WASA international collaboration as an example of reciprocal skills transfer through wind energy development in South Africa

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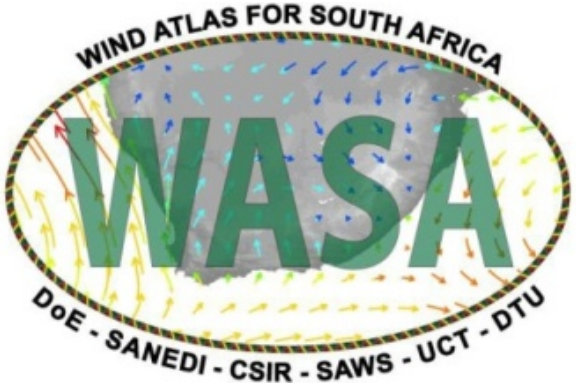

WASA international collaboration as an example of reciprocal skills transfer through wind energy development in South Africa

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Windaba 2015
Cape Town, South Africa

Outline

- Introduction to WASA (overview and methodology)
- WASA Application
- WASA Skills development
- The Three Firsts
- Verification and uncertainties of Phase 1
- Continued R&D
- WASA Phase 2
- Concluding remarks

Wind Atlas for South Africa (WASA)

The Wind Atlas for South Africa is a **Capacity Development and Research Cooperation** Initiative of the South African Department of Energy (DoE)

WASA is implemented by SANEDI.

Phase 1 (2009 – 2014) covers **Western Cape and parts of Northern and Eastern Cape provinces** and were funded by the Global Environment Facility (GEF) R8 million with UNDP support through the South African Wind Energy Programme (SAWEP) and co-funded by Danida (DKK9.9 million).

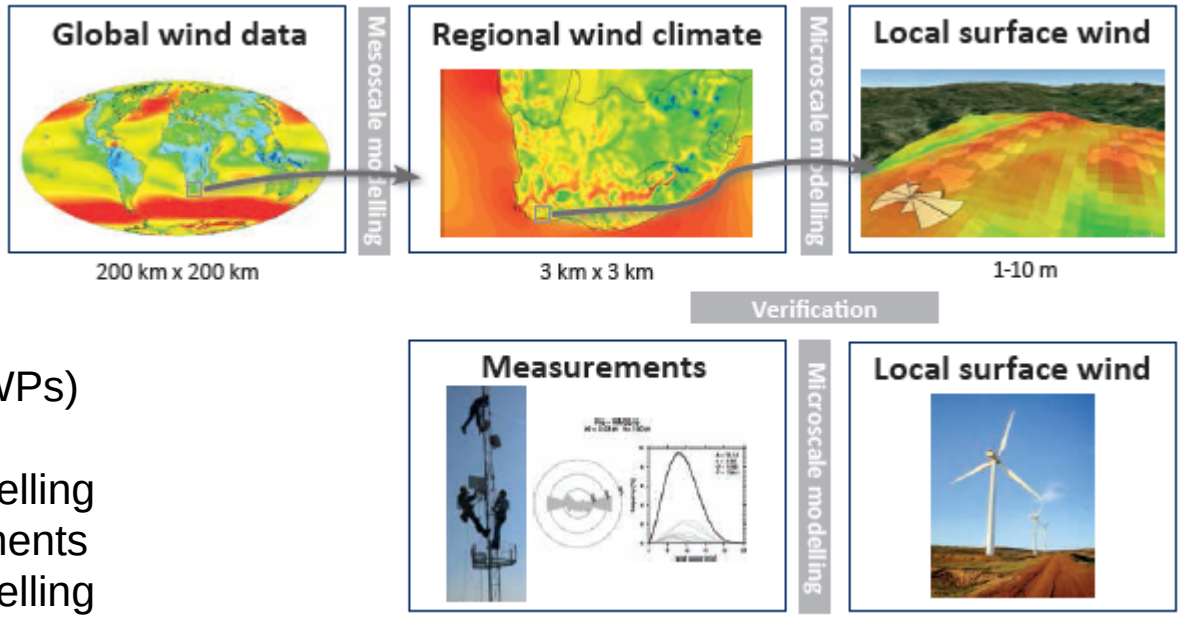
Phase 2 (2014 to 2018) covers the **remaining areas of Eastern Cape, KZN and Free State provinces** and is funded by the Government of Denmark (DKK 12 million)

SAWEP Phase 2 to cover **remaining areas of the Northern Cape province**

Partners:

- **UCT CSAG** *(Climate System Analysis Group, University of Cape Town)*
  - mesoscale modelling
- **CSIR** *(Built Environment, Council for Scientific and Industrial Research)*
  - Measurements, microscale modelling, application
- **SAWS** *(South African Weather Service)*
  - extreme wind assessment
- **DTU Wind Energy** *(Dept of Wind Energy, Technical University of Denmark)*
  - partner in all activities

WASA Methodology



Six work packages (WPs)

WP1 Mesoscale Modelling
WP2 Wind Measurements
WP3 Microscale Modelling
WP4 Application
WP5 Extreme Wind Atlas
WP6 Documentation & Dissemination, see:
http://www.wasaproject.info

WASA Application

- **Estimation of Annual Energy Production AEP (WASA Guides). Saves time and costs as the bankability of a potential wind farm site can now be estimated** and physical wind measurements are only undertaken for bankable wind sites.

