Evaluation of WRF mesoscale model for icing events characterization: Some insights on model performance

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VORTEX

Motivation

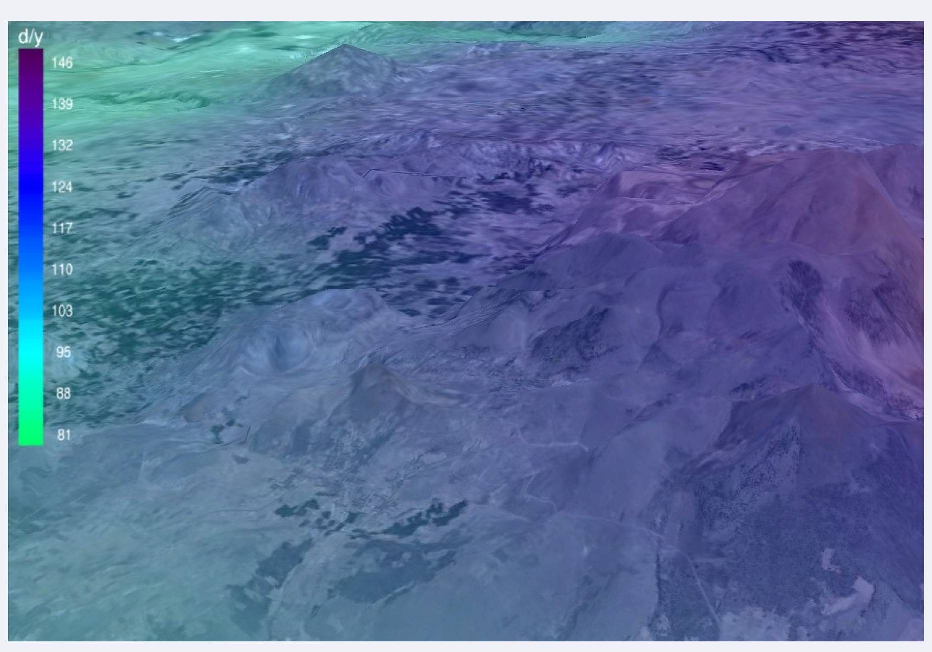
* **Development of windpower markets in extreme cold climates** enhances the need of site-specific environment conditions information.

* **Power production loss estimation** can be biased by limited assumptions on site icing events characterization.

* **Lack of observed icing conditions** is a recurring constrain for many projects.

* **Hindcast modeling solutions have been proved skillful** alternatives to represent wind regime and temperature at near windfarm resolution.

* **This work** shows a verification analysis of WRF model wind, temperature and moisture output parametres as driving conditions for icing accretion model and events identifications by using date from 6 sites provided by Gamesa at 5 European different countries.

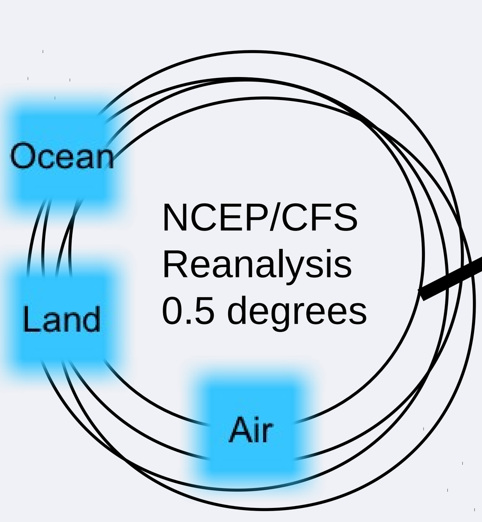


(1) This figure shows the number of days per year below a temperature threshold based on Vortex WRF 3km temperature output driven by NCEP/CFS Reanalysis 0.5 degrees data.

Model setup and configuration

Step1 – Cold weather events detection: 1km resolution WRF model hindcasts driven by NCEP/CFS reanalysis at 0.5 degrees. 80x80 points grid were used. Activation of **Thompson** microphysics scheme. The model output is processed in order to select potential icing events based on crossed distribution of humidity and temperature.

Step2 – Icing rate calculation and wind distributions: High 100m WRF resolutions during icing episodes. Output used to feed Makkonen icing accretion model to produce estimation of icing events duration based on icing rate threshold of 10 gr/h. Results are also used for characterizing wind distributions during icing events.



WRF 1km output.
Selection of potential icing events based on temperature and moisture.

WRF 100m output.
Temperature, wind, density and humidity are used to feed Makkonen model

1) Average over a 10 year period in order to provide number of hours per year with Icing rate > 10g/hour.

2) Calculation of wind distributions during Icing events normalized over hours per year.

