Abstract

Memory decay curves describe streamflow dynamics across Europe at multiple timescales

Mira Anand & Wouter Berghuijs

Department of Earth Sciences, VU Amsterdam | m.l.f.anand@vu.nl

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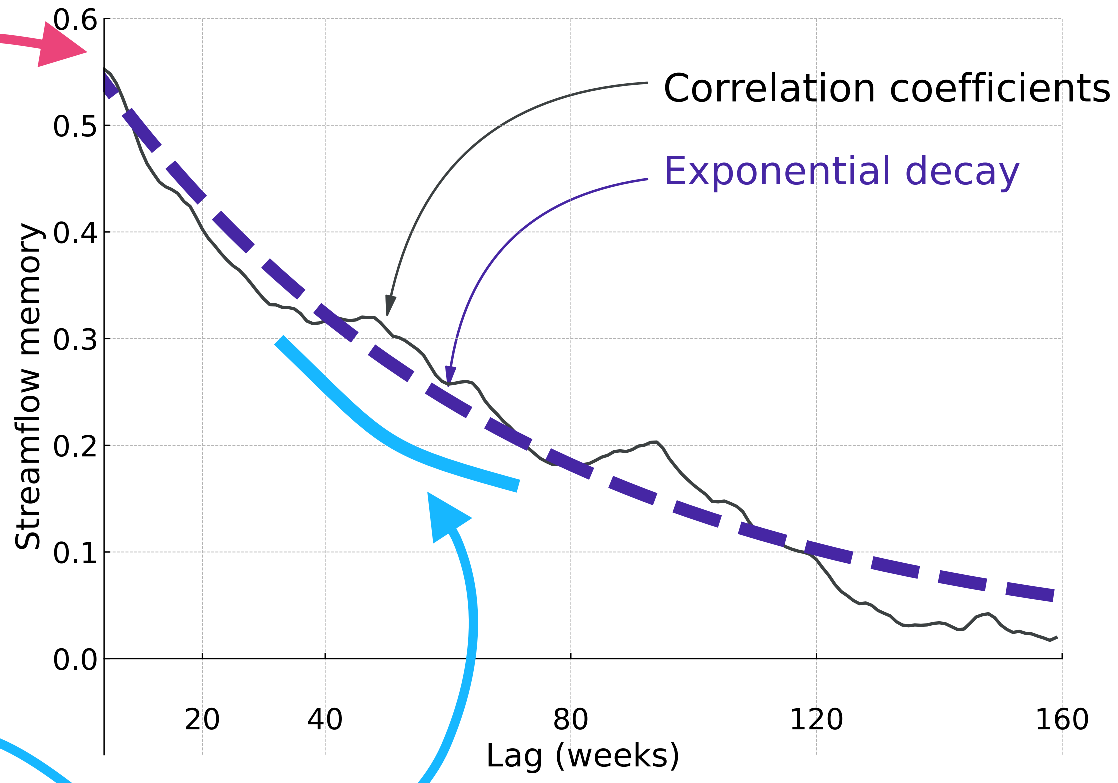
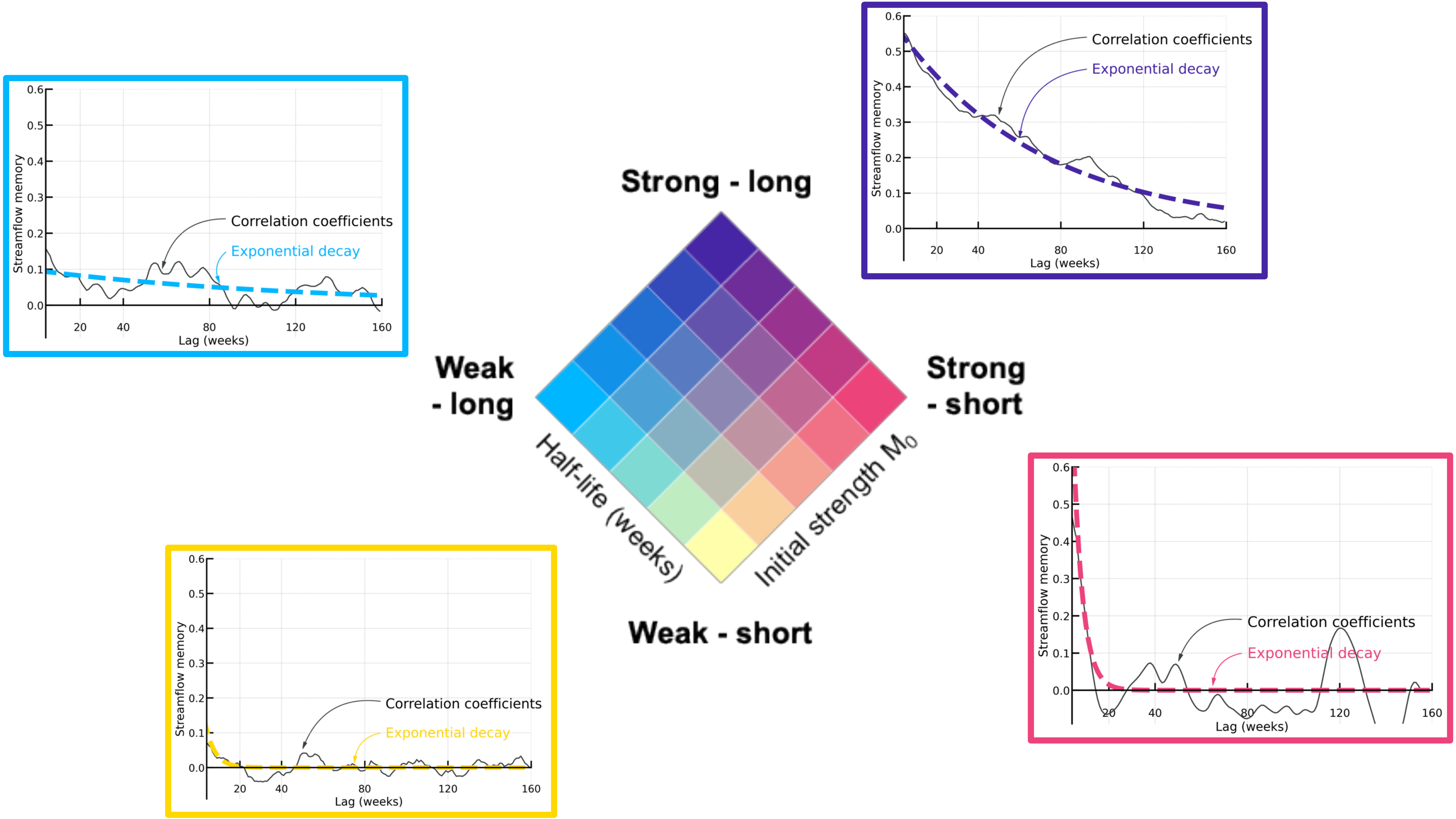
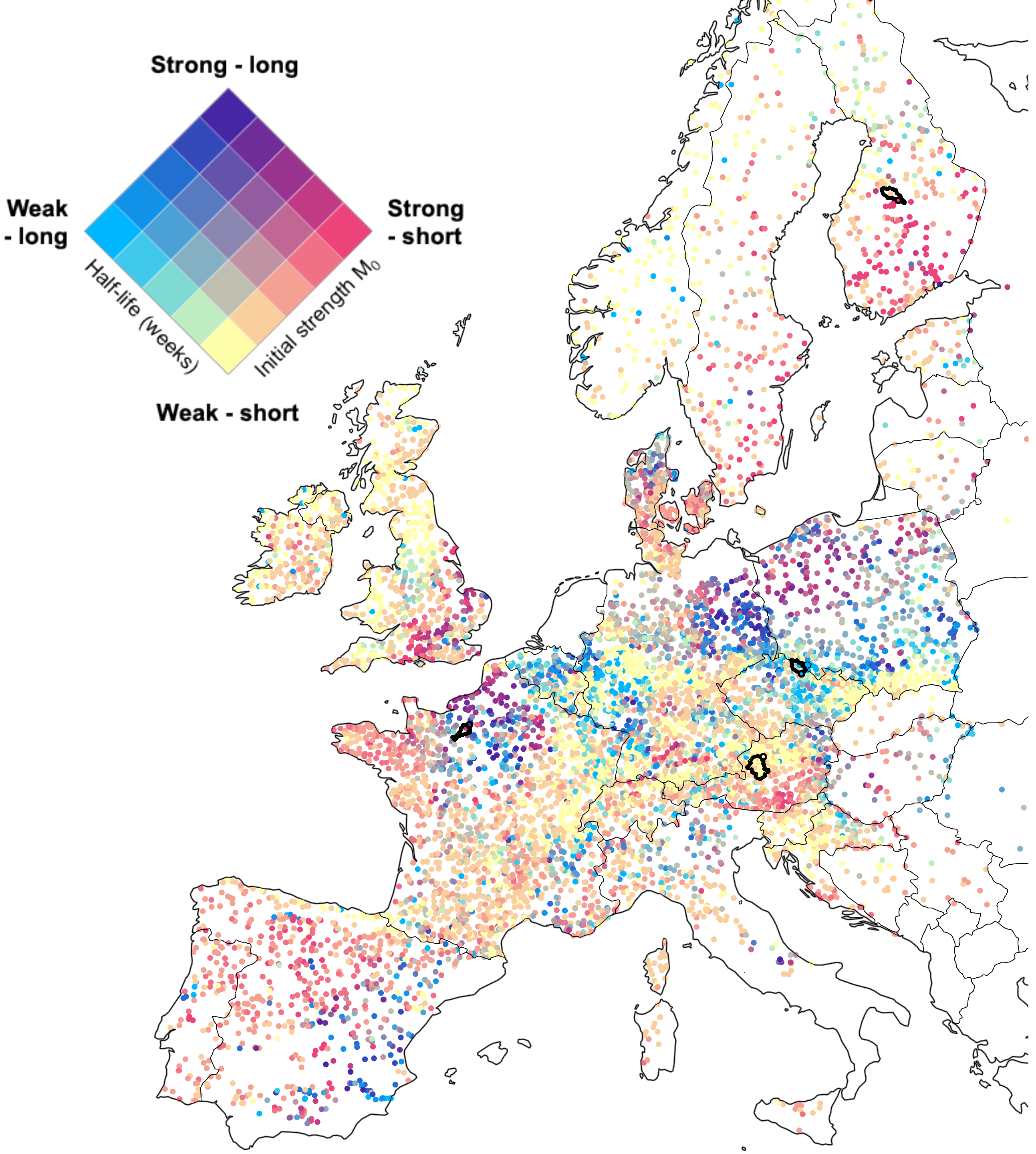
Memory decay curves

