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Assessing groundwater recharge with isotopic analysis (δ^2H and $\delta^{18}O$-H_2O) in response to climate and land use change in Montérégie, southern Quebec

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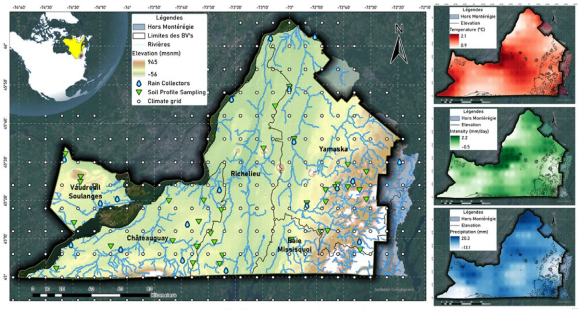

Fig. 1. Montérégie, sampling, and data locations (left). Climatic post-90 trends (right).

Groundwater recharge is significantly influenced by climate change, urbanization, and agricultural activities, which can alter the type, seasonality, and intensity of precipitation, as well as the soil surface and sub-surface properties which are crucial for infiltration and recharge processes. A spatial and temporal analysis of water isotopic signatures in precipitation and soil profiles enables us to quantify regional recharge and evaluate its response to climate and land use changes across a heterogeneous geological context. Our study focuses on Montérégie (~12,000 km^2), a region characterized by a humid continental climate recognized for its extensive agricultural production and substantial urban development, driven in part by its proximity to Montréal (Fig. 1). It is composed of four transboundary watersheds and a local one, draining into the St. Lawrence River.

Nineteen specialized collectors [1] were used for biweekly sampling of precipitation (rain and snow) and installed next to government weather stations with daily data collection capabilities. Public available data on land use, soil texture, and slope were processed to identify different recharge units and to select appropriate soil profiles for isotopes and water content analysis. Between 2022 and 2023, a total of 568 rain and 77 snow samples were collected and analyzed. Additionally, 44 soil profiles (comprising 583 samples) were examined during the summer-autumn period of 2023. We revealed a significant temporal isotopic seasonality linked to temperature, characterized by low values during winter (~-150‰ for δ^2H and ~-21‰ for $\delta^{18}O$-H_2O relative to VSMOW) and high values during summer (~-10‰ for δ^2H and ~+1‰ for $\delta^{18}O$-H_2O relative to VSMOW), along with slight regional variations influenced to local climatic conditions. Isotopic profiles of soil water confirm the seasonal variability observed in precipitation. By integrating soil water content, water balance calculations, and an isotopic model, we are able to quantify recharge at a regional scale and assess the impacts of both climate change and land use dynamics.

REFERENCES

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