Use NASA GES DISC Data in ArcGIS

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Outline

- GIS relevant data at NASA Goddard Earth Sciences Data and Information Services Center (GES DISC).
- GES DISC Services and Support for GIS Users.
- Use of GES DISC data in ArcGIS – Use cases

The NASA GES DISC

- GES DISC is one of twelve NASA Science Mission Directorate Data Centers.
- The GES DISC's mission is to maximize NASA's investment benefit by providing data and services that enables people to fully realize the scientific and educational potential of Earth science data.

http://disc.gsfc.nasa.gov/

GES DISC Data Archive, Ingestion and Distribution

- GES DISC archive: 860 TB as of 6/2/2015
- Distribute about 5.6 TB each day
- Ingest 500 GB each day*

*with net archive increase of 240 GB each day because real-time data are removed from archive after two months.

Major GIS Data Products of GES DISC

- Precipitation and hydrology, including soil moisture
- Land Data Assimilation System data (LDAS)
- Atmospheric composition and dynamics data
- Modern Era Retrospective-Analysis for Research and Applications data assimilation data (MERRA)
- Various other multi-mission supported project data through value added services (e.g., water quality, ocean color)

GES DISC Services

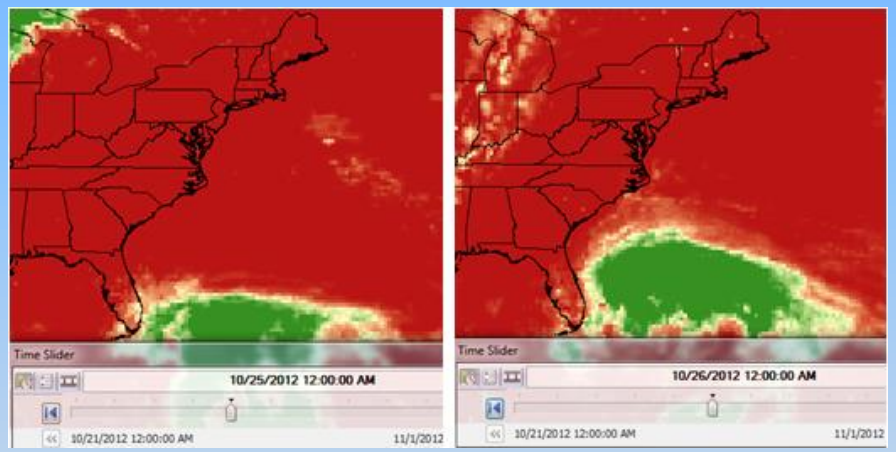
- Search and Discovery
- Access (customized and heritage)
- Visualization, Integration, and Analysis
- Various tools for facilitating data handling
- Data product documentation
- Data cookbook
- User support

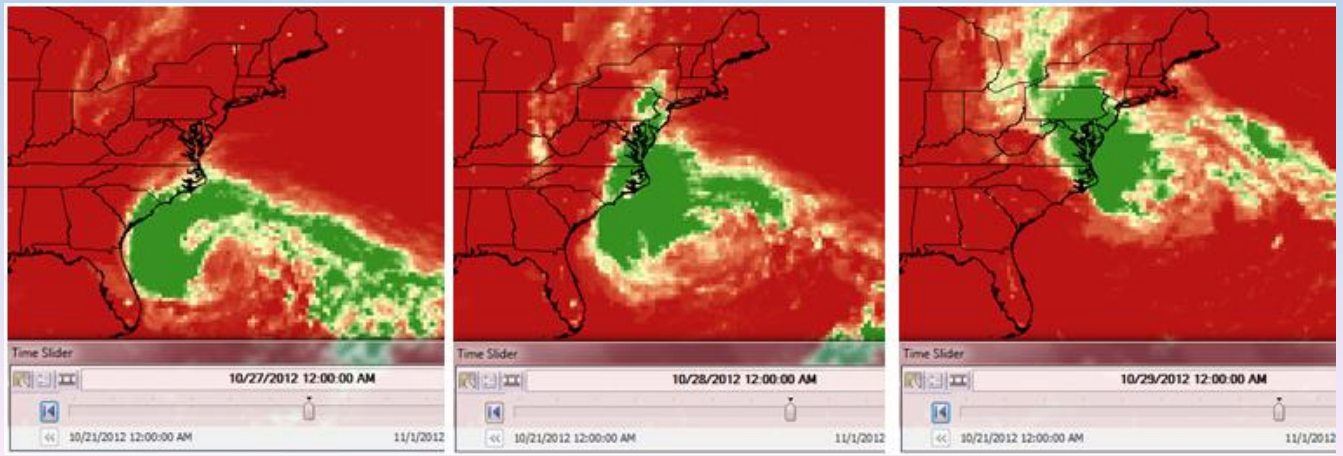
The GES DISC Precipitation Data

- Remote sensing, in-situ, and forecast precipitation and ancillary data
- Multiple temporal resolutions, e.g.:
  - 3-hour near-real-time monitoring product
  - Half-hourly, 3-hourly, daily, monthly satellite rainfall archives
  - Monthly ground observation archives (1986-present)
  - Composite Climatology (yearly, monthly)
- Global grids with spatial resolution up to 10-km
- Higher resolution for swath data (e.g., 5-km)
- Data useful to many GIS research and applications (agriculture, environmental, drought/flood, health, etc)

The GES DISC Precipitation Data

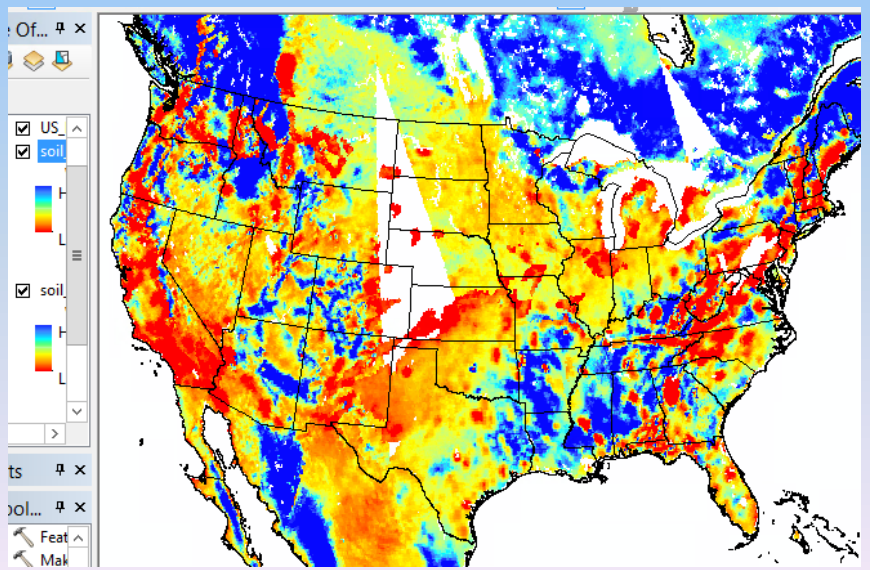
- Visualizing Precipitation events during Hurricane Sandy using TRMM data

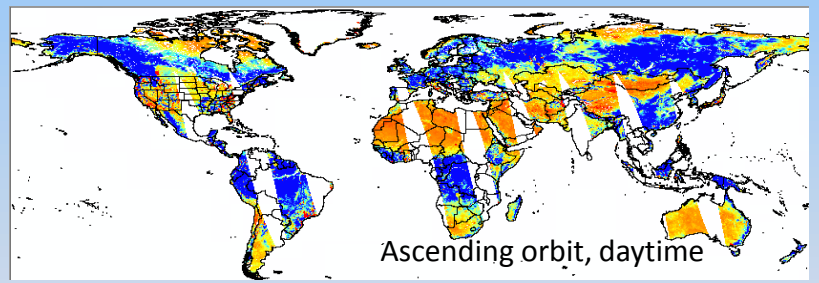


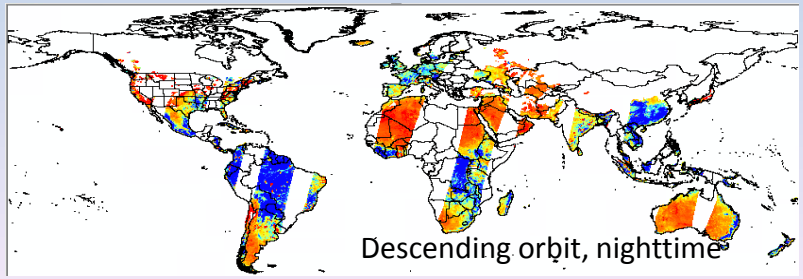


High Resolution Soil Moisture Data

- Derived from Land Parameter Retrieval Model (LPRM)/Advanced Microwave Scanning Radiometer-EOS measurements
- Global coverage at spatial resolution up to 10-km
- Available daily from 2012 (25-km from 2002-2011)







LPRM soil moisture, 2015-06-01

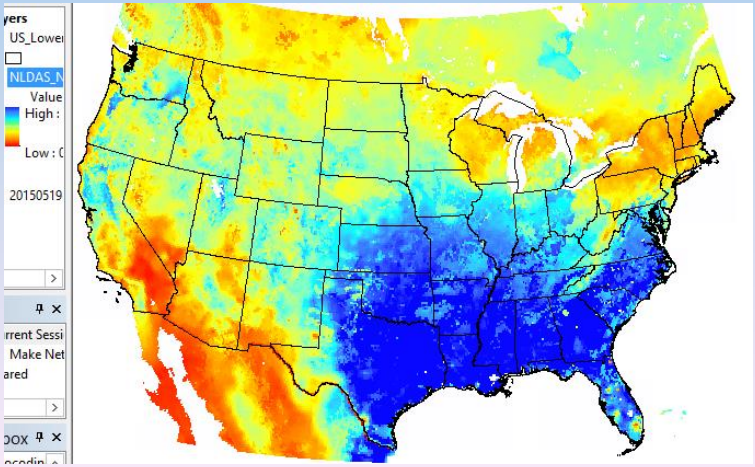
ftp://hydro1.sci.gsfc.nasa.gov/data/s4pa/WAOB/

North America and Global Land Data Products

- The Land Data Assimilation Systems enable more accurate reanalysis and forecast simulations by numerical weather prediction models.
- High temporal and spatial resolutions:
  - Temporal from hourly to monthly
  - Spatial from 15km (NLDAS) to 30km (GLDAS)
  - Available from 1979 to present
- Several dozens of (near) land surface parameters.

