Experiments in soil physics – changes in ”bare soil”parameterization

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Contents

Changes in description of water flux through the soil surface

- Two options considered:

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

- version 1 (with a = -1, ½, 1, 2):

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

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Changes in description of water flux through the soil surface

- Option 2:

$$\vec{F}_m = -D(\theta)\vec{\nabla}\theta$$

- version 1 (with a = -1, ½, 1, 2):

$$\vec{F}_m = -D(\theta)\left(\frac{T}{T_0}\right)^a \vec{\nabla}\theta$$

- version 2:

$$\vec{F}_m = -D(\theta)e^{\left(\frac{T}{T_0}\right)}\vec{\nabla}\theta$$

Introduction of correction factor for water flux

- Correction factor, time-depending:

$$\alpha(t) = -\frac{0{,}7}{t_s^2 - t_r^2} t^2 + \frac{1{,}5t_s^2 - 0{,}8t_r^2}{t_s^2 - t_r^2}$$

- In general (remember this until the last slide):

$$\alpha(t) = -\frac{\beta}{t_s^2 - t_r^2} t^2 + \frac{\chi \cdot t_s^2 - \gamma \cdot t_r^2}{t_s^2 - t_r^2}$$

- Fluxes through soil with correction factor (for a= -1, 0, ½, 1, 2 etc.)

$$\vec{F}_m = -\alpha(t) D(\theta) \left(\frac{T}{T_0}\right)^a \vec{\nabla}\theta \qquad \vec{F}_m = -\alpha(t) D(\theta) \exp\left(\frac{T}{T_0}\right) \vec{\nabla}\theta$$

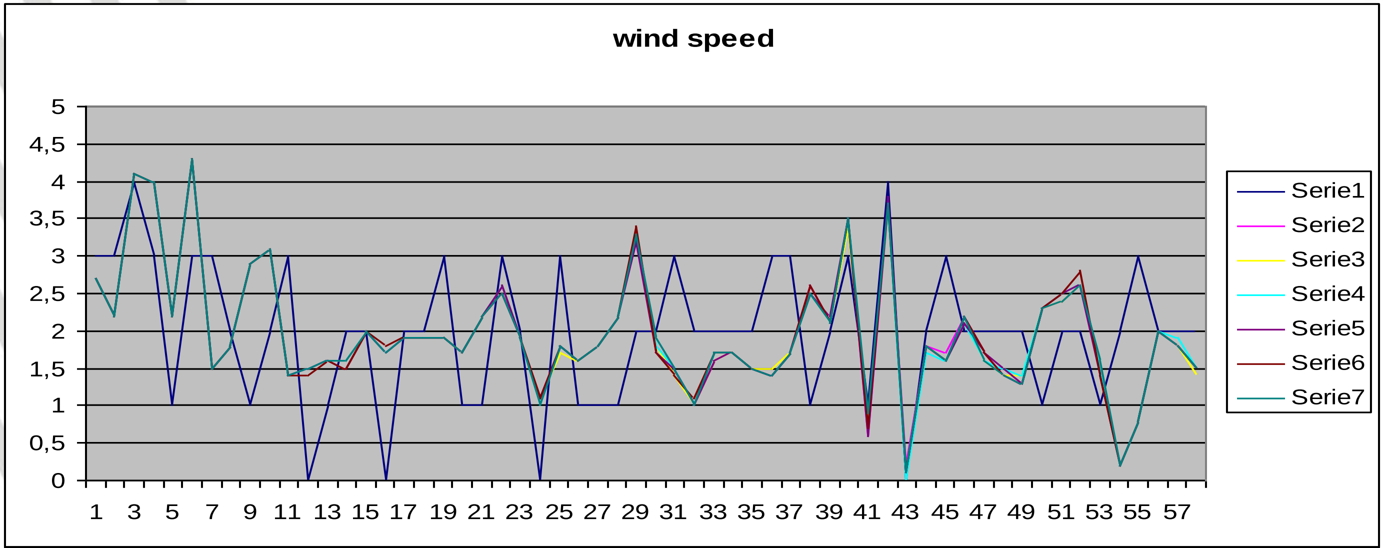
Setup of analysis

Fields:

- Soil Water Content at 1, 2, 6, 18, 54, 162, 486 and 1458 cm.
- Soil Temperature at 1, 2, 6, 18, 54, 162, 486 and 1458 cm.
- Surface soil temperature.
- Air temperature and dew point temperature 2 m agl.
- Relative Humidity at 2 m agl.
- u- and v-wind component at 10 m a. g. l.
- Total precipitation.

Time period: from April, 1st to September, 30th, 2013 (spring and summer)
Comparison:
Results of COSMO Model (reference) with measurements at synops.
Results of COSMO Model (altered parameterization) with measurements at synops.
Results of different model versions (reference and altered parameterization).

Example – results for 06.04.2013-00 UTC



Series 1 – Measurement

Series 2 – Reference

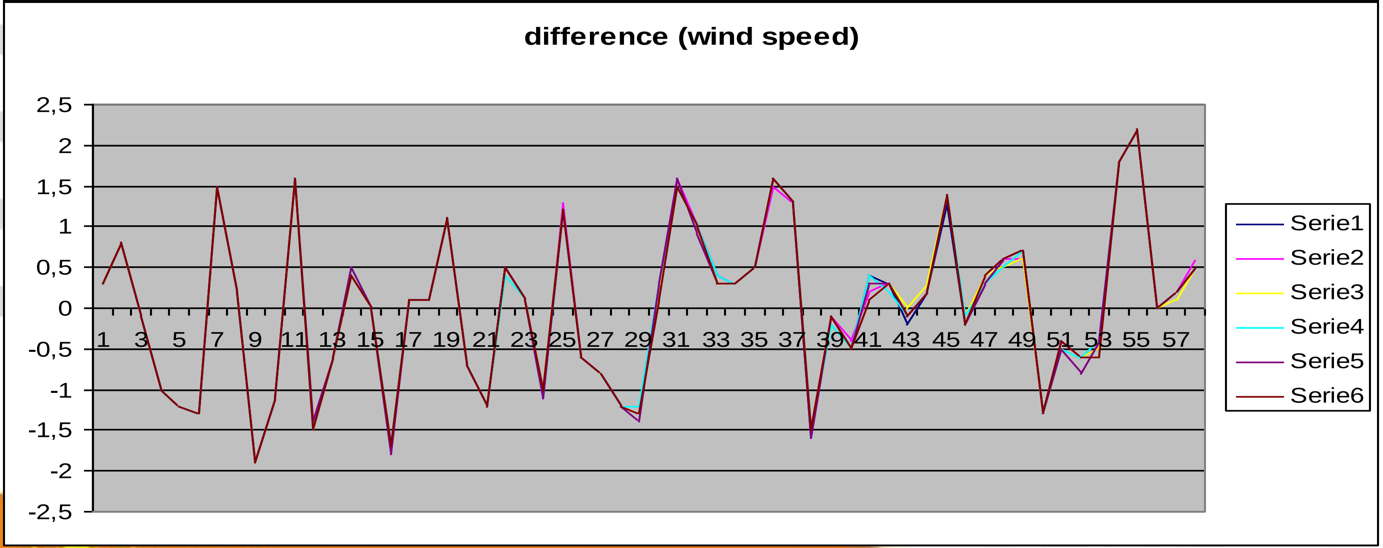
Series 3 – sqrt(T)

