Basin-scale evaporation rate estimation based on isotopic approach: adaptation to the Mediterranean conditions

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Alexandra Mattei, Frédéric Huneau, Emilie Garel, Sébastien Santoni, Yuliya Vystavna

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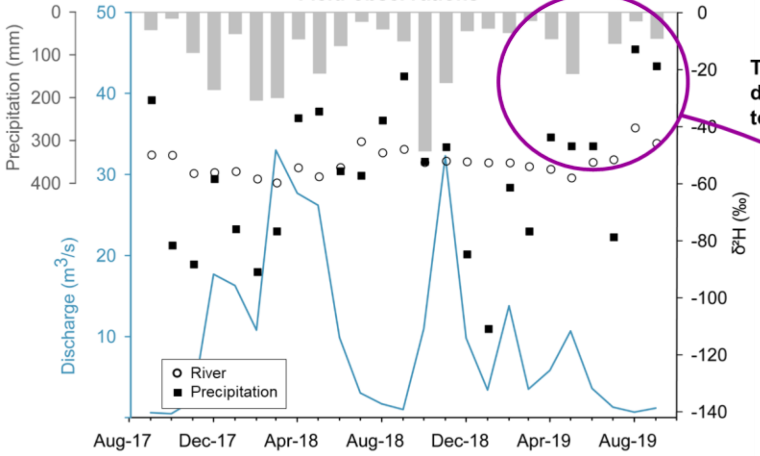
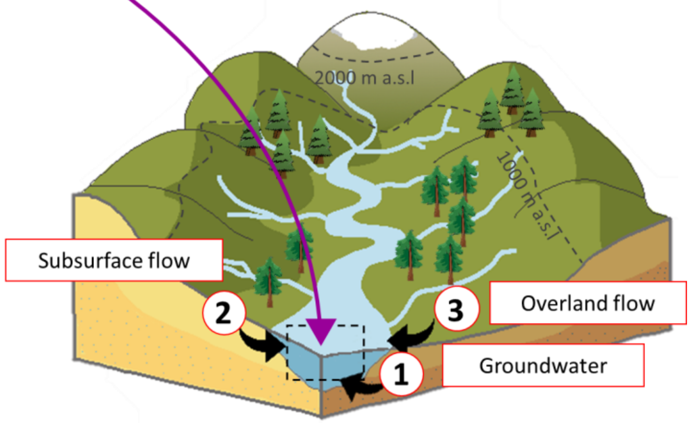
A.
Field observations



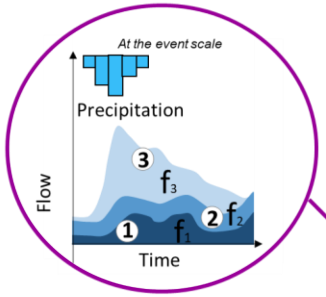
The marked climatic seasonality and uneven precipitation distribution complicates the use of isotope mass balances to obtain basin-scale estimation



Evaporation is not the only process altering the seasonal isotopic composition in the river

Steps of the modified mass balance approach :

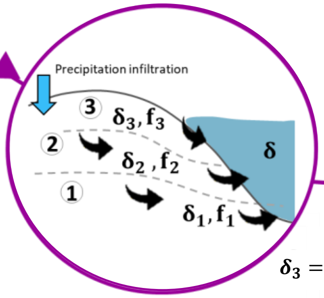
B.
Quantifying reservoir mixing processes by EMMA



Contribution of the different water reservoirs f_1, f_2 and f_3

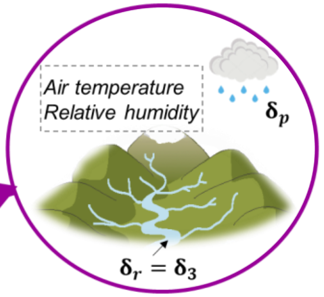
1: Groundwater
2: Subsurface water (subsurface stormflow)
3: Surface water (hortonian and saturated overland flow)

C.
Determining overland flow isotope composition δ_3



$$\delta_3 = \frac{\delta - \delta_1 f_1 - \delta_2 f_2}{f_3}$$

D.
Estimating evaporation rate using isotope mass balance method



Key findings

- **In regions with marked climatic seasonality**, various flow contributions characterized by different flow paths and residence times have contrasting isotope signatures. The **mixing of these water sources** in various proportions and depending on the hydrological wetness of the watershed **controls the isotopic composition of the river water**.
- Applying **isotope mass balance** approach in regions with a **marked climatic seasonality** can lead, as highlighted here in Mediterranean context, to a **huge misinterpretation of evaporation rate**.
- **Including seasonal dynamics of river contribution sources** in the isotope mass balance approach, as proposed with the developed modified mass balance approach, is necessary to obtain **reliable evaporation rate estimate** in marked climatic seasonality regions.

