Detection of organised flow structures in real atmosphere

R. Kellnerová*, K. Jurčáková*

Wind speed from measurements on two meteorological masts were analysed in order to identify large organised structures in the atmospheric boundary flow. We investigated a 100 m high mast surrounded by a flat terrain in Høvsøre (Denmark) and a 80 m high mast in a suburban area in Kopisty (Czech Republic).

Velocity data were obtained by 3D ultrasonic anemometers, with sampling frequencies 10-20 Hz. These data served as input for Proper Orthogonal Decomposition (POD). Data comprised of all three components of instantaneous velocities recorded over acquisition time 1-2 hours at 4-6 vertical elevations.

The data had been carefully preselected - only a near-neutral thermal atmospheric condition data based on high wind speed and neutral temperature lapse rate were used. All the data had undertaken a robust pre-processing prior the advanced statistical tools were applied. Artificial spikes were removed, short recording faults and sampling frequency fluctuations were re-sampled by sample&hold technique.

Three pre-processing methods were applied to the Danish data: "UVW-data" (data after double rotation), 2D-data (data after alignment with wind vanes and double rotation) and PF-data (data after alignment with wind vanes and planar fit). Beside the standard statistics, the POD, quadrant and spectral analyses were performed. We revealed that a vane alignment correction plays the essential role in the data quality. The 2D-data and PF-data showed similar results comparing to each other as well as comparing to the wind tunnel simulations. Thus they were considered to be better options for pre-processing (contrary to double rotation solely).

During strong windy days at both locations, the POD modes revealed vertically correlated structures, exceeding the mast height, representing strong gusts or weak calms, which lasted typically 1-2 minutes and captured 30-40% of the entire turbulent kinetic energy of the atmospheric flow. The longitudinal (U) and vertical (W) velocity component were strongly negatively correlated (Fig. 1). Quadrant analysis confirmed that TKE is organised into large patterns of sweep (gust) and ejection (calm) events, since they both achieved 80%-90% of the total instantaneous momentum flux. This finding is in strong agreement with results from wind tunnel modelling of turbulent flow above aerodynamically rough surfaces.

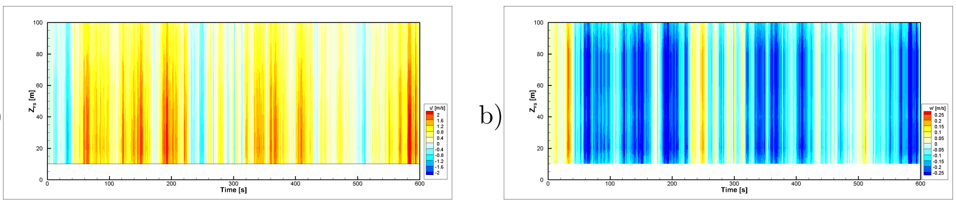
a) 

Figure 1: POD Mode 1 based on PF-data from Danish mast for velocity fluctuations (a) u' and (b) w'.

*Institute of Thermomechanics of the Czech Academy of Sciences, Prague, Czech Republic