Supplementary material
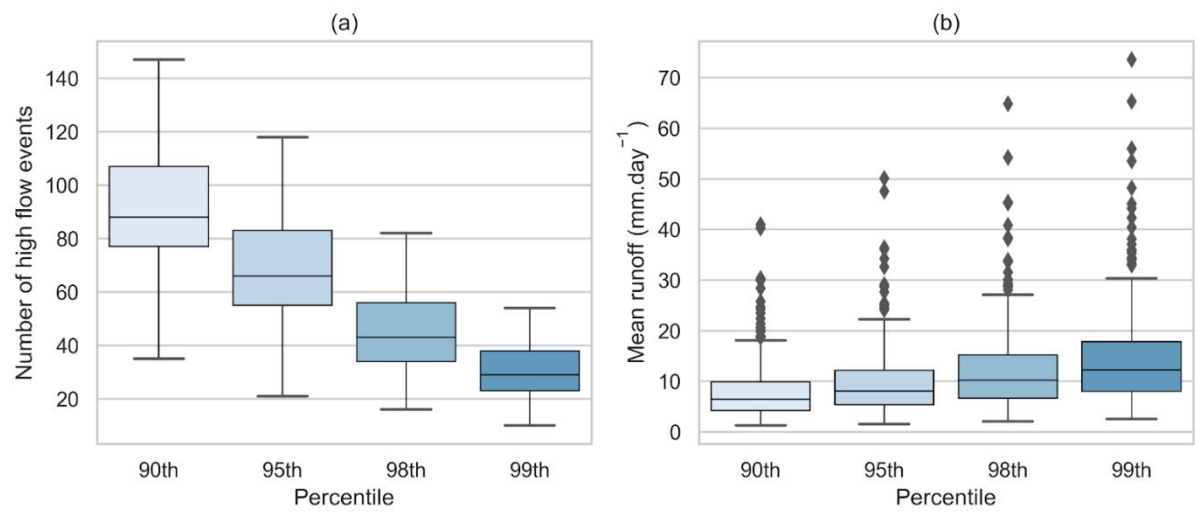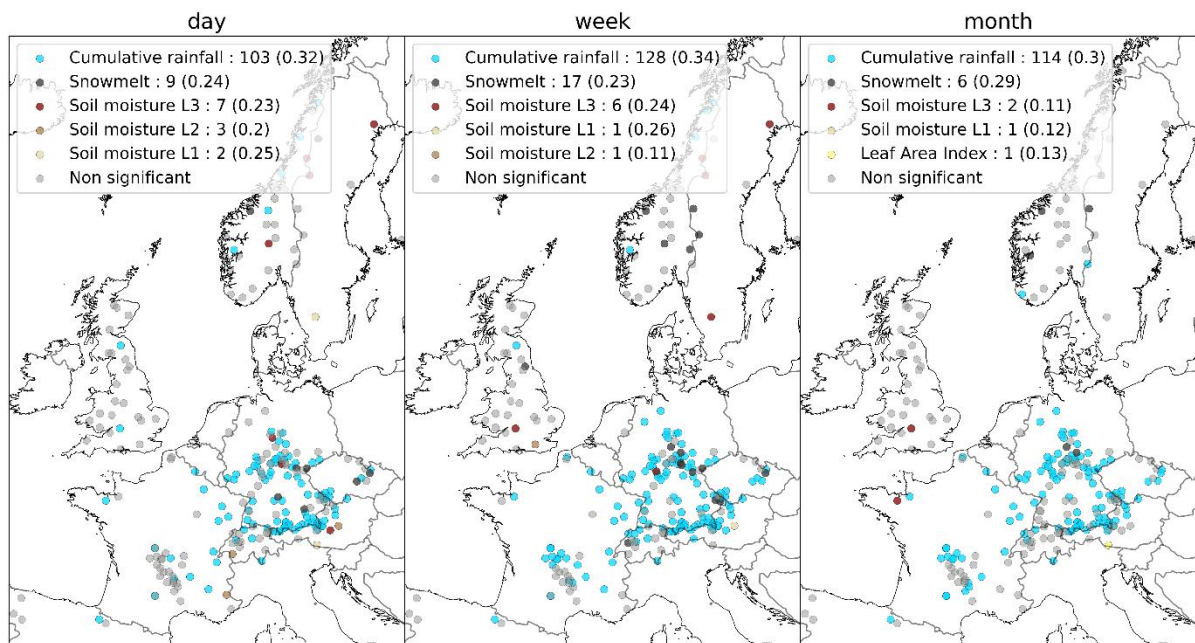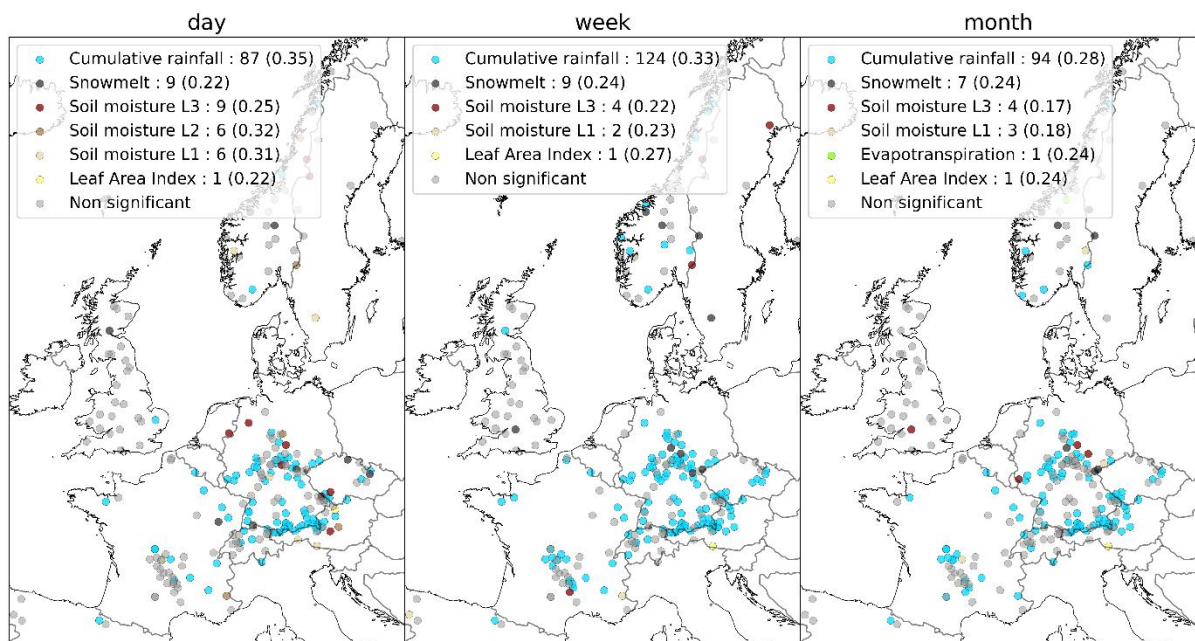