For more information read the published, full-length, article:

Mattei, A, et al. (2021). "Evaporation in Mediterranean conditions: estimations based on isotopic approaches at the watershed scale." Hydrological Processes. https://doi.org/10.1002/hyp.14085

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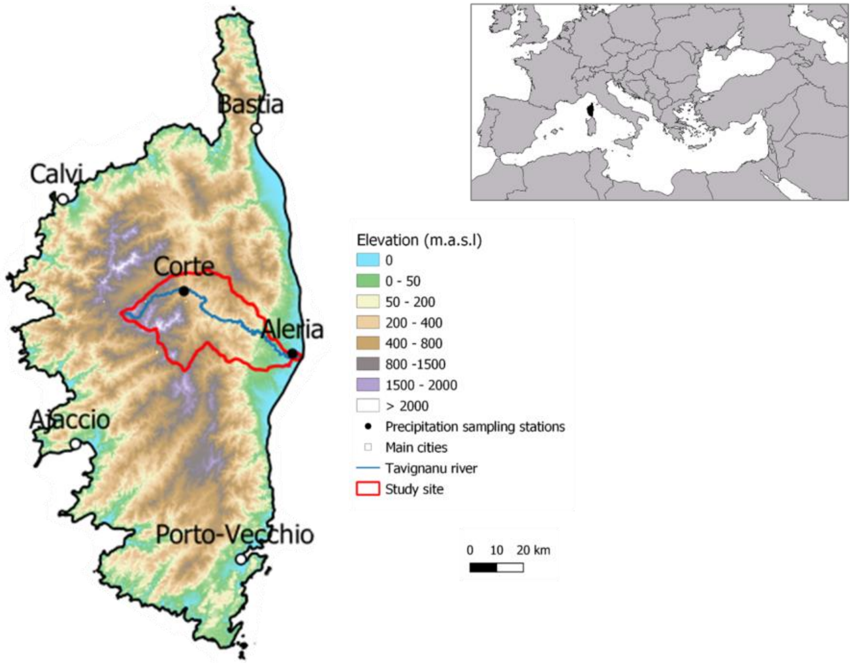
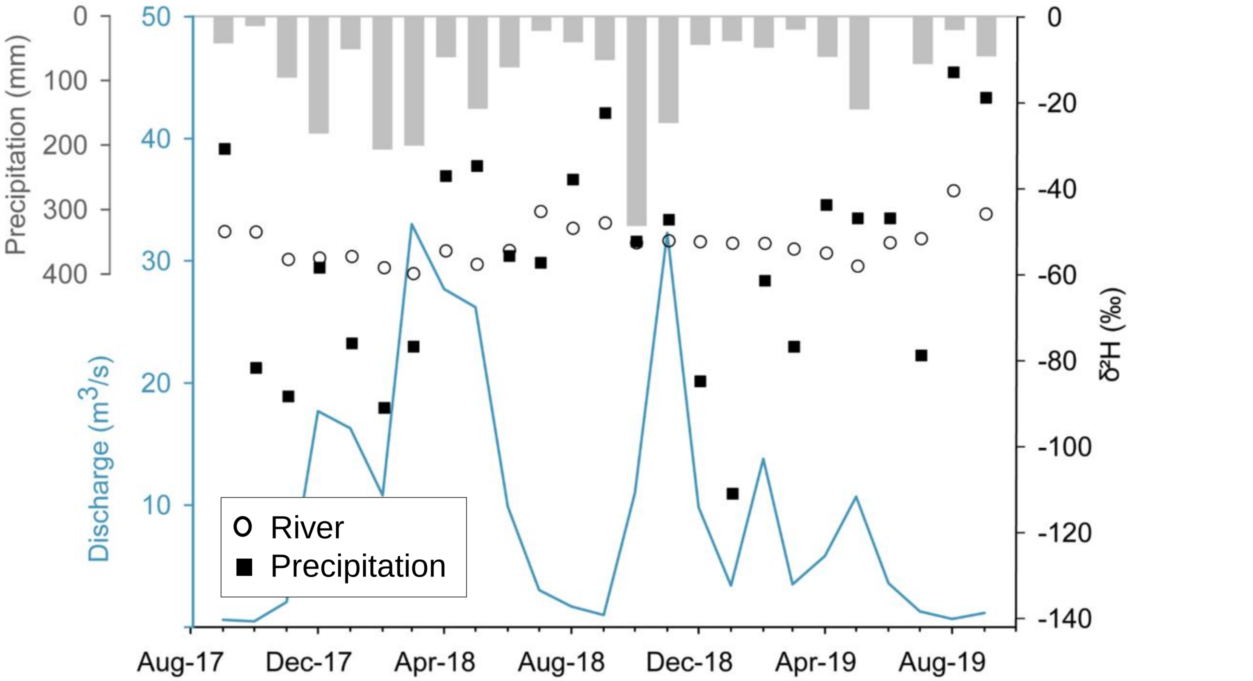
The Tavignanu watershed (Corsica, Western Mediterranean) as pilot site

