Building the NNEW Weather Ontology

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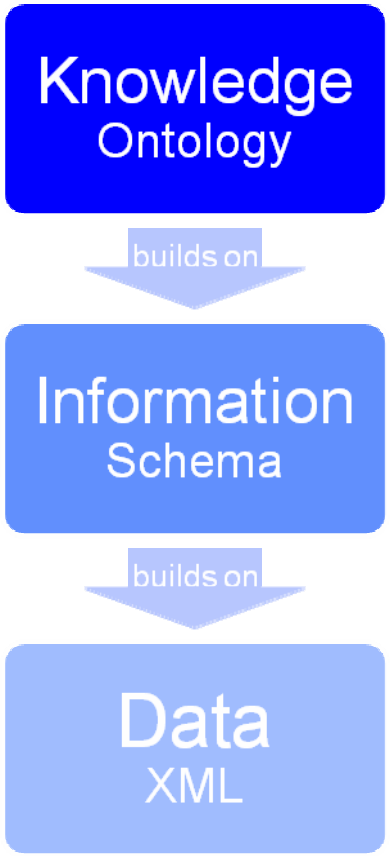
Outline

- Introduction
- Ontology Development Methods & Tools
- NNEW Weather Ontology Design
- Application: Semantic Search
- Summary

What is an Ontology?

"An ontology defines a common vocabulary for researchers who need to share information in a domain. It includes machine-interpretable definitions of basic concepts in the domain and relations among them." (Noy 2000)



- **Definition:** Set of elements and the relationships between them
- **Purpose:** Formally model a domain
  - Used for information integration and knowledge sharing
- **Formal specification:** Popular language is Web Ontology Language (OWL), a semantic markup language
- **Representation:** Modeled as a graph

Role of Ontologies within WXXM

- **Ontologies are used by Observations & Measurements model**

```
<om:observation>
   <om:observedProperty
    xlink:href="http://sweet.jpl.nasa.gov/ontology.owl#Temperature"/>
```

→ External JPL SWEET Ontology

  - **Provide linkage from data instance to higher-level knowledge tree**
  - **Enable semantically-enhanced data queries (SPARQL)**

- **WXXM leverages and extends the Observations & Measurements model**

```
<wx:observation>
   <om:observedProperty
    xlink:href="http://wmo.org/ont/wx/1.1/wx.owl#Precipitation"/>
```

→ External Weather Ontology (New)

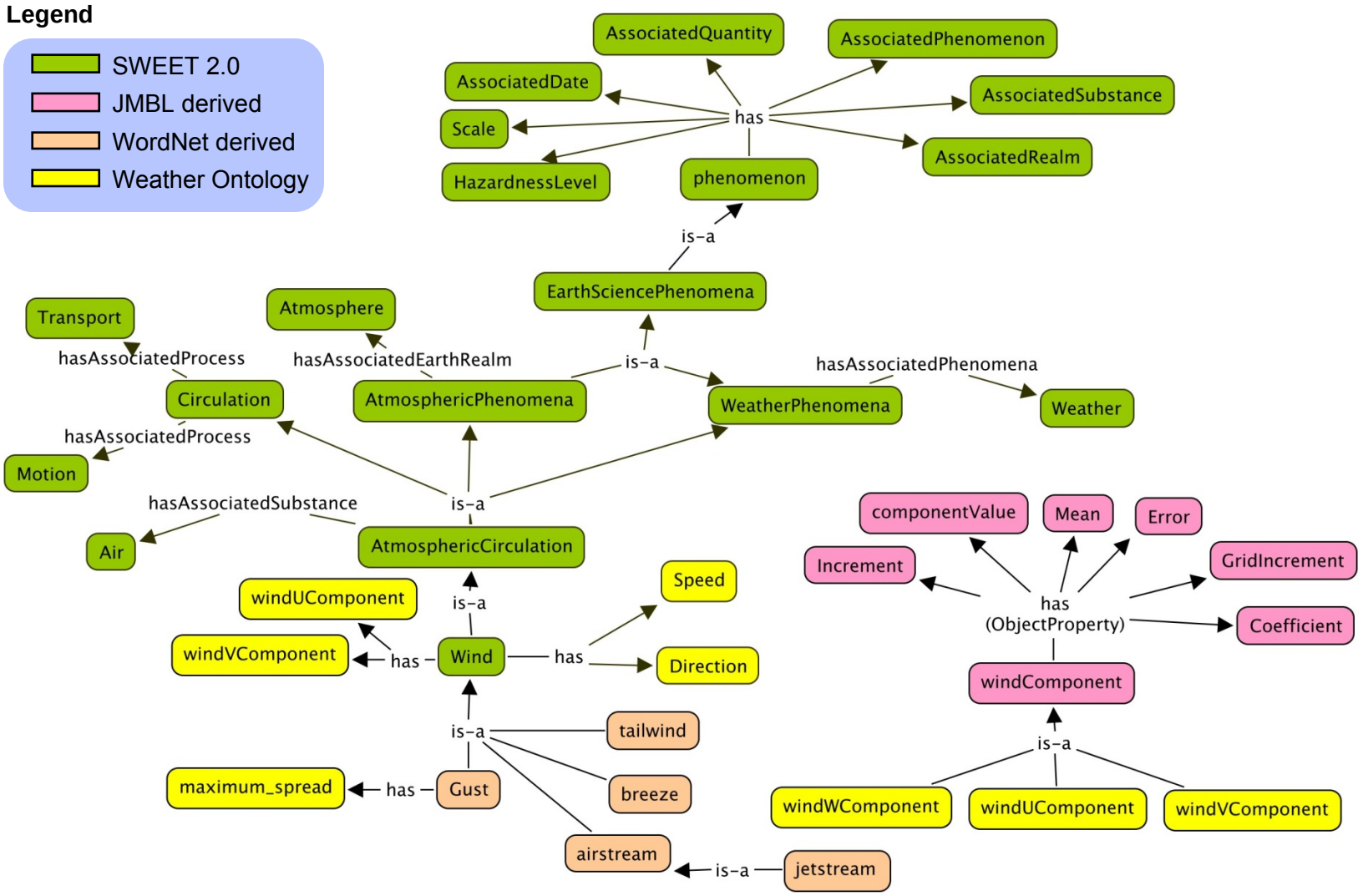
  - **Though some work in this area exists, no single ontology meets the needs of the WXXM community today**

Relevant Ontologies / Vocabularies

- **Wordnet**
  - **Large domain-independent lexical database**
- **Suggested Upper Merged Ontology (SUMO)**
  - **Upper and mid-level ontology containing a WordNet mapping**
- **JPL's Semantic Web for Earth and Environmental Technology (SWEET 2.0)**
  - **Mid-level ontology to enables scalable classification of Earth system science concepts**
- **NetCDF Climate and Forecast Conventions (CF) Standard Names**
  - **Non-hierarchical list of terms that represent quantitative measurements of different weather phenomena**
- **Joint METOC Broker Language (JMBL) Parameter List**
  - **Similar to CF but with the addition of statistical parameters**

Constructing the Weather Ontology for NNEW is the art of combining these efforts in a coherent structure, and extending where necessary.

