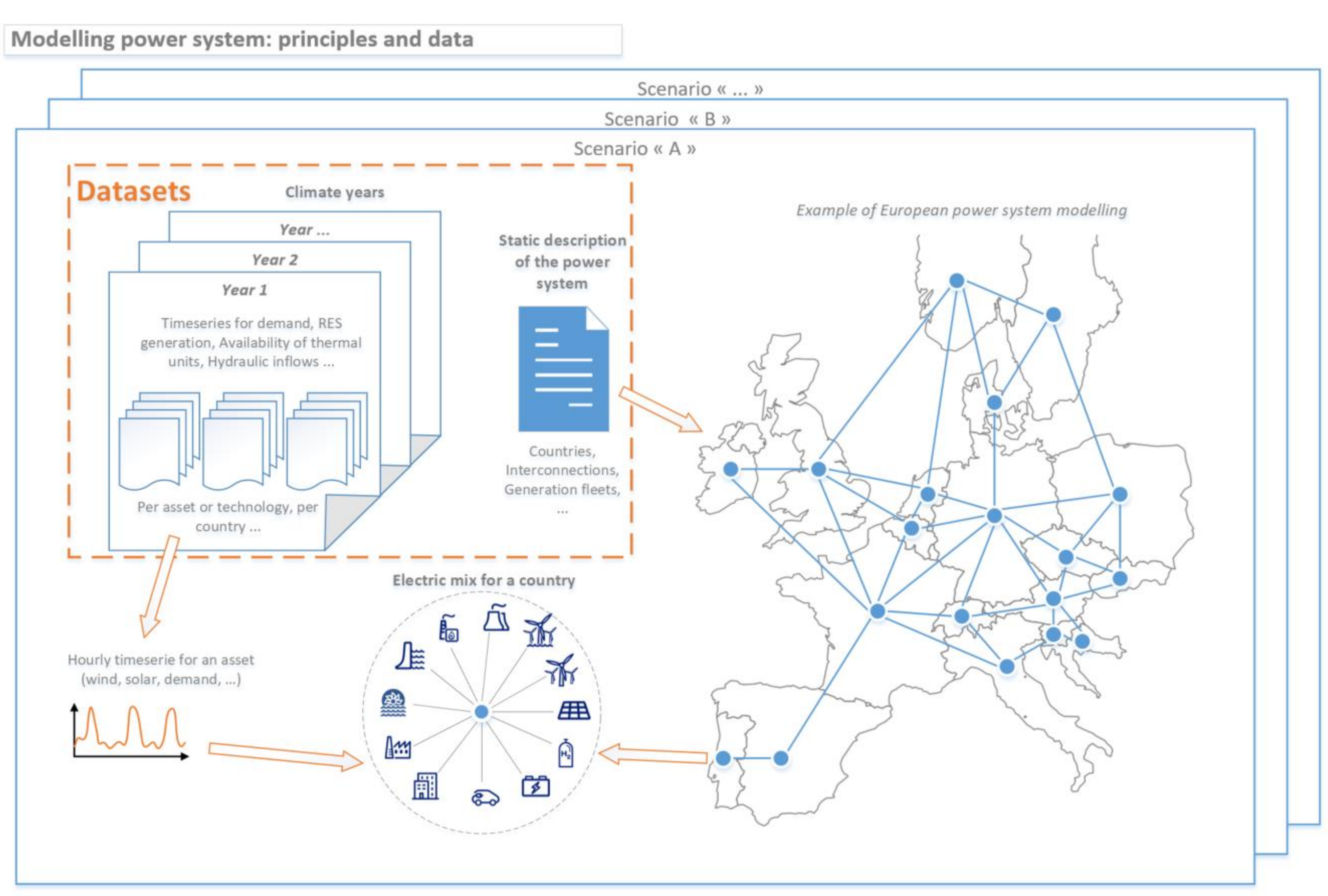
A methodology for Climate change impacts on wind energy resource over Europe for future electricity mixes analysis

Context

The energy sector is sensitive to weather and climate as it is highly dependent on different factors (both on demand side, such as heating and cooling needs, and generation side with cooling water needs for thermal power plants, renewable energy generation etc). This represents a challenge for supply-demand balancing, especially with the massive integration of renewable energy in the power system. Climate information is thus crucial for the energy sector to adapt to climate variability and change. In this context, we focus on the impact of climate change on European wind resources and propose a robust and realistic methodology to assess future load factor projections.

