QUICK GUIDE – PARK WITH SCALER AND MESOSCALE WIND DATA CALIBRATED WITH WIND MEASUREMENTS

Purpose:

This quick guide shows you how to calculate expected Annual Energy Production (AEP) as time-step calculations based on EMD mesoscale model data, calibrated against local wind measurements.

PARK calculates in time steps (hourly) based on mesoscale data, taking advantage of the fact that EMD downloads include the mesoscale terrain data – therefore at present only data downloaded from EMD server can be used with the described concept. Mesoscale data from other sources can be used treating them as "measurements" (with all possible *caveats* in doing so!).

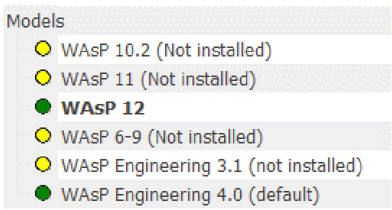
In this guide we assume you are familiar with the basic use of windPRO, like the creation of objects and how to import data into Meteo objects.

Outline of Guide:

1. **License and version requirements**
2. **Setup and data input**
3. **Calibration of the mesoscale data**
4. **Calculations**
5. **Results of PARK calculation**

1. LICENSE AND VERSION REQUIREMENTS

WindPRO 4.1 or above, with license to the module PARK, METEO and a subscription to EMD-WRF Mesoscale data or purchase of WRF on-demand cluster credits. Also, WAsP (11 or above) must be installed.



2. SETUP AND DATA INPUT

Establish the mesoscale wind data in Meteo objects. There are two ways:

A) **Based on EMD ERA5 EU+ or other pre-run ([see list](#)) mesoscale datasets**: Create a Meteo object, choose the "ON-Line" option, select the point to download, and choose period (recommended at least recent 20 years) – data will be downloaded. For more information, see the Meteorological Data Handling manual.

B) **Based on WRF on demand**: Run a WRF calculation on EMD cluster using the Mesoscale Data button in the Climate tab:

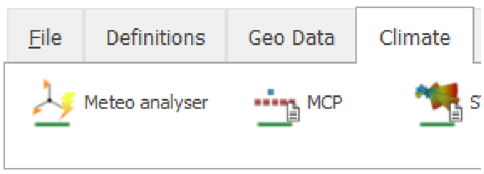
Once the data has been generated you will receive an email when it is ready. Then re-open the calculation and directly download the data. Meteo object(s) are automatically created. For more information see the EMD-WRF quick guide.

If not already established in the project:

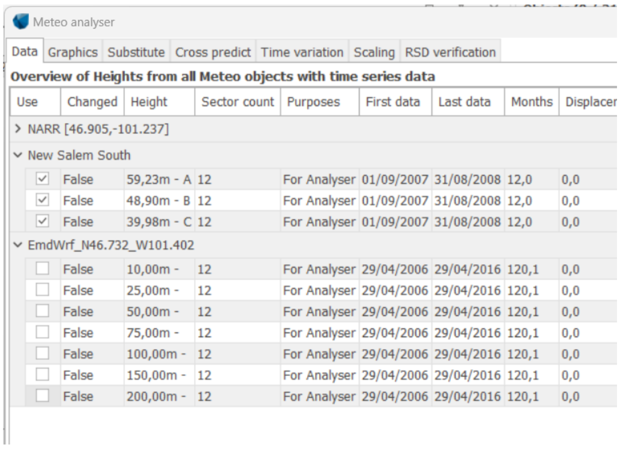
- Insert the WTG objects to simulate.
- Establish roughness and elevation data and make a site data object linking these together.

3. CALIBRATION OF THE MESOSCALE DATA

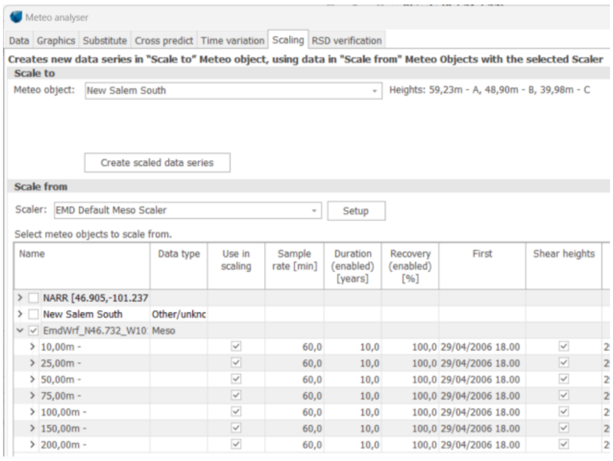
Having the local mast and the modelled data in Meteo Objects, the calibration can be performed in the "Meteo Analyzer" which can be opened from the "Climate" tab:



Select <u>only</u> the mast data (1 or more heights):



Then go to "Scaling" tab. Here we *Scale to* the New Salem South Mast, *from* the EMD-WRF data you select here, based on the *EMD Default Meso Scaler*:

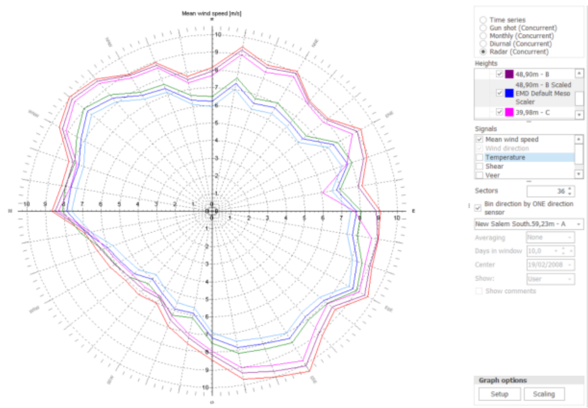


Then click "Create scaled data series".

Now, the Scaler will downscale the Mesoscale data based on the Meso terrain (included in the relevant Meteo Object) **and** the microscale terrain you entered + the model selected in the Scaler (default: WAsP). For each height with real measurements, a new one will be created with "scaled data". These will be established by interpolation from the 25, 50 and 75m Mesoscale data and transformed to the measurement mast position and selected heights based on the terrain data.

Here a part of the time series is seen with the measurements and the downscaled Mesoscale data. The downscaled data will have the same time coverage as the original Mesoscale data.

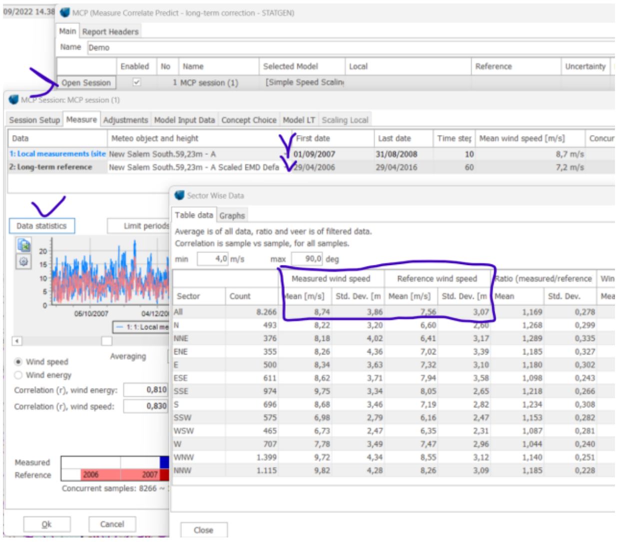
Now the data can be compared with the real measurements, at the same location and height. A particularly useful tool is the Radar graph:



IMPORTANT: Check the option "Bin direction by ONE direction sensor" and select one of the <u>Scaled</u> datasets. Otherwise the graph will show non-concurrent data from each source (measurements vs. modelled), and – since mesoscale data are often directionally biased – the comparison will be poor at least. As observed here, measurements record higher speeds in the multiple directions, compared to the Scaled data. This could be due a mesoscale model bias but, also, could be related to a poor downscaling by WAsP. Also, tower shadow could be a reason. It is possible to compensate for bias by direction in the Scaler (see Energy manual, Post-calibration).

The most important calibration, however, is to bring the Mesoscale data as close to the measured wind speed distribution (Weibull fit) as possible. This can be done like this:

Open an MCP session, and load same-height measurements and Scaled data (based on "pure" downscaling, no post-calibration):



In the "Correlate" tab, the four important figures for calibration can be found: the mean and standard deviations for the two concurrent data series. At the same time, it can be observed how well the data series correlate, and, how large the Veer is. If it is high (> 5°), it should be considered if the measurements might have a directional bias that needs to be corrected.

