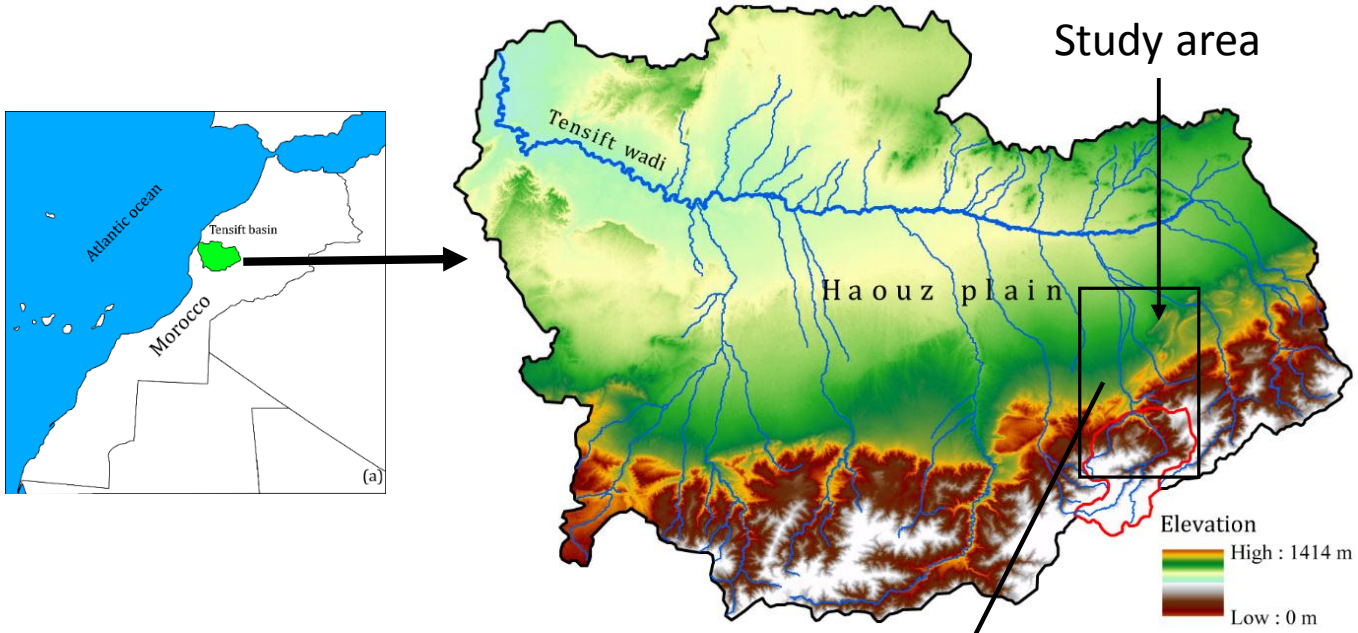
# Anthropogenically-induced recharge in a semiarid mountain front context

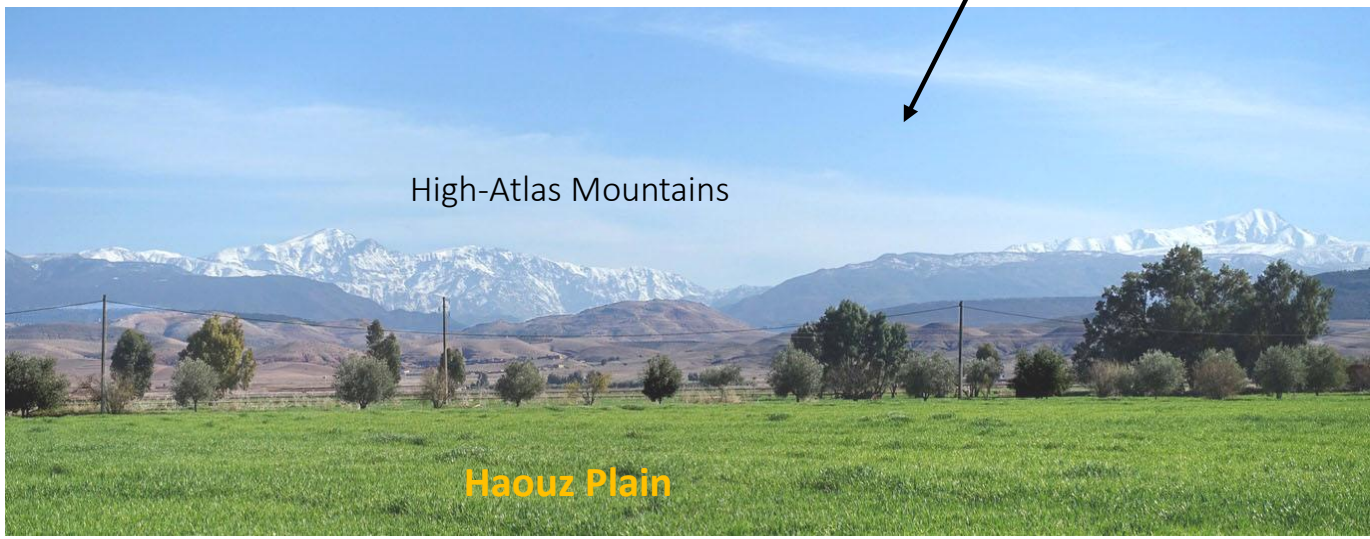
*Bouimouass Houssne, Fakir Younes, Tweed Sarah, Leblanc Marc*

bouimouass.h@gmail.com

houssne.bouimouass@alumni.univ-avignon.fr

- Semiarid climate.
- high spatial & temporal heterogeneity in precipitation (250 mm in the plain and 650 mm in the mountain).
- High evaporative demand (1400 mm/year)
- No perennial surface water resources, high dependency on groundwater.
- Combined effect of droughts and overexploitation led to a severe groundwater withdrawal (1-2 m/year).
- **Unknown groundwater recharge sources.**




*Paper in Hydrological Processes (DOI: 10.1002/hyp.13685)*

**Main Goal** : Investigating groundwater recharge sources in the mountain-plain transitional area.

Stable isotopes and major ions

Groundwater levels

Spatio-temporal variation of stables isotopes signatures and groundwater

Insights into groundwater flow and recharge sources in the mountain front area .

