Analyzing and Visualizing Precipitation and Soil Moisture in ArcGIS

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Objective

- Introduce hydrological data available from the NASA Goddard Earth Science Data and Information Services Center (GES DISC)

- Demonstrate the use of GES DISC data in ArcGIS to visualize and analyze events like drought, and flood and climate/vegetation relationships.
The Uniqueness of NASA GES DISC Data

### Atmospheric Composition
- Total Ozone Mapping Spectrometer (TOMS)
- Upper Atmosphere Research Satellite (UARS)
- Solar Radiation and Climate Experiment (SORCE)
- Aura: Ozone Monitoring Instrument (OMI), High Resolution Dynamics Infrared Sounder (HIRDLS), Microwave Limb Sounder (MLS)
- Atmospheric CO2 Observations from Space (ACOS)
- Historical datasets from Nimbus, Tiros, SME, others
- Orbiting Carbon Observatory 2 (OCO-2)
- SNPP Ozone Mapping & Profiler Suite (OMPS)
- Carbon Monitoring System (CMS)
- Total and Spectral Solar Irradiance Sensor (TSIS)
- Sentinel 5 TROPOMI

### Atmospheric Dynamics
- TIROS Operational Vertical Sounder (TOVS)
- Aqua: Atmospheric Infrared Sounder (AIRS)
- SNPP: CrIS

### Precipitation
- Tropical Rainfall Measuring Mission (TRMM)
- Hydrology Collections
- Global Precipitation Mission (GPM)

### Modeling
- Modern-Era Retrospective Analysis For Research and Applications v2 (MERRA 2)
- Global Land Data Assimilation System (GLDAS)
- North American Land Data Assimilation System (NLDAS)

### MEaSUREs
- MEaSUREs 2006
- MEaSUREs 2012
Characteristics of GES DISC Hydrology Data

- Remote sensing, in-situ, modeling, and forecast
- Multiple spatio/temporal resolutions:
  - Half-hourly, 3-hourly, daily, monthly satellite measurements
  - Hourly modeled products
  - Monthly ground observation archives
  - Composite Climatology (yearly, monthly)
  - Near real-time (NRT) products
  - Global grids (raster) with spatial resolution up to 10-km
  - Higher resolution swath (feature points) data (e.g., 4-km)
Events & Data & Methods

- Events
  - The 2015 south India flood
  - The ongoing California drought
  - The 2010-2011 East Africa drought

- Data
  - 0.1 deg resolution precipitation from the Global Precipitation Measurement (GPM) Mission
  - 0.25 deg resolution precipitation from the Tropical Rainfall Measurement Mission (TRMM)
  - 0.125 deg resolution root zone soil moisture from the North America Land Data Assimilation System (NLDAS)
  - 0.1 & 0.25 deg soil moisture from the Land Parameter Retrieve Model (LPRM)
  - 5 km resolution NDVI from MODIS
  - 0.625x0.5 deg resolution MERRA2

- Methods:
  - Visualize time series using ArcMap time slider
  - Anomalies derived from time series data
  - Water Basin-based analysis (zonal statistics/time series)
Event
The 2015 south India flood
High Spatiotemporal GPM Data for Storm and Flood Visualization and Analysis

South India Flood – 2015 Northeast Monsoon

Daily GPM Precipitation, Nov. 7-10 and 14-17

Nov. 7
Nov. 8
Nov. 9
Nov. 10
Nov. 11
Nov. 15
Nov. 16
Nov. 17

0  12.5  25 mm/hr
South India Flood – 2015 Northeast Monsoon

Half Hourly GPM Precipitation, 4:30pm Nov. 8 – 4:00am November 9
Event
The California drought
GEOS DISC data are available in various GIS formats, including NetCDF within which a time dimension can be defined.

- Time enabled NetCDF data can be easily visualized in ArcGIS.

- A common method to find temporal feature is using standardized anomaly:

\[ A = \frac{X - X_m}{X_s} \]

- \( A \): standardized anomaly
- \( X_m \): long term mean (for a calendar month, year, etc)
- \( X_s \): standard deviation to the long term mean
- \( X \): measurement for a particular period (month, year, etc)
California Drought since 2013
Negative anomaly in CA: 2013 Jan-Feb
TRMM Precipitation and LPRM Soil Moisture
TRMM Precipitation Anomaly - 2015

January

February

March

April

May

June

July

August

September

October

November

December
GPM Precipitation Anomaly - 2015

Maps show the distribution of precipitation anomalies across the United States for each month of 2015.
GPM Precipitation Anomaly vs SPI - 2015

Acknowledgement:
SPI images are screen-copied from the West Wide Drought Tracker Web site of the Western Regional Climate Center:  http://www.wrcc.dri.edu/wwdt/archive.php
Event
The 2010-2011 East Africa drought
Water Basin-based Analysis

- Raster data often analyzed with point and polygon features
- Zonal statistics analysis in level 3 world water basins
- Visualize time series feature data
  - Import zonal statistical table into polygon shapefile (dbf)
  - Simple python scripts
Visualize the zonal anomaly time series with simple script

```python
sm_lyr.visible=0
def rain(date):
    rain_lyr.symbology.valueField = date
    rain_lyr.symbology.reclassify()
    rain_lyr.visible=1
    sm_lyr.visible=0
    arcpy.RefreshActiveView()
    rain('2016_01')
start_year = 1998
end_year = 2016
for year in range(start_year,end_year):
    for month in range (1,13):
        rain_lyr.symbology.valueField =
            'D'+'%4d'%(year)+'_'+'%02d'%(month)
        rain_lyr.symbology.reclassify()
        arcpy.RefreshActiveView()
        time.sleep(2)
end_year = 2016
```
Relationship between Precipitation and Vegetation: East Africa Drought

- 16-day composites of precipitation and NDVI from Jan. 2010 to Dec. 2011
- All water basins exhibits statistically significant precipitation/NDVI correlation when one or two time period lags are applied to NDVI data.
TRMM Precipitation and LPRM Soil Moisture Anomalies - 2011

Zonal statistics within level 3 water basin
Access GES DISC Hydrology Data

- All GES DISC hydrology data accessible online through interoperable services, such as OPeNDAP and OGC WCS/WMS data servers.
- The Giovanni system is an easy online visualization, analysis, and access portal.

http://giovanni.gsfc.nasa.gov/giovanni/

- A subset of Giovanni served parameters

![Giovanni System Screenshot](image-url)
GES DISC Hydrology Data for Drought Systems

- GES DISC hydrology data are widely used in GIS communities
- UC Irvine’s Global Integrated Drought Monitoring and Prediction System (GIDMaPS)
  - MERRA
  - GLDAS
  - GPCP
  - NLDAS

Picture screen-copied from http://drought.eng.uci.edu/
Summary and Future Directions

- GES DISC’s multi-spatiotemporal hydrology data are valuable in drought and flood applications.
- The data can be easily visualized and analyzed in ArcGIS.
- The latest ArcGIS analysis and visualization capabilities such as Big Data Store, GeoEvent, and AGOL will make GES DISC data be more efficiently explored.
Question?

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