VeWa: Investigating effects of Vegetation on Water flows and mixing in northern ecosystems using stable isotopes and conceptual models

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Background

As a step towards integrating insights from tracers and modelling studies in northern landscapes, we provide a preliminary analysis of six well-known experimental catchments (Fig. 1). These are part of the VeWa (*<u>Ve</u>getation effects on <u>wa</u>ter flow and mixing in high-latitude ecosystems)* project, which aims to understand the nature of water partitioning along cross-regional hydroclimatic gradients of moisture and temperature and to assess the role of vegetation, soils and other landscape features. Our goal in carrying out this comparative analysis was to identify open research questions on the ecohydrological partitioning and coupling of waters in northern catchments and assess research priorities.

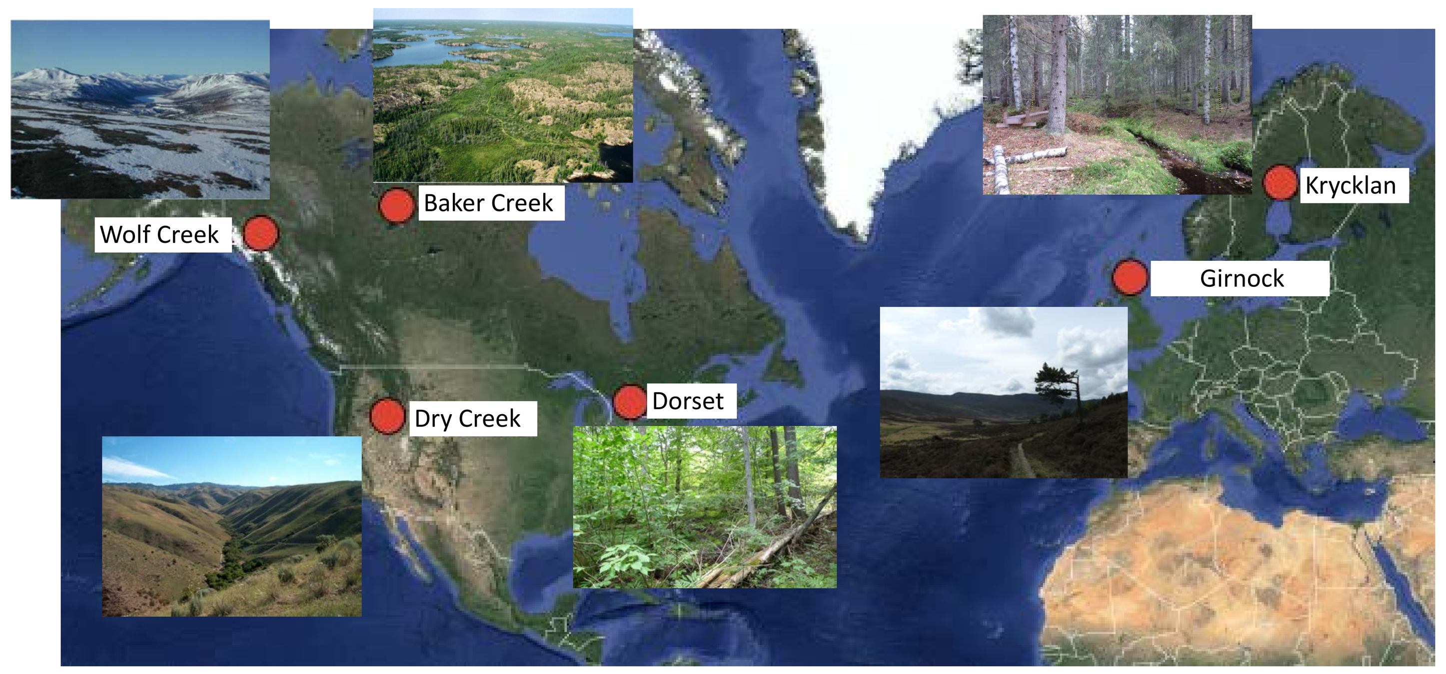


Figure 1. Locations of the six VeWa catchments (maps.google.co.uk).

