Correlations in renewable energy sources (CorRES)

A time series simulation tool for variable renewable energy

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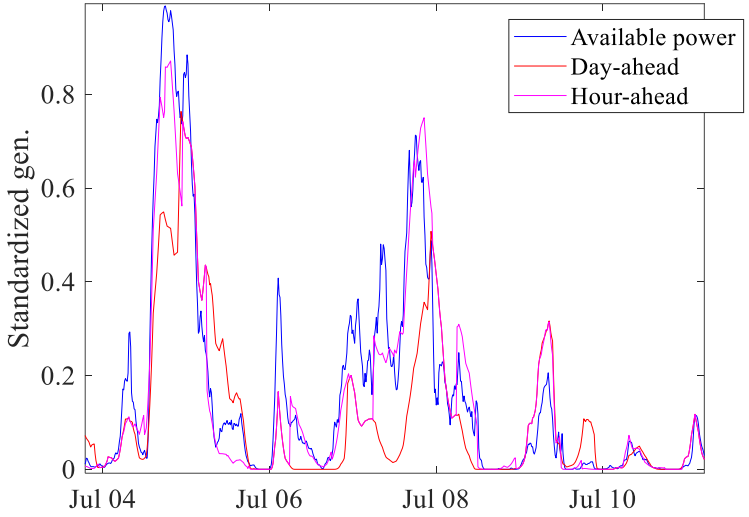
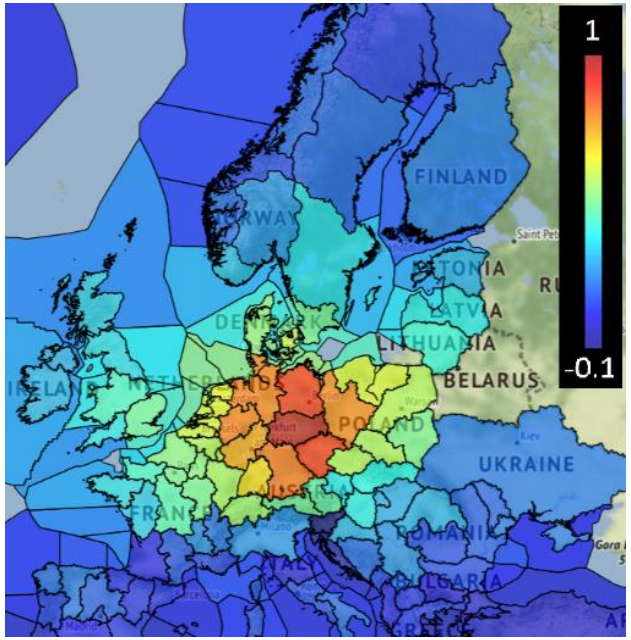
CorRES: What is it?

- Correlations in renewable energy sources (CorRES)
  - **Tool to simulate wind and solar generation time series**
  - Developed at DTU Wind

- **Used for power and energy system studies**
  - Large-scale runs (pan-European and beyond)
  - Can run 10000+ plants in one run
  - 35+ years on hourly (or higher) resolution

- **Used also in plant-level analyses**
  - E.g., revenue under variable electricity prices
  - Correlation between wind (and solar) generation and electricity price

