J3.2 GIS FOR EXPANDING THE APPLICATION POTENTIAL OF TRMM DATA

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1. INTRODUCTION

The ongoing Tropical Rainfall Measuring Mission (TRMM) was launched on November 28, 1997 to monitor and study tropical and subtropical rainfall systems (----. 2000). TRMM standard products (accessible via http://lake.nascom.nasa.gov/data/dataset/TRMM/index.html) are archived and distributed by the Distributed Active Archive Center (DAAC) at the GSFC Earth Sciences Data and Information Services Center. These standard products are stored in the Hierarchical Data Format (HDF), one that is not generally familiar to TRMM users. To address this problem, as well as to broaden the TRMM user base and to expand the potential types of applications of TRMM data, the DAAC has been engaged in several efforts to develop value-added TRMM products and services. One such effort is to make the capabilities of a Geographical Information System (GIS) available to TRMM users. A GIS is a mapping software combined with a spatial database for analysis of multiple layers of information for a particular geographical location. A GIS would allow users to perform many types of analyses involving TRMM data and both the human and physical geography.

The key objectives of the DAAC's GIS efforts to bridge the gap between TRMM data and GIS tools are to (1) facilitate the access to and use of TRMM data, (2) increase the number and types of TRMM users, and (3) increase the potential types of applications of TRMM data. Two approaches were adopted, one focused on facilitating use of the data and the other on facilitating access to the data.

2. GIS-COMPATIBLE TRMM DATA

The DAAC's first approach to promoting a broader use of TRMM data within the GIS community is to offer geographical subsets (at the state and regional level) of data in a format easily incorporated in a GIS. For the development effort thus far, the TRMM data used is the TRMM Combined Instrument (TCI) Rainfall product (standard product 2B31) that has been resampled to 0.1 degree latitude and 0.1 longitude resolution (derived product G2B31) and spatially subset (RG2B31).

2.1 *Operational Production of GIS-compatible TRMM Data*

An automated system was developed to operationally convert selected TRMM data into GIS-compatible formats (Pollack et al., 2000). In general, the four main steps involved are (1) subsetting (spatial and parameter) the original satellite data based on user requirements, (2) transforming the results into some intermediate form for GIS input, (3) producing the GIS data layers with attached spatial information, and (4) exporting the coverages to ARC/INFO interchange and shapefile formats. Both the final GIS products and some intermediate files are available to users. The main disadvantage of operational conversion of data is the processing and storage costs involved, given the large amounts of TRMM data archived by the DAAC. However, the key benefit to the users is the easy incorporation of TRMM data as just another GIS layer, because no format conversion is needed.

2.1 *Data Distribution via Remote Sensing Information Partners*

The distribution of the operationally produced, GIS-compatible TRMM data makes use of a related DAAC initiative to establish a network of Remote Sensing Information Partners (RSIP's). The purpose of the RSIP program is to promote the use of remote sensing data by research and application users. The RSIP program provides participating institutions (1) easy and inexpensive access to TRMM and other DAAC data holdings and value-added products and services and (2) the ability to routinely acquire these data for local storage, use, and distribution. The RSIP's serve as secondary data distribution sites that "own" the data for their own research and application use and serve their local user communities (Qu et al., 2001). DAAC GIS-compatible TRMM and other data are ftp-transferred in near real-time by

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the RSIP's, which, in turn, support their local users by producing additional value-added products derived from the DAAC satellite data. Currently, the University of New Mexico's Earth Data Analysis Center (EDAC), for example, is routinely transferring the GIS-compatible form of the TCI data (RG2B31) via FTP. EDAC then combines this product with other data layers to support the study and monitoring of environmental conditions in the Sevilleta National Wildlife Refuge, within which a network of automated weather stations has been deployed.

