High-Resolution Wind Resource Map for South Africa 2020
March 2021

METADATA	
Data set name	High-Resolution Wind Resource Map for South Africa 2020
Data set coverage	Land area of South Africa
Data set date	Compiled and published in March 2021
Data set creator	DTU Wind Energy
Data set publisher	DTU Wind Energy and Council for Scientific and Industrial Research
Contact persons	Rogier Floors (DTU) or Ursula von Saint Ange (CSIR)
Contact details	rofl@dtu.dk (DTU) or UvstAnge@csir.co.za (CSIR)
Data type	Raster data sets with a grid cell size of 0.0025 degrees
Data format	Tagged Image Format files (TIF) and Arc/Info ASCII grid (ASC)
File name(s)	WASA3_<version ID>_<parameter>_<height AGL>.tif
Data origin	Microscale WAsP modelling in each grid point; no interpolation
Data storage	Wind Atlas for South Africa download site and DTU Data

DATA PARAMETERS	
Mean wind speed	Annual wind speed U [ms^{-1}] @ 20, 50, 100 and 150 m a.g.l.
Mean power density	Annual power density P [Wm^{-2}] @ 20, 50, 100 and 150 m a.g.l.
Mean air density	Annual air density ρ [kgm^{-3}] @ 20, 50, 100 and 150 m a.g.l.
Weibull A parameter	Weibull scale parameter A [ms^{-1}] @ 20, 50, 100 and 150 m a.g.l.
Weibull k parameter	Weibull shape parameter k [n/a] @ 20, 50, 100 and 150 m a.g.l.
Ruggedness index RIX	Site RIX value [n/a] calculated by WAsP (standard parameters)

COORDINATE SYSTEM	
Projection	Geographic latitude and longitude (lat/lon)
Datum	World Geodetic System 1984 (WGS 84)

TECHNOLOGY	
Modelling software	WAsP Resource Mapping: PyWAsP Swarm 0.1.0, PyWAsP 0.4.1
Wind-climatological input	3.3-km NWA, WRF 3.8.1, ERA5 boundary conditions, 1990-2019
Elevation input	100-m elevation grid derived from SRTM+ (NASA version 3)
Land cover input	300-m land cover grid, ESACCI 2015 (version 2.0.7) w/ DTU table
Air density input	0.25-degree ERA5 global reanalysis data 2010-2019

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DESCRIPTION

Purpose

These data sets were created as part of the Wind Atlas for South Africa project (WASA). The wind resource maps were originally designed for inclusion in GIS-based strategic environmental assessments (SEA) for the entire land mass of South Africa. The maps cover all 9 provinces of South Africa, corresponding to an area of about 1,221,000 km^2. The wind resource maps are based on high-quality wind data and contemporary models; but the maps are subject to change without notice if and when more accurate and reliable data, models and procedures become available.

Methodology

Reference is made to the information and documentation available from wasa.csir.co.za. Much more detailed descriptions of the data sets and model validation are reported on this web site and elsewhere.

Limitations

The data set is limited by the operational envelopes of the wind atlas methodology and the WAsP models. The accuracy depends on a) the accuracy of the VNWA, which has been validated against the data from 19 WASA measurement masts, b) the WAsP 12 microscale modelling and c) the input topographical data.

In complex terrain (RIX > 5%), the wind resources may be significantly over-estimated by the WAsP IBZ microscale model. Above and close to built-up areas like cities, towns and villages, the results are less reliable. Close to and above forested areas, the results are also less reliable and should be interpreted and used accordingly.

The data set was designed specifically for planning purposes and should be used with utmost care for design, development and detailed assessments of actual wind farms; where local, on-site measurements are strongly recommended. Such measurement campaigns may be designed using this data set and the VNWA.

