
SBA
Research

Information theory approach for enhancing time series analysis and predictability of soil environments

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Problem statement

When dealing with environmental systems:

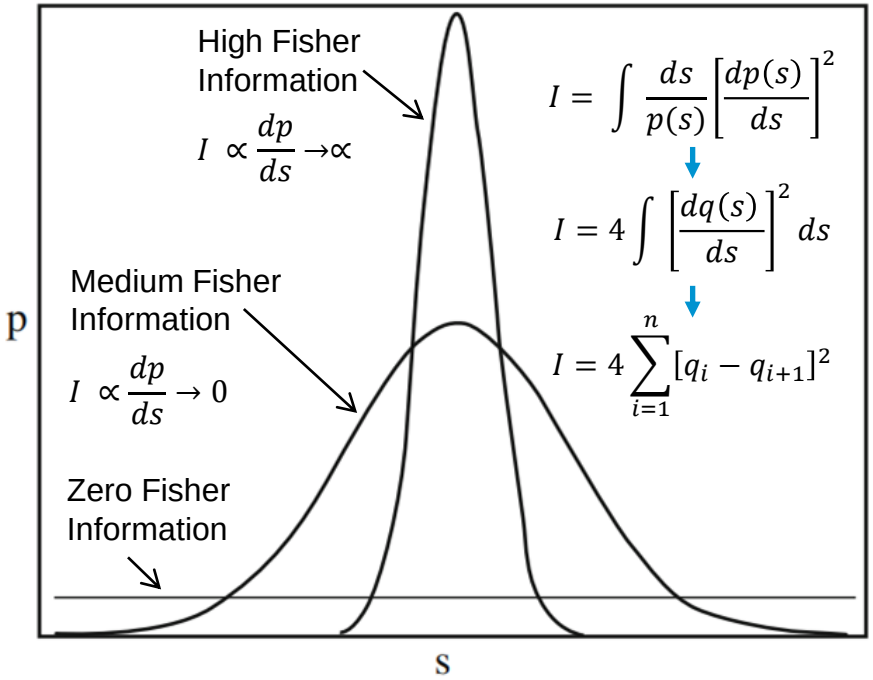
- **Missing** & **low resolution** data
- High **complexity**

Need methods for:

- Data **imputation** with minimal loss of system complexity
- Studying the overall **dynamic behavior**
- Determining **regime shifts** before they happen
- An **overview** of patterns

Current state of research - Fisher Information (FI)

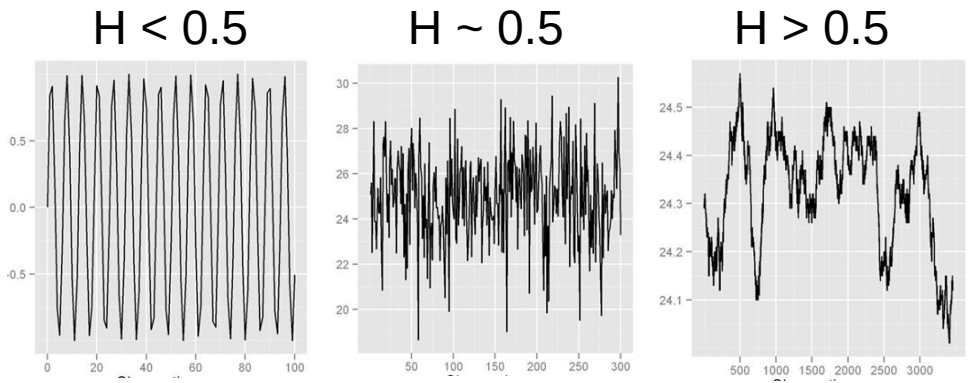
- **Multivariate** binning
- Captures **dynamic order**
- **Early regime shift** detection
- Previous uses:
  - Global temperature variation
  - Lake eutrophication
  - Marine ecosystem



(Eason et al., 2013), (Ahmad et al., 2016)

Current state of research - Hurst Exponent

- Used for **studying patterns** in the data & checking the **potential for prediction**:
  - H < 0.5 (anti-persistent)
  - H ~ 0.5 (random)
  - H > 0.5 (persistent)
- Previous uses:
  - financial systems
  - healthcare industry
  - ecology



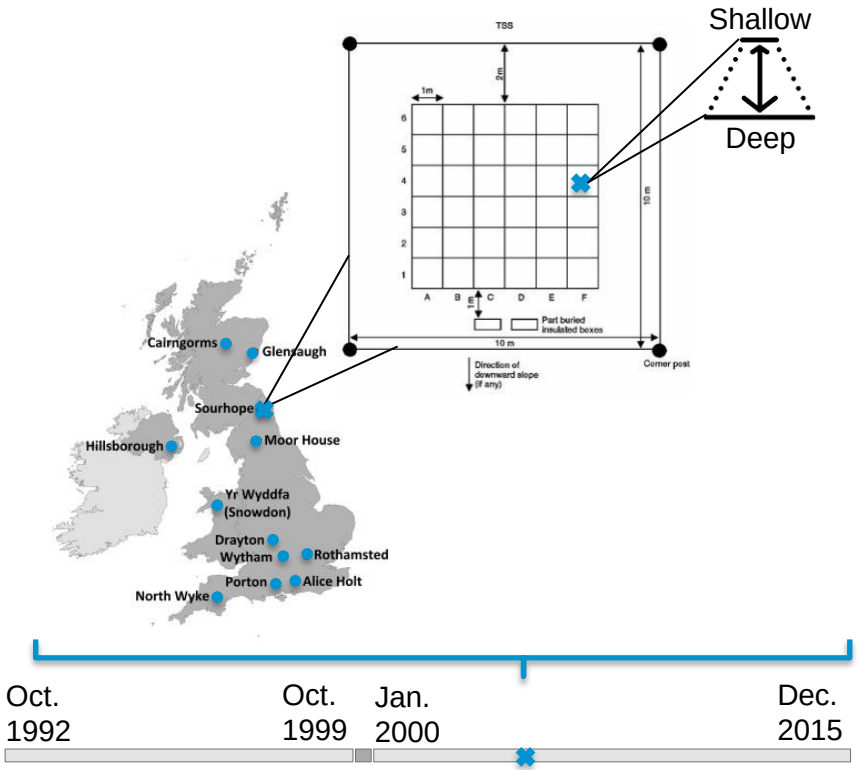
(Mollaei, 2019), (Mansukhani, 2016)