An ongoing RSIP effort by the DAAC is to make the distributed data at the RSIPs and at the DAAC mutually visible and accessible over the internet in an interoperable way. This is done via Open GIS Consortium (OGC)-compliant servers and clients, such as those described in Sec. 3.2 and 3.3. Current prototyped capabilities include the online display of maps (images), the original data, and some ancillary data (e.g., state boundaries). Data being tested include the TCI Rainfall and a Normalized Difference Vegetation Index (NDVI) product from the Earth Observing System's Moderate Resolution Imaging Spectroradiometer (MODIS).

3. INTERACTIVE WEB ACCESS TO TRMM DATA

The DAAC's second approach to promoting a broader use of TRMM data is to provide online, interactive capabilities for GIS data searching, visualization, mapping, and analysis; access to ancillary data; and retrieval of data (in various formats) or results of analysis of the data. Specific ongoing efforts include (1) a WebGIS; (2) a WMT-DODS (Web Mapping Testbed-Distributed Oceanographic Data System) server (Note: DODS is not restricted to ocean data; the name exists for historical reasons.); and (3) an interactive Web-based mapping software client. The latter two efforts are both OGC-compliant, which, together with TRMM data in formats that are compliant with current, developing interoperability standards, allow the seamless integration of TRMM data with other compliant geospatial data from local or distributed sources, regardless of the original data format. The interoperable aspect is schematically illustrated in Fig. 1.

3.1 *WebGIS*

The DAAC WebGIS (http://daac.gsfc.nasa.gov/WEBGIS/) was developed, in part, to address the unique requirements of the DAAC for Internet delivery of data (i.e., HDF and binary data formats, large data volume, and large number of files) (Pollack et al., 2001a). An eventual goal of the WebGIS is to provide on-the-fly format conversion, instead of the routine operational conversion described in Sec. 2.1. In the current version of the WebGIS, based on a Java applet, the user can select search criteria (geographical region and date of TRMM data) and a choice of ancillary GIS data layers (political boundaries, cities, roads, rivers, etc.). The WebGIS searches the DAAC TRMM data holdings and reads and displays the retrieved data and associated GIS data layers to create a map. The resulting map is then displayed in a Web browser, and the user can optionally download the map or data in GIS formats (shapefiles, OGC standards). In addition, the original TRMM data (in HDF or binary) are available to the user.

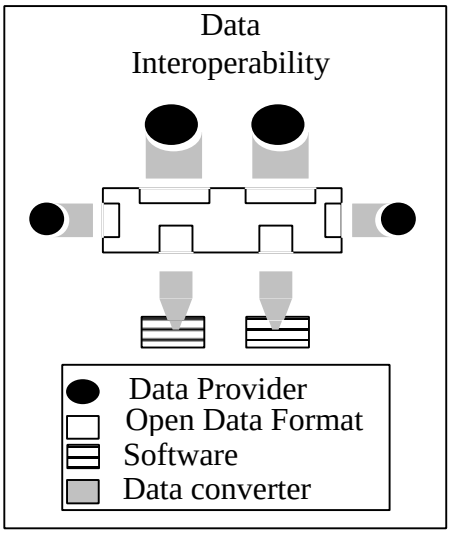

Fig. 1. Schematic of interoperability from DAAC perspective. DAAC represented as a data provider (black oval) using open standards (white shape) to offer data to various end user software packages (horizontal-lined rectangles).

There are two key benefits of using WebGIS for data access and delivery. One is reduced data volume, because the online mapping and analysis capabilities of a WebGIS may be sufficient for some users, so that they do not need to transfer the original data. The other benefit is that users do not need specialized tools to handle the data; only a Java-enabled browser is required. TRMM users can thus gain some of the benefits of a GIS for analysis without having to purchase any software.

3.2 *OGC-Compliant Server*

The WMT-DODS server at the DAAC is being developed to make DODS- or WMT-enabled data sets (including TRMM) at the DAAC accessible via OGC-compliant clients, such as Digital Earth

(DE)-enabled viewers (Lynnes et al., 2001). DODS provides a way for users to access DODS-enabled data anywhere on the Internet from within their existing, customary analysis and visualization software packages. Data are transferred between server and client via format-neutral objects (Hankin, 2001). The Web Mapping Testbed (WMT) project is an OGC effort to achieve seamless data access to, and visualization and analysis of, the diverse and widely distributed geospatial data holdings on the Web (http://www.opengis.org/). The WMT-DODS is a DAAC effort to bridge these two related systems, by enhancing DODS to support DE/WMT protocols.

