Mesoscale Mapping of RE Resources
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Introduction to mesoscale and microscale wind resource mapping

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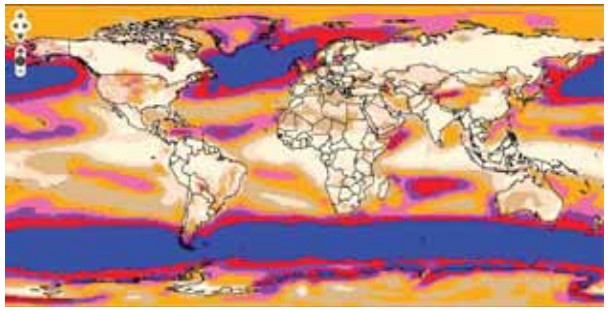
Wind resource mapping types, coverage, resolution

Macro

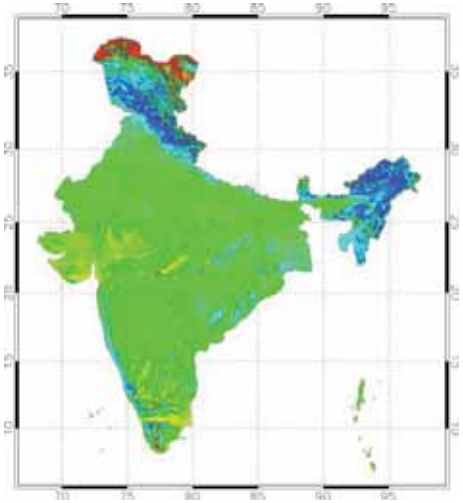
Global coverage



~50-200 km

Meso

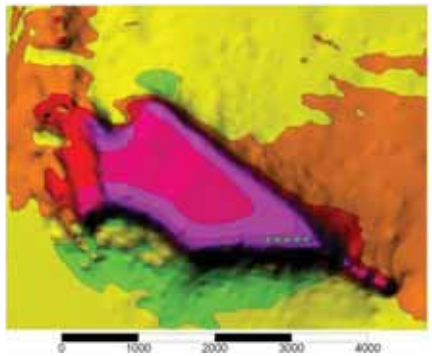
National coverage



~5 km

Micro

Local/site coverage



~10 – 100m

resolution increasing

Sources:
NASA data Indian Wind Atlas CWET/Risø DTU

Macro scale wind resource modelling

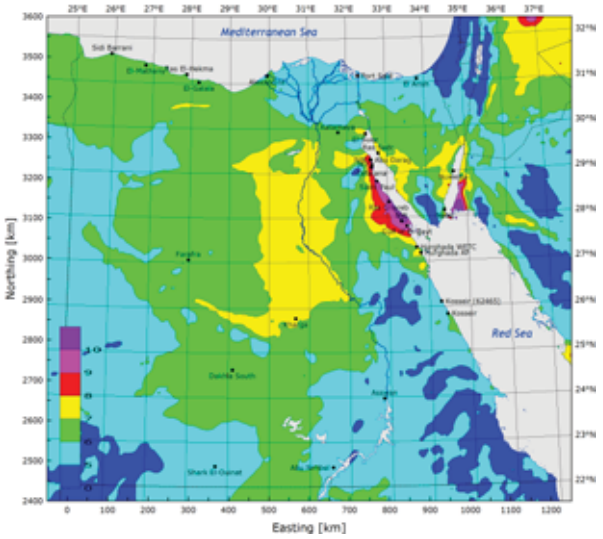
Table 7.1 | Global assessments of the technical potential for wind energy.

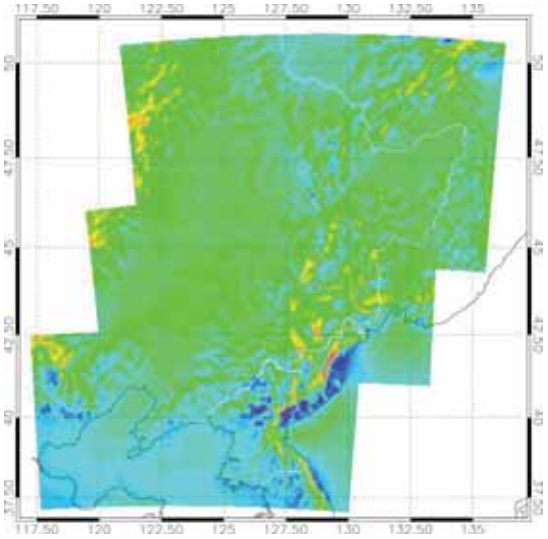
Study	Scope	Methods and Assumptions*	Results**
Krewitt et al. (2009)	Onshore and offshore	Updated Hoogwijk and Graus (2008), itself based on Hoogwijk et al. (2004), by revising offshore wind power plant spacing by 2050 to 16 MW/km^2	*Technical (more constraints):* 121,000 TWh/yr 440 EJ/yr
Lu et al. (2009)	Onshore and offshore	>20% capacity factor (Class 1); 100 m hub height; 9 MW/km^2 spacing; based on coarse simulated model data set; exclusions for urban and developed areas, forests, inland water, permanent snow/ice; offshore assumes 100 m hub height, 6 MW/km^2, <92.6 km from shore, <200m depth, no other exclusions	*Technical (limited constraints):* 840,000 TWh/yr 3,050 EJ/yr
Hoogwijk and Graus (2008)	Onshore and offshore	Updated Hoogwijk et al. (2004) by incorporating offshore wind energy, assuming 100 m hub height for onshore, and altering cost assumptions; for offshore, study updates and adds to earlier analysis by Fellows (2000); other assumptions as listed below under Hoogwijk et al. (2004); constrained technical potential defined here in economic terms separately for onshore and offshore	*Technical/Economic (more constraints):* 110,000 TWh/yr 400 EJ/yr
Archer and Jacobson (2005)	Onshore and near-Shore	>Class 3; 80 m hub height; 9 MW/km^2 spacing; 48% average capacity factor; based on wind speeds from surface stations and balloon-launch monitoring stations; near-shore wind energy effectively included because resource data includes buoys (see study for details); constrained technical potential = 20% of total technical potential	*Technical (limited constraints):* 627,000 TWh/yr 2,260 EJ/yr *Technical (more constraints):* 125,000 TWh/yr 450 EJ/yr

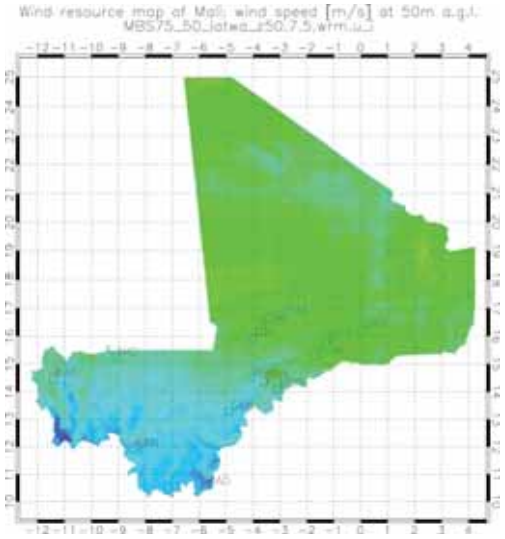
SRREN report: range tech. pot. 19 – 125 PWh / year (onshore and nearshore)

