From point to catchment scale - using soil moisture observation to understand karstic discharge at the Swabian Alb (Germany)

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Motivation

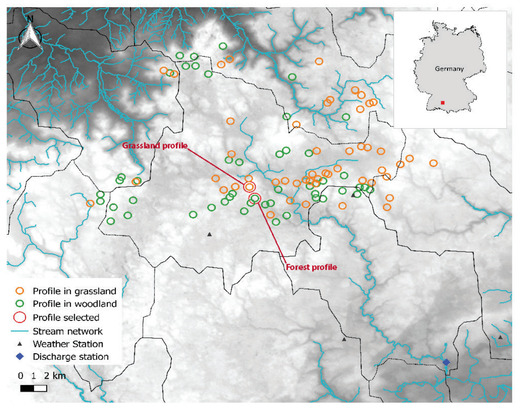
- The most typical approach to characterize a karst system: the disintegration of its output signal measured at the karst spring which includes discharge observations, the hydrochemical signal or tracer information

- In this ongoing study: elaboration on the value of soil moisture observations to characterize the karstic groundwater recharge dynamics

- Storage-discharge relationship in catchment can be hysteretic and can reveal different hydrological processes *

- Hysteresis analysis can help developping more realistis models for karst systems **

Study area, Experimental setup & Data



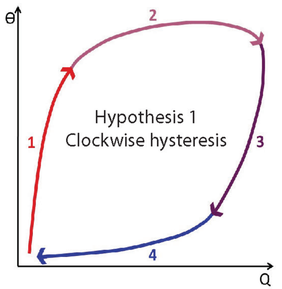
Study area

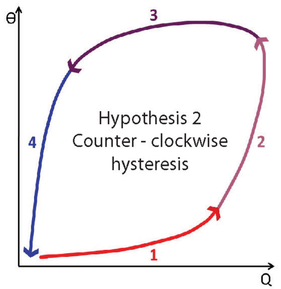
Location:	Swabian Alb - Baden-Württemberg - Southwest Germany
Geology:	Upper Jurassic carbonate rocks - Karstified
Soil:	Rendzina soil

Data

Soil moisutre data:	50 soil moisture profiles measurement in grassland 49 soil moisture profiles measurement in woodland Soil moisture probe at 10 and 20 cm depth Measurements from 2009 to 2017 - 1h resolution
Discharge data:	GrosseLauter river - 1h resolution
Rainfall data:	1h resolution

Hypotheses & approach





1- The discharge does not react immediatly to the rainfall event - the soil moisture increases

2- The discharge increases while the soil saturation is reached

3- The soil moisture decreases but the discharge continue to increases because of infiltration

4- The discharge descreases

1- The discharge reacts quickly after the rainfall event while the soil moisture does not react

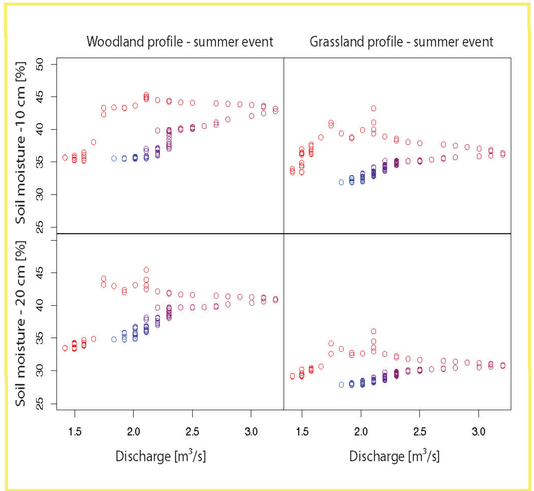
2- The soil moisture increases but its doesn't affect directly the discharge reaction that it is still increasing