Available documentation

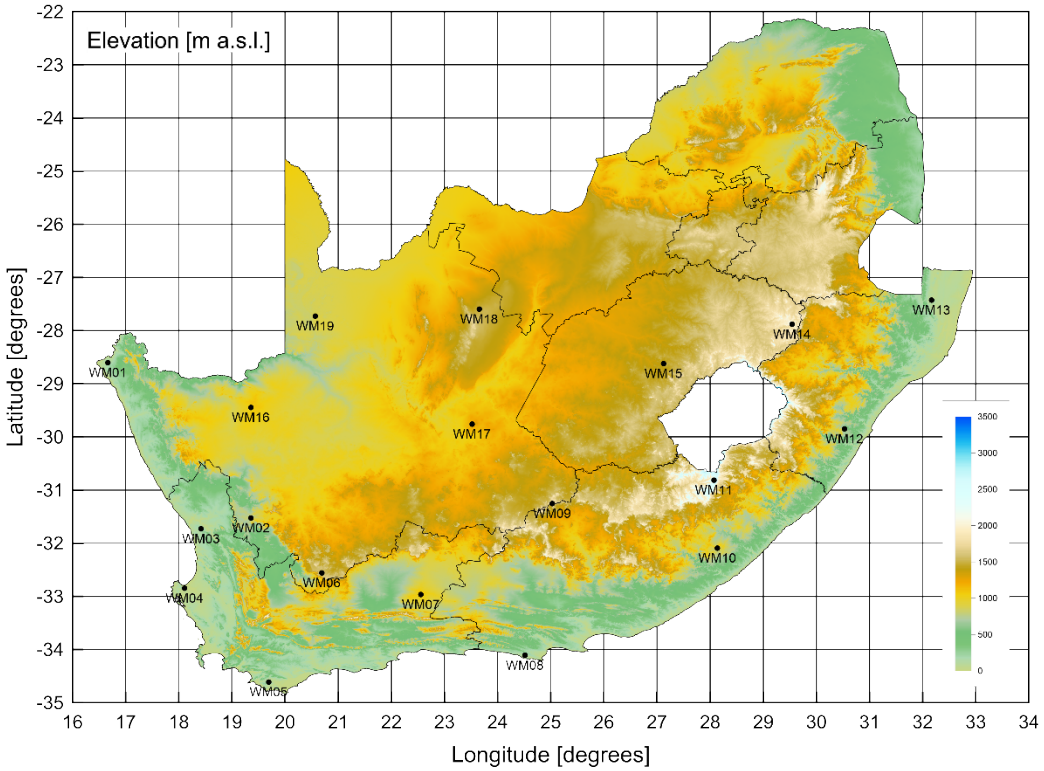
The wind atlas methodology is described in the European Wind Atlas (1989); the application of WAsP in the software documentation, see www.wasp.dk. The Validated Numerical Wind Atlas (VNWA) for South Africa is a product of the Wind Atlas for South Africa project (WASA) and is described on the WASA download pages. Air density calculation and data: Floors, R., & Nielsen, M. (2019). Estimating Air Density Using Observations and Re-Analysis Outputs for Wind Energy Purposes. *Energies* 12(11), 2038. doi.org/10.3390/en12112038.

Acknowledgements

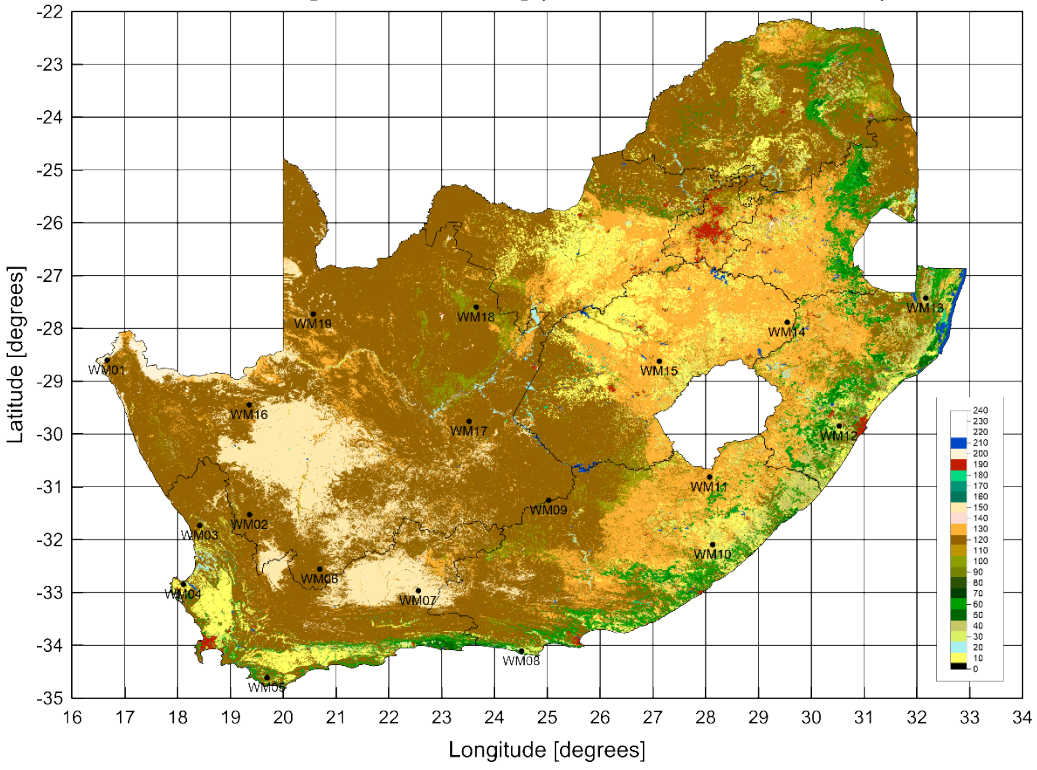
WASA team for provision of wind-climatological and topographical data. WAsP development teams at DTU Wind Energy and at World in a Box Oy for WAsP Resource Mapping System (PyWAsP Swarm) development and application. SRTM Plus data were downloaded from NASA's Land Processes Distributed Active Archive Center (LP DAAC) located at the USGS Earth Resources Observation and Science (EROS) Center. ESACCI 2015 land cover data are copyright © ESA Climate Change Initiative, Land Cover project 2017. South African province boundaries by Municipal Demarcation Board (MDB).

