New high-res resource map for the WASA domain and improved data for wind farm planning and development

Mortensen, Niels Gylling; Hansen, Jens Carsten; Kelly, Mark C.; Mabille, Eugéne; Prinsloo, Eric; Szewczuk, Steve; Spamer, Yvette

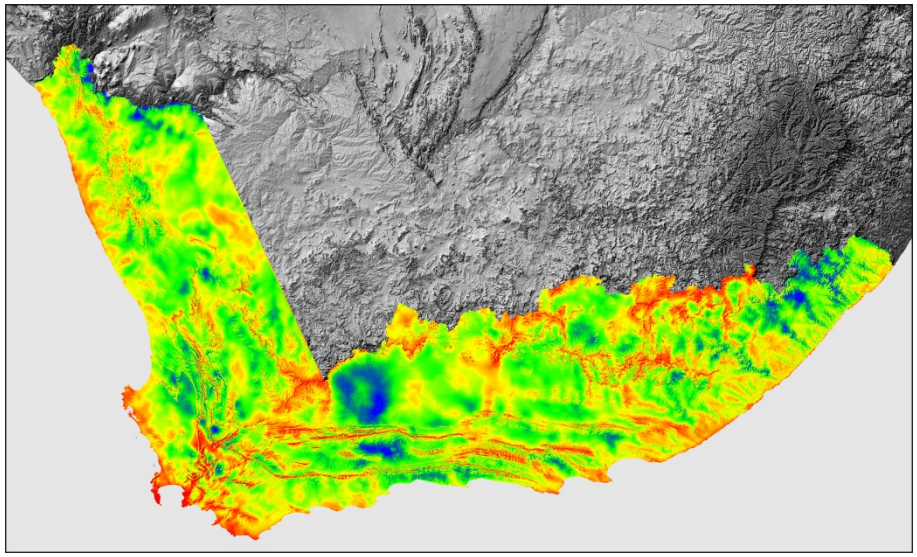
Publication date:
2014

Microscale Modelling and Applications

New high-res resource map for the WASA domain and improved data for wind farm planning and development

Niels G. Mortensen, Jens Carsten Hansen and Mark C. Kelly
DTU Wind Energy

Eugéne Mabille, Eric Prinsloo, Steve Szewczuk and Yvette Spamer
CSIR Built Environment



WASA Final Wind Seminar
Cape Town, South Africa

Microscale Modelling and Applications

- Microscale modelling (here WAsP)
  - Verification of measurements
  - Verification of microscale modelling
  - Verification of mesoscale modelling
- High-resolution resource maps for the WASA domain
  - WAsP Resource Mapping System
  - 2013-edition based on KAMM/WAsP
  - 2014-edition based on WRF/WAsP
  - Changes from 2013 to 2014
- Summary and conclusions
- Improved data for wind farm planning and development
  - 3-km generalised wind climates (WRF, 2014)
  - Case study examples

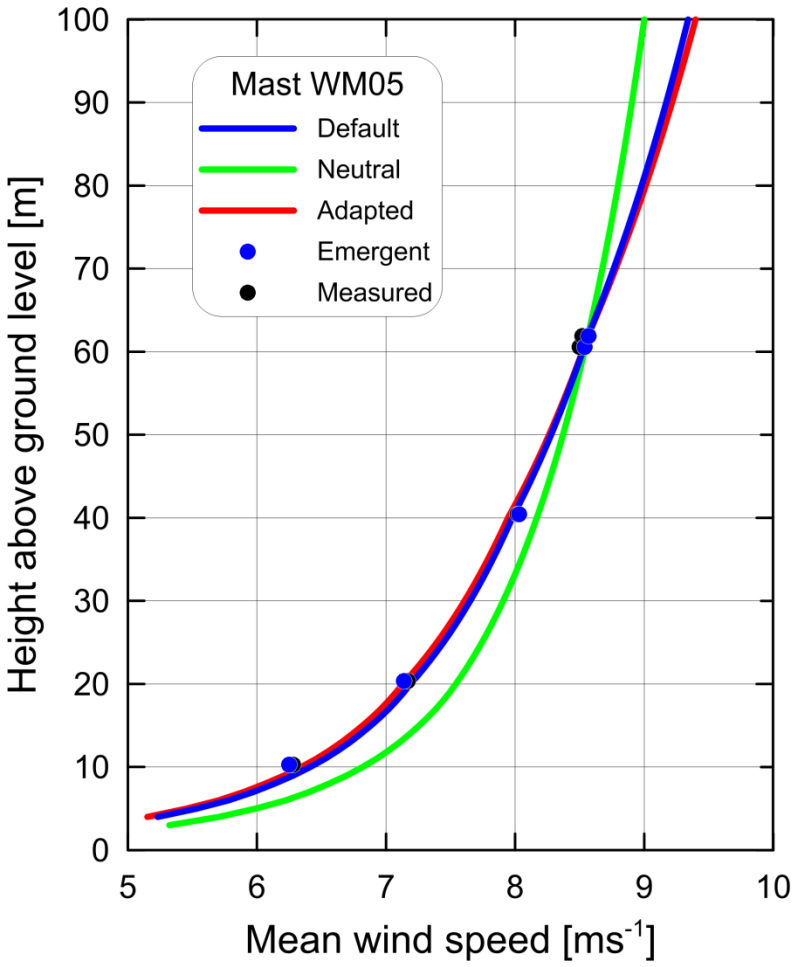
Microscale modelling using WAsP

Wind-climatological inputs
- Three-years-worth of wind data
- Ten 62-m masts in domain
- Five levels of anemometry

