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The role of catchment topography on the spatial and temporal dynamics of soil moisture and subsurface flow

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EGU General Assembly, Vienna, 24 April 2012

Introduction

- Soil moisture (SM) and transient water table (WT): highly variable in space/time → dominant controls on their response still poorly understood
  (McGuire & McDonnell, 2010, WWR; Brocca et al., 2012, JoH)

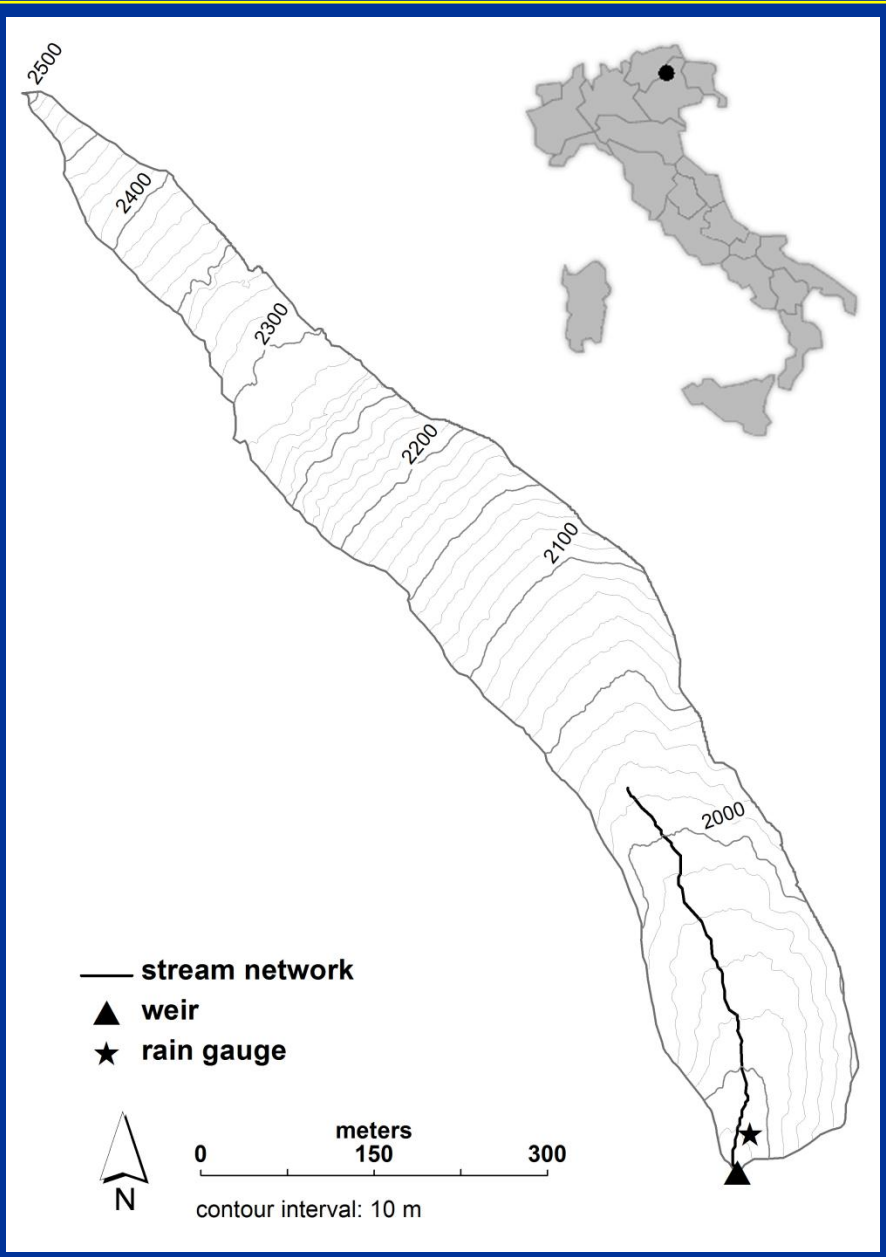
- In mountain catchments: complex topography → useful discretization in landscape elements (riparian/hillslope zone) → insight into spatial sources of runoff
  (Jencso et al., 2010, WWR; Penna et al., 2011, HESS)

- Separate analysis of two zones: different dynamics (Seibert et al., 2003, WWR; Haught & van Meerveld, 2011, HP) → insight into stream-hillsope connectivity → role of catchment heterogeneity (Van Nieuwenhuyse et al., 2011, HP) and hillslope properties (Hopp et al., 2009, JoH) on runoff response

Key Questions

- Is catchment topography a dominant control on the spatio-temporal variability of SM and WT?
- In space: different dynamics in the riparian and hillslope zone? Which units are the main spatial sources to runoff?
- In time: different WT dynamics in wet/dry periods?
- What is the role of initial conditions and rainfall amount on stream-hillslope connectivity?

