Groundwater-surface water interactions as driver for streamflow dynamics:

Insights from an experimental headwater catchment

Julian Klaus

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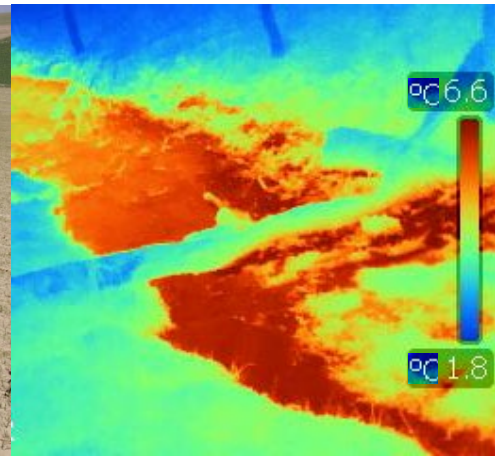

This work was possible because many contributed:


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Jeff Iffly


Laurent Gourdol


Laurent Pfister


Rene Therrien

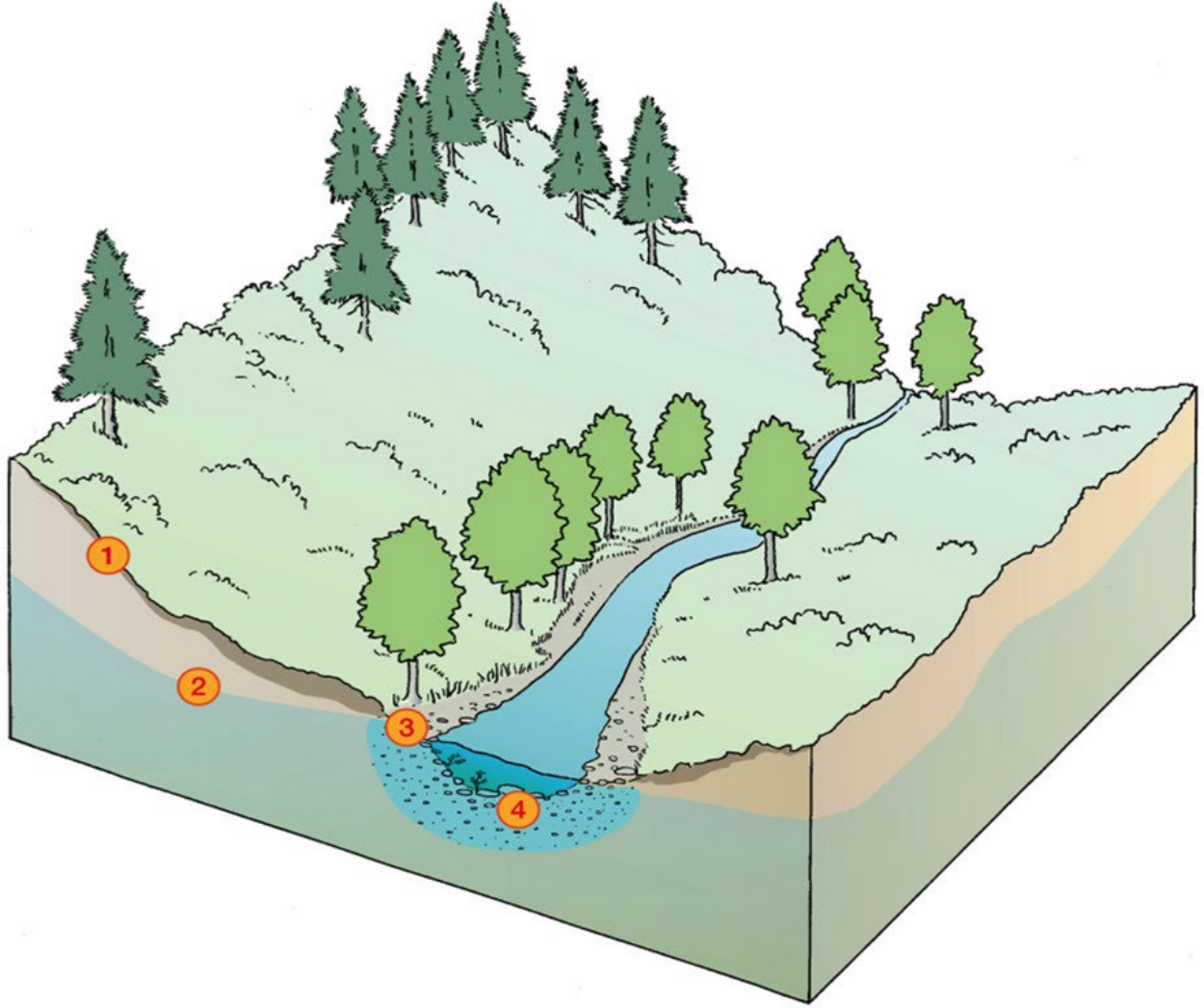

Dan Partington

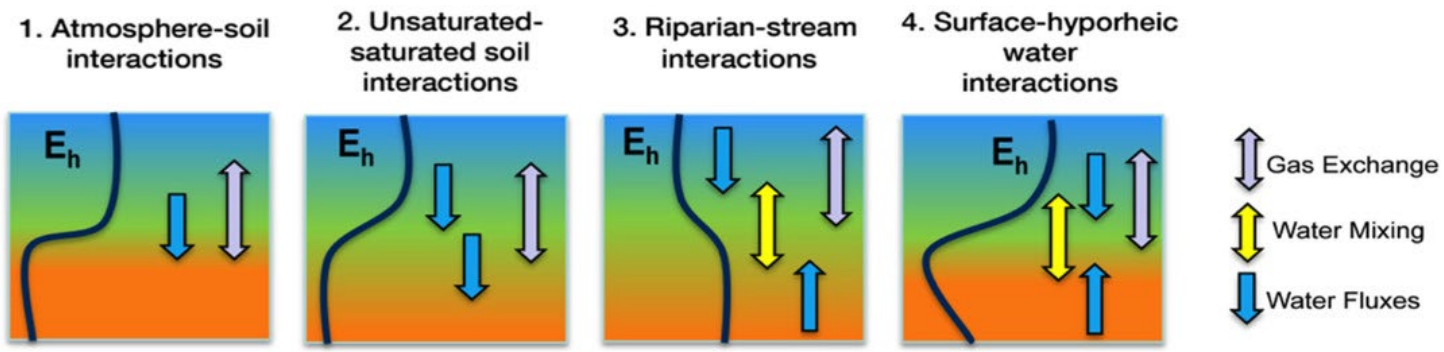

Günter Blöschl


Christophe Hissler


Francois Barnich


Markus Weiler


1
2
3
4

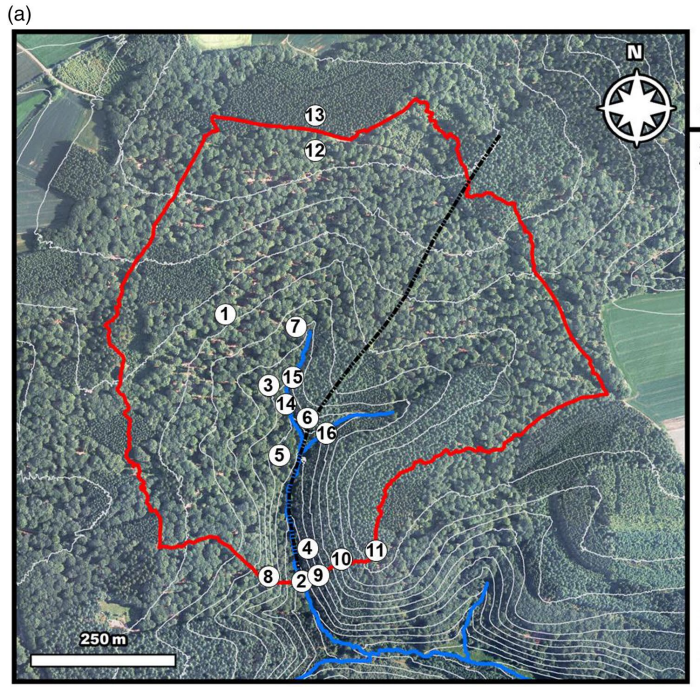

1. Atmosphere-soil interactions
2. Unsaturated-saturated soil interactions
3. Riparian-stream interactions
4. Surface-hyporheic water interactions
E_h
E_h
E_h
E_h
Gas Exchange
Water Mixing
Water Fluxes

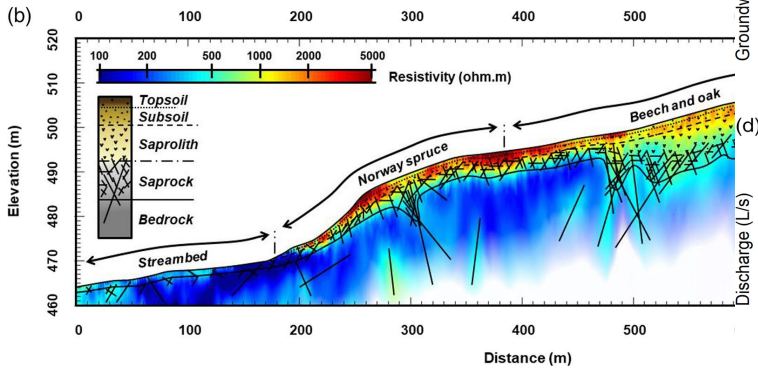
GW-SW interface as hotspot of Ecosystem processes

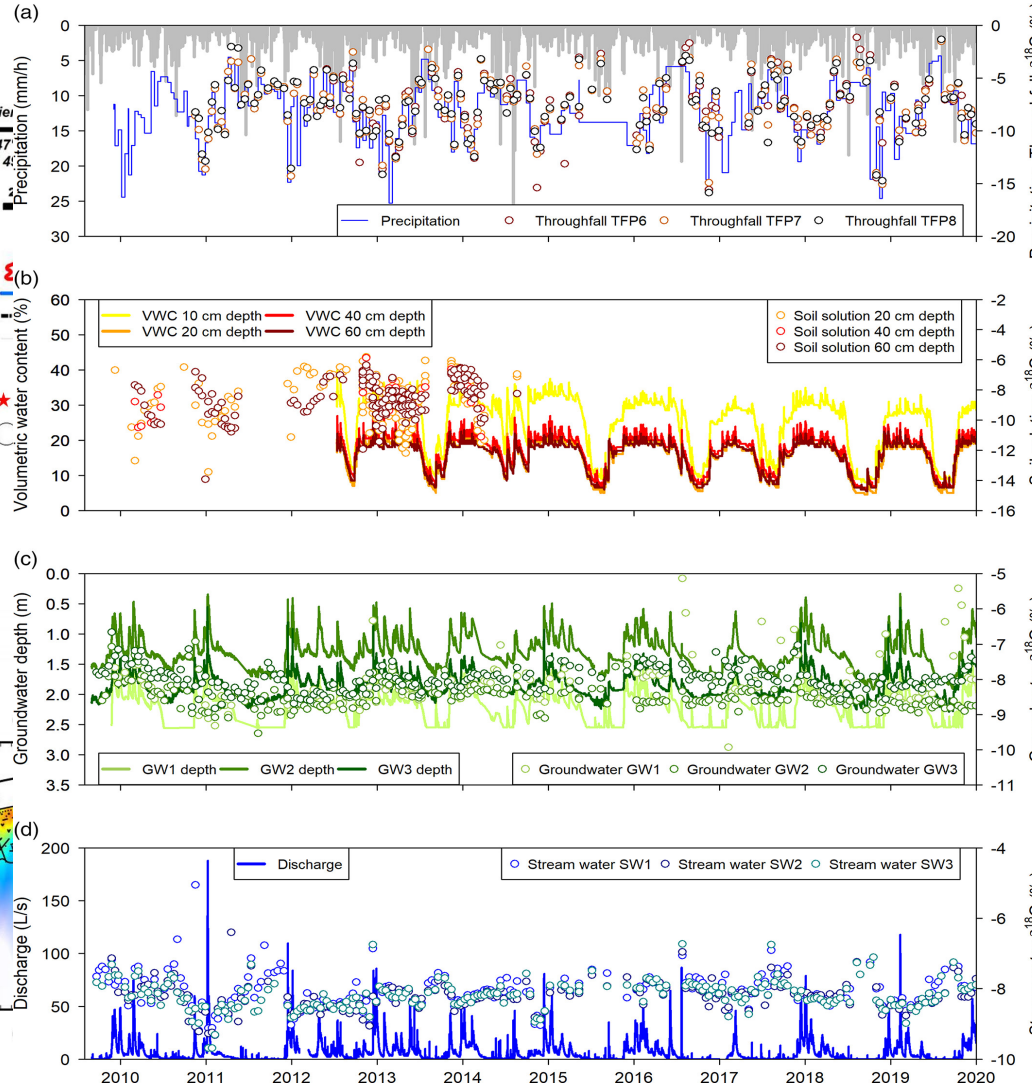
UNIVERSITÄT BONN GEOGRAPHIE

- Observation of surface saturation
- Simulation of surface saturation and GW-SW interaction
- Understanding drivers of GW-SW interaction through tracer experiments