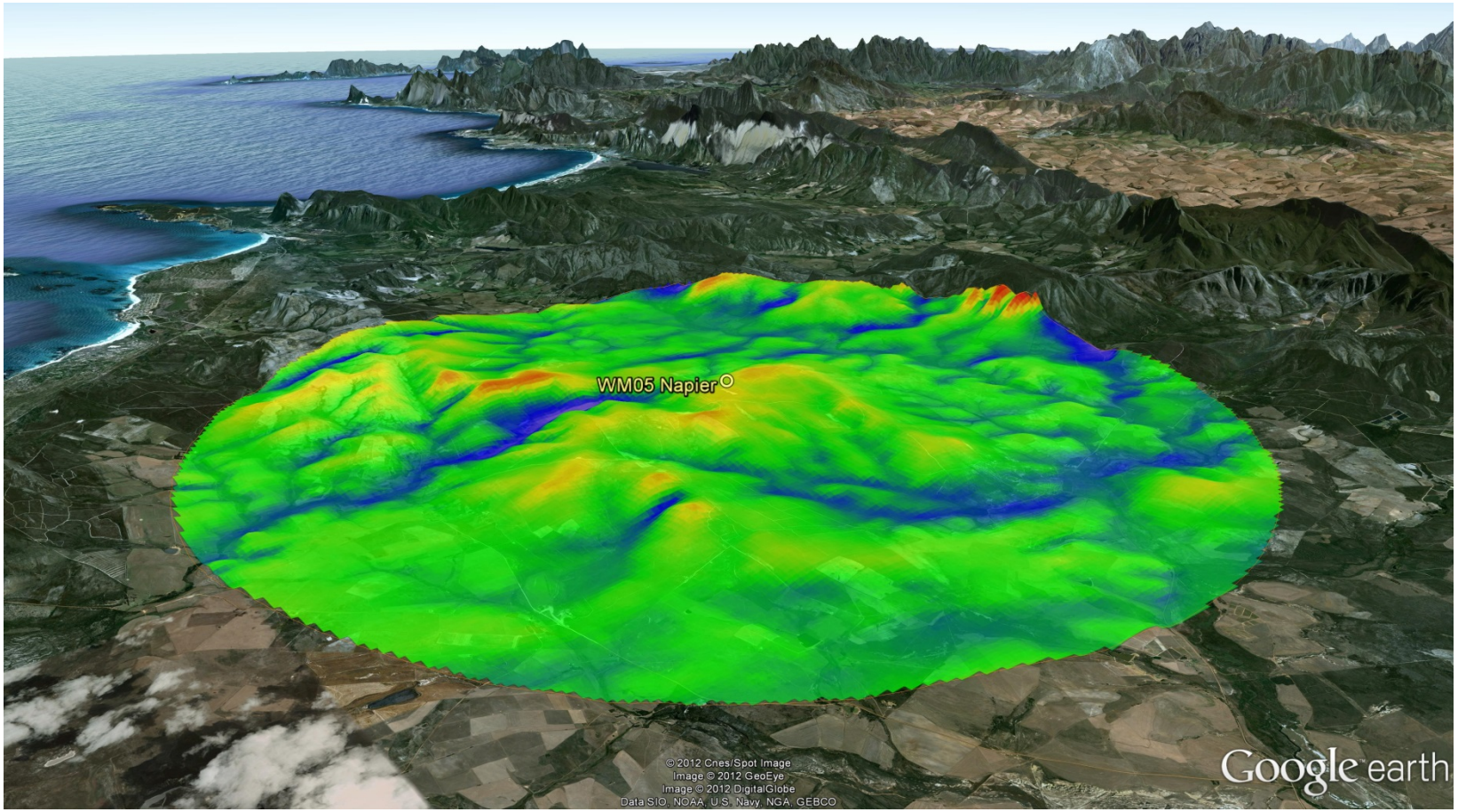
Topographical inputs
- Elevation maps (SRTM 3)
- Different roughness maps

Results and data
- Wind measurements verification
- Microscale modelling verification
- WAsP workspaces and projects

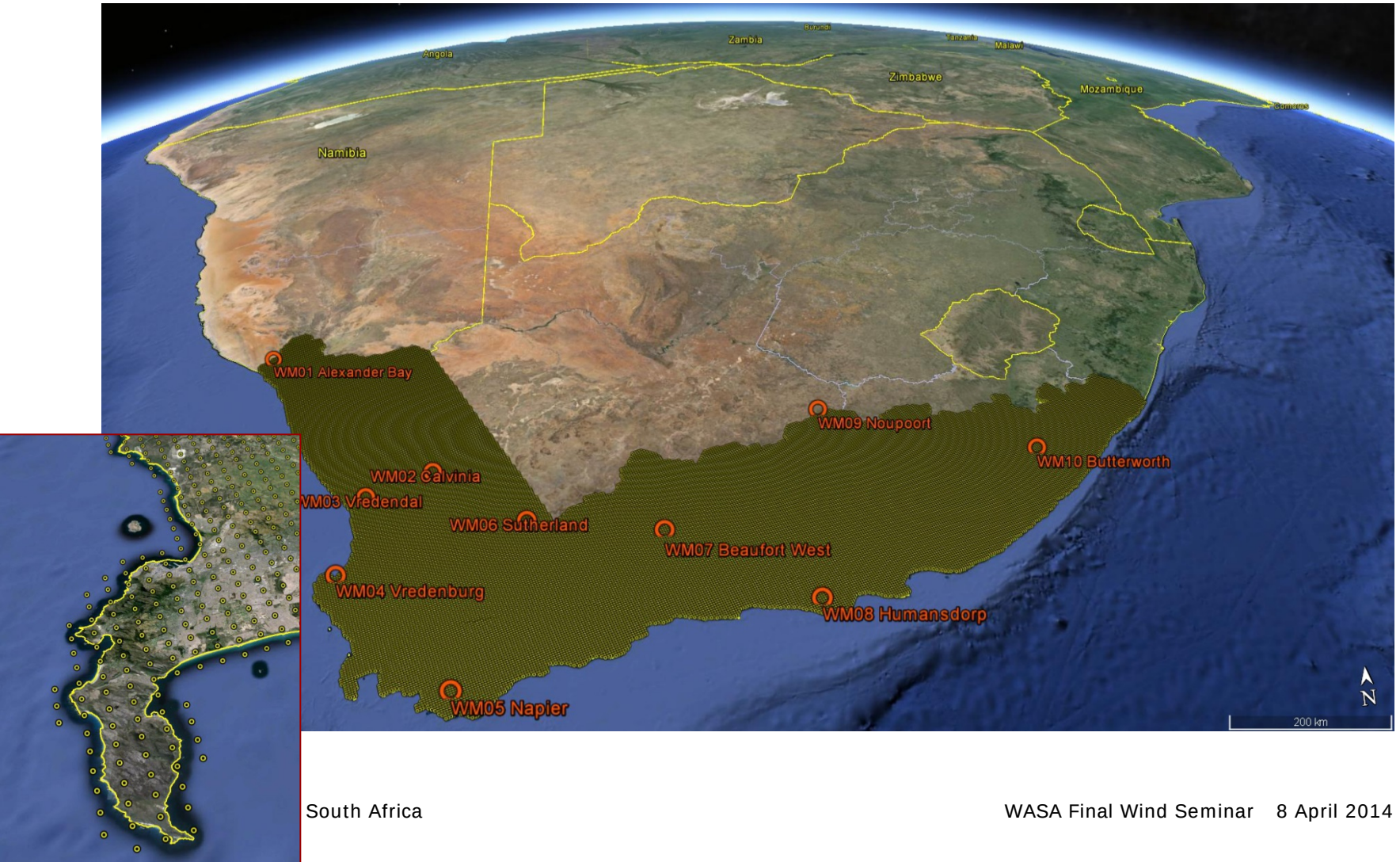
Documentation reports
- Site and Station Inspection
- Observational Wind Atlas