NNEW Weather Ontology Fragment



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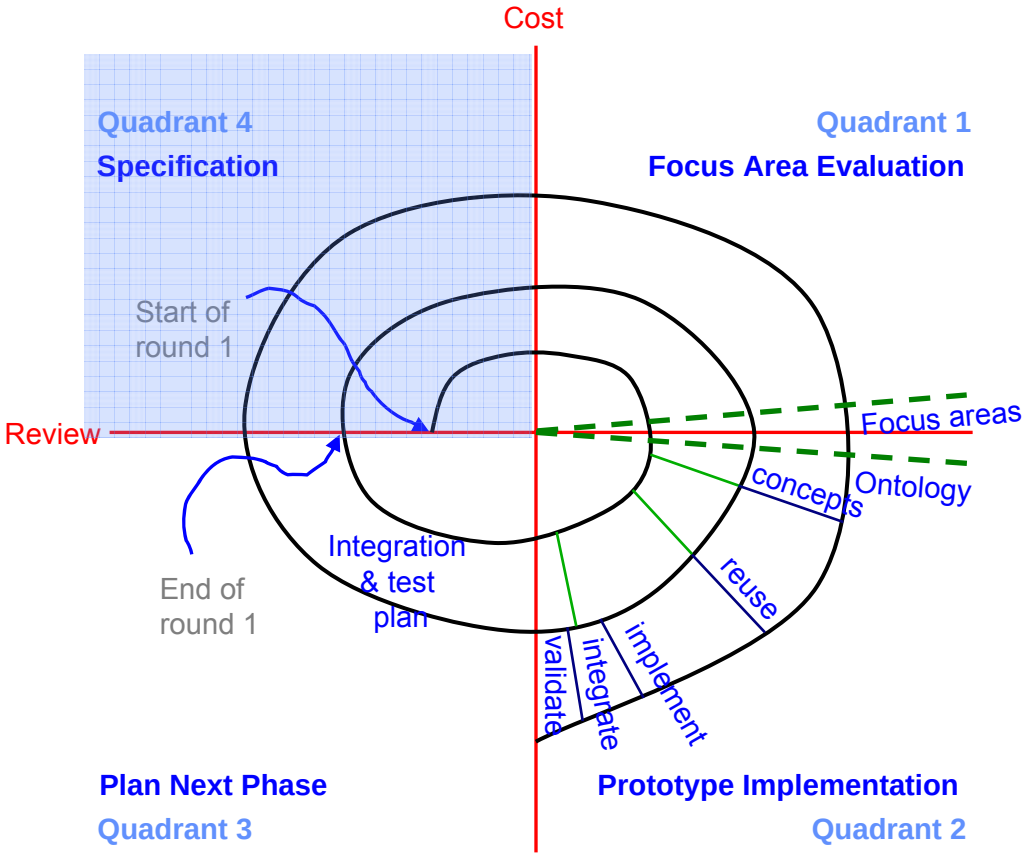
Ontology Development Methods

- **Ontology-level method:**
  - Spiral development methodology
  - **Specification:** Define the domain and scope of the ontology
  - **Focus Area Evaluation:** Segment the overall domain and scope of ontology into smaller focus areas. Prioritize the focus area.



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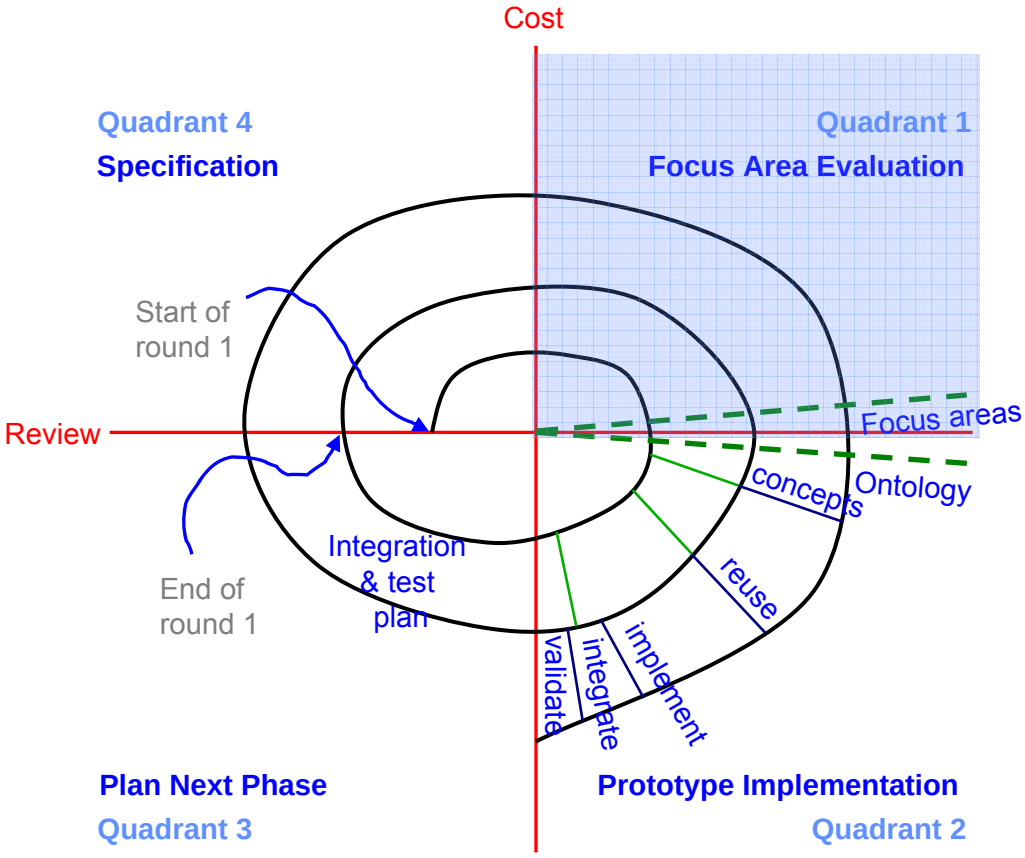
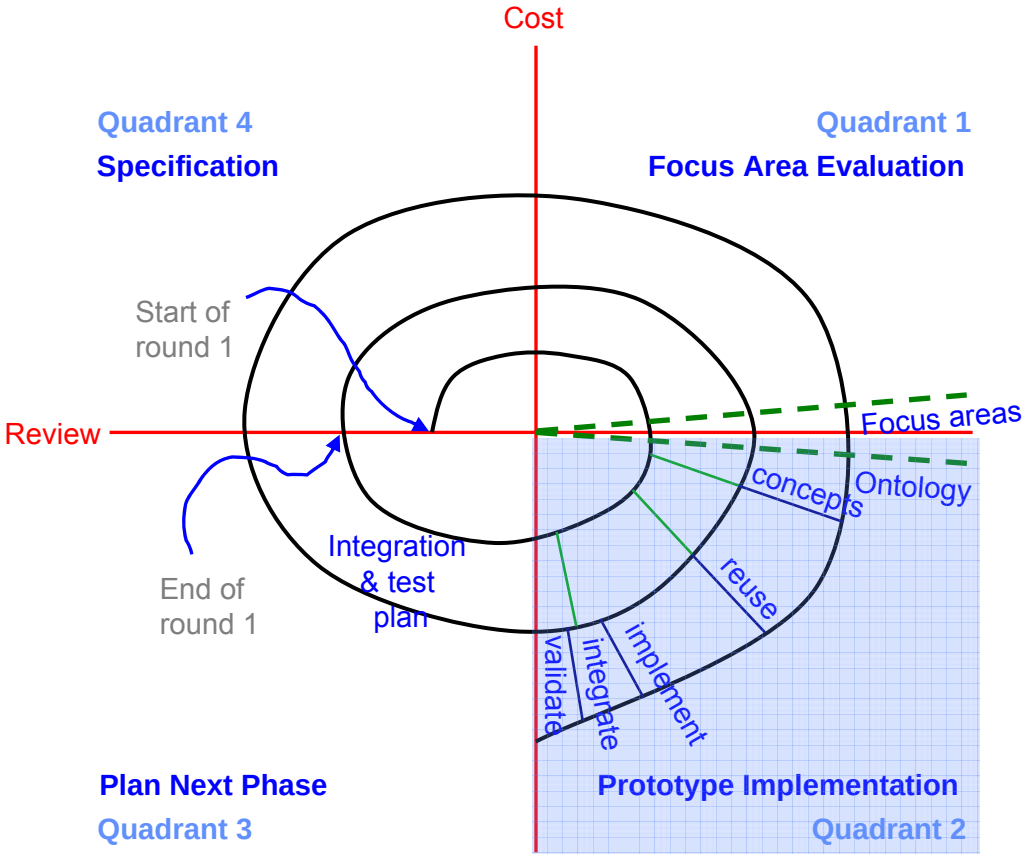


