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HOW DO CONCENTRATION-DISCHARGE RELATIONS VARY AMONG RAINFALL-RUNOFF EVENTS? AN ANALYSIS FOR THE RESSI EXPERIMENTAL CATCHMENT (ITALIAN PRE-ALPS)

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Motivation

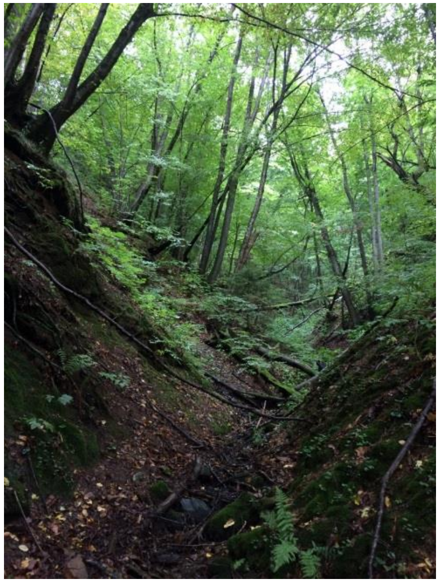
- Understanding discharge and solute responses is pivotal for water resources management and pollution mitigation measures

- Previous studies that analyzed concentration-discharge (C-Q) relations using high temporal resolution tracer data collected during rainfall-runoff events have shown that C-Q relations may vary for different events and depend on season, event characteristics or antecedent wetness conditions

Research objectives

- Compare the concentration-discharge relations for different tracers
- Characterize the hysteretic relations between discharge and tracer concentrations at the event timescale
- Determine whether the changes in hysteresis can be explained by event characteristics

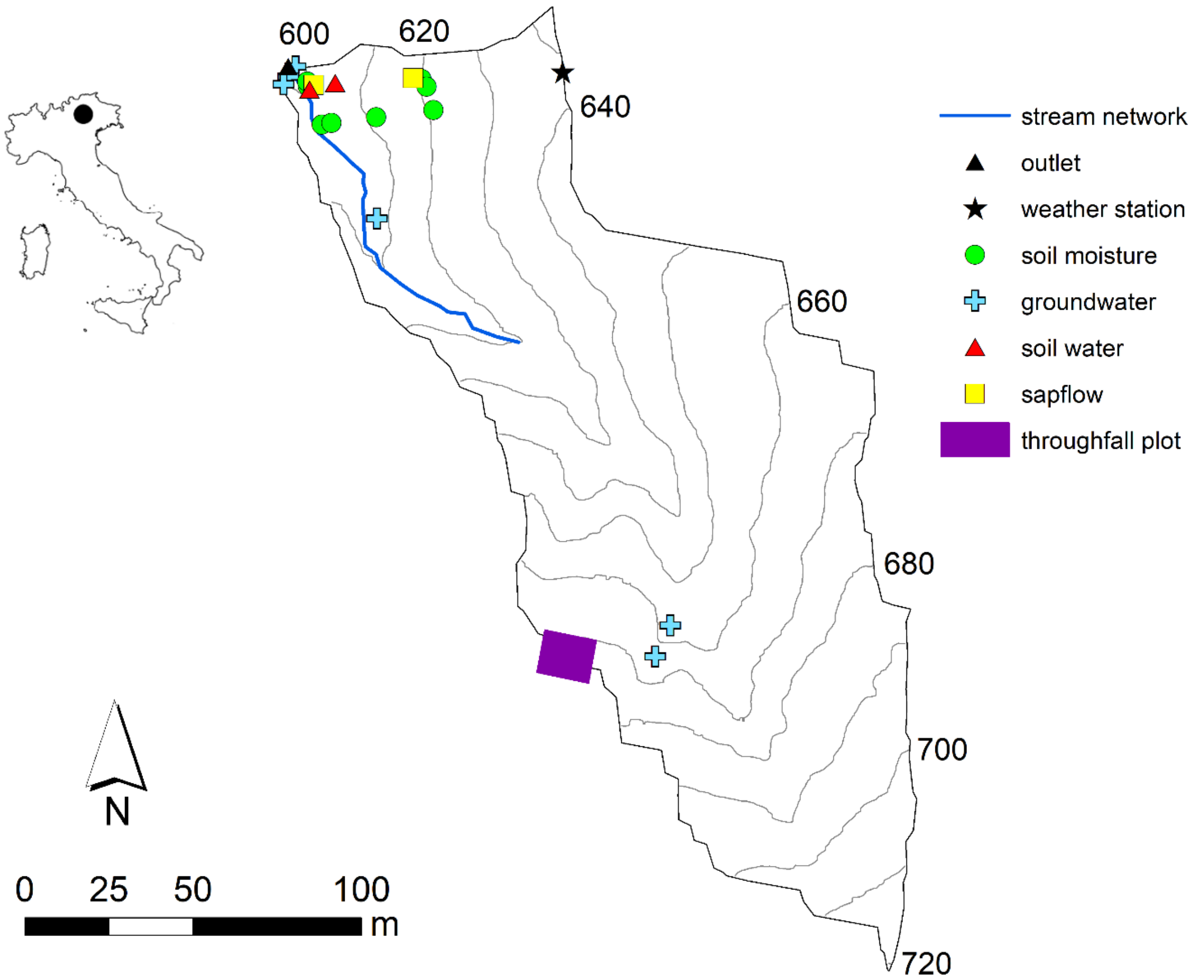
Study area: Ressi catchment (Italian pre-Alps)