Microscale modelling based on one met. mast

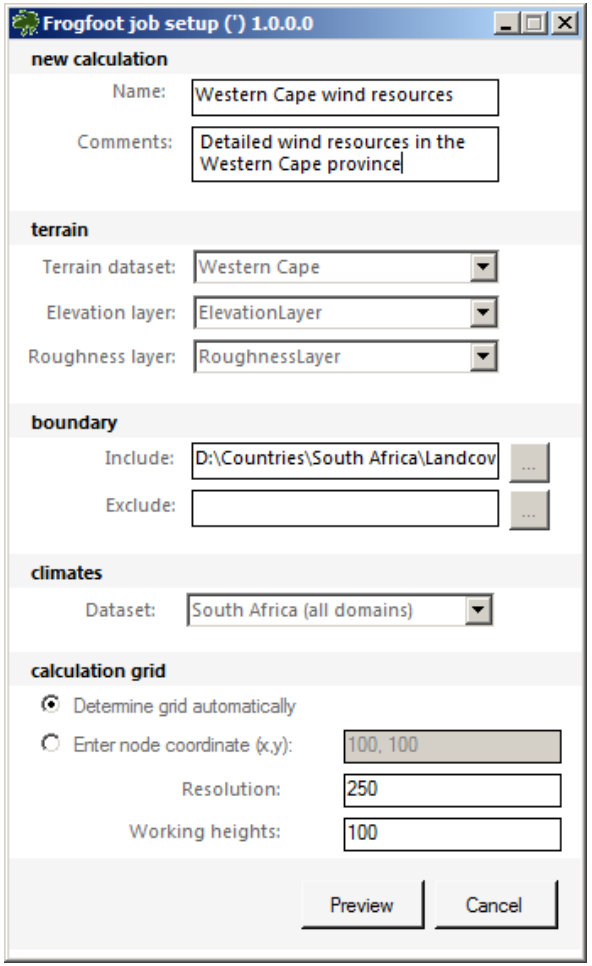


Numerical Wind Atlas 2014 – many virtual masts



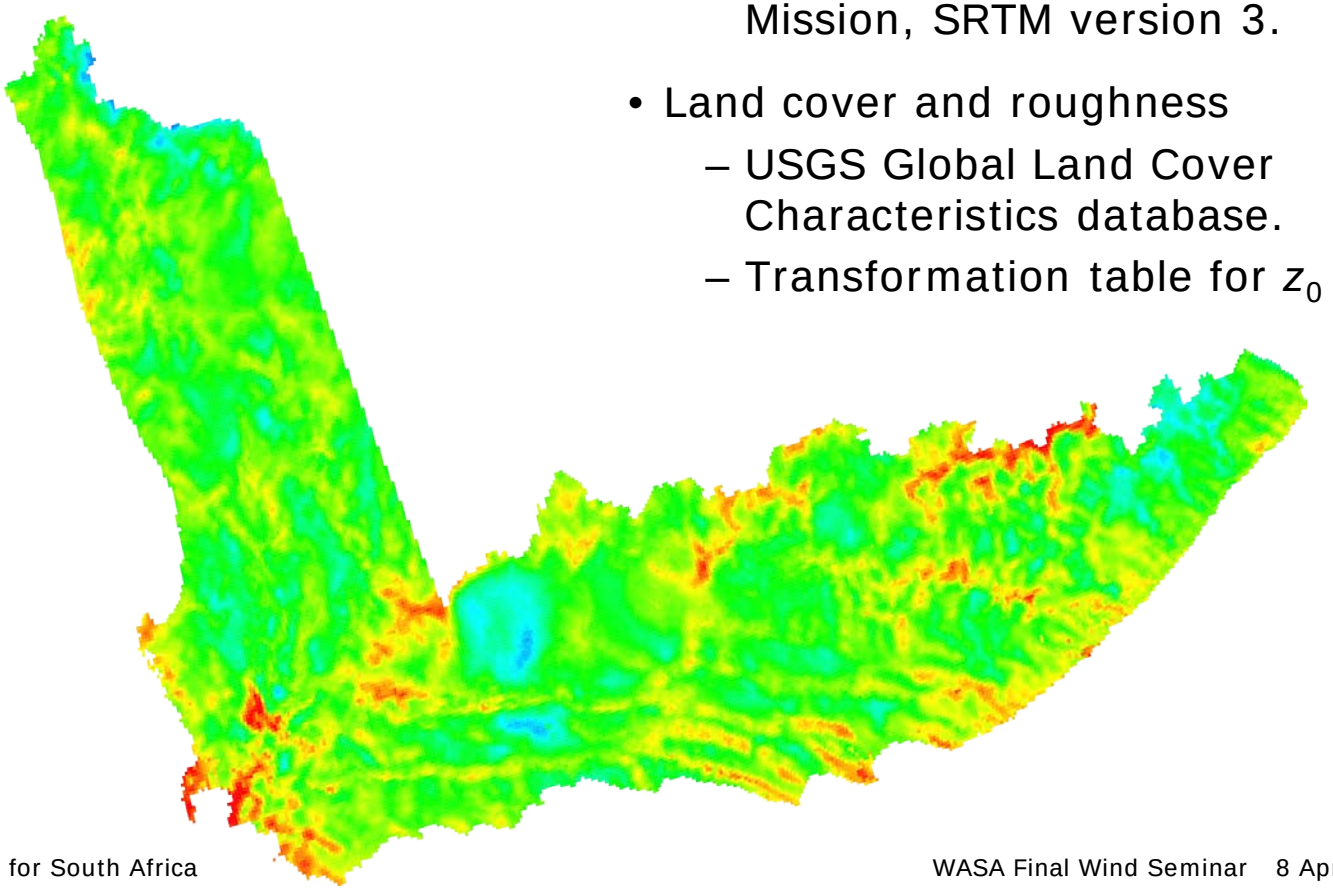
WAsP Resource Mapping System

- New 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.
  - Export to GIS formats
- WAsP standard modelling
  - Industry-standard model
  - Linearized flow model
  - Default parameters
  - Standard atmosphere (ρ)

