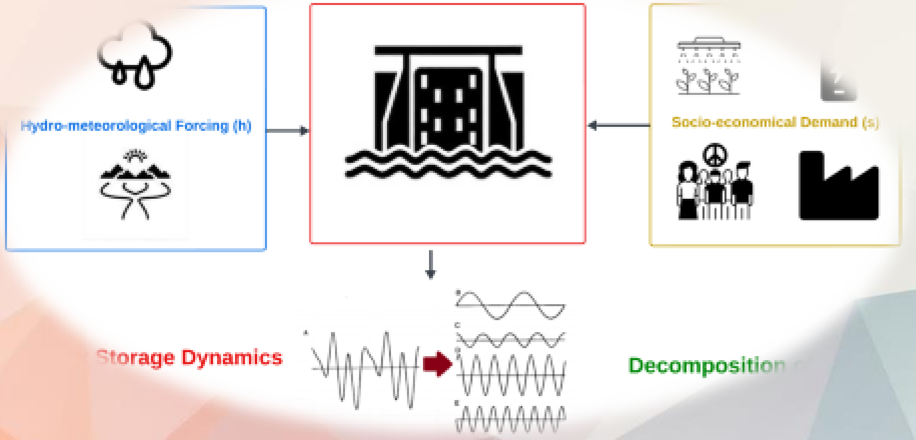
UNICA

Unveiling the Climatic Drivers of Multi-Year Droughts in Sardinia



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University of Cagliari, Italy

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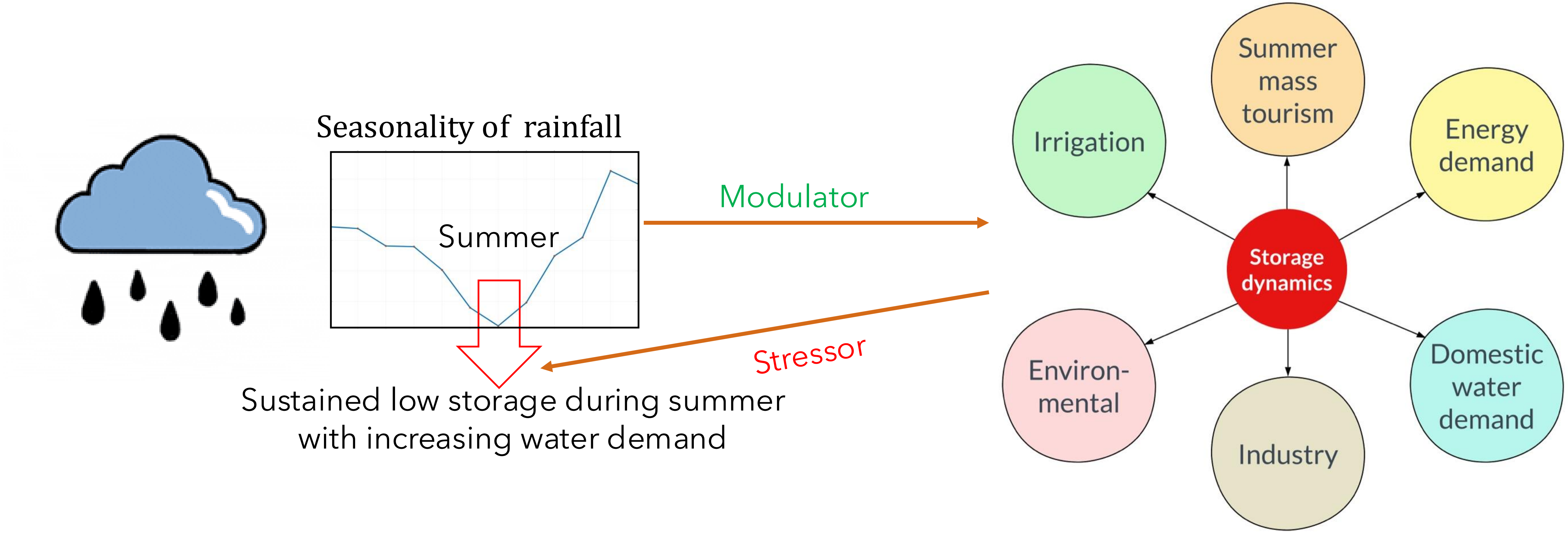
INTRODUCTION

Role of Reservoirs in Mediterranean Climate > Modulator-Stressor Paradox



- Low reservoir storage effects different sectors

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RESEARCH OBJECTIVES

Assumption:

Accumulated precipitation signal as a predecessor to the reservoir signal

- Quantification of the drought characteristics using indices
- Decompose complex storage to find the dominant frequencies during severe drought.
- Find the correlation b/w the accumulated precipitation signal and the reservoir signal to find the scale of hydro-meteorological forcing
- Try to find the leading drivers for multi-year severe drought.

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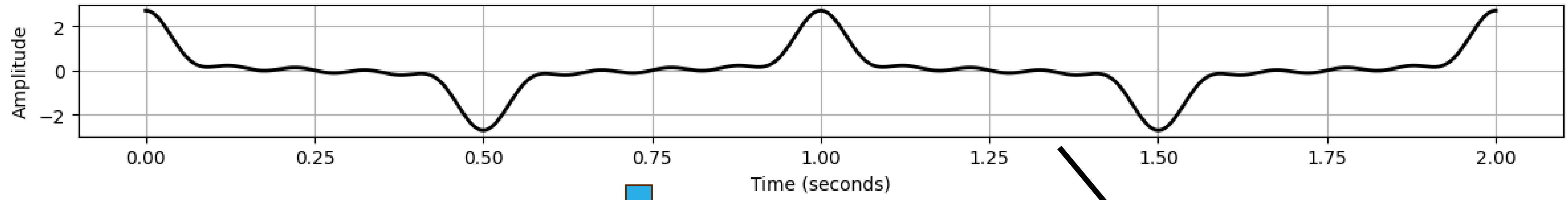

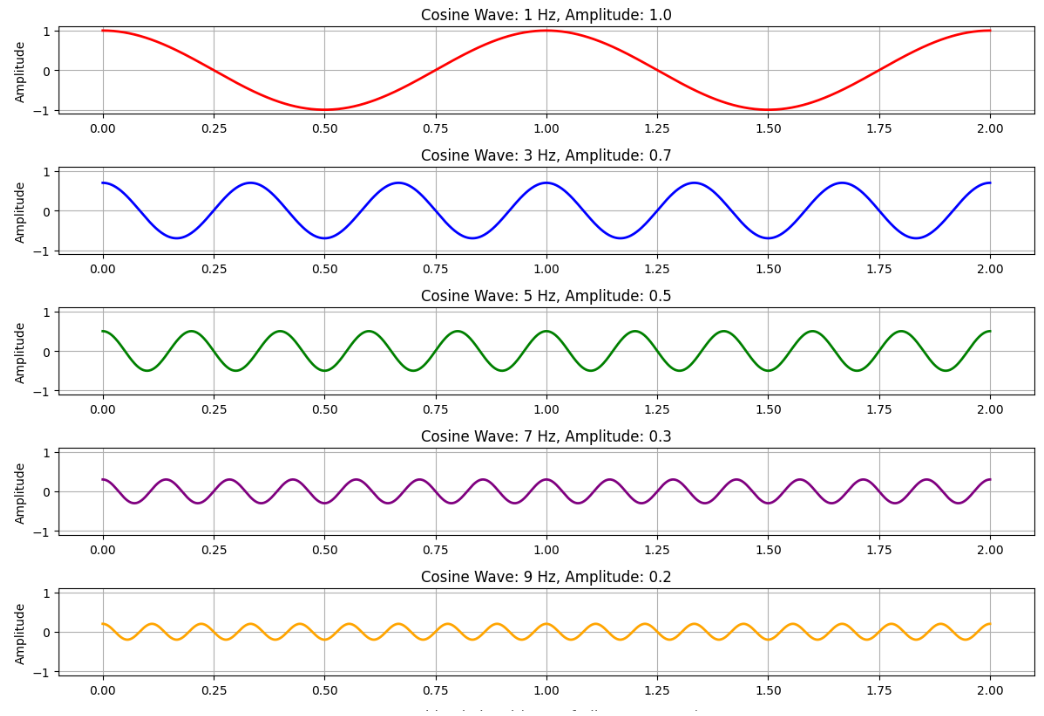

$$\hat{f}(\xi) = \int_{-\infty}^{\infty} f(t)e^{-2\pi i \xi t}\, dt$$

FOURIER TRANSFORM

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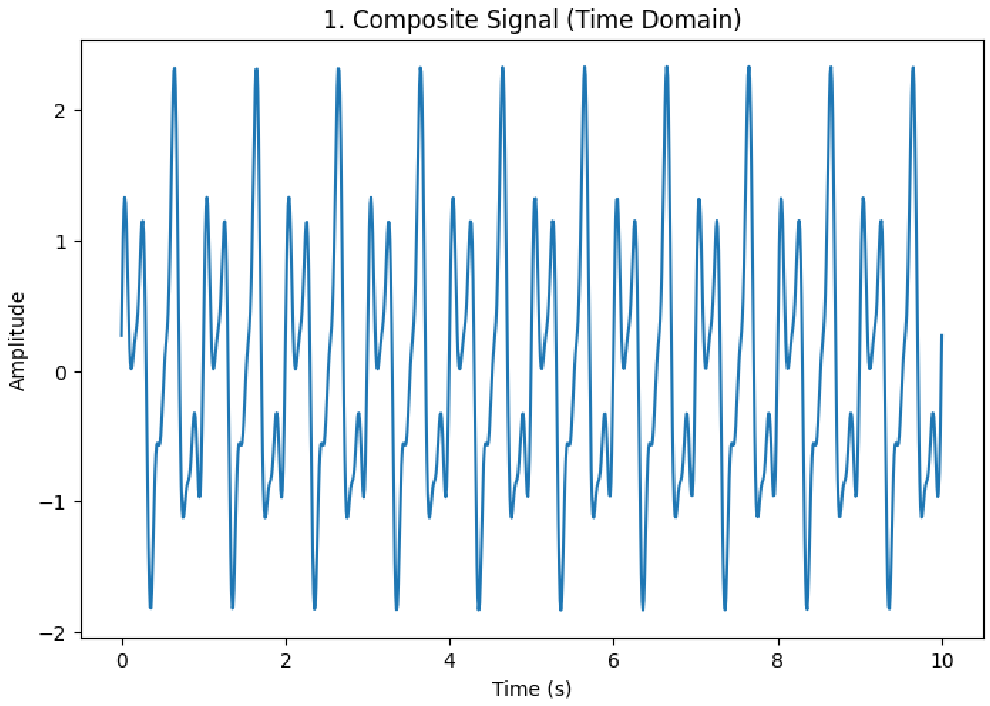