Ontology development methods

- **Prototype implementation:**
  - **Conceptualize**: Enumerate important concepts
  - **Reuse:** Identify reuse opportunities at upper/mid/low ontologies for straight reuse or as starting point
  - **Implement:** Define the classes, class hierarchy, and properties for the concept
  - **Validate:** Validate the ontology focus area



Design Principles

- **Design principles:**
  - **Expressive representation**

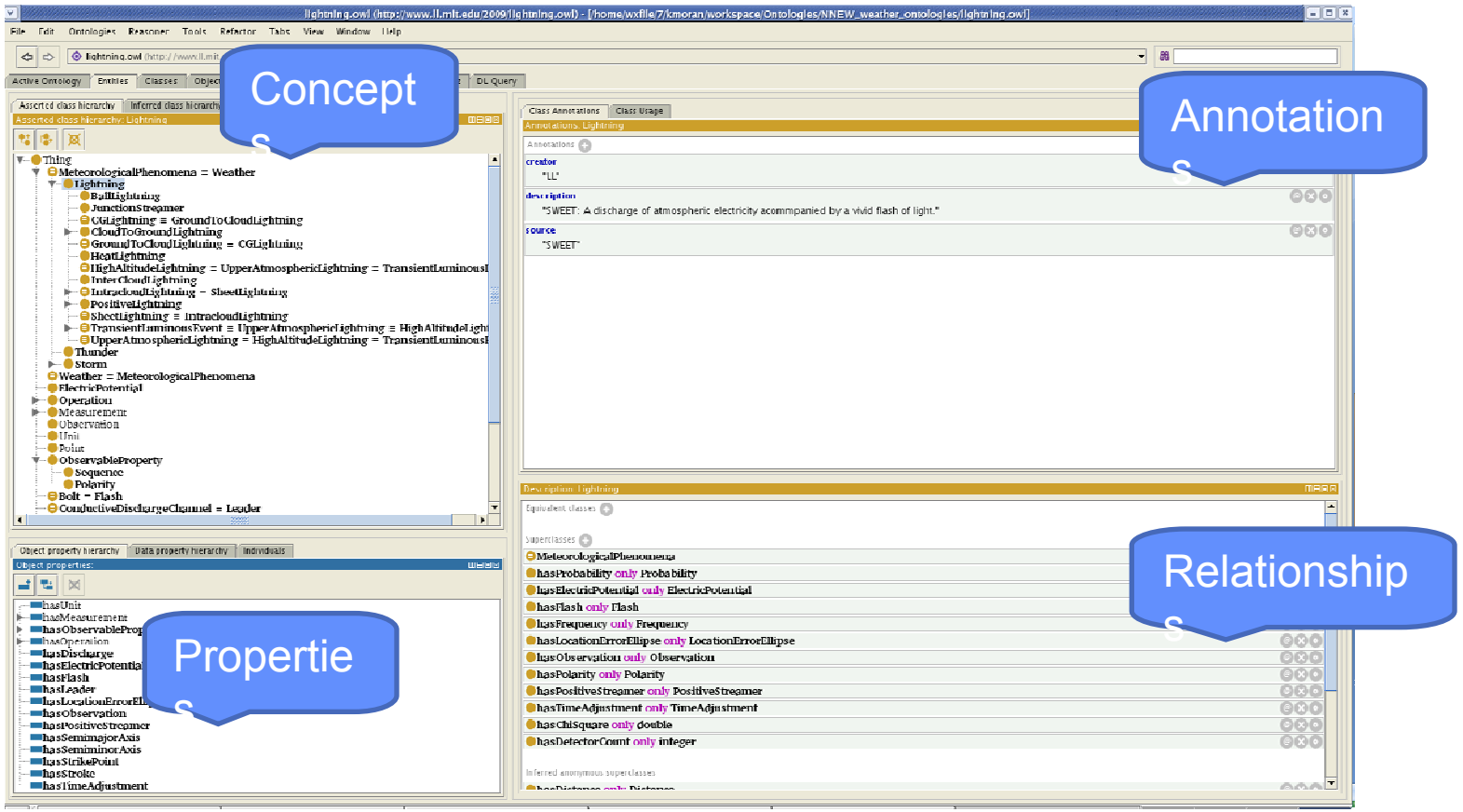
    Model concepts with hierarchies and relationships, not with flat term concatenation
  - **Internal concept reuse**

    Reusing concepts *within* an ontology ensures consistency and reduces ambiguity
  - **Consistent scoping**

