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/set-ups – 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

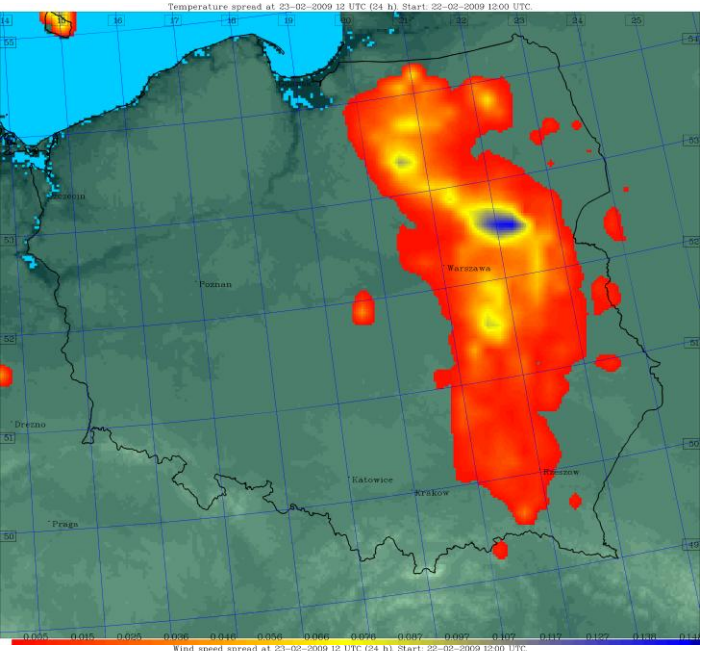
• Changes of other parameters have insignificant impact on (any) values.

Conclusions:

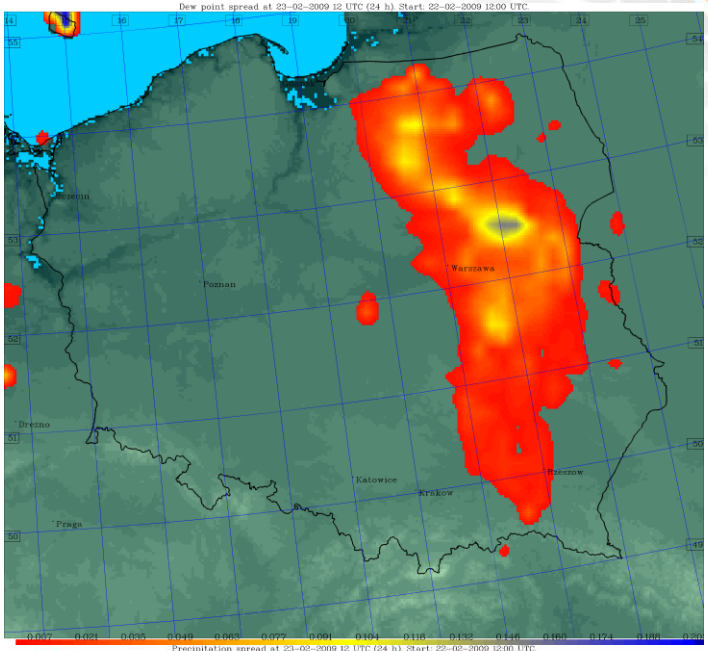
- Due to the (convection-permitting) scale of problem and space resolution of model domain shallow convection scheme – a basic one for tests.
- Numerical setup – 3-order standard Runge-Kutta scheme.
- All eleven test cases were used to study an impact of variability of “c_soil”/“czbot_w_so” (within their 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.

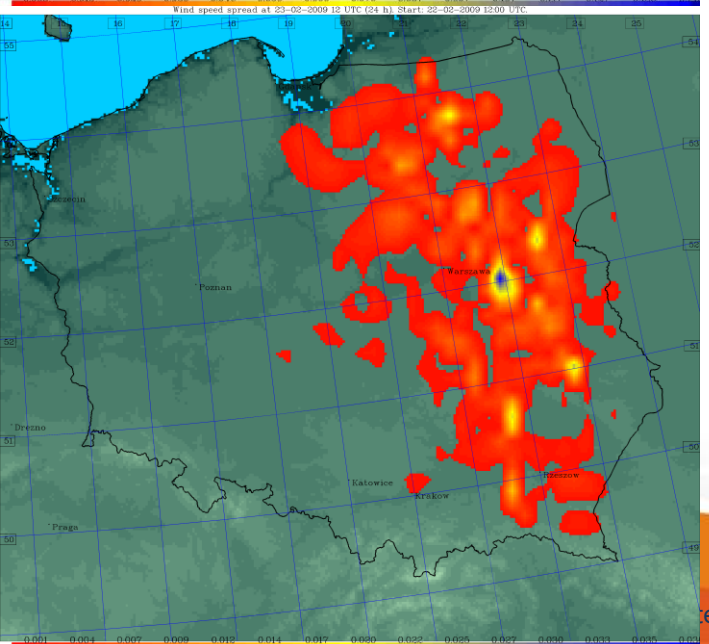
”c_soil” sensitivity test results:
Winter case (February 22nd, 2009)



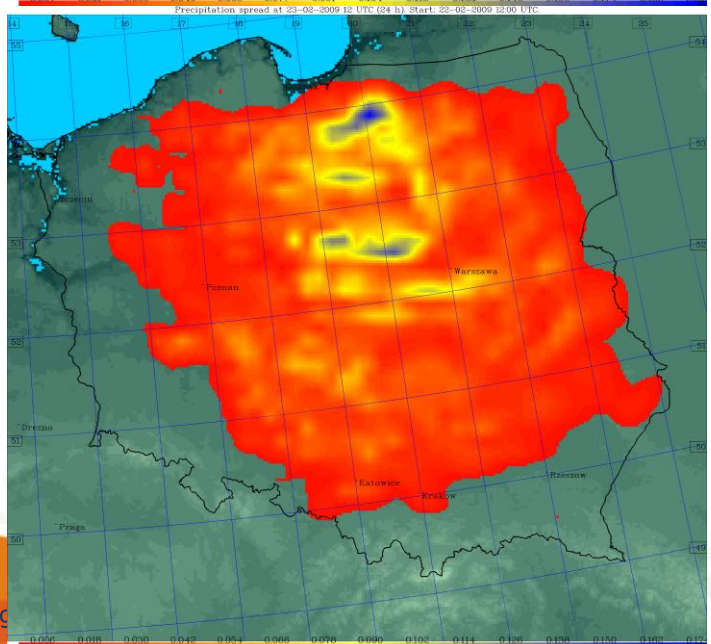
Temperature spread 24h



Dew point spread 24h



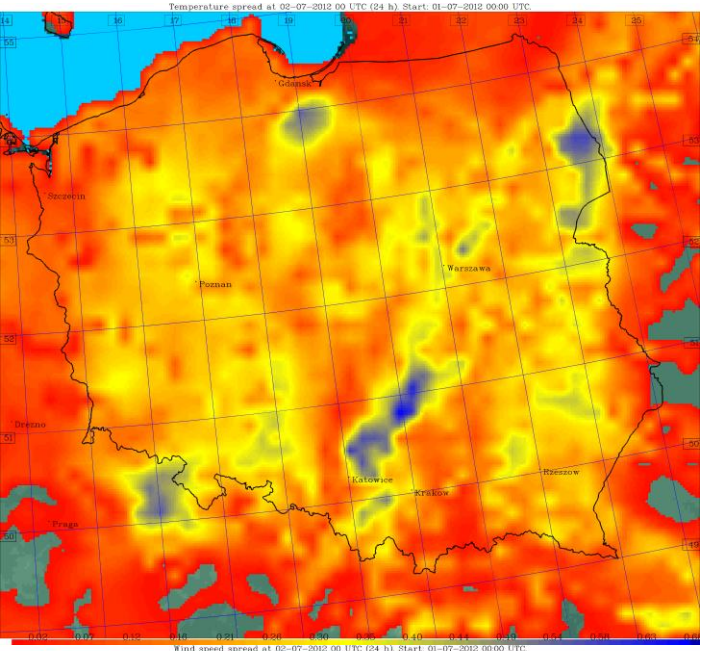
Wind speed spread 24h



Precipitation spread 24h

”c_soil” sensitivity test results:
Summer case (July 1st, 2012)

Temperature spread 24h



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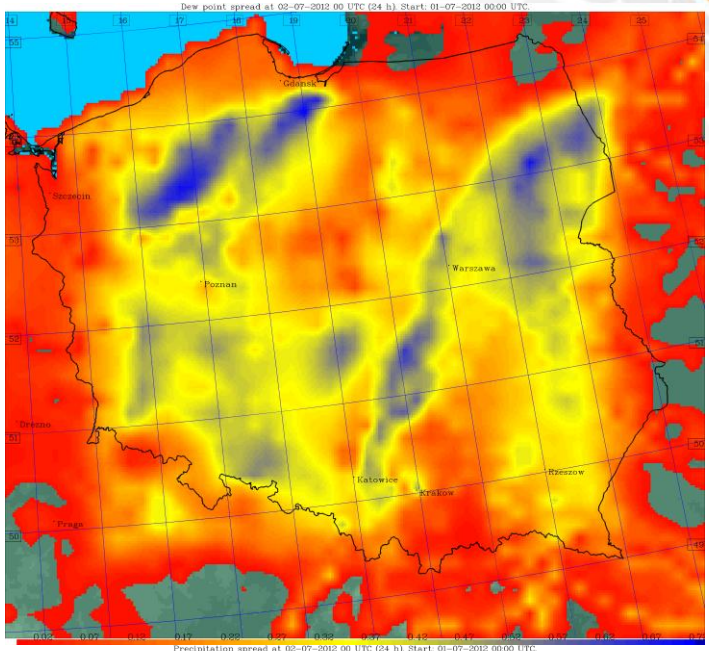

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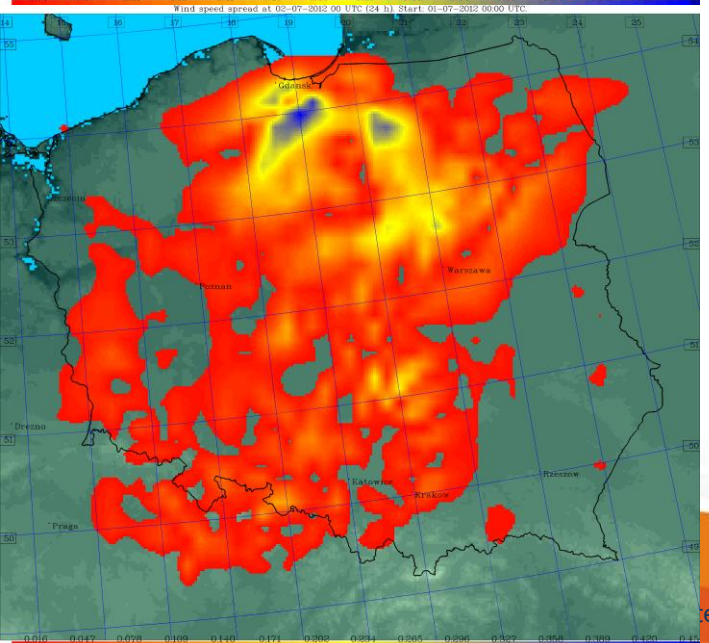
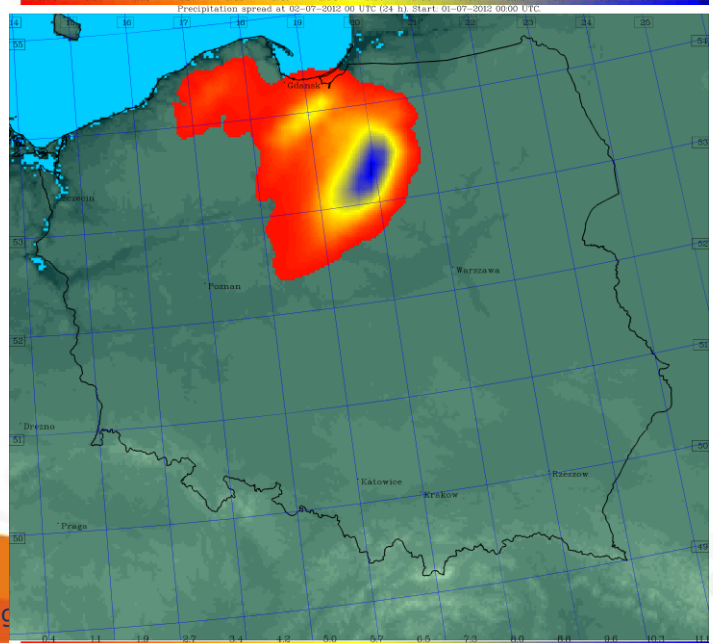


