Subsurface-state equals runoff?- it depends

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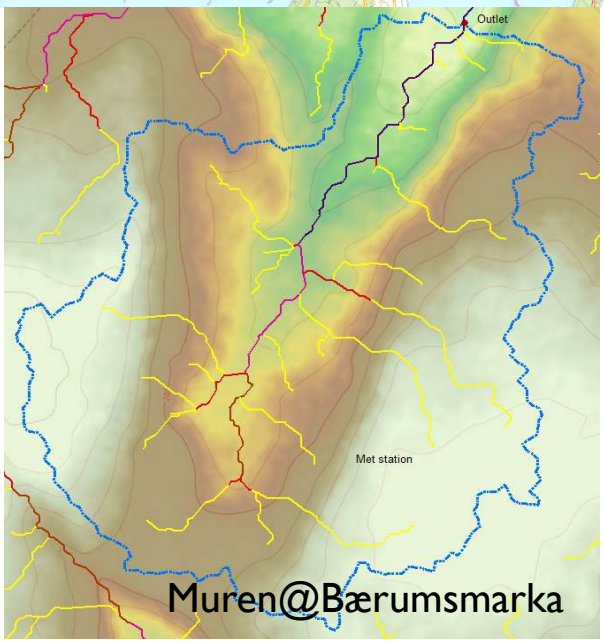
Foto Heidi Bache Stranden

The Muren catchment

- The Muren research catchment was re-established 2017 in order to answer, or provide some insight into:
- What is the relationship between subsurface storage and runoff?
- What is the relationship between the subsurface storage, runoff recession and the celerities/velocities of water transported out of the catchment

Where are we?

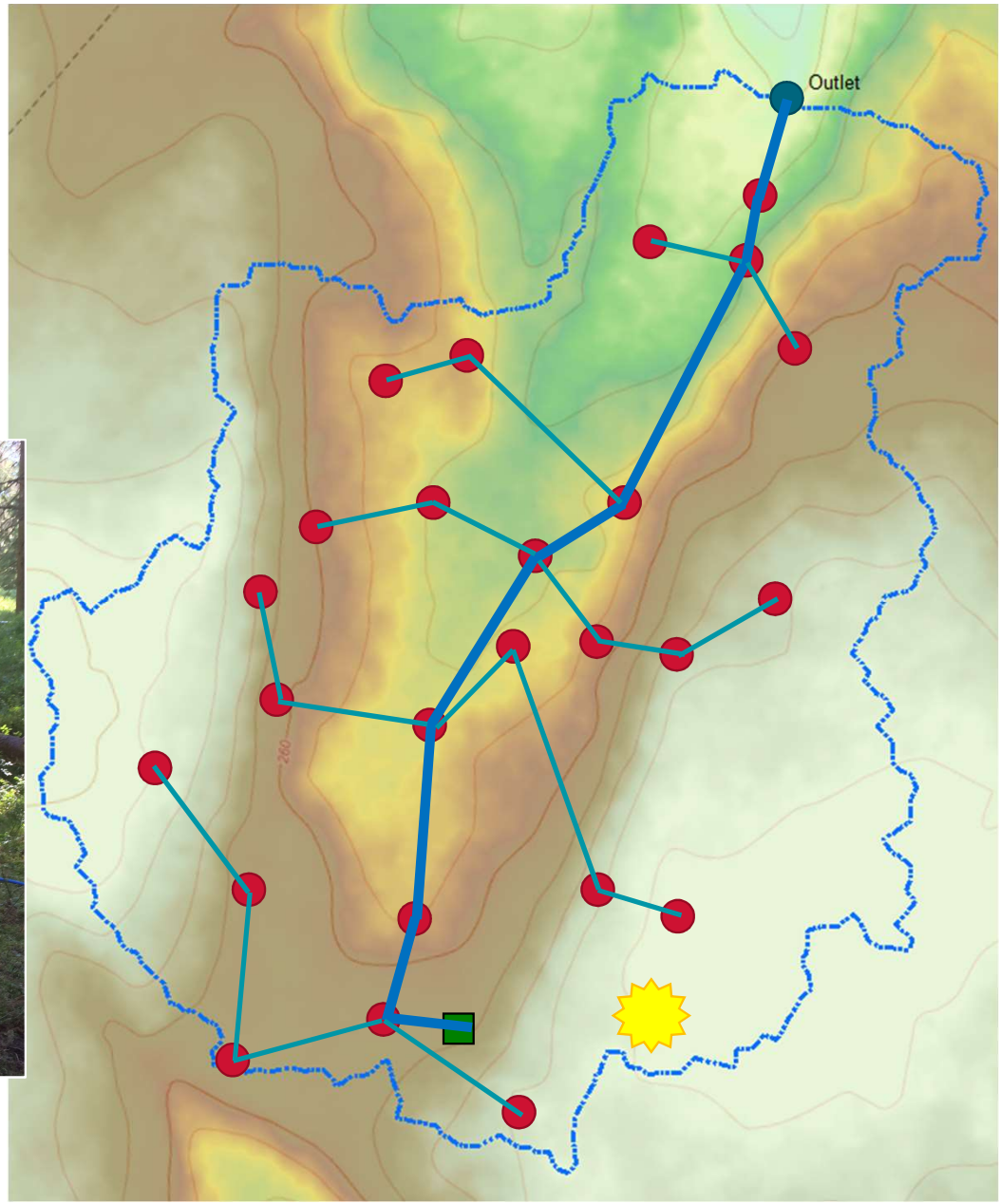
Catchment area 0.0075 km² (=7500 m²),
forested, shallow glacial till (< 0.8 m)



