Using spectral evaluation to assess the added value of higher resolution modelling

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Background & Goals

Background

:: Higher resolution modelling brings challenges to evaluate the benefits and justify the cost of higher resolution modelling using appropriate verification metrics
:: Many moment-based statistical scores, especially those frequently used to evaluate models (RMSE, MAE) suffer from double-penalty errors
:: Spectral evaluation, which provides additional physical insights, is usually performed in a quantitative nature

Goals

:: Demonstrate the quantitative spectral evaluation framework
:: Apply the methodology for both wind speed and wind shear in complex terrain of Croatia

Data & methods

Measurements

:: 4 wind towers and 16 AWS
:: sensors at 10m, 30m and 44m(60m) AGL

Model

:: ALADIN/ALARO AL8, AL2, DA2
:: Period 2010-2012
:: Operational configs

Methods

1. calculate power spectral density PSD
2. integrate in different frequency bands
3. Compare results for measurements vs model

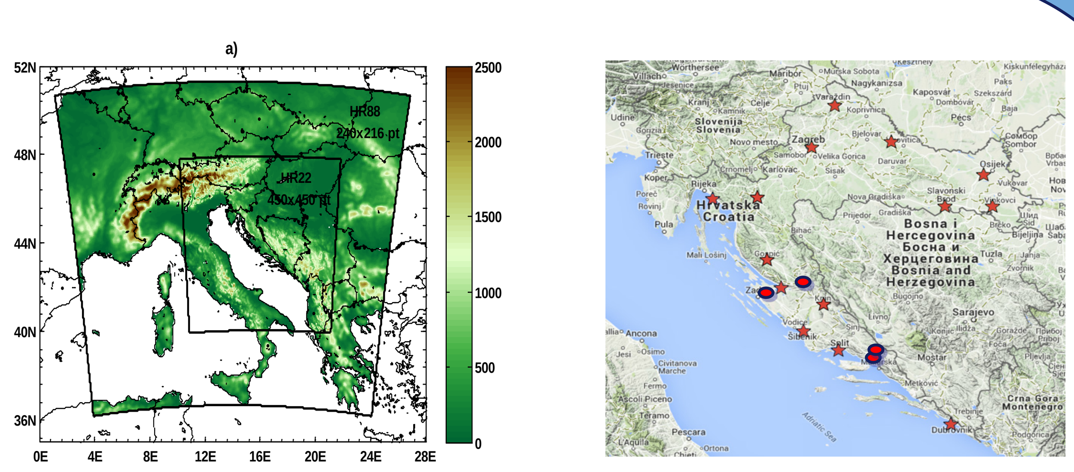

Figure 1: a) ALADIN model domains with orography – larger at 8 km (AL8) and smaller at 2 km (AL2, DA2) and b) Orography and location of wind stations (stars) and masts (elypses)

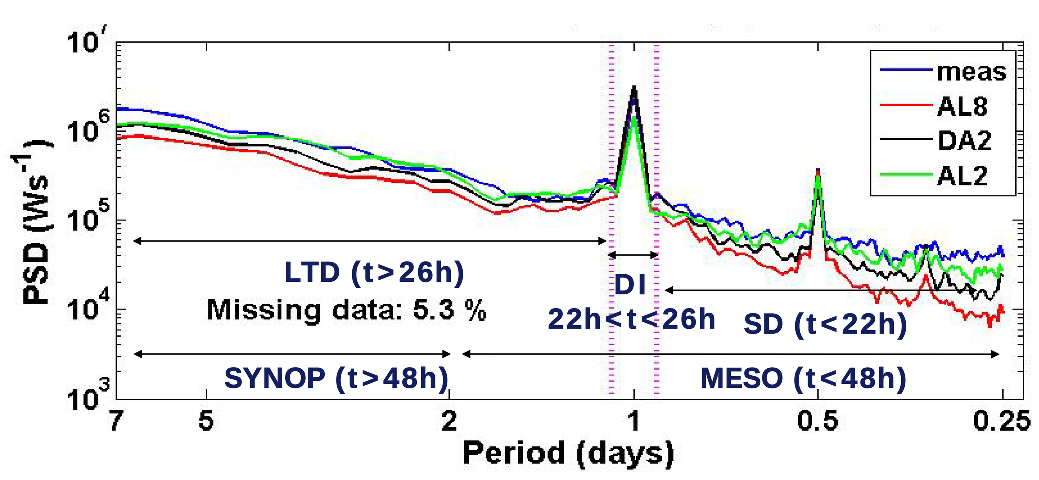

Figure 2: Example: Measured and modelled PSD for a station with predefined integration ranges

