Technical University of Denmark

Wind Atlas Analysis and Application Program: WAsP 6 Help Facility

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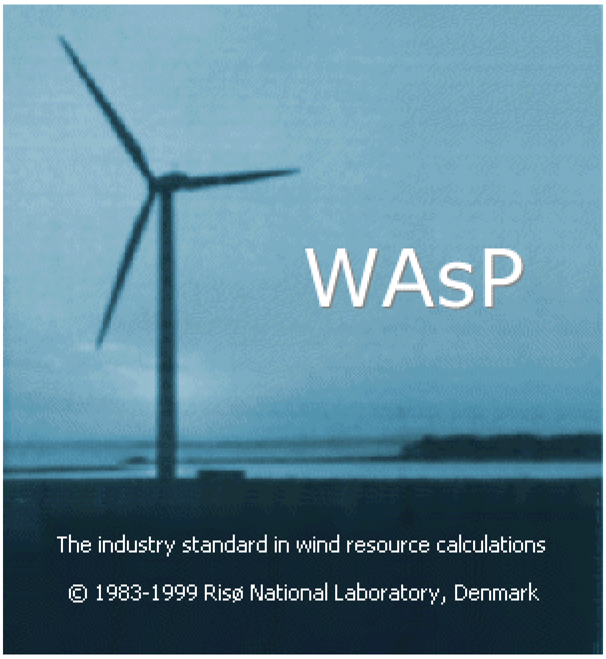

The WAsP 6.0 Help Facility

Wind Energy and
Atmospheric Physics

Risø National Laboratory

June 1999

Welcome

In 1987 the Wind Energy and Atmospheric Physics Department at Risø National Laboratory introduced WAsP – a powerful tool for wind data analysis, wind atlas generation, wind climate estimation and siting of wind turbines. Over the years, the program has become the industry standard for wind resource assessment and siting of wind turbines and wind farms and it has been employed in more than 65 countries all over the world.

A new release of this indispensable tool for everybody working with wind energy is now available – WAsP 6.0 for Windows 95, 98 and NT 4.0. The new program has been developed by the same team who worked out the Danish Wind Atlas and the European Wind Atlas.

The algorithms at the heart of the WAsP software have been tested and applied for more than 15 years in many different parts of the world. As time has passed, most of our efforts have been devoted to refining the WAsP algorithms and supporting the existing software. Meanwhile, user interface design standards have moved on. Many users (and prospective users) have indicated their desire for a new, modern, user interface. WAsP 6.0 is intended to meet these demands.

WAsP 6.0 is 100% 32-bit Windows software which runs under Windows 95, Windows 98 and Windows NT 4.0. It conforms to standard windows software user-interface conventions, making it easy to learn and easy to use.

We recommend that you work through the Quick Start Tutorial – to see for yourself what WAsP 6 is all about. If you're already using the existing DOS versions of WAsP, you might read on here before entering the tutorial.

With the release of WAsP 6.0, we also plan to handle feedback and support in a much more systematic and dynamic way than before. The main focal point for these efforts will be the WAsP home page at www.wasp.dk. Among other things, we plan to maintain a list of Frequently Asked Questions (FAQ), a list of known bugs in the software, a list of User Requested Features as well as information on our own ideas for the future development of WAsP. Last, but not least, there will be a Download Page where you can download the latest version of the software and help file. Users who do not have access to the Internet will receive free updates to version 6.0 on disk.

As it says in the License Agreement and Copyright Statement, the WAsP software is provided 'as is' and 'does not represent a commitment on the part of Risø National Laboratory' etc. However, we are of course aware that the programs may contain errors, programming bugs and inconsistencies – especially with the introduction of this major upgrade. Therefore, we guarantee that we will do our best to check, maintain and correct the programs in the WAsP package, and that we'll make available or distribute corrected versions to registered users of the software.

We wish you the best of luck with your wind projects and hope WAsP 6.0 can help you reach your goals.

The WAsP team at Risø

What is WAsP?

WAsP is a PC-program for the vertical and horizontal extrapolation of wind data. It contains several models to describe the wind flow over different terrains and close to sheltering obstacles. WAsP consists of four main calculation blocks:

Analysis of raw data. This option enables an analysis of any time-series of wind measurements to provide a statistical summary of the observed, site-specific wind climate. This block is implemented in a separate tool, the OWC Wizard.

Generation of wind atlas data. Analysed wind data can be converted into wind atlas data sets. In a wind atlas data set the wind observations have been 'cleaned' with respect to site specific conditions. The wind atlas data sets are site-independent and have been reduced to standard conditions.

Wind climate estimation. Using a wind atlas data set calculated by WAsP or one obtained from another source – e.g. the European Wind Atlas – the program can estimate the wind climate at any specific point by performing the inverse calculation as is used to generate a wind atlas. By introducing descriptions of the terrain around the predicted site, the models can predict the actual, expected wind climate at this site.

Estimation of wind power potential. The total energy content of the mean wind is also calculated by WAsP. Furthermore, an estimate of the actual, yearly mean power production of a wind turbine can be obtained by providing WAsP with the power curve of the wind turbine in question.

The program thus contains analysis and application parts which may be summarized in the following way:

Analysis

time-series of wind speeds and directions —> wind statistics

wind statistics + site description —> wind atlas data sets

Application

wind atlas data + site description —> estimated wind climate

estimated wind climate + power curve —> estimated power production

The WAsP models and the wind atlas methodology are described in detail in the European Wind Atlas and the User's Guide to WAsP 4.

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Acknowledgements

The WAsP program was originally developed, designed and implemented by Ib Troen, Niels G. Mortensen and Erik L. Petersen, Risø National Laboratory, with financial support from the Commission of the European Communities (DGXII).

The present Windows-version was developed by a team consisting of Lars Landberg, Niels G. Mortensen and Ole Rathmann from the Wind Energy and Atmospheric Physics Department at Risø, Sofus S. Mortensen from Lambda Soft (DK) and Duncan N. Heathfield from World in a Box Limited (UK).

The WAsP 6.0 Help Facility

This is the second general release of the help facility for the WAsP 6 program. This help facility should eventually become the complete, on-line User's Guide and Technical Reference for the WAsP program.

The main characteristics of the WAsP Help Facility are:

- Based on Microsoft HTML help
    - Requires Internet Explorer 4.0 for full functionality
- Complete on-line documentation
    - Text, tables and images
    - Table of contents, index and keywords
    - Books and topics can be printed
- Fast and easy to use
    - Context-sensitive help (F1)
    - Full-text search facility
- Hyperlinks to topic, URL, e-mail, multi-media, ...
- Easy to update and distribute

Using the WAsP help facility

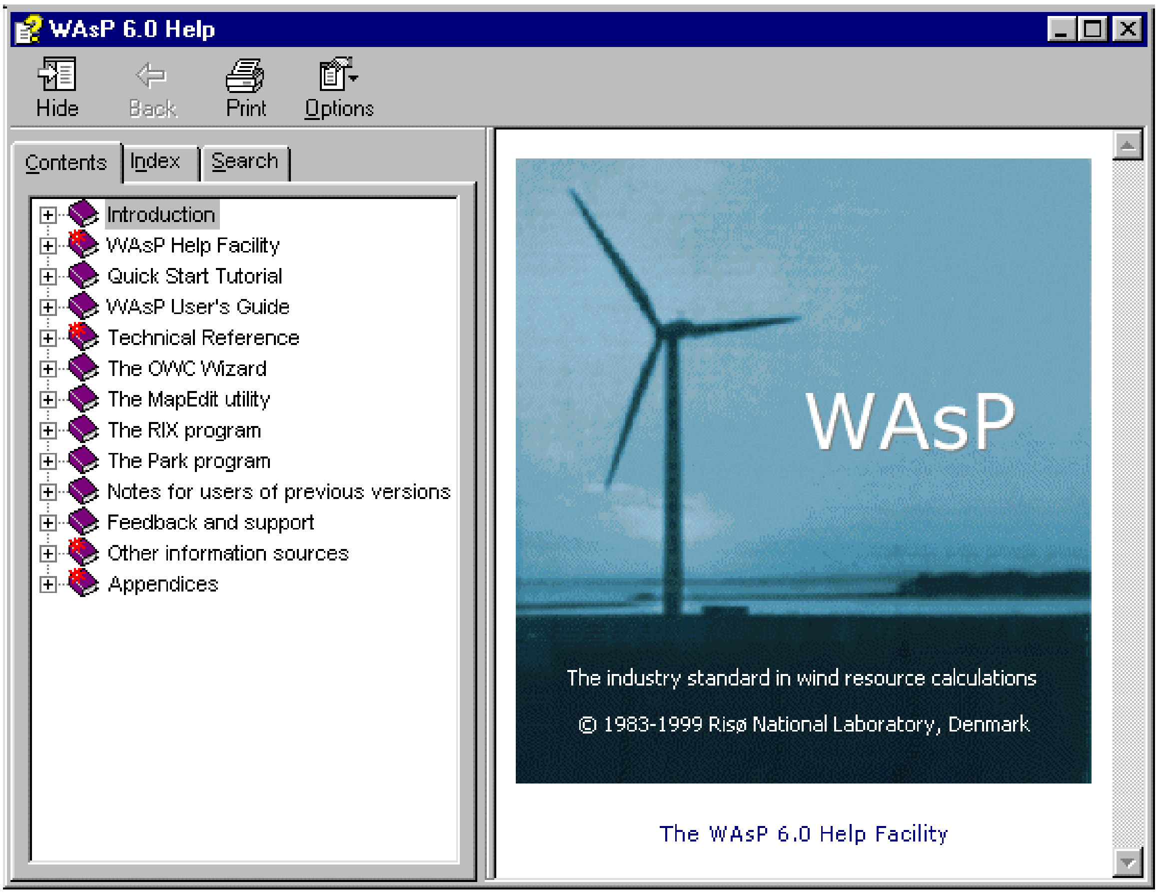
The help facility can be invoked and used in two different two ways: as context-sensitive help or as a stand-alone application.

Context-sensitive help

Pressing the F1 key on your keyboard invokes context-sensitive help for the active window or dialog. This works in the WAsP 6 program and also for the Observed Wind Climate Wizard.

Stand-alone application

The help facility can be invoked from the main menu of WAsP 6 by choosing the **Contents and Index** menu point from the **Help** sub menu. Or, it can be invoked from the **WAsP 6.0** sub menu in the **Programs** sub menu of the **Start** menu of Windows.



The help facility can be browsed in several ways: you may use the **Contents** tab to navigate the help facility via the table of contents, or you may use the **Index** tab to navigate via the keywords of the index. Finally, you may use the full-text search facility by choosing **Search**.

In the different topics of the help facility you may find links to other topics or to Web-pages; these can be invoked directly with the left-hand button of the mouse. Links to e-mail addresses will start your e-mail application when invoked.

Topics and entire books can be printed when choosing the **Print** menu point.

What's new in this edition

The WAsP help facility is continuously under development, so changes and additions to it's structure and contents should be expected. Major changes compared to the first general release are:

• A *WAsP Help Facility* book has been added. This describes the characteristics and use of the help facility and also contains a list of changes to earlier versions.

• The *Tools* book in the *WAsP User's Guide* now contains lists of other software and hardware that may come in handy when working with WAsP in practice.

• A *Technical Reference* section has been added. This contains information on specifications and limitations of the program, on the WAsP parameters and on WAsP and auxiliary file formats.

• *The OWC Wizard* book has been updated to reflect the present, much updated Observed Wind Climate Wizard program.

• The *Feedback and Support* section has been slightly rearranged and divided. It now contains a FAQ and a brief description of the WAsP Utility Programs.

• An *Other information sources* section has been added. This was previously part of the *Feedback and Support* section. New topics containing the references cited in the help facility and selected Risø readings in wind power meteorology have been added.

• An *Appendices* section has been added. This contains a table of air density as a function of site elevation and air temperature.

Plan for the next edition

The contents of the next edition will to some extent depend on the user response to the present version. However, we do plan to add a book called **Modelling with WAsP**. This will contain information on the background and theory, on the different WAsP models and on the limitations of the wind atlas methodology, eg:

- Wind power meteorology
- Wind measurements and data
- Topographical concepts
- The roughness model
- The shelter model
- The orographic flow model
- Site calibration and customisation
- Limitations of the wind atlas methodology
- Wind resource assessment in specific situations (off-shore, near-shore, complex terrain, wind resource mapping, etc.)

We also aim to provide more sample data and example projects with the WAsP package.

Bibliographical Reference

Title: WAsP 6.0 Help Facility

Authors: Niels G. Mortensen (Risø) and Duncan N. Heathfield (World in a Box)

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Abstract: The Wind Atlas Analysis and Application Program (WAsP) is a PC-program for horizontal and vertical extrapolation of wind data. The program contains a complete set of models to calculate the effects on the wind of sheltering obstacles, surface roughness changes and terrain height variations. The analysis part consists of a transformation of an observed wind climate (speed and direction distributions) to a wind atlas data set. The wind atlas data set can subsequently be applied for estimation of the wind climate and wind power potential, as well as siting of specific wind turbines. The present Help Facility includes a Quick Start Tutorial, a User's Guide and a Technical Reference. It further includes descriptions of an Observed Wind Climate Wizard, the MapEdit map editor utility, the RIX program for calculating the ruggedness index of a site in complex terrain and the PARK program.

Descriptors (INIS/EDB): COMPUTER PROGRAM DOCUMENTATION; DATA ANALYSIS; MAPS; RESOURCE ASSESSMENT; SITE CHARACTERIZATION; W CODES; WIND; WIND POWER.

Introduction

This section of the WAsP help facility is intended to provide a very brief introduction to the essential features and uses of WAsP.

A concise explanation of the most basic techniques is followed by a simple step-by-step example.

New users will get an idea of what WAsP is for and how to use it. Existing users of older versions of WAsP will be introduced to the new way of working in WAsP 6.0.

The Quick Start Tutorial starts here.

Just the basics...

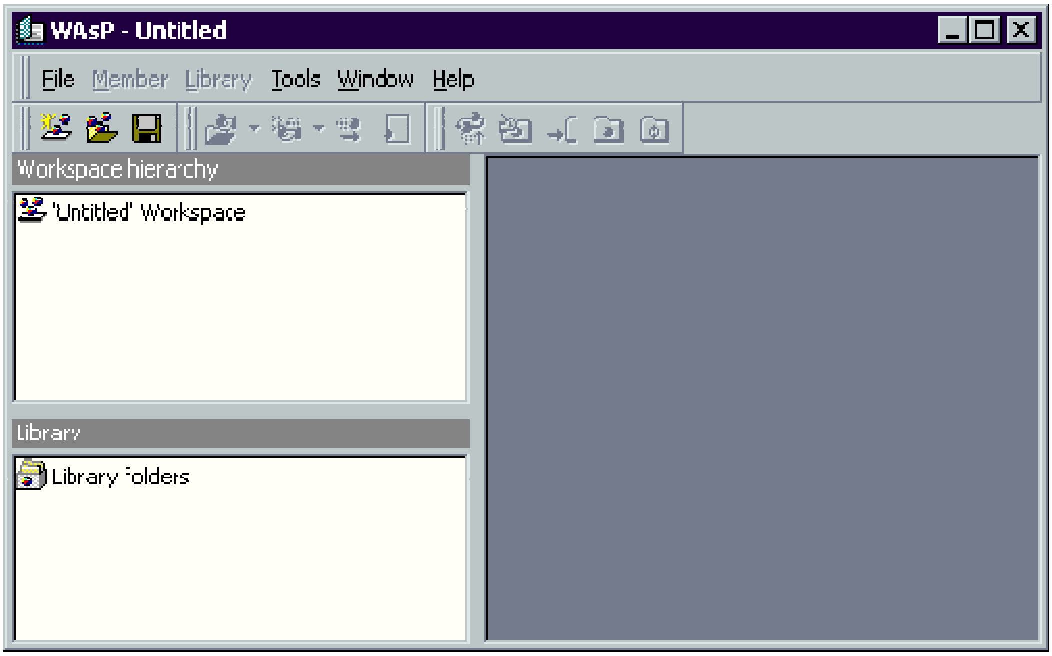
This section is not intended to be a complete guide to using WAsP. Instead, you are introduced to just enough of the basics to let you work through the simple step-by-step example.

Read through the following sections in order

1. Wasp workspaces
2. Working with the workspace hierarchy
3. Saving the workspace members

Opening a new WAsP workspace

When you first open WAsP, you are presented with an empty window. To start work, you need to open a workspace. In WAsP, all work is performed within the context of a workspace. Workspaces can be created, saved and re-opened. To open a new workspace, select **New workspace** from the **File** menu.



Two white window 'panes' have appeared on the left hand side of the main window: the workspace hierarchy and the library. The library pane simply makes it faster to find files. It is explained elsewhere in the documentation. For now, ignore the library pane and concentrate on the workspace hierarchy, which is the most important area of the program.

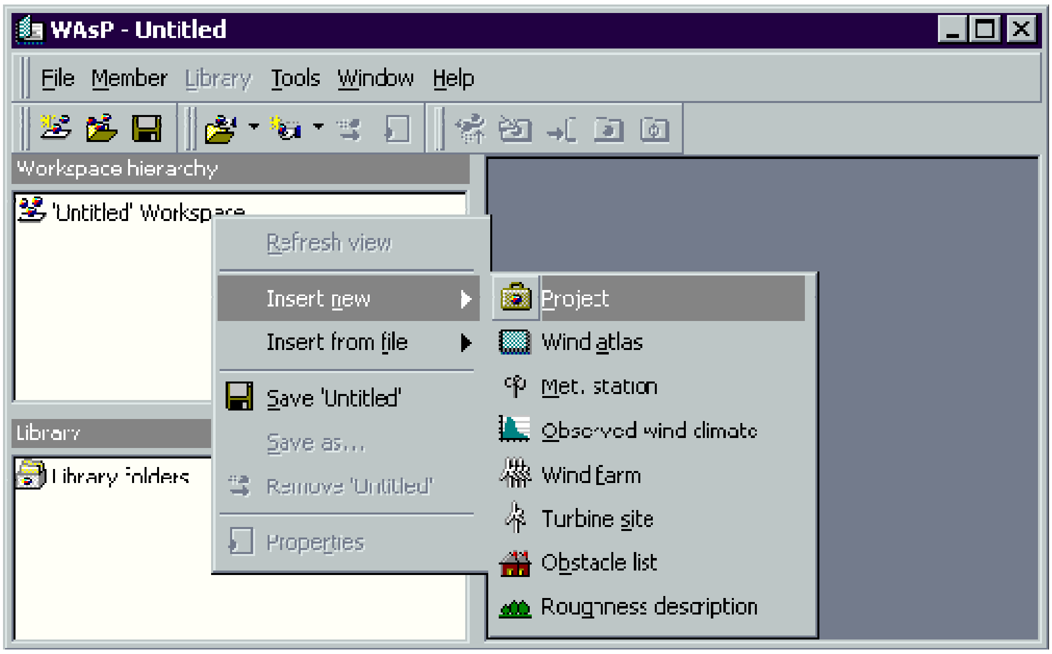
Now read about Working with the workspace hierarchy.

Working with the workspace hierarchy

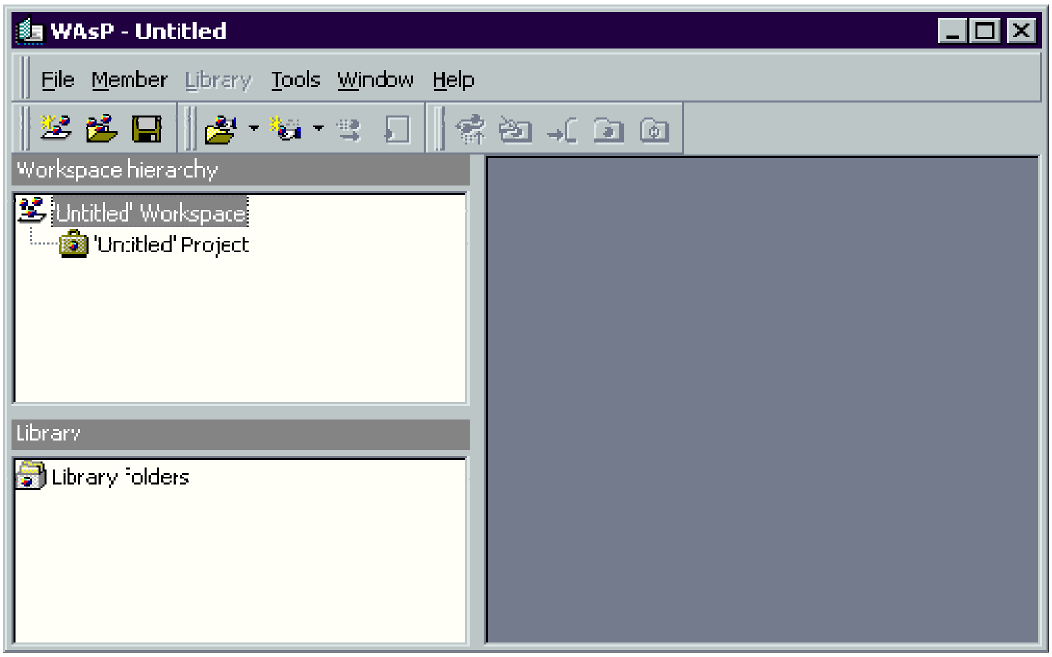
The workspace hierarchy contains a single icon, representing the 'root' of the workspace. This workspace is empty. To work with WAsP, you need to add new items to the workspace. These items are arranged in a hierarchy and are called hierarchy members or just 'members', for short. The workspace root is always at the very top of the hierarchy. All of the members of the workspace are children of the workpace root.

To insert a new member to the hierarchy, do the following:

- Click with the right hand mouse button on the workspace icon.
- A small 'pop-up' menu appears. Select **Insert new**.
- Another menu appears. Select **Project**.



A project hierarchy member is inserted as a child of the workspace root.



Every member of the hierarchy has a right-click menu. Most member's right-click menus include insertion sub-menus.

To insert another member to the hierarchy:

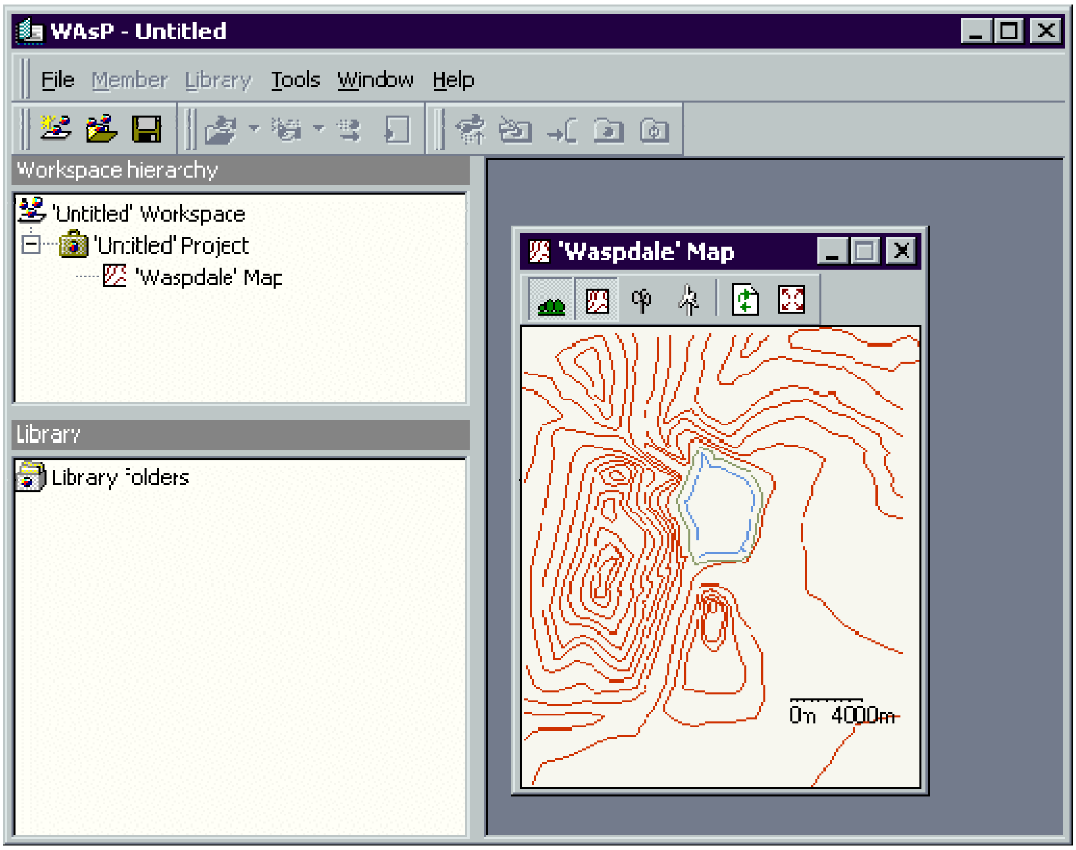
- Select **Insert from file** from the pop-up menu
- Select **Map** from the insertion sub-menu
- A file-choice dialog box appears. Select the file called 'Waspdale.map'

The map is now a member of the hierarchy, as a child of the project.

To view the map:

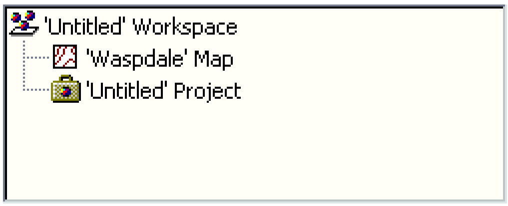
- Select **View** from the map icon's right-click menu.

The map window appears in the right-hand side of the main window.



Most members in the hierarchy have an associated window in addition to the simple icon which is displayed in the hierarchy itself.

All members of the hierarchy (except the hierarchy root) can be inserted, moved around or deleted. You can re-organise the existing hierarchy members by dragging them around with the mouse. To move the map so that it is a child of the workspace root, simply drag the map icon onto the workspace icon.



The map and the project are now both children of the workspace root. There are constraints on where different types of hierarchy member can be placed in the hierarchy, but most types of member (including maps) are allowed to be children of the workspace root.

You have already learned the most important techniques for working with WAsP!

It is largely a matter of manipulating the members of the workspace hierarchy using the mouse. Learning to use WAsP is now simply a question of getting to know the various members of the workspace hierarchy and understanding how to use them.

Now read about Saving the workspace and members.

Saving the workspace and members

Each member of the workspace has an associated data file. When you work with a hierarchy member in WAsP, you are dealing with a copy of the data and you can make changes to anything. The changes to the data are not written to the file unless you save them.

You can save changes to individual hierarchy members by using the right-click menu.

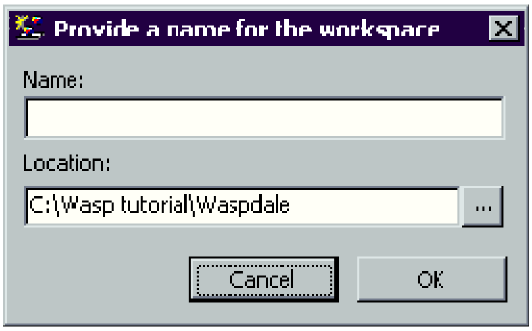
To save the map:

- Select **Save** from the map icon's right-click menu.

To save a copy of the map:

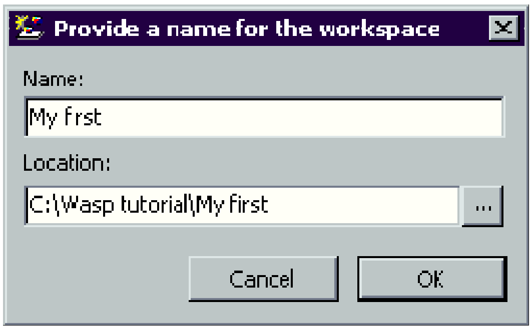
- Select **Save as** from the map icon's right-click menu.
- Provide a name and path for the map file in the file dialog box which appears.

Every WAsP workspace and every WAsP project is stored in its own folder on your computer. So, when you first save a project or workspace you need to provide the name of a new folder rather than a file name. A special dialog box appears to help you do this.



To save the workspace:

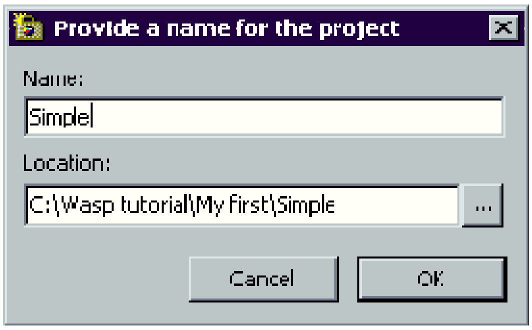
- Select **Save** from the workspace icon's right-click menu.
- Type a name in the box which appears.
- Notice that the new folder name is being added automatically to the location.



When you press OK, a new folder with that name is automatically created, and a new workspace file with the same name is placed into the folder. You are now invited to save the project too.

To save the project:

- Type a name in the box which appears.
- Notice that the project folder is being created as a a sub-folder of the workspace folder.



You can save whole branches of the workspace hierarchy in a single operation. For example, if you save a project, any changes to any of the children of the project are automatically saved too. (That's why, in the example above, you were invited to save the project, even though you had only asked to save the workspace.

At any time, you can save the whole workspace by clicking on the **save workspace** icon in the main toolbar. Any new files which you create in the context of a project or a workspace are (by default) saved to the project or workspace folder.

Introduction

This example works through a complete turbine siting operation, starting with time-series wind data and ending up with a prediction of the power yield from erecting a wind turbine.

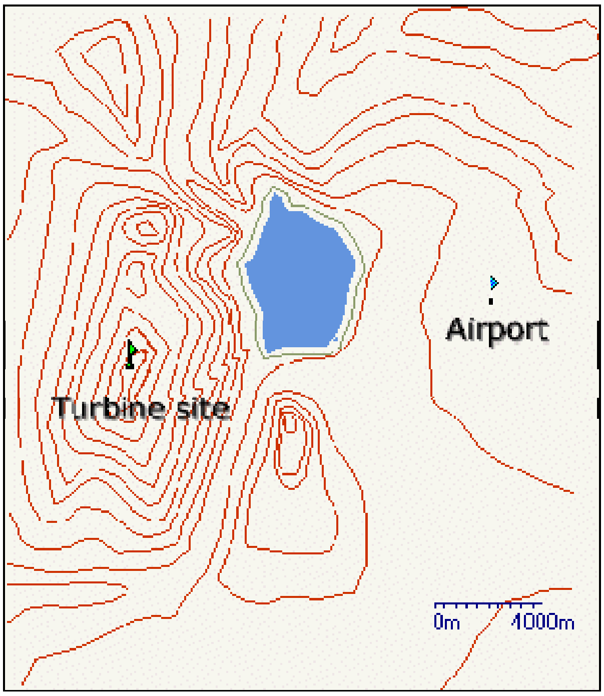
At the bottom of each page is a Proceed... link which will take you to the next page in the example.

Proceed...

The situation

The company *Friends of Wind Energy, Waspdale Ltd.* has asked you to provide a prediction of the power yield from locating a wind turbine in Waspdale. They propose to erect a 200 kW wind turbine at the summit of Waspdale hill (they have modest energy requirements).

No wind measurements have been taken at the turbine site itself, but data have been collected from a meteorological station at nearby Waspdale airport. A map of Waspdale is shown below.



You are equipped with:

- a contour map of the area
- the wind data from the airport
- a simple description of the land use in the area
- an annotated sketch of the airport buildings near the met. station
- a description of the power-generating characteristics of the turbine

These have been converted into digital files, as follows:

- a digital map of topography and roughness
- a data file containing wind data
- a data file describing the buildings at the airport
- a data file containing a power production curve for the turbine

Proceed...

Working with WAsP to provide a prediction

From engineering data, you know how much power will be generated by the turbine at a given wind speed. If the plan was to erect the turbine at exactly the same place where the meteorological data had been collected, then it would be a really simple task to work out how much power to expect.

However, just from looking at the map it is obvious that the proposed turbine site is completely different from the meteorological station at the airport: the properties of the meteorological station itself will affect the wind data recorded there. In addition, the properties of the turbine site will have an effect on the way that the wind behaves near the turbine. It is also unlikely that the turbine would be erected at the same height as the anemometer.

What you need is a way to take the wind climate recorded at the meteorological station, and use it to predict the wind climate at the turbine site. That's what WAsP does.

Using WAsP, you can analyse the recorded data, correcting for the recording site effects to produce a site-independent characterisation of the local wind climate. This site-independent characterisation of the local wind climate is called a wind atlas. You can also use WAsP to apply site effects to wind atlas data to produce a site-specific interpretation of the local wind climate.

Providing a prediction in the Waspdale case will therefore be a two-stage process. First, the data from the meteorological station need to be analysed to produce a wind atlas, and then the resulting wind atlas needs to be applied to the proposed turbine site to estimate the wind power.

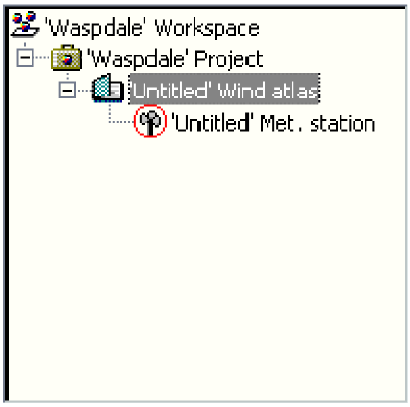
Proceed...

Setting up a met. station

To begin, you need to open a new workspace in WAsP. Add a new project to the workspace and save them both, calling them both 'Waspdale'. Return to the GUI essentials if you don't know how to do this.

Now insert a new wind atlas as a child of the project. The wind atlas will be generated from a meteorological station. Insert a new met. station hierarchy member as a child of the wind atlas**.**

The workspace should now look like this:



Provide names for the wind atlas and met. station by saving them. To do this, simply save the whole workspace: you will be prompted for the file names for the newly-created hierarchy members. Call the wind atlas 'Waspdale' and call the met. station 'Airport'.

WAsP now requires:

- a description of the data recording site
- a summary of the wind data recorded at the site

Proceed...

Adding wind observations

You now need to insert some wind data to the hierarchy.

Select the met station and use **Insert from file** to insert an **Observed wind climate** member. You will be asked to provide the name of a file to use. Navigate to the folder containing the sample data which was created when you installed WAsP, and select the file called 'Waspdale.tab'.

You can read more about how to create observed wind climate files from raw data measurements elsewhere in the documentation.

The workspace should now look like this:

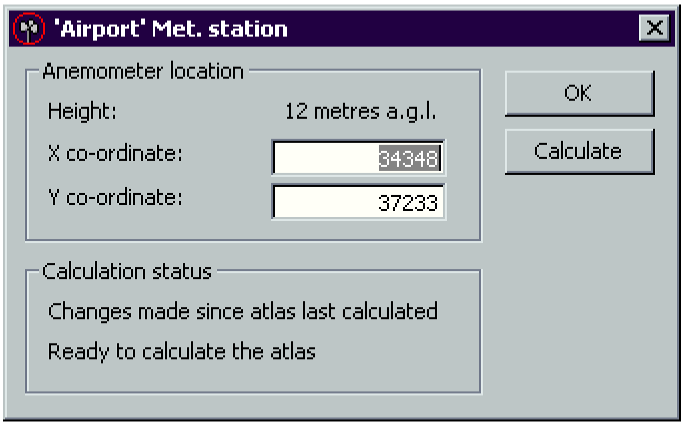
Proceed...

Describing the site

Now WAsP needs to know about the site where the data were collected. First, introduce a map as a child of the project. You should use the project's **Insert from file** method and select the file called 'Waspdale.map'. Now you need to locate the met. station in the map.

To locate the met. station:

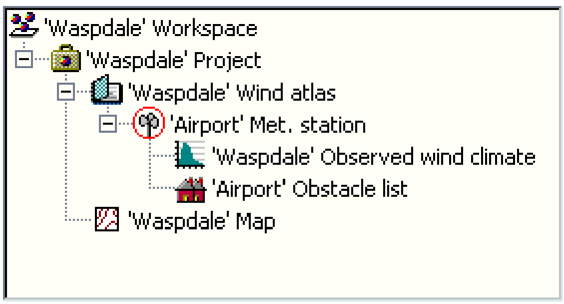
- From the met. station's pop-up menu, select **Edit location**.
- When a dialog appears, set the location to (34348,37233).
- Press OK.



At the met. station site, several buildings and shelterbelts of trees were found in the vicinity of the anemometer mast. WAsP needs to know about these.

Insert a list decribing the obstacles, use the **Insert from file** method of the met. station to add an **Obstacle list**. When the choose file dialog box appears, select the file 'Airport.obs'.

The workspace hierarchy should now look something like this:



Proceed...

The atlas calculation

WAsP is now ready to calculate the wind atlas for Waspdale, but before proceeding, pause to examine the members of the hierarchy which are contributing to the analysis. The map, the observed wind climate and the obstacle list all contain data and can be viewed. Each has a command called **View** on its right-click menu which will open the window associated with the member. Open each one and have a look. To see where the met. station is in the map, select the **Highlight location in map** command from the met. station's right-click menu, or click on the little anemometer icon in the map's toolbar.

Now get WAsP to generate the wind atlas. From the met. station's right-click menu, select the **Calculate atlas** command. When the calculation is finished, the small red ring which surrounded the met. station icon has gone. This indicates that the calculations for the met. station are up to date.

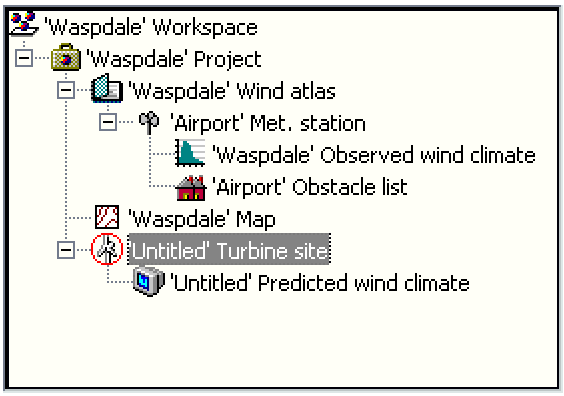
To see the results of the calculation, select the **View** command from the Wind atlas' right-click menu. The wind atlas is displayed. This is a site-independent characterisation of the wind climate for the Waspdale area.

Proceed...

Setting up a turbine site

Now that the project contains a wind atlas with site-independent wind climate data, we can apply those data to the proposed turbine site. WAsP will adjust the data for the situation found at the turbine site, and will produce a prediction of the wind climate for the site itself.

You need to add a turbine site heirarchy member to the workspace. Insert a new turbine site as a child of the project. The workspace now looks like this:



WAsP has automatically added a new hierarchy member called a predicted wind climate as a child of the turbine site. This member will be used to contain all of the predictions which WAsP generates for the turbine site. It cannot be separated from its turbine site parent.

Save the workspace. You will be prompted to provide a name for the turbine site. Call it 'Hilltop', since the plan is to erect the turbine on a hill.

WAsP now requires:

- the location of the site in the map
- a description of the type of wind turbine that you propose to use.

There are no obstacles near the hilltop, so there is no need to add an obstacle list to this site.

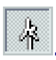
Proceed...

Locating the turbine site

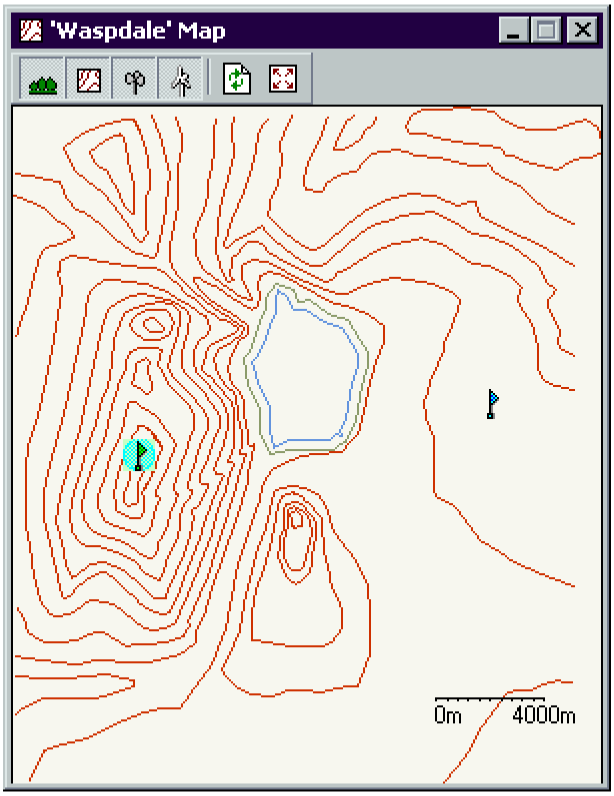
First, locate the turbine site in the map. Because the map and the turbine site are in the same project, WAsP automatically knows that the site lies in the area covered by the map. All that you need to do is provide the co-ordinates.

