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DEVELOPING ONLINE PRECIPITATION VISUALIZATION SYSTEMS FOR EDUCATION

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1. INTRODUCTION

Precipitation is an important atmospheric variable in our daily life. Each year, floods and droughts happen around the world, causing heavy property damage and human casualties. Traditionally rain gauge measured precipitation is the main source for weather forecast and research. However, satellite remote sensing has increasingly become important in providing precipitation information over vastly undersampled oceans and continents. In particular, the Tropical Rainfall Measuring Mission (TRMM) is a joint U.S.-Japan satellite mission to monitor tropical and subtropical (40° S - 40° N) precipitation and to estimate its associated latent heating. The TRMM satellite provides the first detailed and comprehensive dataset on the four dimensional distribution of rainfall and latent heating over vastly undersampled tropical and subtropical oceans and continents. The TRMM satellite was launched on November 27, 1997. TRMM data products are archived at and distributed by the NASA Goddard Earth Sciences Data and Information Services Center (GES DISC).

To encourage students, especially those underrepresented minority students, to consider academic, operational or research careers in geosciences, it is necessary to let them participate in earth science education and applications as early/frequently as possible and expose to hands-on projects. However, existing issues in data accessing, such as, data format, data volume, etc. are the major hurdles for conducting these activities.

The GES DISC has taken a major step towards meeting these challenges. TRMM Online Visualization and Analysis System (TOVAS, URL: http://lake.nascom.nasa.gov/tovas), developed by the hydrology data support team at the GES DISC, provides a fast and easy way for a wide variety of users to obtain global precipitation information over the Internet.

TOVAS allows users to plot, subset and output TRMM Level 3 gridded data products that range from 3-hourly near-real-time to monthly. Simple functions, such as, area averaging and accumulating, allow users to quickly obtain precipitation characteristics in areas of their interests. Time series allows users to understand 3-hourly, daily, seasonal to interannual variations. An ASCII output capability allows users to use subsetting data for their own research and applications. Detailed information about the data and the TOVAS functions will be given in the next section and application examples will be presented in Section 3.

2. DATA AND FUNCTIONS

The TRMM satellite flies at an altitude of 402.5 km. The TRMM satellite carries three rain-measuring instruments. NASA GSFC provided the TRMM Microwave Imager (TMI), the Visible Infrared Scanner (VIRS), and the observatory, and operates the TRMM satellite via the Tracking and Data Relay Satellite System (TDRSS). The Japan Aerospace Exploration Agency (JAXA) provided the Precipitation Radar (PR), the first space-borne precipitation radar, and launched the TRMM observatory. TRMM standard products at three levels are available at the GES DISC. Level 1 products are the VIRS calibrated radiances, the TMI brightness temperatures, and the PR return power and reflectivity measurements. Level 2 products are derived geophysical parameters at the same resolution and location as those of the Level 1 source data. Level 3 products are the time-averaged parameters mapped onto a uniform space-time grid. An evaluation of the sensor, algorithm performance and first major TRMM results appear in the Special Issue on the Tropical Rainfall Measuring Mission (TRMM), the combined publication of the Journal of Climate and Journal of Applied Meteorology (2000).

Based on the distribution statistics, it appears that most users prefer Level-3 products. At present, we only include Level-3 products in TOVAS and they are, 3B42RT (3-hourly), 3B42 (daily), 3B43 (monthly), and historical monthly rainfall provided by Cort J. Willmott and Kenji Matsuura from Center for Climatic Research Department of Geography University of Delaware (Willmott and Matsuura 1995). The selected products provide global precipitation at different temporal and spatial scales.

Basic features and functions of TOVAS are listed below,

- Area, point and time selection

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- Data subsetting
- Rain rate or accumulated rainfall output
- Analyses: area/point averaging or accumulating, time series, animation, and Hovmoller.
- ASCII output.
- Access related data, software, documentation and published articles

3. EXAMPLES OF USING TOVAS

3.1 Flood in Mozambique

In February, 2000, parts of Mozambique received rainfall of over 300 mm in one day, causing extensive erosion and urban infrastructure damage in Matola and Maputo cities, according to the Ministry of Public Works and Housing (2000). The rainfall made the rivers Umbeluzi, Incomati, Limpopo and Buzi to spring its banks. Before the water levels receded, a tropical depression Eline brought in record rainfall in the upstream catchment areas of these rivers. More than 300 people died and about 2 million had been displaced or affected. Agricultural lands and most of the infrastructure in the affected areas were destroyed.