Area (km^2)	0.02
Elevation range (m a.s.l.)	598-721
Mean slope (°)	31

Average annual precipitation (1992-2007) (mm)	1695
Average annual temperature at 597 m a.s.l. (1992-2007) (°C)	9.7

Hydrometric and tracer monitoring

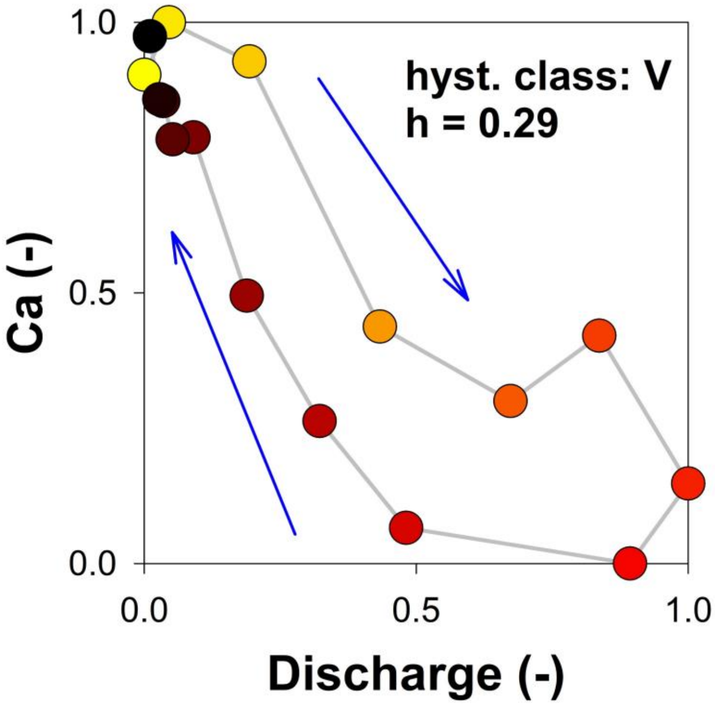


Tracers:

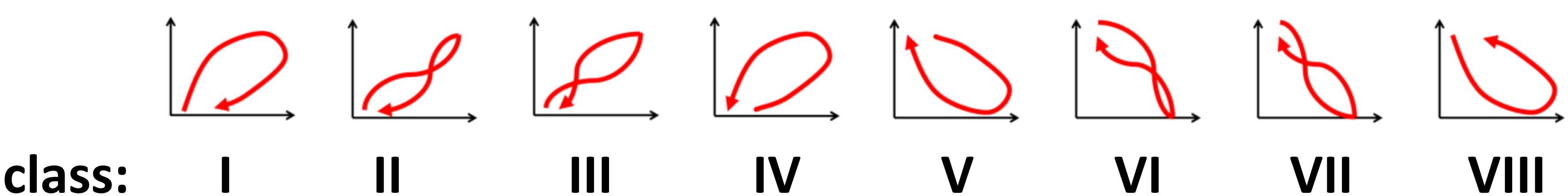
- Stable isotopes of water (^{2}H and ^{18}O) → laser spectroscopy
- Electrical conductivity (EC) → portable meter
- Major ions → ion chromatographer

Information on the catchment and tracer data can be found in Penna et al. (2015), Marchina et al. (2020) and Zuecco et al. (2021)