This could be done by following the same procedure as used for siting the met. station (type the co-ordinates into the site dialog box). However, since the location of the turbine site has not been exactly decided, we do not need to be so precise at this stage. We can use a different method.

From the turbine site's right-click menu, select **Locate in map**. The map window will appear, and the turbine site will be highlighted in the middle of the map area. If the turbine site disappears as you are working with it, check that the turbine site button in the toolbar is in the down position, like this:

.

It is now possible to drag the turbine site in the map to the location you want. Put it on top of the hill in the west of the area, like this:



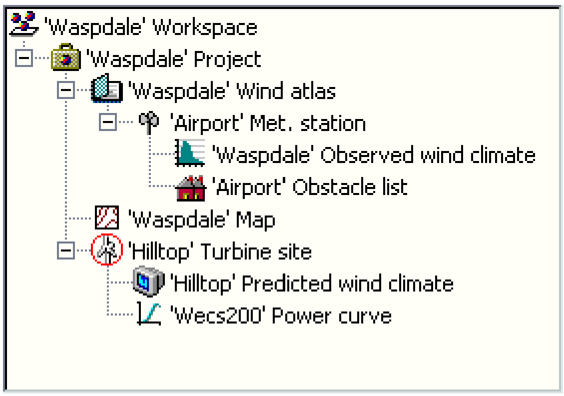
If you want to adjust the location of the site to an exactly-specified position, then use the site dialog box which can be reached at any time from the right-click menu of the turbine site icon in the workspace hierarchy. You can also call up the dialog box by right-clicking on the flag icon in the map.

Proceed...

Assigning the power curve

In order to predict how much power will be produced by the turbine, WAsP needs to know the power production characteristics of the turbine. You provide this information to WAsP by associating a power curve hierarchy member with the turbine site. From the turbine site's right-click menu, select **Insert from file**, and then choose Wecs200.pow when prompted.

The hierarchy shold now look like this:



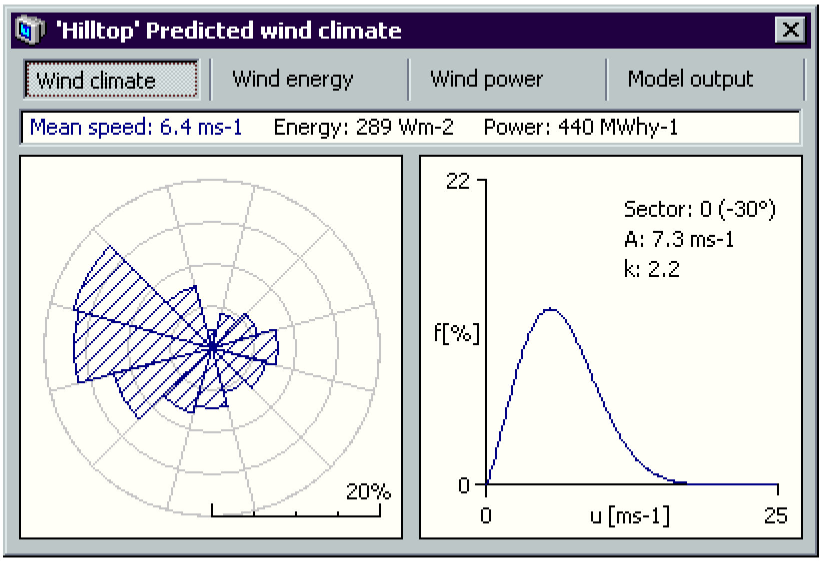
It is not yet possible to view the predicted wind climate, but you can open the power curve window.

Proceed...

Predicting the wind climate

WAsP is now ready to predict the wind climate for the turbine site. From the turbine site's right-click menu, select **Calculate wind climate**. As with the met. station, the small red ring surrounding the turbine site icon disappears as soon as the calculation is performed.

You can now open the predicted wind climate window to view the results:



The numbers shown above might differ slightly from those returned to you, because the location of the sites might not be exactly the same. WAsP has estimated that about 440 MWh per year would be generated by erecting a turbine on the hilltop.

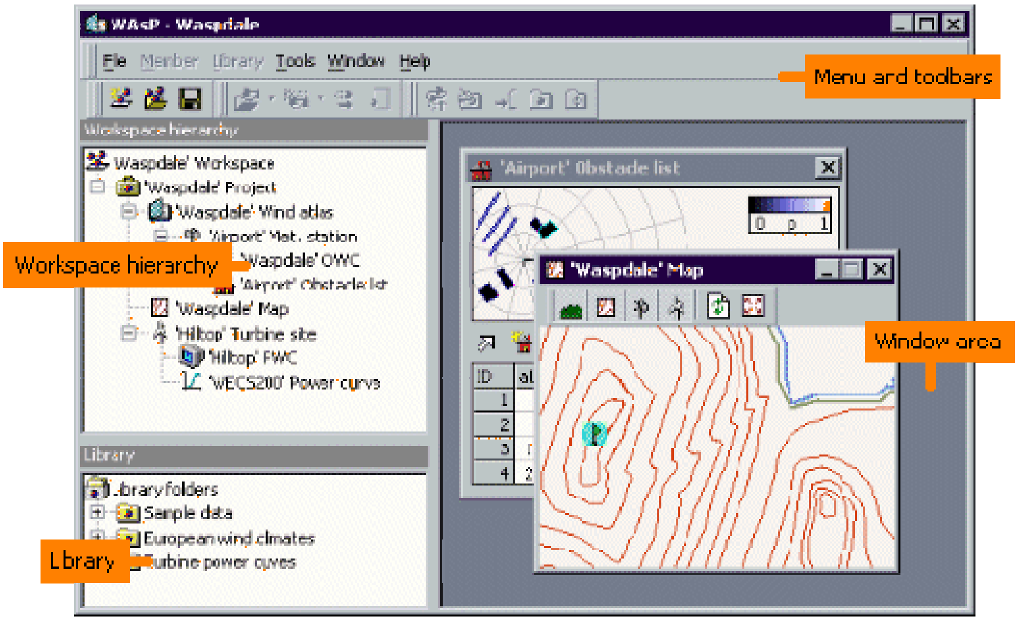
You can now return to the *Friends of Wind Energy, Waspdale Ltd.* and make your report!

Proceed...

There's a lot more to learn...

There's still a lot more to learn about the user interface of WAsP, but as you have seen, you don't need to know about that in order to get work done. For first-time WAsP users, it's important to understand more about what WAsP is actually doing behind the scenes. WAsP results are not useful unless the models' limitations are understood. Before using WAsP for any real world applications, it's important to read the material which explains WAsP modelling in more detail.

Overview of the WAsP user interface



The main window of WAsP has four work areas.

At the top of the main window lies the application menu and toolbars. These can be moved to new positions.

On the left hand side of the main window are two panes: the workspace hierarchy pane and the library pane. These cannot be moved or closed, but they can be re-sized. The workspace hierarchy pane and the library pane are only visible when a workspace is currently open in WAsP.

The remaining space in the main window is the window area. This space is used to display windows which can be opened, moved, resized and closed while working with the program.

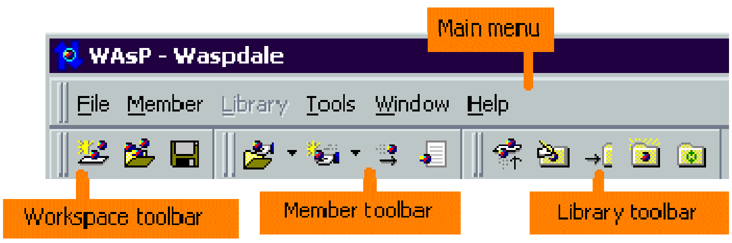
Use the right-hand mouse button!

Working with menus and the keyboard is not the quickest way to get things done in WAsP. Whatever you are doing, try clicking with the right-hand mouse button and see what happens. Often there is a handy context-sensitive pop-up menu which will contain the very command you need.

So if you want to view a map, don't go to the main menu and look for a nested sub-menu called 'Display' with a massive list of all the things that could ever be displayed. Instead, click on the map's icon with the mouse and then hit the right-hand mouse button.

Menu and toolbars

WAsP has a main menu and three toolbars.



The main menu

The main menu contains the following sub-menus.

File. Lets you open, save and close workspaces.

Member. A context-sensitive menu which lets you call the methods of the currently selected hierarchy member.

Library. A context-sensitive menu which lets you call perform operations on the library.

Tools. A list of launchable utility programs and some user options.

Window. A menu to help you manage the windows which are currently open.

Help. Information about WAsP.

The Member and Library sub-menus are sometimes disabled, depending on the what part of the program you are using.

The toolbars

Each toolbar contains buttons which correspond to the most frequently-used items accessible from the sub-menus of the main menu.

Click on one of the items below to read more about using the toolbars.

- The workspace toolbar
- The member toolbar
- The library toolbar

The toolbars can be moved around or closed. WAsP will remember the way that you organise the toolbars between runs.

WAsP workspaces

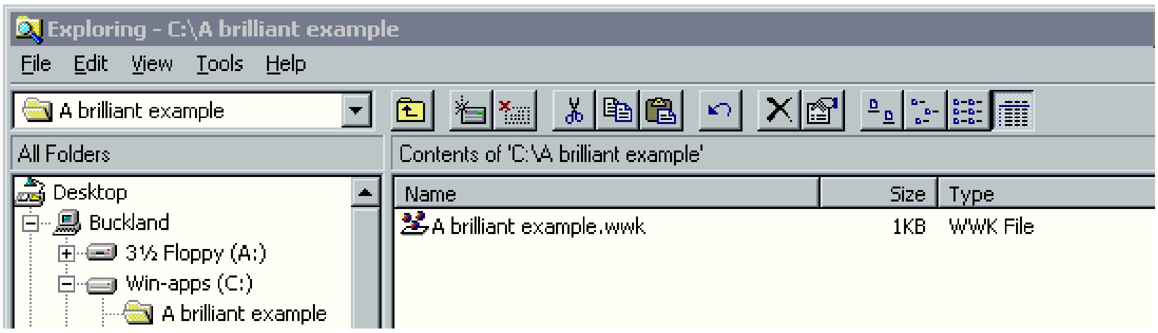
In WAsP, all work is performed within the context of a workspace. Workspaces can be created, saved and re-opened. When you start WAsP, you need to re-open or create a workspace before you can do any work.

Workspace files and workspace folders

Workspaces are saved as files, which have the extension 'wwk'. Workspaces files do not contain any actual data of their own, but are used simply to record the relationships between other data files.

When a new WAsP workspace is first saved to file, it is saved into a newly-created folder with the same name as the workspace itself. This makes it easier to organise any newly-created files which will be included in the workspace.

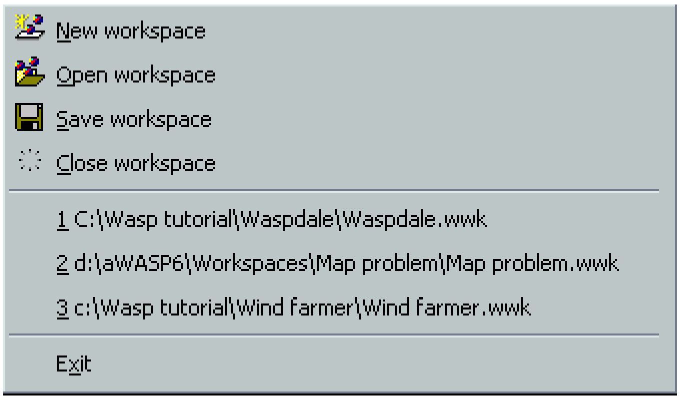
For example, if you create and save a new workspace called 'A brilliant example' at the root of drive 'C' on your computer, the resulting arrangement will look like this in Windows Explorer:



It's not possible to rename a workspace using a 'Save as..' operation. Once a workspace has been created, it can only be saved using the original name.

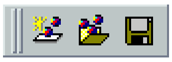
Working with workspaces

The **File** menu can be used to create, open, save and close workspaces.



The menu also includes a list of the most recently used workspaces.

There is a workspace toolbar which offers the main workspace functions.

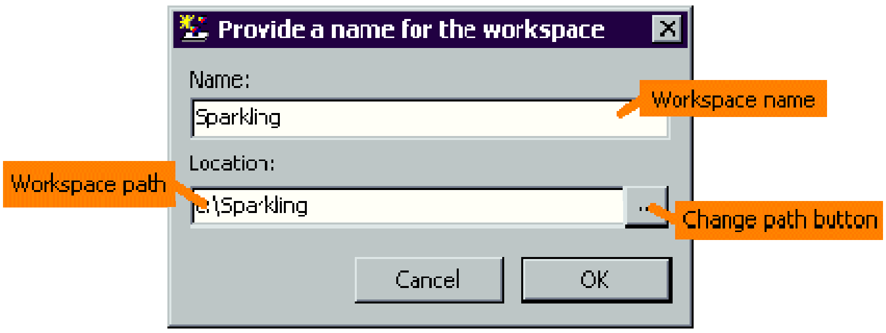


Saving an existing workspace

Use **Save workspace** from the **File** menu. The workspace and all its contents will be saved to file.

Saving a newly-created workspace

The first time that a newly-created workspace is saved, it needs to be given a name. Because a new folder is created on the computer's file system to hold the new workspace file, a special dialog box is used.



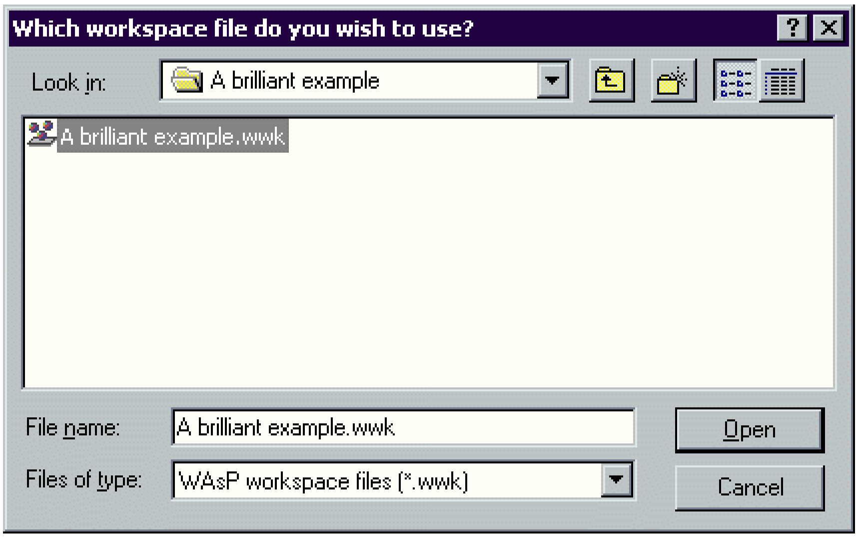
The name in the workspace name box automatically appears at the end of the location shown in the workspace path box because a new folder will be created to contain the new file.

First, check that the path is correct. You can change the path by clicking on the change path button and selecting a directory. In the example above, the root of drive 'C' has been selected as the location for the new workspace.

Next, provide a name for the workspace. The workspace location will be automatically synchronised with the name of the workspace. In the example above, a new folder called 'Sparkling' will be created in the root of drive 'C' and a new workspace file called 'Sparkling.wwk' will be inserted into the folder.

Opening an existing workspace

To open a workspace, simply use **Open workspace** from the **File** menu and select the workspace file (*.wwk) itself using the standard file dialog box. Remember that the workspace file will be found in a folder with the same name.

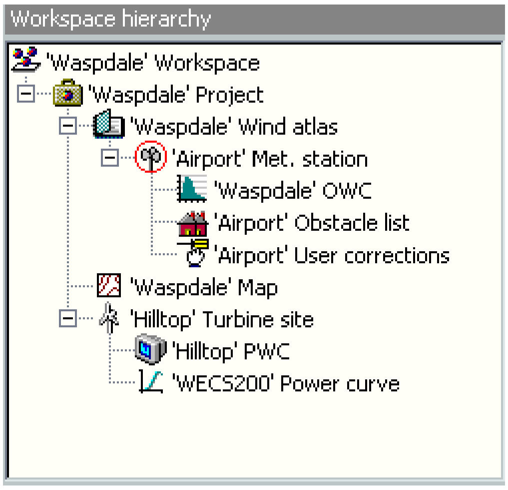


About the workspace hierarchy

When a workspace is open in WAsP, the contents of the workspace are organised into a hierarchy. The items in the hierarchy are called hierarchy members, or just members if the context is clear. The generic symbol for a hierarchy member is a small coloured ball .

The hierarchy is visually represented in a hierarchical tree rather similar to the one used in Windows Explorer. Each member is represented by an icon and some text. The tree is called the workspace hierarchy, or just hierarchy if the context is clear.

Here's an example.



At the top of the hierarchy is the workspace root. Members can be parents and children of one another. Two members which share the same parent are called siblings, or peers. The workspace root cannot have a parent, but all other members always have a parent.

The organisation of the members in the hierarchy forms associations between the members. The members and their associations together represent a description of the situation which is being modelled. Work in WAsP is done by adding, removing, moving and manipulating hierarchy members to change the modelled situation.

The hierarchy enforces rules governing the possible parent-child associations between different types of hierarchy member. Some types of member can never be children of some other types of member, and some types of member cannot have children at all.

What is a hierarchy member?

Members and their files

The WAsP models need data files for input and output. Each hierarchy member represents a WAsP data file on the computer's file system. Members can be thought of as 'pointers' to files, and the hierarchy's purpose it to represent modelling relationships between the files. The organisation of members in the hierarchy is not related to the arrangement of their corresponding files on the computer's file system.

Members can be:

- inserted into the hierarchy as new
- inserted into the hierarchy from file
- saved to file
- saved to a file with a different name
- removed from the hierarchy

When WAsP works with hierarchy members, nothing is written to the members' original file contents until the changes are explicitly saved. This is because WAsP works with copies of the data files or, for some hierarchy members, simply holds all the information in memory.

When a member is removed from the hierarchy, the corresponding file is not deleted from the file system. If you move or delete a file referenced by a workspace between WAsP sessions, then it will be missing when you next open the workspace.

Different members, different rôles

Some members preserve information about the arrangement of their children. When these members are re-opened, they automatically re-open all of their children into the workspace too. The workspace root itself is one such member, so when a workspace is re-opened, all of the members which were in the workspace the last time it was saved will be re-opened and their relationships restored. Projects, met. stations and turbine sites also preserve information about their children between runs.

Other members are largely responsible for holding data, and do not preserve information about the organisation of the hierarchy. These hierarchy members have windows which can be opened in the right hand side of the main window, allowing their data to be viewed and, in some cases, manipulated.

Introducing the hierarchy members

There are several types of hierarchy member which can appear in the workspace. The list below provides a brief introduction to them. They are explained in more detail elsewhere.

Workspace root

There is always one (and only one) root in each workspace. It sits at the top of the hierarchy and has no parent. The workspace root can have members of any type as its children. When a previously saved workspace is opened, all of the children of the workspace are also re-opened.

Project

Projects are used to manage related groups of hierarchy members. Projects offer several facilities which make it easy to perform operations which are relevant to all of the members of the project. Projects are always children of the workspace root. When a previously saved project is opened, all of the children of the project are also re-opened, so entire projects can be saved and used in other workspaces.

Map

WAsP uses maps to get information about the orography and roughness characteristics of the landscape in which the modelling is being done. Maps can appear in various places in the workspace hierarchy, but typically each project will have one map.

, Wind atlas

Wind atlases are the central items in the hierarchy. A WAsP wind atlas contains data describing a site-independent characterisation of the wind climate for an area. The WAsP models are devoted to analysing wind data collected from met. stations to produce wind atlases and applying the atlas to estimate the wind climate (and power production) for turbine sites.

A wind atlas is illustrated using a closed book icon if the atlas is simply a static data file. An open book icon is used if the wind atlas is associated with a met. station which might re-calculate the atlas.

Met. station

A meteorological station (met. station for short) is used to calculate a wind atlas. It represents a data collection site located somewhere in an associated map. A met. station does not have any data except its location in the map. It is associated with a wind climate which has been observed at the station. It may be associated with a list of obstacles surrounding the station and a description of the roughness lengths of the surrounding area.

When a met. station is re-opened, all of the children of the met.station are also re-opened. This makes it possible to save a met. station and its associated child members as a complete branch of the hierarchy and re-use it in other workspaces or projects.

Observed wind climate

A summary of the wind data recorded at a met. station is called an observed wind climate (or OWC for short).

Turbine site

A turbine site is used to estimate the power output which would result from locating a turbine somewhere in an associated map. Every turbine site always has a predicted wind climate. A turbine site does not have any data except its location in the map and the hub height of the turbine. A turbine site may be associated with a list of obstacles surrounding the station and a description of the roughness lengths of the surrounding area.

When a turbine site is re-opened, all of the children of the turbine site are also re-opened. This makes it possible to save a turbine site and its associated child members as a complete branch of the hierarchy and re-use it in other workspaces or projects.

Predicted wind climate

A predicted wind climate contains output calculated by a turbine site. It corresponds to an observed wind climate in that it is a site-specific description of the wind climate, but also contains extra information about energy and power yield.

Wind farm

Wind farms are collections of 'lightweight' turbine sites which are calculated in a batch. The output is less detailed than a turbine site, and they are less flexible, but they offer a convenient way to work with several sites together.

Resource grid

Power curve

A power curve describes the way that a turbine's power output changes with wind speed. It can be associated with one or many turbine sites or wind farms.

Obstacle list

Met. stations and (less commonly) turbine sites can have obstacles in their surroundings. An obstacle list is a description of some obstacles which can be associated with a site.

Roughness description

An alternative to providing roughness information in a map is to provide a site-specific description. Turbine sites and met. stations can both be associated with roughness descriptions.

User corrections

A set of user corrections can be associated with a met. station or turbine site. It provides a way of informing WAsP about some site-specific adjustments which cannot be described using the other hierarchy members.

Modelling with the hierarchy members

WAsP modelling involves:

- analysing observed wind data to calculate wind atlases and
- applying wind atlases to particular turbine sites to calculate an estimate of the wind climate and power.

In the workspace hierarchy, these calculation jobs are performed by met. stations, turbine sites and wind farms.

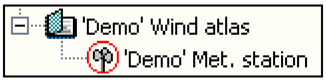
Met. stations are used to calculate wind atlases

A wind atlas is calculated by adjusting a summary of recorded wind data to remove the influencing effects of the collection site itself. To calculate a wind atlas, a met. station uses the following hierarchy members:

- an observed wind climate
- the map in which the met. station is located
- (optionally) a list of the obstacles surrounding the data collection site
- (optionally) a description of the surface roughness for the area surrounding the site
- (optionally) a set of user corrections to apply to the summary data

In summary, uses + + + + to produce

Met. stations are always children of the atlases which they are calculating, and so the output is 'moved up' the hierarchy into the parent atlas, thus:



Turbine sites are used to calculate predicted wind climates

A predicted wind climate is calculated by adjusting the data from a wind atlas for the influencing effects of the turbine site itself. To calculate a predicted wind climate, a turbine site uses the following hierarchy members:

- a wind atlas
- the map in which the turbine site is located
- (optionally) a power curve describing the turbine's generating characteristics
- (optionally) a list of the obstacles surrounding the turbine site
- (optionally) a description of the surface roughness for the area surrounding the site
- (optionally and rarely) a set of user corrections to apply to the wind atlas

If no power curve is used, then the output will be simply a predicted wind climate which describes wind directions, speed and energy.

In summary, uses + + + + to produce

Turbine sites are always parents of the predicted wind climates which they are calculating, and so the output is 'moved down' the hierarchy into the child predicted wind climate, thus:

Wind farms are used to calculate power production for several sites

Wind farms calculate summary wind climate data for each of several turbine sites by adjusting the data from a wind atlas for the influencing effects of the turbine sites itself. To calculate the summary data, a wind farm uses the following hierarchy members:

- a wind atlas
- the map in which the wind farm sites are located
- a power curve describing the generating characteristics of all of the turbines

In summary, uses + + to produce summary data displayed by

Resource grids are used to calculate power production for a grid of sites

Resource grids calculate summary wind climate data for each of several sites by adjusting the data from a wind atlas for the influencing effects of the sites itself. To calculate the summary data, a resource grid uses the following hierarchy members:

- a wind atlas
- the map in which the resource grid is located
- a power curve describing the generating characteristics for the resource grid

In summary, uses + + to produce summary data displayed by

Wind farms and resource grids appear less often in the help

It's obvious that (in terms of the hierarchy interactions) the wind farm and resource grid calculations are a simpler subset of the turbine site calculations. To simplify the documentation, they are often ignored when explaining general modelling issues. The explanations focus on the met. stations and the turbine sites. It's generally safe to assume that wind farms and resource grids can be treated as turbine sites which have no children in the hierarchy.

Patterns of association

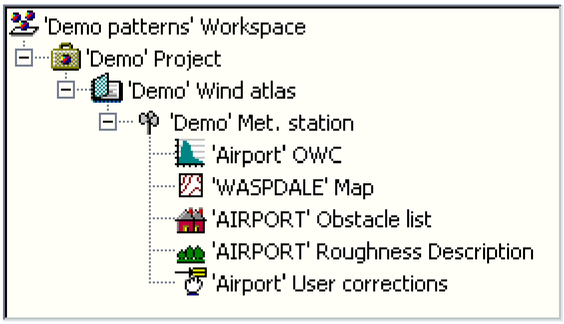
The organisation of the members in the hierarchy forms associations between the members.

The associations are only important to members that perform calculations: met. stations, turbine sites and wind farms. In order to perform their calculations, these members need to work out which other members to use. The calculating members seek to assemble a correct set of other members.

Simple associations

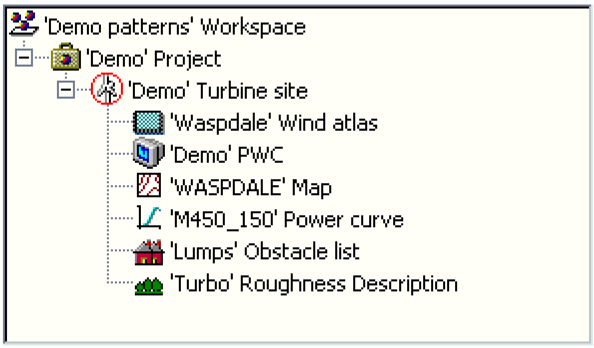
The simplest kind of association is the parent-child association. A calculating member can simply have all of the necessary members as its children.

For a met. station's calculation, the associated members could be organised thus:

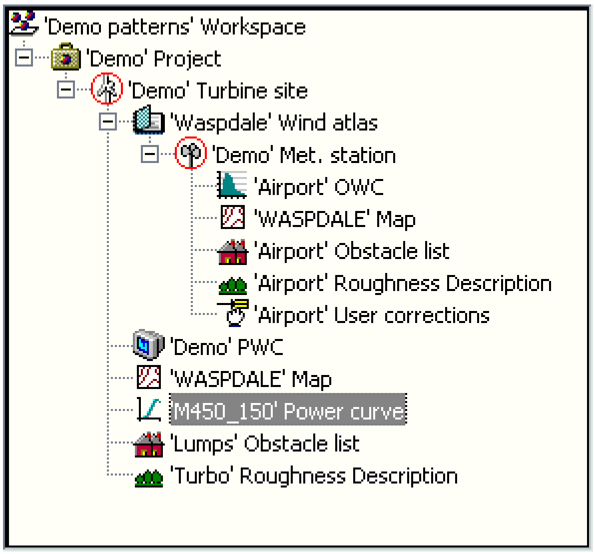


Notice that the met. station is a child of the wind atlas which it is calculating. This is always the case, since output from met. stations 'moves up' the hierarchy.

For a turbine site's calculations, the associated members could be organised thus:



Notice that the turbine site is a parent of the predicted wind climate which it is calculating. This is always the case, since output from turbine sites 'moves down' the hierarchy. Notice also that the wind atlas being used is just a static data file (the closed book icon is displayed). If the wind atlas was dynamically calculated from a turbine site, the workspace could look like this:

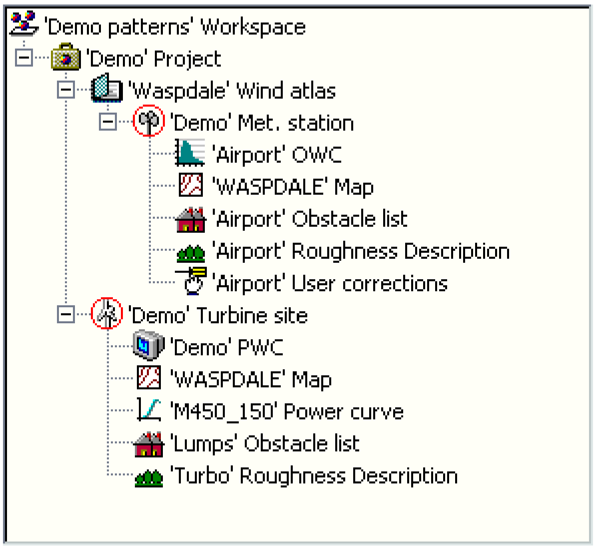


The arrangement illustrated above would work perfectly well, but it is rather inelegant. The same map appears twice in the project. If a new turbine site was added to the project, then the wind atlas would need to be added to that turbine site too. It's possible to take advantage of more complex associations to simplify the hierarchy and to make it easier to add new sites to the project.

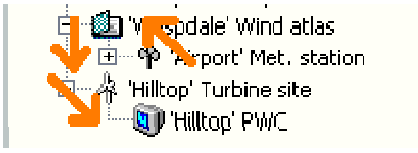
More complex associations

Members are associated if they have a parent-child association, but members can also explore further up the hierarchy in search of associations. Any ancestor (parent's parent, *etc.*) can be treated as associated, as can peers of any ancestor. This system allows a modelling situation with many relationships to be expressed concisely.

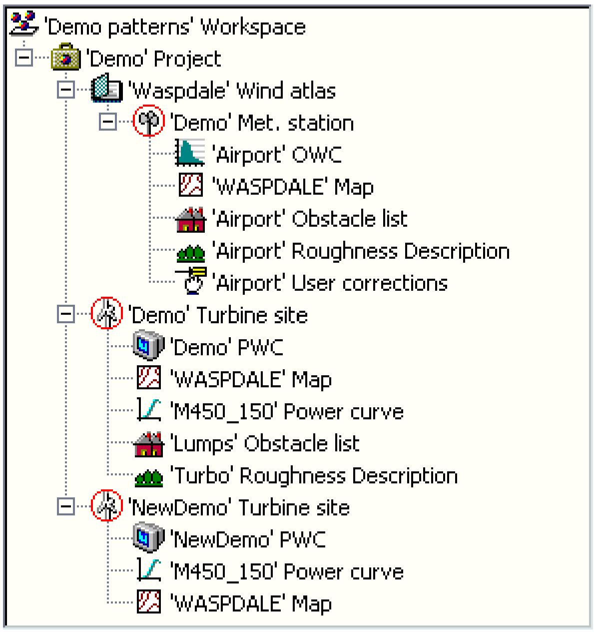
Working with the example given above, the hierarchy could be re-organised so that the wind atlas and the turbine site are peers, like this:



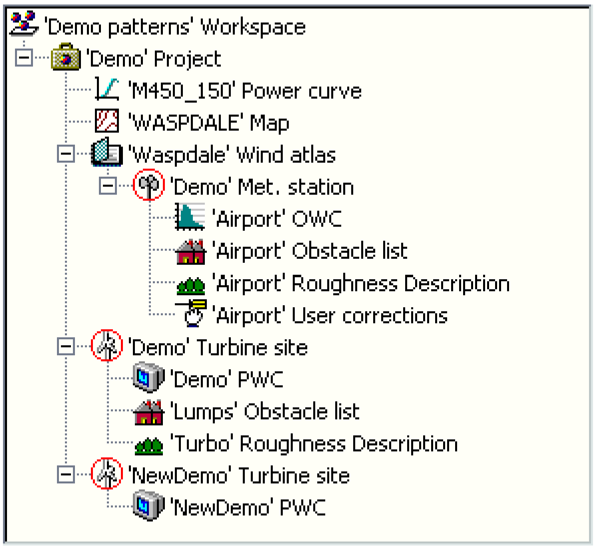
Modelling output is moving up the hierarchy because the met. station is writing results to the atlas, along the hierarchy because the atlas and the turbine site are peers, and down the hierarchy because the turbine site is writing results to the predicted wind climate, thus:



This pattern allows more turbine sites to be added to the project without needing to replicate the atlas, as follows:

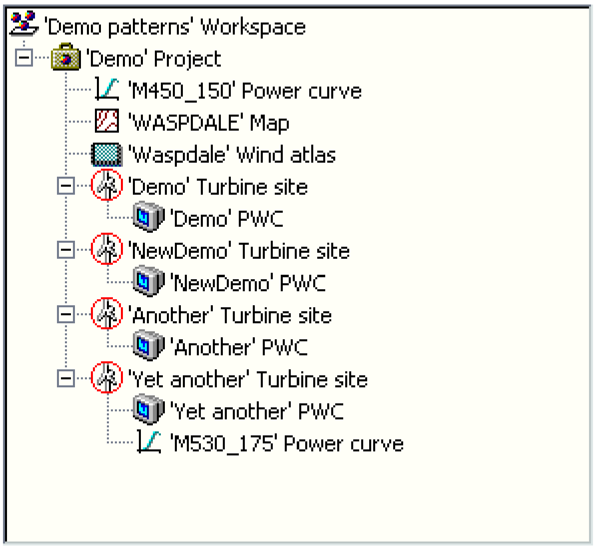


In the hierarchy illustrated above, the same map appears in three places. By making the map a peer of the turbine sites and wind atlas, it can be shared by the turbine sites and the met. station. The same power curve also appears twice. It, too, can be made a peer of the two turbine sites and can then be used by both of them, thus:



It is not possible for sites to share site-specific information, such as obstacle lists and observed wind climates which by definition are unique to the site itself.

If a member is associated with more than one member of the same type, then the nearest relative is the one used. This allows a group of peers to use the same member, but one or more of them can use a different member. For example, several turbine sites could be using the same power curve but one of them could use a different type, as shown in the hierarchy illustrated below:



The first three turbine sites will all use the 'M450_150' power curve, but the 'Yet another' turbine site will use the 'M350_175' power curve.

Legitimate parent-child associations

The table below specifies the how parent-child associations can be formed between different types of hierarchy members. There's no need to remember or refer to this table when using the software, because the hierarchy members themselves automatically enforce these rules.

Object type	**Valid parents**	**Valid children (and number)**
Workspace root	None	Any (0..n)
Project	Workspace	Atlas (0..n) Wind farm (0..n) Resource grid (0..n) Turbine site (0..n)

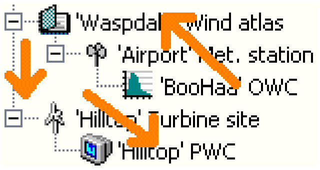
		Map (0..1) Atlas (0..1) Power curve (0..1)
Wind farm	Workspace Project	Map (0..1) Atlas (0..1) Power curve (0..1)
Resource grid	Workspace Project	Turbine site (0..n) Map (0..1) Atlas (0..1) Power curve (0..1)
Turbine site	Workspace Project Wind farm	Predicted wind climate (1) Roughness description (0..1) Obstacle list (0..1) User corrections (0..1) Map (0..1) Atlas (0..1) Power curve (0..1)
Map	Workspace Project Wind farm Resource grid Turbine site Met. station	None
Atlas	Workspace Project Wind farm Resource grid Turbine site	Met station (0..1)
Met. station	Workspace Atlas	Observed wind climate (0..1) Roughness description (0..1) Obstacle list (0..1) User corrections (0..1) Map (0..1)
Observed wind climate	Workspace Met station	None
Predicted wind climate	Workspace Turbine site	None
User corrections	Workspace Turbine site Met station	None
Roughness description	Workspace Turbine site Met station	None
Obstacle list	Workspace Turbine site Met station	None
Power curve	Workspace Project Wind farm	None

Resource grid
Turbine site

Associated members have the same number of sectors

The WAsP models represent the world in sectors. The number of sectors used for modelling is not fixed but data structured with 8 sectors is of course incompatible data structured with 12 sectors. So, all associated hierarchy members which are being used together for modelling must have the same number of sectors.

The number of sectors used is determined by the structure of the observed wind climate, since this feeds directly into the wind atlas and then on through the turbine sites to determine the structure of the predicted wind climates.



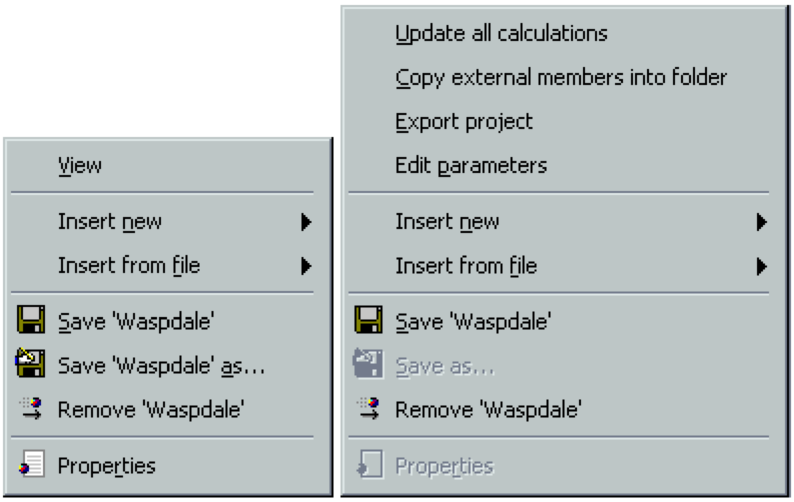
The number of sectors in an observed wind climate is determined when it is first generated from raw data using the OWC Wizard.

Hierarchy members' methods

The member's menus

Each hierarchy member has menu of commands, or methods. This menu is headed **'Member'** and appears as a sub-menu of the main menu.. It also appears as a pop-up menu if a member is clicked with the right mouse button, or when the **F**2 key is pressed while one of the hierarchy members is selected.

This menu is the most important tool for working with WAsP. Depending on which hierarchy member is selected, the contents of the menu presented will be different. Some members do not offer all of these methods, and some offer extra methods in addition to those shown. The illustration below shows a basic member's menu (for a wind atlas) and a more complex one (for a project).



The members' toolbar

There is also a hierarchy member toolbar which offers buttons for some of the most common hierarchy member methods.

The buttons (from left to right) correspond to the menu items **Insert from file**, **Insert new**, **Remove** and **Properties**.

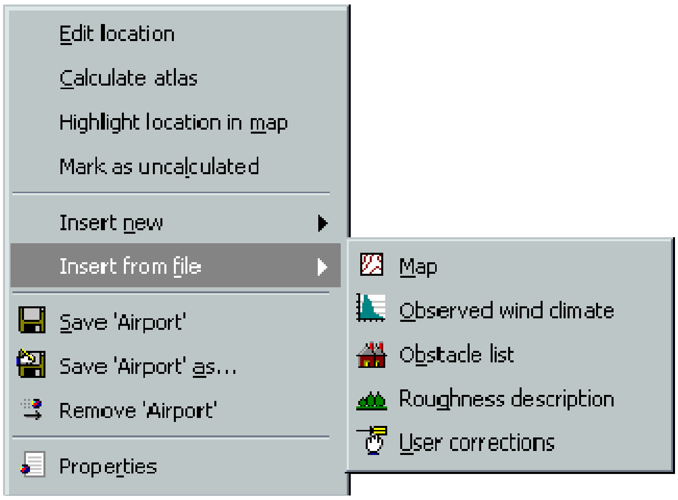
Viewing a member's interface window

Any member which has its own user interface window will have a method called '**V**iew' at the top of its menu. Clicking this will bring up the window in the window area on the right-hand side of the main window. It's possible to have several windows open at once and to leave them open while doing other work.

Inserting members

To insert a member to the workspace hierarchy

- Select the hierarchy member which will be the parent of the member to be inserted
- From the parent member's menu, select either **Insert from file** or **Insert new**. A secondary menu will appear, listing the types of hierarchy member which are legitimate children of the parent member. The 'from file' insertion menu looks like this (for a met. station).



- Select the type of member to insert. If the **Insert from file** menu was used, then a file selection dialog box will appear. Select the file you wish to use to create the hierarchy member. If the **Insert new** menu was used, then the new member will be created immediately.
- The new member will be added to the hierarchy as a child of the parent member.

The member-specific insertion menus

Depending on the type of parent member, the insertion sub-menus will contain different types of insertable member. Some members cannot be inserted as new members, and can only be inserted from file, so sometimes the **Insert from file** or **Insert new** sub-menus contain different lists.

User corrections and maps cannot be created or edited from within the WAsP application, so these types of member never appear on the **Insert new** sub-menu.

Although WAsP cannot create and edit observed wind climates directly, observed wind climates do appear on the insert new menu for met. stations. When an observed wind climate hierarchy member is inserted as new, the OWC Wizard is automatically launched to guide you through the process of creating a new observed wind climate file.

