Meteorological data for RES integration studies

European Meteorological High Resolution Renewable Energy Source : JRC-EMHIRES dataset

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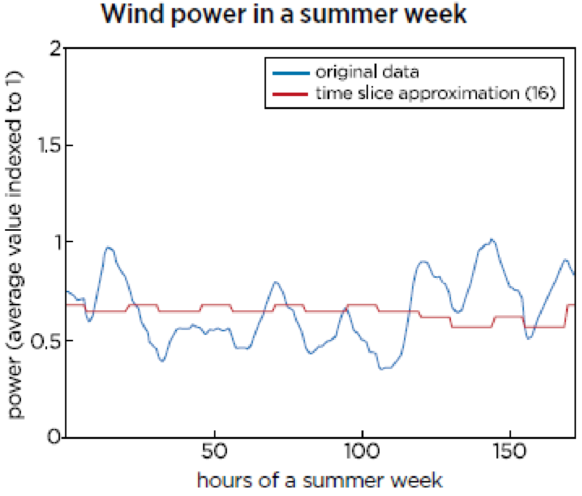
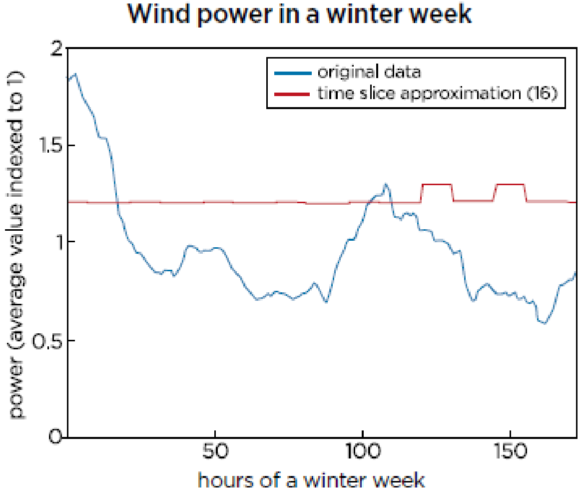
Outline

- Spatial resolution of wind and solar resource: why it matters?
- The need of increasing spatial resolution of weather data for energy models
- Approach to obtain high spatial resolution data
- Improvement of the downscaling with respect to common reanalyses – wind resource
- Improvement of the downscaling with respect to common techniques – wind power

Spatial resolution of wind/solar resource : why it matters ?

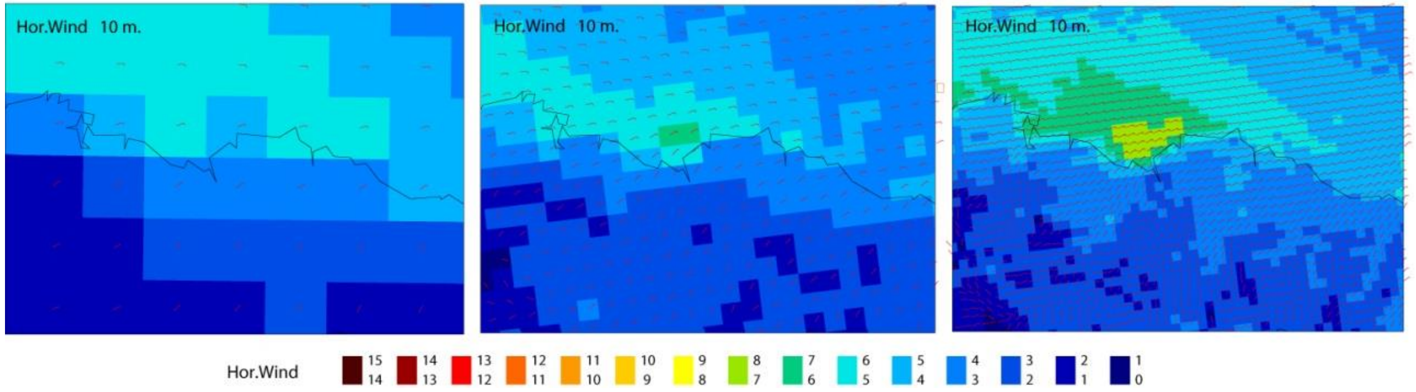
AVRIL report wind power for a peak in Europe, compared to a time slice approximation with 16 time slices



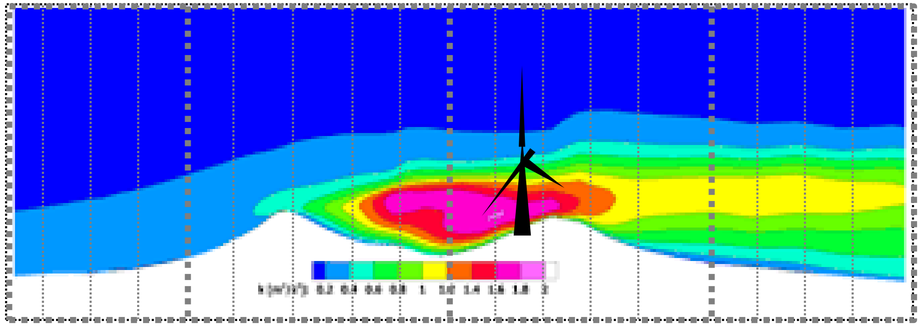


Current meteorological data used for power system analysis have coarse spatial resolution, **leading to errors of ~30-40% in the forecasting of wind power**

