The Response of Water-Table Depth to Hydro-Meteorological Factors and Fallow Duration: A Case Study in the Sigang District of Tainan, Taiwan

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Abstract & Slides

國立臺灣大學 National Taiwan University SEHH EGU

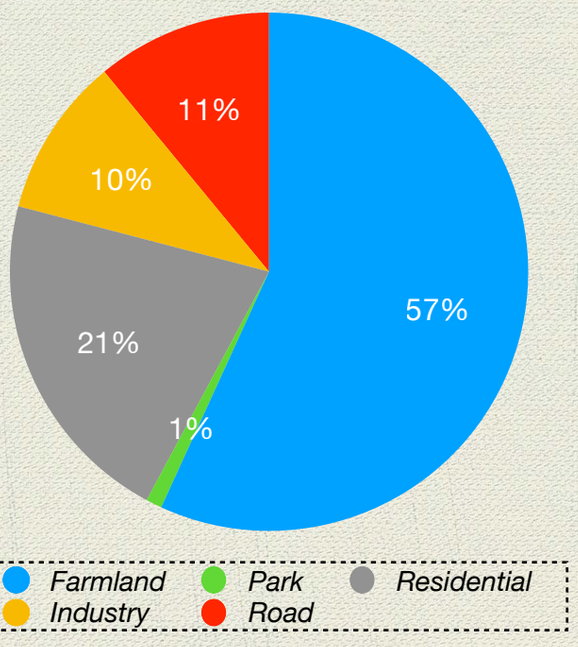
Agenda

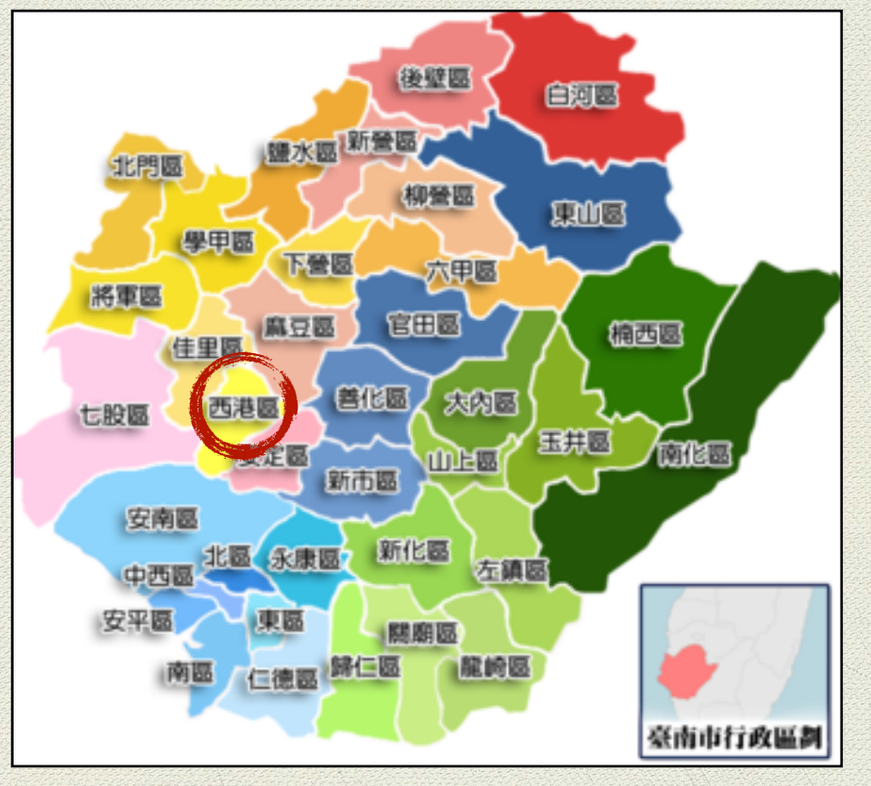
- INTRODUCTION
- METHODOLOGY
- RESULTS & DISCUSSION
- CONCLUSION & FUTURE RECOMMENDATIONS

