Storage and redistribution in the forest floor influence evaporation, retention and infiltration patterns

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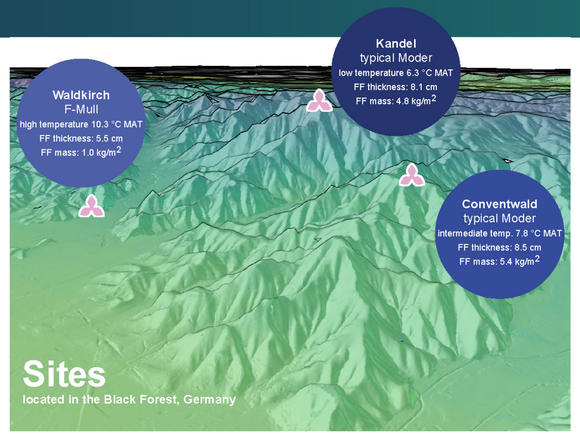
HYDROLOGY

Motivation

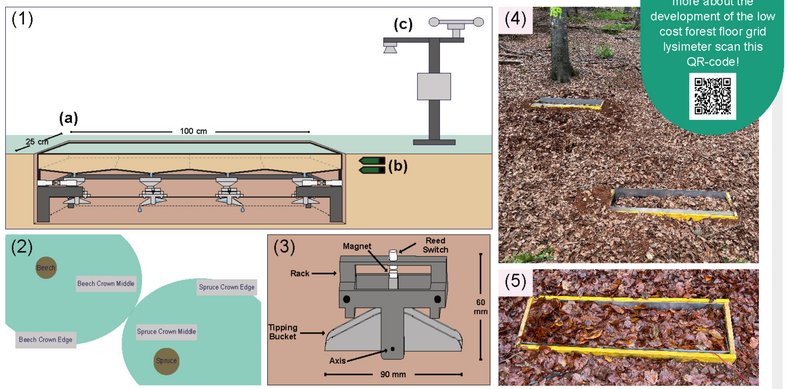
The forest floor (FF) has a high water retention capacity, which facilitates water transfer between the atmosphere and the soil. However, little is known about the FF's water retention characteristics and water transport effects.

Due to the prevalence of laboratory studies on the storage capacity of a forest's litter layer, we designed and built a new grid lysimeter to directly and in-situ measure water fluxes from and into the FF. The goal was to learn more about **storage capacities**, **retention durations**, evaporation rates, and the resulting **infiltration redistribution patterns.**

We present the findings from a network of forest floor lysimeters and soil moisture probes installed at three different altitudes in the Black Forest, southwest Germany. The three sites have an annual mean temperature gradient of 6.3°C to 10.3°C, resulting in humus forms ranging from typical F-Mull to typical Moder according to KA6.



Materials & Methods



If you want to learn more about the development of the low cost forest floor grid lysimeter scan this QR-code!

- Our sensor network includes:
  - four forest floor grid lysimeters (FFGL) (1a), arranged to always have two below beech and two under spruce trees, one in the crown middle and below the crown edge (2)
  - soil moisture probes next to the lysimeters at 5 and 15 cm depth (1b)
  - microclimate stations: air temperature, humidity and wind speed below the canopy (1c).
- The quantification of water fluxes works by combining the continous weight measurement of load cells and the drainage data from the specifically developed 3D-printed tipping bucket system (3).
- The photos show the position of the lysimeters in the forest (4+5).

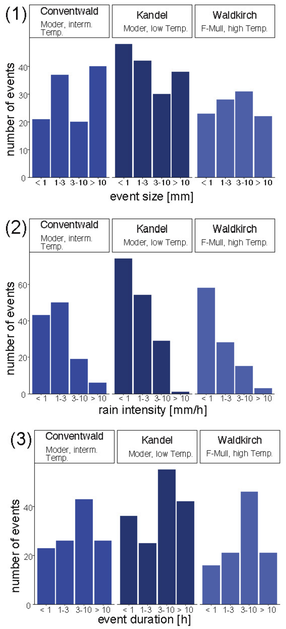
To analyse the observed data (Aug. - Nov. 2024), we first had to define events with different characteristics.

An event occured whenever 3 successive timesteps show a positive change in lysimeter weight of at least 5 g.