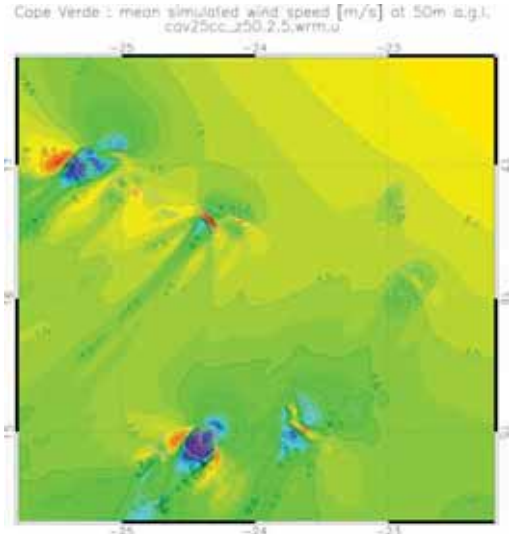
GLOBAL WIND ATLAS ADDRESSES SHORT COMINGS

Mesoscale modelling



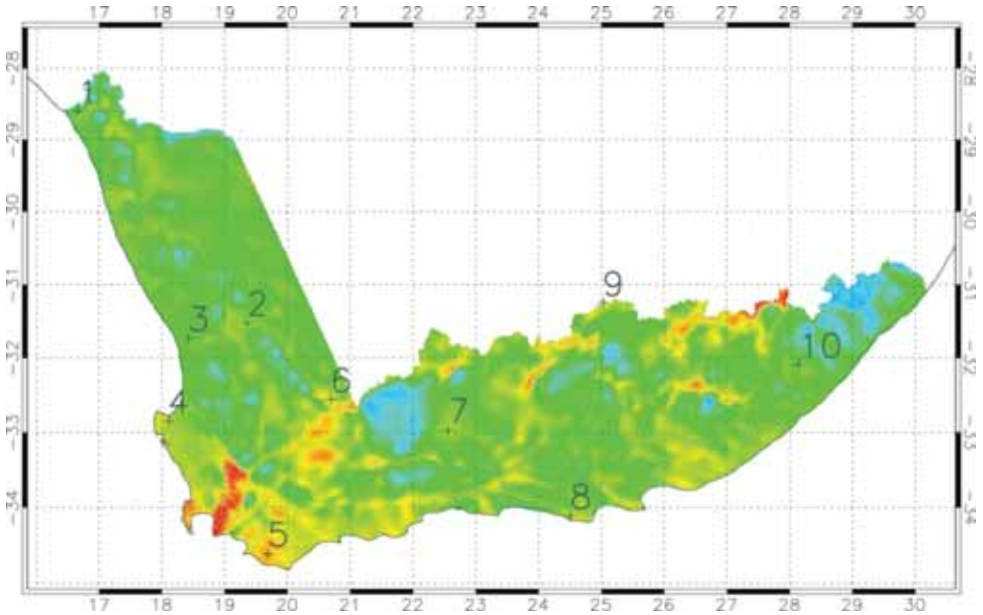






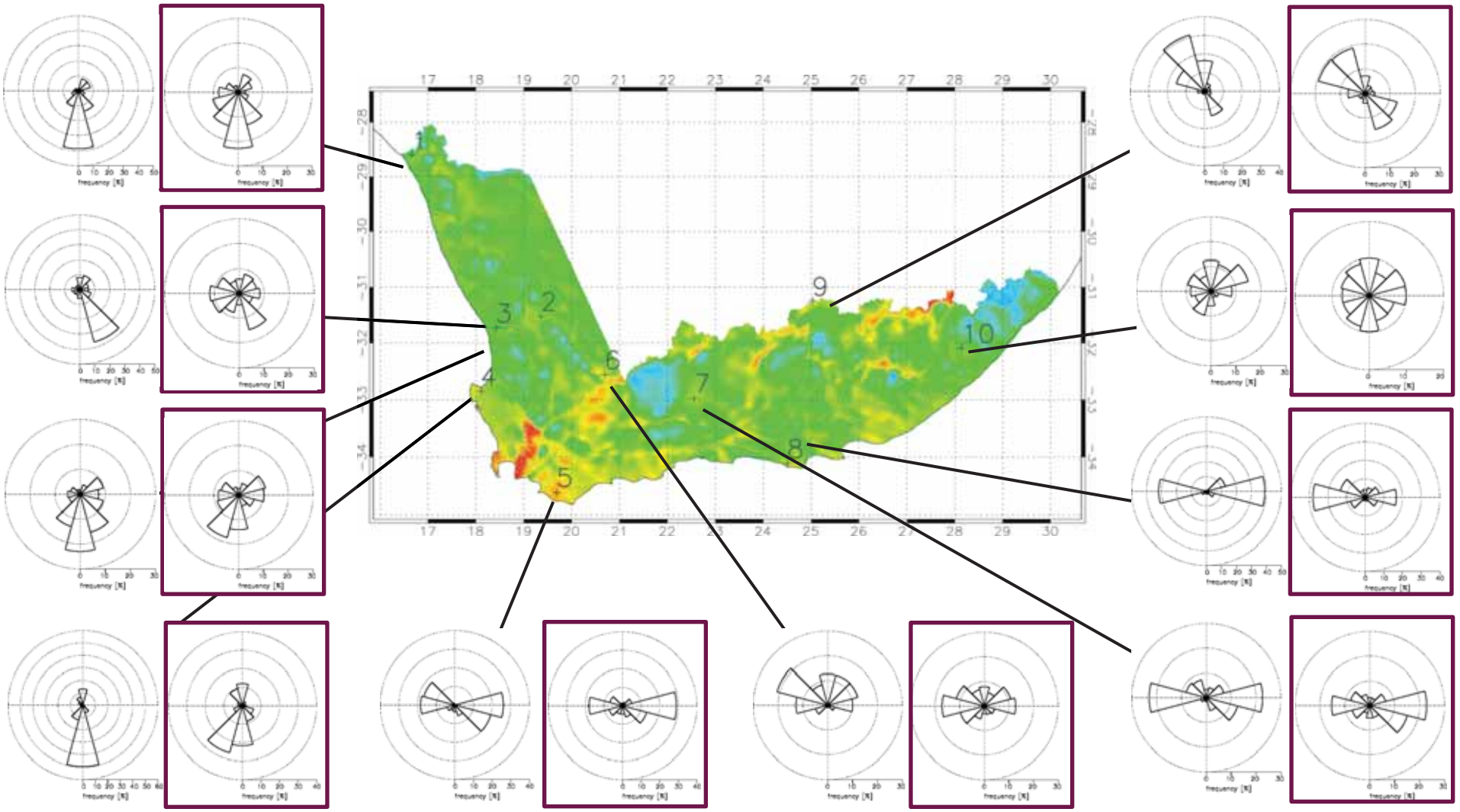
Sources:
Egyptian Wind Atlas
Wind Atlas for Dongbei
Mali Wind Atlas
Cape Verde Wind Atlas

Mesoscale modelling…
…only "half the story"



http://www.wasaproject.info/

Mesoscale modelling and measurement verification...
...makes a wind resource assessment

