SAWEP Workshop
Wind Atlas for South Africa (WASA)

Cape Town, 4th March 2010

Introduction to the Workshop
and
WASA project overview and status

Risø DTU
National Laboratory for Sustainable Energy

Purpose of the Workshop

Presentation and Demonstration of WASA methods, tools and products

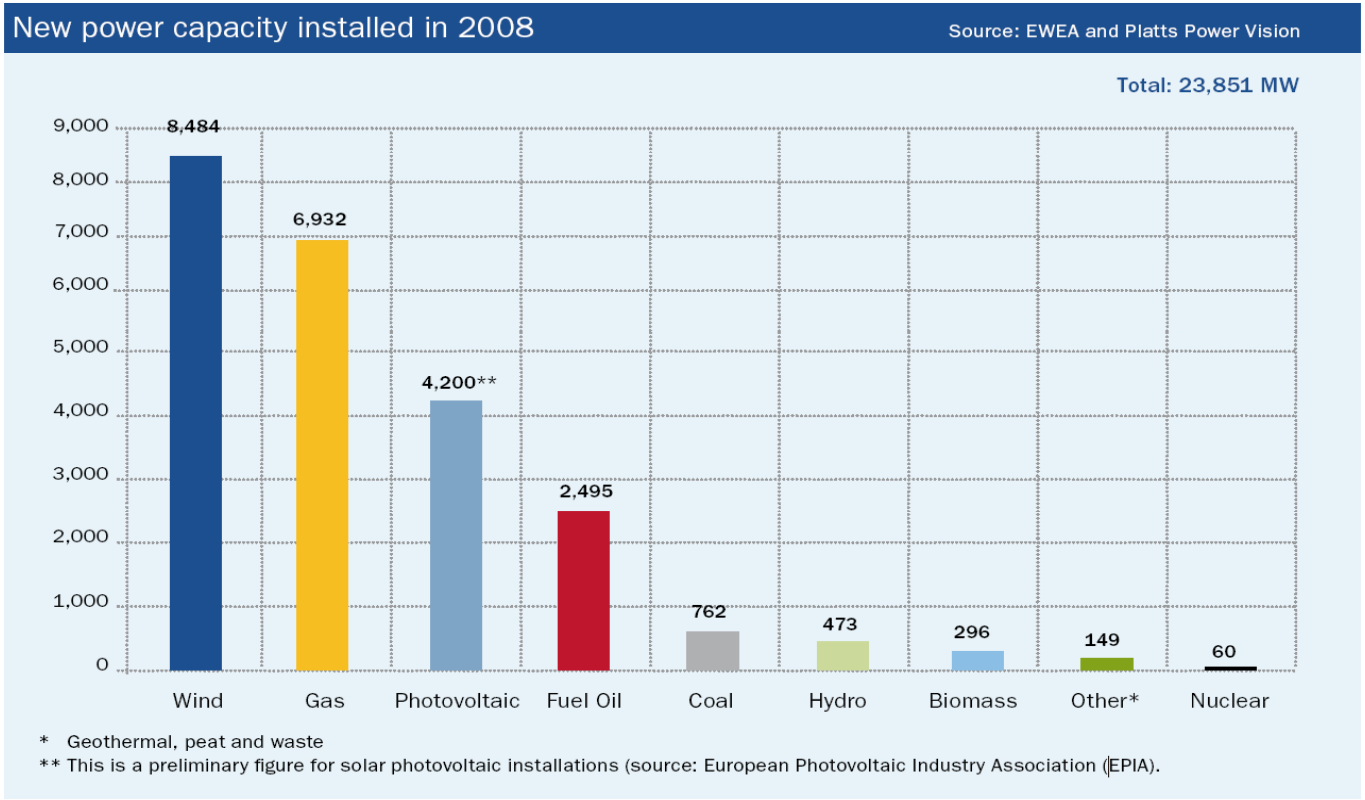
- Introduction to the WASA project
- Presentation and demonstration of the WASA wind measurement programme – designed for verification, how it works and how you can access it
- Presentation of meso-scale modelling methods to be employed and why
- Presentation and demonstration of the Wind Atlas Method and the WAsP and WEng software, which will be used for micro-scale modelling in WASA work packages (WP3, WP4 and WP5)
    - WAsP and WEng characteristics, functionality and operation
    - Climatological and topographical inputs
    - Best practices, limitations and sensitivities
- Discussion of WASA project plans

Risø is part of the Technical University of Denmark (DTU)

- January 2007, Risø National Laboratory merged with the Technical University of Denmark (DTU)
- Research, education, innovation and assistance of public authorities
- 7,000 students, 4,200 employees, 2,000 of whom are scientists
- More than 200 in wind energy research
- Annual revenue of DKK 3.2 billion

Risø DTU is the national laboratory for sustainable energy

Wind power can make a difference

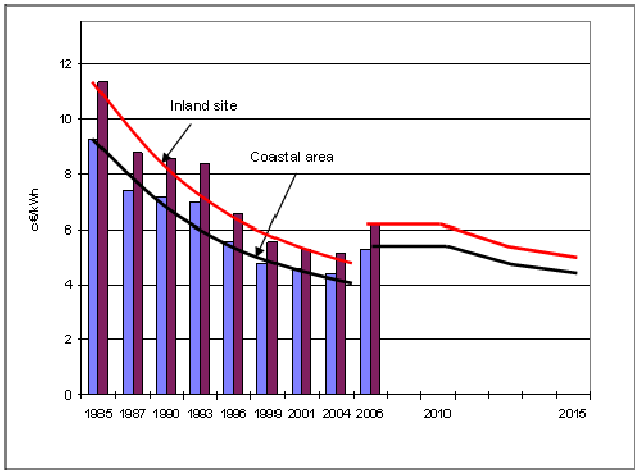


- **More wind energy** installed in the EU in 2008 **than any other generation technology**

