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Large-scale, low-frequency hydrological variability of climate-sensitive catchments over france: regional classification and links to north-atlantic atmospheric circulation variability

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Characterizing and understanding long-term variations in hydrological characteristics is a key issue for climate change-related hydrological investigation, in order to distinguish "natural" variability and trends from anthropogenic forcing. In this study we investigated the spatial distribution of hydrological variations over France, focusing on low-frequency variability, i.e. interannual to multidecadal time-scales. The analysis was based on a subset of 152 streamflow records climate-sensitive catchments for the period 1968-2008. The two hypotheses to be tested concerned the possibility of distinguishing spatial patterns based on 1- the low-frequency variability of streamflow, 2- the statistical linkages of streamflow with large-scale circulation taking the winter-months NAO index (NAOI) as a reference. The methodological approach was based on univariate and bivariate (NAOI/streamflow) continuous wavelet analysis of streamflow records, associated to a multivariate wavelet clustering approach (Rouyer et al., 2008) of local wavelet spectra and wavelet coherence. Streamflow was first converted to specific discharge in order to remove the spatial scale effect induced by catchment area. Wavelet clustering was then performed on the wavelet spectra of mean monthly, annual high and low flow of specific discharge. The range of Morlet wavelet scales used for defining low-frequency felt between 4 and 24 years.

Univariate wavelet clustering based on monthly streamflow records allowed identification of well-defined spatial patterns through three clusters: western stations subject to oceanic influence, eastern stations subject to continental climate and stations located in the southern part of France (Mediterranean area). More clusters were found for mean and annual high flow (up to 6 clusters) than for low flow. This could be explained by a more direct influence of meteorological conditions/atmospheric circulation (high precipitation events and storms) on mean streamflow and high flow. On the other hand, low flows are most of the time related to ground water flow from aquifers which generally act as low frequency filters and may buffer high-amplitude and intense precipitation events. In a second time, wavelet clustering based on the linkages between streamflow and circulation was performed using wavelet coherence between streamflow and NAOI. Mean and high flows showed coherence with NAOI for 4-5 yr, 7-10 yr and 15-17 yr fluctuations; this was not the case of low flows. In any case, well-defined clusters showed up, which were to some extent similar to those previously identified based on streamflow only. The differences between the results from the two approaches (univariate, i.e. only based on streamflow, and bivariate, i.e. based on NAOI/streamflow wavelet coherence) can be related to the fact that other large-circulation patterns than NAO are involved to explain the low-frequency variability observed in streamflow, even for a relatively small area such as conterminous France. Obviously, the influence of the physical characteristics of the catchments would deserve a particular attention, but the differences among catchments would not likely explain such differences in the low-frequency variability.