Precipitation spread 24h



”cz_bot_w_so” sensitivity test results: Winter case (February 22nd, 2009)

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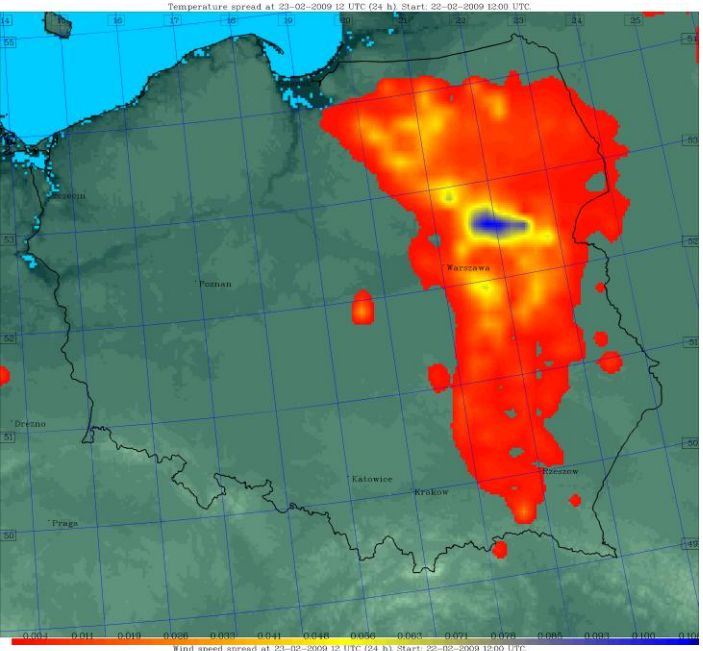

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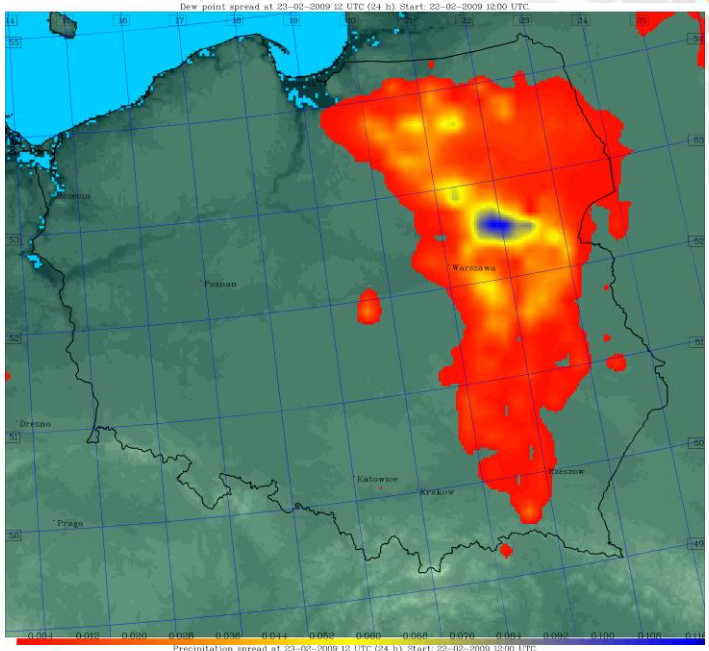

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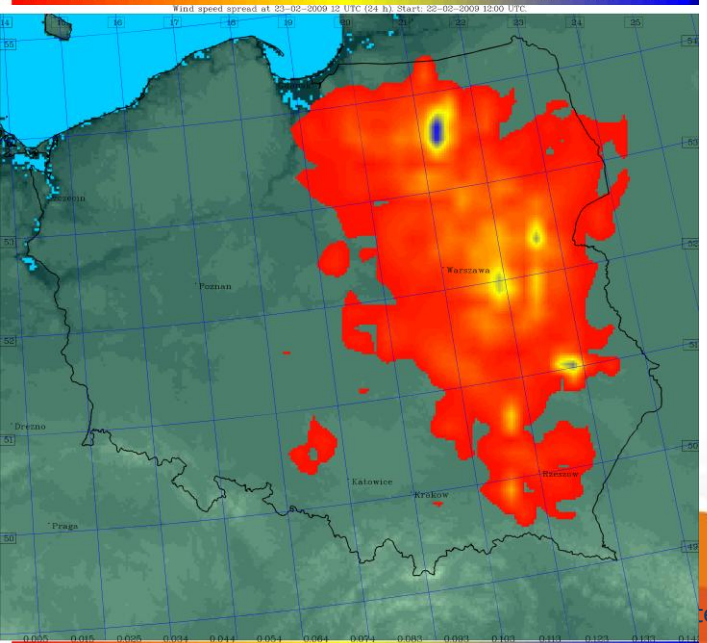
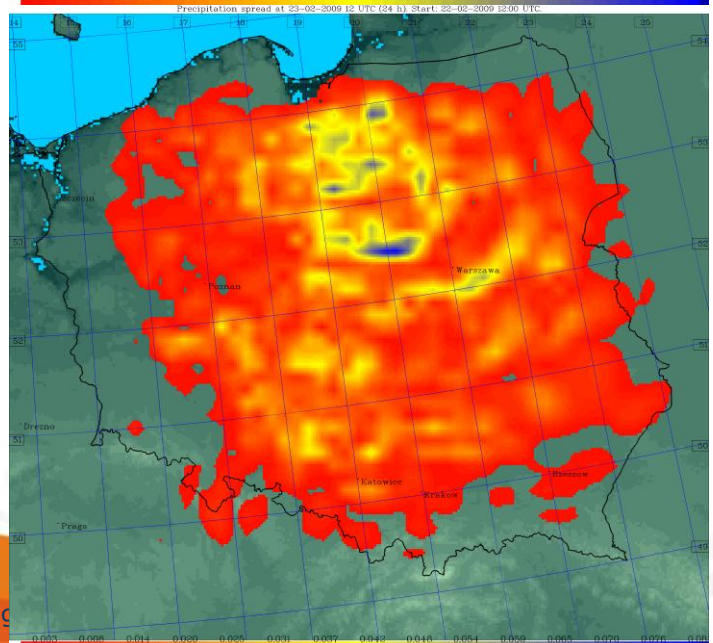


Precipitation spread 24h



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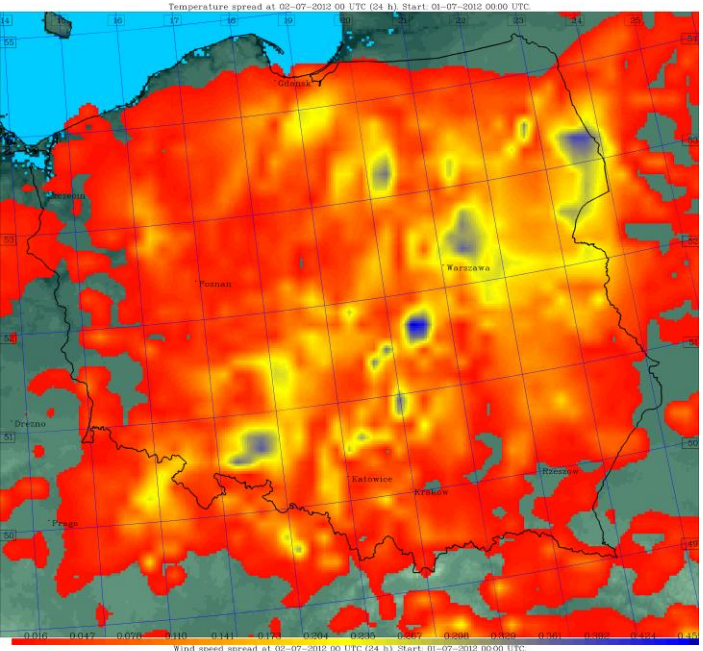

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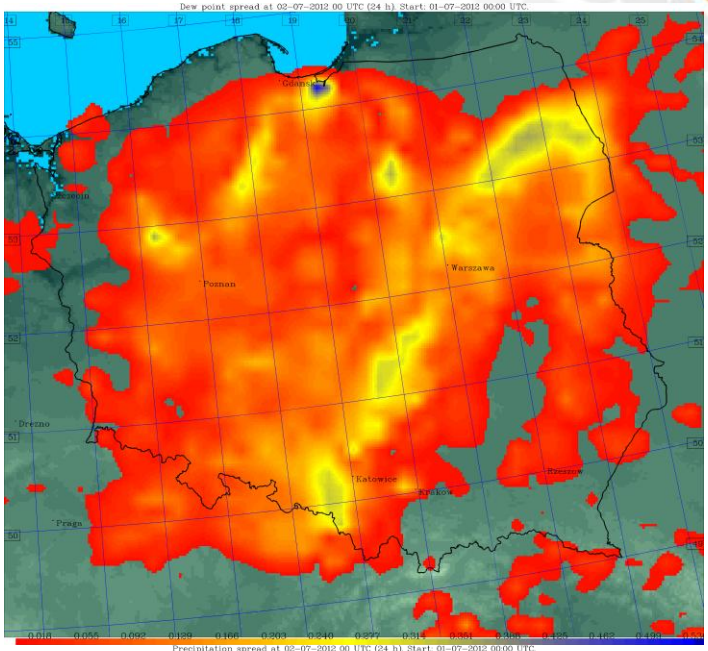

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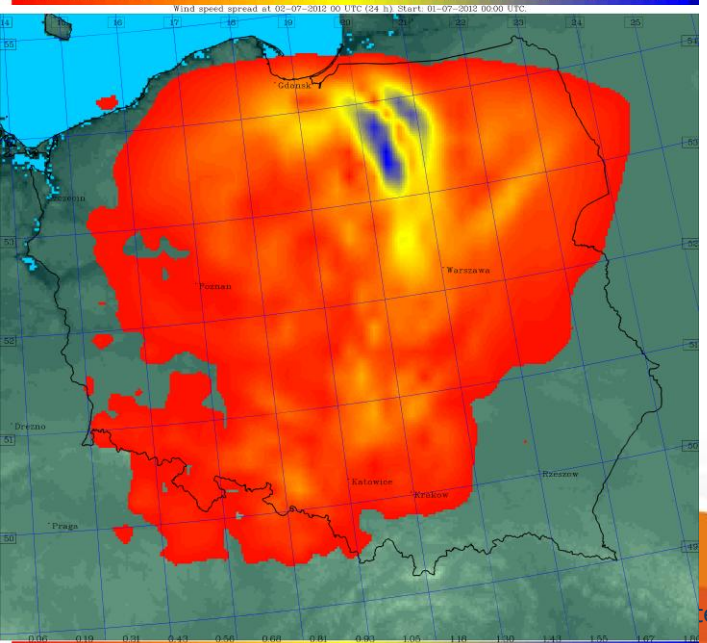
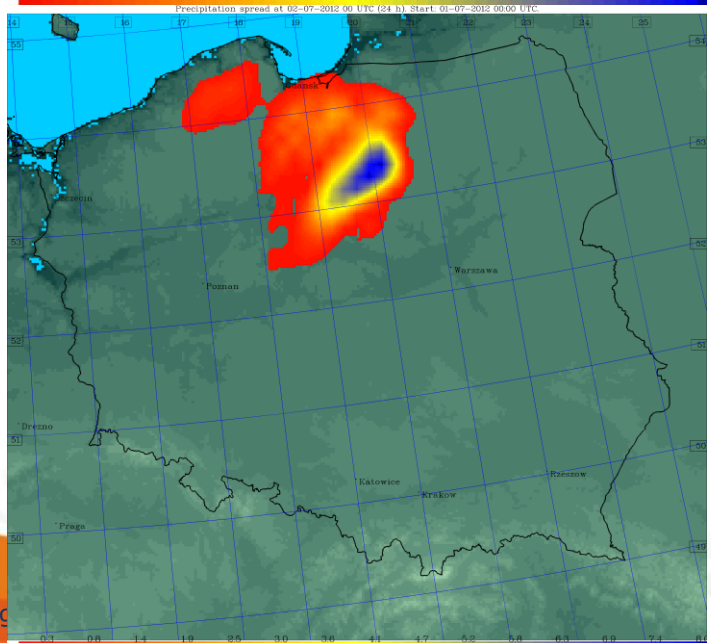


Wind speed spread 24h



Precipitation spread 24h

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.