-In order to help us:

-25 groundwater wells are installed (records every 15 minutes)

-Runoff measurements with «state of the art flowmeter»



Estimating time series of catchment-scale subsurface storage

- 25 observation points of distance from top of soil to GWL (DTS)
- Soildepth (SD from Myrabø et al, 1994, 126 measurements)
- Kriging interpolation of SD and DTS
- Estimated GWL(x,y,t)= SD(x,y,t)-DTS(x,y,t)
- Catchment-scale subsurface storage, S(t)= mean(GWL(x,y,t))

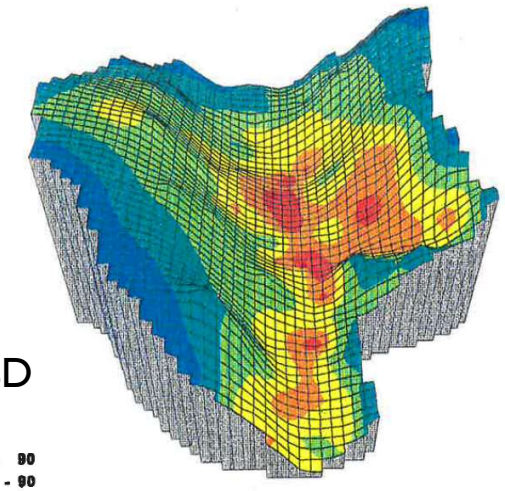
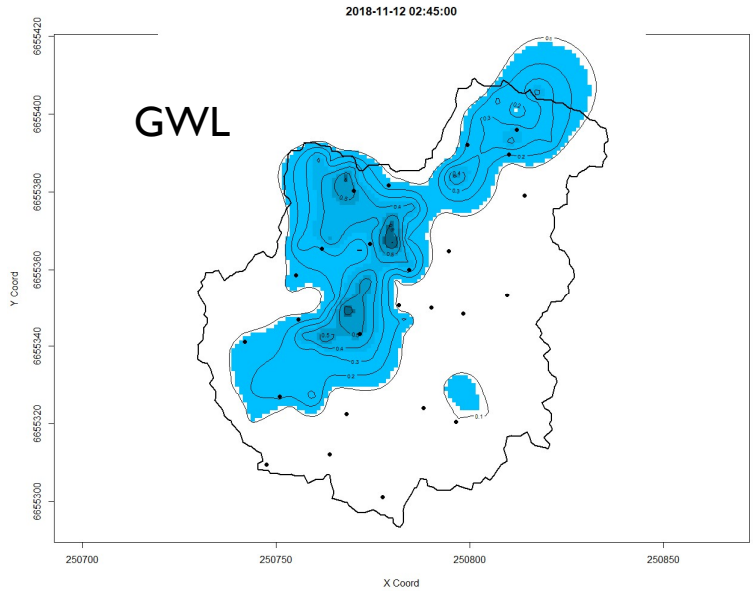
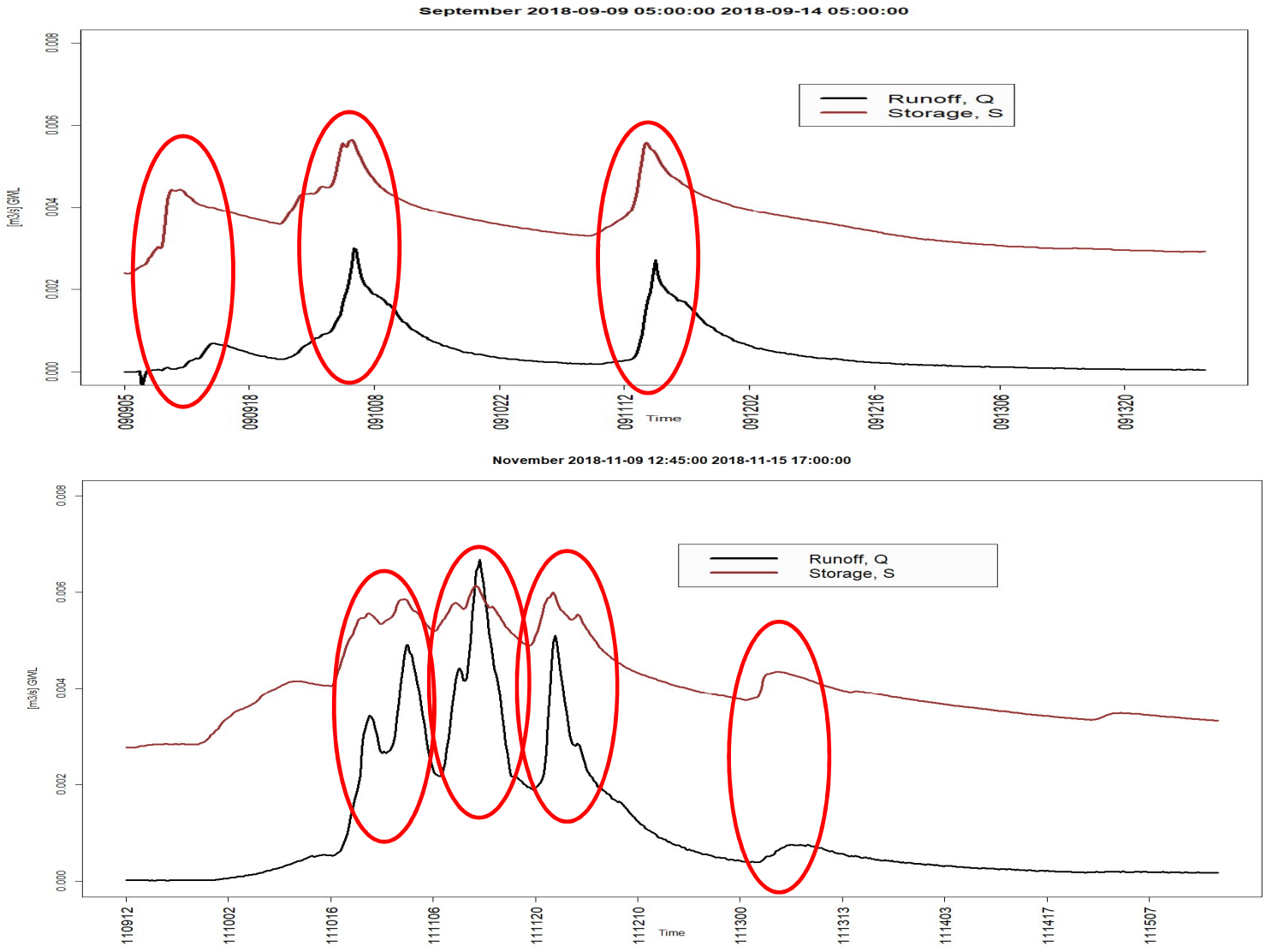


