Instytut Meteorologii i Gospodarki Wodnej
Państwowy Instytut Badawczy

The impact of the modified parameterization of the bare soil on forecast meteorological field and structure of PBL

Grzegorz Duniec, Andrzej Mazur

Institute of Meteorology and Water Management
National Research Institute
Department of Numerical Weather Forecasts – COSMO

POGODYNKA.PL
SERWIS POGODOWY IMGW-PIB

7 IX 2015

Content

- Introduction.
- Numerical experiments and results.
- Plans.

Changed in description flux water through the surface

- We changed flux water through the soil, we considered different options:

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

- **Version 1:**

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

Changed in description flux water through the surface

- **Version 2** (Darcy equation):

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

- **Version 3** (modified Darcy equation):

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

Introduction correction factor in flux water through the soil

- Correction factor depending on time:

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

- Fluxes water through the soil with correction factor:
- **Version 4**: $\vec{F}_m = -\alpha(t) D(\theta) \left(\frac{T}{T_0} \right)^a \vec{\nabla}\theta$
- for a = -1, 0, ½, 1, 2
- **Version 5:** $\vec{F}_m = -\alpha(t) D(\theta) \exp\left(\frac{T}{T_0} \right) \vec{\nabla}\theta$

Changed in description flux water through the surface

- **Version 6:** $$\vec{F}_m = -D(\theta)\left(\frac{T}{T_0}\right)^a \vec{\nabla}\theta$$
- We considered „a = -1, ½, 1, 2”
- **Version 7:** $$\vec{F}_m = -\alpha(t)D(\theta)\left(\frac{T}{T_0}\right)^a \vec{\nabla}\theta$$
- We considered different values of „a” for different kind of soil:

- a = 4,74 for sandy loam
- a = 2,79 for sand
- a = 5,25 for loam
- a= 8,17 for clay loam
- a= 11 for clay

Meteorological profiles

- **We considered following profiles:**

a) **Air temperature profile;**

b) **Dew point temperature profile;**

c) **Component wind speed profile;**

d) **Changes in wind direction with height;**

Meteorological fields

- **We considered following meteorological field:**

a) Air temperature profile at 2 m a. g. l.;

b) Dew point temperature at 2 m a. g. l.;

c) Component wind speed at 10 m a.g. l.;

Numerical experiments and what we analyzed

- **For our numerical experiments we chose data for 2013.**
- **We analyzed the warm and cold season – average values for meteorological fields and profiles...**
- **…and monthly average values for meteorological fields.**
- **We compared:**

a) Results from observations (data from meteorological and aerological stations) with results from COSMO Model (reference, with change flux).

Meteorological and aerological station

- **We took into consideration 61 meteorological stations in Poland and 8 aerological stations in Europe:**

a) **Linderberg;**
b) **Praha – Libus;**
c) **Prostejov;**
d) **Poprad – Ganovce;**
e) **Łeba;**
f) **Legionowo;**
g) **Wrocław;**
h) **Kaliningrad.**

Meteorological and aerological station

- **We considered 30 levels:**

- **50 m, 100 m, 150 m, 200 m, 250 m, 300 m, 350 m, 400 m, 450 m, 500 m, 600 m, 700 m, 800 m, 900 m, 1000 m, 1100 m, 1200 m, 1300 m, 1400 m, 1500 m, 1750 m, 2000 m, 2500 m, 3000 m, 4000 m, 5000 m, 7500 m, 10000m, 12500 m, 15000 m.**

- **In particular, we focused on PBL.**

- **Meteorological fields**

a) air temperature,
b) dew point temperature
c) wind speed

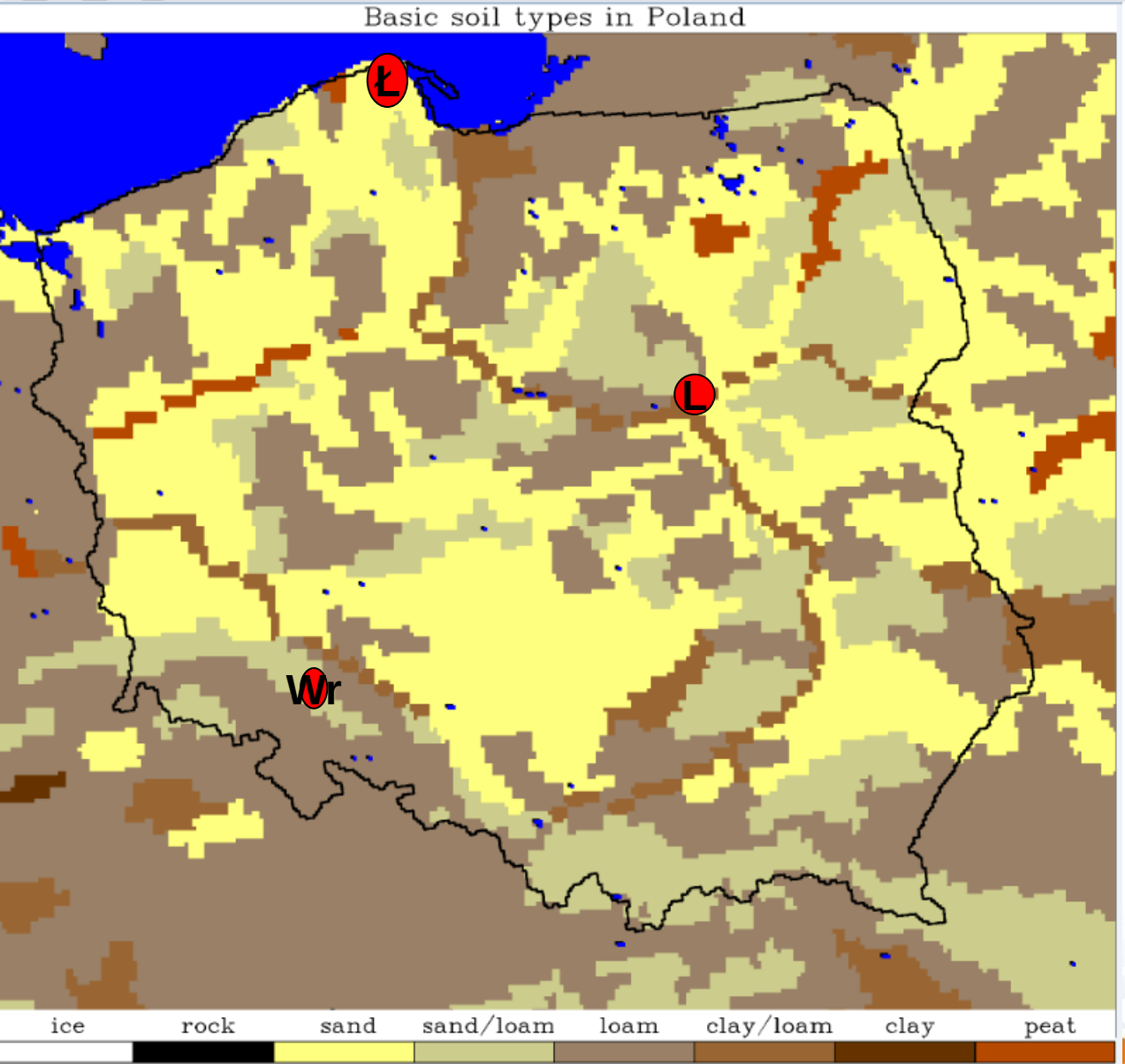
- average monthly
- the best results

$$y = |obs - ref| - |obs - x|$$

y > 0 – red color – „better results”

y < 0 – green color – „worse results”

Basic soil types in Poland

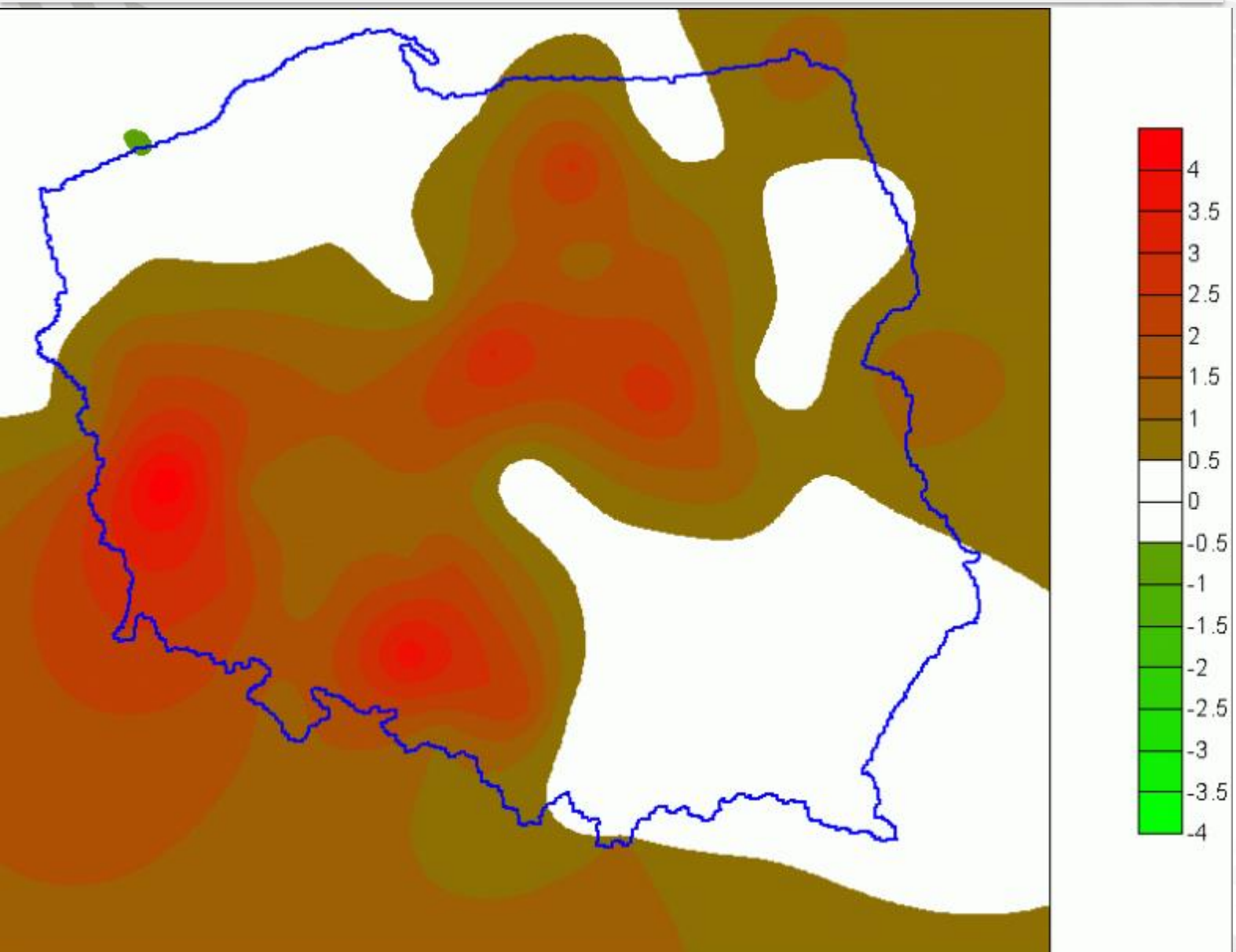


Wrocław - sand/loam

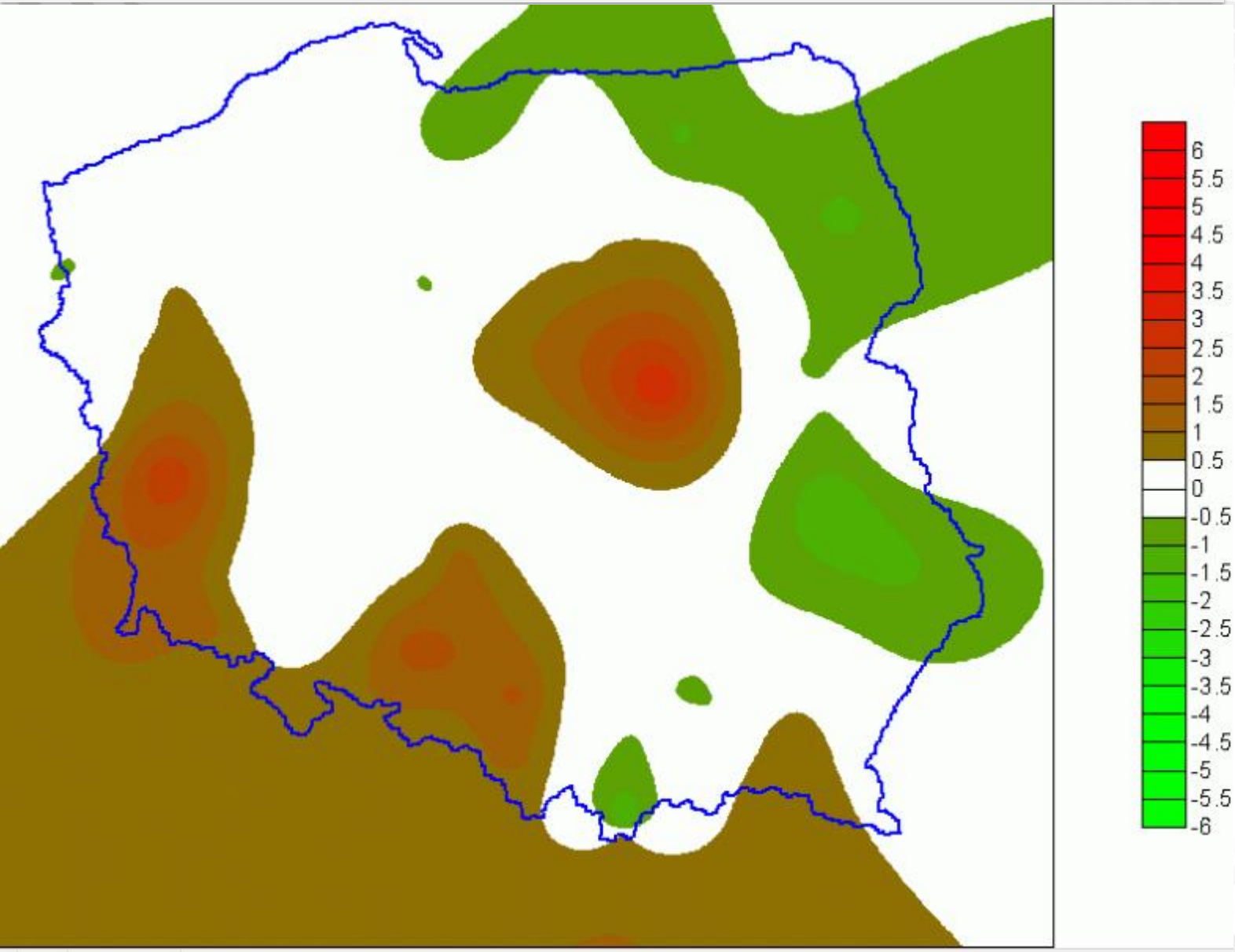
Legionowo – clay/loam

Łeba - sand

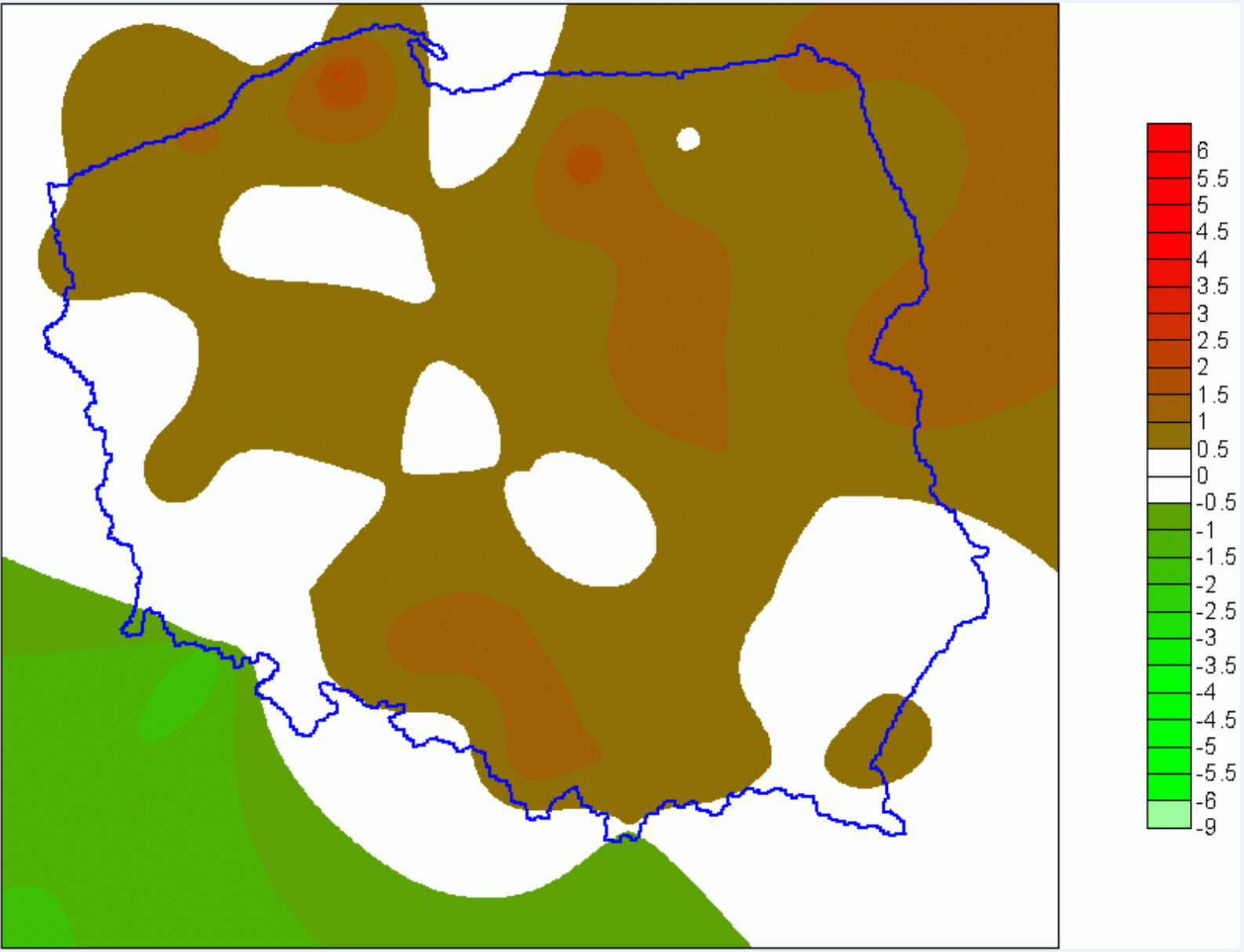
Dew point temperature (August) 00 UTC



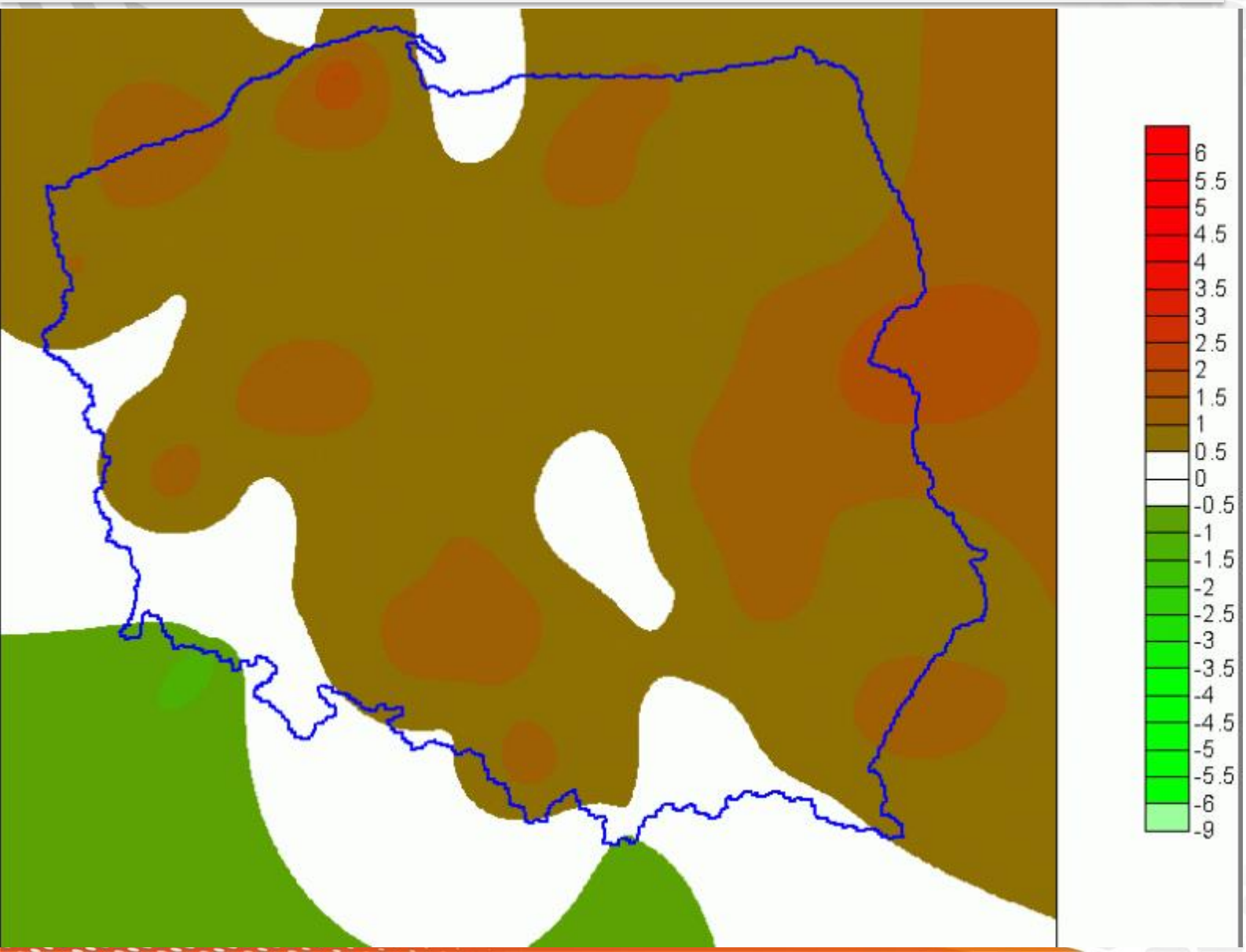
Dew point temperature (July) 12 UTC



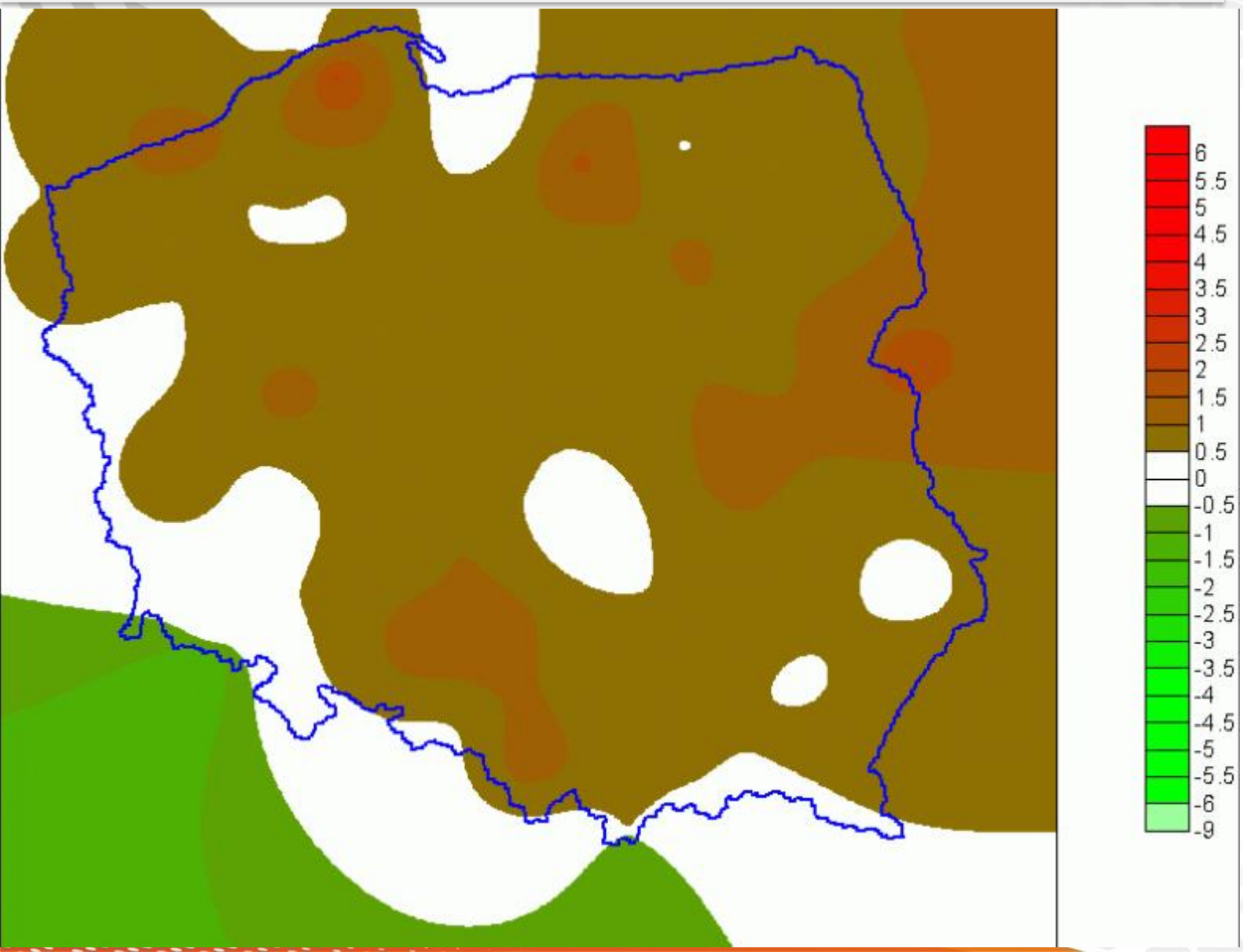
Air temperature at 2 m a. g. l. (July) – 00 UTC