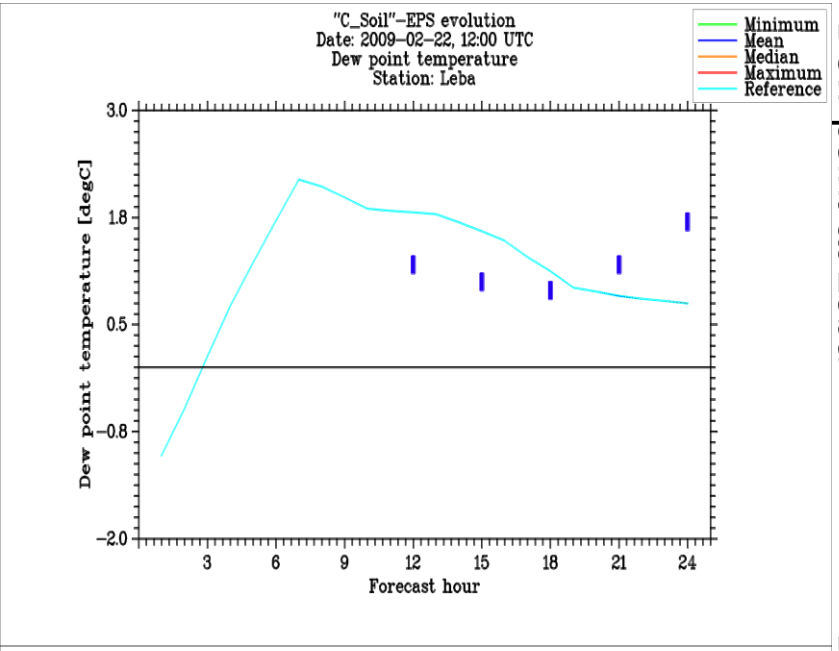
So:

- ”c_soil” is (potentially) much better candidate for ”ensemble base”

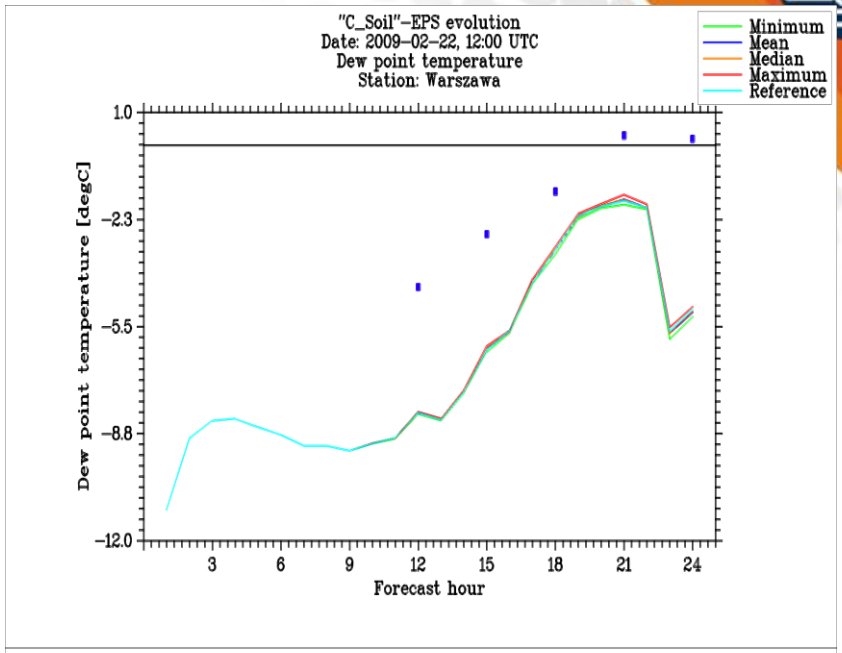
- it is possible to prepare a representative ensemble using two methods:
  1. Random setting a one value of c_soil/czbot_w_so globally, uniformly for the entire domain. Easier to perform (all that’s required is change(s) in namelist), since there is no need for modification of source code.
  2. An alternative 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.

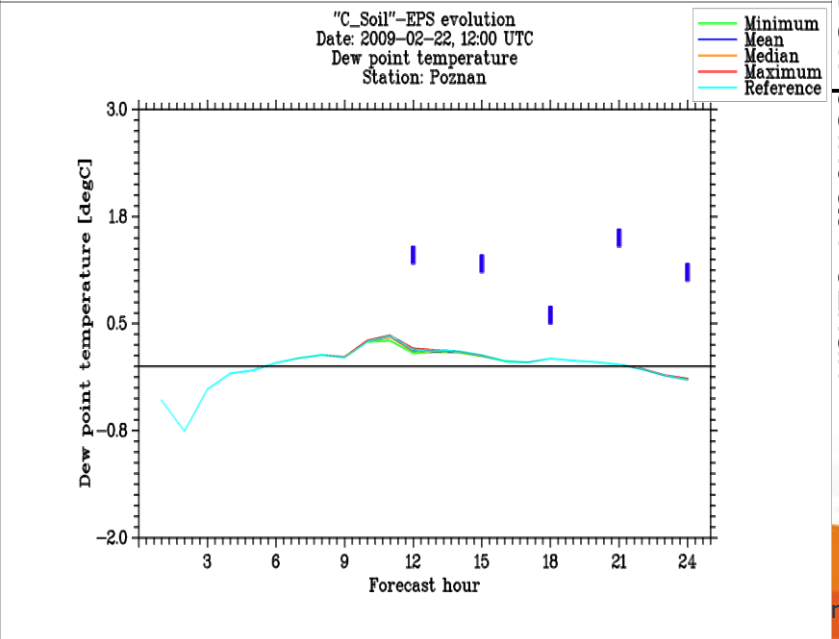
”c_soil” random changes, test results: Winter case (February 22nd, 2009)



