South African Extreme Wind Atlas (WASA)

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South African Extreme Wind Atlas (WASA)

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WASA Project Team

- **SANEDI** *(South African National Energy Development Institute)*
  - executing agency – 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*
WP5 – Extreme Winds
Why do we need extreme wind statistics?

• Wind constitutes most critical environmental loading affecting structural design of built environment in South Africa;

• Information on extreme winds essential in the design of wind farms – situated in areas with relatively strong winds;

• Therefore development of relevant extreme wind information essential in planning of large-scale exploitation of wind power in South Africa.
Origins of strong winds

• Interior: thunderstorm dominated;

• Coast, adjacent interior – extratropical cyclone (cold front) dominated;

• Larger part of South Africa – mixed strong wind climate…

### Zoning of Extreme Wind Causes / Mechanisms

<table>
<thead>
<tr>
<th>Primary Causes</th>
<th>Secondary Causes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Origins of strong winds</strong></td>
<td><strong>Mechanisms</strong></td>
</tr>
</tbody>
</table>

- (a) Thunderstorms
- (b) Extratropical Cyclones
- (c) Origins of wind: Thunderstorms
- (d) Origins of wind: Extratropical Cyclones
- (e) Strong winds: Thunderstorms
- (f) Strong winds: Extratropical Cyclones

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Effect of Mixed Strong Wind Climate

• In interior cause of strong winds can be synoptic and/or mesoscale (thunderstorms);
• Effect on optimal estimation of design wind speeds (especially gusts);
• Ratios between 1:50 yr wind values at different time periods varies across South Africa - complicates conversion between time periods;
• Measured data to form basis of development of extreme wind statistics.
Time resolutions of extreme wind statistics

- Statistics of extreme winds can be provided for different time resolutions, e.g. 10 min, 2-3 sec (gusts) etc.
- Standard factors enable conversion between time periods;
- Fixed factors impossible in mixed climate environment;

- Necessary to provide statistics for different time resolutions.
Optimal development of design wind speed statistics

A. Statistical extraction of extreme wind observations from reanalysis and model data:

- High spatial resolution possible;
- New methods continuously researched:

Low time-resolution data (e.g. 6-hourly wind speed)

High time-resolution statistics (e.g. 1:50 yr 10 min wind speed)
• Temporal variability is missed out by smoothing effect of numerical modelling;
• Only applicable to regions with exclusively synoptic strong wind mechanisms, e.g. SW Cape.
2. Analysis of measured data

- Types of instrument, measuring environment and record lengths to be considered.

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<table>
<thead>
<tr>
<th>Background Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prevailing macroclimatic conditions</td>
</tr>
<tr>
<td>Investigate Available Wind Data</td>
</tr>
<tr>
<td>Audit</td>
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<tr>
<td>Description of the Strong Wind Climate</td>
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<tr>
<td>Causes of the strong winds</td>
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<tr>
<td>Analyze Wind Data</td>
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<tr>
<td>GEV method</td>
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<tr>
<td>Investigate Exposure of Weather Stations</td>
</tr>
<tr>
<td>Assess exposure of weather stations</td>
</tr>
<tr>
<td>Develop Extreme Wind Climatology</td>
</tr>
<tr>
<td>Selection of 1.5 year quantiles</td>
</tr>
</tbody>
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```
• Compatible with mixed strong wind climates using appropriate statistical techniques;
• Low resolution – planned wind farms in remote areas not sufficiently covered by long-term measurements.

1:50 yr 10-min wind speed for WASA project area
1:50 year gust estimations from observed data.

1:50 year gust map with adjustments for uncertainty.

- Refinement of final maps to be done through integration of results from measured and model data.
Application of extreme wind statistics for wind farm planning

- IEC (International Electrotechnical Commission) 61400 - class of international standards for wind turbines;

- Ensure that wind turbines are appropriately engineered against damage from hazards within planned lifetime;

- Wind Turbine Classes:
  - Determine which turbine is suitable for wind conditions of particular site;
  - During construction and design phase assumptions made about local wind climate that wind turbines will be exposed to;
    - \( V_{\text{ref}} \) – 1:50 yr 10 min average speed at hub height,
    - A, B & C: Reference turbulence intensities.

<table>
<thead>
<tr>
<th>Turbine Class</th>
<th>IEC I High Wind</th>
<th>IEC II Med Wind</th>
<th>IEC III Low Wind</th>
</tr>
</thead>
<tbody>
<tr>
<td>( V_{\text{ref}} )</td>
<td>50 m/s</td>
<td>42,5 m/s</td>
<td>37,5 m/s</td>
</tr>
<tr>
<td>A</td>
<td>0,16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>0,14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>0,12</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**IEC standard and WAsP Engineering**

**WAsP Engineering**: Software to compute extreme winds and parameters for IEC standard (e.g. $V_{ref}$, $I_{ref}$) at a particular site, with local environment & topography and Region Extreme Wind Climate (REWC) as input.

**REWC obtained from:**
- Observations
- Global reanalysis data (e.g. NCEP/NCAR, ERA-40, CFSR)
- Mesoscale model simulations
  - Climate simulation
  - Storm episode method
  - Extreme wind class method

(the above statistics to be integrated in the WASP work package on extreme winds)
Acknowledgements

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WASA Phase I Final Wind Seminar

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