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How to discriminate between local and regional flows for the management of karst groundwater resources?

Use of $\delta^2\text{H}$ vs $\delta^{18}\text{O}$ applied to the Huveaune watershed and the hydrogeological catchment of the Port-Miou spring (SE France)

Bruno Arfib¹, Thibaut Garin¹, Bernard Ladouche^{2,3}, Julio Goncalves¹, Benoit Dewandel^{2,3}, Thierry Lamarque⁴

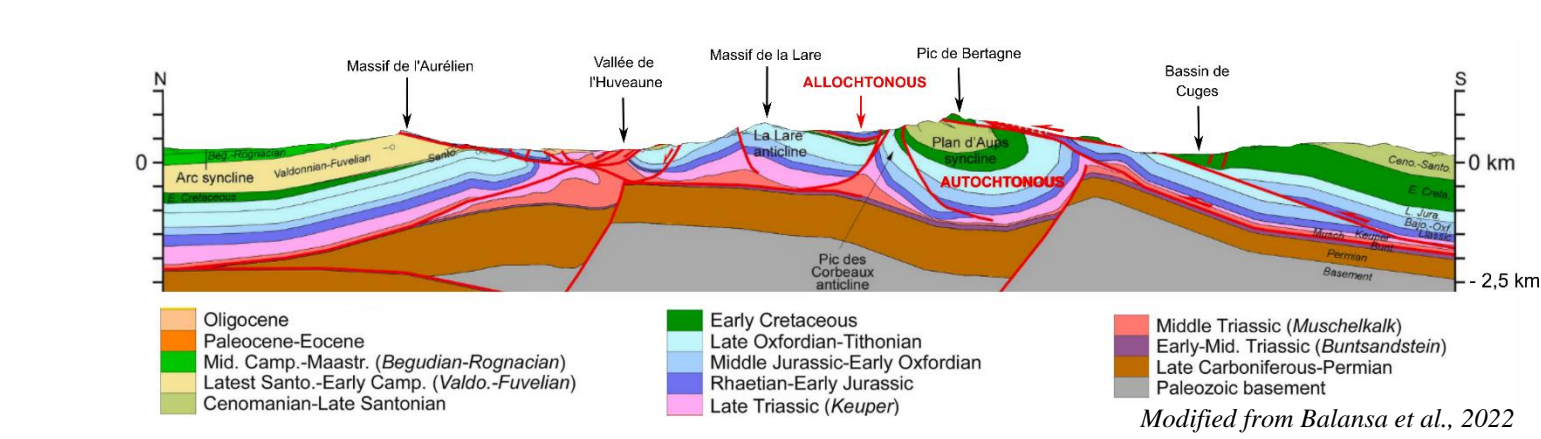
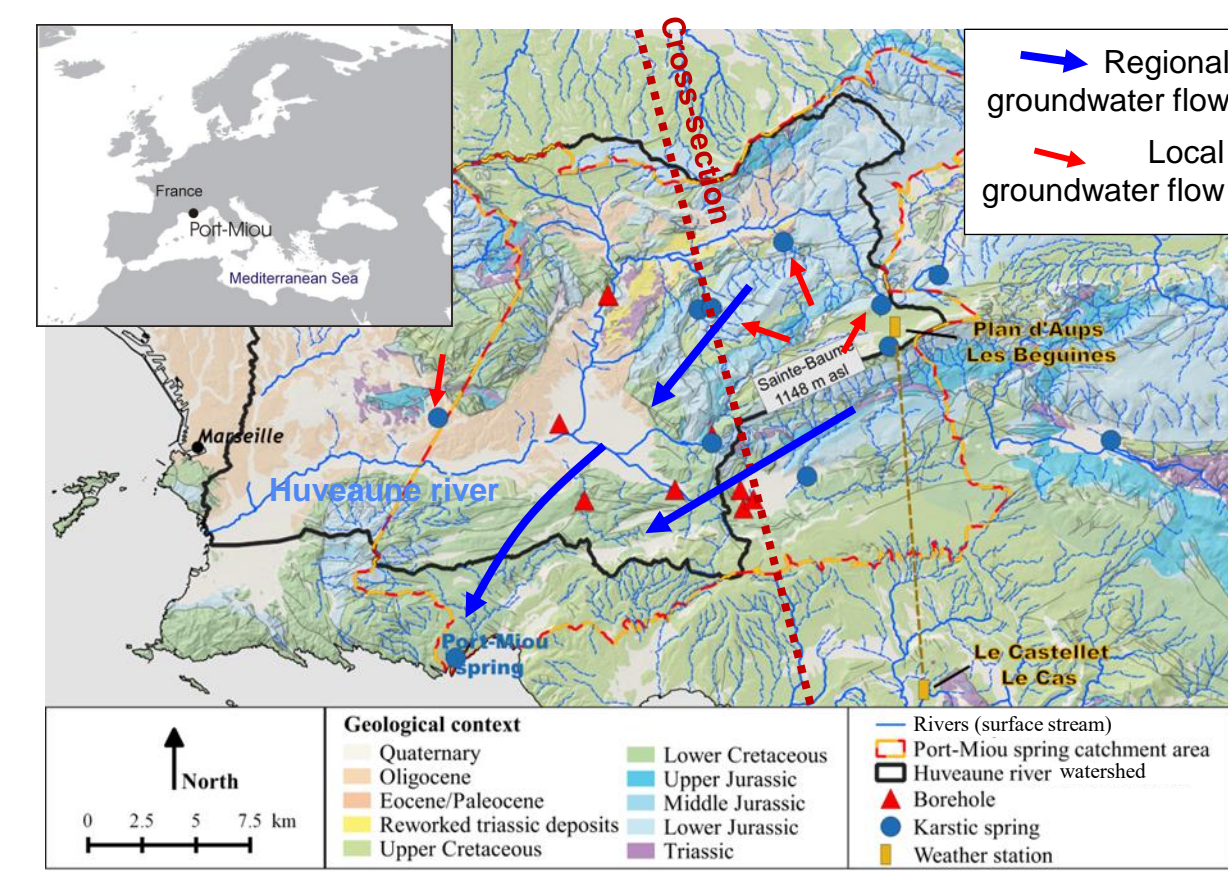
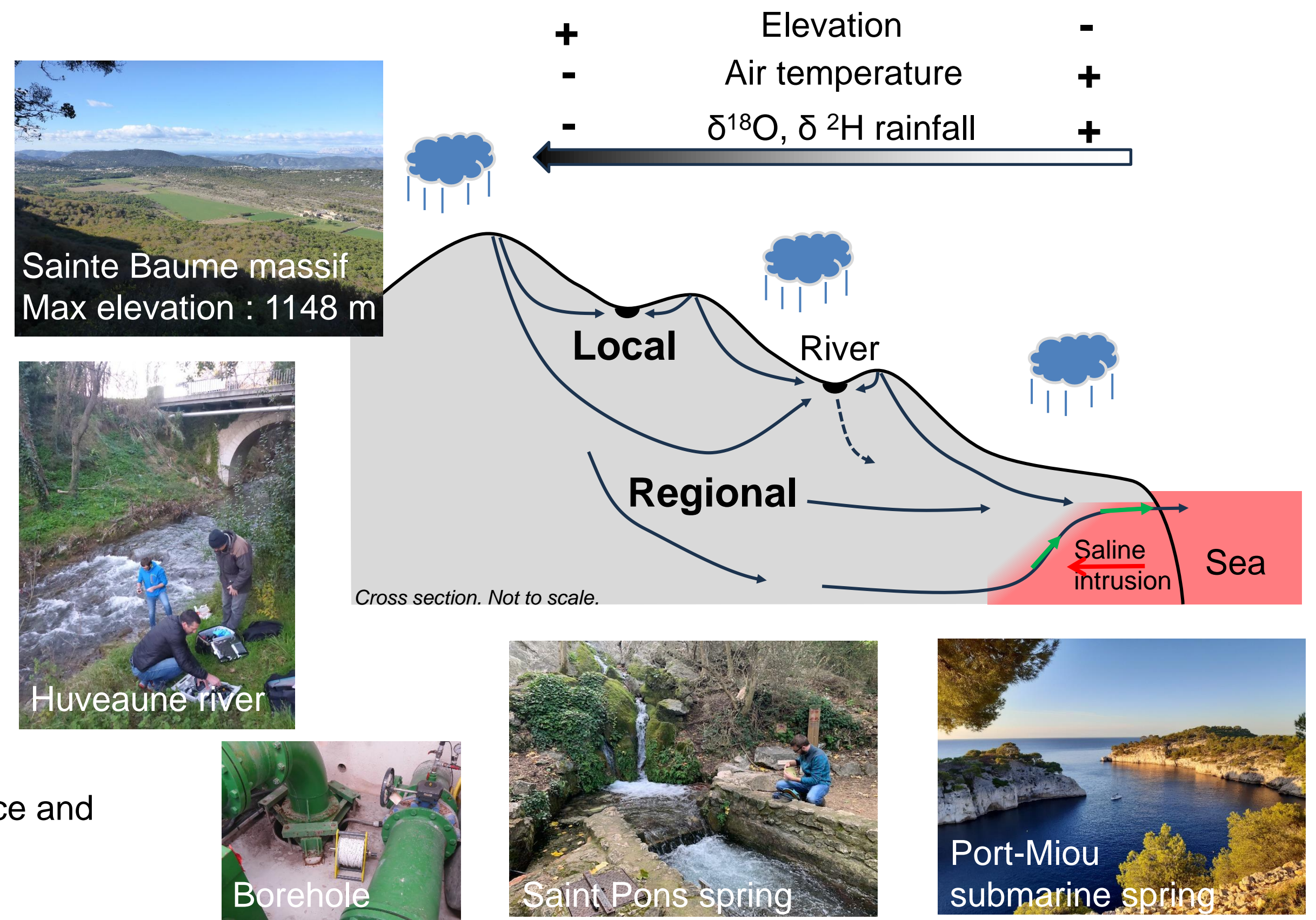
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Challenges and goals

