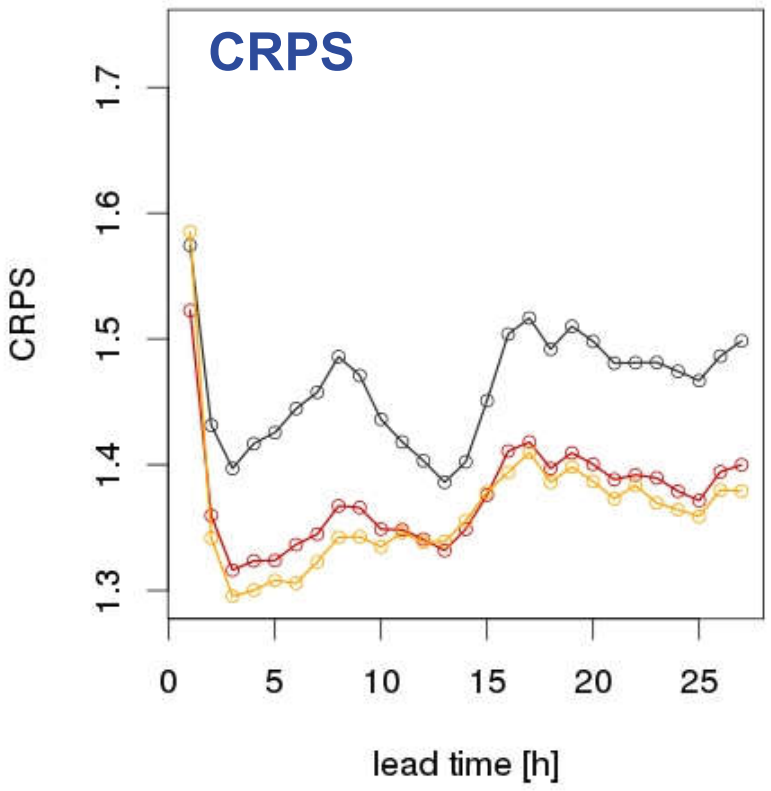
New perturbations (easier to implement with the RP)

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
	10			30000	0.1				0.2	0.2	

Results for 10m gusts, December 2014

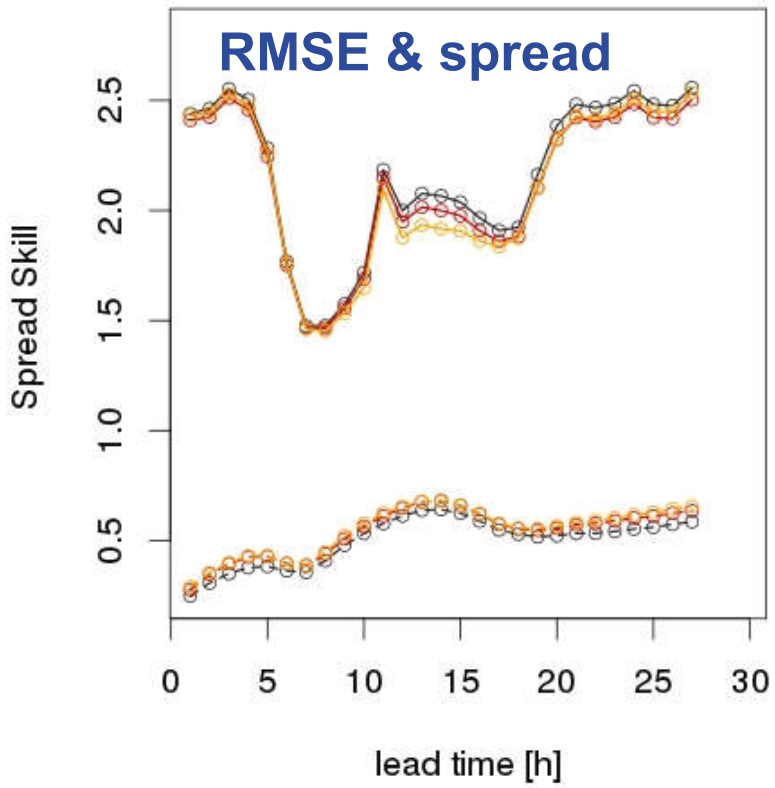
fixed (reference)
fixed with new perturbations
random with new perturbations