- **Estimating of the real wind resource potential.**

- **The high-resolution wind resource map depicts the local wind climate that a wind turbine would encounter**. It also offers important benefits for developers, policy makers, utilities and the industry, including the following:

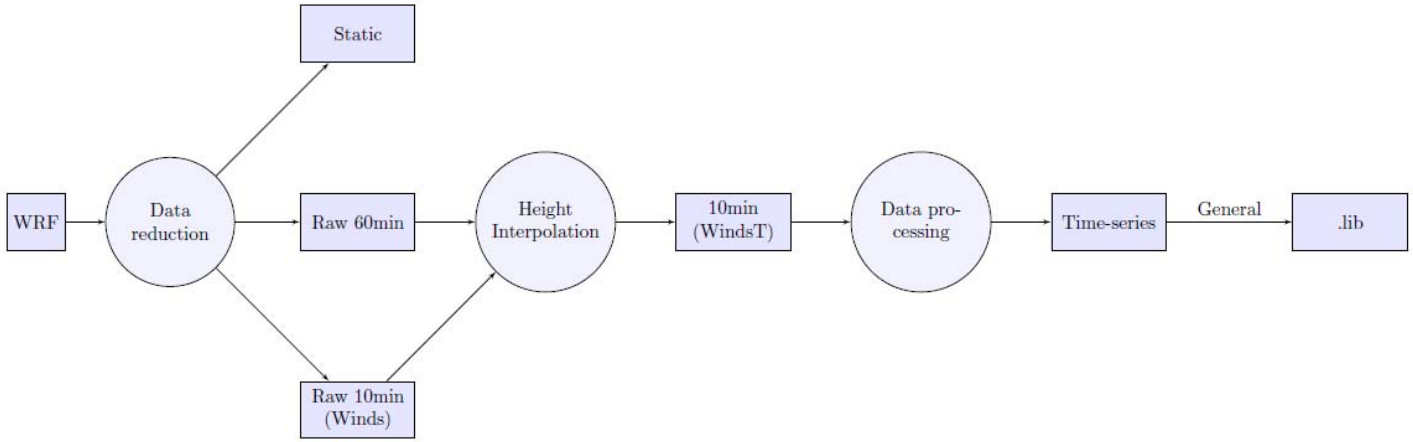
  - **Levels the playing field between small and large industry players** to identify and develop wind hot spots.

  - **Identifies possible wind development zones** in line with the strategic environmental assessment (SEA) studies or in line with frameworks. The DEA's SEA for solar photovoltaic and wind is an example of such an SEA study and is available at http://www.csir. co.za/nationalwindsolarsea/

  - **Long-term grid planning** to connect with high-potential wind development areas.

  - **Wind farm planning** in positioning (micro siting) the wind turbines for optimal wind exposures.

WASA Application cont. Wind time series data



The wind time series provides hourly data that is particularly useful:

- to study the annual, seasonal and diurnal variations in wind resources;
- as input to power system modelling;
- to study the geographical cross correlation of wind across South
- Africa; and
- for long-term corrections of the wind resources

Time series data with spatial and temporal resolutions of 9 km and one hour are available online from 1 Sept 1990 to 31 Dec 2012 (WASA 1)

Skills development achieved – the WASA book

CAPACITY BUILDING AND HUMAN DEVELOPMENT

- **SAWS**
  - 1 doctoral thesis
  - refined the quality control procedures of its wind climate data
- **UCT - CSAG**
  - Understanding the many aspects of the wind climate of South Africa in relation to wind energy has been aided
  - 3 Graduated Students
  - 3 Current Students
- **CSIR**
  - measurements, data management and microscale modelling
- **DTU WIND ENERGY**
  - applied research project for to pilot new models and methods in a real application and collect feedback for further developments and research
  - Teaching students in courses course 46200 Planning and Development of Wind Farms of the DTU Wind Energy Master
- **Journal publications and conferences**
- **Workshops and Training**

http://www.wasaproject.info/docs/WASABooklet.pdf

Skills development planned

“Using the WASA project results in education”

Workshop at SARETEC – 2016

Objective: One-and-a-half day workshop aims at demonstrating how the results of the Wind Atlas for South Africa (WASA) project can be used in tertiary (university-level) education, as part of a wider course on wind energy (or renewable energy in general) for students with an engineering or science background.

Target workshop participants: Participants will be from South Africa & SADC: University lecturers, those involved with planning or administrating education at Masters’ level, Department of Higher Education and Training (DHET), training organisations and researchers who supervise students. To obtain the maximum benefit and ensure the workshop will be focussed, it is only open to invited participants (i.e. not the general public). The workshop itself will be free but participants are expected to cover their own costs of attending.