- Define river watershed and groundwater recharge zones
- Discriminate between local and regional groundwater flows
- Define groundwater $\delta^{18}\text{O}$, $\delta^2\text{H}$ end-members
- Propose to water managers a tool to identify the groundwater origin

Context and case study

- ➔ Mediterranean karst aquifers
- ➔ Deep and multi-phased karstification (Messinian salinity crisis and plioquaternary eustatic variations)
- ➔ Regional groundwater flow disconnected from surface flow : major freshwater resource and limited impact on surface water ecology
- ➔ High range of elevation (from the sea to 1148 m asl)



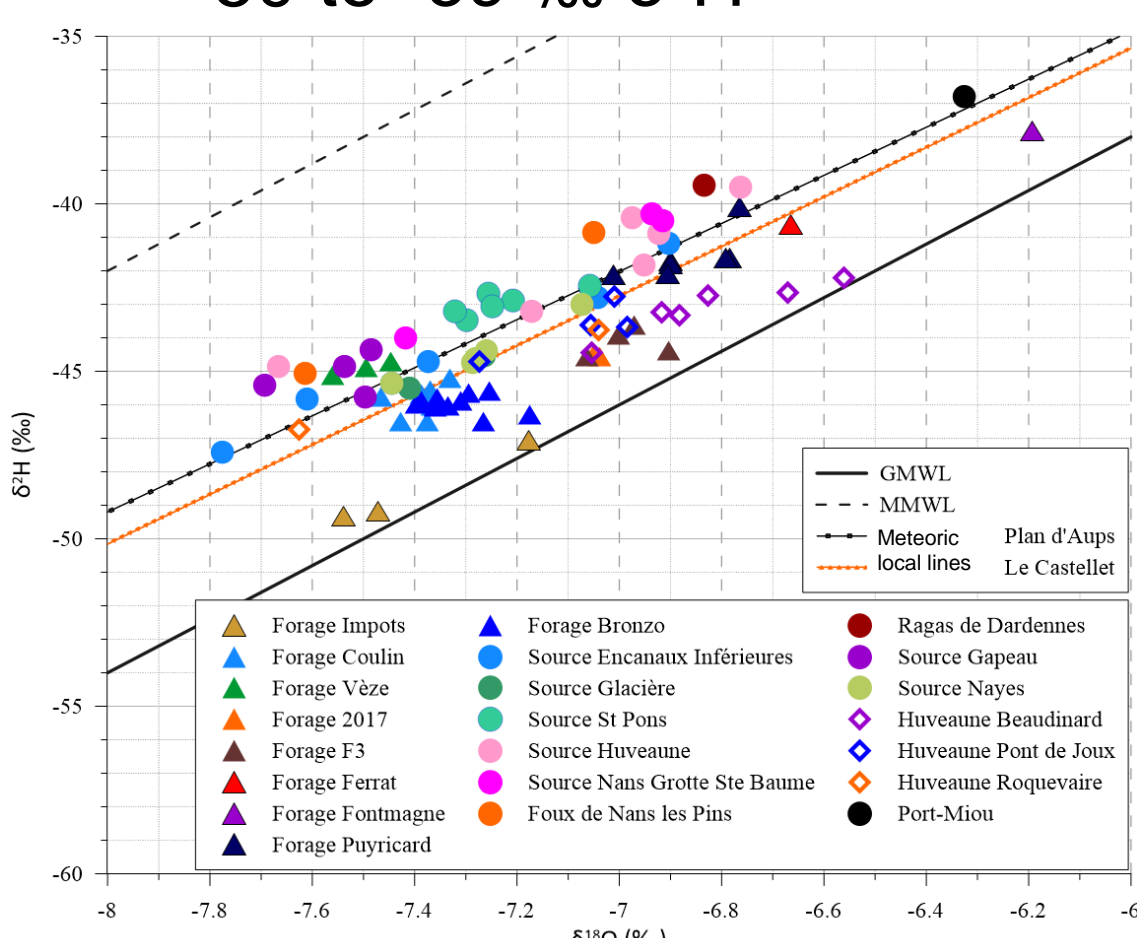
- ➔ Carbonate rocks from Trias, Jurassic, Cretaceous and Oligocene ages
- ➔ Surface watershed (Huveaune) discharging to the West
- ➔ Regional groundwater flow discharging to the South at the Port-Miou submarine spring (recharge area $\approx 400 \text{ km}^2$)
- ➔ Inflow of external freshwater from the Alps for water supply (surface channel transfers)

