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## Curated Reasoning by Formal Modeling of Provenance

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Curated Reasoning by Formal Modeling of Provenance

A Dissertation

Submitted to the Graduate Faculty of the  
University of New Orleans  
in partial fulfillment of the  
requirements for the degree of

Doctor of Philosophy  
in  
Engineering and Applied Science

By  
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## Abstract

The core problem addressed in this research is the current lack of an ability to repurpose and curate scientific data among interdisciplinary scientists within a research enterprise environment. Explosive growth in sensor technology as well as the cost of collecting ocean data and airborne measurements has allowed for exponential increases in scientific data collection as well as substantial enterprise resources required for data collection. There is currently no framework for efficiently curating this scientific data for repurposing or intergenerational use.

There are several reasons why this problem has eluded solution to date to include the competitive requirements for funding and publication, multiple vocabularies used among various scientific disciplines, the number of scientific disciplines and the variation among workflow processes, lack of a flexible framework to allow for diversity among vocabularies and data but a unifying approach to exploitation and a lack of affordable computing resources (mostly in past tense now). Addressing this lack of sharing scientific data among interdisciplinary scientists is an exceptionally challenging problem given the need for combination of various vocabularies, maintenance of associated scientific data provenance, requirement to minimize any additional workload being placed on originating data scientist project/time, protect publication/credit to reward scientific creativity and obtaining priority for a long-term goal such as scientific data curation for intergenerational, interdisciplinary scientific problem solving that likely offers the most potential for the highest impact discoveries in the future.

This research approach focuses on the core technical problem of formally modeling interdisciplinary scientific data provenance as the enabling and missing component to demonstrate the potential of interdisciplinary scientific data repurposing. This research develops a framework to combine varying vocabularies in a formal manner that allows the provenance information to be used as a key for reasoning to allow manageable curation.

The consequence of this research is that it has pioneered an approach of formally modeling provenance within an interdisciplinary research enterprise to demonstrate that intergenerational curation can be aided at the machine level to allow reasoning and repurposing to occur with minimal impact to data collectors and maximum impact to other scientists.

**Keywords:** Provenance, Computer Science, Ontology, Enterprise Modeling, Curation, Reasoning.

## **Chapter 1      Introduction**

### **Background**

The Naval Research and Development (R&D) community is experiencing unprecedented growth of its scientific data holdings from field sensors, model executions and advanced analytics. This rapid growth in scientific data holdings represents new opportunities to solve some of the most difficult and important research questions that remain open within the multiple specialties represented by Naval R&D. These data holdings are a distinctive competitive advantage for the community and a substantial, reoccurring community investment to collect, process, analyze, curate and share among collaborators. How to more effectively curate this exponentially growing core resource of data holdings and persistent collaborative annotations will be the focus of this work.

Naval R&D is by definition interdisciplinary to address the full spectrum of issues that are important within the overall community in order to support naval missions worldwide. The interdisciplinary nature of the research enables holistic treatment of complex problems but also introduces multiple domain definitions, vocabularies, taxonomies, and ontologies inherent in describing the various aspects of these multiple scientific disciplines and user communities of interest.

Collaboration across these various scientific and communities of interest has become even more complex given the large volumes of data and the determination of value and application of data holdings in one domain workflow versus another. Collaboration is critical among research scientists to enable modeling and incremental growth in understanding of process behavior for integration into larger scale physical systems. This essential element of collaboration also complicates the data curation aspects amid the rapidly growing digital representation of countless parameters. There is tremendous need for improvements in this collaborative space within Naval R&D since it represents a critical dimension to preserving the scientific record for others in and out of the initial, originating discipline(s). Enabling collaboration begins initially with discovery/awareness and assessment of available scientific data and annotations that has been made more challenging by the overwhelming nature of the amounts of data being collected. Current means of discovery are almost exclusively peer-to-peer (more clearly, human-to-human) which has clear limitations amid the tsunami of data. This area will receive substantial emphasis in this work since persistent collaboration and annotation is viewed as a fundamental pillar of long-term scientific data curation.

## Sensor Technology Advances

Sensor technology has exploded in terms of the number of scientific sensors available as well as the resolution of their output arrays. More sophisticated sensors have allowed more detailed understanding of physical processes by giving scientists in the various domains even finer resolution windows into amazing phenomena such as tropical cyclones, erosion of shorelines, carbon flux repositories, ocean sources of methane hydrates and even human behavior. Scientific sensors are being positioned in most every area from space to below the ocean surface and every location between these boundary conditions. Sensing of the environment is an obvious primary tool for naval scientists and therefore is crucial to include in the overall process modeling of scientific information flows. Sensing does generally provide the starting point for scientific analysis that then triggers annotations from various domain researchers that may be needed to more fully describe a process or set of complex processes.

Advances in sensor technology (manned and unmanned) and their widespread usage in the scientific community is clearly a component of the growing challenge and opportunity of effective data management. Sensor metadata is a requisite part of this work to develop novel techniques for all scientists to excel in this environment of high resolution, persistent sensing of most every part of the environment.

## **Scientific Modeling Improvements**

Scientific modeling has also recently experienced dynamic changes across the broad spectrum of domains such as riverine modeling, ocean waves, tides, coastal erosion, wind speed and direction, ocean sediment transport, acoustic noise, acoustic propagation and strengths of materials. Scientific models are increasingly higher resolution in an attempt to provide naval decision makers local predictive information as well as regional and global perspectives. Another trend in the scientific modeling community is the use of coupled models that combine multiple domains such as ocean and atmosphere to more naturally model the real world phenomena that exist. Coupled modeling adds to the complexity of the generated model outputs since it crosses domains and communities of interests thereby interjecting challenges in handling of parameters from one domain in another even if the general scientific area is the same (e.g., physics).

## **Scientific Computing**

Advances in scientific computing must be mentioned since these advanced have enabled the initial acquisition and processing of the vast amounts of describing content from the field sensors, model runs, etc. Digital computing technologies such as microprocessors, internal memory (RAM), virtual memory (disk drives) and associated peripherals have become so advanced, widespread and affordable that scientists can

now perform experiments that were impossible just 10 and 20 years ago. Specific scientific computing approaches are critical to improving the handling of valuable data since including particulars regarding these components/technologies chosen early on (such as automatic logs that may be occurring for unrelated purposes) can be of value to holistically modeling the data curation process. This can include underlying networks used, protocols and associated metadata from this transport layer.

## **Cloud Computing**

Cloud computing is a special form and approach to data curation that offers critical new potential (especially private cloud approaches) for the naval scientific community. Cloud computing now offers scientists the seemingly unlimited computational resources of a shared cloud without having the distractions of data management. Scientists also are not burdened with managing the rapidly changing computer processing, storage and networking issues that comprise several other extremely specialized disciplines given the complexities of modern overall computational systems. A potential drawback from a scientist's perspective of cloud computing is she will be required to let go of a part of the process that has historically been fully controlled by the scientist(s). Cloud computing, especially a private cloud approach, does offer the only practical solution to enable efficient curation of large amounts of scientific data holdings and annotations that can support enterprise level collaboration. Cloud computing currently offers distributed file system handling as well



as distributed process control which can be extremely useful to enabling a naval R&D collaborative enterprise that supports effective and long-term content curation. Some of the underlying technical approaches of cloud implementations do complicate metadata handling, process control, etc. but given the need for centralized control of critical scientific data for enterprise usage, it seems worthy of full consideration and evaluation. The current approach in the naval R&D community is very much an individual Principal Investigator (PI), project-based approach where the PI is responsible for data curation and personally collaborating with other scientists as needed. If a PI retires or departs the naval R&D community the scientific data is generally lost over time except for the description in the literature. This is a substantial loss to the overall naval R&D community and is debilitating with regard to solving the most complex of scientific problems (as well as most strategically significant for the naval mission) that may require intergenerational investigation with substantial amounts of interdisciplinary collaboration.

## **Curation**

Curation of naval scientific data holdings has never been more important given the above discussion nor has it ever been more technically possible even on such a large scale with existing challenges. A popularly cited definition of curation is defined as “ways of organizing, displaying and repurposing preserved data.” (Lord, 2003) Lord and Macdonald also provide a working definition with different levels of data curation:

“The activity of managing and promoting the use of data from its point of creation, to ensure it is fit for contemporary purpose and available for discovery and re-use. For dynamic datasets this may mean continuous enrichment or updating to keep it fit for purpose. Higher level of curation will also involve maintaining links with annotation and with other published materials.”

No naval curated enterprise system currently exists to allow for the preservation, collaboration and enablement of advanced intergenerational scientific pursuits. Curation could allow scientists a discovery and collaboration mechanism that would enable many new benefits that will be further discussed in the following pages. The critical need for a curated naval R&D enterprise system for scientific data holdings (including related persistent collaborations, annotations, etc.) is at the core of this research project. The long-term success of this work will be judged best by whether a naval R&D enterprise system is enacted or not and how useful this novel machine-based reasoning encourages diverse scientists to collaborate at a new level to solve the most complex naval problems.

### **The Core Technical Issue...Provenance Underlying and Enabling Curation**

Central to a naval R&D enterprise system is the effective handling of provenance information. Provenance is defined in various ways given the diversity of applicable domains. Simmhan et al (Yogesh L. Simmhan B. P., 2005) define data provenance as

“information that helps determine the derivation history of a data product, starting from its original sources.”

Provenance is at its simplest level information about where data (data objects) is from and what has happened (changes in state) along its journey until the present moment. Provenance information can be viewed as a specialized form of metadata information (even focusing on the data perspective primarily or the process perspective) that is fundamental to understanding ownership, special limitations, potential for cross domain usage, web service enablement, and enterprise level collaboration and awareness of current scientific data holdings as well as persisted, incremental annotations of researcher hypotheses and analysis. Provenance granularity is crucial to most levels of enterprise implementation since this will enable the needed multiple levels of abstraction required to describe underlying, fine grained field data, say, for optimum awareness and utility within the naval scientific research community. Provenance handling is so crucial to the enablement of a naval R&D enterprise system that its effective usage will be the technical centerpiece of this work. This work seeks to optimize provenance handling by addressing some of the remaining open research problems regarding provenance that will most likely impact a future, large scale naval R&D enterprise implementation.

## Open Research Questions with Provenance

Some of the current open research problems noted by the World Wide Web Consortium (W3C) (Paul Groth J. C., 2010) with provenance handling that are especially relevant to a naval R&D enterprise system for scientific data are:

No guidance on what level of granularity should be used in describing provenance of complex objects;

No guidance on publishing provenance updates;

No standard mechanisms to find and access provenance information;

No clear understanding of how to relate provenance at different levels of abstraction, or automatically extract high-level summaries of provenance from detailed records;

No standard representations that support integration of provenance across different sources;

No broadly applicable approaches for dealing with imperfections in provenance;

No means to resolve conflicts in (possibly inferred) provenance data.

Substantial work has been done in the provenance arena that will be detailed in the existing work section as well as developed to show the methodology selected and technical approach of this work that builds upon substantial progress in recent years regarding provenance curation.

## Research Focus

The core open research question of this work is as follows: **Can provenance information be formally modeled to enable effective repurposing, preservation, collaboration and discovery among interdisciplinary naval R&D scientists representing multiple domains generating scientific field and model data as well as annotations?**

The working hypothesis is as follows: **Formal modeling of provenance information will allow effective curated reasoning and repurposing across diverse, interdisciplinary scientific data collections and annotations.**

Research goals of this work are as follows:

1. Investigate whether a framework is possible to allow repurposing of interdisciplinary scientific data through formally modeling of provenance with a research enterprise environment;
2. Explore the evolving W3C PROV (follow-on to the OPM) as a potential augmentation to the framework;
3. Develop sample queries to show how interdisciplinary content can be repurposed with little effort required by the originating scientists;
4. Explore augmenting model with knowledge generation provided by formally modeling the enterprise itself to complement the exploitation of the interdisciplinary scientific data.

## **Chapter 2      Survey of Select Provenance Research**

Substantial interest in the exploitation of provenance information has been shown in the literature for the reasons outlined in the earlier background information of the introductory chapter (e.g., advances in sensors and modeling). However, little progress has been made in the complex arena of interdisciplinary, detailed scientific data curation aided by provenance reasoning. This survey chapter will focus on the following select provenance research areas that will be supportive in the development of a novel approach of curated reasoning based on a formal provenance model: provenance of provenance, eScience curation, geospatial aspects, temporal dimension, scientific workflow engines and systems, Electronic Lab Notebooks, SOA special features, cloud and “big data,” security, open provenance model, W3C PROV family of specifications, access and query and reasoning from provenance.

### **Provenance of Provenance**

Simmhan (Yogesh L. Simmhan B. P., 2005) provides a detailed survey of provenance noting that provenance is also referred to as lineage, pedigree, parentage, genealogy and filiation. This shows how provenance has such broad applications noting it is derived from the French word “provenir,” meaning to come from, applies to most every domain likely gaining special attention in the early art industry. Discussion is given on the growing complexity of large-scale and loosely coupled systems which

establishes a need for middleware (grid and otherwise) to combine the growing number of disparate source components. It is noted that the provenance of data generated from complex transformations such as workflows is of considerable value to scientists since quality is so closely coupled to “where the data is from” and all the changes that have occurred over a data objects life cycle to date. Data provenance is defined in this sense as information that helps determine the derivation history of a data product, starting from its original sources. Simmhan notes that it is convenient to conceptualize the provenance as a directed acyclic graph (DAG) which will be leveraged in this research. Simmhan gives additional background leading up to pointing out how the scientific field is moving towards more collaborative research and organizational boundaries are beginning to disappear in the face of dynamically created Virtual Organizations (VO). This move clearly motivates the provenance of this research which is to aid this movement for the naval R&D community.

Frew (Frew, 2005) notes that scientific research relies as much on the dissemination and exchange of data sets as on the publication of conclusions. Accurately tracking the lineage of the scientific data is shown to be imperative for the complete documentation of scientific work. Frew documents that the motivation of provenance is from the benefits scientists receive from the ability to track the lineage of computational results including accounting for errors or knowing how algorithms have been combined. Frew clearly points out that as much as provenance is helpful to ongoing scientific work; it also enables future generations to use historical data resources which are critical to successfully solving some of the most complex problems. Bose specifies key domains that benefit from lineage or provenance information noting

Geographic Information Systems (GIS), computational flow for scientific modeling, web and grid services, laboratory work, operating system processes and environmental data. Frew also shows how provenance “comes from” the laboratory notebook with modern environments appearing more like MATLAB or general purpose programming languages with scripting for execution flow control. Frew points out that lineage retrieval for complex workflows “will clearly present challenges.”

## **e-Science Curation**

Simmhan (Yogesh L. Simmhan B. P., 2005) created a taxonomy of data provenance characteristics for application in e-Science, especially focused on scientific workflow approaches. Simmhan identifies five primary characteristics of provenance: use, subject, representation, storage and dissemination. Simmhan shows how the two major approaches to representing provenance are annotations or inversion. An annotation being the collection of provenance information regarding processing flow which amounts to storage of pre-computed information regarding what happens to data objects in a workflow. Inversion, on the other hand, requires information that can be used to compute or identify source information such as queries and user-defined functions in databases. The selection of provenance representation is critical to the “curation” of scientific data since curation embodies the long-term, careful management and exploitation of these valuable holdings. Simmhan shows that “there is no metadata standard for lineage representation across disciplines, and due to their diverse needs, it is a challenge for a suitable one to evolve.” This is crucial in e-Science curation within



the naval enterprise given its many disciplines which points to the need for a novel approach to aid in the careful preservation of “where data objects are from and what has happened to them along the way.” Simmhan concludes “provenance is still an exploratory field.” Open research questions pointed out are ways to federate provenance information and assert its truthfulness as well as the ability to seamlessly represent provenance of data derived from both workflows and databases. Simmhan ends with noting “a deeper understanding of provenance is needed to identify novel ways to leverage it to its full potential.”

## **Geospatial Aspects**

Provenance information prominently enters into the geospatial domain given geospatial final products are normally a culmination of many sources that have undergone extensive, distributed processing and updating over some period of time. Geospatial data is known to be complex and thereby an excellent use case for testing new provenance models once they have progressed to measure how a particular provenance modeling approach will handle the complexities introduced by geospatial data types and processing stages whether they are web services or local, controlled processing.

Malaverri (Joana E. G. Malaverri, 2012) gives an approach to assessing the quality of geospatial data using provenance that builds on the features of the Open Provenance Model (OPM to be explained in more detail in a following section).

Malaverri shows how provenance is crucial to determine authorship, data quality and to allow reproducibility of findings. Significant to Malaverri's work is the core concept of trust and how provenance is mandatory in this arena. Malaverri notes that the Federal Geospatial Data Committee (FGDC) provides a set of terms to document geospatial data. The chosen elements utilized were positional accuracy, logical consistency, completeness and attribute accuracy. Each of these elements was given quantifiers from computing the quality of the attributes related to a particular artifact. Malaverri noted that this assignment of "trust values" is not trivial and requires tuning. It is shown how this process is especially difficult for geospatial data given the fact that processing is "essentially a cooperative, distributed effort, which hampers determining its reliability." Malaverri's usage of the OPM is significant as this will be developed to show this movement to create and leverage an open provenance model has led to substantial new developments by the World Wide Web Consortium (W3C) and an initial infrastructure that can be more efficiently extended for curated reasoning.

Geoscience data curation using open source frameworks is the focus of Pan (Jerry Pan, Pan, Jerry, et al. "Geoscience data curation using a digital object model and open-source frameworks: Provenance ap 2011) where it is shown that scientific data (Earth Science observations and model output) has become more heterogeneous in format and more distributed in handling. Pan shows that it is critically important for this specialized metadata (provenance) to be effectively preserved and reused for the long-term. Pan highlights that less attention is being given to situations where workflow engines (will be fully developed in a later section) are not used. Additional curation system requirements are also mentioned beyond provenance to include different types

of metadata, user-oriented functionalities such as rights control, user authentication and authorization, and data dissemination/visualization. Pan used an object abstraction framework to preserve provenance expressing relationships in Resource Description Framework (RDF) triples with a basic ontology. Pan's findings show that there is potential for object semantics and built-in semantic stored to preserve provenance knowledge. Pan leveraged the Fedora Repository and Drupal system in developing semantic relationships for abstract objects.

Tilmes (C. Tilmes, 2011) discusses scientific equivalence and essential provenance for scientific reproducibility. A cascading digital signature or "hash chains" are used to precisely identify sets of granules and provenance and as provenance equivalence identifiers to distinguish data made in an equivalent manner. Granule describes a file or set of related files corresponding to an individually identifiable portion of data. Tilmes assigns a unique, persistent URL to each artifact in the system and then relates those artifacts to others representing their relationship and using various ontologies. The workflow used by Tilmes maps into the OPM showing the continued usage of this early open approach to modeling provenance. Tilmes showed for earth science data, semantic tagging of cascaded digital signatures of a canonical serialization of essential provenance information can enable the scientific process to be reproduced reliably at a high level. Tilmes' goal is to extend this approach for complete provenance artifacts into a linked cloud (cloud issues will be developed in a following section) and provide a service for comparing datasets through their provenance graphs.

A geospatial effort focused on ocean observations is provided by Farcas (Claudiu Farcas, 2011) introducing a scientific data model that enables distributed, large-scale

storage and query of science data. The model is built on multiple levels of abstraction from domain-specific to message encoding. This model was implemented for the first release of the Ocean Observatories Initiative (OOI) Integrated Observatory Network (ION). Farcas notes that the Unidata Common Data Model (CDM) is the architectural basis for the structure and organization of science data in their system. Google Protocol Buffers (GPB) is used to provide a cross-platform serialization technology for rapid prototyping. This approach used by Farcas is different than most other research (found to date) in that it does not seem to build upon the OPM type efforts that have been noted on multiple occasions in this survey chapter even to this point. This approach does show there is still diversity of approaches for handling provenance information especially with the more complex geospatial variety. An extension to Farcas' approach could be the adoption of OPM type (we will discuss the W3C PROV family in a later section that is the latest community standard that has evolved from the OPM) richness that will support interchange of ontologies for rapidly increasing the complexity of model with various domain ontologies.

A state-of-the-art work in the geospatial arena is found in loup's dissertation (loup, 2011) where a sophisticated geospatial service catalog is backed by a descriptive logic model. loup's model and catalog provide architecture to support automatic orchestration of complex compositions which is a rich environment for exploitation of provenance. loup collects provenance information but provenance modeling is not the aim of this work given the ample complexities required to design and build a geospatial service catalog and model that automatically generates Open Geospatial Consortium (OGC) web services. loup's work clearly represents a potential target for later testing of

reasoning based on formally modeled provenance as noted by, “As improvements are made to these reasoning and query engines, they can easily be incorporated into the geospatial service catalog.” There seems to be significant opportunity to include OPM/W3C provenance modeling into loup’s model to allow for new reasoning and focus on provenance which is fundamental to trust and exploitation of various distributed services that can be registered in this sophisticated catalog with an underlying model that supports semantic information. loup’s approach models core service types by classifying by data type and origin restrictions, for example. The origin restrictions, for example, are an area that could be potentially expanded upon to include detailed provenance information for greater trust reasoning, for example. loup’s work provides the most complex handling of state-of-the-art geospatial services found to date and thereby represents a substantial platform for expansion to include reasoning based on formally modeled provenance.

## **Temporal Dimension**

The temporal dimension can be critically important in handling provenance information given the requirement to sequentially manage the processing stages that are applied to a data object as well as know the sequence of model runs that may require data inputs as boundary conditions or may serve as an input to another workflow. The temporal aspects of provenance are related to granularity since provenance information can rapidly grow to even exceed the original data size. However, little targeted research was found regarding the focused temporal aspects of provenance.

Chen (Peng Chen, 2012) describes a representation of provenance data based on logical time that reduces the feature space. Creating time and frequency domain representations of provenance allows the application of clustering, classification and association rule mining. Central to Chen's approach is the assertion that directed, annotated provenance graphs are not ideally suited to data mining for two reasons: 1) provenance graphs can have thousands of nodes and attributes. Clustering in this high dimensional space presents substantial complexity and 2) it is difficult to place structural and non-structural information in a single uniform attribute space. This motivates Chen to propose a graph partitioning algorithm that uses logical clocks as the basis for an abstract representation of provenance. This notion of a logical clock takes a node as input and produces an integer as output. This function maps an integer to each node of a given provenance graph. The correct logical clock must satisfy the condition that if node a occurs before another node b, then a should happen at an earlier time than b. Chen used the Karma provenance tool which allowed the export of OPM graphs (this idea will be discussed in Chapter 3). Again here it is seen that OPM is leveraged for rapidly providing an open model for supporting provenance information. Chen documents temporal representations generated by this method are three orders of magnitude smaller than the original provenance. It is also noted that this can be further reduced by transformation into the frequency domain. Chen also notes there are several open questions such as how well does this approach work for a less well controlled provenance data set? Also, how does the approach extend to other provenance-specific questions such as data lineage?

## Scientific Workflow Engines and Systems

Scientific workflow engines and systems are tightly coupled to provenance management in several domains (bioinformatics is one of the leading areas of exploitation of workflow technology) given that they allow for management of complex process flows that are even normally distributed in nature. This level of coordination is crucial for tracking the operations on data as well as the required scheduling to broker these sequences. There are many scientific workflow engines available now that are tailored for various uses. This section will survey some of the prominent ones as well as showing domains of usage, strengths, weaknesses and ultimately utility to contribute to the goal of this research, curated reasoning by formally modeling the provenance of interdisciplinary scientific research for the naval R&D community.

Barker (Barker & Hemert, 2008) provides an excellent survey of workflow engines and directions by segmenting this area into business and scientific segments. For completeness, the business segment will be examined to ensure all established research is being leveraged, but clearly the scientific segment will likely offer more direct application to the core purposes of this research.

Within the business segment, Barker covers the fundamentals of service orchestration with services interacting at the message level with explicit definition of the control of data flow even across organizations. The Business Process Execution Language (BPEL) is noted to be an executable business process modeling language that is the current de-facto standard approach for orchestration of web services.

However, there are many other languages such as Yet Another Workflow Language (YAWL) with a formal underpinning based on Petri-nets. XML Process Definition Language (XPDL), WfMOpen and Web Services Choreography Description Language (WS-CDL) are also discussed noting the number of languages present in the business segment. This number of custom languages does present challenges for interoperability but BPEL does dominate this segment even without the particular special advantages for specific applications that some of the other languages provide. The business workflow approaches are aimed at a different level of abstraction than is required for scientific processes and therefore are not of substantial value to leverage within the purposes of this research.

Barker describes the scientific workflow segment requiring higher level (not in terms of abstraction) to allow the interconnection of problem solving components to prove a hypothesis. A scientific workflow attempts to capture a series of analytical steps that describe the design process of computational experiments (this series of steps is the core or provenance itself and thereby emphasizing the relevance of workflow research). The scientific workflow systems provide a higher level environment to assist in the scientific discovery process via combining scientific data management, analysis, simulation and visualization. Barker states that as a consequence of the lengthy, iterative design process, workflows become a valued commodity and a source of intellectual capital (a clear motivation for this research is shown here to preserve naval intellectual capital that is being currently generated but not curated for preservation). The output of workflows may be used as a basis for future research, either by the original generating scientists or colleagues in a related field (another clear



potential application to a naval enterprise system that would enable this type of collaboration). The fundamental here is that for a workflow to be reproduced, provenance information must be recorded that indicates where the data originated, how it was altered and which components and what parameter settings were used.

Barker covers several scientific workflow engines to include Taverna, Kepler, Triana, Pegasus, GridNexus, DiscoveryNet and several other bioinformatics particular engines. The specifics of these will not be covered in detail since workflow engines per se are not the focus of this work but how these may assist the formal modeling of provenance will be the ultimate utility. This angle will be fully developed as the paper proceeds but the key point of leveraging is that some of these tools, such as Taverna, automatically generate W3C PROV-compliant ontologies (allowing a level of interoperability and scaling) as well as provide an extendable platform to rapidly model both web services and conventional programmatic processing.

Barker concludes with key findings regarding workflow engines noting that collaboration is key, use caution regarding the hype around workflow engines being oversold to the scientific community, certainly do not implement another workflow language, many scientists are not comfortable using even the most abstract workflow tools and stick to standards (Taverna uses SCUFL, a proprietary language which is a weakness for broad application of Taverna and other scientific workflow engines). It is clear from this detailed survey from Barker that the workflow engine technology will not currently solve the stated goals of this research but it appears there may be utility in using a workflow engine such as Taverna for a rapid prototyping environment (not

deployment) for speeding up the formal modeling and testing of provenance handling to assist decision makers regarding curation.

Ghanem (Ghanem, 2008) provides research into the question can one scientific workflow system satisfy all applications? Ghanem investigates six key systems/languages (actually four systems and two languages): Discovery Net, Taverna, Triana, Kepler, Yawl and BPEL. Ghanem provides detail on the control flow and data flow for each system and then compares the key features of each under these four aspects: syntactical features, control behavior, data behavior and embedding. Ghanem concludes that scientific workflow systems will continue being developed for various domains with guidance by those domains' needs. Ghanem notes that due to this fact, "it is highly unlikely that standardization will occur on any one system, as it did with BPEL in the business process domain. Therefore, modeling and analyzing the process and data capabilities of workflow systems in a framework independent of any particular implementation is a valid and necessary research goal." Ghanem provides clear direction that research should be independent of a particular implementation which underscores the importance of the OPM and following W3C PROV developments for providing at least a base of interoperability for ontologies to describe provenance and therefore allow the continued growth in understanding of how to better leverage this fundamental aspect of scientific experimentation, collaboration and discovery.

Bowers (Shawn Bowers, 2006) develops a simple provenance model for supporting scientific use cases. Bowers approach reduces the use cases to database queries over event logs and shows capability of reconstructing complete data and invocation dependency graphs for a workflow run. Bowers basis of approach is to build

the provenance model on the read, write and state-reset events and finds that this simple approach is enough to capture many relevant science-oriented provenance use cases. The use cases become queries against an event log. Bowers approach does focus on a simple bioinformatics use case single domain and does not involve semantic information or approaches. Extension of these approaches is not likely for the interdisciplinary scientific domain targeted by this research.

Yue (Peng Yue, 2011) develops a provenance framework for web geoprocessing workflows. Yue's focus on geoprocessing is of particular interest since this normally represents the more complex use cases (geospatial/environmental data) where there is potential to gain insights for potential application to this research project. Yue's primary approach is to model provenance at three levels (knowledge, service and data) while extending the OGC Catalog Service for the Web (CSW). Yue registers provenance entities into the OGC CSW by extending the underlying Organization of the advancement of structured Information Standards (OASIS) enterprise business Registry Information Model (ebRIM). EbRIM model defines a set of classes to describe metadata of information resources and the relationship among them. Yue points out the most important class of the ebRIM model is RegistryObject which is inherited by most other classes such as ExtrinsicObject, Service, Association, Classification and Slot. Yue notes the use of BPEL as one of the key technologies as well as WSBPEL. This is an interesting approach shown by Yue especially given the unconventional mix of the business segment of tools with the more conventional scientific world represented by OGC. It is noted that ebRIM is incorporated into the OGC CSW as a standards-based approach even though this does mix two generally separate domains (business and

scientific). This work is significant since a future target of this research could be the testing of results within a CSW or other model/catalog system such as the advanced approach given by (Ioup, 2011).

Stromback (Stromback, 2011) builds on the OPM to leverage this open interchange for provenance ontology with coverage of the five OPM dependencies: artifact used by a process, artifact generated by a process, artifact derived by an artifact, process triggered by process and process controlled by agent. Stromback compared the performance of two leading scientific workflow engines' (VisTrails and Taverna) query performance finding similar results from each. Stromback points out that since the underlying data model is a graph model that there is potential gain from representation within a graph database. Graph databases being based on graph theory are more tailored to graph data management than relational databases. Stromback notes this transform the model into a graph database will be a future research direction. It is useful to note Taverna and VisTrails compare similarly regarding performance and the notion of a graph database to serve as a potential repository could be a useful angle for this research.

Chebotko (Artem Chebotko E. D., 2012) creates a benchmark for measuring and comparing provenance storage and querying systems. The benchmark utilizes 27 predefined provenance templates representing provenance captured for three sample workflows using three vocabularies (OPMV, OPMO and OPMX) that serialize provenance according to the Open Provenance Model in RDF and XML formats. Chebotko does also point to the upcoming W3C PROV family of specifications that are still in draft form as the research was done and are still today as this chapter is being

written. This benchmark could prove useful in future evaluations of this research given its support for OPM and the follow on W3C PROV family of specifications.

Luo (Ruiqi Luo, 2012) provides automated analysis algorithms and complexity results for three provenance problems. Luo notes that correct specification of provenance access control policies are critical in workflow security (the security aspects of provenance will be further described in a following section on security). Results from Luo may be useful in future complexity analysis of other provenance workflows that are developed.

Ruan (Dong Ruan, 2012) clearly notes a workflow management system weakness of a lack of exception handling (this has already been experienced during the initial prototyping of this research). Ruan develops a new language based on a workflow model that shows the level of effort required to address this key weakness with workflow management systems. This weakness is another clear reason why an interdisciplinary scientific R&D collaborative enterprise should not be built upon current workflow management systems.

Deelman (Deelman, 2012) develops a theoretical analysis with simulation results to demonstrate that task clustering failure can have a significant impact on runtime performance of workflows that use existing clustering policies that ignore failures. Deelman primarily focuses on distributed execution of workflows with fault tolerance. This distributed execution and fault tolerance dimension will not be integrated into the current research focus of formally modeling provenance for reasoning purposes.

## Electronic Lab Notebooks (ELNs)

Electronic Lab Notebooks (ELNs) were adopted early on by the pharmaceutical industry primarily focused on medicinal chemistry. These ELNs have allowed for the efficient sharing of information among researchers and is now viewed as a core part of the pharmaceutical workflow process. CambridgeSoft is one of the major ELN options and its largest installation is at Merck & Co with 7000 users leveraging the same ELN system. (King, 2011) King points out that one of the limiting factors at present is the slow adoption by the academic community given the preference for open solutions versus licensed commercial applications. The ELN is shown to offer exceptional safety features since chemicals are tracked from the time of purchase through the production process (provenance). King also points out the primary limiting technical issue with ELNs currently is the lack of interoperability among ELNs.

ELNs usage in regulatory compliance within the pharmaceutical industry has become vital given their detailed recording of project management flows as well as the underlying interchange among all the interacting processes required for new drug approval. (Colin Bird, 2013) Bird also points out the key challenge facing ELNs being the difficulty in exporting data among various ELNs. The fact that many scientists do not feel comfortable with detailed documentation on “failed” experiments was also identified as a factor in slowing the adoption of ELNs. Bird identifies a CombeChem demonstration experiment that utilized semantic technology in combination with ELNs. There is still much room for exploration of semantic web technology within the ELN domain. Bird identifies the key markets for ELNs shown below in Table 1.

<b>ELN Primary Market Audiences</b>
R&D
QA/AC
Chemistry
Biology
Multidiscipline

**Table 1, ELN Primary Market Audiences**

Also identified are the primary ELN vendors and of special interest are the vendors in the multidiscipline space as shown in Table 2 below. The fact that there are only two primary vendors in the multidiscipline space will create challenges to support more interoperable solutions that would likely attract greater academic involvement.

<b>Primary Multidiscipline ELN Vendors</b>
CambridgeSoft
IDBS

**Table 2, Primary Multidiscipline ELN Vendors**

Bird summarizes the substantial potential for ELNs but concluded with the fundamental challenge of trust in sharing which is heightened given the detailed record keeping of provenance content in ELNs.

A key semantic web publication in the ELN arena notes that semantics aid the discovery, reliable re-use of data, provide improved provenance and facilitate automated processing to reduce ambiguity. (Frey, 2009) Frey points out that semantic technology allows the linking between the literature and ELNs. Frey notes that linking data and exploiting relationships is the key benefit of the semantic web but challenge is “getting people to add them.” This recognition is exactly the core challenge explored in this research and why passive approaches are emphasized in later chapters. Frey also concludes that semantic web techniques will not solve all problems obviously with communication and collaboration but will aid computer-to-computer interactions.

The key interoperable issue of sharing content among ELNs is addressed by leveraging the Open Provenance Model (OPM). (Slominski, 2010) Slominski has identified the primary way forward using OPM (now latest is W3C’s PROV O) for interoperability in cloud and grid environments which is the same core technical challenge faced by interchanging among the principal ELN vendors shown earlier.

Managing information within ELNs will require using interoperable ontologies. (Alexander Garcia, 2011) Garcia notes there are still substantial biomedical methodology gaps and points to the need for interchange among developed ontologies. Garcia utilizes a tagging approach from the semantic web arena to aid in the management of ELN content. Again, the PROV O development is directly applicable in this situation and could be a key developmental component that has been missing for the ELN industry.



## SOA Special Challenges

Venters (Colin C. Venters, 2011) points out that the distributed nature of Service Oriented Architecture (SOA) approaches emphasizes the need for improved techniques for handling trust. The decision to trust is based on evidence to believe or to be confident in someone or something. Venters performs a survey of the literature and notes that it is argued that provenance can increase trust in heterogeneous data and services. Venters states that current definitions suggest that trust derived from provenance should be accompanied by quantitative metrics. These quantitative measures do add some complexity to SOA systems and “how this can be best achieved is still largely unclear.” Venters work shows that deriving trust from provenance information is still in its early stages for SOA systems but certainly is a fundamental concept with broad application. The trust measure for a naval R&D enterprise will be somewhat simplified since the sources will be more controlled even though loosely coupled. Trust will likely be measured more in terms of data quality or applicability for a specific scientific application or repurposing.

Freire (Juliana Freire, 2008) notes that managing provenance for computational tasks has gained significant attention due to its relevance to a wide range of domains and applications. Freire identifies two types of provenance: prospective and retrospective. Prospective provenance captures a computational task’s specification (workflow or script) and corresponds to the steps that must be followed to generate a data product. Retrospective provenance captures the steps executed as well as the information about the environment used to derive a product. Freire discusses the

Provenance-Aware Service Oriented Architecture (PASOA) project that developed a provenance architecture that relies on individual services to record their own provenance. The system does not model the notion of workflow, but it captures assertions produced by services that reflect the relationships between the services and data. The system must infer the complete provenance of a task. Freire states that provenance research is enabling “science collaboratories, which have the potential to change the way people do science – sharing provenance information at a large scale exposes researchers to techniques and tools to which they wouldn’t otherwise have access.” This insight is certainly supportive of the goal of this research and the PASOA may be of application with the caution that it is an inversion approach that requires calculation to generate the provenance as opposed to a stored approach.

Groth (Paul Groth Y. G., 2012) gives multiple scenarios where provenance is critical and documents that “most users only populate about five of the fifteen core fields available in Dublin core.” This underscores the need for automated tools to at least partially capture provenance and certainly aid in the curation of large repositories. This point is central to the ongoing research. Groth also notes that “how to collect adequate provenance, especially from end-users, is a challenging open problem.” Clearly Groth provides additional evidence of the need for formal approaches (machine-based) to handling provenance.

Rajbhandari (Rajbhandari & Walker, 2006) develops a provenance model that facilitates the capturing and recording of process provenance. Rajbhandari focuses on provenance in the bioinformatics area specific to myGrid effort. Utilization of a workflow

engine (as well as focus only on bioinformatics within myGrid) in the actual model limits how this work can be extended for the current interdisciplinary research focus.

She (Wei She, 2011) developed an integrated model for data provenance and access control within a SOA environment. She showed how data provenance information can enhance the access control model to enhance information flow. She develops a role-based trust approach and then a data consistency with impact on trustworthiness. This work could provide some insight into role-based usage of scientific data within an enterprise setting.

### **Cloud and “Big Data” Usage of Provenance**

A cloud computing section is included since the growing centralization of computer resources that then are partitioned out to large and diverse customer bases only increases the need for improved tools to aid the curators of such complex data stores. Formal modeling of provenance can potentially remove some of the human workload (core hypothesis of this research) required to further establish trust, security, inter-process interactions, changes in data state, etc. for reasoning in curation as well as the application of advanced analytics to seemingly unlimited amounts of data (the “Big Data” focus) describing events and transactions.

Zhang (Olive Qing Zhang, 2011) points out that provenance information is important to enhance reliability, credibility, accountability, transparency and confidentiality of digital objects in a cloud. Zhang classifies provenance according to

granularity levels and proposes an approach, DataPROVE, to address challenges of provenance data handling within a cloud environment. Zhang's description of cloud computing distinguishes it "by its appearance of infinite computing resources that can be upgraded or downgraded freely on demand and its pay-per-use billing feature as utility computing." Provenance is shown to support the verification of authenticity, allow for detection and tracking of faults, access control policies, legal issues and policies, etc. Zhang lists provenance levels of granularity at the following levels: Application, Virtual Machine, Physical Machine, Cloud and Internet. Zhang's DataPROVE approach encapsulates the cloud with the following five layers of granularity: System, Data, Work-Flow, Laws and Regulation and Policies. Zhang's overall approach is aimed at improving transparency and accountability of data managed in a cloud configuration (as noted earlier, a cloud can be viewed as a special form of curation). Zhang concludes that provenance information is crucial for increase adoption and sustainment of cloud services. Zhang also notes that provenance collection and utilization must extend to inter-cloud, cloud-to-internet and internet-to-cloud data object movement.

Atkinson (Malcolm Atkinson, 2012) investigates a new workflow language DISPEL that provides definitions that can be mapped onto arbitrary platforms (Hadoop or Dryad, etc.) by specifying the logical properties of workflow components and how they connect together rather than to some specific platform. A DISPEL workflow is shown to be an abstract network of processing elements. DISPEL is centered on data flow rather than a control-flow perspective. This allows for no specification on how data should be produced or consumed, just a processing element flow. Atkinson's approach shows promise for handling of provenance information given its focus on processing

stages but does introduce another language complication for potential system integration.

## Security

Security issues are included in this survey since this is one of the few issues that can completely halt an enterprise or even a discrete project. Provenance assistance in this area can only contribute to overall improved system architecture.

Cheney (Cheney, 2011) states that "...relatively little progress has been made on foundational models that define provenance and relate it to security goals such as availability, confidentiality or privacy." Cheney develops a formal model of provenance for security properties such as disclosure and obfuscation. Cheney's approach is a theoretical one with theorems and associated proofs to add to the approach. No prototype implementation is noted for potential lessons learned to support a prototype implementation phase of this research.

Davidson (Susan B. Davidson, 2011) discusses how to integrate privacy guarantees in the design of provenance management systems for scientific workflows. Central to Davidson's paper is the point, "Although we have sketched initial ideas on structural privacy, a formal characterization and study remains to be done." Davidson also points out that the interaction between the private and public modules makes this problem much more difficult. Davidson also continues to point out there are many challenges to efficiently implement search and querying with privacy guarantees. Since

some users have different access privileges and access is normally done via inversion of indices this complicates this entire flow. Davidson shows there remain serious research matters in handling provenance with regard to privacy and some of the identified challenges could be useful to guide potential reasoning approaches during the prototype phase of this research.

### **Open Provenance Model (OPM)**

The OPM has been a catalyst in the rapid, recent progress of more fully leveraging the inherent information content contained within provenance chains especially when it relates to more complex systems requiring levels of interoperability. The OPM was so successful that the W3C community has picked up on this approach to continue it towards standardization (discussed in the next section). Clearly, neither survey Chapter nor current research to further provenance handling would be complete without addressing and learning from the substantial OPM work.

The OPM site (Model, 2012) gives the following background: “The Open Provenance Model OPM is the result of the Provenance Challenge series that was initiated in May 2006, at the first IPAW workshop. OPM was originally crafted in a meeting held in Salt Lake City in August 2007. OPM v1.00 was released to the community in December discussing issues related to this specification, and led to a revised specification, referred to as OPM v1.01. From the outset, the original authors’ intent has been to define a data model that is open from an inter-operability viewpoint

but also with respect to the community of its contributors, reviewers and users. To ensure that these principles are adhered to, an "open source like governance model for OPM was adopted in June 2009, which led to the development of OPM v1.1, the most recent version of the model, which went under a public revision process. ”

The OPM organization provided an abstract model, an XML schema; a vocabulary, OWL ontology and a JAVA library to promote interchange (Model, 2012) which will be further explored by some of the number of publications that cite this reference material.

Liu (Yong Liu, 2010) is the first paper to leverage the OPM in a sensor web application showing the utility of OPM providing a share, common set of standards that effectively frees developers from being completely tied to a workflow management system. Liu noted that “No consensus has been reached in the broader scientific provenance research community, largely because different applications have different requirements for the use of provenance information.” This finding continues to build the case for this research effort that is aimed at this very community of broad, interdisciplinary data collection and curation. This is clearly a challenge but one where incremental progress can only contribute to a future naval enterprise system for curation of scientific data.

Liu’s case study focuses on virtual rainfall sensors with semantic content leveraging a middleware package Tupelo. Liu’s case highlighted that OPM is described independently of implementation details though a Java library is provided for

practical usage. Liu noted that performance evaluations will be carried out in future work.

Moreau (Moreau, 2011) goal is to investigate the ability of OPM to represent provenance among distributed system components. Moreau develops rules to include a “contract” to enable participants within a distributed system to ensure provenance information can be appropriately integrated. Since OPM is aimed at supporting interoperability among disparate systems and sensors, it is most useful that Moreau showed success in that OPM is “suitable for representing distributed systems.”

Freitas (Andre Freitas, 2011) explores the application of the OPM to the open web. Freitas uses the following set of information quality dimensions: accuracy/correctness, compliance, completeness, consistency, interpretability, usability, reputation, security, timeliness, objectivity, accessibility, navigation and concise. Various use cases are given where provenance is shown to be crucial in these different domains. Freitas develops a W3P model based on OPM to accommodate web content. Freitas notes that OPM ontology provides the base ontology from which W3P is derived. W3P also covers social provenance, maximizes the reuse of OPM vocabularies and provides continued evidence that a standard OPM-type approach is crucial for interoperability and extension.

Miles (Miles S. , 2011) describes a very useful research project to map the conventional metadata world found in the Dublin Core to the OPM. There are clear differences between these two “worlds” of metadata but Miles shows how by undertaking this mapping, services can now exploit the best of Dublin Core



“conventional” metadata along with OPM-type metadata that is more aligned with curation in terms of preserving and regenerating states of data or processing chains. This interconnection could certainly be applicable to the thrust of this research effort since if more conventional metadata is available, it certainly needs interconnection to the OPM/W3C PROV family of representation for improved reasoning. This interconnection in and of itself could aid reasoning across a diverse naval enterprise of scientific data.

The Open Provenance Model Core Specification (v1.1) is outlined in (Luc Moreau, 2010) where the fundamental interactions among artifacts, processes, and agents are developed to allow the causal relationship modeling to develop a rich provenance graph describing the chain of events of some (not tied to implementation level or even computing necessarily) process. Moreau notes that “Prior to the first OPM specifications, multiple provenance technologies had been developed, but none aimed at defining a technology-agnostic provenance data model for inter-operability purpose.” This move forward is clearly core to this research effort since this “common space” is required for handling the complexity of disparate and fine-grained scientific data sets with their associated processing chains that may be loosely coupled (involving high performance computer centers, etc.). OPM, like Dublin, has elected to maintain a core that is separate from extensions to allow at least a minimum level of interchange and interoperability.

Sakka (Mohamed Amin Sakka, 2012) takes a robust approach to leveraging OPM and semantic enriching of content with an interoperability layer to allow loosely coupled (especially in the sense of not within a single workflow management system)

handling of provenance for improving trust. Trust is a central motivator and theme throughout most of the existing research on provenance since this applies to so many different applications. Sakka's framework confirms that the general research approach should incorporate the OPM/W3C PROV-type interoperability with semantic enrichment. This approach is to complement the continued acceleration of loosely coupled approaches to the latest level of cloud curation. The more decentralized data and its processing stages are the greater the requirement for this general approach. Sakka does not handle complex, interdisciplinary data which introduces additional complexities of curation but still could benefit from this similar initial approach.

Defude (Defude, 2012) in another paper proposes a mediator-based system for end users to issue queries on a distributed provenance management system as well as a distributed query processing algorithm. Defude leverages OPM as well as standard semantic approaches to build the provenance management system. Defude proposes a mediator level to broker among the various sources of provenance. This approach assumes all sources are using the same provenance management system architecture which Defude notes will be relaxed to continue this line of research. A mediator or broker level within an architectural approach is a likely needed component for an approach for fine-grained scientific data that is the subject of this research.

Deelman (Ewa Deelman, 2010) provides an excellent summary of surrounding approaches to metadata and provenance management for scientific applications. Central to Deelman's enabling approach for multidisciplinary and multi scale applications is to leverage the OPM-type approach to allow interoperability among disparate systems and sources. Deelman further confirms the architectural requirement

to leverage a OPM/W3C PROV approach at the center of this research for improved scientific data curation. Deelman also motivates this research by noting, “There is already good progress, but unified metadata and provenance systems for scientific communities are a long way off.”

## **W3C PROV Family of Specifications**

Antoniou (Grigoris Antoniou, 2012) details a recent meeting where provenance was discussed among leading researchers showing “this is a clear community with clear problems.” The organization of this community around the fundamental concept of provenance is noteworthy especially with the W3C incubator groups being established to build upon the OPM work to produce a family of specifications for ensuring provenance progress continues for the semantic web and other applications. Antoniou specifically identifies a current limitation of provenance research being “querying and reasoning with provenance data.” This limitation is the central reason for exploitation of provenance information to allowed curated reasoning (a novel expression as well) for scientific data handling within an enterprise setting.

The W3C is currently (as this Chapter is being written) building draft versions of a family of specifications that establish a W3C provenance version and continuation of the OPM initial research. The six primary specifications are: PROV-DM, Constraints of the PROV-DM, PROV-N, PROV-O, PROV-AQ and PROV Primer.

PROV-DM (Missier, W3C PROV-DM, 2012) describes the underlying data model of PROV focusing on six components: (1) entities and activities; (2) derivations of entities from entities; (3) agents bearing responsibility for entities that were generated and activities that happened; (4) a notion of bundle, a mechanism to support provenance of provenance; (5) properties to link entities that refer to the same thing; (6) collections forming a logical structure for its members. The PROV-DM builds upon its core structures of Entities, Activities and Agents with a short summary of these interactions being: an Activity caused an Entity with an Agent being responsible.

The Constraints of the Provenance Data Model (James Cheney, 2012) defines a subset of PROV instances called valid PROV instances. The given intent is to represent a history of objects and their interactions which is consistent, and thus safe to use for the purpose of logical reasoning and other kinds of analysis. This is clearly pertinent to this ongoing research.

PROV-N: The Provenance Notation (Missier, W3C PROV-N: The Provenance Notation, 2012) provides examples of the PROV data model and facilitates the mapping of the PROV data model to concrete syntax used as the basis for a formal semantics of PROV. PROV-N defines the notation.

PROV-O: The PROV Ontology (Timothy Lebo, 2012) expresses the PROV Data Model using OWL2 Web Ontology Language (OWL2). PROV-O provides a set of classes, properties and restrictions that can be used to represent and interchange provenance information from disparate systems and contexts. PROV-O can be specialized to create new classes and properties to model provenance information for

different applications and domains. This feature is clearly critical to this research since the model may need extension if a given use case demands but the core interoperability will remain.

PROV-AQ: Provenance Access and Query (Groth, 2012) specifies how to use standard Web protocols (e.g., http) to obtain information about the provenance of resources on the Web.

PROV Model Primer (Miles Y. G., 2012) provides an intuitive introduction and guide to PROV specification for provenance on the Web. It is noted here that the clear aim is the Web while this is closely related to enterprise type applications; there are differences that will require investigation through this research.

## **Access and Query**

Access and query is another focus area for provenance research that is important in an overall survey of select provenance research as well as informative for any implementation or prototyping phase. Access and query issues range from using specialized databases (e.g., graph, XML) to granularity levels and indexing. This research will not particularly focus on this aspect of provenance handling but will certainly require awareness for the test bed implementation developed to test hypotheses and performance (as noted, it is not practical to totally ignore access and query in the provenance arena even if it is not the focus since it is necessary for reasoning).

Lim (Chunhyeok Lim, 2011) took the fundamental approach of beginning with the OPM and using it as the underlying data model for the research which is similar to the basic methodology chosen for this research which is to begin with the W3C PROV (follow-on to OPM) as the underlying data model. Lim designed a relational database schema and then employed some of the basic provenance reasoning features within OPM (e.g., WasTriggered By, WasDerivedFrom and WasGeneratedBy). Lim has a solid approach in leveraging OPM (common open standard at the time) data model and then looking to exploit reasoning from that angle. The current research is different from Lim in that interdisciplinary, fine-grained scientific data is the focus where the data does not begin in a workflow management system. The handling of interdisciplinary scientific data greatly complicates reasoning given that the content does not begin in a workflow management system(s) nor does the content semantics stay neatly within a given domain vocabulary.

## Reasoning from Provenance

Chebotko (Artem Chebotko S. L., 2010) focuses on the idea that “a scientist might release partial provenance information concerning scientific results, source data, scientific workflows, and parameter settings that are just enough to convince stakeholders, but hide certain provenance information to protect intellectual property.” The varying levels of abstraction handling for scientific data supported by provenance could be critical to an actual naval enterprise system for the R&D environment given the interest in allowing rapid publication and sharing of data/findings but still protecting the original Principal Investigator (PI) with publishing abilities (for a certain timeframe, maybe two years or so before all data should be available across the naval enterprise for repurposing, etc.). Chebotko’s varying levels of abstraction for security/access control via provenance is clearly a useful angle that could be leveraged in a formal sense for improved curation since this could aid the curator’s management of holdings in more than a binary sense (handle a partial release).

Yan (Shunqing Yan, 2012) demonstrates the broad appeal of provenance information and its application to reasoning in the tracing of cross contamination within the food supply chain. Yan used a heuristic tracing algorithm approach with success in this particular domain. Yan did not leverage the OPM/W3C PROV data model with all the power that it enables for reasoning which will be the beginning point of this research.

Dogan (Gulustan Dogan, 2011) did leverage the OPM to design an architecture with node-level trust information based on provenance which enabled a strong basis to begin the work. Dogan used a solid design but the actual “real-life” network is a future implementation. A prototype is critical to test a proposed (at least an early prototype) approach and will be discussed in the later sections of this paper.

Jung (Im Y. Jung, 2011) develops a trust reasoning approach for data believability using a multi-layer trust reasoning algorithm based on OPM. Jung’s approach “avoids tracking all the artifacts and arcs on OPM.” This approach could be effective for targeted domains but for the interdisciplinary scientific domain of interest for this research, more of the initial OPM-type data model will likely be necessary to promote reasoning in such a complex, fine grained environment.

Bai (Quan Bai, 2011) focused on reasoning via provenance by building a knowledge base and case search engine for assisting in trust estimation. A knowledge based system will not be the focus of this research project per se but Bai does show how versatile provenance information is in the reasoning process.

Bettini (Bettini, 2012) combines provenance information with context data. Then as context data is interchanged among entities, the associated provenance information is attached. Bettini builds on the OPM model but recommends extension to the “ontology with classes and properties to represent missing features: context data, aging functions, probability distributions, expiration time, and quality indicators.” This type extension to OPM or W3C PROV is precisely the planned research methodology of this paper if extensions are needed at the prototyping level. Bettini notes one of the



remaining open issues for their research is the preservation of privacy. Another useful angle from Bettini's work that is useful to the interdisciplinary scientific domain is that of uncertainty handling which can be aided by the extensions to the data model noted above.

Moitra (Abha Moitra, 2010) focuses on the Information Assurance (IA) domain within a cross domain context. Each message in Moitra's approach generates a provenance record as the message moves between agents, systems or processes. Moitra's work provides insight into how the granularity of provenance will be critical to this research project in the sense that the level chosen will enable or limit reason as well as performance, etc. This research project will not focus on the IA domain but the cross domain angle of Moitra is certainly applicable. Moitra concludes noting that "We also believe the approach to be suitable for including more subjective information such as opinions and knowledge of outside conditions." This dimension could be useful in this research project's handling of scientific annotations.

Chao (Chao, 2012) provides an initial at rhythms of scientific data usage for long-term curation. Reasoning based on patterns of usage could certainly be applicable to this ongoing research project. Chao does not leverage the W3C PROV semantic approach as a beginning point but only focuses on usage patterns without modeling more of the data object's life cycle and semantic content. Though the underlying research methodology used by Chao does not begin with the core W3C PROV approach in this effort, the utility of encoding rhythms within the semantic data model could be useful to reasoning in a complex interdisciplinary scientific domain.

## Chapter 3      An Active, Simple Bathymetry Use Case

### Introduction

Experimental prototyping is initiated with the “simple” use case of bathymetric data. It is significant to note that the experimental prototyping focus is not on the underlying technical implementations but on the value/lessons learned for overall provenance framework design and later testing through queries which guide the documentation of significant aspects in these workflows. The bathymetry is considered “simple” since the data is only x,y,z triples (x,y position and z=depth value) with no metadata concerning provenance. This use case is considered active since all provenance will need to be generated. This chapter explores how active scientific data sets can generate provenance information to aid in the repurposing of the content as well as improved long-term curation. The open source workflow management system Taverna (myGrid-OMII-UK, 2013) is utilized in this experiment to explore usage of workflow management systems for active provenance generation as well as to efficiently leverage the fact that Taverna has implemented support for the W3C PROV O ontology which allows rapid experimentation with this latest provenance ontology. Results and issues are described in this chapter relating to the active provenance generation using Taverna.

## **Taverna Workflow Management System**

The data is first prepared to match the Taverna base 64 encoding for ease of XML import. Two primary processing functions (TINing and color coding of depth bins) are implemented to allow for provenance generation to experiment with the PROV O ontology. The interaction with the Taverna workflow management system is shown below in Figure 1 showing available services, graphical user interface for workflow creation and all available build-in Taverna capabilities that allows for a somewhat rapid prototyping process. Some of the main complications encountered were found in integration of external Java source with Taverna and debugging with limited exception handling.

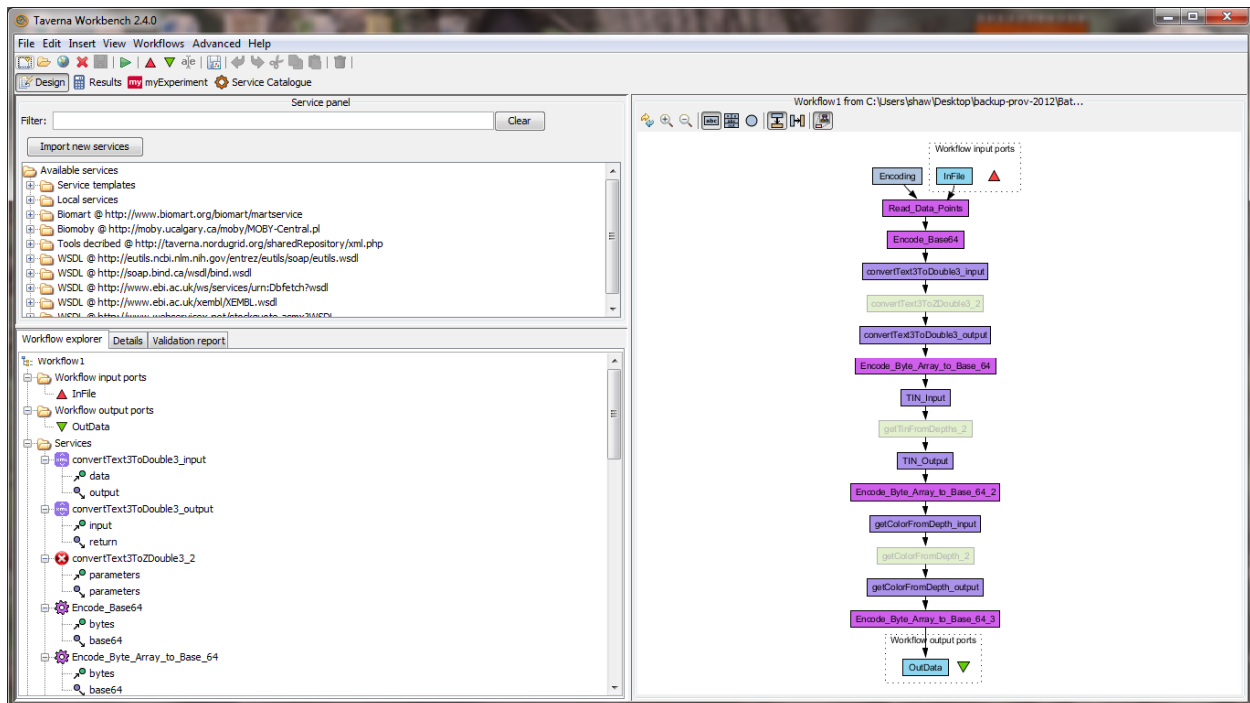


Figure 1, Taverna Workflow Management System

Figure 2 below shows the results of a successful validation of the workflow run through the Taverna environment.

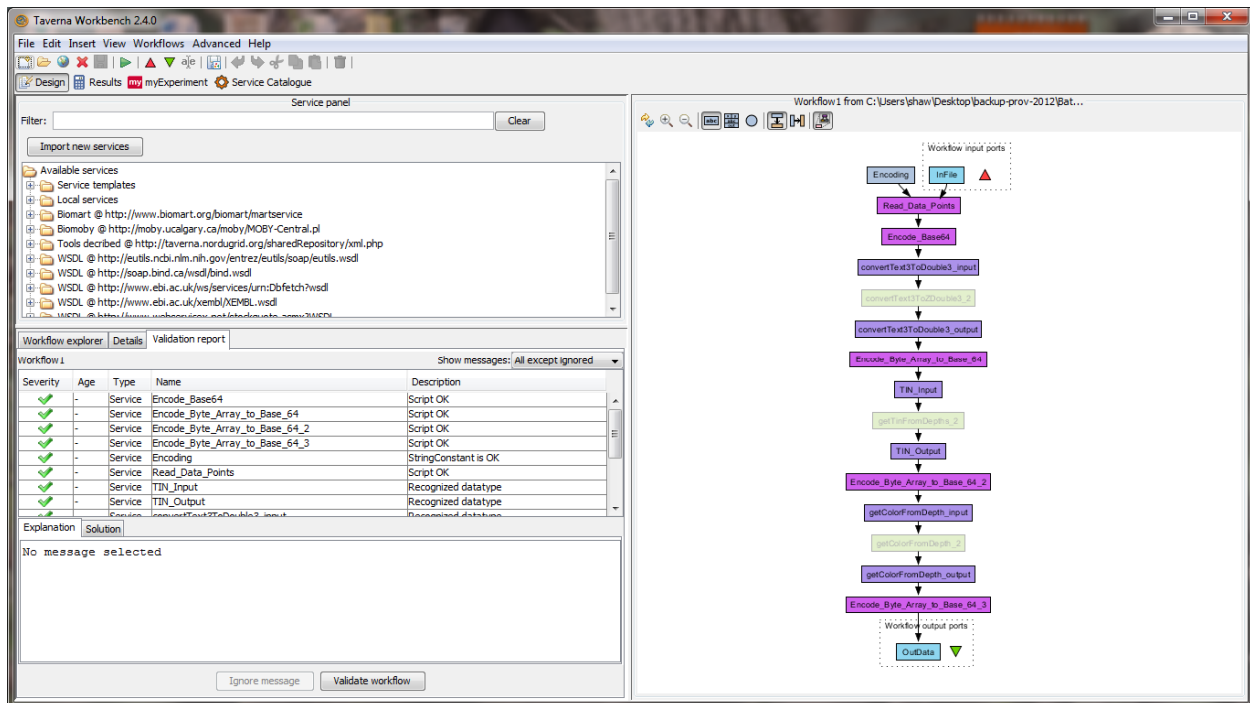
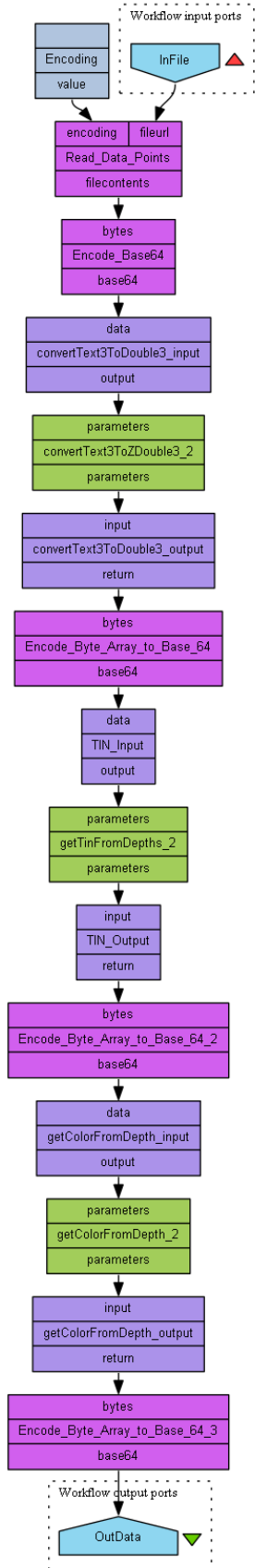


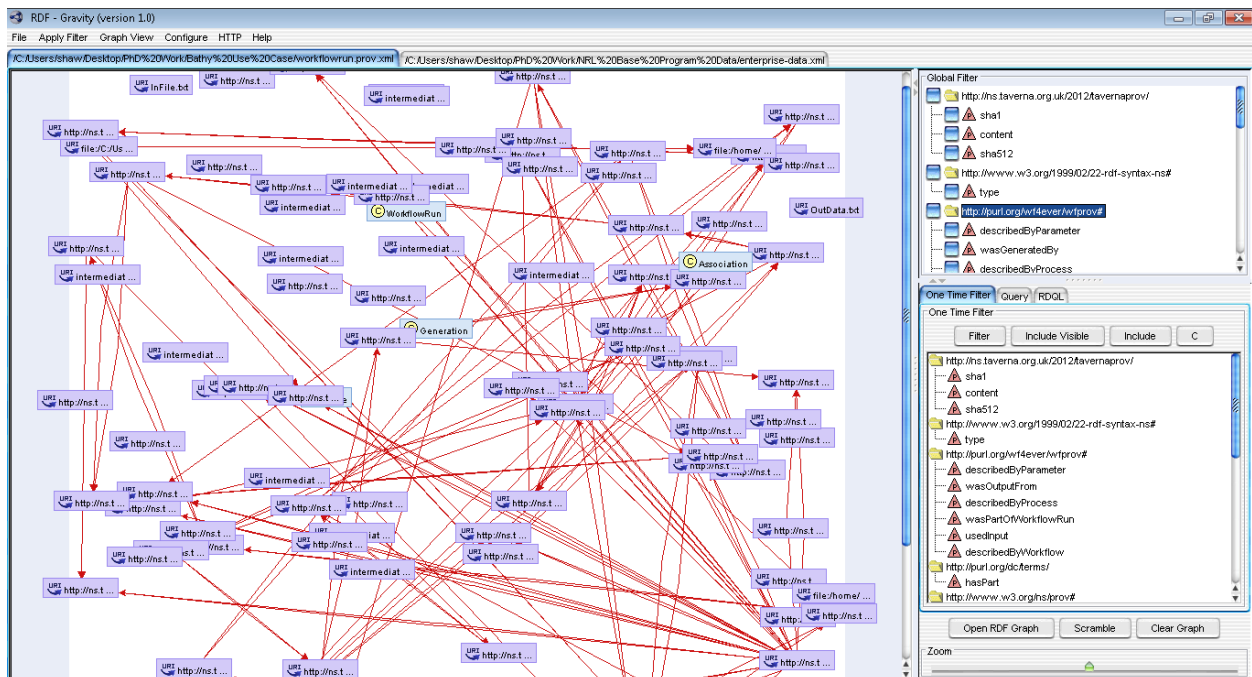
Figure 2, Successful Taverna Validation Report

A detailed view of the workflow created to generate provenance information is shown below in Figure 3.



**Figure 3, Detailed Taverna Workflow**

The end goal of the workflow process using Taverna has been about generating provenance graphs that include the new PROV O ontology describing and providing provenance for a scientific data set that had no initial provenance information stored with the data itself. The final result is shown below in Figure 4 highlighting PROV O properties such as wasOutputFrom, usedInput, wasGeneratedBy, etc. This shows success in taking an initial scientific data set with no provenance content and incorporated this structured vocabulary in with the data in a RDF graph form such that it can now be added to the overall knowledge store along with the enterprise graphs and following hyperspectral graphs.



**Figure 4, Taverna Workflow with PROV O Ontology**

## Summary

Primary results from this active provenance case using a simple bathymetric data set shows that a workflow management system can be leveraged to generate provenance in a formal manner for some defined set of processing stages such that the content can be added to an overall knowledge base. Taverna proved to be a useful tool to allow initial investigation into the utility of PROV O and it was found that Taverna was very effective at producing PROV O ontology and that PROV O ontology is an excellent base vocabulary to begin to build a knowledge system around for repurposing and long-term curation. PROV O was also shown to allow interchange among varying provenance vocabularies which is crucial for environments with multiple workflow management systems and/or Electronic Data Notebooks. This above described process allowed the simple bathymetry data to be converted into a full provenance supported graph to add to the enterprise knowledge base described in previous chapter and also to be compatible with the next chapter's discussion of hyperspectral data inclusion. A detailed listing of the Taverna workflow XML initial portion (truncated for size management within this document) is found in Appendix A.



## **Chapter 4      Modeling the Enterprise**

### **Introduction**

Modeling the naval research enterprise (or other domains) is crucial to building a knowledge base that can allow reasoning not only with the data itself but all the organizational and value added information that becomes annotations (or potential annotations since normally these are not captured without enterprise modeling) as the data is created, transformed, consumed and disseminated. This chapter describes how the research enterprise was modeled such that the knowledge could be used to complement actual scientific data such as bathymetry or hyperspectral imagery (both showing prominence within the enterprise and therefore a focus within this research as case studies) to show organizational behaviors related to collected data which is of value to curation and repurposing across the enterprise.

### **Enterprise Modeling Approach**

Modeling began with the allowance to utilize (the last) six years of research platform request data that scientists generate to offset ship/airplane collection costs. This data was unstructured text describing experimental goals with some information regarding types of data to be collected. Using this platform request data as a proxy to model what core internal data is being collected first allowed the frequency of various types of data across the enterprise to be considered. Graphically this is shown below in



The transformation of the unstructured proxy organizational data into RDF is shown below in Figure 6 where the added structure is composed of a unique ID composed of the level of research (6.1 or 6.2), the two digit year and the sequence of the request during the year (1,...n). This unique ID forms the basis of the URI reference that is needed to uniquely identify objects in the RDF domain. Scientist is a number (1...42), dataType is the overall data type(s) being collected, sensor = sensor(s) used, purpose = purpose of collection, location is generally a text string of the area-of-collection, title = title of project. This process is actually generating a research vocabulary (arv) that allows the combination of this structured vocabulary with the developed framework to include provenance leveraging the W3C PROVO ontology.

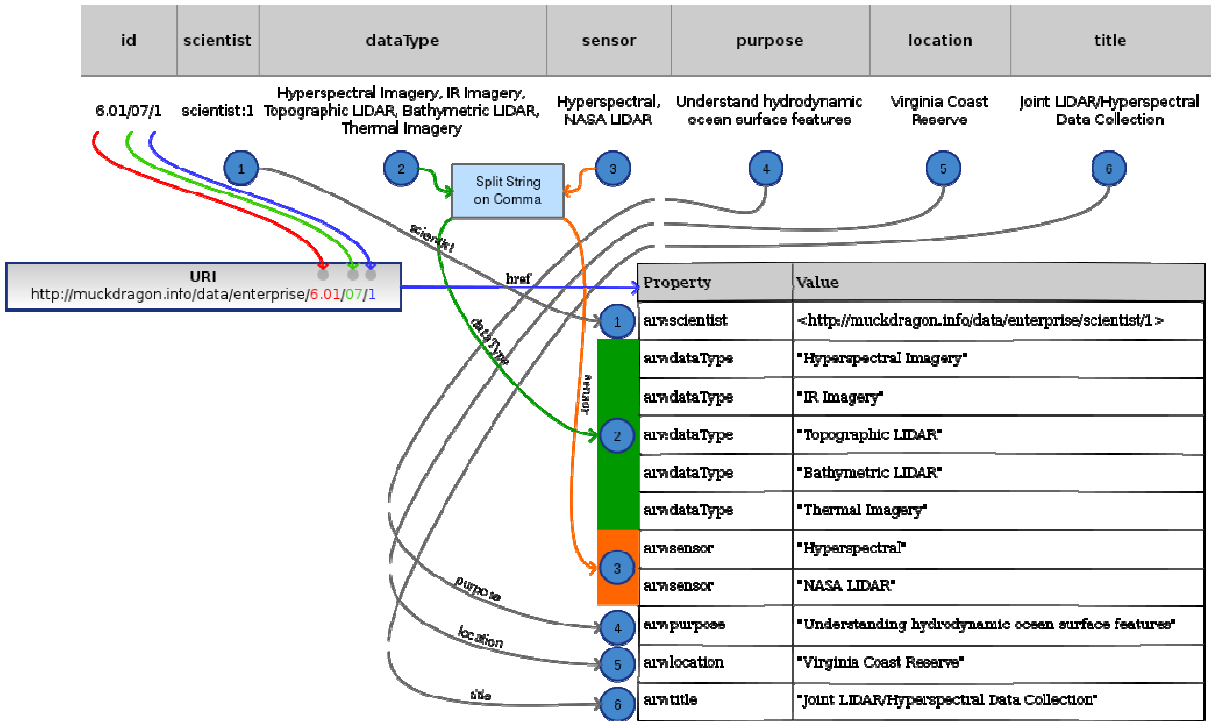


Figure 6, Enterprise Data Transform into RDF

## Enterprise Modeled in RDF

This mapping of unstructured proxy information into a structured form and then into a RDF mapping (using simple comma separated value to RDF) to allow exploitation among similar graphs was crucial for involving scientific context in the utilization of the data and was the first time this research enterprise has been formally modeled. If a targeted collection system were to be developed, this information content could be much richer (using a direct approach) as compared to generation via a proxy measure such as platform request information.

Now given formally structured RDF graphs describing organizational usage of the particular data types the content can be reasoned on with conventional (graph-based) computational methods/queries as described with detailed queries in following chapters. A snapshot of this graph is shown below in Figure 7 depicting each unique data node (formation as described above) with associated relationships (or properties). This depiction is not easy to interpret visually since the intent is for machine processing but shown here for completeness of the overall movement of organizational usage of scientific data into formalized graphs for reasoning and assistance to curation and repurposing.