LDAS Land Parameter Examples

- Skin and zonal soil moisture content
- Precipitation (rainfall, snowfall)
- Surface and subsurface runoffs
- Vegetation types, canopy surface water, conductance,
- Evaporation, transpiration, evapotranspiration
- Pressure, temperature, humidity
- Albedo, radiation fluxes
- Wind speeds, aerodynamic conductance
- More …



Total evapotranspiration
for May 2015

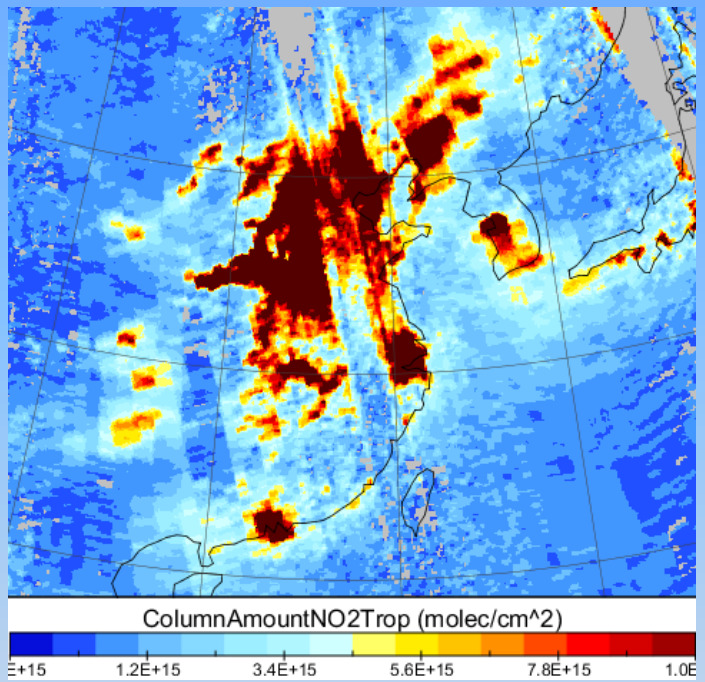
ftp://hydro1.sci.gsfc.nasa.gov/data/s4pa/NLDAS/NLDAS_NOAH0125_M.002

Atmospheric Data Products

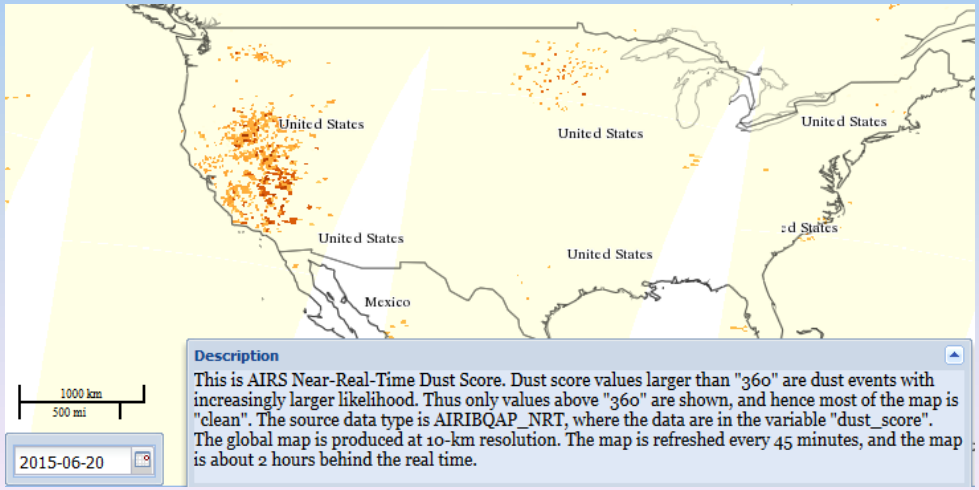
- Many atmospheric parameters, including
  - Aerosol optical thickness, dust scores
  - NO2, SO2, CO2, O3, CO, CH4, UVB
  - Water/humidity, temperature, pressure, cloud, wind
  - Radiance, radiation flux
- Data from multiple satellites/instruments (AIRS, OMI, MODIS)
- 2D (surface, column total) and/or 3D (with vertical profile)
- Multiple temporal resolution (daily, monthly, etc).
- Most Gridded data at spatial resolution 0.25-deg or coarser.
- Orbital swath data at higher resolution (e.g., 13-km at nadir).

http://disc.sci.gsfc.nasa.gov/Aura/data-holdings/OMI
http://disc.sci.gsfc.nasa.gov/AIRS/data-holdings

Atmospheric Data Products



Severe air pollution over northeast China on 2013/10/23 captured by the OMI NO2 measurement.

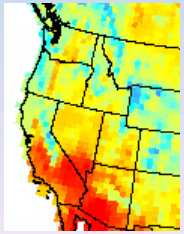


Dusts shown in the AIRS dust score parameter

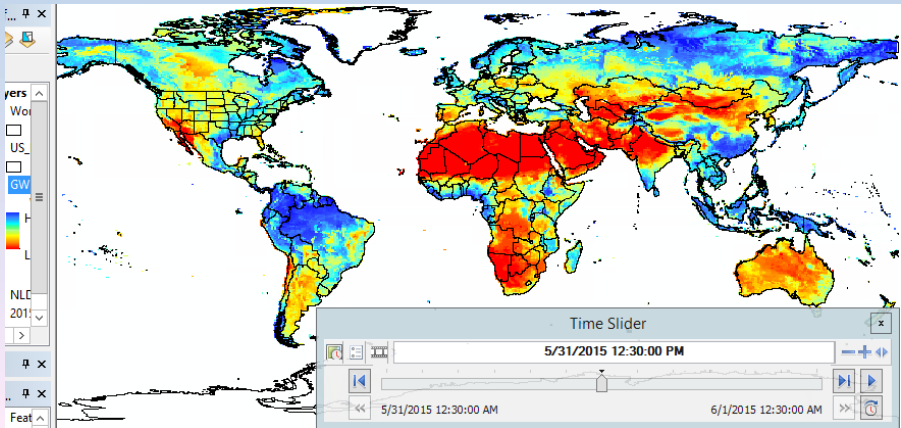
http://disc.sci.gsfc.nasa.gov/nrt/data-holdings/airs-nrt-products/MapViewer

MERRA Data Products

- Modern Era Retrospective-Analysis for Research and Applications data assimilation products
- Both 2D surface and 3D parameters
- Many variables important to land GIS applications, e.g.
  - Surface and zonal soil moisture contents
  - Vegetation greenness fraction, LAI, evaporation
  - Overland runoff, base flow
  - Spatial resolution: 2/3- by ½-deg
- Temporal resolution: hourly, 3-hourly, 6-hourly, etc

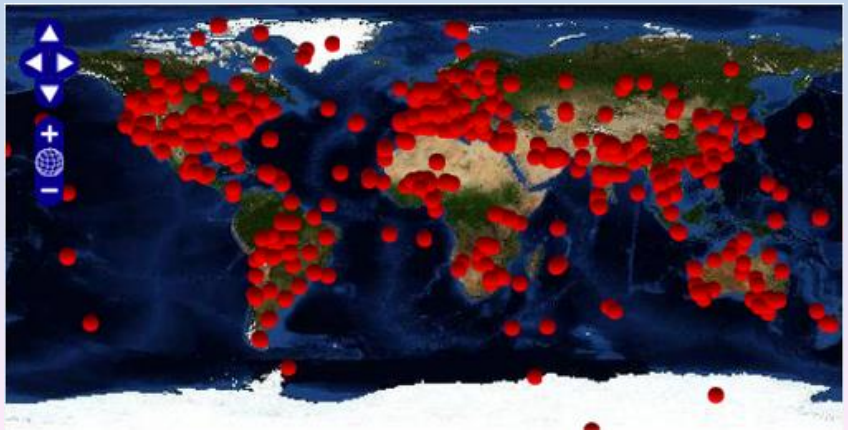


Surface moisture, 2015-05-31 12:30pm



Aerosol Robotic Network Data

- The AErosol ROBotic NETwork (AERONET*) program is a federation of ground-based remote sensing aerosol networks.
- GES DISC supports AERONET AOD data at processing Level 2 (cloud-screened, re-calibrated and quality assured data).
- GES DISC's AeroStat portal serves AERONET and collocated multi-satellite AOD measurements (more in the service part).



http://aeronet.gsfc.nasa.gov/

Other Project-based Data through Value-added Services

- Value-added products for various project- and/or mission-based, such as the ocean products:
  - Chlorophyll a concentration
  - Colored dissolved organic matter index
  - Diffuse attenuation coefficient
  - Sea surface temperatures
  - Particle organic and inorganic carbon
  - Remote sensing reflectances
  - Aerosol optical thickness

