Towards turbine location-aware multi-decadal wind power predictions with CMIP6

Nina Effenberger, Nicole Ludwig

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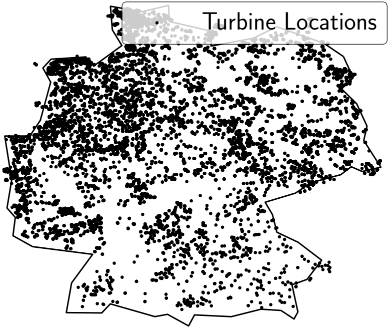
Assessing wind power potential in the face of climate change

A gridded approach does not seem representative

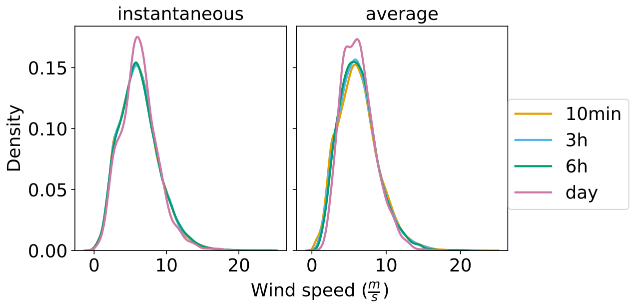
How much power will a wind turbine generate over its lifetime?
How much wind power potential will we have in the future?



Choosing data

Temporal resolutions matter

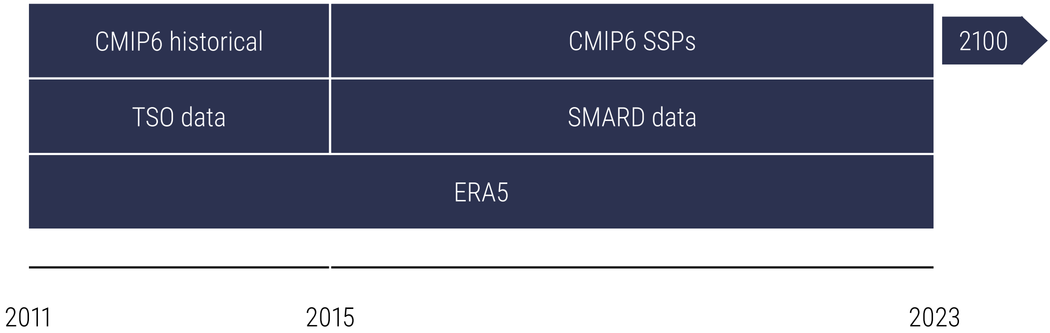
Effenberger, Ludwig and White (ERL 2023)



- Wind data is Weibull-distributed
- Averaging introduces a systematic bias
- Instantaneous data should be used