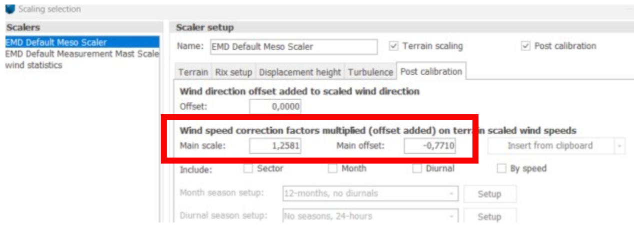
Now calculate the needed Scale and Offset factors for bringing the Scaled data in level with the measurements. The formulas are:

$$\text{Scale} = \sigma_{meas} / \sigma_{model}$$

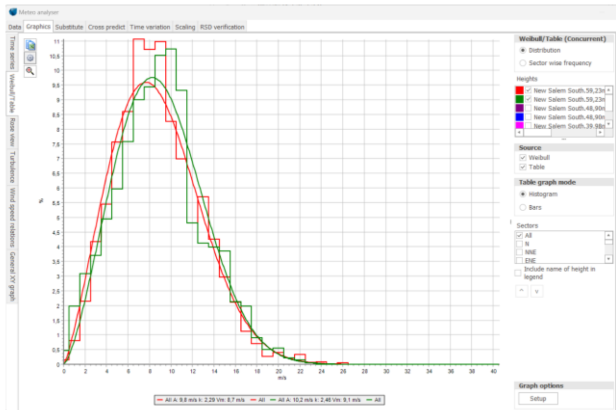
$$\text{Offset} = V_{meas} - ((\sigma_{meas} / \sigma_{model}) * V_{model})$$

It should be noticed that, at this location, the mesoscale data is close to measurements and thus the post-calibration factors will be small. In some regions, the necessary scaling can be larger and, therefore, it is NOT recommended to just use the Mesoscale data "as is" but always calibrate using wind measurements or turbine production data (see the other PARK quick guide on how to use turbine production).

Now, return to Meteo Analyzer. In the Scaling tab, enter the "Setup" of the Scaler and make a copy of the "EMD Default Meso Scaler". Name it, e.g., "Calibrated Meso Scaler". Enter the determined Scale and Offset under "Post Calibration":



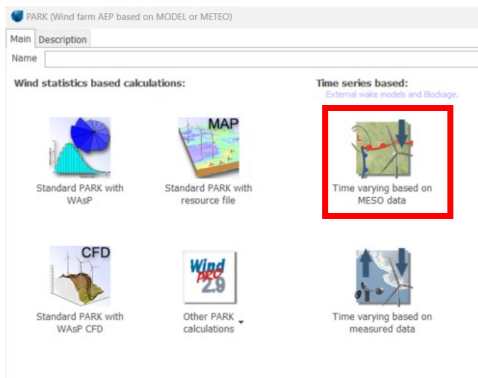
Then run again "Create scaled data series". Afterwards, the weibull fits for the measurements and downscaled Mesoscale data will be closer:



Here it resulted in an over prediction using a crude all annual average scale and offset of the mean wind, indicating that there may be directionnal issues or other parameters can be found to fine tune the scaler for a better match. There are several additional features that might handle this, like the displacement height model, RIX, etc. For now, we accept the current result.

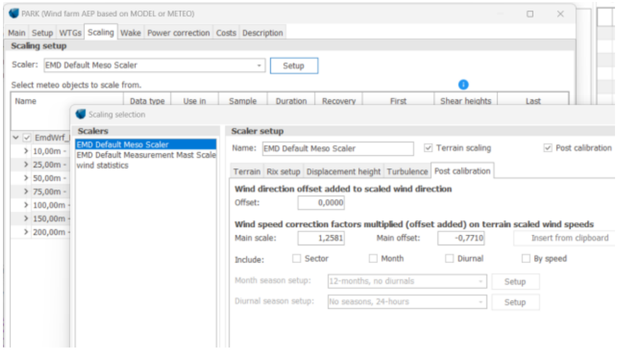
4. CALCULATIONS

Now we have a CALIBRATED SCALER that reproduces measurements well during the concurrent period. If the Mesoscale data are long-term consistent, we thus have a very long data series and can perform long-term wind-based calculations. The Next step is to open PARK and select *Time-varying based on Meso data*:



Go to the "WTGs" tab and select the turbines to include in the calculation.