Presented by: WASA Team

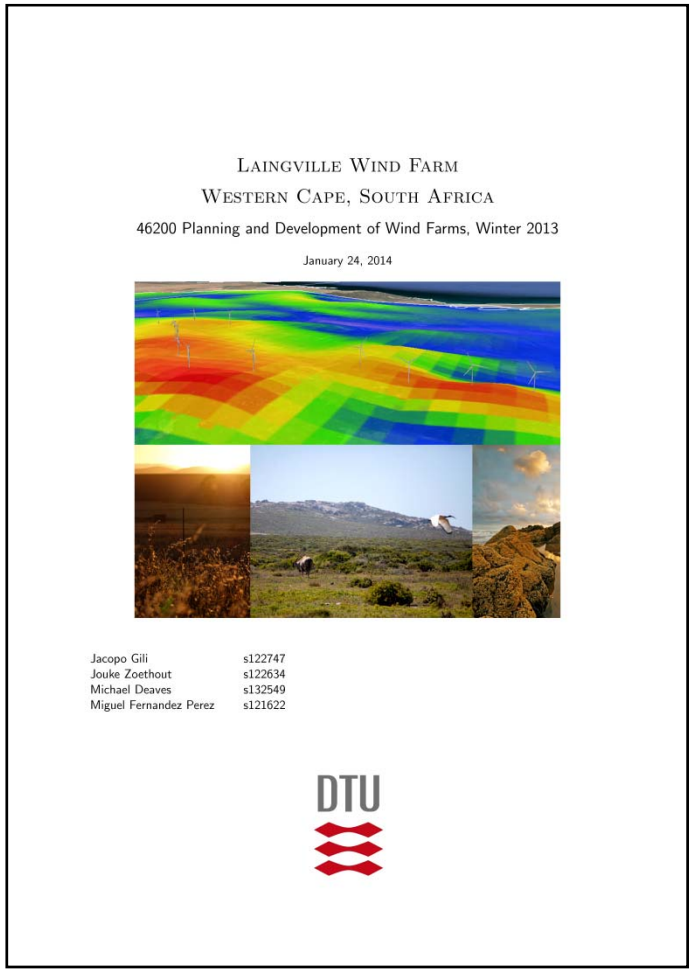
Organised by: SANEDI

Funded by: Danish RE EE Programme

Education examples: WASA impact at DTU

DTU two-year MSc in Wind Energy

- Course 46200: Planning and Development of Wind Farms
  - 7 student WASA projects (→)
- Course 46300: Wind Turbine Technology and Aerodynamics
  - WASA project three firsts
  - WASA project used to explain good engineering practice
- Special courses
  - WASA data used for projects, e.g. *Influence of atmospheric stability and land cover on wind flow modelling of mean wind speed*.



LAINGVILLE WIND FARM

WESTERN CAPE, SOUTH AFRICA

46200 Planning and Development of Wind Farms, Winter 2013

January 24, 2014

Jacopo Gili s122747
Jouke Zoethout s122634
Michael Deaves s132549
Miguel Fernandez Perez s121622

DTU

“reciprocal skills transfer” ?

The WASA project is a cooperation of the partners to make cutting edge results and capacity building in South Africa

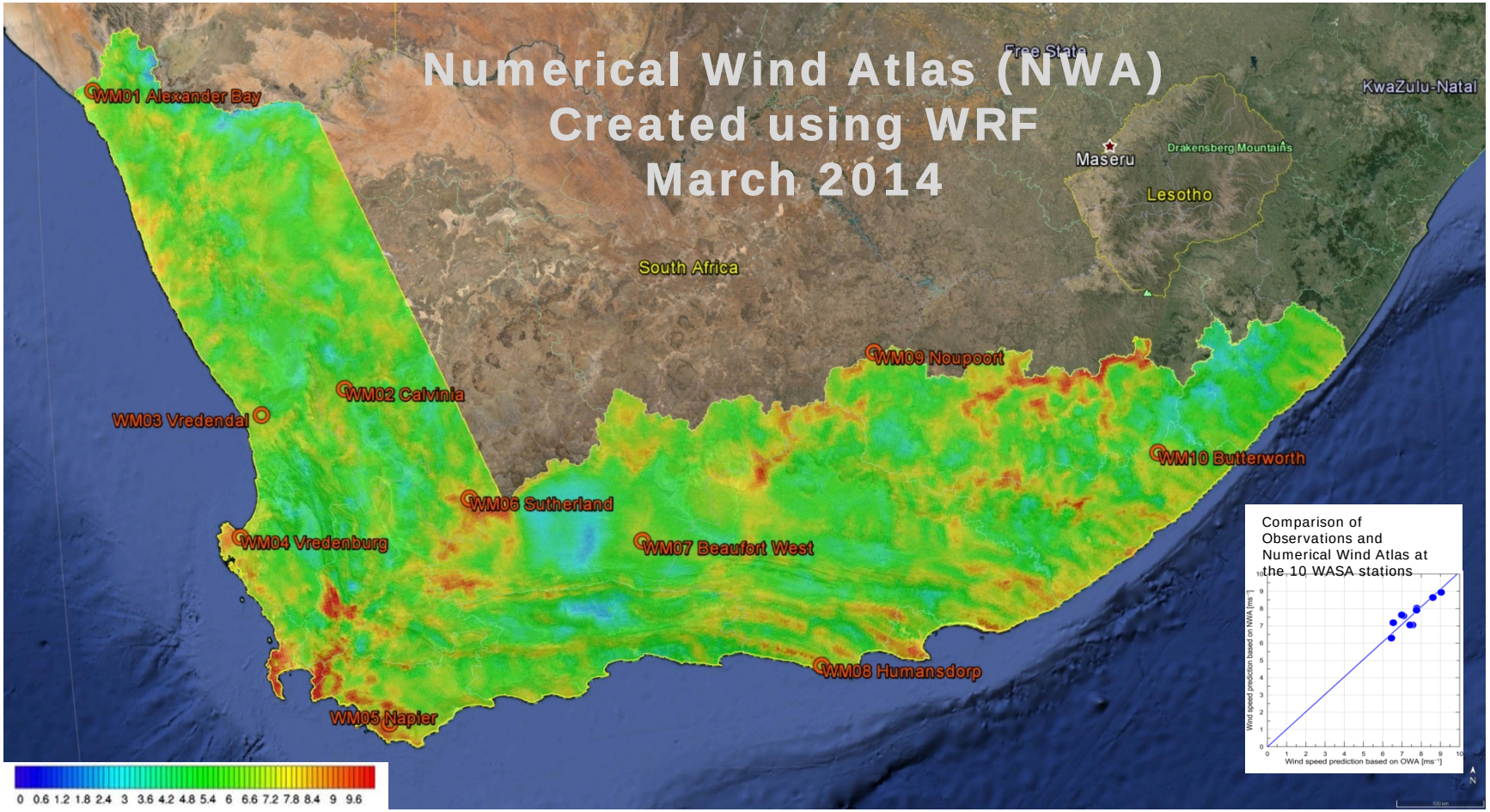
- VNWA “standard” method - statistical KAMM-based for quick result 2012
- First VNWA researched dynamic (time-series) WRF-based method 2014
- First High-resolution wind resource map (2014)
- First Extreme Wind Atlas (2014)
- Shared results, data and methodology in the public domain – even for the high-risk research-based work

The wind energy development is a global challenge that we have been working on for almost 40 years.