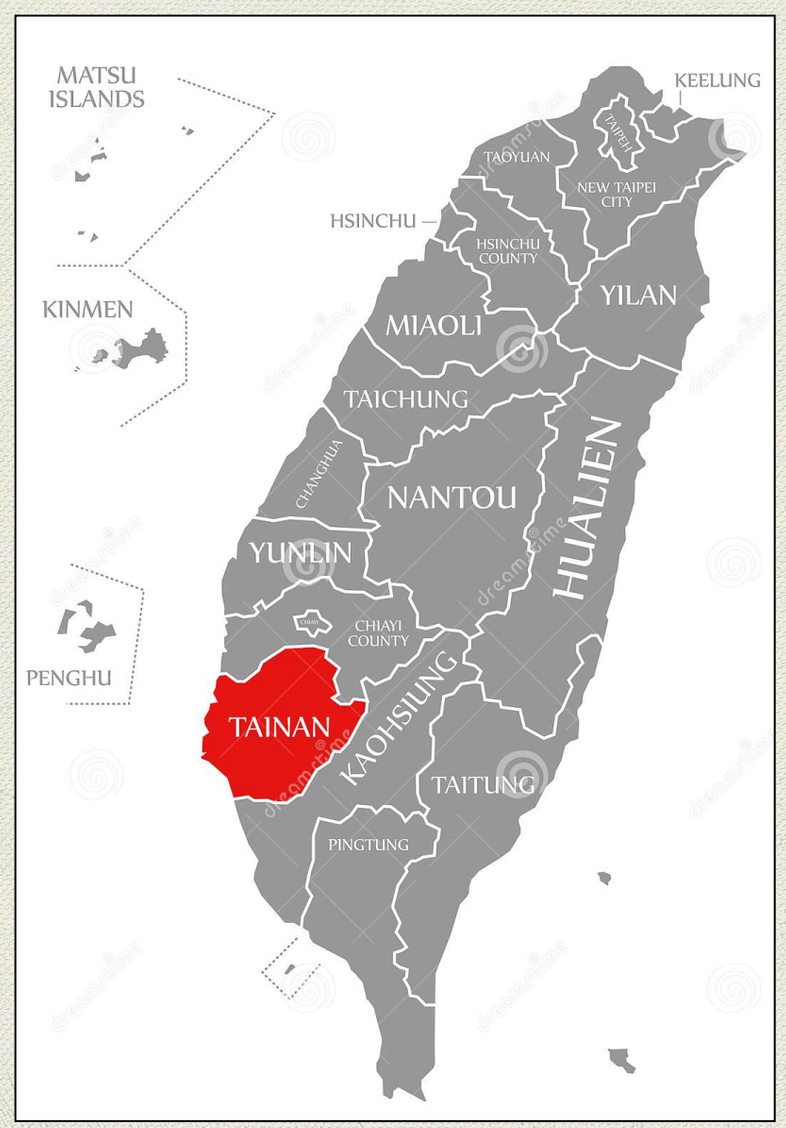
Introduction

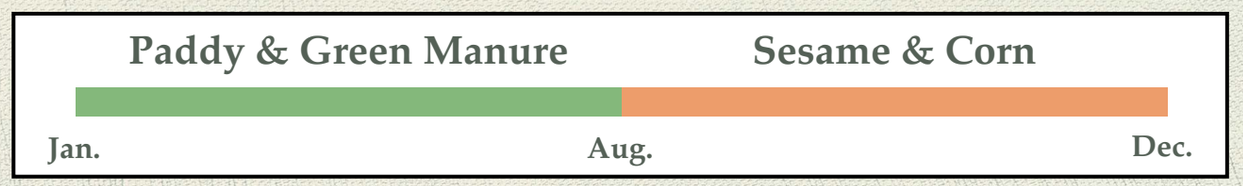
Introduction

Study Area









Source: Tainan City Government

Introduction

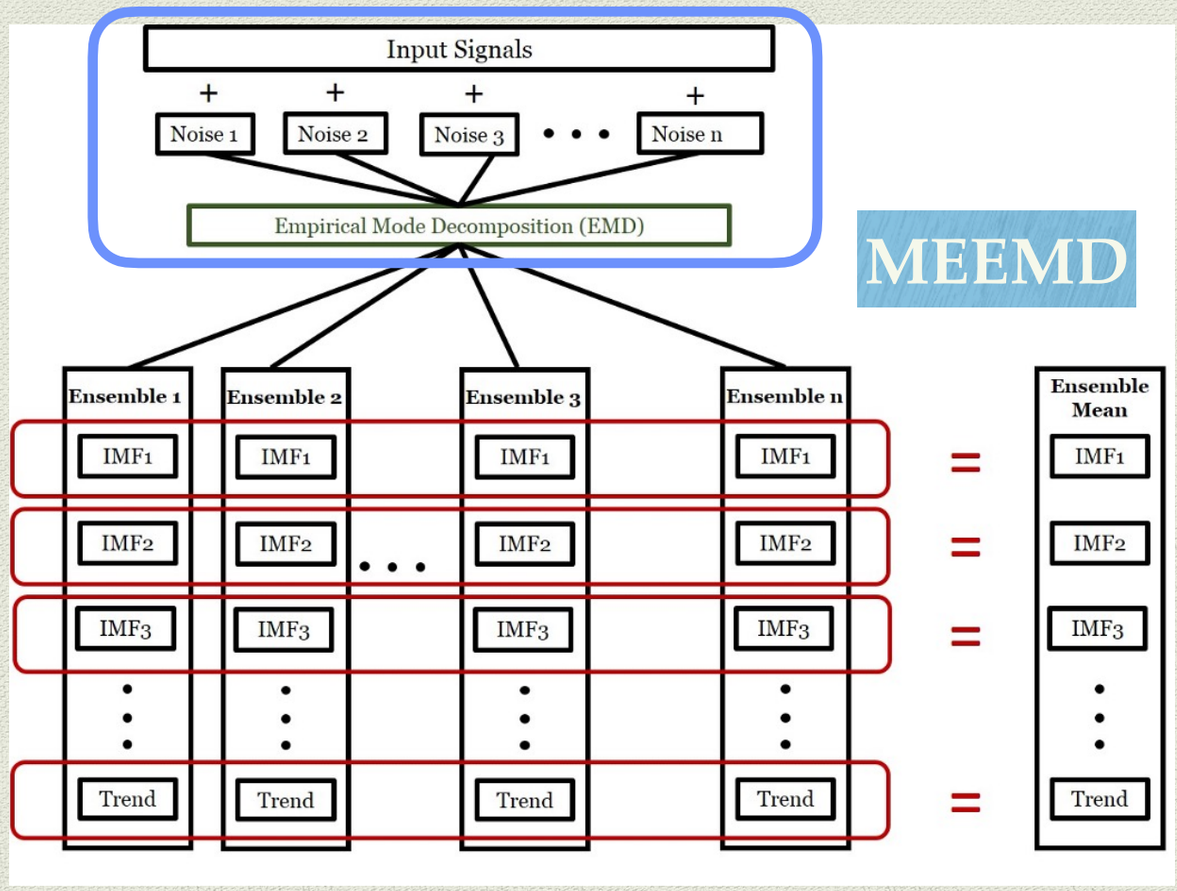
Data Acquisition

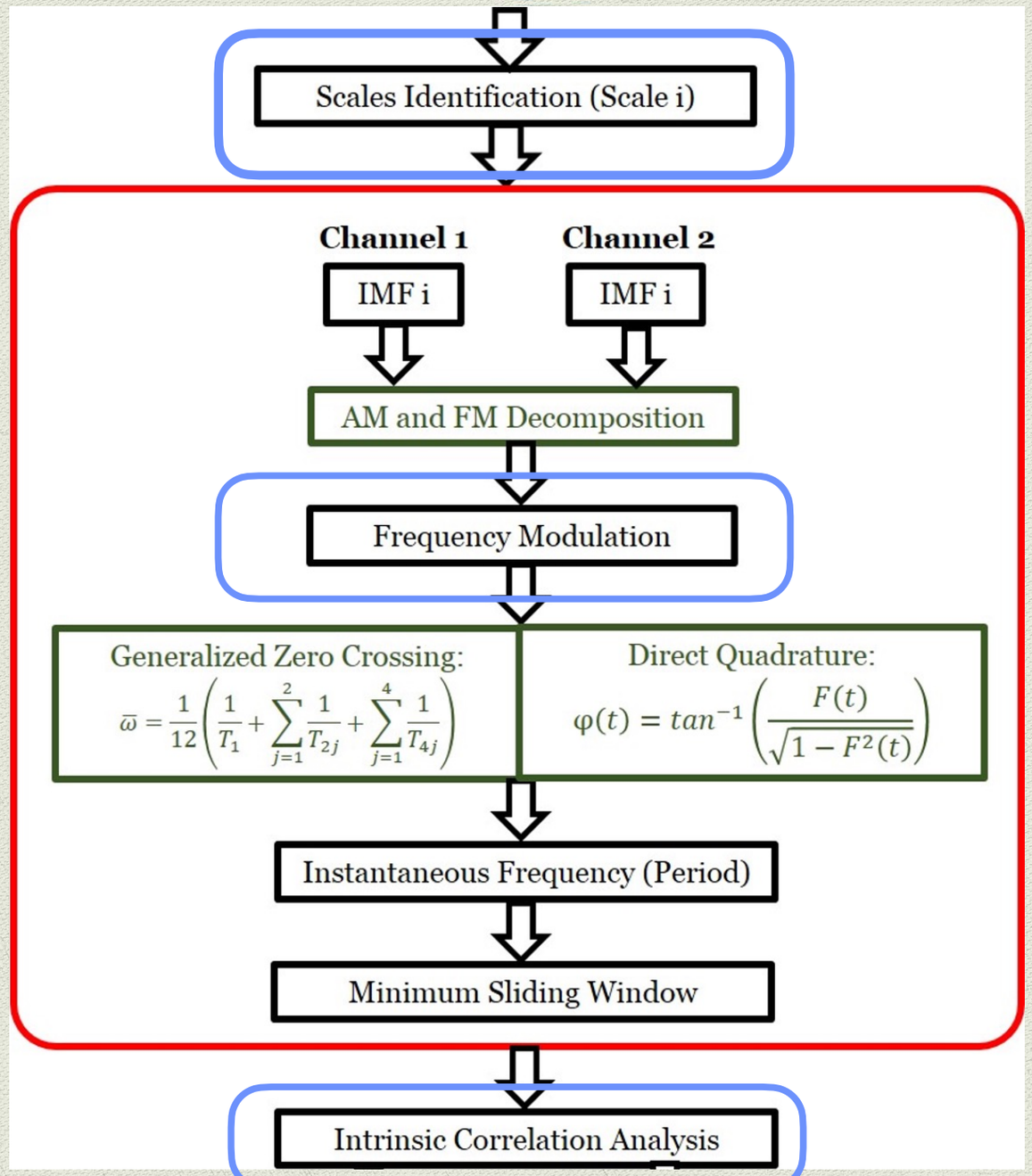
Factors	Data Type	Sampling Time	Unit
Groundwater Level	Position Data	Jul.1999 - Jun.2021	(m)
Water Level Of Zheng-Wun River	Position Data	Jan.2011 - Dec.2020	(m)
Temperature	Grid Data (1 *km* x 1 *km*)	Jan.1980 - Dec.2019	(°C)
Precipitation	Grid Data (1 *km* x 1 *km*)	Jan.1980 - Dec.2019	(mm)
Relative Humidity	Grid Data (2 *km* x 2 *km*)	Jan.1980 - Dec.2020	(%)
NDVI	Satellite Data (Landsat 7)	Jul.1999 - Dec.2020	(-)

Objectives

- To identify the correlation between **the water level of Zheng-Wun River** and groundwater level in Sigang District.
