



The KAMM/WAsP numerical wind atlas - a powerful ingredient for wind energy planning

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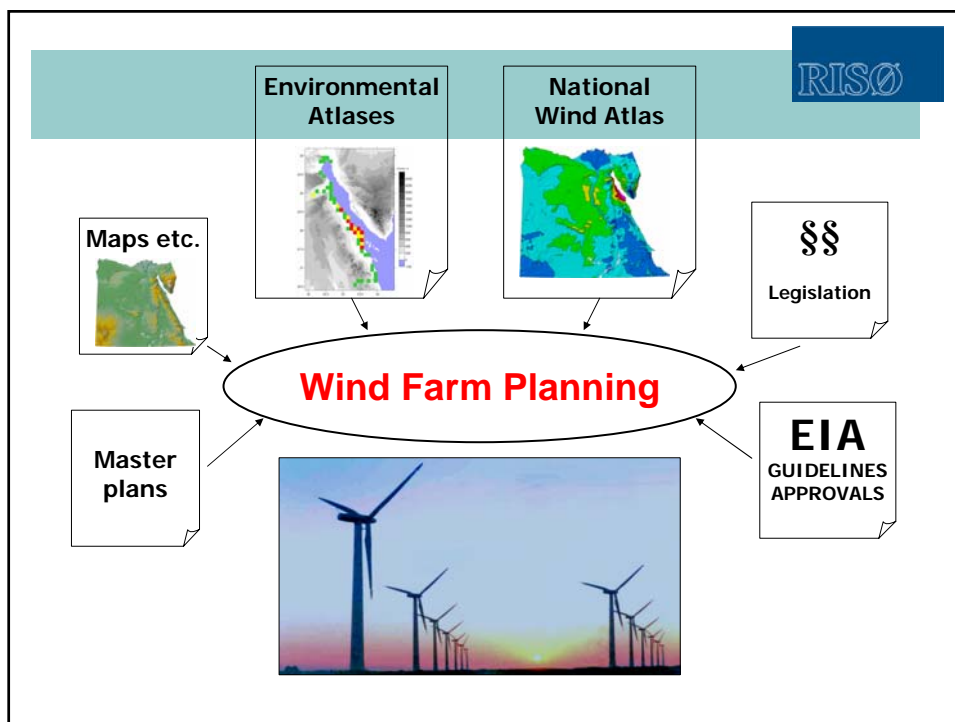
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The KAMM/WAsP Numerical Wind Atlas

A powerful ingredient for wind energy planning

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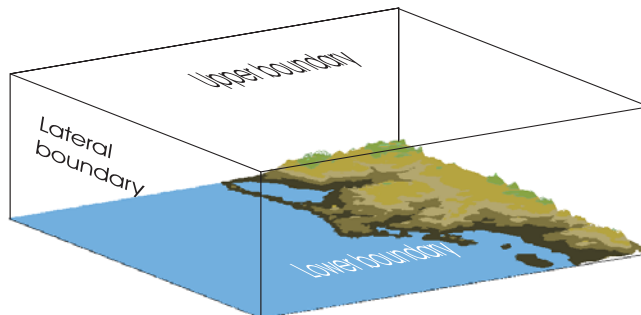
Outline

- Wind resource mapping
 - reanalysis wind climatology (NCEP/NCAR)
 - mesoscale modelling (KAMM)
- Numerical wind atlas
 - numerical wind atlas concept
 - verification of methodology
- Applications and sustainability
 - planning, feasibility studies, project preparation
 - wind farm planning and AEP estimation

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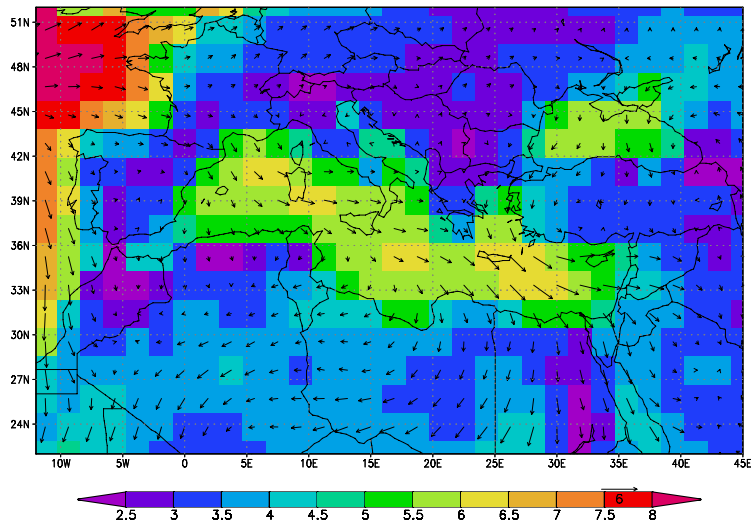
Wind resource mapping by modelling