3.3 *OGC-Compliant Client*

The DAAC is currently developing an OGC-compliant Web viewer to provide access to tools and information designed to allow end users to search for, visualize, and retrieve selected TRMM and other DAAC data Pollack et al., 2001b). This OGC client combines DAAC's WebGIS and OGC efforts (Sec. 3.1, 3.2) by offering a tool to allow users online access to DAAC data and those from other sources, converted on-the-fly to OGC-compliant formats. To facilitate online analysis and visualization, ancillary data are maintained by the DAAC for use in the Web viewer. The viewer currently implements OGC's GetMap (display image) and GetCoverage (display data) specifications.

The benefits to the users are (1) the open standards and formats are not specific to any given software package, (2) data conversion is transparent, and (3) data from distributed sources and various formats can be easily combined and analyzed in a seamless environment.

4. CONCLUSION

The several Web capabilities being developed at the DAAC could be variously integrated into coherent, application-driven, interoperable, data access systems. Adhering to OGC standards means users from any OGC-compliant client would be able to access DAAC data. The WMT-DODS server would be able to serve data to any such client, while the DAAC OGC-compliant client could offer, in addition, specific enhanced capabilities to its users.

These initiatives aim to provide TRMM users easier access to analysis tools and emerging technologies that show great potential for enhancing TRMM data analysis. They will allow a much larger and more diverse user community to make use of TRMM and other DAAC data, and greatly increase the information density of the data accessed by users. The DAAC will continue to explore ways to bring the benefits of GIS to the TRMM user and, thus, to help foster new applications of TRMM data.

5. REFERENCES

Hankin, S., 2001: DODS, the Distributed Ocean Data System. In Proc. 17th Int'l. Conf. Interactive Info. and Processing Sys. for Meteor., Oceanography, and Hydrology, 2001, Amer. Meteor. Soc., Albuquerque, NM, 175-177.

Lynnes, C., L. Pham, P. Sweatman, N. Pollack, P. Cornillon, D. Holloway, and J. Gallagher, 2001: Interoperability between Digital Earth and DODS (abst.). Presented at Digital Earth 2001, New Brunwick, Canada.

Pollack, N., W. Teng, L. Chiu, G. Serafino, and D. Wong, 2000: Operational production and distribution of GIS-compatible remotely sensed data to facilitate their use. In Proc. Amer. Soc. Photogrammetry and Remote Sens. Annual Meeting, 2000, ASPRS, Wash., DC.

Pollack, N., W. Teng, and G. Serafino, 2001a: Enhancing GDAAC data access and usage with a WebGIS. In Proc. Amer. Soc. Photogrammetry and Remote Sens. Annual Meeting, 2001, ASPRS, St. Louis, MO.

Pollack, N., W. Teng, G. Serafino, R. Swafford, and P. Sweatman, 2001b: Digital Earth as an integral part of the GDAAC's data distribution strategy (abst.). Presented at Digital Earth 2001, New Brunwick, Canada.

Qu, J., G. Serafino, M. Kafatos, R. Lathrop, and J. Trimble, 2001: New application of Earth science remote sensing data at NASA/GES DISC: Remote Sensing Information Partner (RSIP) with Rutgers University. In Proc. IEEE 2001 Int'l. Geosci. Remote Sens. Symp., July 9-13, 2001, Sydney.

-----, 2000: Special issue on the Tropical Rainfall Measuring Mission (TRMM). Combined pub. 1 Dec. 2000 J. Climate, **13**, 4069-4228 and Pt. 1 Dec. 2000 J. Appl. Meteor., **39**, 1961-2301.