- Binding target of 20% renewable energy for the EU to achieve by 2020, means approximately **35% of electricity**.
- 65 GW wind power capacity installed in EU by 2008 - **4.2% of electricity** demand

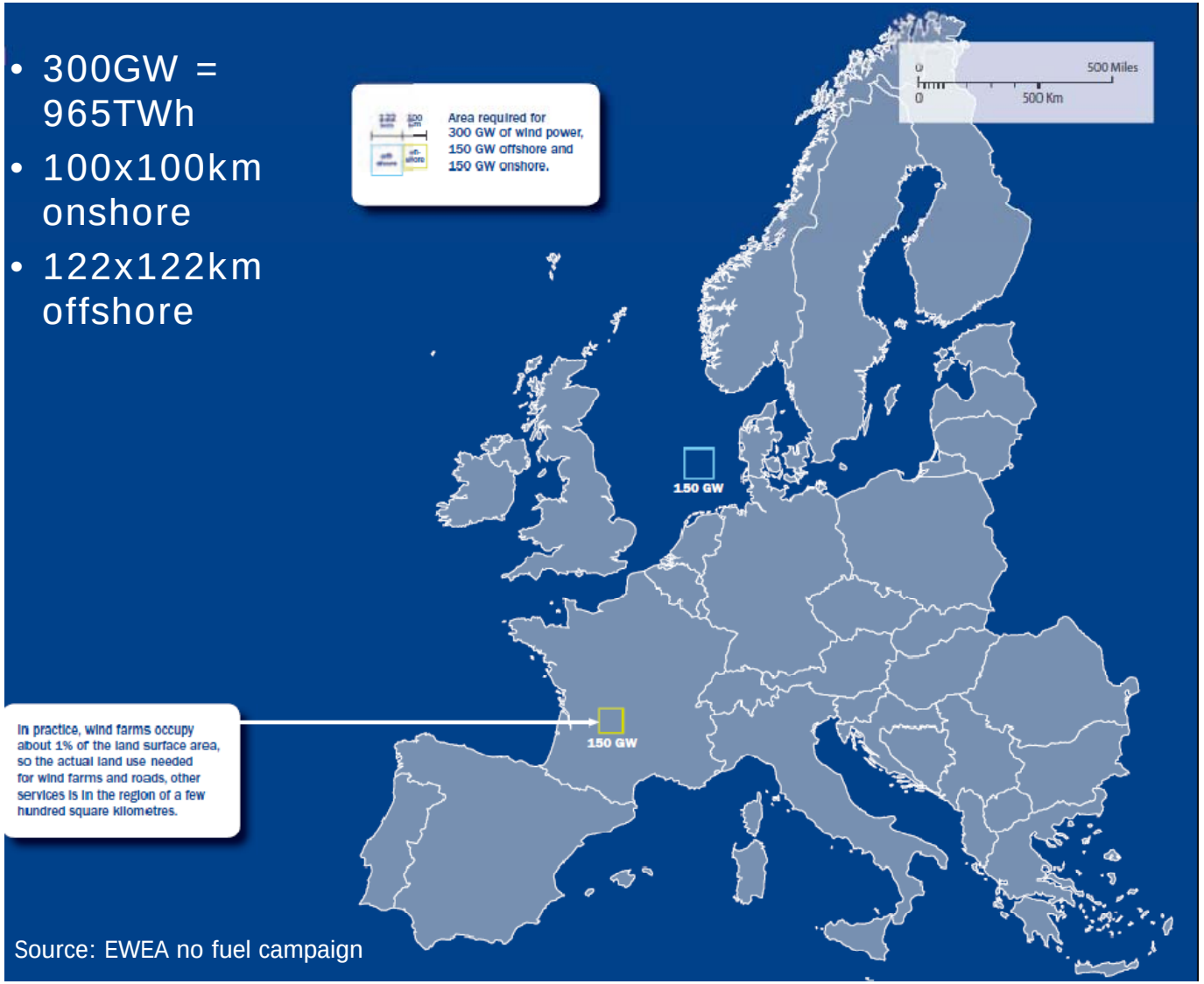
Source: GWEC

Size of Wind Turbines



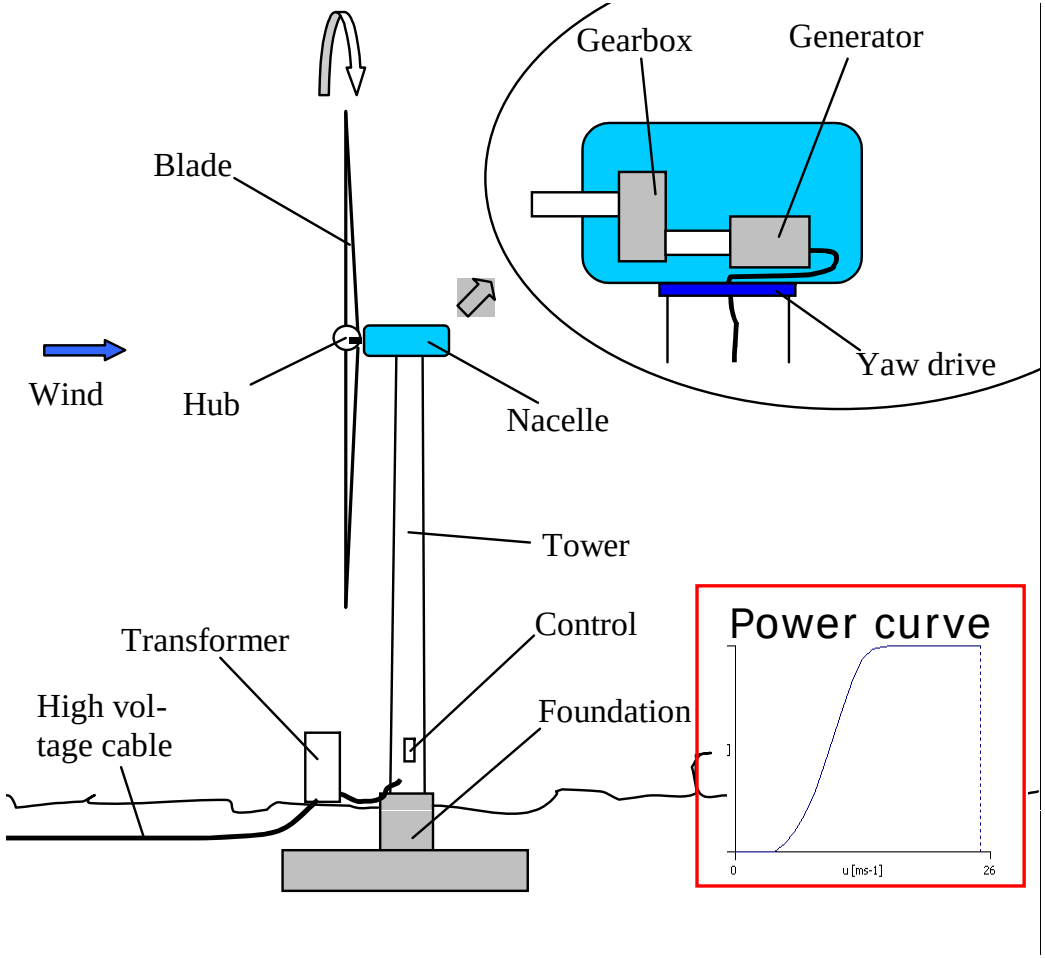
Area used for 20% wind in 2030

- 300GW = 965TWh
- 100x100km onshore
- 122x122km offshore



Source: EWEA no fuel campaign

The wind turbine – 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^2

Football field: 68 x 105 = 7,140 m^2

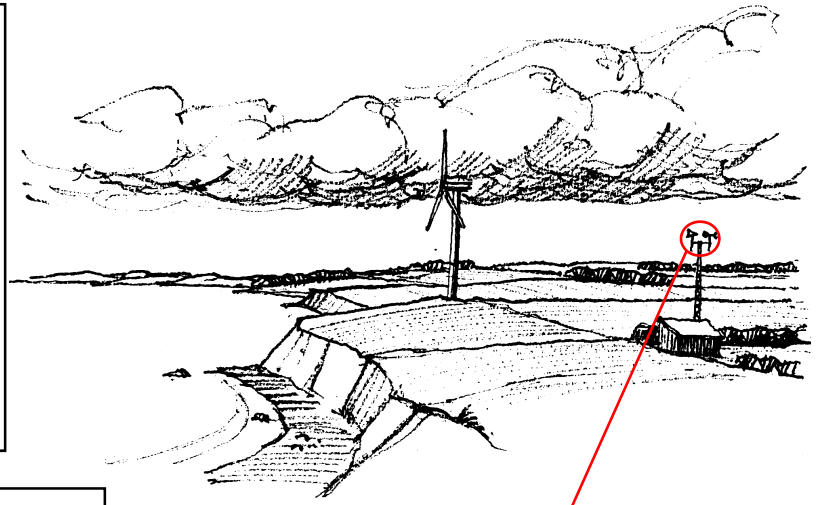
