How Does Wind Respond to Rising Temperatures?

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Differences in pressure, or pressure gradients, cause wind. So, how does wind respond to rising temperatures? Several studies have addressed different aspects of this question in recent years.

McPhaden and Zhang (2002)[1], for example, studied surface winds over the Pacific Ocean and the currents they produce in the water below that flow outward from the equator and eventually sink and flow back from both hemispheres to meet and rise near the equator. Over the period 1950-1999, they discovered that this overturning circulation of the ocean "has been slowing down since the 1970s, causing a decrease in upwelling of about 25% in an equatorial strip between 9°N and 9°S." As for the reason for the decrease in wind speeds, the scientists indicate the gradual decline may possibly have been caused by global warming - which is just the opposite of what climate alarmists say should happen - but they also note that natural variability may just as easily have been the cause of what they observed.

In a very different part of the world, Siegismund and Schrum (2001)[2] investigated wind speed characteristics over the North Sea for the period 1958-1997, finding that "the annual mean wind speed for the North Sea shows a rising trend of ~10% during the last 40 years," in harmony with what climate alarmists typically predict. In addition, they determined that "since the early 1970s 'strong wind' events are more frequent than in the 1960s," also in harmony with climate-alarmist predictions. As for the cause of these phenomena, however, the researchers say their data "may suggest an anthropogenic origin, but this hypothesis can neither be supported nor disproved by analyzing such short time series." Thus, in order to gain a better understanding of the relationship - if any - that may exist between global air temperature and wind speed, longer time periods need to be examined, and several scientists have done just that.

Slonosky *et al*. (2000)[3] analyzed atmospheric surface pressure data from 51 stations located throughout Europe and the eastern North Atlantic over the period 1774-1995, finding that atmospheric circulation over Europe was "considerably more variable, with more extreme values in the late 18th and early 19th centuries than in the 20th century." About the same time, Pirazzoli (2000)[4] studied tide-gauge and meteorological (wind and atmospheric pressure) data over the period 1951-1997 for the northern portion of the Atlantic coast of France, discovering that the number of atmospheric depressions (storms) and strong surge winds for this region "are becoming less frequent."

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[1] http://www.co2science.org/articles/V5/N11/C1.php.
[2] http://www.co2science.org/articles/V5/N8/C2.php.
[3] http://www.co2science.org/articles/V4/N20/C1.php.
[4] http://www.co2science.org/articles/V4/N13/C3.php.

Four years later, Barring and von Storch (2004)[5] analyzed pressure readings for Lund (since 1780) and Stockholm (since 1823) in Sweden in an effort to create a record of storminess. Results indicated their proxy time series for storminess were "remarkably stationary in their mean, with little variations on time scales of more than one or two decades." More specifically, they reported that "the 1860s-70s was a period when the storminess indices showed general higher values," as was the 1980s-90s, but that, subsequently, "the indices have returned to close to their long-term mean." Based on these findings, Barring and von Storch concluded their paper by stating that that their storminess proxies "show no indication of a long-term robust change towards a more vigorous storm climate." In fact, during "the entire historical period," in their words, storminess was "remarkably stable, with no systematic change and little transient variability." It can therefore be concluded that for Sweden, at least, and perhaps for much of the surrounding region, there has been no warming-induced increase in windstorms over the entire transitional period between the Little Ice Age and the Modern Warm Period, which suggests there is little reason to believe that this non-trend would change with any further warming of the globe, in stark contradiction of what most climate alarmists claim will occur.

For the period 1820-2002, annual and monthly pressure data exhibited semi-decadal oscillations but no significant upward or downward trend.

Contemporaneously, Hanna *et al*. (2004)[6] examined several climatic variables over the past century in Iceland, including air pressure, temperature, precipitation and sunshine data, in an effort to determine if there is "possible evidence of recent climatic changes" in that cold island nation. For the period 1820-2002, annual and monthly pressure data exhibited semi-decadal oscillations but no significant upward or downward trend. As for what may be responsible for the oscillations in the data, they mention the likely influence of the sun, in consequence of their finding a 12-year peak in their spectral analysis of the pressure data, which they say is "suggestive of solar activity."

