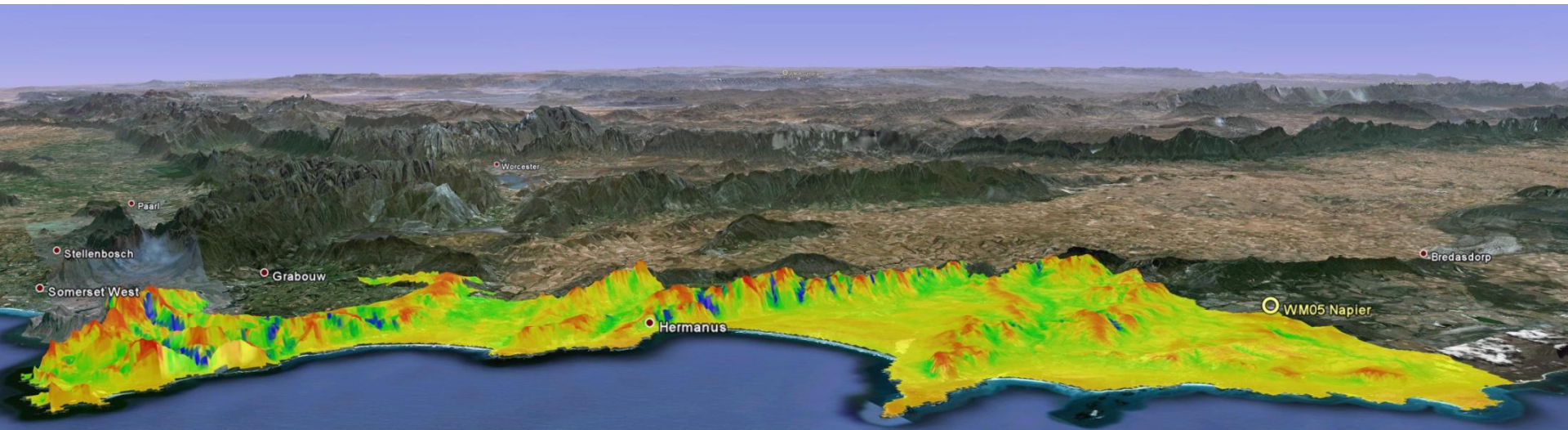


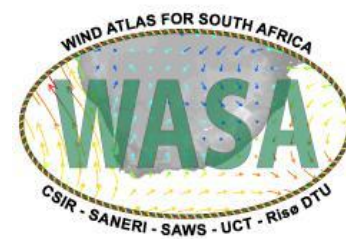
# Wind Atlas for South Africa (WASA) project

