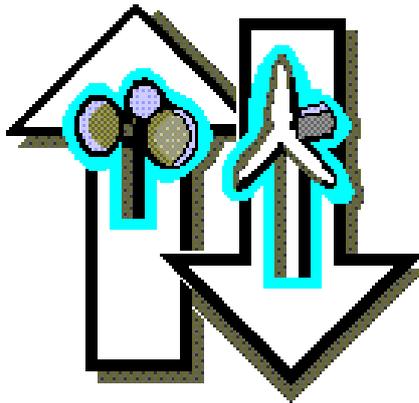


WindPRO / Energy

WAsP In WindPRO



EMD International A/S

Niels Jernes Vej 10, DK-9220 Aalborg, Denmark

www.emd.dk or www.windpro.com

phone +45 9635 4444, fax. +45 9635 4446

e-mail: windpro@emd.dk



Published by:

EMD International A/S
Niels Jernesvej 10
9220 Aalborg Ø
Tel: +45 9635 4444
Fax: +45 9635 4446
Email: emd@emd.dk
web: www.emd.dk

Author(s)

Lasse Svenningsen, PhD

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Front cover

The front cover shows the WASP and then WindPRO logos.

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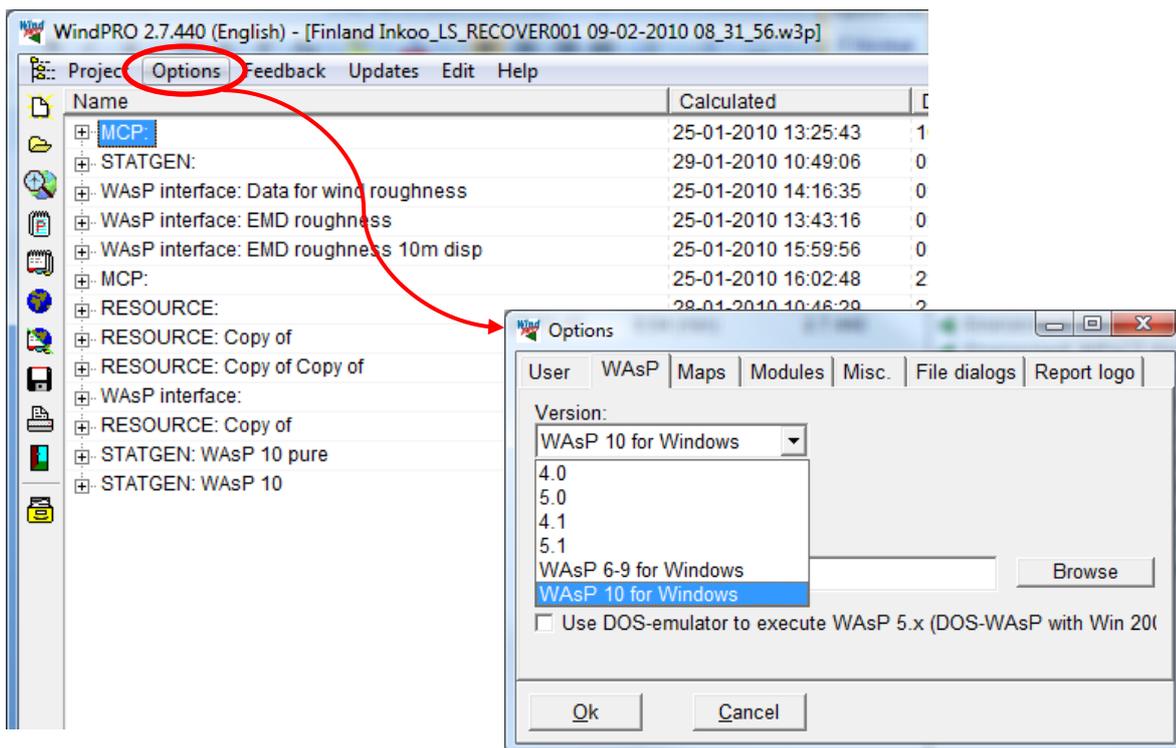
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1 WAsP in WindPRO

WAsP calculations in WindPRO use and internal WAsP engine included in the WindPRO installation. This WAsP engine only requires a valid WAsP license (i.e. the WAsP license manager and a valid dongle). So no local WAsP installation is needed.

In WindPRO 2.6 the included WAsP engine corresponds to WAsP 8/9 and was the only choice.