Study Area: Bridge Creek Catchment



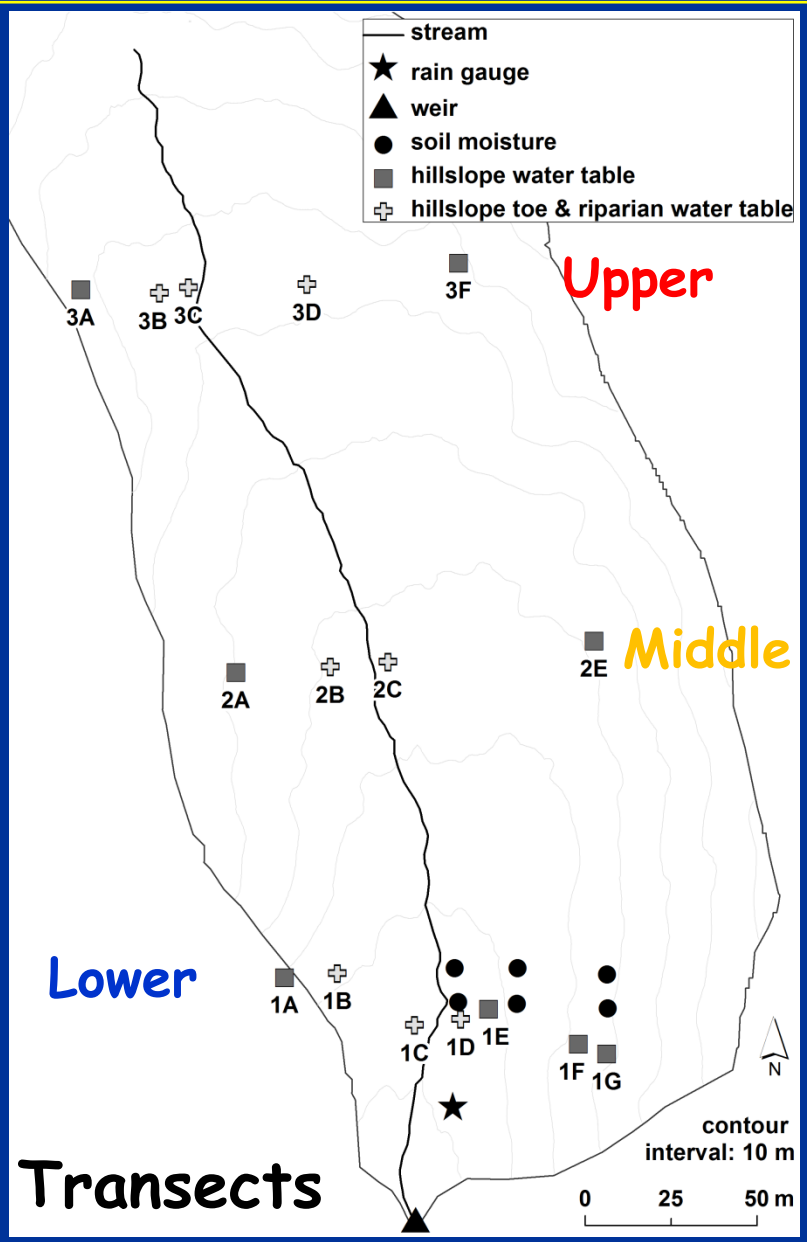
Italian Dolomites (Eastern Alps)

Area (km^2)	0.14
Elevation (m ASL)	1932-2515
Mean slope (°)	29.9
Mean annual precipitation	1220 mm (49% snow)
Mean monthy temperature	-5.7°C 14.1°C
Streamflow range (7 years)	4 - 90 ls^{-1}

