

Hydrological droughts are not always widespread across the entire stream network in cold, humid catchments



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Background

- ❖ **Water resources** are typically **managed at the catchment scale**, yet little information can be found on the **spatial coherence of hydrological droughts** within a catchment.
- ❖ We often operate under the assumption that a **drought event** detected at a **stream gauge** indicates that the **entire hydrographic network is experiencing drought**.

Objective

Describing the spatial coherence of hydrological droughts within a catchment.

Data & Methods

- ❖ **Open-source** retrospective **streamflow estimates** of **6718 reaches** with minimal influence from dams over **52 years**, across **109 catchments** within QC, Canada¹ (**Hydroclimatic Atlas of Southern Quebec**²).

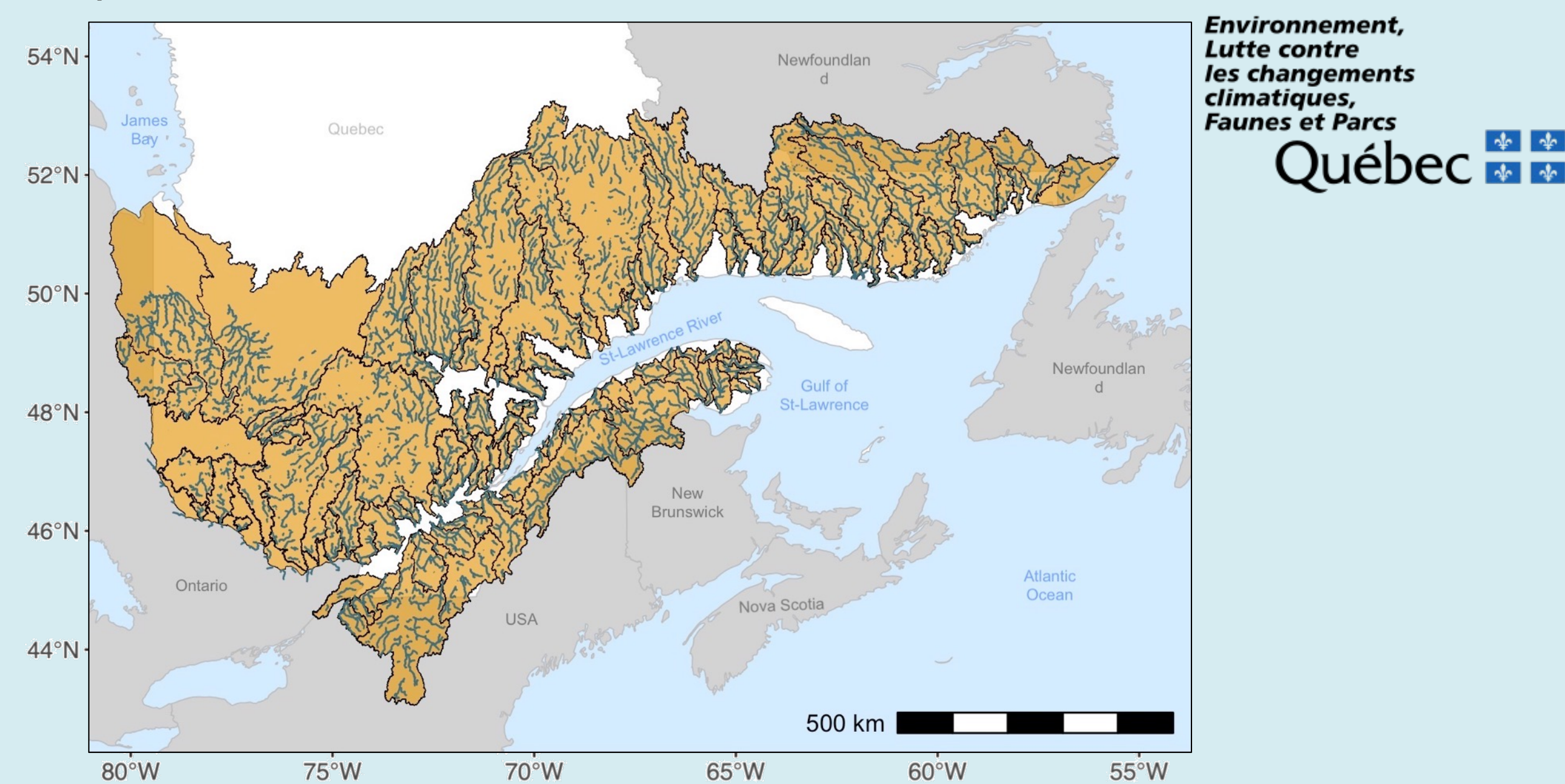


Figure 1. Study area showing selected stream reaches for the 109 catchments across the 8 hydrological regions of southern Quebec, Canada.