- To unravel the correlation between **precipitation** and groundwater level in Sigang District (Zeng-Wun River).
- To untangle the correlation between **temperature** and groundwater level in Sigang District (Zeng-Wun River).
- To uncover the correlation between **relative humidity** and groundwater level in Sigang District.
- To unravel the correlation between **Fallow** and groundwater level in Sigang District (Zeng-Wun River).

Framework





You-Ren Hsiao (2018). Characterization of Nonstationary and Nonlinear Hydrologic, Environmental and Epidemic Time Series Based on Empirical Mode Decomposition (EMD)-based Algorithms and Time-dependent Intrinsic Correlation (TDIC)

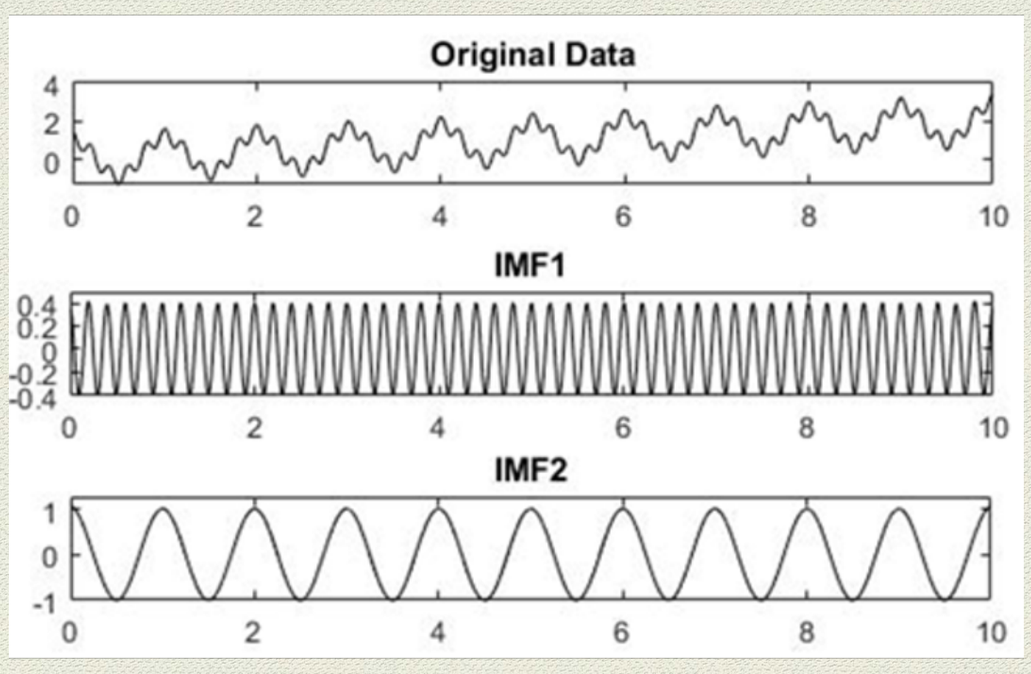
Methodology

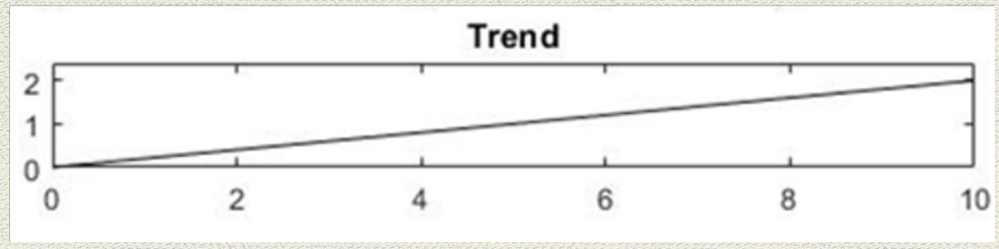
Methodology

Empirical Mode Decomposition (EMD)

