



# Using NASA Earth Observation Data in ArcGIS

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NASA Goddard Earth Science Data and Information  
Services Center

# Outline

## ❑ Who Are We

- **GES DISC: Multi-Disciplinary Data Archive and Service Center**

## ❑ Earth Observation (EO) Data Characteristics vs. GIS User Needs

- GES DISC EO Data Characteristics
- Challenges for Handling EO Data in GIS
- GIS User Needs from EO data

## ❑ EO Data Service in GIS

- Use Giovanni to explore and transform EO data to GIS tools
- GES DISC OGC Services
- ArcGIS Related Support: Data Recipe, Image Service, upcoming ArcGIS services

# GES DISC - Big Data Archive



The screenshot shows the GES DISC website with a dark blue header and a large Earth image background. The main content area features a search bar and a 'Browse Data by Category' button. Below this, there are three columns: 'Projects & Missions' (listing Cloud Absorption Radiometer (CAR), MEASURES, and SSBV), 'Featured Gallery Images' (showing a map of the United States with precipitation data), and 'News' (listing articles about Hurricane Florence, Sentinel-SP TROPOMI, and GPS Radio Occultation). The footer contains links for 'NASA Official: Long Pham', 'Science Focus Areas', 'Tools', 'Resources', and 'About Us'.

GES DISC  
Atmospheric Composition, Water & Energy Cycles, and Climate Variability

Explore...

Data Collections Enter search (e.g., rainfall, GPI) Browse Data by Category

<https://disc.gsfc.nasa.gov>

Archive Size: 2,180,934 TB  
Archived Data Files: 115,269,146  
Files Distributed\*: 2,343,875,582  
Data Volume Distributed\*: 22,242.420 TB

**Projects & Missions**

**Cloud Absorption Radiometer (CAR)**  
The Cloud Absorption Radiometer (CAR) is an airborne multi-wavelength scanning radiometer that can perform several functions including: d...

**MEASURES**  
MEASURES: Making Earth System Data Records for Use in Research Environments, is a NASA project, solicited through Research Opportunities in ...

**SSBV**  
The Shuttle Solar Backscatter Ultraviolet (SSBV), nearly identical to Nimbus-7 SBUV and NOAA SBUV/2 instruments flown on eight space shuttles...

**View All Projects & Missions ...**

**Featured Gallery Images**

Map of the United States showing precipitation data. Legend: Daily accumulated precipitation for the rainy KY Derby Day in 2018. Louisville is indicated with a '+' symbol. Dataset GPM\_3IMERGDL curated by GES DISC.

**View All Gallery Images ...**

**News**

Using NLDAS data to examine Hurricane Florence's record rainfall and its effects on the Carolinas  
Nov 1, 2018

Copernicus Sentinel-SP TROPOMI Level-2 Total Column Ozone Product Release News  
Oct 29, 2018

Release of GPS Radio Occultation Boundary Layer Depth Products  
Oct 25, 2018

**View All News ...**

**NASA Official: Long Pham**  
Web Curator: M. Hegde

**Science Focus Areas**

- Atmospheric Composition
- Water & Energy Cycles
- Climate Variability

**Tools**

- Giovanni
- MERRA Subsetter
- Data Rods for Hydrology
- DQVz
- AIRS NRT Viewer
- OGC Web Map Service
- OPeNDAP and GDS

**Resources**

- HowTo
- Glossary
- FAQ
- News
- Gallery
- Alerts

**About Us**

- Who We Are
- Citing Our Data
- Contact Us
- User Working Group

- Archives total volume > 2.3 Petabytes consisting of >110 million data files covering >2500 public and restricted collections, distributes >23 Petabytes
- Multi-disciplinary data holdings** include observations and model data of **atmospheric composition, water/energy cycles, climate variability**
- These include for example Aqua AIRS, Aura HIRDLS/MLS/OMI, **TROPOMI**, SORCE, TOMS, TOVS, TRMM/**GPM**, UARS, LDAS and MERRA/**MERRA-2**.
- Through various available tools and services, the GES DISC provides users with multi-sensor and model visual comparisons and data access for a number of projects spanning several disciplines.

# GES DISC- Multi-Disciplines Data Holdings

1200+ data collections being **curated**

## Atmospheric composition missions:

- Nimbus 1-7\* BUV, SBUV, TOMS
- Shuttle SBUV\*
- UARS\*
- Aqua AIRS
- Aura HIRDLS\*, OMI, MLS
- ACOS\*
- **SNPP Sounder, OMPS**
- JPSS-1 Sounder, OMPS
- GOSAT(ACOS)/OCO-2/**OCO-3**
- **Copernicus Sentinel 5P (TROPOMI)**
- TOVS Pathfinder\*

