Tools and approaches to facilitate *data synthesis*

Earth Cube Workshop on
"Interoperability of Ocean Time Series Data"

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EARTHCUBE
TRANSFORMING GEOSCIENCES RESEARCH

NCEAS
National Center for Ecological Analysis and Synthesis

NATIONAL SCIENCE FOUNDATION
LTER NETWORK
LONG TERM ECOLOGICAL RESEARCH

NSF

Data Synthesis

Bringing together ***disparate data,*** concepts, or theories, integrated in ways that yield new knowledge, insights, or explanations

National Center for Ecological Analysis and Synthesis
NSF-funded ***Synthesis Center,*** 1995-2017

Collaborative ***Working Groups***
Using ONLY ***Existing Data***

from:
Pickett STA, Kolasa J, Jones CG. 2007.
Ecological Understanding: The Nature of Theory and the Theory of Nature. 2nd ed. Academic Press.

Data Synthesis Challenges

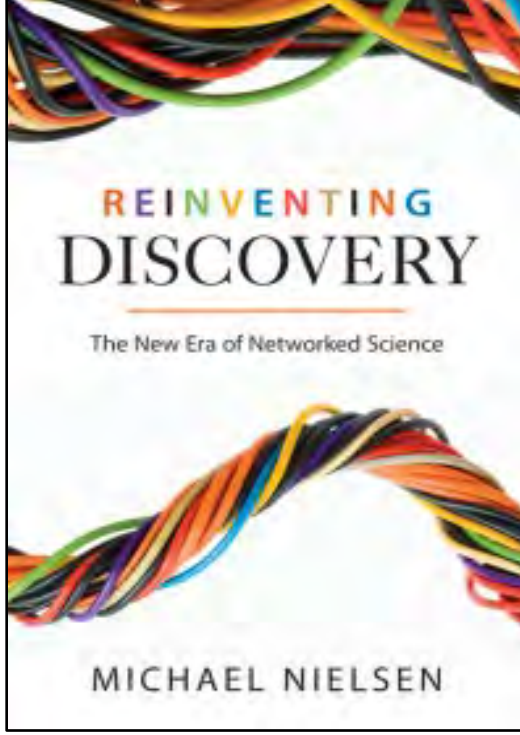
- Distributed: stewarded by many groups, individuals
- Undocumented: sparsely and *inconsistently* documented
- Inaccessible: varying degrees of presentation and preservation, via Web, paper archives, etc.
- Heterogeneous: broad range of topics & measurements (semantics), formats (structure), data access protocols (syntax), data models (theory), etc.

Why preserve and share Data?

Data **are** the raw materials for science

…re-use: syntheses, AND validating results

...increased scope and robustness of research findings



How to preserve and share Data?

FAIR principles: **F**indable, **A**ccessible, **I**nteroperable, **R**e-usable

(Wilkinson et al. https://doi.org/10.1038/sdata.2016.18)

FAIR for DATA SYNTHESIS:

Data that are Findable, Accessible, Interoperable, Re-usable

- FIND: **Shared, vocabularies** for vessels, roles, measurements;
  Globally Unique Identifiers (GUIDs)
- ACCESS: Powerful, **open API's**; Globally Unique Identifiers (GUIDs)
- INTEROPERABLE: open source, compatible technologies
- REUSABLE: standardized protocols, methods

- S.O.S.: **Shared**, **Open**, and **Semantic**

  Ontologies to describe terms, schemas

  Machine-assisted discovery, reasoning, integration

Key Technology Needs

…synthesis analyses typically require a broad range of data ranging across multiple scales and encompassing multiple disciplines– heterogeneous in syntax and semantics, distributed across organizations, and often voluminous….

