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Improving Dryland Crop Simulation by Assimilating Soil Moisture and Vegetation Data

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Global population is projected to keep increasing rapidly in the next 3 decades, particularly in dryland regions of the developing world, making it a global imperative to enhance crop production. However, improving current crop production in these regions is hampered by yield gaps due to poor soils, lack of irrigation and other management practices. Here we develop a crop modelling capability to help understand gaps, and apply to dryland regions where data for parametrizing and testing models is generally lacking. We present a data assimilation framework to improve simulation capability by assimilating in-situ soil moisture and vegetation data into the FAO AquaCrop model. AquaCrop is a water-driven model that simulates canopy growth, biomass and crop yield as a function of water productivity. The key strength of AquaCrop lies in the low requirement for input data thanks to its simple structure. A global sensitivity analysis is first performed using the Morris screening method and the variance-based Extended Fourier Amplitude Sensitivity Test (EFAST) method to identify the key influential parameters on the model outputs. We begin with state-only updates by assimilating different combinations of soil moisture and vegetation data (vegetation indices, biomass, etc.), and different filtering/smoothing assimilation strategies are tested. Based on the state-only assimilation results, we further evaluate the utility of joint state-parameter (augmented-states) assimilation in improving the model performance. The framework will eventually be extended to assimilate remote sensing estimates of soil moisture and vegetation data to overcome the lack of in-situ data more generally in dryland regions.