Wind speed data at different horizontal spatial resolutions – HIRLAM NWP model



Wind speed modelled data vertical crossed section

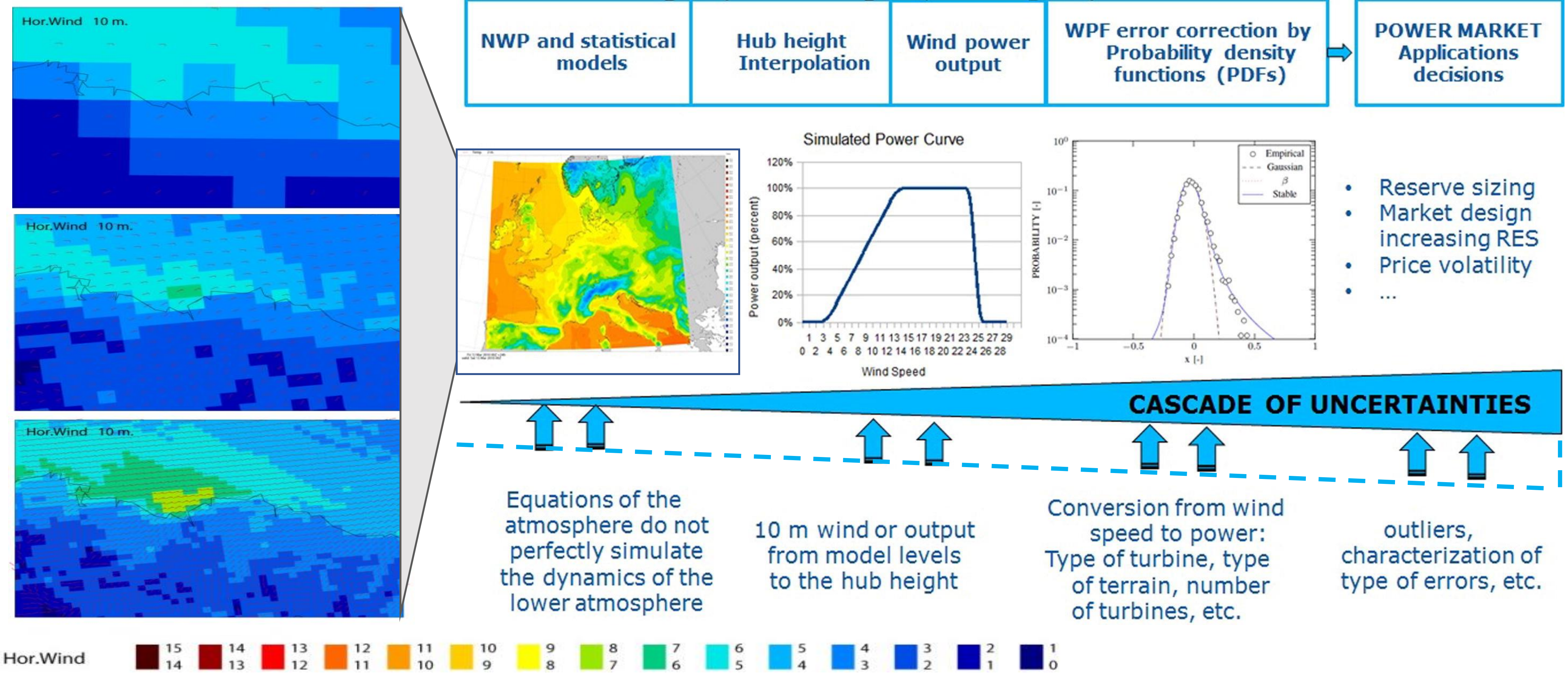


Gonzalez-Aparicio and Zucker (2015). Impact of wind power uncertainty forecasting on the market integration of wind energy of Spain.

