12 Meteorological data handling

12.1   Introduction

Meteorological data is commonly supplied as time series, meaning large data amounts. There is a large range of data sources, from local measurements to refined mesoscale model data. While local measurements often have gaps or erroneous values and cover typically shorter periods, model data are usually available for long periods back in time, whilst at the same time not being so accurate.

Different data sources complement each other, and efficient tools for comparisons and manipulations are essential for preparing the data representing the long-term meteorological reality at the specific location. In windPRO the tools for importing, screening, comparing, repairing and validating meteorological data can handle most situations thanks to decades of development.

This chapter describes **two** main components:

The **Meteo Object** : For importing, screening, analyzing, synthesizing, merging, wake-cleaning (along with PARK calculation), etc. data from a single source (mast, remote sensor, model output, etc.) with one or more heights.

The **Meteo Analyser** : For comparison of multiple Meteo Objects data series (same station or different stations), featuring cross-predictions, substitutions, gap filling and RSD (Remote Sensing Device) verification.

In both components, the SCALER function can be used. See details in Chapter 3 Energy on this comprehensive model-based tool to transfer/extrapolate time series from one to another point for comparison and thereby evaluation/calibration of the model.

Finally, it's worth mentioning the online data service, whence data from all over the world can be downloaded into a Meteo Object (subject to license conditions). It is probably the easiest-to-use and most comprehensive service to be found in the business.

12.2   Meteo Object: the data container

The Meteo Object is the input object for wind data and other measurements or model data.

Input can be from the very simplest form:
* input manually one wind speed (annual mean) in one sector together with Weibull k=2, and you can calculate AEP based on just a simple mean wind speed and a Rayleigh distribution (Weibull with k=2)

to the very advanced form:
* import measurements from a SODAR or LIDAR file with 25 different heights for a long measurement period with high time resolution. The data files might even have changed format or units during the measurement period. The Meteo Object importer can also read from compressed files, such as .ZIP directly. Finally, it can read the NRG logger files (.RWD) directly (although this is processed through the NRG data retriever software that must be installed).

    Data from other loggers must first be converted to ASCII files (such as .txt or .csv) with the logger proprietary software. Additionally, windPRO has an automatic filter for Zephir LIDAR data files so that all definitions for all channels are filled out automatically.

* A newer option is to load data directly from databases through an API. This is currently established for Ammonit online system. At a later stage more systems can be added on request.

The measurements can be used directly (i.e. without use of models) for AEP calculations in the calculation module METEO. The most common method of use, however, is with MCP for long-term correction (see Chapter 3) and using these data and terrain information to generate a long-term representative wind statistic or time

series. These can then be used to calculate AEP with ATLAS, WAsP interface or (most commonly) the PARK module.

12.3   Meteo Object – tab by tab

12.3.1   Guide – including online data description

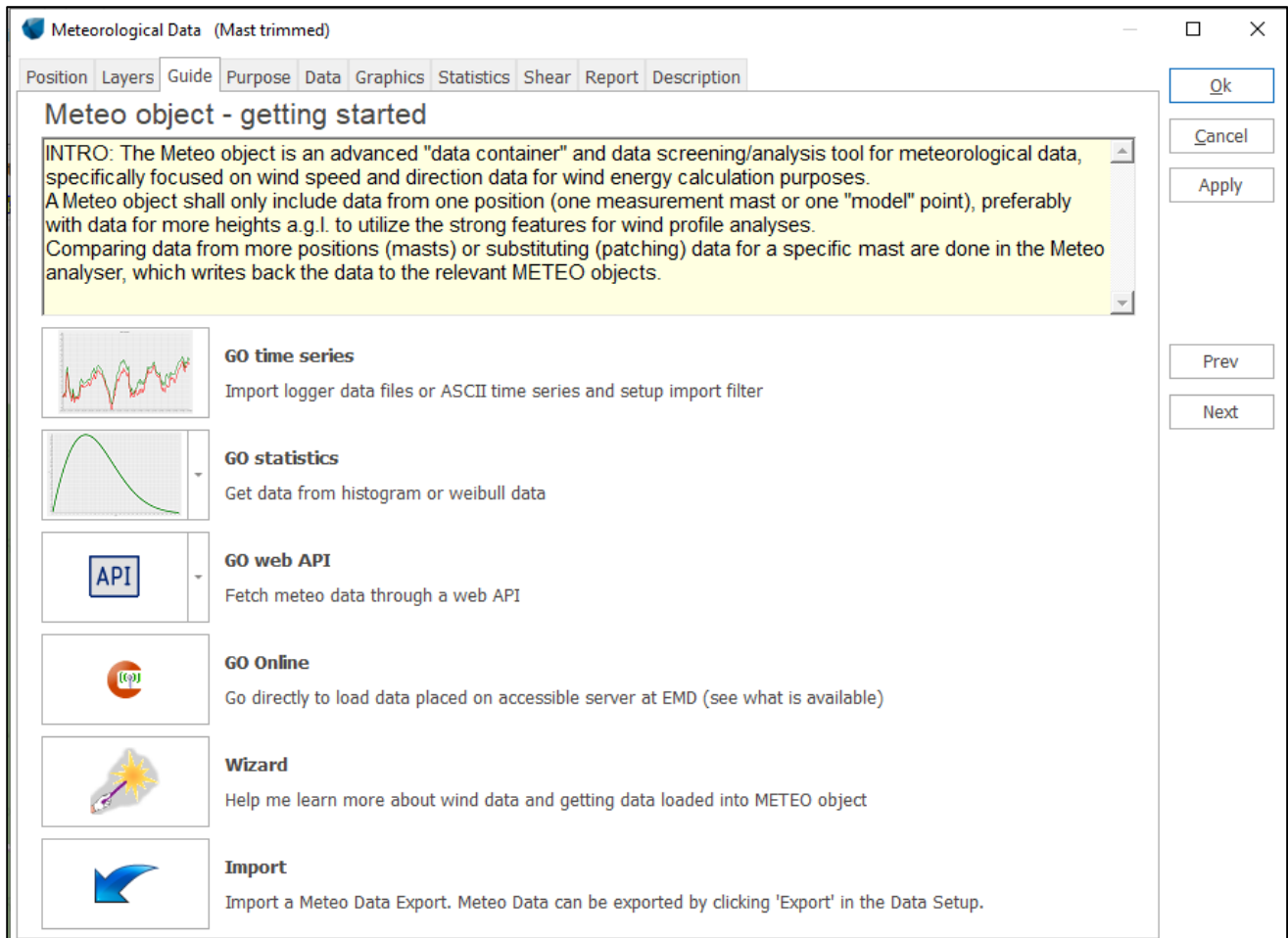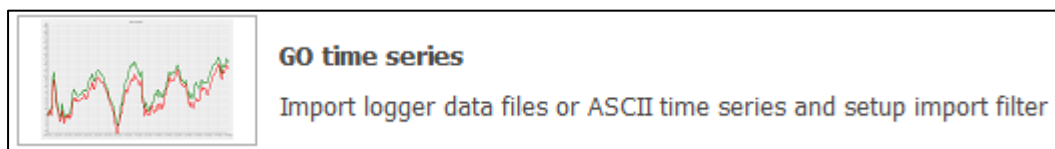The different options for starting are explained here.

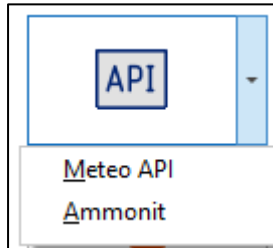*Figure 1 Guide in Meteo Object*

1.

Typically, time series will be the most common format in which data is made available – if users have any doubts about reading them, start with the Wizard.

2.

APIs make it possible to download measurement data from external data servers.

Two options are currently available: the Ammonit server and the generic EMD Meteo API:

The EMD Meteo API is an open API interface which allows you to connect to your own data servers by implementing the EMD Meteo API. For more information on how to connect please contact support@emd.dk

Once connected and logged in, you can download your company's own data directly from windPRO:
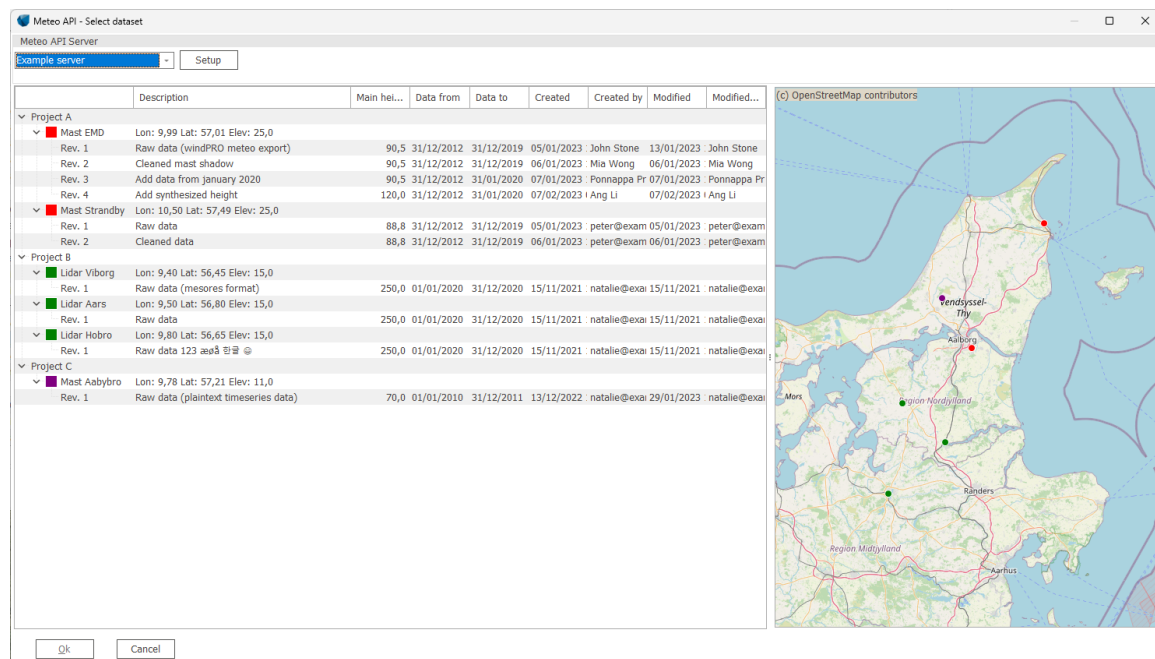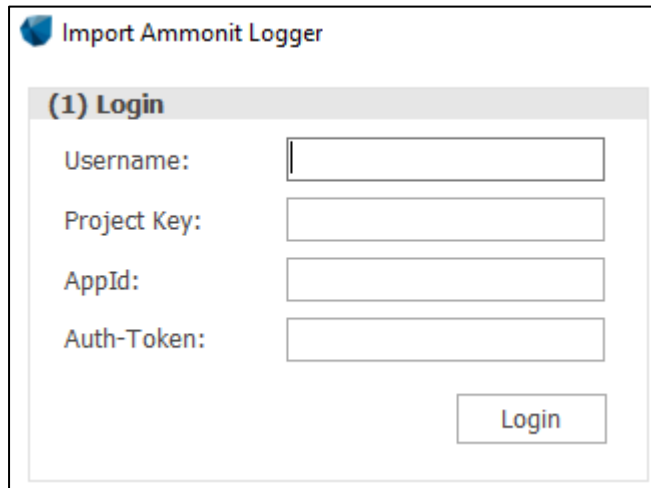

Figure 2 Example implementation of the EMD Meteo API

The other API option is the Ammonitor API:
To access the Ammonit server, select this option, and enter your project credentials and a name in the AppId (e.g. windPRO):
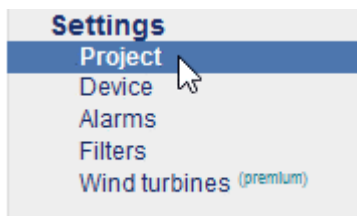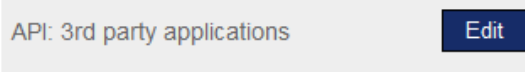
Open a browser and log into AmmonitOR and visit the *Project* settings:
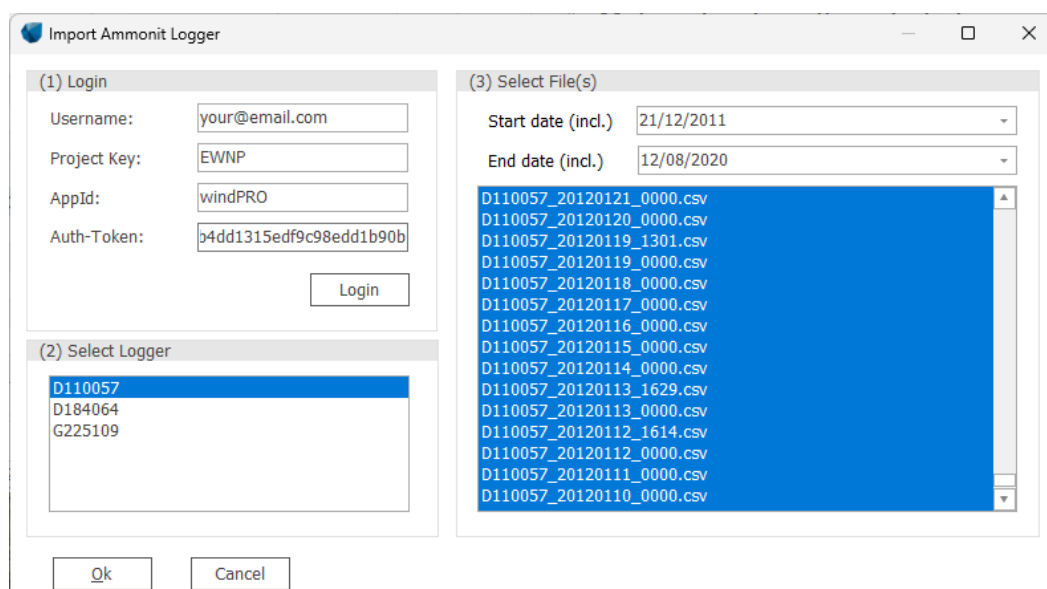

Click the *Edit* button under "API: 3rd party applications":

Click the *Allow access* button for the application name you chose for AppID (e.g. "windPRO"):

Go back to windPRO and click *Login* to select which data to download. You can filter by logger and by start/end date:

Hitting *Ok* starts the data download and everything is loaded into the Meteo Object.

The new EMD Meteo API is aimed at programmers, modellers or analysts who work with machine-driven interfaces and workflows, typically using programming languages like python or R. It provides access to more than 1Pb of high-quality climate data and other services at EMD.

To obtain access, contact the EMD Sales Dept.: sales@emd.dk.

3.

GO Online

Go directly to load data placed on accessible server at EMD (see what is available)

This option gives access to data on the EMD online server, where we add (mostly) free data for fast and easy download. Data for purchase is also available, and in this case the EMD server links to commercial data servers. Click the *GO Online* button to see your current options. These are expanded regularly. If a Meteo Object with online data is reopened, the Online button changes into "Refresh online data", to allow you to update previously downloaded data.

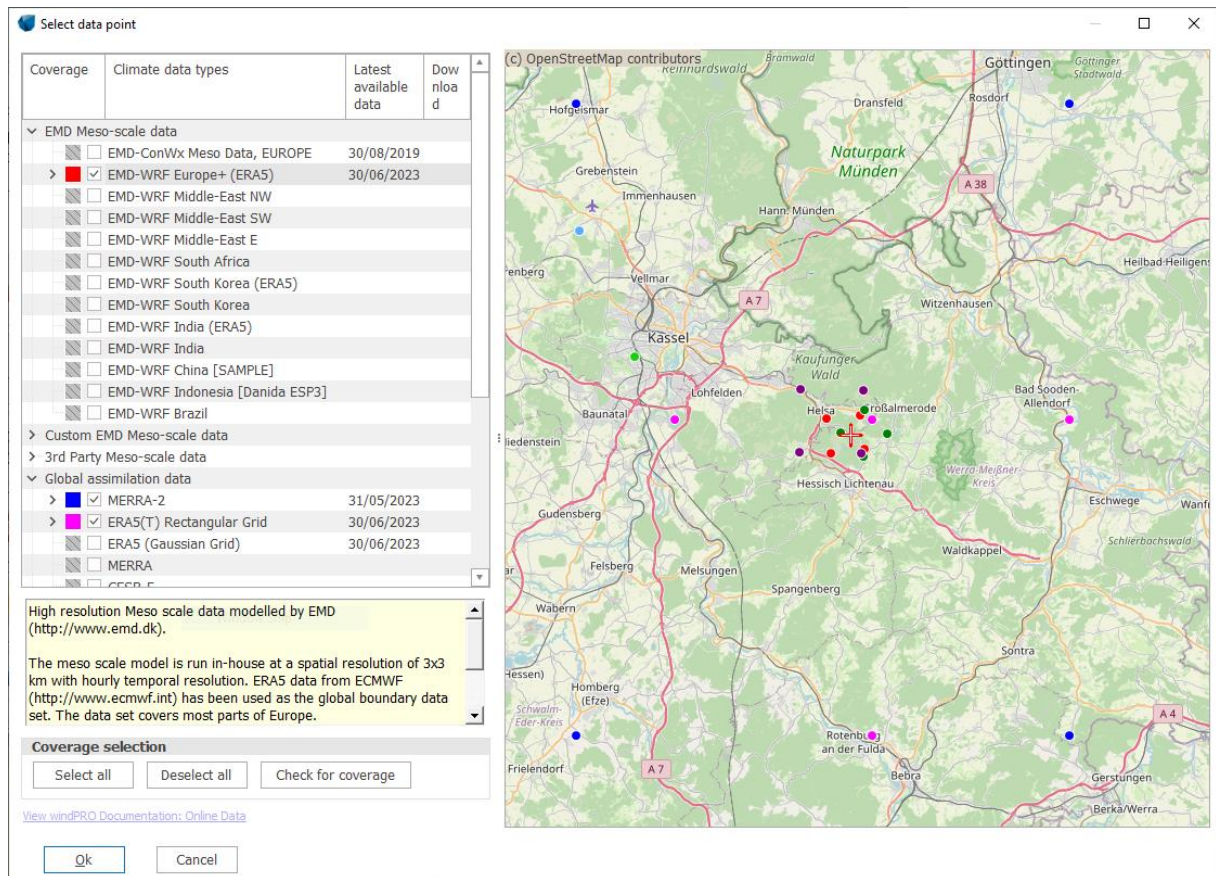The online data download interface looks like this:

Figure 3 Online data download in Meteo Object – with spatial coverage check

The first screen shows the list of available datasets. Here, check relevant datasets to test if there is coverage near the site. The date of the most recent record is shown.

The list of the datasets available is nowadays very long. The focus is on wind, but several data sets have several other climate parameters, including Heliosat solar irradiation and the Danish Wind Index.

The datasets are regularly updated, and the latest information about the data can be found here: help.emd.dk/mediawiki/

After coverage check, dots on the map and radio buttons in the list show the locations of the data.

Click on one of the dots to see which database it refers to. With *Ok* the selected dataset will be downloaded. The data will automatically be imported in the Meteo Object, ready for analyses.

Note that it is possible to download more datasets at a time from the Meteo Analyser! Users have the choice of filtering the download period according to the available data and their own requirements.
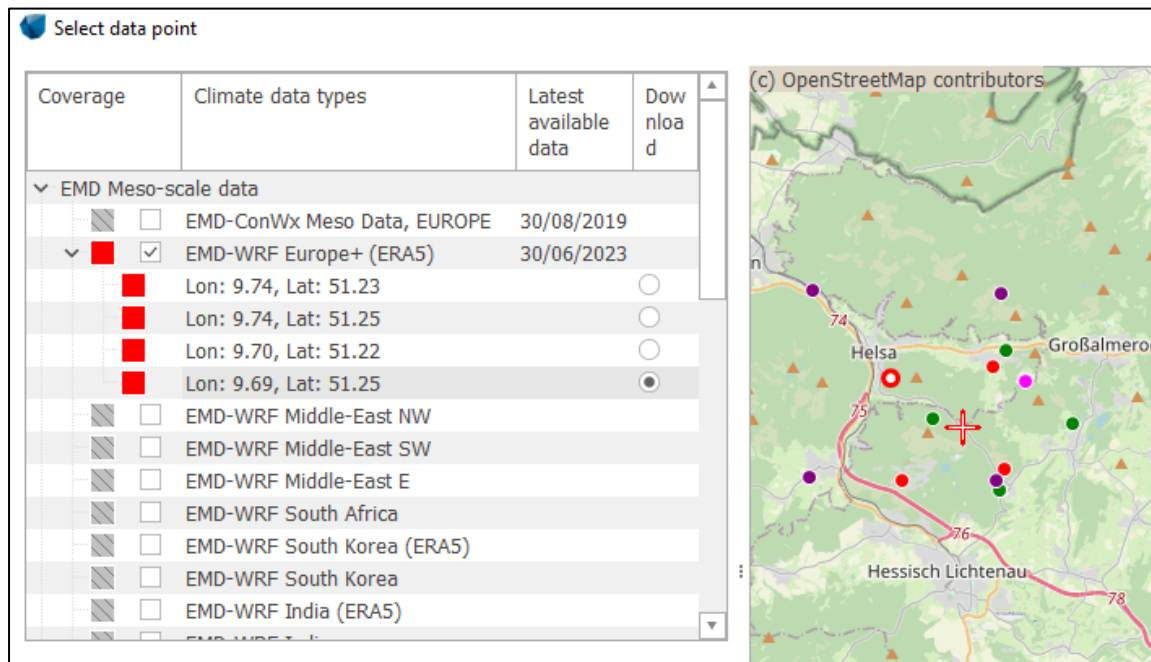
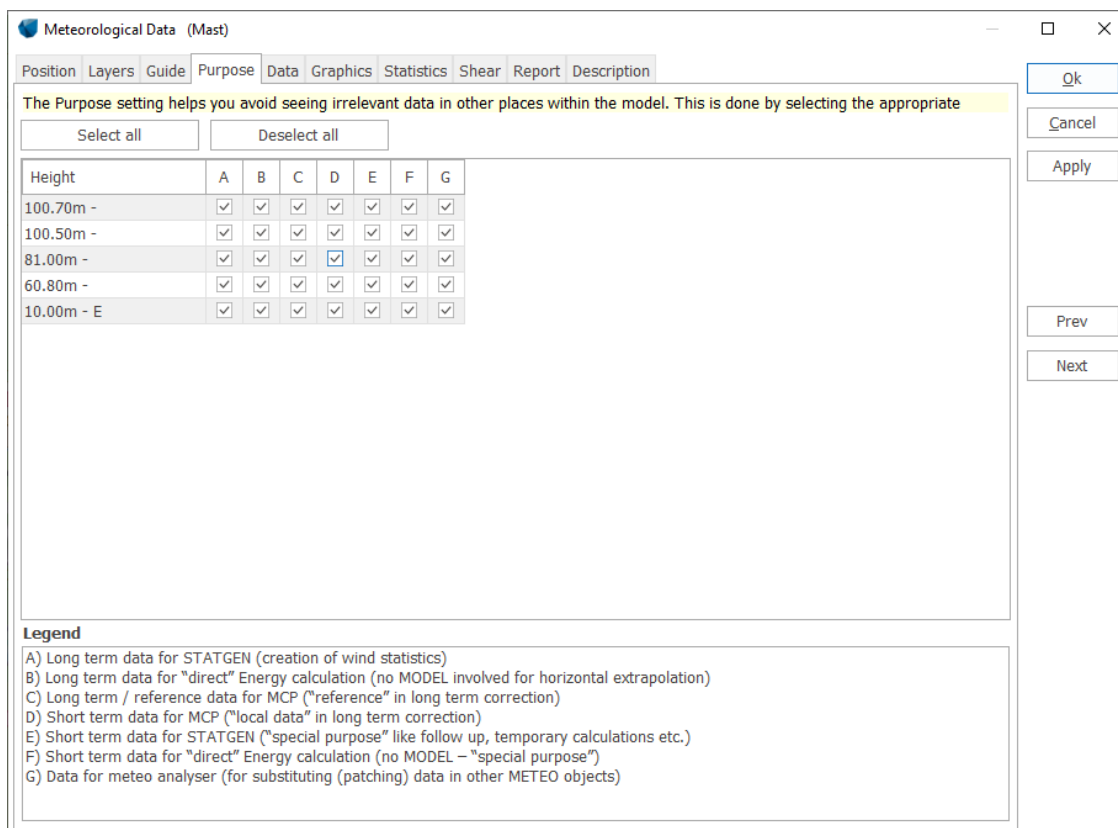*Figure 4 Selection of data set for download.*
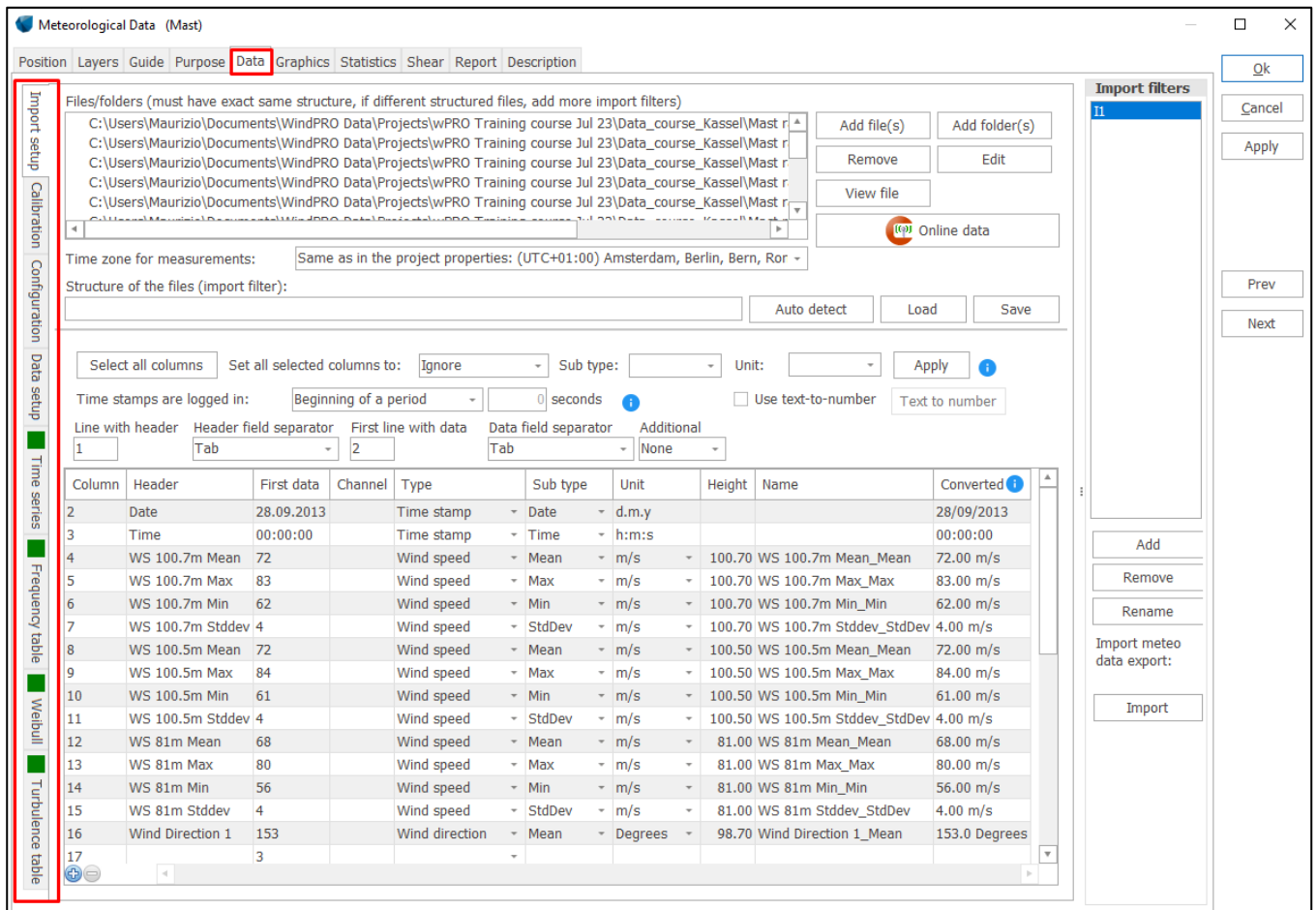
12.3.2   **Purpose**

Figure 5 "Purpose" settings help to structure the data and their use.

If there are several datasets loaded in a windPRO project, giving them a purpose may provide a better overview. Only the relevant data based on the purpose chose in this tab will be available in specific places within windPRO.

12.3.3   Data

Figure 6 The Data tab - Import setup

The Data tab controls and hosts a number of functions and applications, listed as further tabs to the left side of the window; before importing data:

- Import setup (identifying file structure(s))
- Calibration (applying correction to the data)
- Configuration (input of configuration of the measuring equipment and check against standards)
- Data setup (setting up the signals required for each height)

and after importing data more tabs will appear:
- Time series (raw data table, can be sorted by any signal)
- Frequency table (summary table binned by sector and wind speed)
- Weibull data (Weibull fit parameters per sector)
- Turbulence data (summary table binned by sector and wind speed)

Below, each function in this tab is explained.

12.3.3.1   Import setup

This is the heart of the importing system. It teaches windPRO how the files are formatted and should be read.

File types supported: Only ASCII files can be imported. This means raw logger files, Excel files or database files must be converted to text files before data can be imported. Compressed text files are supported (.zip, .rar etc.).

Add file(s): links to the data files to be imported. Note, these **MUST** all have the same structure – if not, add more "Import filters" and add the different files "below" each import filter.

Add folder(s): links to folder(s) with the data files to be imported. Note, these **MUST** have the same structure – if not, add more import filters. If there are data from more masts or different files in the folder, it is possible to set a mask, e.g. "*.txt", so only relevant files will be used.
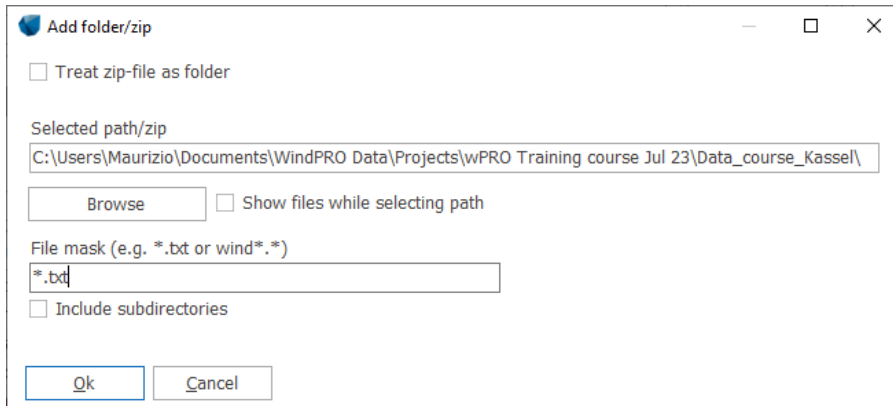

Figure 7 Adding folders in Meteo Object, and specifying the optional "file mask".

Remove: removes the selected files in the list from the import filter.

Edit: edits the import setting, like the file mask in "Add folder(s)".