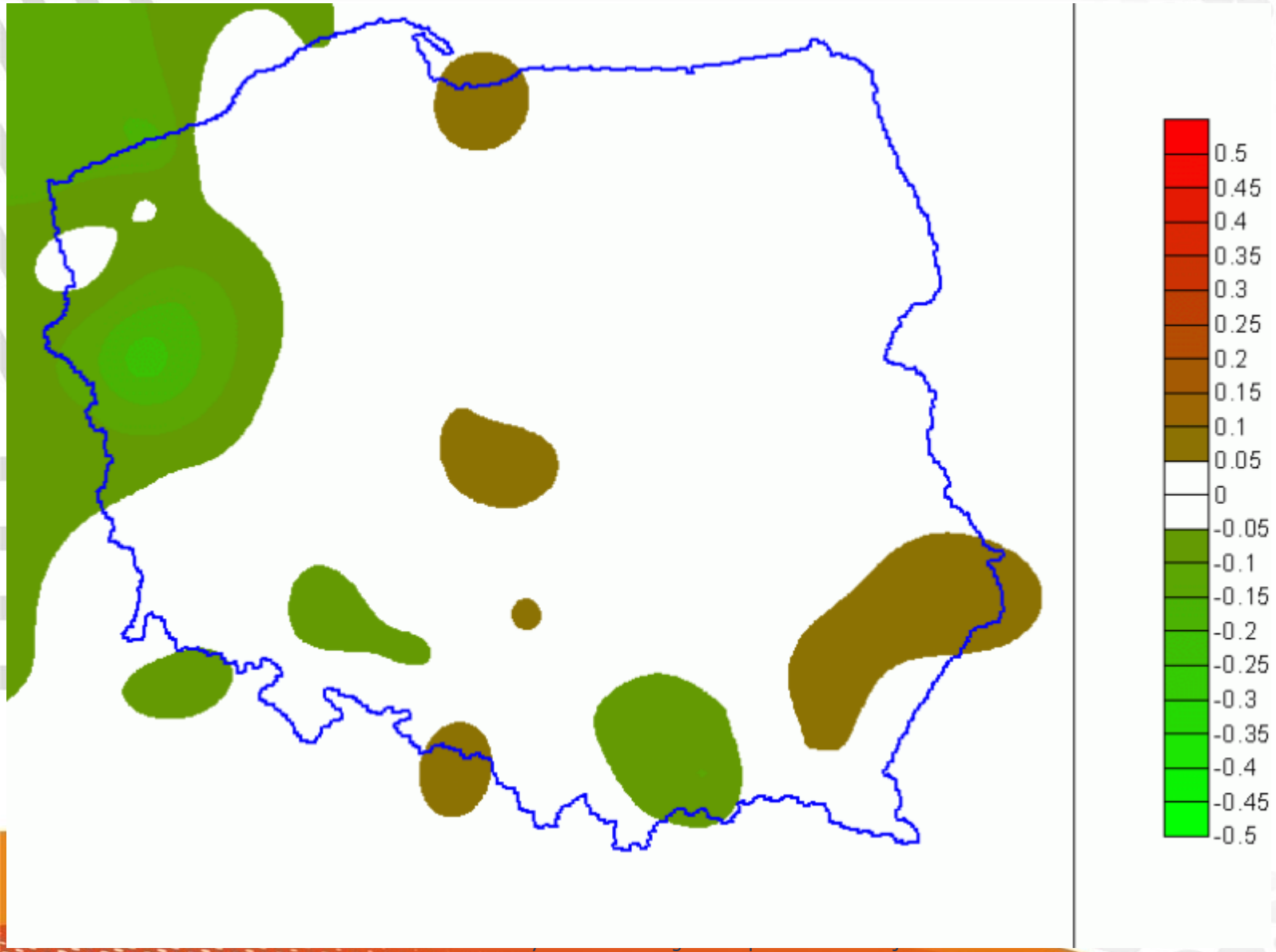
Air temperature at 2 m a. g. l. (April) – 12 UTC



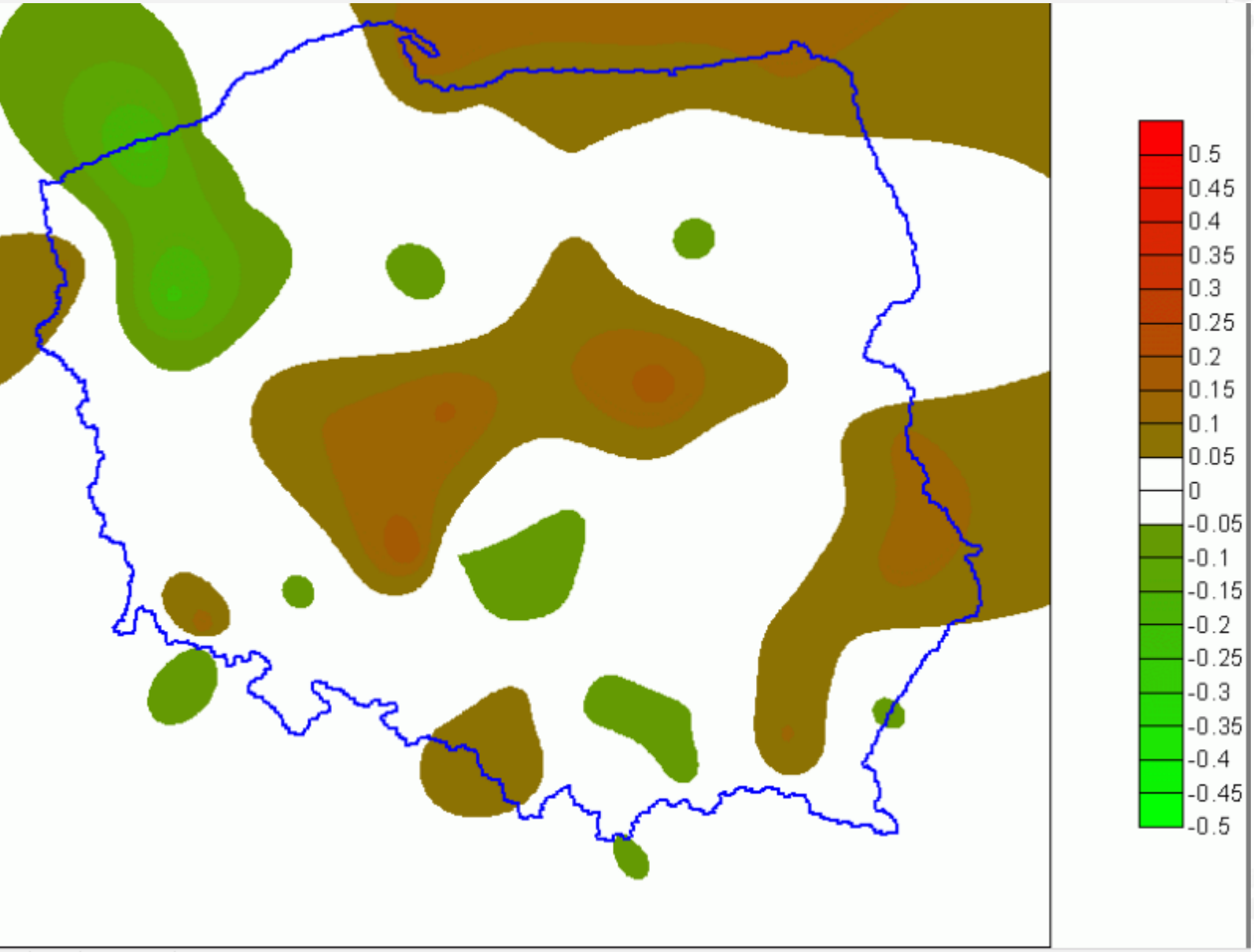
Air temperature at 2 m a. g. l. (April)



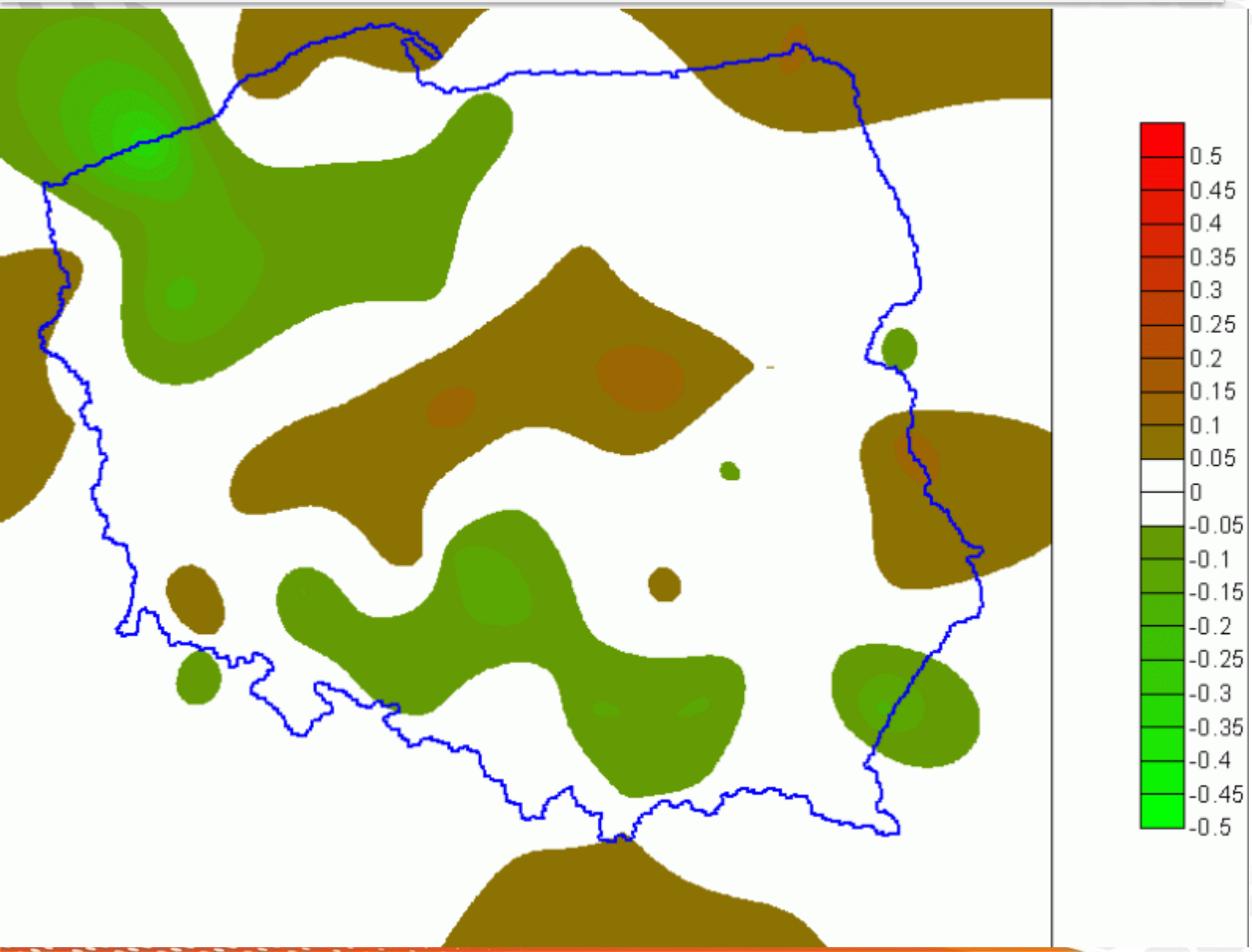
Wind speed (January) – 00 UTC



Wind speed (April) 12 UTC

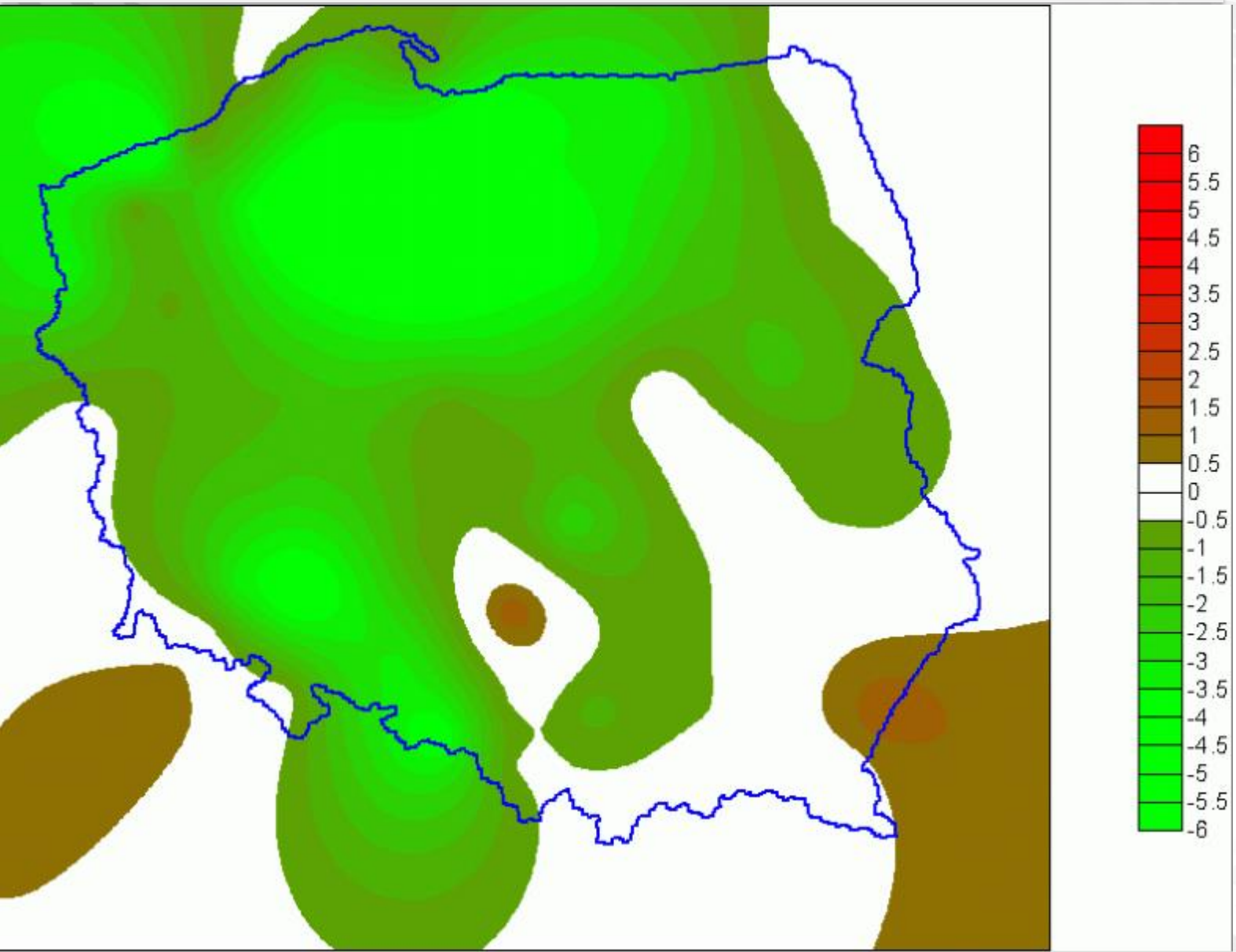


Wind speed (April)