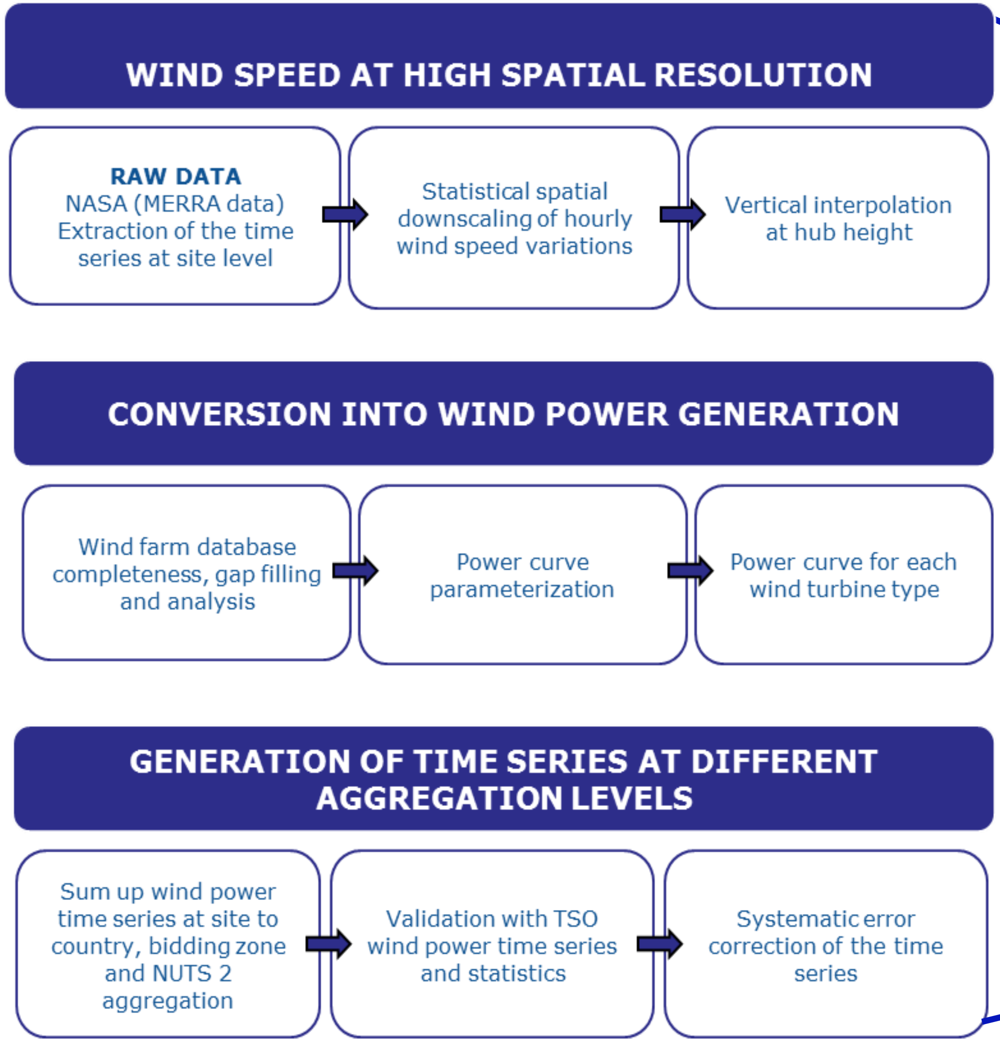
The need to increase spatial resolution of weather data for energy models

Weather data at different spatial resolutions

WIND POWER FORECASTING (WPF)



Approach to obtain high spatial resolution data



INCREASING THE RESOLUTION OF THE WIND RESOURCE REQUIRES A PRIOR ASSESSMENT OF THE IMPROVEMENT VERSUS THE UNCERATINTIES INVOLVED

WEATHER/METEOROLOGICAL DATA:

- **ECMWF forecasts**: 100 m hourly wind speed (12 x 12 km spatial resolution) available for 2012-2015
- **NASA – MERRA reanalysis**: 10 and 50 m hourly wind speed (70 km x 70 km spatial resolution) for 1986-2015
- **JRC-EMHIRES**: Downscaling to NASA-MERRA reanalysis at wind farm level

TECHNICAL PARAMETERS IN THE CONVERSION OF THE RESOURCE INTO POWER

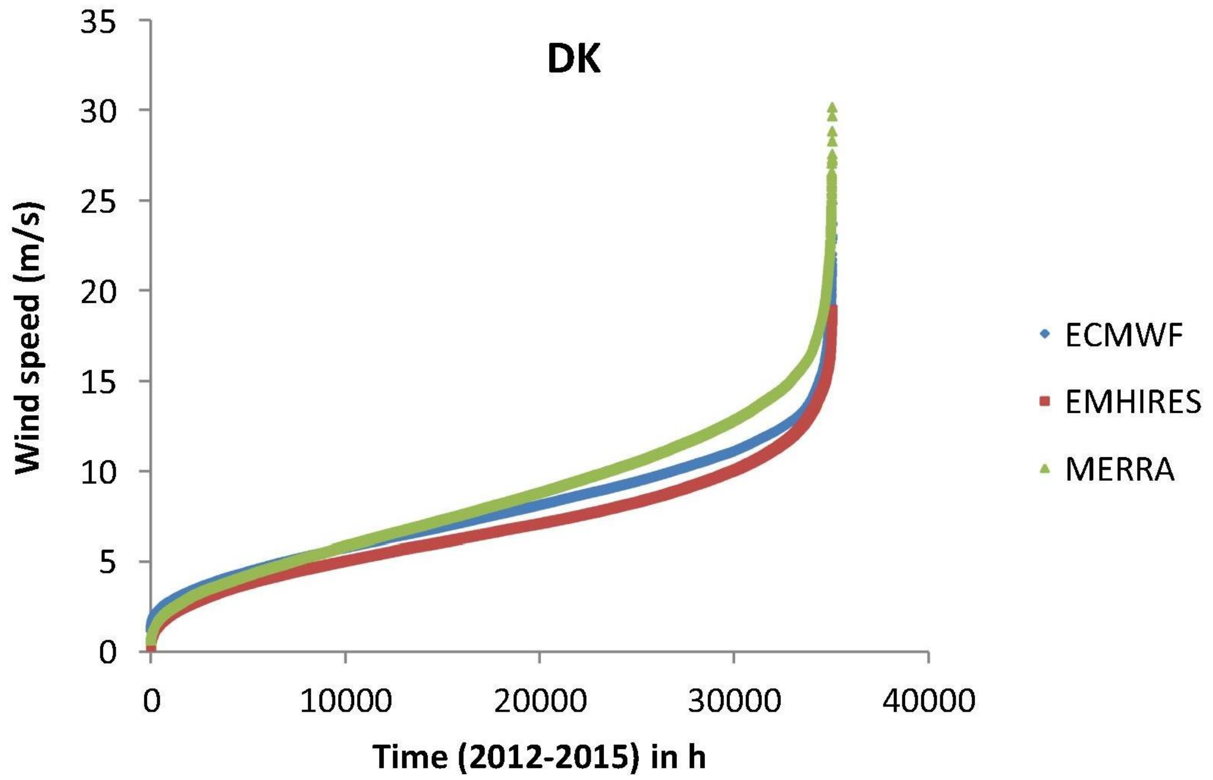
GONZALEZ APARICIO Iratxe; MONFORTI Fabio; VOLKER P.; ZUCKER Andreas; CARERI Francesco;; HULD Thomas; BADGER Jake. ***Simulating European wind power generation applying statistical downscaling to reanalysis data***. Applied Energy 199 (2017) 155-168.