Series 4 – f(T)

Series 5 – f(T²)

Series 6 – α(t)exp(T)

Series 7 – exp(T)



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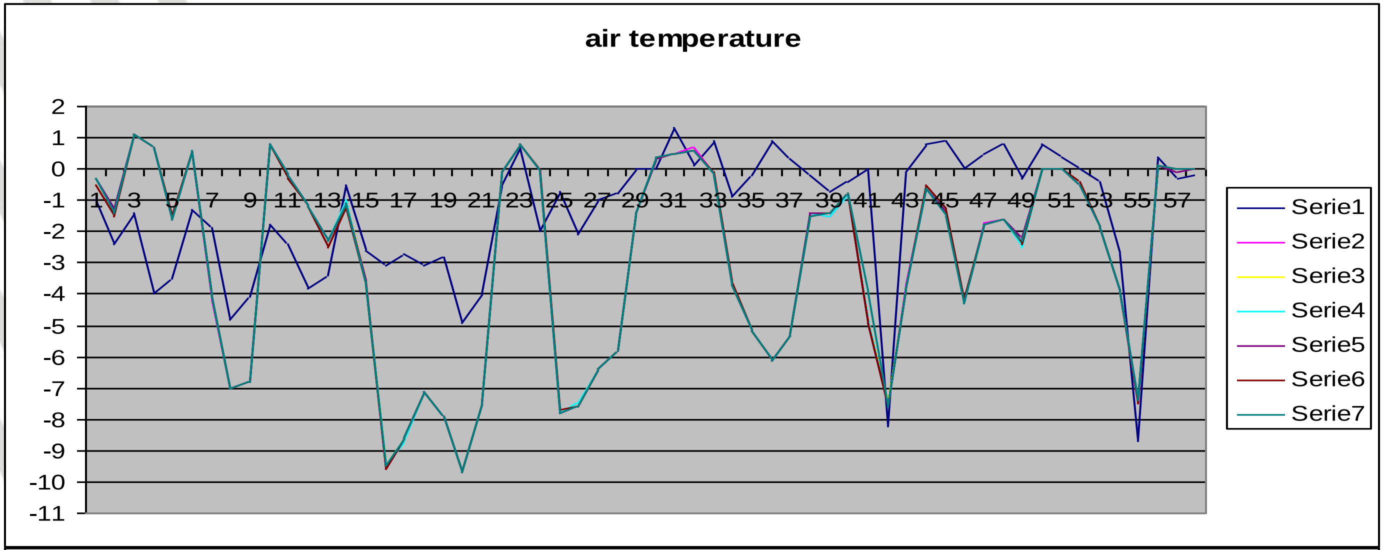

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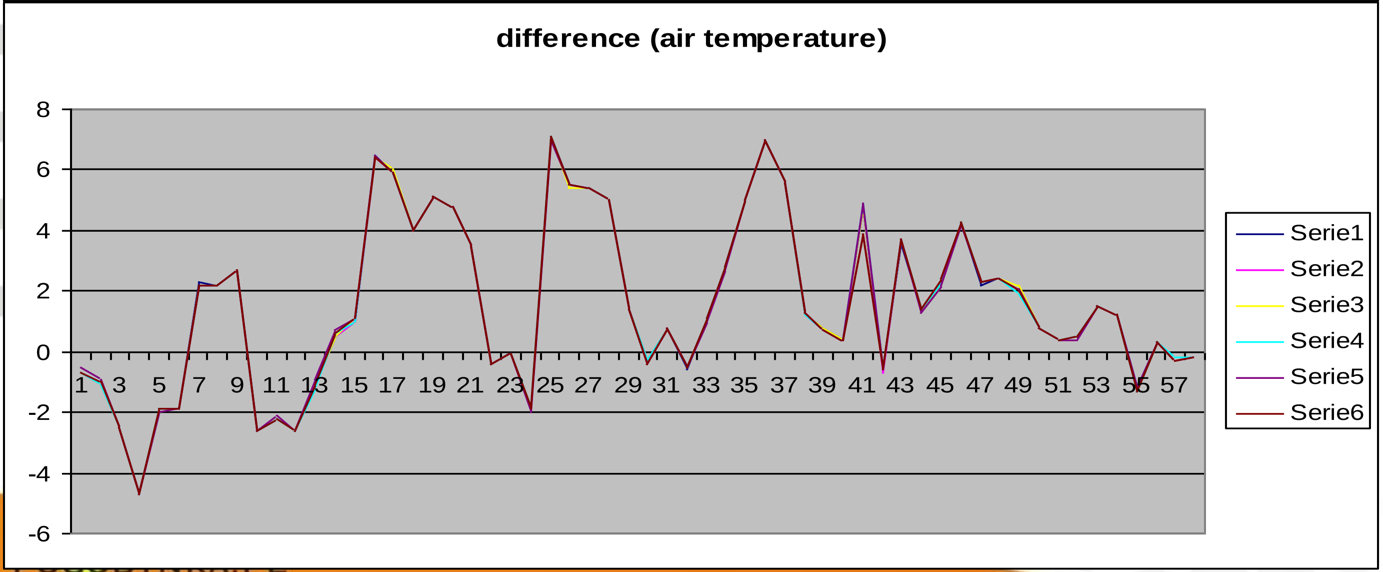

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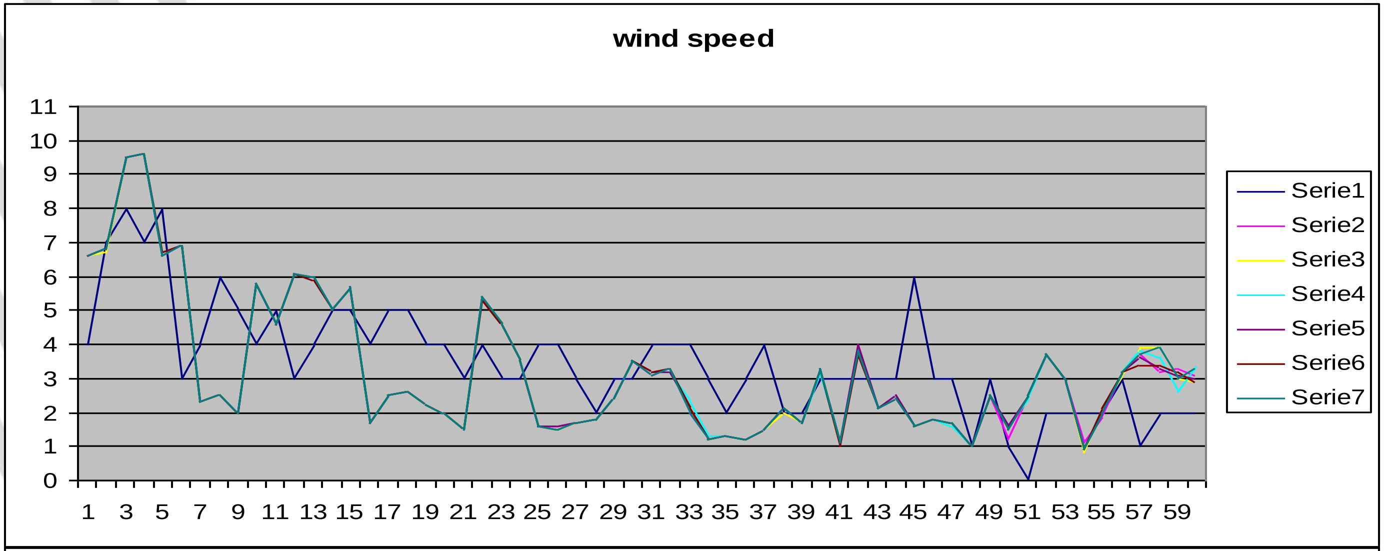
Example – results for 06.04.2013-12 UTC