*Paper in Hydrological Processes (DOI: 10.1002/hyp.13685)*

19 precipitation samples collected from different altitudes spanning the High-Atlas to the Haouz plain.

56 groundwater samples from 27 private wells collected from September 2017 to March 2018.

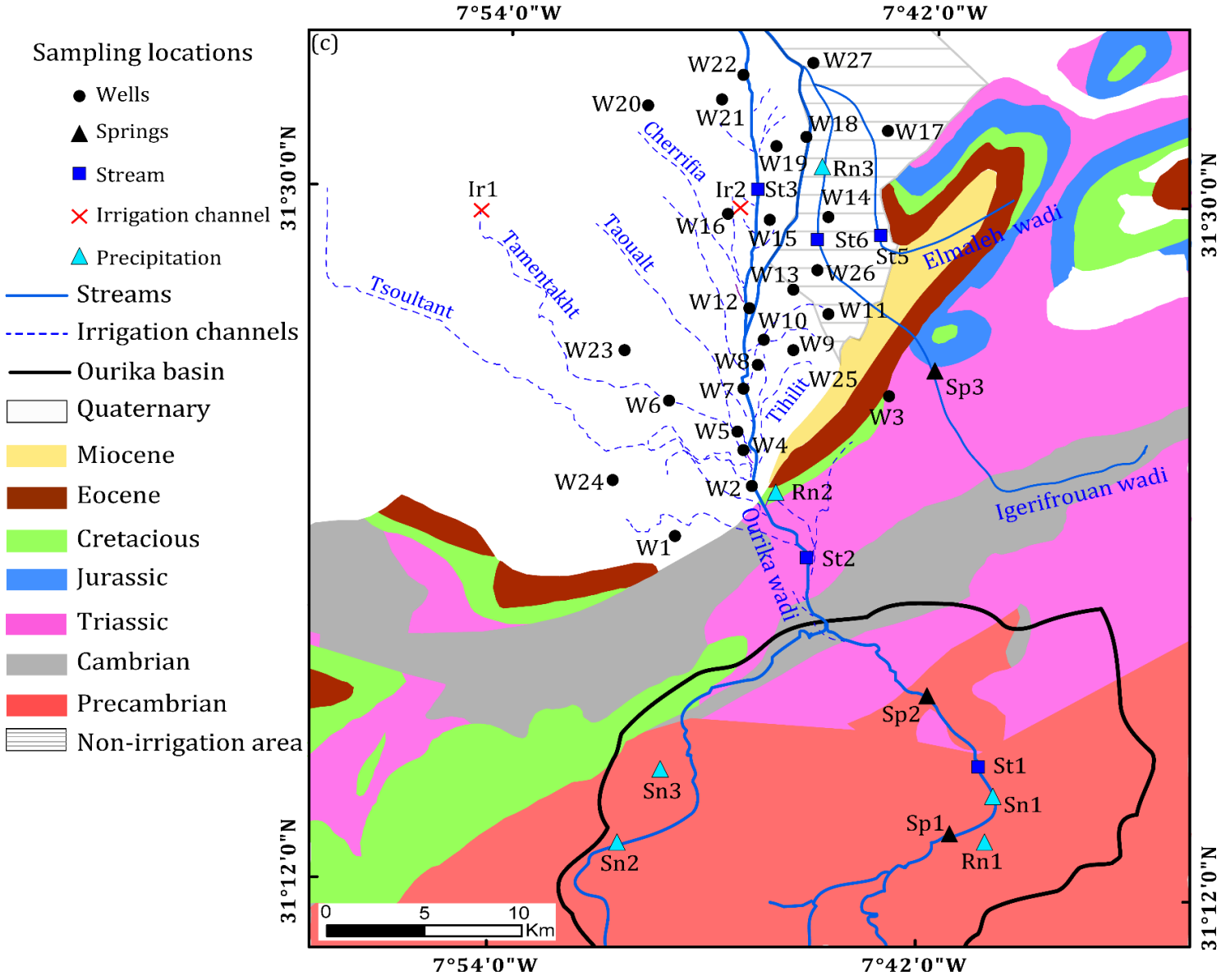
11 samples collected from 2 springs in the mountain block.

14 samples collected from 5 locations in the Ourika wadi and its two tributaries.

02 samples collected from 02 irrigation channels.

Samples were analyzed for 18O, 2H and major ions.

Water table levels measured manually in 55 well in September 2017 and March 2018.