MONFORTI-FERRARIO Fabio, GONZALEZ-APARICIO Iratxe. ***Comparing the impact of uncertainties on technical and meteorological parameters in wind power time series modelling in the European Union***. Applied Energy 206 (2017) 439-450

Improvement of the downscaling with respect to common reanalysis - wind resource

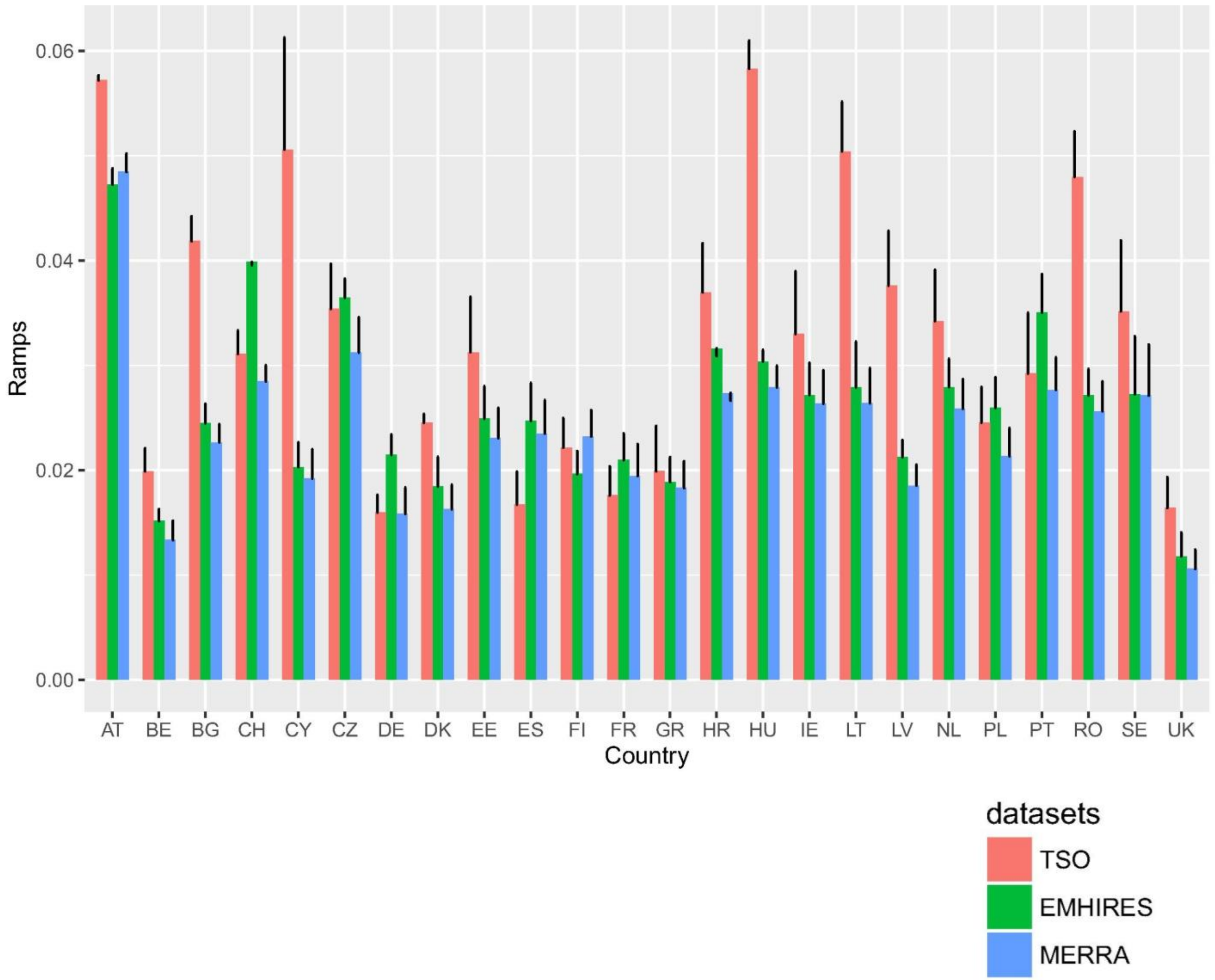
Results are in line with the physical behavior of the wind speed variability at different spatial resolutions.

Countries with little orography (such as Belgium, Denmark, Netherlands and United Kingdom) common reanalyses do not account for the local roughness and can slow down the winds significantly with respect to EMHIRES and ECMWF, over predicting the wind speed and introducing less variability than EMHIRES and ECMWF.



Improvement of the downscaling with respect to common techniques - wind power

EMHIRES improves with MERRA in the 95% coverage of ramping rates during 2015 and it also better captures the large negative sudden increases of wind power out of the 95% of the cases..