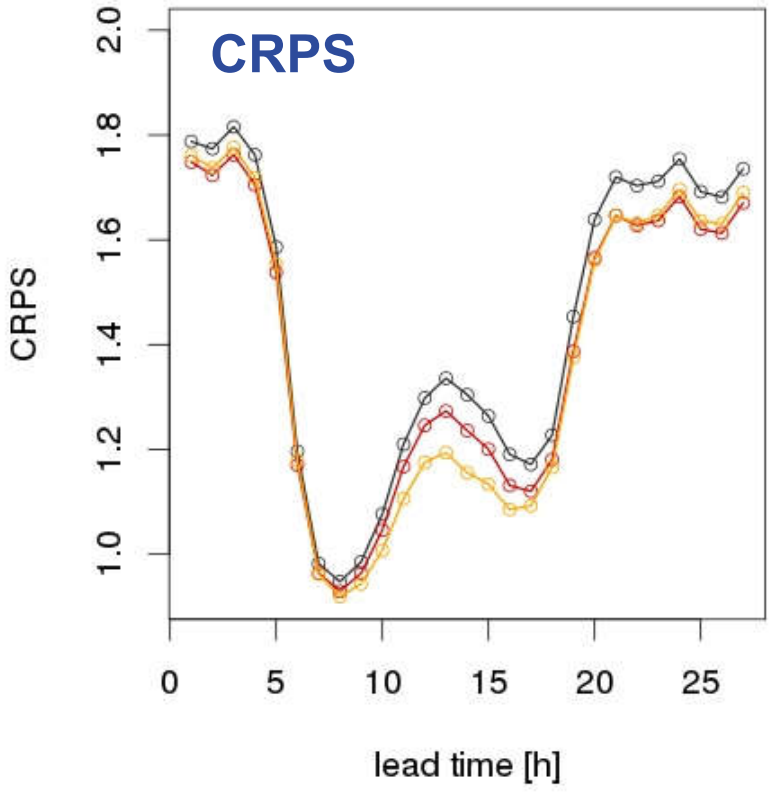




Results for T_2M, August 2013

fixed (reference)
fixed with new perturbations
random with new perturbations





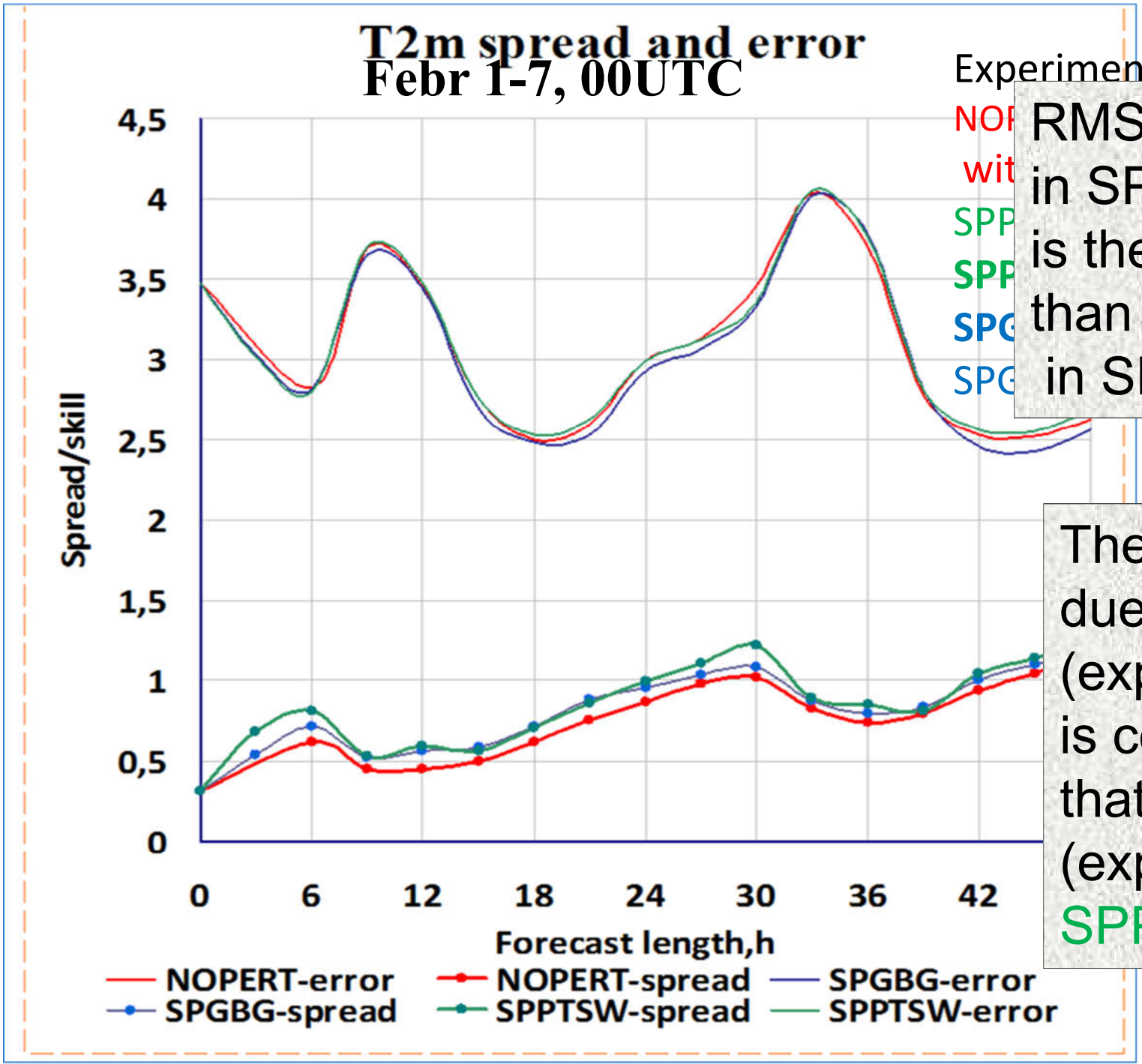
Application of stochastic pattern generator (SPG)* in COSMO-Ru2-EPS

