Validation of the wind resource prediction for coupled ALADIN/WAsP modelling system in complex terrain

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Summary

In order to explore potential to predict local wind climate ALADIN/HR mesoscale model was coupled with the local-scale wind resource numerical model WAsP. Time series of predicted geostrophic wind at 850 hPa were calculated by the mesoscale model ALADIN/HR and used to extract wind atlas files readable by WAsP. WAsP was forced to downscale geostrophic wind climate to near-ground. A case study was carried out for the reference meteorological station located in a fairly complex terrain in the Croatian hinterland. Modelling results are compared with the measured data and presented in the paper.

Key Words: ALADIN/HR, WAsP, geostrophic wind, wind resource

1. Introduction

One of the most important factors in efficient use of wind energy is accurate wind resource assessment at potential wind farm site. A number of different approaches are applied in practice, including on-site measurements or, in the absence of measurements, application of different sophisticated numerical models for wind resource modelling. One of the modelling approaches is to combine models at different scales: to combine models describing mesoscale wind drivers with local-scale models that more accurately take into account local effects. By this approach, significant improvements are reported in wind resource assessment accuracy over large regions, compared to application of direct mesoscale model outputs, for example [1].

For everyday operational meteorological practice the Croatian Meteorological and Hydrological Service uses a Croatian version of the limited area numerical weather prediction model ALADIN (Aire Limitee Adaptation Dynamique Developement International), the so called ALADIN/HR model.

In order to explore local wind climate prediction potential for the ALADIN/HR mesoscale model, coupled with the well-known microscale numerical model WAsP, a case study was carried out for the part of the South Croatian region of Dalmatia.

2. Modelling approach

The prediction of geostrophic wind at 850 hPa pressure level was done using the ALADIN hydrostatic mesoscale model at 8 km horizontal resolution. This first-order closure spectral model is initialized from the downscaled global analysis of the global spectral model ARPEGE/IFS (Action de Recherche Petite Echell Grande Echelle/Integrated Forecast System). Vertical 37-level resolution is defined by usage of the hybrid vertical coordinate, [2]. The physical parametrization package includes vertical diffusion, [3], shallow convection [4], and Kuo-type deep convection scheme. The model uses a radiation parametrization, [5] and [6], and two-layer soil parametrization, [7].

The model was initialized every day at 00 UTC, during the Dec 2004-Nov 2005 period. The 3-hourly sampling started at +6 hour forecast range (due to model-spin up), and included the +27 hour forecast range values. In this way, a yearly time sequence of the model geopotential values was available for calculation of the geostrophic wind components at all model levels. Finally, the geostrophic wind components at 850 hPa level were calculated by using the model forecast geopotential fields at the same level at four model grid points nearest to the station location. In the calculation, the Coriolis term was calculated for the station location exactly, neglecting its variability in the vertical direction in the lower troposphere.

As a final step, a well known small-scale, linearised flow model WAsP, [8], with typical domain size of 10x10 km^2, was forced to use ALADIN predictions of geostrophic wind at 850 hPa as inputs in the application part of the WAsP method. The average height of ALADIN predictions at 850 hPa during the analysed period was 1451 m. Downscaling of the wind climate was estimated for a reference point of the met mast Pometeno brdo which is located in a rather complex terrain, at the top of the 610 m high hill.