Bridge Creek Catchment

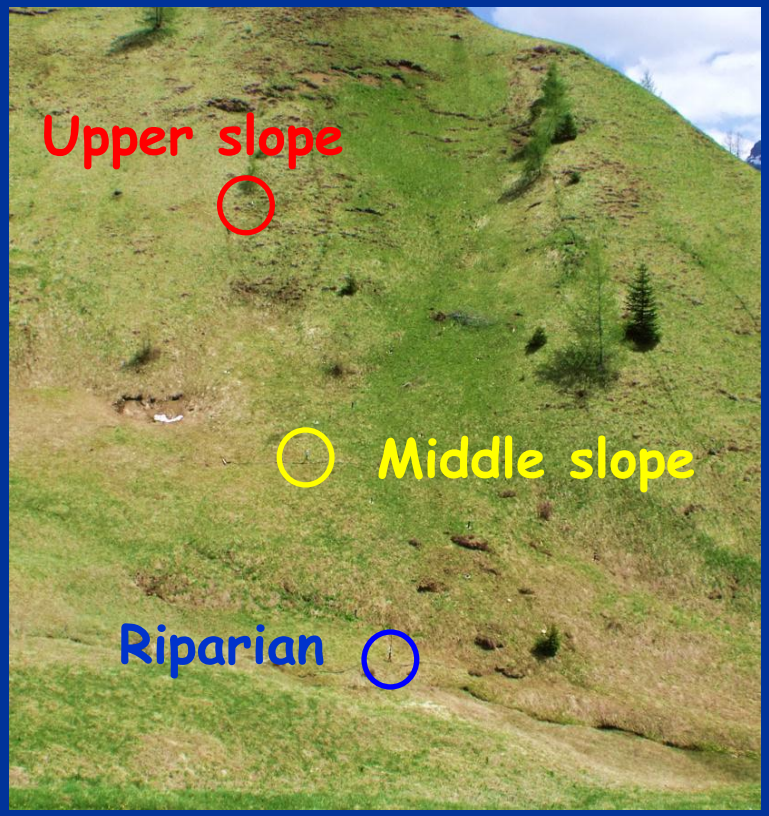
Bridge Creek Catchment

Instrumentation



June-October 2011

Variab.	Type	N.	Depth
WT	Capacitance	16	0.7-1.5 m
SM	FDR	15	5, 20, 40 cm



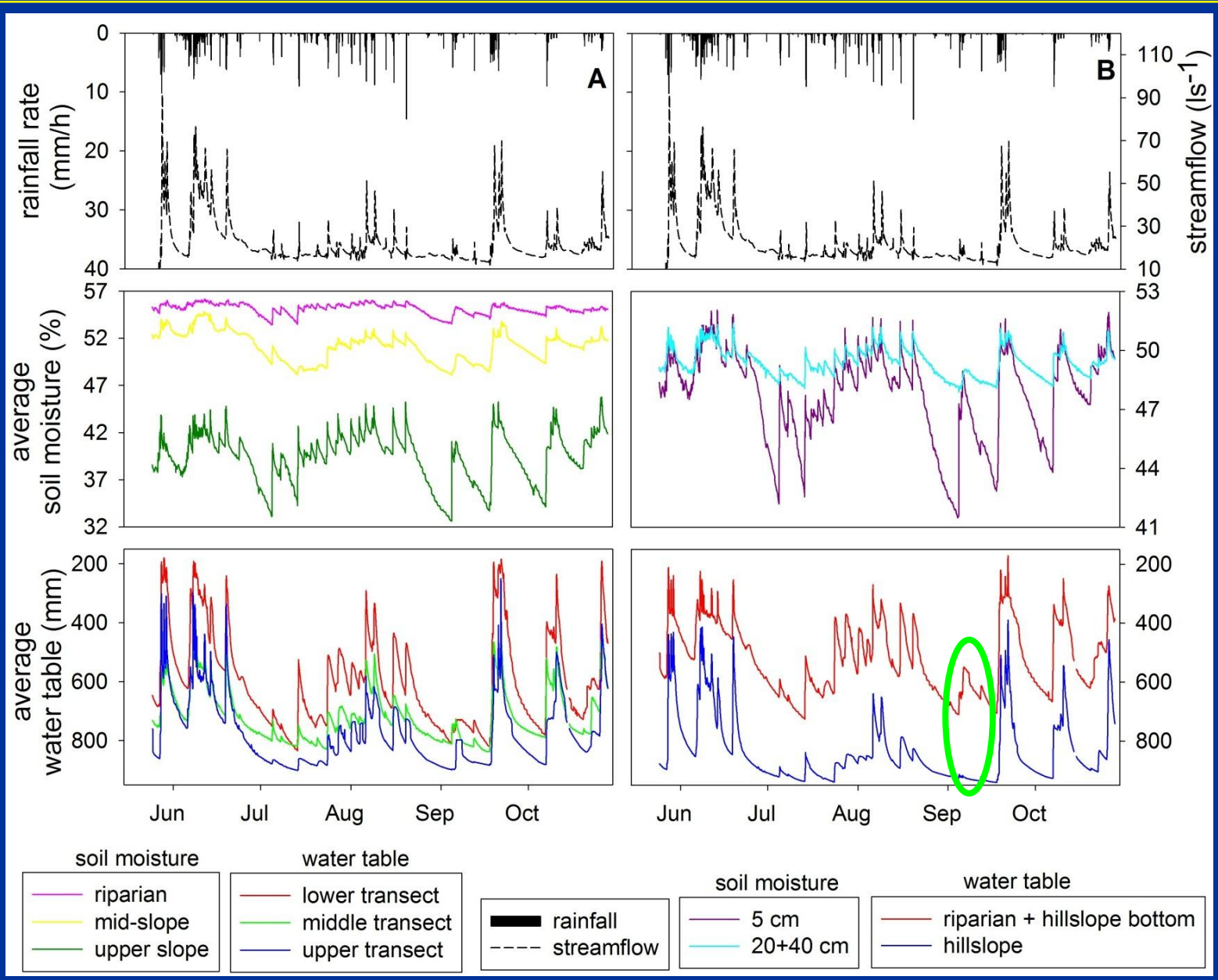
Temporal dynamics of SM and WT

Along hillslope