Figure: Myrabø et al. 1994

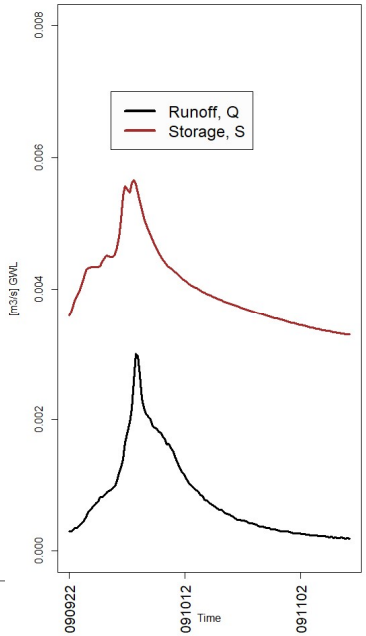


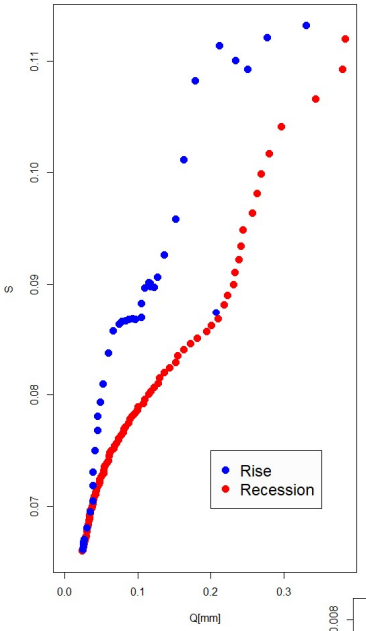
Runoff and Storage at Muren September and November 2018

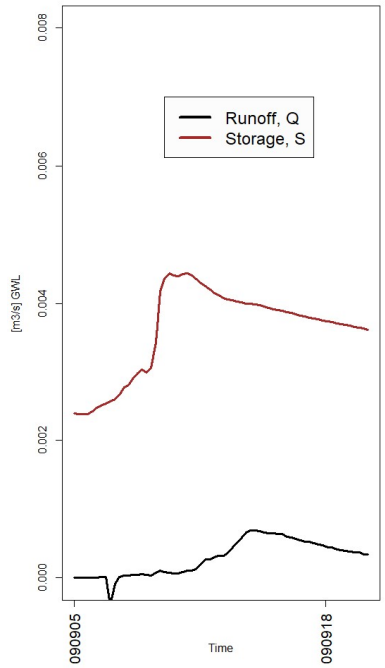
A closer look at these events..