Study site localisation



Monthly variations in precipitation and stream water δ²H, discharge and rainfall



- Precipitation pattern shows marked seasonal variations, following the thermal seasonality.

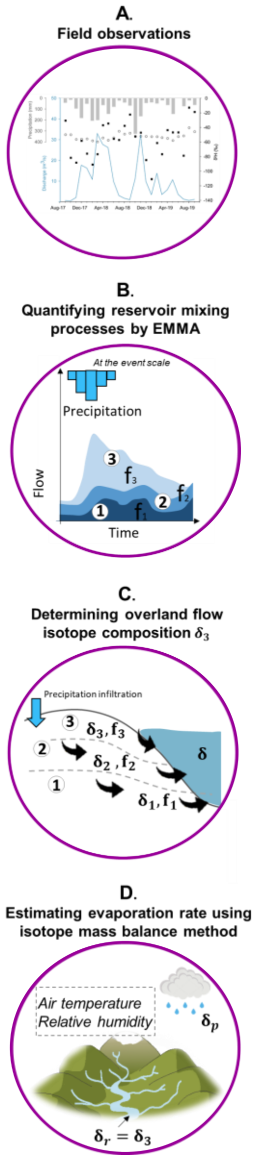
- River water shows seasonal differences that are, in comparison to precipitation, lagged and highly damped.

⇒ **Important contribution of water reservoirs with longer residence times and more stable δ²H, integrating seasonally-variable precipitation inputs.**

- Spring and summer months values are ²H-depleted compared to precipitation and relatively stable

⇒ **Important contribution of water reservoirs with even longer residence times, which integrate precipitation events over years**

Classical isotope mass balance approach is not reliable for estimating evaporation rates as overland flow is not the main year-round contributor of river discharge.