DISCLAIMER

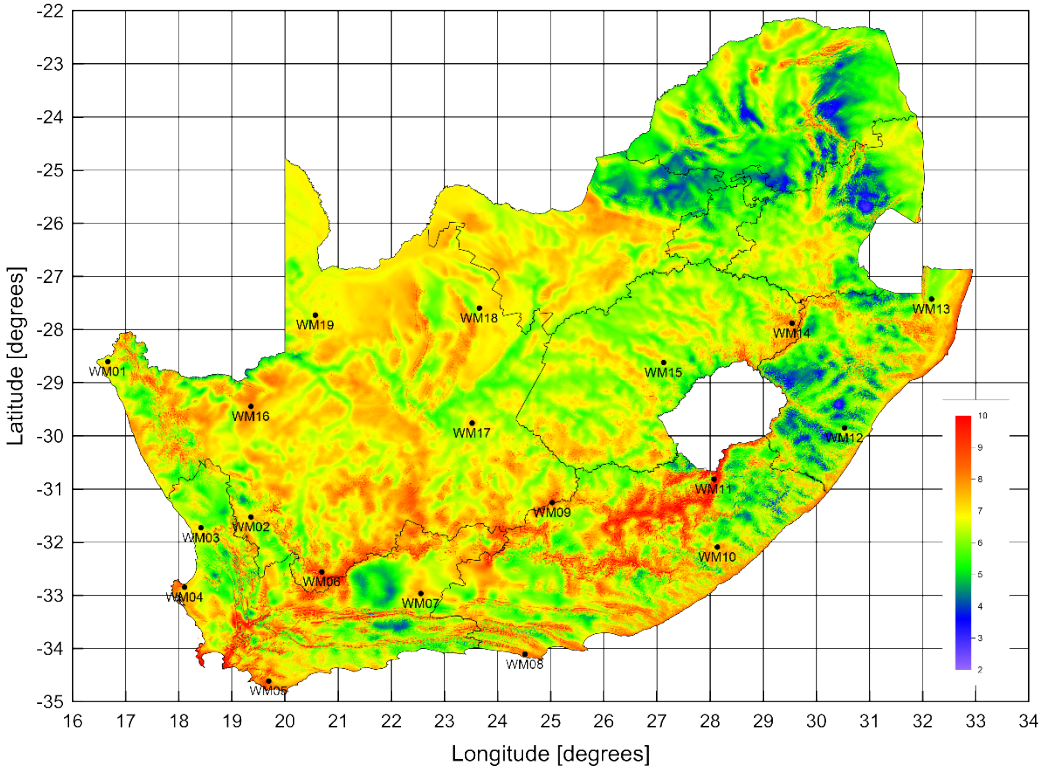
South Africa terrain elevation (SRTM+, NASA version 3)



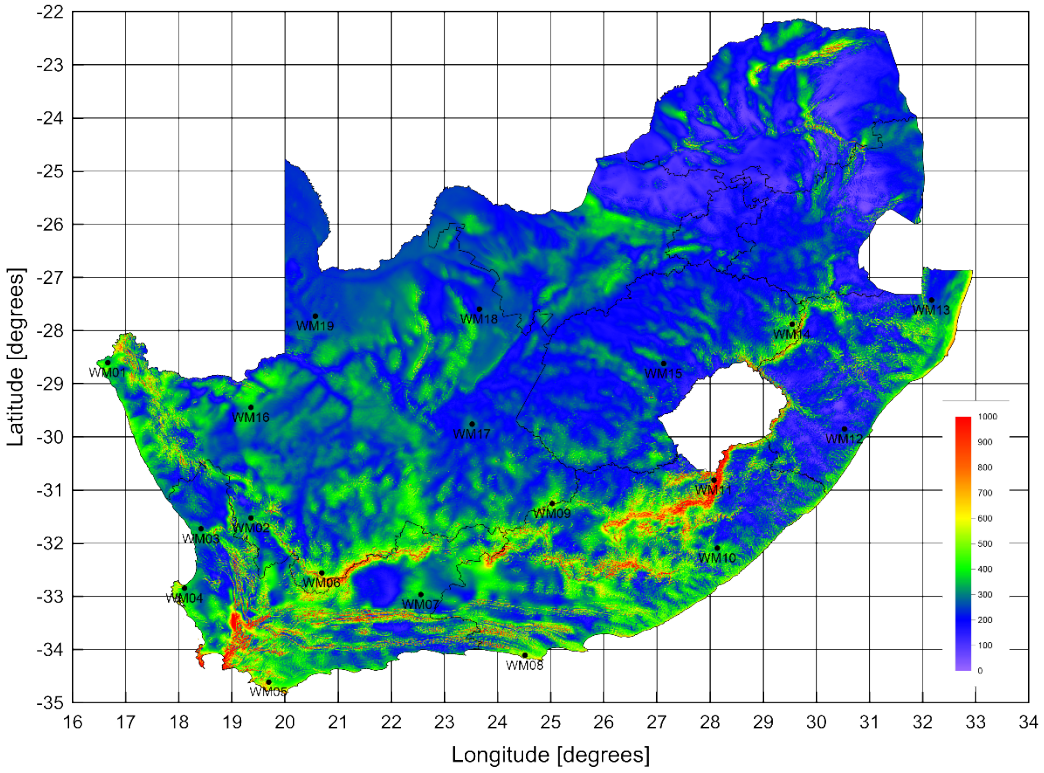
South Africa land cover [land cover code] (ESACCI version 2.0.7, 2015)