Method

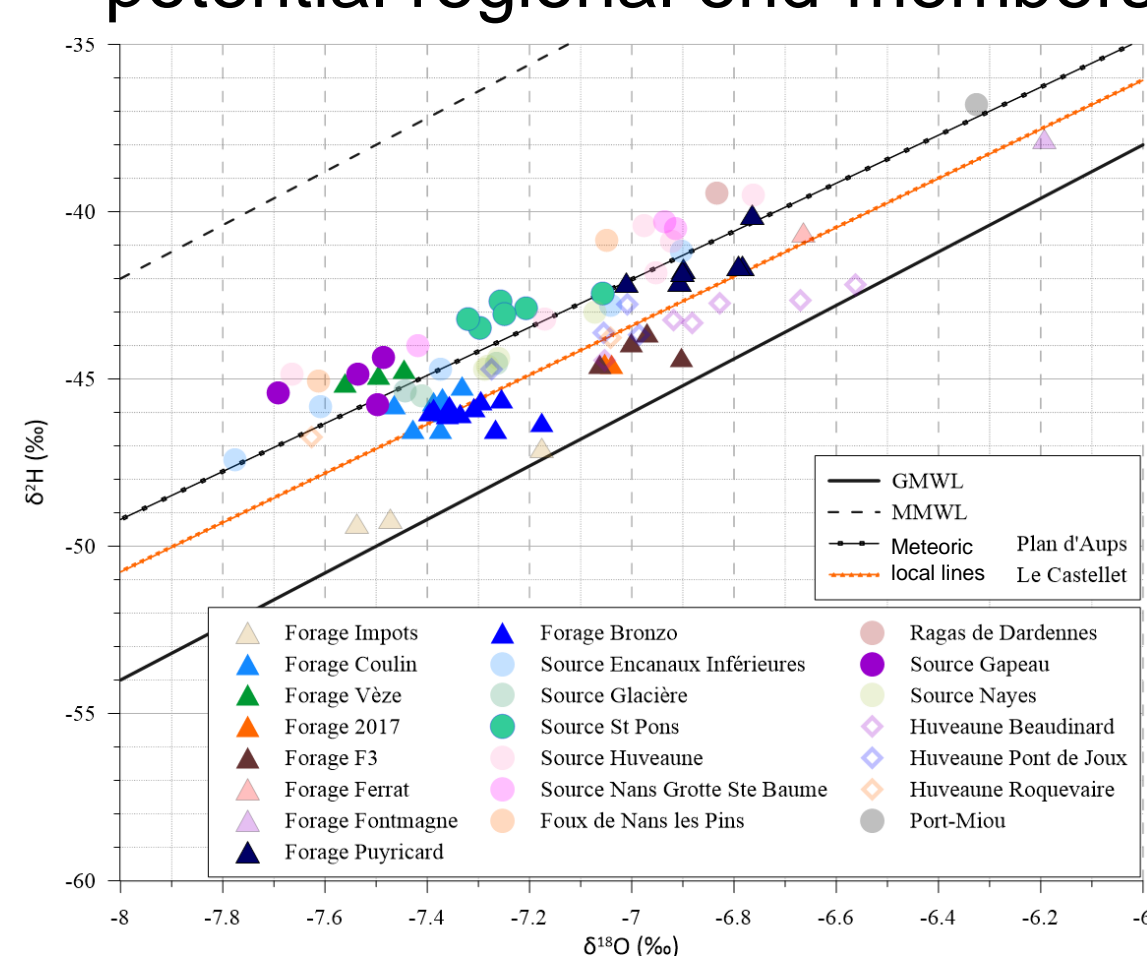
- ❑ 23 water sampling points (river, spring, borehole)
- ❑ 97 analyses, under a variety of hydrological conditions (low-water, flood, base-water, high-water) between 2018 and 2020
- ❑ Major ions
- ❑ $\delta^{18}\text{O}$, $\delta^2\text{H}$ (Picarro, Univ. Montpellier, Univ. Marseille, uncertainty $< 0.15\text{‰}$ for $\delta^{18}\text{O}$ and $< 1.5\text{‰}$ for $\delta^2\text{H}$)

