windsim
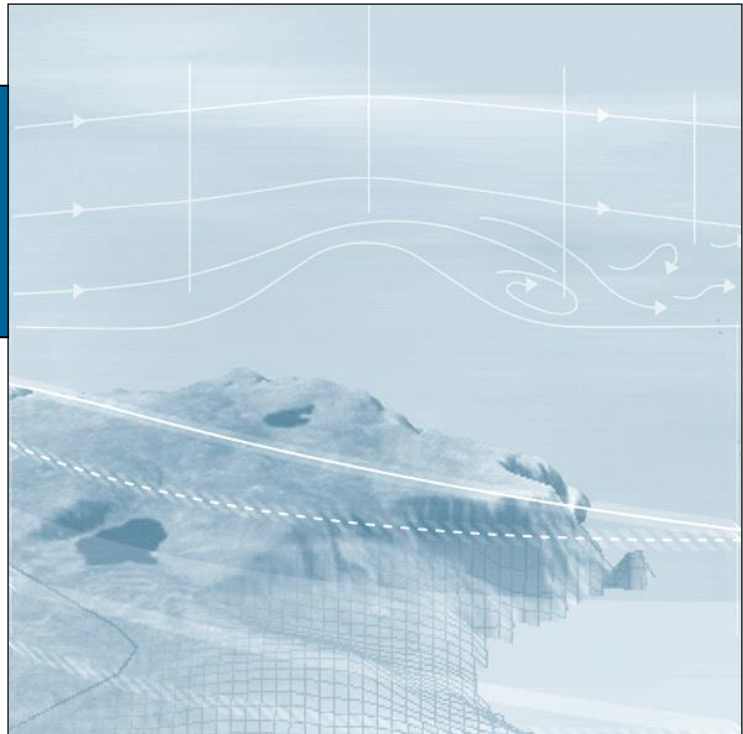
WindSim 12 Release Notes

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WindSim | WindSim 12 Release Notes

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WindSim 12

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1. Terrain

New grid settings are enabled:

1   Geometrical and Arithmetical grid expansion

2   First vertical cell height

Figure 1: example of Terrain properties highlighting new options

1. Geometrical and Arithmetical grid expansion

The Geometrical grid expansion and Arithmetical grid expansion are two different methods of expanding the grid used in our software.

The Arithmetical grid expansion is the traditional method of grid expansion where the grid is expanded at a uniform rate. This means that the number of cells in the grid increases by a constant factor in each expansion step.

On the other hand, the Geometrical grid expansion allows the user to set the grid to expand at a faster rate in the vertical direction than the Arithmetical method. This is achieved by increasing the number of cells in the grid by a factor that is multiplied by itself in each expansion step. This allows for a denser resolution in the lower part of the grid while using fewer cells overall.

By using the Geometrical grid expansion option, users can create models with fewer cells while still maintaining a similar resolution in the lower part of the grid, this can be useful for optimizing computational resources and achieving more efficient results.
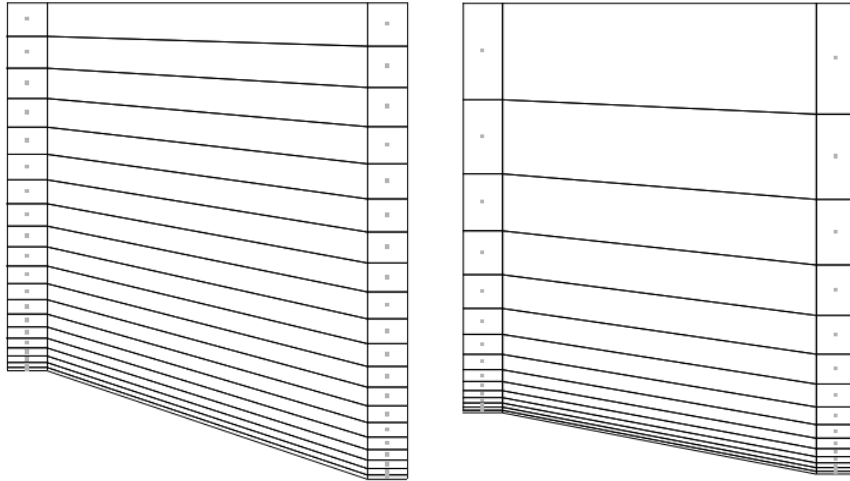

Figure 2: example of Arithmetical (left) and Geometrical expansion (right).