- better **metadata**: structured descriptions of data for discovery/re-use
- **interoperable frameworks** to preserve and access data/metadata
- **better tools** to interact with frameworks through visual and other assistive technologies
- **scientific workflows** to facilitate transparency, reproducibility, sharing, and re-use of analyses
- **robust semantics** controlled vocabularies/ontologies + machine reasoning for finding and re-using data

Approaches

- Data Repository Initiatives (e.g. ERDDAP, DataONE)

- Emerging Standards & Services
  - Schema.org (Google, Yahoo, Microsoft), W3C recommendations (DCAT, **RDF/OWL, OWL Time**, SOSA, QB4ST), ESIP SWEET, OBO Foundry EnvO, BODC NERC, Darwin Core, EML, Nexus/Newick, FASTA, FGDC, ISO, OGC, CF, etc.

Tools

- Software choices matter:
  - Open source, multi-platform, scalable (HPC, cloud)
  - BETTER: script/code-based software: R, MATLAB, Python, SAS, scientific workflow apps (Galaxy, Kepler, VisTrails, Taverna)
  - NOT AS GOOD: GUI-driven applications: Spreadsheets, black-box compiled applications
- Code repositories needed for preservation of workflows, libraries, functions, etc.
  - GitHub not sufficient for FAIR code?

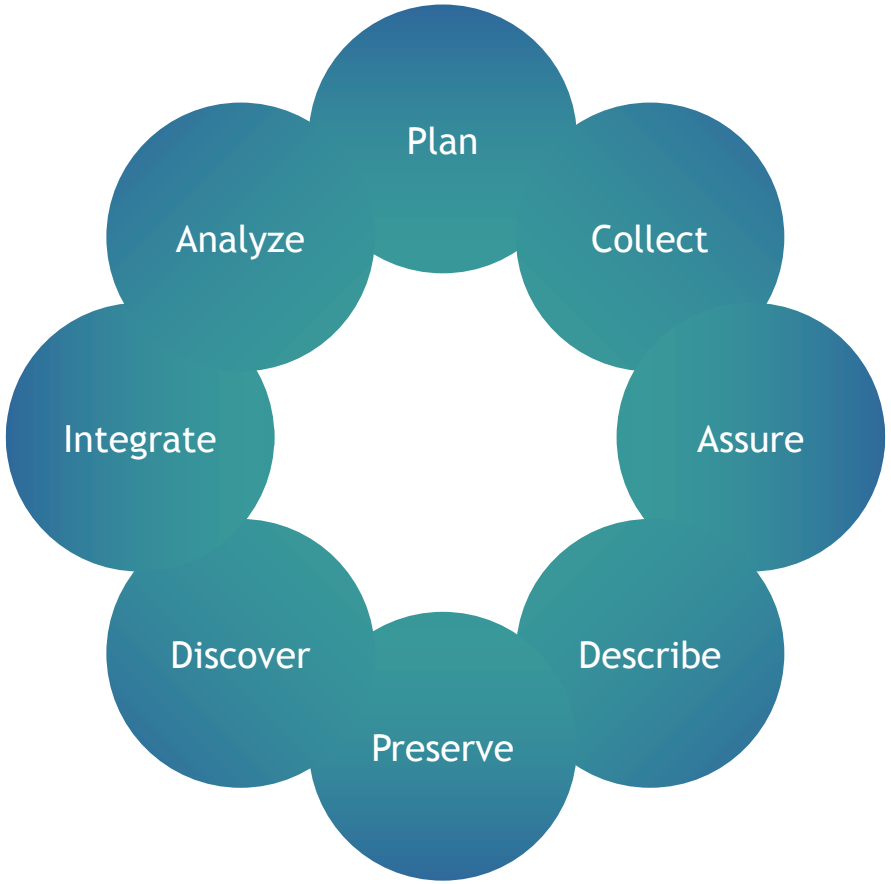
TOOLS?

Analyze

Integrate

Discover

Preserve



Plan

Collect

Assure

Describe

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Frameworks?