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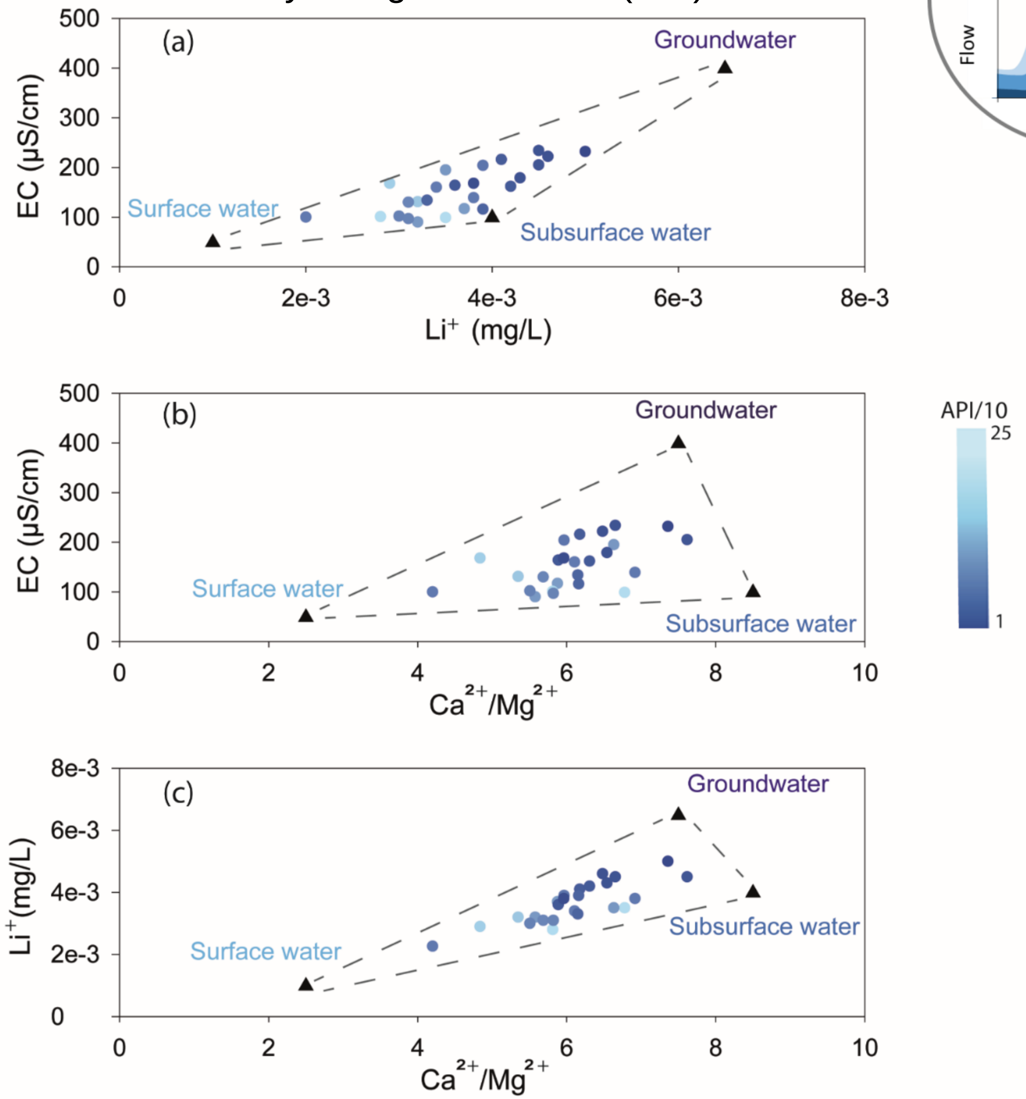
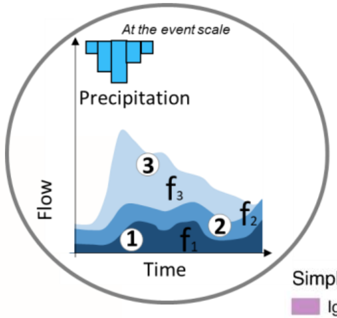
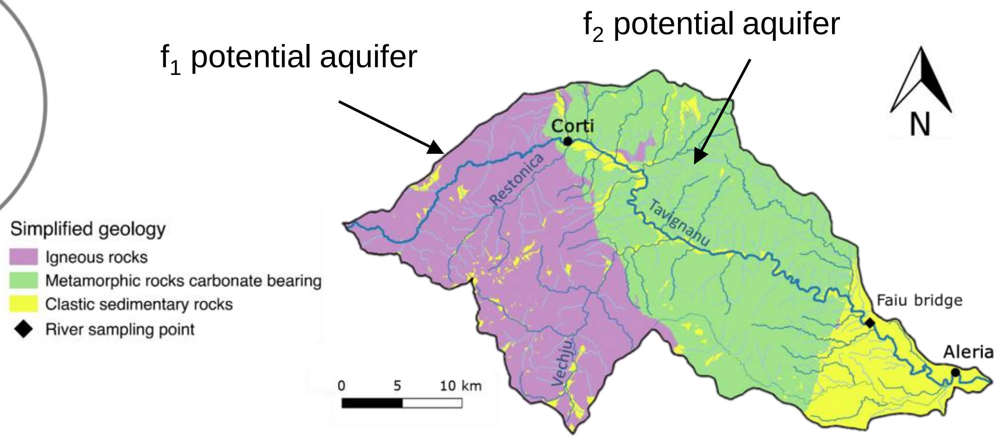
Seasonal water mixing at the watershed scale

Plots of the conductivity and concentrations of Li^{+}, Ca^{2+}, Mg^{2+}. The shade of blue illustrates the hydrological wetness (API).





