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Effects of irrigation: A study with new parameterizations within the WRF-ARW model, the case of the Po Valley (Italy)

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Local climate and agriculture production are strongly intertwined. Agriculture strongly relies on irrigation to increase the yield, both in arid region and not. However, the impact of irrigation on the local climate is not well understood. The majority of the studies found that it has a local cooling effect with a different magnitude depending on the representation, region and model used. For some specific regions, such as Southern Europe and India, the response is less clear as some studies obtained local warming. The common method to represent irrigation processes in the literature study is by saturating the whole soil column. This leads to a water request that is almost a hundred times more of what is available, which is unrealistic and it could cause an overestimation of the irrigation impact. The methods developed in this paper allow the model to account for the human decision component of the process: water amount and start, frequency and length of irrigation are decided a priori. In particular, this study focuses on three new surface irrigation methods, within the limited area model Weather Research Forecast (WRF-ARW 3.8.1), which summarize the most common ones: channel, drip, and sprinkler. The channel and drip methods apply the water to the surface, but the latter has leaf and canopy interception. For the sprinkler, the water used for irrigation is sprayed in the lowest model level and interact with the microphysics. These methods allow a more realistic representation of surface irrigation with respect to the commonly used saturation one.
The test case for this study is the Po valley (northern Italy) during the heat wave of July 2015, at the convection-permitting scale as well as the convection parameterized one.
Irrigation parameterizations improve the results due to a reduction in the biases of potential evapotranspiration (MODIS), the monthly mean and maximum temperature (stations' data). It is found that both soil moisture and surface atmospheric variables are more influenced by the scheme itself rather than the a priori assumptions of timing. The cooling effect has a clear daily cycle up to 1.2 K averaging over the irrigated land, with the maximum effect during the middle of the day. The magnitude of the cooling effect agrees with the previous studies. Irrigation affects the surface fluxes by reducing the sensible heat and increasing the upward moisture flux. Interestingly, precipitation is affected by irrigation at both the convection permitting and parameterized scale. The monthly precipitation accumulated, in the irrigated area of the Po Valley, is increased by 9.5% for the high-resolution run.