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High-resolution precipitation sampling to isotopically evaluate the impact of an urban environment on precipitation

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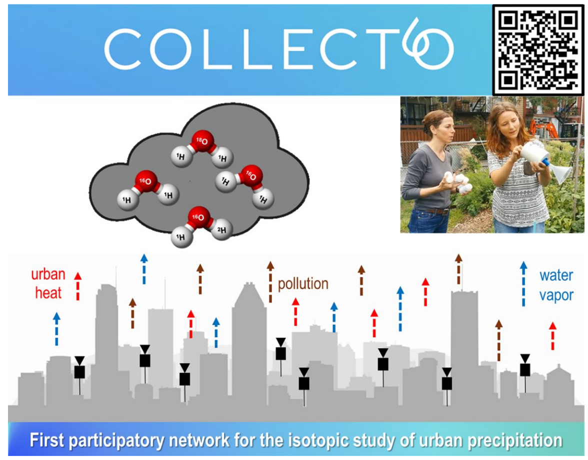

Climate is currently facing a wide range of anthropogenic pressures that are resulting in changes, at different temporal and spatial scales. Between 1988 and 2017, Southeastern Canada has known a 2°C increase, and precipitation has become scarcer and more intense.[1]

Temperature and precipitation are also modified at the city's scale. Over 2013-2017 in Montreal, we observed an increasingly high Urban Heat Island (UHI), with daily minimum temperatures on average 2°C higher in the city than its surroundings.[1] Precipitation has become scarcer in town compared to the region (-4% on average).[1] Montreal is the Eastern Canadian city whose climate is the most impacted by the urban environment.[1] However, as the city is very heterogeneous in time and space, the processes involved in these modifications are still poorly understood. Water-stable isotopes have proved to be most useful in understanding global climate changes and could be valuable at this local scale. Such a study required high-resolution sampling.

We implemented Collect'O, the first participatory network to sample precipitation for this isotopic study of the urban environment. Over 50 citizens of the Greater Montreal area were involved in simultaneously collecting rain and snow for more than 20 selected meteorological events, with cumulative samplers we specially built for the preservation of the isotopic signal.[2] Three surface water automatic samplers were also modified to allow for intra-event rain sampling for isotopic study.

For each event, the isotopic signal is highly variable between all stations (maximum of 8‰ in $\delta^{18}O$ on a single event), which was never considered at such a scale. Our results highlight the precipitation evaporation induced by the UHI, fueling the following air masses in water vapor. Water vapor issued from combustion processes (transports, home heating) contributes to 5% of the precipitation on the city's outskirts.

Since our data shows that precipitation lowers the UHI amplitude and atmospheric particulate matter concentrations,[1] a better adaptation of cities to current and future precipitation modification is necessary to protect the most fragile citizens. This study provides valuable insights into the understanding of urban precipitation modification, which is necessary for the improvement of hydrological models.

[1] https://doi.org/10.1016/j.uclim.2023.101781

[2] https://doi.org/10.1002/rcm.9710