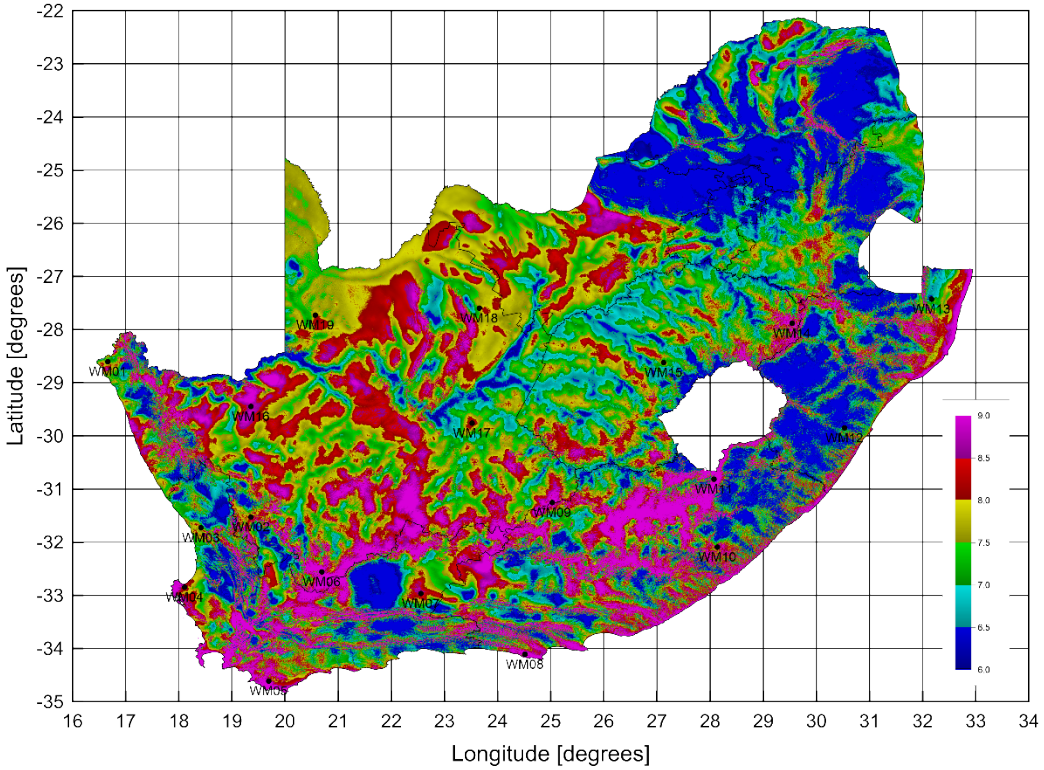
South Africa mean wind speed [ms^{-1}] @ 100 m a.g.l.



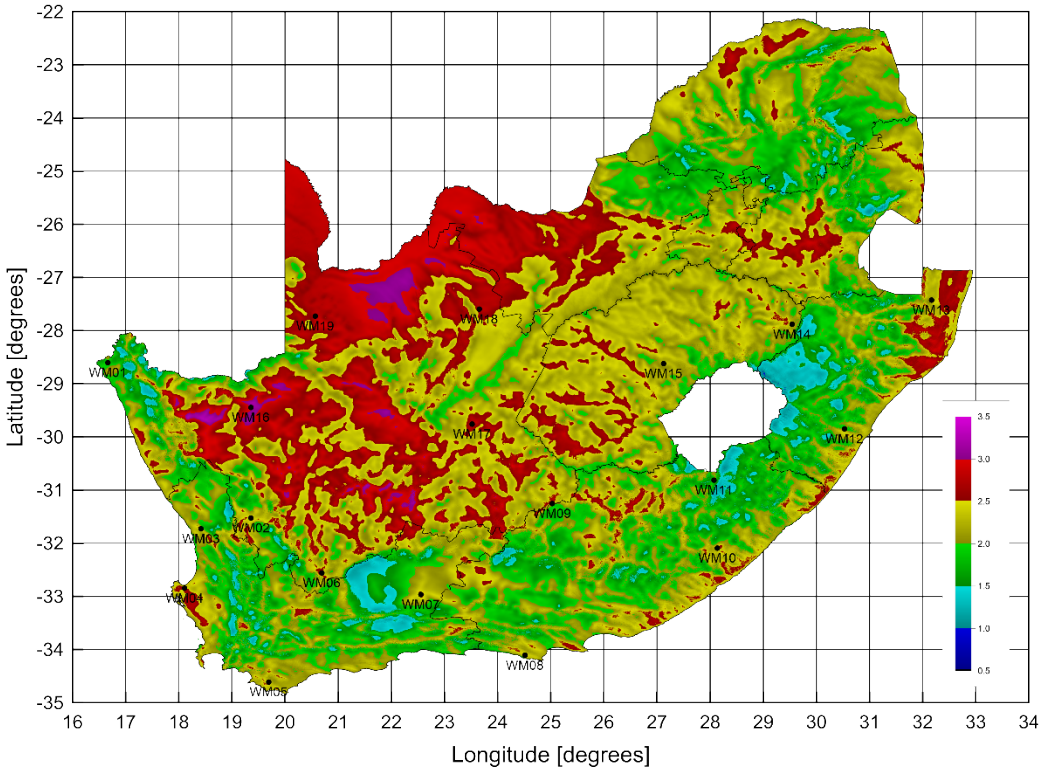
South Africa mean power density [Wm^{-2}] @ 100 m a.g.l.