## Model data:

- MERRA\*/**MERRA-2**
- **NLDAS, GLDAS, FLDAS, NCA-LDAS**

## Research-derived data:

- MEaSUREs
- CMS

## Near-real time:

- AIRS
- MLS

## Water cycle/precipitation missions:

- TRMM\*
- **GPM**
- SMERGE

## Future assigned missions:

- TROPICS
- Copernicus Sentinel 6
- GeoCarb

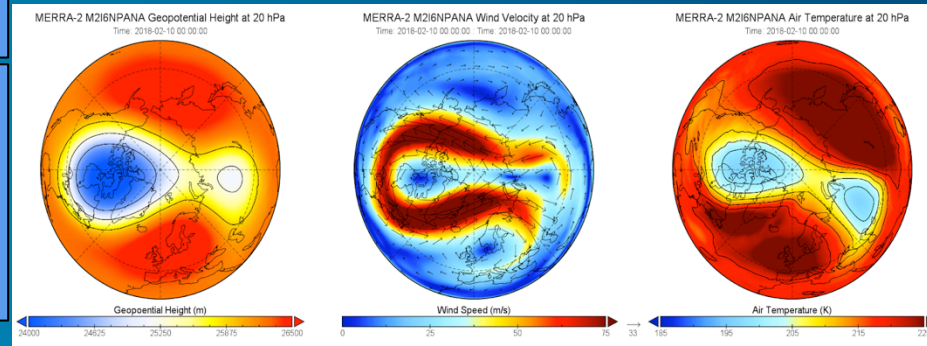
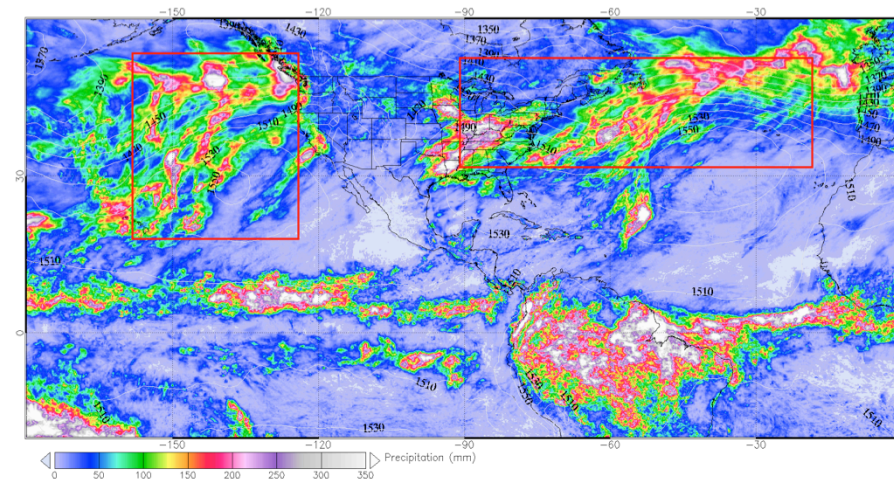
## Climate variability/solar missions:

- SORCE
- TCTE
- TSIS
- CAR

\* end-of-mission/project

GES DISC Goddard Earth Science Data and Information Services Center  
<https://disc.gsfc.nasa.gov>

GPM



polar vortex from MERRA-2

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- **GIS User Needs from EO data**

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# GES DISC Earth Observation (EO) Data Characteristics:

## Multi-spatiotemporal Datasets

→ **Instrument type:** Remote sensing, in-situ, modeling

→ **Measurement Resolutions:**

◆ **Spatially:**

- Global grids (raster) with spatial resolution up to 4-km
- Higher resolution swath (feature points) data (e.g., 2.2-km)

◆ **Temporally:**

- Half-hourly, 3-hourly, daily, monthly satellite measurements
- Hourly, 3-hourly, daily and monthly modeled products
- Monthly ground observation archives
- Composite Climatology (yearly, monthly)
- Near-real-time (NRT) products

