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Velocity standard deviations in low-wind regime in rural and suburban topography

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In the surface layer, wind velocity fluctuation standard deviations normalized by friction velocity are predicted by means of empirical functions of the stability parameter, as derived by the classical similarity theory proposed by Monin and Obukhov. It assumes constant turbulent fluxes, so it is conventionally applied in the inertial sublayer over homogeneous terrain and in case of high-wind speeds. However, it may be useful to evaluate turbulence variables even in calm-wind regime and/or within the roughness sublayer over complex terrain.
Low wind is a critical issue because, in these conditions, wind fluctuations are produced not only by turbulence but also by a meandering motion of the flow that is not taken into account by similarity.
We analysed three different datasets of wind velocity observations from sonic anemometers both in rural and suburban terrain and characterized by a remarkable percentage of low-wind episodes. This point enables us to assess the effects of both the complexity of topography and of wind regime on the velocity fluctuations.
The values of the empirical coefficients of the similarity functions were re-evaluated in stable and unstable stratification performing a non-linear best-fit procedure on available experimental data. The sets of coefficients are site-specific and we estimated the limits of their applicability to different cases.
We observed that the modified functions diverge from classical predictions in particular in stable stratification, when meandering effects are more frequent.
Similarity theory prescribes constant values for the normalized standard deviations in neutral case. We found that they get their maximum in the low-wind range and reach constant values for higher wind speeds. In order to derive a more general formulation suitable for a wide range of wind regimes, we assessed an analytical formulation for the neutral normalized standard deviations as functions of the mean wind speed.