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DEVELOPING A GLOBAL AGRICULTURE INFORMATION SYSTEM

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1. INTRODUCTION

Monitoring global agricultural crop conditions during the growing season and estimating potential seasonal production are critically important for market development of U.S. agricultural products and for global food security. Two major operational users of satellite remote sensing for global crop monitoring are the USDA Foreign Agricultural Service (FAS) and the U.N. World Food Program (WFP). The primary goal of FAS is to improve foreign market access for U.S. agricultural products. The WFP uses food to meet emergency needs and to support economic and social development. Both use global agricultural decision support systems that can integrate and synthesize a variety of data sources to provide accurate and timely information on global crop conditions.

The Agricultural Information System (AIS), currently under development, is based on the existing TRMM Online Visualization and Analysis System (TOVAS). The AIS will provide environmental data and information to support agricultural activities; specifically, it will operationally provide access to NASA Earth Science Enterprise (ESE) and other data products (e.g., rainfall, crop model outputs) and services.

The AIS will enable the remote, interoperable access to distributed data, by taking advantage of the GrADS-DODS Server (GDS), a stable, secure data server that provides subsetting and analysis services across the Internet, for any GrADS-readable data set. The subsetting capability allows users to retrieve a specified spatial region from a large data set, eliminating the need to first download everything. The analysis capability allows users to retrieve the results of an operation applied to one or more data sets on the server.

The first release of AIS will contain: 1) Analysis of current conditions that contains links to complete product (rainfall, surface reflectance, etc.) analysis maps for selected regions worldwide and the conterminous United States; 2) An Agriculture Online Visualization and Analysis System (AOVAS) that allows to access global, current and historical data and analysis and generate customized maps, time series, and digital data.

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2. AOVAS AND GIOVANNI ARCHITECTURE

Few observational data are available for disaster monitoring in remote and poor third world countries. Satellite remote sensing observations provide a unique way in providing such data from space. The Tropical Rainfall Measuring Mission (TRMM) is a join mission between NASA and the Japan Aerospace Exploration Agency (JAXA) designed to monitor and study tropical rainfall (TRMM Special Issue, 2000). The GES DISC archives and distributes TRMM data. However, accessing these products can be a challenging task to many non data experts. For example, all these products require different software for processing, which could require a significant investment from the user side. To overcome this difficulty and facilitate data access, the GES DISC has developed a web based system, TRMM Online Visualization and Analysis System (TOVAS).

TOVAS is based primarily on TRMM data (Liu et al. 2002a, 2002b, and 2002c; Liu et al. 2002): Three hourly TRMM and Other Satellite Rainfall (3B42RT) for Jan 2002-present, TRMM Level-3 Three-hourly Rainfall (3B42) for Jan 1998-present, TRMM Level-3 Monthly Rainfall (3B43) for Jan 1998-present, Willmott and Matsuura Global Precipitation (Willmott and Matsuura, 1995) for Jan 1950-Dec 1999, Global Precipitation Climatology Center (GPCC) Monthly Global Precipitation for Jan 1986-present. TOVAS has been in operation since March 2000.

AOVAS (Figure 1), based on TOVAS, is a part of the GES-DISC Interactive Online Visualization and Analysis Infrastructure or "Giovanni." The principle design goal for Giovanni was to provide a quick and simple interactive means for science data users to study various phenomena by trying various combinations of parameters measured by different instruments, arrive at a conclusion, and then generate graphs suitable for a publication. Alternatively, Giovanni would provide a means to ask relevant what-if questions and get back answers that would stimulate further investigations. This would all be done without having to download and preprocess large amounts of data. A secondary design goal was for Giovanni to be easily configurable, extensible, and portable. The GES DISC currently runs Giovanni on Linux, SGI, and Sun platforms.

Another goal of Giovanni was to off-load as much as possible the data processing workload onto the machines hosting the data and to reduce data transfers to a minimum.

Given the enormous amount of data at the GES DISC Distributed Active Archive Center (DAAC) in HDF, it was a requirement was that Giovanni support HDF, HDFEOS, as well as binary.

Finally, Giovanni needed to be flexible, adaptable, and easy to set up quickly for measurement-based projects at the GES DISC.

