Hydrological partitioning of soil water in a hillslope segment using dual continuum model

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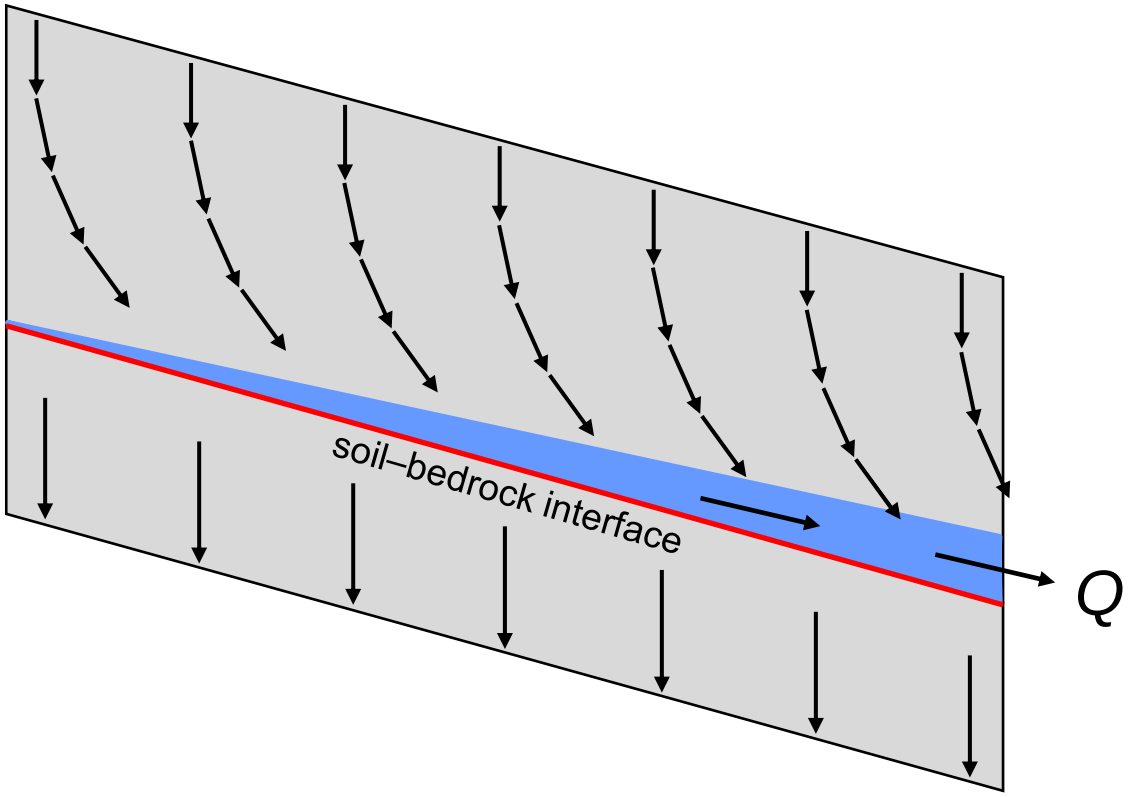
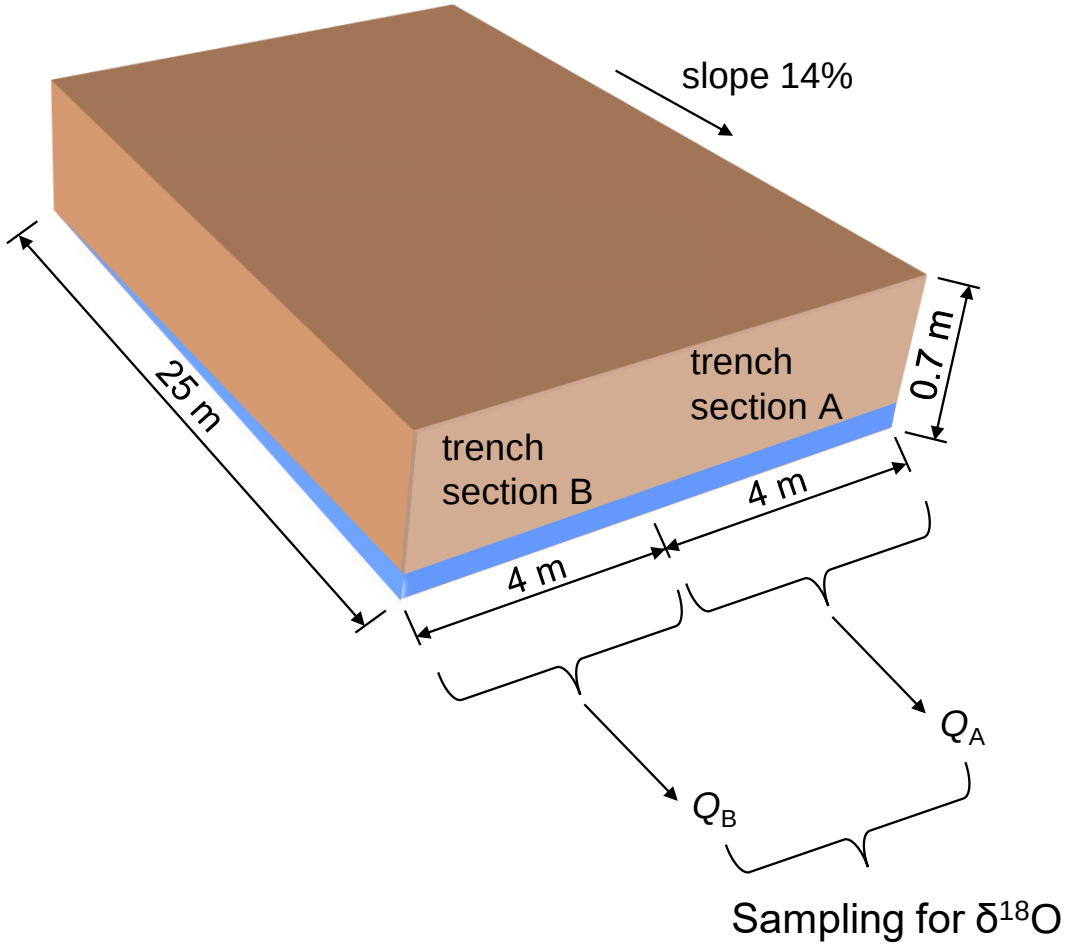
Stormflow