Figure S1: Boxplots of the number of high flow events for each catchment and percentile (a) and their corresponding runoff magnitude (b).
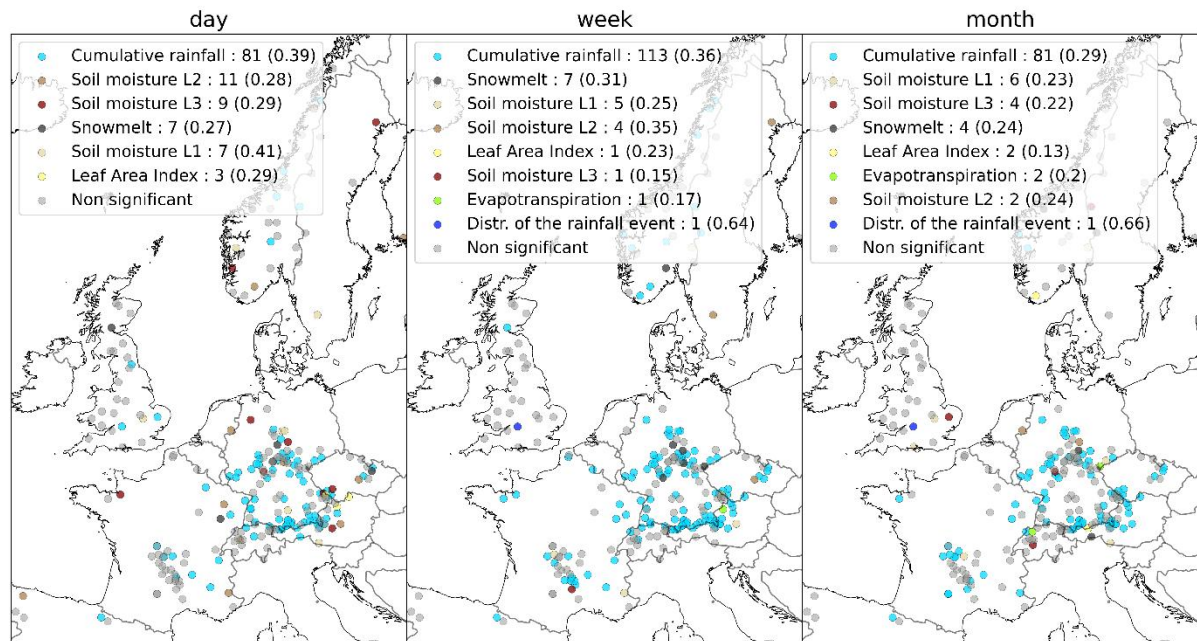
(a) Dominant driver for different time scales preceding the high flow event (Q > 95th percentile)