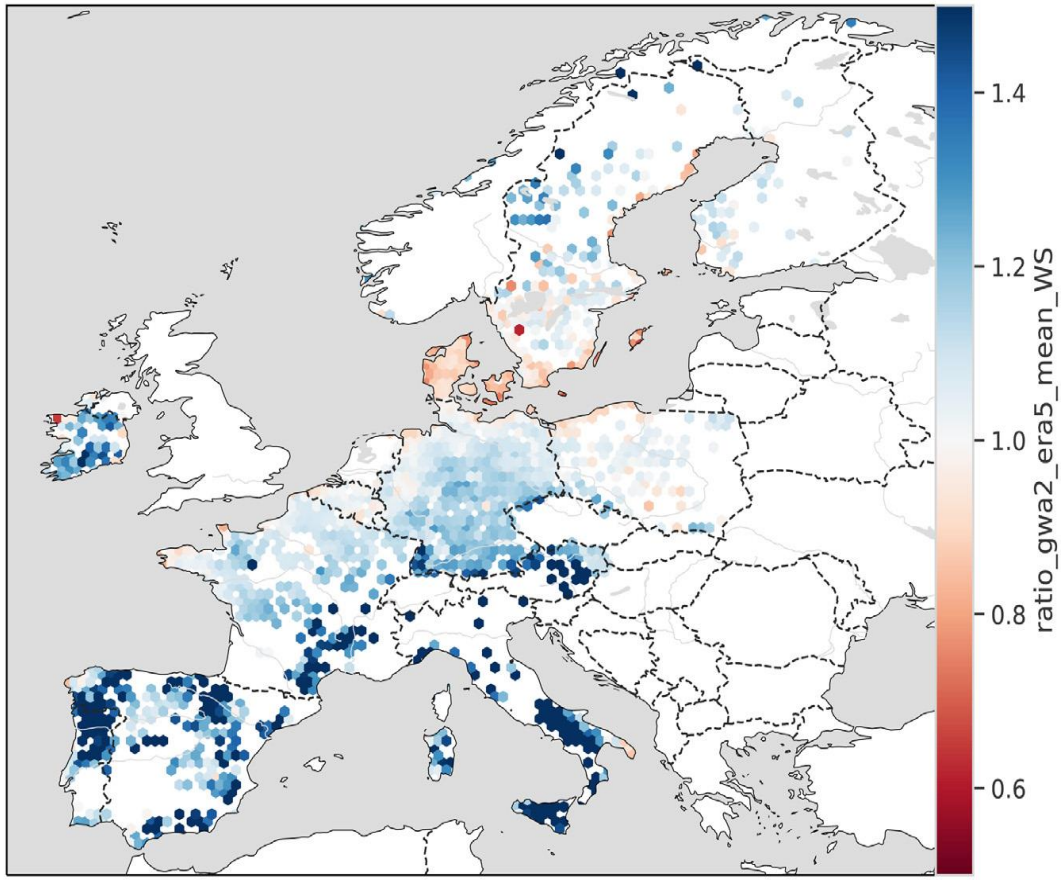




Spatial correlations in wind generation looking from a German onshore region

CorRES: Meteorological data

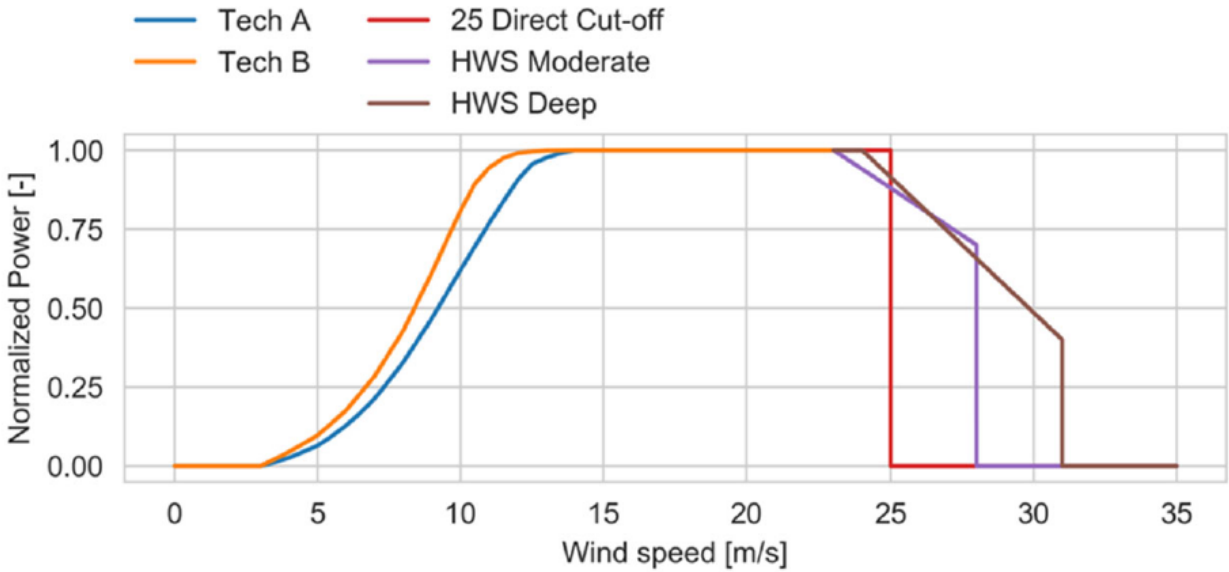
- **Weather reanalysis data**
  - ERA5
    - » 1982-2021 (continuously updated)
    - » **Global**
  - Also NEWA mesoscale, and more
- **Wind**
  - Linkage to Global Wind Atlas (GWA) high resolution wind data
- **Solar**
  - ERA5-Land for higher resolution irradiance data