- ❖ **Drought events** were identified and characterized with the **Standardized Streamflow Index (SSI)**³ at an accumulation period of 3 months.

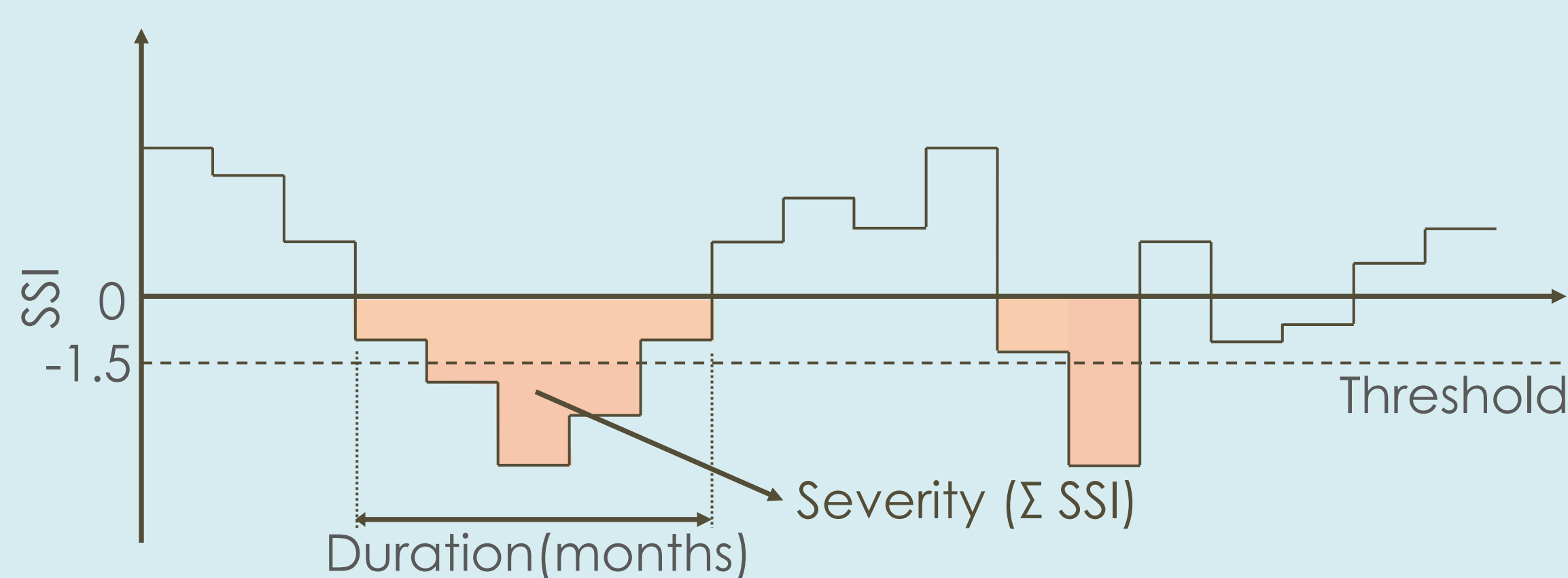


Figure 2. Drought identification and characterization with the SSI. Each value of SSI represents the number of standard deviation from the long-term monthly streamflow mean.

Results

- ❖ **37%** of all events are **widespread** (covering 90% of the stream network of a catchment), **14%** are **localized** (less than 10% of the stream network).
- ❖ **Spatial coherence** is linked with **drought severity** (fig.3, table 1).
- ❖ **Widespread droughts** are **~2X more severe** than **localized droughts** at the catchment scale (fig.3, table 1).