- Exponential decay curves describe autocorrelation from one month -> three years
- Initial strength M_0 [-] and half-life [weeks]




Strong - long
Weak - long
Strong - short
Weak - short
Half-life (weeks)
Initial strength M0
Streamflow memory
Lag (weeks)
Correlation coefficients
Exponential decay
0.0
0.1
0.2
0.3
0.4
0.5
0.6
20
40
80
120
160

- Memory geographically connects to climate and landscape features
- Memory decay curves expose memory across timescales



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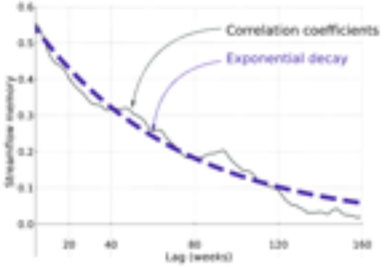
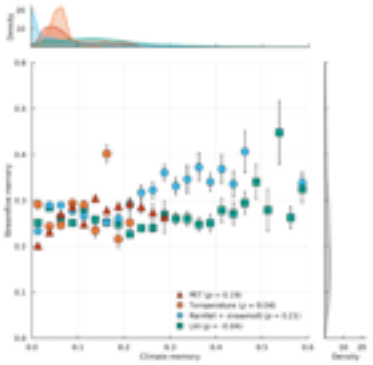
Calculating memory decay curves

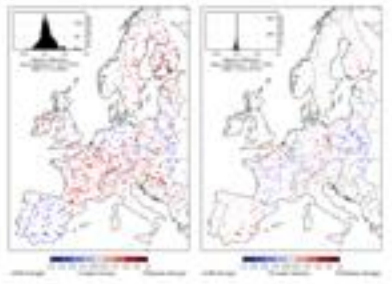


Spatial and temporal patterns of memory

What causes streamflow memory?



Does modelled streamflow data have memory?



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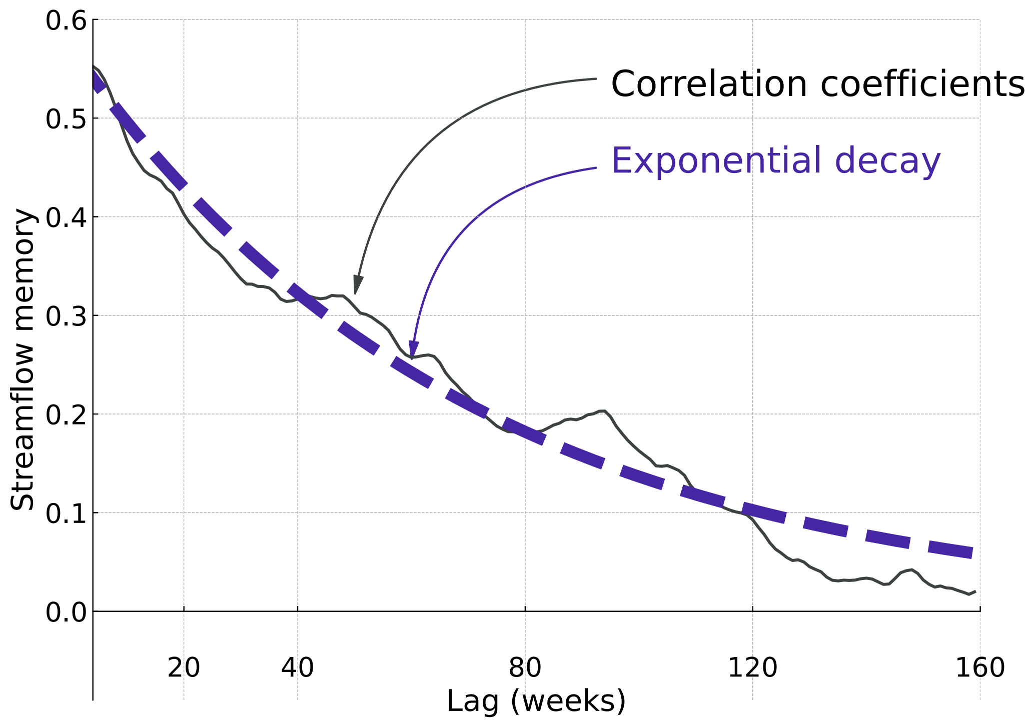
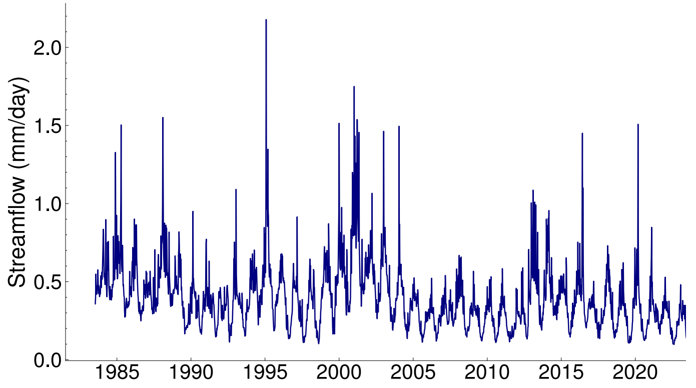
Calculating memory decay curves

