Open Source GIS Connectors to NASA GES DISC Satellite Data

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Steve Kempler[1], Long Pham[1], Wenli Yang[1,2]

[1]NASA/GSFC Code 610.2, [2]Center for Spatial Information Science and Systems, George Mason University

Long.B.Pham@nasa.gov

Making GES DISC GIS Data Directly Imported into ArcGIS

Introduction

The NASA Goddard Earth Sciences Data and Information Services Center (GES DISC) houses a suite of high spatiotemporal resolution GIS data including satellite-derived and modeled precipitation, air quality, and land surface parameter data. The data are valuable to various GIS research and applications at regional, continental, and global scales. On the other hand, many GIS users, especially those from the ArcGIS community, have difficulties in obtaining, importing, and using our data due to factors such as the variety of data products, the complexity of satellite remote sensing data, and the data encoding formats. We introduce a simple open source ArcGIS data connector that significantly simplifies the access and use of GES DISC data in ArcGIS.

Get GES DISC Data into ArcGIS: the Normal Steps

GES DISC data can be downloaded through searching various geospatial portals or through direct access to data services such as ftp, http, OPeNDAP, and OGC WCS. A typical process involves the use of GES DISC's Mirador portal http://mirador.gsfc.nasa.gov/, as the following:

- Search the Mirador portal
- Browse and select the desired data products through a long list of available products
- Browse and select desired files from the selected product
- Download individual files or get a list of download URLs and then download files
- Import the downloaded files into ArcGIS

Some of the above steps can be challenging for GIS users because a user may be presented with numerous products and data files to select or with many variables having unfamiliar names to select. After files are downloaded, importing them into ArcGIS can also be challenging and require referring to an importing recipe.

GES DISC ArcGIS Data Connector Toolbox

The ArcGIS data connector toolbox is designed to significantly simplify the steps of getting and importing GES DISC data in ArcGIS. It is customized for users to get the most GIS-relevant data. It currently comprises three separate connectors to OPeNDAP, WCS, and time series data services, respectively (Fig. 1). The OPeNDAP and WCS connectors are for getting raster data while the time series connector is for getting point feature data with long time series. The WCS connector allows users to get GeoTIFF formatted data and to resample/interpolate data into different cell sizes.

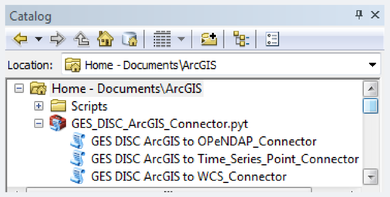

Figure 1. The GES DISC GIS Data Connector Toolbox

The toolbox comprises several Python files and associated xml files which can be placed in any local directory. In this figure, the toolbox is shown to be placed in the "Documents\ArcGIS" directory.

With the connector toolbox, users do not need to go through search portals and download/import files. Getting GES DISC data into ArcGIS involves two simple steps:

Double click a tool (Fig. 1) to start a menu window (Fig. 2) → Select variable(s) and define Spatiotemporal range (Fig. 2)

- The tool menu windows

The tool menu window is similar to other ArcGIS menu window. Figure 2(a) shows the time series data connector window for a North America Land Data Assimilation (NLDAS) data product containing various soil water content variables. Users select one or more variables and define point locations and time range to get needed data. Figure 2(b) shows the OPeNDAP connector for another NLDAS product.

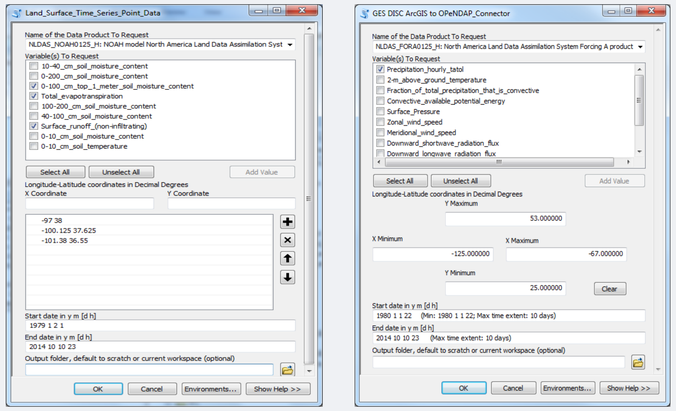

Figure 2. (a) Time Series Point Data Connector (b) OPeNDAP Raster Data Connector

- The user/tool interaction flow:

User starts a tool → User defines tool parameters → Tool sends request to server → Server sends files to user → Tool imports files to ArcGIS