Inserting from the member methods toolbar

Clicking on one of the two insertion buttons on the member methods toolbar also causes the a list of insertable member types to be displayed as a drop-down list.

Inserting from the library

An alternative way to insert members from file is to open them from the library.

Moving members

Moving members from one place in the hierarchy to another is a simple matter of dragging with the mouse.

As the dragged hierarchy member is moved over potential 'target' parent members, the mouse pointer changes. If it would be impossible for the dragged member to be a child of the target, a 'no drop' icon is displayed, otherwise, the mouse pointer is the same as the hierarchy member being dragged.

This is what the 'no-drop' icon looks like.

If a member is dropped onto a parent which cannot accept it, a message is displayed and the move operation is not completed.

It is not possible to copy members by dragging them around the workspace: members can only be inserted, moved and removed.

Removing members

To remove a member from the hierarchy, simply select it and from its hierarchy member menu, choose **Remove**.

If the member has unsaved changes, you will be asked whether you wish to save the changes before removing the member.

Removing a member from the workspace hierarchy does not cause the corresponding file to be deleted from the file system.

Saving members

All hierarchy members can be saved. If the member has children, then all the children (and the children's children) as also saved at the same time. So, when the workspace root is saved, every member in the whole workspace is saved.

Simple save

To save a member's data, simply select it and from its hierarchy member menu, choose **Save**. If the member has not been saved before, you will be asked to provide a name for the file.

Save as...

If the file has been saved before and you wish to save it with a new name, you can use the **Save as** method. You will be asked to provide a new name for the file. This method is not available for workspaces and projects.

The old file will not be deleted from the file system, but remember that if you make changes to or delete other members which are referenced by the old file, then WAsP may be unable to re-open the old file again successfully.

What happens when a member is saved?

For members whose files contain mostly data (like an obstacle list), the original source file is replaced with the working copy that WAsP has been using since the member was last saved.

For members whose files mostly contain information about the organisation of other members in the hierarchy (such as project files), the original file is overwritten with data describing the current arrangement of members in the hierarchy. When those members are re-opened in the hierarchy, their children will also be re-opened, so inserting a met. station member from file might also insert an obstacle list and an observed wind climate.

Members' properties

Many hierarchy members have a **Properties** method.

If this method is invoked, a dialog is displayed which shows some of the properties of the member, particularly relating to how it relates to the underlying file system. Here is an example for a wind atlas hierarchy member.

There's no information here which you actually need in order to do WAsP modelling, but it can sometimes be useful if the relationship between the hierarchy member and the files on the system is confused.

If the name of the saving file name or the working temporary file name is longer than can be displayed in the label provided, then the whole name will appear as a pop-up 'tip' if the mouse pointer is allowed to linger over the label for a moment.

Refreshing the workspace hierarchy display

If a problem is encountered, then it's possible to force WAsP to refresh the workspace hierarchy display. To do this, select the workspace hierarchy and press the **F5** key on the keyboard. Alternatively, select the **Refresh view** method of the workspace root heirarchy member.

Function keys

A few keyboard function keys and key combinations are recognized by WAsP:

Del pressing this key deletes the highlighted item.

F1 invokes context-sensitive help for the active window.

F2 invokes and displays the members' methods menu.

F5 refreshes the workspace hierarchy and library displays.

F11 is equivalent to **Ctrl-C** and copies the contents of the active window to the Windows clipboard.

Ctrl-C copies the contents of the active window to the Windows clipboard.

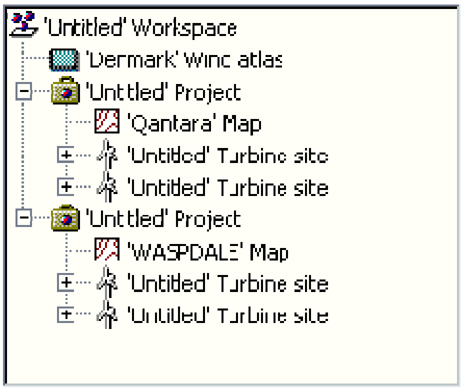
About the workspace root

 The workspace root has no modelling role in WAsP. It simply represents the workspace itself in the workspace hierarchy display. The workspace has no data and simply maintains a list of its children.

Children of the workspace root

Usually, the workspace root is a parent of one or more projects (within which modelling work can be done), but the root can also be a parent of any other type of hierarchy member. What is more, it can have any number of any type of children. The rules about member's associations are completely relaxed for the workspace root. This makes it possible to use the workspace root as a 'scratch' area in which to hold hierarchy members when they are not being used in modelling work.

Very occasionally, it might be useful to involve the workspace root's children in modelling. If there is a member which for some reason needs to be shared between several projects, then placing it as a child of the workspace root means that it will be available for any calculations performed in any project. For example, a workspace could contain several projects, each with a different map and several turbine sites. It could be convenient to have all of the projects use the same wind atlas, in which case the wind atlas could be made a peer of all the projects, as shown below.



This might indeed be the best arrangement, but projects have some extra facilities not offered by workspaces and in consequence it's often best simply to include all of the members involved in a piece of modelling work within projects.

About projects

Projects provide a structure to work with related hierarchy members. Projects are used to contain any modelling work which describes the same place or the same basic situation. As a general guide, a project should be used to group together things which would all be described in the same report.

Unlike workspaces, which can have jumbled collections of unrelated child hierarchy members, hierarchy members organised into projects must be arranged according to the rules governing parent-child associations. All of the children of a project share the same model parameter values. Projects also offer useful methods for performing operations on all of the project's children and managing their files.

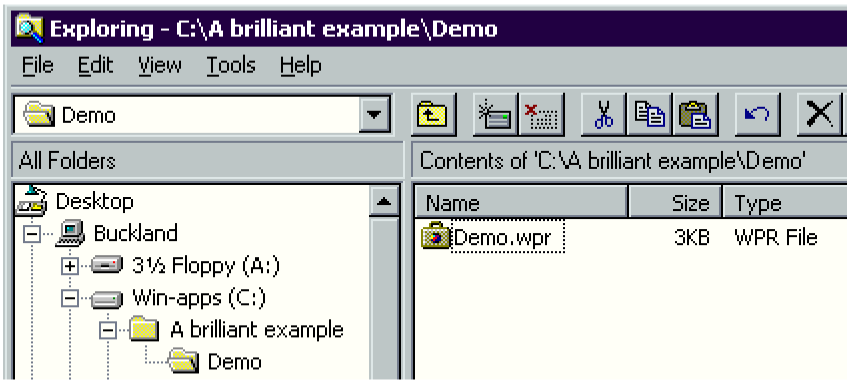
Like workspaces, project files do not contain any actual data of their own, but are used simply to record the relationships between other data files.

Project files and project folders

Projects are saved as files, which have the extension 'wpr'. Projects files are used to record the relationships between other data files and to preserve the values of modelling parameters. They contain no other data and simply 'point to' other files on the file system.

When a new WAsP project is first saved to file, it is saved into a newly-created folder with the same name as the project itself. This makes it easier to organise any newly-created files which will be included in the project. The idea is the same as for workspaces, so that if you create a new workspace, insert a new project and save them both, two new folders will be created on the computer's file system. The project's folder will be a sub-folder of the workspace.

For example, if you create and save a new workspace called 'A brilliant example' at the root of drive 'C' on your computer, add a new project to the workspace and save it as 'Demo', the resulting arrangement will look like this in Windows Explorer:



Although the project's folder is located as a sub-folder of the workspace's folder, the project is entirely independent of the workspace. The project can be opened into other workspaces, or moved around on the file system. You can even merge the contents of the project and workspace folders.

The workspace does, of course, have a pointer to the project, so moving or deleting the project from the file system will make it impossible for it to be automatically re-opened in the workspace. This dependency is one-way: the project has no pointer to its parent workspace.

It's not possible to rename a project using a 'Save as..' operation, but WAsP does provide a project export method to help you copy and share projects.

Updating all calculations in a project

It's possible for a project to contain a large number of turbine sites and (in rare cases) quite a few met. stations. If a simple change is made to some aspect of the project (such as editing a parameter value or adjusting a shared map), then all of the output from all of the sites should be re-calculated.

To make this easier, each project's method list contains a method called **Update all calculations**. This method can be invoked whenever there is at least one member of the project which can be calculated. The project simply works through all of those members and prompts them to be recalculated automatically.

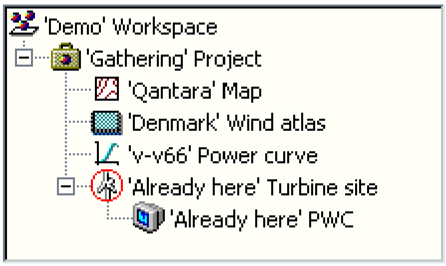
Because modelling output flows from met. stations, through wind atlases and on to turbine sites, the project first makes all of the met. stations recalculate their wind atlases, and then works through again, dealing with the turbine sites.

Gathering project members' files

A project file, like a workspace file, contains only pointers to other files, not a copy of the data in those files. It's possible, therefore, that the members gathered into a project have files scattered all over the file system. That's fine, and is often a convenient way to work, but sometimes it is useful to be able to gather all of those scattered files into one place. It can get a bit confusing...

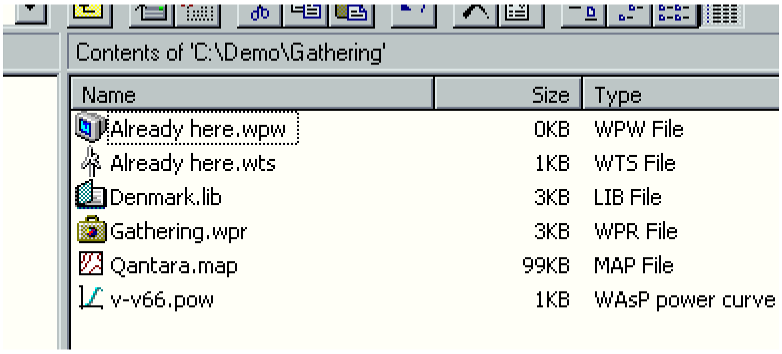
Projects' method lists include a method called **Copy external members into folder**, which does exactly what it says. Each project has its own folder in which the project file is saved. This method works through all of the members of a project and places a copy of each member's file into the project's own folder. The original files are not moved, but copies are made. The pointers in the project's file are changed to point to the files which are now to be found in the same folder.

For example, the illustration below shows a project which has just been assembled. The map, atlas and power curve have all been opened from file from existing folders elsewhere on the file system. Only the turbine site and its ever-faithful friend the predicted wind climate are newly-created members.



The project's folder on the file system looks like this (in Windows Explorer):

After invoking the **Copy external members into folder** method on the 'Gathering' project, the file system view looks like this:



Exporting complete projects

Project files preserve a list of pointers to the files of the members contained in the project. The files can actually be scattered around all over the computer file system. This makes it difficult to take a copy of everything in a project for back up, or to share files between computers or people.

Projects' method lists include a method called **Export project** to make it easier. Using this method is a bit like using a **Save as**.. method on a normal file. You need to provide a name for a new project, just as if you were saving a project for the first time. However, instead of simply creating a new folder and making a copy of the project file, the method also makes copies of all of the files referenced by the project and placed these copies into the new folder too. The pointers in the new project's file are changed to point to the copied files which are now in the new project folder.

These pointers are now simple relative file names, not absolute path file names. That's to say that they no longer contain information about the path on the computer's file system, but just contain the names of the files. That means that the project can be read on any computer, regardless of its file system configuration.

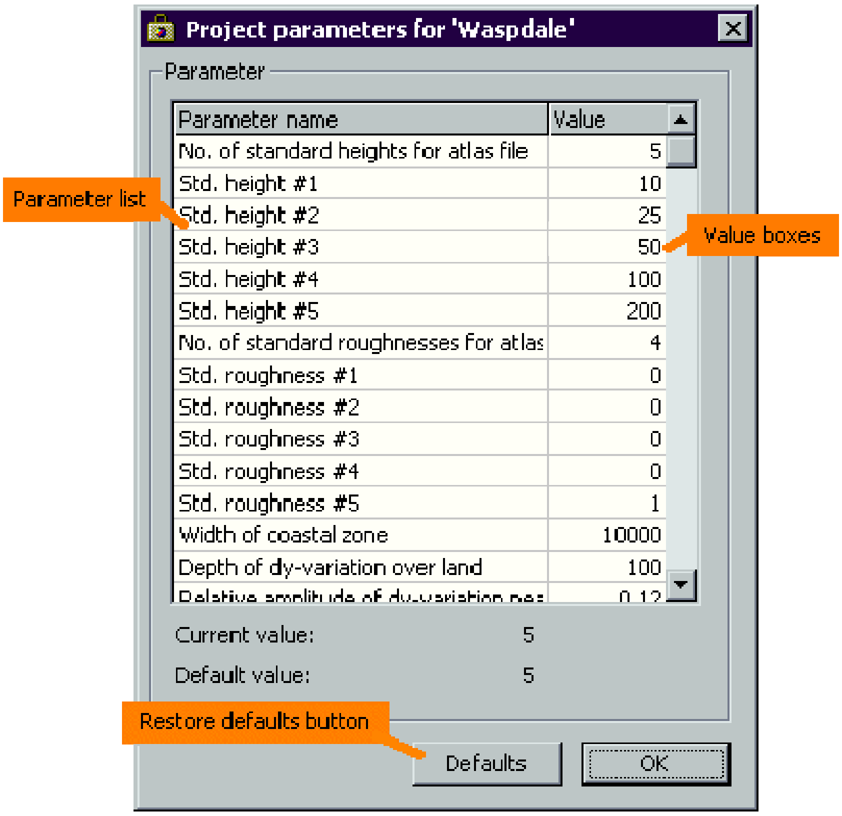
About project parameters

The behaviour of the WAsP models can be adjusted by making alterations to model parameters. The parameters are used whenever a calculation is performed, such as when a met. station calculates a wind atlas.

A unique parameter set is associated with each WAsP project. All members which are children of the project will make use of the same parameters. It's possible to have a workspace which contains two projects (say, for example, one from Iran and another from Europe) and for the calculations performed within each project to use completely different parameter values.

Editing project parameters

To edit a project's parameters, select the **Edit parameters** method from the project's methods. The parameter editor dialog box will appear.



To change a parameter value, select the parameter from the list and either double-click on it, or press the **Enter** key. A small box will appear, allowing you to enter a new value.

Do not edit a parameter without first checking that you understand what it means, and reading the documentation describing the values which can be legitimately used. If an invalid value is submitted, it will be rejected but the message which appears might not be very helpful. WAsP will try to restore the previous or default value.

To restore all of the parameters to their default values, click on the restore defaults button.

About maps

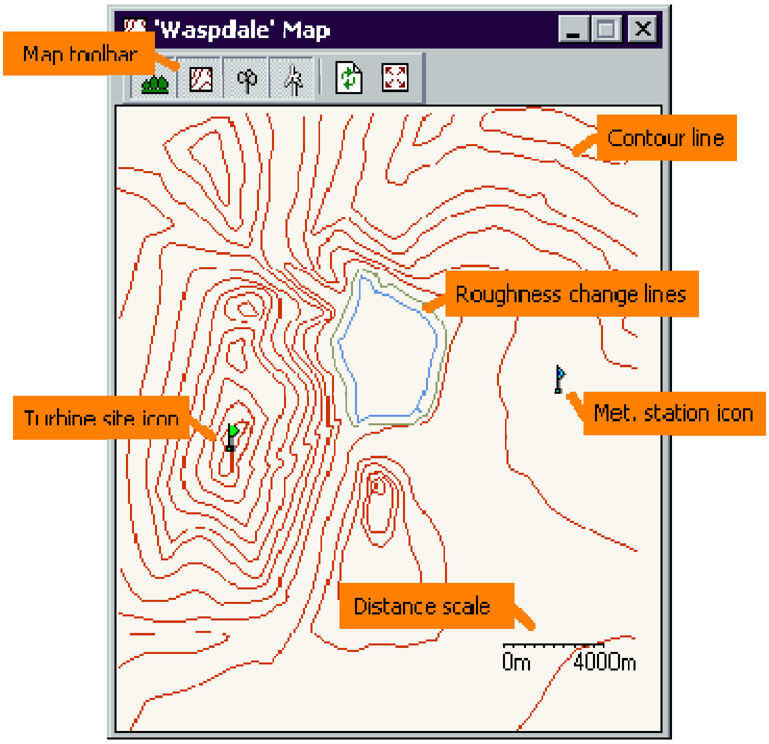
Maps are used to describe the orography and surface roughness of the area surrounding sites (turbine sites and met. stations).

WAsP uses vector maps, in which terrain surface elevation is represented by height contours and roughness lengths by roughness change lines. The format of the corresponding map file is described in the Technical Reference section.

It is not possible to create and edit maps from within the WAsP program.

The map window

The map window shows elevation contour lines, roughness change lines and the locations of any turbine sites or met stations which are associated with the map in the workspace hierarchy



You can explore the map and change the map display using the mouse and the toolbar.

Navigating around the map

The map image can be dragged around inside the display window using the mouse. Click and hold down the left mouse button. The mouse pointer icon changes to a paper-sliding hand. By moving the mouse around, the map is moved just as a piece of paper on a desk would be moved.

It's possible to zoom the map display. To zoom in, double-click on the map with the left mouse button. The mouse pointer position will be at the centre of of the new display. After a zoom, only part of the total map may be visible in the display window. The whole map has actually been drawn, though, so it can still be navigated by dragging around as described above. It is not a good idea to zoom in too many times, because a zoomed map requires a great deal of memory. Depending on your computer's configuration, you will notice the map re-draw takes much longer after 4 or 5 zooms.

To zoom out, double-click on the map with the right mouse button. If you zoom out so that the map is smaller than the display window, you may wish to make the window smaller. Click on the toolbar button marked to shrink the window to the map.

To restore the map to the original view, click on the toolbar button marked .

Changing the map display

Hide or show the roughness change lines and elevation lines by clicking on the toolbar buttons marked and . Hide or show the locations of met. stations and turbine sites by clicking on the toolbar buttons marked and .

The colours used for drawing the map can be adjusted from the main options window.

Getting precise spatial information from the map

The map displays a ground scale to give a general idea of the map's meaning. If the scale appears in an inconvenient place, it can be dragged around in the map by using the left mouse button.

To see the current co-ordinates of the mouse pointer in terms of the map co-ordinate system, simply press or hold down the right mouse button.

Working with sites in maps

If a turbine site or met. station is associated with a map hierarchy member, and has valid co-ordinates, then it can be displayed in the map.

The turbine sites and met stations  displayed in a map are more than just illustrations. It is possible to interact with the sites by working within the map itself.

To select and identify a site, click on the marker in the map with the *left* mouse button. The name of the site and the exact ground co-ordinates are shown in a pop-up label.

A site can be moved by dragging it in the map using the left mouse button. As you drag, the drop co-ordinates are displayed in a pop-up label. After dropping the site to its new location, you can make very fine adjustments to the exact position by editing the data in the site's control dialog window.

To display a site's control dialog window, select the site in the map and then click on it with the right mouse button. This dialog is the same as that which appears when the **Edit location** method of the site is invoked from the workspace hierarchy.

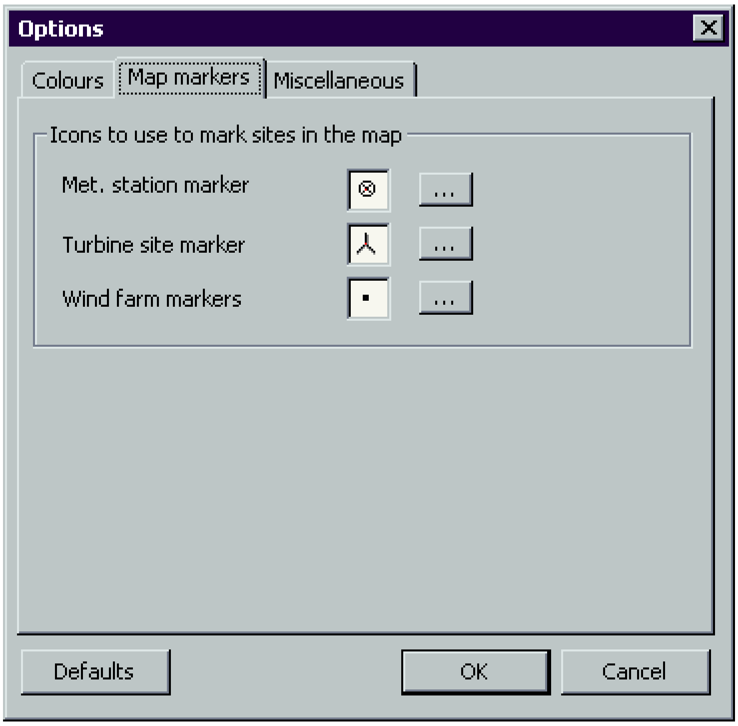
Exporting map displays

The map cannot be printed directly, but the map graphic can be copied to the Windows system clipboard. It can then be pasted into other Windows applications and printed.

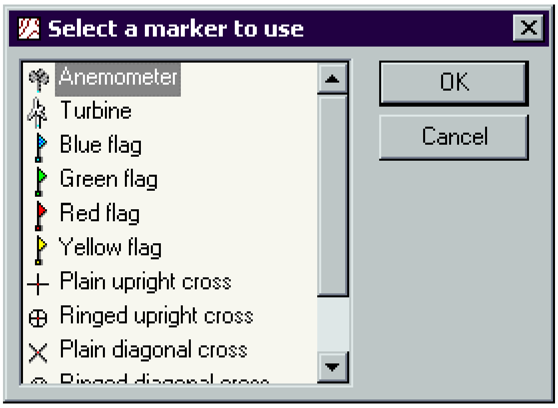
To copy the map graphic, use either **Ctrl-C** or press the **F11** key on the keyboard while the map is selected. The whole map is placed in the clipboard, even if the display window only shows a small part of the map itself. The map graphic is exported at whatever zoom level is currently being used, so the image might take up a lot of memory!

Changing map markers

Here you can choose which marker WAsP should use when indicating the location of met. stations, turbine sites and wind farm sites in the map.



To choose a marker, press the button marked with three dots next to the one you wish to change. Another dialog will appear, displaying a list of markers.



Select a marker from the list.

Preparing map files for use in WAsP

It is not possible to create or edit map files from within this version of WAsP. To alleviate this restriction, we have provided three possible 'workarounds':

1. WAsP will accept map files in BNA format, which is output from Golden Software's DIDGER program, a cheap and simple digitising package.
2. WAsP is supplied with a utility program called MapEdit, which is a lightweight map editor program. The MapEdit tool will accept vector maps in several formats and provides extensive tools for adjusting, checking, digitising and maintaining map files.
3. WAsP 6.0 also includes an earlier version of WAsP for DOS, which *does* include facilities for digitising and editing map files. The map file format has not changed between the versions, so it is possible to use the old program as a map creator and editor tool.

We will provide a more satisfactory solution to this issue in a later release. What we provide will be largely determined by user feedback, so please do send an e-mail explaining your preferences.

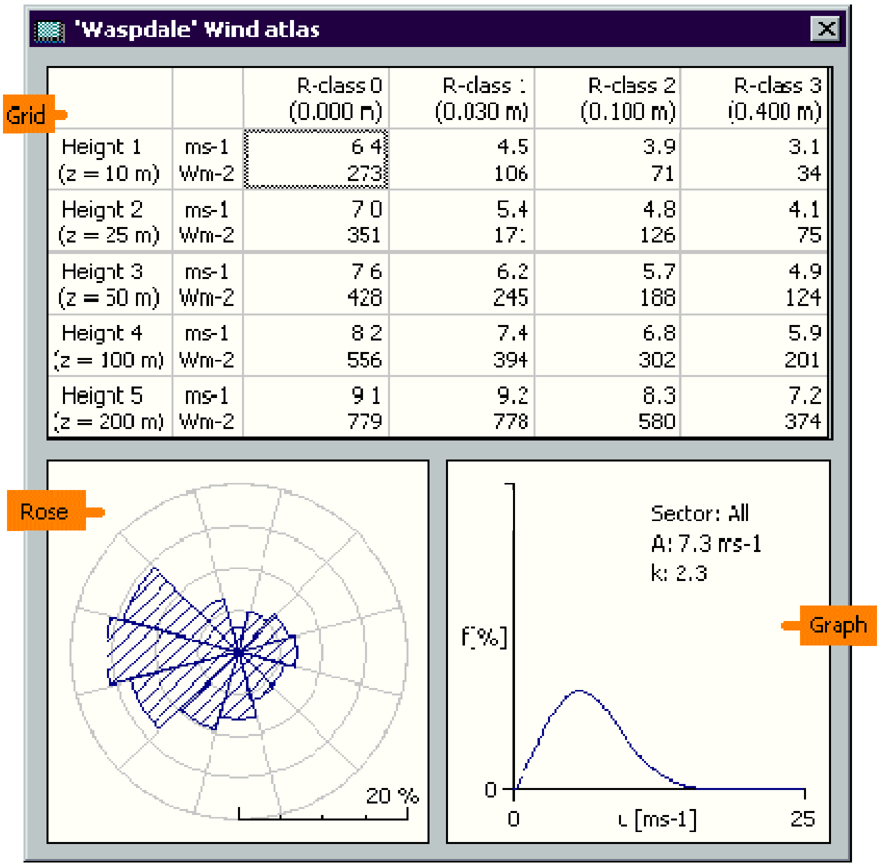
Wind atlases

Wind atlases contain the site-independent or regional wind climate, derived from the wind measurements at a meteorological station through the wind atlas analysis. The observed wind climate has been reduced to standard conditions, i.e. wind roses and wind speed distributions for five standard heights and four roughness classes in a number of sectors (usually 12).

To calculate a wind atlas, use a met. station hierarchy member. The format of the corresponding wind atlas file is described in the Technical Reference section.

The wind atlas window

The wind atlas window provides a graphical representation of the data in the wind atlas. There are more data contained in an atlas than can be displayed at one time in the window, but it is possible to see all of the data by interacting with the atlas display.



		R-class 0 (0.000 m)	R-class : (0.030 m)	R-class 2 (0.100 m)	R-class 3 (0.400 m)
Height 1 (z = 10 m)	ms-1 Wm-2	6 4 273	4.5 106	3.9 71	3.1 34
Height 2 (z = 25 m)	ms-1 Wm-2	7 0 351	5.4 17:	4.8 126	4.1 75
Height 3 (z = 50 m)	ms-1 Wm-2	7 6 428	6.2 245	5.7 188	4.9 124
Height 4 (z = 100 m)	ms-1 Wm-2	8 2 556	7.4 394	6.8 302	5.9 201
Height 5 (z = 200 m)	ms-1 Wm-2	9 1 779	9.2 778	8.3 580	7.2 374

The window has three data display areas: the grid, the rose and the graph.

The grid shows the mean wind speed and mean energy density of the wind for the different roughness lengths and standard heights. The rose displays the frequencies of wind by sector. The graph shows the frequency distribution of wind speeds, and the Weibull-A and Weibull-k parameters for the sector.

For each combination of a roughness length and a standard height, there is a wind rose. For each sector in each rose, there is a distribution graph.

To display the rose for a particular combination of roughness length and standard height, click on the corresponding cell in the grid. It is also possible to navigate around in the grid using the direction keys on the keyboard.

To read numbers from the rose, allow the mouse pointer to linger for a moment over one of the sectors. A label will appear, giving the directional frequency for that sector.

When first displayed, the graph shows the curve for all sectors (non-directional). To display the graph for one sector only, click with the mouse on one of the sectors in the rose. The rose sector will be highlighted and the graph will be adjusted to display the data for that sector. Hitting the spacebar on the keyboard will move the selection around the rose. To return to the non-directional display, click on the rose anywhere outside the area marked with rings.

To read off a particular value from the graph, move the mouse pointer over the graph area. A 'read-off' line will appear, labelled with the precise frequency for the wind speed.

Exporting output

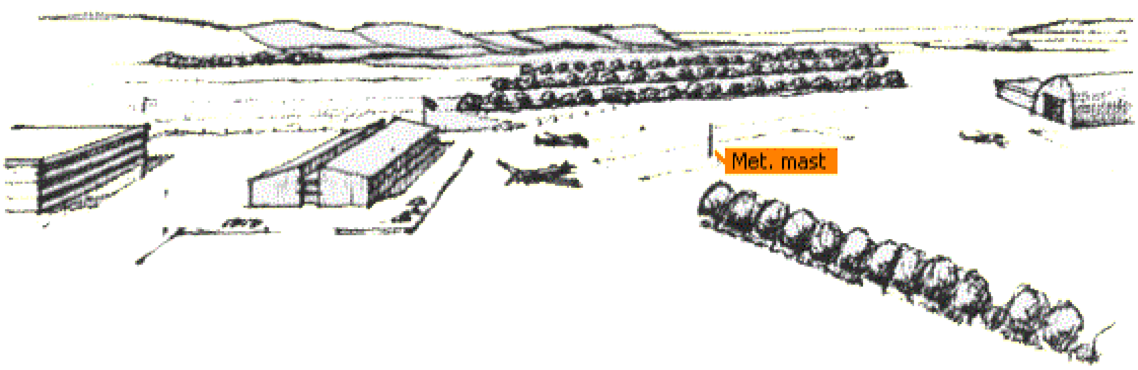
It is not possible to print the wind atlas contents directly, but the rose and graph graphics and the grid's contents can be copied to the Windows system clipboard. They can then be pasted into other Windows applications and printed.

To copy the rose or graph, click on one with the mouse and then use **Ctrl-C** or press the **F11** key on the keyboard. To copy the grid contents, click on the grid and then press the **F11** key on the keyboard.

About met. stations

Meteorological stations (met. stations) are used to calculate wind atlases. A met. station has no data of its own except the co-ordinates of its location in the map and a list of its children.

The illustration below shows the area surrounding the met. mast at the imaginary 'Waspdale' airport. It's clear that the data collected at the mast will be influenced by the buildings, hills and trees. Fortunately, such influences are systematic and (thanks to WAsP) predictable.



Met. stations calculate a wind atlas by adjusting the data found in an observed wind climate to remove the influencing effects of the collection site itself. The site effects are represented by a map, and (optionally) by an obstacle list, a site-specific roughness description and some user corrections to the wind data collection.

Calculation status

Four types of hierarchy member can perform calculations: met. stations, turbine sites, resource grids and wind farms. These calculating members are sensitive to changes in the hierarchy which affect them. They also search up and down the hierarchy to look for the other members with which they collaborate to do modelling work.

Ready to calculate?

Calculating members have a method called **Calculate** which is only available if the hierarchy is correctly set up to allow the calculation to proceed. If a calculating member is not ready to be calculated, then a different method is available, called **Explain why cannot be calculated**. If this method is invoked, then a brief explanation of what more needs to be done is presented.

Detection of changes in influencing information

If a calculating member detects a change to an associated influencing member or to the arrangement of its associated influencing members, then it 'realises' that the results data ought to be recalculated to reflect the new situation being modelled in the heirarchy.

When this happens, the calculating member's icon changes to display a red ring marker , , , . When calculating member are recalculated, the icon returns to normal.

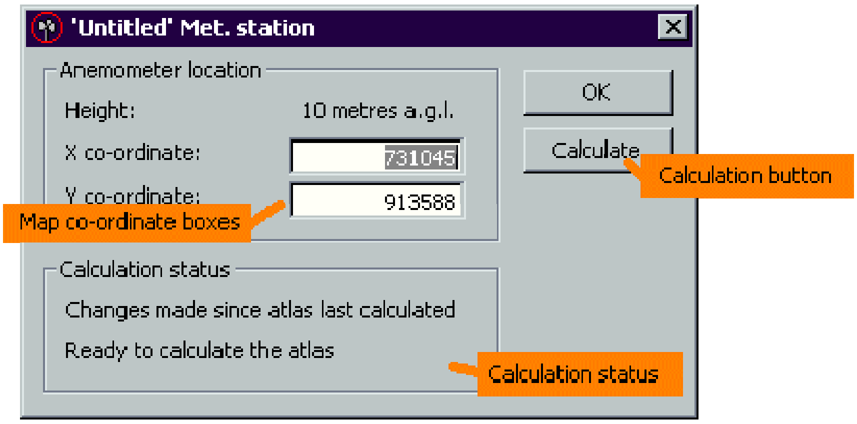
Overriding change detection

It's possible to tell a calculating member whether its wind atlas is due for recalculation. If the member 'thinks' that it ought to do a recalculation, then it has a method called **Mark as calculated** which will override its status. Conversely, if it thinks that it is up-to-date, then a method called **Mark as uncalculated** is available.

The met. station control dialog

The met. station has a control dialog which can be used to specify the precise co-ordinates of the met. station in an associated map and to force a re-calculation of the associated wind atlas.

The dialog is displayed if a met. station's **Edit location** method is invoked, or if the met. station's icon in the map is clicked with the right-hand mouse button.



Editing the met. station co-ordinates

The *x* and *y* co-ordinates of the met. station can be typed in, allowing more precise positioning than by dragging in the map.

The calculation button is not visible if the met. station is not ready to perform a calculation. The calculation status display shows information which can be deduced.

Met. stations in the map window

If a met. station is associated with a map hierarchy member, and has valid co-ordinates, then it can be displayed in the map, where it is indicated by an icon marker.

Hide or show the locations of met. stations in the map display by clicking on the toolbar button marked with the met. station icon .

To select and identify a met. station, click on the marker in the map with the *left* mouse button. The name of the site and the exact ground co-ordinates are shown in a pop-up label.

Dragging the met. station into position on the map

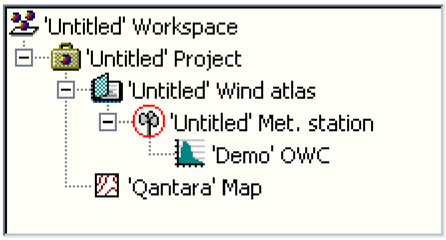
To display the met. station in the map, select the met. station's **Highlight location in map** method. If the map is not showing, it will be opened. The met. station's icon will be highlighted. If the met. station has never been located in the map, the select the method called **Locate in map**. The map window is opened and the met. station is automatically positioned at the centre of the mapped area.

It's now possible to change the location of the met. station by dragging it in the map using the left-hand mouse button. A label appears giving the exact co-ordinates as you drag the met. station. Depending on the zoom level, it might be difficult to position the met. station precisely. If this is a problem, simply right-click on the icon in the map and the met. station control dialog will appear, allowing you to edit the co-ordinates.

Preparing to calculate an atlas

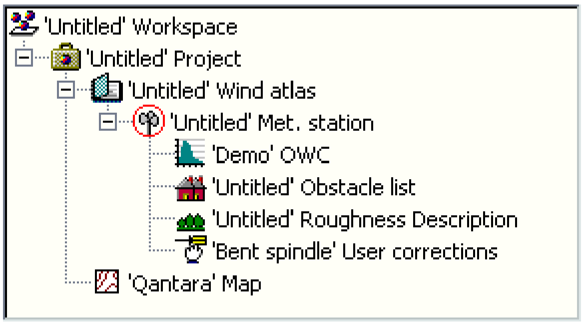
To calculate a wind atlas, a met. station must:

- Have a wind atlas hierarchy member as its parent
- Be located in an associated map
- Have an observed wind climate as one of its children
- Be a member of a project



Optionally, a met. station can:

- Have an obstacle list as one of its children
- Have a roughness description as one of its children
- Have a set of user corrections as one of its children



Starting from scratch, here's how to prepare to calculate a wind atlas with a met. station.

1. Create a new workspace
2. To the workspace, insert a new project
3. To the project, insert a new wind atlas
4. To the wind atlas, insert a new met. station
5. The the project, insert a map from file
6. To the met. station insert an observed wind climate from file
7. Locate the met. station in the map

Setting the location of a met. station

There are two ways to set the location of a met. station in the map.

- Editing the co-ordinates in a dialog box
- Dragging the met. station into position on the map

Calculating a wind atlas

If the met. station is ready to calculate its wind atlas, then the calculation performed by either

- Selecting the met. station's **Calculate atlas** method
- Hitting the calculate button on the met. stations's control dialog
- Instructing the met. station's project to update all calculations

After a wind atlas is calculated,

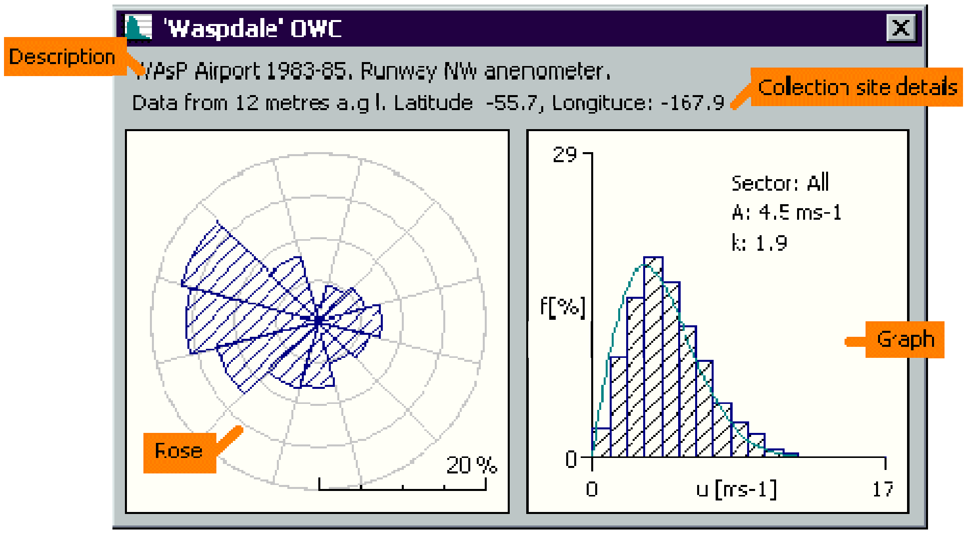
- if the wind atlas window is open, the data display will be immediately refreshed to display the new data
- the met. station icon will change to indicate that the wind atlas is not due for re-calculation
- any turbine sites associated with the newly-recalculated wind atlas will change status to indicate that their predicted wind climates are due for recalculation

About observed wind climates

Observed wind climates (OWC) contain a time-independent summary of wind data which are needed to calculate a wind atlas. The format of the corresponding observed wind climate file is described in the Technical Reference section.

The observed wind climate window

The OWC window provides a graphical representation of the data in the OWC.



On the left is a wind rose, showing the relative frequencies of wind direction for each sector. The graph to the right shows a histogram of the frequencies of wind speeds at the collection site. The Weibull-*A* and Weibull-*k* parameters for the distribution are pre-calculated and displayed. The derived Weibull curve is overlaid onto the histogram.

When first displayed, the graph shows a histogram of wind speed frequencies for all sectors (non-directional). To display the graph for one sector only, click with the mouse on one of the sectors in the rose. The rose sector will be highlighted and the graph will be adjusted to display the data for that sector. Hitting the spacebar on the keyboard will move the selection around the rose. To return to the non-directional display, click on the rose anywhere outside the area marked with rings.

Exporting output

It is not possible to print the observed wind climate contents directly, but the rose and graph graphics can be copied to the Windows system clipboard. They can then be pasted into other Windows applications and printed.

To copy the rose or graph, click on one with the mouse and then use **Ctrl-C** or press the **F11** key on the keyboard.

About turbine sites

Turbine sites are used to calculate a predicted wind climate for a particular point. A turbine site has no data of its own except the co-ordinates of its location and a list of its children.

A turbine site calculates a predicted wind climate by taking a wind atlas which describes the general wind climate of an area and applying it to a particular location, adjusting for the effects of the features of the site itself. The site has an (*x*, *y*) location in space and two *z* locations: the elevation of the site and the height above ground level for which the prediction is generated.

Each power curve has a default height. That's the usual height for the type of turbine which is described by the power curve. It's not necessary to use this height: a predicted wind climate can be generated for any height over 1 metre, regardless of which power curve is being used.

It's possible to calculate a predicted wind climate for a point without specifying a particular turbine power curve. That's the equivalent of erecting a turbine mast but not fitting a turbine to it. The predicted wind climate in that case will of course not contain any predictions describing the likely power yield of the turbine, but a prediction containing data for the wind directions, frequencies, speeds and energy will be produced.

In fact, it's quite appropriate to think of a turbine site as simply a point in 3-D space where a turbine could be erected. WAsP can calculate a prediction of the wind climate for that point. You can take things further by specifying a particular turbine type (by choosing a power curve to use). WAsP will then generate a prediction of the power yield for the combination of the point and the turbine type in addition the the basic data in the predicted wind climate.

Calculation status

Four types of hierarchy member can perform calculations: met. stations, turbine sites, resource grids and wind farms. These calculating members are sensitive to changes in the hierarchy which affect them. They also search up and down the hierarchy to look for the other members with which they collaborate to do modelling work.

Ready to calculate?

