WRF-ARW simulations of shallow and deep bora flows at the Dubrovnik airport (LDDU), Croatia

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Founded in 1861

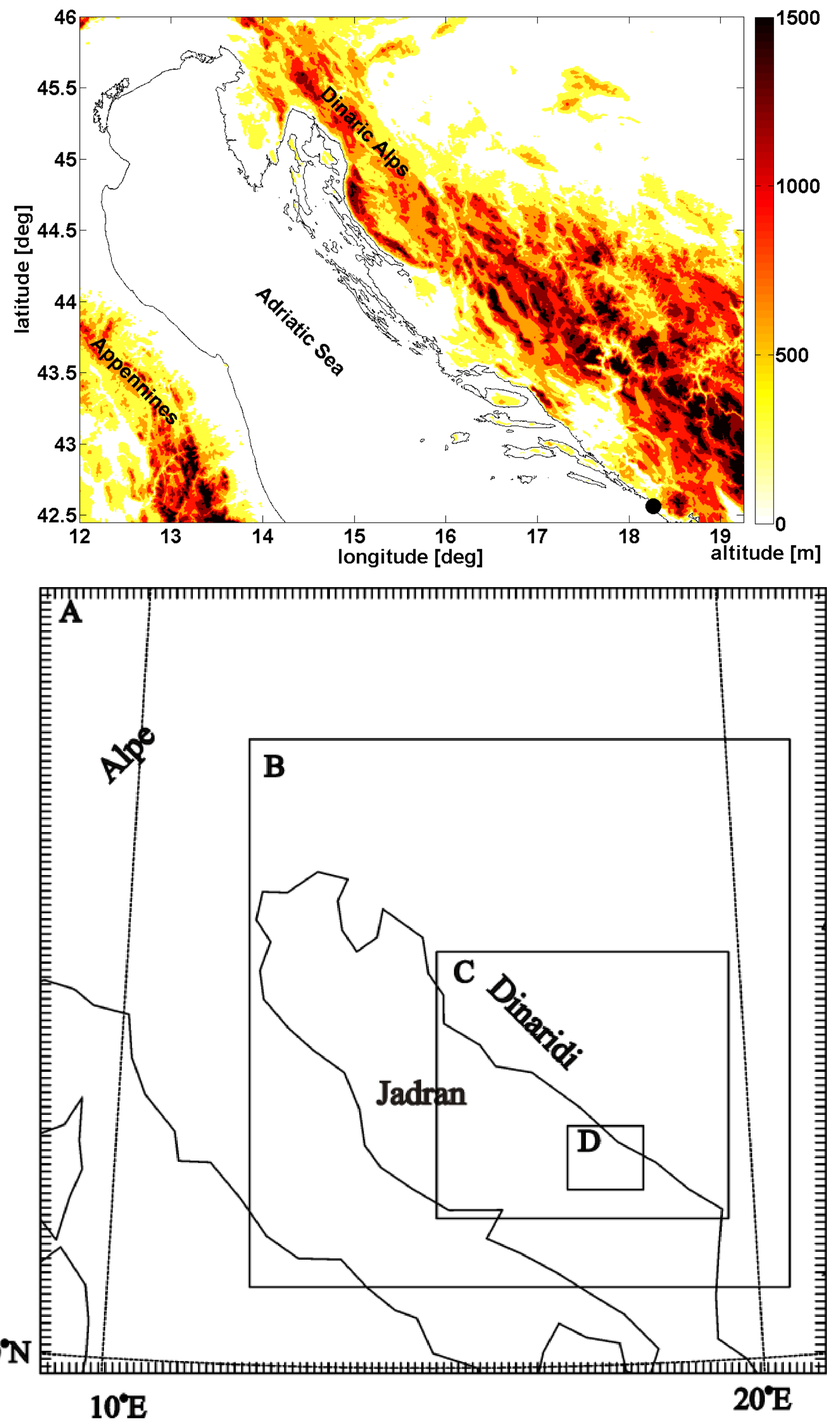

Figure 1. Top: topographic map of the Adriatic Sea and the Dinaric Alps. Bottom: the figure shows four nested WRF-ARW model domains (A, B, C and D) with horizontal resolutions of 13.5 km (A), 4.5 km (B), 1.5 km (C), and 0.5 km (D). Domains with large resolutions (domains C and D) include the southern part of the Adriatic and the wider area around Dubrovnik.