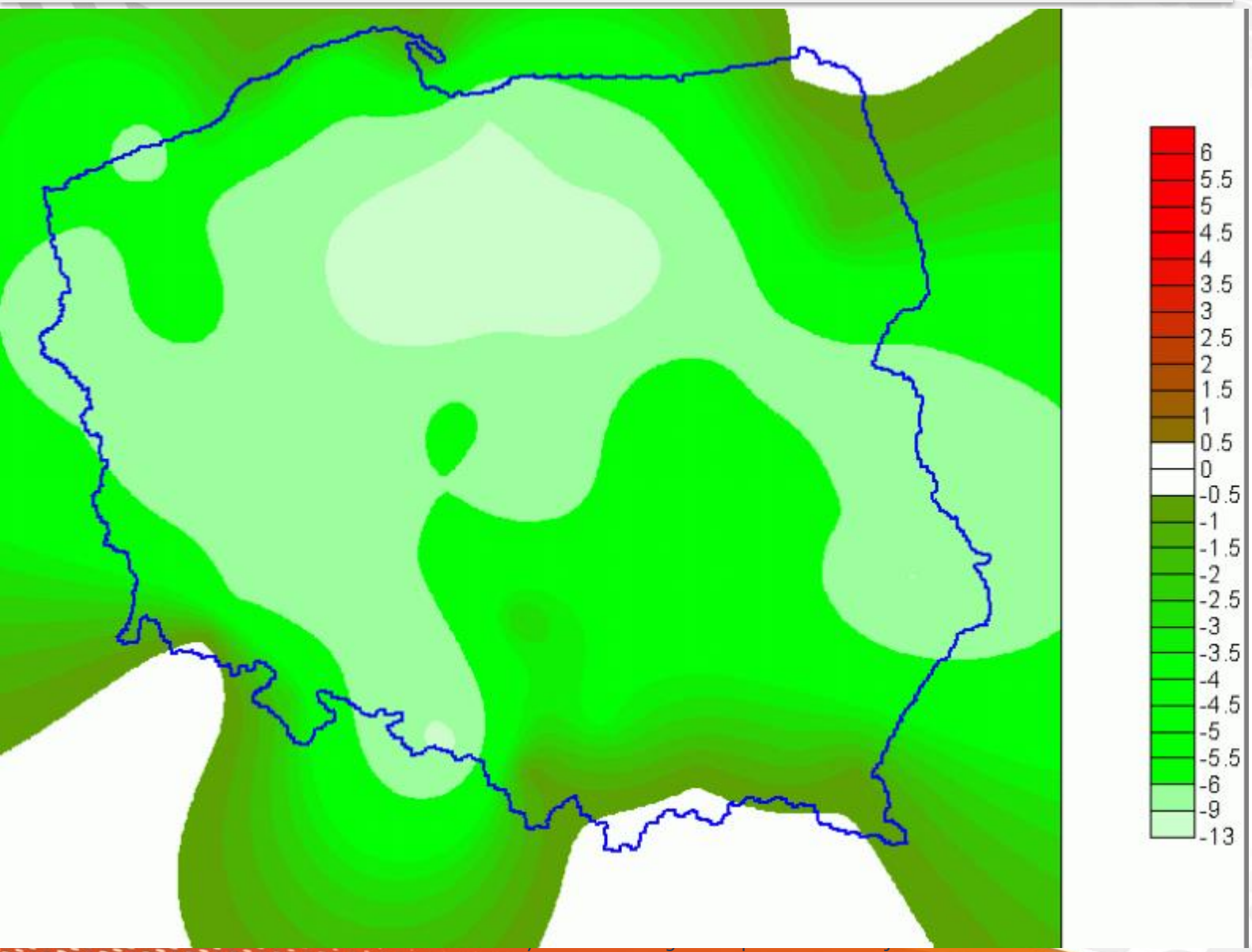


- average monthly
- the worst results

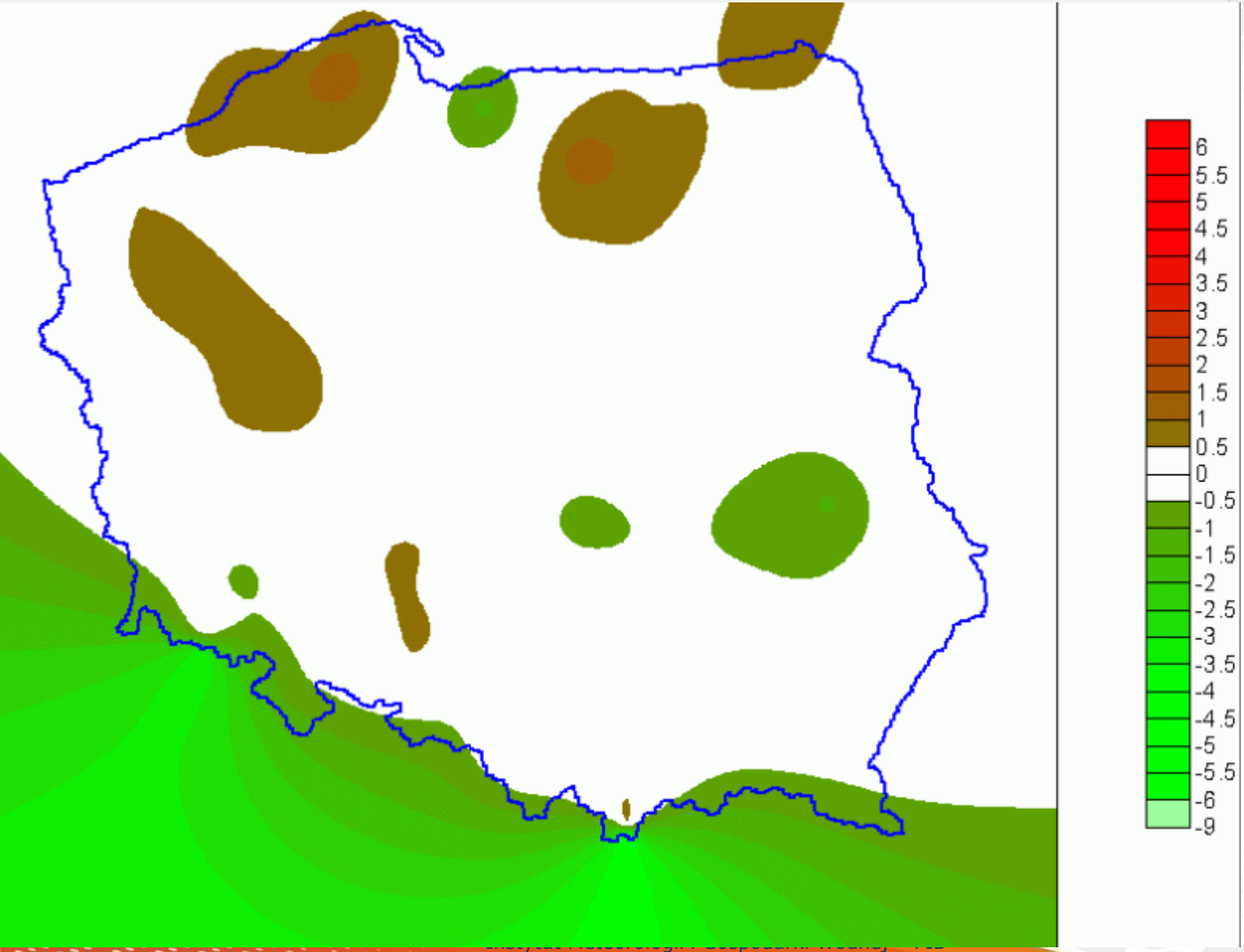
Dew point temperature (March) 00 UTC



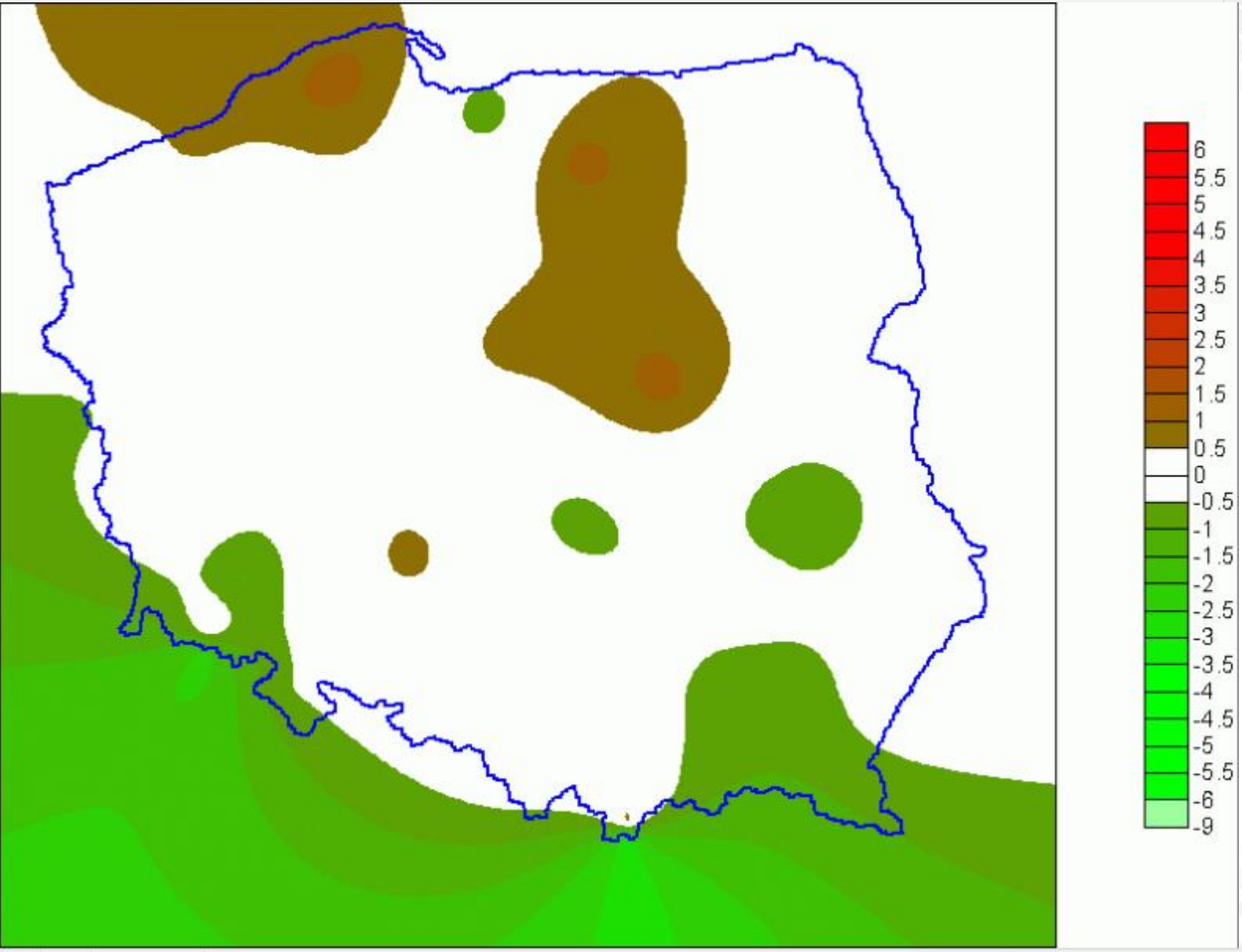
Dew point temperature (March) 12 UTC



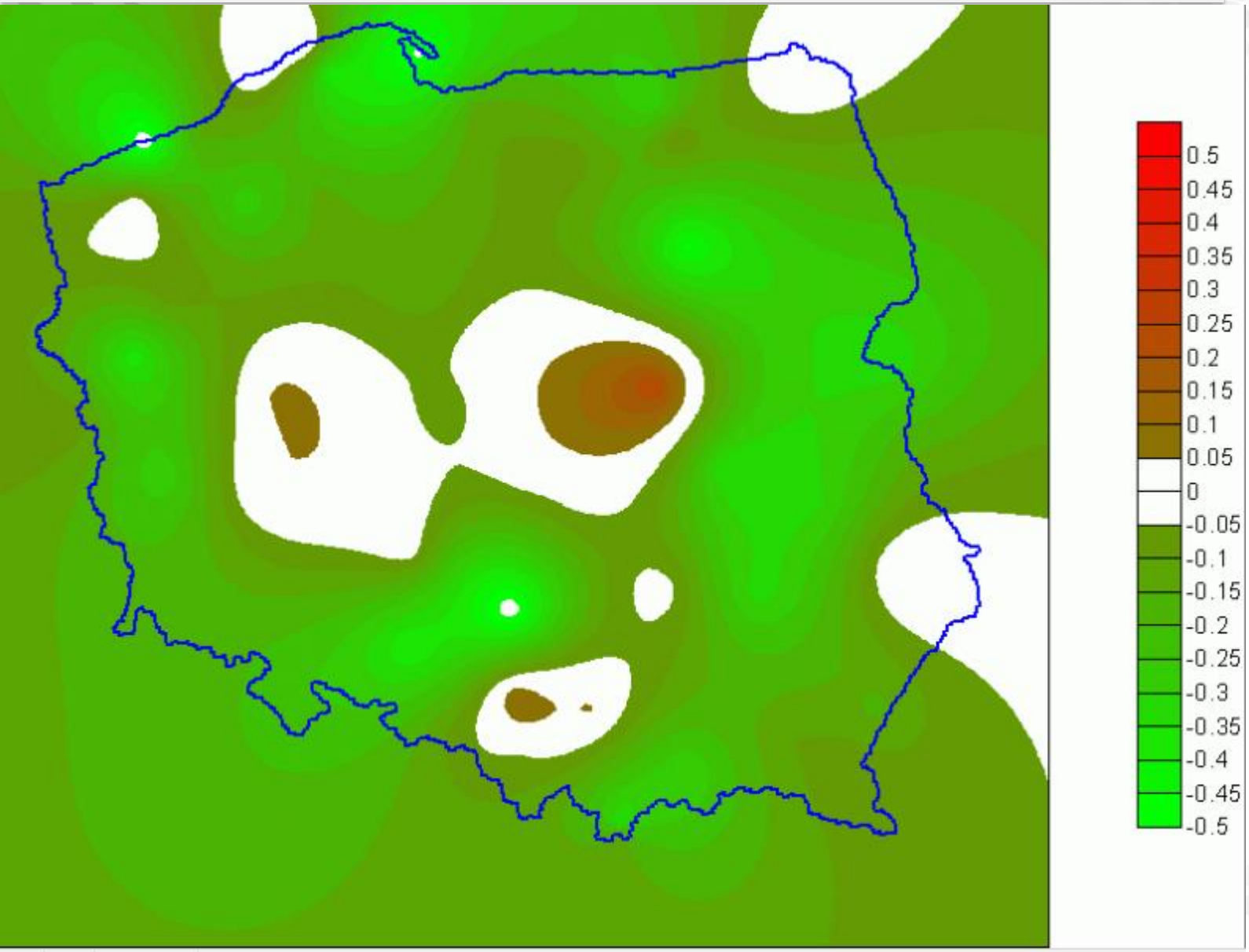
Air temperature at 2 m a. g. l. (May) 00 UTC



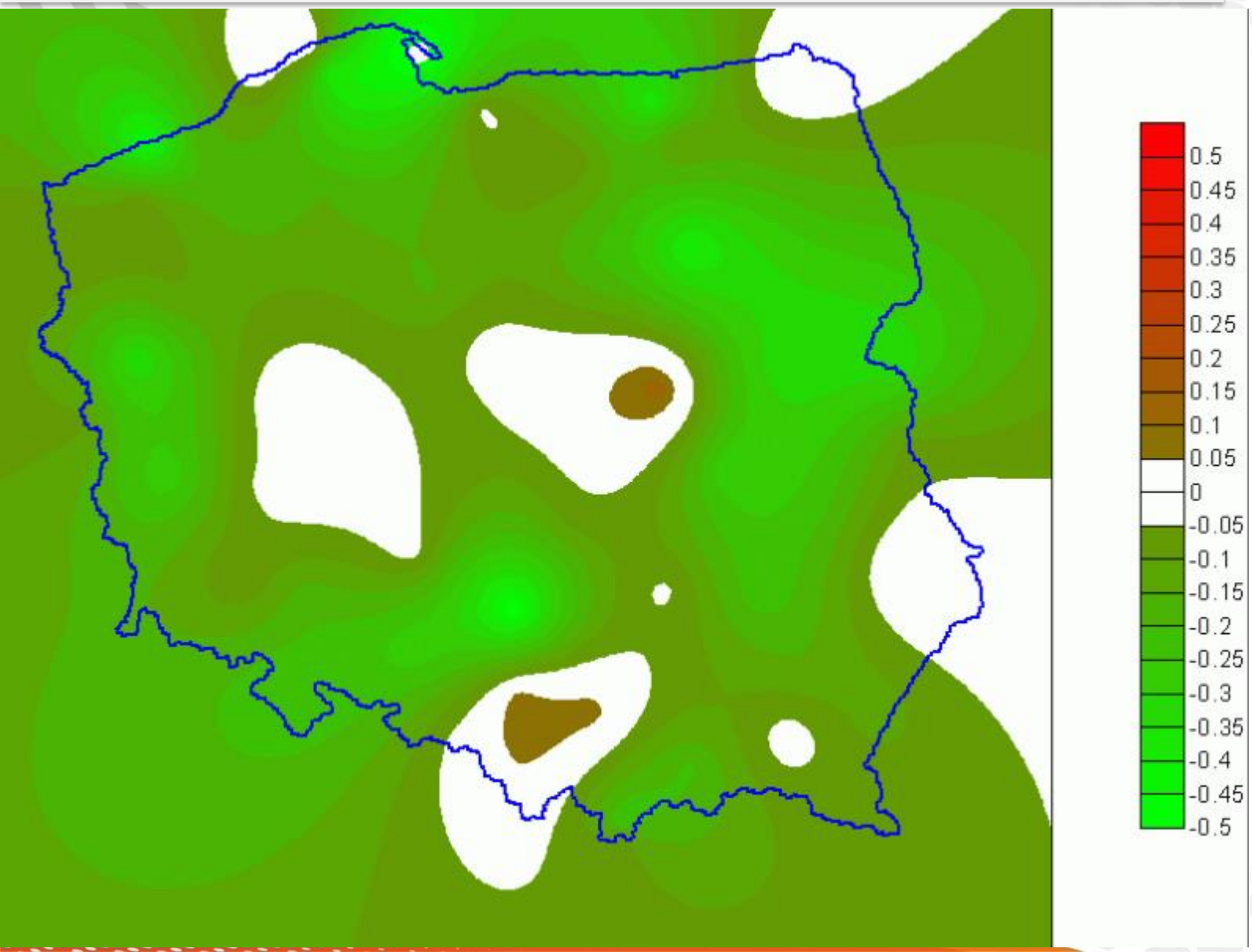
Air temperature at 2 m a. g. l. (May) 12 UTC



Wind speed (September) 00 UTC

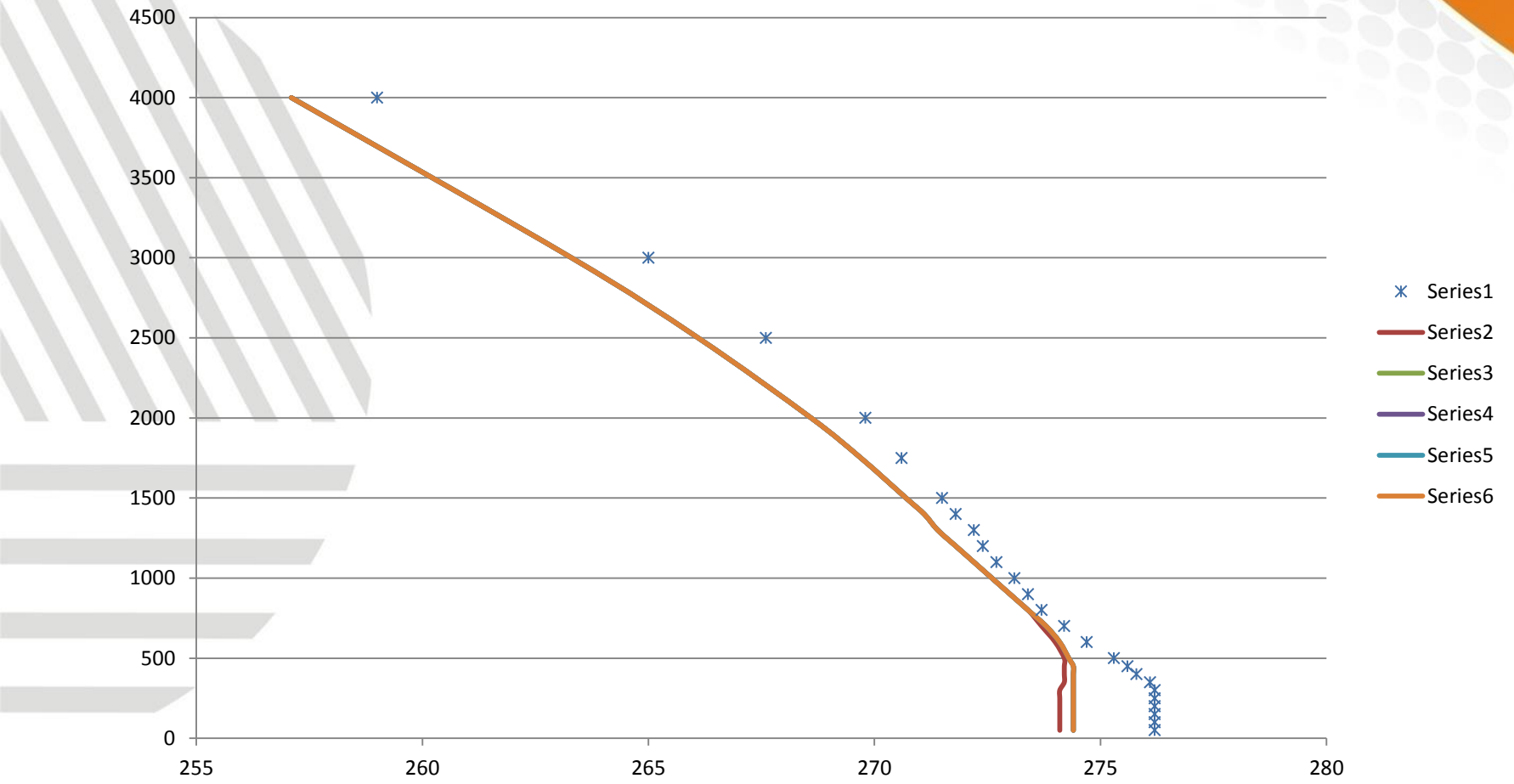


Wind speed (September)



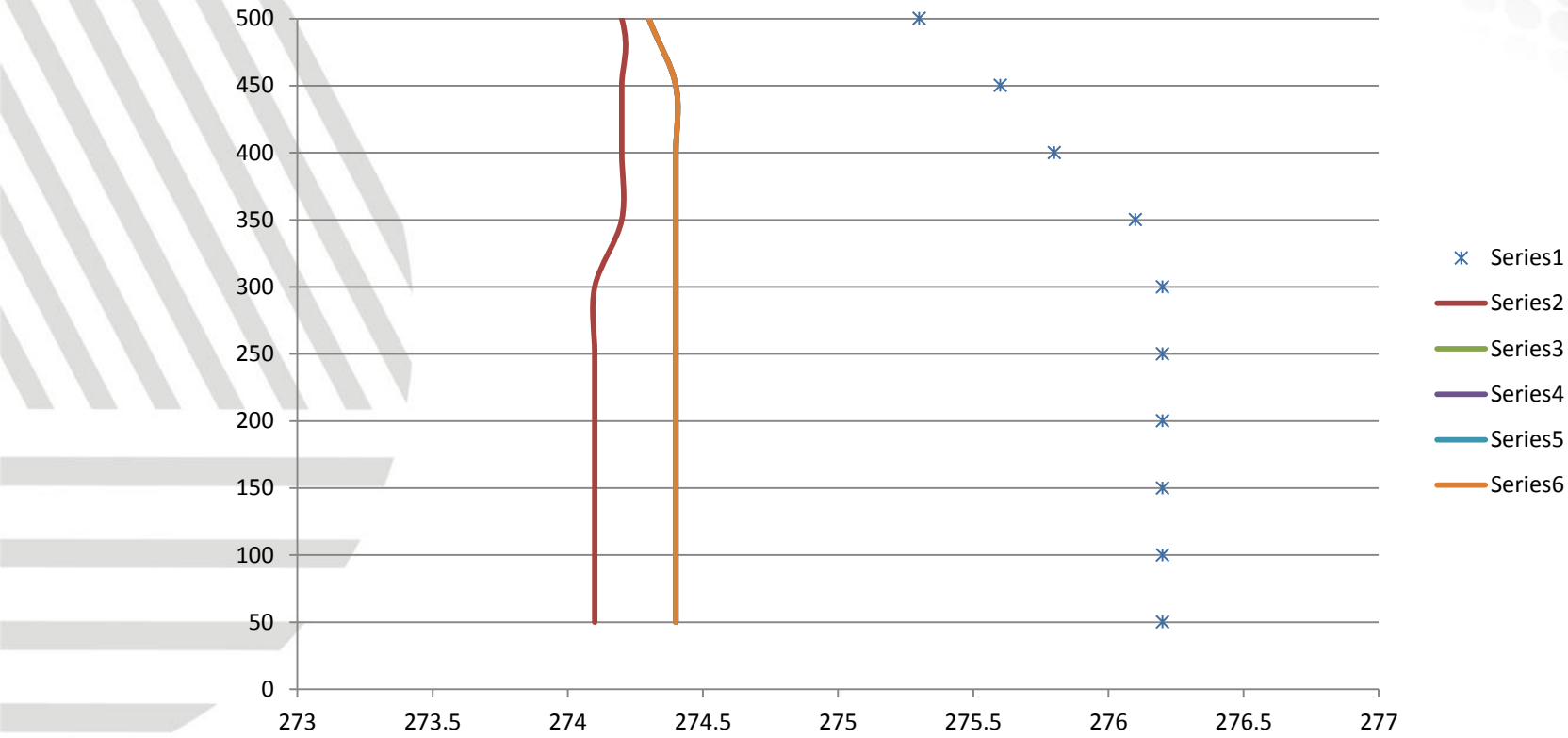
- profiles
- cold season
- station: Praha - Libus

Profile of air temperature



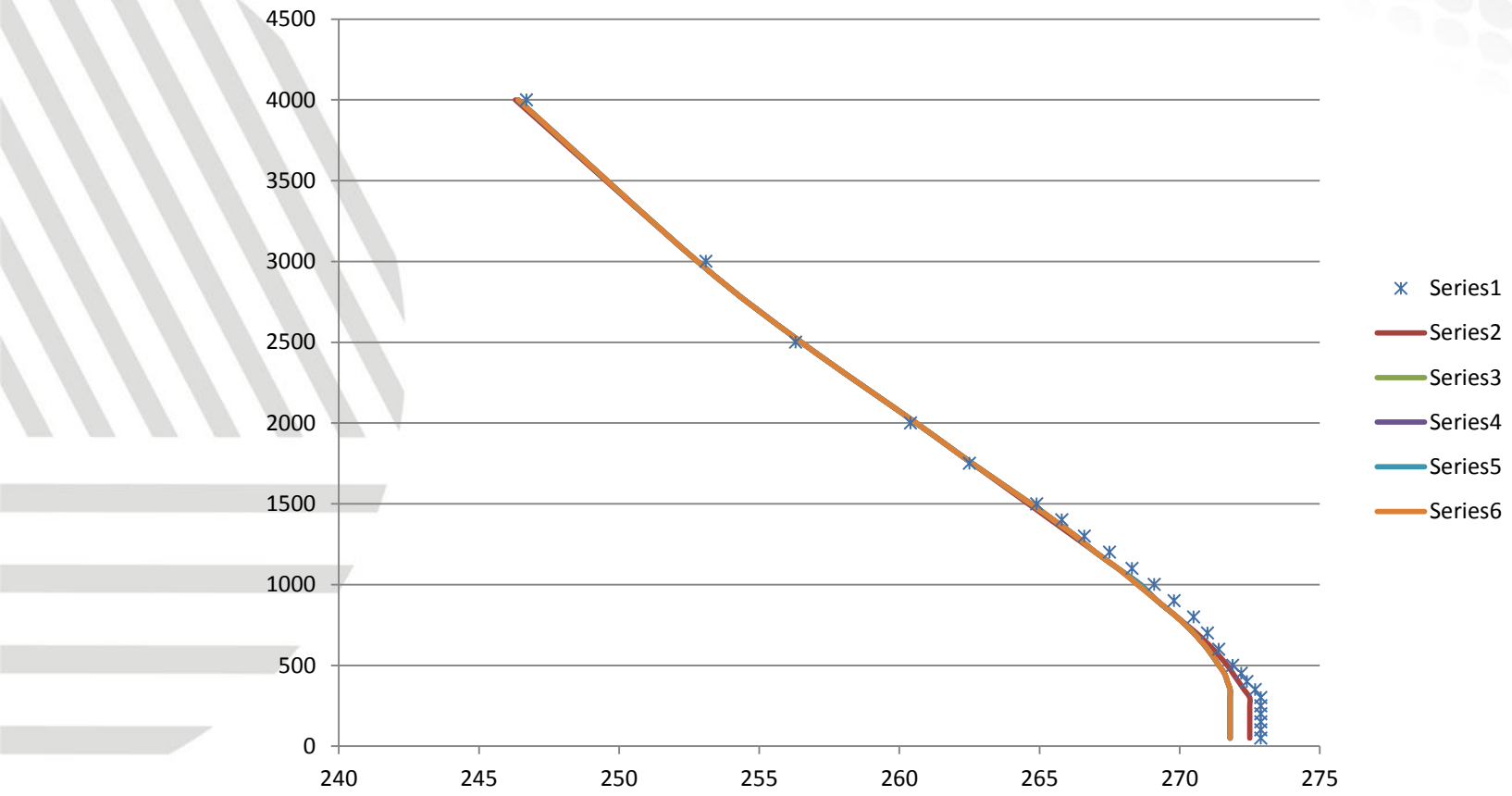
1. Measurement;
2. Reference
3. Results from COSMO model with modified parameterization – version 3;
4. Results from COSMO model with modified parameterization – version 6 for a=0,5;
5. Results from COSMO model with modified parameterization – version 5;
6. Results from COSMO model with modified parameterization – version 7;

Profile of air temperature



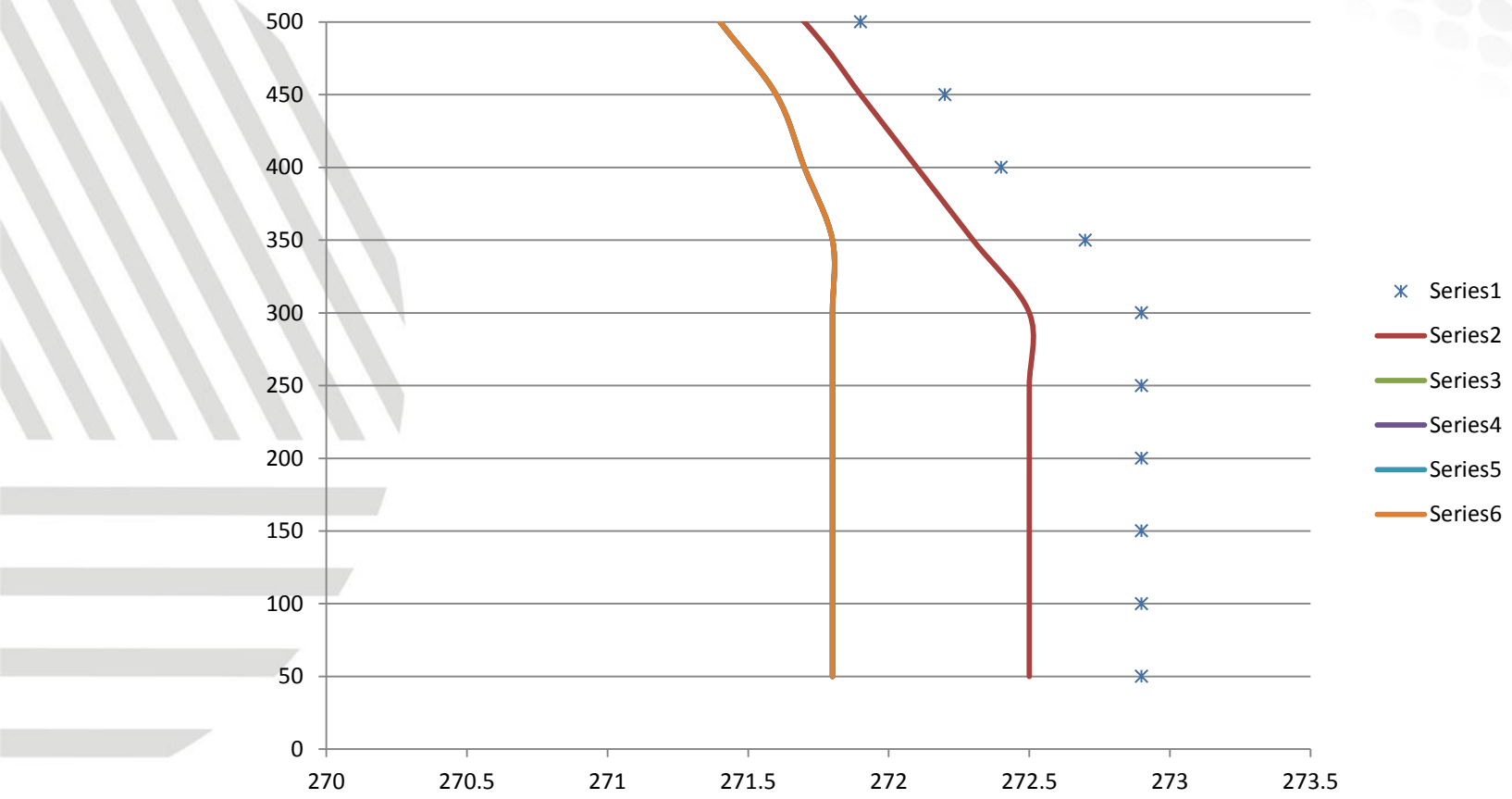
1. Measurement;
2. Reference
3. Results from COSMO model with modified parameterization – version 3;
4. Results from COSMO model with modified parameterization – version 6 for a=0,5;
5. Results from COSMO model with modified parameterization – version 5;
6. Results from COSMO model with modified parameterization – version 7;