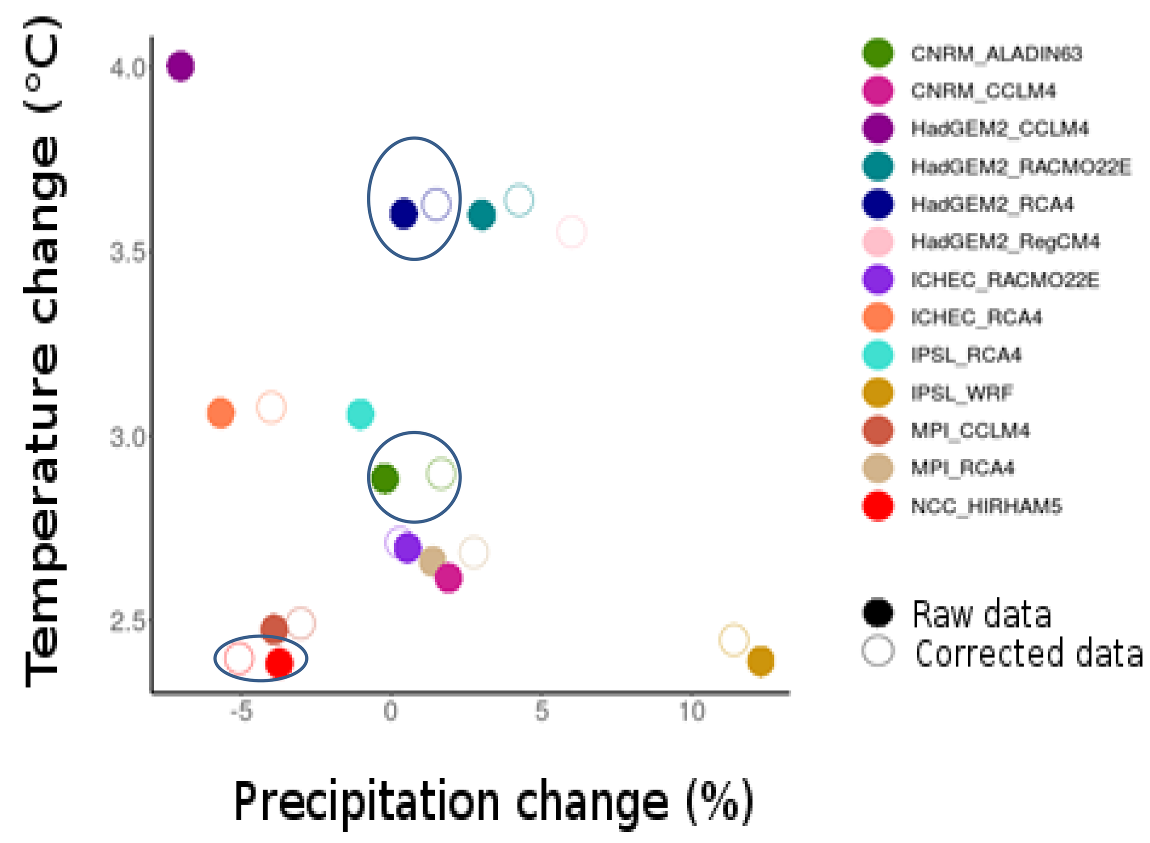


Data description and downscaling

Reference: COSMO-REA6 (2000-2018)

