A Screening Method to Identify Extreme Events Affecting Drinking Water Quality.

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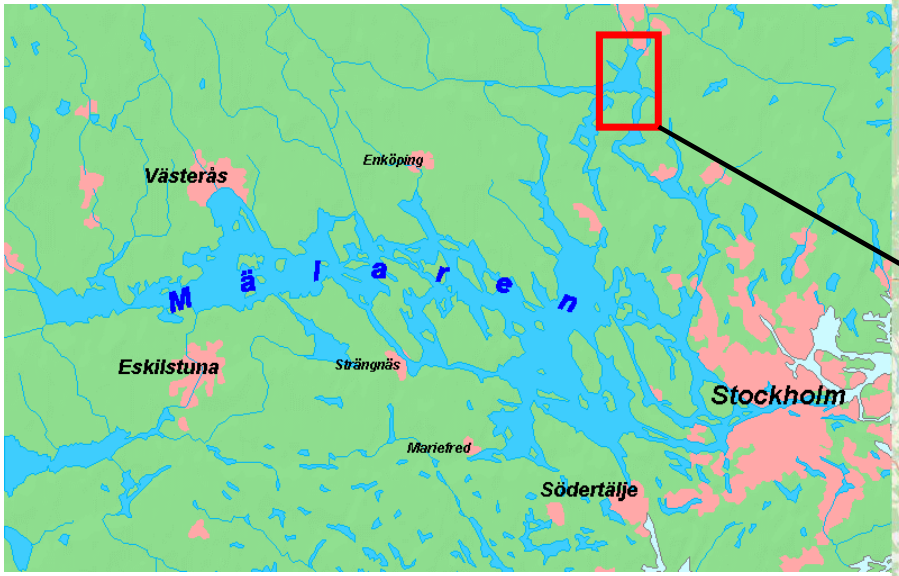
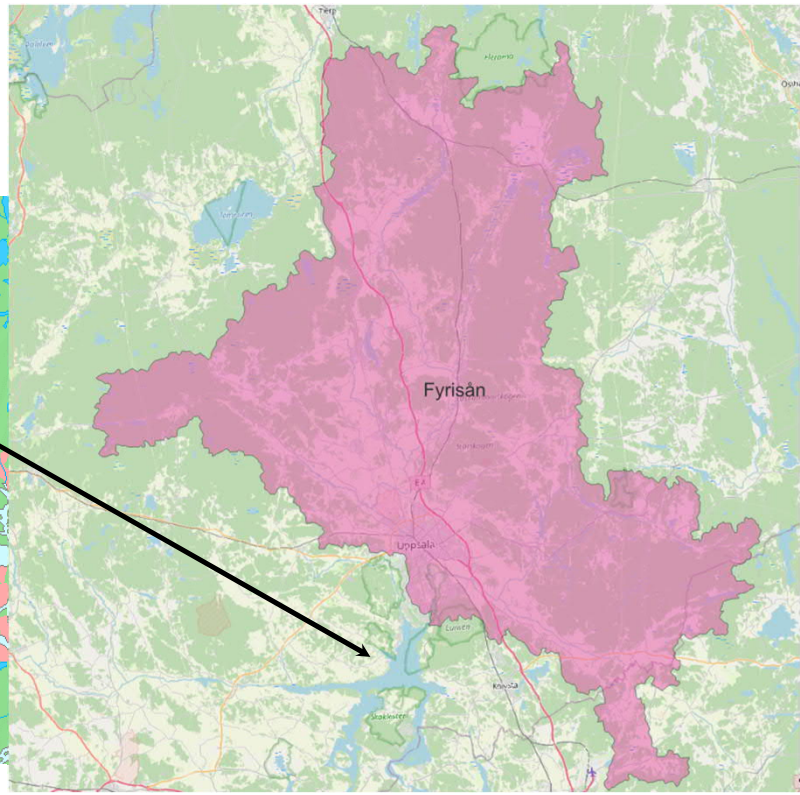
Background

- Water4All project MEWS (Managing Events and Extremes in Water Supplies) https://mews-water.com/
  - Sweden – Lake Mälaren – Described here
  - Israel – Lake Kinnert
  - Germany Ohra Resevoir
- Study effects of hydroclimatic extreme events on drinking water supplies
  - Hydrology effects - storm size, discharge and nutrient loads
  - Hydrodynamic effects – transport time and biogeochemistry
- Simulations
  - Historical
  - Future climate https://www.isimip.org/