Giovanni consists of HTML and CGI scripts written in Perl, Grid Analysis and Display System (GrADS) scripts, and one or more GrADS-DODS (Distributed Oceanographic Data System) Servers (GDS) running on remote machines that have GrADS readable data. In addition, there is an image map Java applet through which a user can select a bounding box area to process. The data flow is illustrated in Figure 2.

GrADS was chosen for its widespread use for providing easy access, manipulation, and visualization of Earth science data. It supports a variety of data formats such as binary, GRIB, NetCDF, HDF, and HDFEOS. When combined with DODS, as in GDS, the result is a secure data server that provides subsetting and analysis across the network or even the Internet. The ability of GDS to subset data on the server drastically reduces the amount of data that need to be transferred across the network and improves overall performance. GDS provides spatial or temporal subsetting of data while applying any of a number of analysis operations including basic math function, averages, smoothing, correlation, and regression. An equally important feature is the ability to run GrADS data transformations on the server.

Via the Giovanni Web interface (Figure 3), the user selects one or more data sets, the spatial area, the temporal extent, and the type of output. Supported output types are listed in Table 1. The selection criteria are passed to the CGI scripts for processing.

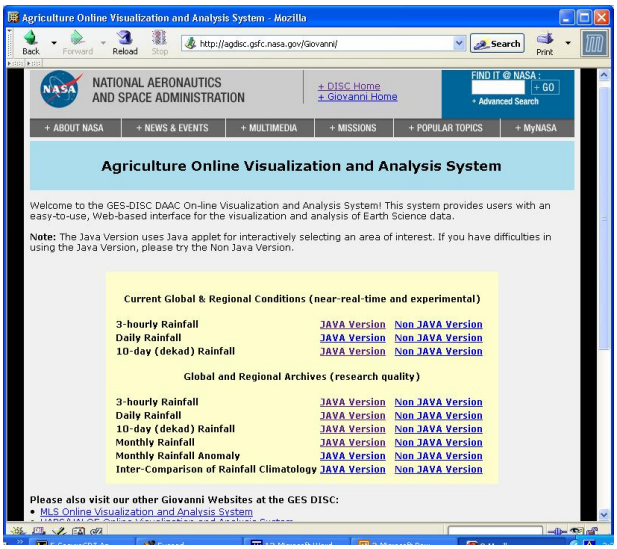

Figure 1. AOVAS front page.

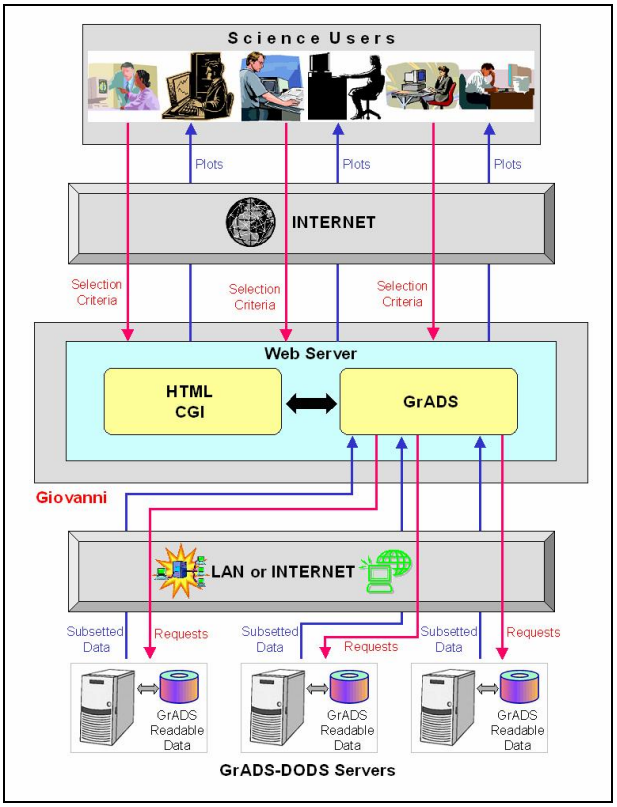

Figure 2. GIOVANNI system diagram.

Table 1. Functions supported by GIOVANNI.