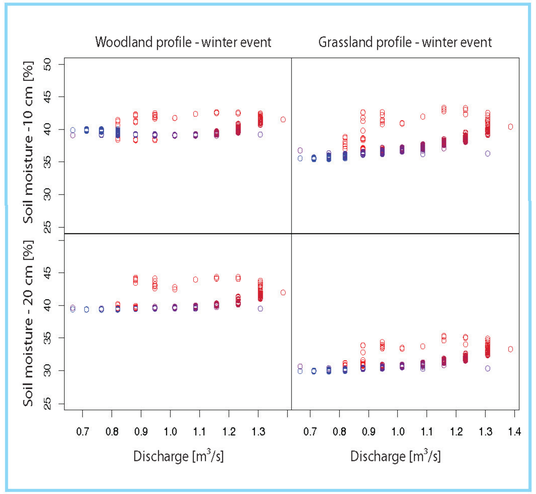
3- The discharge decreases and soil moisture begins to decrease

4- The soil moisture decreases

First qualitative analysis
-> Selection of 1 profile in the grassland, 1 profile in the woodland equipped with soil moisture probes at 10 cm and 20 cm depth
-> Selection of 1 soil moisture - discharge event during summer (dry conditions) and 1 soil moisture - discharge event during winter (wet conditions)

Results





Start of the event — End of the event

Clockwise reaction observed: it seems that the soil storage has first to be refilled before the water is infiltrated to the saturated zone.

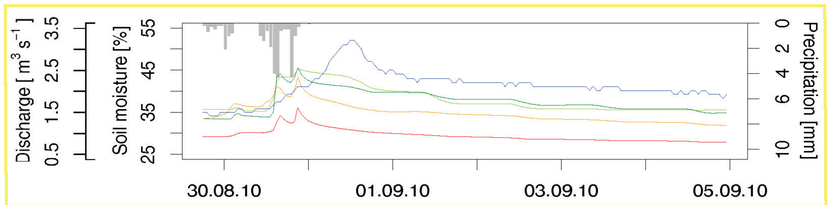
The woodland soil moisture increases faster than in the grassland: it can be interpreted as the presence of preferential flow

Clockwise reaction and the faster increase of soil moisture in woodland still observed during the winter event.

The hysteretic curve is less wide compared to the curve during the summer event, the soil moisture thinly increases compare to the discharge. The field capacity seems to be reached faster than during the summer event.

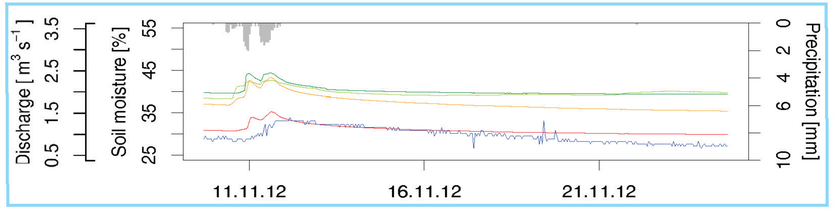
Selected events

Summer event - duration ~ 6 days



Woodland Soil moisture –10cm
Woodland Soil moisture –20cm
Grassland Soil moisture –10cm
Grassland Soil moisture –20cm

Winter event - duration ~ 15 days



Conclusions

- Hysteresis reaction observed, with only the clockwise direction in this study

- New possibility to identify karst hydrological processes in a qualitative way

- Different behaviors observed between land uses and antecedent hydrological conditions

Perspectives

This approach has been conducted on 2 profiles and 2 events. It will be applied to a larger number of profile and events in a systematic way. Other measurements and analyses will be included to improve processes characterization. For instance, independent estimates of evapotranspiration will help to separate unsaturated percolation in the soil from the reduction of soil moisture due to vaporization.

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* Fovet, O., L. Ruiz, M. Hrachowitz, M. Faucheux, and C. Gascuel-Odoux. 2015. 'Hydrological Hysteresis and Its Value for Assessing Process Consistency in Catchment Conceptual Models'. Hydrology and Earth System Sciences 19 (1): 105–23. https://doi.org/10.5194/hess-19-105-2015.
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