WAsP best practices and checklist

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The following list of requirements, best practices and recommendations is not exhaustive, but is meant to provide a brief summary of some important considerations regarding WAsP modelling. More information is available in the WAsP help system and at www.wasp.dk.

Measurement programme

- ❑ Design measurement programme based on preliminary WAsP analysis
  - Use SRTM elevation and water body data + land cover from Google Earth
- ❑ Follow WAsP similarity principle as much as possible when siting the mast(s)
- ❑ Height of reference anemometer(s) similar to hub height (preferably > 2/3 h_{hub})
- ❑ Optimum boom direction is @ 90° (lattice) or @ 45° (tubular) to prevailing wind
- ❑ Deploy 2 or more masts for horizontal extrapolation and validation
- ❑ Deploy 2 or more masts if RIX and ΔRIX analyses are required
- ❑ Deploy 2 or more levels on masts for wind profile analyses and validation
- ❑ Deploy 2 or more levels on masts for redundancy in instrumentation
- ❑ Measure temperature (@ hub height) and pressure for air density calculations
- ❑ Are anemometers calibrated according to international standards?

Wind data analysis

- ❑ Collect required information, e.g. by filling out a WAsP Data Description Form
- ❑ All fields in Climate Analyst should correspond to project and data specifications
- ❑ Plot and inspect time traces of all meteorological measurements
- ❑ Visual inspection of time-series – in particular reference wind speed and direction
- ❑ Visual inspection of polar scatter plot – any patterns or gaps?

Observed wind climate

- ❑ Use a number of whole years when calculating the OWC (OMWC)
- ❑ Check Weibull fit: is power density discrepancy < 1%?
- ❑ Check Weibull fit: is mean wind speed discrepancy < a few per cent?
- ❑ Check within context of long-term wind climate (MCP or similar)

Elevation map(s)

- ❑ Size of map: should extend at least several (2-3) times the horizontal scale of significant terrain features from any site – meteorological mast, reference site, wind turbine site or resource grid point. This is typically 5-10 km.
- ❑ Coordinates and elevations must be in meters. Elevations should be a.s.l.
- ❑ Set map projection and map datum in the Map Editor so they are embedded in map
- ❑ Add spot heights within wind farm site; interpolate height contours if necessary
- ❑ High-resolution contours around all calculation sites (contour interval ≤ 10 m)
- ❑ Low-resolution contours away from calculation sites ok (contour interval ≥ 10 m)
- ❑ Non-rectangular maps are allowed (circular, elliptic, etc.)
- ❑ Check range of elevations in final map

Roughness/Land cover map(s)

- ❑ Size: map should extend at least max(150×*h*, 10 km) from any site; i.e. meteorological mast, reference site, turbine site or resource grid point.
- ❑ Coordinates and roughness lengths must be in meters
- ❑ Set map projection and map datum in the Map Editor
- ❑ Set the roughness length of all water surfaces to 0.0 m!
- ❑ Check range of roughness length values in final map
- ❑ Map date should correspond to modelling scenario (meteorological mast or wind farm) – use two maps in hierarchy if necessary.
- ❑ Check for dead ends and cross points – and edit map as needed
- ❑ Check consistency of roughness values – there must be no LFR-errors!

Sheltering obstacles

- ❑ Is site closer to obstacle than 50 obs. heights and height lower than about 3 obs. heights?
- ❑ If yes to both, treat as sheltering obstacle; if not, treat as *roughness element*

WAsP modelling – site visit

- ❑ Go on a site visit if at all possible! Use e.g. the WAsP Site/Station Inspection Checklists
- ❑ Print and bring the WAsP forms for recording the necessary information
- ❑ Bring GPS and check projection and datum settings – change if required
- ❑ Determine coordinates of all masts, sites, landmarks and other characteristic points on site
- ❑ Bring sighting compass and determine boom directions and check wind vane calibration
- ❑ Take photos of station, mast and surroundings (12 × 30°-sector panorama)
- ❑ Download GPS data and photographs to PC as soon as possible (daily)

WAsP modelling – parameters

- ❑ Wind atlas (GWC) structure: roughness classes should span and represent site conditions
- ❑ Wind atlas (GWC) structure: standard heights should span and represent project conditions
- ❑ Ambient climate: Set air density to site-specific value (WAsP 10 and 11 only)
- ❑ Adjust off- & on-shore mean- and RMS-heat fluxes values to site conditions (*caution!*)

WAsP modelling – analysis and application

- ❑ Get site-specific (density, noise, …) wind turbine generator data from manufacturer
- ❑ Within forest: effective height = nominal height minus displacement length
- ❑ Complex or steep terrain when RIX > 0 for one or more sites (terrain slopes > 17°)
- ❑ Make RIX and ΔRIX analyses if RIX > 0 for any calculation site – and use WAsP CFD too

WAsP modelling – offshore

- ❑ Roughness length of sea (and other water) surfaces: set to 0.0 m in WAsP!
- ❑ Add combined elevation/roughness change line (0, 0, 0) around wind farm site
- ❑ Change wake decay constant to offshore conditions

WAsP modelling – sensitivity analyses and uncertainties

- ❑ Sensitivity of results to background roughness value and other important parameters?
- ❑ Identify and try to estimate the magnitude of the main uncertainties
- ❑ Estimate technical losses and uncertainty for calculation of net AEP (P_{50} and P_x) @ PCC