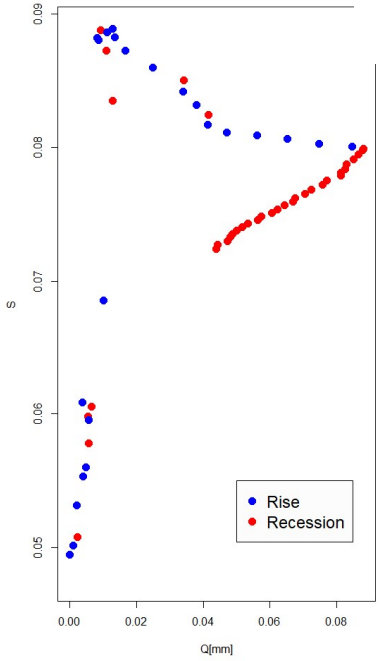


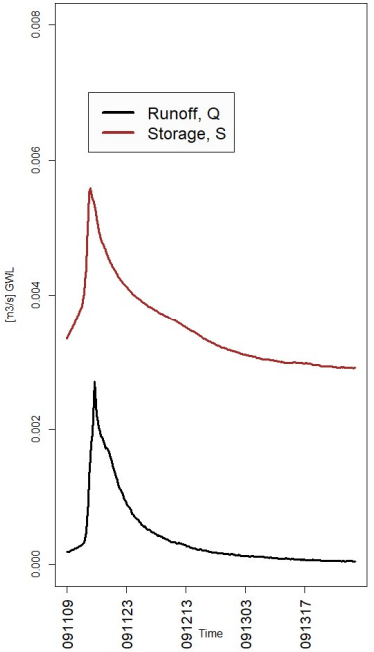
September 2018 events

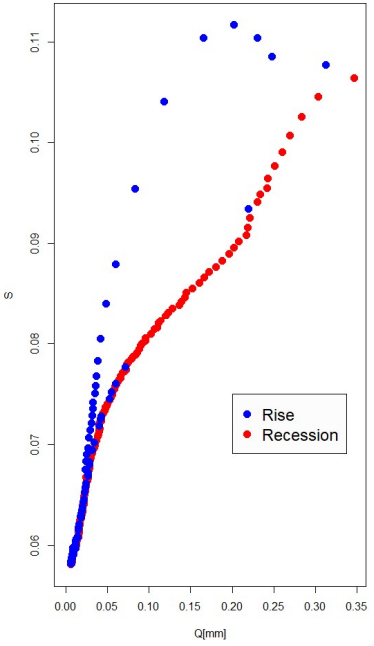


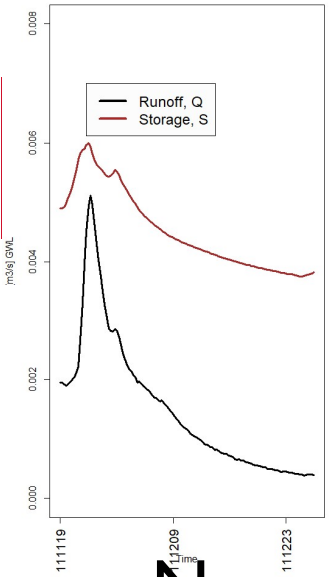


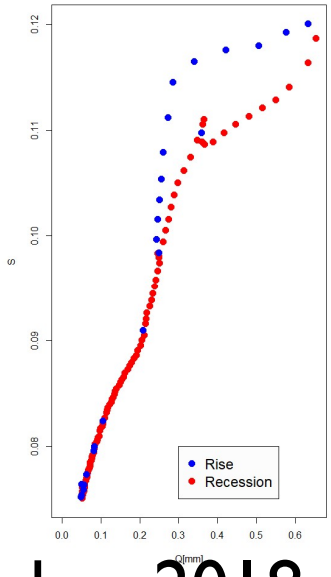


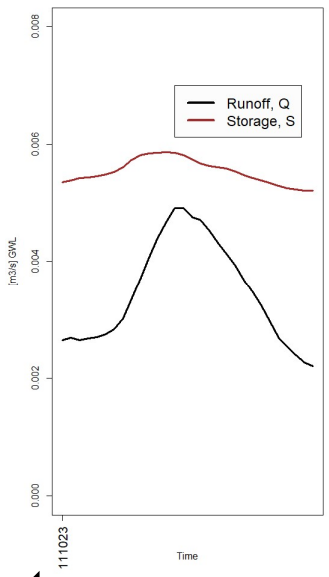


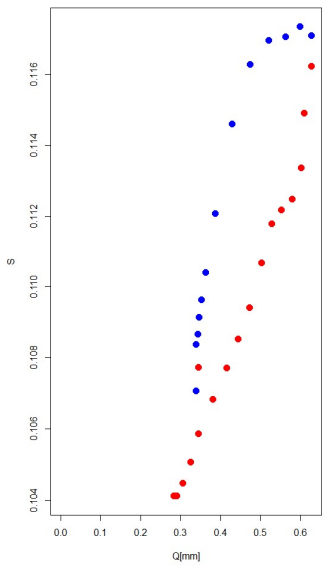


