Global Wind Atlas – validation and uncertainty

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WindEurope Resource Assessment 2017
Global Wind Atlas

The objective of the Global Wind Atlas is to

• Provide global wind resource data sets
• Account for high resolution topography
• Employ microscale modelling world-wide
• Use a unified and documented methodology
• Ensure transparency about the methodology
• Validate results in representative areas

(globalwindatlas.com)

The correct usage of the Global Wind Atlas is

• Aggregation
• Upscaling analysis
• Energy integration modelling
  – energy planners and policy makers

It is not correct to use the data and tools for

• wind turbine and wind farm yield calculations

Topics for this presentation

• Validation of GWA at high-quality mast sites
• Highlight proper use of numerical wind atlases
Global Wind Atlas characteristics

- Climatological data
  - MERRA reanalysis 1979-2013
  - Horizontal resolution, $\Delta = 0.5 \times 0.625$ deg.
  - GWC interpolation to every prediction site

- Topographical data
  - Viewfinder Panoramas (SRTM), $\Delta = 150$ m
  - GlobCover 2009 land cover, $\Delta = 300$ m
  - DTU translation table from LC to $z_0$

- Methodology
  - WAsP modelling (Frogfoot), $\Delta = 250$ m
  - Results aggregated to $\Delta = 1$ km
  - Heights above ground 50, 100, 200 m

- For the present validation
  - Generalised wind climates at MERRA nodes
Global Wind Atlas validation

• Climatological data @ ~90 sites
  – Meteorological masts (25-125 m, 1-13 y)
  – Winddata.com, CREYAP, DTU & partners, ...

• Topographical data
  – SRTM-based elevation vector maps
  – Google Earth-based land cover maps

• Methodology
  – Observed statistics at mast height
  – Predicted statistics at mast height from GWA generalised wind climate + WAsP

• Results (at mast or hub height)
  – Mean wind speed and power density
  – Mean wind turbine and wind farm yields
  – Wind direction distributions
Masts used for validation

Projects and analyses

- DTU Course 46200 (2016, 2017)
- EWEA CREYAP 1-4
- Wind Atlas for South Africa
- Mesoscale and microscale modelling in China
- Cape Verde Wind Farm Extension Project
- Danish Wind Atlas
- Wind Atlas for Egypt

Results for four types of sites

- Non-complex, offshore, complex terrain (RIX > 5%), complex flow (mesoscale)

Countries (projects)

- Cape Verde (4)
- China (12)
- Denmark (12)
- Egypt (23)
- Faroe Islands (1)
- France (2)
- Mexico (4)
- South Africa (17)
- United Kingdom (13)
GWA wind speeds and energy yields (simple + offshore)
Onshore and offshore wind speeds
Onshore and offshore energy yields

Wind turbine yield from GWA [GWh yr⁻¹]

Wind turbine yield from OWA [GWh yr⁻¹]
Complex terrain (RIX > 5%) – wind speed and energy yield
Complex flows (mesoscale) – wind speed and energy yield

Wind speed from GWA [ms⁻¹]

Wind turbine yield from GWA [GWh yr⁻¹]
Comparison of wind direction distributions (WASA 1)

<table>
<thead>
<tr>
<th></th>
<th>Obs</th>
<th>GWA</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><img src="image1" alt="Wind direction distribution" /></td>
<td><img src="image2" alt="Wind direction distribution" /></td>
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<tr>
<td>2</td>
<td><img src="image3" alt="Wind direction distribution" /></td>
<td><img src="image4" alt="Wind direction distribution" /></td>
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<td>3</td>
<td><img src="image5" alt="Wind direction distribution" /></td>
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<tr>
<td>10</td>
<td><img src="image19" alt="Wind direction distribution" /></td>
<td><img src="image20" alt="Wind direction distribution" /></td>
</tr>
</tbody>
</table>
Effect of length of measured time-series
Comparison of **GWA** and WRF modelling (**WASA 1**)

![Comparison of GWA and WRF modelling](image_url)
## Conclusions

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Trueness, $a$ ((Y = a \cdot X))</th>
<th>Spread, $\sigma$ ((\sigma_a))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind speed</td>
<td>101%</td>
<td>10%</td>
</tr>
<tr>
<td>Power density</td>
<td>103%</td>
<td>31%</td>
</tr>
<tr>
<td>Turbine yield</td>
<td>101%</td>
<td>22%</td>
</tr>
</tbody>
</table>

- GWA provides on average a reliable picture of the wind climate and wind resources for both
  - Onshore and offshore conditions
- The spreads of GWA-based predictions of wind speed, power density and yields are significant
  - Single predictions may deviate significantly
- GWA predictions may be strongly biased in
  - Complex and steep topography
  - Flows with strong mesoscale forcing
- No simple correlation between prediction statistics and length of observed time-series
- Global Wind Atlas fulfils its intended role, and may also be used for
  - Project preparation
  - Measurement campaign design
Acknowledgements

- China Meteorological Administration (CMA)
- Danish Ministry of Foreign Affairs (Danida)
- DTU Course 46200 – classes of 2016 and 2017
- Joule project “Measurements and modelling in complex terrain”
- Sund & Bælt
- Wind Atlas for Egypt project
- Wind Atlas for South Africa project (WASA 1 & 2)
- Winddata.com
- WindEurope CREYAP initiative

Thank you for your attention!