Donald W. Denbo[1][*] and John R. Osborne[2]

[1]Joint Institute for the Study of Ocean and Atmosphere, University of Washington, Seattle, WA

[2]OceanAtlas Software, Vashon, WA

1. INTRODUCTION

PMEL's ncBrowse is a general purpose, interactive java tool for graphical browsing of data and attributes in netCDF files. Coordination with Unidata during the development of the tool has helped to assure that ncBrowse reads a wide range of netCDF formats and has minimal dependence on any given set of netCDF file conventions. NcBrowse is a popular (5497 download by 2524 unique sites in 56 countries) general purpose, interactive Java tool for graphical browsing of data and attributes in netCDF files. NcBrowse is platform independent, reads a wide range of netCDF formats and file conventions.

NcBrowse has been enhanced to provide direct access to OPeNDAP (protocol formerly known as DODS) servers. OPeNDAP is the protocol that is used by the National Virtual Ocean Data System. This enhancement uses the Java-DODS library directly and is not restricted to the limitations of the netCDF API, enabling a ncBrowse user to access all the OPeNDAP objects, structures, etc. NcBrowse has also been signifi-cantly enhanced by providing 3-D visualizations of data in netCDF or OPeNDAP datasets using the VisAD library (http://www.ssec.wisc.edu/~billh/visad.html). NcBrowse continues to use the Scientific Graphics Toolkit to create 2-D visualizations. See http://www.epic.noaa.gov/java/ncBrowse and http://www.epic.noaa.gov/java/sgt for more information and download links for ncBrowse and SGT.

2. OPeNDAP Data Access

The OPeNDAP (previously DODS) is a software framework and protocol for providing and accessing scientific data over the internet. We are integrating the capabilities of ncBrowse and OPeNDAP to provide OPeNDAP users with a powerful and portable Java application that can access OPeNDAP metadata and visualize the data files, and provide ncBrowse users access to a growing collection of datasets available via OPeNDAP. A simplified "block" diagram of ncBrowse with the OPeNDAP access added is shown below (Figure 1).
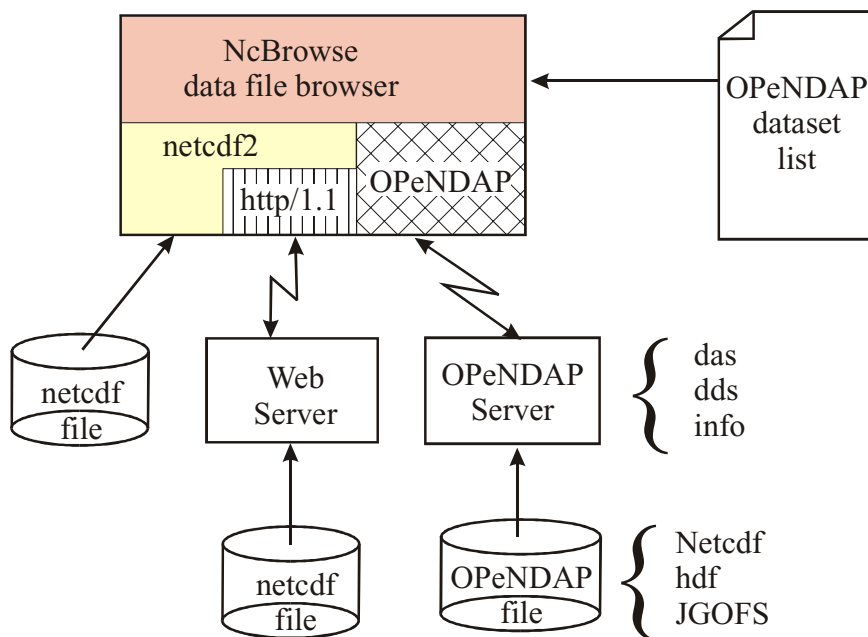

Figure 1. NcBrowse with OPeNDAP (DODS) dataset and metadata access.

* *Corresponding author address:* Donald W. Denbo, NOAA/PMEL/OCRD, 7600 Sand Point Way NE, Seattle, WA 98115; e-mail: dwd@pmel.noaa.gov

2.1 *Design Considerations*

We have implemented this new capability using Unidata's Java-DODS library to provide direct and complete

access to the OPeNDAP datasets. We include full access to the dataset descriptors (DDS), data attributes (DAS), and information services (info) that are provided by remote data servers that conform to the OPeNDAP standards. netCDF supports multi-dimensional arrays, dimensions, and both global and variable attributes. OPeNDAP adds two new data storage types: *Structure* and *Sequence*. The *Structure* data type is a set of variables (similar to a structure in the C programming language), and a *Sequence* is a data type similar to a *Structure*, but is multi-valued. It is possible to think of a *Sequence* as an array of *Structure* values.

The foremost design goal for incorporating OPeNDAP was to keep the ncBrowse interface simple and intuitive. The ncBrowse interface exposes only the required items for each data type. For example, since a netCDF file does not support the *Sequence* and *Structure* data types, the interface components for the new DDS, DAS, info, *Structure*, and *Sequence* features are not displayed.