View file: shows the selected file with the current import settings applied. This is very useful to identify the structure of the file and see if the import settings will work as desired.

Online data (requires an active license for the METEO or MCP module): starts a communication with EMD server (see help.emd.dk/mediawiki/index.php?title=Category%3AWind_Data).

Time zone: if data are in UTC/GMT (the meteorological standard), or in any time other than the project time zone, they will automatically be transformed to the time zone set in the Project Properties. For the individual measurement heights, you'll later have the option to shift in time the data series individually. This is needed, for example, when importing NCAR data where 10 m data are actually forecasts 6 hour ahead, whereas the other data refer to the indicated time.

Import filter (structure of the files): each file structure defined in this window is called a "Filter", and given a name (I1, I2, …), and can be saved for later use. This helps saving time if similarly formatted files are used in different projects. If you do not have a Filter saved, use the "Auto detect" feature.

Auto detect: a powerful tool to recognize the "base structure" of many types of data files.

Use text-to-numbers: converts, for example, wind directions described as N, NNE, ENE, etc., to numbers.

When "Auto detect" is used, the lower part of the window is filled automatically. Several standard logger output files can be automatically detected, and new types are continuously added. Some file formats, however, must be manually set up, if they are, for example, user-defined Excel exports etc. Let's see how to do this.

There must be an entry for each data signal which will be used in the object. The signals not used will just be ignored if the option "ignore" is chosen. Signals can always be set up and used at a later stage.

1. Choose "type" in the dropdown list, such as "Time stamp" or "wind speed" (note that the standard deviation (StDev) of a wind speed signal is also classified as a wind speed).
2. Choose "sub type", such as "year" or "mean" etc.
3. Choose "unit" – note that non-metric units (e.g. mph, knots, Fahrenheit) will be automatically converted to metric units in the object.
4. Choose "height" – this must be in meters. Files set to "feet" will be auto converted to meters. Always check that height is correct.

Figure 8 Setting up import filter in Meteo Object

Figure 9 The signal types available currently.

The signal type list is expanded when new demands occur. Above the status of predefined types are shown. Some types have sub types and more units to choose from. And some types will have a special status. E.g. the Solar irradiation is dedicated to irradiation on horizontal plane, the only type that can be used in Solar-PV calculations at present, where direct and diffuse just can be used for evaluations.

When all signals are set up, go to the "data setup" tab.

12.3.3.2   Calibration

The Calibration tab is used to:
1. View the scale and offset parameters input in the logger, when available in a file format recognized by windPRO.
2. Input correction or recalibration parameters (scale and offset) to be applied to the data when necessary. This can be relevant when the values from the data logger differ from the values from calibration certificates. Knowing the official values from calibration certificates, windPRO can automatically calculate the needed correction to be applied on the "wrongly" logged data.
3. Check the average magnetic declination value valid at the position of the Meteo Object for the middle of the data period. Wind direction data can be then corrected for magnetic declination if necessary
4. Provide documentation of data treatment, through the Report (see 12.3.8)

The tab consists in two main parts: the Calibration table and the Timeline. The Calibration table and timeline are automatically created from the Import setup tab. If files are added at a later stage, these will be detected, and the table will be amended accordingly.
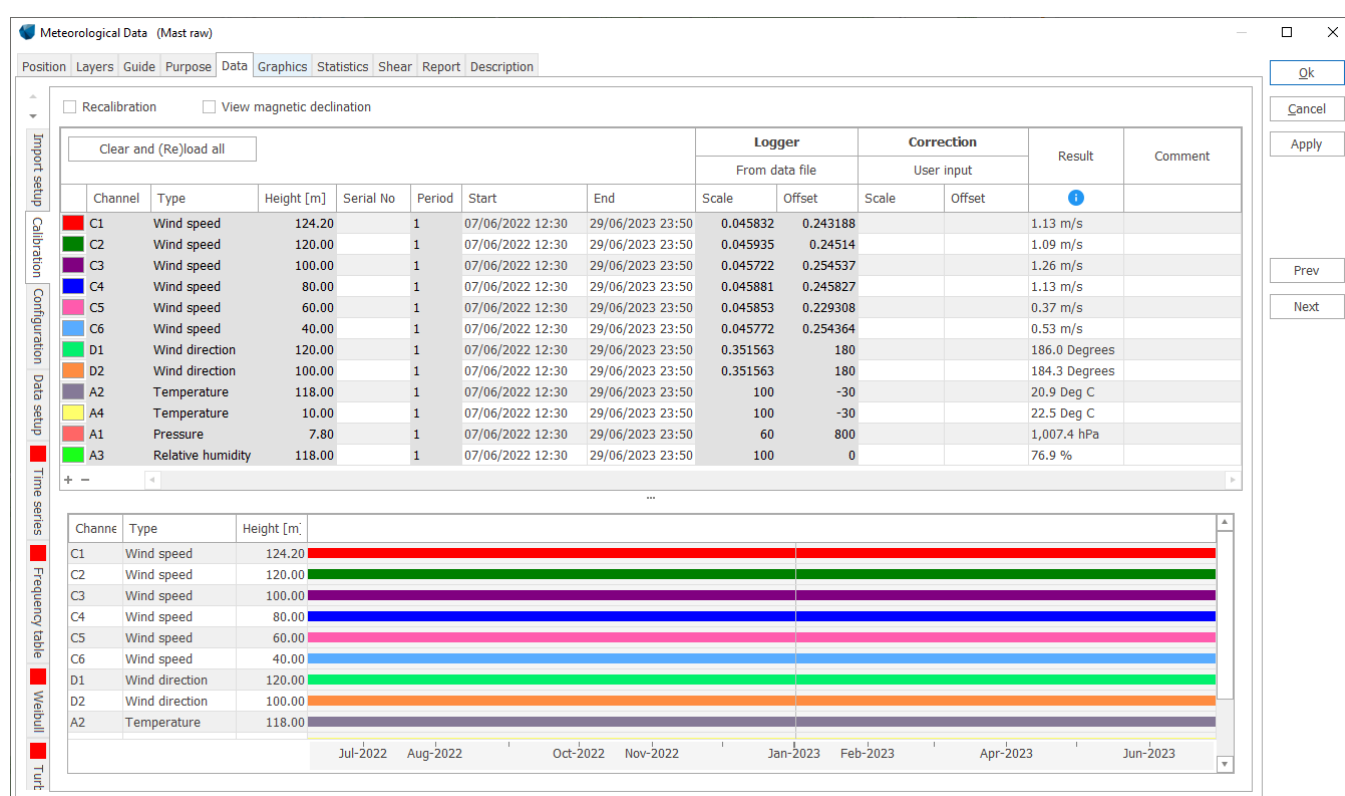
Figure 10 Calibration tab

Calibration table
Each line of the calibration table relates to a calibration period of a given sensor.
A calibration period is defined as an interval of time for which a specific set of scale, offset and magnetic declination relating a specific dataset from a given sensor. A given sensor can have more than one calibration period, for example when it has been recalibrated as recommend by Measnet after 2 years.

The calibration periods are firstly automatically created by windPRO after screening all data files defined in Import setup.
A calibration period is created for each time interval with constant Channel (if available), serial number (if available) AND constant 2 scale/offset values (if available), for any Type of data (speed, direction, temperature …) with sub type defined as "Mean" in the import filter.

Please note that windPRO detects only one calibration period per file. It is therefore not recommended to gather all data into one data file if several calibration periods are covered.

The calibration periods can also be created manually using the + at the bottom of the table or a right click on the line and select Duplicate line. An existing line can be split in 2 lines to allow the user to identify distinctive periods for different calibration factors in case this has not been detected automatically. Alternatively, right click on a line of the table.

The columns **From data file** under the header **Logger** relate to the Scale and Offset values read from the file (if available).
The columns **User input** under the header **Correction** allows the user to decide which scale and offset to apply to a dataset. The same correction is applied to all signals under the same channel, like mean wind speed, min and max wind speed. The standard deviation is however only using the scale factor, not the offset.
The **Result** column shows the result of the correction of first data of the first file loaded under the given Import filter. It can be useful to make a sanity check of the result to expect. In the rare case when several calibration periods are created from files under a same import filter (occurring if the scale and offset information from the files changes in raw data files), then it is only the result of the first file which is shown and not the result for each file.
The **Comment** column is available for user text input.

Recalibration table
The Calibration table can be extended to a more advanced table by checking the checkbox **Recalibration** in the upper left corner. The recalibration table is used to:
- Provide documentation of the calibration values applied to the data
- Calculate the corrections to apply to data in case of mismatch between the logger and official values

Figure 11 Recalibration table

The columns **User input** under the Logger header allows to manually enter the scale and offset as setup in the logger, when these are not available or properly detected.
The columns under the header **Official (from certificates)** give the option to input the scale/offset values as presented in the calibration certificates documents.
Under the Correction header, the **Calculated** columns are automatically filled when data is available in the Logger columns and the Official (from certificates) columns.
The calculated correction for scale is calculated as: Scale(official)/Scale(logger).
The calculated correction for offset is calculated as: Offset(official)-(scale(official)/scale(logger))xOffset(logger)
When both logger values are available in the From data file or User input columns, only User input is used for the Calculated correction columns. If a cell of User input is left blank, the value 1 is assumed for scale data and 0 for offset data.

The Final columns under the Correction header consists firstly in the selected of the correction to apply, that is either the calculated one as presented in the Calculated columns, or the User Input ones or none. Then to the right of the **Apply** column a final visual check of the correction selected and used later on in windPRO can be made.

Note that some EMD on-line data have calibration factors for heatflux automatically input in the table while downloading.

Timeline
The Timelines gives an overview of the different calibration period(s) for each sensor as defined in the Calibration table. This feature is especially useful when a sensor is concerned by several calibration periods. If a sensor

has been (re)calibrated over time, a new calibration period is created on the same line in a lighter color. Clicking on a line will mark the corresponding line in the table and vice versa.

Note that the function of the timeline is to provide a view of different calibration periods, not of the data availability. If there are holes in the time series, they will not be reflected here but for example under Graphics tab, Recovery.

Magnetic declination

By checking **View magnetic declination**, it is possible to see the magnetic declination as provided by the International Geomagnetic Reference Field, 13th Generation, released in December 2019 (http://geomag.bgs.ac.uk/data_service/models_compass/igrf_calc.html). The value is calculated at the position of the Meteo Object and for the central date of the whole measurement period.
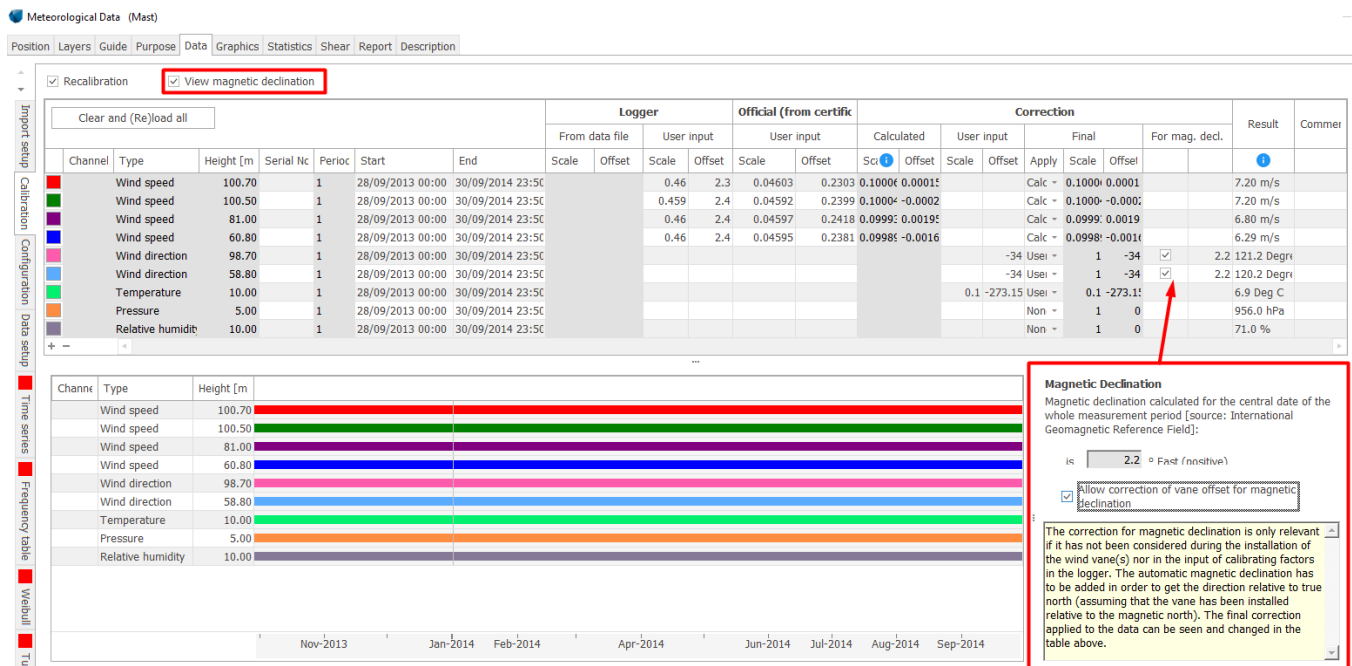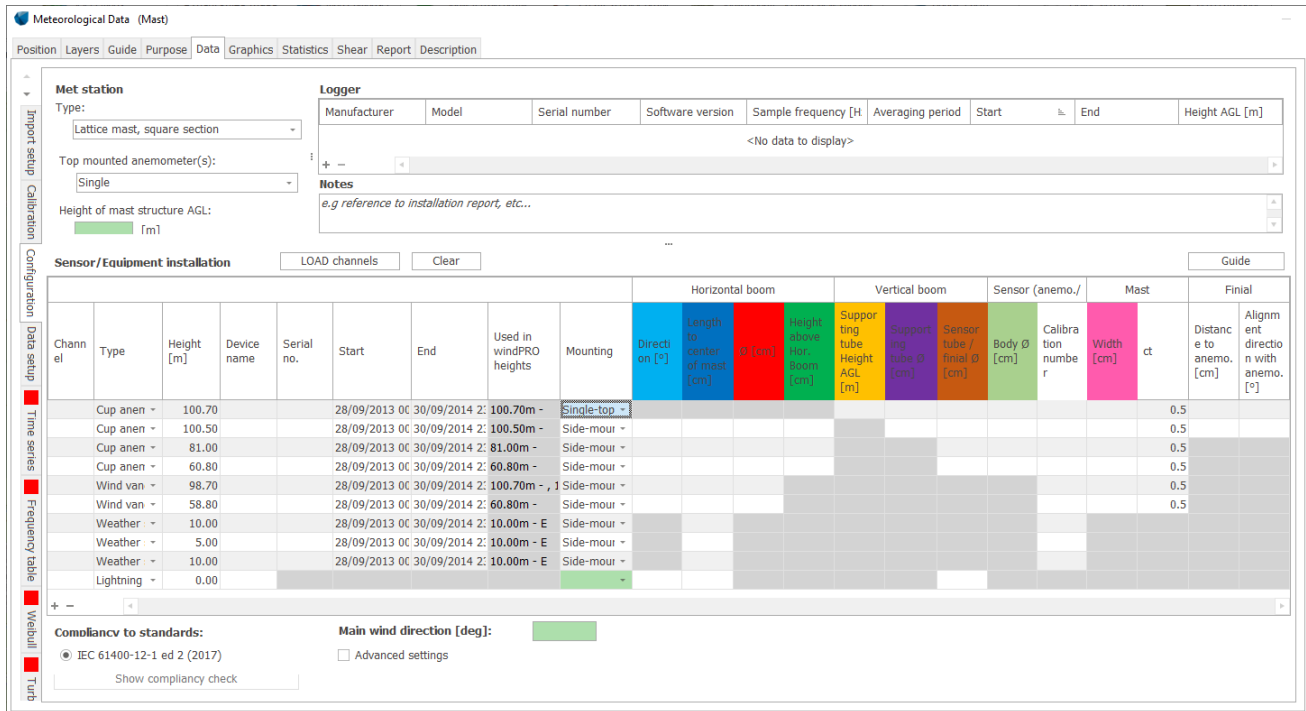
Figure 12 Magnetic declination

If needed, the direction data can be corrected for the magnetic declination by checking **Allow correction of vane offset for magnetic declination**. The correction for magnetic declination is only relevant if it has not been considered during the installation of the wind vane(s) nor in the input of calibrating factors in the logger. The value of magnetic declination is added to the direction data in order to get the direction relative to true North (assuming that the vane has been installed relative to the magnetic North). The final correction applied to the data can be seen in the Calibration table, where it can also be deselected or changed manually.

12.3.3.3 Configuration

The Configuration tab is used to:
- Document the configuration of the sensor installation on a typical mast
- Evaluate the compliance of this configuration to standards for wind data measurements (at the moment IEC 61400-12-1 ed. 2).

Figure 13 Configuration tab

Met station
It is possible to define the type of Met station between Lattice mast, (triangular or square section), tubular mast, SODAR or LIDAR. The difference between lattice (whatever section type) and tubular has an influence on the IEC check for the distortion from the mast (involving Ct value or not, see below). For SODAR or LIDAR, no configuration table nor compliancy check is available at present.
It shall be specified if the top mounted anemometer(s) is single or side-by-side, since this is relevant for the IEC checks.
The height of the mast structure AGL is the total height of the lattice or tubular mast from bottom to top.

Logger
If available in the raw data file, information on the logger, such as the manufacturer, Model, serial number … is presented automatically. It is also possible to input the information manually and to add a line if the logger has been changed with a new one during the measurement campaign.

Notes
This field is available for user-defined text for documentation purposes. It could be relevant to enter references to various installation and maintenance reports related to the installation and operation of the measurement mast.

Sensor/Equipment installation
The sensor/Equipment installation table lists the various sensors involved in the measurement campaign of the data defined in Import filter and allows to input the dimensions relevant for the compliancy check to standards. The relevant input concerns:
- the horizontal booms (direction, length from mast center and diameter)
- the vertical booms, that is both the smaller tube directly attached to the sensor and the supporting tube. The supporting tube is the additional tube used to stabilize the smaller tube attached to the body of single or side-by-side top anemometers
- The body diameter of the sensor
- The calibration number from the certificates (for documentation purposes)
- The mast width and thrust (Ct), the latter only in case of lattice tower
- The distance to anemometer and the alignment with the anemometer of the lightning finial.

The dimensions of certain sensor/equipment types are not relevant for compliancy check and therefore not available for input in the table (grey cell).
The cells of the table can be filled in from the Clipboard (preferably from a Copy from Excel) using Paste relative to currently selected cell will.

The dimensions are presented in the diagram below, using the same colour as the headers of the table.
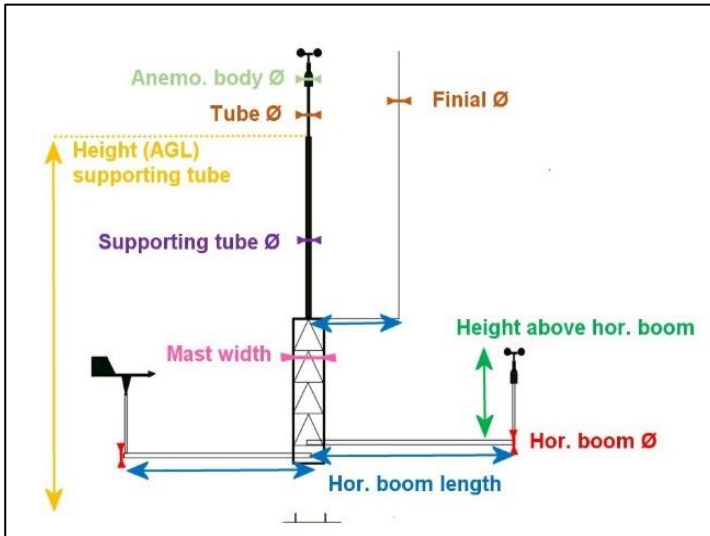

Figure 14 Diagram of the dimensions to input in the Sensor/Equipment installation table

This diagram is also available under the Guide button.

The table is based on the Calibration table but changing the data type (wind speed, wind direction, …) to corresponding sensors (anemometer, wind vane, …). Wind speed signal is by default assumed to come from a cup anemometer. It is possible to change the Type of sensor to sonic anemometer in the drop-down menu of the Type column. The data such as temperature, pressure or humidity are reported as belonging to a sensor type called Weather station.

Loads Channels: (Re-)Loads the Sensor/equipment installation table based on the Calibration tab.

If two calibration periods have been defined for a data type in the calibration tab, two sensor lines will be created in the configuration table matching each period and assuming that the configuration between the two periods could be different. If this is not the case, lines can be manually deleted (with the – at the bottom of the table) or modified; the Start and End date can also be manually changed.

At the bottom of the list, a line is added for a lightning finial.

Mounting
The mounting is relevant for the IEC compliancy checks. The mounting is filled in automatically as a first best guess. It is recommended to check that it corresponds to the mast configuration at stake. The mounting of the top anemometer(s) and of the lightning finial require user input. The different types of mounting are:
- Single-top: The top anemometer is placed on the top of the mast and centered on the cross section
- Side-mounted: The sensor is placed on a horizontal boom
- Shared boom: The sensor is placed on a horizontal boom together with another sensor (at the same height and direction)
- Top (Lightning finial): The lightning finial is placed on the top of the mast and centered on the cross section
- Boom (lightning finial): The lightning finial is placed on horizontal boom

Used in windPRO heights
This column is automatically filled once the data have been setup and loaded under the data setup tab. It refers to the heights that are defined and used in the Meteo Object from the Data setup tab. It can be used for traceability of the data.

Lightning finial, distance, and alignment
The horizontal distance between the finial and a given top anemometer is calculated automatically in windPRO for most of the common combination of anemometer and finial mounting, as presented in the following table.

Table 1. Automatic input of distance and alignment direction between finial and anemometer in Sensor/Equipment installation table used for the IEC checks about distortion from finial.

Combinations of anemometer and finial		Automatic input in Configuration table	
Anemometer mounting	Finial mounting	Distance to anemometer	Finial-anemometer alignment direction
Single, top (centred)	On a boom	Length of finial boom	direction of finial
Single, side mounted	Top (centred)	Length of anemometer boom	180 + direction of anemometer boom
Single, side mounted	On a boom	-	-
Side-by-side, top	Top (centred)	Length of anemometer boom	180 + direction of anemometer boom
Side-by-side, top	On a boom	-	-

The calculated distance or alignment can be modified manually in the table ("Distance to anemo." Column).

Main wind direction
The input of main wind direction is used for the check of the mast distortion and of the lightning finial giving wake in compliance with IEC 61400-12-1 Ed 2.

Advanced settings
Checking the advanced settings gives access to tolerance values used in some Compliance checks. The IEC/Tolerance for boom orientation vs main wind direction gives a margin (+/-) around the ideal orientation of the boom that will return OK to compliancy.
The tolerance IEC/Wake sector for distortion from finial is the wind direction sector in which the finial is supposed to give wake, assuming that it is centered on the finial.
The default values are arbitrary and can be changed.

Main wind direction [deg]:	30.0
☑ Advanced settings	
IEC/Tolerance for Boom orientation vs main wind direction +/- [deg]:	2.0
IEC/Wake sector for distortion from finial [deg]:	15.0

Compliancy check
The input made in the Sensor/equipment installation table is used to check the configuration of the mast to the most important requirements defined in Annex G of the IEC standard 61400-12-1 Ed.2.0 Wind energy power generation systems – Part 12-1: Power performance measurements of electricity producing wind turbines.

Once the table is filled, provided there is an input in all the green cells (Height of mast structure, Main wind direction and Mounting of lightning finial), the Compliancy check can be launched clicking on the button **Show compliancy check**.

For more detail about the checks conducted, please refer to the online documentation: https://www.emd-international.com/files/windpro/210629_Notes-compliancy%20check.pdf, also available from the Compliancy Check window through the link in the bottom right corner in the window.

A color code is used to give a quick overview of the result of the compliancy check. Green color is used for compliancy, red for non-compliancy and orange for a non-critical non compliancy. When a check involving two condition is not passed, the result is NO. It is possible to see which condition is not fulfilled by mouseover the cell, as shown in the example below.

Figure 15 Example of explanatory text in case one condition is not met

In case of missing data, the checks cannot be performed. The required input from the configuration table is listed for each check in the online documentation

Note that it is possible to select whether all or only some compliancy checks shall be presented in the final report (See 12.3.8).

12.3.3.4   Data setup

This is the tab where we can finally load the data from the files whose structure has been defined previously.

Note: in the Meteo Object, "Heights" always refer to the height of wind <u>speed</u> measurements!

This is how to proceed. Ignore the **Add…** button for now, as it will be treated later.
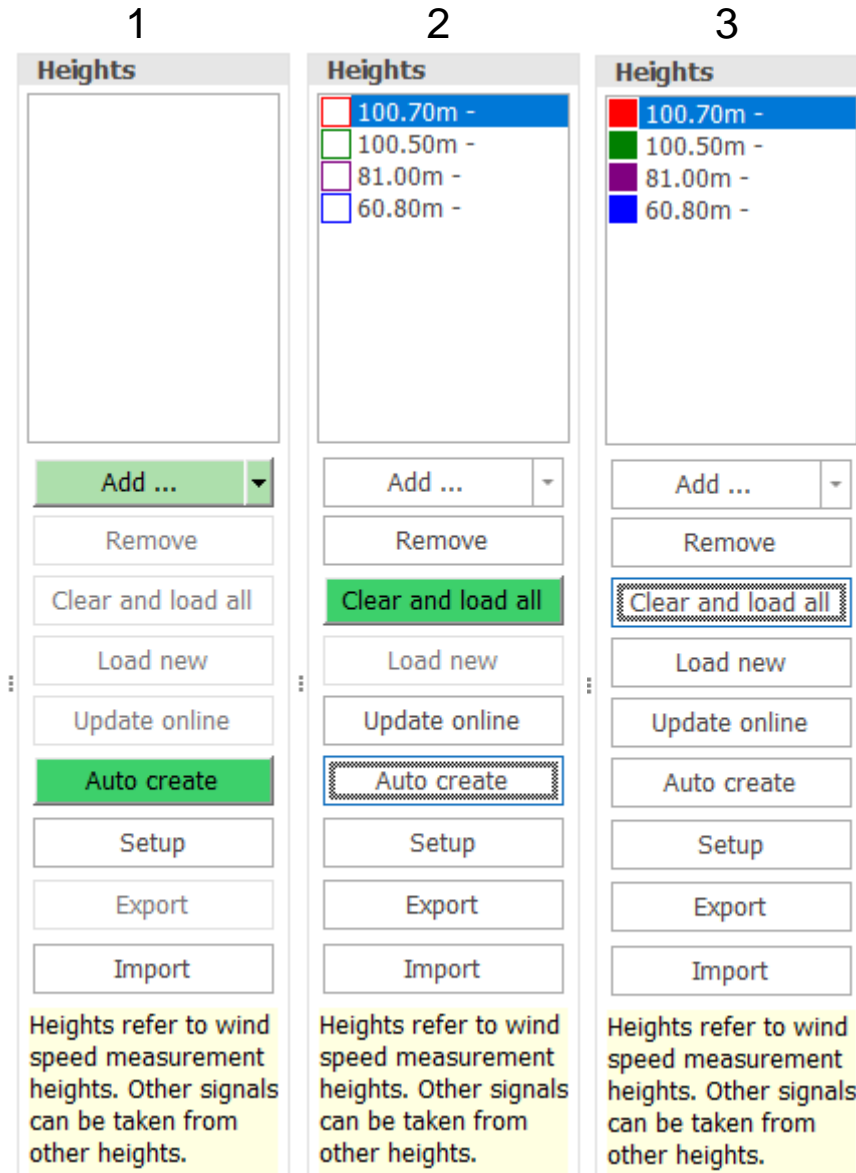

*Figure 16 The data panel in the Data setup tab. (1) Click **Auto-create**, to create signals at the available heights. (2) Click **Clear and load all** to load data into the signals. (3) Click **Add…** to add more wind data at other heights.*

The "**Auto Create**" button is, by default, green, as this will be the typical starting point. This will automatically create all the wind speed measurement heights in the import setup, providing the file can be read by windPRO. The signals created by default are:
- Wind speed
- Wind direction
- Turbulence intensity

Wind direction is taken from the wind vane vertically closest to each anemometer/wind speed signal.

Clear and load all will clear data, in case of already loaded data. If new data have been added to the import filter, the **Load new** will make sure the data already loaded data are maintained with flagging, disabling etc.

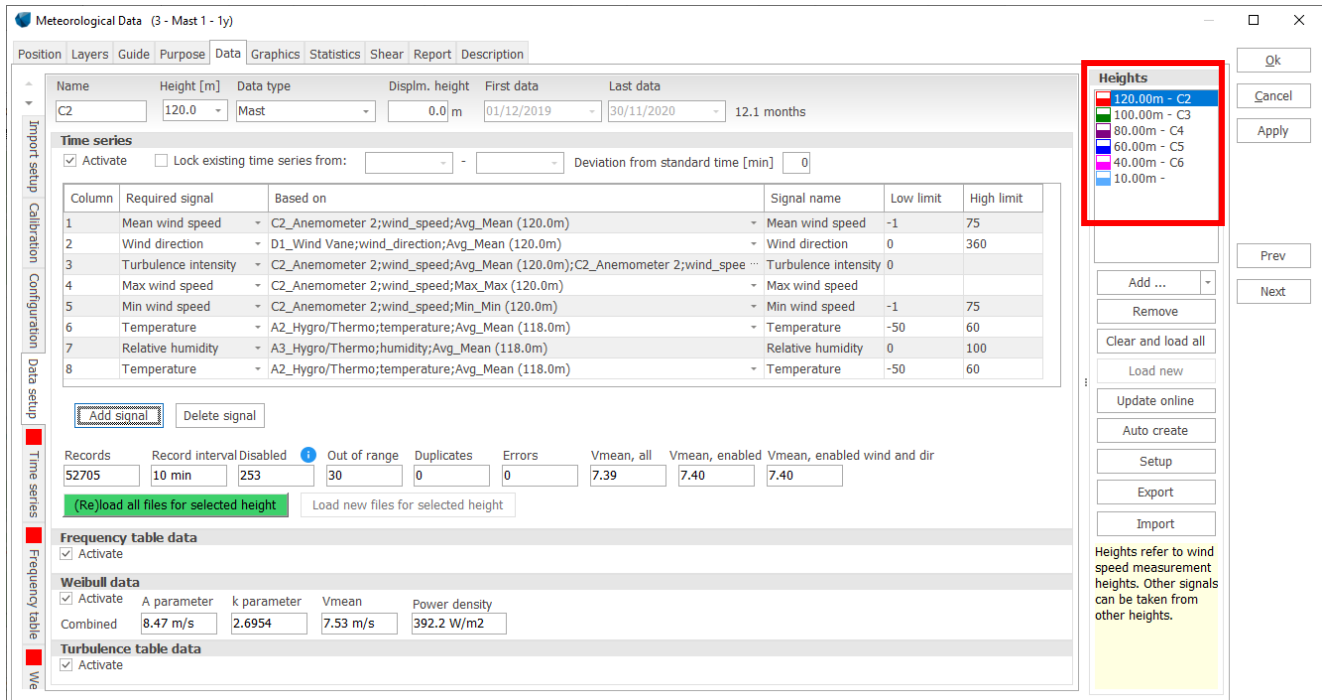And this is how the window will look like, after importing data.

