

Abrupt late 1980s surface climate warming effects on drought risk over main french crop production basins

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Abstract:

Since late 1980s, warming trend intensifies strongly over Western Europe, resulting in an abrupt shift in air surface temperature over France (Sutton & Dong 2012; Reid et al., 2016). This rapid warming has modified the hydrological cycle with especially a significant decrease in runoff between January and July (Brulebois et al., 2015). As cumulative annual liquid precipitation didn't significantly evolve after 1987/1988, evapotranspiration might be the main driver of the water cycle evolution.

Along with this abrupt warming, stagnation of crop yields is observed since the 1990s over France, especially for bread wheat (Schauberger et al., 2018). In addition to maize and grapevine, the impact of climate hazard and agro-climatic risk linked to water cycle on the evolution of bread wheat yields is a major issue for agricultural insurance companies (Fusco et al., 2018). In this context, two major concerns need to be assessed: what are the patterns of water balance responses to abrupt changes in temperature? How did this abrupt warming impact drought risk over crops of interest main production basins?

SIM (Safran-Isba-Modcou) dataset of reanalyzed surface meteorological observations offers the opportunity to address the complexity of processes leading to changes in local water cycle (Soubeyroux et al., 2008). Daily liquid precipitation and potential evapotranspiration on an 8km spatial resolution from 1959 to 2021 are used to quantify the evolution of climate hazard linked to water cycle on a continuous time-scale and over the entire French territory. A simplified two reservoirs water balance model is also used to compute daily water balance using agronomic parameters of crops of interest, taking into account crop cover stage (Jacquart & Choisnel, 1995). The evolution of frequency and intensity of drought risk is analyzed using Tweedie distributions (Dunn, 2004).

Our results suggest that the abrupt warming in air temperature in 1987/1988 had strong influence on water balance evolution. Potential evapotranspiration significantly increases after 1987/1988 over the whole French territory especially in spring and summer. The evolution of annual and seasonal cumulative liquid precipitation differs in space and time and is less pronounced, leading to an intensification of water cycle. Water balance displays various evolutions depending on the crop and the production basin studied. The exceeding of water stress threshold is more frequent or more pronounced, leading to modifications of intensity and/or duration of drought events that significantly modify the risk. Risk evolution depends on the crop cover and main production basin.

Evolving climate hazard linked to water cycle impacts agro-climatic risks, identified as one of the main factor affecting the evolution of crop yields. Both mean conditions changes and modifications of the spatio-temporal variability of water balance affect the probability to overcome risk threshold. This is of major concern for the agricultural sector, especially insurance companies, and may lead to adaptation process from managers.

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