Calculating members have a method called **Calculate** which is only available if the hierarchy is correctly set up to allow the calculation to proceed. If a calculating member is not ready to be calculated, then a different method is available, called **Explain why cannot be calculated**. If this method is invoked, then a brief explanation of what more needs to be done is presented.

Detection of changes in influencing information

If a calculating member detects a change to an associated influencing member or to the arrangement of its associated influencing members, then it 'realises' that the results data ought to be recalculated to reflect the new situation being modelled in the heirarchy.

When this happens, the calculating member's icon changes to display a red ring marker . When calculating member are recalculated, the icon returns to normal.

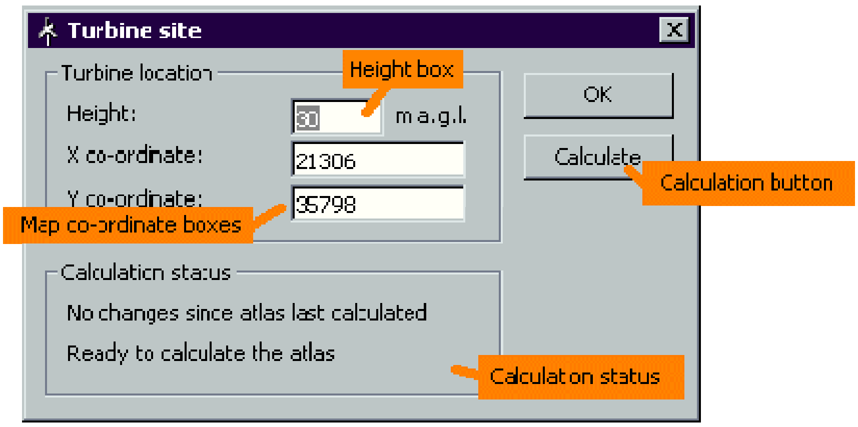
Overriding change detection

It's possible to tell a calculating member whether its wind atlas is due for recalculation. If the member 'thinks' that it ought to do a recalculation, then it has a method called **Mark as calculated** which will override its status. Conversely, if it thinks that it is up-to-date, then a method called **Mark as uncalculated** is available.

The turbine site control dialog

The turbine site has a control dialog which can be used to specify the precise location of the site and to force a re-calculation of the associated predicted wind climate.

The dialog is displayed if a turbine site's **Edit location** method is invoked, or if the turbine site's icon in the map is clicked with the right-hand mouse button.



Editing the turbine site co-ordinates

The x and y co-ordinates of the turbine site can be typed in, allowing more precise positioning than by dragging in the map. The height of the calculation can also be entered. If you type a value here, it will immeditately override any default value which has been used because a power curve has been associated with the site.

The calculation button is not visible if the turbine site is not ready to perform a calculation.

Turbine sites in the map window

If a turbine site is associated with a map hierarchy member, and has valid co-ordinates, then it can be displayed in the map, where it is indicated an icon marker.

Hide or show the locations of turbine site in the map display by clicking on the toolbar button marked with the turbine site icon .

To select and identify a turbine site, click on the marker in the map with the *left* mouse button. The name of the site and the exact ground co-ordinates are shown in a pop-up label.

Dragging the turbine site into position on the map

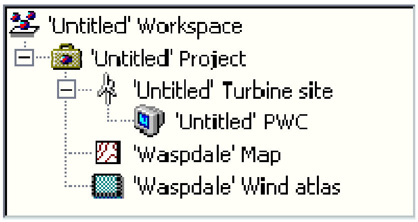
To display the turbine site in the map, select the turbine site's **Highlight location in map** method. If the map is not showing, it will be opened. The turbine site's icon will be highlighted. If the turbine site has never been located in the map, the select the method called **Locate in map**. The map window is opened and the turbine site is automatically positioned at the centre of the mapped area.

It's now possible to change the location of the turbine site by dragging it in the map using the left-hand mouse button. A label appears giving the exact co-ordinates as you drag the turbine site. Depending on the zoom level, it might be difficult to position the turbine site precisely. If this is a problem, simply right-click on the icon in the map and the turbine site control dialog will appear, allowing you to edit the co-ordinates.

Preparing to calculate a predicted wind climate

To calculate a predicted wind climate, a turbine site must:

- Be associated with a wind atlas
- Be located in an associated map
- Have an observed wind climate as one of its children
- Be a member of a project



Optionally, a turbine site can:

- Be associated with a power curve
- Have an obstacle list as one of its children
- Have a roughness description as one of its children
- Have a set of user corrections as one of its children

Starting from scratch, here's how to prepare to calculate a predicted wind climate with a turbine site.

1. Create a new workspace
2. To the workspace, insert a new project
3. To the project, insert a new turbine site
4. To the project, insert a wind wind atlas from file
5. To the project, insert a map from file
6. Locate the turbine site in the map
7. Specify a height for the turbine site

Setting the location of a turbine site

There are two ways to set the location of a turbine site in the map.

- Editing the co-ordinates in a dialog box
- Dragging the turbine site into position on the map

Calculating a predicted wind climate

If the turbine site is ready to calculate its associated predicted wind climate, then the calculation can be performed by either

- Selecting the turbine site's **Calculate** method
- Hitting the calculate button on the turbine site's control dialog
- Instructing the turbine site's project to update all calculations

After a predicted wind climate is calculated,

- if the predicted wind climate window is open, the data display will be immediately refreshed to display the new data,
- the turbine site icon will change to indicate that the predicted wind climate is not due for re-calculation.

About wind farms

 Wind farms provide a convenient way to calculate predictions for several sites simultaneously.

A wind farm consists of a set of sites which differ from each other only in their map location. They must all lie within the same map, but can be arranged in any pattern.

Each site in a wind farm is like a simpler version of a normal turbine site. All the sites have the same height. If a power curve is associated with the wind farm, then that curve is used for all of the sites in the farm. A site cannot have an associated obstacle list, nor a site-specific roughness description. A site does not have an associated predicted wind climate hierarchy member, but instead just a few key summary data are generated for each site.

If you need a lot of detail about each site, then you need actually to have several turbine sites in the same project.

Wind farm sites are simpler than turbine sites, but are also easier to manage as a group. A wind farm presents data about the total power or energy yield for a set of sites. You can also adjust the height for all of the sites in a wind farm simultaneously. You need to create each site in the wind farm individually, but this is usually much quicker than creating several normal turbine sites.

WAsP does not model the interference between the turbines in a wind farm. Each site is treated as though the other sites nearby did not exist. If you want to explore the effects of interference between the sites in your wind farm, then you need to use a separate program such as PARK, from Risø National Laboratory.

Calculation status

Four types of hierarchy member can perform calculations: met. stations, turbine sites, resource grids and wind farms. These calculating members are sensitive to changes in the hierarchy which affect them. They also search up and down the hierarchy to look for the other members with which they collaborate to do modelling work.

Ready to calculate?

Calculating members have a method called **Calculate** which is only available if the hierarchy is correctly set up to allow the calculation to proceed. If a calculating member is not ready to be calculated, then a different method is available, called **Explain why cannot be calculated**. If this method is invoked, then a brief explanation of what more needs to be done is presented.

Detection of changes in influencing information

If a calculating member detects a change to an associated influencing member or to the arrangement of its associated influencing members, then it 'realises' that the results data ought to be recalculated to reflect the new situation being modelled in the heirarchy.

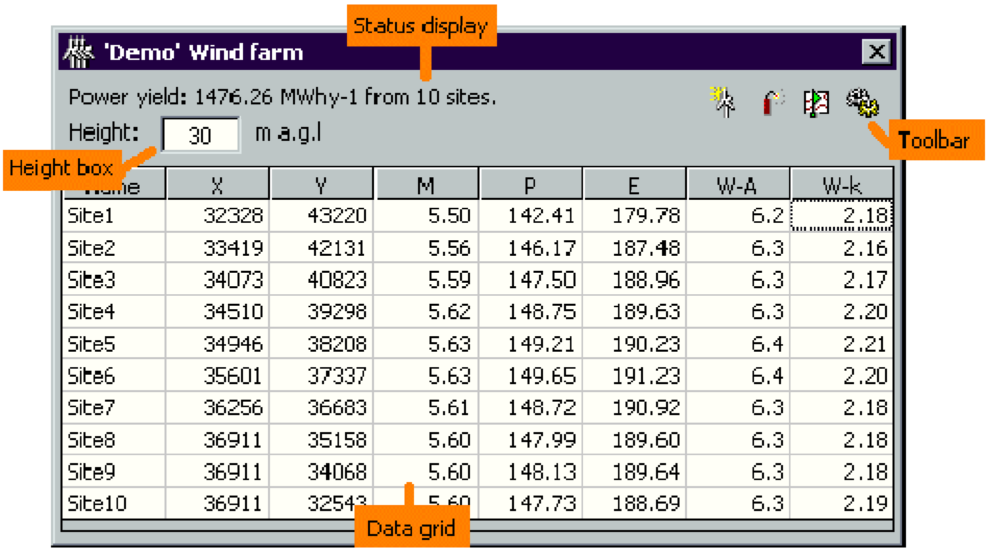
When this happens, the calculating member's icon changes to display a red ring marker
. When calculating member are recalculated, the icon returns to normal.

Overriding change detection

It's possible to tell a calculating member whether its wind atlas is due for recalculation. If the member 'thinks' that it ought to do a recalculation, then it has a method called **Mark as calculated** which will override its status. Conversely, if it thinks that it is up-to-date, then a method called **Mark as uncalculated** is available.

The wind farm window

The wind farm window shows a grid containing the data for each site, and provides a toolbar for managing the sites in the farm.



Name	X	Y	M	P	E	W-A	W-k
Site1	32328	43220	5.50	142.41	179.78	6.2	2.18
Site2	33419	42131	5.56	146.17	187.48	6.3	2.16
Site3	34073	40823	5.59	147.50	188.96	6.3	2.17
Site4	34510	39298	5.62	148.75	189.63	6.3	2.20
Site5	34946	38208	5.63	149.21	190.23	6.4	2.21
Site6	35601	37337	5.63	149.65	191.23	6.4	2.20
Site7	36256	36683	5.61	148.72	190.92	6.3	2.18
Site8	36911	35158	5.60	147.99	189.60	6.3	2.18
Site9	36911	34068	5.60	148.13	189.64	6.3	2.18
Site10	36911	32543	5.60	147.73	188.69	6.3	2.19

The summary data display shows the total power yield from all of the sites in the farm. This is equal to the Annual Energy Production (AEP) of the wind farm, i.e. park effects have *not* been taken into account.

The height box shows the calculation height for all of the sites in the farm. The height can be changed by adjusting the number shown. It's not possible for different sites to have different heights.

The grid contains key summary data for each site. Each row presents the data for one site. To select a site, click on the corresponding row in the grid. If the site is located in an associated map and the map is showing, then the site will be automatically highlighted in the map.

The first three columns show the name for the site and the *x* and *y* co-ordinates. These three cells can be edited: to edit the contents either double-click on the cell or select the cell and press the **Enter** key on the keyboard.

Columns five to eight in the grid present results data which summarise the wind climate at each site (the power, the energy, the Weibull-*A* and the Weibull-*k* values). These cells cannot be edited. Power yield data are not available unless a power curve is associated with the wind farm. Some of these data are not saved to file, so when re-opening as previously calculated wind farm, they will not be available until you recalculate the wind farm.

The toolbar has four buttons:

Pressing this button will add a new site to the wind farm. Another way of creating new sites is by copying an existing site by dragging and dropping in the map. WAsP will automatically assign a generated name for the site, but you can of course change this name to something more meaningful. There is no need for each site to have a different name: these names are just labels which are not used by WAsP.

Pressing this button will remove the currently selected site from the wind farm. Another way of doing this is to select a site and press the **Delete** key on the keyboard. Take care that you have selected the right site before doing the remove operation, since no confirmation is sought before the site is removed.

If the currently selected site is located in an associated map, then pressing this button will cause the map to be displayed with the location of the currently selected site highlighted. If the site is not located in an associated map, then it will be automatically positioned at the middle of the map.

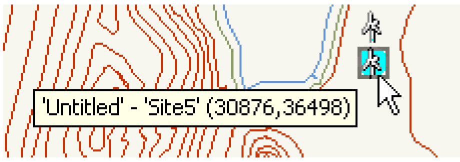
This is the calculate button. Pressing it will cause the whole farm to be recalculated. If the farm cannot be calculated then the button icon is changed to . Pressing the button will cause a message to be displayed which explains why the wind farm cannot be calculated.

Wind farms in the map window

Sites in wind farm can be displayed in an associated map.

The same button on the map toolbar is used to control the display of normal turbine sites and wind farm sites. By default, the same icon is used as a wind farm site marker as a turbine site marker but you can change the marker which is used. In the map display, there is no indication that the sites are members of the same wind farm.

To select a wind farm site, click on it with the left mouse button. It will be highlighted and if you wait a moment, then a label will appear which displays the name of the wind farm, the name of the site and the exact co-ordinates of the site.



When selected, the site can be moved by dragging it with the left mouse button held down. It is also possible to copy the site by pressing and holding down the **Ctrl** key and then dragging the highlighted site with the left mouse button. When you drop the site into a new location, a new site is automatically created and added to the wind farm. The original site remains unmoved. Doing this several times is a really quick way to set up a wind farm.

If a site is highlighted, then clicking on it with the right mouse button will cause the wind farm window to be displayed, with the highlighted site selected.

Setting up a wind farm from the map

If a wind farm includes at least one site, then you can quickly and easily add more by working in the map.

1. Highlight one of the existing sites in the map by clicking on the marker with the left mouse button.
2. Press and hold down the **Ctrl** key on the keyboard.
3. Click on the highlighted site with the left mouse button and drag the highlighted marker to a new location.
4. Drop the marker.
5. A new site is added immediately to the wind farm.

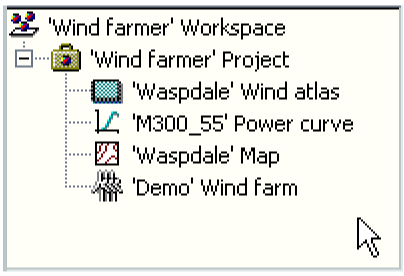
Preparing to calculate a wind farm

To be calculated, a wind farm must

- Be associated with a wind atlas
- Have all of its sites located within an associated map
- Be a member of a project

Optionally, a wind farm can:

- Be associated with a power curve



Starting from scratch, here's how to prepare to calculate a wind farm

1. Create a new workspace
2. To the workspace, insert a new project
3. To the project, insert a wind wind atlas from file
4. To the project, insert a map from file
5. To the project, insert a new wind farm
6. Set the height for the wind farm calculations
7. In the wind farm window, click on the new site button to create the first site
8. In the wind farm window, select the newly-created site
9. In the wind farm window, click on the button to highlight the site in the map

10. In the map window, drag the highlighted site to a likely location

It should now be possible to calculate the farm.

Calculating a wind farm

If the wind farm is ready to be calculated, then the calculation can be performed by either

- Selecting the wind farm's **Calculate** method
- Hitting the calculate button on the wind farm's window
- Instructing the wind farm's project to update all calculations

After a wind farm is calculated,

- if the wind farm window is open, then the data grid will be immediately refreshed to display the new data,
- the wind farm icon will change to indicate that it is not due for re-calculation.

About resource grids

Resource grids let you manage a rectangular set of points for which summary predicted wind climate data are calculated. The points are regularly spaced and are arranged into rows and columns. This lets you see a pattern of wind climate or wind resources for an area. You don't need to create each point in the grid individually. Instead you just specify the location of the grid, the number of rows and columns and the distance between the points.

Each point in the grid is like a simpler version of a normal turbine site. All the points have the same height. If a power curve is associated with the grid, then that curve is used for all of the points in the grid. A point cannot have an associated obstacle list, or a site-specific roughness description. A point does not have an associated predicted wind climate hierarchy member, but instead just a few key summary data are generated for each point. If you want to generate a more detailed prediction for a point, then you need to create a normal turbine site.

For each point, WAsP calculates the following data:

- the elevation
- the mean wind speed
- the energy
- the power (if a power curve is associated)
- the Weibull-*A* value
- the Weibull-*k* value

When a resource grid is saved, not all of the calculated data are saved to file. Mean wind speed data are never saved. If power data were calculated, then energy data are not saved. If power data were not calculated, then they are not saved.

Calculation status

Four types of hierarchy member can perform calculations: met. stations, turbine sites, resource grids and wind farms. These calculating members are sensitive to changes in the hierarchy which affect them. They also search up and down the hierarchy to look for the other members with which they collaborate to do modelling work.

Ready to calculate?

Calculating members have a method called **Calculate** which is only available if the hierarchy is correctly set up to allow the calculation to proceed. If a calculating member is not ready to be calculated, then a different method is available, called **Explain why cannot be calculated**. If this method is invoked, then a brief explanation of what more needs to be done is presented.

Detection of changes in influencing information

If a calculating member detects a change to an associated influencing member or to the arrangement of its associated influencing members, then it 'realises' that the results data ought to be recalculated to reflect the new situation being modelled in the heirarchy.

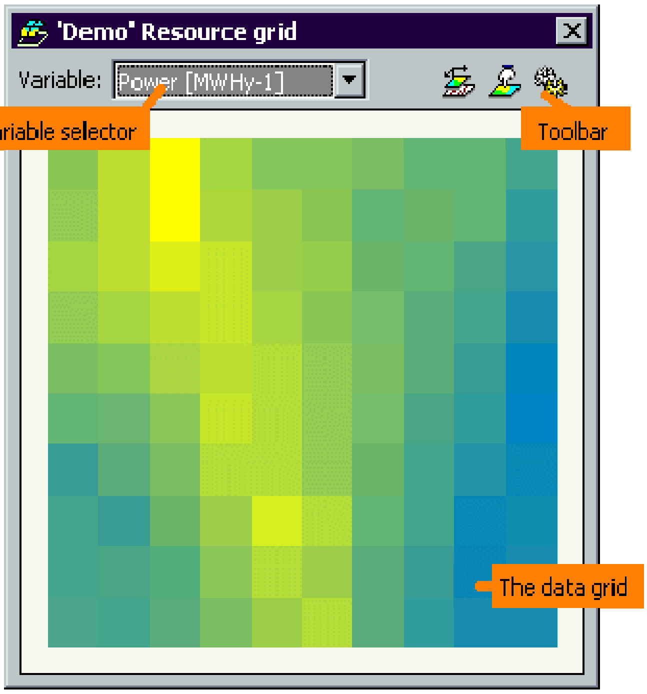
When this happens, the calculating member's icon changes to display a red ring marker , , , . When calculating member are recalculated, the icon returns to normal.

Overriding change detection

It's possible to tell a calculating member whether its wind atlas is due for recalculation. If the member 'thinks' that it ought to do a recalculation, then it has a method called **Mark as calculated** which will override its status. Conversely, if it thinks that it is up-to-date, then a method called **Mark as uncalculated** is available.

The resource grid window

The resource grid window displays the calculated data for the points in the grid, and provides a toolbar to let you work with the grid.



If the grid has data to display, then you can choose which data to view by selecting a variable from the variable selector. The data grid will be updated to show the data for the selected variable. If no variable is selected or if no data are available, then a simple array of points markers is shown to illustrate the structure of the grid.

There is no scale, but if you allow the mouse pointer to linger for a moment over the coloured grid, then a label will appear which provides details of the current location and the data value for that point.

Whichever variable is selected, and whatever the data values are, the data are always displayed using a simple linear colour scale in which the range of colours is scaled from the minumum value found to the maximum value found. The WAsP options window allows you to change the colours used.

The toolbar has three buttons.

If the resource grid is located within the area covered by an associated map, then pressing this button will show the map with the resource grid displayed as a colour underlay.

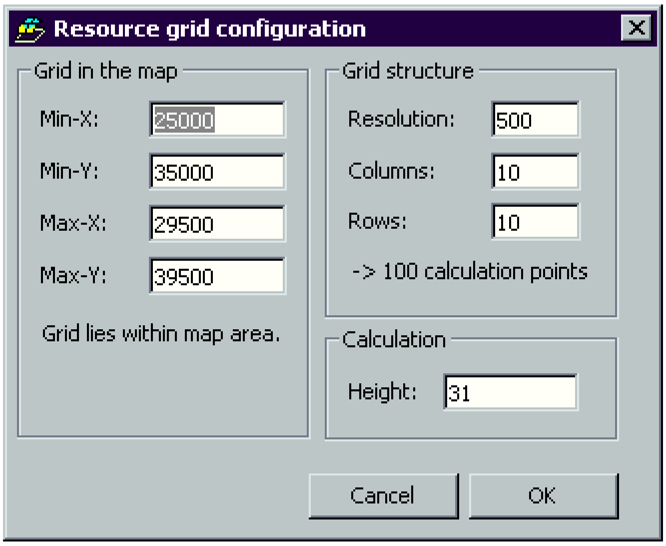
This button lets you configure the grid. Pressing this button displays the resource grid configuration dialog.

This is the calculate button. Pressing it will cause the whole grid to be recalculated. If the grid cannot be calculated then the button icon is changed to . Pressing the button will cause a message to be displayed which explains why the resource grid cannot be calculated.

The buttons on the toolbar correspond to methods of the resource grid's menu.

Configuring a resource grid

To configure the resource grid, either press the configure button on the toolbar of the resource grid window, or choose to configure from the menu of methods. A window like the one shown below will appear.



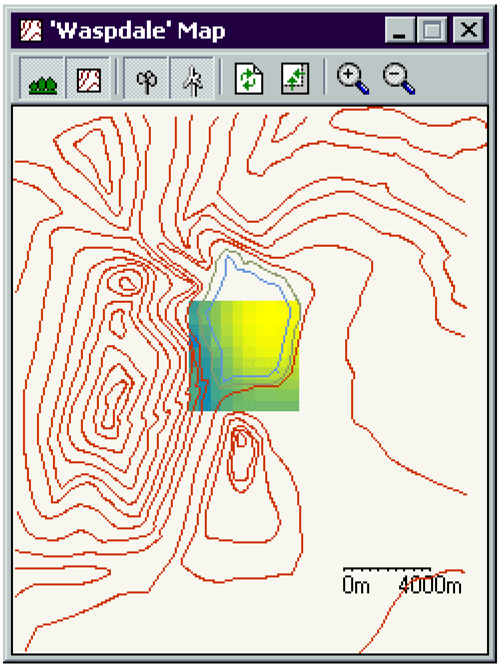
The grid is configured by providing several data values. The four data on the left are used to locate the grid in the map and the three on the right are used to define the structure of the grid. Since these data are inter-dependent, WAsP automatically completes the values for some of the data as you work. For example, if you simply provide values for Min-X and Min-Y and then go directly on to specify the resolution and rows and columns, then WAsP will calculate the Max-X and Max-Y.

WAsP immediately determines whether the grid lies completely within the area of any associated map and displays the number of calculation points contained in the grid which you have specified.

This dialog can also be used to set the height for the calculation. If a power curve is associated with the grid, then the default height for that curve is used automatically. You can simply override such a value by editing the box shown here. If you subsequently rearrange the hierarchy so as to associate a different power curve with the resource grid, then WAsP will ask whether you want to use the current height or replace it with the default height for the newly-associated power curve.

Resource grids in the map window

To display the resource grid in the map window, press the display in map button on the resource grid window toolbar, or select the appropriate method from the menu of methods. The map will be shown and the resource grid will be illustrated as an 'underlay' to the contour and roughness change lines.



The grid shown is the same as whichever variable has been selected in the resource grid window variable selector. If no variable has been selected, then the outline of the grid is shown instead. If you change the selected variable in the resource grid window, the grid in the map will not be automatically updated: you need to force the grid to redisplay itself in the map.

Unlike met. stations, turbine sites and wind farm sites, the resource grid cannot be set to display continuously with the map. If you resize or redraw the map, then the grid will disappear, and you need to force it to redisplay to see it again.

It is not possible to move or resize the grid from the map window: you need to use the resource grid configuration dialog.

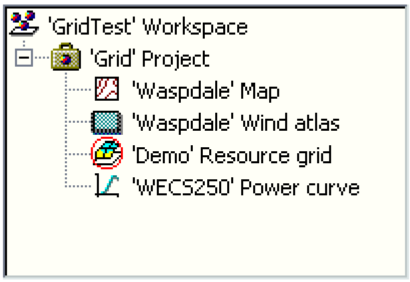
Preparing to calculate a resource grid

To be calculated, a resource grid must

- Be associated with a wind atlas
- Be entirely located in an associated map
- Be a member of a project

Optionally, a resource grid can:

- Be associated with a power curve



Starting from scratch, here's how to prepare to calculate a resource grid

1. Create a new workspace
2. To the workspace, insert a new project
3. To the project, insert a new resource grid
4. To the project, insert a wind wind atlas from file
5. To the project, insert a map from file
6. In the resource grid configuration dialog, specify the location of the grid in the map
7. In the resource grid configuration dialog, specify the size and resolution of the grid
8. Specify a height for the resource grid calculations

Calculating a resource grid

If the resource grid is ready to be calculated, then the calculation can be performed by either

- Selecting the resource grid's **Calculate** method
- Hitting the calculate button on the resource grid's window
- Instructing the resource grid's project to update all calculations

After a resource grid is calculated,

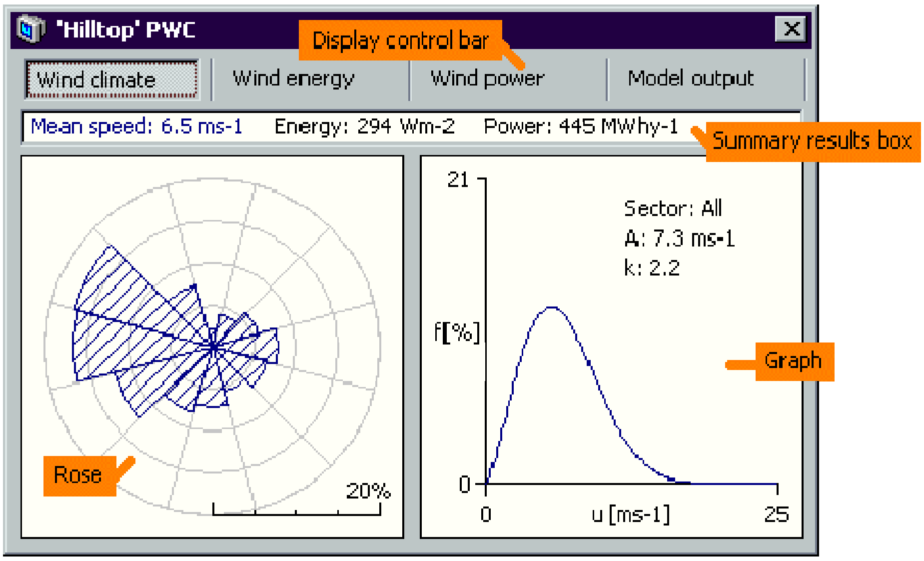
- if the resource grid window is open and a variable is selected for display, the data grid will be immediately refreshed to display the new data,
- the resource grid icon will change to indicate that it is not due for re-calculation.

About predicted wind climates

Predicted wind climates (PWC) contain the results of the WAsP application, i.e. the estimated wind climate and power production for an application (turbine) site. The results are calculated by the WAsP models and based on a previously calculated wind atlas.

The predicted wind climate window

The predicted wind climate window displays the results for a turbine site calculation. The summary results box displays the mean wind speed, the total energy and total power yield.



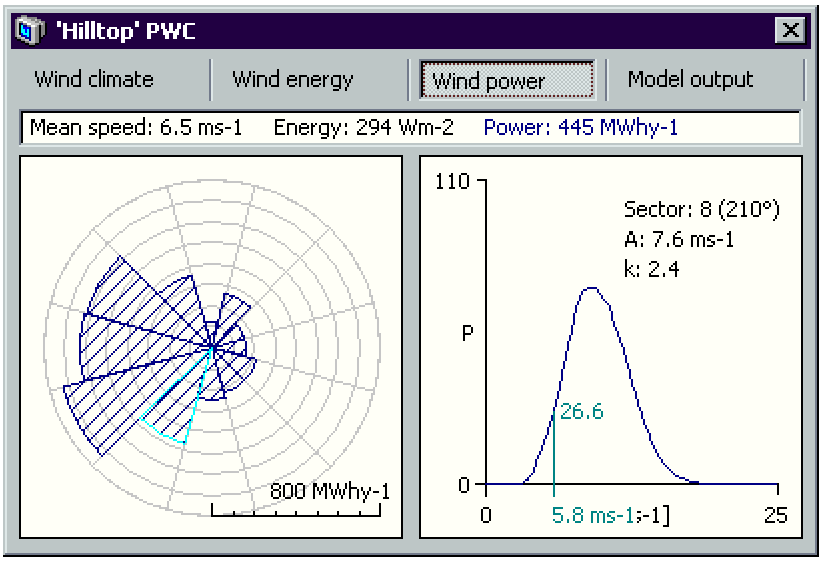
There are four data displays.

- Rose and graph for the predicted wind climate
- Rose and graph for energy
- Rose and graph for power
- Grid showing detailed model output data

Select a data display by clicking the appropriate button on the display control bar.

Using the 'rose and graph' displays

The three rose and graph displays are functionally similar, although they of course display different data.



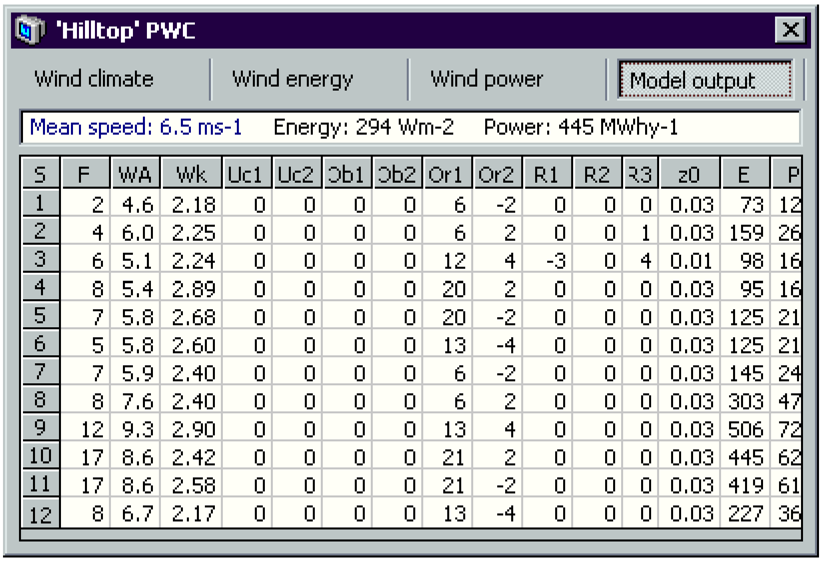
To see the actual values used to construct the rose, move the mouse pointer slowly over a rose sector.

Each sector has a corresponding curve, and there is also a curve for all sectors (non-directional). To select a sector, click on it in the rose display. Hitting the spacebar on the keyboard will move the selection around the rose. To select all sectors, click on the rose anywhere outside the area marked with rings.

When a sector is selected, the graph will be changed to reflect the data for that sector. Moving the mouse pointer over the graph will reveal a 'read-off' line, labelled with the precise frequency datum for the point on the curve. The graph area is also used to display the Weibull-A and Weibull-k paramters for the sector.

Using the grid display

The grid display shows the details of the model's output. Various output data values are given for each sector.



'Hilltop' PWC

Wind climate | Wind energy | Wind power | Model output

Mean speed: 6.5 ms-1 Energy: 294 Wm-2 Power: 445 MWhy-1

S	F	WA	Wk	Uc1	Uc2	Ob1	Ob2	Or1	Or2	R1	R2	R3	z0	E	P
1	2	4.6	2.18	0	0	0	0	6	-2	0	0	0	0.03	73	12
2	4	6.0	2.25	0	0	0	0	6	2	0	0	1	0.03	159	26
3	6	5.1	2.24	0	0	0	0	12	4	-3	0	4	0.01	98	16
4	8	5.4	2.89	0	0	0	0	20	2	0	0	0	0.03	95	16
5	7	5.8	2.68	0	0	0	0	20	-2	0	0	0	0.03	125	21
6	5	5.8	2.60	0	0	0	0	13	-4	0	0	0	0.03	125	21
7	7	5.9	2.40	0	0	0	0	6	-2	0	0	0	0.03	145	24
8	8	7.6	2.40	0	0	0	0	6	2	0	0	0	0.03	303	47
9	12	9.3	2.90	0	0	0	0	13	4	0	0	0	0.03	506	72
10	17	8.6	2.42	0	0	0	0	21	2	0	0	0	0.03	445	62
11	17	8.6	2.58	0	0	0	0	21	-2	0	0	0	0.03	419	61
12	8	6.7	2.17	0	0	0	0	13	-4	0	0	0	0.03	227	36

To see less abbreviated column titles, move the mouse pointer slowly over the grid. A label will appear, showing the fill title of the column.

The window can be resized to allow more room to display the grid.

Exporting output

It is not possible to print the predicted wind climate contents directly, but the summary results box, the rose and graph graphics and the grid's contents can be copied to the Windows system clipboard. They can then be pasted into other Windows applications and printed.

To copy the summary results box, simply click on it. All three summary data will be automatically selected. Use either **CTRL-C** or press the **F11** key on the keyboard to copy the data to the clipboard.

To copy the rose or graph, click on one with the mouse and then press the **F11** key on the keyboard. To copy the grid contents, click on the grid and then press the **F11** key on the keyboard. When the grid contents are copied, the contents of the summary data are also placed in the clipboard.

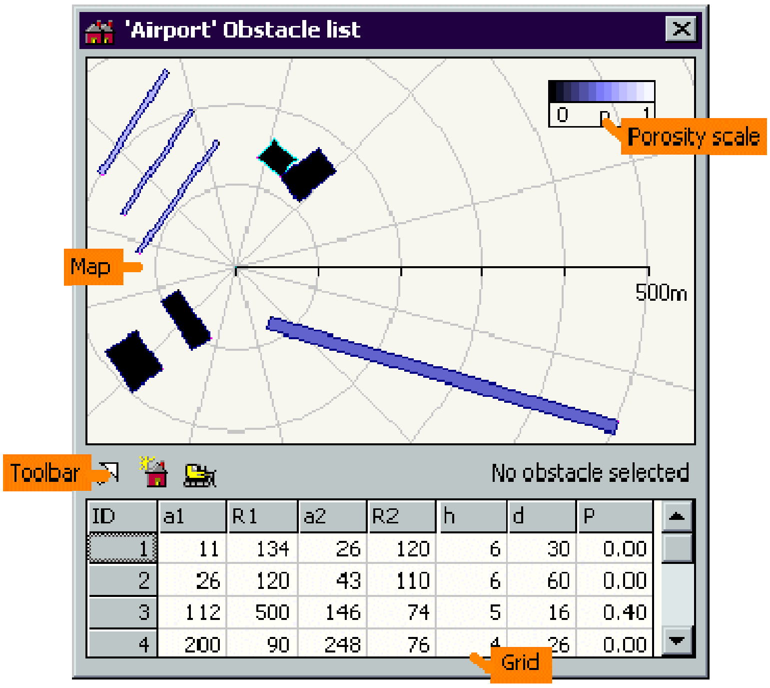
About obstacle lists

Obstacle lists are used to describe objects in the vicinity of a site (turbine site or met. station) which might affect the behaviour of the wind at the site. Examples include shelterbelts and buildings.

Data in WAsP obstacle lists describe the obstacles using a site-relative coordinate system and obstacles are represented as 3-dimensional boxes with a rectangular footprint and cross-section. A maximum of 50 obstacles can be specified in one list. The format of the corresponding obstacle list file is decscribed in the Technical Reference section.

The obstacle list window

The obstacle list window provides a plan view of the obstacles described in the obstacle list.



The layout of the obstacles is illustrated in a map, with obstacles coloured according to their porosity. There is a key to the porosity colour scale and a ground distance scale.

If the mouse pointer is moved slowly over an obstacle, then a label will appear, displaying the ID number, height and porosity of that obstacle. Moving the mouse pointer slowly over another part of the map will reveal the ground co-ordinates of the mouse pointer position.

The actual data describing the obstacles are displayed in an editable grid in which each row contains the data describing one obstacle. Clicking on a row in the grid will cause the corresponding obstacle to be highlighted in the map. The grid's column titles are very abbreviated. Allowing the mouse pointer to linger over the grid will cause a label to appear, revealing the full title of the column.

Adjusting the layout

The window can be re-sized. If the area illustrated by the map is tall and narrow, it may be more convenient to display the grid to the right of the map. It's possible to move the grid by clicking on the **Move the grid** button on the toolbar. Clicking again on the same button moves the grid back.

If the porosity scale appears in an inappropriate place, it can be dragged to a new location using the right mouse button. The ground distance scale cannot be dragged from its original position.

Working with obstacle lists

It's possible to add, edit and remove obstacles by working with the grid.

Adding a new obstacle to the list

Click the **Add new obstacle** button on the toolbar. A new obstacle is added to the top of the list with ID number 1. The new obstacle is created with made-up data which ensure that the new obstacle is at further away than existing obstacles. A row is added to the top of the grid. Edit the grid to set the data describing the new obstacle.

Removing an obstacle from the list

Select the obstacle to be removed by clicking on the obstacle in the map or by selecting the row in the grid containing data for that obstacle. Remove the selected obstacle by clicking on the **Remove currently selected obstacle** button on the toolbar, or by pressing the **Delete** key on the keyboard.

Editing obstacle data

Select the grid cell containing the datum to be edited and either press the **Enter** key on the keyboad or double-click on the cell with the mouse. A box appears on the grid which allows the number to be edited.

ID	a1	R1	a2	R2	h	d	P
1	26	120	43	110	6	60	0.00
2	112	500	146	74	5	16	0.40
3	200	90	248	[illegible]	4	26	0.00
4	215	154	237	144	6	46	0.00

Type the new value into the box and either press **Enter** or click elsewhere on the window to close the editor box. The map view of the obstacles is immediately redrawn to reflect the changes.

Exporting output

It is not possible to print the obstacle list directly, but the map graphic and the grid's contents can be copied to the Windows system clipboard. They can then be pasted into other Windows applications and printed.

To copy the map, click on it with the mouse and then press the **F11** key on the keyboard. To copy the grid contents, click on the grid and then press the **F11** key on the keyboard.

Preparing an obstacle list from field data

Preparing an obstacle list from field data and observations is described in detail in Chapter 5 of the User's Guide to WAsP 4.

About roughness descriptions

When calculating a wind atlas from met. station data, or to predict the wind climate at a turbine site, WAsP can make adjustments for the roughness lengths of the terrain around the site. Of course, WAsP requires information about the roughness environment to do this.

If the map associated with a site contains roughness change lines, then WAsP can derive information about the roughness environment automatically. There is no need to provide any other information.

However, if the map contains only elevation data, then an alternative way to provide a WAsP with information about the roughness environment for a site is to associate a roughness description with the site, by inserting one as a child member of the site in the workspace hierarchy.

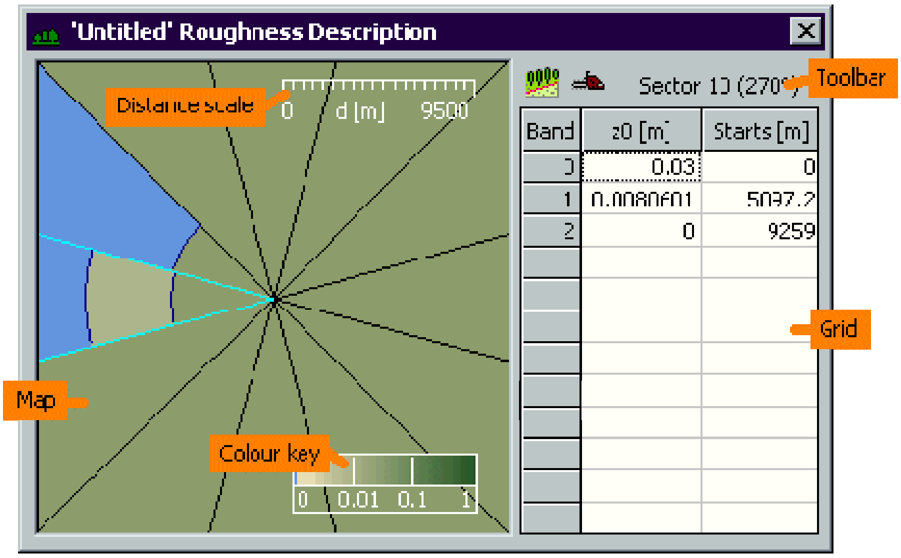
A roughness description divides the area surrounding the site into sectors. Each sector is in turn divided into bands of different roughness length.

There are two formats for roughness description files.

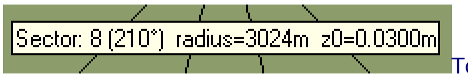
The roughness description window

The roughness description window illustrates the roughness of the terrain surrounding a turbine site or met. station.