References

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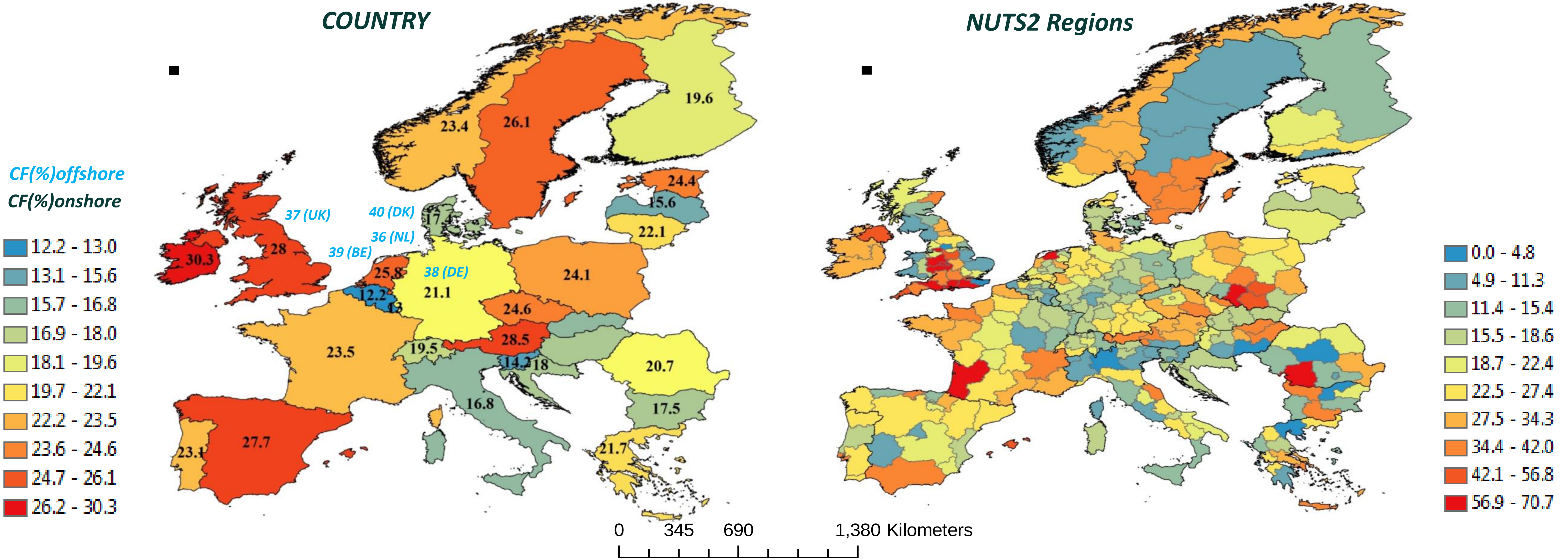
- GONZALEZ-APARICIO Iratxe, ZUCKER Andreas. ***Impact of wind power uncertainty forecasting on the market integration of wind energy in Spain***. Applied Energy 159 (2015) 334-349.
- FERNANDEZ-BLANCO, KAVVADIAS, HIDALGO-GONZALEZ; ***Quantifying the water-power linkage on hydrothermal power systems: A Greek case study***. 203 (2017) 240-253.
- GONZALEZ-APARICIO Iratxe, HULD Thomas, CARERI Francesco, MONFORTI Fabio, ZUCKER Andreas; *EMHIRES dataset* - ***Part II: Solar power generation. European Meteorological derived HIgh resolution RES generation time series for present and future scenarios. Part II: PV generation using the PVGIS model***. (2017) EUR 28629 EN; doi:10.2760/044693.
- GONZALEZ APARICIO Iratxe; ZUCKER Andreas; CARERI Francesco; MONFORTI Fabio; HULD Thomas; BADGER Jake. ***EMHIRES dataset. Part I: Wind power generation European Meteorological derived HIgh resolution RES generation time series for present and future scenarios.*** *(2016)* EUR 28171 EN; 10.2790/831549.
- GONZALEZ APARICIO Iratxe , ZUCKER Andreas. ***Meteorological data for RES-E integration studies - State of the art review.*** (2015) EUR 27587; 10.2790/349276.
- MOUSTAFLEOU I; GONZALEZ-APARICIO, I; ALVES-DIAS P; HULD T; ZUCKER A. ***On the development of long-term PV generation time series using the PVGIS mode for European power system analysis***. (2017) 33rd European Photovoltaic Solar Energy Conference – Grid Energy System Integration; 25th – 29th September 2017 (Netherlands).