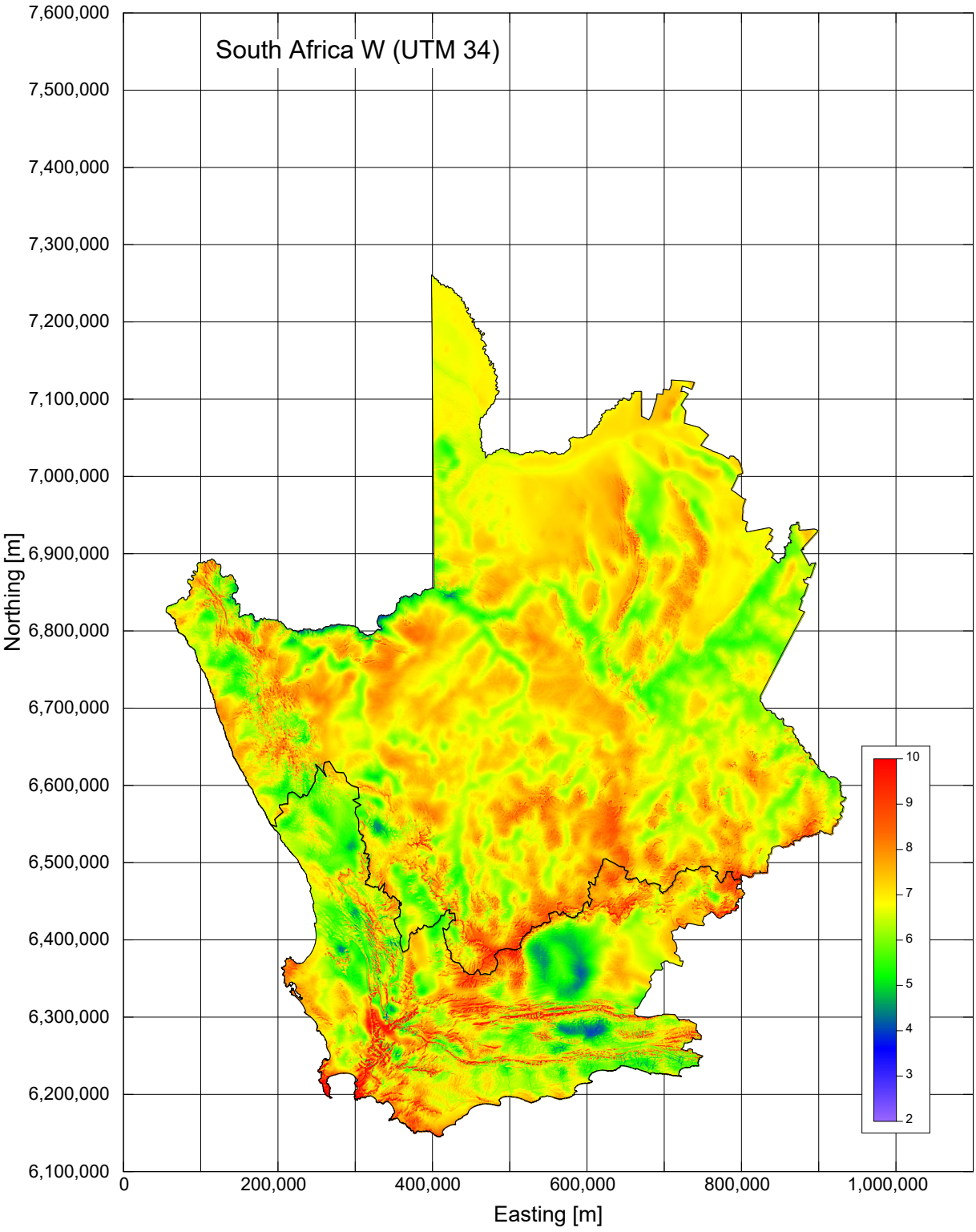
South Africa mean Weibull scale parameter *A* [ms^{-1}] @ 100 m a.g.l.