Results

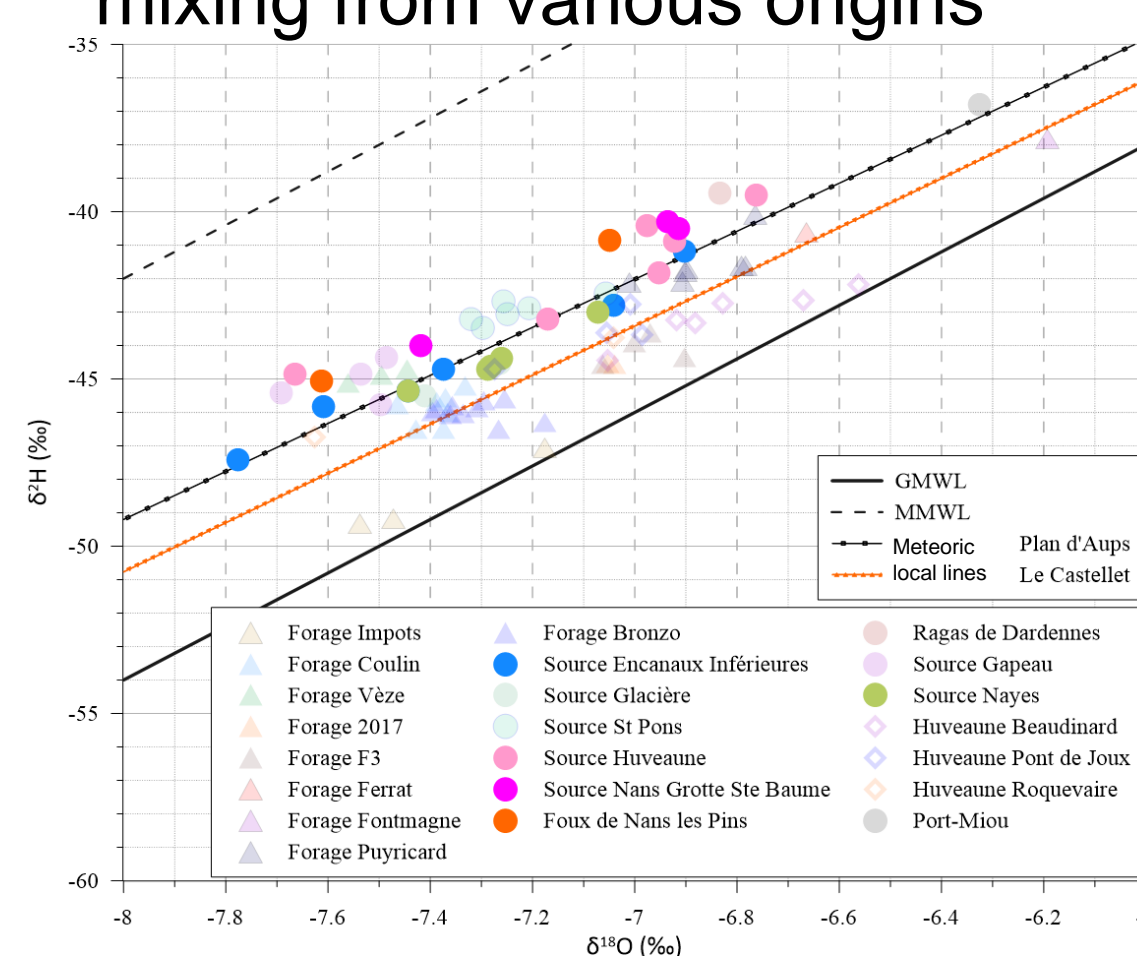
Stable isotopes range :
 ≈ -7.8 to -6.6‰ $\delta^{18}\text{O}$
 ≈ -50 to -39‰ $\delta^2\text{H}$



