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Drought, heat, irrigation, water use, crop yield loss and adaptation: a spatial assessment of the 2003 heat wave in France

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Advanced food production systems are sensitive to the impacts of drought and heat as testified by the crop losses that occurred in France in 2003. Temperatures up to 6°C above long-term means and precipitation deficits up to 300 mm resulted in crop yields 30% below long-term averages. Importantly, shortages in developed countries can affect food security in more vulnerable regions. Changing irrigation practices may mitigate part of the impact of drought on crop yield. Adaptation strategies in irrigated systems are mainly informed by crop transpiration needs, but during hot summer days farmers also irrigate to reduce ambient air temperature and thus minimize heat stress. This opens a conflicting perspective in environments constrained by water resources availability where it is generally advocated to (drip) irrigate at night to minimize evaporative losses. Also, agricultural water use was legally constrained in several French regions during the summer of 2003.
We assess the impact of irrigation, and the additional water used, to lower maize yield loss during the 2003 heatwave and associated drought in France using a crop model and remotely sensed soil moisture. Even though yield loss was lower in regions with higher maize irrigation percentages; yield loss was still very considerable. Modelling suggests that regional drought mitigation increased with increasing maize irrigation percentages between 0 and 40%. At higher irrigation percentages the compensating effect of irrigation was small. Although the current irrigation infrastructure is sufficient under normal meteorological conditions, areas without irrigation infrastructure experienced high irrigation requirements during the extreme conditions in 2003. Water used for irrigation increased with about 1761 million m3 compared to 2002. Adapting to increased frequency of droughts under further climate change will require robust water allocation policies.