- Mesoscale model
- Output: annual averages of wind speed and power
- Regular horizontal grid
- Area: 10,000-100,000's of km²
- Resolution: 3-5 km
- Wind measurements are not required, but...
- Super-computer and skilled staff are needed!
- Uncertainty inherently larger than observational wind atlas



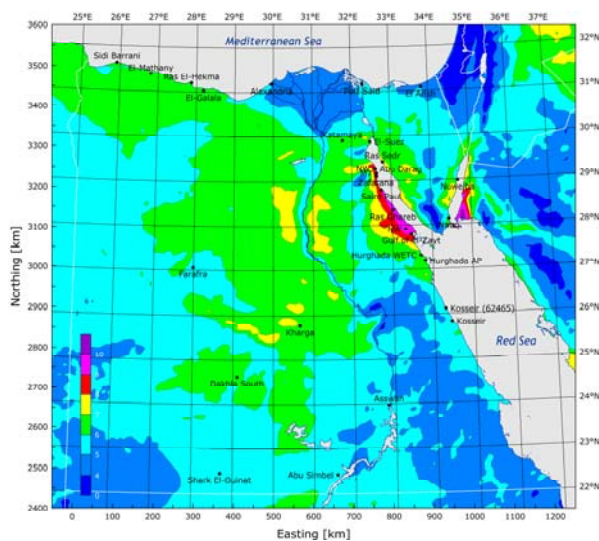
Regional winds from NCEP/NCAR reanalysis

RISØ



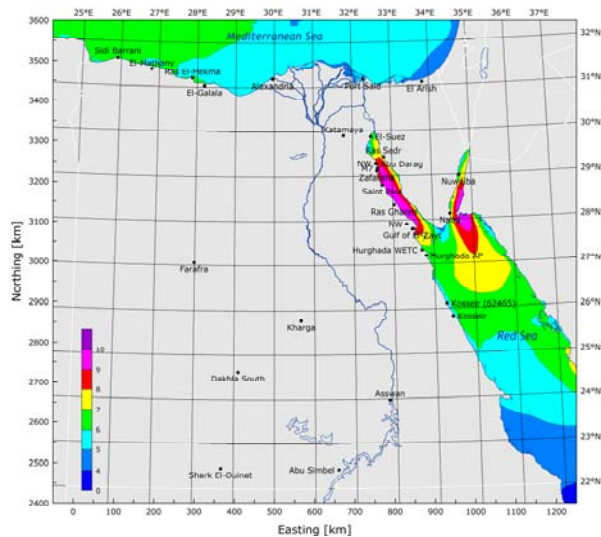
Wind resource map of Egypt

RISØ



- Mean wind speed 50 m a.g.l. [ms^{-1}]
- KAMM modelling
- Resolution 7.5 km
- NCEP/NCAR data
- SRTM30 elevation
- GLCC land cover
- Terrain features may give higher wind speeds locally!
- Output formats:
 - map graphics
 - statistics

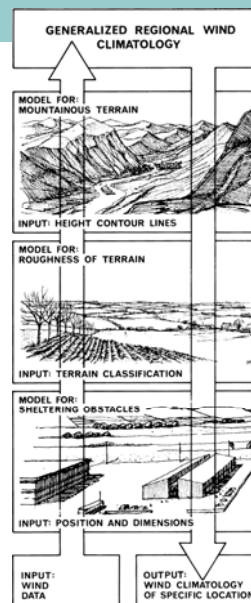
...and Egyptian offshore wind resources



- Mean wind speed 50 m a.s.l. [ms^{-1}]
- KAMM modelling
- Resolution 7.5 km
- NCEP/NCAR data
- Output formats:
 - map graphics
 - statistics