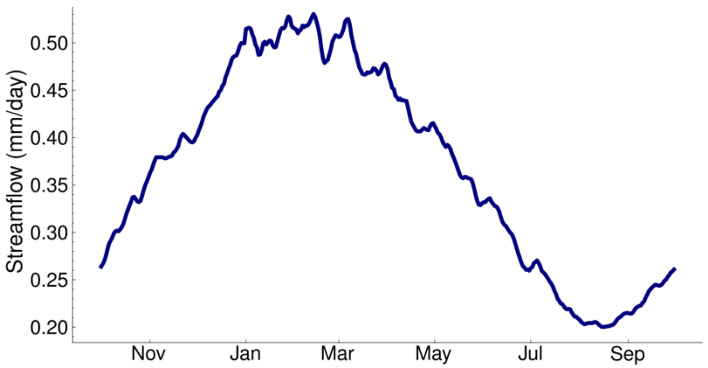


Calculating memory

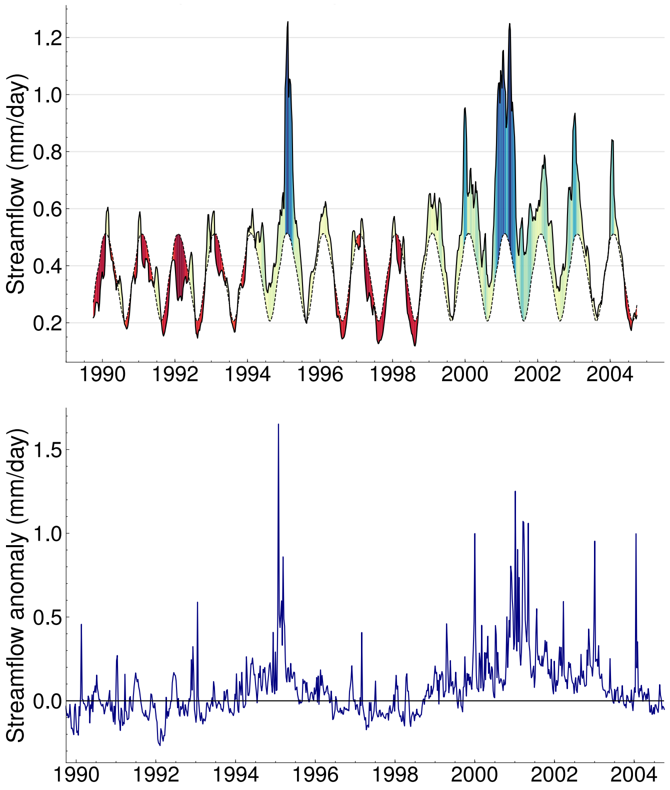
1. Weekly mean streamflow



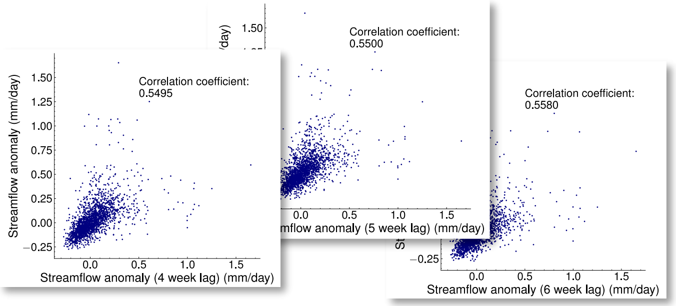
2. Mean yearly cycle



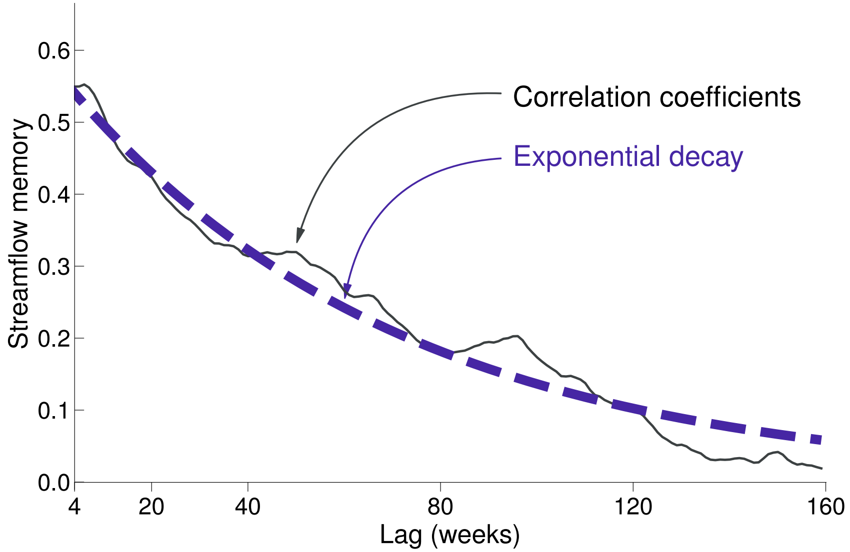
3. Streamflow anomaly time series



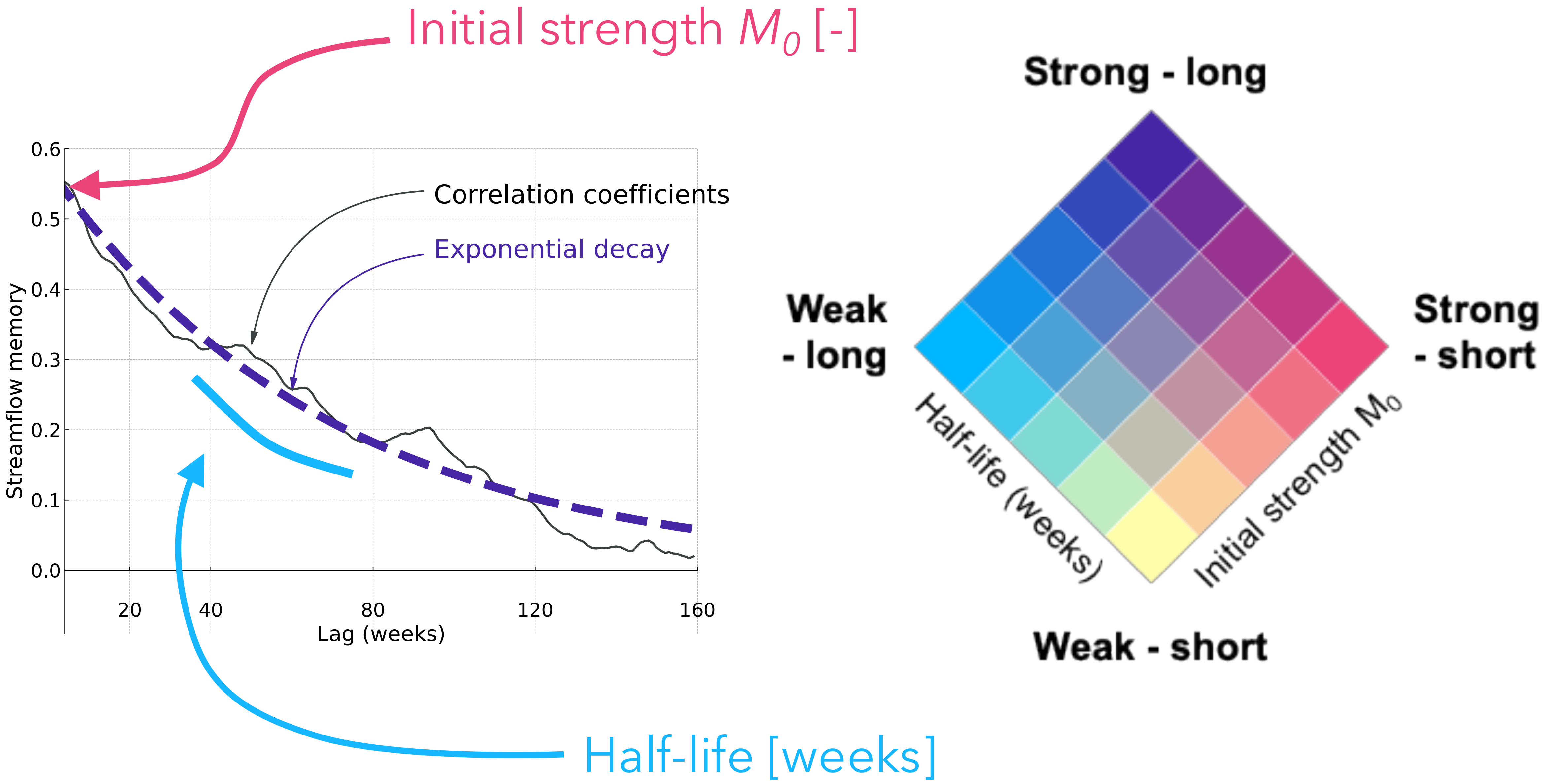
4. Autocorrelations at weekly timesteps from **lag 4** to **lag 160** (3 yrs)



