

# Summaries of Research

## Software to Access HDF5 Datasets via OPeNDAP's Data Access Protocol

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With compensated fundings from the NASA ESDIS project, the scope of the work in the original proposal was kept. The primary goals of this cooperative agreement for the period between October, 2006 and August 9, 2009 were:

- (1) To enhance the HDF5-OPeNDAP handler so that it can serve as an operational HDF5 data handler for NASA Earth Science community**
- (2) To implement a prototyped HDF5-friendly OPeNDAP client library so that the unique file structure of an HDF5 file can be preserved**
- (3) To participate in the Earth Science Data Systems Working Groups(ESDSWG)**
- (4) To submit a technical note about the mapping from HDF5 to DAP2 to the Standards Process Group(SPG)**
- (5) To support the design of DAP4**
- (6) To build a Hyrax distribution for the VMware hypervisor platform**

The following summaries of research are organized to correspond with the above goals.

### **(1) To enhance the HDF5-OPeNDAP handler**

#### *New features to handle general HDF5 data*

##### a) HDF5 compound datatype

The HDF5 compound datatype can support very complex data structures. We map the HDF5 compound datatype to DAP structure. The addition of this support allows the handler to serve complex HDF5 data.

##### b) HDF5 group

Defining an appropriate mapping from the HDF5 hierarchical group structure to DAP is not trivial since DAP does not have a concept that corresponds to the group in HDF5. After in-depth investigations and discussions, we decided to map all HDF5 datasets to DAP variables, with information about the HDF5 group structure mapped as a DAP attribute.

##### c) HDF5 object/region references

Since future NPP/NPOESS HDF5 data relies heavily on object and region references to organize data aggregations and granules, we also implemented the feature that maps an HDF5 object/regional reference to a DAP URL.

#### *New features to handle NASA HDF-EOS5 data*

##### a) HDF-EOS5 Grid and Swath

The ability to map EOS Grid and Swath to DAP was added to allow users to visualize and analyze Aura EOS Grid and Swath files with OPeNDAP clients and the data handler. We followed CF Conventions to ensure that the widely-used tools can visualize HDF-EOS5 Grid and some HDF-EOS Swath data via OPeNDAP. This can greatly improve the easy access of NASA HDF-EOS5 data via internet.

#### *Integration with DAP Server 4 framework (Hyrax)*

We have fully integrated the HDF5-OPeNDAP data handler with the DAP server 4 framework (Hyrax).

#### *Testing NASA HDF-EOS5 data*

We have tested the handler with HDF-EOS5 swath and grid files generated by Aura OMI, MLS, HIRDLS and TES instruments. Widely used visualization tools such as IDV, GrADS, Ferret, NCL, IDL and MatLab have been used to test the easy access of files via OPeNDAP.

#### *Community Outreach*

We have communicated frequently with developers at NASA GES DISC and helped them make the HDF5-OPeNDAP handler in operational use.

### **(2) To implement a prototyped HDF5-friendly OPeNDAP client library**

#### *Prototyped library*

This prototyped library was implemented and tested with the GrADS OPeNDAP client. The vertical profile of HDF-EOS5 swath data can be successfully visualized with GrADS through the prototype.

#### *Demo tools*

We also implemented two demo tools *ocdump* and *dap2h5* based on the prototyped HDF5-friendly OPeNDAP client library.

### **(3) To participate in the Earth Science Data Systems Working Groups(ESDSWG)**

During the project period, the PI Kent Yang participated in SPG and Technology Infusion Group of ESDSWG. The Co-I James Gallagher participated in SPG. We also presented posters in ESDSWG annual meetings.

### **(4) To submit a technical note about the mapping from HDF5 to DAP2**

We submitted a technical note to SPG that describes the mapping from HDF5 to DAP2. The key goal of this technical note is to share our experience of mapping HDF-EOS5 Grid and Swath, HDF5 group and HDF5 Object and region references to DAP2. We believed that the note can be used as a reference for those who would like to access HDF5 data using DAP2-compliant software.

#### **(5) To support the design of DAP4**

A significant portion of OPeNDAP's work on this project has been to ensure that new features in DAP4 will be able to represent data stored using HDF5 with the greatest possible fidelity. Many features in the initial design for DAP4 have been altered to mesh more tightly with the data model of HDF5. Of particular importance are the notions of 'dimension scales' and the abstract concept of separate dimension objects. By adopting these two features, the DAP4 data model will be able to cover a greater fraction of data stored in HDF4, HDF5, NetCDF3 and NetCDF3 4 files.

