Spatiotemporal characterization and forecasting of drought in North Algeria

Abstract

This thesis aims to estimate the risk of meteorological, agricultural and hydrological drought by using a multivariate probabilistic analysis of drought characteristics to assess both the severity and duration of drought in the past and the future in the Center and West regions of northern Algeria. The thesis includes (1) the study of the impact of climate change on water resources and the water balance in order to determine their consequences on agricultural production at the level of the central and western plains; (2) identification of the meteorological drought magnitude that could trigger the corresponding hydrological drought through their characteristics; (3) evaluation of the future risk of different types of drought according to two emission scenarios (RCP 4.5 and 8.5); and (4) estimating the return periods of drought events using multivariate frequency analysis and study of their rates of change in the future under the effect of climate change. The analysis was based on drought characteristics calculated from the indices inherent to drought. The propagation of meteorological drought to hydrological drought was studied at the level of the two watersheds of Tafna and Macta characterized by different lithology. The evaluation of the impact of temperature on agricultural drought is carried out in the vast agricultural plains of the North-West and the center spreading over the watersheds of the Tafna, the Macta, the Chellif, and the coastal Algerian. The assessment of the risk of drought occurrence in the past and the future was based on multivariate analysis using 26 multivariate copula functions. Future events were estimated from the GR2M hydrological model and nine climate data simulations from the RCA4 regional climate model coupled with nine global climate models.

The analysis revealed a propagation from meteorological drought to hydrological drought where the response time depends on the memory effect of the watershed and the severity and duration of the associated meteorological event. The RCA4-CSIRO-MK3 model is the most pessimistic and the Gumbel and Clayton copulas belonging to the Archimedean family of copulas were the most adapted to drought characteristics. A strong consensus between the risk of recurrence of the drought events that have occurred, determined by the bivariate copulas, and the projected events, determined by the climate models under the RCP8.5 scenario. A maximum reduction in the 5, 10, 50 and 100 year return periods was shown increasing the risk of hydrological drought by 40% under RCP8.5 and around 30% under RCP 4.5.

Meteorological drought events in the plains are more severe and last longer, particularly during the hot season (between May and September) between 2021 and 2071 according to the two future scenarios. In addition, agricultural production is threatened by a spring agricultural drought (between February and April) between 2050 and 2100 under the RCP4.5 scenario, which can have serious consequences on agricultural income as well as food security. Adaptation plans that consist in optimizing the use of water resources must be taken into account for optimal water regulation of western dams and for planning future irrigation schedules.

Keywords: climate models, copulas, agricultural drought, hydrological drought, risk analysis, climate change.