Expanding the solar/pressure link further, Veretenenko *et al*. (2005)[7] examined the potential influence of galactic cosmic rays (GCR) on the long-term variation of North Atlantic sea level pressure over the period 1874-1995. Comparisons of long-term variations in cold-season (October-March) sea level pressure with different solar/geophysical indices revealed that increasing sea level pressure coincided with a secular rise in solar/geomagnetic activity that was accompanied by a decrease in GCR intensity, whereas long-term decreases in sea level pressure were observed during periods of decreasing solar activity and rising GCR flux. Spectral analysis further supported a link between sea level pressure, solar/geomagnetic activity and GCR flux, as similar spectral characteristics (periodicities) were present among all data sets at time scales ranging from approximately 10 to 100 years.

The results of this analysis support a link between long-term variations in cyclonic activity and trends in solar activity/GCR flux in the extratropical latitudes of the North Atlantic. Concerning

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5 http://www.co2science.org/articles/V7/N47/C1.php.

6 http://www.co2science.org/articles/V7/N44/C2.php.

7 http://www.co2science.org/articles/V8/N52/C1.php.

how this relationship works, Veretenenko *et al*. hypothesize that GCR-induced changes in cloudiness alter long-term variations in solar and terrestrial radiation receipt in this region, which in turn alters tropospheric temperature gradients and produces conditions more favorable for cyclone formation and development.

In another study, Gulev and Grigorieva (2004)[8] used the Voluntary Observing Ship wave data of Worley *et al*. (2005) to characterize significant wind-driven wave height (HS) over various ocean basins throughout all or parts of the 20th century. The two Russian scientists report that "the annual mean HS visual time series in the northeastern Atlantic and northeastern Pacific show a pronounced increase of wave height starting from 1950," which finding sounds pretty much like it vindicates climate-alarmist thought on the subject. "However," as they continue, "for the period 1885-2002 there is no secular trend in HS in the Atlantic," and "the upward trend in the Pacific for this period ... becomes considerably weaker than for the period 1950-2002."

Given such findings, it is clear that annual mean wind-driven wave heights over the last decade of the 20th century – the warmth of which climate alarmists claim was unprecedented over the last two millennia – were not higher than those that occurred earlier in the century.

Gulev and Grigorieva also note that the highest annual HS in the Pacific during the first half of the century "is comparable with that for recent decades," and that "in the Atlantic it is even higher than during the last 5 decades." In fact, in the Atlantic the mean HS of the entire *decade* of the 1920s is higher than that of any recent decade; and the mean HS of the last half of the 1940s is also higher than that of the last five years of the record. In the Pacific it also looks like the mean HS from the late 1930s to the late 1940s may have been higher than that of the last decade of the record, although there is a data gap right in the middle of this period that precludes us from conclusively proving this latter point. Given such findings, it is clear that annual mean wind-driven wave heights over the last decade of the 20th century -- the warmth of which climate alarmists claim was unprecedented over the last two millennia -- were *not* higher than those that occurred earlier in the century.

Writing as background for their study, McVicar *et al*. (2010)[9] note that there has been great interest "in the widespread declining trends of wind speed measured by terrestrial anemometers at many mid-latitude sites over the last 30-50 years," citing the work of Roderick *et al*. (2007), McVicar *et al*. (2008), Pryor *et al*. (2009) and Jiang *et al*. (2010); and they say that this *stilling*, as it has come to be called, is "a key factor in reducing atmospheric evaporative demand," which drives actual evapotranspiration when water availability is not limiting, as in the case of lakes and rivers. In addition, they note that near-surface *wind speed* (*u*) nearly always increases as land-surface *elevation* (z) increases, as demonstrated by the work of McVicar *et al*. (2007), and that increasing wind speeds lead to increases in atmospheric evaporative demand, while decreasing wind speeds do the opposite, both of which changes can

[8] http://www.co2science.org/articles/V8/N9/C1.php.