Data insights

- Data on **Soil solution chemistry**
- Measurements: **12 sites** across UK

- Small volume of water collected →
  - **discarded** samples

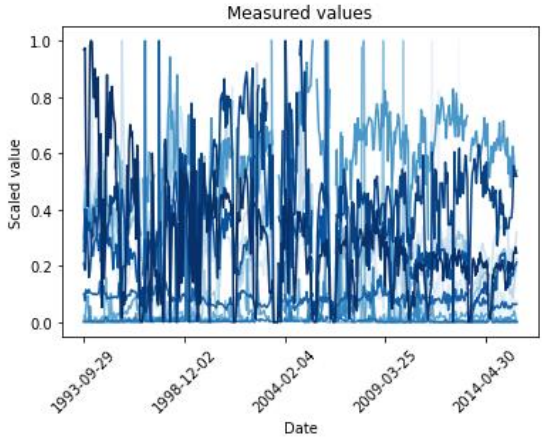
  or
  - **combined** samples per depth

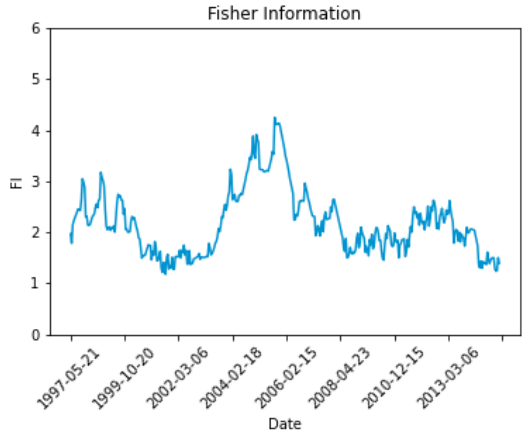


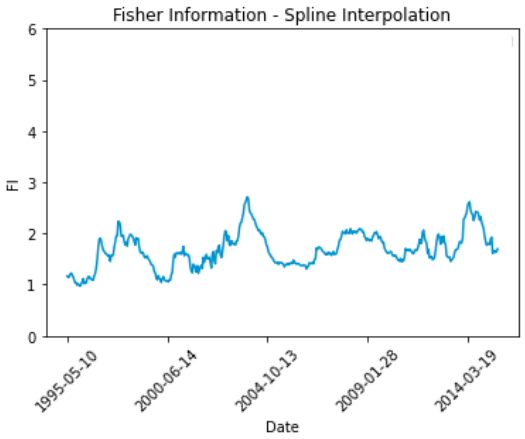
(Rennie, 2020)

Results

- Fisher Information
  - Applied on **raw** data
    → possible indication of **sharp** regime shift
  - Applied on **interpolated** data
    → **smoother** variation & gradual increase (follows the observed ecosystem properties)





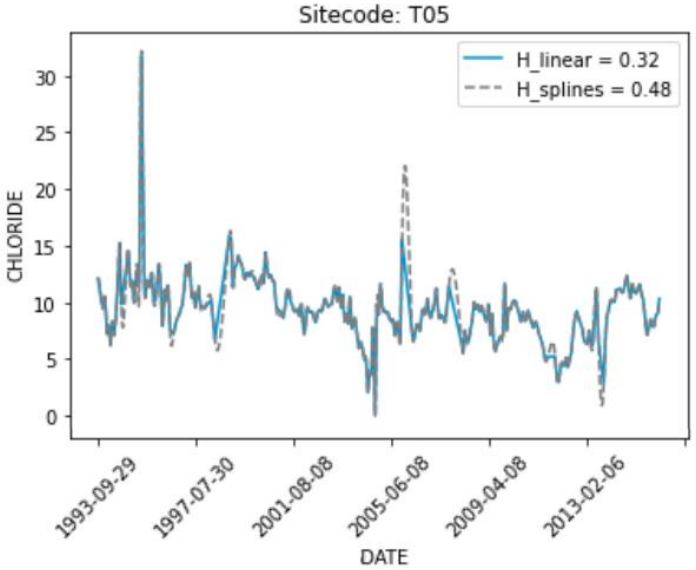


Results

- Hurst Exponent
  - Linear Interpolation

    → **anti-persistent** pattern (H < 0.5)
  - Spline Interpolation

    → **random** pattern (H ~ 0.5)



! Interpolation can result in loss of information

Conclusion

- Difficult to understand raw environmental data
- Fisher Information & the Hurst exponent help us to identify **underlying patterns** & **potential for predictions** in the time-series
- Data interpolation:
  - Generates Fisher Information results that are coherent with observed ecosystem properties
  - Result in an information loss for the Hurst exponent

Discussion

- Different preprocessing can generate different insights:
  - Raw data vs. different interpolations
  - Outlier filtering

  → Handle with care!
- Difficult to validate results

Further thoughts

- **Correlation** between Fisher Information and physical measures
- **Extension** with other datasets (biodiversity, weather, etc.)
- Additional study and understanding of the possible **drivers of change**
- **Comparison** to prediction models

Q & A

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Abstract

References

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