Profile of dew point temperature



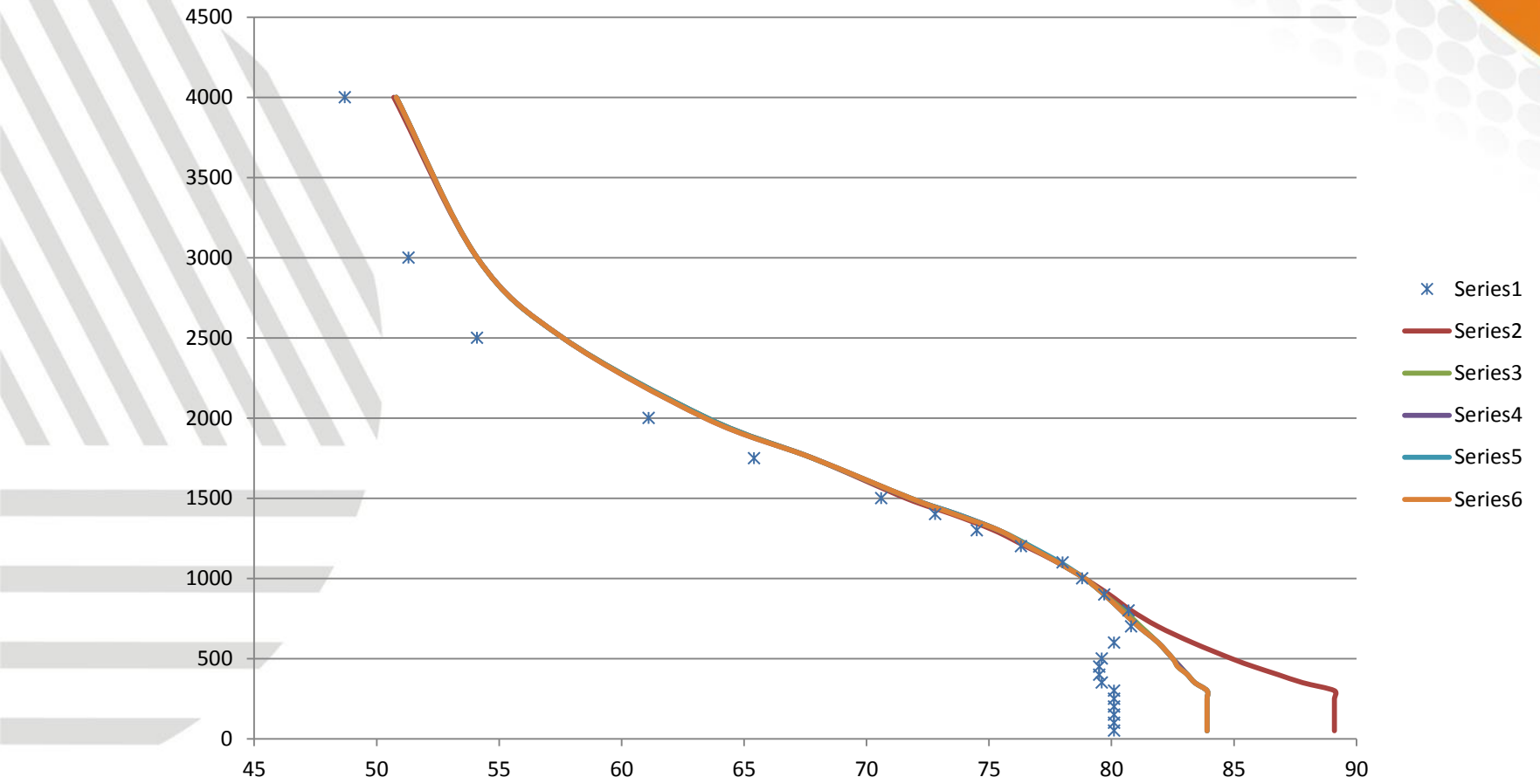
1. Measurement;
2. Reference
3. Results from COSMO model with modified parameterization – version 3;
4. Results from COSMO model with modified parameterization – version 6 for a=0,5;
5. Results from COSMO model with modified parameterization – version 5;
6. Results from COSMO model with modified parameterization – version 7;

Profile of dew point temperature



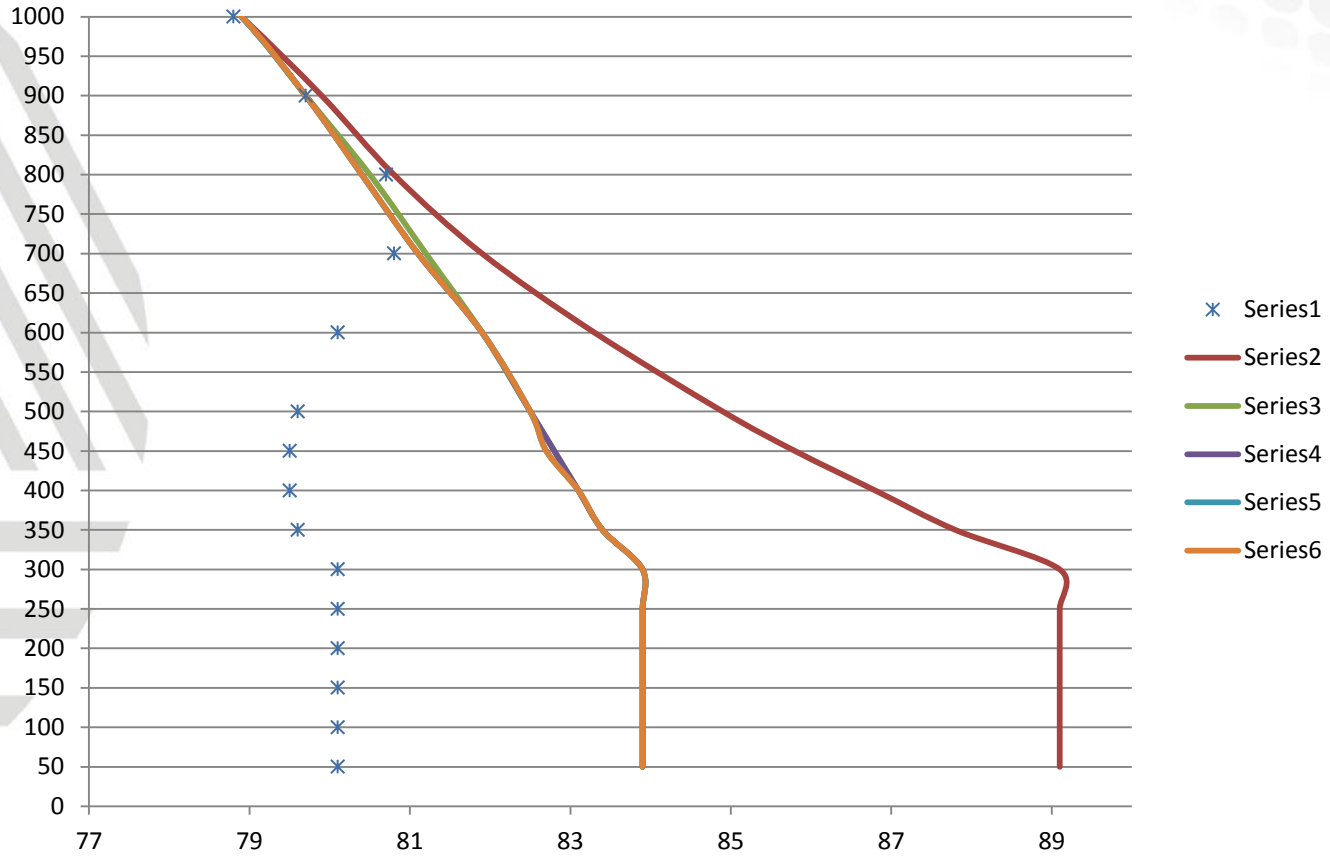
1. Measurement;
2. Reference
3. Results from COSMO model with modified parameterization – version 3;
4. Results from COSMO model with modified parameterization – version 6 for a=0,5;
5. Results from COSMO model with modified parameterization – version 5;
6. Results from COSMO model with modified parameterization – version 7;

Profile of relative humidity



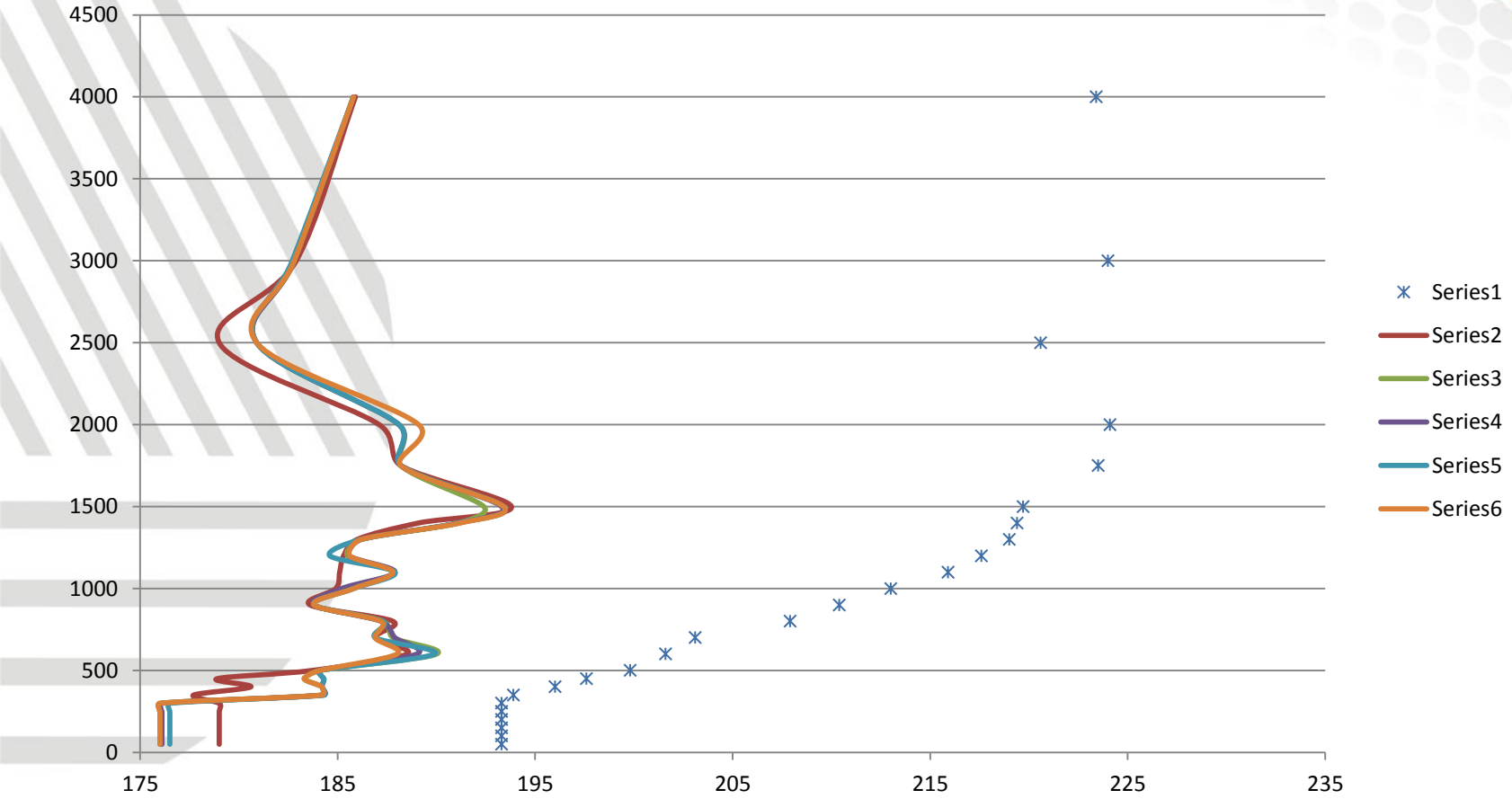
1. Measurement;
2. Reference
3. Results from COSMO model with modified parameterization – version 3;
4. Results from COSMO model with modified parameterization – version 6 for a=0,5;
5. Results from COSMO model with modified parameterization – version 5;
6. Results from COSMO model with modified parameterization – version 7;

Profile of relative humidity



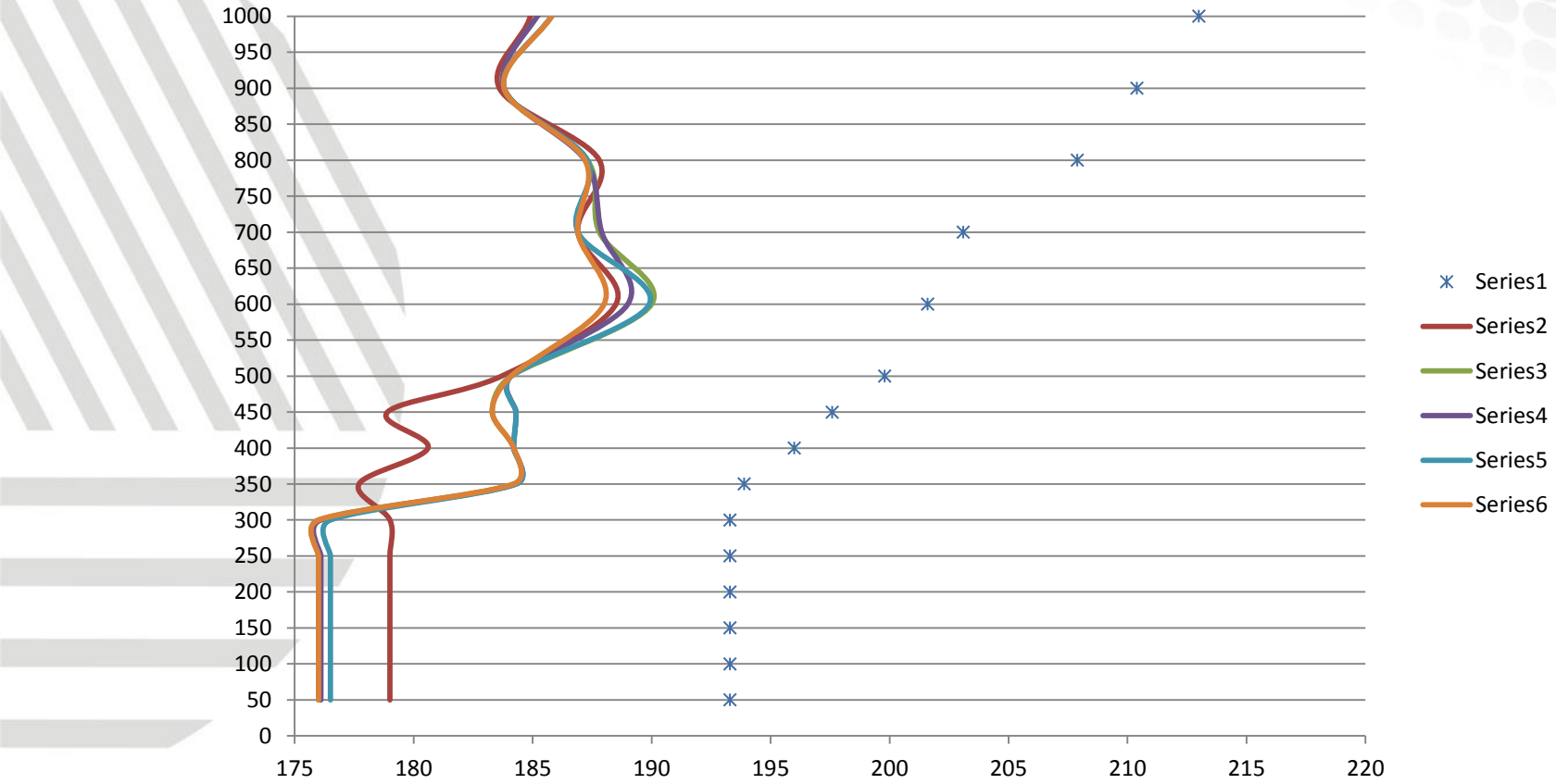
1. Measurement;
2. Reference
3. Results from COSMO model with modified parameterization – version 3;
4. Results from COSMO model with modified parameterization – version 6 for a=0,5;
5. Results from COSMO model with modified parameterization – version 5;
6. Results from COSMO model with modified parameterization – version 7;

Profile of wind direction



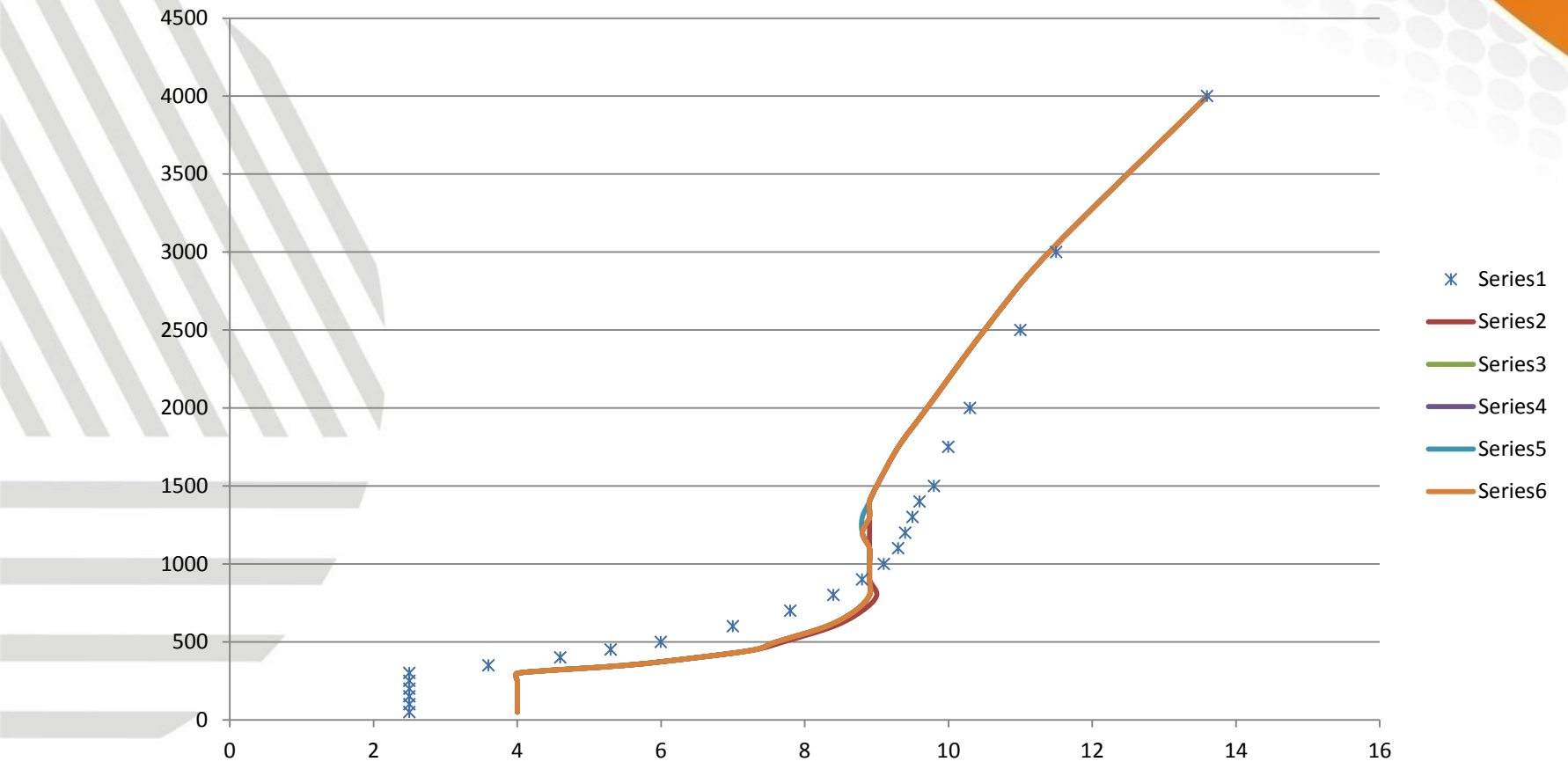
1. Measurement;
2. Reference
3. Results from COSMO model with modified parameterization – version 3;
4. Results from COSMO model with modified parameterization – version 6 for a=0,5;
5. Results from COSMO model with modified parameterization – version 5;
6. Results from COSMO model with modified parameterization – version 7;

Profile of wind direction



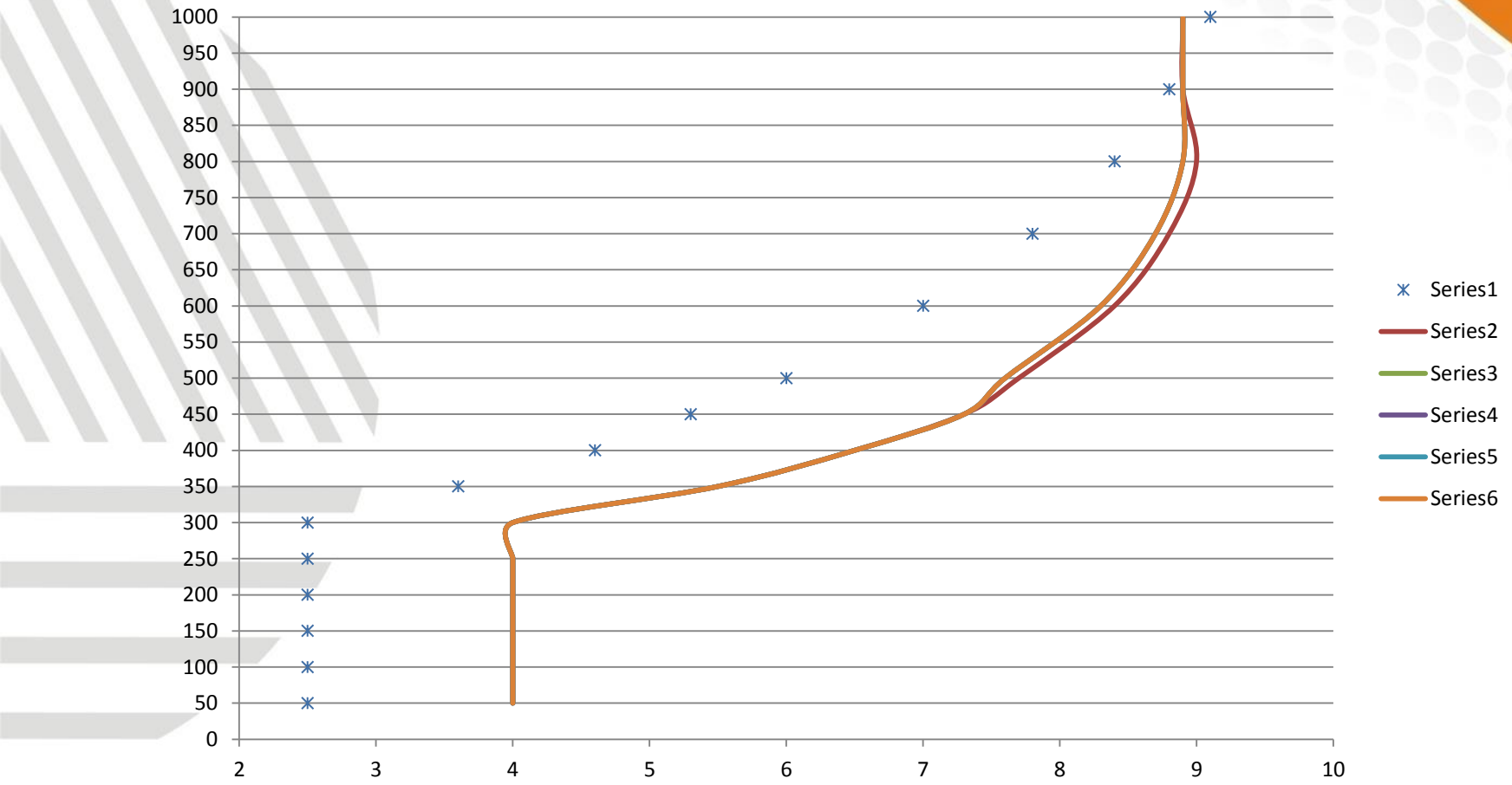
1. Measurement;
2. Reference
3. Results from COSMO model with modified parameterization – version 3;
4. Results from COSMO model with modified parameterization – version 6 for a=0,5;
5. Results from COSMO model with modified parameterization – version 5;
6. Results from COSMO model with modified parameterization – version 7;