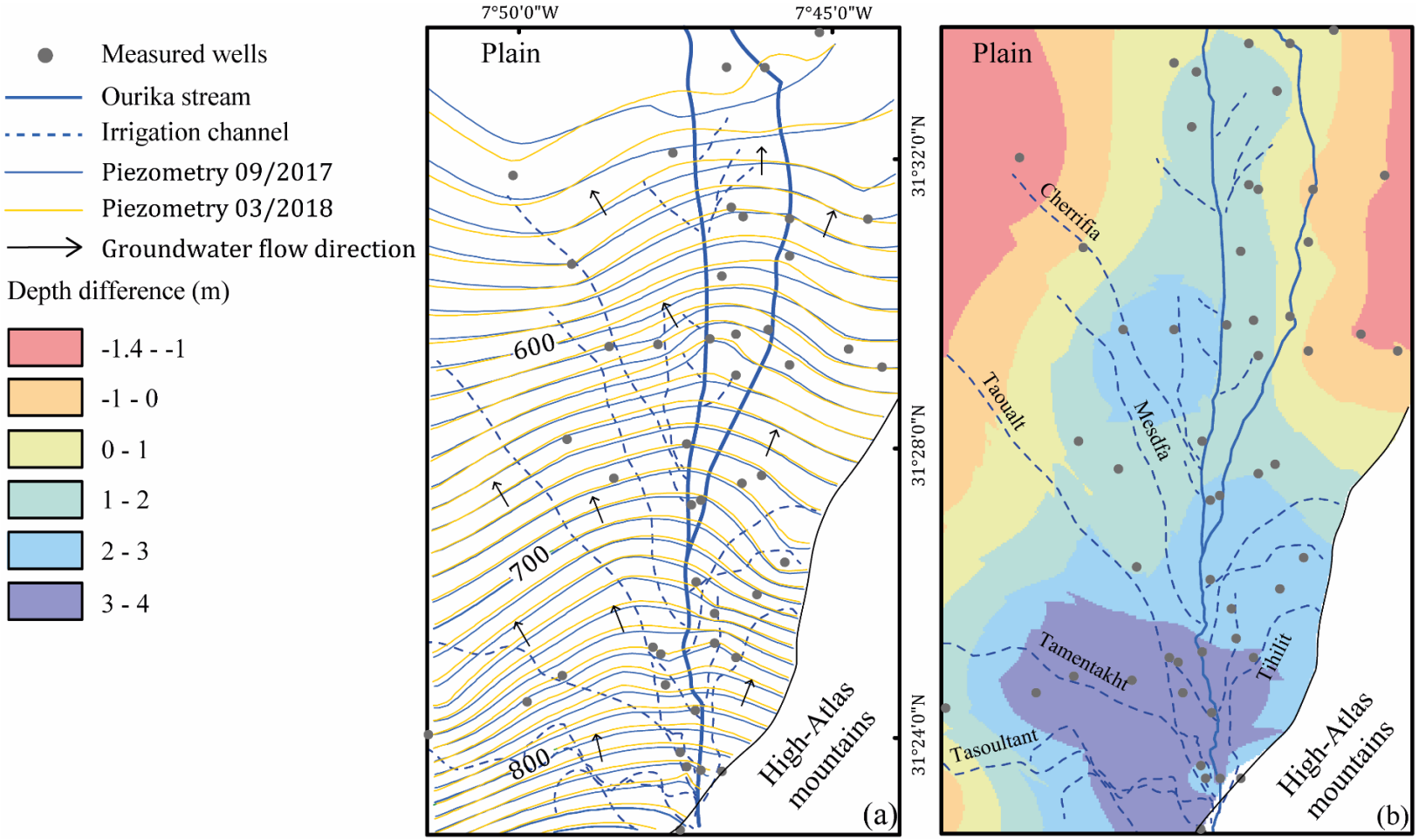





*Paper in Hydrological Processes (DOI: 10.1002/hyp.13685)*

- The piezometric mound shifted from the wadi towards the irrigated area in the mountain-front, However it turns to be centered around the wadi further downstream in the plain.

- GWR occurs along the wadi.
- Maximum recharge is observed in the irrigated area.
- Maximum recharge is observed in the irrigated area.




*Paper in Hydrological Processes (DOI: 10.1002/hyp.13685)*

- Traditional irrigation practices Influence groundwater recharge in the mountain front area.

- inert-annual means of seguias diversion from 2001 to 2018

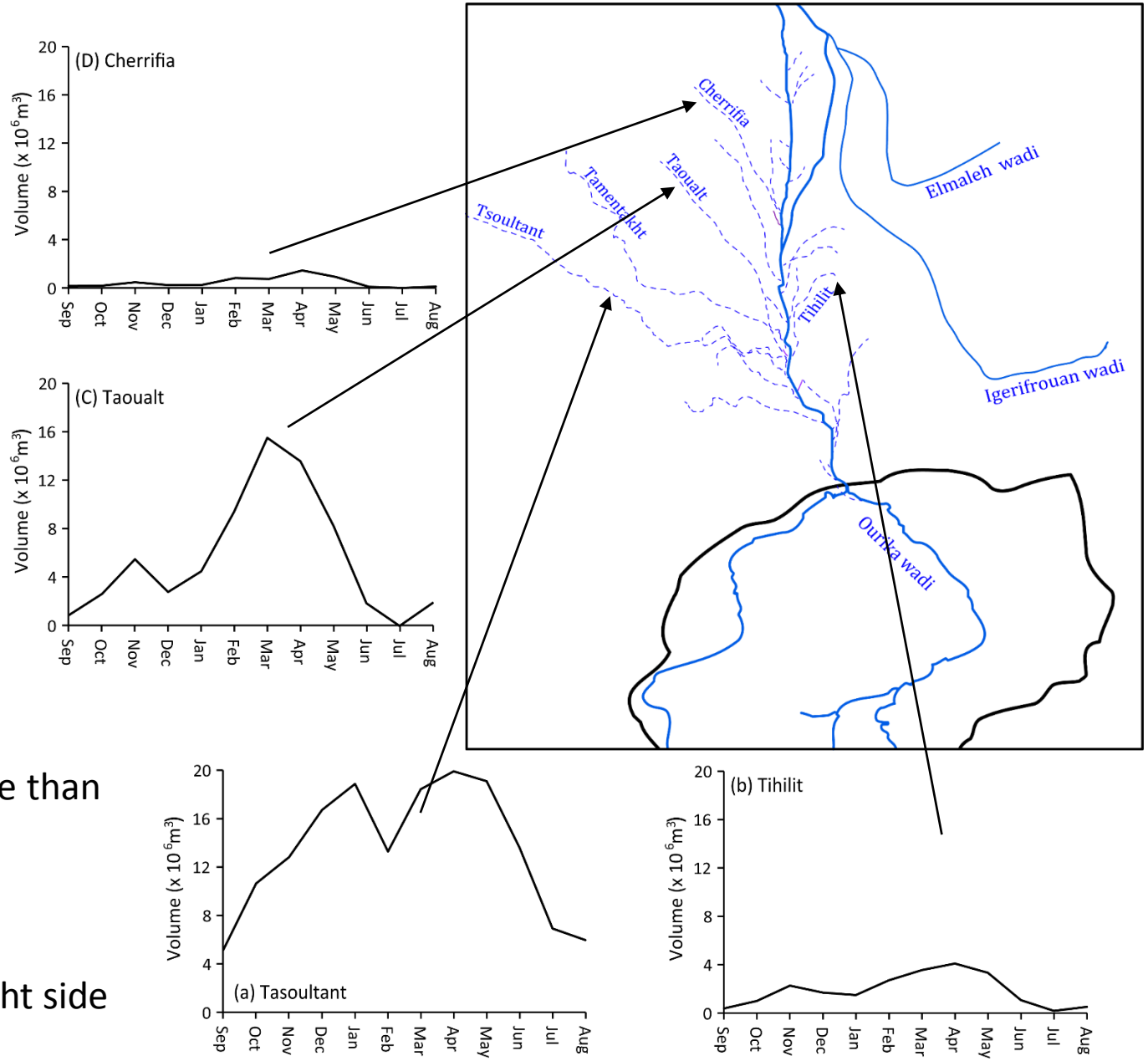
- Water is distributed according to a community-managed irrigation system established several centuries ago.