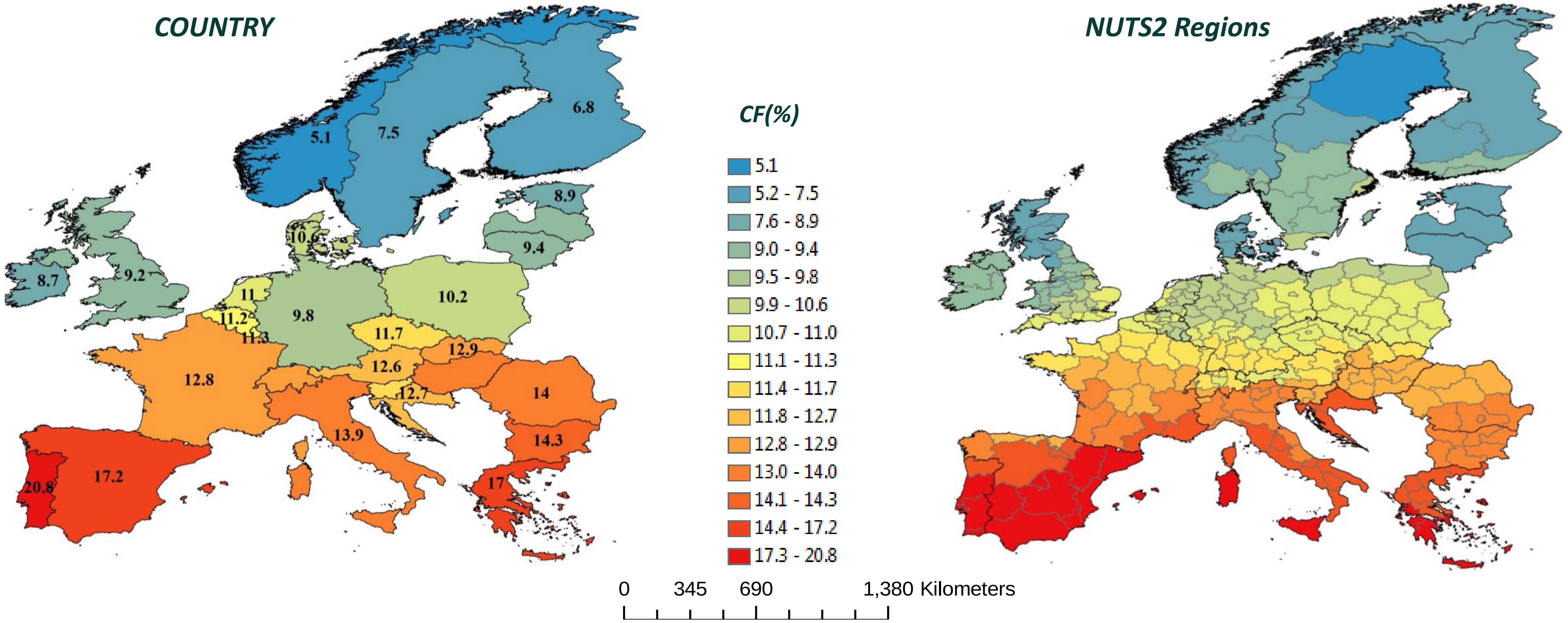
Anexes

Wind power annual capacity factors dataset



**** EMHIRES dataset: annual wind capacity factors averaged over 30 years (1986-2015) hourly time series.***
The country time series are corrected with TSO data and the NUTS 2 time series are given by the *ab initio* ***methodology***

Solar PV power annual capacity factors dataset



**** EMHIRES dataset: annual PV capacity factors averaged over 30 years (1986-2015) hourly time series.***
The country time series are corrected with TSO data and the NUTS 2 time series are given by the *ab initio* ***methodology***

Wind speeds at each farm site

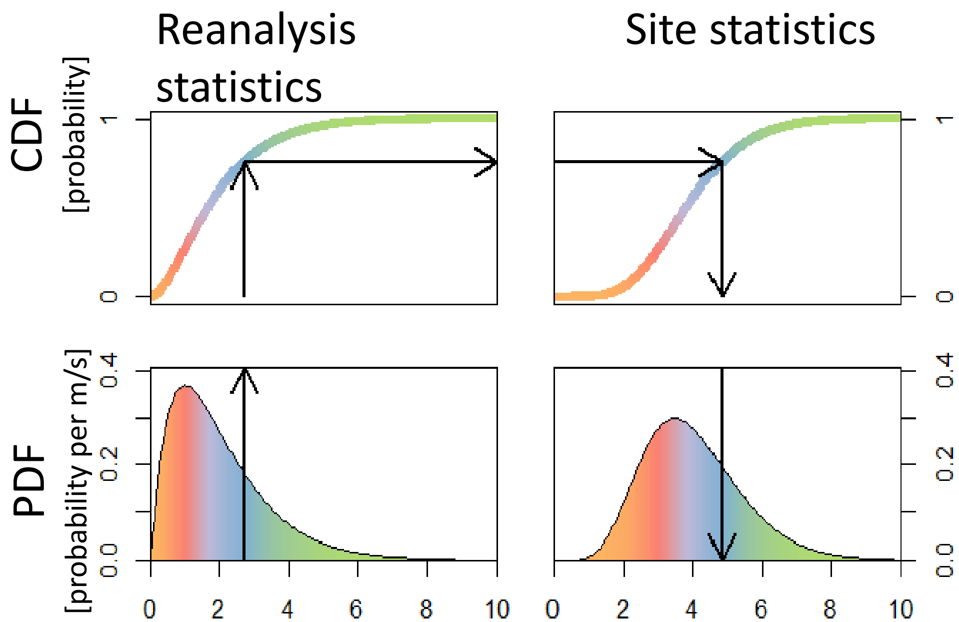
Based on data from DTU's Global Wind Atlas

$$F_x(x) = 1 - e^{-\left(\frac{x_{micro}}{A_{micro}}\right)^{k_{micro}}} = 1 - e^{-\left(\frac{x_{meso}}{A_{meso}}\right)^{k_{meso}}}$$

eq [1]

$$x_{micro} = A_{micro}\left(\frac{x_{meso}}{A_{meso}}\right)^{\frac{k_{meso}}{k_{micro}}}$$