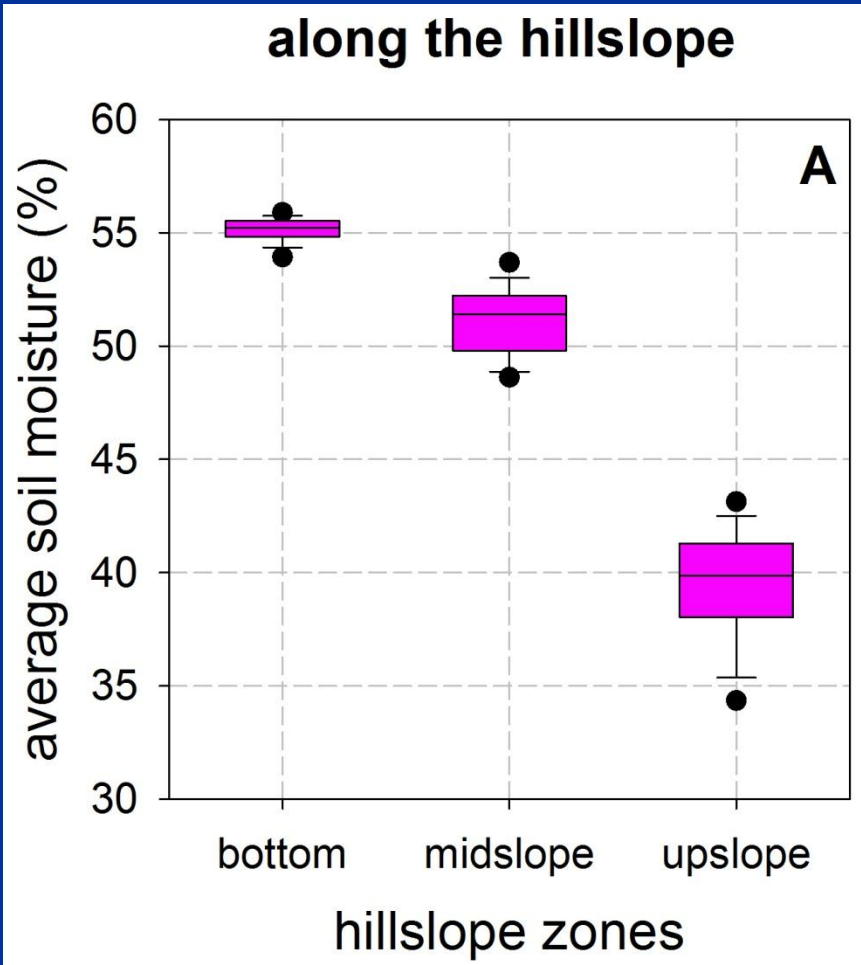
Along catchment

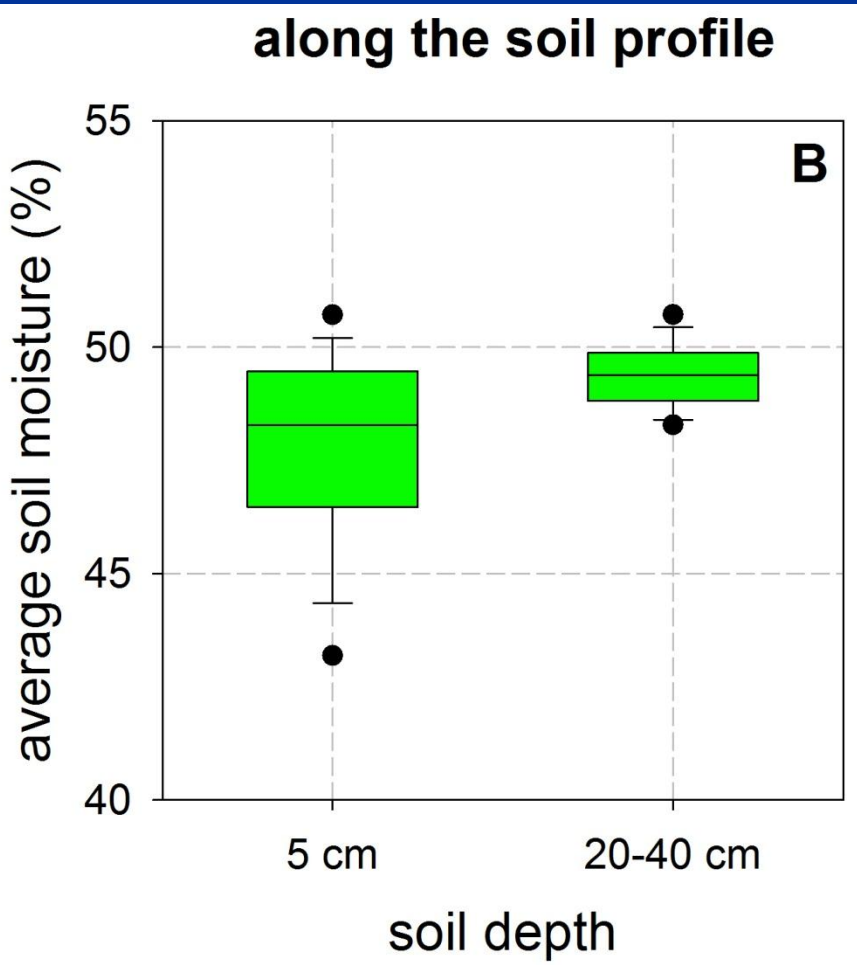
In depth

Hillslope positions



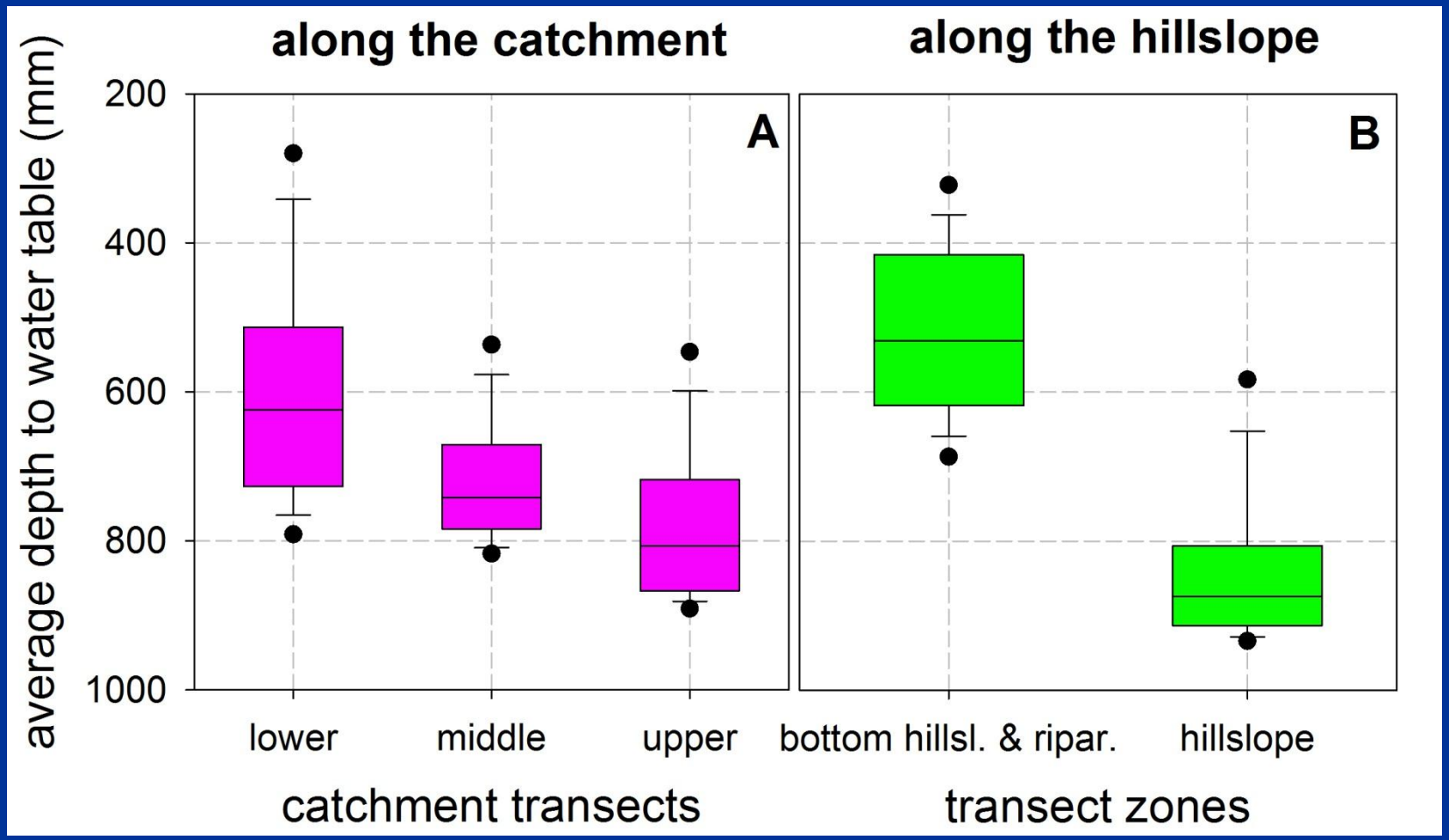
Topographic control on SM spatial variability





- Along hillslope: SM decreases, variability increases
- In depth: 5 cm wets up/dries down more and quicker