2. First vertical cell height

In WindSim, the first vertical cell height is an important parameter that determines the starting point for the simulation of wind flow in the atmosphere. The default value for this parameter in WindSim is 2m, which is a good tradeoff between accuracy and computational efficiency.

Choosing an appropriate first vertical cell height is crucial for accurate wind resource assessment results, as it affects the resolution of the wind flow characteristics at different heights. A higher first vertical cell height may lead to a coarser resolution of the wind flow, while a lower height can increase the computational time and complexity.

However, the default value of 2m may not always be optimal for every site. The first vertical cell height should be adjusted based on the terrain and weather conditions of the site being studied. For example, if the site has complex terrain or vegetation, a lower first vertical cell height may be necessary to accurately capture the wind flow. On the other hand, if the site is relatively flat and uniform, a higher first vertical cell height may be sufficient.

Overall, the first vertical cell height is a critical parameter in WindSim that should be carefully considered and optimized for each wind resource assessment study.

2. Wind Fields

New Wind Fields settings are enabled:

1   New "HYPRE" solver and new Phoenics version
2   New boundary condition at the top (Diffusive link)
3   Simplified values for convergency
4   Reduced wind database horizontally

1. New "HYPRE" solver and new Phoenics version

The new solver setup in WindSim, which is enabled by the integration of the HYPRE library, features the BoomerAMG preconditioner and solver. This library utilizes the algebraic multigrid (AMG) algorithm for the linear equation solver in the GCV algorithm. This new solver setup has been shown to exhibit improved convergence behavior when working with large models that are run with the parallel option.

This solver also enables future development possibilities, such as the ability to solve on semi-unstructured grids. The new solver is available with the latest version of Phoenics. The integration of HYPRE library will help in achieving high-performance computations and accurate simulation results.

2. New boundary condition at the top (Diffusive link)

The Diffusive link boundary condition is a new option that allows users to set a fixed pressure at the top of the model while also imposing a constant speed. This can be a useful tool for controlling the flow of air in the model.

One of the benefits of using the Diffusive link boundary condition is that it enables users to lower the height of the model and use fewer cells vertically. This is because by imposing a constant speed at the top, the model is able to maintain a consistent flow of air without the need for a larger vertical grid. This can be useful for optimizing computational resources and achieving more efficient results. Additionally, this feature allows users to have more control over the boundary conditions of the simulation and achieve more accurate results.

3. Simplified values for convergency

Simplifying the process of determining the desired level of convergence to stop the simulation, we have introduced two convenient options for users to choose from:

Exploratory (0.005): This setting is designed for rapid evaluation of simulation scenarios with lower accuracy. It is useful for quickly screening different options to determine which ones

are most promising and worthy of further investigation. However, the low accuracy of this setting means that the results should be treated with caution and not relied upon for critical decisions. We recommend using this setting only for exploratory or preliminary analysis.

Accurate (0.0005) default: This setting is designed for high accuracy simulation results, at the cost of longer simulation times. It is suitable for the most critical simulation applications where accuracy is paramount. The high accuracy of this setting means that the results are trustworthy and reliable. We recommend using this setting as the default for most simulation scenarios, especially those where accuracy is critical, and where time is not a constraint.
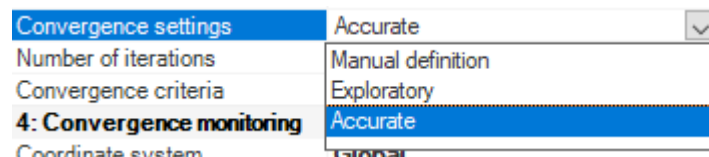
Figure 4: Convergence setting options

4. Reduced wind database horizontally

The "XY reduced wind database" option allows users to perform certain modules only on the internal part of the horizontal grid when a refinement type (Refinement area, Refinement file or Actuator Disc) is defined. This results in a faster and more efficient simulation process, as well as a uniform grid outside of the refined area.

