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

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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
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

Interim High-Resolution Wind Resource Map for South Africa

Metadata and further information

October 2017

**DATA**

- Data set name: Interim High-Resolution Wind Resource Map for South Africa
- Data set date: October 2017
- Data provider: DTU Wind Energy and CSIR
- Contact persons: Natascha Mortensen (DTU) or Eugene Mahlale (CSIR)
- Contact details: nina@dtu.dk (DTU) or EMahale@csir.co.za (CSIR)
- Data format: ArcGIS ASCII
- File name(s): ZA_<province>_<resolution>_<parameter>_<version>1.asc
- Data origin: Microscale modelling in each grid point, no interpolation

**DATA PARAMETERS**

- Mean wind speed: Annual mean wind speed ($\text{m/s}$) at 50, 100 and 200 m a.g.l.
- Mean power density: Annual mean power density ($\text{W/m}^2$) at 50, 100 and 200 m a.g.l.
- Terrain elevation: Elevation of modelling site in (m) above mean sea level
- Roughness index $\text{RIX}$: Site RIX value calculated by WASP (standard parameter setup)

**COORDINATE SYSTEM**

- Projection: Universal Transverse Mercator (UTM)
- Zone number: 31S (two provinces) and 38S (seven provinces)
- Datum: World Geodetic System 1984 (WGS 84)

**TECHNOLOGY**

- Calculation software: WASP Resource Mapping System with WASP engine version 11
- Wind-climatological input: 5-km NWA (WRF-based, code name: WASA2-WYN-MAM1-10D)*
- Elevation data input: 100 m elevation grid derived from SRTM+ (NASA version 3)
- Roughness data input: 300-m land cover grid derived from Global Cover 2006 (version 2.3)
- Air density input: Standard atmosphere approximation w/ elevation variations only

The wind resource maps are subject to change without notice if and when more accurate and reliable data, models and procedures become available.
**Metadata documents for wind resource data sets**

- Metadata for data sets
  - Data set specifications
  - Data provider
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  - Available documentation
  - Acknowledgements
  - Disclaimer
  - Four maps of $U$, $P$, $z$ and RIX

**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/nationalwindsolarsea/

- National Wind Datasets Download
- 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: \(\sim 1.22\) 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

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WASA Project Steering Committee:
DoE (chair), DEA, DST, UNDP, Danish Embassy, SANEDI
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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
Database folder – available files

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