Wind atlas for Egypt - overview and applications

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Wind Atlas for Egypt – overview and applications

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Wind Atlas for Egypt project(s)

- Previous project (1991-1996)
  - Wind Atlas for the Gulf of Suez (4 stations)
  - Hurghada Wind Energy Technology Centre
  - Demonstration Wind Farm
  - Wind Energy Master Plan for Egypt
  - Wind Atlas for the Gulf of Suez (13 stations)
  - Preliminary Wind Atlas for Egypt (25 stations)
  - Wind Atlas for Egypt (31 stations + NWA)
Wind Atlas for Egypt

- 11 wind atlas stations in operation (+12 NREA + 8 EMA)
- Database of met. measurements (~175 y, ~5 mill. obs.)
- Database of WAsP wind atlas data
- Training courses for technicians
- Training course for professionals
- Cup anemometer rehabilitation and calibration facility
- Instruments and safety features for the wind atlas stations
- Satellite-based on-line data transmission system
- SW/HW for wind data analysis and wind flow modelling
- Mesoscale modelling of Egypt using the KAMM model
- Database of KAMM modelling results (Numerical Wind Atlas)
- Wind Atlas for Egypt (2006, ~260 pages + 6 CD’s)

Meteorological mast in Zafarana
Meteorological station in Zafarana

Hurghada Cup Anemometer Calibration Facility
Wind Atlas for Egypt applications

- Application 1: Overview of Egyptian wind resources
  - Input: numerical wind atlas database
  - Output: Maps, statistics, …
- Application 2: Numerical wind atlas + WAsP
  - Input: numerical wind atlas database
  - Output: WAsP results (wind climates, power productions,…)
- Application 3: Observational wind atlas + WAsP
  - Input: observational wind atlas
  - Output: WAsP results (wind climates, power productions,…)

- Topographical inputs
- Summary
- The future

1. New wind resource maps of Egypt

- Map shows PWC
- Mean wind speed 50 m a.g.l. [ms⁻¹]
- 7 speed classes
- KAMM modelling
- Resolution 7.5 km
- NCEP/NCAR data
- GTOPO30 elevation
- GLCC land cover
- Terrain features may give higher wind speeds locally!
- Output formats:
  - map graphics
  - statistics, …
1. New wind resource maps of Egypt

Elliott et al. (1987)

2. Numerical wind atlas

- Analysis procedure (KAMM)
  NCEP/NCAR reanalysis data
  + roughness map (GLCC)
  + elevation map (GTOPO30)
  ⇒ Regional Wind Climate

- Application procedure (WAsP)
  Regional Wind Climate
  + sheltering obstacles
  + roughness map
  + elevation map
  ⇒ Predicted Wind Climate
  + power and thrust curves
  ⇒ Predicted wind farm AEP
Regional wind climate

- KAMM modelling
- Resolution 7.5 km
- Map shows RWC
- Wind climate over flat, uniform terrain
- Mean wind speed 50 m a.g.l. [ms⁻¹]
- Linear speed scale
- Output format: WAsP *.lib file
  - Weibull $A$ and $k$
  - Standard heights
  - Standard $z_0$

Detailed wind resources at Ras El-Hekma

- WAsP modelling of detailed wind speed @ 10 m a.g.l.
- Resolution 100 m
- KAMM wind map indicates Class 2
- Offshore resource is higher: Class 5
- Coastal resource is higher: Class 3/4
- Hill/ridge resource is higher: Class 6
Verification of Numerical Wind Atlas

3. Observational wind atlas

- Analysis procedure (WAsP)
  - Observed Wind Climate
    + sheltering obstacles
    + roughness map (GE)
    + elevation map (SRTM3)
    \[\Rightarrow\] Regional Wind Climate

- Application procedure (WAsP)
  - Regional Wind Climate
    + sheltering obstacles
    + roughness map
    + elevation map
    \[\Rightarrow\] Predicted Wind Climate
  + power and thrust curves
  \[\Rightarrow\] Predicted wind farm AEP
Egyptian regional wind climates

- WAsP modelling
- 30 met. stations
- Graph shows RWC
- Wind climate over flat, uniform terrain
- Mean wind speed and power density 50 m a.g.l.
- Output format: WAsP *.lib file
  - Weibull A and k
  - Standard heights
  - Standard $z_0$

Gulf of Suez regional wind climates
Probably the best wind farm site in the world…

Detailed wind resources at Zafarana
Topographical inputs for WAsP

- Elevation maps
  - Shuttle Radar Topography Mission 3" elevation data
  - Digitised topographical maps
- Roughness (land-use) maps
  - SRTM Water Body Data
  - Satellite imagery (GE Pro)
  - Digitised topographical maps
  - Aerial photography
  - Site visits (mines!)
- Obstacle descriptions
  - Site visits

Shuttle Radar Topography Mission

- Grid point elevations
- 3" (~90 m) resolution
- Vertical accuracy 5-10 m
Inspection of raw SRTM data

- Check for missing information (voids = white)
- Check for spikes and wells

Katamaya elevation map from SRTM data

20x20 km with 10-m contours
2x2 km with 1-m contours
Zafarana elevation map from surveying

Alexandria roughness map from Google Earth
A complete package…

- Wind-climatological inputs
  - Numerical wind atlas (all over Egypt)
  - Observational wind atlas (30+ stations)
- Topographical inputs
  - SRTM 3" elevation data
  - SRTM Water Body Data
  - Google Earth Pro satellite imagery
- Software tools
  - WAsP, Map Editor, Utility Programs
  - Surfer, Grapher, Didger
- Other resources
  - Wind atlases, wind farm planning report, training, …
  - Bird Migration Atlas, EIA reports, guidelines, …

Wind Farm Planning

Bird Migration Atlas

Wind Atlas for Egypt

Maps & other data

Master plans

EIA GUIDELINES APPROVALS

Legislation

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The future…

- Numerical wind atlas
  - Long-term data (1968-95) – infrequent updating ok
- Observational wind atlas
  - Some reference met. stations should continue
  - New measurement programmes may be initiated
  - Cup anemometers must be rehabilitated and recalibrated
  - Databases can be updated and extended
  - Wind Atlas for Egypt can be updated
- Conclusions
  - present approach to wind resource assessment and siting in Egypt may be continued for several years
  - NWA methodology may be applied elsewhere…