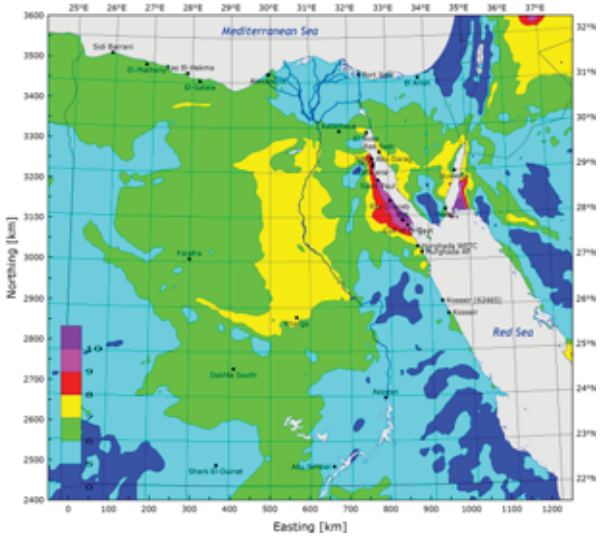


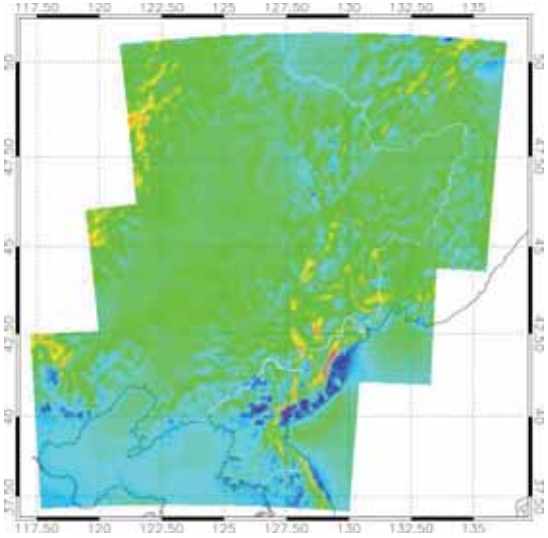
Boxed wind roses derived from observation, unboxed derived from KAMM/WAsP.

http://www.wasaproject.info/

Mesoscale modelling
with uncertainty estimate of wind speeds

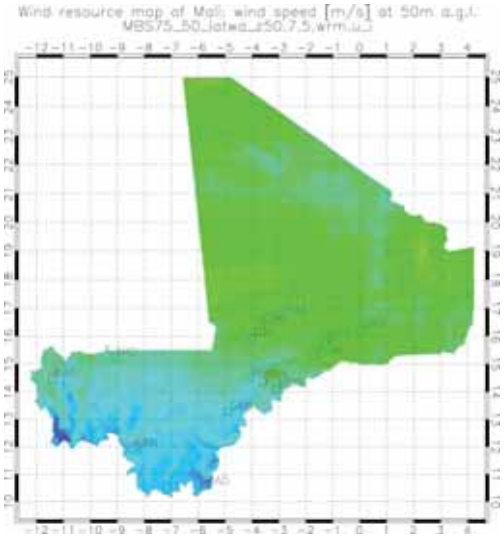
6.7%

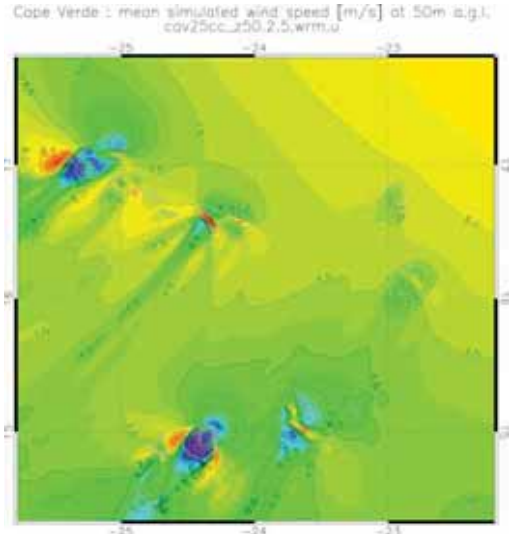




9.6 %

4.3 %

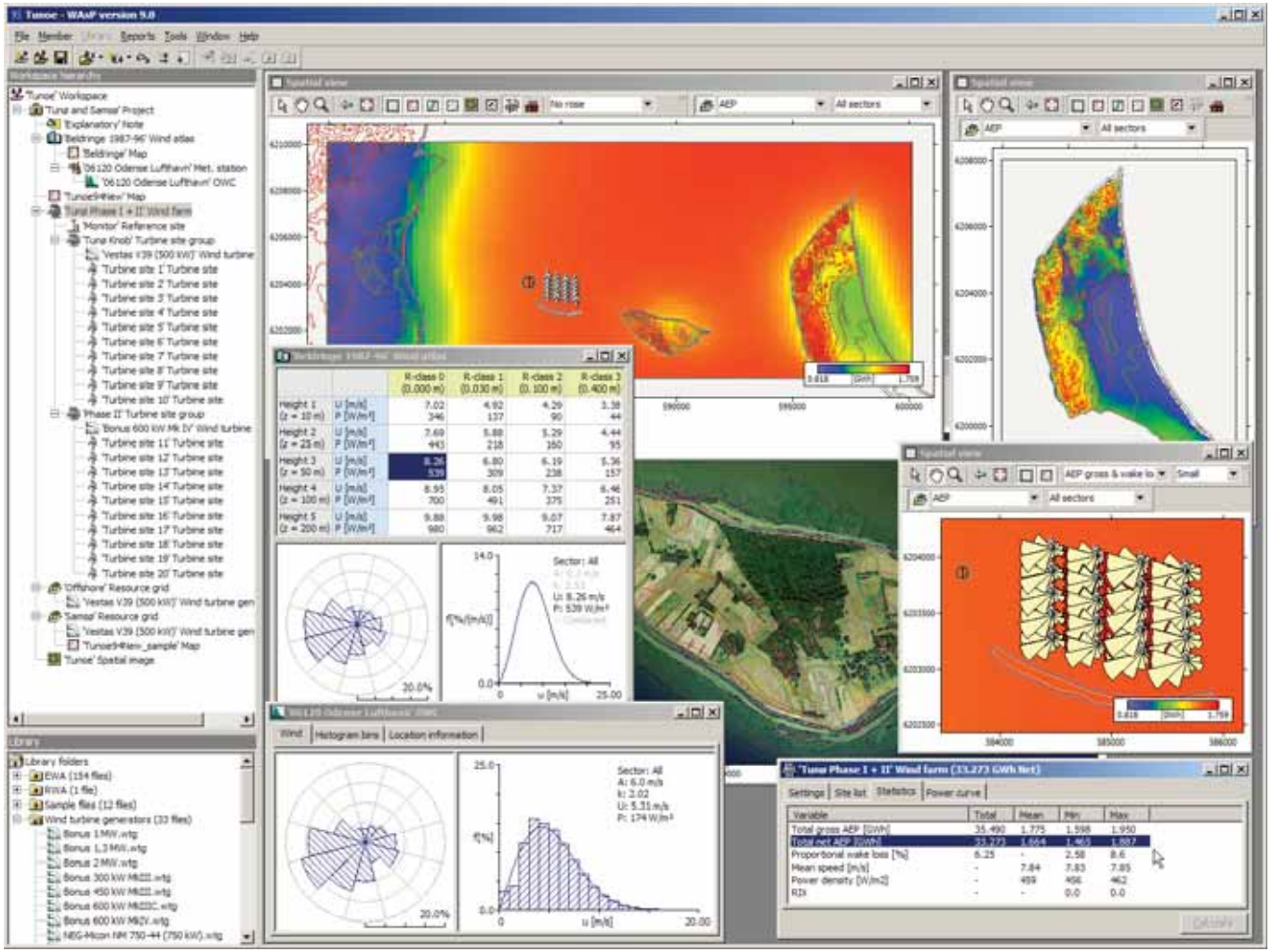




5.6 %

Sources:
Egyptian Wind Atlas
Wind Atlas for Dongbei
Mali Wind Atlas
Cape Verde Wind Atlas