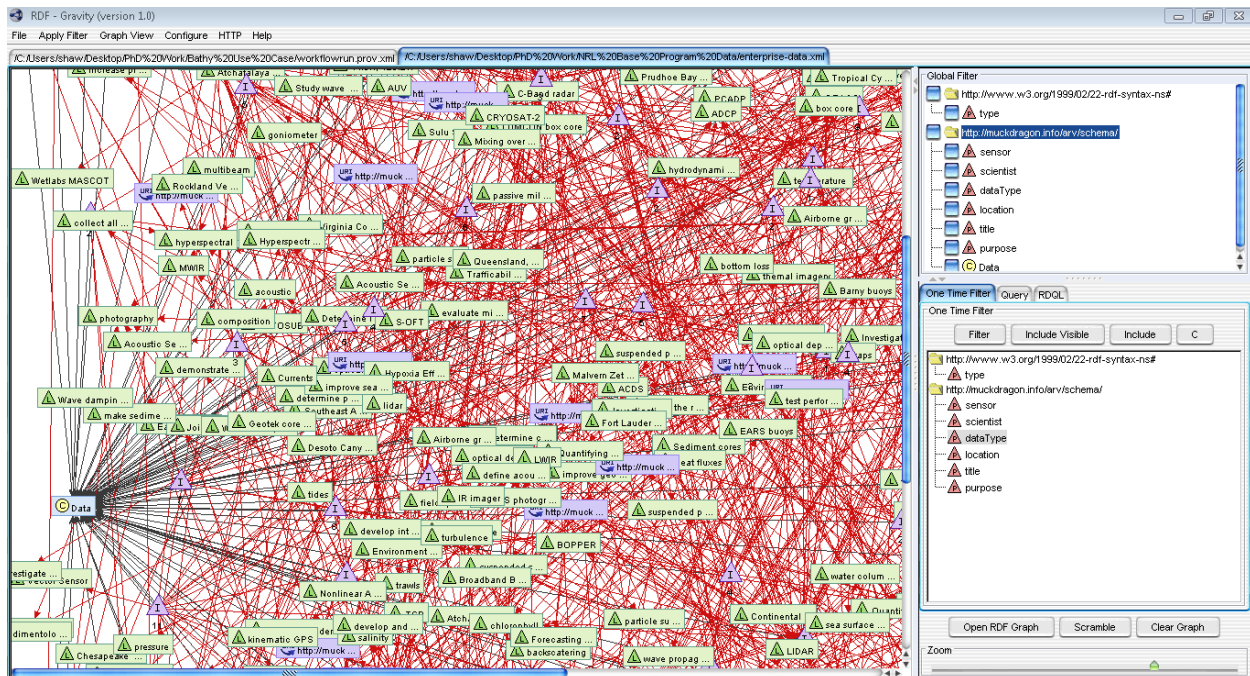


Figure 7, Enterprise Data Graph

## Summary

These enterprise graphs are loaded into the developed research framework (describe in following chapters) with a button on the user interface shown later that executes this load in order to put the SQARQL queries into organizational context (if desired) for a given query. This portion of the research has shown unlimited potential for capturing a more complete context for scientific data provenance lifecycle within a research enterprise. A full listing of the enterprise research vocabulary generated to formally model enterprise research actions with scientific data is shown in Appendix B.

## **Chapter 5      A Passive Hyperspectral Imagery Use Case, Initial Model**

### **Introduction**

This Chapter will explore the formal modeling of a hyperspectral data set stored in the HDF file format that provides passive (provenance information is provided) provenance capability that offers greater potential for repurposing with little impact on the originating scientists. This initial modeling will allow more extensive usage of regular expressions and will not employ an overly expressive model but focus on building an initial framework approach that can be improved. Multiple SPARQL queries are formed as examples of the framework to show the repurposing ability of the formally modeled provenance information. Also additional quantitative data collection and analysis is performed across the naval research enterprise to show potential impact of this modeling.

The selection of a hyperspectral use case originates in the modeling of the enterprise itself that demonstrated substantial investment in this particular data type as shown in the enterprise chapter discussions previously. The hyperspectral data itself will be shown first in its processed state which is the beginning point for this use case.

### **HICO details**

The Hyperspectral Imager for the Coastal Ocean (HICO) is a hyperspectral imaging sensor that is mounted to the International Space Station (ISS). HICO was initially sponsored by the Office of Naval Research (ONR) and is the first space-based hyperspectral sensor optimized for environmental characterization of both coastal and open ocean areas. HICO samples in the 350 to 1070 nanometer spectral range in 128 spectral channels with a spatial ground sampling distance of 100 meters. (M.D. Lewis, 09) Lewis describes the post processing of the imagery into 3 primary levels with subcategories. The focus of this research will be level 2 processed data in HDF5 file format. The primary difference between level 2 and level 3 is level 3 is remapped to a standard projection such as UTM. The sophisticated processing stages described by Lewis are so extensive that the provenance information collected is exceptionally rich for formal modeling and repurposing.

An example of the HICO true color data with the default color palette is shown below in Figure 8. The processing of hyperspectral imagery relies on the key branch point of generating a remote sensing reflectance that is then branched from to create the multiple products from the 128 bands. A remote sensing reflectance example is shown below in Figure 9.



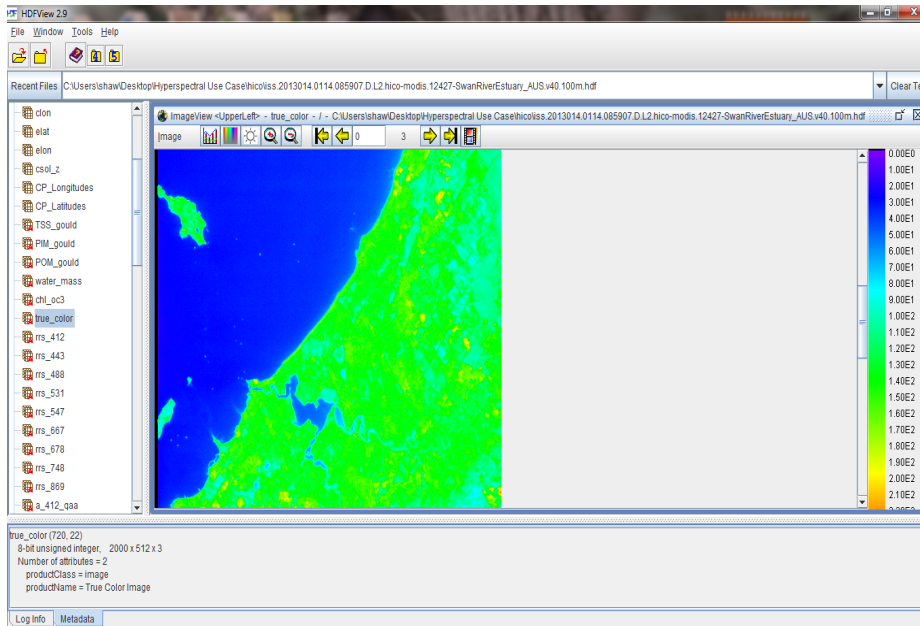


Figure 8, HICO True Color Image

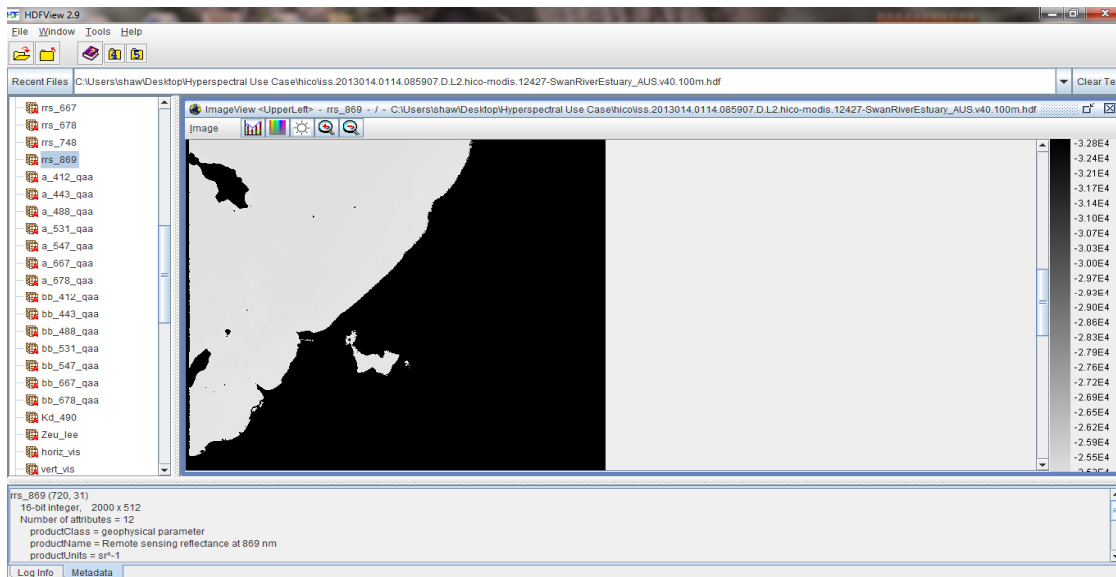
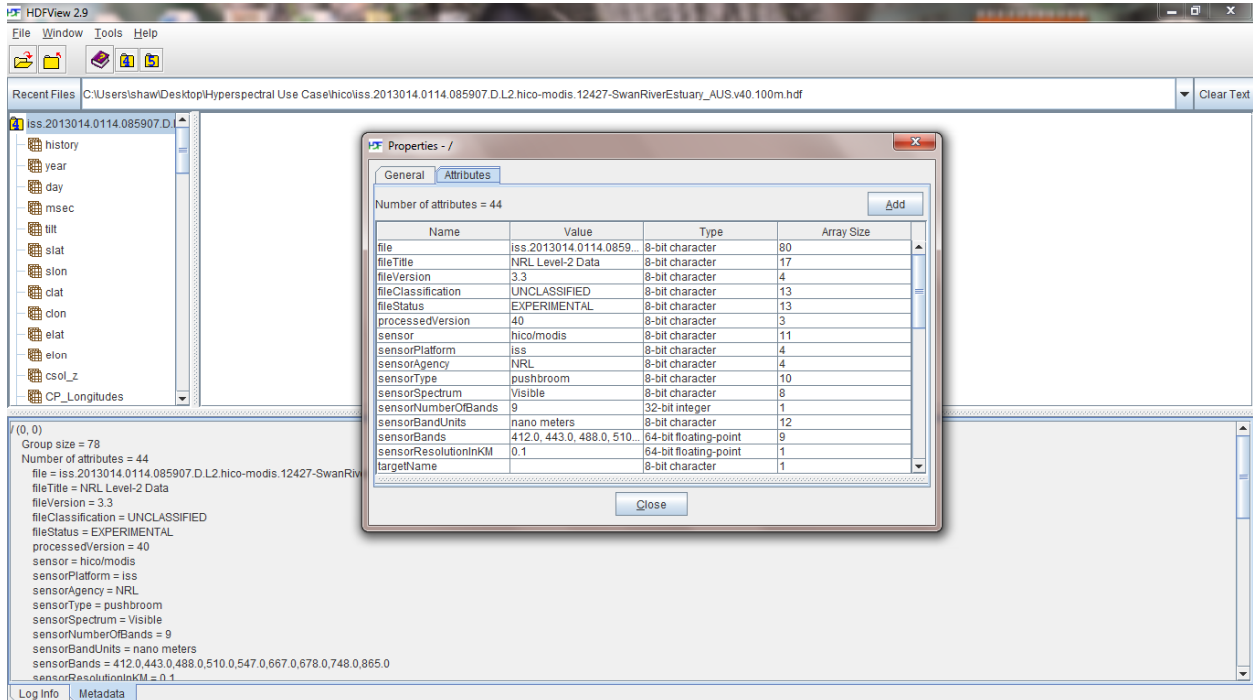


Figure 9, Remote Sensing Reflectance – A Key Branch Point for Provenance

Exploring the HICO data shows detailed attribution (44 attributes) with extensive provenance information as shown below in Figure 10.



**Figure 10, HICO Detailed Attribution – Passive Provenance**

One of the productClasses/geophysical parameters is the Chlorophyll Concentration. A particular instantiation of this geophysical parameter is one generated by the OC3 algorithm (further provenance information) as shown below in Figure 11.

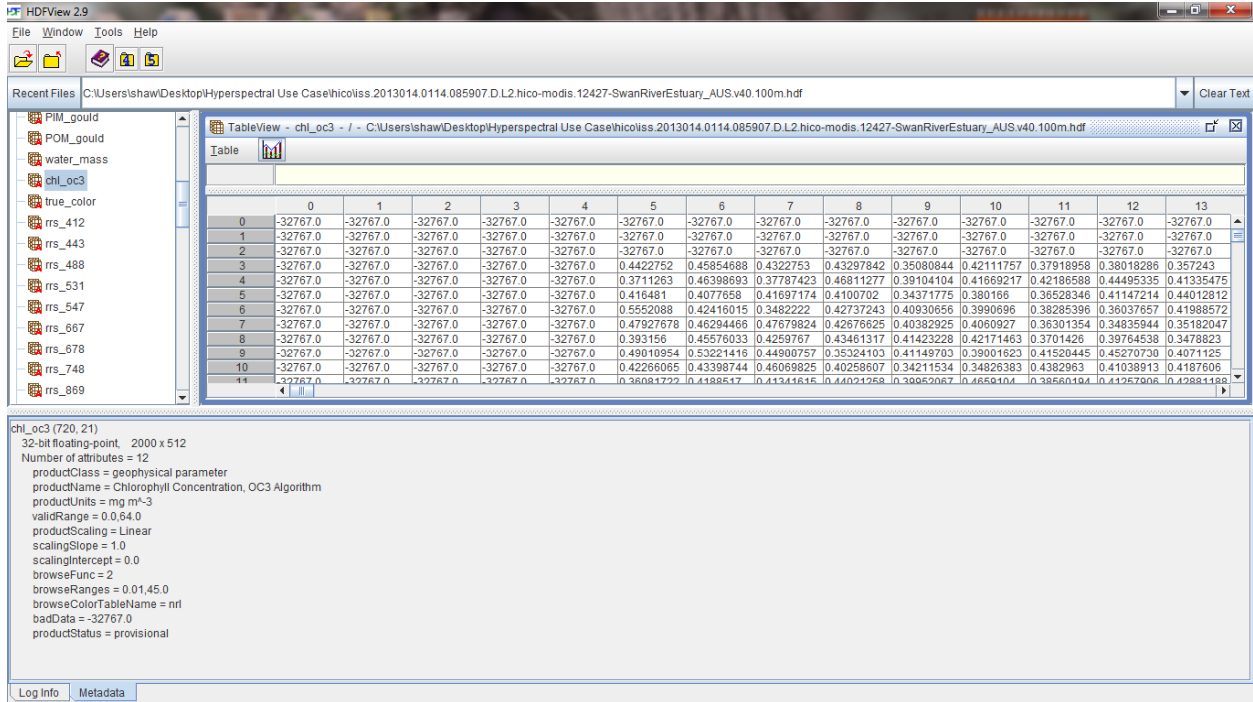


Figure 11, OC3 Algorithm Chlorophyll Concentration

Exploring the hyperspectral data and its stored provenance information, as discussed above, leads to the mapping of this feature and attribute information for each geophysical parameter into RDF as the common domain to reason off this content along with the previously described bathymetry and enterprise graphs. This mapping is accomplished primarily with Java HDF libraries and Jena libraries to perform the serialization into RDF/XML and Turtle options.

## Initial Queries

Initial framework development to support these SPARQL queries relies primarily on regular expression matching among the geophysical parameters and their attributes to build the attributed graphs. The initial framework is also tested by a test set of 19 queries shown below in Table 3.

1.	Where is ocean column particulate absorption information available?
2.	What is the particulate absorption distribution of values?
3.	What algorithm(s) was used in the particulate absorption value calculation?
4.	Where is phytoplankton absorption available?
5.	What is the phytoplankton absorption distribution of values?
6.	What algorithm(s) was used in the phytoplankton absorption calculation?
7.	Where is chlorophyll-a concentration available?
8.	What is the chlorophyll-a concentration distribution of values?
9.	What algorithm(s) was used in the chlorophyll-a calculation?
10.	Where are Sea Surface temperatures available?
11.	What is the distribution of Sea Surface temperatures?
12.	What algorithm(s) was used to calculate Sea Surface temperature?
13.	Where are total suspended particles available?
14.	What is the distribution of total suspended particles?
15.	What algorithm(s) was used to calculate the total suspended particles values?
16.	What enterprise scientists are generating particulate absorption, phytoplankton absorption, chlorophyll-a, sea surface temperature and total suspended particles AND what sensors are being employed?
17.	List all parameters generated by any scientist generating any one of the values noted in previous query.
18.	When is Chlorophyll Concentration Available?
19.	What is the function of the OC3 Algorithm?

**Table 3, Initial Test Queries**

The initially constructed framework query interface is shown below in Figure 12 which allows the above queries to be shown and executed in SPARQL as well as the inclusion of the enterprise graphs via the Load Ext Dataset button. A clear model function is also available and the results shown in the RDF triple language Turtle or abbreviated TTL. The reliance on regular expressions are clearly shown in the SPARQL query WHERE portion with the FILTER regex searches.

# Initial Provenance Framework Interface

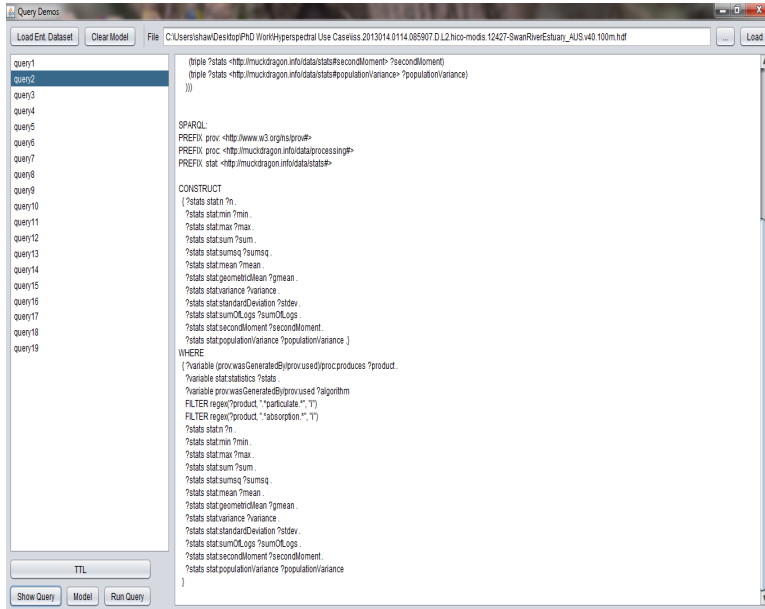
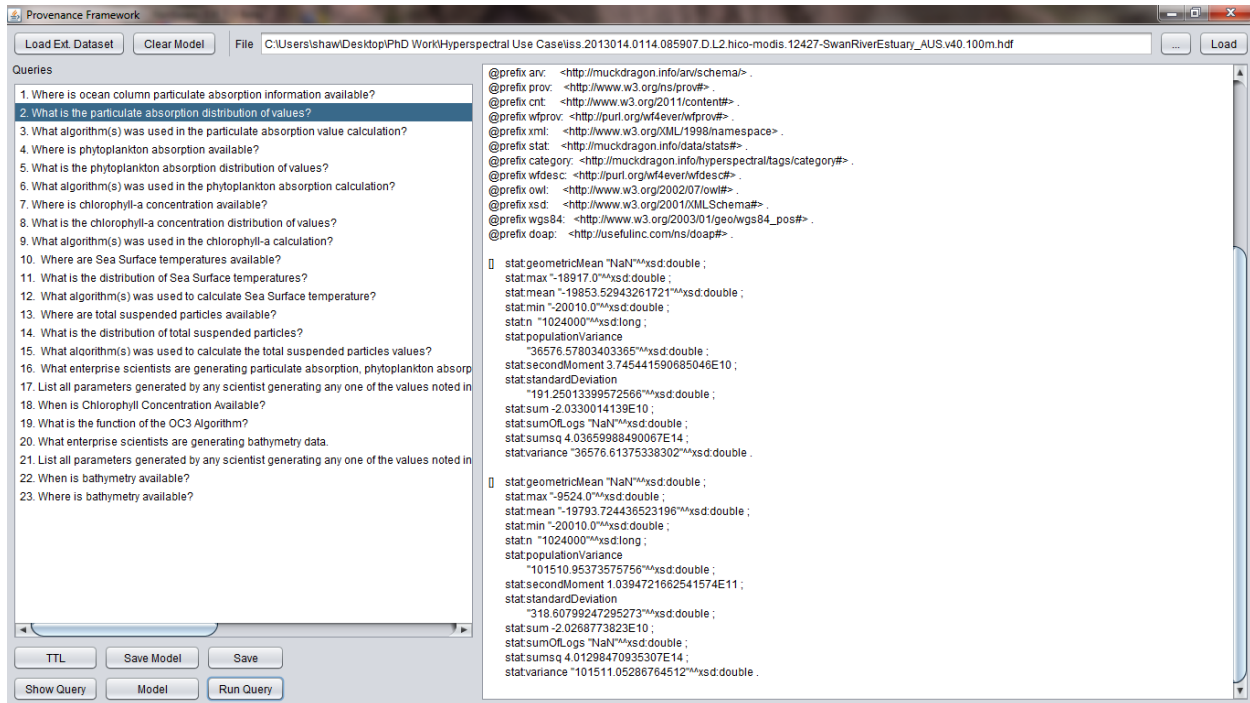


Figure 12, Query 2 within Initial Provenance Framework

Initial Query 2 (What is the particulate absorption distribution of values?) results are shown below in Figure 13. These are promising results that show the statistical distribution of particular absorption which would allow repurposing among various scientific domains from water visibility, riverine modeling, carbon flux modeling and habitat modeling.



**Figure 13, Query 2 Results Initial Provenance Framework**

The model will be improved in the following chapter to reduce the usage of regular expressions, clean up the query results to remove prefix and other non-critical information for query result interpretation, add additional queries.

## Additional Quantitative Analysis of Hyperspectral Enterprise Holdings

Fundamental to the potential impact of this work is a more detailed quantitative analysis of how useful the repurposing of this hyperspectral content would be in a practical sense. Table 4 below shows additional quantitative data to analyze the potential for impact across the enterprise. These results show the past, current and future significant investment in the hyperspectral arena, the fact that substantial portions of this hyperspectral repository would likely follow similar passive provenance availability for modeling and the overall potential for

improved curation of this content and repurposing across the broad spectrum of interdisciplinary scientists within the enterprise.

<b>Quantitative Question</b>	<b>Results</b>
How much hyperspectral data is available in the enterprise?	Approximately 100 TB across the enterprise.
What approximate percentage of hyperspectral content has the passive provenance information available?	60-70%
Will this formal modeling of provenance only support a Carbon Flux research project, say?	No. Riverine modeling research, sediment modeling in the near-shore region, diver visibility research, coastal erosion modeling, Object burial modeling, bathymetric modeling, Ozone modeling, water quality research, etc.
Are new data being collected now?	Yes, the CASI sensor is providing new data at a rate of 30GB/hour.
How many hyperspectral sensors does the naval enterprise currently have?	Primary ones are: CASI-1500, SWIR-1700, SWIR-2500, Microshine, PHILLS, I, II, and III.
Are any new hyperspectral sensor purchases planned (as a measure of future relevance of this repurposing via formally modeling of provenance)?	Yes, three new systems are planned for purchase in the near future.

**Table 4, Additional Quantitative Hyperspectral Enterprise Information**

## Summary

This chapter has shown that hyperspectral data can be formally modeled with an initial framework to generate complex SPARQL queries for repurposing the content across an enterprise. Additional quantitative analysis across the enterprise shows that the impact of this formal modeling and repurposing could be substantial given the current size of the hyperspectral holdings, the fact that new data are being generated daily and future sensors are being purchased with a current direct applicability of this

modeling approach to an approximate 60-70% of this type data. Also, if a practical application based on this research would be implemented then all future collections could be somewhat standardized across the enterprise based on initial lessons learned from that implementation for an even greater intergenerational impact. The following chapter will refine the framework model to minimize regular expressions and also allow for more efficient integration of scientific data types beyond the hyperspectral type.



## **Chapter 6 A Passive Hyperspectral Imagery Use Case, More Expressive Model**

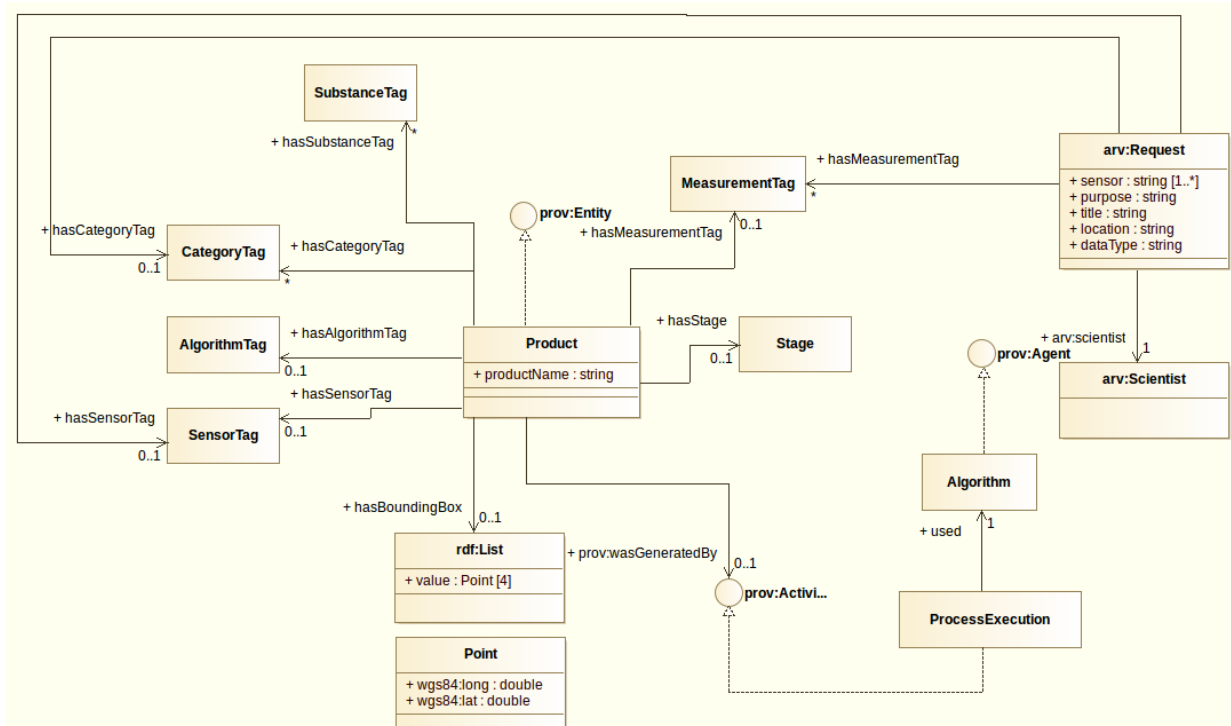
### **Introduction**

This Chapter expands the initial framework model to add a more expressive underlying model that allows less usage of regular expressions and structures the framework for the easier addition of additional data types and ontologies that may be available. The more expressive model is an improvement to the query generation process as will be shown by more compact SPARQL queries with all queries and results from previous chapter being shown with an additional four queries added to broaden the scope of the overall model interrogation. Model improvements are shown that allow the minimization of the usage of regular expressions to include a new tagging strategy for each hyperspectral product. The full listing of SPARQL queries and their associated results demonstrates the effectiveness of these model improvements.

### **Enhanced Modeling Approach for Provenance Framework**

A new modeling approach for the hyperspectral content was developed to generalize the handling of the provenance content as shown below in Figure 14. The critical agent action of `wasGeneratedBy` and `hasCategoryTag`, for example, are shown in the new model which generalizes many aspects of the modeling of the hyperspectral

data provenance. This generalization will be shown in the changes to the queries where simple text string searches are minimized.



**Figure 14, More Expressive Hyperspectral Model Design**

The generated model graph is shown in part below in Figure 15 to provide a visualization of what is occurring at the machine level but obviously this complex graph is not meant for human visual interpretation.

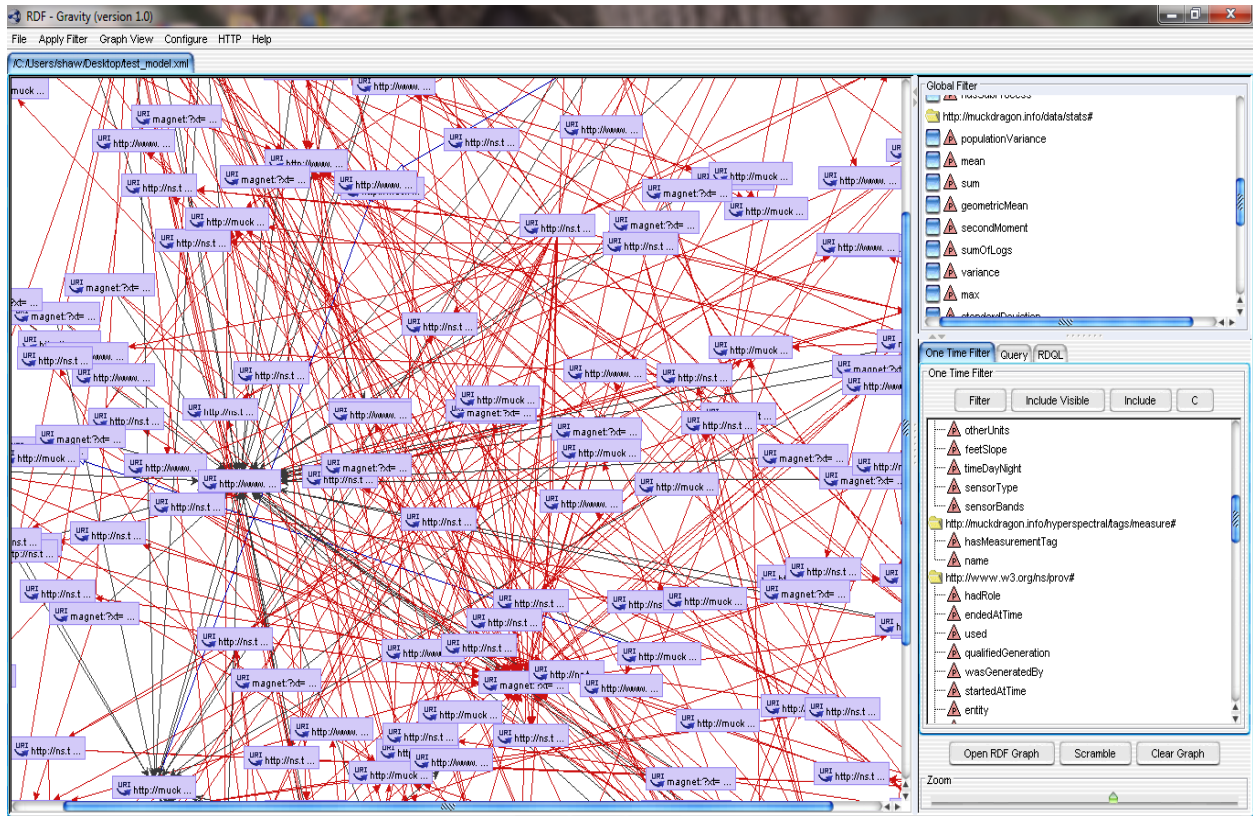


Figure 15, Overall Model Graph Visualization

## Additional Queries

The following new queries in Table 5 were added to this improved version of the hyperspectral model to more fully test the overall model graph to include the early bathymetry segment.

<b>Additional Queries Added to Model</b>
20. What enterprise scientists area generating bathymetry data?
21. List all parameters generated by any scientist generating any one of the values noted in the previous query?
22. When is bathymetry available?
23. Where is bathymetry available?

**Table 5, Additional Queries**

### **SPARQL Queries within Enhanced Provenance Framework**

Each of the 23 queries will be shown for completeness beginning with query 1 shown in Figure 16 through query 23 in Figure 38 respectively. The new model tagging strategy can be seen below in Figure 16 for example where the tagging is employed (shown by the “hasMeasurementTag” or “hasSubstanceTag” portion of the SPARQL query). These queries also show that spatio temporal handling of the data is shown with Figures 22 and 33. The range of the queries shown is meant to exercise the scope of how broadly the hyperspectral data can be passively repurposed for improved curation within an enterprise setting. The queries shown represent a complex interaction with the original data content with no additional involvement from the data originators. This shows practical repurposing to an extent that interdisciplinary scientists can vary the application of the content without initial involvement given the formal modeling of the provenance and the prototype query framework.

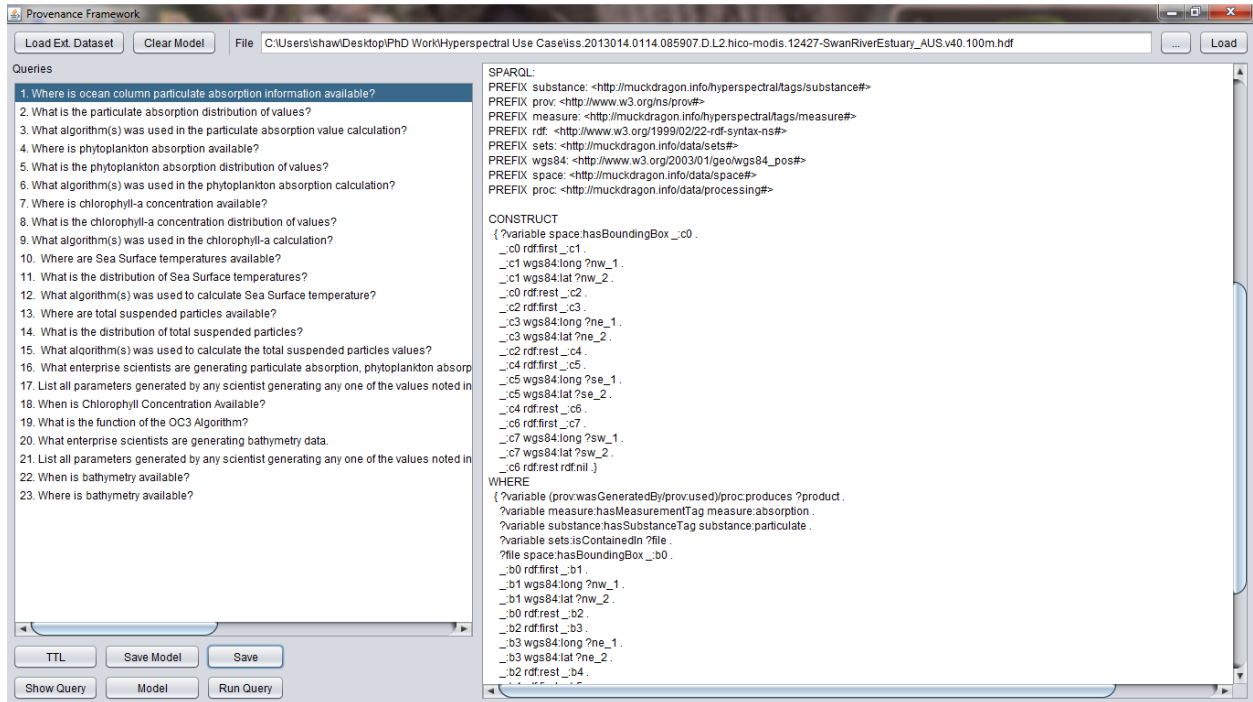


Figure 16, Hyperspectral Enhanced Query 1

The screenshot shows the Provenance Framework application window. The file path is `C:\Users\shaw\Desktop\PHD Work\Hyperspectral Use Case\liss.2013014.0114.085907.D.L2.hico-modis.12427-SwanRiverEstuary_AUS.v40.100m.hdf`. The Queries list on the left contains 23 questions, with question 2, "What is the particulate absorption distribution of values?", selected. The SPARQL query in the main pane is as follows:

```

SPARQL:
PREFIX substance: <http://muckdragon.info/hyperspectral/tags/substance#>
PREFIX prov: <http://www.w3.org/ns/prov#>
PREFIX measure: <http://muckdragon.info/hyperspectral/tags/measure#>
PREFIX data: <http://muckdragon.info/data/info#>
PREFIX proc: <http://muckdragon.info/data/processing#>
PREFIX stat: <http://muckdragon.info/data/stats#>

CONSTRUCT
{
  ?stats stat:n ?n .
  ?stats stat:min ?min .
  ?stats stat:max ?max .
  ?stats stat:sum ?sum .
  ?stats stat:sumsq ?sumsq .
  ?stats stat:mean ?mean .
  ?stats stat:geometricMean ?gmean .
  ?stats stat:variance ?variance .
  ?stats stat:standardDeviation ?stdev .
  ?stats stat:sumOfLogs ?sumOfLogs .
  ?stats stat:secondMoment ?secondMoment .
  ?stats stat:populationVariance ?populationVariance .
}
WHERE
{
  ?variable (prov:wasGeneratedBy|prov:used)|proc:produces ?product .
  ?variable data:hasStats ?stats .
  ?variable measure:hasMeasurementTag measure:absorption .
  ?variable substance:hasSubstanceTag substance:particulate .
  ?variable prov:wasGeneratedBy|prov:used ?algorithm .
  ?stats stat:n ?n .
  ?stats stat:min ?min .
  ?stats stat:max ?max .
  ?stats stat:sum ?sum .
  ?stats stat:sumsq ?sumsq .
  ?stats stat:mean ?mean .
  ?stats stat:geometricMean ?gmean .
  ?stats stat:variance ?variance .
  ?stats stat:standardDeviation ?stdev .
  ?stats stat:sumOfLogs ?sumOfLogs .
  ?stats stat:secondMoment ?secondMoment .
  ?stats stat:populationVariance ?populationVariance .
}

```

Figure 17, Hyperspectral Enhanced Query 2

The screenshot shows the Provenance Framework application window with the same file path. The Queries list on the left has question 3, "What algorithm(s) was used in the particulate absorption value calculation?", selected. The Algebra query in the main pane is as follows:

```

Algebra:
(sequence
  (path ?variable (seq (seq <http://www.w3.org/ns/prov#wasGeneratedBy> <http://www.w3.org/ns/prov#used>) <http://muckdragon.info/data/processing#>|<http://muckdragon.info/data/info#>))
  (bpg
    (triple ?variable <http://muckdragon.info/hyperspectral/tags/measure#hasMeasurementTag> <http://muckdragon.info/hyperspectral/tags/measure#absorption>
      (triple ?variable <http://muckdragon.info/hyperspectral/tags/substance#hasSubstanceTag> <http://muckdragon.info/hyperspectral/tags/substance#particulate>))
    (path ?variable (seq <http://www.w3.org/ns/prov#wasGeneratedBy> <http://www.w3.org/ns/prov#used>) ?algorithm)
    (bpg (triple ?algorithm <http://muckdragon.info/data/processing#> ?aname)))
  )
)

```

The SPARQL query in the main pane is as follows:

```

SPARQL:
PREFIX substance: <http://muckdragon.info/hyperspectral/tags/substance#>
PREFIX prov: <http://www.w3.org/ns/prov#>
PREFIX measure: <http://muckdragon.info/hyperspectral/tags/measure#>
PREFIX proc: <http://muckdragon.info/data/processing#>

CONSTRUCT
{
  ?variable prov:wasGeneratedBy ?aname .
}
WHERE
{
  ?variable (prov:wasGeneratedBy|prov:used)|proc:produces ?product .
  ?variable measure:hasMeasurementTag measure:absorption .
  ?variable substance:hasSubstanceTag substance:particulate .
  ?variable prov:wasGeneratedBy|prov:used ?algorithm .
  ?algorithm proc:name ?aname .
}

