Homogenization of the wind speed time series in Czech Republic

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* Wind speed is one of the most problematic meteorological elements

* Spatially and temporally highly variable element

* Station practically measure only site conditions without influence of the greater neighborhood

* The problem in measurement methodology (change from Beaufort to Ultrasonic)

* Great influence of the changes in immediate surroundings - afforestation, new buildings

* Worldwide similar results, with the wind speed trend decrease - is it reality or is it caused by overall changes?
Annual 2.7 m/s
DJF 3.0 m/s
MAM 2.8 m/s
JJA 2.3 m/s
SON 2.6 m/s
Average wind speed - difference 1961-1990

Wind gust 1961-2014

I. to 300 m.s.l

II. 301-600

III. 601-900/above 600

IV. above 900/
No category

Brázdil et al. (2017)

Brázdil et al. (2016)
Average wind speed

Brázdil et al. (2017)
It looks great!!!
But is it all without problems?
Quality control and homogenization
Change of instruments

1. Metra Anemograf
2. Vaisala
3. Ultrasonic

Brázdil et al. (2016)
Photo: CHMI, Ostrava
- Necessary to correct and frequently calibrate instruments
- Anemograph or automatic cup instruments (Vaisala): The problem with the ball-bearing, when the device is unable to spin (more calm and lower high speed)
Station Červená - change 1954 - 2006
Foto: OMK Ostrava
Spatial relationships

(a) Annual, DJF, MAM, JJA, SON

Correlation coefficient vs. Distance (km)

(b) Annual, DJF, MAM, JJA, SON

Correlation coefficient vs. Altitude (m)
Data Quality Control

* Own approach, combination of several methods

Interquartile ranges

Comparing with neighbours
Comparing with expected values
Most suspicious values were found in the case of the wind speed (0.8 %)
* Detection - monthly data

* Two types of reference series
  * calculated one reference series from nearest or best correlated neighbours stations

* Pair-wise detection - comparison with each neighbours station individually

* SNHT, Bivariate and t-test
* For daily data

* Our own method - DAP (Distribution Adjusting by Percentiles) - an adaptation of a method for the correction of regional climate model outputs by Deque (2007) - variable correction

* Is based on comparison of percentiles (empirical distribution) of differences (or ratios) between candidate and reference series before and after a break.
1. First in year 2008 (1961 - 2007)

<table>
<thead>
<tr>
<th>Element</th>
<th>Nb. series</th>
<th>Nb. series with break</th>
<th>Ratio (%)</th>
<th>Nb. Breaks in series</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>181</td>
<td>100</td>
<td>55.2</td>
<td>81</td>
</tr>
<tr>
<td>Max Temp</td>
<td>178</td>
<td>122</td>
<td>68.5</td>
<td>56</td>
</tr>
<tr>
<td>Min Temp</td>
<td>179</td>
<td>92</td>
<td>51.4</td>
<td>87</td>
</tr>
<tr>
<td>Precipitation</td>
<td>761</td>
<td>117</td>
<td>15.4</td>
<td>644</td>
</tr>
<tr>
<td>Water vapour</td>
<td>173</td>
<td>123</td>
<td>71.1</td>
<td>50</td>
</tr>
<tr>
<td>Wind speed</td>
<td>176</td>
<td>132</td>
<td>75.0</td>
<td>44</td>
</tr>
<tr>
<td>Sunshine</td>
<td>102</td>
<td>55</td>
<td>53.9</td>
<td>47</td>
</tr>
</tbody>
</table>

Selected element: Wind speed

Diagram showing the number of breaks per decade from 1961 to 2011, with categories for no metadata, location, manual instrument, and automatic instrument.
Average correction higher than median

Highest correction in winter months

Average correction = 0.45 m/s (median = 0.36 m/s)

Most of the correction factor was negative = the older part of the series declined
Homogenization - results

![Graph showing wind speed trends over time]
Homogenization solve everything???
Unfortunately, no!!!
Number of day below/above certain threshold
(for example: number of the windstorms)

Homogenization (Anclim/ProClimDB)
Correction (DAP – Distribution Adjusting by Percentiles)
Fill the gaps (ProClimDB)
Štěpánek et al. 2011, 2013

268 time series of the Average wind speed
1961-2015

71 time series of the wind gust
1961-2015

Number of the days with
Wind speed = 0 m/s

Number of the days with
Wind speed < 1 m/s

Number of the days with
Wind speed > 8 m/s

Number of the days with
Wind gust > 10 m/s

Number of the days with
Wind gust > 15 m/s

Number of the days with
Wind gust > 20 m/s

RESULTS

Homogeneity testing (Anclim/ProClimDB)
Number of the days with various wind speed/gust
Štěpánek et al. 2013
Number of days below/above certain threshold (breeze; wind < 1.5 m/s)
Number of days below/above certain threshold

Wind speed > 8 m/s

Number of days

Number of days below/above certain threshold

Wind gust > 15 m/s

Number of days

Number of days below/above certain threshold

Wind gust > 20 m/s
<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Wind speed = 0 m/s</td>
<td>9.6</td>
<td>9.6</td>
<td>100</td>
</tr>
<tr>
<td>Wind speed &lt; 1 m/s</td>
<td>54</td>
<td>53</td>
<td>98</td>
</tr>
<tr>
<td>Wind speed &gt; 8 m/s</td>
<td>9.7</td>
<td>4.7</td>
<td>48</td>
</tr>
<tr>
<td>Wind gust &gt; 10 m/s</td>
<td>199.8</td>
<td>149.8</td>
<td>75</td>
</tr>
<tr>
<td>Wind gust &gt; 15 m/s</td>
<td>75.9</td>
<td>42.8</td>
<td>56</td>
</tr>
<tr>
<td>Wind gust &gt; 20 m/s</td>
<td>22.9</td>
<td>11.5</td>
<td>50</td>
</tr>
</tbody>
</table>
Brno - Tuřany (raw data)
Homogenization results

Wind speed = 0 m/s

Wind gust > 10 m/s

Wind speed < 1 m/s

Wind gust > 15 m/s

Wind speed > 8 m/s

Wind gust > 20 m/s

Vaisala Ultrasonic calibration
1. The observed change in wind speed is part of nature?
   
   Perhaps, but regarding the way we measure it, we may never know.

2. The observed change in wind speed is the work of man?
   
   The change of the station surroundings and the increase in roughness of the terrain definitely has an impact on reducing wind speed.

3. The observed change in wind speed is caused by automatization?
   
   Yes, the change in methodology and measurement instruments made significant impact on the time series and the question is how much it influences trend and how we are able to rightly correct it by homogenization.
Thank you for your attention