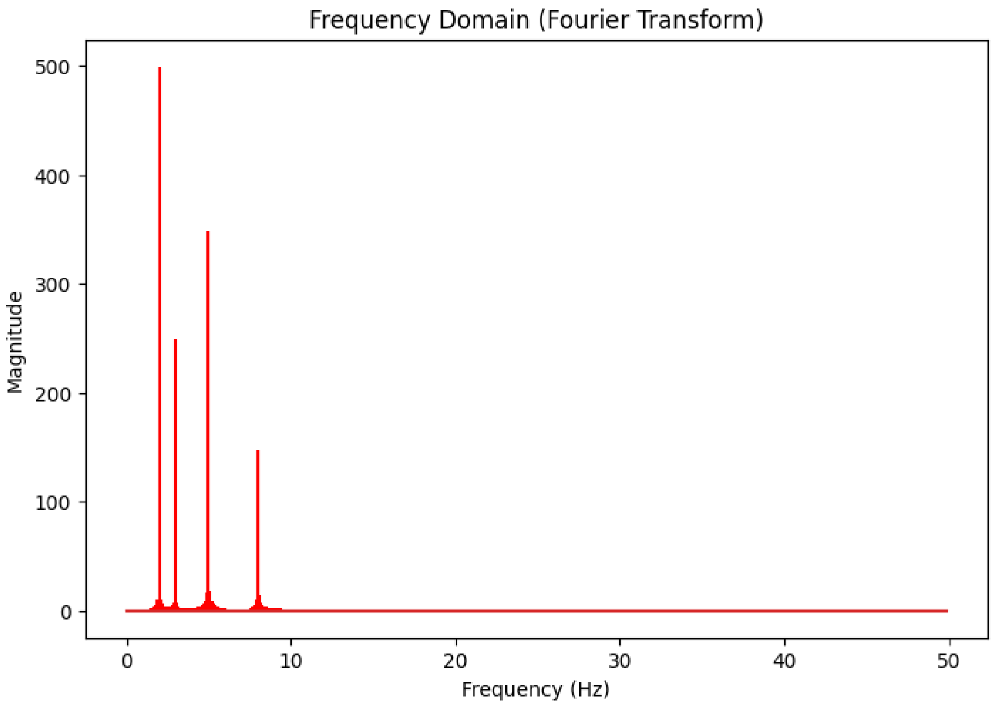

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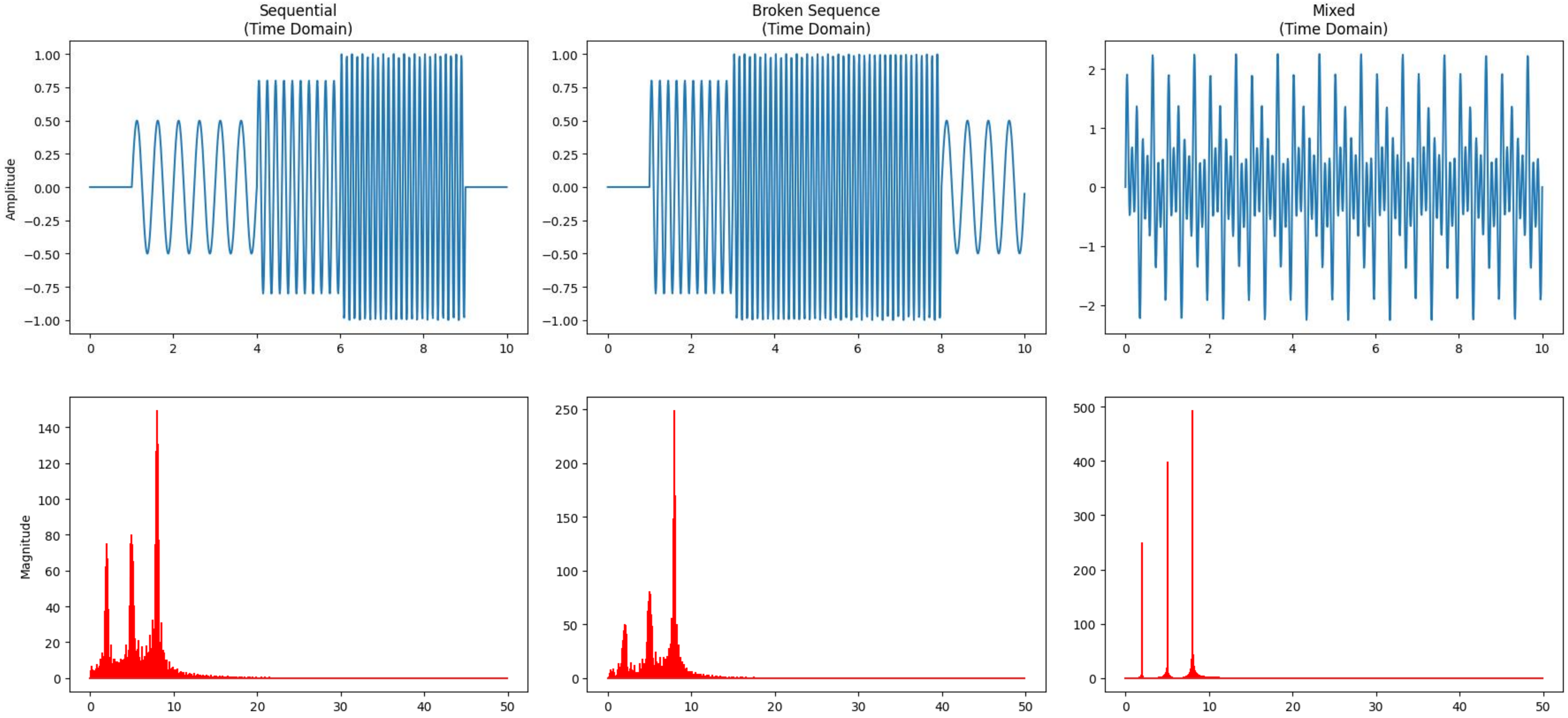
DRAWBACKS OF FOURIER ANALYSIS



WAVELET TRANSFORM

Continuous Wavelet Transform (CWT) of a signal $f(t)$:

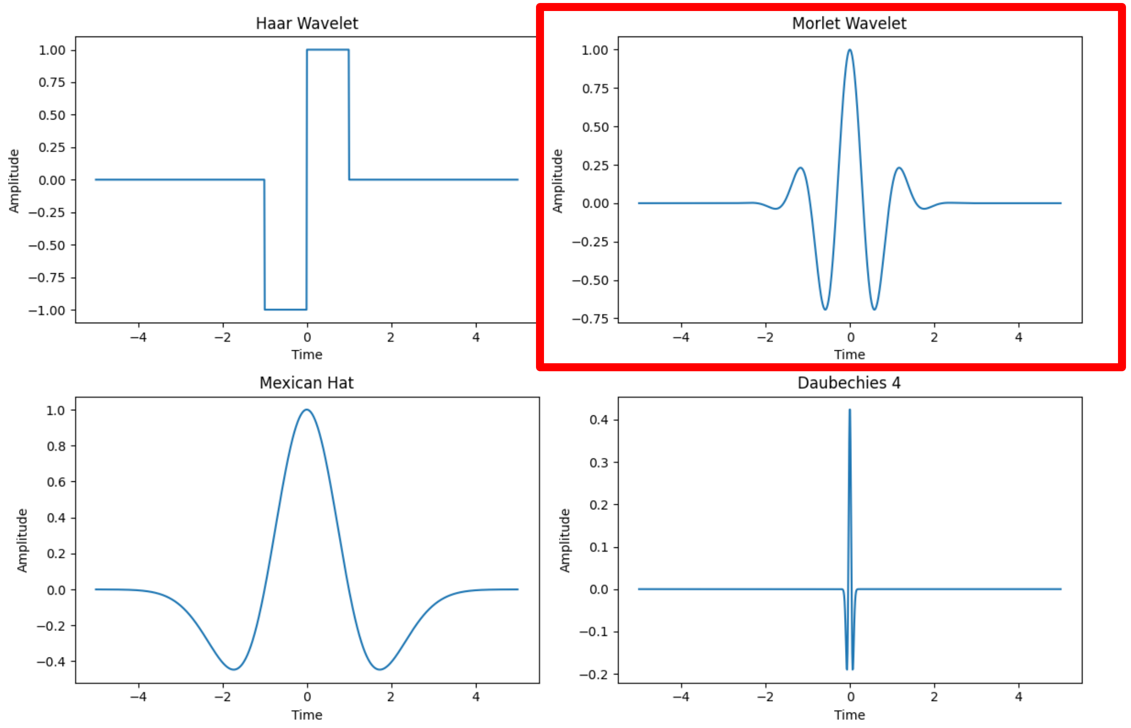
$$\widehat{W}(a,b) = \int_{-\infty}^{\infty} f(t).\psi^{*}\left(\frac{t-b}{a}\right) dt$$