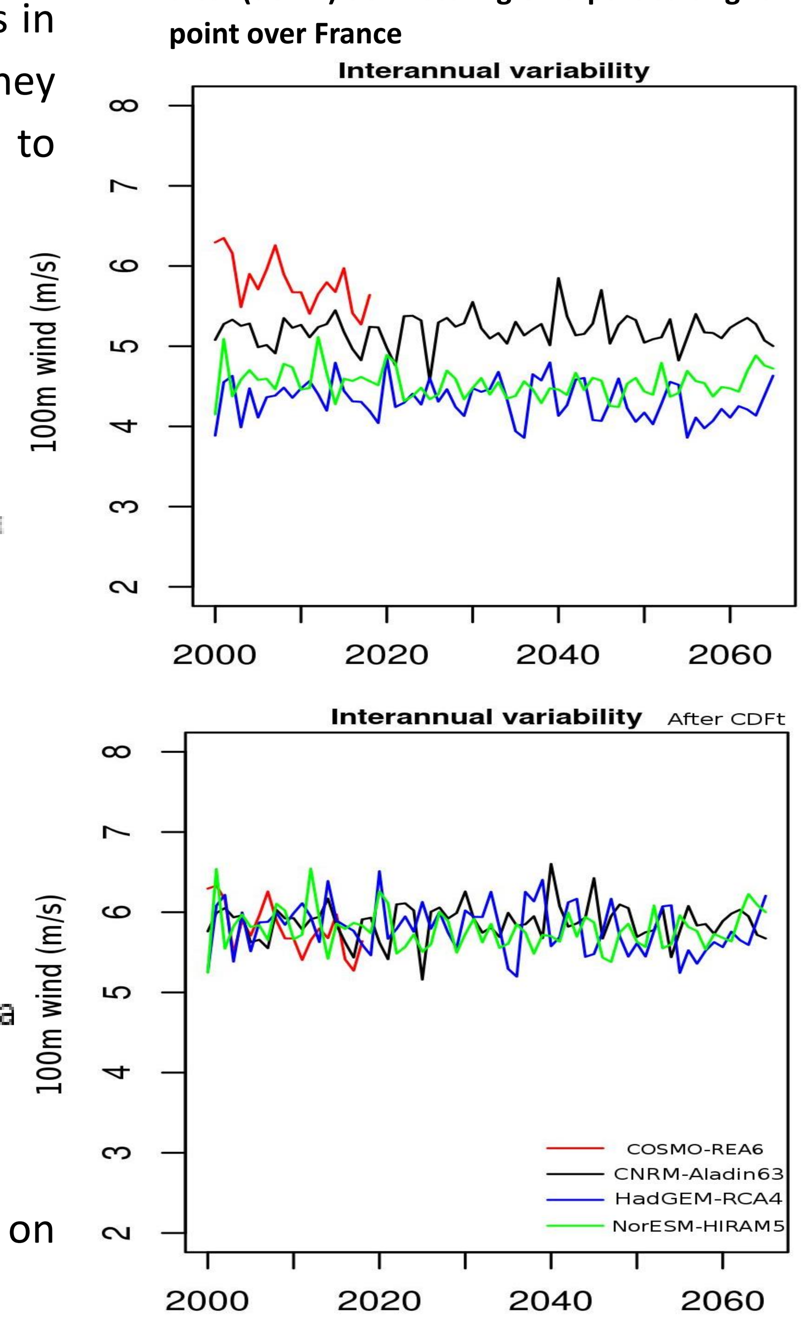
Climate models: Euro-Cordex (2000-2065)

3 models selected to cover the possible range of T/P changes in response to climate change by 2050 (T/P chosen because they present the most important mean changes in response to climate change).



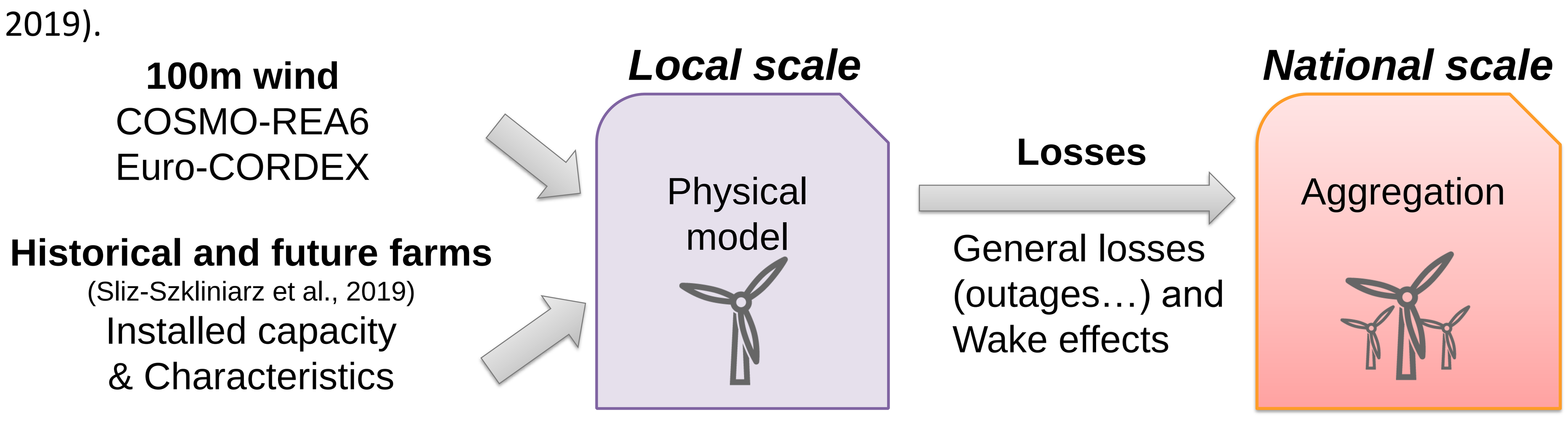
Downscaling method: CDFt applied hourly and monthly on 100m wind over Europe

