#### Technical University of Denmark



#### Global Wind Atlas – validation and uncertainty

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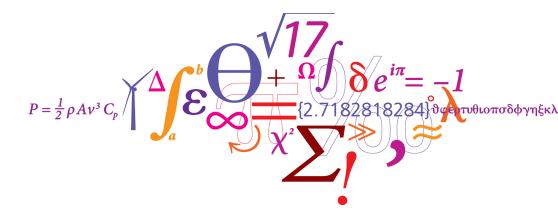
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# **Global Wind Atlas – validation and uncertainty**

Niels G Mortensen, Neil Davis, Jake Badger, Andrea N Hahmann

WindEurope Resource Assessment 2017



**DTU Wind Energy** Department of Wind Energy

# **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

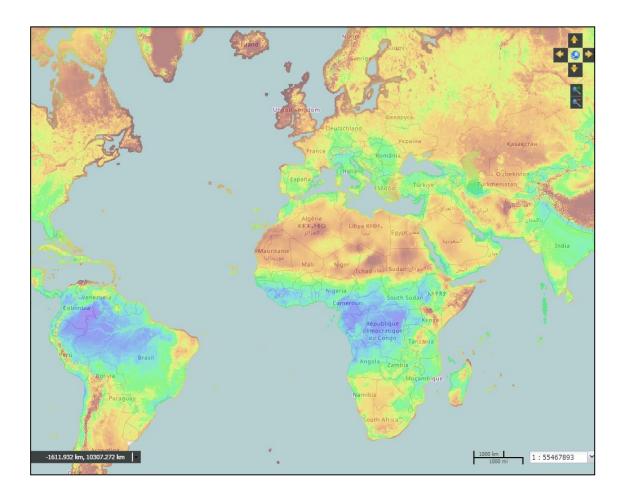
### Topics for this presentation

- 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  $\Delta = 1 \text{ km}$
  - 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

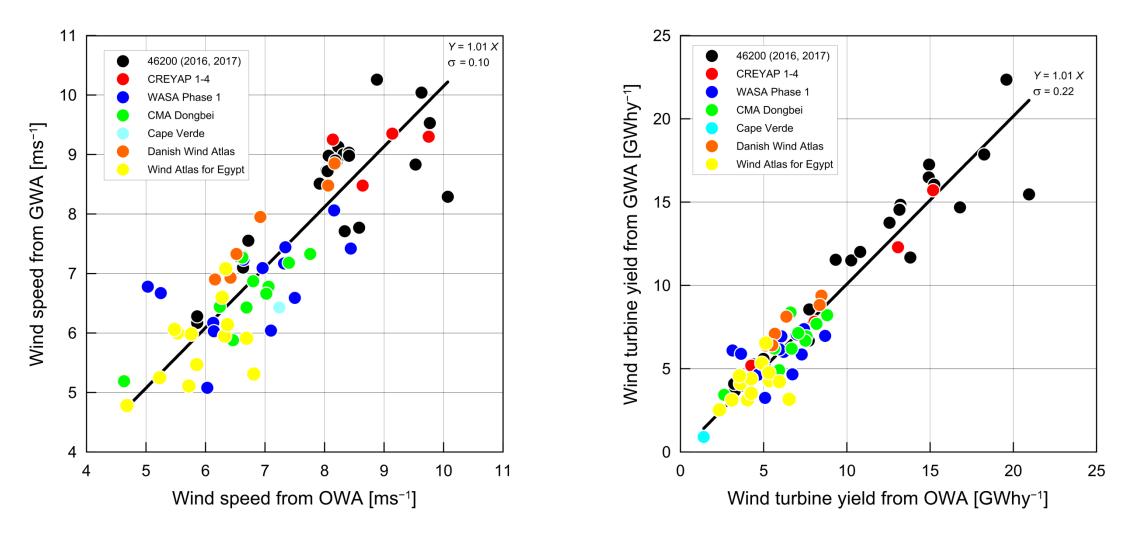
### **Results for four types of sites**

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

### Countries (projects)

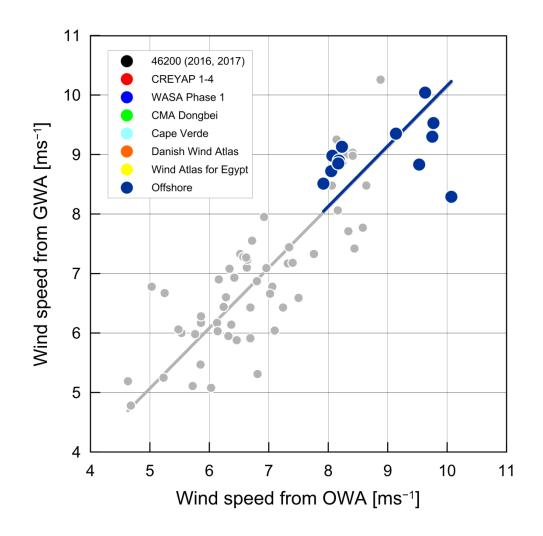
- Cape Verde (4)
- China (12)
- Denmark (12)
- Egypt (23)
- Faroe Islands (1)
- France (2)
- Mexico (4)
- South Africa (17)
- United Kingdom (13)