Mass flux at wind speed of 10 m/s:
10 x 6362 x 1.225 = **77935 kg/s**
at air density of 1.225 kg/m^3

Wind resources - the problem

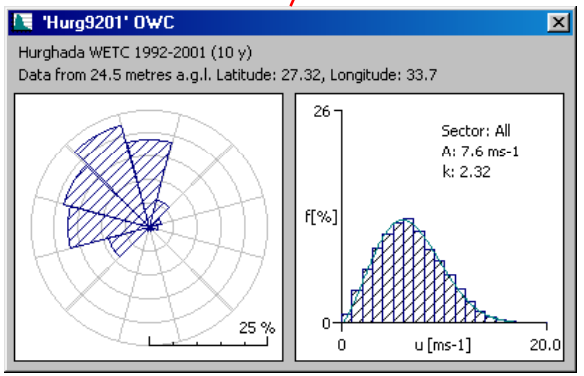
Determining the wind resources accurately is important and difficult

Main parameters governing wind power economics:

- Investment costs
- Operation and maintenance costs
- Electricity production / Wind resources
- Turbine lifetime
- Discount rate
- Environmental benefits

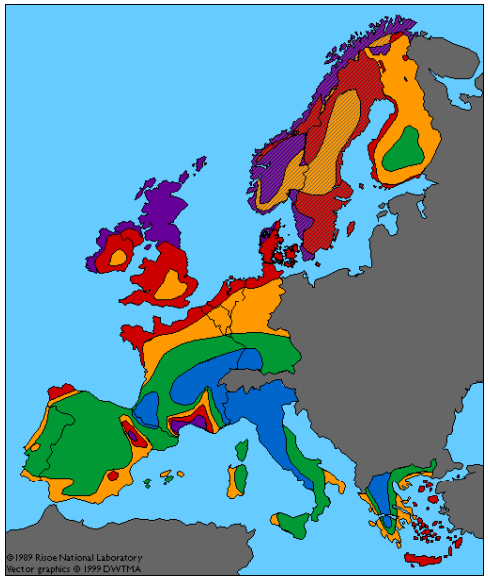


- Wind speed, U [m/s]
- Kinetic Energy flux, $P = \frac{1}{2}\rho U^3$ [W/ m^2]
- ΔU of 5% (e.g. U=10.0+0.5m/s) ⟹ ΔP of 15%