Figure 17 The Data setup tab, after data loading

You can now switch between different measurement heights by clicking in the **Heights** panel to the right.

Never change the value indicated in the Height [m] field on the left! This would effectively <u>modify the height</u> of that particular instrument/signal!
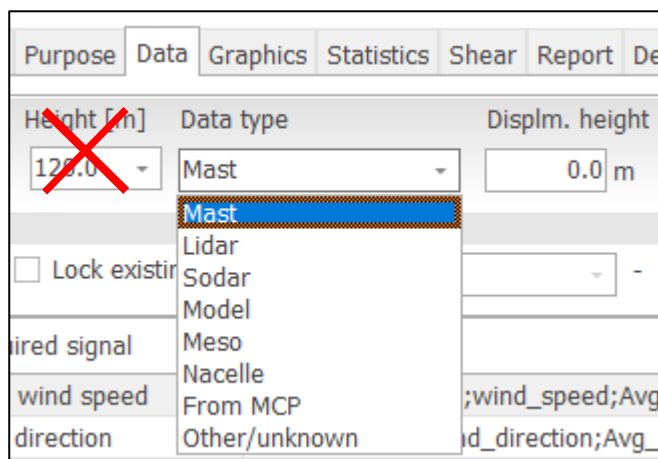

Figure 18 Data type and displacement height

It is possible to set a displacement height, if the mast is, for example, in a forest (positive disp. height) or on a very narrow rock (island) (negative disp. height), which is NOT included in the elevation data. The data type, mast, Lidar, etc. can be specified. This information can be used by modules like PARK and SITE COMPLIANCE, and is used in the wind profile graphic, discussed later. The data type Mast, Lidar etc. can be selected and is used for relevant purposes. For example, for downscaling Meso data in Scaler the data type must be Meso. Creating a wake-cleaned wind speed signal will be handled differently if the datatype is Nacelle or Mast. If Nacelle, the turbine nearest the Meteo Object is not included in calculations. However, it is checked that there is indeed a Turbine Object within 5 m distance.

Add… (Figure 16**)** adds a new height. We will treat it later.

Update online refreshes data previously loaded from On-line data (updates with most recent months and, optionally, extends data back in time, if data are available).

Setup allows setting of rules for concurrency, disabling of turbulence and rules for use of data for the turbulence table. Also, a special feature is available for very-high time resolution data.

Export exports all or selected data into a flat text file format. The flag definitions are included in the export (see their explanation in the text file itself). Below is an example where 80m and 60m data are exported:

Figure 19 Export selections

WindPRO Meteo Data Export version 7													
Geographical Coordinates (	Longitude	9.707051	Latitude:	51.24978									
Local Coordinates: (UTM (n	Easting:	549346.4	Northing:	5677839	EPSG: 32632								
Description:	Mast												
User label:													
Date time format:	dd/mm/yyyy hh:nn												
Decimal separator:	.												
Digit group separator:	,												
Displacement height [m]:	0												
All time stamps:	(UTC+01:00) Amsterdam, Berlin, Bern, Rome, Stockholm, Vienna												
UTC offset [minutes]:	-60												
StatusValues:													
Ok	0												
Disabled	1												
Below limit	2												
Above limit	4												
Duplicate	8												
Null value	16												
Missing	32												
Other error	128												
Note that SampleStatus takes precedence over DataStatus which means that DataStatus is only relevant if SampleStatus is OK.													
TimeStamp	MeanWin [m/s]	Directionl [Degrees]	TurbIntUI	Comment	TimeStam	SampleSt	DataStatu	DataStatu	DataStatu	MeanWin [m/s]	Directionl [Degrees]	TurbIntUI	Comment
28/09/2013 00:00	7.2	119	0.0556		0	0	0	0	0	7.2	119	0.0556	
28/09/2013 00:10	7.2	119	0.0556		0	0	0	0	0	7.1	119	0.0563	
28/09/2013 00:20	7.1	120	0.0563		0	0	0	0	0	7	120	0.0571	
28/09/2013 00:30	7.2	118	0.0694		0	0	0	0	0	7.2	118	0.0694	
28/09/2013 00:40	7.71	118	0.039		0	0	0	0	0	7.7	118	0.039	

Figure 20 Export format from Meteo Object

Status values are coded, so the sum in the status columns can be decoded for precise identification of, for example, "disabled", "out of range" (this means that multiple flags can be applied to the same data point). There is also a status column for all signals as well as one for each signal. The headers are exported unicoded (UID), meaning that the same text will appear no matter from which Windows language it is exported. Thus, it is easy to maintain a large database with exports from many different users around the world, as only one windPRO meteo importer will be needed.

Import imports data from the export file (Note: a whole Object export can be performed from the Object List).

Back to the central part of the Data setup tab:

Figure 21 Data panel below the signals in Data setup tab

Add signal is used for adding other signals not automatically considered by windPRO; for example, temperature or max. wind speed. The range of signals that can be included is constantly expanded:

Figure 22 Current predefines signals.

Full flexibility is given for creating a specific signal at a certain height from other signals/measurements. The signals available match the import filter types + sub types and some extra signals, calculated from more signals, e.g. Turbulence Intensity, which requires wind speed and Std.dev wind speed.

Let's see a few examples.

If the data come from files with different formats (multiple import filters used), always check the dropdown buttons in the column "Based on" to see if the signals from the different import filters (I1, I2, …) are correctly included:

Figure 23 In this example, wind speed data come from Filter I1, which refers to certain data files only, whereas the direction is going to be read from Filter I2, referring to other files, with a different data structure. The Filters were defined in the Import Setup tab

Note also the column **Low/high limit** (next to Signal name): this is used to define the valid range of the values the data can assume. By default the low limit for wind speed is -1 m/s. It is important not to set this to "0". If "0" wind speeds are not included in the data set, the Weibull distribution will be wrong and the calculations will be wrong.

Shear can be added as a signal, giving options for comprehensive analyses of shear within the Graphics tab. Since shear requires more heights, these can be selected in drop-down buttons as illustrated in next figure.

When adding shear, the user has full flexibility about which heights will be used to calculate the shear time series (minimum of 2 heights is needed).

Column	Required signal		Based on		Signal name
1	Mean wind speed	▾	WS 100.7m Mean_Mean (100.7m)	▾	Mean wind speed
2	Wind direction	▾	Wind Direction 1_Mean (98.7m)	▾	Wind direction
3	Turbulence intensity	▾	WS 100.7m Mean_Mean (100.7m);WS 100.7m Stddev_StdDev (100.7m)	⋯	Turbulence intensity
4	Temperature	▾	Temperature_Mean (10.0m)		Temperature
5	Shear	▾	WS 100.7m Mean_Mean (100.7m);WS 81m Mean_Mean (81.0m)	⋯	Shear

Select wind speed signals for shear calculation

Signal	Use
WS 100.5m Mean_Mean (100.5m)	☐
WS 100.7m Mean_Mean (100.7m)	☑
WS 60.8m_Mean (60.8m)	☐
WS 81m Mean_Mean (81.0m)	☑

Ok | Select all | Deselect all

Figure 24 Setup of shear calculation

Delete signal removes unwanted signals from a height.

(Re)load all files for selected height loads the data from the files for the selected height only. The right side button (**Load new files for selected height**) only loads new files added after the last load operation. The Reload button preserves the results of any data cleaning ("disabling") operation that might have been done previously. This doesn't happen with the "Clear and load all" button presented earlier.

Name	Height [m]	Data type	Displm. height	First data	Last data	
	100.7 ▾	Mast ▾	0.0 m	28/09/2013 ▾	30/09/2014 ▾	12.1 months

Time series

☑ Activate   ☐ Lock existing time series from: [   ] ▾ - [   ] ▾   Deviation from standard time [min] 0

Figure 25 Features at the top of the tab

The various **Activate** options activate the different types of data presentations, such as the Weibull or Turbulence tabs. If you have no intention of using the Weibull distribution, or you have table data but no time series data, this feature is useful.

Lock existing time series is used when new data are added, but previously loaded data do not exist as files on the PC or they have been added with different import settings in WindPRO 2.5 or previous versions. Basically, adding new data requires intact import filters and files for all data except when older data series are locked.

12.3.3.4.1 The Add… button: adding & generating wind data at new heights

Add … ▾ | Next
Add height
Add merged height
Add synthesized height
Add scaled height
Add stability
Add wake cleaned height
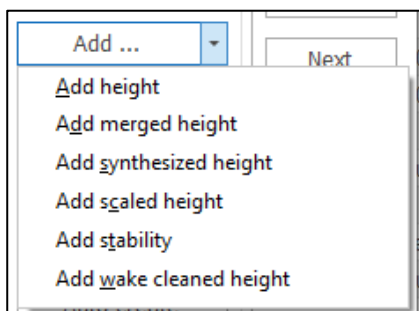
We have so far left behind a very important feature: the Add… button. It essentially creates a new measurement height, where wind data can be read from files or generated by different methods.

Its submenu gives hints of the different features and purposes:

Add height simply creates a new height, where the presence of wind data is automatically assumed, and the user will have to select their source, as in Figure 23.

Add merged height allows to merge two or more wind speed time series based on wind direction; it is typically used to remove the mast shading effects when two anemometers are mounted at the same height

Add synthesized height gives access to a shear calculator that extrapolates measured data to another height on the basis of the measured wind shear.

Add scaled height creates a new data series, which can be, for example, a downscaled mesoscale time series (if EMD mesoscale data are loaded) or the output of a flow model used to extrapolate wind data from one or more measurement heights to a new height. There are many possible scenarios here due to the high flexibility of the Scaler tool.

Add stability creates an artificial atmospheric stability classification based on user-defined classes for day, night and season.

Add wake-cleaned height is based on a PARK model (which must be pre-run), which cleans the measured data series from wakes generated by neighbouring turbines.

Let's discuss the details of each feature.

12.3.3.4.2 Remove tower shading: Add merged height
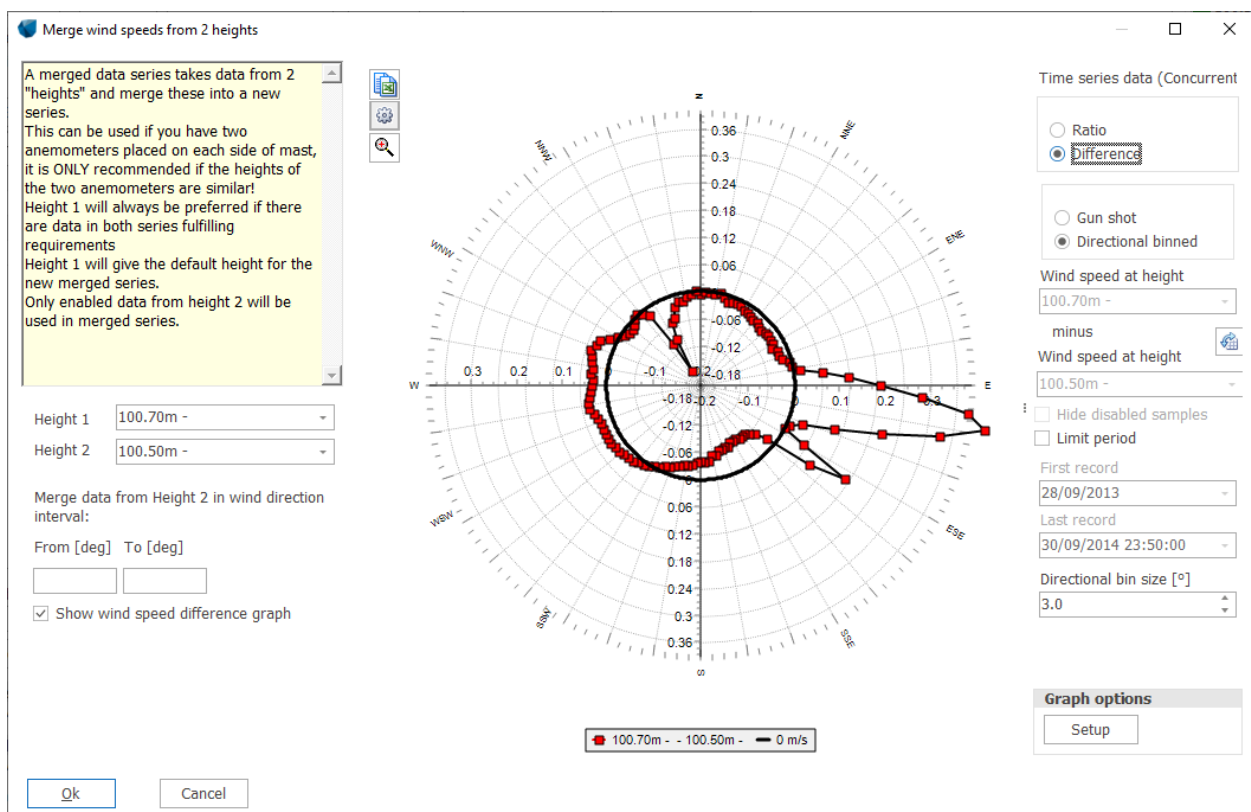
Figure 26 Compare wind speeds by direction

When two wind speed measurements are at the same height, both measurements can be used to remove the influence of tower shading and thereby get a "clean" signal. Note that the original data are never modified: we will create a new time series, merging the two existing ones.

This procedure should be used only after the quality control procedures have filtered out ("disabled") bad data.

A typical setup is shown above. Here, wind speed data from "Height 1" is used as "base" and wind speed data from "Height 2" is merged into the "base" data within the given sector defined by "From [deg] - To [deg]". Only wind speed data from "Height 2" that have survived quality control are used for the merging. The merging is not

performed if the direction data of "Height 1" are disabled. Looking at the data above, it is obvious that wind speed data from "Height 1" are underestimated due to mast shadow between 320° and 350° (the difference, "Height 1" minus "Height 2", is negative). We then enter this angular window in the relevant fields; clicking on **Ok,** the following screen appears:
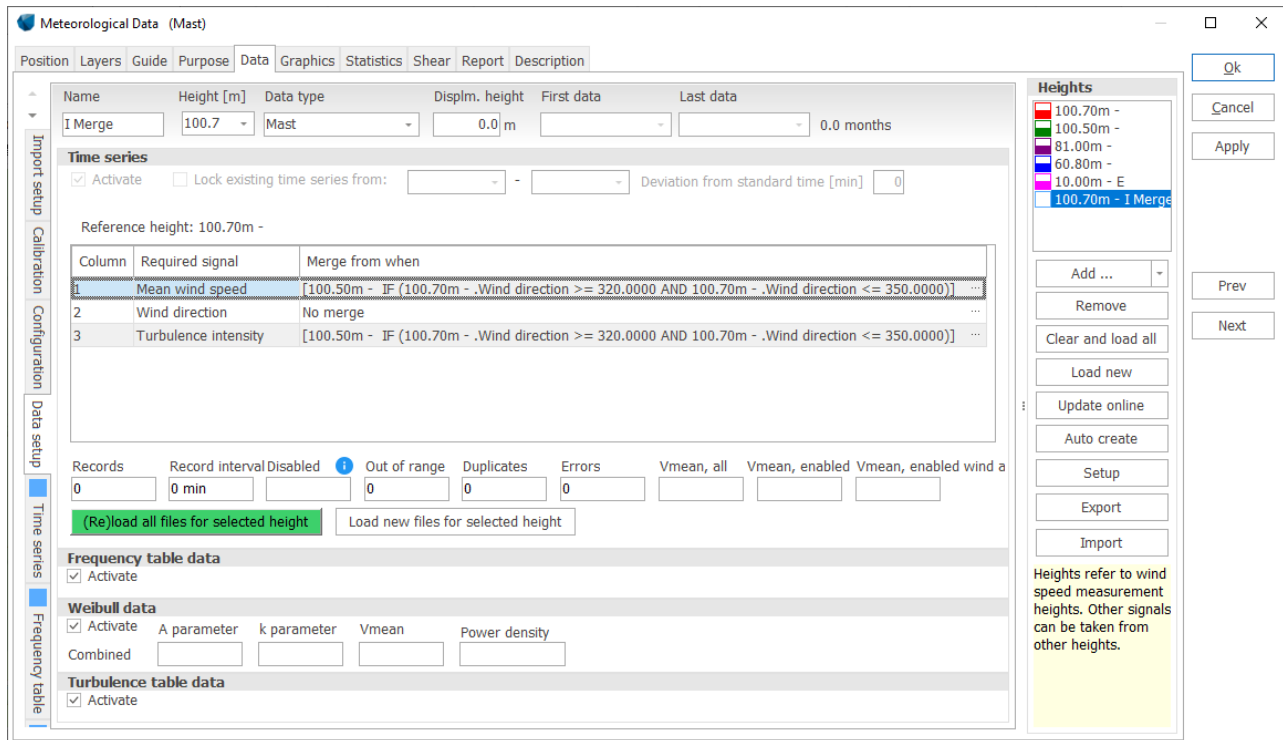
Figure 27 Merging data from more sensors

The rules established for the merged series are shown. Before loading the merged data (green button), the rules can be edited by clicking the small dots to the right of each rule; any rule based on any signal can be created.

12.3.3.4.2.1 Shear-extrapolate to new height: Add synthesized height

Data can be scaled to a new height based on a shear extrapolation. Referring to Figure 28, the two first options, **Internal shear** and **External shear,** rely on a shear matrix, calculated within the current Meteo Object in the first case or exported from another Meteo Object in the second case. The third option uses a shear table from the shear tab of the current Meteo Object (see 12.3.6 about the shear tab).

The **Reference height** is the height from which wind speed will be extrapolated from to the target height specified in **Height**. Both heights need to be specified to start the shear matrix calculation.

To calculate the shear values, at least two heights must be selected and one of them will also define the direction.

The shear matrix contains shear values in several bins: monthly bins (yearly variation), hour bins (daily variations) and directions. It is up to the user to define these resolutions.

The shear matrix is calculated from Weibull-fitted mean wind speeds in each bin (season, time of day and direction) and will therefore partly represent atmospheric stability conditions. The extrapolation to a new height will then be based on the individual bin values for shear. Note: In complex terrain, on a smooth hill, or in a forest, very inaccurate extrapolations can occur. Using a model, such as WAsP (or better, WAsP-CFD, when terrain is really complex) for the extrapolation will be the best choice.

The shear matrix can be more or less detailed, depending on how good and long-term period of data is available.
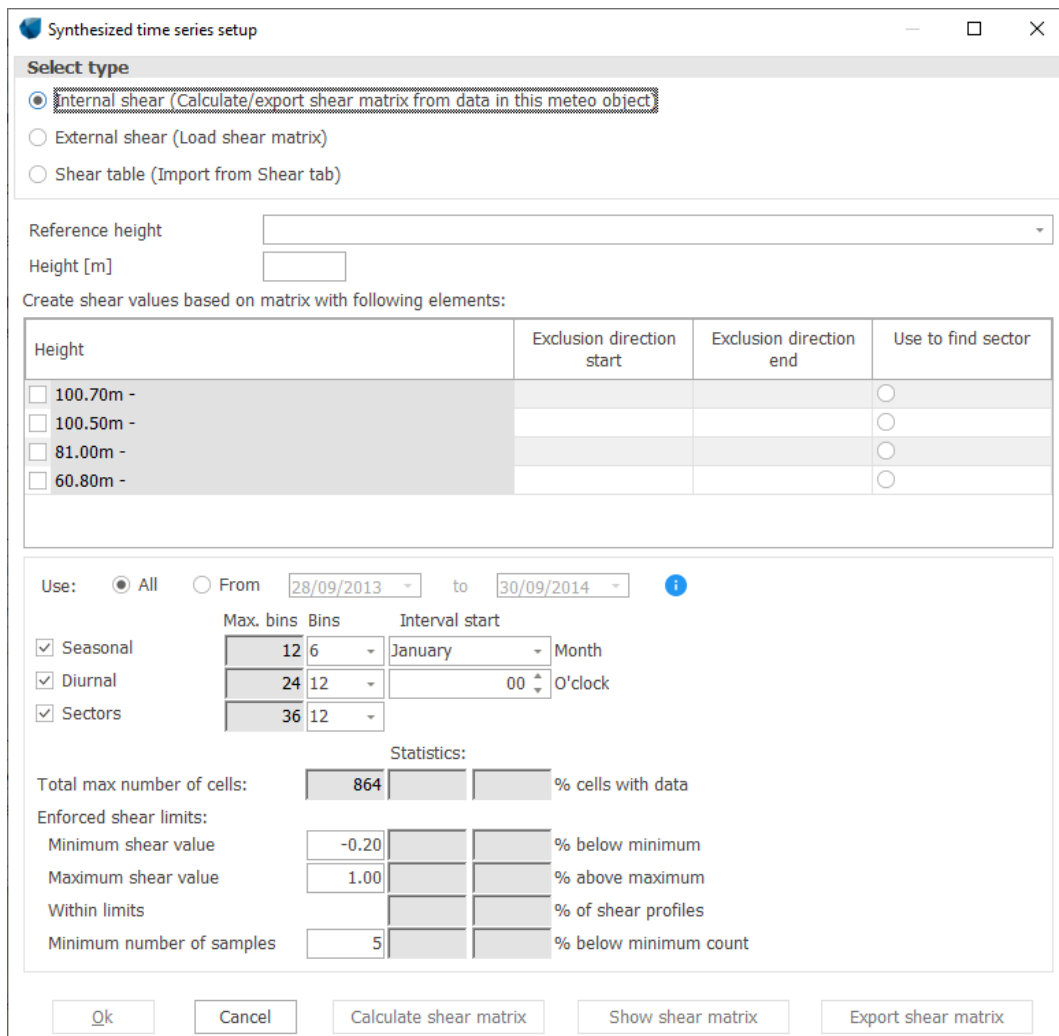
If there is too little data for a bin (direction sector, diurnal period and seasonal period), the bin will be given data based on the following priority:

1. Annual value for the direction and diurnal period.
2. Mean value for the nearest two directions
3. Overall mean

For instance, if a direction has almost no data, not even a year's worth of values might be present for a certain diurnal bin, then the two nearest directions are used. If those (or just one of them) also have too little data, the algorithm moves to step 3. Note that these substitutions are not very critical, since they will basically represent bins where wind is rarely experienced.

Note that if a <u>fixed</u> displacement height is entered in the Meteo Object, it will be applied to the height used to create the shear values as well as to the reference and target heights. If the met mast is experiencing a displacement height, it is recommended to include the displacement height in the Meteo Object to calculate the shear matrix.

Figure 28 Create synthesized data

Finally, click on **Calculate shear matrix**. Once it has been calculated, it can be viewed (and/or exported) and finally used to synthesize the data (clicking OK).

Figure 29 Shear matrix (shown here for all directions)
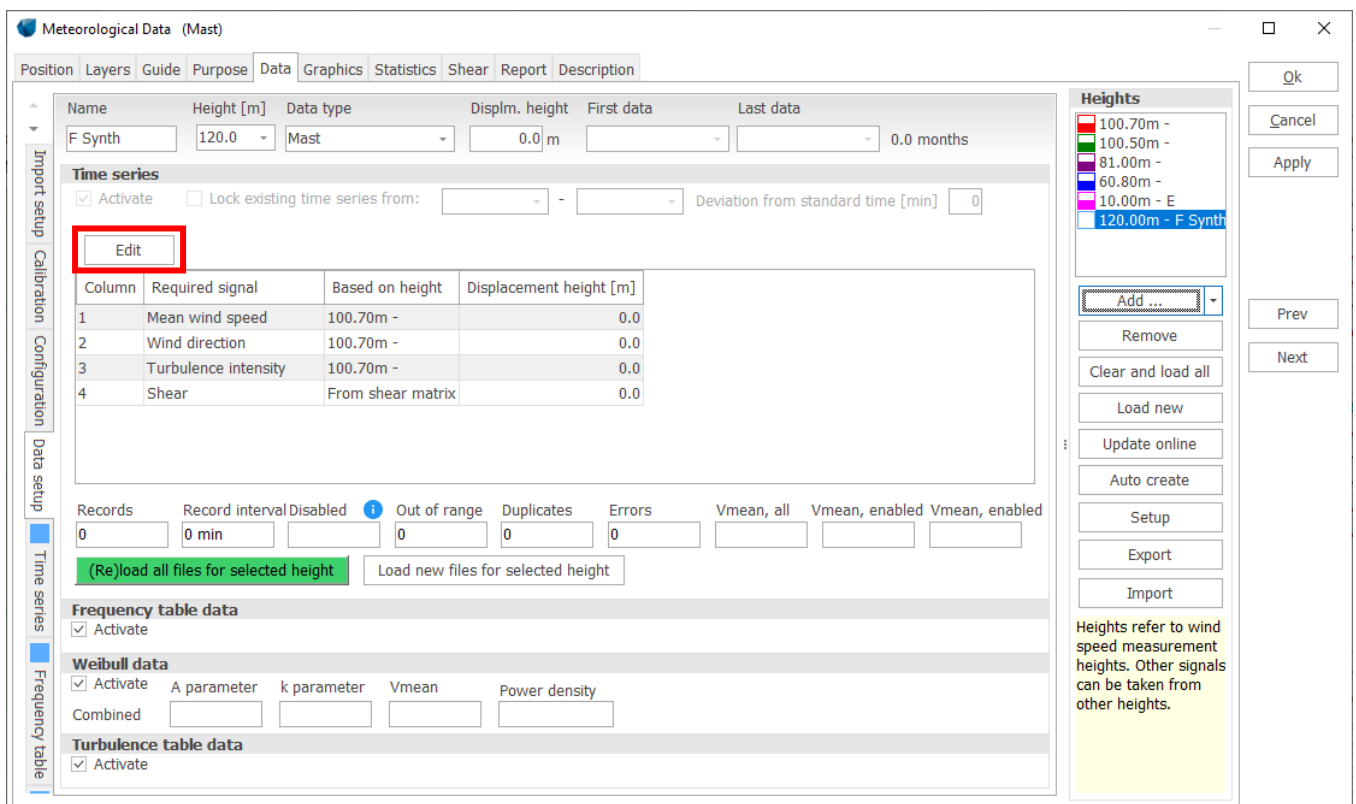
Figure 30 Load synthesized data with the green button

The new synthesized height is created and must be loaded. With the "Edit" button you can go back to the shear calculation setup and adjust.
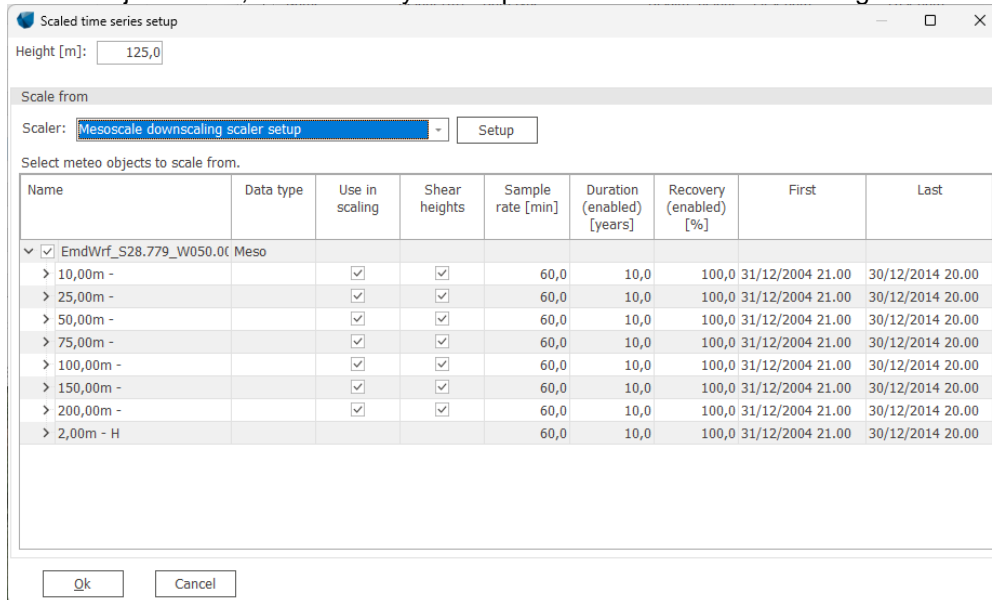
When data are loaded, the tabs with the different data presentations will be added.

In the case of an exported shear matrix, a .shearmat file is created. This file contains all the information needed to replicate the matrix in another Meteo Object (or the same). This option can be useful especially for co-located

remote sensors (LIDAR, SODAR). Care must be taken that an imported shear matrix is representative (for example concurrent in time or same terrain or stability conditions) of the data that it is going to be applied to.

12.3.3.4.2.2 Add Scaled height

Here, the Scaler is used e.g. to downscale mesoscale data to the microscale and create a time series within the Meteo Object. Then, it will be easy to compare the scaled data to the original data within the Object.

Scaled time series setup

Height [m]: 125,0

Scale from

Scaler: Mesoscale downscaling scaler setup   [Setup]

Select meteo objects to scale from.

Name	Data type	Use in scaling	Shear heights	Sample rate [min]	Duration (enabled) [years]	Recovery (enabled) [%]	First	Last
✓ EmdWrf_S28.779_W050.0(	Meso							
> 10,00m -		✓	✓	60,0	10,0	100,0	31/12/2004 21.00	30/12/2014 20.00
> 25,00m -		✓	✓	60,0	10,0	100,0	31/12/2004 21.00	30/12/2014 20.00
> 50,00m -		✓	✓	60,0	10,0	100,0	31/12/2004 21.00	30/12/2014 20.00
> 75,00m -		✓	✓	60,0	10,0	100,0	31/12/2004 21.00	30/12/2014 20.00
> 100,00m -		✓	✓	60,0	10,0	100,0	31/12/2004 21.00	30/12/2014 20.00
> 150,00m -		✓	✓	60,0	10,0	100,0	31/12/2004 21.00	30/12/2014 20.00
> 200,00m -		✓	✓	60,0	10,0	100,0	31/12/2004 21.00	30/12/2014 20.00
> 2,00m - H				60,0	10,0	100,0	31/12/2004 21.00	30/12/2014 20.00

[Ok]   [Cancel]
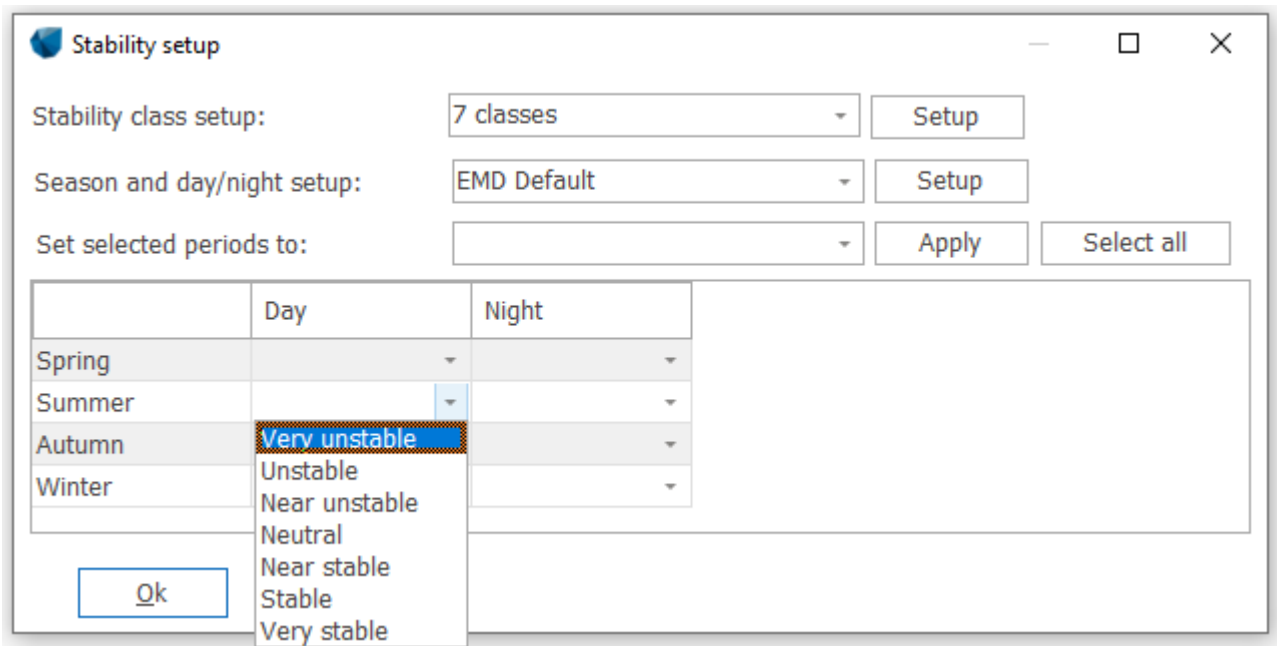
Figure 31 Selecting the scaler and heigths

It is important to note that the data are scaled to the same position of the current Object. Therefore, it is possible to move a Meteo Object containing mesoscale data to a position where a "virtual mast" is needed. The mesoscale-based Meteo Object knows its original position and uses the mesoscale terrain from this position, but then the microscale terrain is used for the new current position.