Toolbox Backend Configuration

- Define an offered product and its variables

The customization for exposing users to the most GIS-relevant data products and variables is through a backend configuration file, which defines the selected products and variables offered to the users. Figure 3 is an excerption from the configuration file which offers a subset of hydrologic and near surface variables from a Global Land Data Assimilation System product. The corresponding user menu is also shown in the Figure.

```
{'name':'GLDAS_NOAH025_3H.001: NOAH model Global Land Data Assimilation System product',
'RODurl':'http://hydrol.sci.gsfc.nasa.gov/daac-bin/access/timeseries.cgi?',
'RODvariables':{
'Precipitation_rate':'GLDAS:GLDAS_NOAH025_3H.001:precip',
'Rainfall_rate':'GLDAS:GLDAS_NOAH025_3H.001:Rainf',
'Snowfall_rate':'GLDAS:GLDAS_NOAH025_3H.001:Snowf',
'0-100_cm_top_1_meter_soil_moisture_content':'GLDAS:GLDAS_NOAH025_3H.001:SOILM0-100cm',
'0-10_cm_layer_1_soil_moisture_content':'GLDAS:GLDAS_NOAH025_3H.001:SOILM0-10cm',
'10-40_cm_layer_2_soil_moisture_content':'GLDAS:GLDAS_NOAH025_3H.001:SOILM10-40cm',
'40-100_cm_layer_3_soil_moisture_content':'GLDAS:GLDAS_NOAH025_3H.001:SOILM40-100cm',
'Total_Evapotranspiration':'GLDAS:GLDAS_NOAH025_3H.001:Evap',
'Near_surface_air_temperature':'GLDAS:GLDAS_NOAH025_3H.001:Tair',
'Near_surface_specific_humidity':'GLDAS:GLDAS_NOAH025_3H.001:Qair',
'Surface_Runoff':'GLDAS:GLDAS_NOAH025_3H.001:Qs',
'0-10_cm_soil_temperature':'GLDAS:GLDAS_NOAH025_3H.001:TSOIL0-10cm',
'Near_surface_wind_magnitude':'GLDAS:GLDAS_NOAH025_3H.001:Wind'},
'starttime':'1979 1 2 1',
'endtime':'2014 11 30 23},
```

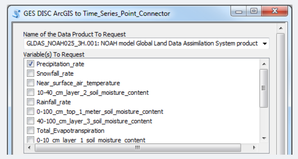

Figure 3. Available variables defined in the backend configuration file and the corresponding user menu in the tool

- The addition or deletion of offered data

The addition of new data or deletion of existing data can easily be done through editing the configuration file without having to change the tool itself. A script is needed to update the offered data's time stamp in the configuration file.

- The toolbox update information

A 'status' key is used in the configuration file to indicate the tool status. If the status is set to 'current', users will start a normal tool menu. When it is set to 'updated', users will be provided in a message window showing the download URL of an updated version (Fig. 4). The toolbox won't be supported if the status is set to 'obsolete' and users will be informed so.

```
[{'status':'updated',
'new_version':'http://disc.sci.gsfc.nasa.gov/TBD/GES_DISC_ArcGIS_Connector.zip
Email to gsfc-help-disc@lists.nasa.gov for more information',
```

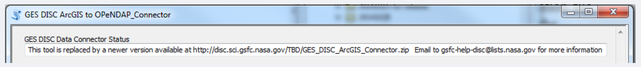

Figure 4. The toolbox status information in configure file (top) and message window (bottom)

Visualizing the Tropospheric NO_2 Time Series

A use case of visualizing nitrogen dioxide (NO_2) concentration over the world's large metropolitan areas for the past decade is presented . The tropospheric NO_2 derived from the NASA Ozone Mapping Instrument (OMI) measurement is imported into ArcGIS using the WCS tool. A shapefile of world large cities is acquired from http://nordpil.com/go/resources/world-database-of-large-cities/.

- The geoprocessing workflow

Buffer analysis is used to derive 1-degree radius metropolitan areas for cities with year 2000 population of over 3-million and zonal analysis is used to compute mean monthly NO_2 for the buffer areas (Fig. 5).

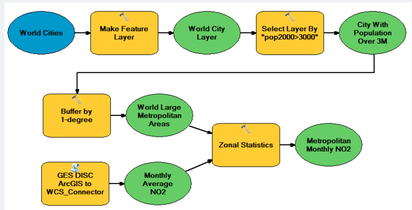

Figure 5. The goeprocessing workflow

- Visualizing time series in ArcGIS
  - Figure 6 shows the snapshots of the ArcGIS time slider visualization tool for the month of October during years 2004 and 2014. Red indicates value above the 11-year October mean while blue below. The figure indicates decrease in NO_2 in the U.S. metropolitan areas and increase in many of the other world metropolitan areas, especially in Asia except for Japan.
  - Figure 7 shows the monthly NO_2 anomalies for selected metropolitan areas. The monthly anomalies are computed by subtracting each month's value by the 11-year mean for the same month, and then normalized by the standard deviation of the month. The graphs were created using the ArcMap graphic tool. A user can click on different cities to view the graphics corresponding to cities.