## Wind atlas methodology – the why and the how

Jens Carsten Hansen

*Mid-term Workshop, 14 and 16 March 2012*

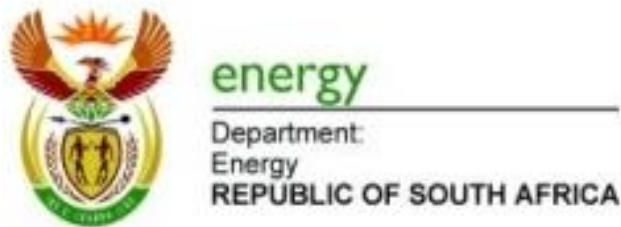




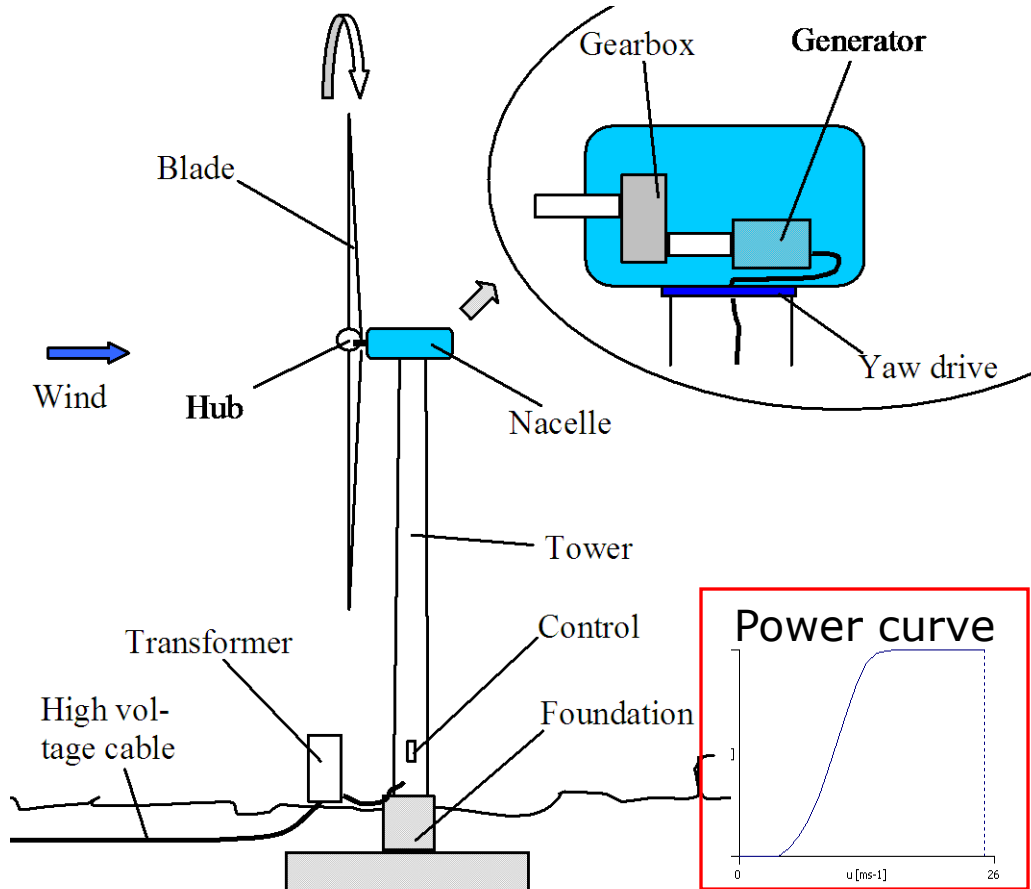
# Acknowledgements

The Wind Atlas for South Africa (WASA) project is an initiative of the South African Government - Department of Minerals and Energy (now DoE) and the project is co-funded by

- UNDP-GEF through the South African Wind Energy Programme (SAWEP)
- Royal Danish Embassy



# The wind turbine – size, air mass and speed



## 3 MW wind turbine

Nominal revolutions: 16 rpm

### Weight

Nacelle: 70 t

Rotor: 41 t

Towers: 100 m - 250 t

### Rotor

Diameter: 90 m

Area swept: 6,362 m<sup>2</sup>



Football field: 68 x 105 = 7,140 m<sup>2</sup>

### Mass flux at wind speed of 10 m/s:

$10 \times 6362 \times 1.225 = 77935 \text{ kg/s}$

at air density of 1.225 kg/m<sup>3</sup>

# Why Wind Atlas ?

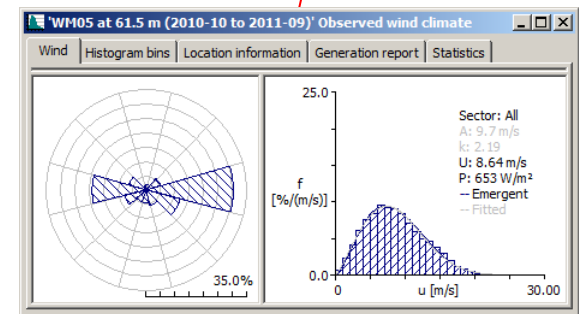
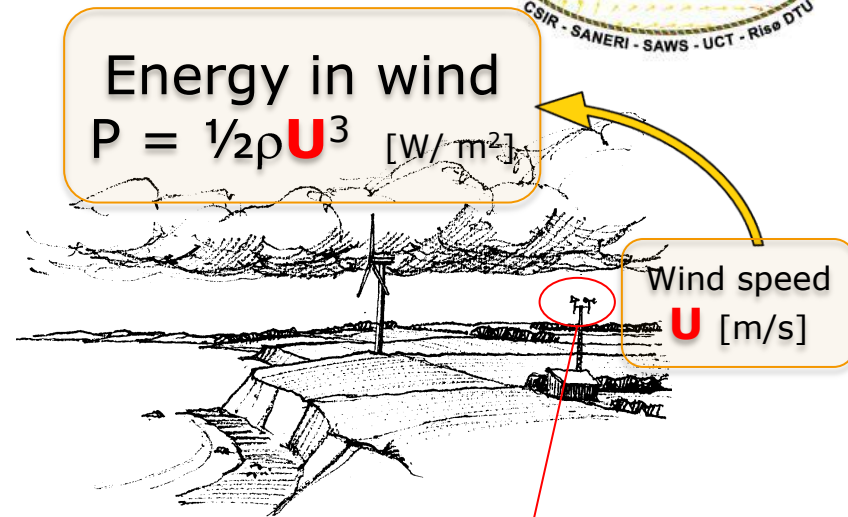
## Wind power economics