### GWA wind speeds and energy yields (simple + offshore)

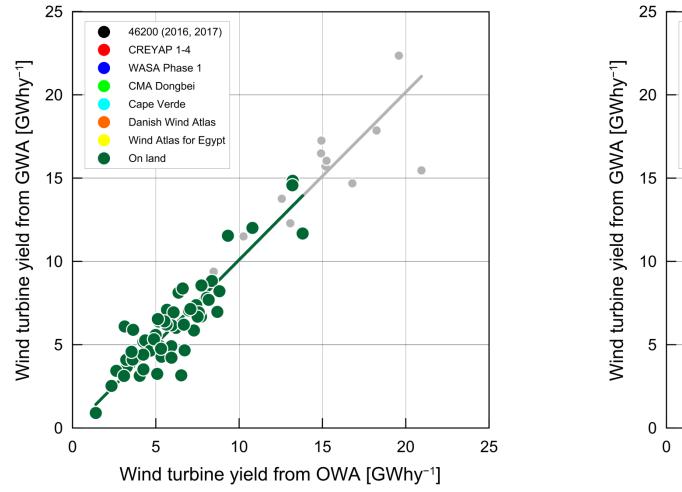


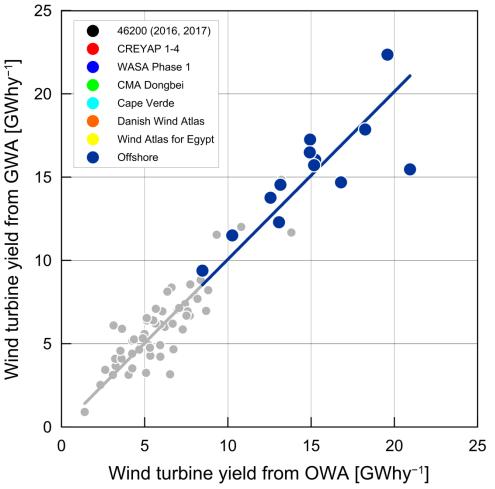
#### 11 46200 (2016, 2017) CREYAP 1-4 10 WASA Phase 1 CMA Dongbei Wind speed from GWA [ms<sup>-1</sup>] Cape Verde Danish Wind Atlas 9 Wind Atlas for Egypt On land 8 7 6 5 4 5 6 7 8 9 10 11 4 Wind speed from OWA [ms<sup>-1</sup>]

