



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

### Purpose:

To calculate expected AEP (Annual Energy Production) 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!).

This guide assumes the user is familiar with the basic use of windPRO, establishment of objects and tasks like import of measured data in 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 3.1 or above, with license to the module PARK 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.

- A) **Based on EMD WRF Mesoscale data sets:** Create a Meteo Object, choose to “GO Online”, and select the point to download and the period (recommended at least recent 20 years). The data will be downloaded.
- B) **Based on WRF on-demand:** Run a WRF calculation on the EMD cluster at any location in the world. Receive an email when it is ready, then reopen calculation and choose download. Meteo Object(s) are automatically created.

If not already established in project:

- Load the local mast measurements in a Meteo Object.
- Create the turbines to be calculated (Objects).
- Create microscale terrain data (roughness and elevation), make a Site Data Object with a link to them. The purpose for the Site Data Object can be, e.g., STATGEN, so no wind statistics is needed in it. Alternatively, WAsP-CFD or FLOWRES result files from other model providers can be used.

#### 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 Analyser. Select only the mast data (1 or more heights):

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Meteo analyser

Data Graphics Substitute Cross predict Time variation Scaling RSD verification

Overview of Heights from all Meteo objects with time series data

Use	Changed	Height	Sector count	Purposes	First data	Last data	Months	Displacer
NARR [46.905,-101.237]								
New Salem South								
<input checked="" type="checkbox"/>	False	59,23m - A	12	For Analyser	01/09/2007	31/08/2008	12,0	0,0
<input checked="" type="checkbox"/>	False	48,90m - B	12	For Analyser	01/09/2007	31/08/2008	12,0	0,0
<input checked="" type="checkbox"/>	False	39,98m - C	12	For Analyser	01/09/2007	31/08/2008	12,0	0,0
EmdWrf_N46.732_W101.402								
<input type="checkbox"/>	False	10,00m -	12	For Analyser	29/04/2006	29/04/2016	120,1	0,0
<input type="checkbox"/>	False	25,00m -	12	For Analyser	29/04/2006	29/04/2016	120,1	0,0
<input type="checkbox"/>	False	50,00m -	12	For Analyser	29/04/2006	29/04/2016	120,1	0,0
<input type="checkbox"/>	False	75,00m -	12	For Analyser	29/04/2006	29/04/2016	120,1	0,0
<input type="checkbox"/>	False	100,00m -	12	For Analyser	29/04/2006	29/04/2016	120,1	0,0
<input type="checkbox"/>	False	150,00m -	12	For Analyser	29/04/2006	29/04/2016	120,1	0,0
<input type="checkbox"/>	False	200,00m -	12	For Analyser	29/04/2006	29/04/2016	120,1	0,0

Then go to “Scaling”. Follow the text in this window: we *Scale to* the New Salem South Mast, *from* the EMD-WRF data you select here, based on the *EMD Default Meso Scaler*:

Meteo analyser

Data Graphics Substitute Cross predict Time variation Scaling RSD verification

Creates new data series in “Scale to” Meteo object, using data in “Scale from” Meteo Objects with the selected Scaler to

Meteo object: New Salem South Heights: 59,23m - A, 48,90m - B, 39,98m - C

Create scaled data series

Scale from

Scaler: EMD Default Meso Scaler Setup

Select meteo objects to scale from.

Name	Data type	Use in scaling	Sample rate [min]	Duration (enabled) [years]	Recovery (enabled) [%]	First	Shear heights
NARR [46.905,-101.237]							
New Salem South Other/unkn							
<input checked="" type="checkbox"/>	EmdWrf_N46.732_W101.402 Meso	<input checked="" type="checkbox"/>	60,0	10,0	100,0	29/04/2006 18.00	<input checked="" type="checkbox"/> 2
<input type="checkbox"/>	> 10,00m -	<input checked="" type="checkbox"/>	60,0	10,0	100,0	29/04/2006 18.00	<input checked="" type="checkbox"/> 2
<input type="checkbox"/>	> 25,00m -	<input checked="" type="checkbox"/>	60,0	10,0	100,0	29/04/2006 18.00	<input checked="" type="checkbox"/> 2
<input type="checkbox"/>	> 50,00m -	<input checked="" type="checkbox"/>	60,0	10,0	100,0	29/04/2006 18.00	<input checked="" type="checkbox"/> 2
<input type="checkbox"/>	> 75,00m -	<input checked="" type="checkbox"/>	60,0	10,0	100,0	29/04/2006 18.00	<input checked="" type="checkbox"/> 2
<input type="checkbox"/>	> 100,00m -	<input checked="" type="checkbox"/>	60,0	10,0	100,0	29/04/2006 18.00	<input checked="" type="checkbox"/> 2
<input type="checkbox"/>	> 150,00m -	<input checked="" type="checkbox"/>	60,0	10,0	100,0	29/04/2006 18.00	<input checked="" type="checkbox"/> 2
<input type="checkbox"/>	> 200,00m -	<input checked="" type="checkbox"/>	60,0	10,0	100,0	29/04/2006 18.00	<input checked="" type="checkbox"/> 2