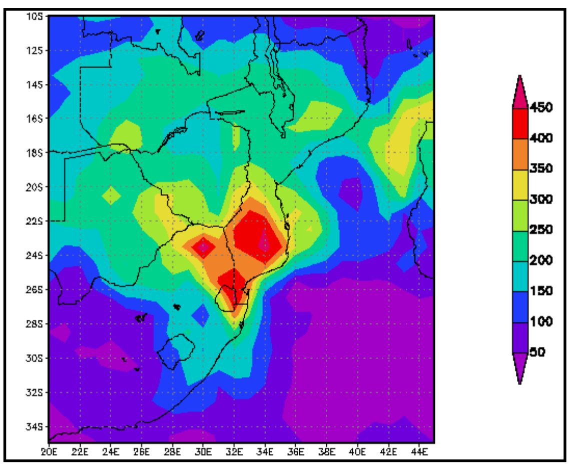

Figure 1. Regional accumulated rainfall for February, 2000.

Using TOVAS, the regional rainfall in February, 2000 was plotted (Figure 1). The figure shows that there are three areas with heavy rainfall. The largest area is found in south Mozambique. The second largest is found at the border between Mozambique and Swaziland/South Africa. The third area is found in the northeast corner of South Africa. Detailed time series plot from the daily TRMM 3B42 rainfall data (Figure 2) reveals that two major precipitation events dominate the rainfall in February. The first event happened in the early February and the maximum rainfall is found on February 4. This event caused extensive damage in the southern cities mentioned earlier. The second event is found in the late February and the maximum rainfall is on February 22, resulted from the landfall of the tropical depression Eline. A plot of daily 3B42 rainfall between 1998 and 2000 (not shown here) reveals that the year of 2000 has the most heavy rainfall days during the three year period. The data from Willmott and Matsuura (1995) can also be used to study rainfall during the past 50 years.

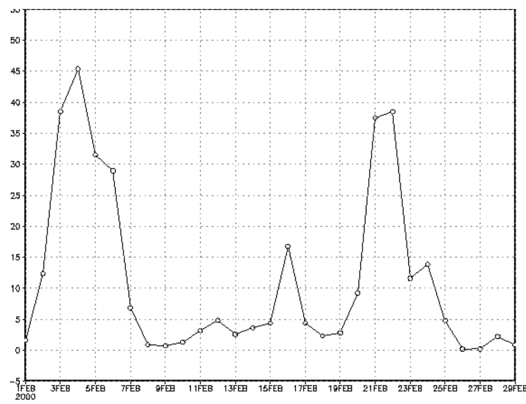

Figure 2. Time series of daily TRMM 3B42 rainfall total for the southern part of Mozambique.

3.2 Floods in China

In the summer, 1998, severe floods, the worst since 1954, occurred along the Yangtze River. 290 millions of people were affected in 28 provinces. 3656 people were killed and over 17 millions of houses were destroyed. 21.8 million hectares of farmland were swamped. The total economic loss exceeded over 30 billion US dollars.

The regional rainfall for July and August, 1998 was plotted using TOVAS. Figures 3 and 4 are the regional rainfall for July and August, respectively. Figure 3 shows that most rainfall in July is concentrated on the areas between Dongting Lake and Poyang Lake. By contrast, most rainfall in August is found in the upstream areas of the Yangtze River (Figure 4). Daily rainfall product, the TRMM 3B42, reveals that weather systems, such as, the one shown in Figure 5, played an important role to the regional flooding.

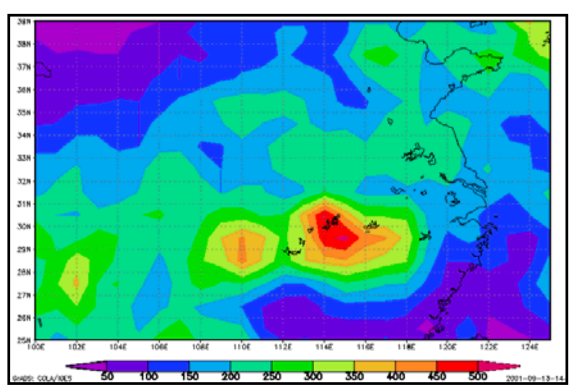

Figure 3. Regional accumulated rainfall for July, 1998.

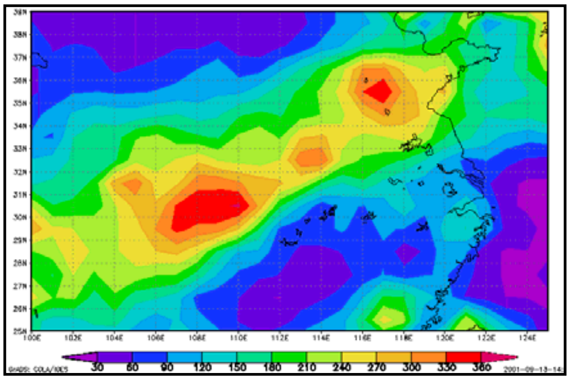

Figure 4. Regional accumulated rainfall for August, 1998.