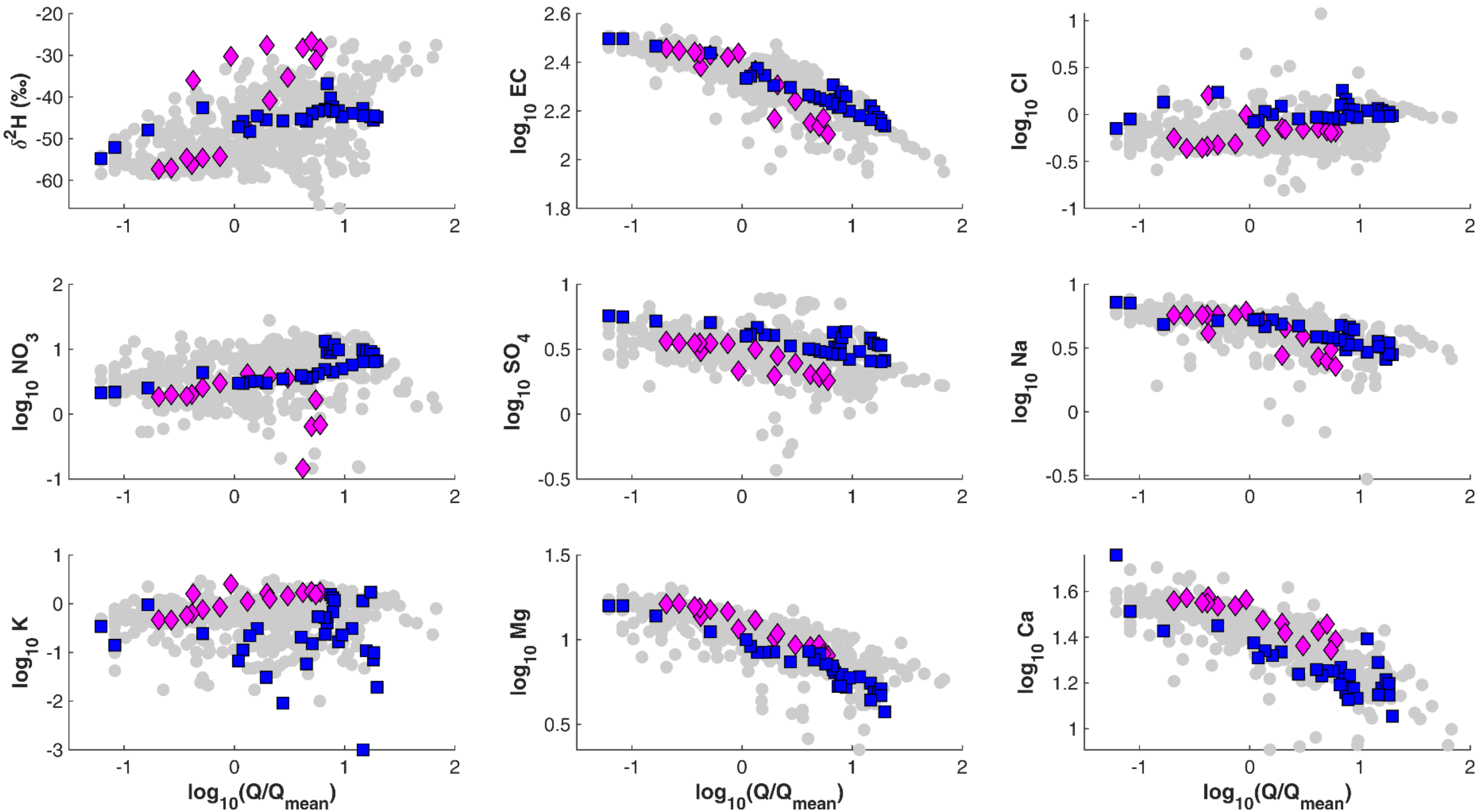
Hysteresis index and classes



- Hysteresis analysis for concentration-discharge (C-Q) relations for 20 rainfall-runoff events between 2015 and 2018
- Hysteresis index (h) and classification based on Zuecco et al. (2016)
- Minimum-maximum normalization of discharge (x axis) and concentration (y axis) at the event timescale