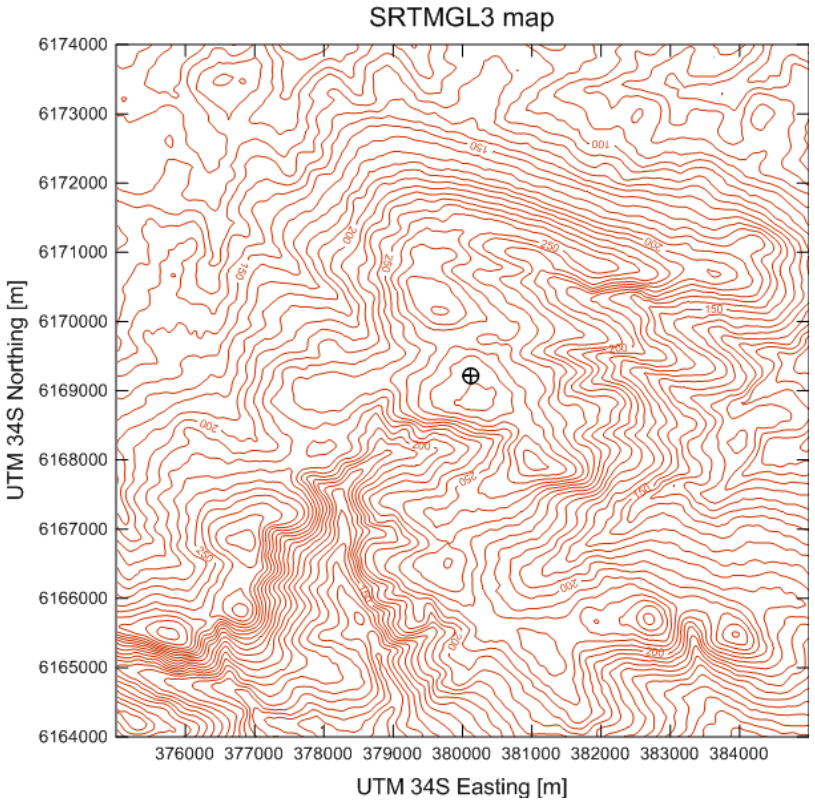


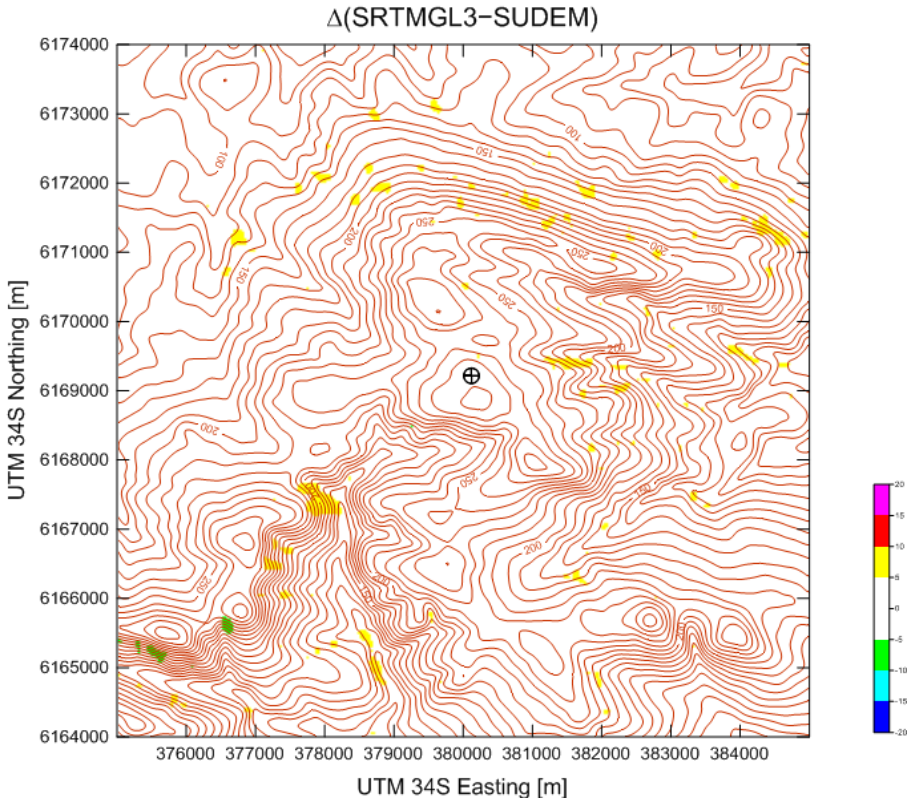
Available input data for detailed resource mapping

- Verified Numerical Wind Atlas
  - WRF mesoscale model, 3 km
- Elevation
  - 100-m elevation grids from Space Shuttle Topography Mission, SRTM version 3.
- Land cover and roughness
  - USGS Global Land Cover Characteristics database.
  - Transformation table for z_0