- Investment costs
- Operation and maintenance costs
- Electricity production  $\sim$  **Wind resources**
- Turbine lifetime
- Discount rate
- **Environmental benefits**

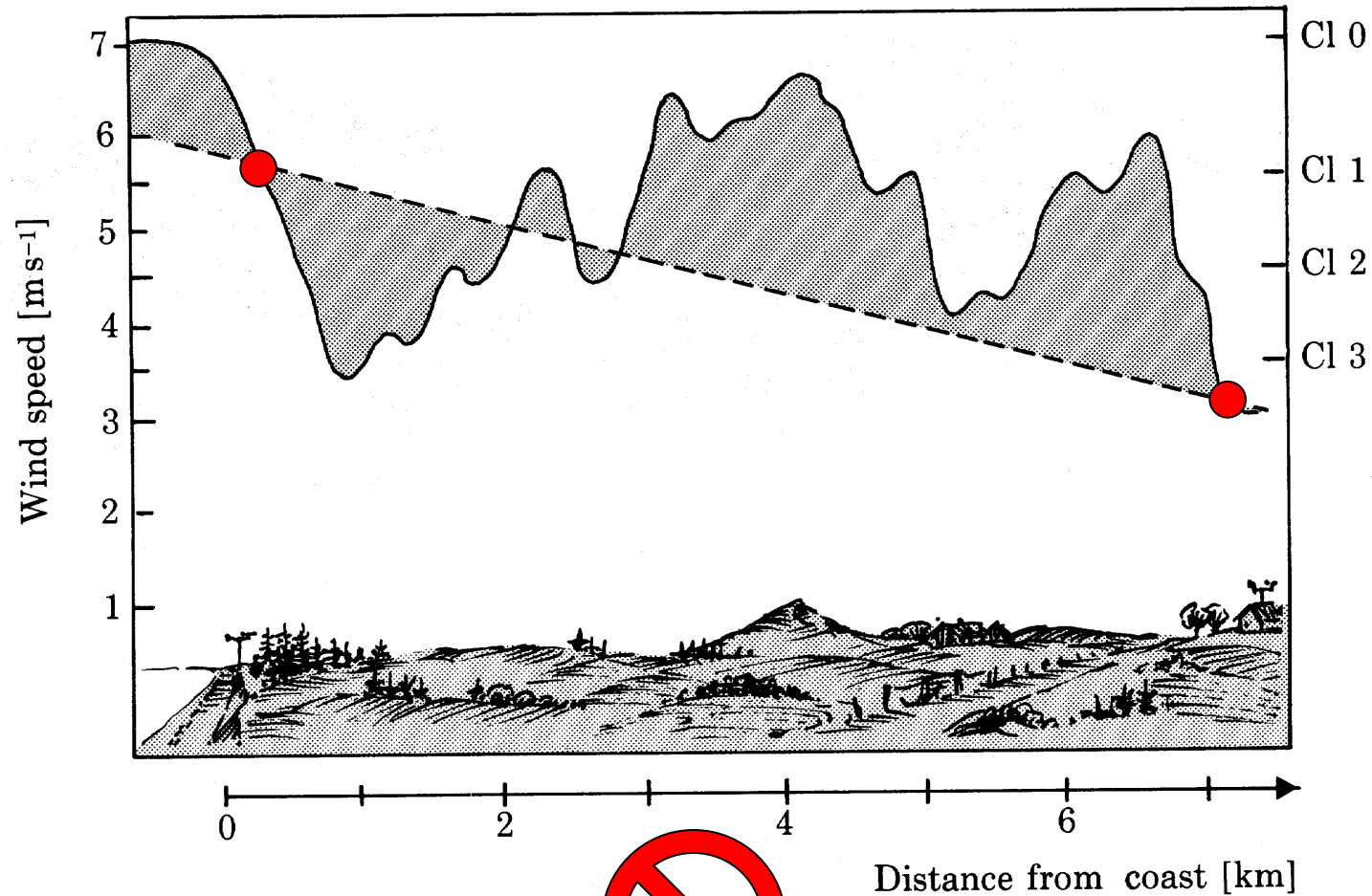
Wind provides the income in cost-benefit