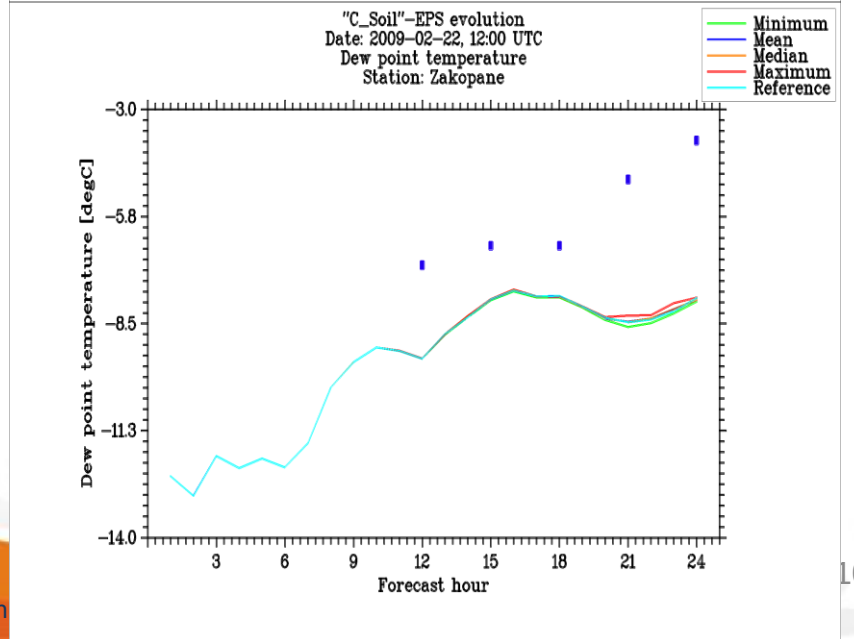
Dew point at Łeba



Dew point at Warsaw

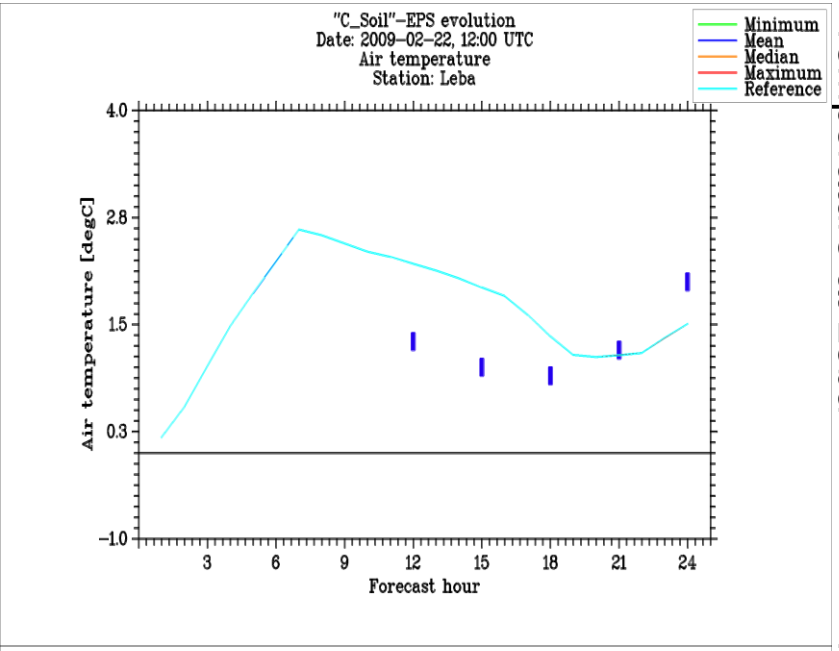


Dew point at Poznań

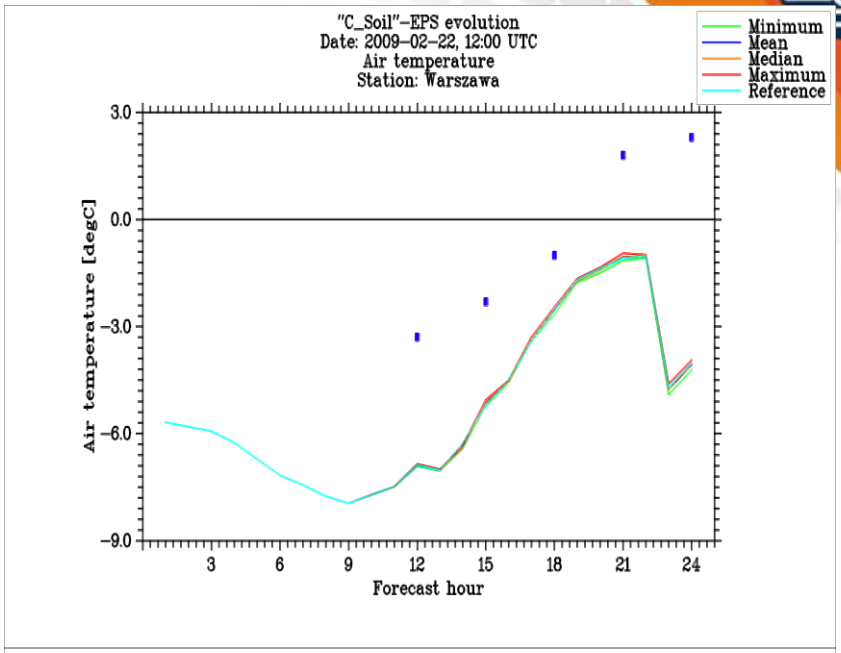


Dew point at Zakopane

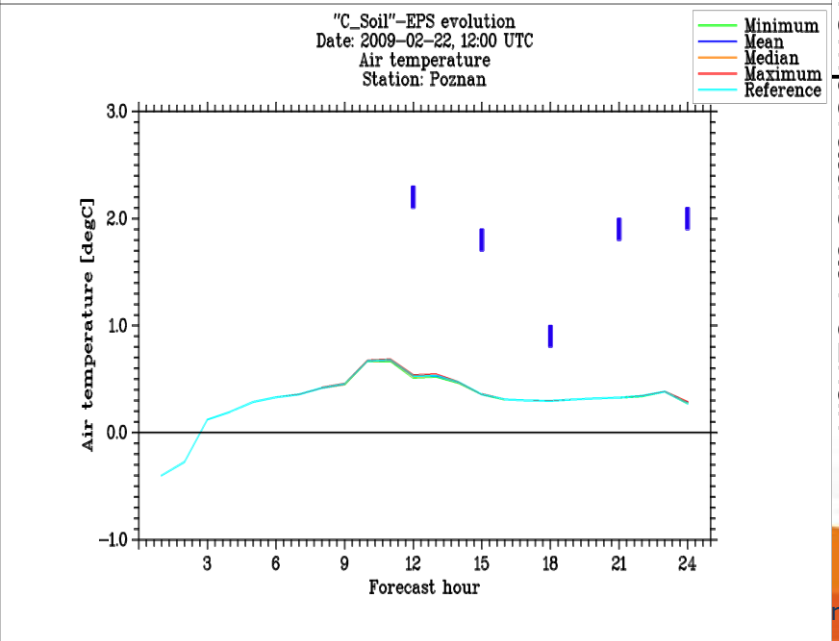
”c_soil” random changes, test results: Winter case (February 22nd, 2009)



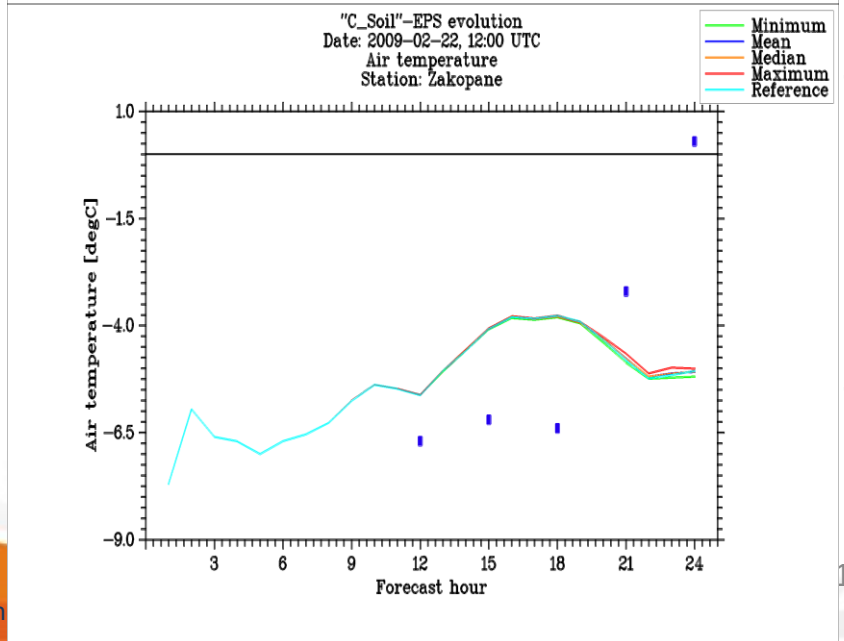
Temperature at Łeba



Temperature at Warsaw



Temperature at Poznań



Temperature at Zakopane

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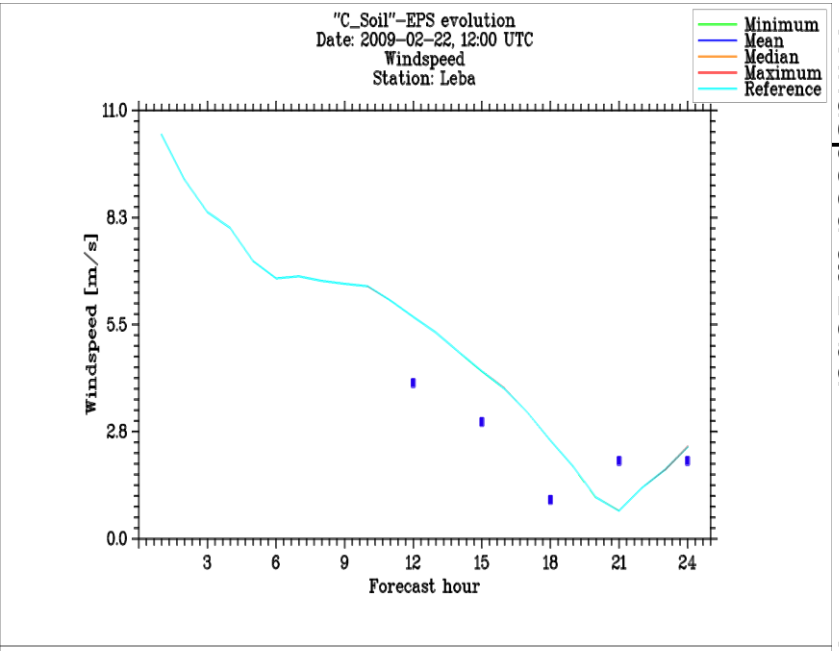
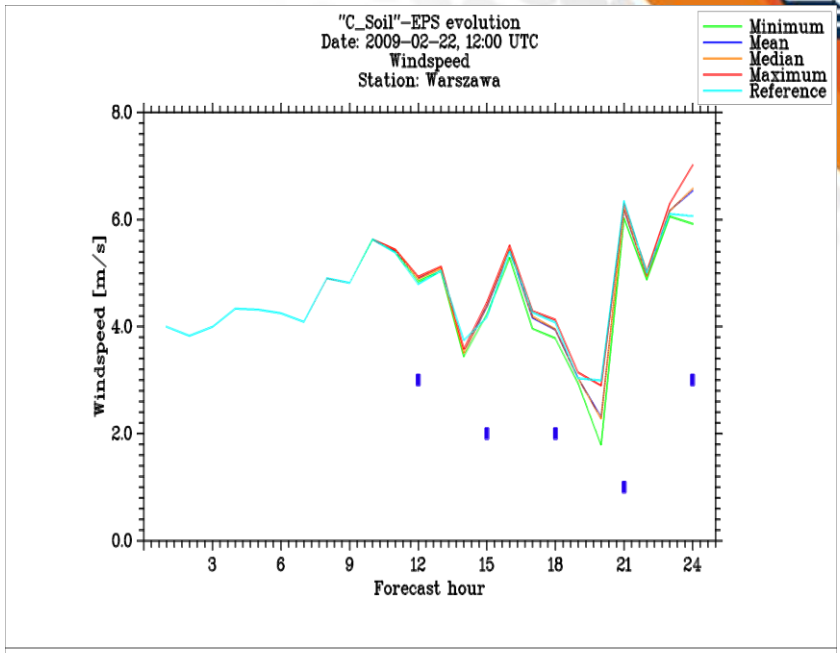
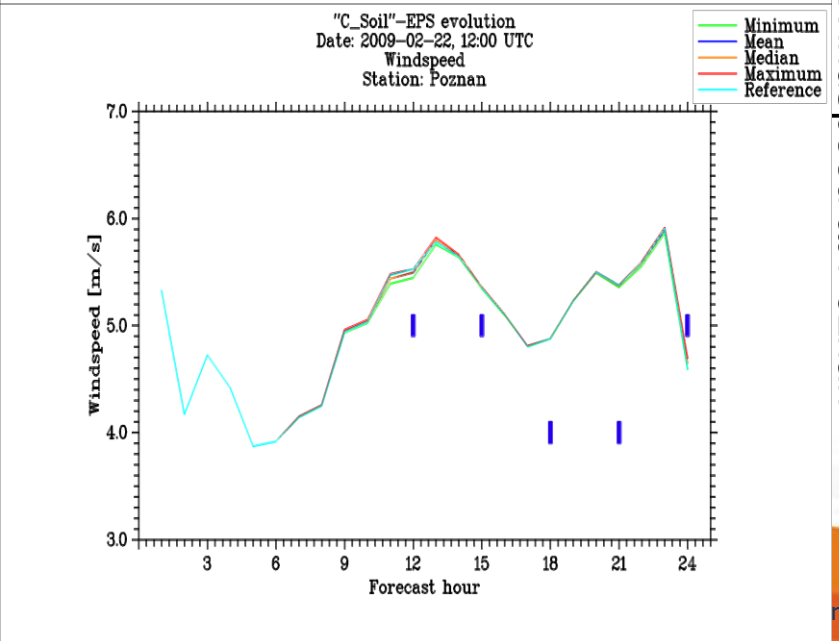


