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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# Contents

# INTRODUCTION

- Moist atmospheric processes are clearly sensitive to soil conditions. A simple method was proposed to assess a possibility to produce reasonable number of valid ensemble members, taking into consideration predefined soil parameters.
- During the first phase a predefined group of different model configurations/set-ups was tested providing the first selection of soil-related parameters which will be used in our further ensemble experiments.
- Further tests answered whether small perturbations of selected parameter(s) were strong enough to induce most significant changes in the forecast of the state of atmosphere, and to create a "proper" ensemble member.
- Detailed sensitivity test was carried out to establish an environment to assess validity of the selection of ensemble members in a quasi-operational mode. Eleven cases (selected synoptic situations) were run and results were evaluated during this phase.
- Finally, two methods of preparing a well-defined ensemble based on the soil parameters perturbation were evaluated for the purpose of (potential) operational work.

## RESULTS OF FIRST PHASE

- For selected model runs no significant differences (sensitivities) with changes of numerical schemes (HE-VI, RK1 and/or RK2).
- Changes of “czbot_w_so” (depth of bottom of last hydrological active soil layer) have a noteworthy impact on values of water and ice content down to 1458 cm below ground level.
- 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
- Changes of other parameters have insignificant impact on (any) values.

Hence:

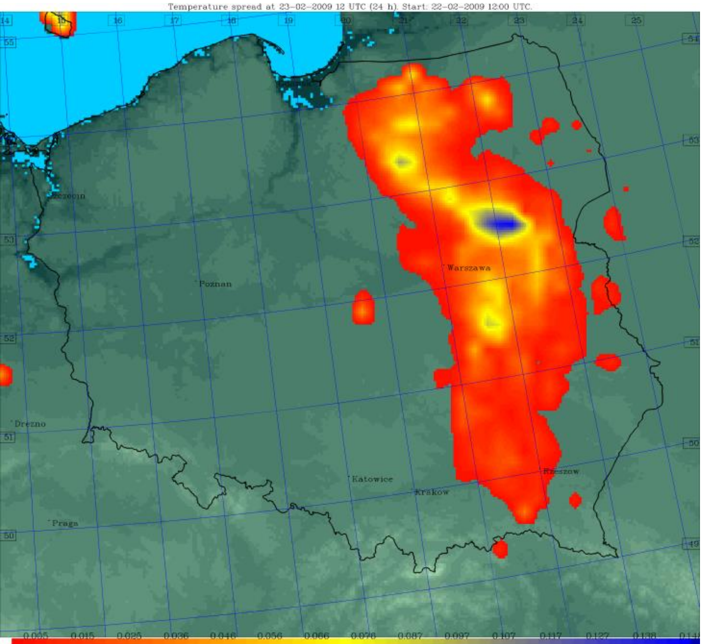
Due to the (convection-permitting) scale of problem and space resolution of model domain shallow convection scheme was accepted as basic for tests.

”Numerics” – 3-order standard Runge-Kutta scheme.

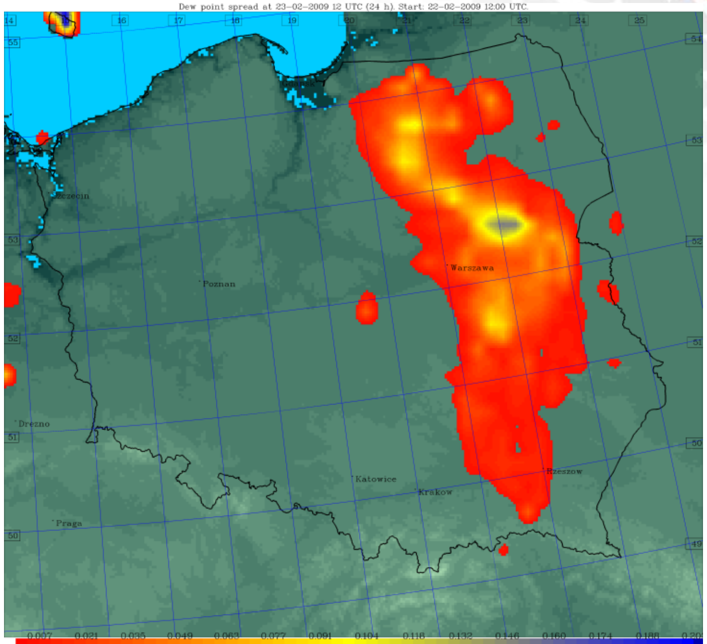
All eleven test cases were consequently used to study the variability of the “c_soil” parameter within the range from 0 to 2.0 with step of 0.1 and of “czbot_w_so” parameter, within the range of 0.0 to 5.0m with step of 0.25m.

*) c_soil - surface-area index of the evaporating fraction of gridpoints over land, related to c_lnd - surface-area index of gridpoints over land.

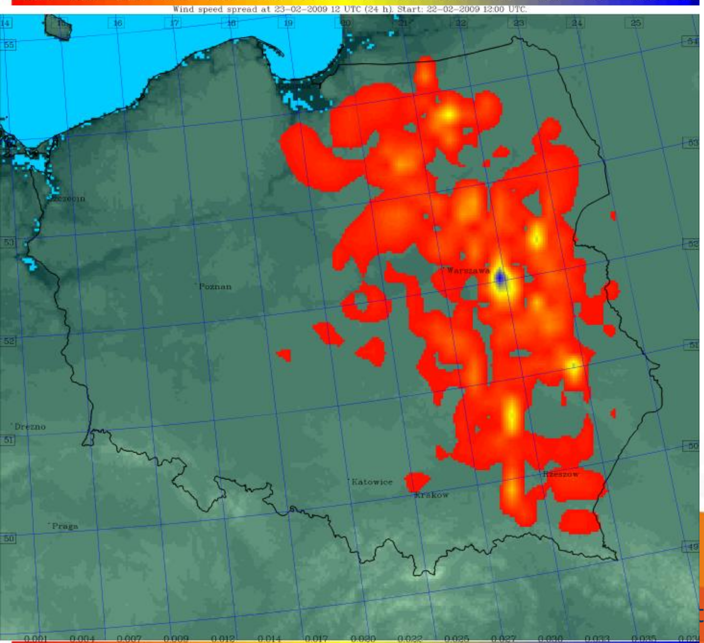
# "c_soil" sensitivity test results:
# Winter case (February 22$^{nd}$, 2009)



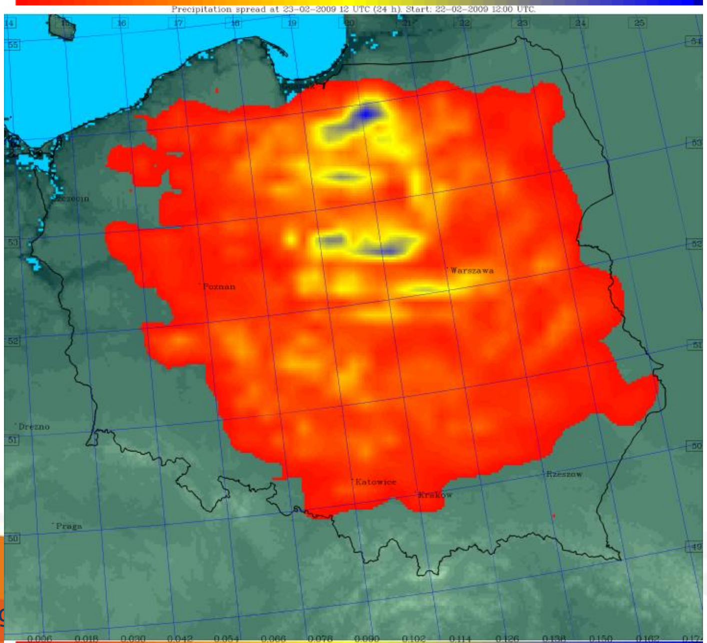

Temperature spread 24h




Dew point spread 24h

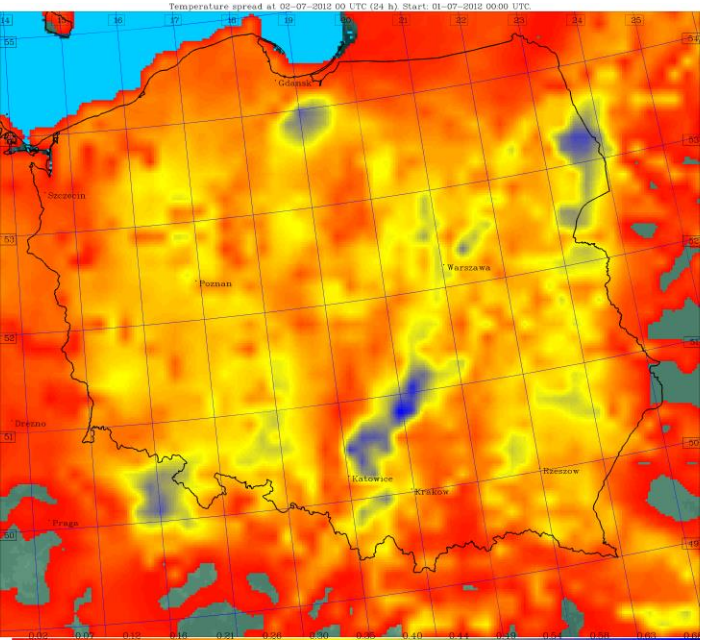



Wind speed spread 24h

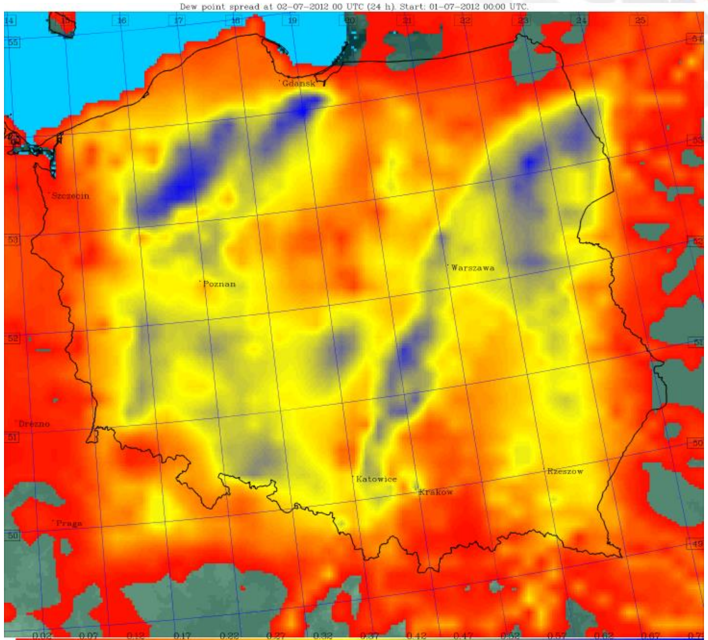



Precipitation spread 24h

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




Temperature spread 24h

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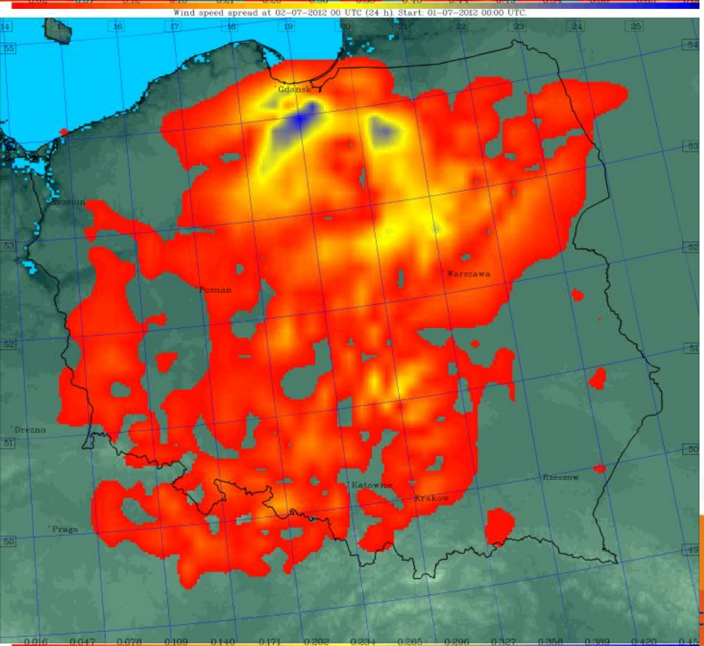
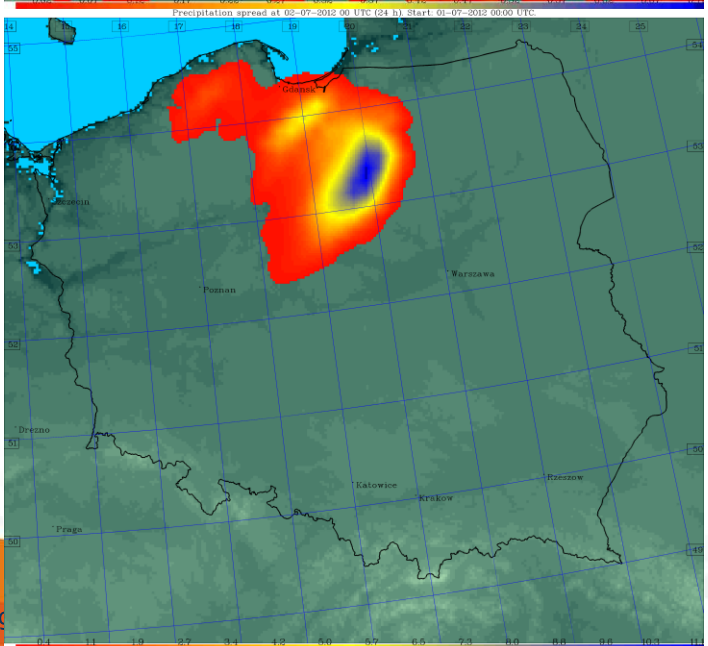
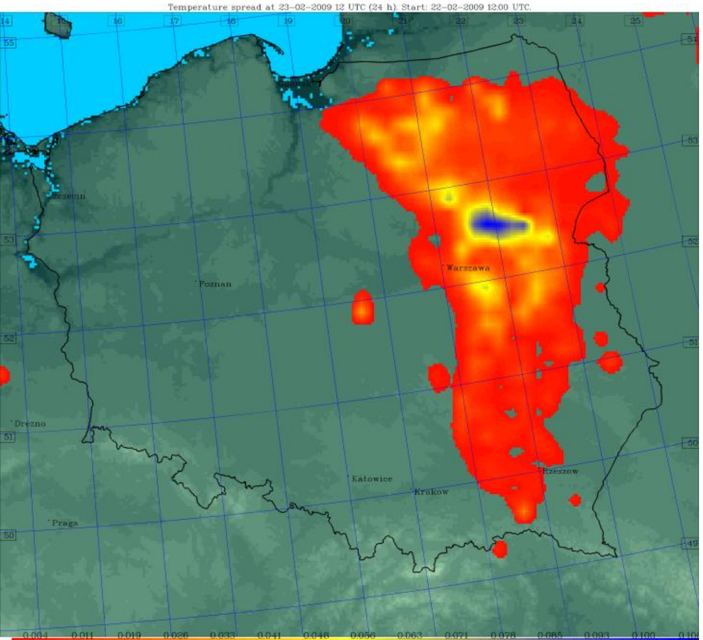



