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Modeling temporal and spatial variability of crop yield

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Sara Bonetti[1], *Gabriele Manoli*[2], *Elia Scudiero*[3], *Francesco Morari*[2], *Mario Putti*[2] *and Pietro Teatini*[2], *(1)Duke University, Durham, NC, United States, (2)University of Padua, Padua, Italy, (3)University of California Riverside, Chino, CA, United States*

Abstract:
In a world of increasing food insecurity the development of modeling tools capable of supporting on-farm decision making processes is highly needed to formulate sustainable irrigation practices in order to preserve water resources while maintaining adequate crop yield. The design of these practices starts from the accurate modeling of soil-plant-atmosphere interaction. We present an innovative 3D Soil-Plant model that couples 3D hydrological soil dynamics with a mechanistic description of plant transpiration and photosynthesis, including a crop growth module. Because of its intrinsically three dimensional nature, the model is able to capture spatial and temporal patterns of crop yield over large scales and under various climate and environmental factors. The model is applied to a 25 ha corn field in the Venice coastland, Italy, that has been continuously monitored over the years 2010 and 2012 in terms of both hydrological dynamics and yield mapping. The model results satisfactorily reproduce the large variability observed in maize yield (from 2 to 15 ton/ha). This variability is shown to be connected to the spatial heterogeneities of the farmland, which is characterized by several sandy paleo-channels crossing organic-rich silty soils. Salt contamination of soils and groundwater in a large portion of the area strongly affects the crop yield, especially outside the paleo-channels, where measured salt concentrations are lower than the surroundings. The developed model includes a simplified description of the effects of salt concentration in soil water on transpiration. The results seem to capture accurately the effects of salt concentration and the variability of the climatic conditions occurred during the three years of measurements. This innovative modeling framework paves the way to future large scale simulations of farmland dynamics.

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