Subsurface runoff and recharge dynamics in a Mediterranean catchment based on StorAge Selection functions and end-member splitting analysis

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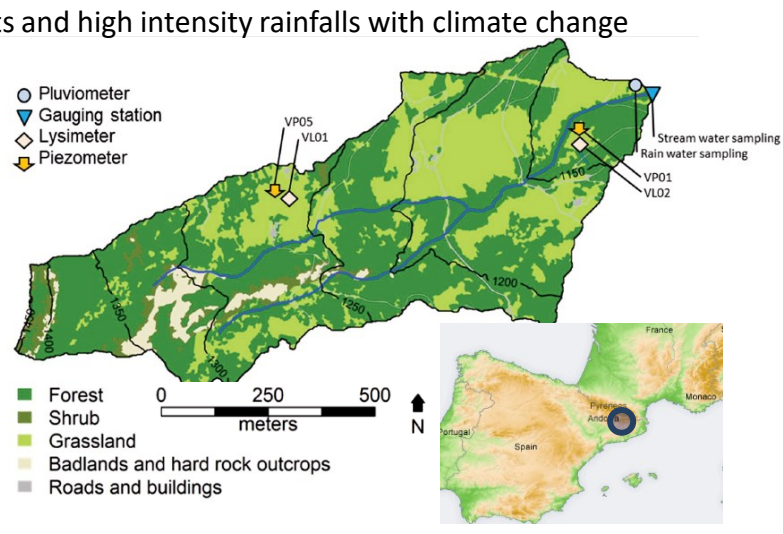
Motivation

- rainfall-runoff dynamics are highly variable due to Mediterranean climatic conditions affecting **storage and release of water in the subsurface**
- need to better understand subsurface storage and **runoff processes at varying catchment wetness** due to an increase in both droughts and high intensity rainfalls with climate change

Study site

- Long-term experimental Can Vila catchment in Vallcebre in the Pyrenees
- Mediterranean climate:
  Precip.: 880 mm/a; PET: 818 mm/a
- Vegetation: Oak and Scots pine forest
- Soil: Silty loam to silty clay loam soils



Sampling

- Isotope sampling (^{18}O & ^{2}H)
  - >550 rainfall & >980 stream samples taken flow dependent (30 Min. -1 Wk)
  - Groundwater and xylem
- Hydrometric
  - Discharge measurements, ET estimates with Hargreaves, GW levels, soil moisture

Analysis

- Storage Age Selection (SAS) functions (Benettin & Bertuzzo, 2018)
  - Run from 2004 to 2017; 2004 – 2010 spin up period
  - Calibration on stream ^{18}O data 2011-13 & 2015-17: flow weighted Kling-Gupta-Efficiency
  - Two approaches for SASQ: fixed or time-variant power-law shape
- Endmember mixing & splitting (Kirchner & Allen, 2020)
  - Stream and rainfall ^{18}O data 2011-13 & 2015-17, Discharge rainfall amount
  - Grouping into: 1.) Summer vs. Winter rainfall, 2.) High vs. low intensity rainfall, 3.) Rainfall at high flow vs. at low flow

