Turbine location-aware multi-decadal wind power predictions using CMIP6

Nina Effenberger, Nicole Ludwig

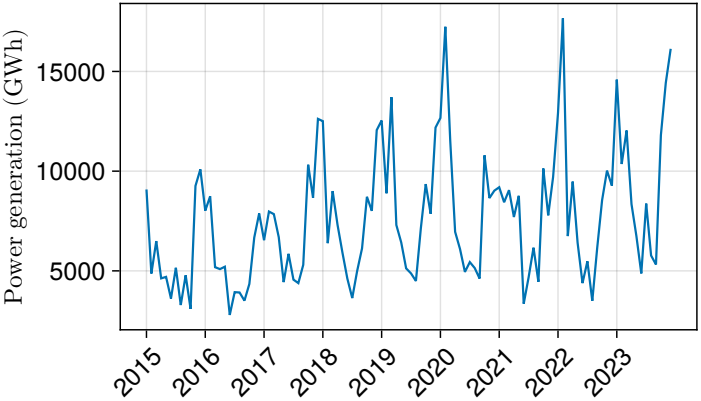
Climate Physics - ETH Zürich

EGU 25

Sharing is encouraged

How much wind power will turbines in Germany generate in the future?

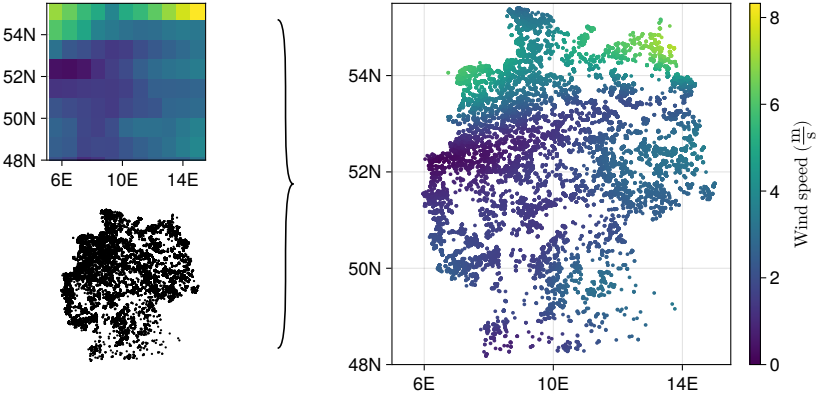
Turbine location-aware multi-decadal wind power predictions using CMIP6



Gaussian processes give location-specific predictions

Combining data sources

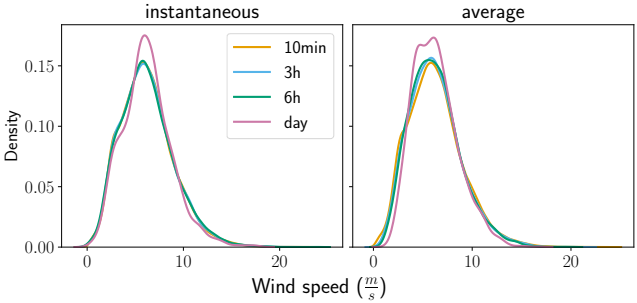
Effenberger and Ludwig, Neurips CCAI 2024



Choosing data

Temporal resolutions matter

Effenberger, Ludwig and White (ERL 2023)

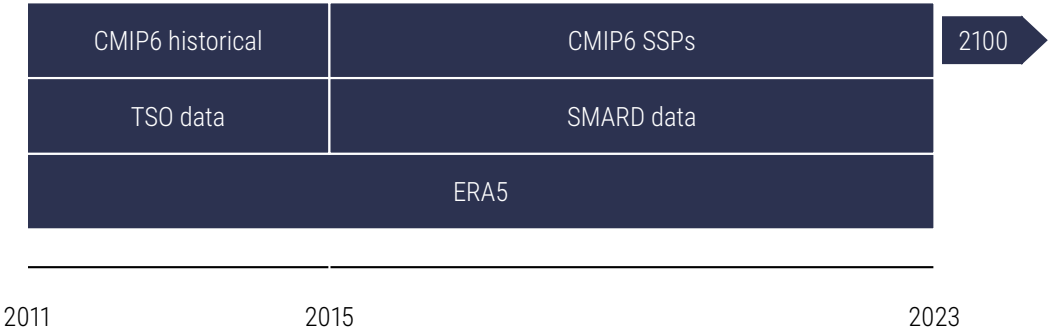


- Averaging wind speeds introduces a systematic bias
- Instantaneous data should be used

To the paper:

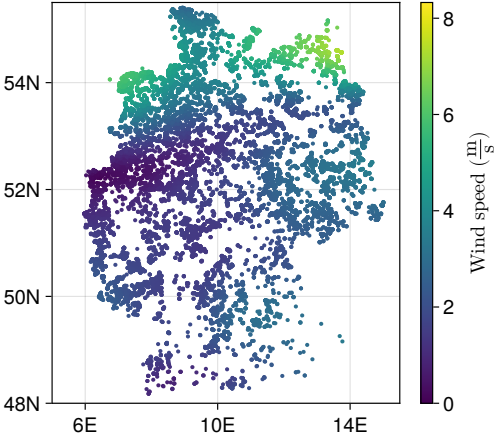
Climate, power and weather data

Most data is not temporally aligned



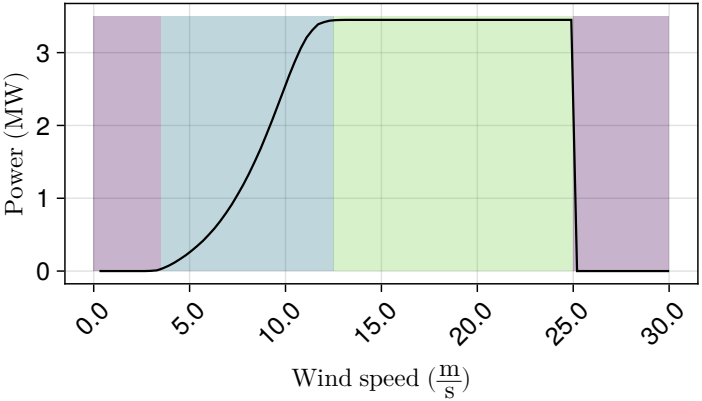
Generating wind speed predictions per time point

We can do this for every 6th hour



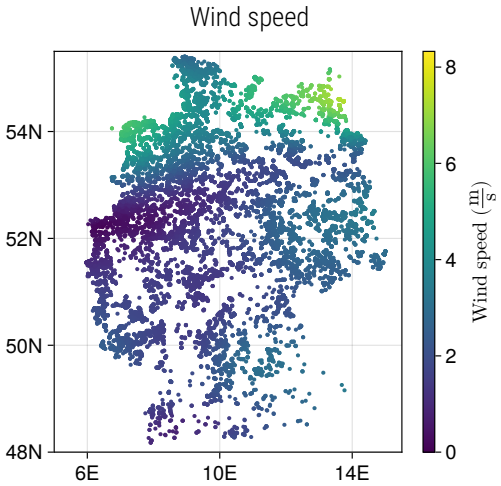
Wind speed to power

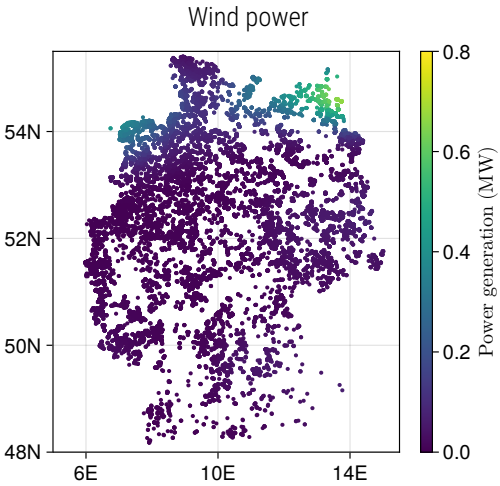
Deterministic modeling



And generating location-specific power predictions

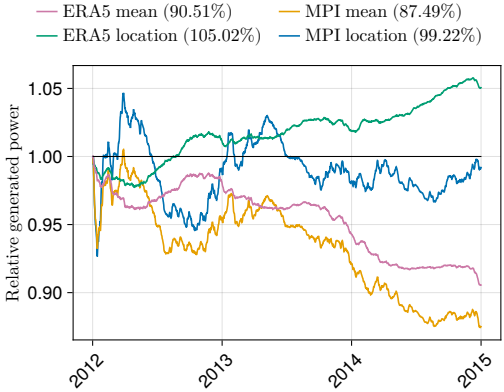
We can feed the wind speeds into power curves





Power forecasts using CMIP6 and ERA5

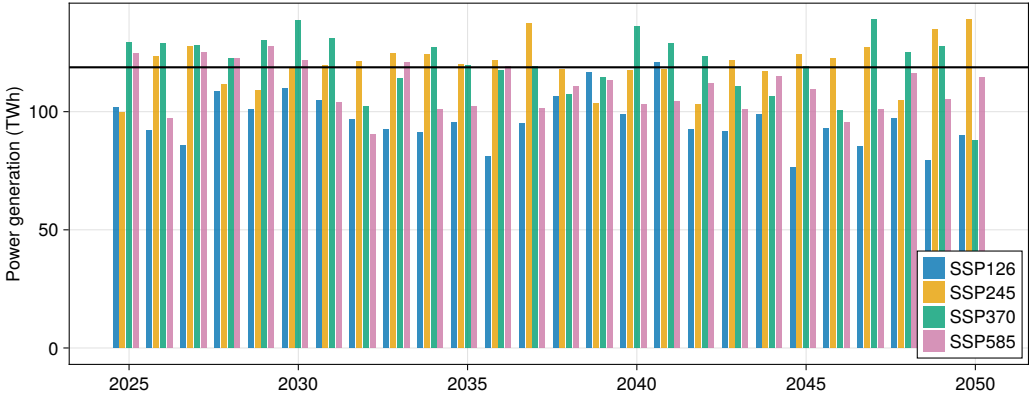
Indirect validation: Cumulative predictions of MPI model and ERA5 relative to actual power generation



- Compute wind speeds per location using Gaussian processes.
- Compute power output per location using power curves.
- Sum over all locations.
- Compute power relative to actual power generation.

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.



Black line indicates actual power generation in 2023.

Multi-decadal wind power predictions for Germany

Find the pre-print on arxiv

- Accounting for turbine locations rather than grid points is important.
- Actual power generation data can be used to validate power predictions with climate models.
- Wind will likely remain a reliable source of renewable energy in the future.

To the pre-print

Questions? Comments? **nina.effenberger@env.ethz.ch**