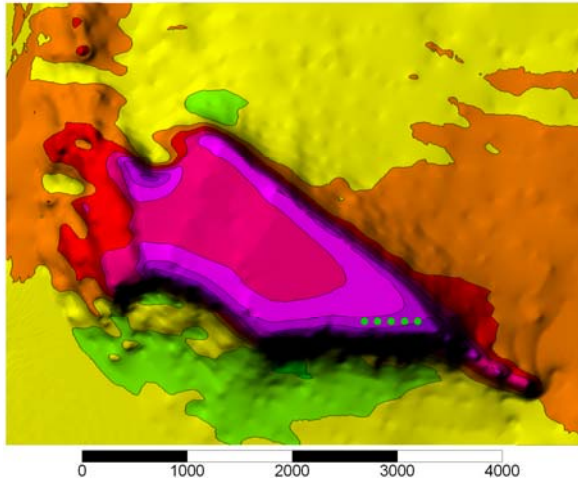
Numerical wind atlas

- NWA analysis procedure \uparrow (WAsP-like)
 - **KAMM Predicted Wind Climate**
 - ($> 50,000$ virtual met. stations!)
 - + roughness map (GLCC)
 - + elevation map (SRTM30)
 - \Rightarrow **Regional Wind Climate**
- Application procedure \downarrow (WAsP)
 - **Regional Wind Climate**
 - + sheltering obstacles
 - + roughness map (GE)
 - + elevation map (SRTM3)
 - \Rightarrow **Predicted Wind Climate**
 - + power and thrust curves
 - \Rightarrow **Predicted wind farm AEP**

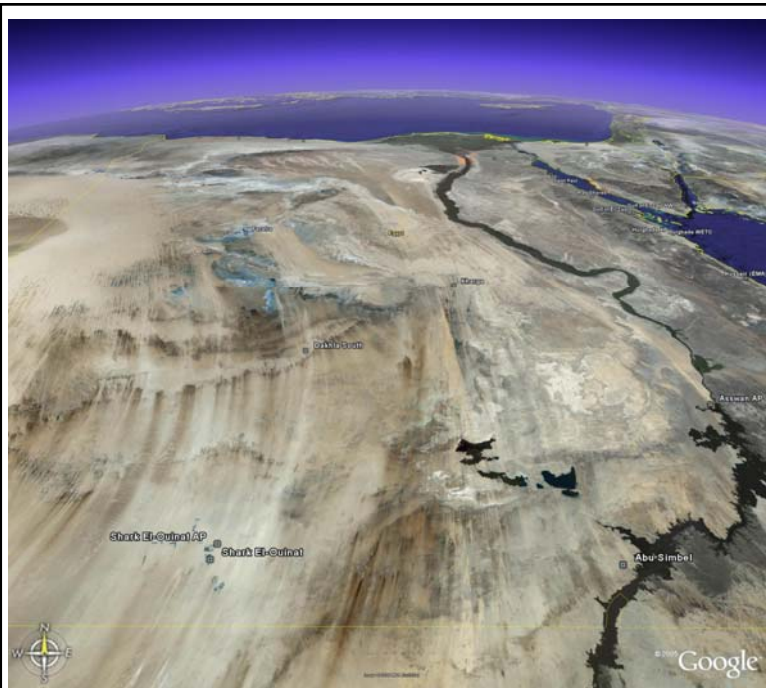


Detailed wind resources

RISO



- WASP modelling of detailed mean wind speed @ 10 m a.g.l.
- Resolution 25 m
- KAMM regional wind climate
- *But does it work in practice?!?*



