



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

**Mortensen, Niels Gylling; Hahmann, Andrea N.; Hansen, Jens Carsten; Mabilie, Eugène; Prinsloo, Eric**

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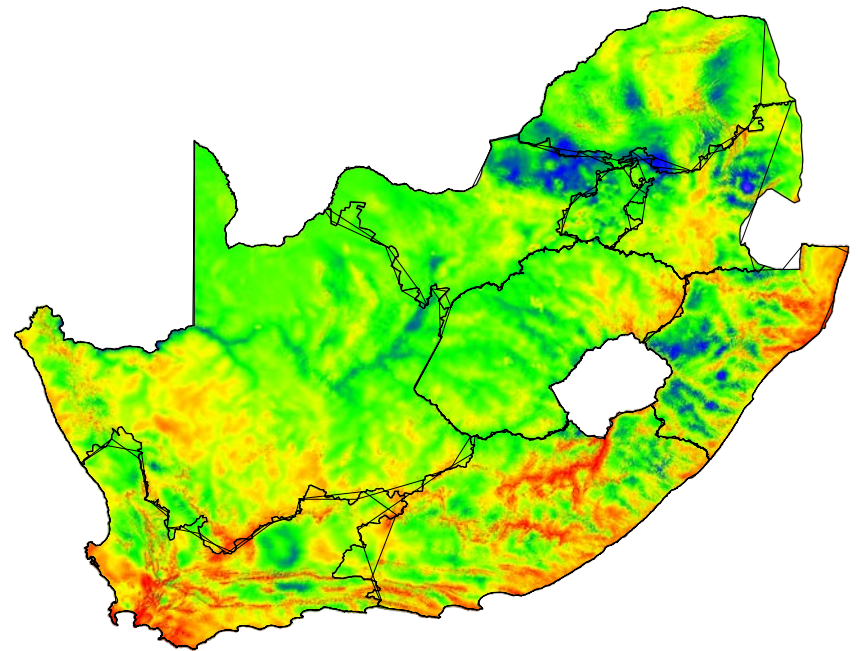
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## **WASA 2 Application for planning purposes: Interim High-Resolution Wind Resource Map for Strategic Environmental Assessment in South Africa**

Niels G Mortensen, Andrea N Hahmann & Jens Carsten Hansen  
DTU Wind Energy

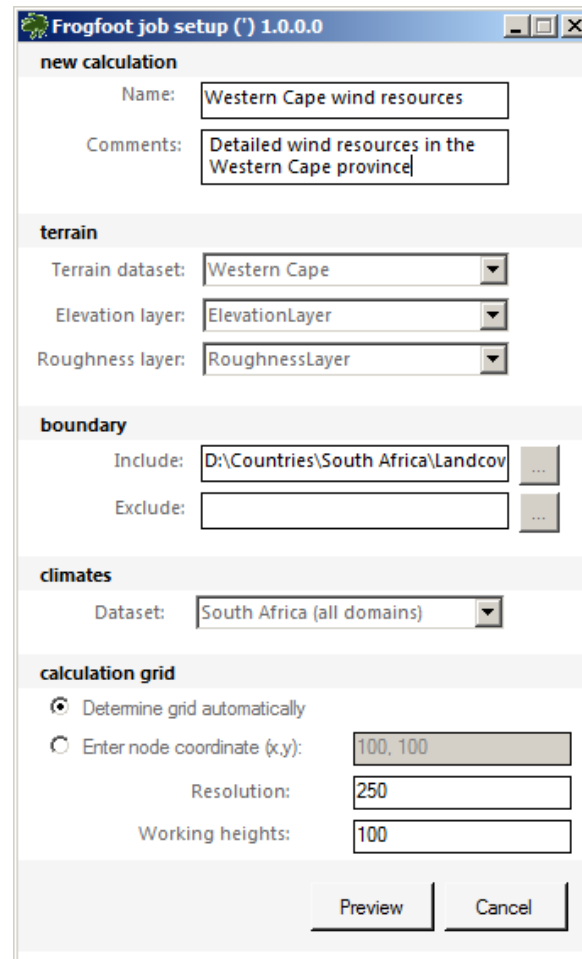
Eugène Mabilille and Eric Prinsloo  
CSIR



*WASA 2 Mid-term Workshop  
Cape Town, South Africa*

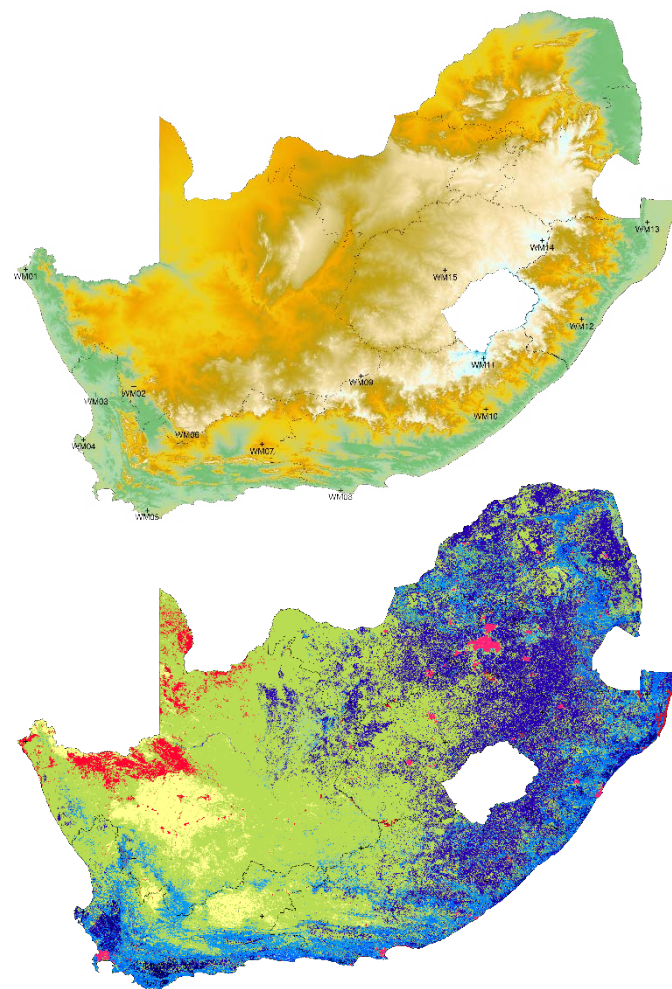
# Updated wind resource mapping methodology