Wind measurements are in one point in space  
 Wind varies significantly across the terrain  
 Spatial distribution needed for planning and projects  
 Accuracy is essential ( $\Delta U$  of 5%  $\rightarrow$   $\Delta P$  of 15%)

**Modelling is necessary and challenging**

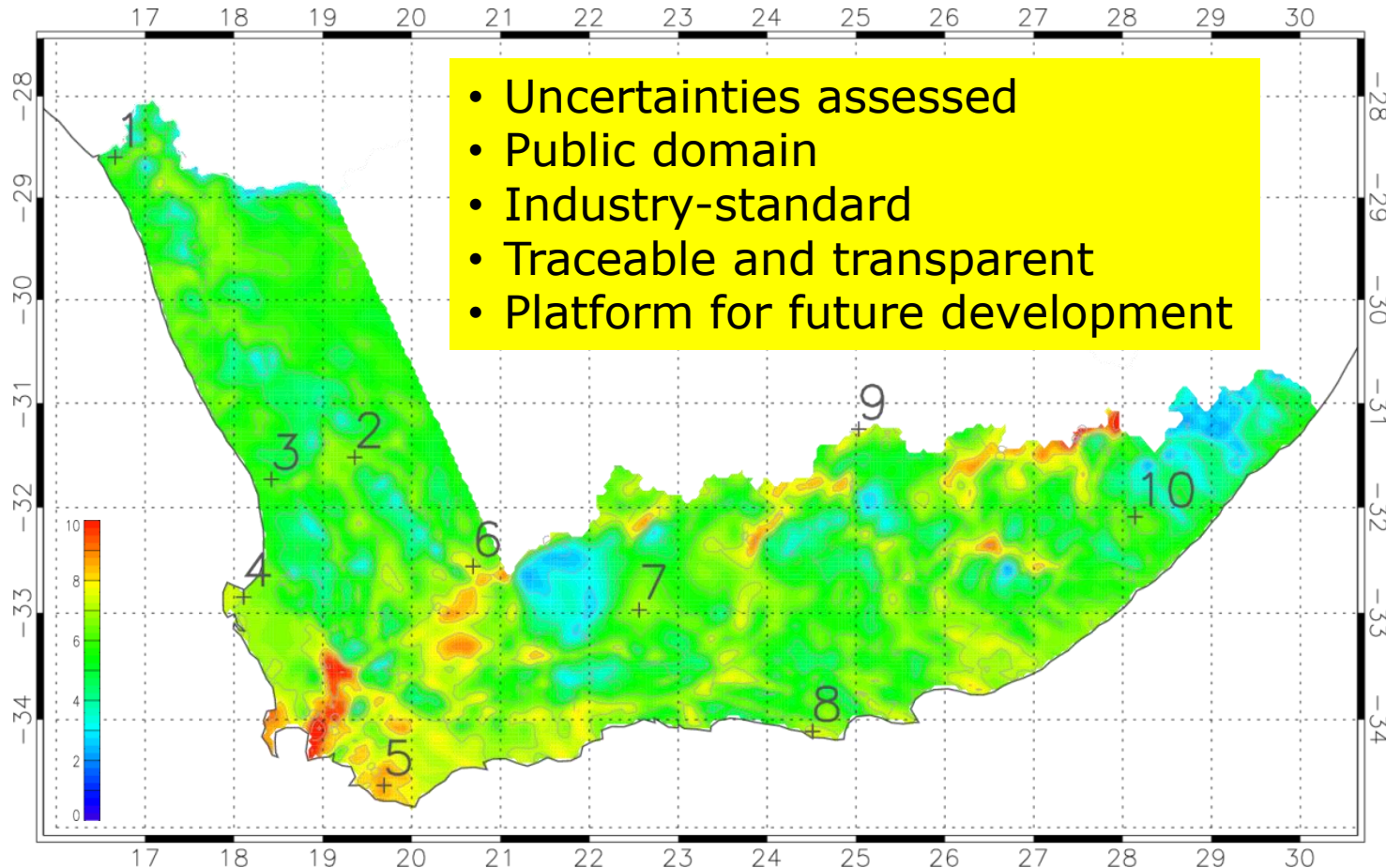
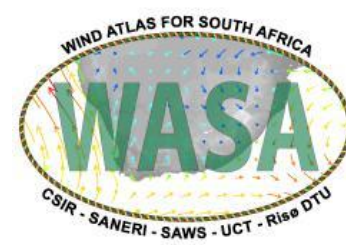