- important runoff mechanism on hillslopes
- saturated flow above the interface
- accelerated by preferential flow



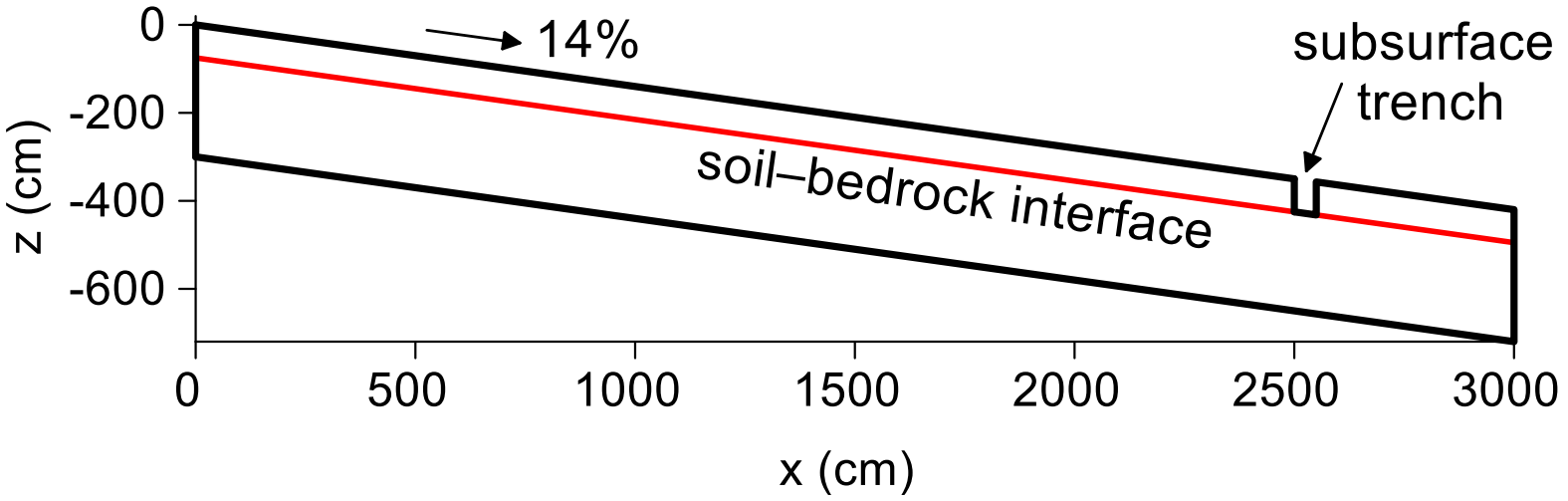
Experimental hillslope in a headwater catchment