Series 1 – Measurement

Series 2 – Reference

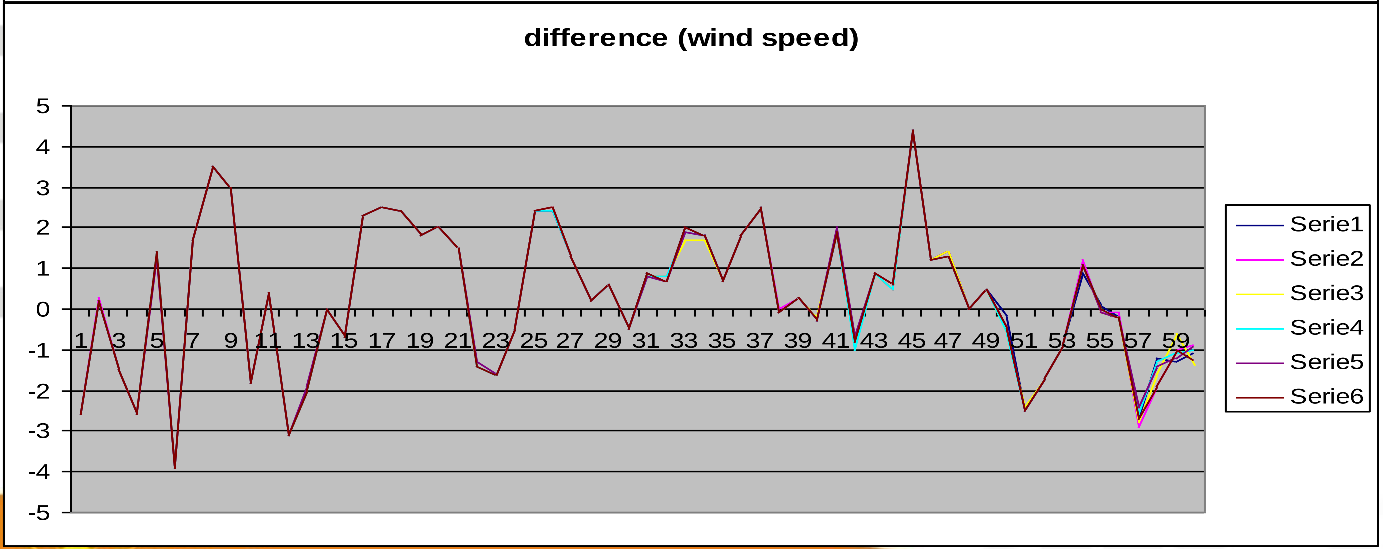
Series 3 – sqrt(T)

Series 4 – f(T)

Series 5 – f(T²)

Series 6 – α(t)exp(T)

Series 7 – exp(T)



Series 1 – Reference

Series 2 – sqrt(T)

Series 3 – f(T)

Series 4 – f(T²)

Series 5 – α(t)exp(T)

Series 6 – exp(T)

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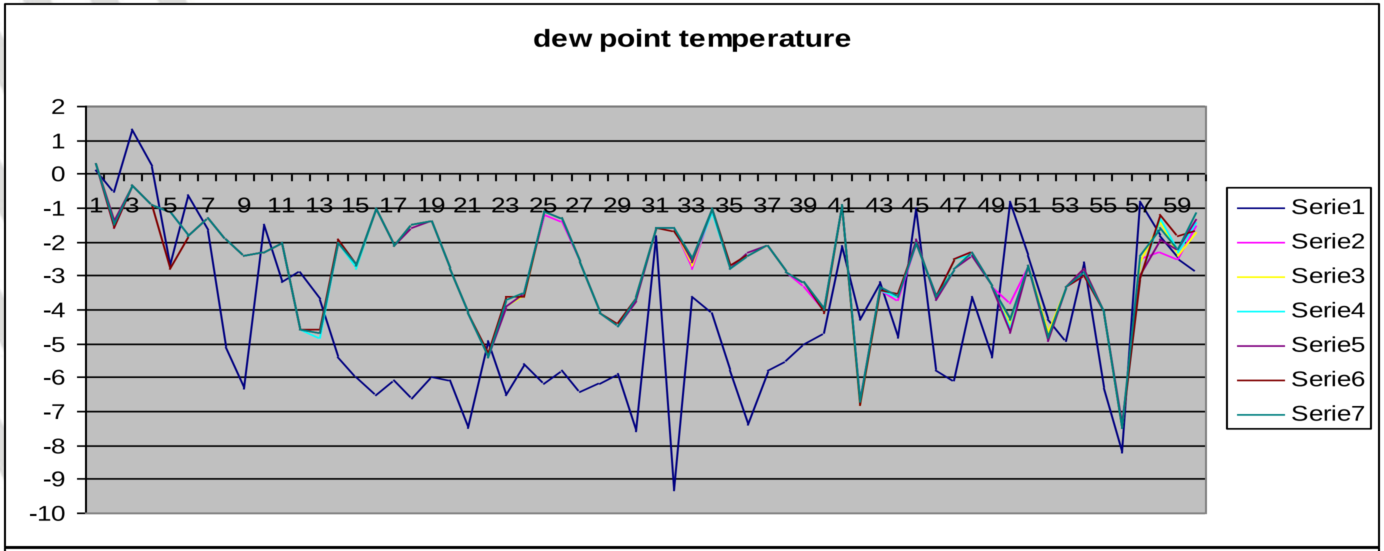
Example – results for 06.04.2013-12 UTC



Series 1 – Measurement

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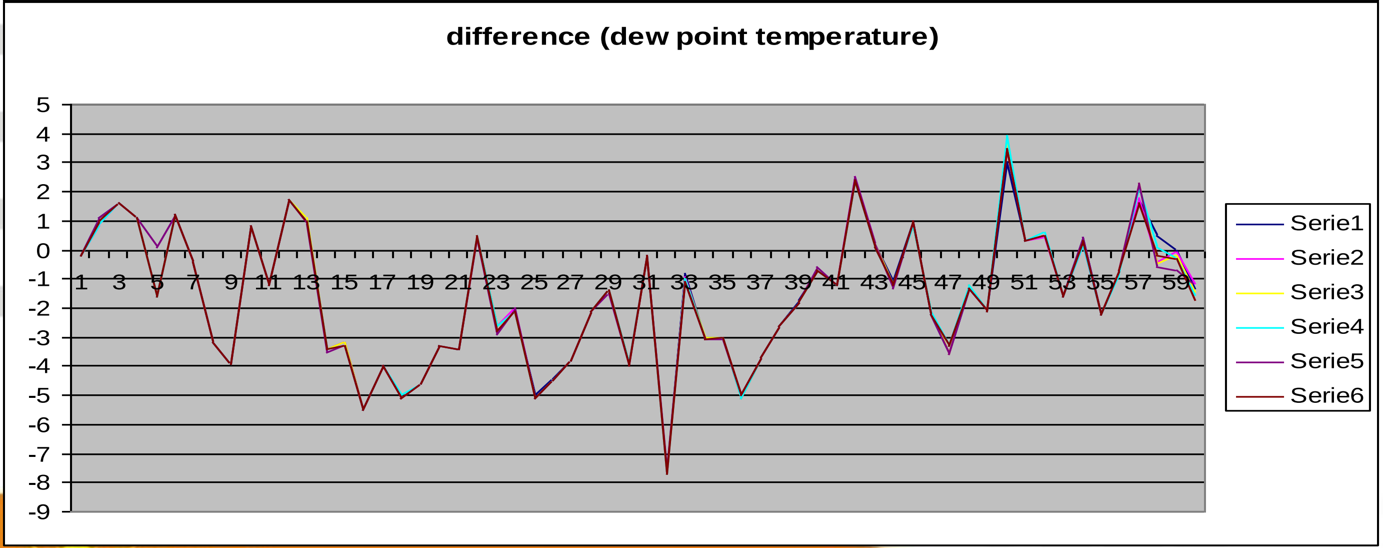

