Climate Change and Offshore Wind in New York State

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The Climate System And Atmospheric Variability
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ISSUE: How is the marine boundary layer wind profile affected when you factor in trends (what makes a trend?), climate signals (teleconnections—do they interfere or re-enforce), and reference to long-term climate stations (what is a “representative” wind climatology?).
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BIG QUESTION: How does atmospheric variability in all its flavors affect our characterization of the wind resource over the longer term?
Atmospheric State

Source: Scripps Institute, NOAA ESRL

Temperature Baseline: 1901 – 2000

Global T anomaly (degrees C)

CO₂
CH₄

CO₂ (Keeling Curve)

CH₄ (Methane)

Latest CO₂ reading
March 21, 2018

Temperature anomaly (red dots above long-term mean)

409.88 ppm

800K years

Global T anomaly (degrees C)

Year

1880  1900  1920  1940  1960  1980  2000  2020

CO₂ (ppm)

CH₄ (ppm)

1600  1650  1700  1750  1800  1850  1900

280  300  320  340  360  380  400  420

(ppm)
Global Warming and Wind

Hypothesis: leads to a reduction in the meridional thermal gradient (since higher latitudes experience greater warming) and hence the pressure gradient which drives the wind.

Question: how will (are) these large scale changes affect(ing) distribution of offshore wind in New York?
A few years ago…

Wind speed trends over the contiguous United States

S. C. Pryor,¹, R. J. Barthelmie,¹ D. T. Young,¹ E. S. Takle,² R. W. Arritt,² D. Flory,² W. J. Gutowski Jr.,² A. Nunes,³ and J. Roads³,⁴

Received 4 November 2008; revised 15 April 2009; accepted 15 May 2009; published 23 July 2009.

[1] A comprehensive intercomparison of historical wind speed trends over the contiguous United States is presented based on two observational data sets, four reanalysis data sets, and output from two regional climate models (RCMs). This research thus contributes to detection, quantification, and attribution of temporal trends in wind speeds within the historical/contemporary climate and provides an evaluation of the RCMs being used to develop future wind speed scenarios. Under the assumption that changes in wind climates are partly driven by variability and evolution of the global climate system, such changes should be manifest in direct observations, reanalysis products, and RCMs. However, there are substantial differences in temporal trends derived from observational wind speed data, reanalysis products, and RCMs. The two observational data sets both exhibit an overwhelming dominance of trends toward declining values of the 50th and 90th percentile and annual mean wind speeds, which is also the case for simulations conducted using MM5 with NCEP-2 boundary conditions. However, converse trends are seen in output from the North American Regional Reanalysis, other global reanalyses (NCEP-1 and ERA-40), and the Regional Spectral Model. Equally, the relationship between changing annual mean wind speed and interannual variability is not consistent among the different data sets. NCEP-1 and NARR exhibit some tendency toward declining (increasing) annual mean wind speeds being associated with decreased (increased) interannual variability, but this is not the case for the other data sets considered. Possible causes of the differences in temporal trends from the eight data sources analyzed are provided.
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WASHINGTON – The wind, a favorite power source of the green energy movement, seems to be dying down across the United States. And the cause, ironically, may be global warming – the very problem wind power seeks to address. “It’s a very large effect,” said study co-author Eugene Takle, a professor of atmospheric science at Iowa State University. In some places in the Midwest, the trend shows a 10 percent drop or more over a decade. That adds up when the average wind speed in the region is about 10 to 12 miles per hour. “There’s been a jump in the number of low or no wind days in the Midwest”, said the study’s lead author, Sara Pryor, an atmospheric scientist at Indiana University. Jeff Freedman, an atmospheric scientist with AWS Truewind, an Albany, N.Y., renewable energy consulting firm, has studied the same topic. He said his research has found no definitive trend of reduced surface wind speed. One of the problems Pryor acknowledges with her study is that over many years, changing conditions near wind-measuring devices can skew data. If trees grow or buildings are erected near wind gauges, that could reduce speed measurements.

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Or does it? My 2c

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My 2¢ { Or does it? }
Offshore Wind Resource

Courtesy UL-AWST
Potential Offshore Wind (OSW) Sites in NY

Of 6 potential offshore wind areas characterized, 5 were selected as the closest, most advanced and/or most representative of the resource potential reasonably available during the Study period.

From NYSERDA Clean Energy Cost Study (May 2016)
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But first, historical trends...

Ambrose Light/Buoy 44065

Annual Wind Speed (Extrapolated to 90 m) at ALSN6/44065

Using Shear Exponent = 0.11
Trend = 0.21 ms\(^{-1}\) Per Decade
\(r^2 = 0.29986\)

Trend: +0.21 m s\(^{-1}\)

Years with at least 8000 hourly records
Buoy 44025

Trend: +0.21 m s\(^{-1}\)

Annual Wind Speed (Extrapolated to 90 m) at 44025

Using Shear Exponent = 0.11
Trend = 0.21 ms\(^{-1}\) Per Decade

\(r^2 = 0.29567\)
To meet the REV goals, solar and wind energy production will need to increase ten-fold

Thus, *it is crucial that a high-resolution assessment of the potential influence of climate change on NY’s integrated renewable energy resource is available for planning, policy, and development purposes*
Meteorological and climatological influences (mesoscale): strengthen/weaken sea breezes; offshore low-level jet synoptic scale: frequency of frontal passages, low/high pressure systems, intensity/persistence of surface pressure gradients (do we have more/fewer storms, more intense/weaker storms?)
High Resolution Climate Modeling

Perform **dynamic downscaling** of the selected CMIP5 models in WRF for 3 periods:

2. near-future (2018 - 2035)
3. mid-future (2036 - 2055)

Variables of interest:

- Surface (10 m) and **hub height** (80m, 100 m, and 120 m) wind speed and direction
- Surface irradiance
- Precipitation
Generally, average annual higher wind speeds are found as we go further offshore. But, under sea breeze/offshore low-level jet conditions...
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About the sea breeze...

B Grid (12 km): Wind Speed and Direction For Composite Hour = 2200 GMT

Height = 70 m

No wind!

speed/direction arrows every 24 km
Sea breeze days better for load matching than onshore wind
Heat Index versus Peak Load, NYC (2008 – 2012)

Polynomial Fit: Max Heat Index Versus Max Load

$\text{HI} = -42.379 + 2.049015 \times T + 10.14333 \times RH - 0.2247554 \times T \times RH - 6.8378310^{-3} \times T^2 - 5.48171710^{-2} \times RH^2 + 1.2287410^{-5} \times T^2RH + 8.528210^{-4} \times TRH^2 - 1.9910^{-6} \times T^2RH^2$
80 m Wind Speed
The Future?

RCP: Representative Concentration Pathways

RCP4.5
Long Island

RCP8.5
80 m Wind Speed

The Future?

RCP: Representative Concentration Pathways

RCP4.5

RCP8.5

This is just the CMIP5 Model/Ensemble—not downscaled!

CMIP5: Coupled Model Intercomparison Project [Phase 5]
New York State Mesonet
126 surface stations (standard)
17 Profiler (LiDAR, Radiometer)
17 Flux (H, LE, CO$_2$, Rn)
20 Snow depth

http://www.nysmesonet.org

Nick Bassill NYSTM
Wantagh
Wantagh, NY Seabreeze (10 April 2017)
10 minutes—hub height winds go from 4 to 17 m s\(^{-1}\)!
Thank You!

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