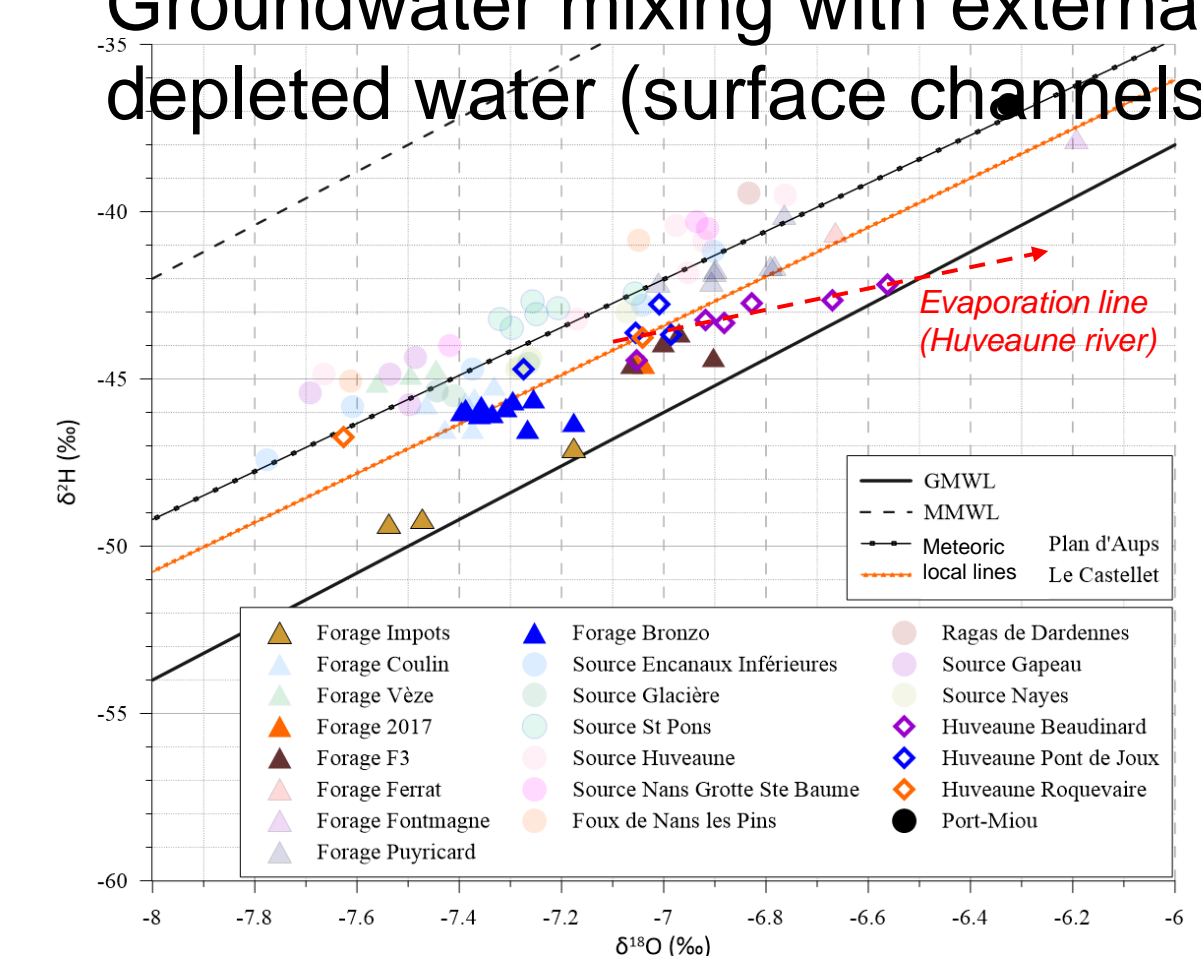
Selection of points with very low range of variation ($< 0.2\text{‰}$ $\delta^{18}\text{O}$): potential regional end-members



High range of variation = influence of rainfall quickly infiltrated or mixing from various origins