$$x(t) = \sum_{i=1}^{n} C_i(t) + r(t)$$

Signal — $C_i(t)$ → **IMFs**





Signal = Slow Oscillation+Rapid Oscillation

Ming-Liang Lin (2020). Spatiotemporal Trend and Variability of Warming and Extreme Weather in Taiwan Based on Multi-dimensional Complementary Ensemble Empirical Mode Decomposition (MCEEMD)

Methodology

Intrinsic Mode Function (IMF)

$$x(t) = \sum_{i=1}^{n} C_i(t) + r(t)$$

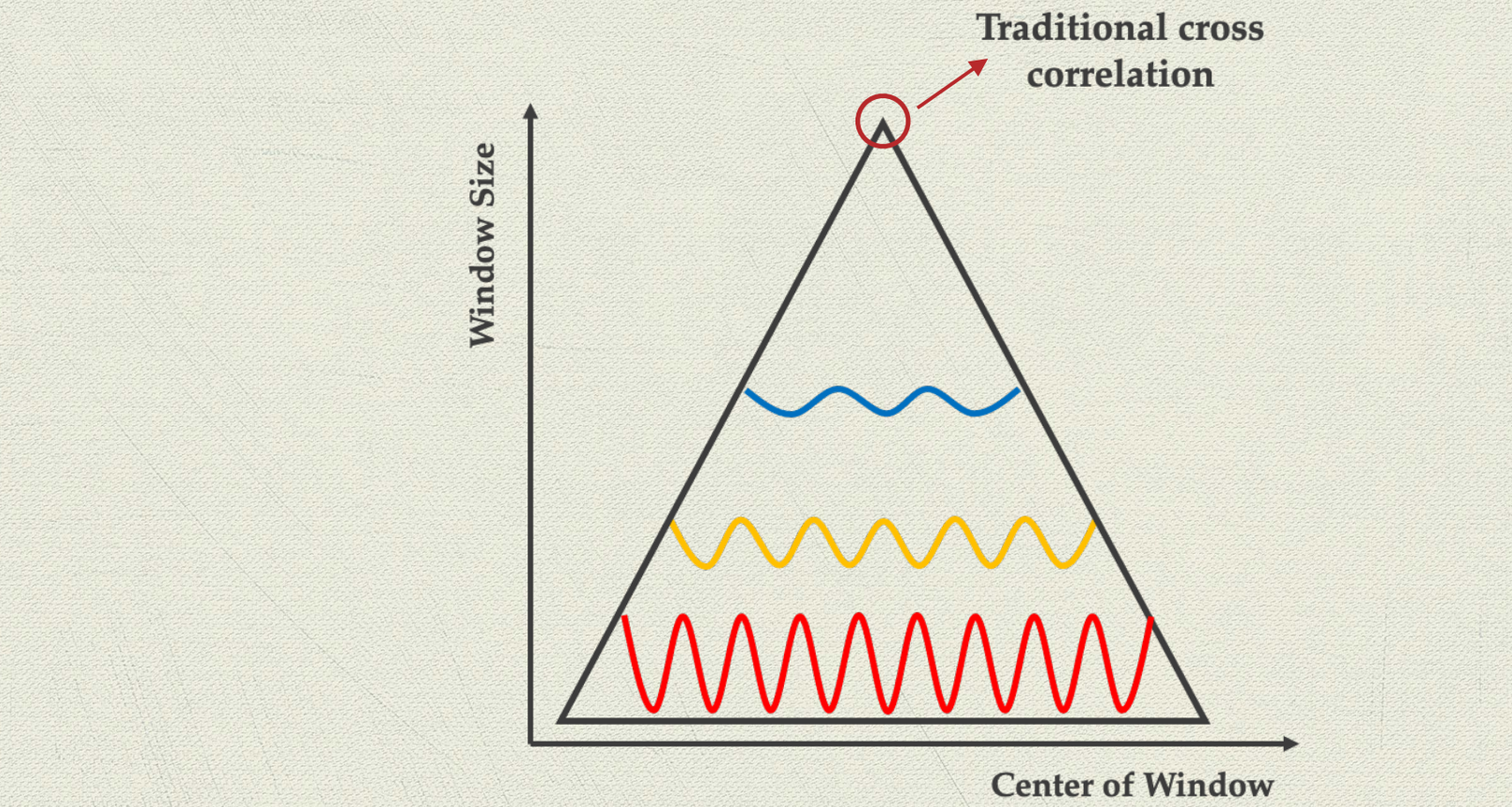
Sifting Process by Huang *et al.* (1998)