Wind speed spread 24h

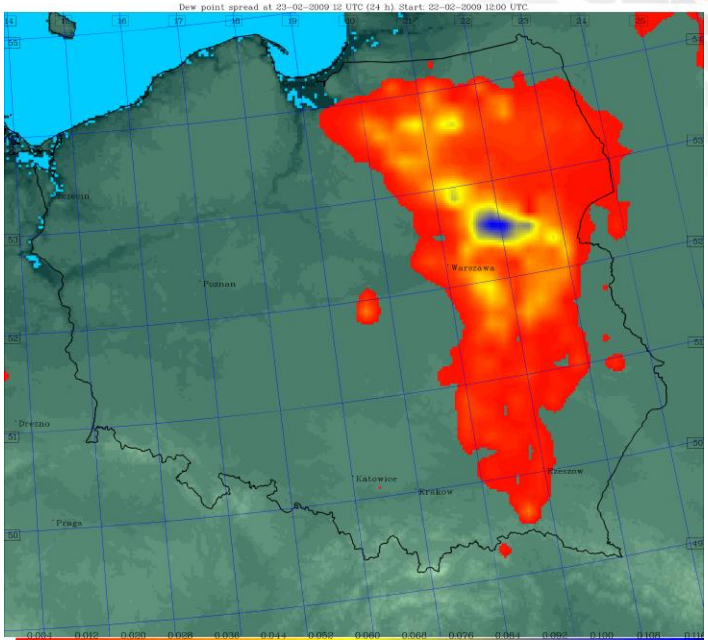



Precipitation spread 24h

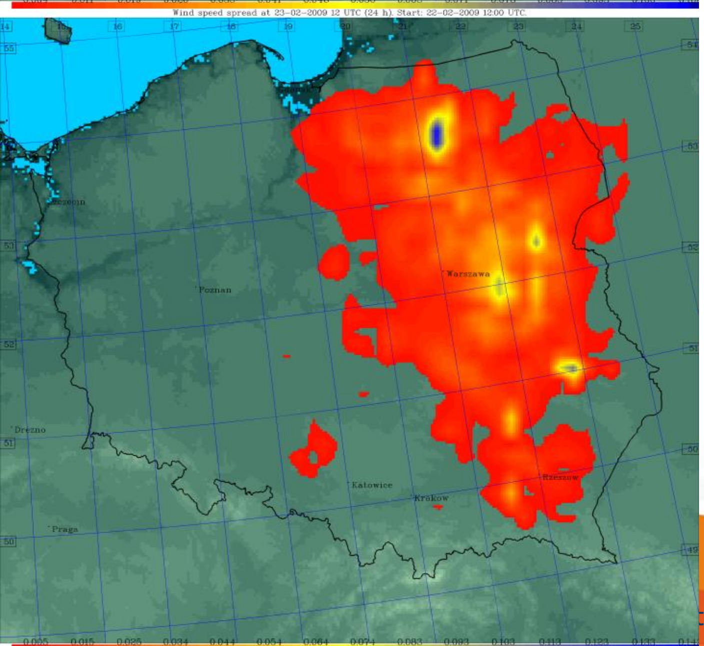
## ”cz_bot_w_so” sensitivity test results: Winter case (February 22nd, 2009)




Temperature spread 24h




Dew point spread 24h

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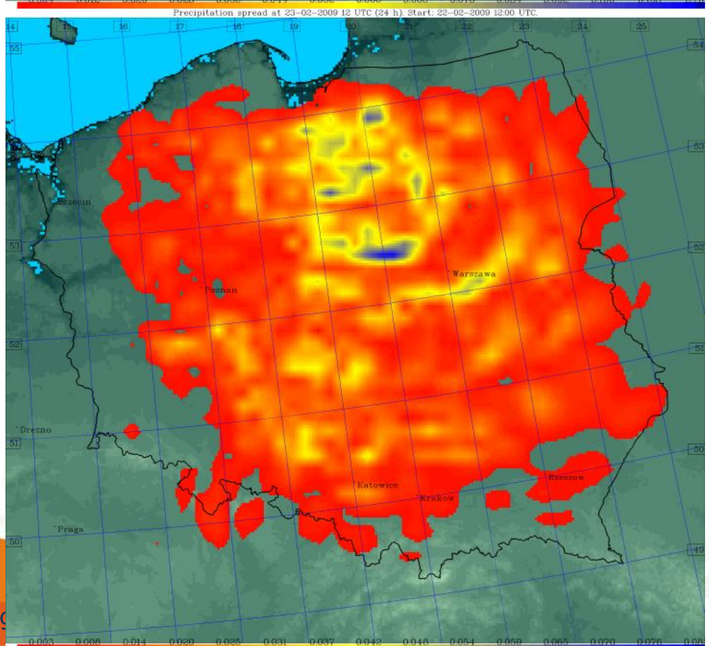


Precipitation spread 24h

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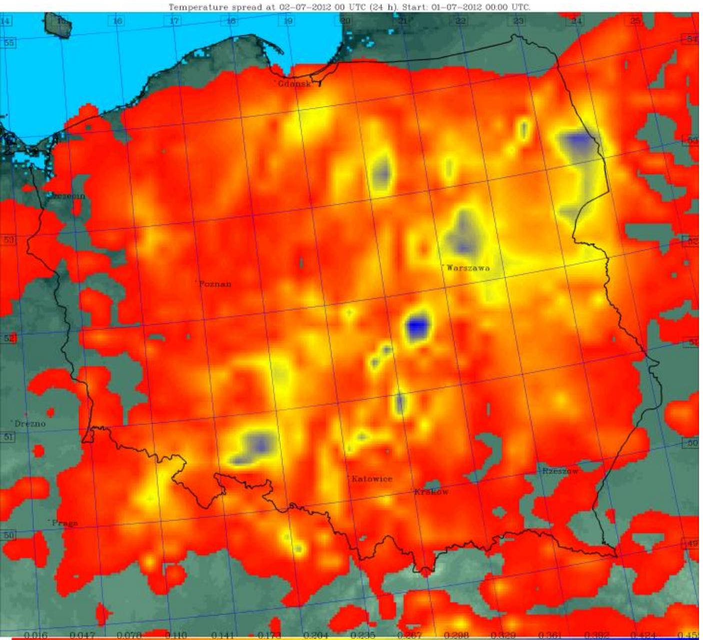
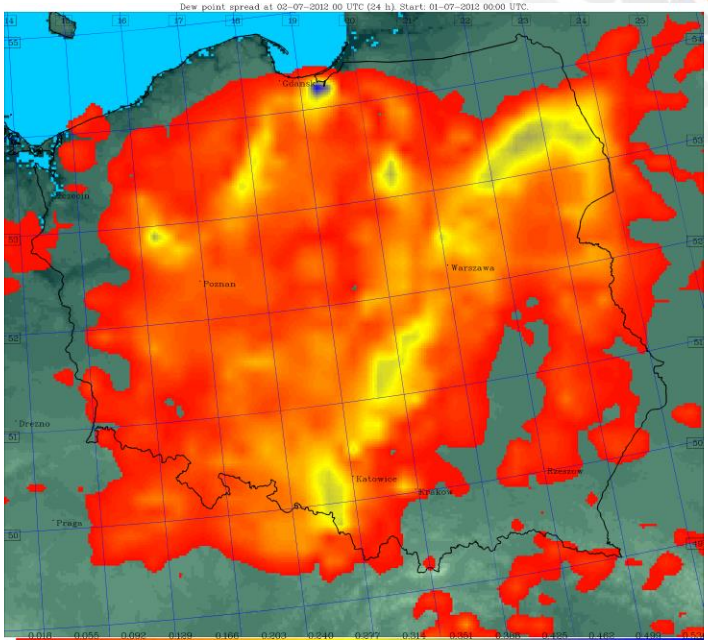
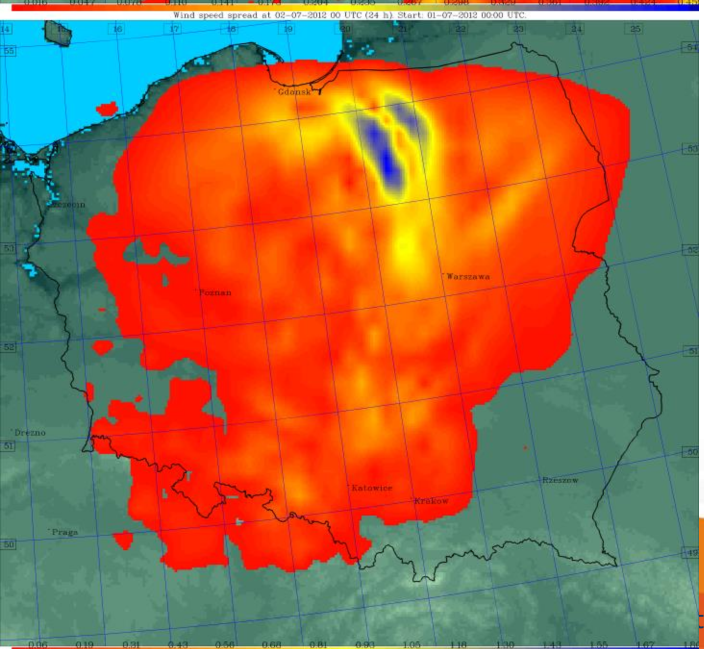


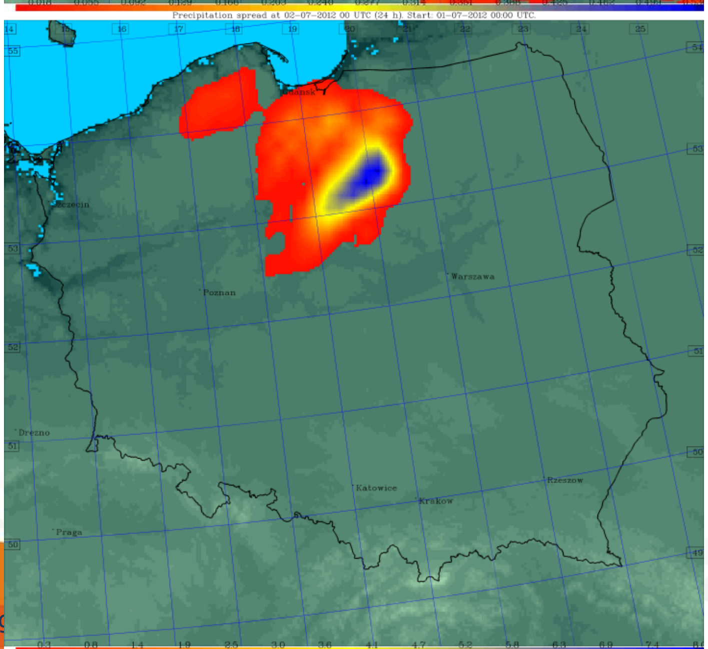

Temperature spread 24h




Dew point spread 24h




Wind speed spread 24h




Precipitation spread 24h

## CONCLUSIONS FROM SENSITIVITY TESTS

- As in preliminary computations, changes of “czbot_w_so” had a noteworthy impact on values of ”deep soil” parameters, like water/ice and water content, temperature of soil layers etc. down to 1458 cm. Impact on values of lower-atmosphere parameters like air temperature, dew point, precipitation amount or wind speed is relatively minor. Moreover, this parameter has an integer form (level index) rather than floating point, so it is not as useful for preparation of an ensemble as c_soil.
- 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. The ”spread” (standard deviation of values against reference one can be as big as 2 degree (temperature) or 1.5 m/s (wind speed). Impact on values of soil parameters like water/ice and water content, or soil layers temperature is rather irrelevant.