day

- Cumulative rainfall : 103 (0.32)
- Snowmelt : 9 (0.24)
- Soil moisture L3 : 7 (0.23)
- Soil moisture L2 : 3 (0.2)
- Soil moisture L1 : 2 (0.25)
- Non significant

week

- Cumulative rainfall : 128 (0.34)
- Snowmelt : 17 (0.23)
- Soil moisture L3 : 6 (0.24)
- Soil moisture L1 : 1 (0.26)
- Soil moisture L2 : 1 (0.11)
- Non significant

month

- Cumulative rainfall : 114 (0.3)
- Snowmelt : 6 (0.29)
- Soil moisture L3 : 2 (0.11)
- Soil moisture L1 : 1 (0.12)
- Leaf Area Index : 1 (0.13)
- Non significant

(b) Dominant driver for different time scales preceding the high flow event (Q > 98th percentile)

day

- Cumulative rainfall : 87 (0.35)
- Snowmelt : 9 (0.22)
- Soil moisture L3 : 9 (0.25)
- Soil moisture L2 : 6 (0.32)
- Soil moisture L1 : 6 (0.31)
- Leaf Area Index : 1 (0.22)
- Non significant

week

- Cumulative rainfall : 124 (0.33)
- Snowmelt : 9 (0.24)
- Soil moisture L3 : 4 (0.22)
- Soil moisture L1 : 2 (0.23)
- Leaf Area Index : 1 (0.27)
- Non significant

month

- Cumulative rainfall : 94 (0.28)
- Snowmelt : 7 (0.24)
- Soil moisture L3 : 4 (0.17)
- Soil moisture L1 : 3 (0.18)
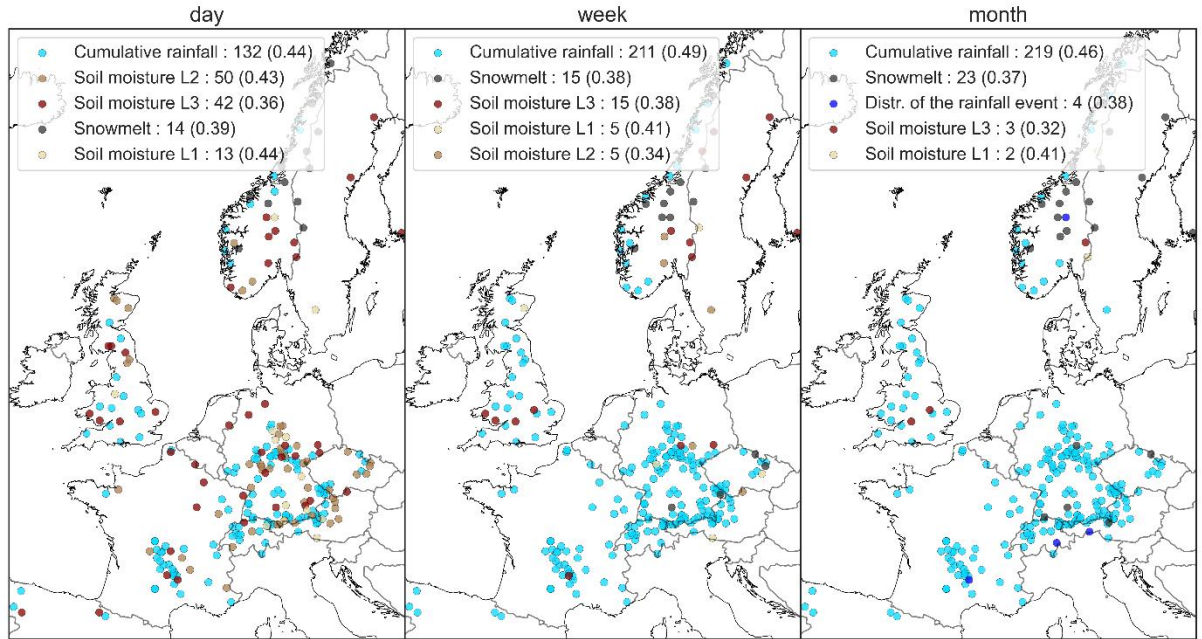- Evapotranspiration : 1 (0.24)
- Leaf Area Index : 1 (0.24)
- Non significant