http://disc.sci.gsfc.nasa.gov/oceans/oceans-giovanni

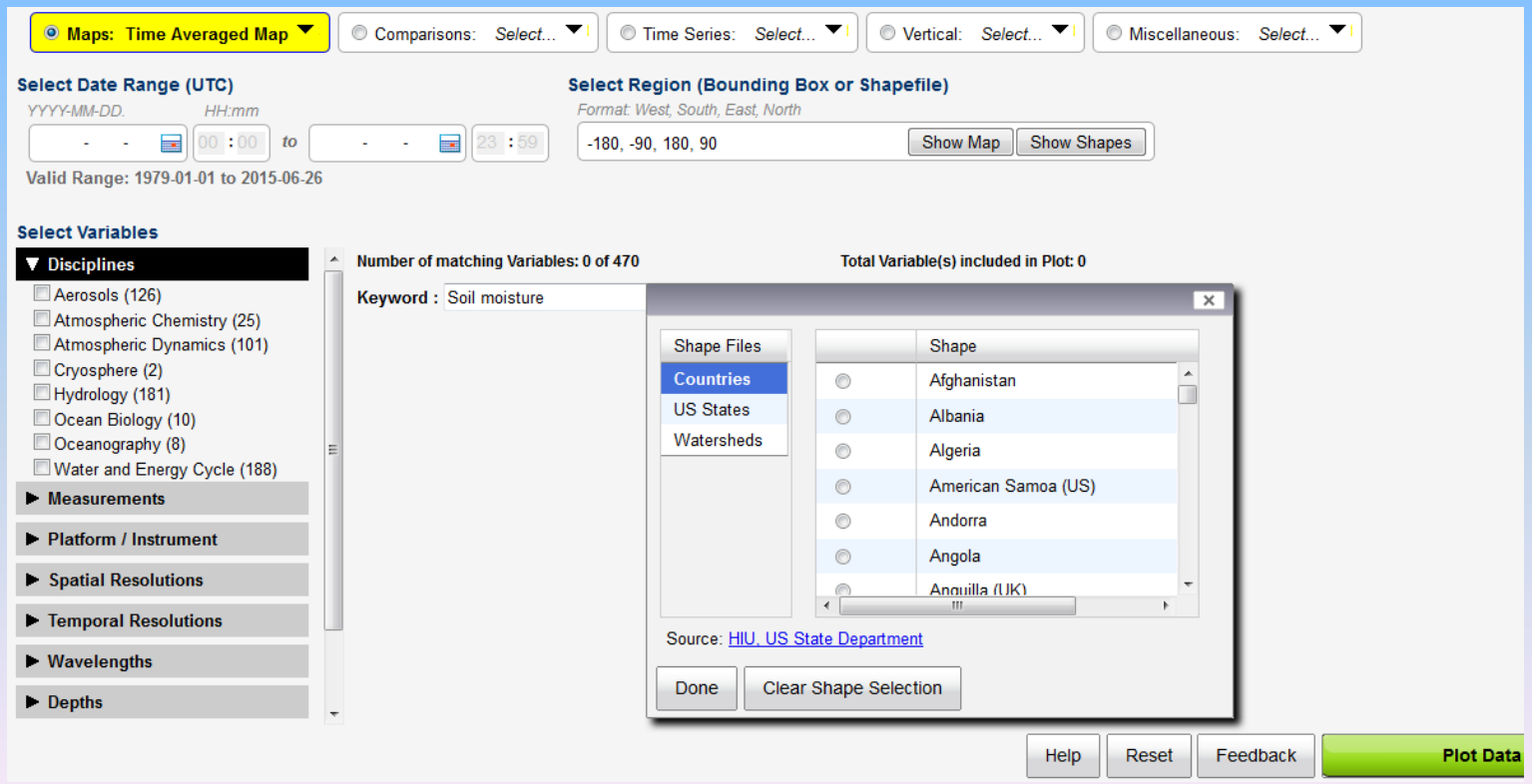
GES DISC Information Services

- Many Information services for discovery, access, analysis and visualization:
  - Online analysis and visualization **Giovanni** (GES DISC Interactive Online Visulization ANd aNalysis Infracstructure)
  - Data search (Mirador)
  - Simple Subset Wizard
  - OPeNDAP
  - OGC Web Map Server and Web Coverage Server (WMS/WCS)
  - Long time series point data download service
  - Grads Data Service (GDS)
  - Data quality screening Service
  - Data read and manipulation tools

http://disc.sci.gsfc.nasa.gov/services

GIOVANNI

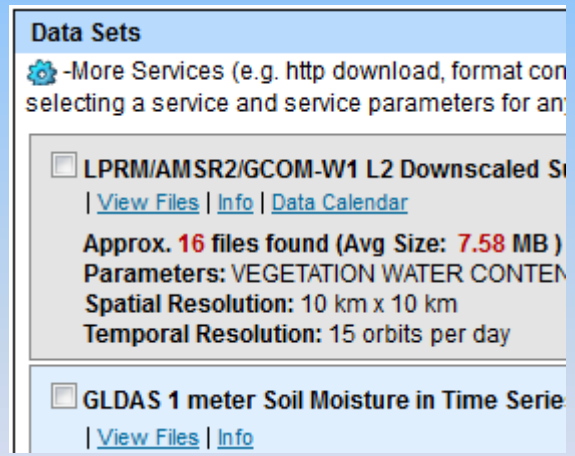
- An online data and information service system that provides a simple and intuitive way to visualize, analyze, and access Earth science data.



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

Mirador

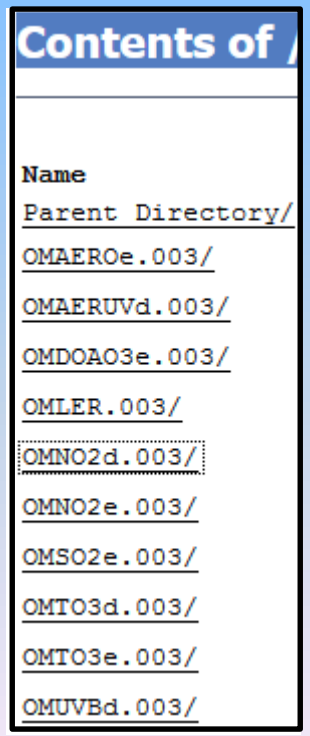
- Mirador: a portal with simple and clean interface to search, browse, order, and download data.

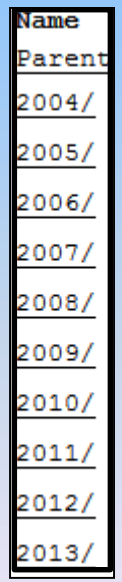


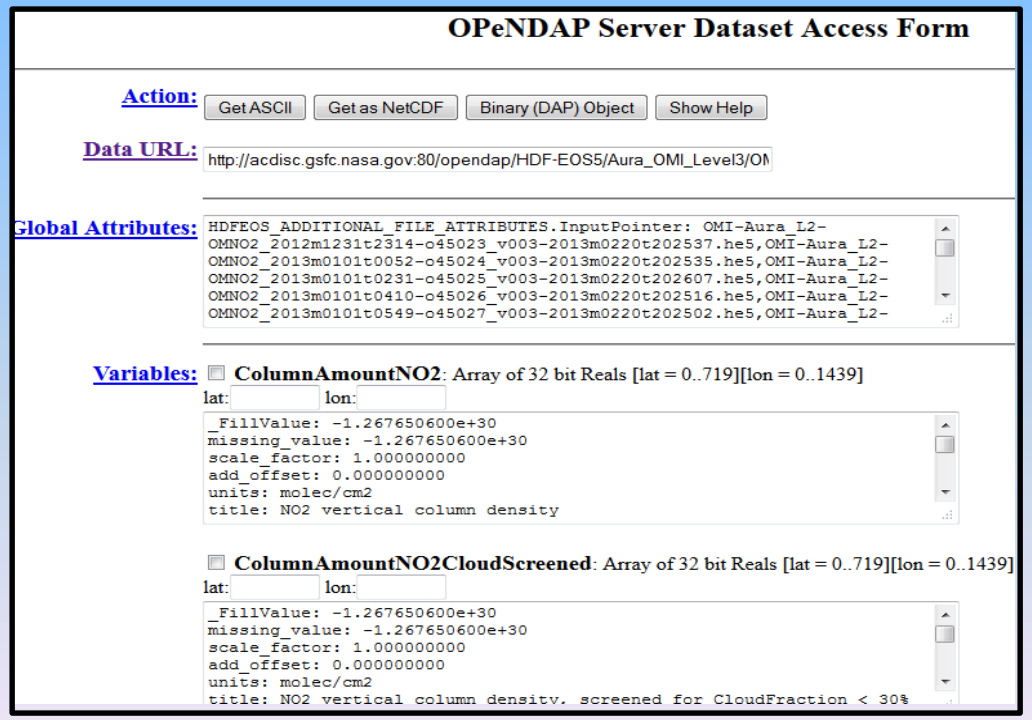
http://mirador.gsfc.nasa.gov/

OPeNDAP Services

- Open-source Project for a Networked Data Access Protocol
- OPeNDAP: access, w/wo subsetting, data with netCDF (and other formats)



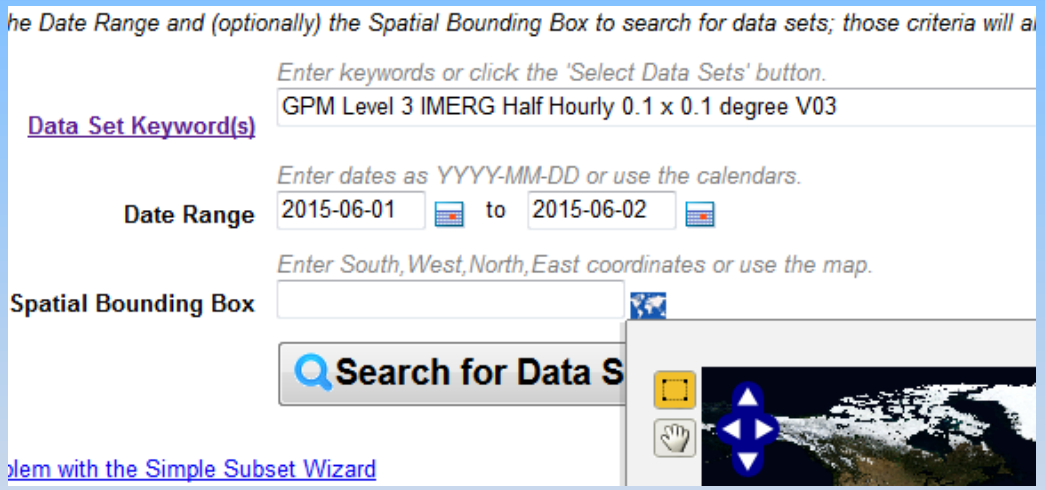


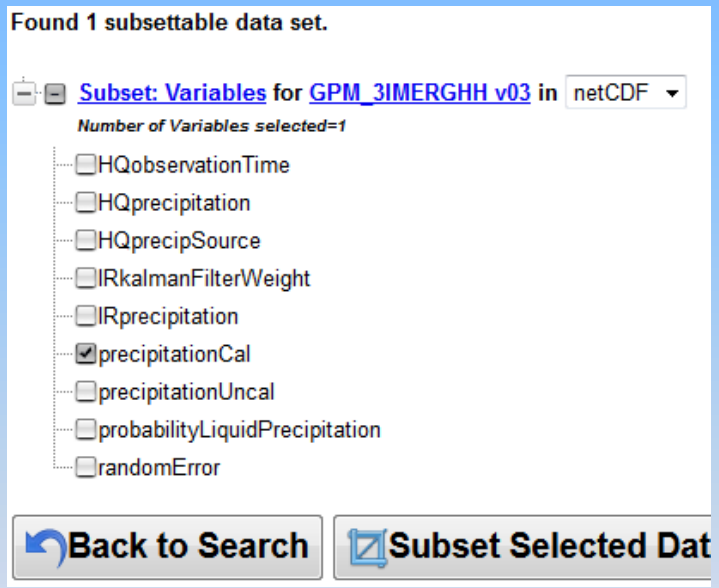


http://disc.sci.gsfc.nasa.gov/services/opendap

Simple Subset Wizard (SSW)

- Search and subset data sets across multiple data centers





Search, find, and access the 0.1-degree half hourly GPM precipitation data in netCDF format

http://disc.sci.gsfc.nasa.gov/SSW/

OGC Interoperable Services

- Open Geospatial Consortium (OGC)
- Various service end points, accessible from ArcGIS
- Web Map Service (WMS) examples
  - The latest TRMM precipitation image: http://disc1.sci.gsfc.nasa.gov/daac-bin/wms_trmm?VERSION=1.1.1&SERVICE=WMS&REQUEST=GetMap&LAYERS=TRMM_3B42_V7_Daily&STYLES=&SRS=EPSG:4326&BBOX=-180,-50,180,50&WIDTH=1440&HEIGHT=400&FORMAT=image/png
- Web Coverage Service (WCS) examples
  - 2-month OMI NO2 daily time series data in netCDF format: http://acdisc.sci.gsfc.nasa.gov/daac-bin/wcsL3?request=getCoverage&version=1.0.0&service=WCS&bbox=-179.875,-89.895,179.875,89.875&CRS=EPSG:4326&resx=0.25&resy=0.25&format=netCDF&time=2015-05-01/2015-06-30&coverage=OMNO2d:ColumnAmountNO2
  - 10-year AIRS Ozone monthly time series: http://acdisc.sci.gsfc.nasa.gov/daac-bin/wcsAIRSL3?request=getCoverage&version=1.0.0&service=WCS&bbox=-179.5,-89.5,179.5,89.5&CRS=EPSG:4326&resx=1.0&resy=1.0&format=netCDF&time=2005-01/2014-12&coverage=AIRX3STM:TotCO_D