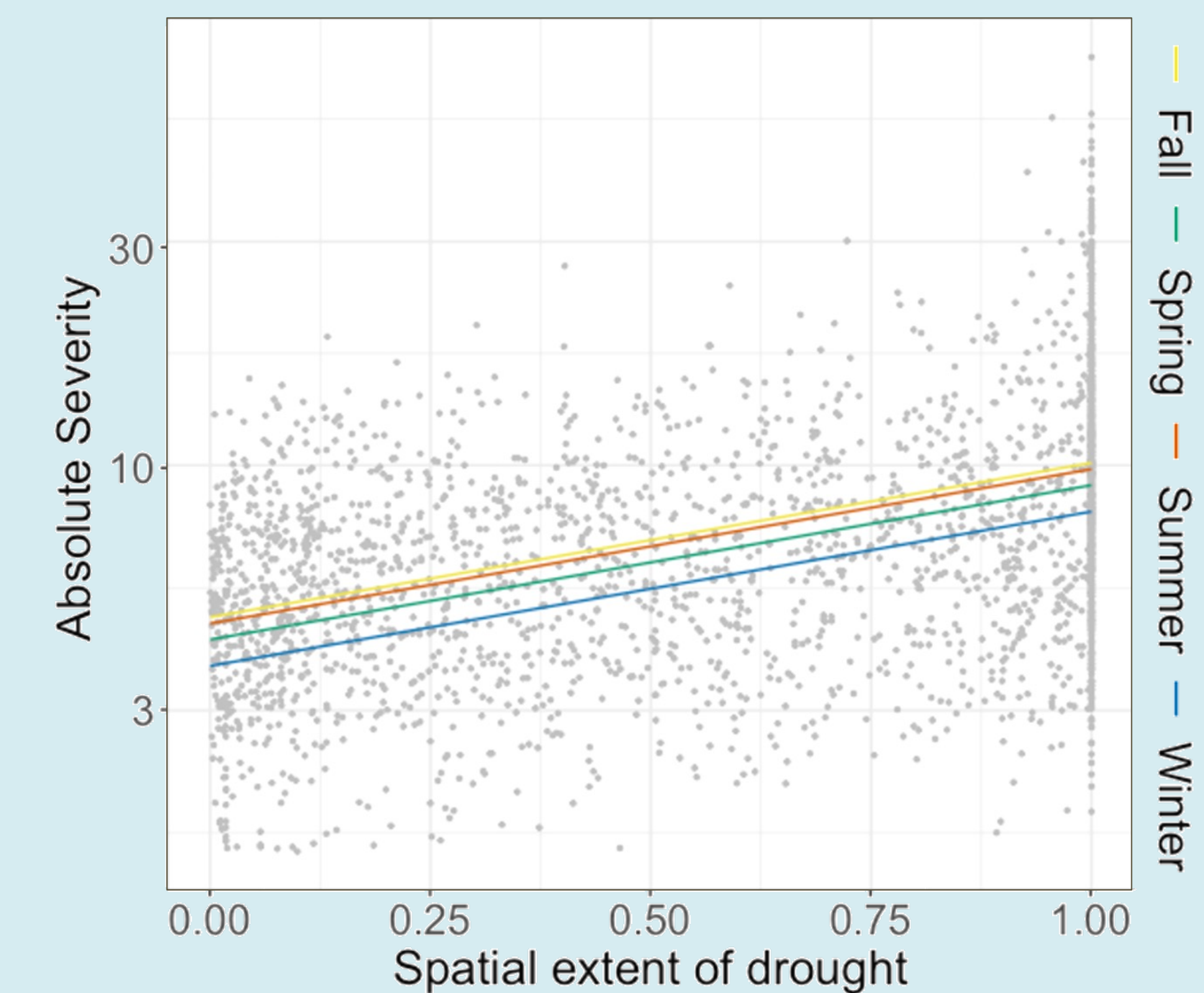


Figure 3. Relationship between the spatial extent of drought and its absolute severity (Σ SSI) across seasons. The absolute severity is represented in log (natural logarithm) scale on the y axis ($e^1 \sim 3$, $e^2 \sim 10$, $e^3 \sim 30$).

Table 1. Linear mixed model parameters. Estimated R^2 value is 0.37 ($n = 2864$). Estimated values of variance (σ) for the random effects of catchment and year of occurrence are 0.018 and 0.031, respectively.

	Estimate	95% confidence interval	Standard error	z-value	p-value
(Intercept)	1.305	[1.228, 1.384]	0.040	32.78	< 0.001
Spatial extent	0.782	[0.729, 0.835]	0.027	28.86	< 0.001
Occurrence: Fall	0.187	[0.122, 0.251]	0.033	5.70	< 0.001
Occurrence: Spring	0.118	[0.056, 0.180]	0.032	3.71	< 0.001
Occurrence: Summer	0.172	[0.109, 0.234]	0.032	5.36	< 0.001

- ❖ **~40%** of drought events are **missed** when using a **single hydrometric station VS using all available data** to identify drought events in a catchment (fig.4).

