The Virtual Solar-Terrestrial Observatory: A Deployed Semantic Web Application Case Study for Scientific Research

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Goals

AI Goal: AI in service of supporting the next generation of science – interdisciplinary, distributed eScience

Science Goal: Scientists should be able to access a global, distributed knowledge base of scientific data that:

- appears to be integrated
- appears to be locally available

But… data is obtained by multiple instruments, using various protocols, in differing vocabularies, using (sometimes unstated) assumptions, with inconsistent (or non-existent) meta-data. It may be inconsistent, incomplete, evolving, and distributed

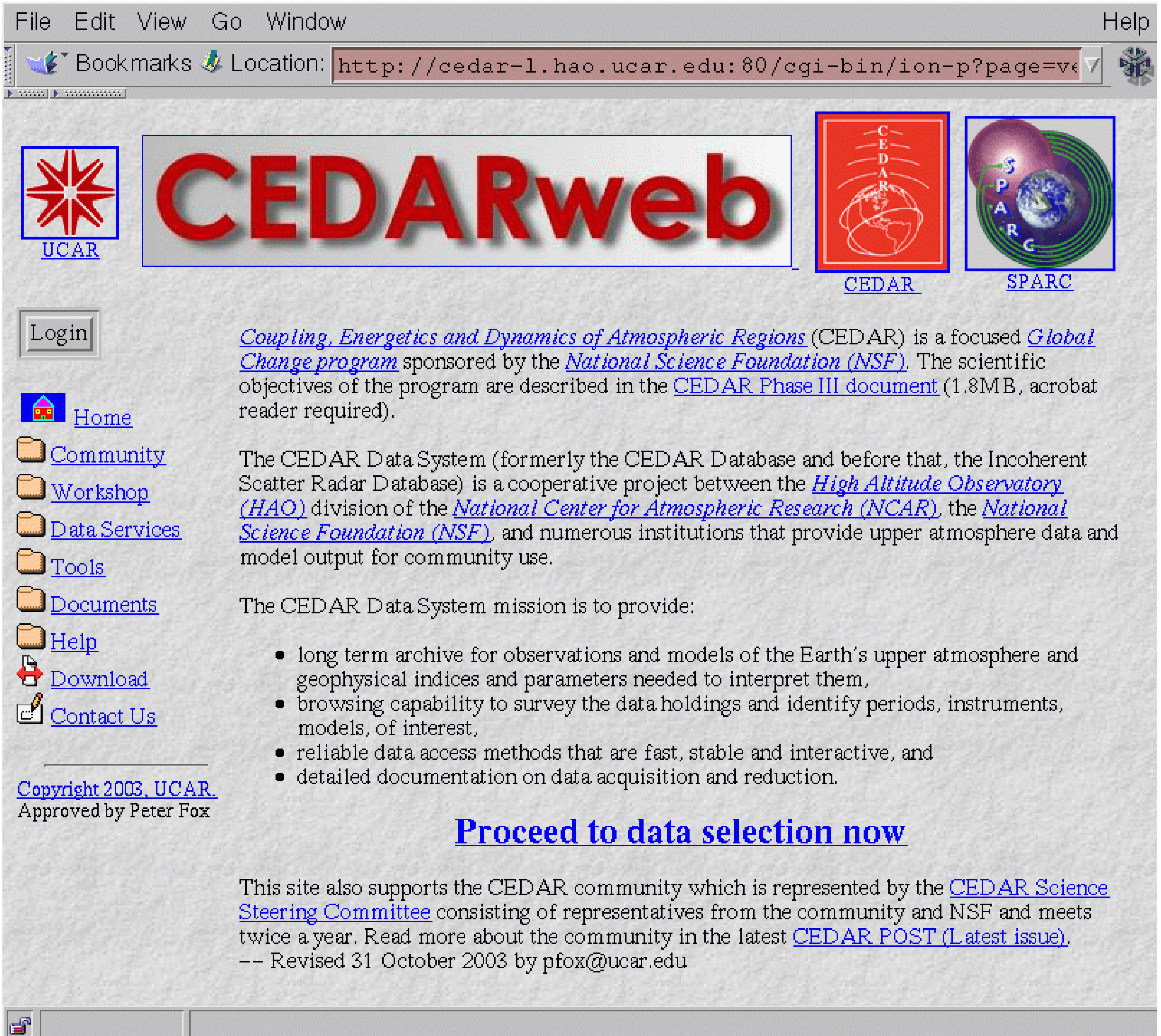
Virtual Observatory

- Workshop: A Virtual Observatory (VO) is a suite of software applications on a set of computers that allows users to uniformly find, access, and use resources (data, software, document, and image products and services using these) from a collection of distributed product repositories and service providers. A VO is a service that unites services and/or multiple repositories.
  lwsde.gsfc.nasa.gov/**VO**_Framework_7_Jan_05.doc
- VxOs - x is one discipline

Virtual Solar Terrestrial Observatory (VSTO – vsto.org)

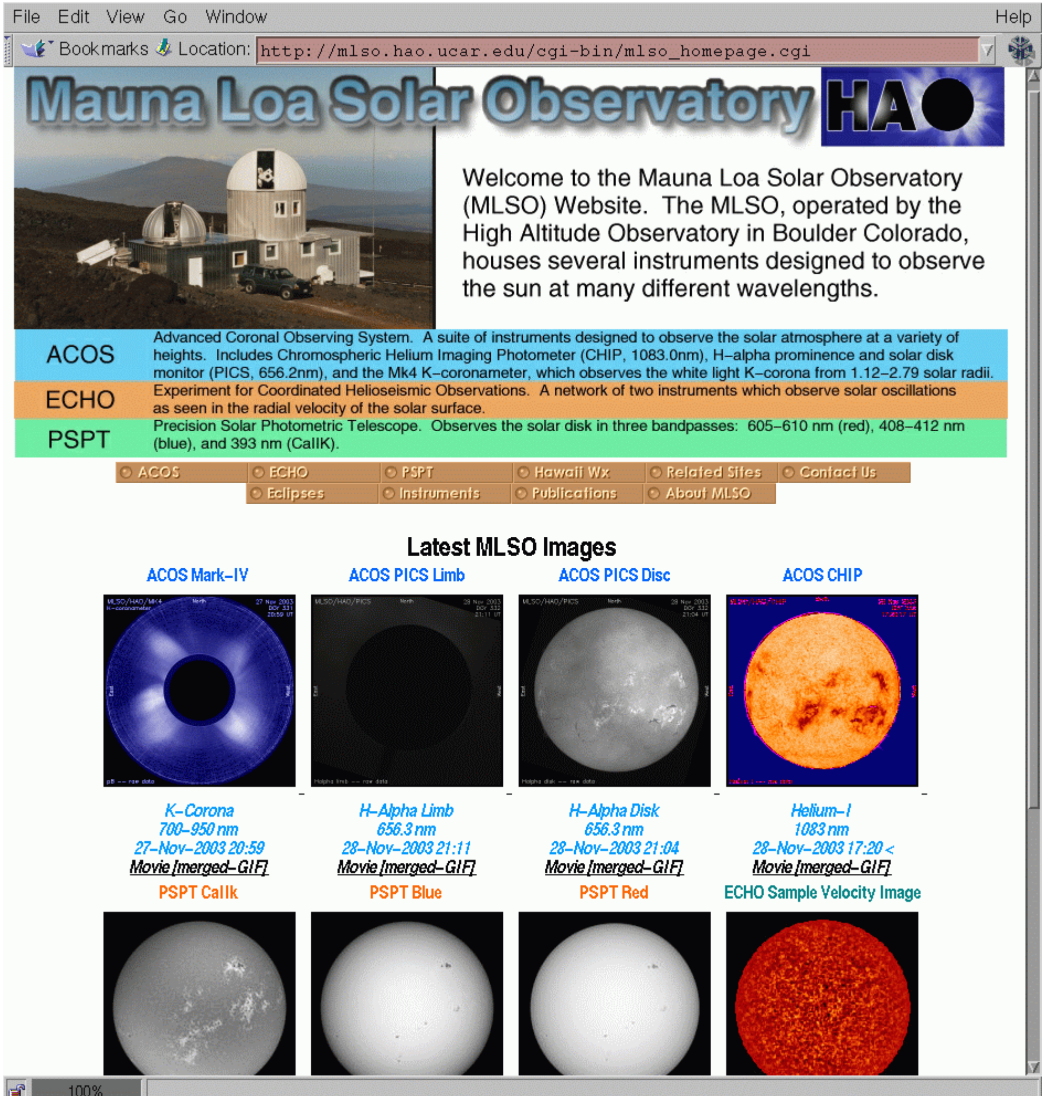
- A distributed, scalable education and research environment for searching, integrating, and analyzing observational, experimental, and model databases.
- Subject matter covers the fields of solar, solar-terrestrial and space physics
- Provides virtual access to specific data, model, tool and material archives containing items from a variety of space- and ground-based instruments and experiments, as well as individual and community modeling and software efforts bridging research and educational use
- 3 year NSF-funded project; initial deployment in year 1, multiple deployments by year 2; now in year 3 with outreach
- While aimed at one interdisciplinary area, it also serves as a replicable prototype for interdisciplinary virtual observatories

Content: Coupling Energetics and Dynamics of Atmospheric Regions WEB



Community data archive for observations and models of Earth's upper atmosphere and geophysical indices and parameters needed to interpret them. Includes browsing capabilities by periods, instruments, models, …

Content: Mauna Loa Solar Observatory



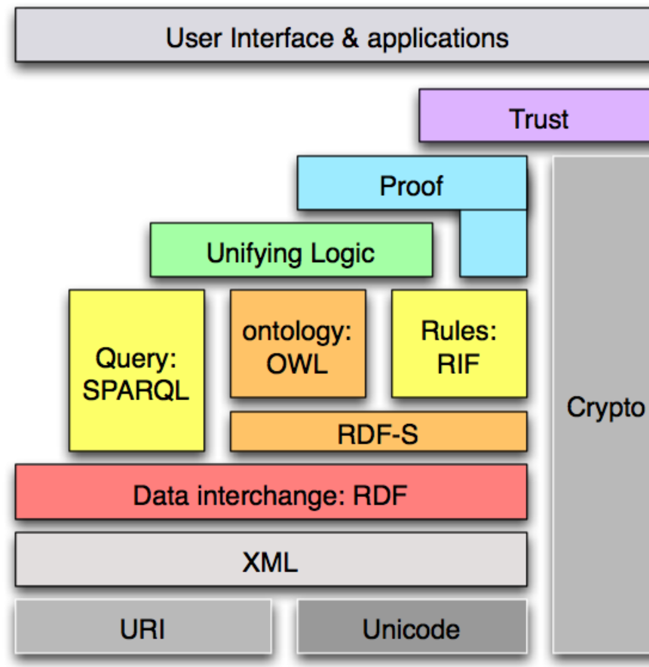
McGuinness, Fox , et al July 24, 2007

Near real-time data from Hawaii from a variety of solar instruments.

Source for space weather, solar variability, and basic solar physics

Other content used too – CISM – *C*enter for *I*ntegrated *S*pace Weather *M*odeling

Semantic Web as a Technical Approach: Basic elements



- Use case(s)
- Team – carefully chosen interdisciplinary with mixed skills
- Perform analysis
- Develop model/ontology
- Use tools
- Adopt technical approach and architecture
- Leverage existing infrastructure; API, portal and web services
- Open World: evolve, iterate, redesign, redeploy

Science Use Case

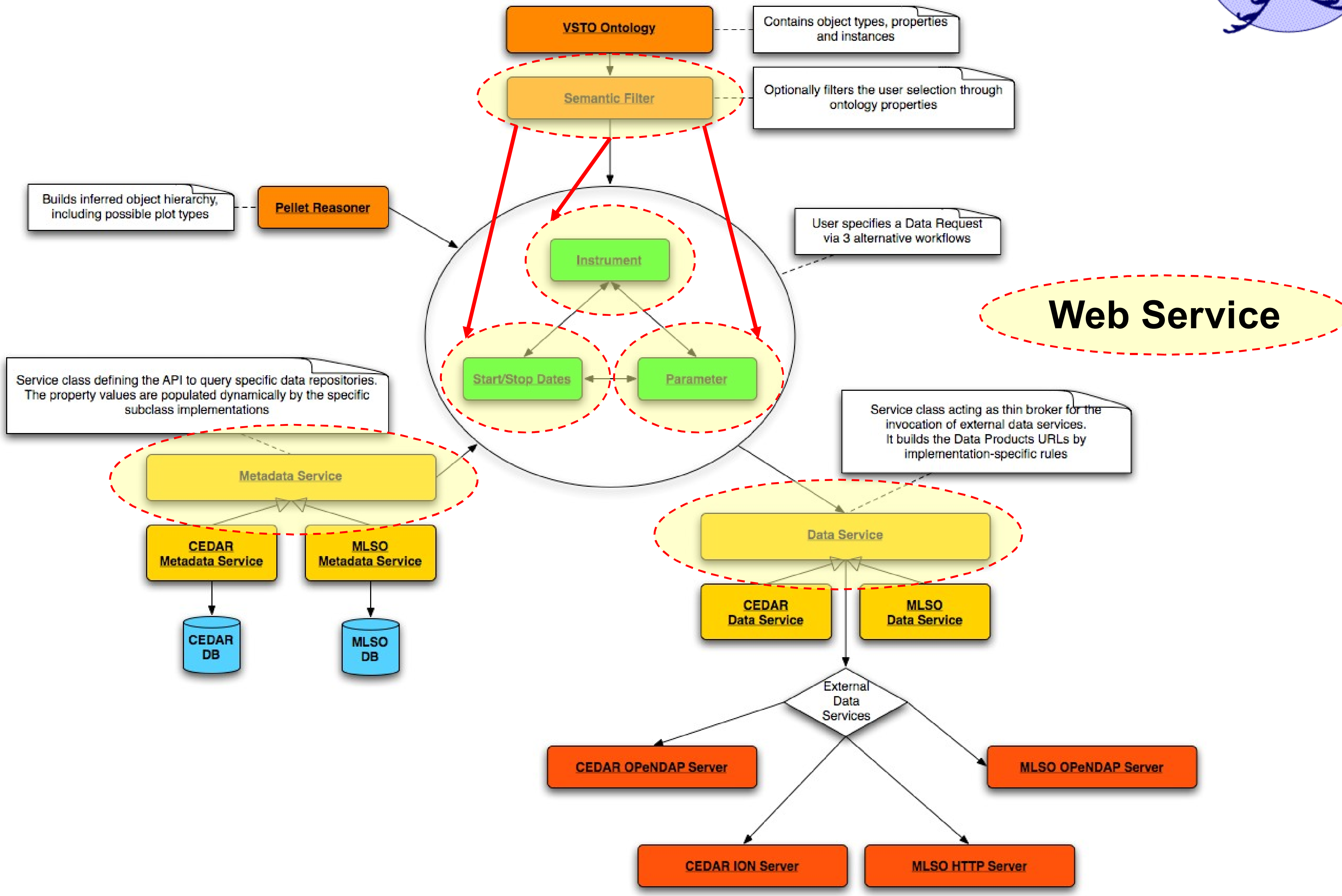
General: Find data subject to particular constraints and present it in a manner that makes sense for the context.