## **Onshore and offshore wind speeds**

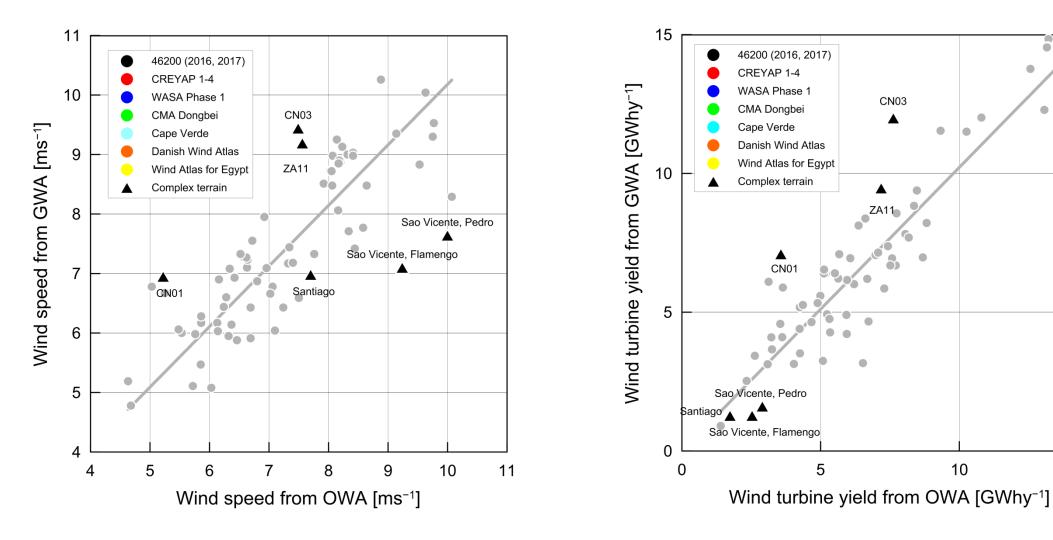


## **Onshore and offshore energy yields**





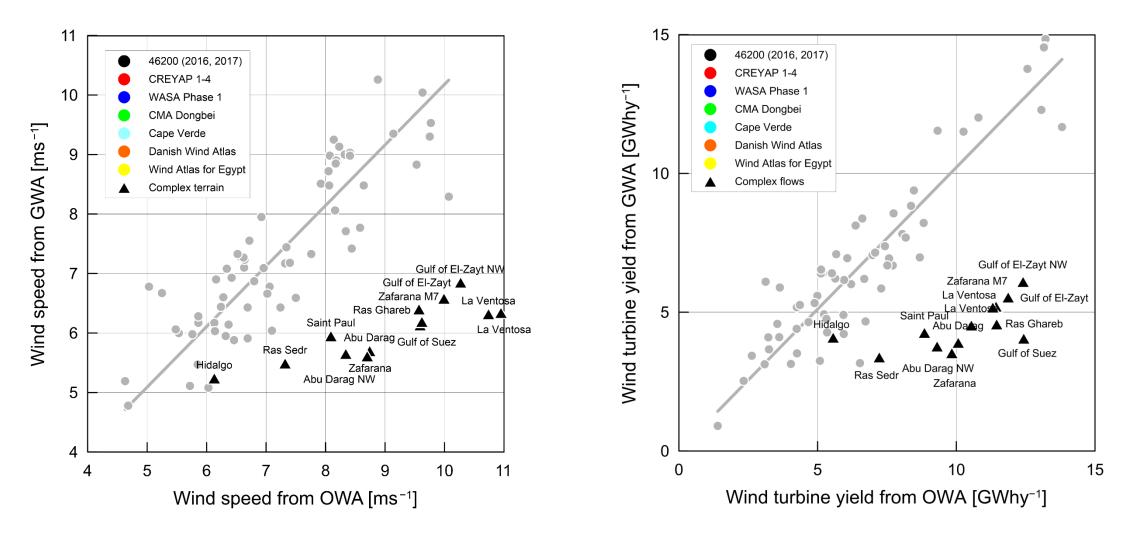
## Complex terrain (RIX > 5%) – wind speed and energy yield



10

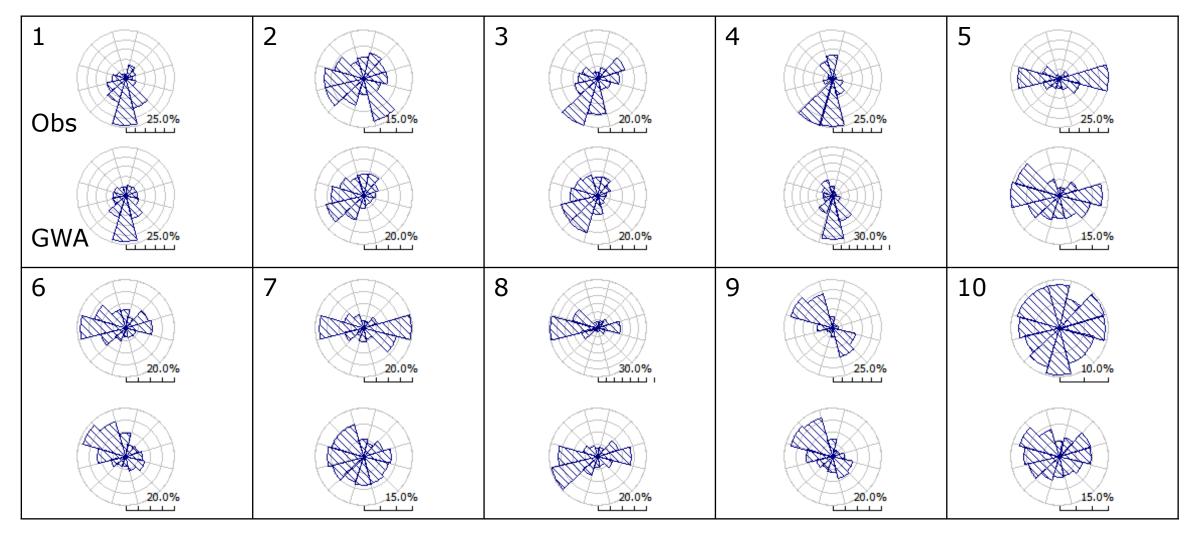
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### Complex flows (mesoscale) – wind speed and energy yield