- Experiments with COSMO-Ru2-EPS have been performed for winter period
- SPG was used in additive mode
- RMSE did not grow in SPG experiments
- The spread was comparable with that in SPPT experiments

**) Tsyrulnikov M. and Gayfulin D. A limited-area spatio-temporal stochastic pattern generator for simulation of uncertainties in ensemble applications. – Meteorologische Zeitschrift, 2017, v. 26, N5, 549-566.*

SPG was implemented to the COSMO code within KENDA PP

Perturbation based on SPG



RMSE in SPG experiments is the same or smaller than in SPPT experiments

The spread increase due to SPG (experiment SPGBG) is comparable with that due to SPPT (experiment SPPTSW)

Task 5:
Initial Conditions for the CP ensembles

Member selection for ICs and LBCs

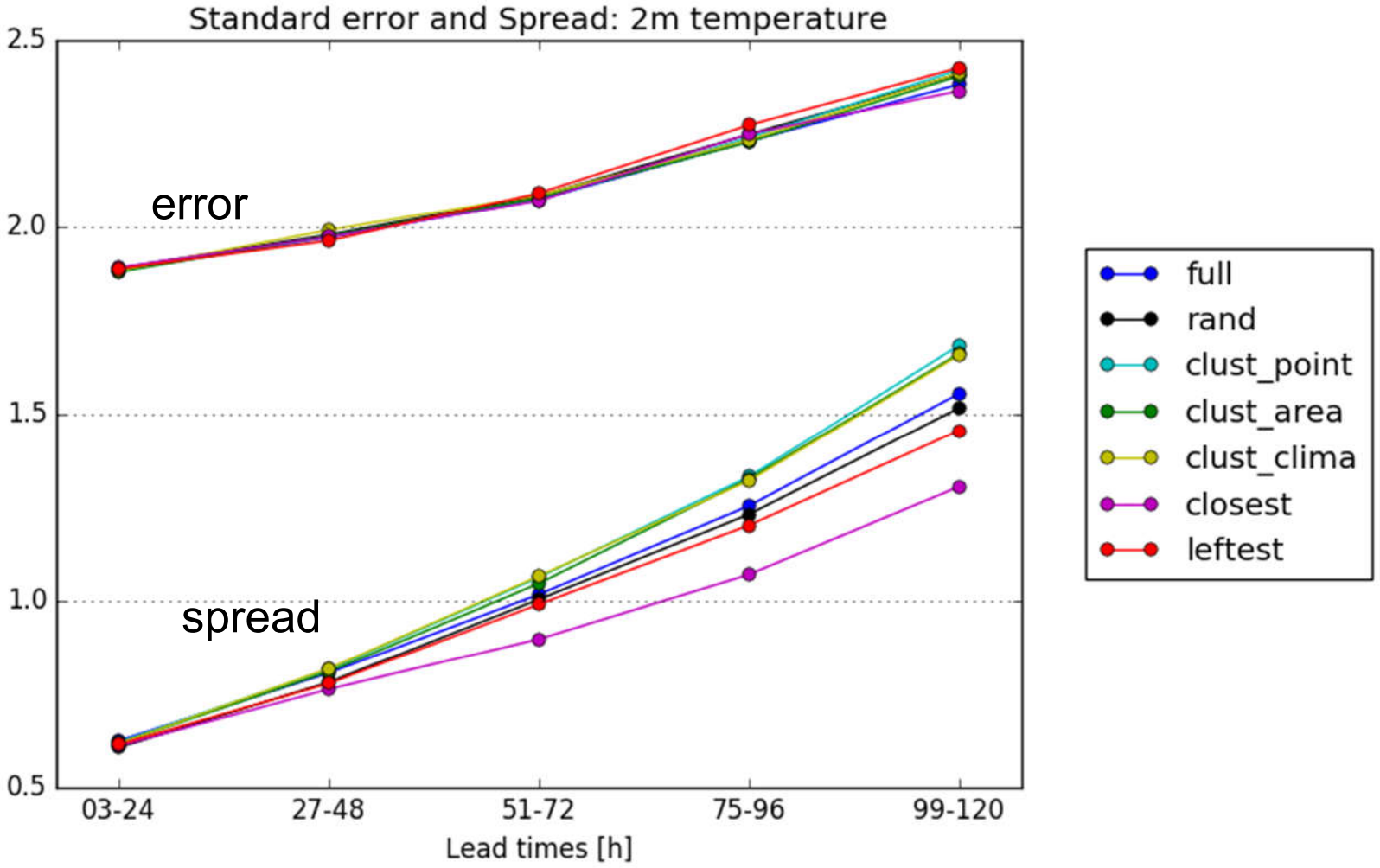
- Operational setup: the perturbed members just use members 1-20 of KENDA and IFS-ENS

Questions:

- Is it possible to increase the COSMO-E forecast quality by using a smarter selection?
- How big is the difference in forecast quality between using the ‘best’ and the ‘worst’ set of 20 perturbed members?

→ similar approach used as in COSMO-LEPS clustering:
3 variables: wind, temperature, humidity on 3 model levels (~850, 700, 500 hPa)

2m temperature, spread/error



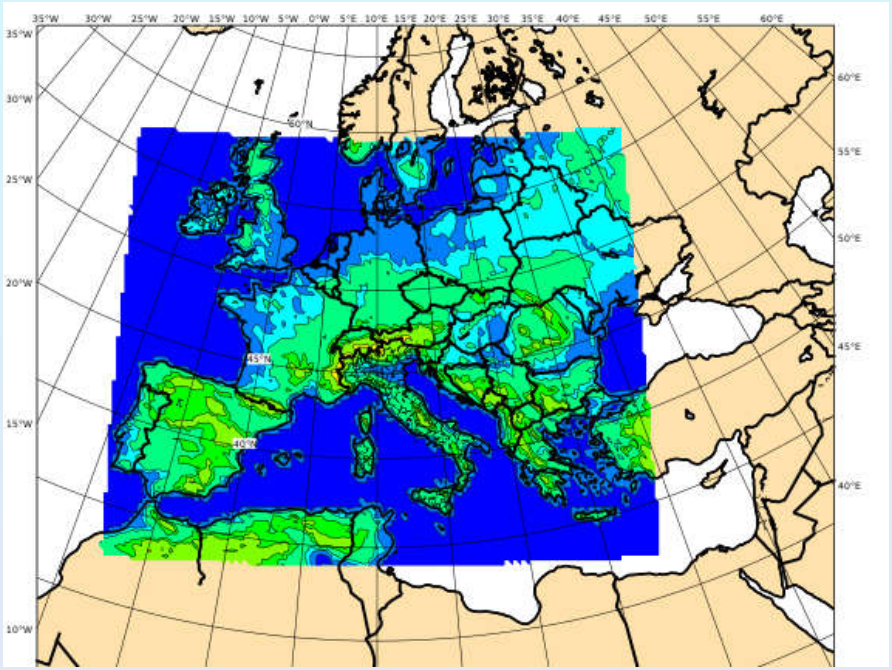
- 'clust' shows larger spread than 'full'! → tails 'overpopulated'
- 'rand' third, 'closest' clearly worst