- *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

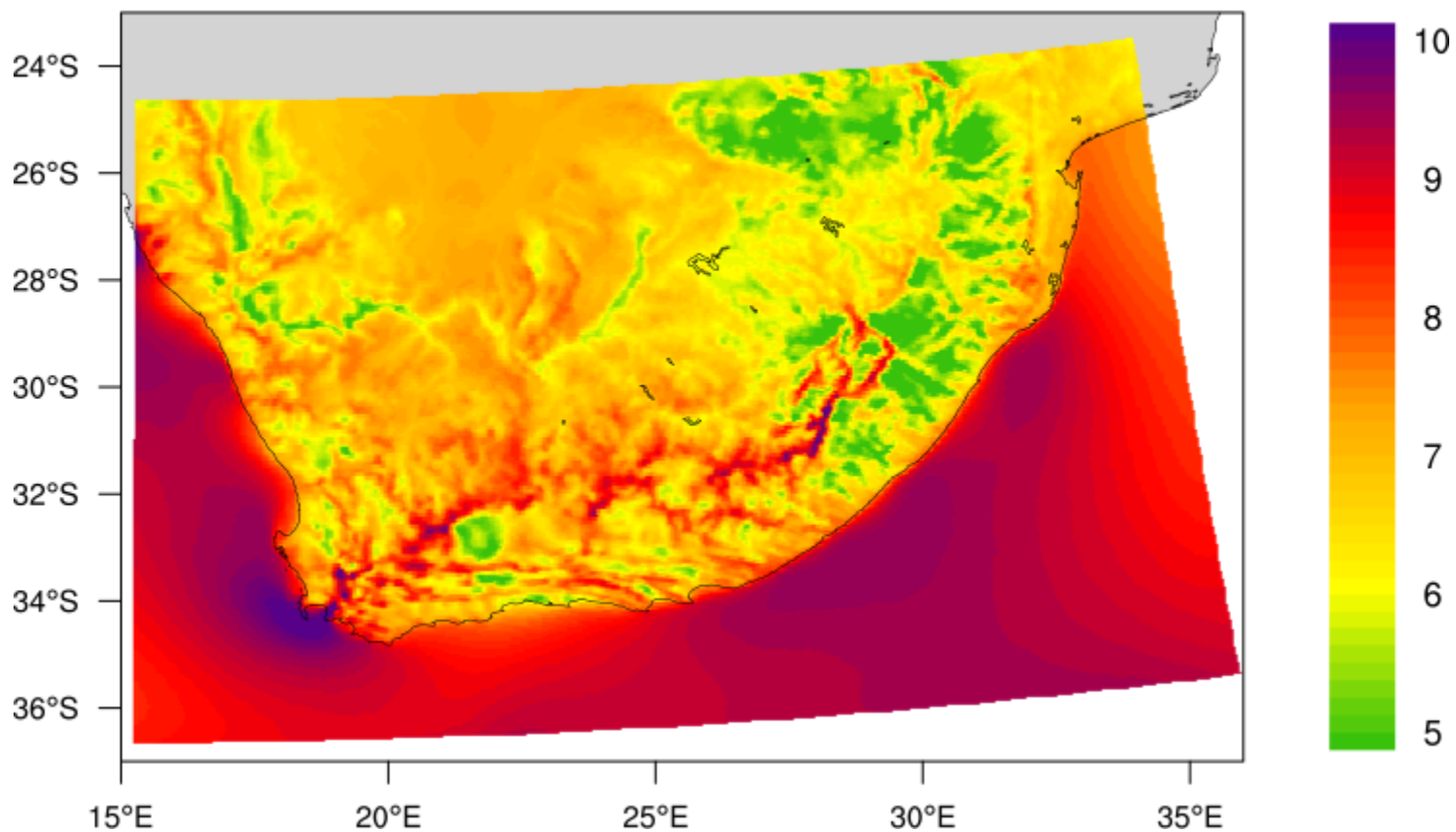
- Validated Numerical Wind Atlas
  - WRF mesoscale model
  - Virtual mast for every 3/5 km
  - WASA 1 domain: 3 km
  - All of South Africa: 5 km
- Elevation
  - 100-m elevation grid from space shuttle Endeavour (SRTM+, NASA version 3).
- Land cover
  - 300-m land cover grid derived from ESA GlobCover 2009.
  - Transformation table for  $z_0$



