Measurements and forecasts of bora turbulence at the Dubrovnik airport (LDDU), Croatia

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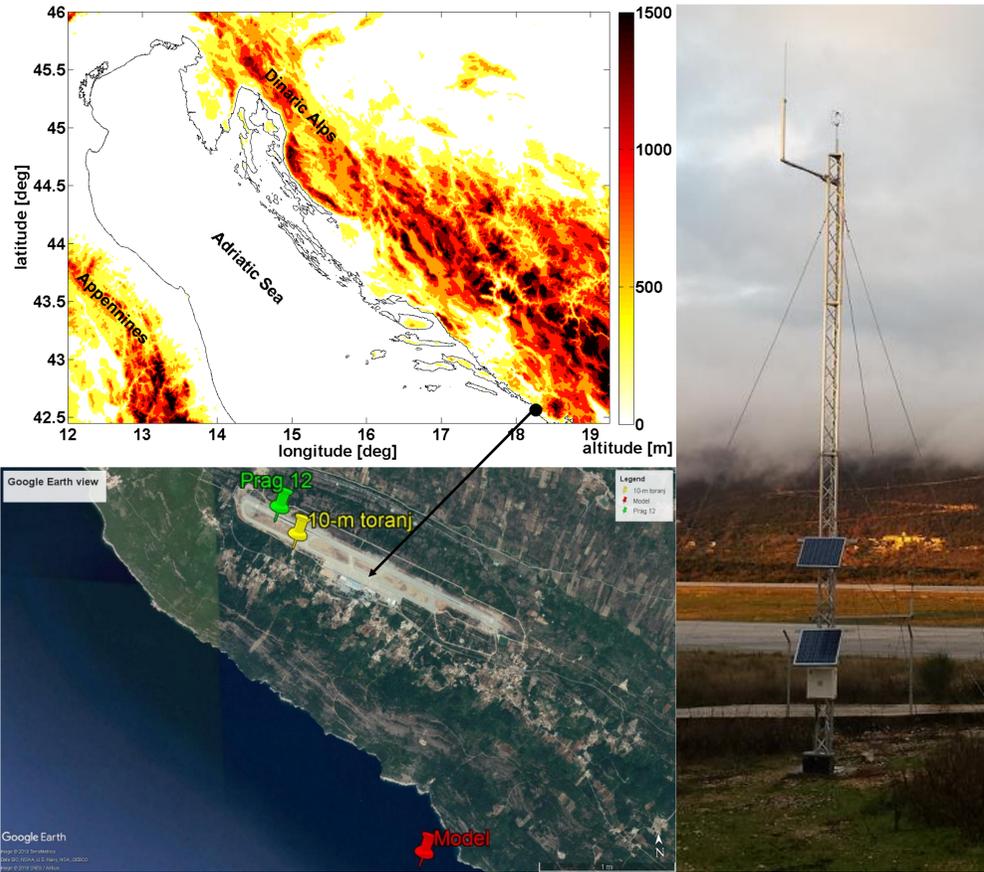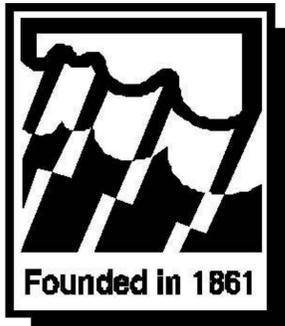Email: *zvecenaj@gfz.hr*

Figure 1. Top left: topographic map of the Adriatic Sea and the Dinaric Alps. Bottom left: Google Earth view of the Dubrovnik airport (LDDU) with pinpointed locations of the 10-m meteorological tower (yellow pin), anemometer of the Croatian Control d.o.o. at the runway threshold 12 (green pin) and the grid-point of the numerical weather prediction model ALADIN (red pin). Right: the 10-m meteorological tower with ultrasonic anemometers installed at two levels above the ground (3 and 10 m).