We constantly seek to push the limits and bring down uncertainties because it adds value.

The WASA project is an excellent example of good cooperation where everybody contribute their expertise – and we as a team get stronger.

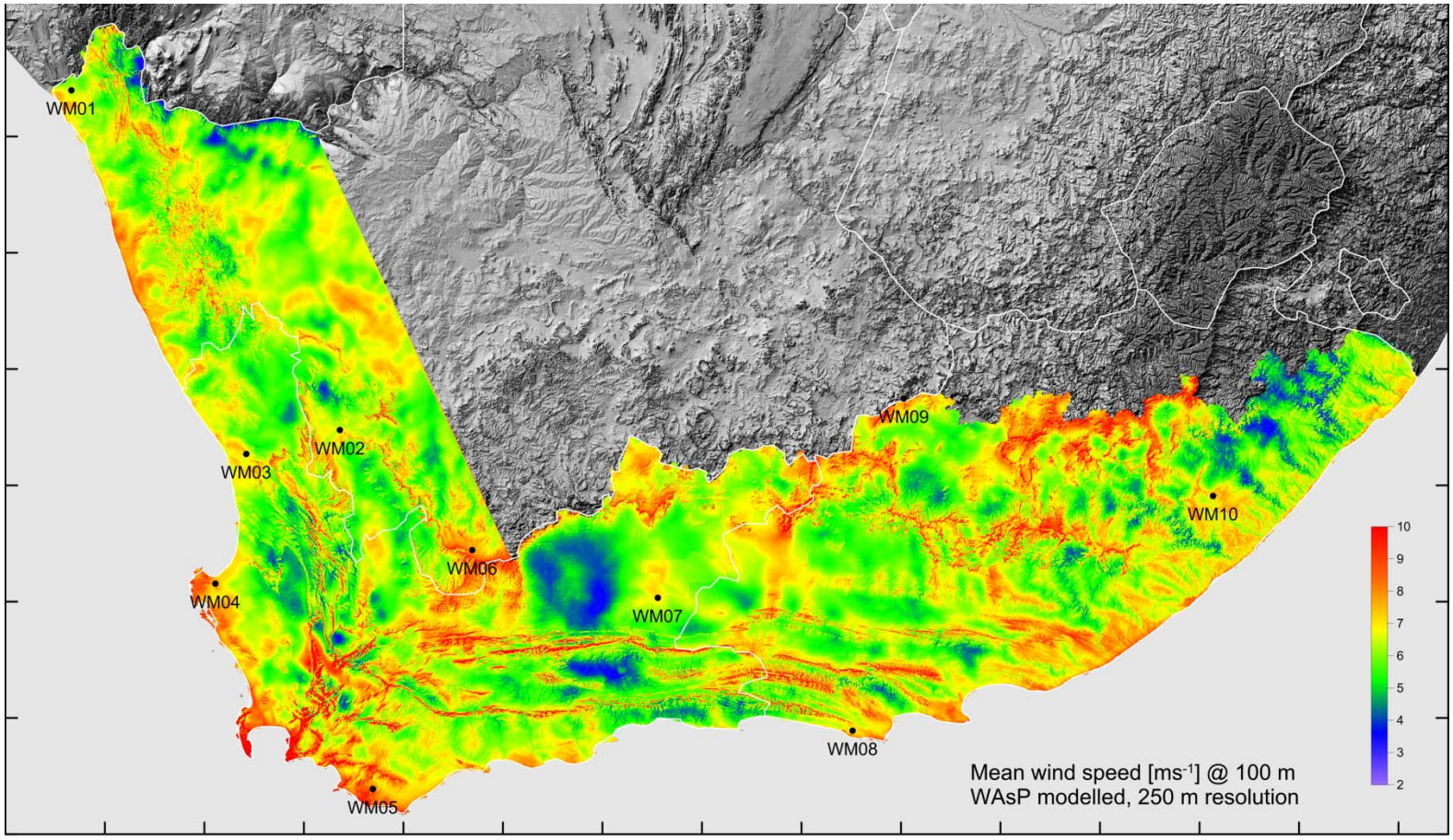
Numerical Wind Atlas for South Africa
a map and much more – wind climate