Study Site Lake Mälaren Sweden





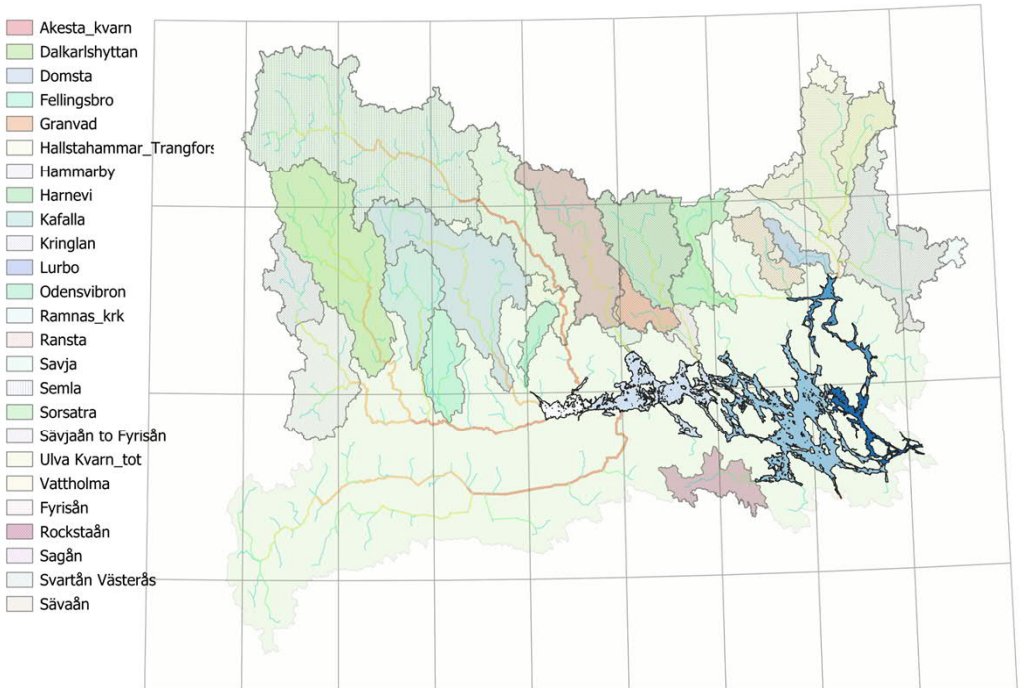
Surface Area 1 140 km^2
Watershed area 22 600 km^2
Residence Time 2.2 yr
Population Served ~ 2 000 000