2.2 *Example*

New windows have been added to ncBrowse to enable a user to view the attribute and data structures provided by the OPeNDAP protocol. For example, the *GEOSECS - Geochemical Ocean Section Study* dataset has been accessed from the Lamont Doherty Earth Observatory of Columbia University at http://ingrid.ldeo.columbia.edu/SOURCES/.GEOSECS/dods. The attribute and data structures provided by the OPeNDAP protocol are shown in Figure 2. ncBrowse
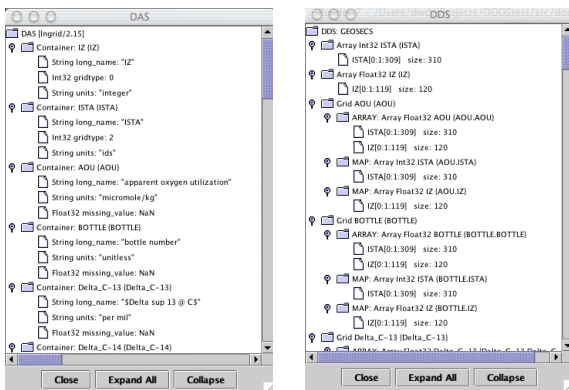
Figure 2. DAS and DDS dialogs.

also combines the DAS and DDS by using the long names of the variables and attributes for the users convenience (Figure 3). Combining the DAS and DDS objects allow a user to easily determine what attributes are associated with a specific variable.

The added complexity of accessing the OPeNDAP *Structure* and *Sequence* data types has been handled by using the swing JTree component. Using a graphical tree
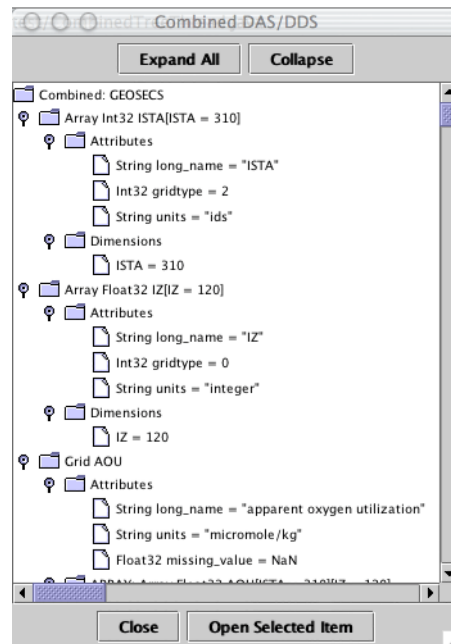
Figure 3. Combined DAS and DDS information.

structure allows a user to easily navigate through a complex data structure to find a variable of interest to browse.

3. 3D Visualization

ncBrowse was previously limited to 2-D visualizations. While in most cases this is not a significant limitation, there are, however, instances where 2-D visualizations of fields with 3 or more dimensions are not sufficient to adequately browse the data. We have added 3-D capabilities to ncBrowse by using the *VisAD* package from the University of Wisconsin.

The new capabilities include:
- 3-D float trajectories, colored by the value of a variable along the trajectory.
- 3-D surfaces, colored by the value of a variable on the surface.
- 3-D vector plots.

3.1 *Design Considerations*

As before with adding OPeNDAP support, a prime consideration in adding the new 3-D visualizations is to keep the interface simple and intuitive. To accomplish this, we decided to add 3-D visualizations under a new tab panel in the "Map Variable..." display (Figure 4).

The 2-D visualizations of ncBrowse use the Scientific Graphics Toolkit (SGT) to generate the graphics. It was decided to create a set of classes to "wrap" the VisAD display classes. Wrapping VisAD enables us to pass objects that are based on the SGT data objects to the
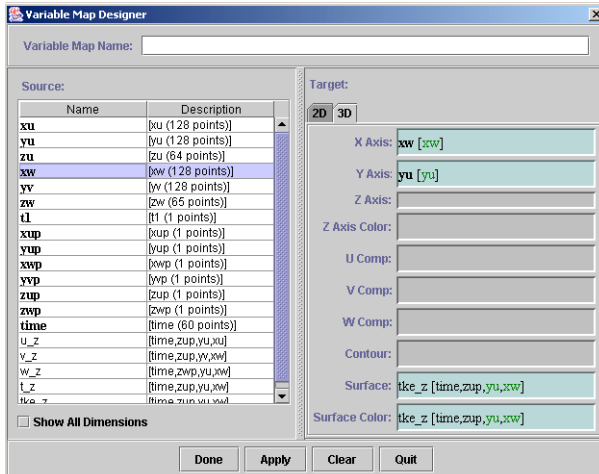
Figure 4. Assigning variable *tke_z* to both the surface and surface's color.