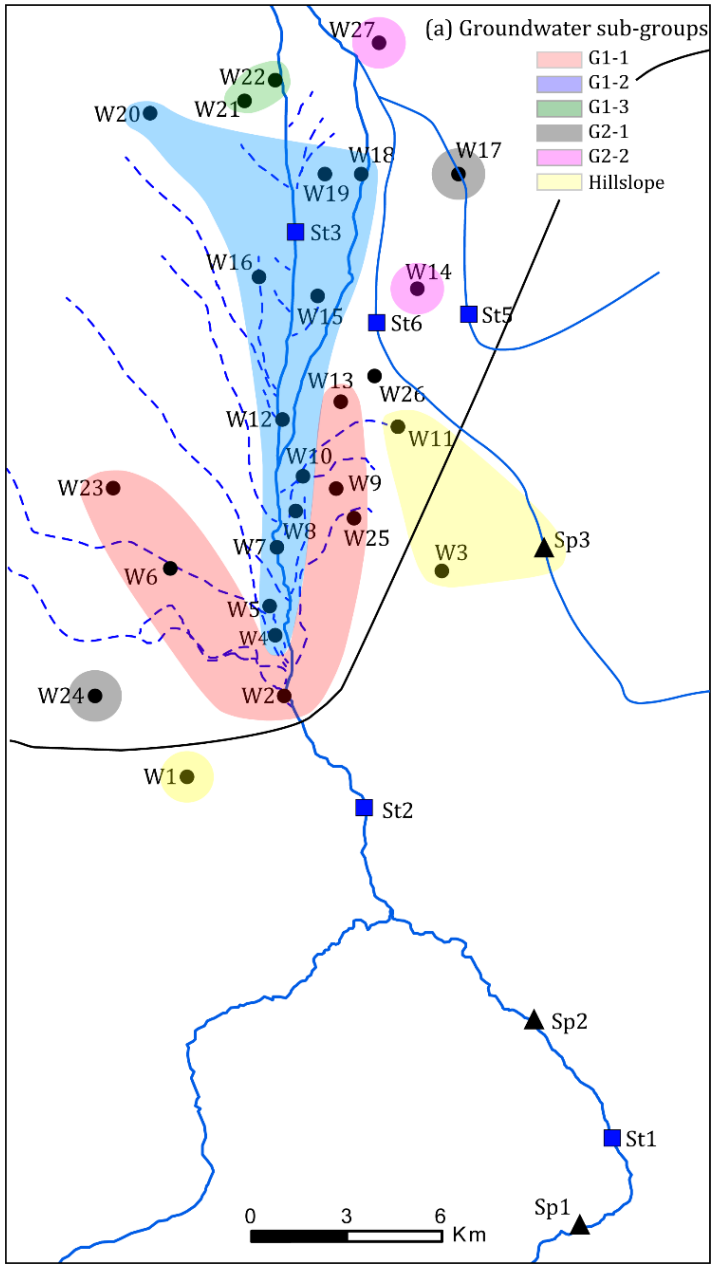
- Farmers in the mountain front takes advantages of the snow that accumulates and stored in the High-Atlas which melt later and sustain streamflow during the dry season.