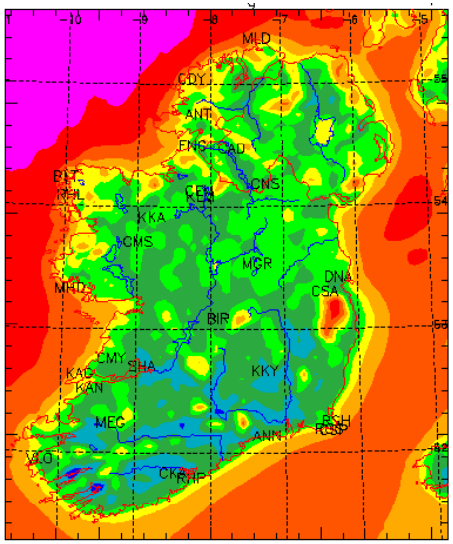
- Wind resources are in fact more P than U
- Both U and P are statistical distributions
- We measure U (and D) in one point in space, but need it in the entire atmospheric boundary layer

The Wind Atlas Method



the *observational wind atlas* method and the microscale flow model, WAsP, were conceived in the 80's for the European Wind Atlas

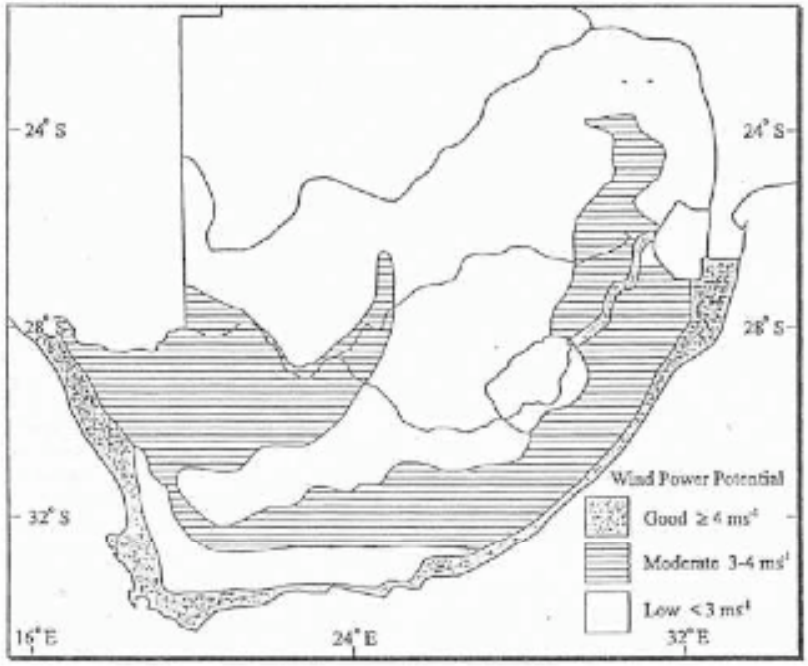
the *numerical wind atlas and* mesoscale model techniques for larger domains, mesoscale effects and long-term wind climates came in the 90's



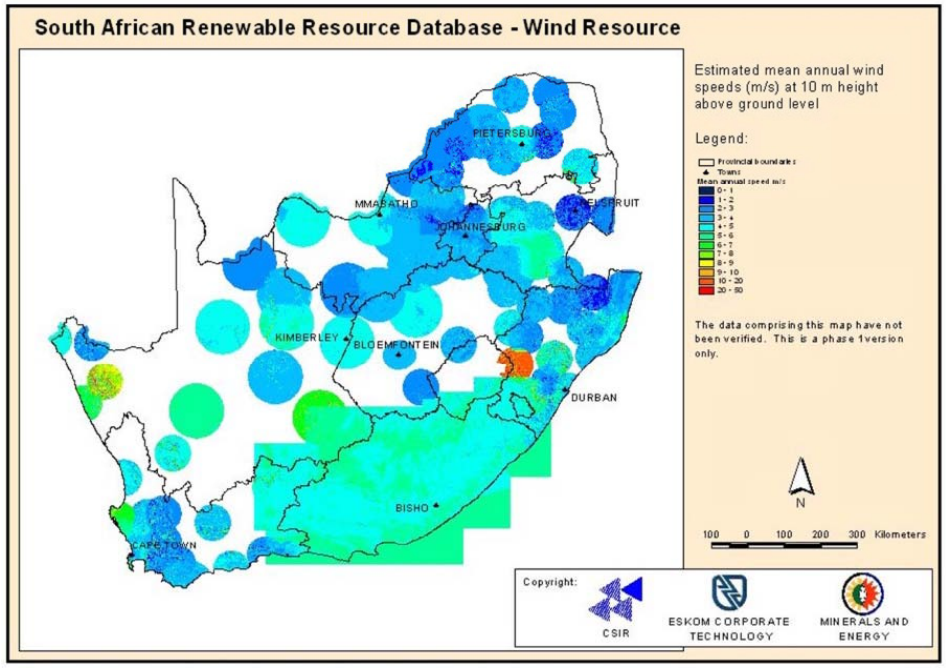
state-of-the-art for wind resource assessment and planning is a combination of microscale and mesoscale modelling with verification against measurements