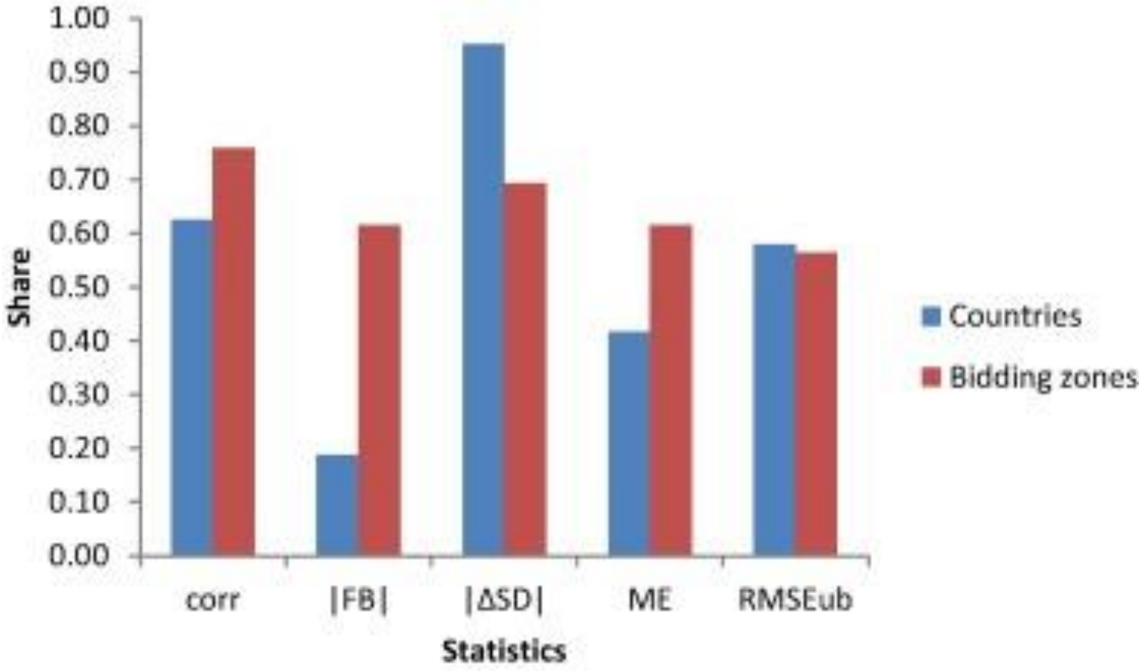
eq [2]



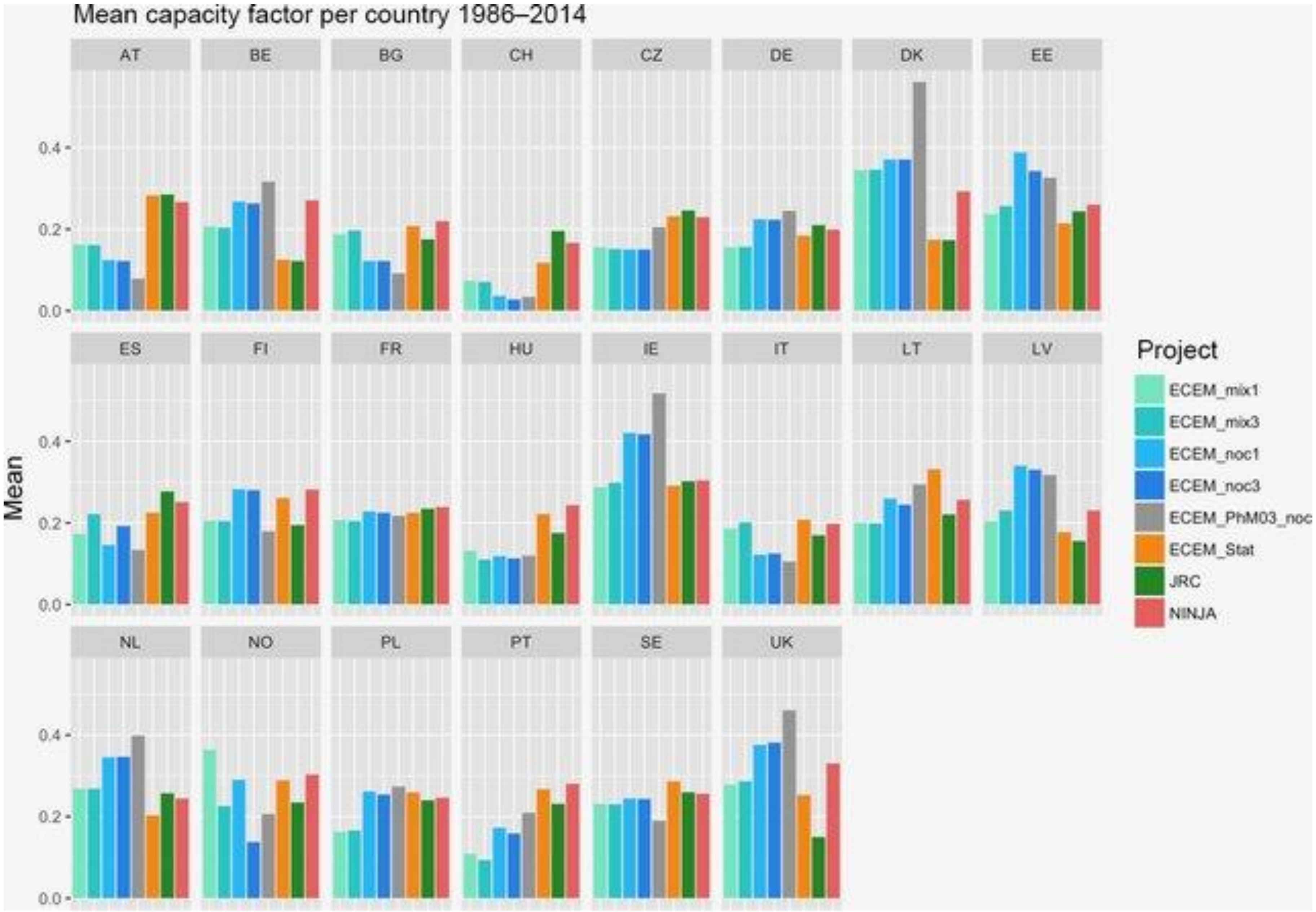
For any "site" :

