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Hydrometeorological variability on a large french catchment and its relation to large-scale circulation across temporal scales

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In the present context of global changes, considerable efforts have been deployed by the hydrological scientific community to improve our understanding of the impacts of climate fluctuations on water resources. Both observational and modeling studies have been extensively employed to characterize hydrological changes and trends, assess the impact of climate variability or provide future scenarios of water resources. In the aim of a better understanding of hydrological changes, it is of crucial importance to determine how and to what extent trends and long-term oscillations detectable in hydrological variables are linked to global climate oscillations.
In this work, we develop an approach associating large-scale/local-scale correlation, enmpirical statistical downscaling and wavelet multiresolution decomposition of monthly precipitation and streamflow over the Seine river watershed, and the North Atlantic sea level pressure (SLP) in order to gain additional insights on the atmospheric patterns associated with the regional hydrology. We hypothesized that: i) atmospheric patterns may change according to the different temporal wavelengths defining the variability of the signals; and ii) definition of those hydrological/circulation relationships for each temporal wavelength may improve the determination of large-scale predictors of local variations.
The results showed that the large-scale/local-scale links were not necessarily constant according to time-scale (i.e. for the different frequencies characterizing the signals), resulting in changing spatial patterns across scales. This was then taken into account by developing an empirical statistical downscaling (ESD) modeling approach which integrated discrete wavelet multiresolution analysis for reconstructing local hydrometeorological processes (predictand : precipitation and streamflow on the Seine river catchment) based on a large-scale predictor (SLP over the Euro-Atlantic sector) on a monthly time-step. This approach basically consisted in 1- decomposing both signals (SLP field and precipitation or streamflow) using discrete wavelet multiresolution analysis and synthesis, 2- generating one statistical downscaling model per time-scale, 3- summing up all scale-dependent models in order to obtain a final reconstruction of the predictand. The results obtained revealed a significant improvement of the reconstructions for both precipitation and streamflow when using the multiresolution ESD model instead of basic ESD ; in addition, the scale-dependent spatial patterns associated to the model matched quite well those obtained from scale-dependent composite analysis. In particular, the multiresolution ESD model handled very well the significant changes in variance through time observed in either prepciptation or streamflow. For instance, the post-1980 period, which had been characterized by particularly high amplitudes in interannual-to-interdecadal variability associated with flood and extremely low-flow/drought periods (e.g., winter 2001, summer 2003), could not be reconstructed without integrating wavelet multiresolution analysis into the model.
Further investigations would be required to address the issue of the stationarity of the large-scale/local-scale relationships and to test the capability of the multiresolution ESD model for interannual-to-interdecadal forecasting. In terms of methodological approach, further investigations may concern a fully comprehensive sensitivity analysis of the modeling to the parameter of the multiresolution approach (different families of scaling and wavelet functions used, number of coefficients/degree of smoothness, etc.).