VisAD displays. The translation from SGT data objects to VisAD data objects occur inside the wrapping layer. By using SGT data objects and by doing the translation transparently to the application, enables SGT applications to have easier access to VisAD 3-D visualizations.

3.2 *Examples*

Below we present several examples of ncBrowse's new 3-D visualization capabilities. The examples include 3-D vectors on a surface (Figure 5), surface of topogra-
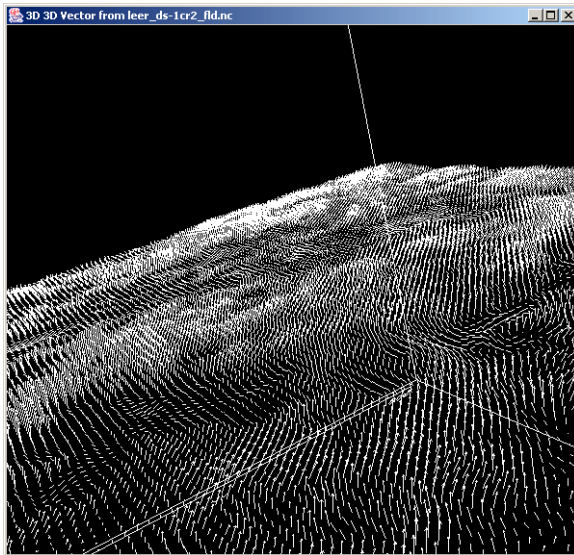

Figure 5. 3-D velocity vectors on a surface.

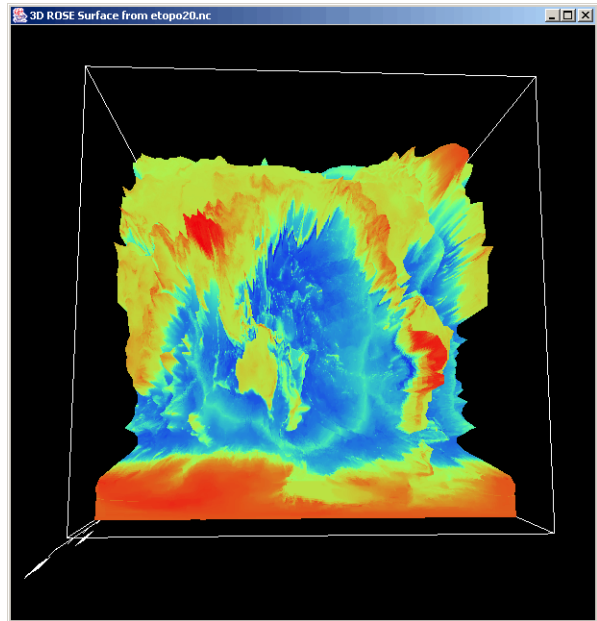phy from eptopo20 (Figure 6), and a temperature-salinity-pressure plot (Figure 7).
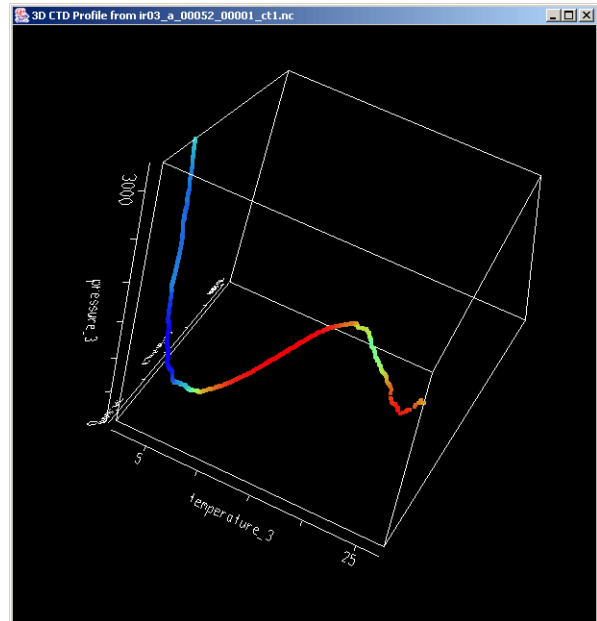

Figure 6. Etopo20 relief map

Figure 7. Temperature-Salinity-Pressure plot colored by dissolved oxygen.

4. FUTURE DIRECTIONS

4.1 *OPeNDAP server access.*

- Enhance ncBrowse to find OPeNDAP datasets from standard lists. For example, using THREDDS to find the datasets.
- Recognize metadata conventions typically used in the WOCE and JGOFS data files.

4.2 *3-D Visualizations*

- Placing several 3-D objects in a single display. For example, bathymetry, temperature surface, and float trajectory.
- Support VRML output of 3-D visualizations.

5. REFERENCES

Denbo, D.W. (2001): ncBrowse: A graphical netCDF file browser. *17th Conference on Interactive Information and Processing Systems (IIPS) for Meteorology, Oceanography, and Hydrology*, AMS, 14-19 January 2001, Albuquerque, NM, 473-476.

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