Figure 2. Basic characteristics of the bora event #3. Upper panel: 10-min mean horizontal wind speed (black line with circles) and 10-min wind gusts (blue line with squares). The red squares denote wind gusts that would be logged by the standards of the LDDU. Middle panel: 10-min mean horizontal wind direction. 0° denotes 20°azimuth. Bottom panel: pseudo-temp from the numerical weather prediction model ALADIN.
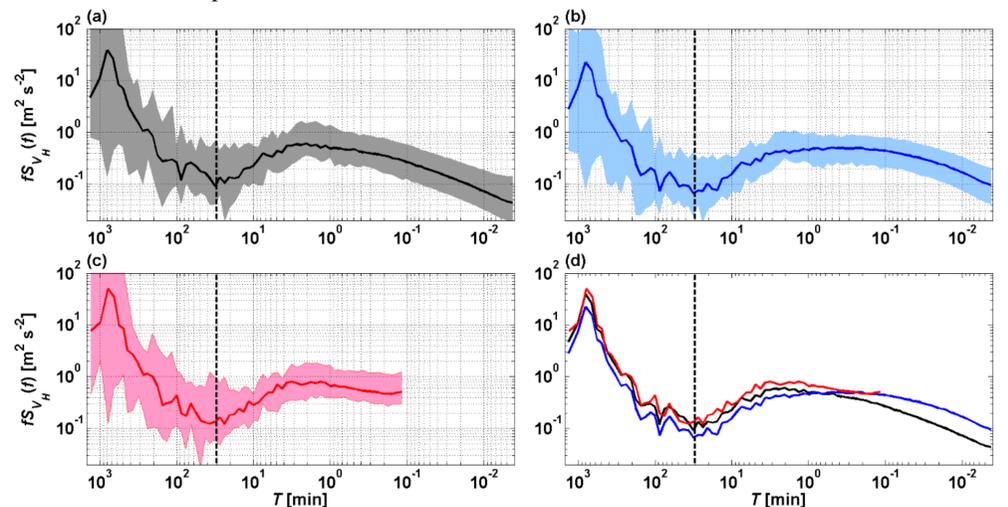
Figure 3. Composites of 12 bora events weighted spectra by the frequency, $fS(f)$, of the horizontal wind speed component for: (a) 10 m level and (b) 3 m level at the 10-m meteorological tower and (c) anemometer at the runway threshold 12. Shaded areas represent the 25-75 percentiles span, while thick solid lines represent medians. Panel (d) shows all three medians of spectra for comparison. Dashed vertical line denotes the time scale of 30 min.

Summary

- At the LDDU, bora turbulence is contained within the time scales smaller than 30 min.
- Maximum values for the turbulence kinetic energy (TKE) for N-bora are for factor 2 larger than the values for SM-bora.
- Maximum values of turbulence kinetic energy dissipation rate (ε) for SM- and N-bora are comparable.
- The size of turbulent eddies for N-bora is roughly by the factor 3 larger than that for the SM- bora.
- The N-bora exhibit a larger scattering in the relationship between the measured values of the horizontal wind gusts (V_{gst}) and estimated values of both TKE and ε relative to the SM-bora.
- Forecast of horizontal wind gusts and turbulence at LDDU using ALADIN numerical model looks promising.