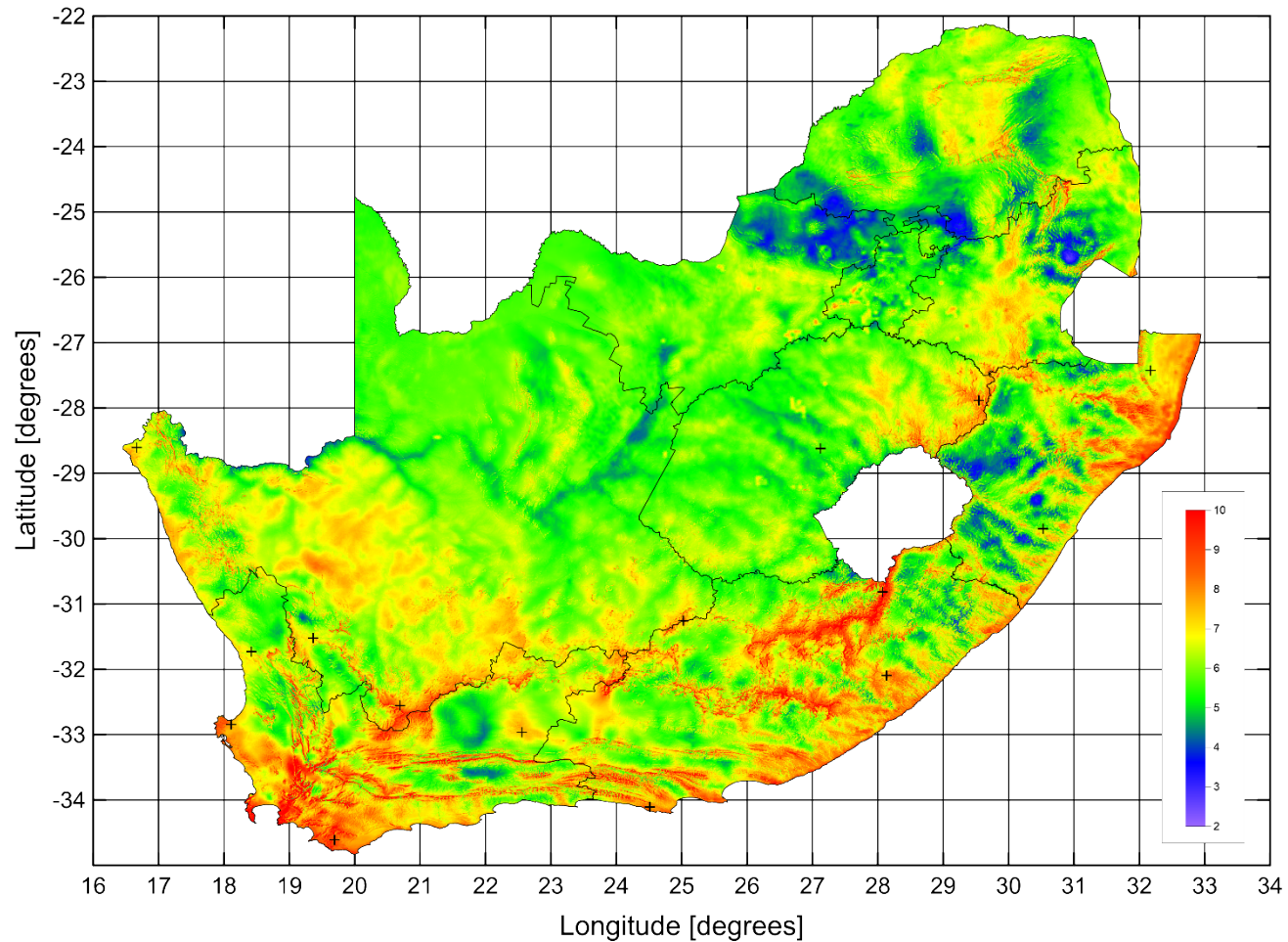
## WRF 5-km simulated winds

WASA2, mean wind speed (m/s)