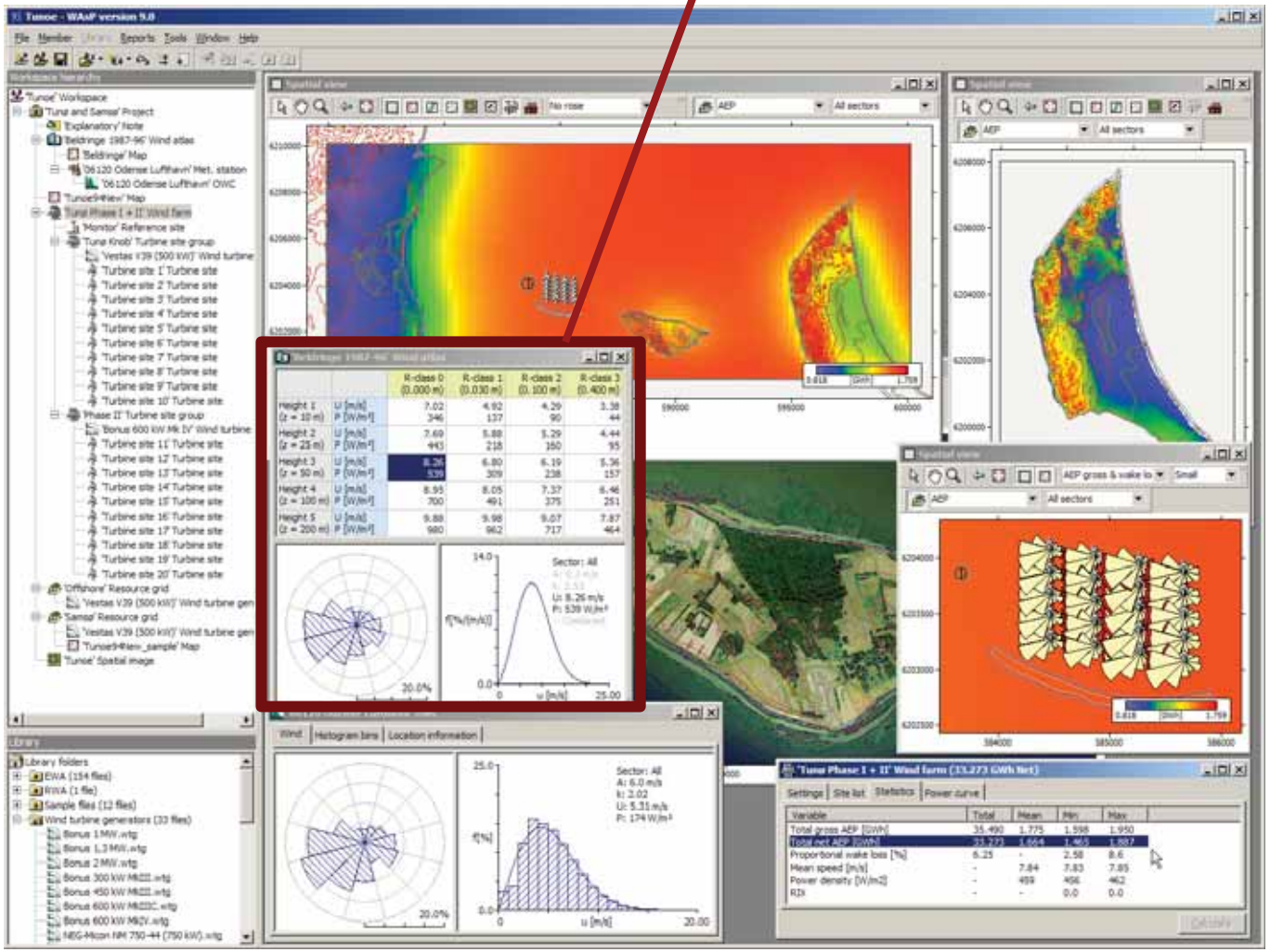
Microscale modelling



www.wasp.dk

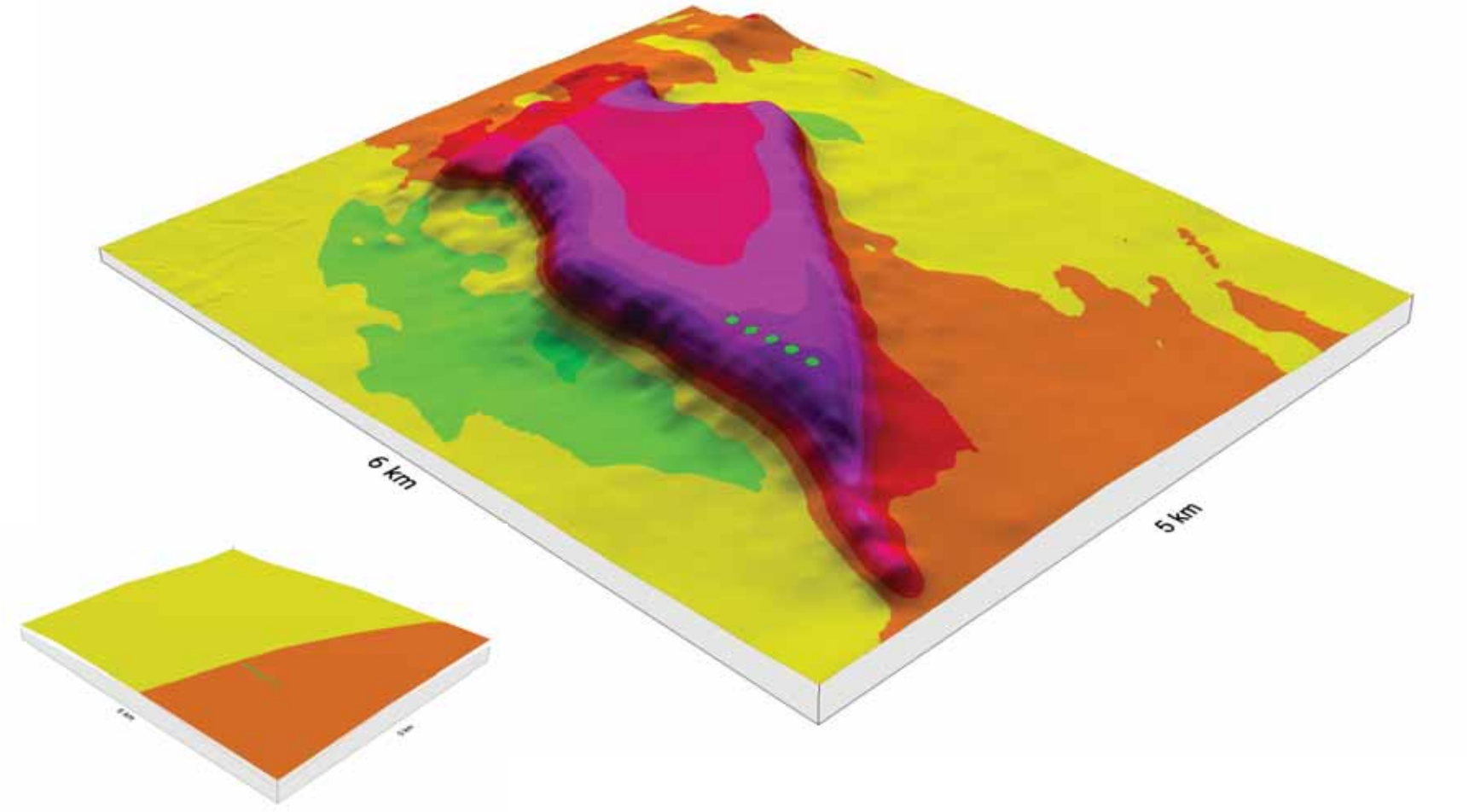
Microscale modelling

Input from mesoscale modelling output



Microscale modelling

Resource is discovered