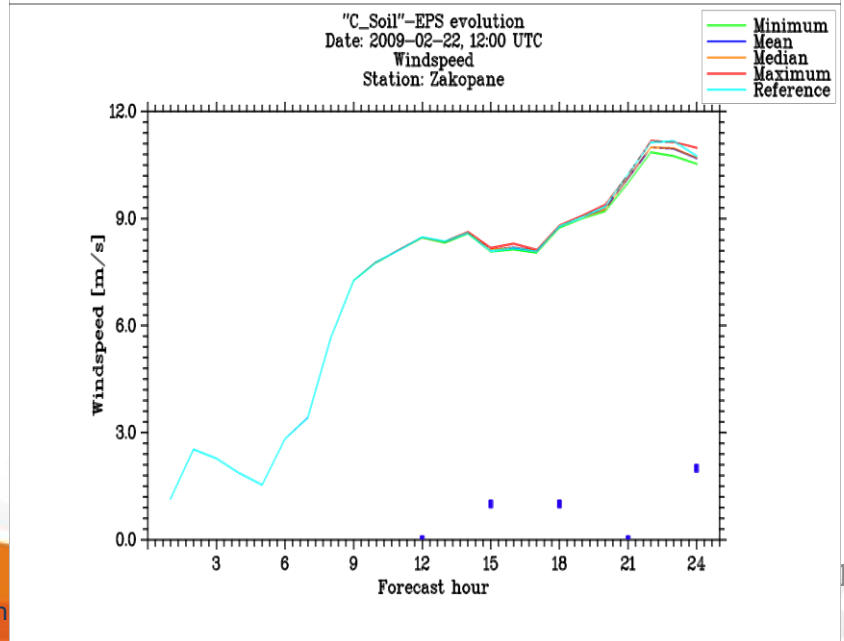
Windspeed at Łeba



Windspeed at Warsaw

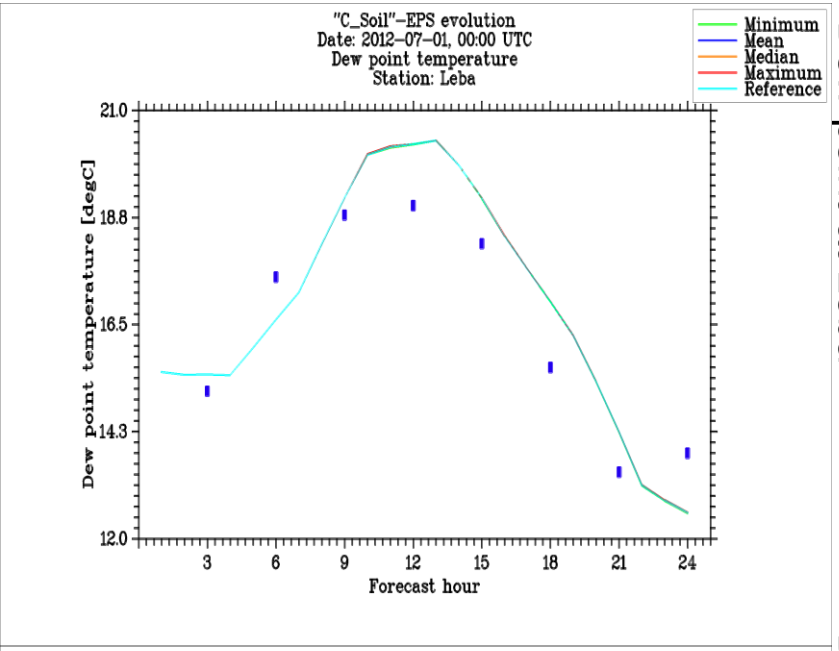


Windspeed at Poznań

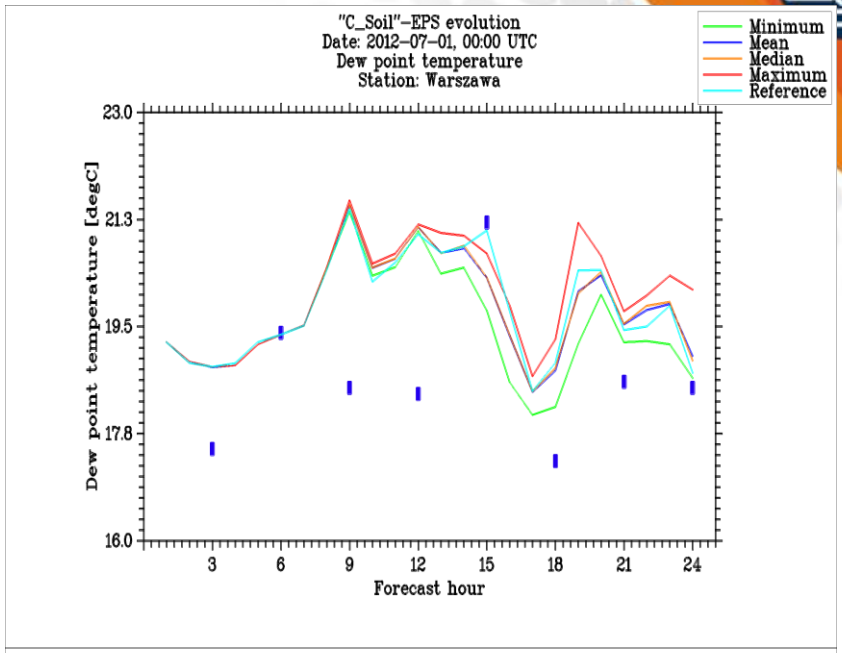


Windspeed at Zakopane

”c_soil” random changes, test results:
Summer case (July 1st, 2012)



Dew point at Łeba



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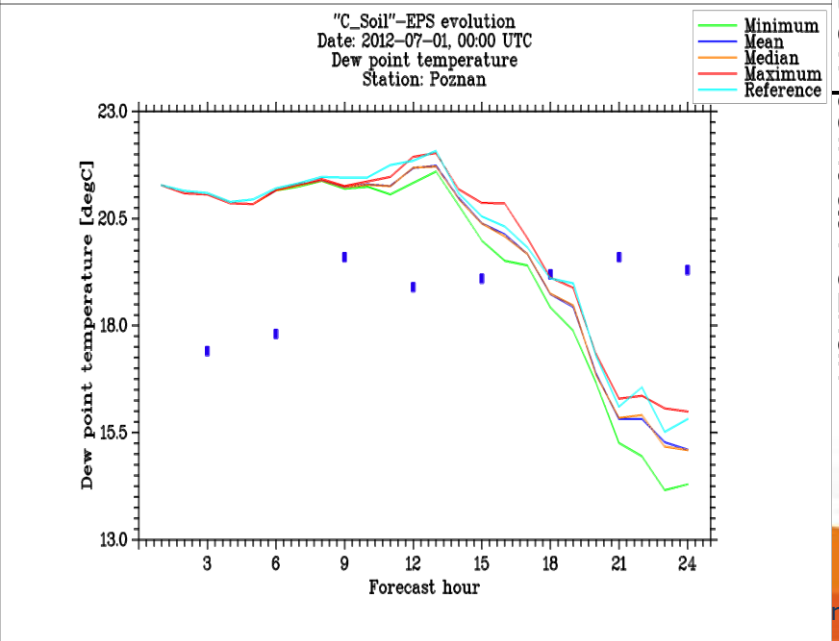

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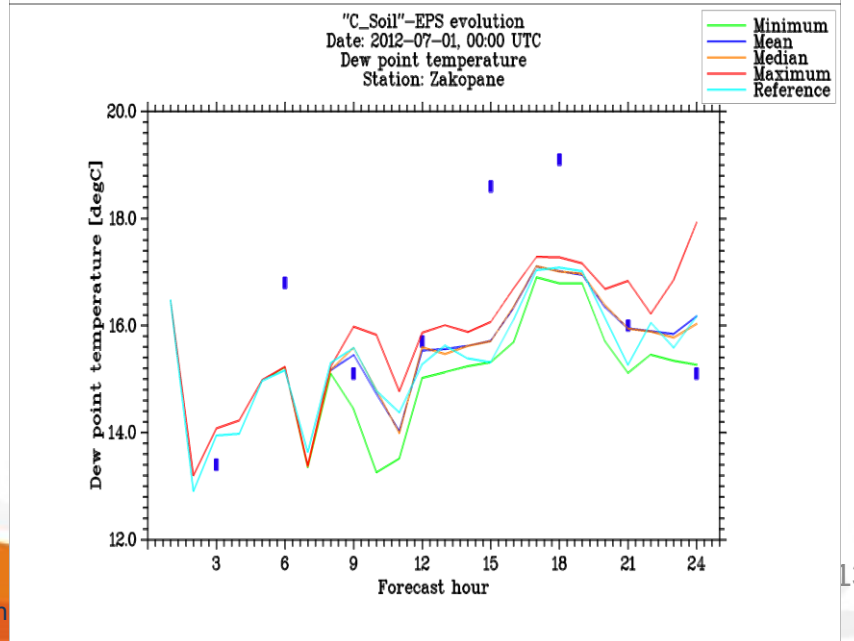

Dew point at Zakopane

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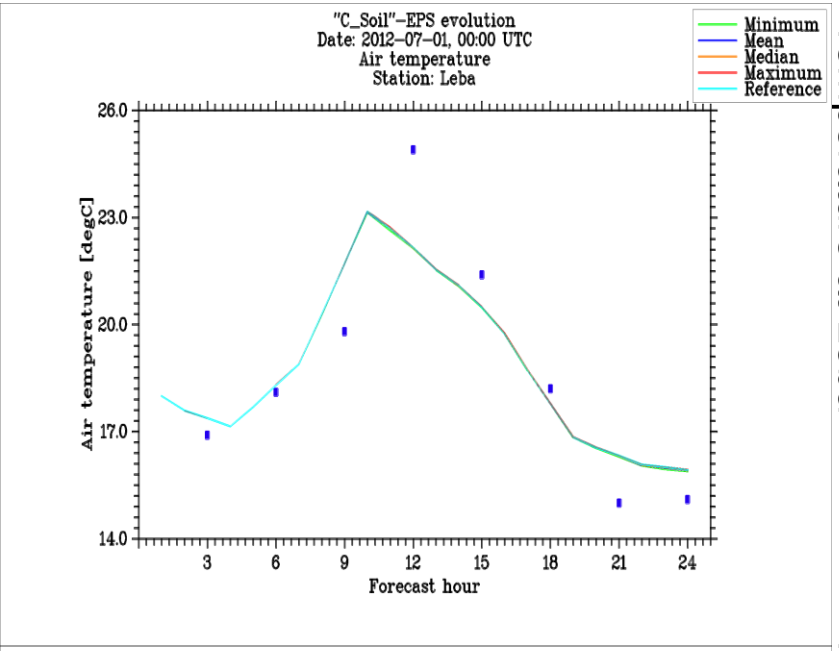
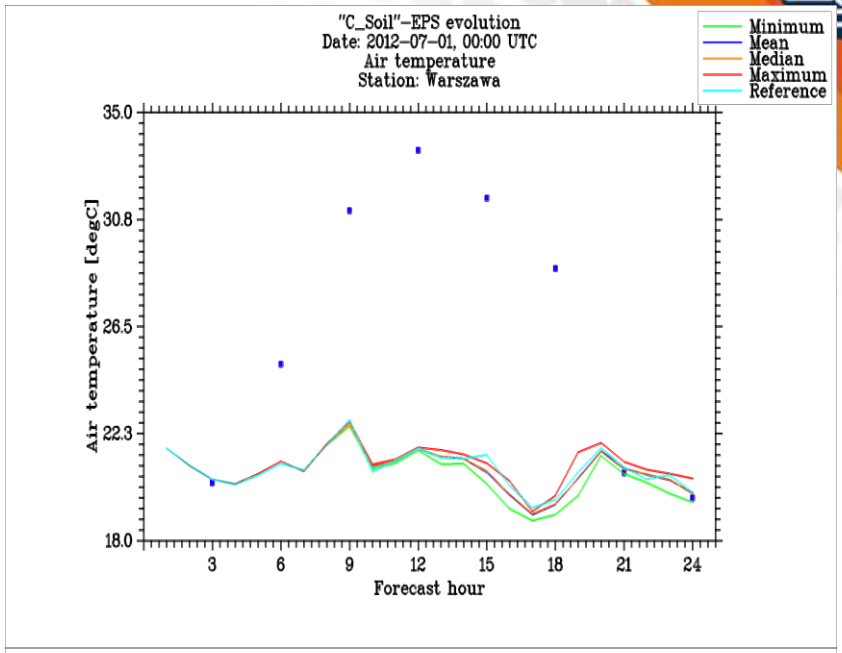
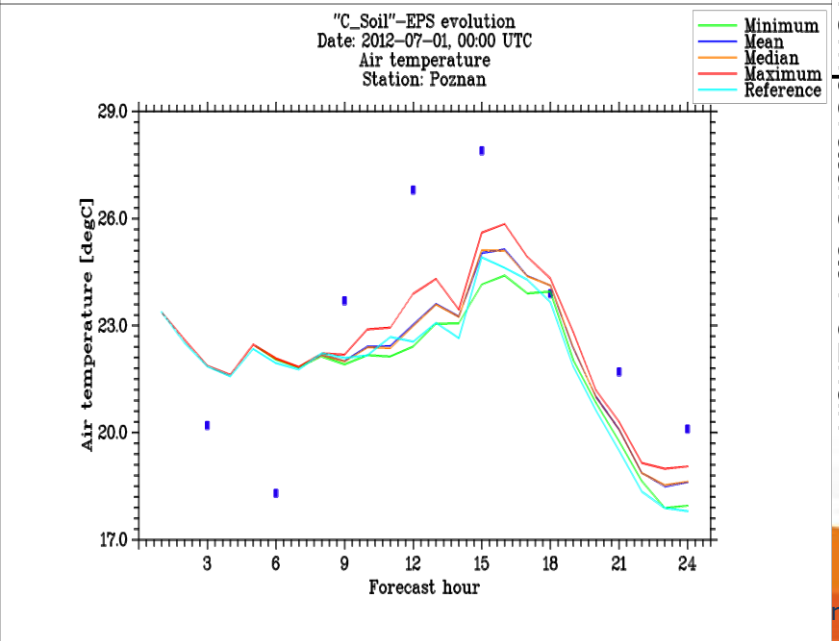
Summer case (July 1st, 2012)



