EPS Observational Note 03

EPS-ON-03

Temporal Lead–Lag Behaviour in Distributed Environmental Proxy Signals

Author: Michael A Jones
Year: 2026

Abstract

Environmental observations within the Earth system frequently display temporal relationships across atmospheric, oceanic, hydrological, and geophysical domains. Signals observed in one domain may appear prior to, concurrently with, or following variability in another.

Within the **Earth Proxy System (EPS) framework**, such behaviour may be interpreted as temporal relationships among distributed proxy observations arising from interactions within the coupled Earth system.

This observational note explores the concept of **leading, lagging, and synchronous behaviour** among environmental proxy signals and its relevance for interpreting Earth-system variability.

1 Introduction

The Earth system exhibits complex variability arising from interactions among atmospheric circulation, ocean dynamics, hydrological cycles, and geophysical processes.

Because these systems interact across different spatial and temporal scales, environmental observations often display **temporal relationships** across multiple observational datasets.

Signals appearing in one domain may precede or follow changes in another, reflecting dynamic interactions within the coupled Earth system.

Within the **EPS framework**, such behaviour may be interpreted through distributed proxy observations exhibiting temporal relationships relative to Earth-system variability.

2 Temporal Relationships Among Environmental Signals

Environmental proxy observations may display several types of temporal behaviour:

Leading Signals

Signals appearing prior to observable variability in other environmental domains.

These may represent early responses within components of the Earth system.

Synchronous Signals

Signals occurring concurrently across multiple environmental domains.

These may reflect simultaneous system responses to shared drivers or interactions.

Lagging Signals

Signals appearing after variability occurs in other environmental systems.

These may represent delayed responses within slower Earth-system components.

3 Examples of Temporal Relationships

Temporal relationships between environmental observations may occur across many domains of the Earth system.

Examples may include:

- atmospheric circulation changes preceding hydrological variability
- ocean temperature variability influencing atmospheric behaviour
- geophysical signals corresponding with environmental changes
- climate regime transitions producing lagging environmental responses

Such behaviour illustrates the dynamic interactions occurring within the coupled Earth system.

4 Distributed Temporal Proxy Behaviour

Within the EPS framework, distributed environmental proxy observations may exhibit **temporal structures** reflecting Earth-system interactions.

Proxy observations may therefore be interpreted in relation to one another through temporal relationships including:

• lead–lag patterns
• synchronous signal behaviour
• evolving proxy relationships during regime transitions

These temporal patterns may provide insights into the dynamics of Earth-system variability.

5 EPS Interpretation

Within the EPS conceptual framework, temporal relationships among environmental observations may be expressed through the broader observational relationship:

V_ES ↔ S_d | { I_p , C_es }

Where:

- **V_ES** represents Earth-system variability
- **S_d** represents distributed proxy observations
- **I_p** represents planetary influences
- **C_es** represents coupled Earth-system interactions

Temporal behaviour among distributed proxy observations may therefore represent expressions of evolving Earth-system dynamics.

6 Conclusion

Environmental proxy observations frequently exhibit temporal relationships across atmospheric, oceanic, hydrological, and geophysical domains.

Within the **EPS framework**, such behaviour may be interpreted as distributed proxy expressions of Earth-system variability arising from interactions within the coupled Earth system.

Understanding these temporal relationships may provide insights into the dynamics of Earth-system variability and regime behaviour.