```

Figure 18, Hyperspectral Enhanced Query 3

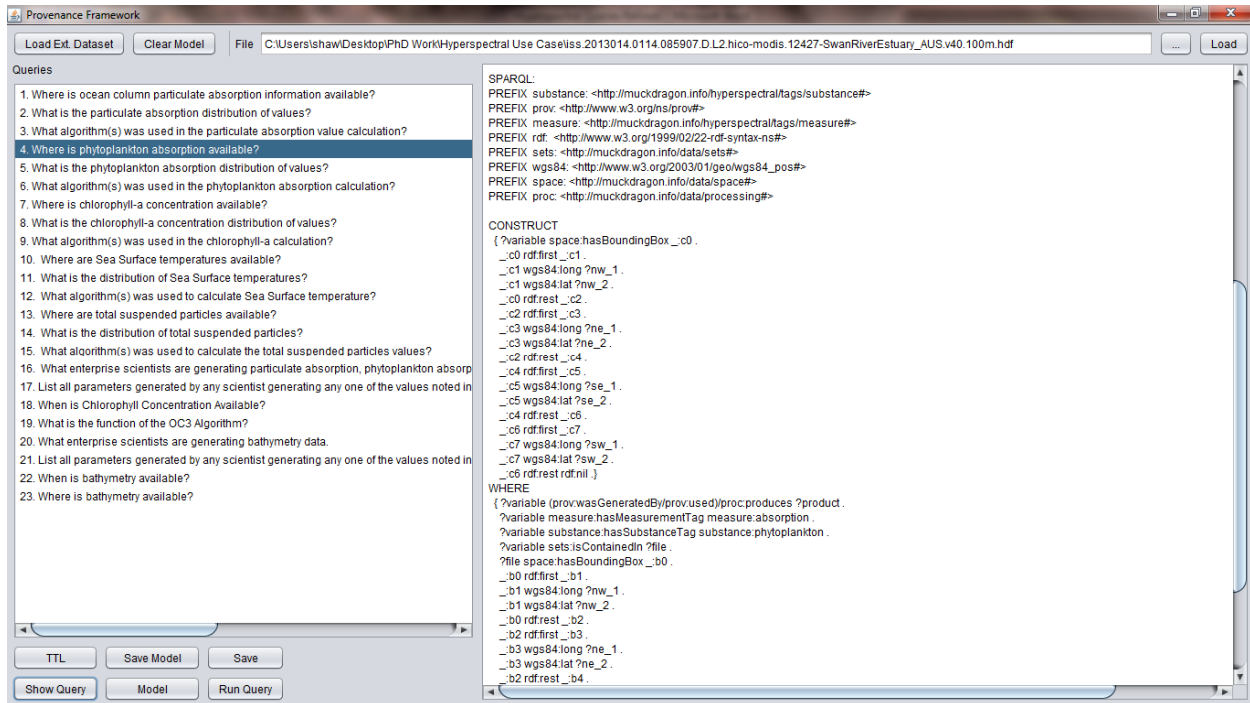


Figure 19, Hyperspectral Enhanced Query 4

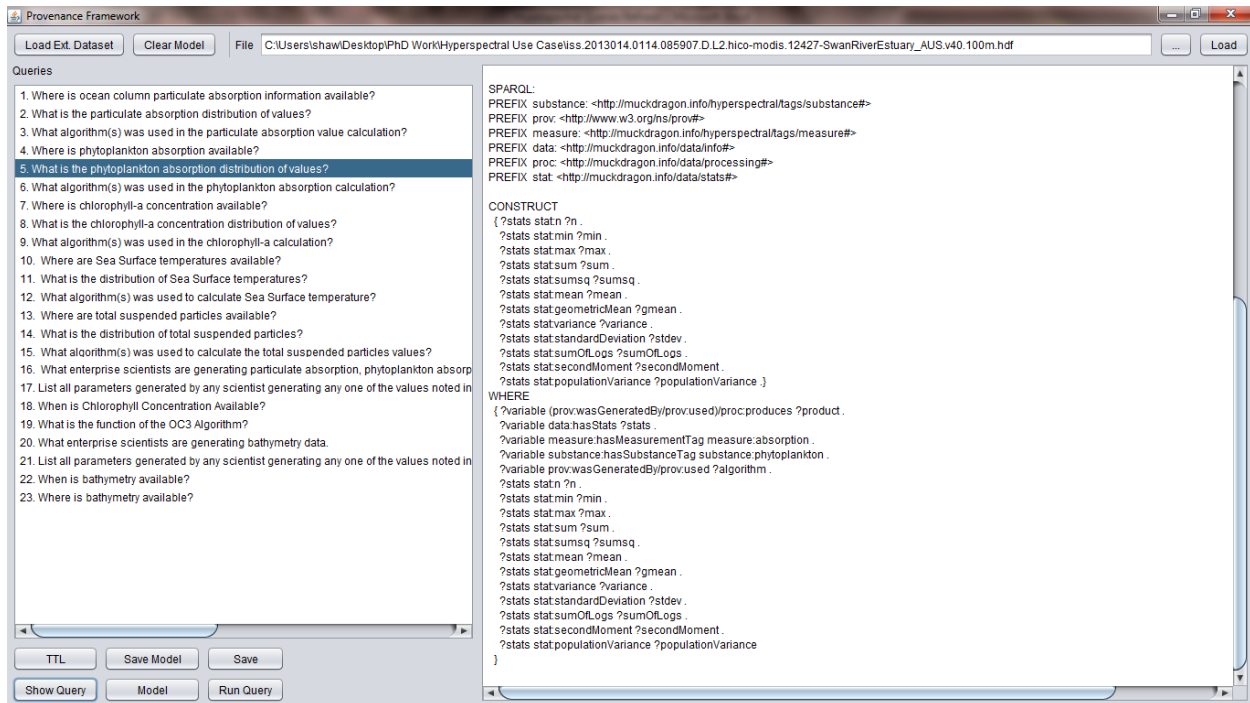


Figure 20, Hyperspectral Enhanced Query 5

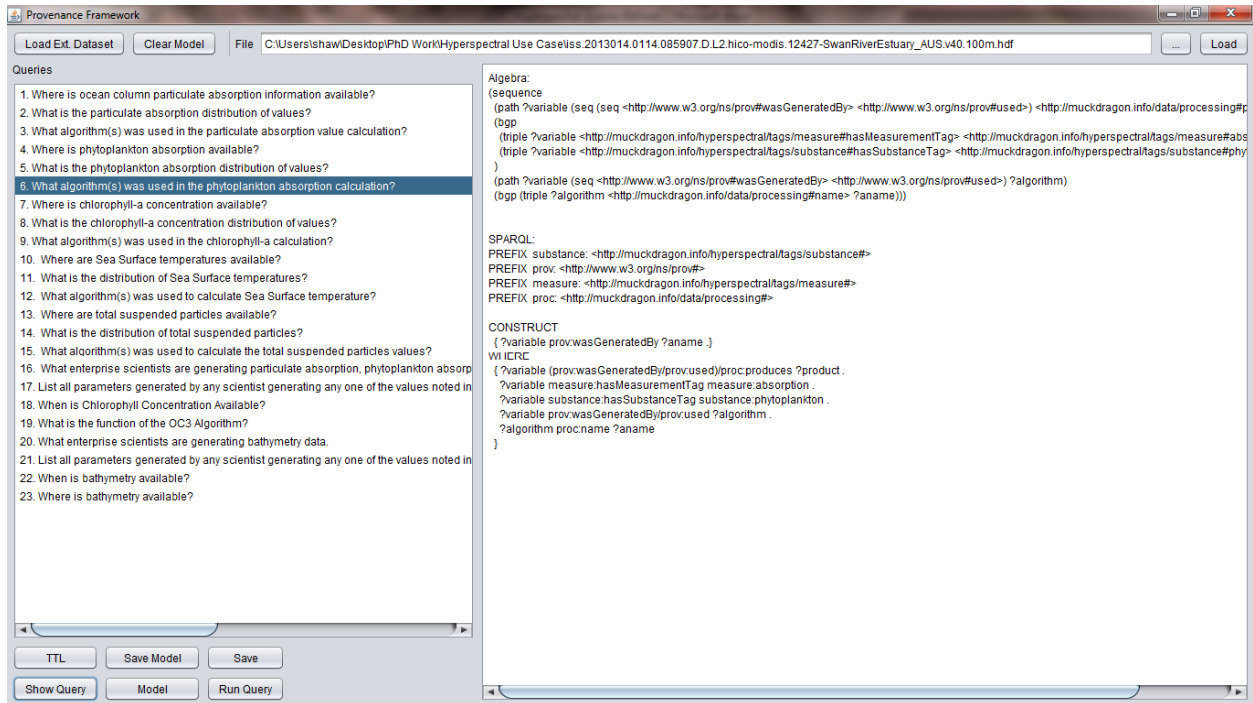


Figure 21, Hyperspectral Enhanced Query 6

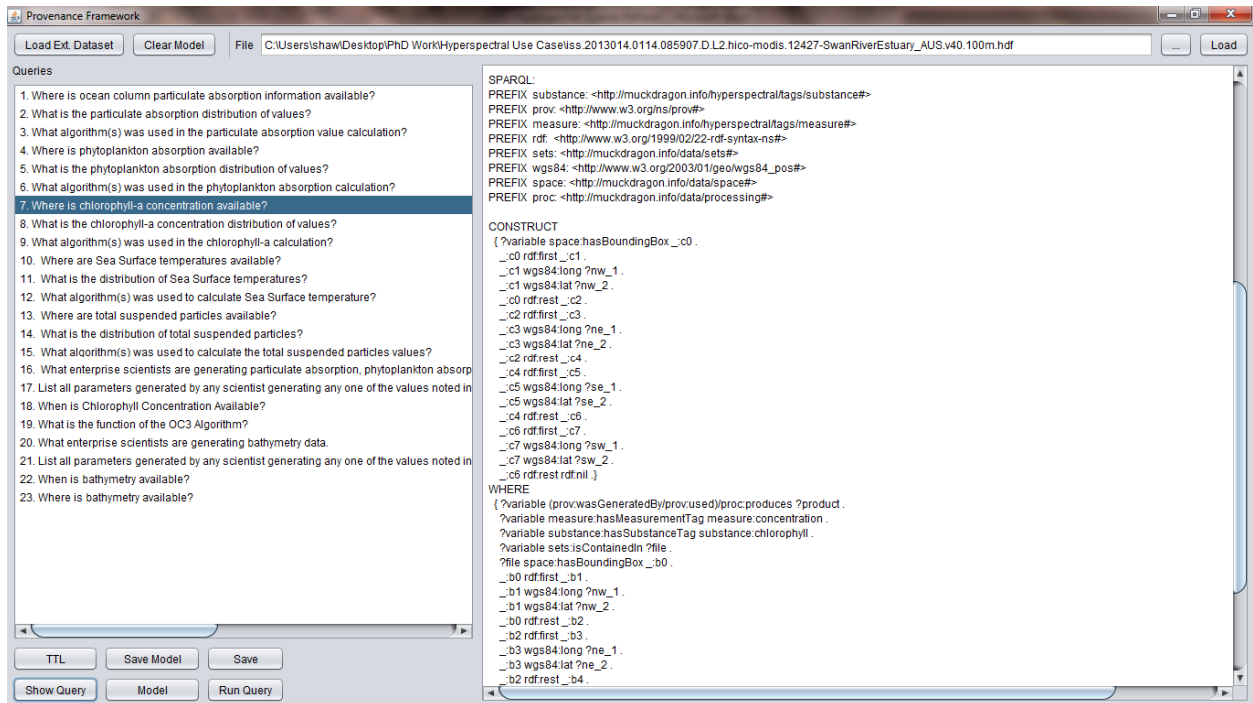


Figure 22, Hyperspectral Enhanced Query 7



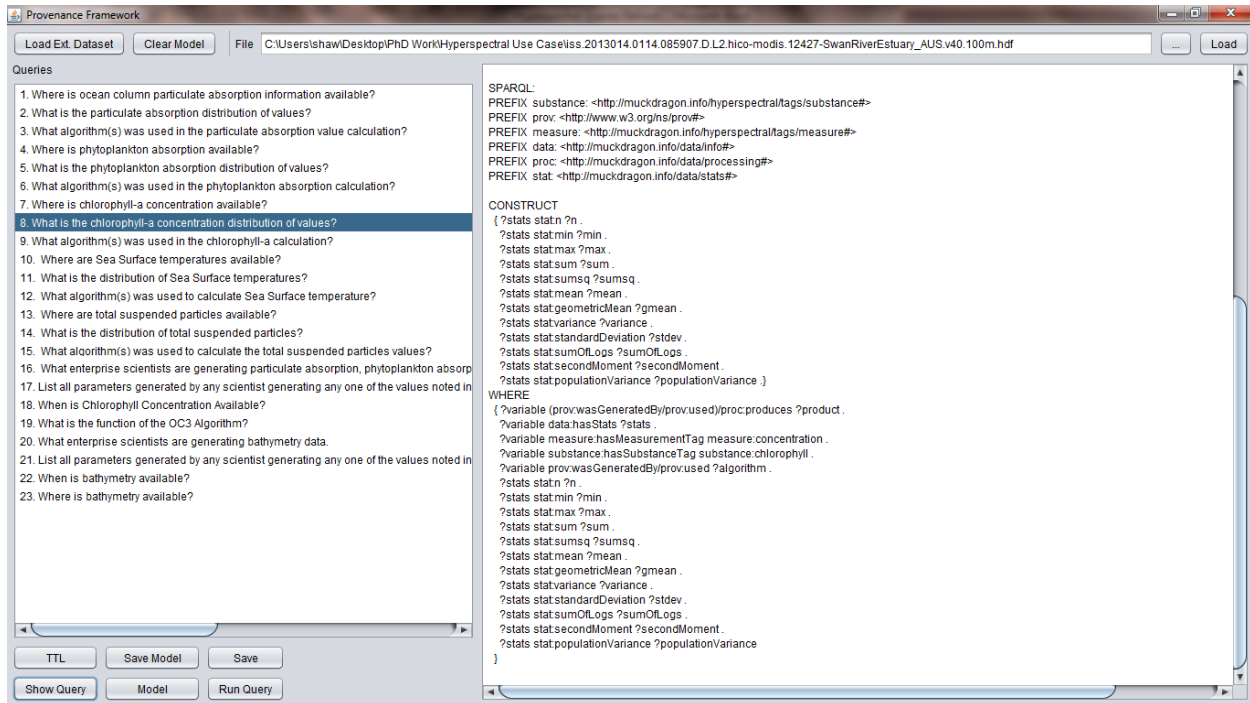


Figure 23, Hyperspectral Enhanced Query 8

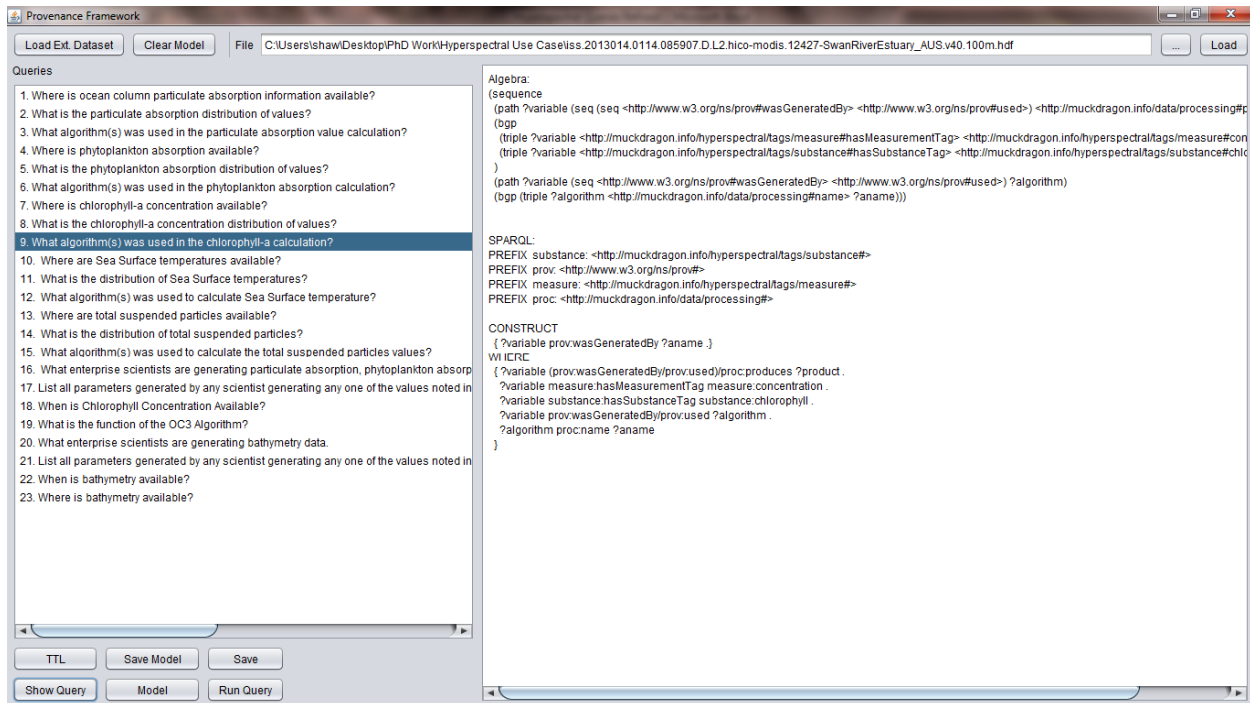


Figure 24, Hyperspectral Enhanced Query 9

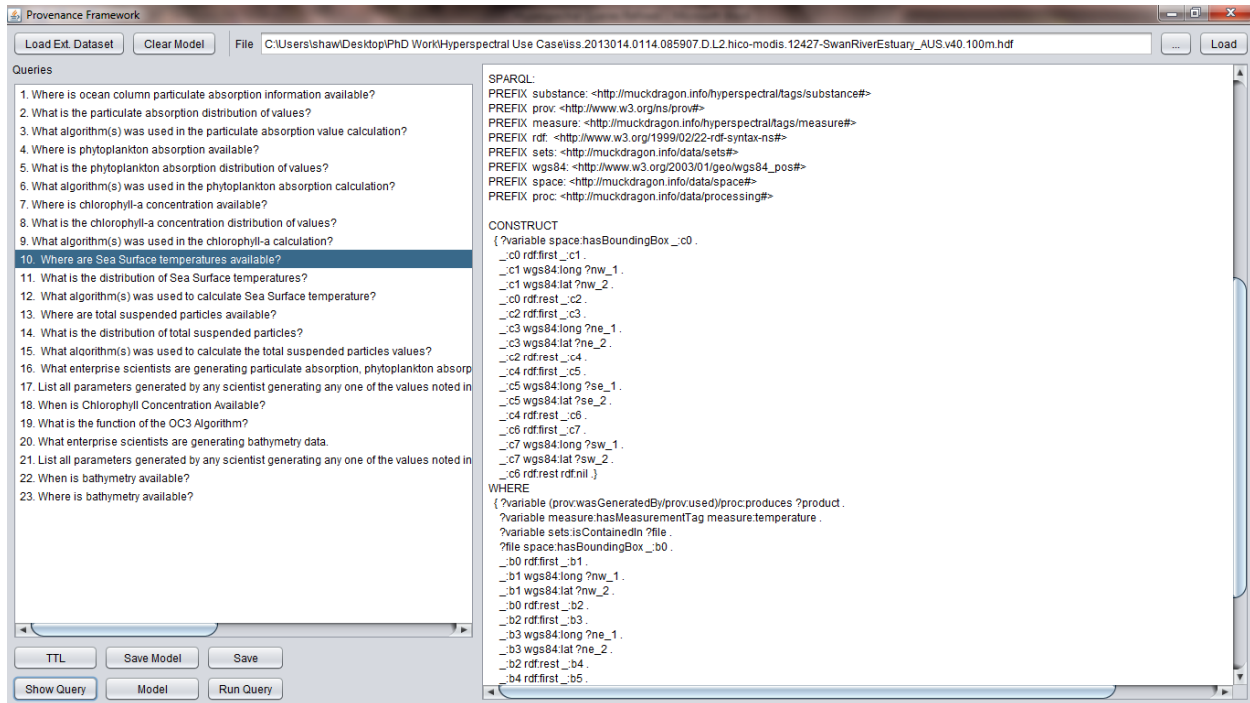


Figure 25, Hyperspectral Enhanced Query 10

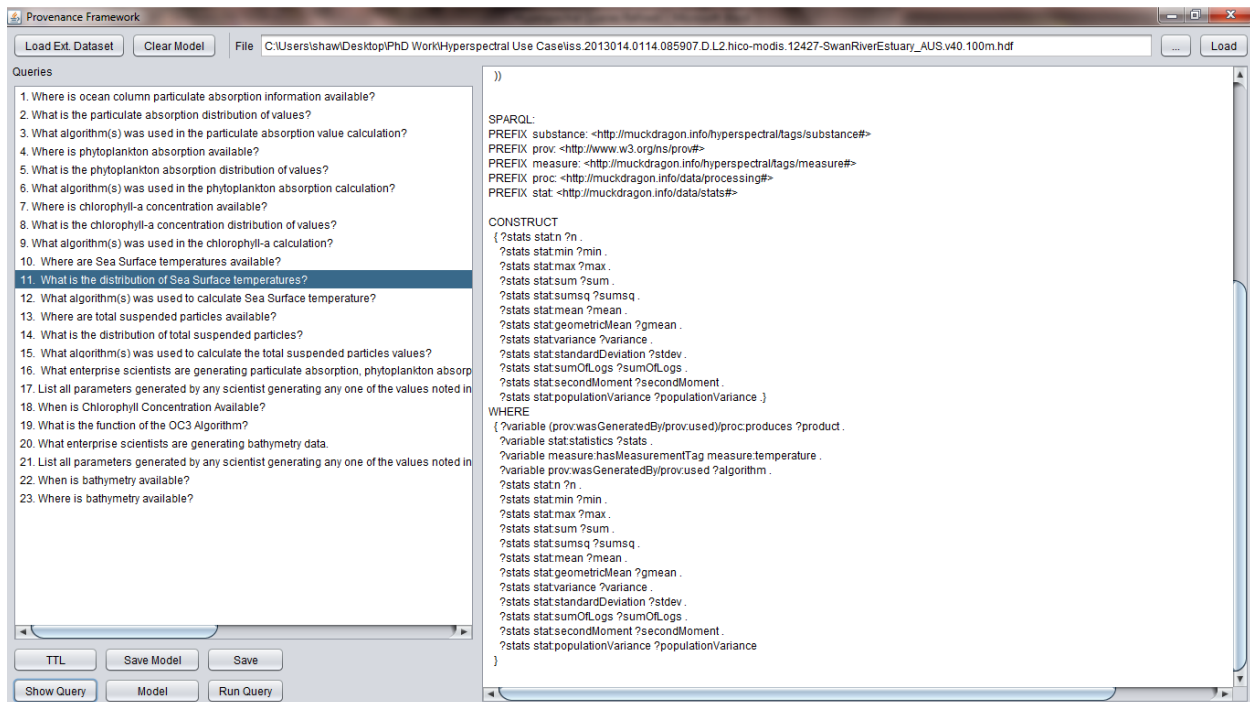


Figure 26, Hyperspectral Enhanced Query 11

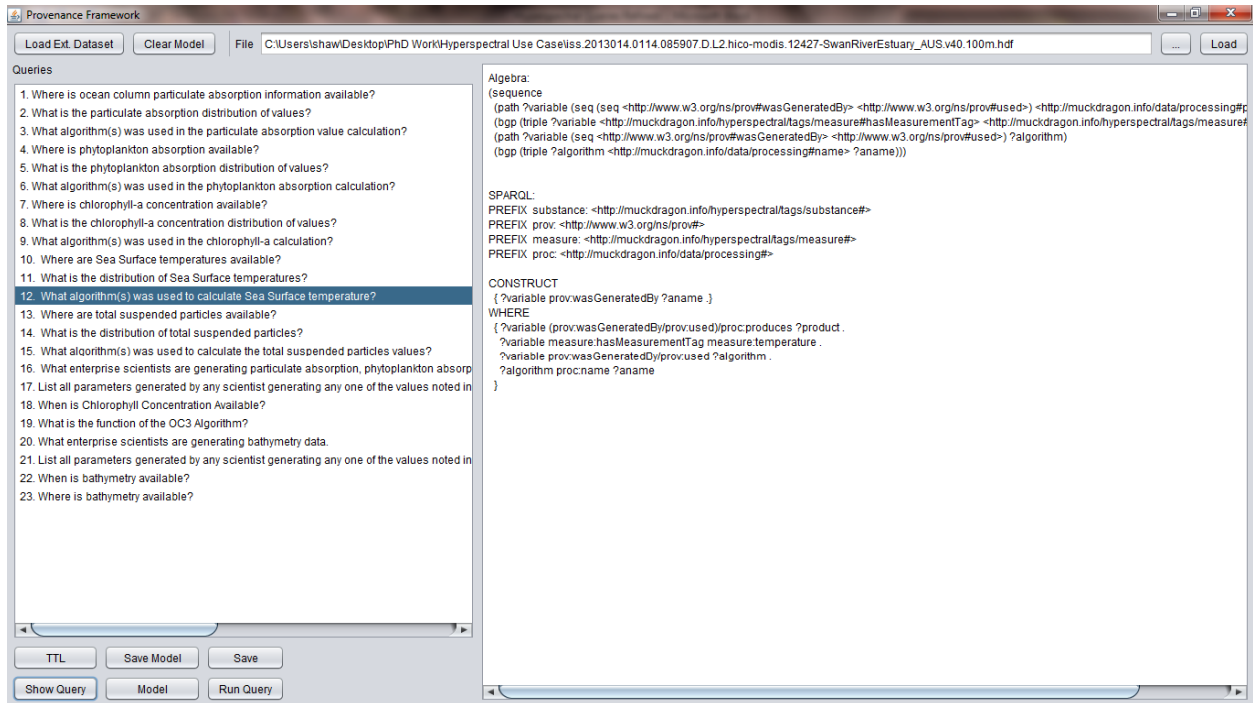


Figure 27, Hyperspectral Enhanced Query 12

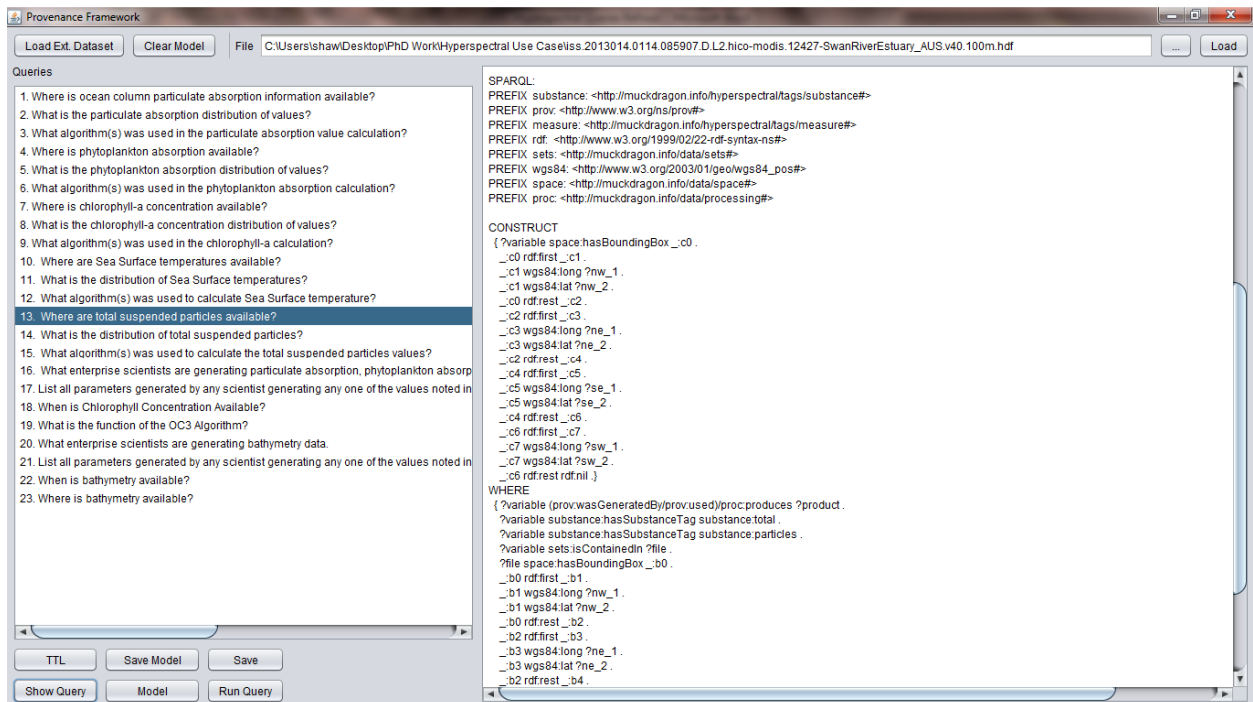


Figure 28, Hyperspectral Enhanced Query 13

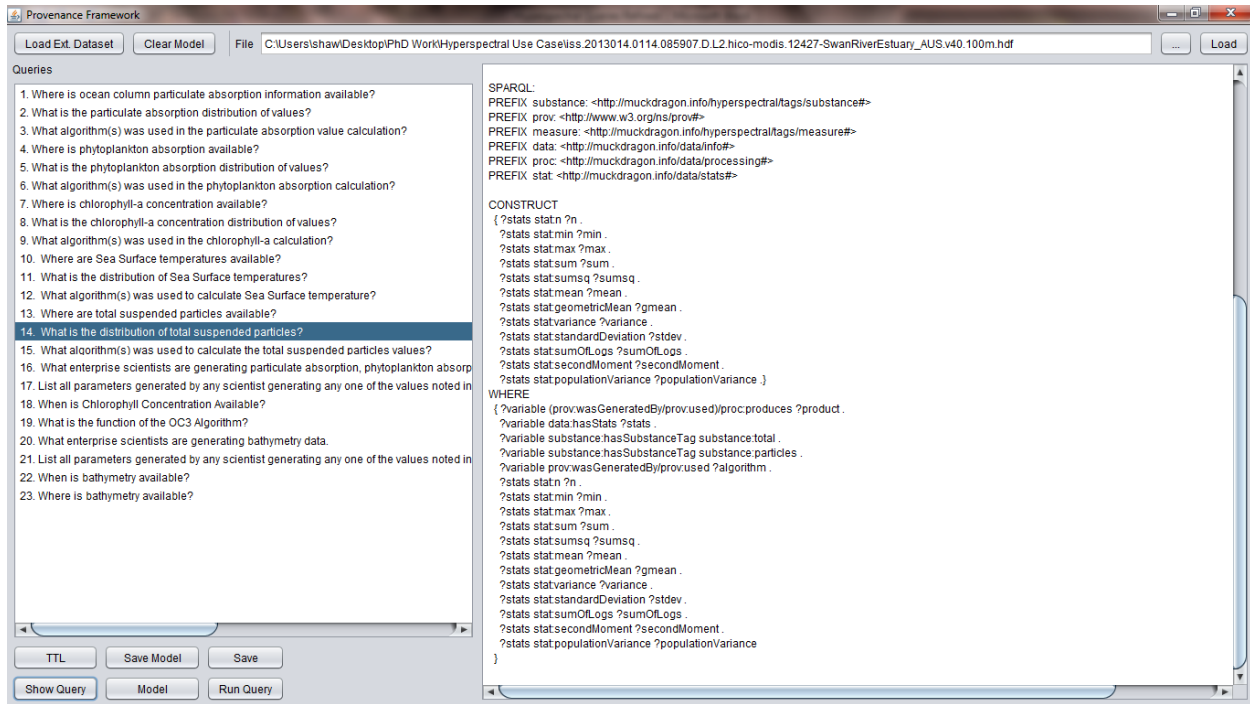


Figure 29, Hyperspectral Enhanced Query 14

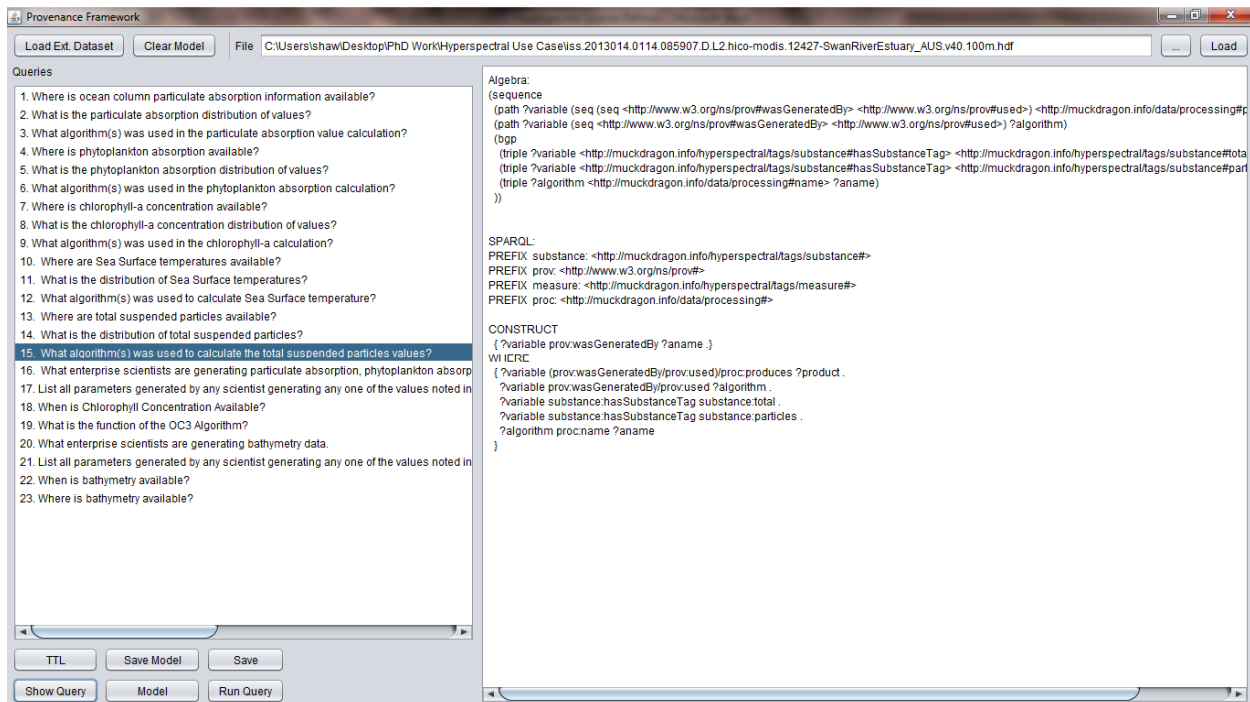


Figure 30, Hyperspectral Enhanced Query 15

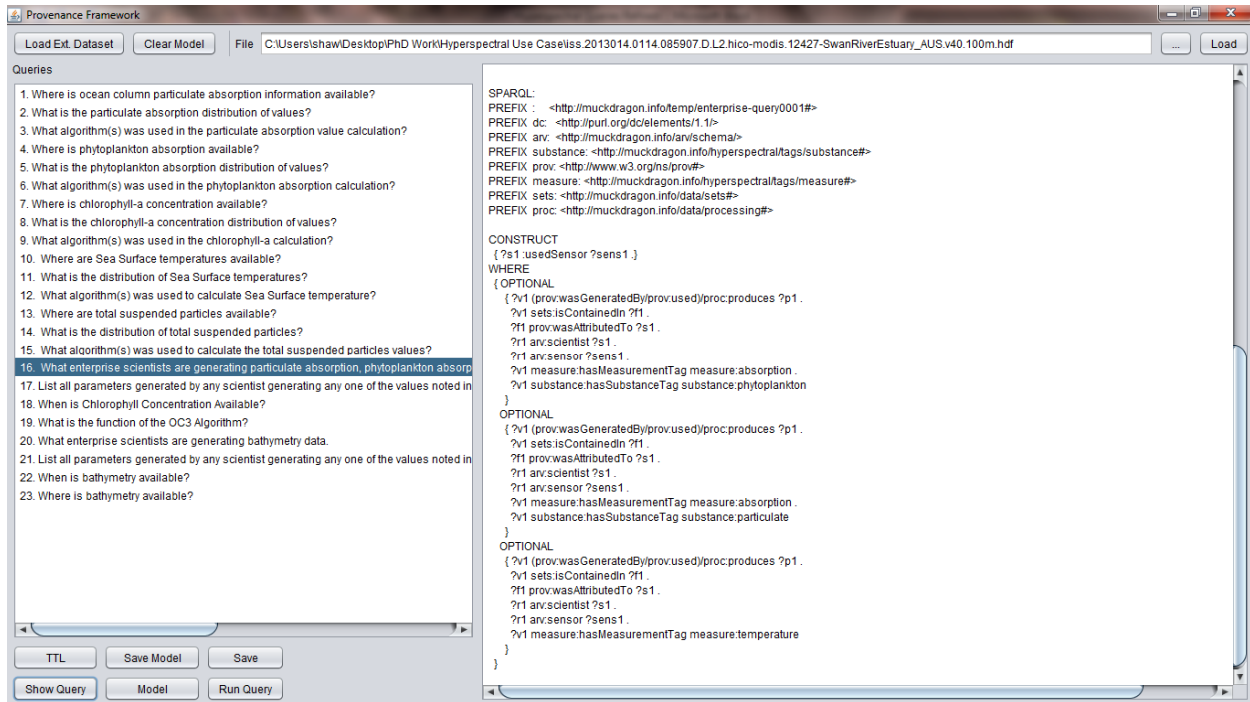


Figure 31, Hyperspectral Enhanced Query 16

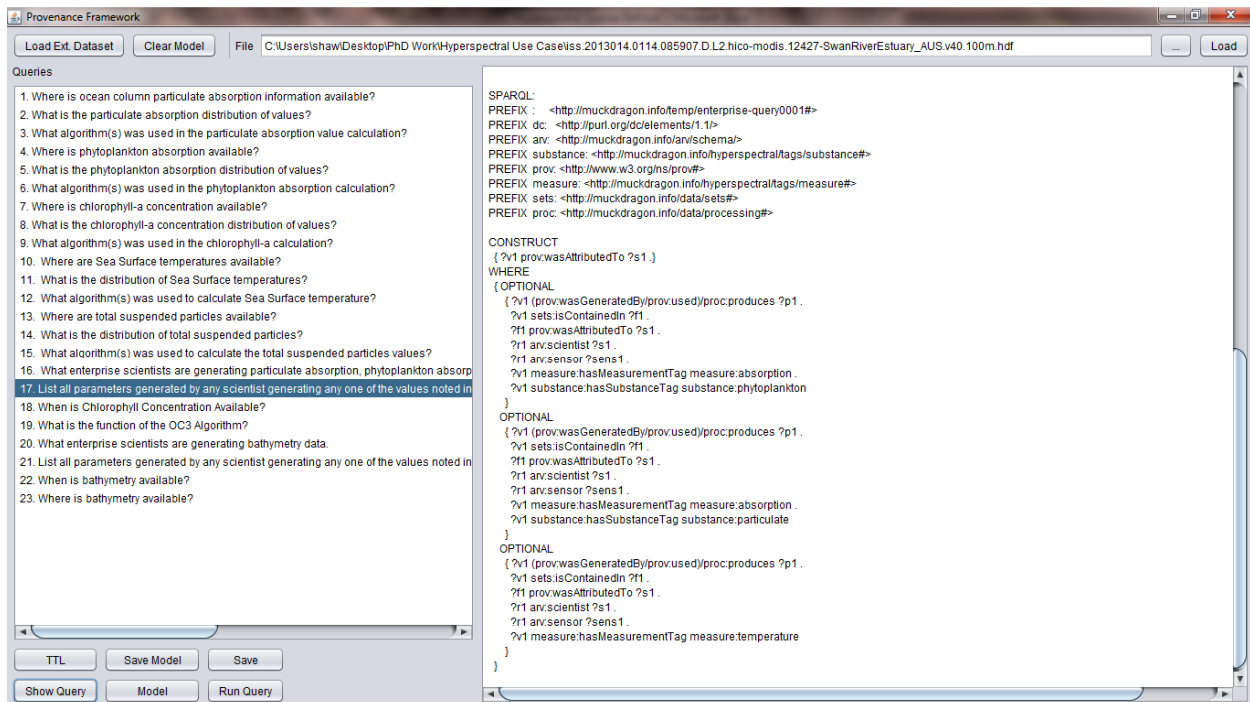


Figure 32, Hyperspectral Enhanced Query 17

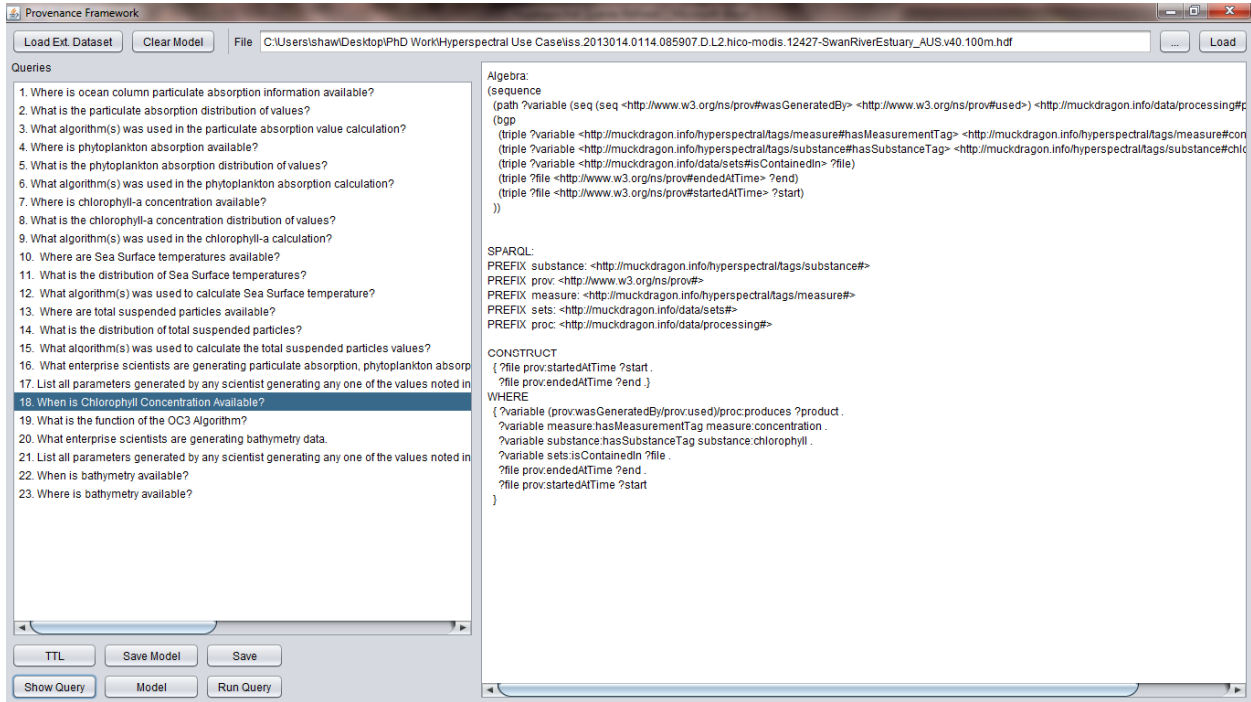


Figure 33, Hyperspectral Enhanced Query 18

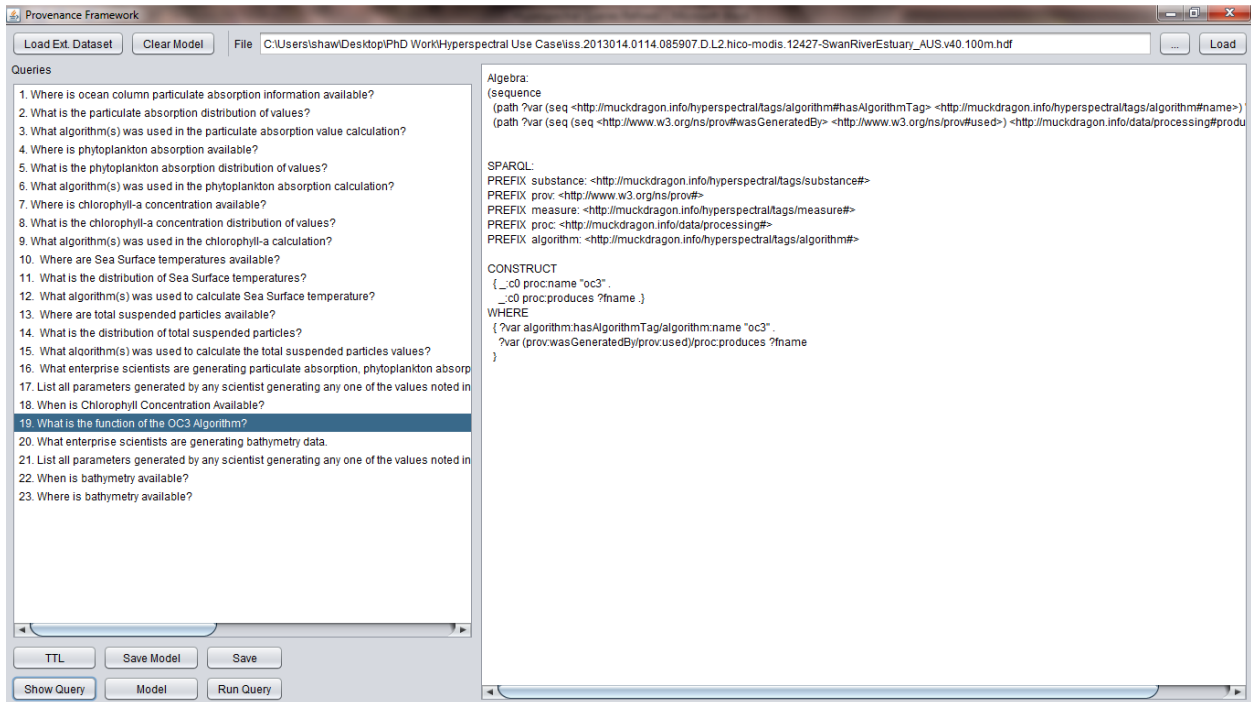


Figure 34, Hyperspectral Enhanced Query 19

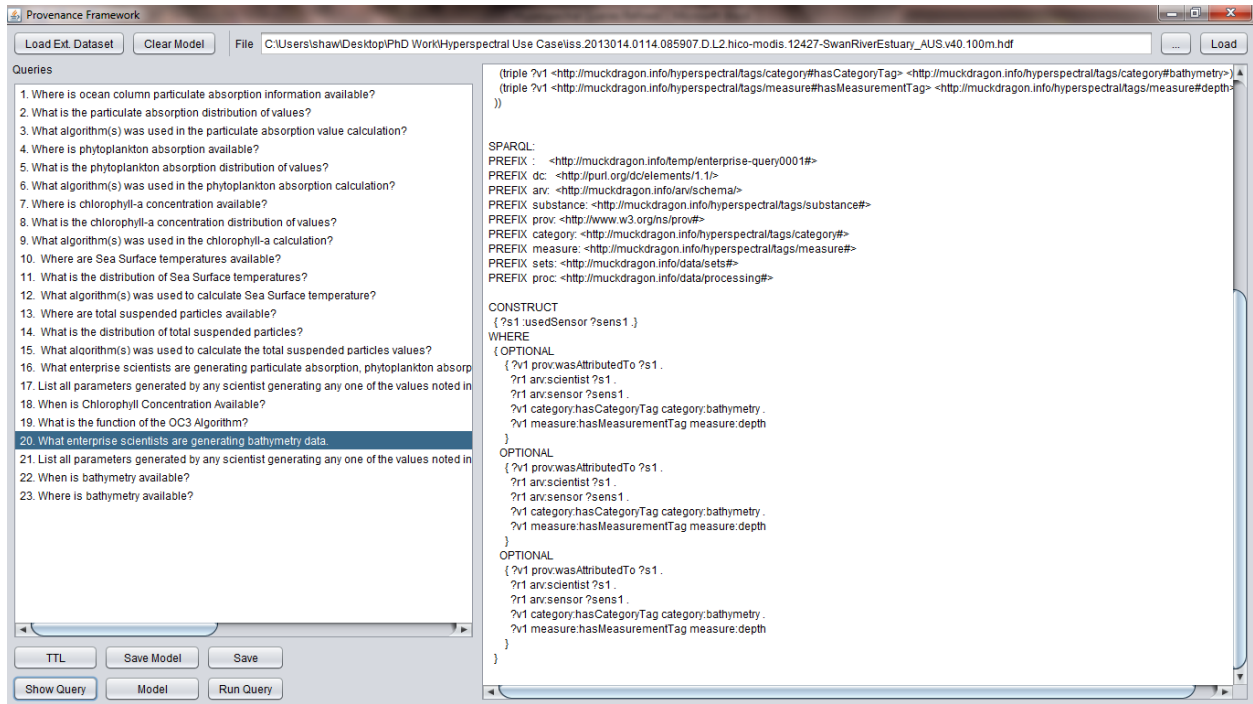


Figure 35, Hyperspectral Enhanced Query 20

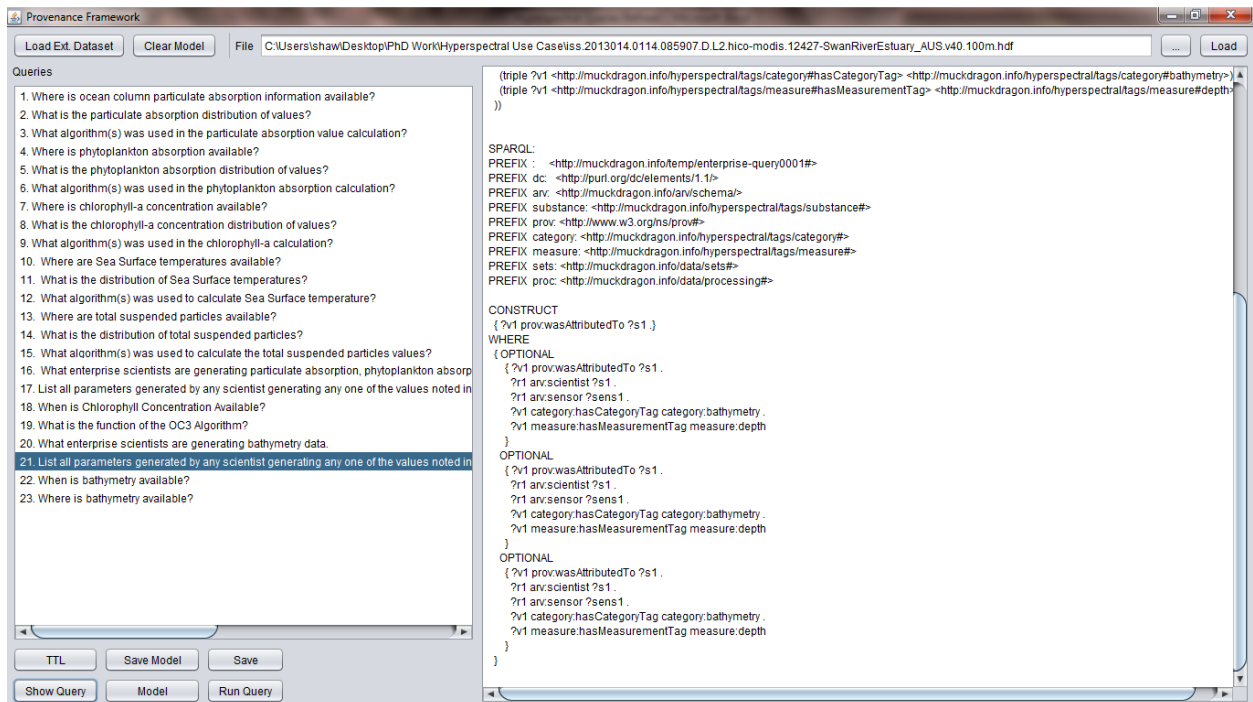


Figure 36, Hyperspectral Enhanced Query 21

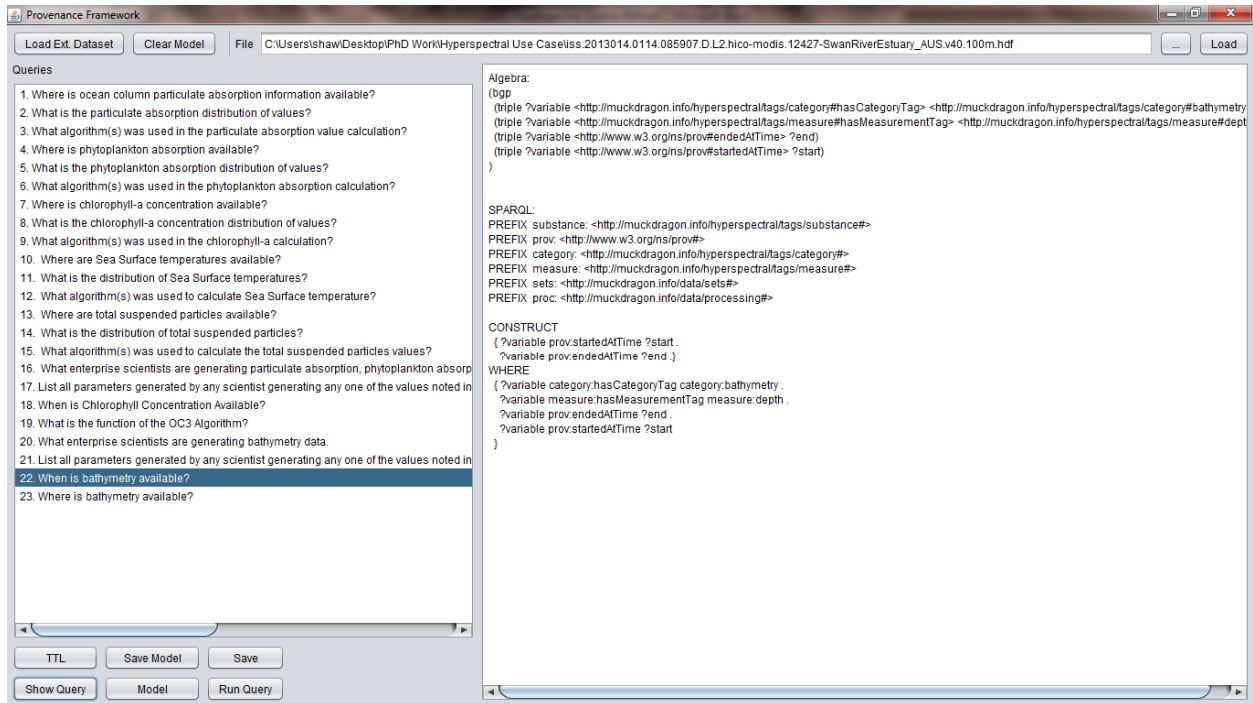


Figure 37, Hyperspectral Enhanced Query 22

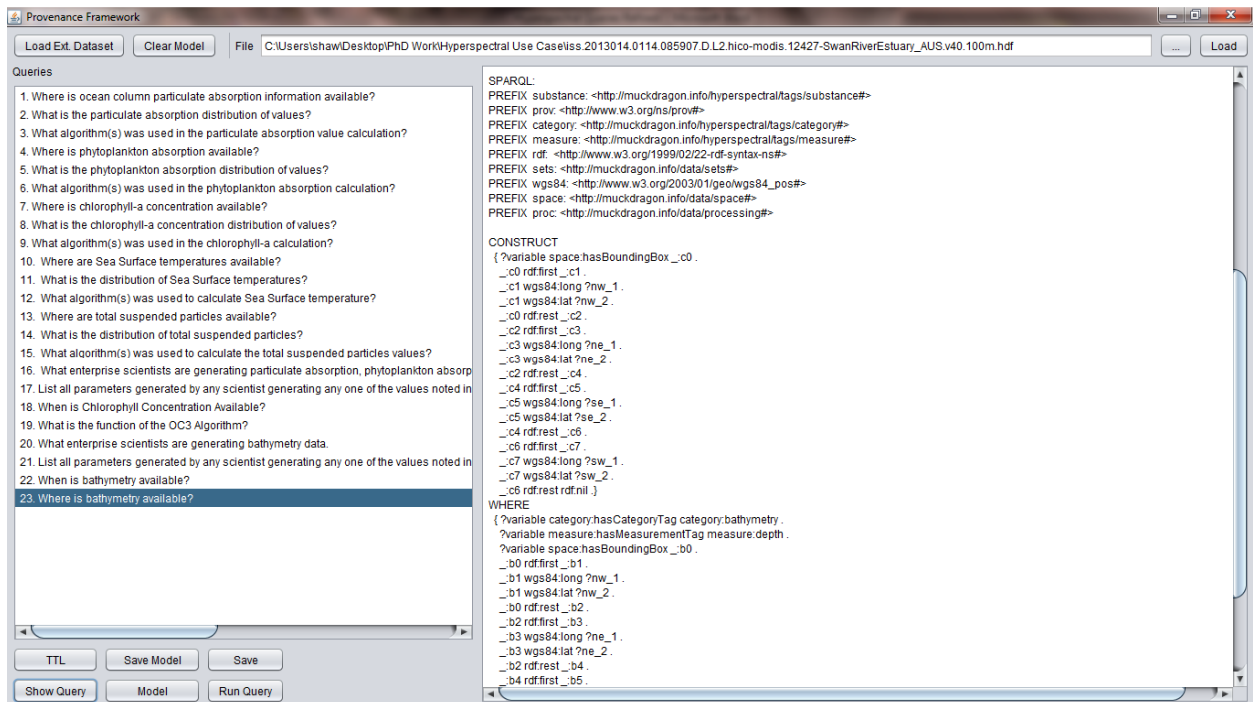


Figure 38, Hyperspectral Enhanced Query 23



## SPARQL Query Results within Enhanced Provenance Framework

The next section will show the query results in Figures 39 – 61. Note the detailed statistical information available shown in Figure 40, algorithm provenance specifics in Figure 41, and no returns in Figures 48-50, 54 and 55 inserted to test cases where null results should be returned with the current model.

The screenshot displays the Provenance Framework application window. The title bar reads "Provenance Framework". Below the title bar are buttons for "Load Ext. Dataset", "Clear Model", and a "File" menu. The file path is "C:\Users\shaw\Desktop\PhD Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-SwanRiverEstuary\_AUS.v40.100m.hdf".

The main area is divided into two panes. The left pane, titled "Queries", contains a list of 23 numbered queries. The first query is selected and highlighted in blue: "1. Where is ocean column particulate absorption information available?". The other queries are: "2. What is the particulate absorption distribution of values?", "3. What algorithm(s) was used in the particulate absorption value calculation?", "4. Where is phytoplankton absorption available?", "5. What is the phytoplankton absorption distribution of values?", "6. What algorithm(s) was used in the phytoplankton absorption calculation?", "7. Where is chlorophyll-a concentration available?", "8. What is the chlorophyll-a concentration distribution of values?", "9. What algorithm(s) was used in the chlorophyll-a calculation?", "10. Where are Sea Surface temperatures available?", "11. What is the distribution of Sea Surface temperatures?", "12. What algorithm(s) was used to calculate Sea Surface temperature?", "13. Where are total suspended particles available?", "14. What is the distribution of total suspended particles?", "15. What algorithm(s) was used to calculate the total suspended particles values?", "16. What enterprise scientists are generating particulate absorption, phytoplankton absorp", "17. List all parameters generated by any scientist generating any one of the values noted in", "18. When is Chlorophyll Concentration Available?", "19. What is the function of the OC3 Algorithm?", "20. What enterprise scientists are generating bathymetry data.", "21. List all parameters generated by any scientist generating any one of the values noted in", "22. When is bathymetry available?", "23. Where is bathymetry available?".

The right pane, titled "file:PIM\_gould", displays the SPARQL query results. The results are structured as follows:

```
space:hasBoundingBox
([ wgs84:lat "114.73446655273438"^^xsd:double ;
  wgs84:long "-30.88399887084961"^^xsd:double
  ] [ wgs84:lat "116.6244888305664"^^xsd:double ;
  wgs84:long "-30.88399887084961"^^xsd:double
  ] [ wgs84:lat "116.6244888305664"^^xsd:double ;
  wgs84:long "-32.54011535644531"^^xsd:double
  ] [ wgs84:lat "114.73446655273438"^^xsd:double ;
  wgs84:long "-32.54011535644531"^^xsd:double
  ] ).
file:POM_gould
space:hasBoundingBox
([ wgs84:lat "114.73446655273438"^^xsd:double ;
  wgs84:long "-30.88399887084961"^^xsd:double
  ] [ wgs84:lat "116.6244888305664"^^xsd:double ;
  wgs84:long "-30.88399887084961"^^xsd:double
  ] [ wgs84:lat "116.6244888305664"^^xsd:double ;
  wgs84:long "-32.54011535644531"^^xsd:double
  ] [ wgs84:lat "114.73446655273430"^^xsd:double ;
  wgs84:long "-32.54011535644531"^^xsd:double
  ] ).
```

