Status of ensemble developments at RHM

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Outline

1. Soil perturbations (new)

2. Preparations for ICON EPS at RHM

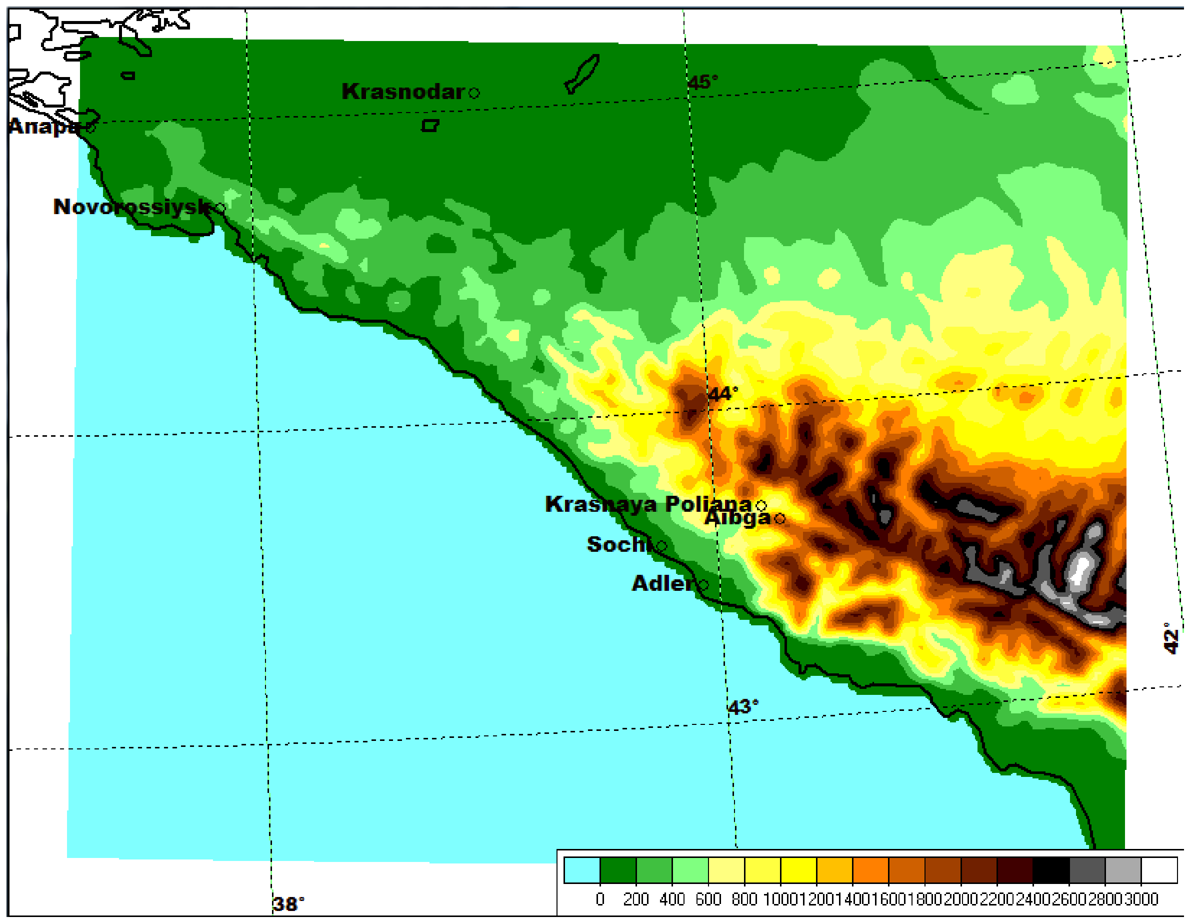
New development:

Soil perturbations

Domain, model, and cases

- 300*400 km area centered at Sochi (latitude 44N)
- Model resolution: 2.2 km, 50 levels.
- Initial and lateral boundary conditions for ensemble members were taken from COSMO-LEPS adapted for a larger Sochi region (resolution 7 km) - made by the Italian colleagues.
- Cases:

February and May 2014



Soil perturbations: approach

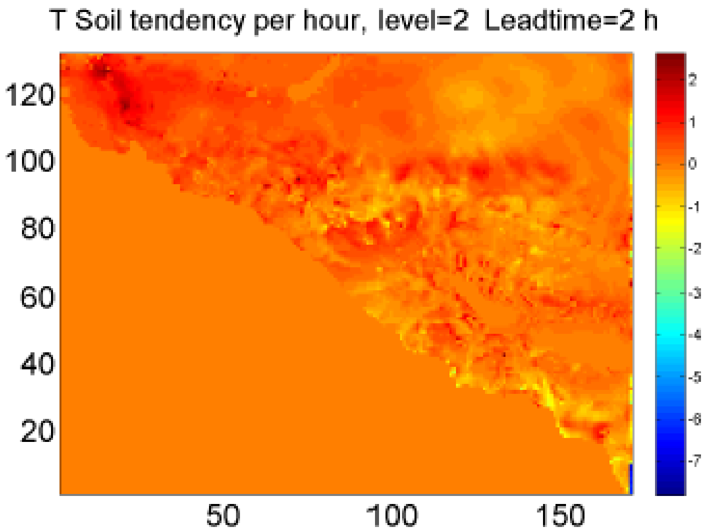
- Rely on SPG perturbations
- Due to lack of reliable error statistics in the soil, we set up the *simplest* scheme:

  - not contradicting to common sense,

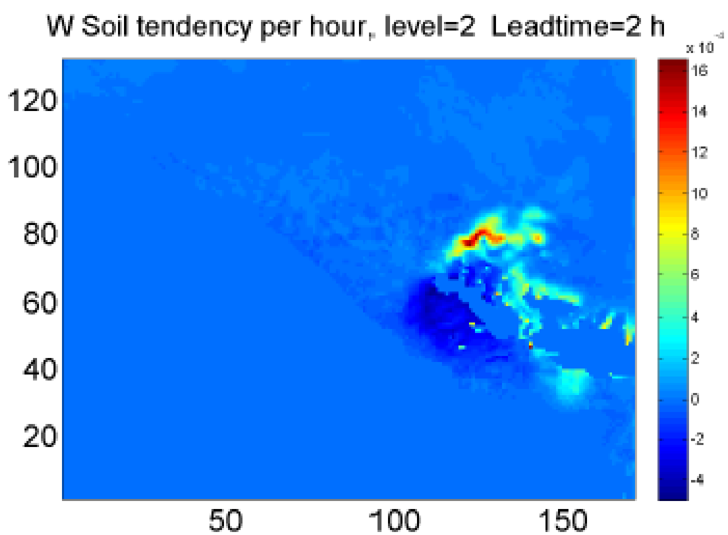
  - consistent with statistics of the soil fields, and

  - providing reasonable spread

Examination of soil fields tendencies



- The $\boldsymbol{T_{so}}$ tendencies are homogeneous and more or less Gaussian
- Perturbations can be introduced in the same manner as we did for the "Gaussian" atmospheric variables T, u, v: use AMPT



- The $\boldsymbol{W_{so}}$ tendencies are highly variable and do not look Gaussian at all
- SPPT looks more appropriate here

Forecast start date is May 1, 2014, 0 UTC

T_{so}: AMPT model-error perturbations

AMPT: **A**dditive **M**odel-error perturbations scaled by **P**hysical **T**endencies:

$\mathcal{P}(z,t) = \widehat{\mathbb{E}}\, |P(x, y, z, t)|$ $\widehat{\mathbb{E}}$ *is the domain averaging operator*

$T'(x,y,z,t) = \epsilon \cdot \mathcal{P}(z,t) \cdot \xi(x, y, t)$ $\epsilon \sim 1$ *is the tuning parameter*

- Spatial length scale of ξ is 50 km (the same as for T,u,v)
- Time scale of ξ is 3h (longer that 1h for T,u,v)

T_{so}: initial-error perturbations

- The soil fields have much longer time scales than the atmospheric fields ➔ weeks of cycling are needed to reach an equilibrium forecast error statistics in an ensemble

- Without long cycling, we imposed initial T_{so} perturbations (generated with SPG and in addition to the model-error perturbations) with the tuned magnitude of 1K

W_{so}: SPPT model-error perturbations

- SPPT: the random field's standard deviation=1
- W_{so} is constrained to be within *wilting point* and *field capacity*.

W_{so}: initial-error perturbations

- Like others, we perturb Soil Moisture Index.
- The perturbation standard deviation=10%. The spatial structure is the same as in W_{so} model-error perturbations.

