The Airborne Wind Energy Resource Analysis Tool AWERA

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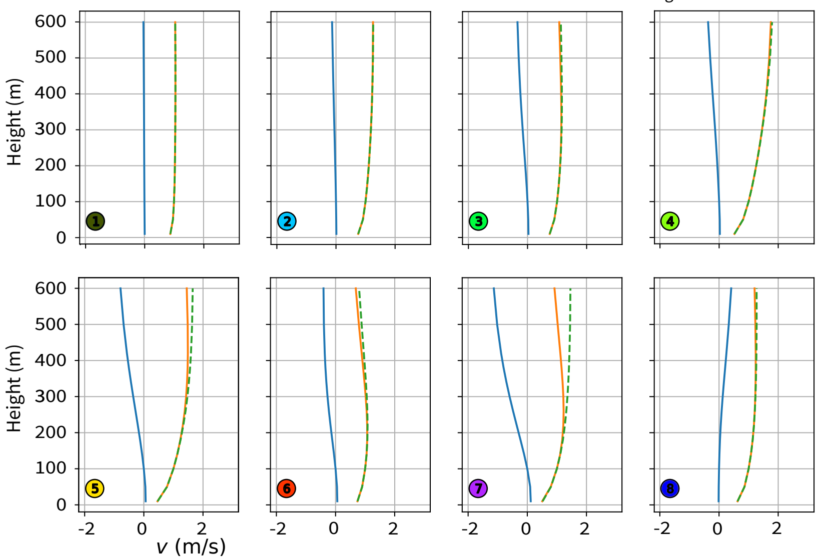
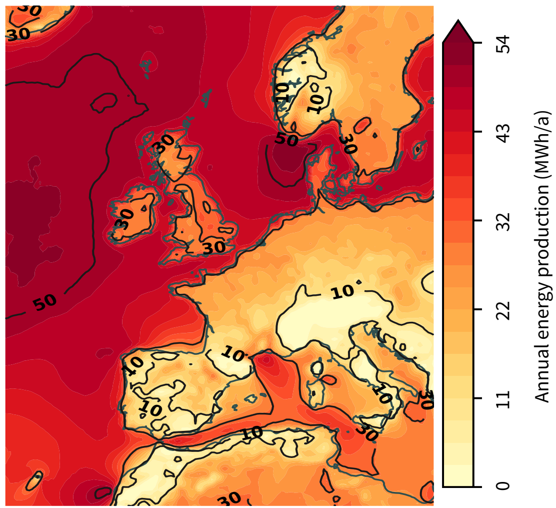
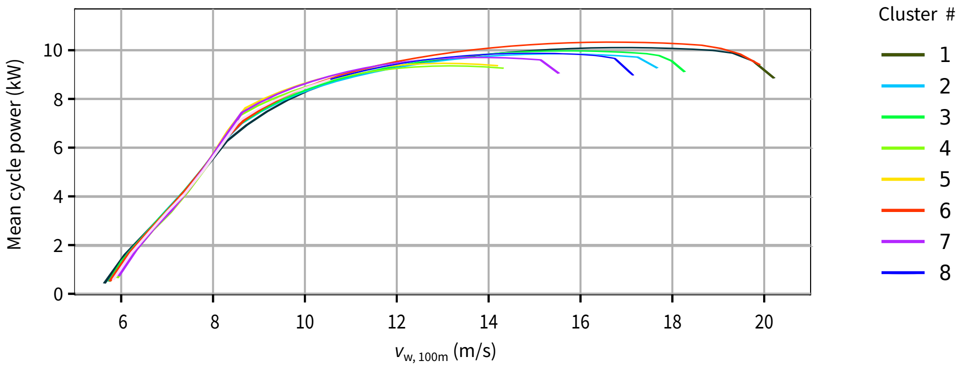
1. Clustered normalized wind profile shapes



3. Annual energy production



2. Power curves for each wind profile



1. The clustering process uses vertical profiles of normalised horizontal wind speed components. The generated cluster profiles thus represent only the shape of the profiles, and are normalised to 1m/s at reference height of 100 m. Fully denormalising to match back to an original wind data sample at a specific time and location is represented by the cluster 100m wind speed ($v_{w,\,100m}$).

2. The power is therefore determined for each cluster profile when scaled to a range of $v_{w,\,100m}$, yielding a power curve.

3. Knowing the cluster and $v_{w,\,100m}$ of a sample, the estimated power is taken from the respective power curve.

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The Airborne Wind Energy Resource Analysis Tool AWERA

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The open-source tool AWERA [1] was developed for assessing the potential of airborne wind energy systems (AWES) on large geographical and temporal scales. AWERA can be used for spatial and temporal studies of the wind resource and power production potentials, and means for comparing different types of AWESs. It can also be used for uncertainty quantification of the computed power production for all simulation components, from wind resource to system dynamics.

AWES are characterised by a more complex power generation than conventional wind turbines. Flight operation and harvesting depend not only on the wind speed at hub height but on an extended vertical wind profile and its temporal variation. The wind resource and associated wind power density at optimal harvesting height was described in [2], indicating a high production potential for AWES accessing higher altitude winds.

Accounting for the specific harvesting process leads to a substantially improved performance estimation. There are different models describing the full flight and system dynamics or using a sequence of simplified quasi-steady force equilibrium states [3] to estimate the power output for a given vertical wind profile. The latter model was used in [4] to predict the harvested power of a prototype kite system for eight representative absolute wind profiles. These profiles are determined using a principal component analysis paired with a clustering algorithm on an ensemble of measured vertical wind profiles.

The harvesting characteristics are determined for the absolute clustering wind profiles, which then are used to obtain the spatial distribution of the annual energy production for Europe, significantly reducing the computing time compared to processing all samples individually. For validation, harvesting characteristics resulting for either approach are compared for various clustering representations. AWERA holds the opportunity to add different AWES types and power production estimation models.

The resulting hourly power is used to compute the annual energy production and capacity factor and to evaluate characteristics such as the down-time, which can be used to assess the potential for providing base load capacity. It is also possible to extract hourly timelines of measures, such as power timelines for site assessment.

Our aim was to provide a performance assessment tool and parametrisation of wind data. We invite all AWE stakeholders to add public versions of systems parametrisations and to use the tool for evaluating the power production at any location, which is an important input for broad-scope energy system evaluations.

References:

[1] AWERA tool. https://github.com/lthUniBonn/AWERA

[2] Bechtle, P., Schelbergen, M., Schmehl, R., Zillmann, U., Watson, S.: Airborne wind energy resource analysis. Renewable Energy ***141****, 1103–1016 (2019).*

[3] van der Vlugt, R., Bley. A., Noom, M., Schmehl, R.: Quasi-steady model of a pumping kite power system. Renewable Energy ***131****, 83–99 (2019).*

[4] Schelbergen, M., Kalverla, P.C., Schmehl, R., Watson, S.: Clustering wind profile shapes to estimate airborne wind en- ergy production. Wind Energy Science ***5****(3), 1097–1120 (2020).*