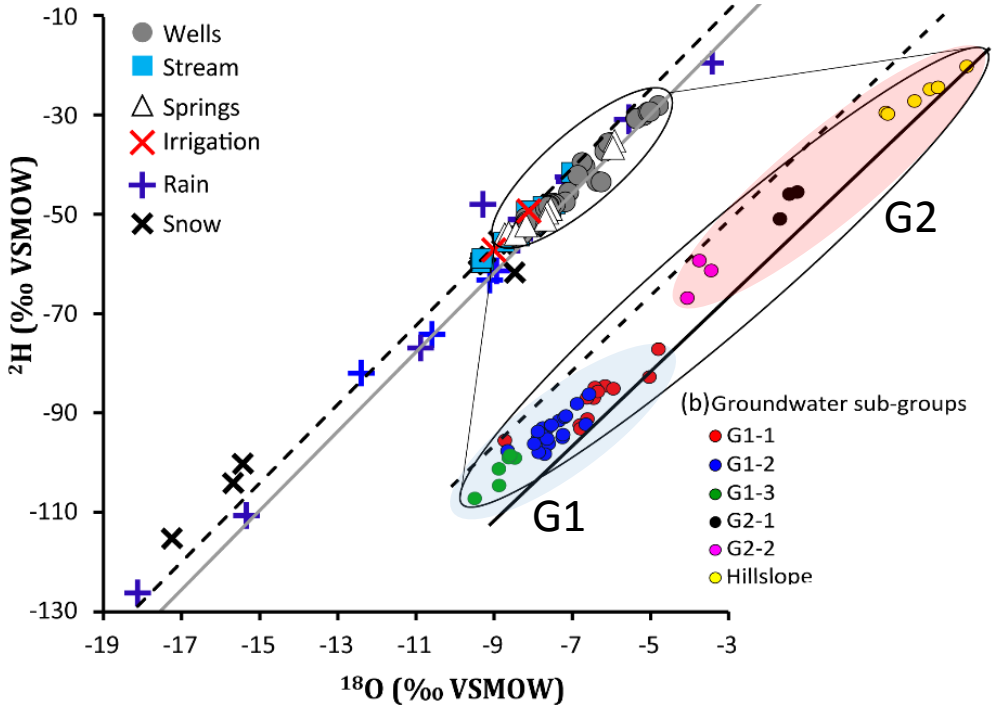
- The seguias network is more developed in the left side than the right

- Seguias upstream have the priority to divert water

- Seguias of the left side divert more water than the right side



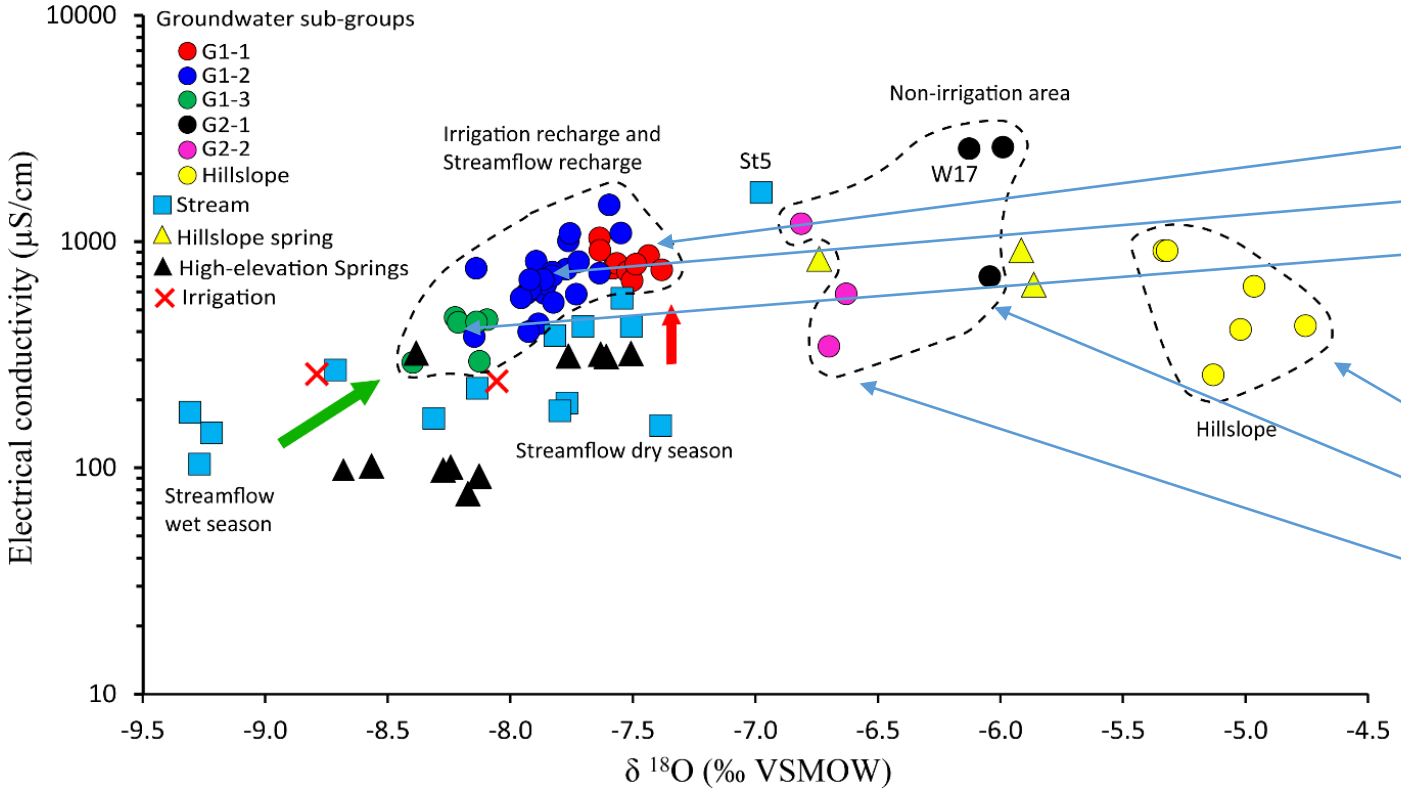



- 2 groups of samples based on the isotopic signatures : G1 (irrigated area) and G2 (non-irrigated area).
- G1 is relatively depleted in stable isotopes compared to the weighed mean of stable isotopes of precipitation.
- G2 is relatively enriched in stable isotopes compared to the weighed mean of stable isotopes of precipitation.
- Isotopic content of groundwater tend to depletion with the regional groundwater flow direction. .