Why SPPT can lead to instabilities if the tendency changes sign?

Let at some point, there is an **excessive** amount of water W in some soil layer, and the model “wants” to reduce it. The model tendency is, thus, $\Delta W<0$.

Imagine SPPT **inverts the sign** of the tendency, so that the perturbed tendency $\Delta W^* > 0$.

Then at the next time step, W will become LARGER, and the system will be even more “eager'' to reduce W so that the tendency grows in modulus:

$|\Delta W_{\mathrm{next}}| > |\Delta W_{\mathrm{previous}}|$.

And so on: ΔW will grow until the model “explodes”. This is what we have seen in soil.

Remedy:

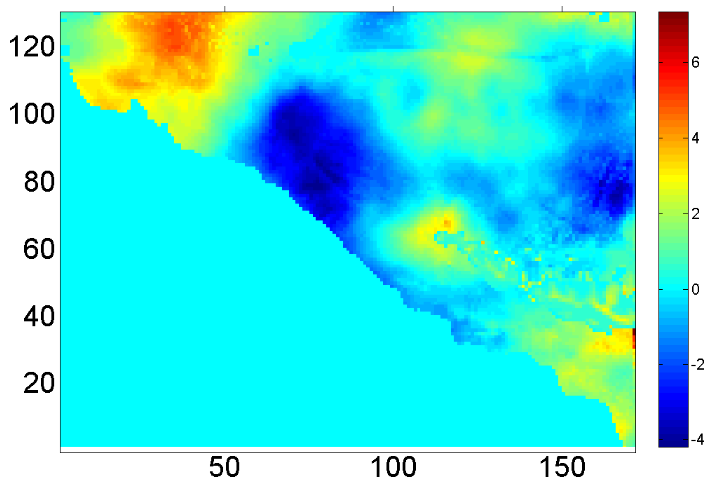
Ban tendency sign reversal!

With this remedy and without any limitations on the increase of the unperturbed tendency without the sign reversal, we were able to run SPPT with the multiplier as large as 30 (!)

Forecast perturbations (w.r.t. the unperturbed run) in SOIL

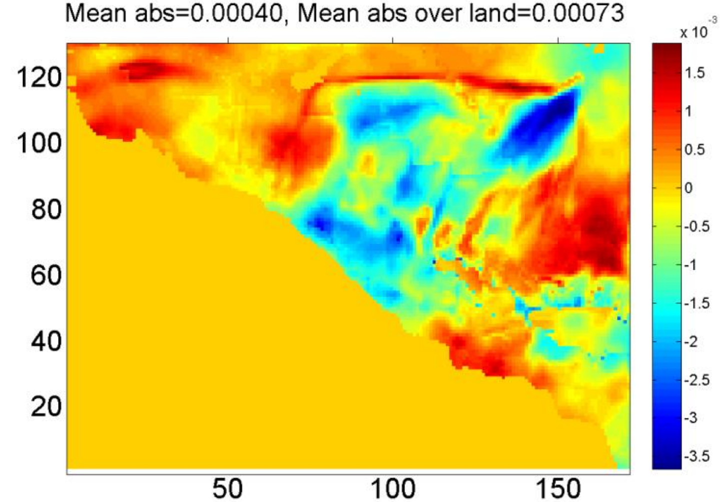
T_{so}

Leadtime=12 level=3
T_S diff, air+soil vs air
Mean abs=0.74999, Mean abs over land=1.38878



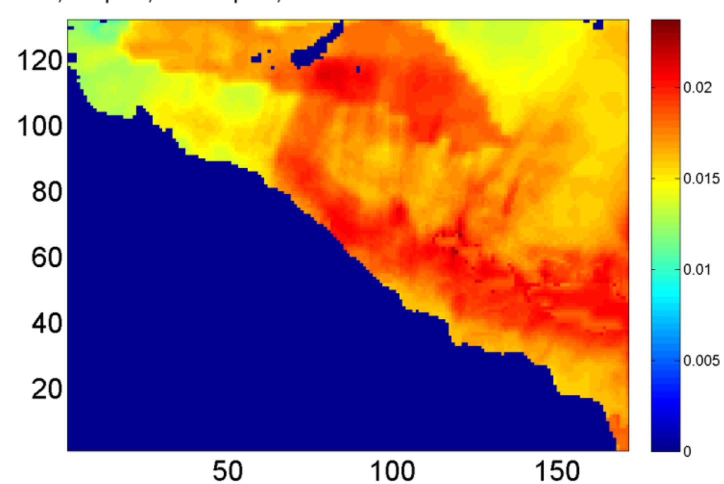
W_{so}

Leadtime=12 level=3
W_S diff, air+soil vs air
Mean abs=0.00040, Mean abs over land=0.00073