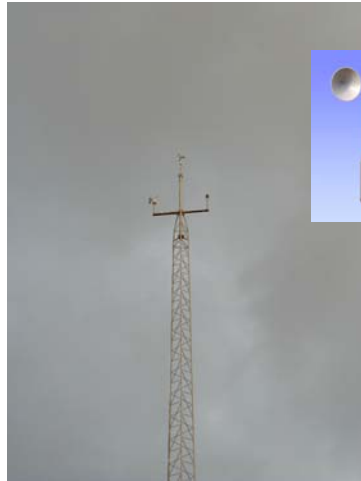
RISO

Meteorological mast in Egypt

RISØ



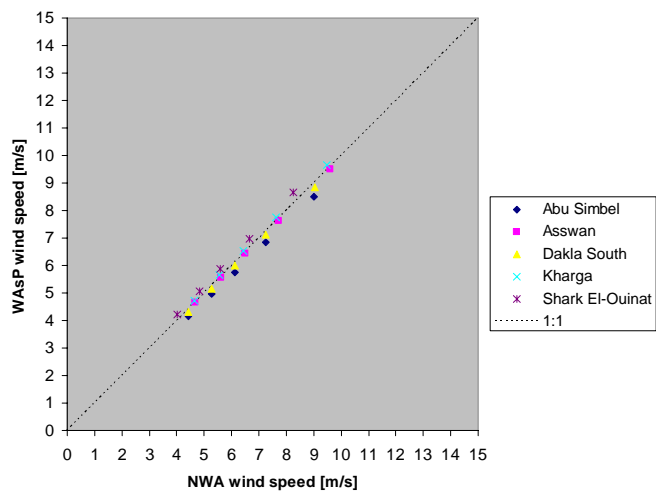
25-m lattice tower, concrete foundation

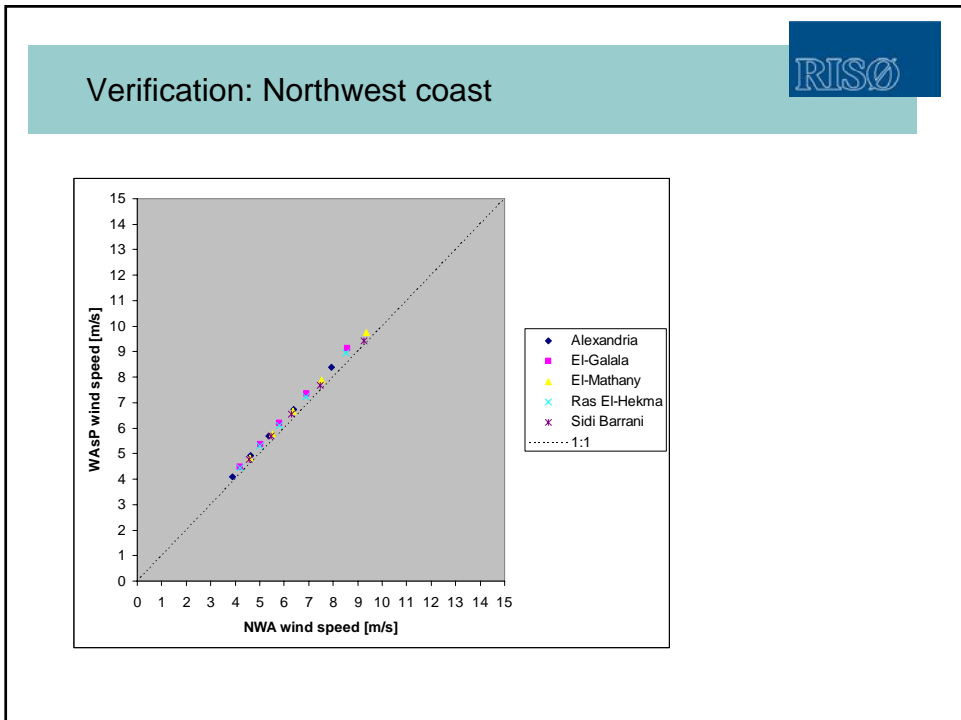
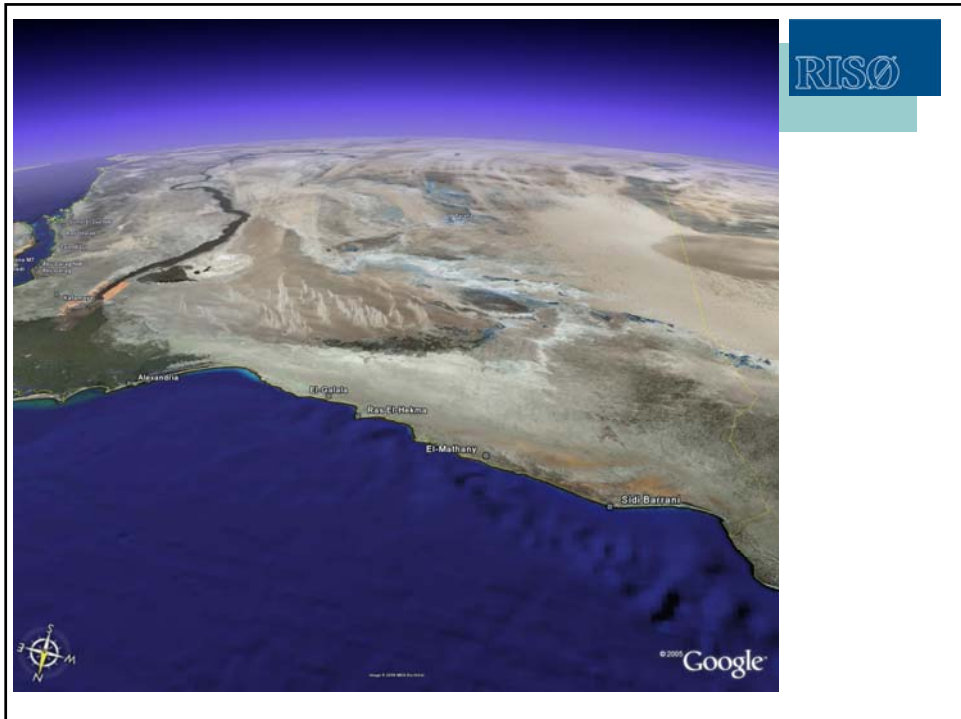