J. P. Murcia, et al., “Validation of European-scale simulated wind speed and wind generation time series”, *Applied Energy*, 2022 (https://doi.org/10.1016/j.apenergy.2021.117794)

CorRES:
Wind conversion to power generation

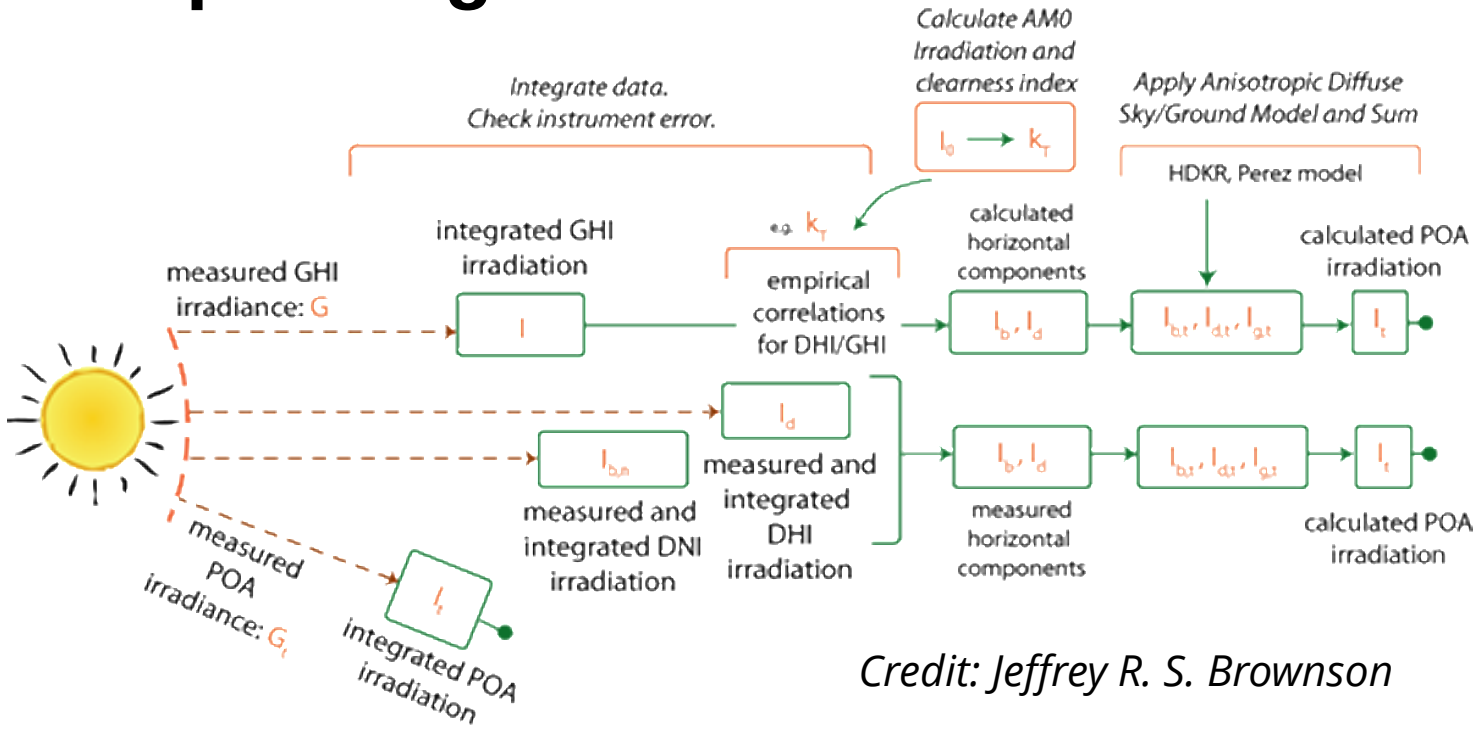
- **Wake losses (via PyWake)**
  - Machine learning model for “automatic” loss calculation
  - Or using given wake-impacted power curves (e.g., from PyWake)
  - Also farm-to-farm wakes
- **Can be linked to global wind installation data**
  - Plant data
  - Power curve data