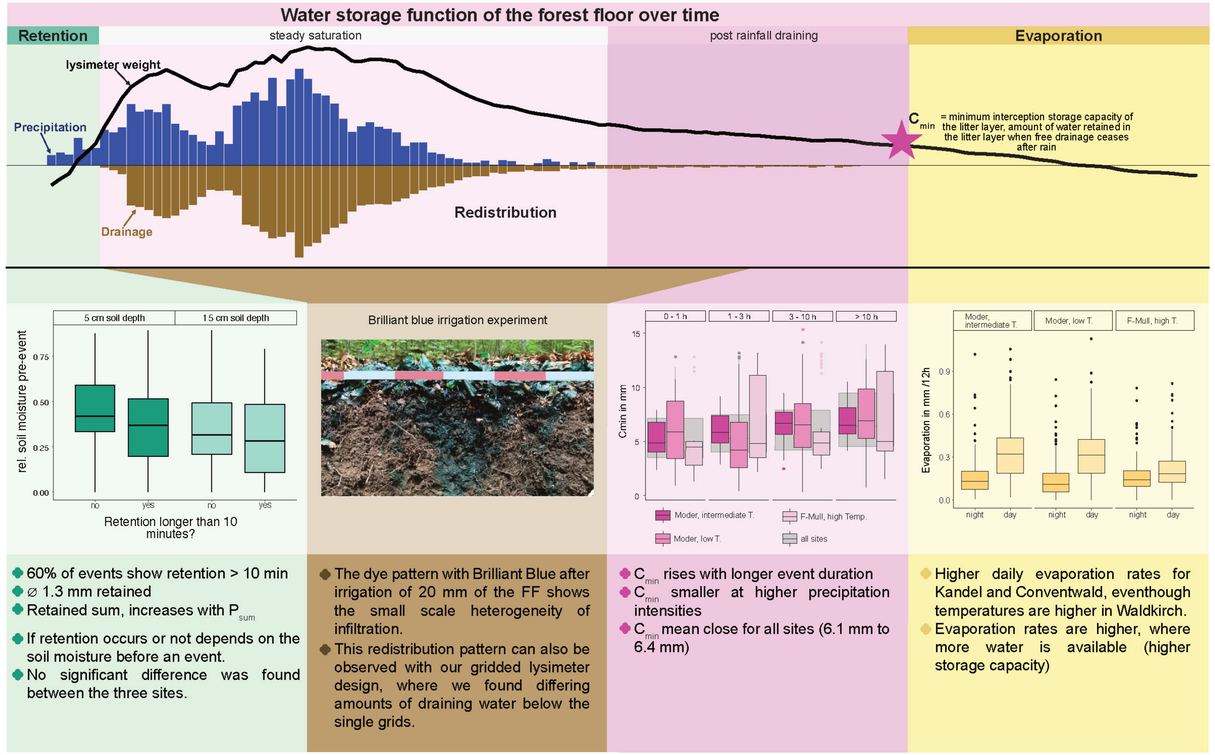
Total precipitation must be greater than 0.5 mm, and the events must be separated by a minimum of six hours free from precipitation.

In total, we observed 380 events across 12 lysimeters.

Events were categorized by size (1), intensity (2), and duration (3).



Results



- 60% of events show retention > 10 min
- ⌀ 1.3 mm retained
- Retained sum, increases with P_{sum}
- If retention occurs or not depends on the soil moisture before an event.
- No significant difference was found between the three sites.

- The dye pattern with Brilliant Blue after irrigation of 20 mm of the FF shows the small scale heterogeneity of infiltration.
- This redistribution pattern can also be observed with our gridded lysimeter design, where we found differing amounts of draining water below the single grids.

- C_{min} rises with longer event duration
- C_{min} smaller at higher precipitation intensities
- C_{min} mean close for all sites (6.1 mm to 6.4 mm)

- Higher daily evaporation rates for Kandel and Conventwald, eventhough temperatures are higher in Waldkirch.
- Evaporation rates are higher, where more water is available (higher storage capacity)

Conclusion

We present the small-scale variation of spatio-temporal infiltration and storage patterns influenced by the forest floor.

- Pre-event soil moisture influenced water retention the most.
- Forest floor type influenced minimum storage capacity.
- Moder shows higher storage capacities than the F-Mull.
- Evaporation depens on the amount of water stored in the organic layer.

What's next?

We will further investigate water fluxes of the forest floor along different
- ... seasons, ...
- ... climatic conditions, and ...
- ... forest floor types (broadleaf vs. needle litter).

In a next step we will include LED-based optical sensors below the lysimeters to allow us to link water and carbon fluxes in the forest floor.

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