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Comparing monthly statistical distributions of wind speed measured at wind towers and estimated from ERA-Interim

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Comparing monthly statistical distributions of wind speed measured at wind towers and estimated from ERA-Interim

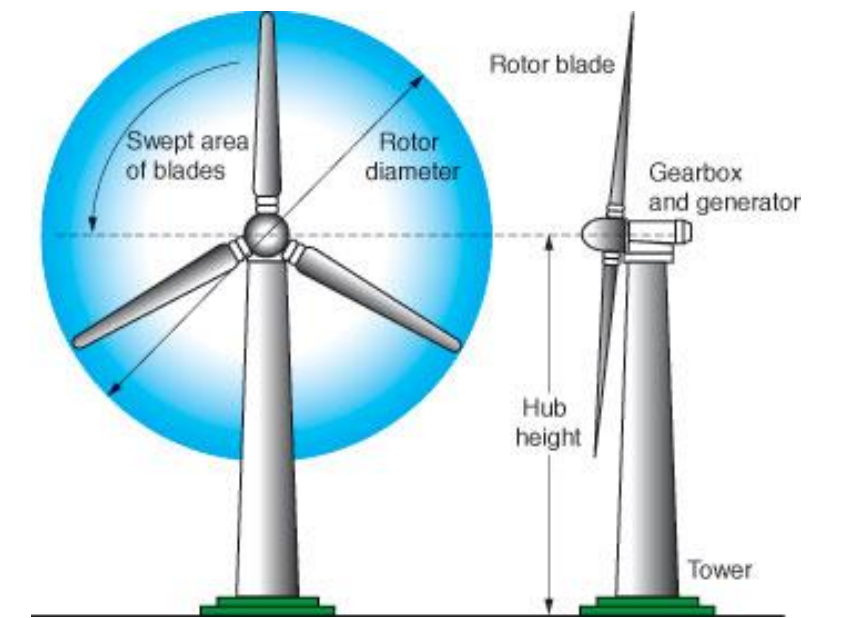
- The energy sector is undergoing a major transformation with an increasing share of power supply from variable renewable energy sources and an increasing variability in energy demand in a variable and changing climate. The European Climatic Energy Mixes (ECEM) project will develop a demonstrator to assess how well different energy supply mixes in Europe will meet demand, over seasonal to long-term decadal time horizons, focusing on the role climate has on the mixes.
- To that end, there is a need for long-term time series of many surface climate variables to develop energy profiles
- Given the paucity of observations, a reanalysis product such as ERA-Interim is a candidate to supply such variables over a long time period (30+ years) and on a regular global grid

Rationales

Wind speed must be known at hub height of a windmill

Standard hub height of a windmill is approx. 80 m. Wind speed must be known at this height to estimate the amount of electricity power produced by the windmill. Interest focuses on monthly statistical distributions of wind speed to determine periods when the wind power plants are expected to produce more or less than expected.

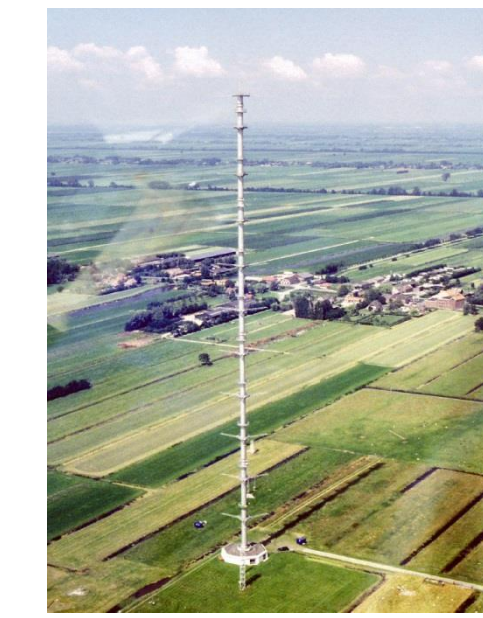
Can monthly statistical distributions wind speed at this height be derived from the estimates of wind speed provided by ERA-Interim at different pressure levels?