COSMO-LEPS

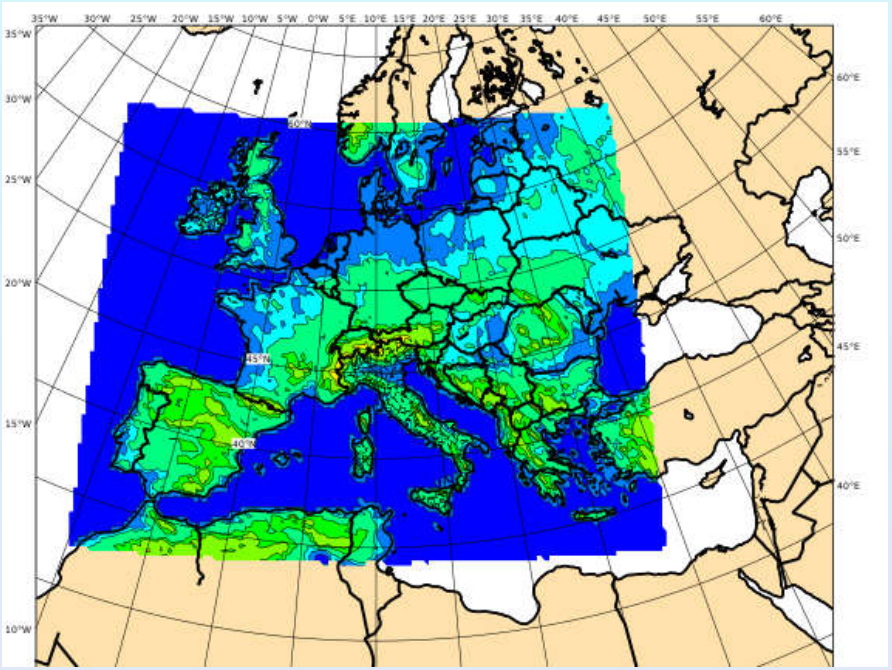
COSMO-LEPS 5-km upgrade

- In agreement with the Consortium strategies, we are assessing the sensitivity of COSMO-LEPS forecast skill to the use of different parameterisations of moist convection and to enhanced horizontal resolution.
- From 24/11 to 31/12/2017 and from 1/5 to 31/5/2018, in addition to **oper7** (COSMO-LEPS @ 7 km), we also ran a test configuration (only at 00UTC), denoted with **test5**.