Figure 39, Hyperspectral Enhanced Query 1 Results

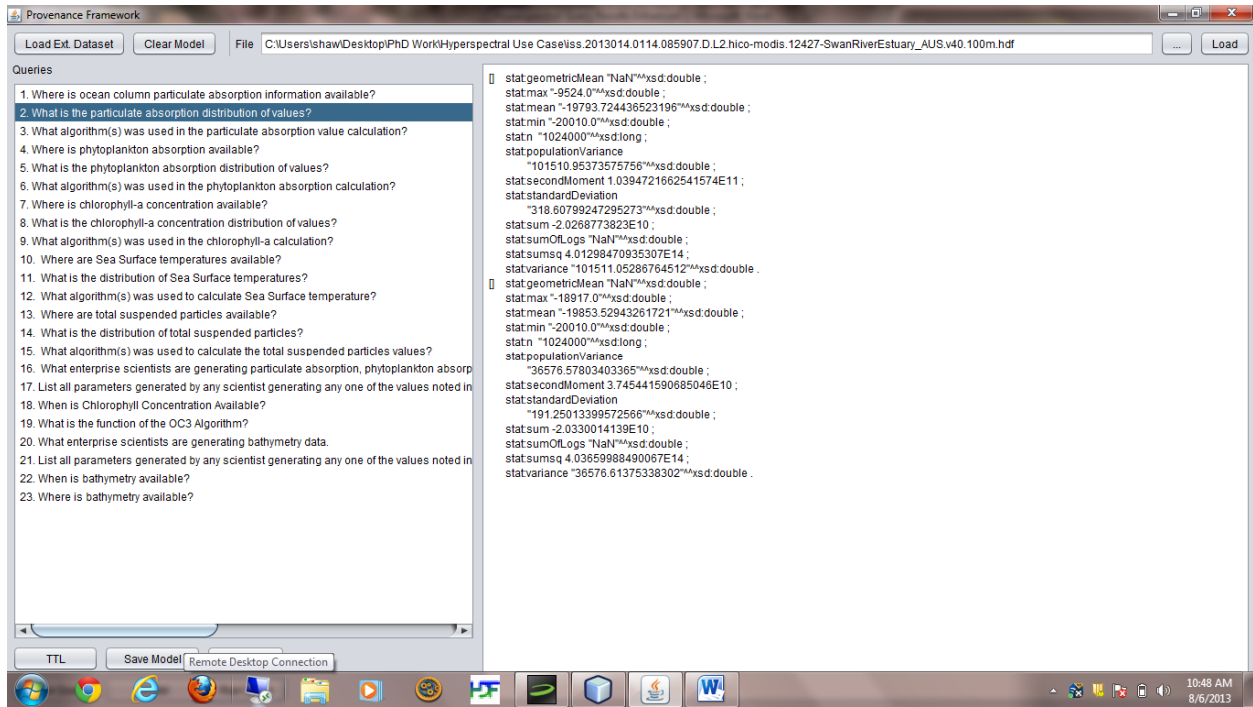


Figure 40, Hyperspectral Enhanced Query 2 Result

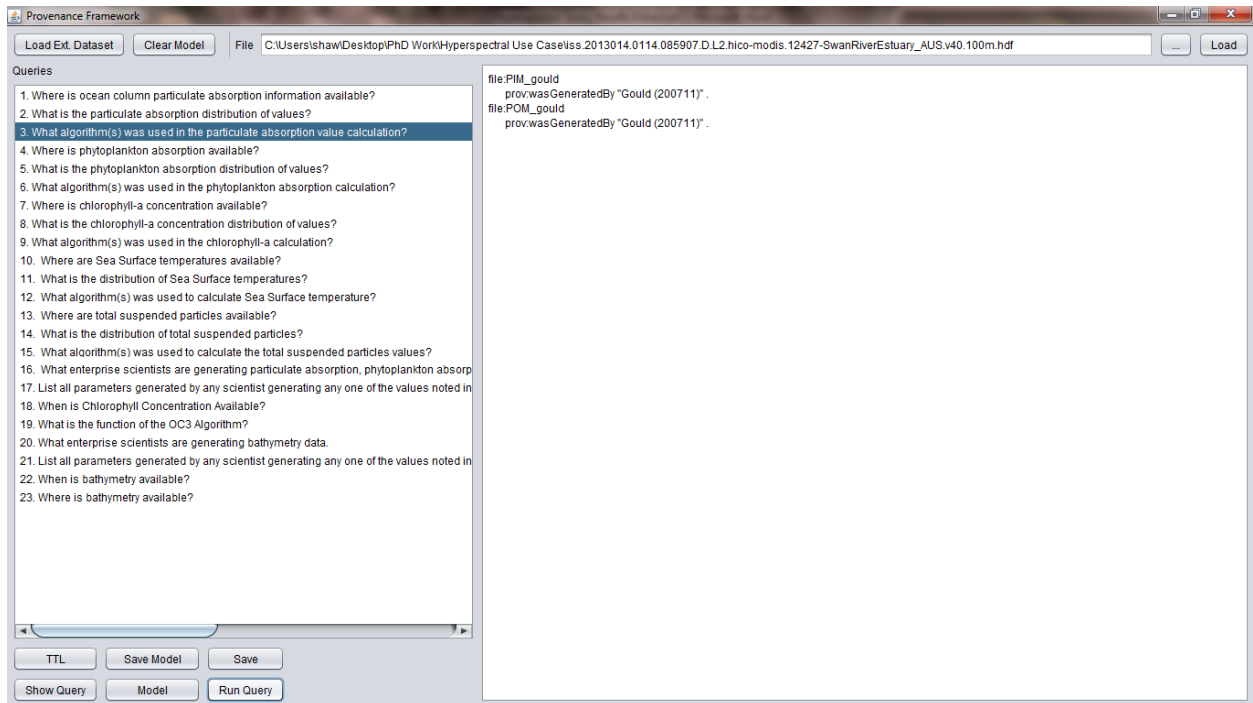


Figure 41, Hyperspectral Enhanced Query 3 Results

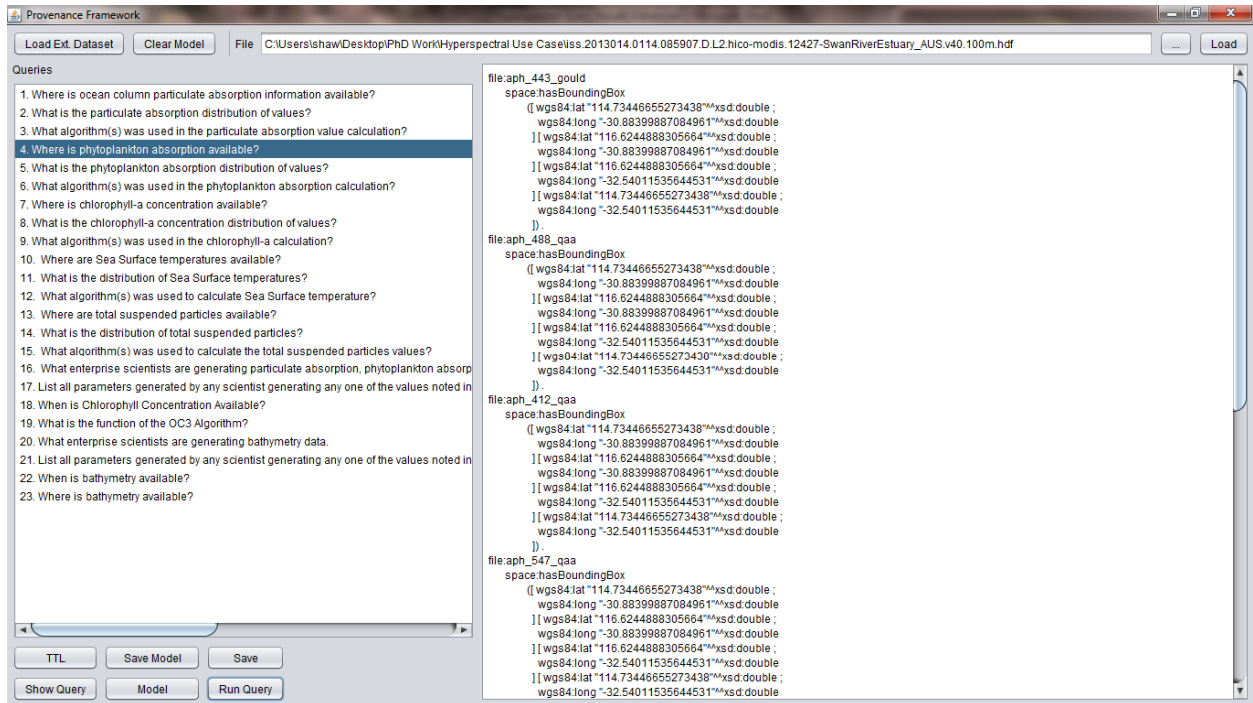


Figure 42, Hyperspectral Enhanced Query 4 Results

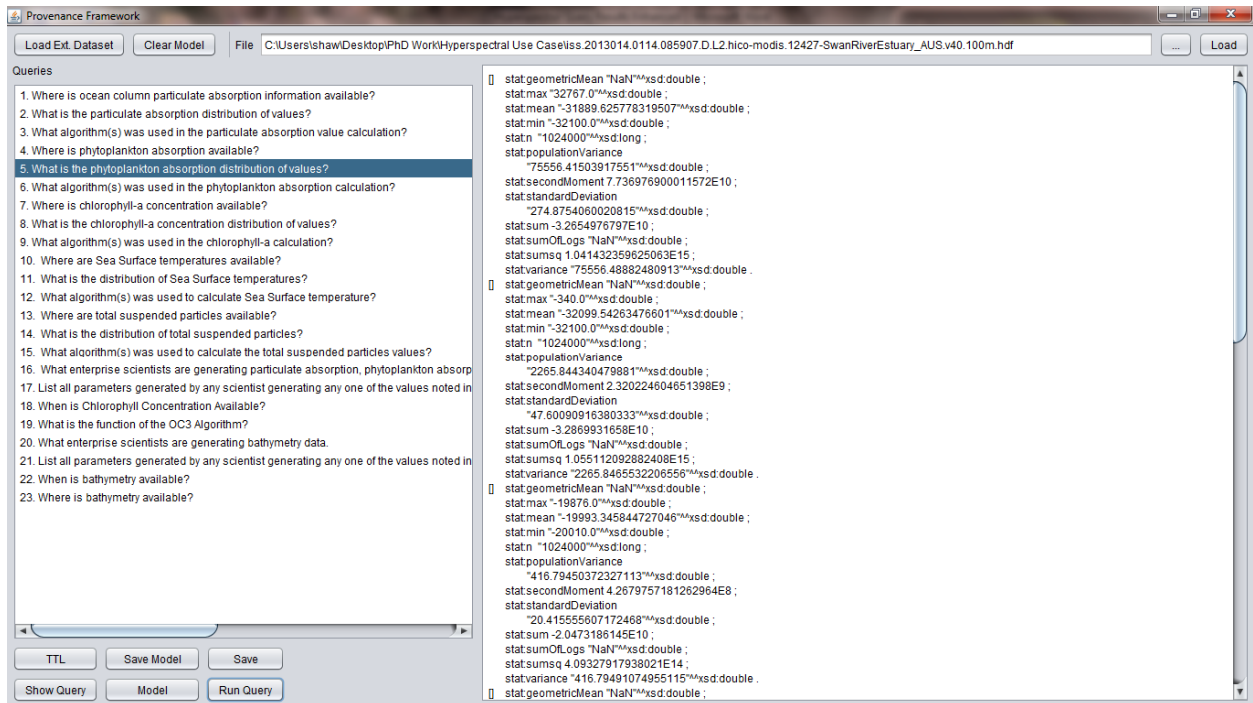


Figure 43, Hyperspectral Enhanced Query 5 Results

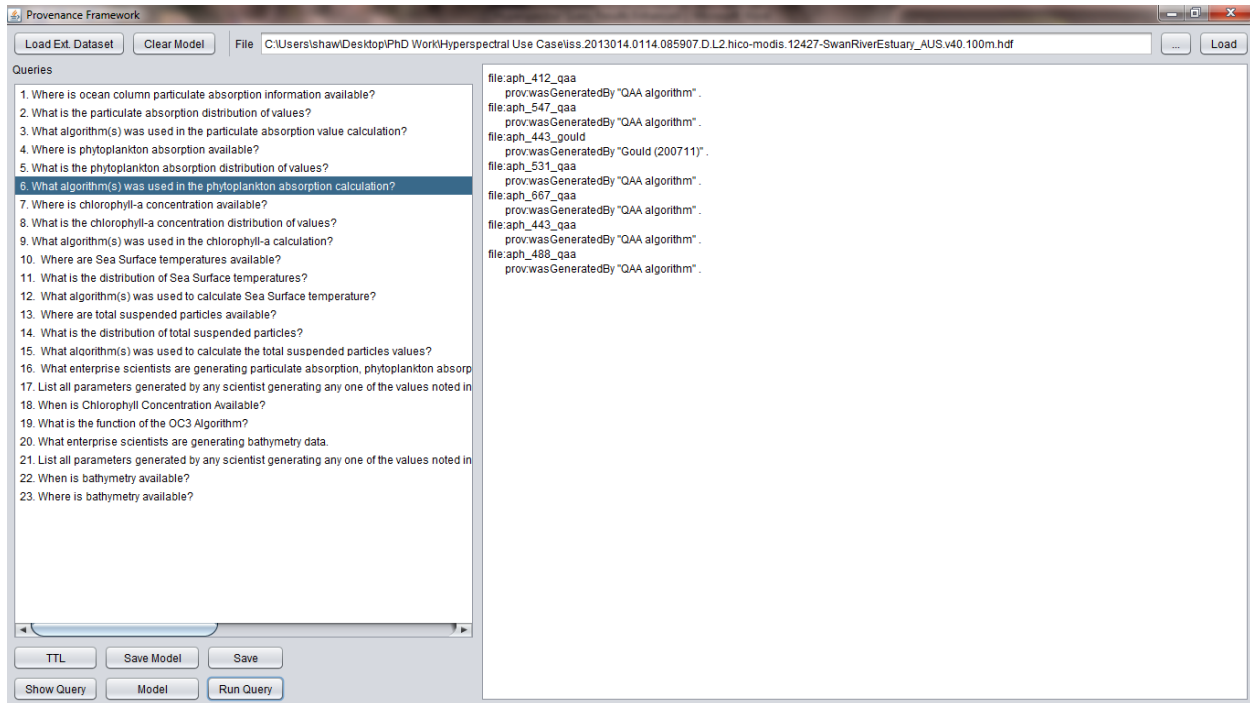


Figure 44, Hyperspectral Enhanced Query 6 Results

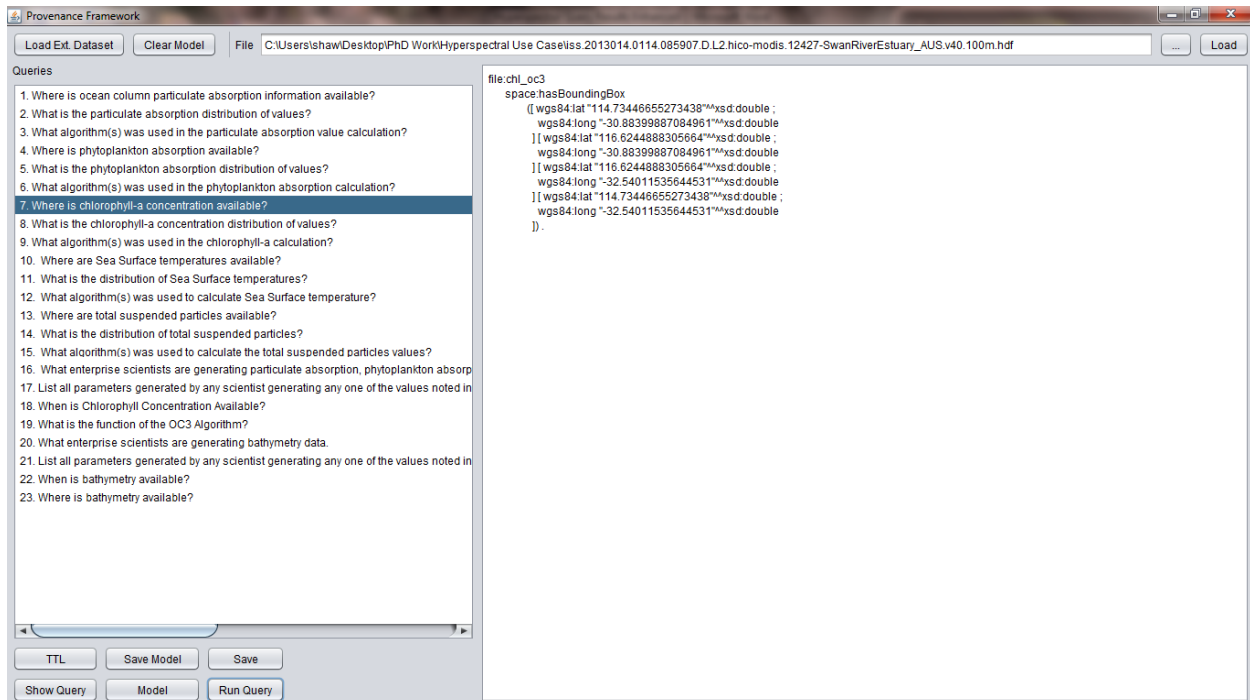


Figure 45, Hyperspectral Enhanced Query 7 Results

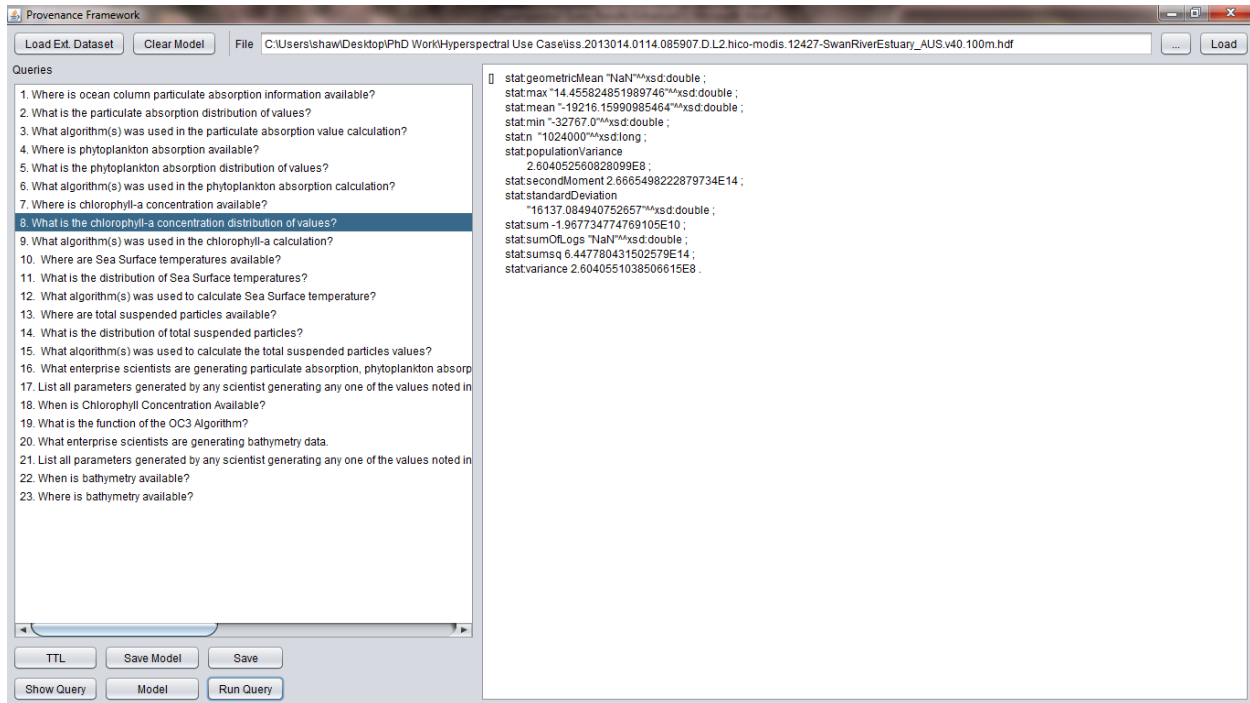


Figure 46, Hyperspectral Enhanced Query 8 Results

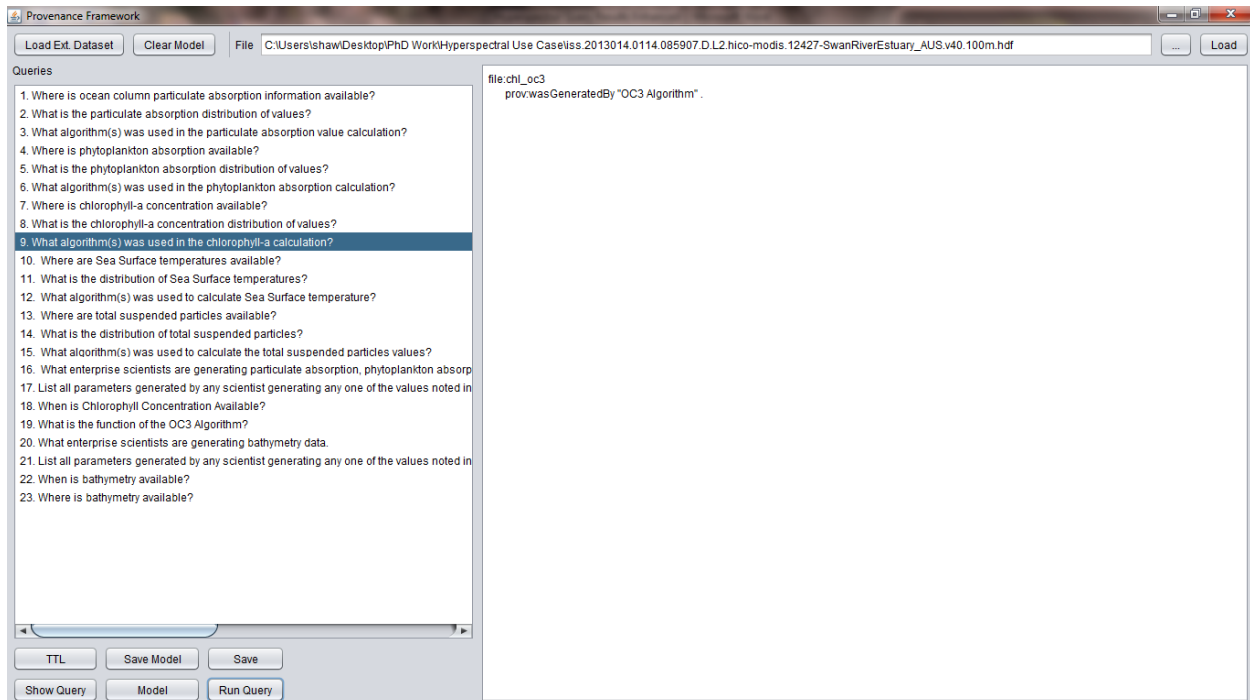


Figure 47, Hyperspectral Enhanced Query 9 Results

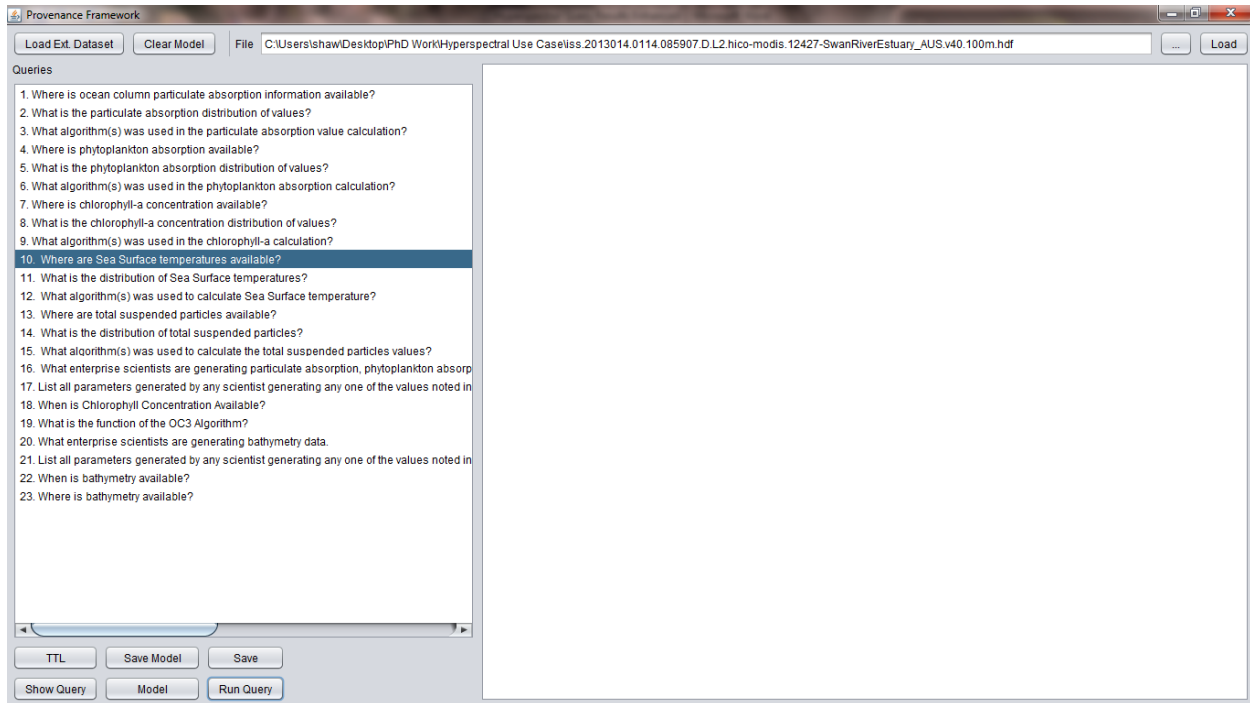


Figure 48, Hyperspectral Enhanced Query 10 Results

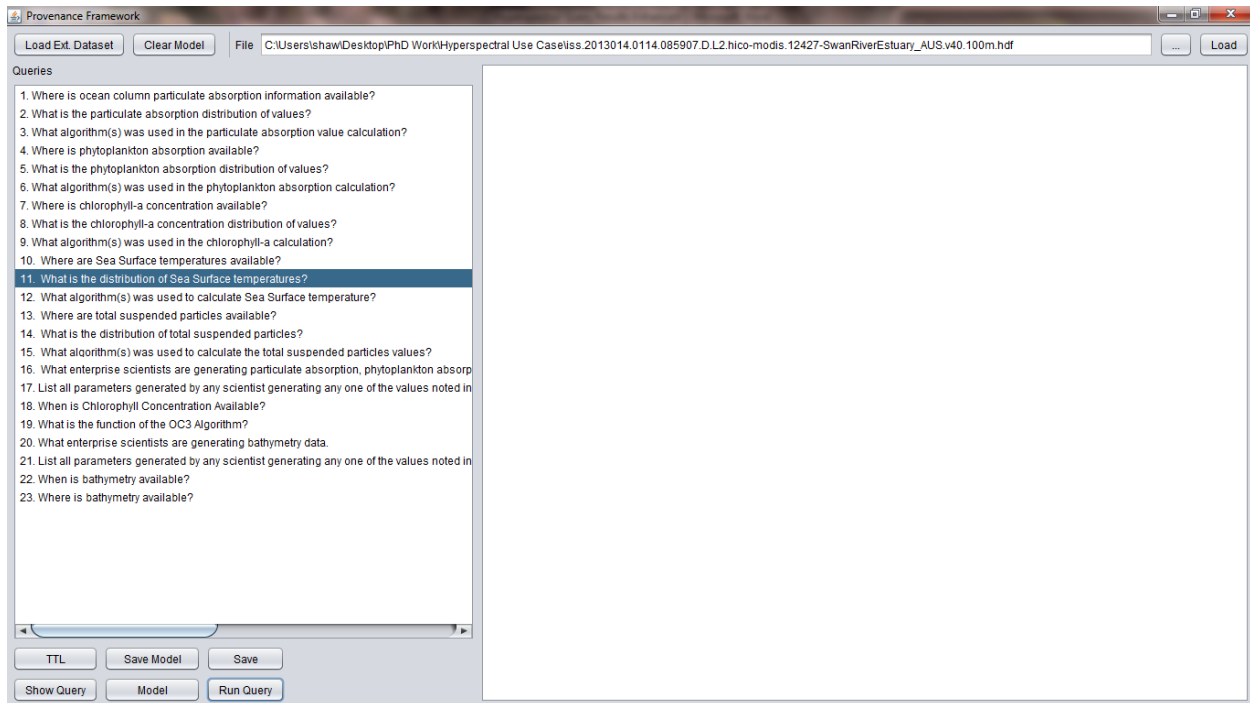


Figure 49, Hyperspectral Enhanced Query 11 Results

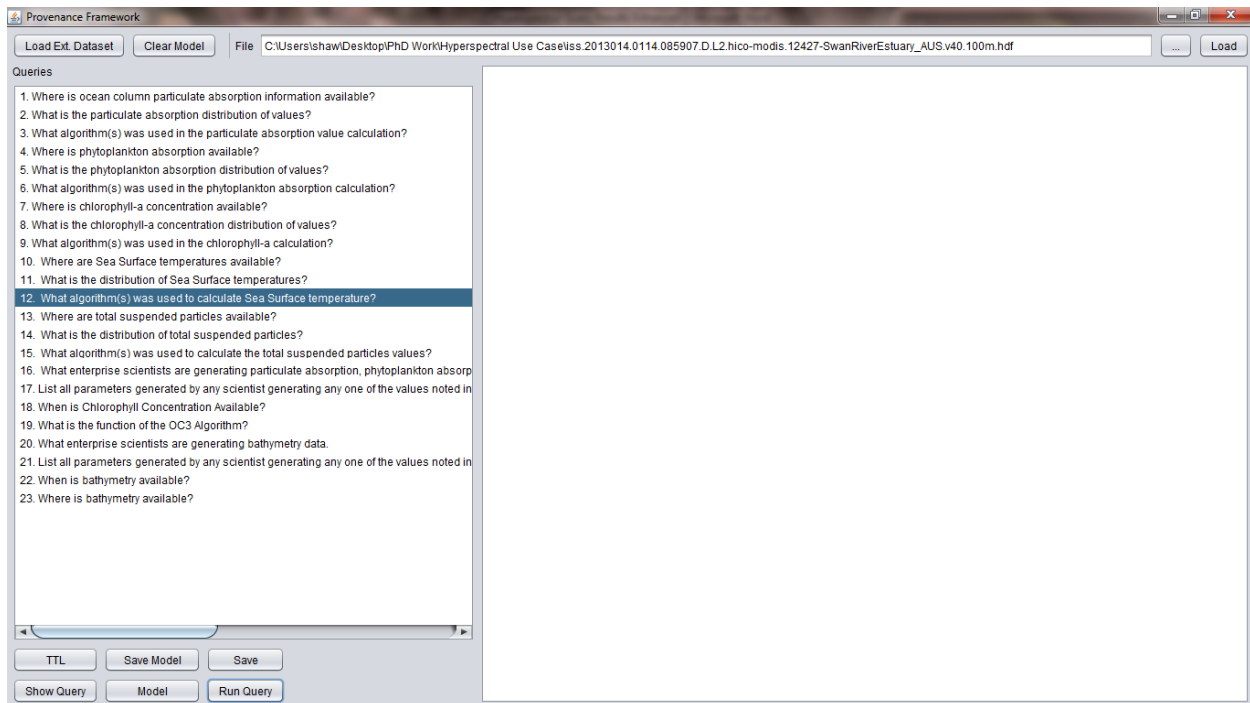


Figure 50, Hyperspectral Enhanced Query 12 Results

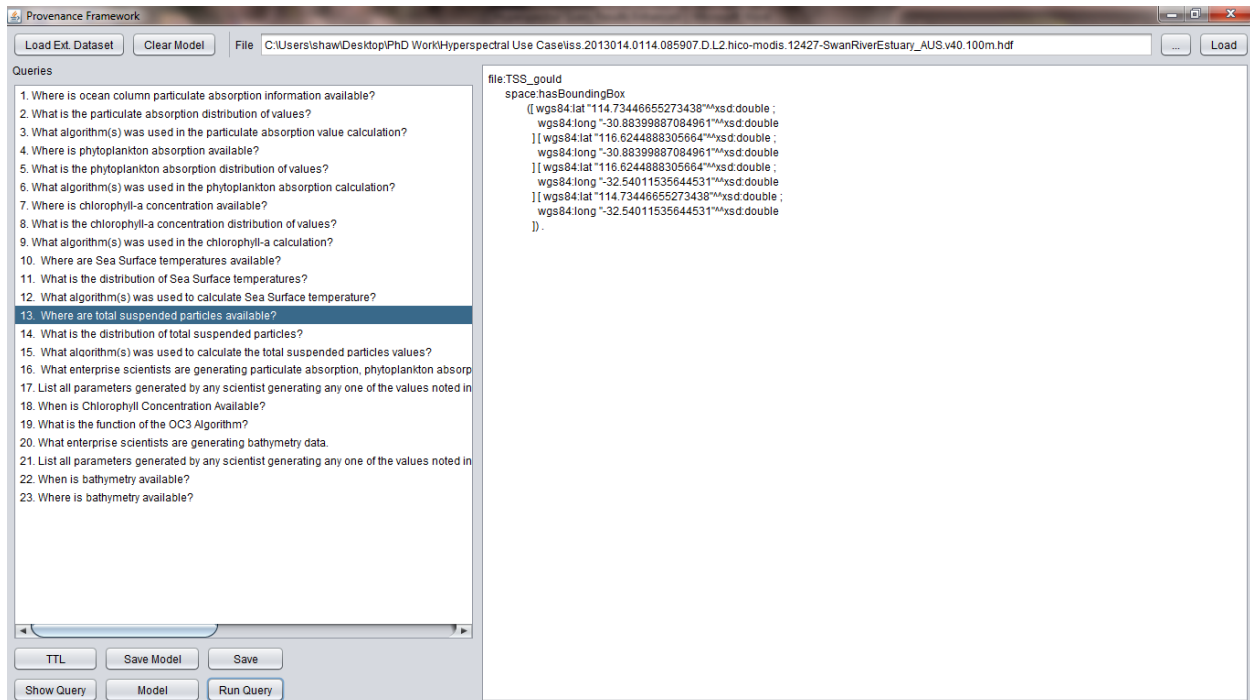


Figure 51, Hyperspectral Enhanced Query 13 Results

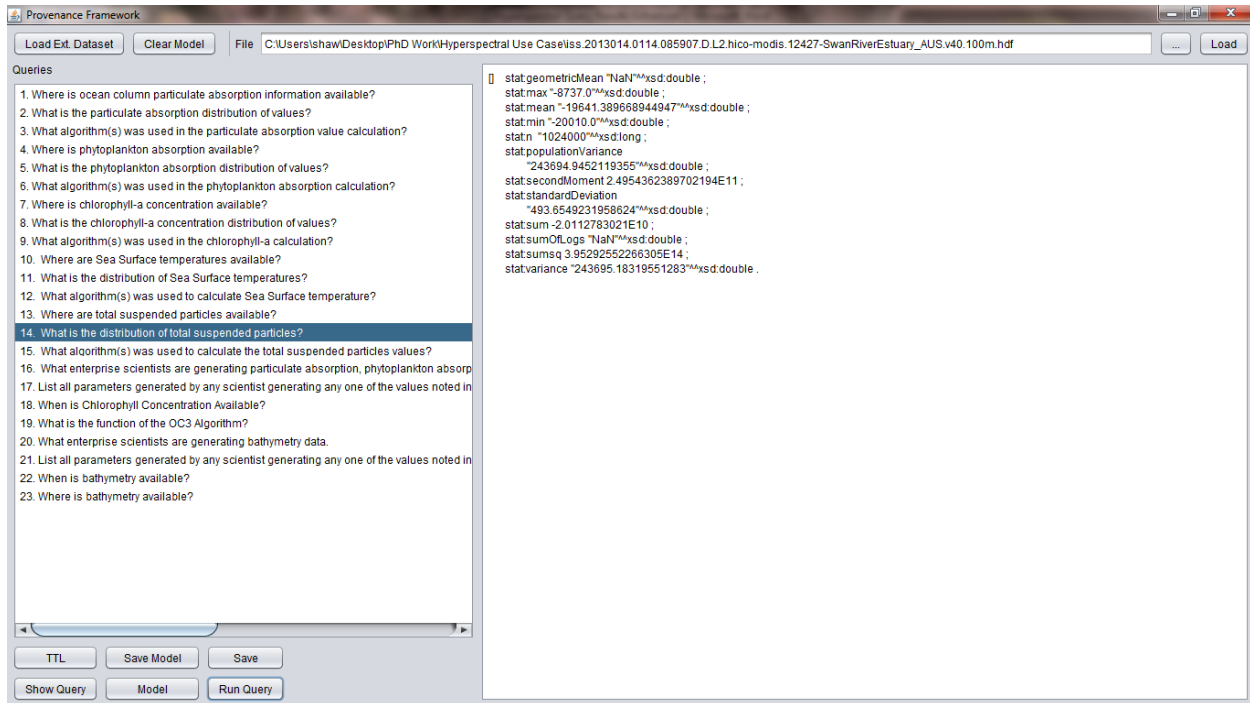


Figure 52, Hyperspectral Enhanced Query 14 Results

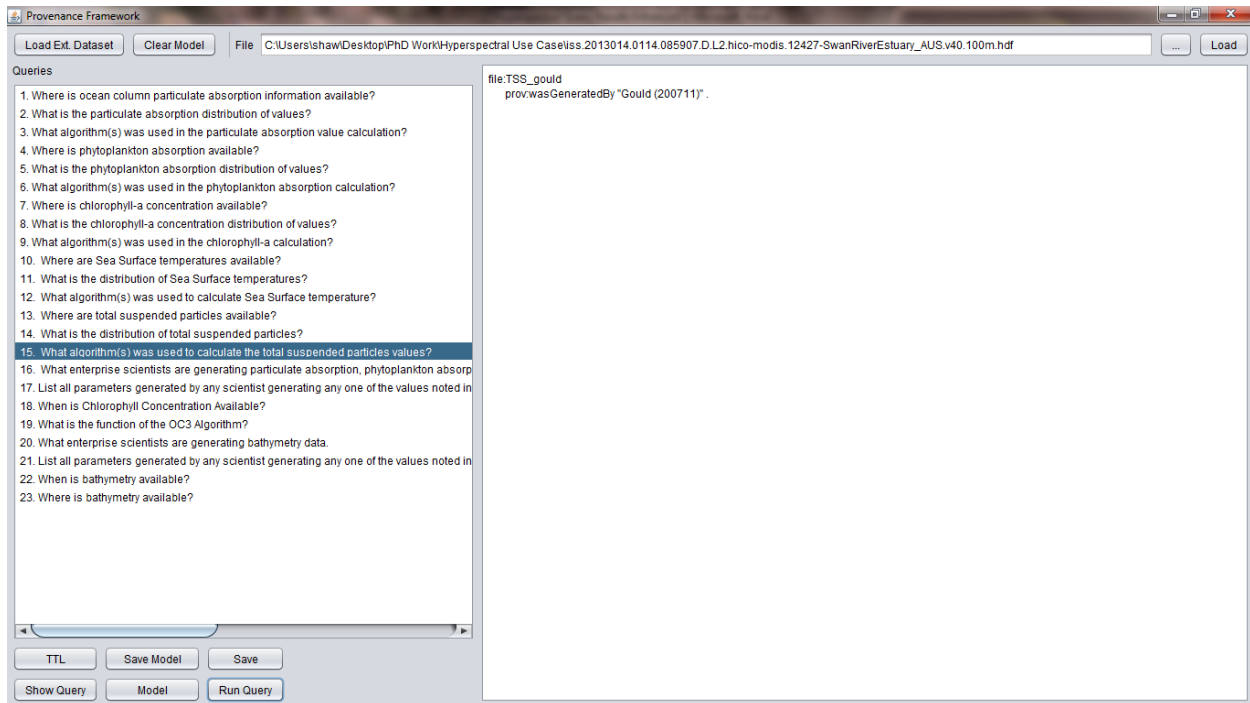


Figure 53, Hyperspectral Enhanced Query 15 Results



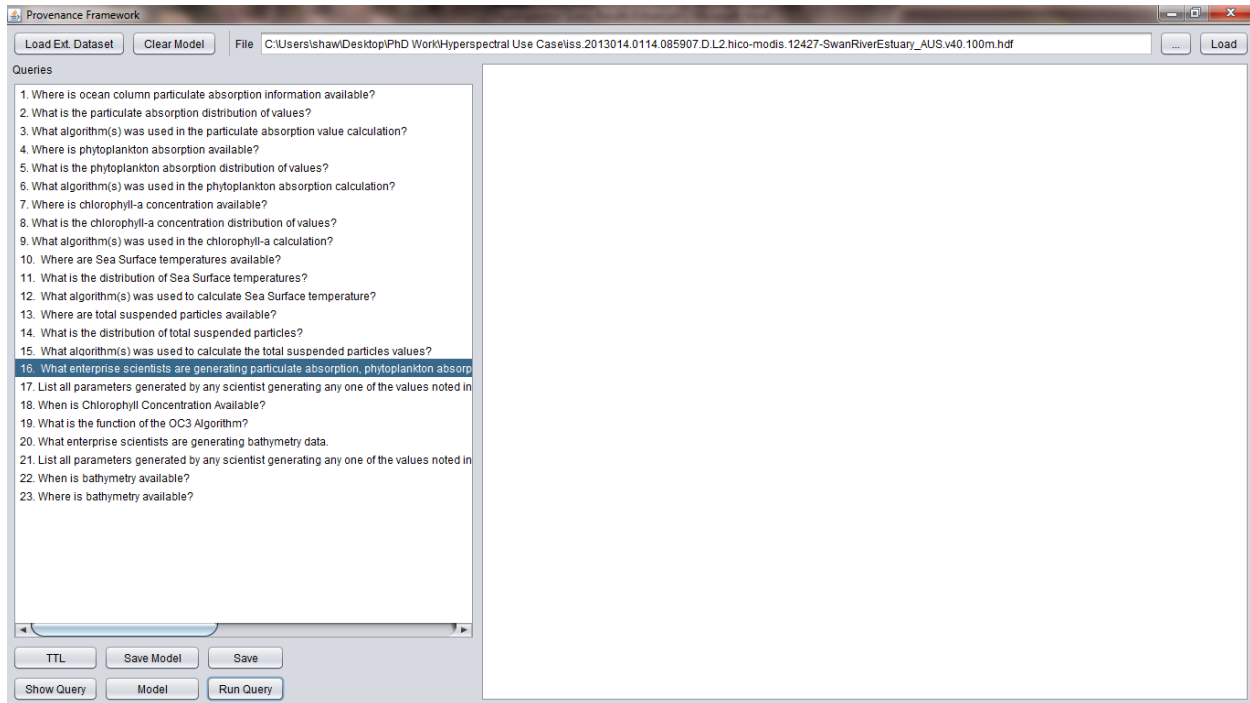


Figure 54, Hyperspectral Enhanced Query 16 Results

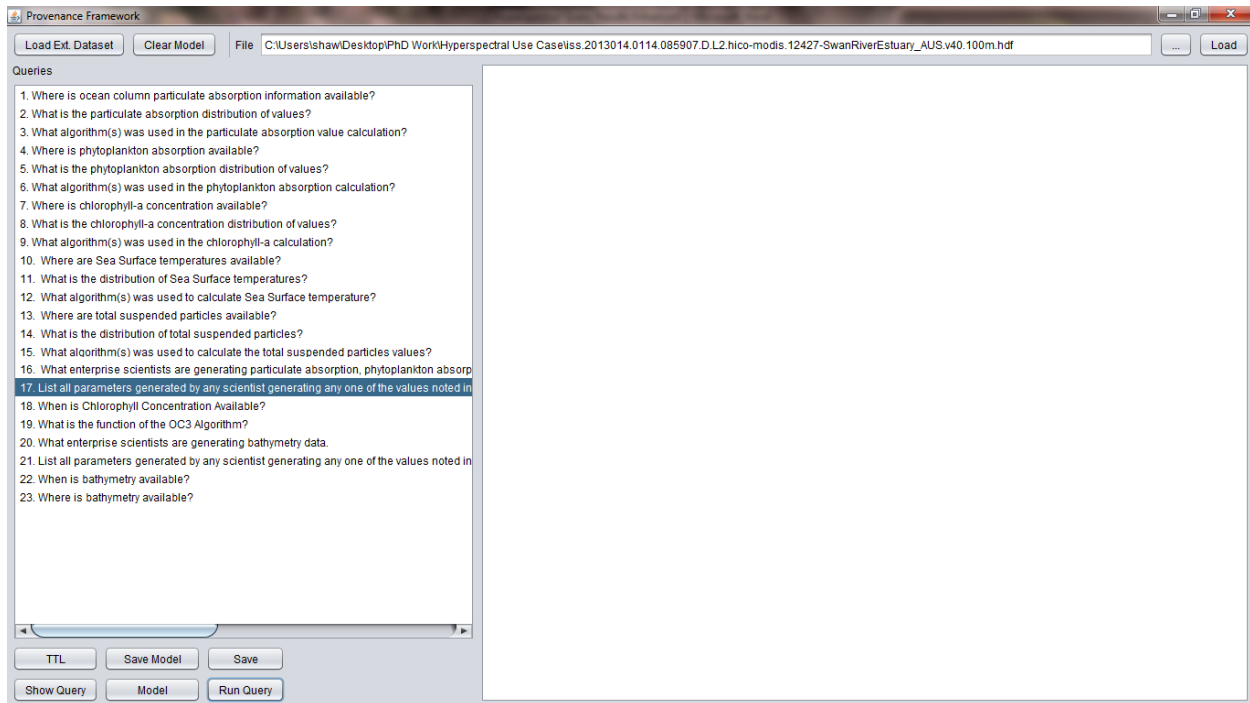


Figure 55, Hyperspectral Enhanced Query 17 Results

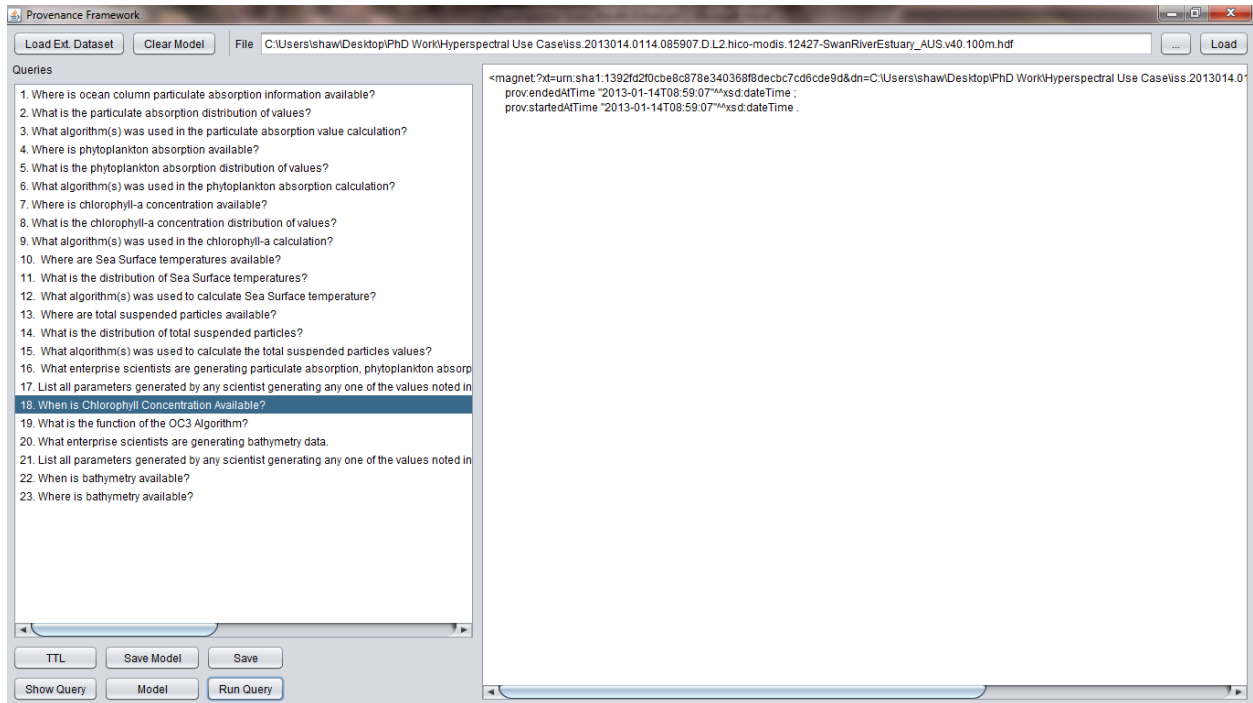


Figure 56, Hyperspectral Enhanced Query 18 Results

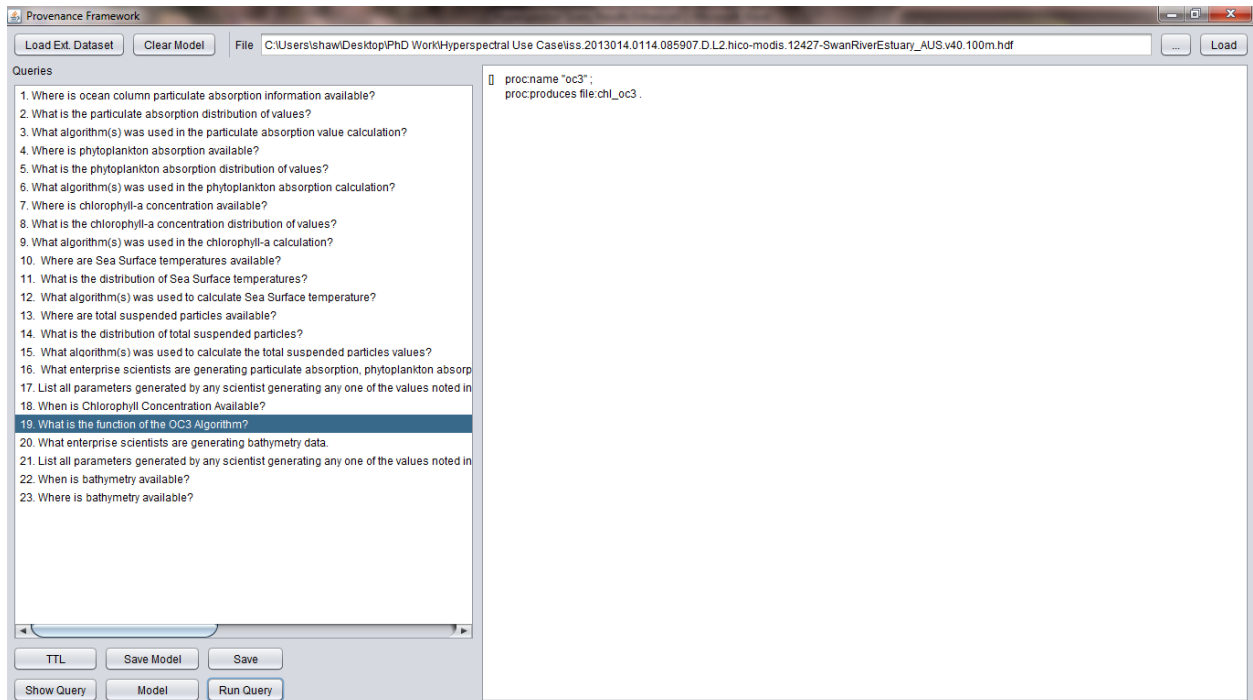


Figure 57, Hyperspectral Enhanced Query 19 Results

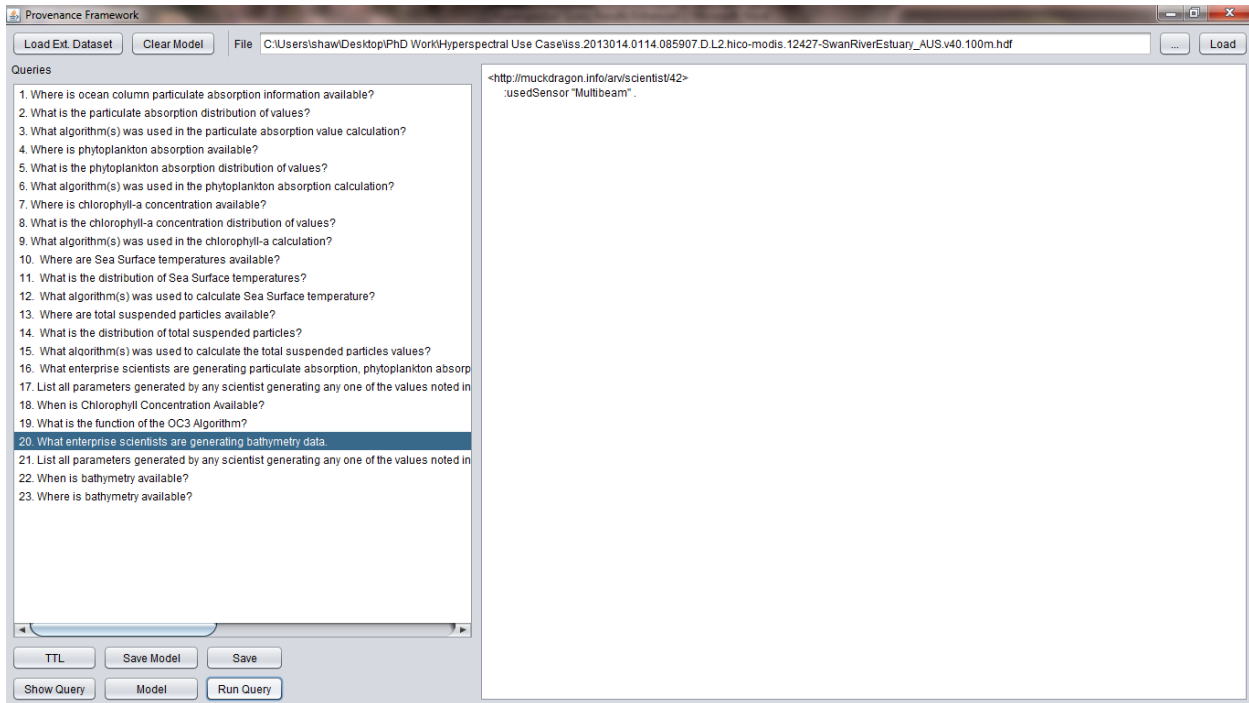


Figure 58, Hyperspectral Enhanced Query 20 Results

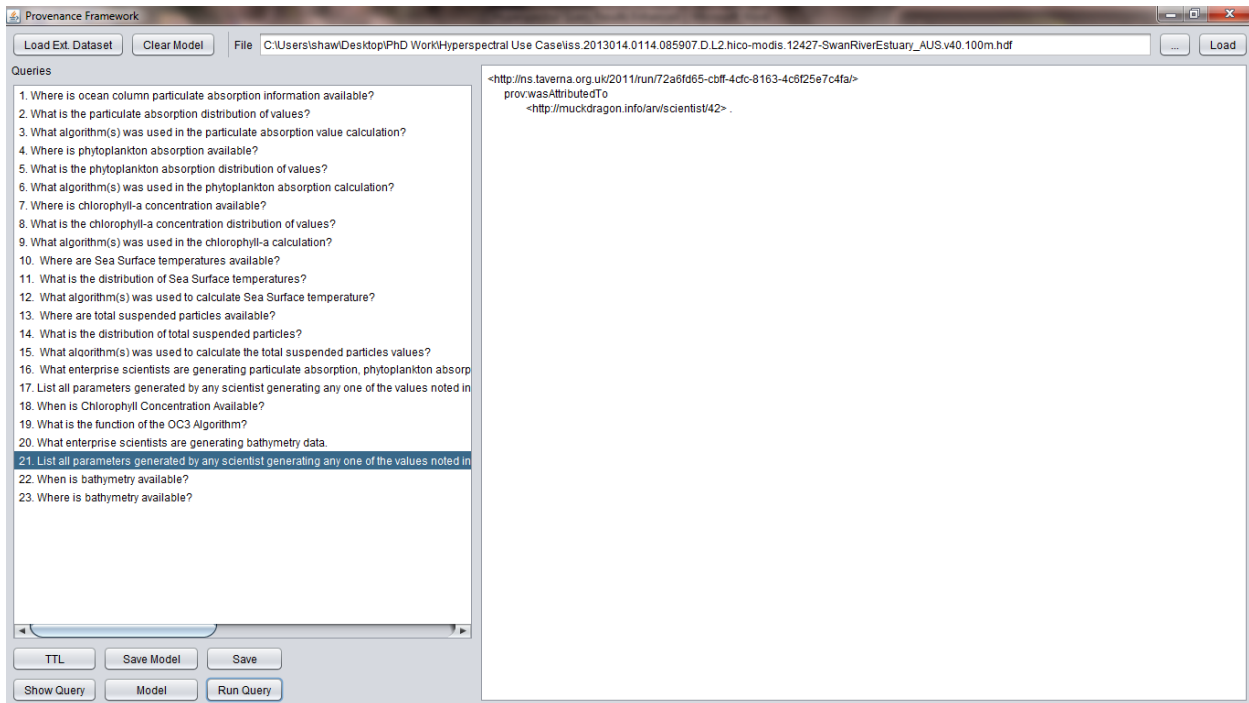


Figure 59, Hyperspectral Enhanced Query 21 Results

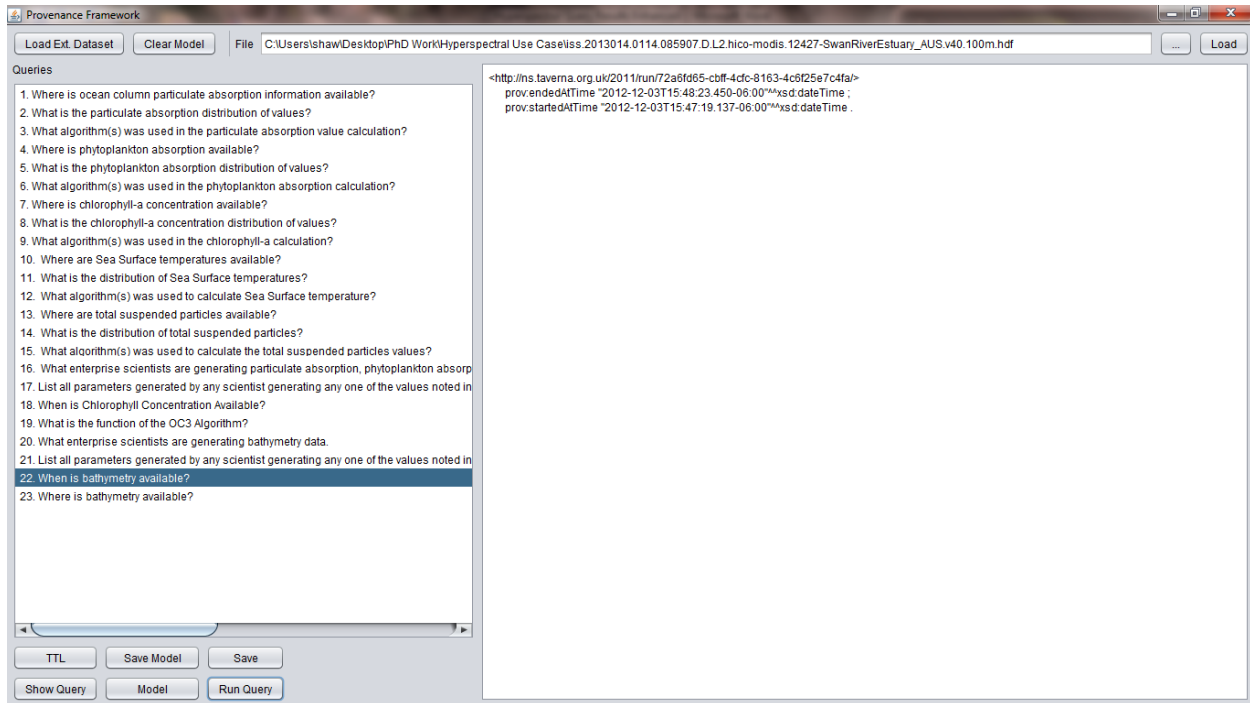


Figure 60, Hyperspectral Enhanced Query 22 Results

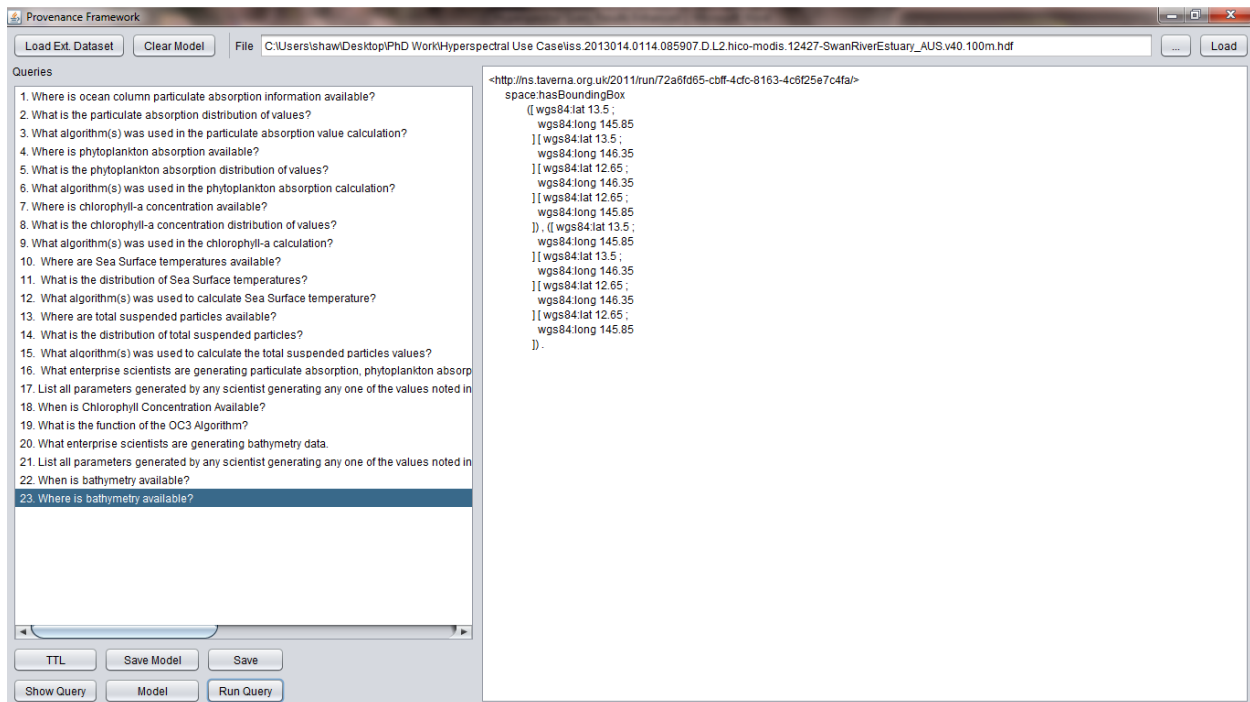


Figure 61, Hyperspectral Enhanced Query 23 Results

## Summary

This chapter detailed the improved modeling of hyperspectral data to avoid the reliance on regular expressions. These improvements strengthened the model and have shown more compact queries with broad ranging query coverage for utility in repurposing interdisciplinary content in an enterprise setting for improved curation. This extensive listing of SPARQL queries and their associated results demonstrate the possibility of passively formally modeling scientific data with stored provenance within an enterprise for interdisciplinary repurposing and improved curation.

The full generated model including enterprise graphs, initial bathymetry graphs and the final more expressive hyperspectral graphs are shown in Appendix C.

## Chapter 7      Conclusions

This research has pursued multiple experiments and prototype developments to explore knowledge management issues within an interdisciplinary scientific enterprise environment to show that it is possible to have a curated reasoning framework to repurpose scientific data based on formally modeling data provenance.

Initial simple scientific data (bathymetry) was modeled requiring active provenance generation. This initial provenance generation required substantial effort even though this was a “simple” scientific data set in the sense that the data itself (x,y, depth) was simple but the fact that no stored provenance information was present greatly complicated the repurposing of this content. An approach of leveraging the workflow management arena proved valuable in that using the open source Taverna workflow management system allowed not only the capture of processing stages to build data provenance but also enabled the rapid exploration of the new W3C emerging provenance vocabulary PROV O. The PROV O ontology was found to be effective at not only modeling provenance but also serving as an interchange mechanism that is crucial to allow interchange of provenance among workflow management systems, Electronic Data Notebooks (primarily now in the chemistry and biology disciplines) and other frameworks that may evolve. Handling the active case where provenance must be generated is clearly a challenging case but approaches to deal with these important data sets can leverage workflow management-type environments. Challenges with current workflow management systems are the complexities in customizing the environments without minimal error handling built in, overhead introduced by using a

workflow management system and the lack of current acceptance of workflow management systems across most environmental scientific disciplines as well as a lack of usage of web services for scientific data processing (processing still generally occurs with local algorithm implementation using MATLAB or custom software).

Central to an effective enterprise curation system is formally modeling the enterprise environment itself. This stage of the research was critical to understand (and more importantly to understand at the machine level to enable reasoning) all the interactions occurring with the scientific data at the highest level (could be exploited by enterprise leadership) as well as the lowest level of sensors employed over a specific region at a given time. Modeling the enterprise used for this research proved critical to show what is currently the focus in terms of scientific data collections and what is likely the future trajectory of these collections and their potential for reuse. Semantic web approaches proved effective at allowing the combination of not only interdisciplinary scientific data but organizational behaviors related to the data itself due to the flexible nature of RDF itself. The enterprise modeling was done with the last six years of platform (ship/plane) requests that are unstructured and were used as a proxy for this modeling since no process is currently in place to actively collect this type content. A future task as well as an improvement could be to intentionally collect and structure this type data to describe scientific uses/collection of enterprise data. Simple automated approaches could be developed to both simplify the process of requesting platform support for scientific data collection as well as automate the RDF graph generation that is required to formally model this information for application within the curation framework (other uses as well).

The hyperspectral use cases proved to be exceptionally rich given the passive provenance content that directly lends itself to formal modeling, graph generation and SPARQL query generation. The use of an underlying semantic web technology approach proved useful given the flexibility of the Anyone can say Anything about Any (AAA) topic approach. Even the initial modeling of hyperspectral data provenance using regular expressions proved to be very useful and practical in terms of generating queries that other scientists could readily use to further exploit collected data. The enhanced model did reduce the need for regular expressions and allows the further inclusion of other data types more readily into the provenance framework. Upon further investigation, hyperspectral data is available in large amounts within the enterprise and will continue to be given the purchasing of new sensors which shows that this data type could serve as an excellent beginning for an enterprise curation system to generate a quick win and then momentum. A future improvement to this initial work even within the hyperspectral arena could be the large scale modeling of the approximately 100 TBs of available hyperspectral data currently available. This improvement would also show how to efficiently and uniformly store provenance across all hyperspectral holdings within the enterprise.

The core hypothesis of this research that provenance could be formally modeled to allow curated reasoning within an interdisciplinary scientific research enterprise has been shown to be true by the developed provenance framework and practical SPARQL queries that were passively generated from hyperspectral data. The active case of provenance generation does still require additional research in terms of how to efficiently capture provenance information when not initially captured using web



services, workflow management systems, EDNs, etc. (where provenance would be automatically generated). Modeling of the overall enterprise and combining this generated knowledge with data provenance proved to be effective at allowing more complex query interaction with the scientific data itself and also shows the need for a focused effort on capturing enterprise knowledge intentionally as compared to by proxy (repurposing unstructured platform request data) as done in this research.

## Appendix A Initial Portion of Taverna Provenance Workflow Run

```
<?xml version="1.0" encoding="UTF-8"?>

<rdf:RDF xml:base="workflowrun.prov.ttl" xmlns="file:/home/arven/Documents/bathymetry-
prov/workflowrun.prov.ttl" xmlns:xsd="http://www.w3.org/2001/XMLSchema#"
xmlns:wfprov="http://purl.org/wf4ever/wfprov#" xmlns:wfdesc="http://purl.org/wf4ever/wfdesc#"
xmlns:tavernaprov="http://ns.taverna.org.uk/2012/tavernaprov/"
xmlns:scufl2="http://ns.taverna.org.uk/2010/scufl2#" xmlns:rdfs="http://www.w3.org/2000/01/rdf-
schema#" xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
xmlns:prov="http://www.w3.org/ns/prov#" xmlns:owl="http://www.w3.org/2002/07/owl#"
xmlns:doap="http://usefulinc.com/ns/doap#" xmlns:dcterms="http://purl.org/dc/terms/"
xmlns:cnt="http://www.w3.org/2011/content#"><rdf:Description
rdf:about="file:/home/arven/Documents/bathymetry-prov/workflowrun.prov.ttl" >
  <prov:qualifiedAssociation
  <rdf:nodeID="node17e8nsm2kx1"/></rdf:Description><rdf:Description
  <rdf:about="file:/home/arven/Documents/bathymetry-prov/workflowrun.prov.ttl" >
    <prov:startedAtTime rdf:datatype="http://www.w3.org/2001/XMLSchema#dateTime">2012-
    12-12T17:41:19.450-06:00</prov:startedAtTime></rdf:Description><rdf:Description
  <rdf:about="file:/home/arven/Documents/bathymetry-prov/workflowrun.prov.ttl" >
    <prov:wasAssociatedWith rdf:resource="file:/home/arven/Documents/bathymetry-
    prov/workflowrun.prov.ttl" >
      <prov:engine rdf:resource="file:/home/arven/Documents/bathymetry-
      prov/workflowrun.prov.ttl" >
```

rdf:about="file:/home/arven/Documents/bathymetry-prov/workflowrun.prov.ttltaverna-prov-export"><prov:wasInformedBy rdf:resource="http://ns.taverna.org.uk/2011/run/aa68676d-79d2-42d3-b1b2-1c229d06d1a1/" /></rdf:Description>+<rdf:Description rdf:nodeID="node17e8nsm2kx1">-<rdf:Description rdf:nodeID="node17e8nsm2kx1"><prov:agent rdf:resource="file:/home/arven/Documents/bathymetry-prov/workflowrun.prov.ttltaverna-engine" /></rdf:Description>-<rdf:Description rdf:nodeID="node17e8nsm2kx1"><prov:hadPlan rdf:resource="http://ns.taverna.org.uk/2011/software/taverna-2.4.0" /></rdf:Description>-<rdf:Description rdf:about=""><prov:wasGeneratedBy rdf:resource="file:/home/arven/Documents/bathymetry-prov/workflowrun.prov.ttltaverna-prov-export" /></rdf:Description>-<rdf:Description rdf:about="http://ns.taverna.org.uk/2011/run/aa68676d-79d2-42d3-b1b2-1c229d06d1a1/"><dcterms:hasPart rdf:resource="http://ns.taverna.org.uk/2011/run/aa68676d-79d2-42d3-b1b2-1c229d06d1a1/process/714caa44-125d-411b-ad3d-f1b64a922529/" /></rdf:Description>-<rdf:Description rdf:about="http://ns.taverna.org.uk/2011/run/aa68676d-79d2-42d3-b1b2-1c229d06d1a1/"><dcterms:hasPart rdf:resource="http://ns.taverna.org.uk/2011/run/aa68676d-79d2-42d3-b1b2-1c229d06d1a1/process/be7131f2-1960-4465-89aa-8031a150ae0d/" /></rdf:Description>-<rdf:Description rdf:about="http://ns.taverna.org.uk/2011/run/aa68676d-79d2-42d3-b1b2-1c229d06d1a1/"><dcterms:hasPart rdf:resource="http://ns.taverna.org.uk/2011/run/aa68676d-79d2-42d3-b1b2-1c229d06d1a1/process/e6463805-a8d1-47c0-85b1-4876a40bc9ae/" /></rdf:Description>-<rdf:Description rdf:about="http://ns.taverna.org.uk/2011/run/aa68676d-79d2-42d3-b1b2-1c229d06d1a1/"><wfprov:describedByWorkflow rdf:resource="http://ns.taverna.org.uk/2010/workflowBundle/2c545d5e-624e-4ecf-b918-144141b13bf0/workflow/Workflow1/" /></rdf:Description>-<rdf:Description rdf:about="http://ns.taverna.org.uk/2011/run/aa68676d-79d2-42d3-b1b2-

1c229d06d1a1/"><wfprov:usedInput rdf:resource="http://ns.taverna.org.uk/2011/data/aa68676d-79d2-42d3-b1b2-1c229d06d1a1/ref/92f8267a-a7dc-4b44-8807-ebbf3c820aa"/></rdf:Description>-<br><rdf:Description rdf:about="http://ns.taverna.org.uk/2011/run/aa68676d-79d2-42d3-b1b2-1c229d06d1a1/"><wfprov:wasEnactedBy rdf:resource="file:/home/arven/Documents/bathymetry-prov/workflowrun PROV.ttl#taverna-engine"/></rdf:Description>-<rdf:Description rdf:about="http://ns.taverna.org.uk/2011/run/aa68676d-79d2-42d3-b1b2-1c229d06d1a1/"><rdf:type rdf:resource="http://purl.org/wf4ever/wfprov#WorkflowRun"/></rdf:Description>-<rdf:Description rdf:about="http://ns.taverna.org.uk/2011/run/aa68676d-79d2-42d3-b1b2-1c229d06d1a1/"><rdfs:label>Workflow run of Workflow1</rdfs:label></rdf:Description>-<br><rdf:Description rdf:about="http://ns.taverna.org.uk/2011/run/aa68676d-79d2-42d3-b1b2-1c229d06d1a1/"><prov:endedAtTime rdf:datatype="http://www.w3.org/2001/XMLSchema#dateTime">2012-12-12T17:40:23.874-06:00</prov:endedAtTime></rdf:Description>-<rdf:Description rdf:about="http://ns.taverna.org.uk/2011/run/aa68676d-79d2-42d3-b1b2-1c229d06d1a1/"><prov:qualifiedAssociation rdf:nodeID="node17e8nsm2kx2"/></rdf:Description>-<br><rdf:Description rdf:about="http://ns.taverna.org.uk/2011/run/aa68676d-79d2-42d3-b1b2-1c229d06d1a1/"><prov:qualifiedUsage rdf:nodeID="node17e8nsm2kx3"/></rdf:Description>-<br><rdf:Description rdf:about="http://ns.taverna.org.uk/2011/run/aa68676d-79d2-42d3-b1b2-1c229d06d1a1/"><prov:startedAtTime rdf:datatype="http://www.w3.org/2001/XMLSchema#dateTime">2012-12-12T17:38:17.912-06:00</prov:startedAtTime></rdf:Description>-<rdf:Description rdf:about="http://ns.taverna.org.uk/2011/run/aa68676d-79d2-42d3-b1b2-1c229d06d1a1/"><prov:used rdf:resource="http://ns.taverna.org.uk/2011/data/aa68676d-79d2-42d3-b1b2-1c229d06d1a1/ref/92f8267a-a7dc-4b44-8807-ebbf3c820aa"/></rdf:Description>-<rdf:Description

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rdf:nodeID="node17e8nsm2kx2"><rdf:type  
rdf:resource="http://www.w3.org/ns/prov#Association"/></rdf:Description><rdf:Description  
rdf:nodeID="node17e8nsm2kx2"><prov:agent rdf:resource="file:/home/arven/Documents/bathymetry-prov/workflowrun.prov.ttltaverna-engine"/></rdf:Description><rdf:Description  
rdf:nodeID="node17e8nsm2kx2"><prov:hadPlan  
rdf:resource="http://ns.taverna.org.uk/2010/workflowBundle/2c545d5e-624e-4ecf-b918-144141b13bf0/workflow/Workflow1/"></rdf:Description><rdf:Description  
rdf:nodeID="node17e8nsm2kx3"><rdf:type  
rdf:resource="http://www.w3.org/ns/prov#Usage"/></rdf:Description><rdf:Description  
rdf:nodeID="node17e8nsm2kx3"><prov:entity  
rdf:resource="http://ns.taverna.org.uk/2011/data/aa68676d-79d2-42d3-b1b2-1c229d06d1a1/ref/92f8267a-a7dc-4b44-8807-ebbf3c820aa"/></rdf:Description><rdf:Description  
rdf:nodeID="node17e8nsm2kx3"><prov:hadRole  
rdf:resource="http://ns.taverna.org.uk/2010/workflowBundle/2c545d5e-624e-4ecf-b918-144141b13bf0/workflow/Workflow1/in/InFile"/></rdf:Description><rdf:Description  
rdf:about="http://ns.taverna.org.uk/2010/workflowBundle/2c545d5e-624e-4ecf-b918-144141b13bf0/workflow/Workflow1/in/InFile"><rdfs:label>Workflow input  
InFile</rdfs:label></rdf:Description><rdf:Description  
rdf:about="http://ns.taverna.org.uk/2011/data/aa68676d-79d2-42d3-b1b2-1c229d06d1a1/ref/92f8267a-a7dc-4b44-8807-ebbf3c820aa"><wfprov:describedByParameter  
rdf:resource="http://ns.taverna.org.uk/2010/workflowBundle/2c545d5e-624e-4ecf-b918-

144141b13bf0/workflow/Workflow1/in/InFile"/></rdf:Description>-<rdf:Description  
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1c229d06d1a1/ref/92f8267a-a7dc-4b44-8807-ebbf3c820aa"><wfprov:describedByParameter  
rdf:resource="http://ns.taverna.org.uk/2010/workflowBundle/2c545d5e-624e-4ecf-b918-  
144141b13bf0/workflow/Workflow1/processor/Read\_Data\_Points/in/fileurl"/></rdf:Description>-  
<rdf:Description rdf:about="http://ns.taverna.org.uk/2011/data/aa68676d-79d2-42d3-b1b2-  
1c229d06d1a1/ref/2f2f27b7-9658-4cbf-becb-e8339fe6bed9"><wfprov:describedByParameter  
rdf:resource="http://ns.taverna.org.uk/2010/workflowBundle/2c545d5e-624e-4ecf-b918-  
144141b13bf0/workflow/Workflow1/out/OutData"/></rdf:Description>-<rdf:Description  
rdf:about="http://ns.taverna.org.uk/2011/data/aa68676d-79d2-42d3-b1b2-  
1c229d06d1a1/ref/2f2f27b7-9658-4cbf-becb-e8339fe6bed9"><wfprov:wasOutputFrom  
rdf:resource="http://ns.taverna.org.uk/2011/run/aa68676d-79d2-42d3-b1b2-  
1c229d06d1a1"/></rdf:Description>-<rdf:Description  
rdf:about="http://ns.taverna.org.uk/2011/data/aa68676d-79d2-42d3-b1b2-  
1c229d06d1a1/ref/2f2f27b7-9658-4cbf-becb-e8339fe6bed9"><prov:qualifiedGeneration  
rdf:nodeID="node17e8nsm2kx4"/></rdf:Description>-<rdf:Description  
rdf:about="http://ns.taverna.org.uk/2011/data/aa68676d-79d2-42d3-b1b2-  
1c229d06d1a1/ref/2f2f27b7-9658-4cbf-becb-e8339fe6bed9"><prov:wasGeneratedBy  
rdf:resource="http://ns.taverna.org.uk/2011/run/aa68676d-79d2-42d3-b1b2-  
1c229d06d1a1"/></rdf:Description>-<rdf:Description rdf:nodeID="node17e8nsm2kx4"><rdf:type  
rdf:resource="http://www.w3.org/ns/prov#Generation"/></rdf:Description>-<rdf:Description  
rdf:nodeID="node17e8nsm2kx4"><prov:activity  
rdf:resource="http://ns.taverna.org.uk/2011/run/aa68676d-79d2-42d3-b1b2-  
1c229d06d1a1"/></rdf:Description>-<rdf:Description rdf:nodeID="node17e8nsm2kx4"><prov:hadRole

```

rdf:resource="http://ns.taverna.org.uk/2010/workflowBundle/2c545d5e-624e-4ecf-b918-
144141b13bf0/workflow/Workflow1/out/OutData"/></rdf:Description><-rdf:Description
rdf:about="http://ns.taverna.org.uk/2010/workflowBundle/2c545d5e-624e-4ecf-b918-
144141b13bf0/workflow/Workflow1/out/OutData"><rdfs:label>Workflow output
OutData</rdfs:label></rdf:Description><-rdf:Description
rdf:about="http://ns.taverna.org.uk/2011/run/aa68676d-79d2-42d3-b1b2-
1c229d06d1a1/process/be7131f2-1960-4465-89aa-8031a150ae0d/"><wfprov:describedByProcess
rdf:resource="http://ns.taverna.org.uk/2010/workflowBundle/2c545d5e-624e-4ecf-b918-
144141b13bf0/workflow/Workflow1/processor/Encoding/"></rdf:Description><-rdf:Description
rdf:about="http://ns.taverna.org.uk/2011/run/aa68676d-79d2-42d3-b1b2-
1c229d06d1a1/process/be7131f2-1960-4465-89aa-8031a150ae0d/"><wfprov:wasPartOfWorkflowRun
rdf:resource="http://ns.taverna.org.uk/2011/run/aa68676d-79d2-42d3-b1b2-
1c229d06d1a1/"></rdf:Description><-rdf:Description
rdf:about="http://ns.taverna.org.uk/2011/run/aa68676d-79d2-42d3-b1b2-
1c229d06d1a1/process/be7131f2-1960-4465-89aa-8031a150ae0d/"><rdfs:label>Processor execution
Encoding (facade0:Workflow1:Encoding)</rdfs:label>

```

## Appendix B

## Enterprise Model

@prefix : <<http://www.semanticweb.org/owl/owlapi/turtle#>> .

@prefix arv: <<http://muckdragon.info/arv/schema/>> .

@prefix prov: <<http://www.w3.org/ns/prov#>> .

@prefix cnt: <<http://www.w3.org/2011/content#>> .

@prefix measure: <<http://muckdragon.info/hyperspectral/tags/measure#>> .

@prefix wfprov: <<http://purl.org/wf4ever/wfprov#>> .

@prefix xml: <<http://www.w3.org/XML/1998/namespace>> .

@prefix space: <<http://muckdragon.info/data/space#>> .

@prefix dcterms: <<http://purl.org/dc/terms/>> .

@prefix sensor: <<http://muckdragon.info/hyperspectral/tags/sensor#>> .

@prefix rdfs: <<http://www.w3.org/2000/01/rdf-schema#>> .

@prefix category: <<http://muckdragon.info/hyperspectral/tags/category#>> .

@prefix wfdesc: <<http://purl.org/wf4ever/wfdesc#>> .

@prefix xsd: <<http://www.w3.org/2001/XMLSchema#>> .

@prefix owl: <<http://www.w3.org/2002/07/owl#>> .

@prefix tavernaprov: <<http://ns.taverna.org.uk/2012/tavernaprov/>> .

@prefix rdf: <<http://www.w3.org/1999/02/22-rdf-syntax-ns#>> .



@prefix wgs84: <[http://www.w3.org/2003/01/geo/wgs84\\_pos#](http://www.w3.org/2003/01/geo/wgs84_pos#)> .

@prefix doap: <<http://usefulinc.com/ns/doap#>> .

@prefix scuf12: <<http://ns.taverna.org.uk/2010/scuf12#>> .

<<http://muckdragon.info/arv/request/6.2/12/6>>

a arv:Data ;

arv:dataType "particle size" , "fluorescence" , "LIDAR" , "attenuation" , "temperature" , "bathymetry"  
 , "absorption" , "backscattering" , "Hyperspectral Imagery" , "conductivity" ;

arv:location "Florida Bay, FL" ;

arv:purpose "determine nature of the polarimetric signal in coastal environments" ;

arv:scientist <<http://muckdragon.info/arv/scientist/24>> ;

arv:sensor "LIDAR" , "LISST" , "CDOM" ;

arv:title "Polarimetric LIDAR and Hyperspectral Imaging of Coastal Environment" .

<<http://muckdragon.info/arv/request/6.2/08/1>>

a arv:Data ;

arv:dataType "sediment" , "SAS" ;

arv:location "Gulf of Mexico, MS, AL and FL" ;

arv:purpose "examine sensitivity of low frequency SAS to seafloor environment" ;

arv:scientist <<http://muckdragon.info/arv/scientist/11>> ;

arv:sensor "ASCS" , "SAS" ;

arv:title "Environmentally Adaptive Subbottom SAS" .

<<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/out/OutData>>

rdfs:label "Workflow output OutData" .

<[magnet:?xt=urn:sha1:67fe8510980921b0e26ac0d91a19870d67f0bd65&dn=/home/arven/hdf/iss.2013014.0114.085907.D.L2.hico.12427-SwanRiverEstuary\\_AUS.v40.100m.hdf](magnet:?xt=urn:sha1:67fe8510980921b0e26ac0d91a19870d67f0bd65&dn=/home/arven/hdf/iss.2013014.0114.085907.D.L2.hico.12427-SwanRiverEstuary_AUS.v40.100m.hdf)>

prov:wasAttributedTo

<<http://muckdragon.info/arv/scientist/24>> .

<[http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/Encode\\_Byte\\_Array\\_to\\_Base\\_64/out/base64](http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/Encode_Byte_Array_to_Base_64/out/base64)>

rdfs:label "Encode\_Byte\_Array\_to\_Base\_64 output base64" .

<<http://muckdragon.info/arv/request/6.2/10/6>>

a arv:Data ;

arv:dataType "water column" , "pressure" , "sediment" , "wave propagation" , "acoustics" ;

arv:location "Panama City Beach, FL" ;

arv:purpose "understand how shock waves propagate through marine sediments" ;

arv:scientist <<http://muckdragon.info/arv/scientist/27>> ;

arv:sensor "hydrophone" , "air gun" ;

arv:title "Nonlinear Acoustics in Marine Sediments" .

<<http://muckdragon.info/arv/request/6.2/07/3>>

a arv:Data ;

arv:dataType "Hyperspectral imagery" , "SAR" , "thermal imagery" , "photogrammetry" ;

arv:location "Pearl River, MS and Huntsville, AL" ;

arv:purpose "Tactical scenario development in riverine environment" ;

arv:scientist <<http://muckdragon.info/arv/scientist/6>> ;

arv:sensor "camera" , "hyperspectral" , "SAR" , "thermal imager" ;

arv:title "Combination SAR and Optical Imagery applied to the Riverine environment" .

<<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861->

[b43ed445d18b/workflow/Workflow1/processor/Encode\\_Byte\\_Array\\_to\\_Base\\_64\\_2/in/bytes](http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/Encode_Byte_Array_to_Base_64_2/in/bytes)>

rdfs:label "Encode\_Byte\_Array\_to\_Base\_64\_2 input bytes" .

<<http://muckdragon.info/arv/request/6.2/11/6>>

a arv:Data ;

arv:dataType "platform signatures" , "clutter" , "acoustics" ;

arv:location "Jacksonville, FL" ;

arv:purpose "test micro sensors for acoustic profiling" ;

arv:scientist <<http://muckdragon.info/arv/scientist/4>> ;

arv:sensor "acoustic modem" ;

arv:title "A Distributed Autonomous, Persistent Surveillance Network for Underwater Environments,  
A Concept Drift Classifier for Structural Acoustics MCM and Harbor" .

<<http://muckdragon.info/arv/request/6.2/12/8>>

a arv:Data ;

arv:dataType "cores" , "power" , "sediment" ;

arv:location "Mississippi Sound, Gulf of Mexico" ;

arv:purpose "study sediment type impact on power production" ;

arv:scientist <<http://muckdragon.info/arv/scientist/23>> ;

arv:sensor "cores" , "BUG" ;

arv:title "Environmental Optimization of Sea-Bed Energy Harvesting for Navy Devices" .

<<http://muckdragon.info/arv/request/6.2/12/5>>

a arv:Data ;

arv:dataType "Hyperspectral imagery" , "multispectral imagery" ;

arv:location "Fort Lauderdale, FL" ;

arv:purpose "potential to receive particle information in upper part of water column" ;

arv:scientist <<http://muckdragon.info/arv/scientist/6>> ;

arv:sensor "CASI-1500 Hyperspectral imager" , "Multispectral Polarimetric Imager" , "Whisk Broom Hyperspectral Polarimetric Imager" ;

arv:title "Polarimetric Hyperspectral Imaging of the Coastal Environment" .

<<http://muckdragon.info/arv/request/6.2/12/7>>

a arv:Data ;

arv:dataType "temperature" , "bathymetry" , "turbulence" , "seismic" , "conductivity" , "acoustics" ;

arv:location "Cape Town, South Africa" ;

arv:purpose "quantifying mechanisms of diapycnal mixing determination" ;

arv:scientist <<http://muckdragon.info/arv/scientist/18>> ;

arv:sensor "seismic" , "ADCP" , "CTD" ;

arv:title "Quantifying Mechanisms of Diapycnal Mixing in the Agulhas Frontal Region" .

<<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/>>

a wfprov:WorkflowRun , owl:NamedIndividual ;

rdfs:label "Workflow run of Workflow1" ;

space:hasBoundingBox

( [ wgs84:lat 13.5 ;

wgs84:long 145.85

] [ wgs84:lat 13.5 ;

wgs84:long 146.35

] [ wgs84:lat 12.65 ;

wgs84:long 146.35

] [ wgs84:lat 12.65 ;

wgs84:long 145.85

]);

category:hasCategoryTag

category:bathymetry ;

measure:hasMeasurementTag

measure:depth ;

sensor:hasSensorTag sensor:multibeam ;

dcterms:hasPart <<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/process/5788eb60-afdf-45de-b218-5add30d5c3b8/>> ,  
<<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/process/6a8b2d53-f766-49aa-aebb-de4728985703/>> , <<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/process/3b900a61-7b9a-469a-bc06-487ff5dee1f8/>> ,  
<<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/process/2a438326-f37c-4573-8b52-296eea79c555/>> , <<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/process/32d801fc-e451-4e93-baef-0fc7749fba85/>> ,  
<<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/process/4e2e26fb-de03-471a-9625-7a622a8da676/>> , <<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/process/fc12c4fe-9764-4875-85e3-05dff00405d5/>> ,  
<<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/process/ac4f49f0-44a2-4a50-b0be-b18d4d31e72f/>> , <<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/process/eb80b8c8-a65a-400e-8935-9077e35336bf/>> ,  
<<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/process/d147dfb2-42b8-45d4-bec4-0a40cdeeac25/>> , <<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/process/a8db0d6f-864b-4614-96ef-14a9b594cdd3/>> ,  
<<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/process/97eb200b-5226-41c2-b27c-cd57226d3569/>> , <<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/process/39441ae0-9fde-4a19-b262-6e821bc0de7a/>> ,  
<<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/process/50e8ea65-dc28-4c18-93a2-a74f4bb32b76/>> , <<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/process/bbacde92-9524-4f16-aa0b-bb132b855995/>> ;

wfprov:describedByWorkflow

```
<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-
b43ed445d18b/workflow/Workflow1/> ;

wfprov:usedInput <http://ns.taverna.org.uk/2011/data/72a6fd65-cbff-4cfc-8163-
4c6f25e7c4fa/ref/bc6412a7-5b6c-4a85-b43c-d36abd93aa3e> ;

wfprov:wasEnactedBy :taverna-engine ;

prov:endedAtTime "2012-12-03T15:48:23.450-06:00"^^xsd:dateTime ;

prov:qualifiedAssociation

[ a    prov:Association ;

      prov:agent :taverna-engine ;

      prov:hadPlan <http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-
b43ed445d18b/workflow/Workflow1/>

    ] ;

prov:qualifiedUsage

[ a    prov:Usage ;

      prov:entity <http://ns.taverna.org.uk/2011/data/72a6fd65-cbff-4cfc-8163-
4c6f25e7c4fa/ref/bc6412a7-5b6c-4a85-b43c-d36abd93aa3e> ;

      prov:hadRole <http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-
b43ed445d18b/workflow/Workflow1/in/InFile>

    ] ;

prov:startedAtTime "2012-12-03T15:47:19.137-06:00"^^xsd:dateTime ;
```



prov:used <<http://ns.taverna.org.uk/2011/data/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/ref/bc6412a7-5b6c-4a85-b43c-d36abd93aa3e>> ;

prov:wasAssociatedWith

:taverna-engine ;

prov:wasAttributedTo

<<http://muckdragon.info/arv/scientist/42>> .

<<http://muckdragon.info/arv/request/6.2/08/2>>

a arv:Data ;

arv:dataType "radar" , "wind" , "temperature" , "atmospheric profile" , "humidity" ;

arv:location "Guam" ;

arv:purpose "reduce errors in tropical cyclone structure and intensity forecasts and wave forecasts" ;

arv:scientist <<http://muckdragon.info/arv/scientist/12>> ;

arv:sensor "radar" , "LIDAR" , "temperature" ;

arv:title "Tropical Cyclone Structure Data Assimilation by Using Non-Conventional Data" .

<<http://muckdragon.info/arv/request/6.2/10/5>>

a arv:Data ;

arv:dataType "sediment" , "bottom loss" , "acoustics" ;

arv:location "Pascagoula, MS Gulf of Mexico" ;

arv:purpose "allow determination of the degree of azimuthal anisotropy in bottom loss" ;

arv:scientist <<http://muckdragon.info/arv/scientist/18>> ;

arv:sensor "DTAGS" ;

arv:title "Geoacoustics of anisotropic marine sediments" .

<<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/Encoding/out/value>>

rdfs:label "Encoding output value" .

prov:hadRole

a owl:AnnotationProperty .

<<http://muckdragon.info/arv/request/6.2/07/2>>

a arv:Data ;

arv:dataType "radar altimetry" , "Airborne gravity" , "precise geodesy" , "KGPS" , "sea surface topography" ;

arv:location "Okinawa, Japan" ;

arv:purpose "Production of a gravimetric geoid " ;

arv:scientist <http://muckdragon.info/arv/scientist/5> ;

arv:sensor "Gravity" , "Radar Altimetry" , "KGPS" , "AXBT" ;

arv:title "Airborne gravity, sea surface topography and precise geodesy over WESTPAC" .

prov:wasGeneratedBy

a owl:AnnotationProperty .

<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/process/32d801fc-e451-4e93-baef-0fc7749fba85/>

rdfs:label "Processor execution convertText3ToDouble3\_output  
(facade1:Workflow1:convertText3ToDouble3\_output)" ;

wfprov:describedByProcess

<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/convertText3ToDouble3\_output/> ;

wfprov:usedInput <http://ns.taverna.org.uk/2011/data/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/ref/bac50aa8-23a5-4ea0-97d5-669b39765de4> ;

wfprov:wasPartOfWorkflowRun

<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/> ;

prov:endedAtTime "2012-12-03T15:47:37.340-06:00"^^xsd:dateTime ;

prov:qualifiedAssociation

```
[ a   prov:Association ;

      prov:agent :taverna-engine ;

      prov:hadPlan <http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-
b43ed445d18b/workflow/Workflow1/processor/convertText3ToDouble3_output/>

];
```

prov:qualifiedUsage

```
[ a   prov:Usage ;

      prov:entity <http://ns.taverna.org.uk/2011/data/72a6fd65-cbff-4cfc-8163-
4c6f25e7c4fa/ref/bac50aa8-23a5-4ea0-97d5-669b39765de4> ;

      prov:hadRole <http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-
b43ed445d18b/workflow/Workflow1/processor/convertText3ToDouble3_output/in/input>

];
```

prov:startedAtTime "2012-12-03T15:47:35.556-06:00"^^xsd:dateTime ;

```
prov:used <http://ns.taverna.org.uk/2011/data/72a6fd65-cbff-4cfc-8163-
4c6f25e7c4fa/ref/bac50aa8-23a5-4ea0-97d5-669b39765de4> .
```

```
<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8dec7cd6cde9d&dn=/home/arven/hdf/iss.20130
14.0114.085907.D.L2.hico-modis.12427-SwanRiverEstuary_AUS.v40.100m.hdf>
```

prov:wasAttributedTo

```
<http://muckdragon.info/arv/scientist/24> .
```

<<http://muckdragon.info/arv/request/6.2/09/1>>

a arv:Data ;

arv:dataType "currents" , "atmospheric profile" , "temperature" , "backscatter" , "salinity" ,  
"conductivity" , "acoustics" ;

arv:location "Malta Plateau off coast of Sicily, Italy" ;

arv:purpose "develop a broadband bistatic range-dependent ASW reverberation time series  
simulator" ;

arv:scientist <<http://muckdragon.info/arv/scientist/19>> ;

arv:sensor "sonar" , "XBT" , "bathymetry" , "CTD" ;

arv:title "Broadband Bistatic Time Domain Reverberation Simulation for Range-Dependent  
Waveguides" .

<<http://www.muckdragon.info/PROV/2012/bathymetry>>

a owl:Ontology ;

owl:versionIRI <<http://www.w3.org/TR/2012/WD-prov-o-20120724>> ;

prov:wasGeneratedBy :taverna-prov-export .

<<http://muckdragon.info/arv/request/6.2/11/7>>

```
a    arv:Data ;

arv:dataType "SAR" ;

arv:location "Outer Banks, NC" ;

arv:purpose "improve measurements of surface currents, wave height, breaker type and
bathymetry" ;

arv:scientist <http://muckdragon.info/arv/scientist/8> ;

arv:sensor "ATI SAR" , "XTI SAR" ;

arv:title "SAR-based Characterization of the Coastal Zone" .
```

```
:taverna-prov-export
```

```
rdfs:label "taverna-prov export of workflow run provenance" ;

prov:endedAtTime "2012-12-07T17:56:34.182-06:00"^^xsd:dateTime ;
```

```
prov:qualifiedAssociation
```

```
  [ a    prov:Association ;
```

```
    prov:agent :taverna-engine ;
```

```
    prov:hadPlan <http://ns.taverna.org.uk/2011/software/taverna-2.4.0>
```

```
  ] ;
```

```
prov:startedAtTime "2012-12-07T17:55:45.837-06:00"^^xsd:dateTime ;
```

```
prov:wasAssociatedWith
```

:taverna-engine ;

prov:wasInformedBy <<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/>> .

prov:qualifiedAssociation

a owl:AnnotationProperty .

<<http://muckdragon.info/arv/request/6.2/08/3>>

a arv:Data ;

arv:dataType "SAR" ;

arv:location "Outer Banks, NC and Daytona Beach, FL" ;

arv:purpose "understand physics behind measurement of surface currents" ;

arv:scientist <<http://muckdragon.info/arv/scientist/8>> ;

arv:sensor "SAR" ;

arv:title "SAR/INSAR Imaging of Strong Currents and Current Gradients" .

<<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861->

[b43ed445d18b/workflow/Workflow1/in/InFile](http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/in/InFile)>

rdfs:label "Workflow input InFile" .

<http://ns.taverna.org.uk/2011/data/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/ref/f0b0e122-2a1d-47cf-8d15-58aaf0df4f00>

tavernaprov:content <http://www.muckdragon.info/PROV/2012/intermediates/f0/f0b0e122-2a1d-47cf-8d15-58aaf0df4f00.txt> ;

wfprov:describedByParameter

<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/Read\_Data\_Points/in/encoding> ,

<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/Encoding/out/value> ;

wfprov:wasOutputFrom

<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/process/2a438326-f37c-4573-8b52-296eea79c555/> ;

prov:qualifiedGeneration

[ a prov:Generation ;

prov:activity <http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/process/2a438326-f37c-4573-8b52-296eea79c555/> ;

prov:hadRole <http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/Encoding/out/value>

];

prov:wasGeneratedBy <http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/process/2a438326-f37c-4573-8b52-296eea79c555/> .



<[http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/TIN\\_Input/in/data](http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/TIN_Input/in/data)>

rdfs:label "TIN\_Input input data" .

<<http://www.muckdragon.info/PROV/2012/intermediates/99/99d6ada5-338e-4c2d-bb0c-40cd64931cb9.txt>>

tavernaprov:sha1 "f5c0a7c2b9db97c1e5fb4a397339c7869a5eec6e" ;

tavernaprov:sha512

"cf83e1357eefb8bdf1542850d66d8007d620e4050b5715dc83f4a921d36ce9ce47d0d13c5d85f2b0ff8318d2877eec2f63b931bd47417a81a538327af927da3e" .

<<http://muckdragon.info/arv/request/6.2/12/4>>

a arv:Data ;

arv:dataType "cores" , "particle surface electric charge" , "sediment" , "grain size" , "water sample" , "hydrodynamic shear" , "organic carbon" ;

arv:location "Mississippi Bight, Gulf of Mexico" ;

arv:purpose "quantify relationship between sediment mechanical, physical and biogeochemical properties" ;

arv:scientist <<http://muckdragon.info/arv/scientist/10>> ;

arv:sensor "Geotek core logger" , "Mini-flume" , "X-radiography" , "S-OFT" , "Malvern Zetasizer" ,  
"penetrometer" ;

arv:title "Study the relationship between sedimentary biogeochemical characterizations and  
mechanical strength" .

<[http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-  
b43ed445d18b/workflow/Workflow1/processor/getTinFromDepths/](http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/getTinFromDepths/)>

rdfs:label "Processor getTinFromDepths" .

<<http://muckdragon.info/arv/request/6.2/10/8>>

a arv:Data ;

arv:dataType "optical" , "water samples" , "particle size" , "current velocity" , "LIDAR" ,  
"temperature" , "absorption" , "backscatering" , "scattering" , "conductivity" ;

arv:location "East Sound, WA" ;

arv:purpose "evaluate a microflow cytometer sensor performance in characterization of high  
concentration thin layers" ;

arv:scientist <<http://muckdragon.info/arv/scientist/24>> ;

arv:sensor "optical" , "glider" , "LIDAR" , "MVSM" , "CTD" , "scan fish" , "Cytosense" , "CYTOSUB" ;

arv:title "Characterizing subsurface bio-optical layers" .

<[http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/Encode\\_Base64/](http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/Encode_Base64/)>

rdfs:label "Processor Encode\_Base64" .

<<http://www.muckdragon.info/PROV/2012/intermediates/37/3736657a-72a1-45c5-9e37-e3a31e33de50.txt>>

tavernaprov:sha1 "6dbaaad57360df05fc4cb6008f719cb59466fa85" ;

tavernaprov:sha512

"cf83e1357eefb8bdf1542850d66d8007d620e4050b5715dc83f4a921d36ce9ce47d0d13c5d85f2b0ff8318d2877eec2f63b931bd47417a81a538327af927da3e" .

<<http://muckdragon.info/arv/request/6.2/07/1>>

a arv:Data ;

arv:dataType "VLF Acoustic Scattering " ;

arv:location "Gulf of Mexico, Corpus Christi, TX and Charleston Harbor, SC" ;

arv:purpose "Resolve environmental acoustics and target scattering in difficult MCM environments" ;

arv:scientist <<http://muckdragon.info/arv/scientist/4>> ;

arv:sensor "SAR Sonar" ;

arv:title "Long Range Mine ID" .

tavernaprov:sha1

a owl:AnnotationProperty .

<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/process/39441ae0-9fde-4a19-b262-6e821bc0de7a/>

rdfs:label "Processor execution convertText3ToDouble3\_input  
(facade1:Workflow1:convertText3ToDouble3\_input)";

wfprov:describedByProcess

<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/convertText3ToDouble3\_input/>;

wfprov:usedInput <http://ns.taverna.org.uk/2011/data/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/ref/36002dbd-6b77-41ae-8915-96d7dbad8460>;

wfprov:wasPartOfWorkflowRun

<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/>;

prov:endedAtTime "2012-12-03T15:47:27.827-06:00"^^xsd:dateTime;

prov:qualifiedAssociation

[ a prov:Association;

prov:agent :taverna-engine;

prov:hadPlan <http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/convertText3ToDouble3\_input/>

```

];

prov:qualifiedUsage

[ a   prov:Usage ;

    prov:entity <http://ns.taverna.org.uk/2011/data/72a6fd65-cbff-4cfc-8163-
4c6f25e7c4fa/ref/36002dbd-6b77-41ae-8915-96d7dbad8460> ;

    prov:hadRole <http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-
b43ed445d18b/workflow/Workflow1/processor/convertText3ToDouble3_input/in/data>

];

prov:startedAtTime "2012-12-03T15:47:25.838-06:00"^^xsd:dateTime ;

prov:used <http://ns.taverna.org.uk/2011/data/72a6fd65-cbff-4cfc-8163-
4c6f25e7c4fa/ref/36002dbd-6b77-41ae-8915-96d7dbad8460> .

<http://www.muckdragon.info/PROV/2012/intermediates/f0/f0b0e122-2a1d-47cf-8d15-
58aaf0df4f00.txt>

    tavernaprov:sha1 "663b90c899fa25a111067be0c22ffc64dcf581c2" ;

    tavernaprov:sha512

"cf83e1357eefb8bdf1542850d66d8007d620e4050b5715dc83f4a921d36ce9ce47d0d13c5d85f2b0ff8318
d2877eec2f63b931bd47417a81a538327af927da3e" .

```

<http://ns.taverna.org.uk/2011/data/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/ref/bc6412a7-5b6c-4a85-b43c-d36abd93aa3e>

tavernaprov:content <http://www.muckdragon.info/PROV/2012/InFile.txt> ;

wfprov:describedByParameter

<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/in/InFile> ,

<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/Read\_Data\_Points/in/fileurl> .

<http://muckdragon.info/arv/request/6.2/08/4>

a arv:Data ;

arv:dataType "SAR" ;

arv:location "Panama City, FL" ;

arv:purpose "resolve acoustics and target scattering issues " ;

arv:scientist <http://muckdragon.info/arv/scientist/4> ;

arv:sensor "SAR" ;

arv:title "Long Range Mine Identification" .

wfprov:wasPartOfWorkflowRun

a owl:AnnotationProperty .

<<http://muckdragon.info/arv/request/6.2/12/3>>

a arv:Data ;

arv:dataType "radar" , "video" , "aerosol samples" , "brightness temperature" , "acoustics" , "IR" ;

arv:location "Monterey Bay, CA" ;

arv:purpose "model surface expression for breaking waves to estimate energy transforms" ;

arv:scientist <<http://muckdragon.info/arv/scientist/38>> ;

arv:sensor "acoustic arrays" , "video" , "weather station" , "aerosol sampler" , "Microwave radiometers" , "WindSat" , "IR" ;

arv:title "Oceanic whitecaps as a surface expression of under and above water processes: Toward an integral remote sensing of the air-sea interface" .

prov:endedAtTime

a owl:AnnotationProperty .

<[http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-](http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/getColorFromDepth_output/out/return)

[b43ed445d18b/workflow/Workflow1/processor/getColorFromDepth\\_output/out/return](http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/getColorFromDepth_output/out/return)>

rdfs:label "getColorFromDepth\_output output return" .

<<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/convertText3ToZDouble3/out/parameters>>

rdfs:label "convertText3ToZDouble3 output parameters" .

<[http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/Encode\\_Byte\\_Array\\_to\\_Base\\_64/in/bytes](http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/Encode_Byte_Array_to_Base_64/in/bytes)>

rdfs:label "Encode\_Byte\_Array\_to\_Base\_64 input bytes" .

<[http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/convertText3ToDouble3\\_output/out/return](http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/convertText3ToDouble3_output/out/return)>

rdfs:label "convertText3ToDouble3\_output output return" .

<<http://muckdragon.info/arv/request/6.2/10/7>>

a arv:Data ;

arv:dataType "acoustics" ;

arv:location "Gulf of Mexico" ;

arv:purpose "initial design of an underwater distributed surveillance system" ;

arv:scientist <<http://muckdragon.info/arv/scientist/28>> ;

arv:sensor "riverine micro-sensor acoustic nodes" ;



arv:title "Performance of a Persistent Riverine Surveillance System" .

<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/process/4e2e26fb-de03-471a-9625-7a622a8da676/>

rdfs:label "Processor execution Encode\_Byte\_Array\_to\_Base\_64\_2  
(facade1:Workflow1:Encode\_Byte\_Array\_to\_Base\_64\_2)";

wfprov:describedByProcess

<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-  
b43ed445d18b/workflow/Workflow1/processor/Encode\_Byte\_Array\_to\_Base\_64\_2/> ;

wfprov:usedInput <http://ns.taverna.org.uk/2011/data/72a6fd65-cbff-4cfc-8163-  
4c6f25e7c4fa/ref/71e16759-d9ae-4935-8921-175563f54a60> ;

wfprov:wasPartOfWorkflowRun

<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/> ;

prov:endedAtTime "2012-12-03T15:48:03.573-06:00"^^xsd:dateTime ;

prov:qualifiedAssociation

[ a prov:Association ;

prov:agent :taverna-engine ;

prov:hadPlan <http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-  
b43ed445d18b/workflow/Workflow1/processor/Encode\_Byte\_Array\_to\_Base\_64\_2/>

];

prov:qualifiedUsage

[ a prov:Usage ;

prov:entity <http://ns.taverna.org.uk/2011/data/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/ref/71e16759-d9ae-4935-8921-175563f54a60> ;

prov:hadRole <http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/Encode\_Byte\_Array\_to\_Base\_64\_2/in/bytes>

];

prov:startedAtTime "2012-12-03T15:47:59.616-06:00"^^xsd:dateTime ;

prov:used <http://ns.taverna.org.uk/2011/data/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/ref/71e16759-d9ae-4935-8921-175563f54a60> .

<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/process/d147dfb2-42b8-45d4-bec4-0a40cdeeac25/>

rdfs:label "Processor execution getColorFromDepth\_input  
(facade1:Workflow1:getColorFromDepth\_input)";

wfprov:describedByProcess

<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/getColorFromDepth\_input/> ;

wfprov:usedInput <http://ns.taverna.org.uk/2011/data/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/ref/bfa5dff-2f77-47b2-b0d0-19e1e5fb2fbd> ;

wfprov:wasPartOfWorkflowRun

<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/> ;

prov:endedAtTime "2012-12-03T15:48:05.767-06:00"^^xsd:dateTime ;

prov:qualifiedAssociation

[ a prov:Association ;

prov:agent :taverna-engine ;

prov:hadPlan <http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/getColorFromDepth\_input/>

];

prov:qualifiedUsage

[ a prov:Usage ;

prov:entity <http://ns.taverna.org.uk/2011/data/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/ref/bfa5dff-2f77-47b2-b0d0-19e1e5fb2fbd> ;

prov:hadRole <http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/getColorFromDepth\_input/in/data>

];

prov:startedAtTime "2012-12-03T15:48:03.929-06:00"^^xsd:dateTime ;

prov:used <http://ns.taverna.org.uk/2011/data/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/ref/bfa5dff-2f77-47b2-b0d0-19e1e5fb2fbd> .

<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/process/97eb200b-5226-41c2-b27c-cd57226d3569/>

rdfs:label "Processor execution Encode\_Base64 (facade1:Workflow1:Encode\_Base64)";

wfprov:describedByProcess

<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/Encode\_Base64/> ;

wfprov:usedInput <http://ns.taverna.org.uk/2011/data/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/ref/b7e4c42f-9bde-447f-9aff-46cee4dc84e7> ;

wfprov:wasPartOfWorkflowRun

<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/> ;

prov:endedAtTime "2012-12-03T15:47:24.798-06:00"^^xsd:dateTime ;

prov:qualifiedAssociation

[ a prov:Association ;

prov:agent :taverna-engine ;

prov:hadPlan <http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/Encode\_Base64/>

];

prov:qualifiedUsage

[ a prov:Usage ;

prov:entity <http://ns.taverna.org.uk/2011/data/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/ref/b7e4c42f-9bde-447f-9aff-46cee4dc84e7> ;

prov:hadRole <http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/Encode\_Base64/in/bytes>

];

prov:startedAtTime "2012-12-03T15:47:22.528-06:00"^^xsd:dateTime ;

prov:used <http://ns.taverna.org.uk/2011/data/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/ref/b7e4c42f-9bde-447f-9aff-46cee4dc84e7> .

<http://www.muckdragon.info/PROV/2012/intermediates/eb/eb2bdf1a-df20-4d41-a0c7-fb785f725f6e.octet-stream>

tavernaprov:sha1 "bb93a12059f295ec51687ca00554af7c5c7b3d9c" ;

tavernaprov:sha512

"cf83e1357eefb8bdf1542850d66d8007d620e4050b5715dc83f4a921d36ce9ce47d0d13c5d85f2b0ff8318d2877eec2f63b931bd47417a81a538327af927da3e" .

<http://muckdragon.info/arv/request/6.2/12/9>

a arv:Data ;

arv:dataType "LIDAR" , "Hyperspectral Imagery" , "SAR" ;

arv:location "Queensland, Australia" ;

arv:purpose "trafficability studies from remotely sensed imagery" ;

arv:scientist <<http://muckdragon.info/arv/scientist/1>> ;

arv:sensor "LIDAR" , "Hyperspectral imagery" , "SAR" ;

arv:title "Trafficability from Remote Sensing" .

<<http://muckdragon.info/arv/request/6.1/08/7>>

a arv:Data ;

arv:dataType "water samples" , "current velocity" , "temperature" , "bathymetry" , "optics" ,  
"salinity" , "conductivity" ;

arv:location "Monterey Bay, CA" ;

arv:purpose "improve understanding of the coupled bio-optical and physical processes for light field"  
;

arv:scientist <<http://muckdragon.info/arv/scientist/9>> ;

arv:sensor "glider" , "scanfish" , "temperature" , "niskin bottle" , "ADCP" , "CTD" ;

arv:title "Bio-Optical Studies of Predictability and Assimilation for the Coastal Environment" .

<<http://ns.taverna.org.uk/2011/data/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/ref/36002dbd-6b77-41ae-8915-96d7dbad8460>>

tavernaprov:content <<http://www.muckdragon.info/PROV/2012/intermediates/36/36002dbd-6b77-41ae-8915-96d7dbad8460.txt>> ;

wfprov:describedByParameter

<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-  
b43ed445d18b/workflow/Workflow1/processor/Encode\_Base64/out/base64> ,  
<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-  
b43ed445d18b/workflow/Workflow1/processor/convertText3ToDouble3\_input/in/data> ;

wfprov:wasOutputFrom

<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/process/97eb200b-  
5226-41c2-b27c-cd57226d3569/> ;

prov:qualifiedGeneration

[ a prov:Generation ;

prov:activity <http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-  
4c6f25e7c4fa/process/97eb200b-5226-41c2-b27c-cd57226d3569/> ;

prov:hadRole <http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-  
b43ed445d18b/workflow/Workflow1/processor/Encode\_Base64/out/base64>

];

prov:wasGeneratedBy <http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-  
4c6f25e7c4fa/process/97eb200b-5226-41c2-b27c-cd57226d3569/> .

<http://muckdragon.info/arv/request/6.3/12/9001>

a arv:Data ;

arv:dataType "Bathymetry" ;  
  
arv:location "Marianas Trench" ;  
  
arv:purpose "Sonar Test Range" ;  
  
arv:scientist <<http://muckdragon.info/arv/scientist/42>> ;  
  
arv:sensor "Multibeam" ;  
  
arv:title "Marianas Trench Bathymetry" .

<<http://muckdragon.info/arv/request/6.2/08/5>>

a arv>Data ;  
  
arv:dataType "currents" , "temperature" , "atmospheric profile" , "turbulence" , "salinity" ,  
"conductivity" , "acoustics" ;  
  
arv:location "Desoto Canyon, Gulf of Mexico, MS" ;  
  
arv:purpose "develop an algorithm that diagnoses acoustic performance directly from oceanographic  
data" ;  
  
arv:scientist <<http://muckdragon.info/arv/scientist/13>> ;  
  
arv:sensor "ACDS" , "VMP profiler" , "sonar" , "multibeam" , "EARS" , "ADCP" , "CTD" ;  
  
arv:title "ACOMMS Performance in Turbulent Layers" .

<<http://muckdragon.info/arv/request/6.2/12/2>>



a arv:Data ;

arv:dataType "current velocity" , "temperature" , "bathymetry" , "conductivity" , "acoustics" ;

arv:location "Continental Shelf, TX" ;

arv:purpose "improve understanding of small-scale to sub-mesoscale physical processes over sub-mesoscale bumps on continental shelf" ;

arv:scientist <<http://muckdragon.info/arv/scientist/35>> ;

arv:sensor "VMP" , "Barny buoy" , "CTD" ;

arv:title "Mixing over Rough Topography (MORT)" .

<[http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/TIN\\_Input/out/output](http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/TIN_Input/out/output)>

rdfs:label "TIN\_Input output output" .

<<http://www.muckdragon.info/PROV/2012/intermediates/2c/2c944733-c9d6-44ef-a7e6-f92fb8a1ff68.txt>>

tavernaprov:sha1 "e2bf2161a62b00ff98ae39eec209028f4ef12f72" ;

tavernaprov:sha512

"cf83e1357eefb8bdf1542850d66d8007d620e4050b5715dc83f4a921d36ce9ce47d0d13c5d85f2b0ff8318d2877eec2f63b931bd47417a81a538327af927da3e" .

<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-  
b43ed445d18b/workflow/Workflow1/processor/getTinFromDepths/out/parameters>

rdfs:label "getTinFromDepths output parameters" .