(c) Dominant driver for different time scales preceding the high flow event (Q > 99th percentile)
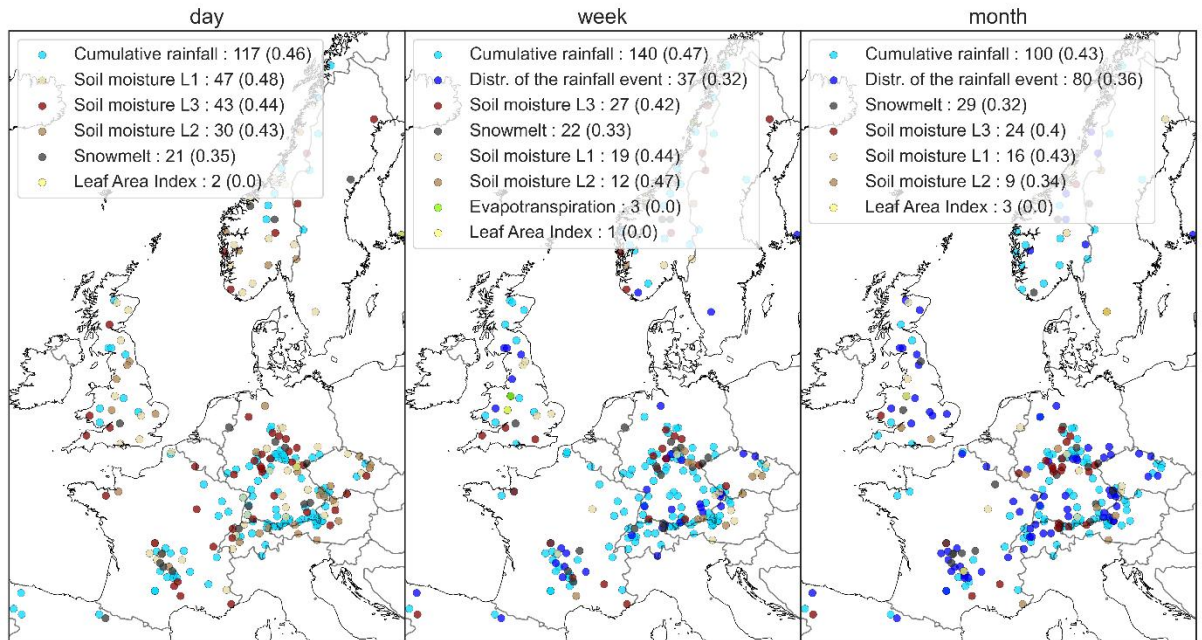

Figure S2: Illustration of most influential drivers of extreme high flows exceeding the 95th (a), 98th (b) and 99th (c) percentile using the multi-inference method.

(a) Dominant drivers for different time scales preceding high flow events (Q > 90th percentile)

day

- Cumulative rainfall : 132 (0.44)
- Soil moisture L2 : 50 (0.43)
- Soil moisture L3 : 42 (0.36)
- Snowmelt : 14 (0.39)
- Soil moisture L1 : 13 (0.44)

week

- Cumulative rainfall : 211 (0.49)
- Snowmelt : 15 (0.38)
- Soil moisture L3 : 15 (0.38)
- Soil moisture L1 : 5 (0.41)
- Soil moisture L2 : 5 (0.34)

month

- Cumulative rainfall : 219 (0.46)
- Snowmelt : 23 (0.37)
- Distr. of the rainfall event : 4 (0.38)
- Soil moisture L3 : 3 (0.32)
- Soil moisture L1 : 2 (0.41)

(b) Dominant drivers for different time scales preceding high flow events (Q > 99.5th percentile)

day

- Cumulative rainfall : 117 (0.46)
- Soil moisture L1 : 47 (0.48)
- Soil moisture L3 : 43 (0.44)
- Soil moisture L2 : 30 (0.43)
- Snowmelt : 21 (0.35)
- Leaf Area Index : 2 (0.0)

week

- Cumulative rainfall : 140 (0.47)
- Distr. of the rainfall event : 37 (0.32)
- Soil moisture L3 : 27 (0.42)
- Snowmelt : 22 (0.33)
- Soil moisture L1 : 19 (0.44)
- Soil moisture L2 : 12 (0.47)
- Evapotranspiration : 3 (0.0)
- Leaf Area Index : 1 (0.0)