Where,

$\psi(t)$ is the mother wavelet- Morlet Wavelet

a is the scaling factor – controls frequency

b is the translation factor – controls time shift



… many more

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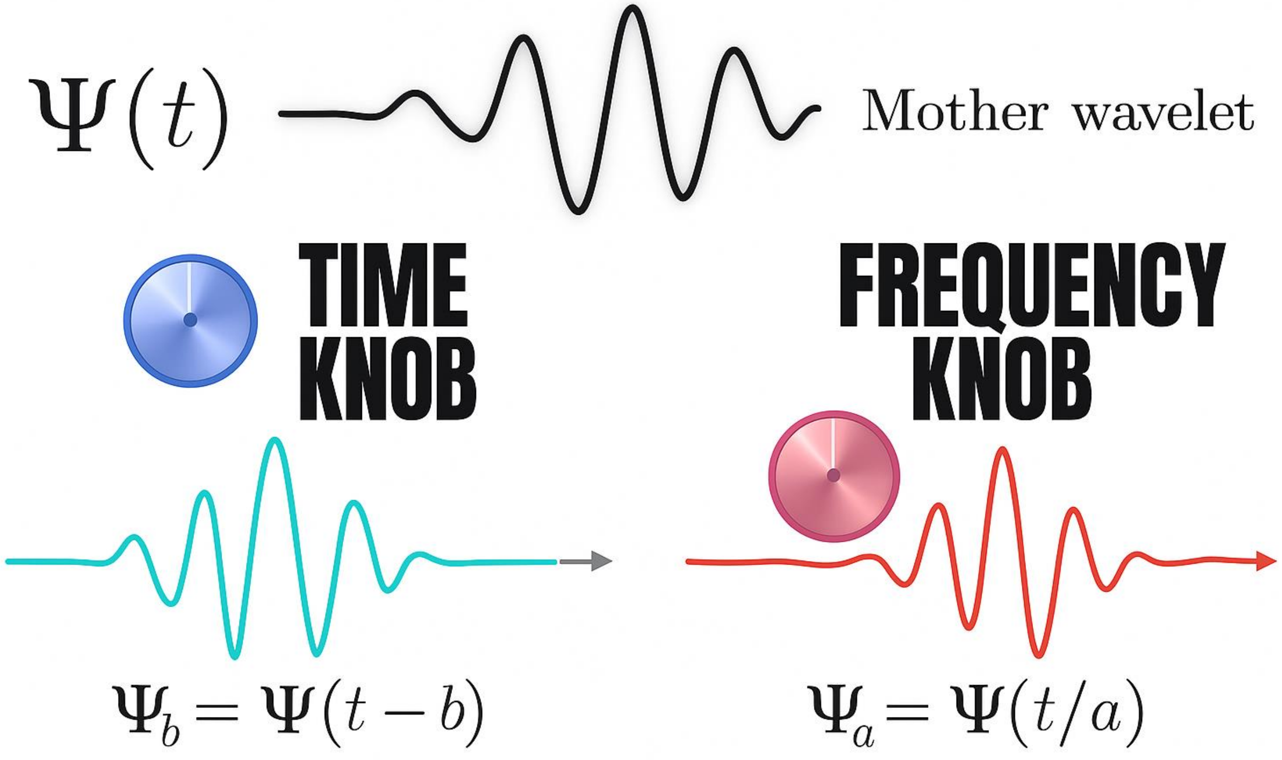
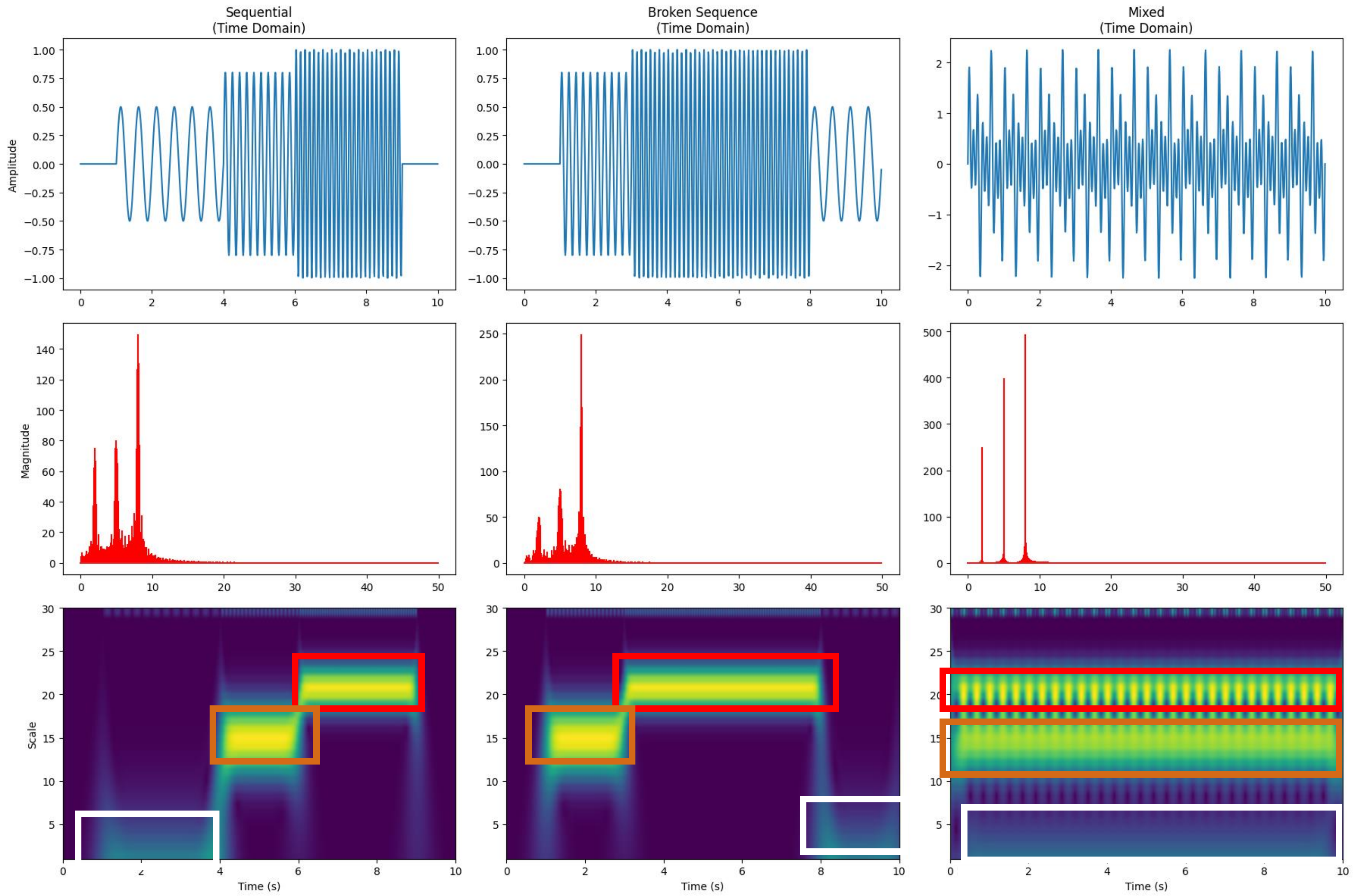
WAVELET TRANSFORM



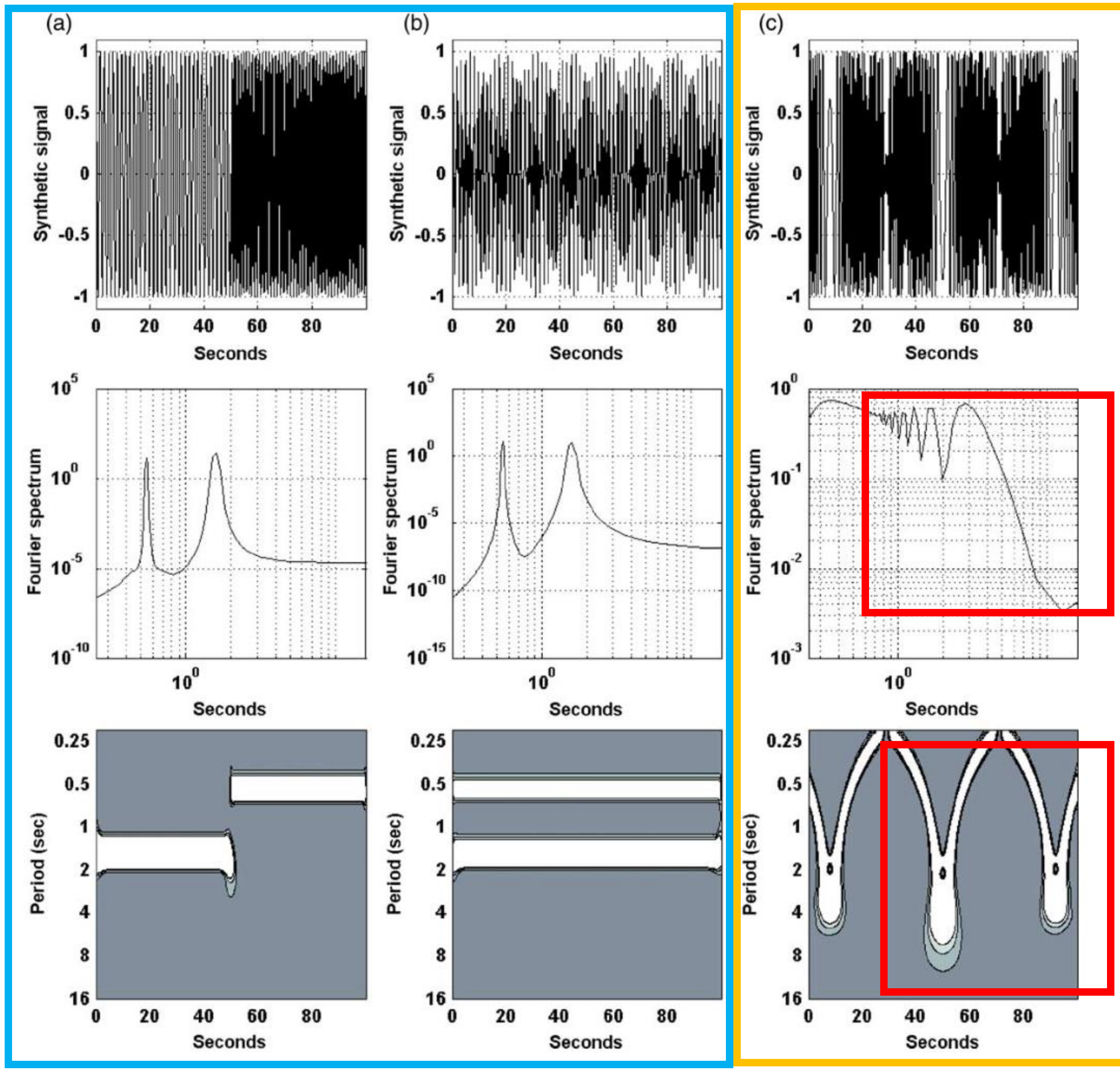
Source: Matlab example for signal processing