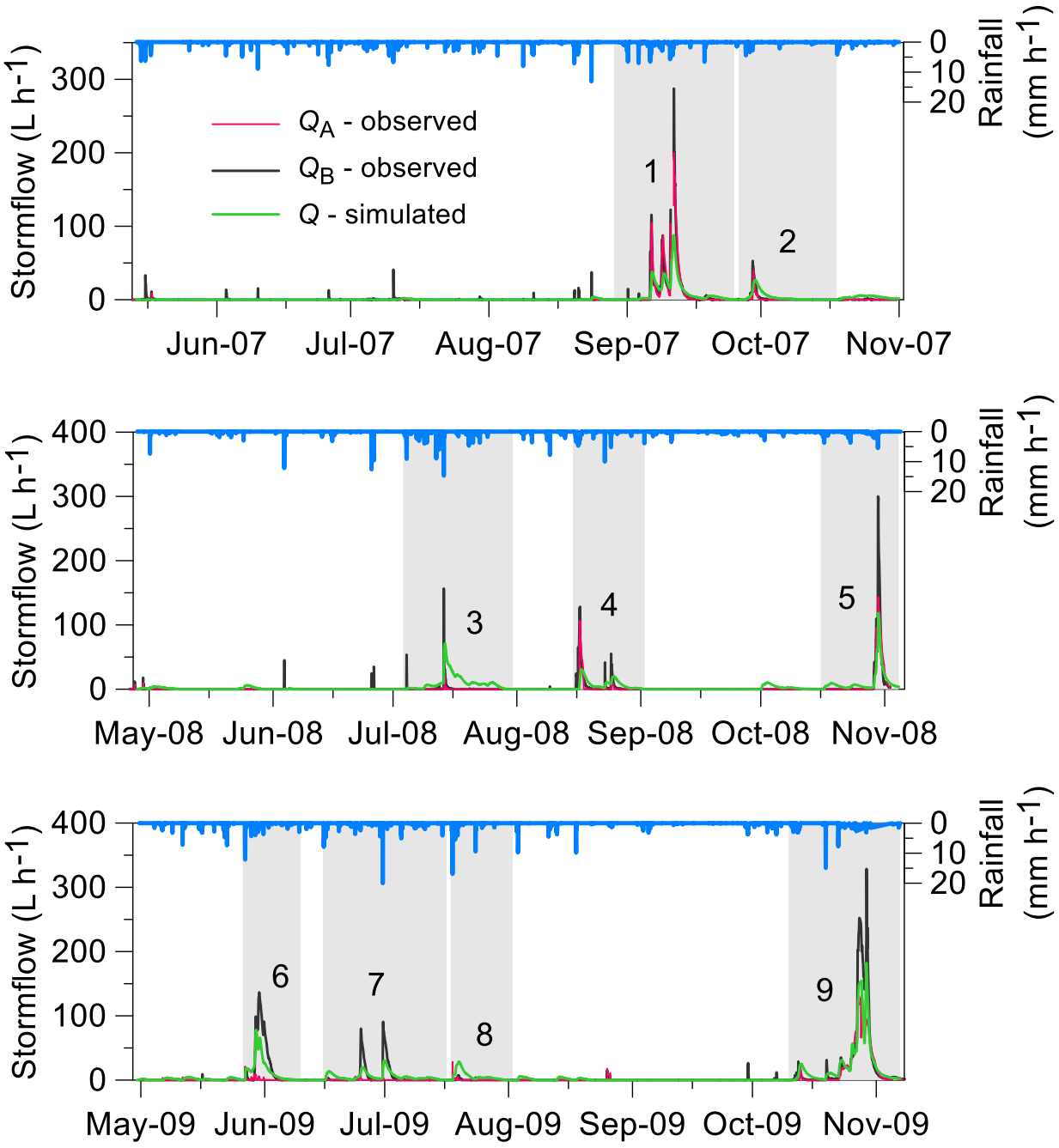


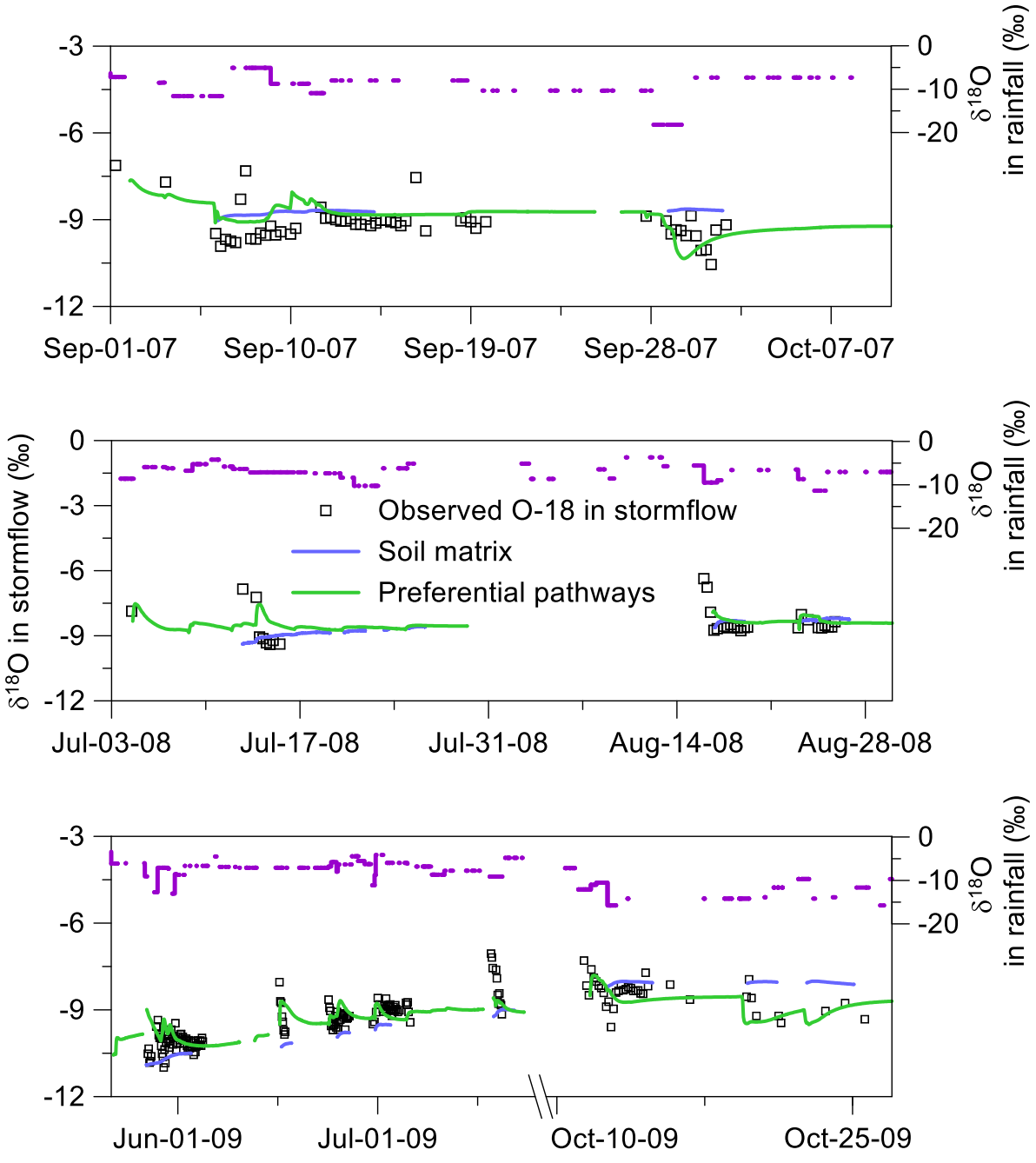
- subsurface trench – stormflow and isotope content