oper7



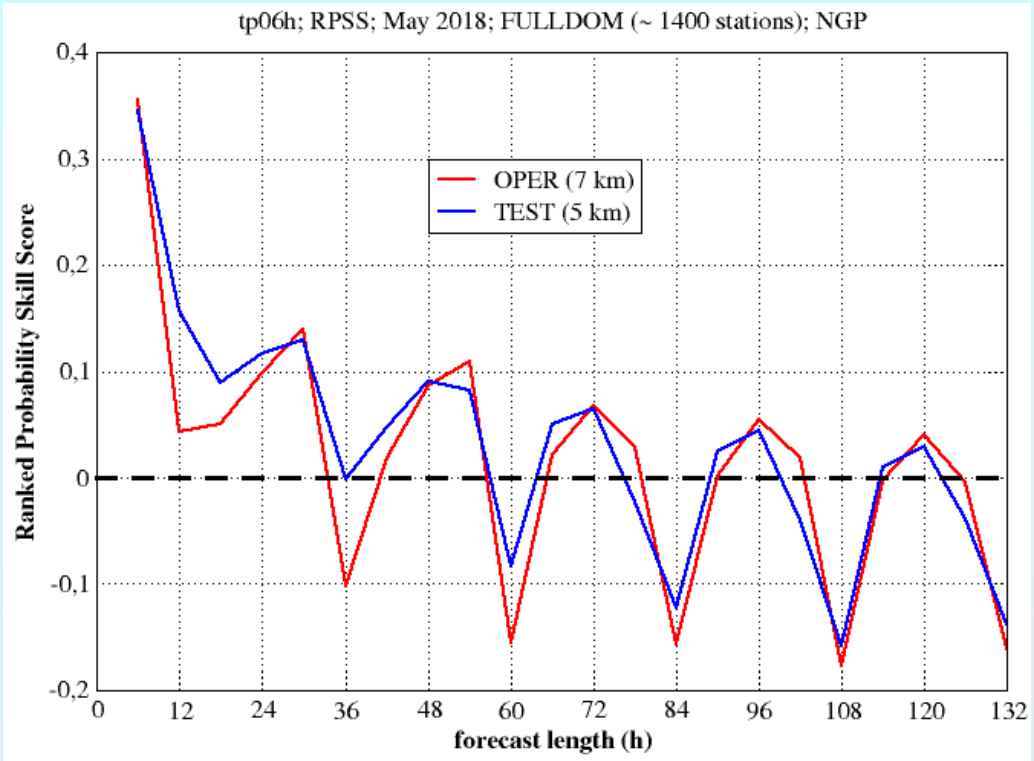
test5



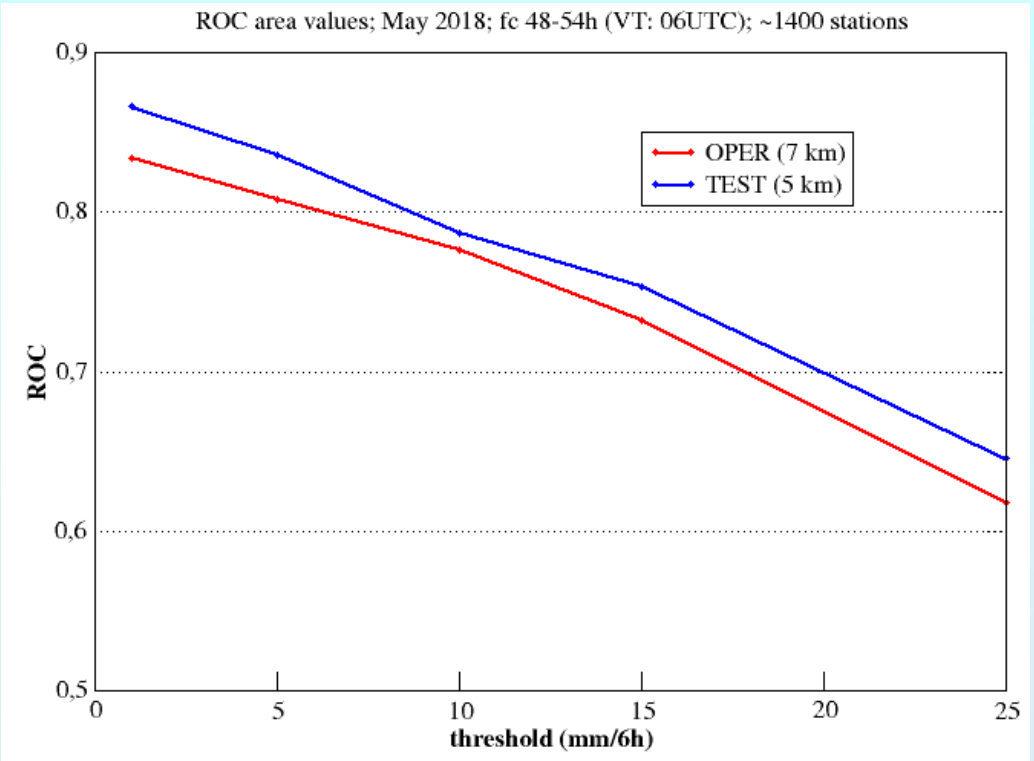
May 2018 experimentation: oper7 vs test5

- Variable: 6h cumulated precipitation (thresholds: 1, 5, 10, 15, 25, 50 mm).
- Scores: Ranked Probability Skill Score (RPSS), ROC area at fixed forecast range.