month

- Cumulative rainfall : 100 (0.43)
- Distr. of the rainfall event : 80 (0.36)
- Snowmelt : 29 (0.32)
- Soil moisture L3 : 24 (0.4)
- Soil moisture L1 : 16 (0.43)
- Soil moisture L2 : 9 (0.34)
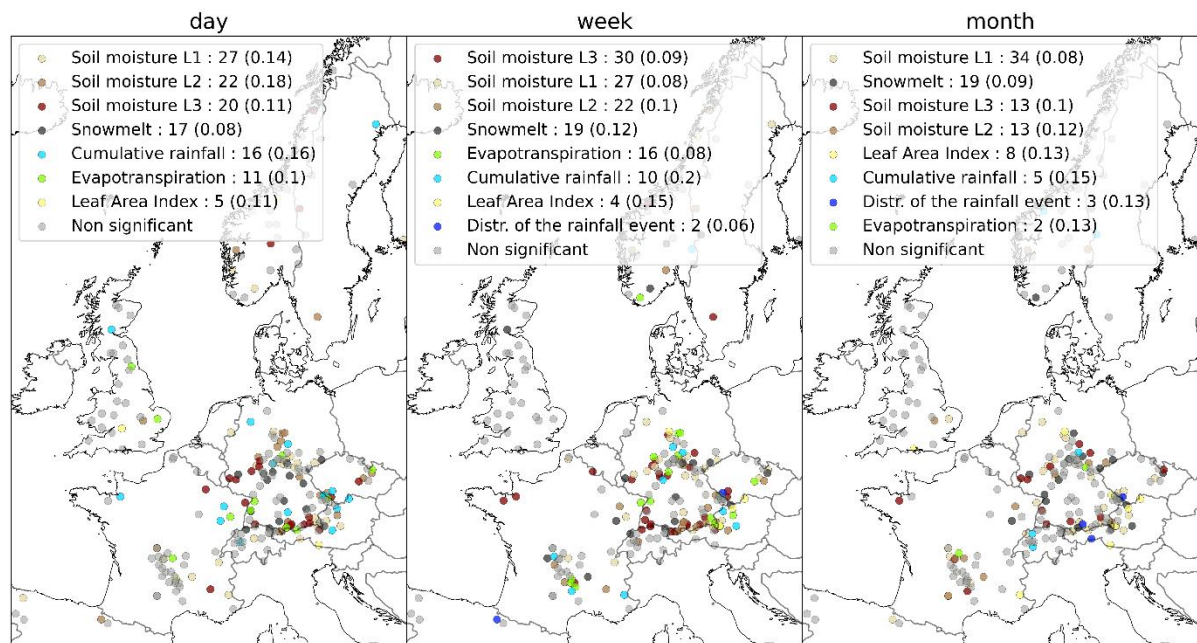- Leaf Area Index : 3 (0.0)

Figure S3: Illustration of most influential drivers of extreme high flows exceeding the 90th (a) and 99.5th (b) percentile using the correlation analysis method.
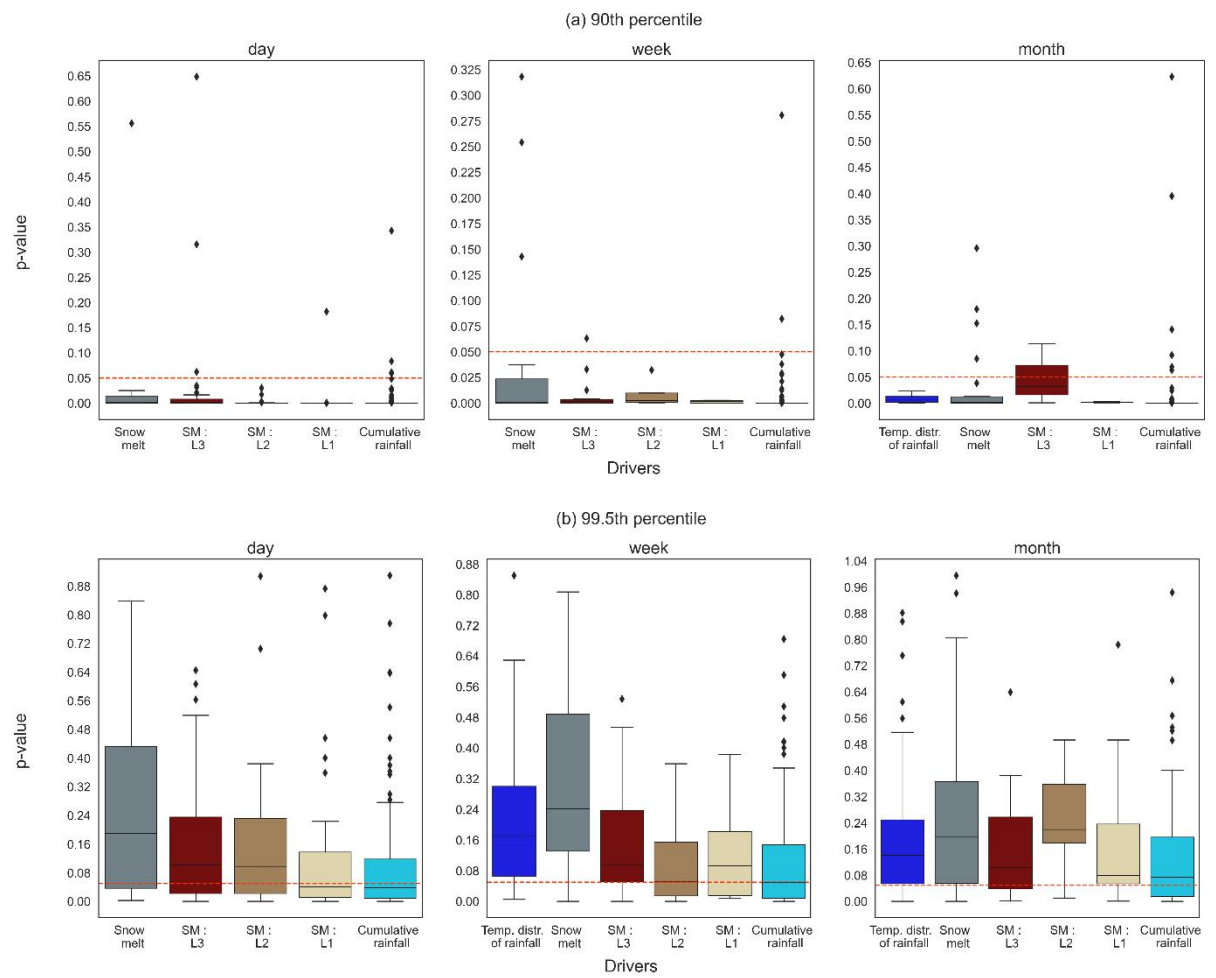
Figure S4: Significance of the correlation analysis across different percentiles and drivers.