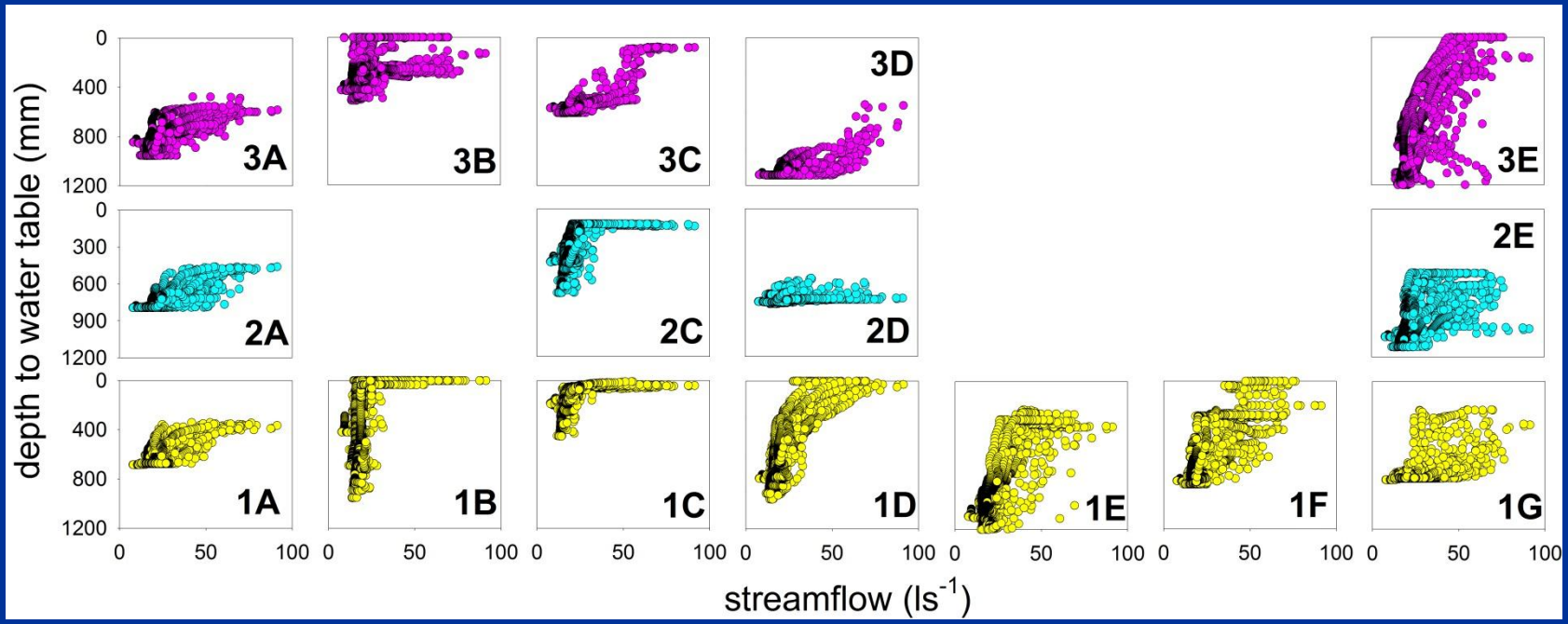
Topographic control on WT spatial variability



- Along catchment: higher level and variability close to outlet
- Hillslope/Riparian: significantly different levels

Hillslope and Riparian WT dynamics

- High spatial variability of WT response
  (Haught & van Meerveld, 2011, HP; Bachmair et al., 2012, WRR)
- However: certain degree of similarity within the same zone



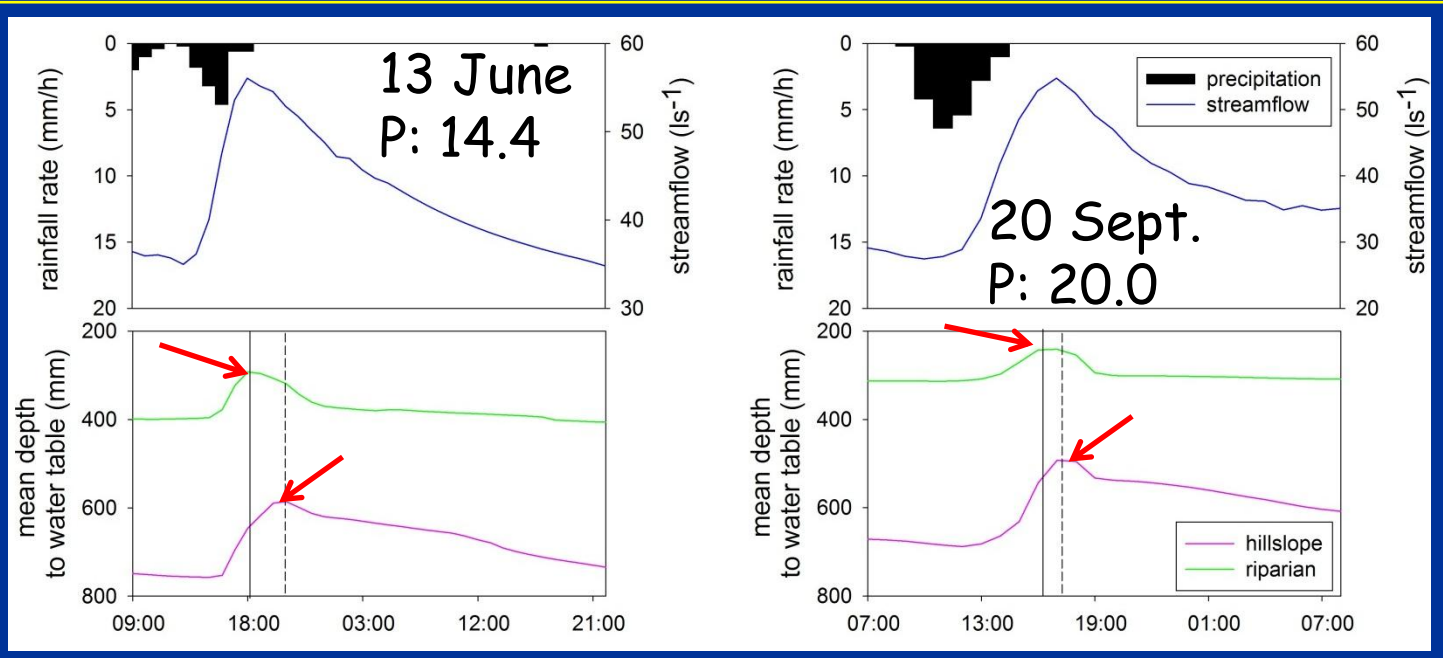
Upper trans.

Middle trans.

Lower trans.

