

COTEKINO Priority Project - Task 3. Soil/surface perturbations

Extensive tests of lower-boundary-variation-based COSMO-EPS Case study for selected terms/different ensemble creation method

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INTRODUCTION

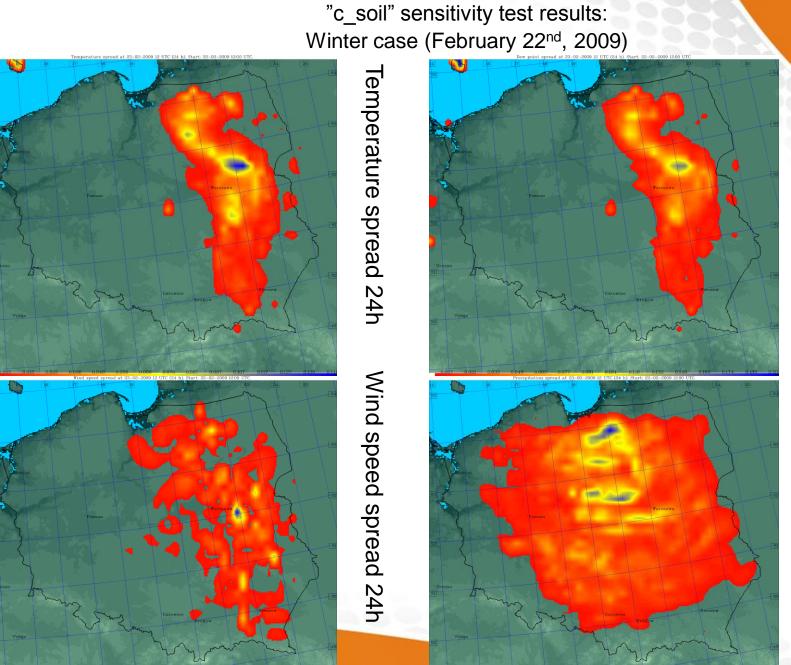
- Moist atmospheric processes are clearly sensitive to soil conditions.
- Simple method to set valid ensemble using selected soil-related parameters.
- First phase tests of a predefined group of different model configurations/setups – preliminary selection of parameters to be used in further experiments.
- Next sensitivity tests to assess validity of preparation/selection of ensemble members in a quasi-operational mode. Goal: to answer if small perturbation of a parameter(s) is strong enough to induce significant changes in a forecast, and to create a valid ensemble. Eleven cases (selected synoptic situations) were run and results were evaluated.
- Finally, two methods of preparing a well-defined ensemble based on the soil parameters perturbation were evaluated for (potential) operational implementation.

RESULTS OF FIRST PHASE

- (Changes of) "czbot_w_so" (depth of bottom of last hydrological active soil layer) a noteworthy impact on values of water and ice content and on soil temperature down to 1458 cm below gl.
- "c_soil"*) a remarkable impact on values of air temperature at 2m agl., dew point temperature and relative humidity at 2m agl., wind speed and direction at 10m agl. and surface specific humidity
- Changes of other parameters have insignificant impact on (any) values.

Conclusions:

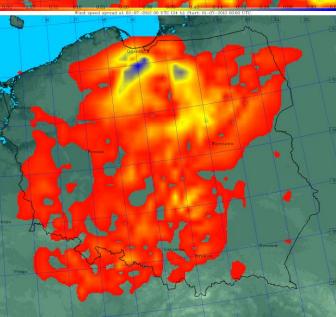
- Due to the (convection-permitting) scale of problem and space resolution of model domain shallow convection scheme – a basic one for tests.
- Numerical setup 3-order standard Runge-Kutta scheme.
- All eleven test cases were used to study an impact of variability of "c soil"/"czbot w so" (within their valid range) on forecasts.
- *) c_soil surface-area index of the evaporating fraction of gridpoints over land, related to c_land surface-area index of gridpoints over land.