Profile of wind speed



1. Measurement;
2. Reference
3. Results from COSMO model with modified parameterization – version 3;
4. Results from COSMO model with modified parameterization – version 6 for a=0,5;
5. Results from COSMO model with modified parameterization – version 5;
6. Results from COSMO model with modified parameterization – version 7;

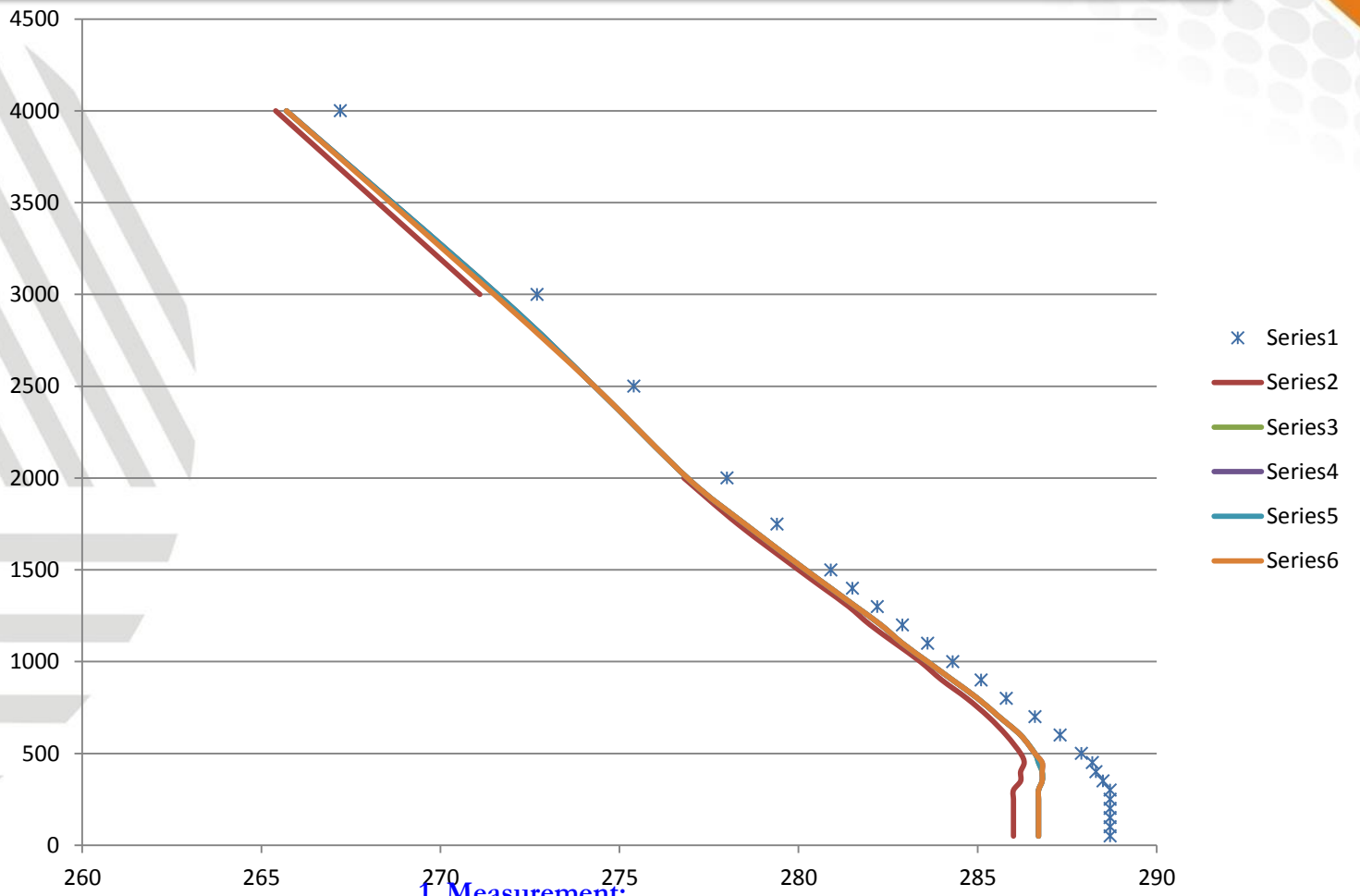
Profile of wind speed



1. Measurement;
2. Reference
3. Results from COSMO model with modified parameterization – version 3;
4. Results from COSMO model with modified parameterization – version 6 for a=0,5;
5. Results from COSMO model with modified parameterization – version 5;
6. Results from COSMO model with modified parameterization – version 7;

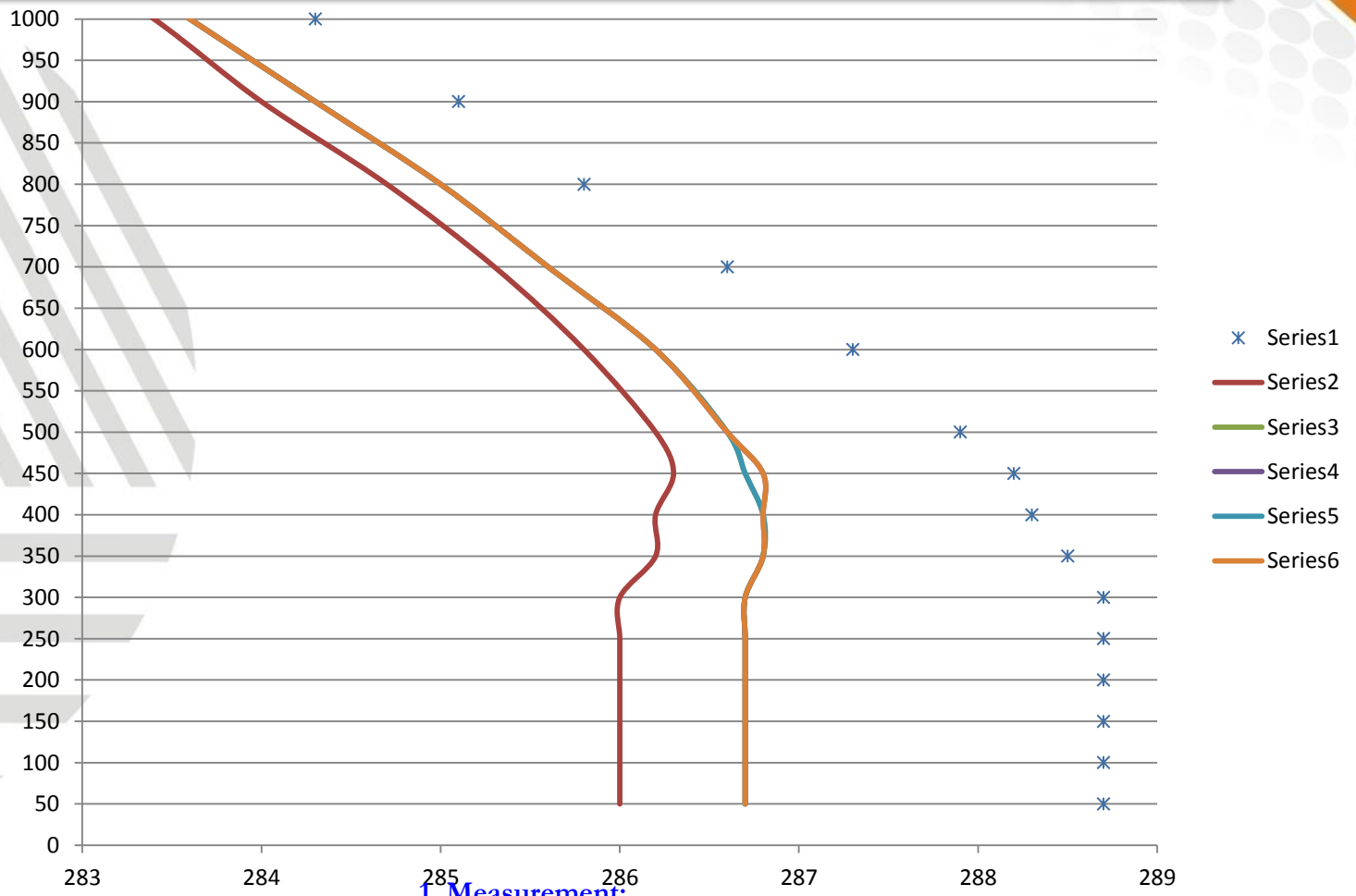
- profiles
- warm season
- station: Praha - Libus

Profile of air temperature



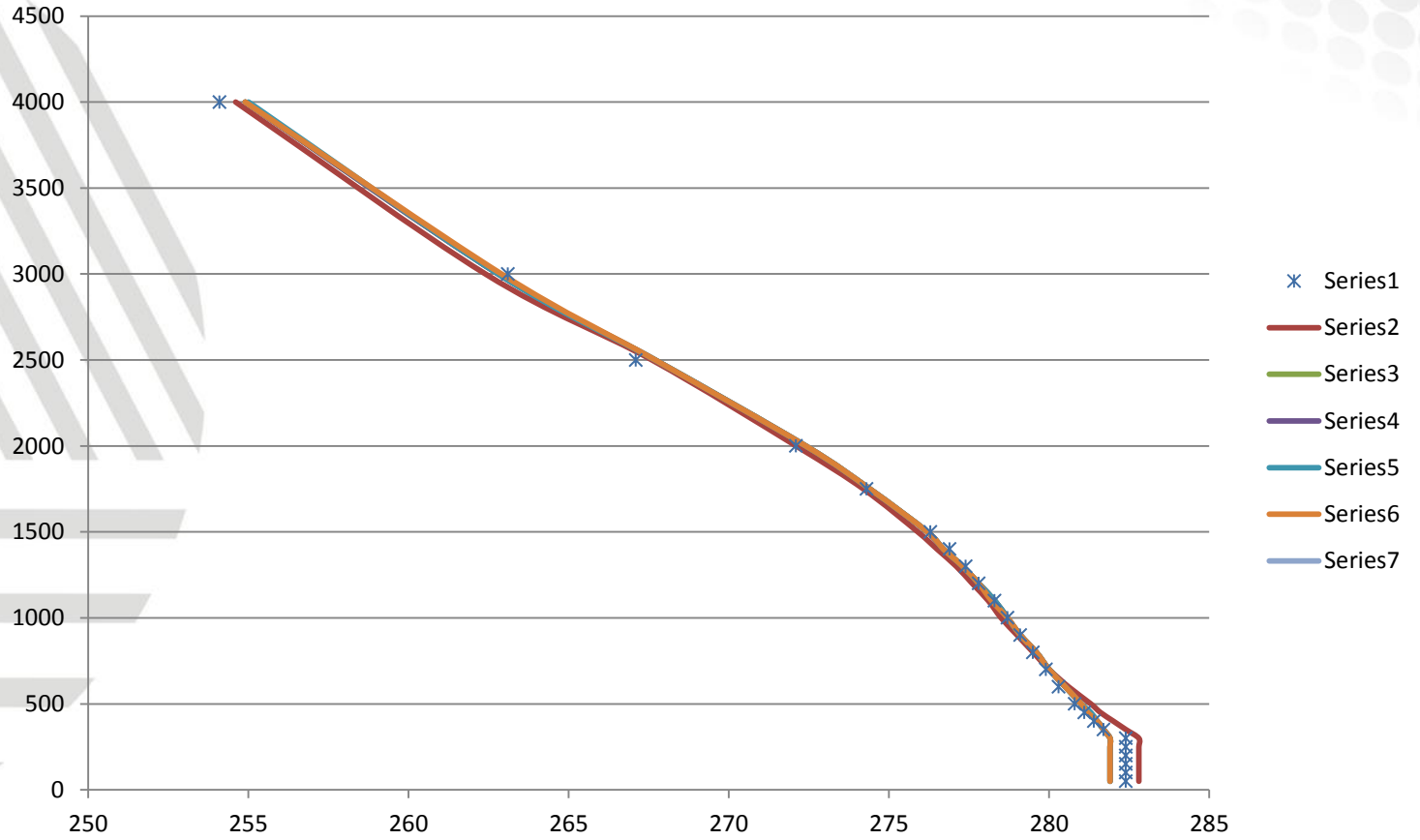
1. Measurement;
2. Reference
3. Results from COSMO model with modified parameterization – version 3;
4. Results from COSMO model with modified parameterization – version 6 for a=0,5;
5. Results from COSMO model with modified parameterization – version 5;
6. Results from COSMO model with modified parameterization – version 7;

Profile of air temperature



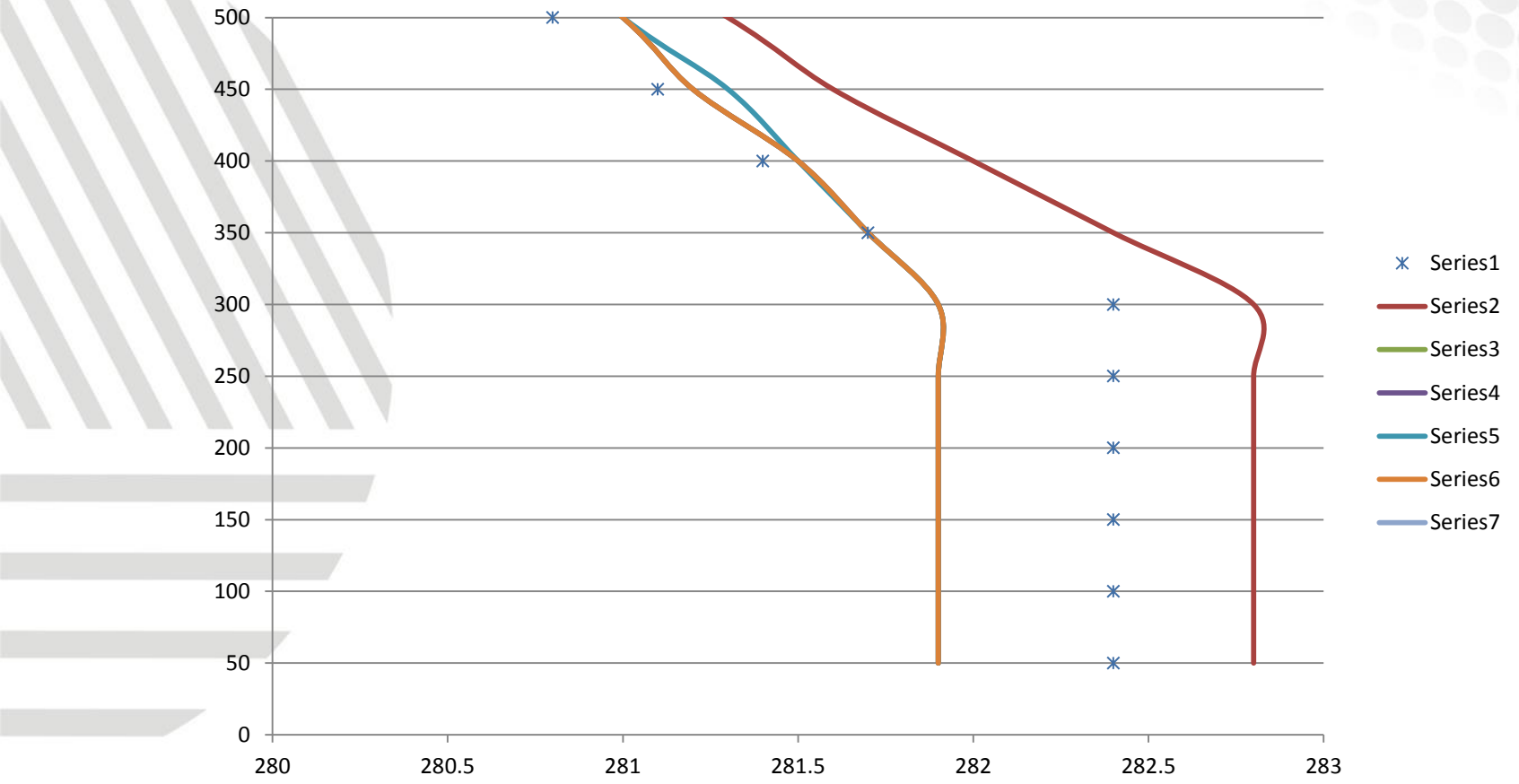
1. Measurement;
2. Reference
3. Results from COSMO model with modified parameterization – version 3;
4. Results from COSMO model with modified parameterization – version 6 for a=0,5;
5. Results from COSMO model with modified parameterization – version 5;
6. Results from COSMO model with modified parameterization – version 7;

Profile of dew point temperature



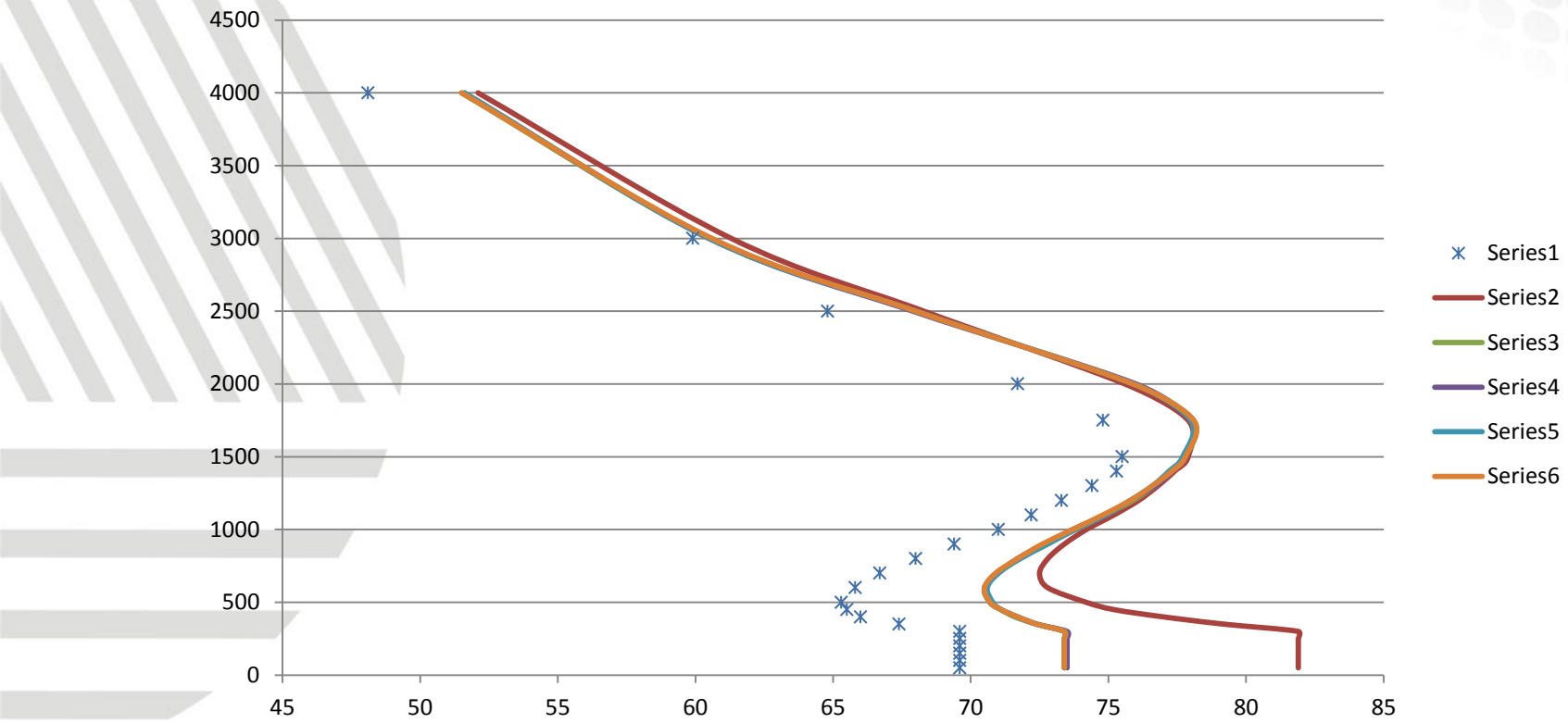
1. Measurement;
2. Reference
3. Results from COSMO model with modified parameterization – version 3;
4. Results from COSMO model with modified parameterization – version 6 for a=0,5;
5. Results from COSMO model with modified parameterization – version 5;
6. Results from COSMO model with modified parameterization – version 7;

Profile of dew point temperature



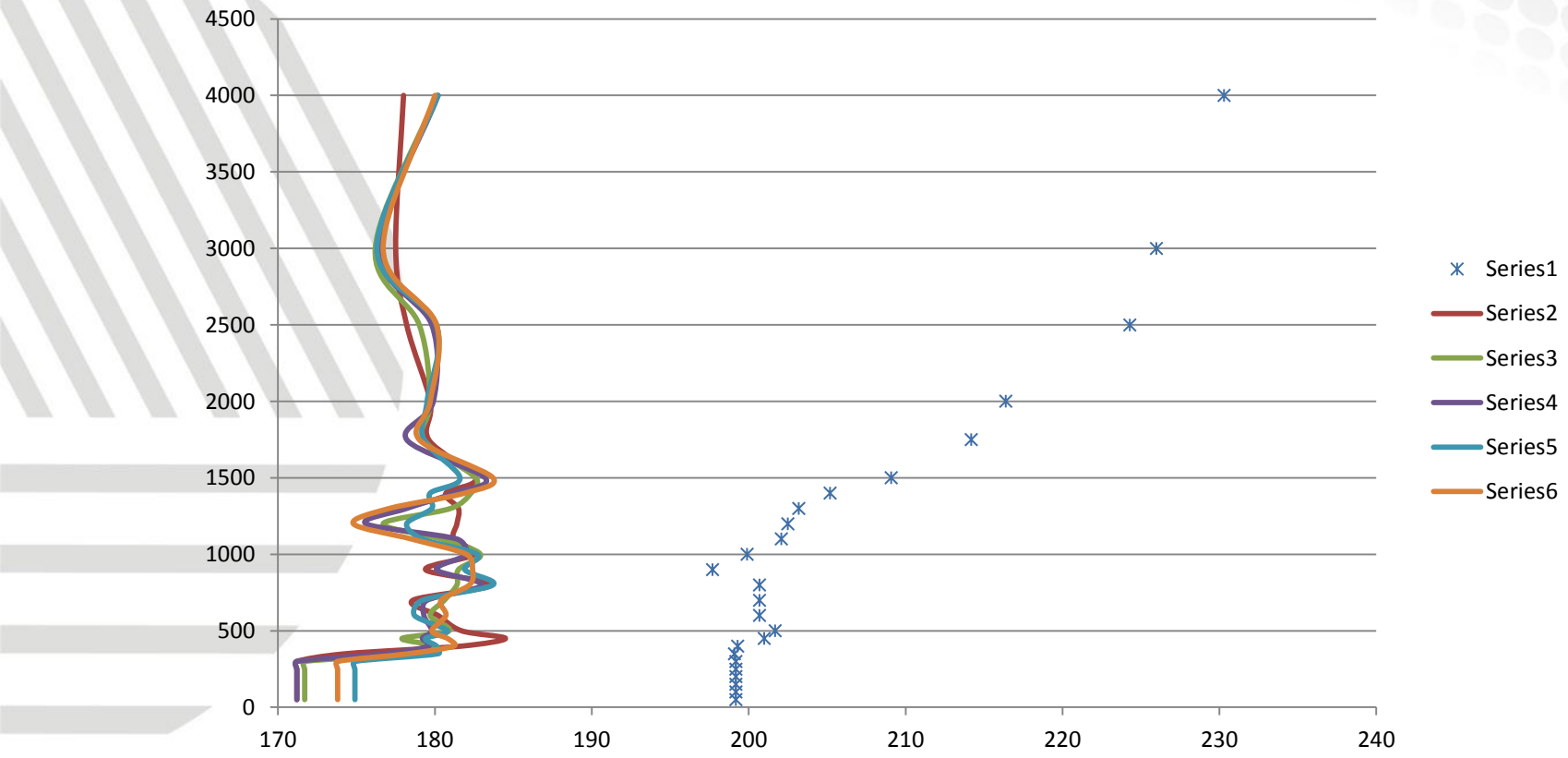
1. Measurement;
2. Reference
3. Results from COSMO model with modified parameterization – version 3;
4. Results from COSMO model with modified parameterization – version 6 for a=0,5;
5. Results from COSMO model with modified parameterization – version 5;
6. Results from COSMO model with modified parameterization – version 7;