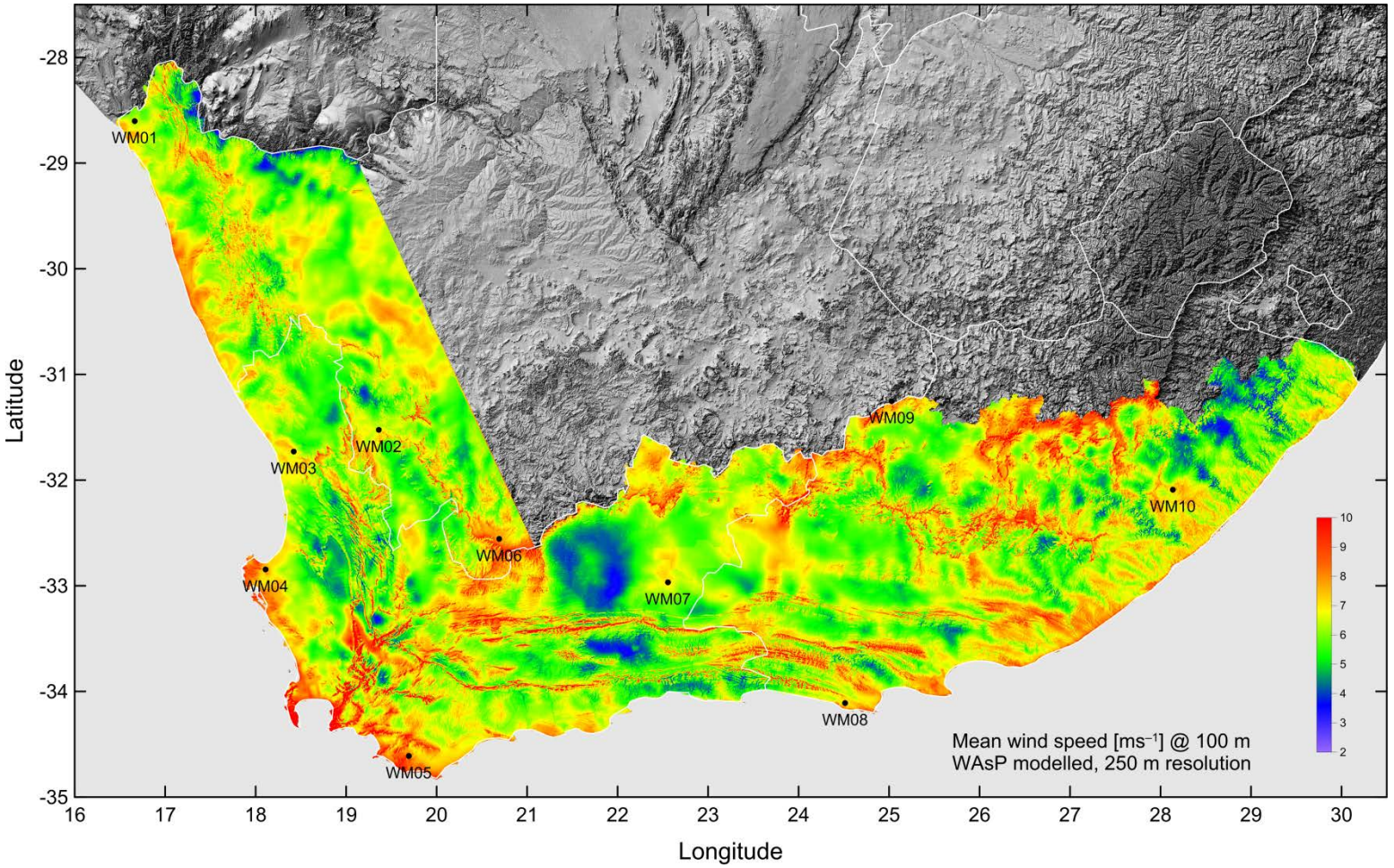


Elevation input – SRTM 3.0 versus SUDEM

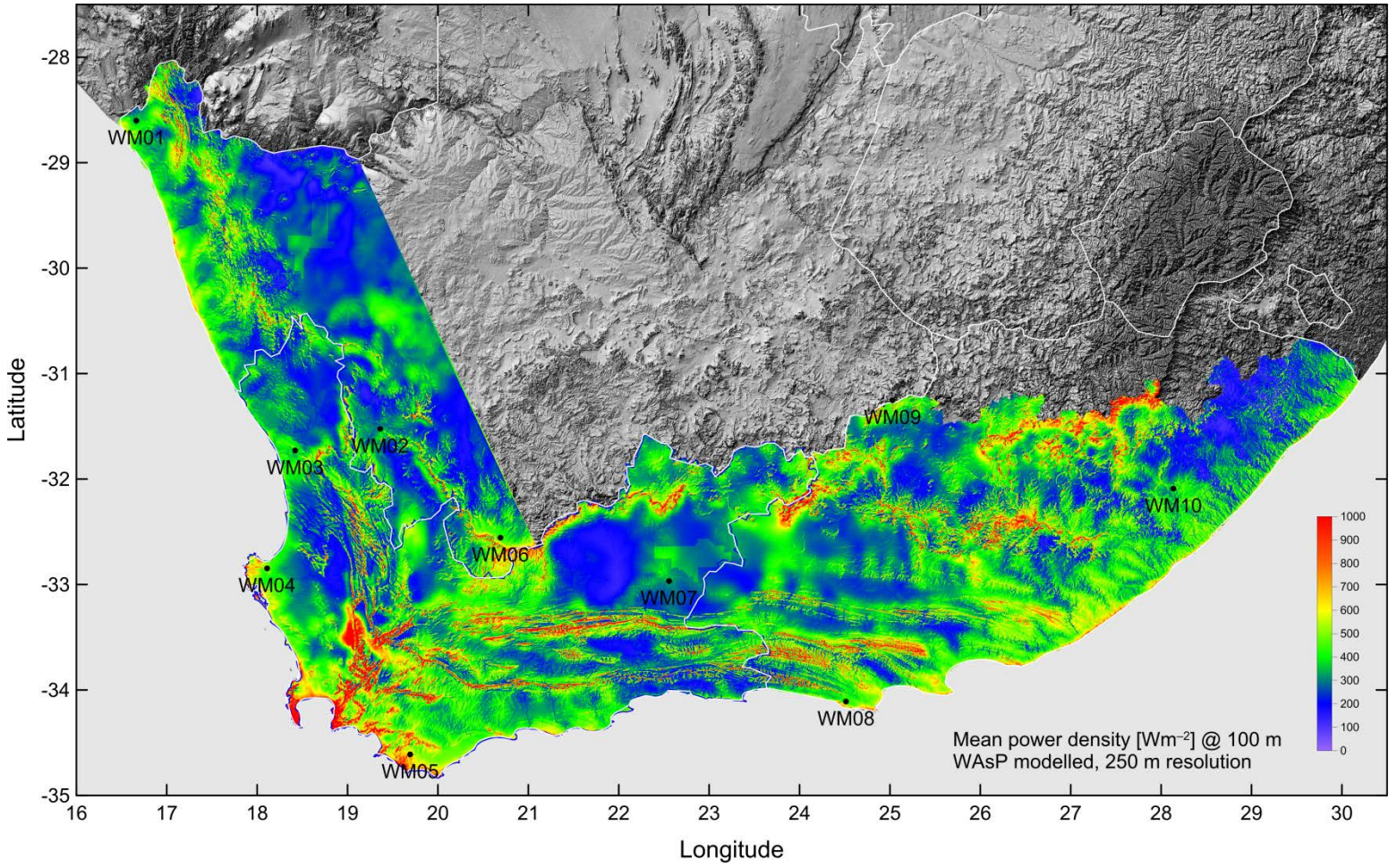




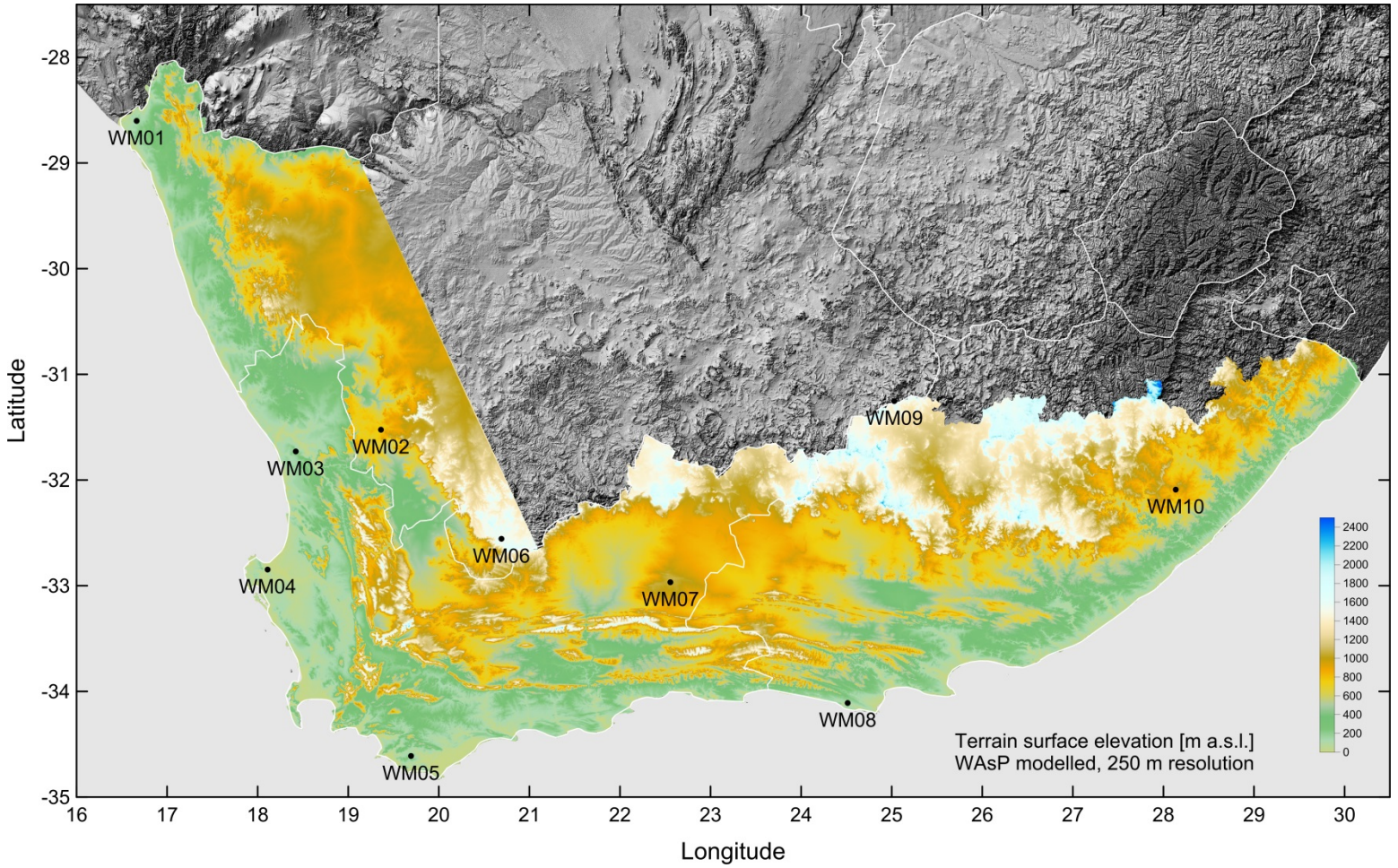