[9] http://www.co2science.org/articles/V13/N26/C1.php.

be of great significance for people dependent upon water resources derived from mountainous headwater catchments. Consequently, it would be advantageous to learn how this *latter* phenomenon (the change in near-surface wind speed with ground elevation) may also have varied over the last few decades of global warming, since the authors write that "over half the global population live in catchments with rivers originating in mountainous regions (Beniston, 2005), with this water supporting about 25% of the global gross domestic product (Barnett *et al*., 2005)."

Defining *u*z as change in wind speed with change in elevation (*u*z = Δ*u*/Δz, where Δ*u* = *u*2-*u*1, Δz = z2-z1, and z2 > z1), McVicar *et al*. calculated monthly averages of *u*z based on monthly average *u* data from low-set (10-meter) anemometers maintained by the Chinese Bureau of Meteorology at 82 sites in central China and by MeteoSwiss at 37 sites in Switzerland from January 1960 through December 2006, which activity, in their words, constituted "the first time that long-term trends in *u*z in mountainous regions have been calculated." Results indicated, according to the seven scientists, that "for both regions *u*z trend results showed that *u* has declined more rapidly at higher than lower elevations." Such a decline in wind speed at many mid-latitude sites and a further decline in wind speed at higher elevations, should act to reduce water loss via evaporation from high altitude catchments in many of the world's mountainous regions, providing more water for people who obtain it from such sources. In addition, McVicar *et al*. note that the "reductions in wind speed will serve to reduce rates of actual evapotranspiration partially compensating for increases in actual evapotranspiration due to increasing air temperatures."

A search of the literature allowed the scientists to identify similar massive wind-induced movements of sand in England, Scotland, Denmark, Portugal and the Netherlands during these same times of relative coolness.

More recently, Alexander *et al*. (2011)[10] analyzed storminess across the whole of southeast (SE) Australia using extreme (standardized seasonal 95th and 99th percentiles) geostrophic winds deduced from eight widespread stations possessing sub-daily atmospheric pressure observations dating back to the late 19th century. According to the four researchers, their results "show strong evidence for a significant reduction in intense wind events across SE Australia over the past century." More specifically, they say that "in nearly all regions and seasons, linear trends estimated for both storm indices over the period analyzed show a decrease," while "in terms of the regional average series," they say that "all seasons show statistically significant declines in both storm indices, with the largest reductions in storminess in autumn and winter."

Taking a longer view, Ekman (1999)[11] utilized sea level data from Stockholm, Sweden, that stretched back in time over two and a quarter centuries to 1774, to investigate long-term trends in the levels of the Baltic and North Seas, as well as the relationships of these trends to

[10] http://www.co2science.org/articles/V14/N31/C1.php.
[11] http://www.co2science.org/articles/V3/N29/C1.php.

various climatic factors. Throughout the 1800s, they determined there had been a rapidly decreasing number of dominating winter winds from the northeast. Since such winds typically tend to reduce sea levels at Stockholm, this regime shift led to a gradual increase in the rate of rise of sea level there. Subsequently, the winter winds gradually shifted to where the dominant airflow was from the southwest. Since winds from this direction tend to promote high sea levels at Stockholm, the rate of rise in sea level there continued to increase. The net result of these wind regime changes was thus a continual increase in the rate of rise of sea level at Stockholm over the entire two-century period, resulting in a mean sea level rise of 1.0 mm/year over the 20th century. Hence, as the world transitioned from the Little Ice Age to the Modern Warm Period, sea levels around Stockholm rose, not from the melting of polar ice, but from a systematic shifting of wind direction.