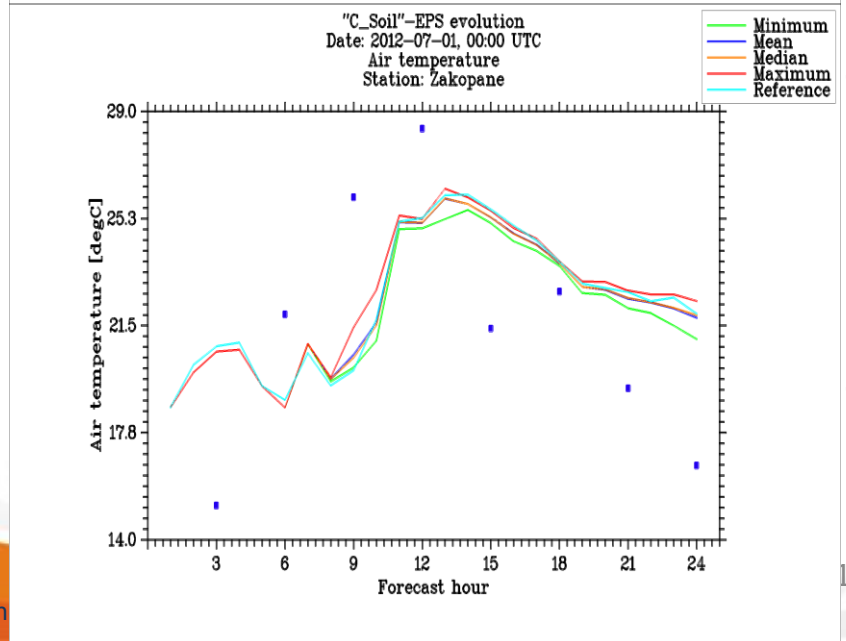
Temperature at Łeba



Temperature at Warsaw



Temperature at Poznań



Temperature at Zakopane

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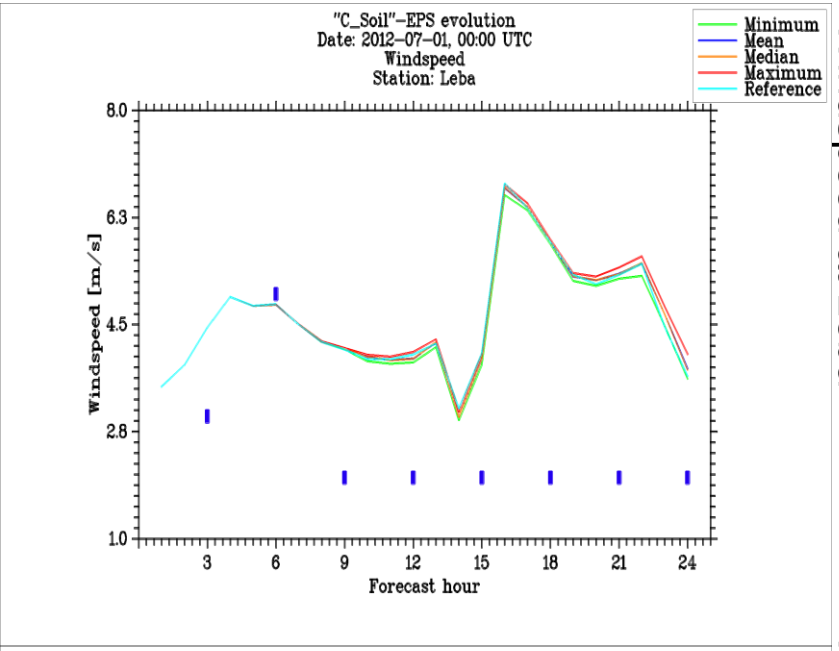
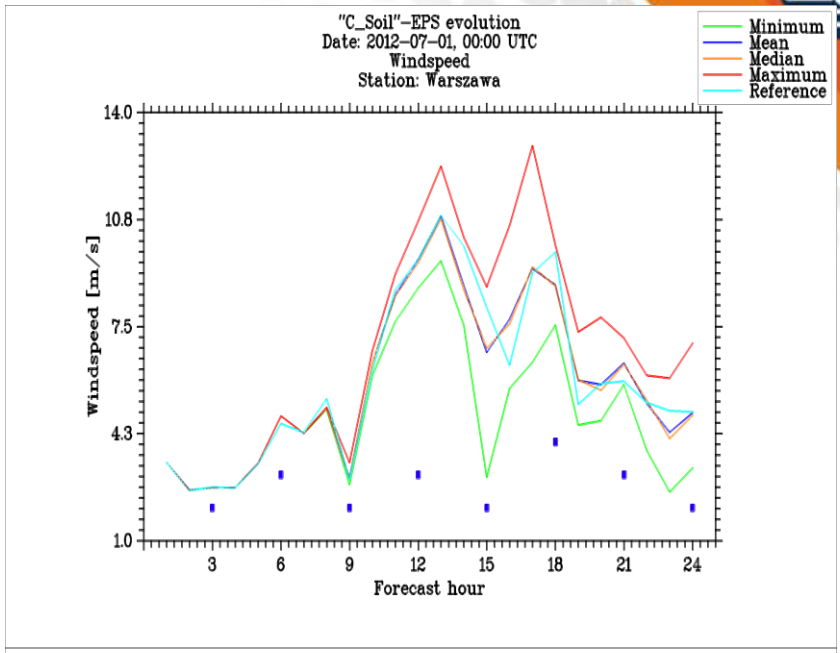
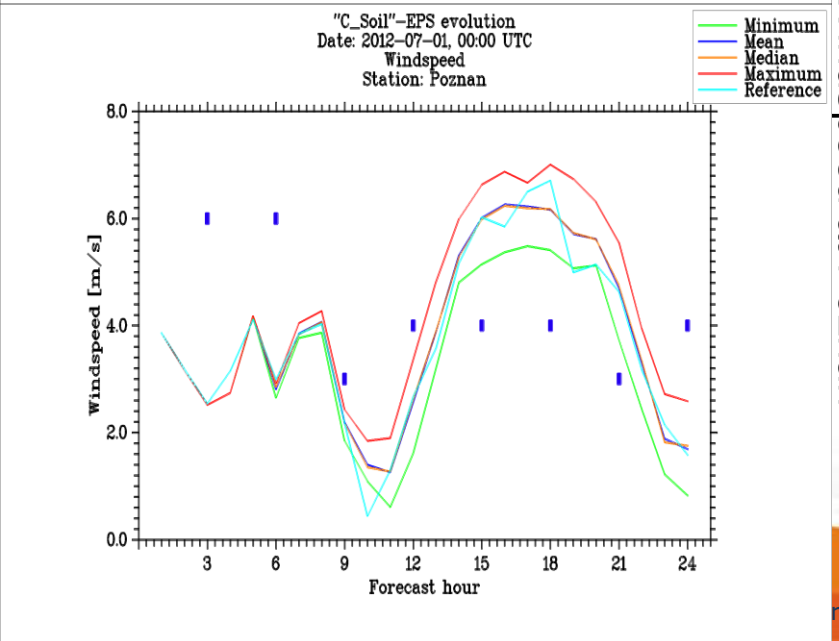
Summer case (July 1st, 2012)



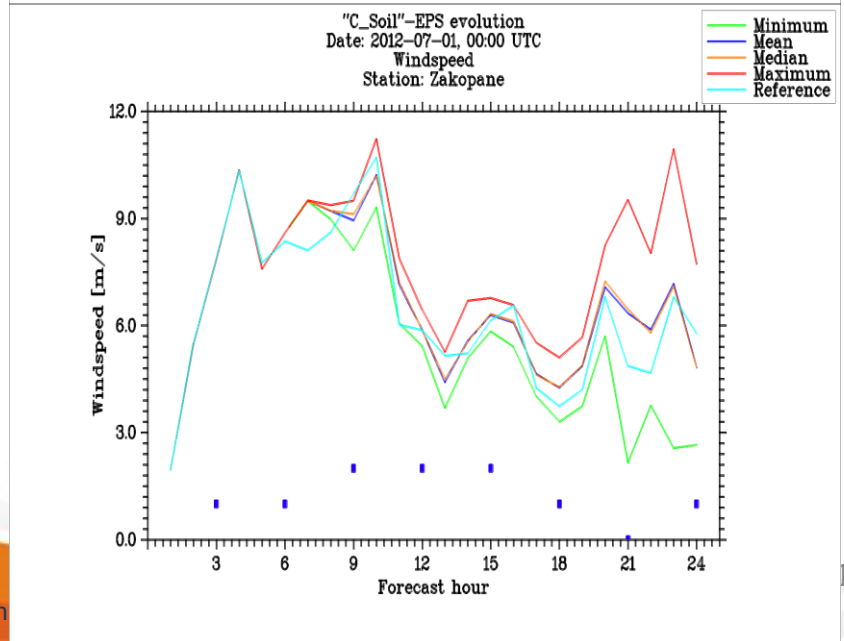
Windspeed at Łeba



Windspeed at Warsaw



Windspeed at Poznań



Windspeed at Zakopane

CHANGED PARAMETERIZATION OF SOIL PROCESSES

Dickenson's description of flux water through the soil:

$$F_m = \rho_m \left(1 + 1550 \frac{D_{\min}}{D_{\max}} \frac{B - 3{,}7 + \frac{5}{B}}{B+5} \right) 1{,}02 D_{\max} s_u^{B+2} \left(\frac{s_t}{s_u} \right)^{\left\{ 5{,}5+0{,}8B\left[1+0{,}1(B-4)\log\frac{K_0}{K_R} \right] \right\}} \frac{s_t}{\sqrt{z_u z_t}}$$

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).

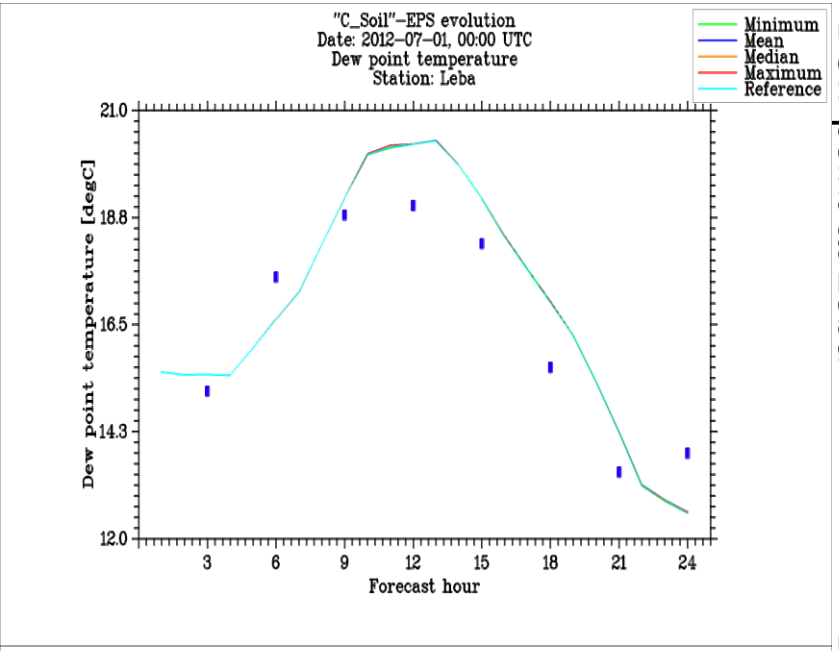
Dickenson's parameterization – replaced by Darcy equation with various modifications:

$$F_m = \exp\left(\frac{T}{T_0} \right)^a \cdot \rho_m \left(1 + 1550 \frac{D_{\min}}{D_{\max}} \frac{B - 3{,}7 + \frac{5}{B}}{B+5} \right) 1{,}02 D_{\max} s_u^{B+2} \left(\frac{s_t}{s_u} \right)^{\left\{ 5{,}5+0{,}8B\left[1+0{,}1(B-4)\log\frac{K_0}{K_R} \right] \right\}} \frac{s_t}{\sqrt{z_u z_t}}$$

