Accessing, Visualizing, and Analyzing NASA Hydrology Data in GIS: A Use Case for East Africa Drought

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Introduction

The NASA Goddard Earth Sciences Data and Information Services Center (GES DISC) is the home of NASA precipitation, hydrology, and atmospheric composition and dynamics data. We also house the MODIS-RTA Reanalysis/Analysis for Research and Applications (MERRA) data assimilation and the North American and Global Land Data Assimilation System (NLDAS and GLDAS) data products. These products are highly relevant to the range of research and applications in GIS. However, this extensive and precise resource is underutilized in the Geographic Information Systems (GIS) communities. The primary factors contributed to this situation include the unfamiliarity of many GIS users with the GES DISC products and the lack of functionalities of traditional GIS software packages in processing, analyzing, and visualizing NASA satellite data that are mostly raster-based with time components.

We introduce the GES DISC the precipitation/hydrology products, the currently available services of delivering GES-enabled data products, and the ongoing efforts of making our data more easily accessible and used by the GIS community. We present a use scenario in which the GES DISC archived Tropical Rainfall Measuring Mission (TRMM) precipitation data and the NASA MODIS Normalized Vegetation Index (NDVI) data were processed and analyzed in the ArcGIS software. The use case shows how the 2010-2011 East African drought is clearly captured by the TRMM measurements; how the region’s vegetation growing conditions, as depicted by NDVI, responded to the drought; and how the drought and the vegetation response can be visualized and assessed at different watersheds in GIS.

GES DISC Hydrology Data and Services

GES DISC hosts several dozens of precipitation/hydrology data products at various spatial and temporal resolutions. Some of these data products are archived in formats without geospatial reference information encoded in the data files and are not readily importable into GIS systems, such as the ArcGIS system. Several efforts have been made in GES DISC in providing GIS-ready data. These include:

- The on-the-fly netCDF conversion
- Subsetting services
- Variable subsetting
- Spatial reprojecting

Figure 1 shows TRMM precipitation data subverted and format-converted data in ArcGIS.

Visualizing and Analyzing the East Africa Drought

From the late spring of 2010 to the summer of 2011, the Horn of Africa suffered a severe and prolonged drought not seen in decades. The drought caused more than 10 million people in need for food and clean water in Ethiopia, Somalia, and Kenya. The precipitation deficit was well captured by the TRMM data. We used ArcGIS to map and visualize watershed level precipitation anomaly, as compared to long term mean, and the response of vegetation, as shown in the MODIS NDVI images, to the water deficit.

- Data
  - MODIS NDVI data, obtained from the Hydro1K Basins dataset prepared by the USGS Land Processes Distributed Active Archive Center (LP DAAC)

Method

- Modifying the map view to show NDVI values as percent change from the 2001-2010 period
- Using a linear trend line to show NDVI values for the entire 16-day period
- Pearson correlation analysis performed

Results and analyses

- Time series precipitation anomaly maps show the spatiotemporal patterns of water deficiencies
- Time series vegetation anomaly maps show vegetation responses to the drought
- 44 among 55 water basins exhibit statistically significant precipitation/vegetation correlation (t-test at 0.95 confidence level)
- All water basins exhibit statistically significant precipitation/vegetation correlation when one and two 6-day periods are applied to vegetation, indicating that the vegetation in this area generally responds to precipitation within about two to four weeks (Figure 10).

SUMMARY AND FUTURE WORK

- GES DISC hydrology and other data products are relevant to a range of GIS research and applications such as drought mapping/monitoring and vegetation analysis at various natural areas and/or administrative regions.
- The majority of GES DISC data are GIS-ready through various GES DISC services. The major GIS-ready data format is the CF-netCDF and version 4 HDF based HDF-EOS format.
- The ArcGIS plug-in tools facilitate data usabilities in GIS communities.
- We will continue to work on developing services and tools to enable more easy and efficient use of our data products in GIS. The following outlines some of our future efforts:
  - Make all our data available in CF-netCDF formats.
  - Make some of our data products, especially hydrology data, available in GeoTIFF format.
  - Develop more plug-ins for data that are not currently importable to ArcGIS.
  - Develop additional remote data connectors to enable direct import of our data into ArcGIS, with spatial and temporal subsetting capabilities.
  - Develop more collaborations with users and vendors of the GIS communities.