Generalised wind speeds – based on WRF mesoscale modelling

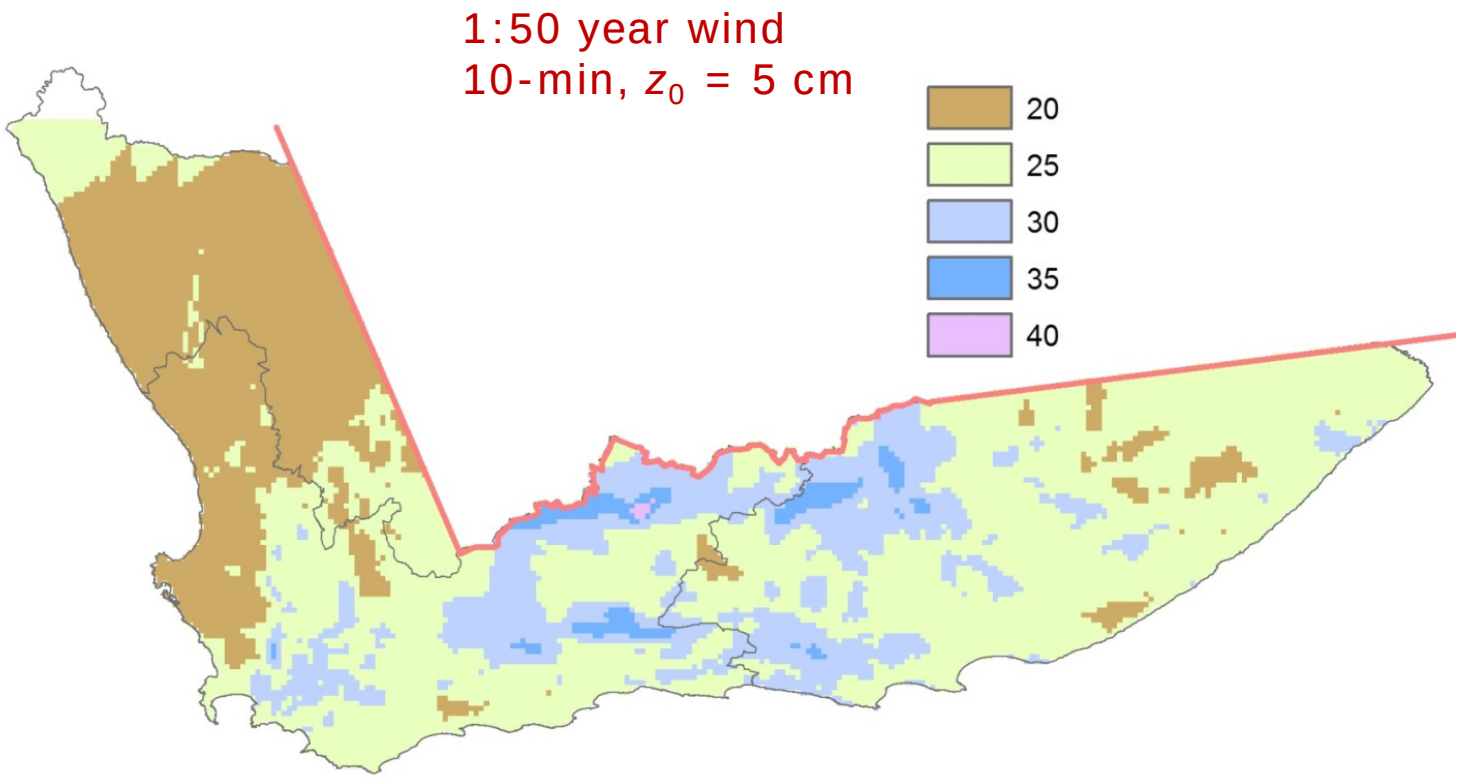
mean wind speed [m/s] 100 m above ground level, flat terrain, 3 cm roughness everywhere

High-Resolution Wind Resource Map



High-Resolution Wind Resource Map using WRF-based NWA, March 2014 mean wind speed (m/s) at 100 m agl in a grid spacing of 250 m.

Extreme Wind Atlas for South Africa
a map and much more – design winds



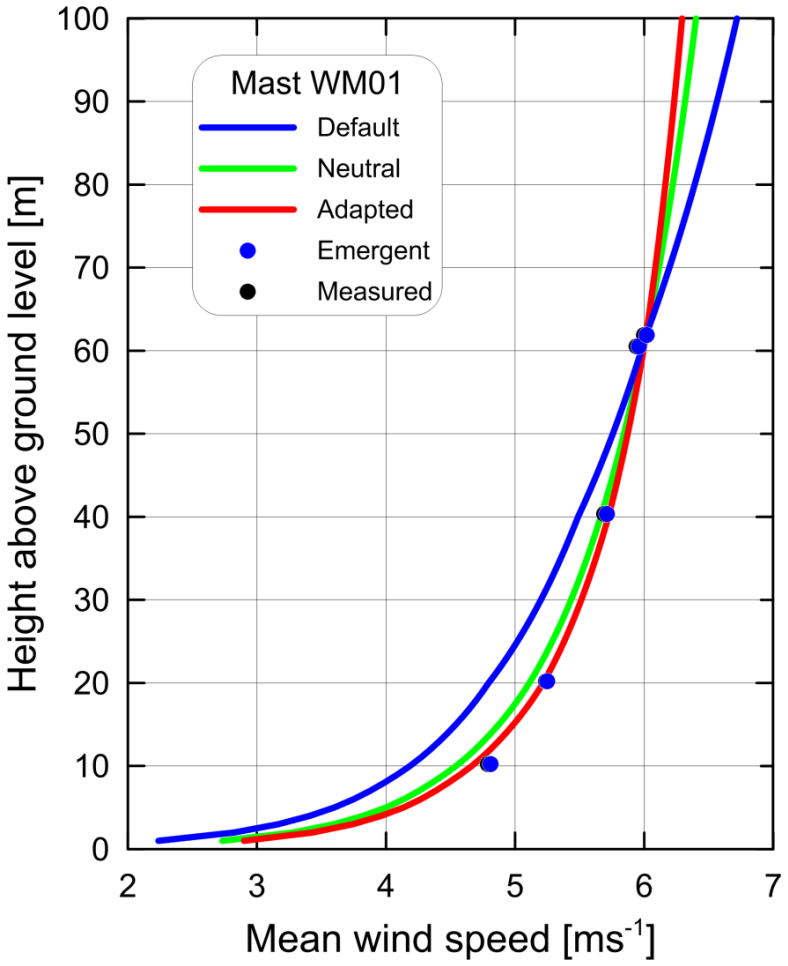
Microscale modelling at the 10 WASA masts

Wind-climatological inputs
- Three-years-worth of wind data
- Five levels of anemometry

Topographical inputs
- Elevation maps (SRTM 3 data)
- Simple land cover maps (SWBD + Google Earth); water + land

Modelling tools
- WAsP software

Preliminary results
- Wind atlas data sets from 10 sites
- Microscale modelling verification
  - Site and station inspection
  - Simple land cover classification
  - Adapted heat flux values