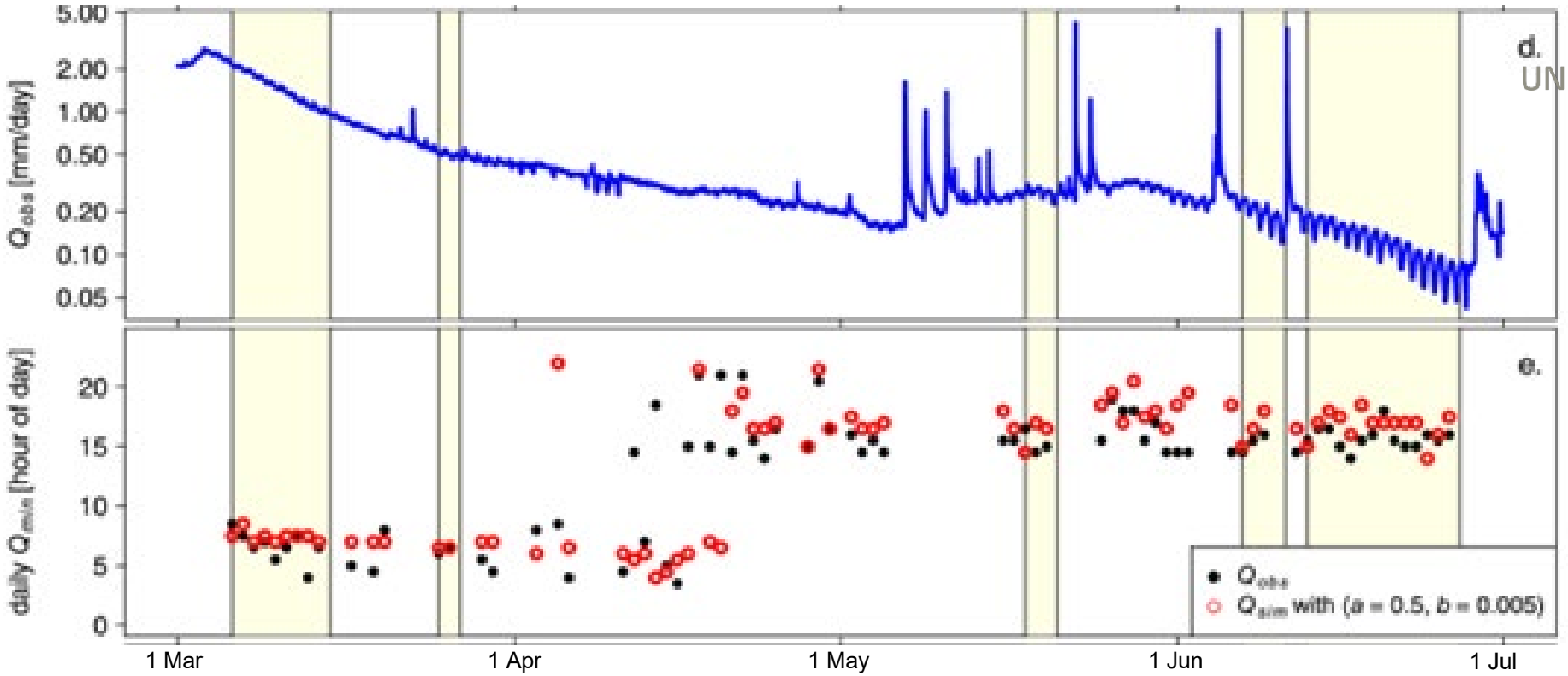
The Weierbach Observatory

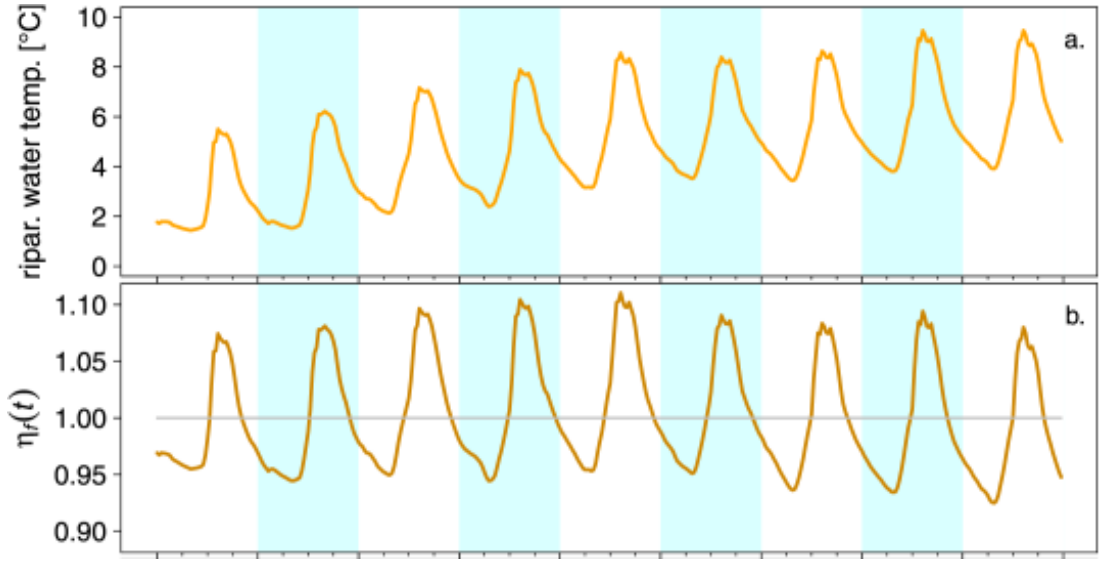




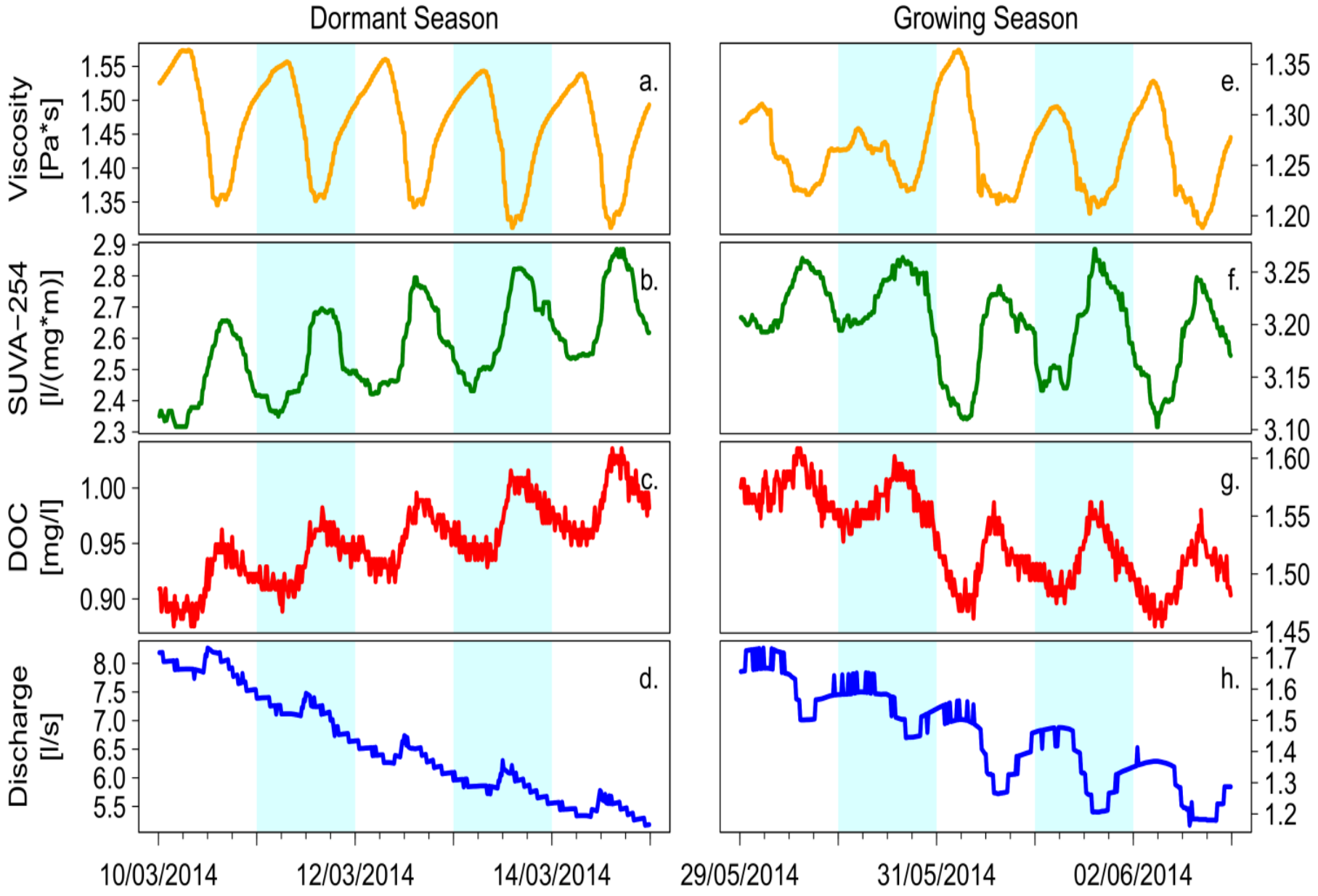


Hissler et al., 2021, HP





Schwab et al. (2016), WRR

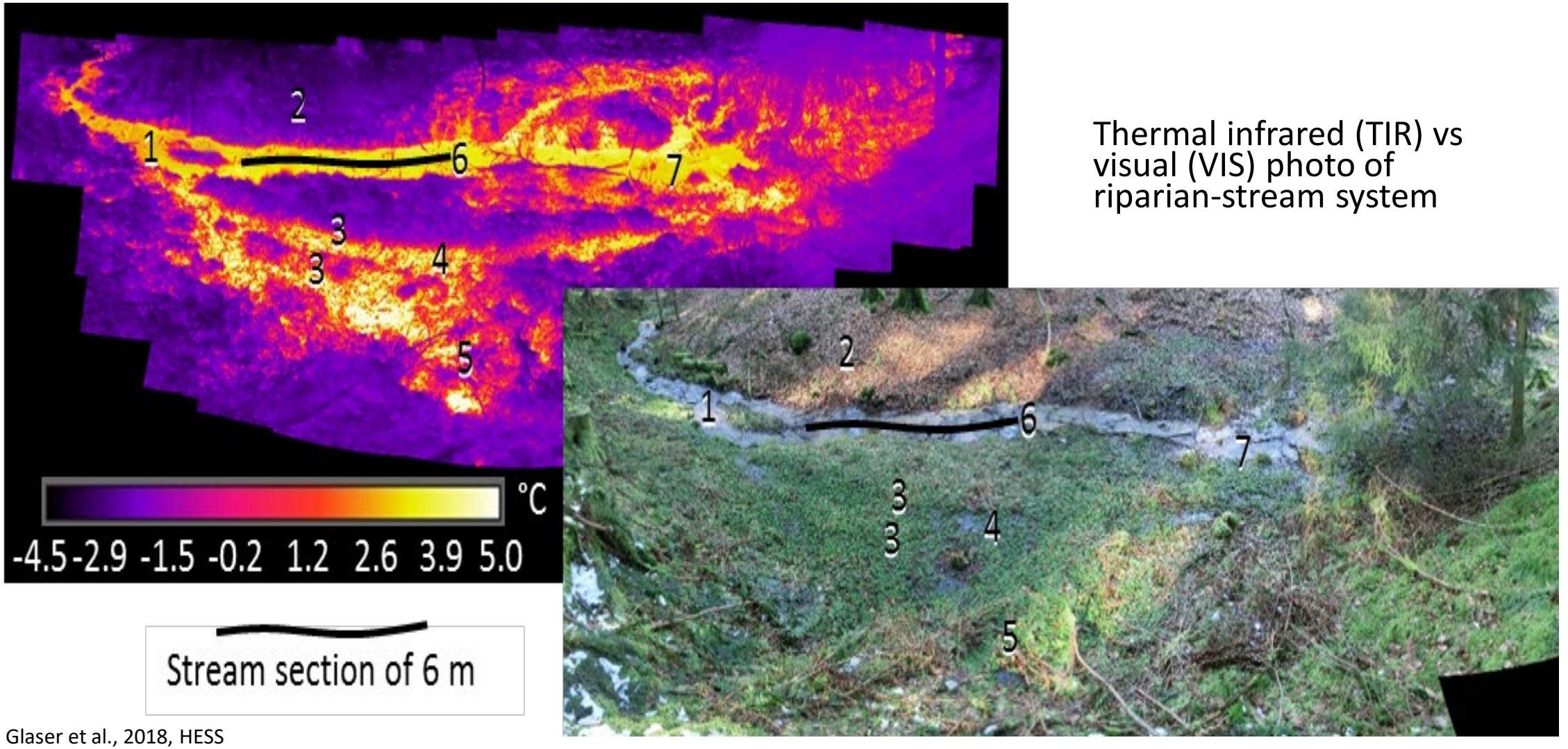


High SUVA254: terrestrial DOC sources

Low SUVA254: aquatic DOC sources

Schwab et al. (2018), BGS

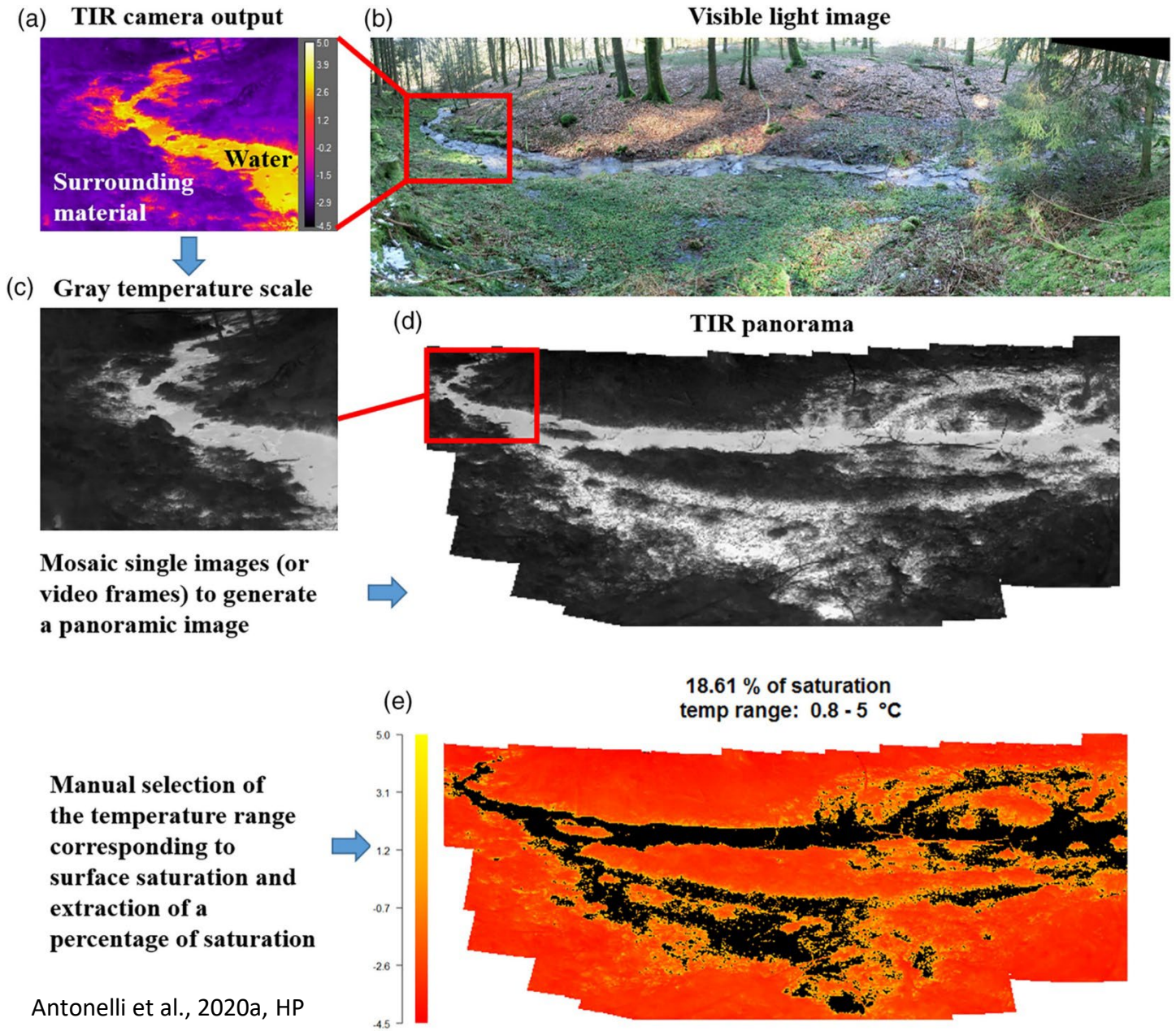
Observing surface saturation



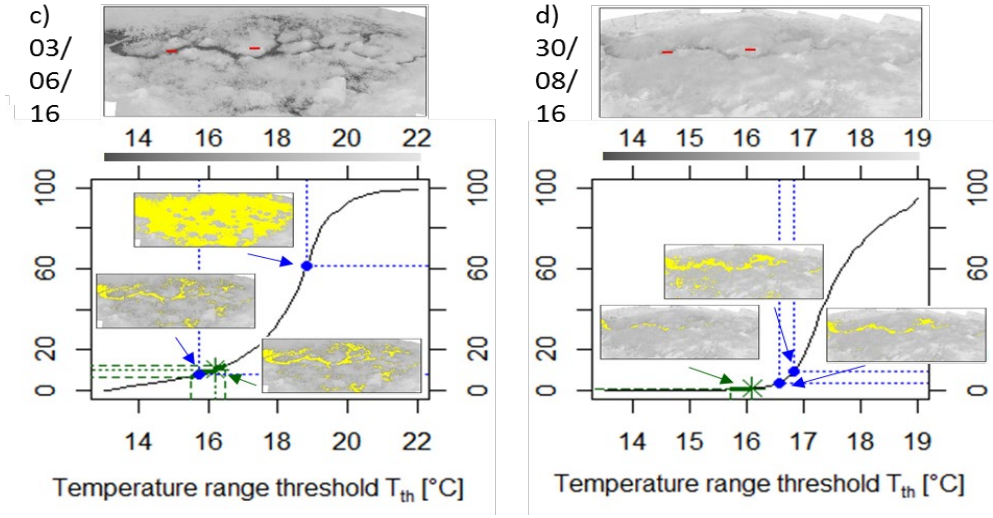
Thermal infrared (TIR) vs visual (VIS) photo of riparian-stream system