    Converge on a common granularity for each sub-domain

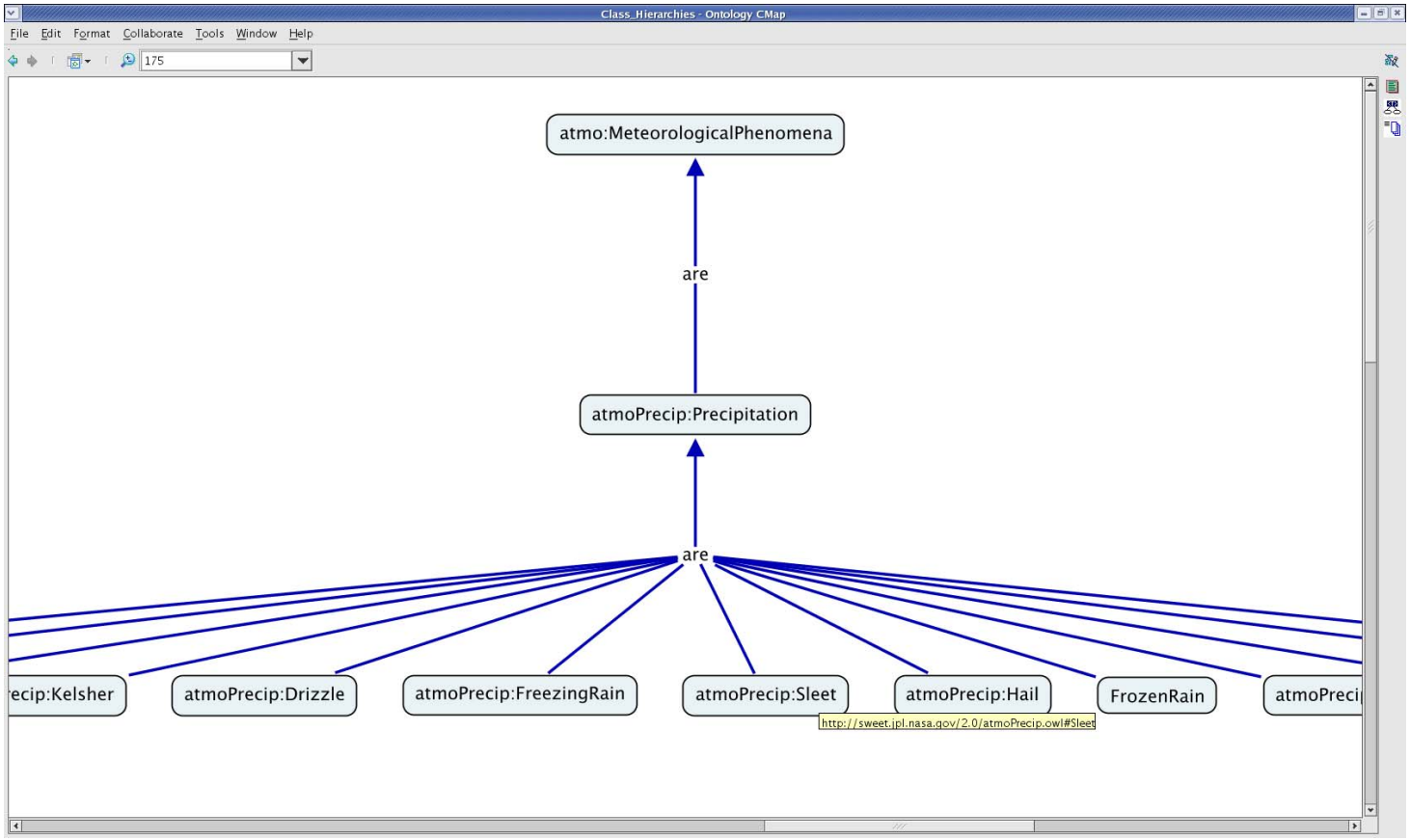
Ontology Development Tools

- **Viewing & editing ontologies**
  - **Protégé: Free, open-source ontology edit from Stanford**

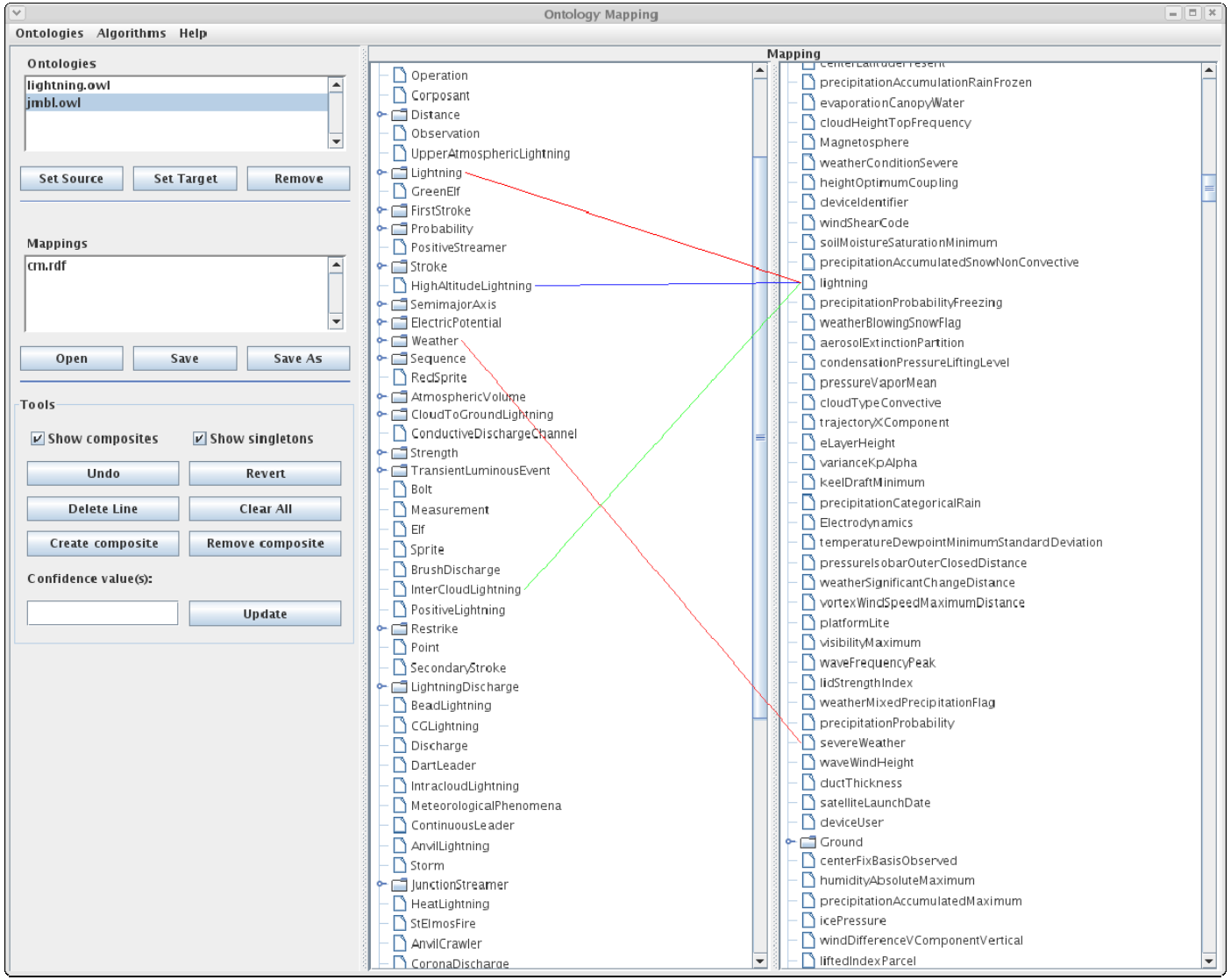


Ontology Development Tools

- **Visualizing ontologies**
  - **CMap Tools COE: Florida Institute for Human & Machine Cognition tool for concept mapping in OWL**