# Challenges for Handling EO Data in GIS

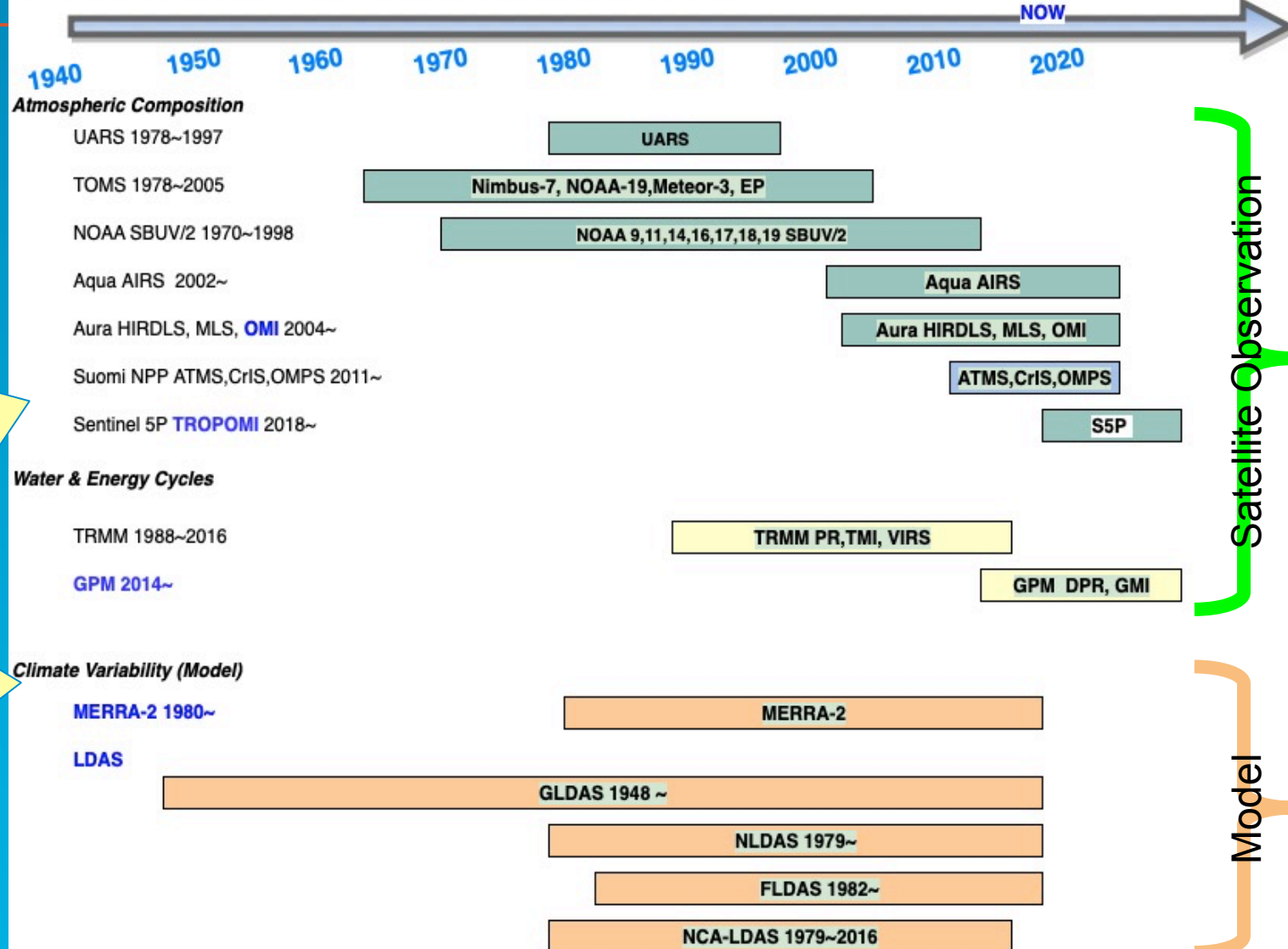
1. Complex Data Format: HDF, HDF-EOS, netCDF

2. Non-Grid format: swath data

3. Need additional analytics for long data records

Data Side

## GES DISC Earth Observation Mission Data Timeline



4. Multitude of applications

5. Cross-disciplinary applications

User Side

# GIS **User Needs** from NASA EO data

Can I plug in  
ArcGIS with  
your EO data?

Which spatial  
and temporal  
resolution  
should I use ?

Should I use  
model data  
or satellite  
data? Which  
parameter?

HOUSTON, WE HAVE A  
**PROBLEM!**



# Potential GIS Applications from GES DISC Data

(Extreme Weather Events, Climatic Anomaly , Public Health ...etc)

- Precipitation (TRMM/GPM)
- Hydrology (Land Data Assimilation System data (LDAS) with numerous land parameters)
- Modern Era Retrospective-Analysis for Research and Applications data assimilation data (MERRA/2), with numerous land, ocean and atmospheric parameters
- Atmospheric Compositions
  - Volcano Eruption (SO<sub>2</sub>: AIRS/OMI/TROPOMI/OMPS/MEaSUREs)
  - Air Quality/Public Health (AOD/AI/NO<sub>2</sub>/PM: TOMS/OMI/OMPS/MERRA-2/TROPOMI...etc)

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# Giovanni -- a simple and intuitive way to visualize, analyze, and access vast amounts of EO data

The screenshot displays the Giovanni web interface in a browser window. The URL bar shows <https://giovanni.gsfc.nasa.gov/giovanni/>. The page header includes the NASA logo, the text "GIOVANNI The Bridge Between Data and Science v 4.30", and links for "Feedback", "Help", and "Login".