Data and approach

- Sites cover range of climates, with contrasting snow influence and flow regimes (Table 1 and Fig. 2)
- Precipitation and stream water sampled for isotope analysis
- HBV-light model applied to all sites (Seibert & Vis, 2012) with basic model structure using observed hydrometeorological variables (length time series ranges from 11 to 27 years), Thorntwaite method for PET

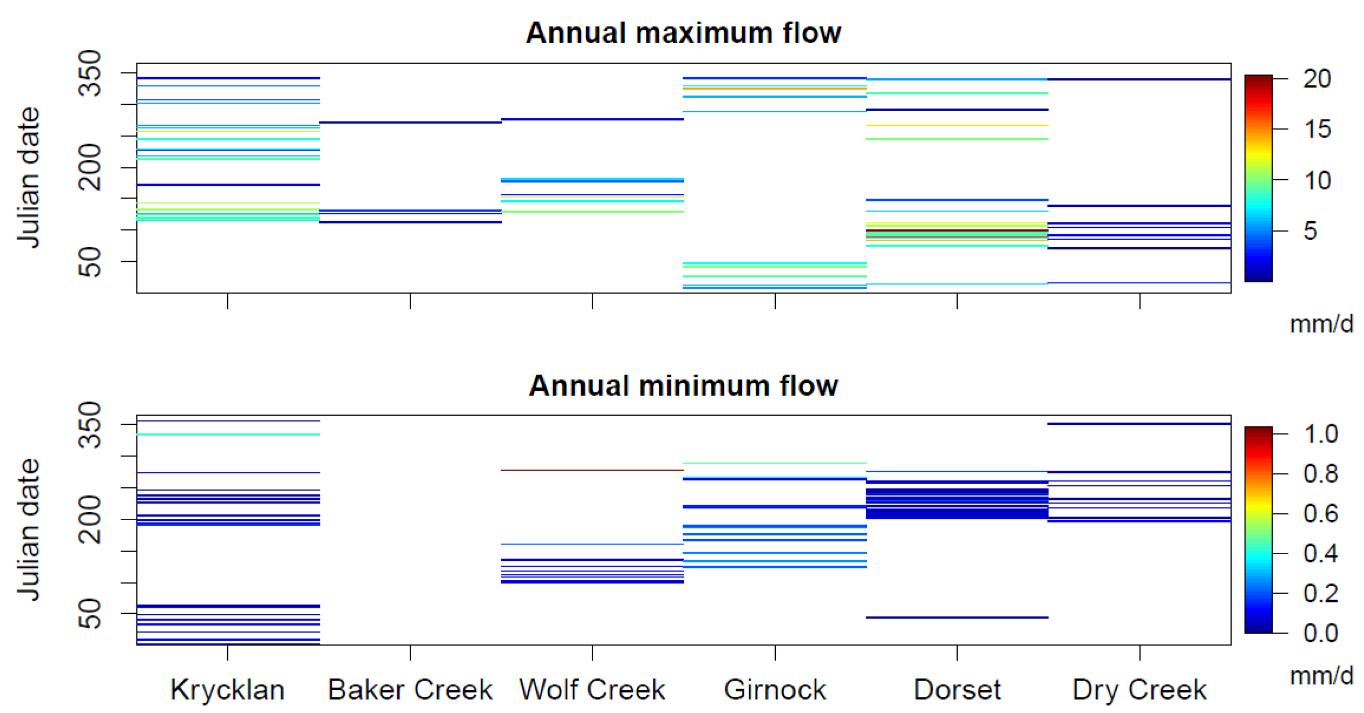


Figure 2. Timing and magnitude of annual maximum and minimum flows (Tetzlaff et al., 2015). (Baker Creek had no discharge data in winter)

HBV modelling

- Reasonable model performance: mean NS was >0.6 for Dorset, Krycklan and Girnock, but only ±0.5 for Baker Creek, Wolf Creek and Dry Creek. Lower efficiency for Baker Creek and Wolf Creek is mainly due to difficulties measuring winter low flows when stream is frozen. For Dry Creek the initial model structure might be too simple given the large elevation differences and associated vegetation distributions.
- Snow dynamics were well captured by model with largest snow packs at Wolf Creek, Krycklan and Dorset (Fig. 3).
- The uncertainty in storage values for the different model runs was large. However, for the soil moisture store all model runs showed similar dynamics. The dynamics in the groundwater stores changed between model runs, especially in the Girnock (Fig. 3).

Table 1. Characteristics of the six VeWa catchments (MAT: mean annual temperature, MAP: MA precipitation, MAQ: MA discharge).

