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1.   Introduction

In the context of a larger effort to model atmospheric, meteorological, and oceanographic data using ISO/OGC Feature types and Coverages, Unidata is looking at ways to represent these datasets in netCDF and in particular the possibility of extending the CF convention [1] to include those representations.

The larger effort began when a number of communities (the CDM work at Unidata, the CSML work at BADC, and the OGC Sensor Web Enablement Observations and Measurements) realized they were developing similar lists of data types. The combined list includes: 1) grid, 2) point/station observation, 3) vertical profile/sounding, 4) trajectory, 5) swath, and 6) radar/radial. This paper details the current state of the Unidata effort from the viewpoint of how the larger effort might suggest possible extensions to the OGC WCS.

2. OGC Web Coverage Service

The OGC Web Coverage Service (WCS) specification [2] defines a protocol for requesting subsets of gridded datasets. The WCS data model is based on the ISO coverage schema defined in the ISO 19123 specification [3]. Coverage data can be seen as a set of parameter fields and the spatial/temporal domain over which those parameter fields vary.

The WCS protocol is currently restricted to regularly spaced gridded data (regularly spaced in the given coordinate reference system). There is a current effort in the WCS working groups to extend this beyond regularly spaced grids and beyond the spatial/temporal limitations on the domain.

Though WCS currently restricts itself to gridded data, the ISO coverage concept is not the reason for this restriction.

3. ISO/OGC Coverages and Features

The ISO coverage schema (ISO 19123) is part of the ISO/TC211 family of specifications and is an extension of the ISO feature concept. Simple features generally represent objects that have a spatial extent or geometry and a set of attributes or parameters. For instance, a feature could represent a lake with a "name" attribute.

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A coverage represents a spatial domain with a set of parameters that vary over the domain. For instance, a coverage could represent the same lake in the earlier example but now each point on the lake has a depth value (and of course the lake could still have a name). So a coverage can be thought of as a feature with a mapping from each point in its spatial domain to a parameter value.

In some cases, these two representations (simple feature and coverage) can be thought of as two possible views into the same dataset. For instance, a collection of station observations can be seen as a collection of simple features each representing a station at a particular time and having a set of parameter values (temperature, pressure, etc). It is often convenient to view a time series of these observations at a given station. This lends itself more to a coverage view where time is part of the domain over which the parameters vary.

This relationship between feature and coverage has lead many to consider how the OGC Web Feature Service (WFS) and WCS might work together. In particular, it is interesting to consider how feature services might apply to coverage data.

For now, we will consider how the WCS restriction to gridded data might be extended to other data types.

4. Extending WCS to Non-gridded Coverages

The ISO coverage schema has already been used to model non-gridded types of data. One example is the Climate Science Modeling Language [4] which uses the ISO coverage schema to model a variety of data types including PointSeries, Profile, Trajectory, Section, and Swath.

Another effort underway models the Unidata Common Data Model (CDM) scientific data types using the ISO coverage schema [5,6]. This effort models a set of data types similar to those modeled by CSML.

To allow WCS to serve these non-gridded coverage types, a number of changes or extensions would need to be made to the WCS specification. One of the needed extensions involves developing encodings of the response that can represent the various data types. Another extension involves expanding the types of queries (subset requests) that are available in the WCS request.

5. Encodings for WCS Coverage Responses

There are a number of commonly used encodings for WCS coverage responses. Among them are GML, netCDF-CF, and HDF. Our efforts focus on netCDF so we will discuss current efforts aimed at extending netCDF-CF for gridded and non-gridded data.

The Unidata Observation Dataset Convention [7] is a first attempt to describe a netCDF attribute convention for non-gridded data. It includes point collections, station collections, profile, and trajectory datasets. This convention has been submitted to the CF community for discussion and possible future adoption.

WCS makes extensive use of the coordinate reference system (CRS) of a grid. The CF convention, however, does not support all the CRS details required by WCS. The CF community is already working on an extension that would more fully capture CRS details.

Though CF does recommend that grids be regularly spaced in some CRS, it is not a requirement. So, it is not confined to the current WCS regularly spaced grid restriction. There is also an effort in the netCDF/CF community to develop an unstructured grid convention.

6. Extending the WCS Queries for Non-gridded Coverages

The current WCS request can subset a coverage dataset with a latitude/longitude/Z (or X/Y/Z) bounding box, a time range, and a parameter selection. These subset query constructs are very general and should be valid when applied to any spatial/temporal coverage dataset. Once non-gridded coverage types are in use, other types of subsetting might be desired.

For instance, a coverage that consists of a collection of stations each with a time series of observations. The subset capabilities described above are well suited for returning a coverage subset consisting of all the stations within the given bounding box. However, if only a small number of the stations in the bounding box are desired, something more like a station list query capability might be desired.

Another possibility has to do with coverage type conversion or extraction. For instance, given a grid X/Y/Z/time coverage dataset, a request could be made to extract a trajectory coverage from the grid coverage. This would require including the trajectory geometry (an X/Y/Z/time curve) in the WCS request. Other possibilities include extracting from a grid 1) a time series at an X/Y/Z point, 2) a profile at an X/Y/time point, or 3) a station collection for all stations in a list.

Though outside of the WCS context, the NetCDF Subset Service (NCSS) [8] implements extraction of point data and profiles from gridded datasets. The NCSS also implements selecting subsets from station collection datasets.

7. Future Plans

For these ideas to mature, a number of efforts need to continue:

- Modeling of scientific data types with the ISO coverage schema.

- Development of netCDF conventions for these data types. Propose these conventions to CF community.

- Model the query/subsetting capabilities desired for and between data types. (Probably done as part of or in concert with the data type modeling.)

- Provide feedback and recommendations to the OGC WCS working group.

8. References

[1] NetCDF Climate and Forecast (CF) Metadata Convention, http://www.cfconventions.org/.

[2] OGC Web Coverage Service (WCS), http://www.opengeospatial.org/standards/wcs.

[3] ISO/FDIS 19123 Geographic information — Schema for coverage geometry and functions, ISO/FDIS 19123:2005(E).

[4] CSML (Climate Science Modeling Language), http://ndg.nerc.ac.uk/csml/.

[5] CDM (Common Data Model), http://www.unidata.ucar.edu/software/netcdf-java/CDM/.

[6] Nativi, S., J. Caron, B. Domenico, L. Bigagli: Unidata's Common Data Model Mapping to the ISO 19123 Data Model, submitted for publication to the Earth Science Informatics (ESIN) journal.

[7] Unidata Observation Dataset Convention, http://www.unidata.ucar.edu/software/netcdf-java/formats/UnidataObsConvention.html

[8] NetCDF Subset Service (NCSS), http://www.unidata.ucar.edu/projects/THREDDS/tech/interfaceSpec/NetcdfSubsetService.html