Cross-cutting Interoperability in an Earth Science Collaboratory

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The Situation Today

Earth Science Stuff is (still) hard to use...

- data
- science tools / svc
- analysis results
- knowledge about
  - data
  - tools
  - analysis methods

- find
- share
- reuse
- put together
  - data + data
  - data + tool
  - tool + tool
  - desktop + online svc
What Is An Earth Science Collaboratory?

- A rich data analysis environment with:
  - Access to a wide spectrum of Earth Science data
  - A diverse set of science analysis services and tools
  - A means to collaborate on data, tools and analysis
  - Supports sharing of data, tools, results and knowledge

Earth Science Collaboratory

Cyberinfrastructure

Laboratory Notebook

Workflows

Tool Library

Data Library

Data Centers
Types of Interoperability

- Horizontal
- Vertical
- Procedural
- Meta

Search Client

Common Protocol

Catalog A
Catalog B
Catalog C

Types of Interoperability

- Horizontal
- Vertical
- Procedural
- Meta

Article
Analysis Results
Workflows
Tools/Svcs
Data

standard formats
CF* Convention

data citations
Types of Interoperability

- Horizontal
- Vertical
- Procedural
- Meta

Procedural Interoperability Challenge

Provenance

Fusion

Analysis

Processing

Subsetting

Access

Search

Spatio-temporal congruence

Data locators

Structural metadata

Catalog metadata

Web Coverage Service

Catalog Services for the Web

Methane

Temperature

Water vapor

11/29/11
## Types of Interoperability

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Framework</th>
<th>Framework</th>
<th>Meta-Interop</th>
</tr>
</thead>
<tbody>
<tr>
<td>Search</td>
<td>OGC Catalog Services for the Web</td>
<td>OpenSearch</td>
<td>Envelopment</td>
</tr>
<tr>
<td>Access</td>
<td>OGC Web Coverage Service</td>
<td>Data Access Protocol (OPeNDAP)</td>
<td>Gateways, Profile</td>
</tr>
<tr>
<td>Analysis</td>
<td>CF/netCDF</td>
<td>GIS formats</td>
<td>Profile?</td>
</tr>
<tr>
<td>Provenance</td>
<td>Open Provenance Model</td>
<td>Proof Markup Language</td>
<td>??</td>
</tr>
<tr>
<td>Model-Data “Fusion”</td>
<td>Data resampling</td>
<td>Model resampling</td>
<td>??</td>
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</tbody>
</table>

### ESC Interoperability Status

- **Laboratory Notebook**: Some interoperability
- **Workflows**: Little or no interoperability
- **Tool Library**
- **Data Library**
- **Data Centers**

Cyberinfrastructure
Cross-Cutting Interoperability Strategies for Legacy Standards

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Interoperability Addressed</th>
<th>Example</th>
<th>Achilles' Heel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Client plug-ins</td>
<td>Procedural: Search-access-analysis</td>
<td>Environmental Data Connector for ArcGIS</td>
<td>Scalability</td>
</tr>
<tr>
<td>Omnivorous APIs</td>
<td>Meta: standard formats</td>
<td>netCDF-Java API, reads (some) HDF</td>
<td>Adoption</td>
</tr>
<tr>
<td>Gateways</td>
<td>Meta: OPeNDAP + OGC</td>
<td>OPeNDAP + WCS</td>
<td>Performance</td>
</tr>
<tr>
<td>Multi-lingual Servers</td>
<td>Meta: OPeNDAP + OGC</td>
<td>THREDDS Data Server, ERDDAP</td>
<td>?</td>
</tr>
<tr>
<td>Standards Convergence</td>
<td>Meta: standard formats</td>
<td>netCDF4 + HDFS</td>
<td>Scope, Cost</td>
</tr>
<tr>
<td>&quot;Microformats&quot;</td>
<td>Vertical</td>
<td>Data citations, esp. w/DOI</td>
<td>Adoption, Identifiers</td>
</tr>
</tbody>
</table>

We need standards for higher levels in the information stack to enable cross-cutting interoperability

<table>
<thead>
<tr>
<th></th>
<th>Article</th>
<th>Results</th>
<th>Workflow</th>
<th>Tool</th>
<th>Data</th>
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</thead>
<tbody>
<tr>
<td>Article</td>
<td>M</td>
<td>V</td>
<td>V</td>
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<tr>
<td>Results</td>
<td>V</td>
<td>H</td>
<td>V</td>
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<td>M</td>
<td>V</td>
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<tr>
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<td>V</td>
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<td>H</td>
<td></td>
</tr>
<tr>
<td>Data</td>
<td>V</td>
<td></td>
<td></td>
<td></td>
<td>H, M</td>
</tr>
</tbody>
</table>

H = Horizontal Interoperability
V = Vertical Interoperability
M = Meta-Interoperability
Lessons for Standards Engineering?

- Go beyond horizontal interoperability: consider implications for vertical and procedural interoperability
- Incorporate both syntax AND semantics
- Leverage microformats
- Embrace the Open World Assumption