# Measurements and Linear interpolation - NO



# First Verified Numerical Wind Atlas for South Africa

a map – and much more



*Generalized climatological (30-year) annual mean wind speed [m/s] 100 m above ground level, flat terrain, 3 cm roughness everywhere*

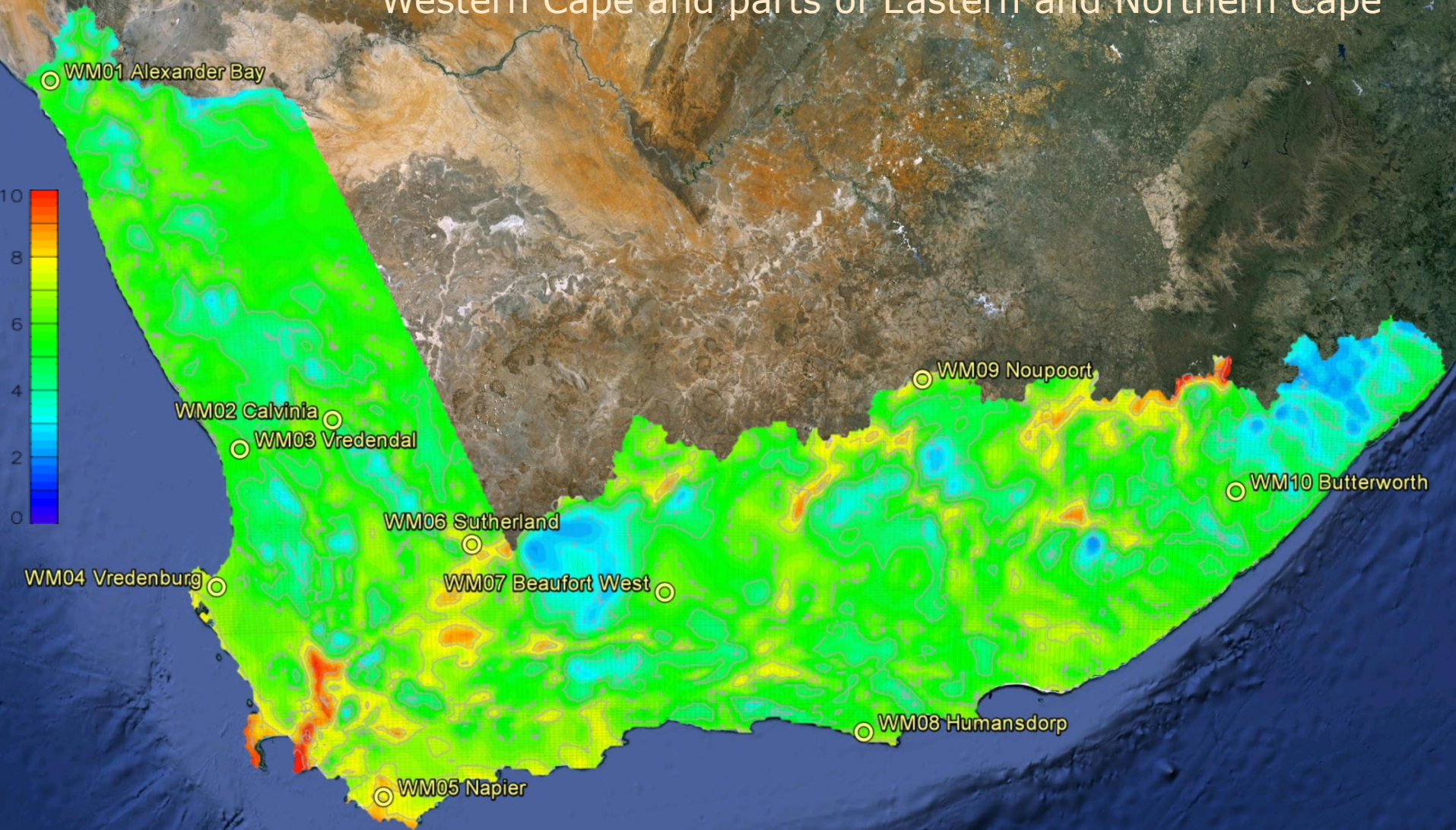
# Some challenges and needs for wind resource assessment