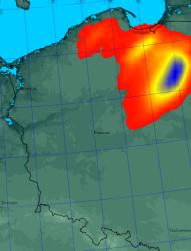


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Precipitation spread 24h

Dew point spread 24h



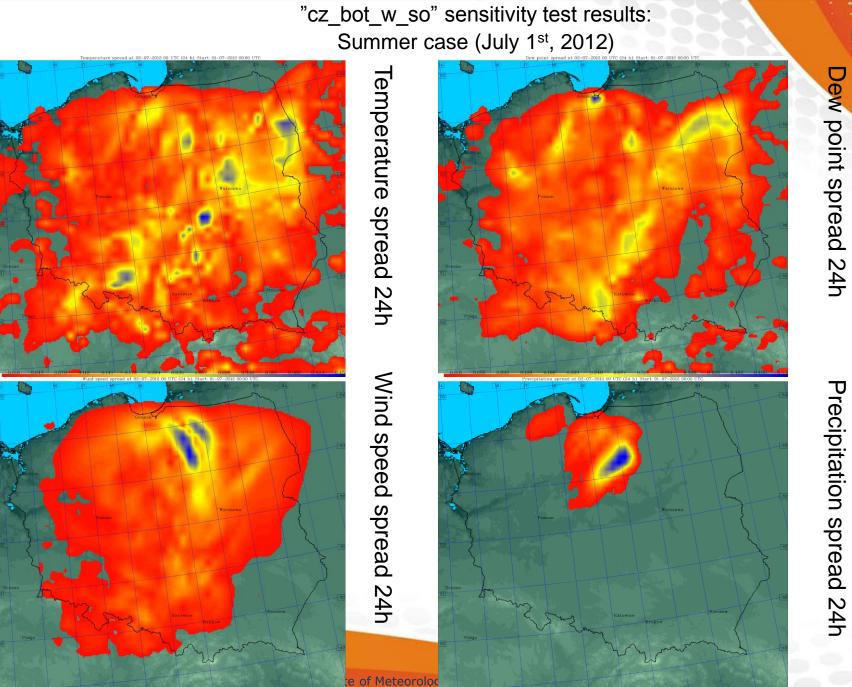


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Precipitation spread 24h

Dew point spread 24h

Extensive tests of lower-boundary-variation-based COSMO EPS. "cz_bot_w_so" sensitivity test results: Winter case (February 22nd, 2009) Temperature spread 24h Dew point spread 24h Wind speed spread 24h Precipitation spread 24h e of Meteorolog



Precipitation spread 24h

Extensive tests of lower-boundary-variation-based COSMO EPS.



CONCLUSIONS FROM SENSITIVITY TESTS

- Changes of "czbot_w_so" had a noteworthy impact on values of "deep soil" parameters, but an influence on values of lower-atmosphere parameters like air temperature, dew point, precipitation amount or wind speed is relatively small. Moreover, this parameter has an integer form (level index) rather than floating point, so it is not very useful for preparation of an ensemble.
- On the contrary, changes of "c_soil" have a noteworthy impact on values of air temperature at 2m agl., dew point temperature and relative humidity at 2m agl., wind speed and direction at 10m agl. and surface specific humidity.

So:

- "c_soil" is (potentially) much better candidate for "ensemble base"
- it is possible to prepare a representative ensemble using two methods:
 - Random setting a one value of c_soil/czbot_w_so globally, uniformly for the entire domain.
 Easier to perform (all that's required is change(s) in namelist), since there is no need for modification of source code.
 - 2. An alternative approach to modify source code to (randomly) modify values of c_soil/czbot_w_so from gridpoint to gridpoint over the domain.

Next slides: example of results of 2nd approach.

Extensive tests of lower-boundary-variation-based COSMO EPS. "c_soil" random changes, test results: Winter case (February 22nd, 2009) "C_Soil"-EPS evolution Date: 2009-02-22, 12:00 UTC Dew point temperature "C_Soil"-EPS evolution Minimum Mean Median Maximum Reference Minimum Date: 2009-02-22, 12:00 UTC Dew point temperature Mean Median Maximum Reference e₩ Station: Leba Station: Warszawa point at point temperature [degC] Leba 21 12 15 24 12 15 18 21 24 Forecast hour Forecast hour Dew point at Minimum Mean Median Maximum Reference "C_Soil"-EPS evolution Date: 2009-02-22, 12:00 UTC Minimum Mean Median Maximum Reference "C_Soil"-EPS evolution)ew Date: 2009-02-22, 12:00 UTC Dew point temperature Dew point temperature Station: Poznan Station: Zakopane point at Poznań [degC][degC] r point temperature [--11.3 12 21 12 15 18 21 Forecast hour Forecast hour rology ar

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Extensive tests of lower-boundary-variation-based COSMO EPS.

CHANGED PARAMETERIZATION OF SOIL PROCESSES

Dickenson's description of flux water through the soil:

$$F_{m} = \rho_{m} \left(1 + 1550 \frac{D_{\min}}{D_{\max}} \frac{B - 3.7 + \frac{5}{B}}{B + 5} \right) 1.02 D_{\max} s_{u}^{B+2} \left(\frac{s_{t}}{s_{u}} \right)^{\left\{5.5 + 0.8B \left[1 + 0.1(B - 4) \log \frac{K_{0}}{K_{R}}\right]\right\}} \frac{s_{t}}{\sqrt{z_{u} z_{t}}} = \frac{s_{t}}{\sqrt{z_{u} z_{t}}}$$

with B and K_0 - soil-type-related parameters, K_R , D_{min} and D_{max} - constants, ρ_m , is fraction of saturated soil filled by water; $s_{u,t}$ - soil water content (s_u in the uppermost layer, s_t in the total active layer).