5. Fit exponential decay curve to autocorrelations



Streamflow data from do Nascimento, Thiago VM, et al. "EStreams: An integrated dataset and catalogue of streamflow, hydro-climatic and landscape variables for Europe." Scientific Data 11.1 (2024): 879.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Correlation coefficients
Exponential decay
Streamflow memory
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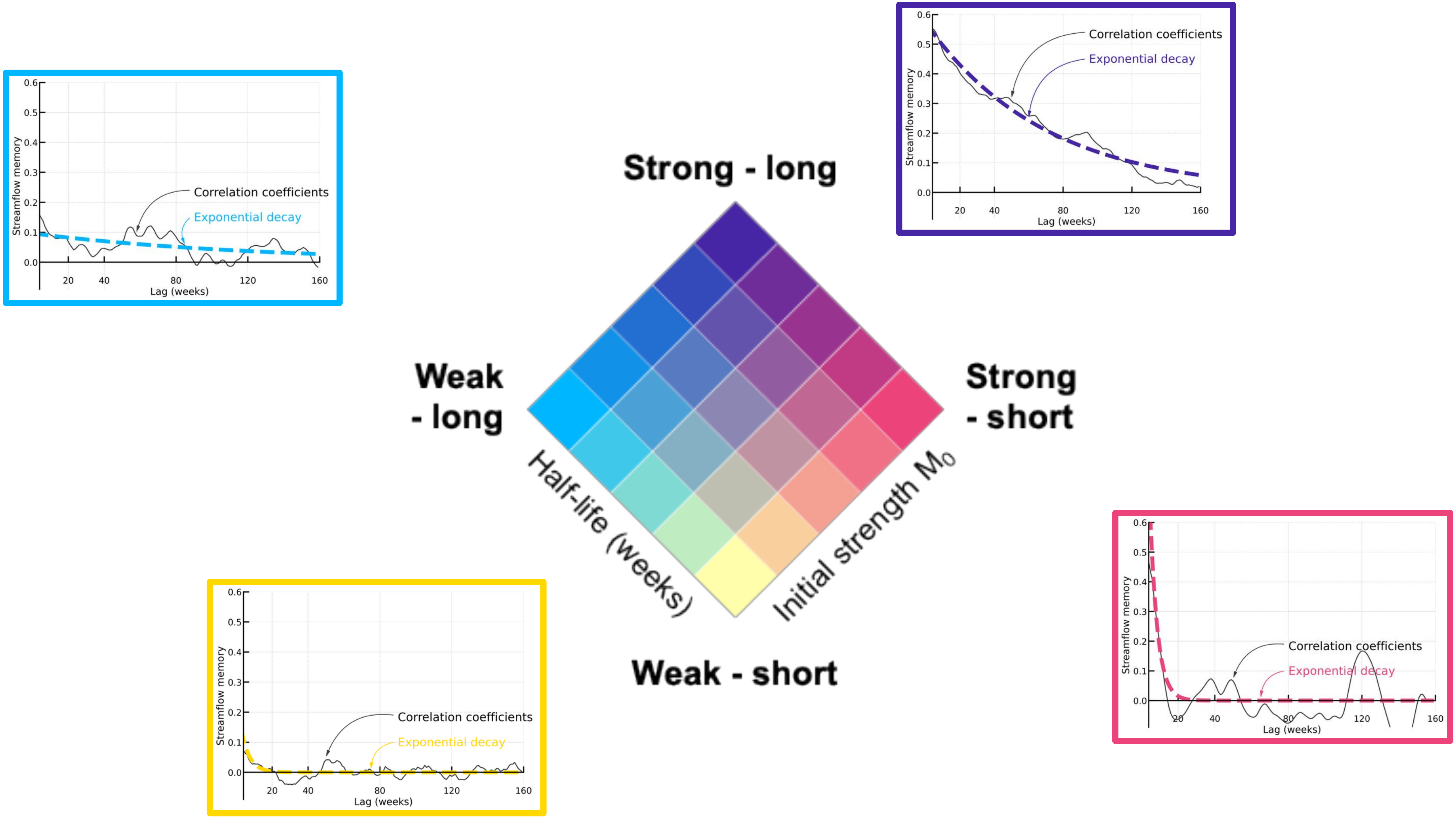
Lag (weeks)
Half-life [weeks]
Strong - long
Weak
- long
Strong
- short
Weak - short
Half-life (weeks)
Initial strength M_0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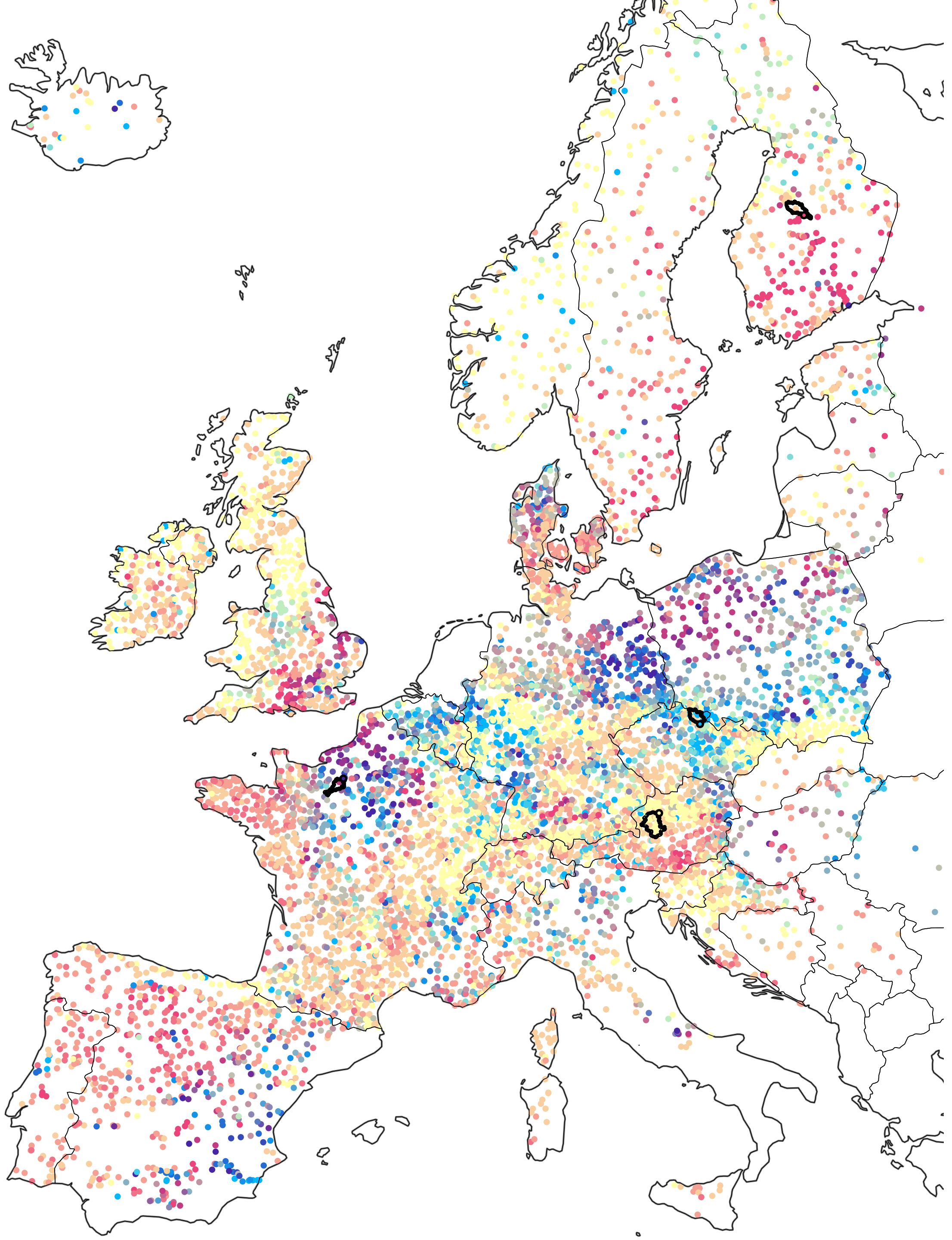
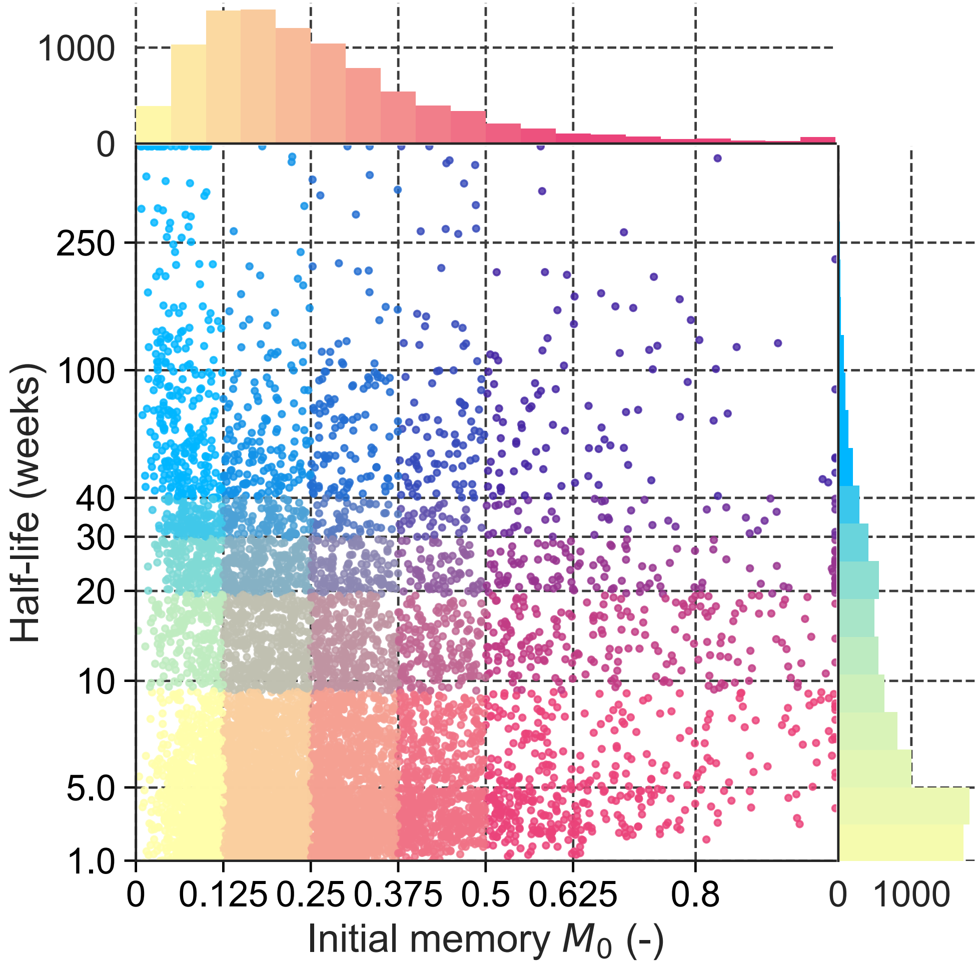
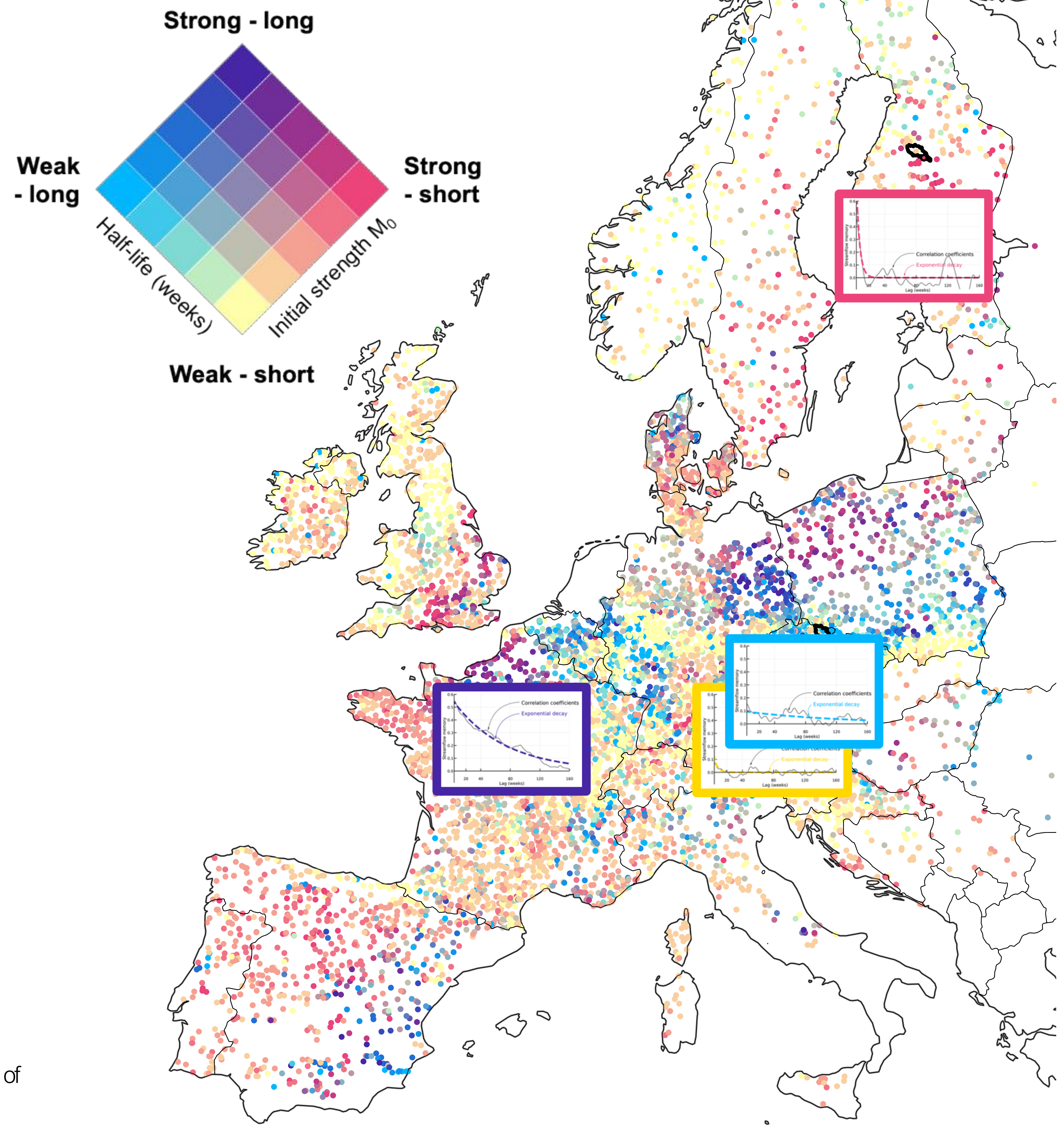
Spatial and temporal patterns of memory