https://commons.wikimedia.org/w/index.php?curid=2158958

Models

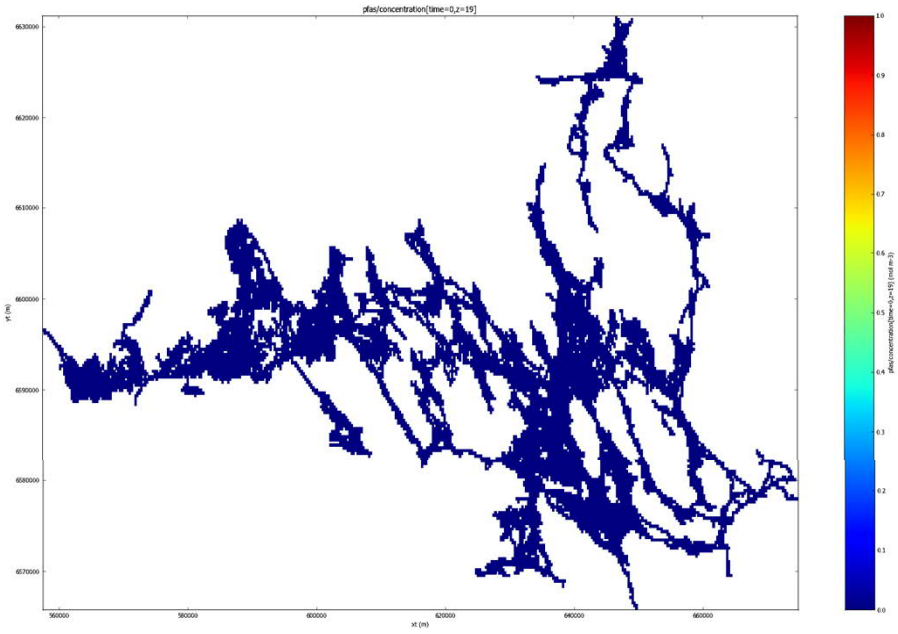
GWLF

- Sub-surface flow simulated by simple Lumped parameter structure
- Land used specific surface runoff (SCS CN)
- Calibrated with long data record 21 watersheds
- Short run time



PyGETM

- 3D
- Spatially-varying weather forcing
- Takes long time to run (1 year ≈ 12 hours runtime).



Key Concept:

- The effect of an extreme event is not just related to increased precipitation amount, but also antecedent watershed and waterbody conditions:
  - Soil moisture – Runoff Response
  - Thermal structure and water level – Reservoir transport and biogeochemistry
- Antecedent conditions affect not only watershed and water body response but also the coupling between systems.
- Antecedent conditions are complexly affected by climate change

Analysis:

Run MEWS coupled model simulations over long-term historical and future climate scenarios – evaluate conditions that lead to lake events

Delema:

- Historical 1970-2014 (45y)
- Future 2015-2100 (85y) * 3 scenarios
- 5 GCM models
- 1500 years min 130 years