WRF-ARW model (non-hydrostatic form)

- **Nested domains (Fig. 1 bottom): 13.5 km (A) ➔ 4.5 km (B) ➔ 1.5 km (C) ➔ 0.5 km (D).**
- **Vertical grid: η-coordinate with 97 levels ➔ the lowest level at about 5 m above the surface and with the defined 25 levels in the first 1 km.**
- **At the top of the model, the absorbing layer is used to prevent the reflection of the waves into the domain.**
- **Dudhia and the RRTM (Rapid Radiative Transfer Model) schemes for longwave and shortwave radiation.**
- **Morrison 2-Moment scheme for mixed processes of cloud formation and precipitation.**
- **Five-level soil temperature parameterization.**
- **Mellor-Yamada-Janjić (MYJ) scheme for atmospheric boundary layer**
- **Betts-Miller-Janjić scheme ➔ cumulus parameterization is only applied in the largest domain.**
- **90 m resolution from SRTM orography.**
- **Initial and boundary conditions ➔ NCEP data ➔ GFS analysis.**

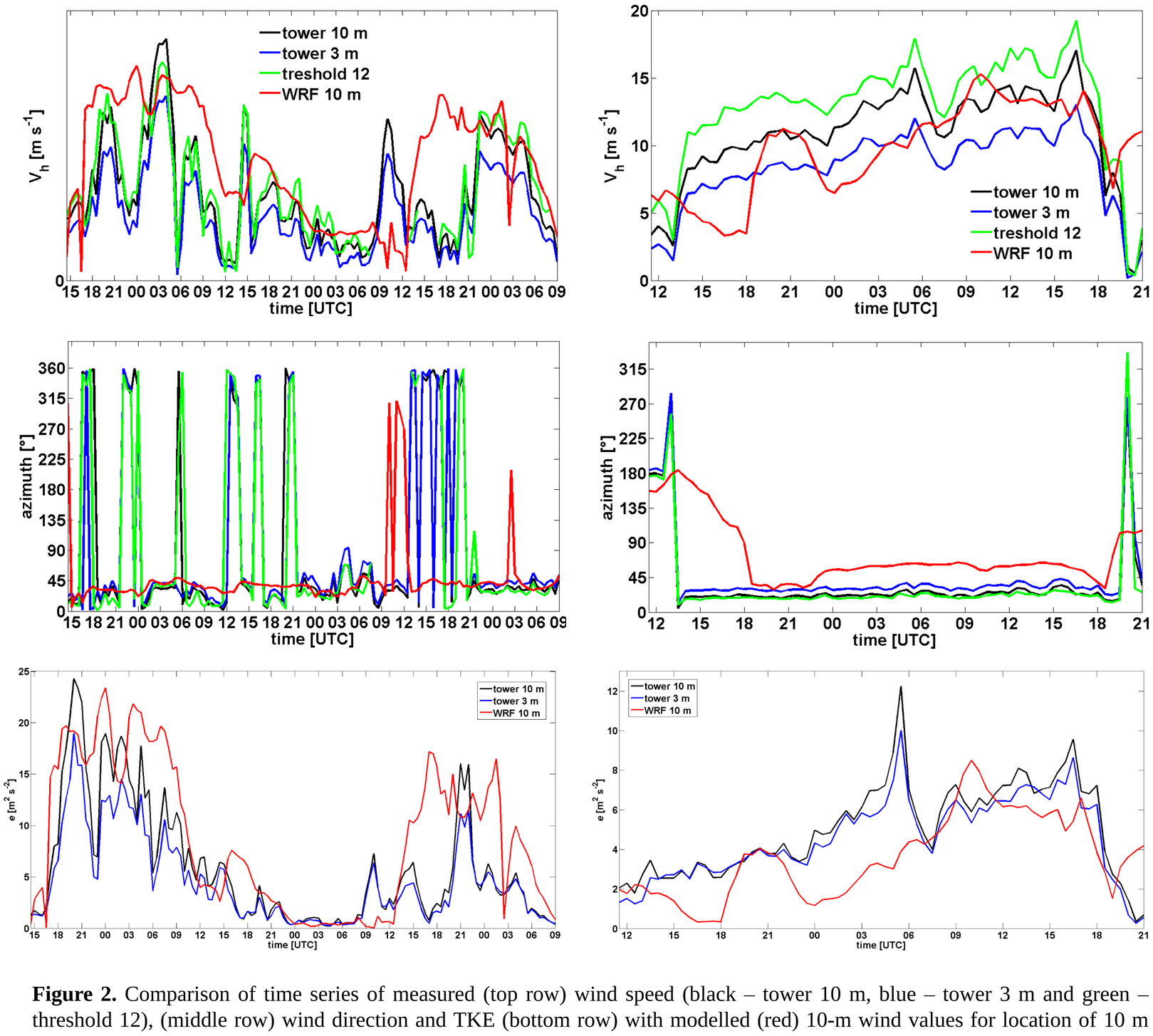

Figure 2. Comparison of time series of measured (top row) wind speed (black – tower 10 m, blue – tower 3 m and green – threshold 12), (middle row) wind direction and TKE (bottom row) with modelled (red) 10-m wind values for location of 10 m tower measurements. Left column time series represent the N-bora event in the period from 21 January 2018 at 15 UTC to 24 January 2018 at 09 UTC. Right column time series represent the SM-bora event in the period from 21 March 2018 at 12 UTC to 22 March 2018 at 21 UTC.