12-h forecast perturbations

Wso, air pert,no soil pert, lev=3 Tfcst=12 mean abs=0.00914

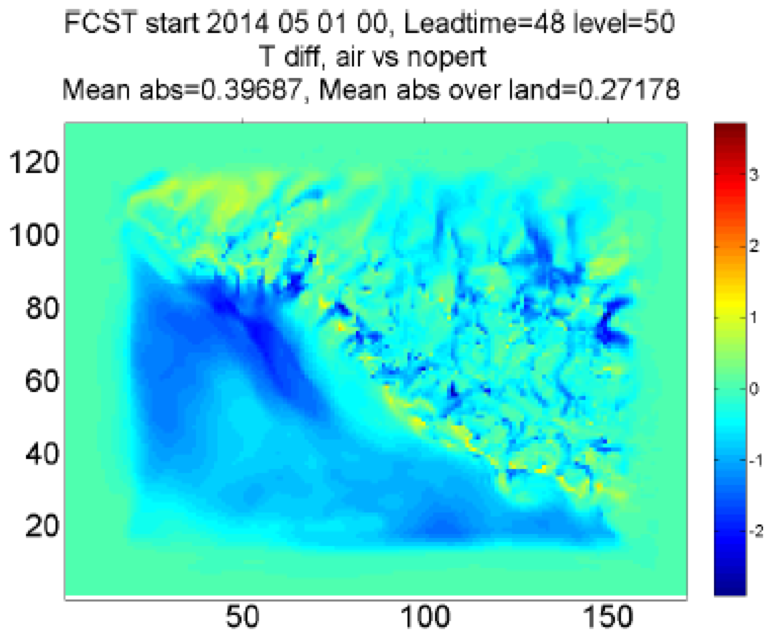


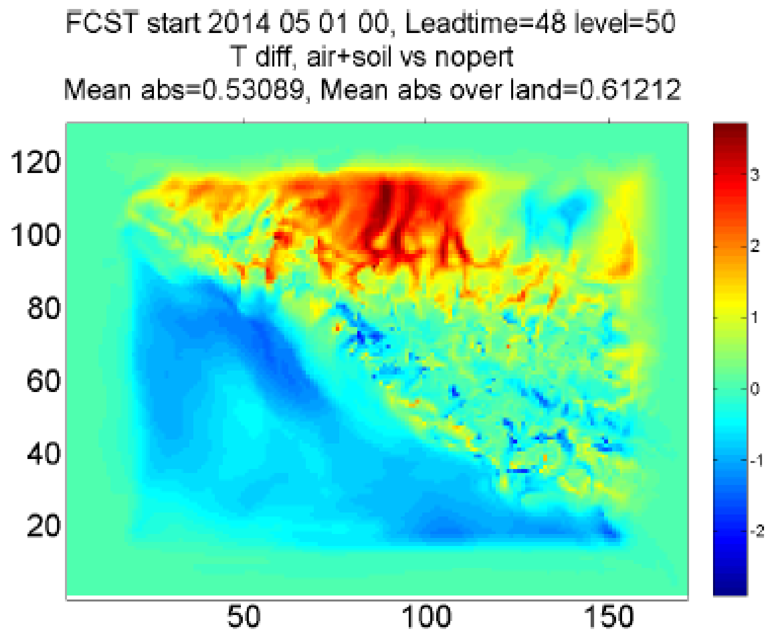
12-h W_{so} forecast itself

May 1, 2014, 0 UTC start

Forecast perturbations at the lowest model level

May 1, 2014





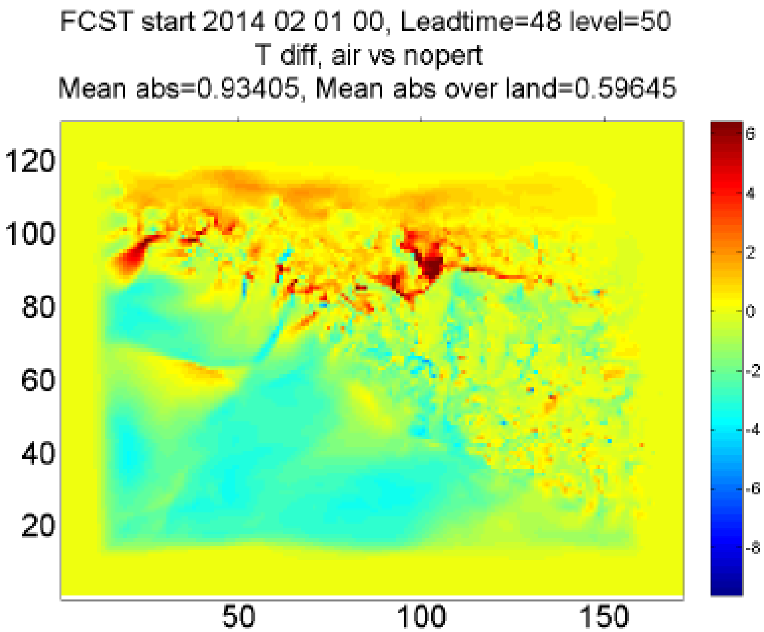
Perturbations in atmosphere only

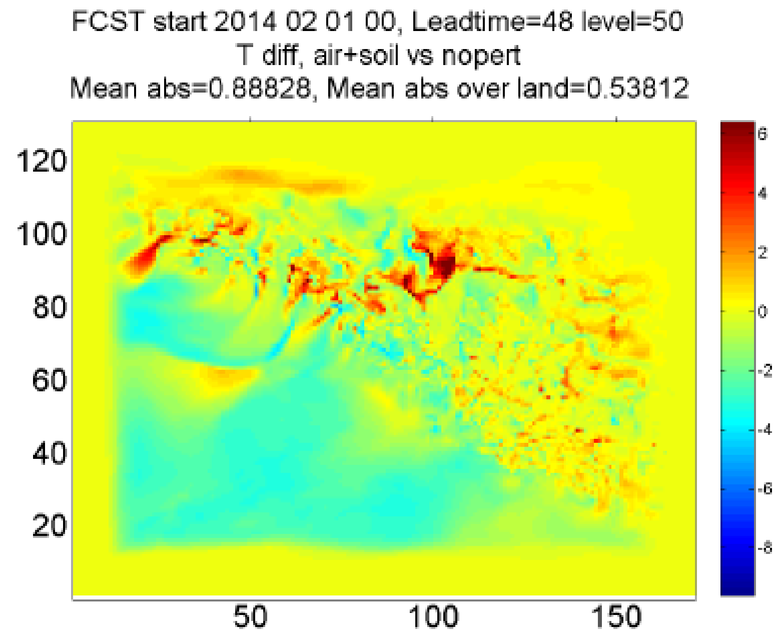
Perturbations in atmosphere +soil

Lead-time 48 h

Forecast perturbations at the lowest model level

February 1, 2014





Perturbations in atmosphere only

Perturbations in atmosphere +soil

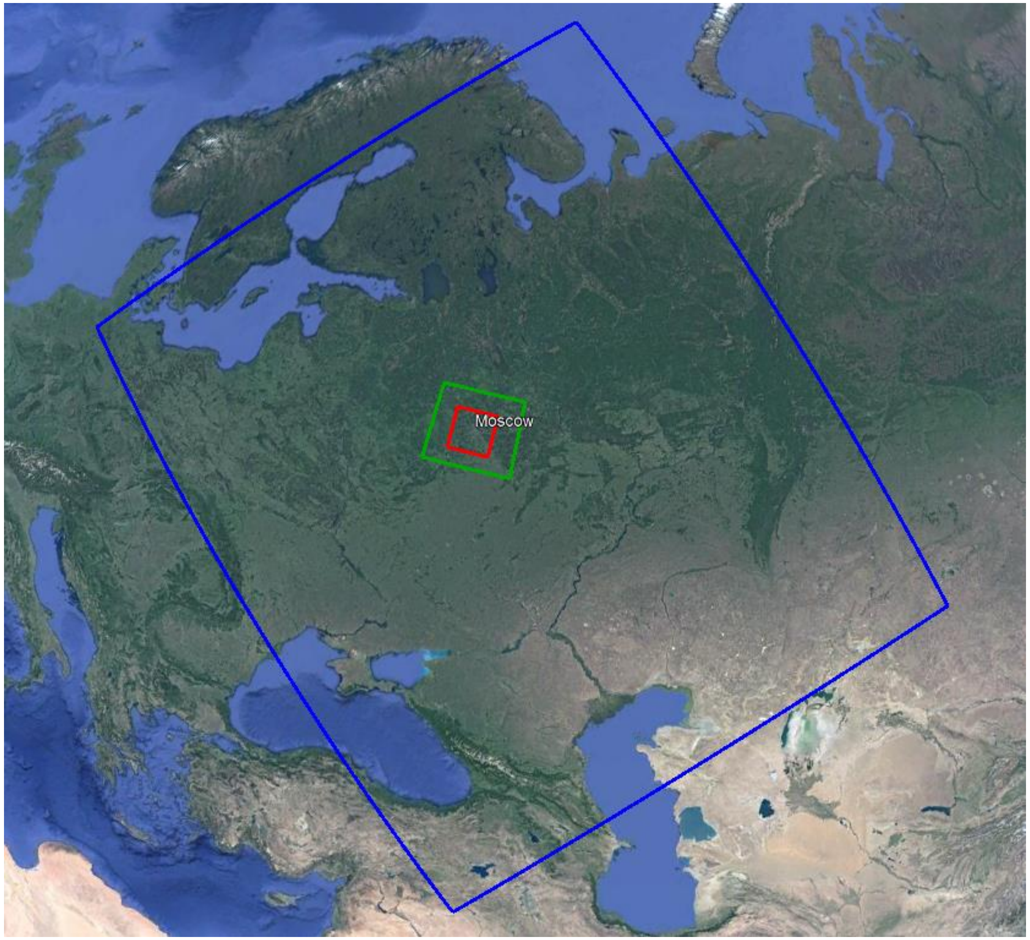
Lead-time 48 h

Summary on soil perturbations

1. An algorithm to perturb soil moisture and soil temperature is proposed and tested in perturbation experiments.
2. Soil temperature and moisture should be perturbed in different ways
3. Some SPPT induced instabilities are explained and a remedy is proposed and tested.