Profile of relative humidity



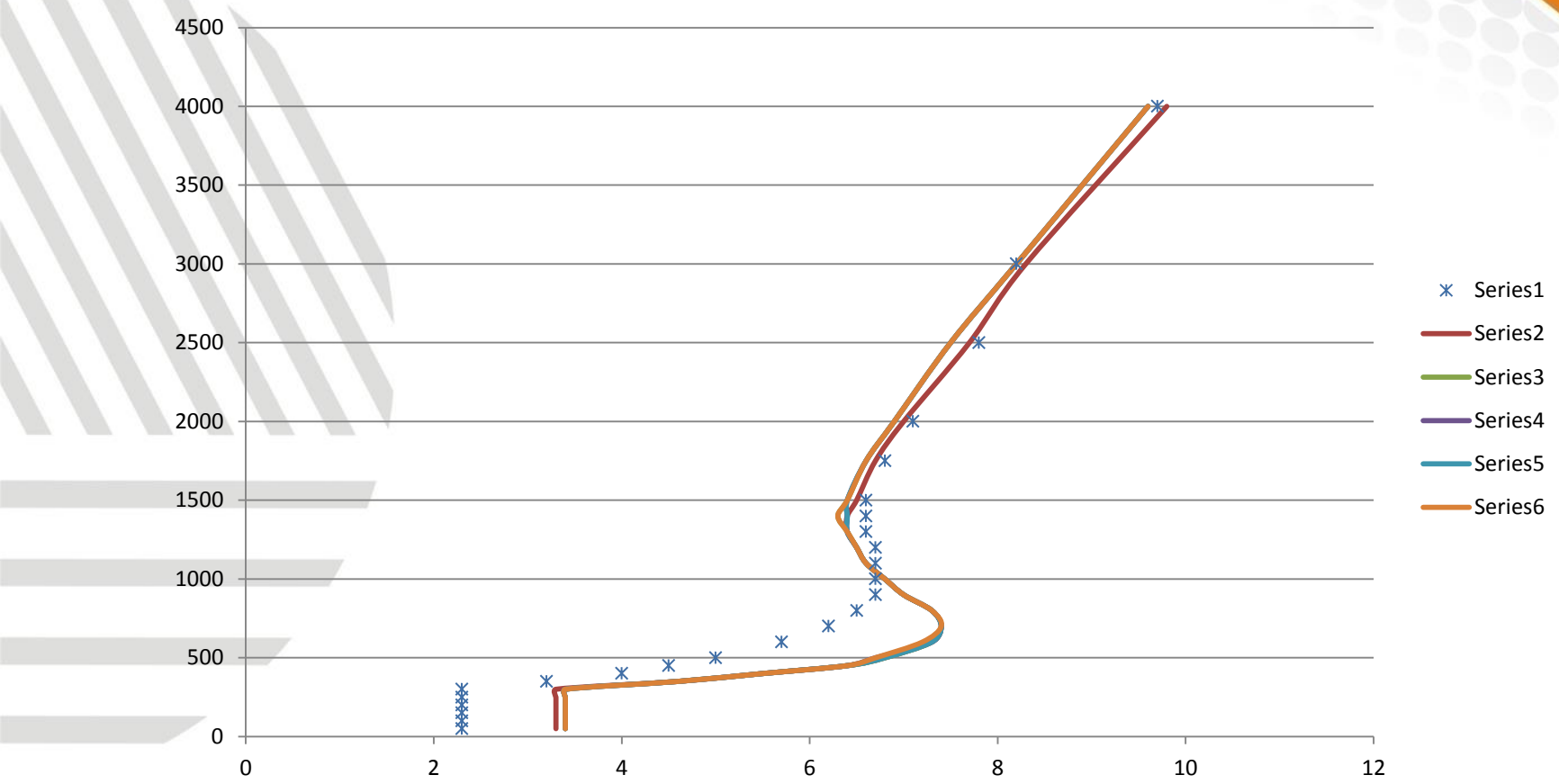
1. Measurement;
2. Reference
3. Results from COSMO model with modified parameterization – version 3;
4. Results from COSMO model with modified parameterization – version 6 for a=0,5;
5. Results from COSMO model with modified parameterization – version 5;
6. Results from COSMO model with modified parameterization – version 7;

Profile of wind direction



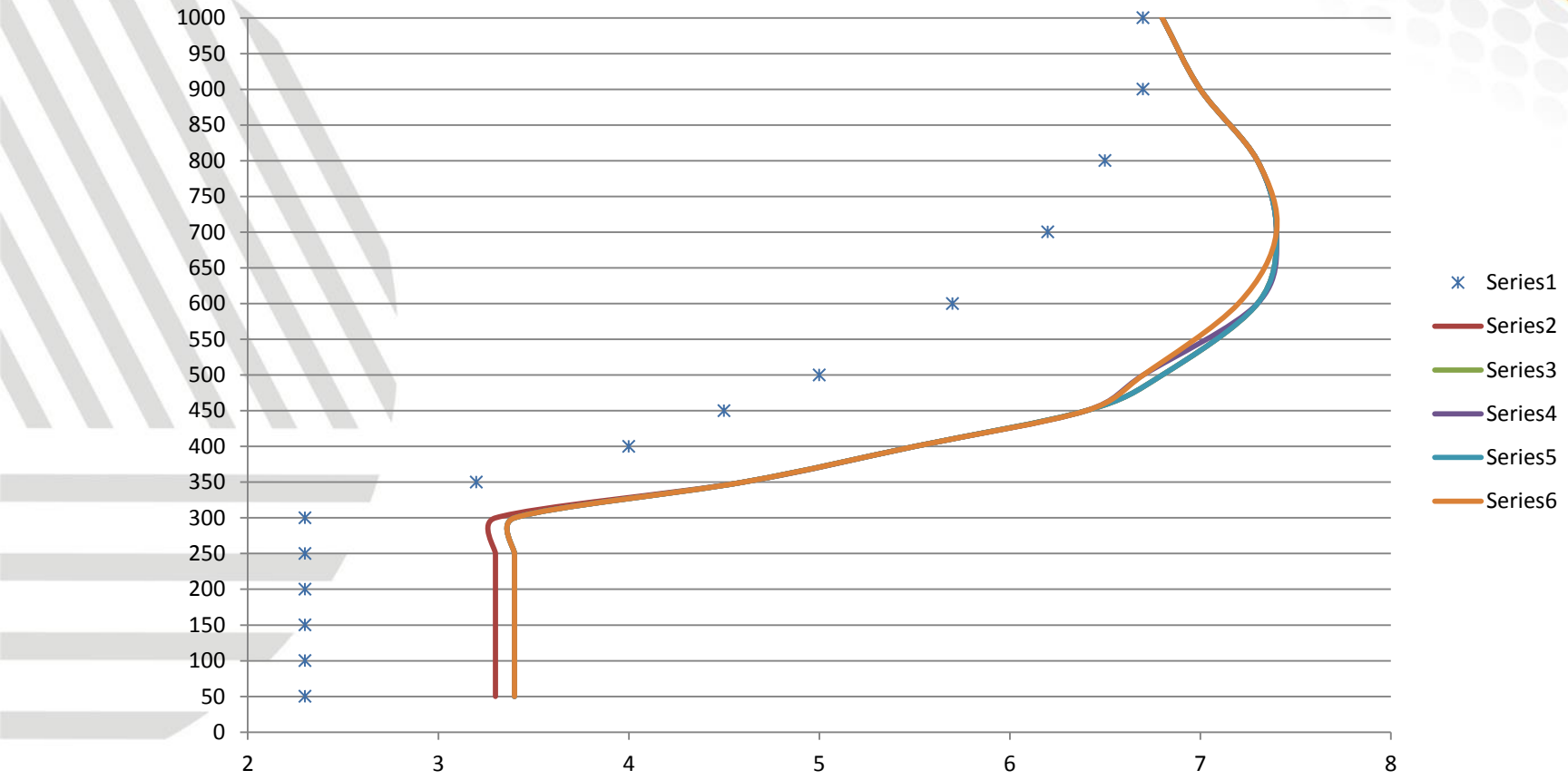
1. Measurement;
2. Reference
3. Results from COSMO model with modified parameterization – version 3;
4. Results from COSMO model with modified parameterization – version 6 for a=0,5;
5. Results from COSMO model with modified parameterization – version 5;
6. Results from COSMO model with modified parameterization – version 7;

Profile of wind speed



1. Measurement;
2. Reference
3. Results from COSMO model with modified parameterization – version 3;
4. Results from COSMO model with modified parameterization – version 6 for a=0,5;
5. Results from COSMO model with modified parameterization – version 5;
6. Results from COSMO model with modified parameterization – version 7;

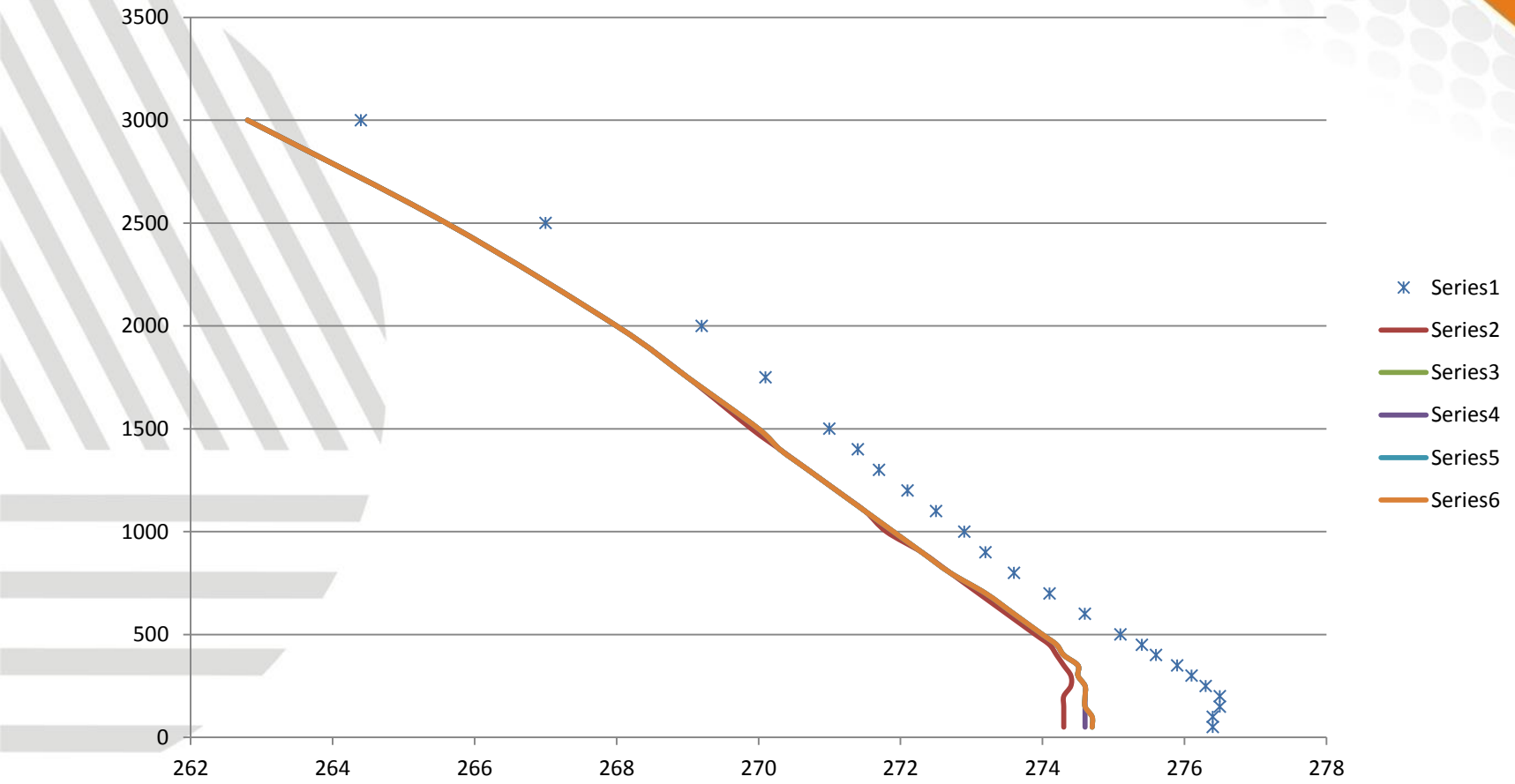
Profile of wind speed



1. Measurement;
2. Reference
3. Results from COSMO model with modified parameterization – version 3;
4. Results from COSMO model with modified parameterization – version 6 for a=0,5;
5. Results from COSMO model with modified parameterization – version 5;
6. Results from COSMO model with modified parameterization – version 7;

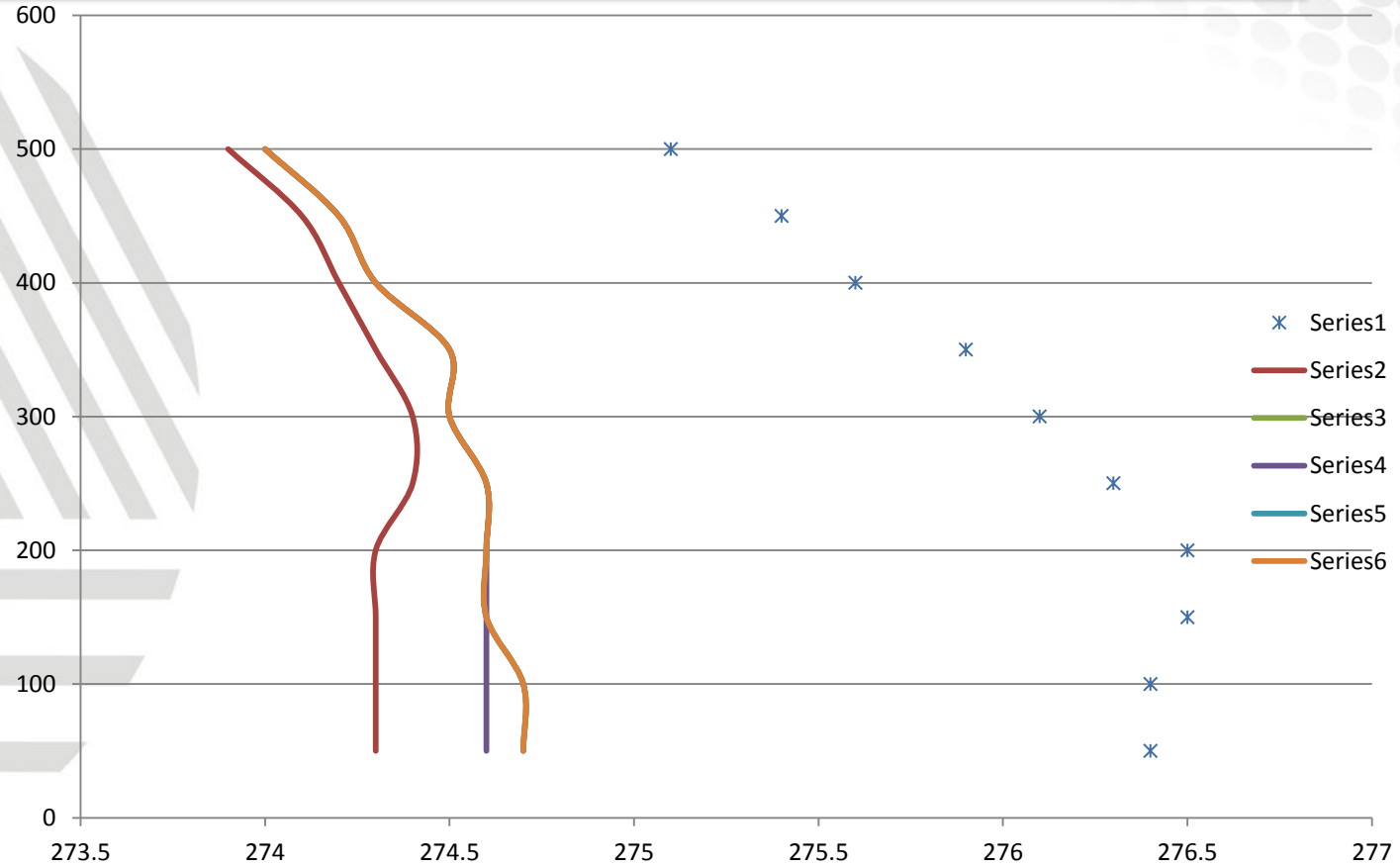
- profiles
- cold season
- station: Wrocław

Profile of air temperature



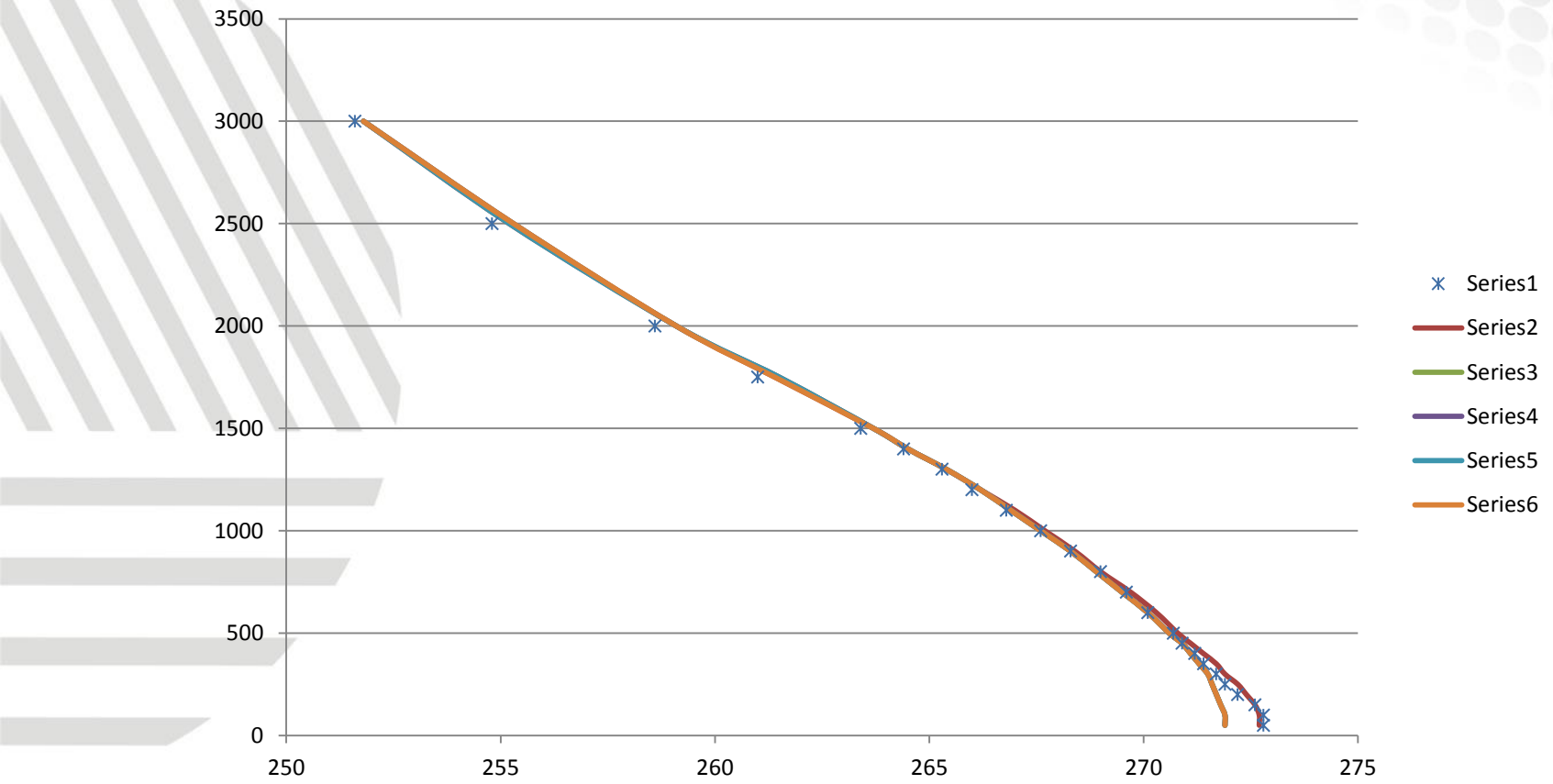
1. Measurement;
2. Reference
3. Results from COSMO model with modified parameterization – version 3;
4. Results from COSMO model with modified parameterization – version 6 for a=0,5;
5. Results from COSMO model with modified parameterization – version 5;
6. Results from COSMO model with modified parameterization – version 7;

Profile of air temperature



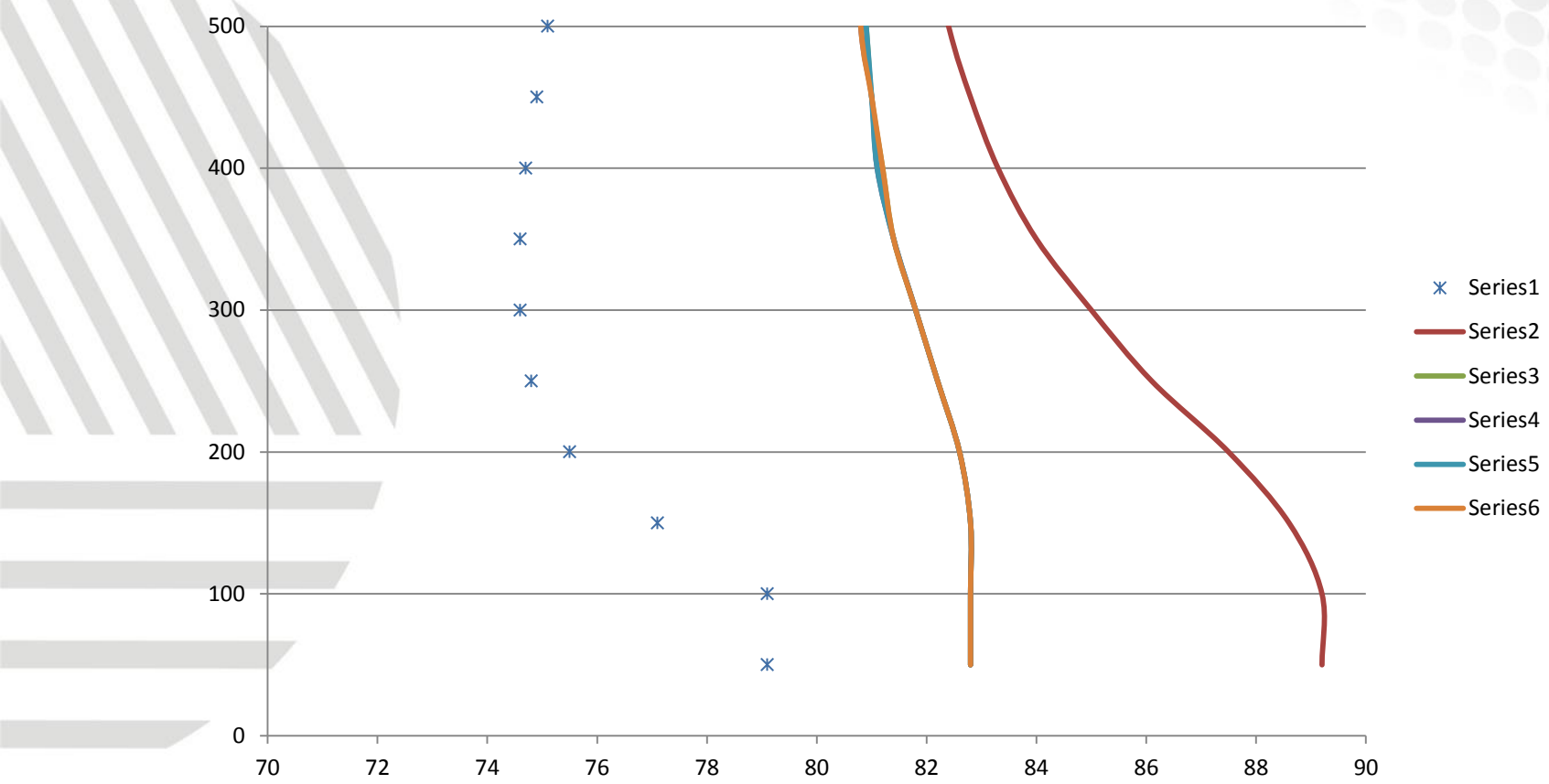
1. Measurement;
2. Reference
3. Results from COSMO model with modified parameterization – version 3;
4. Results from COSMO model with modified parameterization – version 6 for a=0,5;
5. Results from COSMO model with modified parameterization – version 5;
6. Results from COSMO model with modified parameterization – version 7;