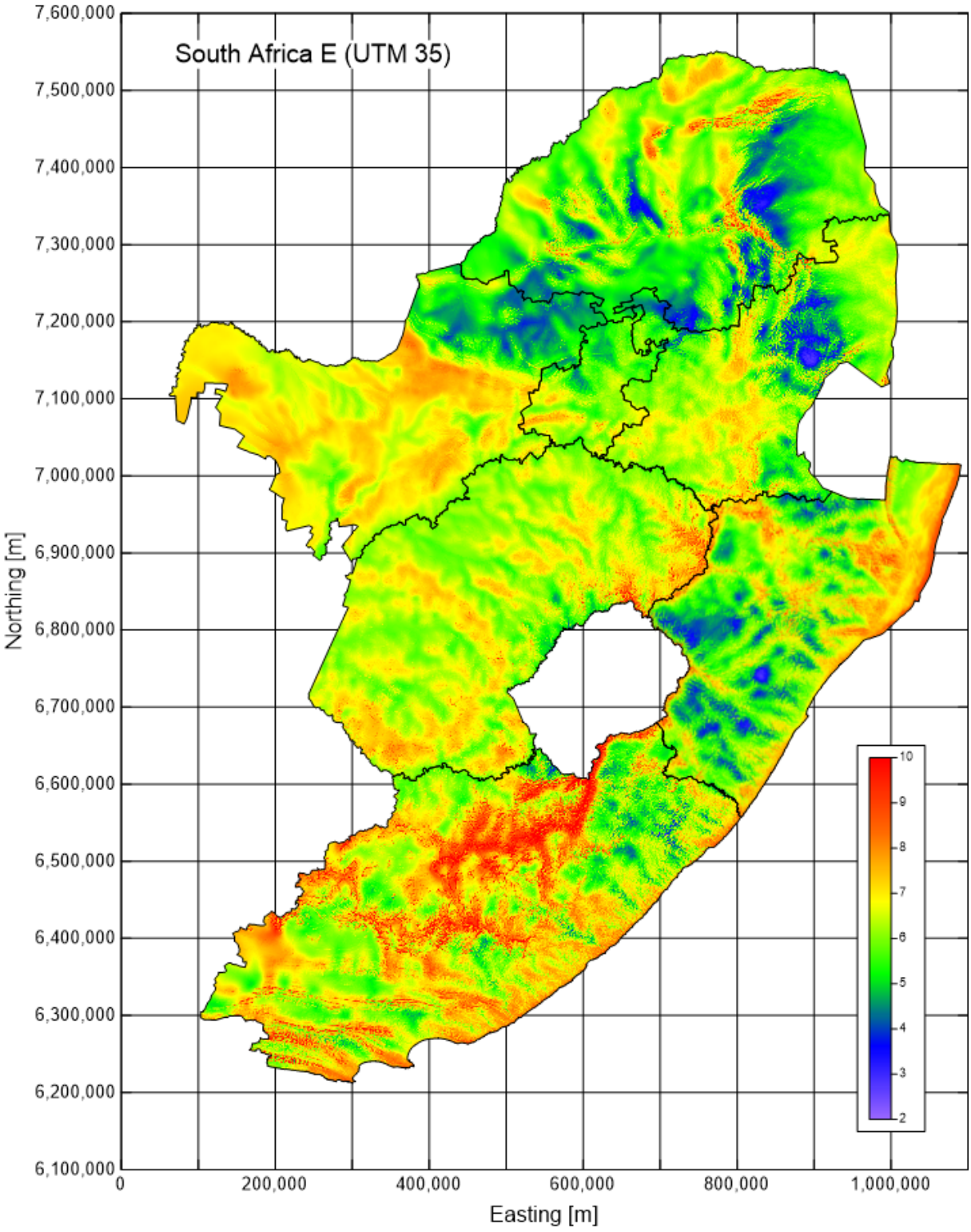
South Africa mean Weibull shape parameter *k* @ 100 m a.g.l.



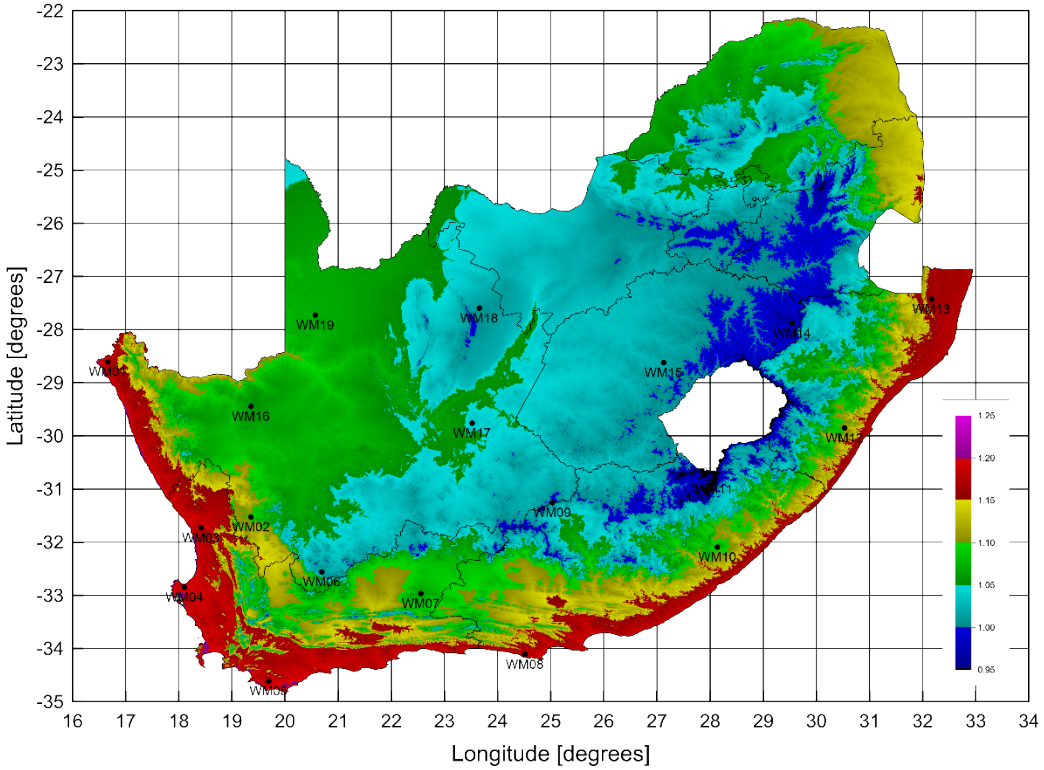
South Africa W mean wind speed [ms^{-1}] @ 100 m a.g.l.