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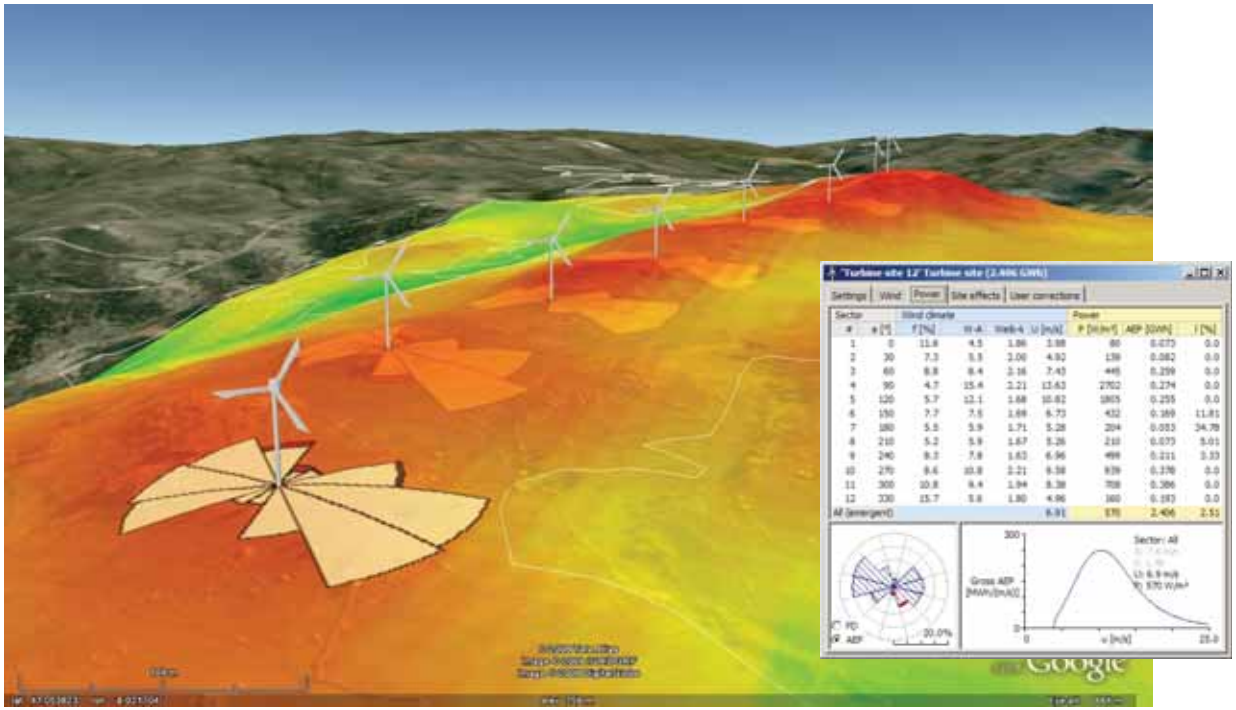
Microscale modelling

Resource is discovered

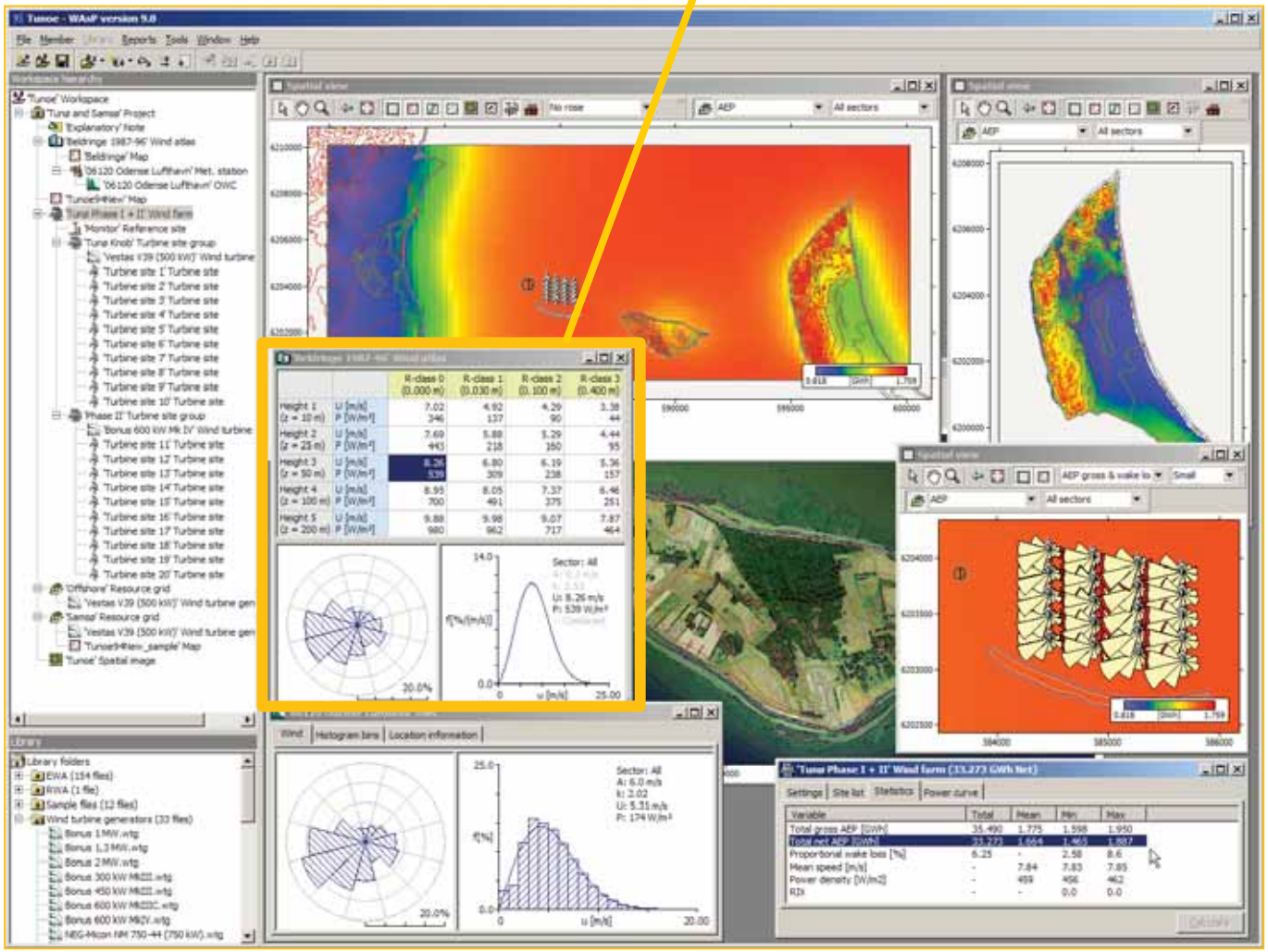


BUT CAREFUL: High resolution does not mean accurate
Verification component essential

