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Observations of cloud and rainfall enhancement over irrigated agriculture in an arid environment

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The impact of irrigated agriculture on clouds and rainfall remains uncertain, particularly in less studied arid regions. Irrigated crops account for 20% of global cropland area, and non-renewable groundwater accounts for 20% of global irrigation water demand. Quantifying the feedbacks between agriculture and the atmosphere are therefore not only necessary to better understand the climate impacts of land-use change, but are also crucial for predicting long-term water use in water-scarce regions.

Here we use high spatial-resolution satellite data to show the impact of irrigated crops in the arid environment of northern Saudi Arabia on cloud cover and rainfall patterns. Land surface temperatures over the crops are 5-10 K lower than their surroundings, linked to evapotranspiration rates of up to 20 mm/ month. Daytime cloud cover is up to 30% higher over the cropland compared to its immediate surroundings, and this enhancement is highly correlated with the seasonal variability in leaf area index. The cloud enhancement is associated with a much more rapid cloud cloud development during the morning. Afternoon rainfall is 85% higher over, and just downwind, of the cropland during the growing season, although rainfall remains very low in absolute terms.

The feedback sign we find is the opposite to what has been observed in tropical and semiarid regions, where temperature gradients promote convergence and clouds on the warmer side of land-surface type discontinuities. This suggests that different processes are responsible for the land-atmosphere feedback in very dry environments, where lack of moisture may be a stronger constraint. Increased cloud and rainfall, and associated increases in diffuse radiation and reductions in temperature, can affect vegetation growth thus producing an internal feedback. These effects will therefore need to be taken into account to properly assess the impact of climate change on crop productivity and water use, as well as how global land-use change affects climate.