Output Type	Description
Area Plot	Area plot averaged or accumulated over any available data period within any rectangular area
Time Plot	Time series averaged over any rectangular area
Hovmoller Plots	Longitude-time and latitude-time plots
Animations	Animations available for area plots
ASCII Output	ASCII output available for all plot types, suitable feeding GIS or other applications

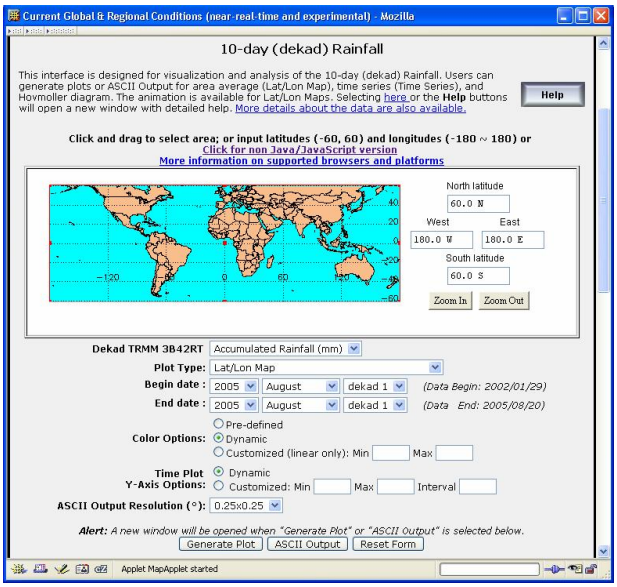

Figure 3. Example web interface of Giovanni for AOVAS.

3. CURRENT IMPLEMENTATIONS

Current implementations mainly consist of TRMM and other rainfall products:

Analysis of Current Conditions

Contains links to complete product (rainfall, surface reflectance, etc.) analysis maps for selected regions worlwide and the conterminous United States.

- 3-hourly Global and Regional Rainfall Maps
- 24-hour Global and Regional Rainfall Maps
- 10-day Global and Regional Rainfall Maps
- 30-day Global and Regional Rainfall Maps

Agriculture Online Visualization and Analysis System

Allow to access global, current and historical data and analysis and generate customized maps, time series, and digital data.

Current (near-real-time and experimental):

- 3-hourly Global and Regional Rainfall
- Daily Global and Regional Rainfall
- 10-day (dekad) Global and Regional Rainfall

Archives (research quality):

- 3-hourly Global and Regional Rainfall
- Daily Global and Regional Rainfall
- 10-day (dekad) Global and Regional Rainfall
- Monthly Global and Regional Rainfall
- Monthly Global and Regional Rainfall Anomaly and Climatology
- Inter-Comparison of Rainfall Climatological Data Products

The analysis of current conditions provides maps of global and regional rainfall and allows a fast and easy access to TRMM rainfall data. Figure 4 is the html page for map access and Figure 5 an example of the maps. Additional maps will be added in the future.

The AOVAS provides users a powerful and customized analysis and visualization tool for TRMM and other rainfall products. Figure 6 is an example showing a severe flood in the Mumbai (India) area during the 3rd dekad of July, 2005.

4. FUTURE DIRECTIONS

More rainfall and agriculture related products will be added. More functions and maps will be added as well. We will continue to analyze user feedback and suggestions from our collaborators, such as, USDA, United Nations World Food Programme.

An important future direction for Giovanni to take is full support of Geographic Information System (GIS) and output formats suitable for GIS, for example GeoTIFF. Giovanni also needs to better support multi-instrument analyses with smart handling of multiply defined grids. Other directions include the ability to represent errors due to missing data and data quality in meaningful ways.