- X=wind speed,u
- NASA reanalysis determine A_{meso} and k_{meso} using a Weibull distribution
- A_{micro} and k_{micro} given by Global Wind Atlas
- Use sector information and eq [2] to determine u_{micro}

Comparison with common approaches

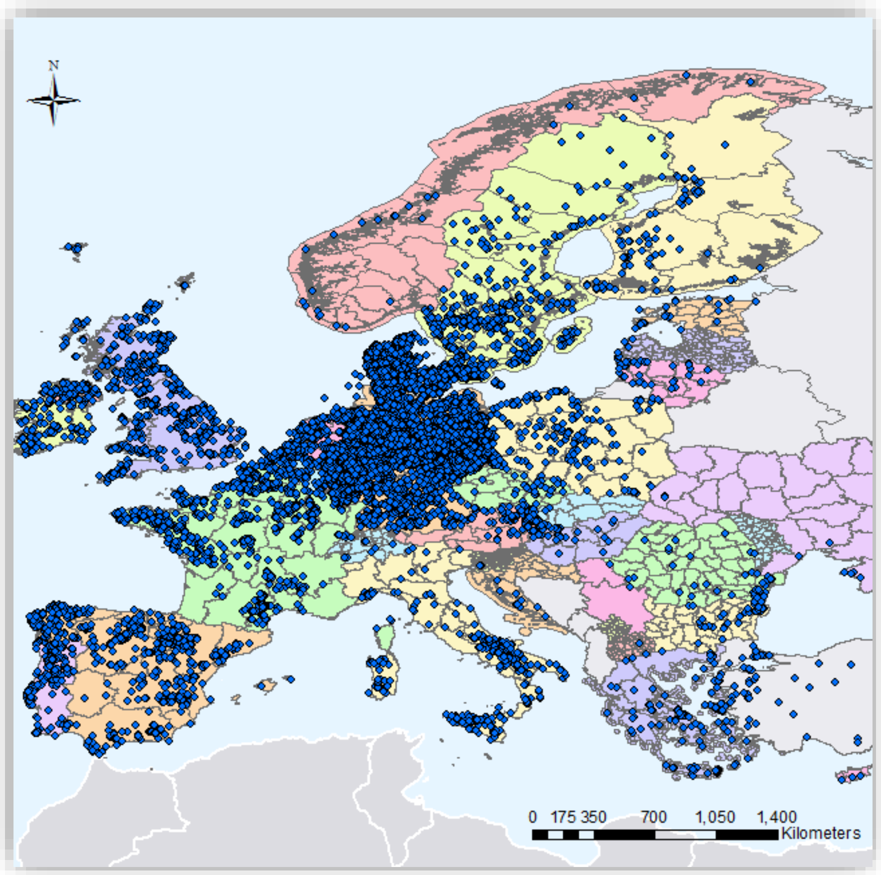


Share of countries and bidding zones where EMHIRES performs better than common-based approaches for different metrics. The share is computed accounting for weighted factors in each country and bidding zone with the installed capacity, considered the total European Installed capacity as the 100%



Mean capacity factor per country 1986–2014
AT
BE
BG
CH
CZ
DE
DK
EE
ES
FI
FR
HU
IE
IT
LT
LV
NL
NO
PL
PT
SE
UK
Mean
0.0
0.2
0.4
Project
ECEM_mix1
ECEM_mix3
ECEM_noc1
ECEM_noc3
ECEM_PhM03_noc
ECEM_Stat
JRC
NINJA

Reconstructed and homogenized WFDB



Current methods
Approximations of few (5-10) power curves at averaged hub heights (80 and 100m)

EMHIRES:
1061 power curves of the 160 manufacturers registered in Europe at the precise hub height of the wind farm.

Improvement: matching 91% of EWEA's 2015 statistics, while the original database matched 70%

PV power hourly time series in EMHIRES using the PVGIS model - approach

- Time-resolved geospatial maps of solar radiation are calculated from **geostationary satellite data**. The resulting data set has hourly time resolution and a spatial resolution of **~5km**. EMHIRES is based on the SARAH solar radiation data from the CM SAF collaboration, for a 1986-2015 period.
- Global and direct horizontal irradiance are used to calculated the **local optimum inclination angle and the in-plane irradiance**.
- The PVGIS model for the EMHIRES-PV performance take into account the effects of **shallow-angle reflectivity, spectral variations, as well as the influence of air temperature and wind speed on PV performance**.
- The resulting maps of hourly PV power are then averaged spatially over the relevant regions.
- At country level, a factor has been applied to be in line with the TSO time series data