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

#### Quick Guide – PARK with mesoscale and site data for calibration

Data	G	raphics	Su	bstitute	Cro	ss predict	Tin	ne variation	Scaling	RSD	verification		
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Use	Э	Chang	ed	Height		Sector co	unt	Purposes	First o	lata	Last data	Months	Displace
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× N	lew	Salem S	out	h									
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	$\checkmark$	False		48,90m	- B	12		For Analyser	01/09/	2007	31/08/2008	12,0	0,0
	$\checkmark$	False		39,98m	- C	12		For Analyser	01/09/	2007	31/08/2008	12,0	0,0
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		False		10,00m	-	12		For Analyser	29/04/	2006	29/04/2016	120,1	0,0
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		False		50,00m	-	12		For Analyser	29/04/	2006	29/04/2016	120,1	0,0
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		False		200,00n	n -	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 analys	er										
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	Create scaled data series										
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Scaler: EMD	Default Meso S	Scaler			Setup						
Select meteo o	bjects to scale	e from.				5					
Name		Data type	Use in scaling	Sample rate [min]	Duration (enabled) [years]	Recovery (enabled) [%]	First	Shear heights			
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> 50,00m			¥	60,0	10,0	100,0	29/04/2006 18.00	1			
> 75,00m ·			4	60,0	10,0	100,0	29/04/2006 18.00	9			
> 100,00m			1	60,0	10,0	100,0	29/04/2006 18.00	Sec.			
> 150,00m			1	60,0	10,0	100,0	29/04/2006 18.00	1			
> 200,00m	-		4	60,0	10,0	100,0	29/04/2006 18.00	1 m			

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 <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 windPRO manual, Postcalibration).

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):

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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:

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

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

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":

Scalers	Scaler setup								
EMD Default Meso Scaler EMD Default Measurement Mast Scale	Name: EMD D	Vefault Meso Scal	R. 2	Zerrain scaling	Post calibration				
wind statistics	Terrain Rix setup Displacement height Turbulence Post calibration								
	time and end	t: 0,0000							
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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. 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.



# 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.

ain Setup WT	Gs Scaling Wake Power correction Ci	osts Description				
scaling setup						
Scaler: EMD De	afault Meso Scaler	- Setup				
select meteo ob	jects to scale from.	0				
Name	Data type     Use in     Scaling selection	Sample Duration Recovery First Shear heights Last				
- Condition	Scalers	Scaler setup				
> 10,00m - > 25,00m -	EMD Default Meso Scaler EMD Default Measurement Mast Scale wind statistics	Name: EMD Default Meso Scaler Strating Post calibrat				
> 50,00m - > 75,00m -		Wind direction offset added to scaled wind direction           Offset:         0,0000				
> 150,00m -		Wind speed connection factors multiplied (offect addad) on tomain esolad wind speeds				
> 200,00m -		Main scale: 1,2581 Main offset: -0,7710 Insert from clipboa				
		Include: Sector Month Diurnal By speed				
		Month season setup: 12-months, no diurnals - Setup				

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.

PARK (Wind farm AEP based on MODEL or	METEO)				
tain Setup WTGs Scaling Wake Power	correction Costs De	escription			
Include air density correction					
Fixed air density     kg/m <sup>3</sup>	Use standard (1.225	i kg/m³)			
Elevation dependent air density	Data from setup will available in a time s	a	Setup		
	Station: MANDAN E Temperature: 5,5 %				
✓ Use temperature in air density	correction				
If from scaler				View	
Use pressure in air density corr	ection				
● from scaler ○ from meteo object:				View	
Include turbulence correction					
from scaler      from meteo object:			View	Scalir	g
Edit correction setup Used	reference turbulence	intensity for power curve: 0,12			
Include shear correction					
from scaler      from meteo object:				View	
Include veer correction (includes	calculation for hub h	eight +/- 0.5 rotor diameter)			
● from scaler ○ from meteo object:				View	

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 wakereduced 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.