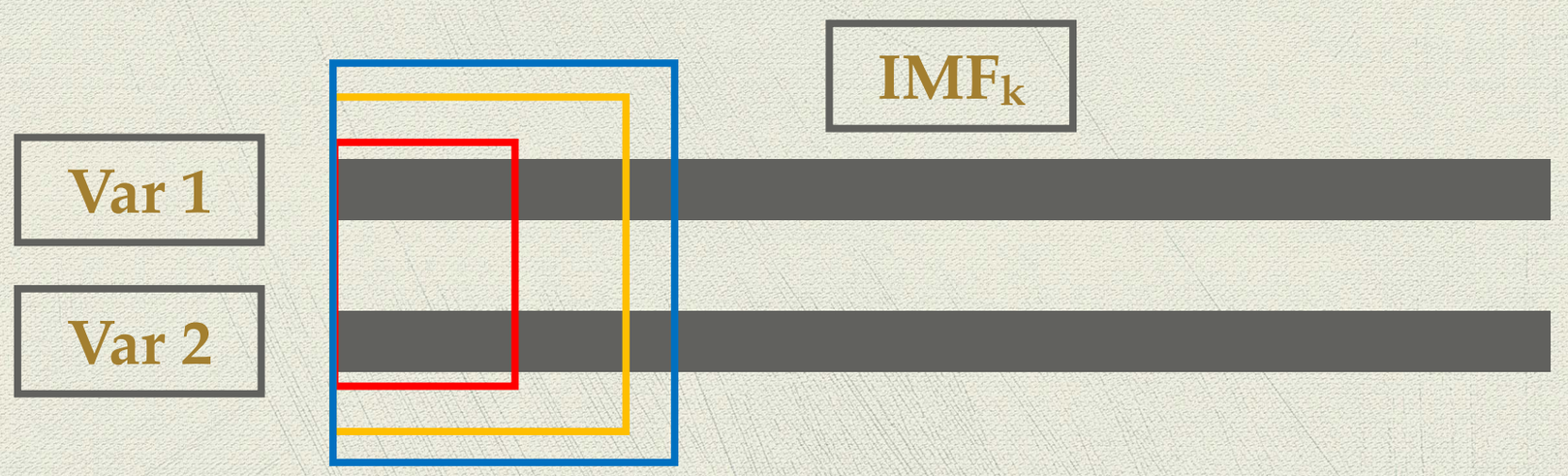
$$SD_k = \sum_{t=0}^{T} \frac{|h_{k-1}(t) - h_k(t)|^2}{{h_{k-1}}^2(t)} \leq 0.2 \sim 0.3$$

- In the whole dataset, the number of extrema (i.e., the number of maxima and minima) and the number of zeros crossing differ at most by one.
- At any point, the mean value of the envelope defined by the local maxima and the envelope defined by the local minima is around 0.
  - **Note that the amplitude and frequency of an IMF can vary with time.**

Methodology

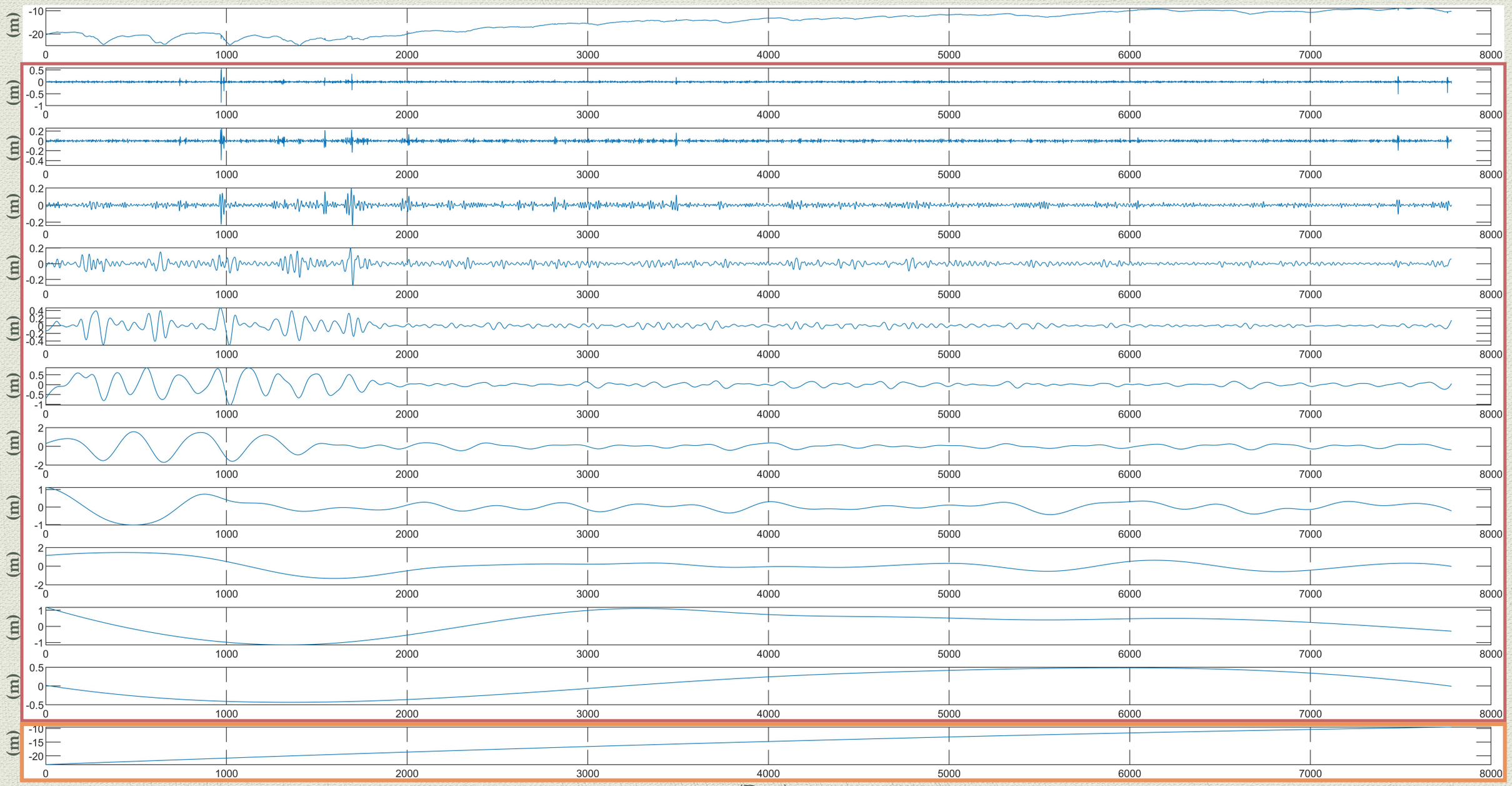
Time Dependent Intrinsic Correlation (TDIC)