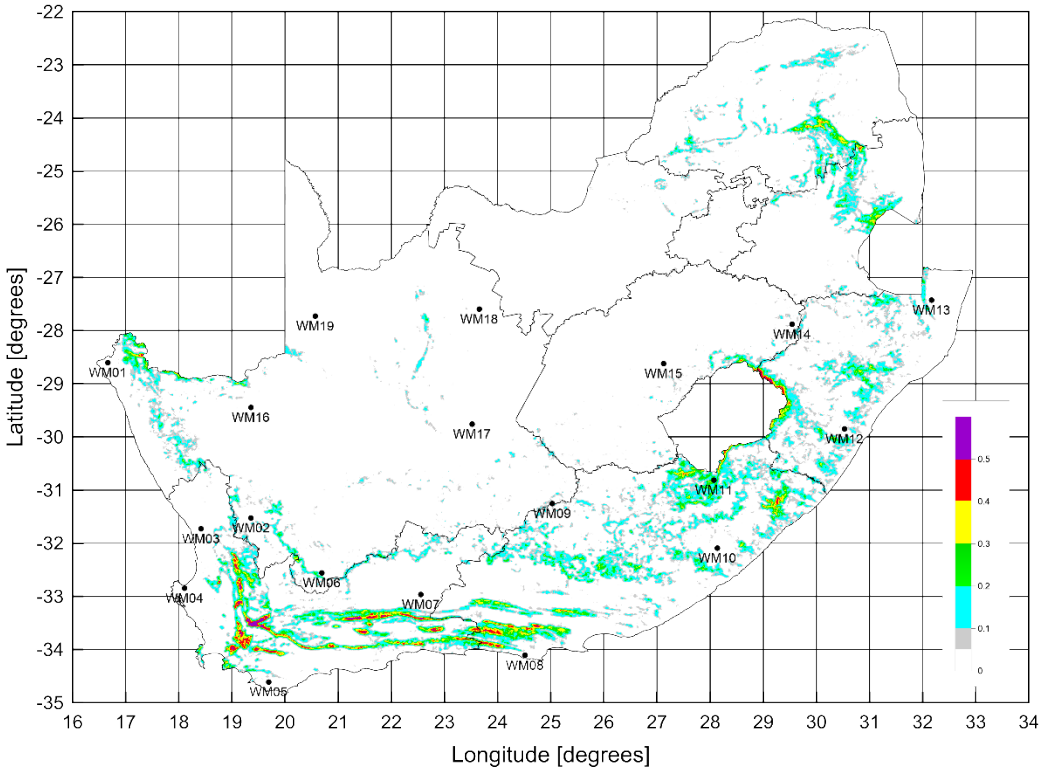
South Africa E mean wind speed [ms^{-1}] @ 100 m a.g.l.



South Africa air density [kgm^{-3}] @ 100 m a.g.l.



South Africa E ruggedness index



Generalised wind climates

In addition to the high-resolution wind resource maps, the underlying WAsP generalised wind climates for all of South Africa are available.

Generalised wind climate (LIB) files for all of South Africa, plotted in QGIS.

For all of South Africa, the following information is available in zipped (ZIP) or NetCDF (NC) archives:

- WAsP 12 generalised wind climate files, LIB file format

Generalised wind information in the form of Weibull parameters and wind roses are given for 10, 25, 50, 100 and 250 m above ground level and at 0.0025 deg. horizontal resolution. The archives contain 285,390 LIB-files from the 3.3 km × 3.3 km WASA 3 validated Numerical Wind Atlas.