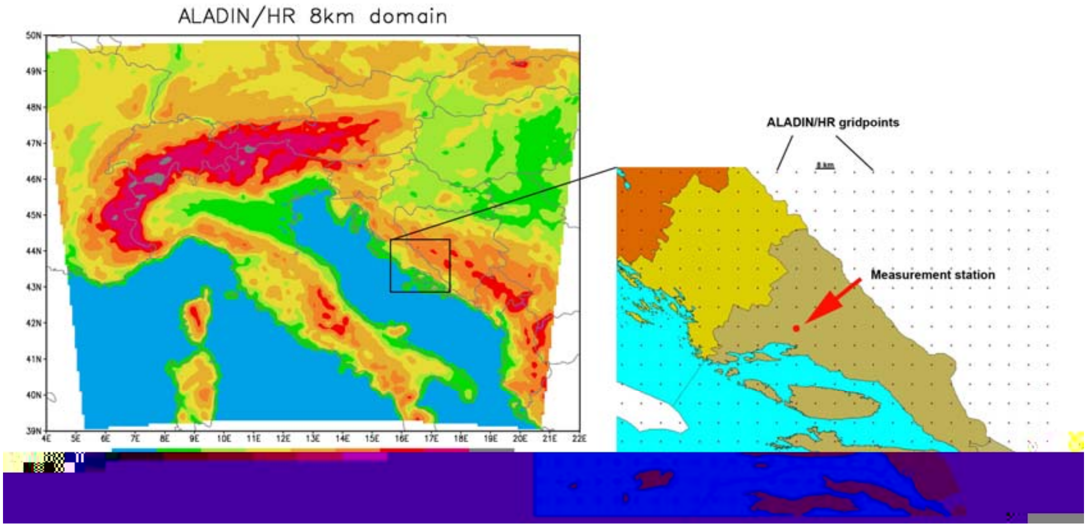

Figure 1. Modelling domain of the ALADIN/HR model and the reference meteorological site of Pometeno brdo.

3. Results

Table 1 shows main properties of the reference measurement site and the ALADIN/HR modelling grid point. The distance between the two is 339 m. Time series are adjusted to UTC, and measured data averaged over 3 hour intervals. Figure 2 shows comparison of daily and monthly wind averages at 850 hPa and measured data at 40 m a.g.l. during Dec 2004 – Nov 2005. The correlation coefficient between the two is 0.68, with spikes that match very well in the two time-series. 74% of ALADIN/HR spikes correspond to surface *Bora* exceeding 10 m/s, and the rest to *Jugo* (strong SE wind sirocco), demonstrating the capability of ALADIN to predict windy days with high confidence. Comparison of the Weibull distributions of measured surface and modelled geostrophic (i.e. 850 hPa) wind are shown in the figure 3.

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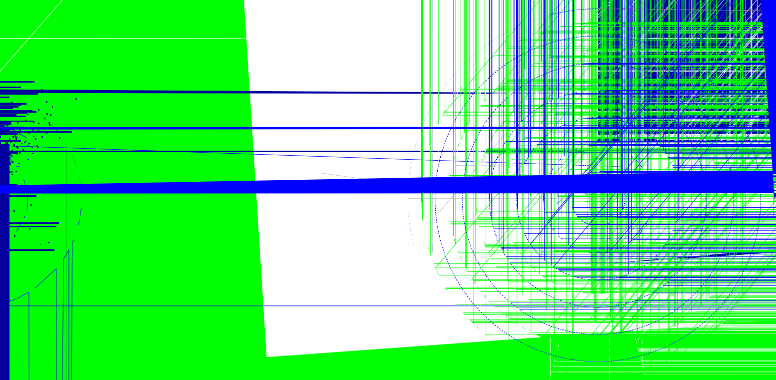

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wind climate over Pometeno brdo simply does not contain the full *Bora* forcing in its statistics due to the nature of physical processes leading to the formation of *Bora* (i.e. contains mainly synoptic and not local scale forcings). Furthermore, this means that downscaling of geostrophic wind climate, obtained by mesoscale model ALADIN/HR can not be reliably carried out with WAsP at the site of Pometeno brdo. This is almost an expected result for a site influenced by thermally driven circulation, considering the wind atlas method concept and the physical bases used by the WAsP for relation between geostrophic and surface wind (the geostrophic drag law).

Table 2 Comparison of ALADIN/WAsP modelling results and observed wind climate at the site of Pometeno brdo.

	Reference site - observed (40 m a.g.l.)	**ALADIN/WAsP modelled (40 m a.g.l.)**	**Error, %**
Average wind speed, m/s	6.03	4.37	-27.5
Power density, W/m^2	385	297	-22.8
Average wind speed, m/s (Reduced data set – Bora excluded)	4.65	3.72	-20.0

wind climate is sufficiently and appropriately segmented to situations, and modelling results for different situations aggregated. Based on validation tests at one measuring site, it seems that some of the atmospheric situations in complex terrain might be modelled by the tested ALADIN/WAsP method, but, prior to any firm conclusion, the method should be additionally tested and validated. The rest of the atmospheric situations, or at least the *Bora* events, should be modelled by other coupling strategies that take into account the mesoscale dynamics of strong downslope winds. Finally, further tests accounting for the more accurate ABL wind prediction in complex terrain will use a combination of ALADIN/HR 2 km resolution near-surface wind predictions, and WAsP horizontal extrapolation to resolve local orographic influences on wind flow.

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