Illustration of wind data before (top) and after (down) downscaling on a particular grid point over France



Methodology

Load factors are calculated based on a physical model that converts 100m wind at the coordinates of each wind farm in the target country to production using the turbine's power curve (Jourdier, 2019).



Wind farms information over France

Historical farms: The Wind Power database (TWP, 2020)

Future farms by 2030:

- **Installed capacity:** 27GW onshore (WindEurope) and 18GW offshore (https://leshorizons.net/etat-projets-parcs-eoliens-mer-france)
- **Typical turbines set for this analysis:**
  - V136-4.MW for onshore
  - V164-9.5MW for offshore

Realized simulations:

Simulation over the historical period: Model validation

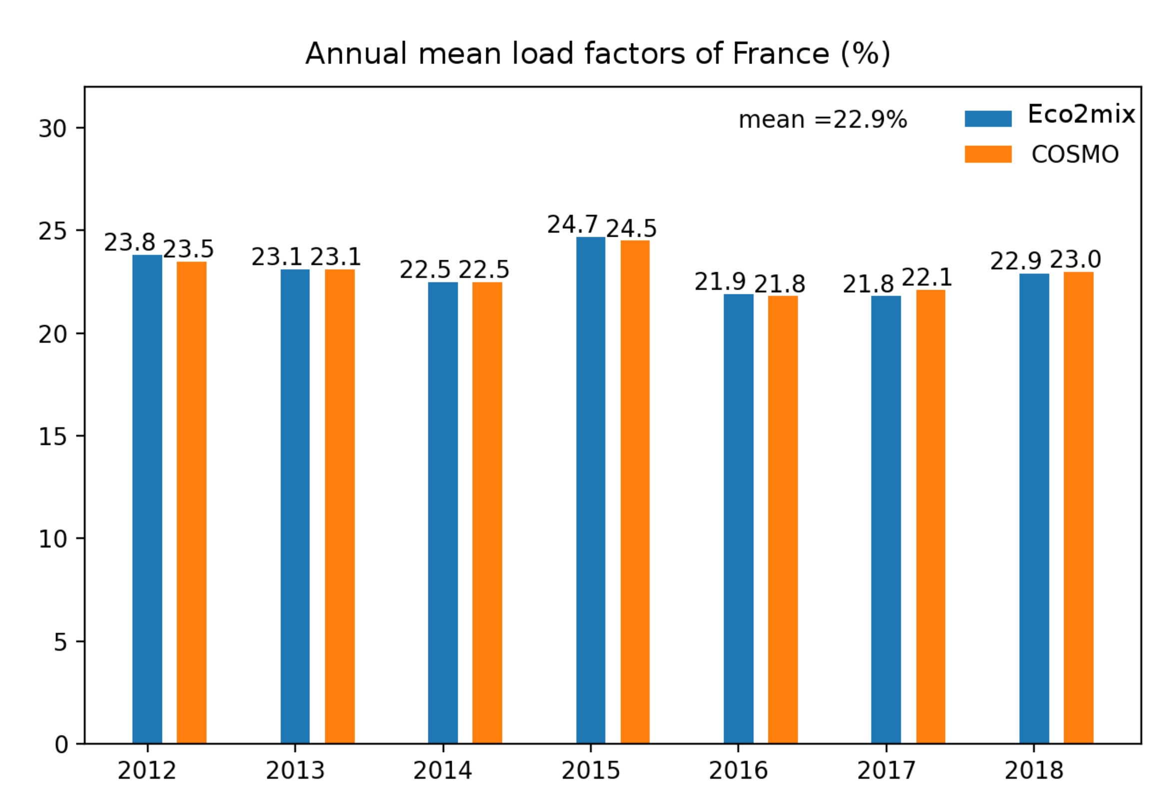
Simulations over the future:

- 2030 wind farms + 2030 climate
- 2030 wind farms + 2050 climate

} Assess the impact of climate change on onshore and offshore load factors

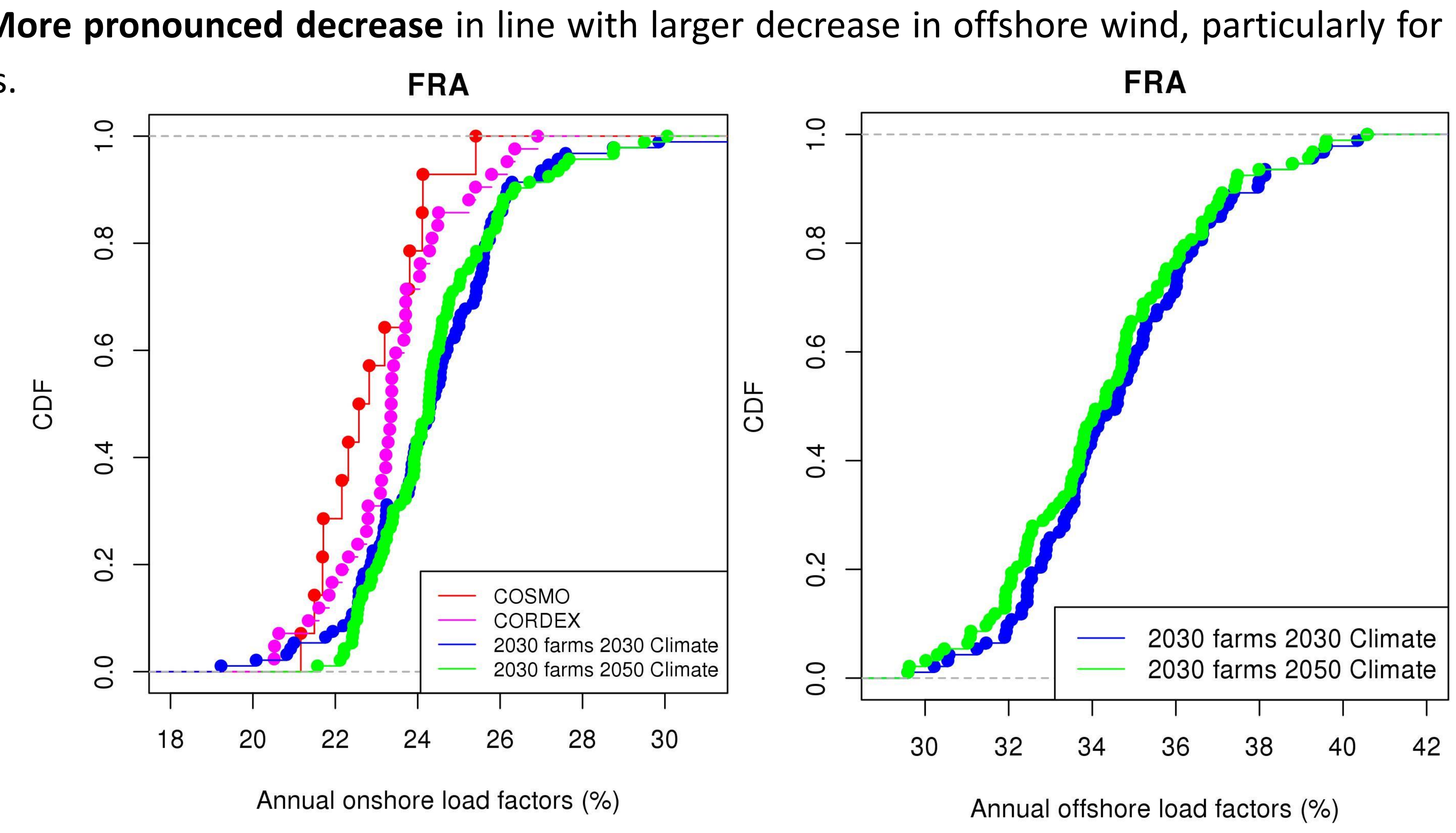
Results

→ Methodology validated over France in comparison to Eco2mix data published by RTE, the French Transmission System Operator (TSO) on annual mean load factors, seasonal and diurnal cycle.