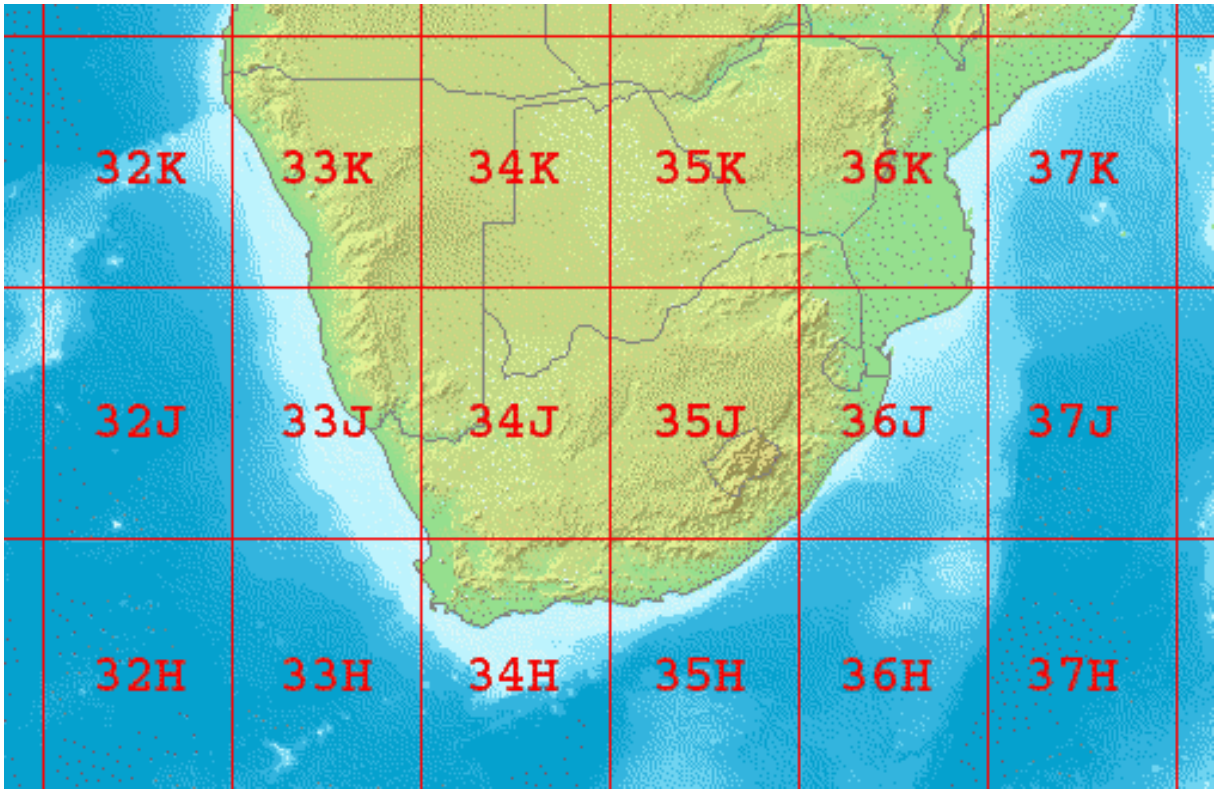
In addition, two auxiliary files are available that provide an overview of the LIB file names & locations:

- WASA3_Libs_coords_2020.csv: the 285,390 points (lat, lon) and LIB file names in a CSV file
- WASA3_Libs_coords.qgs: a QGIS file containing links to three data layers:
  1. 285,390 points with LIB file names and index number (WASA3_Libs_coords_2020.csv)
  2. 19 points with WASA mast WM01 to WM19 site locations (WASA 1+2+3 masts.geo.csv)
  3. District boundaries for all of South Africa; can be downloaded from the Municipal Demarcation Board data portal (MDB_District_Municipal_Boundary_2018-shp > Download > Shapefile).

How to find and extract generalised wind climates (LIB files) from the archives is described by Hansen *et al*. (2021). *Wind Atlas for South Africa (WASA) – Best practice guide for application of WASA*.

Database of wind climates

In addition to the high-resolution wind resource maps and generalised wind climates, a comprehensive data base of predicted wind climates is also available for all of South Africa.



UTM zones in southern Africa (from commons.wikimedia.org/wiki/File:LA2-Africa-UTM-zones.png)

For each tile in the map covering South Africa – 33H, 33J, 34H, 34J, 35H, 35J, 35K, 36J, 36H, 36K – the following information (SI units) is provided in NetCDF format files at 0.0025 deg. resolution:

- Weibull *A*- and *k*-parameters for 12 sectors @ 20, 50 and 100 m a.g.l.
- Wind direction distribution (rose) for 12 sectors @ 20, 50 and 100 m a.g.l.
- Mean wind speed (emergent) @ 20, 50 and 100 m a.g.l.
- Mean power density (emergent) @ 20, 50 and 100 m a.g.l.
- Mean Weibull *A*- and *k*-parameters @ 20, 50 and 100 m a.g.l.
- Mean air density @ 20, 50 and 100 m a.g.l.
- Terrain surface elevation [m a.s.l.]
- Terrain ruggedness index, RIX

Climate information at each of the 0.0025 deg. (≈250 m) modelling grid points makes it possible to calculate, say, specific mean power density from 0-25 ms^{-1}, energy yield for any given wind turbine, capacity factor for any given wind turbine, etc.

The data base of wind climates is described further by Hahmann et al. (2021). *Mesoscale and Microscale Downscaling for the Wind Atlas of South Africa (WASA) Project: Phase 3.*