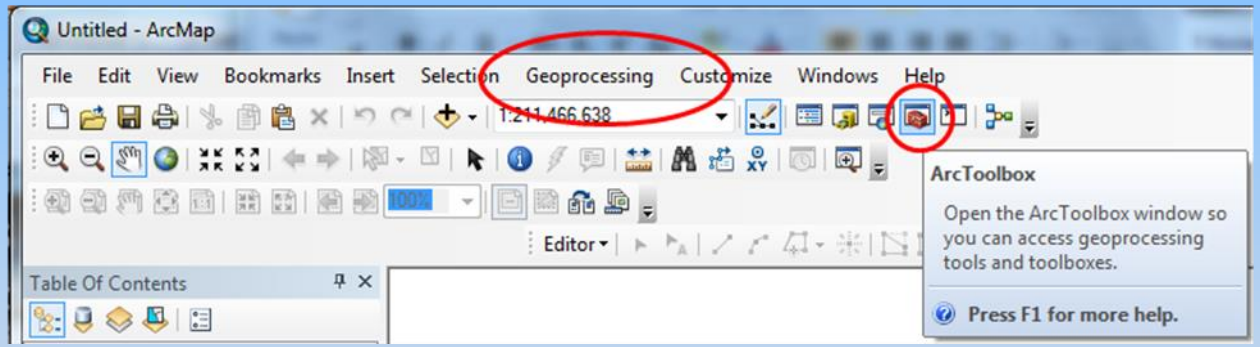
Service Cookbook

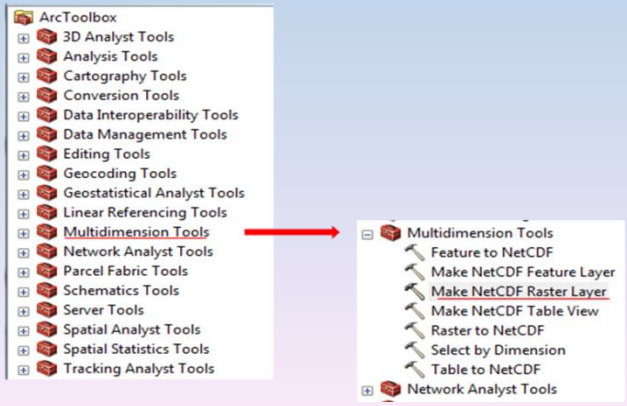
- Step-by-step instructions, with working examples, on accessing, manipulating, visualizing, and analyzing GES DISC data:
  - How to Import Gridded Data in NetCDF Format into ArcGIS
  - How to Import Satellite Swath Data in NetCDF Format into ArcGIS
  - How to Define and Visualize Time Dimension in ArcGIS
  - How to Import HDF5-formatted IMERG GPM Precipitation Data into ArcGIS
  - How to Define Vertical Dimension in ArcMap
  - Many more …

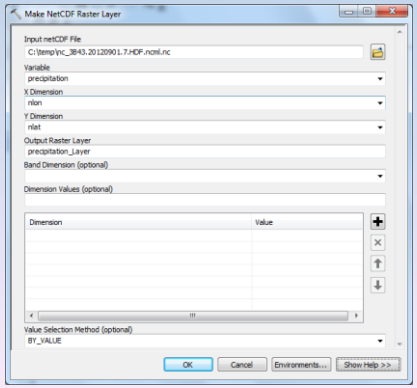
http://disc.sci.gsfc.nasa.gov/recipes/

Service Cookbook Example

- How to Import Gridded Data in NetCDF Format into ArcGIS
- Include overview, use scenario, procedures with screen copy of each step, and discussion.

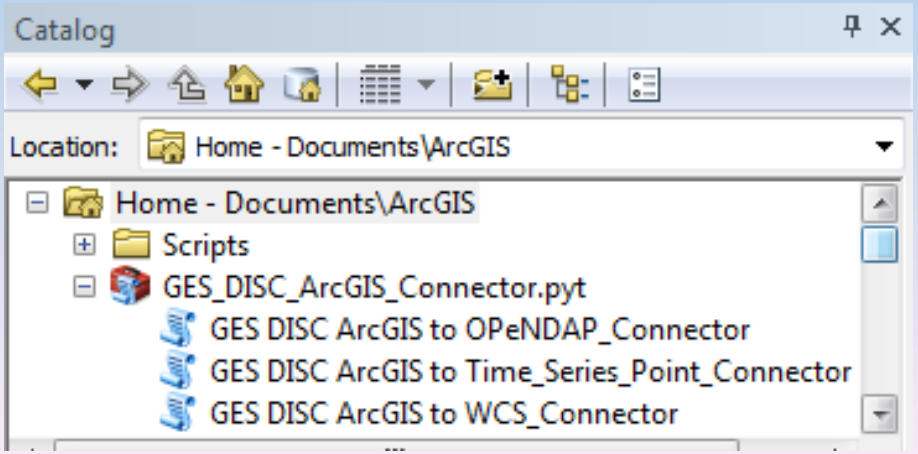






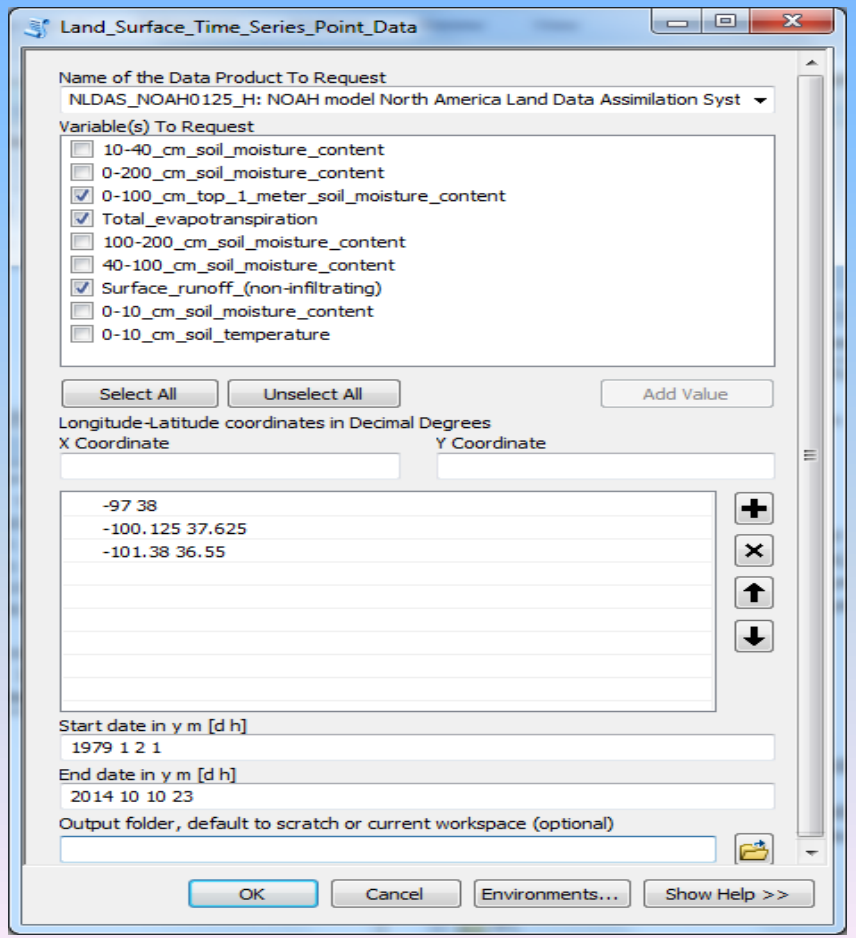
The ArcGIS Data Connector Toolbox

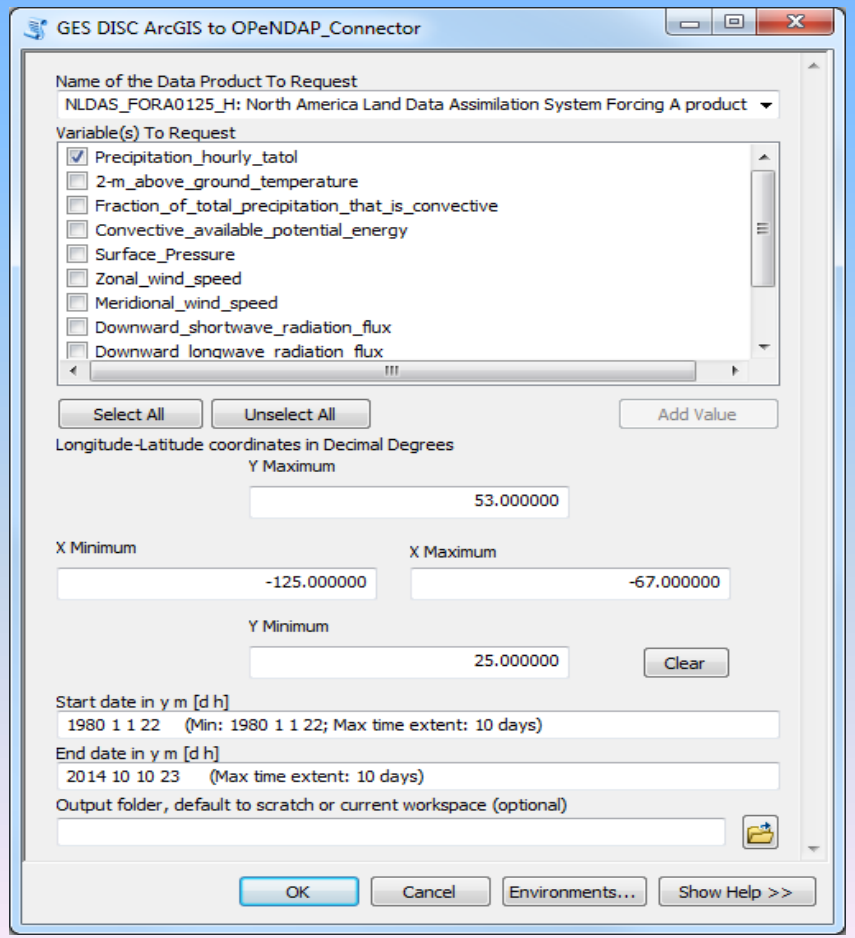
- Simplify the steps of getting GES DISC data and importing into ArcGIS
- Add/import selected data into ArcMap without additional steps
- Include three separate connectors to OPeNDAP, WCS, and Time Series services