As from WindPRO 2.7 the user can choose which WAsP engine to use, either the new WAsP 10 or the previous equivalent to WAsP 9.0 and older. The WAsP setup is accessed from the calculation window via “Options > Options” and then select “WAsP” tab (see below).



It is important to be aware that the WAsP default parameter settings are a property of the WAsP engine. So that changing WAsP engine in WindPRO 2.7, will change WAsP defaults.

The default parameters have remained unchanged from the very first WAsP versions, but have been changed in WAsP 10.

Our recommendation and the default of WindPRO 2.7 (at time of writing 2nd March 2010 where 2.7 is still beta) is to use the WAsP engine WAsP 6-9. This is so due to some initial problems in WAsP 10 which have not yet been fully solved from Risø. However, WAsP 10 includes an important correction to the off shore stability model, where there old WAsP (6-9) models too high shear off shore. Off shore stability settings are only used by WAsP where the user specifies a roughness of exactly 0. For purely off shore calculations we recommend to use the WAsP 10.

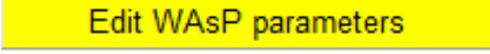
2 How are the parameters accessed?

Everywhere in WindPRO (from version 2.7) where WASP calculations are utilized it is possible to change the WASP parameters via the button “Edit WASP parameters”. If parameter settings are identical to the defaults of the selected WASP engine (see previous paragraph) the button is grey, if not it becomes yellow (see below).



Edit WASP parameters

Default parameters of selected WASP engine.



Edit WASP parameters

Caution! Deviation(s) from defaults of selected WASP.

New calculations get the default settings of the selected WASP engine, unless the user has changed parameters. In case the user has adjusted WASP parameters, a new calculation always inherit the values as of the previous change within the project – so changing the parameters one place (e.g. in Meteo object) changes the defaults for all other types of new calculations (e.g. Park and Statgen). If an existing calculation is copied the particular parameter settings are included in the copy.

3 Recommendations for parameter settings

Following the “Best practice” recommendations of the WASP team, users should only consider adjusting a few of the many WASP parameters. These parameters are related to the wind atlas structure (standard heights and standard roughnesses) and heat flux (stability) as indicated in the text box from “WASP Best Practices” inserted below. Other parameters should be left unchanged unless explicitly recommended by contact with the WASP or WindPRO support teams.

WASP modelling – parameters

- Wind atlas structure: standard roughness classes should span site conditions
- Wind atlas structure: standard heights should represent project
- Adjust off- & on-shore mean- and RMS-heat flux values to site conditions (*caution*)

From: <http://www.wasp.dk/Support/DownloadFiles/WASP%20Best%20Practices.pdf>

A very brief description of all the WASP parameters including those which it is NOT recommended to edit can be found at: <http://www.wasp.dk/support/FAQ/WebHelp/WASPparameters.htm> (Default values in this link refer to version 9.0, i.e. old WASP defaults).

4 The effect of changing WASP parameters

A key concept of the WASP methodology or Wind Atlas Methodology is the generation of regional wind atlases, cleaned of local effects of orography, roughness and possible obstacles. A wind atlas specifies the “cleaned” wind profile as sector-wise Weibull parameters at several heights and for several standard roughness classes. The Statgen calculation in WindPRO calls WASP and creates the wind atlas. When applying the wind atlas in e.g. a Park calculation from WindPRO, WASP will interpolate between the specified standard heights and roughnesses as part of the flow modelling.

4.1 Standard roughness classes (of a wind atlas)

Regarding roughness the main importance is that the wind atlas standard roughness classes span the roughnesses attributed in the surface roughness model. If this is not the case extrapolation errors are a likely result.

The standard roughness classes in WAsP 10 are:

Standard roughness lengths [m]:	0.0	0.03	0.1	0.4	1.5
Corresponding roughness classes:	0.0	1.0	2.0	3.0	4.0

If the dominating roughness length in a project is not close to any of the standard roughness lengths one can experiment and change one of the standard roughness lengths to equal the dominating roughness length in the project.

Roughness length 0 (and class 0), plays a special role as WAsP interprets areas attributed exactly this value as sea/offshore. WAsP treats sea quite differently from land concerning stability parameters, which has a strong effect on the vertical profile (more about stability parameters in later section). In reality the roughness length of sea water is not zero, but around 0.0002m, this is also what is used internally in WAsP - **but the user must follow the WAsP convention and use exactly 0 (length or class) for offshore areas.**

4.2 Standard heights (of a wind atlas)

The standard heights in a wind atlas are utilized to interpolate the wind climate (sectorwise Weibull A and k) to heights between these standard heights. The five default standard heights are:

Default standard heights [m]	10	25	50	100	200
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To avoid interpolation errors it is important that the height of interest, i.e. the turbine hub height is not too different from the standard heights. It is recommended to change the nearest of the standard heights to the actual hub height when making the wind statistics from Statgen. Of course the user should be aware that this might increase interpolation errors for other heights which are further from the changed standard height.

4.2.1 Self and cross prediction in Meteo Analyzer

A special case in this context is the cross prediction check in the Meteo Analyzer. Here, a wind atlas is generated based on of each selected height and mast. Then, each of these wind atlases are used to predicted the wind climate (mean wind speed) at the other masts and heights. If the standard heights are not set to match the actual heights represented by the masts, self prediction errors and cross prediction errors resulting from interpolation are likely to occur. This is especially the case if stability parameters have been altered by the user (the more stable, the larger the interpolation errors).

A	A [%]	B	B [%]	C	C [%]
<input checked="" type="checkbox"/>	1.1	<input checked="" type="checkbox"/>	4.4	<input checked="" type="checkbox"/>	13.1
<input checked="" type="checkbox"/>	-2.2	<input checked="" type="checkbox"/>	0.9	<input checked="" type="checkbox"/>	10.1
<input checked="" type="checkbox"/>	-12.9	<input checked="" type="checkbox"/>	-10.2	<input checked="" type="checkbox"/>	0.0

Simple cross/self prediction for several heights (A: 40m, B: 30m, C: 10m) of the same mast – using default standard heights in the wind atlas. Notice the error in self prediction (red circles) for the two heights deviating from WASP default standard heights (height A and B).

A	A [%]	B	B [%]	C	C [%]
<input checked="" type="checkbox"/>	0.0	<input checked="" type="checkbox"/>	3.3	<input checked="" type="checkbox"/>	12.1
<input checked="" type="checkbox"/>	-3.2	<input checked="" type="checkbox"/>	0.0	<input checked="" type="checkbox"/>	9.2
<input checked="" type="checkbox"/>	-12.9	<input checked="" type="checkbox"/>	-10.2	<input checked="" type="checkbox"/>	0.0

Same as above but with WASP standard heights changed to match those of the mast i.e. (A: 40m, B: 30m, C: 10m). Notice, that now the error in self prediction (red circles) is zero for all heights.

4.3 Heat flux parameters

In total there are four parameters referring to heat flux in the WASP parameters; a mean and an RMS (Root-Mean-Square), both for land and for offshore surfaces. The mean values are referred to as “Offset” and measure the average stability conditions. The “RMS” values indicate the degree of the variation around the mean.

Parameter	Minimum	Maximum	Default	Value
Rms heatflux over land	0	200	100	100
Rms heatflux over water	0	200	30	30
Offset heatflux over land	-200	200	-40	-40
Offset heatflux over water	-200	200	15	15

Screen dump of the editable WASP heat flux parameters in WindPRO also showing the default values.

As mentioned previously WASP distinguishes between onshore and offshore conditions from the roughness values attributed to each area. Onshore heat flux parameters are always used unless a roughness of exactly 0 is attributed to an area, then WASP will use offshore heat flux parameters.

Default “Offset” and “RMS” heat flux for onshore is: -40 W/m^2 and 100 W/m^2 , respectively. This indicates slightly stable (negative mean flux) conditions on average, with a rather strong variation around the mean.

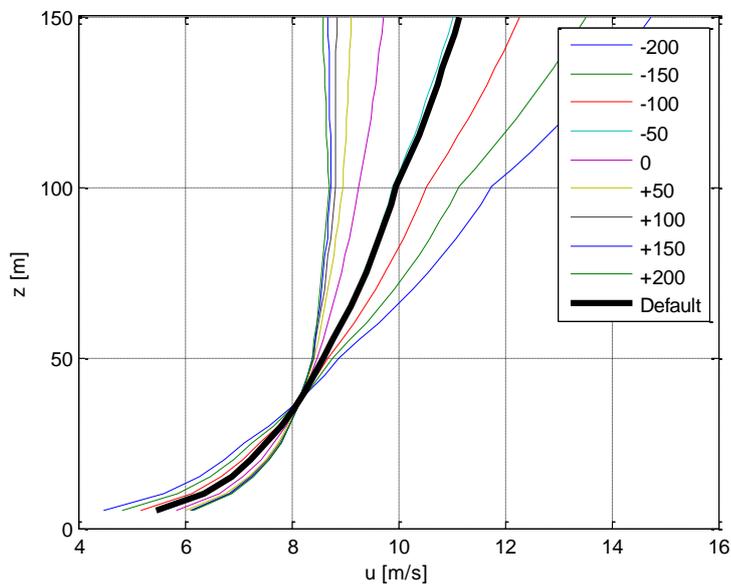
Default “Offset” and “RMS” heatflux for offshore is: $+30 \text{ W/m}^2$ and 15 W/m^2 , respectively. This indicates slightly unstable (positive mean flux) conditions on average, with only little variation around the mean.