WAVELET TRANSFORM



Understanding Non-stationary Signal using Wavelet Transform

Stationary signals



Non-stationary signals

Higher frequencies are **narrower**

Lower frequencies are **wider**

Low periods

High Periods

D. Labat / Journal of Hydrology 314 (2005) 275–288

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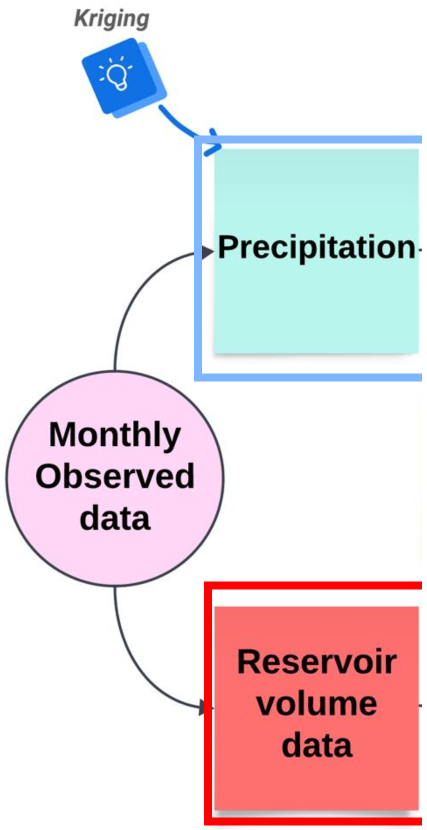
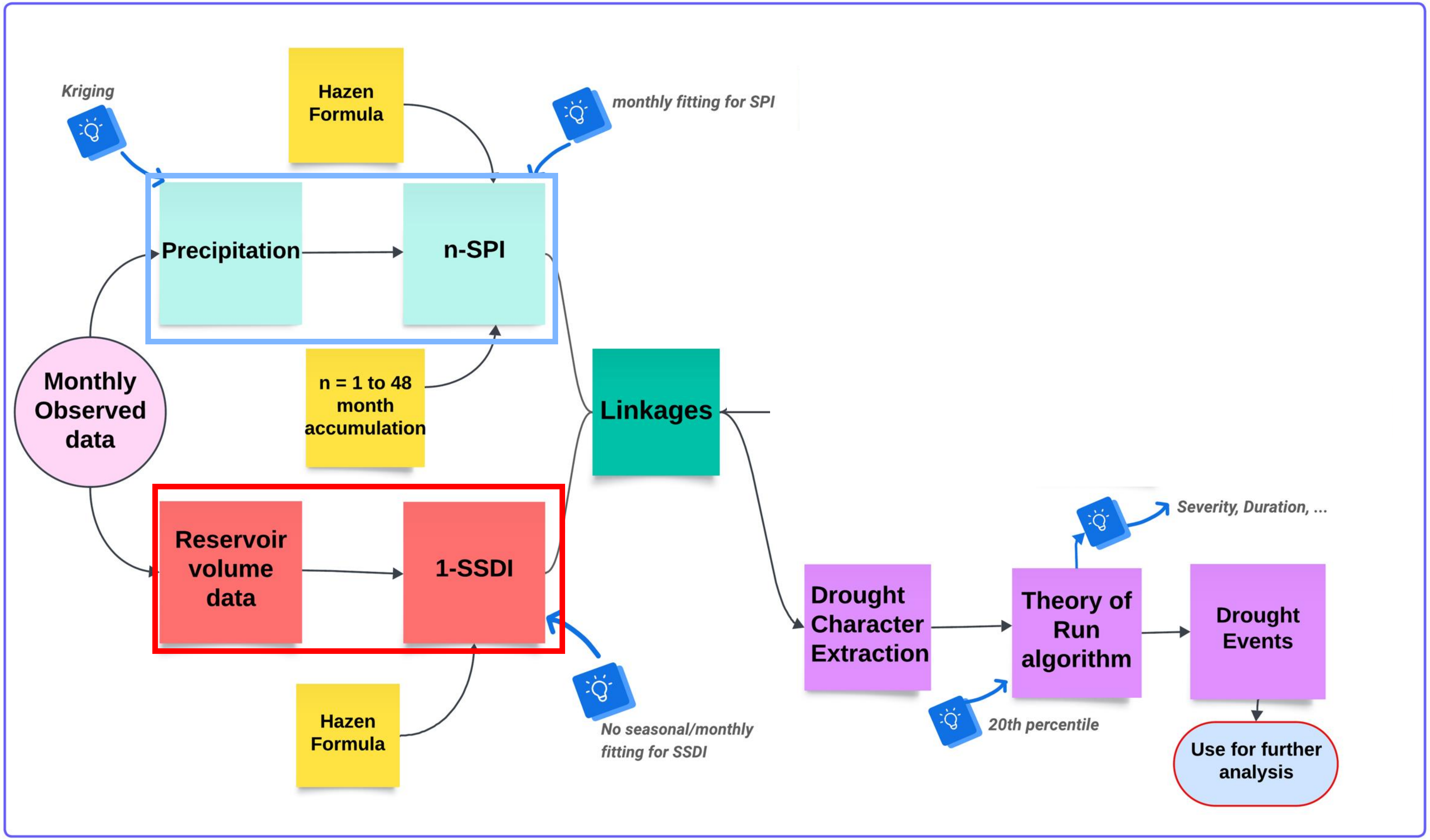
METHODOLOGY



METHODOLOGY



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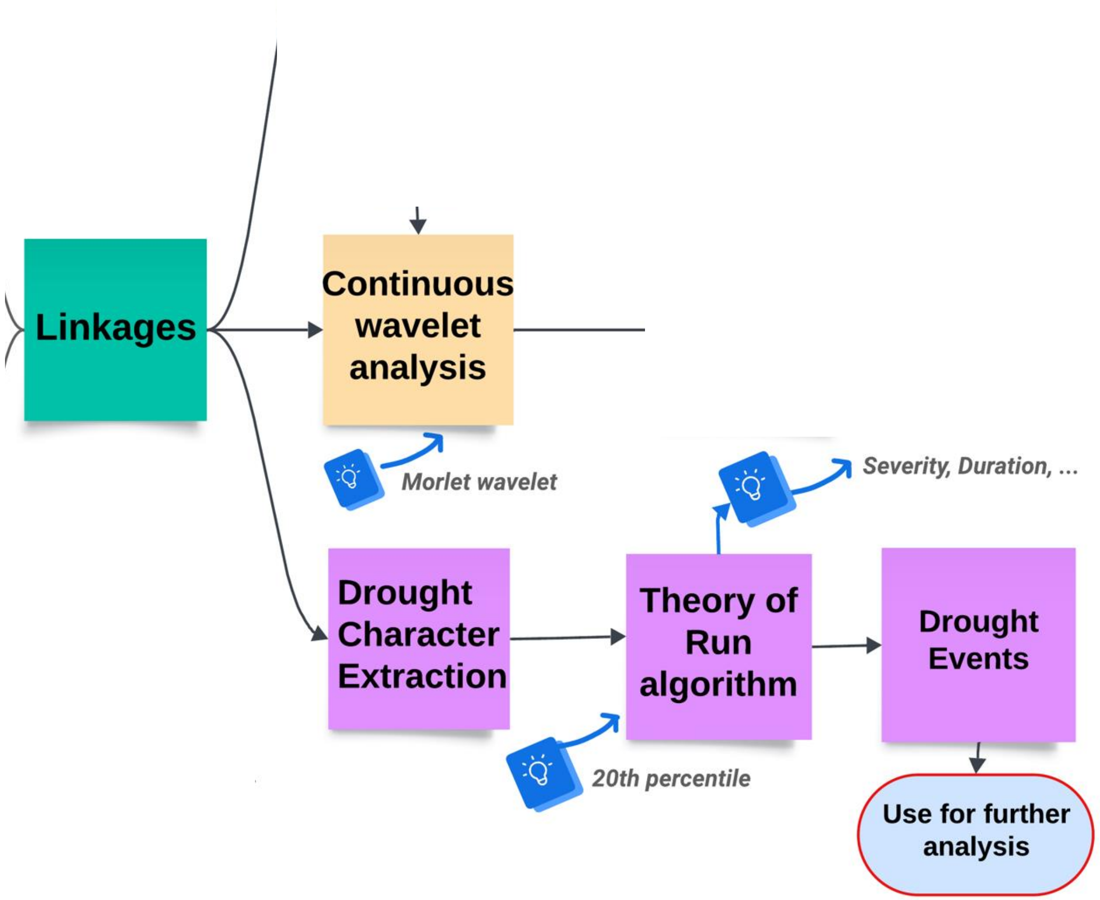
METHODOLOGY



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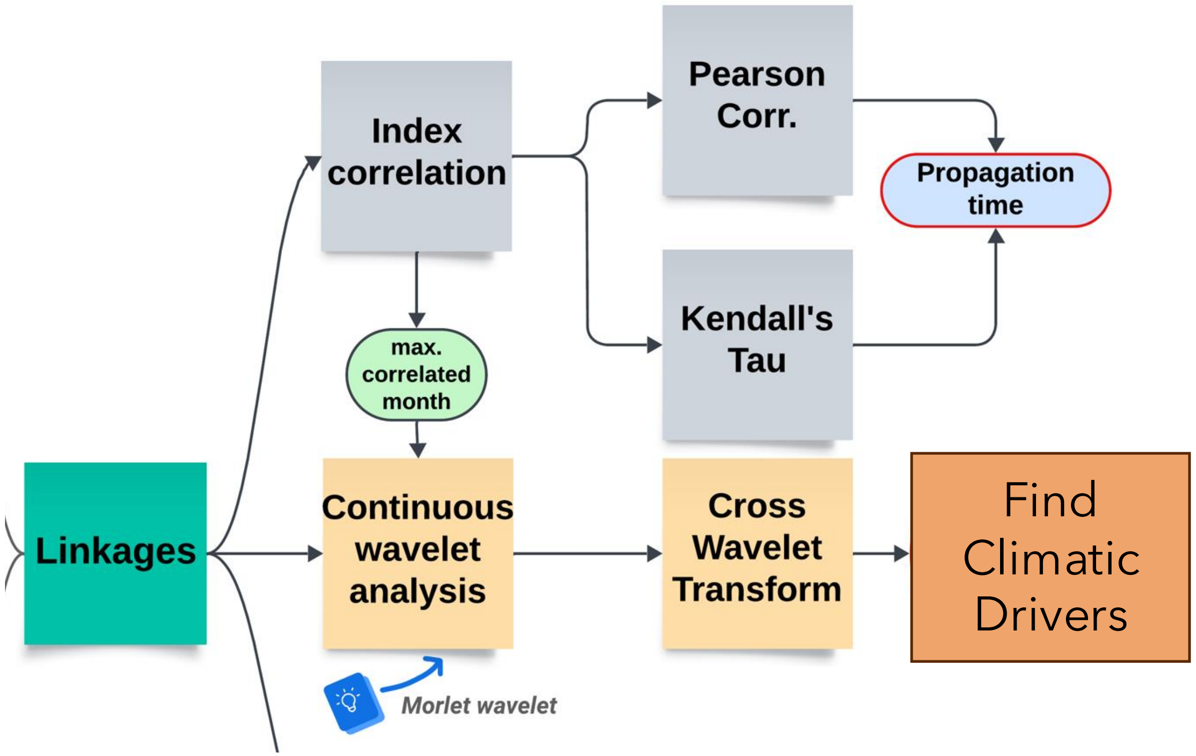
METHODOLOGY



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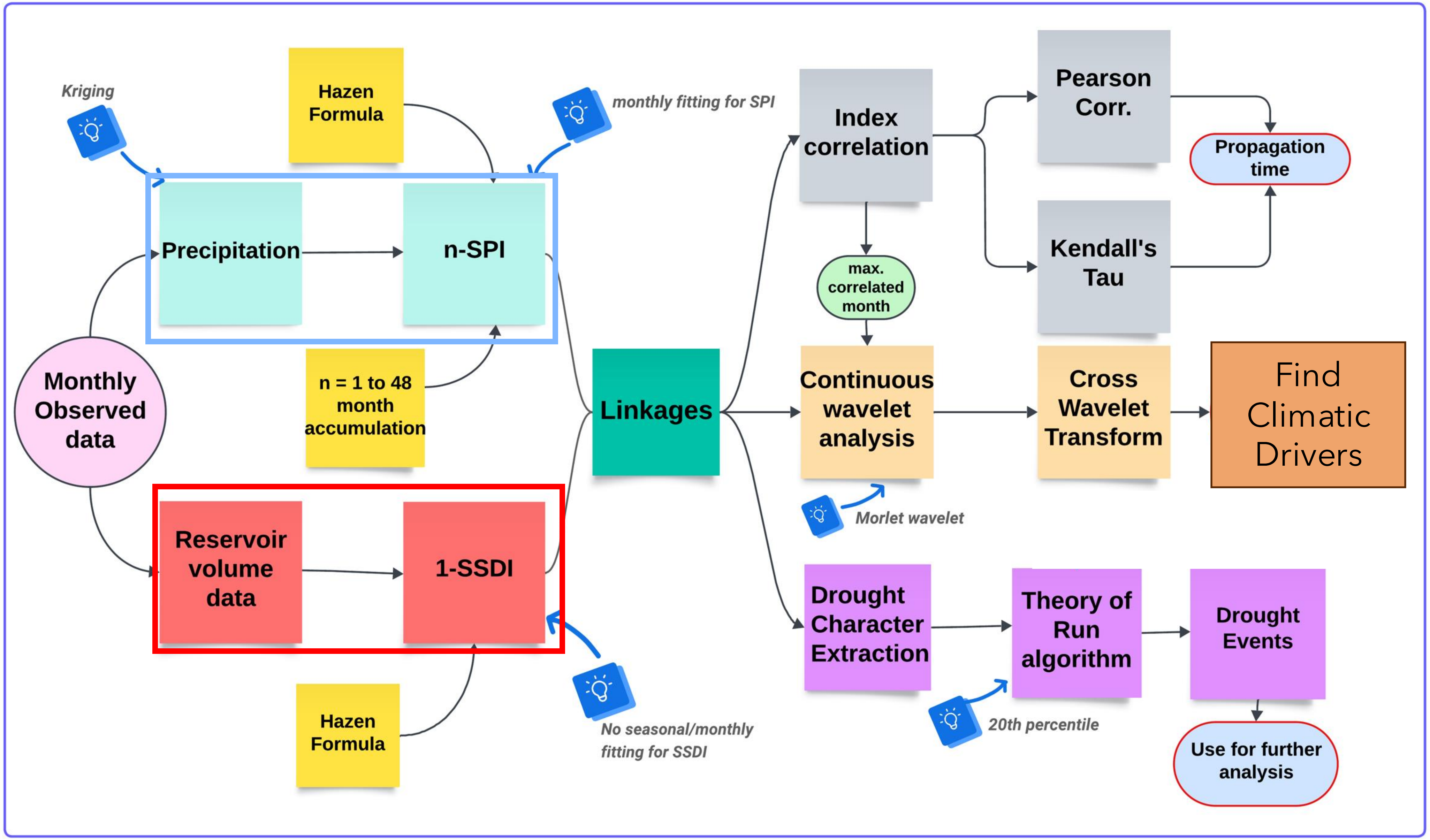
METHODOLOGY



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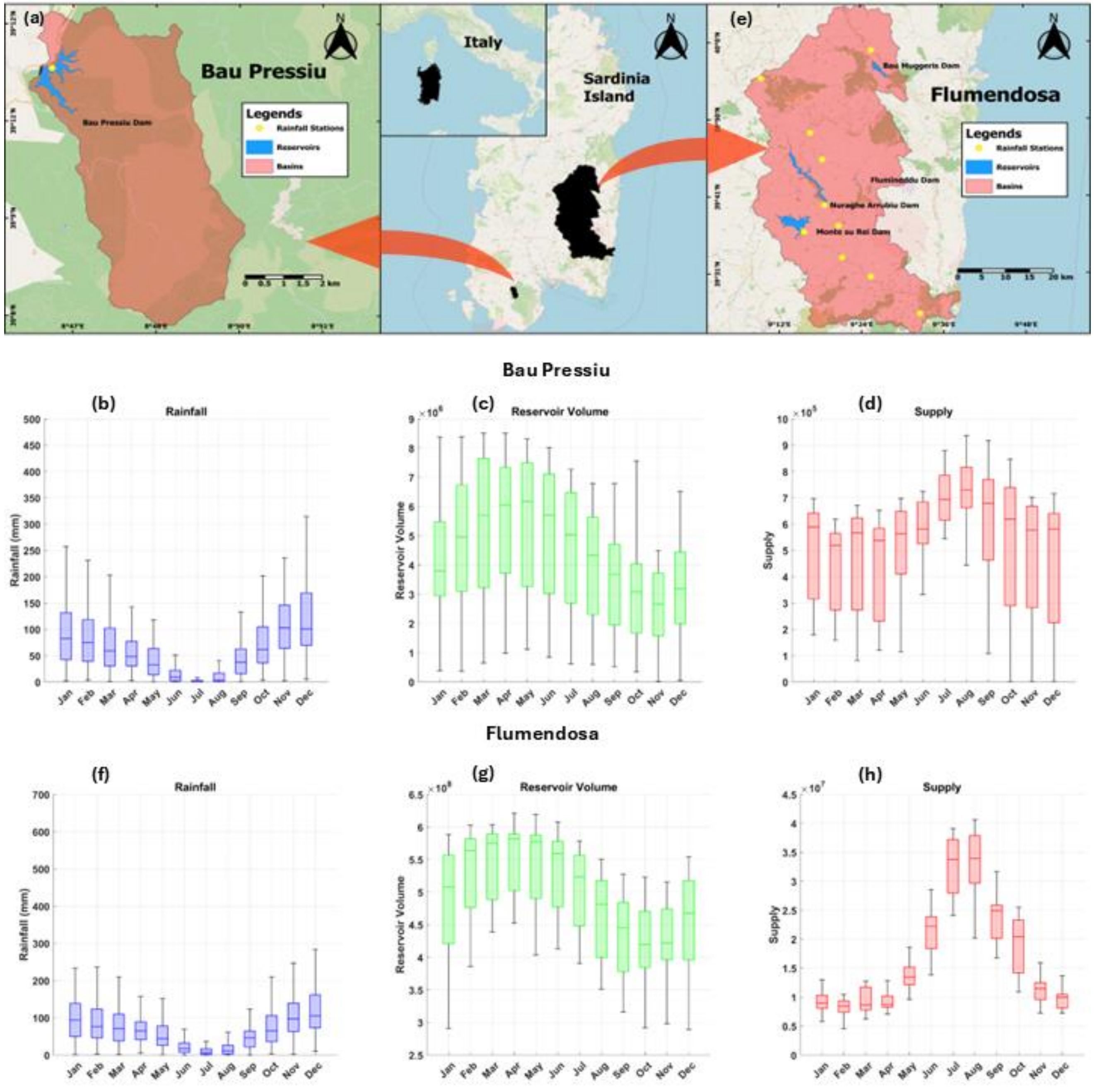
EGU General Assembly 2025

CASE STUDY

- We have used the monthly rainfall stations' data from 1990 to 2023 for Bau Pressiu and from 2006-2023 for Flumendosa
- Rainfall is concentrated in the autumn-winter months and long periods of dry weather during summer.
- Annual rainfall is about 500-700 mm. (640 mm)