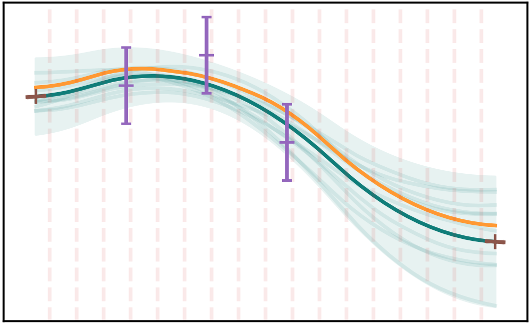
Climate, power and weather data

Most data is not temporally aligned



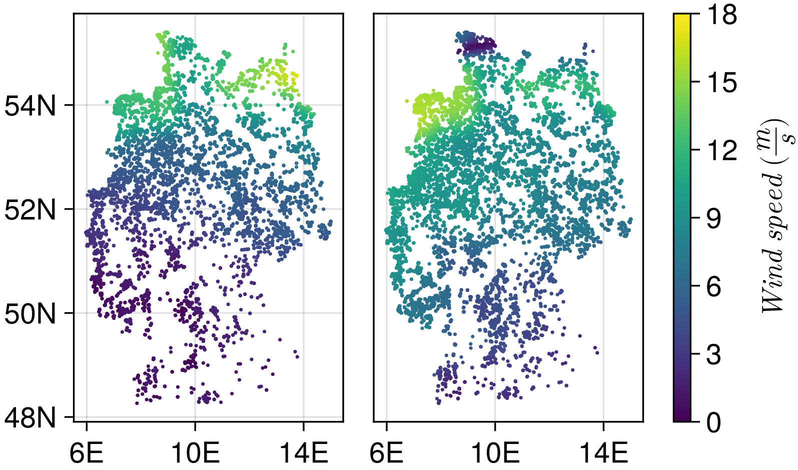
A (multi-output) Gaussian Process is a probability measure P over functions $f : \mathbb{R}^d \to \mathbb{R}^{d'}$.
For a GP prior, we can compute posterior measures like

$$\mathrm{P}(f \mid f(X) + \epsilon = y).$$



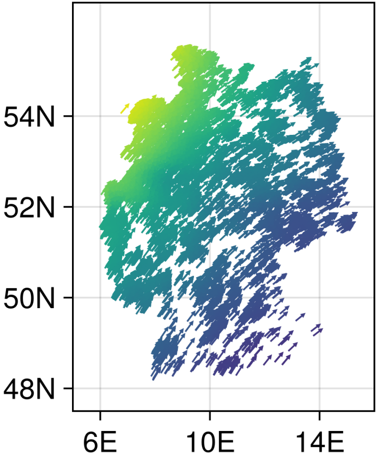
Predicting wind speeds at turbine locations

The density of turbines matters for wind power generation



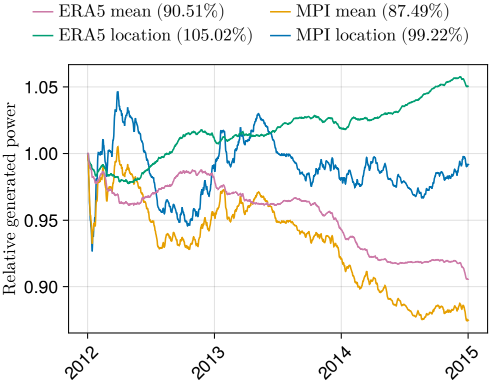
Compute wind speeds over time

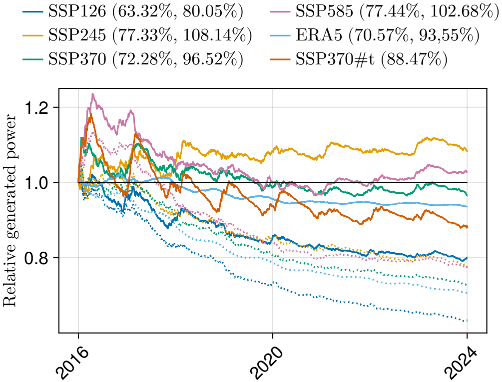
Then extrapolate to hub-height and generate power predictions



Power forecasts using CMIP6 and ERA5

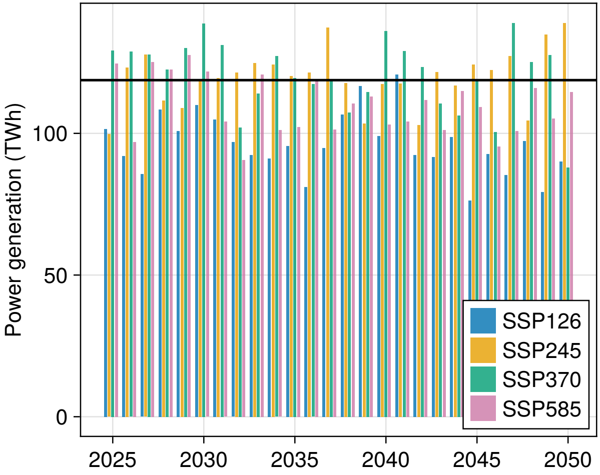
Indirect validation





Multi-decadal wind power predictions for Germany

More wind power in SSP2-4.5 and 3-7.0, less wind power in SSP1-2.6 and SSP5- 8.5.



Find the pre-print on arxiv!