Profile of dew point temperature



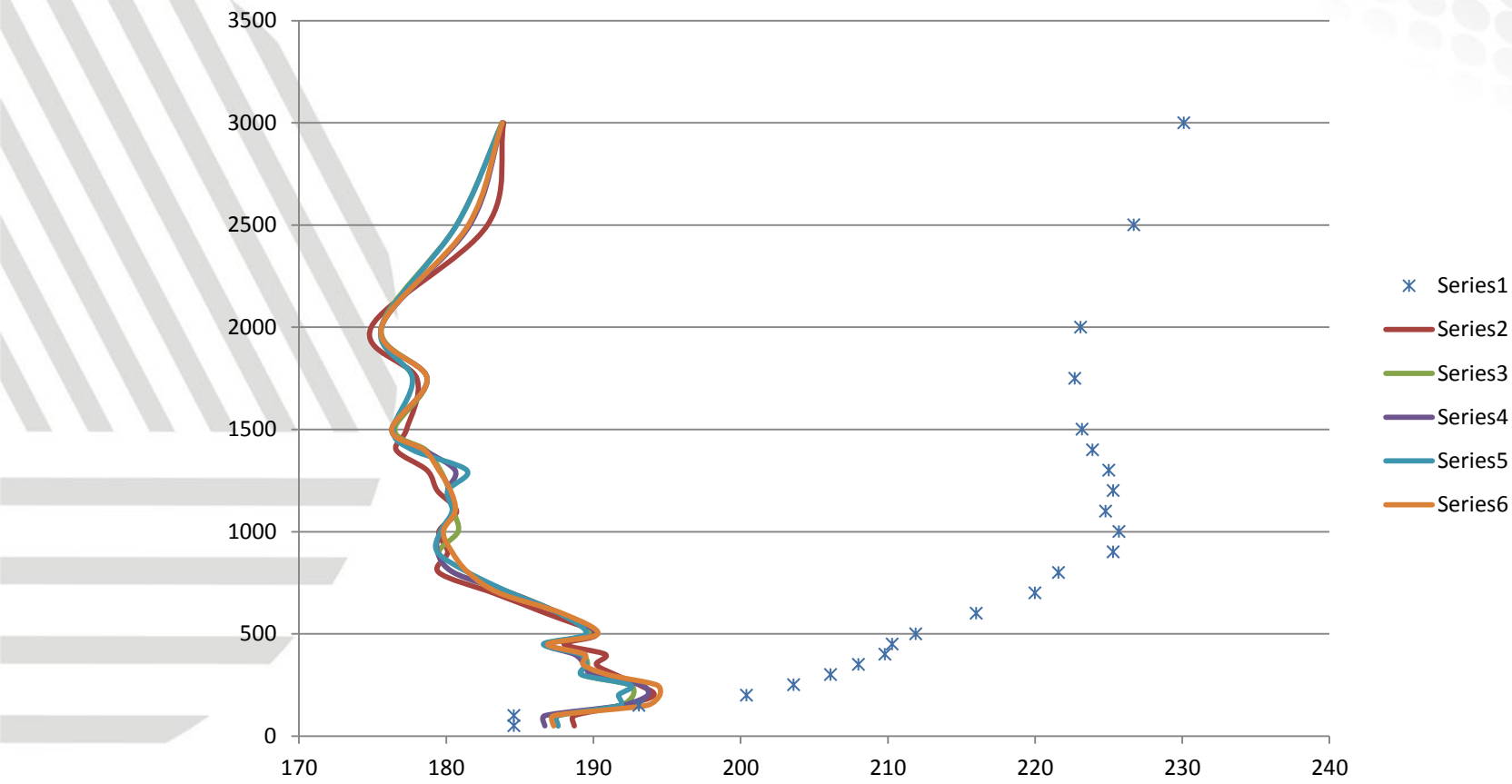
1. Measurement;
2. Reference
3. Results from COSMO model with modified parameterization – version 3;
4. Results from COSMO model with modified parameterization – version 6 for a=0,5;
5. Results from COSMO model with modified parameterization – version 5;
6. Results from COSMO model with modified parameterization – version 7;

Profile of relative humidity



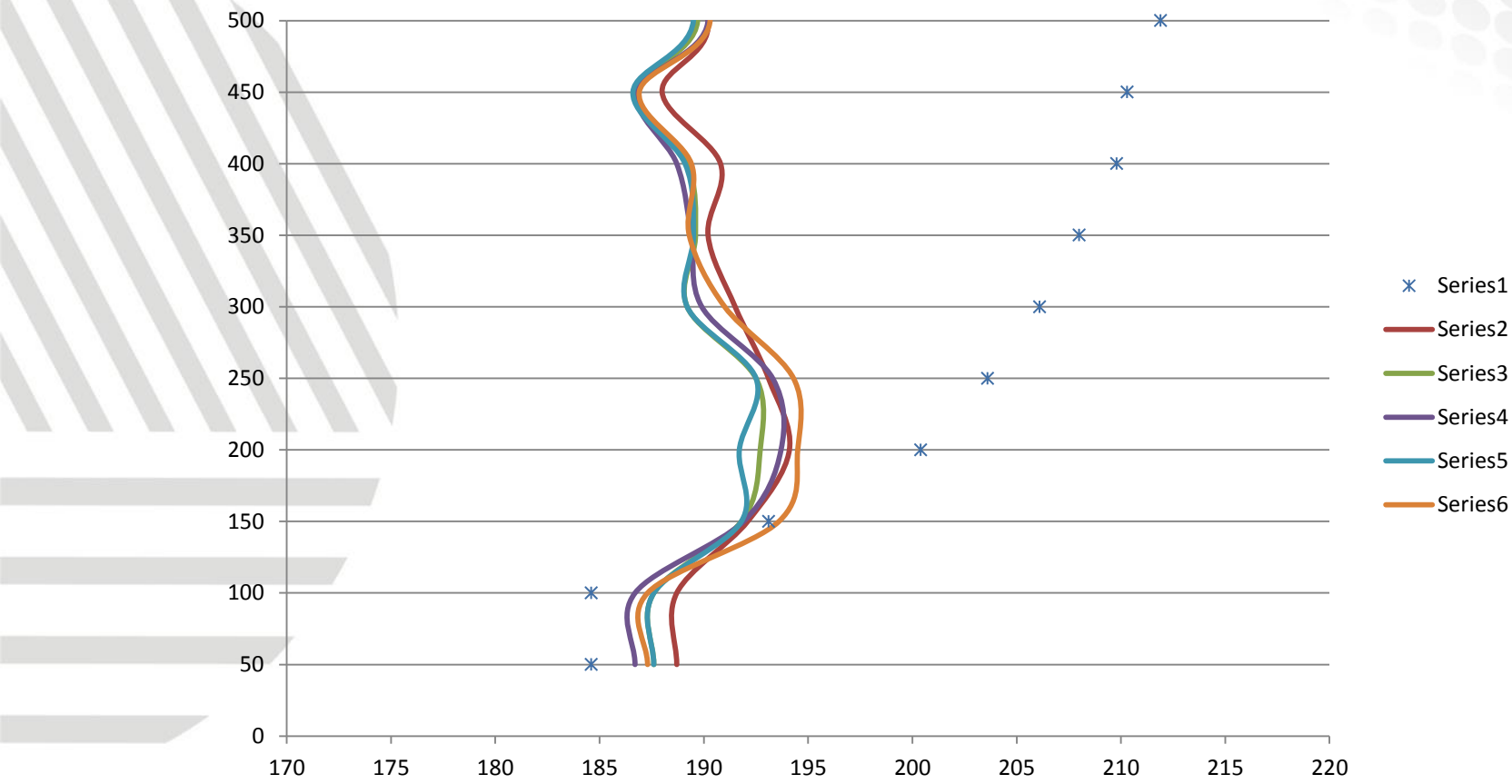
1. Measurement;
2. Reference
3. Results from COSMO model with modified parameterization – version 3;
4. Results from COSMO model with modified parameterization – version 6 for a=0,5;
5. Results from COSMO model with modified parameterization – version 5;
6. Results from COSMO model with modified parameterization – version 7;

Profile of wind direction



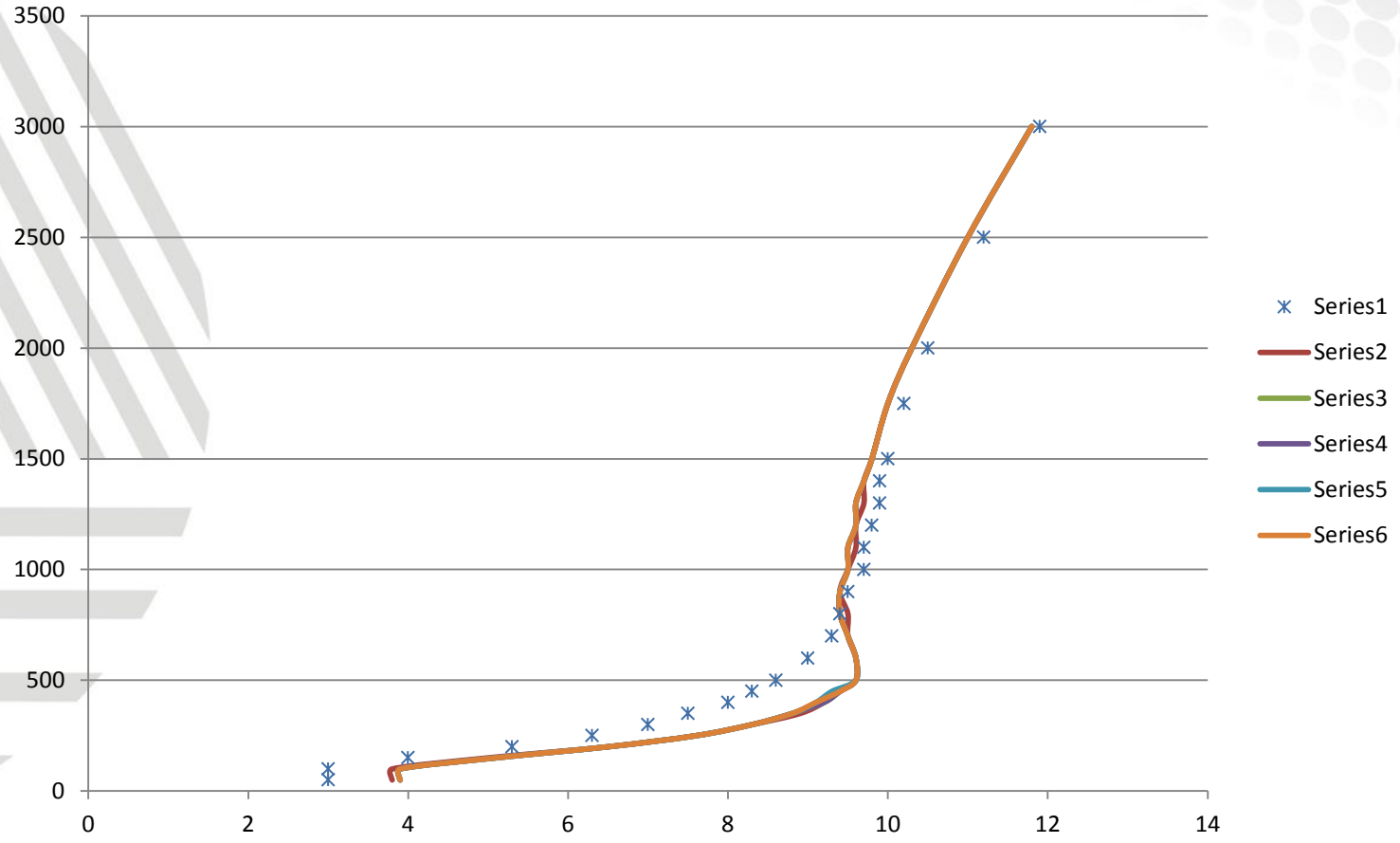
1. Measurement;
2. Reference
3. Results from COSMO model with modified parameterization – version 3;
4. Results from COSMO model with modified parameterization – version 6 for a=0,5;
5. Results from COSMO model with modified parameterization – version 5;
6. Results from COSMO model with modified parameterization – version 7;

Profile of wind direction



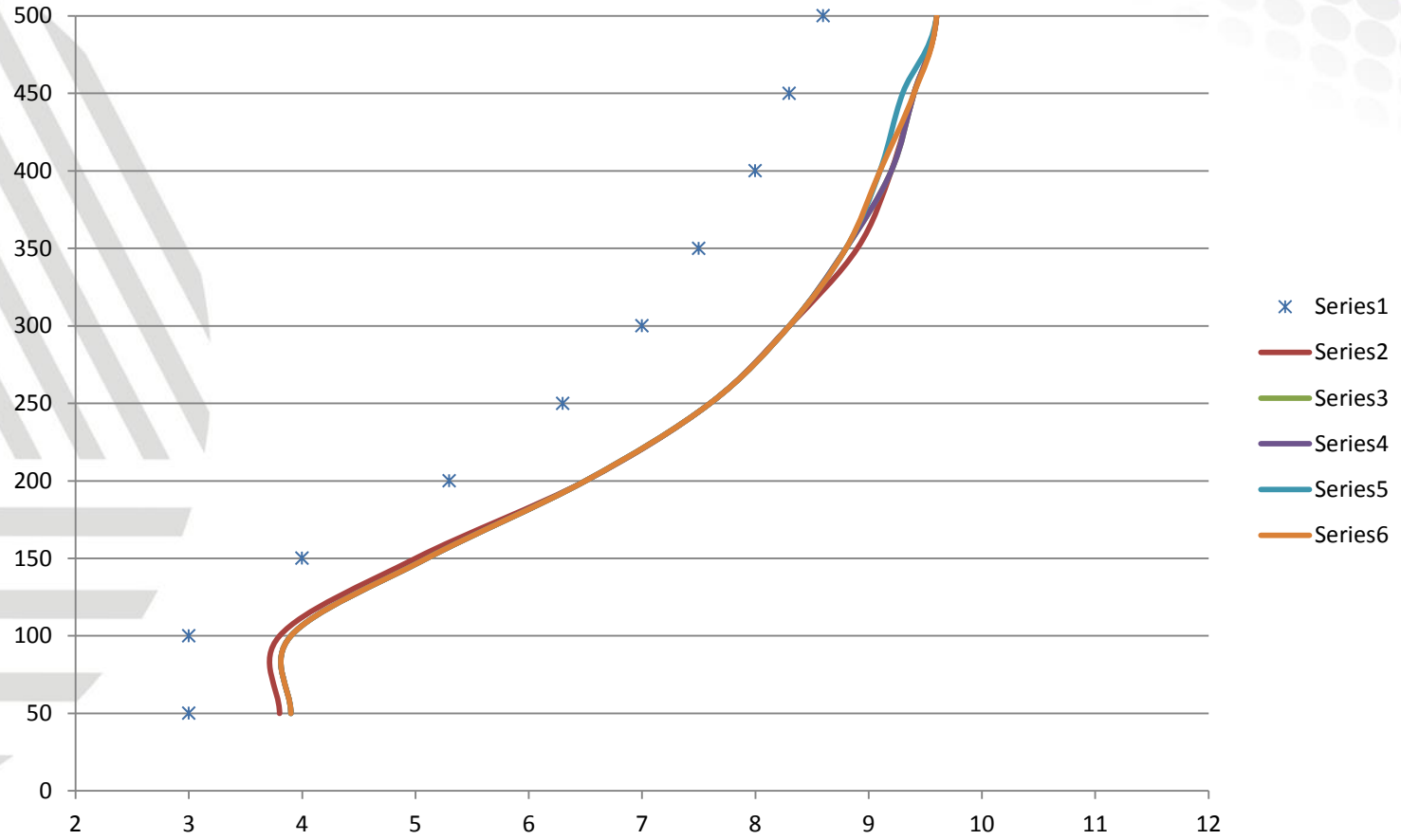
1. Measurement;
2. Reference
3. Results from COSMO model with modified parameterization – version 3;
4. Results from COSMO model with modified parameterization – version 6 for a=0,5;
5. Results from COSMO model with modified parameterization – version 5;
6. Results from COSMO model with modified parameterization – version 7;

Profile of wind speed



1. Measurement;
2. Reference
3. Results from COSMO model with modified parameterization – version 3;
4. Results from COSMO model with modified parameterization – version 6 for a=0,5;
5. Results from COSMO model with modified parameterization – version 5;
6. Results from COSMO model with modified parameterization – version 7;

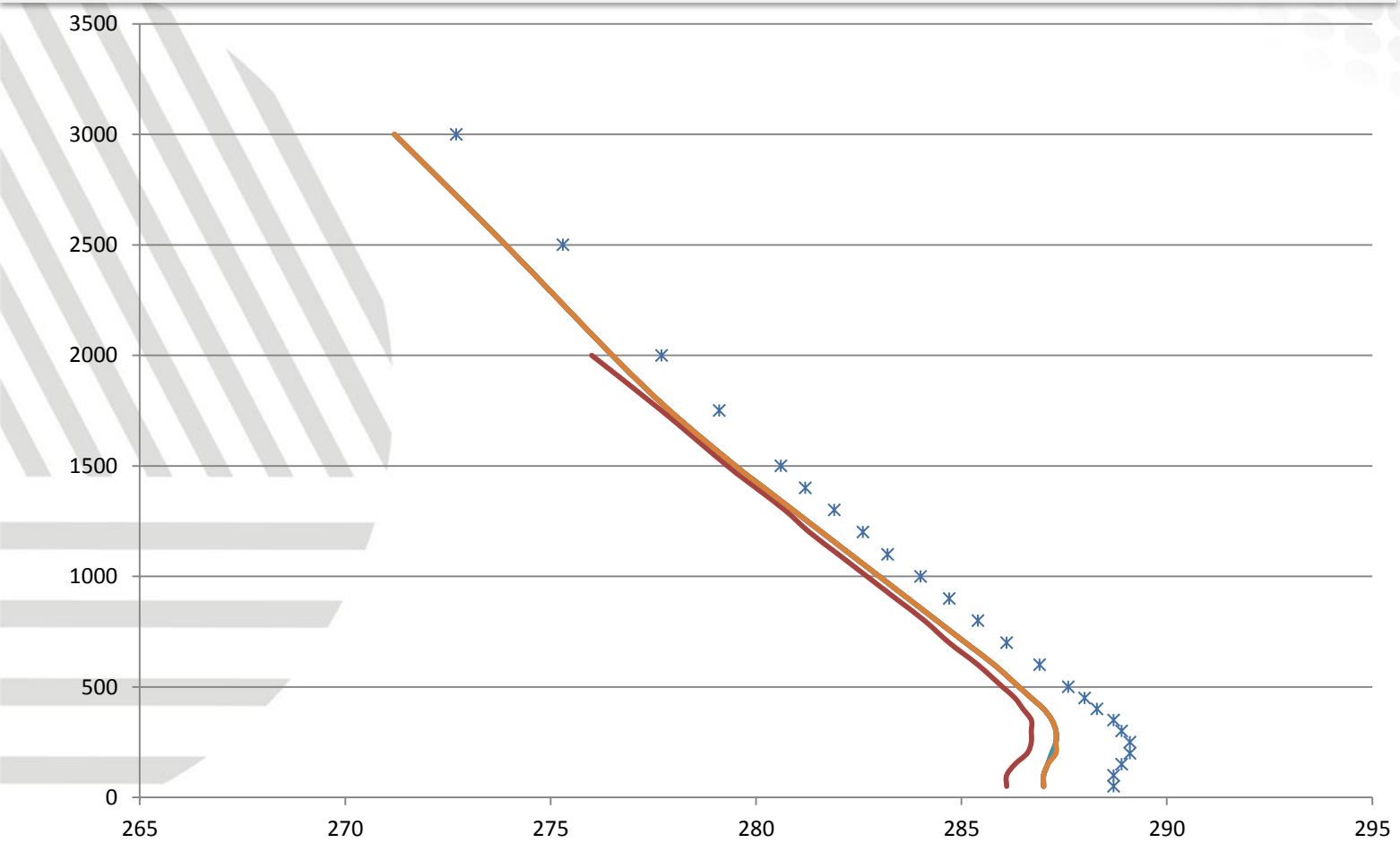
Profile of wind speed



1. Measurement;
2. Reference
3. Results from COSMO model with modified parameterization – version 3;
4. Results from COSMO model with modified parameterization – version 6 for a=0,5;
5. Results from COSMO model with modified parameterization – version 5;
6. Results from COSMO model with modified parameterization – version 7;

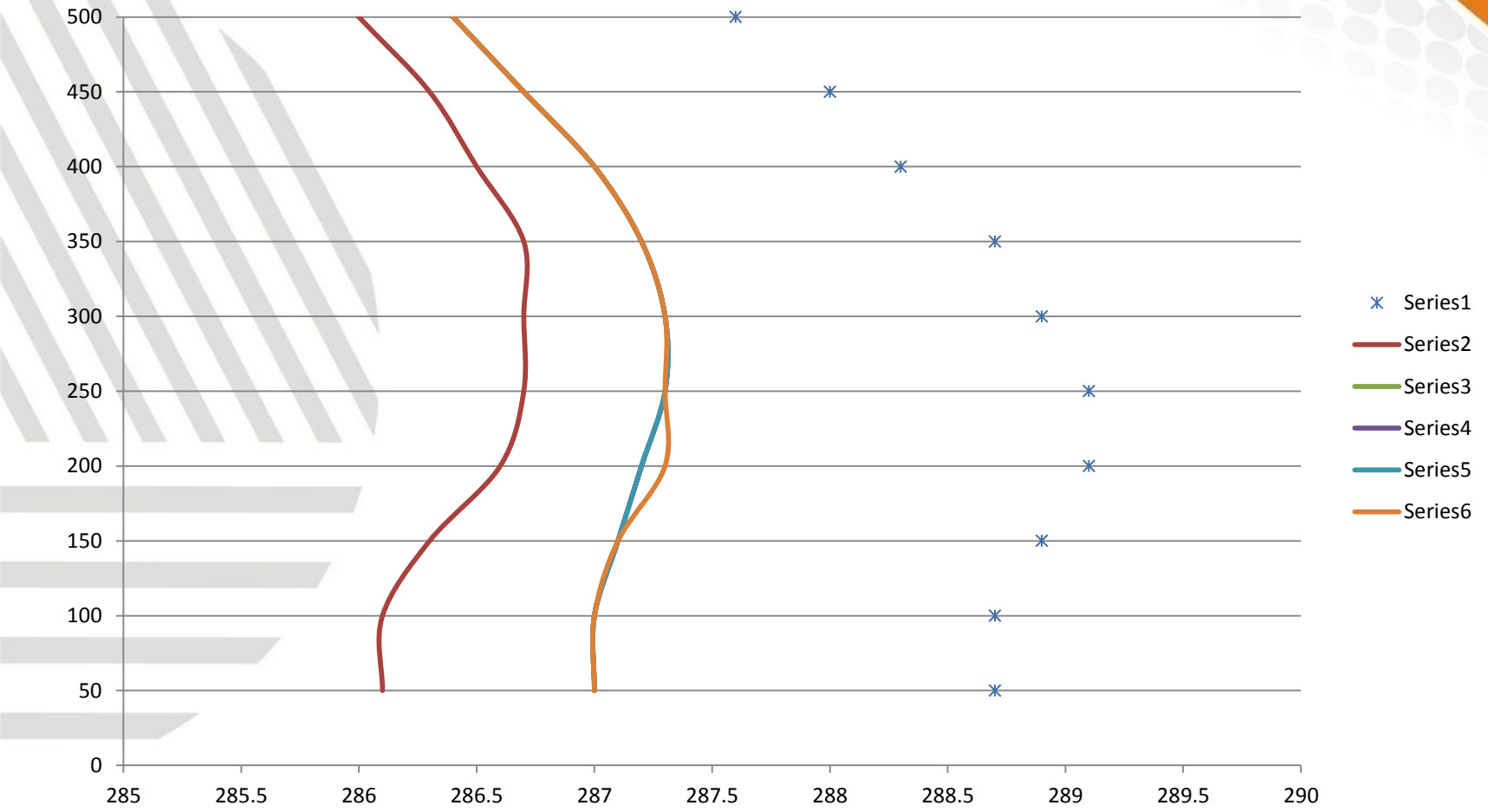
- profiles
- warm season
- station: Wrocław