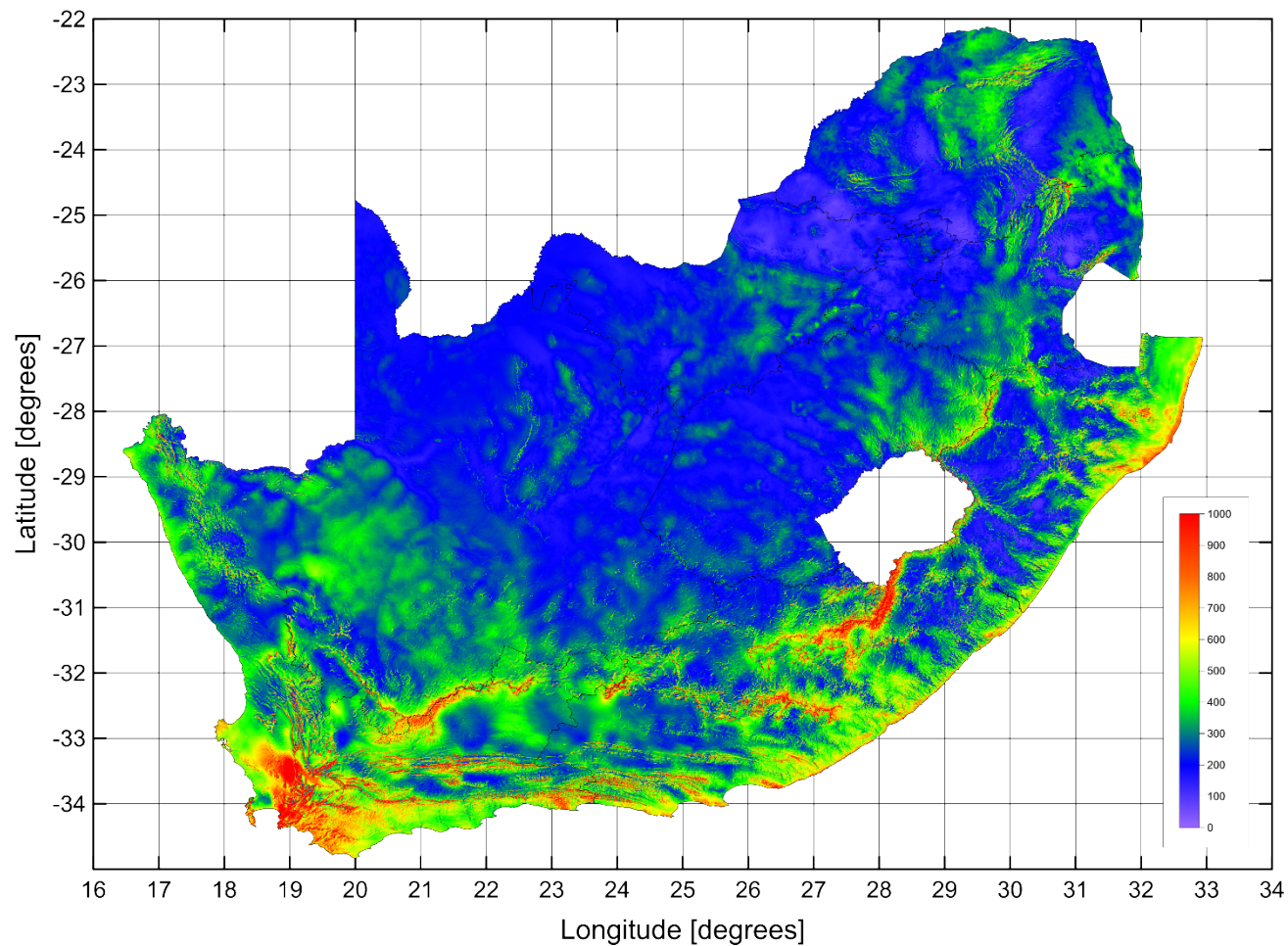
Oct 2005 - Sept 2013



## South Africa wind speed @ 100 m

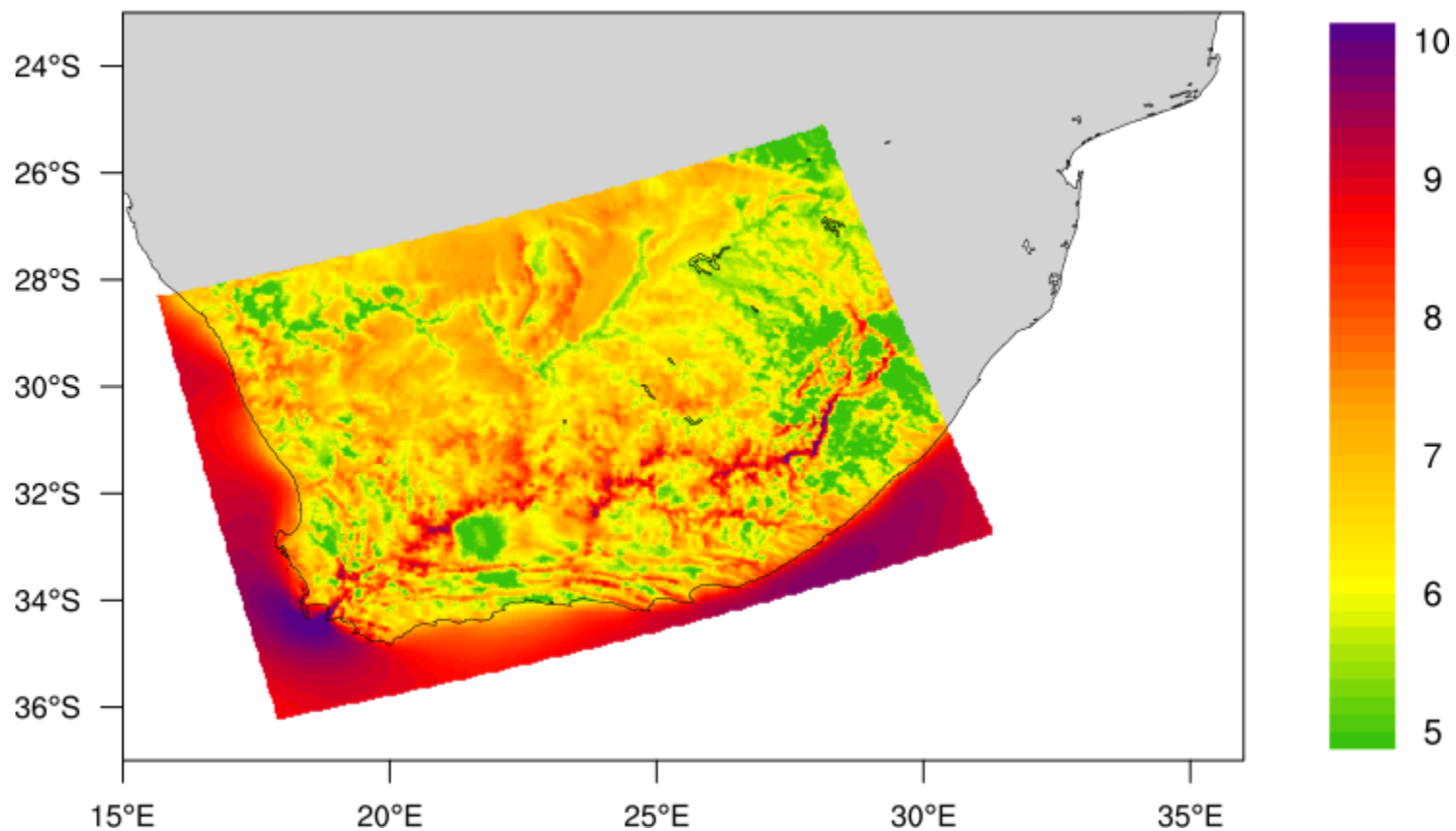


## South Africa power density @ 100 m



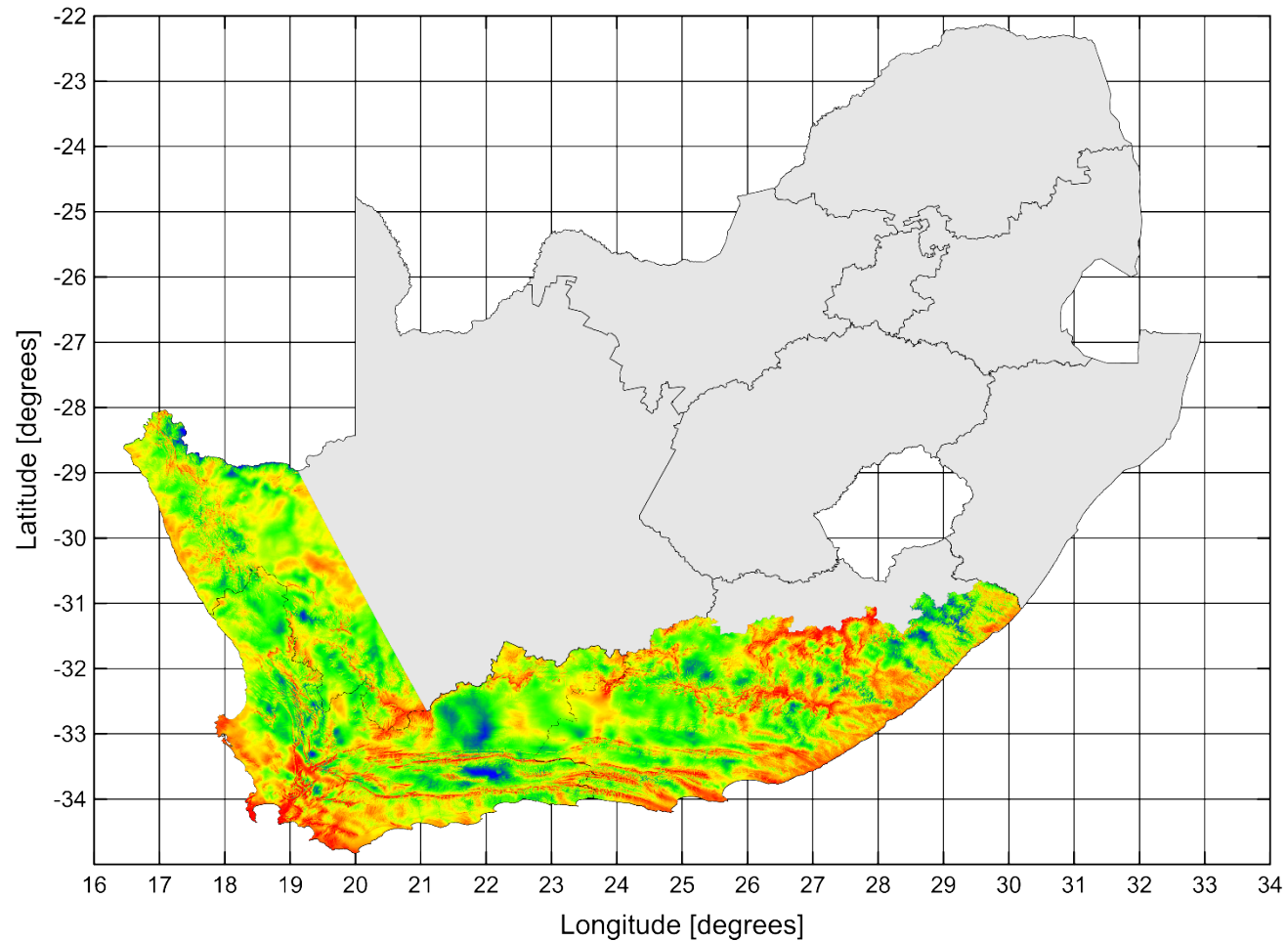
## WRF 3-km simulated winds

WASA1, mean wind speed (m/s) Oct 2005 - Sept 2013

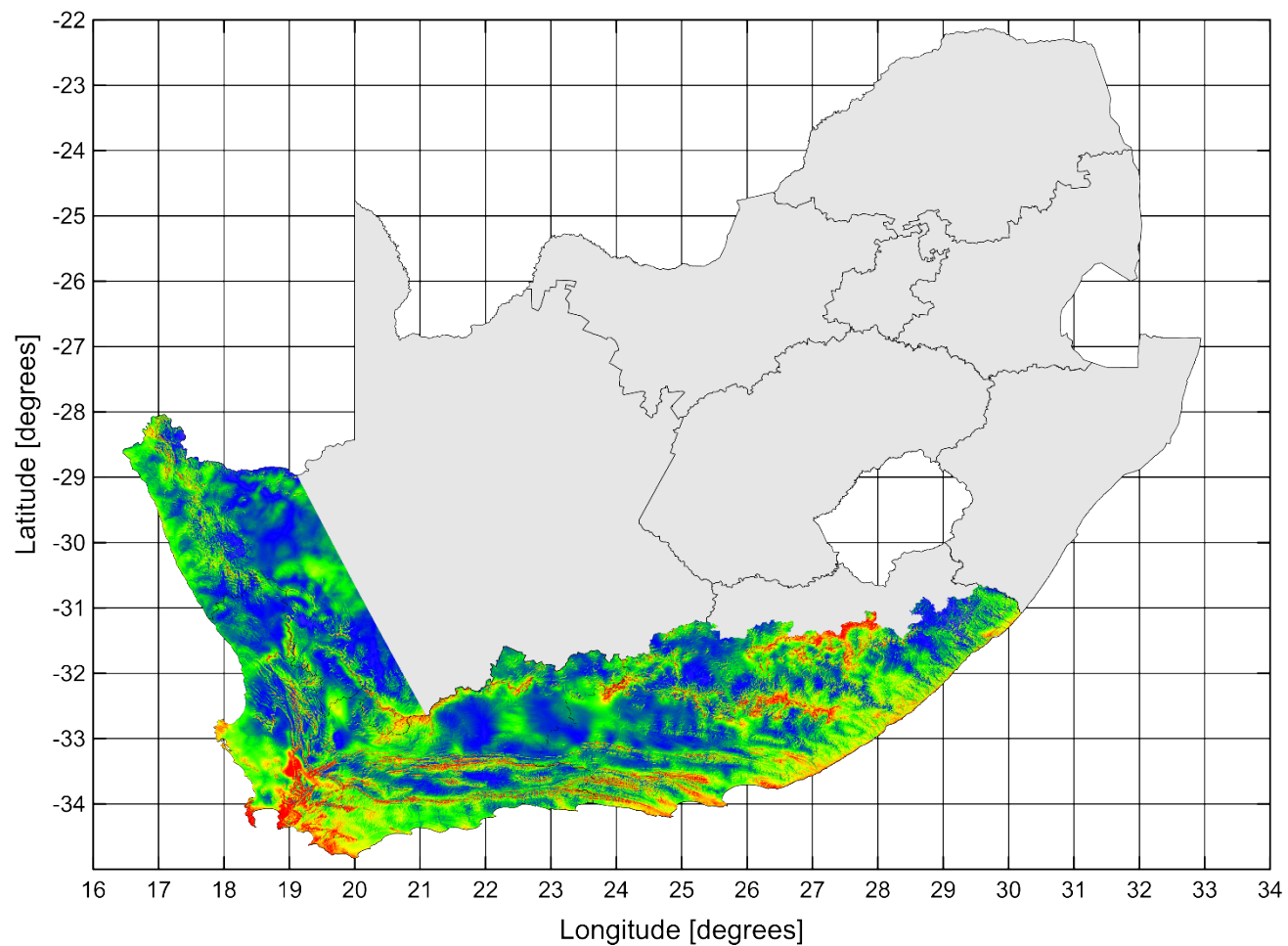




## WASA1 wind speed @ 100 m



## 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 [ $\text{ms}^{-1}$ ]
- Mean power density  $P$ 
  - 10 min average in [ $\text{Wm}^{-2}$ ]
  - 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 ( $\times 12$ )
  - ASCII TXT output format
- For each site, height and sector
  - Weibull  $A$  parameter [ $\text{ms}^{-1}$ ]