Observational wind atlases for South Africa

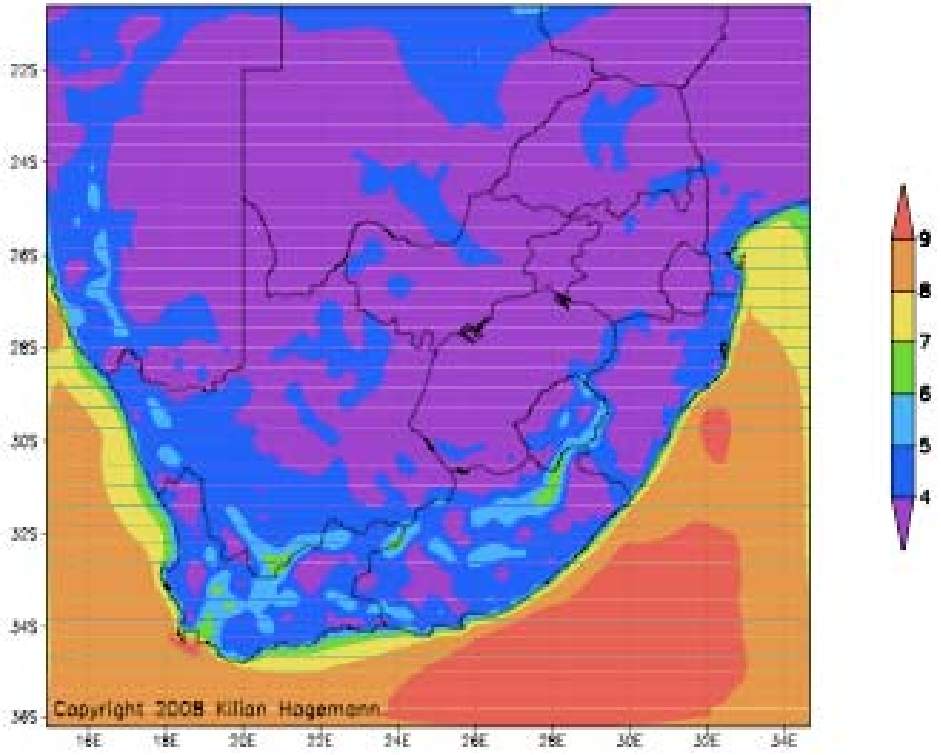
DME; R. Diab 1995



SABREGEN; ESKOM 2001

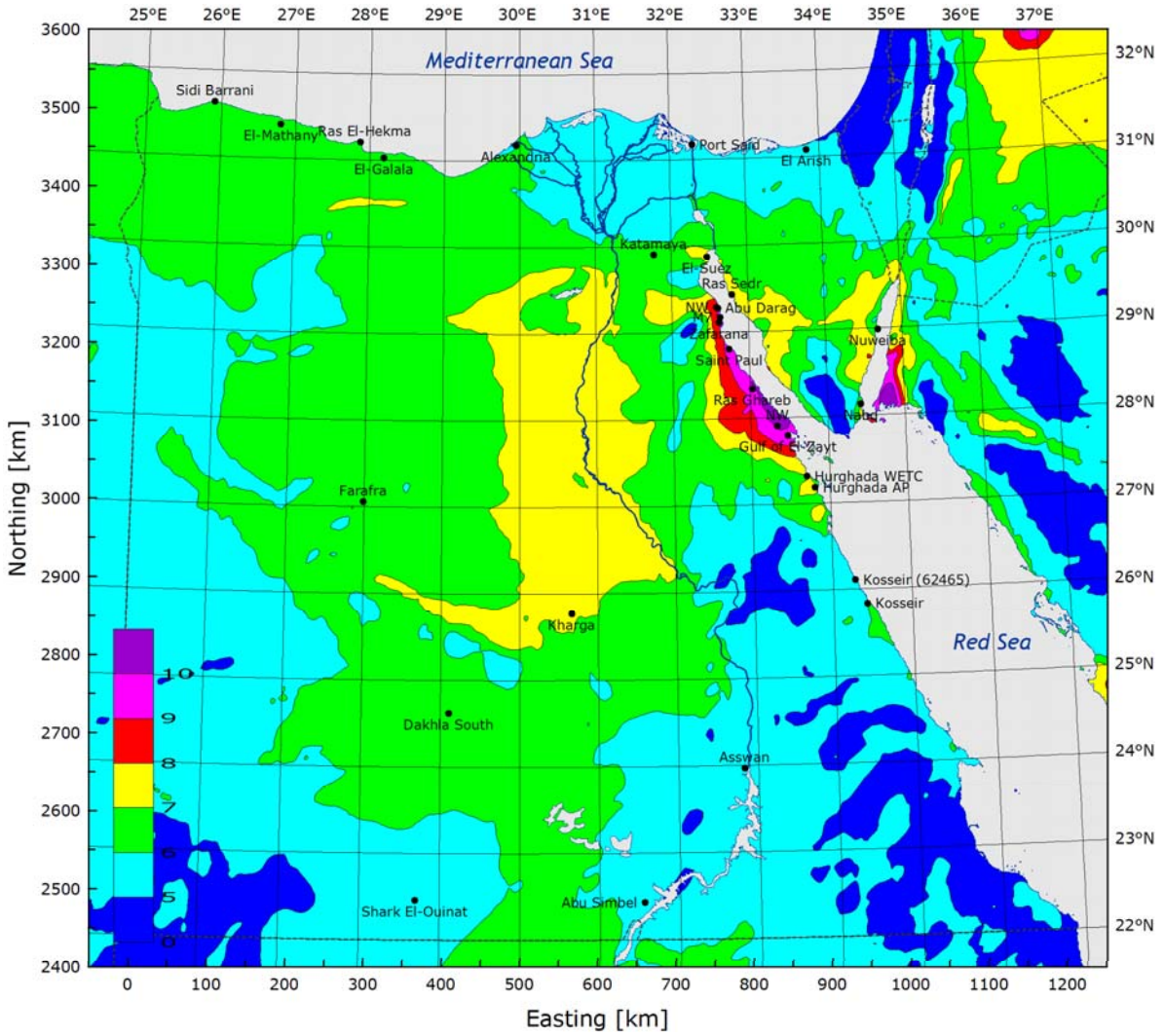


Statistical/dynamical downscaling using self organizing maps and Penn State/NCAR mesosocale model (MM5)