Two-dimensional dual continuum model (Vogel et al., 2000 JH)

- the soil matrix and preferential flow domain
- Richards equations and advection-dispersion equations, exchange of water and tracer
- hydraulic and transport parameters (Vogel et al., 2010 VZJ; Dusek and Vogel, 2014 VZJ, 2016 JH, 2018 JH)
- growing seasons 2007, 2008, and 2009




Stormflow (L h-1)
Rainfall (mm h-1)
QA - observed
QB - observed
Q - simulated
1
2
3
4
5
6
7
8
9
Jun-07
Jul-07
Aug-07
Sep-07
Oct-07
Nov-07
May-08
Jun-08
Jul-08
Aug-08
Sep-08
Oct-08
Nov-08
May-09
Jun-09
Jul-09
Aug-09
Sep-09
Oct-09
Nov-09


-3
-6
-9
-12
0
-10
-20
δ18O in rainfall (‰)
Sep-01-07
Sep-10-07
Sep-19-07
Sep-28-07
Oct-07-07
δ18O in stormflow (‰)
Observed O-18 in stormflow
Soil matrix
Preferential pathways
Jul-03-08
Jul-17-08
Jul-31-08
Aug-14-08
Aug-28-08
Jun-01-09
Jul-01-09
Oct-10-09
Oct-25-09