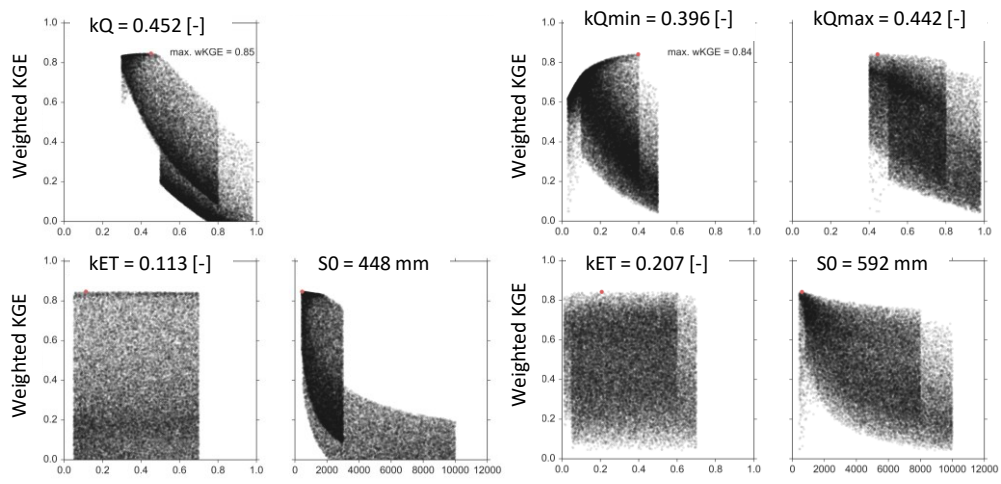
Results

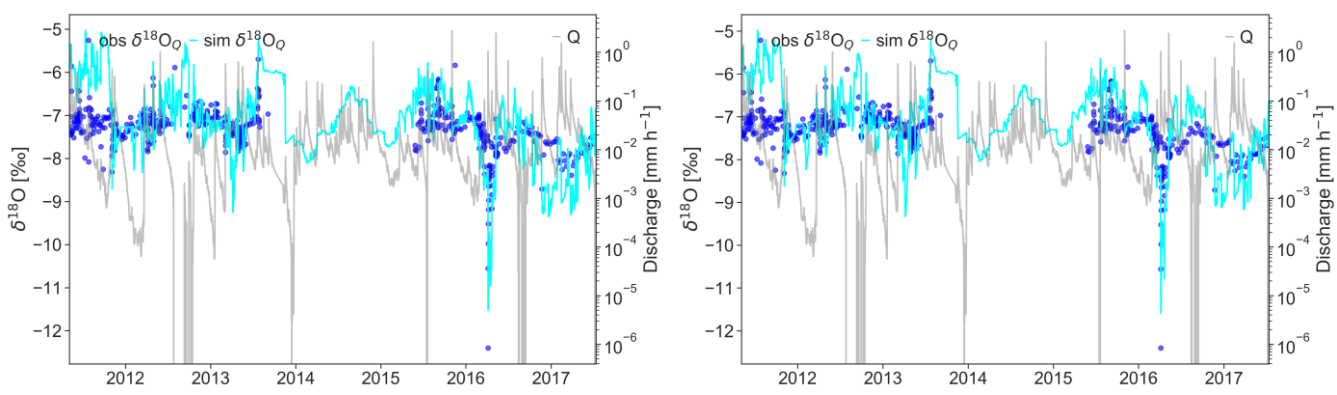
Storage Age Selection (SAS) functions

- Goodness of fit similar: weighted KGE ≈ 0.84
- kET not identifiable
- Preference of young water contribution to stream (kQ < 1)
- S0 relatively well identifiable and in same order of magnitude

fixed power-law shape (const. kQ over time)

time-variant power-law shape (SASQ changes with catchment wetness between kQmin and kQmax)