Hillslope-Riparian WT relation

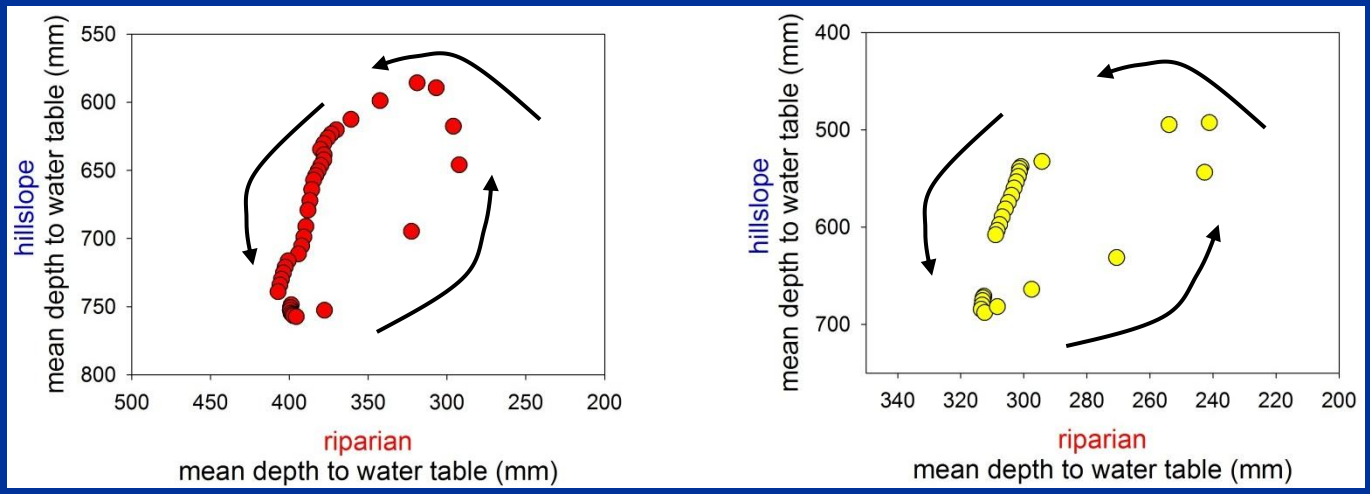
peak-to-peak lag time: lagged hillslope response



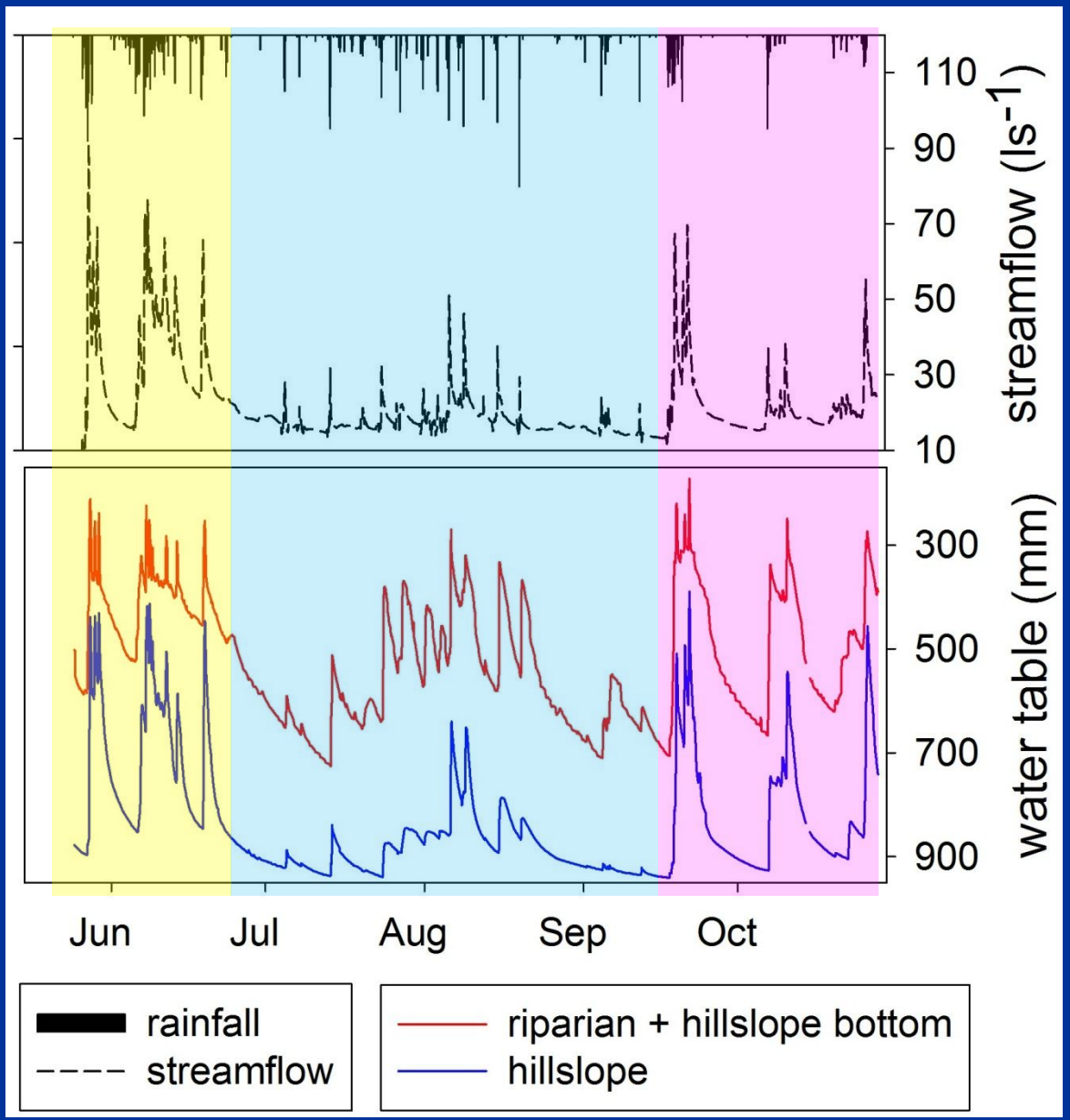
hysteresis

(Penna et al., 2010, IAHS Pub.;

Rodhe & Seibert, 2011, HP)