*Paper in Hydrological Processes (DOI: 10.1002/hyp.13685)*

# Several groups can be distinguished based on the spatial distribution of groundwater stable isotopes compositions.



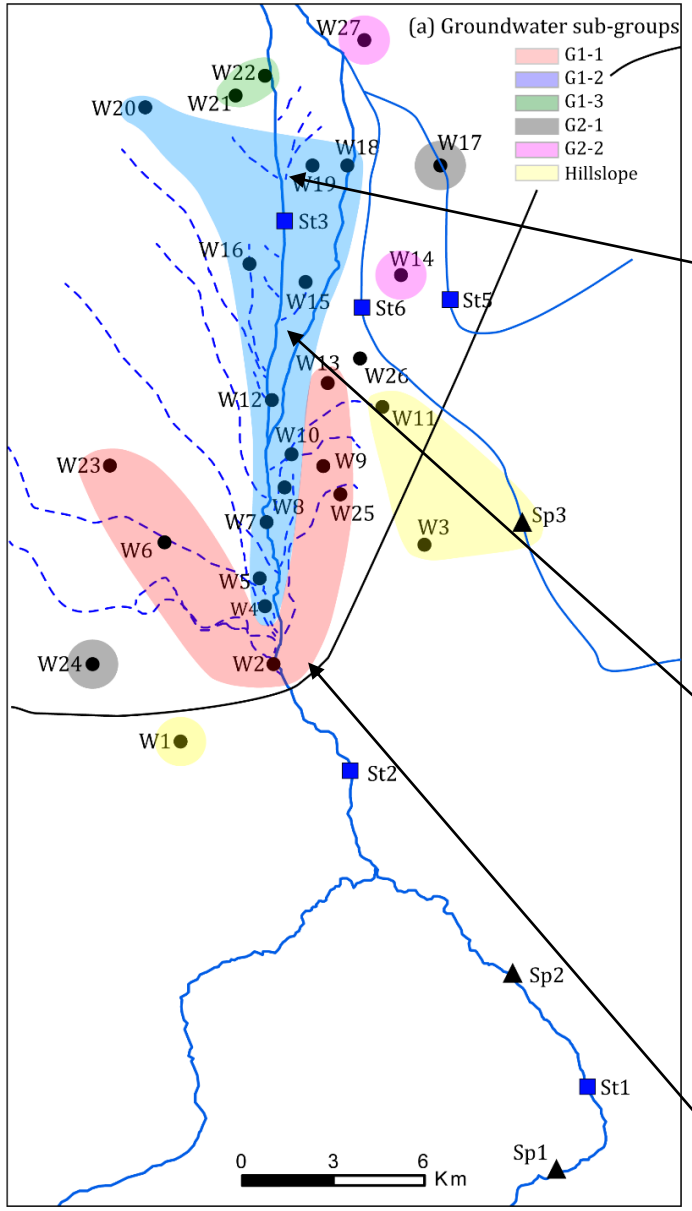

G1 subdivided into 3 subgroups :
- G1-1 (surface water-based irrigated area),
- G1-2 (around the wadi),
- G1-3 (further downstream inside the plain).

G2 subdivided into 3 subgroups :
- Hillslope area
- G2-1 (non-irrigated mountain front)
- G2-2 (further downstream inside the plain)

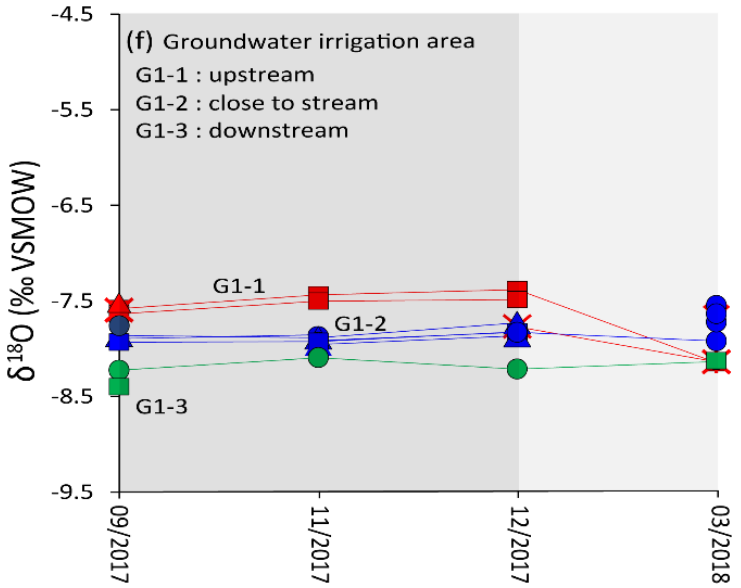
Isotopic signature of G1-1 and some of G1-2 samples is similar to this of dry season streamflow. The totality of dry season water is diverted by seguias to irrigate lands close to the mountain front.

Isotopic signature of G1-3 and some of G1-2 samples is similar to this of wet season streamflow.

