LONG-TERM DECLINING TRENDS IN HISTORICAL WIND MEASUREMENTS AT THE BLUE HILL METEOROLOGICAL OBSERVATORY, 1885-2013

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ABSTRACT. The Blue Hill Meteorological Observatory, located on the 625-foot summit of Great Blue Hill ten miles south of Boston, Massachusetts (MA), has been the site of continuous monitoring of the local weather and climate since its founding in 1885. The meticulous, extensive and high-quality climate record maintained at this location has included the measurement of wind among many other parameters since its earliest days, and this provides a unique opportunity to examine wind speed trends at this site over nearly 130 years. Although multiple wind sensors have been in use during this time and the record of observers was ended in 1939, as a result of which some local contributions to this windspeed trend have been continued to be possible through careful analysis of these changes and the application of adjustments to ensure consistency. The Blue Hill mean wind speed for the period 1885 to 1990 has been determined as 10.8 m s⁻¹ in the middle 20th century to present value of 9.0 m s⁻¹ with an increase in the rate of the decline beginning around 1980. The wind speed time series shows a significant (p < 0.01) downward trend over the entire period from 1885-2013 (-0.088 m s⁻¹ decade⁻¹) that is stronger and also significant for the sub-periods from 1961-2013 (-0.268 m s⁻¹ decade⁻¹) and 1979-2008 (-0.341 m s⁻¹ decade⁻¹; p < 0.01). This declining trend persists in all seasons and has significant implications for the efficiency of wind power generation in the area, if it reflects regional change in the near-surface wind regime. Preliminary analysis of the influence of large-scale atmospheric circulation is presented (a very weak impact of the North Atlantic Oscillation index and other northern hemisphere teleconnection patterns is found in the context of global stalling (i.e. the theory of a widespread decline in measured near-surface wind speed), including an analysis of the wind speed change as a function of wind direction.

Blue Hill Observatory and Wind Data

- **Location:** Summit of Great Blue Hill, Milton, MA (10 miles -16 km- SSW of Boston)
- **Founder:** Abbott Lawrence Otis on February 1, 1885
- **Elevation:** 635 feet (i.e. 194 meters) above sea-level.
- **Wind series:** Longest continuous wind record in North America (1885 to present)
- **Monthly wind data:** Averaged from daily mean derived from 24-hourly measurements.
- **Webpage:** For more information visit [http://www.bluehill.org](http://www.bluehill.org)

Annual and Seasonal Wind Speed Trends, 1885-2013

- **Annual mean wind speed by wind direction for 1870-1982:** The annual mean wind speed by wind direction for 1870-1982 (in blue) is compared with trends at each period of 10 years (in red) and the entire period of 1870-1982 (in black). The computation of varying 10-year trends revealed a wind from the southwest that is stronger in winter, and a wind from the northeast that is stronger in summer.
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Metadata, Quality Control and Adjustments

- **High-quality near-surface wind series were obtained after:** The recovery of data from the BHO archives; (ii) passing of quality control to remove aberrant data and to check for data consistency, and (iii) applying the following instrument adjustments:

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Anemometer Height</th>
<th>Anemometer Type</th>
<th>Wind Speed Recorder Type</th>
<th>Correction Applied</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feb. 1885 – Jun. 1908</td>
<td>34-35 feet (10.5-m) Robinson 4-cup (USWB) Draper recorder</td>
<td>Unknown</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>Jun. 1908 – Oct. 1931</td>
<td>50-52 feet (15.5-m) Robinson 4-cup (USWB) Draper recorder</td>
<td>Draper recorder</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>Oct. 1931 – Feb. 1940</td>
<td>52 feet (16-m) Draper recorder</td>
<td>Draper recorder</td>
<td>Eq. 1</td>
<td></td>
</tr>
<tr>
<td>Feb. 1940 – Oct. 1958</td>
<td>52 feet (16-m) Draper recorder</td>
<td>Draper recorder</td>
<td>Table 1</td>
<td></td>
</tr>
<tr>
<td>Oct. 1959 – Jul. 1964</td>
<td>60-62 feet (18.3-m) WSP-3 cup anemometer chart recorder</td>
<td>WSP-3 cup chart recorder</td>
<td>Eq. 2</td>
<td></td>
</tr>
<tr>
<td>Jul. 1964 – Present</td>
<td>52 feet (16-m) NWS 3-cup</td>
<td>NWS 3-cup contacting chart recorder</td>
<td>Table 1</td>
<td></td>
</tr>
</tbody>
</table>

* Eq. 1 Corrected = (Recorded × 0.5058) / 1.019
* Eq. 2 Corrected = (Recorded - 0.236) / 1.019
* Applied to monthly wind speed data.

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