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Nocturnal cooling in a very shallow cold air pool

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Cold air pools (CAPs) may develop during nights in very shallow depressions. The depth of the stagnant air within a CAP influences the process of the cooling of nocturnal air and the resulting minimum temperature. A seven-month long field experiment was performed during winter 2013/2014 in an orchard near Krško, Slovenia, located inside a very shallow basin only a few meters deep and approximately 500 m wide. Two locations at different elevations inside the basin were selected for measurement. The results showed that the nights (in terms of cooling) can be classified into three main categories; nights with overcast skies and weak cooling, windy nights with clear sky and strong cooling but with no difference in temperatures between locations inside the basin, and calm nights with even stronger cooling and significant temperature differences between locations inside the basin. On calm nights with clear skies, the difference at two measuring sites inside the basin can be up to 5 °C but the presence of even weak winds can cause sufficient turbulent mixing to negate any difference in temperature. To better understand the cooling process on calm, clear nights, we developed a simple 1-D thermodynamic conceptual model focusing on a very shallow CAP. The model has 5-layers (including two air layers representing air inside the CAP), and an analytical solution was obtained for the equilibrium temperatures. Sensitivity analysis of the model was performed. As expected, a larger soil heat conductivity or higher temperature in the ground increases the morning minimum temperatures. An increase in temperature of the atmosphere also increases the simulated minimum temperatures, while the temperature difference between the higher and lower locations remains almost the same. An increase in atmosphere humidity also increases the modelled equilibrium temperatures, while an increase of the humidity of the air inside the CAP results in lower equilibrium temperatures. The humidity of the air within the CAP and that of the free atmosphere strongly influence the differences in equilibrium temperatures at higher and lower locations. The more humid the air, the stronger the cooling at the lower location compared to the higher location.