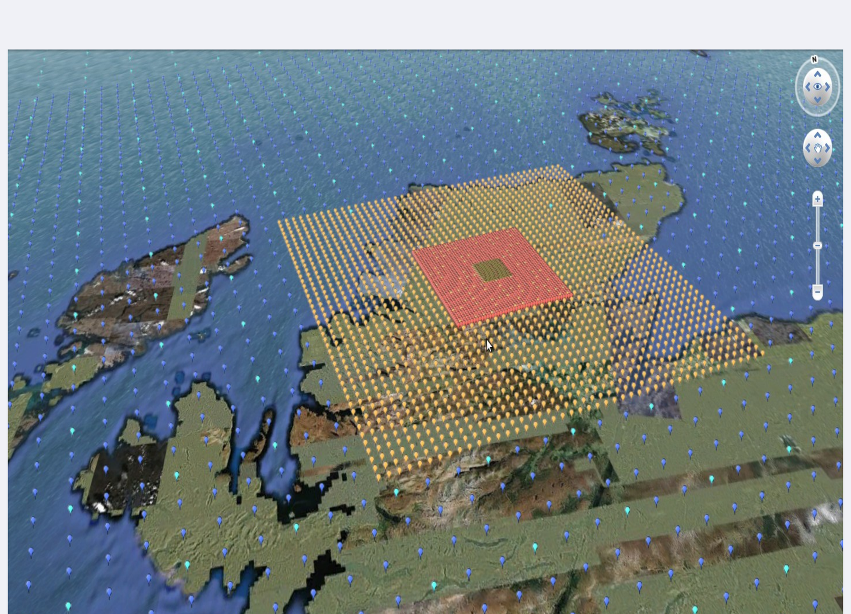


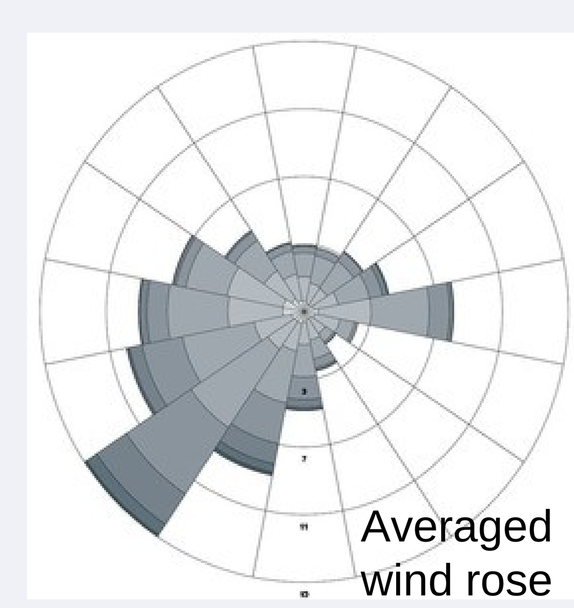
Figure 1 Nested domains that define downscaling approach at a 1Km WRF temperature and moisture characterization

Results

Icing events occurrences match: The table shows the number of days with icing rate above 10g/hour at 6 sites. It can be observed how Vortex relevantly matches the icing occurrences on a mean value when compared to anemometry data. In relation to turbines stops, results are discouraging. The main reason for this might be that a relationship between anemometry data and turbines in icing episodes seems to be currently lacking in the wind energy industry.

Site	Period	#Days Iced Anem.	#Days Vortex Icing	#Days Turbines Stopped
Germany1	24 months	23	49	9
Portugal	3 months	7	18	
Spain	72 months	274	295	
Germany2	24 months	20	23	0
Poland	72 months	178	299	
Sweden	12 months	38	63	

Wind distribution during icing events: Figure 2 shows the 16-sector wind rose for one of the analyzed sites during 10 years and during icing events respectively. It is observed how icing events do not correspond to the main wind speed direction at this site and how icing events have higher probability of occurrence in lower wind conditions.



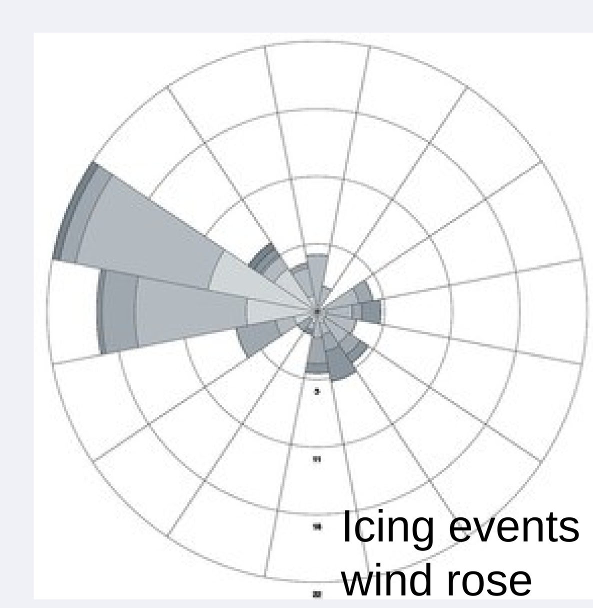


Figure 2: a) Wind distribution at a German site for the mean wind speed over a 10 year period and b) wind distribution at the site during icing episodes.

Conclusions

This work shows results from a validation exercise conducted by Vortex with the support of Gamesa observed data at five European countries to assess WRF model performance on tracking icing and extreme cold events conditions.

Output results from high resolution (100m) WRF model hindcasts were employed to feed Makkonnen icing accretion model to produce estimation of icing events duration based on icing rate threshold of 10 gr/h. Results from the validation showed:

-Very relevant temperature tracking, with correlations of the order of R2>0.95 and >0,98 for daily and monthly correlations respectively.
-Quite satisfactory predicted hours above 10g/h accretion rate against observational anemometry data. However, specific icing events are not coherent in time as expected. Model performs on a mean value rather than as a purely icing time series generator, which imply that error tends to compensate.
-Poor correlation between icing prediction and turbines availability. Although at the moment of this research it was not possible to determine how turbine availability can effectively be employed to calibrate model icing detection, a specific research will follow to quantify uncertainty on observed icing detection.
-Final 100m model runs and observed crossed wind speed/direction distributions show a significant level of similarity, which encourage the use modeling solutions to discriminate extreme and non extreme resource conditions.