GIS-based water budget framework for assessing regional scale spatio-temporal variation and the impact of climate change on groundwater recharge over the past 100 years

Lamine Boumaiza[1], Julien Walter[1] , Romain Chesnaux[1] , Mélanie Lambert[1] , Madan Kumar Jha[2] , Heike Wanke[3] , Andrea Brookfield[4] , Okke Batelaan[5] , Paulo Galvão[6] , Nour-Eddine Laftouhi[7] , Christine Stumpp[8]

[1]Université du Québec à Chicoutimi, [2]Indian Institute of Technology, [3]University of the West of England, [4]University of Waterloo, [5]Flinders University, [6]Federal University of Minas Gerais, [7]Cadi Ayyad University, [8]University of Natural Resources and Life Sciences.

E-mail: julien_walter@uqac.ca

Knowledge of groundwater recharge (GWR) and its distribution are necessary for sustainable groundwater resources management. However, quantifying GWR remains particularly challenging as this parameter cannot be measured directly. At the regional scale, GWR varies spatially, and under current climate change, it is expected to vary with time. The proposed communication aims (i) to demonstrate a pragmatic GIS-based water budget framework for assessing GWR at regional scale, and (ii) to evaluate the effect of climate change over a period of 100 years (1910–2009). The SaguenayLac-Saint-Jean region (13,200 km2) of Quebec (Canada) was selected for this study. The GIS-based water budget framework was based on a model incorporating vertical inflows (VI), actual evapotranspiration (AET), and surface runoff (RuS). Vertical Inflows (VI) include water amounts from rainfall and snowmelt that were provided by the Centre expertise hydrique du Québec (CEHQ). The CEHQ used physically based distributed hydrological model HYDROTEL for computing the water amounts derived from snowmelt. VI data were generated on daily time intervals over a period of 100 years (1910–2009). With 165 interpolated VI observation points over the SLSJ region, more than 60,000 values for each year over 100 years were considered in this study. The potential evapotranspiration (PET) was estimated using an empirical equation developed to the particular northern humid climatic conditions of Quebec. VI and PET were then combined to calculate the actual evapotranspiration (AET). Based on the SLSJ surface deposits, soil types were grouped according to their water infiltration capacity, which was combined with land use characteristics and terrain slope to estimate surface runoff (RuS) using the curve number method. The trend analysis of temperature time series reveals an average of 1.1 ± 0.6°C increase over 100 years. Also, an increase in the water budget components is observed. Despite the increasing trends of RuS and AET, GWR still showed an increasing trend with an average increase of 0.7 ± 0.4 mm/yr over the past 100 years. The last 10 years of the observations period (2000– 2009) indicate that 6% of the study area has GWR rates of 35–50% of the VI. GWR rates of 20–35% of the VI occur in 58% of the study area, while 36% has GWR rates of 5–20% of the VI. This finding provides useful information for future studies focusing on predicting long-term GWR evolution and for the development of efficient long-term groundwater management strategies.