Supporting TRMM and GPM Applications

Chris Lynnes & Bill Teng

November 13, 2013

2013 GPM Applications Workshop
College Park, Maryland
Discussion

- Data Access and Visualization Tools
- Applications Projects
Goddard Earth Sciences Data and Information Services Center

• One of EOSDIS* Science Data Centers
• Archive, Distribute and Support Usage of Remote Sensing Data and Related Models
  o Hydrology
  o Atmospheric Composition
• Value-added Data Products and Services

*Earth Observing System Data and Information System
Services for Users

- Search and Access (Mirador)
- Subsetting
- Reformatting
- Online Visualization and Analysis (Giovanni)
- Documentation
- Help Desk
Search + Access

• Mirador Search

• Access
  o FTP / HTTP
  o OPeNDAP
  o WMS
Search GES DISC with Keywords in Mirador
Data Set Listing for Search

Data Sets

- More Services (e.g. http download, format conversion, subsets etc) are available for the data set(s). Whenever you select a service and service parameters for any data set which has these services.

- Daily TRMM and Others Rainfall Estimate (3B42 V7 derived) (TRMM_3B42_daily)
  View Files: All | 006 | 007  Info: 006 | 007  Giovanni_Analysis: 006 | 007  Data Calendar: 006 | 007
  Approx. 64 files found (Avg Size: 2.197 MB)
  Parameters: PRECIPITATION RATE
  Spatial Resolution: 0.25 degree x 0.25 degree
  Temporal Resolution: Daily

- TRMM 3-Hourly 0.25 deg. TRMM and Others Rainfall Estimate Data (TRMM_3B42)
File List for Search

Daily TRMM and Others Rainfall Estimate (3B42 V7 derived)

The following services are available for the data set(s). Whenever you add files to the shopping cart, you can convert the data to NetCDF or gzipped NetCDF.

Add Selected Files To Cart  Add All Files in All Pages To Cart

Select All in Page  File Names/Descriptive File Names

- **3B42_daily.2002.02.01.7.bin (2.20 MB)**
  - One Click Download: BIN (FTP) | NetCDF | OPeNDAP

- **3B42_daily.2002.01.31.7.bin (2.20 MB)**
  - One Click Download: BIN (FTP) | NetCDF | OPeNDAP

- **3B42_daily.2002.01.30.7.bin (2.20 MB)**
  - One Click Download: BIN (FTP) | NetCDF | OPeNDAP

- **3B42_daily.2002.01.29.7.bin (2.20 MB)**
  - One Click Download: BIN (FTP) | NetCDF | OPeNDAP

- **3B42_daily.2002.01.28.7.bin (2.20 MB)**
  - One Click Download: BIN (FTP) | NetCDF | OPeNDAP

- **3B42_daily.2002.01.27.7.bin (2.20 MB)**
  - One Click Download: BIN (FTP) | NetCDF | OPeNDAP
Drill down by Project

is designed to monitor and study tropical rainfall
The Tropical Rainfall Measuring Mission (TRMM) is a joint endeavor between NASA and Japan’s National Space Development Agency. It is designed to monitor and study tropical rainfall and the associated release of energy that helps to power the global atmospheric circulation, shaping both global weather and climate.

<table>
<thead>
<tr>
<th>Data Group</th>
<th>Description</th>
<th>Date Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ancillary (1)</td>
<td>TRMM Ancillary data products</td>
<td>2000-02-07 to 2013-11-04</td>
</tr>
<tr>
<td>Climatology (12)</td>
<td>TRMM Composite Climatology (TCC) consists of a merger of selected TRMM rainfall products over both land and ocean to give a &quot;TRMM-best&quot; climatological estimate. Inputs to the composite were selected based on knowledge of the performance of the retrievals, limitations of the algorithms, and the presence of artifacts.</td>
<td>1998-01-01 to 2010-05-31</td>
</tr>
<tr>
<td>Gridded (22)</td>
<td>Gridded data products from VIRS, TMI, and PR, at a range of spatial and temporal resolutions</td>
<td>1997-12-01 to 2013-11-04</td>
</tr>
<tr>
<td>Ground-based Instrument (15)</td>
<td>Ground-based instrument data products</td>
<td>1995-01-03 to 2013-10-31</td>
</tr>
<tr>
<td>Orbital (13)</td>
<td>Orbital data products from VIRS, TMI, and PR, at the sensor’s resolution</td>
<td>1997-12-07 to 2013-11-04</td>
</tr>
<tr>
<td>Subset (23)</td>
<td>Parameter, gridded, regional gridded, and coincidence subset data derived from TRMM standard data products</td>
<td>1993-01-01 to 2013-11-04</td>
</tr>
</tbody>
</table>
Drill down by Science Area

Keyword Projects Science Areas

Estimate budget at global and regional scales.