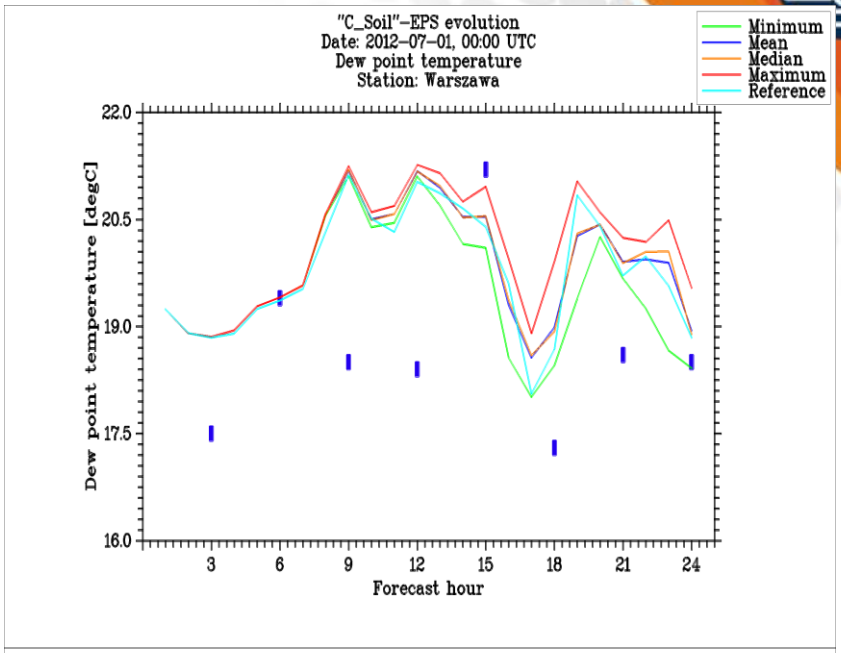
$$F_m = -D(\theta)\nabla\theta \longrightarrow F_m = -D(\theta)\exp\left(\frac{T}{T_0} \right)^a \nabla\theta$$

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

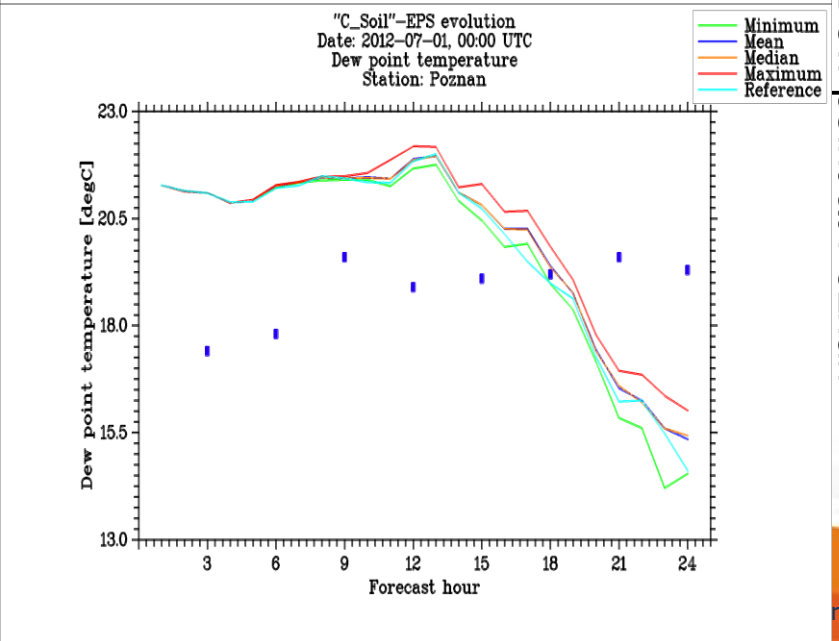
”c_soil” random changes + altered parameterization: Summer case (July 1st, 2012)



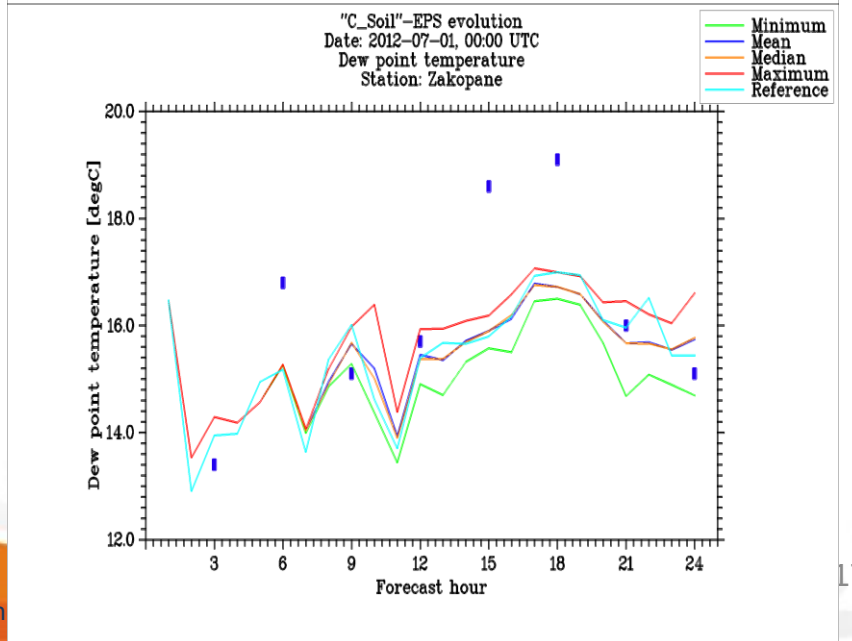
Dew point at Łeba



Dew point at Warsaw

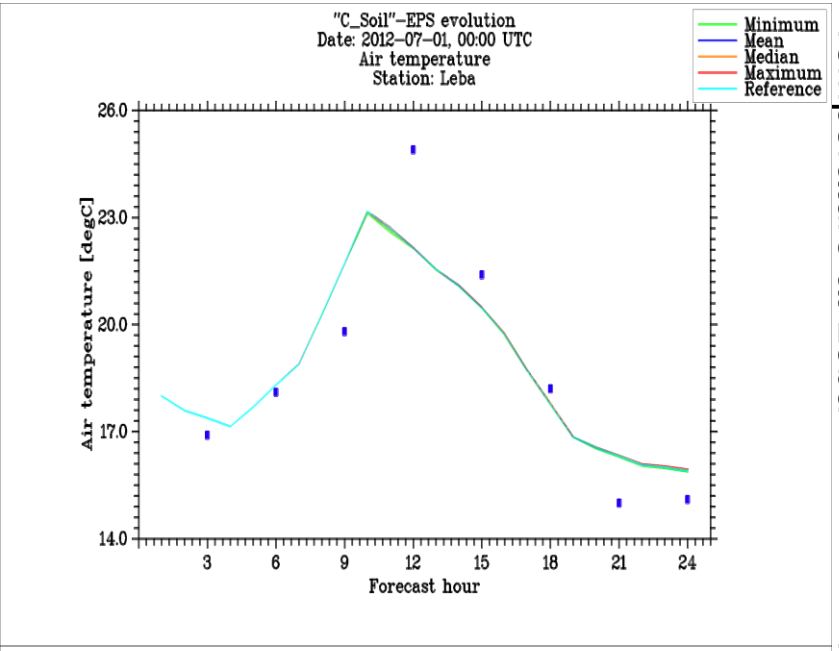


Dew point at Poznań

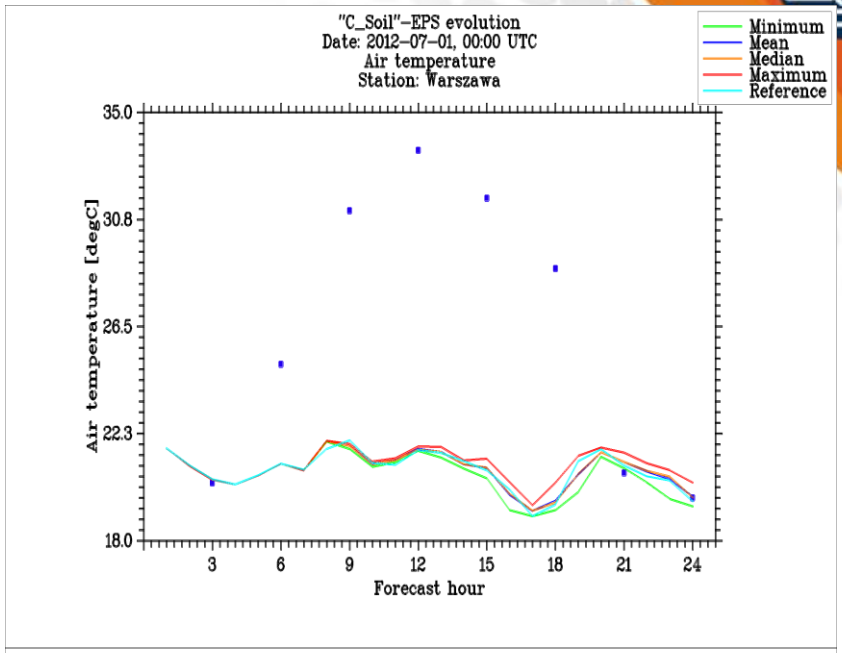


Dew point at Zakopane

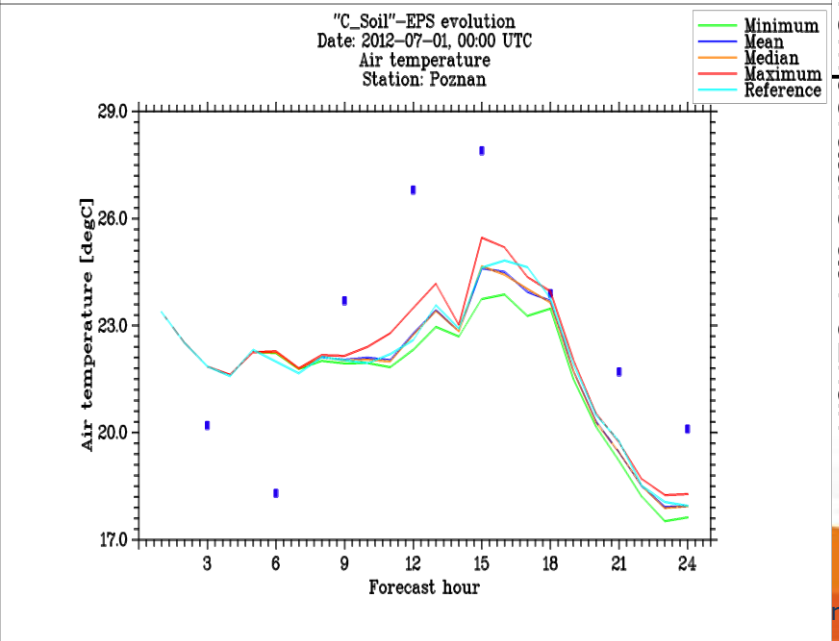
”c_soil” random changes + altered parameterization: Summer case (July 1st, 2012)