The main content area is titled "Select Plot" and contains several interactive elements:

- Select Plot:** A dropdown menu is set to "Maps: Time Averaged Map". Other options include "Comparisons", "Vertical", "Time Series", and "Miscellaneous".
- Select Date Range (UTC):** A date range selector showing "Valid Range: 1948-01-01 to 2019-07-10".
- Select Region (Bounding):** A region selector with a format of "West, South, East, North".
- Select Variables:** A list of variables categorized by "Disciplines" and "Measurements". The "Disciplines" list includes Aerosols (188), Atmospheric Chemistry (76), Atmospheric Dynamics (424), Cryosphere (13), Hydrology (1209), Ocean Biology (59), Oceanography (62), and Water and Energy Cycle (1272). The "Measurements" list includes Aerosol Index (6), Aerosol Optical Depth (88), Air Pressure Anomaly (1), Air Pressure (58), Air Temperature Anomaly (2), Air Temperature (105), Albedo (25), Altitude (8), Angstrom Exponent (20), Atmospheric Moisture (122), Black Carbon (5), and Buoyancy (2).
- Number of matching Variables:** A text box showing "0 of 2007" and a "Keyword" search field.
- Time Series Choices:** A panel on the right side of the interface showing four options:
  - ☐ **Hovmoller, Longitude-Averaged**: Longitude-averaged Hovmoller, plotted over the selected time and latitude ranges. \* Guest user limited to 4 time steps. [Details...](#)
  - ☐ **Hovmoller, Latitude-Averaged**: Latitude-averaged Hovmoller, plotted over the selected time and longitude ranges. \* Guest user limited to 4 time steps. [Details...](#)
  - ☐ **Area-Averaged Differences**: Time series of area averages of differences between two variables at each spatial grid point. \* Guest user limited to 4 time steps. [Details...](#)
  - ☒ **Area-Averaged**: Time series of area-averaged values. \* Guest user limited to 4 time steps. [Details...](#)
  - ☐ **Seasonal**: Seasonal (inter annual) time series. \* Guest user limited to 4 time steps. [Details...](#)

At the bottom of the interface, there is a footer with the NASA logo, the text "NASA Official: Angela Li Web Curator: M. Hegde", links for "Privacy", "Powered By", and "Contact GES DISC", and buttons for "Reset" and "Plot Data".

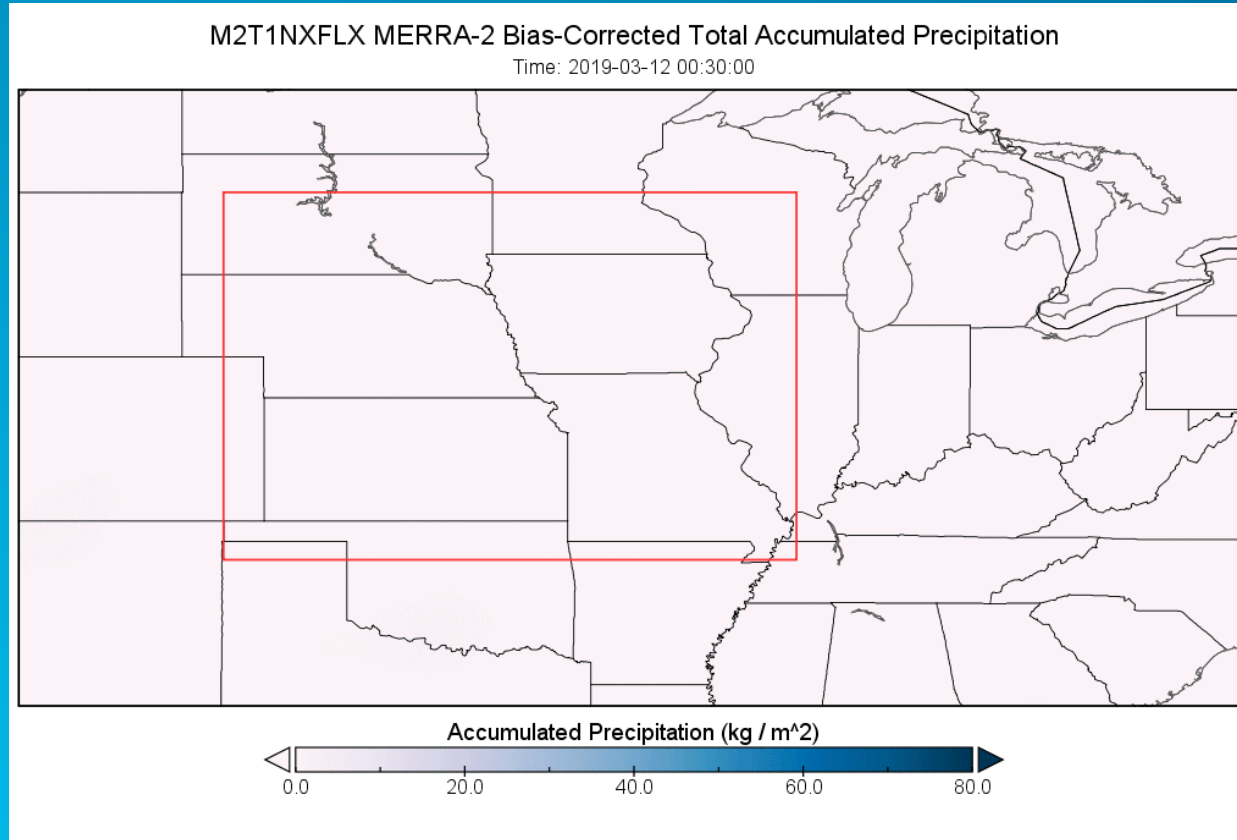
<https://giovanni.gsfc.nasa.gov/giovanni>