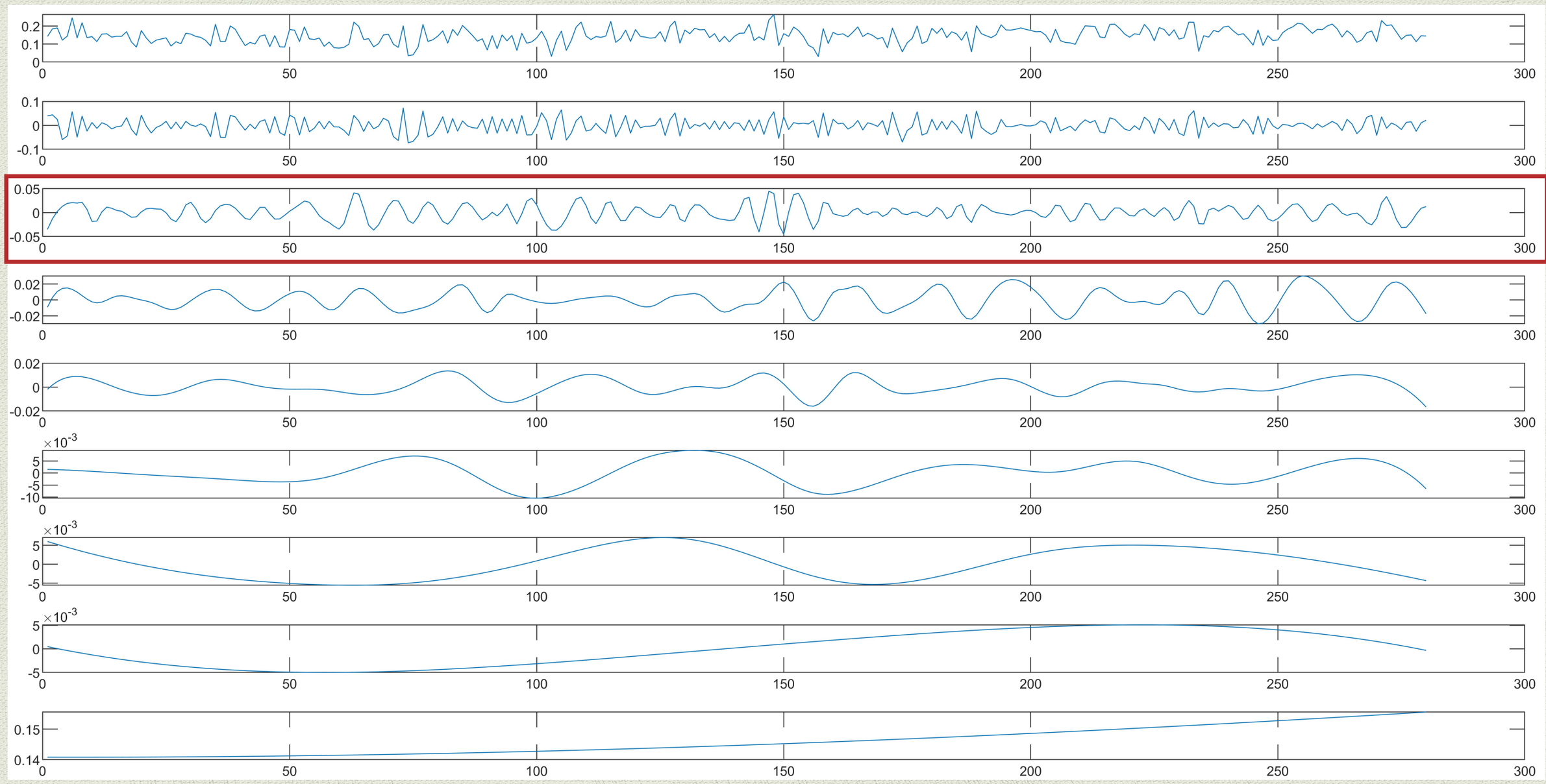
Results & Discussion

Intrinsic Mode Functions

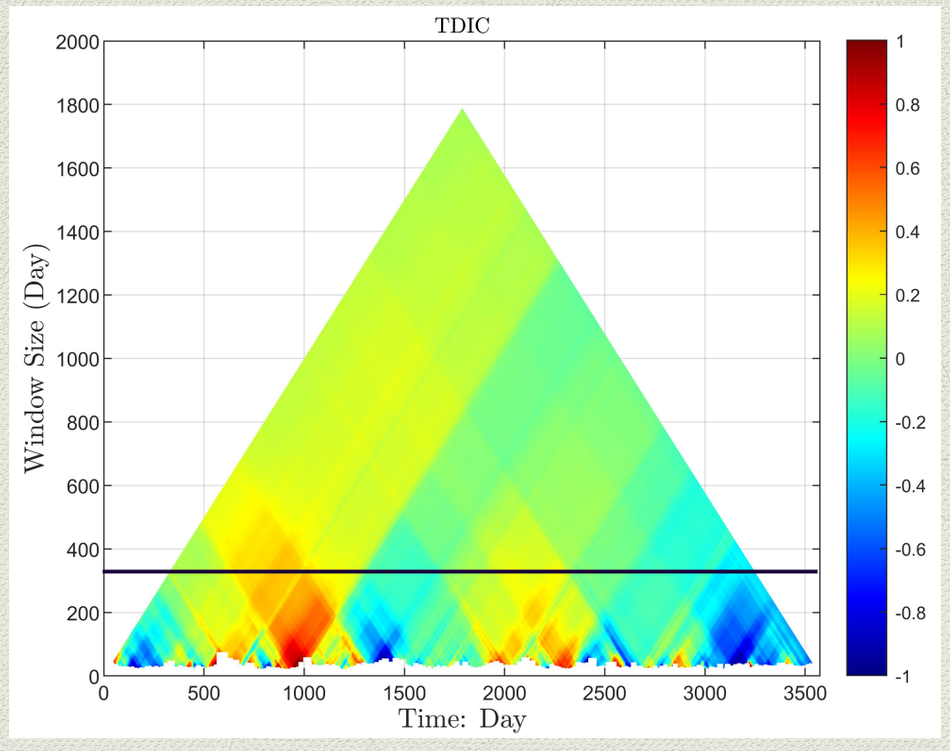


The IMFs of **Groundwater Level** at Jinsyue Station

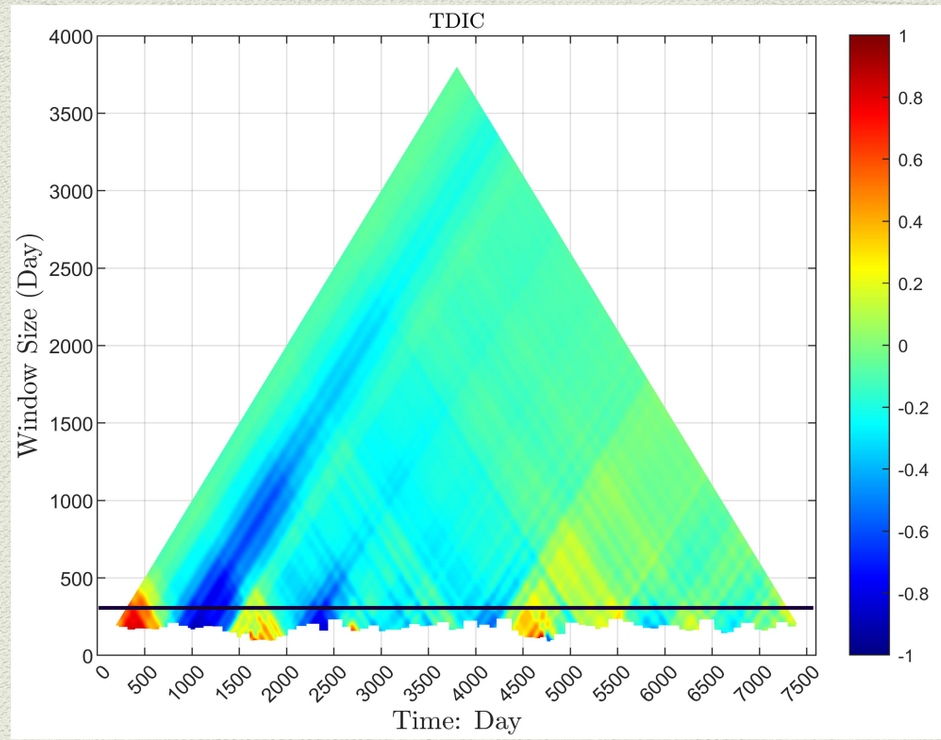
