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Observed and modelled mesoscale motions in the nocturnal boundary layer

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Little is known about mesoscale motions in the stable boundary layer, except in special cases of monotonic gravity waves, solitons and density currents. Models are unable to capture the more typical mesoscale structures in the stable boundary layer. Before models can be seriously evaluated, more information on such structures are required. Analysis of twenty data sets reveal that mesoscale motions in the nocturnal boundary layer are spread continuously over a range of scales and do not follow any spectral or local similarity. The strength of the mesoscale motions (here on time scales less than one hour) can vary by an order of magnitude or more between nights at a given site. Transient mesoscale motions tend to be stronger in complex terrain compared to flat terrain. One exception is that transient mesoscale motions tend to be weaker with drainage flows. The large variation of the strength of the mesoscale motions between nights is largely unpredictable with present understanding, although large vertical shear of wind direction tends to correspond with greater temporal variation of the wind direction. The change of wind direction with time for weak winds is more often a sequence of abrupt events rather than gradual meandering of the wind direction back and forth. The frequency distribution of the one-minute wind direction for the one-hour records with weak winds is often bi-modal or multi-modal.

Models are generally unable to capture such mesoscale motions apparently due to explicit and implicit horizontal diffusion. Simulations using COAMPS reveal the role of explicit horizontal diffusion on the degree of mesoscale motion in the model. Comparisons between the model and field results in complex terrain are presented for different strengths of the horizontal diffusion.