Validation Update

January 2013

WINDIE™ Validation Programme. This document reports on the results of the ongoing validation programme of the WINDIE™ CFD software in terms of wind resource assessment. Validation efforts have mainly taken the shape of cross-predictions between measurement data, whereby WINDIE™ results are synthesised with one measured wind series and transported to another mast's position. The resulting 'virtual' data series can then be compared with measurements at the target station. This assessment is carried out in all WINDIE™ studies, which are usually conducted prior to wind farm construction. Please contact us if you would like us to perform a blind test of WINDIE™ results at your measurement site.

1. Introduction

WINDIE™ is a computational fluid dynamics (CFD) code developed by a team of researchers from the Instituto Superior de Engenharia do Porto (ISEP, www.isep.ipp.pt). This team, lead by Prof. Fernando Aristides Castro, has over 15 years experience in the field of CFD modelling of atmospheric flows applied to the wind industry.

WINDIE™ is a non-linear model that solves the Reynolds-averaged Navier-Stokes equations (RaNS), on terrain-following meshes. It is specially suited to capture complex phenomena such as flow separation, turbulence induced by complex topography, thermal effects, large flow deviations and shear, as well as other flow features such as those induced by neighbouring forested areas.

Over the past 3 years, WINDIE™ has been used to study wind farms totalling over 1.3 GW of installed capacity, spread over 10 countries.

2. Standing Out from the Pack

WINDIE™ CFD code contains a number of features that make it stand out from other wind engineering packages.

Coupling with Mesoscale Data. The use of mesoscale results as boundary conditions to WINDIE™ has been shown to improve results by bringing more realistic boundary conditions to the CFD computational domains.

Modelling Thermal and Coriolis Effects. WINDIE™ can also solve the temperature field and include its effects (in terms of buoyancy and turbulence production/destruction) in the flow field. Coriolis effects are also accounted for.

Forest Canopy Model. WINDIE™ has one of the most advanced forest canopy models, extensively validated with real data (Lopes da Costa (2006)). It describes the vertical shape of the trees in terms of its leaf area density and it has detailed interpolation techniques to model small or complex-shaped tree patches.

Turbulence Modelling Portfolio. WINDIE™ contains no less than 5 turbulence models in its portfolio. These models can help confirm site assessment results or help investigate phenomena that a single model may not capture. In essence, it presents the user with more possibilities of investigating what is going on at a given site.

Growing Validation Track Record. WINDIE™, in its first year of activity as a fully-fledged wind engineering tool has come up against several real cases of considerable complexity. It has consistently outperformed WAsP and other CFD codes in cross-predictions of mean wind speeds and in predictions of wind farm production and wind energy patterns compared with actual wind farm data.

Seasonal & Diurnal Cycle Analysis. By extracting mesoscale boundary conditions from specific events or times of the year, WINDIE™ can simulate seasonal and diurnal cycle effects to shed further light onto local wind flow characteristics.

Megajoule Inovação, Lda.
Rua Engº Frederico Ulrich 2650
4470-605 Maia Portugal

Instituto Superior de Engenharia do Porto
Rua Dr Ant Bernardino de Almeida 431
4200-072 Porto Portugal

3. WINDIE™ Validation Programme

WINDIE™ validation track record is growing every month with new cases in varied conditions. In all cases thus far WINDIE™ results are compared with measurements and with WAsP predictions.

Comparison with Other Models. Whenever results are also available using a commercial wind engineering CFD tool, an additional comparison is performed. The programme comprises 56 comparisons thus far involving 5 different and varied sites: from complex to simple topographies to forested and non-forested areas. More details on each site and individual cross-prediction results can be found at our website, www.megajoule.pt.

The following graph summarise the results of the validation programme with comparisons with WAsP.

