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Meteorological, agricultural and hydrological drought projections over France for the 21st century

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A 50-year drought reanalysis over France has been performed with the Safran-Isba-Modcou hydrometeorological suite (Vidal et al., 2010). In order to deal with the different types of droughts (meteorological, agricultural and hydrological), three sets of standardized indices have been defined: the commonly used Standardized Precipitation Index (SPI) computed from the Safran 8km atmospheric reanalysis, the Standardized Soil Wetness Index (SSWI) based on soil moisture simulated by the Isba land surface scheme at the same spatial resolution, and the Standardized Flow Index (SFI) based on streamflow computed by the Modcou hydrogeological model at more than 900 locations. These indices enabled to reconstruct past drought events at different time scales and in a consistent way through space as well as through the hydrological cycle.

This study presents an assessment of future meteorological, agricultural and hydrological droughts over France. To this aim, an ensemble of climate projections downscaled to the 8km scale have been considered here: (1) a 1961-2100 transient run of version 4.5 of the Arpege General Circulation Model (GCM) under the A2 emissions scenario, downscaled with two statistical methods: a method based on weather types (WT, Boé et al., 2006) and a quantile-quantile method (QQ, Déqué, 2007), (2) 1961-2100 transient runs of version 4.6 of Arpege under the A2, A1B and B2 emissions scenarios, downscaled with the WT method, and (3) projections from 6 CMIP3 GCMs under the A1B scenario for both the 1961-1990 and 2046-2065 time slices, downscaled with the WT method. Isba and Modcou models have been forced by each climate projection, and SPI, SSWI and SFI have been derived by standardizing precipitation, soil moisture and streamflow with respect to the corresponding 1961-1990 GCM control run distributions. 3-month and 12-month indices have been selected here to illustrate the evolution of short-term and long-term droughts.

The first result is a dramatic increase in the area affected by drought (index values under a 20% threshold in the baseline period) shown by Arpege transient runs over the 21st century. This increase is much more pronounced for agricultural and hydrological droughts, and is somewhat limited at the end of the century under the B1 scenario. The WT method furthermore suggests stronger short-term agricultural drought changes than the QQ method, mainly due to large changes in the frequency of extreme index values. Besides, a multimodel spatial analysis enabled to identify regions with the largest changes in drought frequency projected for the 2050s: meteorological droughts in the south-west and north of France, agricultural droughts over mountainous regions, hydrological droughts in the groundwater-dominated Seine basin. The above results may inform decisions of long-term water resource planning under the "no-adaptation" assumption. To go further, an on-going analysis is performed to identify potential changes in drought event characteristics (number, duration, magnitude, seasonality) with a non-stationary drought threshold emulating a progressive adaptation to reduced water resources. An assessment of such changes may provide water managers with appropriate information in order to help them build effective adaptation strategies that could also take account of changes in the timing, duration and intensity of drought events.

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Déqué (2007) Frequency of precipitation and temperature extremes over France in an anthropogenic scenario: Model results and statistical correction according to observed values. Global and Planetary Change, 57(1-2) 16-26. DOI: 10.1016/j.gloplacha.2006.11.030
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