Glaser et al., 2018, HESS

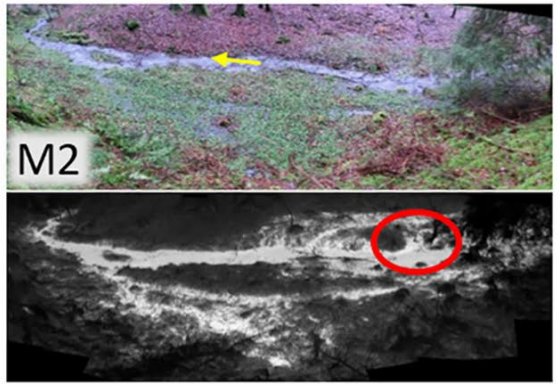
Observing surface saturation

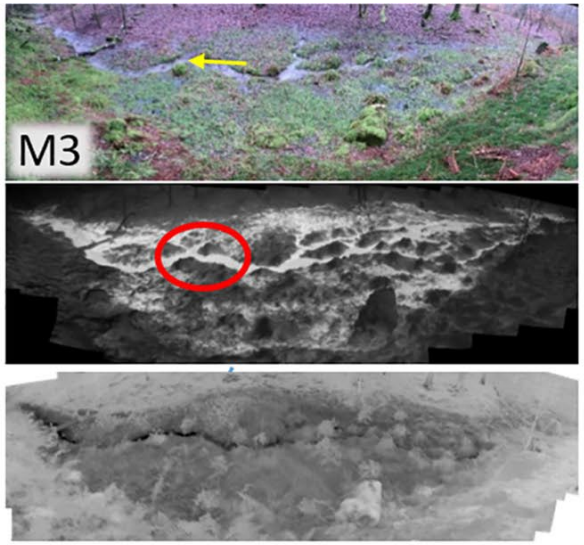


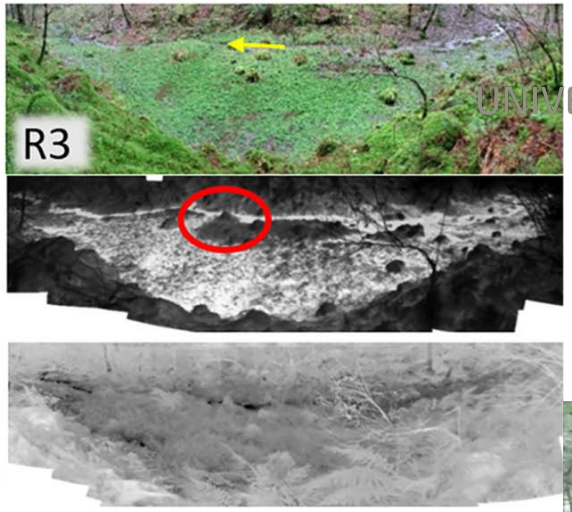
Antonelli et al., 2020a, HP

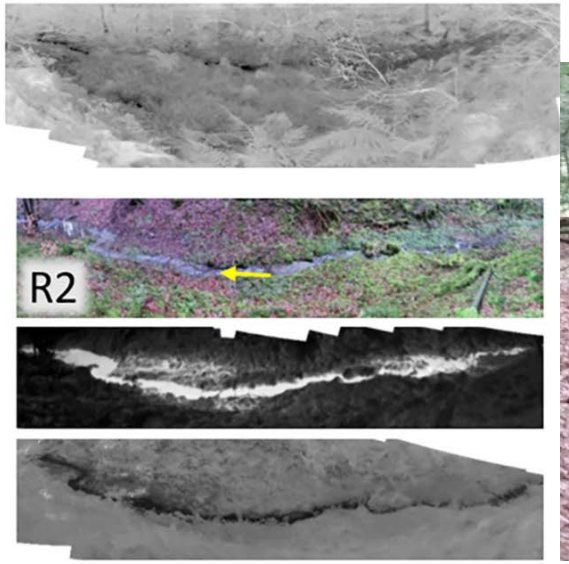


Glaser et al., 2018, HESS

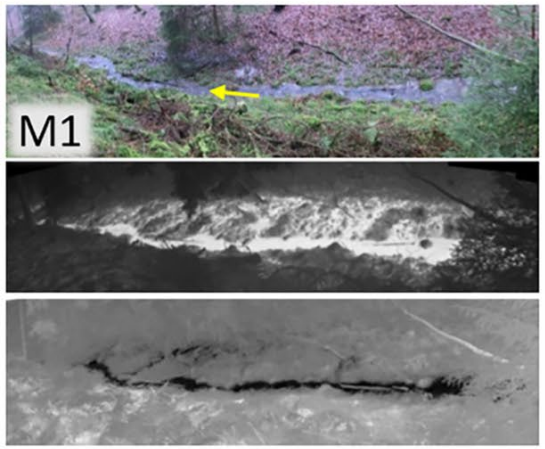

M2

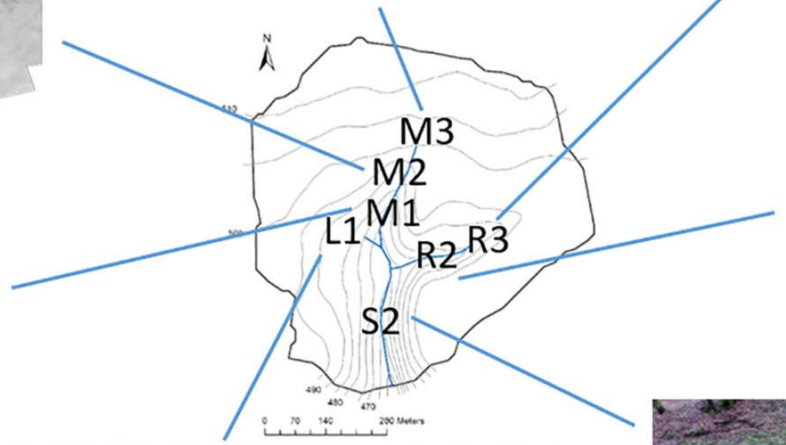

M3

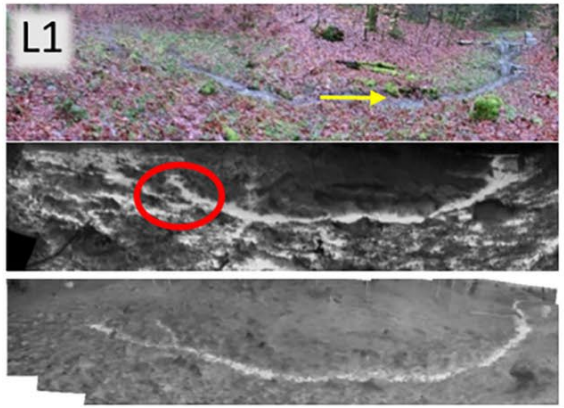

R3

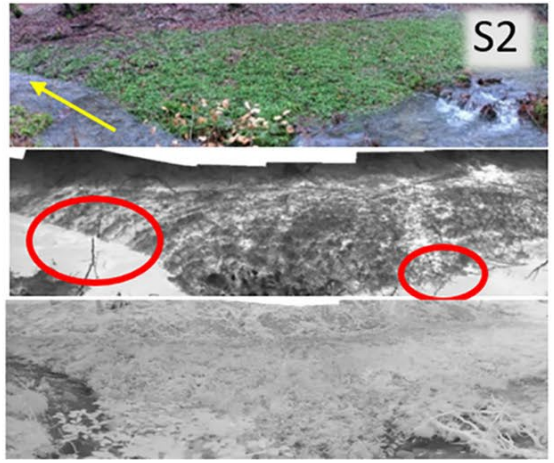


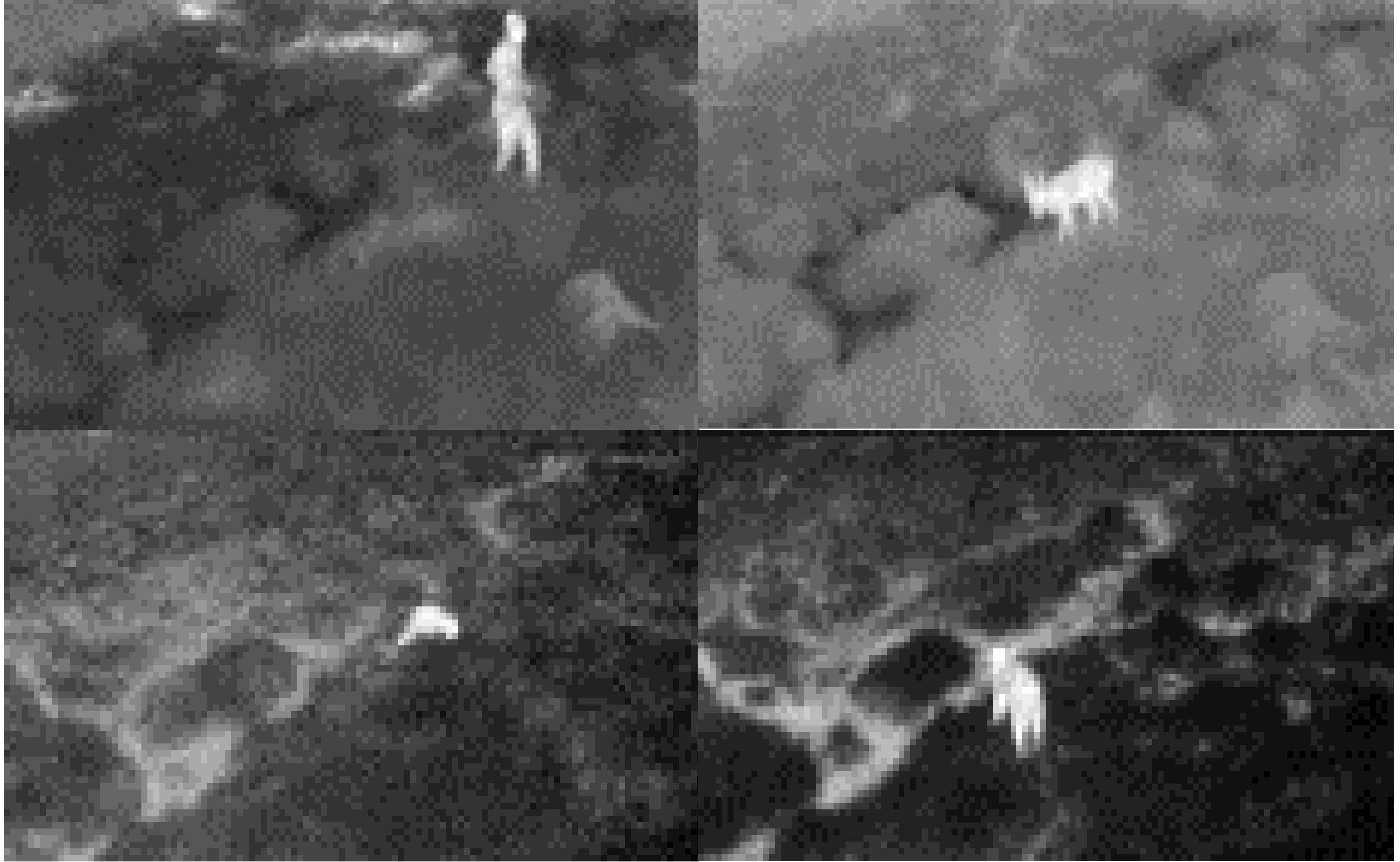
R2


M1

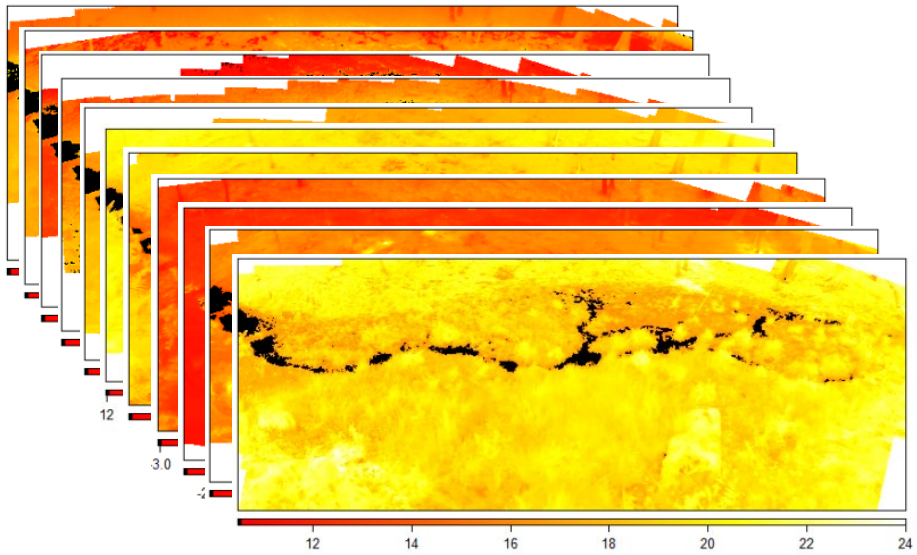

N
M3
M2
M1
L1
R2
R3
S2
490
480
470
0 70 140 280 Meters

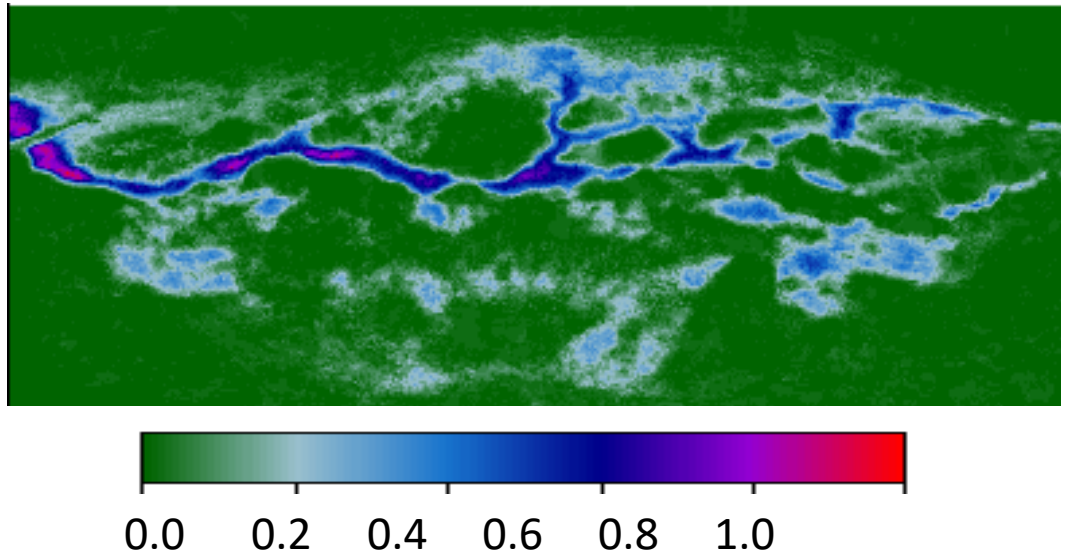

L1

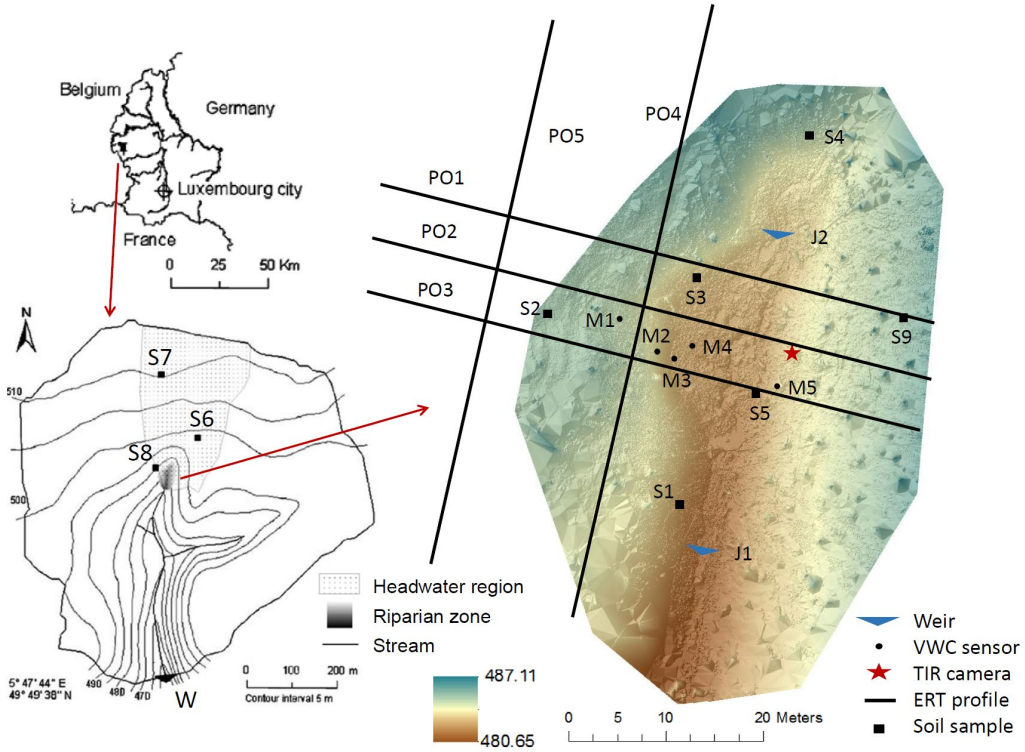

S2

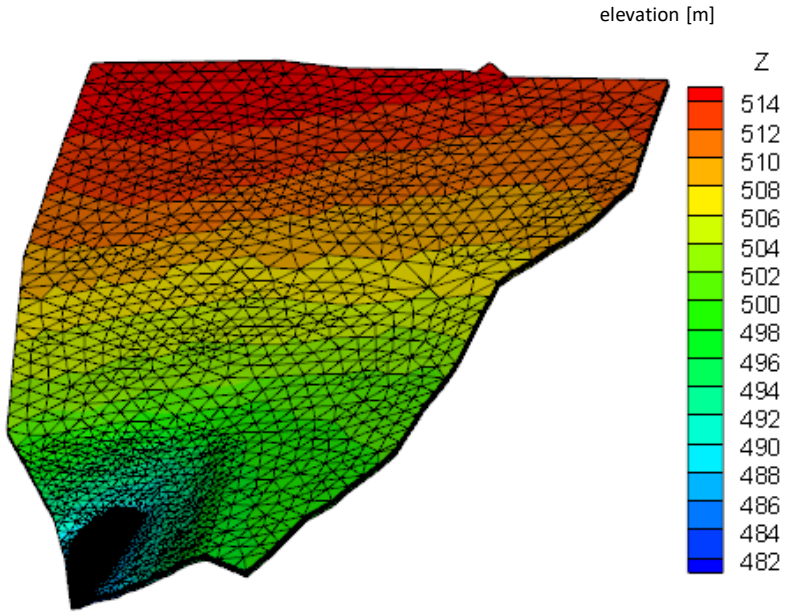


Temporal dynamic of saturation

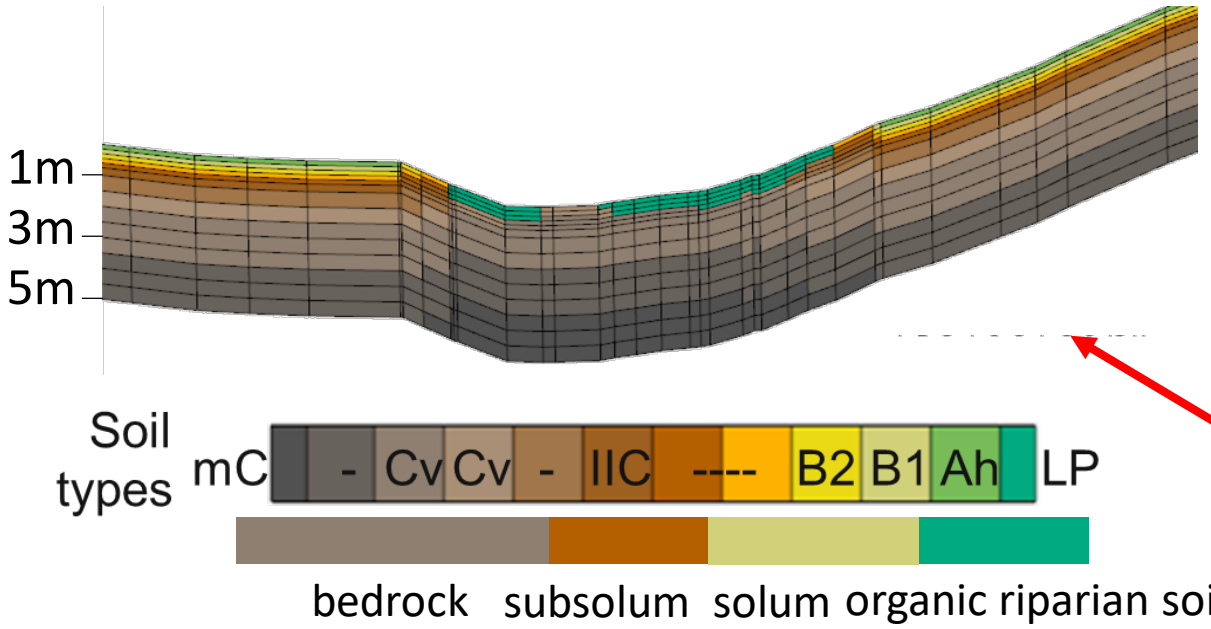


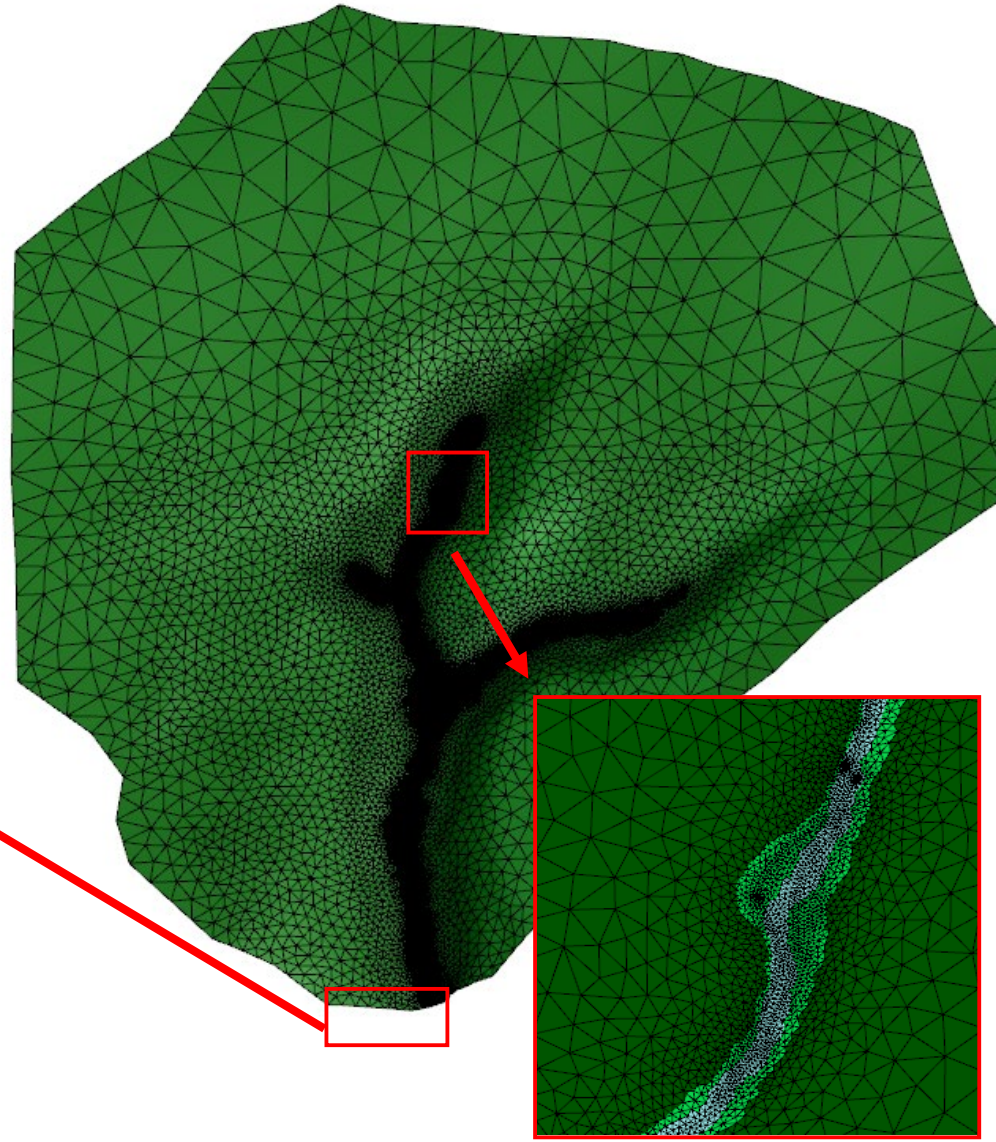



Belgium
Germany
Luxembourg city
France
0 25 50 Km
N
S7
S6
S8
510
500
5° 47' 44" E
49° 49' 38" N
490
480
470
W
0 100 200 m
Contour interval 5 m
PO1
PO2
PO3
PO4
PO5
S4
J2
S3
S2
M1
M2
M4
S9
M3
M5
S5
S1
J1
Headwater region
Riparian zone
Stream
487.11
480.65
0 5 10 20 Meters
Weir
VWC sensor
TIR camera
ERT profile
Soil sample


elevation [m]
Z
514
512
510
508
506
504
502
500
498
496
494
492
490
488
486
484
482