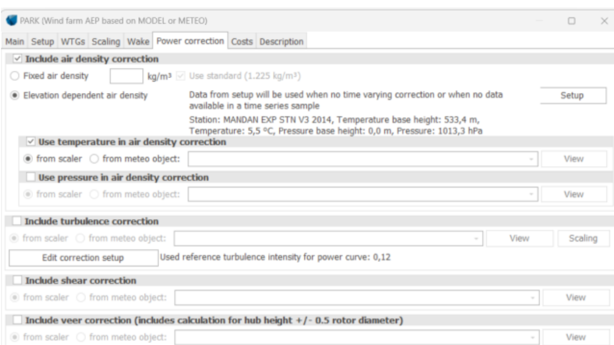
Then go to **Scaling**. Here, simply choose the "Calibrated Meso Scaler" previously created. Choose the Mesoscale data and calculate, e.g., for the last 20 y.



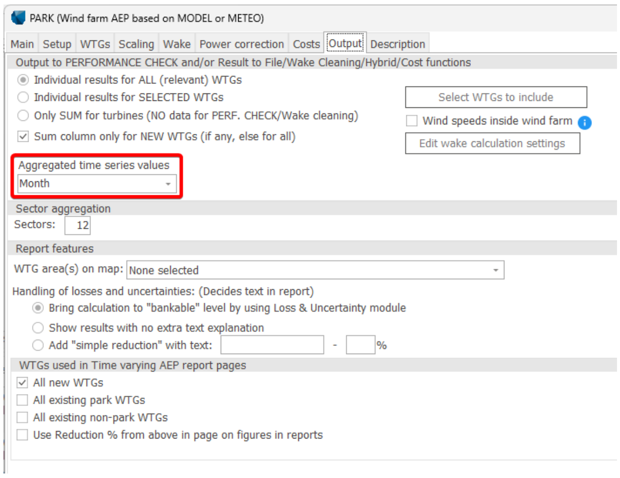
In **Wake,** a list of wake models is available. The recommended one is the N.O. Jensen PARK2 (2018), which is default. In this model, the critical parameter is the Wake Decay Constant (WDC), whose default value for onshore sites is set as default (0.090). The WDC should be otherwise chosen based on ambient turbulence. If this is not available, different terrain types are listed together with their roughness class (RC) and length (z0) to help the user choose.

There are more **Advanced** options. If turbulence is available for the entire calculation period, the WDC can be controlled by turbulence in each time step – this is the easy and "safe" choice. For very large wind farms (+5 rows), deep-array model corrections are available.

Finally, the **Power curve correction** is entered. The recommendation here is only to activate the temperature correction, since this gives a more precise month by month calculation.

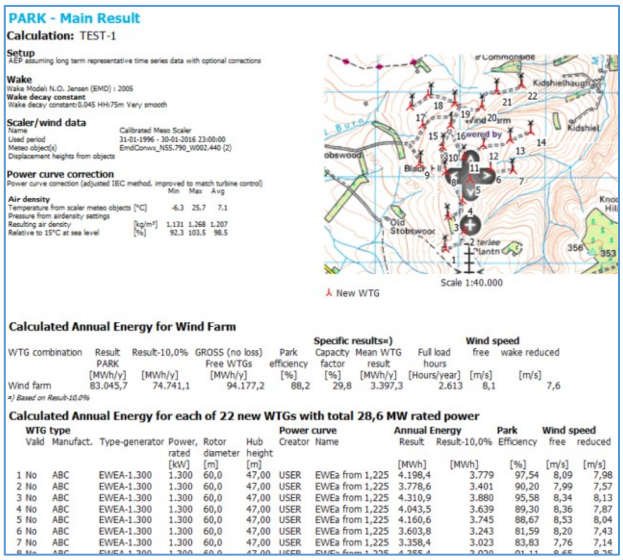


In **Output**, note especially the "Aggregation" options. This is, by default, set to Month, partly to save memory. But, if there is a need for hourly values (for use in PERFORMANCE CHECK or for some detailed calculations in LOSS & UNCERTAINTY), this can be changed to "none".



Now, run the calculation.

5. RESULTS OF PARK CALCULATION



The standard report document provides the calculation assumptions and gives the expected AEP as the average for the period calculated. There will automatically be compensation for data recovery, and, optionally, season unbiasing can be chosen. Note that free as well as wake-reduced wind speeds are shown.

The strongest feature when calculating in time steps is the very detailed validation options offered. With the "result to file" output, the result in time can be taken into Excel for further processing or analyses.