Catchment	Size (km^2)	Mean altitude (masl)	MAT (°C)	MAP (mm)	MAQ (mm)
Krycklan Sweden	0.5	250	1.8	622	310
Baker Creek, Canada	9.3	230	-3.1	311	88
Wolf Creek, Canada	7.6	1650	-2	471	358
Girnock, Scotland	31	350	6.6	1001	602
Dorset, Canada	1.2	370	4.8	1020	536
Dry Creek, US	28	1470	9	653	122

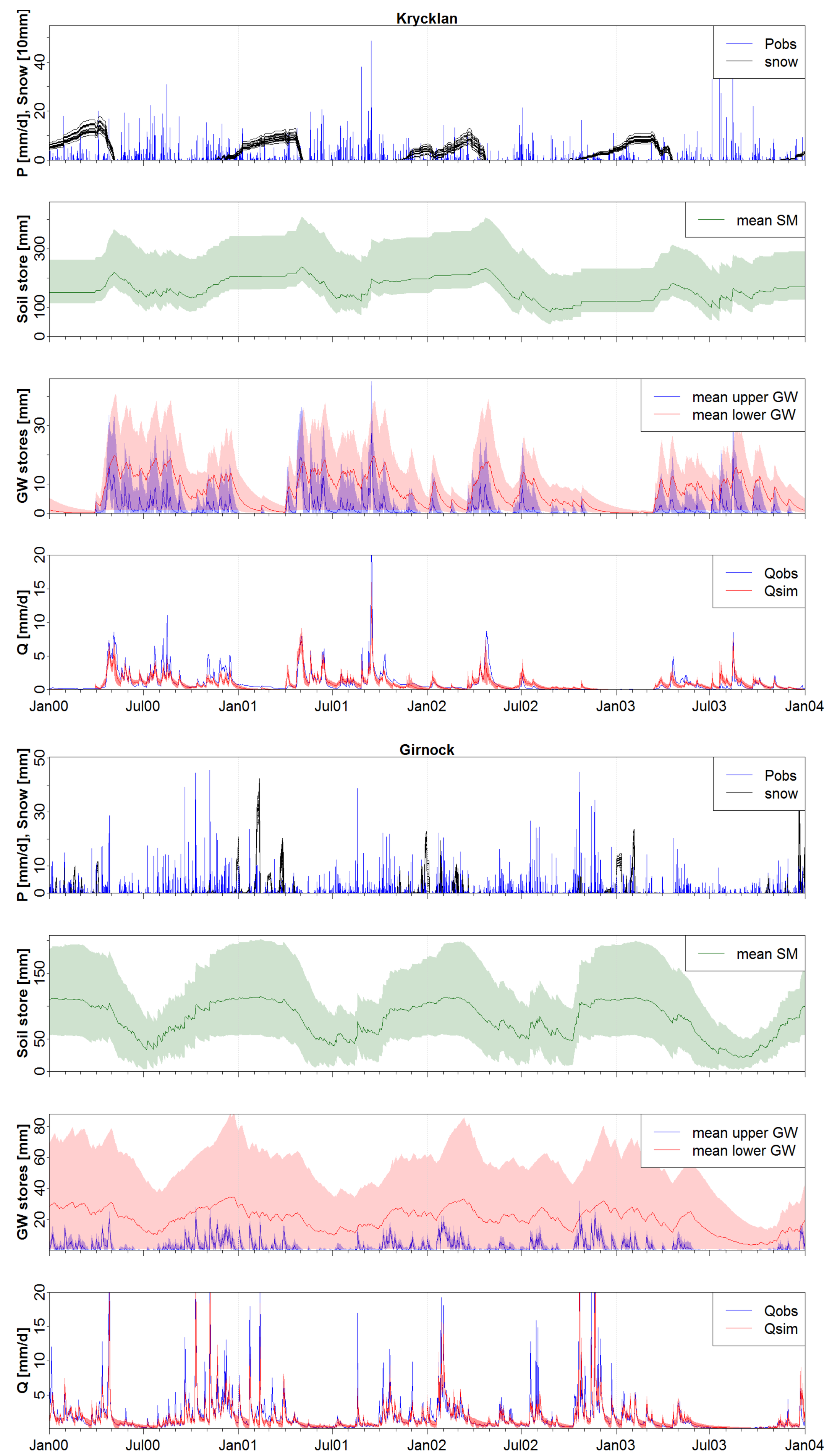


Figure 3. Examples of 4-year time series of model results for Krycklan and Girnock (Tetzlaff et al., 2015). Top row) observed precipitation and modelled snow (results from 20 model runs), 2nd and 3rd row) mean soil store and groundwater stores over 20 model runs with bands indicating the range, bottom row) observed and simulated discharge (average and range 20 model runs).