WASA wind resource @ 100 m – wind speed



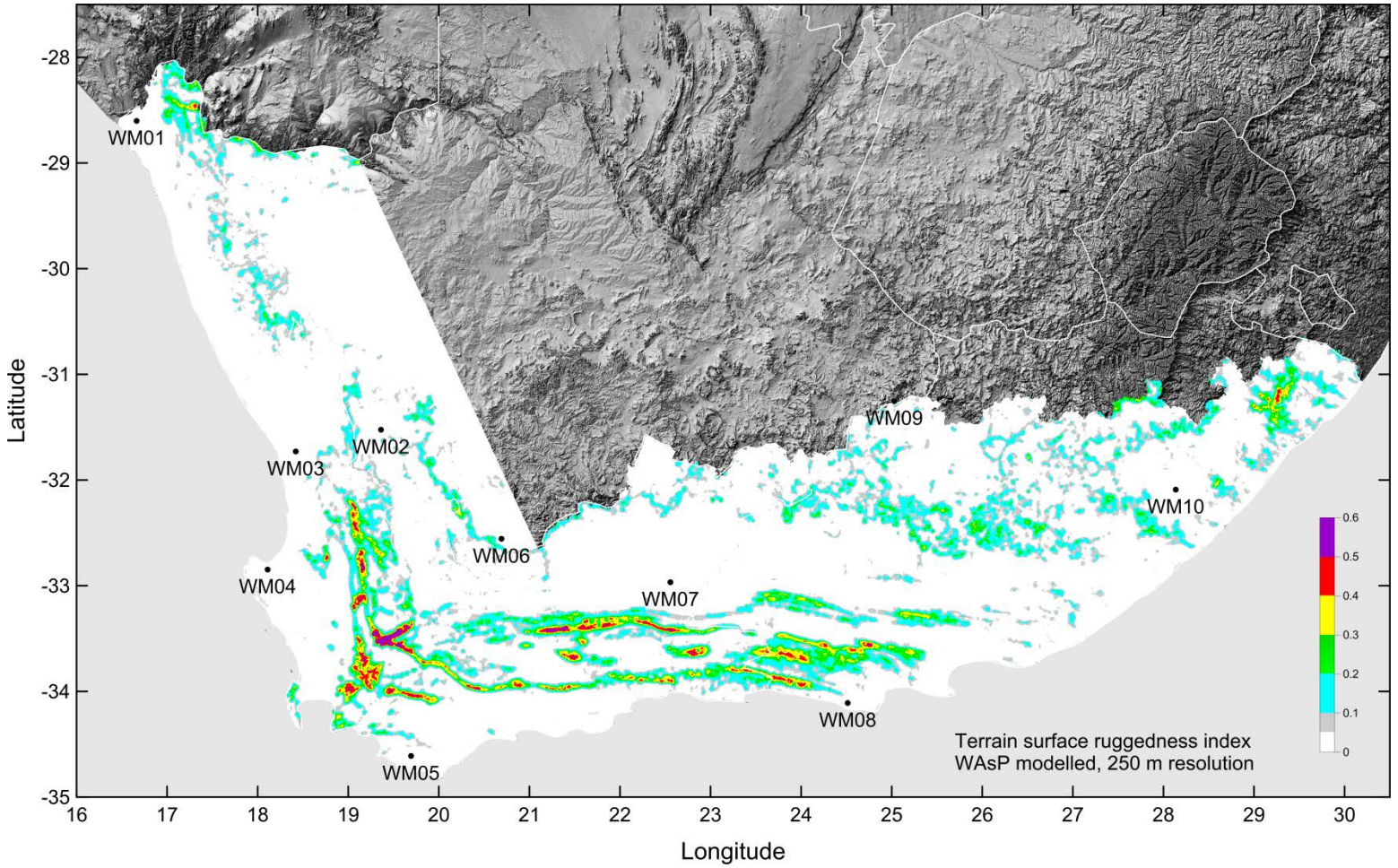
WASA wind resource @ 100 m – power density