For bankability, a wind farm project needs a measurement campaign
and needs due diligence studies

Microscale modelling

Input from analysis of developer's measurements

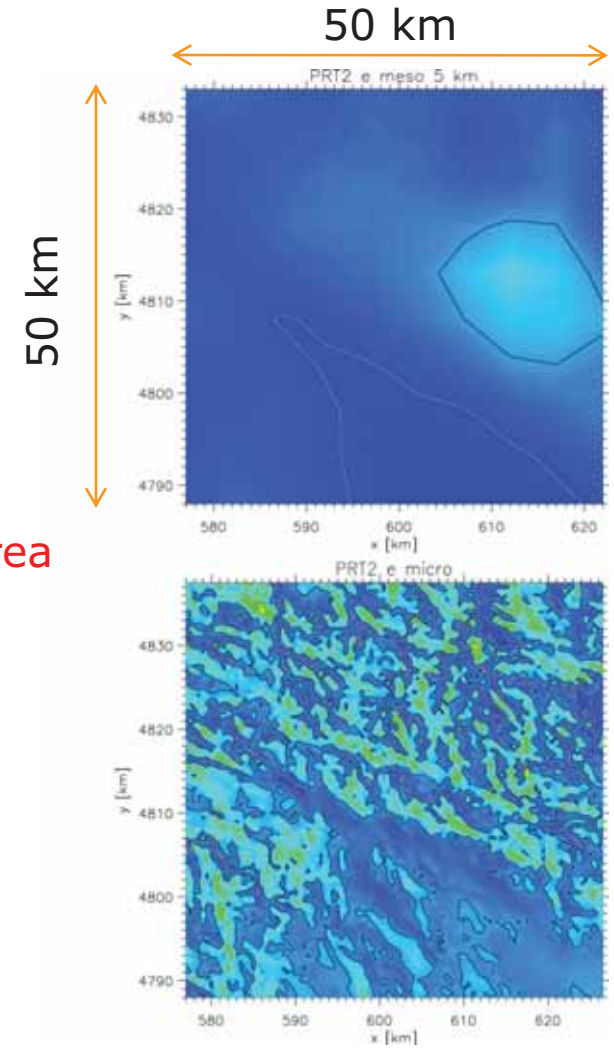


The new Global Wind Atlas
A Clean Energy Ministerial initiative within Global Solar and Wind Atlas