Verification at WASA Masts

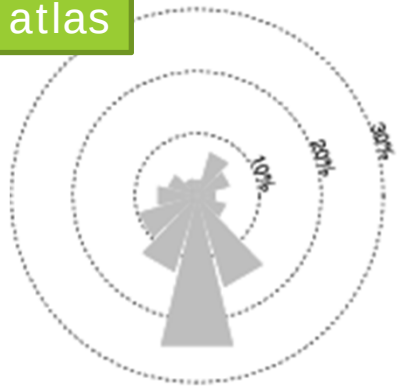
Numerical wind atlas (NWA) compared to observational wind atlas (OWA) Generalized annual mean wind speed at 100 m, z0 = 3 cm

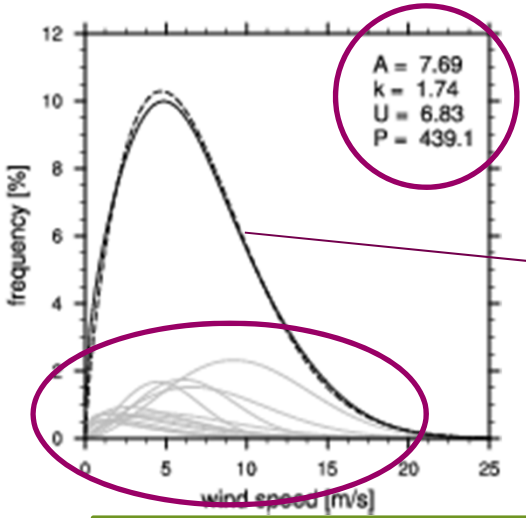
	OWA	WRF-M3N	Error WRF-M3N	Error KAMM
WM01	6.83	6.75	-1.17%	-15.93%
WM02	6.68	7.30	9.28%	7.89%
WM03	7.38	6.96	-5.69%	-7.79%
WM04	7.5	8.14	8.53%	-2.71%
WM05	8.98	9.04	0.67%	-7.22%
WM06	7.86	8.04	2.29%	-4.11%
WM07	7.78	7.40	-4.88%	-11.63%
WM08	8.01	8.16	1.87%	-0.78%
WM09	8.33	8.36	0.36%	-1.81%
WM10	7.12	7.80	9.55%	-3.64%
Mean error			**2.08%**	**-4.77%**
Abs mean error			**4.43%**	**6.35%**

Example: WASA site 1, far northwest

File = WM01.lib
z0 = 0.03 m h= 100 m

Observed wind atlas

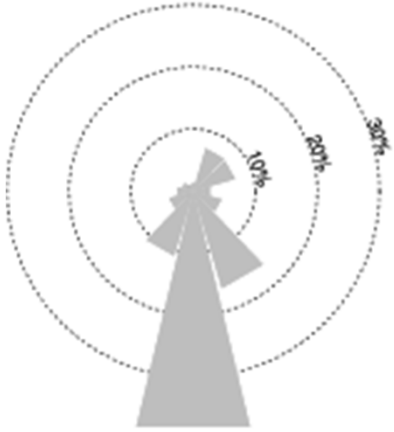


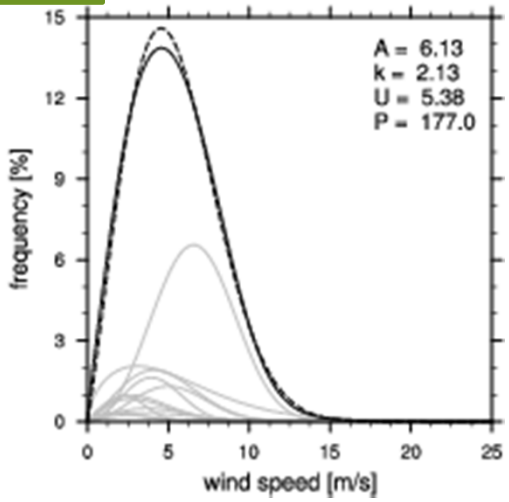


Weighted (solid)
Re-fit (dashed)

