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Coupling of convection and thermally induced circulation at various resolutions

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A correct representation of the coupling between convection and circulation constitutes a prerequisite for a correct representation of precipitation at all scales. In this study, the coupling between convection and a sea breeze is investigated across three main resolutions: large-eddy resolution where convection is fully explicit, convection-permitting resolution where convection is partly explicit and coarse resolution where convection is parameterised. The considered models are the UCLA-LES, COSMO and ICON. Despite the use of prescribed surface fluxes, comparison of the simulations reveals that typical biases associated with a misrepresentation of convection at convection-permitting and coarser resolutions significantly alter the characteristics of the sea breeze. The coarse-resolution simulations integrated without convective parameterisation and the convection- permitting simulations simulate a too slow propagation of the breeze front as compared to the large-eddy simulations. From the various factors affecting the propagation, a delayed onset and intensification of cold pools primarily explains the differences. This is a direct consequence of a delayed development of convection when the grid spacing is coarsened. Scaling the time the sea breeze reaches the centre of the land patch by the time precipitation exceeds 2 mm/day, used as a measure for significant evaporation, yields a collapse of the simulations onto a simple linear relationship although subtle differences remain due to the use of different turbulence and microphysical schemes. Turning on the convection scheme significantly disrupts the propagation of the sea breeze due to a misrepresented timing (too early triggering) and magnitude (too strong precipitation evaporation in one of the tested convection schemes) of the convective processes.