*Paper in Hydrological Processes (DOI: 10.1002/hyp.13685)*



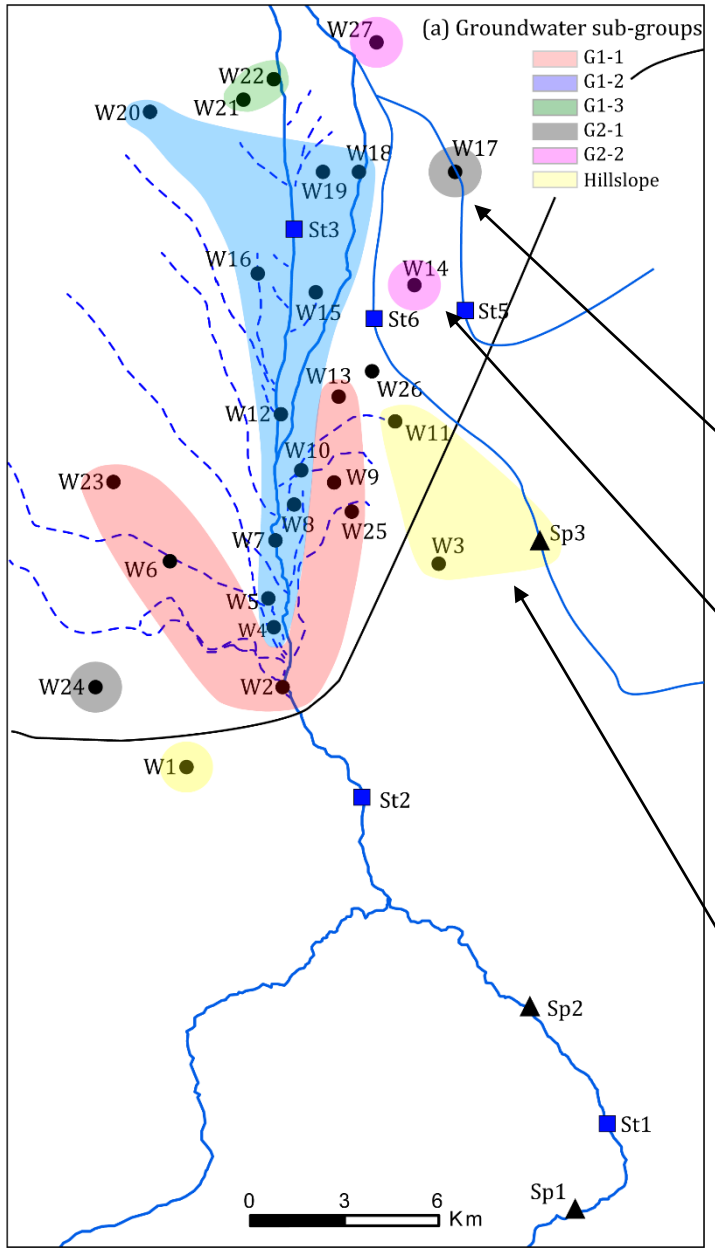

The lowest isotope values are observed in the subgroup G1-3 located in the downstream of the study area, indicating an exclusivity of recharge from isotope-depleted flood water infiltration.

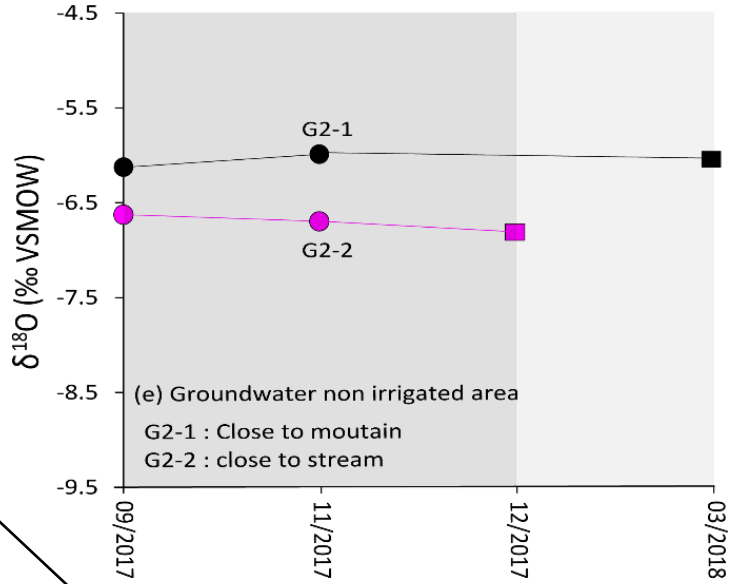


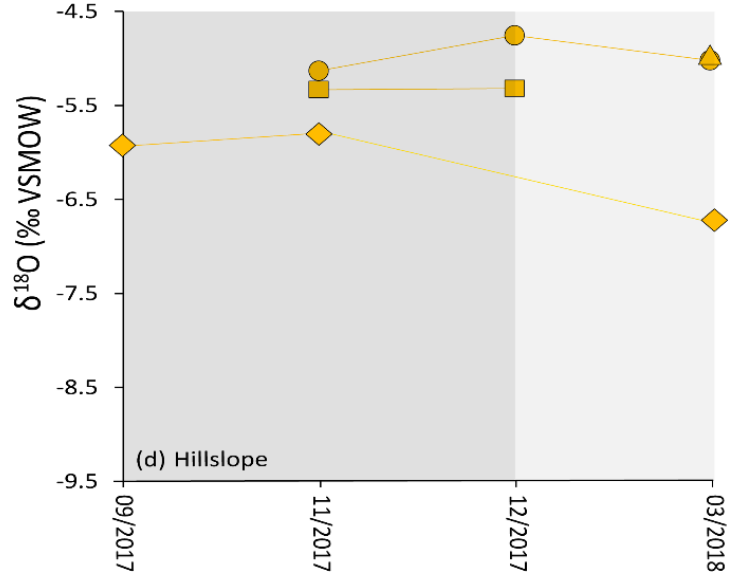

The subgroup G1-2 centered along the wadi receive water during flood events and extended streamflow during the wet season.