Data

- 3D wind speed sampled by 10 Hz frequency using Gill WindMaster ultrasonic anemometers at 3 and 10 m above the ground
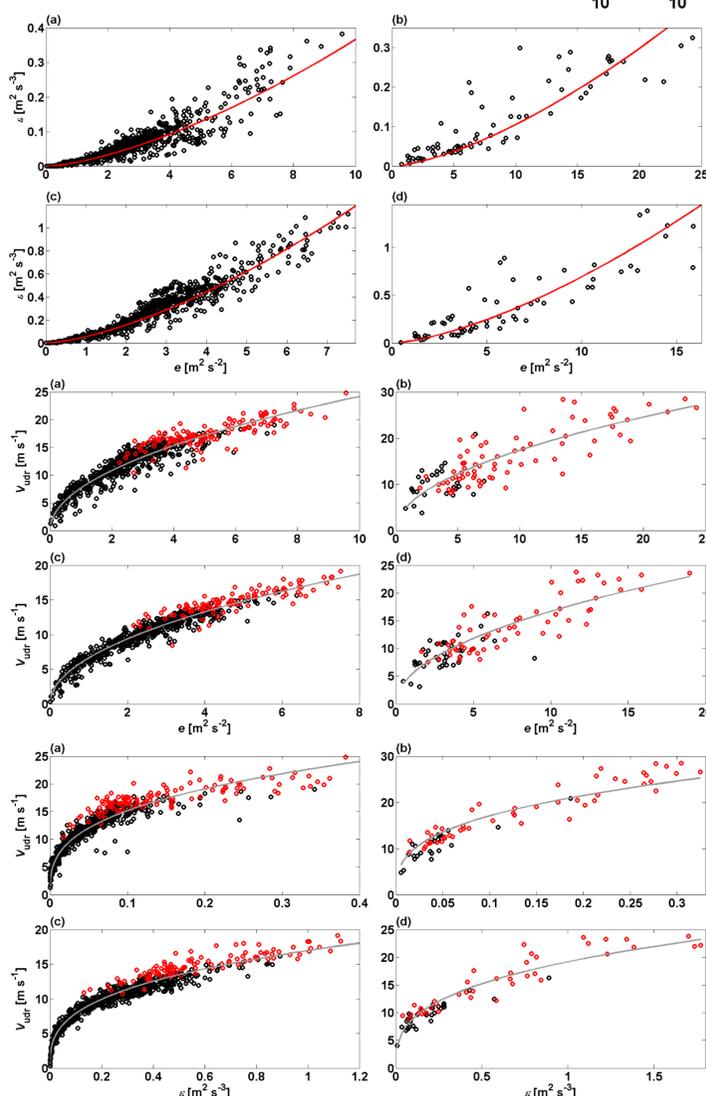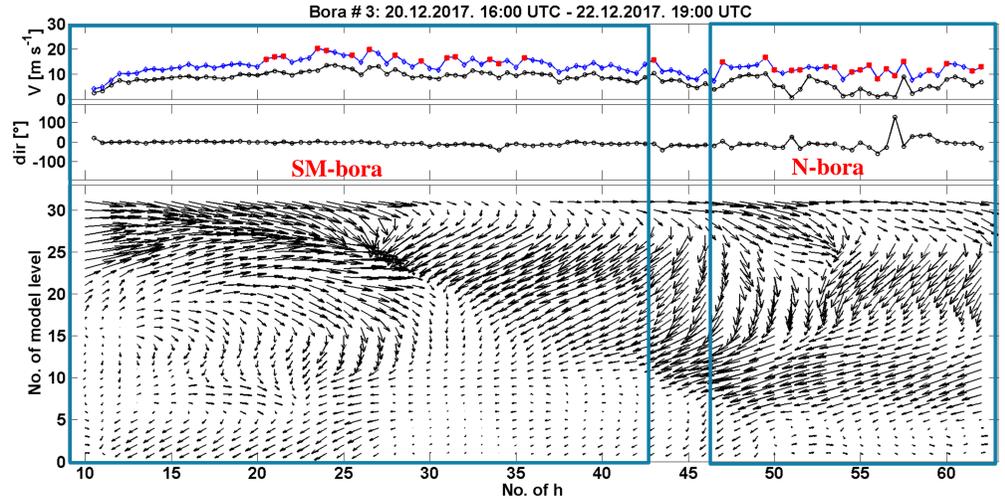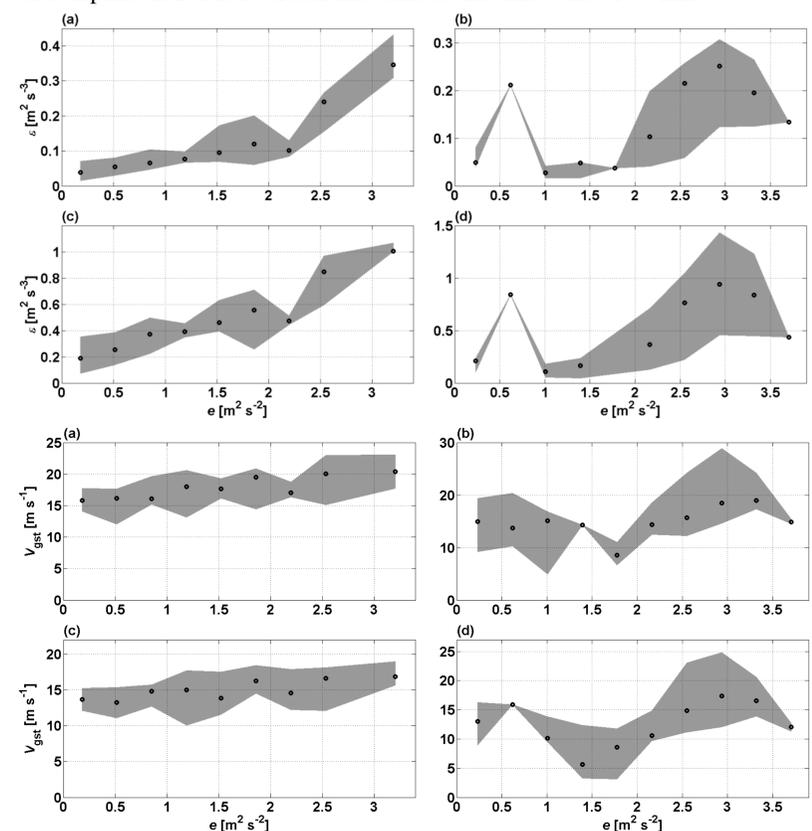- Pseudo-temps from the 4-km NWP model ALADIN

Figure 4. ε vs. e, V_{gst} vs. e and V_{gst} vs. ε scatter diagrams (black circles) with best fits (red solid lines) for (a) SM-bora at the 10-m level above the ground, (b) N-bora at the 10-m level above the ground, (c) SM-bora at the 3-m level above the ground and (d) N-bora at the 3-m level above the ground.

Figure 5. Density plots of dependence of estimated parameters ε (top 4 panels) and V_{gst} (bottom 4 panels) at the 10-m meteorological tower on simulated parameter e from the second level of the NWP model ALADIN of the 4 km horizontal resolution for (a) SM-bora at the 10-m level above the ground, (b) N-bora at the 10-m level above the ground, (c) SM-bora at the 3-m level above the ground and (d) N-bora at the 3-m level above the ground. Gray shaded areas represent 25 to 75 percentiles span and black circles represent medians.