J. P. Murcia Leon et al., “Power Fluctuations In High Installation Density Offshore Wind Fleets”, *Wind Energy Science*, 2021 (https://doi.org/10.5194/wes-2020-95).

CorRES:
Solar PV conversion to power generation

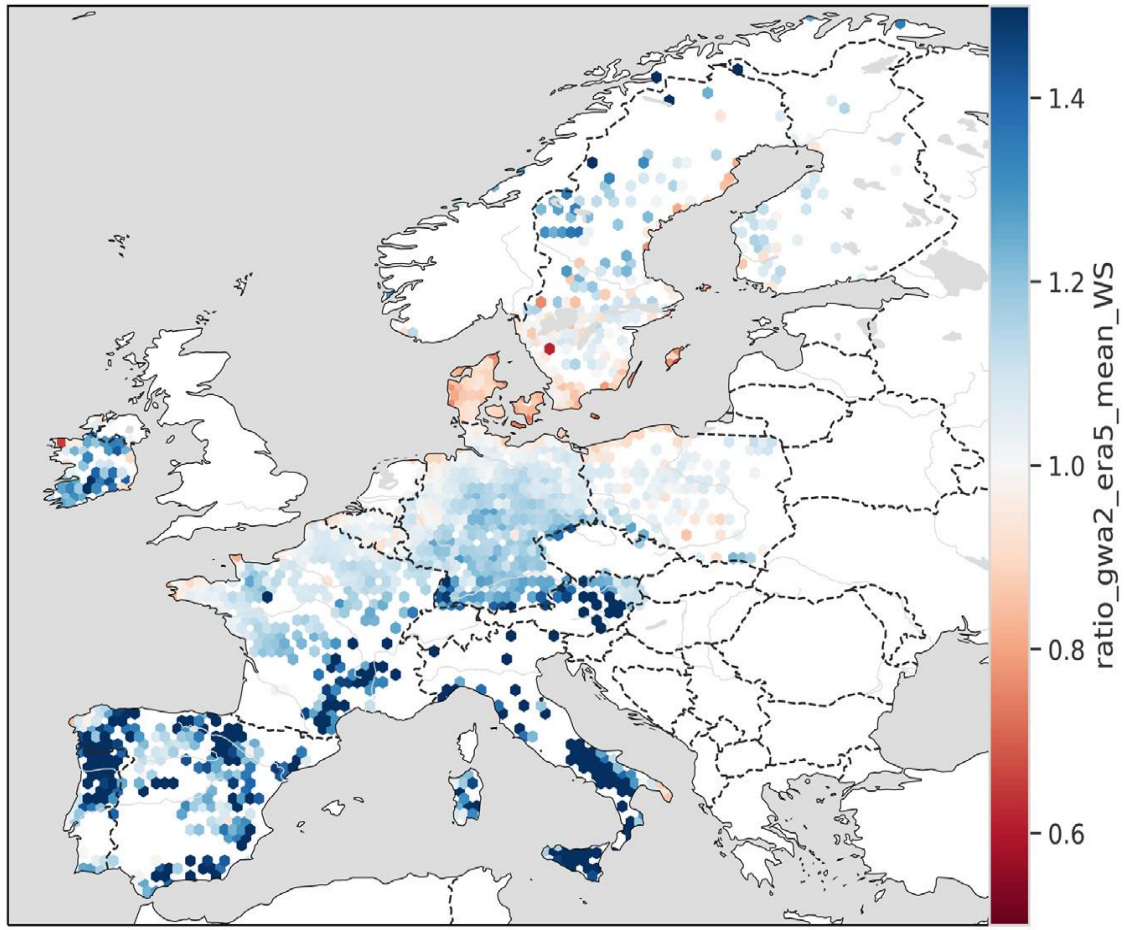
- **PVLib used**
  - Different tilt angles
  - Varying orientations
  - Also tracking
  - Panel & converter selection
- Overplanting can be modelled
- PVLib handles also the split to DNI & DHI when needed