- Energy, electricity and sustainable solutions needed
- Development of power systems are long term efforts
- Search for location of best wind resources
- Planning, implementation and operation of power systems need temporal and spatial wind power distributions
- Cost efficient solutions only
- Traditional climatology and global models do not provide the answer regarding wind resources
- Wind data availability is insufficient and quality inappropriate

# Wind Atlas for South Africa

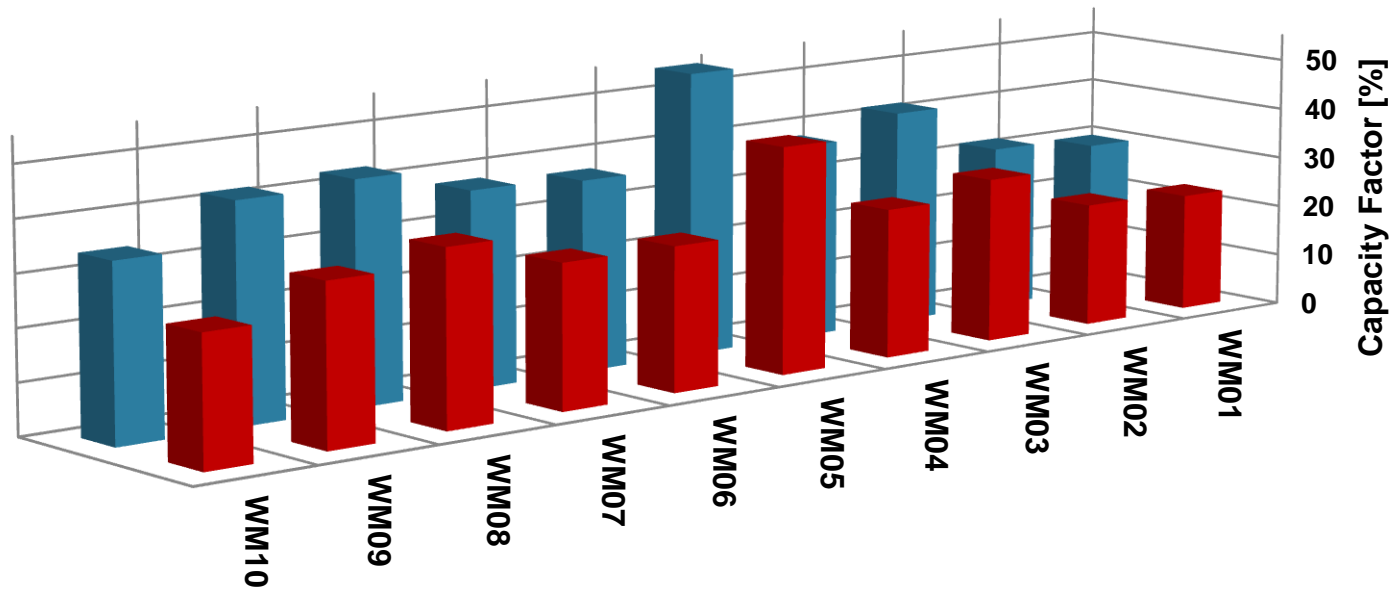
Western Cape and parts of Eastern and Northern Cape