Clarke *et al*. (2002)[12] used an infrared stimulated luminescence technique to date sands from dunes in the Aquitaine region of southwest France. From their measurements they identified three main phases of wind-induced dune formation: 4000-3000 years ago during the long cold interval that preceded the Roman Warm Period, 1300-900 years ago during the early to middle Medieval Warm Period, but during what they describe as its cooler periods, and 550-250 years ago during the Little Ice Age, again during what they call its cooler periods. In addition, a search of the literature allowed the scientists to identify similar massive wind-induced movements of sand in England, Scotland, Denmark, Portugal and the Netherlands during these same times of relative coolness. For the most recent of these cool periods, they also note the existence of voluminous historical records that describe many severe North Atlantic wind storms.

In another study, cores of peat taken from two raised bogs in the near-coastal part of Halland, Southwest Sweden (Boarps Mosse and Hyltemossen) were examined by Bjorck and Clemmensen (2004)[13] for their content of wind-transported clastic material in an effort to determine temporal variations in Aeolian Sand Influx (ASI), which is correlated with winter wind climate in that part of the world. Based on their analysis, the researchers report that “the ASI records of the last 2500 years (both sites) indicate two timescales of winter storminess variation in southern Scandinavia.” Specifically, they note that “decadal-scale variation (individual peaks) seems to coincide with short-term variation in sea-ice cover in the North Atlantic and is thus related to variations in the position of the North Atlantic winter season storm tracks,” while “centennial-scale changes - peak families, like high peaks 1, 2 and 3 during the Little Ice Age, and low peaks 4 and 5 during the Medieval Warm Period - seem to record longer-scale climatic variation in the frequency and severity of cold and stormy winters.”

Bjorck and Clemmensen also found a striking association between the strongest of these winter storminess peaks and periods of reduced solar activity. They specifically note, for example, that the solar minimum between AD 1880 and 1900 “is almost exactly coeval with the period of increased storminess at the end of the nineteenth century, and the Dalton Minimum between AD 1800 and 1820 is almost coeval with the period of peak storminess reported here.” In addition, they say that an event of increased storminess they dated to AD 1650 “falls at the beginning of the Maunder solar minimum (AD 1645-1715),” while further back in time they

[12] http://www.co2science.org/articles/V5/N25/C1.php.
[13] http://www.co2science.org/articles/V7/N43/C3.php.

report high ASI values between AD 1450 and 1550 with “a very distinct peak at AD 1475,” noting that this period coincides with the Sporer Minimum of AD 1420-1530. In addition, they call attention to the fact that the latter three peaks in winter storminess all occurred during the Little Ice Age and “are among the most prominent in the complete record.”

Finally, working with data from the insurance industry, Changnon (2009)[14] analyzed “catastrophes caused solely by high winds” that had had their losses adjusted so as to make them “comparable to current year [2006] values.” Although the *average monetary loss* of each year’s catastrophes “had an upward linear trend over time, statistically significant at the 2% level,” when the *number* of each year’s catastrophes was considered, it was found that “low values occurred in the early years (1952-1966) and in later years (1977-2006),” while “the peak of incidences came during 1977-1991.” Thus, it was not surprising, as Changnon describes it, that “the fit of a linear trend to the annual [catastrophe number] data showed no upward or downward trend.”

To briefly summarize the several findings presented above, it appears that, if anything, the cool nodes of Earth’s millennial-scale climatic oscillation are much more prone to high wind conditions than are its warm nodes and that the gradual warming of the globe over the past two centuries has probably reduced wind speeds over many portions of the planet, although there may well be regional exceptions to this general rule. In addition, changes in wind speed have implications for a host of other phenomena, ranging from reconstructions of true sea level histories to fluctuations in evaporation and wave heights. And, there is some evidence that these wind-driven phenomenon may be solar-induced.

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Cover photo of wind on the waves at Glass Beach in California
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