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Series 6 – exp(T)

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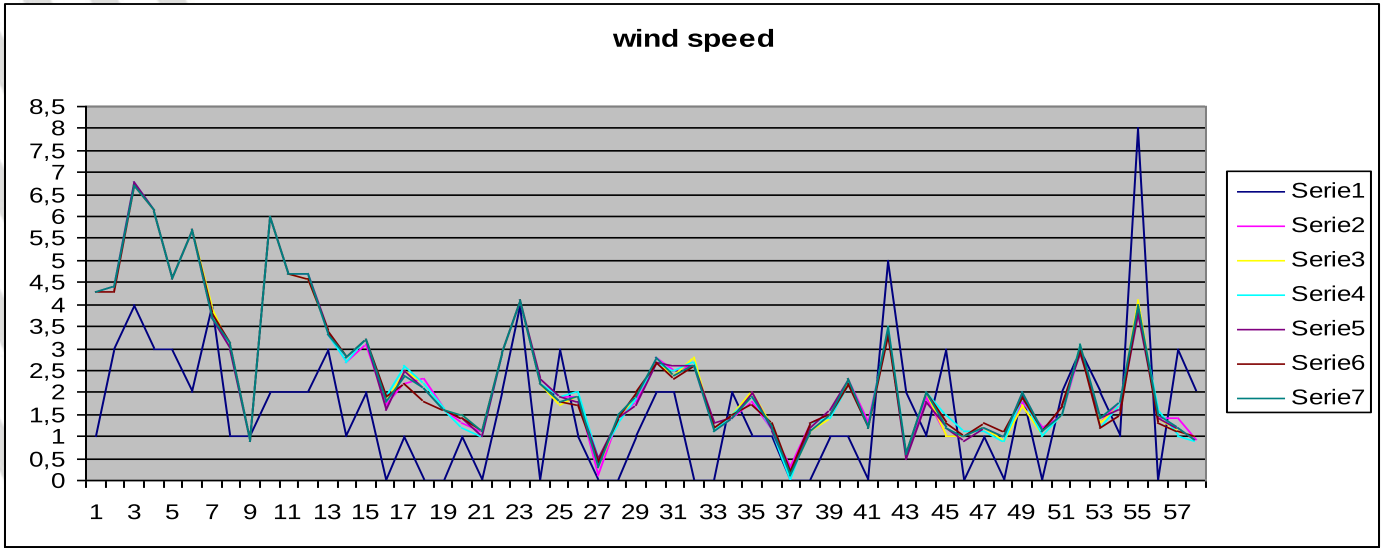
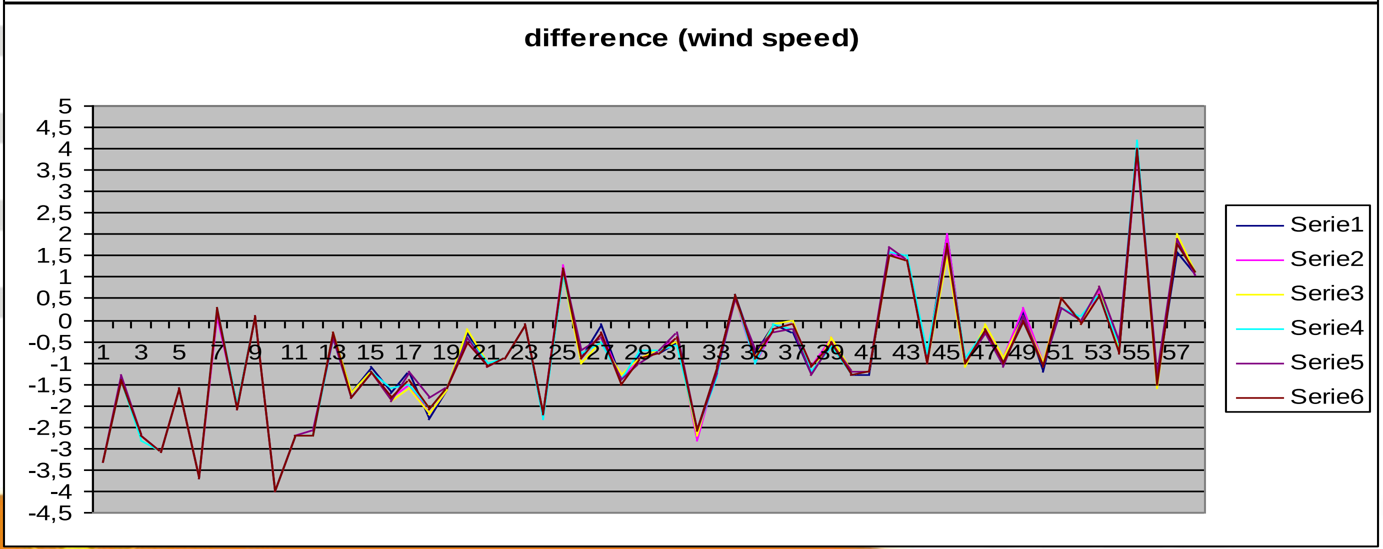
Example – results for 12.06.2013-00 UTC



Series 1 – Measurement
Series 2 – Reference
Series 3 – sqrt(T)
Series 4 – f(T)
Series 5 – f(T²)
Series 6 – α(t)exp(T)
Series 7 – exp(T)