Simplified geology of the Tavignanu watershed



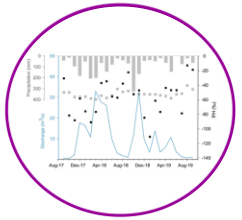
Mean annual contributions* (%)

	Surface (f_3)	Subsurface (f_2)	Groundwater (f_1)
EC - Li+	32	45	23
Ca^{2+}/Mg^{2+} - Li^{+}	35	37	28
Ca^{2+}/Mg^{2+}-EC	36	40	24
Mean	**34**	**41**	**25**
σ	2	4	3

** Values obtained using End Member Mixing Analysis with three end members*

The quantified water reservoir contributions obtained are in agreement with the first hypothesis about the hydrological functioning of the river discussed earlier

A.
Field observations



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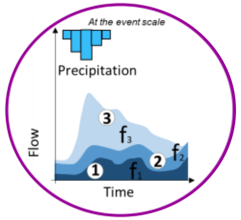
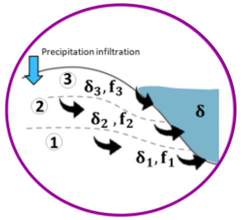
Quantifying reservoir mixing processes by EMMA



C.
Determining overland flow isotope composition δ_3



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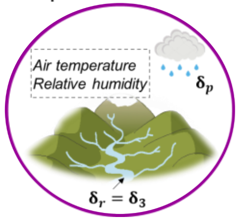
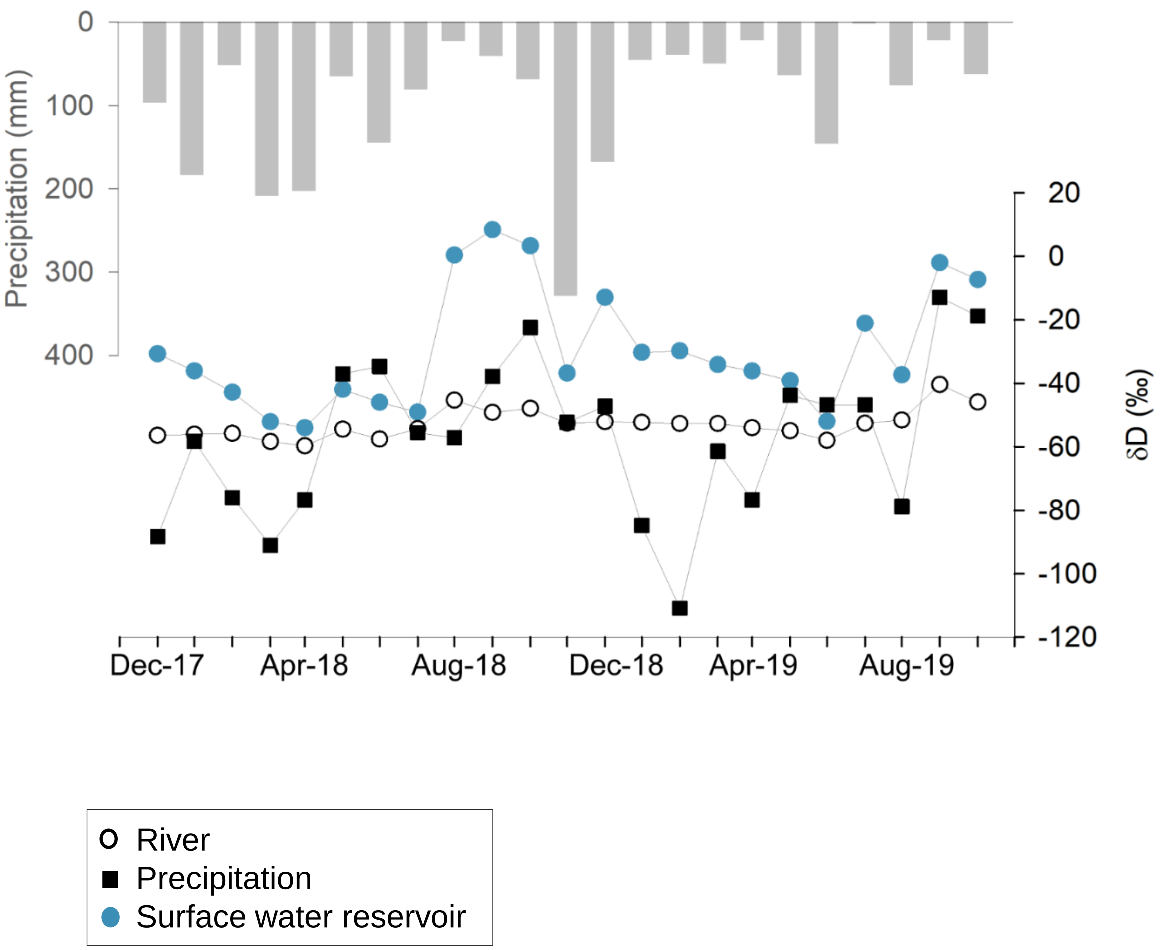
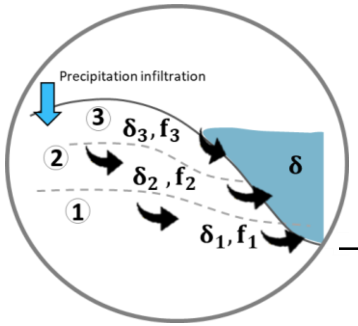