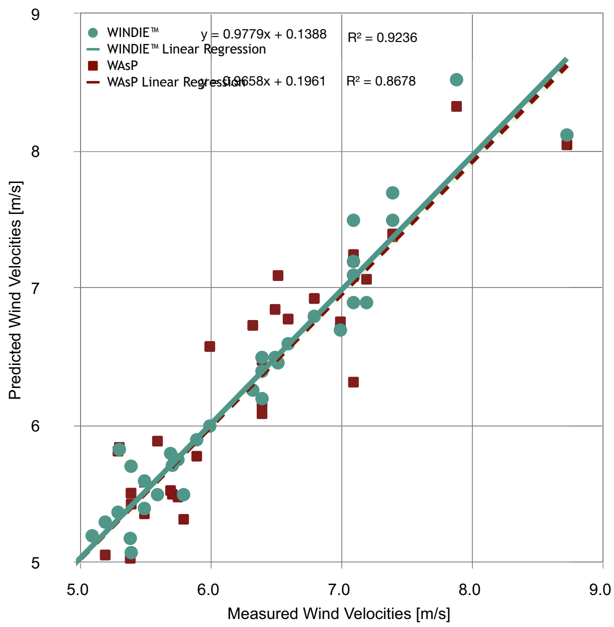

Figure 1. Comparison between WINDIE™ and WAsP.

	WINDIE™	WAsP	Other CFD
Average Diff	**0.0%**	-0.3%	0.4%
RMS	**3.8%**	7.6%	4.2%
STDEV	**3.8%**	5.1%	4.4%
R2	**0.924**	0.868	0.741
R	**0.961**	0.932	0.861

Updated Validations. The continuing programme has added a number of other cases, collected at each commercial study conducted using WINDIE™. These total **120 cross-predictions**, divided between horizontal and vertical cross-predictions, including poorly instrumented sites, in very complex topography and including dense forests. Every customer receives the results of the cross-predictions conducted on each site and these results are used in **lowering the uncertainty of AEP estimates.**

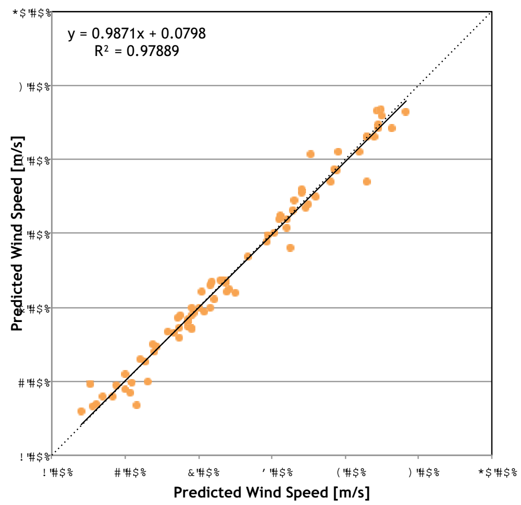

Figure 2. Vertical cross-predictions using WINDIE™

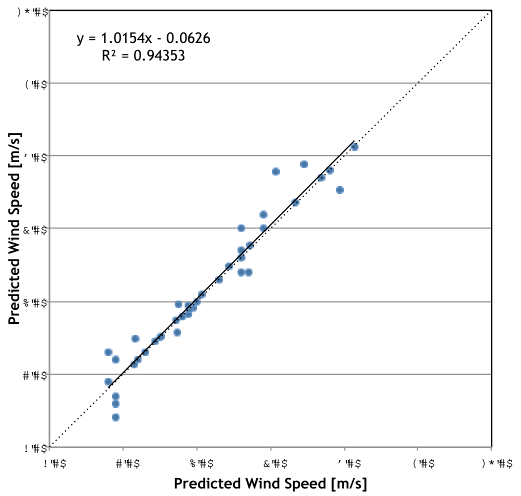

Figure 3. Horizontal cross-predictions using WINDIE™ in well-instrumented complex sites with and without forests

Conclusion. WINDIE™ results were shown to be better than both WAsP and another CFD code used in the wind industry. The programme includes a total of 120 comparisons so far, across 22 different sites in 10 different countries.

Please contact us to perform a blind test of WINDIE™ on your site.

Further Info.

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www.facebook.com/MEGAJOULE
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www.linkedin.com/MEGAJOULE

carlos.santos@megajoule.pt
windie.lda@gmail.com