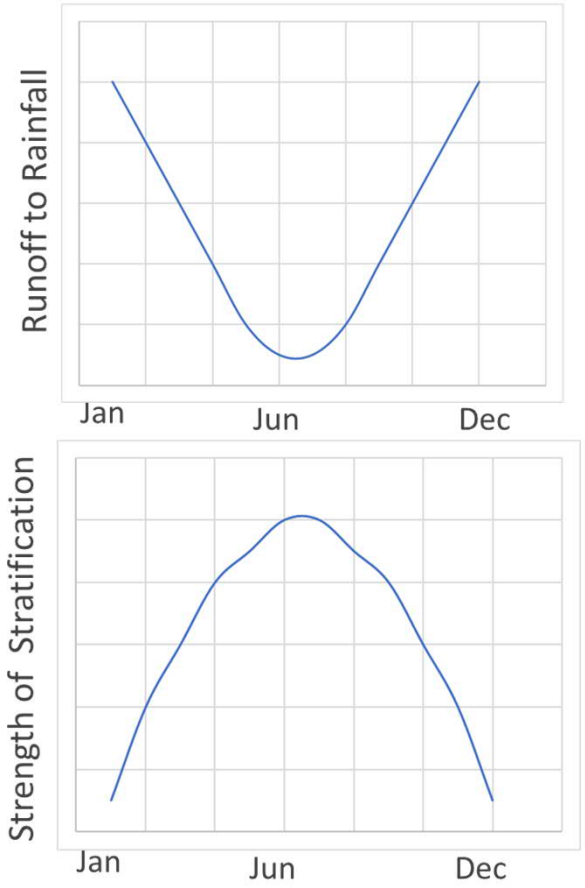
Run time GETM

1yr = 12 h

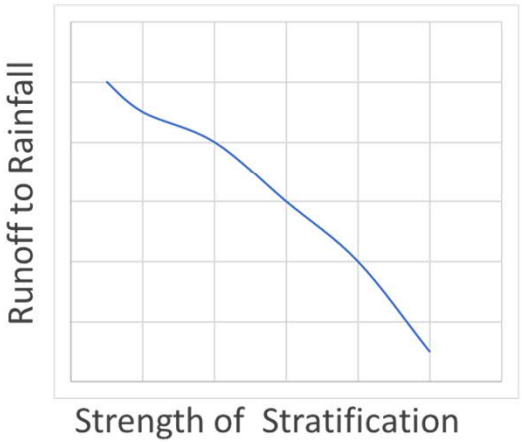
130 yr = 65 days

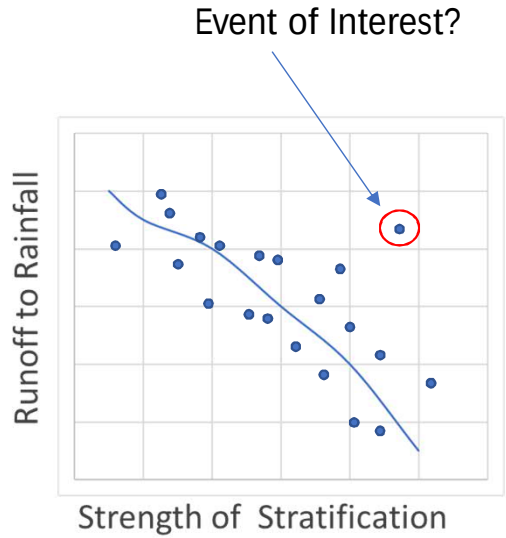
1500 yr = 750 days

Can we develop a screening method to identify events that can later be examined in greater detail?



What Do We Expect From Antecedent Conditions?

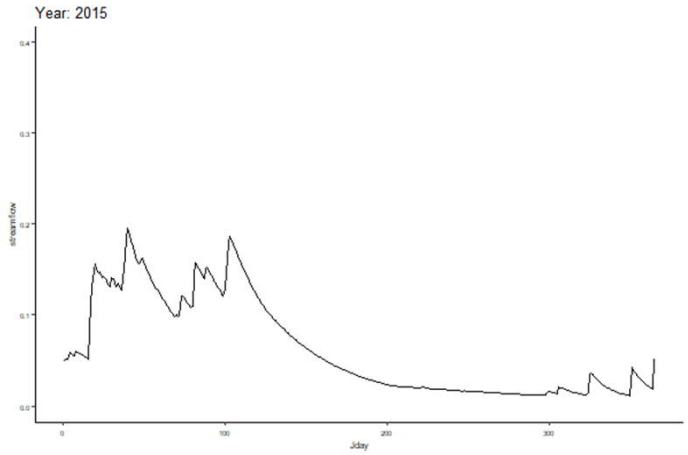




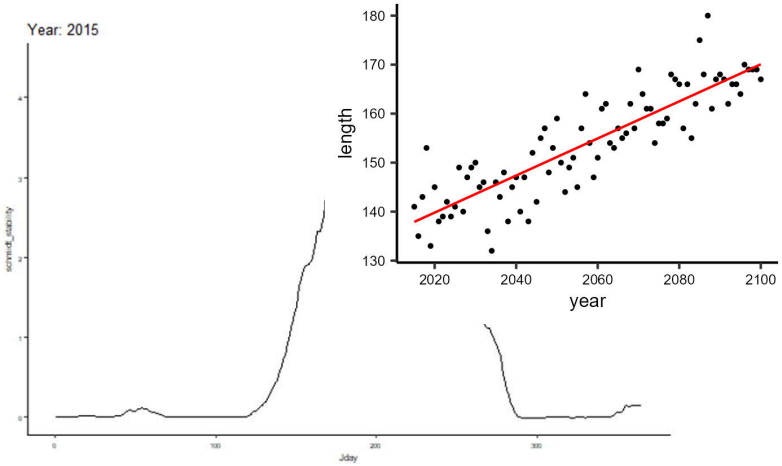
Switch 3D GETM to 1D GOTM – rapid simulation of vertical thermal structure

Seasonal Patterns – Daily Time Step

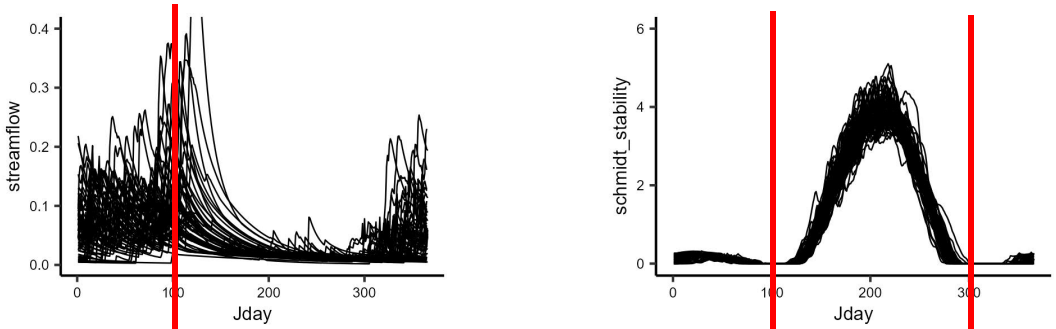
ISIMIP3b gfdl-esm4 ssp585
Stream discharge (cm/d) 2015-2100