Methodology: eg.Horvath et al., 2011, JAMC and Horvath et al., 2012, JGR

Results

:: Integrated normalized PSD of wind speed for different frequency ranges
:: Generally higher resolution models (AL2, DA2) improve results, especially for bora dominated coastal stations and for subdiurnal motions

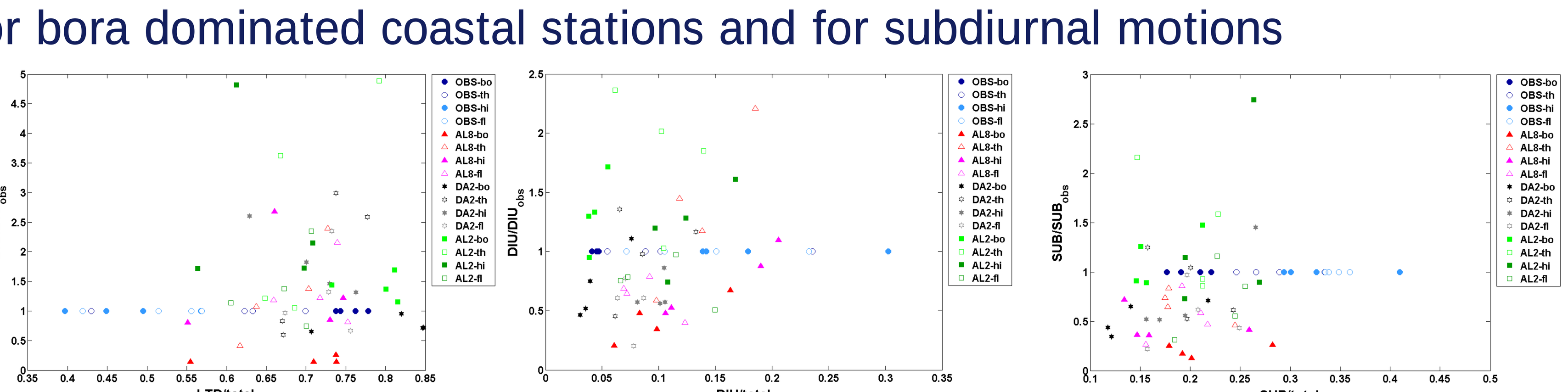

Figure 3: Normalized PSD in longer-than-diurnal (LTD, left), diurnal (DI, center) and subdiurnal (SUB, right) part of measured and modeled wind speed spectra. x-axis values are normalized with total PSD (measured or modeled) and y-axis values are normalized with measurements. Bo, th, hi and fl stand for bora dominated coastal stations (bo), coastal stations with large portion of locally developed and thermally driven circulations (th), highland or near mountain continental stations (hi) and flat terrain continental (fl) stations.

Results continued

:: Additional insights into performance of the most advanced model configuration (AL2) using wind mast wind and wind shear data
:: 4 wind towers at 10m and wind shear between 10m and 44m/60m