<https://disc.gsfc.nasa.gov>

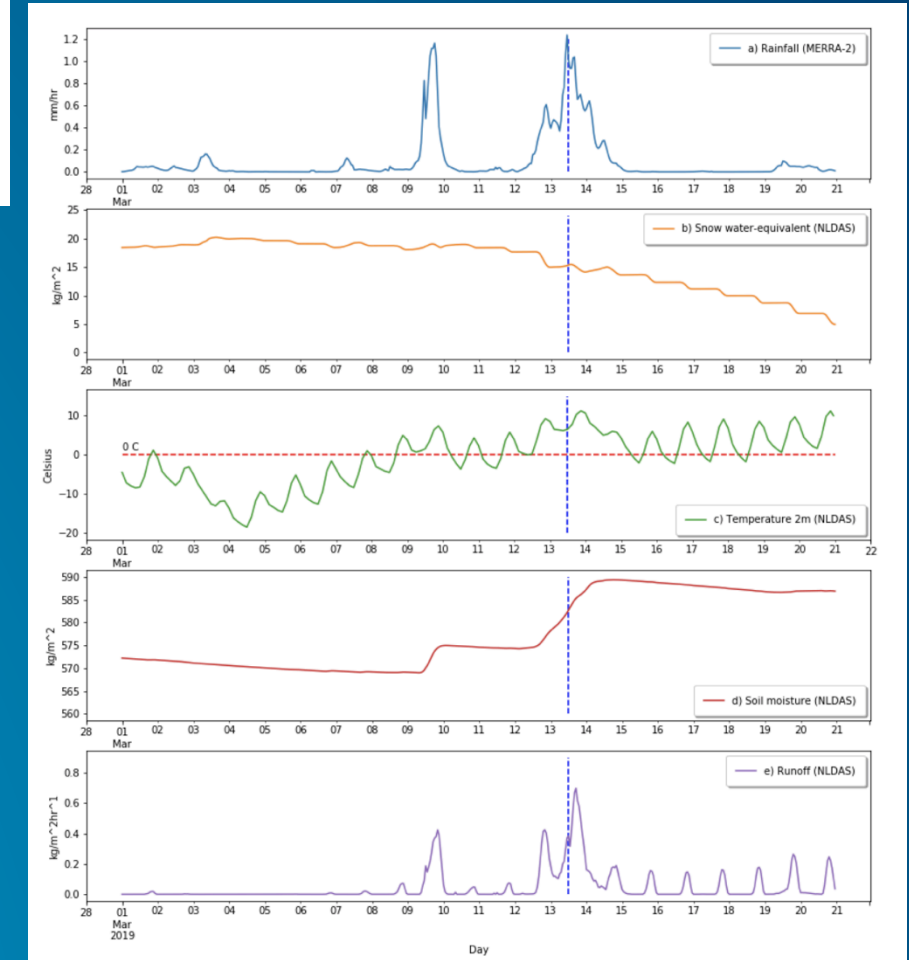
# Use Giovanni to create a Story Map



## “Bomb Cyclone” and Midwest Flood of March 2019



Animation of MERRA-2 accumulated bias-corrected precipitation over the Midwest from March 12-15, 2019. Bomb cyclone rainfall starts from March 12-14, with heavy downpours in Nebraska and South Dakota along the Missouri River



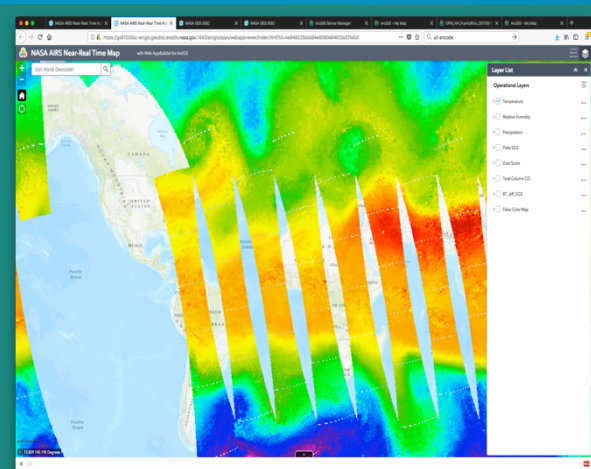
Spatially averaged hourly time series plots of: a) bias corrected total rainfall ( $\text{mm/hr}$ ) from MERRA-2; b) snow water-equivalent ( $\text{kg m}^{-2}$ ) derived from NLDAS NOAH; c) air temperature at 2m ( $^{\circ}\text{C}$ ) from NLDAS Primary Forcing ; d) soil moisture total column ( $\text{kg m}^{-2}$ ) 0-200 cm from NLDAS NOAH; and e) runoff ( $\text{kg m}^{-2} \text{hr}^{-1}$ ) from NLDAS Mosaic acquired from March 1-20, 2019.