Dickenson's parameterization – replaced by Darcy equation with various modifications:

$$F_{m} = \exp\left(\frac{T}{T_{0}}\right)^{a} \cdot \rho_{m} \left(1 + 1550 \frac{D_{\min}}{D_{\max}} \frac{B - 3.7 + \frac{5}{B}}{B + 5}\right) 1.02 D_{\max} s_{u}^{B + 2} \left(\frac{s_{t}}{s_{u}}\right)^{\left\{5.5 + 0.8B\left[1 + 0.1(B - 4)\log\frac{K_{0}}{K_{R}}\right]\right\}} \frac{s_{t}}{\sqrt{z_{u}z_{t}}}$$

$$F_{m} = -D(\theta)\nabla\theta \qquad \longrightarrow \qquad F_{m} = -D(\theta)\exp\left(\frac{T}{T_{0}}\right)^{a}\nabla\theta$$

Next slides: examples of results of combining this parameterization with COTEKINO EPS

Extensive tests of lower-boundary-variation-based COSMO EPS. "c_soil" random changes + altered parameterization: Summer case (July 1st, 2012) "C_Soil"—EPS evolution Date: 2012—07—01, 00:00 UTC Dew point temperature Station: Warszawa "C_Soil"-EPS evolution Minimum Mean Median Maximum Reference Minimum Date: 2012-07-01, 00:00 UTC Dew point temperature Mean Median Maximum Reference e₩ Station: Leba point at Warsaw point at [degc] 20.5 Leba tu 17.5 21 12 15 24 24 Forecast hour Forecast hour Dew point at "C_Soil"-EPS evolution Date: 2012-07-01, 00:00 UTC Dew point temperature Minimum Mean Median Maximum Reference "C_Soil"-EPS evolution Date: 2012-07-01, 00:00 UTC Minimum Mean Median)ew Dew point temperature Maximum Reference Station: Poznan Station: Zakopane point at Poznań [Jeg 20.5 | [Jegg] 18.0 Zakopane tu 14.0 12 21 12 15 18 21 Forecast hour Forecast hour rology ar

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Forecast hour

18

21

24

Forecast hour "C_Soil"-EPS evolution Date: 2012-07-01, 00:00 UTC Windspeed Station: Poznan Windspeed [m/s] 12 15 18 21 24 Forecast hour rology ar

Windspeed [m/s]

Extensive tests of lower-boundary-variation-based COSMO EPS.

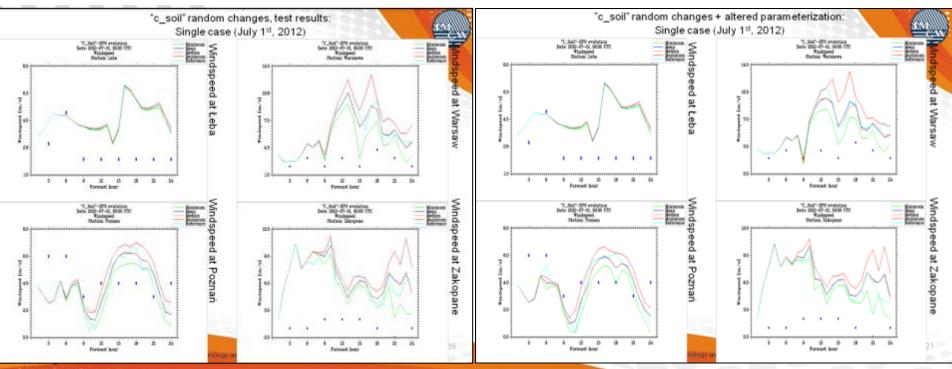
CONCLUSIONS AND PLANS



- Perturbations have almost insignificant influence in locations with small land fraction...
- ... and during cold season due to soil conditions (frozen ground?)
- Detailed analysis (seasonal/annual) necessary!

From standard analysis of forecasts vs. observations at stations:

- Just like in case of deterministic run, change of soil parameterization slightly improved forecasts and ensemble "composition"
- Improvement is stronger in central and southern part of Poland than close to the sea



CONCLUSIONS AND PLANS (cntd.)



To-do list:

- 1. Season or annual ("continuous") run of EPS, detailed comparison with observation (spring-summer, fall-winter) in progress!!! ©
- 2. Semi-operational implementation (parallel to deterministic runs)
- 3. Perturbations of soil temperature combined with altered parameterization of soil processes.
- 4. Relation between amplitude of perturbation and type of a soil?



Thank you for attention



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