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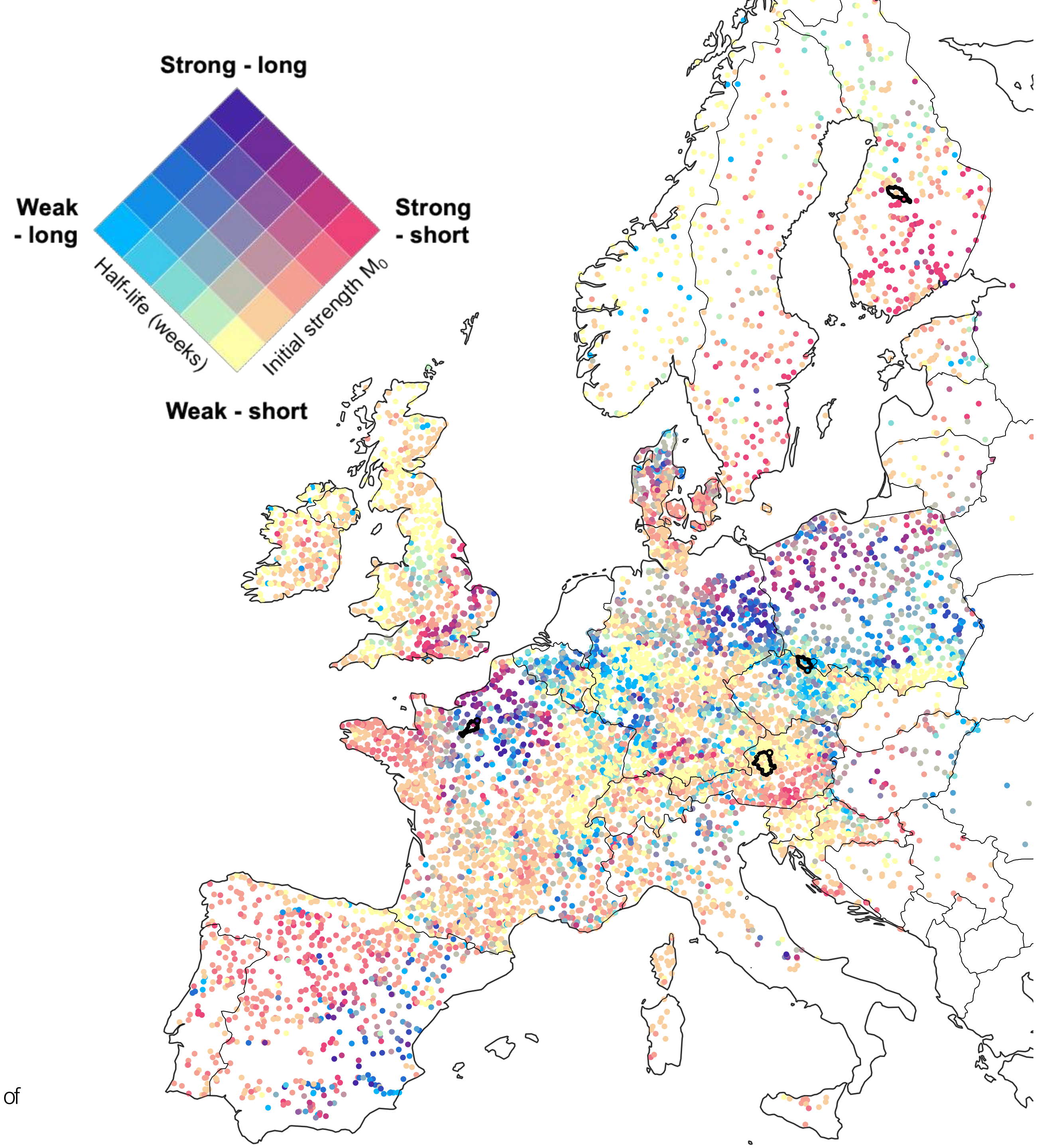
Distinct geographic patterns suggest links to catchment features, e.g.

- Chalk aquifers in England, Paris Basin
- Deep bedrock in Poland, Germany



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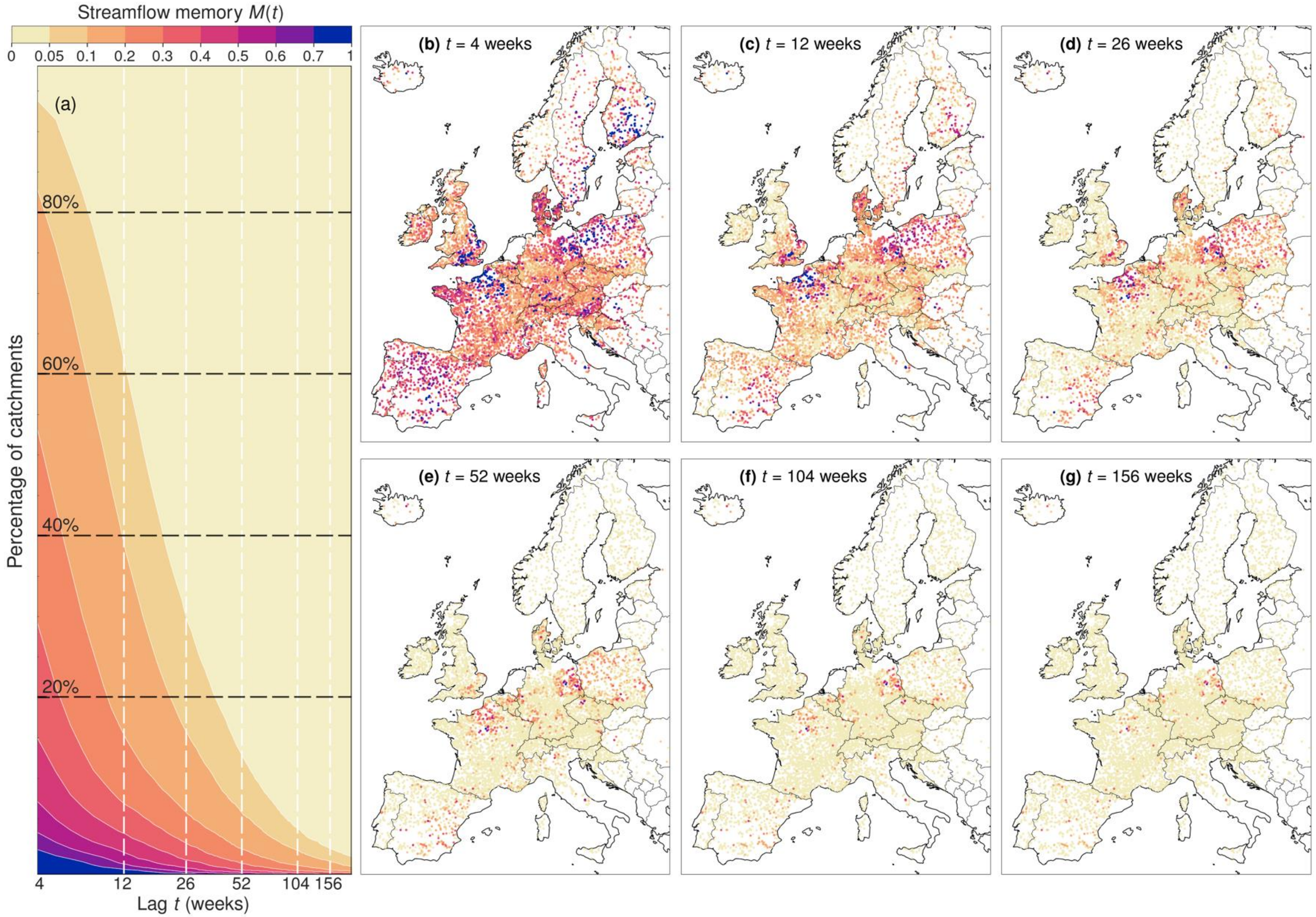
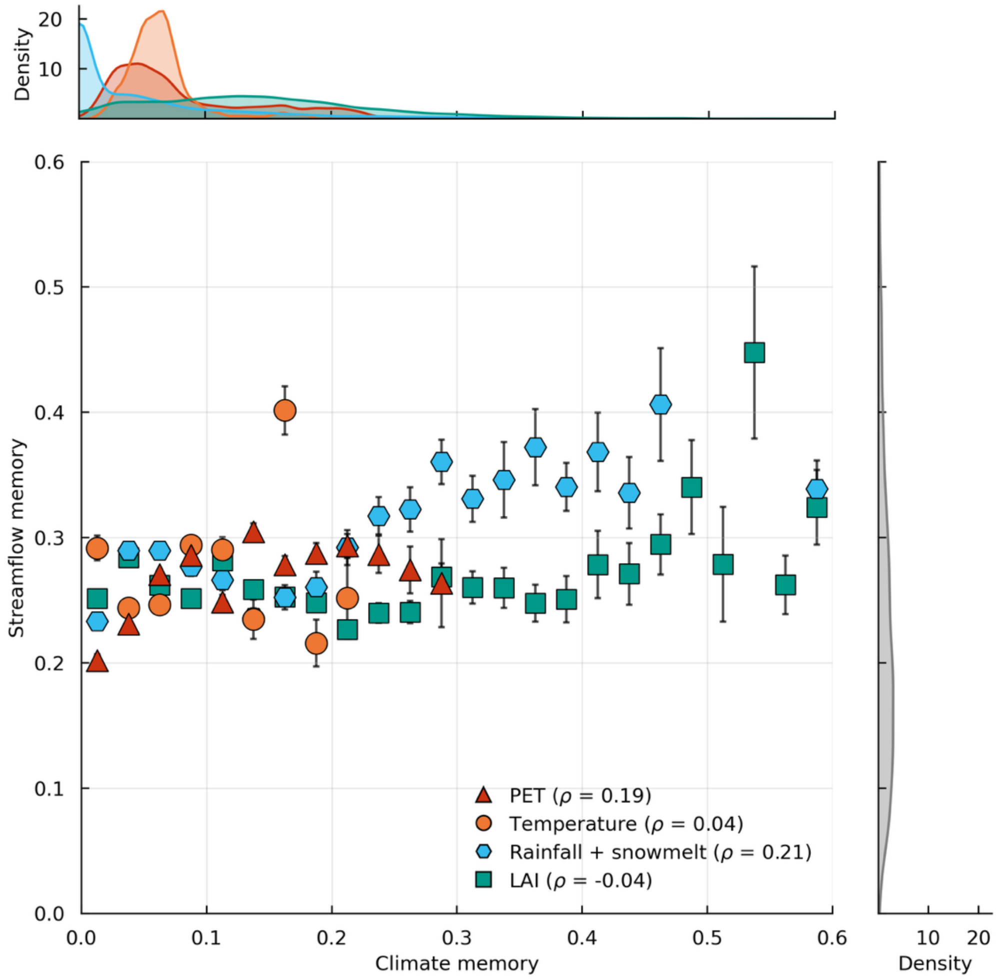
Timescales of memory

- Monthly memory exists in most catchments
- 4 weeks: 31.1% (n = 2889) with M_0 > 0.3
- 1 year: 1.3% (n = 125) with M_0 > 0.3
- Memory in areas with large aquifers or deeper bedrock is *more persistent*

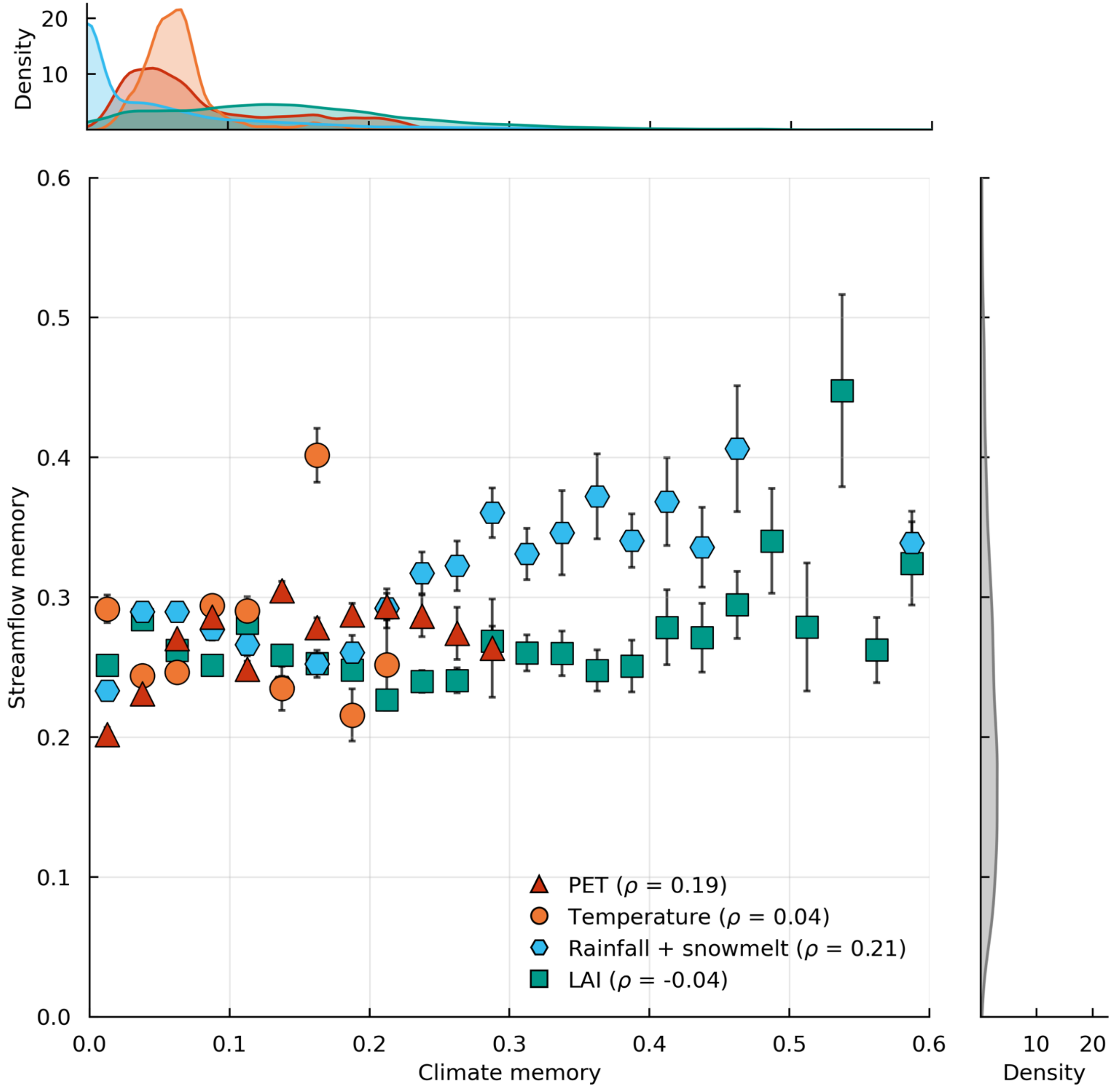


What causes streamflow memory?



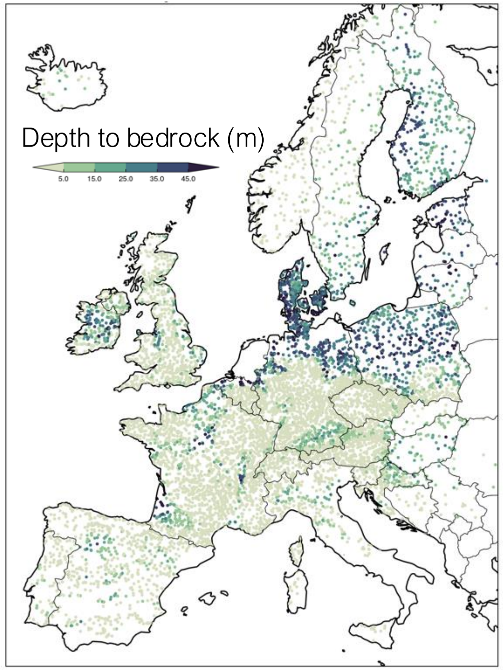
Not (primarily) climate patterns

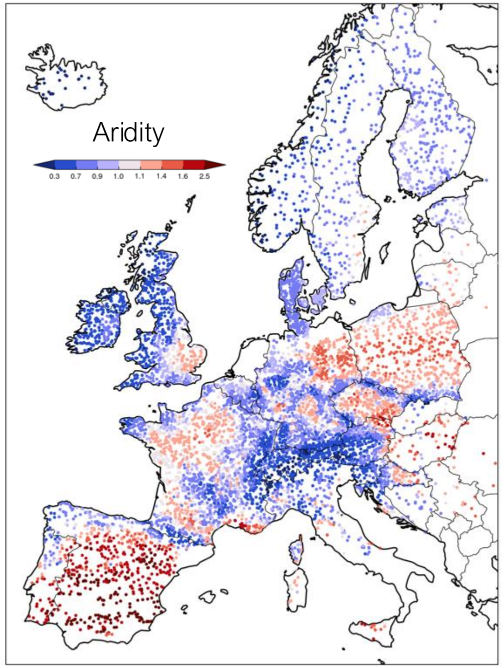
- Comparison to memory in time series of temperature, precipitation, PET, LAI
- Memory of climate correlates to memory of streamflow but is generally **weaker than memory of streamflow**

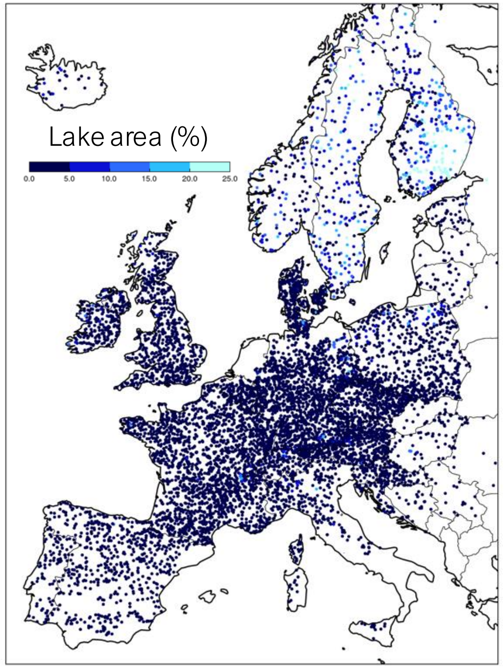


Memory relates to catchment characteristics

- Memory correlates to potential drivers
  - **Climate**: aridity, precipitation
  - **Surface**: presence of lakes, topography, landscape
  - **Subsurface**: bedrock depth, soil characteristics, aquifers
- Characteristics vary for different memory timescales