Drawing of the rotor and blades of a wind turbine. From <https://str.lnl.gov/AprMay10/mirocha.html>

Measurements from wind towers

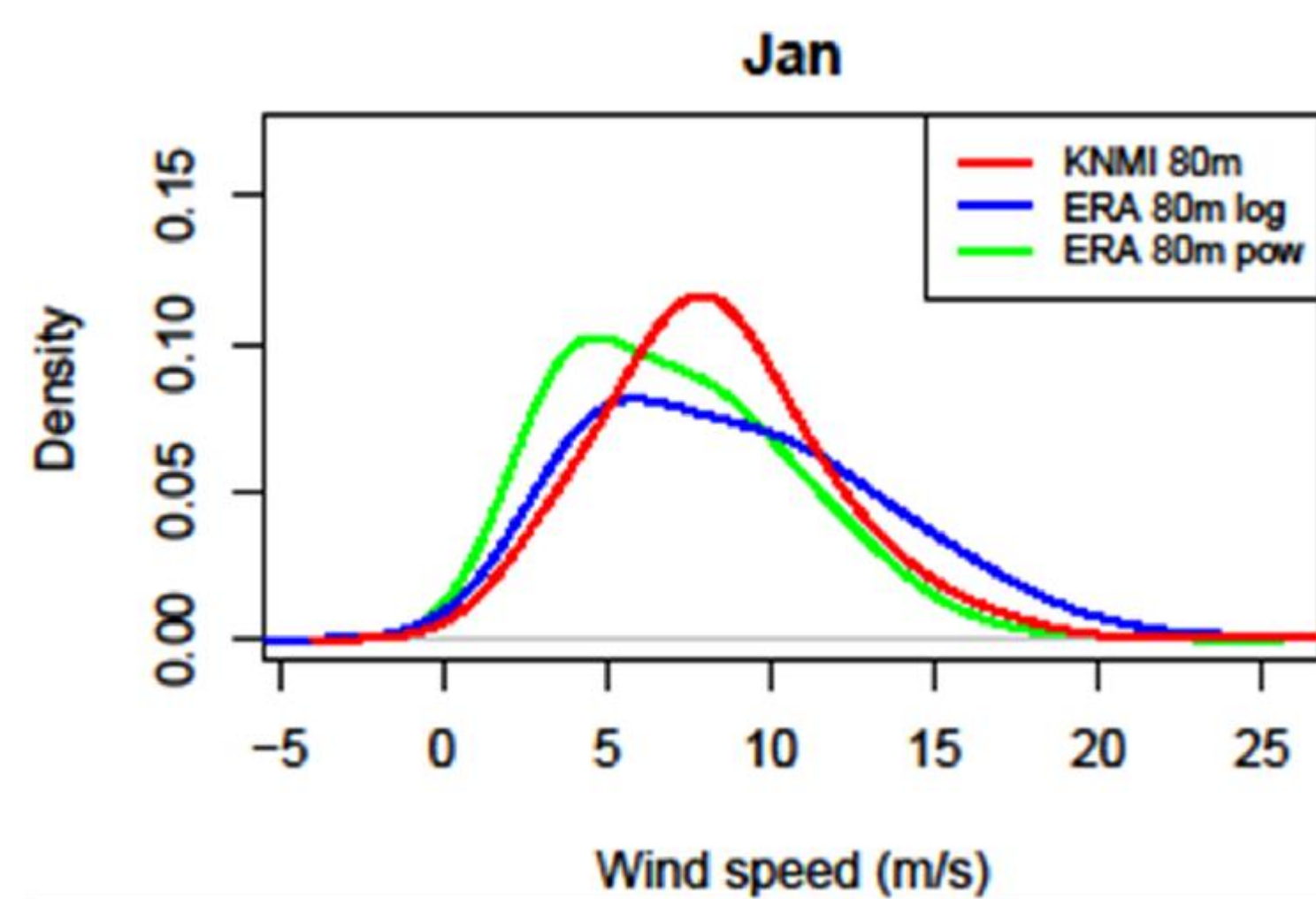
Several time series of wind speed were obtained from the KNMI tower at Cabauw in The Netherlands for the period 2001 to 2014, and from the offshore tower at Docking Shoal in the North Sea for the period 2006 to 2009. Time series were re-sampled with a time step of 6 h, the same than ERA-Interim. Histograms were built for each calendar month and reference 2-parameters (A, k) Weibull distributions were adjusted on them. A is related to the mean speed, and k depicts the asymmetry of the distribution.