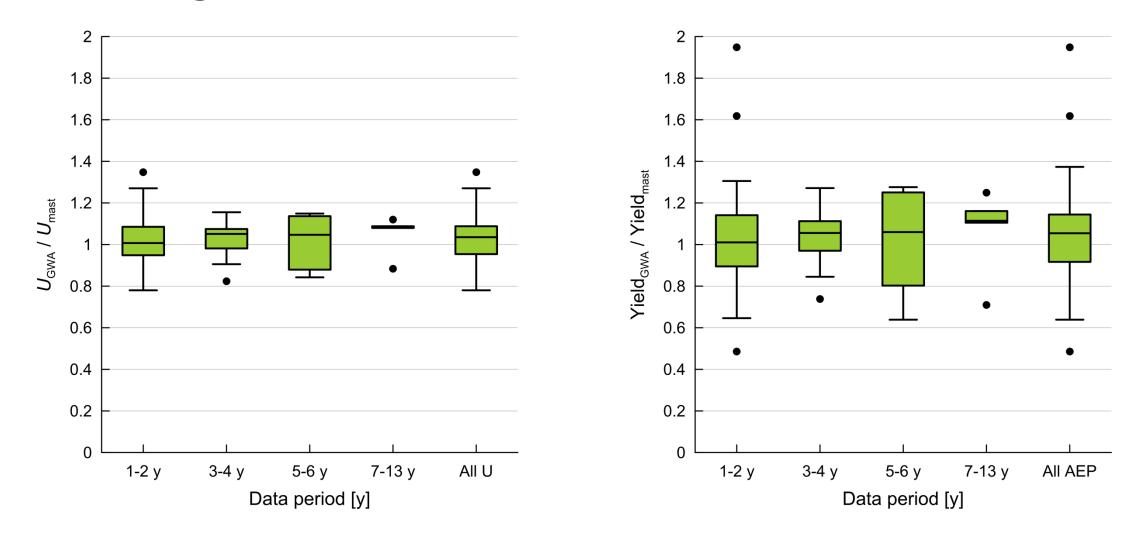




## **Comparison of wind direction distributions** (WASA 1)

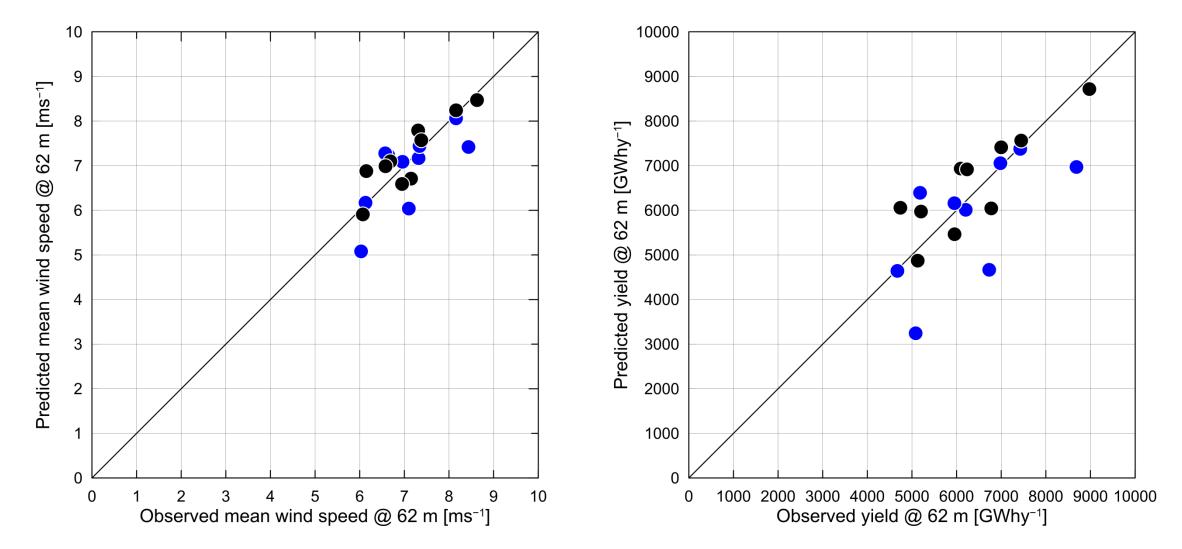


### **Effect of length of measured time-series**





## **Comparison of GWA and WRF modelling** (WASA 1)



# Conclusions

Parameter	Trueness, $a$ ( $Y = a \cdot X$ )	Spread, $\sigma$ ( $\sigma_a$ )
Wind speed	101%	10%
Power density	103%	31%
Turbine yield	101%	22%

- GWA provides <u>on average</u> 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!