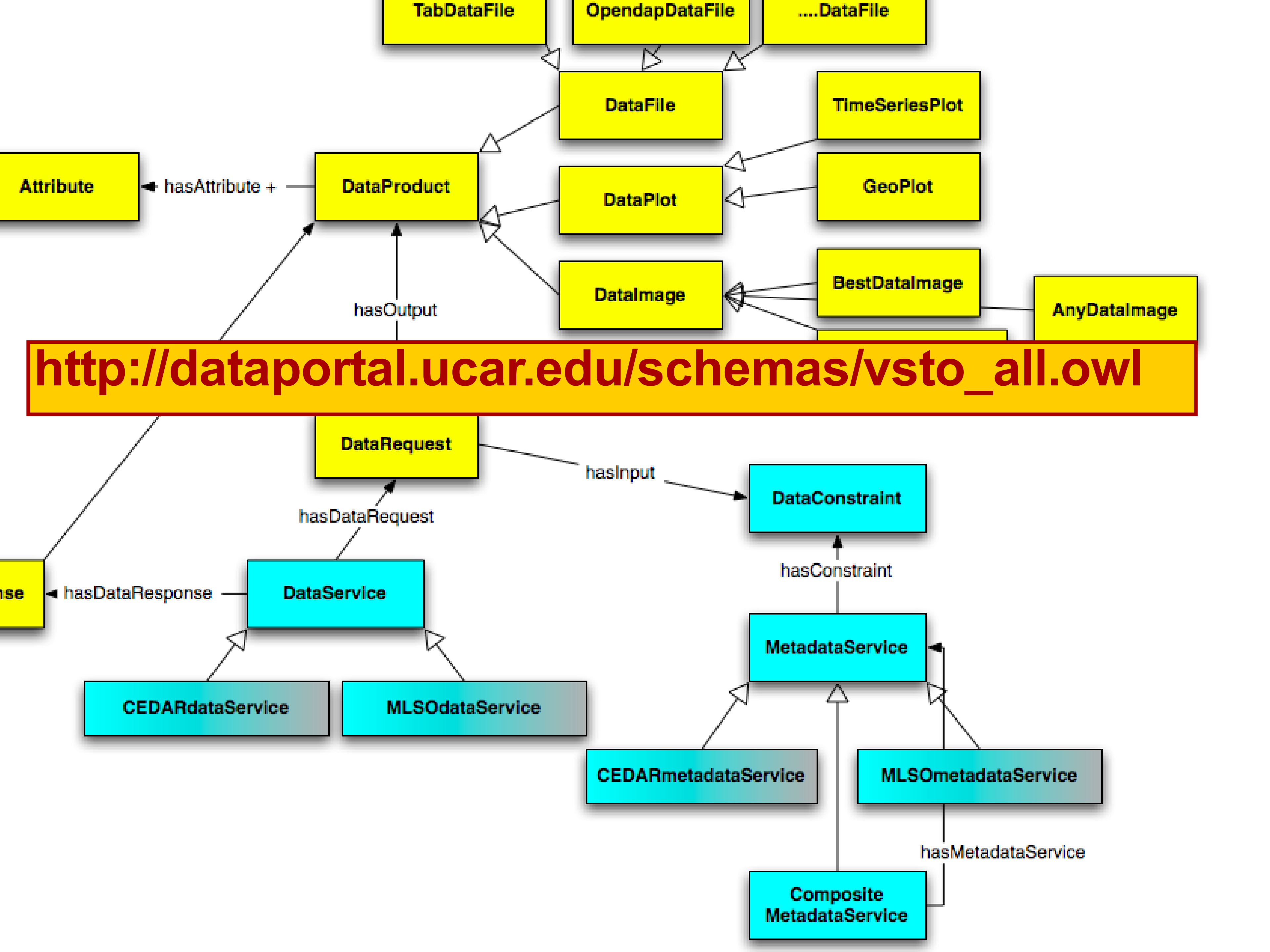
Specific (a): Find data representing the Neutral Temperature (Parameter) taken by the Millstone Hill Fabry-Perot interferometer (Instrument) looking in the vertical direction from January 2000 and plot as a time series.

Specific (b): Find data which represents the state of the neutral atmosphere anywhere above 100km and toward the arctic circle (above 45N) at any time of high geomagnetic activity and plot appropriately.

- Extract information from the use-case - encode knowledge
- Translate this into a complete query for data - inference and integration of data from instruments, indices and models

VSTO – semantics and ontologies operational environment





http://dataportal.ucar.edu/schemas/vsto_all.owl

Instrument Class Excerpt

- Radar
    - Incoherent Scatter
    - Coherent Scatter
        - Ionospheric Doppler(sameas HF)
        - MST
        - MF
        - LF
        - Meteor Wind
- Sounders
- Optical (hasBand, measuresTo, etc.)
    - Interferometer
        - Fabry-Perot
        - Michelson
            - IR
            - Doppler
    - Imagers
        - AirGlow
        - All-Sky Cameras
    - Lidar
    - Polarimeter
    - Spectrometer
        - Polarimeter
        - Heliograph
        - IR ([OH]) Spectrophotometer
    - Photometer
        - Single-Channel
        - Multi-Channel
    - Spectrophotometer

Approach:
- identify instruments & parameters
- organize hierarchically
- compare/extend SWEET (realms, properties, space, …)
- scientific expert review
- ontology expert review
- related scientific review
- populate instances (including meta-data)
- use-case driven

- Main focus areas – instrument (with associated parameters and operating modes), observatory, data product connections, etc.

VSTO Home

NCAR

Home | Data | Communities | About Us | Login

www.vsto.org

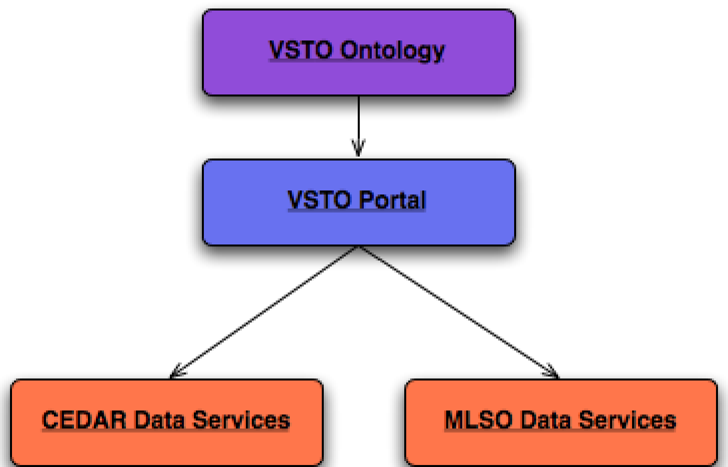
Welcome to the Virtual Solar Terrestrial Observatory

The Virtual Solar Terrestrial Observatory (VSTO) is a unified semantic environment serving data from diverse data archives in the fields of solar, solar-terrestrial, and space physics (SSTSP), currently:

- Upper atmosphere data from the **CEDAR** (Coupling, Energetics and Dynamics of Atmospheric Regions) archive
- Solar corona data from the **MLSO** (Mauna Loa Solar Observatory) archive

The VSTO portal uses an underlying ontology (i.e. an organized knowledge base of the SSTSP domain) to present a general interface that allows selection and retrieval of products (ascii and binary data files, images, plots) from heterogenous external data services.

VSTO Data Access

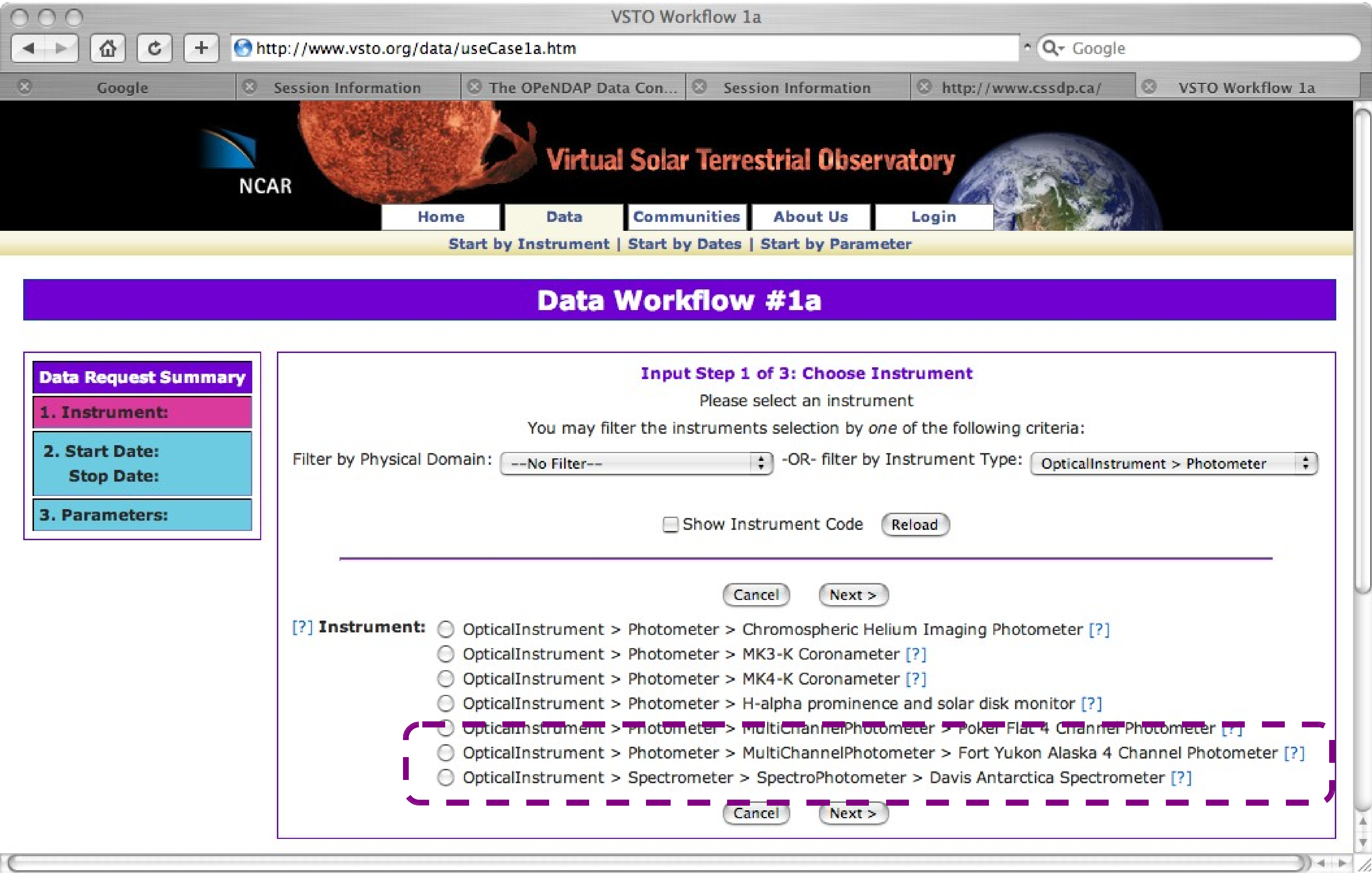


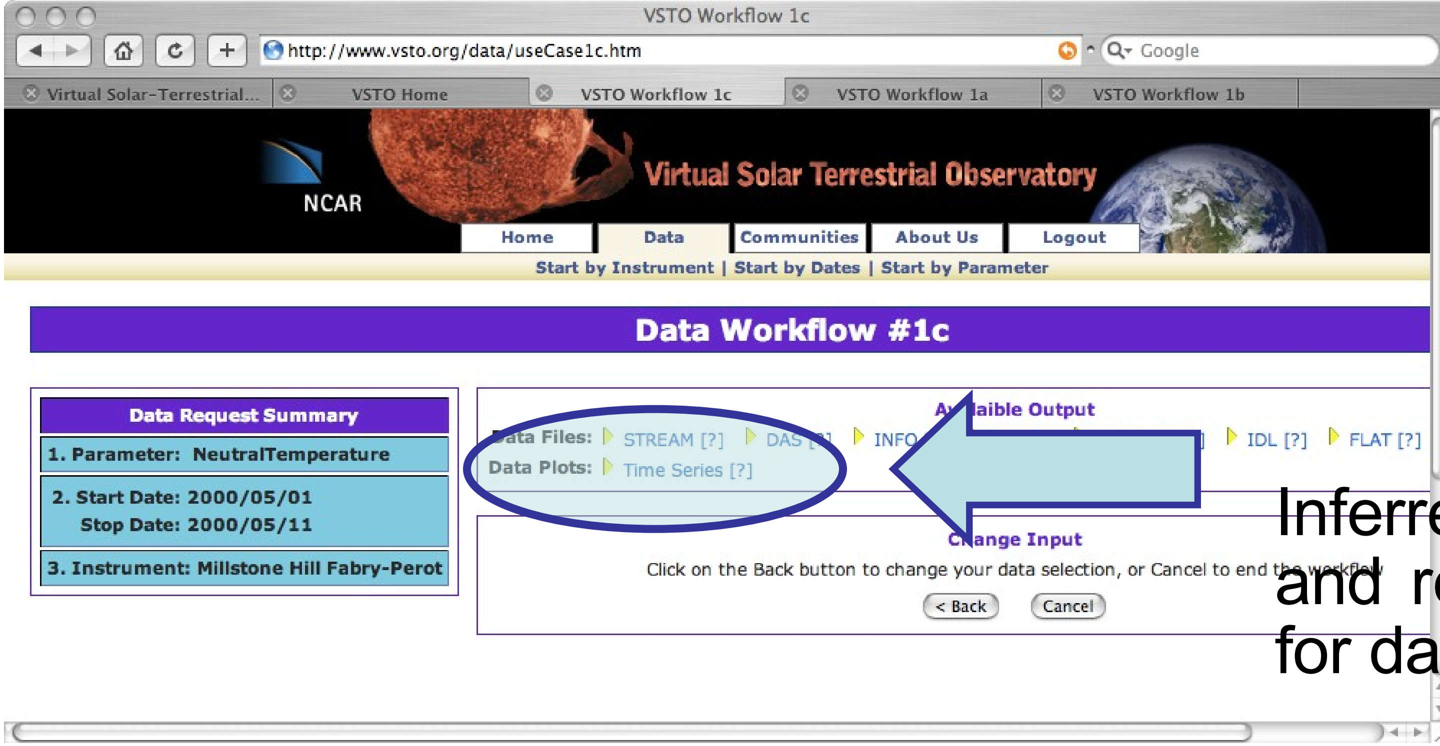
Acknowledgments

VSTO is a collaboration of the ESSL/HAO (High Altitude Observatory) and CISL/SCD (Scientific Computing Division) divisions at NCAR with McGuinness Associates, funded by the National Science Foundation.