Second most important driver for different time scales preceding the high flow event (Q > 99th percentile)

day | week | month

day legend:
- Soil moisture L1 : 27 (0.14)
- Soil moisture L2 : 22 (0.18)
- Soil moisture L3 : 20 (0.11)
- Snowmelt : 17 (0.08)
- Cumulative rainfall : 16 (0.16)
- Evapotranspiration : 11 (0.1)
- Leaf Area Index : 5 (0.11)
- Non significant

week legend:
- Soil moisture L3 : 30 (0.09)
- Soil moisture L1 : 27 (0.08)
- Soil moisture L2 : 22 (0.1)
- Snowmelt : 19 (0.12)
- Evapotranspiration : 16 (0.08)
- Cumulative rainfall : 10 (0.2)
- Leaf Area Index : 4 (0.15)
- Distr. of the rainfall event : 2 (0.06)
- Non significant

month legend:
- Soil moisture L1 : 34 (0.08)
- Snowmelt : 19 (0.09)
- Soil moisture L3 : 13 (0.1)
- Soil moisture L2 : 13 (0.12)
- Leaf Area Index : 8 (0.13)
- Cumulative rainfall : 5 (0.15)
- Distr. of the rainfall event : 3 (0.13)
- Evapotranspiration : 2 (0.13)
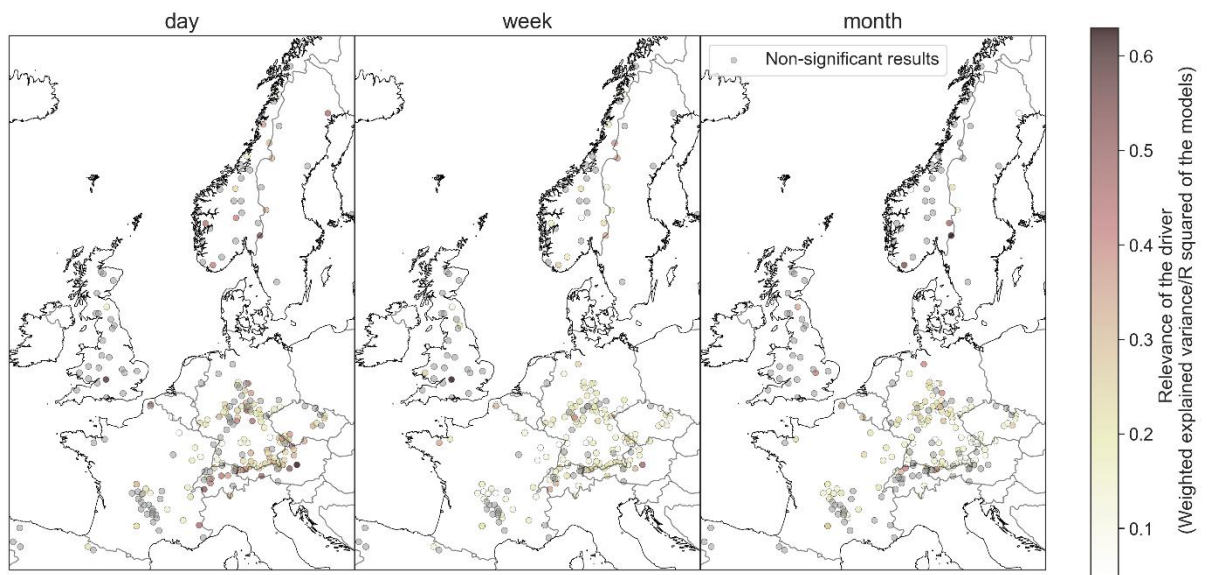- Non significant