#### **(6) To build a Hyrax distribution for the VMware**

The "CheapStix" project was a one-week effort, supported with supplemental funds, to build a Hyrax distribution for the VMware hypervisor platform. Two virtual machines were built, one for use in workshop settings and one for use as a production server. Both are available for download from the [opendap.org](http://opendap.org) web site.

## **Appendix: Publications, Presentations, Posters and website**

### Presentations

"Improving the access of HDF data via OPeNDAP", MuQun Yang, SMC-IT 2009, July 2009

"HDF5 OPeNDAP Project update and demo", MuQun Yang and Hyo-Kyung Lee, the 12<sup>th</sup> HDF and HDF-EOS workshop, November 2008. <http://hdfeos.org/workshops/ws12/presentations/day3/kxy.ppt>

"HDF5 OPeNDAP Project update and demo", MuQun Yang and Hyo-Kyung Lee, the 11<sup>th</sup> HDF and HDF-EOS workshop, November 2007.

<http://www.hdfeos.org/workshops/ws11/presentations/day3/HDF5-OPeNDAP-Final.ppt>

### Posters

"Data Model Evolution in the Data Access Protocol", James Gallagher, John Caron, Dennis Hiembigner, Hyo-Kyung Lee, Rikki McQueary, Russ Rew, Muqun Yang, ESIP Summer Meeting, July 2009

"CheapSticks: The OPeNDAP Data Server on a USB Drive", James Gallagher and Daniel Holloway, ESDSWG Meeting, October 2008

"Accessing HDF5 Data via OPeNDAP", MuQun Yang and Hyo-Kyung Lee, ESDSWG meeting, October 2008

"Accessing HDF5 Data via OPeNDAP", MuQun Yang and Hyo-Kyung Lee, ESIP Summer Meeting, July 2008

"Access HDF5 Data via OPeNDAP", MuQun Yang, Hyo-Kyung Lee and James Gallagher, AMS annual meeting, January 2008

"Access HDF5 Data via OPeNDAP", MuQun Yang and Hyo-Kyung Lee, ESDSWG meeting, October 2007

“Harmonization efforts of HDF5, OPeNDAP and NetCDF-4”, MuQun Yang and Hyo-Kyung Lee, ESIP Summer Meeting, July 2007

### Publications:

"Using a Friendly OPeNDAP Client Library to Access HDF5 Data", MuQun Yang and Hyo-Kyung Lee  
American Meteorological Society - 25th International Conference on Interactive Information Processing Systems (IIPS) for Meteorology, Oceanography, and Hydrology, the 89th American Meteorological Society 2009 annual meeting, Jan. 11th - Jan. 16th, 2009  
<http://ams.confex.com/ams/pdfpapers/148069.pdf>

"Accessing HDF5 data via OPeNDAP" MuQun Yang, Hyo-Kyung Lee, and James Gallagher  
American Meteorological Society - 24th International Conference on Interactive Information Processing Systems (IIPS) for Meteorology, Oceanography, and Hydrology, the 88th American Meteorological Society 2008 annual meeting, Jan. 20th - Jan. 24th, 2008  
<http://ams.confex.com/ams/pdfpapers/130999.pdf>

“HDF5-OPeNDAP Project facilitates use of HDF-EOS Data to track Beijing air quality”, MuQun Yang, Hyo-Kyung Lee and Ruth Aydt, NASA ACCESS project 2008 impact report  
[http://www.hdfgroup.org/projects/opendap/documentation/HDF5-OPeNDAP\\_Impact\\_2008.pdf](http://www.hdfgroup.org/projects/opendap/documentation/HDF5-OPeNDAP_Impact_2008.pdf)

“Accessing NASA HDF-EOS atmospheric chemistry data via OPeNDAP”, MuQun Yang, Hyo-Kyung Lee, NASA ACCESS Project 2007 impact report  
[http://www.hdfgroup.org/projects/opendap/documentation/Easy\\_access\\_Aura\\_HDF\\_-impact\\_tool.pdf](http://www.hdfgroup.org/projects/opendap/documentation/Easy_access_Aura_HDF_-impact_tool.pdf)

### Website:

<http://www.hdfgroup.org/projects/opendap/>