Wind Atlas for South Africa (WASA)

Guidelines for using the extreme wind data from the selective dynamical downscaling method

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This guideline is to obtain design parameters as required in the IEC standard, by the application of the 1:50 year 10 minute wind speed.

We will introduce here how to use the software WEng to calculate the 50-year return wind at a particular site, at a certain height (e.g. hub height). The calculation in WEng is done through the linear computational model LINCOM.

For a particular site, the input data required by WEng could be available in one or more forms as described below:

(1) One single value of the 50-year wind of standard condition (10 m high over homogenous surface with a roughness length of e.g. 5 cm) from measurements or modeling.
(2) A collection of annual maximum wind speed, corrected to the standard condition already.
(3) A collection of annual maximum wind speed, directly from mesoscale modeling, using the selective dynamical downscaling method (SDDM) (see Larsén et al. 2013).

The following sections describe the recipes for applying WEng with input from the three possible data formats.

To prepare WEng, the orographical and roughness length maps should be made ready. The details of making such maps can be found in Mortensen et al. (a report)

1. With input as data format (1)

Figure 1 is a photo shot of WEng applied to a site M5. The input is the wind at standard conditions from a certain direction (see the red arrow). The window in the middle (Wind Editor: insert new wind) is the table for writing the information. The example here is the generalized wind from 180 degrees with a speed of 20.94 m/s. The surface condition is as described: 0.05 m for roughness length and at 10 m height. The calculation gives the results shown in the window “Site/wind view”; the estimate is 31.49 m/s (see the thin blue arrow).

The largest 1:50 year value is 33 m/s, indicated as from the direction of 270 degrees. This is a conservative estimate, as it is assumed that the strong wind data from which the 1:50 year estimate was initially calculated from are from this specific direction. However, with no extreme wind direction information available, it is recommended that the conservative estimate be used. In reality, the results, whether with or without directional information, should not differ in the recommendation regarding the ISO class of wind turbine.

Links to the data are provided at the end of this document.

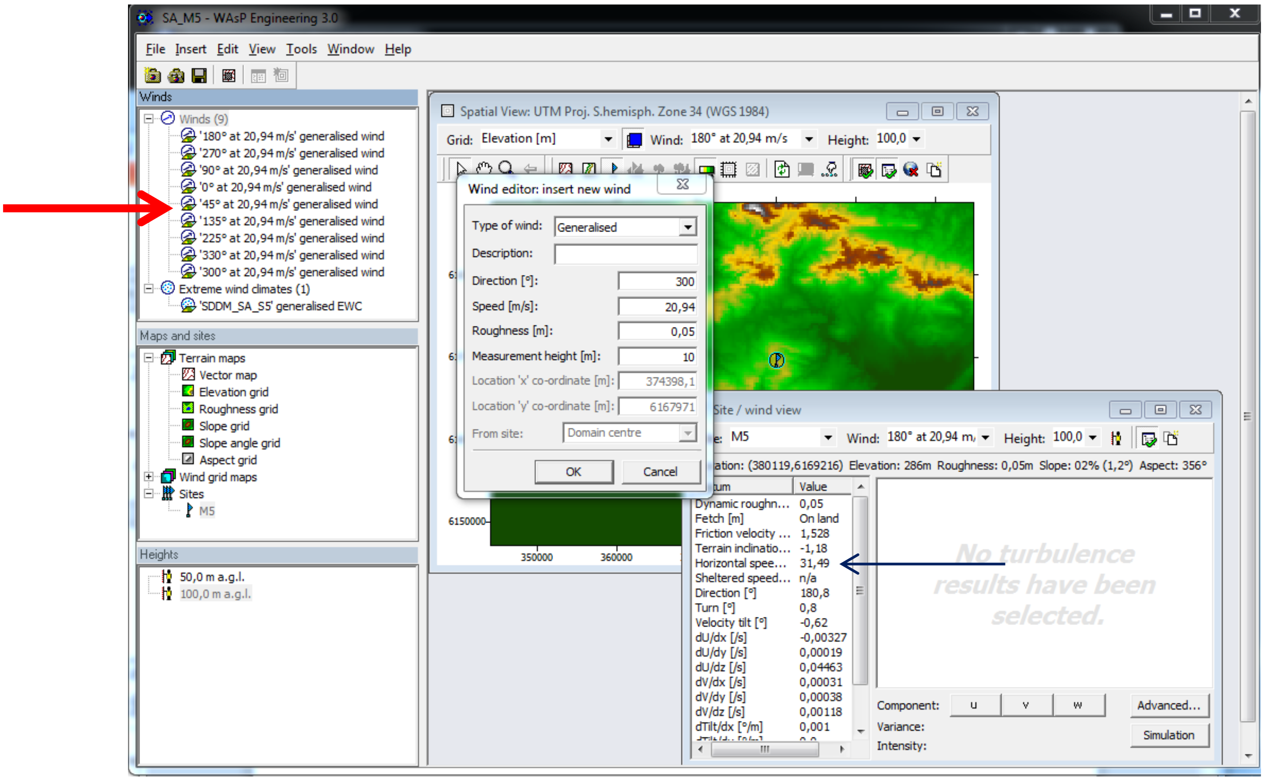

Figure 1. Screen shot of WEng project. The red arrow shows the input of wind from a certain direction. The thin black arrow shows the calculation of wind speed at 100 m with input wind of 20.94 m/s from 180 degrees.