Intrinsic Mode Functions



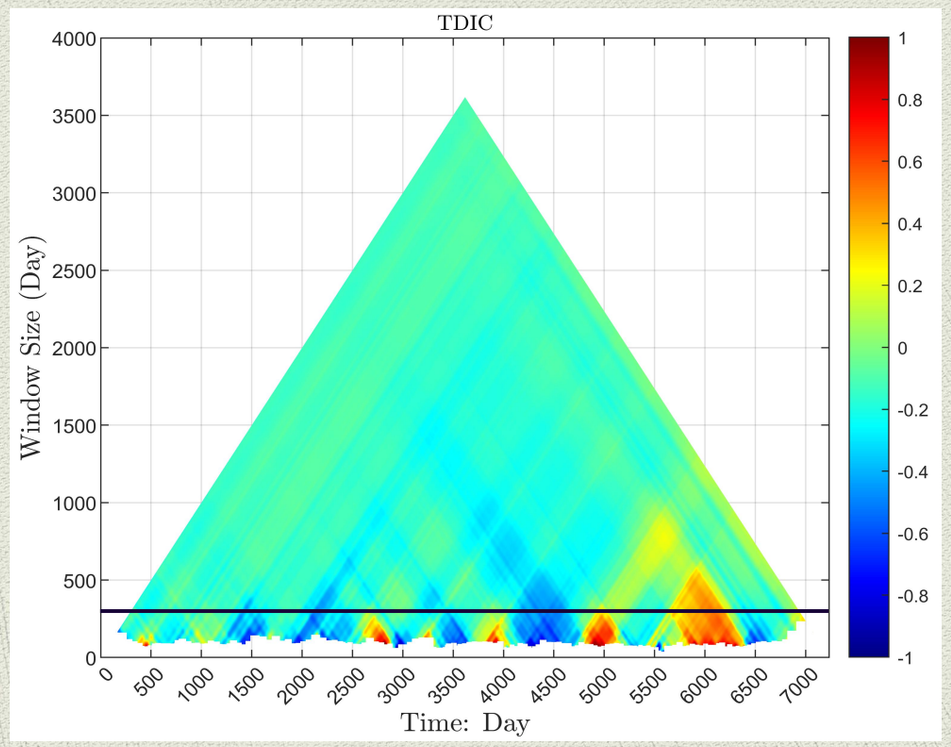
The IMFs of the **NDVI value** at Sigang District



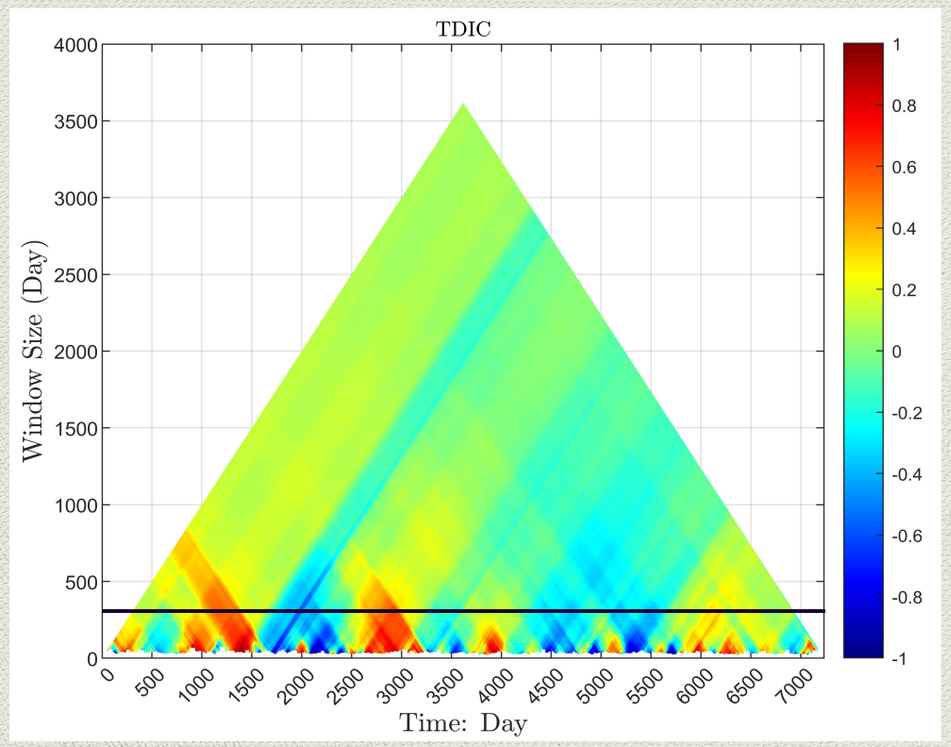
Water Level of Zheng-Wun River at bimonthly scale