Profile of air temperature



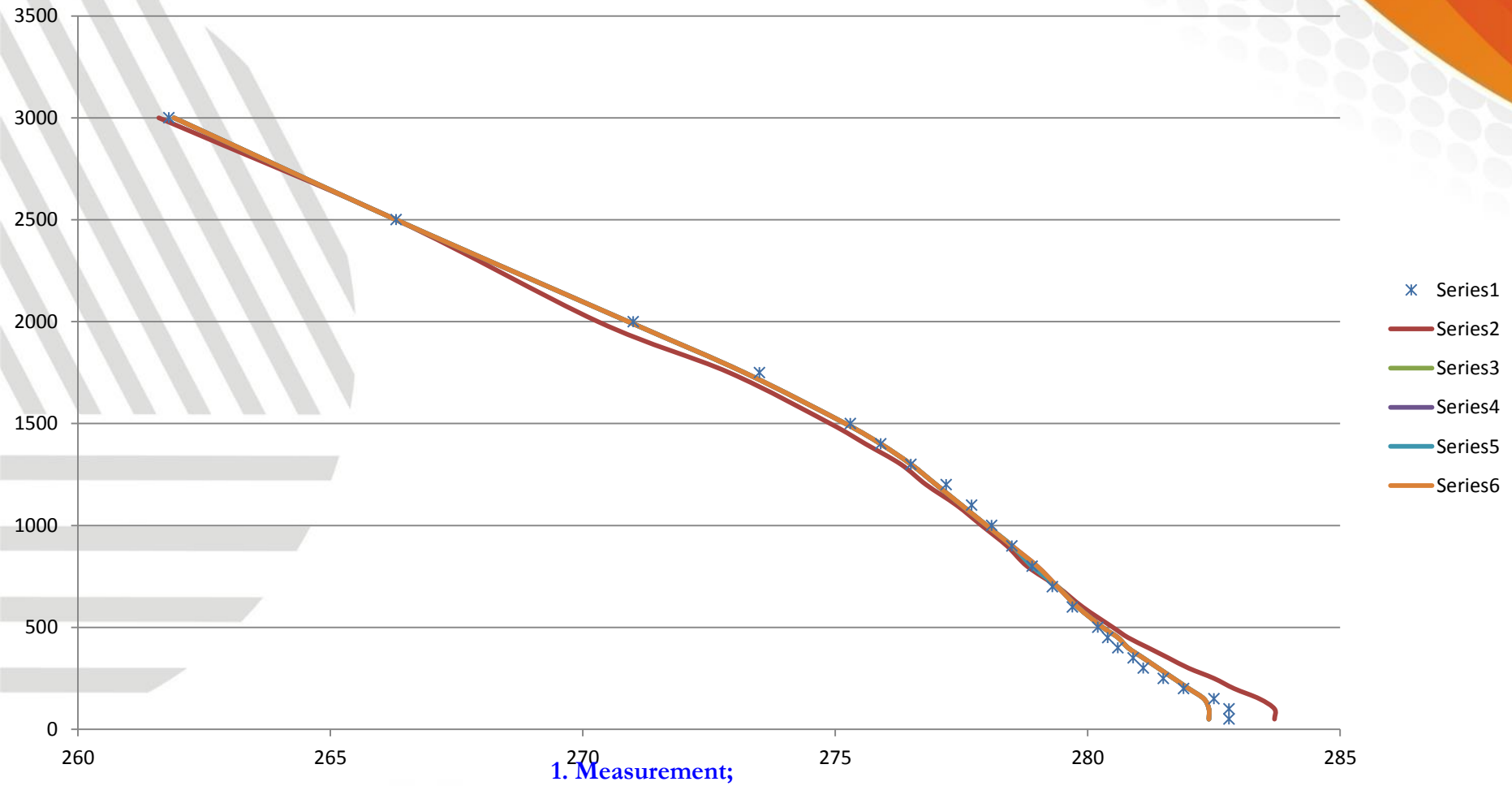
1. Measurement;
2. Reference
3. Results from COSMO model with modified parameterization – version 3;
4. Results from COSMO model with modified parameterization – version 6 for a=0,5;
5. Results from COSMO model with modified parameterization – version 5;
6. Results from COSMO model with modified parameterization – version 7;

Profile of air temperature



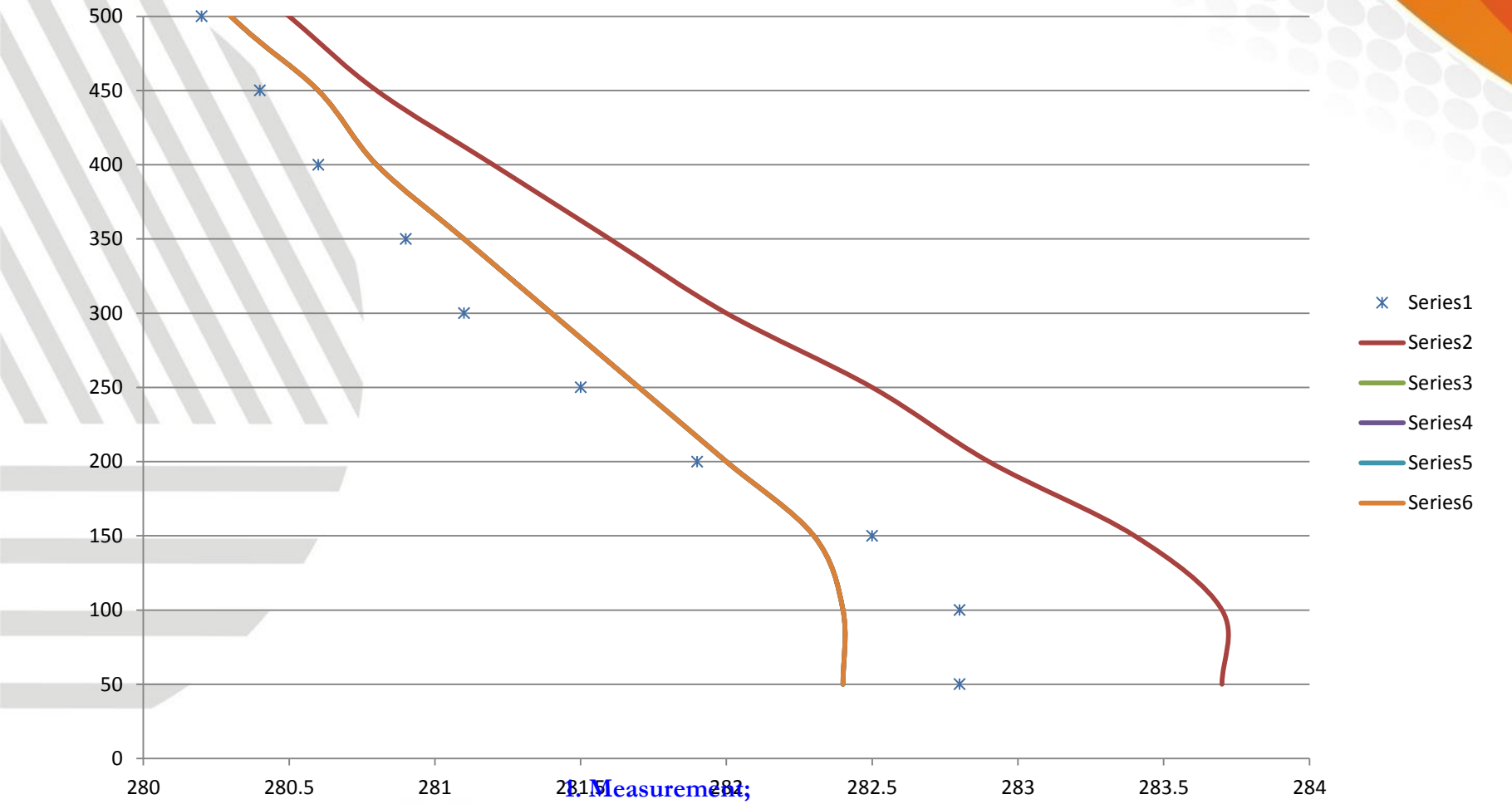
1. Measurement;
2. Reference
3. Results from COSMO model with modified parameterization – version 3;
4. Results from COSMO model with modified parameterization – version 6 for a=0,5;
5. Results from COSMO model with modified parameterization – version 5;
6. Results from COSMO model with modified parameterization – version 7;

Profile of dew point temperature



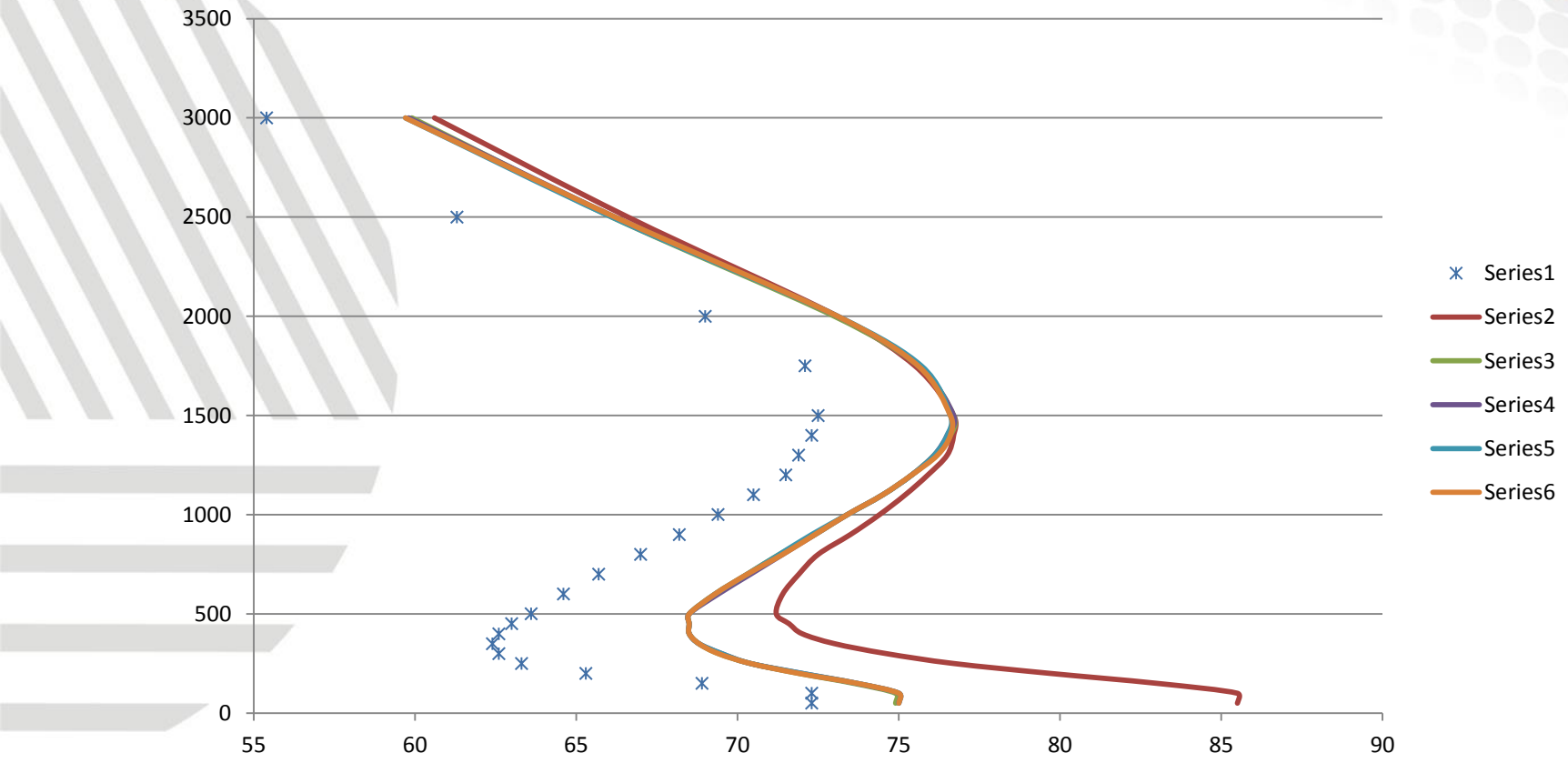
1. Measurement;
2. Reference
3. Results from COSMO model with modified parameterization – version 3;
4. Results from COSMO model with modified parameterization – version 6 for a=0,5;
5. Results from COSMO model with modified parameterization – version 5;
6. Results from COSMO model with modified parameterization – version 7;

Profile of dew point temperature



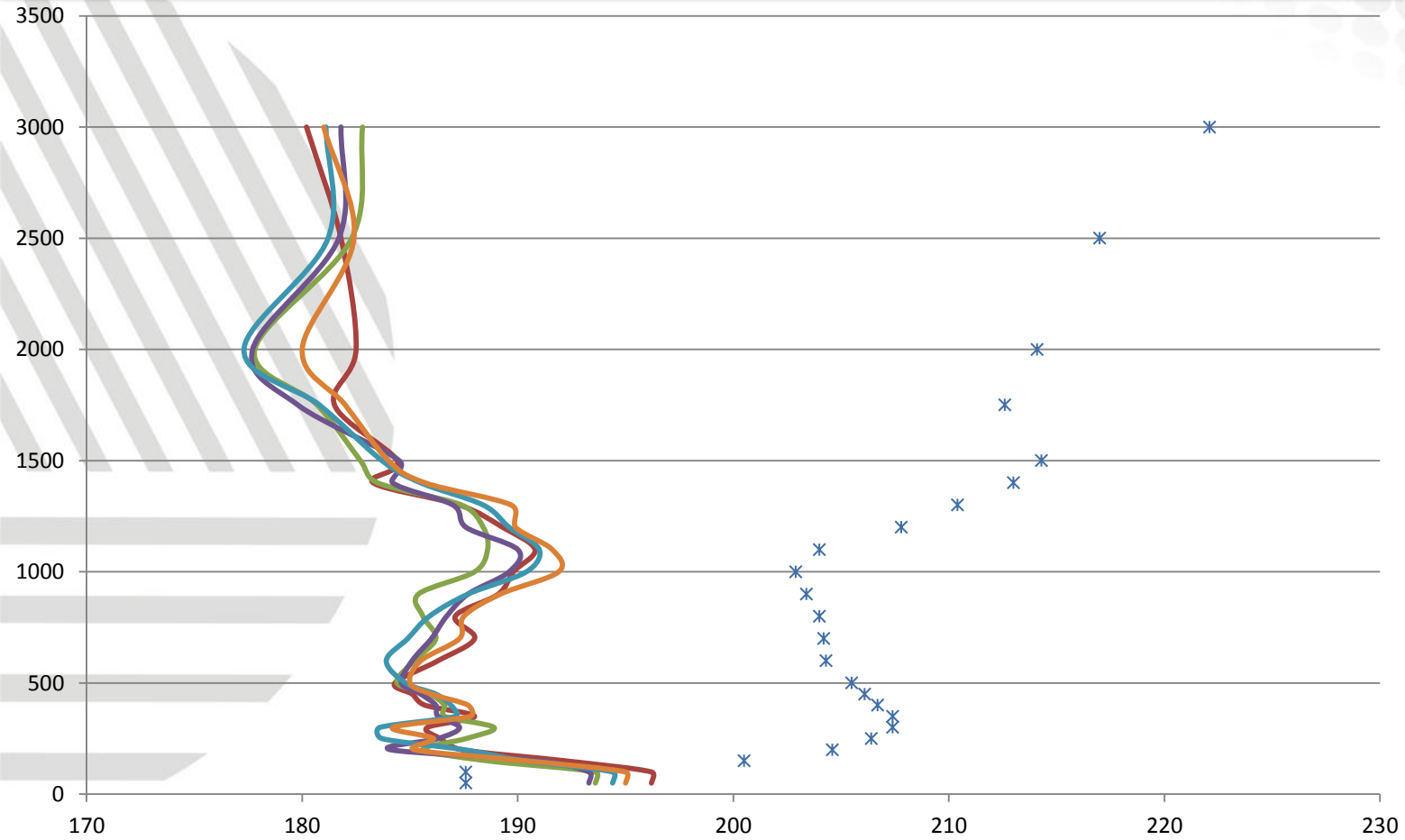
1. Measurement;
2. Reference
3. Results from COSMO model with modified parameterization – version 3;
4. Results from COSMO model with modified parameterization – version 6 for a=0,5;
5. Results from COSMO model with modified parameterization – version 5;
6. Results from COSMO model with modified parameterization – version 7;

Profile of relative humidity



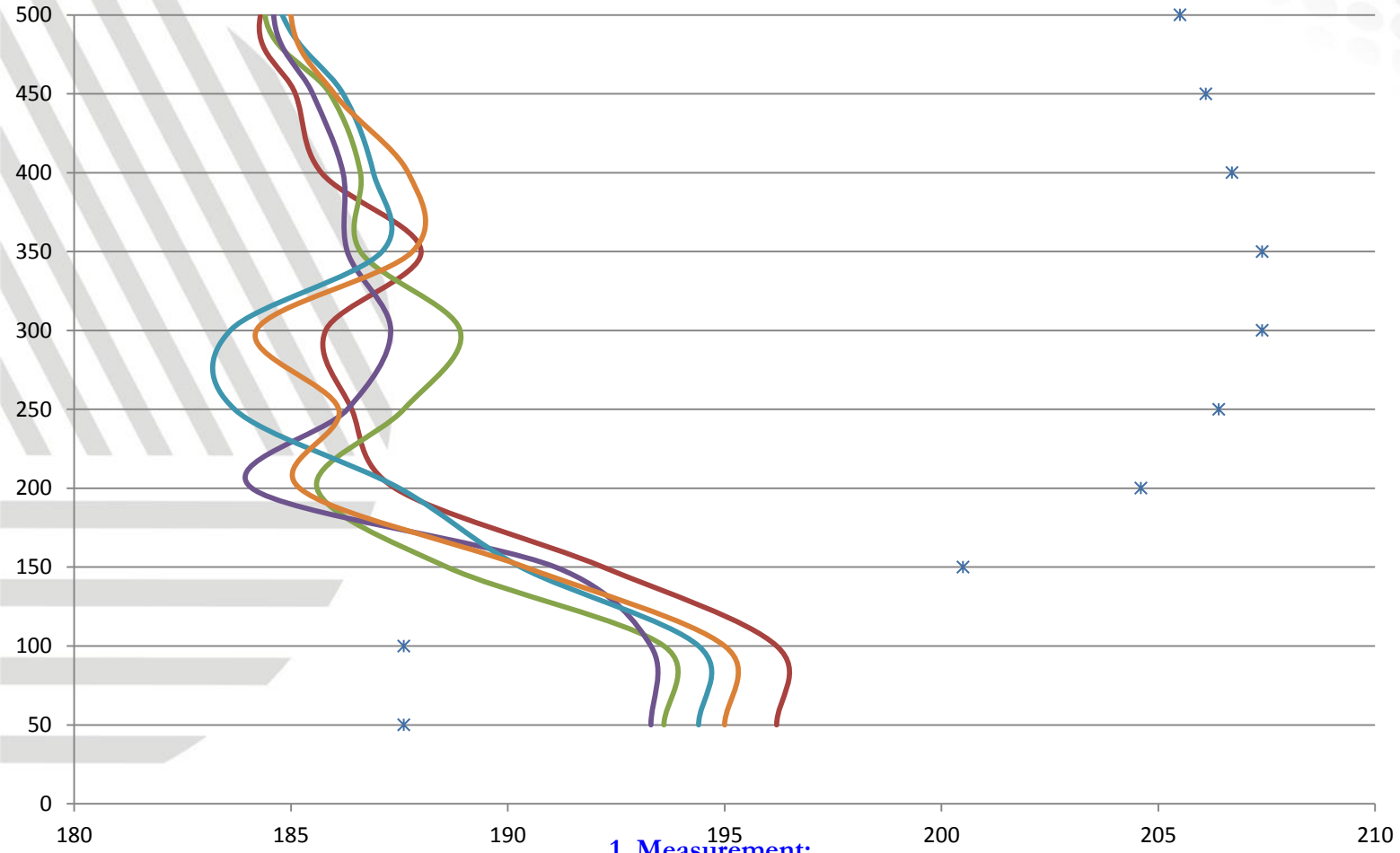
1. Measurement;
2. Reference
3. Results from COSMO model with modified parameterization – version 3;
4. Results from COSMO model with modified parameterization – version 6 for a=0,5;
5. Results from COSMO model with modified parameterization – version 5;
6. Results from COSMO model with modified parameterization – version 7;

Profile of wind direction



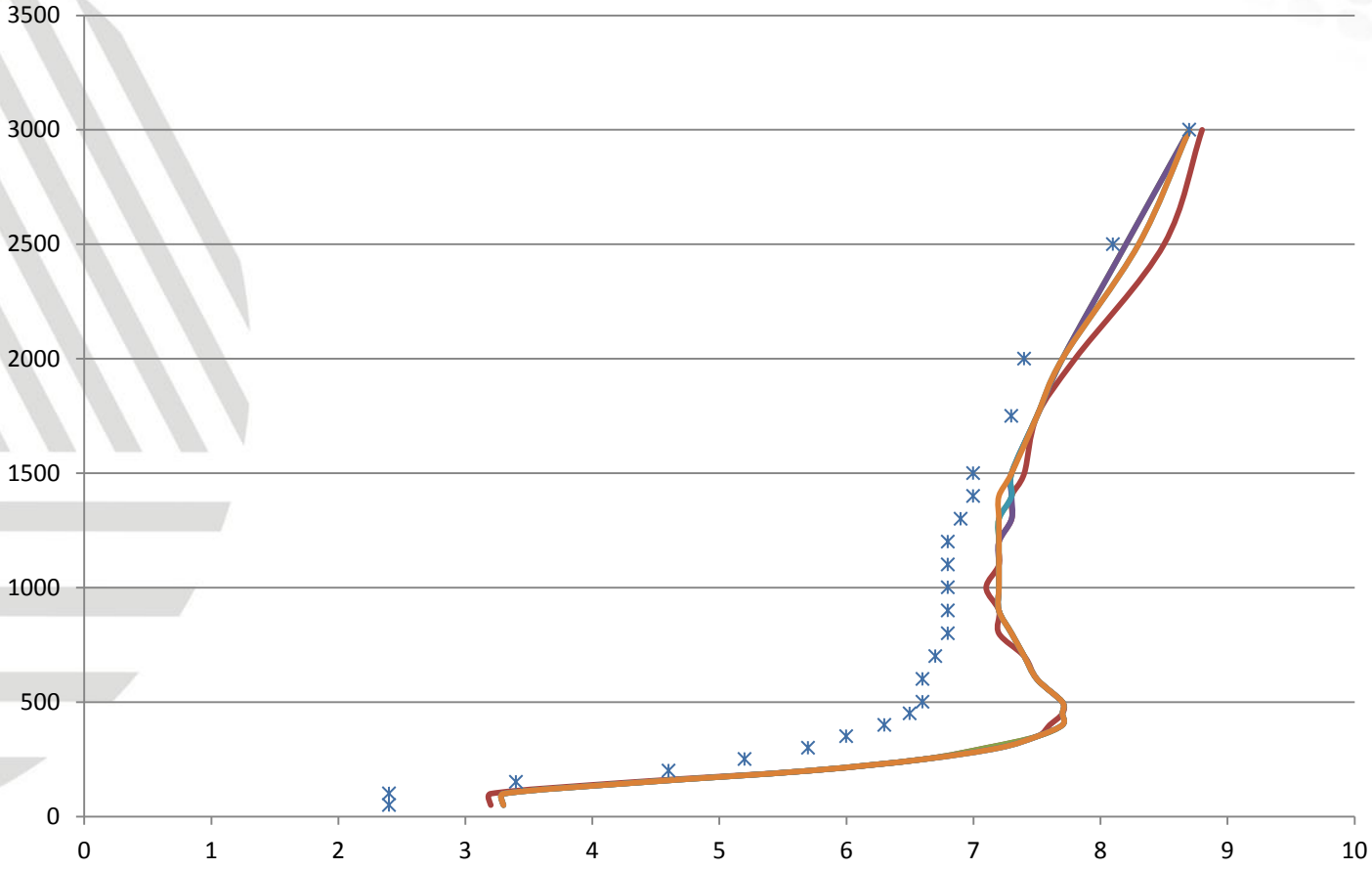
1. Measurement;
2. Reference
3. Results from COSMO model with modified parameterization – version 3;
4. Results from COSMO model with modified parameterization – version 6 for a=0,5;
5. Results from COSMO model with modified parameterization – version 5;
6. Results from COSMO model with modified parameterization – version 7;

Profile of wind direction



1. Measurement;
2. Reference
3. Results from COSMO model with modified parameterization – version 3;
4. Results from COSMO model with modified parameterization – version 6 for a=0,5;
5. Results from COSMO model with modified parameterization – version 5;
6. Results from COSMO model with modified parameterization – version 7;

Profile of wind speed



1. Measurement;
2. Reference
3. Results from COSMO model with modified parameterization – version 3;
4. Results from COSMO model with modified parameterization – version 6 for a=0,5;
5. Results from COSMO model with modified parameterization – version 5;
6. Results from COSMO model with modified parameterization – version 7;

- **Observed improvement forecast of**

a) air temperature;
b) dew point temperature;

during warm season and of

a) wind speed

during cold (January) season.

- **Observed influence on:**

a) profile of air temperature (improved);
b) profile of dew point temperature (improved during warm season for most stations);
c) profile of wind direction (improved for most stations);
d) profile of wind speed (no change or improved in the upper part of profile);
e) profile of relativity humidity (improved).

Future plans

- **We prepared new parameterization for:**

a) interception store;
b) infiltration of rain;
c) runoff from interception store.

- By the end of this year we plan to implement new results to the COSMO model and test.

Thank you for your attention

Grzegorz Duniec, Andrzej Mazur
Instytut Meteorologii i Gospodarki Wodnej
Państwowy Instytut Badawczy
Institute of Meteorology and Water Management
National Research Institute
01-673 Warszawa, ul.: Podleśna 61
tel. +48 22 56-94-134
grzegorz.duniec@imgw.pl
andrzej.mazur@imgw.pl
www.imgw.pl
www.pogodynka.pl