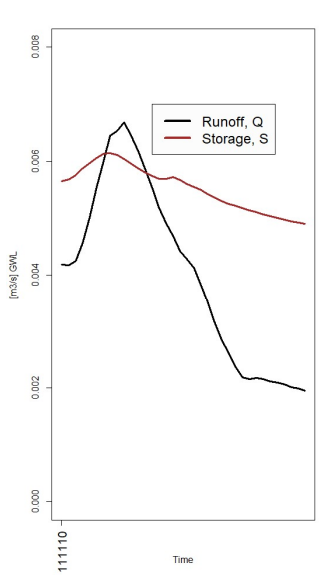


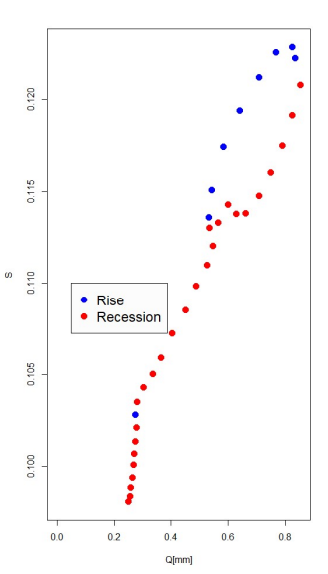




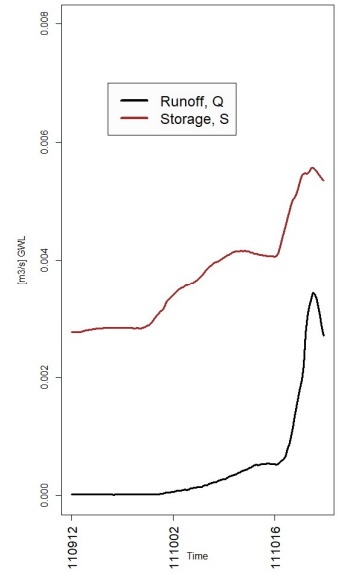


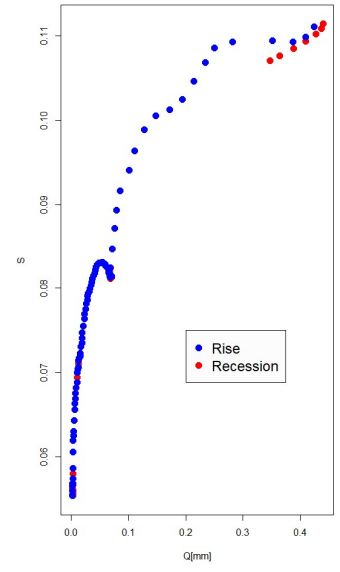


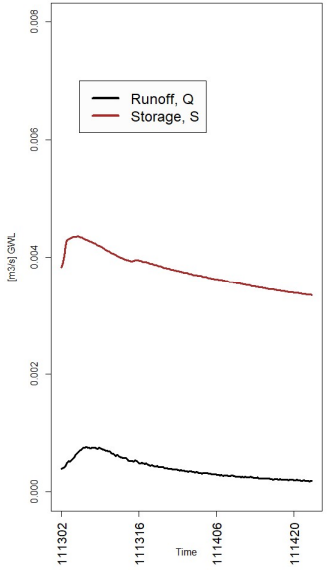


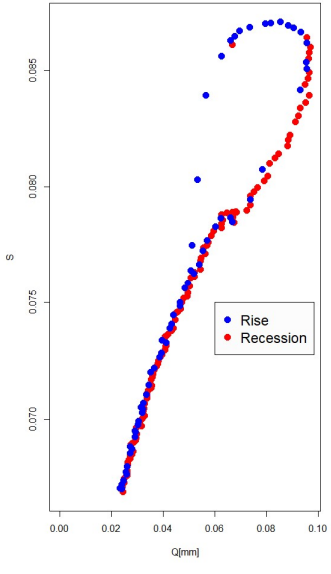


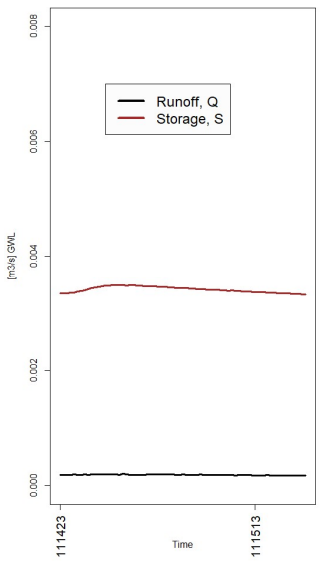