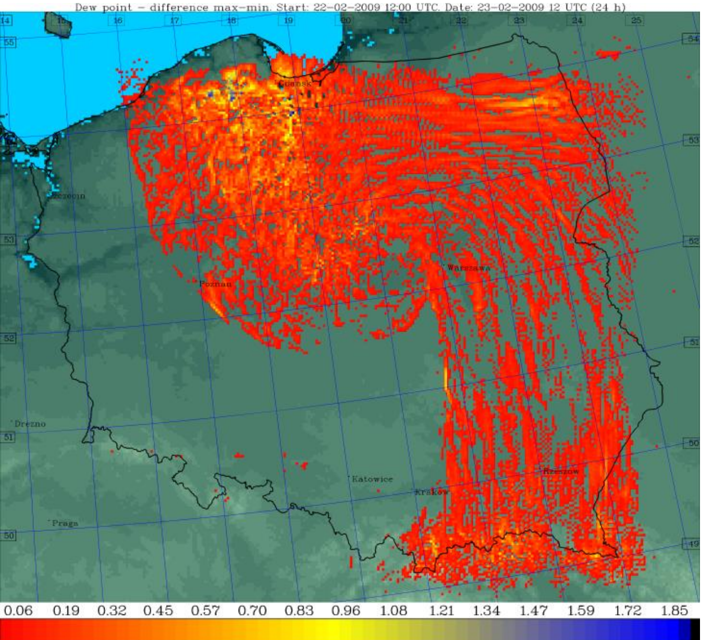
Concerning it all, it can be possible to prepare a representative ensemble using two methods:

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.

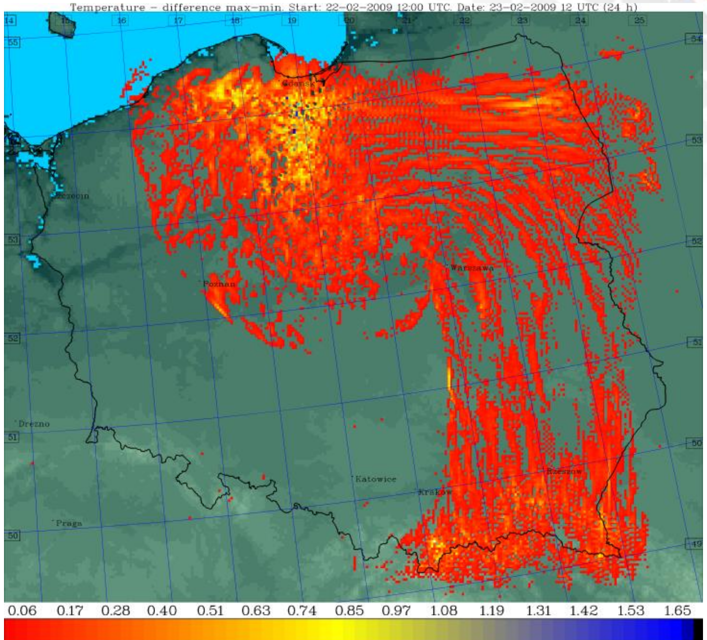
Next slides: example of results of 2nd approach.

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

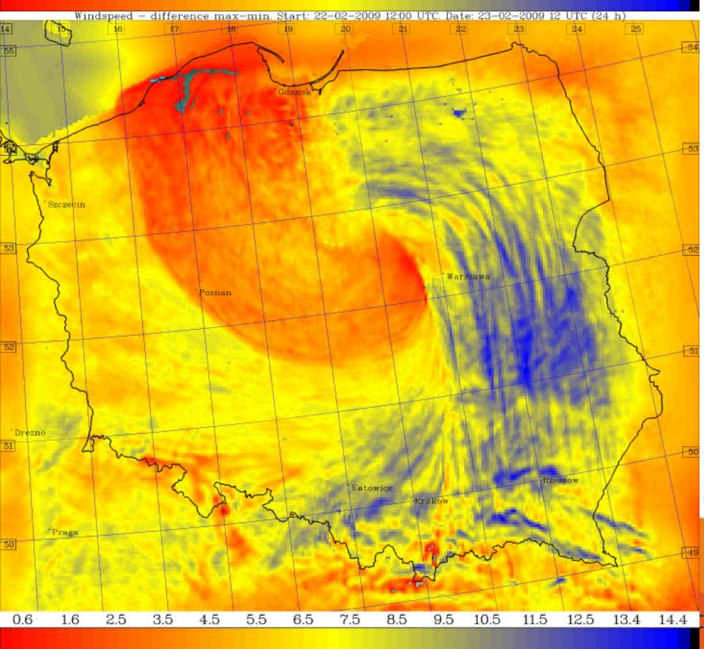
## ”c_soil” random changes, test results: Winter case (February 22nd, 2009)



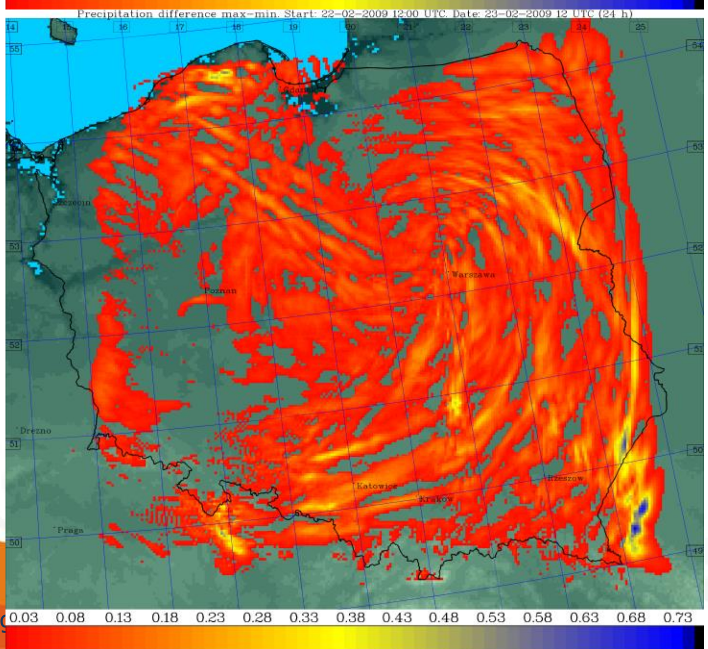

DewPoint Max-Min Difference




Air Temperature Max-Min Difference

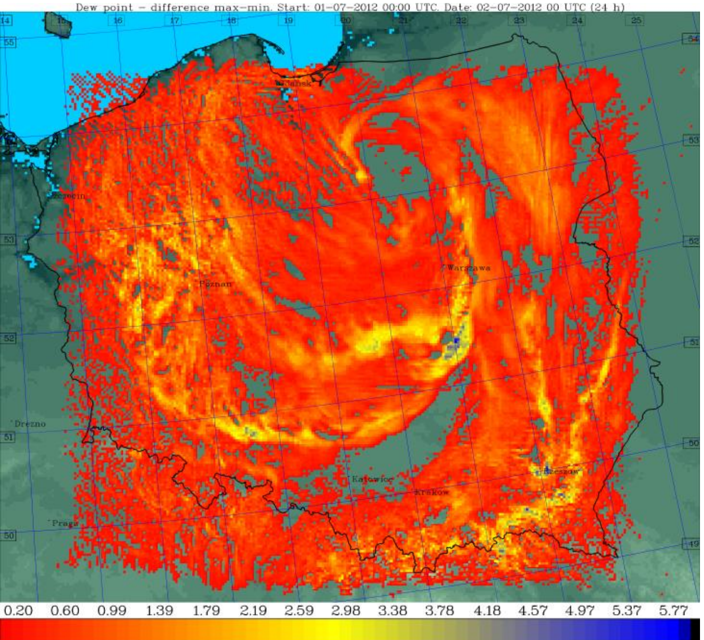



Windspeed Max-Min Difference

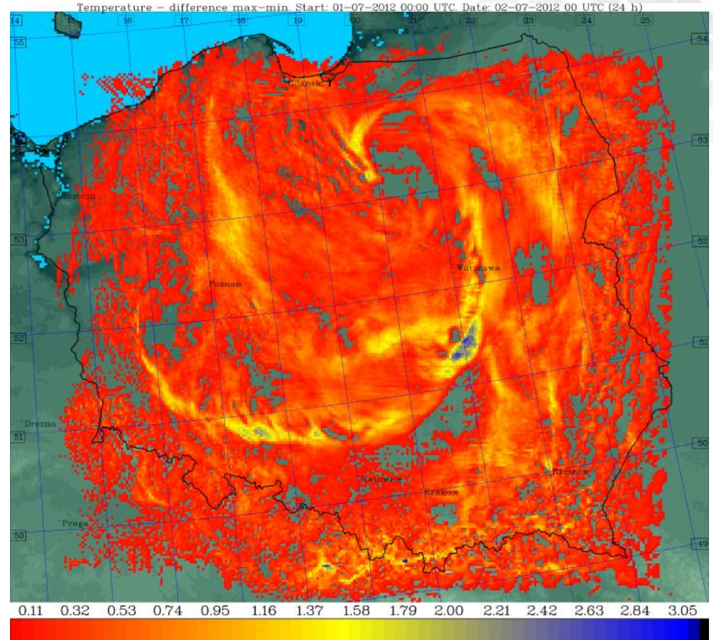



Precipitation Max-Min Difference

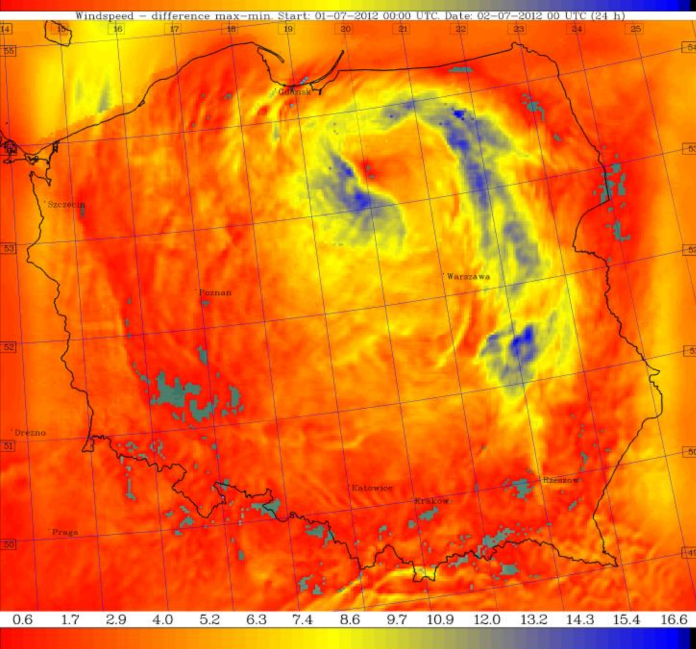
## ”c_soil” random changes, test results: Summer case (July 1st, 2012)