- Large integrative efforts
  - DataONE, Pangaea, EDI, ADC
- These initiatives generally adhere to and promote best-practices, using appropriate community-driven metadata/semantic standards

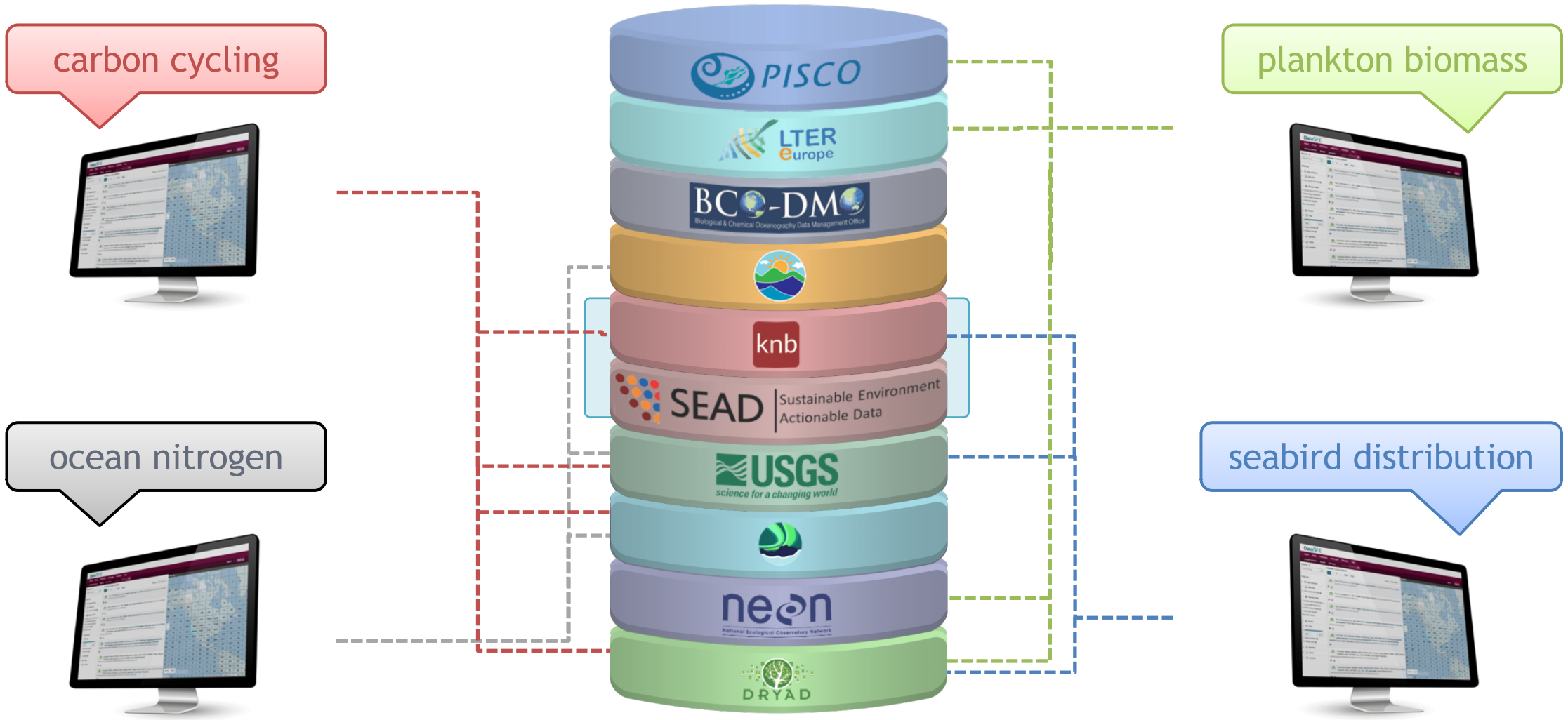
DataONE

Key Principles

- Interoperable
- Federated
- API-centric
- Loose Coupling
- Diverse components
- Tiered deployment
- Semantics & Provenance