12.3.3.4.2.3 Create atmospheric stability statistics: Add stability

This tool creates a statistic of the climate of atmospheric stability on site, relying entirely on user input. In other words, the user must know, and enter, the expected stability conditions at different times of the day and year. This is useful if this knowledge is available, but no hard data are at hand, on the matter.

One can decide in how many classes atmospheric stability should be classified (with a minimum of three, Stable, neutral and unstable), and also how day and night are defined. Then, for each season and period of the day, the expected mean stability condition must be entered:

Figure 32 Setting up stability class definitions

The resulting user-made statistic can be shown in various histograms under the Graphics tab, where a new tab called Stability view will be created.

It is worth mentioning that a more appropriate way of investigating the behaviour of atmospheric stability on site is to estimate its state from hard data (Monin-Obukhov length, heat flux, Temperature differences, …): many of these parameters are available from mesoscale models, such as the EMD-WRF.

Figure 33 Stability can be imported in Meteo Object

Above, the EMD-WRF Europe+ mesoscale data. The "rmol_mean" signal is the inverse Monin-Obukov length available in this data set. Stability can be viewed in Graphics tab under Stability View:
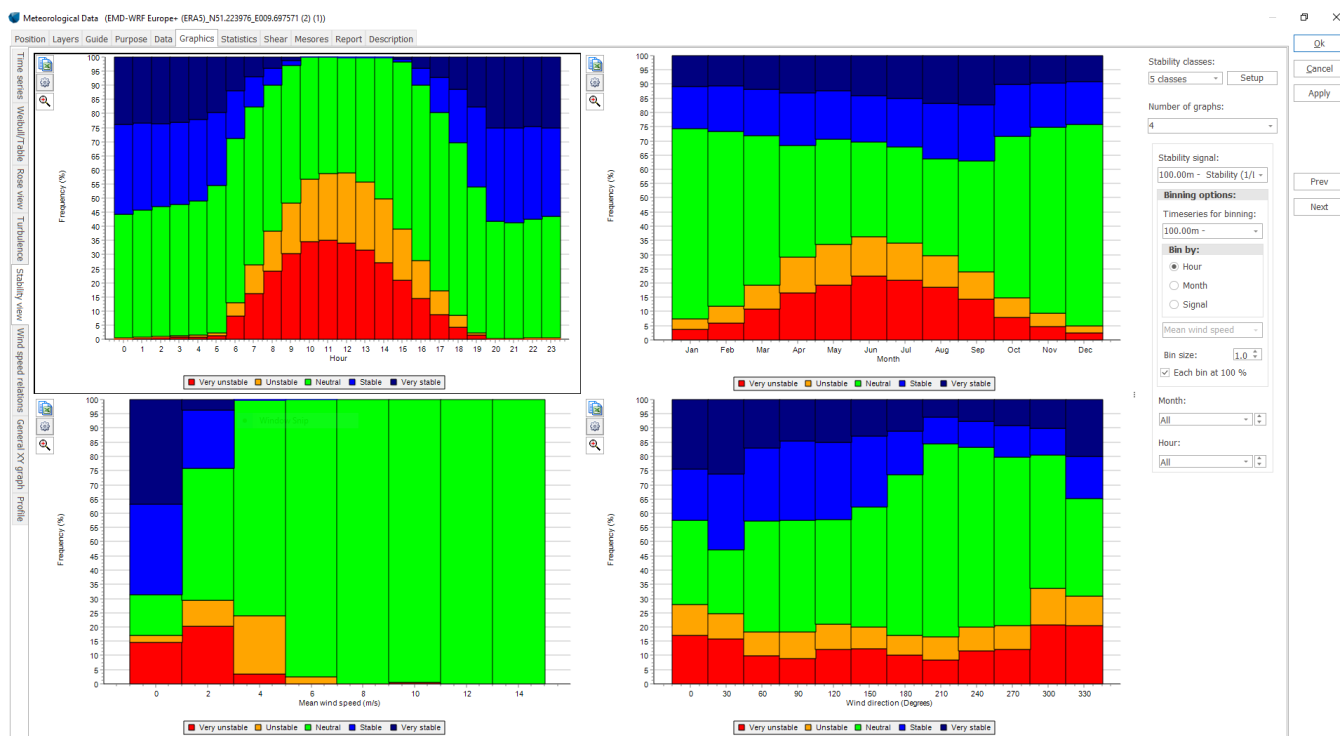
Figure 34 graphic view of stability classes.

Different settings are available. The graphic view is the first step; in future versions of windPRO, the Stability information will be included in calculations.

Figure 35 Setup of stability legend.

In the legend above, the grouping of the stability classes can be user defined. Note in EMD-ConWx mesoscale data, it is the reverse Monin Obukov length (1/L) that will be imported, in the definition above it is the Monin Obukov length, L that is shown, with option for showing 1/L.

12.3.3.4.2.4 Clean measurements from wake effects: Add wake-cleaned height

Figure 36 Setup of the calculation for wake cleaning

Lastly, it is possible to remove the effects of turbine wakes on measurements. This requires to run first a PARK calculation.

The setup window simply requires you to load the PARK result, the height of the instrument affected and to define the kind of instrument you have at that height. This can be a real device on ground (mast, RSD, …), or a nacelle anemometer.

In the first case, the measurement device coordinates are already known from the selected PARK calculation. In the case of a nacelle instrument, the software checks if there is a WTG Object in the PARK calculation within few meters from the Meteo Object used: if not, the calculation cannot be performed. If there is, this WTG Object is automatically removed from the PARK calculation.

The wake cleaning is based on the calculation of a wake reduction matrix with resolutions of 1° and 1 m/s. Note that a simplified PARK model is actually run, where time-based turbulence is not used (a fixed wake decay constant for invalid turbulence values would be used instead). Similarly, curtailment settings will not be included.

Figure 37 Advanced wake settings of the PARK calculation are not included in wake cleaning. The WDC for invalid TI is used, instead of time-dependent values

When the wake-reduced wind speed matrix is calculated, the method is: for each time step, a lookup in the matrix from the wake-reduced wind speed identifies the free wind speed, and replaces the recorded value with this in the wake-cleaned time series.

It is, of course, of high importance that the wake model settings are correct, and that the wake model does a reasonable job.

The advantage of this method compared to e.g. a simple scaling, is that the wind speed reduction dependency on wind speed is handled correctly.

12.3.3.5 Time series

Figure 38 Time series data

With a coloured background, data characteristics such as "Out of range" are clearly shown. Click in the coloured field and the cursor jumps to the first event. Data can be sorted by clicking on the header.

Select: allows to select data with different characteristics – a selection can also be performed "manually" by dragging the mouse in the list.
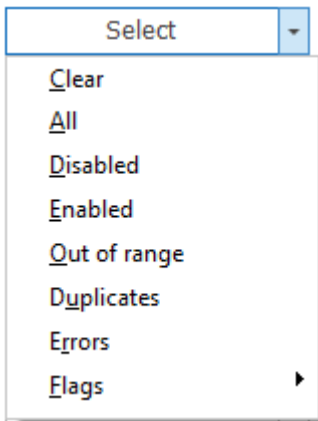
Selected: once data have been selected, you can apply on the selected data any of the actions listed (Copy, Delete, …). For example, data can be copied to clipboard and pasted to other programs, e.g., Excel.

Enable/disable: can be performed manually in the list by checking the checkbox next to the time stamp, as shown above, or via the "Advanced disable/delete" tool, which allows to disable or delete the data according to specified conditions:

Figure 39 Advanced disable/enable/delete

Once the conditions have been entered (above in time and on a specific signal, the wind speeds at 100.7 m), pressing the "Action" button opens the Advanced disable/enable/delete feature for ALL heights and signals (with same time stamp or within ± 5') that fulfill the conditions in the filter settings. Then the user decides which signal should be disabled in those circumstances:

Figure 40 Advanced disable/enable/delete tool

12.3.3.6   **Frequency table**

Only Enabled data <u>not</u> out of range or duplicated are used in the aggregated presentation described here. The aggregated data are automatically updated if changes in the original time series data are performed.

Figure 41 Data frequency table

12.3.3.7   Weibull

Only Enabled data <u>not</u> out of range or duplicated are used in the aggregated presentation described here. The aggregated data are automatically updated if changes in the original time series data are performed.

The method for Weibull fit is energy weighted with the same method used by WAsP, as described in the "European Wind Atlas". The Weibull distribution can be used as input if the Meteo Object data are used for further calculations, e.g., with the WAsP model.

Figure 42 The Weibull fitted data.

12.3.3.8   Turbulence

Only Enabled data <u>not</u> out of range or duplicated are used in the aggregated presentation described here. The aggregated data are automatically updated if changes in the original time series data are performed.

Turbulence data can be shown as mean values and as standard deviations. By copying these two tables to Excel, any combination of mean and standard deviation can be made for turbulence evaluations (e.g., Characteristic values as defined in IEC 61400-1 ed.2: mean + 1 x StDev and ed. 3: mean + 1.28 x StDev).
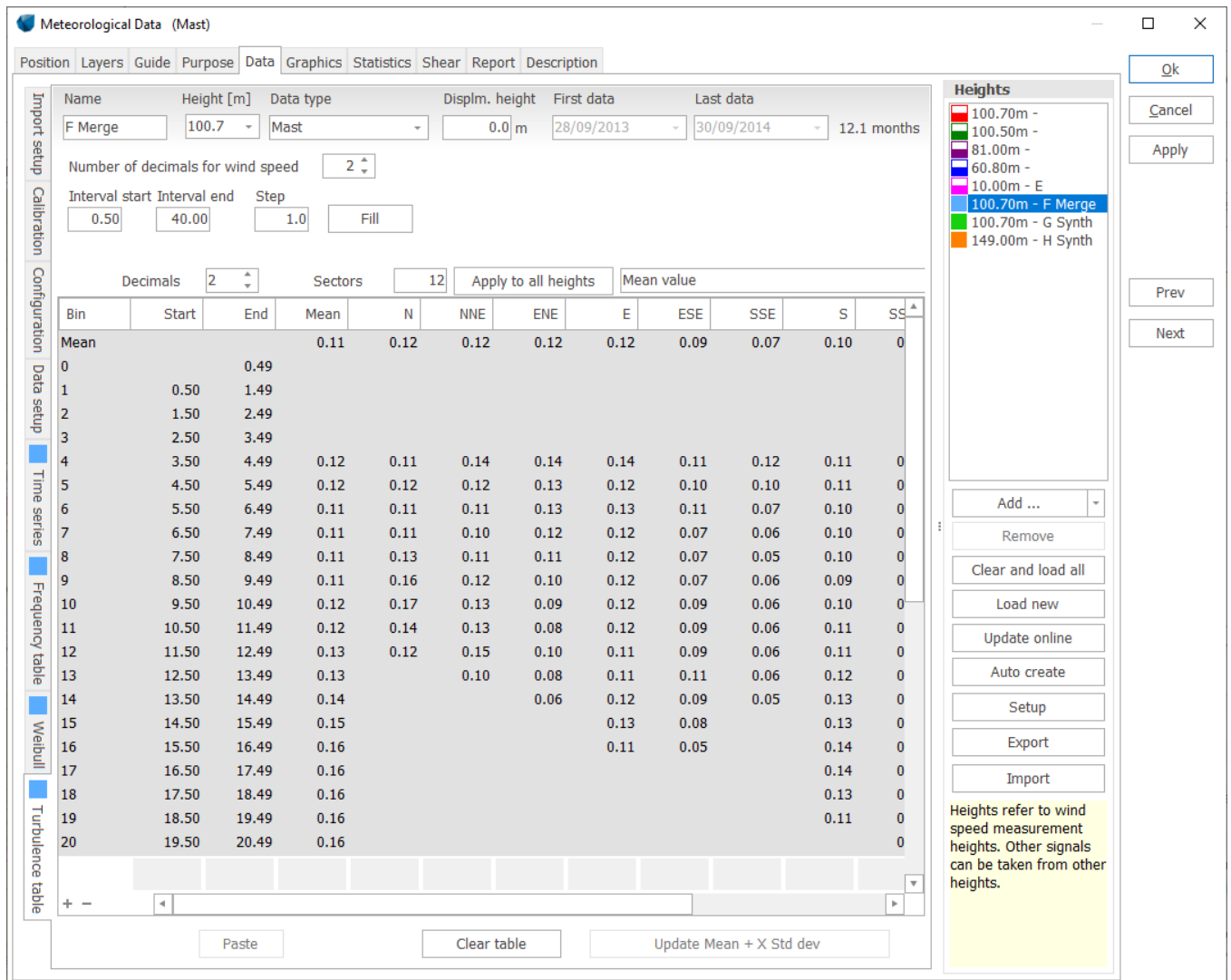
Figure 43 Turbulence data

12.3.4   Graphics

The Graphics tab holds advanced features for the evaluation of the measurements. Also included are features for disabling erroneous data found by the graphic screening of the data.

On each graph there is a "Copy to Excel" button. The graph data "as seen" can be copied to clipboard, and, from there, pasted to Excel or similar.

The Graphics tab has the following main tabs, each with different viewing options:
- Time series
- Weibull/table
- Rose view
- Turbulence
- Wind speed relations
- General XY graph
- Profile

Only a selection of the graphs within each tab will be shown below, as the others should be self-explanatory.

12.3.4.1   Time series

Figure 44 The time series view

The time series view is efficient for finding erroneous data visual comparison – then simply right-click in the graph at the start and end of erroneous data to disable that particular period. You can also add comments (right-click) and these will be listed in a separate report. Zooming by mouse drag is possible as well.

With the check boxes for each height and signal, viewing can be controlled.
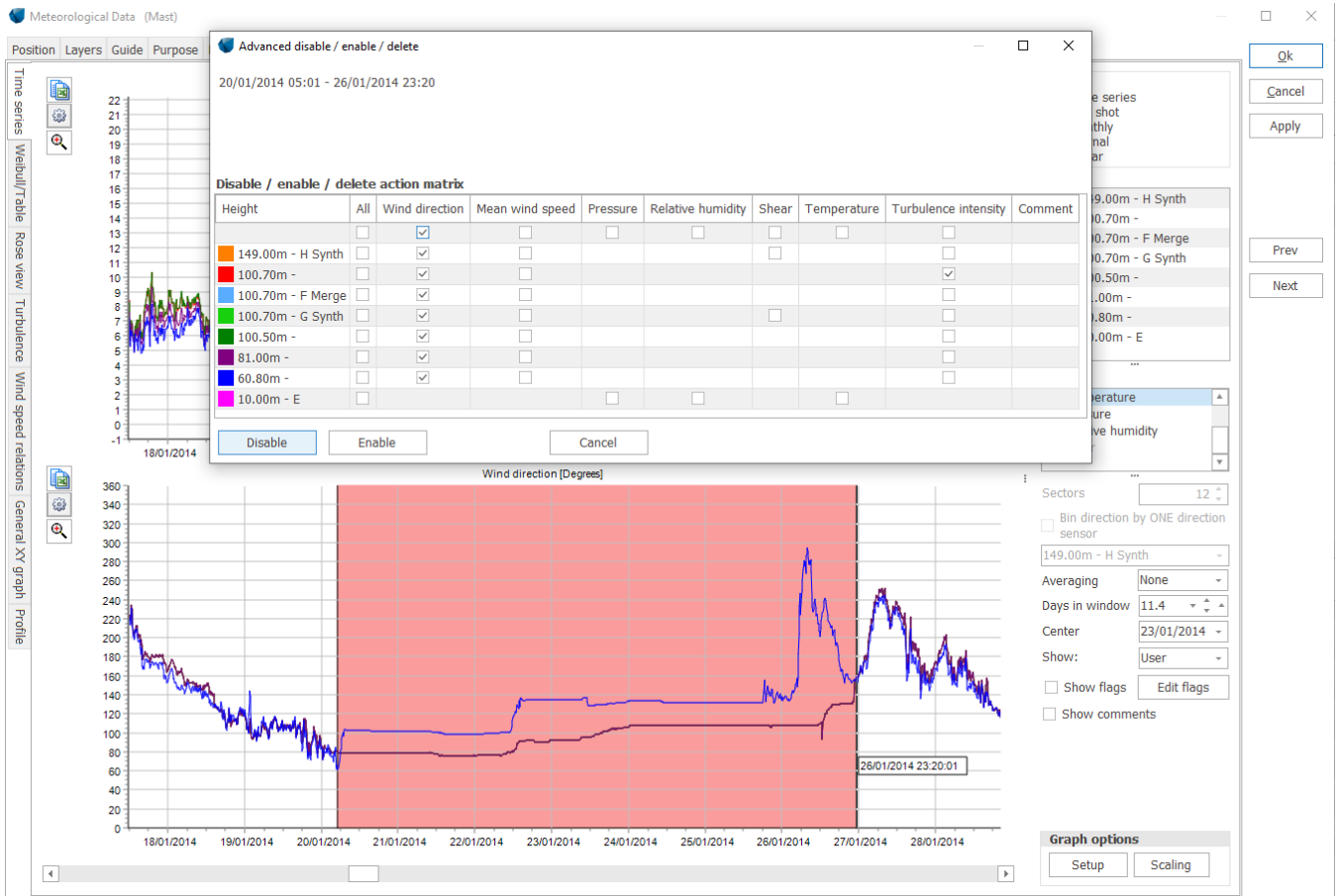
Figure 45 Disable by right-clicking and dragging the mouse along the time series graph.

Furthermore, data can be highlighted with flags based on logical expressions. See section 12.6.

The graphs showing the individual data points, like the "Gun shot" and XY graph, data points can be disabled by right-click on the data point. Thereby obvious outliers can be eliminated.
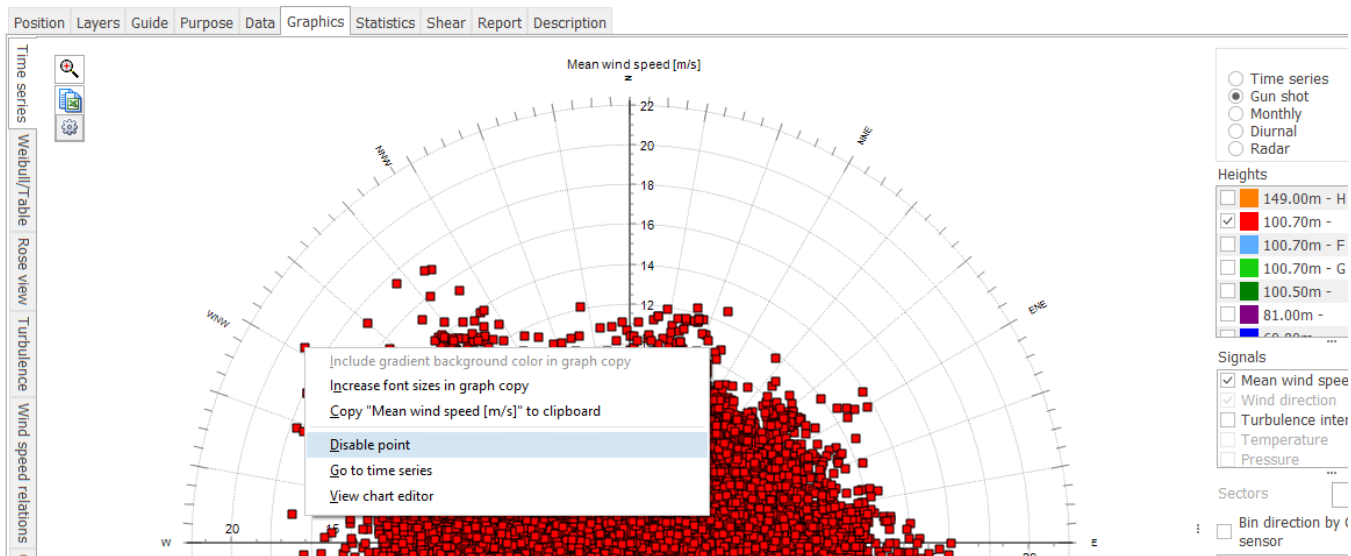
Figure 46 In scatter plots, disabling is available by right click.

12.3.4.2 Weibull/Table
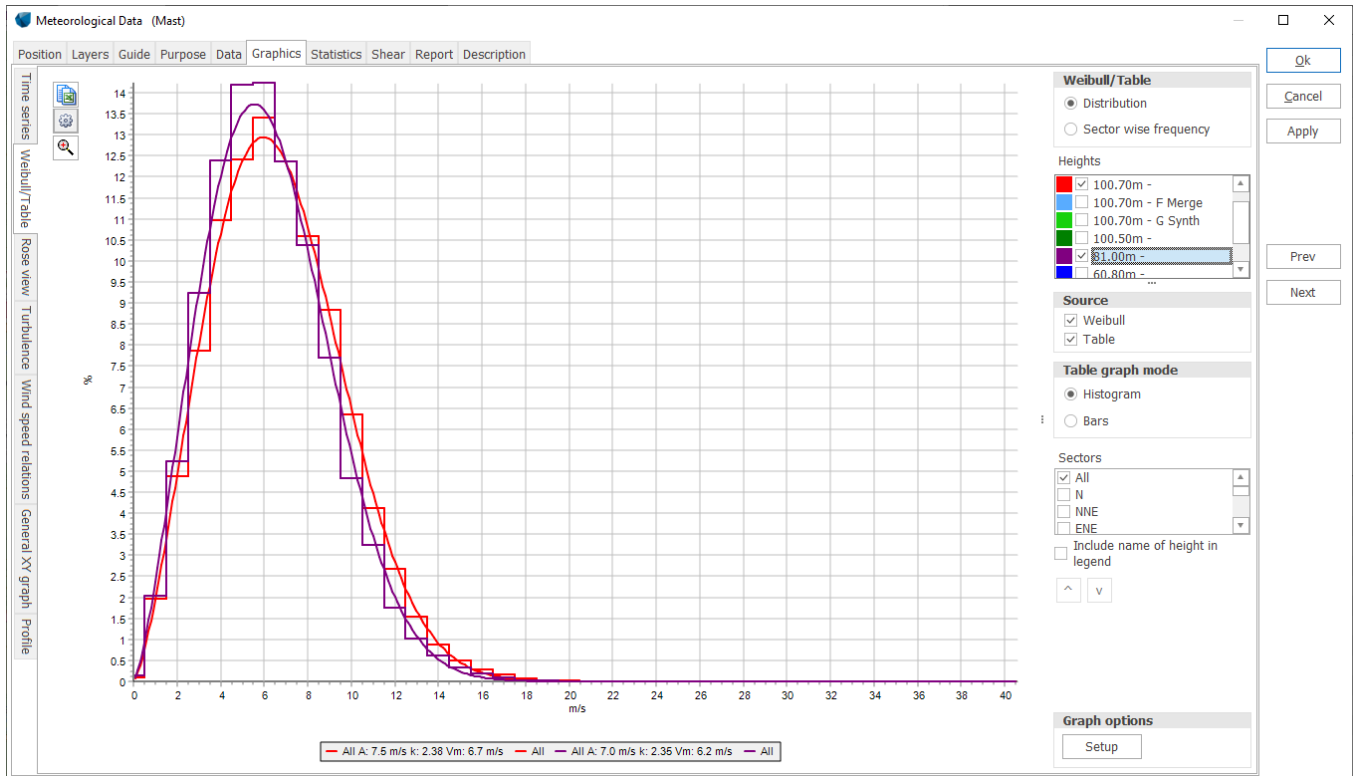
Figure 47 The Weibull/Table graph for two different heights

The measurement histogram and the relevant Weibull fit are shown here. Note that the axis can be scaled manually by the "Edit graph" feature, activated with the ⚙ button or by double-clicking on the graph. This feature is of course available almost anywhere in windPRO.
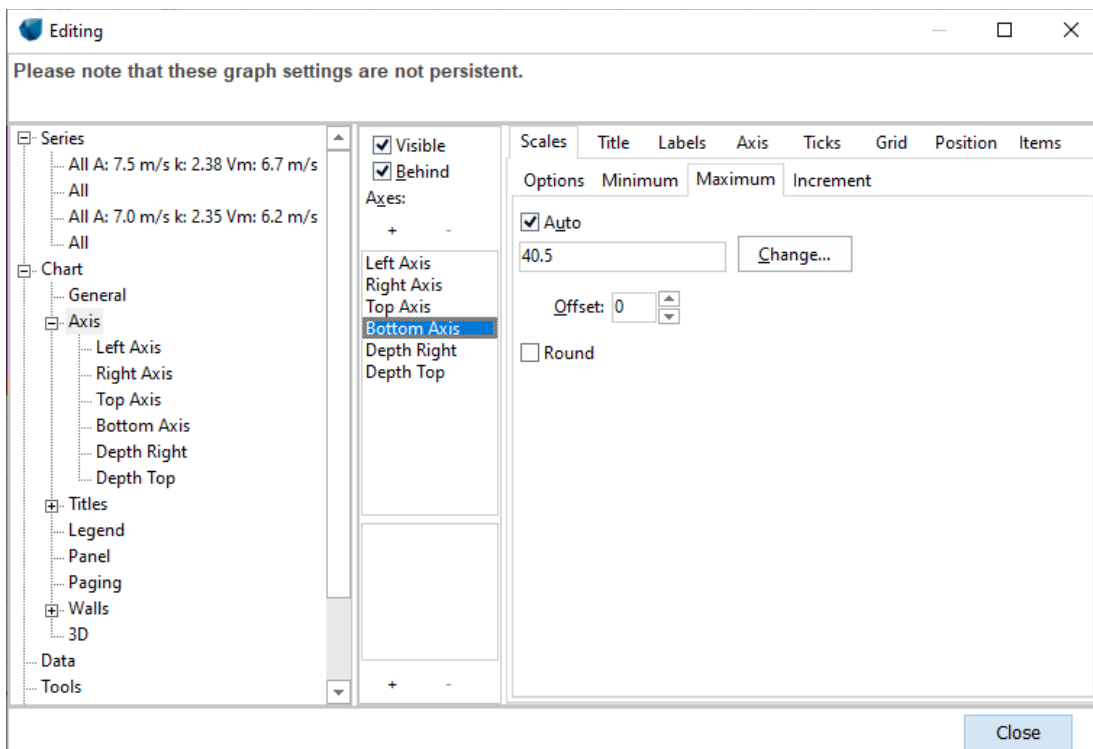
Figure 48 Advanced editing of the graph setup

12.3.4.3   Turbulence
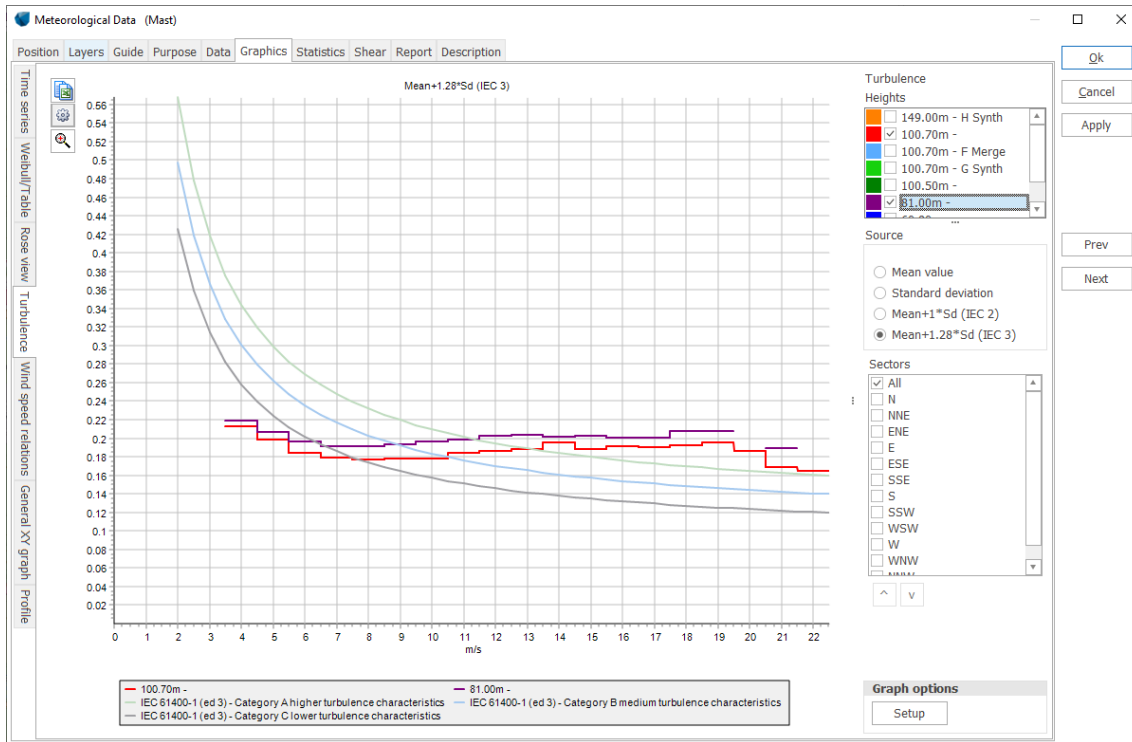
Figure 49 Turbulence graphs

In the Turbulence graphs, different options for including comparisons with the IEC Standard are available. Note that the axes can be scaled manually by the "Edit graph" feature mentioned above.