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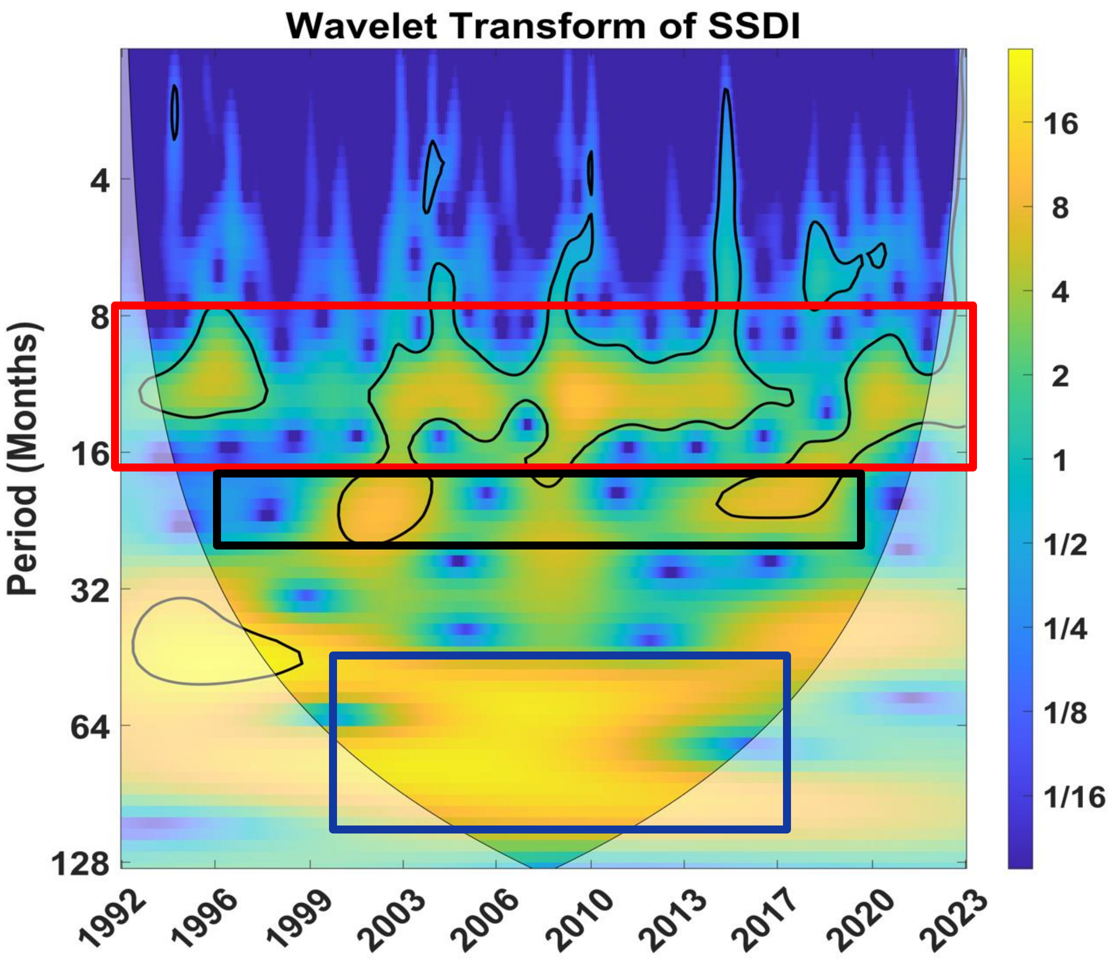
WAVELET TRANSFORM OF SSDI



Y axis- Scale/ Frequency >>> Period in months

***Scale* – Power or Magnitude of WT in months**

1. **Spectrogram (time-frequency plot)** shows **localized blobs** – frequencies .
2. **Higher frequencies** are **narrower** in time (good time resolution, poor frequency resolution).
3. **Lower frequencies** are **wider** in time (good frequency resolution, poor time resolution).

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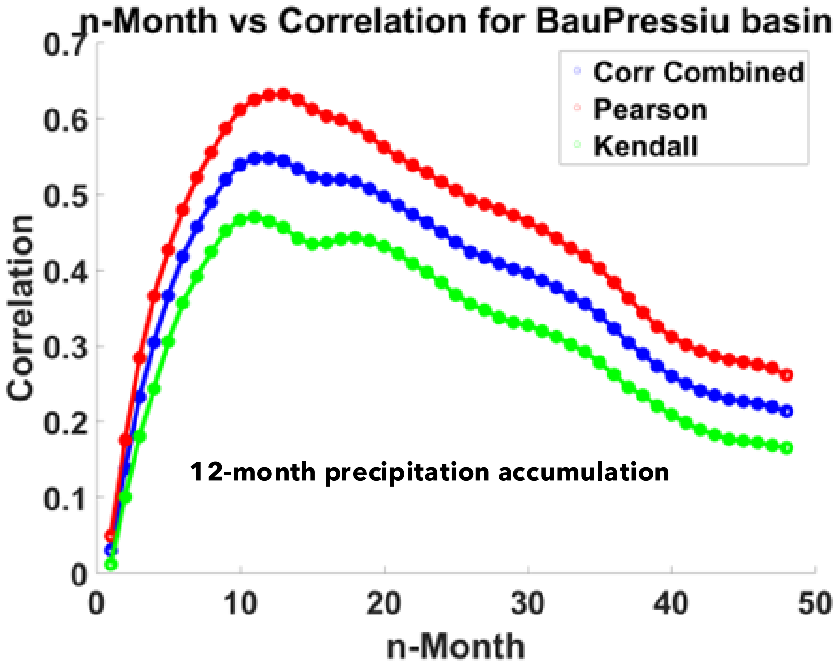
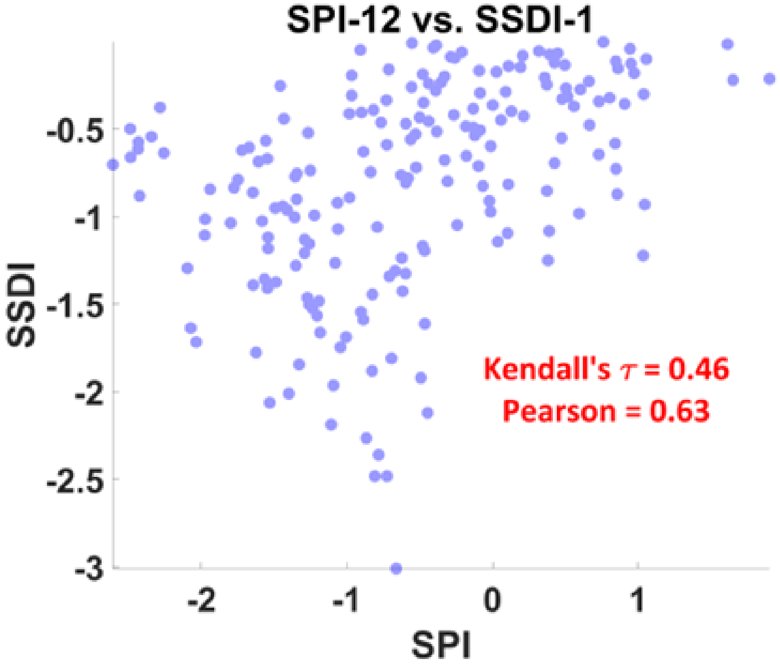
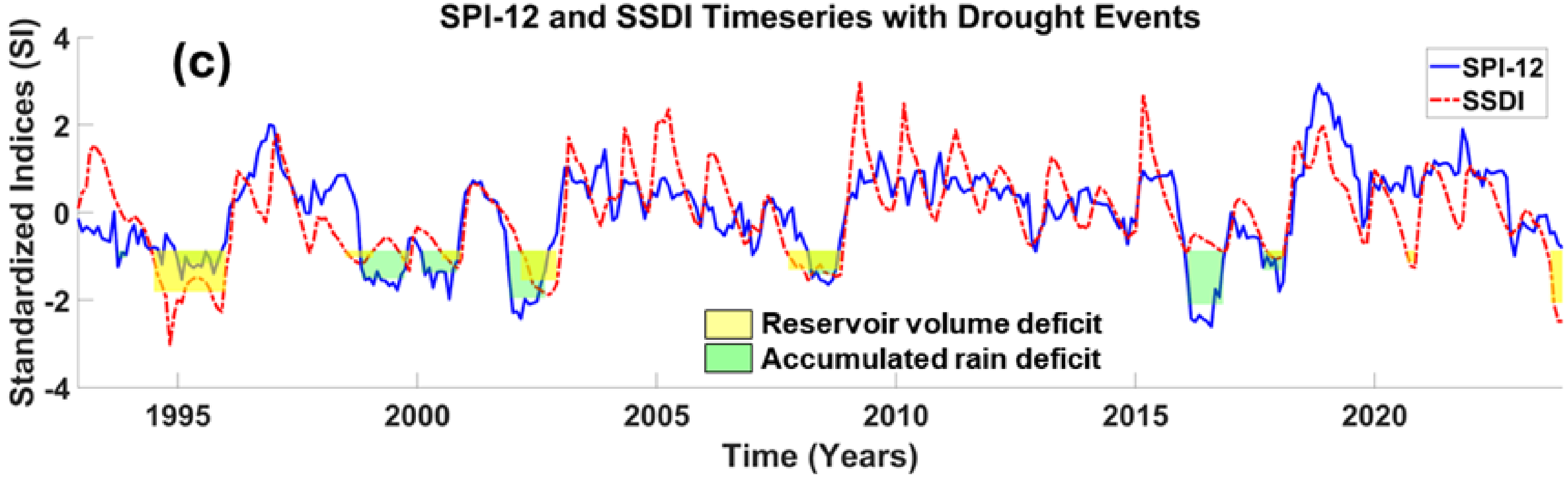
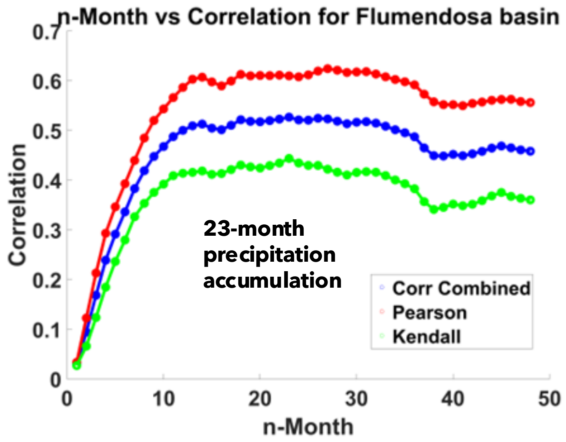


