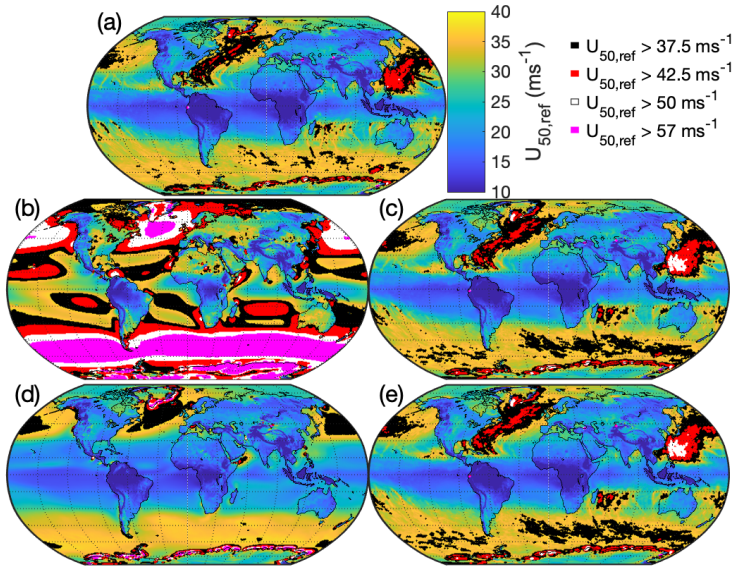
Digital atlas of extreme wind speeds

U.S. Department of Energy | Office of Science
HYPERFACETS
A Framework for Improving Analysis and Modeling of Earth System and Intersectoral Dynamics at Regional Scales



Maps from the extreme sustained wind speeds at 100 m a.g.l. (ms^{-1}) digital atlas. Once in 50-year estimates (U_{50}) are from the Gumbel distribution with parameters estimated from: (a) Maximum Likelihood, (c) Method of Moments, (d) the Weibull parameters, and (e) the Graphical approach. (b) U_{ref} from the Wind Turbine Design Standard (five times the mean annual mean). ERA5 grid cells with U_{50} or U_{ref} estimates in excess of the three thresholds for different onshore wind turbine classes (37.5, 42.5 and 50 ms^{-1}) are identified using the white, red and black squares. U_{50} or U_{ref} estimates above 57 ms^{-1} (design threshold for tropical cyclones) are shown by magenta squares.

Pryor S.C. and Barthelmie R.J. (2021): A global assessment of extreme wind speeds for wind energy applications. *Nat Energy* doi: 10.1038/s41560-020-00773-7.

Scientific Achievement

Estimation of extreme wind speeds is critical to wind turbine design for structural integrity and capital costs for a given site. Such estimates are not available for most locations or are subject to large uncertainty due to temporally limited on site measurements. We derive, validate and distribute a global, homogenized and geospatially explicit digital atlas of U_{50} and associated confidence intervals based on ERA5 reanalysis output at wind turbine hub-heights.

Significance and Impact

Further cost-effective expansion of the wind energy industry will benefit from robust estimates of wind resource and operating conditions. Extreme design loads are determined in part by the 50-year return period sustained wind speed (U_{50}). It is shown that the estimation method used in the wind turbine design standard is generally a conservative estimate of U_{50}. This may cause over-engineering of wind turbines and excess capital costs.

Research Details

This analysis employs 40 years of hourly ERA5 reanalysis output, and generates a digital atlas of extreme wind speeds and uncertainties using a range of geospatial statistics.

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