



GALEON (Geo-interface to Atmosphere, Land, Earth, Ocean netCDF) Interoperability Experiment Report

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WCS experimentation

In keeping with GALEON IE goal, we experimented WCS implementations to exchange netCDF dataset; in particular, we experimented to map the netCDF XML encoding (i.e. ncML) to GML, using the ncML-GML specification [1].

NcMLGML resulted to be extremely useful for mapping from the multi-dimensional netCDF data model to the ISO/OGC Coverage model. Besides, ncML-GML encoding allows to preserve the netCDF data structure and semantics, using for example OPeNDAP [2] to get binary data; this solution is particularly useful to serve FES (Fluid Earth Sciences) Communities.

WCS Server

IMAA-CNR, in collaboration with the University of Florence, experimented an implementation of the WCS 1.0 server, called: WCS-G. This implementation extended WCS 1.0 functionalities, serving (subsets of) netCDF-CF datasets, either in binary netCDF or in ncML-GML format.

The server is based on an underlying OPeNDAP server instance and on the ncML-GML Java API, performing the conversion from netCDF-CF to ncML-GML.

The server experimented a generic conceptual mapping from netCDF to WCS model. To this end, we identified several testbed datasets, with different features and degrees of complexity (summarized in the table 1). WCS-G was primarily targeted to accommodate those datasets, compatibly with WCS 1.0 limitations.

Currently, WCS-G provides access to the following netCDF-CF datasets: simple.nc, sst.nc, sst-2v.nc, trid, striped_can (see below) and few other CEOP datasets.

WCS-G implements both HTTP and SOAP bindings.

- HTTP binding:
 - getCapabilities URL: <http://athena.pin.unifi.it:8080/galeon/WCS-v1.0?REQUEST=GetCapabilities&VERSION=1.0.0&SERVICE=WCS>
 - describeCoverage URL (sst.nc): [http://athena.pin.unifi.it:8080/galeon/WCS-v1.0?REQUEST=DescribeCoverage&COVERAGE=sst\(time-lat-lon\)&VERSION=1.0.0&SERVICE=WCS](http://athena.pin.unifi.it:8080/galeon/WCS-v1.0?REQUEST=DescribeCoverage&COVERAGE=sst(time-lat-lon)&VERSION=1.0.0&SERVICE=WCS)
 - getCoverage URL (subsetting of sst.nc in ncML-GML format): [http://athena.pin.unifi.it:8080/galeon/WCS-v1.0?REQUEST=GetCoverage&VERSION=1.0.0&TIME=2001-01-16T00:00:00Z,2002-12-07T00:00:01Z&SERVICE=WCS&COVERAGE=sst\(time-lat-lon\)&VERSION=1.0.0&SERVICE=WCS](http://athena.pin.unifi.it:8080/galeon/WCS-v1.0?REQUEST=GetCoverage&VERSION=1.0.0&TIME=2001-01-16T00:00:00Z,2002-12-07T00:00:01Z&SERVICE=WCS&COVERAGE=sst(time-lat-lon)&VERSION=1.0.0&SERVICE=WCS)



[lon\)&RESPONSE_CRS=EPSG&CRS=WGS84\(DD\)&FORMAT=ncML-GML&BBOX=1.0,-69.5,359.0,89.5&RESY=1.0&RESX=2.0](#)

- getCoverage URL (subsetting of sst.nc in netCDF format):
[http://athena.pin.unifi.it:8080/galeon/WCS-v1.0?REQUEST=GetCoverage&VERSION=1.0.0&TIME=2001-01-16T00:00:00Z,2002-12-07T00:00:01Z&SERVICE=WCS&COVERAGE=sst\(time-lat-lon\)&RESPONSE_CRS=EPSG&CRS=WGS84\(DD\)&FORMAT=netCDF&BBOX=1.0,-69.5,359.0,89.5&RESY=1.0&RESX=2.0](http://athena.pin.unifi.it:8080/galeon/WCS-v1.0?REQUEST=GetCoverage&VERSION=1.0.0&TIME=2001-01-16T00:00:00Z,2002-12-07T00:00:01Z&SERVICE=WCS&COVERAGE=sst(time-lat-lon)&RESPONSE_CRS=EPSG&CRS=WGS84(DD)&FORMAT=netCDF&BBOX=1.0,-69.5,359.0,89.5&RESY=1.0&RESX=2.0)
 (note: because application/x-netcdf mime-type is not supported by web browsers, the file will be saved using the servlet name. Please rename it using .nc extension)
- SOAP binding
 WSDLs URL: <http://athena.pin.unifi.it:8080/galeon/services>

Table 1: Testbed datasets and the relative N2G API version

Test Dataset	Coverage domain	Coverage co-domain	CRS	Data size	N2G version
<i>simple</i>	2D + T	scalar (single)	Geo	small	ver 0.2
<i>sst</i>	2D + T	scalar (single)	Geo	medium	ver 0.4
<i>sst-2v</i>	2D + T	scalar (array)	Geo	medium	ver 0.6
<i>trid</i>	3D	scalar (single)	Geo	small	ver 0.7
<i>striped_can</i>	2D + T + P	parametric	Geo	large	ver 0.8
<i>ruc</i>	3D + T + P	parametric	Geo + Proj	large	ver 1.0

In summary, WCS-G is a WCS 1.0 implementation which is able to leverage ncML-GML capabilities in order to:

- facilitate the generation of necessary semantics for implementing the WCS protocol and data model, starting from netCDF-CF dataset
- generate and return a netCDF dataset description using both Earth Science and GIS metadata structure and semantics -i.e. ncML and GML grammar, respectively
- address the granularity difference issue existing between netCDF dataset and WCS coverage structures: to introduce the "netCDF set of coverages" structure which makes explicit the implicit and, potentially, complex structure of netCDF datasets
- include ASCII data in XML, directly
- link netCDF binary data

A useful vision is provided by "Extending THREDDS middleware to serve OGC community" presented at EGU '05 [3]



NcML-GML and N2G API

Current version of ncML-GML specification is 0.7.3 [5]. NcML-GML roadmap considers a full GML application for version 1.0.

ncML-GML is:

- An Abstract and Content Model reconciliation schema for ES and GIS info realms
- A Mediation Markup Language between ncML (netCDF Markup Language) and GML
- An extension of ncML core schema, based on GML grammar

For more documentation on ncML-GML v.0.5 see [1, 6].

For these IE, specific API for ncML-GML were designed and developed; they contains a service which generates a ncML-GML representation of a netCDF-CF dataset. Current version is 0.8 [4].

WCS Client

To test the WCS-G server prototype, a WCS 1.0 client was implemented and experimented: the WCS Browser Lite. It was developed using Java/Webstart technology.

WCS Browser Lite features include: SOAP and HTTP bindings support, netCDF and ncML-GML format support.

WCS Browser Lite URL: <http://zeus.pin.unifi.it/projects/wcsClientLite/>

(Known bugs: time subsetting causes an exception; sporadic verification errors on Webstart launch)

Interoperability experiments

It is noteworthy that the set of XML documents for WCS 1.0.0 (including all relevant XSDs located at <http://schemas.opengis.net/wcs/1.0.0/>) were emended on 2005-11-22, to reflect the corrigendum specified in document *OGC 05-076* and others (i.e. *OGC 05-068r1 "Store xlink.ssd file at a fixed location"*, *OGC 05-081r2 "Change to use relative paths"*). Unfortunately, the changes were not reckoned in the versioning of the specification, which remained "WCS 1.0.0". Even more unfortunately, as by the time of this writing (2006-02-03), the above mentioned corrigendum is still reserved (i.e. not publicly available).

This obviously had an impact on the experiment, causing several compatibility problems: WCS-G is currently not compliant with the emended WCS schemas, to preserve compatibility with the existing and available WCS clients.

WCS server

WCS-G has been tested against the following clients:



```
.66</ServiceException>  
</ServiceExceptionReport>
```

OGC specifications analysis

Comments and requests for enhancements to OGC specifications are briefly listed below. Since many of the issues we have encountered during GALEON interoperability experiment are already being addressed by the WCS RWG, in the active discussions on WCS 1.1, some of the following remarks may be not current at the time being.

1. Coverage format negotiation support is scarce. A server can only advertise the supported formats on a global basis (in its capabilities), but actually the supported formats may depend on the very request: e.g. a server may support geoTIFF-encoding only if requested 2-D subsets of its coverages.
2. The list of preferred standard formats may hinder WCS adoption among communities that use different, specialized formats (e.g. netCDF); a possible solution is to support the definition of application profiles, splitting the specification in a general protocol part and a format-specific semantics.
3. About the netCDF semantics as an encoding format, we recommend that the subsets of netCDF encoded coverages returned by a WCS be consistent netCDF files themselves (not just data chunks).
4. The XML vocabularies used in WCS, O&M and GML may be aligned and harmonized, to avoid duplications and ambiguity (we have encountered this problem when trying to publish netML-GML encoded coverages). In particular, RangeSetType should provide consistent support to composite range sets (aka multiple measurements) and to parametric range sets.
5. The semantics of subsetting, resampling, interpolation and such WCS operations should be independent of the domain axis to which the operation is applied. I.e. spatial and time axes may be modelled uniformly. In fact, a WCS serving model data may conceivably support time interpolation as well as spatial interpolation.
6. Unevenly-spaced grids (geometries where the distance among adjacent points along one or more of the grid axes is not constant; aka irregular grids) should be supported. Such geometries are most common in the Earth Science domain (e.g. acquisitions are seldom regularly-spaced in time).
7. URL GetCoverage replies should be supported, for subsequent retrieval.
8. WCS bindings to HTTP GET/POST and SOAP should be consistent (this is a well-known issue addressed in WCS 1.1).
9. A standard description of the expected WCS SOAP interface (e.g a WCS wsdl) should be defined, to improve interoperability of SOAP-based WCS clients and servers. We would recommend SOAP service with literal encoding, due to parameters complexity, using either RPC or Document style.

References

- [1] http://www.unidata.ucar.edu/projects/THREDDS/Nativi/GML-Days/GML_Days_Presentation.pdf



- [3] http://www.unidata.ucar.edu/projects/THREDDS/Nativi/EGU05/Nativi_EGU_05_Vienna_publication.pdf
- [4] <http://athena.pin.unifi.it:8080/ncml-gml/n2g-form.htm>
- [5] <http://zeus.pin.unifi.it/schemas/ncml/netcdf-coverage.xsd>
- [6] http://my.unidata.ucar.edu/projects/THREDDS/GALEON/ncML-GML%200.5_submitted.pdf