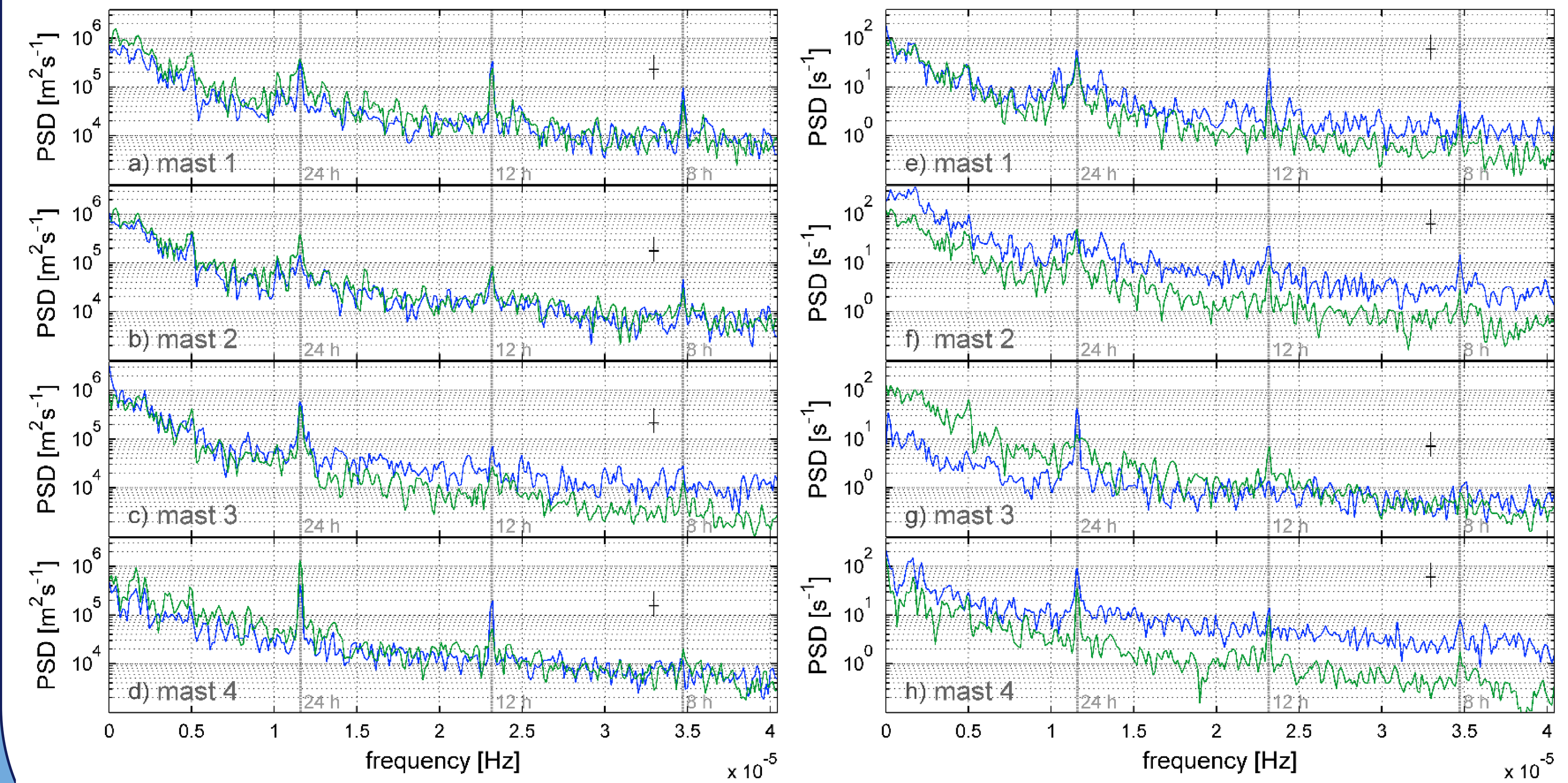

Figure 4: Comparison of PSD of a-d) 10 m wind speed and e-h) wind shear between 10m and 44m/60m as inferred from measurements and AL2 model

:: Integrated PSD values for different frequency bands (AL2)

<u>Contributions to total variance (measurements)</u>

:: LTD – 30-40%
:: DI 4-8%
:: SD 20-35%
:: MESO 30-55%
:: on average SD and DI shares decrease with height, LTD grows

<u>Evaluation of the model (AL2)</u>

→ wind speed
:: overestimates LTD ~ 5-10%
:: underestimates SD ~ 5-15%
:: DI is relatively well simulated (overest. on 1 mast)
:: MESO underestimated ~5-10%

→ wind shear
:: results qualitatively similar as for winds, but errors are larger