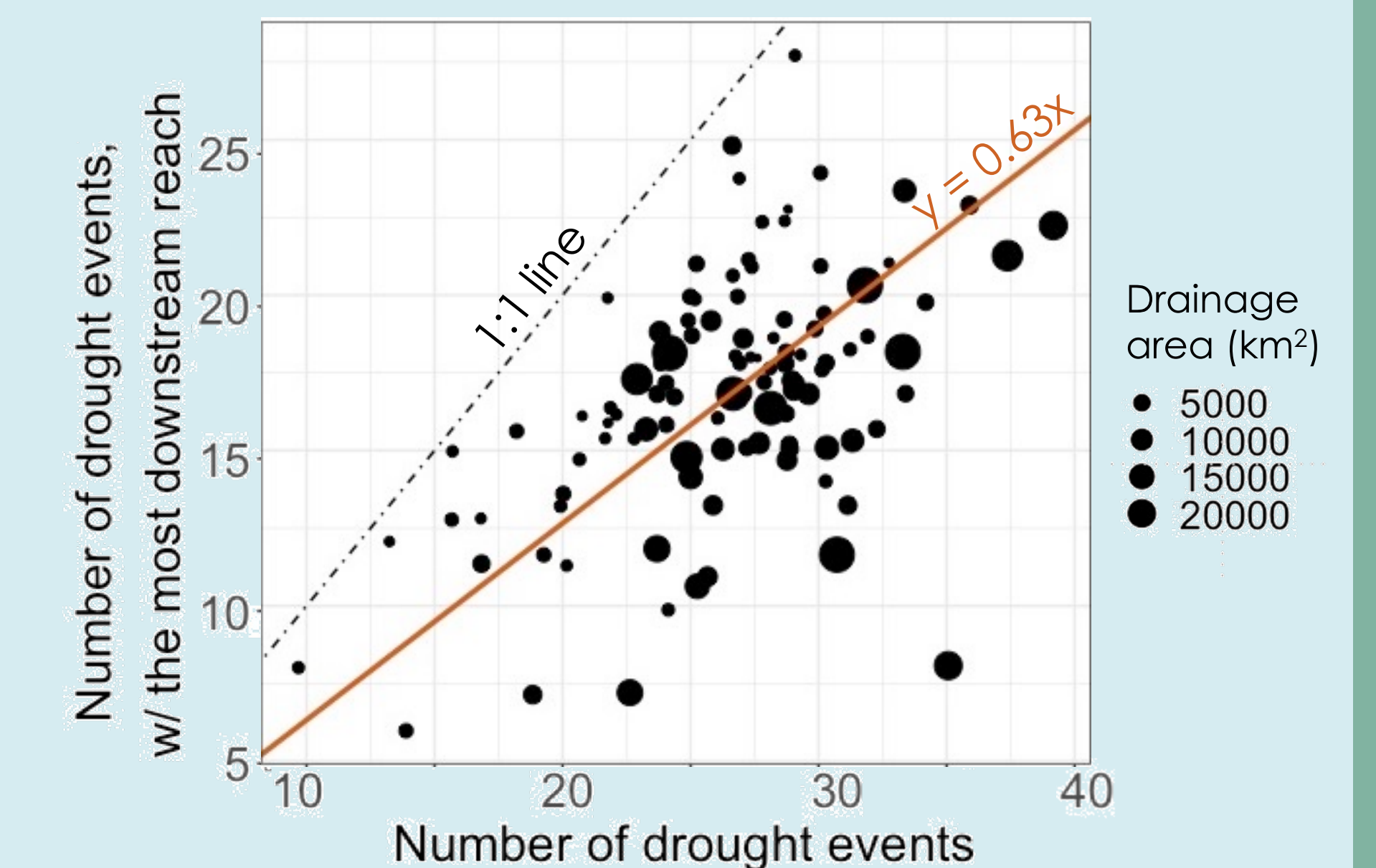


Figure 4. Relationship between the number of events identified per catchment when using only the most downstream reach of a catchment and when using all the available reaches. The size of the data points represents the catchment drainage area, and the regression was obtained with a simple linear model fit between both variables.

Discussion & Conclusion

- ❖ Many **hydrometric networks** have been facing a **steady decline in monitoring efforts** in the last decades⁴ and this study stresses the importance of monitoring streamflow at **multiple locations** to properly **assess hydrological droughts in cold humid regions**.
- ❖ Comparable to recent studies on flash droughts showing that drought events can be concentrated in time⁵, we showed that **hydrological droughts** can also be **concentrated in space**.
- ❖ Given that climate exerts a strong control on **hydrological drought propagation**⁶, further studies need to examine **within-catchment variability** in hydrological drought occurrence under **different climates**.
- ❖ Overall, findings stress the need to better consider the **spatial variability** in drought conditions when managing **surface waters in cold, humid catchments**.

Funding



Contact

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