  - 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

DTU Wind Energy



**Interim High-Resolution Wind Resource Map for South Africa**  
**Metadata and further information**  
 October 2017

METADATA	
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	Niels G. Mortensen (DTU) or Eugène Mabilie (CSIR)
Contact details	nimo@dtu.dk (DTU) or EMabilie@csir.co.za (CSIR)
Data type	Raster data sets with a grid cell size of 250 m
Data format	ArcGIS ASC
File name(s)	ZA_<province>_<resolution>_<parameter>_<version ID>.asc
Data origin	Microscale modelling in each grid point; no interpolation

DATA PARAMETERS	
Mean wind speed	Annual mean wind speed $U$ [ $\text{ms}^{-1}$ ] @ 50, 100 and 200 m a.g.l.
Mean power density	Annual mean power density $P$ [ $\text{Wm}^{-2}$ ] @ 50, 100 and 200 m a.g.l.
Terrain elevation	Elevation of modelling site in [m] above mean sea level
Ruggedness index RIX	Site RIX value calculated by WAsP (standard parameter setup)

COORDINATE SYSTEM	
Projection	Universal Transverse Mercator (UTM)
Zone number	34S (two provinces) and 35S (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-MYN-NOAH-10D)*
Elevation data input	100-m elevation grid derived from SRTM+ (NASA version 3)
Roughness data input	300-m land cover grid derived from GlobCover 2009 (version 2.3)
Air density input	Standard atmosphere approximation w/ elevation variations only