Details can be found through GES DISC's News article!

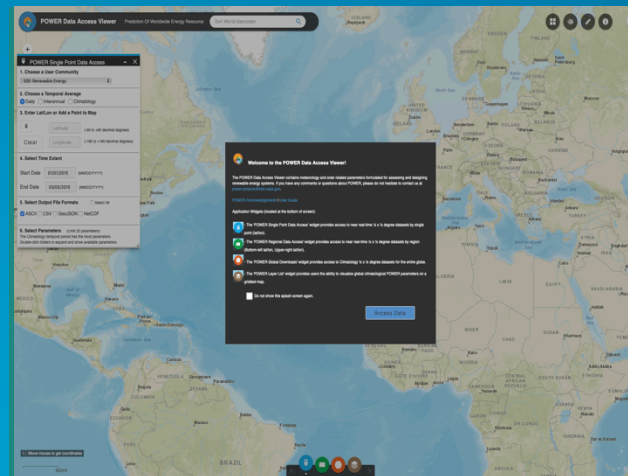
GES DISC Goddard Earth Science Data and Information Services Center  
<https://disc.gsfc.nasa.gov>

# GES DISC OGC Services

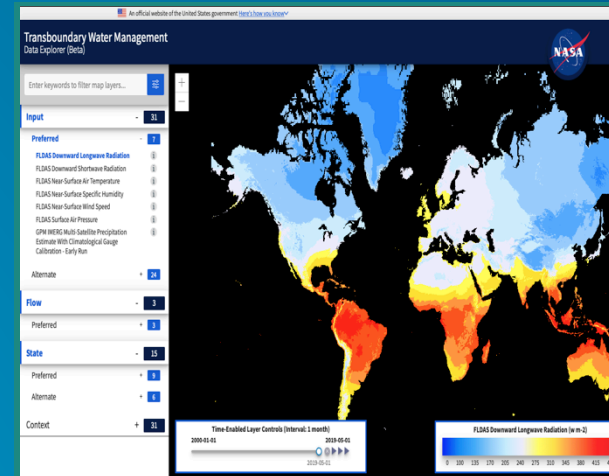
**Transform** EO data to be GIS interoperable using OGC services (WCS/WMS)



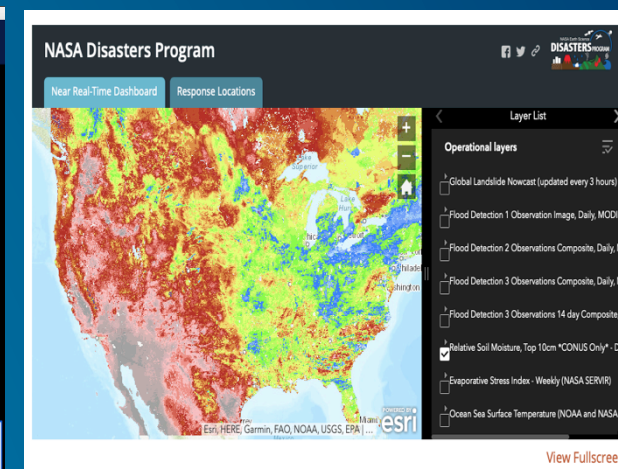
- NASA GES DISC AIRS NRT Data Viewer
- Contain GES DISC's AIRS NRT L1/L2 data