<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-  
b43ed445d18b/workflow/Workflow1/>

dcterms:hasPart <http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-  
b43ed445d18b/workflow/Workflow1/processor/TIN\_Input/> ,

<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-  
b43ed445d18b/workflow/Workflow1/processor/convertText3ToZDouble3/> ,

<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-  
b43ed445d18b/workflow/Workflow1/processor/TIN\_Output/> ,

<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-  
b43ed445d18b/workflow/Workflow1/processor/getColorFromDepth/> ,

<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-  
b43ed445d18b/workflow/Workflow1/processor/Encode\_Byte\_Array\_to\_Base\_64/> ,

<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-  
b43ed445d18b/workflow/Workflow1/processor/getColorFromDepth\_output/> ,

<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-  
b43ed445d18b/workflow/Workflow1/processor/getTinFromDepths/> ,

<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-  
b43ed445d18b/workflow/Workflow1/processor/Encode\_Base64/> ,

<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-

b43ed445d18b/workflow/Workflow1/processor/Read\_Data\_Points/> ,  
<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-  
b43ed445d18b/workflow/Workflow1/processor/getColorFromDepth\_input/> ,  
<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-  
b43ed445d18b/workflow/Workflow1/processor/Encoding/> ,  
<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-  
b43ed445d18b/workflow/Workflow1/processor/convertText3ToDouble3\_output/> ,  
<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-  
b43ed445d18b/workflow/Workflow1/processor/Encode\_Byte\_Array\_to\_Base\_64\_3/> ,  
<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-  
b43ed445d18b/workflow/Workflow1/processor/Encode\_Byte\_Array\_to\_Base\_64\_2/> ,  
<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-  
b43ed445d18b/workflow/Workflow1/processor/convertText3ToDouble3\_input/> ;

wfdesc:hasSubProcess

<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-  
b43ed445d18b/workflow/Workflow1/processor/TIN\_Input/> ,  
<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-  
b43ed445d18b/workflow/Workflow1/processor/convertText3ToZDouble3/> ,  
<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-  
b43ed445d18b/workflow/Workflow1/processor/TIN\_Output/> ,  
<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-  
b43ed445d18b/workflow/Workflow1/processor/getColorFromDepth/> ,  
<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-  
b43ed445d18b/workflow/Workflow1/processor/Encode\_Byte\_Array\_to\_Base\_64/> ,

<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/Encode\_Base64/> ,  
<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/getTinFromDepths/> ,  
<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/getColorFromDepth\_output/> ,  
<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/Read\_Data\_Points/> ,  
<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/getColorFromDepth\_input/> ,  
<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/Encoding/> ,  
<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/convertText3ToDouble3\_output/> ,  
<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/Encode\_Byte\_Array\_to\_Base\_64\_3/> ,  
<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/Encode\_Byte\_Array\_to\_Base\_64\_2/> ,  
<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/convertText3ToDouble3\_input/> .  
  
<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/getColorFromDepth\_output/in/input>

rdfs:label "getColorFromDepth\_output input input" .

<<http://muckdragon.info/arv/request/6.1/08/6>>

a arv:Data ;

arv:dataType "wave" , "water column" , "currents" , "sediment" , "suspended particulates" ;

arv:location "Atchafalaya Bay, LA" ;

arv:purpose "study wave damping over muddy sedimentary bottoms" ;

arv:scientist <<http://muckdragon.info/arv/scientist/3>> ;

arv:sensor "ASCS" , "gravity core" , "box core" , "wave rider" , "ADCP" , "ADP" , "CTD" ,  
"penetrometer" ;

arv:title "Wave damping over fluid mud" .

<<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/process/ac4f49f0-44a2-4a50-b0be-b18d4d31e72f>>

rdfs:label "Processor execution TIN\_Output (facade1:Workflow1:TIN\_Output)" ;

wfprov:describedByProcess

<[http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/TIN\\_Output/](http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/TIN_Output/)> ;

wfprov:usedInput <<http://ns.taverna.org.uk/2011/data/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/ref/8114af59-d8ee-4b43-8eb7-f3559adb2ab5>> ;

wfprov:wasPartOfWorkflowRun

<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/> ;

prov:endedAtTime "2012-12-03T15:47:58.368-06:00"^^xsd:dateTime ;

prov:qualifiedAssociation

[ a prov:Association ;

prov:agent :taverna-engine ;

prov:hadPlan <http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/TIN\_Output/>

];

prov:qualifiedUsage

[ a prov:Usage ;

prov:entity <http://ns.taverna.org.uk/2011/data/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/ref/8114af59-d8ee-4b43-8eb7-f3559adb2ab5> ;

prov:hadRole <http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/TIN\_Output/in/input>

];

prov:startedAtTime "2012-12-03T15:47:55.655-06:00"^^xsd:dateTime ;

prov:used <http://ns.taverna.org.uk/2011/data/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/ref/8114af59-d8ee-4b43-8eb7-f3559adb2ab5> .

<<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/Encoding/>>

rdfs:label "Processor Encoding" .

<<http://muckdragon.info/arv/request/6.2/11/2>>

a arv:Data ;

arv:dataType "ambient noise" , "seismic" , "acoustics" ;

arv:location "Gulf of Mexico" ;

arv:purpose "examine seismo-acoustic noise propagation for sensor buried in complex geologic structures" ;

arv:scientist <<http://muckdragon.info/arv/scientist/11>> ;

arv:sensor "hydrophone" , "seismic" , "DTAGS" ;

arv:title "Low Ambient Noise Geologic Environments on the Littoral Margin for Passive ASW" .

<<http://muckdragon.info/arv/request/6.2/09/4>>

a arv:Data ;

arv:dataType "backscatter" , "acoustics" ;

arv:location "New Jersey continental shelf" ;

arv:purpose "develop and validate algorithms to extract and id target echo" ;

arv:scientist <<http://muckdragon.info/arv/scientist/22>> ;

arv:sensor "backscatter" , "acoustics" ;

arv:title "Multi-static waveguide invariant processing for active detection and localization" .

wfprov:describedByParameter

a owl:AnnotationProperty .

<<http://ns.taverna.org.uk/2011/data/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/ref/b7e4c42f-9bde-447f-9aff-46cee4dc84e7>>

tavernaprov:content <<http://www.muckdragon.info/PROV/2012/intermediates/b7/b7e4c42f-9bde-447f-9aff-46cee4dc84e7.txt>> ;

wfprov:describedByParameter

<[http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/Read\\_Data\\_Points/out/filecontents](http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/Read_Data_Points/out/filecontents)> ,

<[http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/Encode\\_Base64/in/bytes](http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/Encode_Base64/in/bytes)> ;

wfprov:wasOutputFrom

<<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/process/a8db0d6f-864b-4614-96ef-14a9b594cdd3>> ;

prov:qualifiedGeneration



```

[ a    prov:Generation ;

      prov:activity <http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-
4c6f25e7c4fa/process/a8db0d6f-864b-4614-96ef-14a9b594cdd3/> ;

      prov:hadRole <http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-
b43ed445d18b/workflow/Workflow1/processor/Read_Data_Points/out/filecontents>

    ];

      prov:wasGeneratedBy <http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-
4c6f25e7c4fa/process/a8db0d6f-864b-4614-96ef-14a9b594cdd3/> .

<http://muckdragon.info/arv/request/6.2/12/1>

  a    arv:Data ;

      arv:dataType "radar" , "optical depth and thermodynamic properties" , "heat fluxes" , "reflectance" ,
"composition" , "aerosol size" , "LIDAR" , "absorption" , "chlorophyll" , "scattering" , "suspended
sediments" ;

      arv:location "Sulu Sea" ;

      arv:purpose "understand relationship between aerosol particle emissions and their climatic impacts"
;

      arv:scientist <http://muckdragon.info/arv/scientist/37> ;

      arv:sensor "LIDAR" ;

      arv:title "Southeast Asian Studies - South China and Sulu Sea Observations" .

```

<<http://www.muckdragon.info/PROV/2012/InFile.txt>>

tavernaprov:sha1 "0fde0e8116c78d064980792c9e1910098dde155d" ;

tavernaprov:sha512

"cf83e1357eefb8bdf1542850d66d8007d620e4050b5715dc83f4a921d36ce9ce47d0d13c5d85f2b0ff8318  
d2877eec2f63b931bd47417a81a538327af927da3e" .

<<http://www.muckdragon.info/PROV/2012/intermediates/3b/3ba5cc97-2764-4f72-868d-dc6200be1f69.txt>>

tavernaprov:sha1 "addc25ba9700b706b3a44ae17c2f28336aee7462" ;

tavernaprov:sha512

"cf83e1357eefb8bdf1542850d66d8007d620e4050b5715dc83f4a921d36ce9ce47d0d13c5d85f2b0ff8318  
d2877eec2f63b931bd47417a81a538327af927da3e" .

<<http://muckdragon.info/arv/request/6.1/08/5>>

a arv:Data ;

arv:dataType "water column" , "sediment" , "suspended particulates" ;

arv:location "Barrier islands, MS" ;

arv:purpose "monitor variables pertinent to sediments" ;

arv:scientist <<http://muckdragon.info/arv/scientist/10>> ;

arv:sensor "niskin bottles" , "gravity core" , "box core" , "traps" , "CTD" ;

arv:title "Sedimentological and biogeochemical regimes of the Mississippi sediments" .

<<http://muckdragon.info/arv/request/6.2/11/3>>

a arv:Data ;

arv:dataType "optical" ;

arv:location "Woods Hole, MA" ;

arv:purpose "a sea trial of new BOPPER system" ;

arv:scientist <<http://muckdragon.info/arv/scientist/30>> ;

arv:sensor "BOPPERS" , "AUV" ;

arv:title "AUV Data Analysis for Predictability in Time-Evolving Regimes" .

<<http://ns.taverna.org.uk/2011/data/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/ref/bfa5dffb-2f77-47b2-b0d0-19e1e5fb2fbd>>

tavernapro:content <<http://www.muckdragon.info/PROV/2012/intermediates/bf/bfa5dffb-2f77-47b2-b0d0-19e1e5fb2fbd.txt>> ;

wfprov:describedByParameter

<[http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/getColorFromDepth\\_input/in/data](http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/getColorFromDepth_input/in/data)> ,

<[http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/Encode\\_Byte\\_Array\\_to\\_Base\\_64\\_2/out/base64](http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/Encode_Byte_Array_to_Base_64_2/out/base64)> ;

wfprov:wasOutputFrom

<<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/process/4e2e26fb-de03-471a-9625-7a622a8da676>> ;

prov:qualifiedGeneration

[ a prov:Generation ;

prov:activity <<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/process/4e2e26fb-de03-471a-9625-7a622a8da676>> ;

prov:hadRole <[http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/Encode\\_Byte\\_Array\\_to\\_Base\\_64\\_2/out/base64](http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/Encode_Byte_Array_to_Base_64_2/out/base64)>

];

prov:wasGeneratedBy <<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/process/4e2e26fb-de03-471a-9625-7a622a8da676>> .

<[http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/Encode\\_Byte\\_Array\\_to\\_Base\\_64\\_3/](http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/Encode_Byte_Array_to_Base_64_3/)>

rdfs:label "Processor Encode\_Byte\_Array\_to\_Base\_64\_3" .

<http://www.muckdragon.info/PROV/2012/intermediates/0d/0dff030d-8c15-442f-a48b-ec5683eb71a9.octet-stream>

tavernaprov:sha1 "68e2611825e83754c3c46e3d4baa0ead2ce37828" ;

tavernaprov:sha512

"cf83e1357eefb8bdf1542850d66d8007d620e4050b5715dc83f4a921d36ce9ce47d0d13c5d85f2b0ff8318d2877eec2f63b931bd47417a81a538327af927da3e" .

<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-

b43ed445d18b/workflow/Workflow1/processor/Encode\_Byte\_Array\_to\_Base\_64\_2/out/base64>

rdfs:label "Encode\_Byte\_Array\_to\_Base\_64\_2 output base64" .

<http://ns.taverna.org.uk/2011/data/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/ref/2c944733-c9d6-44ef-a7e6-f92fb8a1ff68>

tavernaprov:content <http://www.muckdragon.info/PROV/2012/intermediates/2c/2c944733-c9d6-44ef-a7e6-f92fb8a1ff68.txt> ;

wfprov:describedByParameter

<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/getTinFromDepths/in/parameters> ,

<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-

b43ed445d18b/workflow/Workflow1/processor/TIN\_Input/out/output> ;

wfprov:wasOutputFrom

<<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/process/5788eb60-afdf-45de-b218-5add30d5c3b8/>> ;

prov:qualifiedGeneration

[ a prov:Generation ;

prov:activity <<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/process/5788eb60-afdf-45de-b218-5add30d5c3b8/>> ;

prov:hadRole <[http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/TIN\\_Input/out/output](http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/TIN_Input/out/output)>

];

prov:wasGeneratedBy <<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/process/5788eb60-afdf-45de-b218-5add30d5c3b8/>> .

<<http://ns.taverna.org.uk/2011/data/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/ref/71e16759-d9ae-4935-8921-175563f54a60>>

tavernaprov:content <<http://www.muckdragon.info/PROV/2012/intermediates/71/71e16759-d9ae-4935-8921-175563f54a60.octet-stream>> ;

wfprov:describedByParameter

<[http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/Encode\\_Byte\\_Array\\_to\\_Base\\_64\\_2/in/bytes](http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/Encode_Byte_Array_to_Base_64_2/in/bytes)> ,  
<[http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/TIN\\_Output/out/return](http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/TIN_Output/out/return)> ;

wfprov:wasOutputFrom

<<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/process/ac4f49f0-44a2-4a50-b0be-b18d4d31e72f/>> ;

prov:qualifiedGeneration

[ a prov:Generation ;

prov:activity <<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/process/ac4f49f0-44a2-4a50-b0be-b18d4d31e72f/>> ;

prov:hadRole <[http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/TIN\\_Output/out/return](http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/TIN_Output/out/return)>

];

prov:wasGeneratedBy <<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/process/ac4f49f0-44a2-4a50-b0be-b18d4d31e72f/>> .

<<http://muckdragon.info/arv/request/6.2/09/5>>

a arv:Data ;

arv:dataType "cores" , "power" , "sediment" ;

arv:location "Panama City Beach, FL" ;

arv:purpose "make sediment power generation practical for Navy applications" ;

arv:scientist <<http://muckdragon.info/arv/scientist/23>> ;

arv:sensor "cores" , "SEPTR" , "BUG" ;

arv:title "Unattended, Sea-Bed Power for In-Water Operations" .

<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-  
b43ed445d18b/workflow/Workflow1/processor/Encode\_Base64/out/base64>

rdfs:label "Encode\_Base64 output base64" .

<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-  
b43ed445d18b/workflow/Workflow1/processor/TIN\_Output/>

rdfs:label "Processor TIN\_Output" .

<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-  
b43ed445d18b/workflow/Workflow1/processor/TIN\_Output/out/return>

rdfs:label "TIN\_Output output return" .

<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-  
b43ed445d18b/workflow/Workflow1/processor/getColorFromDepth/>

rdfs:label "Processor getColorFromDepth" .

<http://www.muckdragon.info/PROV/2012/intermediates/ba/bac50aa8-23a5-4ea0-97d5-  
669b39765de4.txt>



tavernaprov:sha1 "f2a4948b08c493bdd602e960b122ed9d20987b8d" ;

tavernaprov:sha512

"cf83e1357eefb8bdf1542850d66d8007d620e4050b5715dc83f4a921d36ce9ce47d0d13c5d85f2b0ff8318  
d2877eec2f63b931bd47417a81a538327af927da3e" .

prov:agent

a owl:AnnotationProperty .

<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/process/2a438326-f37c-  
4573-8b52-296eea79c555/>

rdfs:label "Processor execution Encoding (facade1:Workflow1:Encoding)" ;

wfprov:describedByProcess

<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-  
b43ed445d18b/workflow/Workflow1/processor/Encoding/> ;

wfprov:wasPartOfWorkflowRun

<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/> ;

prov:endedAtTime "2012-12-03T15:47:19.776-06:00"^^xsd:dateTime ;

prov:qualifiedAssociation

[ a prov:Association ;

prov:agent :taverna-engine ;

prov:hadPlan <http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/Encoding/>

];

prov:startedAtTime "2012-12-03T15:47:19.720-06:00"^^xsd:dateTime .

<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/Read\_Data\_Points/in/fileurl>

rdfs:label "Read\_Data\_Points input fileurl" .

<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/process/fc12c4fe-9764-4875-85e3-05dff00405d5/>

rdfs:label "Processor execution Encode\_Byte\_Array\_to\_Base\_64 (facade1:Workflow1:Encode\_Byte\_Array\_to\_Base\_64)" ;

wfprov:describedByProcess

<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/Encode\_Byte\_Array\_to\_Base\_64/> ;

wfprov:usedInput <http://ns.taverna.org.uk/2011/data/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/ref/eb2bdf1a-df20-4d41-a0c7-fb785f725f6e> ;

wfprov:wasPartOfWorkflowRun

<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/> ;

prov:endedAtTime "2012-12-03T15:47:38.664-06:00"^^xsd:dateTime ;

prov:qualifiedAssociation

[ a prov:Association ;

prov:agent :taverna-engine ;

prov:hadPlan <http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/Encode\_Byte\_Array\_to\_Base\_64/>

];

prov:qualifiedUsage

[ a prov:Usage ;

prov:entity <http://ns.taverna.org.uk/2011/data/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/ref/eb2bdf1a-df20-4d41-a0c7-fb785f725f6e> ;

prov:hadRole <http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/Encode\_Byte\_Array\_to\_Base\_64/in/bytes>

];

prov:startedAtTime "2012-12-03T15:47:37.590-06:00"^^xsd:dateTime ;

prov:used <http://ns.taverna.org.uk/2011/data/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/ref/eb2bdf1a-df20-4d41-a0c7-fb785f725f6e> .

<http://muckdragon.info/arv/request/6.1/08/4>

a arv:Data ;

arv:dataType "water samples" , "current velocity" , "temperature" , "bathymetry" , "salinity" ,  
"conductivity" ;

arv:location "Monterey Bay, CA" ;

arv:purpose "improve understanding of the coupled bio-optical and physical processes for light field"  
;

arv:scientist <<http://muckdragon.info/arv/scientist/9>> ;

arv:sensor "ADCP" , "CTD" ;

arv:title "Bio-Optical Studies of Predictability and Assimilation for the Coastal Environment  
(BIOSPACE)" .

prov:qualifiedGeneration

a owl:AnnotationProperty .

tavernaprov:sha512

a owl:AnnotationProperty .

prov:startedAtTime

a owl:AnnotationProperty .

<<http://muckdragon.info/arv/request/6.2/09/2>>

a arv:Data ;

arv:dataType "magnetics" ;

arv:location "Continental Shelf, New Jersey" ;

arv:purpose "improve detection by reducing false alarms and noise in shallow water by understanding oceanographic effects on magnetics" ;

arv:scientist <<http://muckdragon.info/arv/scientist/20>> ;

arv:sensor "magnetics" ;

arv:title "Forecasting Magnetic Fields Generated by Submesoscale Hydrodynamics" .

<<http://muckdragon.info/arv/request/6.2/11/4>>

a arv:Data ;

arv:dataType "optical" , "profiles" , "particle size" , "water column" , "photography" , "turbulence" , "absorption" , "scattering" ;

arv:location "AUTECH, Bahamas" ;

arv:purpose "collect all related parameters to electro-optical problem" ;

arv:scientist <<http://muckdragon.info/arv/scientist/36>> ;

arv:sensor "optical" , "PME CT probe" , "camera" , "Rockland Vertical Microstructure Profiler" , "Nortek velocimeter" , "LISST" , "LLS" ;

arv:title "Increasing EO Imaging Resolution in Underwater Environments via Adaptive Coherent Integration" .

<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/Read\_Data\_Points/in/encoding>

rdfs:label "Read\_Data\_Points input encoding" .

<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/Read\_Data\_Points/>

rdfs:label "Processor Read\_Data\_Points" .

<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/convertText3ToDouble3\_input/output/output>

rdfs:label "convertText3ToDouble3\_input output output" .

<http://ns.taverna.org.uk/2011/data/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/ref/3ba5cc97-2764-4f72-868d-dc6200be1f69>

tavernaprov:content <http://www.muckdragon.info/PROV/2012/intermediates/3b/3ba5cc97-2764-4f72-868d-dc6200be1f69.txt> ;

wfprov:describedByParameter

<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-  
b43ed445d18b/workflow/Workflow1/processor/TIN\_Input/in/data> ,  
<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-  
b43ed445d18b/workflow/Workflow1/processor/Encode\_Byte\_Array\_to\_Base\_64/out/base64> ;

wfprov:wasOutputFrom

<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/process/fc12c4fe-  
9764-4875-85e3-05dff00405d5/> ;

prov:qualifiedGeneration

[ a prov:Generation ;

prov:activity <http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-  
4c6f25e7c4fa/process/fc12c4fe-9764-4875-85e3-05dff00405d5/> ;

prov:hadRole <http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-  
b43ed445d18b/workflow/Workflow1/processor/Encode\_Byte\_Array\_to\_Base\_64/out/base64>

];

prov:wasGeneratedBy <http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-  
4c6f25e7c4fa/process/fc12c4fe-9764-4875-85e3-05dff00405d5/> .

<http://muckdragon.info/arv/request/6.1/08/3>

a arv:Data ;

arv:dataType "SAR" ;

arv:location "Outer Banks, NC and Daytona Beach, FL" ;

arv:purpose "better understand surface currents by interferometric SAR measurements" ;

arv:scientist <<http://muckdragon.info/arv/scientist/8>> ;

arv:sensor "SAR" ;

arv:title "SAR/INSAR Imaging of Strong Currents and Current Gradients" .

<<http://www.muckdragon.info/PROV/2012/intermediates/ca/caafb1b5-e4ed-40fc-9f8d-545f2be960e5.txt>>

tavernaprov:sha1 "d6bbc1f60aa5345685d84a631a7fb31f7b8faebf" ;

tavernaprov:sha512

"cf83e1357eefb8bdf1542850d66d8007d620e4050b5715dc83f4a921d36ce9ce47d0d13c5d85f2b0ff8318d2877eec2f63b931bd47417a81a538327af927da3e" .

<<http://www.muckdragon.info/PROV/2012/intermediates/bf/bfa5dff-2f77-47b2-b0d0-19e1e5fb2fbd.txt>>

tavernaprov:sha1 "c6b2142f40933ffb6784e75b1fd7fd90fea99046" ;

tavernaprov:sha512

"cf83e1357eefb8bdf1542850d66d8007d620e4050b5715dc83f4a921d36ce9ce47d0d13c5d85f2b0ff8318d2877eec2f63b931bd47417a81a538327af927da3e" .



<<http://muckdragon.info/arv/request/6.2/11/5>>

a arv:Data ;

arv:dataType "optical" , "current velocity" , "LIDAR" , "temperature" , "bathymetry" , "absorption" ,  
"backscatter" , "scattering" , "water sample" , "conductivity" ;

arv:location "East Sound, WA" ;

arv:purpose "evaluate a microflow cytometer sensor" ;

arv:scientist <<http://muckdragon.info/arv/scientist/24>> ;

arv:sensor "glider" , "LIDAR" , "bio-optical slow-drop profiler" , "MVSM" , "scan fish" , "CTD" ,  
"Wetlabs MASCOT" , "Cytosense" ;

arv:title "Characterizing subsurface bio-optical layers" .

<<http://muckdragon.info/arv/request/6.2/09/3>>

a arv:Data ;

arv:dataType "surface wave spectrum" , "temperature" , "acoustics" ;

arv:location "Panama City Beach, FL" ;

arv:purpose "improve communications for near-bottom and in-sediment acoustic network sensors" ;

arv:scientist <<http://muckdragon.info/arv/scientist/21>> ;

arv:sensor "wave rider" , "thermistor" , "acoustics" ;

arv:title "Inter-Sensor Sediment Communications" .

dcterms:hasPart

a owl:AnnotationProperty .

<[http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/TIN\\_Input/](http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/TIN_Input/)>

rdfs:label "Processor TIN\_Input" .

<<http://ns.taverna.org.uk/2011/data/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/ref/eb2bdf1a-df20-4d41-a0c7-fb785f725f6e>>

tavernaprov:content <<http://www.muckdragon.info/PROV/2012/intermediates/eb/eb2bdf1a-df20-4d41-a0c7-fb785f725f6e>.octet-stream> ;

wfprov:describedByParameter

<[http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/Encode\\_Byte\\_Array\\_to\\_Base\\_64/in/bytes](http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/Encode_Byte_Array_to_Base_64/in/bytes)> ,

<[http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/convertText3ToDouble3\\_output/out/return](http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/convertText3ToDouble3_output/out/return)> ;

wfprov:wasOutputFrom

wfprov:wasOutputFrom

<<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/process/32d801fc-e451-4e93-baef-0fc7749fba85/>> ;

prov:qualifiedGeneration

[ a prov:Generation ;

prov:activity <<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/process/32d801fc-e451-4e93-baef-0fc7749fba85/>> ;

prov:hadRole <[http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/convertText3ToDouble3\\_output/out/return](http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/convertText3ToDouble3_output/out/return)>

];

prov:wasGeneratedBy <<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/process/32d801fc-e451-4e93-baef-0fc7749fba85/>> .

<<http://muckdragon.info/arv/request/6.1/11/4>>

a arv:Data ;

arv:dataType "optical" , "current velocity" , "Hyperspectral imagery" , "IR" ;

arv:location "Potomac River, MD/VA" ;

arv:purpose "examine extent to which remote sensing imagery can be used to better understand sub surface riverine flow" ;

arv:scientist <<http://muckdragon.info/arv/scientist/31>> ;

arv:sensor "VNIR" , "hyperspectral" , "IR" ;

arv:title "Investigation of river dynamics using combined broad-band hyperspectral, VNIR and IR imaging" .

<<http://muckdragon.info/arv/request/6.1/10/4>>

a arv:Data ;

arv:dataType "current velocity" , "temperature" , "optics" , "salinity" , "conductivity" , "acoustics" ;

arv:location "Monterey Bay, Monterey, CA" ;

arv:purpose "improve understanding of the coupled bio-optical and physical processes in coastal zone" ;

arv:scientist <<http://muckdragon.info/arv/scientist/9>> ;

arv:sensor "optical" , "BOPPER" , "SLOCUM glider" , "ADCP" , "CTD" , "scan fish" ;

arv:title "BIOSPACE" .

<<http://muckdragon.info/arv/request/6.2/09/8>>

a arv:Data ;

arv:dataType "acoustics" ;

arv:location "Panama City Beach, FL" ;

arv:purpose "shallow water ASW" ;

arv:scientist <<http://muckdragon.info/arv/scientist/4>> ;

arv:sensor "acoustics" ;

arv:title "A Distributed Autonomous, Persistent Surveillance Network for Underwater Environments"

<<http://muckdragon.info/arv/request/6.1/08/2>>

a arv:Data ;

arv:dataType "wind" , "temperature" , "humidity" , "Radar" , "lidar" ;

arv:location "Guam" ;

arv:purpose "increase predictability of environmental forcing formation, intensity of tropical cyclones" ;

arv:scientist <<http://muckdragon.info/arv/scientist/7>> ;

arv:sensor "radar" , "wind" , "temperature" , "humidity" , "lidar" ;

arv:title "Tropical Cyclone Structure" .

<<http://muckdragon.info/arv/request/6.1/12/2>>

a arv:Data ;

arv:dataType "tides" , "cores" , "LIDAR" , "Hyperspectral imagery" , "bathymetry" , "position" ,  
"thermal imagery" , "SAR" ;

arv:location "Queensland, Australia" ;

arv:purpose "improve geotechnical property definition such as soil and beach grain size and density"

;

arv:scientist <<http://muckdragon.info/arv/scientist/1>> ;

arv:sensor "NASA Aqua MODIS" , "cores" , "field spectrometers" , "kinematic GPS" , "goniometer" ,  
"Hyperspectral" , "CIMEL sun photometer" , "sun photometers" , "LIDAR" , "HICO" , "deflectometers" ,  
"SAR" , "penetrometer" ;

arv:title "Trafficability from Remote Sensing" .

<[http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-  
b43ed445d18b/workflow/Workflow1/processor/convertText3ToDouble3\\_output/](http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/convertText3ToDouble3_output/)>

rdfs:label "Processor convertText3ToDouble3\_output" .

<[http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-  
b43ed445d18b/workflow/Workflow1/processor/TIN\\_Output/in/input](http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/TIN_Output/in/input)>

rdfs:label "TIN\_Output input input" .

prov:Usage

a owl:Class .

<<http://muckdragon.info/arv/request/6.2/12/10>>

a arv:Data ;

arv:dataType "transmission loss" , "acoustics" ;

arv:location "Continental Shelf, New Jersey" ;

arv:purpose "define acoustic limits of transmission with minimum energy consumption" ;

arv:scientist <<http://muckdragon.info/arv/scientist/39>> ;

arv:sensor "acoustics" ;

arv:title "Analysis of Network throughput, Medium Access Control and Energy Efficiency in Underwater Acoustic Networks" .

wfprov:wasEnactedBy

a owl:AnnotationProperty .

<<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861->

[b43ed445d18b/workflow/Workflow1/processor/getColorFromDepth/out/parameters](http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/getColorFromDepth/out/parameters)>

rdfs:label "getColorFromDepth output parameters" .

<<http://muckdragon.info/arv/request/6.1/07/1>>

a arv:Data ;

arv:dataType "IR imagery" , "Hyperspectral imagery" , "bathymetric LIDAR" , "topographic LIDAR" ,  
"thermal imagery" ;

arv:location "Virginia Coast Reserve" ;

arv:purpose "Understand the hydrodynamic sources of features detectable in IR imagery of water surface" ;

arv:scientist <<http://muckdragon.info/arv/scientist/1>> ;

arv:sensor "NASA LIDAR" , "hyperspectral" ;

arv:title "Joint LIDAR/Hyperspectral Data Collection" .

<<http://muckdragon.info/arv/request/6.1/10/3>>

a arv:Data ;

arv:dataType "water column" , "Hyperspectral imagery" , "sediment" , "bathymetry" , "position" , "IR" ;

arv:location "Saipan" ;

arv:purpose "develop algorithms for bathymetry, bottom type, water column and land based anomalies" ;

arv:scientist <<http://muckdragon.info/arv/scientist/1>> ;

arv:sensor "UAV" , "inGaAS SWIR" , "hyperspectral" , "IR" ;

arv:title "Trafficability and Shallow Water Bathymetry Products from Hyperspectral Imagery in a Volcanic Coast Environment" .

<<http://muckdragon.info/arv/request/6.1/11/5>>

a arv:Data ;



arv:dataType "acoustic" , "megafauna" , "photography" , "sediment" , "erosioin" ;

arv:location "Atchafalaya River, Gulf of Mexico" ;

arv:purpose "identify and predict biological mediation of sediment acoustic and physical properties affected by hypoxia" ;

arv:scientist <<http://muckdragon.info/arv/scientist/14>> ;

arv:sensor "ASCS" , "trawls" , "LUMCON box core" ;

arv:title "Hypoxia Effects on Processes in Muddy Sediments in the Northern Gulf of Mexico" .

<<http://muckdragon.info/arv/request/6.1/11/1>>

a arv:Data ;

arv:dataType "optical" , "waves" , "ocean color" , "photography" , "roughness" , "sea surface temperature" , "salinity" ;

arv:location "Mississippi Bight, Gulf of Mexico" ;

arv:purpose "determine sea surface roughness" ;

arv:scientist <<http://muckdragon.info/arv/scientist/29>> ;

arv:sensor "C-Band radar" , "STARRS" , "microwave" ;

arv:title "STARRS flights supporting Sea Surface roughness Impacts on Microwave Sea Surface Salinity Measurements" .

<http://muckdragon.info/arv/request/6.2/09/9>

a arv:Data ;

arv:dataType "acoustics" ;

arv:location "Continental Shelf, New Jersey" ;

arv:purpose "determine channel properties for underwater acoustic communications" ;

arv:scientist <http://muckdragon.info/arv/scientist/17> ;

arv:sensor "ACDS" , "EARS buoy" , "EMATT UUV" , "ASRA" , "acoustics" ;

arv:title "Acoustic Communications" .

prov:Generation

a owl:Class .

<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/process/3b900a61-7b9a-469a-bc06-487ff5dee1f8/>

rdfs:label "Processor execution Encode\_Byte\_Array\_to\_Base\_64\_3  
(facade1:Workflow1:Encode\_Byte\_Array\_to\_Base\_64\_3)" ;

wfprov:describedByProcess

<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/Encode\_Byte\_Array\_to\_Base\_64\_3/> ;

wfprov:usedInput <http://ns.taverna.org.uk/2011/data/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/ref/0dff030d-8c15-442f-a48b-ec5683eb71a9> ;

wfprov:wasPartOfWorkflowRun

<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/> ;

prov:endedAtTime "2012-12-03T15:48:23.418-06:00"^^xsd:dateTime ;

prov:qualifiedAssociation

[ a prov:Association ;

prov:agent :taverna-engine ;

prov:hadPlan <http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/Encode\_Byte\_Array\_to\_Base\_64\_3/>

];

prov:qualifiedUsage

[ a prov:Usage ;

prov:entity <http://ns.taverna.org.uk/2011/data/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/ref/0dff030d-8c15-442f-a48b-ec5683eb71a9> ;

prov:hadRole <http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/Encode\_Byte\_Array\_to\_Base\_64\_3/in/bytes>

];

prov:startedAtTime "2012-12-03T15:48:23.309-06:00"^^xsd:dateTime ;

prov:used <<http://ns.taverna.org.uk/2011/data/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/ref/0dff030d-8c15-442f-a48b-ec5683eb71a9>> .

<<http://muckdragon.info/arv/request/6.1/08/1>>

a arv:Data ;

arv:dataType "IR imagery" , "long wave IR" , "Hyperspectral imagery" ;

arv:location "Atchafalaya river, LA" ;

arv:purpose "new methods for data-driven approaches for parameterizing nonlinear structure in data" ;

arv:scientist <<http://muckdragon.info/arv/scientist/1>> ;

arv:sensor "IR imager" , "hyperspectral" ;

arv:title "Multi-Sensor Data Collection in a Riverine Watershed" .

<<http://www.muckdragon.info/PROV/2012/intermediates/b7/b7e4c42f-9bde-447f-9aff-46cee4dc84e7.txt>>

tavernaprov:sha1 "13aef6998eee14ad0ae5243994ac5442f9b6cf76" ;

tavernaprov:sha512

"cf83e1357eefb8bdf1542850d66d8007d620e4050b5715dc83f4a921d36ce9ce47d0d13c5d85f2b0ff8318d2877eec2f63b931bd47417a81a538327af927da3e" .

<<http://www.muckdragon.info/PROV/2012/intermediates/36/36002dbd-6b77-41ae-8915-96d7dbad8460.txt>>

tavernaprov:sha1 "ce29c9df5ebe5dc8cf3a74dabc55ae88e84e0088" ;

tavernaprov:sha512

"cf83e1357eefb8bdf1542850d66d8007d620e4050b5715dc83f4a921d36ce9ce47d0d13c5d85f2b0ff8318d2877eec2f63b931bd47417a81a538327af927da3e" .

<<http://muckdragon.info/arv/request/6.1/12/1>>

a arv:Data ;

arv:dataType "MBSAR" , "DSS photogrammetry" , "Radar Altimetry" , "LIDAR" ;

arv:location "Alaska" ;

arv:purpose "improve sea ice/snow algorithm" ;

arv:scientist <<http://muckdragon.info/arv/scientist/5>> ;

arv:sensor "DSS" , "MBSAR" , "LIDAR" ;

arv:title "Determining the Impact of Sea Ice Thickness on the Arctic's Naturally Changing Environment (DISTANCE)" .

<[http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/getColorFromDepth\\_input/output/output](http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/getColorFromDepth_input/output/output)>

rdfs:label "getColorFromDepth\_input output output" .

wfdesc:hasSubProcess

a owl:AnnotationProperty .

<http://ns.taverna.org.uk/2011/data/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/ref/8114af59-d8ee-4b43-8eb7-f3559adb2ab5>

tavernaprov:content <http://www.muckdragon.info/PROV/2012/intermediates/81/8114af59-d8ee-4b43-8eb7-f3559adb2ab5.txt> ;

wfprov:describedByParameter

<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/TIN\_Output/in/input> ,  
<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/getTinFromDepths/out/parameters> ;

wfprov:wasOutputFrom

<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/process/bbacde92-9524-4f16-aa0b-bb132b855995/> ;

prov:qualifiedGeneration

[ a prov:Generation ;

prov:activity <http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/process/bbacde92-9524-4f16-aa0b-bb132b855995/> ;

prov:hadRole <http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/getTinFromDepths/out/parameters>

];

prov:wasGeneratedBy <http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/process/bbacde92-9524-4f16-aa0b-bb132b855995/> .

<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/process/50e8ea65-dc28-4c18-93a2-a74f4bb32b76/>

rdfs:label "Processor execution convertText3ToZDouble3  
(facade1:Workflow1:convertText3ToZDouble3)";

wfprov:describedByProcess

<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/convertText3ToZDouble3/> ;

wfprov:usedInput <http://ns.taverna.org.uk/2011/data/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/ref/caafb1b5-e4ed-40fc-9f8d-545f2be960e5> ;

wfprov:wasPartOfWorkflowRun

<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/> ;

prov:endedAtTime "2012-12-03T15:47:35.382-06:00"^^xsd:dateTime ;

prov:qualifiedAssociation

[ a prov:Association ;

prov:agent :taverna-engine ;

prov:hadPlan <<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/convertText3ToZDouble3/>>

];

prov:qualifiedUsage

[ a prov:Usage ;

prov:entity <<http://ns.taverna.org.uk/2011/data/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/ref/caafb1b5-e4ed-40fc-9f8d-545f2be960e5>> ;

prov:hadRole <<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/convertText3ToZDouble3/in/parameters>>

];

prov:startedAtTime "2012-12-03T15:47:29.016-06:00"^^xsd:dateTime ;

prov:used <<http://ns.taverna.org.uk/2011/data/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/ref/caafb1b5-e4ed-40fc-9f8d-545f2be960e5>> .

<<http://muckdragon.info/arv/request/6.1/09/1>>

a arv:Data ;

arv:dataType "photography" , "sediment" ;

arv:location "Atchafalaya River, Gulf of Mexico, LA" ;



arv:purpose "identify and predict biological mediation of sediment acoustic and physical properties affected by hypoxia" ;

arv:scientist <<http://muckdragon.info/arv/scientist/14>> ;

arv:sensor "ASCS" , "box core" ;

arv:title "Hypoxia Effects on Processes in Muddy Sediments in the Northern Gulf of Mexico" .

<<http://muckdragon.info/arv/request/6.2/09/6>>

a arv:Data ;

arv:dataType "optical" , "sediment" , "temperature" , "bathymetry" , "absorption" , "backscatter" , "conductivity" ;

arv:location "East Sound, WA" ;

arv:purpose "evaluate glider bio-optical sensor performance" ;

arv:scientist <<http://muckdragon.info/arv/scientist/24>> ;

arv:sensor "glider" , "bio-optical profiler" , "MVSM" , "scan fish" , "CTD" , "CYTOSUB" ;

arv:title "Characterizing subsurface bio-optical layers" .

<<http://muckdragon.info/arv/request/6.1/11/2>>

a arv:Data ;

arv:dataType "Hyperspectral imagery" , "thermal imagery" , "IR" ;

arv:location "Santa Catalina, CA" ;

arv:purpose "provide multi wavelength imaging of the study region" ;

arv:scientist <<http://muckdragon.info/arv/scientist/15>> ;

arv:sensor "hyperspectral" , "thermal imager" , "IR" ;

arv:title "Investigation of submesoscale dynamics via combined broad-band infrared and hyperspectral VNIR imaging" .

<<http://muckdragon.info/arv/request/6.1/11/6>>

a arv:Data ;

arv:dataType "cores" , "sun photometers" , "Hyperspectral imagery" , "LIDAR" , "bathymetry" , "position" , "soundings" , "thermal imagery" ;

arv:location "LTER site Northampton County, VA" ;

arv:purpose "test and validate aerosol models" ;

arv:scientist <<http://muckdragon.info/arv/scientist/32>> ;

arv:sensor "kinematic GPS" , "goniometer" , "sun photometers" , "LIDAR" , "HICO" , "deflectometers" , "MODIS" , "hyperspectral" , "spectrometer" , "core sample" , "penetrometer" , "thermal imager" ;

arv:title "Atmospheric Correction Algorithms for Hyperspectral and Multispectral Remote Sensing of Land and Ocean" .

<<http://muckdragon.info/arv/request/6.1/10/6>>

a arv:Data ;

arv:dataType "Hyperspectral imagery" , "absorption" , "scattering" , "backscatter" , "IR" ;

arv:location "Monterey Bay, Monterey, CA" ;

arv:purpose "develop and validate methods for deriving the optical scattering phase function for coastal and open waters" ;

arv:scientist <<http://muckdragon.info/arv/scientist/16>> ;

arv:sensor "hyperspectral" , "IR" ;

arv:title "Multi-angle Optical Remote Sensing in Coastal Environments" .

<<http://ns.taverna.org.uk/2011/data/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/ref/bac50aa8-23a5-4ea0-97d5-669b39765de4>>

tavernapro:content <<http://www.muckdragon.info/PROV/2012/intermediates/ba/bac50aa8-23a5-4ea0-97d5-669b39765de4.txt>> ;

wfprov:describedByParameter

<[http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/convertText3ToDouble3\\_output/in/input](http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/convertText3ToDouble3_output/in/input)> ,  
<<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/convertText3ToZDouble3/out/parameters>> ;

wfprov:wasOutputFrom

<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/process/50e8ea65-dc28-4c18-93a2-a74f4bb32b76/> ;

prov:qualifiedGeneration

[ a prov:Generation ;

prov:activity <http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/process/50e8ea65-dc28-4c18-93a2-a74f4bb32b76/> ;

prov:hadRole <http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/convertText3ToZDouble3/out/parameters>

];

prov:wasGeneratedBy <http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/process/50e8ea65-dc28-4c18-93a2-a74f4bb32b76/> .

<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/Encode\_Base64/in/bytes>

rdfs:label "Encode\_Base64 input bytes" .

<http://muckdragon.info/arv/request/6.1/09/2>

a arv:Data ;

arv:dataType "currents" , "atmospheric profile" , "temperature" , "conductivity" ;

arv:location "Turkish Straits, Turkey" ;

arv:purpose "investigate strait exchange processes" ;

arv:scientist <<http://muckdragon.info/arv/scientist/13>> ;

arv:sensor "ADCP" , "CTD" ;

arv:title "Exchange Processes in Ocean Straits" .

<<http://muckdragon.info/arv/request/6.2/12/12>>

a arv:Data ;

arv:dataType "ambient noise" , "seismic" , "acoustics" ;

arv:location "44.5N, 125.2W" ;

arv:purpose "examine seismo-acoustic ambient noise" ;

arv:scientist <<http://muckdragon.info/arv/scientist/11>> ;

arv:sensor "hydrophone" , "seismic" , "DTAGS" ;

arv:title "Low Ambient Noise Geologic Environments on the Littoral Margin for Passive ASW" .

<<http://www.muckdragon.info/PROV/2012/intermediates/71/71e16759-d9ae-4935-8921-175563f54a60.octet-stream>>

tavernaprov:sha1 "5ccdf5c41ff4864e66a9af55a317968584f39fec" ;

tavernaprov:sha512

"cf83e1357eefb8bdf1542850d66d8007d620e4050b5715dc83f4a921d36ce9ce47d0d13c5d85f2b0ff8318d2877eec2f63b931bd47417a81a538327af927da3e" .

<[http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/convertText3ToDouble3\\_input/](http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/convertText3ToDouble3_input/)>

rdfs:label "Processor convertText3ToDouble3\_input" .

<<http://muckdragon.info/arv/request/6.1/11/3>>

a arv:Data ;

arv:dataType "power" , "sediment" ;

arv:location "Mississippi Bight, Gulf of Mexico" ;

arv:purpose "determine power generation abilities in varying sediment types" ;

arv:scientist <<http://muckdragon.info/arv/scientist/30>> ;

arv:sensor "BUG" , "box core" ;

arv:title "Platform support to investigate the performance of Benthic Unattended Generator (BUG) in sandy, muddy and mixed marine sediments" .

<<http://muckdragon.info/arv/request/6.1/11/7>>

a arv:Data ;

arv:dataType "sonar" , "radar altimetry" , "LIDAR" , "photogrammetry" ;

arv:location "Prudhoe Bay, Alaska" ;

arv:purpose "improve sea ice/snow algorithm" ;

arv:scientist <<http://muckdragon.info/arv/scientist/33>> ;

arv:sensor "DSS photogrammetry" , "Radar altimeter" , "CRYOSAT-2" , "LIDAR" , "microwave" ,  
"WindSat" ;

arv:title "Study of Physical Processes Leading to Full Exploitation of Passive Polarimetric Microwave  
Measurements at Global and Tactical Spatial Scales" .

<<http://muckdragon.info/arv/request/6.2/09/7>>

a arv:Data ;

arv:dataType "tides" , "wave" , "currents" , "temperature" , "bathymetry" , "optics" , "magnetics" ,  
"salinity" , "conductivity" , "acoustics" ;

arv:location "Continental Shelf, New Jersey" ;

arv:purpose "improve detection by reducing false alarms" ;

arv:scientist <<http://muckdragon.info/arv/scientist/9>> ;

arv:sensor "scanfish" , "magnetics" , "ADCP" ;

arv:title "Forecasting Magnetic Fields Generated by Submesoscale Hydrodynamics" .

<<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/convertText3ToZDouble3/>>

rdfs:label "Processor convertText3ToZDouble3" .

<<http://muckdragon.info/arv/request/6.2/11/1>>

a arv:Data ;

arv:dataType "water column" , "cores" , "power" , "sediment" ;

arv:location "Mississippi Sound, Gulf of Mexico" ;

arv:purpose "test performance of Benthic Unattended Generators (BUGs) over varying sediment types" ;

arv:scientist <<http://muckdragon.info/arv/scientist/23>> ;

arv:sensor "cores" , "BUG" , "ADCP" ;

arv:title "Environmental Optimization of Sea-Bed Energy Harvesting for Navy Devices" .

<<http://muckdragon.info/arv/request/6.1/10/5>>

a arv:Data ;

arv:dataType "current velocity" , "temperature" , "turbulence" , "seismic" , "conductivity" ;

arv:location "Capetown, South Africa" ;

arv:purpose "improve understanding of mesoscale stirring" ;



arv:scientist <<http://muckdragon.info/arv/scientist/18>> ;

arv:sensor "scanfish" , "turbulence probes" , "seismic" , "CTD" ;

arv:title "Quantifying Mechanisms of Diapycnal Mixing in Agulhas Frontal Region" .

<[http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-](http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/getColorFromDepth_output/)

[b43ed445d18b/workflow/Workflow1/processor/getColorFromDepth\\_output/](http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/getColorFromDepth_output/)>

rdfs:label "Processor getColorFromDepth\_output" .

<[http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-](http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/convertText3ToDouble3_input_in_data/)

[b43ed445d18b/workflow/Workflow1/processor/convertText3ToDouble3\\_input\\_in\\_data/](http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/convertText3ToDouble3_input_in_data/)>

rdfs:label "convertText3ToDouble3\_input input data" .

<<http://muckdragon.info/arv/request/6.1/12/3>>

a arv:Data ;

arv:dataType "temperature" , "bathymetry" , "turbulence" , "seismic" , "conductivity" , "acoustics" ;

arv:location "Cape Town, South Africa" ;

arv:purpose "better quantify mechanisms of diapycnal mixing" ;

arv:scientist <<http://muckdragon.info/arv/scientist/18>> ;

arv:sensor "ADCP" , "seismic" , "CTD" ;

arv:title "Quantifying Mechanisms of Diapycnal Mixin in the Agulhas Frontal Region" .

<<http://muckdragon.info/arv/request/6.2/12/11>>

a arv:Data ;

arv:dataType "optical" , "temperature" , "bathymetry" , "absorption" , "scattering" , "backscattering"  
, "conductivity" ;

arv:location "East Sound, WA" ;

arv:purpose "evaluate microflow cytometer sensor performance" ;

arv:scientist <<http://muckdragon.info/arv/scientist/24>> ;

arv:sensor "glider" , "Cytosense Submersible cytometer" , "MVSM" , "URI glider" , "scan fish" , "CTD"  
, "Holographic camera" ;

arv:title "Characterizing subsurface bio-optical layers" .

prov:hadPlan

a owl:AnnotationProperty .

<<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861->

[b43ed445d18b/workflow/Workflow1/processor/getColorFromDepth/in/parameters](http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/getColorFromDepth/in/parameters)>

rdfs:label "getColorFromDepth input parameters" .

<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/process/bbacde92-9524-4f16-aa0b-bb132b855995/>

rdfs:label "Processor execution getTinFromDepths (facade1:Workflow1:getTinFromDepths)" ;

wfprov:describedByProcess

<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/getTinFromDepths/> ;

wfprov:usedInput <http://ns.taverna.org.uk/2011/data/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/ref/2c944733-c9d6-44ef-a7e6-f92fb8a1ff68> ;

wfprov:wasPartOfWorkflowRun

<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/> ;

prov:endedAtTime "2012-12-03T15:47:55.296-06:00"^^xsd:dateTime ;

prov:qualifiedAssociation

[ a prov:Association ;

prov:agent :taverna-engine ;

prov:hadPlan <http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/getTinFromDepths/>

];

prov:qualifiedUsage

[ a prov:Usage ;

prov:entity <http://ns.taverna.org.uk/2011/data/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/ref/2c944733-c9d6-44ef-a7e6-f92fb8a1ff68> ;

prov:hadRole <http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/getTinFromDepths/in/parameters>

];

prov:startedAtTime "2012-12-03T15:47:39.892-06:00"^^xsd:dateTime ;

prov:used <http://ns.taverna.org.uk/2011/data/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/ref/2c944733-c9d6-44ef-a7e6-f92fb8a1ff68> .

<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/Encode\_Byte\_Array\_to\_Base\_64\_2/>

rdfs:label "Processor Encode\_Byte\_Array\_to\_Base\_64\_2" .

prov:wasAssociatedWith

a owl:AnnotationProperty .

<http://muckdragon.info/arv/request/6.1/09/3>

a arv:Data ;

arv:dataType "water samples" , "IR imagery" , "LIDAR" , "Hyperspectral imagery" ;

arv:location "East Sound, WA" ;

arv:purpose "study surface thermal imprints of hydrodynamic structures" ;

arv:scientist <http://muckdragon.info/arv/scientist/15> ;

arv:sensor "LIDAR" , "LWIR" , "MWIR" , "hyperspectral" ;

arv:title "Investigation of small scale estuarine dynamics via combined IR and hyperspectral imaging"

.

prov:Association

a owl:Class .

wfprov:usedInput

a owl:AnnotationProperty .

<http://ns.taverna.org.uk/2011/data/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/ref/3736657a-72a1-45c5-9e37-e3a31e33de50>

tavernaprov:content <http://www.muckdragon.info/PROV/2012/intermediates/37/3736657a-72a1-45c5-9e37-e3a31e33de50.txt> ;

wfprov:describedByParameter

<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/getColorFromDepth\_output/in/input> ,

<<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/getColorFromDepth/out/parameters>> ;

wfprov:wasOutputFrom

<<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/process/eb80b8c8-a65a-400e-8935-9077e35336bf>> ;

prov:qualifiedGeneration

[ a prov:Generation ;

prov:activity <<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/process/eb80b8c8-a65a-400e-8935-9077e35336bf>> ;

prov:hadRole <<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/getColorFromDepth/out/parameters>>

];

prov:wasGeneratedBy <<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/process/eb80b8c8-a65a-400e-8935-9077e35336bf>> .

<<http://muckdragon.info/arv/request/6.1/09/4>>

a arv:Data ;

arv:dataType "backscattering" , "hyperspectral" , "scattering" , "absorbtion" , "thermal imagery" , "IR" ;

arv:location "Chesapeake Bay, MD" ;

arv:purpose "determine all inherent optical properties of coastal waters with an off-nadir optical hyperspectral sensor" ;

arv:scientist <<http://muckdragon.info/arv/scientist/16>> ;

arv:sensor "LISST" , "hyperspectral" , "ECO-VSF/HS-6" , "thermal imager" ;

arv:title "Multi-angle Optical Remote Sensing in Coastal Environments and Surface Thermal Imprints for Hydrodynamic Studies" .

<<http://muckdragon.info/arv/request/6.1/11/8>>

a arv:Data ;

arv:dataType "scatter" , "reflectance" , "composition" , "Hyperspectral imagery" , "aerosol size" , "heat flux" , "optical depth" , "absorption" , "chlorophyll" , "suspended sediments" ;

arv:location "Philippines and Vietnam" ;

arv:purpose "understand relationship between aerosol particle emissions and their climatic impacts" ;

arv:scientist <<http://muckdragon.info/arv/scientist/34>> ;

arv:sensor "hyperspectral imager" ;

arv:title "Southeast Asian Studies - Littoral Observations" .

<<http://muckdragon.info/arv/request/6.2/10/2>>

a arv:Data ;

arv:dataType "SAR" ;

arv:location "Outer Banks, NC" ;

arv:purpose "develop interferometric SAR hardware " ;

arv:scientist <<http://muckdragon.info/arv/scientist/8>> ;

arv:sensor "SAR" ;

arv:title "Development of Integrated ATI/XTI SAR" .

<<http://muckdragon.info/arv/request/6.2/12/14>>

a arv>Data ;

arv:dataType "acoustics" ;

arv:location "Jacksonville, FL" ;

arv:purpose "study environmental acoutic signatures" ;

arv:scientist <<http://muckdragon.info/arv/scientist/4>> ;

arv:sensor "AUV" , "acoustics" ;

arv:title "Concept Drift Classifier for Structural Acoustics MCM and Harbor Protection Employing  
Structural Acoustic Classifiers" .

prov:qualifiedUsage

a owl:AnnotationProperty .



<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/process/6a8b2d53-f766-49aa-aebb-de4728985703/>

rdfs:label "Processor execution getColorFromDepth\_output  
(facade1:Workflow1:getColorFromDepth\_output)";

wfprov:describedByProcess

<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/getColorFromDepth\_output/>;

wfprov:usedInput <http://ns.taverna.org.uk/2011/data/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/ref/3736657a-72a1-45c5-9e37-e3a31e33de50>;

wfprov:wasPartOfWorkflowRun

<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/>;

prov:endedAtTime "2012-12-03T15:48:23.294-06:00"^^xsd:dateTime;

prov:qualifiedAssociation

[ a prov:Association;

prov:agent :taverna-engine;

prov:hadPlan <http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/getColorFromDepth\_output/>

];

prov:qualifiedUsage

```

[ a   prov:Usage ;

      prov:entity <http://ns.taverna.org.uk/2011/data/72a6fd65-cbff-4cfc-8163-
4c6f25e7c4fa/ref/3736657a-72a1-45c5-9e37-e3a31e33de50> ;

      prov:hadRole <http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-
b43ed445d18b/workflow/Workflow1/processor/getColorFromDepth_output/in/input>

];

      prov:startedAtTime "2012-12-03T15:48:23.216-06:00"^^xsd:dateTime ;

      prov:used <http://ns.taverna.org.uk/2011/data/72a6fd65-cbff-4cfc-8163-
4c6f25e7c4fa/ref/3736657a-72a1-45c5-9e37-e3a31e33de50> .

<http://ns.taverna.org.uk/2011/data/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/ref/caafb1b5-e4ed-40fc-
9f8d-545f2be960e5>

      tavernaprov:content <http://www.muckdragon.info/PROV/2012/intermediates/ca/caafb1b5-e4ed-
40fc-9f8d-545f2be960e5.txt> ;

      wfprov:describedByParameter

      <http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-
b43ed445d18b/workflow/Workflow1/processor/convertText3ToZDouble3/in/parameters> ,

      <http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-
b43ed445d18b/workflow/Workflow1/processor/convertText3ToDouble3_input/out/output> ;

      wfprov:wasOutputFrom

```

<<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/process/39441ae0-9fde-4a19-b262-6e821bc0de7a/>> ;

prov:qualifiedGeneration

[ a prov:Generation ;

prov:activity <<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/process/39441ae0-9fde-4a19-b262-6e821bc0de7a/>> ;

prov:hadRole <[http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/convertText3ToDouble3\\_input/out/output](http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/convertText3ToDouble3_input/out/output)>

];

prov:wasGeneratedBy <<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/process/39441ae0-9fde-4a19-b262-6e821bc0de7a/>> .

<<http://ns.taverna.org.uk/2011/data/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/ref/d31ea414-7e92-4a4e-ac5d-f359b8f05307>>

tavernaprov:content <<http://www.muckdragon.info/PROV/2012/OutData.txt>> ;

wfprov:describedByParameter

<<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/out/OutData>> ,

<[http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/Encode\\_Byte\\_Array\\_to\\_Base\\_64\\_3/out/base64](http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/Encode_Byte_Array_to_Base_64_3/out/base64)> ;

wfprov:wasOutputFrom

<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/> ,  
<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/process/3b900a61-7b9a-469a-bc06-487ff5dee1f8/> ;

prov:qualifiedGeneration

[ a prov:Generation ;

prov:activity <http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/process/3b900a61-7b9a-469a-bc06-487ff5dee1f8/> ;

prov:hadRole <http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/Encode\_Byte\_Array\_to\_Base\_64\_3/out/base64>

];

prov:qualifiedGeneration

[ a prov:Generation ;

prov:activity <http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/> ;

prov:hadRole <http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/out/OutData>

];

prov:wasGeneratedBy <http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/>  
, <http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/process/3b900a61-7b9a-469a-bc06-487ff5dee1f8/> .

<[http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/Encode\\_Byte\\_Array\\_to\\_Base\\_64\\_3/in/bytes](http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/Encode_Byte_Array_to_Base_64_3/in/bytes)>

rdfs:label "Encode\_Byte\_Array\_to\_Base\_64\_3 input bytes" .

<<http://muckdragon.info/arv/request/6.1/09/5>>

a arv:Data ;

arv:dataType "currents" , "temperature" , "salinity" , "conductivity" , "acoustics" ;

arv:location "New Jersey continental shelf" ;

arv:purpose "determine channel properties and provide reliable, covert and high rate comms for near bottom and in-sediment sensors" ;

arv:scientist <<http://muckdragon.info/arv/scientist/17>> ;

arv:sensor "ACDS" , "Acomms" , "EMATT UUV" , "EARS buoys" , "ASRA" ;

arv:title "Acoustic Communications" .

prov:used

a owl:AnnotationProperty .

<<http://ns.taverna.org.uk/2011/data/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/ref/99d6ada5-338e-4c2d-bb0c-40cd64931cb9>>

tavernaprov:content <<http://www.muckdragon.info/PROV/2012/intermediates/99/99d6ada5-338e-4c2d-bb0c-40cd64931cb9.txt>> ;

wfprov:describedByParameter

<[http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/getColorFromDepth\\_input/out/output](http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/getColorFromDepth_input/out/output)> ,

<<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/getColorFromDepth/in/parameters>> ;

wfprov:wasOutputFrom

<<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/process/d147dfb2-42b8-45d4-bec4-0a40cdeeac25/>> ;

prov:qualifiedGeneration

[ a prov:Generation ;

prov:activity <<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/process/d147dfb2-42b8-45d4-bec4-0a40cdeeac25/>> ;

prov:hadRole <[http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/getColorFromDepth\\_input/out/output](http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/getColorFromDepth_input/out/output)>

];

prov:wasGeneratedBy <<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/process/d147dfb2-42b8-45d4-bec4-0a40cdeeac25/>> .

<<http://muckdragon.info/arv/request/6.1/11/9>>

a arv:Data ;

arv:dataType "tides" , "optical" , "wave" , "sonar" , "fluorescence" , "current velocity" , "attenuation" , "currents" , "temperature" , "backscatter" , "conductivity" , "acoustics" ;

arv:location "East Flower Garden Bank, Continental Shelf, TX" ;

arv:purpose "improve understanding of small-scale mesoscale physical processes over sub-mesoscale bumps on continental shelf" ;

arv:scientist <<http://muckdragon.info/arv/scientist/35>> ;

arv:sensor "Biosonic Echosounder" , "AC-9" , "VMP" , "BAM" , "MicroCats" , "REMUS" , "Wetlabs C-Star" , "scan fish" , "Barny buoys" , "Ecopuck BB3" , "ADCP" , "AUV" , "CTD" ;

arv:title "Mixing Over Rough Topography" .

wfprov:wasOutputFrom

a owl:AnnotationProperty .

<<http://muckdragon.info/arv/request/6.2/12/13>>

a arv:Data ;

arv:dataType "acoustics" ;

arv:location "Continental Shelf, New Jersey" ;

arv:purpose "develop waveguide invariant-based methods that use measured acoustic data" ;

arv:scientist <<http://muckdragon.info/arv/scientist/40>> ;

arv:sensor "XF-4 " , "VLA" , "EARS buoy" , "HLA" , "Vector Sensor" , "J15" , "acoustics" ;

arv:title "Depth-discrimination in littorals using guide sources" .

wfprov:describedByWorkflow

a owl:AnnotationProperty .

<<http://www.muckdragon.info/PROV/2012/intermediates/81/8114af59-d8ee-4b43-8eb7-f3559adb2ab5.txt>>

tavernaprov:sha1 "1e6f8212a7af9f7b13f390432a91f3c9b334d82a" ;

tavernaprov:sha512

"cf83e1357eefb8bdf1542850d66d8007d620e4050b5715dc83f4a921d36ce9ce47d0d13c5d85f2b0ff8318d2877eec2f63b931bd47417a81a538327af927da3e" .

<<http://muckdragon.info/arv/request/6.2/10/1>>

a arv:Data ;

arv:dataType "naval platform signatures" , "acoustics" ;

arv:location "Panama City Beach, FL" ;

arv:purpose "exploit new sensors for persistent surveillanc" ;



arv:scientist <<http://muckdragon.info/arv/scientist/4>> ;

arv:sensor "acoustic modems" ;

arv:title "A Distributed Autonomous, Persistent Surveillance Network for Underwater Environments"

<<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861->

[b43ed445d18b/workflow/Workflow1/processor/convertText3ToDouble3\\_output/in/input](http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/convertText3ToDouble3_output/in/input)>

rdfs:label "convertText3ToDouble3\_output input input" .

<<http://muckdragon.info/arv/request/6.1/10/2>>

a arv:Data ;

arv:dataType "photography" , "sediment" , "acoustics" ;

arv:location "Atchafalaya River shelf, Gulf of Mexico" ;

arv:purpose "identify and predict biological mediation of sediment acoustic and physical properties affected by hypoxia" ;

arv:scientist <<http://muckdragon.info/arv/scientist/14>> ;

arv:sensor "ASCS" , "LUMCON" , "sonar" , "box core" ;

arv:title "Hypoxia Effects on Processes in Muddy Sediments in the Northern Gulf of Mexico" .

wfprov:describedByProcess

a owl:AnnotationProperty .

<<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/convertText3ToZDouble3/in/parameters>>

rdfs:label "convertText3ToZDouble3 input parameters" .

prov:entity

a owl:AnnotationProperty .

prov:activity

a owl:AnnotationProperty .

<<http://muckdragon.info/arv/request/6.1/07/2>>

a arv:Data ;

arv:dataType "Acoustic Sediment Classification Sonar Imagery" , "Sediment cores" ;

arv:location "South of Atchafalaya River, LA" ;

arv:purpose "Determine large-scale sediment distribution and vertical substrate thickness" ;

arv:scientist <<http://muckdragon.info/arv/scientist/2>> ;

arv:sensor "Acoustic Sediment Classifier" ;

arv:title "Mapping Diverse and Dynamic Sediments in Nearshore Environments" .

<<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/getTinFromDepths/in/parameters>>

rdfs:label "getTinFromDepths input parameters" .

<[http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/getColorFromDepth\\_input/in/data](http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/getColorFromDepth_input/in/data)>

rdfs:label "getColorFromDepth\_input input data" .

prov:wasInformedBy

a owl:AnnotationProperty .

<<http://muckdragon.info/arv/request/6.2/10/4>>

a arv:Data ;

arv:dataType "acoustics" ;

arv:location "Continental Shelf, New Jersey" ;

arv:purpose "determine channel capacity with minimum bit error rate" ;

arv:scientist <http://muckdragon.info/arv/scientist/17> ;

arv:sensor "ACDS" , "EMATT UUV" , "EARS buoys" , "ASRA" ;

arv:title "Acoustic Communications" .

<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/process/a8db0d6f-864b-4614-96ef-14a9b594cdd3/>

rdfs:label "Processor execution Read\_Data\_Points (facade1:Workflow1:Read\_Data\_Points)" ;

wfprov:describedByProcess

<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/Read\_Data\_Points/> ;

wfprov:usedInput <http://ns.taverna.org.uk/2011/data/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/ref/bc6412a7-5b6c-4a85-b43c-d36abd93aa3e> ,

<http://ns.taverna.org.uk/2011/data/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/ref/f0b0e122-2a1d-47cf-8d15-58aaf0df4f00> ;

wfprov:wasPartOfWorkflowRun

<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/> ;

prov:endedAtTime "2012-12-03T15:47:22.220-06:00"^^xsd:dateTime ;

prov:qualifiedAssociation

[ a prov:Association ;

prov:agent :taverna-engine ;

prov:hadPlan <[http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/Read\\_Data\\_Points/](http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/Read_Data_Points/)>

];

prov:qualifiedUsage

[ a prov:Usage ;

prov:entity <<http://ns.taverna.org.uk/2011/data/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/ref/bc6412a7-5b6c-4a85-b43c-d36abd93aa3e>> ;

prov:hadRole <[http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/Read\\_Data\\_Points/in/fileurl](http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/Read_Data_Points/in/fileurl)>

];

prov:qualifiedUsage

[ a prov:Usage ;

prov:entity <<http://ns.taverna.org.uk/2011/data/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/ref/f0b0e122-2a1d-47cf-8d15-58aaf0df4f00>> ;

prov:hadRole <[http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/Read\\_Data\\_Points/in/encoding](http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/Read_Data_Points/in/encoding)>

];

prov:startedAtTime "2012-12-03T15:47:19.797-06:00"^^xsd:dateTime ;

prov:used <<http://ns.taverna.org.uk/2011/data/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/ref/bc6412a7-5b6c-4a85-b43c-d36abd93aa3e>> ,

<<http://ns.taverna.org.uk/2011/data/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/ref/f0b0e122-2a1d-47cf-8d15-58aaf0df4f00>> .

<<http://muckdragon.info/arv/request/6.1/09/6>>

a arv:Data ;

arv:dataType "water column" , "sediment" , "atmospheric profile" , "temperature" , "bathymetry" ,  
"seismic" ;

arv:location "Beaufort Sea, Alaskan Coast" ;

arv:purpose "estimate spatial variation in the vertical methane diffusion in comparisons of sediment  
and water column temperatures" ;

arv:scientist <<http://muckdragon.info/arv/scientist/18>> ;

arv:sensor "cores" , "seismic" ;

arv:title "Beaufort Sea Methane Hydrate Distribution: Alaska Permafrost to Deep Sediments  
Deposits" .

tavernapro:content

a owl:AnnotationProperty .

<<http://muckdragon.info/arv/request/6.2/12/16>>

a arv:Data ;

arv:dataType "MBSAR imagery" ;

arv:location "Naval Air Station, PAX River, MD" ;

arv:purpose "calibrate MBSAR for foliage penetration" ;

arv:scientist <<http://muckdragon.info/arv/scientist/8>> ;

arv:sensor "MBSAR imagery" ;

arv:title "Polarimetric Analysis of Ultra Wideband FOPEN Radar Imagery" .

wfprov:WorkflowRun

a owl:Class .

<<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/process/5788eb60-afdf-45de-b218-5add30d5c3b8/>>

rdfs:label "Processor execution TIN\_Input (facade1:Workflow1:TIN\_Input)" ;

wfprov:describedByProcess

<[http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/TIN\\_Input/](http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/TIN_Input/)> ;

wfprov:usedInput <<http://ns.taverna.org.uk/2011/data/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/ref/3ba5cc97-2764-4f72-868d-dc6200be1f69>> ;

wfprov:wasPartOfWorkflowRun

```
<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/>;

prov:endedAtTime "2012-12-03T15:47:39.723-06:00"^^xsd:dateTime ;

prov:qualifiedAssociation

  [ a    prov:Association ;

    prov:agent :taverna-engine ;

    prov:hadPlan <http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-
b43ed445d18b/workflow/Workflow1/processor/TIN_Input/>

  ];

prov:qualifiedUsage

  [ a    prov:Usage ;

    prov:entity <http://ns.taverna.org.uk/2011/data/72a6fd65-cbff-4cfc-8163-
4c6f25e7c4fa/ref/3ba5cc97-2764-4f72-868d-dc6200be1f69> ;

    prov:hadRole <http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-
b43ed445d18b/workflow/Workflow1/processor/TIN_Input/in/data>

  ];

prov:startedAtTime "2012-12-03T15:47:38.814-06:00"^^xsd:dateTime ;

prov:used <http://ns.taverna.org.uk/2011/data/72a6fd65-cbff-4cfc-8163-
4c6f25e7c4fa/ref/3ba5cc97-2764-4f72-868d-dc6200be1f69> .
```



<[http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/Encode\\_Byte\\_Array\\_to\\_Base\\_64/](http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/Encode_Byte_Array_to_Base_64/)>

rdfs:label "Processor Encode\_Byte\_Array\_to\_Base\_64" .

<<http://muckdragon.info/arv/request/6.1/10/1>>

a arv:Data ;

arv:dataType "optical" ;

arv:location "Mississippi Bight, Gulf of Mexico" ;

arv:purpose "determine bio-optical oceanographic measurements to better describe/model environment" ;

arv:scientist <<http://muckdragon.info/arv/scientist/25>> ;

arv:sensor "BOPPERS" ;

arv:title "BIOSPACE" .

<<http://www.muckdragon.info/PROV/2012/OutData.txt>>

tavernaprov:sha1 "07847d8af5374c0149099aa5e0926e0a93cdfaec" ;

tavernaprov:sha512

"cf83e1357eefb8bdf1542850d66d8007d620e4050b5715dc83f4a921d36ce9ce47d0d13c5d85f2b0ff8318d2877eec2f63b931bd47417a81a538327af927da3e" .

<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-  
b43ed445d18b/workflow/Workflow1/processor/Encode\_Byte\_Array\_to\_Base\_64\_3/out/base64>

rdfs:label "Encode\_Byte\_Array\_to\_Base\_64\_3 output base64" .

<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-  
b43ed445d18b/workflow/Workflow1/processor/getColorFromDepth\_input/>

rdfs:label "Processor getColorFromDepth\_input" .

<http://muckdragon.info/arv/request/6.1/07/3>

a arv:Data ;

arv:dataType "wave" , "Currents" , "sediment" , "water column samples" , "suspended particulate" ;

arv:location "Atchafalaya Bay, LA" ;

arv:purpose "Study wave damping over muddy sedimentary bottoms" ;

arv:scientist <http://muckdragon.info/arv/scientist/3> ;

arv:sensor "ASCS" , "PCADP" , "gravity core" , "box core" , "CTD" , "ADP" , "penetrometer" , "Waver  
rider" ;

arv:title "Platform support to study wave damping" .

<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-  
b43ed445d18b/workflow/Workflow1/processor/Read\_Data\_Points/out/filecontents>

rdfls:label "Read\_Data\_Points output filecontents" .