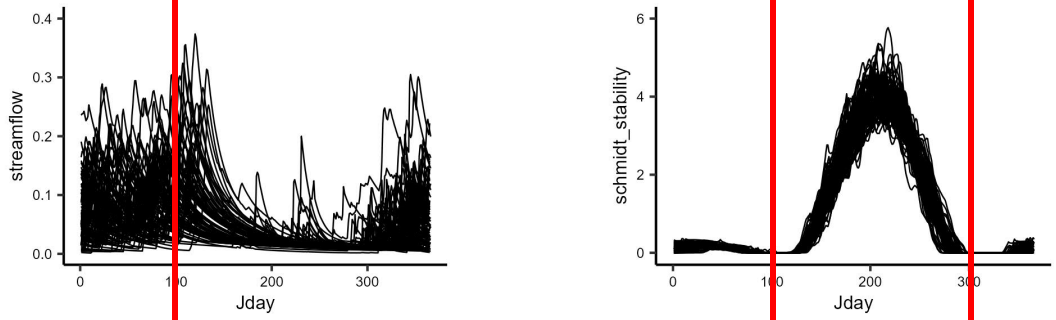
Schmidt Stability (J/m^2) 2015-2100



ISIMIP3a gswp3-w5e5 gridded met



ISIMIP3b gfdl-esm4 Historical



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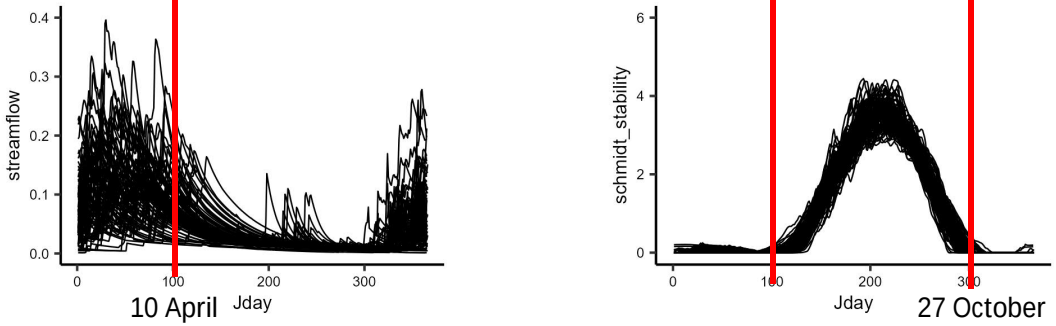
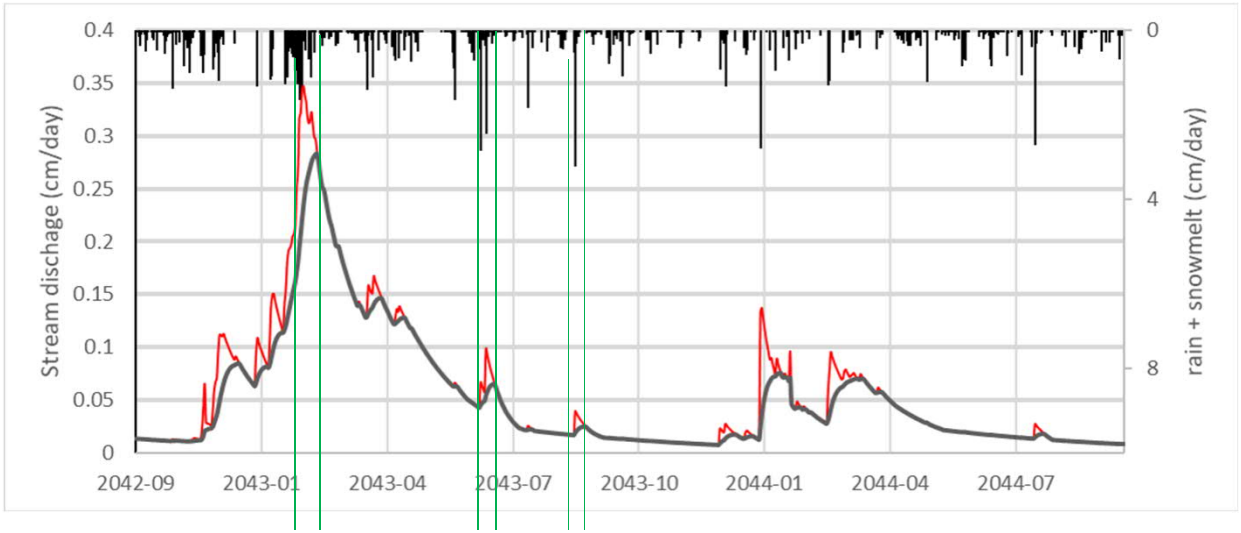