Conclusions

This meta-analysis of six northern catchments has shown that snowpack accumulation and melt typically dominate the catchments' runoff and isotope dynamics. While simple input – output relationships can link stream flow generation to hydrological flowpaths that route water to streams, fractionation at each site is indicative of more complex internal processes that can be influenced by energy inputs and catchment characteristics. How such small scale processes affect stream water dynamics, and whether and how they should be conceptualised in models, are questions that provide an opportunity for hypothesis-driven isotope studies in northern environments.

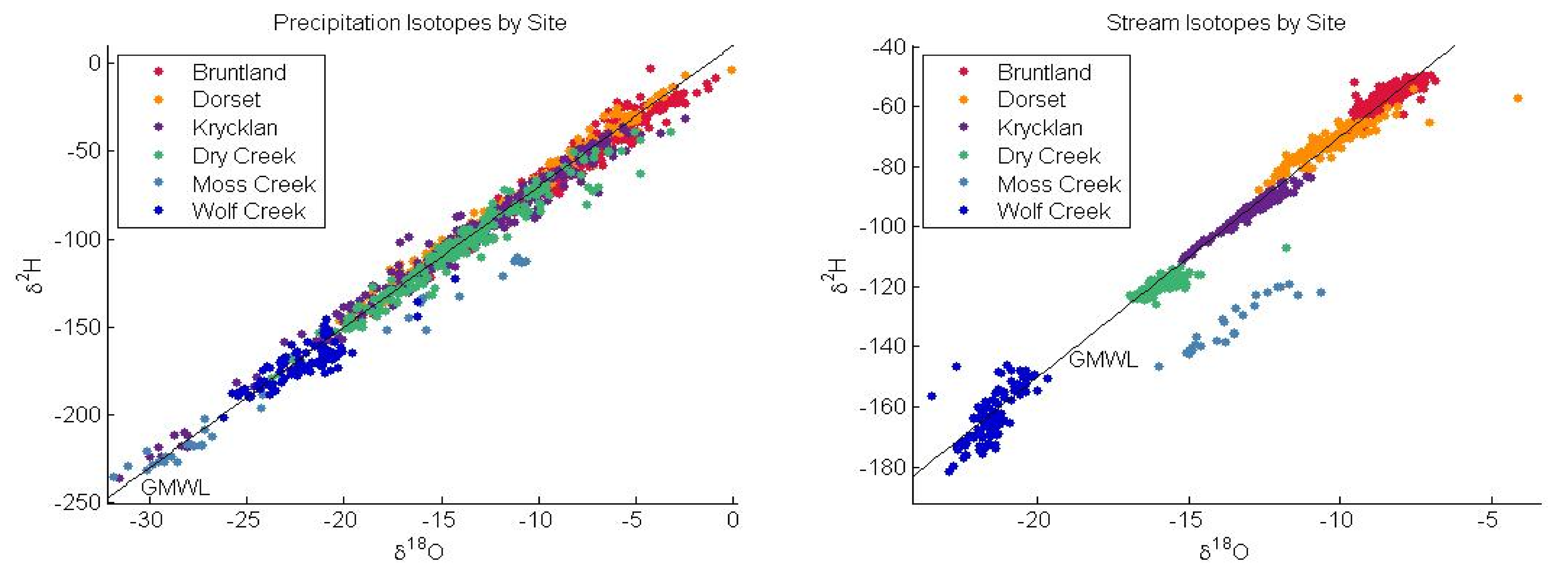
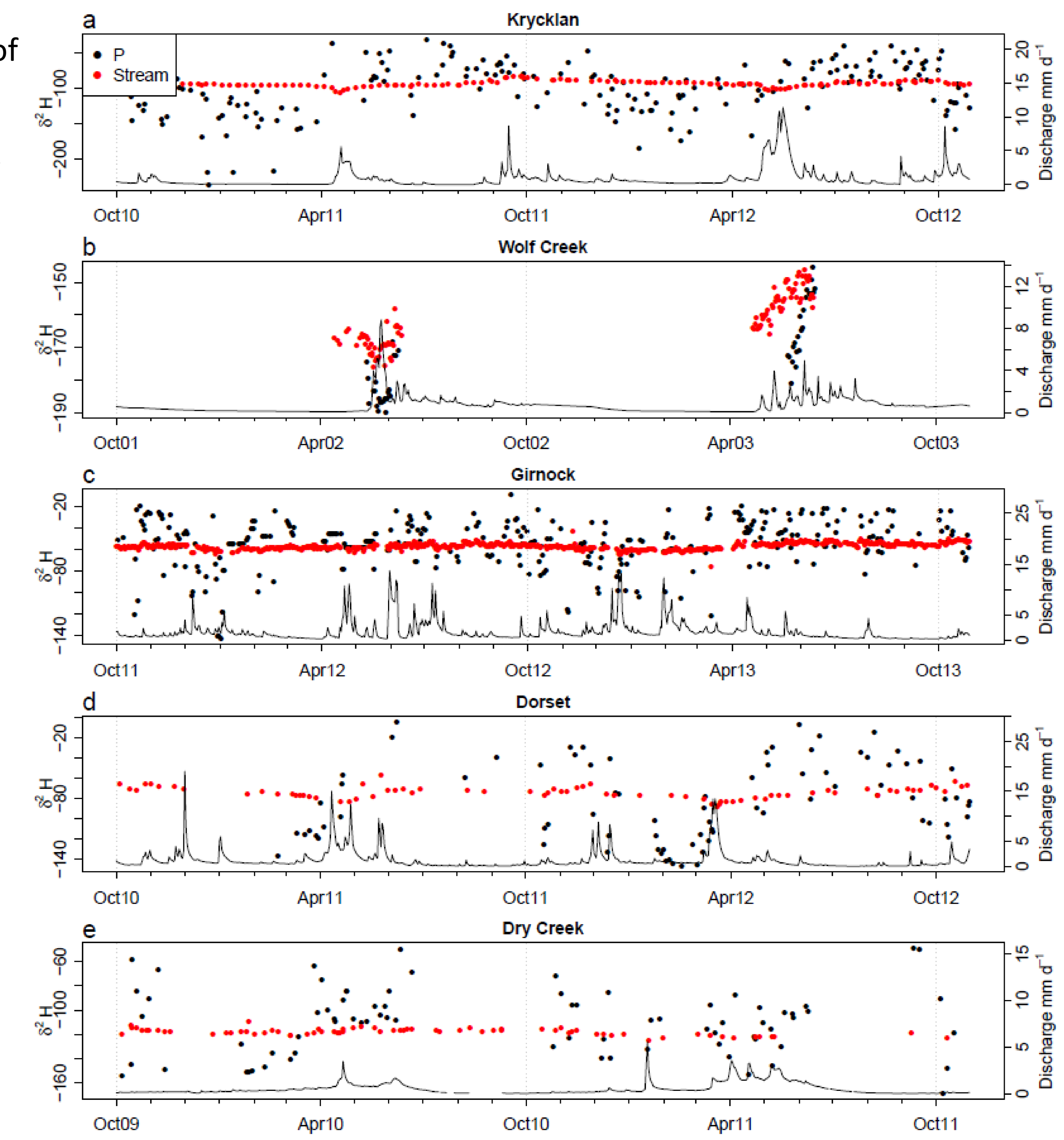


Figure 4. Stable isotopes at all sites plotted along the Global Meteoric Water line (GMWL) for precipitation and stream water (Tetzlaff et al., 2015).

Isotope dynamics

- The space occupied by each site along the meteoric water line broadly reflects the combined effects of latitude and continentality (Fig.4). Thus, precipitation and stream water at Baker Creek (Moss Creek) and Wolf Creek are the most depleted, followed by Dry Creek, Krycklan, Dorset and Girnock (Bruntland).
- There is a marked seasonality in precipitation, which at all sites is more depleted in winter and more enriched in summer, though intra-seasonal variation can also be significant (Fig. 5).
- Much of the intra-site variability in stream water δ^2H-values reflects the annual snowmelt influence which delivers depleted water to the stream channel via rapid flowpaths (Fig. 5).

Figure 5. Time series of deuterium in precipitation and stream water (Tetzlaff et al., 2015).



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