Series 1 – Reference
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Series 3 – f(T)
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Series 5 – α(t)exp(T)
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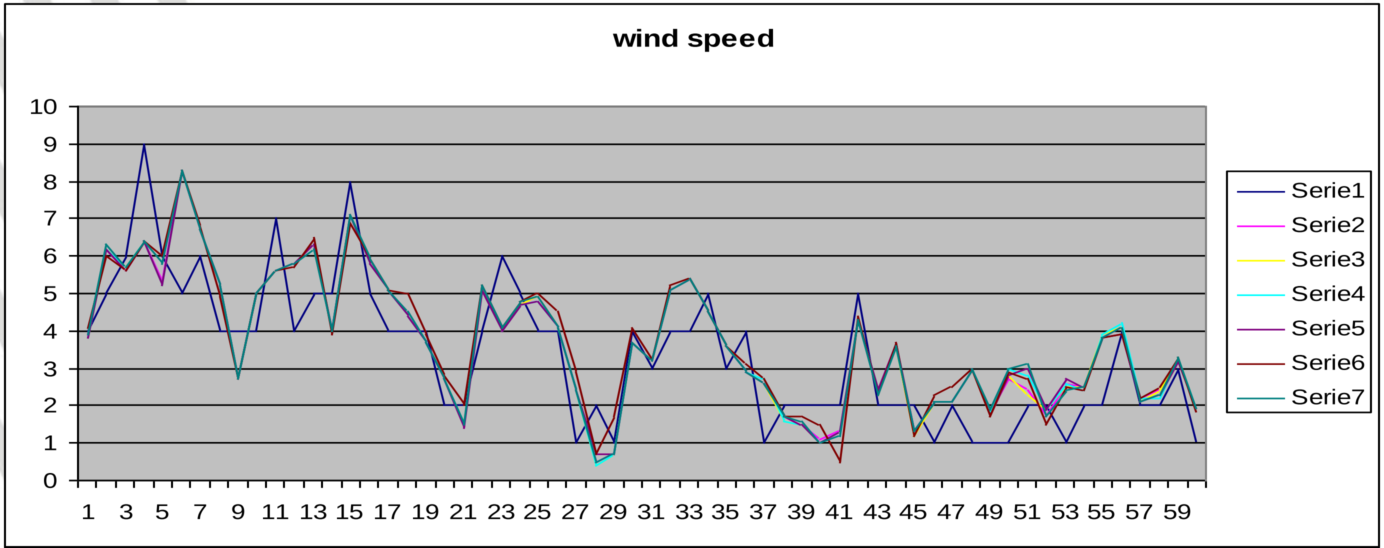
Example – results for 12.06.2013-00 UTC



Series 1 – Measurement

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Series 3 – sqrt(T)

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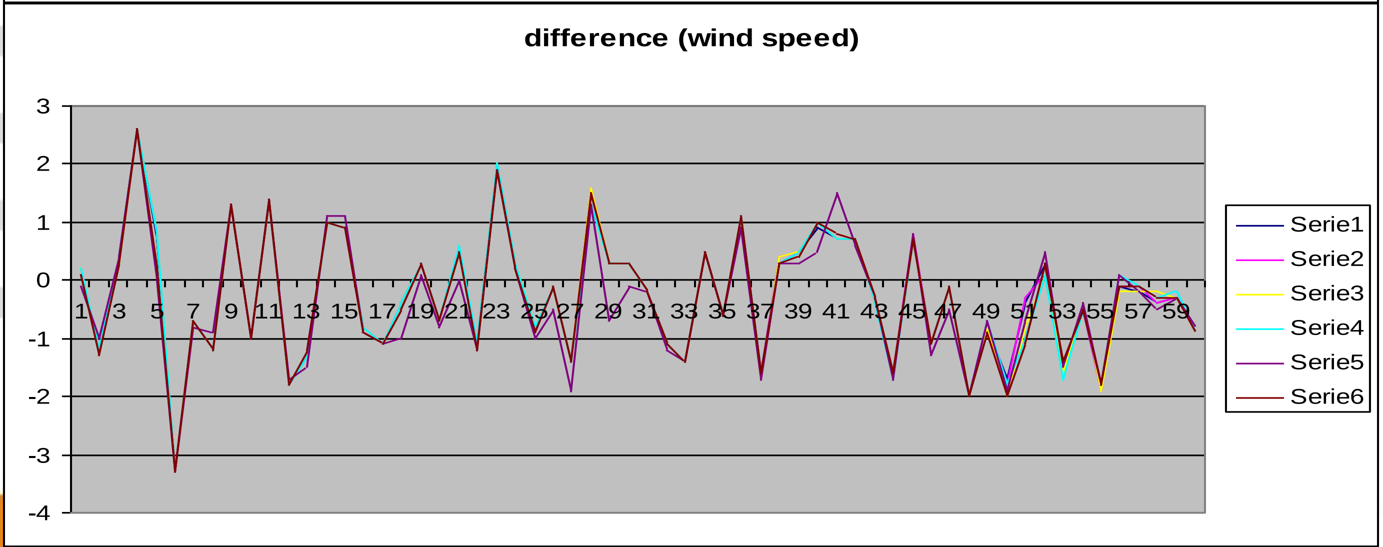

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Series 5 – α(t)sqrt(T)

Series 6 – exp(T)

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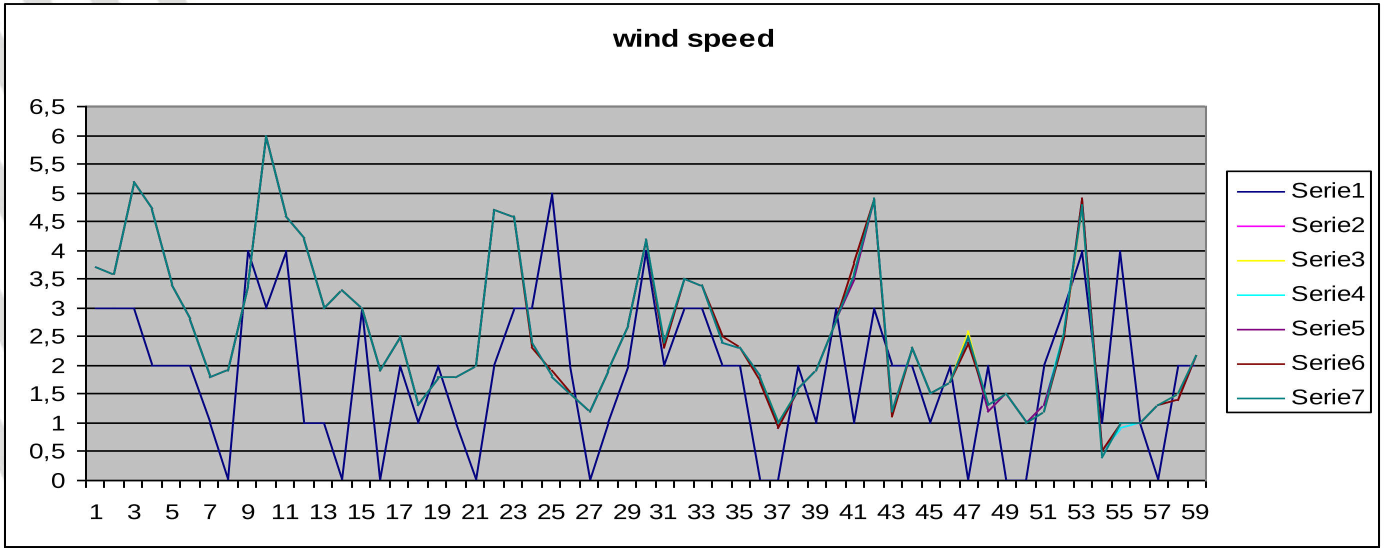
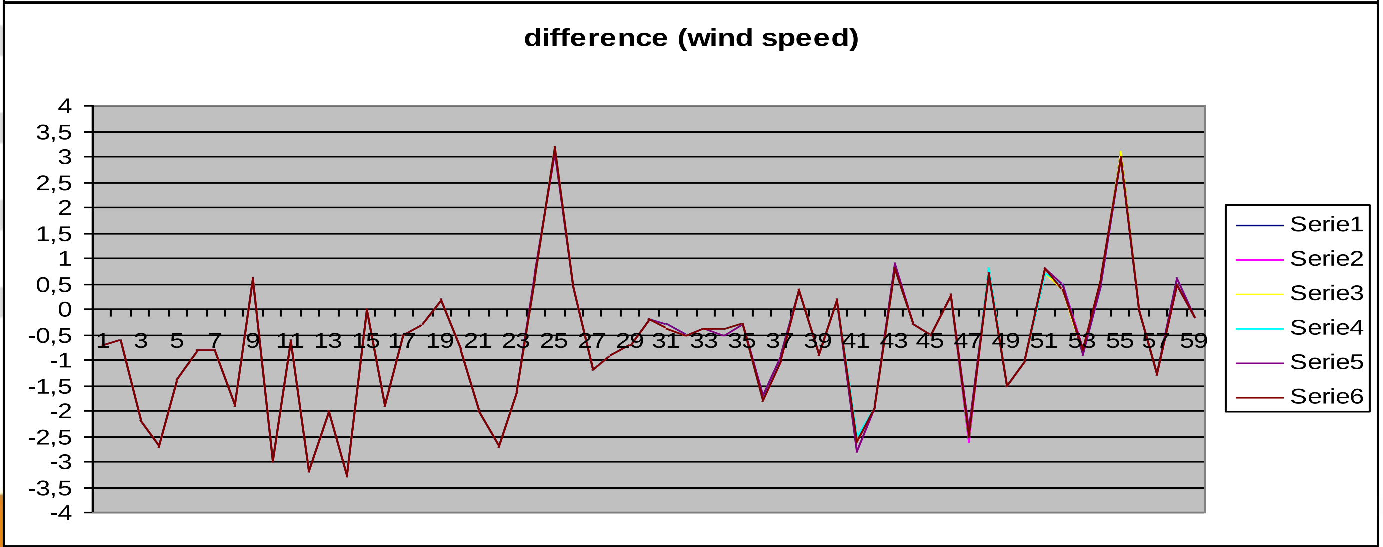
Experiments in soil physics – changes in ”bare soil” parameterization