ACKNOWLEDGMENT

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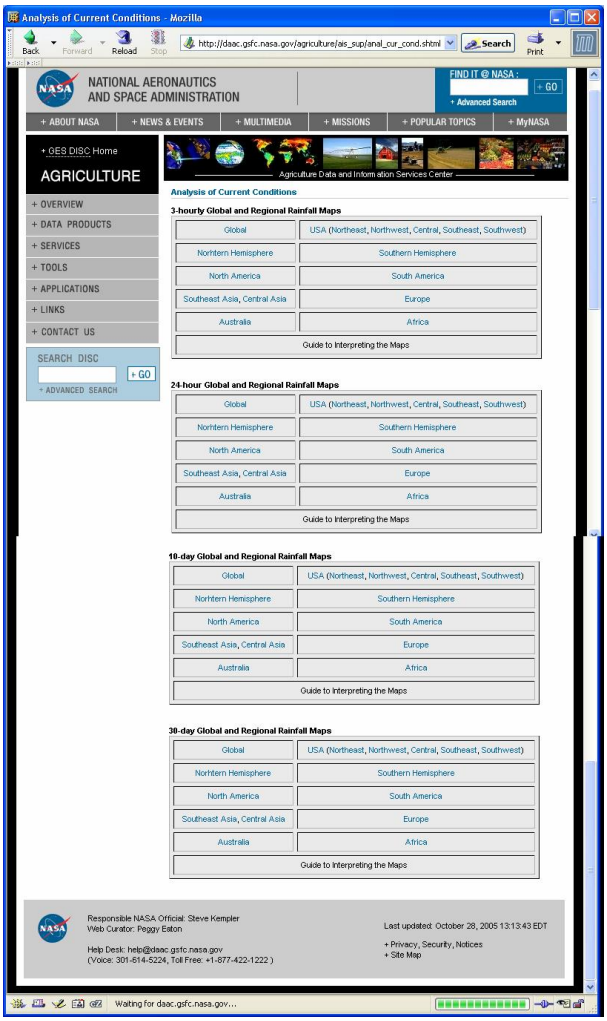

Figure 4. Maps of current conditions, providing a quick and easy access to current global and regional rainfall conditions.

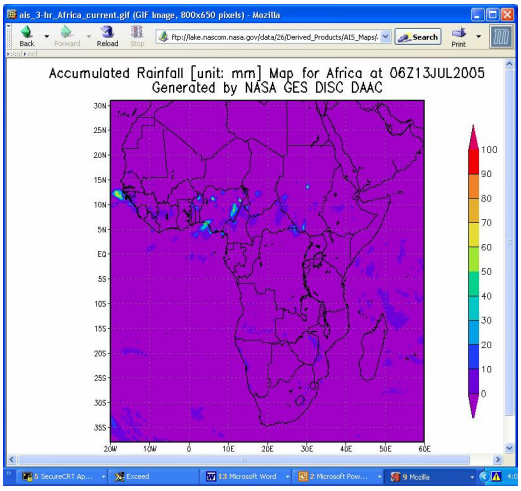

Figure 5. Example of current condition maps described above.

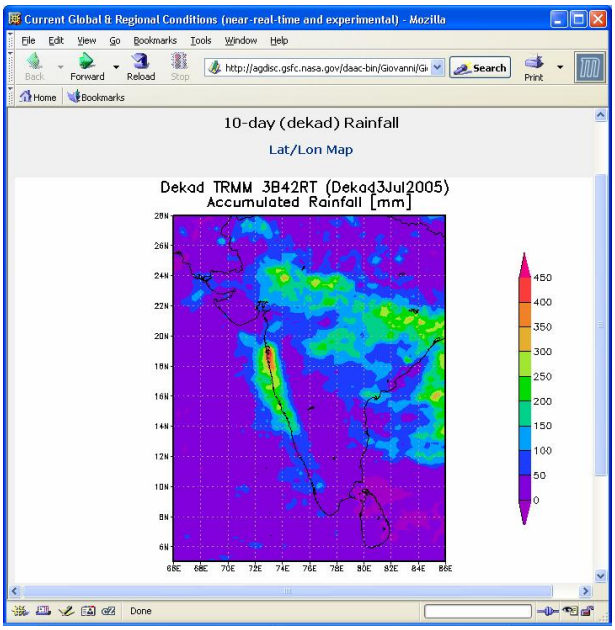

Figure 6. Accumulated rainfall map for Dekad 3, July, 2005.

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Willmott, C. J. and K. Matsuura, 1995: Smart Interpolation of Annually Averaged Air Temperature in the United States. *Journal of Applied Meteorology*, 34, 2577-2586.

INFORMATION:

Project Portal:
http://daac.gsfc.nasa.gov/agriculture/index.shtml

Agriculture Online Visualization and Analysis System (AOVAS):
http://agdisc.gsfc.nasa.gov/Giovanni

TRMM Online Visualization and Analysis System (TOVAS):
http://lake.nascom.nasa.gov/tovas

Data in higher temporal and spatial resolutions:
http://eosdata.gsfc.nasa.gov/data/

All TRMM standard data can be searched and ordered via:
http://lake.nascom.nasa.gov/data/dataset/TRMM

For further details about TRMM, visit:
http://trmm.gsfc.nasa.gov

Questions and comments, please email to:
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