2. With input as data format (2)

When we have a collection of the annual wind maxima of standard conditions, the data can be written in the format of REWC (regional extreme wind climate), see the file (SDDM_SA_S5.rewc) as an example for the site M5. This input is pointed out in Figure 2 with a thick red arrow. This file SDDM_SA_S5.rewc is text file. It includes the corresponding direction to the wind samples. The standard winds and the corresponding direction are shown in the window “Generalized EWC ‘SDDM_SA_S5’” as the wind rose. The Gumbel fit to the samples provides gives the 50-year wind estimate at the standard condition to be 21.0 m/s (shown in the window “Generalized EWC ‘SDDM_SA_S5’”).

It takes a while to obtain the estimates of the 50-year wind of the site condition at 100 m; see the plots in the window “Predicted EWC for M5”. The estimate is 30.8 m/s (shown by the thin blue arrow). This is a lower value than the calculation in the last section, but not significantly, as all uncertainties are taken into account.

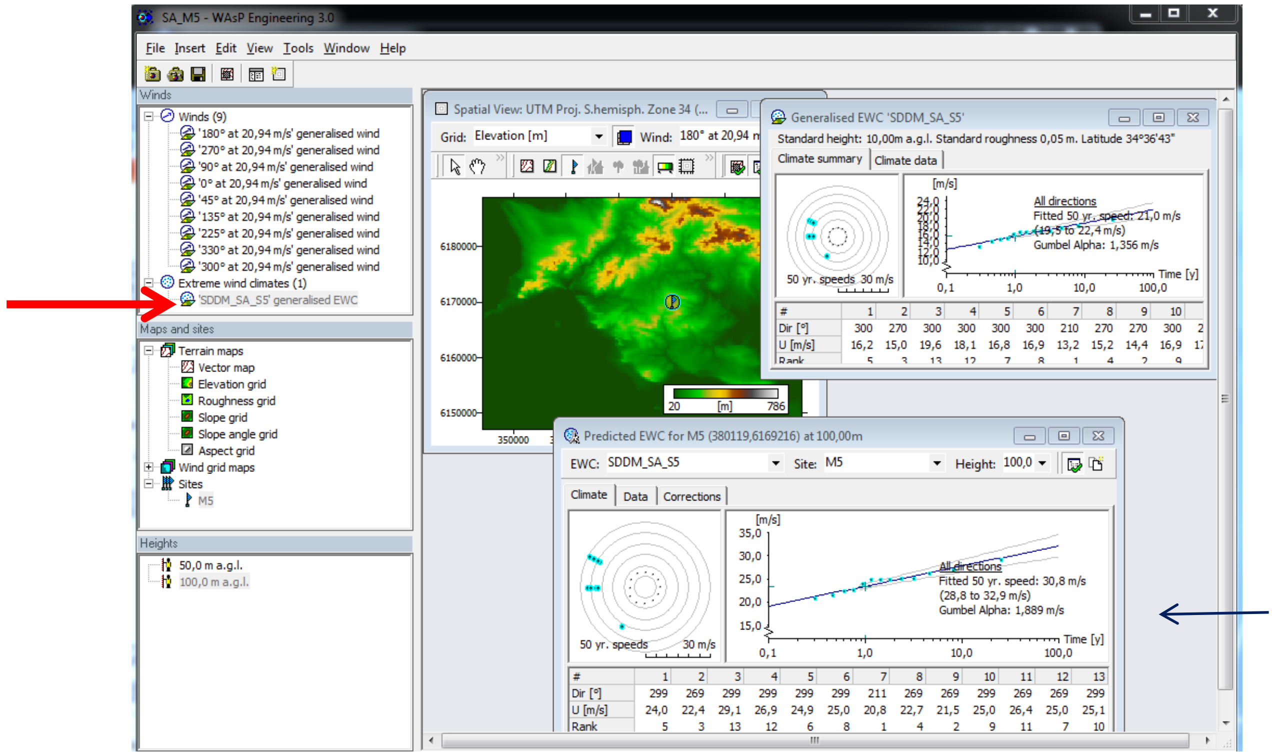

Figure 2. Screen shot of WEng project. The red arrow shows the input of the REWC-file. The thin black arrow shows the directional distribution of the winds and the Gumbel fit.

3. With input as data format (3)

When we have only access to the original output from the mesoscale modeling, we need to prepare the data to the format of (2) through “generalization”. A description of the generalization can be found in Larsén et al. (2013), section 2.4 (Post-processing procedure).