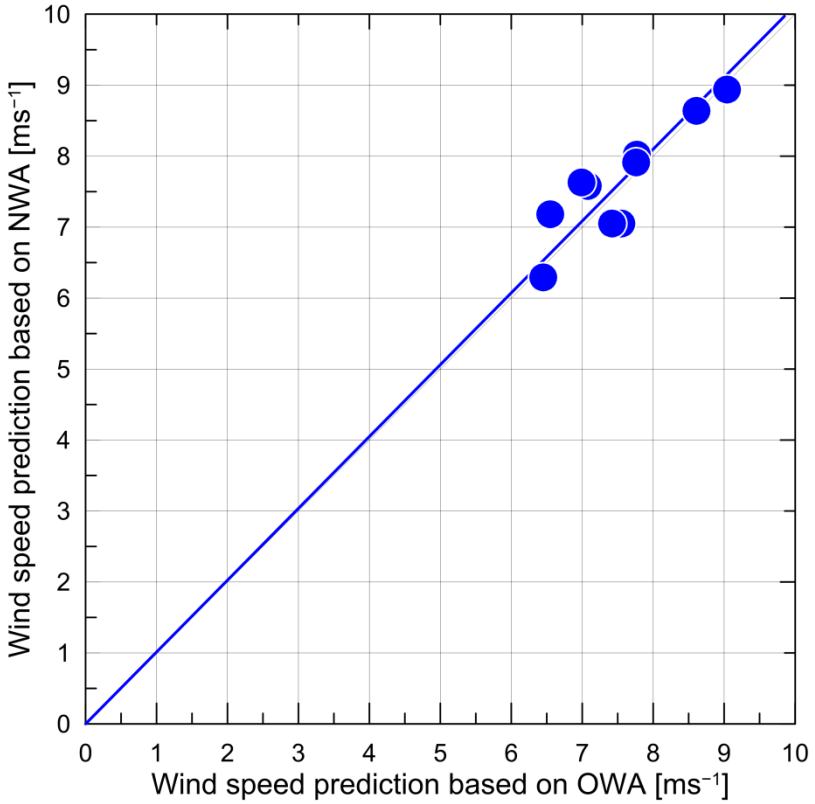
WASA domain terrain elevation

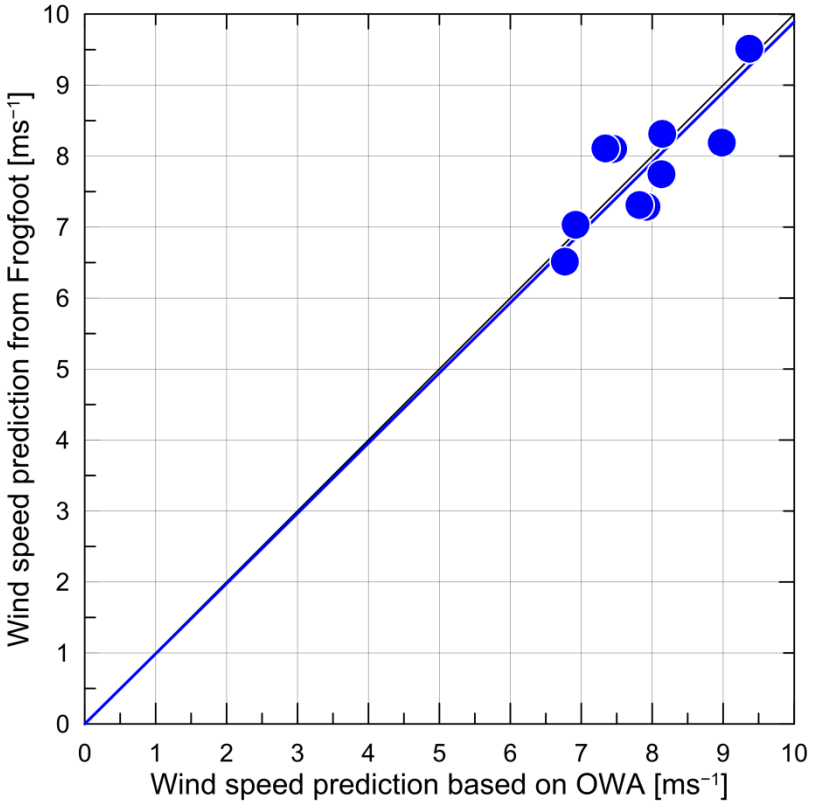


WASA domain terrain ruggedness index



Verification using measurements @ 10 masts

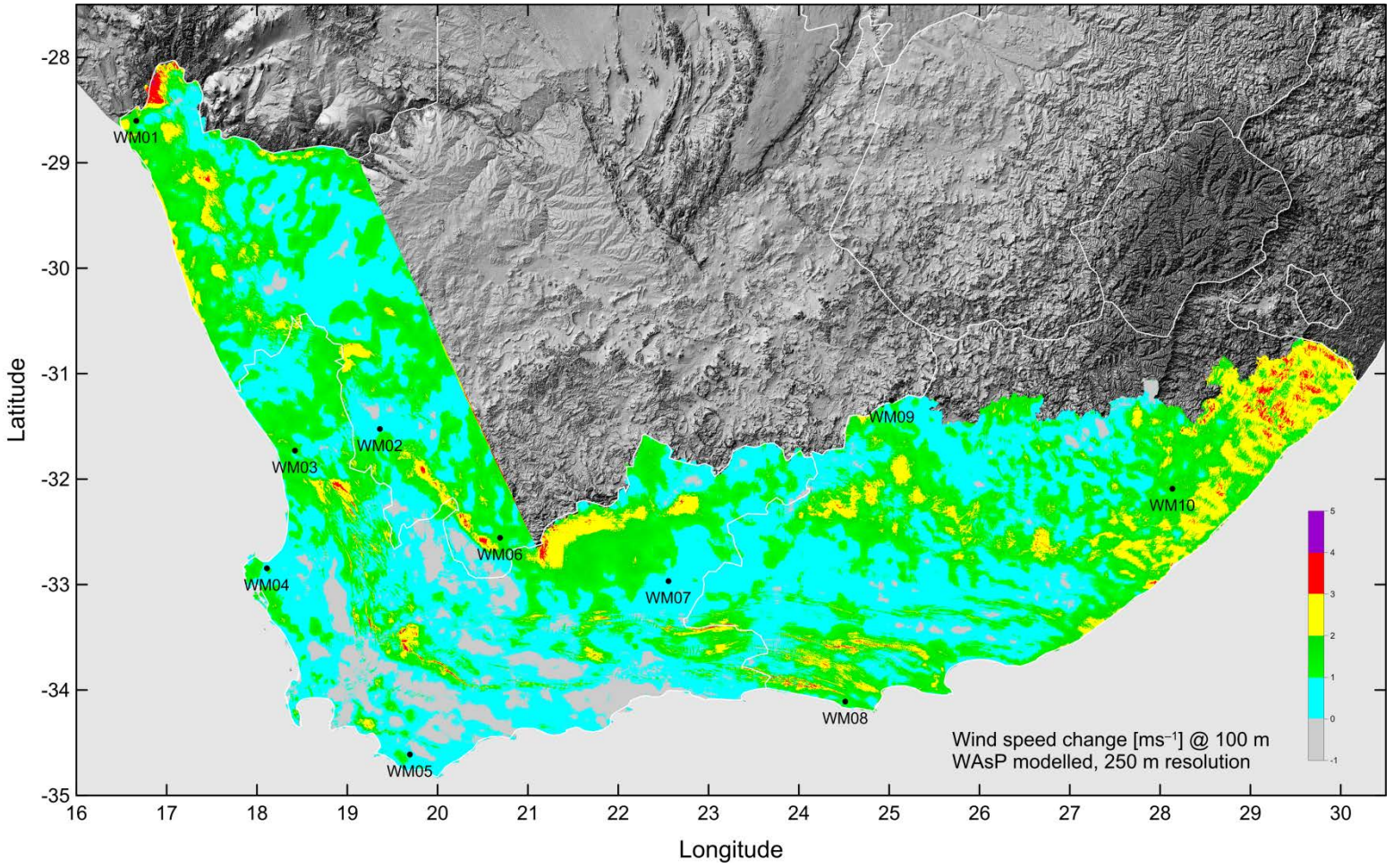




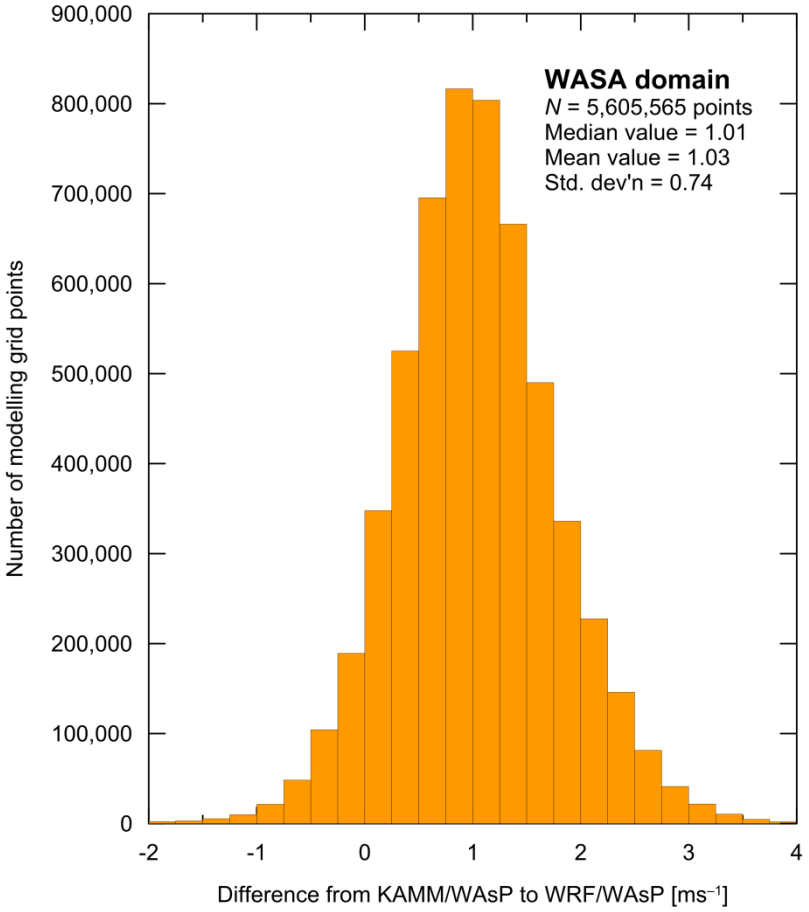
- WRF Verified Numerical Wind Atlas compared to observed winds (3y).
- *Testing wind-climatological inputs*