Credit: Jeffrey R. S. Brownson

PVLib: https://pvlib-python.readthedocs.io/en/latest/

CorRES key features:
High spatial resolution via Global Wind Atlas

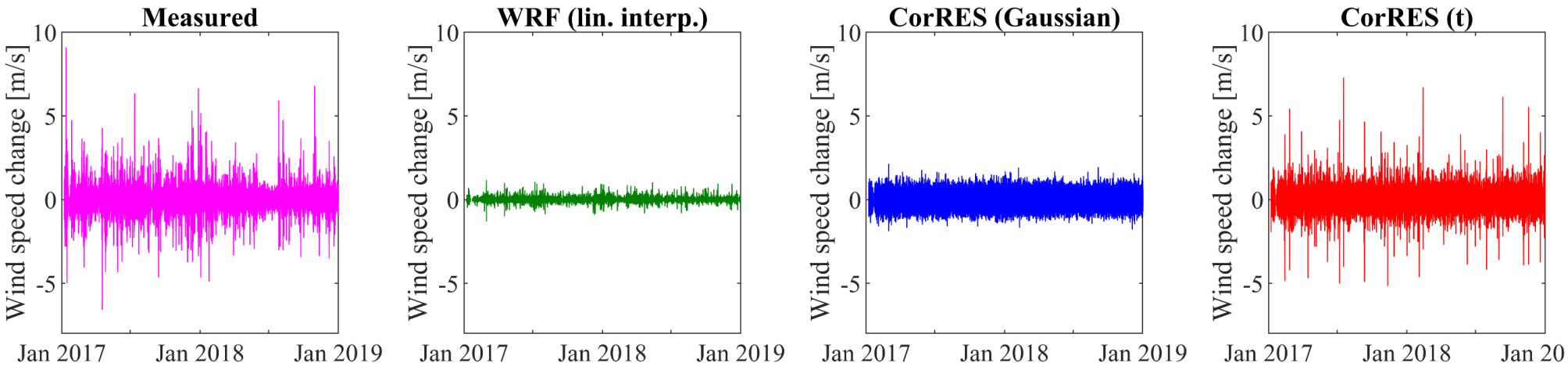


Source: https://commons.wikimedia.org/wiki/File:Europe_topography_map_en.png

J. P. Murcia, et al., “Validation of European-scale simulated wind speed and wind generation time series”, *Applied Energy*, 2022 (https://doi.org/10.1016/j.apenergy.2021.117794)

CorRES key features:
High temporal resolution via stochastic simulation

- **Up to 5 min resolution for wind**
  - Simultaneous running of a few hundred plants (usually applied for offshore wind)