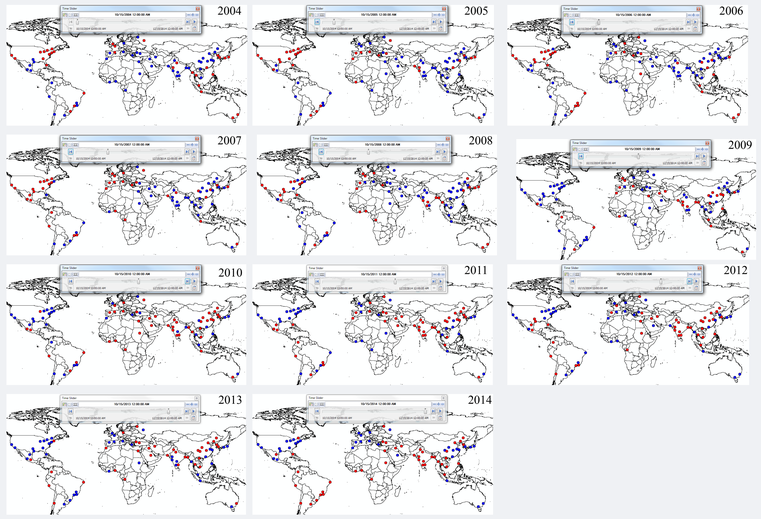

Figure 6. Time series NO_2 visualization in ArcGIS for the month of October, year 2004 to 2014

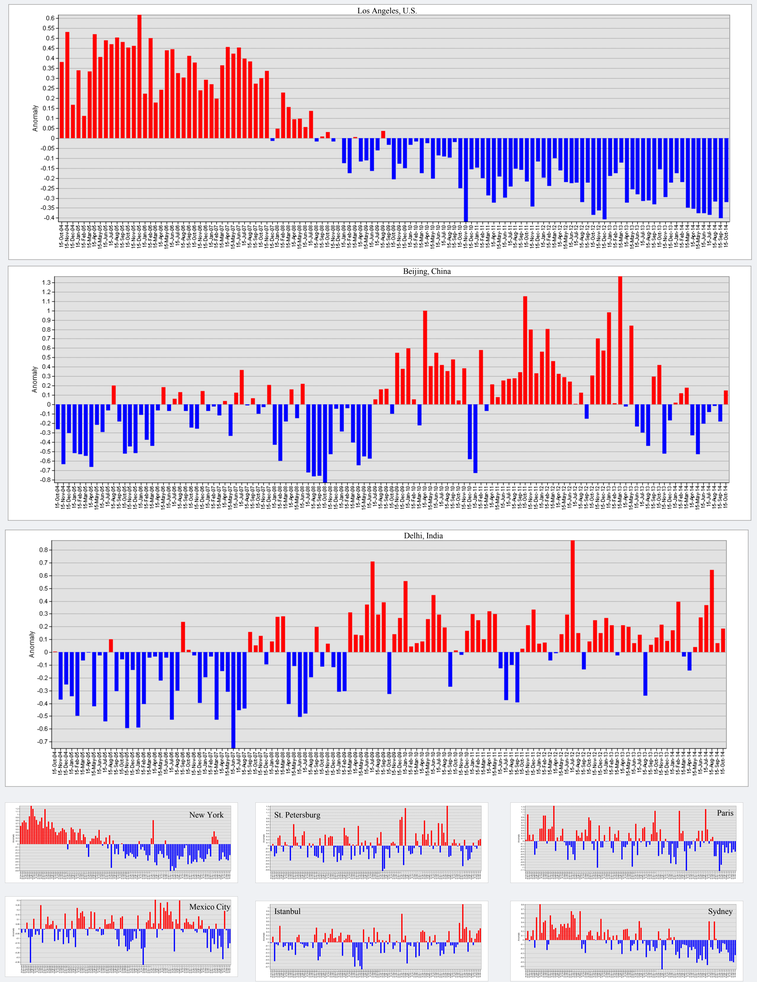

Figure 7. The 11-year monthly Tropospheric NO_2 anomalies for selected world metropolitan areas