On the turbulence integral scales for the bora flows at the NE Adriatic coast

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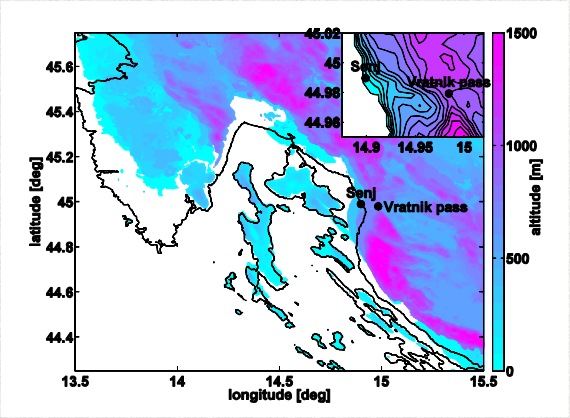

Figure 1. From Belušić et al. (2013): Orography of the northeastern Adriatic region with indicated town of Senj and Vratnik Pass. The inset in the upper right corner shows the detailed orography around the Vratnik Pass (contour interval is 75 m).

1. OBJECTIVES

- To explore similarities and differences in estimated turbulence integral length and time scales for the bora flows at the two representative sites at the NE Adriatic coast
- To estimate necessary sampling rate of bora flows in order to enter the turbulence inertial subrange (IS) at these two sites

2. LOCATIONS & DATA

- Senj is at the coast (44.99°N, 14.90°E) and Vratnik Pass (VP) (44.98°N, 14.98°E) is ~ 10 km east of Senj at 698 m ASL (Fig. 1)
- Single point measurements of 3D wind sampled at 4 Hz with the WindMaster ultrasonic anemometers 13 m and 10 m above the ground in Senj and VP, respectively
- Anemometers operated from Mar 2004 to Jun 2006 in Senj and from Oct 2004 to Sep 2005 in VP with few interruptions
- bora flow: wind of azimuth between 30° and 90° blowing at least for 3 h
- 6243 h of bora flows registered in Senj and 4620 h in VP

3. METHODS

- Turbulent kinetic energy (TKE) and its dissipation rate (ε) are used for estimation of integral length (Λ) and time (τ) scales ➔ TKE – ε model ➔ $\Lambda=\mathrm{TKE}^{3/2}/\varepsilon$ and $\tau=\mathrm{TKE}/\varepsilon$, respectively (e.g. Pope 2011)
- 1-min turbulence averaging scale applied to wind speed components for definition of perturbations for TKE ➔ local bora turbulence is observed (Belušić et al. 2006)
- Inertial dissipation method for estimation of ε (e.g. Večenaj et al. 2010) ➔ $\varepsilon=(2\pi/U)[f^{5/3}S_u(f)/\alpha]^{3/2}$
- Estimations are performed on 1-h intervals
- Pope (2011) ➔ lifetime of energy in inertial subrange is $\approx \tau/10$ ➔ the frequency at which the inertial subrange starts: $f_{IS}=(U/2\pi)(15\alpha)^{3/2}/\Lambda$

4. RESULTS AND DISCUSSION

- Λ in Senj significantly increases with mean streamwise wind speed U extending from ≈ 30 m at low U to ≈ 70 m at high U while at VP it slightly varies between ≈ 20 m and ≈ 30 m through all values of U (Fig. 2) ➔ at higher wind speeds eddies from the energy containing range in Senj become larger while at VP their size is almost constant
- τ is at lower wind speeds almost 2x larger at VP than in Senj but at both sites it exponentially decreases with U (Fig. 3) ➔ at higher wind speeds turbulent eddies from the energy containing range live shorter
- f_{IS} in Senj slightly increases with U barely exceeding 1 Hz at the highest U while at VP it significantly increases with U exceeding 2 Hz already at U = 12 m s^{-1} (Fig. 4)

5. SUMMARY

- There are significant differences in estimated Λ and τ values in Senj and VP ➔ subject for further research
- With the 4 Hz data (Nyquist frequency = 2 Hz) one can probably enter the IS in Senj for all U while at VP only for U lower than 12 m s^{-1}

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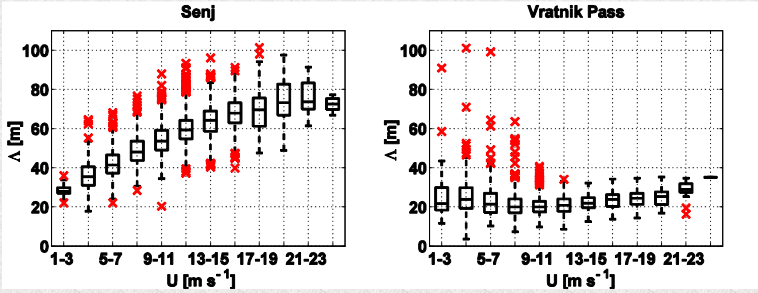

Figure 2. Distribution of Λ as a function of U for 1-h bora intervals in Senj (left) and VP (right). Central bar inside boxes denotes median while bottom and top bars of the boxes denote 25th and 75th percentiles, respectively. Red crosses denote outliers.

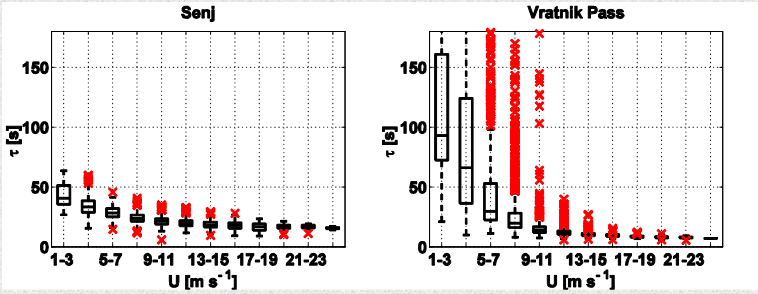

Figure 3. Same as Fig. 2 but for τ.

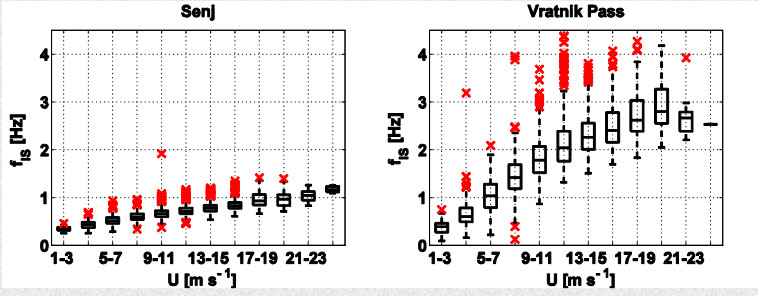

Figure 4. Same as Fig. 2 but for f_{IS}.

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