TKE budget analysis of a single long-lived winter bora flow

Neivo Babić, Željko Večenaj, Kristian Horvath, Branko Grisogono

1Geophysical Institute Andrija Mohorovičić, Horvatovac 95, Zagreb, Croatia; 2Meteorological and Hydrological Service, Grč 3, Zagreb, Croatia
nebabic@gfz.hr, zvecenaj@gfz.hr, kristian.horvath@cirius.dhz.hr, bgrisog@gfz.hr

**GOALS**
- Temporal and spatial variability of turbulent kinetic energy (TKE) gives insight into the nature of turbulence at a certain location of interest.
- This case study concentrates on evaluating various terms in the simplified 1D TKE budget equation of a single bora event (downslope windstorm, east Adriatic coast).
- Finally, calculation and exploration of these terms, especially their contribution to either local production or destruction of TKE, will decide how well are those simplifications justifiable for this particular event and location.

**DATA**
- Site of Pometeno Brdo: zoomed picture shows terrain and orientation of the hill relative to the mean bora direction (red arrow). Green circle denotes the position of the tower with anemometers.

**BORA CRITERIA**
- Total horizontal speed ≥ 4.5 ms⁻¹
- Wind direction ε [25°, 85°]
- Duration ≥ 10 h
- Longest event (123 h) took place in February 2011 (Fig. 2.)

**TKE**
- TKE is calculated as the sum of variances of all wind velocity components, as in e.g. Stull, 1988 (Fig. 3.) (overbars denote 30 min averaging, whilst all turbulent perturbations are defined based on the presence of a gap in the wind velocity spectra, using an estimated averaging period of 15 min):

\[ \overline{\epsilon} = 0.5(\overline{u'^2} + \overline{v'^2} + \overline{w'^2}) \]

**1D TKE BUDGET ANALYSIS**
- Viscous dissipation ε is calculated using the inertial dissipation method (IDM), as in e.g. Večenaj et al., 2011:

\[ \epsilon = \frac{2\pi}{U} \left( f \overline{u'^2} \right)^{3/2} \]

- Non-simplified TKE budget equation is derived as (e.g. Stull, 1988):

\[ \frac{\partial \overline{\epsilon}}{\partial t} + u \frac{\partial \overline{\epsilon}}{\partial x} = \frac{1}{\rho} \frac{\partial}{\partial z} \left( \frac{\rho}{\theta} \overline{\epsilon} \frac{\partial \theta}{\partial z} \right) - V \left( \frac{\partial \overline{\epsilon}}{\partial z} \right) - \epsilon + R \]

- Due to the limitations of the measuring site (only one tower, no means of measuring pressure perturbations), horizontal homogeneity is assumed & all three pressure covariance terms are neglected (these terms are summarized under the residual term R):

**CONCLUSION**
- Viscous dissipation is multiplied by -1 for presentation purposes.

**Fig. 1.** Site of Pometeno brdo: zoomed picture shows terrain and orientation of the hill relative to the mean bora direction (red arrow). Green circle denotes the position of the tower with anemometers.

**Fig. 2.** Total horizontal wind speed (all heights) and sonic temperature @ 10 m (30 min averages) for the longest registered bora event (123h), blowing from 21 Feb, 8:15 UTC to 26 Feb, 11:15 UTC.

**Fig. 3.** Time evolution of TKE @ all three heights.

**Fig. 4.** TKE budget equation terms at mid-levels 15 and 30 m, respectively. Viscous dissipation is multiplied by -1 for presentation purposes.

**Fig. 5.** Production term (IV) + (III) when heat flux > 0, (-1)*destruction (viscous dissipation + (III) when heat flux < 0) & their difference at 15 & 30 m.

**K. Horvath is supported by HRZZ grant 08/40, while measurements on Pometeno Brdo were supported by grant UKF 16/08.
Ž. Večenaj & B.G. are supported by the Croatian Ministry of Sci. & Sports, BORA, No. 118-1193086-1311 & HRZZ, CATURBO No. 09/151.**