Upward Longwave Flux (1)
# Water and Energy Cycles

Through water and energy cycle research we can improve hurricane prediction, quantify tropical rainfall and eventually...  

## Atmospheric Radiation (12)

The process by which electromagnetic radiation is propagated through free space.

<table>
<thead>
<tr>
<th>Atmospheric Radiation (12)</th>
<th>Downward Shortwave Flux (4)</th>
<th>Upward Shortwave Flux (2)</th>
</tr>
</thead>
</table>

## Clouds (67)

A visible aggregate of minute water droplets and/or ice crystals in the Earth's atmosphere.

<table>
<thead>
<tr>
<th>Clouds (67)</th>
<th>Cloud Condensation Nuclei (3)</th>
<th>Cloud Ice Water (11)</th>
<th>Cloud Particle Phase (4)</th>
</tr>
</thead>
</table>

## Heat Flux (23)

Heat flux is the amount of heat that is transferred across a surface of unit area in a unit of time. Also refers to latent and sensible heat fluxes in the atmosphere and between the Earth's surface and atmosphere.

<table>
<thead>
<tr>
<th>Heat Flux (23)</th>
<th>Downward Heat Flux (1)</th>
<th>Heat Diffusivity (1)</th>
<th>Latent Heat Flux (positive upward) (4)</th>
</tr>
</thead>
</table>
Drill down from Science Area to Measurement

<table>
<thead>
<tr>
<th>Precipitation (115)</th>
<th>Anvil Precipitation (1)</th>
<th>Atmospheric Water Vapor (63)</th>
<th>Cloud Ice (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any or all of the forms of water droplets, whether liquid or solid, that fall from clouds and reach the ground.</td>
<td>Cloud Ice Water (11)</td>
<td>Cloud Liquid (1)</td>
<td>Cloud Liquid Water (22)</td>
</tr>
<tr>
<td></td>
<td>Cloud Water Path (3)</td>
<td>Convective Precipitation (1)</td>
<td>Frozen Precipitation (1)</td>
</tr>
<tr>
<td></td>
<td>Ice Flux (1)</td>
<td>Large-scale Precipitation (1)</td>
<td>Liquid Precipitation (1)</td>
</tr>
<tr>
<td></td>
<td>Precipitable Water (14)</td>
<td>Precipitation Flux (1)</td>
<td>Precipitation Production Rate (1)</td>
</tr>
<tr>
<td></td>
<td>Precipitation Rate (25)</td>
<td>Rain Flux (1)</td>
<td>Rain Liquid Water (1)</td>
</tr>
<tr>
<td></td>
<td>Rainfall Rate (34)</td>
<td>Snowfall Rate (20)</td>
<td>Surface Precipitation Flux (3)</td>
</tr>
<tr>
<td></td>
<td>Total Re-evaporation of Precipitation (1)</td>
<td></td>
<td>Water Vapor Conversion (1)</td>
</tr>
<tr>
<td></td>
<td>Total Surface Precipitation (1)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**GES - DISC**
Goddard Earth Sciences Data Information Services Center
# Drill down from Science Area to Measurement

<table>
<thead>
<tr>
<th>Category</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anvil Precipitation</td>
<td>1</td>
</tr>
<tr>
<td>Cloud Ice Water</td>
<td>11</td>
</tr>
<tr>
<td>Cloud Water Path</td>
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<td>Convective Precipitation</td>
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</tr>
<tr>
<td>Large-scale Precipitation</td>
<td>1</td>
</tr>
<tr>
<td>Precipitation Flux</td>
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</tr>
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</tr>
<tr>
<td>Snowfall Rate</td>
<td>20</td>
</tr>
<tr>
<td>Water Vapor</td>
<td></td>
</tr>
</tbody>
</table>
Subsetting and Reformatting

• Subsetting
  o Space, time, variable
  o Shapefile mask: Future..