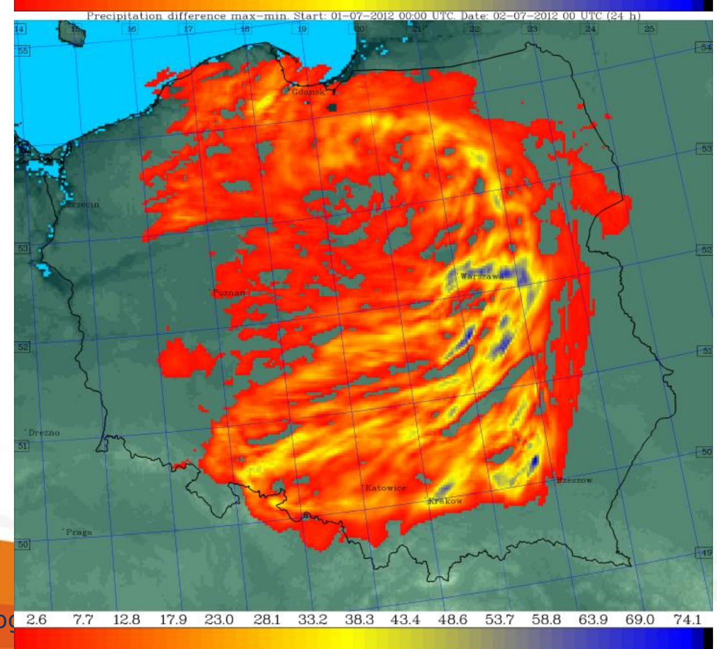

DewPoint Max-Min Difference




Air Temperature Max-Min Difference




Windspeed Max-Min Difference




Precipitation Max-Min Difference

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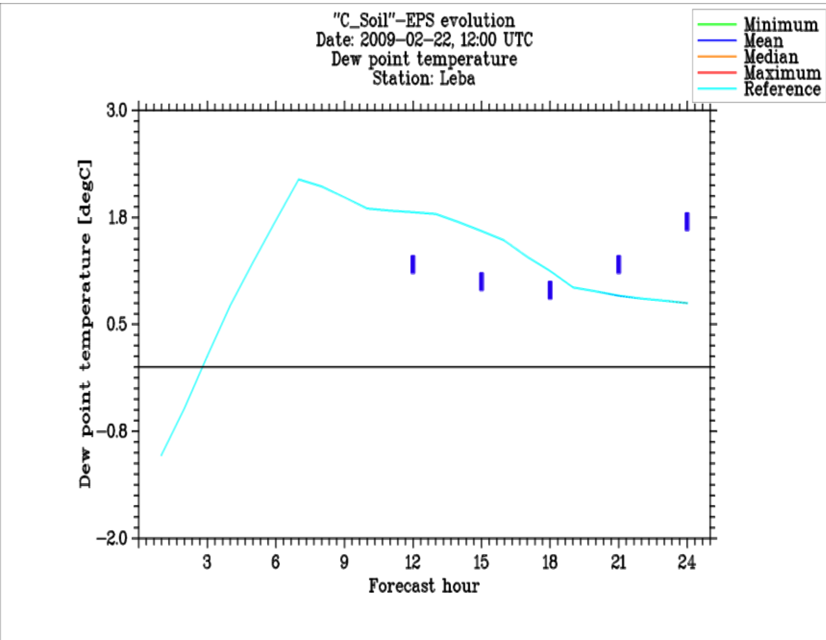
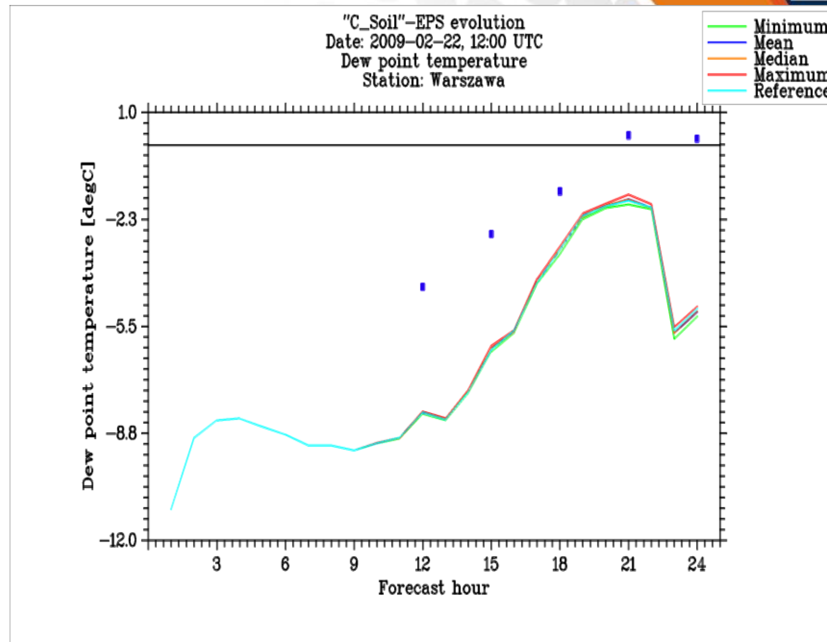
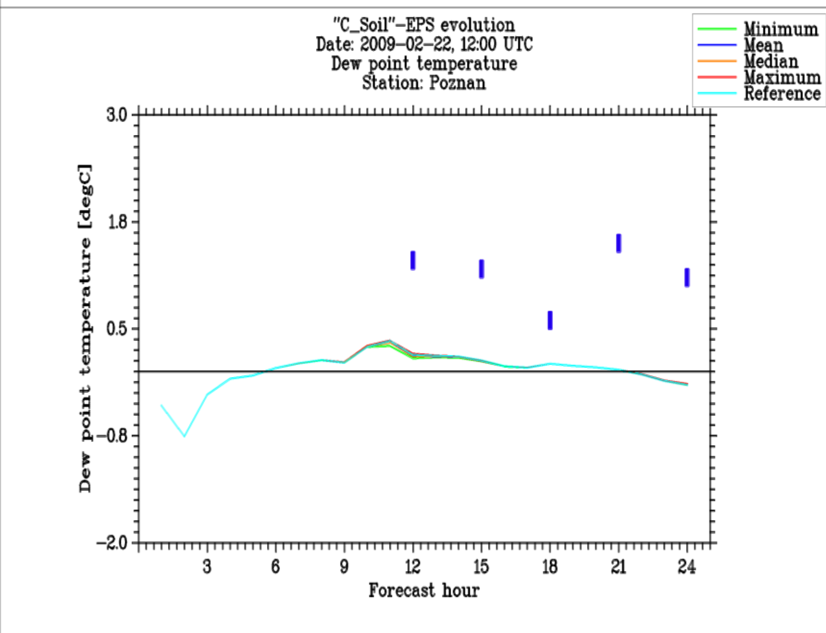


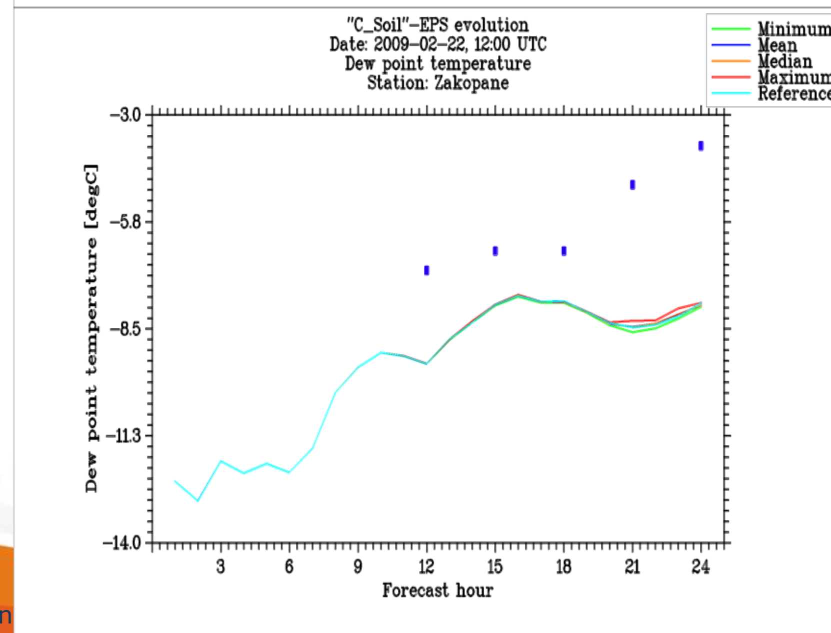

Dew point at Łeba




Dew point at Warsaw




Dew point at Poznań




Dew point at Zakopane

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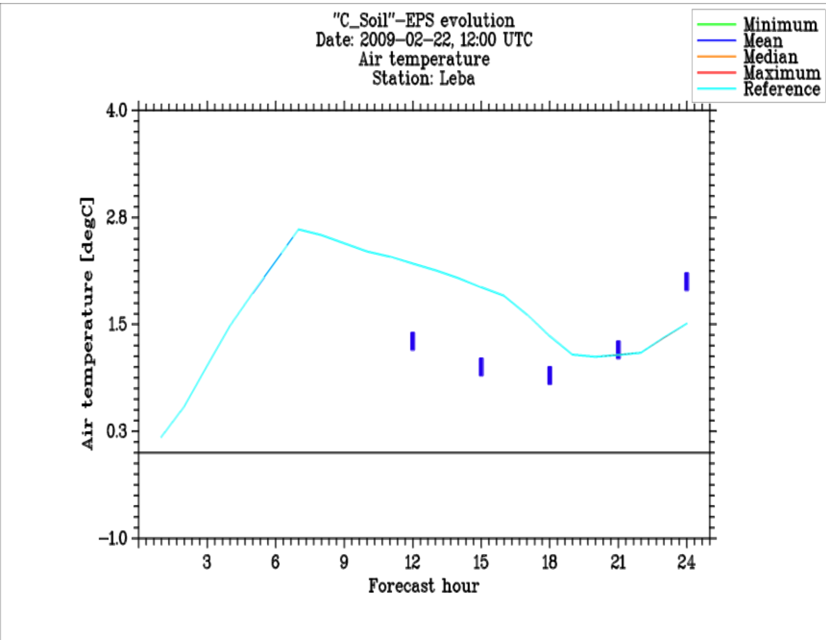
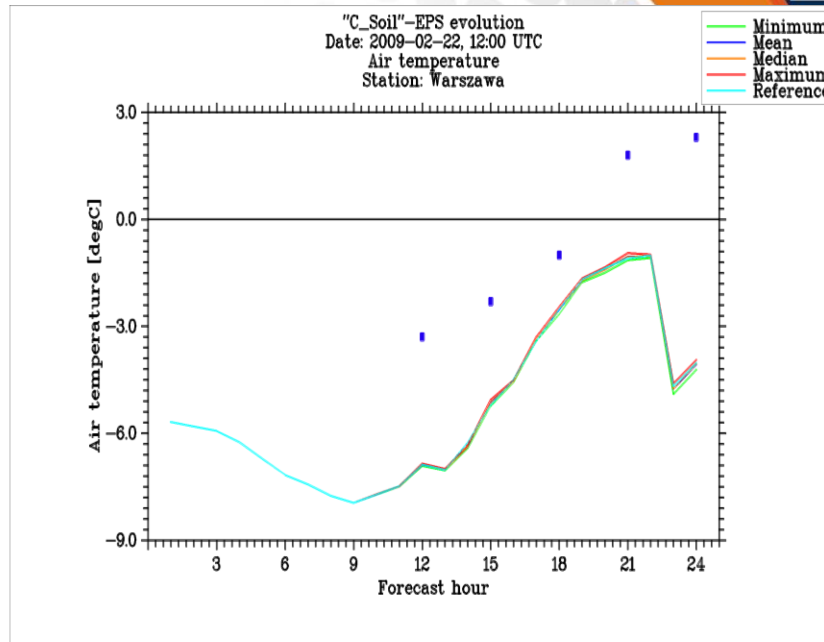
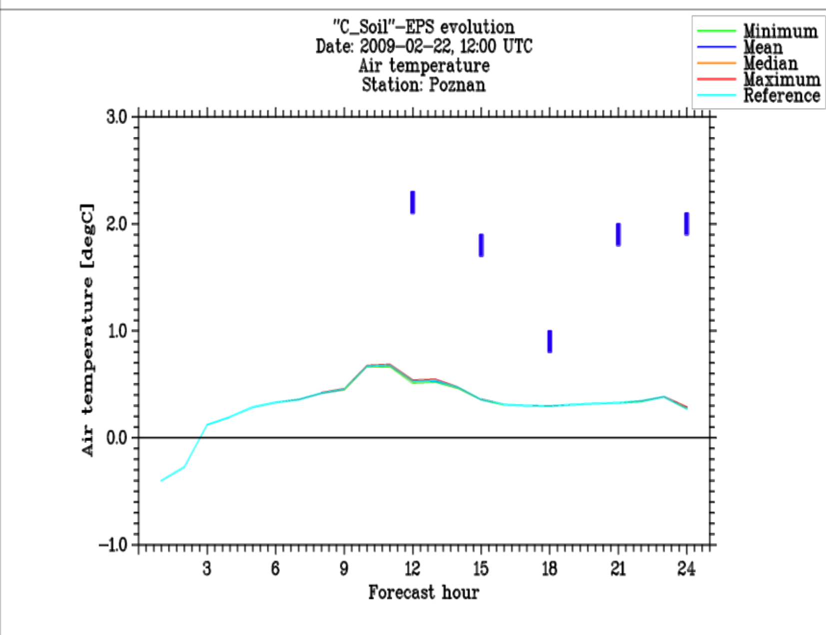



Temperature at Łeba




Temperature at Warsaw

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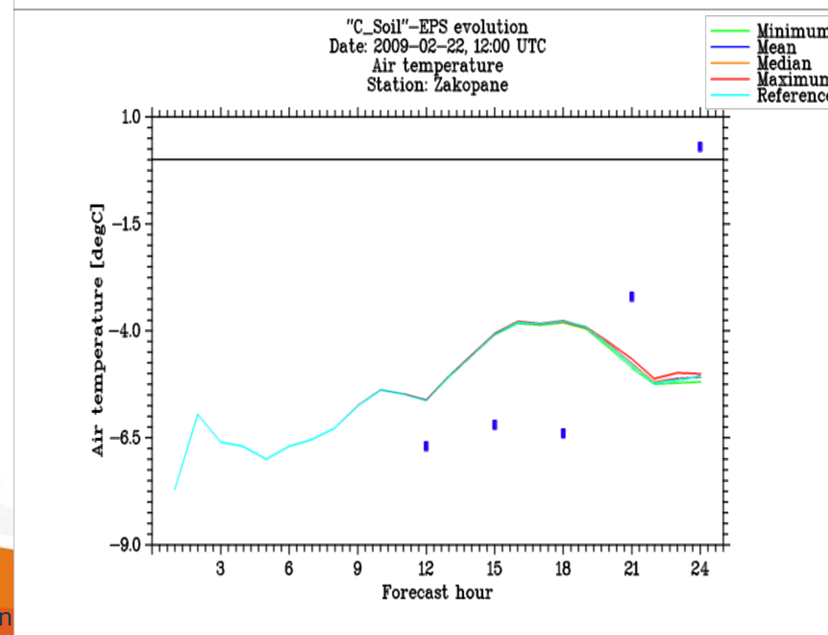