The ArcGIS Data Connector Toolbox

- Select variables, time range and point position or bounding box
- Click Ok to have data downloaded as well as added to ArcMap



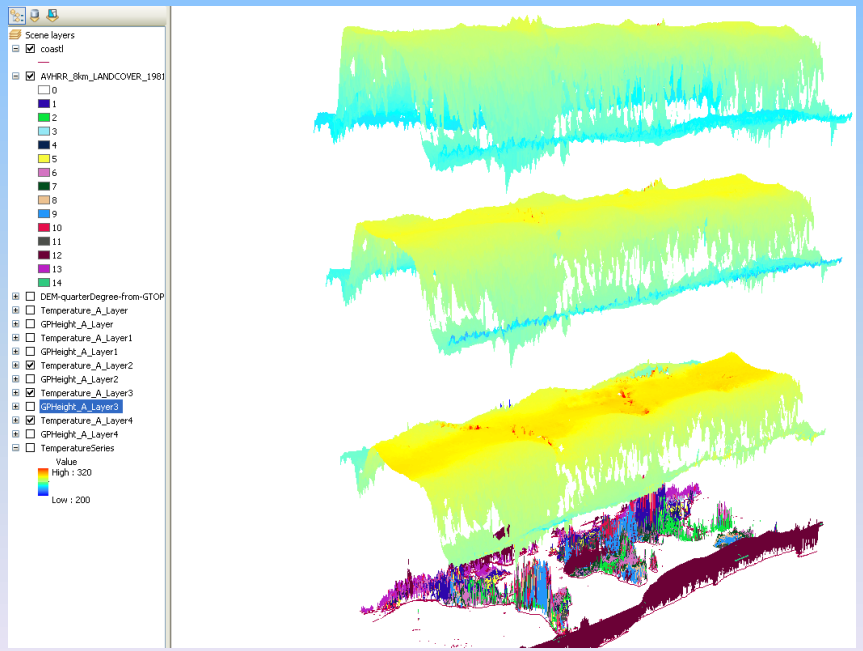


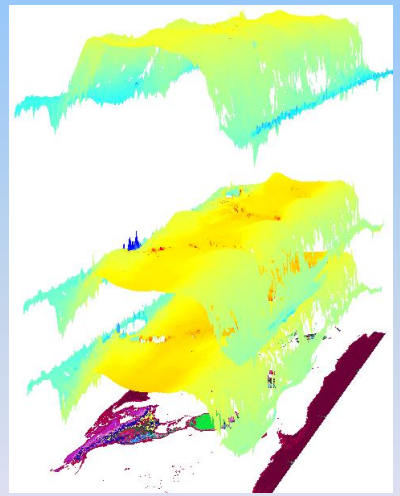
GES DISC Data / ArcGIS Use Case Examples

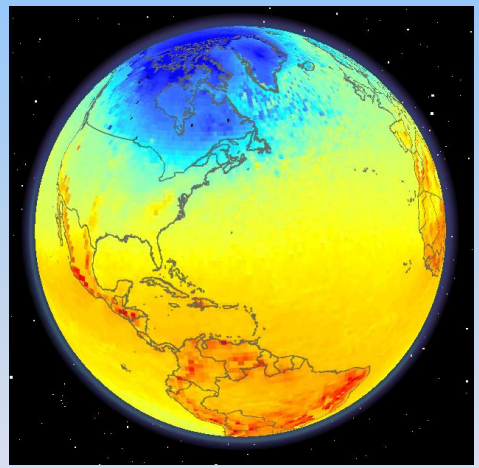
- 3D and vertical profile data visualization
- East Africa drought between 2010 and 2011
- Global air quality in the past decade

Three-Dimensional Data Visualization

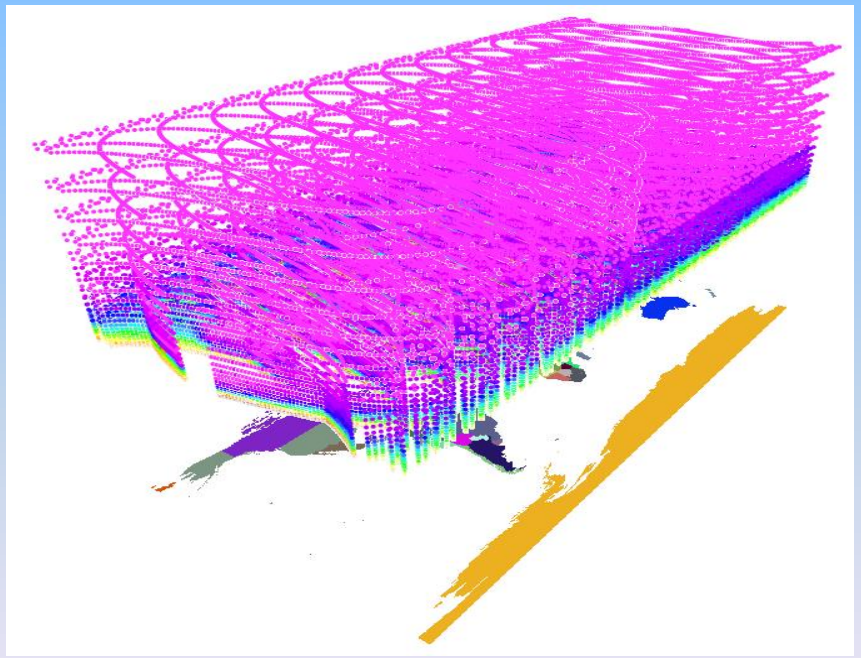
- Many GES DISC data products contains 3D variables, with the vertical variables also changing across space, e.g. airTemperature(layer, y, x) and Height(layer, y, x).

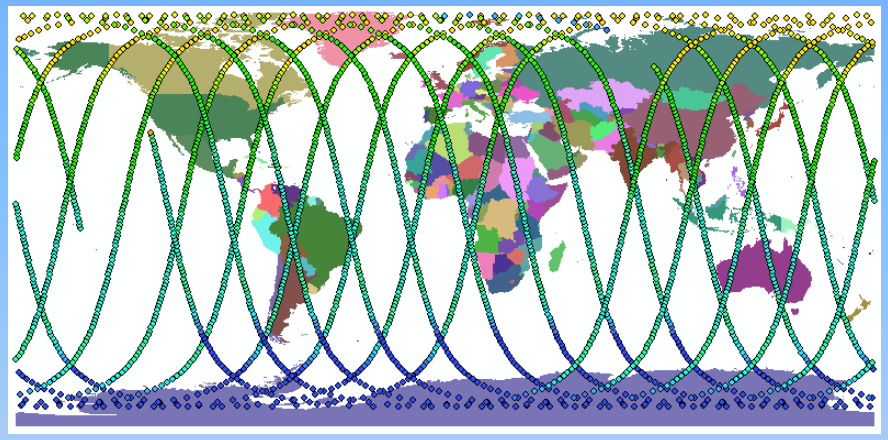


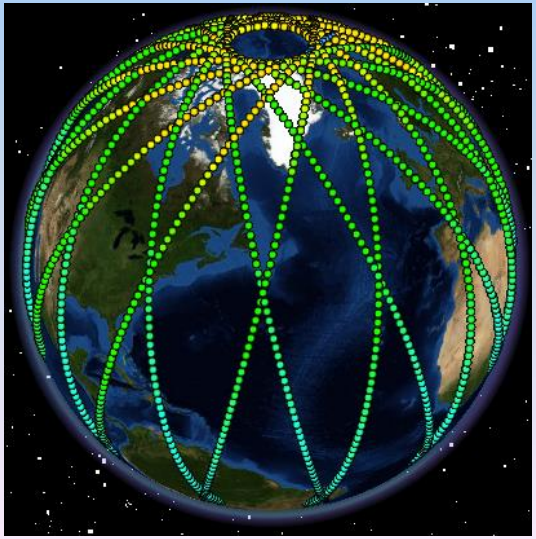




Vertical Profile Visualization







East Africa Drought Study: Background

- From the late spring of 2010 to the summer of 2011, the Horn of Africa suffered a severe and prolonged drought, which caused more than 10 million people in need for food and clean water.
- The precipitation deficit was well captured by the TRMM data archived at GES DISC.
- ArcGIS was used to map and visualize watershed level precipitation anomalies and the response of vegetation, as shown in the NASA MODIS normalized vegetation index images, to the water deficit.

East Africa Drought Study: Method

- Watershed data, obtained from USGS, were dissolved to level 3 water basins.
- TRMM daily precipitations were composited to 16-day total precipitation in corresponding to MODIS 16-day NDVI composites.
- Time series of Precipitation and NDVI were constructed from July 2002 to December 2011.
- Zonal statistics were performed to obtain mean NDVI and precipitation for each water basin.

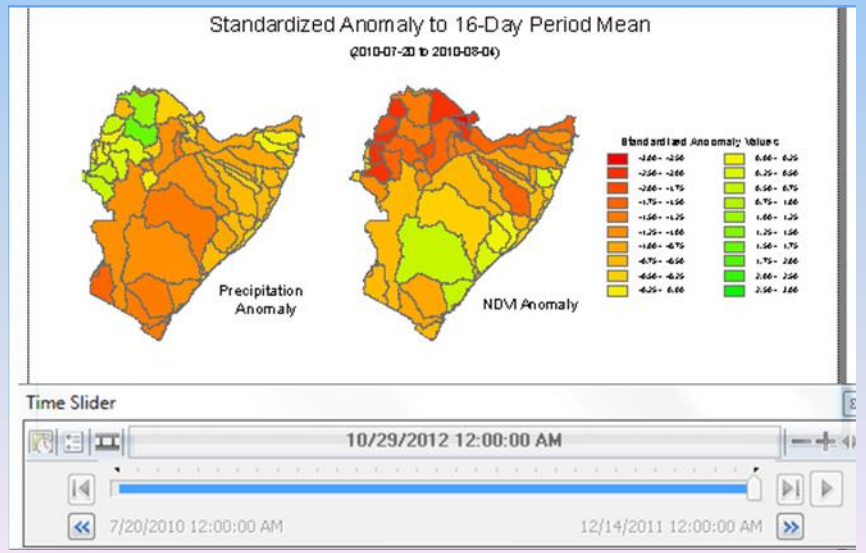
East Africa Drought: Method

- Standard anomalies for each 16-day period computed:

  $a=(x-m)/s$

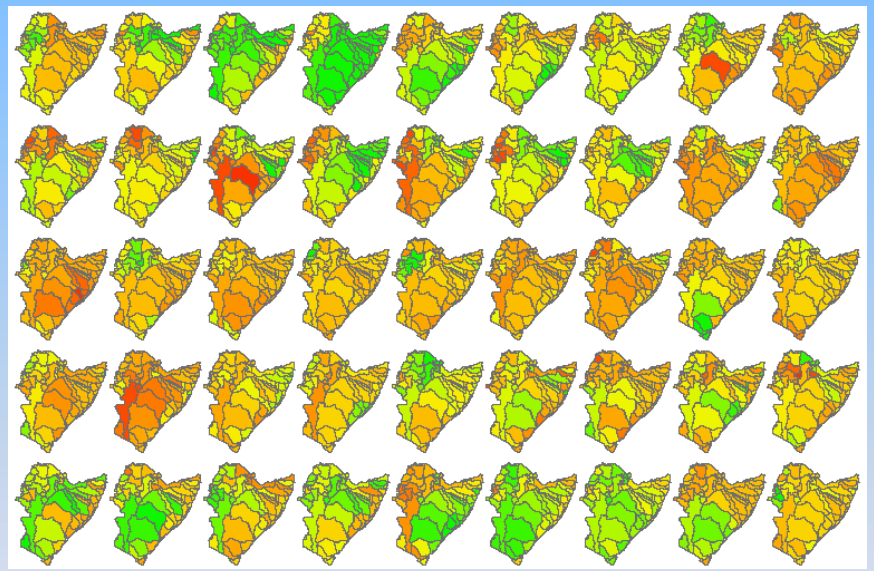
  - *a*: standardized anomaly,
  - *m*: long term mean (between 2002 and 2011)
  - *s:* standard deviation to the long term mean
  - *x:* precipitation or NDVI value for a given 16-day period

- Correlation analyses between precipitation and NDVI were performed.
- Time series were visualized in ArcMap.

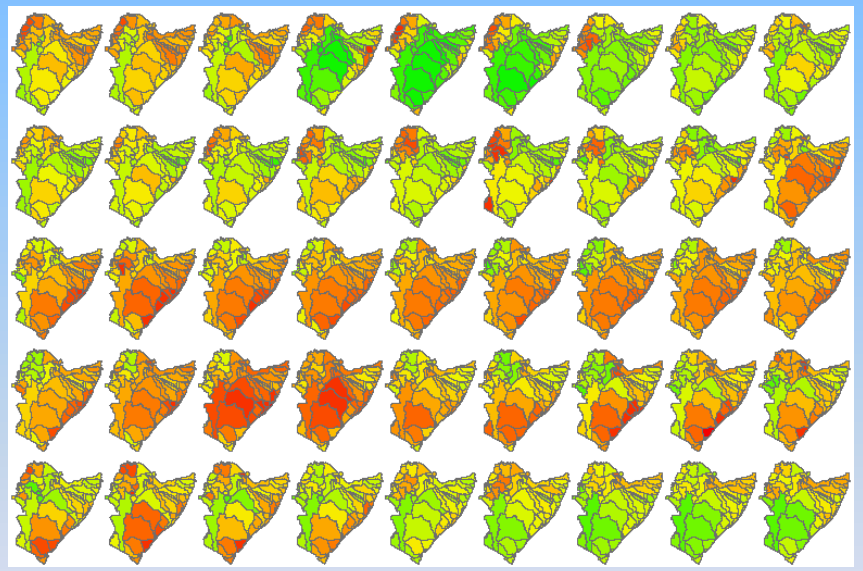


East Africa Drought: Results

- 16-day composites of precipitation and NDVI from January 2010 to December 2011



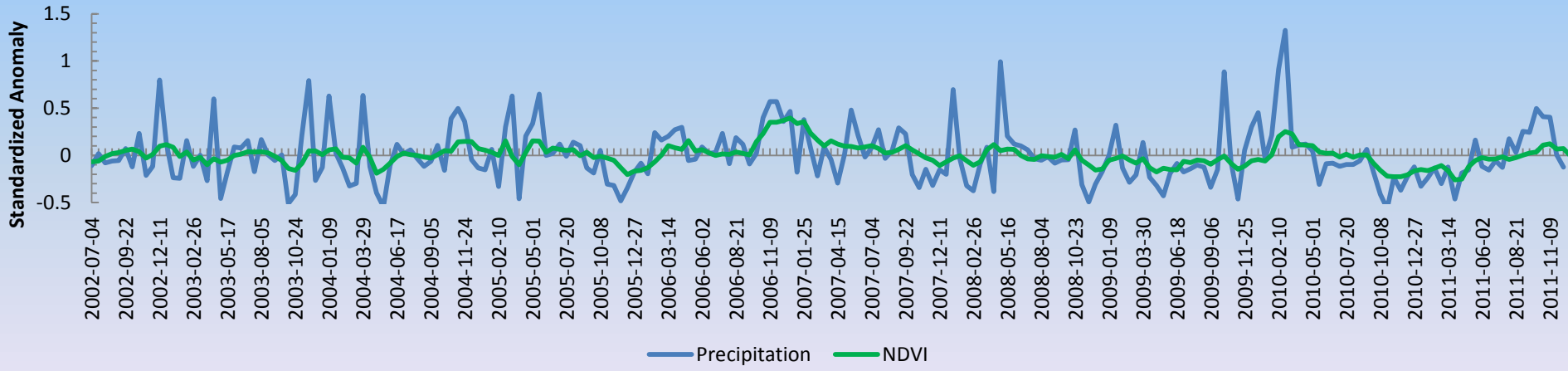
TRMM precipitation



MODIS NDVI

East Africa Drought: Results

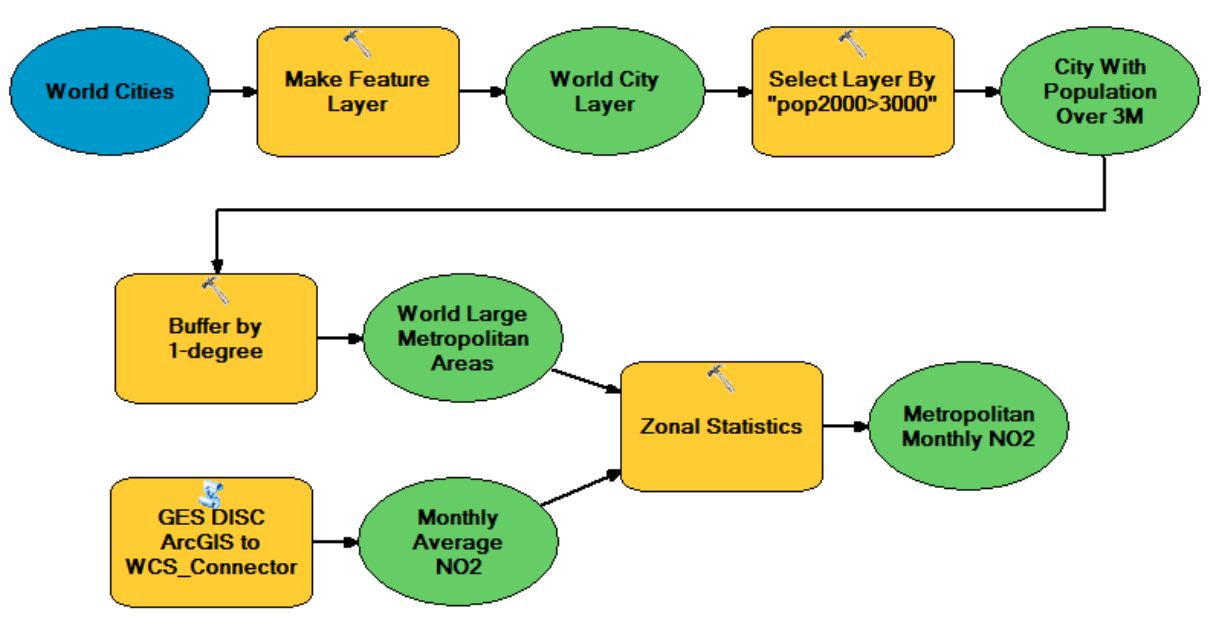
- All water basins exhibit statistically significant precipitation/vegetation correlation when one or two 16-day period lags are applied to vegetation, indicating that the vegetation in this area generally responds to precipitation within about two to four weeks



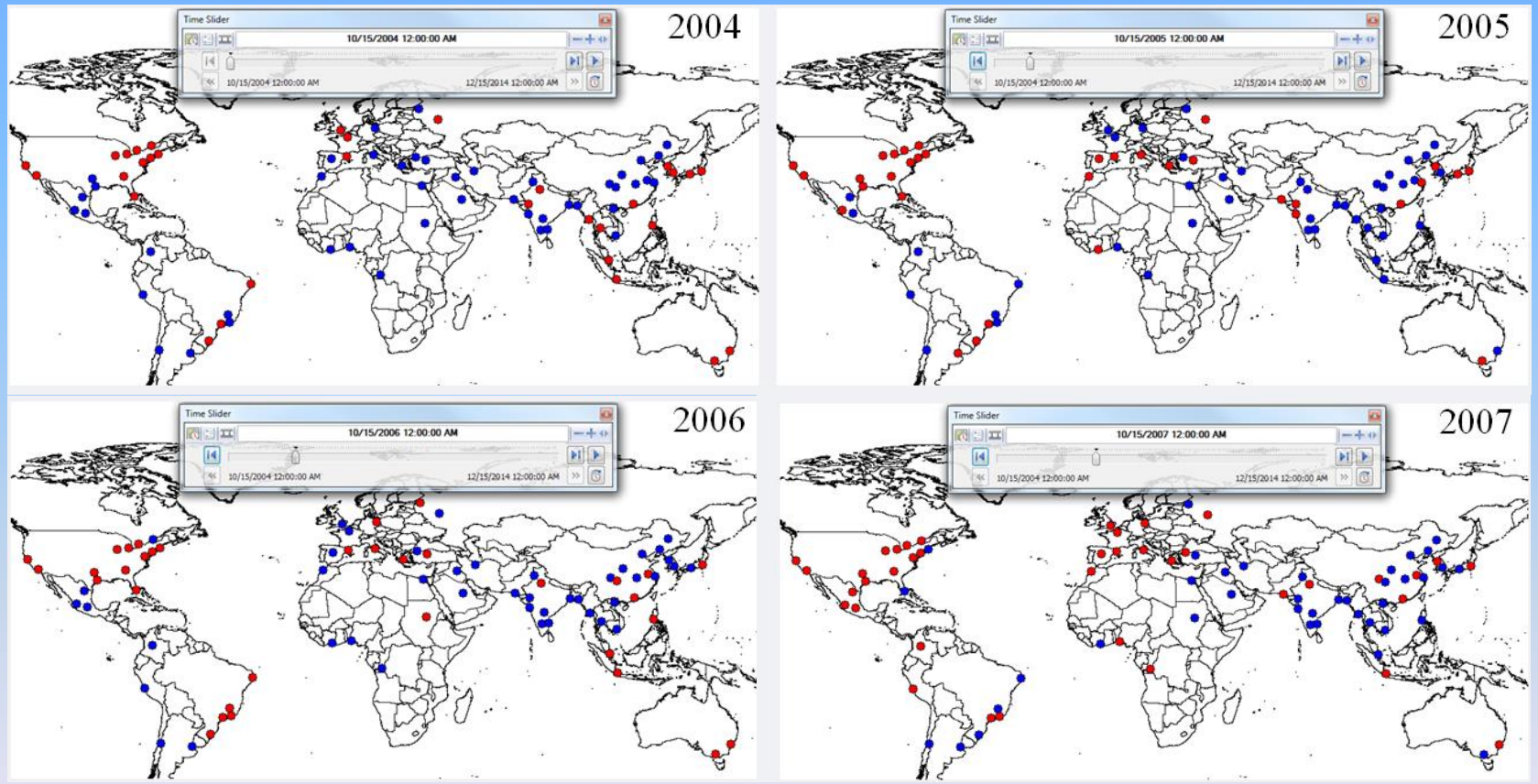
Precipitation vs NDVI anomalies with NDVI lagging one 16-day period