<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/process/eb80b8c8-a65a-400e-8935-9077e35336bf/>

rdfls:label "Processor execution getColorFromDepth (facade1:Workflow1:getColorFromDepth)" ;

wfprov:describedByProcess

<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/getColorFromDepth/> ;

wfprov:usedInput <http://ns.taverna.org.uk/2011/data/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/ref/99d6ada5-338e-4c2d-bb0c-40cd64931cb9> ;

wfprov:wasPartOfWorkflowRun

<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/> ;

prov:endedAtTime "2012-12-03T15:48:23.200-06:00"^^xsd:dateTime ;

prov:qualifiedAssociation

[ a prov:Association ;

prov:agent :taverna-engine ;

prov:hadPlan <http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/getColorFromDepth/>

];

prov:qualifiedUsage

```
[ a    prov:Usage ;

      prov:entity <http://ns.taverna.org.uk/2011/data/72a6fd65-cbff-4cfc-8163-
4c6f25e7c4fa/ref/99d6ada5-338e-4c2d-bb0c-40cd64931cb9> ;

      prov:hadRole <http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-
b43ed445d18b/workflow/Workflow1/processor/getColorFromDepth/in/parameters>

    ];

    prov:startedAtTime "2012-12-03T15:48:06.348-06:00"^^xsd:dateTime ;

    prov:used <http://ns.taverna.org.uk/2011/data/72a6fd65-cbff-4cfc-8163-
4c6f25e7c4fa/ref/99d6ada5-338e-4c2d-bb0c-40cd64931cb9> .

<http://muckdragon.info/arv/request/6.2/10/3>

    a    arv:Data ;

    arv:dataType "themal imagery" , "passive millimeter wave" ;

    arv:location "Richmond, VA" ;

    arv:purpose "demonstrate active emitter geolocation combined with passive thermal imaging at
millimeter wavelengths" ;

    arv:scientist <http://muckdragon.info/arv/scientist/26> ;

    arv:sensor "UAV" , "thermal imager" ;

    arv:title "Millimeter Wave Interferometric Radiometry for the Detection of Low-Power Manmade
Signals" .
```

<http://ns.taverna.org.uk/2011/data/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/ref/0dff030d-8c15-442f-a48b-ec5683eb71a9>

tavernaprov:content <http://www.muckdragon.info/PROV/2012/intermediates/0d/0dff030d-8c15-442f-a48b-ec5683eb71a9.octet-stream> ;

wfprov:describedByParameter

<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/getColorFromDepth\_output/out/return> ,  
<http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/Encode\_Byte\_Array\_to\_Base\_64\_3/in/bytes> ;

wfprov:wasOutputFrom

<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/process/6a8b2d53-f766-49aa-aebb-de4728985703/> ;

prov:qualifiedGeneration

[ a prov:Generation ;

prov:activity <http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/process/6a8b2d53-f766-49aa-aebb-de4728985703/> ;

prov:hadRole <http://ns.taverna.org.uk/2010/workflowBundle/f99e0a2a-6772-4434-8861-b43ed445d18b/workflow/Workflow1/processor/getColorFromDepth\_output/out/return>

];

prov:wasGeneratedBy <<http://ns.taverna.org.uk/2011/run/72a6fd65-cbff-4cfc-8163-4c6f25e7c4fa/process/6a8b2d53-f766-49aa-aebb-de4728985703/>> .

<<http://muckdragon.info/arv/request/6.2/12/15>>

a arv>Data ;

arv:dataType "breaking waves" , "sonar" , "temperature" , "backscatter" , "salinity" , "ocean current"

;

arv:location "Kayak Island, Alaska" ;

arv:purpose "quantify effects of breaking waves on nonlinear changes in the surface drag coefficient"

;

arv:scientist <<http://muckdragon.info/arv/scientist/41>> ;

arv:sensor "TCP" , "ADCP" , "echosounder" , "Barny buoys" ;

arv:title "Breaking-Wave Effects Under High Winds (BWE)" .

## Appendix C

## Complete Hyperspectral Model

@prefix file:

<<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8dec7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph>

D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-SwanRiverEstuary\_AUS.v40.100m.hdf#> .

@prefix stats: <http://muckdragon.info/data/stats#> .

@prefix sets: <http://muckdragon.info/data/sets#> .

@prefix hyperspectral: <http://muckdragon.info/data/types/hyperspectral#> .

<http://muckdragon.info/hyperspectral/tags/algorithm#oc3>

<http://muckdragon.info/hyperspectral/tags/algorithm#name>

"oc3" .

<http://muckdragon.info/data/info#Product>

a <http://www.w3.org/2000/01/rdf-schema#Class> ;

<http://www.w3.org/2000/01/rdf-schema#subClassOf>

<http://www.w3.org/ns/prov#Entity> .

file:aph\_488\_qaa

a <http://www.w3.org/2000/01/rdf-schema#Class> ,

<http://muckdragon.info/data/info#Product> ;

<http://muckdragon.info/data/info#hasMeasurementUnits>

```

"m^-1" ;

<http://muckdragon.info/data/info#hasStats>

[ stats:geometricMean "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:max "32767.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:mean "-31889.625778319507"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:min "-32100.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:n "1024000"^^<http://www.w3.org/2001/XMLSchema#long> ;

stats:populationVariance

    "75556.41503917551"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:secondMoment 7.736976900011572E10 ;

stats:standardDeviation

    "274.8754060020815"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sum -3.2654976797E10 ;

stats:sumOfLogs "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumsq 1.041432359625063E15 ;

stats:variance "75556.48882480913"^^<http://www.w3.org/2001/XMLSchema#double>

];

sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int>

"512"^^<http://www.w3.org/2001/XMLSchema#int>);

```



sets:dataType <<http://www.w3.org/2001/XMLSchema#short>> ;

sets:isContainedIn

<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8dec7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph  
D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-  
SwanRiverEstuary\_AUS.v40.100m.hdf> ;

hyperspectral:badData

"-32100"^^<<http://www.w3.org/2001/XMLSchema#short>> ;

hyperspectral:browseColorTableName

"nrl" ;

hyperspectral:browseFunc

"2"^^<<http://www.w3.org/2001/XMLSchema#int>> ;

hyperspectral:browseRanges

(5.0E-4 "1.0"^^<<http://www.w3.org/2001/XMLSchema#double>>) ;

hyperspectral:productClass

"geophysical parameter" ;

hyperspectral:productName

"Absorption due to phytoplankton at 488 nm, QAA algorithm" ;

hyperspectral:productScaling

"Linear" ;

hyperspectral:productStatus

"provisional" ;

hyperspectral:productUnits

"m<sup>-1</sup>" ;

hyperspectral:scalingIntercept

"3.200000047683716"^^<http://www.w3.org/2001/XMLSchema#double> ;

hyperspectral:scalingSlope

9.999999747378752E-5 ;

hyperspectral:validRange

(1.0E-4 "5.0"^^<http://www.w3.org/2001/XMLSchema#double>) ;

<http://muckdragon.info/hyperspectral/tags/algorithm#hasAlgorithmTag>

<http://muckdragon.info/hyperspectral/tags/algorithm#qaa> ;

<http://muckdragon.info/hyperspectral/tags/measure#hasMeasurementTag>

<http://muckdragon.info/hyperspectral/tags/measure#absorption> ;

<http://muckdragon.info/hyperspectral/tags/substance#hasSubstanceTag>

<http://muckdragon.info/hyperspectral/tags/substance#phytoplankton> ;

<http://www.w3.org/ns/prov#wasGeneratedBy>

[ a <http://muckdragon.info/data/processing#ProcessExecution> ;

<http://www.w3.org/ns/prov#generated>

file:aph\_488\_qaa ;

<http://www.w3.org/ns/prov#used>

[ a <http://muckdragon.info/data/processing#Algorithm> ;

<http://muckdragon.info/data/processing#name>

"QAA algorithm" ;

<http://muckdragon.info/data/processing#produces>

file:aph\_488\_qaa ;

= <http://muckdragon.info/hyperspectral/algorithms/QAA%20algorithm>

]

].

<http://muckdragon.info/data/processing#ProcessExecution>

a <http://www.w3.org/2000/01/rdf-schema#Class> ;

<http://www.w3.org/2000/01/rdf-schema#subClassOf>

<http://www.w3.org/ns/prov#Activity> .

file:a\_412\_qaa

a <http://www.w3.org/2000/01/rdf-schema#Class> ,

<http://muckdragon.info/data/info#Product> ;

<http://muckdragon.info/data/info#hasMeasurementUnits>

"m<sup>-1</sup>";

<http://muckdragon.info/data/info#hasStats>

[ stats:geometricMean "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:max "32767.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:mean "-24645.121079101016"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:min "-25100.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:n "1024000"^^<http://www.w3.org/2001/XMLSchema#long> ;

stats:populationVariance

"378981.50364962505"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:secondMoment 3.8807705973721606E11 ;

stats:standardDeviation

"615.6150369744969"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sum -2.5236603985E10 ;

stats:sumOfLogs "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumsq 6.22347237895399E14 ;

stats:variance "378981.87374911114"^^<http://www.w3.org/2001/XMLSchema#double>

];

```
sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int>
"512"^^<http://www.w3.org/2001/XMLSchema#int>);

sets:dataType <http://www.w3.org/2001/XMLSchema#short>;

sets:isContainedIn
<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8decbc7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph
D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-
SwanRiverEstuary_AUS.v40.100m.hdf>;

hyperspectral:badData
"-25100"^^<http://www.w3.org/2001/XMLSchema#short>;

hyperspectral:browseColorTableName
"nrl";

hyperspectral:browseFunc
"2"^^<http://www.w3.org/2001/XMLSchema#int>;

hyperspectral:browseRanges
("0.01"^^<http://www.w3.org/2001/XMLSchema#double>
"2.0"^^<http://www.w3.org/2001/XMLSchema#double>);

hyperspectral:productClass
"geophysical parameter";

hyperspectral:productName
"Total absorption at 412 nm, QAA algorithm";
```

hyperspectral:productScaling

"Linear" ;

hyperspectral:productStatus

"provisional" ;

hyperspectral:productUnits

"m<sup>-1</sup>" ;

hyperspectral:scalingIntercept

"2.5"^^<http://www.w3.org/2001/XMLSchema#double> ;

hyperspectral:scalingSlope

9.999999747378752E-5 ;

hyperspectral:validRange

(1.0E-4 "5.0"^^<http://www.w3.org/2001/XMLSchema#double>) ;

<http://muckdragon.info/hyperspectral/tags/algorithm#hasAlgorithmTag>

<http://muckdragon.info/hyperspectral/tags/algorithm#qaa> ;

<http://muckdragon.info/hyperspectral/tags/measure#hasMeasurementTag>

<http://muckdragon.info/hyperspectral/tags/measure#absorption> ;

<http://muckdragon.info/hyperspectral/tags/substance#hasSubstanceTag>

<http://muckdragon.info/hyperspectral/tags/substance#total> ;

<http://www.w3.org/ns/prov#wasGeneratedBy>

```

[ a   <http://muckdragon.info/data/processing#ProcessExecution> ;

      <http://www.w3.org/ns/prov#generated>

      file:a_412_qaa ;

      <http://www.w3.org/ns/prov#used>

      [ a   <http://muckdragon.info/data/processing#Algorithm> ;

          <http://muckdragon.info/data/processing#name>

          "QAA algorithm" ;

          <http://muckdragon.info/data/processing#produces>

          file:a_412_qaa ;

          =   <http://muckdragon.info/hyperspectral/algorithms/QAA%20algorithm>

        ]

    ] .

```

file:adg\_412\_qaa

```

a   <http://www.w3.org/2000/01/rdf-schema#Class> ,

<http://muckdragon.info/data/info#Product> ;

<http://muckdragon.info/data/info#hasMeasurementUnits>

"m^-1" ;

<http://muckdragon.info/data/info#hasStats>

```

```
[ stats:geometricMean "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:max "32767.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:mean "-31827.83939648353"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:min "-32100.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:n "1024000"^^<http://www.w3.org/2001/XMLSchema#long> ;

stats:populationVariance

    "163342.42431213122"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:secondMoment 1.6726264249562238E11 ;

stats:standardDeviation

    "404.1566327878008"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sum -3.2591707542E10 ;

stats:sumOfLogs "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumsq 1.03749089594646E15 ;

stats:variance "163342.58382637324"^^<http://www.w3.org/2001/XMLSchema#double>

];

sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int>

"512"^^<http://www.w3.org/2001/XMLSchema#int>);

sets:dataType <http://www.w3.org/2001/XMLSchema#short> ;
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sets:isContainedIn

<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8dec7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph  
D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-  
SwanRiverEstuary\_AUS.v40.100m.hdf> ;

hyperspectral:badData

"-32100"^^<http://www.w3.org/2001/XMLSchema#short> ;

hyperspectral:browseColorTableName

"nrl" ;

hyperspectral:browseFunc

"0"^^<http://www.w3.org/2001/XMLSchema#int> ;

hyperspectral:browseRanges

("0.01"^^<http://www.w3.org/2001/XMLSchema#double>

"1.0"^^<http://www.w3.org/2001/XMLSchema#double>) ;

hyperspectral:productClass

"geophysical parameter" ;

hyperspectral:productName

"Absorption due to gelbstof and detrital material at 412 nm, QAA algorithm" ;

hyperspectral:productScaling

"Linear" ;

hyperspectral:productStatus

"provisional" ;

hyperspectral:productUnits

"m<sup>-1</sup>" ;

hyperspectral:scalingIntercept

"3.200000047683716"^^<http://www.w3.org/2001/XMLSchema#double> ;

hyperspectral:scalingSlope

9.999999747378752E-5 ;

hyperspectral:validRange

(1.0E-4 "5.0"^^<http://www.w3.org/2001/XMLSchema#double>) ;

<http://muckdragon.info/hyperspectral/tags/algorithm#hasAlgorithmTag>

<http://muckdragon.info/hyperspectral/tags/algorithm#qaa> ;

<http://muckdragon.info/hyperspectral/tags/measure#hasMeasurementTag>

<http://muckdragon.info/hyperspectral/tags/measure#absorption> ;

<http://muckdragon.info/hyperspectral/tags/substance#hasSubstanceTag>

<http://muckdragon.info/hyperspectral/tags/substance#detrital> ;

<http://www.w3.org/ns/prov#wasGeneratedBy>

[ a <http://muckdragon.info/data/processing#ProcessExecution> ;

<http://www.w3.org/ns/prov#generated>

file:adg\_412\_qaa ;

<http://www.w3.org/ns/prov#used>

[ a <http://muckdragon.info/data/processing#Algorithm> ;

<http://muckdragon.info/data/processing#name>

"QAA algorithm" ;

<http://muckdragon.info/data/processing#produces>

file:adg\_412\_qaa ;

= <http://muckdragon.info/hyperspectral/algorithms/QAA%20algorithm>

]

].

file:a\_667\_qaa

a <http://www.w3.org/2000/01/rdf-schema#Class> ,

<http://muckdragon.info/data/info#Product> ;

<http://muckdragon.info/data/info#hasMeasurementUnits>

"m<sup>-1</sup>" ;

<http://muckdragon.info/data/info#hasStats>

[ stats:geometricMean "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:max "11526.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:mean "-22920.76698925716"^^<http://www.w3.org/2001/XMLSchema#double> ;

```
stats:min "-25100.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:n "1024000"^^<http://www.w3.org/2001/XMLSchema#long> ;

stats:populationVariance

    "6736541.509296071"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:secondMoment 6.898218505519177E12 ;

stats:standardDeviation

    "2595.4860985866044"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sum -2.3470865397E10 ;

stats:sumOfLogs "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumsq 5.44868455306391E14 ;

stats:variance "6736548.087956313"^^<http://www.w3.org/2001/XMLSchema#double>

];

sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int>

"512"^^<http://www.w3.org/2001/XMLSchema#int>);

sets:dataType <http://www.w3.org/2001/XMLSchema#short> ;

sets:isContainedIn

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D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-
SwanRiverEstuary_AUS.v40.100m.hdf> ;

hyperspectral:badData
```

"-25100"^^<http://www.w3.org/2001/XMLSchema#short> ;

hyperspectral:browseColorTableName

"nrl" ;

hyperspectral:browseFunc

"1"^^<http://www.w3.org/2001/XMLSchema#int> ;

hyperspectral:browseRanges

("0.01"^^<http://www.w3.org/2001/XMLSchema#double>

"2.0"^^<http://www.w3.org/2001/XMLSchema#double>) ;

hyperspectral:productClass

"geophysical parameter" ;

hyperspectral:productName

"Total absorption at 667 nm, QAA algorithm" ;

hyperspectral:productScaling

"Linear" ;

hyperspectral:productStatus

"provisional" ;

hyperspectral:productUnits

"m<sup>-1</sup>" ;

hyperspectral:scalingIntercept

```

"2.5"^^<http://www.w3.org/2001/XMLSchema#double> ;

hyperspectral:scalingSlope

9.999999747378752E-5 ;

hyperspectral:validRange

(1.0E-4 "5.0"^^<http://www.w3.org/2001/XMLSchema#double> ) ;

<http://muckdragon.info/hyperspectral/tags/algorithm#hasAlgorithmTag>

<http://muckdragon.info/hyperspectral/tags/algorithm#qaa> ;

<http://muckdragon.info/hyperspectral/tags/measure#hasMeasurementTag>

<http://muckdragon.info/hyperspectral/tags/measure#absorption> ;

<http://muckdragon.info/hyperspectral/tags/substance#hasSubstanceTag>

<http://muckdragon.info/hyperspectral/tags/substance#total> ;

<http://www.w3.org/ns/prov#wasGeneratedBy>

[ a <http://muckdragon.info/data/processing#ProcessExecution> ;

<http://www.w3.org/ns/prov#generated>

file:a_667_qaa ;

<http://www.w3.org/ns/prov#used>

[ a <http://muckdragon.info/data/processing#Algorithm> ;

<http://muckdragon.info/data/processing#name>

"QAA algorithm" ;

```

<http://muckdragon.info/data/processing#produces>

file:a\_667\_qaa ;

= <http://muckdragon.info/hyperspectral/algorithms/QAA%20algorithm>

]

].

file:aph\_547\_qaa

a <http://www.w3.org/2000/01/rdf-schema#Class> ,

<http://muckdragon.info/data/info#Product> ;

<http://muckdragon.info/data/info#hasMeasurementUnits>

"m<sup>-1</sup>" ;

<http://muckdragon.info/data/info#hasStats>

[ stats:geometricMean "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:max "32767.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:mean "-31947.558913086123"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:min "-32100.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:n "1024000"^^<http://www.w3.org/2001/XMLSchema#long> ;

stats:populationVariance

"41599.104663882696"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:secondMoment 4.259748317581588E10 ;

stats:standardDeviation

"203.95868524789037"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sum -3.2714300327E10 ;

stats:sumOfLogs "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumsq 1.045184634480395E15 ;

stats:variance "41599.145288048014"^^<http://www.w3.org/2001/XMLSchema#double>

];

sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int>

"512"^^<http://www.w3.org/2001/XMLSchema#int>);

sets:dataType <http://www.w3.org/2001/XMLSchema#short> ;

sets:isContainedIn

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D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-  
SwanRiverEstuary\_AUS.v40.100m.hdf> ;

hyperspectral:badData

"-32100"^^<http://www.w3.org/2001/XMLSchema#short> ;

hyperspectral:browseColorTableName

"nrl" ;

hyperspectral:browseFunc



"2"^^<http://www.w3.org/2001/XMLSchema#int> ;

hyperspectral:browseRanges

(5.0E-4 "1.0"^^<http://www.w3.org/2001/XMLSchema#double>) ;

hyperspectral:productClass

"geophysical parameter" ;

hyperspectral:productName

"Absorption due to phytoplankton at 547 nm, QAA algorithm" ;

hyperspectral:productScaling

"Linear" ;

hyperspectral:productStatus

"provisional" ;

hyperspectral:productUnits

"m<sup>-1</sup>" ;

hyperspectral:scalingIntercept

"3.200000047683716"^^<http://www.w3.org/2001/XMLSchema#double> ;

hyperspectral:scalingSlope

9.999999747378752E-5 ;

hyperspectral:validRange

(1.0E-4 "5.0"^^<http://www.w3.org/2001/XMLSchema#double>) ;

<http://muckdragon.info/hyperspectral/tags/algorithm#hasAlgorithmTag>

<http://muckdragon.info/hyperspectral/tags/algorithm#qaa> ;

<http://muckdragon.info/hyperspectral/tags/measure#hasMeasurementTag>

<http://muckdragon.info/hyperspectral/tags/measure#absorption> ;

<http://muckdragon.info/hyperspectral/tags/substance#hasSubstanceTag>

<http://muckdragon.info/hyperspectral/tags/substance#phytoplankton> ;

<http://www.w3.org/ns/prov#wasGeneratedBy>

[ a <http://muckdragon.info/data/processing#ProcessExecution> ;

<http://www.w3.org/ns/prov#generated>

file:aph\_547\_qaa ;

<http://www.w3.org/ns/prov#used>

[ a <http://muckdragon.info/data/processing#Algorithm> ;

<http://muckdragon.info/data/processing#name>

"QAA algorithm" ;

<http://muckdragon.info/data/processing#produces>

file:aph\_547\_qaa ;

= <http://muckdragon.info/hyperspectral/algorithms/QAA%20algorithm>

]

].

file:vcap\_gain

a <http://www.w3.org/2000/01/rdf-schema#Class> ;

<http://muckdragon.info/data/info#hasStats>

[ stats:geometricMean "1.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:max "1.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:mean "1.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:min "1.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:n "9"^^<http://www.w3.org/2001/XMLSchema#long> ;

stats:populationVariance

"0.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:secondMoment "0.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:standardDeviation

"0.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sum "9.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumOfLogs "0.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumsq "9.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:variance "0.0"^^<http://www.w3.org/2001/XMLSchema#double>

];

sets:dataDimensions ("9"^^<http://www.w3.org/2001/XMLSchema#int>);

sets:dataType <http://www.w3.org/2001/XMLSchema#float> ;

sets:isContainedIn

<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8dec7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph  
D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-  
SwanRiverEstuary\_AUS.v40.100m.hdf> .

<http://muckdragon.info/hyperspectral/tags/algorithm#gould>

<http://muckdragon.info/hyperspectral/tags/algorithm#name>

"gould" .

file:longitudes

a <http://www.w3.org/2000/01/rdf-schema#Class> ;

<http://muckdragon.info/data/info#hasStats>

[ stats:geometricMean

"115.67424918280142"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:max "116.62342834472656"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:mean "115.67511040668072"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:min "114.73446655273438"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:n "1024000"^^<http://www.w3.org/2001/XMLSchema#long> ;

stats:populationVariance

"0.199242824126711"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:secondMoment

"204024.65190575205"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:standardDeviation

"0.44636646233780986"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sum 1.1845131305644226E8 ;

stats:sumOfLogs "4864796.71708125"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumsq 1.3702072740275564E10 ;

stats:variance "0.19924301869997144"^^<http://www.w3.org/2001/XMLSchema#double>

];

sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int>

"512"^^<http://www.w3.org/2001/XMLSchema#int>);

sets:dataType <http://www.w3.org/2001/XMLSchema#float> ;

sets:isContainedIn

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D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-

SwanRiverEstuary\_AUS.v40.100m.hdf> ;

hyperspectral:badData

"-999.0"^^<http://www.w3.org/2001/XMLSchema#float> ;

hyperspectral:browseColorTableName

"gray" ;

hyperspectral:browseFunc

"2"^^<http://www.w3.org/2001/XMLSchema#int> ;

hyperspectral:browseRanges

("0.01"^^<http://www.w3.org/2001/XMLSchema#double>  
"10.0"^^<http://www.w3.org/2001/XMLSchema#double>) ;

hyperspectral:productClass

"geophysical parameter" ;

hyperspectral:productName

"Longitudes" ;

hyperspectral:productScaling

"Linear" ;

hyperspectral:productStatus

"provisional" ;

hyperspectral:productUnits

"degree" ;

hyperspectral:scalingIntercept

"0.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

hyperspectral:scalingSlope

"1.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

hyperspectral:validRange

("0.0"^^<http://www.w3.org/2001/XMLSchema#double>

"0.0"^^<http://www.w3.org/2001/XMLSchema#double>).

<http://muckdragon.info/hyperspectral/tags/algorithm#qaa>

<http://muckdragon.info/hyperspectral/tags/algorithm#name>

"qaa" .

file:elat

a <http://www.w3.org/2000/01/rdf-schema#Class> ;

<http://muckdragon.info/data/info#hasStats>

[ stats:geometricMean "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:max "-30.88399887084961"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:mean "-31.493326823234597"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:min "-32.102699279785156"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:n "2000"^^<http://www.w3.org/2001/XMLSchema#long> ;

stats:populationVariance

```

    "0.12395272680344142"^^<http://www.w3.org/2001/XMLSchema#double> ;

    stats:secondMoment

"247.90545360688284"^^<http://www.w3.org/2001/XMLSchema#double> ;

    stats:standardDeviation

    "0.35215725772803075"^^<http://www.w3.org/2001/XMLSchema#double> ;

    stats:sum "-62986.653646469116"^^<http://www.w3.org/2001/XMLSchema#double> ;

    stats:sumOfLogs "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

    stats:sumsq "1983907.1742437459"^^<http://www.w3.org/2001/XMLSchema#double> ;

    stats:variance "0.12401473417052669"^^<http://www.w3.org/2001/XMLSchema#double>

];

sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int>);

sets:dataType <http://www.w3.org/2001/XMLSchema#float> ;

sets:isContainedIn

<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8dec7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph
D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-
SwanRiverEstuary_AUS.v40.100m.hdf> .

file:asd_412_gould

    a    <http://www.w3.org/2000/01/rdf-schema#Class> ,

<http://muckdragon.info/data/info#Product> ;

```



<http://muckdragon.info/data/info#hasMeasurementUnits>

"m<sup>-1</sup>";

<http://muckdragon.info/data/info#hasStats>

[ stats:geometricMean "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:max "-27317.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:mean "-31995.905083984424"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:min "-32100.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:n "1024000"^^<http://www.w3.org/2001/XMLSchema#long> ;

stats:populationVariance

"18482.717371737715"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:secondMoment 1.892630258865942E10 ;

stats:standardDeviation

"135.95122441995153"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sum -3.2763806806E10 ;

stats:sumOfLogs "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumsq 1.048326579057366E15 ;

stats:variance "18482.735421284026"^^<http://www.w3.org/2001/XMLSchema#double>

];

```
sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int>
"512"^^<http://www.w3.org/2001/XMLSchema#int>);

sets:dataType <http://www.w3.org/2001/XMLSchema#short>;

sets:isContainedIn

<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8decbc7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph
D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-
SwanRiverEstuary_AUS.v40.100m.hdf>;

hyperspectral:badData

"-32100"^^<http://www.w3.org/2001/XMLSchema#short>;

hyperspectral:browseColorTableName

"nrl";

hyperspectral:browseFunc

"2"^^<http://www.w3.org/2001/XMLSchema#int>;

hyperspectral:browseRanges

("0.001"^^<http://www.w3.org/2001/XMLSchema#double>
"2.0"^^<http://www.w3.org/2001/XMLSchema#double>);

hyperspectral:productClass

"geophysical parameter";

hyperspectral:productName

"Sediment and Detrital Absorption at 412nm, Gould (200711)";
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hyperspectral:productScaling

"Linear" ;

hyperspectral:productStatus

"provisional" ;

hyperspectral:productUnits

"m<sup>-1</sup>" ;

hyperspectral:scalingIntercept

"3.200000047683716"^^<http://www.w3.org/2001/XMLSchema#double> ;

hyperspectral:scalingSlope

9.999999747378752E-5 ;

hyperspectral:validRange

(1.0E-4 "5.0"^^<http://www.w3.org/2001/XMLSchema#double>) ;

<http://muckdragon.info/hyperspectral/tags/algorithm#hasAlgorithmTag>

<http://muckdragon.info/hyperspectral/tags/algorithm#gould> ;

<http://muckdragon.info/hyperspectral/tags/measure#hasMeasurementTag>

<http://muckdragon.info/hyperspectral/tags/measure#absorption> ;

<http://muckdragon.info/hyperspectral/tags/substance#hasSubstanceTag>

<http://muckdragon.info/hyperspectral/tags/substance#detrital> ,

<http://muckdragon.info/hyperspectral/tags/substance#sediment> ;

<http://www.w3.org/ns/prov#wasGeneratedBy>

[ a <http://muckdragon.info/data/processing#ProcessExecution> ;

<http://www.w3.org/ns/prov#generated>

file:asd\_412\_gould ;

<http://www.w3.org/ns/prov#used>

[ a <http://muckdragon.info/data/processing#Algorithm> ;

<http://muckdragon.info/data/processing#name>

"Gould (200711)" ;

<http://muckdragon.info/data/processing#produces>

file:asd\_412\_gould ;

= <http://muckdragon.info/hyperspectral/algorithms/Gould%20%28200711%29>

]

].

file:rrs\_531

a <http://www.w3.org/2000/01/rdf-schema#Class> ;

<http://muckdragon.info/data/info#hasStats>

[ stats:geometricMean "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:max "-5759.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

```
stats:mean "-28066.896898437604"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:min "-32767.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:n "1024000"^^<http://www.w3.org/2001/XMLSchema#long> ;

stats:populationVariance

    3.1628587234824743E7 ;

stats:secondMoment 3.2387673328460535E13 ;

stats:standardDeviation

    "5623.932620697649"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sum -2.8740502424E10 ;

stats:sumOfLogs "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumsq 8.39044391672158E14 ;

stats:variance 3.1628618122147128E7

];

sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int>
"512"^^<http://www.w3.org/2001/XMLSchema#int>) ;

sets:dataType <http://www.w3.org/2001/XMLSchema#short> ;

sets:isContainedIn

<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8dec7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph
D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-
SwanRiverEstuary_AUS.v40.100m.hdf> ;
```

hyperspectral:badData

"-30000"^^<http://www.w3.org/2001/XMLSchema#short> ;

hyperspectral:browseColorTableName

"neg" ;

hyperspectral:browseFunc

"0"^^<http://www.w3.org/2001/XMLSchema#int> ;

hyperspectral:browseRanges

("-0.03"^^<http://www.w3.org/2001/XMLSchema#double>

"0.03"^^<http://www.w3.org/2001/XMLSchema#double>) ;

hyperspectral:productClass

"geophysical parameter" ;

hyperspectral:productName

"Remote sensing reflectance at 531 nm" ;

hyperspectral:productScaling

"Linear" ;

hyperspectral:productStatus

"provisional" ;

hyperspectral:productUnits

"sr<sup>-1</sup>" ;

hyperspectral:scalingIntercept

"0.05000000074505806"^^<http://www.w3.org/2001/XMLSchema#double> ;

hyperspectral:scalingSlope

1.9999999949504854E-6 ;

hyperspectral:validRange

(2.0E-6 "0.04"^^<http://www.w3.org/2001/XMLSchema#double>) ;

<http://muckdragon.info/hyperspectral/tags/measure#hasMeasurementTag>

<http://muckdragon.info/hyperspectral/tags/measure#reflectance> .

file:POM\_gould

a <http://www.w3.org/2000/01/rdf-schema#Class> ,

<http://muckdragon.info/data/info#Product> ;

<http://muckdragon.info/data/info#hasMeasurementUnits>

"mg l<sup>-1</sup>" ;

<http://muckdragon.info/data/info#hasStats>

[ stats:geometricMean "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:max "-18917.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:mean "-19853.52943261721"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:min "-20010.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

```

stats:n "1024000"^^<http://www.w3.org/2001/XMLSchema#long> ;

stats:populationVariance

    "36576.57803403365"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:secondMoment 3.745441590685046E10 ;

stats:standardDeviation

    "191.25013399572566"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sum -2.0330014139E10 ;

stats:sumOfLogs "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumsq 4.03659988490067E14 ;

stats:variance "36576.61375338302"^^<http://www.w3.org/2001/XMLSchema#double>

];

sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int>

"512"^^<http://www.w3.org/2001/XMLSchema#int>);

sets:dataType <http://www.w3.org/2001/XMLSchema#short> ;

sets:isContainedIn

<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8dec7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph

D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-

SwanRiverEstuary_AUS.v40.100m.hdf> ;

hyperspectral:badData

    "-20010"^^<http://www.w3.org/2001/XMLSchema#short> ;

```



hyperspectral:browseColorTableName

"nrl" ;

hyperspectral:browseFunc

"2"^^<http://www.w3.org/2001/XMLSchema#int> ;

hyperspectral:browseRanges

("0.01"^^<http://www.w3.org/2001/XMLSchema#double>

"5.0"^^<http://www.w3.org/2001/XMLSchema#double>) ;

hyperspectral:productClass

"geophysical parameter" ;

hyperspectral:productName

"Particulate Organic Matter From Sediment and Detrital Absorption at 412nm, Gould (200711)" ;

hyperspectral:productScaling

"Linear" ;

hyperspectral:productStatus

"provisional" ;

hyperspectral:productUnits

"mg l<sup>-1</sup>" ;

hyperspectral:scalingIntercept

"20.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

hyperspectral:scalingSlope

"0.001000000474974513"^^<http://www.w3.org/2001/XMLSchema#double> ;

hyperspectral:validRange

("0.001"^^<http://www.w3.org/2001/XMLSchema#double>

"30.0"^^<http://www.w3.org/2001/XMLSchema#double>) ;

<http://muckdragon.info/hyperspectral/tags/algorithm#hasAlgorithmTag>

<http://muckdragon.info/hyperspectral/tags/algorithm#gould> ;

<http://muckdragon.info/hyperspectral/tags/measure#hasMeasurementTag>

<http://muckdragon.info/hyperspectral/tags/measure#absorption> ;

<http://muckdragon.info/hyperspectral/tags/substance#hasSubstanceTag>

<http://muckdragon.info/hyperspectral/tags/substance#detrital> ,

<http://muckdragon.info/hyperspectral/tags/substance#sediment> ,

<http://muckdragon.info/hyperspectral/tags/substance#particulate> ;

<http://www.w3.org/ns/prov#wasGeneratedBy>

[ a <http://muckdragon.info/data/processing#ProcessExecution> ;

<http://www.w3.org/ns/prov#generated>

file:POM\_gould ;

<http://www.w3.org/ns/prov#used>

[ a <http://muckdragon.info/data/processing#Algorithm> ;

<http://muckdragon.info/data/processing#name>

"Gould (200711)" ;

<http://muckdragon.info/data/processing#produces>

file:POM\_gould ;

= <http://muckdragon.info/hyperspectral/algorithms/Gould%20%28200711%29>

]

].

<http://muckdragon.info/hyperspectral/tags/measure#absorption>

<http://muckdragon.info/hyperspectral/tags/measure#name>

"absorption" .

file:ag\_412\_gould

a <http://www.w3.org/2000/01/rdf-schema#Class> ,

<http://muckdragon.info/data/info#Product> ;

<http://muckdragon.info/data/info#hasMeasurementUnits>

"m<sup>-1</sup>" ;

<http://muckdragon.info/data/info#hasStats>

[ stats:geometricMean "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

```
stats:max "32767.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:mean "-31833.006954101314"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:min "-32100.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:n "1024000"^^<http://www.w3.org/2001/XMLSchema#long> ;

stats:populationVariance

    "165687.51393720857"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:secondMoment 1.6966401427170157E11 ;

stats:standardDeviation

    "407.04751042302104"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sum -3.2596999121E10 ;

stats:sumOfLogs "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumsq 1.037830163715907E15 ;

stats:variance "165687.6757415794"^^<http://www.w3.org/2001/XMLSchema#double>

];

sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int>

"512"^^<http://www.w3.org/2001/XMLSchema#int>);

sets:dataType <http://www.w3.org/2001/XMLSchema#short> ;

sets:isContainedIn

<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8dec7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph
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D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-  
SwanRiverEstuary\_AUS.v40.100m.hdf> ;

hyperspectral:badData

"-32100"^^<http://www.w3.org/2001/XMLSchema#short> ;

hyperspectral:browseColorTableName

"nrl" ;

hyperspectral:browseFunc

"2"^^<http://www.w3.org/2001/XMLSchema#int> ;

hyperspectral:browseRanges

("0.01"^^<http://www.w3.org/2001/XMLSchema#double>

"1.0"^^<http://www.w3.org/2001/XMLSchema#double>) ;

hyperspectral:productClass

"geophysical parameter" ;

hyperspectral:productName

"Gelbstuff Absorption at 412nm, Gould (200711)" ;

hyperspectral:productScaling

"Linear" ;

hyperspectral:productStatus

"provisional" ;

hyperspectral:productUnits

"m<sup>-1</sup>" ;

hyperspectral:scalingIntercept

"3.200000047683716"^^<http://www.w3.org/2001/XMLSchema#double> ;

hyperspectral:scalingSlope

9.999999747378752E-5 ;

hyperspectral:validRange

(1.0E-4 "5.0"^^<http://www.w3.org/2001/XMLSchema#double>) ;

<http://muckdragon.info/hyperspectral/tags/algorithm#hasAlgorithmTag>

<http://muckdragon.info/hyperspectral/tags/algorithm#gould> ;

<http://muckdragon.info/hyperspectral/tags/measure#hasMeasurementTag>

<http://muckdragon.info/hyperspectral/tags/measure#absorption> ;

<http://www.w3.org/ns/prov#wasGeneratedBy>

[ a <http://muckdragon.info/data/processing#ProcessExecution> ;

<http://www.w3.org/ns/prov#generated>

file:ag\_412\_gould ;

<http://www.w3.org/ns/prov#used>

[ a <http://muckdragon.info/data/processing#Algorithm> ;

<http://muckdragon.info/data/processing#name>

"Gould (200711)" ;

<http://muckdragon.info/data/processing#produces>

file:ag\_412\_gould ;

= <http://muckdragon.info/hyperspectral/algorithms/Gould%20%28200711%29>

]

].

file:aph\_412\_qaa

a <http://www.w3.org/2000/01/rdf-schema#Class> ,

<http://muckdragon.info/data/info#Product> ;

<http://muckdragon.info/data/info#hasMeasurementUnits>

"m<sup>-1</sup>" ;

<http://muckdragon.info/data/info#hasStats>

[ stats:geometricMean "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:max "32767.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:mean "-31959.711031250066"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:min "-32100.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:n "1024000"^^<http://www.w3.org/2001/XMLSchema#long> ;

stats:populationVariance

```
"60923.98647365288"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:secondMoment 6.238616214902055E10 ;

stats:standardDeviation

"246.82796837026297"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sum -3.2726744096E10 ;

stats:sumOfLogs "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumsq 1.045999670463976E15 ;

stats:variance "60924.04596979153"^^<http://www.w3.org/2001/XMLSchema#double>

];

sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int>
"512"^^<http://www.w3.org/2001/XMLSchema#int>);

sets:dataType <http://www.w3.org/2001/XMLSchema#short> ;

sets:isContainedIn

<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8dec7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph
D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-
SwanRiverEstuary_AUS.v40.100m.hdf> ;

hyperspectral:badData

"-32100"^^<http://www.w3.org/2001/XMLSchema#short> ;

hyperspectral:browseColorTableName

"nrl" ;
```



hyperspectral:browseFunc

"2"^^<http://www.w3.org/2001/XMLSchema#int> ;

hyperspectral:browseRanges

(5.0E-4 "1.0"^^<http://www.w3.org/2001/XMLSchema#double>) ;

hyperspectral:productClass

"geophysical parameter" ;

hyperspectral:productName

"Absorption due to phytoplankton at 412 nm, QAA algorithm" ;

hyperspectral:productScaling

"Linear" ;

hyperspectral:productStatus

"provisional" ;

hyperspectral:productUnits

"m<sup>-1</sup>" ;

hyperspectral:scalingIntercept

"3.200000047683716"^^<http://www.w3.org/2001/XMLSchema#double> ;

hyperspectral:scalingSlope

9.999999747378752E-5 ;

hyperspectral:validRange

```

(1.0E-4 "5.0"^^<http://www.w3.org/2001/XMLSchema#double>) ;

<http://muckdragon.info/hyperspectral/tags/algorithm#hasAlgorithmTag>

  <http://muckdragon.info/hyperspectral/tags/algorithm#qaa> ;

<http://muckdragon.info/hyperspectral/tags/measure#hasMeasurementTag>

  <http://muckdragon.info/hyperspectral/tags/measure#absorption> ;

<http://muckdragon.info/hyperspectral/tags/substance#hasSubstanceTag>

  <http://muckdragon.info/hyperspectral/tags/substance#phytoplankton> ;

<http://www.w3.org/ns/prov#wasGeneratedBy>

  [ a    <http://muckdragon.info/data/processing#ProcessExecution> ;

    <http://www.w3.org/ns/prov#generated>

      file:aph_412_qaa ;

    <http://www.w3.org/ns/prov#used>

      [ a    <http://muckdragon.info/data/processing#Algorithm> ;

        <http://muckdragon.info/data/processing#name>

          "QAA algorithm" ;

        <http://muckdragon.info/data/processing#produces>

          file:aph_412_qaa ;

        =    <http://muckdragon.info/hyperspectral/algorithms/QAA%20algorithm>

      ]

  ]

```

].

file:tilt

a <http://www.w3.org/2000/01/rdf-schema#Class> ;

<http://muckdragon.info/data/info#hasStats>

[ stats:geometricMean "0.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:max "0.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:mean "0.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:min "0.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:n "2000"^^<http://www.w3.org/2001/XMLSchema#long> ;

stats:populationVariance

"0.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:secondMoment "0.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:standardDeviation

"0.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sum "0.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumOfLogs "-Infinity"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumsq "0.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:variance "0.0"^^<http://www.w3.org/2001/XMLSchema#double>

];

sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int>);

sets:dataType <http://www.w3.org/2001/XMLSchema#float>;

sets:isContainedIn

<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8decbc7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph  
D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-  
SwanRiverEstuary\_AUS.v40.100m.hdf> .

file:a\_547\_qaa

a <http://www.w3.org/2000/01/rdf-schema#Class> ,

<http://muckdragon.info/data/info#Product>;

<http://muckdragon.info/data/info#hasMeasurementUnits>

"m<sup>-1</sup>";

<http://muckdragon.info/data/info#hasStats>

[ stats:geometricMean "NaN"^^<http://www.w3.org/2001/XMLSchema#double>;

stats:max "-17550.0"^^<http://www.w3.org/2001/XMLSchema#double>;

stats:mean "-24694.817876952147"^^<http://www.w3.org/2001/XMLSchema#double>;

stats:min "-25100.0"^^<http://www.w3.org/2001/XMLSchema#double>;

stats:n "1024000"^^<http://www.w3.org/2001/XMLSchema#long>;

stats:populationVariance

```

"240204.35204859936"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:secondMoment 2.4596925649776575E11 ;

stats:standardDeviation

"490.1067094249894"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sum -2.5287493506E10 ;

stats:sumOfLogs "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumsq 6.24716015951802E14 ;

stats:variance "240204.586623391"^^<http://www.w3.org/2001/XMLSchema#double>

];

sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int>
"512"^^<http://www.w3.org/2001/XMLSchema#int>);

sets:dataType <http://www.w3.org/2001/XMLSchema#short> ;

sets:isContainedIn

<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8dec7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph
D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-
SwanRiverEstuary_AUS.v40.100m.hdf> ;

hyperspectral:badData

"-25100"^^<http://www.w3.org/2001/XMLSchema#short> ;

hyperspectral:browseColorTableName

"nrl" ;

```

hyperspectral:browseFunc

"2"^^<http://www.w3.org/2001/XMLSchema#int> ;

hyperspectral:browseRanges

("0.01"^^<http://www.w3.org/2001/XMLSchema#double>

"2.0"^^<http://www.w3.org/2001/XMLSchema#double>) ;

hyperspectral:productClass

"geophysical parameter" ;

hyperspectral:productName

"Total absorption at 547 nm, QAA algorithm" ;

hyperspectral:productScaling

"Linear" ;

hyperspectral:productStatus

"provisional" ;

hyperspectral:productUnits

"m<sup>-1</sup>" ;

hyperspectral:scalingIntercept

"2.5"^^<http://www.w3.org/2001/XMLSchema#double> ;

hyperspectral:scalingSlope

9.999999747378752E-5 ;

hyperspectral:validRange

```
(1.0E-4 "5.0"^^<http://www.w3.org/2001/XMLSchema#double>) ;  
  
<http://muckdragon.info/hyperspectral/tags/algorithm#hasAlgorithmTag>  
  
  <http://muckdragon.info/hyperspectral/tags/algorithm#qaa> ;  
  
<http://muckdragon.info/hyperspectral/tags/measure#hasMeasurementTag>  
  
  <http://muckdragon.info/hyperspectral/tags/measure#absorption> ;  
  
<http://muckdragon.info/hyperspectral/tags/substance#hasSubstanceTag>  
  
  <http://muckdragon.info/hyperspectral/tags/substance#total> ;  
  
<http://www.w3.org/ns/prov#wasGeneratedBy>  
  
  [ a    <http://muckdragon.info/data/processing#ProcessExecution> ;  
  
    <http://www.w3.org/ns/prov#generated>  
  
      file:a_547_qaa ;  
  
    <http://www.w3.org/ns/prov#used>  
  
      [ a    <http://muckdragon.info/data/processing#Algorithm> ;  
  
        <http://muckdragon.info/data/processing#name>  
  
          "QAA algorithm" ;  
  
        <http://muckdragon.info/data/processing#produces>  
  
          file:a_547_qaa ;  
  
        =    <http://muckdragon.info/hyperspectral/algorithms/QAA%20algorithm>
```

]

].

file:rrs\_488

a <http://www.w3.org/2000/01/rdf-schema#Class> ;

<http://muckdragon.info/data/info#hasStats>

[ stats:geometricMean "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:max "-5943.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:mean "-27712.233663085113"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:min "-32767.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:n "1024000"^^<http://www.w3.org/2001/XMLSchema#long> ;

stats:populationVariance

3.649097384401698E7 ;

stats:secondMoment 3.736675721627338E13 ;

stats:standardDeviation

"6040.77888022467"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sum -2.8377327271E10 ;

stats:sumOfLogs "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumsq 8.23765881284083E14 ;



stats:variance 3.649100947976842E7

];

sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int>

"512"^^<http://www.w3.org/2001/XMLSchema#int>);

sets:dataType <http://www.w3.org/2001/XMLSchema#short>;

sets:isContainedIn

<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8decbc7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph

D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-

SwanRiverEstuary\_AUS.v40.100m.hdf>;

hyperspectral:badData

"-30000"^^<http://www.w3.org/2001/XMLSchema#short>;

hyperspectral:browseColorTableName

"neg";

hyperspectral:browseFunc

"0"^^<http://www.w3.org/2001/XMLSchema#int>;

hyperspectral:browseRanges

("-0.03"^^<http://www.w3.org/2001/XMLSchema#double>

"0.03"^^<http://www.w3.org/2001/XMLSchema#double>);

hyperspectral:productClass

"geophysical parameter";

hyperspectral:productName

"Remote sensing reflectance at 488 nm" ;

hyperspectral:productScaling

"Linear" ;

hyperspectral:productStatus

"provisional" ;

hyperspectral:productUnits

"sr<sup>-1</sup>" ;

hyperspectral:scalingIntercept

"0.05000000074505806"^^<http://www.w3.org/2001/XMLSchema#double> ;

hyperspectral:scalingSlope

1.9999999949504854E-6 ;

hyperspectral:validRange

(2.0E-6 "0.04"^^<http://www.w3.org/2001/XMLSchema#double>) ;

<http://muckdragon.info/hyperspectral/tags/measure#hasMeasurementTag>

<http://muckdragon.info/hyperspectral/tags/measure#reflectance> .

file:slat

a <http://www.w3.org/2000/01/rdf-schema#Class> ;

<http://muckdragon.info/data/info#hasStats>

```
[ stats:geometricMean "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:max "-31.32134246826172"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:mean "-31.93085632705683"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:min "-32.540809631347656"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:n "2000"^^<http://www.w3.org/2001/XMLSchema#long> ;

stats:populationVariance

    "0.12402920419472879"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:secondMoment

"248.05840838945758"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:standardDeviation

    "0.3522658794428416"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sum "-63861.71265411377"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumOfLogs "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumsq "2039407.229966688"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:variance "0.12409124981963861"^^<http://www.w3.org/2001/XMLSchema#double>

];

sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int>);

sets:dataType <http://www.w3.org/2001/XMLSchema#float> ;
```

sets:isContainedIn

<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8dec7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph  
D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-  
SwanRiverEstuary\_AUS.v40.100m.hdf> .

<http://muckdragon.info/data/info#Measurement>

a <http://www.w3.org/2000/01/rdf-schema#Class> ;

<http://www.w3.org/2000/01/rdf-schema#subClassOf>

<http://www.w3.org/ns/prov#Entity> .

file:aph\_443\_gould

a <http://www.w3.org/2000/01/rdf-schema#Class> ,

<http://muckdragon.info/data/info#Product> ;

<http://muckdragon.info/data/info#hasMeasurementUnits>

"m<sup>-1</sup>" ;

<http://muckdragon.info/data/info#hasStats>

[ stats:geometricMean "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:max "-19876.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:mean "-19993.345844727046"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:min "-20010.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

```

stats:n "1024000"^^<http://www.w3.org/2001/XMLSchema#long> ;

stats:populationVariance

    "416.79450372327113"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:secondMoment 4.2679757181262964E8 ;

stats:standardDeviation

    "20.415555607172468"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sum -2.0473186145E10 ;

stats:sumOfLogs "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumsq 4.09327917938021E14 ;

stats:variance "416.79491074955115"^^<http://www.w3.org/2001/XMLSchema#double>

];

sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int>
"512"^^<http://www.w3.org/2001/XMLSchema#int>);

sets:dataType <http://www.w3.org/2001/XMLSchema#short> ;

sets:isContainedIn

<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8dec7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph
D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-
SwanRiverEstuary_AUS.v40.100m.hdf> ;

hyperspectral:badData

    "-20010"^^<http://www.w3.org/2001/XMLSchema#short> ;

```

hyperspectral:browseColorTableName

"nrl" ;

hyperspectral:browseFunc

"2"^^<http://www.w3.org/2001/XMLSchema#int> ;

hyperspectral:browseRanges

(5.0E-4 "1.0"^^<http://www.w3.org/2001/XMLSchema#double>) ;

hyperspectral:productClass

"geophysical parameter" ;

hyperspectral:productName

"Phytoplankton Absorption at 443nm, Gould (200711)" ;

hyperspectral:productScaling

"Linear" ;

hyperspectral:productStatus

"provisional" ;

hyperspectral:productUnits

"m<sup>-1</sup>" ;

hyperspectral:scalingIntercept

"20.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

hyperspectral:scalingSlope

"0.001000000474974513"^^<http://www.w3.org/2001/XMLSchema#double> ;

hyperspectral:validRange

("0.001"^^<http://www.w3.org/2001/XMLSchema#double>

"40.0"^^<http://www.w3.org/2001/XMLSchema#double>) ;

<http://muckdragon.info/hyperspectral/tags/algorithm#hasAlgorithmTag>

<http://muckdragon.info/hyperspectral/tags/algorithm#gould> ;

<http://muckdragon.info/hyperspectral/tags/measure#hasMeasurementTag>

<http://muckdragon.info/hyperspectral/tags/measure#absorption> ;

<http://muckdragon.info/hyperspectral/tags/substance#hasSubstanceTag>

<http://muckdragon.info/hyperspectral/tags/substance#phytoplankton> ;

<http://www.w3.org/ns/prov#wasGeneratedBy>

[ a <http://muckdragon.info/data/processing#ProcessExecution> ;

<http://www.w3.org/ns/prov#generated>

file:aph\_443\_gould ;

<http://www.w3.org/ns/prov#used>

[ a <http://muckdragon.info/data/processing#Algorithm> ;

<http://muckdragon.info/data/processing#name>

"Gould (200711)" ;

<http://muckdragon.info/data/processing#produces>

```
file:aph_443_gould ;  
  
= <http://muckdragon.info/hyperspectral/algorithms/Gould%20%28200711%29>  
  
]  
  
].
```

file:rrs\_869

```
a <http://www.w3.org/2000/01/rdf-schema#Class> ;  
  
<http://muckdragon.info/data/info#hasStats>  
  
[ stats:geometricMean "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;  
  
stats:max "-23959.0"^^<http://www.w3.org/2001/XMLSchema#double> ;  
  
stats:mean "-29539.428794921296"^^<http://www.w3.org/2001/XMLSchema#double> ;  
  
stats:min "-32767.0"^^<http://www.w3.org/2001/XMLSchema#double> ;  
  
stats:n "1024000"^^<http://www.w3.org/2001/XMLSchema#long> ;  
  
stats:populationVariance  
  
1.4714506813366888E7 ;  
  
stats:secondMoment 1.5067654976887693E13 ;  
  
stats:standardDeviation  
  
"3835.9511445033395"^^<http://www.w3.org/2001/XMLSchema#double> ;  
  
stats:sum -3.0248375086E10 ;
```



stats:sumOfLogs "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumsq 9.0858737699187E14 ;

stats:variance 1.471452118301648E7

];

sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int>

"512"^^<http://www.w3.org/2001/XMLSchema#int>);

sets:dataType <http://www.w3.org/2001/XMLSchema#short> ;

sets:isContainedIn

<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8dec7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph

D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-

SwanRiverEstuary\_AUS.v40.100m.hdf> ;

hyperspectral:badData

"-30000"^^<http://www.w3.org/2001/XMLSchema#short> ;

hyperspectral:browseColorTableName

"neg" ;

hyperspectral:browseFunc

"0"^^<http://www.w3.org/2001/XMLSchema#int> ;

hyperspectral:browseRanges

("-0.03"^^<http://www.w3.org/2001/XMLSchema#double>

"0.03"^^<http://www.w3.org/2001/XMLSchema#double>);

hyperspectral:productClass

"geophysical parameter" ;

hyperspectral:productName

"Remote sensing reflectance at 869 nm" ;

hyperspectral:productScaling

"Linear" ;

hyperspectral:productStatus

"provisional" ;

hyperspectral:productUnits

"sr<sup>-1</sup>" ;

hyperspectral:scalingIntercept

"0.05000000074505806"^^<http://www.w3.org/2001/XMLSchema#double> ;

hyperspectral:scalingSlope

1.9999999949504854E-6 ;

hyperspectral:validRange

(2.0E-6 "0.04"^^<http://www.w3.org/2001/XMLSchema#double>) ;

<http://muckdragon.info/hyperspectral/tags/measure#hasMeasurementTag>

<http://muckdragon.info/hyperspectral/tags/measure#reflectance> .

file:asd\_443\_gould

```
a    <http://www.w3.org/2000/01/rdf-schema#Class> ,
<http://muckdragon.info/data/info#Product> ;

<http://muckdragon.info/data/info#hasMeasurementUnits>

    "m^-1" ;

<http://muckdragon.info/data/info#hasStats>

    [ stats:geometricMean "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

      stats:max "-27317.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

      stats:mean "-31995.905083984424"^^<http://www.w3.org/2001/XMLSchema#double> ;

      stats:min "-32100.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

      stats:n "1024000"^^<http://www.w3.org/2001/XMLSchema#long> ;

      stats:populationVariance

          "18482.717371737715"^^<http://www.w3.org/2001/XMLSchema#double> ;

      stats:secondMoment 1.892630258865942E10 ;

      stats:standardDeviation

          "135.95122441995153"^^<http://www.w3.org/2001/XMLSchema#double> ;

      stats:sum -3.2763806806E10 ;

      stats:sumOfLogs "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

      stats:sumsq 1.048326579057366E15 ;
```

```
stats:variance "18482.735421284026"^^<http://www.w3.org/2001/XMLSchema#double>

];

sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int>
"512"^^<http://www.w3.org/2001/XMLSchema#int>);

sets:dataType <http://www.w3.org/2001/XMLSchema#short>;

sets:isContainedIn

<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8decbc7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph
D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-
SwanRiverEstuary_AUS.v40.100m.hdf>;

hyperspectral:badData

"-32100"^^<http://www.w3.org/2001/XMLSchema#short>;

hyperspectral:browseColorTableName

"nrl";

hyperspectral:browseFunc

"2"^^<http://www.w3.org/2001/XMLSchema#int>;

hyperspectral:browseRanges

("0.001"^^<http://www.w3.org/2001/XMLSchema#double>
"2.0"^^<http://www.w3.org/2001/XMLSchema#double>);

hyperspectral:productClass

"geophysical parameter";
```

hyperspectral:productName

"Sediment and Detrital Absorption at 443nm, Gould (200711)" ;

hyperspectral:productScaling

"Linear" ;

hyperspectral:productStatus

"provisional" ;

hyperspectral:productUnits

"m<sup>-1</sup>" ;

hyperspectral:scalingIntercept

"3.200000047683716"^^<http://www.w3.org/2001/XMLSchema#double> ;

hyperspectral:scalingSlope

9.999999747378752E-5 ;

hyperspectral:validRange

(1.0E-4 "5.0"^^<http://www.w3.org/2001/XMLSchema#double>) ;

<http://muckdragon.info/hyperspectral/tags/algorithm#hasAlgorithmTag>

<http://muckdragon.info/hyperspectral/tags/algorithm#gould> ;

<http://muckdragon.info/hyperspectral/tags/measure#hasMeasurementTag>

<http://muckdragon.info/hyperspectral/tags/measure#absorption> ;

<http://muckdragon.info/hyperspectral/tags/substance#hasSubstanceTag>

```

    <http://muckdragon.info/hyperspectral/tags/substance#detrital> ,
<http://muckdragon.info/hyperspectral/tags/substance#sediment> ;

<http://www.w3.org/ns/prov#wasGeneratedBy>

[ a    <http://muckdragon.info/data/processing#ProcessExecution> ;

    <http://www.w3.org/ns/prov#generated>

    file:asd_443_gould ;

    <http://www.w3.org/ns/prov#used>

    [ a    <http://muckdragon.info/data/processing#Algorithm> ;

        <http://muckdragon.info/data/processing#name>

        "Gould (200711)" ;

        <http://muckdragon.info/data/processing#produces>

        file:asd_443_gould ;

        =    <http://muckdragon.info/hyperspectral/algorithms/Gould%20%28200711%29>

    ]

] .

<http://muckdragon.info/hyperspectral/tags/substance#detrital>

<http://muckdragon.info/hyperspectral/tags/substance#name>

"detrital" .

```

file:clon

a <http://www.w3.org/2000/01/rdf-schema#Class> ;

<http://muckdragon.info/data/info#hasStats>

[ stats:geometricMean

"115.67204299906078"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:max "116.41979217529297"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:mean "115.67284790420531"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:min "114.92552947998047"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:n "2000"^^<http://www.w3.org/2001/XMLSchema#long> ;

stats:populationVariance

"0.1862092070747929"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:secondMoment

"372.41841414958583"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:standardDeviation

"0.431627568922468"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sum "231345.69580841064"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumOfLogs "9501.517942916842"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumsq 2.6760787902953103E7 ;

```

stats:variance "0.1863023582539199"^^<http://www.w3.org/2001/XMLSchema#double>

];

sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int>);

sets:dataType <http://www.w3.org/2001/XMLSchema#float>;

sets:isContainedIn

<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8dec7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph
D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-
SwanRiverEstuary_AUS.v40.100m.hdf> .

<http://muckdragon.info/hyperspectral/tags/measure#concentration>

<http://muckdragon.info/hyperspectral/tags/measure#name>

"concentration" .

file:year

a <http://www.w3.org/2000/01/rdf-schema#Class>;

<http://muckdragon.info/data/info#hasStats>

[ stats:geometricMean

"2012.999999998063"^^<http://www.w3.org/2001/XMLSchema#double>;

stats:max "2013.0"^^<http://www.w3.org/2001/XMLSchema#double>;

stats:mean "2013.0"^^<http://www.w3.org/2001/XMLSchema#double>;

```



stats:min "2013.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:n "2000"^^<http://www.w3.org/2001/XMLSchema#long> ;

stats:populationVariance

"0.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:secondMoment "0.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:standardDeviation

"0.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sum "4026000.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumOfLogs "15214.76285127939"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumsq 8.104338E9 ;

stats:variance "0.0"^^<http://www.w3.org/2001/XMLSchema#double>

];

sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int>);

sets:dataType <http://www.w3.org/2001/XMLSchema#int> ;

sets:isContainedIn

<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8dec7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph  
D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-  
SwanRiverEstuary\_AUS.v40.100m.hdf> .

file:CP\_Pixels

a <http://www.w3.org/2000/01/rdf-schema#Class> ;

<http://muckdragon.info/data/info#hasStats>

[ stats:geometricMean

"189.84574208576095"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:max "512.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:mean "256.5"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:min "1.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:n "512"^^<http://www.w3.org/2001/XMLSchema#long> ;

stats:populationVariance

"21845.25"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:secondMoment 1.1184768E7 ;

stats:standardDeviation

"147.94593607125543"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sum "131328.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumOfLogs "2686.0604716263524"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumsq 4.48704E7 ;

stats:variance "21888.0"^^<http://www.w3.org/2001/XMLSchema#double>

];

sets:dataDimensions ("512"^^<http://www.w3.org/2001/XMLSchema#int>);

sets:dataType <http://www.w3.org/2001/XMLSchema#double>;

sets:isContainedIn

<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8dec7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph  
D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-  
SwanRiverEstuary\_AUS.v40.100m.hdf> .

file:rrs\_547

a <http://www.w3.org/2000/01/rdf-schema#Class>;

<http://muckdragon.info/data/info#hasStats>

[ stats:geometricMean "NaN"^^<http://www.w3.org/2001/XMLSchema#double>;

stats:max "-6554.0"^^<http://www.w3.org/2001/XMLSchema#double>;

stats:mean "-28269.275082031465"^^<http://www.w3.org/2001/XMLSchema#double>;

stats:min "-32767.0"^^<http://www.w3.org/2001/XMLSchema#double>;

stats:n "1024000"^^<http://www.w3.org/2001/XMLSchema#long>;

stats:populationVariance

2.8957976809644684E7;

stats:secondMoment 2.9652968253076156E13;

stats:standardDeviation

```
"5381.26426492386"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sum -2.8947737684E10 ;

stats:sumOfLogs "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumsq 8.4798452784456E14 ;

stats:variance 2.895800508894653E7

];

sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int>
"512"^^<http://www.w3.org/2001/XMLSchema#int>);

sets:dataType <http://www.w3.org/2001/XMLSchema#short> ;

sets:isContainedIn
<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8decbc7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph
D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-
SwanRiverEstuary_AUS.v40.100m.hdf> ;

hyperspectral:badData

"-30000"^^<http://www.w3.org/2001/XMLSchema#short> ;

hyperspectral:browseColorTableName

"neg" ;

hyperspectral:browseFunc

"0"^^<http://www.w3.org/2001/XMLSchema#int> ;

hyperspectral:browseRanges
```

```
      ("0.03"^^<http://www.w3.org/2001/XMLSchema#double>
"0.03"^^<http://www.w3.org/2001/XMLSchema#double>);

hyperspectral:productClass

  "geophysical parameter" ;

hyperspectral:productName

  "Remote sensing reflectance at 547 nm" ;

hyperspectral:productScaling

  "Linear" ;

hyperspectral:productStatus

  "provisional" ;

hyperspectral:productUnits

  "sr^-1" ;

hyperspectral:scalingIntercept

  "0.05000000074505806"^^<http://www.w3.org/2001/XMLSchema#double> ;

hyperspectral:scalingSlope

  1.9999999949504854E-6 ;

hyperspectral:validRange

  (2.0E-6 "0.04"^^<http://www.w3.org/2001/XMLSchema#double>);

<http://muckdragon.info/hyperspectral/tags/measure#hasMeasurementTag>
```

<http://muckdragon.info/hyperspectral/tags/measure#reflectance> .

file:aph\_443\_qaa

a <http://www.w3.org/2000/01/rdf-schema#Class> ,

<http://muckdragon.info/data/info#Product> ;

<http://muckdragon.info/data/info#hasMeasurementUnits>

"m<sup>-1</sup>" ;

<http://muckdragon.info/data/info#hasStats>

[ stats:geometricMean "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:max "30371.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:mean "-31784.487017578816"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:min "-32100.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:n "1024000"^^<http://www.w3.org/2001/XMLSchema#long> ;

stats:populationVariance

"181542.50191712807"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:secondMoment 1.8589952196313916E11 ;

stats:standardDeviation

"426.0782547900101"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sum -3.2547314706E10 ;

```
stats:sumOfLogs "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumsq 1.03468560125185E15 ;

stats:variance "181542.67920490075"^^<http://www.w3.org/2001/XMLSchema#double>

];

sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int>
"512"^^<http://www.w3.org/2001/XMLSchema#int>);

sets:dataType <http://www.w3.org/2001/XMLSchema#short> ;

sets:isContainedIn

<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8dec7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph
D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-
SwanRiverEstuary_AUS.v40.100m.hdf> ;

hyperspectral:badData

"-32100"^^<http://www.w3.org/2001/XMLSchema#short> ;

hyperspectral:browseColorTableName

"nrl" ;

hyperspectral:browseFunc

"2"^^<http://www.w3.org/2001/XMLSchema#int> ;

hyperspectral:browseRanges

(5.0E-4 "1.0"^^<http://www.w3.org/2001/XMLSchema#double>);

hyperspectral:productClass
```

"geophysical parameter" ;

hyperspectral:productName

"Absorption due to phytoplankton at 443 nm, QAA algorithm" ;

hyperspectral:productScaling

"Linear" ;

hyperspectral:productStatus

"provisional" ;

hyperspectral:productUnits

"m<sup>-1</sup>" ;

hyperspectral:scalingIntercept

"3.200000047683716"^^<http://www.w3.org/2001/XMLSchema#double> ;

hyperspectral:scalingSlope

9.999999747378752E-5 ;

hyperspectral:validRange

(1.0E-4 "5.0"^^<http://www.w3.org/2001/XMLSchema#double>) ;

<http://muckdragon.info/hyperspectral/tags/algorithm#hasAlgorithmTag>

<http://muckdragon.info/hyperspectral/tags/algorithm#qaa> ;

<http://muckdragon.info/hyperspectral/tags/measure#hasMeasurementTag>

<http://muckdragon.info/hyperspectral/tags/measure#absorption> ;



<http://muckdragon.info/hyperspectral/tags/substance#hasSubstanceTag>

<http://muckdragon.info/hyperspectral/tags/substance#phytoplankton> ;

<http://www.w3.org/ns/prov#wasGeneratedBy>

[ a <http://muckdragon.info/data/processing#ProcessExecution> ;

<http://www.w3.org/ns/prov#generated>

file:aph\_443\_qaa ;

<http://www.w3.org/ns/prov#used>

[ a <http://muckdragon.info/data/processing#Algorithm> ;

<http://muckdragon.info/data/processing#name>

"QAA algorithm" ;

<http://muckdragon.info/data/processing#produces>

file:aph\_443\_qaa ;

= <http://muckdragon.info/hyperspectral/algorithms/QAA%20algorithm>

]

].

file:a\_443\_qaa

a <http://www.w3.org/2000/01/rdf-schema#Class> ,

<http://muckdragon.info/data/info#Product> ;

<http://muckdragon.info/data/info#hasMeasurementUnits>

"m<sup>-1</sup>";

<http://muckdragon.info/data/info#hasStats>

[ stats:geometricMean "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:max "32767.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:mean "-24599.19211132717"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:min "-25100.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:n "1024000"^^<http://www.w3.org/2001/XMLSchema#long> ;

stats:populationVariance

"457542.73859173956"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:secondMoment 4.685237643179413E11 ;

stats:standardDeviation

"676.4193857447143"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sum -2.5189572722E10 ;

stats:sumOfLogs "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumsq 6.20111662355066E14 ;

stats:variance "457543.18541125656"^^<http://www.w3.org/2001/XMLSchema#double>

];

```
sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int>
"512"^^<http://www.w3.org/2001/XMLSchema#int>);

sets:dataType <http://www.w3.org/2001/XMLSchema#short>;

sets:isContainedIn

<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8decbc7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph
D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-
SwanRiverEstuary_AUS.v40.100m.hdf>;

hyperspectral:badData

"-25100"^^<http://www.w3.org/2001/XMLSchema#short>;

hyperspectral:browseColorTableName

"nrl";

hyperspectral:browseFunc

"2"^^<http://www.w3.org/2001/XMLSchema#int>;

hyperspectral:browseRanges

("0.01"^^<http://www.w3.org/2001/XMLSchema#double>
"2.0"^^<http://www.w3.org/2001/XMLSchema#double>);

hyperspectral:productClass

"geophysical parameter";

hyperspectral:productName

"Total absorption at 443 nm, QAA algorithm";
```

hyperspectral:productScaling

"Linear" ;

hyperspectral:productStatus

"provisional" ;

hyperspectral:productUnits

"m<sup>-1</sup>" ;

hyperspectral:scalingIntercept

"2.5"^^<http://www.w3.org/2001/XMLSchema#double> ;

hyperspectral:scalingSlope

9.999999747378752E-5 ;

hyperspectral:validRange

(1.0E-4 "5.0"^^<http://www.w3.org/2001/XMLSchema#double>) ;

<http://muckdragon.info/hyperspectral/tags/algorithm#hasAlgorithmTag>

<http://muckdragon.info/hyperspectral/tags/algorithm#qaa> ;

<http://muckdragon.info/hyperspectral/tags/measure#hasMeasurementTag>

<http://muckdragon.info/hyperspectral/tags/measure#absorption> ;

<http://muckdragon.info/hyperspectral/tags/substance#hasSubstanceTag>

<http://muckdragon.info/hyperspectral/tags/substance#total> ;

<http://www.w3.org/ns/prov#wasGeneratedBy>

```

[ a   <http://muckdragon.info/data/processing#ProcessExecution> ;

      <http://www.w3.org/ns/prov#generated>

      file:a_443_qaa ;

      <http://www.w3.org/ns/prov#used>

      [ a   <http://muckdragon.info/data/processing#Algorithm> ;

          <http://muckdragon.info/data/processing#name>

          "QAA algorithm" ;

          <http://muckdragon.info/data/processing#produces>

          file:a_443_qaa ;

          =   <http://muckdragon.info/hyperspectral/algorithms/QAA%20algorithm>

        ]

    ].

```

file:clat

```

a   <http://www.w3.org/2000/01/rdf-schema#Class> ;

    <http://muckdragon.info/data/info#hasStats>

    [ stats:geometricMean "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

      stats:max "-31.108863830566406"^^<http://www.w3.org/2001/XMLSchema#double> ;

      stats:mean "-31.71824752712247"^^<http://www.w3.org/2001/XMLSchema#double> ;
    ]

```

```

stats:min "-32.32797622680664"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:n "2000"^^<http://www.w3.org/2001/XMLSchema#long> ;

stats:populationVariance

    "0.12401247278209454"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:secondMoment

"248.02494556418907"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:standardDeviation

    "0.3522421184882823"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sum "-63436.495054244995"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumOfLogs "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumsq "2012342.4773291938"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:variance "0.12407451003711309"^^<http://www.w3.org/2001/XMLSchema#double>

];

sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int> ) ;

sets:dataType <http://www.w3.org/2001/XMLSchema#float> ;

sets:isContainedIn

<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8dec7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph
D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-
SwanRiverEstuary_AUS.v40.100m.hdf> .

```

file:aph\_531\_qaa

```
a    <http://www.w3.org/2000/01/rdf-schema#Class> ,
<http://muckdragon.info/data/info#Product> ;

<http://muckdragon.info/data/info#hasMeasurementUnits>

    "m^-1" ;

<http://muckdragon.info/data/info#hasStats>

    [ stats:geometricMean "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

      stats:max "32767.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

      stats:mean "-31949.069567382554"^^<http://www.w3.org/2001/XMLSchema#double> ;

      stats:min "-32100.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

      stats:n "1024000"^^<http://www.w3.org/2001/XMLSchema#long> ;

      stats:populationVariance

          "40803.923384026035"^^<http://www.w3.org/2001/XMLSchema#double> ;

      stats:secondMoment 4.178321754524266E10 ;

      stats:standardDeviation

          "201.9999089892032"^^<http://www.w3.org/2001/XMLSchema#double> ;

      stats:sum -3.2715847237E10 ;

      stats:sumOfLogs "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

      stats:sumsq 1.045282662548327E15 ;
```

```
stats:variance "40803.963231646376"^^<http://www.w3.org/2001/XMLSchema#double>