12.3.4.4   Rose view

The Rose graphs are shown below for one height, in a monthly view. The layout can be changed to contain a user-defined number of graphs at a time.
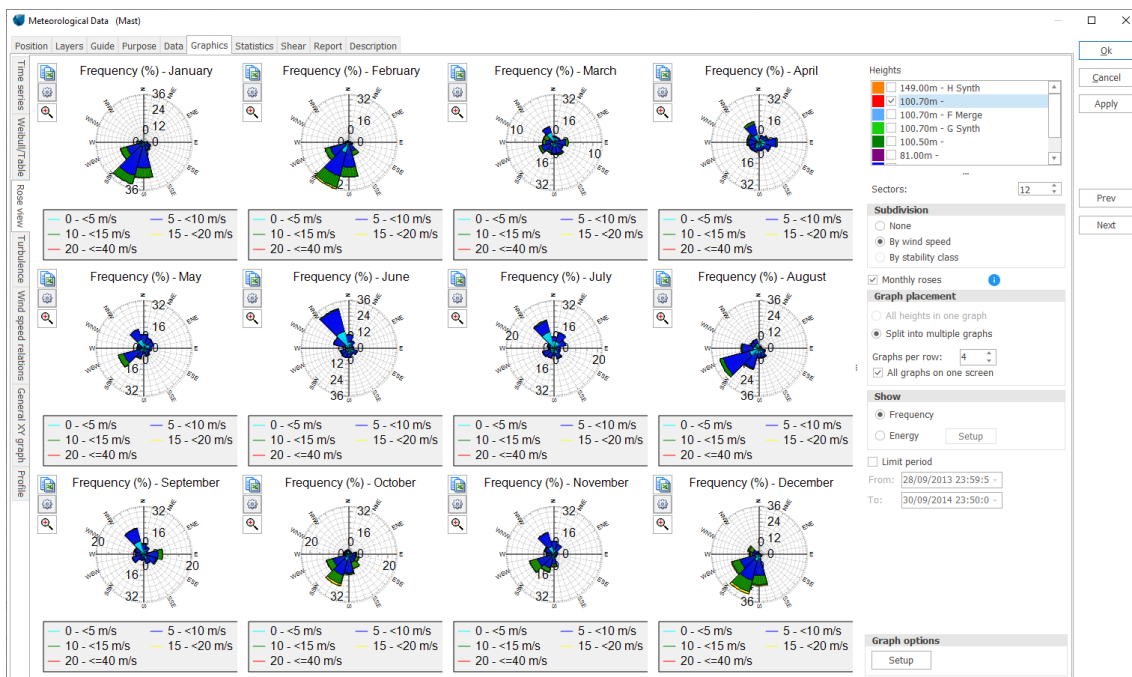
Figure 50 The monthly Rose graphs

12.3.4.5   Wind speed difference

Based on two different wind speed sensors, usually at the same height, a difference/ratio plot can be created. This is a useful way to evaluate boom directions and influence. Data points in the graph can be binned by direction, and flags can be defined and shown on the graph.
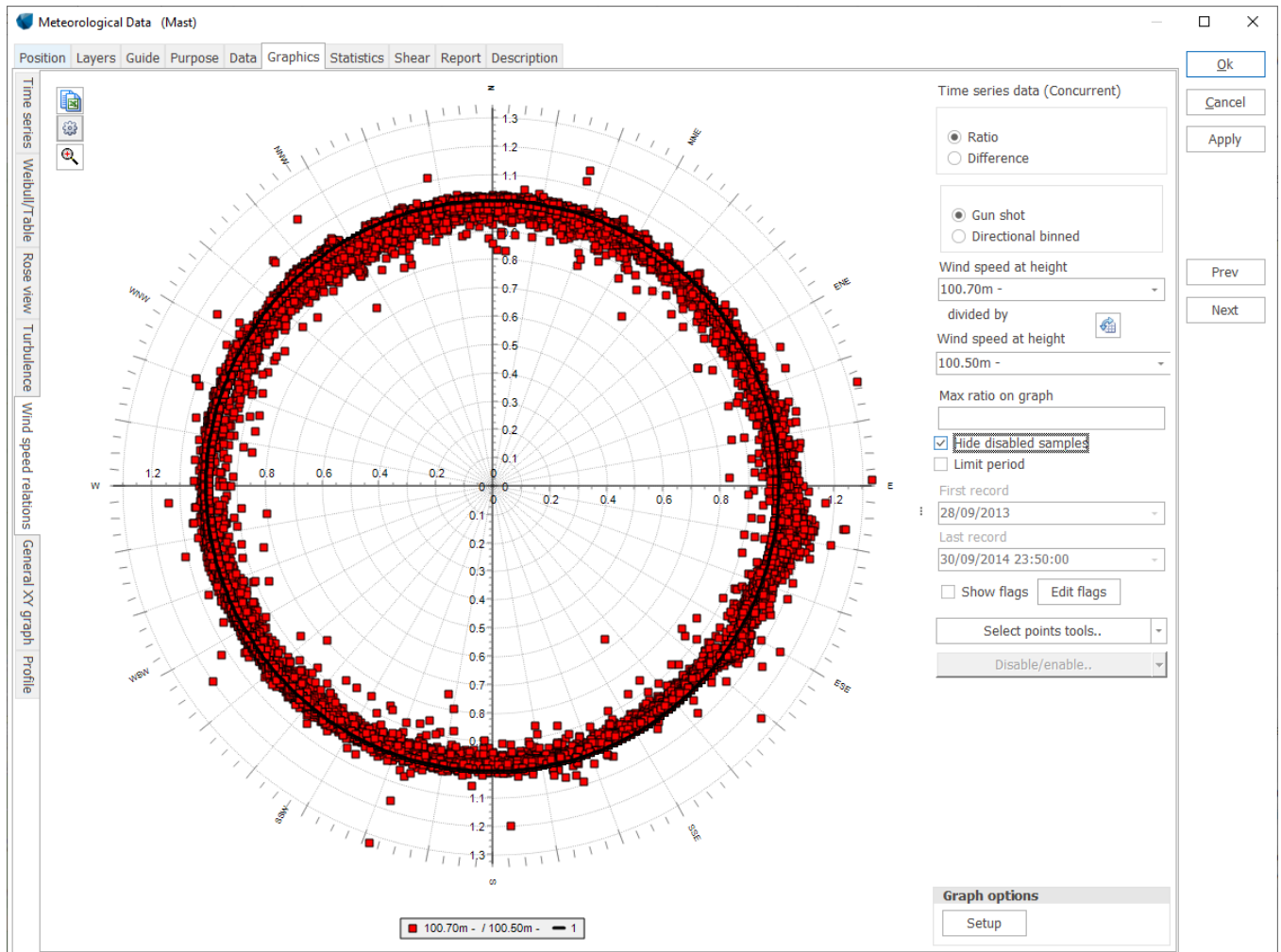
Figure 51 Plot of the directional distribution of the ratios of wind speed from two same-height anemometers

12.3.4.6   General XY graph

With the General XY graph, you can plot any signal versus any other. When the cursor is placed on top of a data point, the hint box shows the values, the date and time. This is an efficient tool to evaluate "outliers":

Double-click on the point, and you're taken to the relevant time in the time series.
Right-click on the point to disable its data.
Use the "Select points tools" to select and possibly disable a whole batch of outliers.

Finally, one can colour-code the data points with a third time series, thus adding a third dimension to the graph.

Figure 52 General XY graph

12.3.4.7   Profile

Figure 53 The profile graph

The profile view shows the terrain together with the wind speed profile. This is an efficient tool to analyse data and compare them to model results.

The profile viewer illustrates how the measured wind profile looks by showing the best fits of both power law profile and logarithmic profile. Also, a WAsP-calculated profile can be shown.

There are 3 view options:

- Aggregated (average values of concurrent data for all heights used; default)
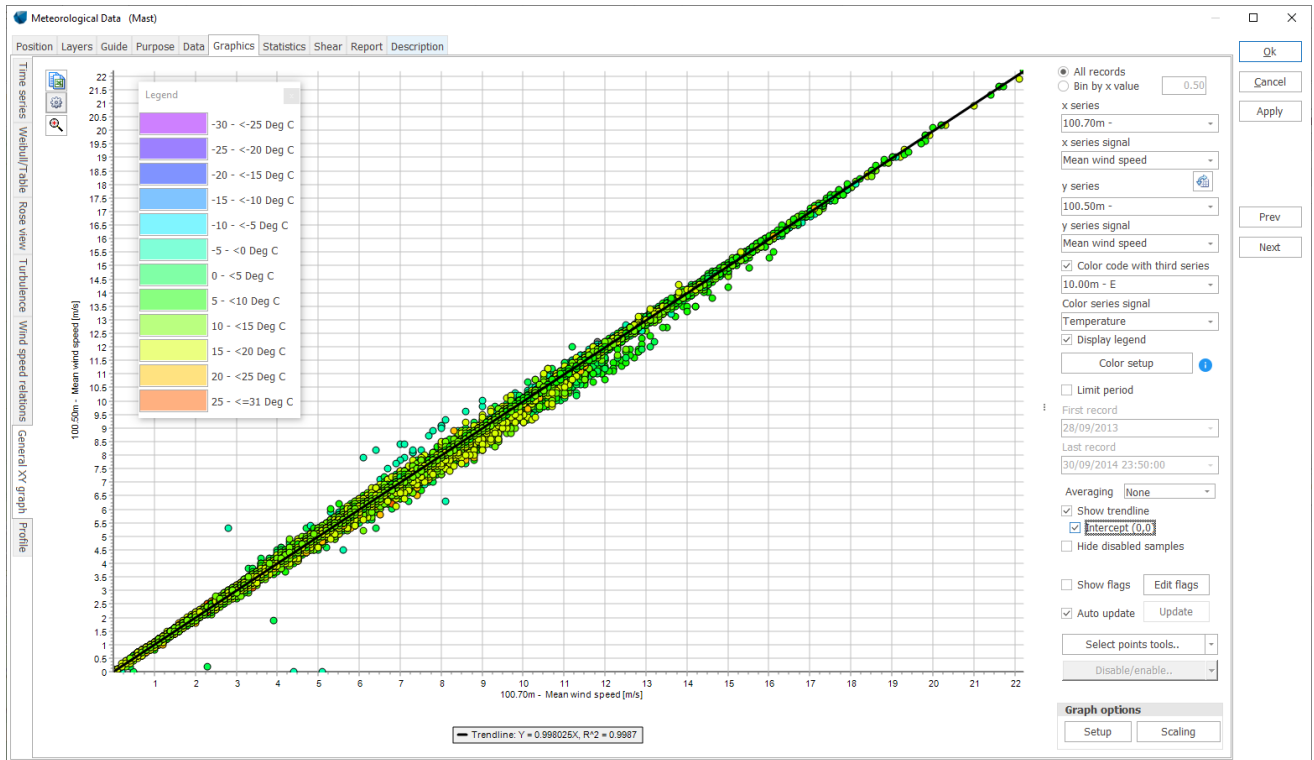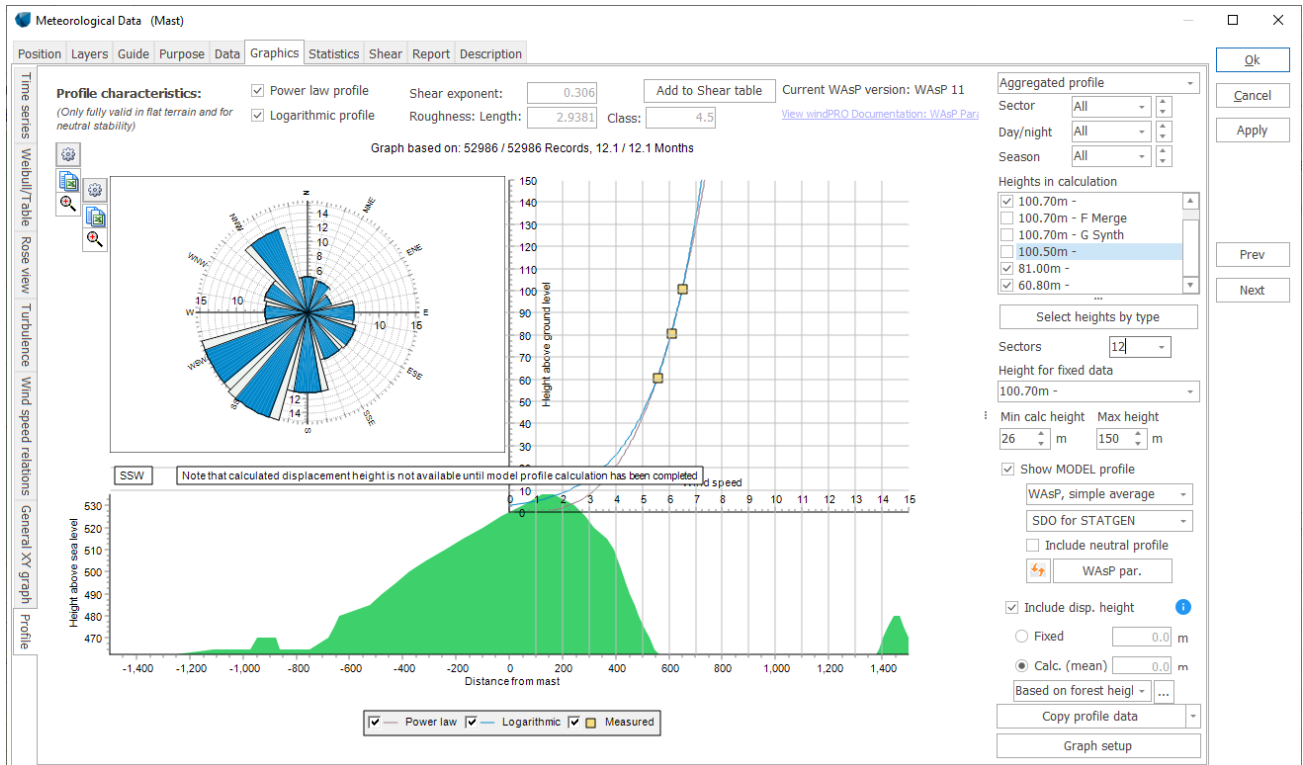- Runtime (record by record)
- Manual (aggregated, but manually controlled values for power and logarithmic profiles)

The "height for fixed data" will be used as input in a WAsP calculation, if the WAsP profile is chosen. (WAsP can only calculate from one measurement height, and creates the profile shape based on a fixed profile, modified by surface and terrain effects).

Note that only in flat terrain the power or logarithmic profiles can be extrapolated to higher levels with reasonable accuracy. If there are flow compressions due to hills, simple power or logarithmic profile extrapolations should NOT be trusted. A WAsP profile will be a better estimate since it will include corrections by a flow model to account for the compression effects.
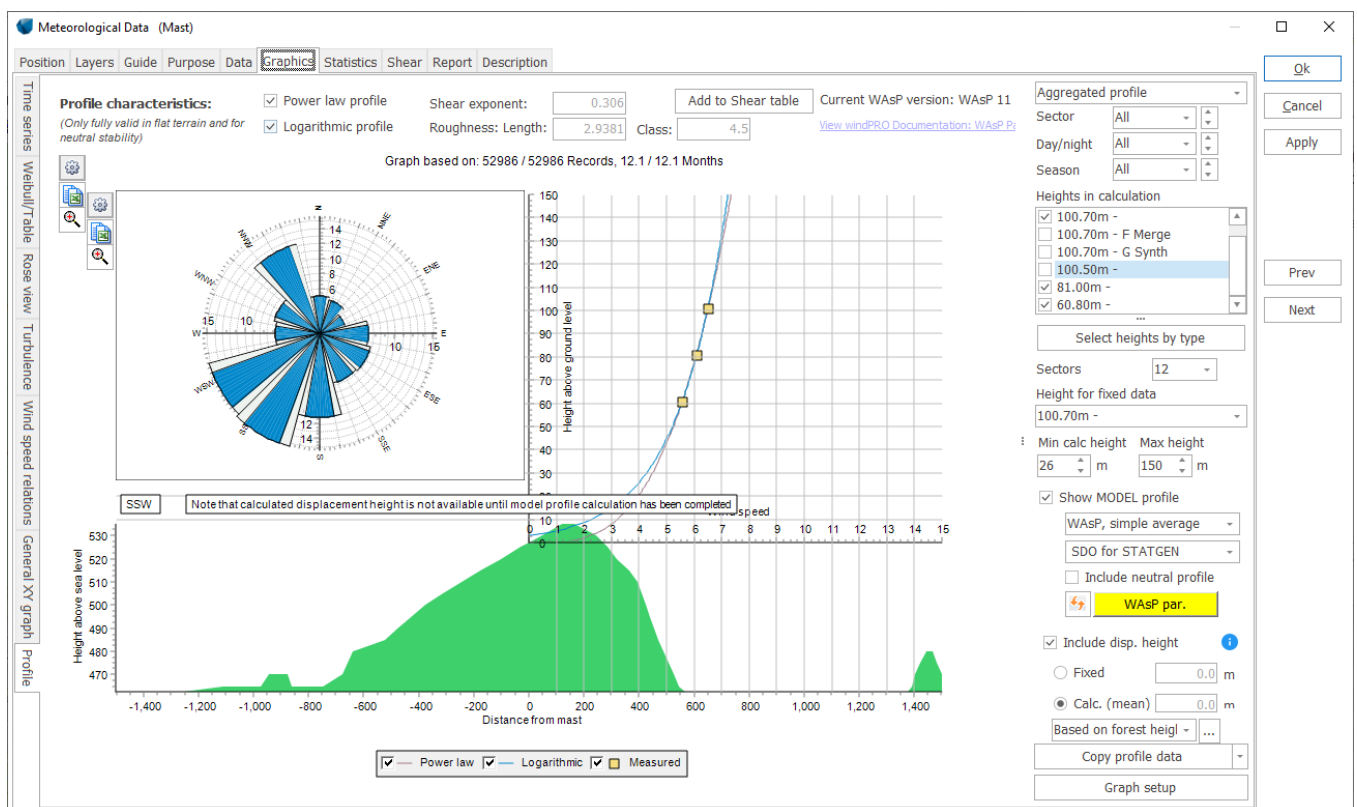
The profile view window holds many options. To mention the more important ones:

Select heights by type – a quick way to select and show data: e.g. only the original data, so the calculated shear values are not influenced by other "artificial" data (remember that only concurrent data are shown!); or only wake-cleaned data, to get the free wind flow expected shear.
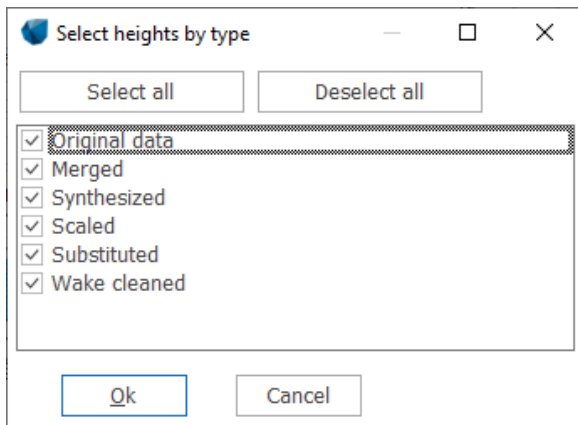
Show MODEL profile – Here, you select the model for generating the mean wind speed profile.
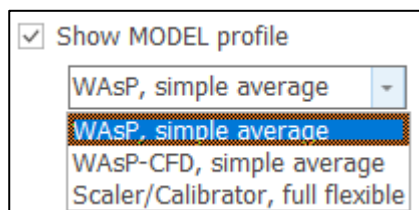
The Scaler-calculated profile has the advantage of being based on the whole time series, thereby resulting in time-dependent profiles, to be compared with the relevant measured profiles.

Include disp. height – Includes in the graph a fixed or sector-wise displacement height, the latter calculated on the basis of tree height data to be provided by the user.
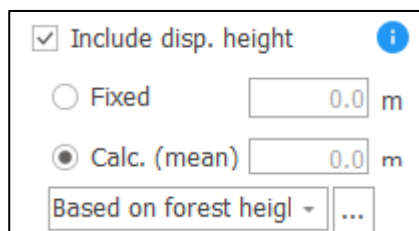
Copy profile data – Used for extracting the data which make up the graph. Includes information such as Meteo Object name and displacement height.

12.3.5   Statistics

There are three different tabs for statistics:

- Main statistics
- Monthly means
- Recovery (data availability)
- Monthly Weibull parameters

Figure 54 First view of Main statistics.

Figure 55 Monthly means

Monthly means can be shown signal by signal – by right-clicking, the tables can be copied to the clipboard and easily integrated into documentation.

Meteorological Data (Mast)

Position | Layers | Guide | Purpose | Data | Graphics | **Statistics** | Shear | Report | Description

Main statistics | Monthly means | **Recovery** | Monthly weibull parameters

Height: Mast.100.70m -   Change status of selected samples to:

Signal(s): Mean wind speed + Wind direction   Enabled   Ok

All: 96.3%   Effective data period: 11.6 months   Total period: 12.1 months
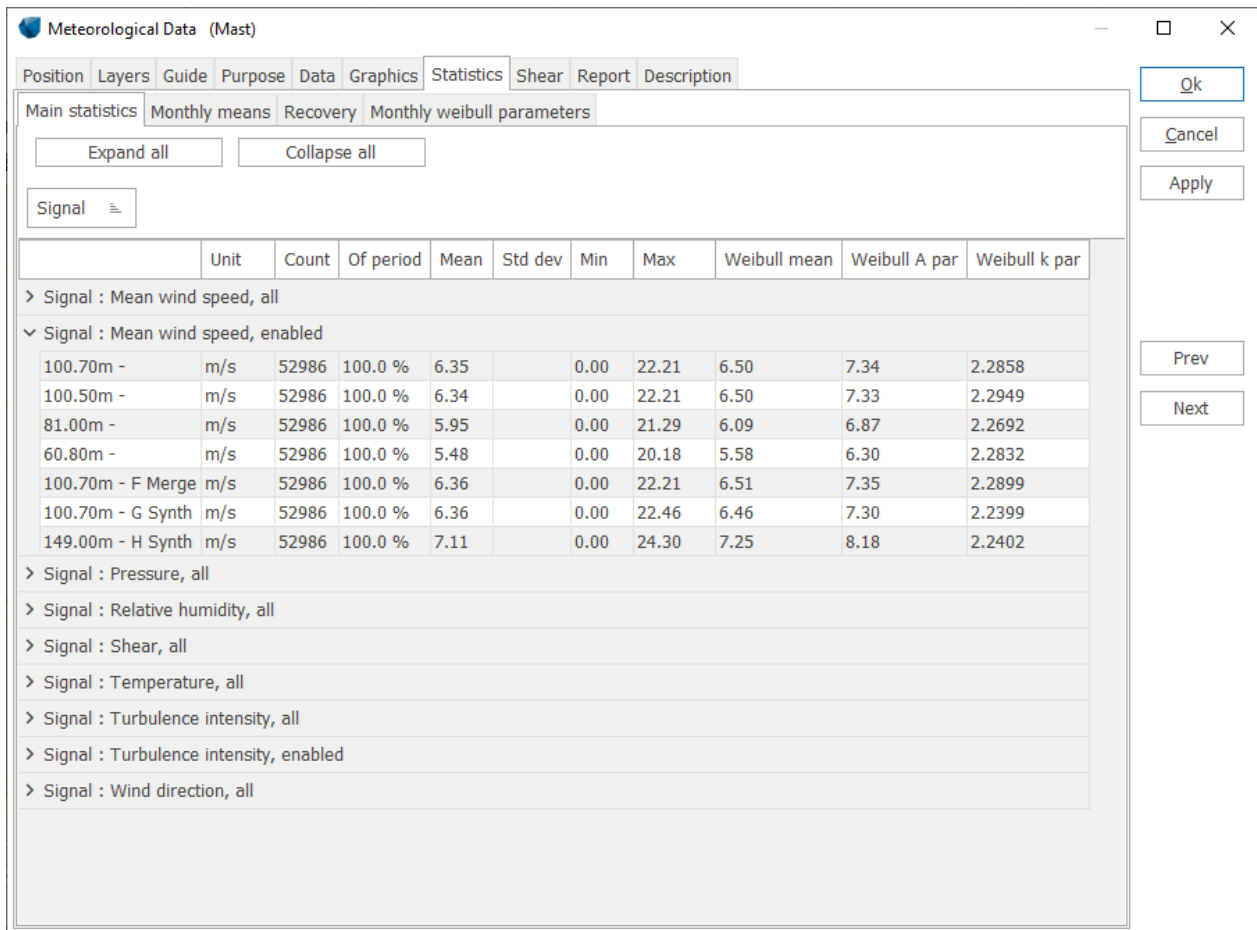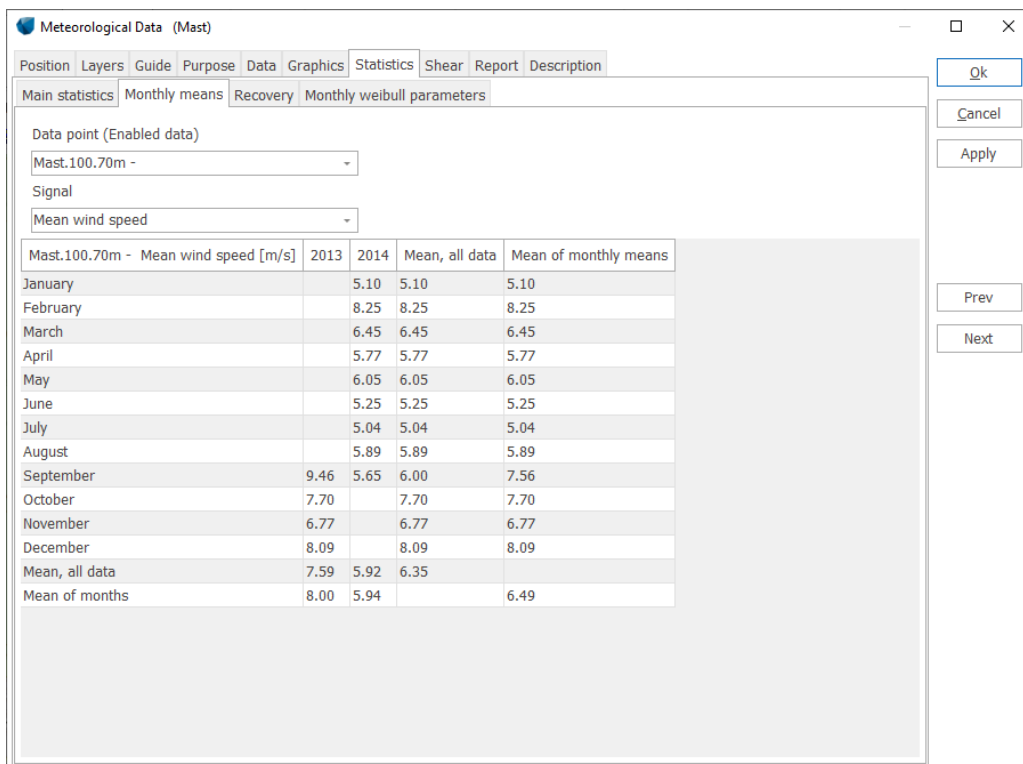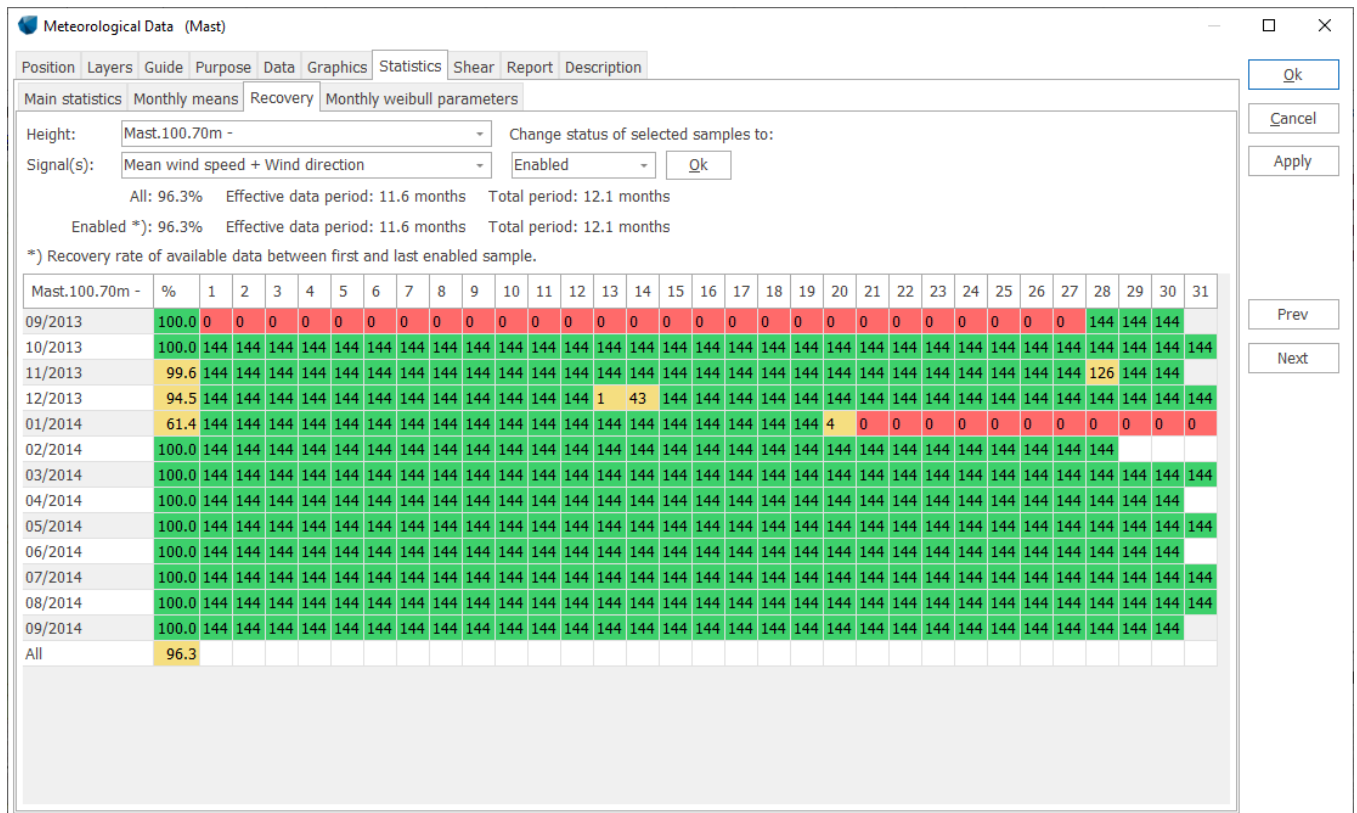
Enabled *): 96.3%   Effective data period: 11.6 months   Total period: 12.1 months

*) Recovery rate of available data between first and last enabled sample.

Mast.100.70m -	%	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
09/2013	100.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	144	144	144	
10/2013	100.0	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144
11/2013	99.6	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	126	144	144	
12/2013	94.5	144	144	144	144	144	144	144	144	144	144	144	144	1	43	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144
01/2014	61.4	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	4	0	0	0	0	0	0	0	0	0	0	0
02/2014	100.0	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144			
03/2014	100.0	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144
04/2014	100.0	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	
05/2014	100.0	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144
06/2014	100.0	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	
07/2014	100.0	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144
08/2014	100.0	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144
09/2014	100.0	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	
All	96.3																															

Figure 56 Data recovery view

Data recovery can be shown height by height and for a signal alone or a combination of wind speed AND direction. In this case, the data are considered available only if BOTH signals are available. The table shows the percentage of available data in the first column and then the number of samples enabled per day and hour.