Mass balance approach

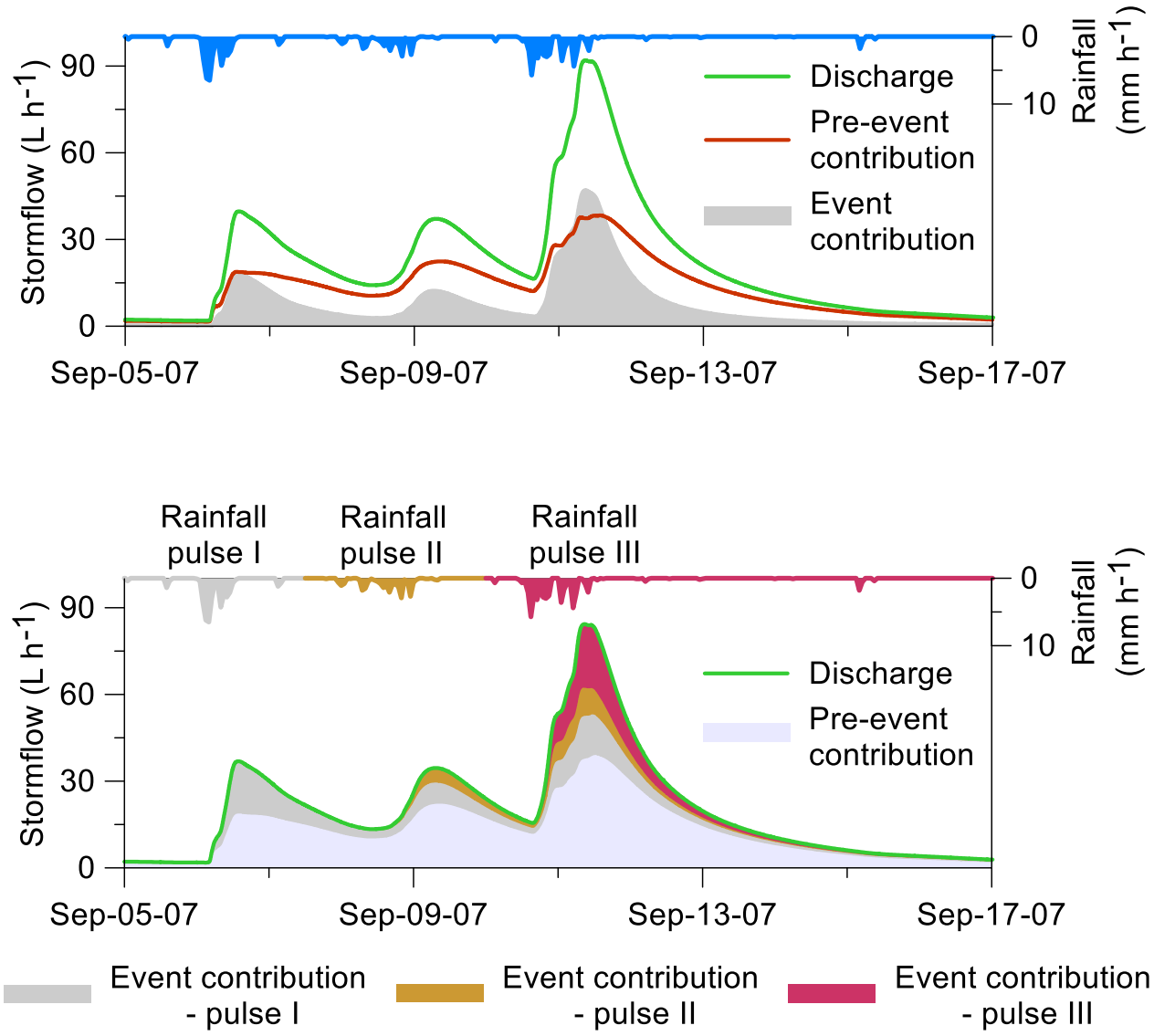
- pre-event (Q_p) and event (Q_e) water contributions to stormflow
- isotopic signatures – soil water (c_p) and rainfall (c_e)

$$Q(t) = Q_p(t) + Q_e(t)$$

$$c(t)Q(t) = c_p Q_p(t) + c_e Q_e(t)$$

- in the simulations: c_p = -18‰ and c_e = -3‰

Episode number	Pre-event water contribution to stormflow (%)
1	65.4
2	84.4
3	62.9
4	64.0
5	67.6
6	72.6
7	76.8
8	79.2
9	52.2


Stormflow (L h-1)
90
60
30
0
Rainfall (mm h-1)
0
10
Discharge
Pre-event contribution
Event contribution
Sep-05-07
Sep-09-07
Sep-13-07
Sep-17-07
Rainfall pulse I
Rainfall pulse II
Rainfall pulse III
Event contribution - pulse I
Event contribution - pulse II
Event contribution - pulse III

Conclusions

- the dominant role of preferential flow in the generation of hillslope stormflow
- the pre-event water makes up 52–84% of the total stormflow
- the soil matrix domain serves as the source of pre-event water, transferred to the preferential pathways