High resolution discovers resources

Wind resource (power density) calculated at different resolutions

mean power density of total area
mean power density for windiest 50% of area



5 km

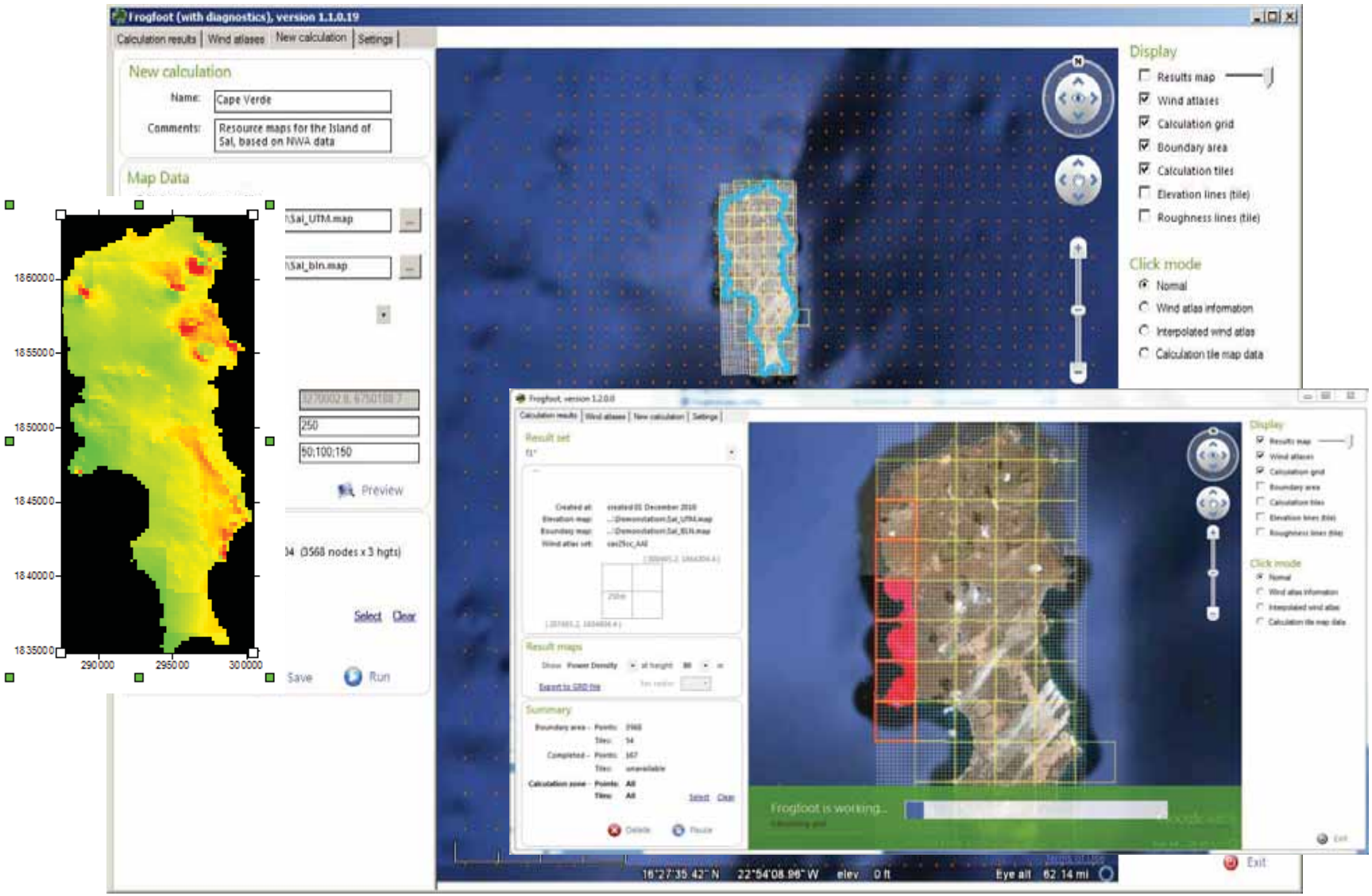
328 W/m^2
398 W/m^2

0.1 km

505 W/m^2
641 W/m^2

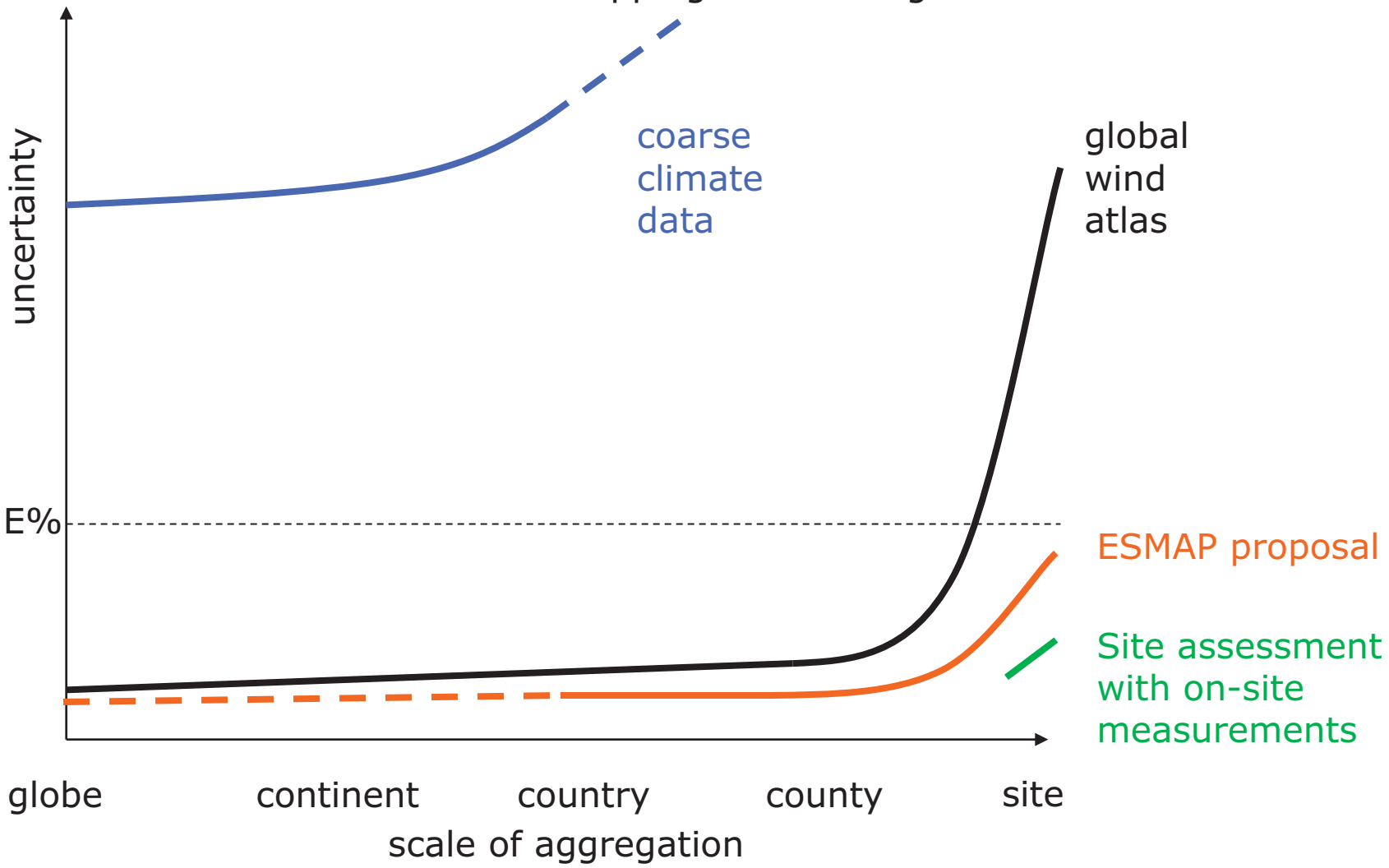
Grant: Danish Energy Agency
EUDP 11-II, Globalt Vind Atlas, 64011-0347

Large scale deployment of microscale modelling



Aggregation

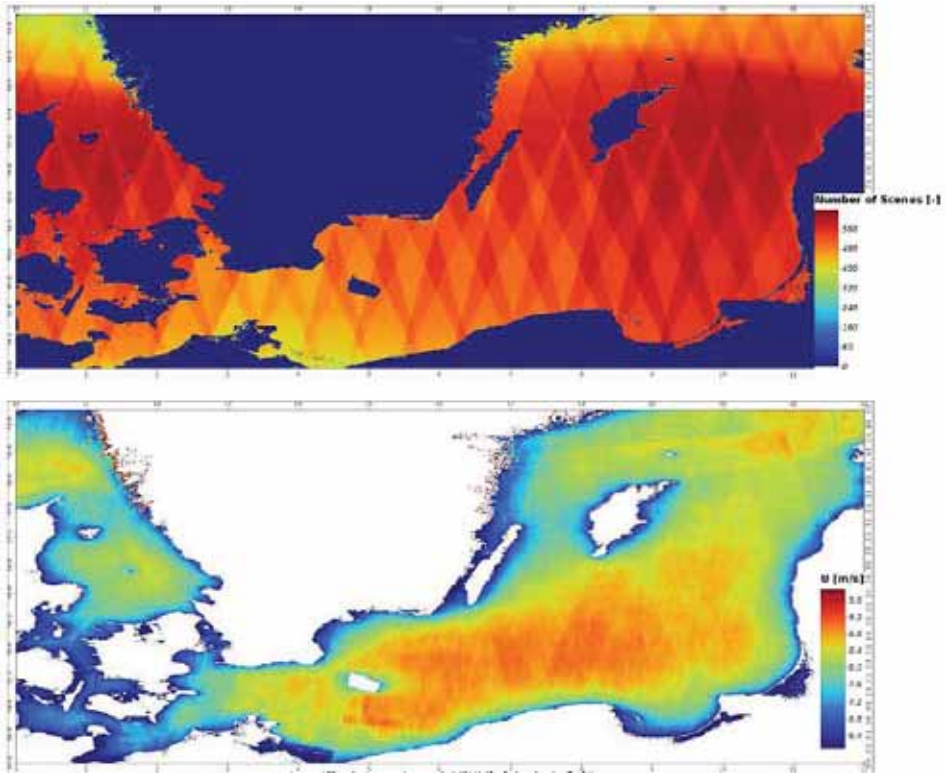
Schematic graph showing uncertainty as function of scale of aggregation for various wind resource mapping methodologies



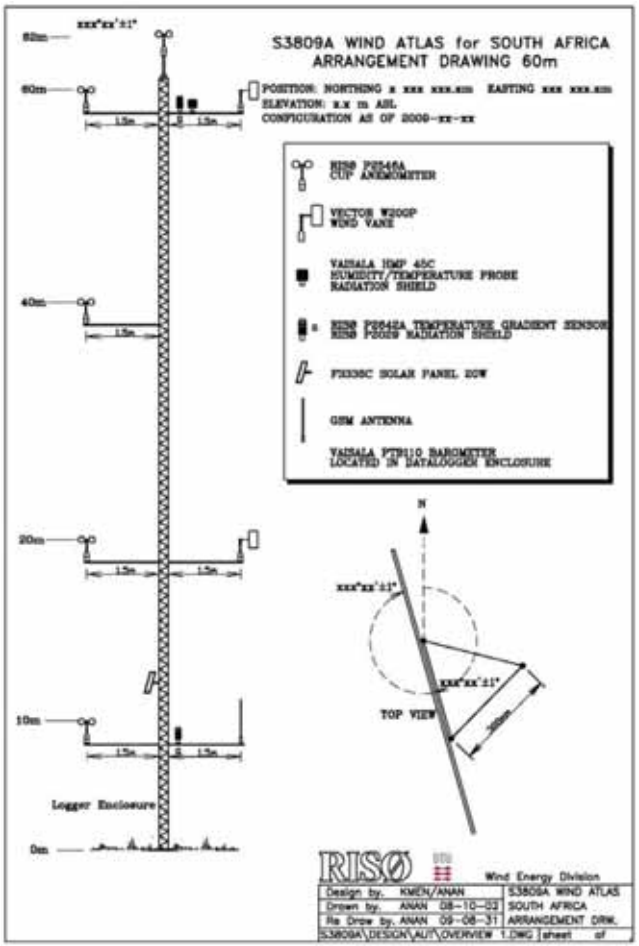
Measurements for verification
In-situ and possibilities for remote sensing offshore