Color coding gives a fast overview of the availability. Green shows that no samples are missing nor disabled. The cells in red show that all samples are missing or disabled, and yellow is in between.

The Effective data period equals the total period x recovery rate.
The results presented under "Enabled" are relative to the enabled period. In this case, if data are disabled at the start or the end of the measurements, the recovery is calculated only between the first and last enabled data.

Change status of selected samples allows to graphically select data in the table and change their status to enabled/disabled.
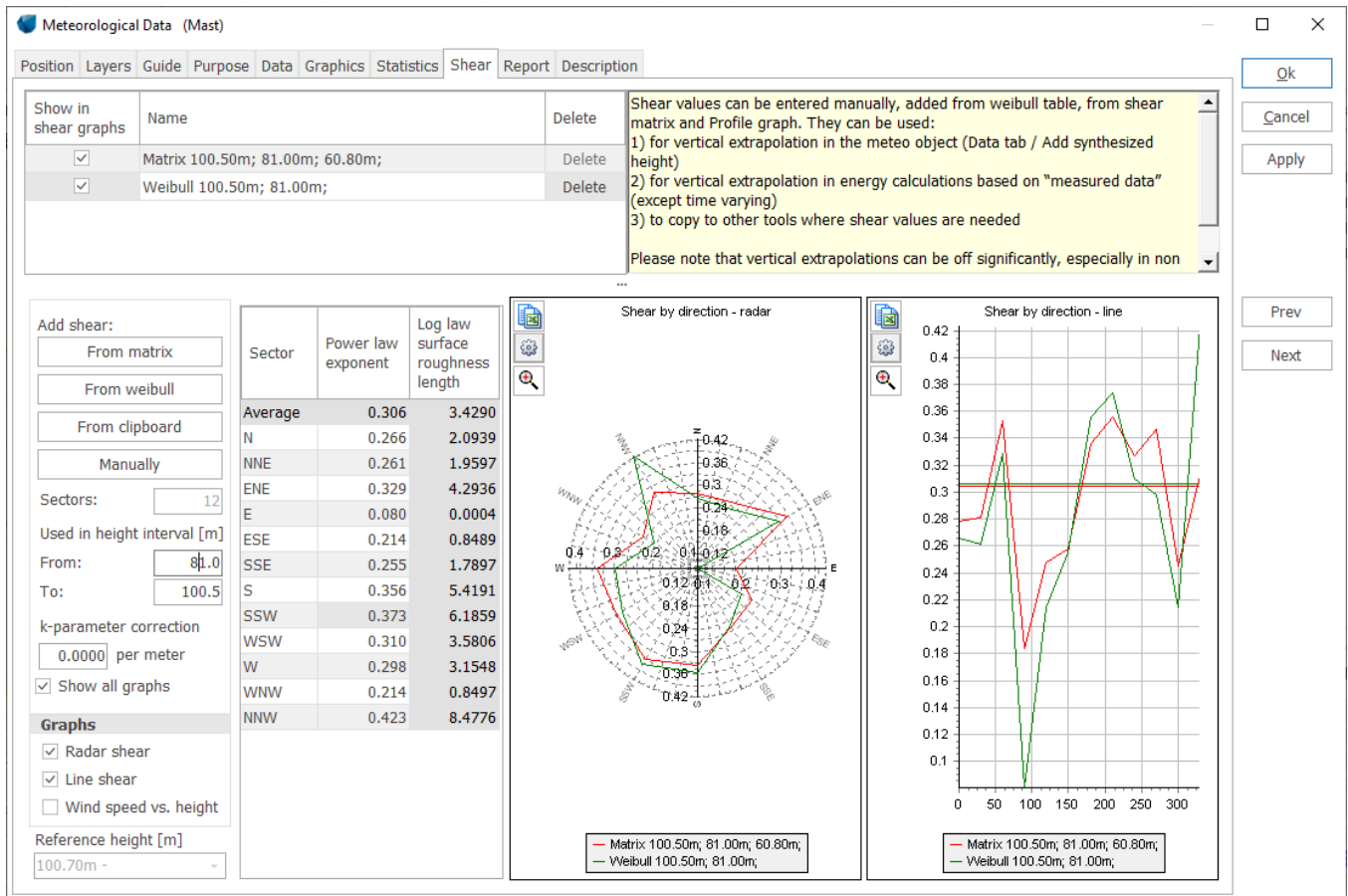
12.3.6   **Shear**

Figure 57 Shear for simple METEO calculations and evaluations

In the graph above, two different shear calculation options are tested against each other.
When doing a METEO AEP calculation based on a Meteo Object, the shear tables available here can be selected as input for the calculation.

Shear can be either entered manually or calculated on the basis of different models:
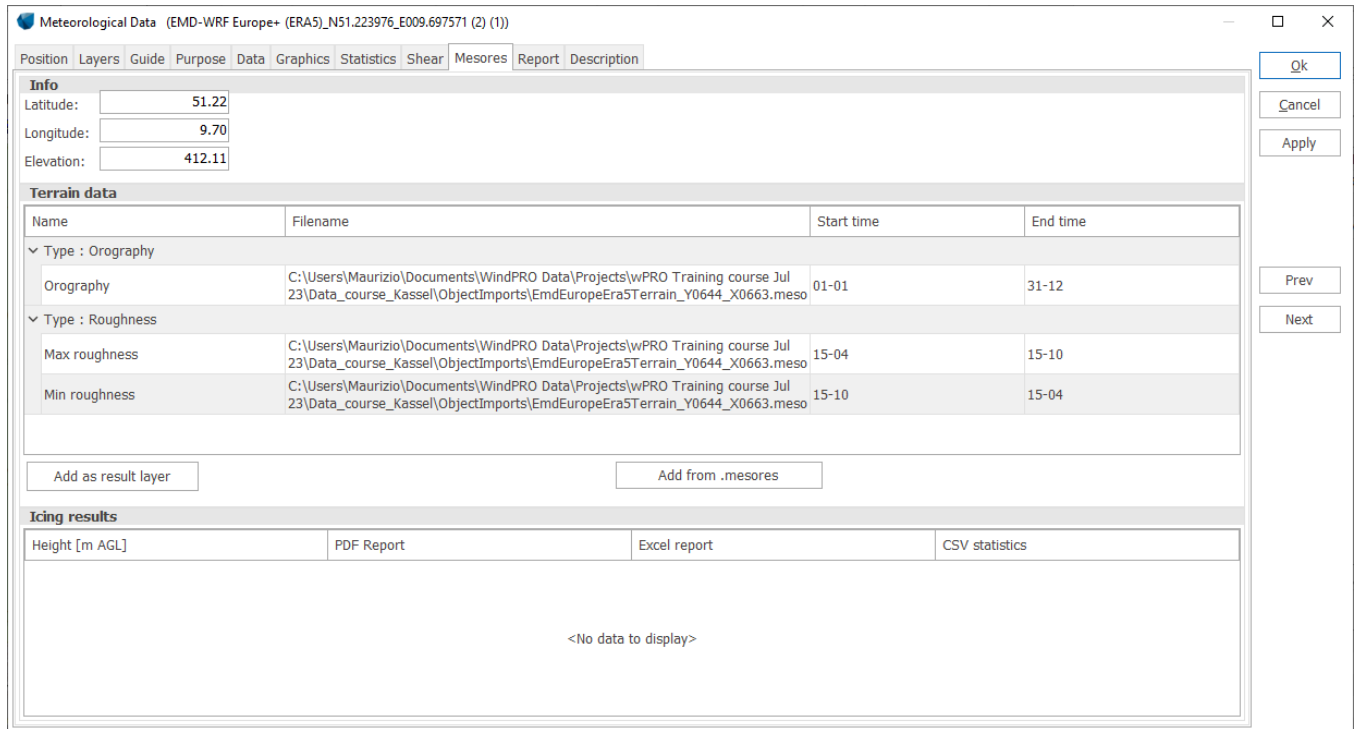
The most robust method is based on the shear matrix, and this also adds value analyzing the data (see 12.3.3.4.2.1).

The Shear tab can hold an unlimited number of shear calculations. The text in the yellow dialog box explains its use.

The shear calculations based on Weibull method use the Weibull mean wind speed. Direction from only one height is used, so the mean Weibull wind speed used is based on concurrent time records.

12.3.7 Mesoscale terrain

This tab only appears in Meteo Objects holding EMD-WRF mesoscale data. It contains the EMD-WRF mesoscale terrain used in the model.

Figure 58 Mesoscale terrain in Meteo Object

Note: there are two different roughness files - a min. (winter) and a max. (summer). The mesoscale model uses seasonal surface roughness.

If an EMD-WRF Icing calculation has been run on our server, additional parameters such as icing intensity, ice load, instrumental icing and meteorological icing will appear here. If at least 10 seasons are included in the calculation, additional reports will apper. These can be accessed in the lower part of the window:

The mesoscale terrain map and icing maps can be added as a result layer by clicking "Add as result layer".
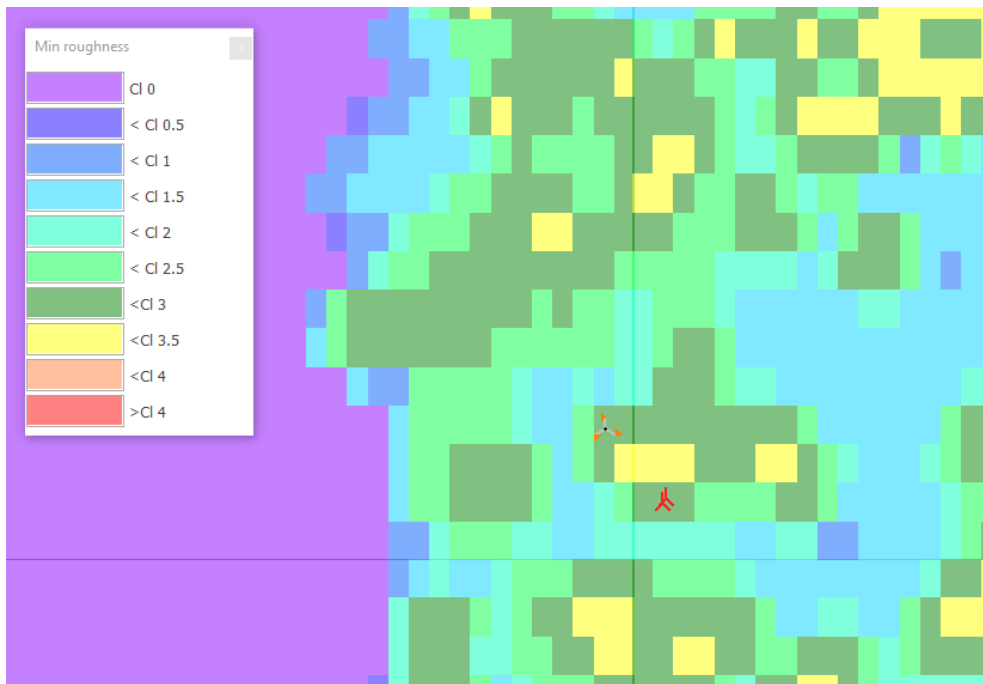
Figure 59 Mesoscale minimum roughness as a Result layer shown on map

12.3.8   **Report**
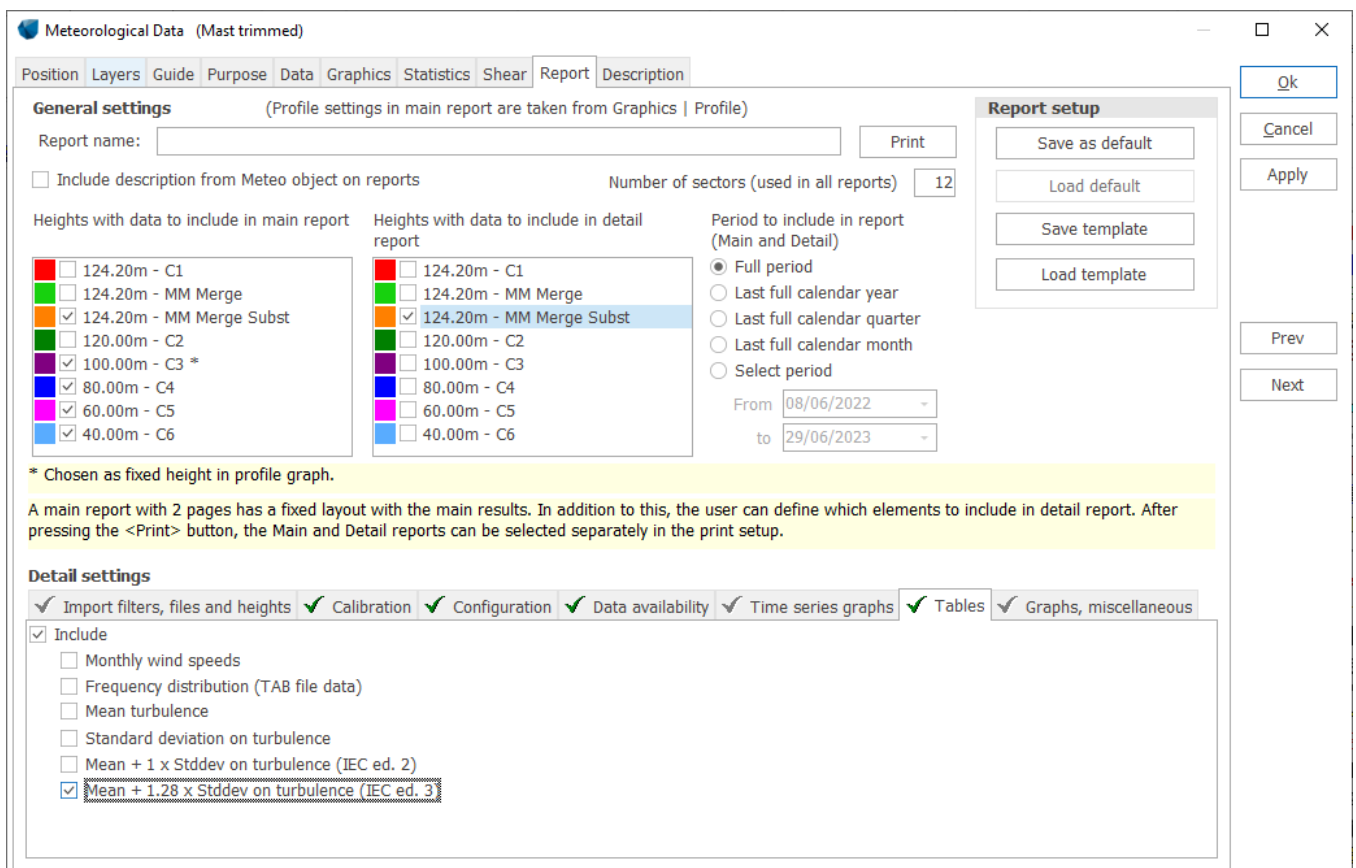
Figure 60 Reports from Meteo Object

The Report tab lets you create a report, where a number of optional tables and graphics can be included. A template with a preferred setup can be saved for later use.

12.4   **Meteo analyser**

The Meteo Analyser is a tool started from the Climate tab:
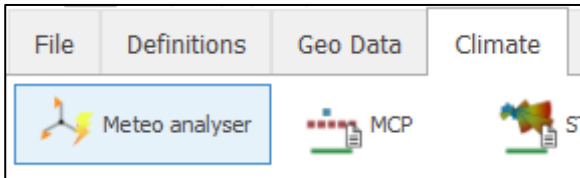
The Meteo Analyser works directly on the data from one or several Meteo Objects. It can therefore perform operations that are not possible within the individual Meteo Objects, such as:

Graphic comparison of data from multiple Meteo Objects.

Disable/Enable concurrent data from multiple Meteo Objects.

Substitute/Fill data from one signal to another, with the option of applying scaling factors.

Cross predict to set up and perform a cross prediction based on the WAsP model from height to height, and from mast to mast (test the accuracy of the model vertical and horizontal extrapolations). In addition, RIX correction parameters can be found.

Time variation data files (.WTI) can be generated from one or more time series affected by gaps, by merging/interpolating/patching. The .WTI files generated hold a complete one-year dataset with user-defined time resolution for use in time-varying PARK calculations or for detailed loss calculations.

Scaling creates a new time series based on the Scaler, for immediate comparison with measurements (e.g. downscale mesoscale data to a measurement mast and compare the two signals. This can then be used for post-calibration of the initial result to get a perfect match with measurements).

RSD verification based on the IEA Wind Expert Group recommended practices.

12.5   Meteo analyser: tab by tab

12.5.1   Data: overview and selection of data

Figure 61 Selection of data in Meteo Analyser

Figure 62 "Show time lines" gives a nice temporal overview of selected data
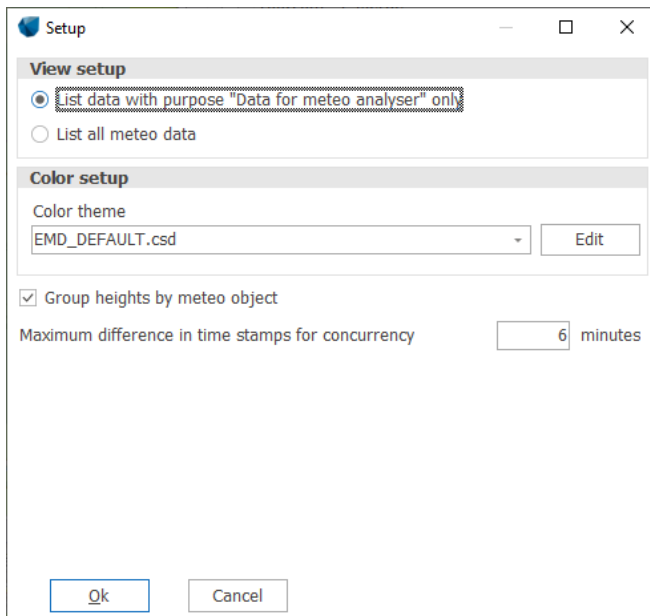
Figure 63 The view allows to filter the visible datasets by the Purpose given in the relevant Meteo Object

12.5.2 Graphics: Compare time series

Figure 64 Graphic comparison of more Meteo Object data.

In the Graphics tab you will see the same graphs as in a Meteo Object, but coming from multiple Meteo Objects.

12.5.3   Substitute: Perform data substitutions

We never overwrite the original data. Thus, first of all, a new data series will be created – or selected, if one or more substituted series have been created. The name of this new dataset will get the extension "Subst." as the last part of the name.
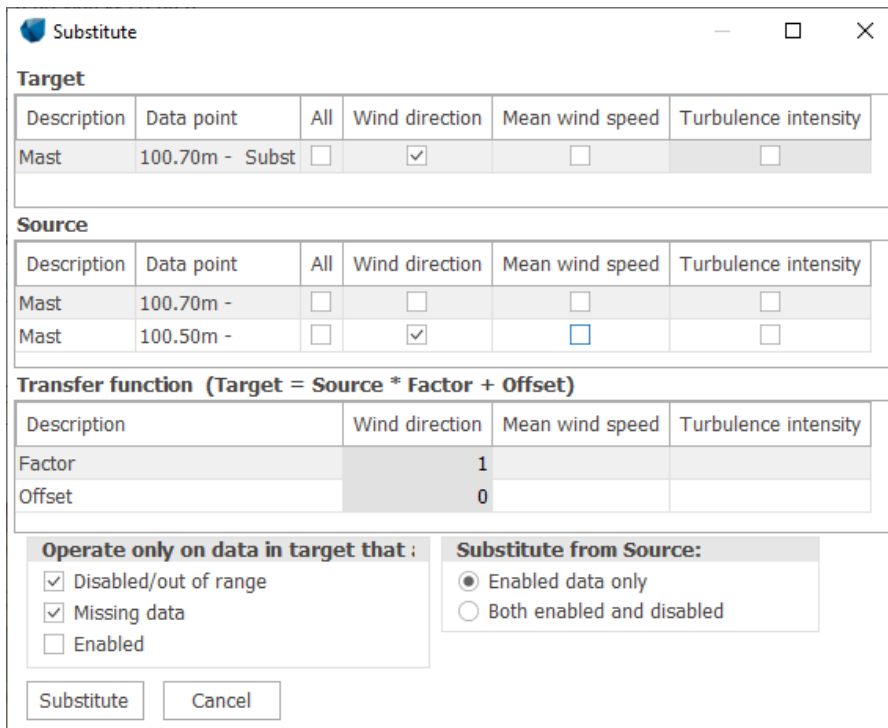

Figure 65 Substitution of data

Then, choose the time series that needs substitutions/repair in the field *Base new substitution data series on*. Then click **Create**.

Now, there are two ways to perform the substitution:

- **Manual**: based on a time series graphic view, where intervals for substitution are marked manually: select "start" and "end" of interval by right clicking.
- **Auto**: where the entire time series is checked for gaps to be filled.

In both cases, the final window you'll get is the following. Here, you can decide which signal(s) are to be substituted and the source and transfer function (scale and offset).

Typically, only disabled and missing data records will be substituted (while disabling of "bad data" is performed first), and only enabled data are used for the substitution.

Figure 66 After choosing between Manual and Auto, this screen will let you decide what data from the Source instruments should be used to patch missing or disabled data in the Target.
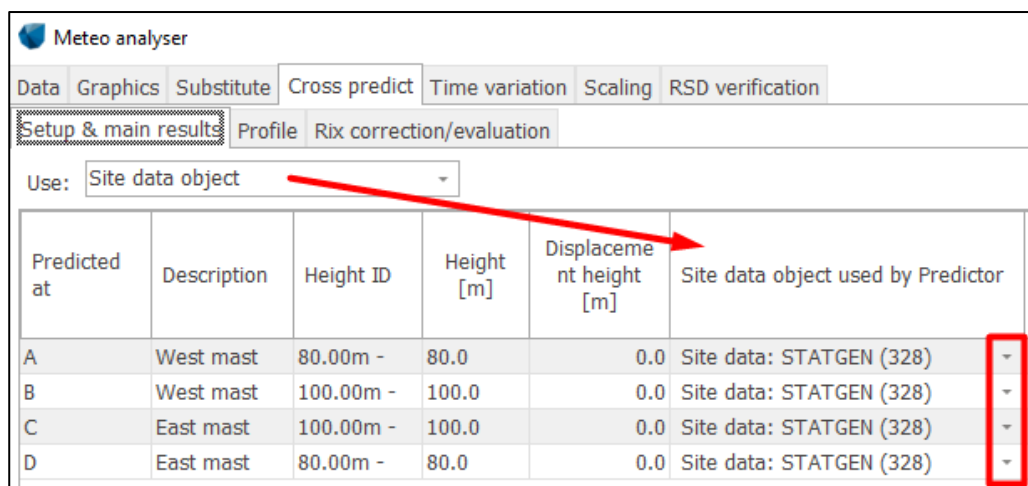
12.5.4 Cross predict: WAsP vertical and horizontal extrapolation

Cross prediction from one mast or height to another by a model based on concurrent data is the best way to find how well the model performs on a site. The model's ability to horizontally and vertically extrapolate is tested in one process on concurrent data.

Four different models can be currently tested. The selection is done by choosing in the field *Use* the type of link between windPRO and WAsP:

- a Site Data Object, for a WAsP calculation
- a WAsP-CFD result file
- the Scaler, to run the calculation in the time domain (again, choose with WAsP or WAsP-CFD)

Next, choose the link itself in the sixth column of the table, which will change name according to your choice above. For example, in the case of a classic WAsP-based calculation, we select the Site Data Object used for STATGEN:
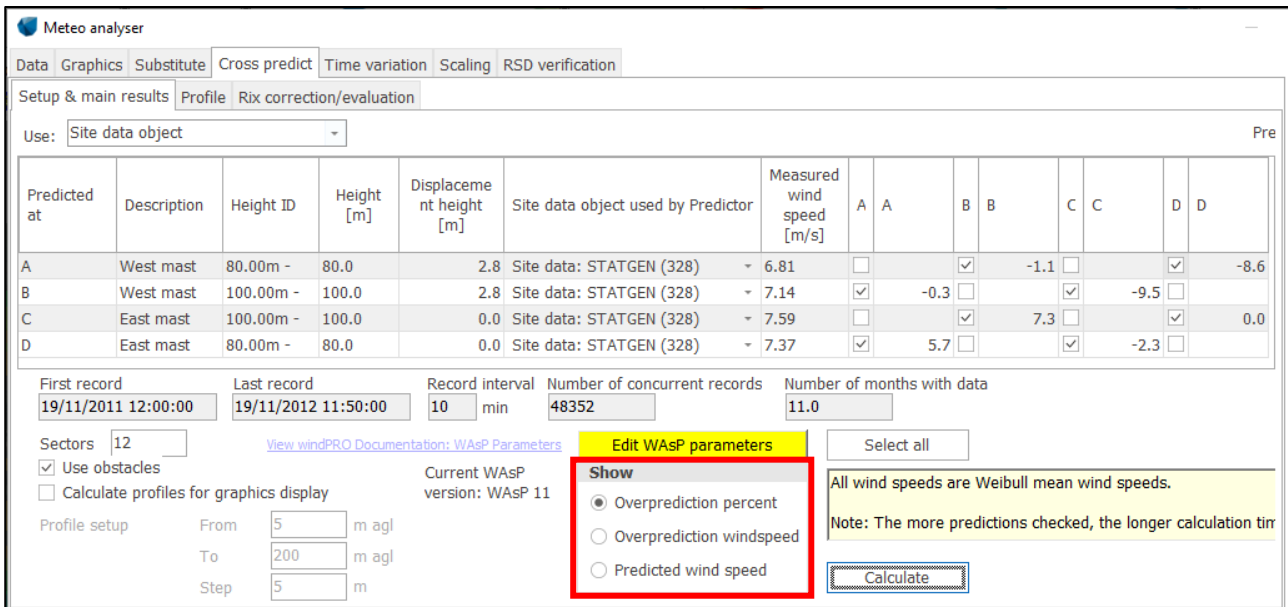
Then, select between which signals/heights the calculation should be done. Typically, between different heights at one mast, and between same heights at different masts.

Finally, click **Calculate**.

The results will be shown by default as the relative error made by the model, but you can switch to the absolute error, or simply the calculated wind speed, which can be compared with the measurements, already shown:

Figure 67 Results of cross predictions

If cross predictions are poor, there can be several reasons:
1. Measurement equipment is poorly calibrated
2. Masts are wrongly positioned in the terrain
3. Terrain is not described well enough (roughness, height contours, summit detail, local obstacles)
4. The wind climate is not the same at the different masts (and thereby the model is not able to cross-predict accurately)
5. The steepness in the terrain is high and a well-know modelling problem, related to flow separation, results in poor model handling of the wind flow transformation.

For the last one a "fix" is available: the RIX correction. If steepness seems to be the problem, the tab *RIX correction/evaluation* can be used to find the best RIX correction parameters (and to evaluate if the RIX method seems to fix the cross prediction issue). It can only be used if at least <u>two</u> masts are available on site!

The RIX correction/evaluation tool shows the logarithmic wind speed deviation versus the Delta RIX. From the site-specific trend line obtained from the cross prediction errors, the slope (Alfa) is extracted, and can then be used in the RIX correction, either in PARK or in LOSS & UNCERTAINTY. In the figure below, the value for Alpha of 0.5 would be the choice in the RIX correction tool.
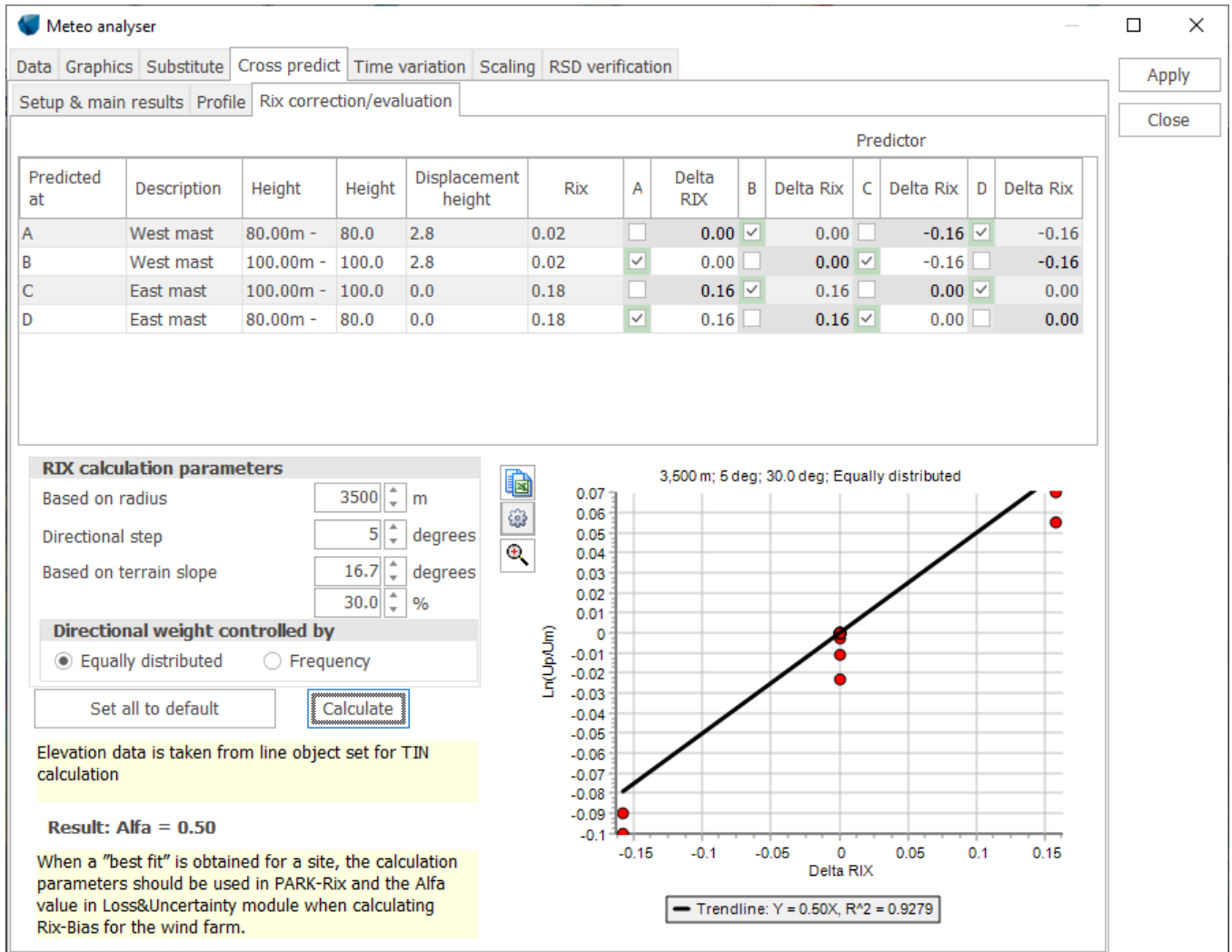
Figure 68 The RIX correction/evaluation tool

Only the cross predictions calculated on the previous tab can be used in the Rix evaluation. See further documentation on RIX calculation in 3.4.11 RIX calculation or in the PARK or LOSS & UNCERTAINTY manual sections.