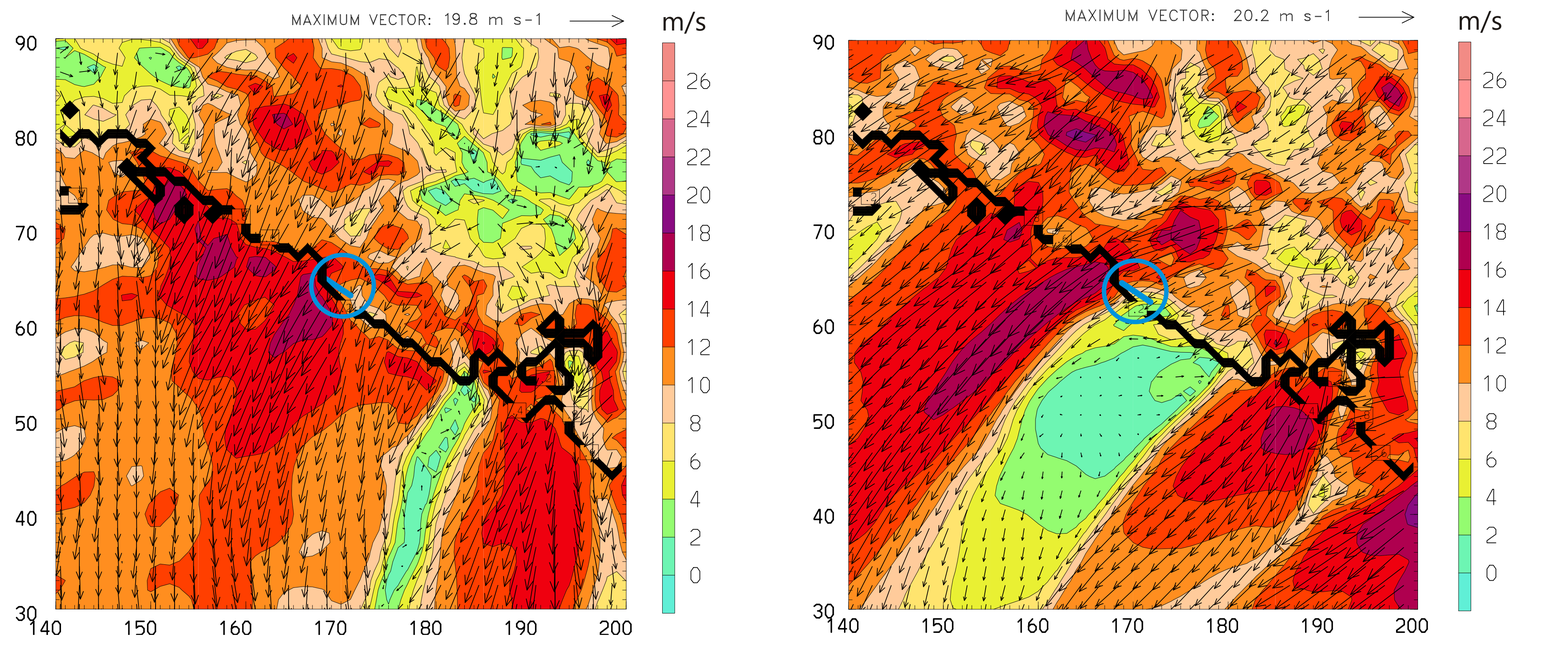

Figure 3. Results of the mesoscale meteorological model WRF for the southern Adriatic area from domain (D) at the 0.5 km horizontal resolution for N-bora event on 21 January 2018 at 20 UTC (left) and SM-bora event on 22 March 2018 at 11 UTC (right). The wind vectors at 10 meters are shown with black arrows. The maximum wind velocity vector length is shown above to the right. Wind speeds are plotted every 2 m/s, and their intensity is represented by a legend. The blue line shows the position of the runway.

Data

- **3D wind speed sampled by 10 Hz frequency using Gill WindMaster Pro ultrasonic anemometers at 3 and 10 m above the ground.**

Summary

- **The WRF-ARW mesoscale research model can be successfully used in detecting 3D critical areas with strong bora jets, strong shear, enhanced vorticity and strong turbulence in the vicinity of LDDU.**

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