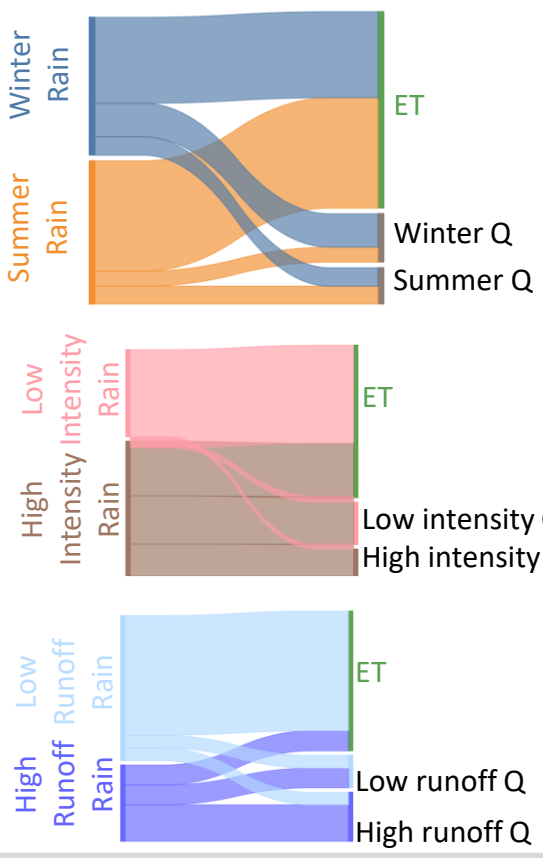


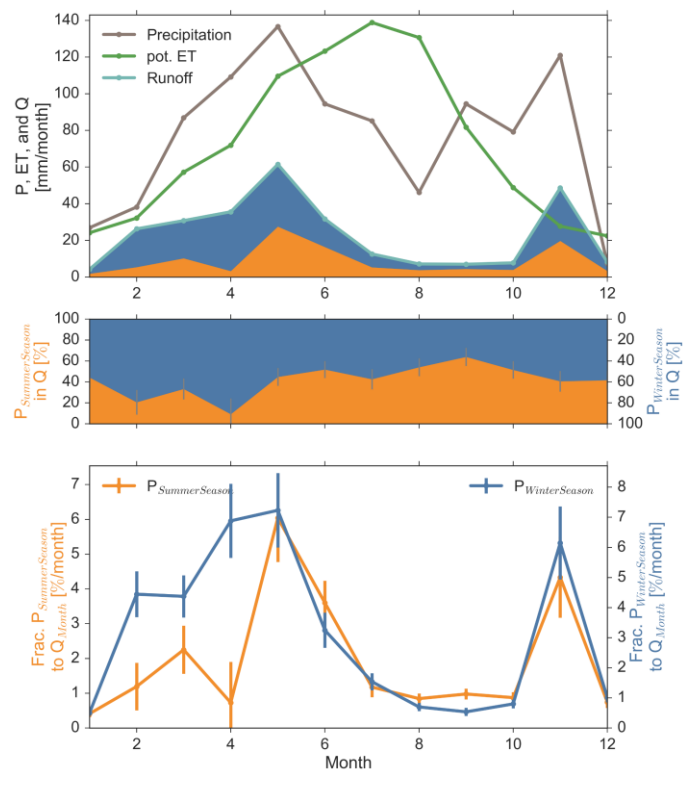


- Next steps to constrain the parameter space:
1. Include xylem and groundwater isotope data to constrain kET and S0
2. Comparison with young water fraction (Fyw) analyses (Gallart et al., in review)
3. Comparison with baseflow age estimates using Tritium (Gallart et al., 2016)

Endmember mixing and splitting

- Winter rainfall contributes to large extend to evapotranspiration
- Summer rainfall is partly contributing to winter runoff





- Summer rainfall is mostly discharged in May, June & Nov.
- Low intensity rainfall does not contribute much to streamflow, but becomes ET
- Rainfall during low runoff sustains mostly ET
- Rainfall at high runoff is mostly quickly discharged

Conclusion

- Runoff in the Vallcebre catchment is largely sustained by relatively young water supporting observations of heterogeneous subsurface flow on the plot scale (Sprenger et al., 2019)
- Though, parameter space needs to be further constrained for SAS functions
- Isotope mass balance approaches reveal partitioning of rainfall for seasonal inputs, but also shows importance of storage and rainfall intensity.

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References: Benettin & Bertuzzo (2018, GMD, doi: 10.5194/gmd-11-1627-2018),
Kirchner & Allen (2020, HESS, doi: 10.5194/hess-24-17-2020), Gallart et al. (2016, HYP, doi: 10.1002/hyp.10991),
Gallart et al. (in revision, doi: 10.22541/au.157979613.39458719), Sprenger et al. (2019, HESS, doi: 10.5194/hess-23-2751-2019)