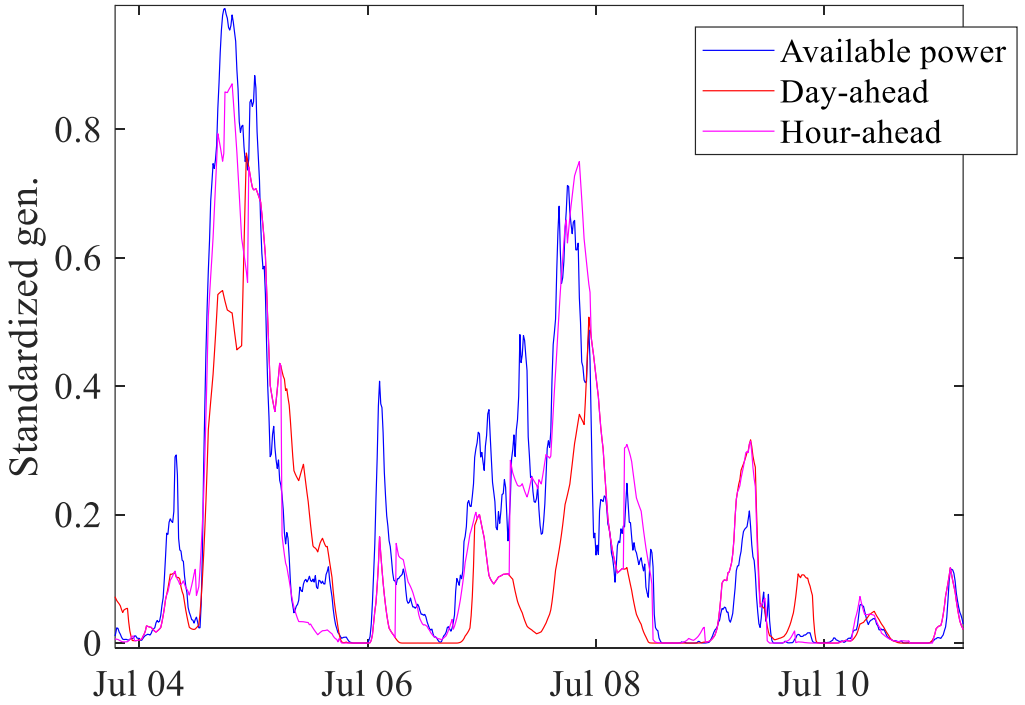
10 min wind speed ramps in measured data (magenta) and in different stages of the CorRES simulation procedure: interpolated from hourly weather data (green) to the final result with stochastic simulation included (red)

M. Koivisto et al., “Combination of meteorological reanalysis data and stochastic simulation for modelling wind generation variability”, *Renewable Energy*, 2020 (https://doi.org/10.1016/j.renene.2020.06.033).

J. P. Murcia Leon et al., “Power Fluctuations In High Installation Density Offshore Wind Fleets”, *Wind Energy Science*, 2021 (https://doi.org/10.5194/wes-2020-95).

CorRES key features: VRE forecast error simulation

- **Wind**
  - **Flexible forecast horizons (e.g., day-ahead, hour-ahead, …)**
  - Based on stochastic simulation
  - Calibrated using measured data
- **Solar**
  - Beta version



Simulated offshore wind generation for and example region:
Day-ahead, hour-ahead and available power

