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

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The soil-moisture feedback describes how precipitation amount, timing and intensity react to spatial anomalies in surface moisture. Given such a positive or negative feedback, spatial patterns in soil-moisture will be reflected in the spatial organisation of the convective cloud field.
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 at the boundaries of dry 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 their collective time-mean precipitation. However, the 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 to understand optimal rules and the consequences of the players'choice to cooperate vs. compete.
Reducing the details of the land-atmosphere interaction to simple feedback parameters helps elucidating the complex interactions between 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.

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