The map displays the area surrounding the site. The area is divided into sectors and each sector can be divided into bands with different roughness lengths. The bands are separated by roughness change lines and are coloured according to a logarithmic scale which starts at blue (which is reserved for areas with a roughness length of exactly zero) and runs from light brown to dark green.



A roughness colour key and a distance scale are displayed on the map. They can be dragged around using the left mouse button if in an inconvenient position. It is possible to display the roughness map using a logarithmic ground scale (where changes close to the site are greatly emphasised in the display). To switch the display to logarithmic mode, right-click on the distance scale and select from the small pop-up menu which appears.



To discover the exact value for an area, move the mouse pointer slowly over the map. A label will appear which indicates which sector is selected, the centre bearing of that sector, the distance (radius) from the site of the current mouse position, and the roughness length in the area under the mouse pointer.

To select a sector, click on it in the map. The data for the selected zone are shown in the grid to the right of the map. Each row in the grid contains the band index, the roughness length of the band and the distance from the site to the start of the band.

Generating a roughness description from a map

If a met. station or turbine site is located in a map which contains roughness information (roughness change lines), then there is no need to use a roughness description member for that site. Still, it's sometimes useful or interesting to get an insight into how WAsP is interpreting the map data for that site. It's possible to get WAsP to generate a roughness description for the site from the map roughness information.

To do this,

1. Check that the site is correctly located in an associated map
2. Insert a new roughness description hierarchy member as a child of the site
3. From the roughness description's methods, select **Obtain description from map**
4. The roughness description's interface window will be opened, to show the derived description

The resulting description can be examined, edited and saved.

Working with roughness descriptions

It's possible to add, edit and remove sector bands by working with the grid. The number of sectors in a roughness description is determined when it is first created, and cannot be edited.

Adding a roughness band to a sector

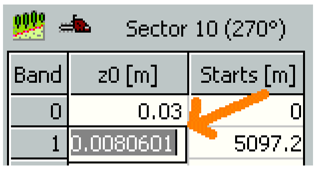
- Select the sector to be edited by clicking on it in the map area. The sector will be highlighted in the map, and the grid's contents will be changed to contain the bands for that sector.
- Click on the **Add roughness band** button on the grid's toolbar . A new band is added to the sector.

Removing a roughness band from a sector

- Select the sector to be edited by clicking on it in the map area. The sector will be highlighted in the map, and the grid's contents will be changed to contain the bands for that sector.
- Select the band to be removed by clicking on the corresponding row in the grid.
- Either click on the **Remove roughness band** button on the grid's toolbar , or press the **Delete** key on the keyboard. The selected band will be removed.

Editing a roughness band

Select the grid cell containing the datum to be edited and either press the **Enter** key on the keyboad or double-click on the cell with the mouse. A box appears on the grid which allows the number to be edited.



Type the new value into the box and either press **Enter** or click elsewhere on the window to close the editor box. The map view is immediately redrawn to reflect the changes.

Exporting output

It is not possible to print the roughness description contents directly, but the map graphic and the grid's contents can be copied to the Windows system clipboard. They can then be pasted into other Windows applications and printed.

To copy the map, click on it with the mouse and then press the **F11** key on the keyboard. To copy the grid contents, click on the grid and then press the **F11** key on the keyboard.

Preparing a roughness description from field data

Preparing a site-specific roughness description from field data and observations is described in detail in Chapter 3 of the User's Guide to WAsP 4.

Roughness description and user correction files

In WAsP 6.0, roughness descriptions are stored in *.rrd files and user corrections are stored in *.ucf files. Earlier versions of WAsP stored both data sets together in a single file with the extension *.rds.

WAsP 6.0 provides backward-compatibility by allowing you to open *.rds files as roughness descriptions or user corrections, and allowing you to work with roughness descriptions as *.rrd files with no user corrections information.

When creating a roughness description heirarchy member from file, you can choose to open an *.rds file. The roughness data will be read in from the file, but any user corrections data will not be used. Similarly, you can choose to open an *.rds file when creating a user corrections hierarchy member from file, and any roughness data found in the file will be ignored. It follows that if you want to use an *.rds file containing both user corrections data and roughness description data, then you need to open the same file twice: once when creating a user corrections member from file, and once when creating a roughness description from file.

If you create a new roughness description in WAsP 6.0 you can still use it with an earlier version of WAsP. The roughness description's menu contains a method called **Save in DOS WAsP format (*.rds)**. If you select this method, then an *.rds file will be generated from the roughness description. It will be saved to the same path as the existing *.rrd file and have the same filename: only the *.rds extension will be different. No user corrections data will be written to the file.

The workspace will now point to this *.rds file, so if you make changes to the roughness description and save them, then they will be saved to the *.rds file and will still be there when you next open the workspace. The *.rrd file which you converted will remain unaltered and unused, unless you wish to revert to using *.rrd format. To do this, select the method called **Save in WAsP 6.0 format (*.rrd)**. This will swap the two files around again, and any changes will now be written to the *.rrd file.

About user corrections

User corrections are used when some source of site-specific, systematic error is known, but cannot be included in the obstacle list or roughness description. They can be applied to sites (met. stations and turbine sites).

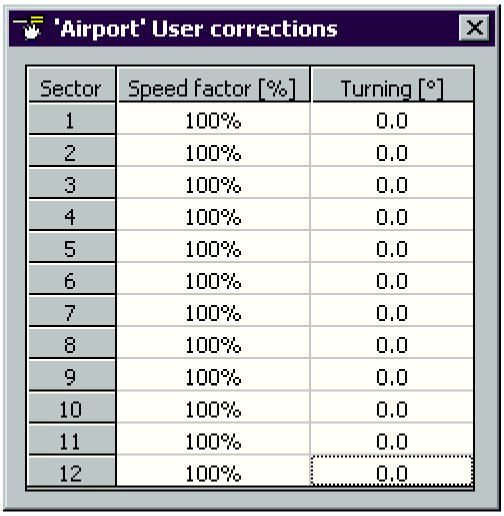
For example, the shadowing effect of a wind vane mounted close to an anemometer used at a met. station might be known to reduce the measured speed in a certain sector by 5%. It would be inappropriate to represent the vane as an obstacle. WAsP can adjust the calculations for the affected site using data provided in user corrections.

User corrections include an speed factor adjustment and a turning adjustment. The turning adjustment is very rarely used, because such adjustments are usually applied to all observations and directions: they can be applied when summarising the raw data from the instrument (see the OWC Wizard).

The user corrections window

The user corrections window displays the corrections for a site in a three-column grid. At present, it is not possible to edit the user corrections from within WAsP itself. The user corrections window simply displays the contents of the file.

The picture below shows a set of user corrections which are completely neutral - these corrections would have no effect on the calculations performed.


'Airport' User corrections

Sector	Speed factor [%]	Turning [°]
1	100%	0.0
2	100%	0.0
3	100%	0.0
4	100%	0.0
5	100%	0.0
6	100%	0.0
7	100%	0.0
8	100%	0.0
9	100%	0.0
10	100%	0.0
11	100%	0.0
12	100%	0.0

Roughness description and user correction files

In WAsP 6.0, roughness descriptions are stored in *.rrd files and user corrections are stored in *.ucf files. Earlier versions of WAsP stored both data sets together in a single file with the extension *.rds.

WAsP 6.0 provides backward-compatibility by allowing you to open *.rds files as roughness descriptions or user corrections, and allowing you to work with roughness descriptions as *.rrd files with no user corrections information.

When creating a roughness description heirarchy member from file, you can choose to open an *.rds file. The roughness data will be read in from the file, but any user corrections data will not be used. Similarly, you can choose to open an *.rds file when creating a user corrections hierarchy member from file, and any roughness data found in the file will be ignored. It follows that if you want to use an *.rds file containing both user corrections data and roughness description data, then you need to open the same file twice: once when creating a user corrections member from file, and once when creating a roughness description from file.

If you create a new roughness description in WAsP 6.0 you can still use it with an earlier version of WAsP. The roughness description's menu contains a method called **Save in DOS WAsP format (*.rds)**. If you select this method, then an *.rds file will be generated from the roughness description. It will be saved to the same path as the existing *.rrd file and have the same filename: only the *.rds extension will be different. No user corrections data will be written to the file.

The workspace will now point to this *.rds file, so if you make changes to the roughness description and save them, then they will be saved to the *.rds file and will still be there when you next open the workspace. The *.rrd file which you converted will remain unaltered and unused, unless you wish to revert to using *.rrd format. To do this, select the method called **Save in WAsP 6.0 format (*.rrd)**. This will swap the two files around again, and any changes will now be written to the *.rrd file.

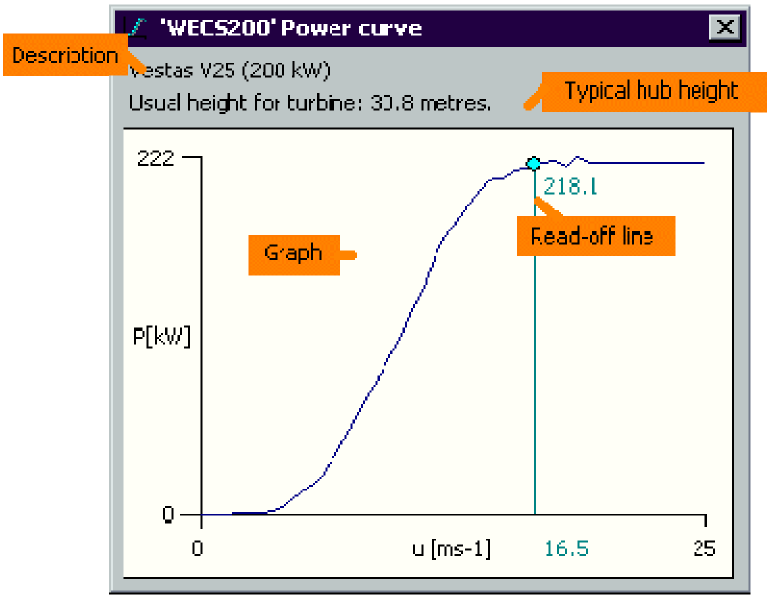
About power curves

Power curves are used to describe wind turbines. They can be associated with turbine sites, wind farms and resource grids.

Power curves contain information about how turbines transform wind energy into power, and the hub height usual for the turbine when deployed. The power curve file may also contain values of the thrust coefficient, *C*t. The format of the power curve file is decscribed in the Technical Reference section.

The power curve window

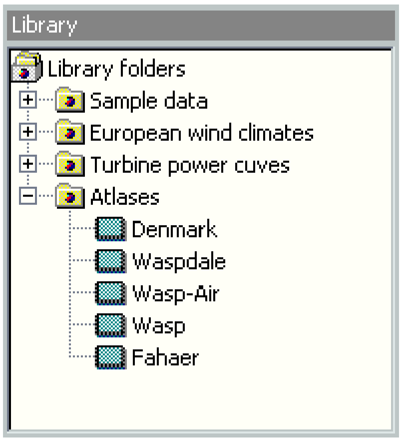
The power curve window shows the turbine description, the typical hub height and a graph of the power output against wind speed.



To obtain a precise data reading, move the mouse over the graph. A read-off line appears and follows the mouse position. If the windspeed for the current mouse pointer position is one of the original data points from the file, a small ball appears where the curve and the read-off line meet.

About the library

The library makes it faster to open files in WAsP. The library contains library folders. Each library folder contains a list of files which can be opened directly into the WAsP workspace hierarchy, thereby avoiding the need to use the file selection dialog. In other words, each library folder is a mapped to a folder on the file system, and presents a list of the files found, filtered by type. The library can be easily re-configured to suit the way you store your files.



The library is arranged as a simple hierarchy, with only three levels:

- the library root
- the library folders
- the library folder contents , , , *etc*.

Library folders cannot contain other library folders.

Each library folder contains a list of files. Only files which can be opened in the WAsP workspace hierarchy are shown. Each file is shown with the icon of the type of hierarchy member which corresponds to the file type. The files' extensions are hidden.

Each library folder is associated with a folder on the computer's file system and presents a list of files that are found in that file system folder. Library folders can list all of the WAsP files found, or can list only one type of WAsP file. They do not list files found in sub-folders on the file system folder.

The library is not visible unless a workspace is open.

Opening files from the library

Files from the library can be opened into the workspace in three ways

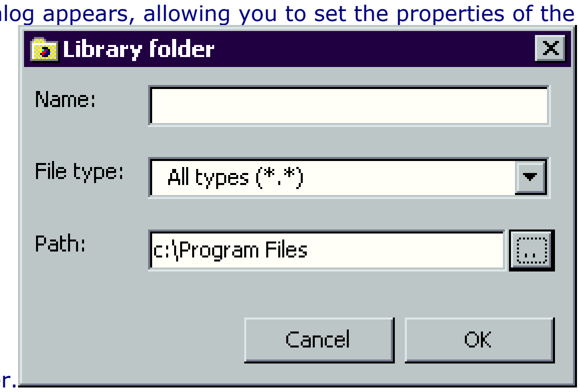
1. Files can be dragged from the library to become children of an existing member in the workspace hierarchy.
2. Files can be opened into the root of the workspace by double-clicking on them in the library
3. Files can be opened into the root of the workspace by selecting **Open member in workspace** from the file's right-click popup menu.

Adding and removing library folders

To add a new library folder

1. Select the library root
2. From root's the right-click menu, select **Add new folder**

3. A dialog appears, allowing you to set the properties of the new library folder.



4. Type a **Name** for the library folder. This is only used to identify the folder in the library.
5. From the **File type** drop-down list, select a type of file to be listed in the library folder. You can set the library folder to list all types of WAsP files, or just one type.
6. Select a **Path** to a folder on the computer's file system. The library folder will list the files from this file system folder.

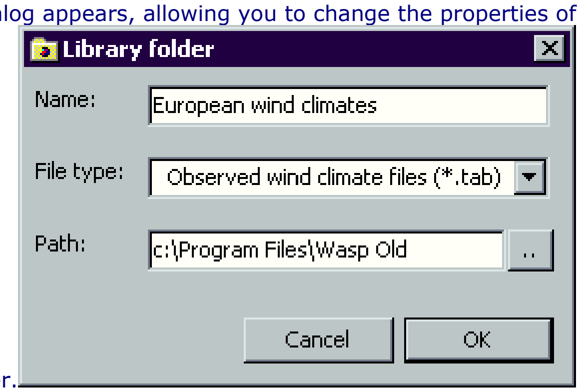
To remove an existing folder

1. Select the library folder to be deleted
2. From library folder's the right-click menu, select **Remove folder**

Editing library folder properties

It's easy to change the properties of a library folder.

1. Select the library folder to be edited
2. From library folder's the right-click menu, select **Edit folder properties**
3. A dialog appears, allowing you to change the properties of the new library folder.



4. Change the **Name** for the library folder.
5. From the **File type** drop-down list, select a type of file to be listed in the library folder. You can set the library folder to list all types of WAsP files, or just one type.
6. Select a **Path** to a folder on the computer's file system. The library folder will list the files from this file system folder.

Refreshing the library contents

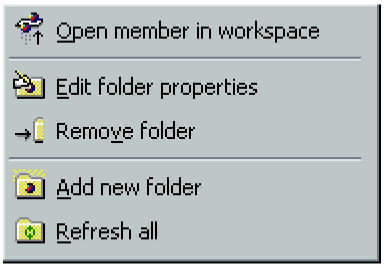
The library's folders' contents are automatically refreshed whenever a folder is added, removed or edited. Sometimes, it is useful to force the library to refresh the file list. For example, if you have moved or deleted a file using the Windows Explorer and want the change to be reflected in the library.

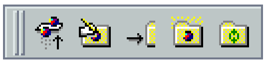
There are two ways to refresh the library's contents.

1. Select the library root and from the root's the right-click menu, select **Refresh all**
2. Click anywhere on the library and press the **F5** key.

The library menu and toolbar

The main window has a toolbar and a menu which can be used to work with the library. The menu and toolbar buttons are the same as the library's right-click pop-up menu.





If the library is not currently selected, then both the toolbar and the menu will be disabled. Different menu options and toolbar buttons become enabled and disabled depending on whether the library root, a library folder or a file is selected.

Options

You can change the way that the WAsP user interface behaves by setting options in the options window. These options do not affect the way that calculations are performed, but are limited to the display and file management.

The options window can be displayed by selecting **Options** from the **Tools** menu of the main window.

With the options window, you can

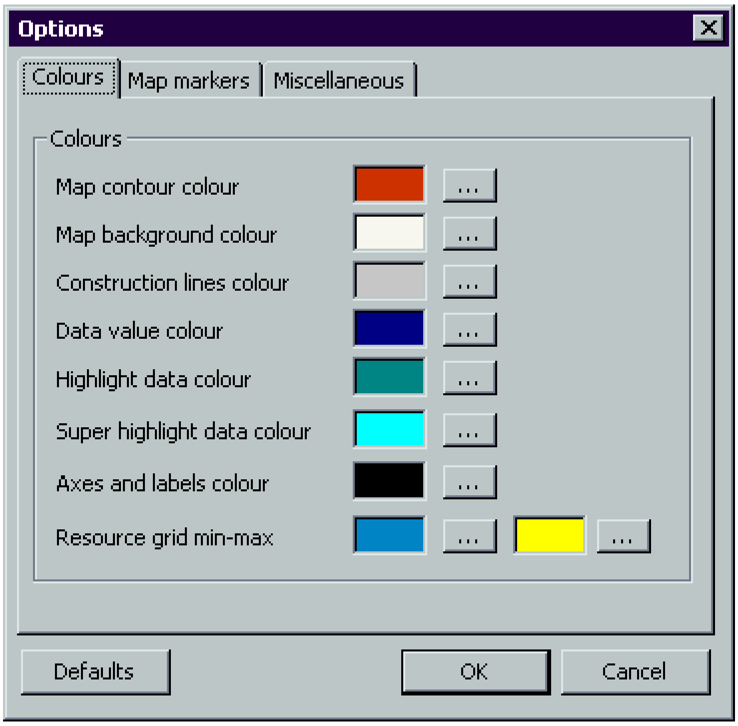
1. Change the display colours
2. Change the markers used in the map
3. Change miscellaneous options

There is a button marked **Defaults**, which is always available. Pressing this button will return *all* settings to their default values.

Setting display colours

Here you can choose which colours WAsP should use when preparing graphical displays.

To change a colour, click on the button next to it marked with three dots.



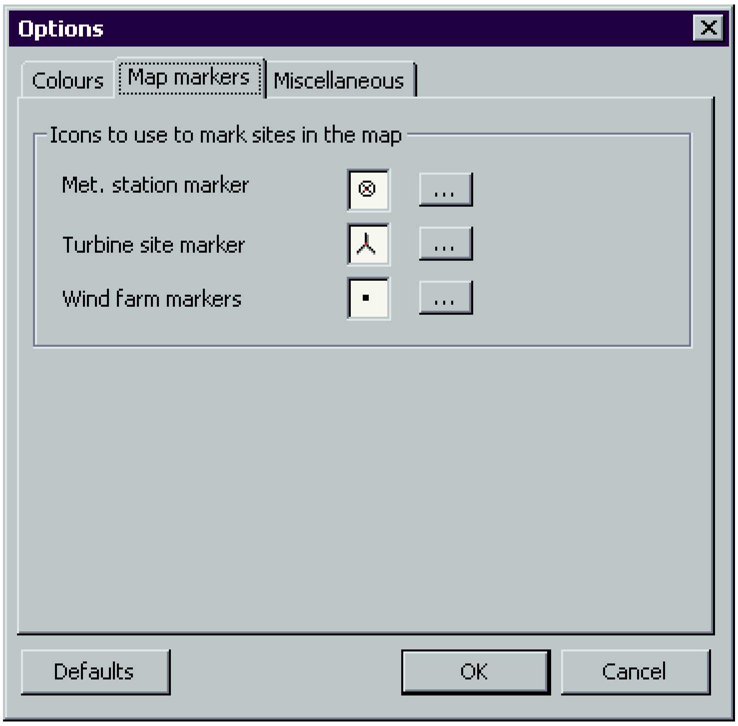
When displaying resource grids, WAsP interpolates between the min and max colours which you select.

If you change a colour, the affected displays will not be immediately adjusted. The next time that they are redrawn, the new colour will be used.

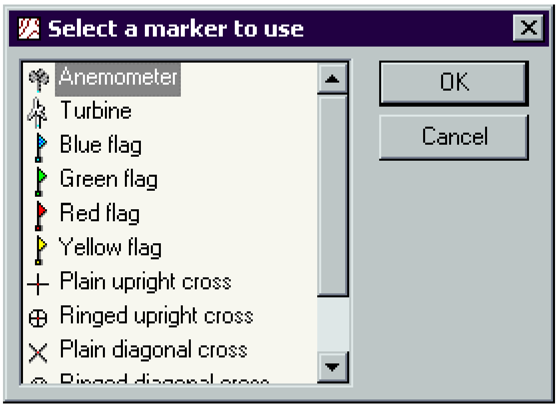
The roughness description colour scale is not editable.

Changing map markers

Here you can choose which marker WAsP should use when indicating the location of met. stations, turbine sites and wind farm sites in the map.



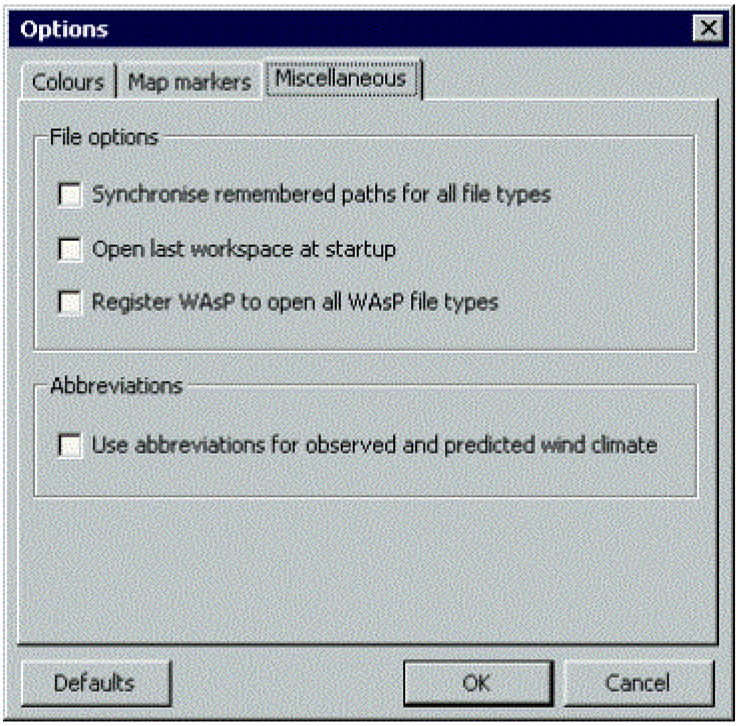
To choose a marker, press the button marked with three dots next to the one you wish to change. Another dialog will appear, displaying a list of markers.



Select a marker from the list.

Miscellaneous options

You can use this part of the options window to change some miscellaneous options.



1. When you open or save a file, WAsP remembers where you found or placed it. Next time you open or save a file of the same type, WAsP will automatically offer you the same directory as you last used. By default, WAsP remembers a separate directory for each type of file, but you can tell WAsP to remember the same directory for all file types. Which setting is best will depend on the way that you work and the way that you organise your files.
2. When WAsP starts, no workspace is open. If you wish, you can tell WAsP to open the workspace which you were last using.
3. When you first run WAsP, the program is associated with several different types of files, so that Windows knows to use WAsP to work with files of those types. It's possible that these settings can be distrupted. Check this box to restore the WAsP file associations. The associations will be restored the next time that you start the WAsP program.
4. The names 'observed wind climate' and 'predicted wind climate' are rather long, and tend to make it difficult to see things in the workspace hierarchy. If you tell WAsP to use abbreviations instead, then 'OWC' and 'PWC' will be used when identifying hierarchy members. This setting will only be effected when you next start WAsP.

WAsP tools

The **Tools** menu is used to launch utility programs from within WAsP. The following tools are available:

- The OWC Wizard
- The WAsP map editor

In addition, the following DOS utility programs are included on the CD-ROM and installed in the WAsP directory:

- The RIX program
- The PARK program

Other software

WAsP is a complete software package for wind data analysis, wind atlas generation, wind resource assessment and siting of wind turbines. Working with wind resource assessment and WAsP in practice, however, requires other pieces of software as well. In addition to a general-purpose office package containing a word-processor, a spreadsheet and a database, the software mentioned below may come in handy if you use WAsP on a regular basis.

Text editor

In order to create, view and edit the contents of text files you need a text editor. You can use **Notepad** to create or edit text files that do not require formatting and are smaller than 64K. Notepad opens and saves text in ASCII (text-only) format only. To create or edit files that require formatting or are larger than 64K, use **WordPad**. Both these text editors are part of your Windows distribution.

File compression software

Some data and WAsP files – in particular the time-series wind data, the terrain map and the resource grid files – can get rather large in size. Software for file size compression and archiving is therefore important, especially if you transfer the files over the Internet or mail them on floppy disks. The **WinZip** software package runs on Windows 95/98/NT4; an evaluation version is available from www.winzip.com.

Digitising software

The creation of a new map by digitisation of paper maps is not possible any more from within the WAsP program. Three possible workarounds are described here. We recommend the **Didger** program from Golden Software for digitisation of maps. The BNA output format from this simple and cheap digitising package can be imported directly by WAsP and the new map editor utility. More information about this program is available from Golden Software.

Graphics and plotting software (2D)

The graphic displays of WAsP data, e.g. of the wind rose, speed distributions or the power curve, can be copied to the Windows clipboard and pasted into your printouts and reports. For even better quality graphics and publication-ready figures, however, you will need dedicated plotting and graphics software: the plotting routines of a spreadsheet program or, better yet, a scientific graphics software package like **Grapher** from Golden Software.

Graphics and plotting software (3D)

Many WAsP input data and results are *spatial* data: the contour and roughness maps, the wind farm layout and the wind resources over an area are important examples. It is of vital importance to be able to display these data and results in the best possible way, so it may be worthwhile to consider a plotting and graphics package specifically designed to illustrate spatial data. The **Surfer** package from Golden Software can make both 2D maps and 3D renderings of you WAsP data.

WAsP Utility Programs

The WAsP Utility Programs is a collection of 16- and 32-bit MS-DOS programs to calculate, analyze, transform, translate, plot, and print WAsP-related data. A brief description of the main features of each of the utility program is given here. Note, that a few utilities have been included in the WAsP 6 package.

Hardware

Site visits to met. stations and wind turbine / wind farm sites are a valuable, and often absolutely necessary, part of wind resource asssessment and siting work. For this, you need a 'real' toolbox...

In the field

For site visits you will at least need the following:

- **Topographical maps** (1:25,000 to 1:100,000). Maps should preferably show the topography at the time of the collection of the met. data, or be as new as possible if you explore the wind resource for wind turbine site assessments. The contour line interval should be 20 m or smaller.
- **Compass** (360-degree). A good-quality, hand-held compass where the divisions are to the nearest degree. A sighting-type model is preferred for taking accurate bearings to nearby obstacles.
- **GPS receiver** (Global Positioning System). A battery-operated, hand-help GPS receiver should be preferred. Remember to use the datum setting corresponding to the map datum.
- **Camera** for taking photographs of the immediate surroundings of the met. station or WT position(s). Take sector-wise photographs from the site for each of 12 30-degree sectors, as well as of the mast set-up and instruments.
- **Measuring tape**. A measuring tape of 25 m or more, to measure the distances to nearby obstacles and, preferably, the actual height of the wind measuring equipment.
- **Summaries of wind measurements**. Statistical summaries of the wind speed and direction data from the met. station. Also, graphical presentations of the same: wind rose plot, wind speed histograms for each sector, etc. Similar information for predicted wind climates.
- **WAsP forms and checklist**. A number of sample forms are provided in the folder \Program Files\Wasp6\Forms. These forms may be used to record characteristics of the wind data, anemometer or wind turbine site, near-by obstacles and surrounding roughness.
- Pocket calculator, notebook, pencil and eraser.

In addition, the following items may come in very handy, though they are not absolutely essential:

- Binoculars
- Odometer or range-finder
- Aerial photographs or satellite imagery

In office

In addition to your PC and a high-quality printer, you may consider:

- **Digitizing tablet** (A3 or larger) for digitizing the height contour and roughness change lines from standard map sheets.
- **Scanner** (flat-bed, A4 or larger) for scanning of background map images to be employed by the MapEdit program.

Units

WAsP uses metric units according to the International System of Units.

Coordinate systems

Three different coordinate systems are used when working with WAsP: geographical coordinates, map coordinates and site-specific coordinates.

Geographical coordinates

Geographical coordinates consist of latitude and longitude and are measured in degrees. Latitude North and longitude East are considered positive, latitude South and longitude West negative. The latitude is used to tell WAsP where on earth the wind measurements were taken so the program can take the earths rotation into account when generating the wind atlas data set. Consequently, the latitude and longitude are used only in the observed wind climate file and when processing a time-series of wind data using the Observed Wind Climate Wizard.

Map coordinates

Map coordinates consist of *x*- and *y*-values in a Cartesian coordinate system and must be given in meters. Any system can be used as long as it is Cartesian and given in meters – the UTM system printed on many maps is an excellent choice. Note, though, that this system changes from one UTM zone to the next, so the entire map should be specified in coordinates corresponding to one UTM zone only. The elevation of height contour lines must also be given in meters, usually above mean sea level [m a.s.l.]. If the map coordinates or elevations are not given in meters these may be transformed on the basis of two fixed points and a linear height transformation, such transformations can be specified directly in the map file.

Site-specific coordinates

Site-specific coordinates are used only when specifying any obstacles relative to the site. The position of an obstacle is specified by two angles (measured from North through 360º clockwise) and two distances, see the obstacle list file. The distances are measured in meters.

About project parameters

The behaviour of the WAsP models can be adjusted by making alterations to model parameters. The parameters are used whenever a calculation is performed, such as when a met. station calculates a wind atlas.

A unique parameter set is associated with each WAsP project. All members which are children of the project will make use of the same parameters. It's possible to have a workspace which contains two projects (say, for example, one from Iran and another from Europe) and for the calculations performed within each project to use completely different parameter values.

WAsP parameters

The project-specific parameters can be viewed and edited in the WAsP Project's methods by invoking **Edit parameters**. The default value and allowable range for each parameter is given below. Parameters #2-6 and #8-12 must of course increase progressively.

#	Description	Default	Range	Old #
1	Number of standard heights for LIB files	5	2-5	12
2	Standard height #1	10	5-200	13
3	Standard height #2	25	5-200	14
4	Standard height #3	50	5-200	15
5	Standard height #4	100	5-200	16
6	Standard height #5	200	5-200	17
7	Number of roughnesses classes for LIB file	4	2-5	18
8	Standard roughness length #1	0.00	0-2.0	19
9	Standard roughness length #2	0.03	0-2.0	20
10	Standard roughness length #3	0.10	0-2.0	21
11	Standard roughness length #4	0.40	0-2.0	22
12	Standard roughness length #5	1.00	0-2.0	23

#	Description	Default	Range	Old #
13	Width of coastal zone	10000	0-20000	2
14	Depth of daily variation over land	100	50-300	3

15 Rel. amplitude of daily variation near ground	0.12	0.01-0.25	4
16 Average offset over land from neutral at $z=P_2$	0.11	0.01-0.25	5
17 Height of inversion in BZ model	1000	100-5000	6
18 Softness of inversion in BZ model	1	0-1	7
19 Decay-length for roughness area size	10^4	10^3-10^6	31
20 True upwind direction in BZ model	false	false/true	34
21 Azimuth resolution in BZ model	5	1-15	42
22 Depth of daily variation over water	50	25-300	51
23 Factor in height of min. stab. induced var.	$2 \cdot 10^{-3}$	0-$5 \cdot 10^{-3}$	54
24 Rms heatflux over land	100	0-200	56
25 Rms heatflux over water	30	0-200	57
26 Offset heatflux over land	-40	-200-200	58
27 Offset heatflux over water	15	-200-200	59
28 Sub-sectors in roughness map analysis	6	1-9	65
29 Max. number of roughness changes per sector	7	1-10	67
30 Max. interpolation radius in BZ model	$2 \cdot 10^4$	10^4-$5 \cdot 10^4$	75

WAsP file formats

WAsP uses several different types of disk files that you should be aware of, or even familiar with. These files are used to store information required by WAsP during execution. Some of the files can be generated by storing the information entered during a session, while others must be prepared beforehand. To avoid confusion and enhance systematics WAsP assumes a default file name extension with each of the file types:

Hierarchy member	Extension
WAsP workspace	WWK
WAsP project	WPR
Meteorological station	WMS
Observed wind climate	TAB
Terrain map	MAP

Obstacle list	OBS
Roughness description	RRD
User corrections	UCF
Wind atlas	LIB
Wind turbine site	WTS
Predicted wind climate	WPW
Wind turbine power curve	POW
Wind farm	RSF
Resource grid	WRG

With these default file name extensions, the files will be recognised by e.g. Windows Explorer as WAsP files. However, you may also specify the name completely and thereby override the default choice. Short descriptions of these files and their formats are given in the following topics.

The WAsP workspace file

The WAsP workspace file contains information on (pointers to) the hierarchy members associated with a WAsP workspace.

Data are stored in an ASCII (text) file with the default file name extension WWK. This file is created and maintained entirely by the WAsP program and the format is therefore not of interest here.

The WAsP project file

The WAsP project file contains information on (pointers to) the hierarchy members associated with a WAsP project.

Data are stored in an ASCII (text) file with the default file name extension WPR. This file is created and maintained entirely by the WAsP program and the format is therefore not of interest here.

The meteorological station file

The meteorological station file contains the map coordinates of the wind mast as well as information on (pointers to) the observed wind climate and other hierarchy members associated with the meteorological station.

Data are stored in an ASCII (text) file with the default file name extension WMS. This file is created and maintained entirely by the WAsP program and the format is therefore not of interest here.

The observed wind climate file

The observed wind climate file contains the frequencies of occurrence of the wind in a number of sectors (the wind rose) and wind speed bins. It further contains the height of observation above ground level and the geographical coordinates (latitude and longitude) of the wind mast.

Data are stored in an ASCII (text) file with the default file name extension TAB. The TAB-file can be generated by the Observed Wind Climate Wizard or may be prepared from a climatological table using a text editor.

The general format of the file is shown below. Numbers in the same line of the file must be separated by blank space(s) or a comma.

Line	**Contents**

1 Text string identifying the observed wind climate/anemometer

2 Latitude [°], Longitude [°] and height a.g.l. of anemometer [m]

3 Number of sectors, speed factor *au* and direction offset *bd* [°]

wind speed bin limits [ms^{-1}] = *au* · {column 1}

wind rose rotated by b_d

4 Sector-wise frequencies of occurrence [%]

5 Upper limit for speed class 1, sector-wise frequencies in class 1

6 Upper limit for speed class 2, sector-wise frequencies in class 2

7–*n* Same as line 5 and 6, but for speed class 3–*n*

The speed distributions may be described by a maximum of 50 wind speed bins and 36 sectors. The wind speed bins need not have the same width; however, the sectors are considered of equal angular width.

Special considerations

The location/position of the observed wind climate must be given in geographical coordinates, i.e. as latitude and longitude in decimal degrees. Conventionally, latitude N and longitude E are considered positive; latitude S and longitude W negative. Latitude can thus take values between -90º and +90º and longitude values between -180º and +180º.

Example

The following window shows part of an observed wind climate file, opened in the Notepad text editor.

Airport.tab - Notepad

File Edit Search Help

```
Waspdale Airport 1983-85. Runway NW anemometer.
  167.90   55.70   12.0
      12    1.00    0.00
            1.96    4.44    5.63    7.49    6.24   5
     1.0   47.9    31.7    23.0    34.5    28.2    4
     2.0  173.7    89.9   158.7   112.9   113.0    8
     3.0  311.4   201.1   250.5   225.7   201.5   17
     4.0  143.7   240.7   263.0   235.1   218.5   24
     5.0  167.7   169.3   137.8   213.2   210.9   21
     6.0  131.7   121.7    73.1   125.4   148.8   15
     7.0   24.0    47.6    43.8    37.6    37.7    4
     8.0    0.0    66.1    27.1    12.5    24.5    1
     9.0    0.0    21.2    12.5     3.1    13.2
    10.0    0.0     7.9     2.1     0.0     3.8    1
    11.0    0.0     2.6     8.4     0.0     0.0
    12.0    0.0     0.0     0.0     0.0     0.0
    13.0    0.0     0.0     0.0     0.0     0.0
    14.0    0.0     0.0     0.0     0.0     0.0
    15.0    0.0     0.0     0.0     0.0     0.0
    16.0    0.0     0.0     0.0     0.0     0.0
    17.0    0.0     0.0     0.0     0.0     0.0
    18.0    0.0     0.0     0.0     0.0     0.0
    19.0    0.0     0.0     0.0     0.0     0.0
    20.0    0.0     0.0     0.0     0.0     0.0
    21.0    0.0     0.0     0.0     0.0     0.0
    22.0    0.0     0.0     0.0     0.0     0.0
```

The terrain map file

The terrain map file contains digital height contour lines and/or roughness change lines. Three types of lines are recognized:

1. Height contours, characterized by their elevation [m a.g.l.]
2. Roughness change lines, characterized by the roughness lengths on either side of the line. The two roughness lengths are given in [m].
3. Combined height contours/roughness change lines. A coast line, for example, is characterized by its elevation (usually 0 m a.g.l.) and also marks the roughness change between water and land.

Data are stored in an ASCII (text) file with the default file name extension MAP. The MAP-file can be established by digitization from a map sheet or may be prepared by reformatting existing digital map information.

The general format of the file is shown below. Numbers in the same line of the file must be separated by blank space(s) or a comma.

Line	**Contents**
1	Text string identifying the terrain map: + ...
2	Fixed point #1 in user and metric [m] coordinates:
	X_1(user) Y_1(user) X_1(metric) Y_1(metric)
3	Fixed point #2 in user and metric [m] coordinates:

X_2(user) Y_2(user) X_2(metric) Y_2(metric)

4 Scaling factor and offset for height scale (Z):

Z_{metric} = {scaling factor}(Z_{user} + {offset})

5a Height contour: elevation (Z) and number of points (n) in line:

Z n

5b Roughness change line: roughness lengths to the left (z_{0l}) and right (z_{0r}) side of the line, respectively, and number of points:

$z_{0l} z_{0r} n$

5c Roughness and contour line: roughness lengths to the left and right of the line, respectively, elevation and number of points:

$z_{0l} z_{0r}$ Z n

6– Cartesian coordinates (X, Y) of line described in 5a, 5b or 5c:

$X_1 Y1$ [... Xn Yn]

$Xn_{+1} Yn+1$

... where [] embrace optional numbers and n is > 0

The pattern given in line 5 (a, b **or** c) and 6 is repeated as many times as there are height contours/roughness change lines in the file. Each line in the map must be described by a minimum of two points.

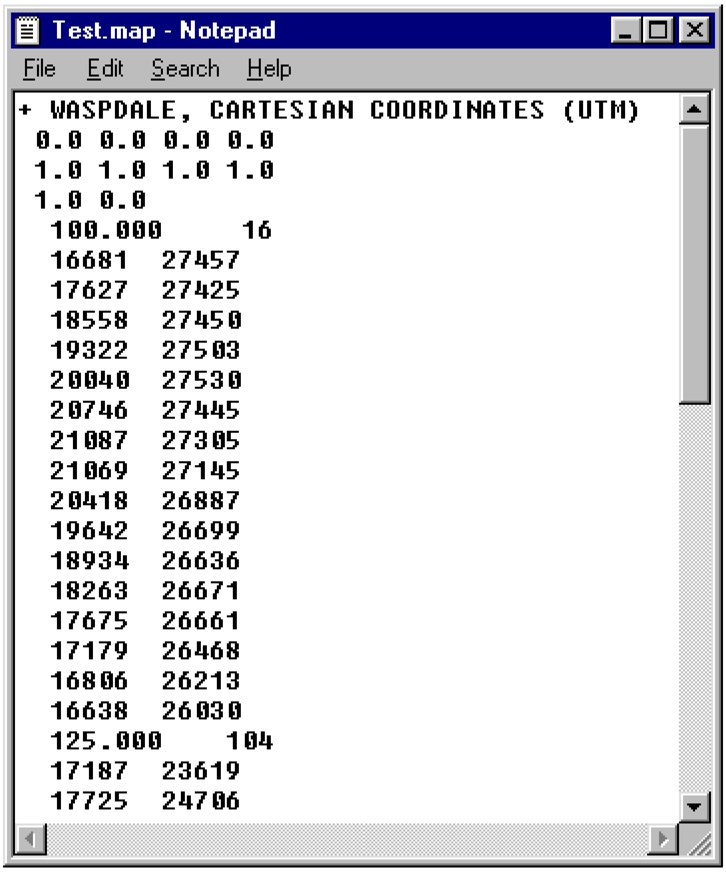
Coordinates and transformation

The '+'-sign in column one of the first line of the file indicates that coordinates in the file are Cartesian. Earlier versions of WAsP (4.X and 5.X) can also read maps given in polar coordinates.