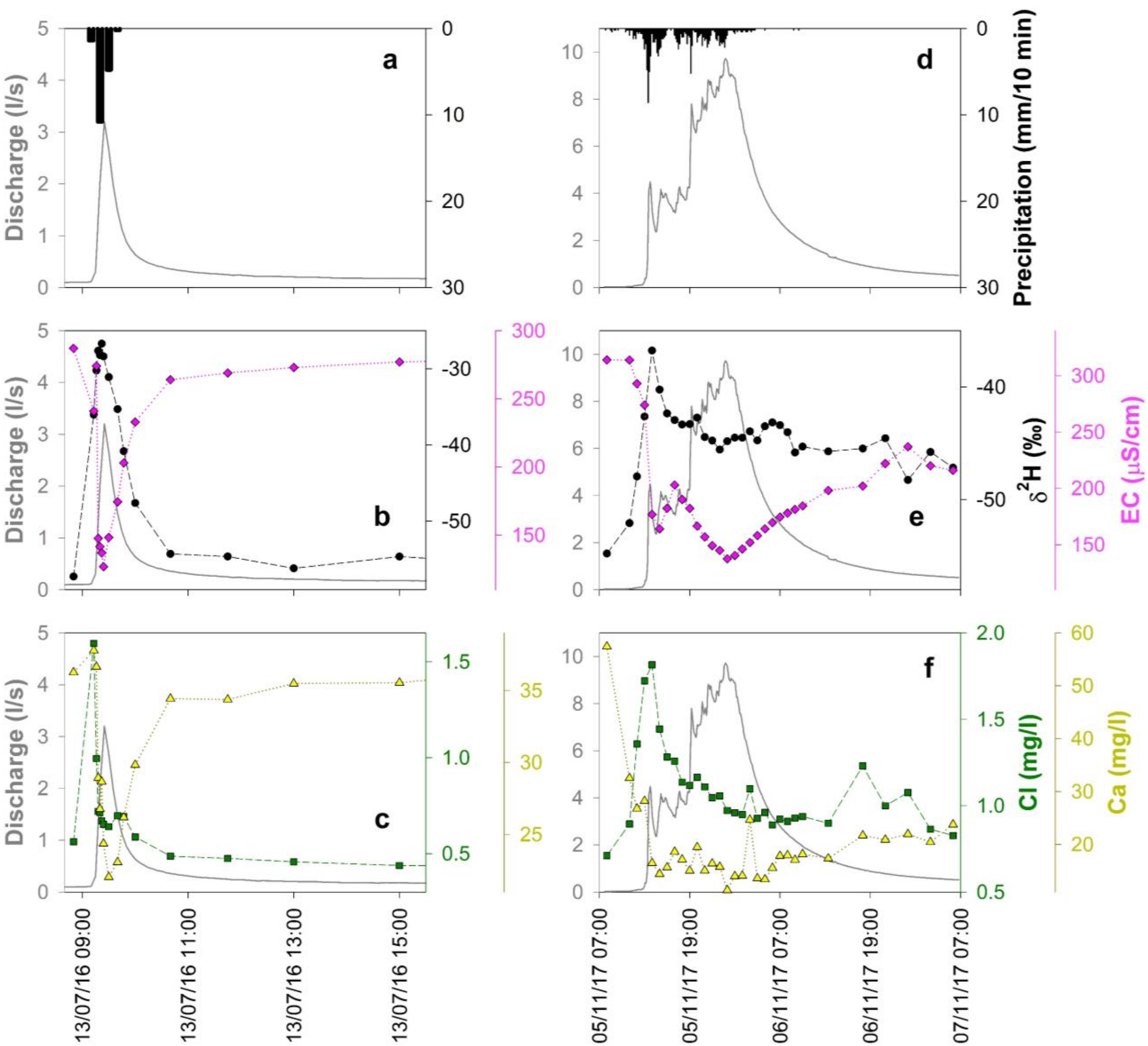


Concentration-discharge (C-Q) relations



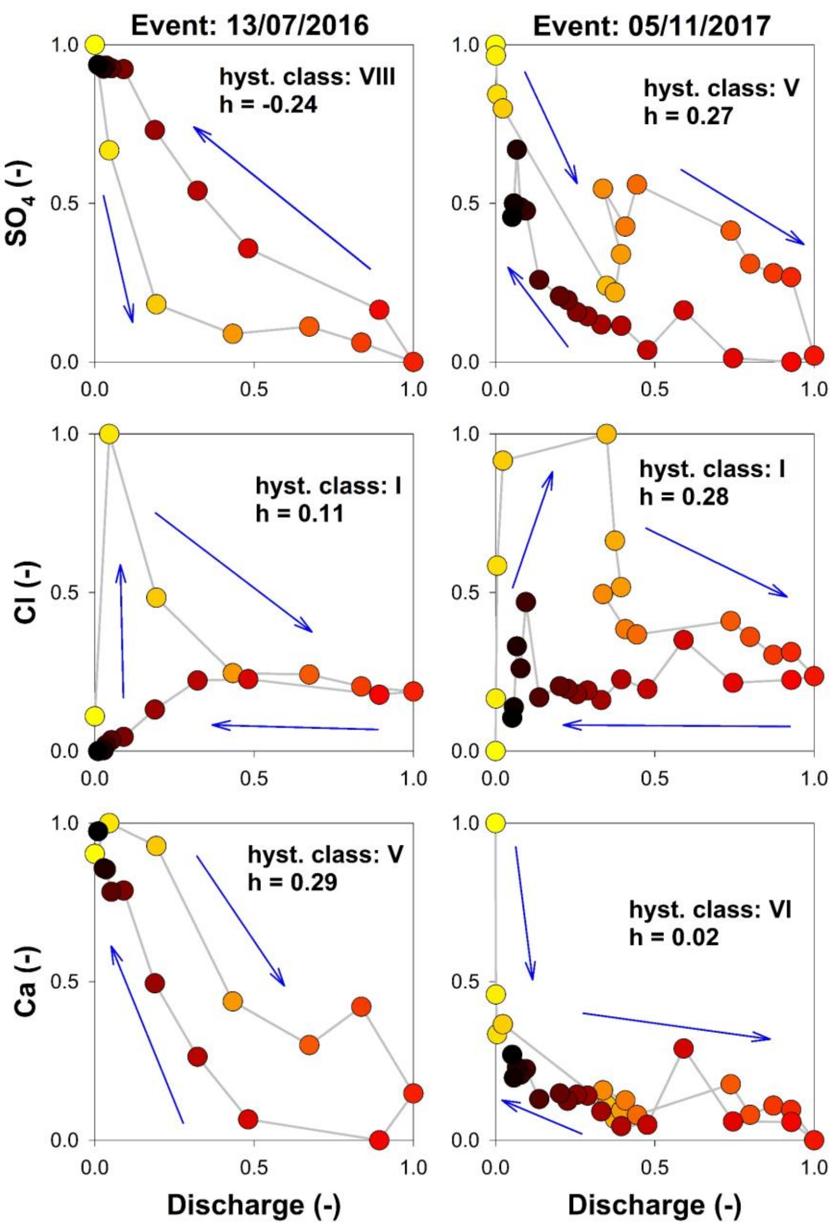
Colour legend: samples collected during **event starting on 13/07/2016**, **event starting on 05/11/2017**, all **other events**