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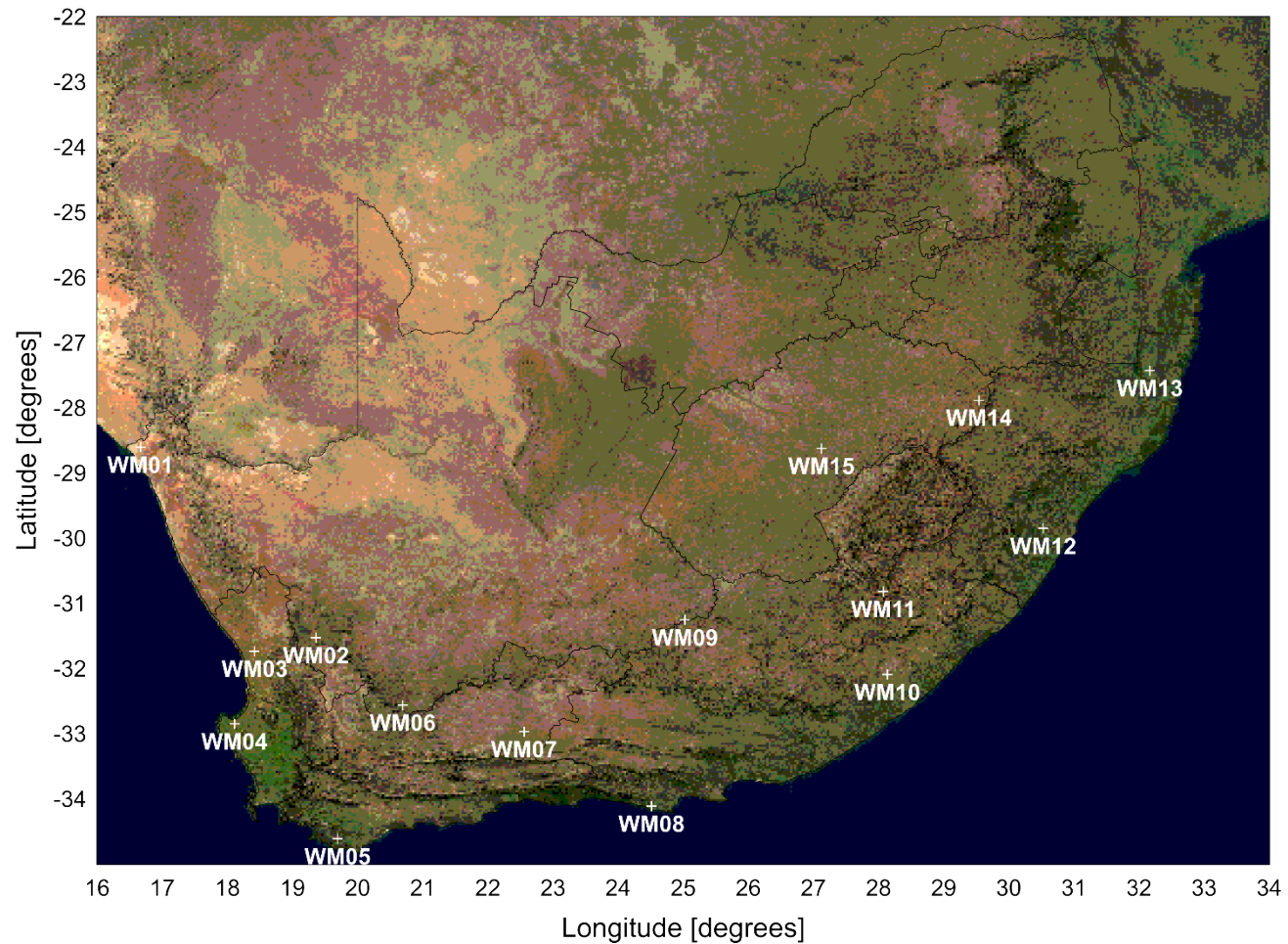
## Metadata documents for wind resource data sets

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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.*

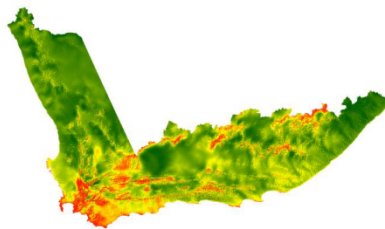
## Validation at WASA 1 and 2 masts



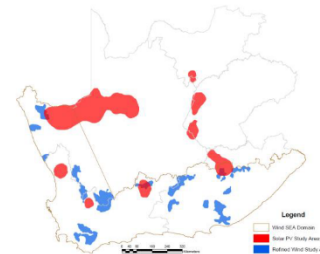
# DEA National Wind and Solar PV SEAs (Phase 1)

## SEA Data available for download & public comments

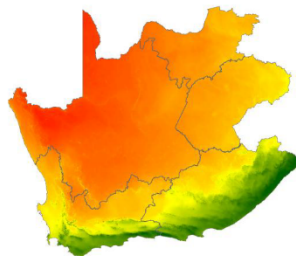
<http://www.csir.co.za/nationalwindsolaresea/>  
<http://egis.environment.gov.za/frontpage.aspx?m=27>



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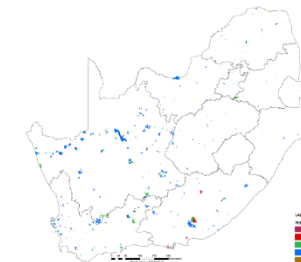


→ [Wind and Solar PV SEA Phase I Study Areas Download](#)