Ontology Development Tools



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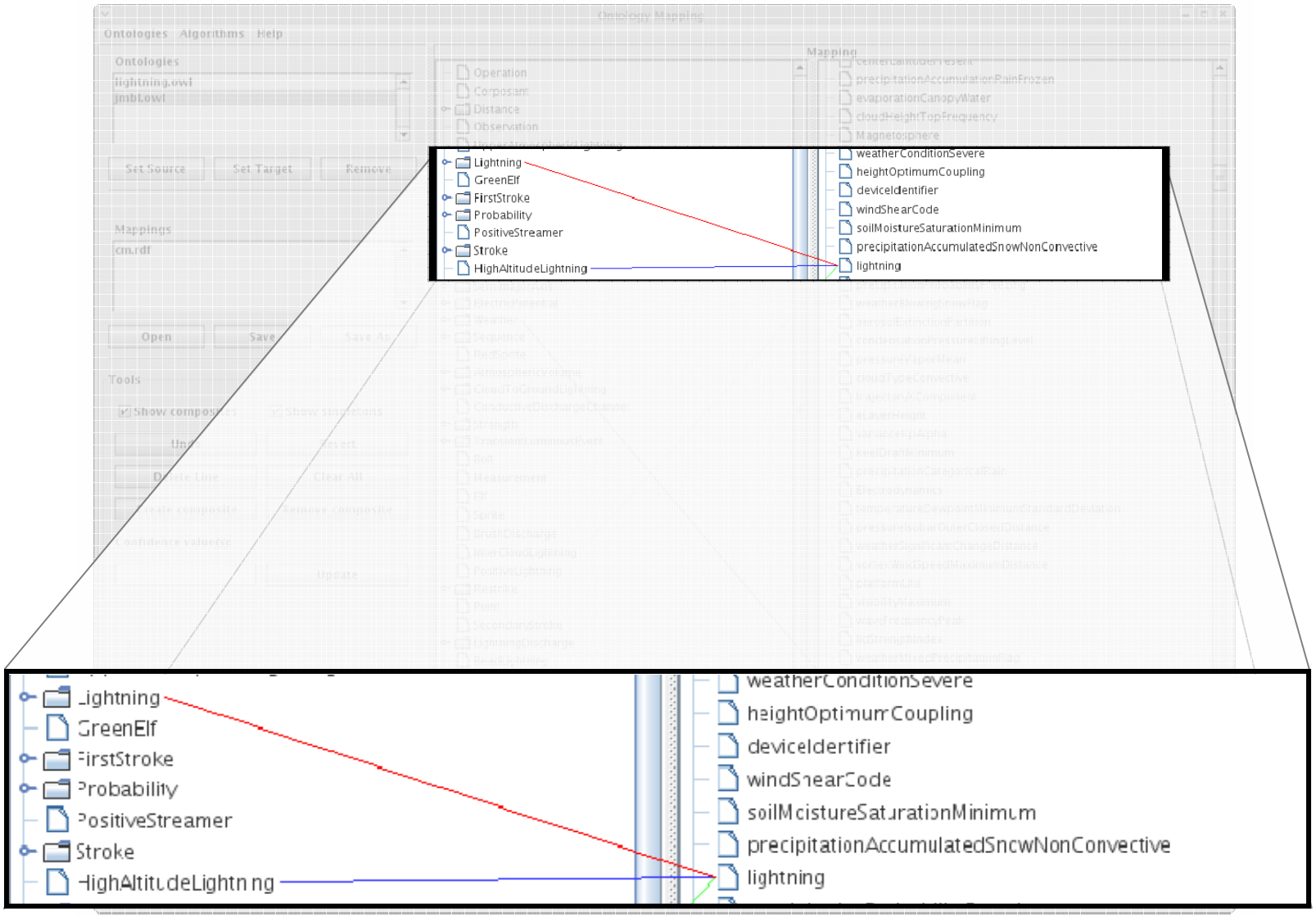

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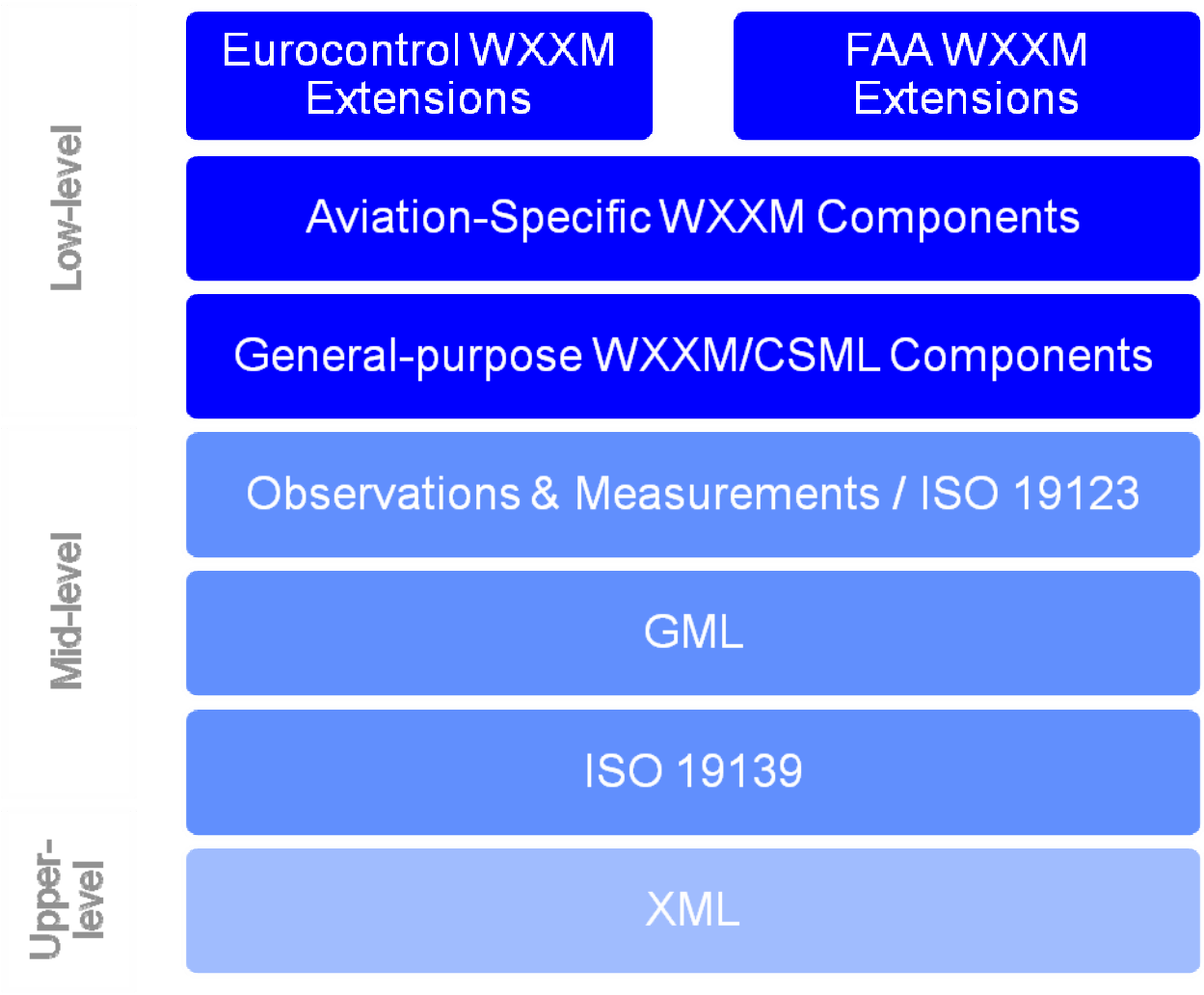
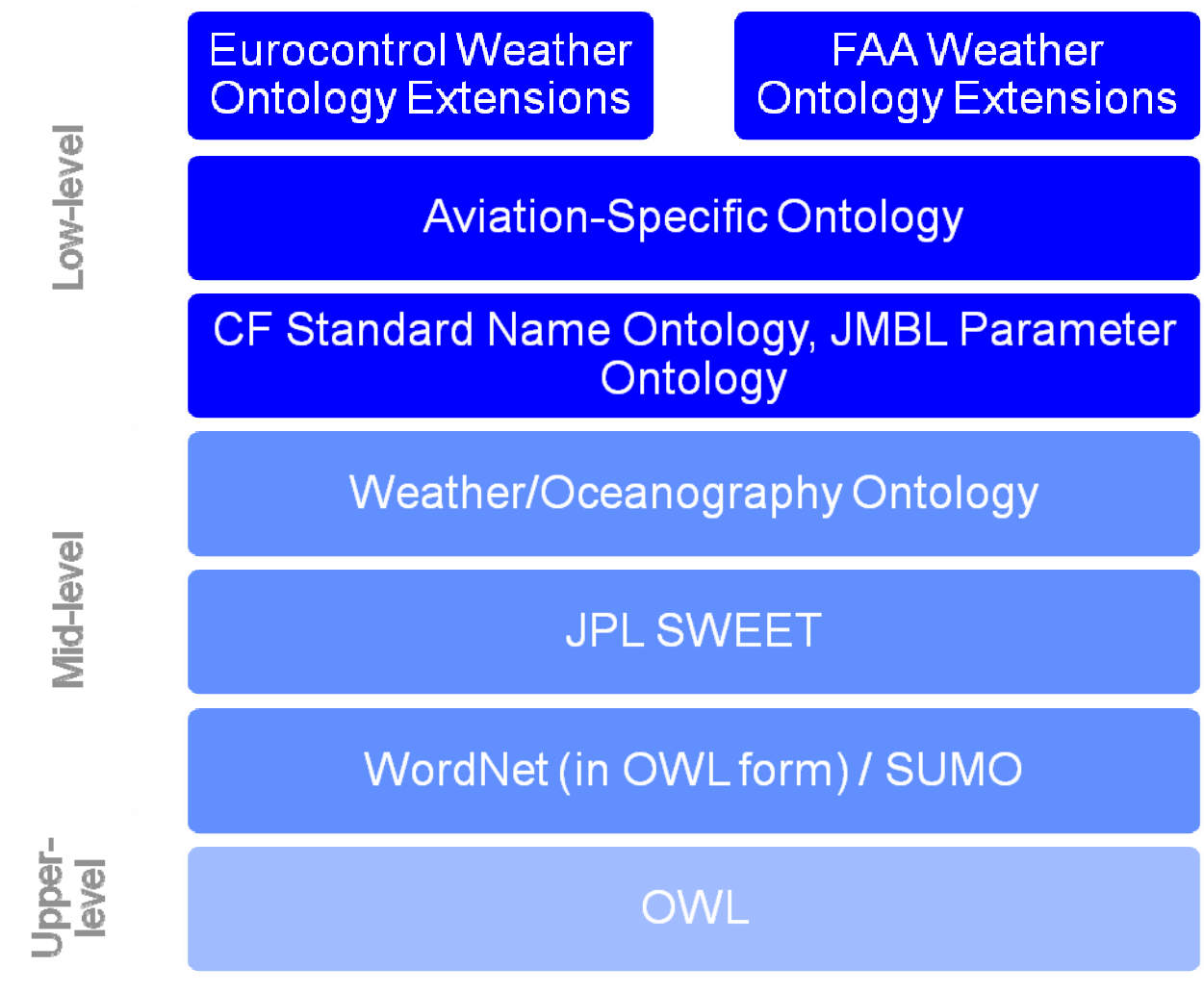
Operational Domain (XML)



Rapidly Changing Information
(Measurements)

Knowledge Domain (OWL)



Relatively Static Information
(Types, Associations, Classifications)

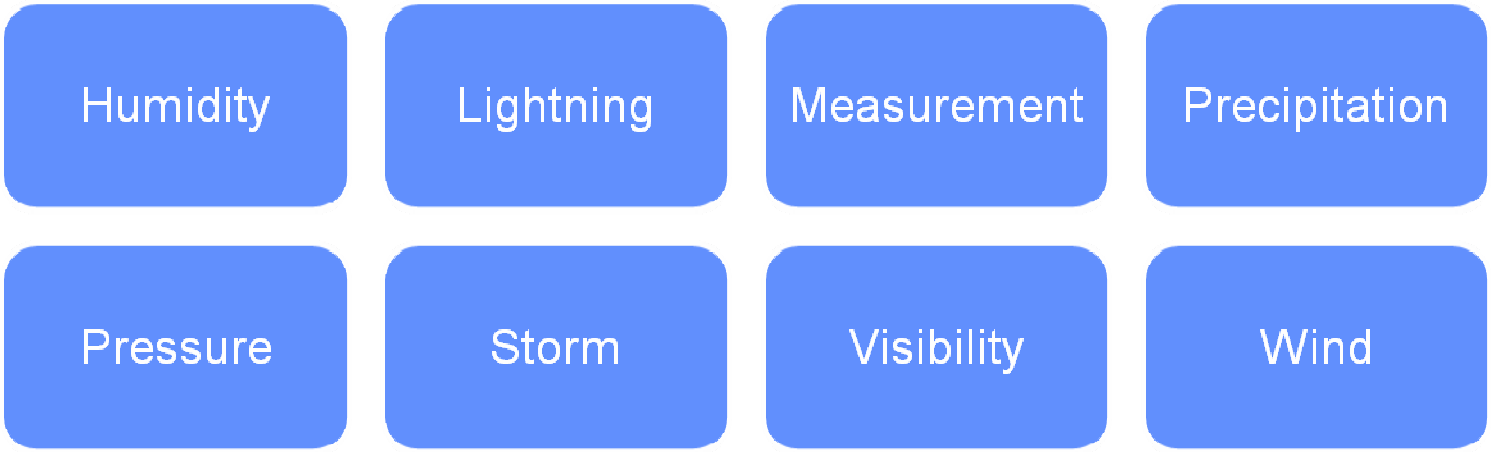
NNEW Weather Ontology Design

Contains low-level, domain-specific concepts, such as different types of measurements that can be recorded for a phenomenon. For example, precipitationAccumulated is included to record the rainfall.

Contains domain-specific concepts, but not necessarily tied to aviation weather. For example, Rain is included as a Weather Phenomena.

Contains general high-level concepts, not necessarily domain-specific. For example, the general notion of a Phenomenon is included here.

NNEW Weather Ontology Statistics



- 8 current focus areas and growing
- 514 unique terms (concepts and properties)
- Weather ontology terms correspond to ≈72 (12%) of CF terms and ≈330 (24%) of JMBL terms

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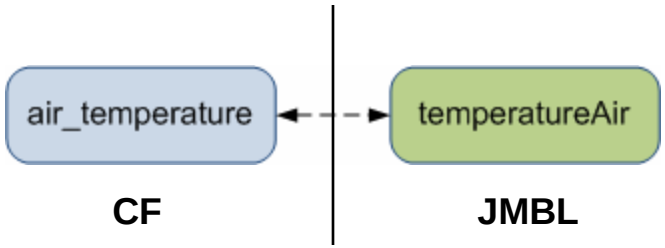
Application: Semantic Search

- Ontologies also enable data integration and semantic searching
- **4-D Wx Data Cube:** Virtual repository that stores distributed weather data
  - Users request data from repository via search
- Producers use different terminology and naming conventions
- Repository must be able to “translate” between terms to return all **semantically similar** data
- **Intelligent discovery**
  - Consults knowledge base/ontology to find alternative meanings
  - Enables discovery of resources without exact keyword match



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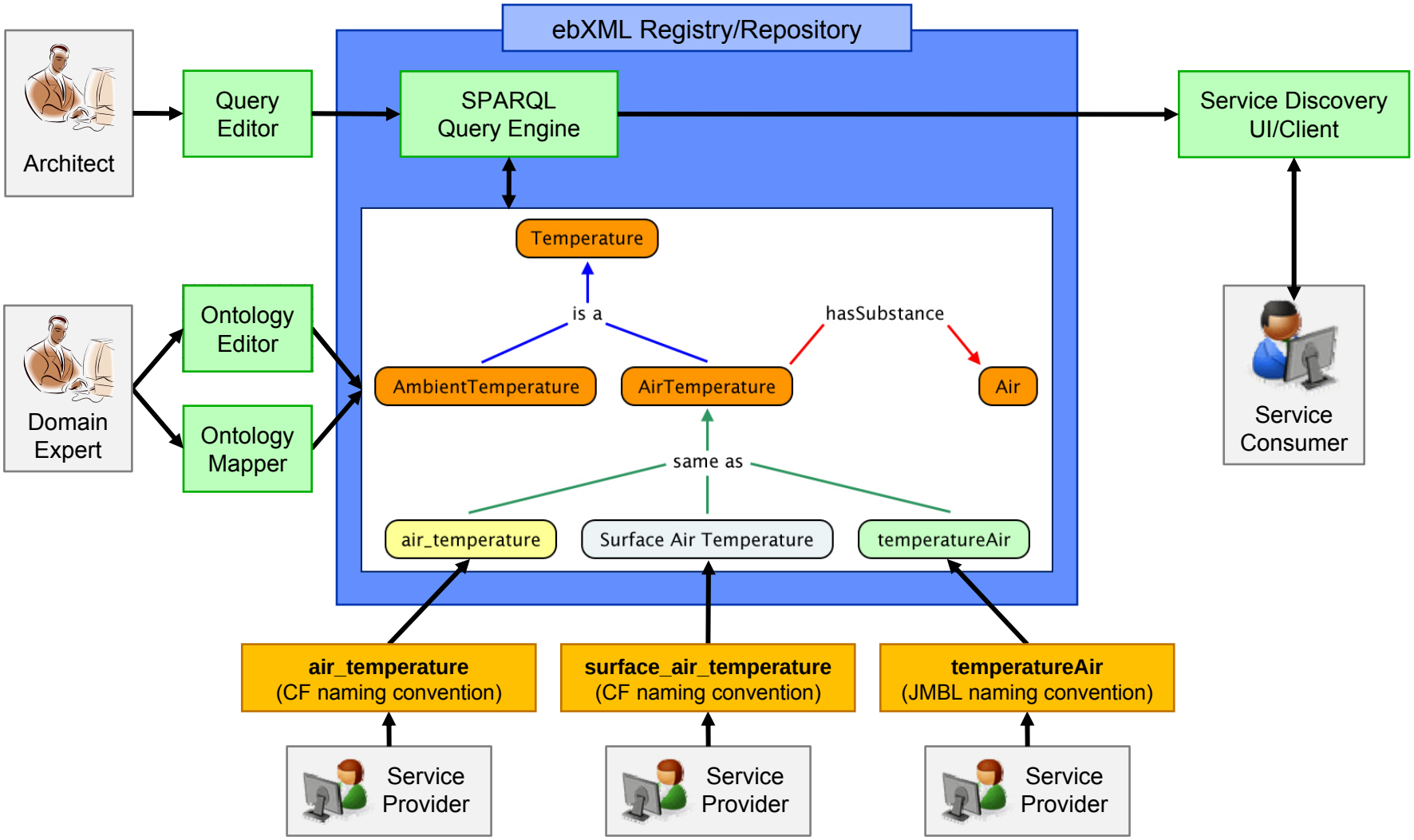

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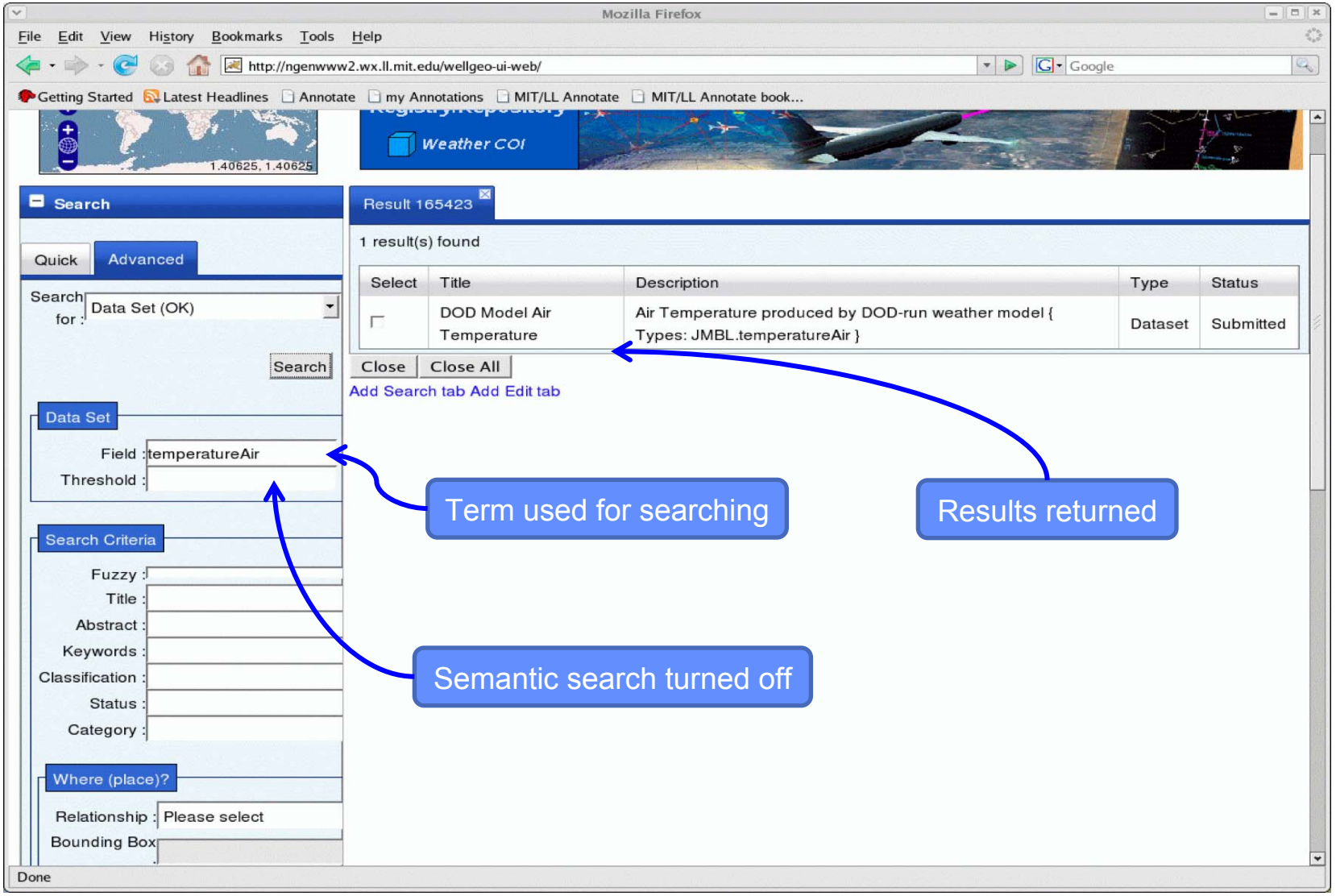

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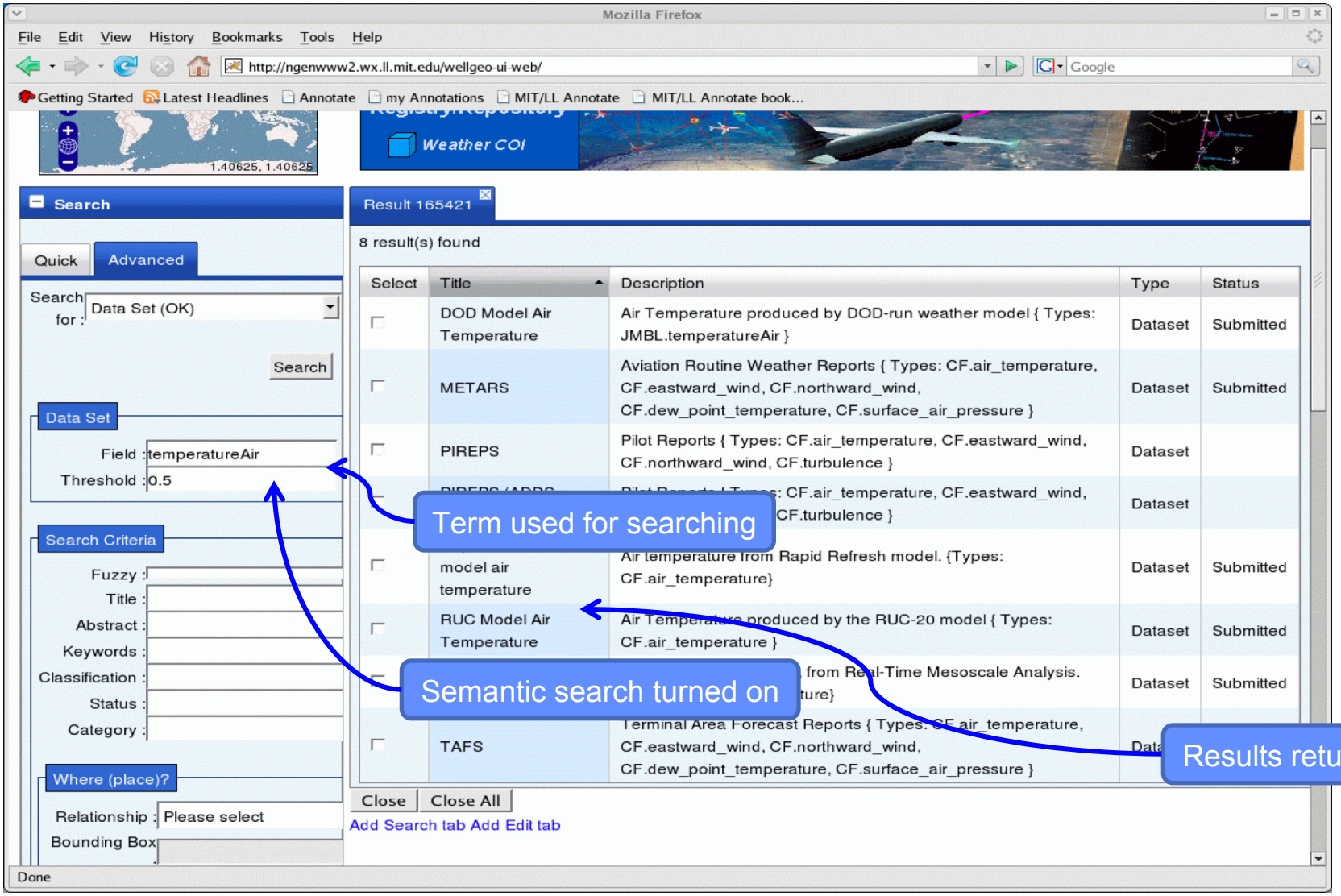

Summary

- Ontologies can be used in conjunction with other data modeling methods to enhance their semantic interoperability
  - WXXM can benefit from the inclusion of ontologies
    - Provide semantics for otherwise context-free data
    - Provide consistent use of terminology
    - Enable reuse of domain knowledge (representation of notions of time, measures, etc)
    - Allow for convergence on distinct and mutually agreed-upon definitions
    - Allow for cross-implementation interoperability
    - Promotes quality information sharing
- Utility of ontology demonstrated in conjunction within ebXML registry/repository OWL profile demonstration
  - Enable information integration for related applications

Resources

- **Protégé: http://protege.stanford.edu**
- **NNEW Ontology wiki page: https://wiki.ucar.edu/display/NNEWD/Data+Models+and+Formats**

- **Kelly Moran: kmoran@ll.mit.edu**
- **Kajal Claypool: claypool@ll.mit.edu**

References

- N. F. Noy and D. L. McGuinness, "Ontology development 101: A guide to creating your first ontology," Online, 2001. [Online]. Available: http://www.ksl.stanford.edu/people/dlm/papers/ontology101/ontology101-noy-mcguinness.html