- NASA LaRC Power Data Viewer**
- Contain GES DISC's MERRA-2 data



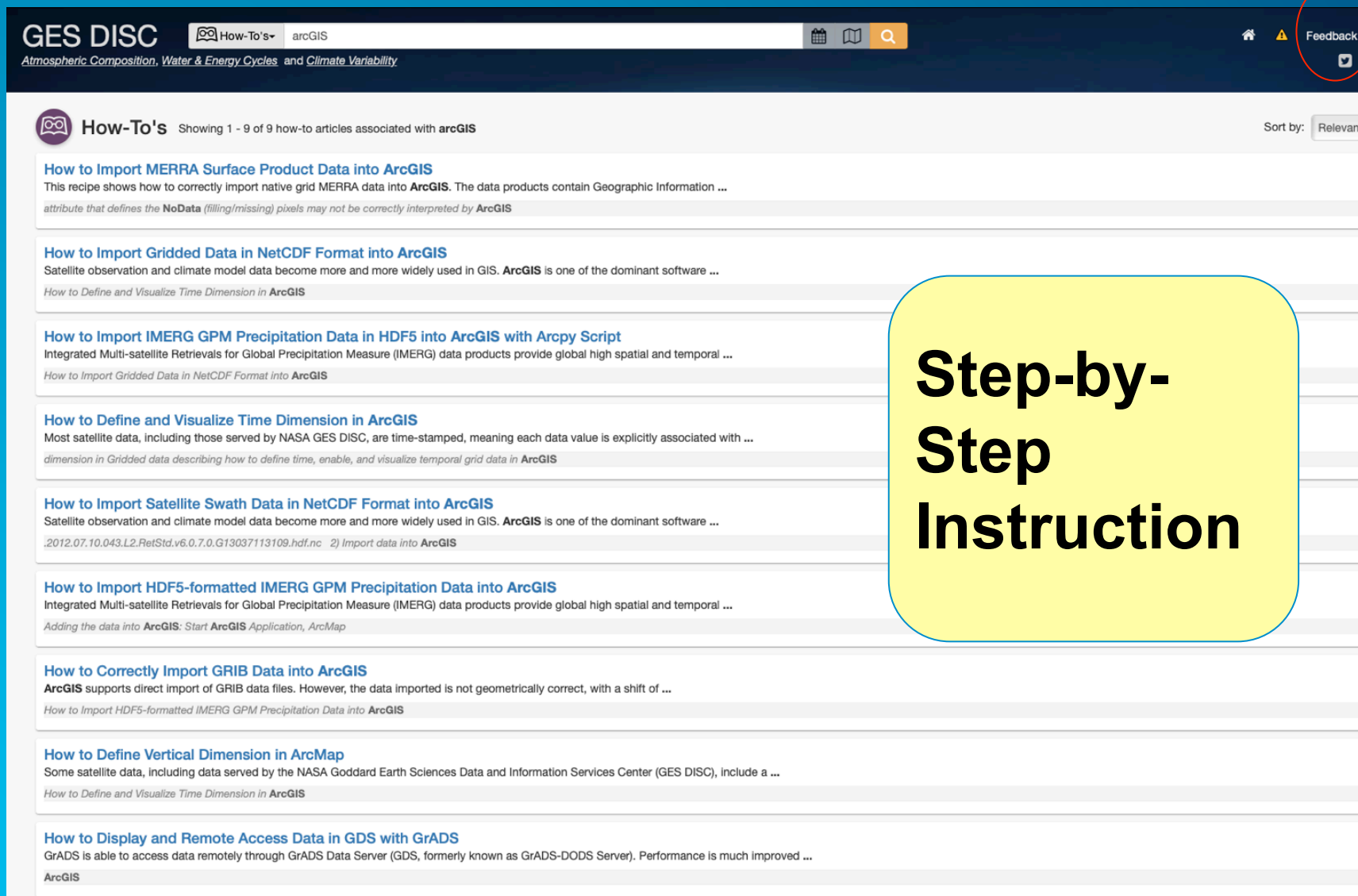
- NASA GSFC Transboundary Water Management Data Explorer
- Contain GES DISC's TRMM GPM, GLDAS, FLDAS, NLDAS data



- NASA Disaster Program Response Viewer
- Contain GES DISC's TRMM/ GPM, OMI/TROPOMI data

