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Low flows in France and their relationship to large scale climate indices

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This study explores the relationship between low flows in France and large scale climate variability. To this aim, a national low flows reference network of near-natural catchments called R2SE was set up. It consists of 220 French gauging stations suited to the monitoring of low flow evolution in France. Daily streamflow records for the period 1968-2008 were used to detect trends in several drought indices: three severity indices (mean annual flow, annual minimum flow and volume deficit) and three timing indices (drought start, center and end). In addition to testing for trend with respect to time, four climate indices were used as covariates: the North Atlantic Oscillation (NAO), the Atlantic Multidecadal Oscillation (AMO) and the frequency of two Weather Patterns corresponding to circulation types associated to wet (WP2) and dry (WP8) conditions over France. Due to their specific dynamics, NAO and WPs were also analyzed seasonally.

Results first show a consistent increase of drought severity in southern France with respect to time, NAO and AMO. Additionally, significant relationships with WPs are found throughout France, with the exception of the Mediterranean coast. Timing indices appear to be less related to large scale climate indices, whereas some evidence of a negative association with time is found (i.e. an earlier start of the annual low flow period). Seasonal climate indices appear to have stronger links with low flow indices than their annual counterparts. The summer (JJA) NAO shows a strong link with severity indices in the northern half of France. This link is found again for the winter (DJF) WP2. Lastly, significant links are detected between timing indices and seasonal WP8, while these links could not be detected at the annual scale.

In order to assess the robustness of the above relationships, a subset of 28 stations with a longer record period is studied on three different periods: 1948-1988, 1968-2008, and on the whole period 1948-2008. Importantly, trends with respect to time clearly lack robustness: trends of opposite sign are found in the first and second period, and no compelling trends are found in the whole period 1948-2008. Conversely, the relationship between low flow indices and climate indices remain stable across all three time periods.

The above result demonstrates that time cannot be used beyond purely descriptive purposes. In particular, this lack of stability precludes the use of time as a covariate for forecasting purposes: extrapolating a temporal trend in the future could lead to misleading predictions. On the other hand, the stability of the relationships between low flow and climate indices provides confidence that these relationships result from physical mechanisms linking atmospheric circulation and surface hydrology. Moreover, it paves the way for useful seasonal forecasting applications. As an illustration, information about drought severity could be inferred several months ahead from either a forecasted summer NAO or more directly from the WP2 frequency observed during the previous winter.