Average annual wind speed at 10 m above ground (m/s)
Kilian Hagemann, University of Cape Town (2008)

Numerical Wind Atlas for Egypt 2001-2005



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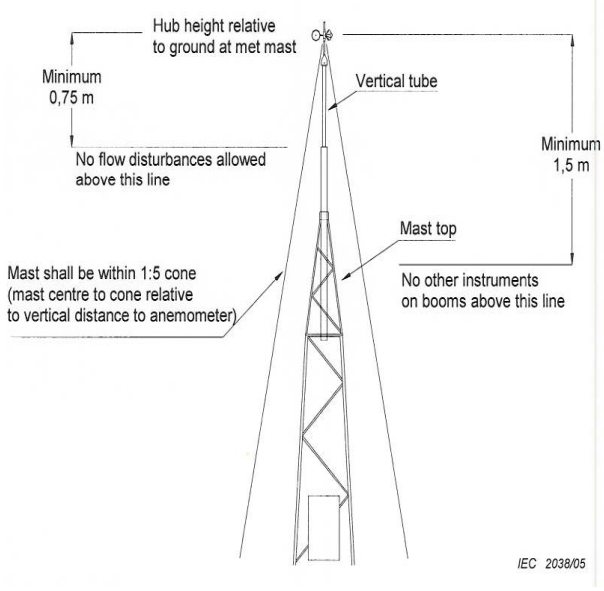
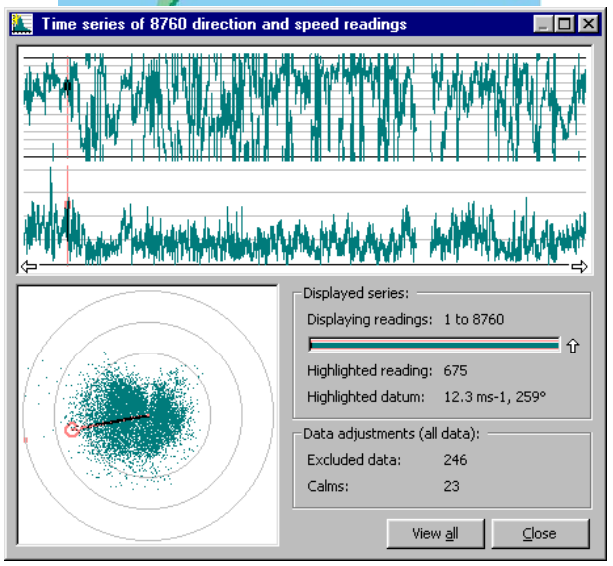
Verification
observed wind climate / wind measurements