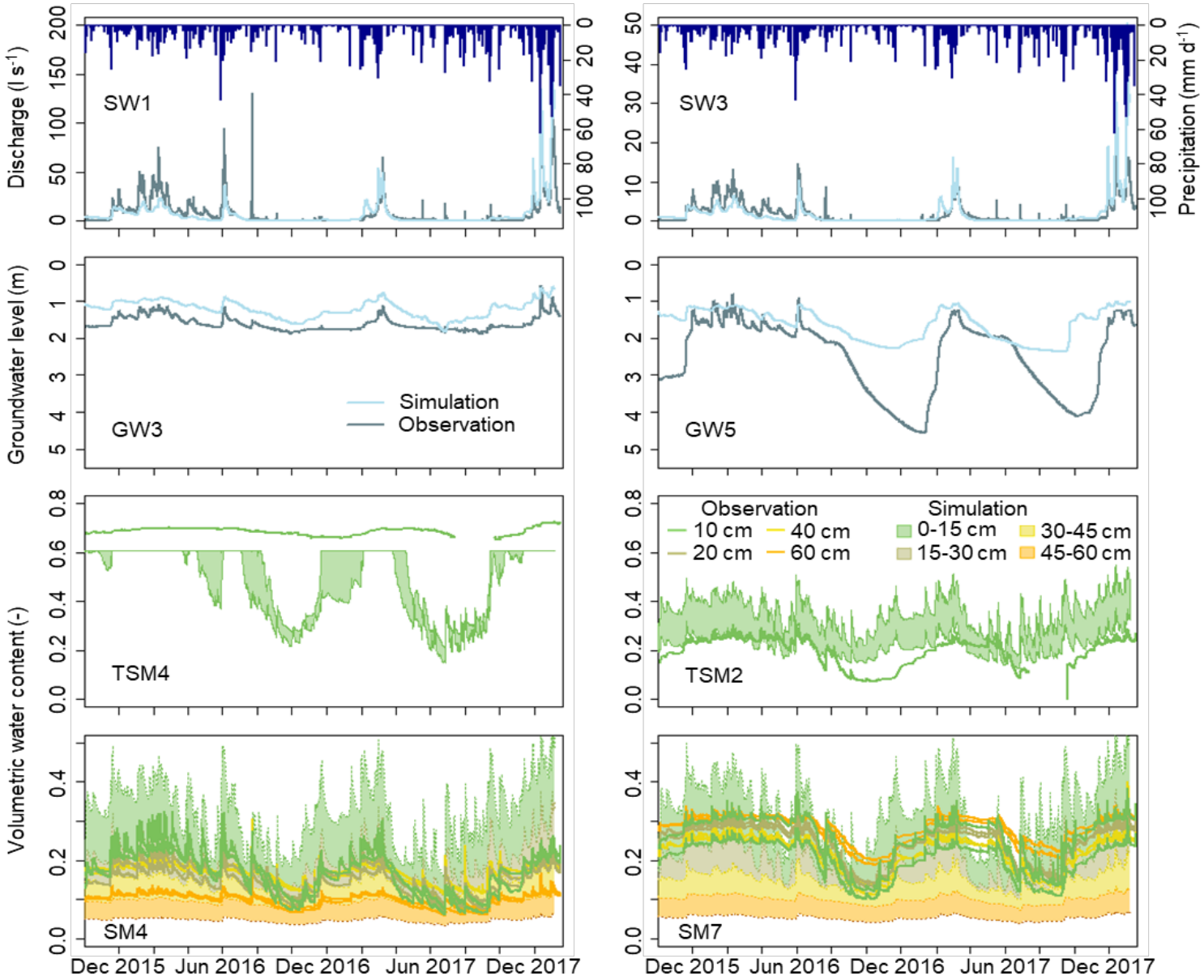
Implementing multi-sourced data to a surface-subsurface hydrological model

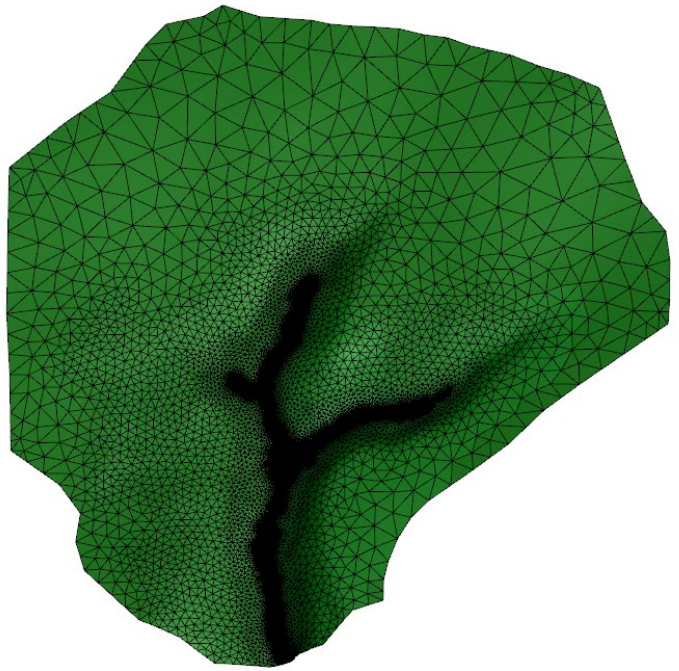




Glaser et al. (2020), HESS

Validation

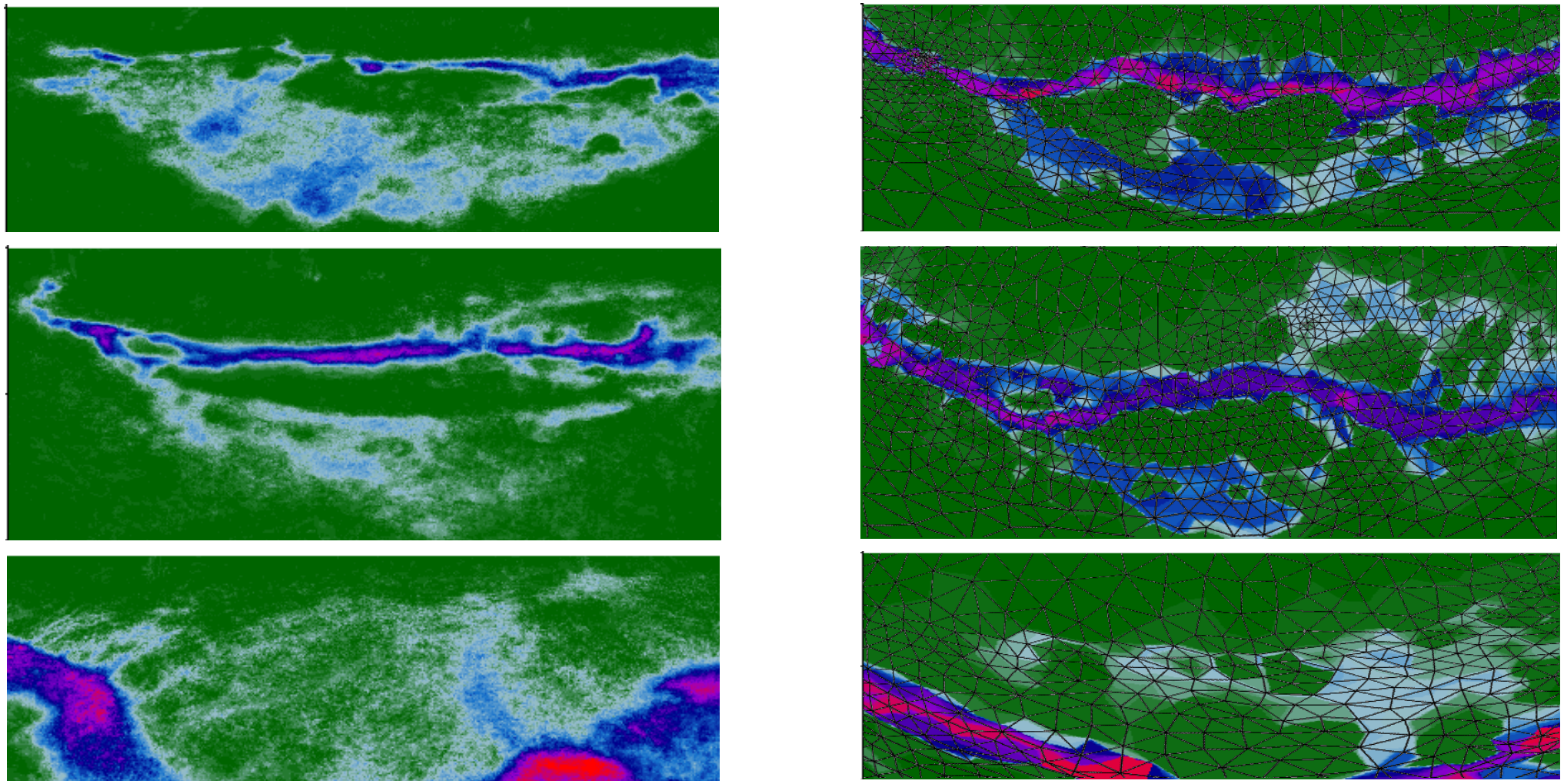




Glaser et al. (2020), HESS

Observation

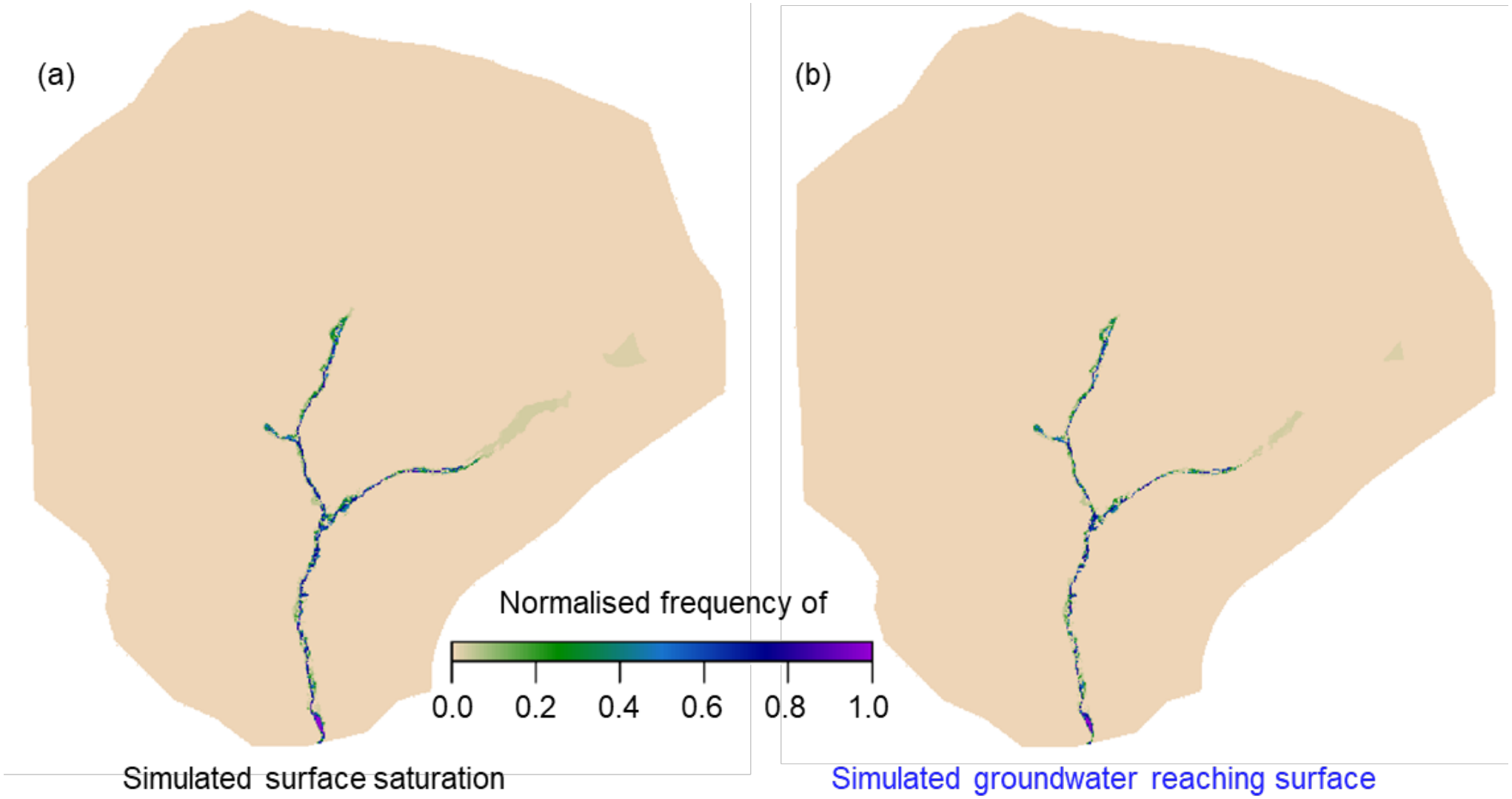
Simulation



Fraction of time of saturation

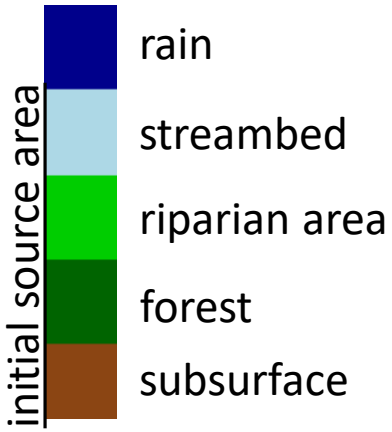
0.0 0.2 0.4 0.6 0.8 1.0

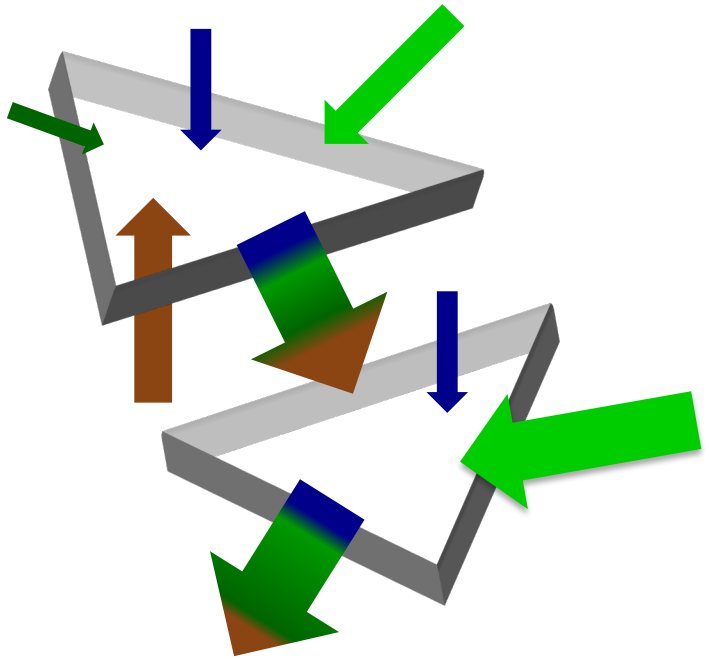
Glaser et al. (2020), HESS



Glaser et al. (2020), HESS

Where is the water coming from?