• Reformatting
  o netCDF for almost all data
    o e.g., Importing netCDF Grid Data into ArcGIS
  o KMZ (Google Earth) for some datasets
  o GeoTIFF: Coming soon...
Enter values for the Date Range and (optionally) the Spatial Bounding Box to search for data sets; those criteria will also be used when data sets are subsetted by Date Range and Spatial Region.

Enter keywords or click the 'Select Data Sets' button.

**Data Set Keyword(s)**: 3B42  
Select Data Sets

**Date Range**: 2001-01-01 to 2001-12-31

Enter dates as YYYY-MM-DD or use the calendars.

Enter South, West, North, East coordinates or use the map.

**Spatial Bounding Box**: 14.06,-120.23,47.11,-69.61

Search for Data

Report a Problem with the Simple Subset Wizard
Subsetting with Simple Subset Wizard

Found 2 subsettable data sets.

Subset: Spatial Region (14.06, -120.23, 47.11, -69.61), Variables for TRMM_3B42 v6 in netCDF

Subset: Spatial Region (14.06, -120.23, 47.11, -69.61), Variables for TRMM_3B42 v7 in netCDF

Number of Variables selected = 1

- high quality precipitation
- IR precipitation
- precipitation
- relativeError
- satellite observation time
- source
Exploratory Analysis of Remote Sensing Data with Giovanni*

Giovanni provides Quick-Start Exploratory Data Analysis: no coding necessary

WRITE CODE
- Select Data
- Find
- Download
- Learn format
- Read
- Subset
- Quality Filter
- Summarize / Analyze
- Visualize

Main Analysis Phase
- Analyze
- Derive Conclusions
- Publish

Web-based Services
- Read
- Extract Variables
- Subset
- Filter Quality
- Reformat
- Regrid
- Visualize
- Explore

linked interactive scatterplot + map
Giovanni Time-Averaged Map

Daily Rainfall Estimate from 3B42 V7, TRMM and other sources. 0.25 deg. [TRMM_3B42_daily_v7] (mm)
Giovanni Time Series

TRMM_3B42_daily v7 Area-Averaged Time Series

Precipitation (mm)

28 Apr 29 Apr 30 Apr 1 May 2 May 3 May

Precipitation: Daily Rainfall Estimate from 3B42 V7, TRMM and other sources, 0.25 deg.
Interactive Scatter Plot

Regression: y = 0.378x + 39.8, R: 0.575, N: 128

Daily Rainfall Estimate from 3B42 V7, TRMM and other sources, 0.25 deg. [TRMM_3B42_daily_v7] (mm) (mm)
Zoom in on Scatterplot
Examine a Subregion
Other Giovanni Services

- Vertical Profile
- Hovmoller
- Histograms
- Animation
- Seasonal analysis
- Anomaly relative to climatology
- Map of differences between two variables
• README
• How-To Recipes
  o Step by Step How-To
  o e.g., Importing netCDF Grid Data into ArcGIS
  o *We take requests for recipes...*
Recipe Structure

- Overview
- Best When...
- Task
- Example
- Estimated time to complete procedures
- Procedure
  - Numbered steps
  - Key screenshots
- Discussion
- Tool or Service

We take requests for recipes...
**Example Recipe: ArcGIS**

**How to Import Gridded Data in NetCDF Format into ArcGIS**

**Overview:**

Satellite observation and climate model data become more and more widely used in GIS. A NetCDF format is not a traditionally used GIS format although it is getting popular among model or satellite (Level 3 or Level 4) data file in NetCDF format into ArcGIS.

**Best When:**

The data is in CF-compliant NetCDF format

**Task:** Viewing Data

**Example:**

Import a TRMM monthly precipitation data file into ArcGIS.