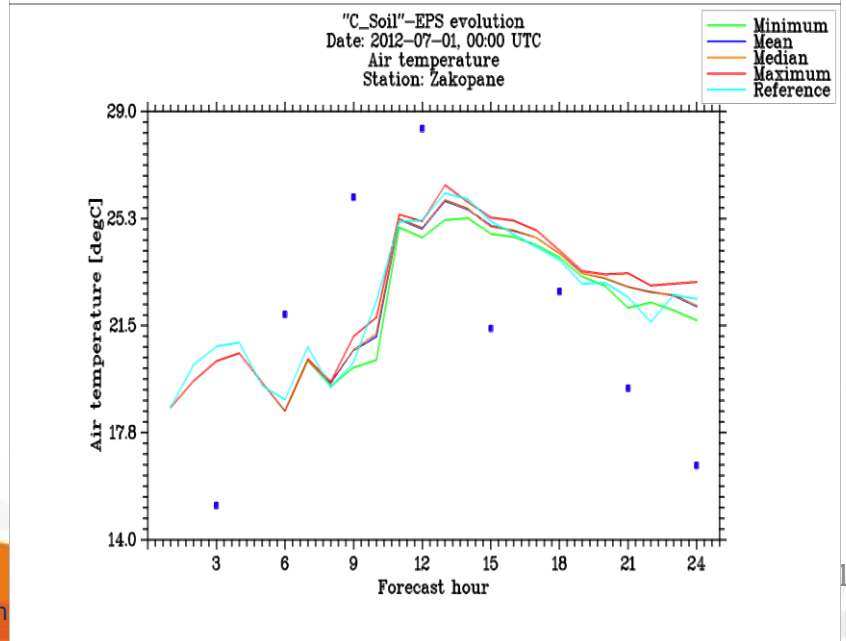
Temperature at Łeba



Temperature at Warsaw

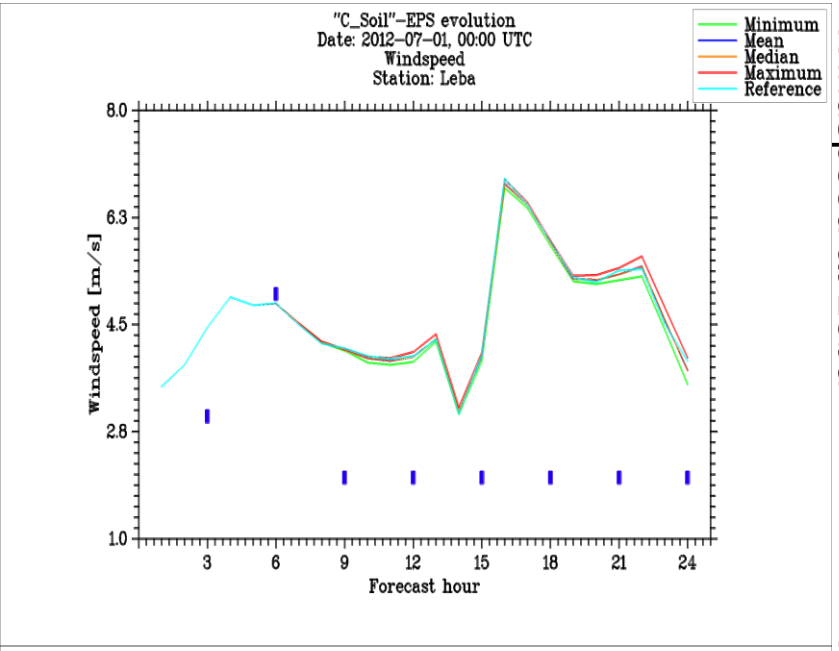


Temperature at Poznań

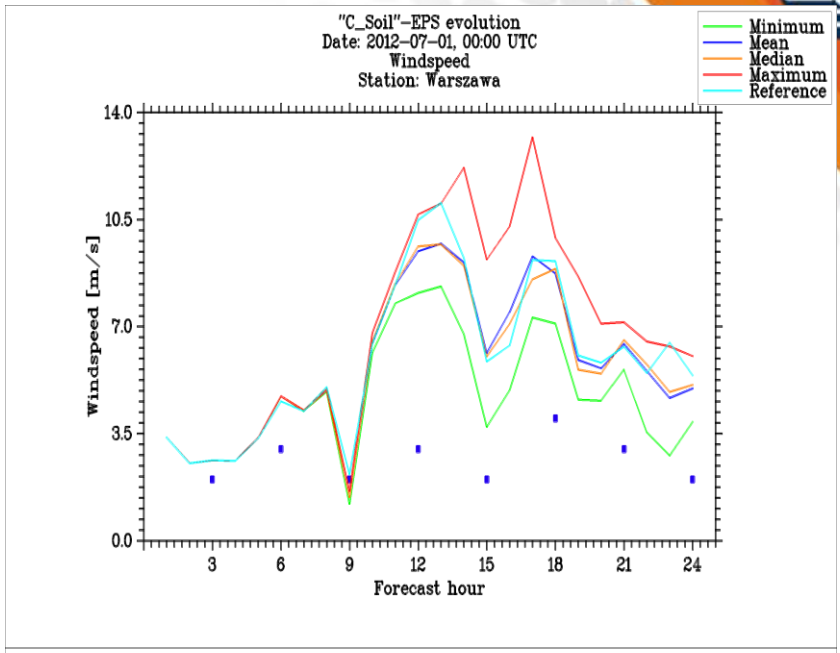


Temperature at Zakopane

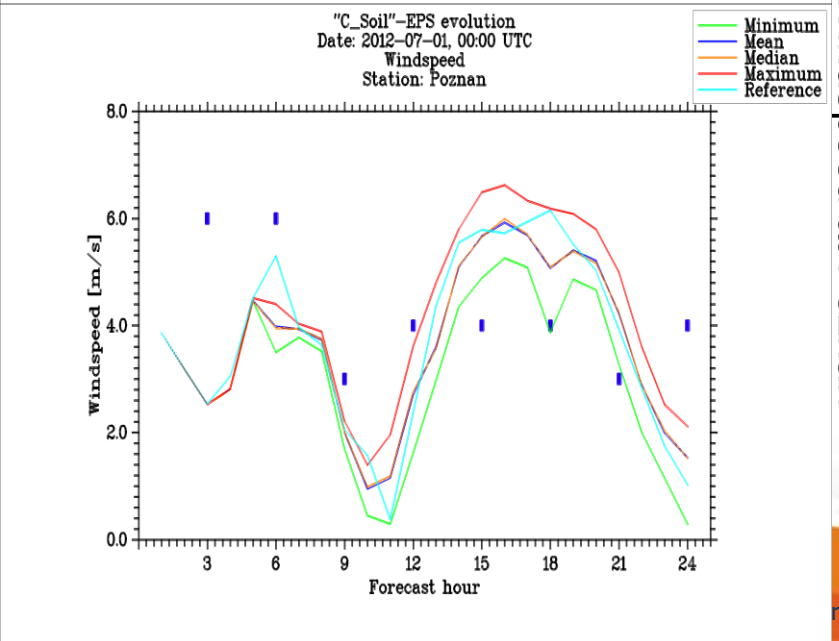
”c_soil” random changes + altered parameterization: Summer case (July 1st, 2012)



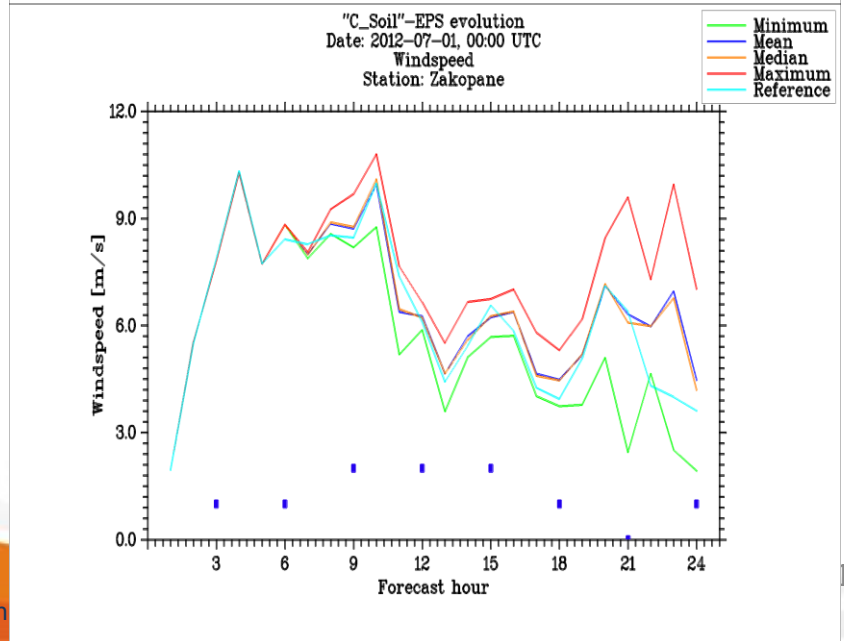
Windspeed at Łeba



Windspeed at Warsaw



Windspeed at Poznań



Windspeed at Zakopane

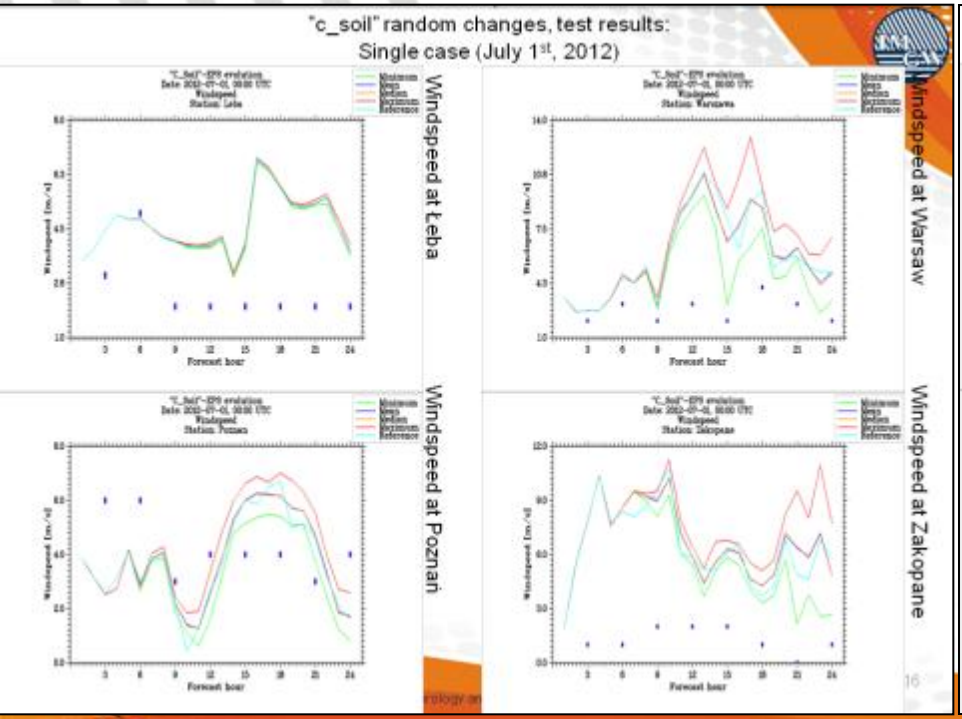
rology an

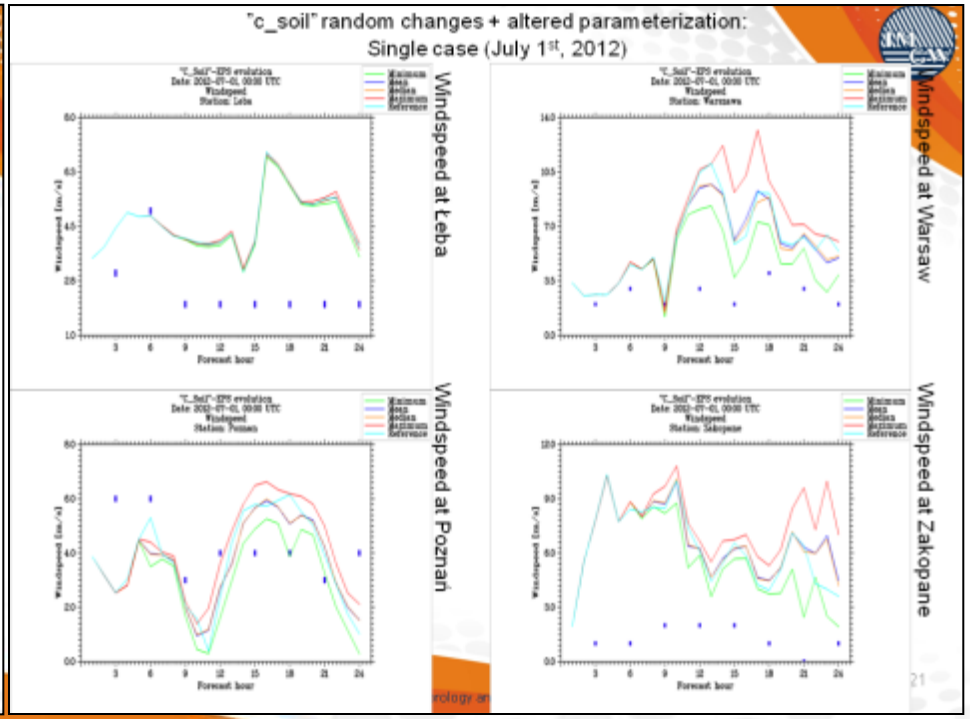
CONCLUSIONS AND PLANS

- 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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