Wind data have been extracted from the original WRF outputs for the following heights: 10 m, 15 m, 45 m, 75 m and 100 m. The wind data are saved as “WCdata.dat” and “ECdata.dat” for Western Cape and Eastern Cape. There are 13 columns in the file:

1 year
2 latitude

3 longitude
4 max wind at 10 m
5 dir corresponding to max wind at 10 m
6 max wind at 15 m
7 dir corresponding to max wind at 15 m
8 max wind at 45 m
9 dir corresponding to max wind at 45 m
10 max wind at 75 m
11 dir corresponding to max wind at 75 m
12 max wind at 100 m
13 dir corresponding to max wind at 100 m

This file contains the annual maximum wind speed and the corresponding direction at each grid point. For Western Cape domain, there are 111 x 72 grid points. For Eastern Cape domain, there are 99 x 192 grid points. The spatial resolution is 4 km. The data period is from 1998 – 2010.

For the generalization, we need to prepare the correction factors. The correction factors are saved in EC_correctionfactors_*m.dat and WC_correctionfactors_*m.dat for Eastern and Western Cape domains, respectively. The data are for 12 sectors, at 5 levels, here 10 m, 15 m, 45 m, 75 m and 100 m. The 7 columns are: sector number, height (m), latitude, longitude, orographical speedup (S_o), roughness length speedup (S_r), effective roughness length (z_{0c}). This was obtained through the use of LINCOM to the orography and roughness length maps.

Now, follow the following steps to obtain the REWC-file (see also the workflow that follows, Figure 3):

(1) Find the closest grid point using the coordination of latitude and longitude

(2) Download from this grid point, the following data: (a) wind data and (b) correction factors

(3) Generalization
For a wind speed at a certain height, that has a direction (wind data from WCdata.dat, ECdata.dat), one finds the corresponding correction factors.
For the generalization, we correct the speedup effects first using this expression: $U_{corr}(z)=U\ S_r/S_o$. Then to obtain the friction velocity $u^*=0.4\ U_{corr}/\ln(z/z_{0c})$. Use this roughness length and friction velocity to obtain the "Geostrophic wind" G using: $G = \frac{u_*}{\kappa}\sqrt{\left(\ln\frac{u_*}{fz_0} - A\right)^2 + B^2}$, where A=1.8 and B=4.5. Use the same G, now with a new roughness length 0.05 m to obtain a new friction velocity. With this new set of roughness length 0.05 m and friction velocity, we obtain the standard wind.

(4) Writing the REWC file
Through the "generalization", we obtain the regional extreme wind climate file *.rewc. But the data that are required by WEng should be in a specific format.
An example of such a file is given for site M05: SDDM_SA_S5.rewc

(5) Prepare 2 maps for WEng: orography and roughness length

(6) Import REWC to WEng
See Example of a WAsP Engineering Project SA_M5.wep or the screen shots in section 2.

(7) Define the turbine site and run WEng

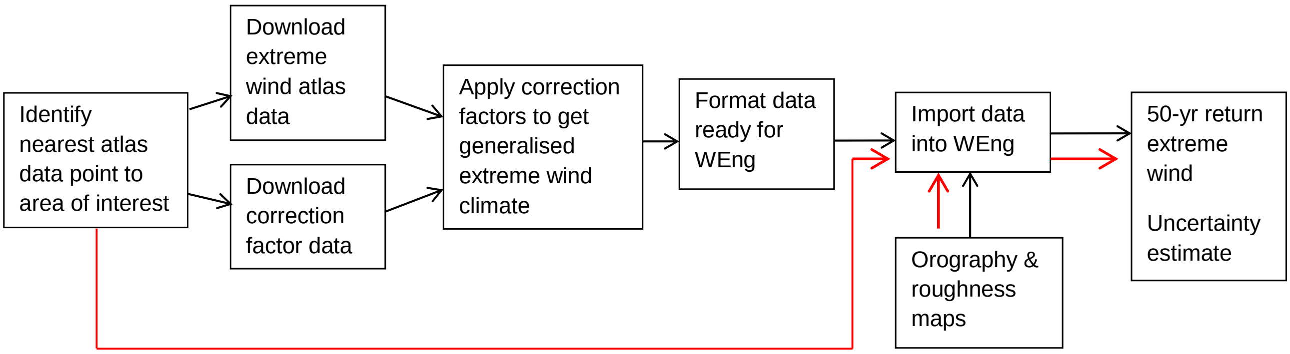

Figure 3. Workflow for use of data format-3 (black arrows) and workflow for use of data of format-1 and 2 (red arrows).

Data links

All the data referred to can be accessed here:

http://www.wasaproject.info/docs/extremedat.zip

References

Larsén X., Badger J., Hahmann A. N. and Mortensen N.G. 2013: The selective dynamical downscaling method for extreme wind atlases, *Wind Energy*, published online, DOI:10.1002/we.1544.