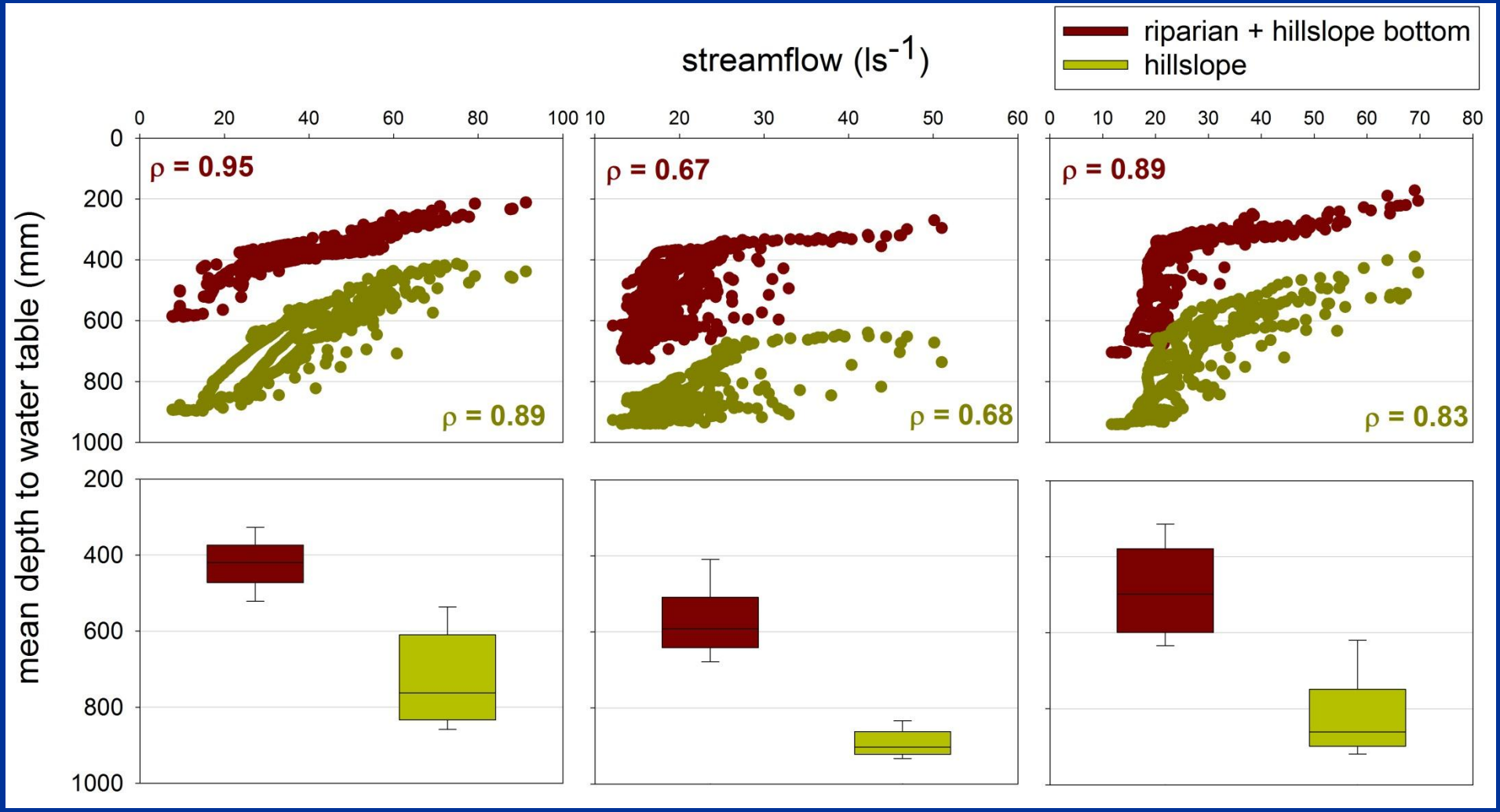
Hillslope-Riparian WT dynamics in wet/dry periods



	period	Mean rainfall (mm/day)
1st wet	24 May-23 June	9.3
dry	24 June-16 Sept.	3.5
2nd wet	17 Sept.-28 Oct.	4.2

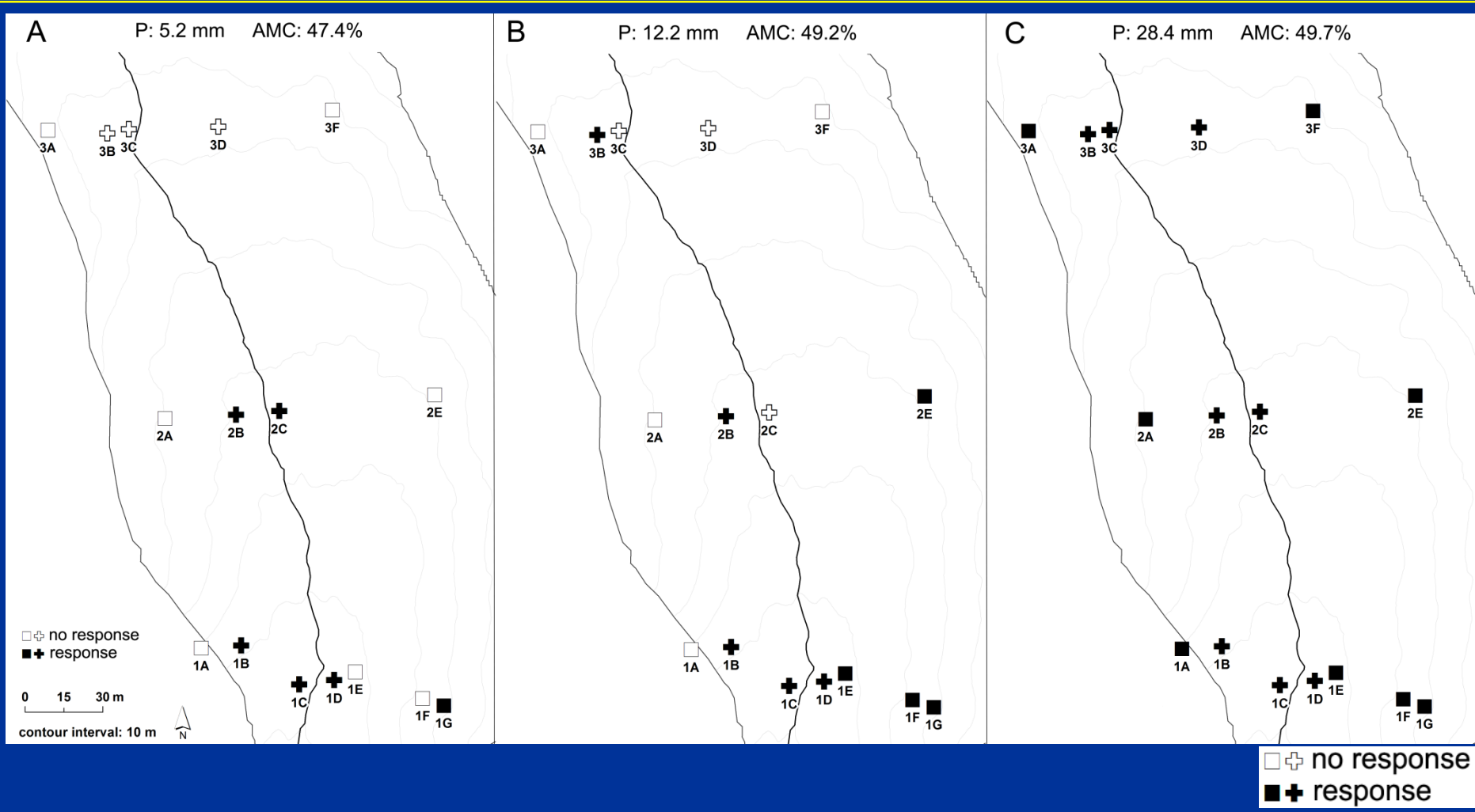
Hillslope-riparian Spearman ρ	
1st wet	0.92
dry	0.88
2nd wet	0.95