The wind data must be

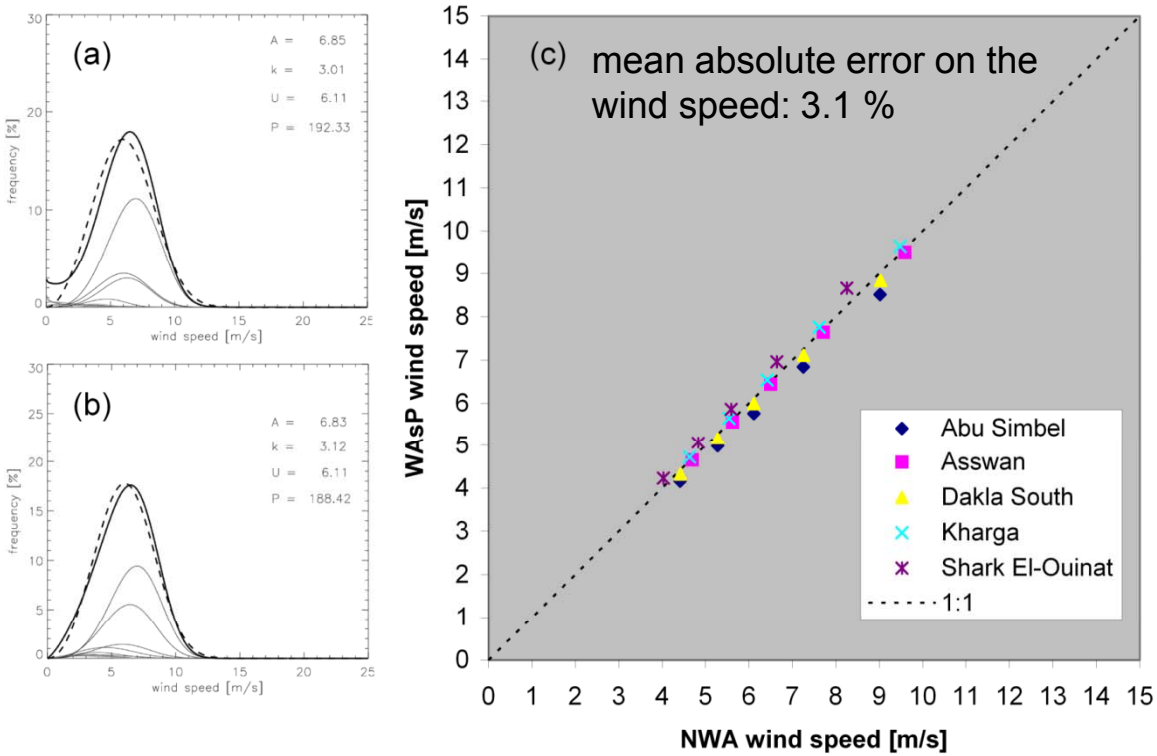
- accurate
- representative
- reliable

Proven sensors and instrumentation





Verification – example



Typical mean absolute error on the wind speed: 5-10 %

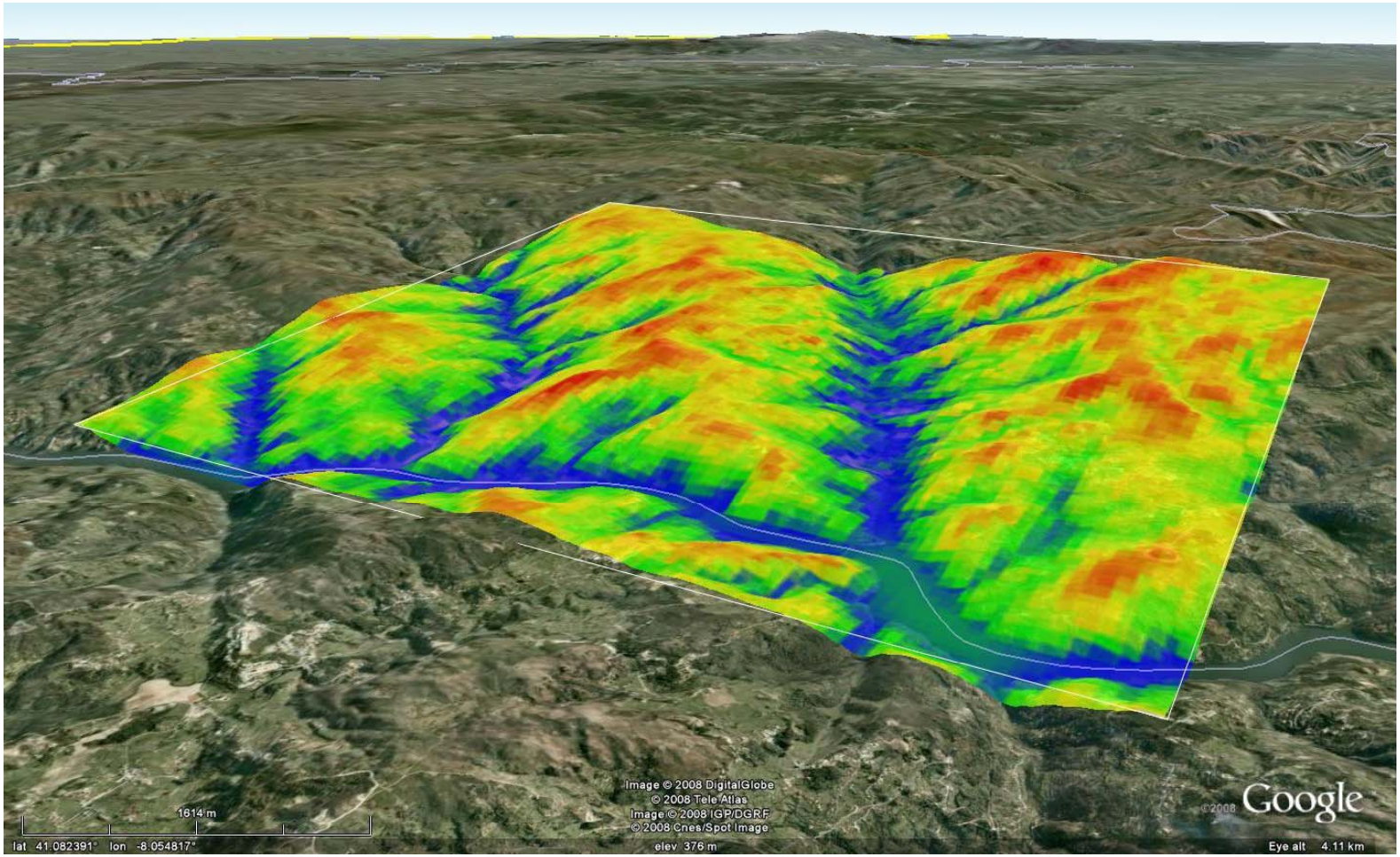
Comparison of generalized wind speed distributions a) mesoscale NWA modelled and b) measured, as well as comparison of c) generalized mean wind speeds at selected sites in Egypt

- heights over flat terrain: 10 m, 25 m, 50 m, 100 m and 200 m
- homogenous surface roughness of z_0 = 0.03 m

Application

- Wind resource assessment for planning and project preparation
- Siting of wind farms and turbines
- Bankable projects – close to masts

Sample wind resource map



The numerical wind atlas method - summary

Mesoscale	**Pre-processing** Wind classes Terrain elevation Terrain roughness Input specifications Model setup	**Modelling** KAMM WRF MC2 MM5 etc.	**Post-processing** Predicted wind climate Regional wind climate Predicted wind resource for selected terrain site coordinates	**Numerical WA** Mesoscale maps Database WAsP *.LIB files Uncertainties Parameters
Measurements	**Met. stations** Siting Design Construction Installation Operation	**Wind data** Data collection Quality control Wind database Wind statistics Observed wind climate	**Verification** Meso - and microscale results vs. measured data Adjust model and model parameters to fit data Satellite imagery (offshore sites only)	**Applications** Best practices Courses and training Microscale flow model Wind farm wake model ⇒ **Wind farm AEP**
Microscale	**Pre-processing** Wind speed distributions Wind direction distribution Terrain elevation Terrain roughness Sheltering obstacles	**Modelling** WAsP MS-Micro CFD-models etc.	**Post-processing** Regional wind climate Predicted wind climate Predicted wind resource for selected terrain site coordinates	**Observational WA** Microscale maps Database WAsP *.LIB files Uncertainties Parameters