Temperature at Zakopane

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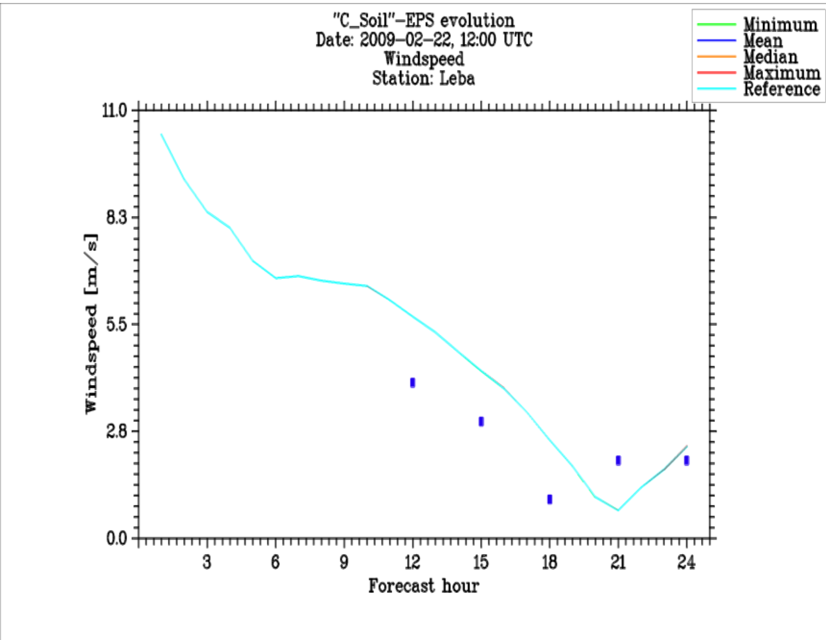
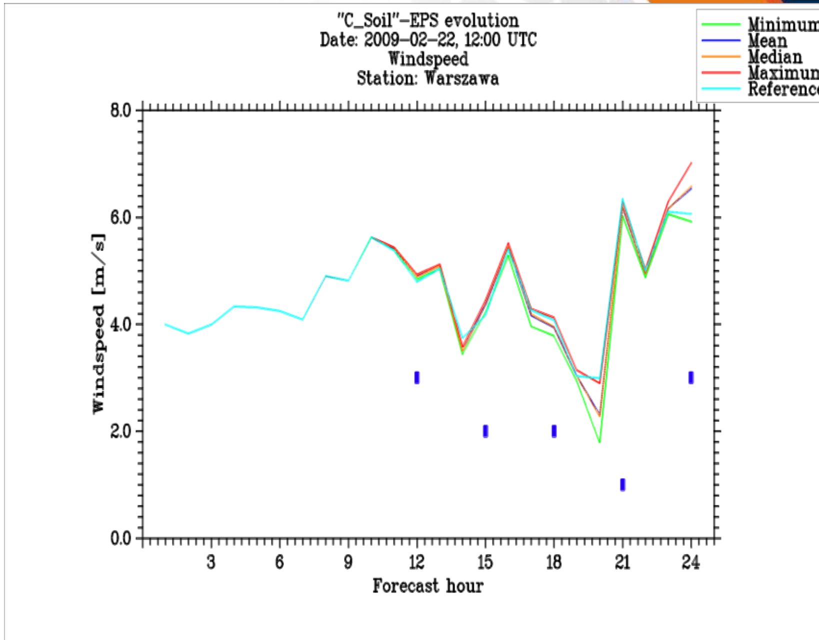
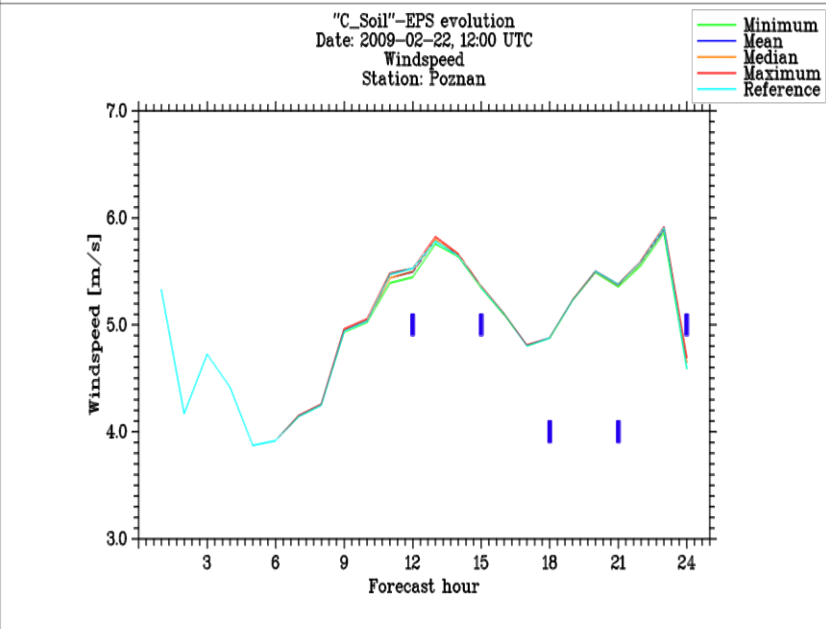


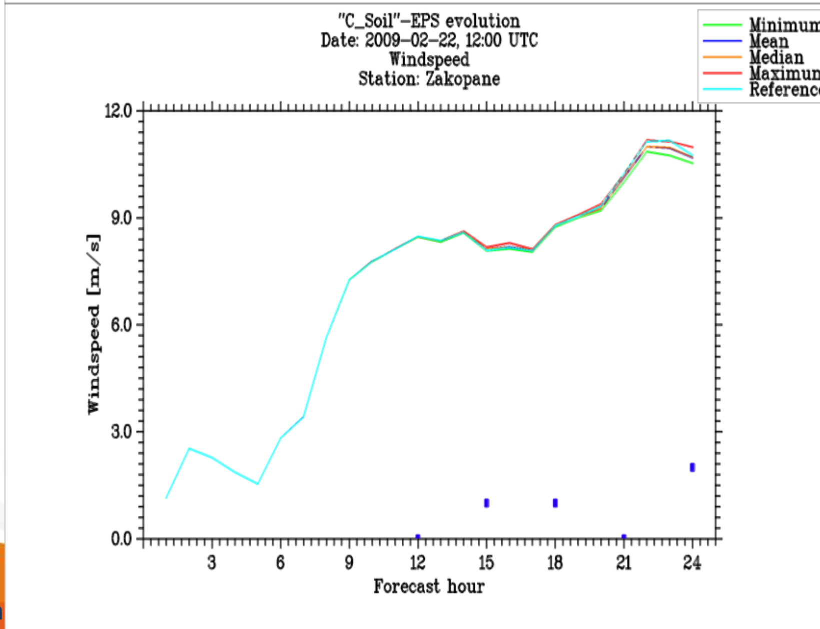

Windspeed at Łeba




Windspeed at Warsaw




Windspeed at Poznań




Windspeed at Zakopane

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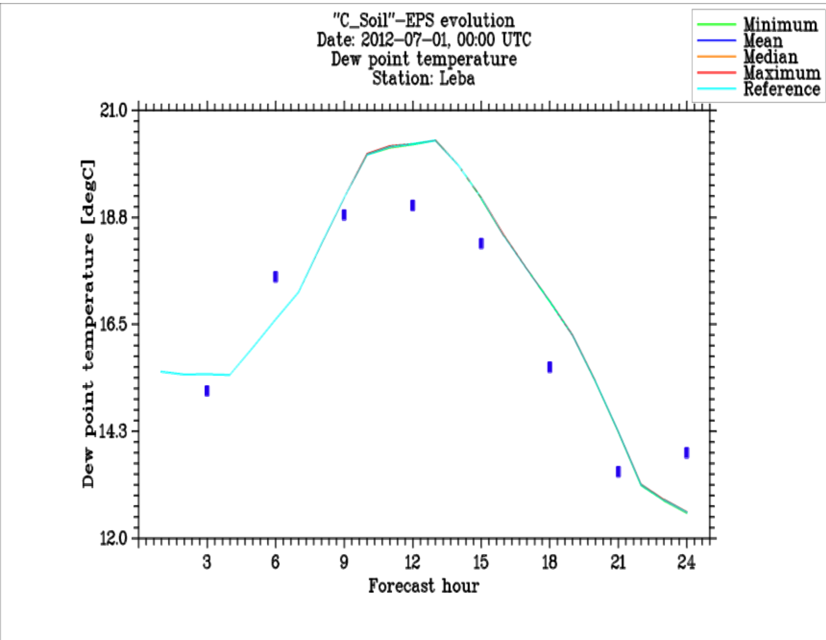
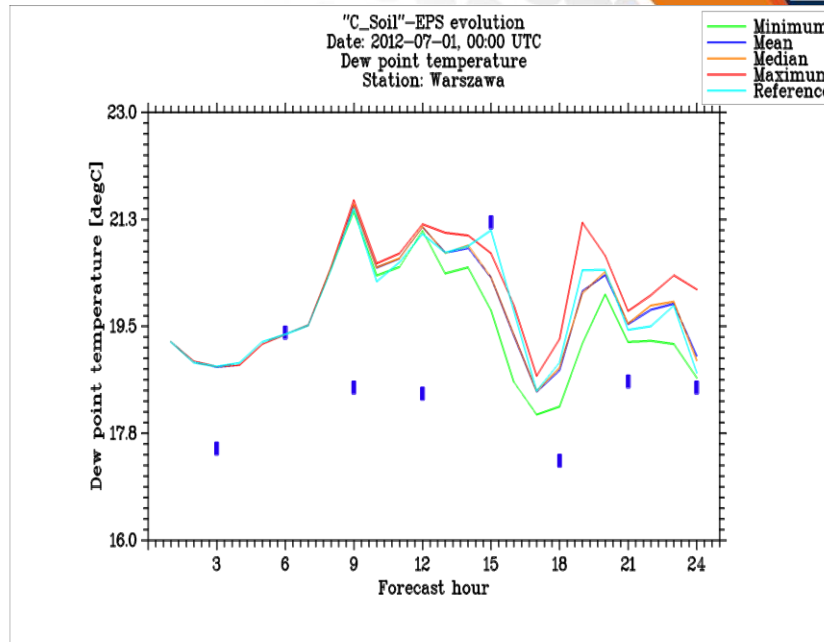
## Summer case (July 1st, 2012)




Dew point at Łeba

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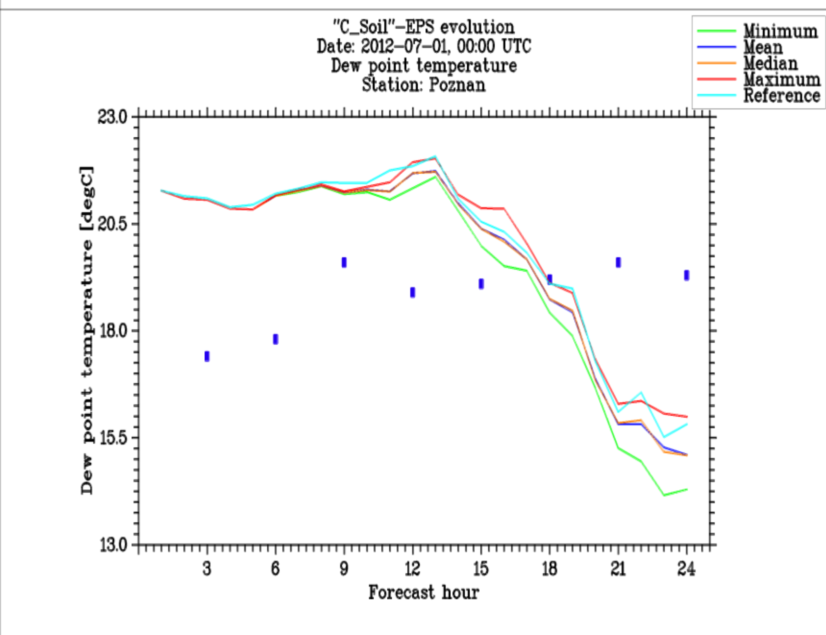
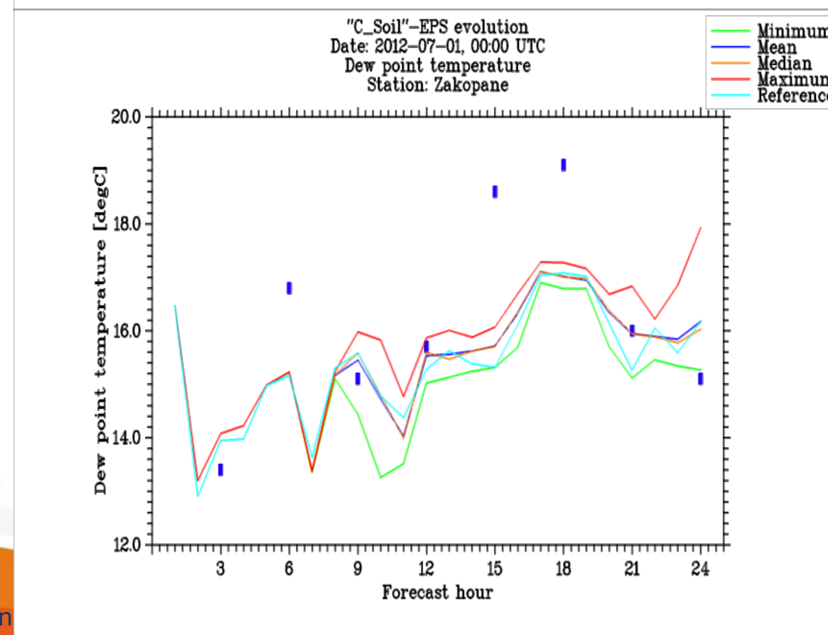



Dew point at Poznań




Dew point at Zakopane

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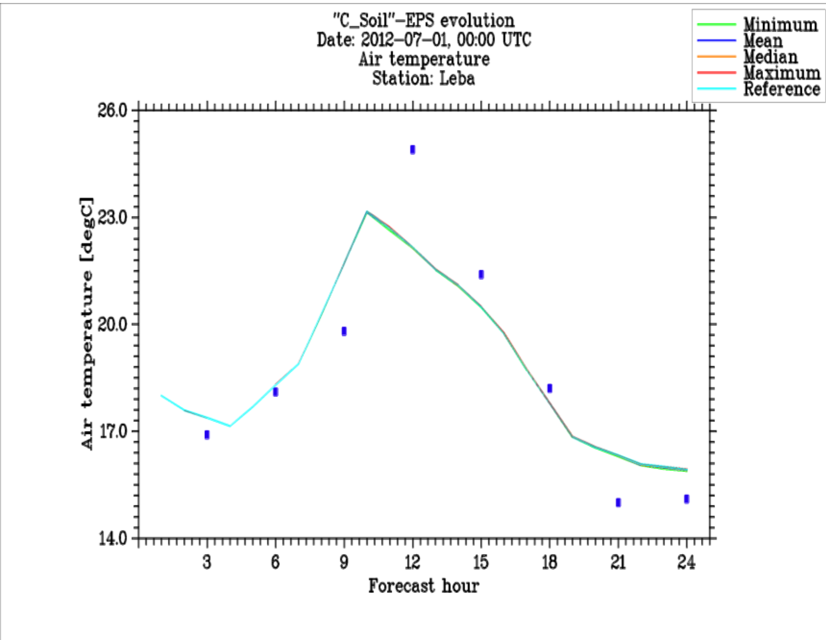
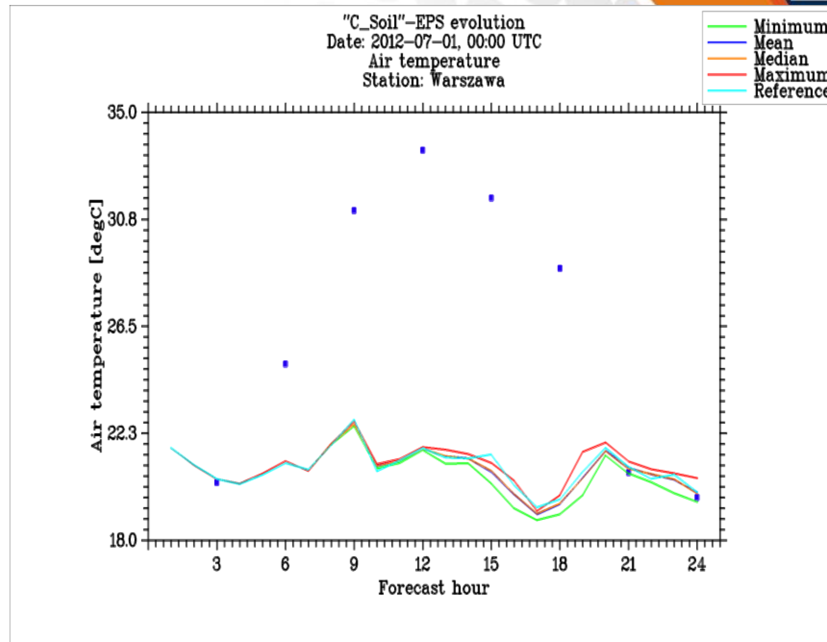
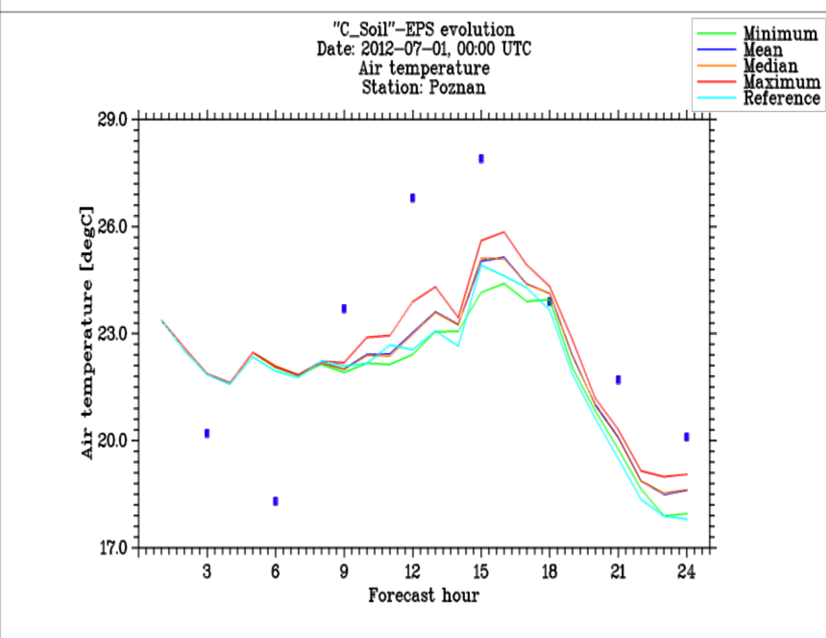


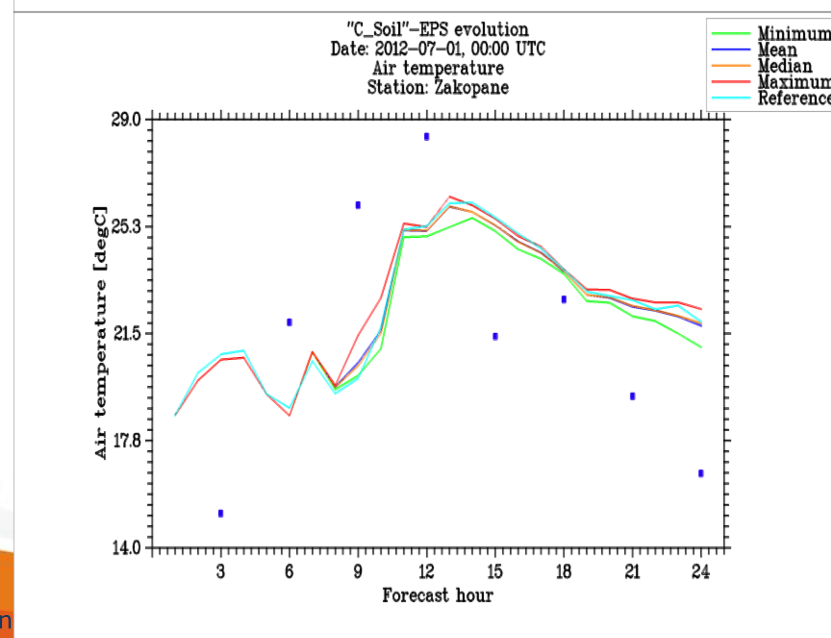

Temperature at Łeba




Temperature at Warsaw




Temperature at Poznań




Temperature at Zakopane

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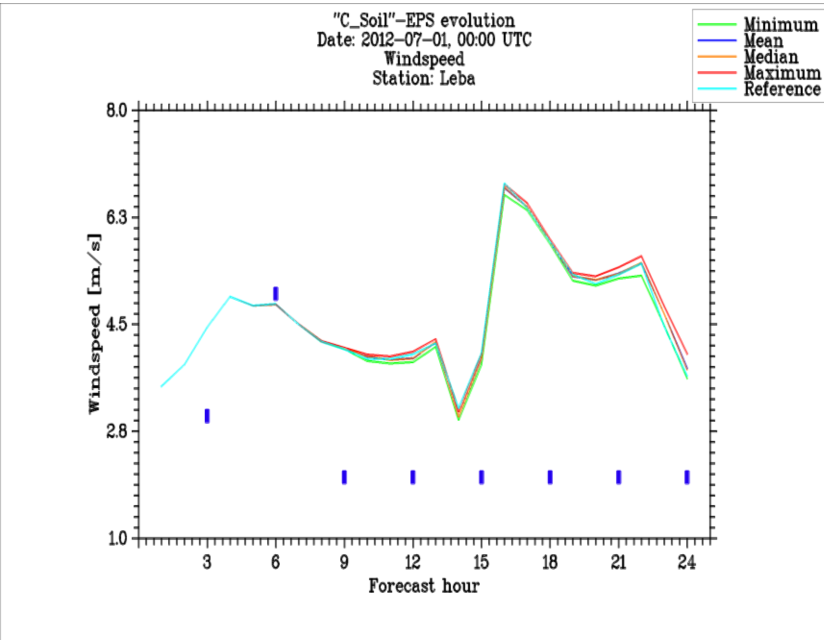
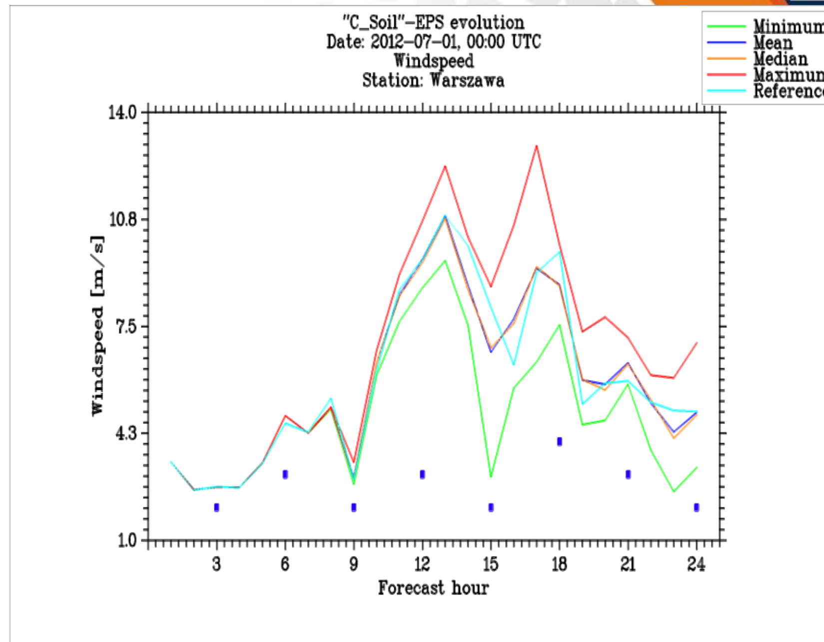



Windspeed at Łeba

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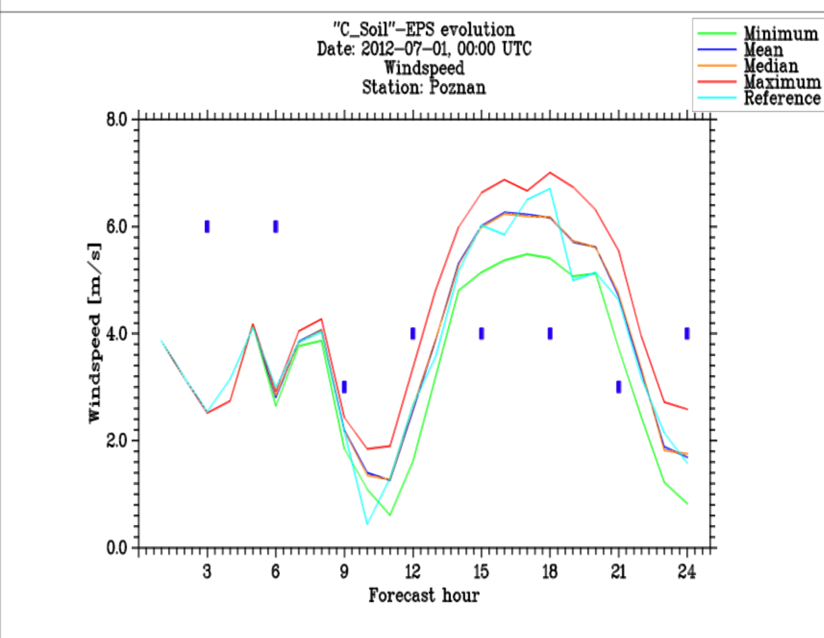
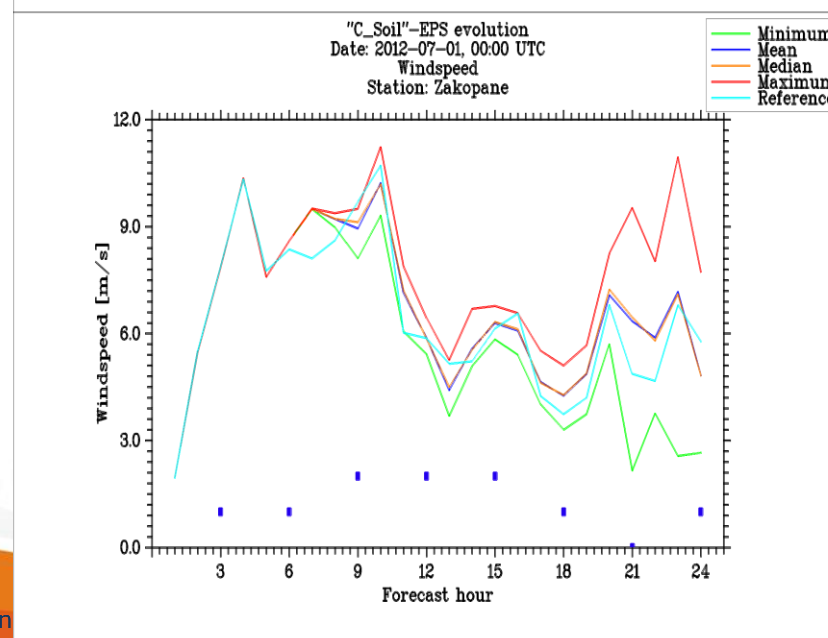



Windspeed at Poznań




Windspeed at Zakopane

## DISCUSSION AND REMARKS

In terms of spread and/or maximum – minimum value differences:

- Perturbations have almost insignificant influence in locations with small land fraction,

- Perturbations have almost insignificant influence during cold season due to soil conditions (frozen ground etc.)

- Detailed analysis (seasonal/annual?) seems to be necessary

## 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 $K_0$ - parameters depending on soil type, hydraulic conductivity at saturation, $K_R$, $D_{min}$ and $D_{max}$ – constants, $\rho_m$, is fraction of saturated soil filled by water. The $s_{u,t}$ is the soil water content ($s_u$ in the uppermost layer, $s_t$ in the total active layer). In the current experiments Dickenson's parameterization was replaced by Darcy equation with various modifications:

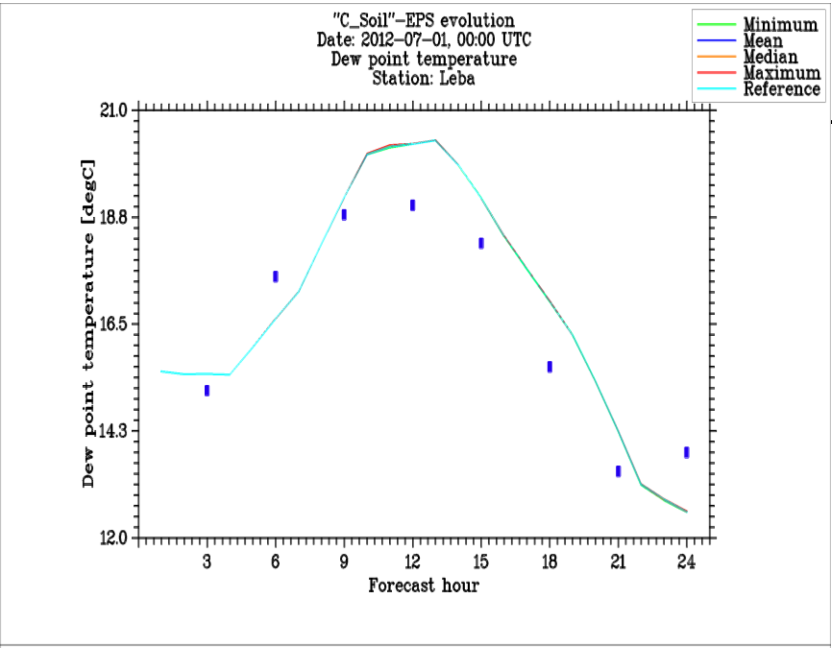
$$F_m = \exp\left(\frac{T}{T_0}\right)^a \cdot \rho_m \left( 1 + 1550 \frac{D_{\min}}{D_{\max}} \frac{B - 3{,}7 + \frac{5}{B}}{B+5} \right) 1{,}02 D_{\max} s_u^{B+2} \left( \frac{s_t}{s_u} \right)^{\left\{5{,}5+0{,}8B\left[1+0{,}1(B-4)\log\frac{K_0}{K_R}\right]\right\}} \frac{s_t}{\sqrt{z_u z_t}}$$

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

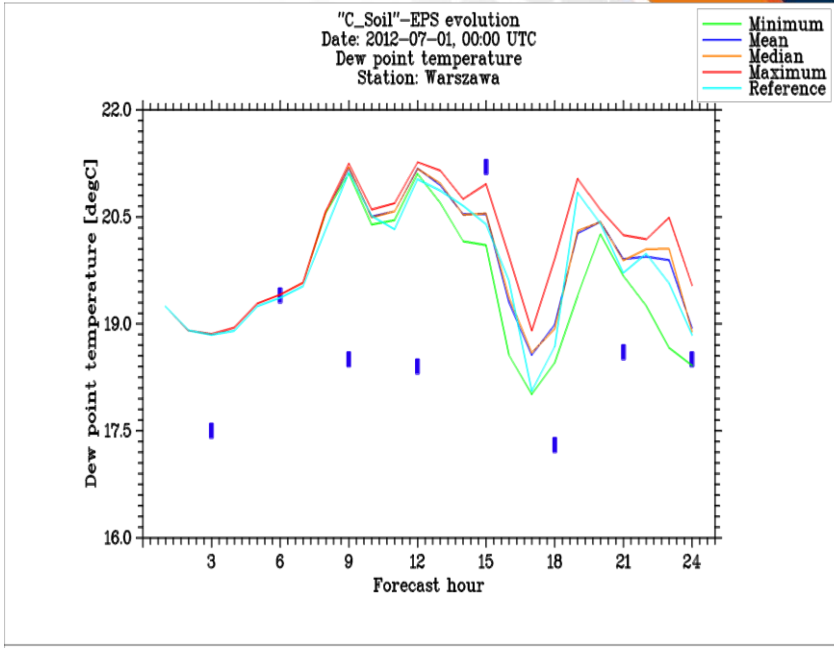


Next slides: examples of results of combining this parameterization with COTEKINO EPS

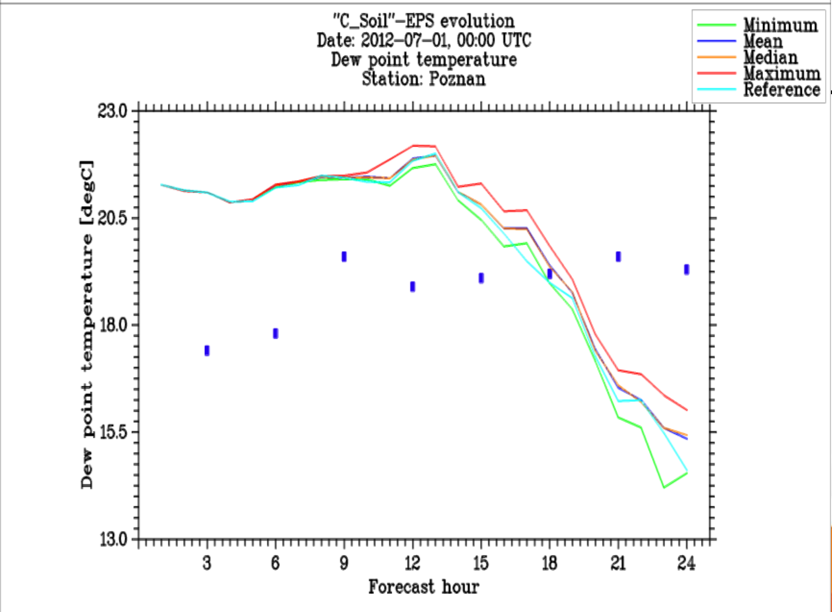
## "c_soil" random changes + altered parameterization: Summer case (July 1st, 2012)



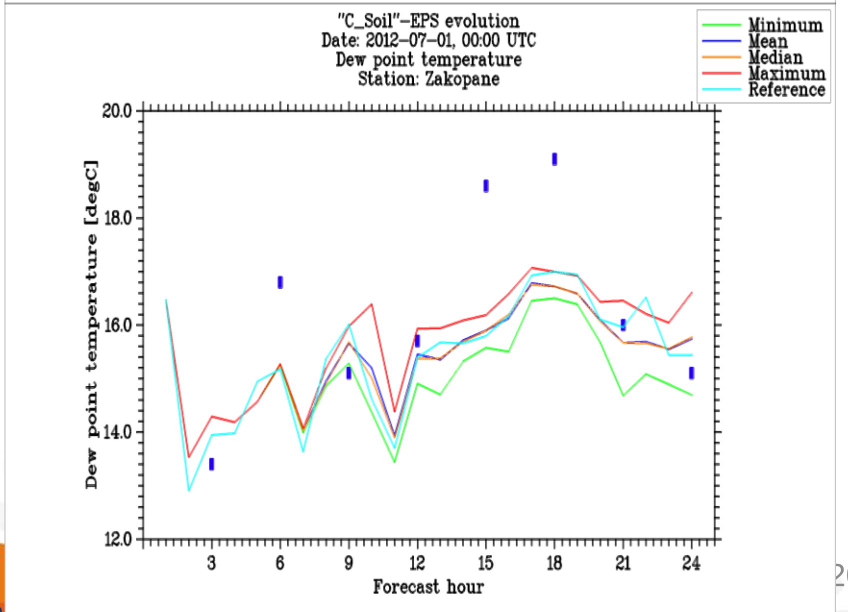

Dew point at Łeba




Dew point at Warsaw




Dew point at Poznań

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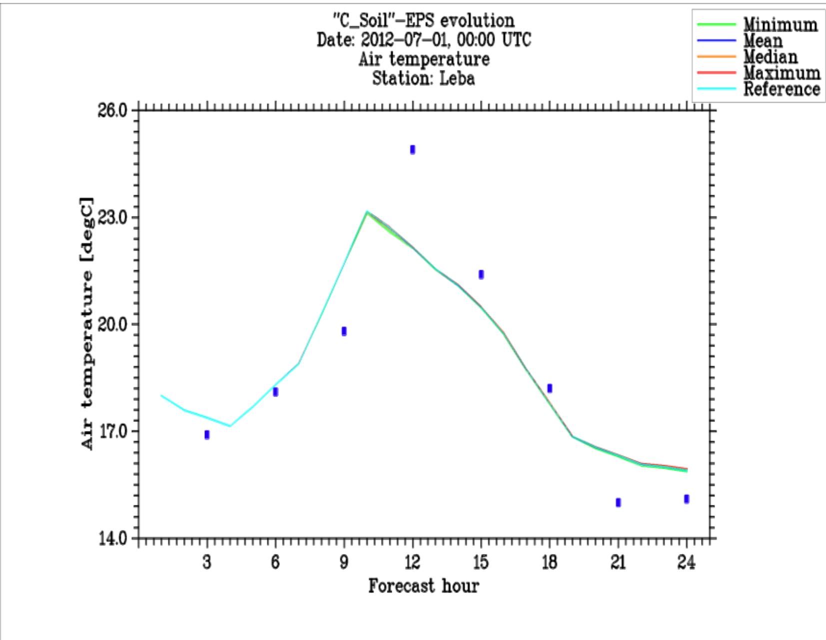
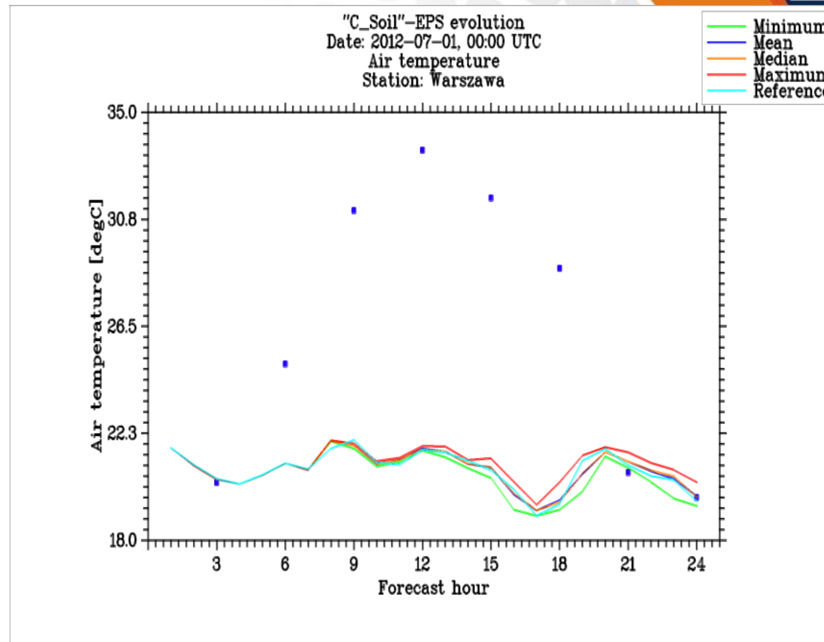
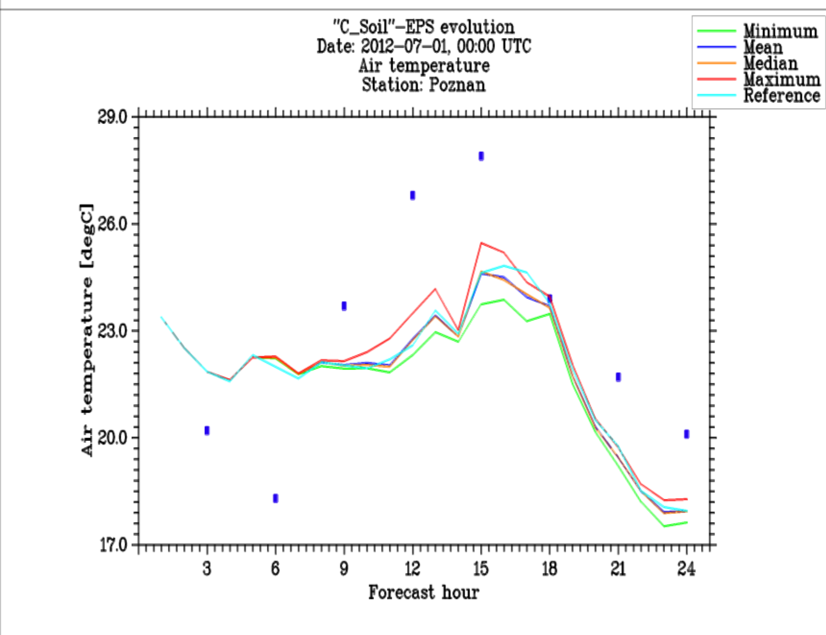


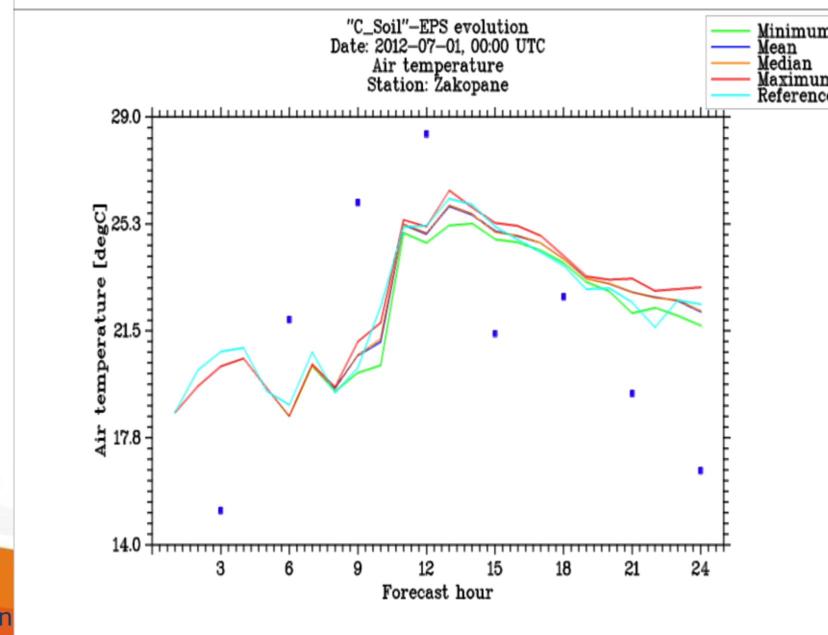

Temperature at Łeba




Temperature at Warsaw




Temperature at Poznań




Temperature at Zakopane

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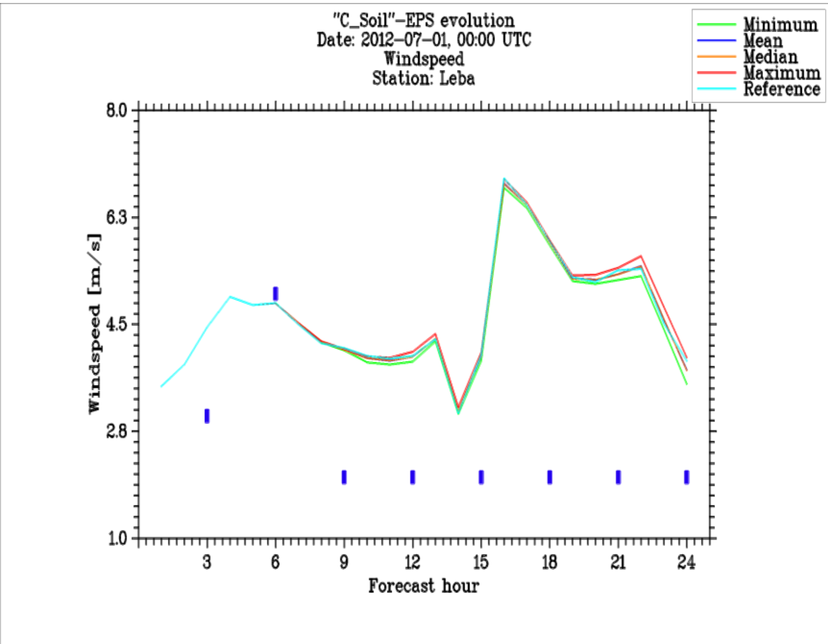
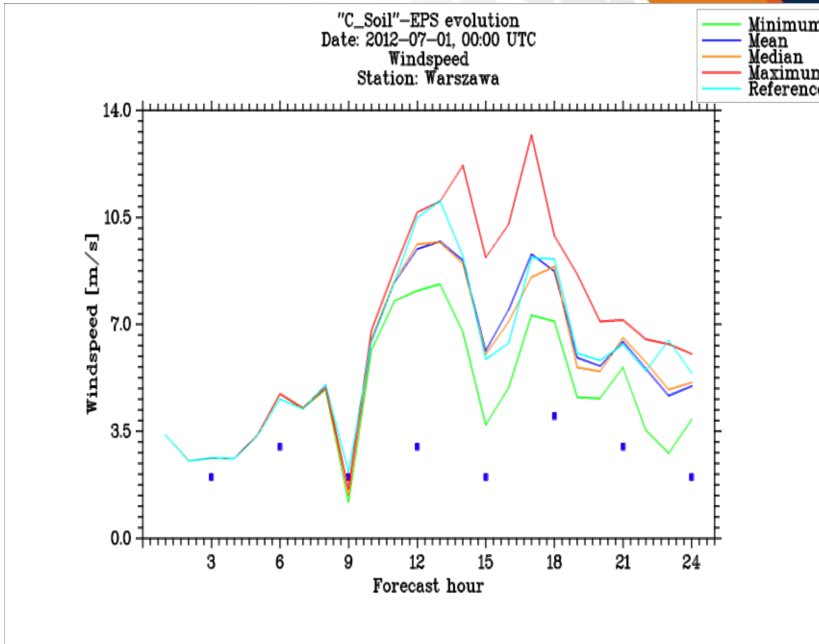
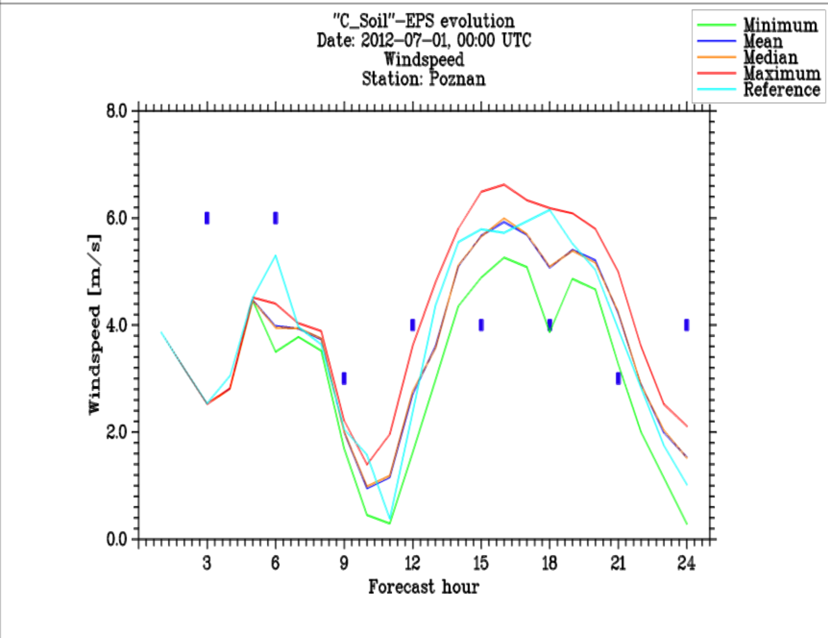
# ”c_soil” random changes + altered parameterization: Summer case (July 1st, 2012)



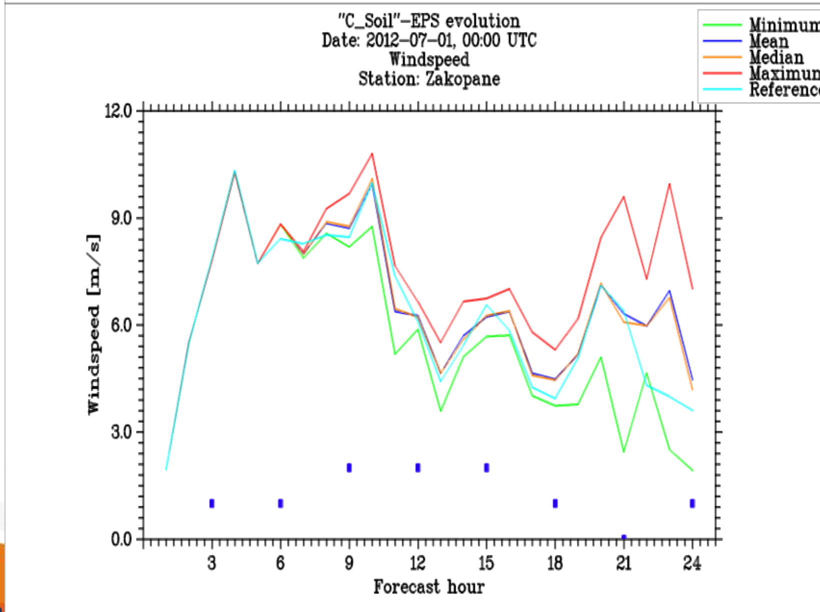

Windspeed at Łeba




Windspeed at Warsaw




Windspeed at Poznań

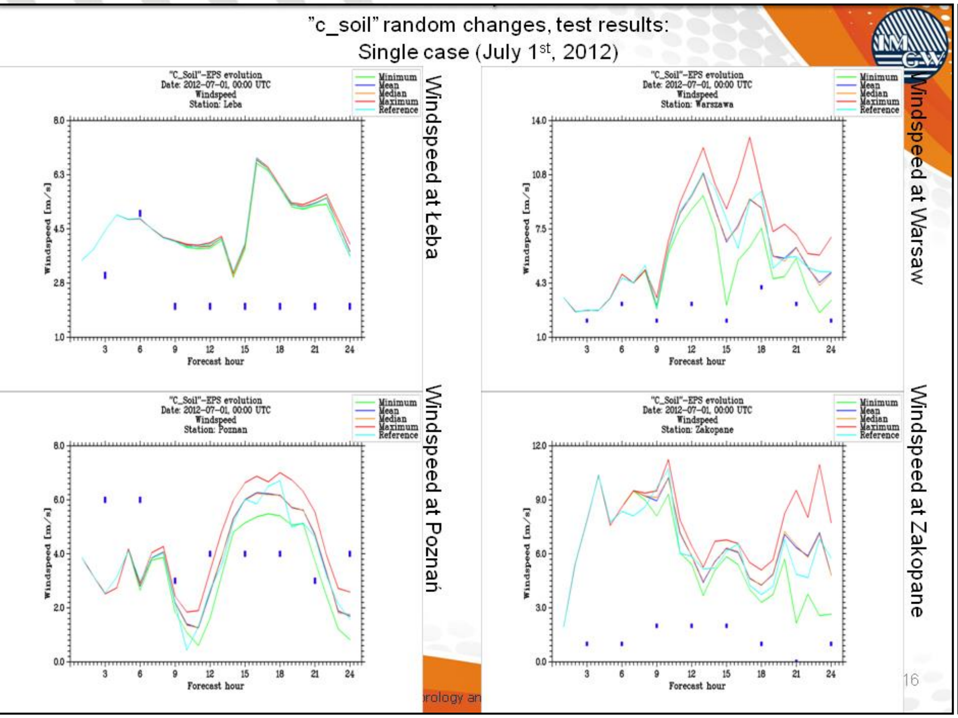


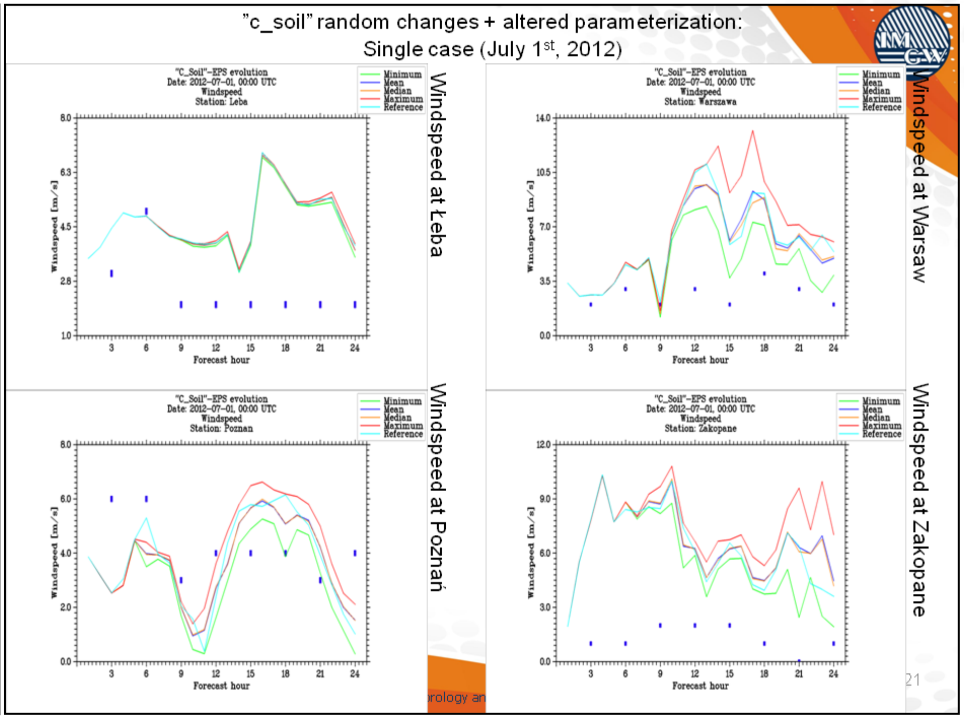

Windspeed at Zakopane

# CONCLUSIONS AND PLANS

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. New improved version of results viewer.
2. Season or annual (”continuous”) run of EPS, detailed comparison with observation (spring-summer, fall-winter) – in progress!!!
3. Semi-operational implementation (parallel to deterministic runs)
4. Perturbations of soil temperature combined with altered parameterization of soil processes.

# Thank you for attention

☺

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