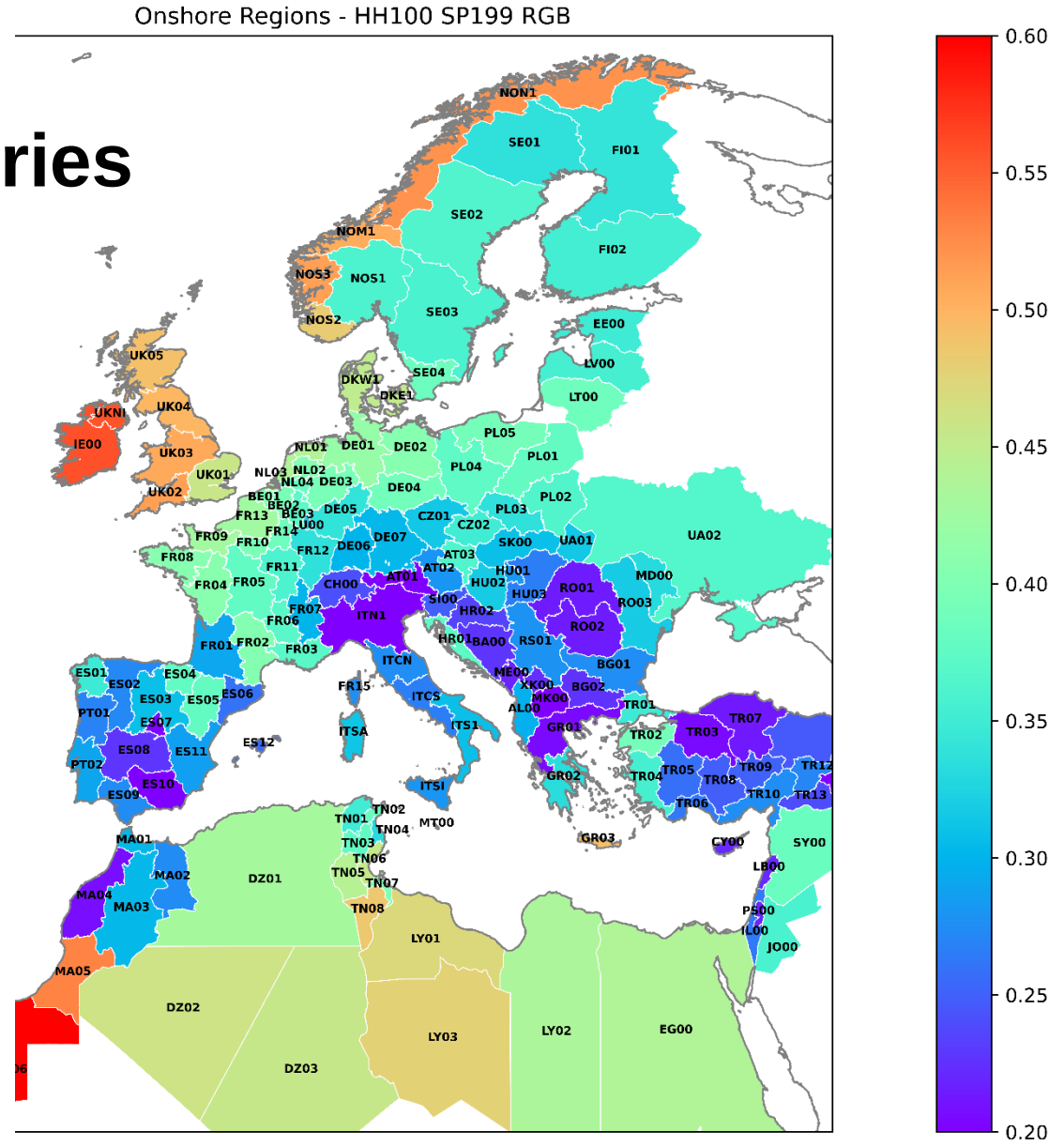
E. Nuño et al, “On the simulation of aggregated solar PV forecast errors”, *IEEE Transactions on Sustainable Energy*, 2018 (https://doi.org/10.1109/TSTE.2018.2818727)

CorRES use cases: Pan-European VRE time series

- Hourly (or higher) resolution
- 35+ years

- **For energy system planning**
- **For power system analyses**

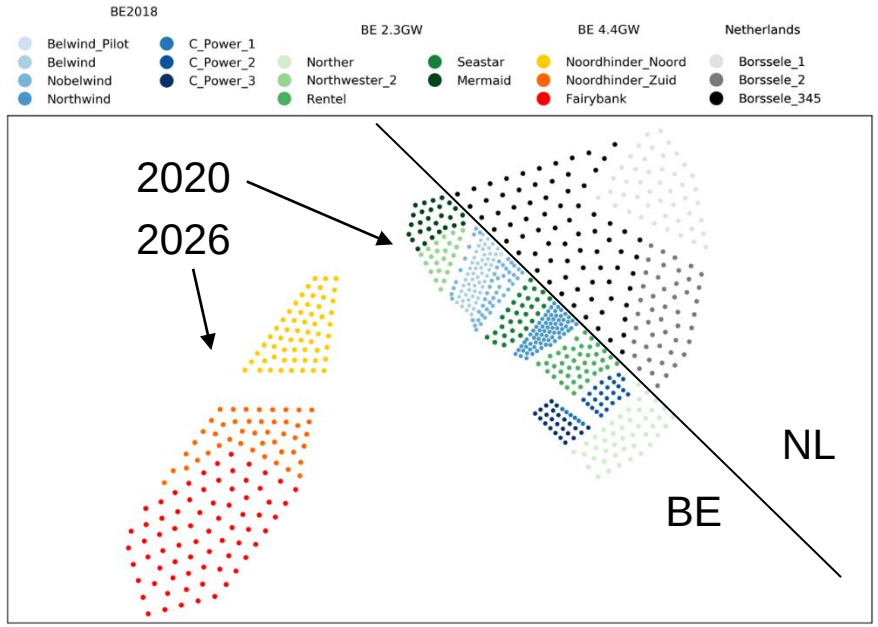
- For different projects
  - Research projects
  - Commissioned work, e.g., for ENTSO-E and Ørsted