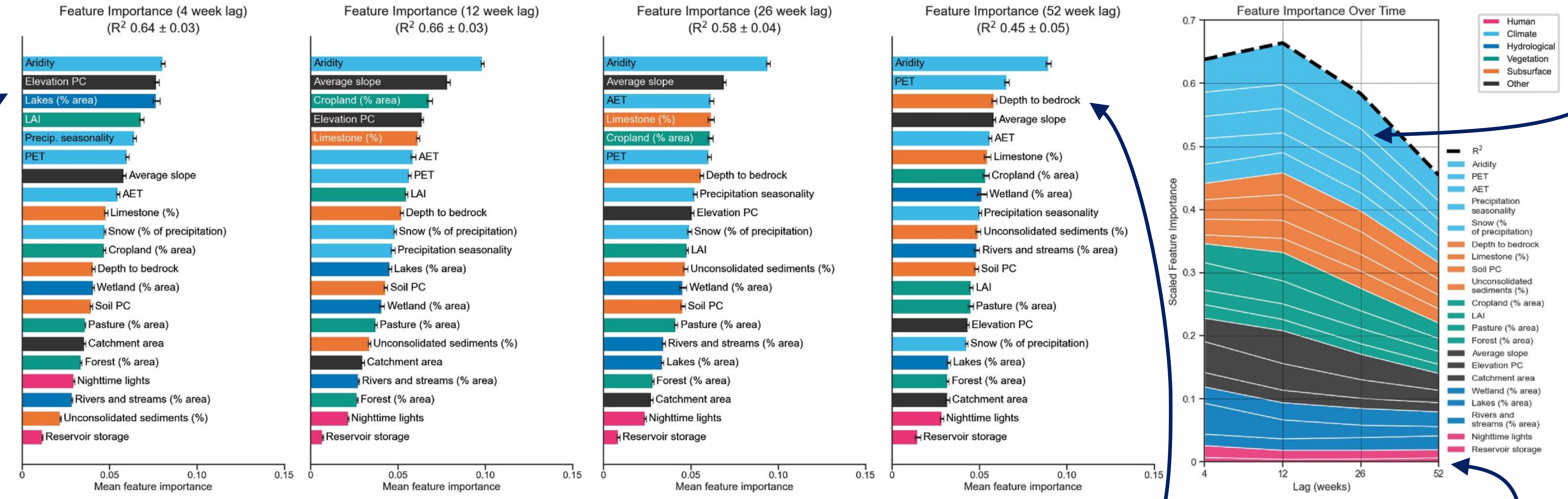




Memory predictions using random forests

Better predictive ability for monthly & seasonal memory

Climate setting has high importance for all timescales

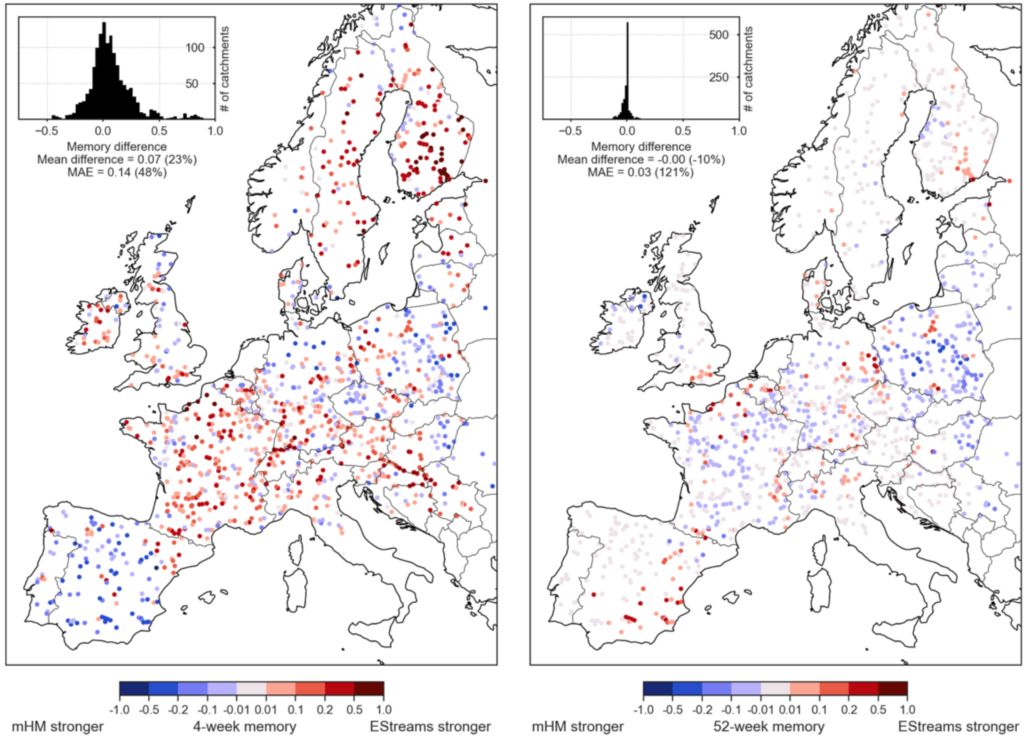


Surface features (i.e. lakes, topography) important for short timescales

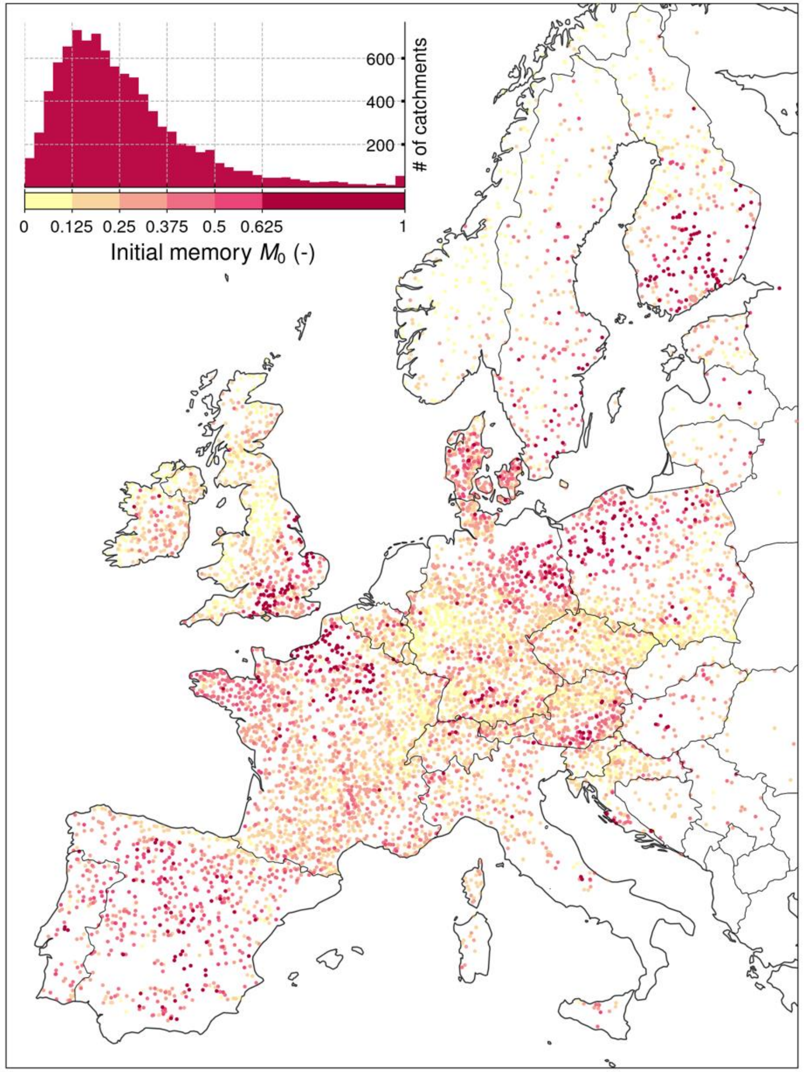
Subsurface features important for long timescales

Anthropogenic features have little predictive ability

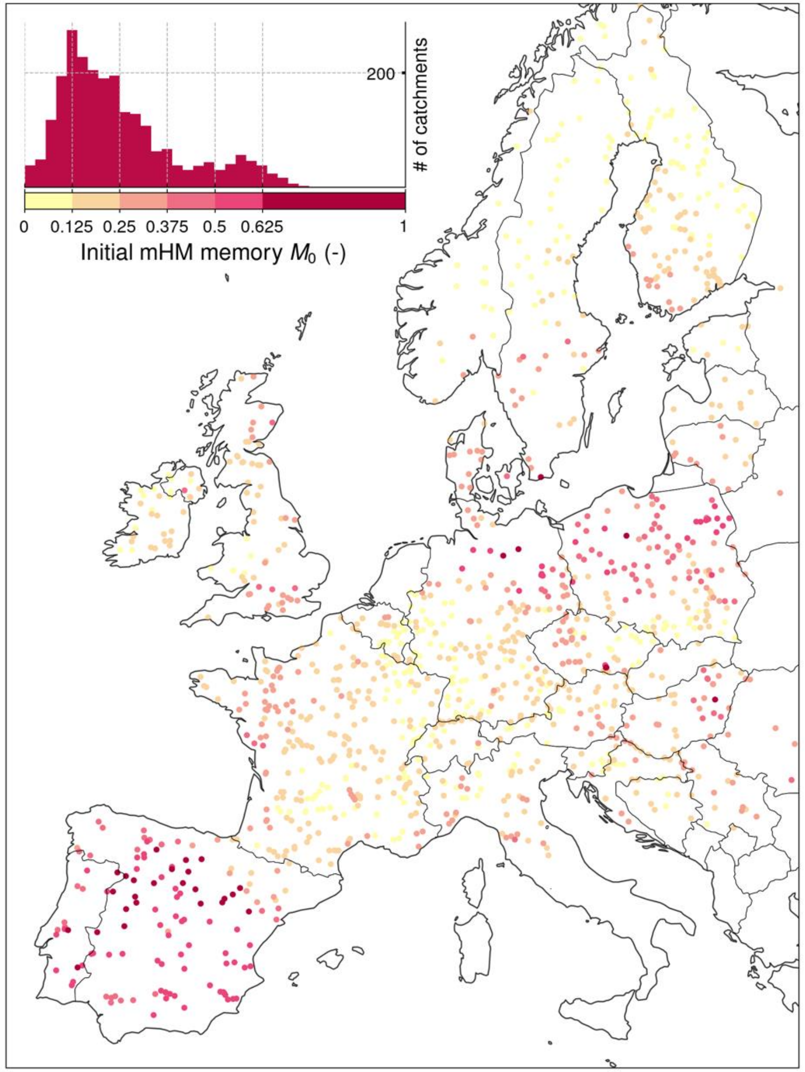
Does modelled streamflow data have memory?