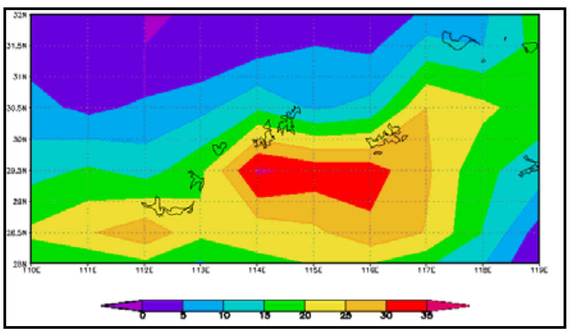

Figure 5. Daily accumulated rainfall for July 17, 1998

3.3 Monitoring rainfall conditions in the Mid-Atlantic region

With Hovmoller plot options, it is easy to obtain seasonal-to-interannual precipitation information over the world. TOVAS allows users to plot Hovmoller maps with a fixed latitude/longitude, or an averaging area with fixed latitudes/longitudes. Users could also adjust the color bar options to make customized plots. Users could also obtain data in ASCII format for additional analyses and applications.

With TOVAS, one could monitor both present and historical rainfall conditions over the world. Here is an example of the application in the Mid-Atlantic region. Figure 6 is a Hovmoller plot for 3B43 monthly rainfall during the period between January 1998 and September 2003. The plot allows an easy comparision of seasonal-to-interannual variations. A period of drier months (marked by a white oval) in 2002 can be easily identified from the plot. It was a severe drought reported in the region and the state emergencies were declared to save water. From the plot, a period of excessive rainfall following the drought (marked by a red oval) can be identified as well.

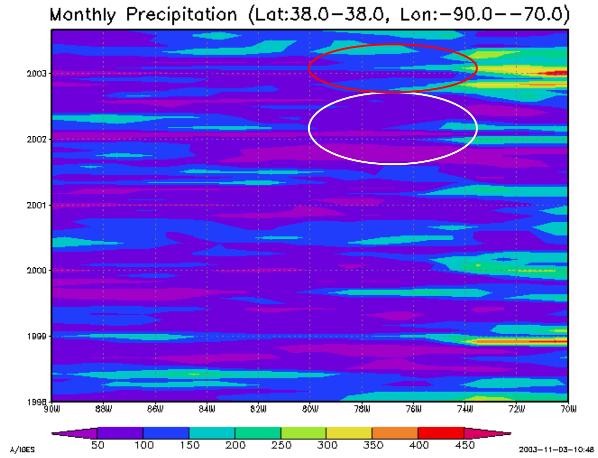

Figure 6. Monthly 3B43 rainfall Hovmoller plot for the Mid-Atlantic region.

Precipitation data have been widely used in many earth science applications ranging from crop yield estimates (e.g., the United Nations World Food Program), tropical infectious diseases (e.g., Anyamba et al., 2000; Zhou et al., 2002; Masuoka et al., 1998; Liu et al. 2002a; 2002b), drought and flood monitoring (Liu et al. 2002c), etc.

Since the launch of TOVAS, we have received reports from users regarding the use of TOVAS in their applications. Below is a list of recent applications:

- Study on coastal urban heat island effect on rainfall.
- Additional rainfall information to supplement ground stations in Sri Lanka.
- Phenology study in Africa and North America.
- Crop yield estimates and flood watch in Africa and Asia.
- Rainfall information for a development project in Afghanistan.
- Fire monitoring activities in Africa.
- Data for hydrological modeling in Africa.
- Range prediction of American butterflies.
- Intercomparison with other products in North America.
- Monitoring rain events in Balkan.
- Investigation of the 1997-98 El Nino/La Nina event.
- Investigation of insect activities in US.

4. CONCLUSION AND FUTURE PLANS

The description and examples of TOVAS have been presented. Future plans will focus on 1) tools to reveal changes at different scales; 2) intercomparison of different precipitation products; and 3) data integration.

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INFORMATION:

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

MODIS Online Visualization and Analysis System (MOVAS):
http://lake.nascom.nasa.gov/movas

Online analysis tools for TRMM rainfall products, NDVI, TOMS aerosols and Willmott climate data:
http://esip.gmu.edu/esip/ES_gridded_online_analysis_gmu.html

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:
hydrology@daac.gsfc.nasa.gov