RPSS: tp06h



ROC: tp06h

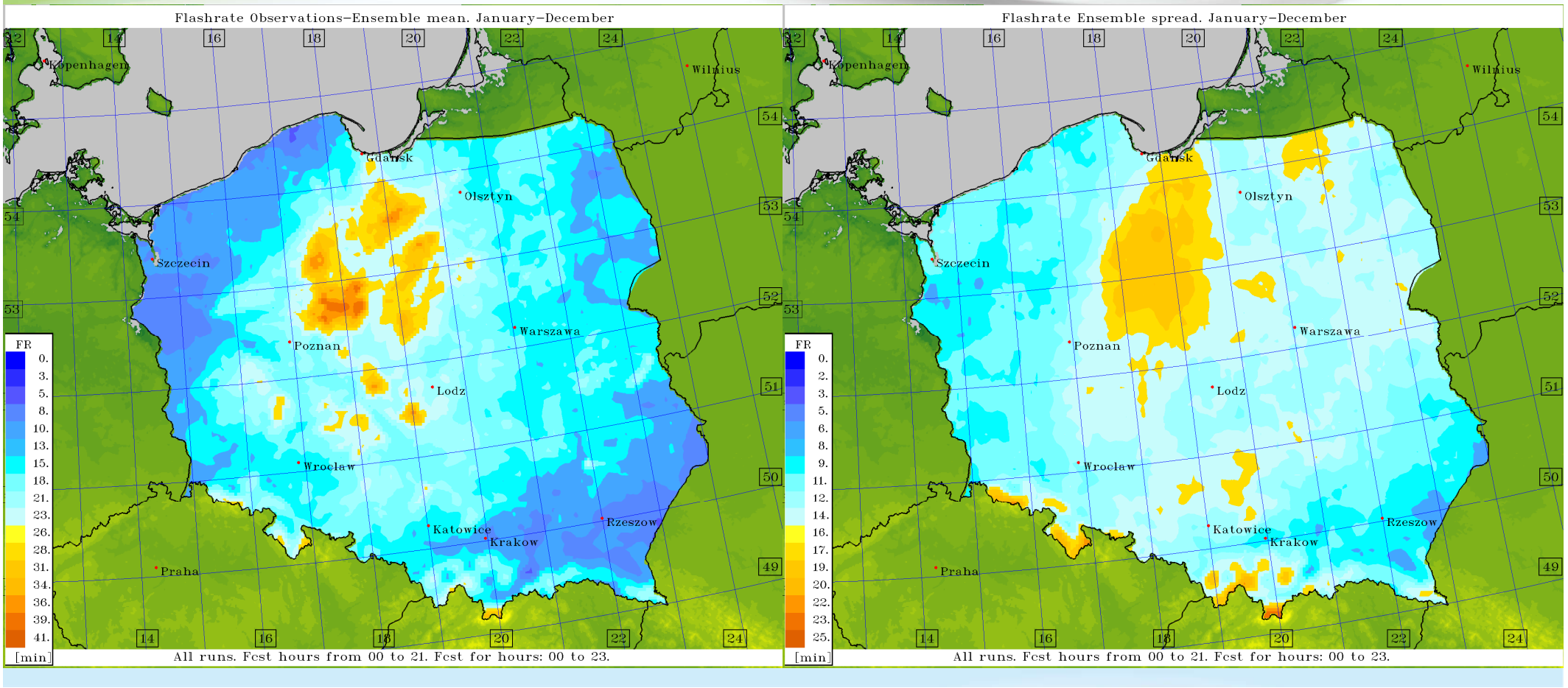


- RPSS: clear daily cycle in the performance of the model; higher skill of **test5** in the short range for day-time precipitation; mixed results later on.
- ROC area: slight positive impact of enhanced resolution for all thresholds.

Future plans

- New model perturbation methods
  - Stochastic modeling of the model error (scheme of EM)
  - Stochastic Pattern Generator -> AMPT: Additive Model-error perturbations scaled by Physical Tendencies
  - Perturbations based on adapted Random Number Generator (RNG)
  - iSPPT (independent SPPT)
  - Model perturbation based on analysis increments
- Post-processing and interpretation of ensembles
  - Calibration
  - Products from ensemble output, e.g. flashrate, visibility -> need of verification
- Transition to ICON-LAM -> test of physics perturbations with the new model)

Ensemble post-processing - flashrate



Mean skill (left) and spread (right) of flashrate, c_soil (operational) perturbation, 2013