In complex terrain, however, the real solution is to abandon a linear model such as WAsP, and upgrade to a CFD calculation!

Finally, the prediction versus measurement can be inspected with the Profile viewer. But note that only one measurement point is shown - the one from the selection "Predicted at". However, more profiles can be shown based on the different predictors (if more exist). For analyses of how well the vertical profile is predicted, use the Meteo Object.
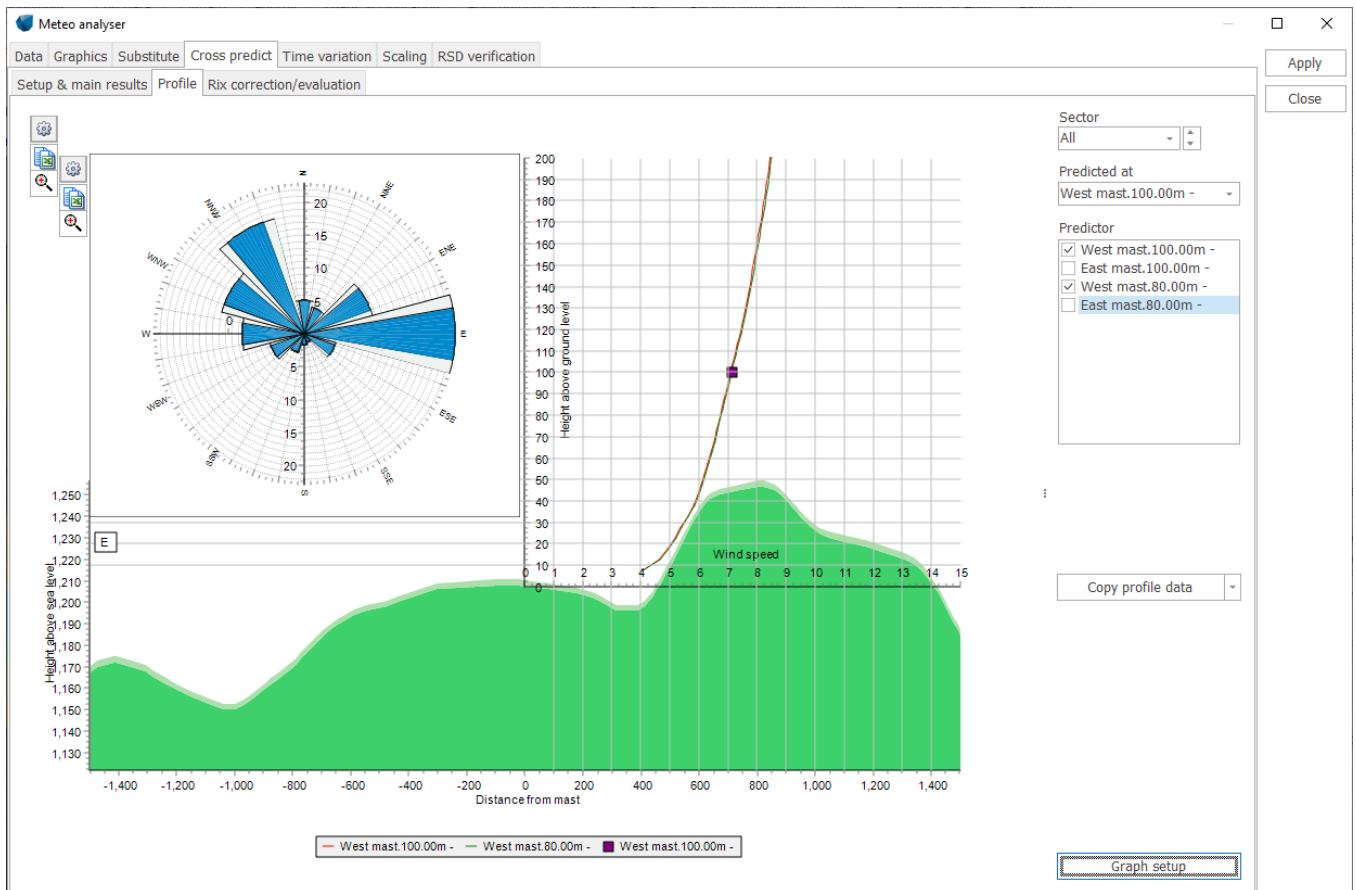
Figure 69 Prediction versus measurement inspected in the Profile viewer

NOTE: The profiles are ONLY shown if you have checked the "Calculate profiles for graphic display" *BEFORE* running the cross prediction calculation:

Figure 70 Check for profile calculation

12.5.5   Time variation: complete 1 year of data

WTI (WindTImevariation) is the extension given to the file generated with this tool. Therefore, the tool is simply named the WTI Generator.

The basic idea is that, for some purposes like calculation of the expected AEP variation in time (as, for example, 12-24 tables for PPA negotiation), often some data are missing, e.g. 15 days. Therefore, no production will be calculated for that half month. Leaving out half a month is, of course, not realistic, but it might not need to be a very accurate calculation for that half month. In this case, the WTI generator is convenient since it can fill in the gaps in reasonably smart ways and make sure that every 10' or 1 h record has a reasonable value for wind speed and direction (and other parameters like temperature, if selected).

Figure 71 Generation of complete time series with no gaps. The setup for generation of a complete wind data series. It can then be used for calculating a "complete" time varying AEP and/or detailed loss calculation.

Another use is in loss calculation. If, for example, the loss due to shut down below -20 °C shall be calculated, a time series with both wind and temperature can be used, where the loss module finds how much energy is calculated to be produced in the time steps where temperature is below 20 °C. If the temperature sensor was not working all the time (1 year), or simply not present, data can be substituted from a nearby met station or mesoscale data into the basic measurement so that all relevant variables are available after the processing by the WTI generator.

Basically, three methods are available for filling gaps:

- Take from other measurement (other height, other mast or a dataset like NCAR)
- Fill the gap by linear interpolation (if the gap is smaller than X hours)
- Fill by patching (copying nearest period of same length into the gap)

The three methods can be used in combination. Data will be "resampled" to any user-defined time resolution, but, typically, a 10' or 60' resolution should be used. NOTE: taking data from another mast does not include any scaling options! Eventually, scaling is needed to bring the two masts to the same level. This must be done upfront with the Substitute function in the Meteo Analyser.

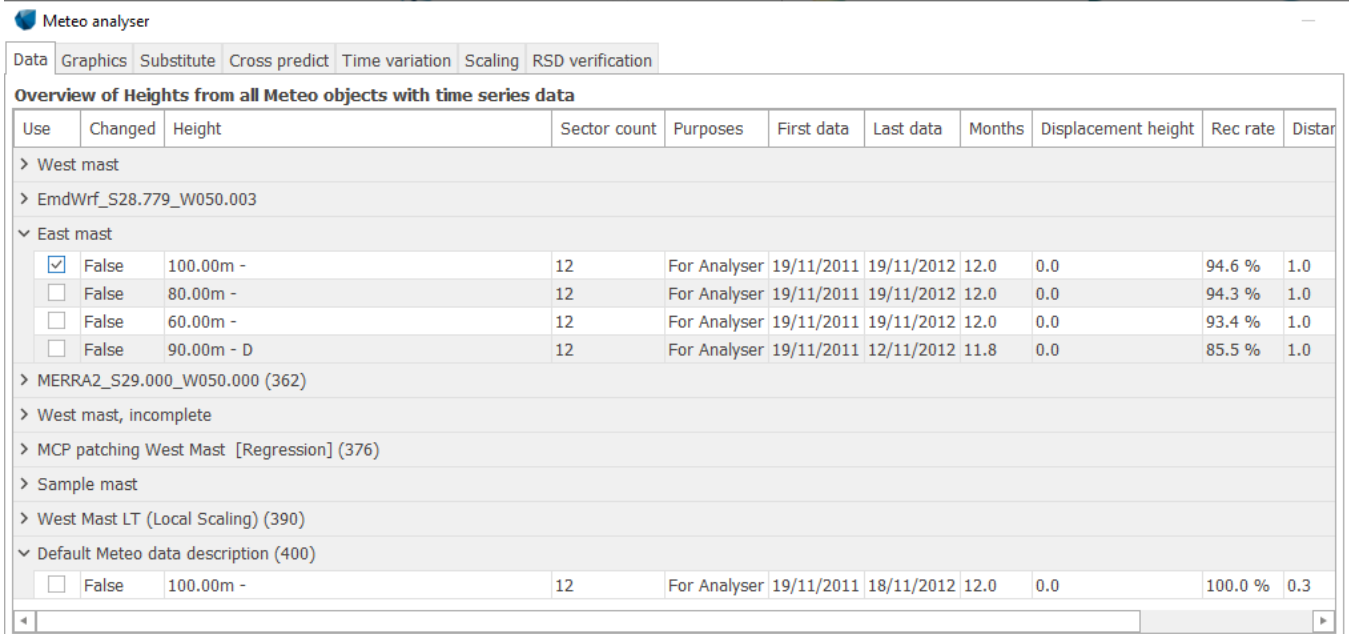The .WTI file is, by default, saved in the project folder and can be selected from PARK Time Varying calculation or from the LOSS & UNCERTAINTY module. The wind speed data is automatically scaled to the calculated mean wind speed for the actual site in order to have as correct of a distribution of the calculated AEP on time stamps as possible, even though the data might not be from the hub height or maybe not even from the site.

12.5.6   Scaling – create a new scaled time series using the Scaler

The scaling can be used on measurements as well as model data. The most obvious use is to scale mesoscale data to a mast position for comparison. This approach is described here.
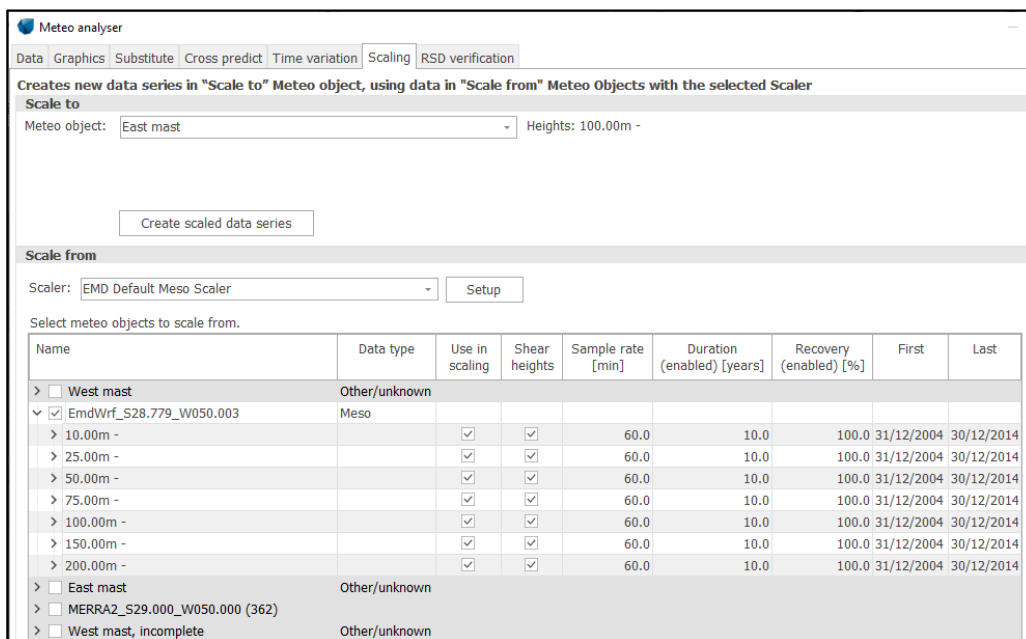
The procedure is to compare mesoscale data downscaled to a measurement station (cleaned using mesoscale terrain and applied with local microscale terrain) to the actual measurements. If the match is not perfect, the downscaled data can then be forced to match an iterative procedure using scaling factors on directional, diurnal and monthly wind speeds. The following is a demonstration of the procedure.

Figure 72 List of data sets (Meteo Objects) in Meteo Analyser

The Meteo Objects in the project are shown above. You only need to check the datasets used for the operation – the Meteo Object representing the measuring station where the mesoscale data shall be "scaled to" - in this case, the East Mast. Then proceed to the Scaling tab:

Figure 73 Scaling setup in meteo analyser

The only Meteo Object that appears in the "Scale to Meteo Object" field is indeed the one selected above.

"Scale from" is where the Scaler is chosen and set up, and the source Meteo Object(s) is selected. In this scenario, the **EMD Default Meso Scaler** is chosen, together with the EMD-WRF mesoscale data near the mast.

Click **Create scaled data series** and the transfer function created by the Scaler generates a time series based on the mesoscale data, at the mast position.

Now, let's *Switch to the Graphics tab* to start the comparisons:
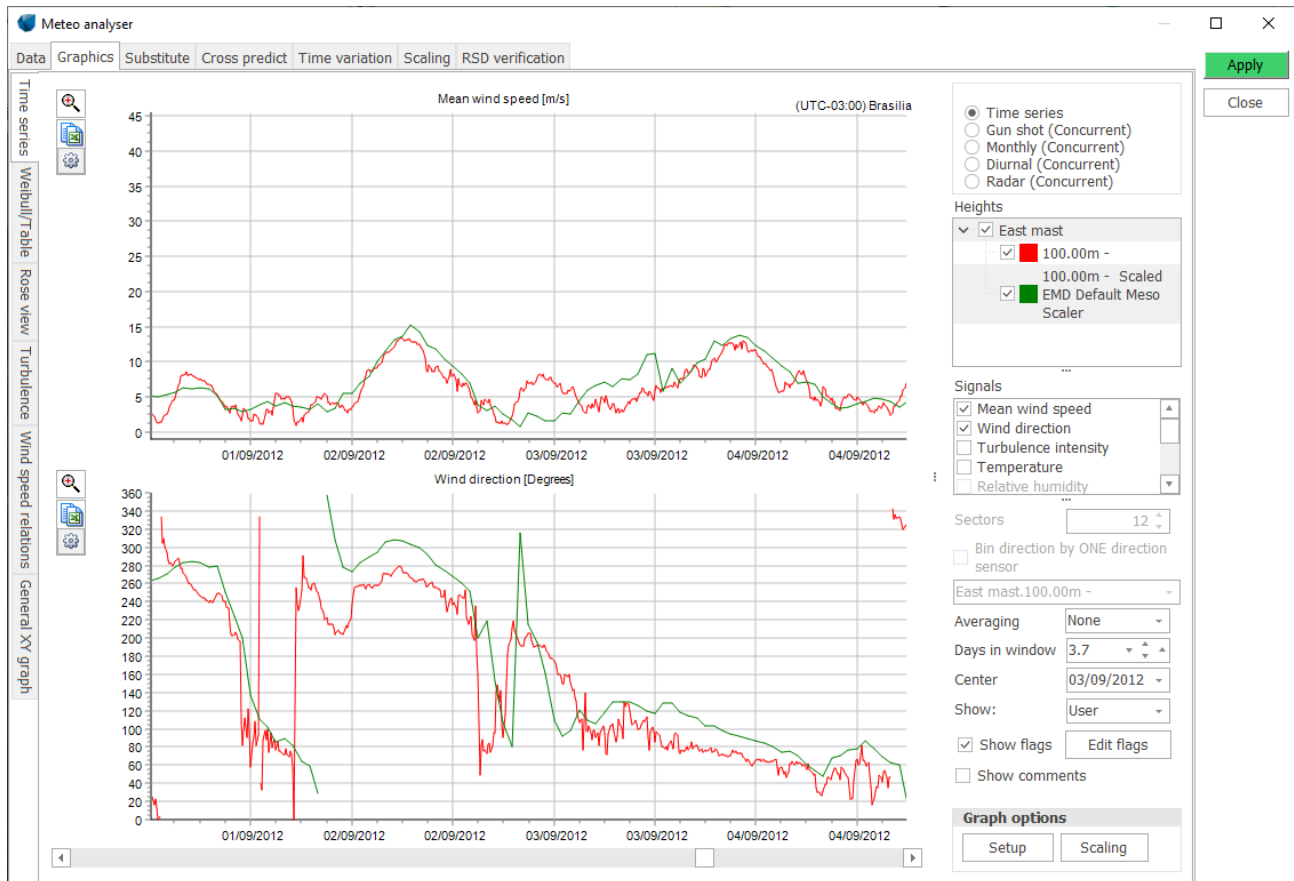
Figure 74 Compare scaled to measured time series (10' vs 1h values, of course!)

If the match looks reasonable at a time series level, the real evaluation will be on the aggregated presentations of concurrent data.
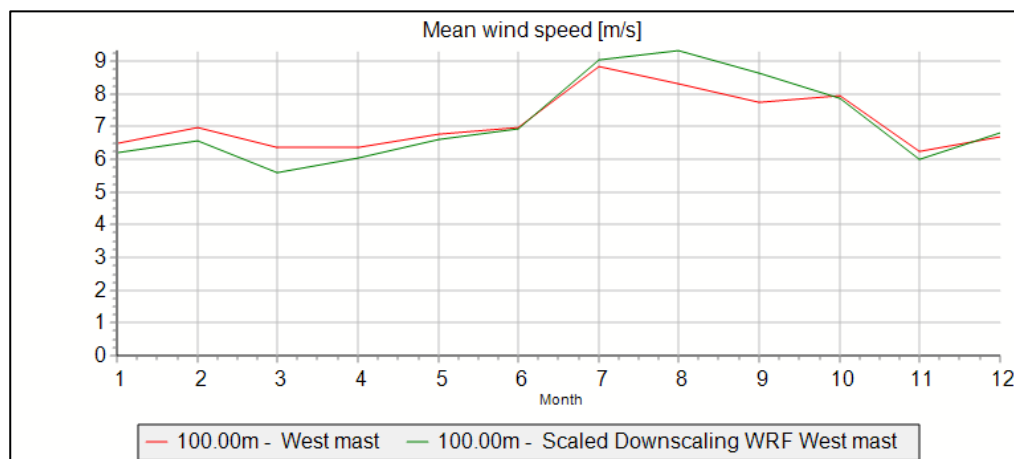
Figure 75 Monthly comparison scaled and measured

Looking at the monthly wind speeds, it is seen the monthly variations match reasonably well, although there is clearly a seasonal bias (overestimation in winter months and viceversa in summer – the site is in the Southern emisphere!).

Another interesting comparison is by direction:
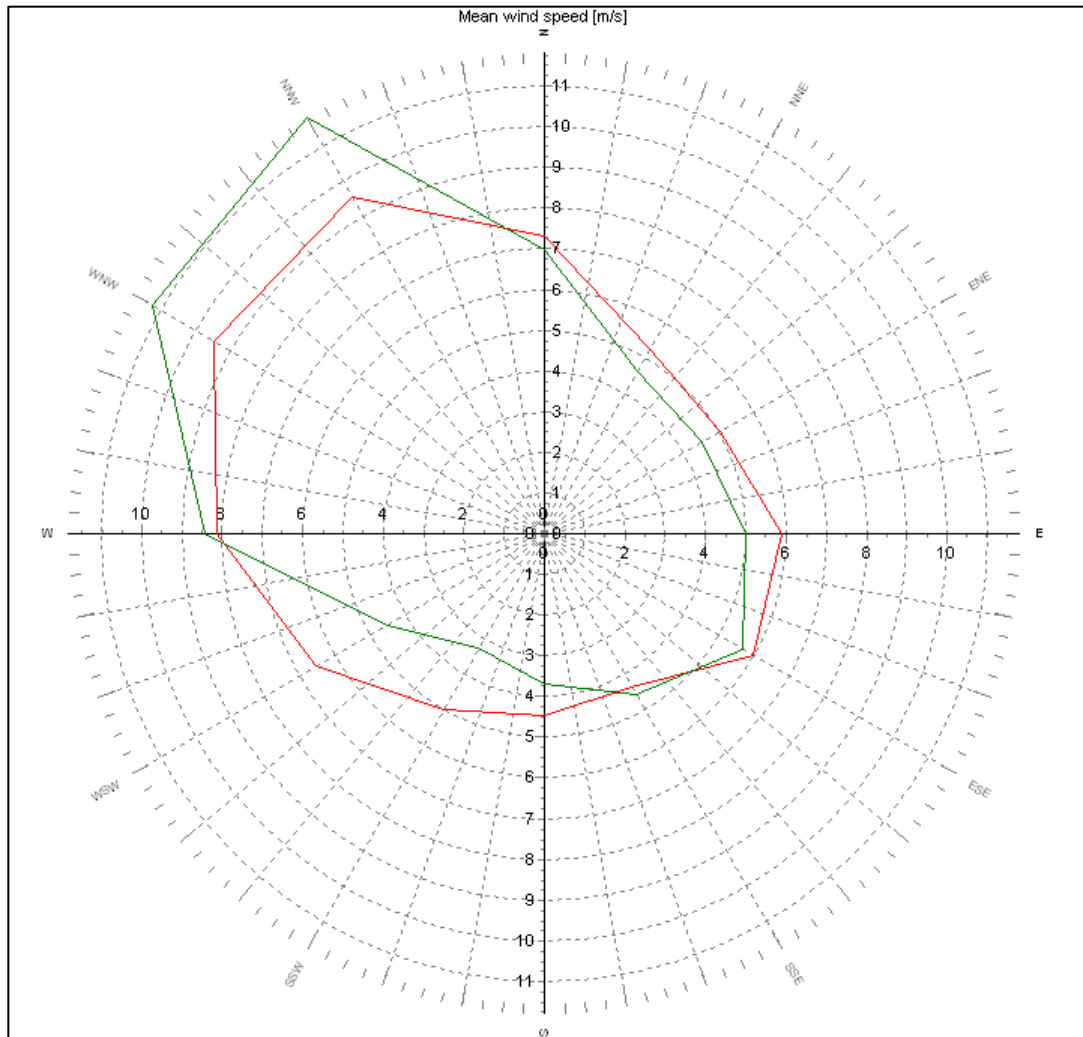
Figure 76 Directional comparison, scaled (green) and measured (red)

If we want a perfect match, the post-calibration can be used. The number of sectors can be increased for a more detailed work.

Click the Excel button on the graph, and copy the data that constitute it.
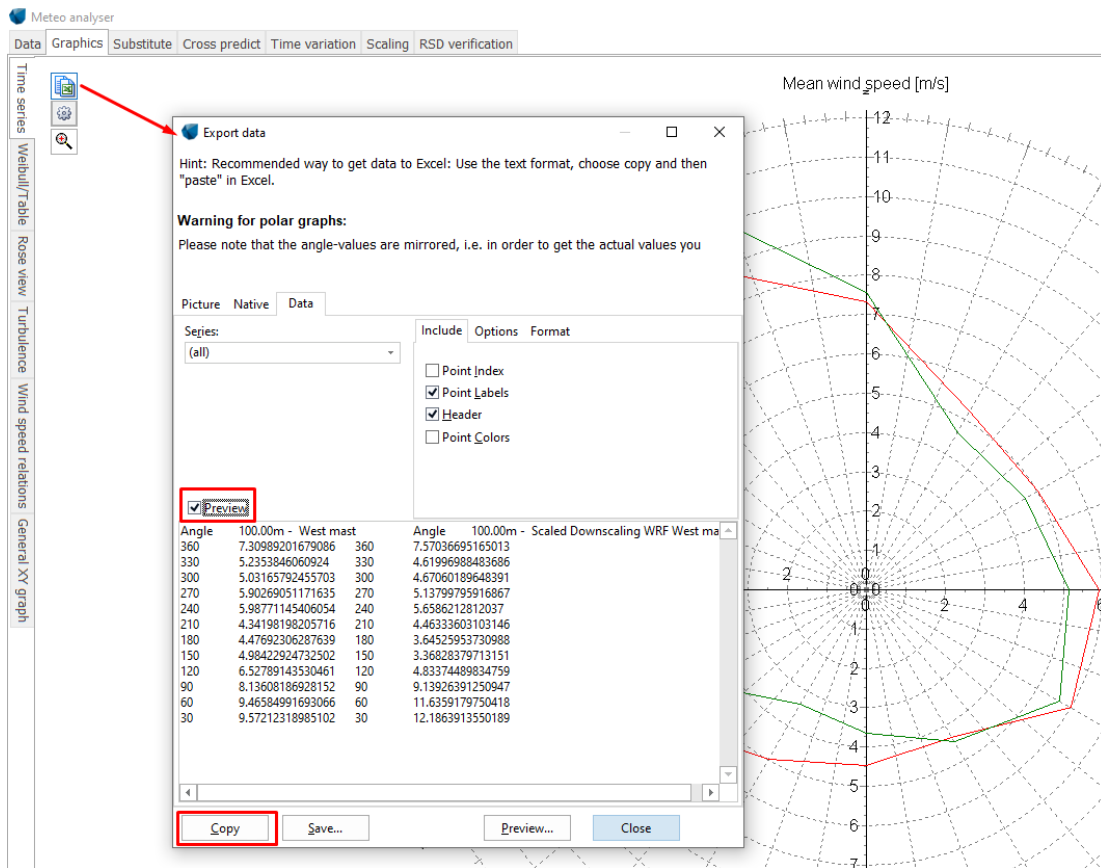
Figure 77 Extracting data from the graph

Figure 78 Calculating the ratios in Excel. Note that the angle shown is mirrored. This is just how the graphic tool works. The order of the sectors is always N – E – S – W. Also note the huge correction required in Sectors 8 and 9.

The data are copied to Excel, and the ratio <u>measured/scaled</u> (sic!) is calculated.

Now, return to the Scaler tab and open its **Setup**. Here, the ratios are inserted by pasting them in the *Post calibration* tab, sector-wise approach.

Figure 79 Enter the post calibration factors in the Scaler. Note how the very large corrections required in Sectors 8 and 9 have been trimmed by windPRO to the default limit of ±25%, a value that can be changed above, if really needed.

Click Ok to return to the main window, where you re-run the model; and the result is:
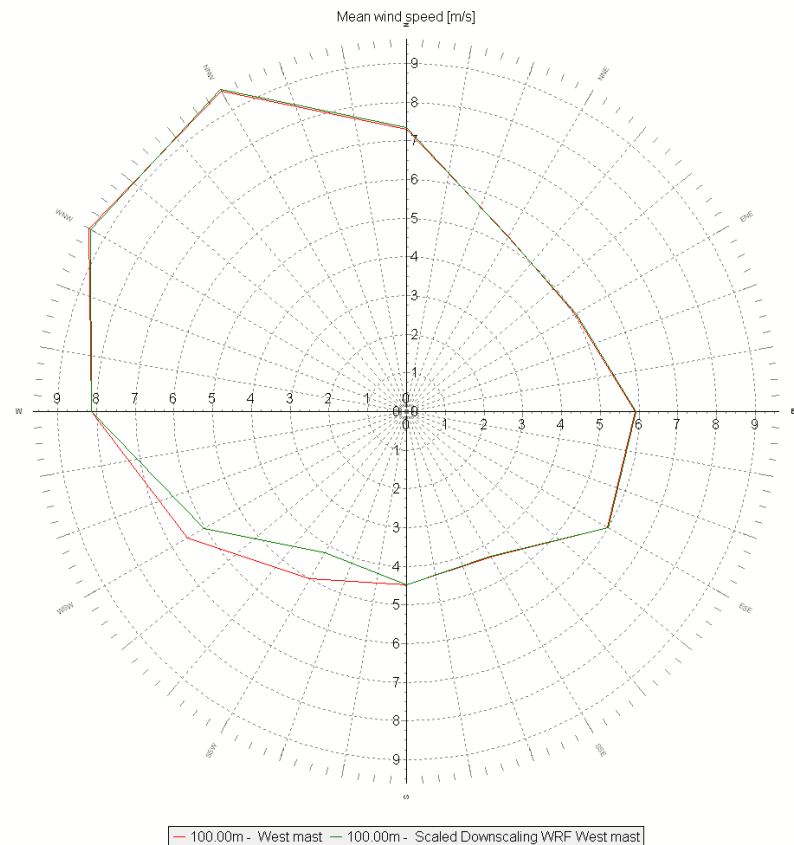
Figure 80 Compare calibrated scaled data to measured. The two sectors where the calibration was not sufficient are the only ones not perfectly matching the measurements.

Now, other aggregated results can be evaluated, and further corrected with the same procedure.
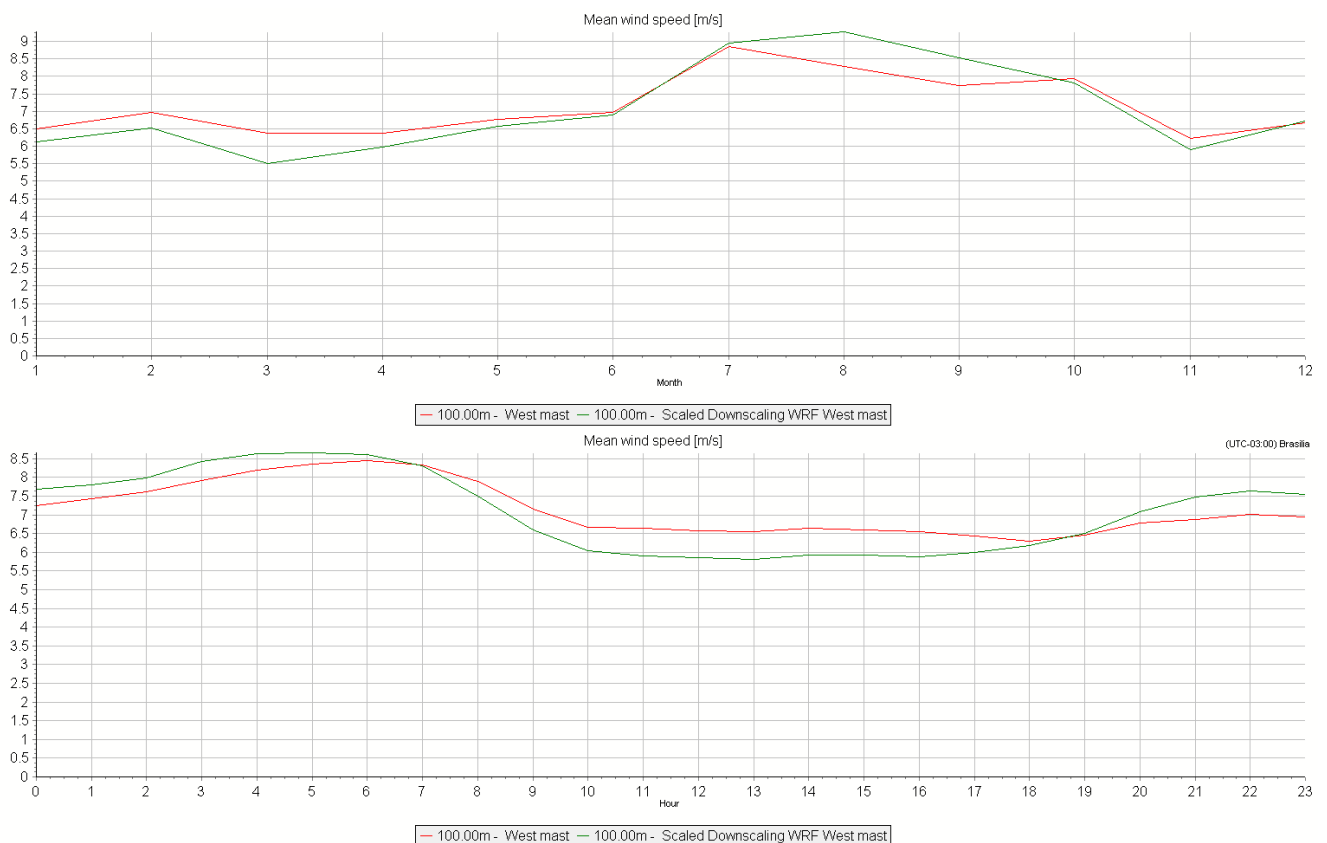
Figure 81 Monthly and diurnal comparison of measured and scaled data

What is important to notice is that the scaling can sometimes be a compensation for how well the calculation model handles the terrain. If the hill speed-up is over/under estimated, this can be compensated with the scaling. This compensation would not then work for all the site, only at the parts of the site that have similar speed-up errors. Therefore, the scaling must be handled very carefully, especially in complex terrain. Having more masts to test the Scaler settings will, of course, be the best method since it gives a more detailed feedback.

