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Numerical simulation of local atmospheric circulations in the pre-Alpine area between Lake Garda and Verona

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The pre-Alpine area between Lake Garda and Verona displays a very complex and heterogeneous territory, allowing the development of several interacting systems of thermally driven local winds, the major being the lake/land breeze system on the coasts of Lake Garda and the up/down-valley wind system between the plain and the river Adige Valley.

In order to investigate the local wind patterns, a series of nested numerical simulations with a horizontal resolution of 500 m were carried out using the ARPS 5.2.9 model (Xue et al. 2000, 2001), considering a fair weather day suitable for a clear development of the expected circulations (15th July 2003). The simulated wind speed and direction, pressure, temperature and water vapour mixing ratio were compared to synoptic scale meteorological charts, to vertical profiles from radiosoundings taken at the major sounding stations of the alpine region and to local scale measurements performed at the surface station of Dolcè (at the inlet of the Adige Valley). Numerical results at all scales were found to be in very good agreement with the available sets of meteorological observations.

The analysis of the diurnal evolution of the 3D fields of temperature, moisture content, wind and turbulent kinetic energy allowed the identification of a very shallow and clearly defined breeze front of cold and humid air moving from off-shore towards the Lake Garda coast, from the late morning (10:00 LST) until the evening (20:00 LST). The diurnal up-valley breeze was also well reproduced: the valley atmosphere displays a thick mixed layer dominated by shallow turbulent convection between 11:00 LST and 21:00 LST. Lateral slope winds were also recognized, as they created cross-valley convective cells. While no clear evidence of a nocturnal land breeze was found in the simulations, the nocturnal down-valley wind in the Adige Valley was clearly reproduced.

Finally, a scalar transport equation was added to the ARPS model in order to simulate transport and diffusion processes for a passive tracer (ideally, a non-reactive pollutant). The cold and stable lake and down-valley breeze corps were found to act like pollutant concentrators at ground level, while the diurnal up-valley wind favours an almost homogenous dispersion of the tracer through the entire Convective Boundary Layer (CBL) thickness. The upper entrainment layer is found to effectively confine the ground-emitted pollutant inside the CBL, except for some occasional plumes that are first conveyed up-slope and then to the centre of the valley above the CBL by cross-valley circulation cells.