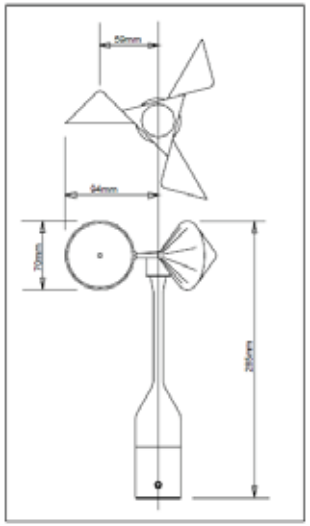
http://www.wasaproject.info/

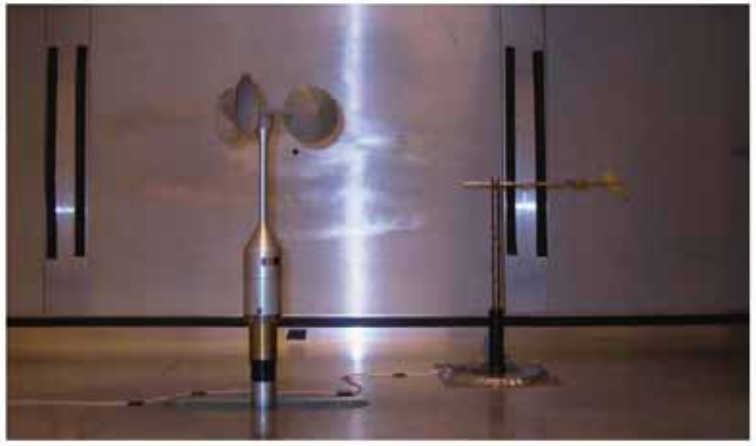
Synthetic Aperture Radar, ocean surface wind retrieval methods



High quality measurement



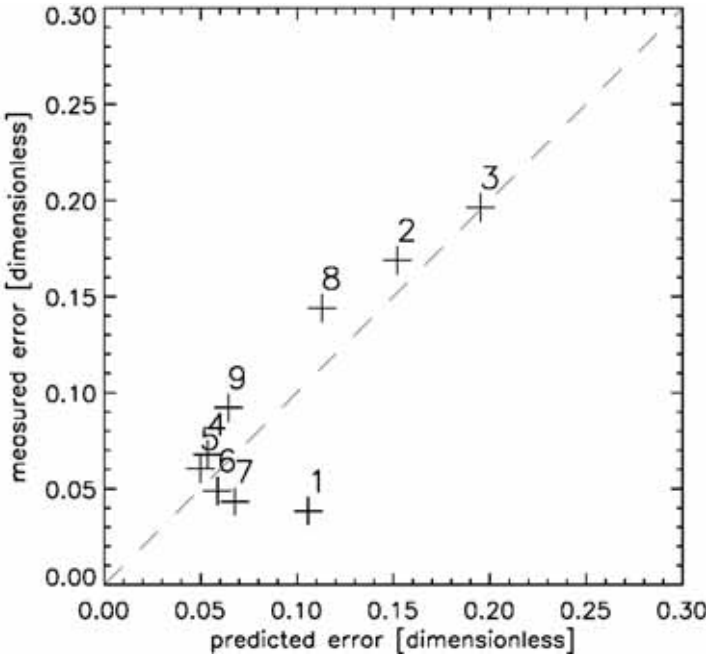


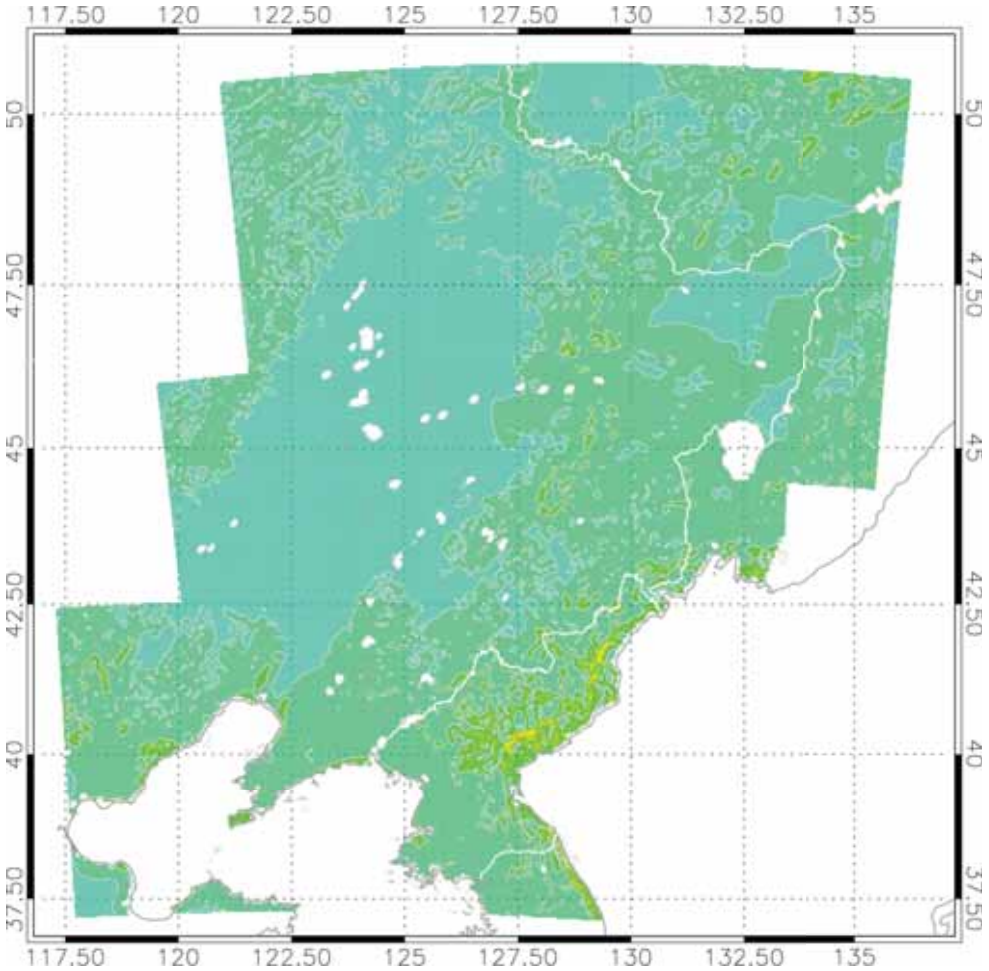


http://www.measnet.com/

An example of an areas of development

Uncertainty mapping





Badger et al, Methods to assess uncertainty of wind resource estimates determined by mesoscale modelling. EWEA Annual Event 2011,Brussels (BE), 14-17 Mar,2011

Summary

1. Downscaling: linkage of models going from large to small scales

2. Modelling can give very high resolution maps...
   ...but verification required to give these value

3. The global wind atlas will give much improved estimate of resource (global/region/country)...
   ...but not precisely where or accurate how much at specific sites

4. Mesoscale modelling and measurements, as in ESMAP proposal, provide
   - robust verified assessment for precise national planning
   - foundation for private developer activities

5. National assessment can fit into Global Solar and Wind Atlas dissemination infrastructure.

THANK YOU FOR LISTENING

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