



Analysing and projecting spatial drought conditions of the Seine catchment based on ocean-atmosphere oscillations over interannual and decadal scales

Kwok Pan Chun¹, Qing He¹, Bastien Dieppois^{2,3}, Nicolas Massei⁴, and Matthieu Fournier⁴

¹Department of Geography, Hong Kong Baptist University, Hong Kong (kpchun@hkbu.edu.hk)

²Centre for Agroecology, Water and Resilience (CAWR), Coventry University, Ryton-on-Dunsmore, UK

³Department of Oceanography, University of Cape Town, Cape Town, South Africa

⁴Normandie Univ, UNIROUEN, UNICAEN, CNRS, M2C, 76000 Rouen, France

Midlatitude droughts are affected by the tropical disturbances, which are linked to sea-surface temperature patterns in the Pacific and Atlantic Oceans. The combined effects of these two ocean basins manifest themselves in the variation of streamflows, from land surface filtering. In this study, we have developed a framework to explore the effects of global sea surface temperature variations along with atmospheric teleconnection patterns, on local hydroclimatic conditions related to droughts over the Seine catchment, a main waterway in northern France. Using the Standardized Runoff-discharge Index (SRI) to quantify hydrological drought conditions over the Seine, the North Atlantic Oscillation (NAO) index was found to be a significant driver for the upstream dryness between 2001 and 2015. The El Niño Southern Oscillation (ENSO) index was also found to be a significant forcing variable, but for the Seine downstream. The Atlantic Multidecadal Oscillation (AMO) and the West Mediterranean Sea (WMED) indices were significant over almost the whole Seine River basin. Results show that the drought spatial patterns of the Seine River vary differently with the atmospheric and oceanic oscillations from interannual to decadal scales. Over a small catchment with a drainage area around 78,700 square kilometres, the spatial drought variations in the Seine catchment appear to be usual, and they are likely to be related to regional conditions which drive local land surface mechanisms linked with microclimates or geological processes. In general, during the negative phase of AMO and the positive phase of ENSO, the sea surface temperature of the North Atlantic Ocean is low. The positive phase of NAO also lowers sea surface temperatures of the North Atlantic Ocean and the West Mediterranean Sea. Droughts are likely to occur at the Seine during the negative phase of AMO and the positive phase of NAO, because the cold North Atlantic Ocean has less evaporation and provides less moisture to France. Based on these results, a statistical downscaling model is developed to relate SRI to atmospheric and oceanic oscillation indices, which are derived from the Institut Pierre Simon Laplace climate model (IPSL-CM5) outputs. Using this statistical downscaling model and scenarios of Representative Concentration Pathways (RCP4.5 and RCP8.5), the drought conditions of the Seine are projected for the mid- and long-term future (2050s and 2080s). Diverse drought results are obtained. Based on relative importance of oscillation indices, the implications of diverse

projections for general drought managements in midlatitude regions related to tropical sea surface temperature disturbances and atmospheric teleconnections are discussed.