The onshore and offshore parameters behave in exactly the same way. If changed to identical values (not default!), onshore (roughness>0) and offshore (roughness=0) will have identical stability corrections in the vertical profiles of a WASP calculation.

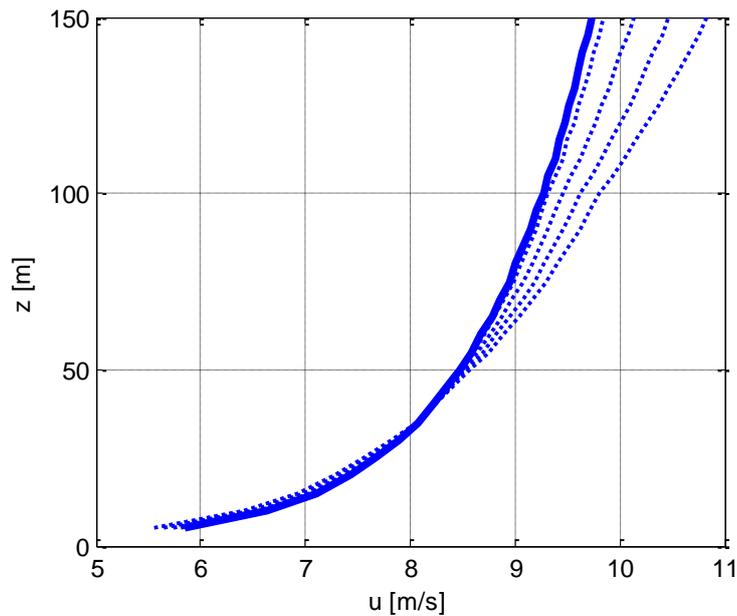
4.3.1 The effect of changing the “Offset” (mean) and “RMS” heat fluxes

With Offset and RMS both equal to zero WASP calculates for a purely neutral atmosphere/vertical profile. Changing the Offset heat flux towards lower (negative) values has the effect of making the vertical profile more stable, thus, increasing the vertical shear considerably. Increasing the “RMS” value has the effect of increasing the shear slightly towards a more stable profile.

The figure below illustrates the default WASP onshore profile (Offset=-40 W/m², RMS=100 W/m²) for flat terrain and roughness class 1, as the black curve. The coloured curves illustrate WASP profiles for same terrain and roughness conditions, but for the different heat flux Offsets indicated in the legend (in W/m²). RMS=0 W/m² (i.e. no variation around the mean heat flux) for all curves except the WASP default profile. Notice that for low Offsets as -200 W/m² the standard heights in the wind atlas are clearly visible as “bumps” at 50m and 100m. This illustrates the possible interpolation error for heights in between the standard heights, if the standard heights are not adjusted according the relevant hub heights.



The figure below illustrates the effect of changing the RMS heat flux between 0 W/m² and 200 W/m² in steps of 50. The Offset heat flux (i.e. mean) is fixed to 0 W/m² in all cases. The thick blue curve is for RMS=0 W/m² and the right most dashed curve is for RMS=200 W/m². The thick blue curve in this graph corresponds to the purple one in the previous graph.



For other non-zero values of the Offset heat flux the effect of changing the RMS between 0 W/m^2 and 200 W/m^2 is fully equivalent to the effect for Offset= 0 W/m^2 shown above; a slight increase of the shear towards a more stable profile.

4.3.2 Should the heat flux parameters always be changed?

The heat flux parameters of the WASP model should only be changed if either there are actual heat flux data available for the site or there is solid knowledge supporting that the WASP default values are not representative for the site.

It is not generally recommendable simply to fit the measured wind profile by trial and error adjustment of the WASP heat flux parameters. The heat flux values should reflect reality. Measured data often have errors and flaws and do not simply reflect the true wind conditions, so that adjusting WASP parameters to fit one measured vertical profile perfectly might sometimes make flow modelling results worse than using WASP standard parameter settings.

Generally, WASP parameters should only need to be changed in very cold or very warm climates.