10 April

27 October

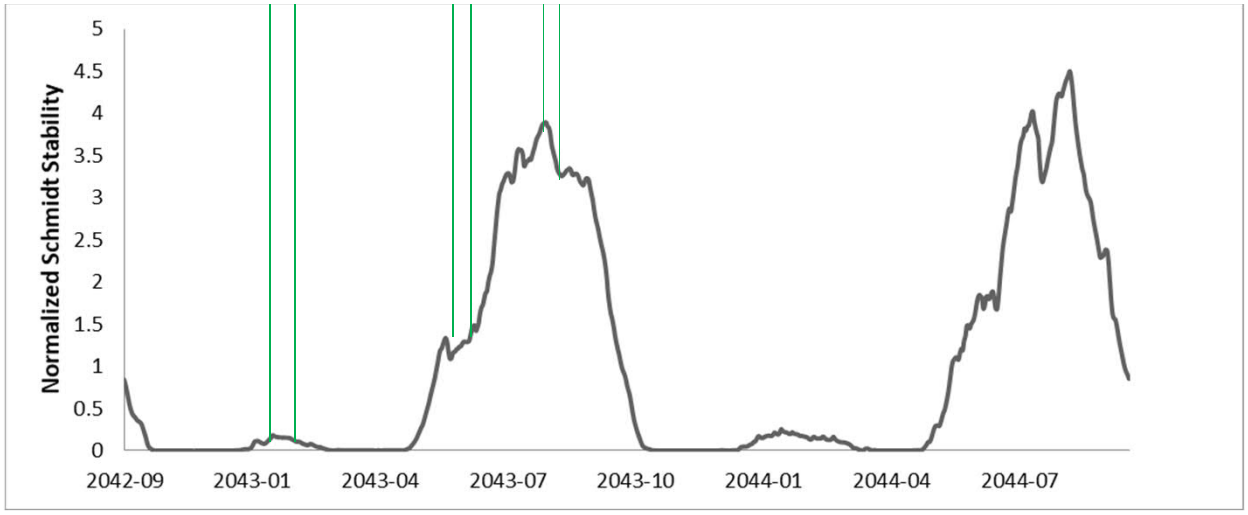
Watershed Antecedent Conditions - Event Identification using Hydrograph Separation



Method Lyne,and Hollick (1979)

$$Q_b(t) = \alpha Q_b(t-1) + (1-\alpha)Q(t)$$

Lake Antecedent Conditions – GETM 3D >> GOTM 1D >> Lake Analyzer >> Schmidt Stability



Winslow, L., J. Read, R. Woolway, J. Brentrup, T. Leach, J. Zwart, S. Albers, and D. Collinge. 2019. Package 'rLakeAnalyzer'.

Lyne, V., and M. Hollick. 1979. Stochastic time-variable rainfall-runoff modelling. Pages 89-93 *in* Institute of engineers Australia national conference. Institute of Engineers Australia Barton, Australia.