];

sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int>
"512"^^<http://www.w3.org/2001/XMLSchema#int>);

sets:dataType <http://www.w3.org/2001/XMLSchema#short>;

sets:isContainedIn
<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8decbc7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph
D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-
SwanRiverEstuary_AUS.v40.100m.hdf>;

hyperspectral:badData
"-32100"^^<http://www.w3.org/2001/XMLSchema#short>;

hyperspectral:browseColorTableName
"nrl";

hyperspectral:browseFunc
"2"^^<http://www.w3.org/2001/XMLSchema#int>;

hyperspectral:browseRanges
(5.0E-4 "1.0"^^<http://www.w3.org/2001/XMLSchema#double>);

hyperspectral:productClass
"geophysical parameter";

hyperspectral:productName
```



"Absorption due to phytoplankton at 531 nm, QAA algorithm" ;

hyperspectral:productScaling

"Linear" ;

hyperspectral:productStatus

"provisional" ;

hyperspectral:productUnits

"m<sup>-1</sup>" ;

hyperspectral:scalingIntercept

"3.200000047683716"^^<http://www.w3.org/2001/XMLSchema#double> ;

hyperspectral:scalingSlope

9.999999747378752E-5 ;

hyperspectral:validRange

(1.0E-4 "5.0"^^<http://www.w3.org/2001/XMLSchema#double>) ;

<http://muckdragon.info/hyperspectral/tags/algorithm#hasAlgorithmTag>

<http://muckdragon.info/hyperspectral/tags/algorithm#qaa> ;

<http://muckdragon.info/hyperspectral/tags/measure#hasMeasurementTag>

<http://muckdragon.info/hyperspectral/tags/measure#absorption> ;

<http://muckdragon.info/hyperspectral/tags/substance#hasSubstanceTag>

<http://muckdragon.info/hyperspectral/tags/substance#phytoplankton> ;

<http://www.w3.org/ns/prov#wasGeneratedBy>

[ a <http://muckdragon.info/data/processing#ProcessExecution> ;

<http://www.w3.org/ns/prov#generated>

file:aph\_531\_qaa ;

<http://www.w3.org/ns/prov#used>

[ a <http://muckdragon.info/data/processing#Algorithm> ;

<http://muckdragon.info/data/processing#name>

"QAA algorithm" ;

<http://muckdragon.info/data/processing#produces>

file:aph\_531\_qaa ;

= <http://muckdragon.info/hyperspectral/algorithms/QAA%20algorithm>

]

].

<http://muckdragon.info/hyperspectral/tags/measure#attenuation>

<http://muckdragon.info/hyperspectral/tags/measure#name>

"attenuation" .

file:c\_531\_qaa

```

a <http://www.w3.org/2000/01/rdf-schema#Class> ,
<http://muckdragon.info/data/info#Product> ;

<http://muckdragon.info/data/info#hasMeasurementUnits>

    "m^-1" ;

<http://muckdragon.info/data/info#hasStats>

    [ stats:geometricMean "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

      stats:max "-15508.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

      stats:mean "-31413.848402343803"^^<http://www.w3.org/2001/XMLSchema#double> ;

      stats:min "-32020.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

      stats:n "1024000"^^<http://www.w3.org/2001/XMLSchema#long> ;

      stats:populationVariance

          "634266.1743028137"^^<http://www.w3.org/2001/XMLSchema#double> ;

      stats:secondMoment 6.494885624860813E11 ;

      stats:standardDeviation

          "796.4086851007963"^^<http://www.w3.org/2001/XMLSchema#double> ;

      stats:sum -3.2167780764E10 ;

      stats:sumOfLogs "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

      stats:sumsq 1.011163276922612E15 ;

      stats:variance "634266.7937039795"^^<http://www.w3.org/2001/XMLSchema#double>

```

```
] ;

sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int>
"512"^^<http://www.w3.org/2001/XMLSchema#int>) ;

sets:dataType <http://www.w3.org/2001/XMLSchema#short> ;

sets:isContainedIn
<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8dec7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph
D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-
SwanRiverEstuary_AUS.v40.100m.hdf> ;

hyperspectral:badData
"-32020"^^<http://www.w3.org/2001/XMLSchema#short> ;

hyperspectral:browseColorTableName
"nrl" ;

hyperspectral:browseFunc
"2"^^<http://www.w3.org/2001/XMLSchema#int> ;

hyperspectral:browseRanges
("0.4"^^<http://www.w3.org/2001/XMLSchema#double>
"15.0"^^<http://www.w3.org/2001/XMLSchema#double>) ;

hyperspectral:productClass
"geophysical parameter" ;

hyperspectral:productName
```

"Beam attenuation at 531 nm, QAA algorithm" ;

hyperspectral:productScaling

"Linear" ;

hyperspectral:productStatus

"provisional" ;

hyperspectral:productUnits

"m<sup>-1</sup>" ;

hyperspectral:scalingIntercept

"16.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

hyperspectral:scalingSlope

5.000000237487257E-4 ;

hyperspectral:validRange

(5.0E-4 "10.0"^^<http://www.w3.org/2001/XMLSchema#double>) ;

<http://muckdragon.info/hyperspectral/tags/algorithm#hasAlgorithmTag>

<http://muckdragon.info/hyperspectral/tags/algorithm#qaa> ;

<http://muckdragon.info/hyperspectral/tags/measure#hasMeasurementTag>

<http://muckdragon.info/hyperspectral/tags/measure#attenuation> ;

<http://www.w3.org/ns/prov#wasGeneratedBy>

[ a <http://muckdragon.info/data/processing#ProcessExecution> ;

<http://www.w3.org/ns/prov#generated>

file:c\_531\_qaa ;

<http://www.w3.org/ns/prov#used>

[ a <http://muckdragon.info/data/processing#Algorithm> ;

<http://muckdragon.info/data/processing#name>

"QAA algorithm" ;

<http://muckdragon.info/data/processing#produces>

file:c\_531\_qaa ;

= <http://muckdragon.info/hyperspectral/algorithms/QAA%20algorithm>

]

].

<http://muckdragon.info/hyperspectral/tags/measure#backscatter>

<http://muckdragon.info/hyperspectral/tags/measure#name>

"backscatter" .

file:F0

a <http://www.w3.org/2000/01/rdf-schema#Class> ;

<http://muckdragon.info/data/info#hasStats>

```
[ stats:geometricMean
"157.7843893989829"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:max "194.93299865722656"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:mean "161.32766638861764"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:min "95.8239974975586"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:n "9"^^<http://www.w3.org/2001/XMLSchema#long> ;

stats:populationVariance

"982.5015276986136"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:secondMoment

"8842.513749287522"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:standardDeviation

"33.24626623639022"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sum "1451.9489974975586"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumOfLogs "45.551065293202974"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumsq "243082.05723086145"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:variance "1105.3142186609402"^^<http://www.w3.org/2001/XMLSchema#double>

];

sets:dataDimensions ("9"^^<http://www.w3.org/2001/XMLSchema#int>);

sets:dataType <http://www.w3.org/2001/XMLSchema#float> ;
```

sets:isContainedIn

<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8dec7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph  
D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-  
SwanRiverEstuary\_AUS.v40.100m.hdf> .

file:water\_mass

a <http://www.w3.org/2000/01/rdf-schema#Class> ;

<http://muckdragon.info/data/info#hasStats>

[ stats:geometricMean "0.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:max "255.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:mean "58.897972330729324"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:min "0.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:n "3072000"^^<http://www.w3.org/2001/XMLSchema#long> ;

stats:populationVariance

"5635.816278830956"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:secondMoment 1.73132276085687E10 ;

stats:standardDeviation

"75.07208611332953"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sum 1.80934571E8 ;



```
stats:sumOfLogs "-Infinity"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumsq 2.7969906965E10 ;

stats:variance "5635.818113407166"^^<http://www.w3.org/2001/XMLSchema#double>

];

sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int>
"512"^^<http://www.w3.org/2001/XMLSchema#int>
"3"^^<http://www.w3.org/2001/XMLSchema#int>);

sets:dataType <http://www.w3.org/2001/XMLSchema#byte> ;

sets:isContainedIn
<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8dec7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph
D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-
SwanRiverEstuary_AUS.v40.100m.hdf> ;

hyperspectral:_Unsigned

"true" ;

hyperspectral:note "0-40% red (asd_443), 0-50% green (aph_443), 0-80% blue (ag_443)" ;

hyperspectral:productClass

"image" ;

hyperspectral:productName

"Water Mass Classification Image, Gould (200711)" ;

<http://muckdragon.info/hyperspectral/tags/algorithm#hasAlgorithmTag>
```

<http://muckdragon.info/hyperspectral/tags/algorithm#gould> .

file:bb\_488\_qaa

a <http://www.w3.org/2000/01/rdf-schema#Class> ,

<http://muckdragon.info/data/info#Product> ;

<http://muckdragon.info/data/info#hasMeasurementUnits>

"m<sup>-1</sup>" ;

<http://muckdragon.info/data/info#hasStats>

[ stats:geometricMean "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:max "3095.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:mean "-26905.220401366412"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:min "-28020.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:n "1024000"^^<http://www.w3.org/2001/XMLSchema#long> ;

stats:populationVariance

"2150600.7129691252"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:secondMoment 2.2022151300803843E12 ;

stats:standardDeviation

"1466.4933730389596"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sum -2.7550945691E10 ;

```
stats:sumOfLogs "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumsq 7.43466481212533E14 ;

stats:variance "2150602.813167185"^^<http://www.w3.org/2001/XMLSchema#double>

];

sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int>
"512"^^<http://www.w3.org/2001/XMLSchema#int>);

sets:dataType <http://www.w3.org/2001/XMLSchema#short> ;

sets:isContainedIn

<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8dec7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph
D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-
SwanRiverEstuary_AUS.v40.100m.hdf> ;

hyperspectral:badData

"-28020"^^<http://www.w3.org/2001/XMLSchema#short> ;

hyperspectral:browseColorTableName

"nrl" ;

hyperspectral:browseFunc

"2"^^<http://www.w3.org/2001/XMLSchema#int> ;

hyperspectral:browseRanges

(5.0E-4 "0.5"^^<http://www.w3.org/2001/XMLSchema#double>);

hyperspectral:productClass
```

"geophysical parameter" ;

hyperspectral:productName

"Total backscatter at 488 nm, QAA algorithm" ;

hyperspectral:productScaling

"Linear" ;

hyperspectral:productStatus

"provisional" ;

hyperspectral:productUnits

"m<sup>-1</sup>" ;

hyperspectral:scalingIntercept

"0.14000000059604645"^^<http://www.w3.org/2001/XMLSchema#double> ;

hyperspectral:scalingSlope

4.999999873689376E-6 ;

hyperspectral:validRange

(5.0E-6 "1.0"^^<http://www.w3.org/2001/XMLSchema#double>) ;

<http://muckdragon.info/hyperspectral/tags/algorithm#hasAlgorithmTag>

<http://muckdragon.info/hyperspectral/tags/algorithm#qaa> ;

<http://muckdragon.info/hyperspectral/tags/measure#hasMeasurementTag>

<http://muckdragon.info/hyperspectral/tags/measure#backscatter> ;

<http://muckdragon.info/hyperspectral/tags/substance#hasSubstanceTag>

<http://muckdragon.info/hyperspectral/tags/substance#total> ;

<http://www.w3.org/ns/prov#wasGeneratedBy>

[ a <http://muckdragon.info/data/processing#ProcessExecution> ;

<http://www.w3.org/ns/prov#generated>

file:bb\_488\_qaa ;

<http://www.w3.org/ns/prov#used>

[ a <http://muckdragon.info/data/processing#Algorithm> ;

<http://muckdragon.info/data/processing#name>

"QAA algorithm" ;

<http://muckdragon.info/data/processing#produces>

file:bb\_488\_qaa ;

= <http://muckdragon.info/hyperspectral/algorithms/QAA%20algorithm>

]

].

file:rrs\_412

a <http://www.w3.org/2000/01/rdf-schema#Class> ;

<http://muckdragon.info/data/info#hasStats>

```
[ stats:geometricMean "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:max "-11174.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:mean "-27649.279208984943"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:min "-32767.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:n "1024000"^^<http://www.w3.org/2001/XMLSchema#long> ;

stats:populationVariance

    3.7754314611166306E7 ;

stats:secondMoment 3.86604181618343E13 ;

stats:standardDeviation

    "6144.456971991111"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sum -2.831286191E10 ;

stats:sumOfLogs "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumsq 8.21490642316846E14 ;

stats:variance 3.775435148065017E7

];

sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int>
"512"^^<http://www.w3.org/2001/XMLSchema#int>);

sets:dataType <http://www.w3.org/2001/XMLSchema#short> ;
```

sets:isContainedIn

<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8dec7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph  
D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-  
SwanRiverEstuary\_AUS.v40.100m.hdf> ;

hyperspectral:badData

"-30000"^^<http://www.w3.org/2001/XMLSchema#short> ;

hyperspectral:browseColorTableName

"neg" ;

hyperspectral:browseFunc

"0"^^<http://www.w3.org/2001/XMLSchema#int> ;

hyperspectral:browseRanges

("-0.03"^^<http://www.w3.org/2001/XMLSchema#double>

"0.03"^^<http://www.w3.org/2001/XMLSchema#double>) ;

hyperspectral:productClass

"geophysical parameter" ;

hyperspectral:productName

"Remote sensing reflectance at 412 nm" ;

hyperspectral:productScaling

"Linear" ;

hyperspectral:productStatus

"provisional" ;

hyperspectral:productUnits

"sr<sup>-1</sup>" ;

hyperspectral:scalingIntercept

"0.05000000074505806"^^<http://www.w3.org/2001/XMLSchema#double> ;

hyperspectral:scalingSlope

1.9999999949504854E-6 ;

hyperspectral:validRange

(2.0E-6 "0.04"^^<http://www.w3.org/2001/XMLSchema#double>) ;

<http://muckdragon.info/hyperspectral/tags/measure#hasMeasurementTag>

<http://muckdragon.info/hyperspectral/tags/measure#reflectance> .

file:adg\_488\_qaa

a <http://www.w3.org/2000/01/rdf-schema#Class> ,

<http://muckdragon.info/data/info#Product> ;

<http://muckdragon.info/data/info#hasMeasurementUnits>

"m<sup>-1</sup>" ;

<http://muckdragon.info/data/info#hasStats>

[ stats:geometricMean "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;



```
stats:max "-13703.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:mean "-31991.502545898948"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:min "-32100.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:n "1024000"^^<http://www.w3.org/2001/XMLSchema#long> ;

stats:populationVariance

    "21077.91227087852"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:secondMoment 2.1583782165379604E10 ;

stats:standardDeviation

    "145.1824123466659"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sum -3.2759298607E10 ;

stats:sumOfLogs "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumsq 1.048040768569853E15 ;

stats:variance "21077.932854797324"^^<http://www.w3.org/2001/XMLSchema#double>

];

sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int>

"512"^^<http://www.w3.org/2001/XMLSchema#int>);

sets:dataType <http://www.w3.org/2001/XMLSchema#short> ;

sets:isContainedIn

<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8dec7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph
```

D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-  
SwanRiverEstuary\_AUS.v40.100m.hdf> ;

hyperspectral:badData

"-32100"^^<http://www.w3.org/2001/XMLSchema#short> ;

hyperspectral:browseColorTableName

"nrl" ;

hyperspectral:browseFunc

"0"^^<http://www.w3.org/2001/XMLSchema#int> ;

hyperspectral:browseRanges

("0.001"^^<http://www.w3.org/2001/XMLSchema#double>

"0.18"^^<http://www.w3.org/2001/XMLSchema#double>) ;

hyperspectral:productClass

"geophysical parameter" ;

hyperspectral:productName

"Absorption due to gelbstof and detrital material at 488 nm, QAA algorithm" ;

hyperspectral:productScaling

"Linear" ;

hyperspectral:productStatus

"provisional" ;

hyperspectral:productUnits

"m<sup>-1</sup>";

hyperspectral:scalingIntercept

"3.200000047683716"^^<http://www.w3.org/2001/XMLSchema#double>;

hyperspectral:scalingSlope

9.999999747378752E-5;

hyperspectral:validRange

(1.0E-4 "5.0"^^<http://www.w3.org/2001/XMLSchema#double>);

<http://muckdragon.info/hyperspectral/tags/algorithm#hasAlgorithmTag>

<http://muckdragon.info/hyperspectral/tags/algorithm#qaa>;

<http://muckdragon.info/hyperspectral/tags/measure#hasMeasurementTag>

<http://muckdragon.info/hyperspectral/tags/measure#absorption>;

<http://muckdragon.info/hyperspectral/tags/substance#hasSubstanceTag>

<http://muckdragon.info/hyperspectral/tags/substance#detrital>;

<http://www.w3.org/ns/prov#wasGeneratedBy>

[ a <http://muckdragon.info/data/processing#ProcessExecution>;

<http://www.w3.org/ns/prov#generated>

file:adg\_488\_qaa;

<http://www.w3.org/ns/prov#used>

```

[ a <http://muckdragon.info/data/processing#Algorithm> ;

  <http://muckdragon.info/data/processing#name>

    "QAA algorithm" ;

  <http://muckdragon.info/data/processing#produces>

    file:adg_488_qaa ;

  = <http://muckdragon.info/hyperspectral/algorithms/QAA%20algorithm>

]

].

```

file:CP\_Longitudes

```

a <http://www.w3.org/2000/01/rdf-schema#Class> ;

<http://muckdragon.info/data/info#hasStats>

[ stats:geometricMean

"115.67424918280142"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:max "116.62342834472656"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:mean "115.67511040668072"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:min "114.73446655273438"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:n "1024000"^^<http://www.w3.org/2001/XMLSchema#long> ;

stats:populationVariance

```

```

"0.199242824126711"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:secondMoment

"204024.65190575205"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:standardDeviation

"0.44636646233780986"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sum 1.1845131305644226E8 ;

stats:sumOfLogs "4864796.71708125"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumsq 1.3702072740275564E10 ;

stats:variance "0.19924301869997144"^^<http://www.w3.org/2001/XMLSchema#double>

];

sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int>
"512"^^<http://www.w3.org/2001/XMLSchema#int>);

sets:dataType <http://www.w3.org/2001/XMLSchema#double> ;

sets:isContainedIn

<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8dec7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph
D Work\Hyperspectral Use Case\jss.2013014.0114.085907.D.L2.hico-modis.12427-
SwanRiverEstuary_AUS.v40.100m.hdf> .

file:adg_443_qaa

```

```

a    <http://www.w3.org/2000/01/rdf-schema#Class> ,
<http://muckdragon.info/data/info#Product> ;

<http://muckdragon.info/data/info#hasMeasurementUnits>

    "m^-1" ;

<http://muckdragon.info/data/info#hasStats>

    [ stats:geometricMean "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

      stats:max "9470.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

      stats:mean "-31919.164357421683"^^<http://www.w3.org/2001/XMLSchema#double> ;

      stats:min "-32100.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

      stats:n "1024000"^^<http://www.w3.org/2001/XMLSchema#long> ;

      stats:populationVariance

        "67088.45875430493"^^<http://www.w3.org/2001/XMLSchema#double> ;

      stats:secondMoment 6.869858176440824E10 ;

      stats:standardDeviation

        "259.014525211313"^^<http://www.w3.org/2001/XMLSchema#double> ;

      stats:sum -3.2685224302E10 ;

      stats:sumOfLogs "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

      stats:sumsq 1.043353745136502E15 ;

      stats:variance "67088.5242704419"^^<http://www.w3.org/2001/XMLSchema#double>

```

```
];

sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int>
"512"^^<http://www.w3.org/2001/XMLSchema#int>);

sets:dataType <http://www.w3.org/2001/XMLSchema#short>;

sets:isContainedIn
<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8decbc7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph
D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-
SwanRiverEstuary_AUS.v40.100m.hdf>;

hyperspectral:badData
"-32100"^^<http://www.w3.org/2001/XMLSchema#short>;

hyperspectral:browseColorTableName
"nrl";

hyperspectral:browseFunc
"0"^^<http://www.w3.org/2001/XMLSchema#int>;

hyperspectral:browseRanges
("0.005"^^<http://www.w3.org/2001/XMLSchema#double>
"0.5"^^<http://www.w3.org/2001/XMLSchema#double>);

hyperspectral:productClass
"geophysical parameter";

hyperspectral:productName
```

"Absorption due to gelbstof and detrital material at 443 nm, QAA algorithm" ;

hyperspectral:productScaling

"Linear" ;

hyperspectral:productStatus

"provisional" ;

hyperspectral:productUnits

"m<sup>-1</sup>" ;

hyperspectral:scalingIntercept

"3.200000047683716"^^<http://www.w3.org/2001/XMLSchema#double> ;

hyperspectral:scalingSlope

9.999999747378752E-5 ;

hyperspectral:validRange

(1.0E-4 "5.0"^^<http://www.w3.org/2001/XMLSchema#double>) ;

<http://muckdragon.info/hyperspectral/tags/algorithm#hasAlgorithmTag>

<http://muckdragon.info/hyperspectral/tags/algorithm#qaa> ;

<http://muckdragon.info/hyperspectral/tags/measure#hasMeasurementTag>

<http://muckdragon.info/hyperspectral/tags/measure#absorption> ;

<http://muckdragon.info/hyperspectral/tags/substance#hasSubstanceTag>

<http://muckdragon.info/hyperspectral/tags/substance#detrital> ;



<http://www.w3.org/ns/prov#wasGeneratedBy>

[ a <http://muckdragon.info/data/processing#ProcessExecution> ;

<http://www.w3.org/ns/prov#generated>

file:adg\_443\_qaa ;

<http://www.w3.org/ns/prov#used>

[ a <http://muckdragon.info/data/processing#Algorithm> ;

<http://muckdragon.info/data/processing#name>

"QAA algorithm" ;

<http://muckdragon.info/data/processing#produces>

file:adg\_443\_qaa ;

= <http://muckdragon.info/hyperspectral/algorithms/QAA%20algorithm>

]

].

file:a\_488\_qaa

a <http://www.w3.org/2000/01/rdf-schema#Class> ,

<http://muckdragon.info/data/info#Product> ;

<http://muckdragon.info/data/info#hasMeasurementUnits>

"m^-1" ;

<http://muckdragon.info/data/info#hasStats>

[ stats:geometricMean "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:max "-11068.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:mean "-24753.33549902308"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:min "-25100.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:n "102400"^^<http://www.w3.org/2001/XMLSchema#long> ;

stats:populationVariance

"190034.77153145225"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:secondMoment 1.945956060482071E11 ;

stats:standardDeviation

"435.92999106790654"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sum -2.5347415551E10 ;

stats:sumOfLogs "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumsq 6.27627676773115E14 ;

stats:variance "190034.95711246505"^^<http://www.w3.org/2001/XMLSchema#double>

];

sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int>

"512"^^<http://www.w3.org/2001/XMLSchema#int>);

sets:dataType <http://www.w3.org/2001/XMLSchema#short> ;

sets:isContainedIn

<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8dec7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph  
D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-  
SwanRiverEstuary\_AUS.v40.100m.hdf> ;

hyperspectral:badData

"-25100"^^<http://www.w3.org/2001/XMLSchema#short> ;

hyperspectral:browseColorTableName

"nrl" ;

hyperspectral:browseFunc

"2"^^<http://www.w3.org/2001/XMLSchema#int> ;

hyperspectral:browseRanges

("0.01"^^<http://www.w3.org/2001/XMLSchema#double>

"2.0"^^<http://www.w3.org/2001/XMLSchema#double>) ;

hyperspectral:productClass

"geophysical parameter" ;

hyperspectral:productName

"Total absorption at 488 nm, QAA algorithm" ;

hyperspectral:productScaling

"Linear" ;

hyperspectral:productStatus

"provisional" ;

hyperspectral:productUnits

"m<sup>-1</sup>" ;

hyperspectral:scalingIntercept

"2.5"^^<http://www.w3.org/2001/XMLSchema#double> ;

hyperspectral:scalingSlope

9.999999747378752E-5 ;

hyperspectral:validRange

(1.0E-4 "5.0"^^<http://www.w3.org/2001/XMLSchema#double>) ;

<http://muckdragon.info/hyperspectral/tags/algorithm#hasAlgorithmTag>

<http://muckdragon.info/hyperspectral/tags/algorithm#qaa> ;

<http://muckdragon.info/hyperspectral/tags/measure#hasMeasurementTag>

<http://muckdragon.info/hyperspectral/tags/measure#absorption> ;

<http://muckdragon.info/hyperspectral/tags/substance#hasSubstanceTag>

<http://muckdragon.info/hyperspectral/tags/substance#total> ;

<http://www.w3.org/ns/prov#wasGeneratedBy>

[ a <http://muckdragon.info/data/processing#ProcessExecution> ;

<http://www.w3.org/ns/prov#generated>

file:a\_488\_qaa ;

<http://www.w3.org/ns/prov#used>

[ a <http://muckdragon.info/data/processing#Algorithm> ;

<http://muckdragon.info/data/processing#name>

"QAA algorithm" ;

<http://muckdragon.info/data/processing#produces>

file:a\_488\_qaa ;

= <http://muckdragon.info/hyperspectral/algorithms/QAA%20algorithm>

]

].

file:chl\_oc3

a <http://www.w3.org/2000/01/rdf-schema#Class> ,

<http://muckdragon.info/data/info#Product> ;

<http://muckdragon.info/data/info#hasMeasurementUnits>

"mg m<sup>-3</sup>" ;

<http://muckdragon.info/data/info#hasStats>

[ stats:geometricMean "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:max "14.455824851989746"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:mean "-19216.15990985464"^^<http://www.w3.org/2001/XMLSchema#double> ;

```

stats:min "-32767.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:n "1024000"^^<http://www.w3.org/2001/XMLSchema#long> ;

stats:populationVariance

    2.604052560828099E8 ;

stats:secondMoment 2.6665498222879734E14 ;

stats:standardDeviation

    "16137.084940752657"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sum -1.967734774769105E10 ;

stats:sumOfLogs "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumsq 6.447780431502579E14 ;

stats:variance 2.6040551038506615E8

];

sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int>
"512"^^<http://www.w3.org/2001/XMLSchema#int>) ;

sets:dataType <http://www.w3.org/2001/XMLSchema#float> ;

sets:isContainedIn

<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8decbc7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph
D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-
SwanRiverEstuary_AUS.v40.100m.hdf> ;

hyperspectral:badData

```

"-32767.0"^^<http://www.w3.org/2001/XMLSchema#float> ;

hyperspectral:browseColorTableName

"nrl" ;

hyperspectral:browseFunc

"2"^^<http://www.w3.org/2001/XMLSchema#int> ;

hyperspectral:browseRanges

("0.01"^^<http://www.w3.org/2001/XMLSchema#double>

"45.0"^^<http://www.w3.org/2001/XMLSchema#double>) ;

hyperspectral:productClass

"geophysical parameter" ;

hyperspectral:productName

"Chlorophyll Concentration, OC3 Algorithm" ;

hyperspectral:productScaling

"Linear" ;

hyperspectral:productStatus

"provisional" ;

hyperspectral:productUnits

"mg m<sup>-3</sup>" ;

hyperspectral:scalingIntercept

```

"0.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

hyperspectral:scalingSlope

"1.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

hyperspectral:validRange

("0.0"^^<http://www.w3.org/2001/XMLSchema#double>
"64.0"^^<http://www.w3.org/2001/XMLSchema#double>) ;

<http://muckdragon.info/hyperspectral/tags/algorithm#hasAlgorithmTag>

<http://muckdragon.info/hyperspectral/tags/algorithm#oc3> ;

<http://muckdragon.info/hyperspectral/tags/measure#hasMeasurementTag>

<http://muckdragon.info/hyperspectral/tags/measure#concentration> ;

<http://muckdragon.info/hyperspectral/tags/substance#hasSubstanceTag>

<http://muckdragon.info/hyperspectral/tags/substance#chlorophyll> ;

<http://www.w3.org/ns/prov#wasGeneratedBy>

[ a <http://muckdragon.info/data/processing#ProcessExecution> ;

<http://www.w3.org/ns/prov#generated>

file:chl_oc3 ;

<http://www.w3.org/ns/prov#used>

[ a <http://muckdragon.info/data/processing#Algorithm> ;

<http://muckdragon.info/data/processing#name>

```



```
    "OC3 Algorithm" ;

    <http://muckdragon.info/data/processing#produces>

    file:chl_oc3 ;

    = <http://muckdragon.info/hyperspectral/algorithms/OC3%20Algorithm>

  ]

].
```

file:Zeu\_lee

```
  a <http://www.w3.org/2000/01/rdf-schema#Class> ,
<http://muckdragon.info/data/info#Product> ;

  <http://muckdragon.info/data/info#hasMeasurementUnits>

  "m" ;

  <http://muckdragon.info/data/info#hasStats>

  [ stats:geometricMean "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

    stats:max "4238.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

    stats:mean "-29928.44678320293"^^<http://www.w3.org/2001/XMLSchema#double> ;

    stats:min "-32767.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

    stats:n "1024000"^^<http://www.w3.org/2001/XMLSchema#long> ;

    stats:populationVariance
```

```
1.2003676391497385E7 ;

stats:secondMoment 1.2291764624893322E13 ;

stats:standardDeviation

"3464.6339076227173"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sum -3.0646729506E10 ;

stats:sumOfLogs "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumsq 9.29500777724434E14 ;

stats:variance 1.2003688113849059E7

];

sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int>
"512"^^<http://www.w3.org/2001/XMLSchema#int>);

sets:dataType <http://www.w3.org/2001/XMLSchema#short> ;

sets:isContainedIn

<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8dec7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph
D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-
SwanRiverEstuary_AUS.v40.100m.hdf> ;

hyperspectral:badData

"-32767"^^<http://www.w3.org/2001/XMLSchema#short> ;

hyperspectral:browseColorTableName

"rev-nrl" ;
```

hyperspectral:browseFunc

"2"^^<http://www.w3.org/2001/XMLSchema#int> ;

hyperspectral:browseRanges

("1.0"^^<http://www.w3.org/2001/XMLSchema#double>

"200.0"^^<http://www.w3.org/2001/XMLSchema#double>) ;

hyperspectral:productClass

"geophysical parameter" ;

hyperspectral:productName

"Euphotic depth, Lee algorithm" ;

hyperspectral:productScaling

"Linear" ;

hyperspectral:productStatus

"provisional" ;

hyperspectral:productUnits

"m" ;

hyperspectral:scalingIntercept

"160.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

hyperspectral:scalingSlope

"0.004999999888241291"^^<http://www.w3.org/2001/XMLSchema#double> ;

hyperspectral:validRange

```
("0.0"^^<http://www.w3.org/2001/XMLSchema#double>
"320.0"^^<http://www.w3.org/2001/XMLSchema#double>);

<http://muckdragon.info/hyperspectral/tags/measure#hasMeasurementTag>

<http://muckdragon.info/hyperspectral/tags/measure#depth>;

<http://www.w3.org/ns/prov#wasGeneratedBy>

[ a <http://muckdragon.info/data/processing#ProcessExecution>;

  <http://www.w3.org/ns/prov#generated>

    file:Zeu_lee;

  <http://www.w3.org/ns/prov#used>

    [ a <http://muckdragon.info/data/processing#Algorithm>;

      <http://muckdragon.info/data/processing#name>

        "Lee algorithm";

      <http://muckdragon.info/data/processing#produces>

        file:Zeu_lee;

      = <http://muckdragon.info/hyperspectral/algorithms/Lee%20algorithm>

    ]

  ].
```

file:vcap\_offset

a <http://www.w3.org/2000/01/rdf-schema#Class> ;

<http://muckdragon.info/data/info#hasStats>

[ stats:geometricMean

"0.20000000298023232"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:max "0.20000000298023224"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:mean "0.20000000298023224"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:min "0.20000000298023224"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:n "9"^^<http://www.w3.org/2001/XMLSchema#long> ;

stats:populationVariance

"0.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:secondMoment "0.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:standardDeviation

"0.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sum "1.8000000268220901"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumOfLogs "-14.48494107779645"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumsq "0.36000001072883614"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:variance "0.0"^^<http://www.w3.org/2001/XMLSchema#double>

];

sets:dataDimensions ("9"^^<http://www.w3.org/2001/XMLSchema#int>);

sets:dataType <http://www.w3.org/2001/XMLSchema#float>;

sets:isContainedIn

<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8dec7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph  
D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-  
SwanRiverEstuary\_AUS.v40.100m.hdf> .

file:ag\_443\_gould

a <http://www.w3.org/2000/01/rdf-schema#Class> ,

<http://muckdragon.info/data/info#Product>;

<http://muckdragon.info/data/info#hasMeasurementUnits>

"m<sup>-1</sup>";

<http://muckdragon.info/data/info#hasStats>

[ stats:geometricMean "NaN"^^<http://www.w3.org/2001/XMLSchema#double>;

stats:max "32767.0"^^<http://www.w3.org/2001/XMLSchema#double>;

stats:mean "-31833.006954101314"^^<http://www.w3.org/2001/XMLSchema#double>;

stats:min "-32100.0"^^<http://www.w3.org/2001/XMLSchema#double>;

stats:n "1024000"^^<http://www.w3.org/2001/XMLSchema#long>;

stats:populationVariance

"165687.51393720857"^^<http://www.w3.org/2001/XMLSchema#double>;

```
stats:secondMoment 1.6966401427170157E11 ;

stats:standardDeviation

    "407.04751042302104"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sum -3.2596999121E10 ;

stats:sumOfLogs "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumsq 1.037830163715907E15 ;

stats:variance "165687.6757415794"^^<http://www.w3.org/2001/XMLSchema#double>

];

sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int>
"512"^^<http://www.w3.org/2001/XMLSchema#int>);

sets:dataType <http://www.w3.org/2001/XMLSchema#short> ;

sets:isContainedIn

<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8dec7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph
D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-
SwanRiverEstuary_AUS.v40.100m.hdf> ;

hyperspectral:badData

    "-32100"^^<http://www.w3.org/2001/XMLSchema#short> ;

hyperspectral:browseColorTableName

    "nrl" ;

hyperspectral:browseFunc
```

"2"^^<http://www.w3.org/2001/XMLSchema#int> ;

hyperspectral:browseRanges

("0.01"^^<http://www.w3.org/2001/XMLSchema#double>

"1.0"^^<http://www.w3.org/2001/XMLSchema#double> ) ;

hyperspectral:productClass

"geophysical parameter" ;

hyperspectral:productName

"Gelbstoff Absorption at 443nm, Gould (200711)" ;

hyperspectral:productScaling

"Linear" ;

hyperspectral:productStatus

"provisional" ;

hyperspectral:productUnits

"m<sup>-1</sup>" ;

hyperspectral:scalingIntercept

"3.200000047683716"^^<http://www.w3.org/2001/XMLSchema#double> ;

hyperspectral:scalingSlope

9.999999747378752E-5 ;

hyperspectral:validRange



(1.0E-4 "5.0"^^<http://www.w3.org/2001/XMLSchema#double>) ;

<http://muckdragon.info/hyperspectral/tags/algorithm#hasAlgorithmTag>

<http://muckdragon.info/hyperspectral/tags/algorithm#gould> ;

<http://muckdragon.info/hyperspectral/tags/measure#hasMeasurementTag>

<http://muckdragon.info/hyperspectral/tags/measure#absorption> ;

<http://www.w3.org/ns/prov#wasGeneratedBy>

[ a <http://muckdragon.info/data/processing#ProcessExecution> ;

<http://www.w3.org/ns/prov#generated>

file:ag\_443\_gould ;

<http://www.w3.org/ns/prov#used>

[ a <http://muckdragon.info/data/processing#Algorithm> ;

<http://muckdragon.info/data/processing#name>

"Gould (200711)" ;

<http://muckdragon.info/data/processing#produces>

file:ag\_443\_gould ;

= <http://muckdragon.info/hyperspectral/algorithms/Gould%20%28200711%29>

]

].

file:slon

a <http://www.w3.org/2000/01/rdf-schema#Class> ;

<http://muckdragon.info/data/info#hasStats>

[ stats:geometricMean

"115.47971926052033"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:max "116.22610473632812"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:mean "115.48052298736572"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:min "114.73446655273438"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:n "2000"^^<http://www.w3.org/2001/XMLSchema#long> ;

stats:populationVariance

"0.18562752317783418"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:secondMoment

"371.25504635566836"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:standardDeviation

"0.4309528783631906"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sum "230961.04597473145"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumOfLogs "9498.18984745194"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumsq 2.667187363391743E7 ;

stats:variance "0.18572038336951893"^^<http://www.w3.org/2001/XMLSchema#double>

```

];

sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int>);

sets:dataType <http://www.w3.org/2001/XMLSchema#float>;

sets:isContainedIn

<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8dec7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph
D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-
SwanRiverEstuary_AUS.v40.100m.hdf> .

file:adg_531_qaa

a <http://www.w3.org/2000/01/rdf-schema#Class> ,
<http://muckdragon.info/data/info#Product>;

<http://muckdragon.info/data/info#hasMeasurementUnits>

"m^-1";

<http://muckdragon.info/data/info#hasStats>

[ stats:geometricMean "NaN"^^<http://www.w3.org/2001/XMLSchema#double>;

stats:max "-23628.0"^^<http://www.w3.org/2001/XMLSchema#double>;

stats:mean "-32025.253307617266"^^<http://www.w3.org/2001/XMLSchema#double>;

stats:min "-32100.0"^^<http://www.w3.org/2001/XMLSchema#double>;

stats:n "1024000"^^<http://www.w3.org/2001/XMLSchema#long>;

stats:populationVariance

```

```
"8919.908896730018"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:secondMoment 9.133986710251537E9 ;

stats:standardDeviation

"94.44531543484334"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sum -3.2793859387E10 ;

stats:sumOfLogs "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumsq 1.050240787789765E15 ;

stats:variance "8919.917607587056"^^<http://www.w3.org/2001/XMLSchema#double>

];

sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int>
"512"^^<http://www.w3.org/2001/XMLSchema#int>);

sets:dataType <http://www.w3.org/2001/XMLSchema#short> ;

sets:isContainedIn

<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8dec7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph
D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-
SwanRiverEstuary_AUS.v40.100m.hdf> ;

hyperspectral:badData

"-32100"^^<http://www.w3.org/2001/XMLSchema#short> ;

hyperspectral:browseColorTableName

"nrl" ;
```

hyperspectral:browseFunc

"0"^^<http://www.w3.org/2001/XMLSchema#int> ;

hyperspectral:browseRanges

(1.0E-4 "0.025"^^<http://www.w3.org/2001/XMLSchema#double>) ;

hyperspectral:productClass

"geophysical parameter" ;

hyperspectral:productName

"Absorption due to gelbstof and detrital material at 531 nm, QAA algorithm" ;

hyperspectral:productScaling

"Linear" ;

hyperspectral:productStatus

"provisional" ;

hyperspectral:productUnits

"m<sup>-1</sup>" ;

hyperspectral:scalingIntercept

"3.200000047683716"^^<http://www.w3.org/2001/XMLSchema#double> ;

hyperspectral:scalingSlope

9.999999747378752E-5 ;

hyperspectral:validRange

```

(1.0E-4 "5.0"^^<http://www.w3.org/2001/XMLSchema#double>) ;

<http://muckdragon.info/hyperspectral/tags/algorithm#hasAlgorithmTag>

  <http://muckdragon.info/hyperspectral/tags/algorithm#qaa> ;

<http://muckdragon.info/hyperspectral/tags/measure#hasMeasurementTag>

  <http://muckdragon.info/hyperspectral/tags/measure#absorption> ;

<http://muckdragon.info/hyperspectral/tags/substance#hasSubstanceTag>

  <http://muckdragon.info/hyperspectral/tags/substance#detrital> ;

<http://www.w3.org/ns/prov#wasGeneratedBy>

  [ a   <http://muckdragon.info/data/processing#ProcessExecution> ;

    <http://www.w3.org/ns/prov#generated>

      file:adg_531_qaa ;

    <http://www.w3.org/ns/prov#used>

      [ a   <http://muckdragon.info/data/processing#Algorithm> ;

        <http://muckdragon.info/data/processing#name>

          "QAA algorithm" ;

        <http://muckdragon.info/data/processing#produces>

          file:adg_531_qaa ;

        =   <http://muckdragon.info/hyperspectral/algorithms/QAA%20algorithm>

      ]

  ]

```

].

file:TSS\_gould

```
a <http://www.w3.org/2000/01/rdf-schema#Class> ,
<http://muckdragon.info/data/info#Product> ;

<http://muckdragon.info/data/info#hasMeasurementUnits>

"mg l^-1" ;

<http://muckdragon.info/data/info#hasStats>

[ stats:geometricMean "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:max "-8737.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:mean "-19641.389668944947"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:min "-20010.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:n "1024000"^^<http://www.w3.org/2001/XMLSchema#long> ;

stats:populationVariance

"243694.9452119355"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:secondMoment 2.4954362389702194E11 ;

stats:standardDeviation

"493.6549231958624"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sum -2.0112783021E10 ;
```

```
stats:sumOfLogs "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumsq 3.95292552266305E14 ;

stats:variance "243695.18319551283"^^<http://www.w3.org/2001/XMLSchema#double>

];

sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int>
"512"^^<http://www.w3.org/2001/XMLSchema#int>);

sets:dataType <http://www.w3.org/2001/XMLSchema#short> ;

sets:isContainedIn
<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8dec7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph
D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-
SwanRiverEstuary_AUS.v40.100m.hdf> ;

hyperspectral:badData

"-20010"^^<http://www.w3.org/2001/XMLSchema#short> ;

hyperspectral:browseColorTableName

"nrl" ;

hyperspectral:browseFunc

"2"^^<http://www.w3.org/2001/XMLSchema#int> ;

hyperspectral:browseRanges

("0.01"^^<http://www.w3.org/2001/XMLSchema#double>
"15.0"^^<http://www.w3.org/2001/XMLSchema#double>);
```



hyperspectral:productClass

"geophysical parameter" ;

hyperspectral:productName

"Total Suspended Particles (PIM+POM), Gould (200711)" ;

hyperspectral:productScaling

"Linear" ;

hyperspectral:productStatus

"provisional" ;

hyperspectral:productUnits

"mg l<sup>-1</sup>" ;

hyperspectral:scalingIntercept

"20.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

hyperspectral:scalingSlope

"0.0010000000474974513"^^<http://www.w3.org/2001/XMLSchema#double> ;

hyperspectral:validRange

("0.001"^^<http://www.w3.org/2001/XMLSchema#double>

"40.0"^^<http://www.w3.org/2001/XMLSchema#double>) ;

<http://muckdragon.info/hyperspectral/tags/algorithm#hasAlgorithmTag>

<http://muckdragon.info/hyperspectral/tags/algorithm#gould> ;

<http://muckdragon.info/hyperspectral/tags/substance#hasSubstanceTag>

<http://muckdragon.info/hyperspectral/tags/substance#total> ,

<http://muckdragon.info/hyperspectral/tags/substance#particles> ;

<http://www.w3.org/ns/prov#wasGeneratedBy>

[ a <http://muckdragon.info/data/processing#ProcessExecution> ;

<http://www.w3.org/ns/prov#generated>

file:TSS\_gould ;

<http://www.w3.org/ns/prov#used>

[ a <http://muckdragon.info/data/processing#Algorithm> ;

<http://muckdragon.info/data/processing#name>

"Gould (200711)" ;

<http://muckdragon.info/data/processing#produces>

file:TSS\_gould ;

= <http://muckdragon.info/hyperspectral/algorithms/Gould%20%28200711%29>

]

].

file:adg\_667\_qaa

```

a    <http://www.w3.org/2000/01/rdf-schema#Class> ,
<http://muckdragon.info/data/info#Product> ;

<http://muckdragon.info/data/info#hasMeasurementUnits>

    "m^-1" ;

<http://muckdragon.info/data/info#hasStats>

    [ stats:geometricMean "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

      stats:max "-31294.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

      stats:mean "-32054.97721191344"^^<http://www.w3.org/2001/XMLSchema#double> ;

      stats:min "-32100.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

      stats:n "1024000"^^<http://www.w3.org/2001/XMLSchema#long> ;

      stats:populationVariance

          "2884.0359914775267"^^<http://www.w3.org/2001/XMLSchema#double> ;

      stats:secondMoment 2.9532528552729874E9 ;

      stats:standardDeviation

          "53.703247647806876"^^<http://www.w3.org/2001/XMLSchema#double> ;

      stats:sum -3.2824296665E10 ;

      stats:sumOfLogs "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

      stats:sumsq 1.052185034846537E15 ;

      stats:variance "2884.038807921675"^^<http://www.w3.org/2001/XMLSchema#double>

```

```

];

sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int>
"512"^^<http://www.w3.org/2001/XMLSchema#int>);

sets:dataType <http://www.w3.org/2001/XMLSchema#short>;

sets:isContainedIn
<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8dec7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph
D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-
SwanRiverEstuary_AUS.v40.100m.hdf>;

hyperspectral:badData
"-32100"^^<http://www.w3.org/2001/XMLSchema#short>;

hyperspectral:browseColorTableName
"nrl";

hyperspectral:browseFunc
"0"^^<http://www.w3.org/2001/XMLSchema#int>;

hyperspectral:browseRanges
(1.0E-4 "0.025"^^<http://www.w3.org/2001/XMLSchema#double>);

hyperspectral:productClass
"geophysical parameter";

hyperspectral:productName
"Absorption due to gelbstof and detrital material at 667 nm, QAA algorithm";

```

hyperspectral:productScaling

"Linear" ;

hyperspectral:productStatus

"provisional" ;

hyperspectral:productUnits

"m<sup>-1</sup>" ;

hyperspectral:scalingIntercept

"3.200000047683716"^^<http://www.w3.org/2001/XMLSchema#double> ;

hyperspectral:scalingSlope

9.999999747378752E-5 ;

hyperspectral:validRange

(1.0E-4 "5.0"^^<http://www.w3.org/2001/XMLSchema#double>) ;

<http://muckdragon.info/hyperspectral/tags/algorithm#hasAlgorithmTag>

<http://muckdragon.info/hyperspectral/tags/algorithm#qaa> ;

<http://muckdragon.info/hyperspectral/tags/measure#hasMeasurementTag>

<http://muckdragon.info/hyperspectral/tags/measure#absorption> ;

<http://muckdragon.info/hyperspectral/tags/substance#hasSubstanceTag>

<http://muckdragon.info/hyperspectral/tags/substance#detrital> ;

<http://www.w3.org/ns/prov#wasGeneratedBy>

```

[ a   <http://muckdragon.info/data/processing#ProcessExecution> ;

      <http://www.w3.org/ns/prov#generated>

      file:adg_667_qaa ;

      <http://www.w3.org/ns/prov#used>

      [ a   <http://muckdragon.info/data/processing#Algorithm> ;

          <http://muckdragon.info/data/processing#name>

          "QAA algorithm" ;

          <http://muckdragon.info/data/processing#produces>

          file:adg_667_qaa ;

          =   <http://muckdragon.info/hyperspectral/algorithms/QAA%20algorithm>

        ]

    ] .

```

file:a\_678\_qaa

```

a   <http://www.w3.org/2000/01/rdf-schema#Class> ,

<http://muckdragon.info/data/info#Product> ;

<http://muckdragon.info/data/info#hasMeasurementUnits>

"m^-1" ;

<http://muckdragon.info/data/info#hasStats>

```

```

[ stats:geometricMean "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:max "32767.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:mean "-22836.840805665342"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:min "-25100.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:n "1024000"^^<http://www.w3.org/2001/XMLSchema#long> ;

stats:populationVariance

    "7266740.005789948"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:secondMoment 7.441141765928906E12 ;

stats:standardDeviation

    "2695.6904685483946"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sum -2.3384924985E10 ;

stats:sumOfLogs "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumsq 5.41478950900771E14 ;

stats:variance "7266747.102222664"^^<http://www.w3.org/2001/XMLSchema#double>

];

sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int>
"512"^^<http://www.w3.org/2001/XMLSchema#int>);

sets:dataType <http://www.w3.org/2001/XMLSchema#short> ;

```

sets:isContainedIn

<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8dec7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph  
D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-  
SwanRiverEstuary\_AUS.v40.100m.hdf> ;

hyperspectral:badData

"-25100"^^<http://www.w3.org/2001/XMLSchema#short> ;

hyperspectral:browseColorTableName

"nrl" ;

hyperspectral:browseFunc

"1"^^<http://www.w3.org/2001/XMLSchema#int> ;

hyperspectral:browseRanges

("0.01"^^<http://www.w3.org/2001/XMLSchema#double>

"2.0"^^<http://www.w3.org/2001/XMLSchema#double>);

hyperspectral:productClass

"geophysical parameter" ;

hyperspectral:productName

"Total absorption at 678 nm, QAA algorithm" ;

hyperspectral:productScaling

"Linear" ;

hyperspectral:productStatus



"provisional" ;

hyperspectral:productUnits

"m<sup>-1</sup>" ;

hyperspectral:scalingIntercept

"2.5"^^<http://www.w3.org/2001/XMLSchema#double> ;

hyperspectral:scalingSlope

9.999999747378752E-5 ;

hyperspectral:validRange

(1.0E-4 "5.0"^^<http://www.w3.org/2001/XMLSchema#double>) ;

<http://muckdragon.info/hyperspectral/tags/algorithm#hasAlgorithmTag>

<http://muckdragon.info/hyperspectral/tags/algorithm#qaa> ;

<http://muckdragon.info/hyperspectral/tags/measure#hasMeasurementTag>

<http://muckdragon.info/hyperspectral/tags/measure#absorption> ;

<http://muckdragon.info/hyperspectral/tags/substance#hasSubstanceTag>

<http://muckdragon.info/hyperspectral/tags/substance#total> ;

<http://www.w3.org/ns/prov#wasGeneratedBy>

[ a <http://muckdragon.info/data/processing#ProcessExecution> ;

<http://www.w3.org/ns/prov#generated>

file:a\_678\_qaa ;

<http://www.w3.org/ns/prov#used>

[ a <http://muckdragon.info/data/processing#Algorithm> ;

<http://muckdragon.info/data/processing#name>

"QAA algorithm" ;

<http://muckdragon.info/data/processing#produces>

file:a\_678\_qaa ;

= <http://muckdragon.info/hyperspectral/algorithms/QAA%20algorithm>

]

].

file:msec

a <http://www.w3.org/2000/01/rdf-schema#Class> ;

<http://muckdragon.info/data/info#hasStats>

[ stats:geometricMean 3.2347000000004295E7 ;

stats:max 3.2347E7 ;

stats:mean 3.2347E7 ;

stats:min 3.2347E7 ;

stats:n "2000"^^<http://www.w3.org/2001/XMLSchema#long> ;

stats:populationVariance

```

"0.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:secondMoment "0.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:standardDeviation

"0.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sum 6.4694E10 ;

stats:sumOfLogs "34584.0636778157"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumsq 2.09265681799990733E18 ;

stats:variance "0.0"^^<http://www.w3.org/2001/XMLSchema#double>

];

sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int>);

sets:dataType <http://www.w3.org/2001/XMLSchema#int> ;

sets:isContainedIn

<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8decbc7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph
D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-
SwanRiverEstuary_AUS.v40.100m.hdf> .

file:rrs_748

a <http://www.w3.org/2000/01/rdf-schema#Class> ;

<http://muckdragon.info/data/info#hasStats>

```

```
[ stats:geometricMean "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:max "-23174.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:mean "-29532.21874902356"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:min "-32767.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:n "1024000"^^<http://www.w3.org/2001/XMLSchema#long> ;

stats:populationVariance

    1.4782153922438748E7 ;

stats:secondMoment 1.5136925616577277E13 ;

stats:standardDeviation

    "3844.7585565481268"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sum -3.0240991999E10 ;

stats:sumOfLogs "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumsq 9.08220516518515E14 ;

stats:variance 1.4782168358150035E7

];

sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int>
"512"^^<http://www.w3.org/2001/XMLSchema#int>);

sets:dataType <http://www.w3.org/2001/XMLSchema#short> ;
```

sets:isContainedIn

<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8decbc7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph  
D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-  
SwanRiverEstuary\_AUS.v40.100m.hdf> ;

hyperspectral:badData

"-30000"^^<http://www.w3.org/2001/XMLSchema#short> ;

hyperspectral:browseColorTableName

"neg" ;

hyperspectral:browseFunc

"0"^^<http://www.w3.org/2001/XMLSchema#int> ;

hyperspectral:browseRanges

("-0.03"^^<http://www.w3.org/2001/XMLSchema#double>

"0.03"^^<http://www.w3.org/2001/XMLSchema#double>) ;

hyperspectral:productClass

"geophysical parameter" ;

hyperspectral:productName

"Remote sensing reflectance at 748 nm" ;

hyperspectral:productScaling

"Linear" ;

hyperspectral:productStatus

"provisional" ;

hyperspectral:productUnits

"sr<sup>-1</sup>" ;

hyperspectral:scalingIntercept

"0.05000000074505806"^^<http://www.w3.org/2001/XMLSchema#double> ;

hyperspectral:scalingSlope

1.9999999949504854E-6 ;

hyperspectral:validRange

(2.0E-6 "0.04"^^<http://www.w3.org/2001/XMLSchema#double>) ;

<http://muckdragon.info/hyperspectral/tags/measure#hasMeasurementTag>

<http://muckdragon.info/hyperspectral/tags/measure#reflectance> .

file:bb\_443\_qaa

a <http://www.w3.org/2000/01/rdf-schema#Class> ,

<http://muckdragon.info/data/info#Product> ;

<http://muckdragon.info/data/info#hasMeasurementUnits>

"m<sup>-1</sup>" ;

<http://muckdragon.info/data/info#hasStats>

[ stats:geometricMean "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

```
stats:max "4554.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:mean "-26729.210980469055"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:min "-28020.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:n "1024000"^^<http://www.w3.org/2001/XMLSchema#long> ;

stats:populationVariance

    "2780892.467100451"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:secondMoment 2.847633886310862E12 ;

stats:standardDeviation

    "1667.6016259342045"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sum -2.7370712044E10 ;

stats:sumOfLogs "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumsq 7.34445170796044E14 ;

stats:variance "2780895.182818403"^^<http://www.w3.org/2001/XMLSchema#double>

];

sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int>

"512"^^<http://www.w3.org/2001/XMLSchema#int>);

sets:dataType <http://www.w3.org/2001/XMLSchema#short> ;

sets:isContainedIn

<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8dec7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph
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D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-  
SwanRiverEstuary\_AUS.v40.100m.hdf> ;

hyperspectral:badData

"-28020"^^<http://www.w3.org/2001/XMLSchema#short> ;

hyperspectral:browseColorTableName

"nrl" ;

hyperspectral:browseFunc

"2"^^<http://www.w3.org/2001/XMLSchema#int> ;

hyperspectral:browseRanges

(5.0E-4 "0.5"^^<http://www.w3.org/2001/XMLSchema#double>) ;

hyperspectral:productClass

"geophysical parameter" ;

hyperspectral:productName

"Total backscatter at 443 nm, QAA algorithm" ;

hyperspectral:productScaling

"Linear" ;

hyperspectral:productStatus

"provisional" ;

hyperspectral:productUnits



"m^-1" ;

hyperspectral:scalingIntercept

"0.14000000059604645"^^<http://www.w3.org/2001/XMLSchema#double> ;

hyperspectral:scalingSlope

4.999999873689376E-6 ;

hyperspectral:validRange

(5.0E-6 "1.0"^^<http://www.w3.org/2001/XMLSchema#double>) ;

<http://muckdragon.info/hyperspectral/tags/algorithm#hasAlgorithmTag>

<http://muckdragon.info/hyperspectral/tags/algorithm#qaa> ;

<http://muckdragon.info/hyperspectral/tags/measure#hasMeasurementTag>

<http://muckdragon.info/hyperspectral/tags/measure#backscatter> ;

<http://muckdragon.info/hyperspectral/tags/substance#hasSubstanceTag>

<http://muckdragon.info/hyperspectral/tags/substance#total> ;

<http://www.w3.org/ns/prov#wasGeneratedBy>

[ a <http://muckdragon.info/data/processing#ProcessExecution> ;

<http://www.w3.org/ns/prov#generated>

file:bb\_443\_qaa ;

<http://www.w3.org/ns/prov#used>

[ a <http://muckdragon.info/data/processing#Algorithm> ;

<http://muckdragon.info/data/processing#name>

"QAA algorithm" ;

<http://muckdragon.info/data/processing#produces>

file:bb\_443\_qaa ;

= <http://muckdragon.info/hyperspectral/algorithms/QAA%20algorithm>

]

].

<http://muckdragon.info/data/processing#Algorithm>

a <http://www.w3.org/2000/01/rdf-schema#Class> ;

<http://www.w3.org/2000/01/rdf-schema#subClassOf>

<http://www.w3.org/ns/prov#Agent> .

<http://muckdragon.info/hyperspectral/tags/substance#total>

<http://muckdragon.info/hyperspectral/tags/substance#name>

"total" .

<http://muckdragon.info/hyperspectral/tags/measure#reflectance>

<http://muckdragon.info/hyperspectral/tags/measure#name>

"reflectance" .

<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8dec7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph  
D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-  
SwanRiverEstuary\_AUS.v40.100m.hdf>

a <http://www.w3.org/2000/01/rdf-schema#Class> ;

<http://muckdragon.info/data/space#hasBoundingBox>

([ <http://www.w3.org/2003/01/geo/wgs84\_pos#lat>

"114.73446655273438"^^<http://www.w3.org/2001/XMLSchema#double> ;

<http://www.w3.org/2003/01/geo/wgs84\_pos#long>

"-30.88399887084961"^^<http://www.w3.org/2001/XMLSchema#double>

] [ <http://www.w3.org/2003/01/geo/wgs84\_pos#lat>

"116.6244888305664"^^<http://www.w3.org/2001/XMLSchema#double> ;

<http://www.w3.org/2003/01/geo/wgs84\_pos#long>

"-30.88399887084961"^^<http://www.w3.org/2001/XMLSchema#double>

] [ <http://www.w3.org/2003/01/geo/wgs84\_pos#lat>

"116.6244888305664"^^<http://www.w3.org/2001/XMLSchema#double> ;

<http://www.w3.org/2003/01/geo/wgs84\_pos#long>

"-32.54011535644531"^^<http://www.w3.org/2001/XMLSchema#double>

] [ <http://www.w3.org/2003/01/geo/wgs84\_pos#lat>

"114.73446655273438"^^<http://www.w3.org/2001/XMLSchema#double> ;

<http://www.w3.org/2003/01/geo/wgs84\_pos#long>

"-32.54011535644531"^^<http://www.w3.org/2001/XMLSchema#double>

]);

hyperspectral:HDF4\_Version

"4.2.7 (HDF Version 4.2 Release 7, February 6, 2012)" ;

hyperspectral:\_History

"Direct read of HDF4 file through CDM library" ;

hyperspectral:createAgency

"Naval Research Laboratory, Stennis Space Center" ;

hyperspectral:createPlatform

"x86\_64-unknown-linux-gnu" ;

hyperspectral:createSoftware

"APS v4.10.0" ;

hyperspectral:createTime

"Thu Jan 17 19:40:24 2013" ;

hyperspectral:file "iss.2013014.0114.085907.D.L2.hico-modis.12427-

SwanRiverEstuary\_AUS.v40.100m.hdf" ;

hyperspectral:fileClassification

"UNCLASSIFIED" ;

hyperspectral:fileStatus

"EXPERIMENTAL" ;

hyperspectral:fileTitle

"NRL Level-2 Data" ;

hyperspectral:fileVersion

"3.3" ;

hyperspectral:inputMasks

"CLDICE,LAND,ATMFAIL,HILT" ;

hyperspectral:inputMasksInt

"531"^^<http://www.w3.org/2001/XMLSchema#int> ;

hyperspectral:localeLowerLeft

("-32.54011535644531"^^<http://www.w3.org/2001/XMLSchema#double>

"116.22685241699219"^^<http://www.w3.org/2001/XMLSchema#double>) ;

hyperspectral:localeLowerRight

("-32.101707458496094"^^<http://www.w3.org/2001/XMLSchema#double>

"116.6244888305664"^^<http://www.w3.org/2001/XMLSchema#double>) ;

hyperspectral:localeNECorner

("-30.88399887084961"^^<http://www.w3.org/2001/XMLSchema#double>  
"116.6244888305664"^^<http://www.w3.org/2001/XMLSchema#double>);

hyperspectral:localeNWCorner

("-30.88399887084961"^^<http://www.w3.org/2001/XMLSchema#double>  
"114.73446655273438"^^<http://www.w3.org/2001/XMLSchema#double>);

hyperspectral:localeSECorner

("-32.54011535644531"^^<http://www.w3.org/2001/XMLSchema#double>  
"116.6244888305664"^^<http://www.w3.org/2001/XMLSchema#double>);

hyperspectral:localeSWCorner

("-32.54011535644531"^^<http://www.w3.org/2001/XMLSchema#double>  
"114.73446655273438"^^<http://www.w3.org/2001/XMLSchema#double>);

hyperspectral:localeUpperLeft

("-31.32134246826172"^^<http://www.w3.org/2001/XMLSchema#double>  
"114.73446655273438"^^<http://www.w3.org/2001/XMLSchema#double>);

hyperspectral:localeUpperRight

("-30.88399887084961"^^<http://www.w3.org/2001/XMLSchema#double>  
"115.12643432617188"^^<http://www.w3.org/2001/XMLSchema#double>);

hyperspectral:processedVersion

"40";

hyperspectral:prodList

"TSS\_gould,PIM\_gould,POM\_gould,water\_mass,chl\_oc3,true\_color,rrs\_412,rrs\_443,rrs\_488,rrs\_531,rrs\_547,rrs\_667,rrs\_678,rrs\_748,rrs\_869,a\_412\_qaa,a\_443\_qaa,a\_488\_qaa,a\_531\_qaa,a\_547\_qaa,a\_667\_qaa,a\_678\_qaa,bb\_412\_qaa,bb\_443\_qaa,bb\_488\_qaa,bb\_531\_qaa,bb\_547\_qaa,bb\_667\_qaa,bb\_678\_qaa,Kd\_490,Zeu\_lee,horiz\_vis,vert\_vis,aph\_412\_qaa,aph\_443\_qaa,aph\_488\_qaa,aph\_531\_qaa,aph\_547\_qaa,aph\_667\_qaa,adg\_412\_qaa,adg\_443\_qaa,adg\_488\_qaa,adg\_531\_qaa,adg\_547\_qaa,adg\_667\_qaa,c\_531\_qaa,c\_667\_qaa,c\_678\_qaa,aph\_443\_gould,ag\_443\_gould,ag\_412\_gould,asd\_412\_gould,asd\_443\_gould,Kd\_488\_lee,latitudes,longitudes,l2\_flags" ;

hyperspectral:sensor

"hico/modis" ;

hyperspectral:sensorAgency

"NRL" ;

hyperspectral:sensorBandUnits

"nano meters" ;

hyperspectral:sensorBands

("412.0"^^<http://www.w3.org/2001/XMLSchema#double>

"443.0"^^<http://www.w3.org/2001/XMLSchema#double>

"488.0"^^<http://www.w3.org/2001/XMLSchema#double>

"510.0"^^<http://www.w3.org/2001/XMLSchema#double>

"547.0"^^<http://www.w3.org/2001/XMLSchema#double>

"667.0"^^<http://www.w3.org/2001/XMLSchema#double>

"678.0"^^<http://www.w3.org/2001/XMLSchema#double>

"748.0"^^<http://www.w3.org/2001/XMLSchema#double>

"865.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

hyperspectral:sensorNumberOfBands

"9"^^<http://www.w3.org/2001/XMLSchema#int> ;

hyperspectral:sensorPlatform

"iss" ;

hyperspectral:sensorResolutionInKM

"0.1"^^<http://www.w3.org/2001/XMLSchema#double> ;

hyperspectral:sensorSpectrum

"Visible" ;

hyperspectral:sensorType

"pushbroom" ;

hyperspectral:targetAOS

"" ;

hyperspectral:targetAngle

"0.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

hyperspectral:targetID

"0"^^<http://www.w3.org/2001/XMLSchema#int> ;

hyperspectral:targetName



"" ;

hyperspectral:targetType

"" ;

hyperspectral:timeDayNight

"Day" ;

hyperspectral:timeEnd

"Mon Jan 14 08:59:07 2013" ;

hyperspectral:timeEndDay

"14"^^<<http://www.w3.org/2001/XMLSchema#int>> ;

hyperspectral:timeEndTime

"32347000"^^<<http://www.w3.org/2001/XMLSchema#int>> ;

hyperspectral:timeEndYear

"2013"^^<<http://www.w3.org/2001/XMLSchema#int>> ;

hyperspectral:timeStart

"Mon Jan 14 08:59:07 2013" ;

hyperspectral:timeStartDay

"14"^^<<http://www.w3.org/2001/XMLSchema#int>> ;

hyperspectral:timeStartTime

"32347000"^^<<http://www.w3.org/2001/XMLSchema#int>> ;

hyperspectral:timeStartYear

"2013"^^<http://www.w3.org/2001/XMLSchema#int> ;

= <file://C:\Users\shaw\Desktop\PhD Work\Hyperspectral Use

Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-SwanRiverEstuary\_AUS.v40.100m.hdf> ;

<http://www.w3.org/ns/prov#endedAtTime>

"2013-01-14T08:59:07"^^<http://www.w3.org/2001/XMLSchema#dateTime> ;

<http://www.w3.org/ns/prov#startedAtTime>

"2013-01-14T08:59:07"^^<http://www.w3.org/2001/XMLSchema#dateTime> .

file:adg\_547\_qaa

a <http://www.w3.org/2000/01/rdf-schema#Class> ,

<http://muckdragon.info/data/info#Product> ;

<http://muckdragon.info/data/info#hasMeasurementUnits>

"m^-1" ;

<http://muckdragon.info/data/info#hasStats>

[ stats:geometricMean "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:max "-25741.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:mean "-32032.89564941355"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:min "-32100.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

```
stats:n "1024000"^^<http://www.w3.org/2001/XMLSchema#long> ;

stats:populationVariance

    "6960.561735022788"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:secondMoment 7.127615216663335E9 ;

stats:standardDeviation

    "83.43002176946256"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sum -3.2801685145E10 ;

stats:sumOfLogs "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumsq 1.050740084989937E15 ;

stats:variance "6960.568532452995"^^<http://www.w3.org/2001/XMLSchema#double>

];

sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int>

"512"^^<http://www.w3.org/2001/XMLSchema#int>);

sets:dataType <http://www.w3.org/2001/XMLSchema#short> ;

sets:isContainedIn

<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8dec7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph

D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-

SwanRiverEstuary_AUS.v40.100m.hdf> ;

hyperspectral:badData

    "-32100"^^<http://www.w3.org/2001/XMLSchema#short> ;
```

hyperspectral:browseColorTableName

"nrl" ;

hyperspectral:browseFunc

"0"^^<http://www.w3.org/2001/XMLSchema#int> ;

hyperspectral:browseRanges

(1.0E-4 "0.025"^^<http://www.w3.org/2001/XMLSchema#double>) ;

hyperspectral:productClass

"geophysical parameter" ;

hyperspectral:productName

"Absorption due to gelbstof and detrital material at 547 nm, QAA algorithm" ;

hyperspectral:productScaling

"Linear" ;

hyperspectral:productStatus

"provisional" ;

hyperspectral:productUnits

"m<sup>-1</sup>" ;

hyperspectral:scalingIntercept

"3.200000047683716"^^<http://www.w3.org/2001/XMLSchema#double> ;

hyperspectral:scalingSlope

9.999999747378752E-5 ;

hyperspectral:validRange

(1.0E-4 "5.0"^^<http://www.w3.org/2001/XMLSchema#double>) ;

<http://muckdragon.info/hyperspectral/tags/algorithm#hasAlgorithmTag>

<http://muckdragon.info/hyperspectral/tags/algorithm#qaa> ;

<http://muckdragon.info/hyperspectral/tags/measure#hasMeasurementTag>

<http://muckdragon.info/hyperspectral/tags/measure#absorption> ;

<http://muckdragon.info/hyperspectral/tags/substance#hasSubstanceTag>

<http://muckdragon.info/hyperspectral/tags/substance#detrital> ;

<http://www.w3.org/ns/prov#wasGeneratedBy>

[ a <http://muckdragon.info/data/processing#ProcessExecution> ;

<http://www.w3.org/ns/prov#generated>

file:adg\_547\_qaa ;

<http://www.w3.org/ns/prov#used>

[ a <http://muckdragon.info/data/processing#Algorithm> ;

<http://muckdragon.info/data/processing#name>

"QAA algorithm" ;

<http://muckdragon.info/data/processing#produces>

file:adg\_547\_qaa ;

```
    = <http://muckdragon.info/hyperspectral/algorithms/QAA%20algorithm>
  ]
].
```

file:a\_531\_qaa

```
  a <http://www.w3.org/2000/01/rdf-schema#Class> ,
<http://muckdragon.info/data/info#Product> ;

<http://muckdragon.info/data/info#hasMeasurementUnits>

  "m^-1" ;

<http://muckdragon.info/data/info#hasStats>

  [ stats:geometricMean "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

  stats:max "-17108.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

  stats:mean "-24729.930656249857"^^<http://www.w3.org/2001/XMLSchema#double> ;

  stats:min "-25100.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

  stats:n "1024000"^^<http://www.w3.org/2001/XMLSchema#long> ;

  stats:populationVariance

    "202276.47932428718"^^<http://www.w3.org/2001/XMLSchema#double> ;

  stats:secondMoment 2.0713111482807007E11 ;

  stats:standardDeviation
```

```
"449.75179472694094"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sum -2.5323448992E10 ;

stats:sumOfLogs "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumsq 6.26454268664072E14 ;

stats:variance "202276.67686010443"^^<http://www.w3.org/2001/XMLSchema#double>

];

sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int>
"512"^^<http://www.w3.org/2001/XMLSchema#int>);

sets:dataType <http://www.w3.org/2001/XMLSchema#short> ;

sets:isContainedIn

<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8dec7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph
D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-
SwanRiverEstuary_AUS.v40.100m.hdf> ;

hyperspectral:badData

"-25100"^^<http://www.w3.org/2001/XMLSchema#short> ;

hyperspectral:browseColorTableName

"nrl" ;

hyperspectral:browseFunc

"2"^^<http://www.w3.org/2001/XMLSchema#int> ;

hyperspectral:browseRanges
```

```
("0.01"^^<http://www.w3.org/2001/XMLSchema#double>
"2.0"^^<http://www.w3.org/2001/XMLSchema#double>);

hyperspectral:productClass

    "geophysical parameter" ;

hyperspectral:productName

    "Total absorption at 531 nm, QAA algorithm" ;

hyperspectral:productScaling

    "Linear" ;

hyperspectral:productStatus

    "provisional" ;

hyperspectral:productUnits

    "m^-1" ;

hyperspectral:scalingIntercept

    "2.5"^^<http://www.w3.org/2001/XMLSchema#double> ;

hyperspectral:scalingSlope

    9.999999747378752E-5 ;

hyperspectral:validRange

    (1.0E-4 "5.0"^^<http://www.w3.org/2001/XMLSchema#double>);

<http://muckdragon.info/hyperspectral/tags/algorithm#hasAlgorithmTag>
```



<http://muckdragon.info/hyperspectral/tags/algorithm#qaa> ;

<http://muckdragon.info/hyperspectral/tags/measure#hasMeasurementTag>

<http://muckdragon.info/hyperspectral/tags/measure#absorption> ;

<http://muckdragon.info/hyperspectral/tags/substance#hasSubstanceTag>

<http://muckdragon.info/hyperspectral/tags/substance#total> ;

<http://www.w3.org/ns/prov#wasGeneratedBy>

[ a <http://muckdragon.info/data/processing#ProcessExecution> ;

<http://www.w3.org/ns/prov#generated>

file:a\_531\_qaa ;

<http://www.w3.org/ns/prov#used>

[ a <http://muckdragon.info/data/processing#Algorithm> ;

<http://muckdragon.info/data/processing#name>

"QAA algorithm" ;

<http://muckdragon.info/data/processing#produces>

file:a\_531\_qaa ;

= <http://muckdragon.info/hyperspectral/algorithms/QAA%20algorithm>

]

].

file:bb\_412\_qaa

```
a    <http://www.w3.org/2000/01/rdf-schema#Class> ,
<http://muckdragon.info/data/info#Product> ;

<http://muckdragon.info/data/info#hasMeasurementUnits>

    "m^-1" ;

<http://muckdragon.info/data/info#hasStats>

    [ stats:geometricMean "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

      stats:max "5717.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

      stats:mean "-26575.206138671678"^^<http://www.w3.org/2001/XMLSchema#double> ;

      stats:min "-28020.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

      stats:n "1024000"^^<http://www.w3.org/2001/XMLSchema#long> ;

      stats:populationVariance

        "3401112.7328795153"^^<http://www.w3.org/2001/XMLSchema#double> ;

      stats:secondMoment 3.4827394384686235E12 ;

      stats:standardDeviation

        "1844.211499335668"^^<http://www.w3.org/2001/XMLSchema#double> ;

      stats:sum -2.7213011086E10 ;

      stats:sumOfLogs "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

      stats:sumsq 7.26674118702882E14 ;
```

```
stats:variance "3401116.054281912"^^<http://www.w3.org/2001/XMLSchema#double>

];

sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int>
"512"^^<http://www.w3.org/2001/XMLSchema#int>);

sets:dataType <http://www.w3.org/2001/XMLSchema#short>;

sets:isContainedIn
<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8decbc7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph
D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-
SwanRiverEstuary_AUS.v40.100m.hdf>;

hyperspectral:badData

"-28020"^^<http://www.w3.org/2001/XMLSchema#short>;

hyperspectral:browseColorTableName

"nrl";

hyperspectral:browseFunc

"2"^^<http://www.w3.org/2001/XMLSchema#int>;

hyperspectral:browseRanges

(5.0E-4 "0.5"^^<http://www.w3.org/2001/XMLSchema#double>);

hyperspectral:productClass

"geophysical parameter";

hyperspectral:productName
```

"Total backscatter at 412 nm, QAA algorithm" ;

hyperspectral:productScaling

"Linear" ;

hyperspectral:productStatus

"provisional" ;

hyperspectral:productUnits

"m<sup>-1</sup>" ;

hyperspectral:scalingIntercept

"0.14000000059604645"^^<http://www.w3.org/2001/XMLSchema#double> ;

hyperspectral:scalingSlope

4.999999873689376E-6 ;

hyperspectral:validRange

(5.0E-6 "1.0"^^<http://www.w3.org/2001/XMLSchema#double>) ;

<http://muckdragon.info/hyperspectral/tags/algorithm#hasAlgorithmTag>

<http://muckdragon.info/hyperspectral/tags/algorithm#qaa> ;

<http://muckdragon.info/hyperspectral/tags/measure#hasMeasurementTag>

<http://muckdragon.info/hyperspectral/tags/measure#backscatter> ;

<http://muckdragon.info/hyperspectral/tags/substance#hasSubstanceTag>

<http://muckdragon.info/hyperspectral/tags/substance#total> ;

<http://www.w3.org/ns/prov#wasGeneratedBy>

[ a <http://muckdragon.info/data/processing#ProcessExecution> ;

<http://www.w3.org/ns/prov#generated>

file:bb\_412\_qaa ;

<http://www.w3.org/ns/prov#used>

[ a <http://muckdragon.info/data/processing#Algorithm> ;

<http://muckdragon.info/data/processing#name>

"QAA algorithm" ;

<http://muckdragon.info/data/processing#produces>

file:bb\_412\_qaa ;

= <http://muckdragon.info/hyperspectral/algorithms/QAA%20algorithm>

]

].

file:csol\_z

a <http://www.w3.org/2000/01/rdf-schema#Class> ;

<http://muckdragon.info/data/info#hasStats>

[ stats:geometricMean

"61.06117577919217"^^<http://www.w3.org/2001/XMLSchema#double> ;

```
stats:max "61.598262786865234"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:mean "61.06196581459035"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:min "60.52285385131836"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:n "2000"^^<http://www.w3.org/2001/XMLSchema#long> ;

stats:populationVariance

    "0.09647882542977904"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:secondMoment

"192.95765085955807"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:standardDeviation

    "0.31068808952752947"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sum "122123.93162918091"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumOfLogs "8223.75248649921"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumsq "7457320.295935306"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:variance "0.09652708897426616"^^<http://www.w3.org/2001/XMLSchema#double>

];

sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int>);

sets:dataType <http://www.w3.org/2001/XMLSchema#float> ;

sets:isContainedIn

<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8dec7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph
```

D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-  
SwanRiverEstuary\_AUS.v40.100m.hdf> .

file:vert\_vis

```
a <http://www.w3.org/2000/01/rdf-schema#Class> ,  
<http://muckdragon.info/data/info#Product> ;  
  
<http://muckdragon.info/data/info#hasMeasurementUnits>  
  
"m" ;  
  
<http://muckdragon.info/data/info#hasStats>  
  
[ stats:geometricMean "0.0"^^<http://www.w3.org/2001/XMLSchema#double> ;  
  
stats:max "2009.0"^^<http://www.w3.org/2001/XMLSchema#double> ;  
  
stats:mean "207.41653515624452"^^<http://www.w3.org/2001/XMLSchema#double> ;  
  
stats:min "0.0"^^<http://www.w3.org/2001/XMLSchema#double> ;  
  
stats:n "1024000"^^<http://www.w3.org/2001/XMLSchema#long> ;  
  
stats:populationVariance  
  
"66568.12443986966"^^<http://www.w3.org/2001/XMLSchema#double> ;  
  
stats:secondMoment 6.816575942642653E10 ;  
  
stats:standardDeviation  
  
"258.00811895726684"^^<http://www.w3.org/2001/XMLSchema#double> ;
```

stats:sum 2.12394532E8 ;

stats:sumOfLogs "-Infinity"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumsq 1.1221989734E11 ;

stats:variance "66568.18944786716"^^<http://www.w3.org/2001/XMLSchema#double>

];

sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int>

"512"^^<http://www.w3.org/2001/XMLSchema#int>);

sets:dataType <http://www.w3.org/2001/XMLSchema#short> ;

sets:isContainedIn

<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8dec7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph

D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-

SwanRiverEstuary\_AUS.v40.100m.hdf> ;

hyperspectral:badData

"0"^^<http://www.w3.org/2001/XMLSchema#short> ;

hyperspectral:browseColorTableName

"vis2" ;

hyperspectral:browseFunc

"0"^^<http://www.w3.org/2001/XMLSchema#int> ;

hyperspectral:browseRanges



("0.0"^^<http://www.w3.org/2001/XMLSchema#double>  
"15.0"^^<http://www.w3.org/2001/XMLSchema#double>);  
hyperspectral:feetIntercept  
"0.0"^^<http://www.w3.org/2001/XMLSchema#double>;  
hyperspectral:feetSlope  
"0.032809999266639356"^^<http://www.w3.org/2001/XMLSchema#double>;  
hyperspectral:otherUnits  
"feet";  
hyperspectral:productClass  
"geophysical parameter";  
hyperspectral:productName  
"Vertical Diver Visibility ( $4/[c+Kd]$ ), 547 nm";  
hyperspectral:productScaling  
"Linear";  
hyperspectral:productStatus  
"provisional";  
hyperspectral:productUnits  
"m";  
hyperspectral:scalingIntercept

```

"0.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

hyperspectral:scalingSlope

"0.00999999776482582"^^<http://www.w3.org/2001/XMLSchema#double> ;

hyperspectral:validRange

("0.01"^^<http://www.w3.org/2001/XMLSchema#double>
"10.0"^^<http://www.w3.org/2001/XMLSchema#double> ) ;

<http://www.w3.org/ns/prov#wasGeneratedBy>

[ a <http://muckdragon.info/data/processing#ProcessExecution> ;

  <http://www.w3.org/ns/prov#generated>

    file:vert_vis ;

  <http://www.w3.org/ns/prov#used>

    [ a <http://muckdragon.info/data/processing#Algorithm> ;

      <http://muckdragon.info/data/processing#name>

        "547 nm" ;

      <http://muckdragon.info/data/processing#produces>

        file:vert_vis ;

      = <http://muckdragon.info/hyperspectral/algorithms/547%20nm>

    ]

] .