Example – results for 06.09.2013-00 UTC



Series 1 – Measurement
Series 2 – Reference
Series 3 – sqrt(T)
Series 4 – f(T)
Series 5 – f(T²)
Series 6 – α(t)exp(T)
Series 7 – exp(T)



Series 1 – Reference
Series 2 – sqrt(T)
Series 3 – f(T)
Series 4 – f(T²)
Series 5 – α(t)exp(T)
Series 6 – exp(T)

Statistical analysis

For all fields following statistics were produced (data for two seasons):

a) RMSE, R (Pearson) Correlation coefficient

b) Coordinates of ”Mass Center” of field $\boldsymbol{t_x}$ of differences

$$\vec{r}_d = \frac{\sum\limits_{\vec{r}_x} t_x \cdot \vec{r}_x}{\sum\limits_{\vec{r}_x} t_x}$$

MDV – Maximum Difference of Values

$$MDV = \max\left[\left|t_r(i,j) - t_c(i,j)\right|\right] \cdot \operatorname{sign}\left[t_r(i,j) - t_c(i,j)\right]$$

c) NDV – Normalized Difference of Values

$$NDV = \frac{\langle T_c \rangle - \langle T_r \rangle}{\langle T_r \rangle} \cdot 100\%; \quad \langle T_x \rangle = \frac{\sum\limits_{i=1}^{i_{max}} \sum\limits_{j=1}^{j_{max}} t_x(i,j)}{i_{max} \cdot j_{max}}$$

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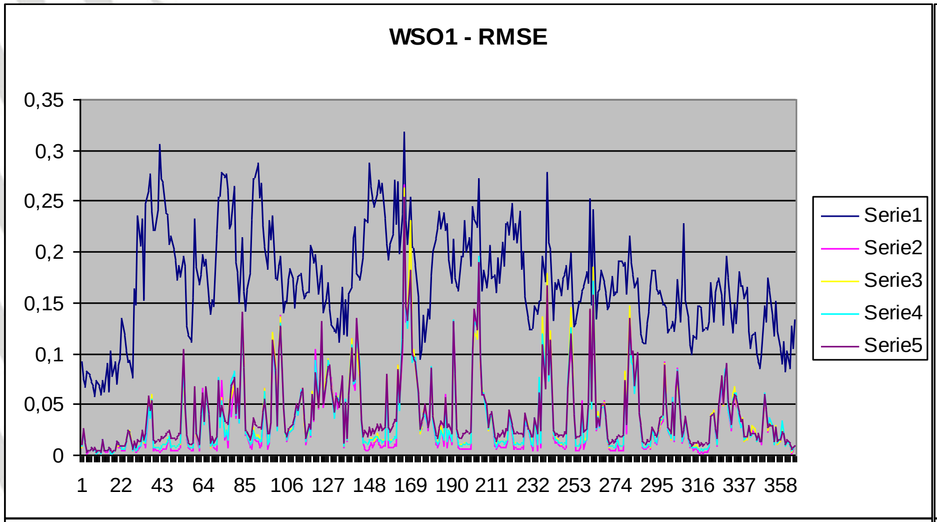
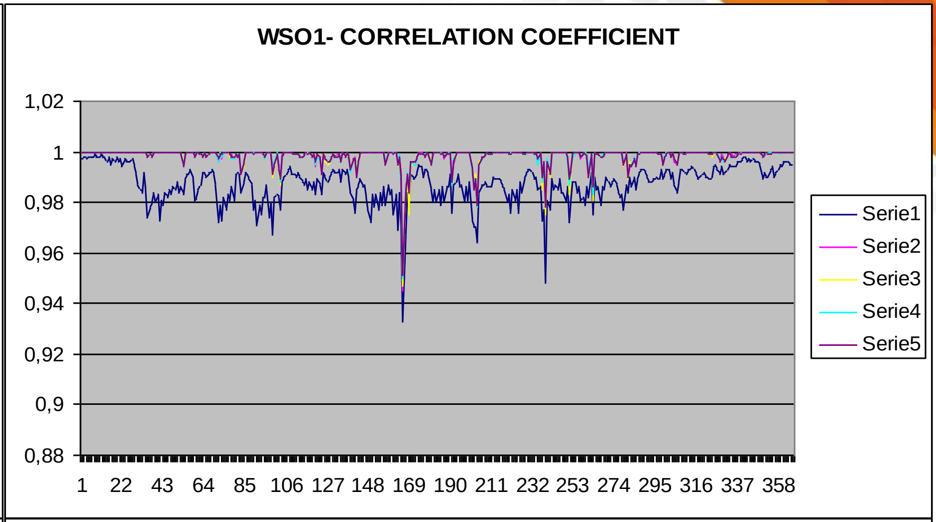
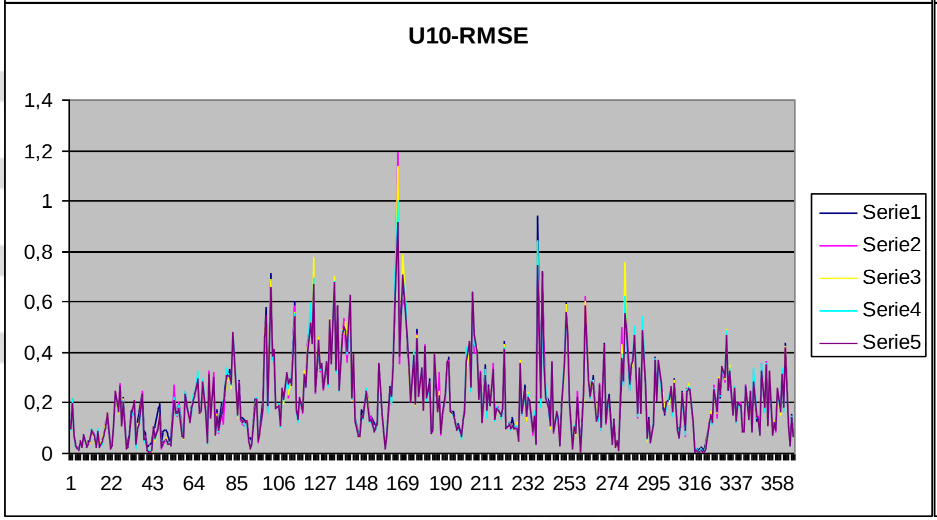
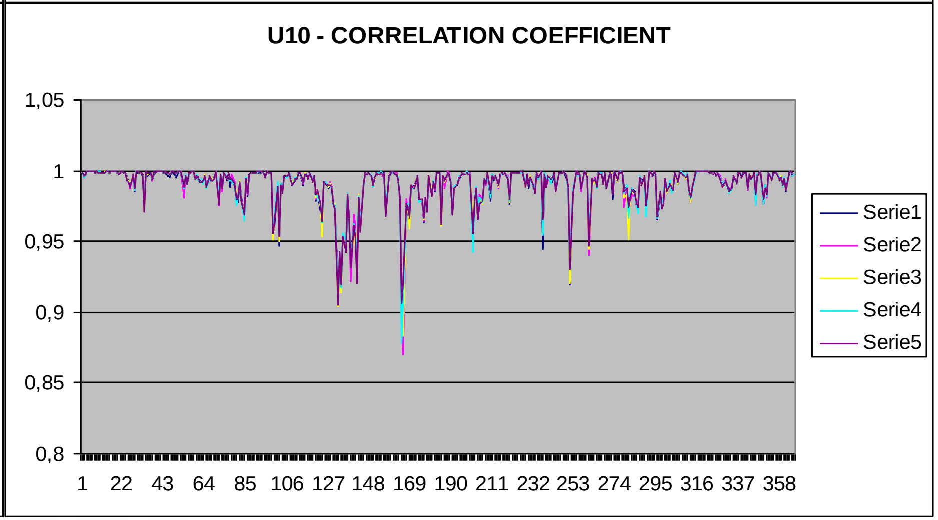
Statistical analysis – examples