4. Soil perturbations affect the atmosphere and perturbations are transferred to the air.
5. The intensity of transferring perturbations from soil to air depends on synoptic situation and season
6. Introduction of soil perturbations increases ensemble spread

Preparations for ICON-based EPS at RHM

Domain



cm02etr:
1200x1400x50, 2.2 km

cm01msk:
180x180x50, 1 km

ic02msk_eps:
2.2 km

center_lon=37.62 E; center_lat=55.75N
startlon_tot=34.62E; end_lon=40.62E
startlat_tot=54.25N; end_lat=57.25N

Planned EPS configuration:

Domain: Moscow region

Model: ICON-LAM

Resolution: ~2.2 km 60-65 lev

ICs&BCs: ICON-EPS

Ensemble size: first 15 with possible increase to 21

Forecast length: 48h

Forecast frequency: 2 times a day (00,12 UTC)

Model-error perturbations:

first – parameter perturbations, later – try AMPT

Additionally: consider LAF, involving members with ICs&BCs from deterministic runs at RHM

Status of EPS development:

- Tests for EPS domain with ICON-LAM were performed.

ICs &BCs were taken from global 13-km ICON runs at the Hydrometcenter of Russia.

- The size of ICs&BCs files is about ~300M per member (if we update BCs each 3 h and run a 48-h forecast).
- We asked DWD for ICs&BCs -> «*DWD will not be able to transfer ICON-EPS data to your service because of COVID-19»*

  Lags? GEFS?– No final solution yet.

- The 48-h ICON-LAM run over the EPS domain can be completed in ~4 min on 128 PE. The optimal results are for 2 threads for 1 MPI process.

Immediate plans

- Modification of AMPT for highly non-Gaussian fields
- "Final" conclusion on whether it's worth perturbing q_v and hydrometeors
- Experiments with soil/q_v/hydrometeor perturbations using COSMO-Ru2-EPS and archive Sochi 2014 data (APSU, 2020)

Further plans

- Development of ICON-based EPS for Moscow region (APSU, next project, 2020-2021). Pre-operational Q1 2021.
- Introduction of SPG to ICON (next project, 2021)
- Experiments with AMPT in ICON-based EPS (next project, 2021-2022)