Main page

Estimating δ_3 using a continuous open system isotope mixing model

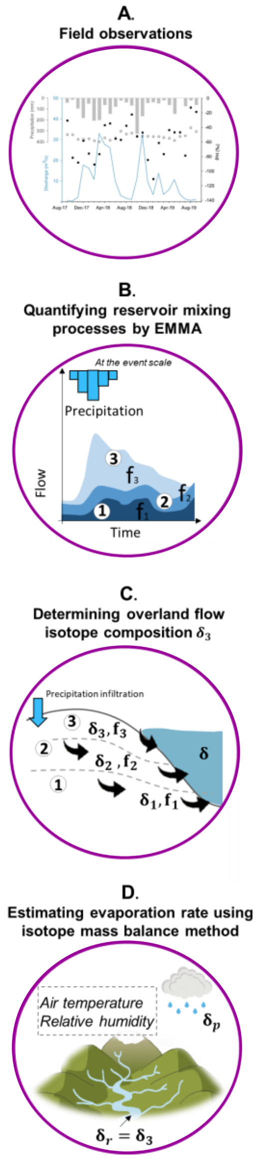
Monthly variations in precipitation, stream water, and surface water reservoir δ^2H





	δ^2H of the river (‰)	
	Non modified approach	**Modified approach**
2017 - 2018	-56.5 ± 0.5	-45.6 ± 9
2018 - 2019	-53.0 ± 0.5	-31.1 ± 9

- In comparison to stream water, the surface water reservoir has a strong seasonal pattern, following the one of precipitation.
- **The influence of evaporation during spring and summer months is evident in the surface water reservoir, this is not the case for stream water.**



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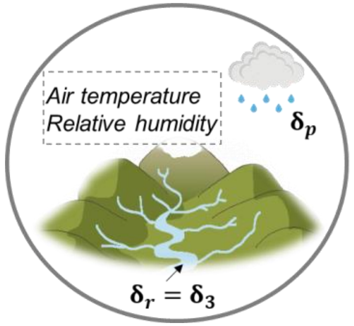
Evaporation rate estimates



	T (°C)	h (%)	δ^2H_p (‰)	Evaporation rate (%)		
				Non modified approach	Modified approach	Hydro-meteorological modelling approach
2017 - 2018	12.8 ± 1	74 ± 5	-63.7 ± 1	10 ± 14	**40 ± 15**	40
2018 - 2019	13.2 ± 1	68 ± 5	-53.8 ± 1	1 ± 14	**46 ± 15**	50

- **The non-modified and modified approaches lead to very different estimates in evaporation rates**
- **Evaporation rates estimated using a non-modified isotope mass balance approach lead to inconsistent results**
- **Evaporation rates estimated using a modified isotope mass balance approach lead to reliable results**
- **Uncertainty analysis demonstrates that evaporation rates obtained with the modified approach are not altered compared to those obtained with the non-modified approach, as long as tracers chosen to determine water volume contributions are appropriate, i.e. with analytical uncertainty lower than the estimated value.**

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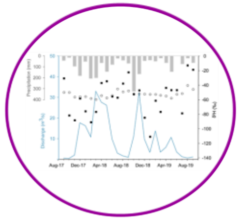

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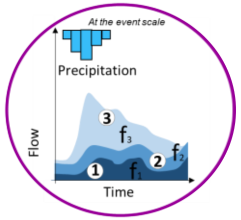

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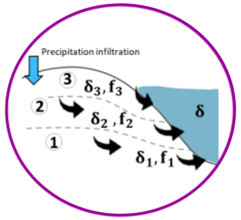

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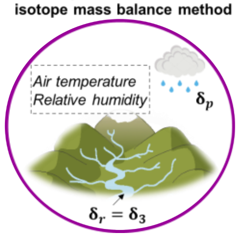

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