Numerical wind atlas KAMM

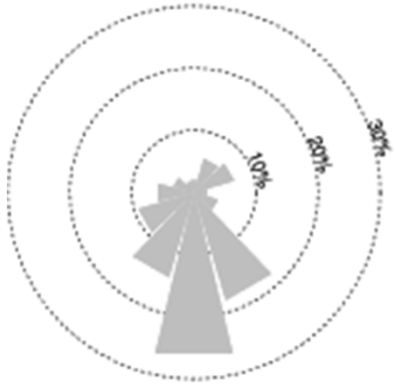
WM01.4_5.lib

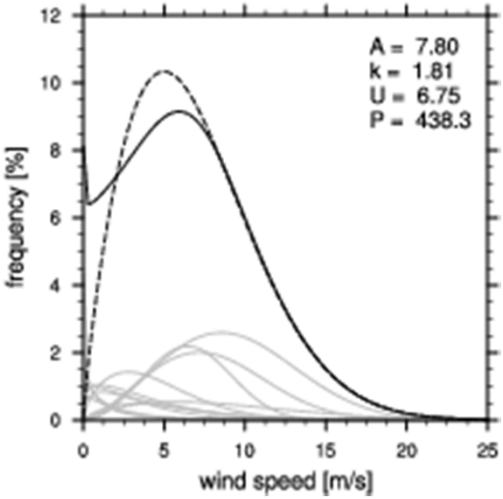




Numerical wind atlas WRF

m_WM01.lib

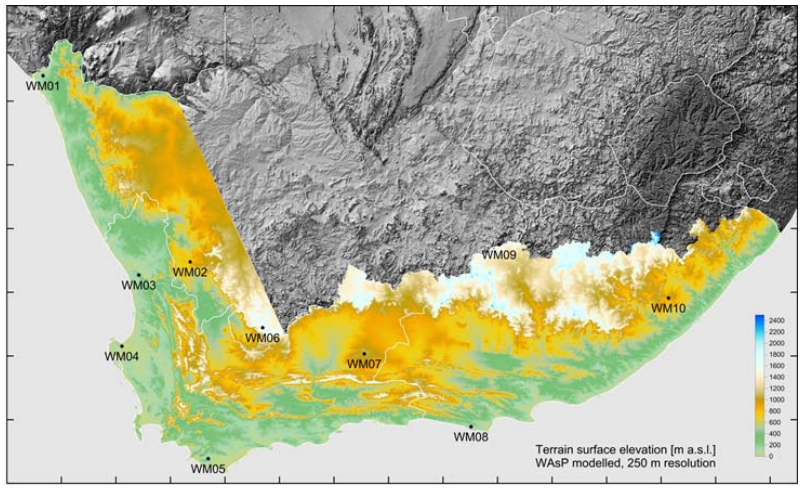


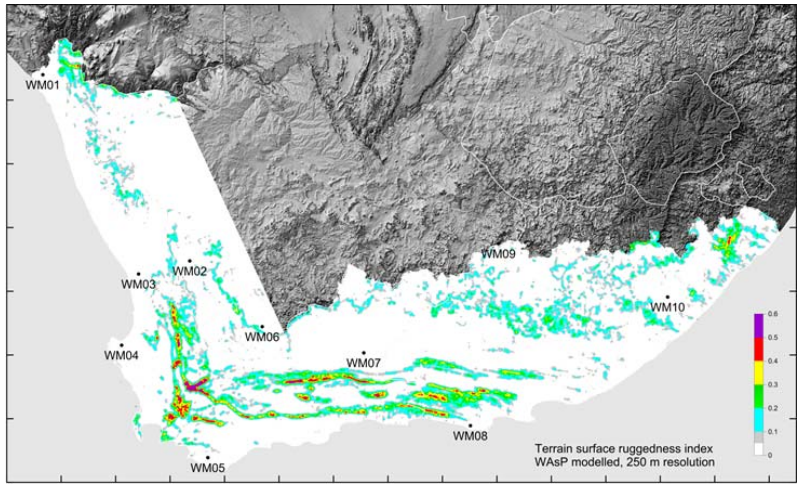


Uncertainties of Phase 1 atlas

Microscale modelling in South Africa

- Elevation and ruggedness (→)
  - Elevations provided
  - Ruggedness Index too
- Land cover and roughness
- Stability and tall profiles
  - Lidar measurements





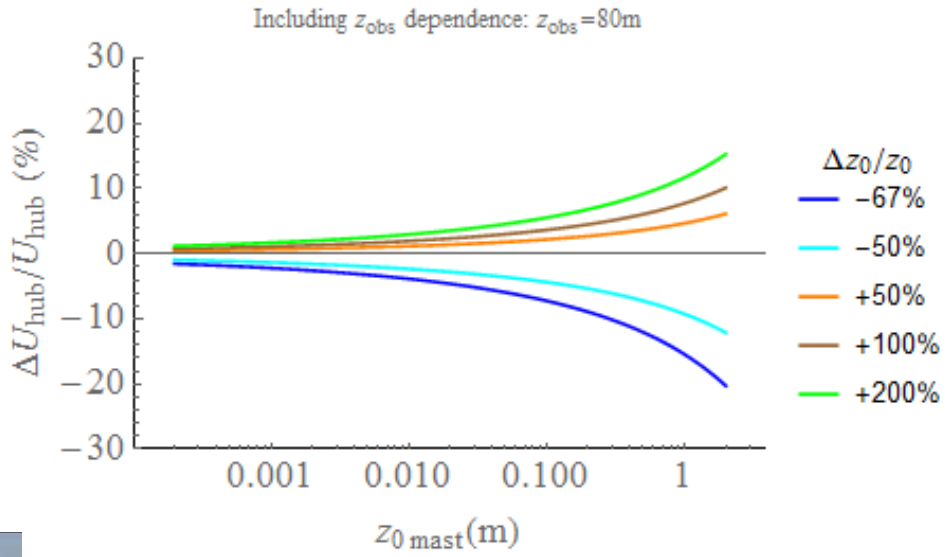
Uncertainties due to roughness assessment

Its important to know your roughness on site and surroundings

Errors on AEP can reach 6-7 % for a 50 % error in roughness

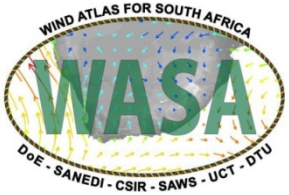
The higher the roughness the higher the AEP errors can be

Work on consistent roughness descriptions are needed



Source: Mark Kelly, DTU Wind Energy (2015)

EU research 2015-2020:
New European Wind Atlas (NEWA)



Long-Term goal to reduce the uncertainty to 3 % on modelling of wind everywhere in 2030 (a very ambitious goal)

Sub-goals 2020 for this project

i. Open source model chain from Global models to micro scale models (to be used to characterize diurnal cycles)
ii. Create experiments to verify the models (Forest , Complex terrain, Forested complex terrain, Coastal zones, High altitude)
iii. Provide a database of standardized input to models (define resolutions on roughness & terrain – Wind geo-server)

Methods

- Develop the interface between microscale and mesoscale models
- Develop microscale models that include stability (for the characterization of the diurnal variations)
- Perform high quality measurement campaigns
- Verify the developed models against measurements
- Develop a standard for validation of models