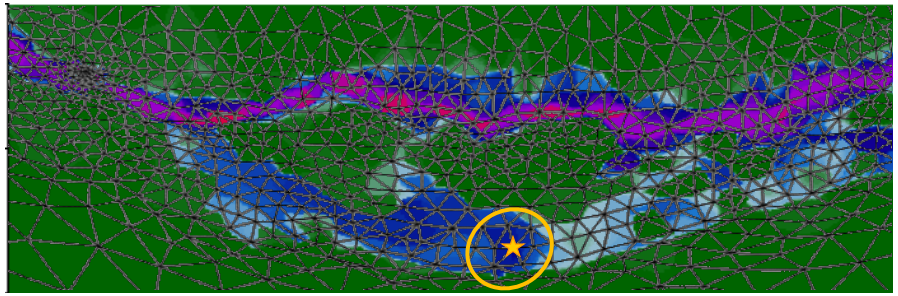




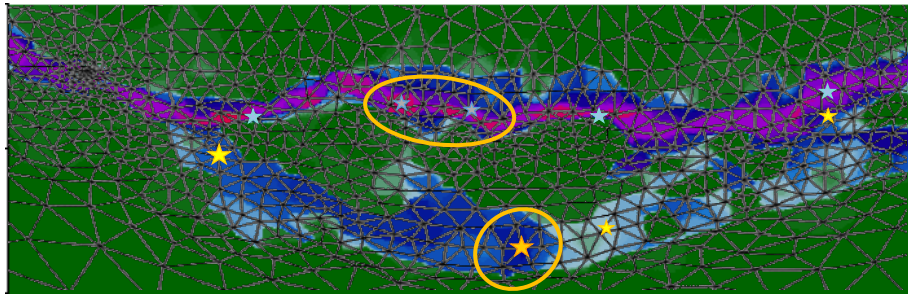
- Describing water/source transport with mixing cells
- Track ratios of mixing through the model cells

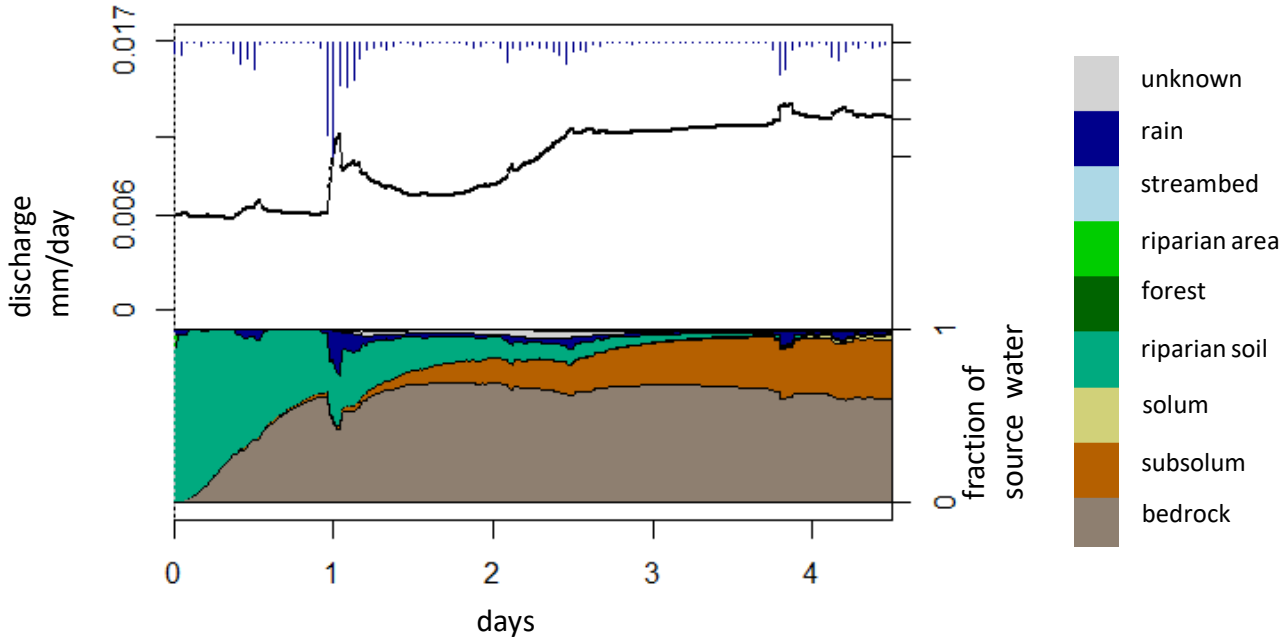
Glaser et al. (2021), WRR

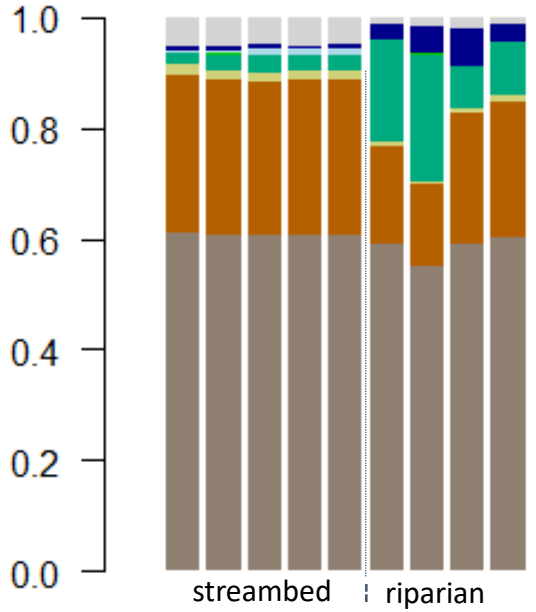
In time



...and space

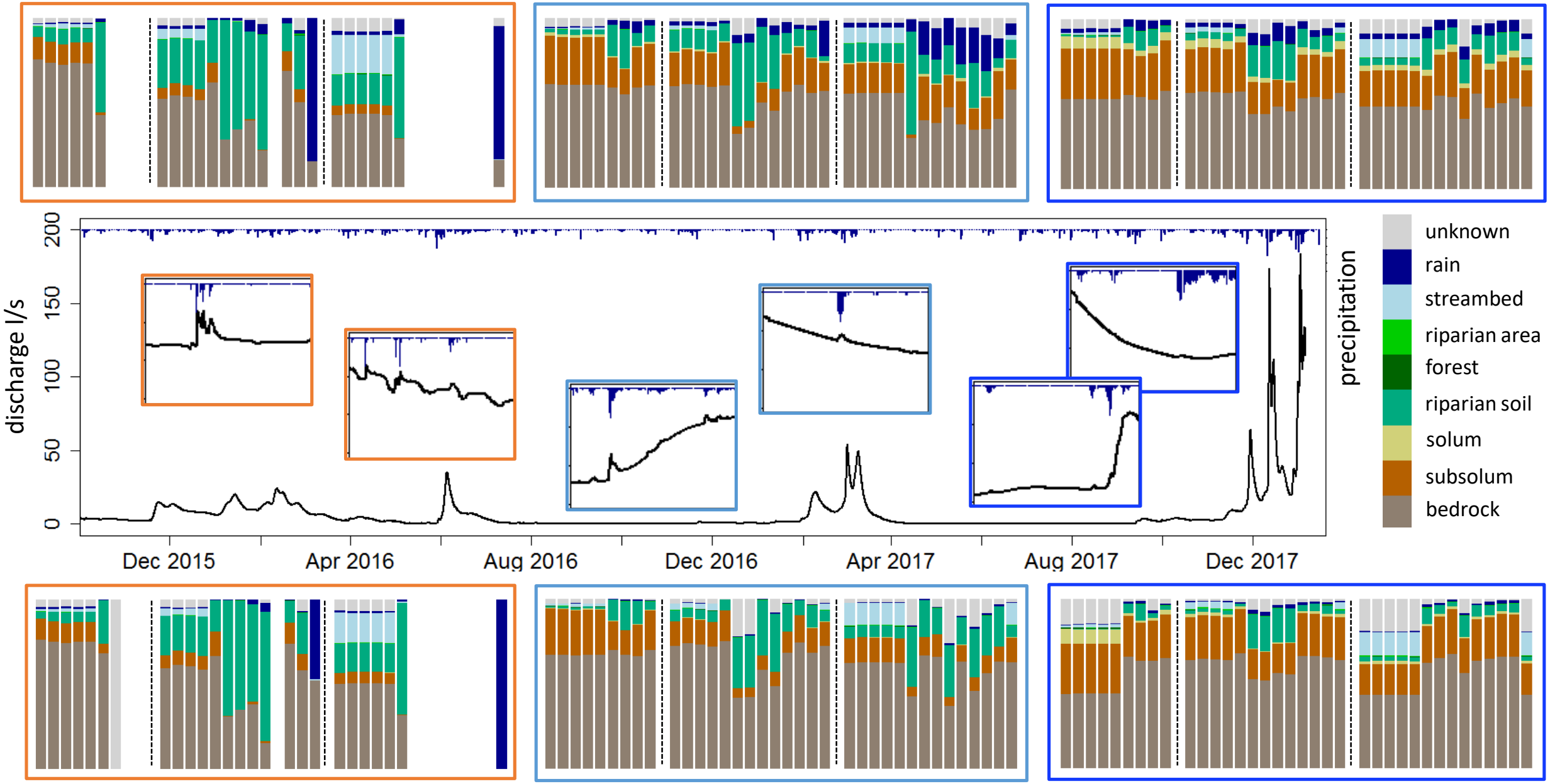




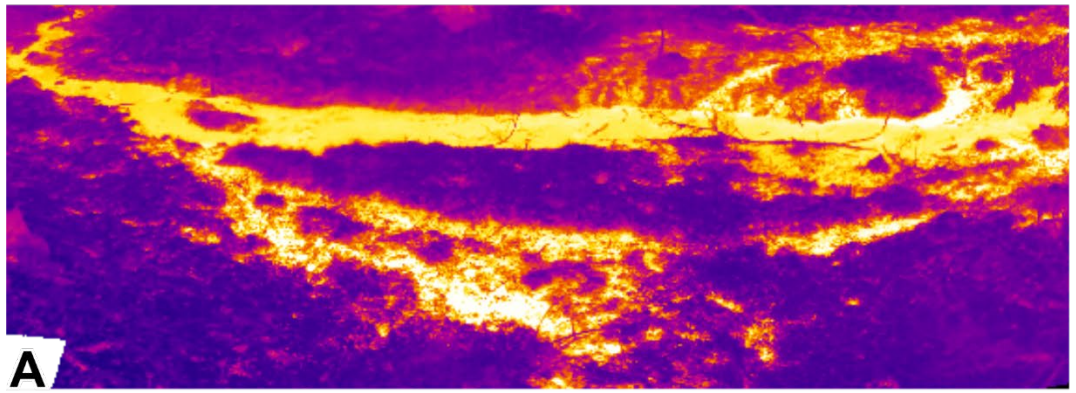


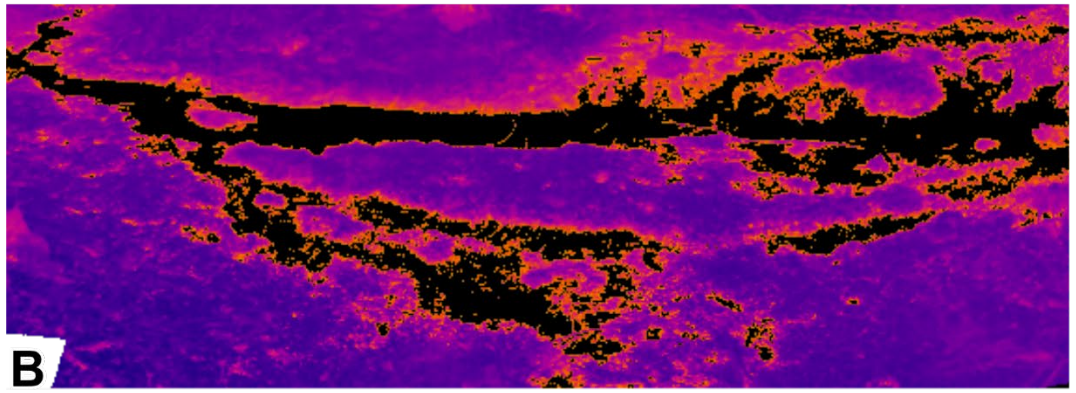
Glaser et al. (2021), WRR

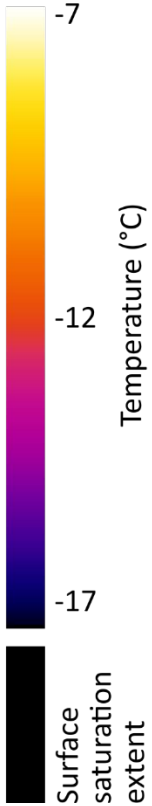
Wet-up

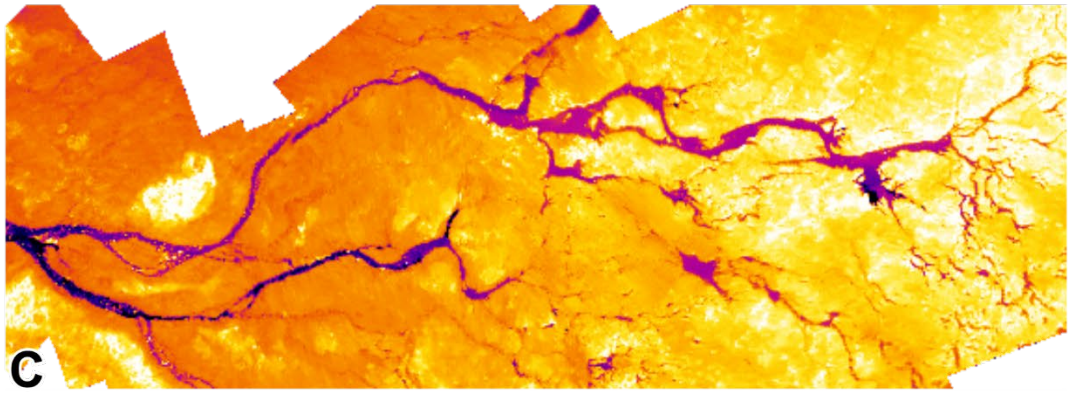


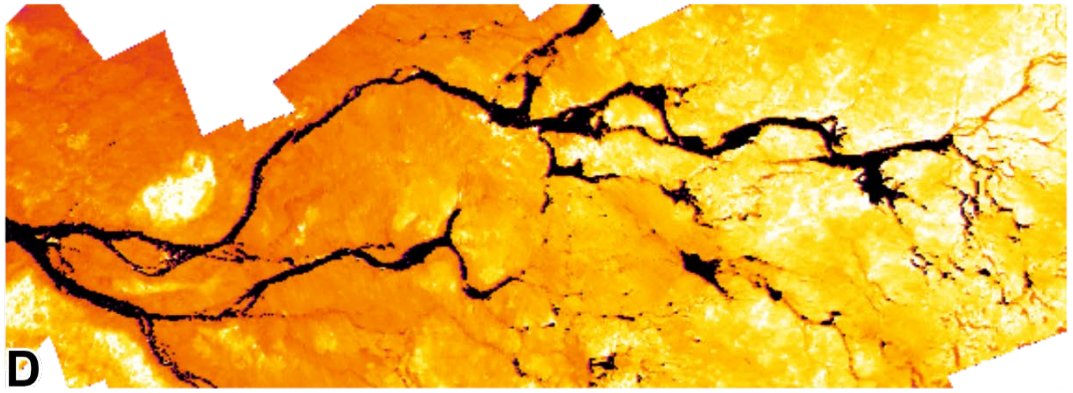
Dry-out

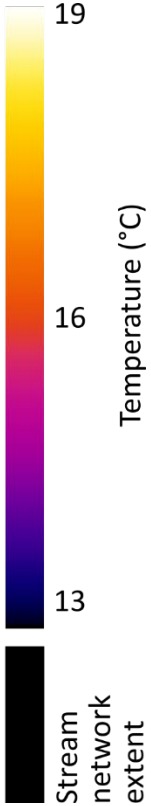


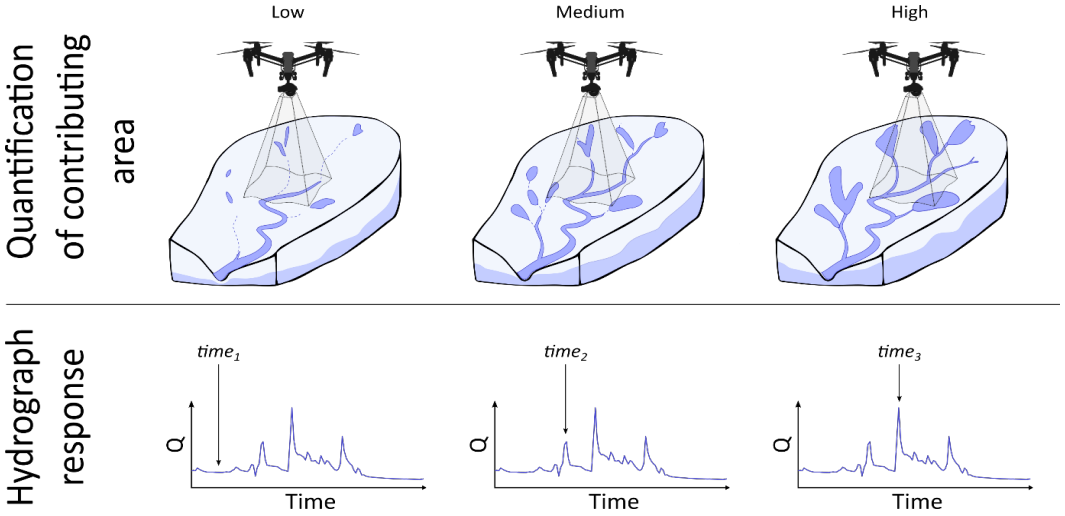






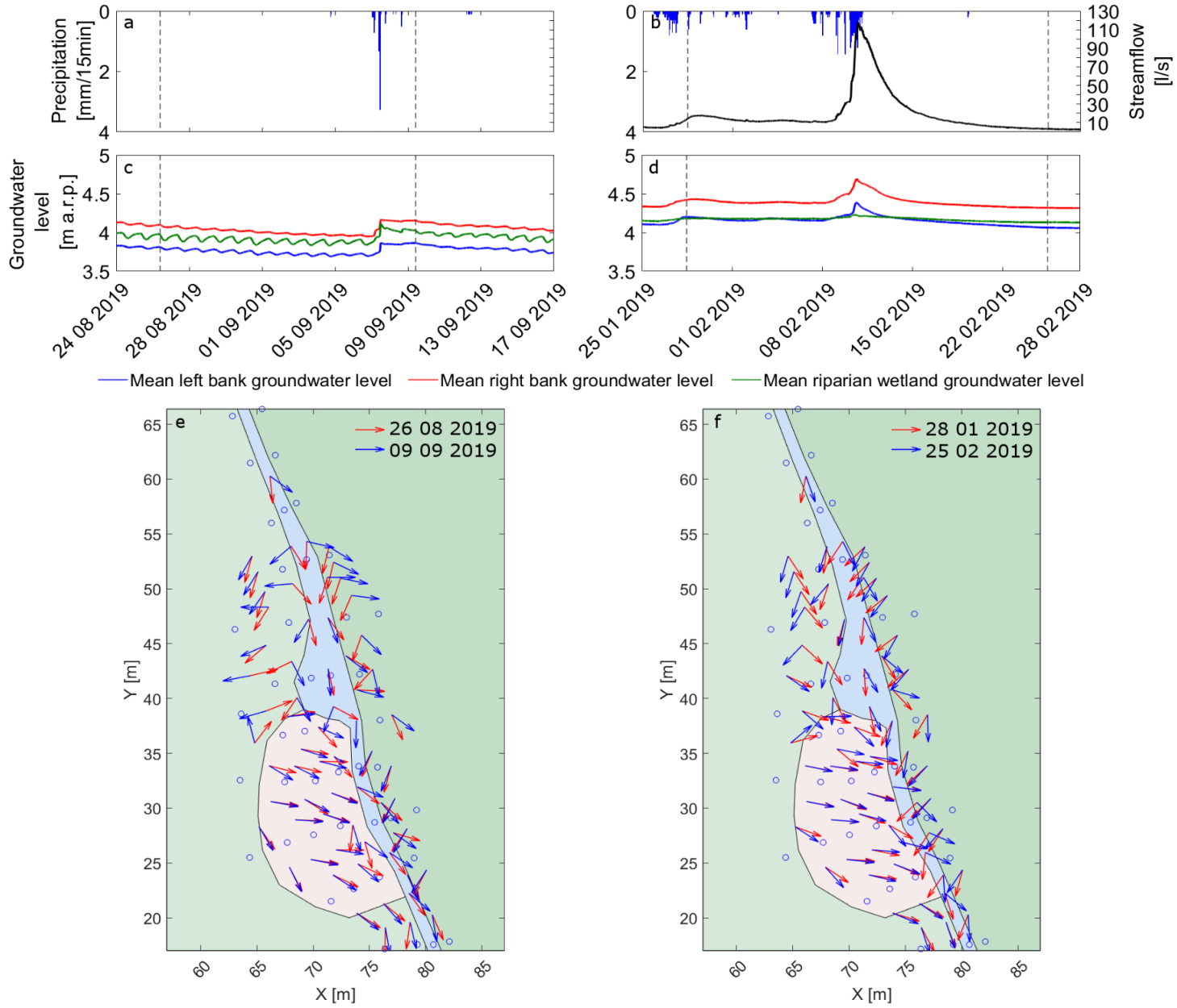




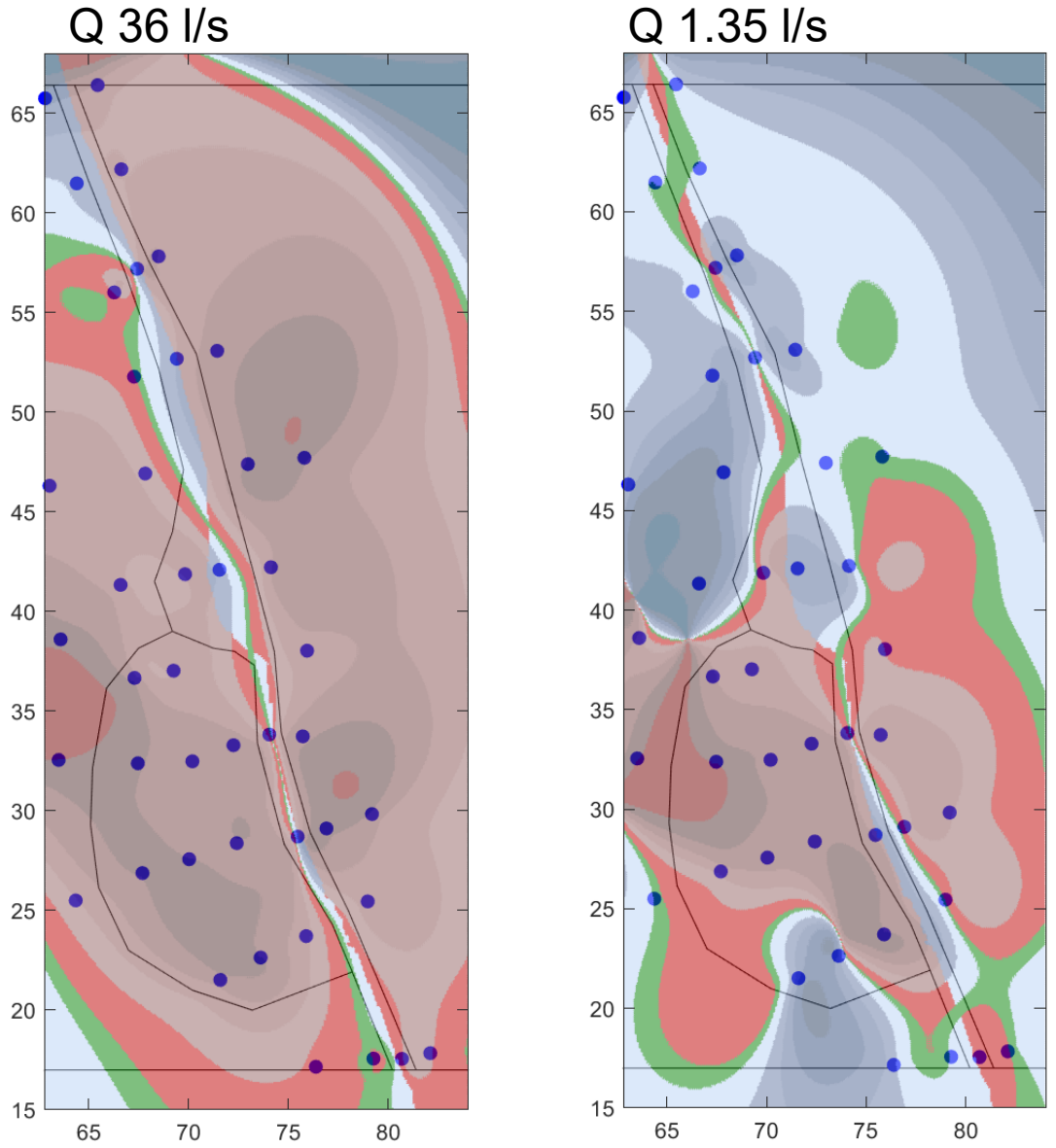


Dugdale et al. (2022), WRR

Now the experimental work

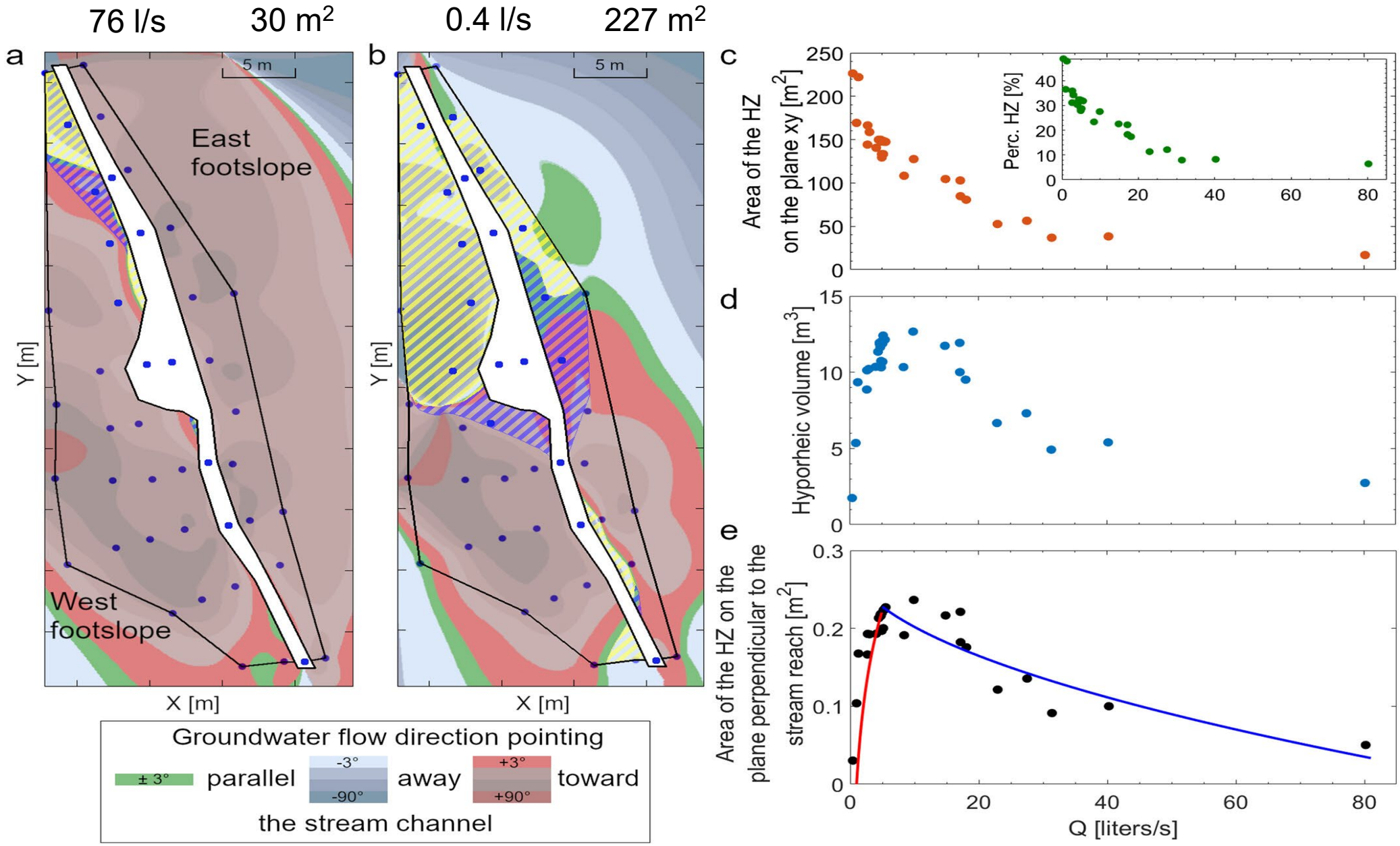


Bonanno et al. (2021), HP



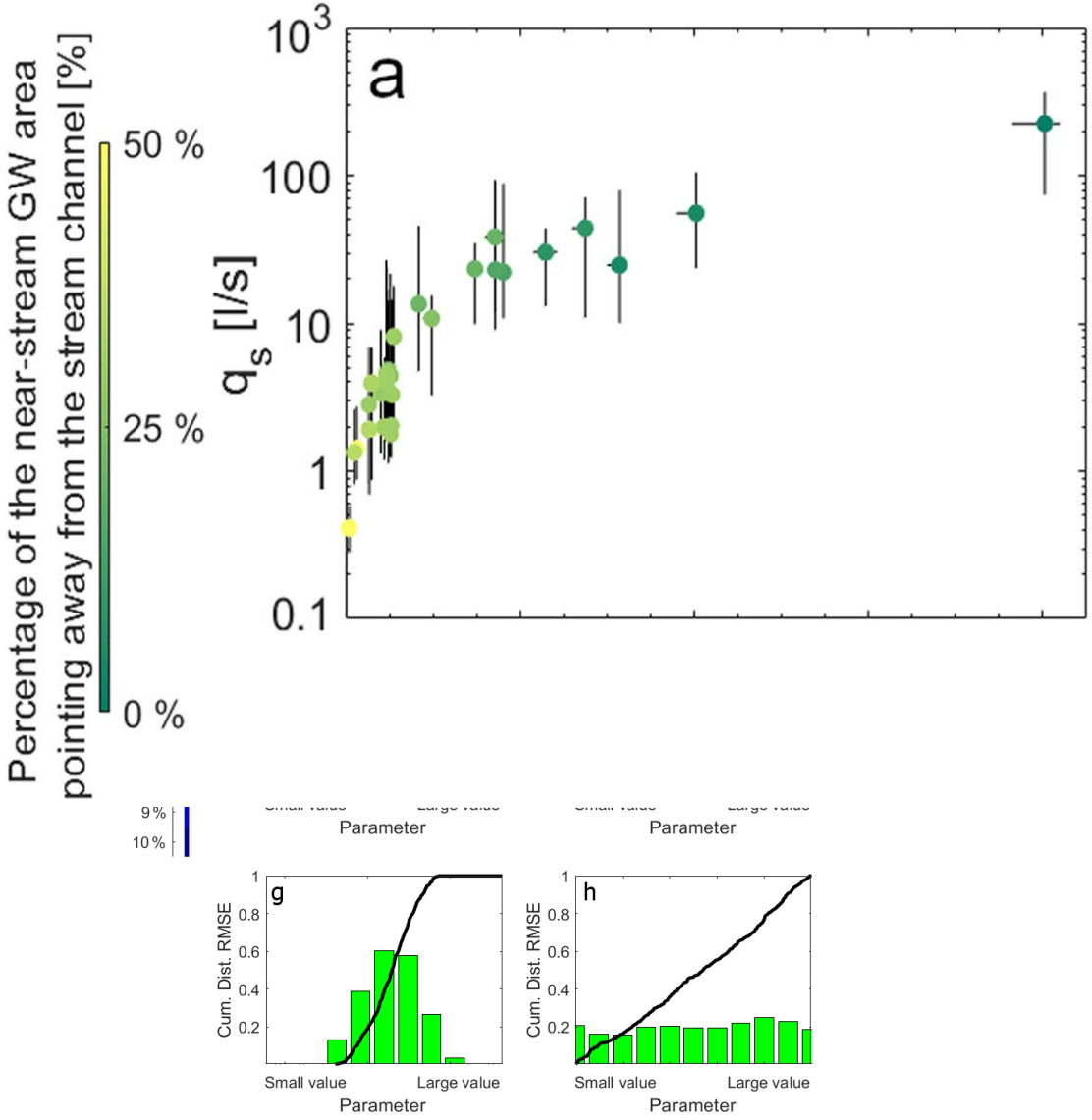
Dark blue: water moving from the channel toward the GW perpendicular to the channel
Light blue: water moving from the stream channel toward the GW
Green: water moving parallel to the stream channel
Light red: water flowing toward the stream channel
Dark red: water flowing almost perpendicularly toward the stream channel

Bonanno et al. (2021), HP

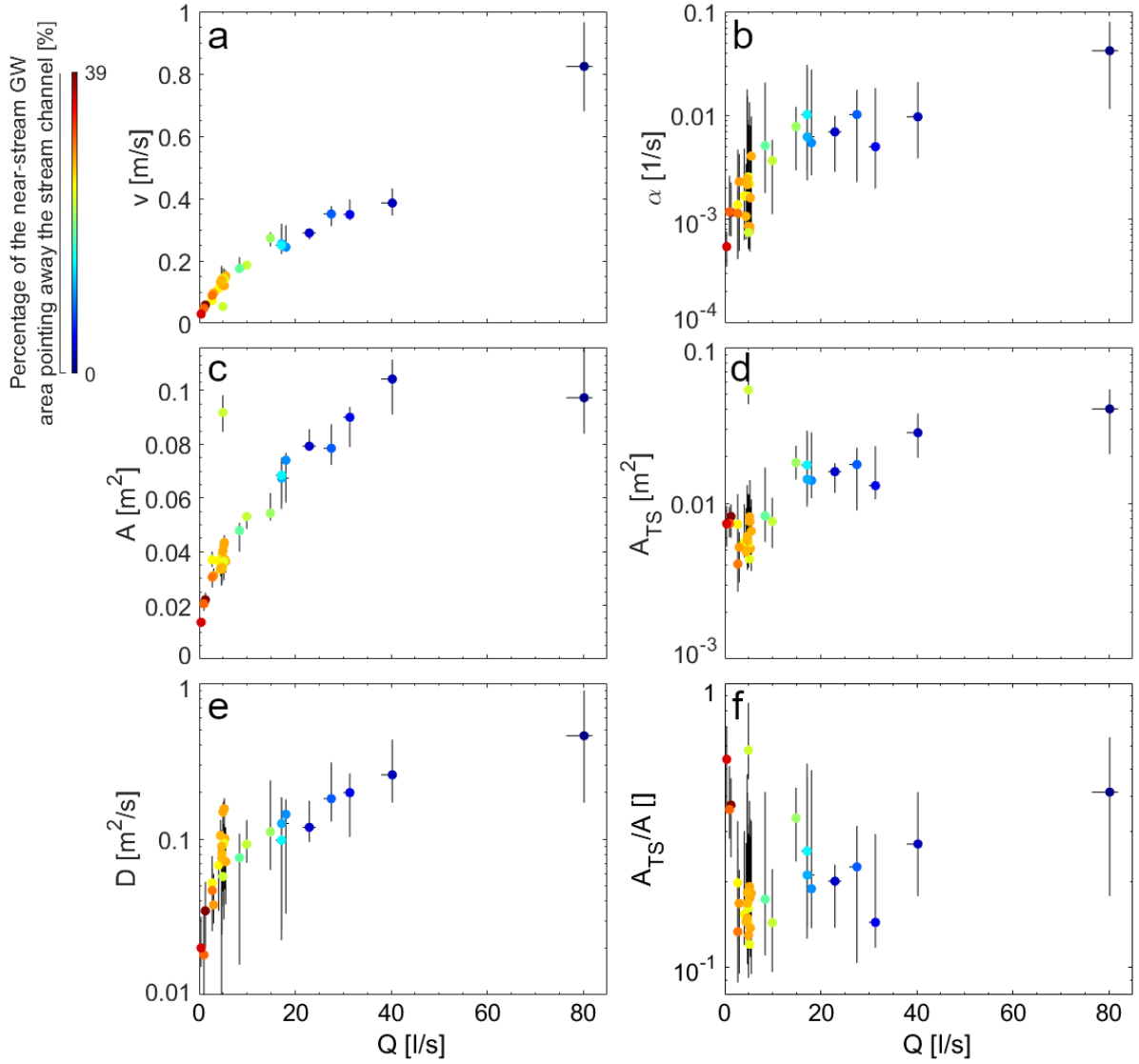


Bonanno et al. (2023),WRR

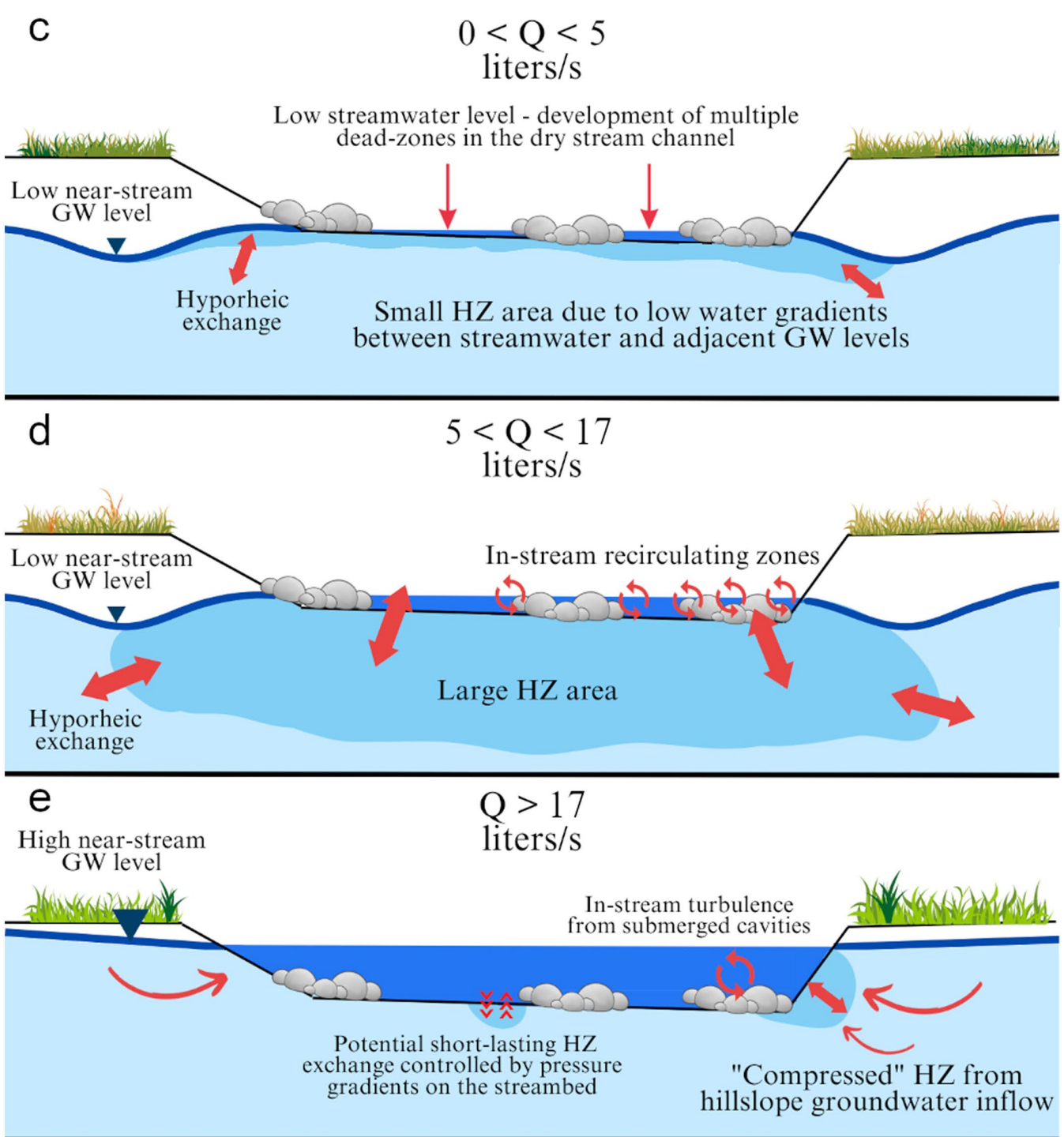
Tracer experiments – Transient Storage

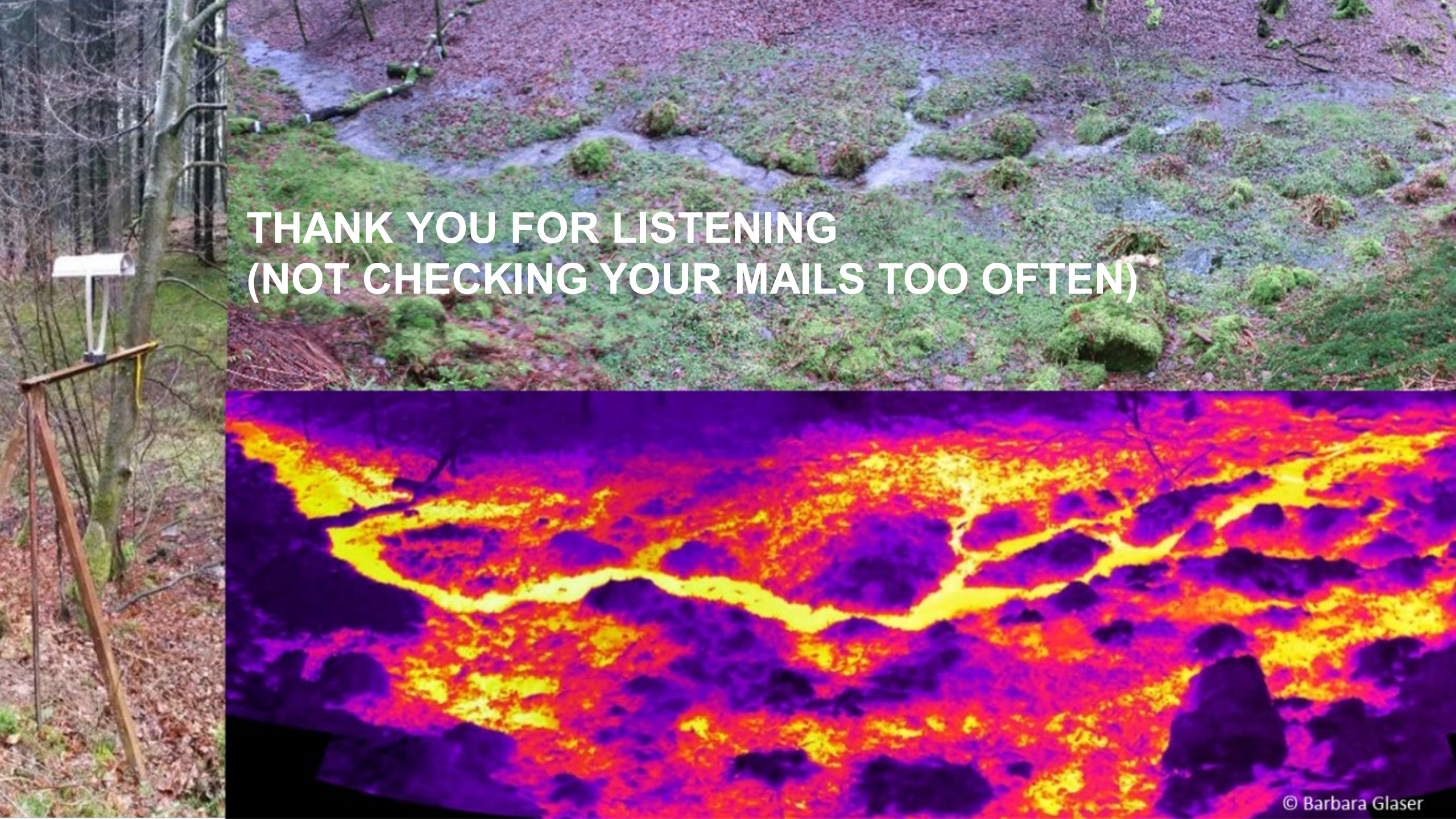


Bonanno et al., 2022, HESS



Bonanno et al., 2023, WRR


c
0 < Q < 5
liters/s
Low streamwater level - development of multiple
dead-zones in the dry stream channel
Low near-stream
GW level
Hyporheic
exchange
Small HZ area due to low water gradients
between streamwater and adjacent GW levels
d
5 < Q < 17
liters/s
Low near-stream
GW level
In-stream recirculating zones
Large HZ area
Hyporheic
exchange
e
Q > 17
liters/s
High near-stream
GW level
In-stream turbulence
from submerged cavities
Potential short-lasting HZ
exchange controlled by pressure
gradients on the streambed
"Compressed" HZ from
hillslope groundwater inflow


THANK YOU FOR LISTENING
(NOT CHECKING YOUR MAILS TOO OFTEN)
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