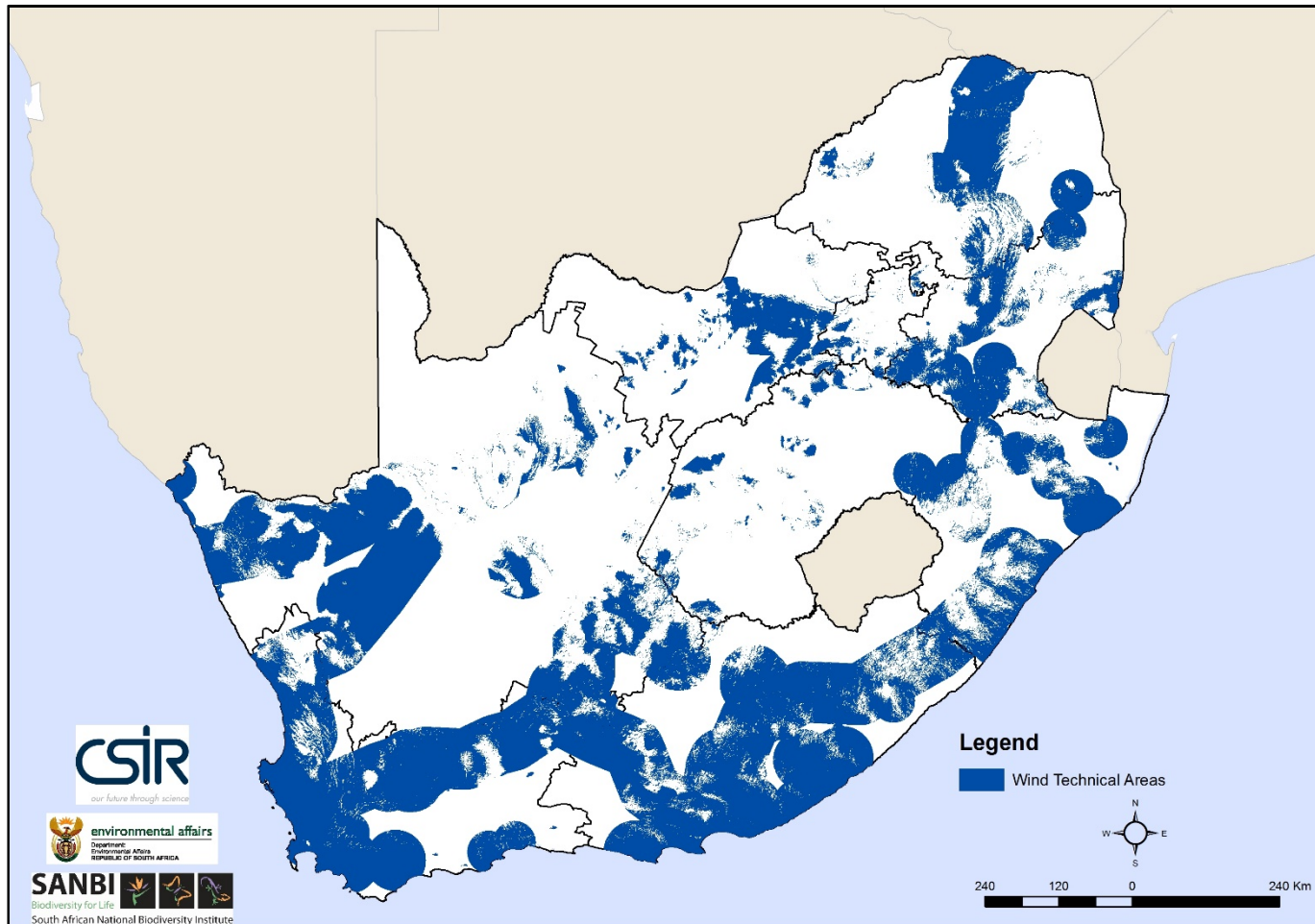
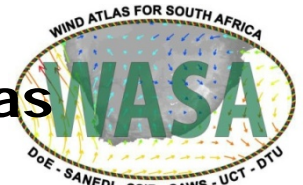
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[Global Horizontal Irradiance](#)  
 Global Horizontal Irradiance (GHI): kWh/m<sup>2</sup>/annum  
[Photovoltaic Yield Static](#)  
 Photovoltaic Yield on fixed tilt plane (kWh(electrical)/kWpeak(installed)/a).  
[PV Yield tracking](#)  
 Photovoltaic Yield with single axis tracking (kWh(electrical)/ kWpeak(installed)/a).  
[Optimal Inclination](#)  
 Optimal inclination for solar panels



→ [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<sup>2</sup>
  - 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

- GEF through South African Wind Energy Programme
- Danish Support to RE Development in the RSA

WASA Project Steering Committee:

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



**energy**

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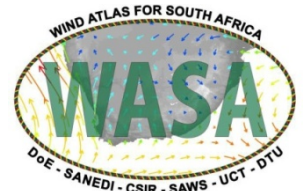


**sanedi**

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*Empowered lives.  
Resilient nations.*



## Further information

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SANEDI WASA site

[www.wasaproject.info](http://www.wasaproject.info)

CSIR Online

[www.wasa.csisr.co.za](http://www.wasa.csisr.co.za)

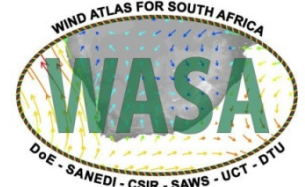
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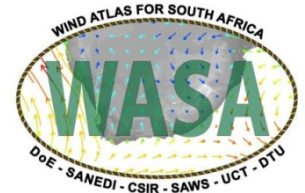
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