November 2018 events

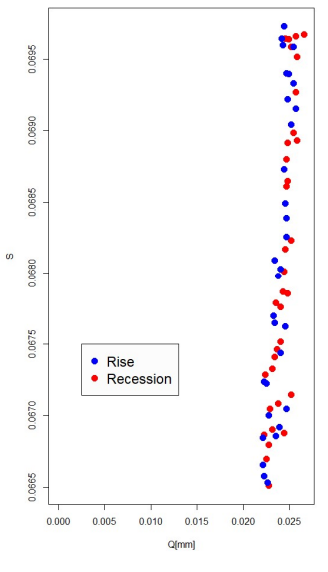




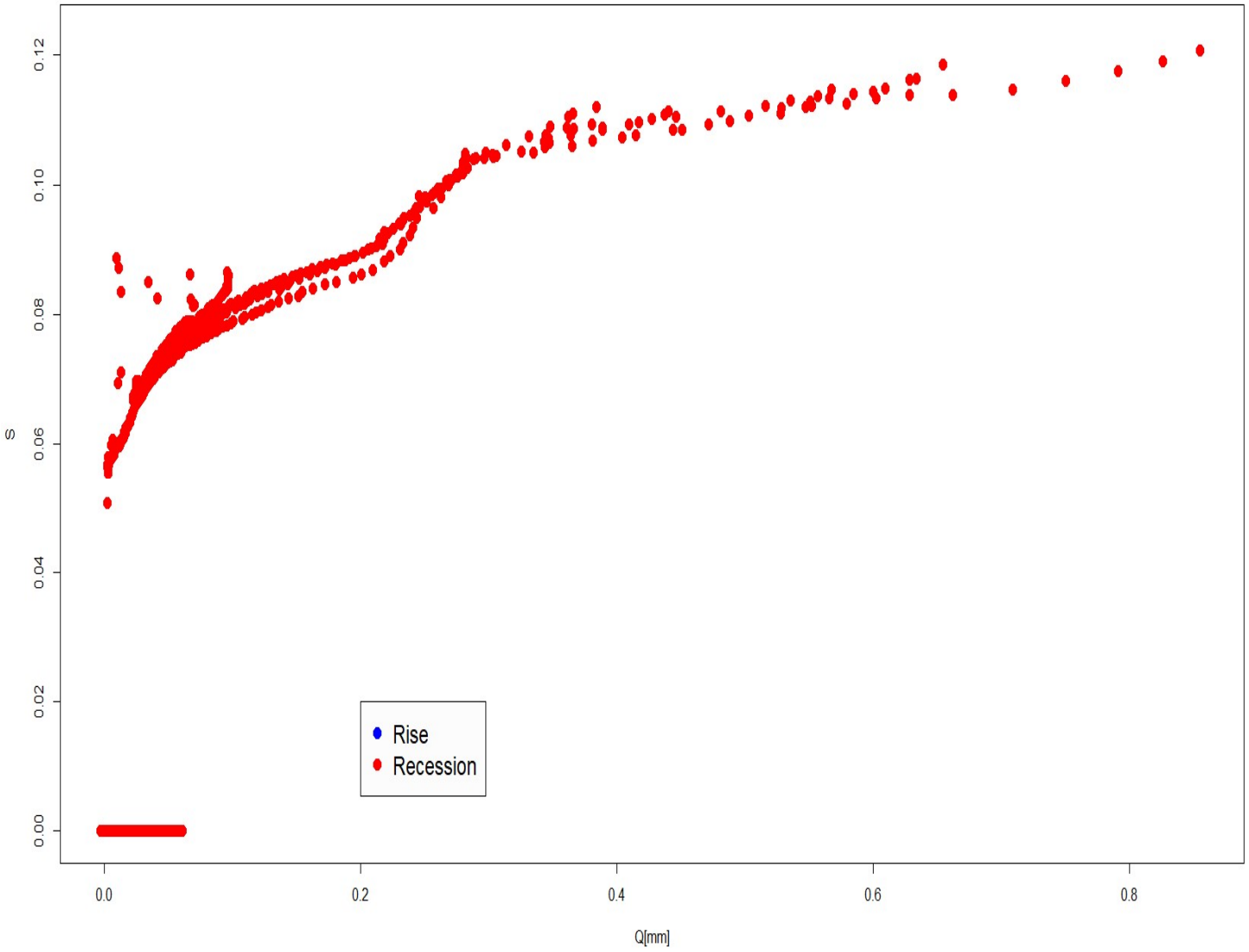








All recessions together (September and November 2018)



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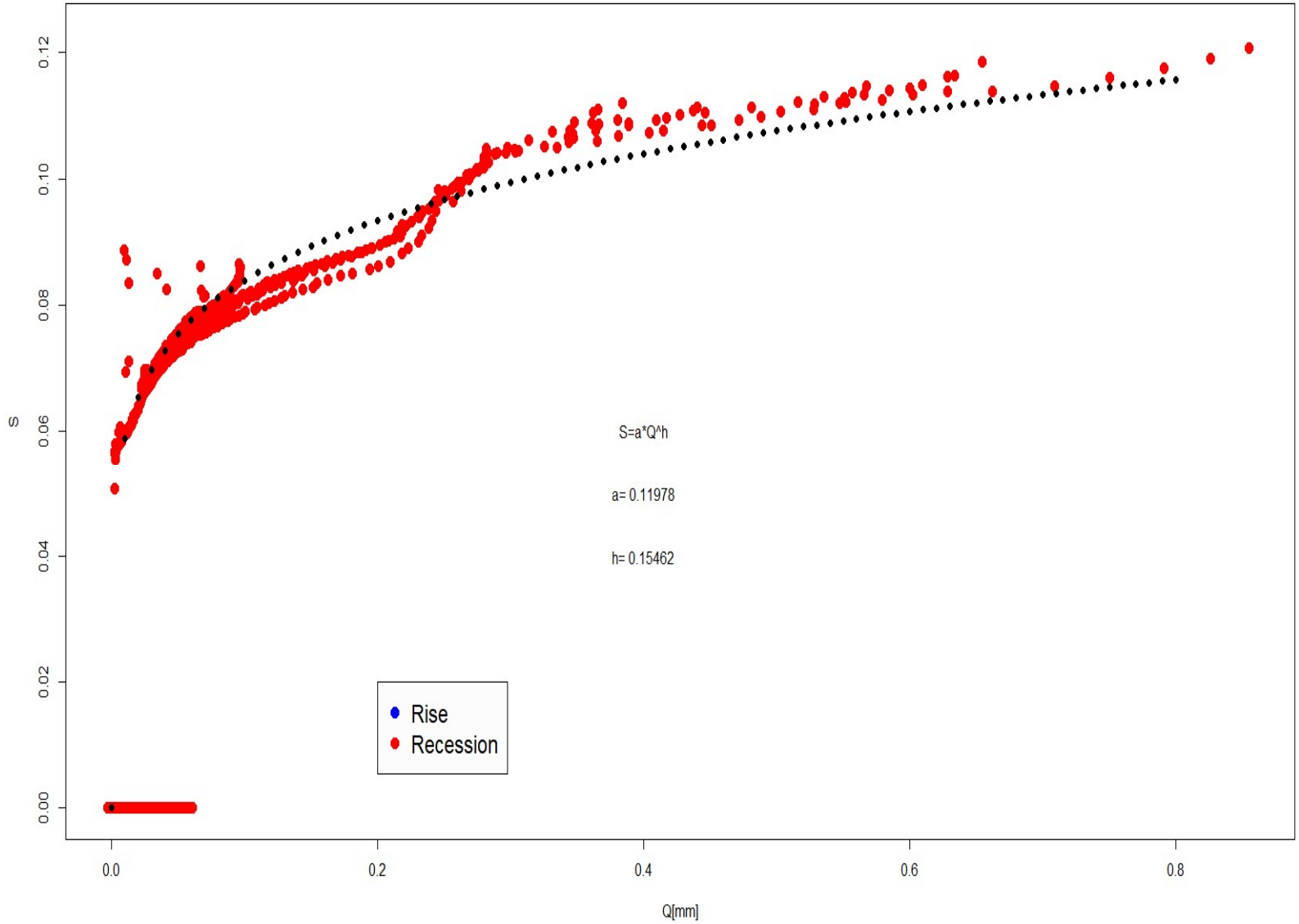
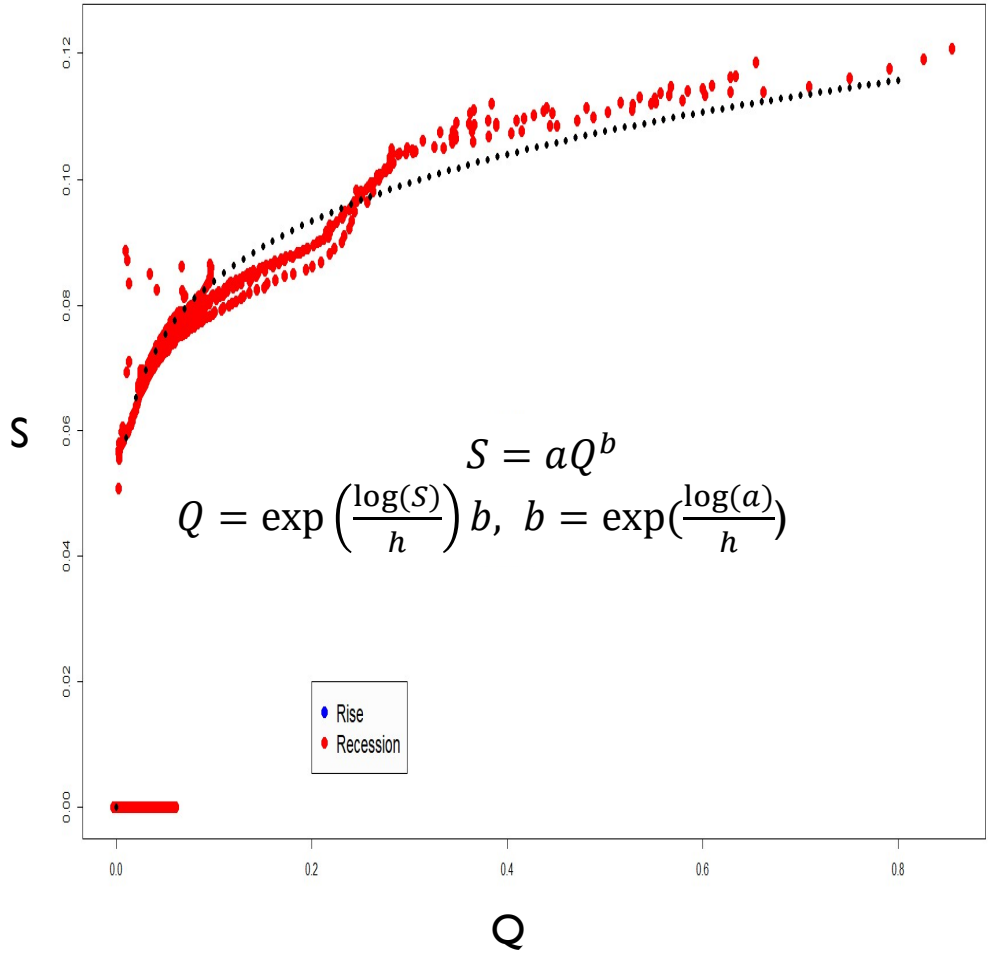