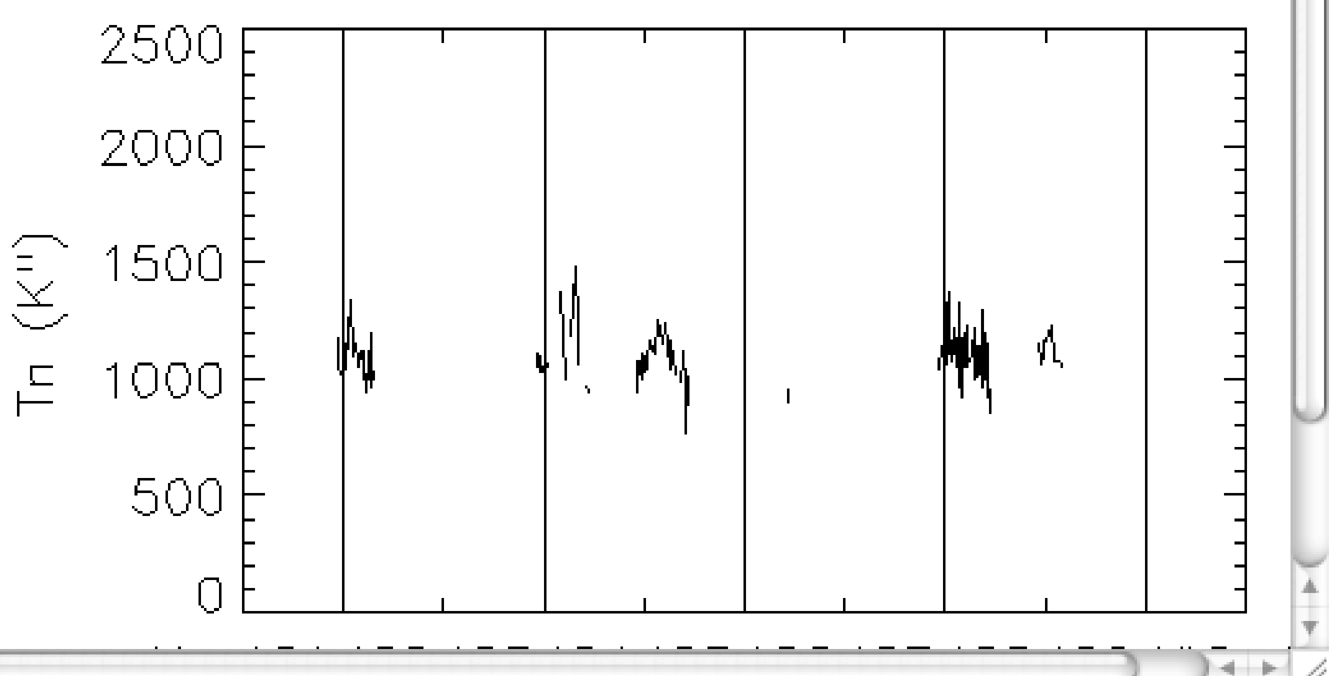
This study made use of the CEDAR Database at the National Center for Atmospheric Research which is supported by the National Science Foundation.

This study made use of data from the Mauna Loa Solar Observatory operated by the High Altitude Observatory at the National Center for Atmospheric Research which is supported by the National Science Foundation.

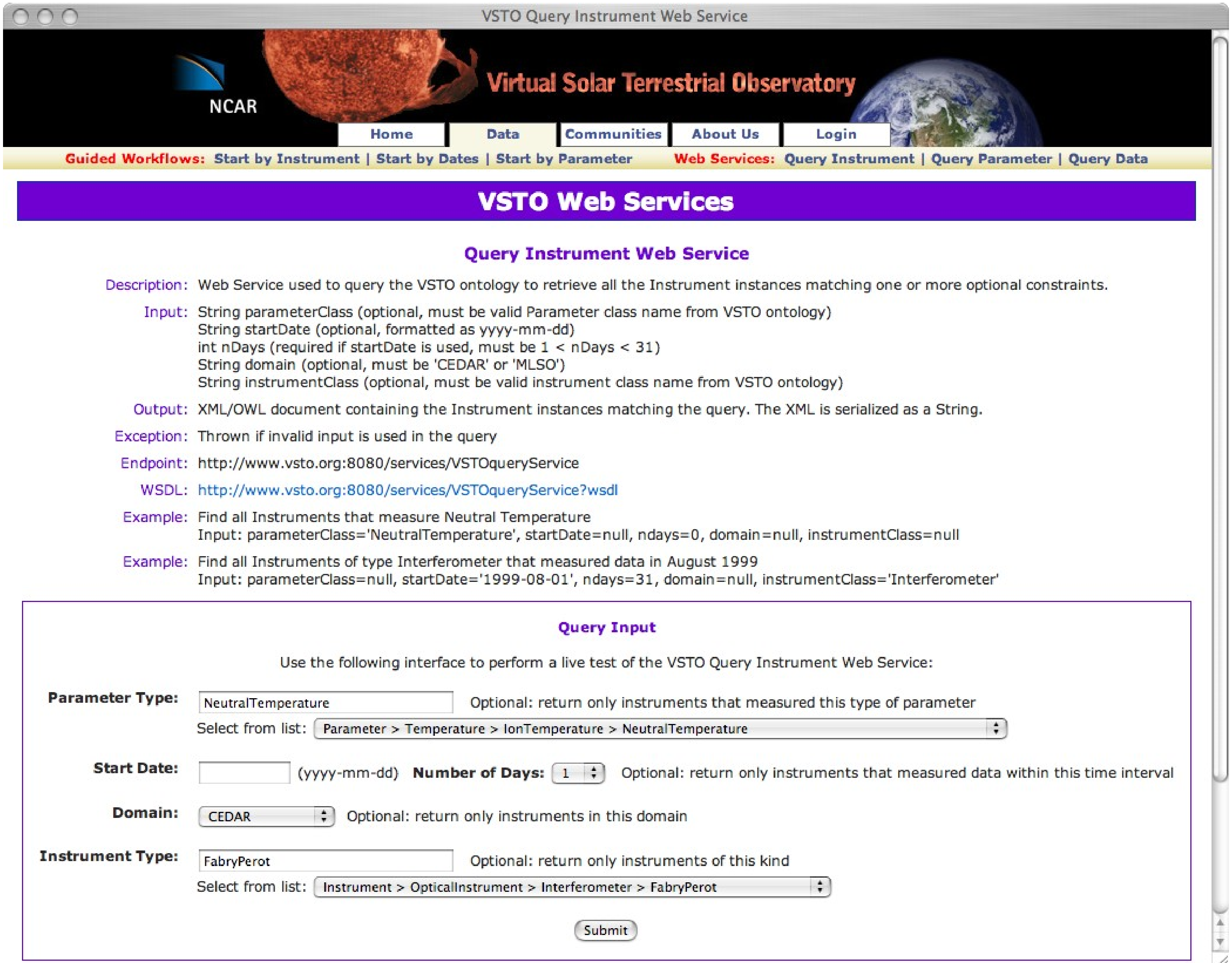

VSTO Workflow 1a
http://www.vsto.org/data/useCase1a.htm
Google
Session Information
The OPeNDAP Data Con...
Session Information
http://www.cssdp.ca/
VSTO Workflow 1a
NCAR
Virtual Solar Terrestrial Observatory
Home
Data
Communities
About Us
Login
Start by Instrument | Start by Dates | Start by Parameter
Data Workflow #1a
Data Request Summary
1. Instrument:
2. Start Date:
Stop Date:
3. Parameters:
Input Step 1 of 3: Choose Instrument
Please select an instrument
You may filter the instruments selection by one of the following criteria:
Filter by Physical Domain: --No Filter--
-OR- filter by Instrument Type: OpticalInstrument > Photometer
Show Instrument Code
Reload
Cancel
Next >
[?] Instrument:
OpticalInstrument > Photometer > Chromospheric Helium Imaging Photometer [?]
OpticalInstrument > Photometer > MK3-K Coronameter [?]
OpticalInstrument > Photometer > MK4-K Coronameter [?]
OpticalInstrument > Photometer > H-alpha prominence and solar disk monitor [?]
OpticalInstrument > Photometer > MultiChannelPhotometer > Poker Flat 4 Channel Photometer [?]
OpticalInstrument > Photometer > MultiChannelPhotometer > Fort Yukon Alaska 4 Channel Photometer [?]
OpticalInstrument > Spectrometer > SpectroPhotometer > Davis Antarctica Spectrometer [?]
Cancel
Next >



Inferred plot type and return formats for data products



Semantic Web Services



Semantic Web Services

VSTO Query Instrument Web Service

http://www.vsto.org:8080/data/queryInstrument.htm

Google

Query Output

Number of results returned: 13


```
<?xml version="1.0" encoding="UTF-8"?>
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#" xmlns="http://dataportal.ucar.edu/schemas/vsto_all.owl#"
        xmlns:vsto="http://dataportal.ucar.edu/schemas/vsto.owl"
        xmlns:cedar="http://dataportal.ucar.edu/schemas/cedar.owl#"
        xmlns:mlso="http://dataportal.ucar.edu/schemas/mlso.owl#"
        xmlns:owl="http://www.w3.org/2002/07/owl#" xml:base="http://dataportal.ucar.edu/schemas/vsto_all.owl">
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    <vsto:hasDescription>South Pole Fabry-Perot Interfer Spectr</vsto:hasDescription>
    <vsto:hasName>SPF</vsto:hasName>
    <vsto:hasIdentifier>5000</vsto:hasIdentifier>
  </vsto:FabryPerot>
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    <vsto:hasName>AHF</vsto:hasName>
    <vsto:hasIdentifier>5015</vsto:hasIdentifier>
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    <vsto:hasName>MJF</vsto:hasName>
    <vsto:hasIdentifier>5060</vsto:hasIdentifier>
  </vsto:FabryPerot>
  <vsto:FabryPerot rdf:ID="cedar_instrument_5140">
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    <vsto:hasName>AQF</vsto:hasName>
    <vsto:hasIdentifier>5140</vsto:hasIdentifier>
  </vsto:FabryPerot>
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    <vsto:hasName>PFP</vsto:hasName>
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    <vsto:hasName>MFP</vsto:hasName>
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    <vsto:hasName>PKF</vsto:hasName>
```

Benefits

- Unified query workflow
- Decreased input requirements for query: in one base reducing the number of selections from eight to three
- Interface generates only syntactically correct queries: which was not always ensurable in previous implementations without semantics
- Semantic query support: by using background ontologies and a reasoner, our application has the opportunity to only expose coherent query
- Semantic integration: in the past users had to remember (and maintain codes) to account for numerous different ways to combine and plot the data whereas now semantic mediation provides the level of sensible data integration required
  - understanding of coordinate systems, relationships, data synthesis, transformations, etc.
- A broader range of potential users (PhD scientists, students, professional research associates and those from outside the fields)

Recent Feedback

- Highlights:
  - Less clicks to data
  - Auto identification and retrieval of independent variables & plotting support
  - Faster
  - Support for finding instruments (without specifying the id includes finding data from instruments that the user did not know to ask for)
- Questions (potentially with 35 responses)
  - What do you like about the new searching interface? (9)
  - Are you finding the data you need? (35: **Yes=34**, No=1)
  - What is the single biggest difference? (8)
  - How do you like to search for data? Browse, type a query, visual? (10, Browse=7, Type=0, Visual=3)
  - What other concepts are you interested in using for search, e.g. time of high solar activity, campaign, feature, phenomenon, others? (5, all of these)
  - Does the interface and services deliver the functionality, speed, flexibility you require? (30, Yes=30, No=0)
  - How often do you use the interface in your normal work? (19, **Daily=13,** Monthly=4, Longer=2)
  - Are there places where the interface/ services fail to perform as desired? (5, Yes=1, No=4)

Conclusion

- Virtual Observatories are emerging (VSTO, Astrophysical, NASA VO program, …) and are (arguably) a significant scientific trend
- AI can change the way science is done – primarily with supporting interdisciplinary work, broadening the group who can do the work, and with increasing reuse potential
- AI /Semantic Web / Ontologies can help with
  - Controlled vocabularies with unambiguous term meanings
  - Mapping/Merging support for data integration
  - Ontology-enhanced search
  - Meta-data descriptions
  - Consistency Checking
  - Completion
  - Structured, "surgical" comparative customized search
  - …
- Keys are mixed skill set teams, collaboration, deployment (with clear benefit), pruning to include achievable goals (choose some low hanging fruit)
- VSTO provides:
  - a deployed service for a particular domain area (solar terrestrial physics)
  - a model for interdisciplinary virtual observatories that is replicable (and reusable, having been tested in the areas of volcanology, plate

More Information

- Virtual Solar Terrestrial Observatory (VSTO): http://vsto.hao.ucar.edu, http://www.vsto.org
- Semantically-Enabled Science Data Integration (SESDI): http://sesdi.hao.ucar.edu
- Coupling, Energetics and Dynamics of Atmospheric Regions (CEDAR): http://cedarweb.hao.ucar.edu
- Mauna Loa Solar Observatory (MLSO): http://mlso.hao.ucar.edu
- W3C's Web Ontology Language (OWL) - http://www.w3.org/TR/owl-features/

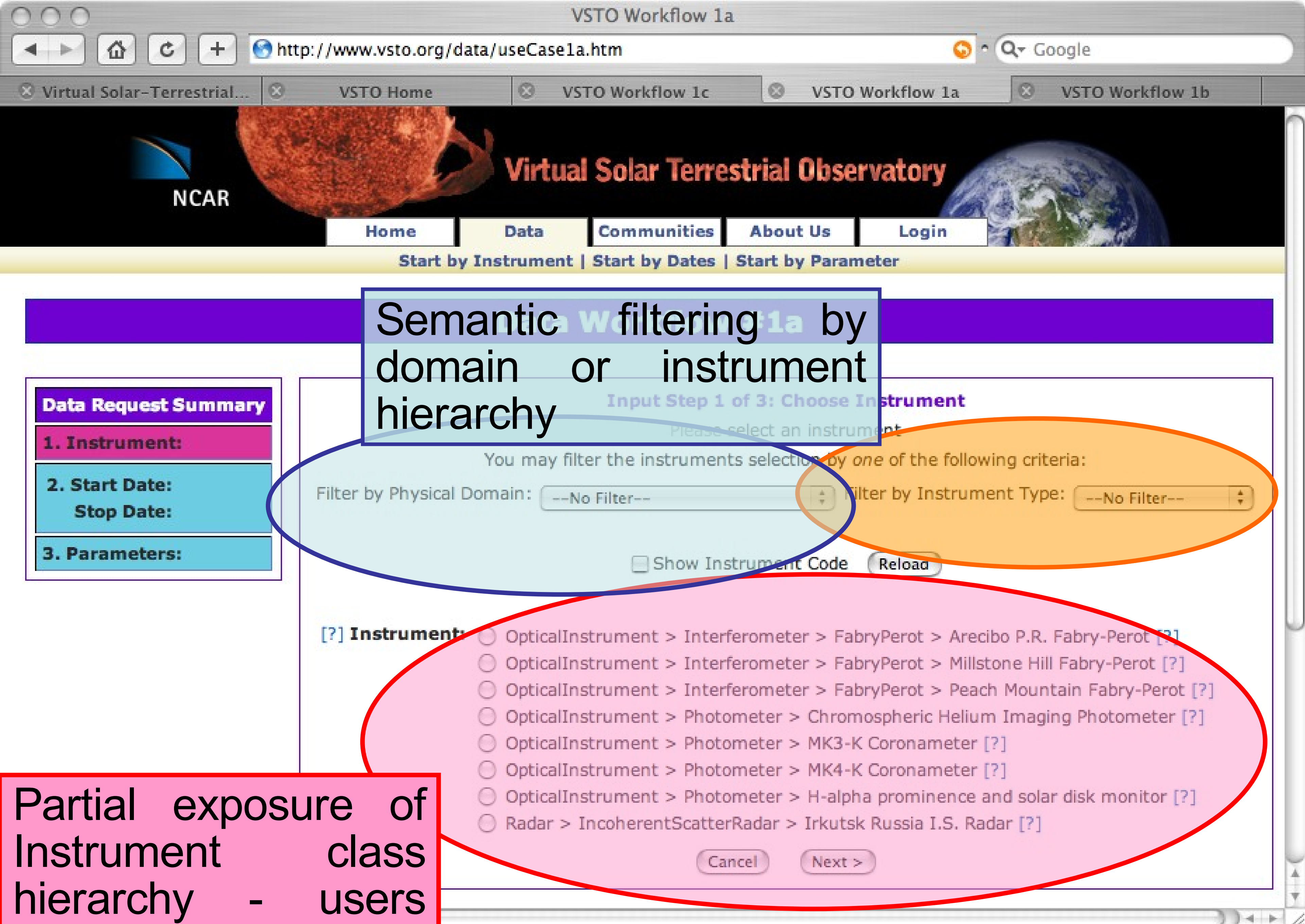
- COME TO THE DEMO/POSTER SESSION on Wednesday to see VSTO in action
- Consider submitting to AAAI SSS on Semantic Scientific Knowledge Integration
- Upcoming Springer Journal JESI – Journal of Earth Science Informatics

contacts:
Deborah McGuinness dlm @ ksl.stanford.edu
Peter Fox pfox @ ucar.edu

Selected Papers/presentations

- AAAI Intelligent Systems Track (COME SEE POSTER- DEMO)
  - McGuinness, D.L.; Fox, P.; Cinquini, L.; West, P.; Garcia, J.; Benedict, J.L.; Middleton, D. A Deployed Semantically-Enabled Interdisciplinary Virtual Observatory. Proceedings of the Twenty-Second Conference on Artificial Intelligence (AAAI-07) Intelligent Systems Track, Vancouver, British Columbia, Canada, July 22-26, 2007.
- Geoinformatics 2007
  - Fox, P., Cinquini, L., McGuinness, D., West, P. Semantic Web Services in a Virtual Observatory.
  - McGuinness, D., Fox, P., Sinha, A.K., Raskin, R., Semantic Integration of Heterogeneous Volcanic and Atmospheric Data.
- AGU 2006
  - Cinquini, McGuinness, Fox, West, Darnell, Garcia, Benedict, Middleton. Semantics and interoperability in the Virtual Solar-Terrestrial Observatory. In American Geophysical Union, Fall Meeting (AGU2006), San Francisco, Ca., December, 2006. Eos Trans. AGU 87(52), Fall Meet. Suppl., Abstract IN41B-0890.
  - Darnell, Cinquini, Fox, West, Middleton, McGuinness, Benedict. Unifying Workflows for Finding and Using Data Across Discipline Boundaries.
  - Fox, McGuinness, Raskin, Sinha, The Technology Behind Data Integration with Semantics.
  - McGuinness, Fox, Cinquini, Benedict, West, Garcia, Darnell, Middleton. Semantic Web Cyberinfrastructure for Virtual Observatories.
  - Middleton, McGuinness, Fox. Progressin Earth and Space Science Infrastructure: Grids, Frameworks, and Semantics.
- International Semantic Web Conference 2006
  - Peter Fox, Deborah L. McGuinness, Don Middleton, Luca Cinquini, J. Anthony Darnell, Jose Garcia, Patrick West, James Benedict, and Stan Solomon. Semantically-Enabled Large-Scale Science Data Repositories. LNCS, 2006
  - Deborah L. McGuinness, Peter Fox, Luca Cinquini, J. Anthony Darnell, Patrick West, James L. Benedict, Jose Garcia, and Don Middleton. Ontology-Enabled Virtual Observatories: Semantic Integration in Practice.
- Geoinformatics 2006
  - Sinha, A.K., Heiken.G., Barnes,C., Wohletz,K., Venezky,D., Fox., McGuinness., Raskin. and Lin,K, 2006, Towards an ontology for Volcanoes, U.S.Geological Survey Scientific Investigations Report 2006-5201, p.51
  - Peter Fox, Deborah L. McGuinness, Rob Raskin, A. Krishna Sinha. Semantically-Enabled Scientific Data Integration, U.S.Geological Survey Scientific Investigations Report 2006-5201
- AGU/JA 2006
  - D.L. McGuinness, A.K. Sinha, P. Fox, R. Raskin, G. Heiken, C. Barnes, K. Wohletz, D. Venezky, K. Lin. Towards a Reference Volcano Ontology for Semantic Scientific Data Integration
  - P. Fox, Deborah L. McGuinness, Rob Raskin, A. Krishna Sinha. Semantically-enabled Science data Integration

Extras

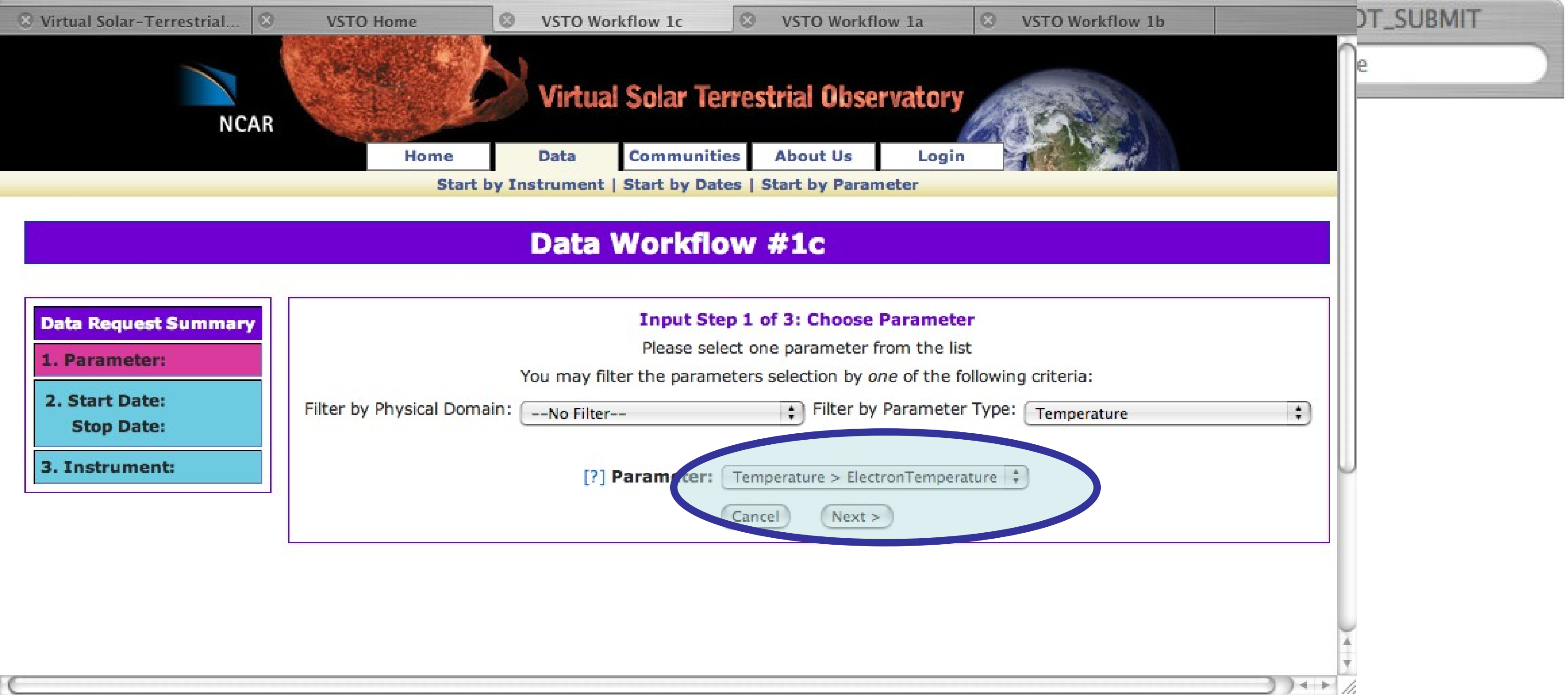


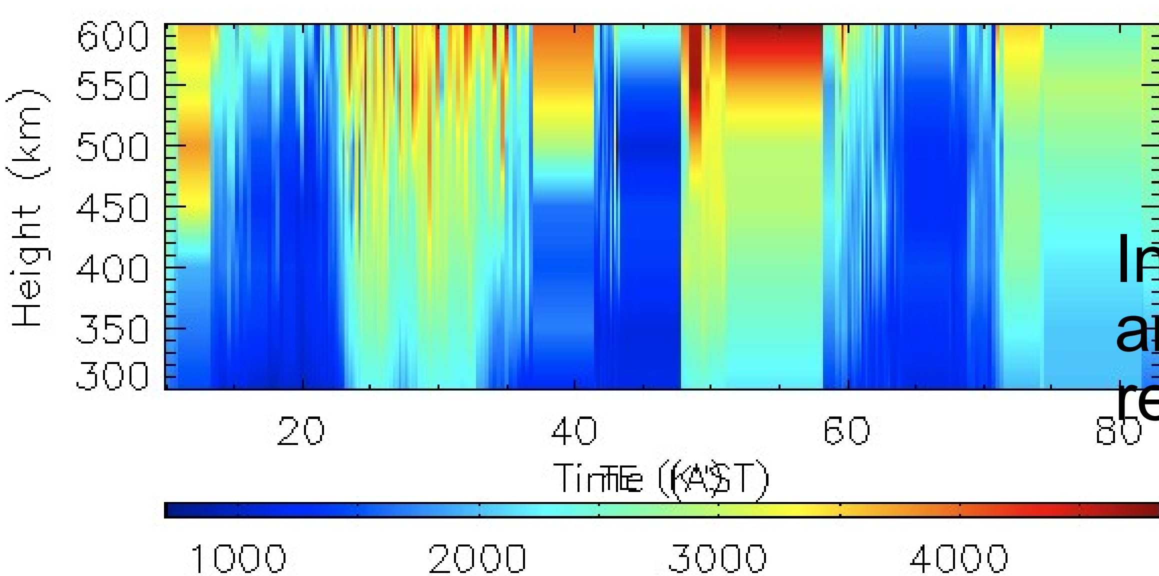
Semantic filtering by domain or instrument hierarchy

Partial exposure of Instrument class hierarchy - users seem to LIKE THIS

VSTO

- Conceptual model and architecture developed by combined team; KR experts, domain experts, and software engineers
- Semantic framework developed and built with a small, cohesive, carefully chosen team in a relatively short time (deployments in 1st year)
- **Production** portal released, includes security, etc. with community migration (and so far endorsement)
- VSTO ontology version 1.0, (vsto.owl)
- Web Services encapsulation of semantic interfaces
- More Solar Terrestrial use-cases to drive the completion of the ontologies - filling out the instrument ontology
- Using ontologies in other applications (volcanoes, climate, …)





Inferred plot type and return required axes data

Issues for Virtual Observatories

Semantics can help with many of these

- Scaling to large numbers of data provid
- Crossing disciplines
- Security, access to resour cies
- Branding and attrib here did this data come from and who credit, is it the correct version, is this an tative source?)
- Pr ce/derivation (propagating key information passes through a variety of services, copies of processing algorithms, …)
- Data quality, preservation, stewardship, rescue
- Interoperability at a variety of levels (~3)

CEDAR User Survey

- 8 questions
- 5-35 responses (per question)
- General summary
- Specific summary
- New use cases

Questions posed (responses)

- What do you like about the new searching interface? (9)
- Are you finding the data you need? (35: Yes=34, No=1)
- What is the single biggest difference? (8)
- How do you like to search for data? Browse, type a query, visual? (10, Browse=7, Type=0, Visual=3)
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- Are there places where the interface/ services fail to perform as desired? (5, Yes=1, No=4)

General

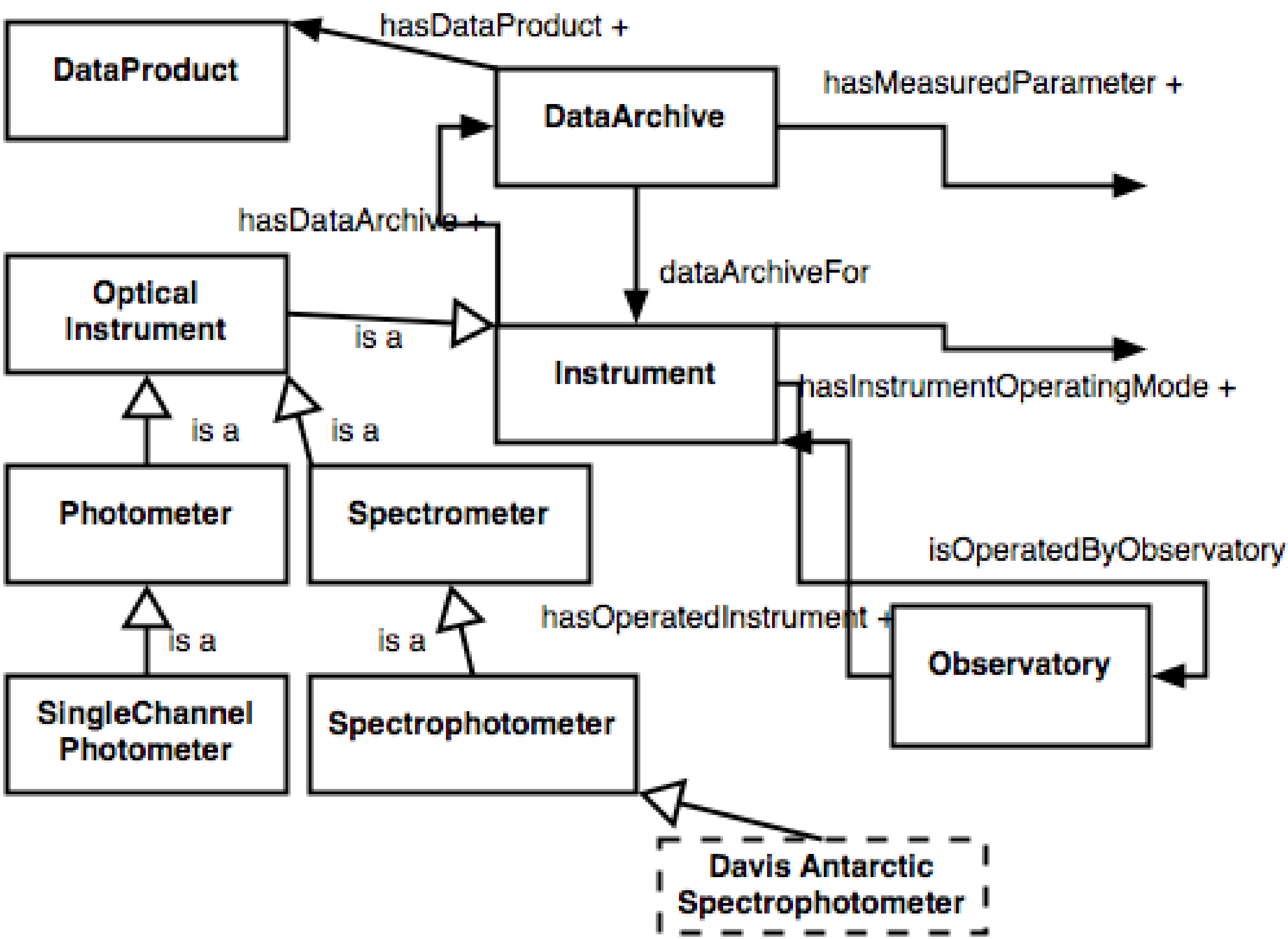
- Less clicks to data (lots)
- Auto identification and retrieval of independent variables (lots)
- Faster (lots)
- Seems to converge faster.. (few)

Specific

- ‘It makes sense now’
- [I] ‘Like the plotting’
- ‘Finding instruments I never knew about’
- ‘Descriptions are very handy’
- ‘What else can you add?’
- ‘How about a python interface [to the services]?’

New use cases

- Programming/ script level interface, i.e. building on the services interfaces; python, perl, c, ruby, tcl,
- Addition of models alongside observational data, i.e. find data from obs/model
- More services (plotting options)



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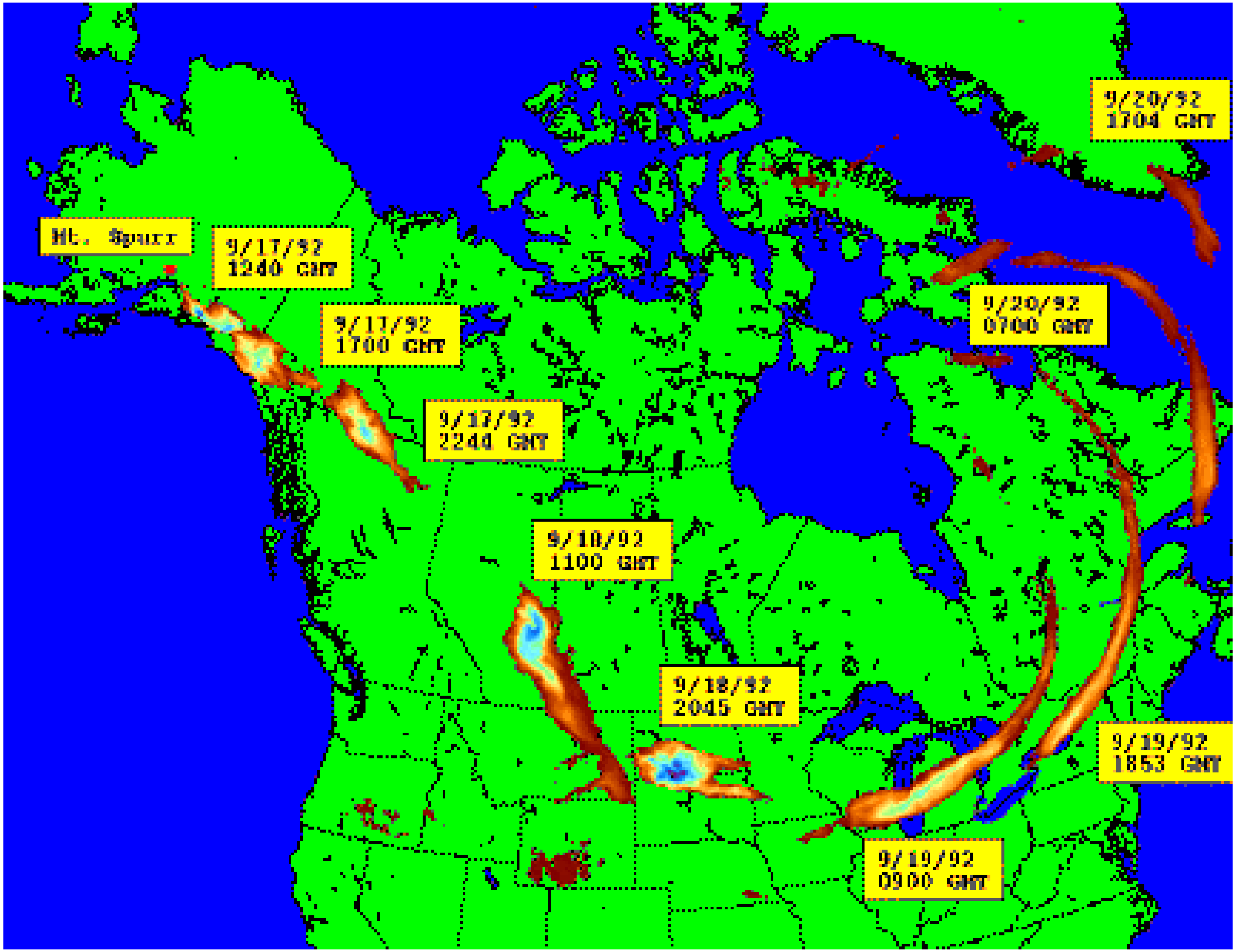
Semantically-Enabled Scientific Data Integration

- Using the same methodology, work in a different interdisciplinary science domain – this time volcanoes, plate tectonics, and the atmosphere

Mt. Spurr, AK. 8/18/1992 eruption, USGS

http://www.avo.alaska.edu/image.php?id=319

Eruption cloud movement from Mt.Spurr, AK,1992



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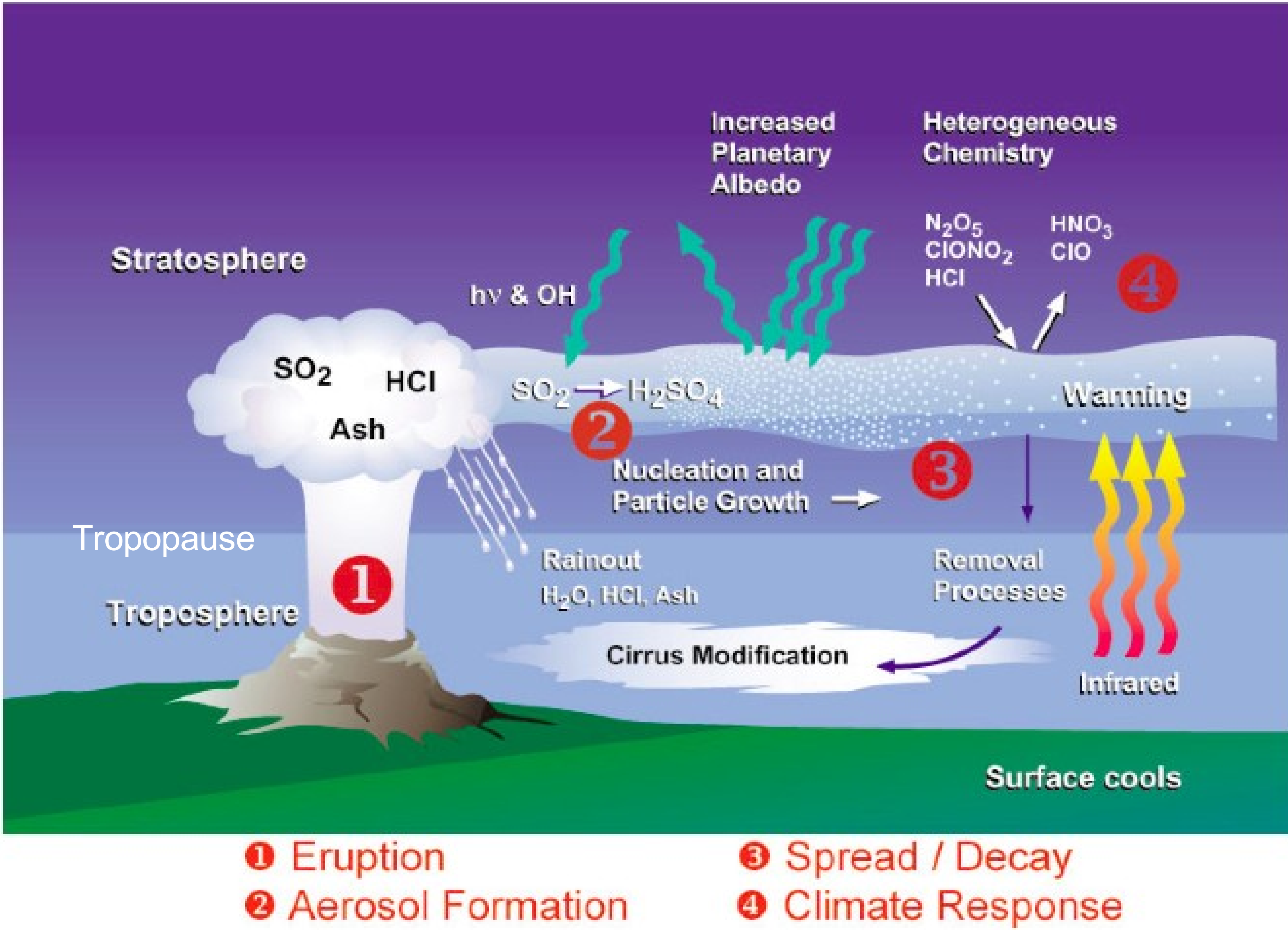

http://aerosols.larc.nasa.gov/volcano2.swf

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Atmosphere Use Case

- Determine the **statistical signatures** of both volcanic and solar **forcings** on the height of the **tropopause**

From paleoclimate researcher – Caspar Ammann – Climate and Global Dynamics Division of NCAR - CGD/NCAR

Layperson perspective:

- look for indicators of acid rain in the part of the atmosphere we experience…

(look at measurements of sulfur dioxide in relation to sulfuric acid after volcanic eruptions at the boundary of the troposphere and the stratosphere)

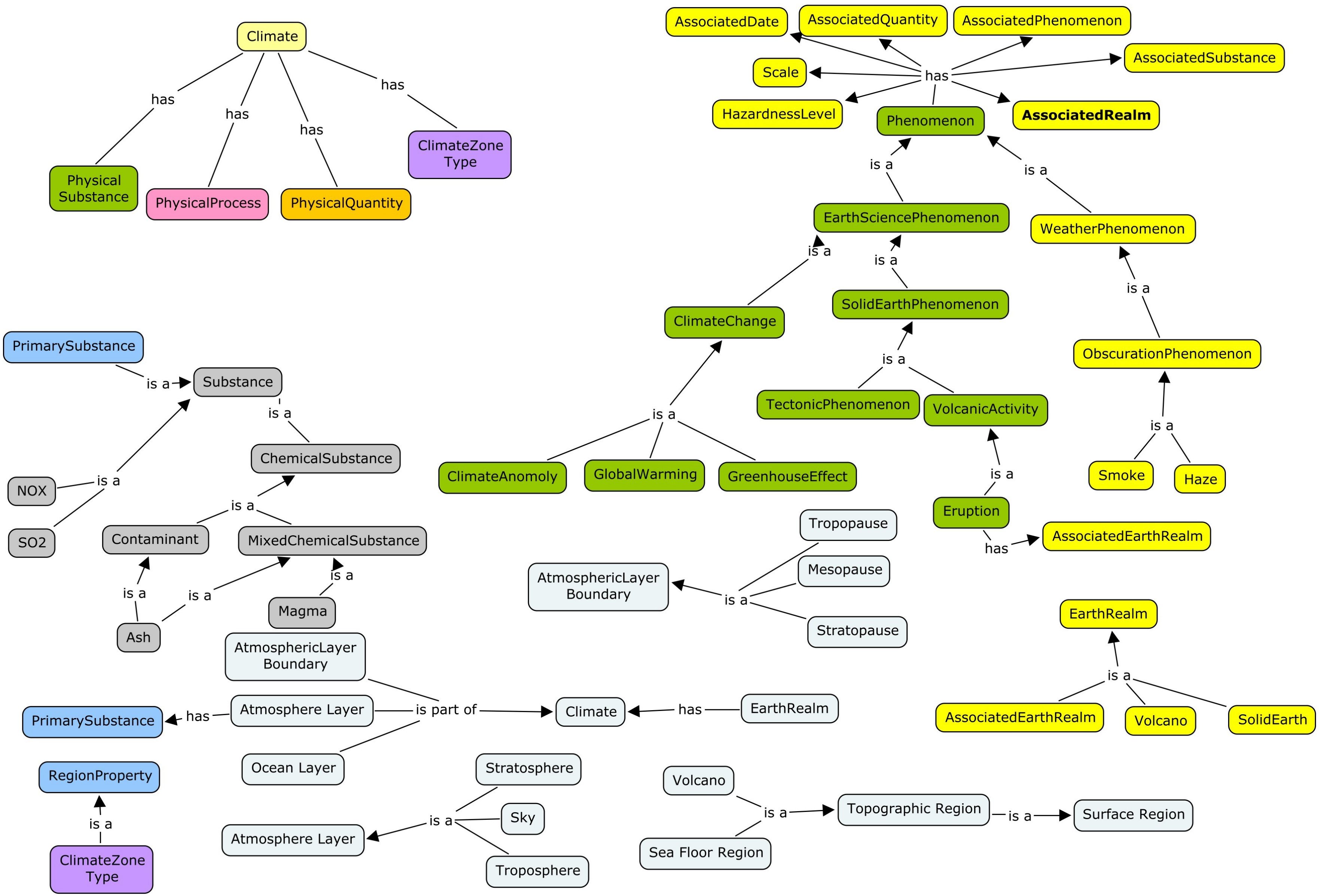
Use Case detail: A volcano erupts

- Preferentially it's a **tropical mountain** (+/- 30 degrees of the **equator**) with **'acidic' magma**; more **SiO2**, and it **erupt**s with great **intensity** so that **material** and large amounts of **gas** are **inject**ed into the **stratosphere**.
- The **SO2 gas convert**s to **H2SO4** (**Sulfuric Acid**) + **H2O** (75% **H2SO4** + 25% **H2O**). The **half life** of **SO2** is about 30 - 40 **day**s.
- The **sulfuric acid condensate**s to little **super-cooled liquid droplet**s. These are the **volcanic aerosol** that will linger around for a **year** or two.
- **Brewer Dobson Circulation** of the **stratosphere** will **transport aerosol** to higher **latitude**s. The **particle**s generate great **sunset**s, most commonly first seen in fall of the respective **hemisphere**. The **sunlight** gets partially **reflect**ed, some part gets **scatter**ed in the forward **direction**.
- Result is that the **direct solar beam** is reduced, yet diffuse **skylight** increases. The **scattering** is responsible for the colorful **sunset**s as more and more of the blue **wavelength** are **scatter**ed away.in mid-**latitude**s the **volcanic aerosol** starts to settle, but most efficient removal from the **stratosphere** is through **tropopause** folds in the vicinity of the **storm track**s.
- If **particle**s get over the **pole**, which happens in spring of the respective **hemisphere**, then they will settle down and fall onto **polar ice cap**s. Its from these **ice cap**s that we recover annual records of **sulfate flux** or **deposit**.
- We get **ice core**s that show continuous **deposition** information. Nowadays we measure **sulfate** or **SO4(2-)**. Earlier **measurement**s were indirect, putting an **electric current** through the **ice** and **measur**ing the delay. With **acid**s present, the **electric flow** would be faster.
- What we are looking for are **pulse like event**s with a build up over a few **month**s (mostly in summer, when the **vortex** is gone), and then a **decay** of the **peak** of about **1/e** in 12 **month**s.
- The **distribution** of these **pulse**s was found to follow an extreme **value distribution** (**Frechet**) with a **heavy tail**.

Use Case detail: … climate

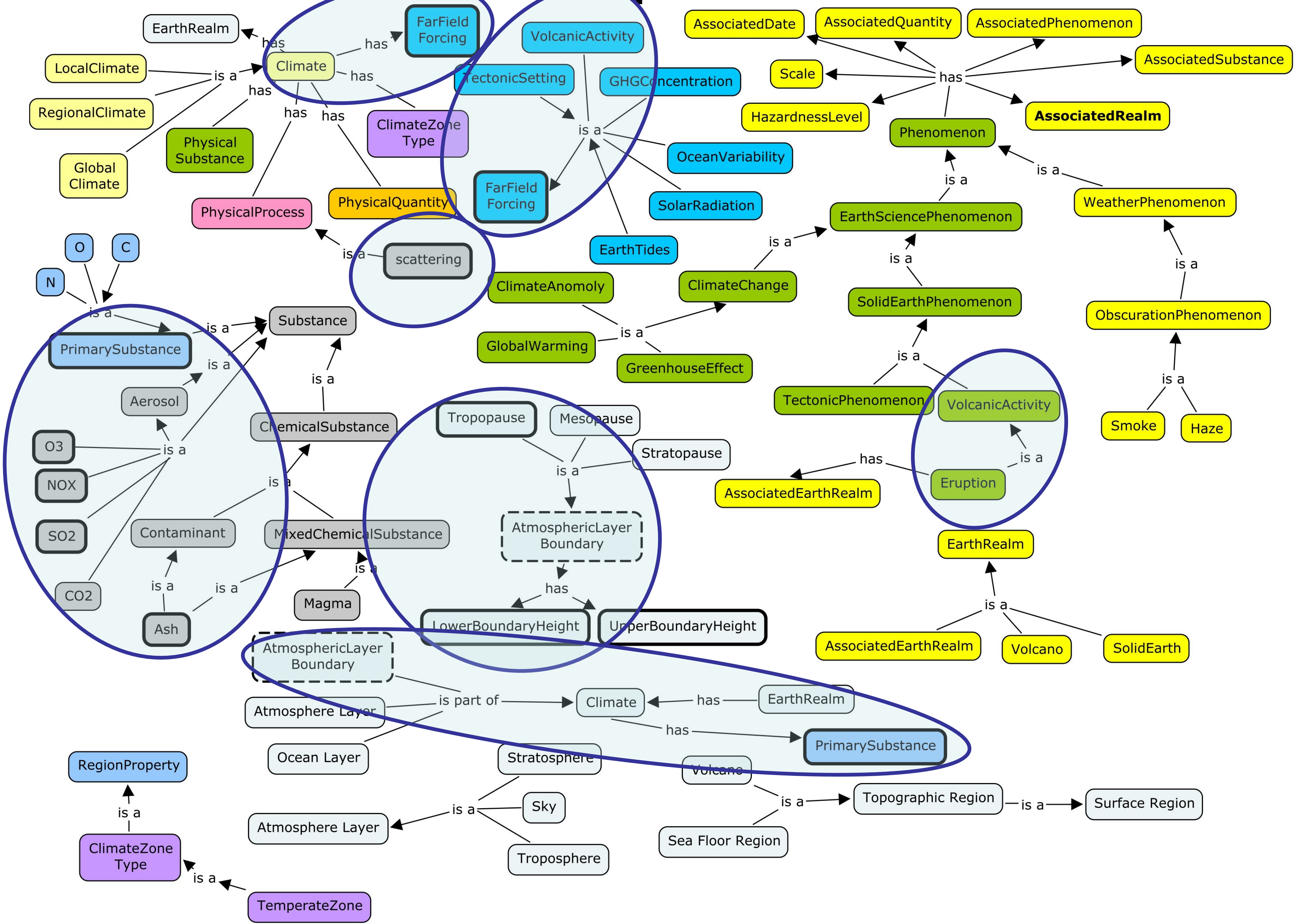
- So **reflection** reduces the total amount of **energy**, **forward scattering** just changes the **beam**, **path length**, but that's it.
- The **dry fog**s in the **sky** (even after **thunderstorm**) still up there, thus **stratosphere** not **troposphere**.
- The **tropical reservoir** will keep delivering **aerosol** for about two **year**s after the **eruption**.
- The **particle**s are excellent ***scatterers*** in **short wavelength**. They do **absorb** in **NIR** and in **IR**. Because of **absorption**, there is a local **temperature** change in the lower **stratosphere**.
- This **temperature** change will cause some **convective motion** to further **spread** the **aerosol**, and second: Its good factual stuff. Once it **warm**s up, it will generate a **temperature gradient**. **Horizontal temperature gradient**s increase the **baroclinicity** and thus **storm**s, and they speedup the local **zonal wind**s. This change in **zonal wind** in high **latitude**s is particularly large in **winter**. This increased **zonal wind** (Westerly) will remove all **cold air** that tries to buildup over **winter** in **high arctic**.
- Therefore, the **temperature** anomaly in **winter** time is actually quite okay.
- Impact of **volcano**es is to cool the **surface** through **scattering** of **radiation**.
- In **winter** time over the **continent**s there might be some warming. In the **stratosphere**, the **aerosol** warm.
- The amount of **GHG** emitted is comparably small to the **reservoir** in the **air**.
- The **hydrologic cycle** responds to a **volcanic eruption**.

Atmosphere (portions from SWEET)

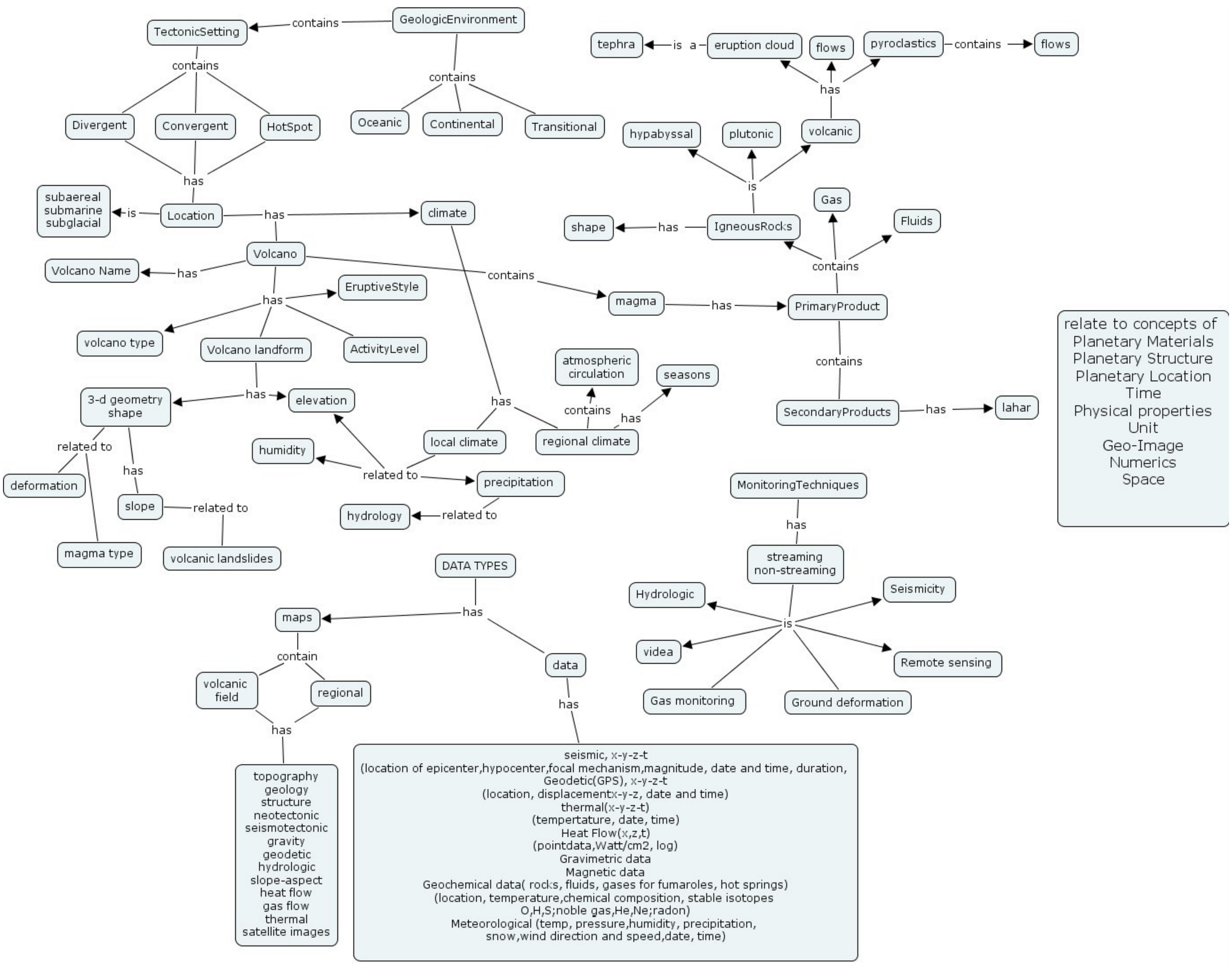


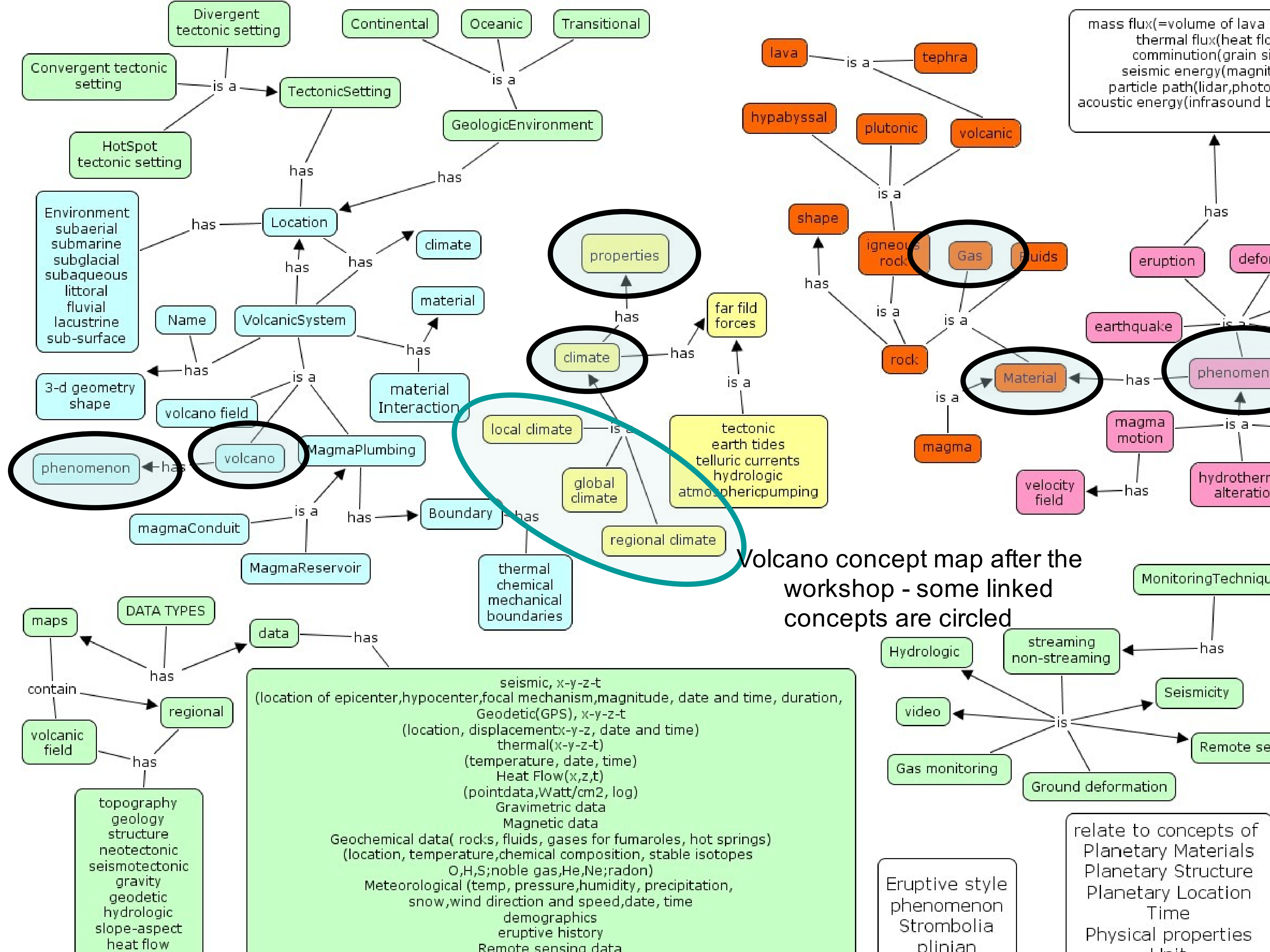
McGuinness, Fox , et al July 24, 2007

Atmosphere II



Volcano Workshop - before





Volcano concept map after the workshop - some linked concepts are circled

Plate tectonics - before workshop

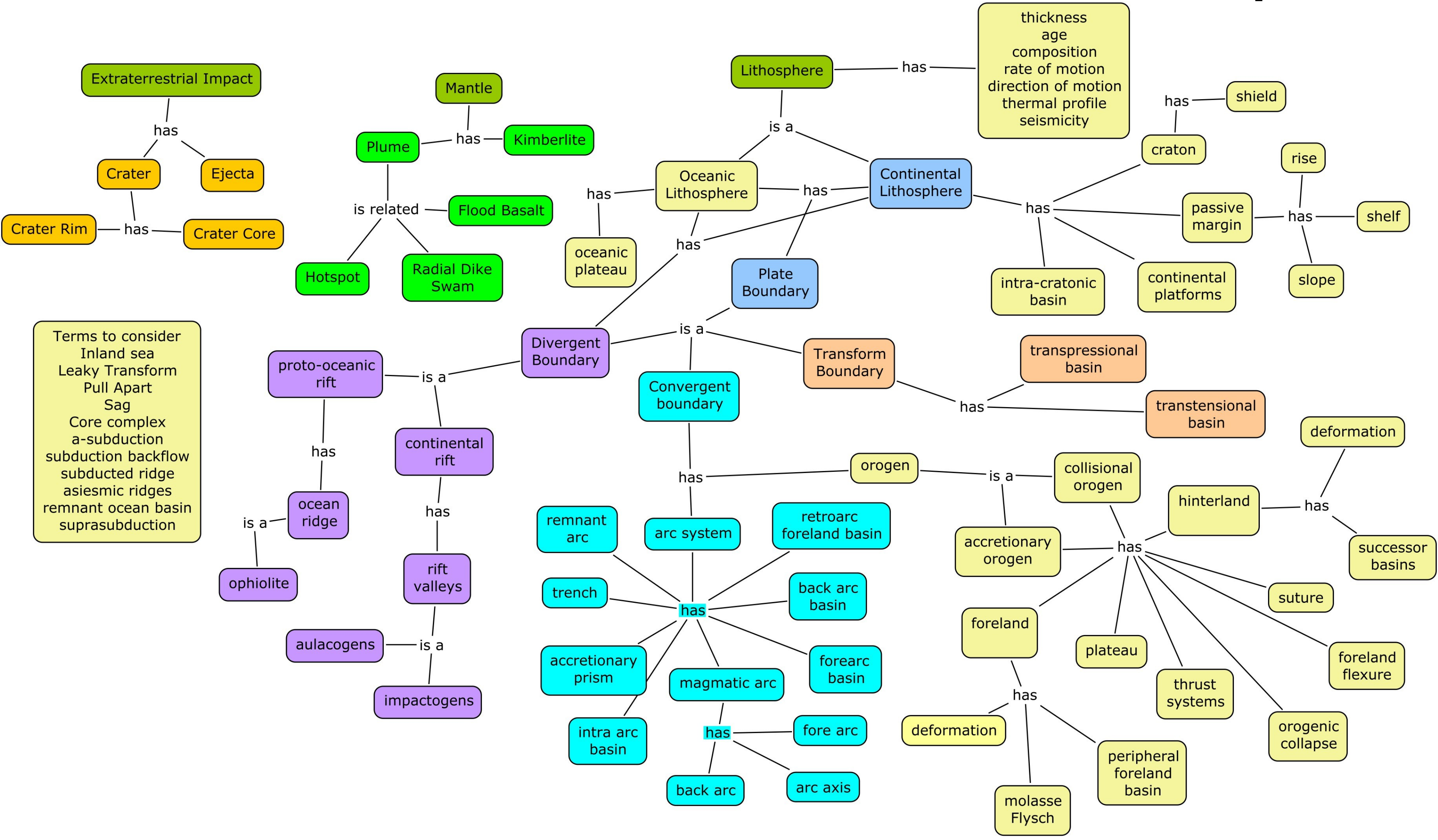


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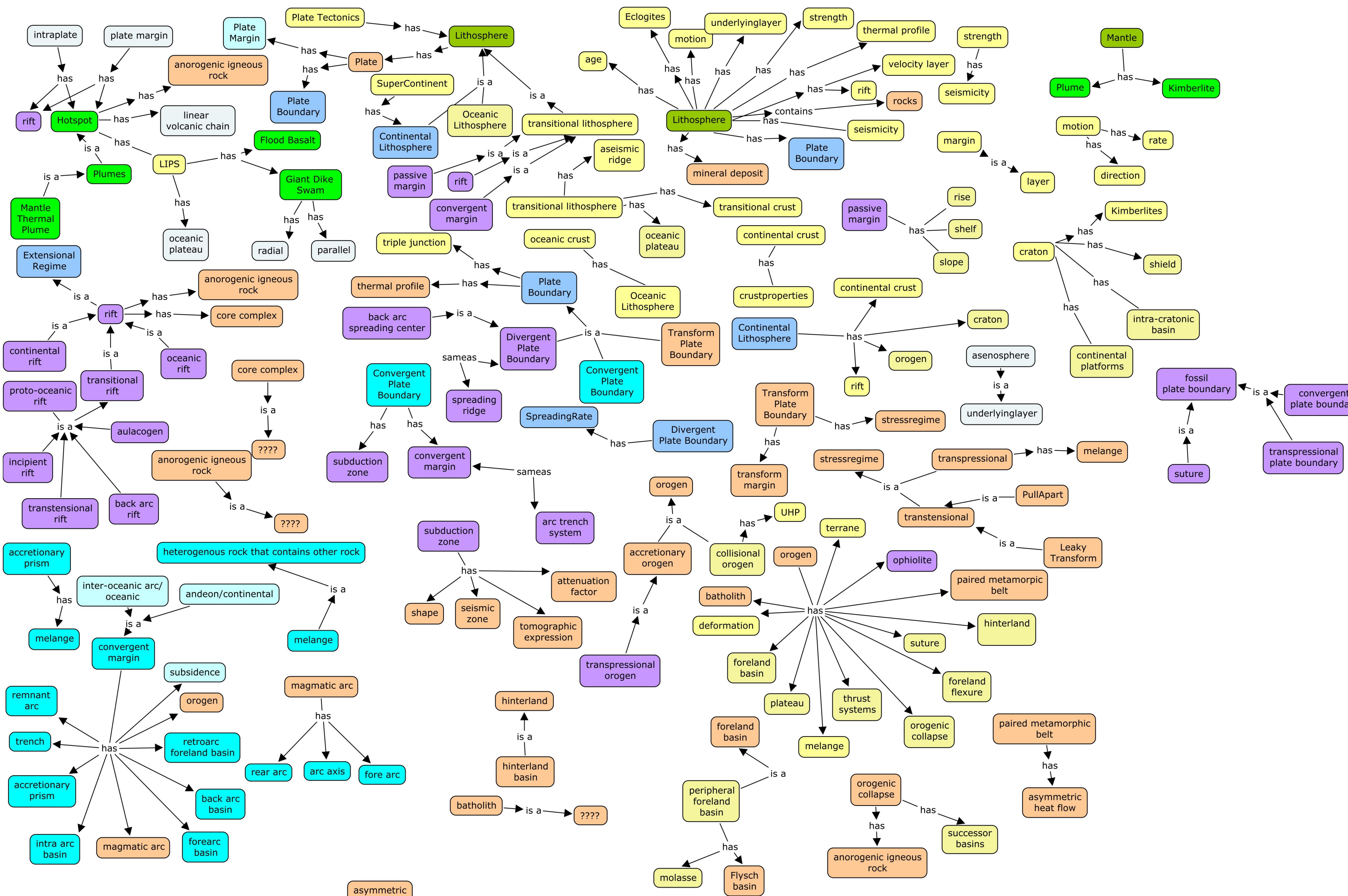
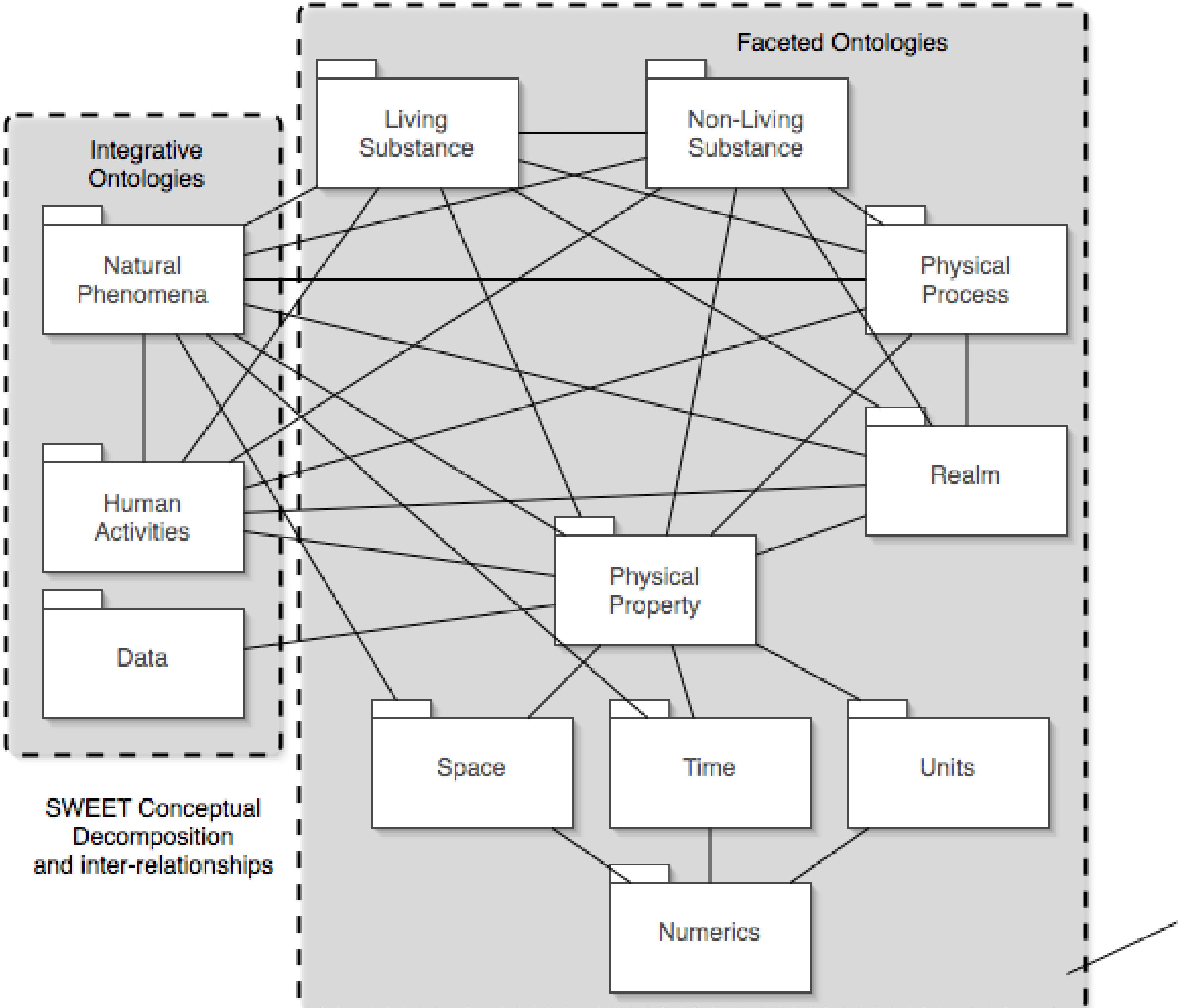
Plate tectonics – after



A few observations worth noting

- CMAPS have been convenient knowledge capture tools
- We facilitate knowledge acquisition meetings AND provide a starting point
- We are experiencing good reuse of ontologies and infrastructure

- Next – VSTO walk thru


Faceted Ontologies
Integrative Ontologies
Living Substance
Non-Living Substance
Natural Phenomena
Physical Process
Human Activities
Realm
Physical Property
Data
Space
Time
Units
Numerics
SWEET Conceptual Decomposition and inter-relationships

Packages for an Ontology for Volcanoes

Phenomenon | **Material** | **Volcanic System**

Data Types | **Instruments** | **Climate**

SWEET — *IMPORT EXISTING ONTOLOGIES* — **GEON**

Import
NASA: Semantic Web for Earth Science
Units Ontology

Import
NASA: Semantic Web for Earth Science
Numerics Ontology

Import
NASA: Semantic Web for Earth Science
Physical Property Ontology

Import
NASA: Semantic Web for Earth Science
Physical Phenomena Ontology

Planetary Structure

Geologic Time

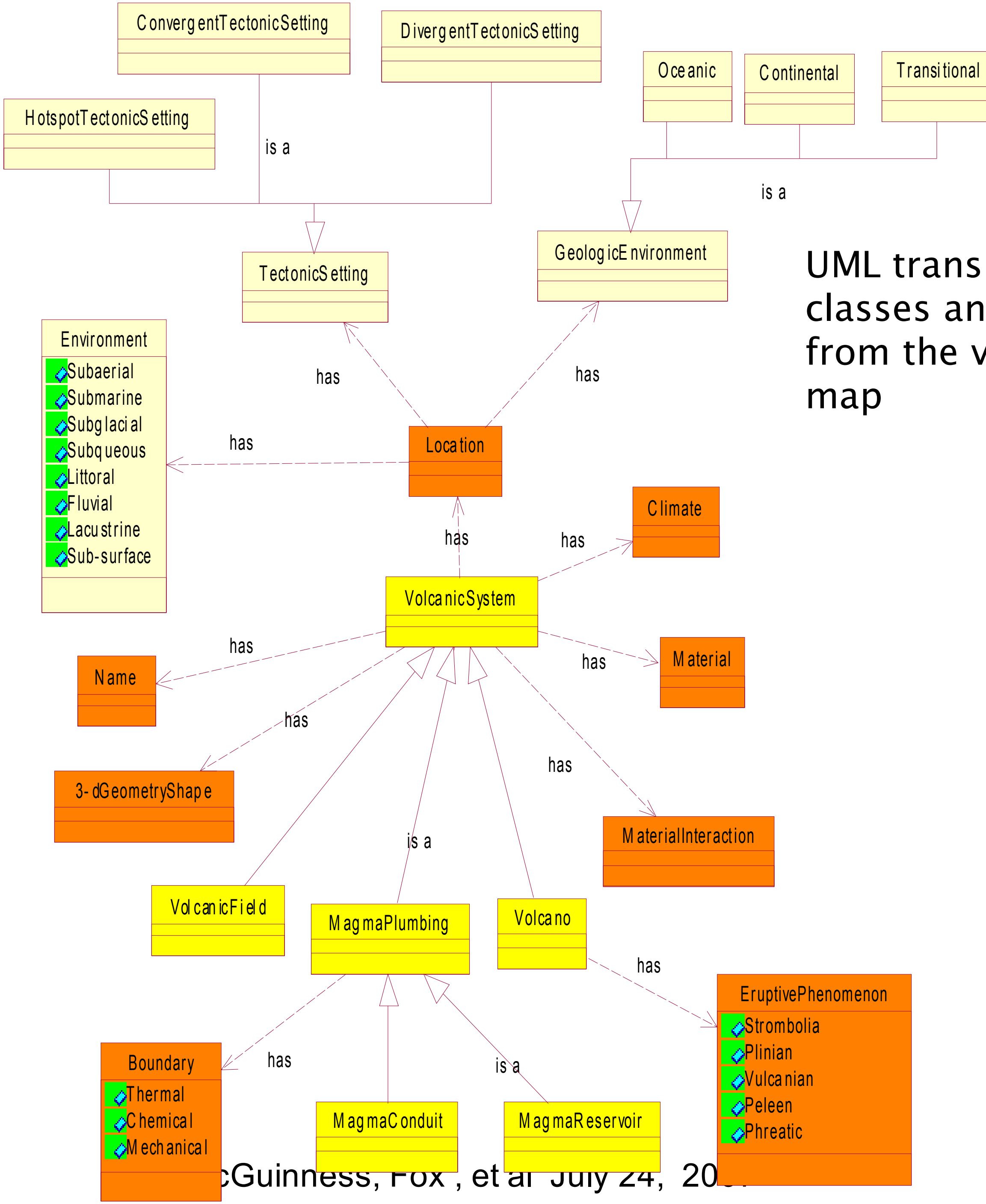
Physical Properties

Planetary Material

GeoImage

PlanetaryLocation

Planetary Phenomenon



UML translation of classes and properties from the volcano concept map

Impact: Changing Science

Scientists: What if you…

- could not only use your data and tools but remote colleague's data and tools?
- understood their assumptions, constraints, etc and could evaluate applicability?
- knew whose research currently (or in the future) would benefit from your results?
- knew whose results were consistent (or inconsistent) with yours?…

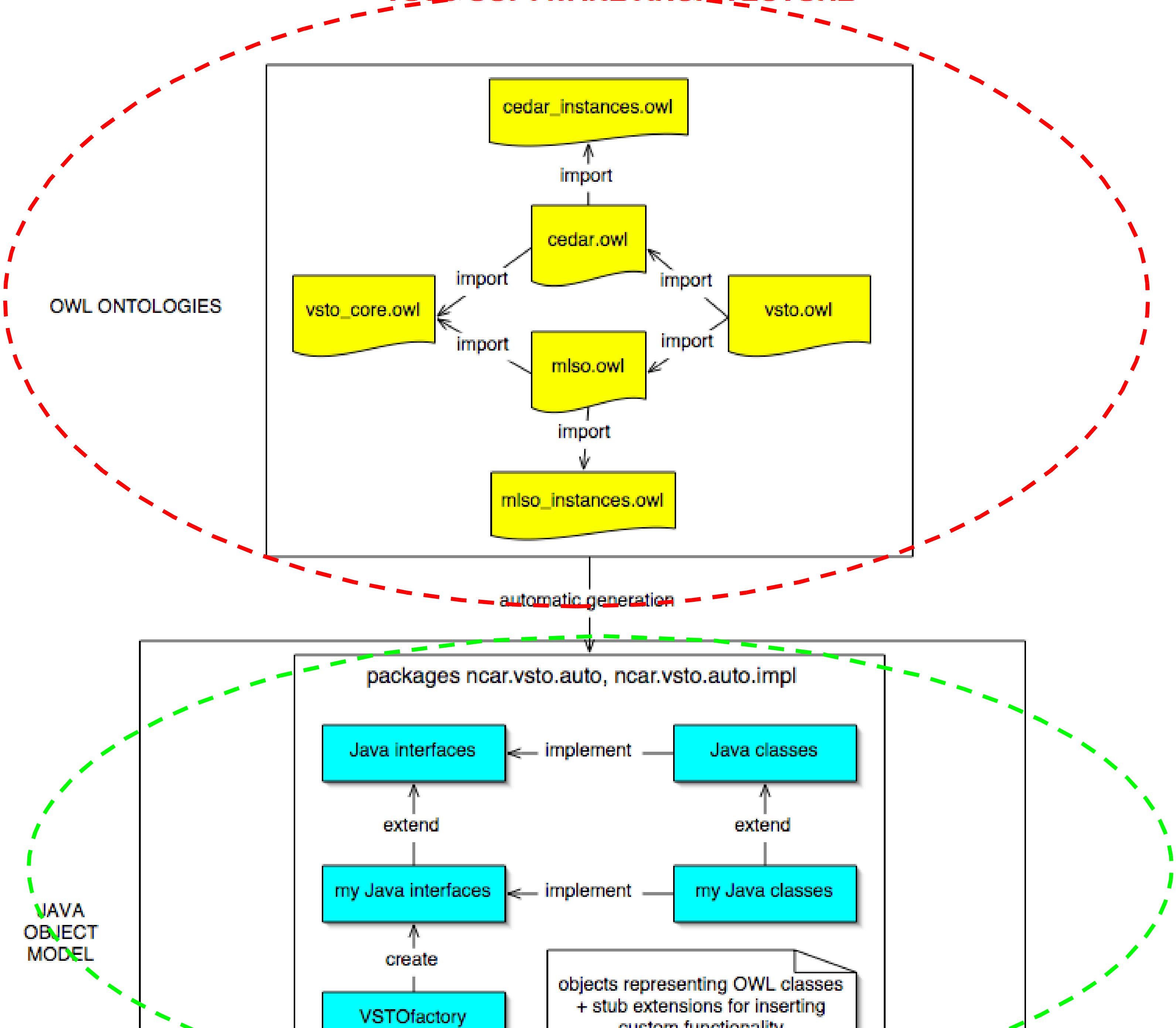
VCs & Funders: What if you …

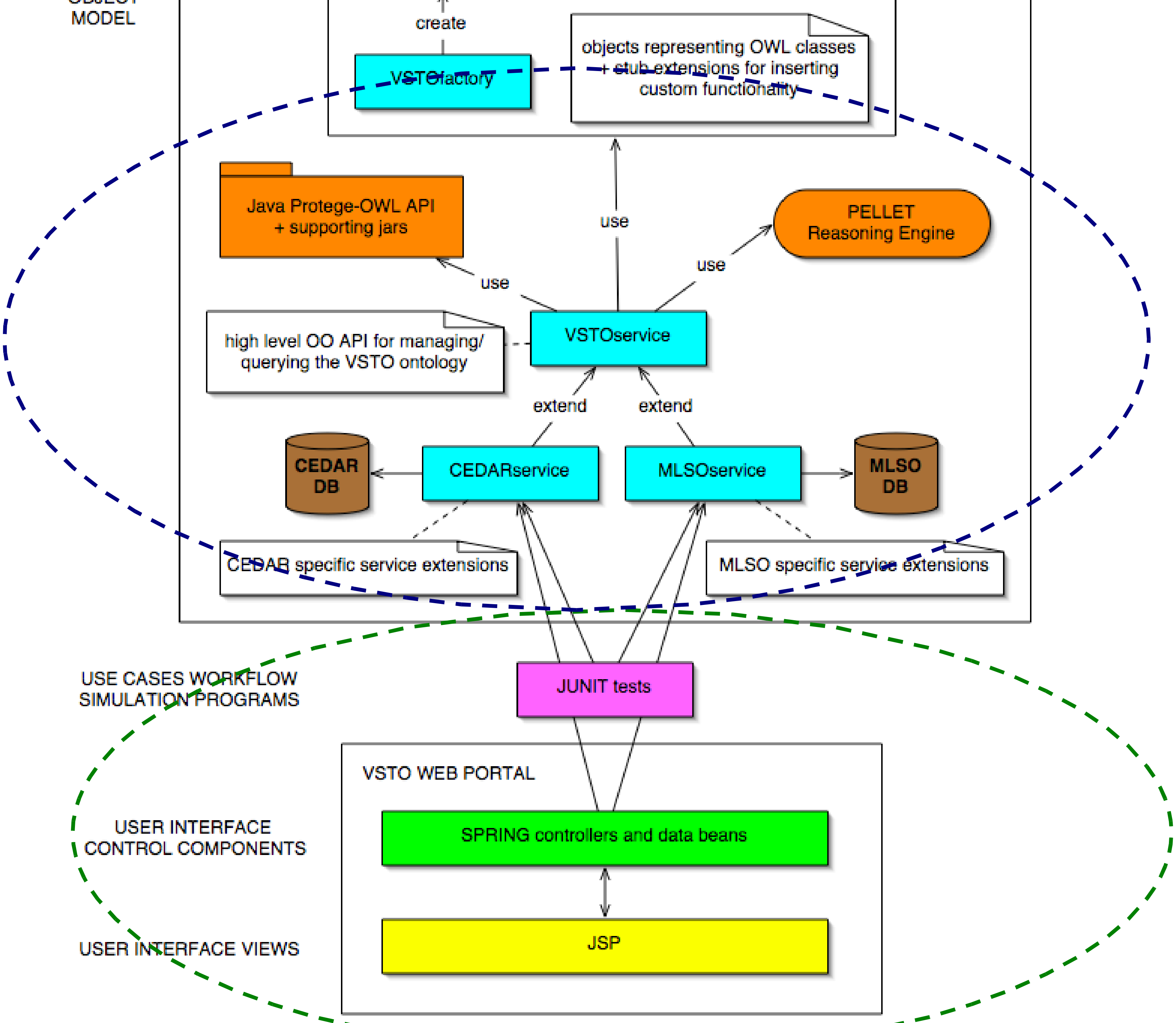
- could identify how one research effort would support other efforts?
- (and your fundees) could reuse previous results?
- (and your fundees) could really interoperate?

Semantic Technologists: What if you…

- could apply your techniques across very large distributed teams of people with related but different apps?
- could compare your techniques with colleagues trying to solve similar problems?

VSTO SOFTWARE ARCHITECTURE





OBJECT
MODEL
create
VSTOfactory
objects representing OWL classes
+ stub extensions for inserting
custom functionality
Java Protege-OWL API
+ supporting jars
use
use
PELLET
Reasoning Engine
use
high level OO API for managing/
querying the VSTO ontology
VSTOservice
extend
extend
CEDAR
DB
CEDARservice
MLSOservice
MLSO
DB
CEDAR specific service extensions
MLSO specific service extensions
USE CASES WORKFLOW
SIMULATION PROGRAMS
JUNIT tests
VSTO WEB PORTAL
USER INTERFACE
CONTROL COMPONENTS
SPRING controllers and data beans
USER INTERFACE VIEWS
JSP