Line 2 and 3 specify a simple coordinate transformation from user coordinates (the numbers given in the file, from line 6 and onwards) to metric coordinates. If the user coodinates given in the file are metric and absolute (like the UTM system provided on many maps), line 2-3 may be replaced by a single line containing non-numeric input.

Example

The following window shows part of a map file, opened in the Notepad text editor. In this case there is no transformation of coordinates (line 2-3) or the elevation values (line 4): the coordinates and elevations are given in [m].



The obstacle list file

The obstacle list file contains the position, size and porosity of any sheltering obstacles close to the site.

Data are stored in an ASCII (text) file with the default file name extension OBS. The OBS-file can be established by entering the information in a WAsP session and subsequently storing the file – or it can be prepared using a text editor.

The general format of the file is shown below. Numbers in the same line of the file must be separated by blank space(s) or a comma.

Line	Contents
1	Text string identifying the obstacle list
2	A_1 [°] R_1 [m] A_2 [°] R_2 [m] h [m] D [m] P [0-1] Characteristics of obstacle #1: Angle (A_1) and distance (R_1) to first corner of obstacle, angle (A_2) and distance (R_2) to second corner, height (h), depth (D) and porosity (P) of obstacle.
3	Characteristics of obstacle #2, format like line 2
n	Characteristics of obstacle #(n-1), $n < 52$

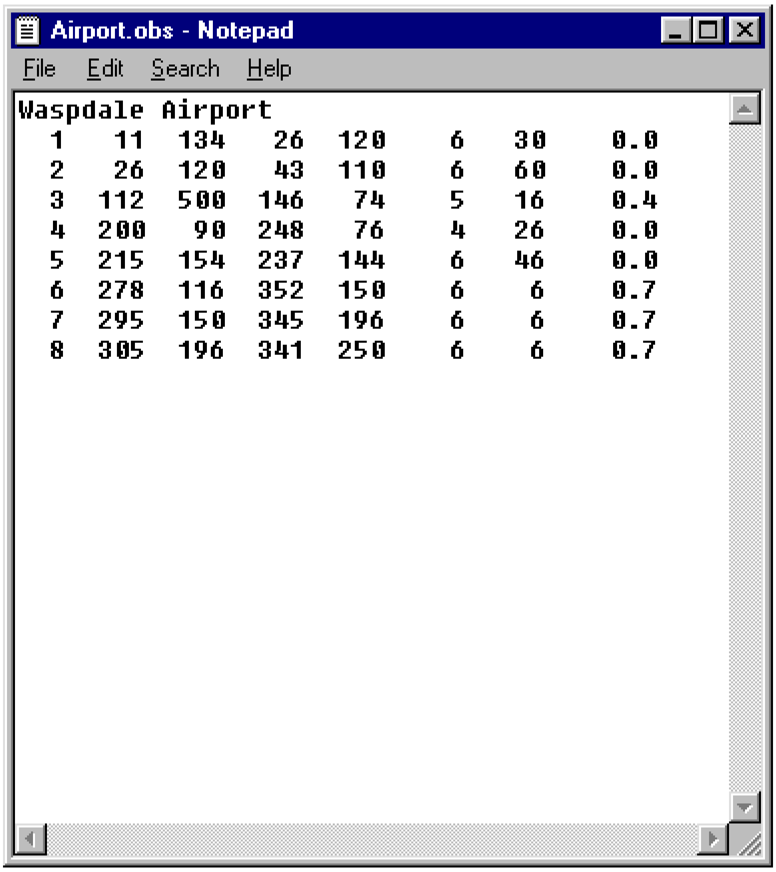
The pattern given in line 2 is repeated as many times as there are obstacles in the file. The obstacle list may contain a maximum of 50 obstacle specifications.

Coordinates

The position of an obstacle is specified in a local, polar coordinate system. Angles (bearings measured with a compass) are given clockwise from north, distance is the length of the radial from the site to the corner of the obstacle (measured with a measuring tape or a range finder). Obstacles are thus specified relative to the specific site and are not linked directly to the terrain map.

Example

The following window shows an obstacle list file, opened with the Notepad text editor. Eight obstacles are specified in the file.




```
Waspdale Airport
  1   11  134   26  120    6   30    0.0
  2   26  120   43  110    6   60    0.0
  3  112  500  146   74    5   16    0.4
  4  200   90  248   76    4   26    0.0
  5  215  154  237  144    6   46    0.0
  6  278  116  352  150    6    6    0.7
  7  295  150  345  196    6    6    0.7
  8  305  196  341  250    6    6    0.7
```

The roughness description file

The roughness description file contains the roughness rose for a site, i.e. sector-wise specifications of the roughness lengths and roughness changes.

Data are stored in an ASCII (text) file with the default file name extension RRD. The RRD-file can be obtained from the roughness description given in a WAsP map or from an existing DOS-WAsP roughness description file (RDS).

The general format of the file is shown below. Numbers in the same line of the file must be separated by blank space(s) or a comma.

Line	Contents
1	Version indication text, e.g. 'WASP 6.0 RRD'
2	Text string identifying the roughness rose description
3	Number of sectors in roughness rose description

4 Numbers of roughness changes in each sector

5 Roughness lengths next to the site [m] in sectors 1-*n*

6 Distances [m] to first roughness change in sectors 1-*n*

7 Roughness lengths beyond first roughness change

even ... more roughness change distances [m]

odd ... more roughness lengths [m]

Distances and roughness lengths written in a similar way as in lines 6-7 are repeated as many times as the number of roughness changes specified in line 4. With no roughness changes in any sector, line 5 would be the last line of the file. A maximum of 10 roughness changes in each sector is allowed.

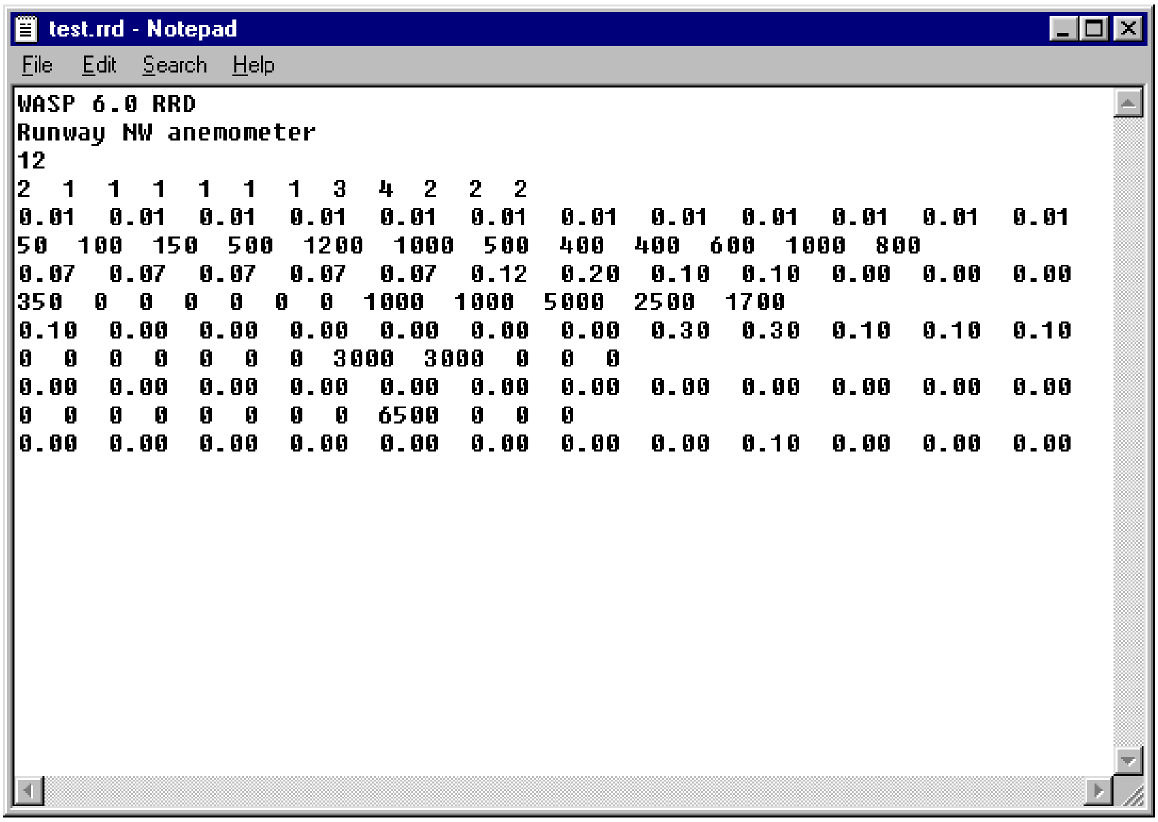
The development of the RRD-file is described in more detail here.

Special considerations

The roughness rose can be displayed and edited from within WAsP. Changes to the roughnesses and roughness change distances can also be entered directly in the file using a text editor.

Example

The following window shows part of a roughness description file, opened in the Notepad text editor.




```
WASP 6.0 RRD
Runway NW anemometer
12
2  1  1  1  1  1  1  3  4  2  2  2
0.01  0.01  0.01  0.01  0.01  0.01  0.01  0.01  0.01  0.01  0.01  0.01
50  100  150  500  1200  1000  500  400  400  600  1000  800
0.07  0.07  0.07  0.07  0.07  0.12  0.20  0.10  0.10  0.00  0.00  0.00
350  0  0  0  0  0  0  1000  1000  5000  2500  1700
0.10  0.00  0.00  0.00  0.00  0.00  0.00  0.30  0.30  0.10  0.10  0.10
0  0  0  0  0  0  0  3000  3000  0  0  0
0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00
0  0  0  0  0  0  0  0  6500  0  0  0
0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.10  0.00  0.00  0.00
```

The user corrections file

The user corrections file contains user-specified correction factors for wind speed and user-specified correction angles for wind direction for each sector.

Data are stored in an ASCII (text) file with the default file name extension UCF. The UCF-file can be generated from an existing DOS-WAsP roughness description file (RDS) or may be prepared using a text editor.

The general format of the file is shown below. Numbers in the same line of the file must be separated by blank space(s) or a comma.

Line	Contents
1	Version indication text, e.g. 'WASP 6.0 UCF'
2	Text string identifying the user-specified corrections
3	Number of sectors
4	Sector-wise correction factors for wind speed
5	Sector-wise correction angles for wind direction [º]

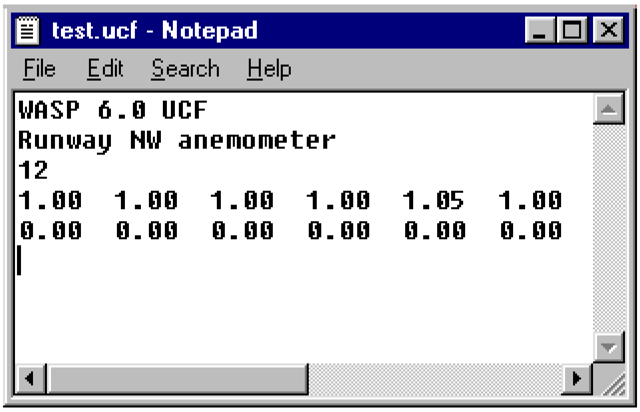
The development of the UCF-file is described in more detail here.

Special considerations

The user corrections can be displayed, but not edited, from within WAsP. Any changes to the user corrections must be entered directly in the file using a text editor.

Example

The following window shows part of a user corrections file, opened in the Notepad text editor. Only corrections for the first six sectors are shown.



The wind atlas file

The wind atlas file contains the sector-wise frequency of occurrence of the wind (the wind rose) as well as the wind speed frequency distributions in the same sectors (as Weibull *A*- and *k*-parameters). The wind climates are specified for a number of reference roughnesses (roughness classes) and heights above ground level.

Data are stored in an ASCII (text) file with the default file name extension LIB. The LIB-file is created by WAsP from an observed wind climate, transforming the local (site-specific) wind climate into regional (site-independent) descriptions of the wind climate.

The general format of the file is shown below. Numbers in the same line of the file must be separated by blank space(s) or a comma.

Line	Contents

1	Text string identifying the wind atlas file
2	Number of roughness classes, heights and sectors in data set
	Default values are: 4, 5 and 12
3	Reference roughness lengths [m]
	Default values are: 0.0, 0.03, 0.10 and 0.40 m
4	Reference heights above ground level [m]
	Default values are: 10, 25, 50, 100 and 200 m a.g.l.
5	Frequencies of occurrence for **reference roughness #1** (0 m)
6	Weibull *A*-parameters for reference height #1 (10 m) in [ms^{-1}]
7	Weibull *k*-parameters for reference height #1 (10 m)
8-9	Weibull *A*- and *k*-parameters for reference height #2 (25 m)
10-11	Weibull *A*- and *k*-parameters for reference height #3 (50 m)
12-13	Weibull *A*- and *k*-parameters for reference height #4 (100 m)
14-15	Weibull *A*- and *k*-parameters for reference height #5 (200 m)
16-26	As lines 5-15, but for **reference roughness #2** (0.03 m)
27-37	As lines 5-15, but for **reference roughness #3** (0.10 m)
38-48	As lines 5-15, but for **reference roughness #4** (0.40 m)

The wind speed and direction distributions may be given for a maximum of 5 reference roughnesses (roughness classes), 5 heights and 36 sectors.

Example

The following window shows part of a wind atlas file, opened in the Notepad text editor. Only the first seven sectors are shown.

```
WAsP Airport 1983-85. Runway NW anemometer.
  4   5  12
 0.000 0.030 0.100 0.400
  10.0   25.0   50.0  100.0  200.0
  2.51   4.73   6.08   7.25   5.98   5.80   7.81
  4.88   5.41   4.99   5.39   6.08   5.99   6.43
 2.346 2.303 2.346 2.971 2.795 2.674 2.615
  5.34   5.92   5.46   5.89   6.64   6.55   7.03
 2.420 2.373 2.420 3.064 2.885 2.756 2.697
  5.73   6.36   5.86   6.32   7.13   7.02   7.55
 2.482 2.439 2.486 3.143 2.959 2.830 2.771
  6.22   6.90   6.36   6.87   7.74   7.62   8.19
 2.404 2.361 2.404 3.045 2.865 2.740 2.682
  6.88   7.63   7.04   7.61   8.57   8.44   9.07
 2.275 2.236 2.279 2.881 2.713 2.596 2.541
  2.27   4.34   5.60   7.47   6.34   5.25   7.67
  3.21   3.95   3.42   3.68   4.30   4.08   4.55
 2.045 2.037 1.811 2.674 2.338 2.307 2.178
  3.84   4.73   4.11   4.39   5.14   4.88   5.44
 2.209 2.201 1.955 2.889 2.525 2.494 2.354
  4.43   5.46   4.76   5.06   5.92   5.62   6.28
 2.486 2.475 2.197 3.244 2.842 2.803 2.646
  5.26   6.47   5.65   5.99   7.02   6.66   7.44
 2.646 2.635 2.342 3.455 3.025 2.982 2.818
```

The wind turbine site file

The wind turbine site file contains the map coordinates of the wind turbine site and the height above ground level [m a.g.l.] for which the calculations are carried out. It further contains information on (pointers to) the predicted wind climate and other hierarchy members associated with the turbine site.

Data are stored in an ASCII (text) file with the default file name extension WTS. This file is created and maintained entirely by the WAsP program and the format is therefore not of interest here.

The predicted wind climate file

The predicted wind climate file contains the estimated overall wind climate, energy density and power production for a wind turbine site. Furthermore, it contains detailed results on the wind climate, energy density, power production and modelling corrections for each of the sectors.

Data are stored in an ASCII (text) file with the default file name extension WPW. The WPW-file is generated by saving the results of a wind turbine calculation. The general format of the file is shown below.

Line	Contents
1	Version indication text, e.g. 'WASP 6.0 SITE DMP'
2	The sector-independent results for the site
3	Results for sector #1
4	Results for sector #2

...

n Results for sector #*m*

The format of each line in the file is shown below. Numbers in the same line of the file are/must be separated by blank space(s) or a comma.

Column		Contents of line 2
1	A	Height above ground level [m a.g.l.]
2	B	Weibull *A*-parameter for total distribution [ms^{-1}]
3	C	Weibull *k*-parameter for total distribution
4	D	Total mean wind speed [ms^{-1}]
5	E	Total energy density [Wm^{-2}]
6	F	Total power production [Why^{-1}]
7	G	Number of sectors
8	H	Site elevation [m a.s.l.]

Column		Contents of line 3-*n*
1	A	Centre angle of the sector
2	B	Frequency of occurrence [%]
3	C	Weibull *A*-parameter for the sector [ms^{-1}]
4	D	Weibull *k*-parameter for the sector
5	E	User-specified correction factor for the sector
6	F	User-specified correction angle for the sector
7	G	Obstacle model correction for wind speed
8	H	Obstacle model correction for wind direction
9	I	Orographic model correction for wind speed
10	J	Orographic model correction for wind direction
11	K	Roughness model correction for wind speed

12	L	Roughness model correction for wind direction
13	M	Number of roughness changes in sector
14	N	Meso-scale roughness length of sector
15	O	Energy density [Wm^{-2}]
16	P	Power production [Why^{-1}]

Example

The following window shows part of a predicted wind climate file, opened in the Notepad text editor. Only the first 6 columns of numbers in each line are shown.

Passat.wpw - Notepad

File Edit Search Help

```
WASP 6.0 SITE DMP
  4.45000e+001  7.00920e+000  1.91992e+000  6.21773e+000  2.93313e+002  1.16852e+009
             0  4.36181e+000  5.12389e+000  1.87305e+000  0.00000e+000  0.00000e+000
            30  4.60184e+000  4.74236e+000  1.53320e+000  0.00000e+000  0.00000e+000
            60  6.53998e+000  6.46900e+000  1.87305e+000  0.00000e+000  0.00000e+000
            90  8.71386e+000  6.64068e+000  1.88477e+000  0.00000e+000  0.00000e+000
           120  1.05242e+001  7.48601e+000  2.06836e+000  0.00000e+000  0.00000e+000
           150  6.75899e+000  6.52129e+000  1.92383e+000  0.00000e+000  0.00000e+000
           180  7.35498e+000  6.71639e+000  2.04883e+000  0.00000e+000  0.00000e+000
           210  9.78382e+000  7.54837e+000  1.97070e+000  0.00000e+000  0.00000e+000
           240  1.16396e+001  7.58285e+000  2.11523e+000  0.00000e+000  0.00000e+000
           270  1.39035e+001  7.42894e+000  1.92383e+000  0.00000e+000  0.00000e+000
           300  1.04883e+001  7.94614e+000  2.13477e+000  0.00000e+000  0.00000e+000
           330  5.32919e+000  6.69440e+000  1.92773e+000  0.00000e+000  0.00000e+000
```

The power curve file

The power curve file contains the wind turbine power output and, optionally, the thrust coefficient as a function of hub-height wind speed.

Data are stored in an ASCII (text) file with the default file name extension POW. The power curve file must be prepared using a text editor. The WAsP package contains a number of power curves obtained from the Danish manufacturers.

The general format of the file is shown below. Numbers in the same line of the file must be separated by blank space(s) or a comma.

Line	**Contents**
1	Text string identifying the wind turbine power curve
2	Wind turbine hub height [m] and rotor diameter [m]
3	Conversion factors for wind speed f_u and power f_p:
	wind speed [ms^{-1}] = $f_u \cdot$ {column 1}
	power output [W] = $f_p \cdot$ {column 2}
4–	wind speed, power output, thrust coefficient (optional)

The power curve may be described by a maximum of 100 points and power production is calculated for the entire interval of wind speeds given in the file.

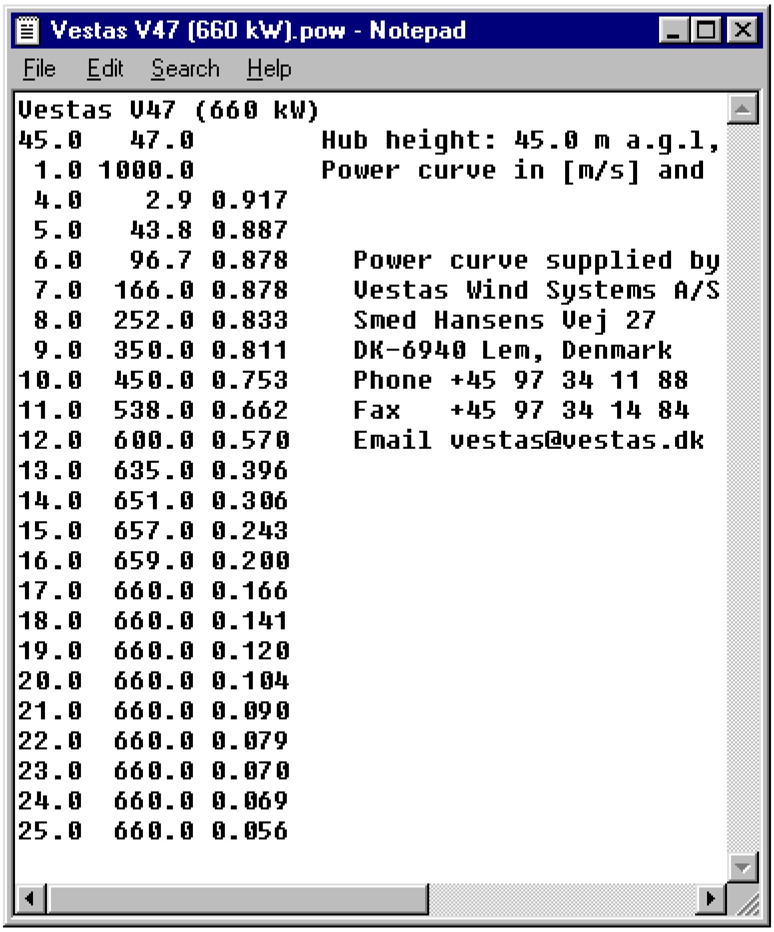
Special considerations

The two numbers given in line 3 are simply the conversion factors from the units of wind speed and power output used in the file to [ms^{-1}] and [W], respectively. Thus, if power output is given in [kW], the factor for power should be 1000.

The factor for power output can also be used to estimate power production at an air density different from the standard value (1.225 kgm^{-3} at 1013.25 hPa and 288 K) by multiplying this factor with the ratio of the two air densities. Thus, if the average air temperature is 20 degrees C and the site elevation is 400 m above sea level (and power output is given in kW at standard conditions) the factor should be changed to 938.8. A site-specific power curve may also be obtained from the wind turbine manufacturer.

Example

The following window shows the power curve file of a Vestas V47 660-kW wind turbine, opened in the Notepad text editor.




```
Vestas V47 (660 kW)
45.0   47.0         Hub height: 45.0 m a.g.l,
 1.0 1000.0         Power curve in [m/s] and
 4.0    2.9 0.917
 5.0   43.8 0.887
 6.0   96.7 0.878     Power curve supplied by
 7.0  166.0 0.878     Vestas Wind Systems A/S
 8.0  252.0 0.833     Smed Hansens Vej 27
 9.0  350.0 0.811     DK-6940 Lem, Denmark
10.0  450.0 0.753     Phone +45 97 34 11 88
11.0  538.0 0.662     Fax   +45 97 34 14 84
12.0  600.0 0.570     Email vestas@vestas.dk
13.0  635.0 0.396
14.0  651.0 0.306
15.0  657.0 0.243
16.0  659.0 0.200
17.0  660.0 0.166
18.0  660.0 0.141
19.0  660.0 0.120
20.0  660.0 0.104
21.0  660.0 0.090
22.0  660.0 0.079
23.0  660.0 0.070
24.0  660.0 0.069
25.0  660.0 0.056
```

The wind farm file

The wind farm file contains the coordinates, height above ground level, estimated overall wind climate and estimated energy density or power production for each of a number of sites in a wind farm. It further contains the wind rose and sector-wise wind speed distributions for each site.

Data are stored in an ASCII (text) file with the default file name extension RSF. The RSF-file is generated by saving the results of a wind farm calculation. The wind farm layout (the labels and *X*- and *Y*-coordinates) can be entered in a new wind farm view, imported as an existing RSF-file or may be prepared with a text editor.

The general format of the file is shown below.

Line	Contents
1	Results for site #1
2	Results for site #2
	...
n	Results for site #*n*

The format of each line in the file is shown below. Numbers in the same line of the file are/must be separated by blank space(s) or a comma.

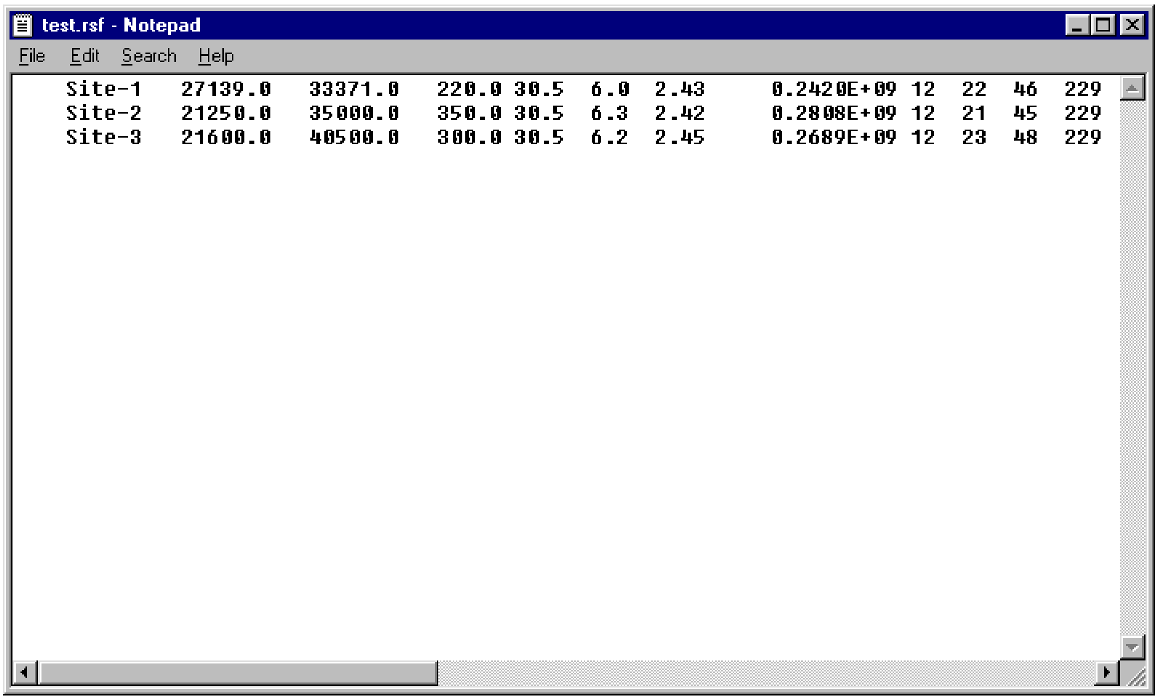
Column		Contents
1	A	Text string (10 characters) identifying the site/WT
2	B	*X*-coordinate (easting) of the site [m]
3	C	*Y*-coordinate (northing) of the site [m]
4	D	*Z*-coordinate (elevation) of the site [m]
5	E	Height above ground level [m a.g.l.]
6	F	Weibull *A*-parameter for the total distribution [ms^{-1}]
7	G	Weibull *k*-parameter for the total distribution
8	H	Energy density [Wm^{-2}] or power production [Why^{-1}]
9	I	Number of sectors
10	J	Frequency of occurrence for sector #1 [%·10]
11	K	Weibull *A*-parameter for sector #1 [ms^{-1}·10]
12	L	Weibull *k*-parameter for sector #1 [·100]
13-15	M-O	As columns 10-12 (J-L), but for sector #2
...	...	...
43-45	AQ-AS	As columns 10-12 (J-L), but for sector #12

Special considerations

Exiting wind farm layouts can be employed by inserting an existing wind farm file to your project.

Example

The following window shows part of a wind farm file, opened in the Notepad text editor. Only the first 12 columns of numbers in each line are shown.




```
Site-1   27139.0   33371.0   220.0 30.5  6.0  2.43    0.2420E+09 12  22  46  229
Site-2   21250.0   35000.0   350.0 30.5  6.3  2.42    0.2808E+09 12  21  45  229
Site-3   21600.0   40500.0   300.0 30.5  6.2  2.45    0.2689E+09 12  23  48  229
```

The resource grid file

The resource grid file contains the coordinates, height above ground level, estimated overall wind climate and estimated energy density or power production for each of a number of sites in a resource grid; which is simply a regular grid of sites. It further contains the wind rose and sector-wise wind speed distributions for each node point in the grid.

Data are stored in an ASCII (text) file with the default file name extension WRG. The WRG-file is generated by saving the results of a resource grid calculation.

The general format of the file is shown below.

Line	Contents
1	N_x N_y X_{min} Y_{min} {*cell size*}
	N_x is the number of grid points in the *X*-direction
	N_y is the number of grid points in the *Y*-direction
	X_{min} is the *X*-coordinate of the lower left corner of the grid [m]
	Y_{min} is the *Y*-coordinate of the lower left corner of the grid [m]
	{*cell size*} is the regular resource grid cell size [m]
2	Results for site #1
3	Results for site #2

...

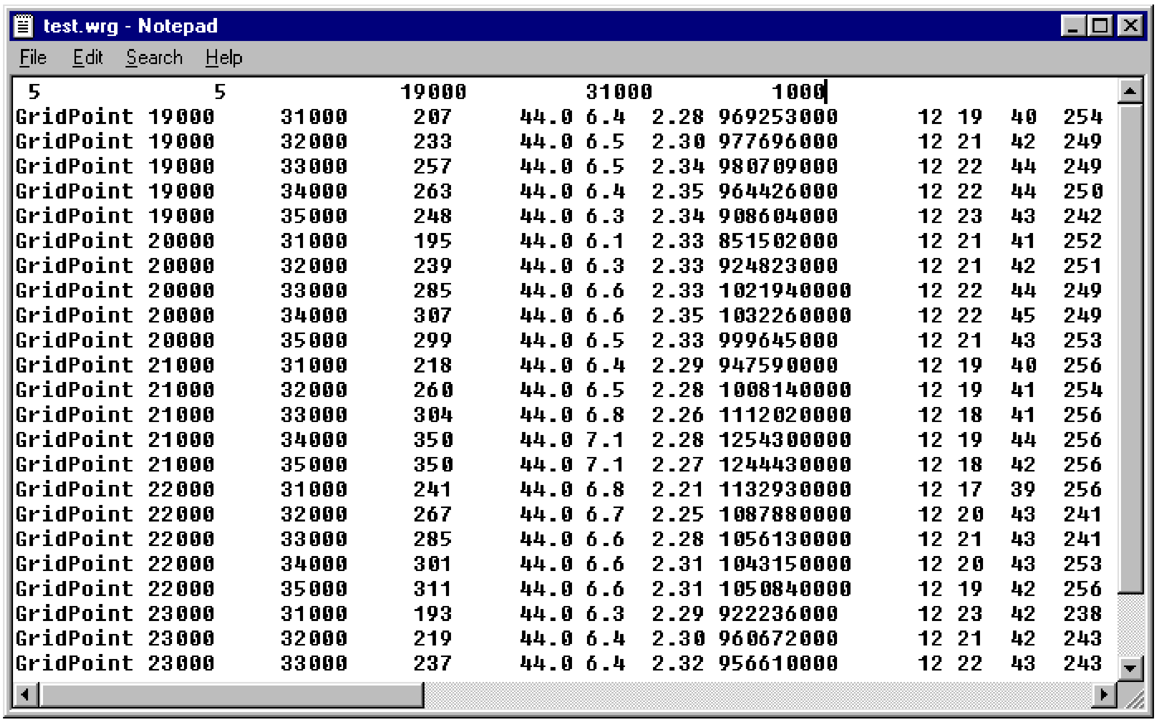
n+1 Results for site #*n*

The format of each line in the file is shown below. Numbers in the same line of the file are/must be separated by blank space(s) or a comma.

Column		Contents
1	A	Text string (10 characters) identifying the site/grid point
2	B	*X*-coordinate (easting) of the site [m]
3	C	*Y*-coordinate (northing) of the site [m]
4	D	*Z*-coordinate (elevation) of the site [m]
5	E	Height above ground level [m a.g.l.]
6	F	Weibull *A*-parameter for the total distribution [ms^{-1}]
7	G	Weibull *k*-parameter for the total distribution
8	H	Energy density [Wm^{-2}] or power production [Why^{-1}]
9	I	Number of sectors
10	J	Frequency of occurrence for sector #1 [%·10]
11	K	Weibull *A*-parameter for sector #1 [ms^{-1}·10]
12	L	Weibull *k*-parameter for sector #1 [·100]
13-15	M-O	As columns 10-12 (J-L), but for sector #2
...	...	...
43-45	AQ-AS	As columns 10-12 (J-L), but for sector #12

Example

The following window shows part of a resource grid file, opened in the Notepad text editor. Only the first 12 columns of numbers in each line are shown.




```
 5              5              19000          31000          1000
GridPoint 19000     31000      207     44.0 6.4   2.28 969253000       12  19   40   254
GridPoint 19000     32000      233     44.0 6.5   2.30 977696000       12  21   42   249
GridPoint 19000     33000      257     44.0 6.5   2.34 980709000       12  22   44   249
GridPoint 19000     34000      263     44.0 6.4   2.35 964426000       12  22   44   250
GridPoint 19000     35000      248     44.0 6.3   2.34 908604000       12  23   43   242
GridPoint 20000     31000      195     44.0 6.1   2.33 851502000       12  21   41   252
GridPoint 20000     32000      239     44.0 6.3   2.33 924823000       12  21   42   251
GridPoint 20000     33000      285     44.0 6.6   2.33 1021940000      12  22   44   249
GridPoint 20000     34000      307     44.0 6.6   2.35 1032260000      12  22   45   249
GridPoint 20000     35000      299     44.0 6.5   2.33 999645000       12  21   43   253
GridPoint 21000     31000      218     44.0 6.4   2.29 947590000       12  19   40   256
GridPoint 21000     32000      260     44.0 6.5   2.28 1008140000      12  19   41   254
GridPoint 21000     33000      304     44.0 6.8   2.26 1112020000      12  18   41   256
GridPoint 21000     34000      350     44.0 7.1   2.28 1254300000      12  19   44   256
GridPoint 21000     35000      350     44.0 7.1   2.27 1244430000      12  18   42   256
GridPoint 22000     31000      241     44.0 6.8   2.21 1132930000      12  17   39   256
GridPoint 22000     32000      267     44.0 6.7   2.25 1087880000      12  20   43   241
GridPoint 22000     33000      285     44.0 6.6   2.28 1056130000      12  21   43   241
GridPoint 22000     34000      301     44.0 6.6   2.31 1043150000      12  20   43   253
GridPoint 22000     35000      311     44.0 6.6   2.31 1050840000      12  19   42   256
GridPoint 23000     31000      193     44.0 6.3   2.29 922236000       12  23   42   238
GridPoint 23000     32000      219     44.0 6.4   2.30 960672000       12  21   42   243
GridPoint 23000     33000      237     44.0 6.4   2.32 956610000       12  22   43   243
```

Terrain map files in BNA format

In general, terrain map files contain digital height contour lines and/or roughness change lines. Three types of lines are recognized:

1. Height contours, characterized by their elevation [m a.g.l.]
2. Roughness change lines, characterized by the roughness lengths on either side of the line. The two roughness lengths are given in [m].
3. Combined height contours/roughness change lines. A coast line, for example, is characterized by its elevation (usually 0 m a.g.l.) and also marks the roughness change between water and land.

The atlas BNA-file is an ASCII (text) file with the default file name extension BNA. The map information is stored as points, polygons and polylines, and the map coordinates must be in meters. A BNA-file can be established by digitization from a map sheet or may be prepared by reformatting digital map information. The BNA-format is one of the export formats recognised by Golden Software's Didger program, a digitizing program designed to run under Windows 95 or NT.

The general format of the file is shown below. Numbers in the same line of the file must be separated by blank space(s) or a comma.

Line	**Contents**
1	"Primary ID","Secondary ID",{type/length}
2	X_1,Y_1
3	X_2,Y_2
	...
n+1	X_n,Y_n
n+2	"Primary ID","Secondary ID",{type/length}

n+3	X_1,Y_1
n+4	X_2,Y_2
	...
n+m+2	X_m,Y_m
...	...

The pattern given in line 1 to n+1 is thus repeated as many times as there are height contours and/or roughness change lines in the file. For WAsP to make use of the BNA-file, it is important to adhere to the following conventions regarding the Primary and Secondary ID's:

The **Primary ID** must contain the elevation of the line, e.g. "125.0". If the line has no elevation, an empty string "" must be present.

The **Secondary ID** must contain the roughnesses of the line, e.g. "0.0 0.03", where the first value corresponds to the left-hand roughness length and the second value to the right-hand roughness length. The roughness length values must be separated by a comma. If the line is not a roughness change line, an empty string "" must be present.

The **type/length** must be a signed integer. The absolute value of this indicates the number of coordinate pairs (points) to follow, the sign indicates the type of line: an area/polygon (positive integer), a curve/polyline (negative integer) or a point (the value 1).

Following the {type/length} are the actual (*X, Y*)-coordinates that specify the object. These can be integers or real numbers and are stored one pair per line, separated by a comma.

Coordinates

The coordinates in the BNA-file must be in meters and must be specified relative to a Cartesian coordinate system. The elevation and roughness length values must also be in meters.

Sample header lines

• Single elevation point (spot height), 47 m a.s.l.:

"47","",1

• Height contour only, 125-m above sea level, containing 245 coordinate pairs in a polygon:

"125.0","",245

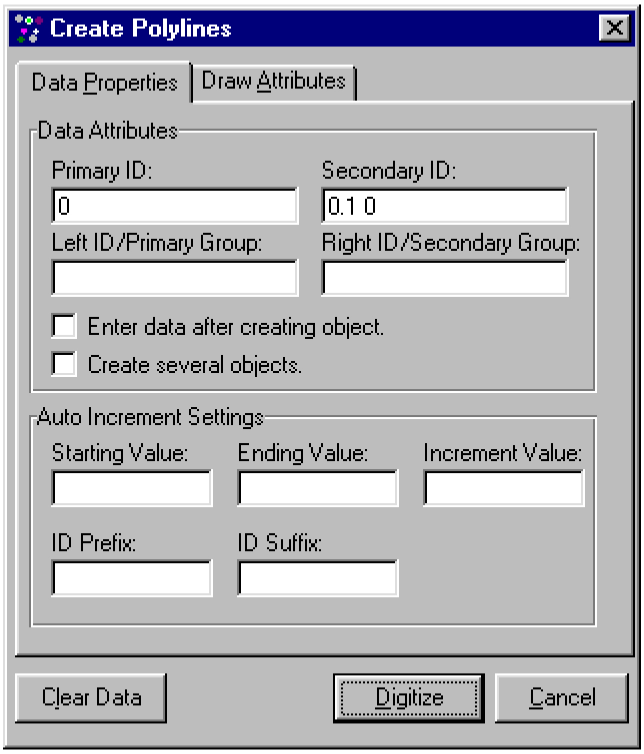
• Roughness change line only, left-hand roughness length 0 m (water) and right-hand roughness length 0.03 m, containing 709 coordinate pairs in a polyline:

"","0.0 0.03",-709

• Combined height contour and roughness change line (coastline), containing 134 coordinate pairs in a polyline:

"0","0.1 0",-134

As an example, this line is specified in Didger's **Create Polylines** dialog box in the following way:



The number of points (134) and the type (- for polyline) are automatically added by Didger. The dialog boxes for creating points and polygons are identical to the one shown above.

WAsP 4 roughness description

The site-specific roughness description file contains the roughness rose for a site, i.e. sector-wise specifications of the roughness lengths and roughness changes, as well as user-specified correction factors for wind speed and correction angles for wind direction for each sector. The file format is used with previous versions of WAsP, but has now been implemented in two separate files: the RRD file and the UCF file. WAsP 6 can open and save all of these files; however, the use of the two new formats are strongly recommended.

Data are stored in an ASCII (text) file with the default file name extension RDS.

The general format of the file is shown below. Numbers in the same line of the file must be separated by blank space(s) or a comma.

Line	Contents
1	Text string identifying the site-specific description
2	Height of WAsP calculations [m]
3	Sector-wise correction factors for wind speed
4	Sector-wise correction angles for wind direction [º]
5	Numbers of roughness changes in each sector
6	Roughness lengths next to the site [m] in sectors 1-*n*
7	Distances [m] to first roughness change in sectors 1-*n*

8	Roughness lengths beyond first roughness change
odd	... more roughness change distances [m]
even	... more roughness lengths [m]

Distances and roughness lengths written in a similar way as in lines 7-8 are repeated as many times as the number of roughness changes specified in line 5. With no roughness changes in any sector, line 6 would be the last line of the file. A maximum of 10 roughness changes in each sector can be specified.