Figure S5: Illustration of the second most influential drivers of extreme high flows exceeding the 99th percentile using the multi-inference method.
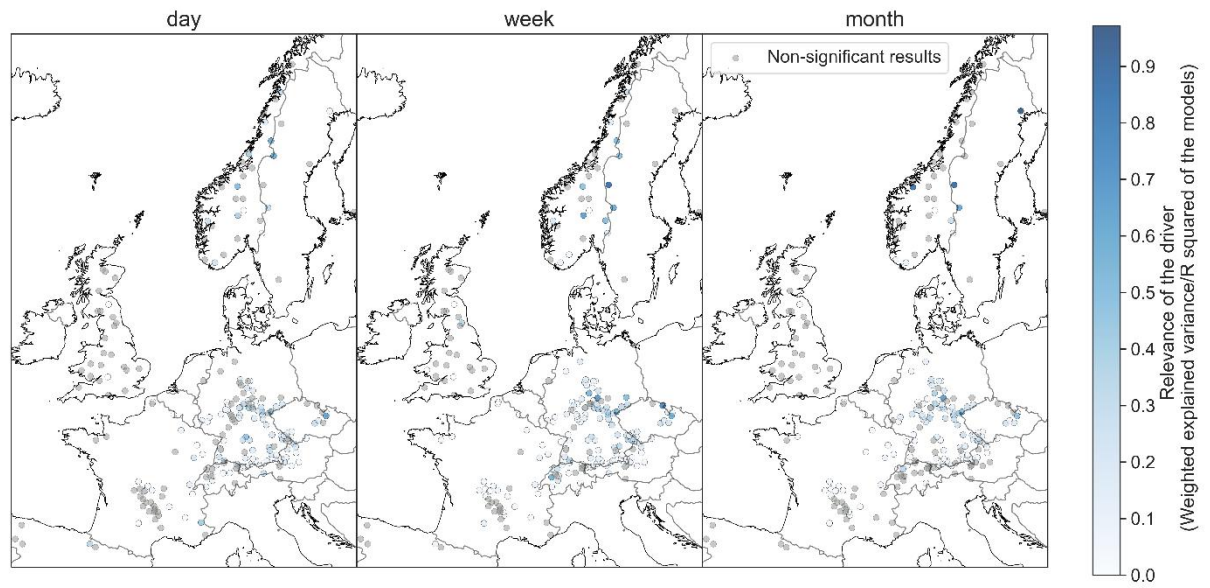
## (a) Relevance of rainfall across time scales (Q > 90th percentile)
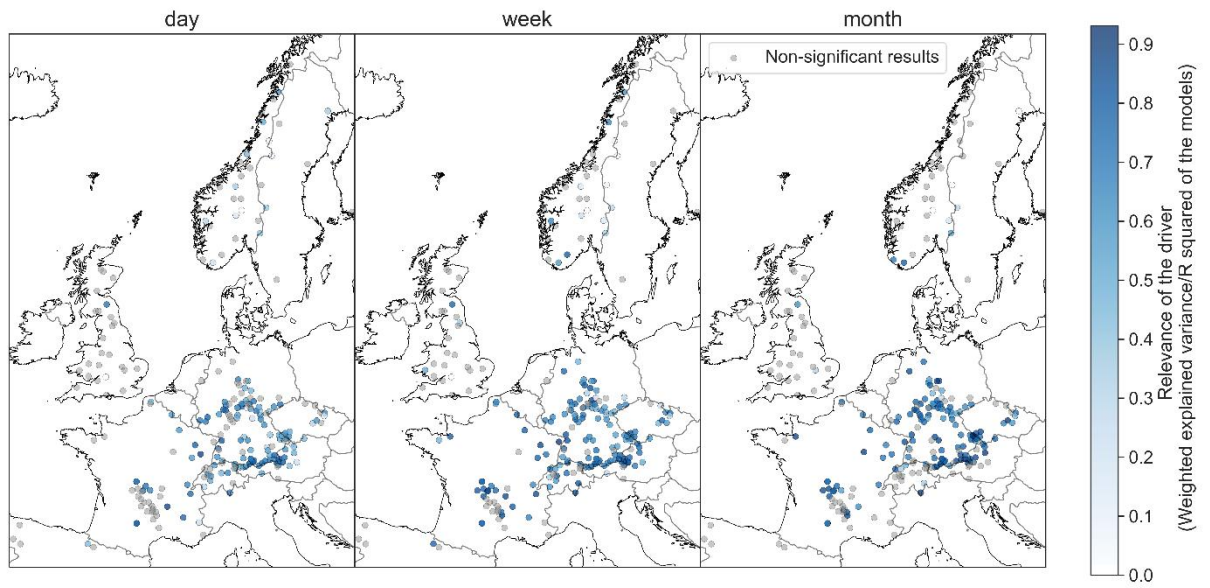
(b) Relevance of soil moisture across time scales (Q > 90th percentile)

(c) Relevance of snowmelt across time scales (Q > 90th percentile)