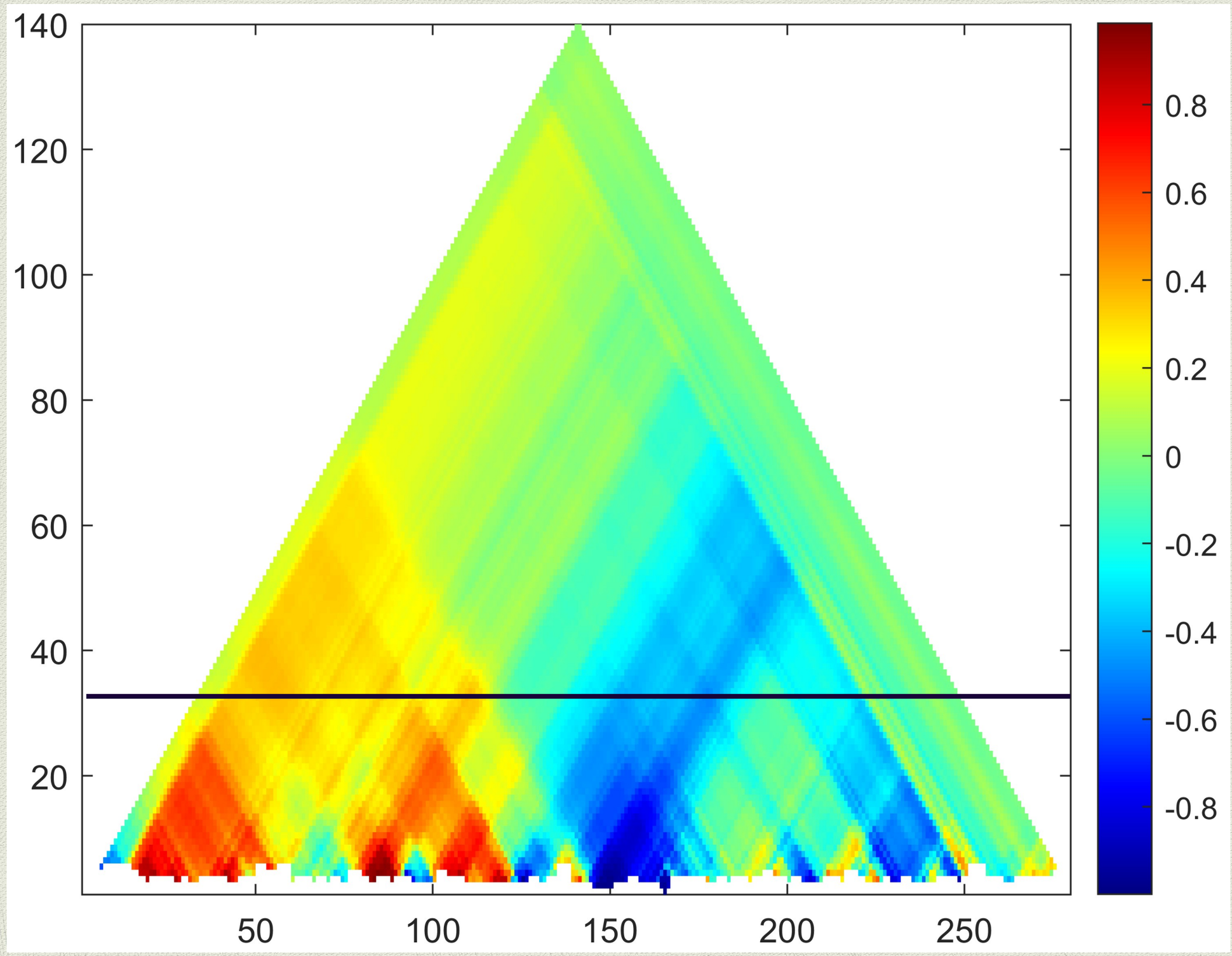
Relative Humidity (Grid 260) at annual scale



Precipitation (Grid 1255) at semi-annual scale



Temperature (Grid 1255) at bimonthly scale



NDVI Value at semi-annual scale

TDICs Summary

	Zheng-Wun River	Relative Humidity	Precipitation	Temperature	NDVI
Annually	—	W / **SS** / N	—	—	—
Semi-Annually	—	—	S / **SS** / N	—	S / **WS** / U
Bimonthly	W / **SS** / P	—	—	S / **SS** / P	—

Strong (S)	**Seasonal Switchover (SS)**	Positve correlated globally (P)
Weak (W)	**Without Switchover (WS)**	Negative correlated globally (N)
		Uncorrelated globally (U)

Conclusion & Future Recommendations

Conclusion

Summary

- The EMD-based algorithms provide **precise quantification** of relationships between water-table depth and the hydro-meteorological factors/fallow duration.
- The TDIC reveals a **switchover feature** among water-table depth and the hydro-meteorological factors at high-frequency components.
- Instead of planting green manure to restore the fertility of the soil, the farmer should also consider **conducting fallow** to recover the groundwater level.

Conclusion

From Global To Local

- From fixed sliding windows to adaptive sliding window
- From linear assumption to the extraction of nonlinear feature
- From constant frequency to instantaneous frequency
- From constant cross-correlation to cross-correlation time series at multiple scales

Future Recommendations

Apply to Other Region in the Chia-Nan Plain

3

A Finer Temporal Resolution for the Data

2

Apply Other EMD-Extensions, e.g. CEEMD

1

Take Time-Lag Effect into Consideration (TDICC)

My Next Step

Thanks For Listening!

About This Work

- **Karen Hsieh (2022). Spatio-Temporal Trend and Variability of Groundwater Level in the Sigang District of Tainan, Taiwan Based on Multi-Dimensional Ensemble Empirical Mode Decomposition (MEEMD) and Time-Dependent Intrinsic Correlation (TDIC). In: Bachelor's Thesis at National Taiwan University.**

Link for the thesis: