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Hydrologic risks in agriculture and water management for high and stable crop yields

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Irrigation is one of the most effective strategies to reduce the variability in agricultural yield and profitability stemming from fluctuations in meteorological conditions during the growing season. This reduction in yield variability comes at the cost of an increase in water consumption and its variability. Hence, hydro-climatic fluctuations need to be kept into account when planning water allocations for maximizing or stabilizing crop yield in a sustainable way. We employ a probabilistic framework to quantify the hydrologic risk of yield reduction, with applications to both rainfed and irrigated agriculture. We link probabilistically the crop development during the growing season to the random occurrence of rain events and irrigation applications. Long-term and real-time yield reduction risk indices are determined analytically, as a function the climatic conditions (i.e. rainfall statistics), soil characteristics, and crop type, for different irrigation strategies. The long-term risk index allows assessing the suitability of a certain irrigation strategy and for investment planning, whereas the real-time risk index provides a probabilistic quantification of drought emergence during a given growing season. This probabilistic framework can be also used to assess the impact of limited water availability on the risk of crop yield reduction, thus guiding optimal water resources allocation among different users – such as agricultural production, human use, and environmental needs. The proposed approach employs few, physically based parameters, so that it is easily and widely applicable to different locations and crops, under current and future climatic scenarios. It is thus a powerful tool for assessing the impact of increasingly frequent dry spells on agricultural productivity, profitability, and sustainability.