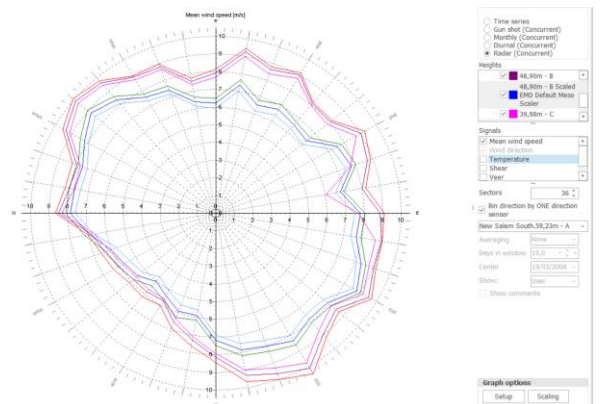
Then click “Create scaled data series”.

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 74m 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:

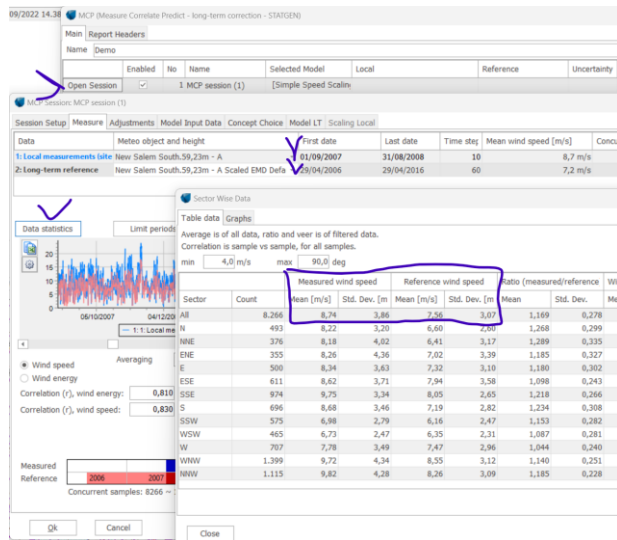


**IMPORTANT:** Check the option “Bin direction by ONE direction sensor” and select one of the Scaled datasets. Otherwise the graph will show non-concurrent data from each source (measurements vs. modelled), and – since mesoscale data are often directionally biased – the comparison will be poor at least. 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 windPRO 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.

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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.

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

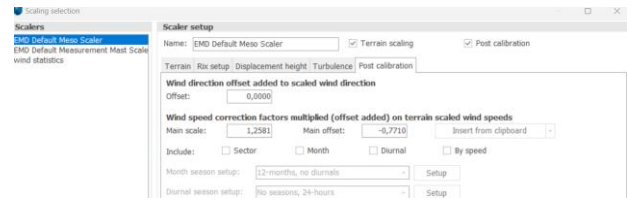
$$\text{Scale} = \sigma_{\text{meas}} / \sigma_{\text{model}}$$

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

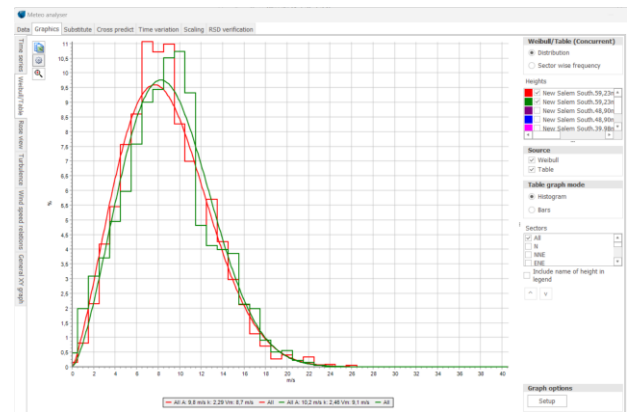
It should be noticed that, at this location, the Meso data is close to measurements and thus the post-calibration factors will be small. In some regions, the necessary scaling can be larger and, therefore, it is NOT recommended to just use the Mesoscale data “as is” but always calibrate using wind measurements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

Now, return to Meteo Analyser. 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”:



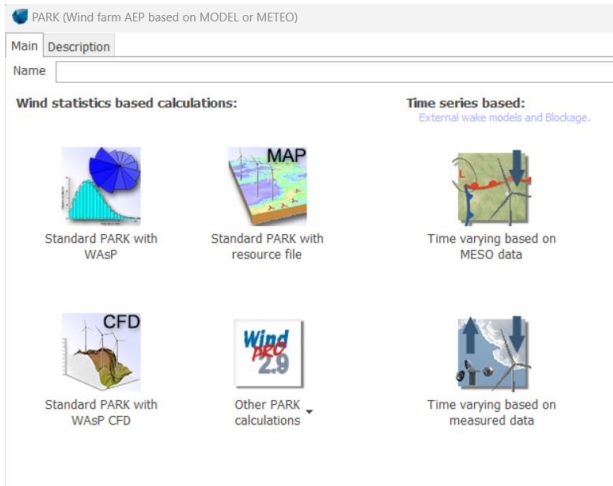
Then run again “Create scaled data series”. Afterwards, the weibull fits for the measurements and downscaled Mesoscale data will be closer:



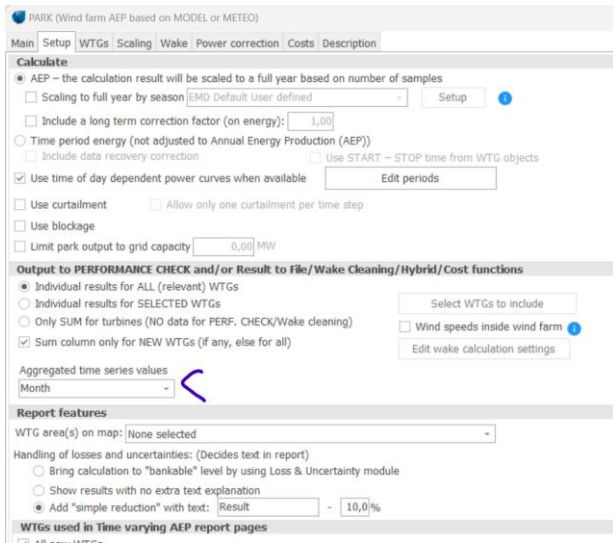
Here it resulted in an over prediction using a crude all annual average scale and offset of the mean wind, indicating that there may be directional issues or other parameters can be found to fine tune the scaler for a better match. There are several additional features that might handle this, like the displacement height model, RIX, etc. The “hunt” can start for making additional “fine tunings”, but, for this example, we accept the current result and now have a CALIBRATED SCALER that reproduces measurements well during the concurrent period. If the Mesoscale data are long-term consistent, we then have a very long data series and can perform long-term wind-based calculations.

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### 4. CALCULATIONS



Click the upper right button to choose a *Time-varying based on Meso data* calculation.

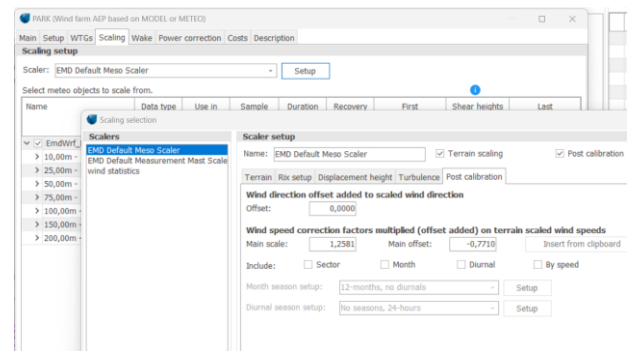


In **Setup**, note especially the “Aggregate” option. This is, by default, set to Month, partly to save memory. But, if there is a need for hourly values (for use in PERFORMANCE CHECK or for some detailed calculations in LOSS & UNCERTAINTY), this can be changed to “none”.

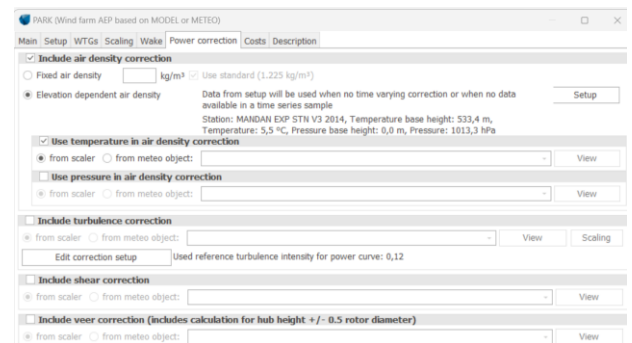
In **Wake**, a list of wake models is available. The recommended one is the N.O. Jensen PARK2 (2018), which is default. In this model, the critical parameter is the Wake Decay Constant (WDC), whose default value for onshore sites is set as default (0.090). The WDC should be otherwise chosen based on 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.

After choosing the turbines for calculation, 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.



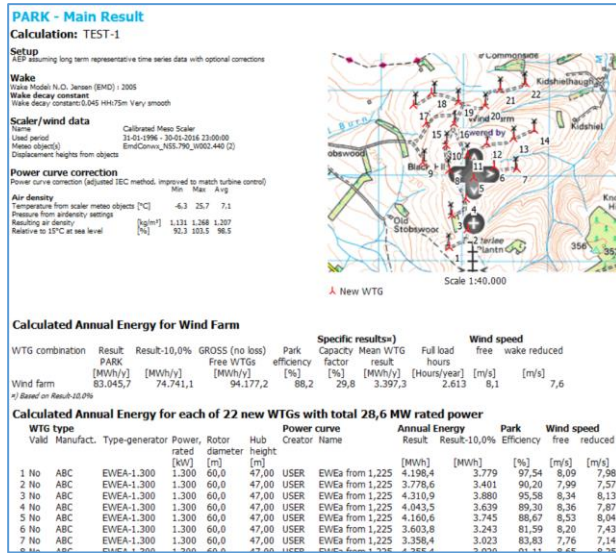
Finally, the **Power curve correction** is entered. The recommendation here is only to activate the temperature correction, since this gives a more precise month by month calculation.



Now, run the calculation.

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## 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.