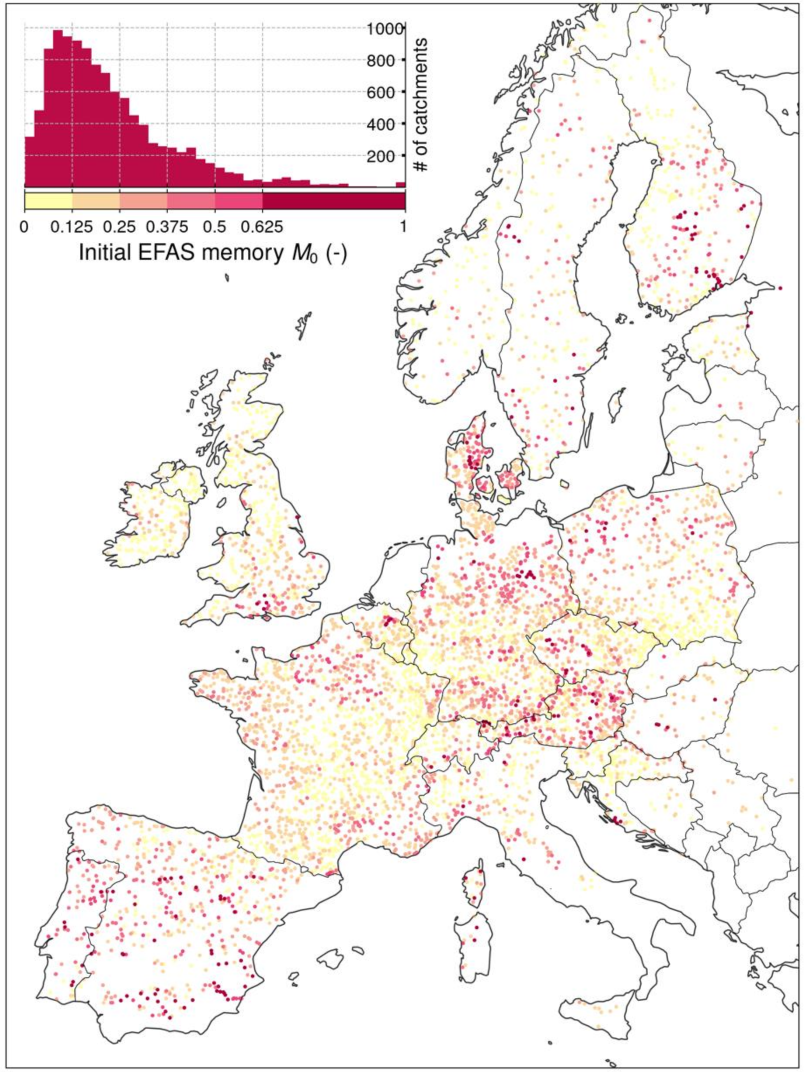


- To predict future hydrological conditions, models should accurately represent memory behaviour
- Comparison to two selected models:
  - EFAS (European Flood Awareness System – LISFLOOD)
  - mHM (mesoscale Hydrologic Model)



Initial strength of measured streamflow memory





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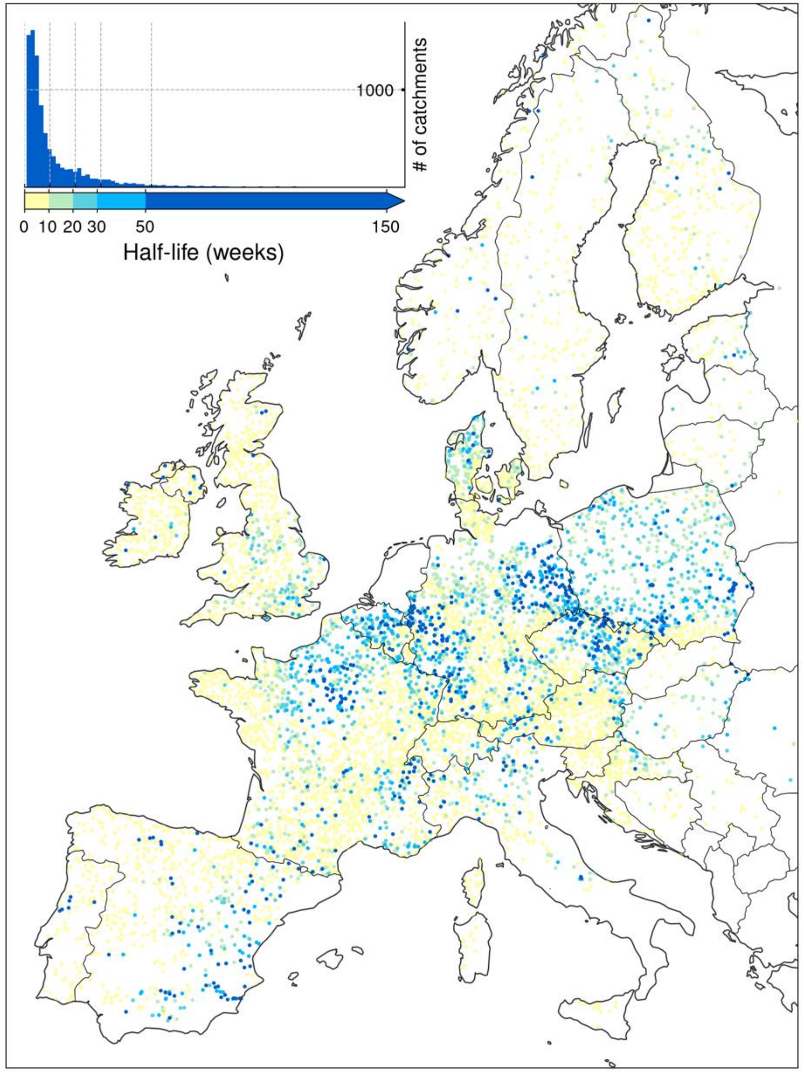
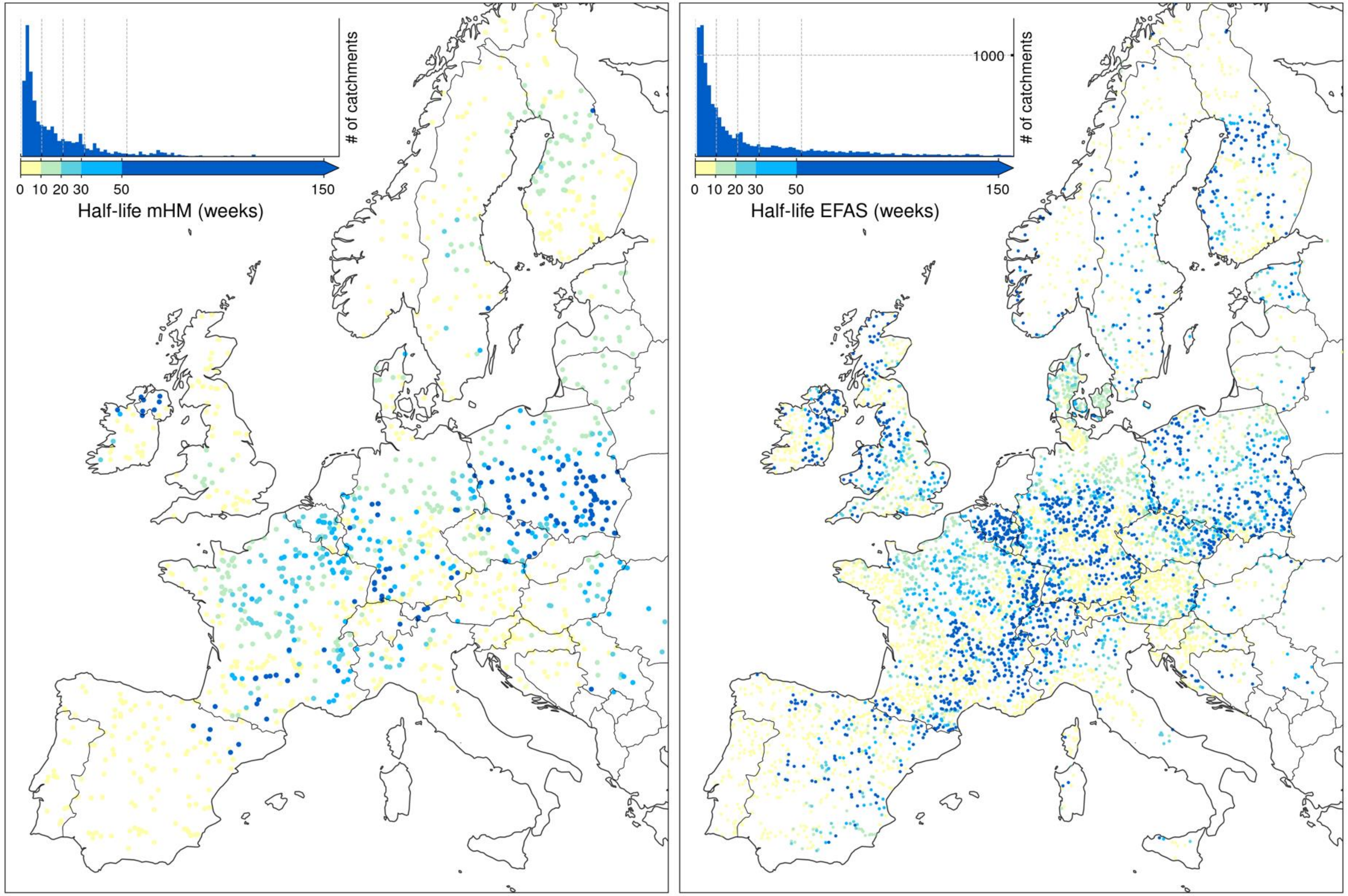


Half-life of measured streamflow memory



Half-life of modelled streamflow memory

- Modelled streamflow shows **weaker monthly** memory and **stronger yearly** memory compared to measured streamflow
- MAE of both models is high relative to mean observed memory, especially for yearly memory