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Assessment of similarity theory under 2m in a semi-arid environment over moderately complex terrain

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The similarity theory equations relate the vertical turbulent flux of a variable with its vertical gradient in the surface layer. They were derived from 16-m towers (or higher) with the first measurement typically at 1 or 2 m above the surface, using pairs of values or adjusting functions to the profiles. The resulting expressions are of widespread use for multiple applications although they are supposed to be only valid over flat homogeneous terrain.

The current work applies the standard functions to a site in the centre of an east-west oriented valley, locally flat and at approximately 2 km from the mountain slopes at both sides. The area is surrounded by rain-fed agricultural fields with the upper soil layer getting dry during Summer. Momentum and sensible heat fluxes are derived with the standard similarity functions considering the Obukhov length as the stability parameter, taking measurements of wind and temperature at 2 m and a supplementary temperature observation at 0.3 m, just above the roughness sub-layer. These results are compared against the turbulent fluxes observed with an eddy-covariance system located at the same site during 8 consecutive months in 2018.

The estimated friction velocity differs less than a 20% respect to the observation for the 74% of cases under unstable conditions (61% for the stable regime). For the sensible heat flux, its goodness depends on the soil moisture. Again, a 74% of cases have a relative error below 20% for dry soils, when the observed latent heat flux is small. When soil moisture is significant, only a 24% of cases provide a sensible heat flux that differs less than a 20% from the observation. In addition, this error is positive and grows with the observed latent heat flux. For the stable regime, the number of cases with a relative error below 20% decreases to 31% and 19% for dry and moist soils, respectively.

These results show that similarity theory provides a good performance for the momentum flux over a moderately heterogeneous terrain with sloping surfaces relatively close and with observations below 2 m above the surface. For the sensible heat flux, estimations are similarly good under unstable conditions over a dry soil, while it gets over-estimated when soil moisture and, consequently, the latent heat flux are important. At night, the sensible heat flux is much smaller and thus ill estimated under the aforementioned conditions.