Series 1- reference – exp(T); Series 2 – reference – sqrt(T); Series 3 – reference – f(1/T); Series 4 – reference – f(T); Series 5 – reference – f(T²)

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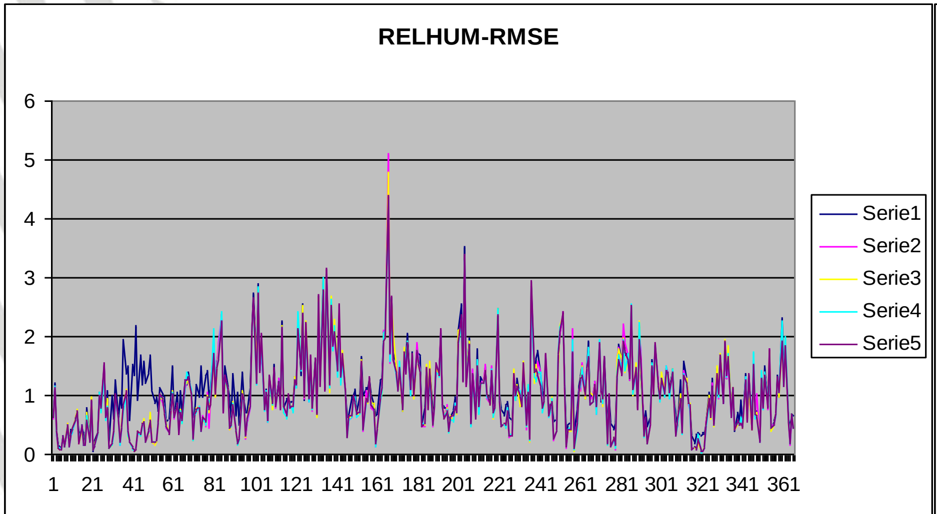
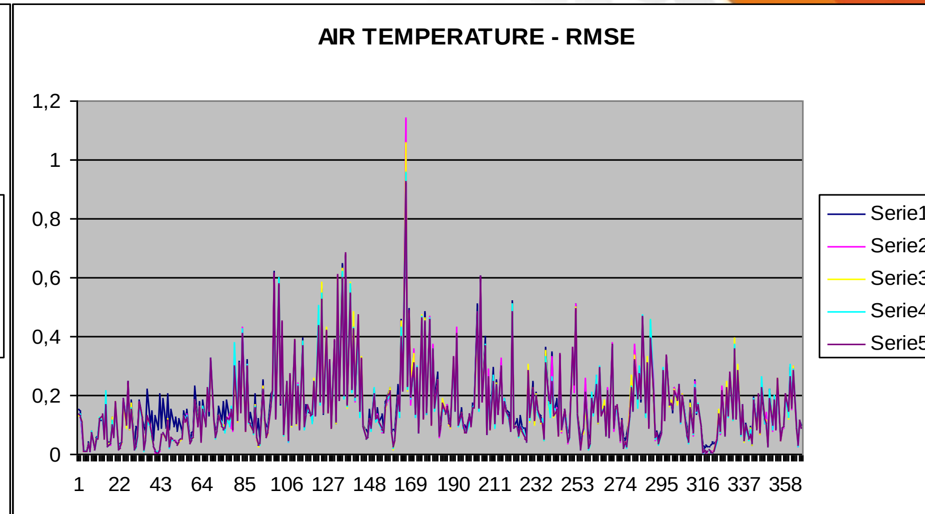
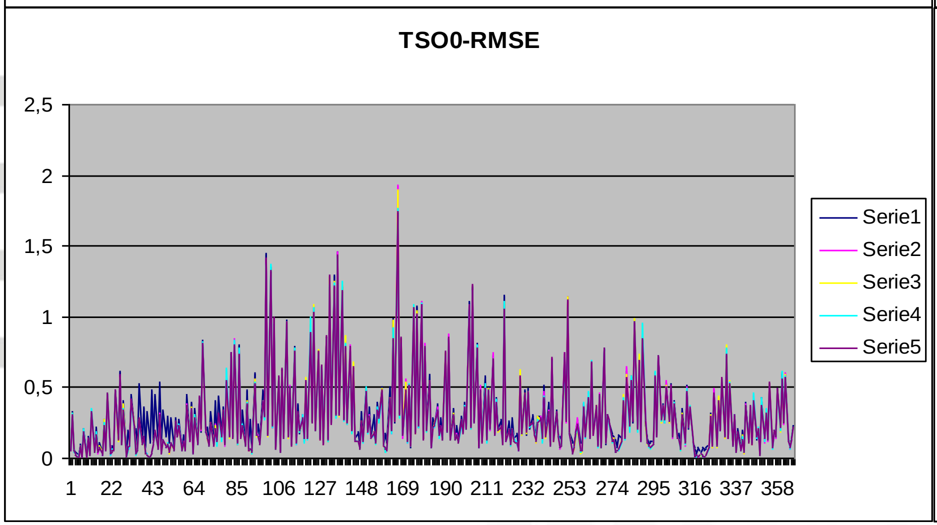
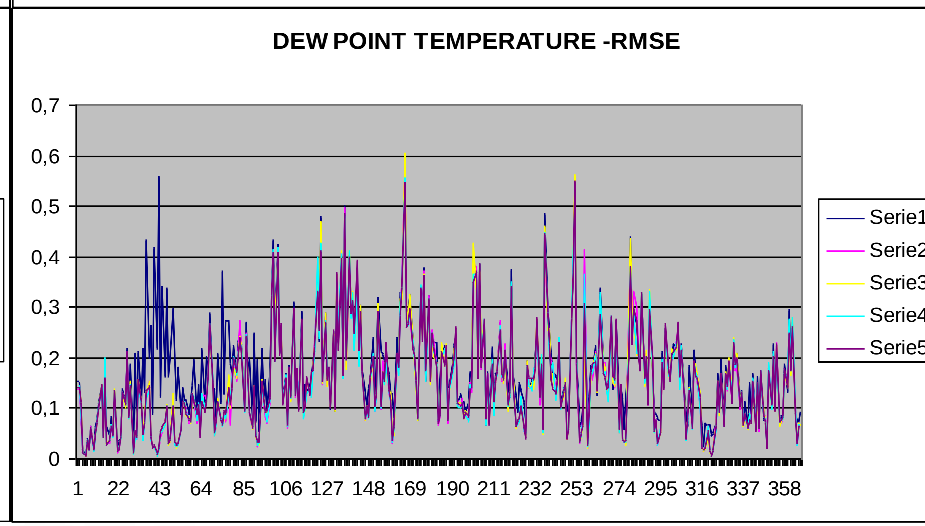
Statistical analysis – examples