Air Quality Changes over the World Large Metropolitan Areas

- Visualizing nitrogen dioxide (NO_2) concentration over the world's largest metropolitan areas in ArcMap for the past decade.
- The tropospheric NO_2 is derived from the NASA Ozone Mapping Instrument (OMI) measurement.

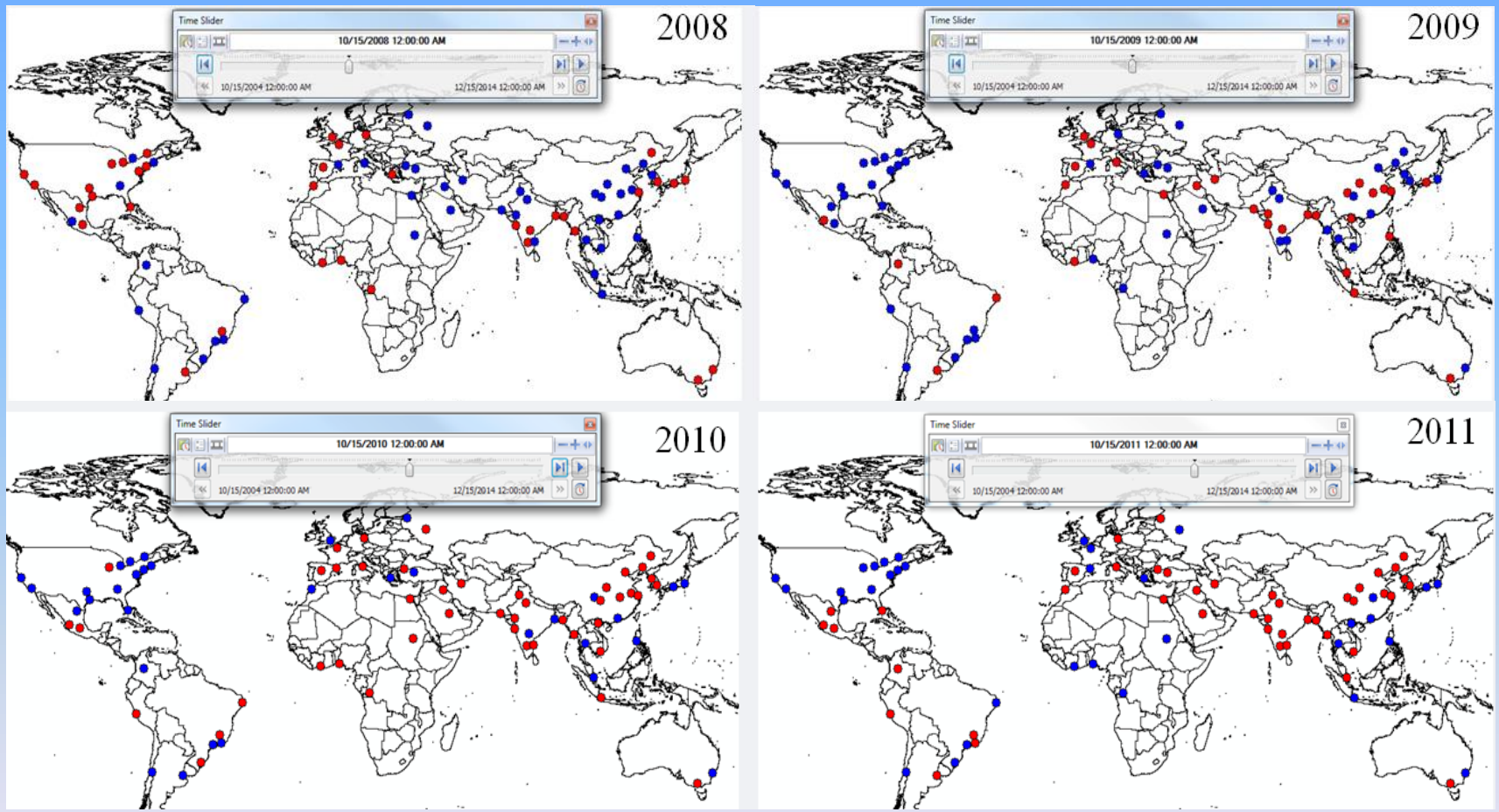


2004 to 2007



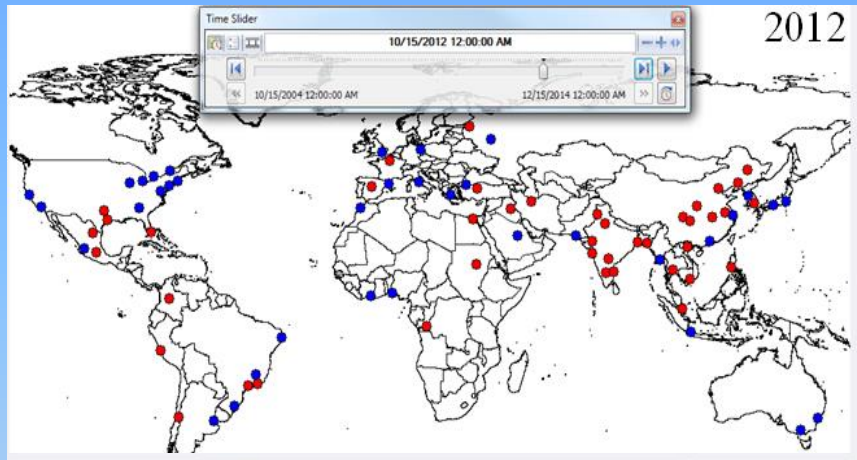
Red: positive anomaly; Blue: negative anomaly