Discharge and tracer dynamics



- Different antecedent wetness conditions
- Total event rainfall: 11-132 mm
- Runoff coefficients: 0.6-25.2%
- Different **temporal dynamics** of **concentrations** in stream water (e.g., **Cl** increases at the beginning of a rainfall-runoff event, whereas **Ca** and **EC** decrease)

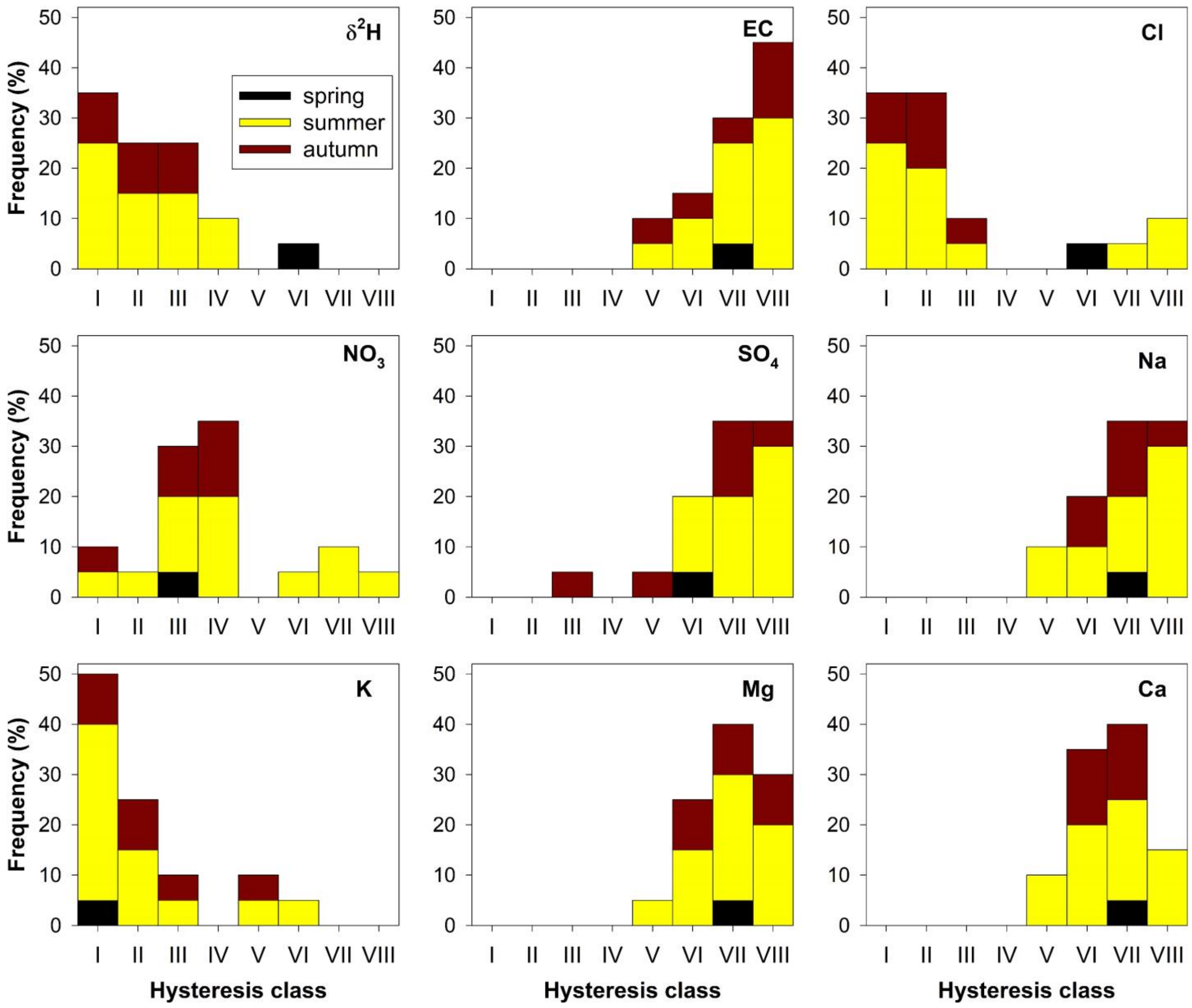
Hysteresis identification



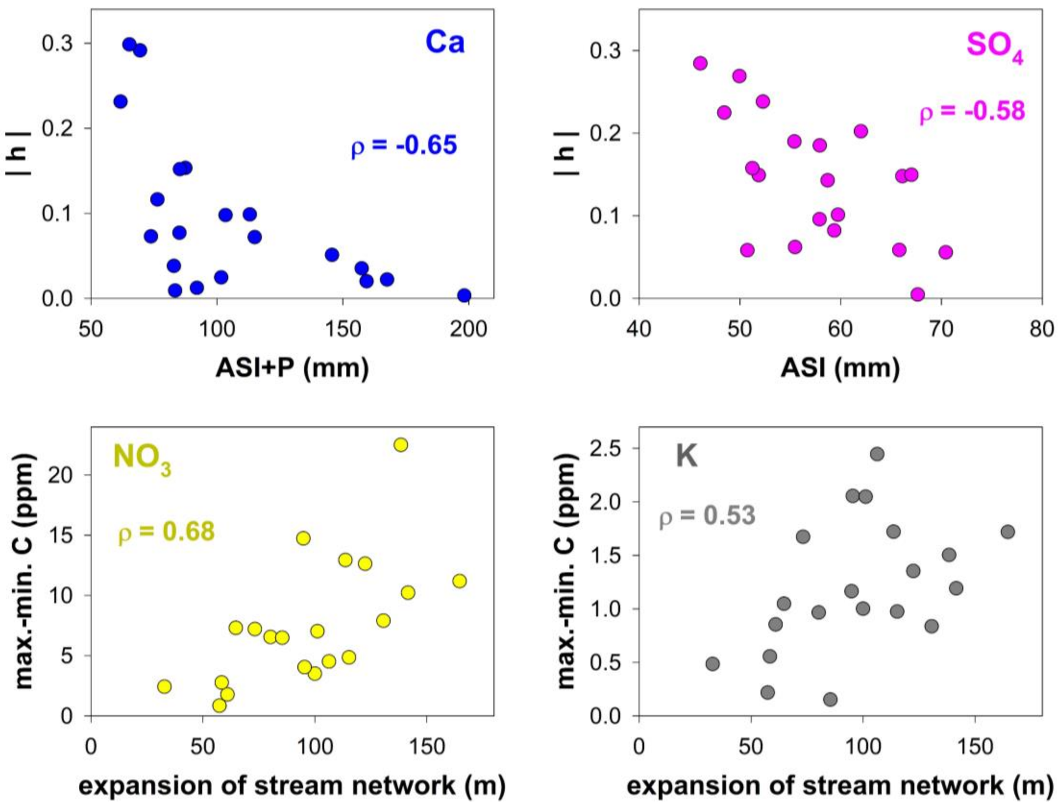
- **Hysteretic relations** between discharge and tracer concentrations
- **Flushing** and generally **clockwise** hysteresis: stable water isotopes, Cl and K
- **Dilution** and generally **anti-clockwise** hysteresis: SO_4, EC, Na and Ca