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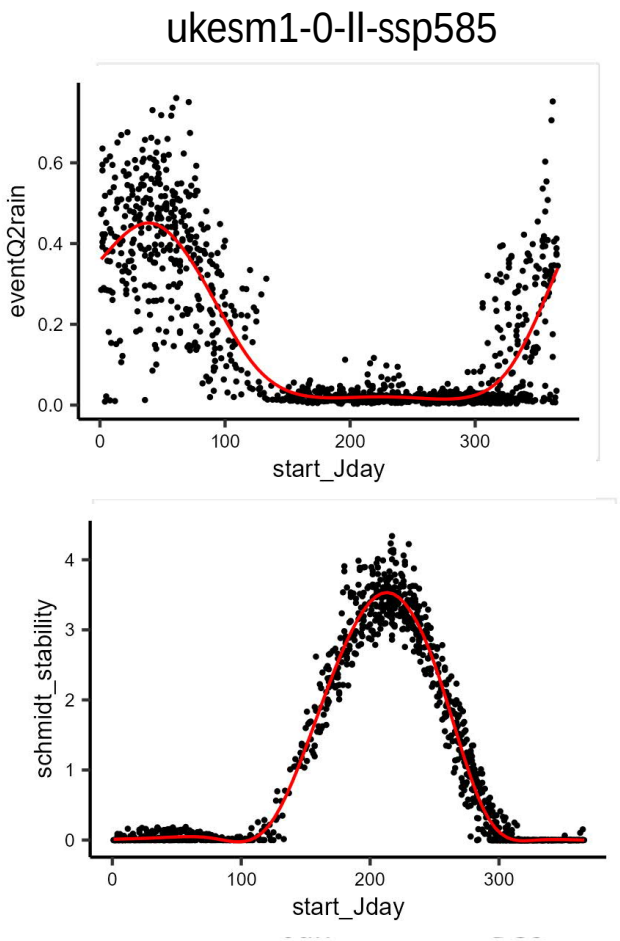
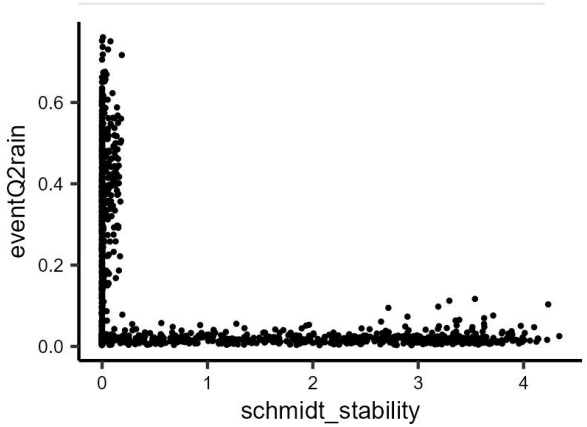
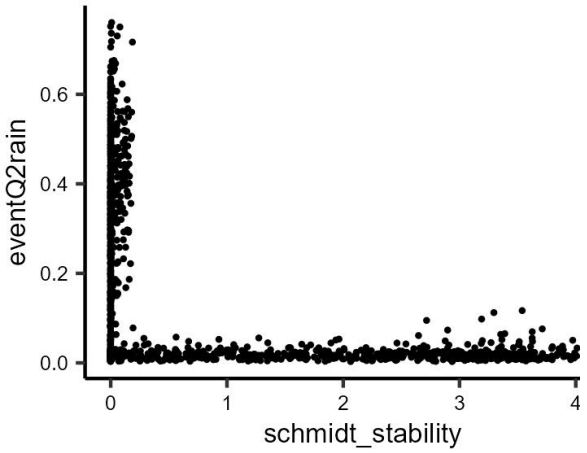