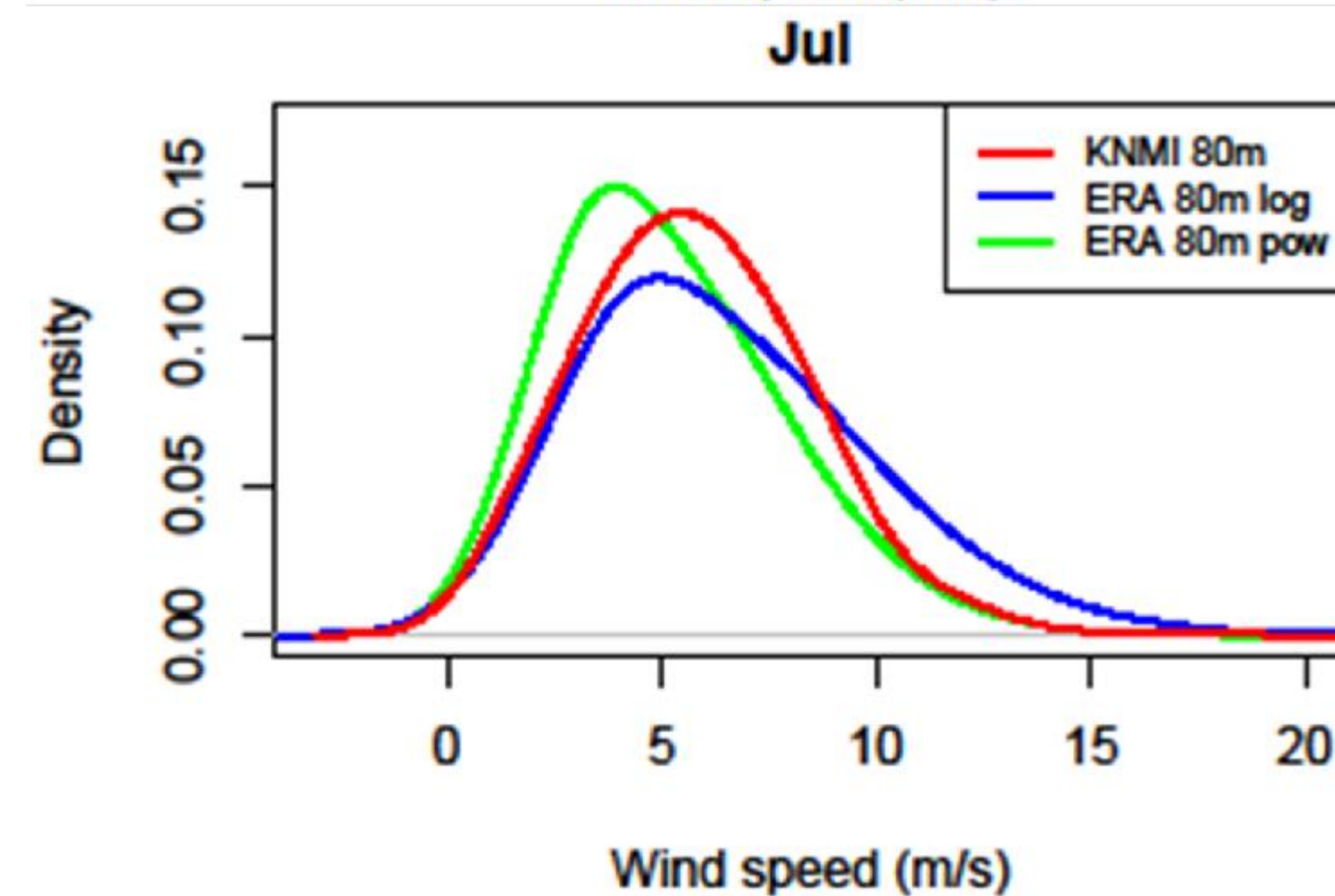
Picture of the KNMI wind tower at Cabauw. From: <http://www.climateexchange.nl/projects/bsikme1/cabauw.htm>

Comparing results to measurements from wind towers

Similarly, estimated 2-parameters Weibull distributions were built using ERA-Interim values of wind speed at different levels. One series was built with a power approach and a second with a log approach with ERA-Interim wind speed at 10 m as input. The aerodynamic roughness length is set to the standard values for short grass ($z_0=0.001$ m) and open sea ($z_0=0.0002$ m). The estimated statistical distributions are then compared to the reference for each month.