By activating this option, the wind simulation is still performed on the complete grid, taking into account the entire area, but the subsequent calculations are run only on the internal part where the points of interest are typically located. This allows users to focus on specific areas of interest without sacrificing the overall accuracy of the simulation.

Terrain - Wind Fields / **Objects-Results-Wind Resources-Energy**

Figure 5: Sketch of the horizontal reduction of refinement grid.

3. Objects

The power curve header now includes IEC turbine class information for improved data analysis and site suitability assessment.

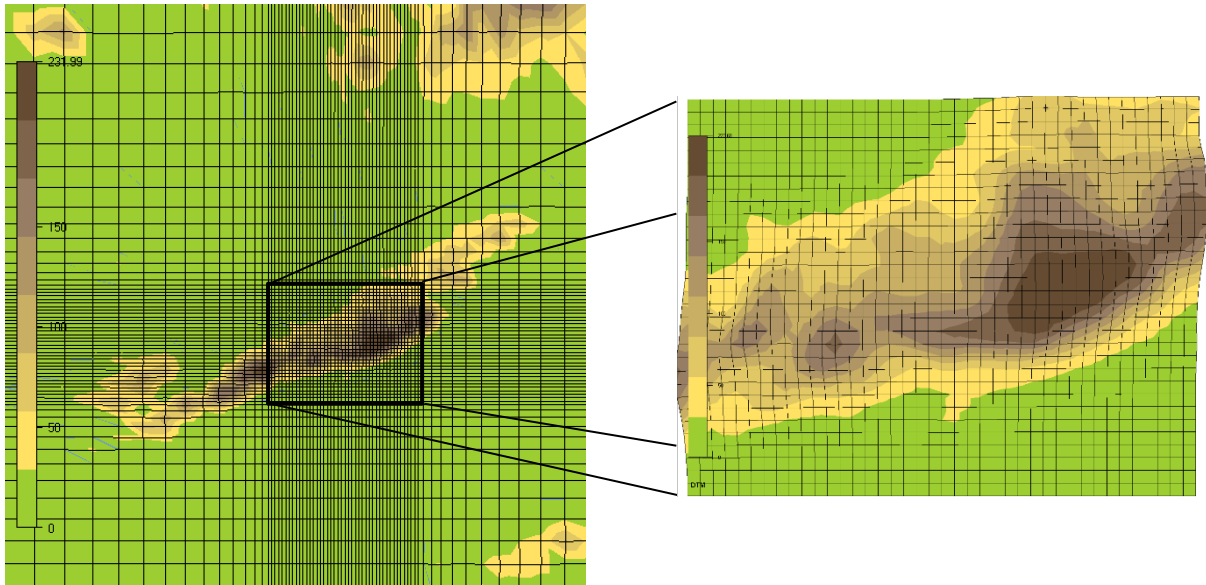### 1. *Power curve header information about IEC turbine class*

The power curve header has been enhanced to include IEC turbine class information, enabling users to easily identify the classification of the turbine and understand its capabilities. This new feature makes it possible to perform IEC analysis within the energy module and assess site suitability automatically, providing more accurate and reliable results. The inclusion of IEC class information in the power curve header streamlines the data analysis process and provides valuable insights for users. For more detailed information on the new IEC analysis, refer to the energy module chapter.