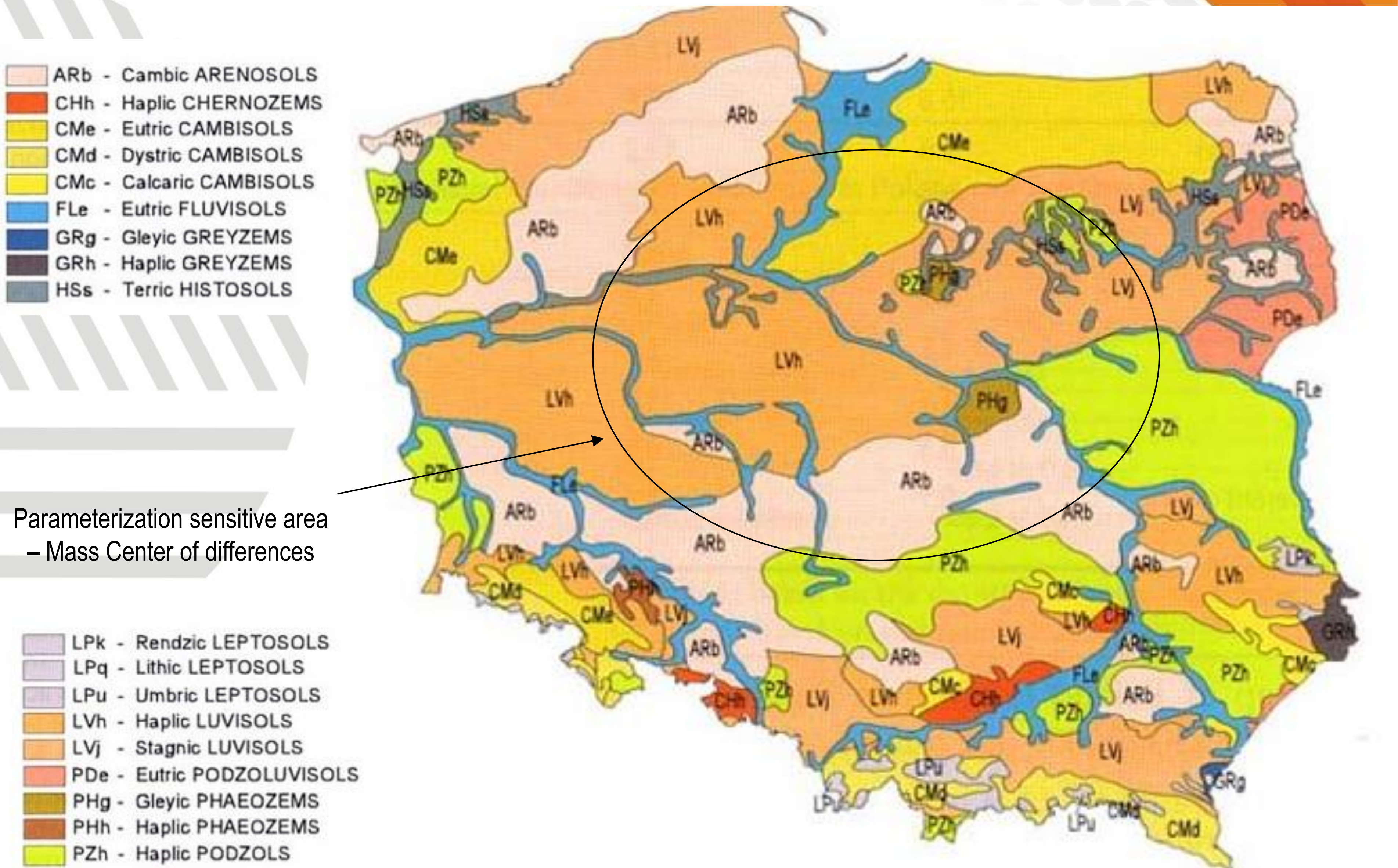






Series 1- reference – exp(T); Series 2 – reference – sqrt(T); Series 3 – reference – f(1/T); Series 4 – reference – f(T); Series 5 – reference – f(T^2)

Statistical analysis – examples



Plans and to-do list

a) …to continue tests of altered parameterization using ensemble forecast (COTEKINO)

b) … to introduce correction to Richards' equation *via* a change in numerical scheme.

c) … to prepare a new parameterization of thermal processes

d) … to combine type of soil (clay, sand, loam…) with different values of exponent "a"

e) ... to utilize a different values of β, χ and γ

$$\alpha(t) = -\frac{\beta}{t_s^2 - t_r^2} t^2 + \frac{\chi \cdot t_s^2 - \gamma \cdot t_r^2}{t_s^2 - t_r^2}$$

f) … to enter in theoretical work on parameterization of plants physiology and its influence on soil processes in model.

Summary

- New parameterization has an impact on Soil Water Content (SWC). This impact declines with depth. It also influences the soil temperature, but mostly in the upper part of soil and only in case if soil is not frozen.
- …it influences on (improves forecasts of) other meteorological fields (windspeed, temperature, dew point, specific water vapor content).
- results are sensitive to parameterization with exponential dependence of temperature together with corrective ratio introduced (best results so far!)
- New parameterization influenced soil fields – magnitude of the influnce quantitatively unknown due to lack of other measurements than soil temperature at four levels.
- Further improvement is expected with changes to Richards' equation

Thank you for attention

☺

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