Solutions for Researchers

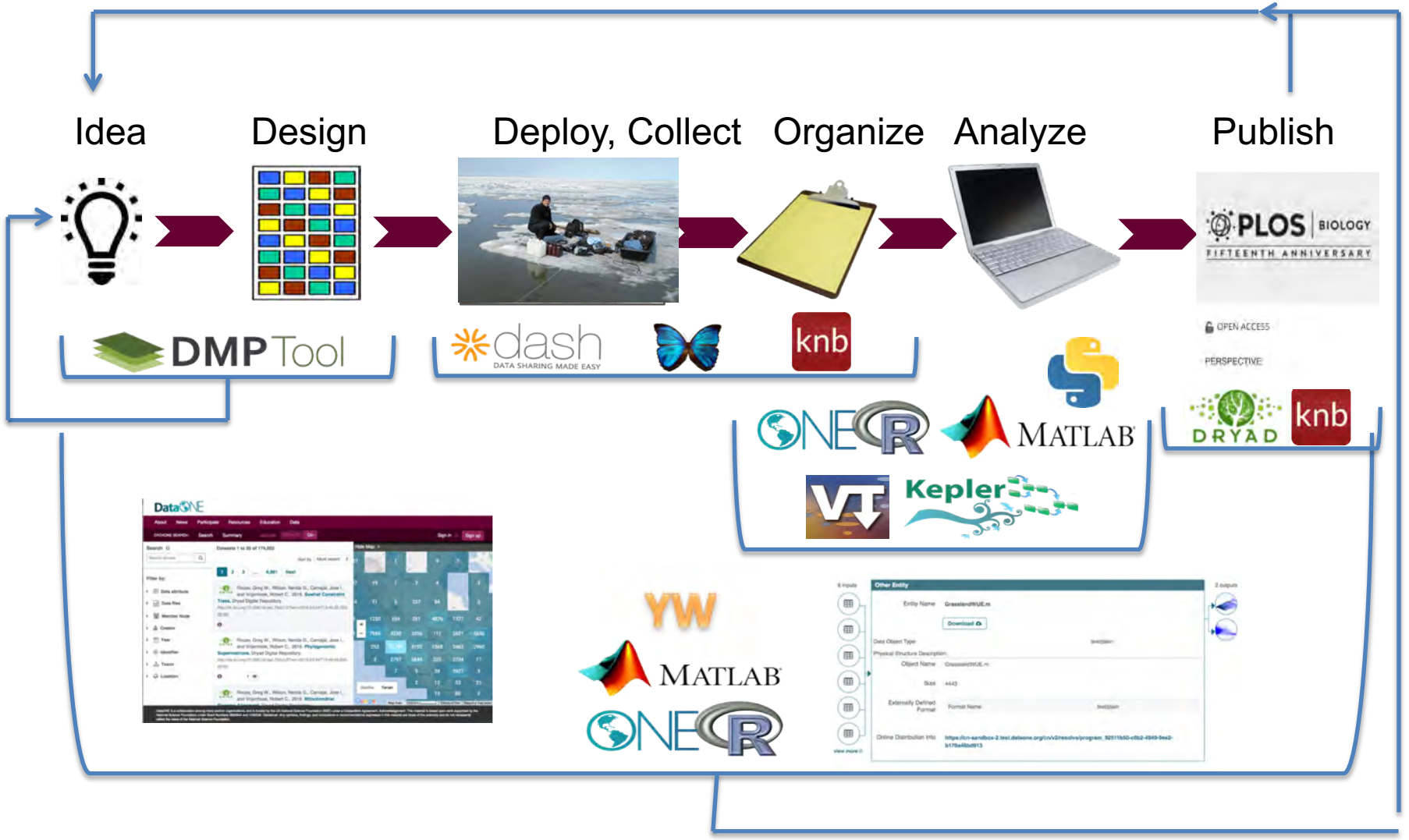
- Data Discovery and Access from Multiple Member Nodes



