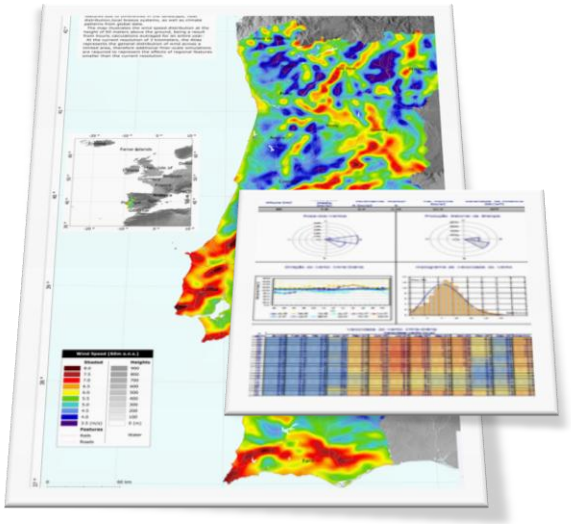
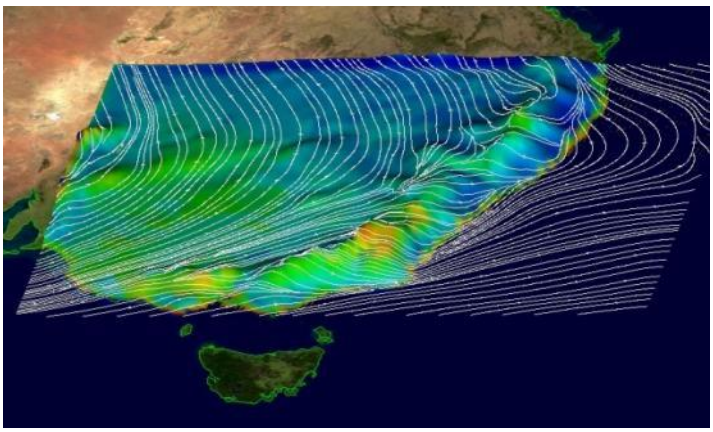


windsight™

Validation of WindSight™ - Mesoscale Modelling for Early Stage Wind Assessment for Portugal

Understanding the wind resources in areas where local measurements are scarce or unavailable is nowadays possible with state-of-the-art mesoscale numerical weather models and public high quality global weather databases.



Since 2007, MEGAJOULE has developed and tested an internal methodology using mesoscale modeling to assess wind resources worldwide: WindSight™.

WindSight™ approach was developed internally with European Community support and in cooperation with Aveiro University Physics research department.

WindSight™ - Concept

Mesoscale modeling is performed using WRF – Weather Research and Forecasting mesoscale's numerical model. WRF was developed by the U.S. National Center for Atmospheric Research (NCAR) as an evolution of the original MM5. It incorporates the latest scientific developments from the leading research centers, and is the result of decades of research.

A dynamic downscaling of global weather data (such as more than 50 years of Reanalysis NCEP/NCAR data or 40 years of ERA40 from ECMWF, among other possibilities)

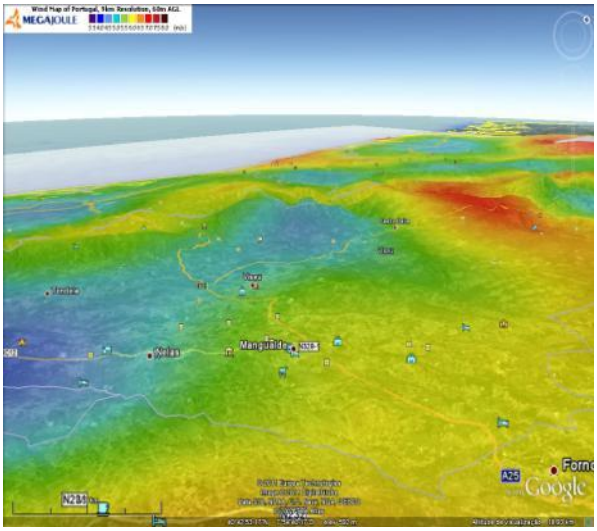
Over the past years, MJ has "tuned" the model configuration for best results in wind assessment. A baseline parameterization and model configuration was defined, although specific model configuration is studied for each project in hands.