**Estimated time to complete the following procedure:** 5 min

**Procedure:**

1) Getting data in NetCDF format
Example Recipe: ArcGIS

2) Import data into ArcGIS

- Start an ArcGIS Application, for example, **ArcMap**

- Open the **ArcToolbox** window with the Show/Hide ArcToolbox Window button found on the standard toolbar or in the ArcToolbox (Figure 1)
Example Recipe: ArcGIS

Figure 4: Sample TRMM Level 3 monthly precipitation displayed in ArcMap
Coming Soon: Shapefile Masking

Average Monthly Precipitation Rate from TRMM 3B43

Recipe in testing...
Projects with USDA

Enhancing Access to NASA Satellite Data by USDA

Work supported by NASA ROSES NNH08ZDA001N-DECISIONS and CAN-02-OES-01 (REASoN)
Projects with USDA

USDA FAS Crop Explorer & TMPA

Introduction
The U.S. Department of Agriculture’s Foreign Agricultural Service (USDA-FAS), in cooperation with the National Aeronautics and Space Administration’s (NASA) Goddard Earth Sciences Data and Information Services Center (GES DISC), has been routinely using satellite-derived data to monitor precipitation around the world. A key feature of this project is its use of near-real-time global satellite precipitation data in an operational manner. Satellite precipitation products are produced by NASA via a semi-automated process and made accessible from this web site for USDA and public viewing. Monitoring precipitation for agriculturally important areas around the world greatly assists the USDA-FAS to identify and locate regional weather events, as well as improve crop production estimates.

Data Processing
The NASA Goddard Space Flight Center (GSFC) system to produce the “TRMM and Other Data” estimates in real time was developed to apply new concepts in merging quasi-global precipitation estimates and to take advantage of the increasing availability of real-time data sets in near real time. The overall system is referred to as the “Version 6 TRMM Real-Time Multi-Satellite Precipitation Analysis.” For convenience, it is referred to here as the “TMPA-RT.”

The TMPA-RT is run quasi-operationally on a best-effort basis at the NASA Precipitation Processing System (PPS), formerly the TRMM Science Data and Information System (TESIS), with ongoing scientific development by the research team led by Drs. Robert Adler and George Huffman in the GSFC Laboratory for Atmospheres. Estimates are posted to the Web about six hours after observation time, although processing issues may delay or prevent this schedule. Due to the experimental nature of these estimates, users are encouraged to report their experiences with the data, and they should expect periodic upgrades or outages as the system develops.

There are three “TRMM and Other Data” products: (1) 3B43RT (High Quality or HQ), which is a combination of all available TMI, SSM/I, AMSR-E, and AMSR-B microwave precipitation estimates; (2) 3B42RT (Variable Rainfall Rate Inferred, or VAR) precipitation estimates from precipitation inferred (IR) observations using system and temporally varying calibration by the HQ; and (3) 3B42RT (HQ = VAR), which is a combination of 3B43RT (HQ) and 3B42RT (VAR). The current combination scheme is simple replacement, i.e., for each gridbox, the HQ value is used if available; otherwise, the VAR value is used. As a final step for the real-time system, the 3B42RT estimates...
Projects with USDA

USDA FAS Crop Explorer & TMPA

TMPA precipitation and dekadal percent normal precipitation
Projects with USDA

USDA FAS Crop Explorer & TMPA

![Image of Crop Explorer and TMPA maps]
Operational flow of GLADSE and other USDA entities and of project components (in blue)
Projects with USDA

LPRM-AMSR-E Soil Moisture
Projects with USDA

EOS/Aqua AMSR-E Loss and Mitigation (LPRM-TMI SM)
Integration into WAOB - Giovanni

Giovanni, a Web-based application, for simple and intuitive way to visualize, analyze, and access vast amounts of Earth science remote sensing data without having to download the data

http://gdata1.sci.gsfc.nasa.gov/daac-bin/G3/gui.cgi?instance_id=soilmoisture_daily
Projects with USDA

Benchmark and Metrics

2006 is the target year…
…what year(s) are similar?

2006 is the target year…
…2002 is an analog year.