The larger the absolute value of the hysteresis index (|h|), the larger the size of the loop

Frequency of hysteresis classes



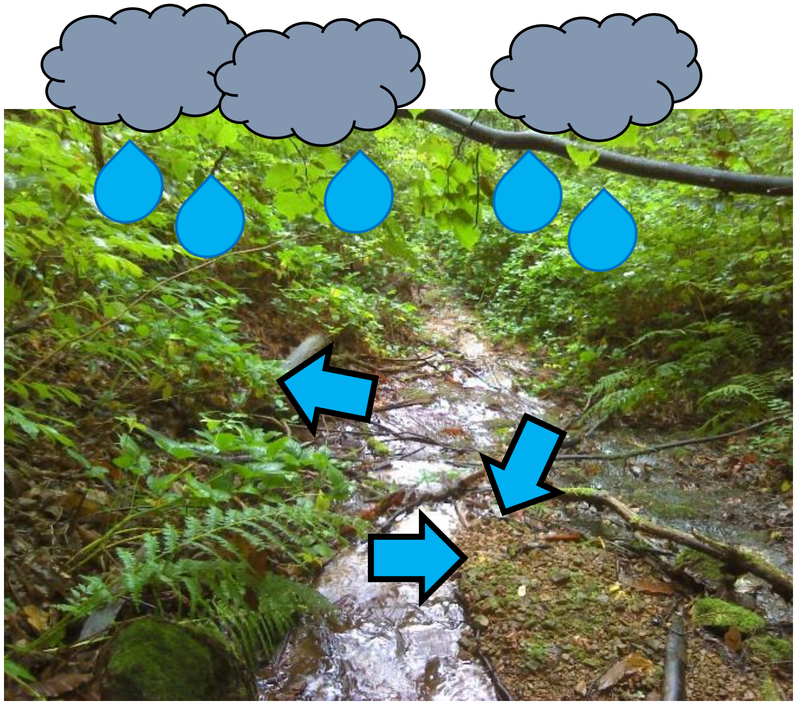
Relations between event characteristics and C-Q hysteresis



ASI: antecedent soil moisture index, based on Haga et al. (2005)
P: event precipitation

- **Size of the hysteresis** (represented by |h|) is likely affected by **antecedent wetness conditions** and the magnitude of the rainfall event (e.g., Ca as tracer)
- **No clear relations** between event characteristics and C-Q hysteresis for Cl, NO_3 and K
- Significant **positive correlation** between the **expansion of the stream network** during the event and the **maximum-minimum concentration** for NO_3 and K

Concluding remarks



- NO$_3$, K and Cl concentrations increased in stream water at the onset of rainfall-runoff events, likely due to a flushing of deposited solutes from the dry parts of the stream channel and the riparian area (→ expansion of the stream network during the event)

- Event characteristics alone cannot explain the changes in concentration-discharge (C-Q) hysteresis

- Size of the hysteresis is likely affected by antecedent wetness conditions (e.g., SO$_4$ and Na) and the magnitude of the rainfall event (e.g., for Ca)

References:

Haga et al., 2005. Flow paths, rainfall properties, and antecedent soil moisture controlling lags to peak discharge in a granitic unchanneled catchment. *Water Resour. Res., 41, W12410.* DOI: 10.1029/2005WR004236

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