Wind Atlas for South Africa (WASA)
Western Cape and areas of Northern and Eastern Cape

Work Packages

WP1 – Mesoscale wind modelling
- KAMM /WRF/WAsP statistical/dynamical downscaling
- WRF – dynamical downscaling

WP2 – Wind measurements
- 10 high quality met stations 50-80m for verification
- Database of measured data

WP3 – Micro scale wind modelling
- Creation of Observational Wind Atlas for selected measurement sites in South Africa

WP4 – Application for wind resource assessment
- Mid-term Workshops for invited stakeholders from e.g. authorities, planners, developers, banks, scientists, etc.
- Develop tools - guidelines and training materials
- Micro-scale resource map for 30-50% of the modelled areas in the three provinces, incl. integration as GIS layer
- Final Workshops and training of trainers for invited stakeholders, incl. opportunities for application in determination of extreme wind climate; seasonal forecasting; and other than wind energy.

WP5 – Extreme winds
- Application of mesoscale modelling results to the estimation of an extreme wind climate of South Africa

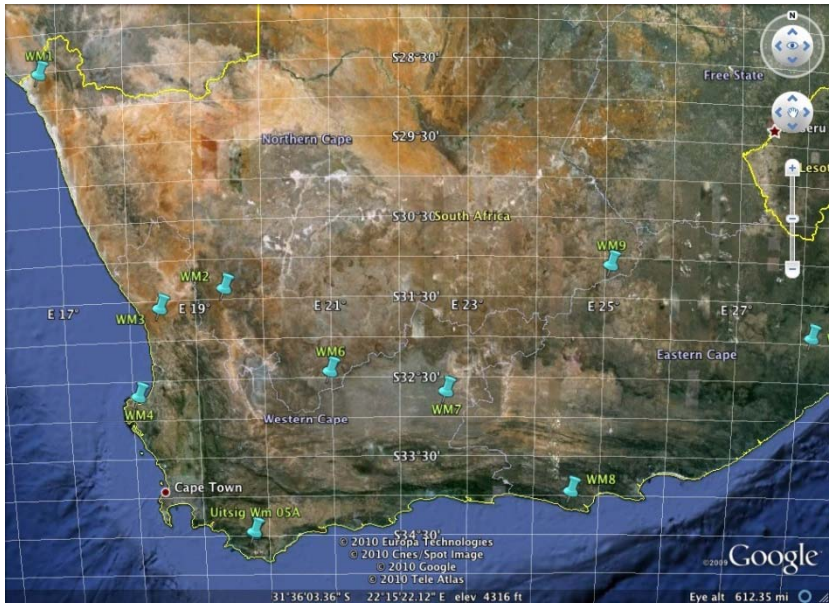
WP6 – Documentation and dissemination
- Prepare and disseminate research publications, incl. final book and homepage publication
- Prepare national wind seminars
- Establish and document research cooperation between South African and international wind research partners.

WASA project – main outputs

- The project is phased
  - Measurement program for verification for a total period of 3-years
  - First wind atlas according to standard proven and tested method after 1 year of measurements
  - Researched wind atlas after 3 years of measurements

- All results in public domain

- UCT to be national compentence center for mesoscale modelling
- CSIR-Stellenbosch to be national competence center for high-quality measurements
- CSIR-Pretoria to be national competence center for microscale modelling
- SAWS to be national competence center for extreme wind assessment
- SANERI responsible for coordination and dissemination



WASA project – status -1

- Contract signed 30 June 2009 by SANERI, CSIR, UCT, SAWS and RISOE – Project Commencement

- Current activities by Work Package

WP1 – Mesoscale wind modelling

– KAMM /WAsP statistical downscaling – ongoing and
– WRF – dynamical downscaling – planning and familiarisation (weather forecast for SA running)
– Awaiting WP2-data for verification

WASA project – status -2

WP2 – Wind measurements

- Site selection criteria developed
- Site selection, site visits, land owner interaction and agreements completed
- Masts designed, procured and manufactured
- Measurement equipment designed and delivered
- Data acquisition system delivered, installed and training completed
- EIA - Basic assessment procedure negotiated and application document submitted
- Current issues
    - Environmental approvals (expected 7 sites in March and 3 sites in May)
    - Land ownership (1 site)
    - Land use regulations (1 site)
    - Civil aviation regulations (1 site)
- Activities awaiting environmental approvals
    - Site preparations and foundation construction
    - Mast transport to site and erection
    - Instrumentation
    - Data acquisition, RODEO, web-access and data availability
- Full measurement system operation expected to start July 2010

WASA project – status -3

WP3 – Micro scale wind modelling

– Micro-scale workshop for all partners held November 2009

WP4 – Application for wind resource assessment

– Mid-term Workshops for invited stakeholders
– Develop tools - guidelines and training materials
– Micro-scale resource map, incl. integration as GIS layer

WP5 – Extreme winds

– Training in WAsP-Engineering for application in upgrading the estimation the extreme wind climate of South Africa

WP6 – Documentation and dissemination

– Research publications
– Homepage publication
– Wind seminars and workshops
– Research cooperation