If available, MJ can assimilate local wind measurements for better results.

Why no Pre-Calculated Wind Data ?

Mesoscale weather numerical modeling is a complex science and in constant development. Calculation domain and several model parameterizations depend on the site's characteristics, latitude and general forcing weather. The WRF model is also in continuous development.

By not making use of pre-calculated wind maps or data MJ ensures that our Clients get the best modeling option available for each case and at any given time



(Wind Map over Portugal in Google Earth kmz format)

Typical application from WindSight™

Typically, mesoscale wind assessment is best suited for greenfield or early stage wind assessments.

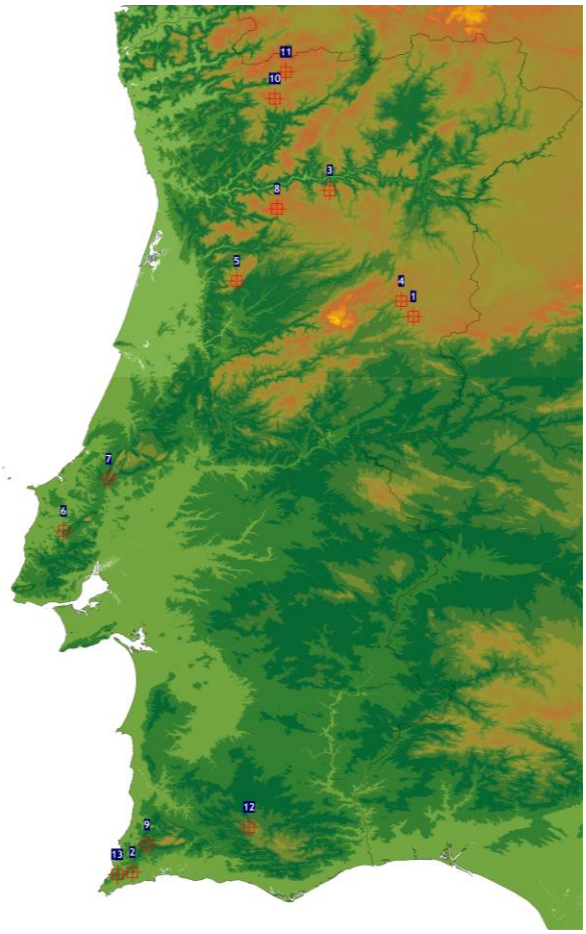
Traditional results are:

- Early stage Wind Resource Mapping (flexible output data – GIS, Google Earth, etc…)
- Early stage micrositing and energy estimates (coupling mesoscale results with WAsP or CFD)
- Preliminary site assessment (detailed IEC wind conditions by coupling mesoscale results with CFD)
- Virtual Long Term reference wind data (for Long Term extrapolation and MCP)

Other outputs include Atmospheric Stability analysis and sensible Heat fluxes for WAsP parameterization, Extreme wind speed analysis, Cold Climate or Icing conditions, Hot Climate conditions,

Validation of Simulated Wind Data Series for Portugal

During 2011 MJ completed its first validation programme for WindSight™ mesoscale modeling (Windsight™ validation White Paper, March 2011) using wind data from 34 different locations worldwide.



(Location of masts used for Windsigth™ validation)