Hillslope-Riparian WT dynamics in wet/dry periods



First wet period | Dry period | Second wet period

Stream-Hillslope connectivity

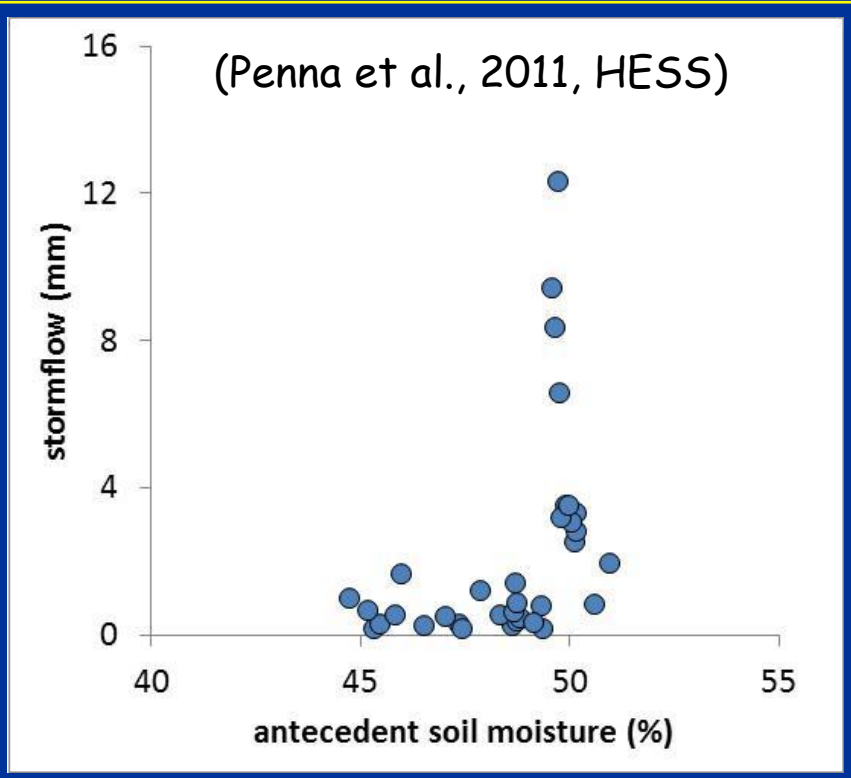


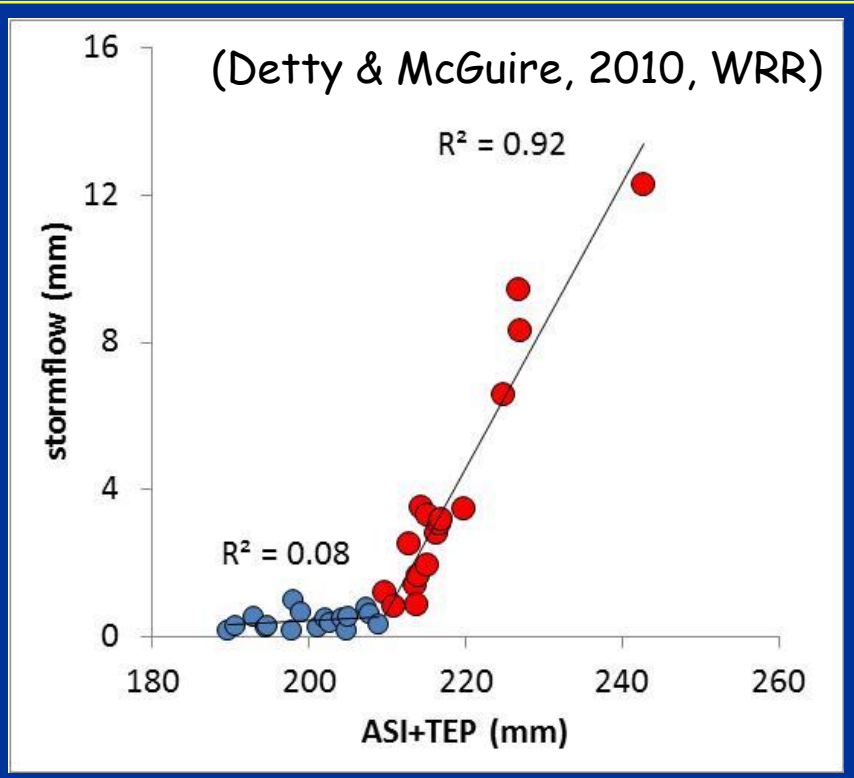
- Connectivity tends to increase with increasing AWC and P
- Extents upwards from riparian and lower part of catchment

Concluding remarks

- Strong control of catchment topography on spatio-temporal variability of SM and WT
- In space: different dynamics in hillslope-riparian zone → lagged response of hillslope WT
- In time: higher hillslope-riparian correlation during wet conditions → important hillslope WT contribution to runoff
- Connectivity dependent on initial conditions + rainfall amount and starting from riparian/lower portions of the catchments

Future investigations





Analysis of hillslope-riparian WT lag time in wet/dry periods:

- Do lag times decrease above the threshold?
- Does size of hysteretic loope decrease?
- Are there other controls on connectivity?

Thank you for your attention