When the Meteo Analyser session is finalized, the **Apply** button writes the modifications to the Meteo Objects. For example, the series to the mast Object will be written there, and the data can be used in calculations as a long-term (!) virtual mast.

12.5.6.1 Structured establishment of main scale and offset

One of the wishes when post calibrating Meso data to match local measurements is to have a similar Weibull distribution. This can be established by following procedure in MCP module:
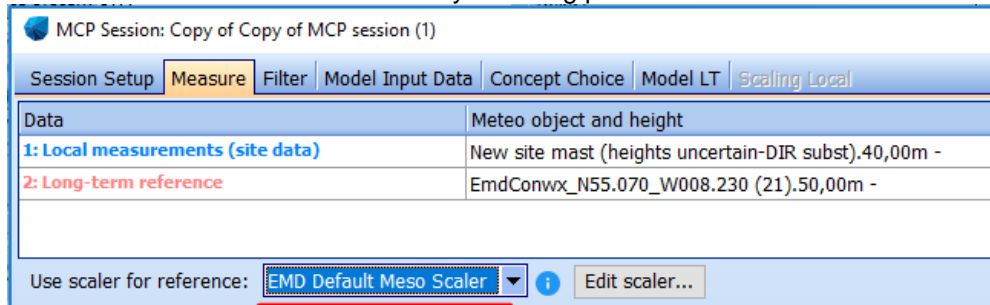
Figure 82 Downscaling in MCP module

Use a default MESO scaler (no post calibration). The MESO data will then be downscaled.
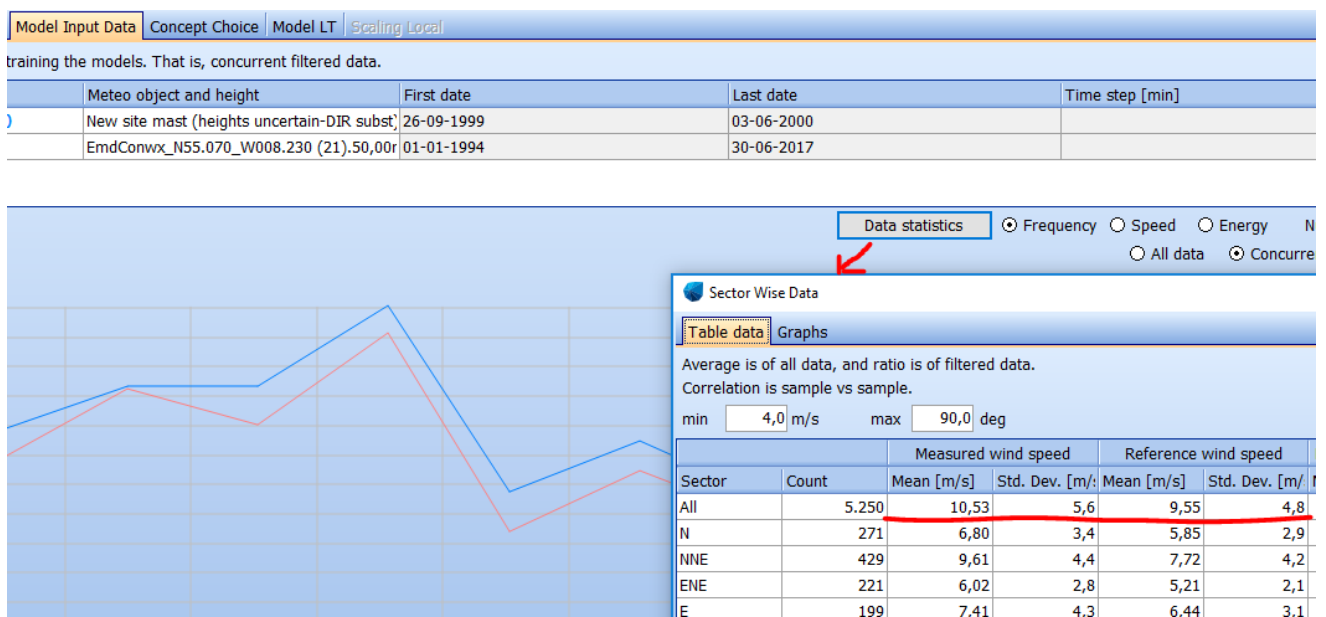
Figure 83 Statistical output from MCP

On the Model Input data page, under "Data statistics", find the Mean and st.dev for the measurements and the downscaled reference.

Now use the formulas from next figure.

Based on the assumption that the cumulative
distributions of the modelled data shall be the
same as the measured, this equation is used:

$$\frac{Umodel - Umean,model}{StDev,model} = \frac{Umeas - Umean,meas}{StDev,meas}$$

From this following formulas for needed Post calibration can be derived:

Scale = Stdev.Measured/Stdev.Modeled

Offset = Mean.measured - ((Stdev.Measured/Stdev.Modeled) x Mean.Modeled)

	Meas	Model			
Mean	6,23	7,72		Scale	Offset
St.dev	2,86	3,48		0,82	-0,11

Figure 84 Establish calculation in Excel or similar tool.

And calculate the Scale and offset.

	Meas	Model			
Mean	10,53	9,55		Scale	Offset
St.dev	5,6	4,8		1,17	-0,61

Results from shown example.

Based on the MCP2005:
Create a scaled series in Meteo analyser based on "Default meso scaling" (no Post calibration)
Read the measured and scaled series in MCP module, load data, go to "correlate" and load concurrent data:

On the "correlate" tab you find the very useful
information:

For enabled data	Wind (site)	Wind (ref)
Mean	6,23 m/s	7,72 m/s
Standard deviation	2,86 m/s	3,48 m/s

Figure 85 The correlation tab in MCP2005 gives mean and st.dev for both series

Note also the wind Veer. If this is high (here only based on wind speeds > 4 m/s), it is most likely that the measurement mast has a direction sensor calibration problem. This should be fixed by recalibration before later directional calibration.

The formulas given in figure "*Establish calculation in Excel or similar tool.*" tells how Scale and Offset are calculated to give the best possible Weibull fit between measured and scaled. This is a very good "basis

calibration" to start with. Afterwards more refined Post calibrations can be performed as described in previous paragraph.

12.5.7   **RSD verification**

Remote Sensing Devices (RSD) will often be installed next to a traditional measurement mast to evaluate the quality of the device. An expert group has established recommendations:
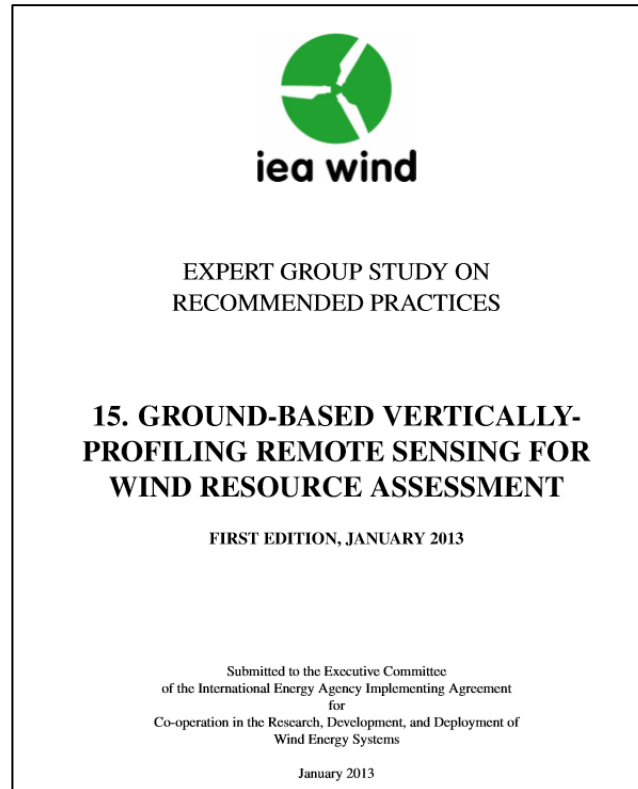
These recommendations have been transferred onto the RSD Verification tool in windPRO, which will reproduce exactly the same tables and graphs required in the IEA text. A link to the document is available in windPRO: please refer to it for knowledge.
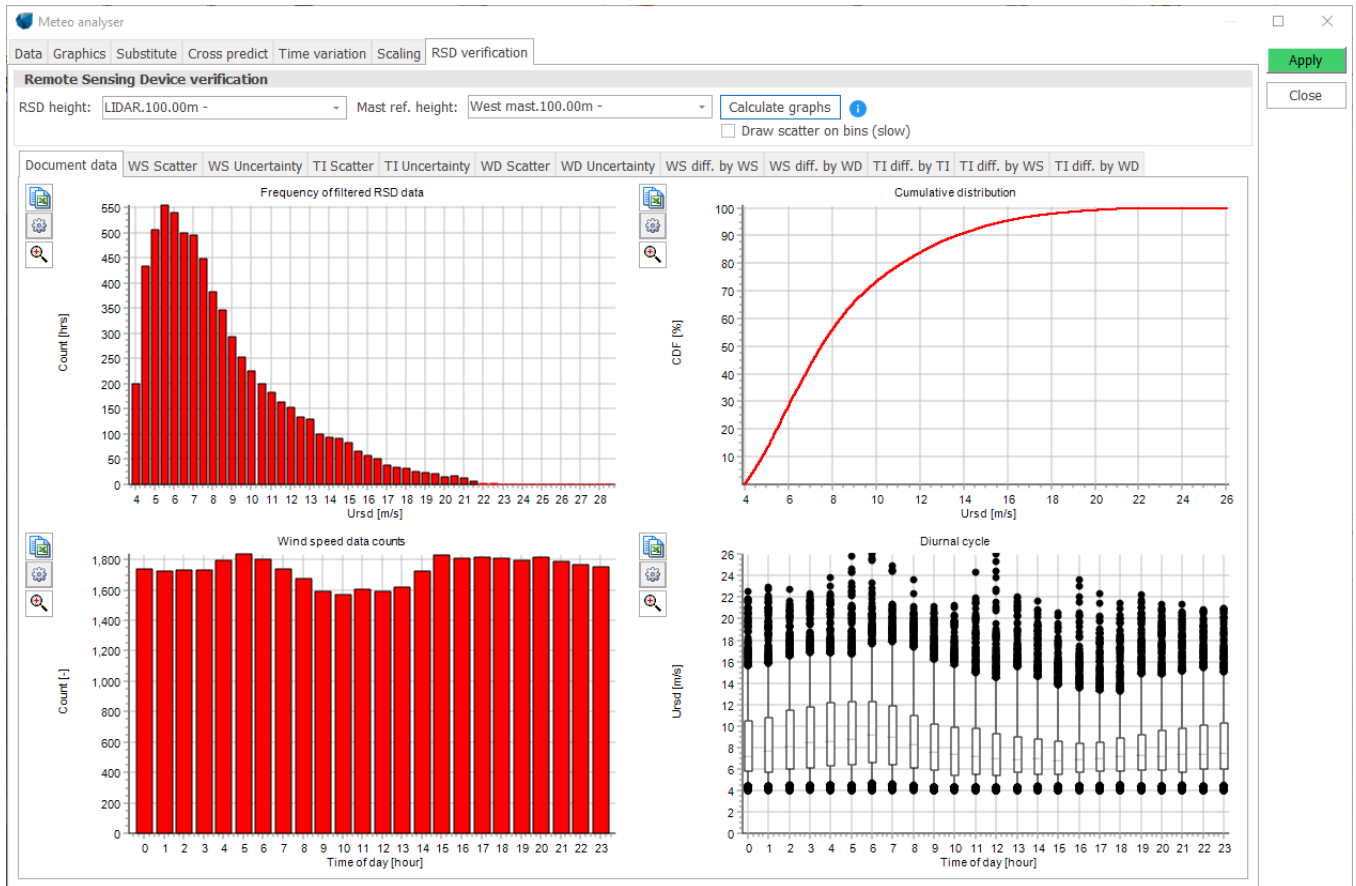
Figure 86 Example graph from RSD verification tool

12.6   Flagging and data screening

windPRO lets you visually highlight data which meet a set of logical expressions, with the purpose to assist in screening and cleaning data without having to scroll through multiple signals simultaneously to spot problematic data.

For information about how to use flags, see: *Quick guide – Cleaning Data with flagging in meteo.* The following section goes into details about the flagging system.

12.6.1   What is a flag?

A flag is a set of logical expressions which can be used to define certain phenomena such as icing, spiking and faulty sensors (or any other trigger). A simple example could be the one below:

If	("Wind speed" is less than 0.2 m/s AND "Temperature" is less than 0°)
OR	("Wind direction" changes less than 2° AND "Temperature" is less than 0°)
THEN	Show a blue flag at the time where the above conditions are met.

Such a set a of conditions will result in a flag being displayed in the background of the time series graph, XY graph or wind speed relations graph:

Flags <u>do not directly influence or change the data</u> in any way but are stored as metadata. Flagging can however be used to disable some or all the highlighted data. Any changes to the original data only occur when you actively decide to disable data.

A flag consists of a name and color. A flag can contain multiple cases, which group conditions together. The properties of a flag can be seen below:

Notice the "Action" property. This allows you to create a flag which looks at the <u>temperature</u> but applies the flag to the <u>wind speed</u> signal. The signals used in a condition may thus not be the same as the signals being flagged.

12.6.2 Building conditions

To add a new flag, open your Meteo Object (also from the Meteo Analyser). Select the "Graphics" tab and click on the "Edit flags" button. This will open the Setup window. windPRO comes with four pre-defined categories of flag: Icing, Bad signal, Mast shadow and Other. Since they are all site-specific, they are still empty. You can edit these flag categories or create your own.

When you **Add a new case** under a certain category, and the **Add** a condition, the following window appears, consisting of five parts:

In the following section the properties of the different parts are explained

Type of data to evaluate

The first property to define is the type of data to evaluate. The choice of data type influences the options available further on. The formulas of the types of data to evaluate can be found below:

Type of Data	Example	Mathematical expression
Value	A is equal to 0.5	If
Difference	Difference between A and B is equal to 0.5	If
Absolute difference	Absolute difference between A and B is equal to 0.5	If
Ratio	Ratio between A and B is equal to 0.5	If You can decide if data should be flagged when B=0 using the "Condition met if second signal is zero"
Shear	Shear between A and B is equal to 0.5	if You can decide if data should be flagged when B=0 using the "Condition met if second signal is zero"
Change in time	Change in time of A is equal to 0.5	If

Signals to evaluate

Next step in the condition building process is to select which signal(s) to evaluate. You can decide to evaluate a specific signal with a name (e.g. the wind speed at 60 m), or all signals of a certain type (e.g. the mean wind speed from any sensor):

In the above example, the conditions will be tested against all the signals categorized in the Data setup as "Mean wind speed". If just one of the mean wind speed signals meets the conditions, then the condition will be true. Bear in mind, that you can flag <u>another</u> signal than the one used in the condition. For instance, you can use the Turbulence Intensity signal in a condition, and then display a flag only on a wind speed signal.

When you chose a type of data involving the evaluation of two signals, you can use the "signal type" to evaluate against any other signal of the same type, but at lower, same or higher height. This can for instance be used for identifying wind speed inversions.

Operator and threshold to evaluate data against

A number of operators are available to compare the signal to a threshold. For example, consider a wind speed signal with the following values: 0,5,10,15,20 m/s. The conditions will then be true for the data below:

If value of wind speed @80m is	Equal to	10	Then the condition is true for	10
If value of wind speed @80m is	Not equal to	10	Then the condition is true for	0;5;15;20
If value of wind speed @80m is	Less than or equal to	10	Then the condition is true for	0;5;10
If value of wind speed @80m is	Greater than	10	Then the condition is true for	15;20
If value of wind speed @80m is	Greater than or equal to	10	Then the condition is true for	10;15;20
If value of wind speed @80m is	Within interval	5 and 15	Then the condition is true for	5;10;15
If value of wind speed @80m is	Outside interval	5 and 15	Then the condition is true for	0;20
If value of wind speed @80m is	Missing	-	Then the condition is true for	-

Condition over multiple consecutive time steps

When building a condition, it is possible to specify for how long this condition must stay true before the flag is applied to the data.

The conditions are evaluated differently over time depending on the type of data being evaluated:

Example Type of Data	Flag data		
Value of A is equal to 0.5 over 2 consecutive time steps	If	AND	
Difference between A and B is equal to 0.5 over 2 consecutive time steps	If	AND	
Absolute difference between A and B is equal to 0.5 over 2 consecutive time steps	If	AND	
Ratio between A and B is equal to 0.5 over 2 consecutive time steps	If	AND	
Shear for A and B is equal to 0.5 over 2 consecutive time steps	if	AND	
Change in time of A is equal to 0.5 over 3 consecutive time steps	If AND No missing samples between and		

Special considerations

They appear only in some cases. If a condition involves dividing numbers (ratios), there is a chance that the denominator will be zero. How to handle division by zero can be controlled using the "Condition met if second signal is zero". Checking it means the condition is considered true, even if there is no value due to division-by-zero.

12.6.3   Multiple conditions

A case can contain multiple conditions. All conditions must be met before a flag can be applied to the time step.

12.6.4   Actions for flags

Once the conditions have been defined, it is time to decide which signals to flag. Per default, the flag will be applied to all signals used in the condition builder, but this can be changed. There are two ways of specifying which signals should be flagged:

- "Affected signal": Flag (some of) the signals which are used in the conditions.
- "Specific signal": Flag whatever signal you want, no matter which signals are used in the condition.

Apply Icing flag to:

⦿ Affected signal
○ Specific signal

☐ All affected signals
☑ All affected Mean wind speed signals
☐ All affected Wind direction signals
☐ All affected Turbulence intensity signals
☐ All affected Temperature signals
☐ All affected Pressure signals
☐ All affected Relative humidity signals
☐ All affected Shear signals

Extend flag to: 0 time steps before conditions are met
Extend flag to: 0 time steps after conditions are met

Example: Create a case with two conditions: One involving temperature, and another involving wind speed. You can specify what should happen when these two conditions are met:

- **All affected signals**: The flag will be applied to the temperature signal and wind speed signal used in the condition at the time steps where both conditions are met.

- **All affected Mean wind speed signals**: The flag will only be applied to the wind speed signal used in the condition at the time steps where both conditions are met. The flag will thus not be applied to the Temperature signal.

If you select both **All affected Mean wind speed signal** and **All affected Temperature signals**, this will be equal to selecting **All affected signals**.

If you select **Specific signal**, you can specify that the flag should be applied to a signal, regardless of the signals used in the conditions.

Apply Bad signal flag to:

○ Affected signal
⦿ Specific signal

☐ Mean wind speed @ 100,0m
☑ Wind direction @ 100,0m
☐ Turbulence intensity @ 100,0m

You can decide if the flag should be applied to more data than just the data which meets the conditions:

Extend flag to: 0 time steps before conditions are met
Extend flag to: 0 time steps after conditions are met

For example, the data surrounding an icing event are often suspicious. Then it's possible to extend the flag, so it is applied to more data than meets the conditions:

Time steps where conditions are met:									
Time steps to flag:									

These extensions can also be negative numbers, so fewer time steps are flagged.

The actual number of flagged samples can be seen in the left-side window:

Show on graph:		Samples
∨ ☑ Icing		13150
☑ Icing		77064

Each case applies a flag to a number of samples. Since multiple conditions can be met at the same time, the total number of applied flags is not necessarily the sum of samples meeting the conditions of the cases. In the image above, the two cases flag data in many of the same time steps.

12.6.5   Flags in Meteo Analyser

The flagging feature is used in the same way in the Meteo Analyser as in the Meteo Object.

When creating conditions in Meteo Analyser, the list of available signals depends on the selection of Meteo Objects in the Data tab.

No flags created in the Meteo Analyser are added to the individual Meteo Objects. Likewise, flags created in the individual Meteo Objects are not added in Meteo Analyser. It is therefore possible to define one set of flags in the individual Meteo Object, and another set of flags in the Meteo Analyser. As always, any disabling made in Meteo Analyser is applied to the individual Meteo Object.

Flagging data with different resolutions
Often in Meteo Analyser, you will have data at different temporal resolutions, e.g. one dataset in 1-hour time-steps, and another in 10-minute time-steps. If you create a condition which applies the flag to both datasets, then it is not possible to see which dataset the flag is applied to, as the flags for each dataset will be merged on the graph. When using the disable or enable features in the flagging window, the two time-series will be treated individually, however this cannot be distinguished when viewing the graph.

12.6.6   Import/Export flags

Flags can be exported from the "Edit flags" window by clicking the **Export** button:

Delete	Clone
Import	Export

The entire flag setup (flag names, colors, cases, conditions and actions) is saved in a XML file in a user-defined location. The exported flag definition can be used in different Meteo Objects, projects, and in Meteo Analyser.

To Import a flag setup, click the **Import** from the **Edit flags** window. Any existing flag definition will be overwritten.

If you import flag definitions from a Meteo Object which does not contain the same signals as the Meteo Object you are exporting to, you will be asked to re-assign the signals in the conditions:

Considerations for creating templates

Using the Import/Export functionality, you can create templates for use in other projects. When creating such a template it is recommended to always define the conditions using the "signal type" conditions, and then apply the flag to an "Affected signal":

This way, the template can be used in any Meteo Object without having to reassign any missing signals. This strategy can also be useful when re-using flag definitions for multiple Meteo Objects in the same project.

12.6.7   Showing flags in time series graph

Flags can be shown in three graphs: the time series graph, XY graph and Wind speed relations graph. They can also be shown in the Time series table (Data tab).

To see the flags in the Time series graph, make sure the "Show flags" checkbox is ticked.

If you only want to display some of the flags or cases, you can open the flag window and untick the relevant checkboxes in the flag list:
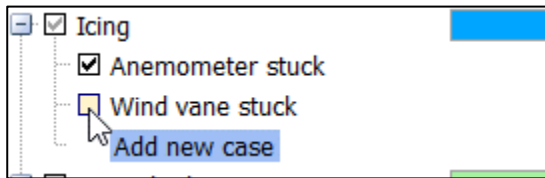
12.6.8 Showing flags in time series table

Flags are shown in the time series table found in the Data tab. The flags are shown as a small square next to the values flagged:

| Disabled	Time stamp (UTC+01:00) Amsterdam, Berlin, Bern, Rome, Stockholm, Vienna	Mean wind speed [m/s]	Wind direction [Degrees]	Turbulence intensity	Comment
☐	28/11/2013 00:30	6.70	265.0	0.0597	
☐	28/11/2013 00:40	6.50	262.0	0.0615	
☐	28/11/2013 00:50	1.00	255.0	2.1997	
☐	28/11/2013 01:00	0.00	253.0	0.0000	
☐	28/11/2013 01:10	0.00	255.0	0.0000	
☐	28/11/2013 01:20	0.00	254.0	0.0000	
☐	28/11/2013 01:30	0.00	262.0	0.0000	
☐	28/11/2013 01:40	0.00	265.0	0.0000	
☐	28/11/2013 01:50	0.00	266.0	0.0000	
☐	28/11/2013 02:00	0.00	270.0	0.0000	
☐	28/11/2013 02:10	0.00	263.0	0.0000	
☐	28/11/2013 02:20	0.00	270.0	0.0000	

Hover the mouse over a flag to display the flag name. The flags shown in the time series table reflect the choice of visible flags in the "Edit Flags".

You can select all data with a certain flag using the **Select** button in the right-hand side:
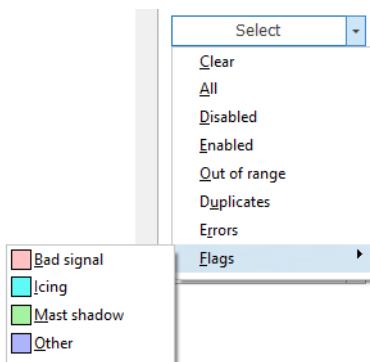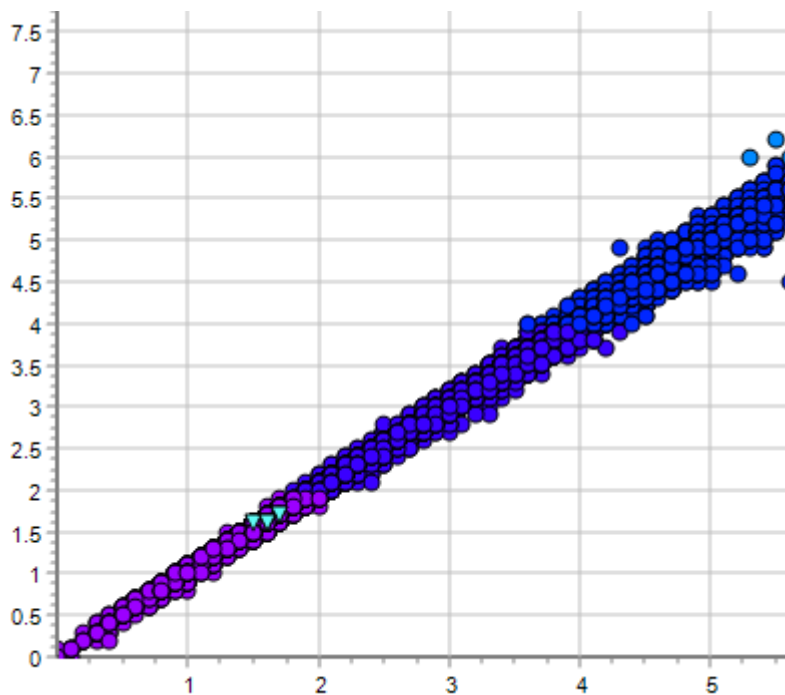

12.6.9 Showing flags in XY graph and Wind Speed Relations graph

When showing flags in the XY graph, the data points will be colored with the same color as the flag:
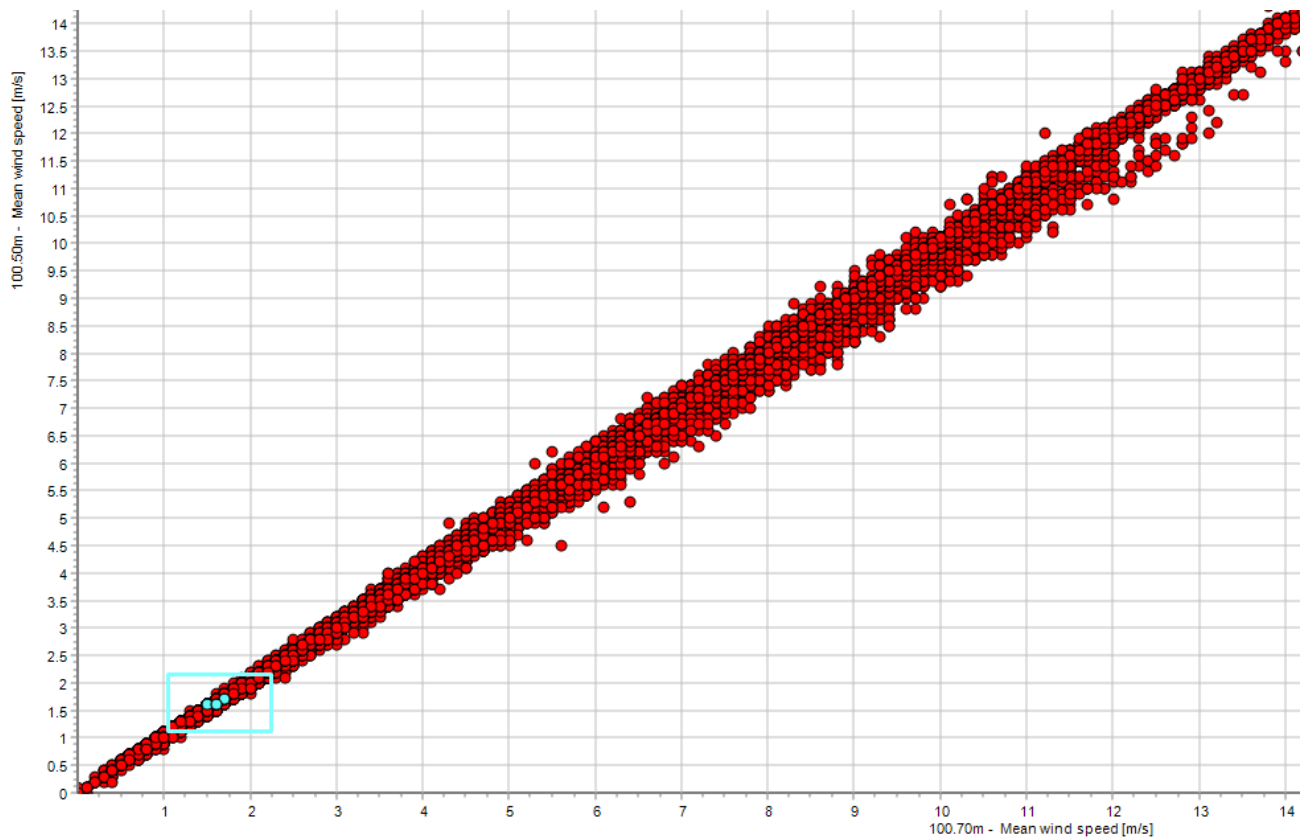
If you use the "Color code with third series" option, the flagged samples will be shaped as triangles:

12.6.10   Cleaning data with flags

There are two ways to disable data with flags.

One way is to use the graph controls in the bottom of the "Edit flag" window. The graph setup can be used without having to close the "Edit flags" window. You can jump between flagged data segments using the **Next**

or **Previous** buttons in the "Edit flags" window, when showing the time series graph. You can control which flags to jump between by highlighting a flag in the list of flags.

To disable the flagged data which has been highlighted in the graph, simply click the **Disable** button. If you want to speed up your disabling process, you can click the small Disable menu, and select **Automatically move to next flag, after disabling**. Then the next flag will be highlighted.

Alternatively, you can disable the traditional way using the select "Advanced Disable/enable" functionality, see section 12.3.4.1.

Currently, flags are completely independent from disabling, so any changes to the flag will not influence the disabling and vice versa. It is not yet possible to print a report of the amount of data disabled due to a flag.