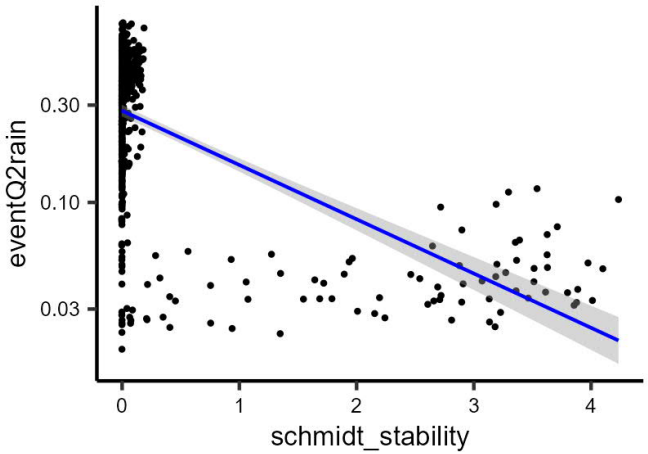
Filtering Events

ukesm1-0-ll-ssp585

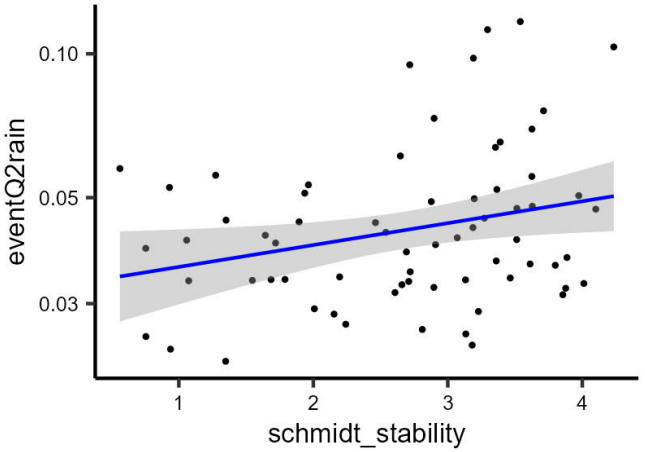
All Data



Remove Events < 0.1 cm/d discharge

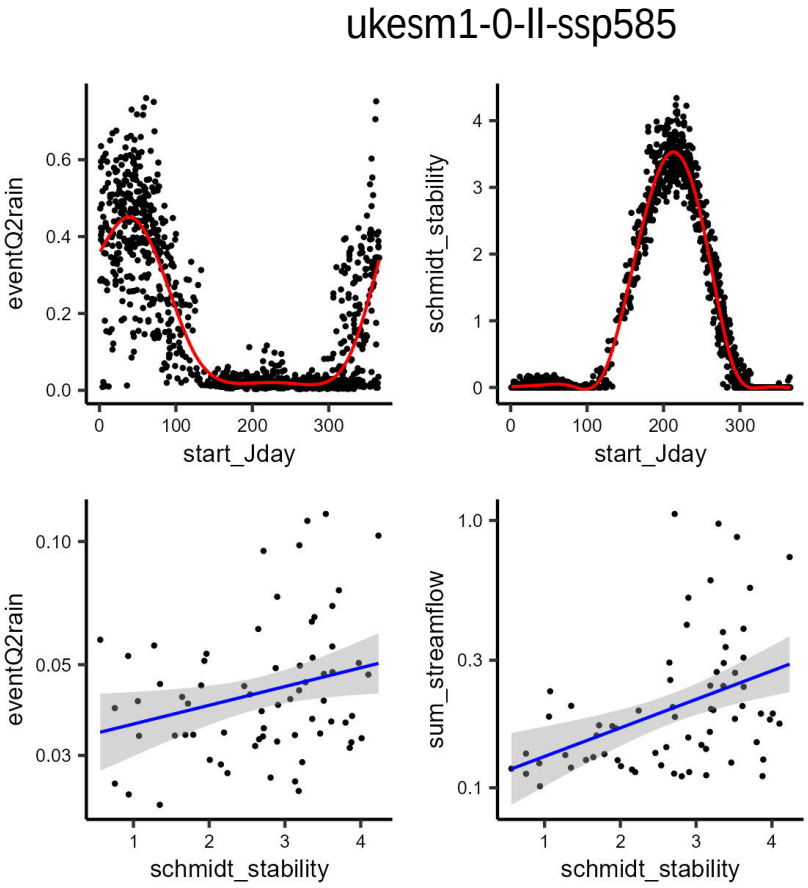


Remove Events < 0.5 normalized Schmidt Stability



Normalized Schmidt Stability

Final Result – So Far



Conclusions

- Method is able to identify events of potential importance
- Much greater seasonal variability in the event Q to rain+melt ratio than in the Schmidt stability. Thermal stratification defines the window of maximum effect - runoff2rainfall defines the importance of the event in the window

Questions

- Are the events identified significant? Still need to run biogeochemistry
- What is more important: large storms under isothermal conditions vs smaller storms under stratified conditions?
- Can future climate scenarios adequately represent extreme events?
- Can gridded data represent precipitation extremes?