The highest isotope values among the group G1 are those of the subgroup G1-1 located in the irrigated area. This area receive water during flood events , extended streamflow events and baseflow during the dry period.

*Paper in Hydrological Processes (DOI: 10.1002/hyp.13685)*



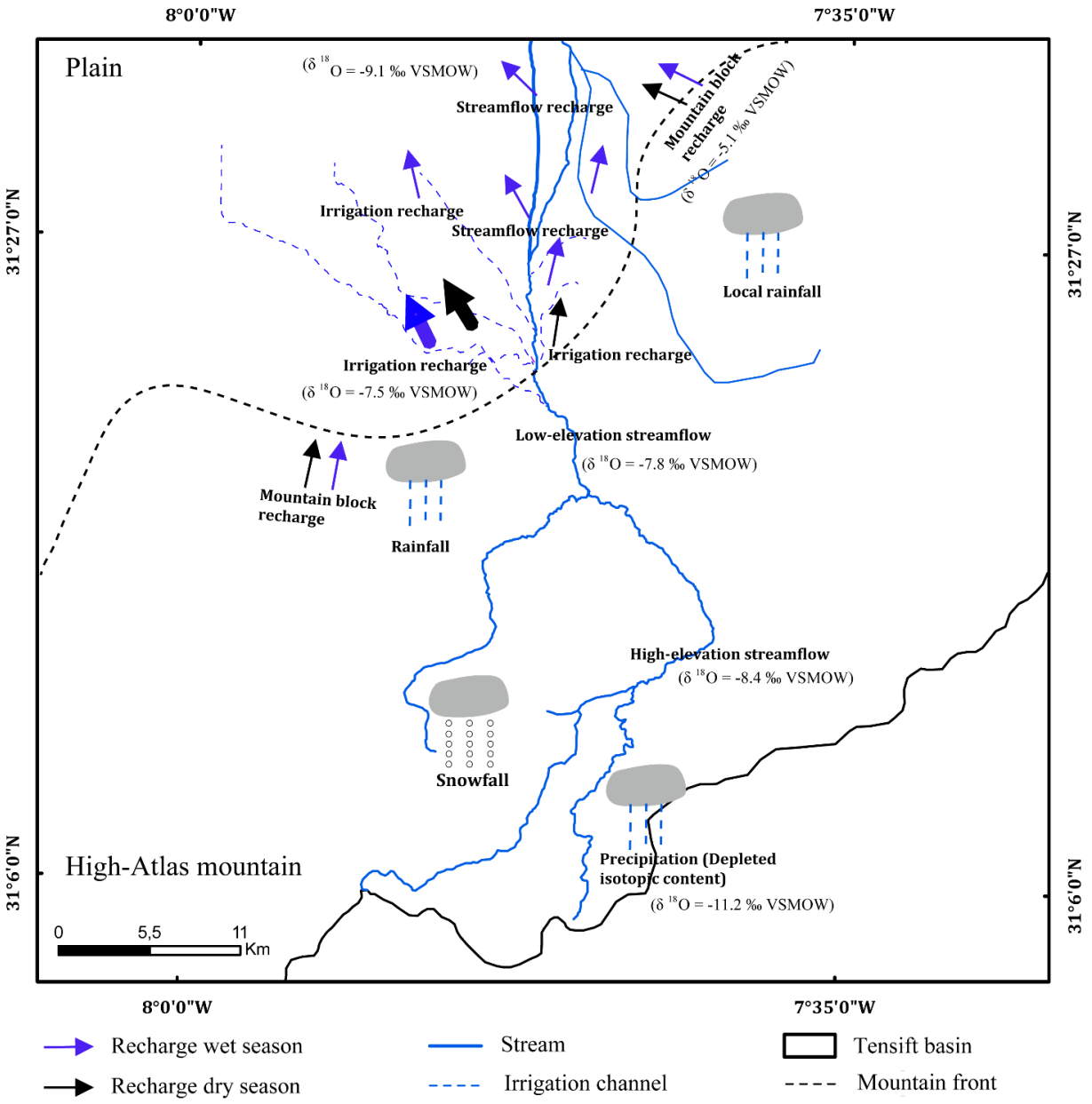




- The subgroups G2-1 and G2-2 located near the hillslope and outside the irrigation area are relatively depleted compared to the hillslope group. In addition to regional groundwater flow, this group sometimes benefits also from recharge through irrigation by flood water diversion.

- The hillslope subgroup has the highest isotopic values in the study area, this group is located inside the hillslopes and recharged via local rainfall and/or inflow from the mountain block.

*Paper in Hydrological Processes (DOI: 10.1002/hyp.13685)*

# Conceptuel model of recharge




The obvious isotopic contrast in the study area allowed the identification of the recharge sources contributing to groundwater in the mountain front of the High-Atlas :

- Traditional irrigation : diverted snowmelt water (winter, spring and early summer) + baseflow (summer and autumn) + flood water.
- In-channel infiltration along the wadi.
- Local precipitation in the foothills.
- Regional inflow from the mountain.

*Paper in Hydrological Processes (DOI: 10.1002/hyp.13685)*

# Conclusions

- A conceptual recharge of groundwater in the mountain-front of the High-Atlas mountains shows 4 sources of groundwater recharge in mountain front of the High-Atlas: Infiltration of irrigation water along channels and fields, in-channel infiltration along the wadi, direct infiltration of local rainfall in the foothills, and the subsurface inflow from the mountain block.

- The effect of traditional irrigation practices on groundwater in the mountain-front area is observed on both water table and isotopic evolution.

- Groundwater resources in such areas become reliant on the irrigation practices as an important source of recharge, and a deep modification of the hydrological cycle is introduced.