Research: Traditional Practice

Closed, Opaque, Irreproducible, Linear

Research: Open-science, FAIR-enabled

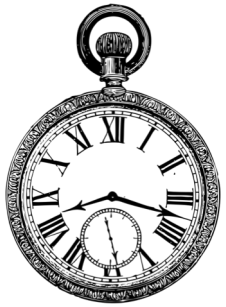


Open, Transparent, Reproducible, Reusable, Dynamic

Lessons for Ocean Time Series Data

- Adopt existing standards where applicable
  - OWL Time, Schema.org, ISO 8601,NERC Vocab

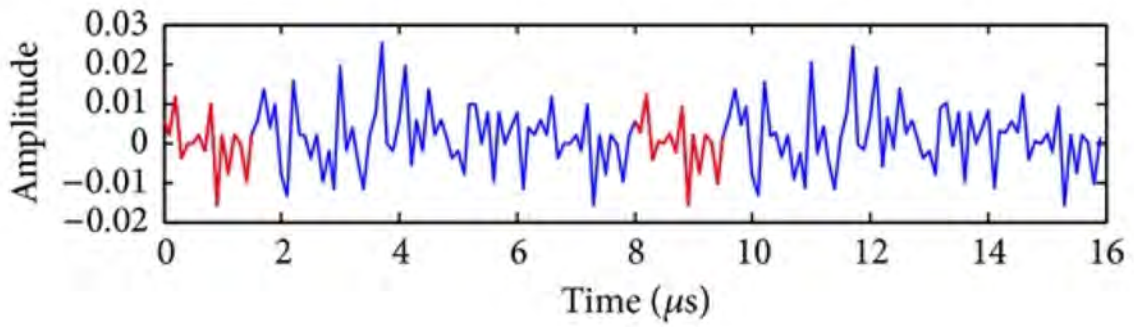
- Interoperate with Existing Frameworks
  - ERDDAP, DataONE API



- Promote FAIR, open source, community-vetted solutions

Lessons for Ocean Time Series Data

- Special querying or sampling needs?
  - Duration, gaps, events, trends: detect, annotate
  - Grain, roll-ups, scaling, synchrony, etc.: compute
  - Real-time and static
  - Sensor details



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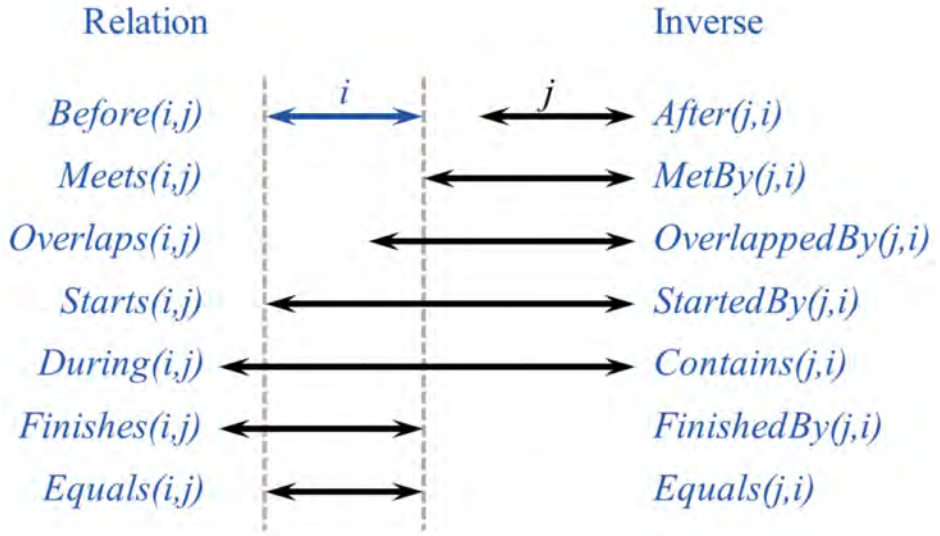
ISO 8601

Tools Needed for Ocean Time Series Data

- Alignment/mapping tools to "conform" legacy data
- Data entry templates for acquiring new data

- Compatible, open-source analytical tools to process standardized data
- Training in use/interpretation



Owl Time