What are we told here?

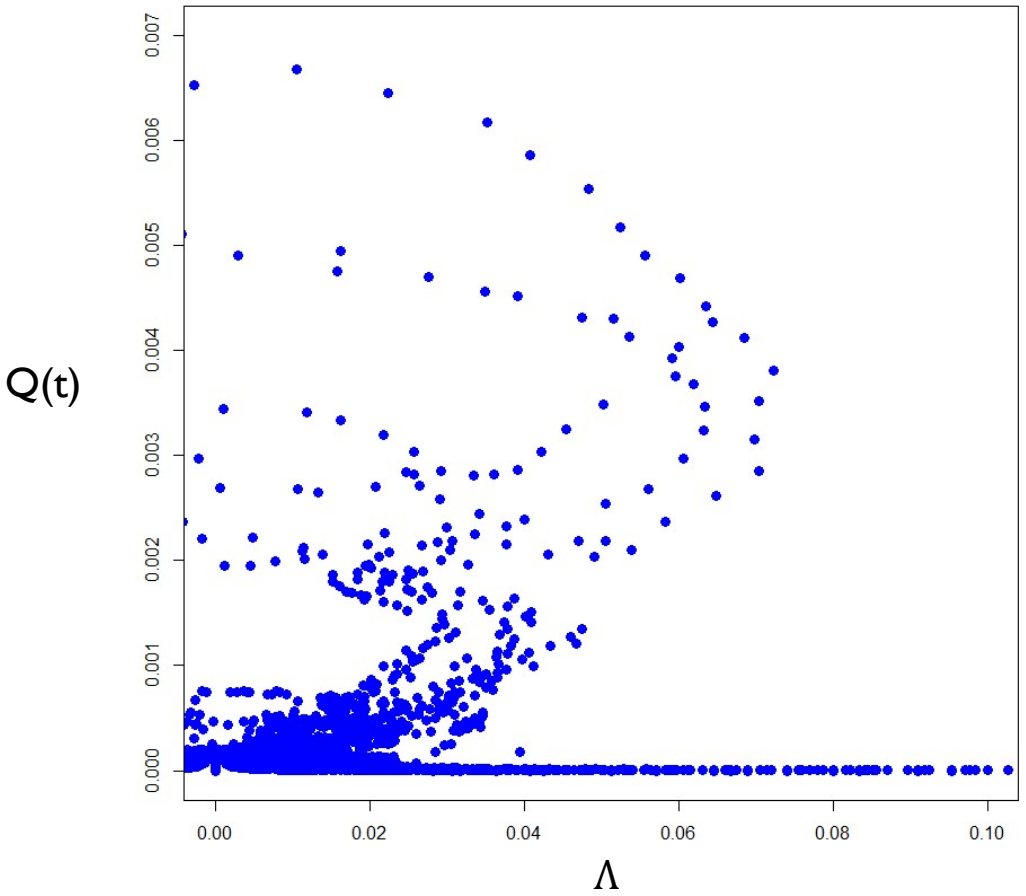
- At recession, the subsurface-state indeed equals runoff ('ish). Seems like a characteristic of the catchment. Is it so for all catchments?
- Muren is not a linear reservoir ($Q(t) = \varphi S(t)$), but can be approximated as a collection of linear reservoirs?
- At recession, the way the water leaves the subsurface, i.e. subsurface celerities/velocities, should be reflected in runoff.