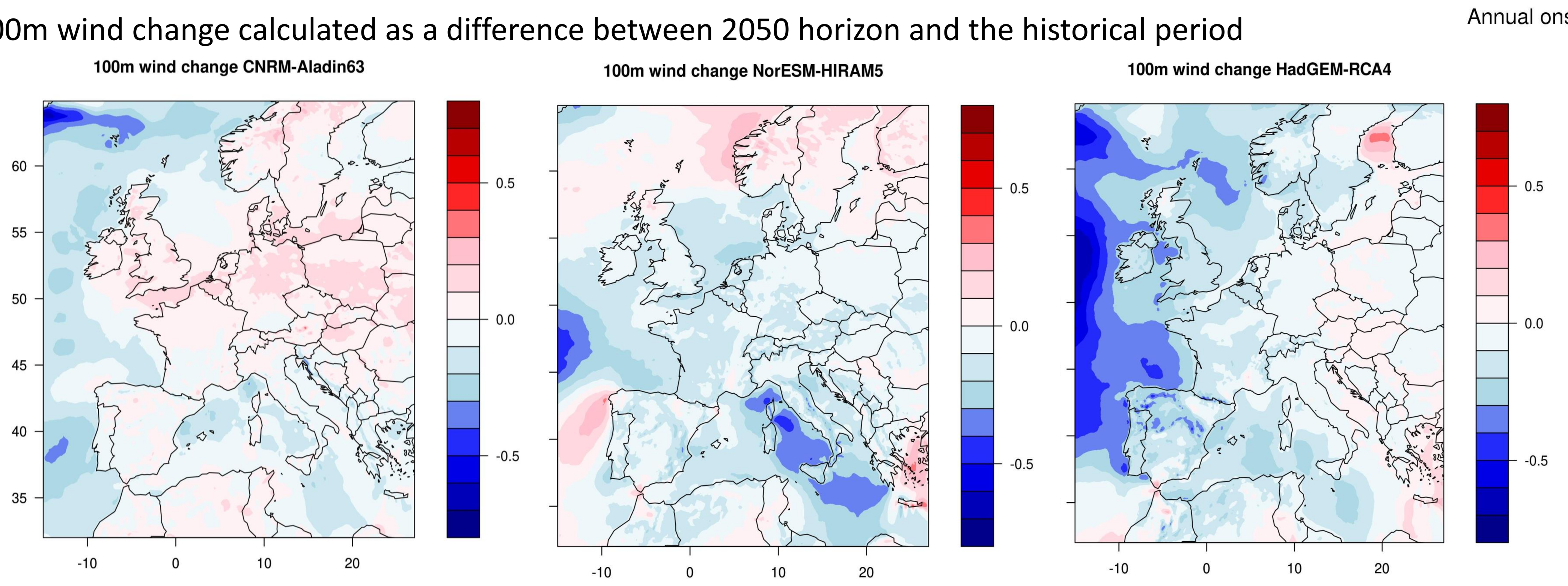


→Onshore: **Increase in load factors by 2030** explained by more powerful turbines, compensating the slight decrease in response to climate change (IPCC-AR6)

→Offshore: **More pronounced decrease** in line with larger decrease in offshore wind, particularly for low-speed winds.



100m wind change calculated as a difference between 2050 horizon and the historical period



- A general weakening of 100m wind in response to climate change in southern Europe over offshore regions (Atlantic and Mediterranean coasts) resulting in a decrease in offshore load factors
- Large regional variability and discrepancies between models in many regions over Europe

→ **Need to integrate different climate models to account for model uncertainties**

→ **Need to analyze load factors at a local-scale to better quantify the impact of climate change on particular sites of interest for wind industry and to enlarge the study to other countries**

References: - Jourdier, B., Evaluation of ERA5, MERRA-2, COSMO-REA6, NEWA and AROME to simulate wind power production over France, Adv. Sci. Res., 17, 63–77, 2020, https://doi.org/10.5194/asr-17-63-2020, 2020
- IPCC-AR6, Masson-Delmotte et al., 2021, Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change,in press
- Sliz-Szkliniarz et al., 2019, "Assessing the cost of onshore wind development scenarios: Modelling of spatial and temporal distribution of wind power for the case of Poland", https://doi.org/10.1016/j.rser.2019.04.039

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