The development of the new RRD- and UCF-files is described in more detail here.

Introducing the OWC Wizard

When calculating a wind atlas from site data, WAsP does not use the time-series of meteorological data. Instead, WAsP needs a tabular summary of the frequency of occurrence of wind speed versus wind direction. This tabular summary is contained in an observed wind climate file (OWC or TAB file).

The OWC Wizard is a utility program which produces OWC files from raw wind speed and direction measurements. The time-series of wind speed and direction data are transformed into a table which describes a time-independent summary of the conditions found at the measuring site.

Data adjustments

As well as simply summarising the time-series data, the Wizard also makes it possible to adjust the raw data before compiling the summary. You can specify which of the raw data to omit from the summary and you can apply linear adjustments to the data values.

Multiple files, different formats

The OWC summary can be generated from one or more raw data files. Each raw data file which is included can have a different format, and can be collected with a different instrument.

Using the Wizard

The Wizard has been designed to be a quick but flexible way of producing OWC files from raw data. The process consists of navigating forward through a series of dialog boxes which sequentially collect the information required before producing the OWC file and saving it.

If the raw data are quite straightforward, then it's only necessary to make one or two selections: the rest of the time the default values can be immediately accepted.

The dialogs contain some instructions, and there is help available for each dialog (press the **F1** key). The places where some input is required or possible are highlighted in white boxes.

The raw meteorological data

The raw meteorological data must be provided as files which contain readings for wind speed and wind direction. The observed wind climate can be produced from one or more raw data files. The data files can contain readings other than speed and direction, but they will of course be ignored when reading the file. If more than one data file is used, then each can have a different format.

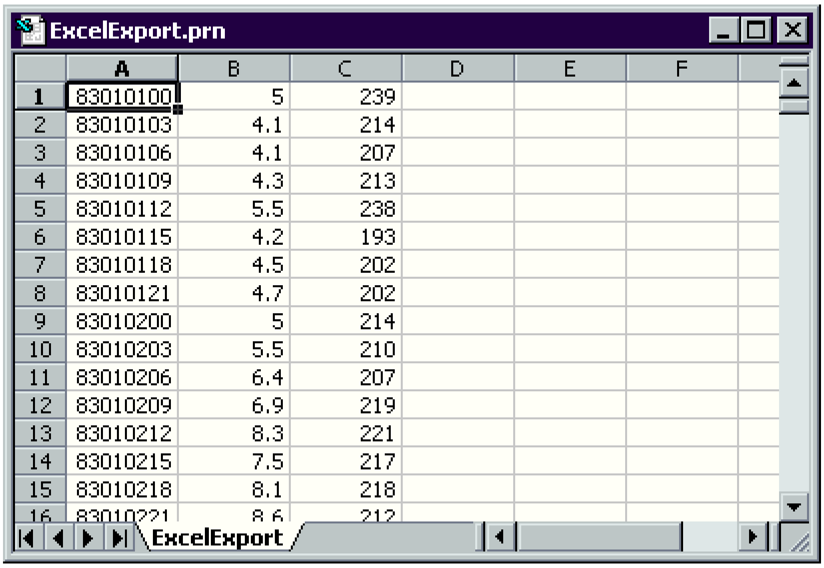
Legitimate formats

The current version of the Wizard does not read binary files, but providing that your files are not binary, the Wizard can read a variety of different data configurations.

- The data must be regularly arranged within the file.
- There should be no gaps in the data arrangement.
- The data contained within the files must be separated from one another.
- Data can be separated by spaces or tabs or end of line markers.
- There can be several header lines at the top of the file.

Example – Importing data from Excel

The picture below shows the standard sample file RawData.dat when viewed in Excel.



ExcelExport.prn

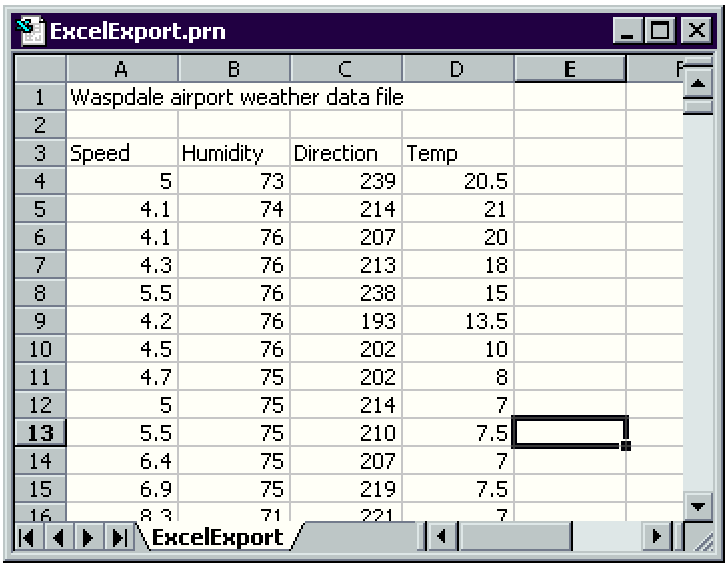
	A	B	C	D	E	F
1	83010100	5	239			
2	83010103	4.1	214			
3	83010106	4.1	207			
4	83010109	4.3	213			
5	83010112	5.5	238			
6	83010115	4.2	193			
7	83010118	4.5	202			
8	83010121	4.7	202			
9	83010200	5	214			
10	83010203	5.5	210			
11	83010206	6.4	207			
12	83010209	6.9	219			
13	83010212	8.3	221			
14	83010215	7.5	217			
15	83010218	8.1	218			
16	83010221	8.6	212			

ExcelExport

If the raw data can be viewed like this in Excel, then the OWC Wizard can read them.

Each row contains a reading. The first column contains the date/time of the reading and the second and third columns contain the wind speed and direction respectively.

Other data arrangements are possible. The first column is not needed, and other columns could be included containing other data. The file could have a header section too, as shown in the picture below.



ExcelExport.prn

	A	B	C	D	E
1	Waspdale airport weather data file				
2					
3	Speed	Humidity	Direction	Temp	
4	5	73	239	20.5	
5	4.1	74	214	21	
6	4.1	76	207	20	
7	4.3	76	213	18	
8	5.5	76	238	15	
9	4.2	76	193	13.5	
10	4.5	76	202	10	
11	4.7	75	202	8	
12	5	75	214	7	
13	5.5	75	210	7.5	
14	6.4	75	207	7	
15	6.9	75	219	7.5	
16	8.3	71	221	7	

ExcelExport

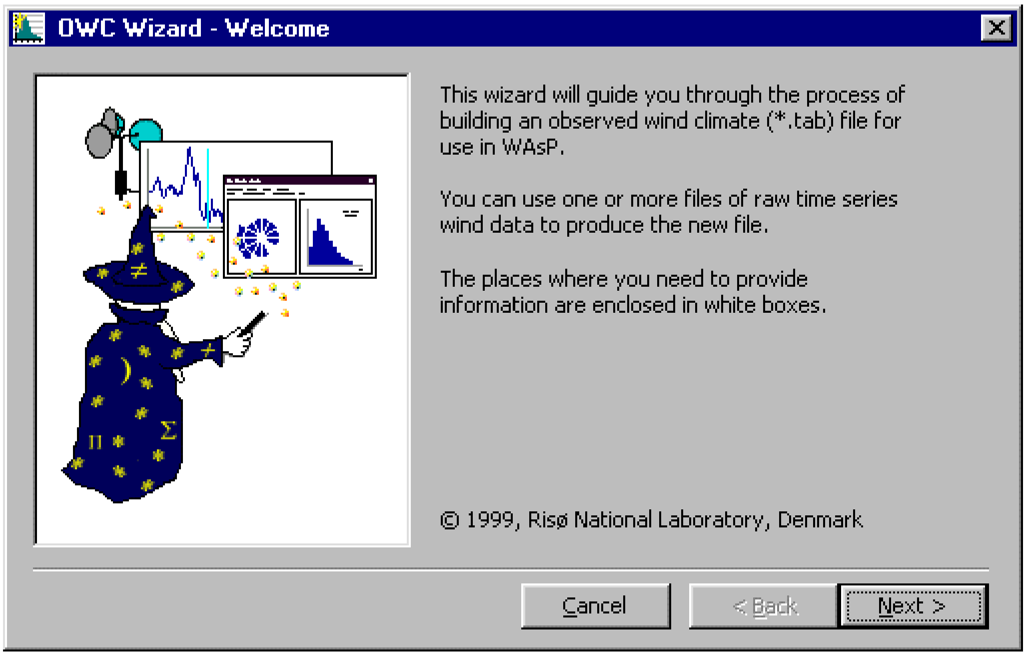
The OWC Wizard can read data like these too.

The best format in which to save data from Excel is **Formatted text (Space delimited)**. Alternatively, you could use **Text (Tab delimited)**. The OWC Wizard will be able to understand either.

Starting the OWC Wizard

There are three ways to start the OWC Wizard

1. From the Windows start menu or Windows Explorer.
2. From the **Tools** menu of the main WAsP program.
3. By inserting a new observed wind climate file into the workspace hierarchy.



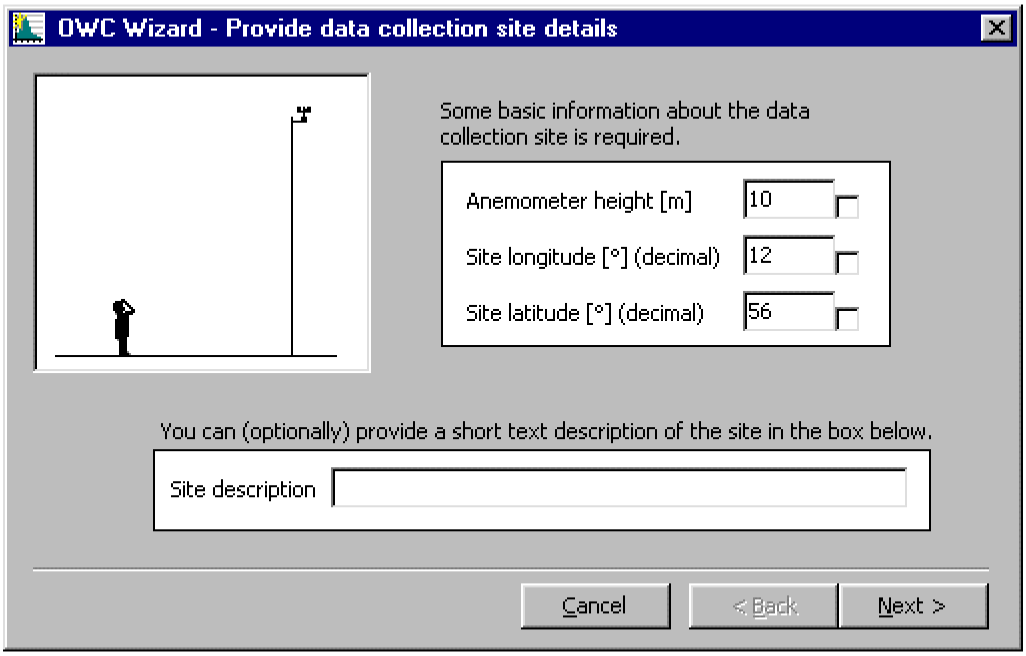
The dialog sequence

The Wizard consists of a series of dialogs which guide you through the process of creating an OWC file from one or more raw data files. The sequence of dialogs is as follows:

1. Welcome to the Wizard
2. Provide details of the site
3. Add data set. For each set, the following sequence of dialogs is displayed.
    1. Select data file
    2. Explain data structure
    3. Specify which rows to use
    4. Define adjustments to the data
    5. Define the speed and direction limits
    6. Review the data set
4. Choose the output settings
5. Save the file
6. Review the mean values of speed and energy and the difference between calculated and (Weibull) fitted values.

Providing site details

Before any data can be accepted, the Wizard needs some basic information about the site where the data were collected.



The anemometer height is the height of the anemometer *above ground level*; it's usually abbreviated m a.g.l. Entering a correct anemometer height is essential to make the subsequent WAsP calculations meaningful. If at all possible, check – or measure directly – the actual anemometer height.

The site longitude and latitude should not be left as zero since the site latitude is used by the WAsP models. Also, this information is included in the resulting file and may be very helpful to others working with the file later.

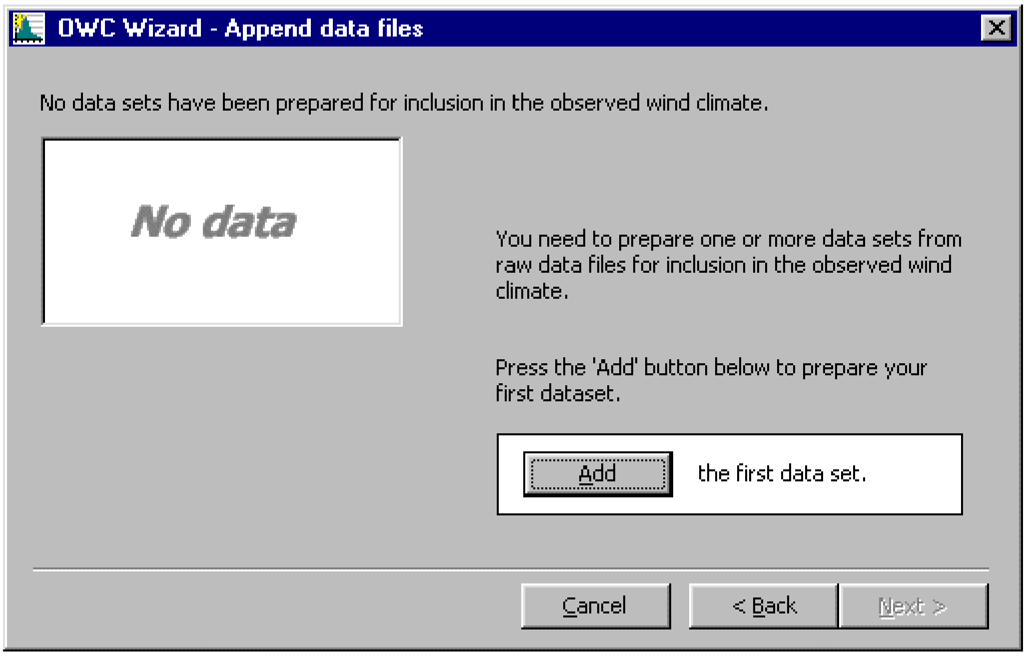
Note, that the location/position of the anemometer site must be provided as its geographical coordinates, i.e. as the latitude and longitude in decimal degrees. Conventionally, latitude N and longitude E are considered positive; latitude S and longitude W negative. Latitude can thus take values between -90º and +90º and longitude values between -180º and +180º.

The site description will be displayed when the OWC is imported and displayed in the main WAsP program hierarchy.

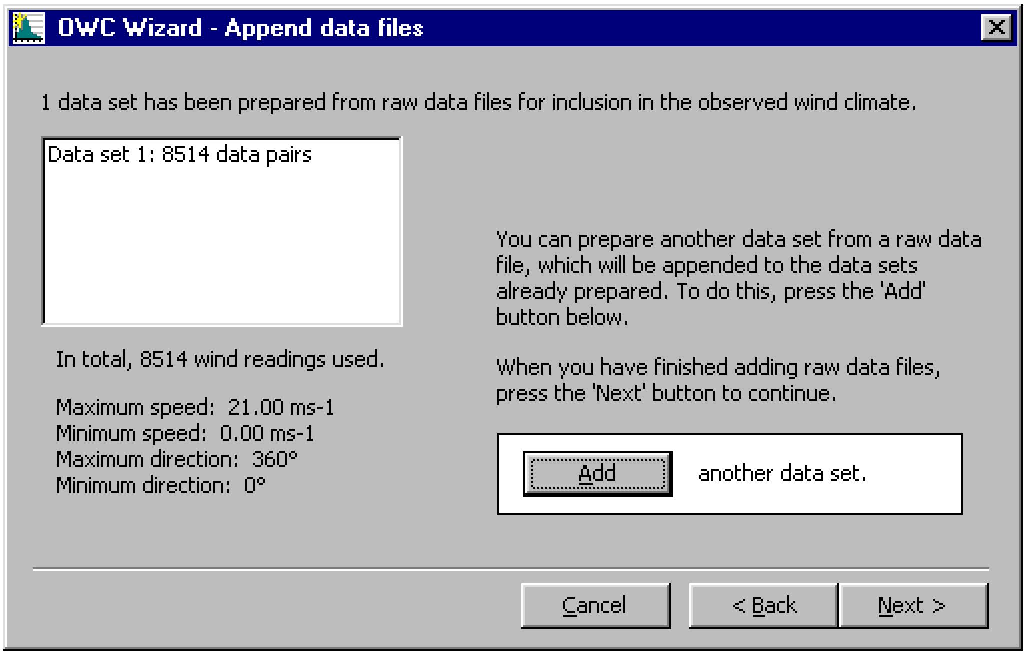
If you tick one or more of the little boxes to the right of the fields where you enter the values, the present value(s) will be the default value(s) for subsequent OWC Wizard sessions.

Managing the data sets

The Wizard can accept one or more data files to use when generating the OWC summary file. If no data files have been added, then it is impossible to proceed from this dialog.



Clicking the **Add** button will launch a series of dialogs which manage the addition of one data file. When the data file has been added, this dialog will re-appear. While waiting for the next input, the Wizard shows a list of the data sets prepared so far and a brief summary of these data files.



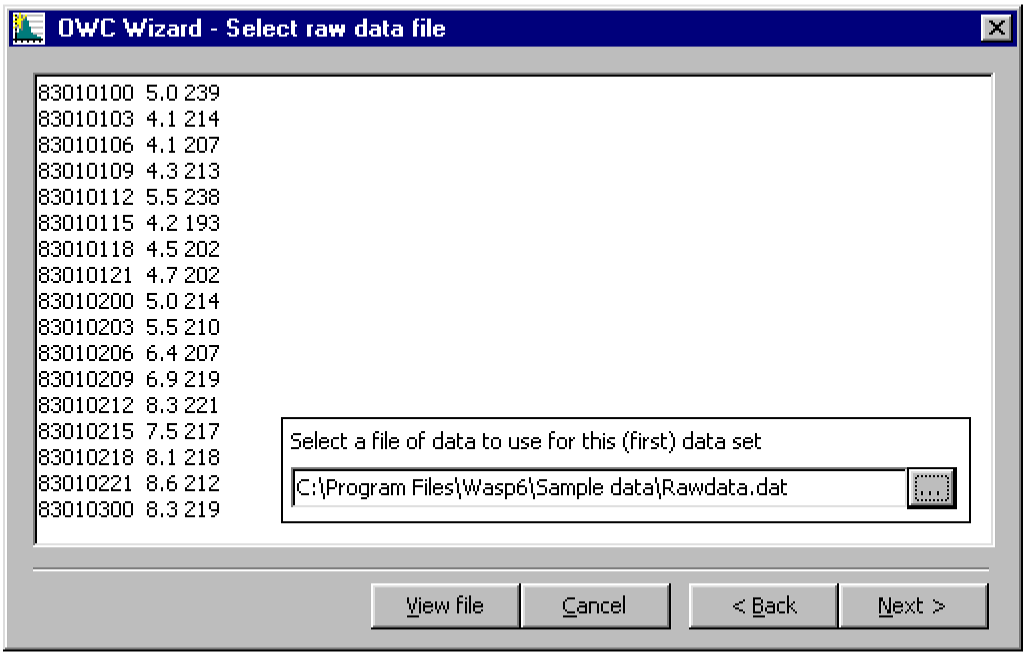
Now that some data have been added, it is possible to

- add another file, or
- go back to change the site details, or
- proceed to the next stage, or
- cancel the current OWCW session.

If you choose to **Cancel**, then all of the data sets which have been added will be lost. If you choose to proceed to the next stage, then it is possible to return back to this dialog and add another data set later.

Selecting the data file

Click the button marked '...' to select the raw data file.



When a file is selected, the Wizard displays the first few lines of the file contents in the background. If you choose **View file**, the file will be opened by NotePad or WordPad.

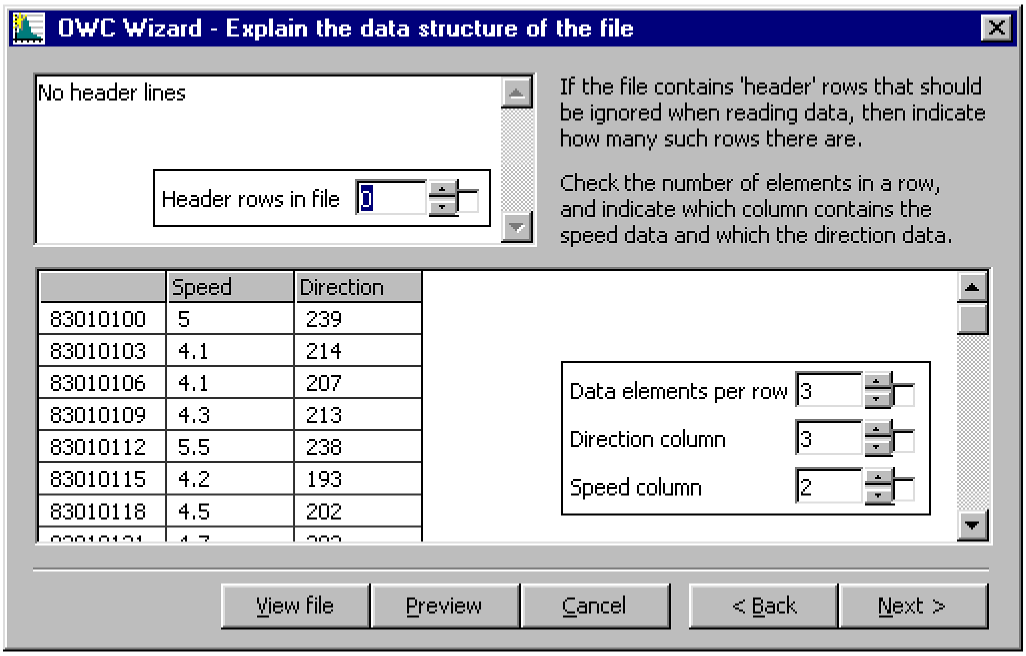
You can read more about the raw meterorological data file format.

Explaining the data structure

The Wizard needs to know how to interpret the contents of the file which is being added. The grid shown in the bottom half of the dialog provides a preview of how the data will be interpreted. The text area in the top left of the dialog shows the header information which is found in the file (and will of course be discarded for the analysis).

The Wizard makes an estimate of the number of header rows in the file and the number of data elements in each row. If a file has already been imported, then the Wizard simply applies the same explanation as was used for the last set. If the imported file is tab-delimited, the Wizard's own estimate may be unsuccessful. The data preview areas will show the right numbers, but in competely the wrong arrangement.

The Wizard's estimate can be corrected by adjusting the figures for **Header rows in file** and **Data elements per row**.



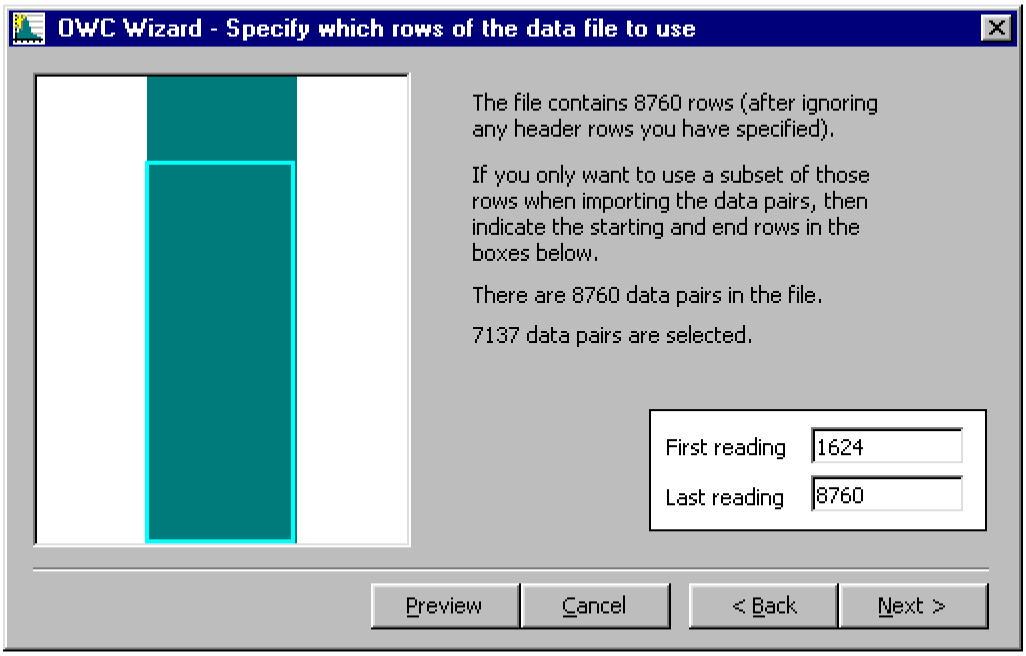
Adjust the figures in the boxes for **Direction column** and **Speed column** until the preview grid displays a correct interpretation of the data file (as in the picture above).

If you choose **View file**, the file will be opened by the NotePad or WordPad text editor.

If you choose **Preview**, the data will be shown in several graphs: the time traces of wind direction and wind speed, and as a polar scatter plot of the observations.

Specifying which rows to use

It may be that the data file contains data from a period which should be excluded from the analysis for some reason. It is possible to specify a subset of the entire data set to be imported. By default, the Wizard assumes that all of the data should be included, but by changing the values for First reading and Last reading, a subset can be defined.



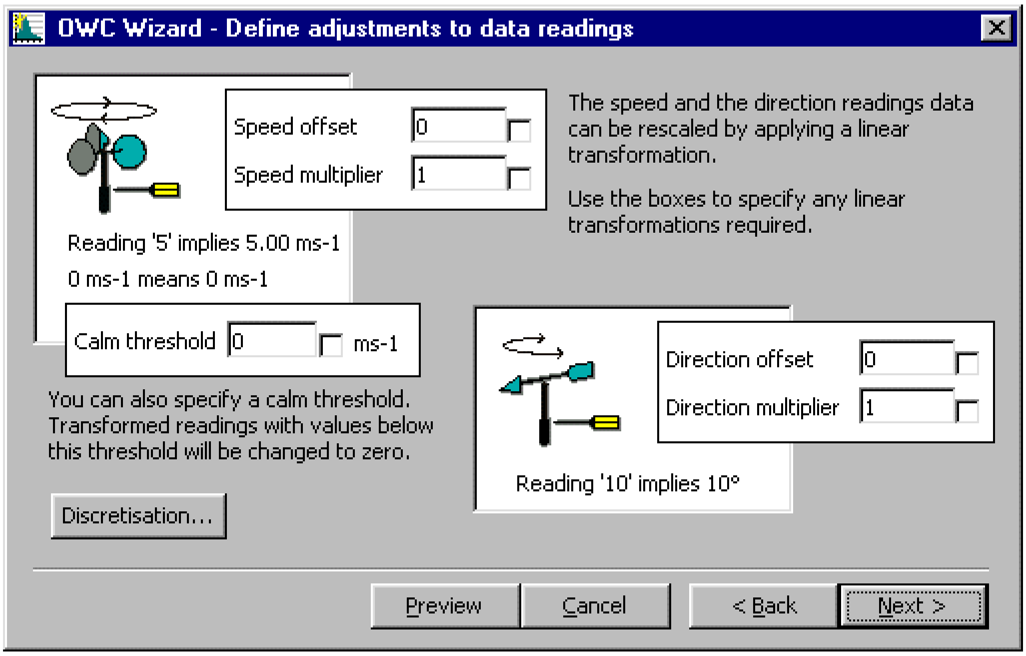
In the picture above, the first 1623 readings in the file have been excluded. The illustration on the left simply provides a quick visual check of the subset relative to the whole data set.

If you choose **Preview**, the data will be shown in several graphs: the time traces of wind direction and wind speed, and as a polar scatter plot of the observations.

Define adjustments to data readings

The contents of each data set are affected by the device used to collect the data. It's also possible that the wind speed and direction data are not recorded in standard SI units in the data file.

The Wizard allows corrections to be made to all data values in the file.



Wind speed correction

A linear correction to the wind speed data can be made by adjusting the figures for **Speed offset** and **Speed multiplier** in the boxes provided. The correction is made according to the usual form $y = ax + b$, where the offset value is b and the multipliert value is a. The result of the correction is previewed as a line of text which calculates how a reading with a value of '5' would be interpreted.

It is also possible to provide a calm threshold. Any reading with a wind speed below this threshold value will be treated as zero.

Wind direction correction

A linear correction to the wind direction data can be made by adjusting the figures for **Direction offset** and **Direction multiplier** in the boxes provided. The result of the correction is previewed as a line of text which calculates how a reading with a value of '10' would be interpreted.

Data discretisation

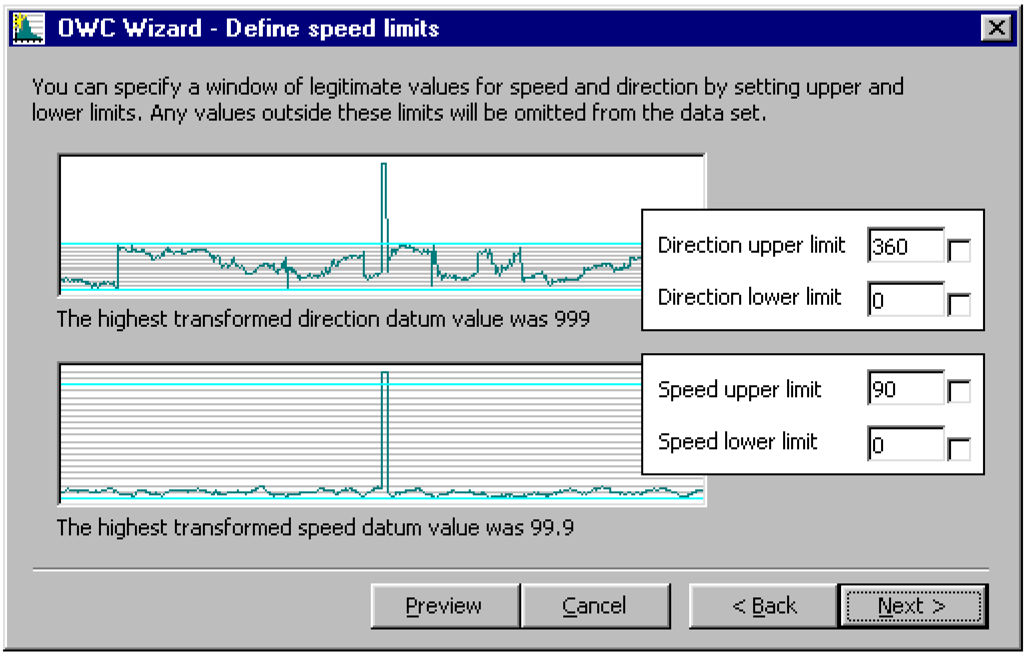
Pressing the **Discretisation...** button allows the information about discretisation in the raw data to be provided to the Wizard.

If you choose **Preview**, the data will be shown in several graphs: the time traces of wind direction and wind speed, and as a polar scatter plot of the observations.

Defining the wind data limits

Some data files contain readings with out-of-range values which indicate an error condition in the reading apparatus or is used as a flag for missing observations. This dialog allows upper and lower limits to be set for wind speed and direction data. Any data values outside these ranges will not be included in the OWC summary.

The picture below shows a data set with occasional very high readings. These readings have been excluded by the (default) value for the upper direction limit of 360 degrees and the (default) value for the upper speed limit of 90 ms^{-1}. Note, that the data window is given in engineering units.



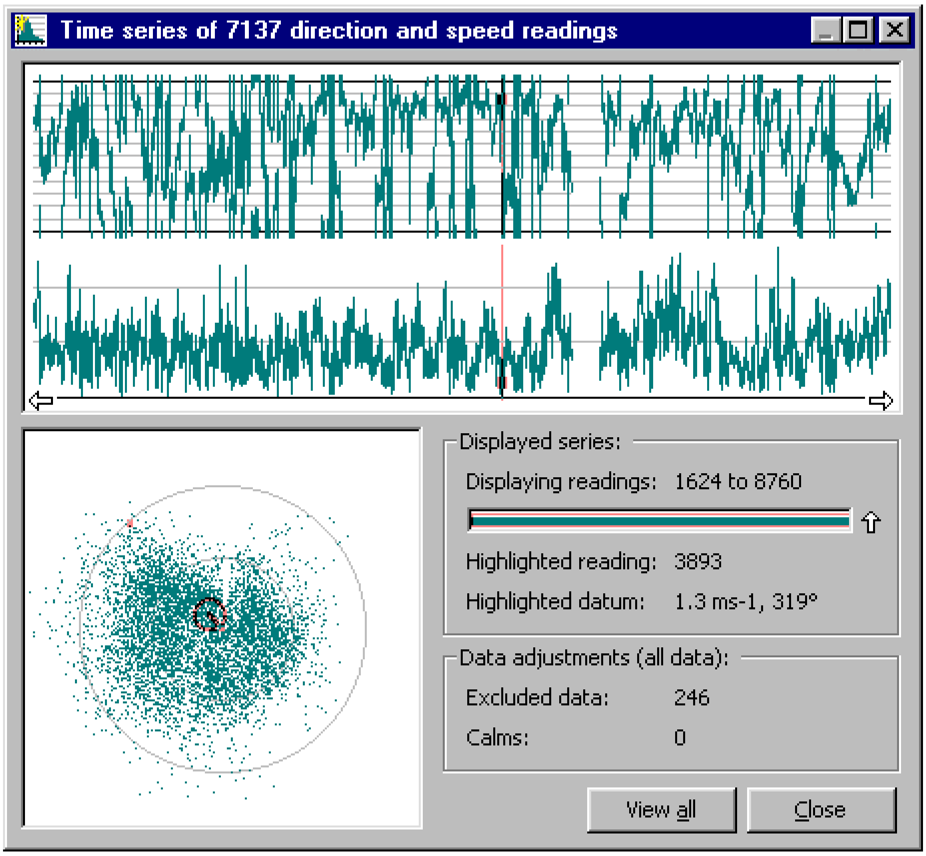
Hint: if the graph does not look right, then go back to the dialog where the speed and direction columns were selected and check that the right columns have been used.

The wind speed and direction limits are shown in the graphs above by coloured, horizontal lines.

If you choose **Preview**, the data will be shown in several graphs: the time traces of wind direction and wind speed, and as a polar scatter plot of the observations.

Displaying the data set

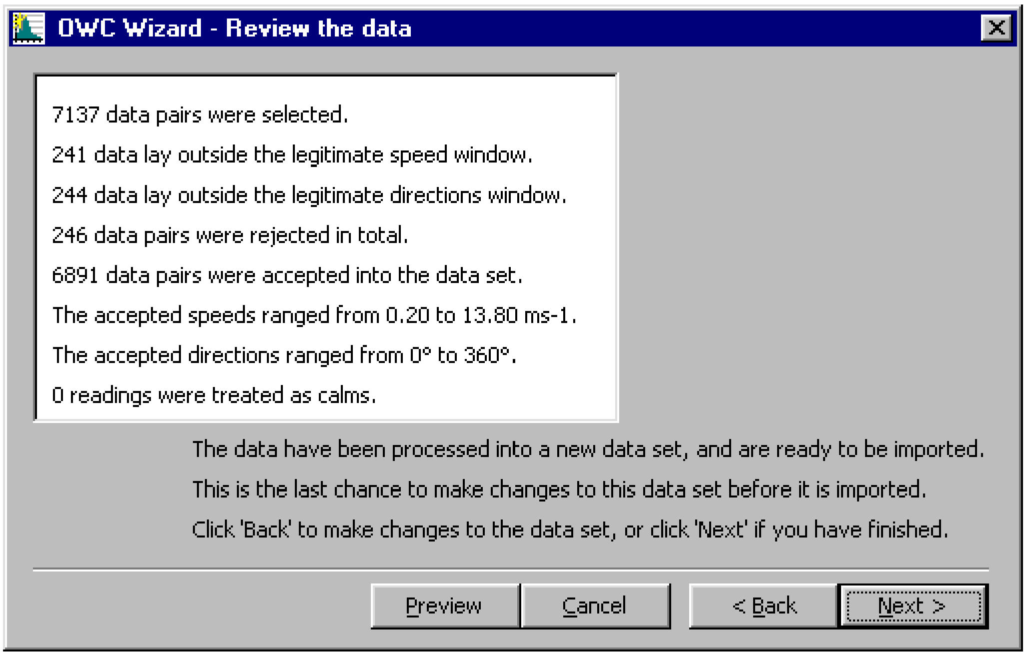
If you choose **Preview** in any of the OWC Wizard windows, the wind data will be shown in several graphs: the time traces of wind direction and wind speed, and as a polar scatter plot of the observations.



By moving the cursor over the time series it is possible to read off the values of wind speed and direction. The display window can be shifted (Pan backwards and Pan forwards) by pressing the arrows in the bottom of the time series display. By choosing **View all** the entire time series is shown.

Reviewing the data set

When the Wizard has gathered all of the information about the data set, it presents a summary review of the data.

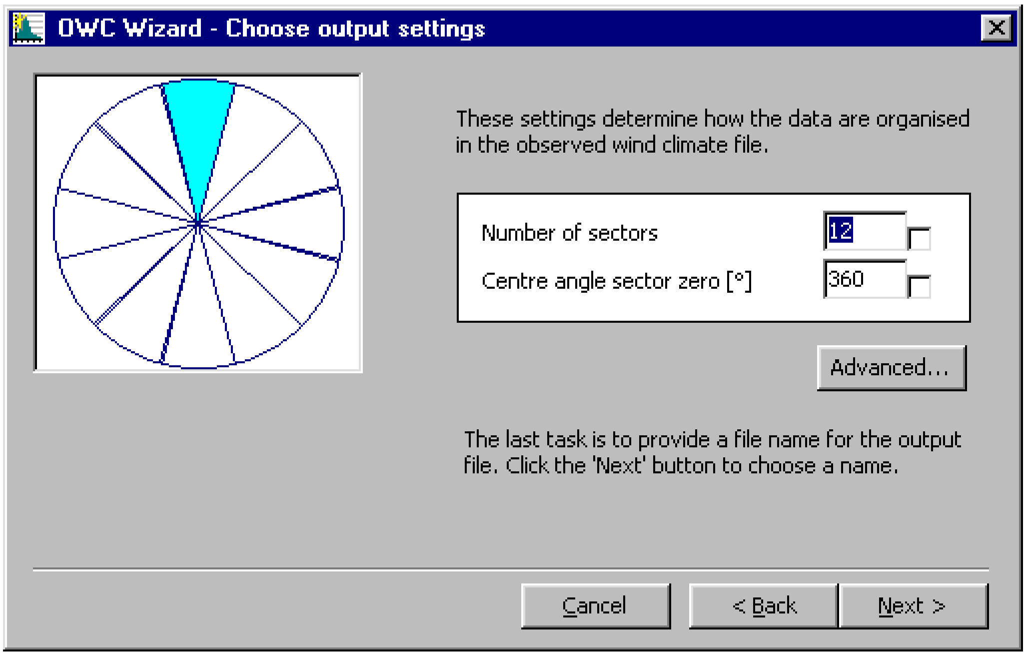


This is the last opportunity to make changes to the settings for this data set before it is added to the OWC summary data. Pressing the **Next** button will import the data set and it will be impossible to remove it without clearing all of the data so far imported to the OWC.

Choosing the output settings

When you have finished adding data sets, the Wizard is almost ready to write the summary to the OWC (TAB) file. Two more settings are required:

- the number of sectors in the analysis
- the centre angle of the first sector



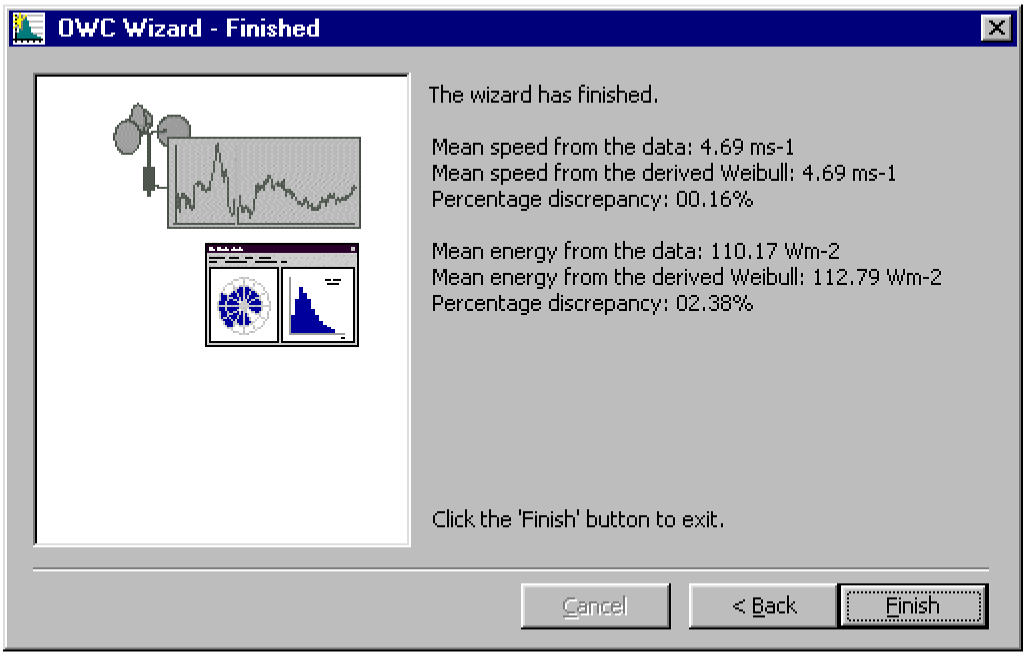
By checking the boxes to the right of the fields where you enter the values, it is possible to save the values currently showing, so that in the future they will be automatically used as default values by the Wizard. Pressing the **Advanced** button brings up the Advanced settings dialog.