Class AI

```
WindSim version      : 500
turbin manufacturer: Vestas
type specification : V90 mode0 hub height 80m
IEC class letter     : A
IEC class number     : I
max effect           : 2000
air density          : 1.225
Cut-in speed         : 4
Cut-out speed        : 25
Rated wind speed     : 13
```

Class CII

```
WindSim version      : 500
turbin manufacturer: Vestas
type specification : V90 mode0 hub height 80m
IEC class letter     : C
IEC class number     : II
max effect           : 2000
air density          : 1.225
Cut-in speed         : 4
Cut-out speed        : 25
Rated wind speed     : 13
```

Special class S and manufacturer's defined Vref and Iref.

```
WindSim version      : 500
turbin manufacturer: Vestas
type specification : V90 mode0 hub height 80m
IEC class letter     : S
IEC Vref             : 32.5
IEC Iref             : 0.13
max effect           : 2000
air density          : 1.225
Cut-in speed         : 4
Cut-out speed        : 25
Rated wind speed     : 13
```
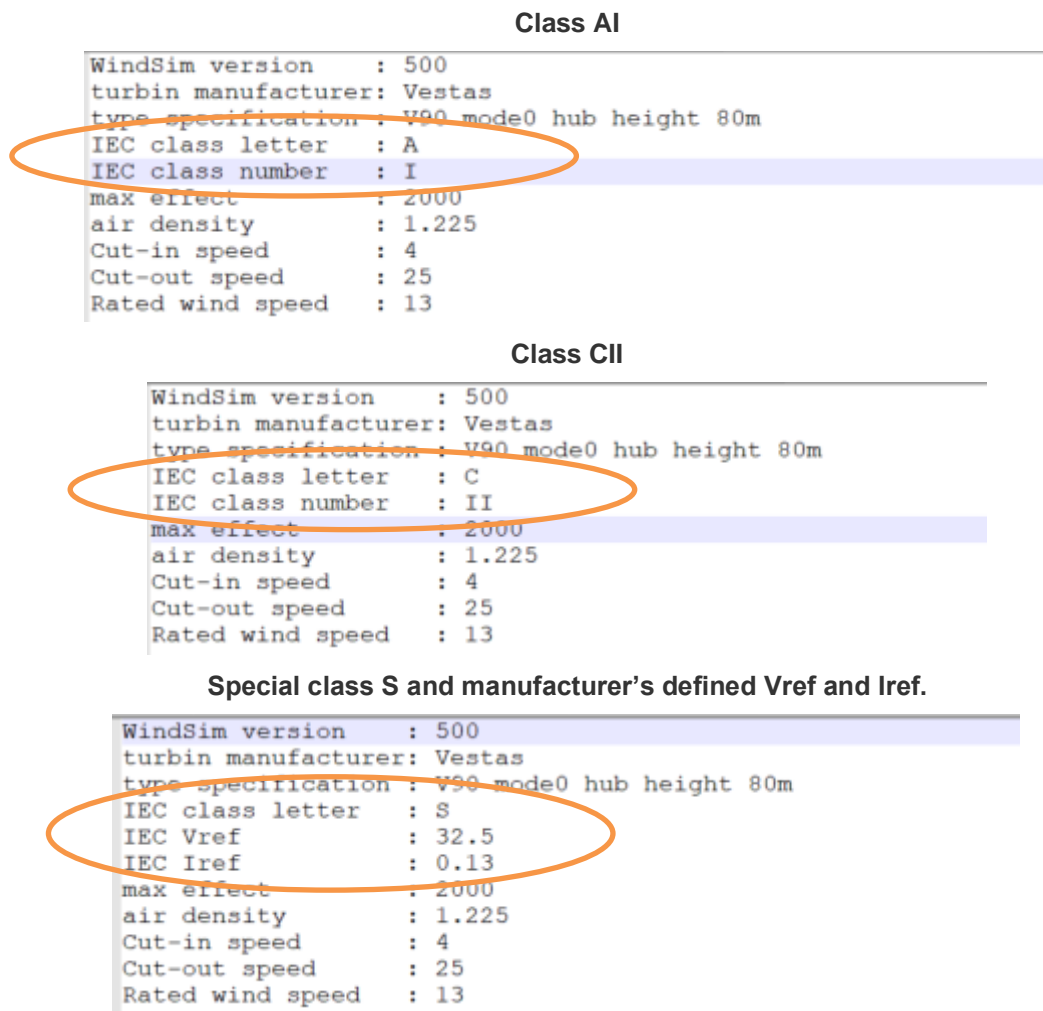
Figure 6: Examples of .pws headers with IEC information included.