```

file:history

a <http://www.w3.org/2000/01/rdf-schema#Class> ;

sets:dataDimensions ("47953"^^<http://www.w3.org/2001/XMLSchema#int>) ;

sets:dataType <http://www.w3.org/2001/XMLSchema#string> ;

sets:isContainedIn

<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8dec7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph  
D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-  
SwanRiverEstuary\_AUS.v40.100m.hdf> .

<http://muckdragon.info/hyperspectral/tags/substance#phytoplankton>

<http://muckdragon.info/hyperspectral/tags/substance#name>

"phytoplankton" .

file:bb\_667\_qaa

a <http://www.w3.org/2000/01/rdf-schema#Class> ,

<http://muckdragon.info/data/info#Product> ;

<http://muckdragon.info/data/info#hasMeasurementUnits>

"m<sup>-1</sup>" ;

<http://muckdragon.info/data/info#hasStats>

```
[ stats:geometricMean "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:max "-972.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:mean "-27280.01336620974"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:min "-28020.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:n "1024000"^^<http://www.w3.org/2001/XMLSchema#long> ;

stats:populationVariance

    "1075241.613696018"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:secondMoment 1.1010474124247224E12 ;

stats:standardDeviation

    "1036.9390839088292"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sum -2.7934733687E10 ;

stats:sumOfLogs "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumsq 7.63160955775327E14 ;

stats:variance "1075242.6637376817"^^<http://www.w3.org/2001/XMLSchema#double>

];

sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int>

"512"^^<http://www.w3.org/2001/XMLSchema#int>);

sets:dataType <http://www.w3.org/2001/XMLSchema#short> ;
```

sets:isContainedIn

<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8dec7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph  
D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-  
SwanRiverEstuary\_AUS.v40.100m.hdf> ;

hyperspectral:badData

"-28020"^^<http://www.w3.org/2001/XMLSchema#short> ;

hyperspectral:browseColorTableName

"nrl" ;

hyperspectral:browseFunc

"1"^^<http://www.w3.org/2001/XMLSchema#int> ;

hyperspectral:browseRanges

(5.0E-4 "0.5"^^<http://www.w3.org/2001/XMLSchema#double>) ;

hyperspectral:productClass

"geophysical parameter" ;

hyperspectral:productName

"Total backscatter at 667 nm, QAA algorithm" ;

hyperspectral:productScaling

"Linear" ;

hyperspectral:productStatus

"provisional" ;

hyperspectral:productUnits

"m<sup>-1</sup>" ;

hyperspectral:scalingIntercept

"0.14000000059604645"^^<http://www.w3.org/2001/XMLSchema#double> ;

hyperspectral:scalingSlope

4.999999873689376E-6 ;

hyperspectral:validRange

(5.0E-6 "1.0"^^<http://www.w3.org/2001/XMLSchema#double>) ;

<http://muckdragon.info/hyperspectral/tags/algorithm#hasAlgorithmTag>

<http://muckdragon.info/hyperspectral/tags/algorithm#qaa> ;

<http://muckdragon.info/hyperspectral/tags/measure#hasMeasurementTag>

<http://muckdragon.info/hyperspectral/tags/measure#backscatter> ;

<http://muckdragon.info/hyperspectral/tags/substance#hasSubstanceTag>

<http://muckdragon.info/hyperspectral/tags/substance#total> ;

<http://www.w3.org/ns/prov#wasGeneratedBy>

[ a <http://muckdragon.info/data/processing#ProcessExecution> ;

<http://www.w3.org/ns/prov#generated>

file:bb\_667\_qaa ;

<http://www.w3.org/ns/prov#used>

[ a <http://muckdragon.info/data/processing#Algorithm> ;

<http://muckdragon.info/data/processing#name>

"QAA algorithm" ;

<http://muckdragon.info/data/processing#produces>

file:bb\_667\_qaa ;

= <http://muckdragon.info/hyperspectral/algorithms/QAA%20algorithm>

]

].

file:PIM\_gould

a <http://www.w3.org/2000/01/rdf-schema#Class> ,

<http://muckdragon.info/data/info#Product> ;

<http://muckdragon.info/data/info#hasMeasurementUnits>

"mg l<sup>-1</sup>" ;

<http://muckdragon.info/data/info#hasStats>

[ stats:geometricMean "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:max "-9524.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:mean "-19793.724436523196"^^<http://www.w3.org/2001/XMLSchema#double> ;

```
stats:min "-20010.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:n "1024000"^^<http://www.w3.org/2001/XMLSchema#long> ;

stats:populationVariance

    "101510.95373575756"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:secondMoment 1.0394721662541574E11 ;

stats:standardDeviation

    "318.60799247295273"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sum -2.0268773823E10 ;

stats:sumOfLogs "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumsq 4.01298470935307E14 ;

stats:variance "101511.05286764512"^^<http://www.w3.org/2001/XMLSchema#double>

];

sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int>

"512"^^<http://www.w3.org/2001/XMLSchema#int>);

sets:dataType <http://www.w3.org/2001/XMLSchema#short> ;

sets:isContainedIn

<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8dec7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph
D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-
SwanRiverEstuary_AUS.v40.100m.hdf> ;

hyperspectral:badData
```



```
"-20010"^^<http://www.w3.org/2001/XMLSchema#short>;  
  
hyperspectral:browseColorTableName  
  
"nrl";  
  
hyperspectral:browseFunc  
  
"2"^^<http://www.w3.org/2001/XMLSchema#int>;  
  
hyperspectral:browseRanges  
  
("0.01"^^<http://www.w3.org/2001/XMLSchema#double>  
"10.0"^^<http://www.w3.org/2001/XMLSchema#double>);  
  
hyperspectral:productClass  
  
"geophysical parameter";  
  
hyperspectral:productName  
  
"Particulate Inorganic Matter From Sediment and Detrital Absorption at 412nm, Gould  
(200711)";  
  
hyperspectral:productScaling  
  
"Linear";  
  
hyperspectral:productStatus  
  
"provisional";  
  
hyperspectral:productUnits  
  
"mg l-1";
```

hyperspectral:scalingIntercept

"20.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

hyperspectral:scalingSlope

"0.0010000000474974513"^^<http://www.w3.org/2001/XMLSchema#double> ;

hyperspectral:validRange

("0.001"^^<http://www.w3.org/2001/XMLSchema#double>  
"30.0"^^<http://www.w3.org/2001/XMLSchema#double>);

<http://muckdragon.info/hyperspectral/tags/algorithm#hasAlgorithmTag>

<http://muckdragon.info/hyperspectral/tags/algorithm#gould> ;

<http://muckdragon.info/hyperspectral/tags/measure#hasMeasurementTag>

<http://muckdragon.info/hyperspectral/tags/measure#absorption> ;

<http://muckdragon.info/hyperspectral/tags/substance#hasSubstanceTag>

<http://muckdragon.info/hyperspectral/tags/substance#detrital> ,

<http://muckdragon.info/hyperspectral/tags/substance#sediment> ,

<http://muckdragon.info/hyperspectral/tags/substance#particulate> ;

<http://www.w3.org/ns/prov#wasGeneratedBy>

[ a <http://muckdragon.info/data/processing#ProcessExecution> ;

<http://www.w3.org/ns/prov#generated>

file:PIM\_gould ;

<http://www.w3.org/ns/prov#used>

[ a <http://muckdragon.info/data/processing#Algorithm> ;

<http://muckdragon.info/data/processing#name>

"Gould (200711)" ;

<http://muckdragon.info/data/processing#produces>

file:PIM\_gould ;

= <http://muckdragon.info/hyperspectral/algorithms/Gould%20%28200711%29>

]

].

<http://muckdragon.info/hyperspectral/tags/substance#particulate>

<http://muckdragon.info/hyperspectral/tags/substance#name>

"particulate" .

file:CP\_Lines

a <http://www.w3.org/2000/01/rdf-schema#Class> ;

<http://muckdragon.info/data/info#hasStats>

[ stats:geometricMean

"737.4971141998069"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:max "2000.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:mean "1000.5"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:min "1.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:n "2000"^^<http://www.w3.org/2001/XMLSchema#long> ;

stats:populationVariance

"333333.25"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:secondMoment 6.666665E8 ;

stats:standardDeviation

"577.4945887192364"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sum "2001000.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumOfLogs "13206.52435051381"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumsq 2.668667E9 ;

stats:variance "333500.0"^^<http://www.w3.org/2001/XMLSchema#double>

];

sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int>);

sets:dataType <http://www.w3.org/2001/XMLSchema#double> ;

sets:isContainedIn

<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8dec7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph

D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-SwanRiverEstuary\_AUS.v40.100m.hdf> .

file:bb\_678\_qaa

```
a <http://www.w3.org/2000/01/rdf-schema#Class> ,
<http://muckdragon.info/data/info#Product> ;

<http://muckdragon.info/data/info#hasMeasurementUnits>

    "m^-1" ;

<http://muckdragon.info/data/info#hasStats>

    [ stats:geometricMean "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

      stats:max "-1164.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

      stats:mean "-27294.427620118044"^^<http://www.w3.org/2001/XMLSchema#double> ;

      stats:min "-28020.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

      stats:n "1024000"^^<http://www.w3.org/2001/XMLSchema#long> ;

      stats:populationVariance

        "1040969.9676516725"^^<http://www.w3.org/2001/XMLSchema#double> ;

      stats:secondMoment 1.0659532468753127E12 ;

      stats:standardDeviation

        "1020.2798558360836"^^<http://www.w3.org/2001/XMLSchema#double> ;
```

stats:sum -2.7949493883E10 ;

stats:sumOfLogs "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumsq 7.63931391055327E14 ;

stats:variance "1040970.9842248994"^^<http://www.w3.org/2001/XMLSchema#double>

];

sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int>

"512"^^<http://www.w3.org/2001/XMLSchema#int>);

sets:dataType <http://www.w3.org/2001/XMLSchema#short> ;

sets:isContainedIn

<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8dec7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph  
D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-  
SwanRiverEstuary\_AUS.v40.100m.hdf> ;

hyperspectral:badData

"-28020"^^<http://www.w3.org/2001/XMLSchema#short> ;

hyperspectral:browseColorTableName

"nrl" ;

hyperspectral:browseFunc

"1"^^<http://www.w3.org/2001/XMLSchema#int> ;

hyperspectral:browseRanges

(5.0E-4 "0.5"^^<http://www.w3.org/2001/XMLSchema#double>) ;

hyperspectral:productClass

"geophysical parameter" ;

hyperspectral:productName

"Total backscatter at 678 nm, QAA algorithm" ;

hyperspectral:productScaling

"Linear" ;

hyperspectral:productStatus

"provisional" ;

hyperspectral:productUnits

"m<sup>-1</sup>" ;

hyperspectral:scalingIntercept

"0.1400000059604645"^^<http://www.w3.org/2001/XMLSchema#double> ;

hyperspectral:scalingSlope

4.999999873689376E-6 ;

hyperspectral:validRange

(5.0E-6 "1.0"^^<http://www.w3.org/2001/XMLSchema#double>) ;

<http://muckdragon.info/hyperspectral/tags/algorithm#hasAlgorithmTag>

<http://muckdragon.info/hyperspectral/tags/algorithm#qaa> ;

<http://muckdragon.info/hyperspectral/tags/measure#hasMeasurementTag>

<http://muckdragon.info/hyperspectral/tags/measure#backscatter> ;

<http://muckdragon.info/hyperspectral/tags/substance#hasSubstanceTag>

<http://muckdragon.info/hyperspectral/tags/substance#total> ;

<http://www.w3.org/ns/prov#wasGeneratedBy>

[ a <http://muckdragon.info/data/processing#ProcessExecution> ;

<http://www.w3.org/ns/prov#generated>

file:bb\_678\_qaa ;

<http://www.w3.org/ns/prov#used>

[ a <http://muckdragon.info/data/processing#Algorithm> ;

<http://muckdragon.info/data/processing#name>

"QAA algorithm" ;

<http://muckdragon.info/data/processing#produces>

file:bb\_678\_qaa ;

= <http://muckdragon.info/hyperspectral/algorithms/QAA%20algorithm>

]

].

<http://muckdragon.info/hyperspectral/tags/measure#depth>

<http://muckdragon.info/hyperspectral/tags/measure#name>



"depth" .

file:l2\_flags

a <http://www.w3.org/2000/01/rdf-schema#Class> ;

<http://muckdragon.info/data/info#hasStats>

[ stats:geometricMean 1.4479673530516112E9 ;

stats:max 3.226241348E9 ;

stats:mean 1.5421095779813275E9 ;

stats:min 1.073741826E9 ;

stats:n "1024000"^^<http://www.w3.org/2001/XMLSchema#long> ;

stats:populationVariance

3.0967831592236128E17 ;

stats:secondMoment 3.1711059550449796E23 ;

stats:standardDeviation

5.564877521948593E8 ;

stats:sum 1.579120207852842E15 ;

stats:sumOfLogs 2.1599668822446786E7 ;

stats:sumsq 2.752286992815454E24 ;

stats:variance 3.0967861834288704E17

];

sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int>

"512"^^<http://www.w3.org/2001/XMLSchema#int>);

sets:dataType <http://www.w3.org/2001/XMLSchema#int>;

sets:isContainedIn

<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8dec7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph

D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-

SwanRiverEstuary\_AUS.v40.100m.hdf>;

hyperspectral:\_Unsigned

"true";

hyperspectral:f01\_name

"ATMFAIL";

hyperspectral:f02\_name

"LAND";

hyperspectral:f03\_name

"PRODWARN";

hyperspectral:f04\_name

"HIGLINT";

hyperspectral:f05\_name

"HILT";

hyperspectral:f06\_name

"HISATZEN" ;

hyperspectral:f07\_name

"COASTZ" ;

hyperspectral:f08\_name

"SPARE" ;

hyperspectral:f09\_name

"STRAYLIGHT" ;

hyperspectral:f10\_name

"CLDICE" ;

hyperspectral:f11\_name

"COCCOLITH" ;

hyperspectral:f12\_name

"TURBIDW" ;

hyperspectral:f13\_name

"HISOLZEN" ;

hyperspectral:f14\_name

"SPARE" ;

hyperspectral:f15\_name

"LOWLW" ;  
hyperspectral:f16\_name  
"CHLFAIL" ;  
hyperspectral:f17\_name  
"NAVWARN" ;  
hyperspectral:f18\_name  
"ABSAER" ;  
hyperspectral:f19\_name  
"STUMPF" ;  
hyperspectral:f20\_name  
"MAXAERITER" ;  
hyperspectral:f21\_name  
"MODGLINT" ;  
hyperspectral:f22\_name  
"CHLWARN" ;  
hyperspectral:f23\_name  
"ATMWARN" ;  
hyperspectral:f24\_name  
"SPARE" ;

hyperspectral:f25\_name

"SEAICE" ;

hyperspectral:f26\_name

"NAVFAIL" ;

hyperspectral:f27\_name

"FILTER" ;

hyperspectral:f28\_name

"SSTWARN" ;

hyperspectral:f29\_name

"SSTFAIL" ;

hyperspectral:f30\_name

"HIPOL" ;

hyperspectral:f31\_name

"PRODFAIL" ;

hyperspectral:f32\_name

"OCEAN" ;

hyperspectral:productClass

"flags" ;

hyperspectral:productName

"scan-line quality flags" .

file:c\_678\_qaa

a <http://www.w3.org/2000/01/rdf-schema#Class> ,

<http://muckdragon.info/data/info#Product> ;

<http://muckdragon.info/data/info#hasMeasurementUnits>

"m<sup>-1</sup>" ;

<http://muckdragon.info/data/info#hasStats>

[ stats:geometricMean "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:max "-15806.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:mean "-31176.824806641293"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:min "-32020.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:n "1024000"^^<http://www.w3.org/2001/XMLSchema#long> ;

stats:populationVariance

"1093044.2757911289"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:secondMoment 1.119277338410116E12 ;

stats:standardDeviation

"1045.4880885109221"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sum -3.1925068602E10 ;

```
stats:sumOfLogs "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumsq 9.96441548082948E14 ;

stats:variance "1093045.3432182218"^^<http://www.w3.org/2001/XMLSchema#double>

];

sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int>
"512"^^<http://www.w3.org/2001/XMLSchema#int>);

sets:dataType <http://www.w3.org/2001/XMLSchema#short> ;

sets:isContainedIn

<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8dec7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph
D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-
SwanRiverEstuary_AUS.v40.100m.hdf> ;

hyperspectral:badData

"-32020"^^<http://www.w3.org/2001/XMLSchema#short> ;

hyperspectral:browseColorTableName

"nrl" ;

hyperspectral:browseFunc

"2"^^<http://www.w3.org/2001/XMLSchema#int> ;

hyperspectral:browseRanges

("0.4"^^<http://www.w3.org/2001/XMLSchema#double>
"15.0"^^<http://www.w3.org/2001/XMLSchema#double>);
```

hyperspectral:productClass

"geophysical parameter" ;

hyperspectral:productName

"Beam attenuation at 678 nm, QAA algorithm" ;

hyperspectral:productScaling

"Linear" ;

hyperspectral:productStatus

"provisional" ;

hyperspectral:productUnits

"m<sup>-1</sup>" ;

hyperspectral:scalingIntercept

"16.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

hyperspectral:scalingSlope

5.000000237487257E-4 ;

hyperspectral:validRange

(5.0E-4 "10.0"^^<http://www.w3.org/2001/XMLSchema#double>) ;

<http://muckdragon.info/hyperspectral/tags/algorithm#hasAlgorithmTag>

<http://muckdragon.info/hyperspectral/tags/algorithm#qaa> ;

<http://muckdragon.info/hyperspectral/tags/measure#hasMeasurementTag>



<http://muckdragon.info/hyperspectral/tags/measure#attenuation> ;

<http://www.w3.org/ns/prov#wasGeneratedBy>

[ a <http://muckdragon.info/data/processing#ProcessExecution> ;

<http://www.w3.org/ns/prov#generated>

file:c\_678\_qaa ;

<http://www.w3.org/ns/prov#used>

[ a <http://muckdragon.info/data/processing#Algorithm> ;

<http://muckdragon.info/data/processing#name>

"QAA algorithm" ;

<http://muckdragon.info/data/processing#produces>

file:c\_678\_qaa ;

= <http://muckdragon.info/hyperspectral/algorithms/QAA%20algorithm>

]

].

file:c\_667\_qaa

a <http://www.w3.org/2000/01/rdf-schema#Class> ,

<http://muckdragon.info/data/info#Product> ;

<http://muckdragon.info/data/info#hasMeasurementUnits>

```
"m^-1" ;

<http://muckdragon.info/data/info#hasStats>

[ stats:geometricMean "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:max "-12123.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:mean "-31185.843353515167"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:min "-32020.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:n "1024000"^^<http://www.w3.org/2001/XMLSchema#long> ;

stats:populationVariance

    "1072960.7814586605"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:secondMoment 1.0987118402136685E12 ;

stats:standardDeviation

    "1035.8387081360434"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sum -3.1934303594E10 ;

stats:sumOfLogs "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumsq 9.96996901326308E14 ;

stats:variance "1072961.829272947"^^<http://www.w3.org/2001/XMLSchema#double>

];

sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int>

"512"^^<http://www.w3.org/2001/XMLSchema#int>);
```

sets:dataType <http://www.w3.org/2001/XMLSchema#short> ;

sets:isContainedIn

<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8dec7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph  
D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-  
SwanRiverEstuary\_AUS.v40.100m.hdf> ;

hyperspectral:badData

"-32020"^^<http://www.w3.org/2001/XMLSchema#short> ;

hyperspectral:browseColorTableName

"nrl" ;

hyperspectral:browseFunc

"2"^^<http://www.w3.org/2001/XMLSchema#int> ;

hyperspectral:browseRanges

("0.4"^^<http://www.w3.org/2001/XMLSchema#double>

"15.0"^^<http://www.w3.org/2001/XMLSchema#double>) ;

hyperspectral:productClass

"geophysical parameter" ;

hyperspectral:productName

"Beam attenuation at 667 nm, QAA algorithm" ;

hyperspectral:productScaling

"Linear" ;

hyperspectral:productStatus

"provisional" ;

hyperspectral:productUnits

"m<sup>-1</sup>" ;

hyperspectral:scalingIntercept

"16.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

hyperspectral:scalingSlope

5.000000237487257E-4 ;

hyperspectral:validRange

(5.0E-4 "10.0"^^<http://www.w3.org/2001/XMLSchema#double>) ;

<http://muckdragon.info/hyperspectral/tags/algorithm#hasAlgorithmTag>

<http://muckdragon.info/hyperspectral/tags/algorithm#qaa> ;

<http://muckdragon.info/hyperspectral/tags/measure#hasMeasurementTag>

<http://muckdragon.info/hyperspectral/tags/measure#attenuation> ;

<http://www.w3.org/ns/prov#wasGeneratedBy>

[ a <http://muckdragon.info/data/processing#ProcessExecution> ;

<http://www.w3.org/ns/prov#generated>

file:c\_667\_qaa ;

<http://www.w3.org/ns/prov#used>

```

[ a   <http://muckdragon.info/data/processing#Algorithm> ;

      <http://muckdragon.info/data/processing#name>

        "QAA algorithm" ;

      <http://muckdragon.info/data/processing#produces>

        file:c_667_qaa ;

      =   <http://muckdragon.info/hyperspectral/algorithms/QAA%20algorithm>

    ]

  ].

```

file:true\_color

```

a   <http://www.w3.org/2000/01/rdf-schema#Class> ;

    <http://muckdragon.info/data/info#hasStats>

      [ stats:geometricMean "0.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

        stats:max "255.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

        stats:mean "76.56585644531445"^^<http://www.w3.org/2001/XMLSchema#double> ;

        stats:min "0.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

        stats:n "3072000"^^<http://www.w3.org/2001/XMLSchema#long> ;

        stats:populationVariance

          "1372.7519142306749"^^<http://www.w3.org/2001/XMLSchema#double> ;

```

```
stats:secondMoment 4.217093880516633E9 ;

stats:standardDeviation

    "37.05067288309576"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sum 2.35210311E8 ;

stats:sumOfLogs "-Infinity"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumsq 2.2226172787E10 ;

stats:variance "1372.7523610901674"^^<http://www.w3.org/2001/XMLSchema#double>

];

sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int>
"512"^^<http://www.w3.org/2001/XMLSchema#int>
"3"^^<http://www.w3.org/2001/XMLSchema#int>);

sets:dataType <http://www.w3.org/2001/XMLSchema#byte> ;

sets:isContainedIn

<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8decbc7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph
D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-
SwanRiverEstuary_AUS.v40.100m.hdf> ;

hyperspectral:_Unsigned

    "true" ;

hyperspectral:productClass

    "image" ;
```

hyperspectral:productName

"True Color Image".

file:latitudes

a <http://www.w3.org/2000/01/rdf-schema#Class> ;

<http://muckdragon.info/data/info#hasStats>

[ stats:geometricMean "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:max "-30.88399887084961"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:mean "-31.715374299836274"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:min "-32.540809631347656"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:n "1024000"^^<http://www.w3.org/2001/XMLSchema#long> ;

stats:populationVariance

"0.14002335730259285"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:secondMoment

"143383.91787785507"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:standardDeviation

"0.37419713259762727"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sum -3.2476543283031464E7 ;

stats:sumOfLogs "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

```
stats:sumsq 1.0301491101042844E9 ;

stats:variance "0.14002349404428624"^^<http://www.w3.org/2001/XMLSchema#double>

];

sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int>
"512"^^<http://www.w3.org/2001/XMLSchema#int>);

sets:dataType <http://www.w3.org/2001/XMLSchema#float> ;

sets:isContainedIn

<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8dec7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph
D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-
SwanRiverEstuary_AUS.v40.100m.hdf> ;

hyperspectral:badData

"-999.0"^^<http://www.w3.org/2001/XMLSchema#float> ;

hyperspectral:browseColorTableName

"gray" ;

hyperspectral:browseFunc

"2"^^<http://www.w3.org/2001/XMLSchema#int> ;

hyperspectral:browseRanges

("0.01"^^<http://www.w3.org/2001/XMLSchema#double>
"10.0"^^<http://www.w3.org/2001/XMLSchema#double>);

hyperspectral:productClass
```



"geophysical parameter" ;

hyperspectral:productName

"Latitudes" ;

hyperspectral:productScaling

"Linear" ;

hyperspectral:productStatus

"provisional" ;

hyperspectral:productUnits

"degree" ;

hyperspectral:scalingIntercept

"0.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

hyperspectral:scalingSlope

"1.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

hyperspectral:validRange

("0.0"^^<http://www.w3.org/2001/XMLSchema#double>  
"0.0"^^<http://www.w3.org/2001/XMLSchema#double>).

file:Kd\_488\_lee

```

a    <http://www.w3.org/2000/01/rdf-schema#Class> ,
<http://muckdragon.info/data/info#Product> ;

<http://muckdragon.info/data/info#hasMeasurementUnits>

    "m^-1" ;

<http://muckdragon.info/data/info#hasStats>

    [ stats:geometricMean "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

      stats:max "10710.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

      stats:mean "-18927.98614062521"^^<http://www.w3.org/2001/XMLSchema#double> ;

      stats:min "-32767.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

      stats:n "1024000"^^<http://www.w3.org/2001/XMLSchema#long> ;

      stats:populationVariance

          2.716191059728643E8 ;

      stats:secondMoment 2.78137964516213E14 ;

      stats:standardDeviation

          "16480.878957936573"^^<http://www.w3.org/2001/XMLSchema#double> ;

      stats:sum -1.9382257808E10 ;

      stats:sumOfLogs "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

      stats:sumsq 6.45005071680052E14 ;

      stats:variance 2.716193712261565E8

```

```
];

sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int>
"512"^^<http://www.w3.org/2001/XMLSchema#int>);

sets:dataType <http://www.w3.org/2001/XMLSchema#short>;

sets:isContainedIn
<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8decbc7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph
D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-
SwanRiverEstuary_AUS.v40.100m.hdf>;

hyperspectral:badData
"-5000"^^<http://www.w3.org/2001/XMLSchema#short>;

hyperspectral:browseColorTableName
"nri";

hyperspectral:browseFunc
"2"^^<http://www.w3.org/2001/XMLSchema#int>;

hyperspectral:browseRanges
("0.02"^^<http://www.w3.org/2001/XMLSchema#double>
"2.0"^^<http://www.w3.org/2001/XMLSchema#double>);

hyperspectral:productClass
"geophysical parameter";

hyperspectral:productName
```

"Diffuse attenuation coefficient at 488 nm, Lee Algorithm" ;

hyperspectral:productScaling

"Linear" ;

hyperspectral:productStatus

"provisional" ;

hyperspectral:productUnits

"m<sup>-1</sup>" ;

hyperspectral:scalingIntercept

"0.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

hyperspectral:scalingSlope

1.9999999494757503E-4 ;

hyperspectral:validRange

("0.01"^^<http://www.w3.org/2001/XMLSchema#double>  
"5.0"^^<http://www.w3.org/2001/XMLSchema#double>) ;

<http://muckdragon.info/hyperspectral/tags/measure#hasMeasurementTag>

<http://muckdragon.info/hyperspectral/tags/measure#attenuation> ;

<http://www.w3.org/ns/prov#wasGeneratedBy>

[ a <http://muckdragon.info/data/processing#ProcessExecution> ;

<http://www.w3.org/ns/prov#generated>

```
file:Kd_488_lee ;

<http://www.w3.org/ns/prov#used>

[ a <http://muckdragon.info/data/processing#Algorithm> ;

  <http://muckdragon.info/data/processing#name>

    "Lee Algorithm" ;

  <http://muckdragon.info/data/processing#produces>

    file:Kd_488_lee ;

  = <http://muckdragon.info/hyperspectral/algorithms/Lee%20Algorithm>

]

].
```

file:CP\_Latitudes

```
a <http://www.w3.org/2000/01/rdf-schema#Class> ;

<http://muckdragon.info/data/info#hasStats>

[ stats:geometricMean "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

  stats:max "-30.88399887084961"^^<http://www.w3.org/2001/XMLSchema#double> ;

  stats:mean "-31.715374299836274"^^<http://www.w3.org/2001/XMLSchema#double> ;

  stats:min "-32.540809631347656"^^<http://www.w3.org/2001/XMLSchema#double> ;

  stats:n "1024000"^^<http://www.w3.org/2001/XMLSchema#long> ;
```

stats:populationVariance

"0.14002335730259285"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:secondMoment

"143383.91787785507"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:standardDeviation

"0.37419713259762727"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sum -3.2476543283031464E7 ;

stats:sumOfLogs "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumsq 1.0301491101042844E9 ;

stats:variance "0.14002349404428624"^^<http://www.w3.org/2001/XMLSchema#double>

];

sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int>

"512"^^<http://www.w3.org/2001/XMLSchema#int>);

sets:dataType <http://www.w3.org/2001/XMLSchema#double> ;

sets:isContainedIn

<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8dec7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph

D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-

SwanRiverEstuary\_AUS.v40.100m.hdf> .

<http://muckdragon.info/hyperspectral/tags/substance#sediment>

<http://muckdragon.info/hyperspectral/tags/substance#name>

"sediment" .

file:elon

a <http://www.w3.org/2000/01/rdf-schema#Class> ;

<http://muckdragon.info/data/info#hasStats>

[ stats:geometricMean

"115.87414917328944"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:max "116.62342834472656"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:mean "115.87495547866826"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:min "115.12643432617188"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:n "2000"^^<http://www.w3.org/2001/XMLSchema#long> ;

stats:populationVariance

"0.18685944741281862"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:secondMoment

"373.7188948256372"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:standardDeviation

"0.43238053133178417"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sum "231749.91095733643"^^<http://www.w3.org/2001/XMLSchema#double> ;

```
stats:sumOfLogs "9505.009362467456"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumsq 2.685438433326158E7 ;

stats:variance "0.18695292387475598"^^<http://www.w3.org/2001/XMLSchema#double>

];

sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int> ) ;

sets:dataType <http://www.w3.org/2001/XMLSchema#float> ;

sets:isContainedIn

<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8dec7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph
D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-
SwanRiverEstuary_AUS.v40.100m.hdf> .

file:bb_547_qaa

a <http://www.w3.org/2000/01/rdf-schema#Class> ,
<http://muckdragon.info/data/info#Product> ;

<http://muckdragon.info/data/info#hasMeasurementUnits>

"m^-1" ;

<http://muckdragon.info/data/info#hasStats>

[ stats:geometricMean "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:max "1511.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:mean "-27069.746775390133"^^<http://www.w3.org/2001/XMLSchema#double> ;
```



```
stats:min "-28020.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:n "1024000"^^<http://www.w3.org/2001/XMLSchema#long> ;

stats:populationVariance

    "1634668.5046509218"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:secondMoment 1.673900548762544E12 ;

stats:standardDeviation

    "1278.5421780326383"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sum -2.7719420698E10 ;

stats:sumOfLogs "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumsq 7.52031599604144E14 ;

stats:variance "1634670.1010084422"^^<http://www.w3.org/2001/XMLSchema#double>

];

sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int>

"512"^^<http://www.w3.org/2001/XMLSchema#int>);

sets:dataType <http://www.w3.org/2001/XMLSchema#short> ;

sets:isContainedIn

<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8decbc7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph
D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-
SwanRiverEstuary_AUS.v40.100m.hdf> ;

hyperspectral:badData
```

"-28020"^^<http://www.w3.org/2001/XMLSchema#short> ;

hyperspectral:browseColorTableName

"nrl" ;

hyperspectral:browseFunc

"2"^^<http://www.w3.org/2001/XMLSchema#int> ;

hyperspectral:browseRanges

(5.0E-4 "0.5"^^<http://www.w3.org/2001/XMLSchema#double>) ;

hyperspectral:productClass

"geophysical parameter" ;

hyperspectral:productName

"Total backscatter at 547 nm, QAA algorithm" ;

hyperspectral:productScaling

"Linear" ;

hyperspectral:productStatus

"provisional" ;

hyperspectral:productUnits

"m<sup>-1</sup>" ;

hyperspectral:scalingIntercept

"0.14000000059604645"^^<http://www.w3.org/2001/XMLSchema#double> ;

hyperspectral:scalingSlope

4.999999873689376E-6 ;

hyperspectral:validRange

(5.0E-6 "1.0"^^<http://www.w3.org/2001/XMLSchema#double>) ;

<http://muckdragon.info/hyperspectral/tags/algorithm#hasAlgorithmTag>

<http://muckdragon.info/hyperspectral/tags/algorithm#qaa> ;

<http://muckdragon.info/hyperspectral/tags/measure#hasMeasurementTag>

<http://muckdragon.info/hyperspectral/tags/measure#backscatter> ;

<http://muckdragon.info/hyperspectral/tags/substance#hasSubstanceTag>

<http://muckdragon.info/hyperspectral/tags/substance#total> ;

<http://www.w3.org/ns/prov#wasGeneratedBy>

[ a <http://muckdragon.info/data/processing#ProcessExecution> ;

<http://www.w3.org/ns/prov#generated>

file:bb\_547\_qaa ;

<http://www.w3.org/ns/prov#used>

[ a <http://muckdragon.info/data/processing#Algorithm> ;

<http://muckdragon.info/data/processing#name>

"QAA algorithm" ;

<http://muckdragon.info/data/processing#produces>

```
file:bb_547_qaa ;  
  
= <http://muckdragon.info/hyperspectral/algorithms/QAA%20algorithm>  
  
]  
  
].
```

file:day

```
a <http://www.w3.org/2000/01/rdf-schema#Class> ;  
  
<http://muckdragon.info/data/info#hasStats>  
  
[ stats:geometricMean  
"13.9999999999999059"^^<http://www.w3.org/2001/XMLSchema#double> ;  
  
stats:max "14.0"^^<http://www.w3.org/2001/XMLSchema#double> ;  
  
stats:mean "14.0"^^<http://www.w3.org/2001/XMLSchema#double> ;  
  
stats:min "14.0"^^<http://www.w3.org/2001/XMLSchema#double> ;  
  
stats:n "2000"^^<http://www.w3.org/2001/XMLSchema#long> ;  
  
stats:populationVariance  
  
"0.0"^^<http://www.w3.org/2001/XMLSchema#double> ;  
  
stats:secondMoment "0.0"^^<http://www.w3.org/2001/XMLSchema#double> ;  
  
stats:standardDeviation  
  
"0.0"^^<http://www.w3.org/2001/XMLSchema#double> ;
```

stats:sum "28000.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumOfLogs "5278.114659230383"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumsq "392000.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:variance "0.0"^^<http://www.w3.org/2001/XMLSchema#double>

];

sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int>) ;

sets:dataType <http://www.w3.org/2001/XMLSchema#int> ;

sets:isContainedIn

<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8dec7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph  
D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-  
SwanRiverEstuary\_AUS.v40.100m.hdf> .

file:Kd\_490

a <http://www.w3.org/2000/01/rdf-schema#Class> ,

<http://muckdragon.info/data/info#Product> ;

<http://muckdragon.info/data/info#hasMeasurementUnits>

"m<sup>-1</sup>" ;

<http://muckdragon.info/data/info#hasStats>

[ stats:geometricMean "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:max "32000.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

```
stats:mean "-19035.31657421767"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:min "-32767.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:n "1024000"^^<http://www.w3.org/2001/XMLSchema#long> ;

stats:populationVariance

    2.674057676774947E8 ;

stats:secondMoment 2.7382350610175456E14 ;

stats:standardDeviation

    "16352.5541985402"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sum -1.9492164172E10 ;

stats:sumOfLogs "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumsq 6.44863021832416E14 ;

stats:variance 2.674060288161947E8

];

sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int>
"512"^^<http://www.w3.org/2001/XMLSchema#int>) ;

sets:dataType <http://www.w3.org/2001/XMLSchema#short> ;

sets:isContainedIn

<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8dec7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph
D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-
SwanRiverEstuary_AUS.v40.100m.hdf> ;
```

hyperspectral:badData

"-5000"^^<http://www.w3.org/2001/XMLSchema#short> ;

hyperspectral:browseColorTableName

"nrl" ;

hyperspectral:browseFunc

"2"^^<http://www.w3.org/2001/XMLSchema#int> ;

hyperspectral:browseRanges

("0.02"^^<http://www.w3.org/2001/XMLSchema#double>

"2.0"^^<http://www.w3.org/2001/XMLSchema#double>) ;

hyperspectral:productClass

"geophysical parameter" ;

hyperspectral:productName

"Diffuse attenuation coefficient at 490 nm, KD2 algorithm" ;

hyperspectral:productScaling

"Linear" ;

hyperspectral:productStatus

"provisional" ;

hyperspectral:productUnits

"m<sup>-1</sup>" ;

hyperspectral:scalingIntercept

"0.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

hyperspectral:scalingSlope

1.9999999494757503E-4 ;

hyperspectral:validRange

("0.01"^^<http://www.w3.org/2001/XMLSchema#double>

"5.0"^^<http://www.w3.org/2001/XMLSchema#double>) ;

<http://muckdragon.info/hyperspectral/tags/measure#hasMeasurementTag>

<http://muckdragon.info/hyperspectral/tags/measure#attenuation> ;

<http://www.w3.org/ns/prov#wasGeneratedBy>

[ a <http://muckdragon.info/data/processing#ProcessExecution> ;

<http://www.w3.org/ns/prov#generated>

file:Kd\_490 ;

<http://www.w3.org/ns/prov#used>

[ a <http://muckdragon.info/data/processing#Algorithm> ;

<http://muckdragon.info/data/processing#name>

"KD2 algorithm" ;

<http://muckdragon.info/data/processing#produces>

file:Kd\_490 ;



```
= <http://muckdragon.info/hyperspectral/algorithms/KD2%20algorithm>
]
].
```

```
<http://muckdragon.info/hyperspectral/tags/substance#particles>
```

```
<http://muckdragon.info/hyperspectral/tags/substance#name>
```

```
"particles" .
```

```
file:rrs_667
```

```
a <http://www.w3.org/2000/01/rdf-schema#Class> ;
```

```
<http://muckdragon.info/data/info#hasStats>
```

```
[ stats:geometricMean "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;
```

```
stats:max "-17463.0"^^<http://www.w3.org/2001/XMLSchema#double> ;
```

```
stats:mean "-29073.12573925759"^^<http://www.w3.org/2001/XMLSchema#double> ;
```

```
stats:min "-32767.0"^^<http://www.w3.org/2001/XMLSchema#double> ;
```

```
stats:n "1024000"^^<http://www.w3.org/2001/XMLSchema#long> ;
```

```
stats:populationVariance
```

```
1.928985480075836E7 ;
```

```
stats:secondMoment 1.9752811315976562E13 ;
```

stats:standardDeviation

"4392.023865887523"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sum -2.9770880757E10 ;

stats:sumOfLogs "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumsq 8.85285370932685E14 ;

stats:variance 1.9289873638525587E7

];

sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int>

"512"^^<http://www.w3.org/2001/XMLSchema#int>);

sets:dataType <http://www.w3.org/2001/XMLSchema#short> ;

sets:isContainedIn

<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8dec7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph  
D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-  
SwanRiverEstuary\_AUS.v40.100m.hdf> ;

hyperspectral:badData

"-30000"^^<http://www.w3.org/2001/XMLSchema#short> ;

hyperspectral:browseColorTableName

"neg";

hyperspectral:browseFunc

"0"^^<http://www.w3.org/2001/XMLSchema#int> ;

hyperspectral:browseRanges

("-0.03"^^<http://www.w3.org/2001/XMLSchema#double>  
"0.03"^^<http://www.w3.org/2001/XMLSchema#double>);

hyperspectral:productClass

"geophysical parameter";

hyperspectral:productName

"Remote sensing reflectance at 667 nm";

hyperspectral:productScaling

"Linear";

hyperspectral:productStatus

"provisional";

hyperspectral:productUnits

"sr<sup>-1</sup>";

hyperspectral:scalingIntercept

"0.05000000074505806"^^<http://www.w3.org/2001/XMLSchema#double>;

hyperspectral:scalingSlope

1.9999999949504854E-6;

hyperspectral:validRange

(2.0E-6 "0.04"^^<http://www.w3.org/2001/XMLSchema#double>);

<http://muckdragon.info/hyperspectral/tags/measure#hasMeasurementTag>

<http://muckdragon.info/hyperspectral/tags/measure#reflectance> .

file:k\_oz

a <http://www.w3.org/2000/01/rdf-schema#Class> ;

<http://muckdragon.info/data/info#hasStats>

[ stats:geometricMean

"0.014777806280188318"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:max "0.08622000366449356"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:mean "0.031239111584404275"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:min "0.0019359999569132924"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:n "9"^^<http://www.w3.org/2001/XMLSchema#long> ;

stats:populationVariance

8.5949025650909E-4 ;

stats:secondMoment

"0.00773541230858181"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:standardDeviation

"0.03109544240837757"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sum "0.2811520042596385"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumOfLogs "-37.931659194275234"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumsq "0.016518351141827564"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:variance 9.669265385727262E-4

];

sets:dataDimensions ("9"^^<http://www.w3.org/2001/XMLSchema#int>);

sets:dataType <http://www.w3.org/2001/XMLSchema#float> ;

sets:isContainedIn

<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8dec7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph  
D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-  
SwanRiverEstuary\_AUS.v40.100m.hdf> .

file:rrs\_678

a <http://www.w3.org/2000/01/rdf-schema#Class> ;

<http://muckdragon.info/data/info#hasStats>

[ stats:geometricMean "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:max "-5275.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:mean "-29083.817730469582"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:min "-32767.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:n "1024000"^^<http://www.w3.org/2001/XMLSchema#long> ;

stats:populationVariance

1.9177558591735784E7 ;

stats:secondMoment 1.963781999793744E13 ;

stats:standardDeviation

"4379.221085973924"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sum -2.9781829356E10 ;

stats:sumOfLogs "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumsq 8.85807116667768E14 ;

stats:variance 1.9177577319838636E7

];

sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int>

"512"^^<http://www.w3.org/2001/XMLSchema#int>);

sets:dataType <http://www.w3.org/2001/XMLSchema#short> ;

sets:isContainedIn

<magnet:?xt=urn:sha1:1392fd2f0cbe8c878e340368f8dec7cd6cde9d&dn=C:\Users\shaw\Desktop\Ph

D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-

SwanRiverEstuary\_AUS.v40.100m.hdf> ;

hyperspectral:badData

"-30000"^^<http://www.w3.org/2001/XMLSchema#short> ;

hyperspectral:browseColorTableName

"neg" ;

hyperspectral:browseFunc

"0"^^<http://www.w3.org/2001/XMLSchema#int> ;

hyperspectral:browseRanges

("-0.03"^^<http://www.w3.org/2001/XMLSchema#double>

"0.03"^^<http://www.w3.org/2001/XMLSchema#double>) ;

hyperspectral:productClass

"geophysical parameter" ;

hyperspectral:productName

"Remote sensing reflectance at 678 nm" ;

hyperspectral:productScaling

"Linear" ;

hyperspectral:productStatus

"provisional" ;

hyperspectral:productUnits

"sr<sup>-1</sup>" ;

hyperspectral:scalingIntercept

"0.05000000074505806"^^<http://www.w3.org/2001/XMLSchema#double> ;

hyperspectral:scalingSlope

1.9999999949504854E-6 ;

hyperspectral:validRange

(2.0E-6 "0.04"^^<http://www.w3.org/2001/XMLSchema#double>) ;

<http://muckdragon.info/hyperspectral/tags/measure#hasMeasurementTag>

<http://muckdragon.info/hyperspectral/tags/measure#reflectance> .

file:Tau\_r

a <http://www.w3.org/2000/01/rdf-schema#Class> ;

<http://muckdragon.info/data/info#hasStats>

[ stats:geometricMean

"0.0778697362329205"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:max "0.3098999857902527"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:mean "0.11635999754071238"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:min "0.015399999916553497"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:n "9"^^<http://www.w3.org/2001/XMLSchema#long> ;

stats:populationVariance

"0.009198458671445663"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:secondMoment

"0.08278612804301097"^^<http://www.w3.org/2001/XMLSchema#double> ;



stats:standardDeviation

"0.10172642727126699"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sum "1.0472399778664112"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumOfLogs "-22.974461070062954"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumsq "0.2046429692920822"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:variance "0.010348266005376371"^^<http://www.w3.org/2001/XMLSchema#double>

];

sets:dataDimensions ("9"^^<http://www.w3.org/2001/XMLSchema#int>) ;

sets:dataType <http://www.w3.org/2001/XMLSchema#float> ;

sets:isContainedIn

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D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-  
SwanRiverEstuary\_AUS.v40.100m.hdf> .

file:aph\_667\_qaa

a <http://www.w3.org/2000/01/rdf-schema#Class> ,

<http://muckdragon.info/data/info#Product> ;

<http://muckdragon.info/data/info#hasMeasurementUnits>

"m^-1" ;

<http://muckdragon.info/data/info#hasStats>

```
[ stats:geometricMean "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:max "-340.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:mean "-32099.54263476601"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:min "-32100.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:n "1024000"^^<http://www.w3.org/2001/XMLSchema#long> ;

stats:populationVariance

    "2265.844340479881"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:secondMoment 2.320224604651398E9 ;

stats:standardDeviation

    "47.60090916380333"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sum -3.2869931658E10 ;

stats:sumOfLogs "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumsq 1.055112092882408E15 ;

stats:variance "2265.8465532206556"^^<http://www.w3.org/2001/XMLSchema#double>

];

sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int>

"512"^^<http://www.w3.org/2001/XMLSchema#int>);

sets:dataType <http://www.w3.org/2001/XMLSchema#short> ;
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sets:isContainedIn

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D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-  
SwanRiverEstuary\_AUS.v40.100m.hdf> ;

hyperspectral:badData

"-32100"^^<http://www.w3.org/2001/XMLSchema#short> ;

hyperspectral:browseColorTableName

"nrl" ;

hyperspectral:browseFunc

"2"^^<http://www.w3.org/2001/XMLSchema#int> ;

hyperspectral:browseRanges

(5.0E-4 "1.0"^^<http://www.w3.org/2001/XMLSchema#double>) ;

hyperspectral:productClass

"geophysical parameter" ;

hyperspectral:productName

"Absorption due to phytoplankton at 667 nm, QAA algorithm" ;

hyperspectral:productScaling

"Linear" ;

hyperspectral:productStatus

"provisional" ;

hyperspectral:productUnits

"m<sup>-1</sup>" ;

hyperspectral:scalingIntercept

"3.200000047683716"^^<http://www.w3.org/2001/XMLSchema#double> ;

hyperspectral:scalingSlope

9.999999747378752E-5 ;

hyperspectral:validRange

(1.0E-4 "5.0"^^<http://www.w3.org/2001/XMLSchema#double>) ;

<http://muckdragon.info/hyperspectral/tags/algorithm#hasAlgorithmTag>

<http://muckdragon.info/hyperspectral/tags/algorithm#qaa> ;

<http://muckdragon.info/hyperspectral/tags/measure#hasMeasurementTag>

<http://muckdragon.info/hyperspectral/tags/measure#absorption> ;

<http://muckdragon.info/hyperspectral/tags/substance#hasSubstanceTag>

<http://muckdragon.info/hyperspectral/tags/substance#phytoplankton> ;

<http://www.w3.org/ns/prov#wasGeneratedBy>

[ a <http://muckdragon.info/data/processing#ProcessExecution> ;

<http://www.w3.org/ns/prov#generated>

file:aph\_667\_qaa ;

<http://www.w3.org/ns/prov#used>

[ a <http://muckdragon.info/data/processing#Algorithm> ;

<http://muckdragon.info/data/processing#name>

"QAA algorithm" ;

<http://muckdragon.info/data/processing#produces>

file:aph\_667\_qaa ;

= <http://muckdragon.info/hyperspectral/algorithms/QAA%20algorithm>

]

].

<http://muckdragon.info/hyperspectral/tags/substance#chlorophyll>

<http://muckdragon.info/hyperspectral/tags/substance#name>

"chlorophyll" .

file:horiz\_vis

a <http://www.w3.org/2000/01/rdf-schema#Class> ,

<http://muckdragon.info/data/info#Product> ;

<http://muckdragon.info/data/info#hasMeasurementUnits>

"m" ;

<http://muckdragon.info/data/info#hasStats>

[ stats:geometricMean "0.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:max "3970.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:mean "306.21097753904576"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:min "0.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:n "1024000"^^<http://www.w3.org/2001/XMLSchema#long> ;

stats:populationVariance

"146590.3890675767"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:secondMoment 1.5010855840519855E11 ;

stats:standardDeviation

"382.8714304076413"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sum 3.13560041E8 ;

stats:sumOfLogs "-Infinity"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumsq 2.46124085077E11 ;

stats:variance "146590.53222239332"^^<http://www.w3.org/2001/XMLSchema#double>

];

sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int>

"512"^^<http://www.w3.org/2001/XMLSchema#int>);

sets:dataType <http://www.w3.org/2001/XMLSchema#short> ;

sets:isContainedIn

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D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-  
SwanRiverEstuary\_AUS.v40.100m.hdf> ;

hyperspectral:badData

"0"^^<http://www.w3.org/2001/XMLSchema#short> ;

hyperspectral:browseColorTableName

"vis2" ;

hyperspectral:browseFunc

"0"^^<http://www.w3.org/2001/XMLSchema#int> ;

hyperspectral:browseRanges

("0.0"^^<http://www.w3.org/2001/XMLSchema#double>  
"25.0"^^<http://www.w3.org/2001/XMLSchema#double>) ;

hyperspectral:feetIntercept

"0.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

hyperspectral:feetSlope

"0.032809999266639356"^^<http://www.w3.org/2001/XMLSchema#double> ;

hyperspectral:otherUnits

"feet" ;

hyperspectral:productClass

"geophysical parameter" ;

hyperspectral:productName

"Horizontal Diver Visibility (4.8/c), 547 nm" ;

hyperspectral:productScaling

"Linear" ;

hyperspectral:productStatus

"provisional" ;

hyperspectral:productUnits

"m" ;

hyperspectral:scalingIntercept

"0.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

hyperspectral:scalingSlope

"0.009999999776482582"^^<http://www.w3.org/2001/XMLSchema#double> ;

hyperspectral:validRange

("0.01"^^<http://www.w3.org/2001/XMLSchema#double>  
"10.0"^^<http://www.w3.org/2001/XMLSchema#double>) ;

<http://www.w3.org/ns/prov#wasGeneratedBy>

[ a <http://muckdragon.info/data/processing#ProcessExecution> ;

<http://www.w3.org/ns/prov#generated>



```

file:horiz_vis ;

<http://www.w3.org/ns/prov#used>

[ a   <http://muckdragon.info/data/processing#Algorithm> ;

    <http://muckdragon.info/data/processing#name>

        "547 nm" ;

    <http://muckdragon.info/data/processing#produces>

        file:horiz_vis ;

    =   <http://muckdragon.info/hyperspectral/algorithms/547%20nm>

]

].

```

file:rrs\_443

```

a   <http://www.w3.org/2000/01/rdf-schema#Class> ;

<http://muckdragon.info/data/info#hasStats>

[ stats:geometricMean "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

  stats:max "-10652.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

  stats:mean "-28089.586332031035"^^<http://www.w3.org/2001/XMLSchema#double> ;

  stats:min "-32767.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

  stats:n "1024000"^^<http://www.w3.org/2001/XMLSchema#long> ;

```

stats:populationVariance

3.1213301171718445E7 ;

stats:secondMoment 3.1962420399839688E13 ;

stats:standardDeviation

"5586.889264473356"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sum -2.8763736404E10 ;

stats:sumOfLogs "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumsq 8.39923877351788E14 ;

stats:variance 3.1213331653487638E7

];

sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int>

"512"^^<http://www.w3.org/2001/XMLSchema#int>);

sets:dataType <http://www.w3.org/2001/XMLSchema#short> ;

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D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-

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hyperspectral:badData

"-30000"^^<http://www.w3.org/2001/XMLSchema#short> ;

hyperspectral:browseColorTableName

"neg" ;

hyperspectral:browseFunc

"0"^^<http://www.w3.org/2001/XMLSchema#int> ;

hyperspectral:browseRanges

("-0.03"^^<http://www.w3.org/2001/XMLSchema#double>

"0.03"^^<http://www.w3.org/2001/XMLSchema#double>) ;

hyperspectral:productClass

"geophysical parameter" ;

hyperspectral:productName

"Remote sensing reflectance at 443 nm" ;

hyperspectral:productScaling

"Linear" ;

hyperspectral:productStatus

"provisional" ;

hyperspectral:productUnits

"sr<sup>-1</sup>" ;

hyperspectral:scalingIntercept

"0.05000000074505806"^^<http://www.w3.org/2001/XMLSchema#double> ;

hyperspectral:scalingSlope

1.9999999949504854E-6 ;

hyperspectral:validRange

(2.0E-6 "0.04"^^<http://www.w3.org/2001/XMLSchema#double>) ;

<http://muckdragon.info/hyperspectral/tags/measure#hasMeasurementTag>

<http://muckdragon.info/hyperspectral/tags/measure#reflectance> .

file:bb\_531\_qaa

a <http://www.w3.org/2000/01/rdf-schema#Class> ,

<http://muckdragon.info/data/info#Product> ;

<http://muckdragon.info/data/info#hasMeasurementUnits>

"m<sup>-1</sup>" ;

<http://muckdragon.info/data/info#hasStats>

[ stats:geometricMean "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:max "1912.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:mean "-27030.164721680645"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:min "-28020.0"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:n "1024000"^^<http://www.w3.org/2001/XMLSchema#long> ;

stats:populationVariance

"1752310.9689954247"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:secondMoment 1.794366432251315E12 ;

stats:standardDeviation

"1323.7494778991515"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sum -2.7678888675E10 ;

stats:sumOfLogs "NaN"^^<http://www.w3.org/2001/XMLSchema#double> ;

stats:sumsq 7.49959286630537E14 ;

stats:variance "1752312.6802382765"^^<http://www.w3.org/2001/XMLSchema#double>

];

sets:dataDimensions ("2000"^^<http://www.w3.org/2001/XMLSchema#int>

"512"^^<http://www.w3.org/2001/XMLSchema#int>);

sets:dataType <http://www.w3.org/2001/XMLSchema#short> ;

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D Work\Hyperspectral Use Case\iss.2013014.0114.085907.D.L2.hico-modis.12427-

SwanRiverEstuary\_AUS.v40.100m.hdf> ;

hyperspectral:badData

"-28020"^^<http://www.w3.org/2001/XMLSchema#short> ;

hyperspectral:browseColorTableName

"nrl" ;

hyperspectral:browseFunc

"2"^^<http://www.w3.org/2001/XMLSchema#int> ;

hyperspectral:browseRanges

(5.0E-4 "0.5"^^<http://www.w3.org/2001/XMLSchema#double>) ;

hyperspectral:productClass

"geophysical parameter" ;

hyperspectral:productName

"Total backscatter at 531 nm, QAA algorithm" ;

hyperspectral:productScaling

"Linear" ;

hyperspectral:productStatus

"provisional" ;

hyperspectral:productUnits

"m<sup>-1</sup>" ;

hyperspectral:scalingIntercept

"0.14000000059604645"^^<http://www.w3.org/2001/XMLSchema#double> ;

hyperspectral:scalingSlope

4.999999873689376E-6 ;

hyperspectral:validRange

(5.0E-6 "1.0"^^<http://www.w3.org/2001/XMLSchema#double>) ;

<http://muckdragon.info/hyperspectral/tags/algorithm#hasAlgorithmTag>

<http://muckdragon.info/hyperspectral/tags/algorithm#qaa> ;

<http://muckdragon.info/hyperspectral/tags/measure#hasMeasurementTag>

<http://muckdragon.info/hyperspectral/tags/measure#backscatter> ;

<http://muckdragon.info/hyperspectral/tags/substance#hasSubstanceTag>

<http://muckdragon.info/hyperspectral/tags/substance#total> ;

<http://www.w3.org/ns/prov#wasGeneratedBy>

[ a <http://muckdragon.info/data/processing#ProcessExecution> ;

<http://www.w3.org/ns/prov#generated>

file:bb\_531\_qaa ;

<http://www.w3.org/ns/prov#used>

[ a <http://muckdragon.info/data/processing#Algorithm> ;

<http://muckdragon.info/data/processing#name>

"QAA algorithm" ;

<http://muckdragon.info/data/processing#produces>

file:bb\_531\_qaa ;

= <http://muckdragon.info/hyperspectral/algorithms/QAA%20algorithm>

]

].

## Bibliography

Abha Moitra, B. B. (2010). Addressing Uncertainty and Conflicts in Cross-Domain Data Provenance. San Jose: Military Communications Conference.

Alexander Garcia, O. G. (2011). Annotating Experimental Records Using Ontologies. *International Conference on Biomedical Ontology* (pp. 87-94). Buffalo: ICBO.

Andre Freitas, T. K. (2011). W3P: Building an OPM based provenance model for the Web. 27(6).

Artem Chebotko, E. D. (2012). UTPB: A Benchmark for Scientific Workflow Provenance Storage and Querying Systems. Honolulu: IEEE Eighth World Congress on Services.

Artem Chebotko, S. L. (2010). Secure Abstraction Views for Scientific Workflow Provenance Querying. 3(4).

Barker, A., & Hemert, J. v. (2008). Scientific Workflow: A Survey and Research Directions. In A. B. Hemert, *Lecture Notes in Computer Science*. Springer.

Bettini, D. R. (2012). Context provenance to enhance the dependability of ambient intelligence systems. In P. Thomas, *Personal and Ubiquitous*. Springer, 10.1007/s00779-011-0448-3.

C. Tilmes, Y. Y. (2011). Distinguishing Provenance Equivalence of Earth Science Data. *Procedia Computer Science*.



- Chao, T. C. (2012). Exploring the Rhythms of Scientific Data Use. Toronto: ACM Proceedings of the 2012 iConference.
- Cheney, J. (2011). A formal framework for provenance security. IEEE 24th Computer Security Foundations Symposium (CSF).
- Chunhyeok Lim, S. L. (2011). Storing, reasoning, and querying OPM-compliant scientific workflow provenance. 27(6).
- Claudiu Farcas, M. M. (2011). Ocean Observations Initiative Scientific Data Model. Oceans.
- Colin Bird, C. W. (2013). Laboratory notebooks in the digital era: the role of ELNs in record keeping for chemistry and other sciences. *The Royal Society of Chemistry*.
- Colin C. Venters, P. T. (2011). Provenance: Current Directions and Future Challenges for Service Oriented Computing. Irvine: IEEE 6th International Symposium on Service Oriented System Engineering.
- Deelman, W. C. (2012). Fault Tolerant Clustering in Scientific Workflows. Honolulu: IEEE Eighth World Congress on Services.
- Defude, M. A. (2012). A Mediator-based System for Distributed Semantic Provenance Management Systems. Prague: ACM 16th International Database, Engineering and Applications Symposium.
- Dong Ruan, S. L. (2012). A User-Defined Exception Handling Framework in the VIEW Scientific Workflow Management System. Honolulu: IEEE Ninth International Conference on Services Computing.
- Ewa Deelman, B. B. (2010). Metadata and Provenance Management. In A. S. Rotem, *Scientific Data Management, Challenges, Technology and Deployment*. Boca Raton: Taylor & Francis CRC.
- Frew, R. B. (2005). Lineage Retrieval for Scientific Data Processing: A Survey. 37(1).
- Frey, J. G. (2009). The value of the Semantic Web in the laboratory. *Drug Discovery Today*, 552-561.

- Ghanem, V. C. (2008). Scientific workflow systems - can one size fit all? Cairo: Biomedical Engineering Conference.
- Grigoris Antoniou, O. C. (2012). *Semantic Data Management*. Dagstuhl Reports.
- Groth, G. K. (2012, June 19). *W3C PROV-AQ: Provenance Access and Query*. Retrieved November 2, 2012, from W3C PROV-AQ: Provenance Access and Query: <http://www.w3.org/TR/prov-aq/>
- Gulustan Dogan, T. B. (2011). Evaluation of Network Trust Using Provenance Based on Distributed Local Intelligence. Baltimore: Military Communications Conference.
- Im Y. Jung, H. E. (2011). Multi-Layer Trust Reasoning on Open Provenance Model for e-Science Environment. Busan: IEEE Ninth International Symposium on Parallel and Distributed Processing with Applications.
- Ioup, E. (2011). *A Geospatial Service Model and Catalog for Discovery and Orchestration*. New Orleans: University of New Orleans Scholar Works@UNO.
- James Cheney, P. M. (2012, September 11). *W3C Constraints of the Provenance Data Model*. Retrieved November 2, 2012, from W3C Constraints of the Provenance Data Model: <http://www.w3.org/TR/2012/WD-prov-constraints-20120503/>
- Jerry Pan, C. L. (Pan, Jerry, et al. "Geoscience data curation using a digital object model and open-source frameworks: Provenance ap 2011). Geoscience Data Curation Using a Digital Object Model and Open Source Frameworks: Provenance Applications. IEEE Geoscience and Remote Sensing Symposium (IGARSS).
- Joana E. G. Malaverri, C. B. (2012). A Provenance Approach to Assess the Quality of Geospatial Data. ACM.

- Juliana Freire, D. K. (2008). Provenance for Computational Tasks: A Survey. *10*(3).
- King, A. (2011, November). Waving goodbye to the paper lab book. *Chemistry World*, pp. 46-49.
- Lord, P. a. (2003). *e-Science curation report-data curation for e-science in the UK*. JCSR.
- Luc Moreau, B. C. (2010). The Open Provenance Model Core Specification (v1.1). *27*(6).
- M.D. Lewis, R. G. (09). The Hyperspectral Imager for the Coastal Ocean (HICO): sensor and Data Processing Overview. *Oceans 09* (pp. 1-9). Biloxi: MTS.
- Malcolm Atkinson, C. S. (2012). Data-intensive architecture for scientific knowledge discovery. In A. Elmagarmid, *Distributed and Parallel Databases*. Springer.
- Miles, S. (2011). Mapping attribution metadata to the Open Provenance Model. *27*(6).
- Miles, Y. G. (2012, July 24). *W3C PROV Model Primer*. Retrieved November 2, 2012, from W3C PROV Model Primer: <http://www.w3.org/TR/prov-primer/>
- Missier, L. M. (2012, July 24). *W3C PROV-DM*. Retrieved November 2, 2012, from W3C PROV-DM: <http://www.w3.org/TR/prov-dm/>
- Missier, L. M. (2012, July 24). *W3C PROV-N: The Provenance Notation*. Retrieved November 2, 2012, from W3C PROV-N: The Provenance Notation: <http://www.w3.org/TR/2012/WD-prov-constraints-20120503/>
- Model, O. P. (2012, 11 2). *Open Provenance Model*. (Open Provenance Model) Retrieved 11 2, 2012, from Open Provenance Model: <http://openprovenance.org/>
- Mohamed Amin Sakka, B. D. (2012). A Semantic Framework for the Management of Enriched Provenance Logs. Fukuoka: IEEE 26th International Conference on Advanced Information Networking and Applications.

Moreau, P. G. (2011). Representing distributed systems using the Open Provenance Model. 27(6).

myGrid-OMII-UK. (2013, August 8). *Taverna*. Retrieved from Taverna Workflow Management System:

<http://www.taverna.org.uk/>

Olive Qing Zhang, M. K. (2011). How to Track Your Data: The Case for Cloud Computing Provenance. IEEE Third International Conference on Cloud Computing Technology and Science.

Paul Groth, J. C. (2010). *State of the Art Report*. Provenance Incubator Group.

Paul Groth, Y. G. (2012). Requirements for Provenance on the Web. 7(1).

Peng Chen, B. P. (2012). *Temporal Representation for Scientific Data Provenance*. IEEE.

Peng Yue, Z. S. (2011). A Provenance Framework for Web Geoprocessing Workflows. Vancouver, BC: IEEE 2011 Geoscience and Remote Sensing Symposium.

Quan Bai, X. S. (2011). Case-Based Trust Evaluation from Provenance Information. Changsha: IEEE International Joint Conference on Trust, Security and Privacy in Computing and Communications.

Rajbhandari, S., & Walker, D. W. (2006). Incorporating Provenance in Service Oriented Architecture. Seoul: Next Generation Web Services Practices.

Ruiqi Luo, P. Y. (2012). Analysis of Scientific Workflow Provenance Access Control Policies. Honolulu: IEEE Ninth International Conference on Services Computing.

Shawn Bowers, T. M. (2006). A Model for User-Oriented Data Provenance in Pipelined Scientific Workflows. In L. M. Foster, *IPAW 2006*. Springer.

- Shunqing Yan, Y. Z. (2012). A Case Study of CPNS Intelligence: Provenance Reasoning over Tracing Cross Contamination in Food Supply Chain. 32nd International Conference on Distributed Computing Systems Workshops.
- Slominski, A. (2010). Flexible Creation and Adaptive Execution of Scientific Workflows in Cloud and Grid Environments by using Web 2.0-based Electronic Lab Notebook metaphor. *IEEE 6th World Congress on Services* (pp. 326-327). Miami: IEEE.
- Stromback, V. I. (2011). Creating Infrastructure for Tool-Independent Querying and Exploration of Scientific Workflows. Stockholm: IEEE.
- Susan B. Davidson, S. K. (2011). On Provenance and Privacy. New York: ACM.
- Timothy Lebo, S. S. (2012, July 24). *W3C PROV-O: The PROV Ontology*. Retrieved November 2, 2012, from W3C PROV-O: The PROV Ontology: <http://www.w3.org/TR/prov-o/>
- Wei She, I.-L. Y. (2011). Rule-Based Integrated Access Control and Data Provenance for SOA Based Net-Centric Systems. Irvine: IEEE 6th International Symposium on Service Oriented System Engineering.
- Yogesh L. Simmhan, B. P. (2005). A Survey of Data Provenance in e-Science. *34*(3, September).
- Yogesh L. Simmhan, B. P. (2005). *A Survey of Data Provenance Techniques*. Bloomington, IN: Computer Science Department, Indiana University.
- Yong Liu, J. F. (2010). A Provenance-Aware Virtual Sensor System Using the Open Provenance Model. Chicago: International Symposium on Collaborative Technologies and Systems (CTS).

## Vita

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