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Observations of wind direction variability in the nocturnal boundary layer

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Nocturnal boundary layers are characterized by stable conditions where very weak winds dominate the atmosphere and generate high variability of wind direction (Vickers and Mahrt, 2007). In recent years, the term submeso have been referring to study any non-turbulent motions on scales smaller than 2 km, including the complex mix of motions on scales between the main turbulent eddies and smallest mesoscale motions (Mahrt, 2014). The main goal of this study is to examine submeso variability and the propagation of large sudden wind direction shifts under nocturnal conditions by using a micrometeorological network composed of four stations located within a large homogeneous area and flat terrain in north-western Victoria, Australia. Previous studies have not associated wind direction shifts with propagation of motions (Mahrt, 2008). In order to detect large sudden wind direction shifts from the time series, we defined "events" at the main station as changes larger than 60 deg. To analyze the characteristics of changes in time, sampling windows centred around the events were extracted. A total of 381 events were detected at the main station in the period from 24 March to 19 June 2013, leading to 130 samples using a sampling window of 20 min. Changes in temperature, wind and turbulence were analyzed for each sampling window. The distribution of changes at the main station shows that the temperature has a tendency to decrease for large wind direction shifts, with negative temperature changes occurring in 74% of cases. Other variables do not show a clear tendency to decrease or increase when a change in wind direction occurs. The three satellite stations were used along with the main station to study the propagation of events. An important question is whether the propagation is related to the mean wind; however, there is no noticeable preference for wind direction and no obvious similarity with the propagation, indicating that the events are not flow perturbations advected by the local wind. This indicates that developing their parameterization in numerical models might require different techniques and observations from the typical and relatively widely available point measurements.