4. Wind Resources

New export feature of wind resource map to Surfer format ".grd".

1. *Export of wind resource maps to Surfer format ".grd"*

The new export feature allows users to easily share and analyze their wind resource maps in other tools. This export option generates a .grd file that contains grid information and variable values at each node, making it easy to import and visualize the data. A link to the location of the exported files will be provided in the report, making it easy to access and use the data. The files will be located in the "project\layout\energy\grd" and "project\windfield\grd" directories. This new feature allows users to work with their wind resource maps in a variety of software, making it more convenient to share and analyze the data with others.
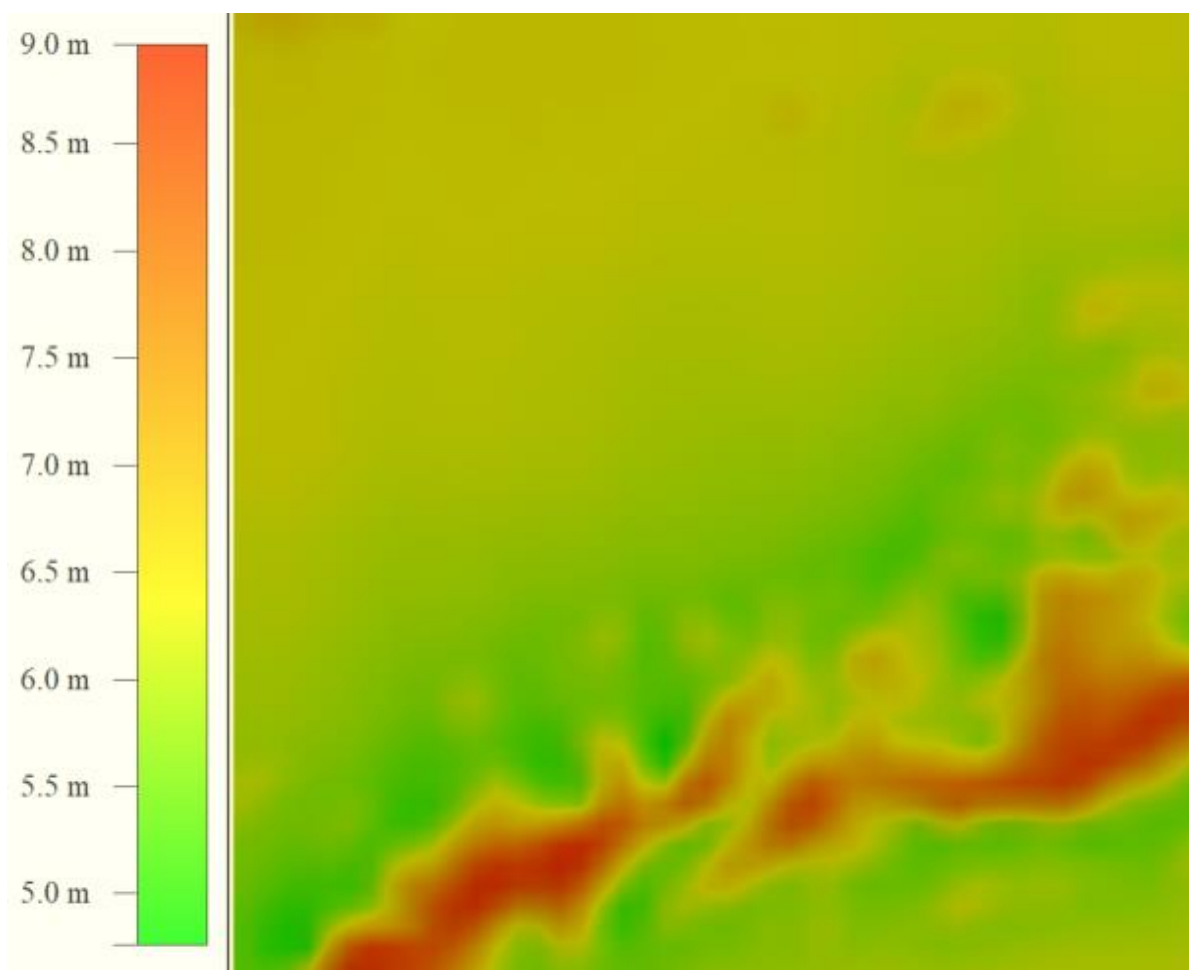
Figure 6: Examples of .grd map showing mean wind speed at 50m height.