- WAsP Resource Mapping System compared to observed winds (3y).
- *Testing wind & topographical inputs*

Difference between 1st and 2nd edition maps



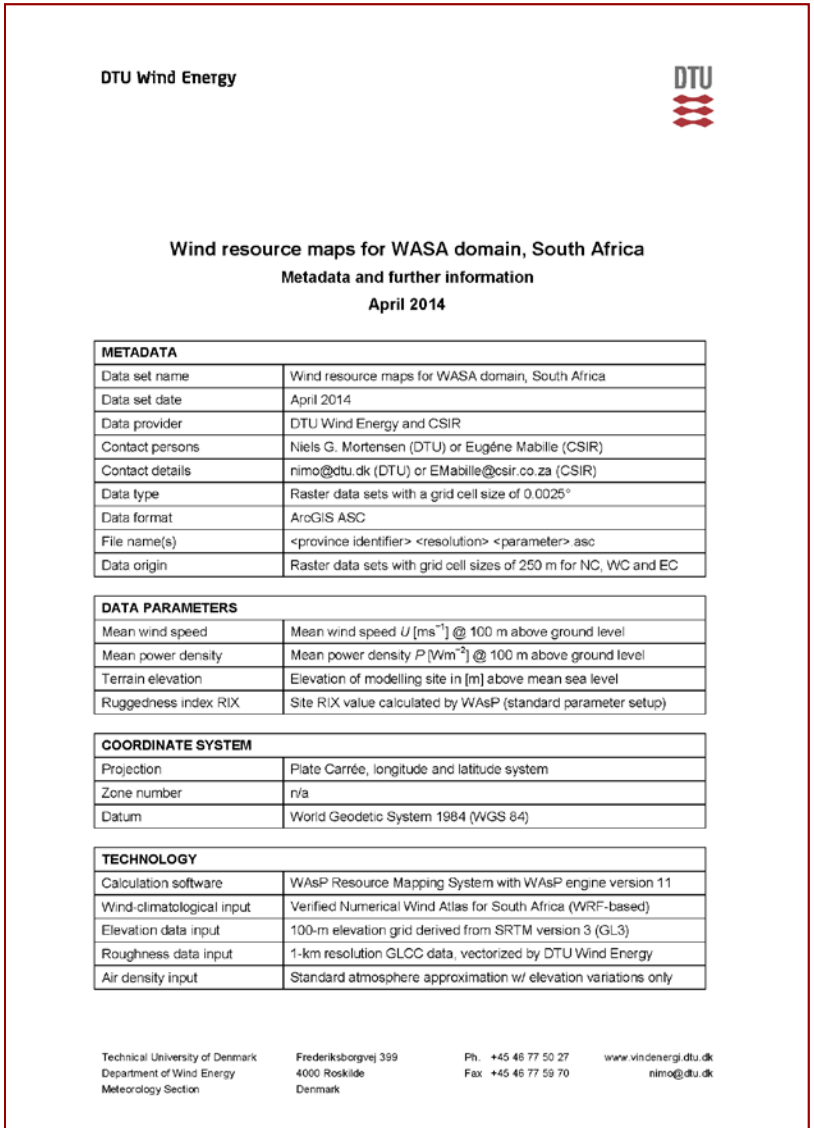
Difference between first and second edition map



- Differences from 1st to 2nd edition
  - WASA domain +1.0 ms^{-1}
  - Northern Cape +1.1 ms^{-1}
  - Western Cape +0.8 ms^{-1}
  - Eastern Cape +1.2 ms^{-1}
- Differences are largest in some
  - Coastal regions
  - Escarpments
  - Ridges and hills
  - Mountain areas
- Differences are large too in
  - Low-wind regions
  - NE Eastern Cape

High-resolution wind resource map availability

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



DTU Wind Energy

DTU

Wind resource maps for WASA domain, South Africa

Metadata and further information

April 2014

METADATA	
Data set name	Wind resource maps for WASA domain, South Africa
Data set date	April 2014
Data provider	DTU Wind Energy and CSIR
Contact persons	Niels G. Mortensen (DTU) or Eugéne Mabille (CSIR)
Contact details	nimo@dtu.dk (DTU) or EMabille@csir.co.za (CSIR)
Data type	Raster data sets with a grid cell size of 0.0025°
Data format	ArcGIS ASC
File name(s)	<province identifier> <resolution> <parameter>.asc
Data origin	Raster data sets with grid cell sizes of 250 m for NC, WC and EC

DATA PARAMETERS	
Mean wind speed	Mean wind speed U [ms^{-1}] @ 100 m above ground level
Mean power density	Mean power density P [Wm^{-2}] @ 100 m above ground level
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	Plate Carrée, longitude and latitude system
Zone number	n/a
Datum	World Geodetic System 1984 (WGS 84)

TECHNOLOGY	
Calculation software	WAsP Resource Mapping System with WAsP engine version 11
Wind-climatological input	Verified Numerical Wind Atlas for South Africa (WRF-based)
Elevation data input	100-m elevation grid derived from SRTM version 3 (GL3)
Roughness data input	1-km resolution GLCC data, vectorized by DTU Wind Energy
Air density input	Standard atmosphere approximation w/ elevation variations only

Technical University of Denmark
Department of Wind Energy
Meteorology Section

Frederiksborgvej 399
4000 Roskilde
Denmark

Ph. +45 46 77 50 27
Fax +45 46 77 59 70

www.vindenergi.dtu.dk
nimo@dtu.dk

Summary and conclusions – detailed resource map

- Wind resources in WASA domain have been mapped (again)
  - Large-scale: ~346,500 km^2 (5,605,565 sites)
  - High-resolution: 250-m between model sites
  - Results in public domain: wasadata.csir.co.za/wasa1
- Data sets specifically developed for
  - Planning and Strategic Environmental Assessment
  - Wind farm planning and development
- Comprehensive verification and quality assurance
  - Software development phase
  - Manual checks in several areas
- Wind resources estimated quite well now
  - VNWA on average 2% too high
  - Detailed wind resource map on average 1% too low

Wind farm planning and development

- 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.