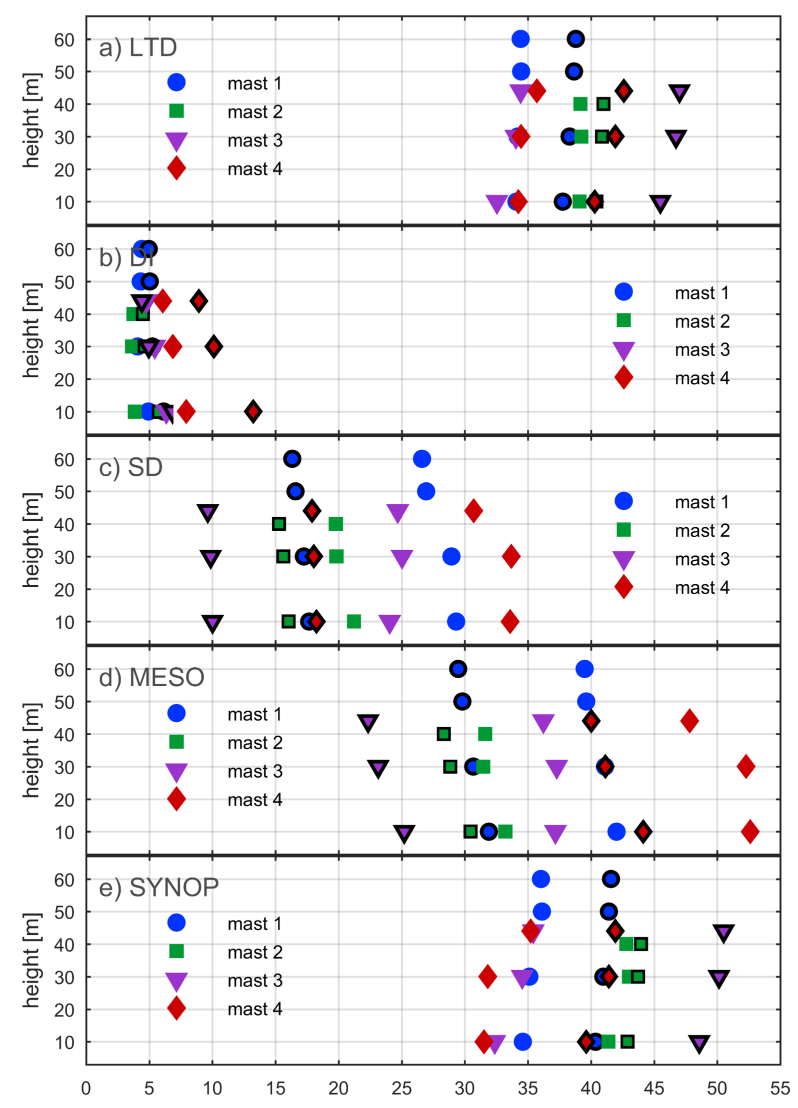

Figure 5: Integrated measured and modelled PSD- V10m

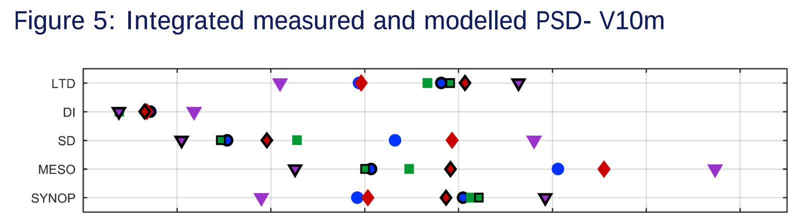

Figure 6: Integrated measured and modelled PSD- wind shear

Conclusions

:: Quantitative spectral evaluation was done using wind data from several locations in Croatia and different ALADIN model configurations
:: Contribution to total wind variability in measurements along the eastern Adriatic coasts are: LTD 30-40%, DI 4-8%, SD 20-35%, MESO 30-55%
:: Models are reasonably good in representing the wind and wind shear variability and while results generally improve with resolution, however, there is still room for improvement.

References: 1. Horvath, K., A. Bajic, and S. Ivatek-Sahdan, 2011: Dynamical downscaling of wind speed in complex terrain prone to bora-type flows. J. Appl. Meteor. Climatol., 50, 1676-1691., 2. Horvath, K., D. Koracin, R. K. Vellore, J. Jiang, and R. Belu, 2012: Sub-kilometer dynamical downscaling of near-surface winds in complex terrain using wrf and mm5 mesoscale models. J. Geophys. Res., 117, D11111, 19pp., doi:10.1029/2012JD017432.