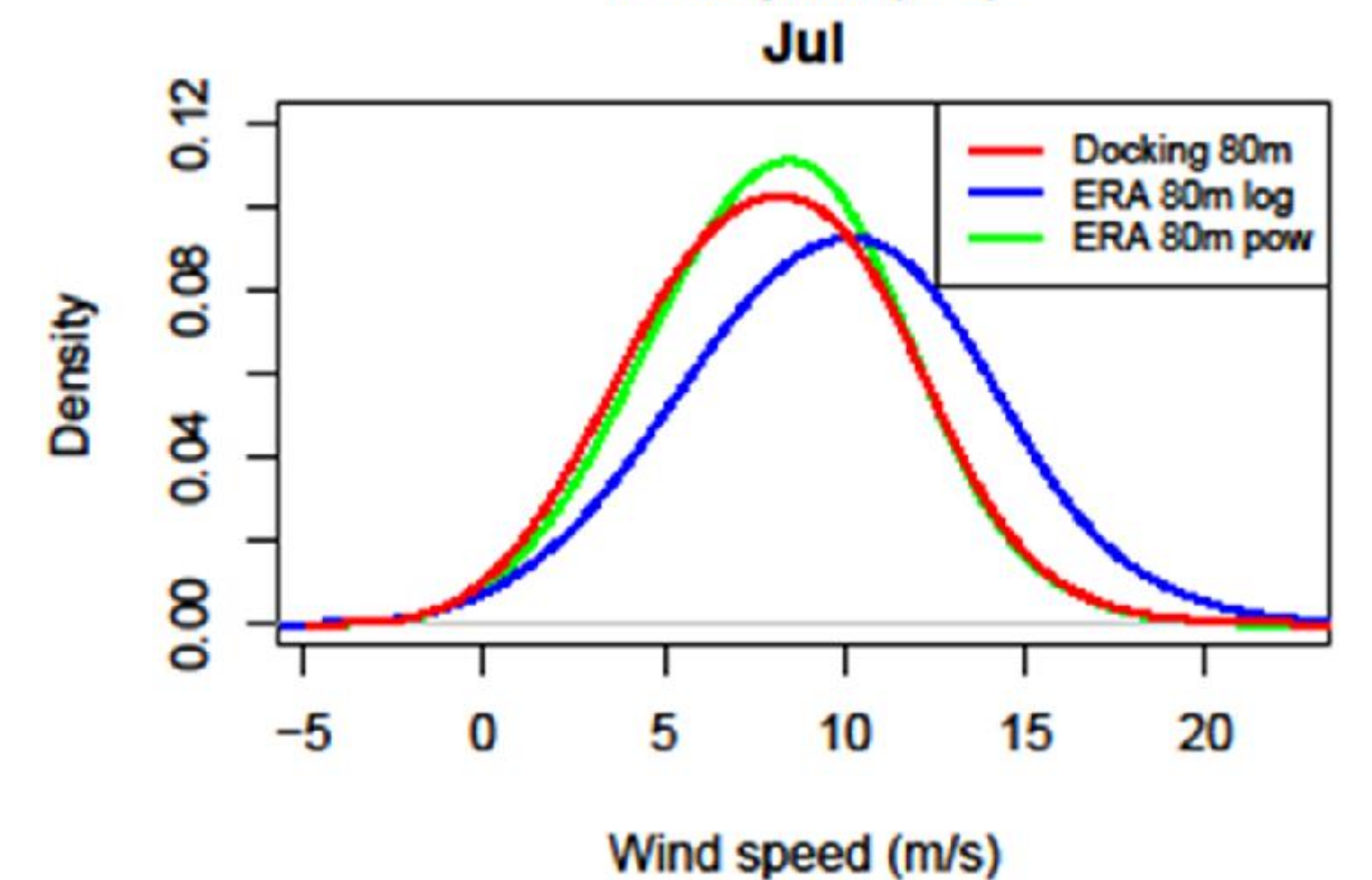
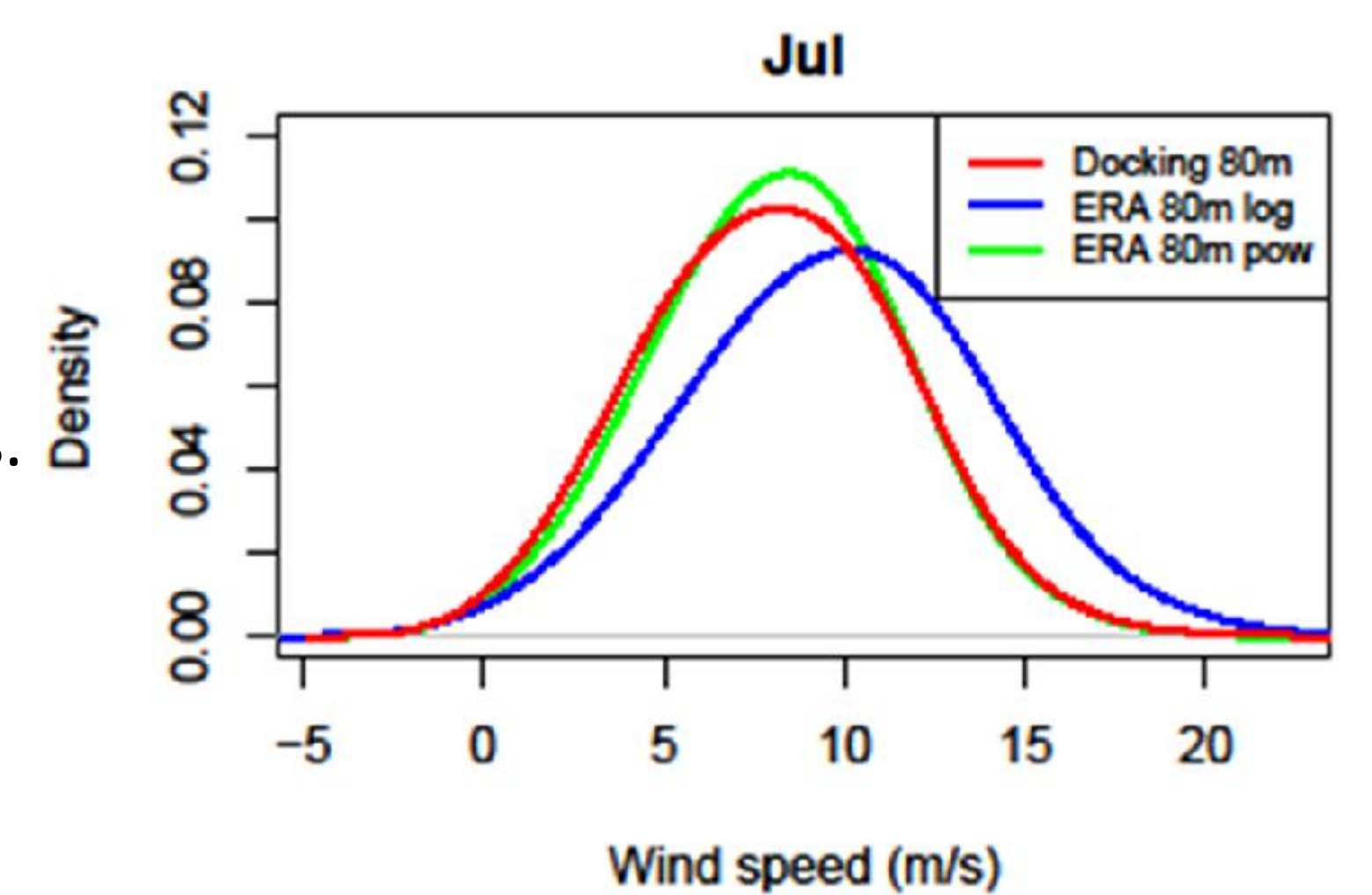


At Cabauw, the performances of each approach depend on the month (only Jan and Jul shown here). The distributions in green (power) is biased towards lower wind speeds. The blue one exhibits more frequently high speeds than the reference. Nevertheless, bias is small and around -1 m/s for the power approach and 1 m/s for the log approach.



The log approach produces stronger winds on average than the power approach at both sites. For both sites, the **differences** between means of the estimates and those of measurements **are small for each calendar month**. These are preliminary results. Further studies are underway that will include additional measurements from two other towers in Europe: Karlsruhe (Germany) for the period 1979 to 2014, and offshore FINO1 (German Bight) for the period 2004 to 2014.

At Docking Shoal, the power approach exhibits statistical distributions very close to the reference ones for each month. Those from the log approach are biased towards higher wind speeds. Bias is less than -2 m/s for the power approach and 6 m/s for the log approach.



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Conclusion

These results show that monthly statistical distributions of wind speed at hub height of a windmill can be derived from the estimates of wind speed provided by ERA-Interim. Improvements are possible. Such approaches will allow the construction of long-term time series of wind energy production for any site, therefore contributing to the assessment of how well different energy supply mixes in Europe will meet demand, over seasonal to long-term decadal time horizons.