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Global analysis of climate-driven interannual variability of food production and related water scarcity

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Interannual climatic and hydrologic variability has been substantial during the past decades in many regions. While climate variability and its impacts on precipitation and soil moisture have been studied intensively, less is known on subsequent implications for global food production. In this study we quantify effects of hydroclimatic variability on global "green" and "blue" water availability and demand in global agriculture, and thus complement former studies that have focused merely on long-term averages. We further quantify some options to overcome food deficit due to chronic or sporadic water scarcity.

We found that 24% of the world's population lives in chronically water scare food production units (FPUs) (i.e. water is scarce every year), while an additional 19% live under occasional water scarcity (water is scarce in some years). Among these 2.6 billion people altogether, 55% would have to rely on international trade to reach the reference diet, while for 24% domestic trade would be enough. For the remaining 21% of population exposed to some degree of water scarcity, local food storage and/or intermittent trade would be enough to secure the reference diet over the occasional dry years.

The analysis is based on historical climate forcing dataset over the period 1977-2007, while demography, diet composition and land use are fixed to reference conditions (year 2000). In so doing, we isolate the effect of interannual hydroclimatic variability from other factors that drive food production. We analyse the potential of FPUs to produce a reference diet for their inhabitants (3,000 kilocalories per capita per day, with 80% vegetal food and 20% animal products). The LPJmL vegetation and hydrology model was used to calculate spatially and explicitly the variation in food production, green-blue water availability and the water requirements to produce that very diet. An FPU was considered water scarce if its water availability was not sufficient to produce the diet (i.e. assuming food self-sufficiency to estimate dependency on trade from elsewhere).