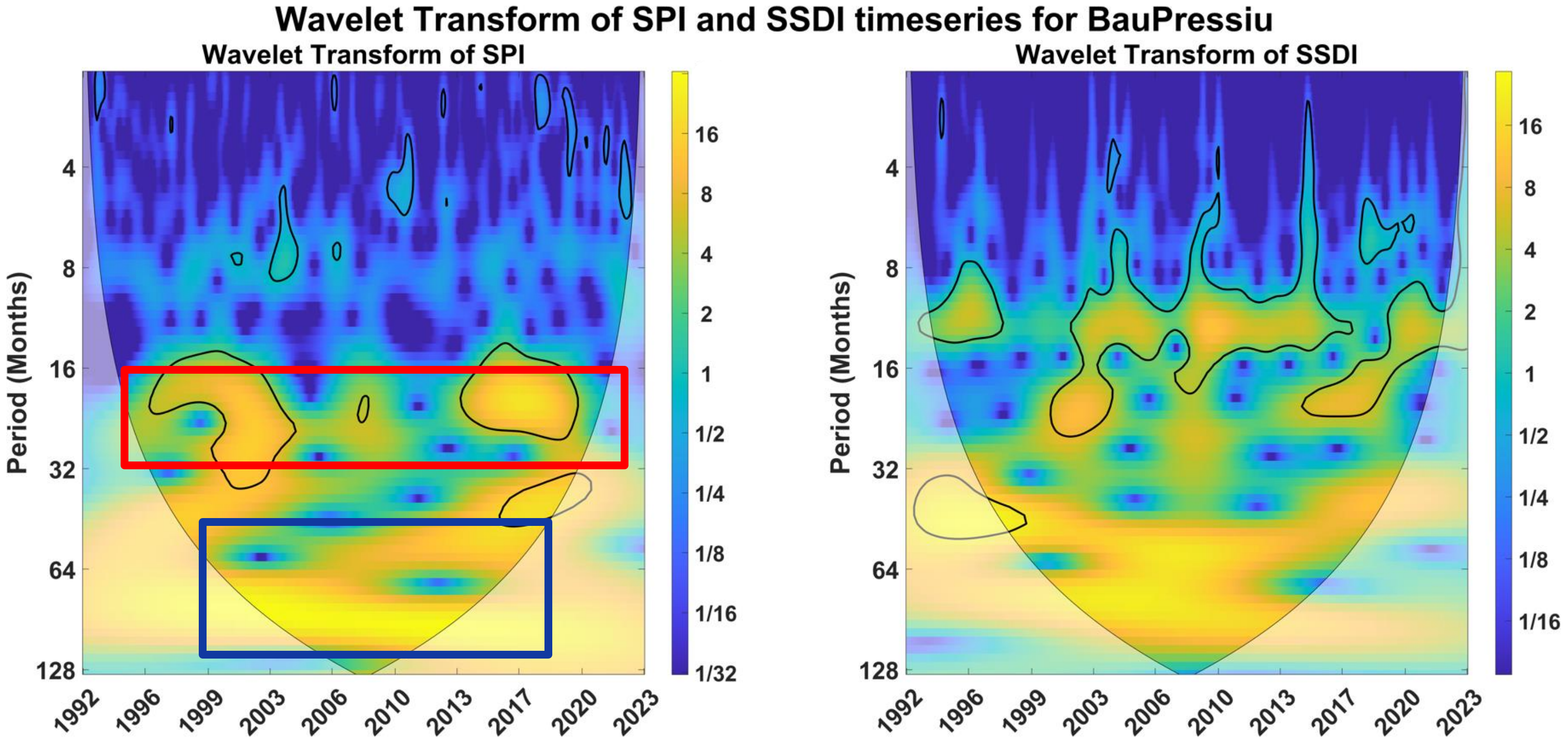


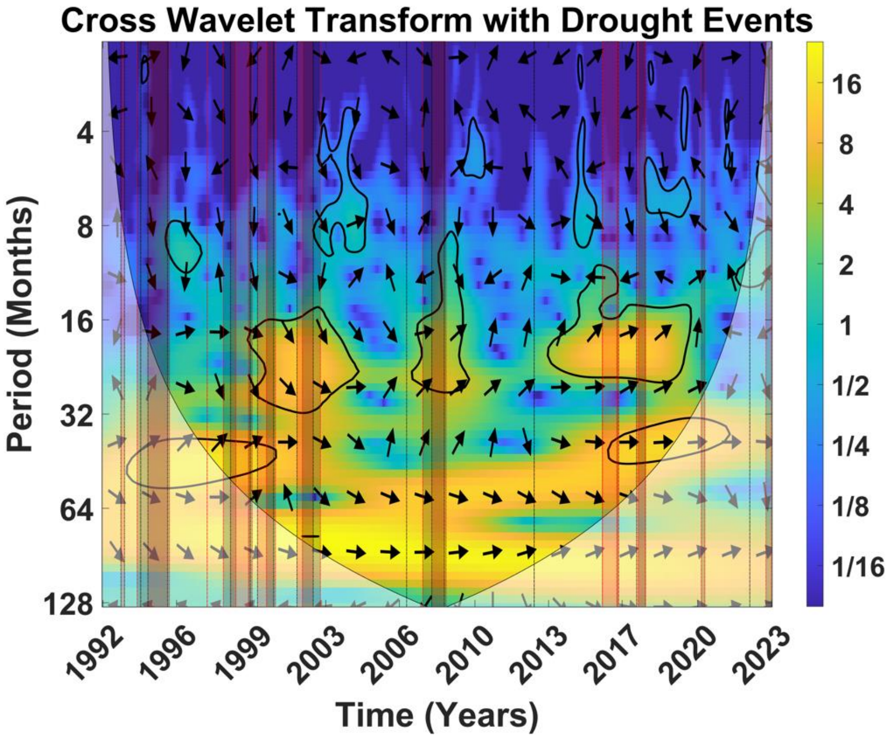
- Lag between drought from acc. Rain deficit to volume deficit.
- Less severe droughts are dampened by reservoir effect (1998,2001,2003,2017 & 2018)
- Events like 1994-1996 and 2006-07 are multi year severe drought which got worse due to reservoir effect.





Wavelet Analysis for Bau Pressiu Basin





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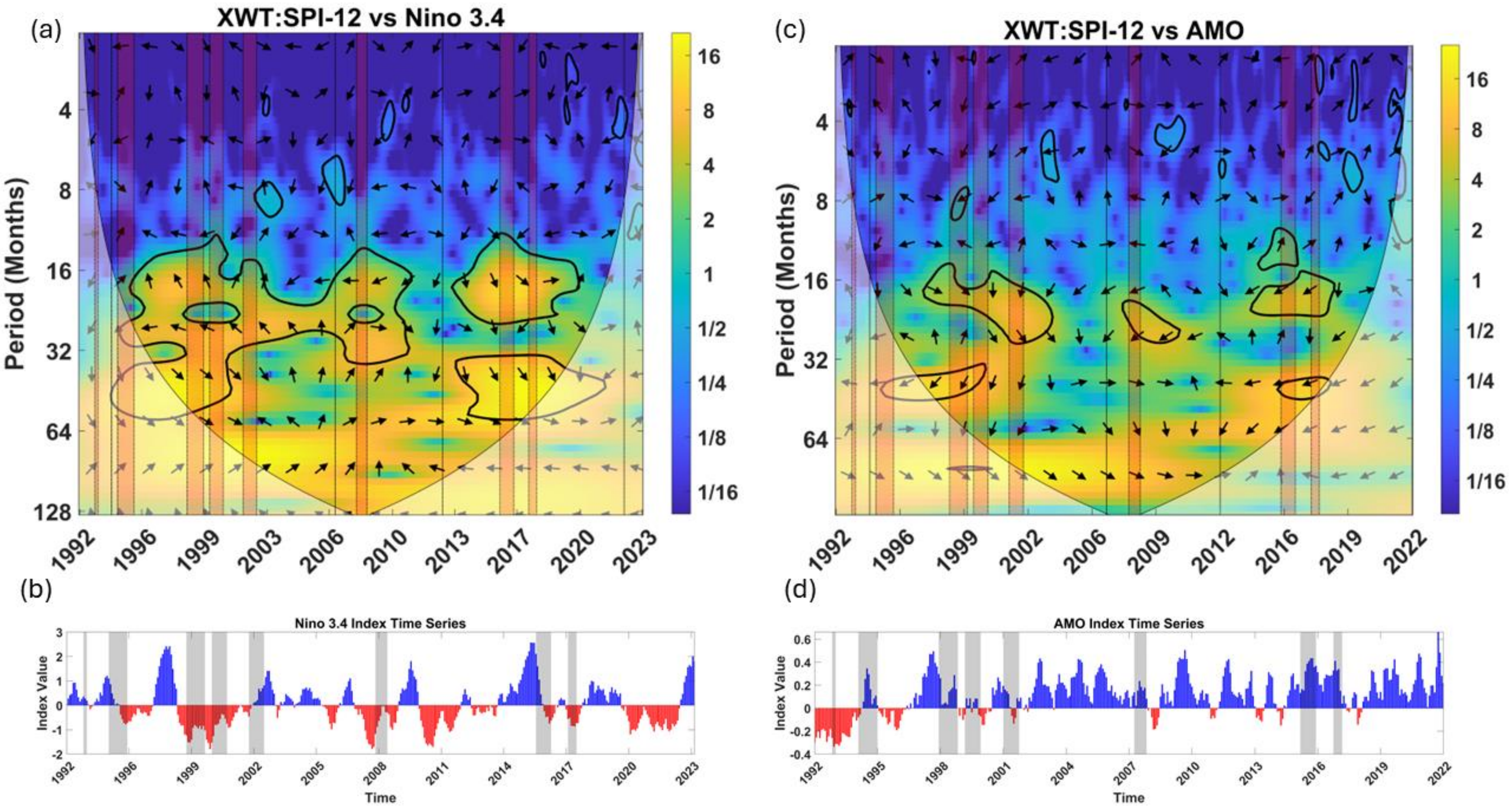
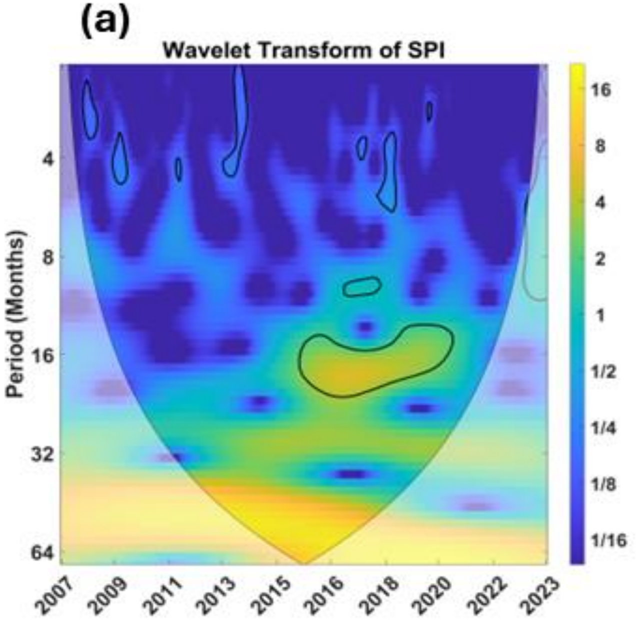
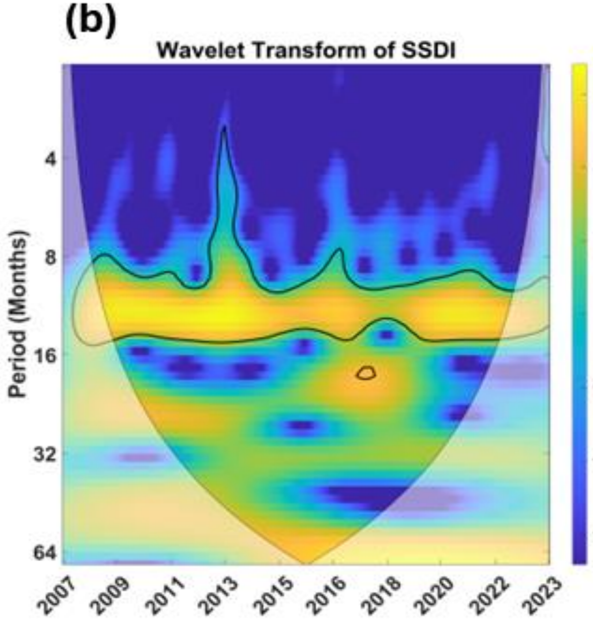
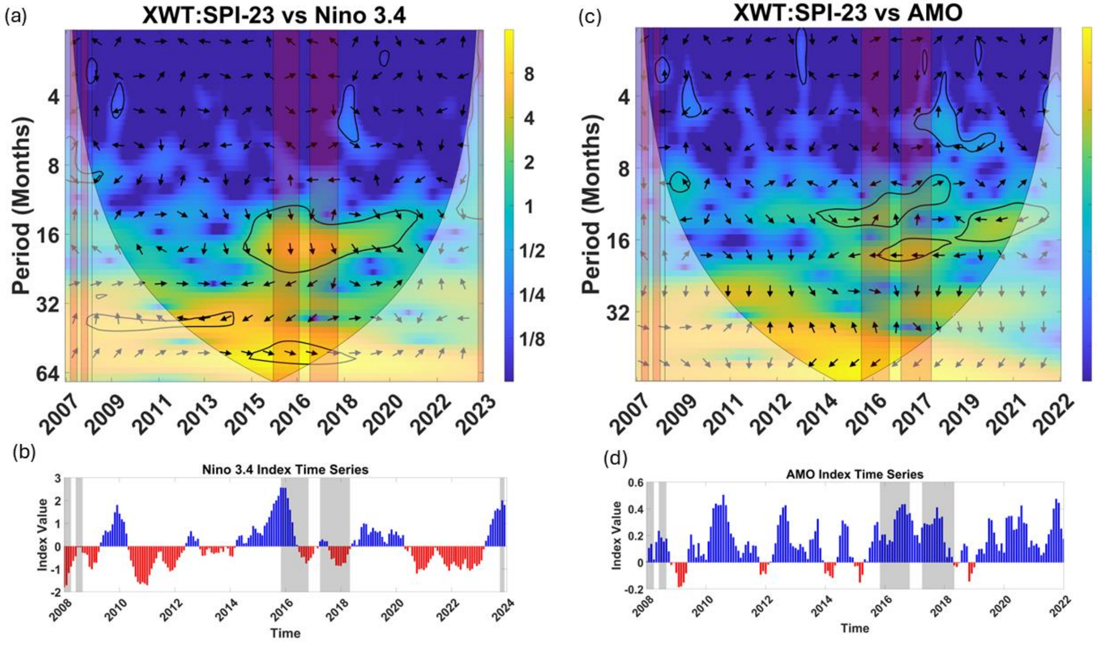
Teleconnections between severe multiyear droughts and climate indicators

