EGU2020-20644
https://doi.org/10.5194/egusphere-egu2020-20644
EGU General Assembly 2020

A dynamical systems approach to optimizing irrigation strategy under the influence of land-atmosphere feedbacks.

Bettina Meyer[1], Douglas J. Parker[2], and Jan O. Haerter[1]
[1]Copenhagen University, Niels Bohr Institute, Physics, København Ø, Denmark (bettina.meyer@nbi.ku.dk)
[2]School of Earth and Environment, University of Leeds

The soil-moisture feedback describes how precipitation amount, timing and intensity react to spatial anomalies in surface moisture. For heterogeneous moisture distributions with moist/dry patches on the scale of 10− 50km, numerical studies supported by observations indicate a negative soil-moisture feedback, where it rains more over dry patches (Imamovic, 2018; Rieck et al., 2014). The circulation established by the heterogeneous soil-moisture patches not only modifies the spatial rain distribution but allows for more water to be extracted from the atmosphere, thereby increasing the domain mean precipitation.

We here suggest that the negative soil-moisture feedback can be exploited when irrigating agricultural land: if farmers cooperate by following a spatially heterogeneous irrigation pattern, they can increase both their collective time-mean precipitation and thus the total water available for growing crops. However, the spatially non-local nature of the feedback allows individual farmers to exploit this strategy, thereby saving their own resources; a typical 'tragedy of commons' situation.
We formulate this setup in terms of an optimisation problem and study its parameter phase space, both analytically and numerically, in order to understand optimal rules and the consequences of the players' choice to cooperate vs. compete. Different constraints in terms of water availability (reservoir) and average soil moisture as defined by the evaporation timescale are explored.

Reducing the details of the land-atmosphere interaction into simple feedback parameters helps to elucidate the complex interactions between the precipitation, soil moisture and the human intervention by irrigation. Taking into account the negative soil-moisture feedback in irrigation models opens up new strategies to optimise water management and thereby increase crop yield.