All that remains is to save the output file.

Saving the OWC file

The last piece of information required by the Wizard is the name of the output file to which to save the data. When the file is saved, the Wizard has finished its job.

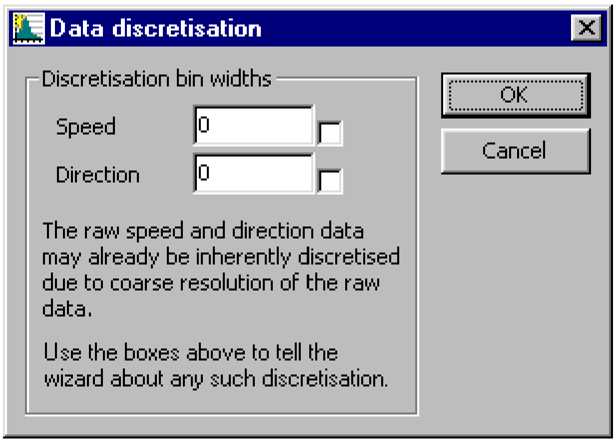
Before *you* **Finish** the Wizard, check carefully the displayed mean values of wind speed and energy density. The difference between the means calculated directly from the data series and the mean calculated from the fitted Weibull distributions should be small (say, a few per cent). If this is not the case, the fitted Weibull distributions are not accurate representations of your data and you must process the time series all over again. The most likely cause for large discrepancies is if you have not specified the right discretizations of the data.



If you started the Wizard from within the main WAsP program by choosing to insert a new OWC in the hierarchy, then WAsP will insert the newly created OWC at the place you requested. The name of the file will of course be used as the description of the new OWC member. You can open the OWC window immediately to see the what the Wizard has produced.

Data discretisation

Pressing the **Discretisation...** button from the define adjustments to data readings causes the Data discretisation dialog to be displayed.



Using this dialog, it is possible to specify the discretisation bins apparent in the raw data. The Wizard will then automatically correct for the effect of such bins when calculating the summary. The dicretisation bin widths must be given in raw data units.

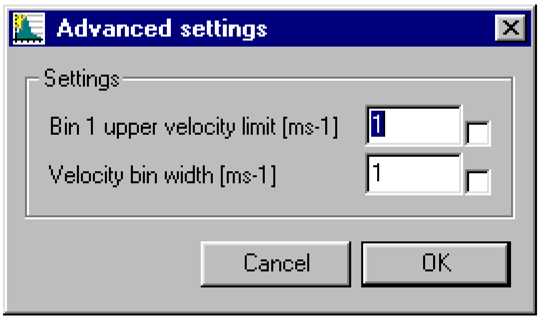
By checking the boxes to the right of the fields where you enter the values, it is possible to save the values currently showing, so that in the future they will be automatically used as default values by the Wizard.

Advanced settings for the OWC

Pressing the Advanced button from the Output data settings dialog brings up the advanced settings dialog.

This dialog is used to set

- the upper velocity limit for the first speed bin (default value is 1 ms^{-1})
- the velocity bin with for the summary table (the default value is 1 ms^{-1})



By checking the boxes to the right of the fields where you enter the values, it is possible to save the values currently showing, so that in the future they will be automatically used as default values by the Wizard.

About the MapEdit utility

With the new WAsP map editor utility you can retrieve, edit, check, reformat and store WAsP map files. It is also possible to digitize scanned maps on screen using the mouse. This utility will take over many of the tasks that were previously carried out in the EDIT mode of the MAPDATA menu in WASP 4 and 5.

A brief description of the things you can do with the map editor is given below. More information is available in the help facility of the MapEdit program.

Map file input and import

- input of WAsP map files (ASCII and binary formats)
- import of MatLab, XYZ and other formats

Map data analysis and check

- overlay of scanned map and vector map
- visual inspection and zoom
- summaries of map information
- consistency check of roughness line node points
- joining of roughness lines and height contours

Map transformations

- changing map units
- transformations based on 1/2/3 fixed points

Editing of map contents

- view roughness lines, contours or both
- change colours of roughness lines and contours
- move, delete and insert point or line
- close, split and join line(s)
- change line properties
- join several roughness lines in node point

Digitization of scanned maps

- input of bitmap background images (*.bmp)
- scaling of scanned map
- on-screen digitization using the mouse

The ruggedness of a terrain

The somewhat indeterminate term 'complex terrain' is often used in connection with the orographic characteristics of a landscape; primarily for hilly and mountainous terrain consisting of a 'complex' mixture of several (steep) hills or mountains. While most people have an idea of the general meaning of this term – albeit somewhat biased because of differences in experience – there exist no widely accepted measure of terrain complexity to which we can all refer, like eg terrain height (measured in m a.s.l.) or the steepness of a winding, mountain road (measured in per cent).

Even in the field of wind-flow modelling, it is not always clear what 'complex' means. One well-known measure of terrain complexity (or steepness) is relative relief, ie the difference between the highest and lowest level within unit areas of eg 100 km^2 (Rutkis, 1971; William-Olsson, 1974). This was used as a means for judging the influence of the mountains and thereby the degree of reliability of the results presented in the European Wind Atlas (Troen and Petersen, 1989). However, maps of relative relief generally do not show the effects of local topography.

One objective measure of the steepness or ruggedness of the terrain around a site is the so-called ruggedness index or RIX (Bowen and Mortensen, 1996), defined as the percentage fraction of the terrain within a certain distance from a specific site which is steeper than some critical slope, say 0.3 (Wood, 1995). This index was proposed as a coarse measure of the extent of flow separation and thereby the extent to which the terrain violates the requirements of linearized flow models.

The ruggedness index has also been used to develop an orographic performance indicator for WAsP-predictions in complex terrain (Bowen and Mortensen, 1996; Mortensen and Petersen, 1997) – where the indicator is defined as the difference in the percentage fractions between the predicted and the reference site. This indicator may provide the sign and approximate magnitude of the prediction error for situations where one or both of the sites are situated in terrain well outside the recommended operational envelope.

The ruggedness index

In practice, the ruggedness index is calculated for each of a number of radii originating at the site (meteorological station or wind turbine). A flat site will then have a RIX of 0%, a very complex (steep) site an index of, say, 30% – meaning that about one third of the terrain is steeper than our critical slope.

The value of the index defined above will of course depend on the size of the area we are looking at (the radius) and the threshold slope; however, the study indicates that these should be chosen within fairly narrow limits, see below. Given these values, the index is easy to calculate, providing a site-specific measure of terrain ruggedness, and seems to show rather well the effects of local topography on the accuracy of WAsP predictions (Bowen and Mortensen, 1996 and 1997).

The RIX program

The purpose of the RIX program is to calculate the ruggedness index of a specific site. In addition to the overall index, the program also calculates indices for each of a number of user-specified sectors.

The program is a DOS utility and must be invoked from an MS-DOS window, by typing its name at the prompt with the name of a WAsP map file and the site coordinates as arguments:

RIX *mapfile* X_{site} Y_{site} [*options*]

where *mapfile* = [*drive*][*path*]*filename*[.*ext*] specifies the WAsP map file, which must be in ASCII (text) format. The default *ext* is MAP and the site coordinates must be given in metres. A summary of command line arguments is shown if the program is started with a question mark 'RIX -?'. Ruggedness indices for each of a number of sites in a wind farm can be calculated by specifying the name of a WAsP resource file which contains the site coordinates:

RIX *mapfile rsffile* [*options*]

where *rsffile* = [*drive*][*path*]*filename*[.*ext*] specifies an existing WAsP resource file; the default *ext* of which is RSF.

The RIX program will be incorporated into the WAsP program in a later version.

Configuring the RIX program

The default configuration of the program is given in the text file RIX.CFG:

```
%
% rix configuration file
% sets up default values
%
```

radius = 3500

threshold = 0.3

sectors = 12

subsectors = 6

verbose = no

display_sectors = yes

skip_flat_center = yes

With this configuration, the program then takes the terrain within 3500 m of the site into account, the threshold slope is 0.3, and indices are calculated for 12 sectors based on six profiles in each sector. The number of sectors and azimuthal resolution correspond to the default values used by WAsP in calculating the orographic corrections. The radius 3500 m and threshold slope 0.3 are the values used by Bowen and Mortensen (1996, 1997).

Command-line options

The program can be invoked with one or more options in the command line:

-r# sets the size (radius) of the terrain for which the RIX is calculated. The default value is 3500 m.

-t# sets the threshold slope for calculation of the RIX value. The default value is 0.3.

-s# sets the number of sectors for which the RIX values are calculated and displayed. The default value is 12.

-u# sets the number of subsectors (terrain profiles) used for the RIX calculations. The default value is 6.

-o*file* specifies an output (text) file containing the results. Results are shown on screen as default.

-v verbose mode. Default is 'no' (-nv).

-d display sector-wise RIX values. Default is 'yes'.

-skip skip flat center of map. Default is 'yes'.

Options which do not take an argument can be negated by putting an 'n' between the hyphen and the option letter(s).

Using the RIX program

For a single site (e.g. a meteorological station or wind turbine) the command line could look like this:

RIX \wasp\project\mymap.asc 317070 6176091

where the results would then be shown directly on the screen. Calculating RIX for several sites (e.g. the wind turbine positions in a wind farm) the command line could look like this:

RIX \wasp\project\mymap.asc \wasp\project\park.rsf -Opark.rix where the results would then be calculated for the positions specified in PARK.RSF and written to the file PARK.RIX.

Interpretation of the results

The ruggedness index is described in some detail by Bowen and Mortensen (1996, 1997) and Mortensen and Petersen (1997). The main conclusions of the studies are:

If the RIX is ~0% the slopes of the terrain are less steep than 0.3 and the flow is likely to be attached, i.e. follow the terrain surface. This situation is generally within the performance envelope of WAsP.

If the RIX is >0% parts of the terrain are steeper than 0.3 and flow separation may occur in some sectors. This situation is generally outside the performance envelope of WAsP and prediction errors may be expected. Large RIX values will lead to large errors in the flow modelling. The accuracy of the prediction, however, will depend on the relation between the two sites:

- If the predictor (meteorological station) and predicted (wind turbine) sites are equally rugged, i.e. have approximately the same RIX value, the modelling errors are significant but similar in magnitude. The overall prediction should still be accurate as the two errors would tend to cancel each other out. Such a situation obviously occurs for the self prediction at any category of site. However, it may also occur for two neighboring sites in rugged terrain which have similar orography and orientation. This represents an important application involving the prediction of the wind speeds and energy at adjacent sites along a steep ridge in a wind farm.
- If the predictor site is rugged and the predicted site less rugged, i.e. the RIX value of the reference site is larger than that of the predicted site, the modelling errors are significant and unequal. The overall prediction will be underestimated with a significant negative error.
- If the predictor site is smooth or less rugged than the complex predicted site, i.e. the RIX value of the reference site is smaller than that of the predicted site, the modelling errors are significant and unequal. The overall prediction will be overestimated with a significant positive error.

The references given in the text above may be found in the References section.

About the Park program

The Park program is a DOS utility for calculating the shelter effects in a wind farm and, consequently, wind farm performance and efficiency. It estimates the power output from individual turbines at specified wind conditions as well as the annual production if wind-climatological data are available. WAsP DMP and RSF files can be used directly as input to Park.

The Park program is described in the accompanying Park User's Guide.

The Park program will be closely integrated into the WAsP program in a later version.

Welcome to version 6.0

WAsP 6.0 is 100% 32-bit Windows software which runs under Windows 95, Windows 98 and Windows NT 4.0. It conforms to standard windows software user-interface conventions, making it easy to learn and easy to use. A brief introduction to the program is given below.

New, faster ways of getting work done

WAsP 6 allows you to organise your work in completely new ways. Operations that used to require batch files can now be accomplished by dragging and dropping with the mouse. A new hierarchical 'workspace' paradigm makes it possible to work with many sites at the same time, sharing wind atlases and maps between them. Proposals for large wind farms can be quickly created and investigated, with changes to contributing data being instantly reflected in all the affected results. Changes to the situation under investigation are made by simple, fast, drag-and-drop operations. By organising their work into exportable 'projects', users can easily share information with others. When projects are exported, all of the files necessary to re-open the same project on another computer are automatically copied into the new location. This also makes it easy to back up work in progress.

Backward-compatibility for existing users

Existing users of WAsP will be able to use most of their files without adjustments. A few new file formats have been defined, but most files which worked under WAsP 4 and later will work perfectly well with WAsP 6. Despite the new user interface, it will be possible for 'old hands' to continue to use the same mental model of the WAsP system, while gradually starting to explore and make use of the new features.

A tried-and-tested wind resource calculation engine

Perhaps the most important feature of the new WAsP is an old feature! The WAsP calculation engine is the standard for wind resource calculations, and represents years of experience, refinement and testing. Some enhancements to the core calculation routines are being made for version 6, but you can rest assured that the same algorithms that have made previous versions of WAsP so successful are working away at the heart of the new program.

How do you get started?

We recommend that you work through the new version of Getting Started – the Quick Start Tutorial – to see for yourself what WAsP 6 is all about. We hope that you come to like the new way of WAsP'ing even though it may take a little while before you are 'up-to-speed' again.

We have tried to provide the same – or better – functionality in the new version of WAsP. However, there might be some specific features you miss, or features of the old DOS versions you have come to like (!?). If this is the case we have some good news for you.

You can help us make a better WAsP!

Existing users of WAsP have a wealth of experience in wind resource assessment and siting using the old WAsP programs. We therefore invite you to provide us with your feedback. Which old features do you miss the most? Which files have you got which you can only use with the old version? Which new features would you like to have built into WAsP? Your suggestions will – like our own ideas, the frequently asked questions and reported bugs – be recorded by the WAsP team and displayed on the WAsP home page.

File format changes

With only one exception, we have left the file formats unchanged for WAsP 6.0: the old roughness description file (*.rds) has been divided into a reformatted roughness description file (*.rrd) and a new user correction file (*.ucf). This change of files is described in more detail here.

In addition, an alternative extension has been defined for resource grids (*.wrg). The old *.rsf extension can still be used, but in some circumstances, WAsP will be unable to distinguish between a resource grid file with the *.rsf extension and a wind farm file with the *.rsf extension.

Note, that WAsP 6 handles only a subset of the file formats handled by previous versions of WAsP. Descriptions of the different file formats used by WAsP are given in the Technical Reference section.

Whatever happened to...

Where have all the good old WAsP features gone? This page provides a list of old features which have been repackaged or renamed. There are explanations about what's changed and links to information about the new features.

RAWDATA – the meteorological data input routines

This function is now provided by a utility program called the OWC Wizard. This Wizard accepts raw data files and produces *.tab files. Tab (or histogram) files are now called observed wind climate files, or OWC files. Hence the name OWC Wizard.

The output format is the same, so you can use *.tab files created with the old WAsP and the new Wizard interchangeably. The new Wizard does not yet accept binary files as raw data input, so you might need to use the old WAsP if you only have binary raw data files.

MAPDATA – the map input, display and editing routines

This function is now shared between WAsP, the new WAsP map editor utility and other software. The WAsP program accepts and can display map files containing height contour lines and roughness change lines. The editing of maps is taken care of by the WAsP map editor utility, from within which you can retrieve, edit, check and store maps. It is also possible to digitize scanned maps on screen using the mouse.

The creation of a new map by digitisation of paper maps is not possible any more from within the WAsP program. Three possible workarounds are described here. We recommend the Didger program from Golden Software for digitisation of maps. The BNA output format from this simple and cheap digitising package can be imported directly by WAsP and the new map editor utility.

Batch files - automating the program

You cannot use batch files with the new WAsP. We hope that the new workspace hierarchy structure will provide a flexible alternative way of performing multiple operations.

What on earth is...?

This page provides a list of features which are new, renamed or have been repackaged. There are explanations about what's changed and links to information about the new features.

OWC and the OWC Wizard

OWC stands for observed wind climate. This is just the good old *.tab file. The OWC Wizard is a utility program which builds a tab file from one or more raw data files. In the old WAsP, this was the RAWDATA feature.

User corrections

Corrections specified by the user were stored in the roughness description file (*.rds) in previous versions of WAsP. These corrections are now stored in a new user correction file (*.ucf). The site-specific roughness description (roughness rose) is now stored in a reformatted roughness description file (*.rdd).

Good news for DOS die-hards

Yes, we're still shipping the old one...

It takes time to get acquainted to new software and changing your work routines – and even more time to get productive (or so it seems, at least). Therefore, we're still maintaining and supporting the DOS versions of WAsP: WAsP 4 (16-bit) and WAsP 5 (32-bit). A copy of the WAsP 4 package is included on the installation CD and updates of the WAsP 5 package will still be shipped to registered users.

So, if you're comfortable with digitising maps 'the old way' or find it fast and efficient to use the old WAsP map editor, please go ahead: WAsP 6 and the new WAsP map editor utility **MapEdit** both accept the map file formats from previous versions of WAsP.

Reporting problems

If you have any problems using the WAsP software, please send an email to waspsupport@risoe.dk. If you do not have email, you may send a fax to the number given here. Please mention your WAsP license number in the mail/fax.

Don't hesitate

Don't hesitate to send some feedback, even if you are not sure whether it is a bug, a suggestion or just a question. Information about any user difficulty is really valuable, even if they are not caused by progam errors. Some users are shy making of bug reports because they wrongly assume that the error it is somehow 'their fault' because they don't fully understand the program. Please, don't hesitate to report a problem to us.

Check the bugs list and FAQ

A list of known bugs will be maintained at www.wasp.dk. You may also want to check the list of Frequently Asked Questions (FAQ) which will be maintained at the same address.

Check that you have the latest version

The latest version of the WAsP program can be downloaded from www.wasp.dk in the form of an update file to the main installation on the CD-ROM.

Provide the version number

Let us know which version of WAsP you are using (please provide the full version number). Please also mention which operating system you are running.

Tell us how to reproduce the error

Before you report the problem, try to make it happen again. Include a description of how to reproduce the bug when you send the bug report.

Provide the program's own error description

When WAsP shows you an error message, you can request details. When the details are showing, you can press the 'Copy' button to put a complete exception report onto the Windows system clipboard. Paste this into the email you send.

Provide the file

If the software is having problems with a particular file, then please send it (zipped) along with the description. If the file is bigger than 50KB, then email first so that we can arrange more appropriate way of transferring the file.

Provide the whole project

To fix a bug, it is sometimes helpful to be able to reproduce the situation you're describing. The easiest thing is to have the whole project. You can export the whole project to a directory on your computer, then zip it up and send it along with the feedback message. Again, if the resulting file is bigger than 50KB, then send an email first and we can arrange another way of transferring the file.

Making suggestions

The future development of WAsP could depend on you! Even though we have many ideas ourselves for the future development of the WAsP program and the built-in models, we welcome very much your suggestions and requests for new features.

Which features to include and how to implement them depend strongly on the response we get from the WAsP users. Please email or fax your comments and suggestions to the addresses given here.

Beginning with the release of WAsP 6 we will maintain a list of the WAsP team's own ideas and the suggestions already received from the users at the WAsP home page www.wasp.dk.

Frequently Asked Questions (FAQ)

Beginning with the release of WAsP 6.0 we have established and will maintain this list of Frequently Asked Questions – regarding the use of WAsP and WAsP-related software. Unless otherwise stated, the Q&A's refer to version 6.0 of WAsP, even though most of the information may be valid for previous versions as well.

Q: How can I use Surfer to make a wind resource map of an area?

A: Golden Software's Surfer program can read and utilise WAsP's wind farm (RSF) and resource grid files (WRG) directly. In the **Grid** menu of Surfer, choose **Data** and enter the name of the wind farm or resource grid file. You will then get the message "File type not recognized!". Choose 'ASCII Data (.TXT)' and press the 'Ok' button. You may then get the message "Surfer error: Current data columns do not contain 3 or more distinct XYZ points". Disregard this message and carry on specifying the **Data Columns** used for the *X* and *Y* coordinates and the wind energy density/power production: column B contains the *X* coordinate, column C the *Y* coordinate and column H the energy density or power production. Surfer can now make a grid from the data in the usual way – and a map of the wind resource can be made.

You can also make Surfer recognize these file types by adding the following two lines to the file Surfer32.ini (in the [GS Worksheet Import Filters] section) using a text editor like Notepad:

WAsP Wind Farm=WSIDAT32.DLL;RSF;GSdata

WAsP Resource Grid=WSIDAT32.DLL;WRG;GSdata

WAsP training and courses

Training courses in the use of the WAsP program are held every year at Risø and/or abroad. The two-day courses are usually announced on the WAsP home page www.wasp.dk. Some pratical details regarding the courses are given below.

Specific courses can also be provided as in-house training for key staff. Please contact Risø for further details and a quotation.

Background

Realistic assessment of the wind resource is a key parameter in any wind energy project – large or small. The course aims at providing practical experience and confidence in wind data analysis, wind climate estimation and power production calculations – using the WAsP program, a state-of-the art collection of PC tools developed specifically for these purposes.

Who should attend?

The course is intended for engineers, scientists and others, primarily working within the field of wind energy, who require a working knowledge of the WAsP program. Aspects of the theories underlying the program will be presented, but the course will stress practical experience and examples on the use of WAsP. Although the course requires no prior knowledge of meteorology or wind energy conversion technology, some familiarity with one of these areas, as well as basic knowledge of PC computers and Windows, would be advisable prerequisites.

Presenters

The courses are presented by Lars Landberg, Niels Gylling Mortensen and Ole Rathmann from the Wind Energy and Atmospheric Physics Department at Risø National Laboratory.

Language

The language on all courses will be English.

Fee

The course fee usually covers tuition, course material, two lunches, one dinner, light refreshments etc. Travel, accommodation and per diem are not included.

Time schedule

Preliminary registrations already received are held until 4 weeks before each course, but will be discarded if no binding registration is received by then. Other binding registrations must be received no later than 3 weeks before a course. Confirmation, practical details pertaining to the course in question, and an invoice will subsequently be mailed by Risø. The course fee must be paid no later than one week before the course.

Hardware

Since practical experience is essential, the participant(s) from each company or institution should preferably bring their own PC w/ the WAsP program installed. Please advise us well ahead of the course, should this not be feasible.

Q & A session

The courses contain a Q & A session where questions raised by the participants will be answered. Questions or issues that you would like to be treated in this session, without reference to the person or company posing the question, can be mailed or faxed directly to Risø before the course.

WAsP Utility Programs

The WAsP Utility Programs is a collection of 16- and 32-bit DOS programs to calculate, analyze, transform, translate, plot, and print WAsP-related data. Present version is 1.5. A brief description of the main features of each of the utility program is given below. Note, that a few utilities have been included in the WAsP 6 package.

Wind-climatological fingerprint

As in the European Wind Atlas. Fingerprint page with graphs (*.ps or *.plt file) and X-tables (*.txt or *.tex) of daily/yearly and monthly/yearly mean wind speeds.

Fitting Weibull distribution functions

Generates measured and fitted data (*.dat) for e.g. plotting the total and sector-wise wind speed distributions. WAsP summary table (*.txt or *.tex).

Plotting the histogram and wind rose

Generates data and Grapher files for plotting the wind speed and direction distributions. Data can be used with other plotting programs as well.

Weibull distribution characteristics

Statistics and data files (on screen and *.dat) for a given Weibull distribution (*A* and *k*). Total energy and window (e.g. 0-25 ms^{-1}) energy. Power production from specified power curve. Data file suitable for plotting.

Plotting the obstacle set-up

Generates data and Grapher files for plotting an obstacle set-up.

Coordinate transformation

Coordinate transformation of single points, lists and WAsP ASCII *.map files:

- Latitude/longitude to UTM
- UTM to latitude/longitude
- UTM to UTM (zone 32 and 33)
- Un-scaling a WAsP ASCII map file to absolute coordinates. Export to *.bln and *.xyz files as well.

Transformation of map and grid files

- Map to grid transformation: WAsP *.map file to Surfer *.grd file
- Grid to map transformation: Surfer *.grd file to WAsP *.map file

Translation of vector map formats

- AutoCad *.dxf to *.map file translation (ASCII *.dxf-file subset only)
- Atlas *.bna to *.map-file translation

Map editing (included in WAsP)

Map editing features like WAsP in a Windows environment. Roughness line analysis, e.g. joining these where they meet in node points and pointing out lines where the roughness values are in conflict. On-screen digitization of scanned maps.

Ruggedness index (included in WAsP)

Calculates the ruggedness index (RIX value) for a single site or for multiple sites given in an RSF-file. Input is a WAsP map file.

Plotting the power- and c_p-curves

Generates data and Grapher files for plotting the power-and c_p-curves. Data can be used with other plotting programs as well.

Resource- to grid-file conversion

Calculation of Surfer grid files containing Weibull *A*, Weibull *k*, mean wind speed, mean energy density, terrain elevation, or power production. Grid may contain absolute or normalized values. Export to (*x, y, z*) file as well.

Printing wind atlas files

Generates text or LaTeX file, resembling the right-hand-side pages of the European Wind Atlas, from a WAsP *.lib file.

PostScript BoundingBox

Finding the BoundingBox of encapsulated PostScript files (*.eps), e.g. Grapher and Surfer for DOS output files.

Sample station description

Proposal for a comprehensive, yet compact, standard description of a wind-measuring station, based on the outputs from WAsP and the Utility Programs.

Further information and ordering

More information can be obtained by contacting the WAsP team at Risø. Order by mail or fax; including information on contact person, shipping address and invoicing address (if different). Orders are usually shipped within one or a few days by courier or air mail.

Contacting the WAsP team at Risø

If you have any problems using the WAsP software, please send an e-mail to waspsupport@risoe.dk. This way your problem and questions will be registered properly and distributed to the right person in the WAsP team.

For general inquiries, sales, shipping, invoicing etc. send email to wasp@risoe.dk.

E-mail:	niels.g.mortensen@risoe.dk ole.rathmann@risoe.dk lars.landberg@risoe.dk
Web:	http://www.wasp.dk
Fax:	+45 46 77 59 70
Post:	Risø National Laboratory, VEA-125, DK-4000 Roskilde, Denmark
Telephone:	+45 46 77 50 97 (Ms. Rikke Nielsen)

References

The publications cited in this help facility are listed below.

Bowen, A.J. and N.G. Mortensen (1996). Exploring the limits of WAsP: the Wind Atlas Analysis and Application Program. Proceedings of the 1996 European Union Wind Energy Conference, Göteborg, Sweden, May 20-24, 584-587.

Bowen, A.J. and N.G. Mortensen (1997). WAsP prediction errors due to site orography. Risø-R-995(EN). Risø National Laboratory, Roskilde. In preparation.

Mortensen, N.G. and E.L. Petersen (1997). Influence of topographical input data on the accuracy of wind flow modelling in complex terrain. Proceedings of the 1997 European Wind Energy Conference, Dublin, Ireland, October 6-9, 317-320.

Rathmann, O., N.G. Mortensen, L. Landberg and A. Bowen (1996). Assessing the accuracy of WAsP in non-simple terrain. Wind Energy Conversion 1996. Proceedings of the 18th British Wind Energy Association Conference, Exeter, England, 25-27 September 1996, 413-418.

Rutkis, J. (1971). Tables on relative relief in middle and western Europe. University of Uppsala, Department of Physical Geography, UNGI Rapport 9. 21 pp.

Troen, I. and E.L. Petersen (1989). European Wind Atlas. Risø National Laboratory, Roskilde. 656 pp. ISBN 87-550-1482-8.

William-Olsson, W. (1974). A map of the relative relief of the western half of Europe, 1:4000000. Esselte Map Service, Stockholm.

Wood, N. (1995) The onset of separation in neutral, turbulent flow over hills. Boundary-Layer Meteorology 76, 137-164.

Risø readings in wind power meteorology

This is a list of selected papers, reports and published conference proceedings authored by or in collaboration with the staff of the Wind Power Meteorology Programme of the Wind Energy and Atmospheric Physics Department at Risø.

Wind power meteorology in general

Petersen, E.L., N.G. Mortensen, L. Landberg, J. Højstrup and H.P. Frank (1998). Wind Power Meteorology. Part I: Climate and turbulence. Wind Energy 1, 2-22.

Petersen, E.L., N.G. Mortensen, L. Landberg, J. Højstrup and H.P. Frank (1998). Wind Power Meteorology. Part II: Siting and Models. Wind Energy 1, 55-72.

Troen, I. and E.L. Petersen (1989). European Wind Atlas. ISBN 87-550-1482-8. Risø National Laboratory, Roskilde. 656 pp.

Wind measurements

Kristensen, L. (1993) The cup anemometer and other exciting instruments. Risø-R-615(EN), Risø National Laboratory, Roskilde, Denmark. 82 pp.

Kristensen, L. (1998). Cup anemometer behavior in turbulent environments. J. Atmos. Ocean. Tecnol. 15, 5-17.

Mortensen, N.G. (1994). Wind measurements for wind energy applications – a review. Wind Energy Conversion 1994. Proceedings of the 16th British Wind Energy Association Conference, Stirling, June 15-17, 353-360.

Mortensen, N.G. (1994). Flow-response characteristics of the Kaijo Denki omni-directional sonic anemometer (DAT 300/TR-61B), Risø-R-704(EN), Risø National Laboratory, Roskilde, Denmark, 32 pp.

Mortensen, N.G., and J. Højstrup (1995). The Solent sonic – response and associated errors. Ninth Symposium on Meteorological Observations and Instrumentation, Charlotte, NC, March 27-31, 501-506.

WAsP and wind modelling

Bowen, A.J. and N.G. Mortensen (1996). Exploring the limits of WAsP: the Wind Atlas Analysis and Application Program. Proceedings of the 1996 European Union Wind Energy Conference and Exhibition, Göteborg, Sweden, May 20-24, 584-587.

Frank, H.P. and L. Landberg (1997). Modelling the wind climate of Ireland. Boundary-Layer Meteorol. 85, 359-378.

Landberg, L. (1997). The mast on the house. In proceedings from BWEA 19, Edinburgh, 16-18 July, ed. R Hunter, 167-172.

Mortensen, N.G. and E.L. Petersen (1998). Influence of topographical input data on the accuracy of wind flow modeling in complex terrain. Proceedings of the 1997 European Wind Energy Conference and Exhibition, Dublin, Ireland, October 6-9, 317-320.

Walmsley, J.L., I. Troen, D.P. Lalas and P.J. Mason (1990). Surface-layer flow in complex terrain: Comparison of models and full-scale observations. Boundary-Layer Meteorol. 52, 259-281.

Wind atlases

Mortensen, N.G. and Usama Said Said (1996). Wind Atlas for the Gulf of Suez. Measurements and modeling 1991-95. ISBN 87-550-2143-3. Risø National Laboratory, Roskilde, and New and Renewable Energy Authority, Cairo. 114 pp.

Mortensen, N.G., P. Nielsen, L. Landberg, O. Rathmann and M.N. Nielsen (1999). A detailed and verified wind resource atlas for Denmark. 1999 European Wind Energy Conference and Exhibition, Nice, France, March 1-5.

Troen, I. and E.L. Petersen (1989). European Wind Atlas. ISBN 87-550-1482-8. Risø National Laboratory, Roskilde. 656 pp.

Petersen, E.L., I. Troen, S. Frandsen and K. Hedegaard (1981). Windatlas for Denmark. A rational method for wind energy siting, Risø-R-428, Risø National Laboratory, Roskilde, Denmark. 229 pp.

Short term prediction

Landberg, L., and S.J. Watson (1994). Short-term prediction of local wind conditions. Boundary-Layer Meteorol. 70, 171-195.

Landberg, L. (1999). Short-term prediction of the power production from wind farms. J. Wind Eng. Ind. Aerodyn. 80, 207-220.

On the Web

For general information about wind power, as well as links to other web sites related to wind power, a good place to start is www.windpower.dk, the award-winning home page of the Danish Wind Turbine Manufacturers Association. A download of the entire home page is also provided on the WAsP 6 distribution disk.

For specific information on the characteristics of a particular wind turbine, you should contact the manufacturer directly. A list of major Danish manufacturers is given below.

For information on the wind climate of a particular country or region, you might check the list of wind atlases given here. The national or state meteorological service may also be able to help you; the national services are organized in the World Meteorological Organization (www.wmo.ch).

Danish wind turbine manufacturers

Bonus Energy A/S	www.bonus.dk	bonus@bonus.dk
NEG-Micon A/S	www.neg-micon.dk	mail@neg-micon.dk
Nordex A/S	www.nordex.dk	nordex@nordex.dk
Vestas Wind Systems A/S	www.vestas.dk	vestas@vestas.dk
Wincon West Wind A/S		emn@wincon.dk

The WAsP library contains a folder with wind turbine power curves from all the manufacturers mentioned above. More power curves are available in the WAsP 4 package which is included on the CD-ROM.

Wind Atlases of the World 1998

The wind atlas methodology and the WAsP program has until now been applied in more than 65 countries around the world for national, regional and local studies. A list of major national and regional studies, several of which contains WAsP data files on disk, is given below.

Algeria

Hammouche, R. (1991). Atlas Vent de l'Algérie. Office National de la Météorologie, Alger. 150 pp.

Australia

Dear, S.J., M.J. Bell and T.J. Lyons (1990). Western Australian Wind Atlas. Report No. 64, Minerals and Energy Research Institute of Western Australia, Perth. 28 pp. + 14 App.

Belgium

European Wind Atlas (1989), see Europe.

Denmark

Petersen, E.L., I. Troen, S. Frandsen and K. Hedegaard (1981). Wind atlas for Denmark. A rational method for wind energy siting. Risø-R-428. Risø National Laboratory, Roskilde. 229 pp.

European Wind Atlas (1989), see Europe.

Mortensen, N.G., L. Landberg, O. Rathmann, G. Jensen and E.L. Petersen (1999). Wind Atlas Analysis of 24 Danish Stations (1987-96). In preparation for publication as Risø-R-1092(EN). Risø National Laboratory, Roskilde.

Egypt

Mortensen, N.G. and Usama Said Said (1996). Wind Atlas for the Gulf of Suez. Measurements and modeling 1991-95. ISBN 87-550-2143-3. Risø National Laboratory, Roskilde, and New and Renewable Energy Authority, Cairo. 114 pp.

Europe

Troen, I. and E.L. Petersen (1989). European Wind Atlas. ISBN 87-550-1482-8. Risø National Laboratory, Roskilde. 656 pp.

Finland

Tammelin, B. (1991). Suomen Tuuliatlas. Vind Atlas för Finland. In Finnish/Swedish. Finnish Meteorological Institute, Helsinki. 355 pp.

France

European Wind Atlas (1989), see Europe.

Germany

European Wind Atlas (1989), see Europe.

Traup, S. and B. Kruse (1996). Wind und Wind-energiepotentiale in Deutschland. Winddaten für Windenergienutzer. In German. Selbstverlag des Deutschen Wetterdienstes, Offenbach am Main. 445 pp.

Greece

European Wind Atlas (1989), see Europe.

Greenland

Mortensen, N.G. and L. Landberg (1993). Wind Energy in selected townships of Greenland: Qasigiannguit, Sisimiut and Narsaq. In Danish. Prepared for Nukissiorfiit/Greenland Power Company. Risø-I-718(DA). Risø National Laboratory, Roskilde. 37 pp.

Ireland

European Wind Atlas (1989), see Europe.

Watson, R. and L. Landberg (1999). The Irish Wind Atlas. University College Dublin, Dublin. In preparation.

Italy

European Wind Atlas (1989), see Europe.

Jordan

Højstrup, J. (1989). Wind Atlas for Jordan. Risø National Laboratory, Ministry of Energy and Mineral Resources, Jordan Electrical Authority, and Jordan Meteorological Department. 86 pp.

Luxembourg

European Wind Atlas (1989), see Europe.

The Netherlands

European Wind Atlas (1989), see Europe.

Portugal

European Wind Atlas (1989), see Europe.

Russia

Rathmann, O. (1998). Wind atlas analysis for 12 meteorological stations on the Kola Peninsula. Risø-I-1285(EN). Risø National Laboratory, Roskilde. 36 pp.

South Africa

Diab, R. (1995). Wind Atlas of South Africa. Department of Mineral and Energy Affairs, Pretoria, ?? pp.

Spain

European Wind Atlas (1989), see Europe.

Sweden

Krieg, R. (1992). Vindatlas för Sverige. In Swedish. Slutrapport på projekt 506 269-2 på uppdrag av NUTEK. SMHI, Norrköping. 26 pp.

United Kingdom

European Wind Atlas (1989), see Europe.

Air density table

Air density [kg/m³] as a function of elevation *Z* [m a.s.l.] and mean temperature (from -25ºC to 40ºC) at the same elevation. A lapse rate of 6.5 K/km and a sea level pressure of 1013.25 HPa are assumed. Power curves are often referenced to 'standard conditions' corresponding to sea level pressure and 15ºC.

Z	**-5**	0	**5**	**10**	**15**	20	**25**	**30**	**35**	40
0	1.316	1.292	1.269	1.247	1.225	1.204	1.184	1.164	1.145	1.127
100	1.300	1.276	1.254	1.232	1.211	1.190	1.170	1.151	1.133	1.115
200	1.283	1.260	1.238	1.217	1.196	1.176	1.157	1.138	1.120	1.103
300	1.267	1.245	1.223	1.202	1.182	1.163	1.144	1.126	1.108	1.091
400	1.251	1.230	1.208	1.188	1.169	1.150	1.131	1.113	1.096	1.079
Z	**-10**	**-5**	0	**5**	**10**	**15**	20	**25**	**30**	**35**
500	1.258	1.236	1.214	1.194	1.174	1.155	1.136	1.118	1.101	1.084
600	1.242	1.220	1.199	1.179	1.160	1.141	1.123	1.106	1.089	1.072
700	1.226	1.205	1.185	1.165	1.146	1.128	1.110	1.093	1.077	1.061
800	1.210	1.190	1.170	1.151	1.133	1.115	1.098	1.081	1.065	1.049
900	1.195	1.175	1.156	1.138	1.120	1.102	1.085	1.069	1.053	1.038
Z	**-15**	**-10**	**-5**	0	**5**	**10**	**15**	20	**25**	**30**
1000	1.200	1.180	1.161	1.142	1.124	1.106	1.089	1.073	1.057	1.042

1100	1.184	1.165	1.146	1.128	1.111	1.094	1.077	1.061	1.045	1.030
1200	1.169	1.151	1.132	1.115	1.097	1.081	1.065	1.049	1.034	1.019
1300	1.154	1.136	1.118	1.101	1.084	1.068	1.052	1.037	1.022	1.008
1400	1.140	1.122	1.105	1.088	1.072	1.056	1.040	1.025	1.011	0.997
Z	-20	-15	-10	-5	0	5	10	15	20	25
1500	1.143	1.125	1.108	1.091	1.075	1.059	1.043	1.028	1.014	1.000
1600	1.128	1.111	1.094	1.078	1.062	1.046	1.031	1.017	1.003	0.989
1700	1.114	1.097	1.081	1.065	1.049	1.034	1.019	1.005	0.991	0.978
1800	1.100	1.083	1.067	1.052	1.037	1.022	1.008	0.994	0.980	0.967
1900	1.086	1.070	1.054	1.039	1.024	1.010	0.996	0.983	0.969	0.957
Z	-25	-20	-15	-10	-5	0	5	10	15	20
2000	1.088	1.072	1.056	1.041	1.026	1.012	0.998	0.985	0.971	0.959
2100	1.074	1.058	1.043	1.028	1.014	1.000	0.987	0.973	0.961	0.948
2200	1.060	1.045	1.030	1.016	1.002	0.988	0.975	0.962	0.950	0.938
2300	1.046	1.031	1.017	1.003	0.990	0.977	0.964	0.951	0.939	0.927
2400	1.033	1.018	1.005	0.991	0.978	0.965	0.953	0.941	0.929	0.917