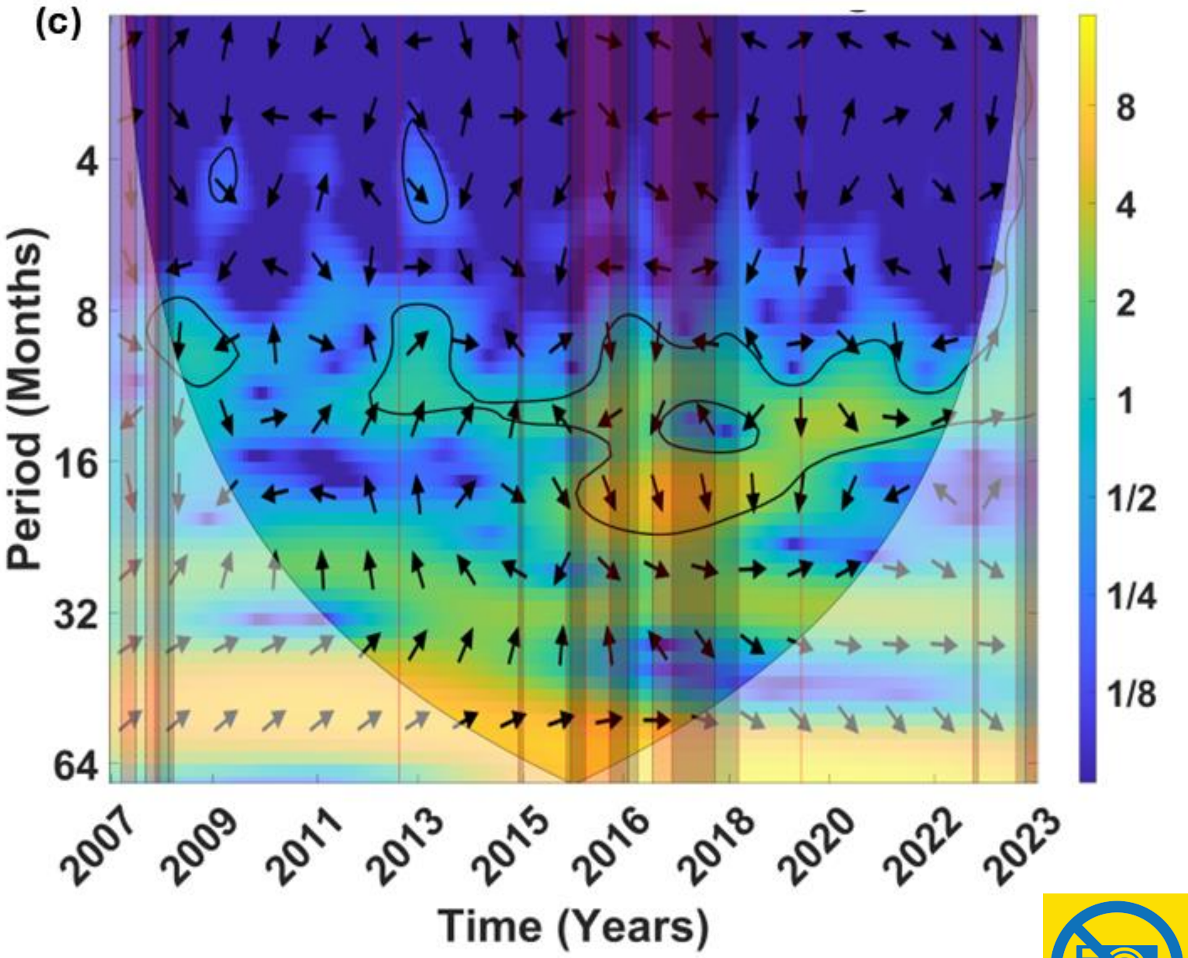


Flumendosa Basin









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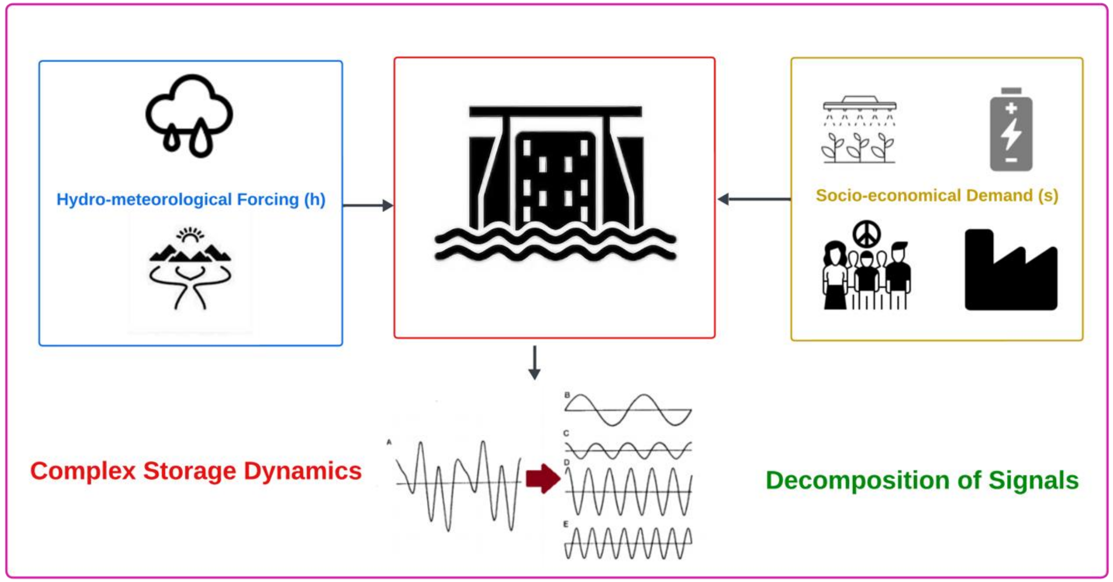
SUMMARY

- Reservoir signal has strong inter-annual periodicity, coming from societal demand
- Oscillate synchronously with 12/23 month accumulated precipitation periods, indicating minimal lag (<6 months) between drought onset and reservoir depletion
- High power at 16–32 months (~1.5–3 years) matches ENSO's influence on multi-year drought persistence, directly impacting reservoir depletion rates, which highlights ENSO as the primary modulator of drought variability in Sardinia. This aligns with Mediterranean teleconnections.
- Minor power at 64–128 months (~5–10 years) suggests potential links to the Atlantic Multidecadal Oscillation (AMO), aligning with observed AMO-positive phases (e.g., post-1990s), exacerbating drought trends in southern Europe.

THANK YOU FOR YOUR ATTENTION



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Comments - Suggestions - Questions