CorRES use cases:
Offshore wind integration studies

- For example towards 2030 offshore wind integration study for the Belgian TSO Elia
- Very dense offshore wind installations
  - Wake modelling important
  - Including farm-to-farm wakes
  - Simultaneous storm shutdown risk

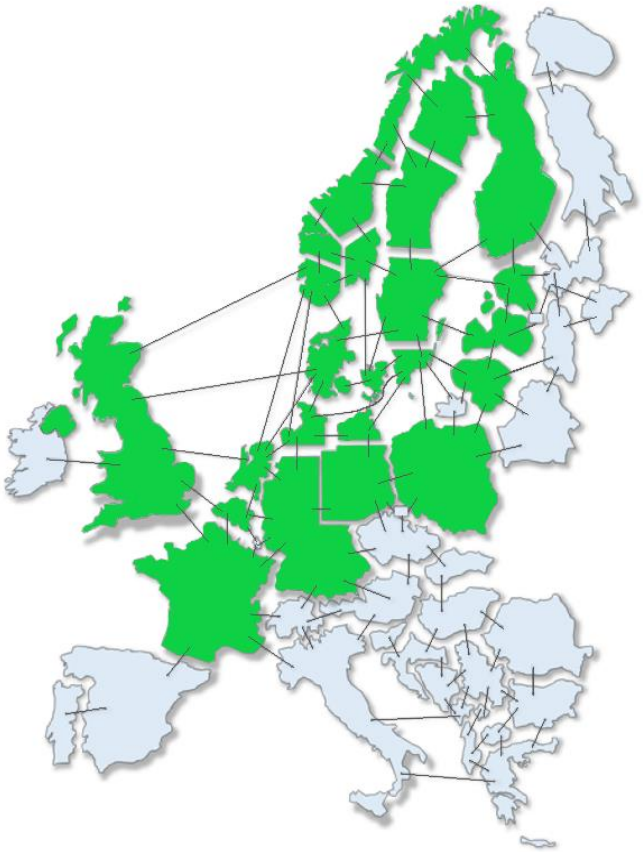
- Impacts on:
  - **Ramp rates**
  - **Fleet-level storm shutdowns**
  - **Expected forecast errors**



DTU Wind Energy, “Report for Elia: MOG II System Integration: Public version”, 2020 (https://orbit.dtu.dk/en/publications/elia-mog-ii-system-integration-public-version).

CorRES use cases:
In energy system analyses

CorRES → Balmorel → Scenarios



- For example for studying:
  - **Offshore energy hubs & meshed grids**
  - **Impact of sector coupling**
  - **Impacts on future VRE plant revenues**

J. Gea-Bermúdez et al., “Optimal generation and transmission development of the North Sea region: impact of grid architecture and planning horizon”, *Energy*, 2020 (https://doi.org/10.1016/j.energy.2019.116512)

J. Gea-Bermúdez, et al., “The role of sector coupling in the green transition: A least-cost energy system development in Northern-central Europe towards 2050”, *Applied Energy*, 2021 (https://doi.org/10.1016/j.apenergy.2021.116685)