Application for planning purposes: Interim High-Resolution Wind Resource Map for Strategic Environmental Assessment in South Africa

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Peer reviewed version

Link back to DTU Orbit

WASA 2 Application for planning purposes:
Interim High-Resolution Wind Resource Map for
Strategic Environmental Assessment in South Africa

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DTU Wind Energy

Eugéne Mabille and Eric Prinsloo
CSIR

WASA 2 Mid-term Workshop
Cape Town, South Africa
Updated wind resource mapping methodology

- **Frogfoot** implementation of WASP
  - Database of wind climates
  - Database of elevation maps
  - Database of roughness maps

- Principle of operation
  - Batch mode operation
  - Distributed computing
  - Wind atlas interpolation to every prediction site.
  - Results in MySQL database
  - Export to GIS formats

- WASP 11 standard modelling
  - Industry-standard model
  - Linearized IBZ flow model
  - Default parameters
Available input data for modelling

- Validated Numerical Wind Atlas
  - WRF mesoscale model
  - Virtual mast for every 3/5 km
  - WASA 1 domain: 3 km
  - All of South Africa: 5 km

- Elevation
  - 100-m elevation grid from space shuttle Endeavour (SRTM+, NASA version 3).

- Land cover
  - 300-m land cover grid derived from ESA GlobCover 2009.
  - Transformation table for $z_0$
WRF 5-km simulated winds

WASA2, mean wind speed (m/s)  Oct 2005 - Sept 2013

[Map showing wind speed distribution]
South Africa wind speed @ 100 m
South Africa power density @ 100 m
WRF 3-km simulated winds

WASA1, mean wind speed (m/s)  Oct 2005 - Sept 2013
WASA1 wind speed @ 100 m
WASA1 power density @ 100 m
Interim High-Resolution Wind Resource Map

Detailed wind resource maps
- 250 × 250 m grid results
- Modelling resolution ∼1 m
- 50, 100 and 200 m a.g.l.
- ArcGIS ASC output format

- Mean wind speed $U$
  - 10 min average in [ms$^{-1}$]

- Mean power density $P$
  - 10 min average in [Wm$^{-2}$]
  - Site-specific air density

- Elevation $z$
  - Meters above sea level [m]

- Ruggedness index RIX
  - WASP standard parameters

Database of wind climates
- For each province
  - 250 × 250 m grid results
  - 50, 100 and 200 m a.g.l.
  - Sector-wise results (×12)
  - ASCII TXT output format

- For each site, height and sector
  - Weibull A parameter [ms$^{-1}$]
  - Weibull k parameter
  - Frequencies of occurrence

- Data for calculation of
  - Specific power density
  - Wind turbine energy yield
  - Wind turbine capacity factor
  - and much more...
Metadata documents for wind resource data sets

- Metadata for data sets
  - Data set specifications
  - Data provider
  - Contact information
- Data set parameters
- Coordinate system
- Technology (models & data)
- Detailed notes
  - Purpose
  - Methodology
  - Limitations
  - Available documentation
  - Acknowledgements
  - Disclaimer
  - Four maps of $U$, $P$, $z$ and RIX

Metadata and further information
October 2017

**METADATA**

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<td>Data provider</td>
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<td>Contact persons</td>
<td>Niels G. Madsen (DTU) or Eugene Mobile (CSIR)</td>
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<td>Contact details</td>
<td><a href="mailto:nimo@dtu.dk">nimo@dtu.dk</a> (DTU) or <a href="mailto:EMobile@csir.co.za">EMobile@csir.co.za</a> (CSIR)</td>
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**DATA PARAMETERS**

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<th>Parameter</th>
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<tr>
<td>Mean wind speed</td>
<td>Annual mean wind speed ($\text{m/s}$) @ 50, 100 and 200 m a.g.l.</td>
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<tr>
<td>Mean power density</td>
<td>Annual mean power density ($\text{W/m}^2$) @ 50, 100 and 200 m a.g.l.</td>
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<tr>
<td>Terrain elevation</td>
<td>Elevation of modelling area in (m) above mean sea level</td>
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<td>Ruggedness index RIX</td>
<td>Site RIX value calculated by WASp (standard parameter setup)</td>
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**COORDINATE SYSTEM**

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<tr>
<td>Projection</td>
<td>Universal Transverse Mercator (UTM)</td>
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<tr>
<td>Zone number</td>
<td>31S (two provinces) and 38S (seven provinces)</td>
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<td>Datum</td>
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**TECHNOLOGY**

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<td>Air density input</td>
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Metadata documents for wind resource data sets

- Metadata for data sets
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- Limitations
  - Operational envelope of WAsP
  - Validated numerical wind atlas (WRF mesoscale model)
  - Input topographical data
  - Complex terrain (RIX > 5%)
  - Built-up areas
  - Forested areas

The wind resource maps are subject to change without notice if and when more accurate and reliable data, models and procedures become available.
Validation at WASA 1 and 2 masts
DEA National Wind and Solar PV SEAs (Phase 1)

SEA Data available for download & public comments

http://www.csir.co.za/nationalwindsolarenergy/

- National Wind Datasets Download
- Global Horizontal Irradiance
  - Global Horizontal Irradiance (GHI): kWh/m²/annum
- Photovoltaic Yield Static
  - Photovoltaic Yield on fixed tilt plane (kWh(electrical)/kWpeak(installed)/a)
- PV Yield Tracking
  - Photovoltaic Yield with single axis tracking (kWh(electrical)/kWpeak(installed)/a)
- Optimal Inclination
  - Optimal inclination for solar panels

- Wind and Solar PV SEA Phase I Study Areas Download

- National Solar Datasets Download
- Renewable Energy EIA Applications Map and Comment Form Download
WASA data used to identify Wind Technical Areas to inform the Phase 2 Strategic Environmental Assessment for wind and solar energy
Wind farm planning and development (caution!)

- Identification and ranking of potential wind farm sites.
- Initial analyses and design
- Project planning
- Pre-feasibility studies
  - Resource assessment
  - Some site assessment
- Design of measurement campaign
  - Number of masts
  - Siting of masts
  - Orientation of sensor booms
  - Mounting of lightning rod and navigation lights.
Summary and conclusions

- Wind resources in South Africa
  - Large-scale: ~1.22 mio. km$^2$
  - High-resolution: 250-m grids
  - Results in public domain

- Data sets available
  - Detailed wind resource maps
  - Database of wind climates
  - Three heights at every site

- Data sets specifically developed for
  - Strategic Environmental Assessment (SEA)
  - WF planning and development

- Validation and QA in progress
  - Software development phase
  - Comparisons at WASA masts

- Preliminary validation of WASA1 (3-km) to WASA2 (5-km):
  - Mean absolute percentage error (MAPE) decreases 15%
  - Spread decreases by 40%
  - Bias is almost 0%!

- WASA 2 and 3 focus areas
  - Land cover data & modelling
  - Long-term extrapolation
  - Atmospheric stability
  - Adaptation of modelling
  - Uncertainty modelling

- WASA 2 ends by end of 2018
  - 3-km mesoscale modelling
  - Updated data and reports
Acknowledgements

The Wind Atlas for South Africa (WASA) project is an initiative of the South African Government – Department of Energy (DoE) – and the project is co-funded by

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WASA Project Steering Committee:

DoE (chair), DEA, DST, UNDP, Danish Embassy, SANEDI
Further information

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SANEDI WASA site
www.wasaproject.info

CSIR Online
www.wasa.csir.co.za

WASA download site
wasadata.csir.co.za/wasa1
### Results folder – available files

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