Actual Δ winter wheat yields from trend (T/ha):
2006 -1.63; 2002 -1.38
Projects with USDA

![Bar chart showing the difference between measured and estimated yield deviations from a 10-year trend (mT/ha) for various locations.](chart)

- **Iowa**: Estimated yield deviation based on surface precipitation measurements.
- **Parana, Brazil, Central Argentina, Jalisco, Mexico, Free State, S Africa**: Estimated yield deviation based on satellite precipitation measurements.
Projects with USDA

![Bar chart showing difference between measured and estimated yield deviations from 10-yr trend (mT/ha)]

- Estimated yield deviation based on surface precipitation measurements
- Estimated yield deviation based on satellite precipitation measurements
- Estimated yield deviation based on satellite soil moisture (AMSR-E) measurements
- Estimated yield deviation based on satellite soil moisture (TMI) measurements
- Estimated yield deviation based on assimilated root zone soil moisture (RZSM)

Countries and their respective bars:
- Iowa
- Paraná, Brazil
- Central Argentina
- Jalisco, Mexico
- Free State, S Africa
Toward Handing Off to WAOB and Making a Difference

- Live, operational, forward-processing satellite precipitation and soil moisture data products.
- Service options for accessing and integrating data products into GLADSE.
- Operational Giovanni portal.
- **Key result:** Crop yield estimates derived from satellite-based precipitation and soil moisture data are closer to measured yields than are estimates derived from surface-based precipitation measurements.
- Establishing analog analysis methodology in station-rich areas; apply in station-poor areas of the world; significantly extend global coverage.
- WAOB is focal point for economic intelligence within USDA. Improving WAOB's agricultural estimates (WASDE) will be significant for USDA and visibly demonstrate value of NASA resources for societal benefits.
Data Reorganization for Optimal Time Series Data Access, Analysis, and Visualization

Work supported by NASA ROSES NNH11ZDA001N-ACCESS
“Digital Divide” Problem

- Data archived in the form of all variables one time step per file
- Users often need long time series for single variables at single grid “points”
- Access is orthogonal to archive → Inefficient
**Project with CUAHSI**

<table>
<thead>
<tr>
<th>Data sets</th>
<th>Temporal</th>
<th>Spatial</th>
<th>Dim</th>
<th>Total grids</th>
<th># Files per data set</th>
<th>Total vol</th>
</tr>
</thead>
<tbody>
<tr>
<td>NLDAS</td>
<td>hourly</td>
<td>1979- present</td>
<td>0.125°</td>
<td>N. Amer</td>
<td>224x464</td>
<td>93542*</td>
</tr>
<tr>
<td>GLDAS</td>
<td>3-hourly</td>
<td>1948- present</td>
<td>0.25°</td>
<td>Global</td>
<td>600x1440</td>
<td>259200*</td>
</tr>
</tbody>
</table>

* Per parameter; reduced by NLDAS land ~ 0.9; GLDAS land ~ 0.3
Project with CUAHSI

ACCESS Project Solution for Bridging the Digital Divide

Original Data Archive

- All variables
- All grid points
- One time step per file

Reorganized Data Archive

- One variable
- One grid point
- All time steps per file

Legend:
- Time
- Longitude (X)
- Latitude (Y)
Early time series service of NLDAS Noah 0-100 cm soil moisture, e.g.,

http://hydro1.sci.gsfc.nasa.gov/daac-bin/access/timeseries.cgi?variable=NLDAS:NLDAS_NOAH0125_H.002:SOILM0-100cm&startDate=1979-01-02T00&endDate=2012-09-30T23&location=NLDAS:X217-Y042&type=plot
Project with CUAHSI

NLDAS_NOAH0125_H.002 0-100 cm top 1 meter soil moisture content [kg/m^2] @ (lon=-97.8125, lat=30.3125)
Presentation for Lawrence

Chris: Do you know how to paste Gilberto's sample presentation format into this Google Presentation?

Steve: See if this works. (GV)

Project with CUAHSI

TNRIS* Use Case

*N Texas Natural Resources Information System
NLDAS parameters with time series access available (0.125° hourly, 1979-present)

Forcing

- Precipitation hourly total
- 2-m above ground temperature
- 10-m above ground zonal wind speed
- 10-m above ground meridional wind speed
- Potential evaporation

Noah

- 0-100 cm top 1 meter soil moisture content
- 0-10 cm soil temperature
- Surface runoff
- Total evapotranspiration

GLDAS ..., TMPA, LPRM
MERRA ...
AIRS ...
Thank You
GES DISC:

http://disc.gsfc.nasa.gov

GES DISC Science Data Manager:

Dr. Gilberto Vicente

gilberto.a.vicente@nasa.gov