The recession characteristic $\Lambda = log(Q(t)) - log(Q(t + \Delta t))$

- Used in the DDD rainfall-runoff model for:
- 1) subsurface wave velocites, i.e assigning scale to the UHs for different levels of saturation

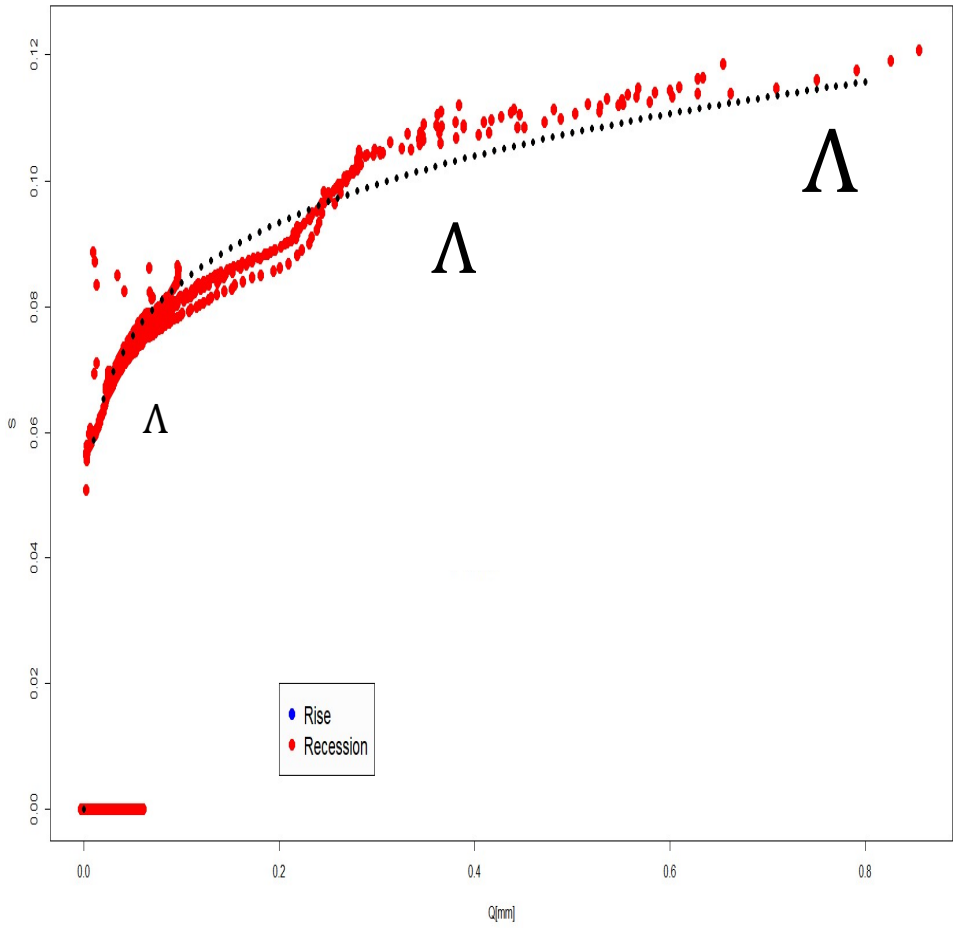
- 2) the frequency distribution of groundwater fluctuations, i.e. estimating (at the catchment scale) water holding capacities of the subsurface for different levels of saturation



Extremely difficult to sample!

How can the S-Q relationship be of use?

- Easier to look for «true» recession events from runoff records if we know we have to look for sequences where $\Lambda_1 = log(Q(t_1)) - log(Q(t_1 + \Delta t)) > \Lambda_2 > \Lambda_3 > \Lambda_4 > \cdots$
- The distribution of Λ tells us about the distribution of S and we can estimate velocities/celerities for different levels of storage, S (see Skaugen and Onof, 2014)



Conclusions so far

- Storage-runoff relationship is hysterectic, S increases faster than Q during the rising limb of the hydrograph (which makes sense?)
- At recession, S vs Q can be approximated as one-to-one
- Recession analysis becomes easier: look for sequences where $\Lambda_1 > \Lambda_2 > \Lambda_3 > \Lambda_4 > \cdots$
- Muren catchment (and probably others) can be modelled as a collection of linear reservoirs.

Skaugen T. and C. Onof, 2014. A rainfall runoff model parameterized form GIS and runoff data. *Hydrol. Process.* **28**, 4529-4542, DOI:10.1002/hyp.9968.