# Capacity Factors in SA

## WASP predictions for 1 WTG on 10 WASA sites - 1 year of data

- Theoretical values, assuming 100% availability, no wakes, no losses
- Note that WASA masts are for model verification and not at windiest sites



	WM01	WM02	WM03	WM04	WM05	WM06	WM07	WM08	WM09	WM10
■ 2-MW Ø90m	30	32	42	38	55	37	38	43	42	34
■ 3-MW Ø90m	23	24	32	29	44	28	28	34	31	25

# Capacity factors – worldwide averages

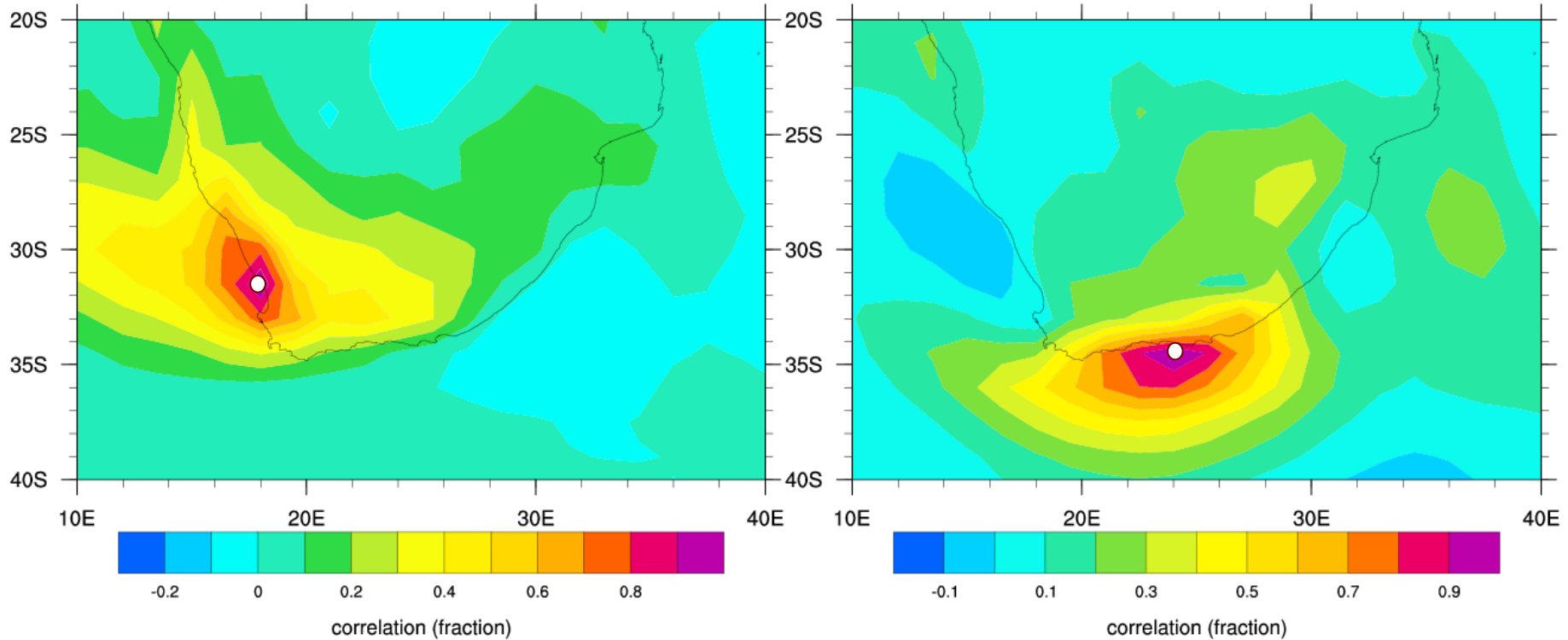
## Electricity from Wind Power (BTM Consult)

