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 / svcs
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
Types of Interoperability

- Horizontal
- Vertical
- Procedural
- Meta

```
       Search Client
       /          /
     Common Protocol
    /       \       /
Catalog A  Catalog B  Catalog C
```

Types of Interoperability

- Horizontal
  - Article
  - Analysis Results
  - Workflows
  - Tools/Svcs
    - standard formats
    - CF* Convention
- Vertical
  - Data
  - data citations

Procedural

Meta
Types of Interoperability

- Horizontal
- Vertical
- Procedural
- Metadata

Procedural Interoperability Challenge

- Search
  - Catalog Services for the Web
  - methane
  - temperature
  - water vapor

- Access
  - structural metadata
  - data locators

- Processing
  - spatio-temporal congruence

- Provenance
  - Analysis

- Subsetting
  - Fusion
Types of Interoperability

<table>
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<th>Procedure</th>
<th>Framework</th>
<th>Framework</th>
<th>Meta-Interop</th>
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<tr>
<td>Search</td>
<td>OGC Catalog Services for the Web</td>
<td>OpenSearch</td>
<td>Envelopment</td>
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<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>
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<tr>
<td>Provenance</td>
<td>Open Provenance Model</td>
<td>Proof Markup Language</td>
<td>??</td>
</tr>
<tr>
<td>Model-Data</td>
<td>“Fusion” regridding</td>
<td>Model resampling</td>
<td>??</td>
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</table>

ESC Interoperability Status

Cyberinfrastructure

Laboratory Notebook

Workflows

Tool Library

Data Library

Data Centers

Some interoperability

Little or no interoperability
Cross-Cutting Interoperability
Strategies for Legacy Standards

<table>
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<th>Strategy</th>
<th>Interoperability Addressed</th>
<th>Example</th>
<th>Achilles' Heel</th>
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<tr>
<td>Client plug-ins</td>
<td>Procedural: Search-access-analysis</td>
<td>Environmental Data Connector for ArcGIS</td>
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<tr>
<td>Omnivorous APIs</td>
<td>Meta: standard formats</td>
<td>netCDF-Java API, reads (some) HDF</td>
<td>Adoption</td>
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<tr>
<td>Gateways</td>
<td>Meta: OPeNDAP + OGC</td>
<td>OPeNDAP + WCS</td>
<td>Performance</td>
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<td>Multi-lingual Servers</td>
<td>Meta: OPeNDAP + OGC</td>
<td>THREDDS Data Server, ERDDAP</td>
<td>?</td>
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<tr>
<td>Standards Convergence</td>
<td>Meta: standard formats</td>
<td>netCDF4 + HDF</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>
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We need standards for higher levels in the information stack to enable cross-cutting interoperability

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