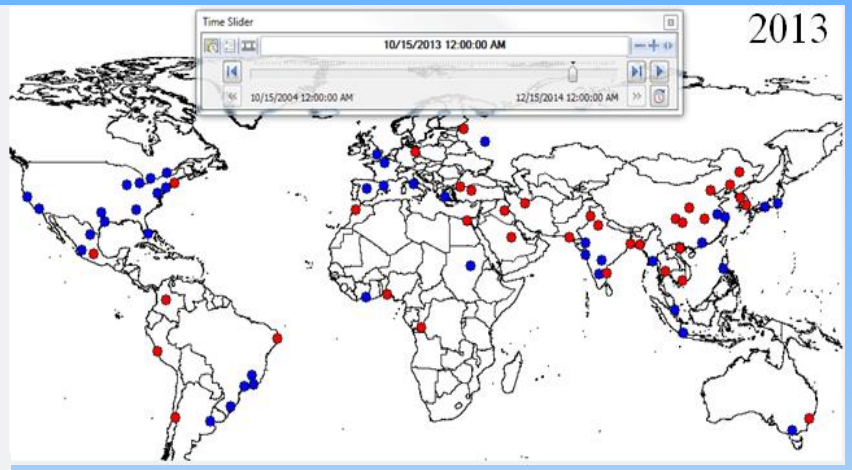
2008 to 2011

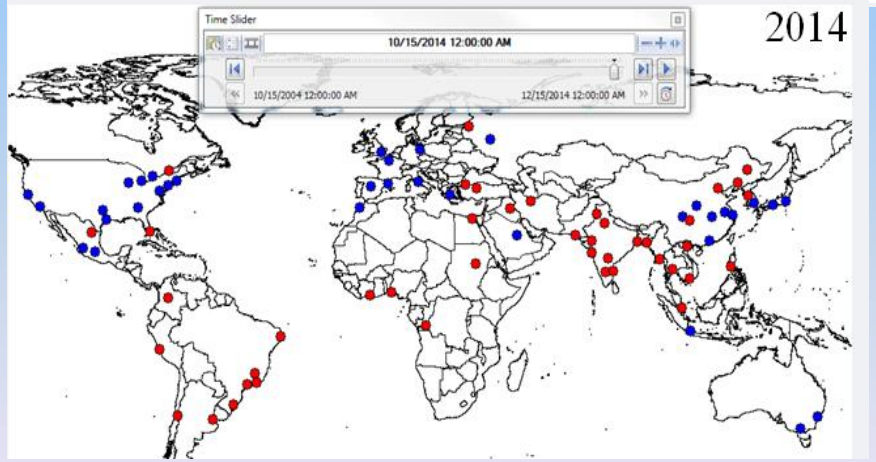


Red: positive anomaly; Blue: negative anomaly

2012 to 2014

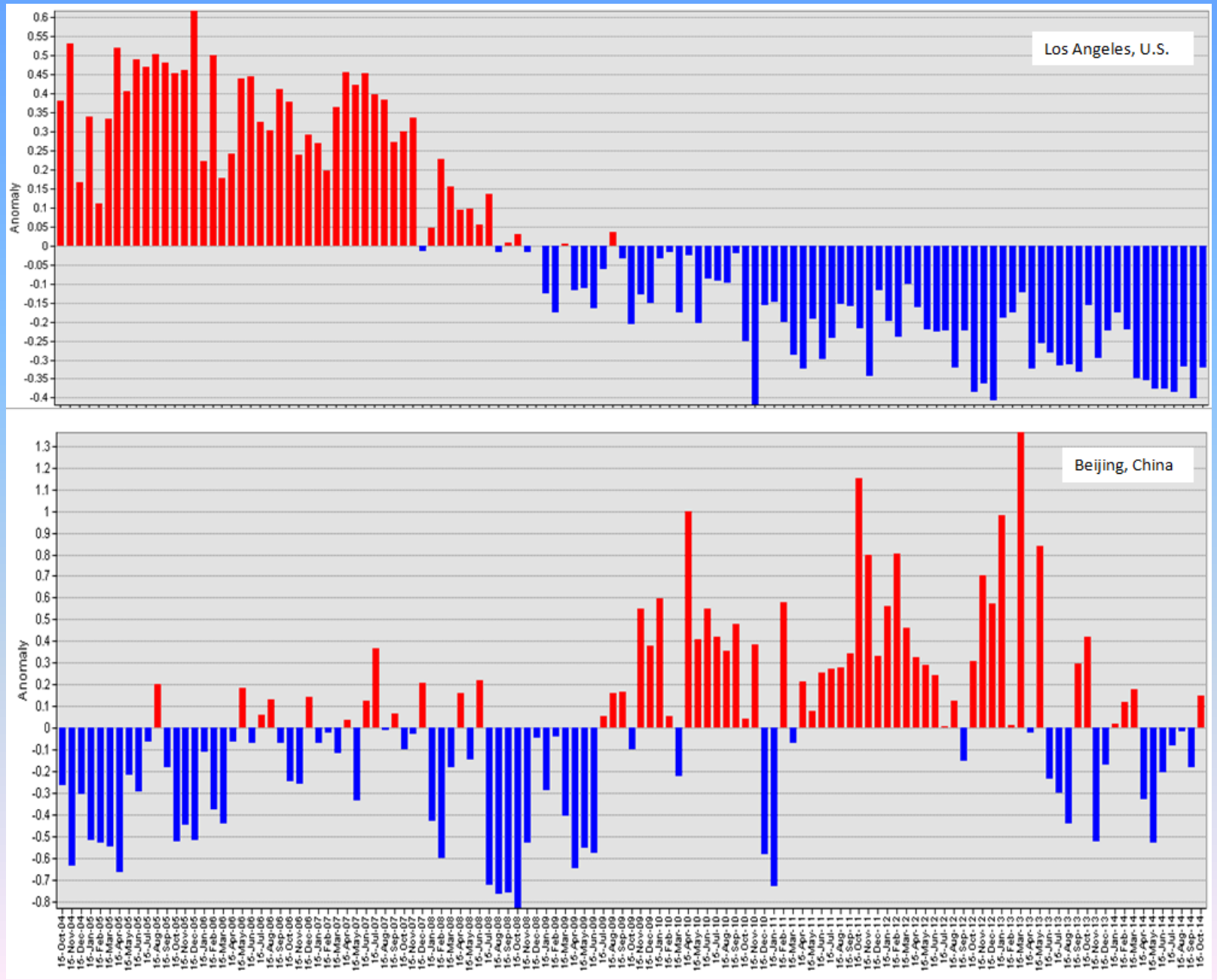




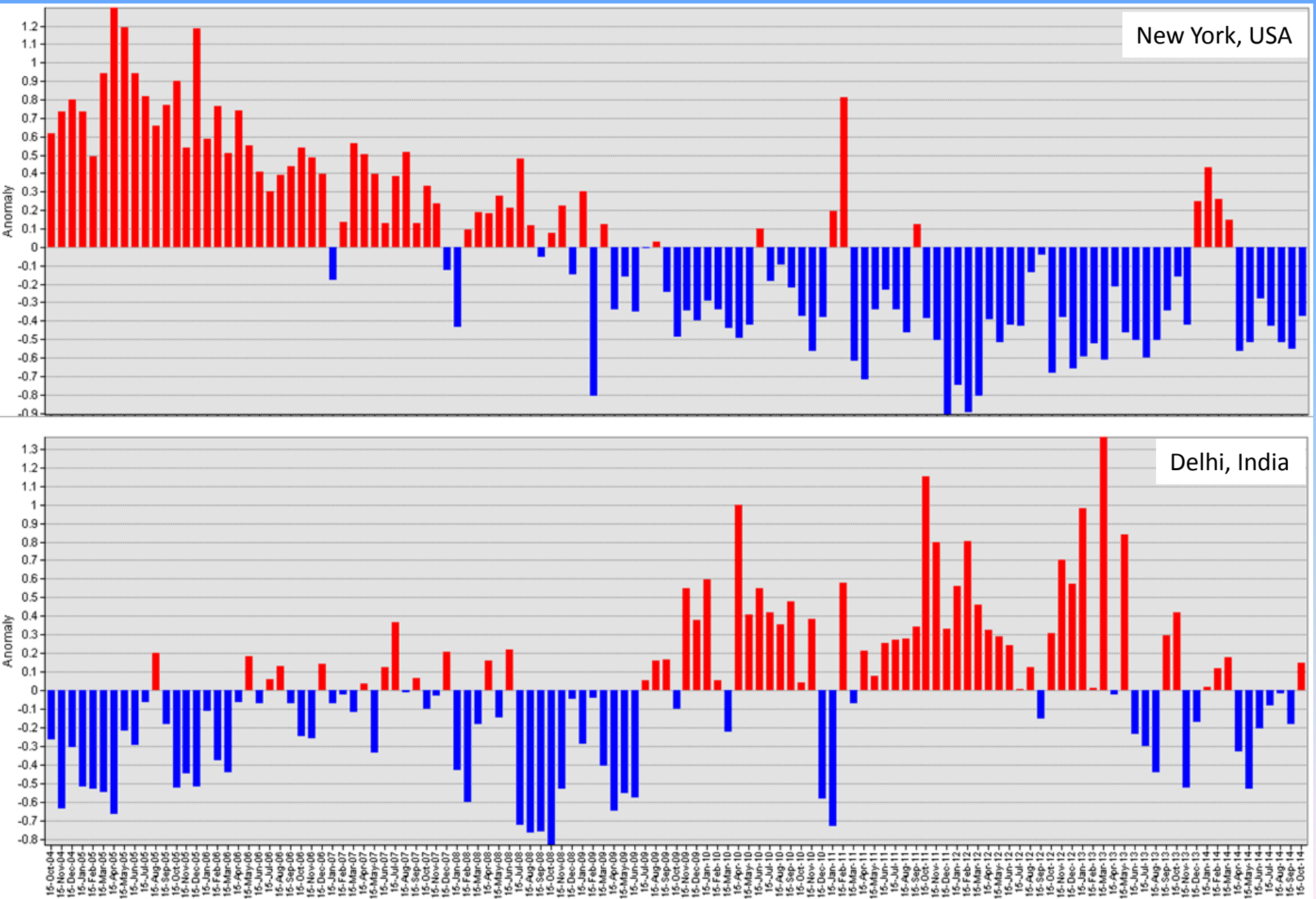


Red: positive anomaly; Blue: negative anomaly

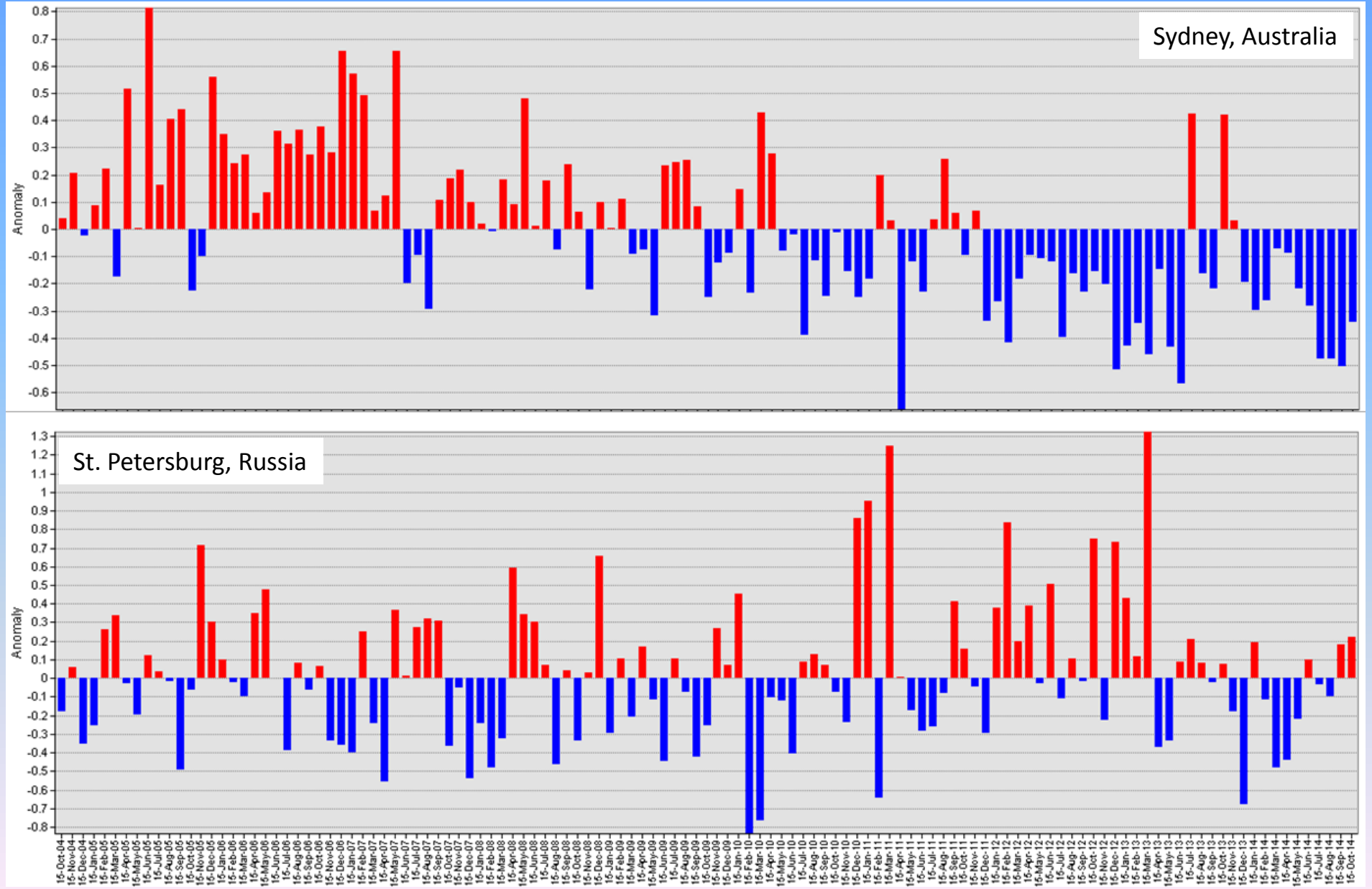
Los Angeles vs Beijing



New York vs Delhi



Sydney vs St. Petersburg



Summary

- GES DISC archives a vast volume of diversified Earth Science data highly relevant to GIS.
- The user friendly data and information service capabilities at GES DISC enables GIS users easily searching and accessing its GIS data.
- GES DISC data can be readily visualized and analyzed in ArcGIS for a wide range of GIS/remote sensing research, education, and applications.