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How certain are we about the model-based estimations of global irrigation water withdrawal?

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Irrigation agriculture is the most important user of the global freshwater resources worldwide, which makes it one of the key actors conditioning sustainable development and water security. The anticipated future climate change, population growth, and rapidly rising global demand for food will likely lead to agricultural expansion by allowing the development of irrigated areas. This together with the fact that irrigated crops are approximately four times more profitable than rainfed crops will place much additional pressure on water resources in the next years. Therefore, it is of vital importance to devise solutions that minimize the negative impacts of agricultural expansion, particularly on biodiversity and water use, so as to help us achieve environmental and economic sustainability. To realize such an ambition, quantifying irrigation water withdrawal at different spatio-temporal scales is essential. Global Hydrological Models (GHM) are often used to produce irrigation water withdrawal estimates. Yet GHMs questionably rely on several uncertain estimates of irrigated areas, crop evapotranspiration processes, precipitation and irrigation efficiency, which are the four main inputs in the structure of GHMs. Here we show that, once basic uncertainties regarding these estimates are properly integrated into the calculations, the point-based irrigation water withdrawal estimates actually correspond to uncertainty intervals that span several orders of magnitude already at the grid cell level. Our approach is based on the concept of "sensitivity auditing", a practice of process-oriented skepticism towards mathematical models. The numerical results suggest that current estimates of global irrigation water withdrawals are spuriously accurate due to their neglect of several ambiguities/uncertainties, and thus need to be re-assessed. Our analysis highlights that models of global irrigation water demands need to better integrate uncertainties, both technical and epistemological, so as to avoid misguiding the

development of strategies intended to help ensure water and food security.