Figure S6: Illustration of the relevance of rainfall (a), soil moisture (b) and snow melt (c) in the selected catchments of extreme high flows exceeding the 90th percentile using the multi-inference method.
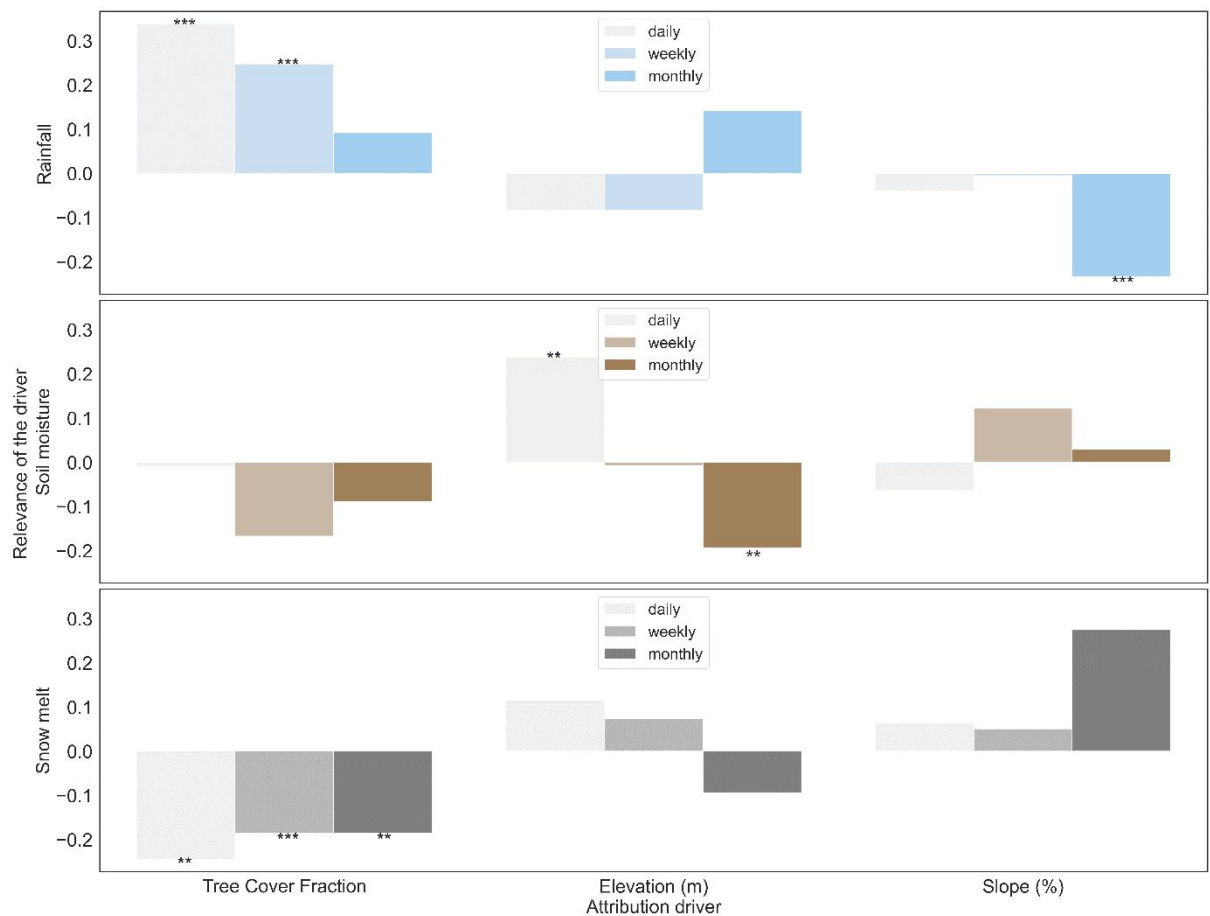
Figure S7: Attributing the spatial patterns of the relevance of considered drivers of high flows to vegetation and terrain characteristics for high flow events exceeding the 90th percentile. Vertical axis corresponds to the partial correlation between driver relevance and each attribution variable. Results are shown for the considered different time scales. Stars on top of the bars indicate statistically significant partial correlations (** : p-value <0.05 , *** : p-value < 0.005).

Table S1: Searches for flood-related articles (TS: topic, PY: Year Published)

Searches	Web of Science Query
1	TS = ((flood* near/50 (rain*)) OR (flood* near/50 (precipitation*))) AND PY= 2002-2021
2	TS=((flood* near/50 evapo*) OR (flood* near/50 vegetation*)) AND PY=2002-2021
3	TS=((flood* near/50 (snow*)) OR (flood* near/50 (melt*))) AND PY=2002-2021
4	TS=((flood* near/50 (soil* near/1 moisture*)) OR (flood* near/50 (soil* near/1 water*))) AND PY=2002-2021
5	#1 AND #2 AND #3 AND #4