5. Energy

1. AEP and IEC report Exports

The AEP and IEC results are tab-separated text files that provide data on Annual energy production and turbine class suitability according to IEC 61400-1 ed. 4 (2019) standards.

The AEP Results file contains information related to the annual energy production of a wind farm. This file includes data such as the average wind speed, Weibull parameters, energy and waked energy, extreme wind (50-years), shear exponent, inflow angle, and information about the nearest turbines.

The IEC Results file contains information related to the turbine class suitability analysis of a wind farm according to IEC 61400-1 ed. 4 (2019) standards. This file includes data such as the turbine class and related Iref and Vref, extreme wind (50-years), Weibull parameters, wind distribution analysis results, mean effective turbulence intensity, turbulence analysis results, IEC inflow angle analysis results, shear exponent minimum and maximum, and extreme turbulence analysis results.

2. Matrix table export

The Matrix table export is a tab-separated file that provides a sector-wise breakdown of turbine energy production, energy including wake, turbulence, and speed frequencies. The turbulence matrix includes data on Ambient and Effective turbulence and their extrapolation when observed data is missing. This allows for the analysis of specific cases such as directional curtailment, sector management systems, IEC analysis checks, and more. The tab-separated format makes it easy to import the data into other software for further processing.

1. Change in the time series AEP normalization

Traditionally, calculations in WindSim have been based on a wind rose (frequency distribution) representation of the measurement time series. In the default configuration, a climatology is first converted into a wind rose (.wws) by the Objects module. This wind rose is then transferred to the turbine positions using the sector-wise speed-ups and directional shifts calculated in Wind Fields. However, in the presence of a directional shift between the

climatology and turbine positions, this method will face inaccuracies due to the requirement to interpolate the wind speed frequencies between two sectors. Oftentimes the impact of the interpolation error on AEP is small (especially if many sectors are used in the computation), but it can be in the range of several percent in case the climate is strongly dominated by one or two wind directions.

In order to avoid this error, previous WindSim version (11) introduced a way to calculate the AEP by directly transferring the measurement time series to a turbine position without a conversion to a wind rose. Then the power output of the turbine would be calculated at every measurement time using the transferred, instantaneous wind speed. WindSim 12 retains this functionality (enabled by setting "Export power history" to True), but the normalization of the AEP has changed in the new release. In WindSim 11, our calculation assumed that in the absence of measurements, the power output was 0. In the case of data gaps, this would then lead to a discrepancy with the AEP calculated from frequency table and Weibull distribution, which, through the removal of the time dimension, implicitly assume that they have been generated from a data series without data gaps. In WindSim 12, however, the time-series-based AEP calculation has been changed to ignore data gaps, and calculate the average power output only over the instances of time when measurements are available. This leads to a proportionately (relative to the length of the data gaps) higher AEP values, but ones that in terms of normalization are more in line with the other methods we present in the report.

6. Meso Micro Coupling

The User Interface of the software has undergone several improvements, including the addition of a postprocessing feature for Self-Organizing Map (SOM) cases. The Wind Resource and Energy module now incorporates SOM results by weighting frequency-based sectors, as typically used in WindSim.

Please note that the postprocessing feature is currently in beta testing, as some energy export and IEC calculation functionality is not yet available. For more information, please refer to the guide "GettingStarted_Meso-microscale_coupling.pdf".