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A nested large-eddy simulation study of the Ora del Garda wind in the Alps

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High-resolution numerical simulations performed with the Weather Research and Forecasting (WRF) model are analyzed to investigate the atmospheric boundary layer (ABL) structures associated with the development of a lake-breeze and valley-wind coupled system developing in the southeastern Italian Alps, the so-called "Ora del Garda" wind. Five domains were nested for the simulations: three mesoscale domains, forced by reanalysis data field, are used to drive the finest two domains, in which the large-eddy technique is used, achieving a final horizontal resolution of 80 m. Model results complement an existing dataset composed of a series of measurement flights and surface observations. The flights explored specific valley sections at key locations in the study area, namely over the lake's shore, at half valley and at the end of the valley where the breeze blows. Model results display a good agreement with the experimental dataset. In particular, the surface diurnal cycles of radiation, wind, air temperature and sensible heat flux are satisfactorily reproduced, despite some discrepancies in the timing of thermally-driven circulation onset and offset. The typical structure of the valley ABL, characterized by shallow or even absent mixed layers surmounted by slightly stable layers extending up to the lateral crest level, is also well reproduced in the simulated fields. Moreover, the simulations confirm characteristic local-scale features of the thermally-driven wind field suggested by the analysis of the airborne dataset as well as from previous observations in the area. For example, the model shows the development of inhomogeneities in the cross-valley thermal field, caused by the propagation of the lake breeze and by the different heating between the sidewalls of the valley, as well as the formation of a hydraulic jump in the area where the Ora del Garda flows down into an adjacent valley from an elevated saddle.