Top-pole mounting to avoid flow distortion

Verification: Western Desert

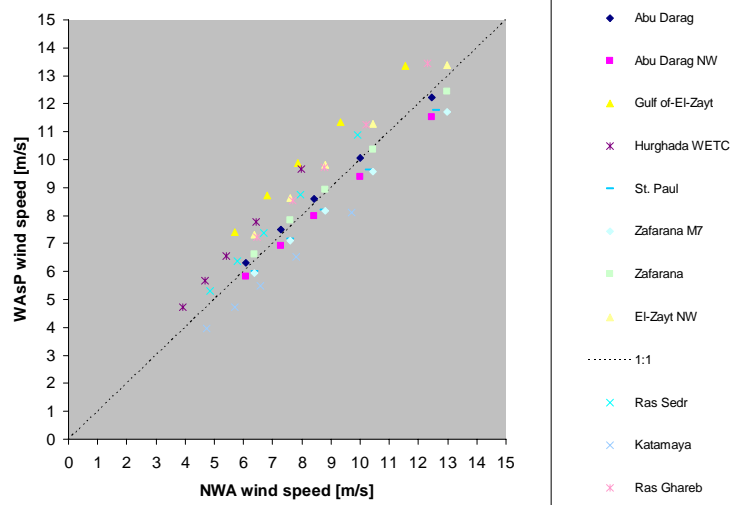
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Verification – Gulf of Suez/Red Sea



Verification in Egypt – summary



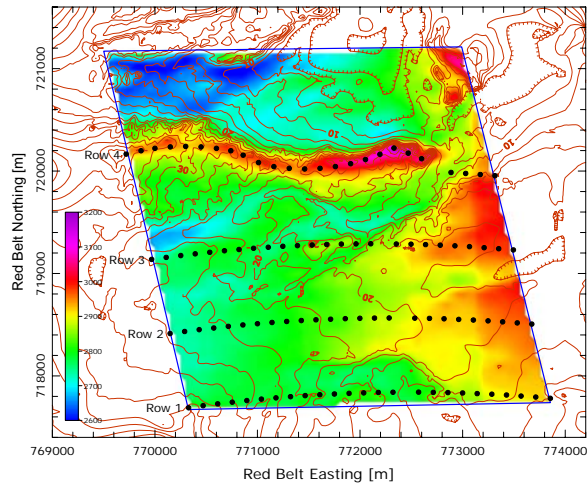
Domain	Grid size	Mean abs. error	
		All stations	Selected stations
	[km]	[%]	[%]
Western Egypt	7.5	12.4	—
Eastern Egypt	7.5	7.6	—
Northwest Coast	5.0	5.2	—
Western Desert	5.0	3.1	—
Gulf of Suez	5.0	9.4	5.6
Red Sea	5.0	10.5	4.4

Numerical Wind Atlas – application range



- 1. National scale** wind resource overview
 - Input: numerical wind atlas database (large domains)
 - Output: resource maps, statistics, GIS data,...
 - Purpose: national planning, decision making, master plans,...
- 2. Regional scale** resource assessments and wind power planning
 - Input: numerical wind atlas database (regional domains)
 - Output: as 1. + predicted wind climates, power productions,...
 - Purpose: regional planning, feasibility studies,...
- 3. Local scale** resource assessments and wind farm planning
 - Input: observational wind atlas data
 - Output: as 1. + predicted wind climates, power productions,...
 - Purpose: planning, feasibility studies, project preparation,...
 - Bankable resource assessments close to met. stations

Detailed wind resources at Zafarana



A complete NWA package

- Wind-climatological inputs
 - Numerical wind atlas (nation-wide)
 - Observational wind atlas (met. stations)
- Topographical inputs (nation-wide)
 - SRTM 3" elevation data
 - SRTM Water Body Data (coasts, lakes, rivers)
 - Google Earth satellite imagery (land-use)
 - Topographical and thematic maps
- Software tools
 - Microscale modelling tools
 - Terrain mapping tools
- Technology transfer and capacity building

The future...

- Numerical wind atlas (KAMM/WAsP methodology)
 - Long-term data (1948-present) – infrequent updating ok
- Observational wind atlas
 - Some reference met. stations should continue
 - New measurement programmes may be initiated
 - Wind Atlas can be updated, extended and detailed
- Main conclusions for Egypt
 - wind resource assessment, siting and wind farm planning can now be done within hours anywhere in Egypt
 - Mean absolute error on U typically around 5%
 - present approach may be continued for several years

THE END

Thank you for your attention! ☺



(slide by Magnus, 10 years old)