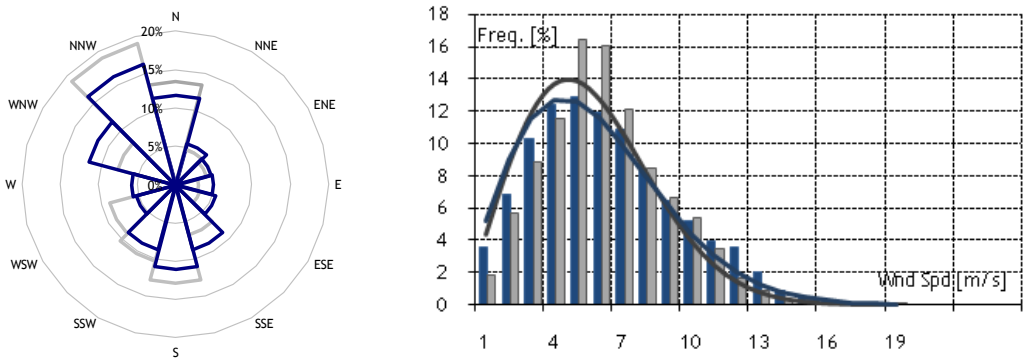
Also in 2011 a specific validation Portugal mainland was also competed. This validation was based on the 3x3 km resolution simulated wind data series, based on input data from the global data from NCEP FNL (Final) Operation Global Analysis data set. No data assimilation or MOS was performed, to ensure an independent blind test.

The simulated data was compared against local measurements for 13 sites in Portugal.

The local measurements were taken at lattice masts used for wind assessment fully compliant with IEC/MEASNET requirements. The masts are operated by MJ and are not in any way assimilated in the input global datasets or in the model runs, thus, ensuring fully independent blind tests.

Measurement heights used are 40 and 60 m above ground level.

The test sites range from flat terrain to complex sites and also from coastal (< 10 km to shoreline) to inland sites.



(Example of Wind Rose and Histogram for a Complex/Inland site, WindSight (grey), Observed (blue)))

Results showed a **RMSE error in average wind speed of 0.47 m/s and a BIAS of - 0.04 m/s**.

The cumulative distribution of results (table 2) showed that for **80 % of cases, average wind speed difference was below 0.56 m/s** and below 0.44 m/s for 50 % of cases.

Global statistics for Average Wind Speed comparison		
MAE (m/s)	RMSE (m/s)	BIAS (m/s)
0.43	0.47	-0.04

Maximum Mean Absolute Error (MAE) for different frequency levels	
Frequency [%]	Maximum MAE (m/s)
50%	0.45
80%	0.56
90%	0.73

Conclusions

The statistics above prove the **usefulness of WindSight™ mesoscale wind assessment particularly for greenfield and early stage wind studies in Portugal Mainland**.

For 3x3 resolution it can be assumed that there is **80 % probability that real average wind speed will be within +/- 0.56 m/s of simulated average wind speed**.

Uncertainty in wind speed means that the WindSight™ approach is most applicable for a greenfield or early stage viability studies. At these stages, developers should more willing to take more risk, while benefiting from a pragmatic and comparable approach to wind assessment.

Agreement in Wind Rose and Wind Speed Histogram was sufficiently good to provided a good base for early stage turbine micrositing and AEP estimates (coupling mesoscale wind data with micrositing tools and linear or CFD models). This is particularly interesting for projects were wind farm layout must be defined in very early stages and without any local data.

Early stage wind assessment, while possible with mesoscale modeling, should never substitute on-site reliable wind measurements for more than 1 year, in order to ensure typical bankable uncertainty on AEP estimates.

Further Info.:

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megajoule@megajoule.pt

Annex - List of sample sites

ID	Complexity	Elevation [m]	Average Wind Speed [m/s]		Deviation [m/s]
			Observed	Simulated	
35	Complex / Inland	901	6.46	6.66	0.20
36	Flat / Coastal	142	6.40	6.57	0.17
37	Complex / Inland	896	6.01	5.28	-0.73
38	Complex / Inland	898	6.10	6.61	0.51
39	Complex / Inland	949	6.15	5.66	-0.50
40	Complex / inland	277	7.38	6.94	-0.44
41	Complex / inland	426	8.76	7.93	-0.83
42	Complex / inland	1304	7.22	6.98	-0.25
43	Complex / inland	349	6.46	6.91	0.45
44	Complex / inland	1046	6.60	7.16	0.56
45	Complex / inland	1124	6.99	6.70	-0.29
46	Complex / inland	509	6.49	6.78	0.29
47	Flat / Coastal	125	7.14	7.52	0.37