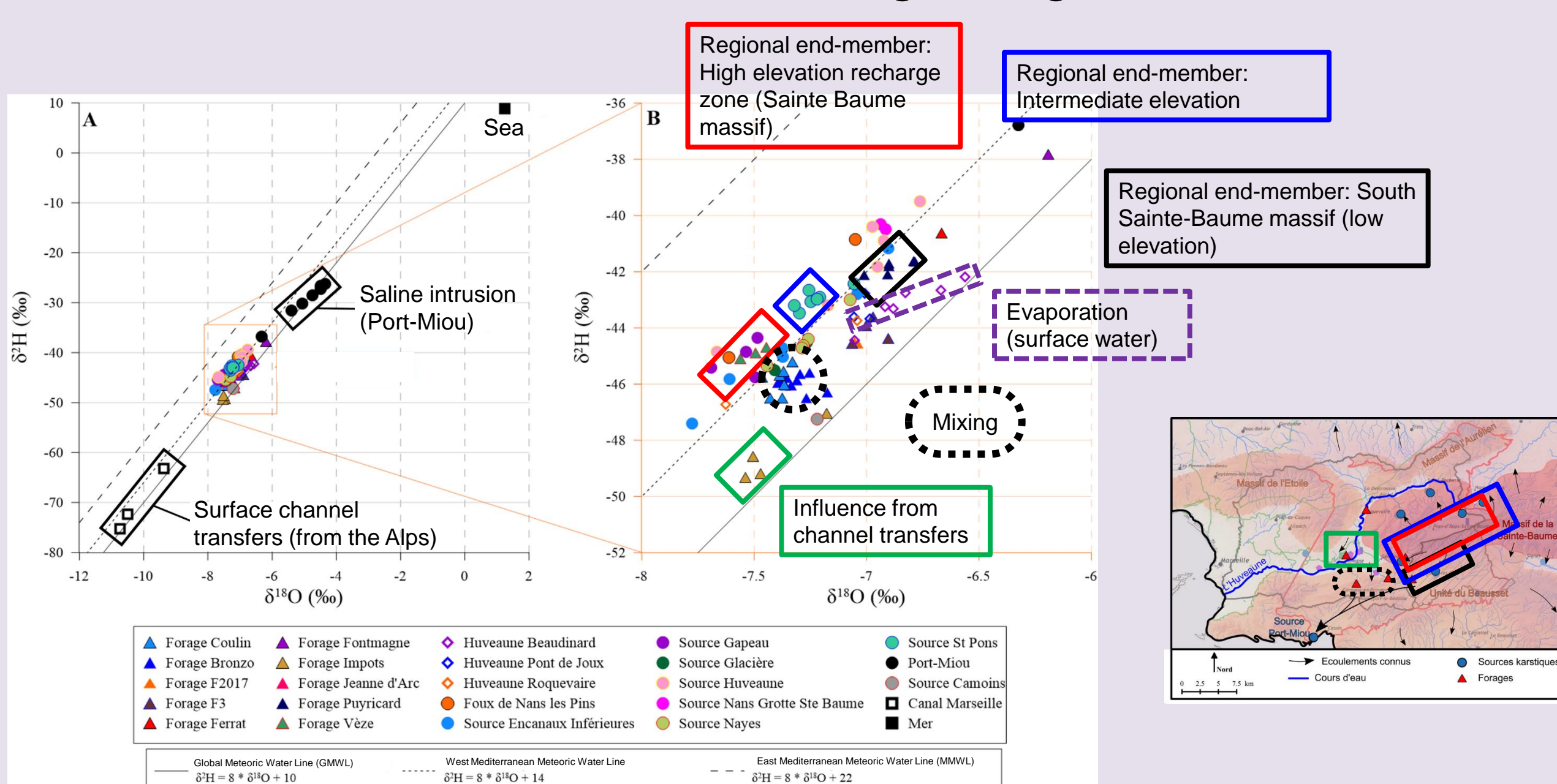


Evaporation effect on Huveaune river samples. Groundwater mixing with external depleted water (surface channels)



A graphical tool for water management

Several end-members identified for regional groundwater flows



Advantages :

- *In situ* sampling easy to proceed
- Low cost analysis
- New sampling points (e.g. new boreholes) can be immediately added to the database
- Method adapted to highlight points influenced by rapid infiltration (risk of rapid transfer of pollutant)
- Offers a long-term monitoring of the water cycle
- Data useful for climate change studies

Requires :

- An isotopic contrast between local and regional groundwater (elevation, surface water evaporation, water from external catchment area...)
- Sampling in different hydrological conditions
- Sampling many springs, boreholes and rivers at regional scale to characterize the spatial and temporal variations

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