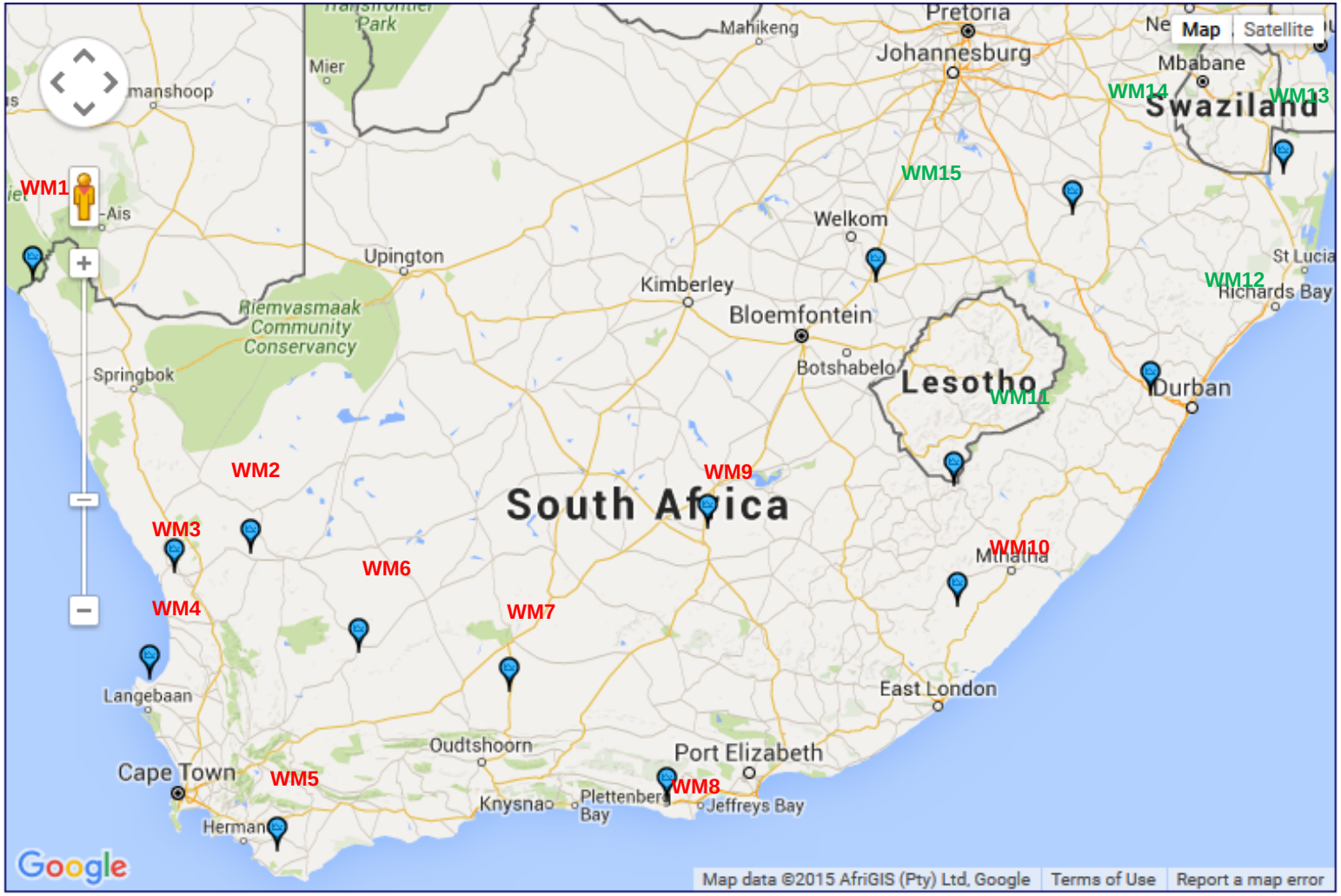
Budget – 13 mio Euro

Partners – 7 EU member countries (Denmark lead)

Continued R&D in South Africa
WASA Phase 2

- WASA is being expanded with WASA Phase 2 that started in 2015 and covers Free State, KwaZulu-Natal and remaining parts of Eastern Cape province.
- In addition to enlarging the WASA area, this phase will also seek to improve on the procedures, tools and data used for wind resource and energy yield assessments in South Africa.

Physical Wind Measurements for Verification



Global Wind Atlas – launch October 2015

IRENA and DTU launched the *Global Wind Atlas.*

The Global Wind Atlas provides new comprehensive, free, common datasets worldwide and suite of tools for planners.

The **Global Wind Atlas is NOT a replacement of Wind Atlas for South Africa**, but rather a predecessor to it for countries and locations that do not have a full wind atlas.

The Global Wind Atlas skips the mesoscale modelling part. However, it keeps the microscale modelling part and provides information of the variability of the wind resource that when left out led to underestimation of the resource.

The full wind atlas like WASA has both mesoscale effects and microscale variability, which combined reduces uncertainties further.

The Global Wind Atlas has used WASA for verification.

Concluding remarks

- WASA has done much more than skills transfer and reciprocal skills transfer – namely a contribution to the global development of knowledge and tools for wind resource assessment
- the booming wind energy sector in South Africa needs independent reliable information for policy makers and investors (national and international) regarding wind energy resources
- Uncertainties have been brought down to a low level in the majority of the WASA domain terrain which
  - makes results reliable for decision makers
  - Makes it clearer where the uncertainties still are significant and therefore easier to prioritise future research focus
- Under the WB ESMAP initiative the WASA methodology is already being expanded to other parts of Africa that will benefit from the further refining of the accuracy that is pursued and shared by the WASA team.

WASA fundamentals and guiding principles

- Public domain
- Traceable and transparent
- Industry-standard
- Uncertainties assessed
- Platform for future development

WRF Simulations for South Africa