	Cumulative MW - end 2010	Est. average full load hours	Est. average capacity factor	Est. electricity production in 2010 TWh
Country/Region				
USA	40,274	2,300	26.3%	92.63
Germany	27,364	1,813	20.7%	49.61
Spain	20,300	2,200	25.1%	44.66
P.R. China <sup>1)</sup>	44,781	1,800	20.5%	80.61
India	12,966	1,800	20.5%	23.34
Italy	5,793	2,000	22.8%	11.59
France	5,961	2,100	24.0%	12.52
United Kingdom	5,862	2,628	30.0%	15.40
Denmark	3,805	2,250	25.7%	8.56
Portugal	3,837	2,200	25.1%	8.44
Canada	4,011	2,278	26.0%	9.14
The Netherlands	2,241	2,100	24.0%	4.71
Japan	2,429	2,100	24.0%	5.10
Australia	2,084	2,500	28.5%	5.21
Greece	1,482	2,500	28.5%	3.70
Sweden	2,141	2,100	24.0%	4.50
Austria	1,013	1,794	20.5%	1.82
Rest of World	14,190	2,000	22.8%	28.38
<b>Total</b>	<b>199,520</b>	<b>(avg. 2,054)</b>	<b>(avg. 23.5%)</b>	<b>409.91</b>

Source: BTM Consult - A Part of Navigant Consulting - March 2011

Energy unit: 1 Tera Watt Hour (TWh) = 1 Billion kWh

# Spatial correlations (lag 0) between 6-hourly wind speed ERA Interim Annual 1989

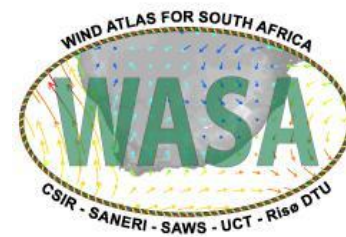


Wind-speed correlations in the large-scale flow.

## Users

Authorities	Policies, regulations, plans
Planners	Resource and development planning
Investors, owners and banks	Financial planning, risk assessment and decisions
Developers (small and large)	Project development
Industry (small and large)	Project design and implementation, Wind turbine design and development
Power sector	Power system planning, development and operation
Consultants	Independent expertise and tools development
Academic community	Research, methods and tools development

**All need the Wind Atlas**, using WAsP or similar micro-scale model to calculate estimated energy production from wind farms as part of project and planning decisions.



## The WASA Project Team

- SANERI (*South African National Energy Research Institute*)
  - executing partner – contracting the implementing partners
  - coordination and dissemination
- UCT CSAG (*Climate System Analysis Group, University of Cape Town*)
  - mesoscale modelling
- CSIR (*Built Environment, Council for Scientific and Industrial Research*)
  - measurements and microscale modelling
- SAWS (*South African Weather Service*)
  - extreme wind assessment
- DTU Wind Energy\* (*Dept of Wind Energy, Technical University of Denmark*)
  - partner in all activities

\* the original DTU partner (Risø DTU) is part of DTU Wind Energy established Jan 2012



# Work plan

30 June 2009	Project Commencement at contract signature
March 2010	<p>First public project workshop presenting</p> <ul style="list-style-type: none"> <li>• Project plans, methods and tools</li> <li>• First unverified wind atlas</li> </ul>
July/August 2010	10 WASA measurement stations in operation
September 2010	Wind data publishing monthly on web-site activated
March 2012	<p>Midterm Workshop presenting</p> <ul style="list-style-type: none"> <li>• First Verified Numerical Wind Atlas according to standard proven and tested method after 1 year of measurements</li> </ul>
March 2014	<p>Final Workshop and Wind Seminar presenting</p> <ul style="list-style-type: none"> <li>• Researched wind resource atlas</li> <li>• Extreme wind atlas</li> </ul>