# GES DISC ArcGIS Data Recipe

<https://disc.gsfc.nasa.gov/information/howto?keywords=arcGIS&page=1>



**GES DISC** How-To's arcGIS Feedback

*Atmospheric Composition, Water & Energy Cycles and Climate Variability*

**How-To's** Showing 1 - 9 of 9 how-to articles associated with **arcGIS** Sort by: Relevancy

- How to Import MERRA Surface Product Data into ArcGIS**  
This recipe shows how to correctly import native grid MERRA data into **ArcGIS**. The data products contain Geographic Information ...  
*attribute that defines the **NoData** (filling/missing) pixels may not be correctly interpreted by **ArcGIS***
- How to Import Gridded Data in NetCDF Format into ArcGIS**  
Satellite observation and climate model data become more and more widely used in GIS. **ArcGIS** is one of the dominant software ...  
*How to Define and Visualize Time Dimension in **ArcGIS***
- How to Import IMERG GPM Precipitation Data in HDF5 into ArcGIS with Arcpy Script**  
Integrated Multi-satellite Retrievals for Global Precipitation Measure (IMERG) data products provide global high spatial and temporal ...  
*How to Import Gridded Data in NetCDF Format into **ArcGIS***
- How to Define and Visualize Time Dimension in ArcGIS**  
Most satellite data, including those served by NASA GES DISC, are time-stamped, meaning each data value is explicitly associated with ...  
*dimension in Gridded data describing how to define time, enable, and visualize temporal grid data in **ArcGIS***
- How to Import Satellite Swath Data in NetCDF Format into ArcGIS**  
Satellite observation and climate model data become more and more widely used in GIS. **ArcGIS** is one of the dominant software ...  
*.2012.07.10.043.L2.RetStd.v6.0.7.0.G13037113109.hdf.nc 2) Import data into **ArcGIS***
- How to Import HDF5-formatted IMERG GPM Precipitation Data into ArcGIS**  
Integrated Multi-satellite Retrievals for Global Precipitation Measure (IMERG) data products provide global high spatial and temporal ...  
*Adding the data into **ArcGIS**: Start **ArcGIS** Application, ArcMap*
- How to Correctly Import GRIB Data into ArcGIS**  
**ArcGIS** supports direct import of GRIB data files. However, the data imported is not geometrically correct, with a shift of ...  
*How to Import HDF5-formatted IMERG GPM Precipitation Data into **ArcGIS***
- How to Define Vertical Dimension in ArcMap**  
Some satellite data, including data served by the NASA Goddard Earth Sciences Data and Information Services Center (GES DISC), include a ...  
*How to Define and Visualize Time Dimension in **ArcGIS***
- How to Display and Remote Access Data in GDS with GrADS**  
GrADS is able to access data remotely through GrADS Data Server (GDS, formerly known as GrADS-DODS Server). Performance is much improved ...  
**ArcGIS**

**Step-by-  
Step  
Instruction**

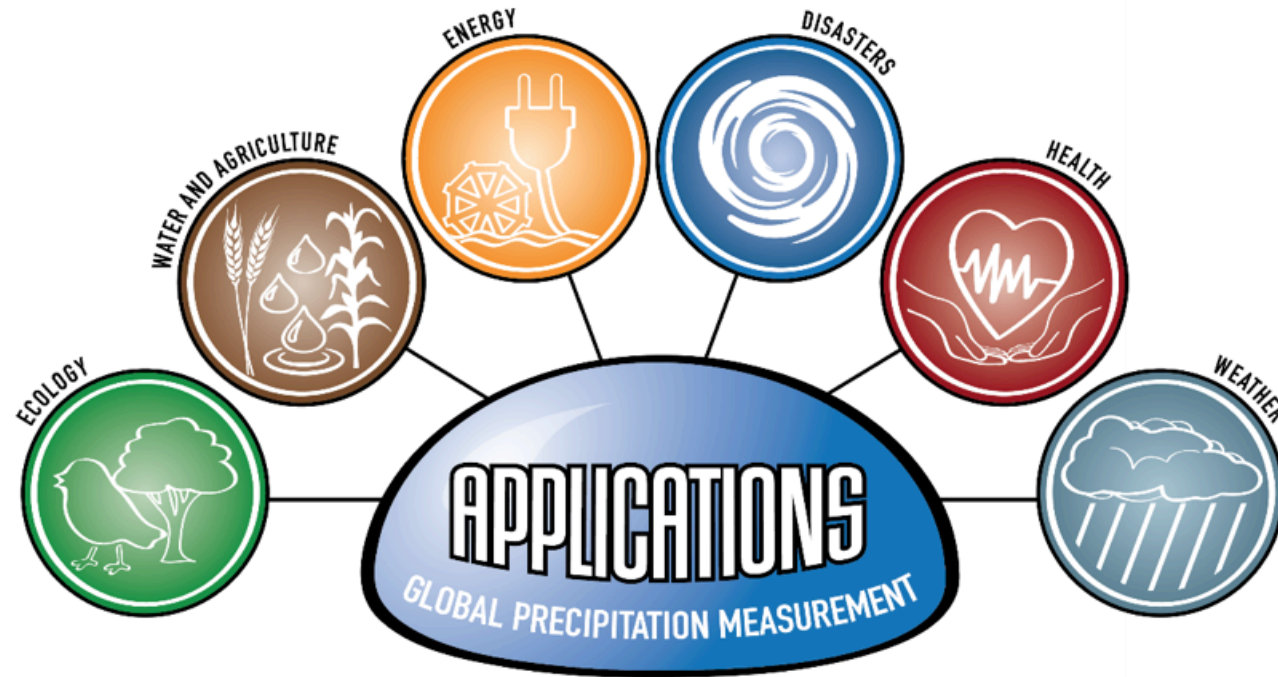
Click **“Feedback”**  
to tell us what you  
need!

# Setting up ArcGIS Image Service for long term data record

- Long term data analysis through image service
  - GES DISC data usually contain long time data records, e.g., 40 years of hourly data
  - A single mosaic is not feasible for long time series
  - Hierarchical mosaics: daily, monthly, yearly, multi-year
  - Services can be set up at different hierarchical levels

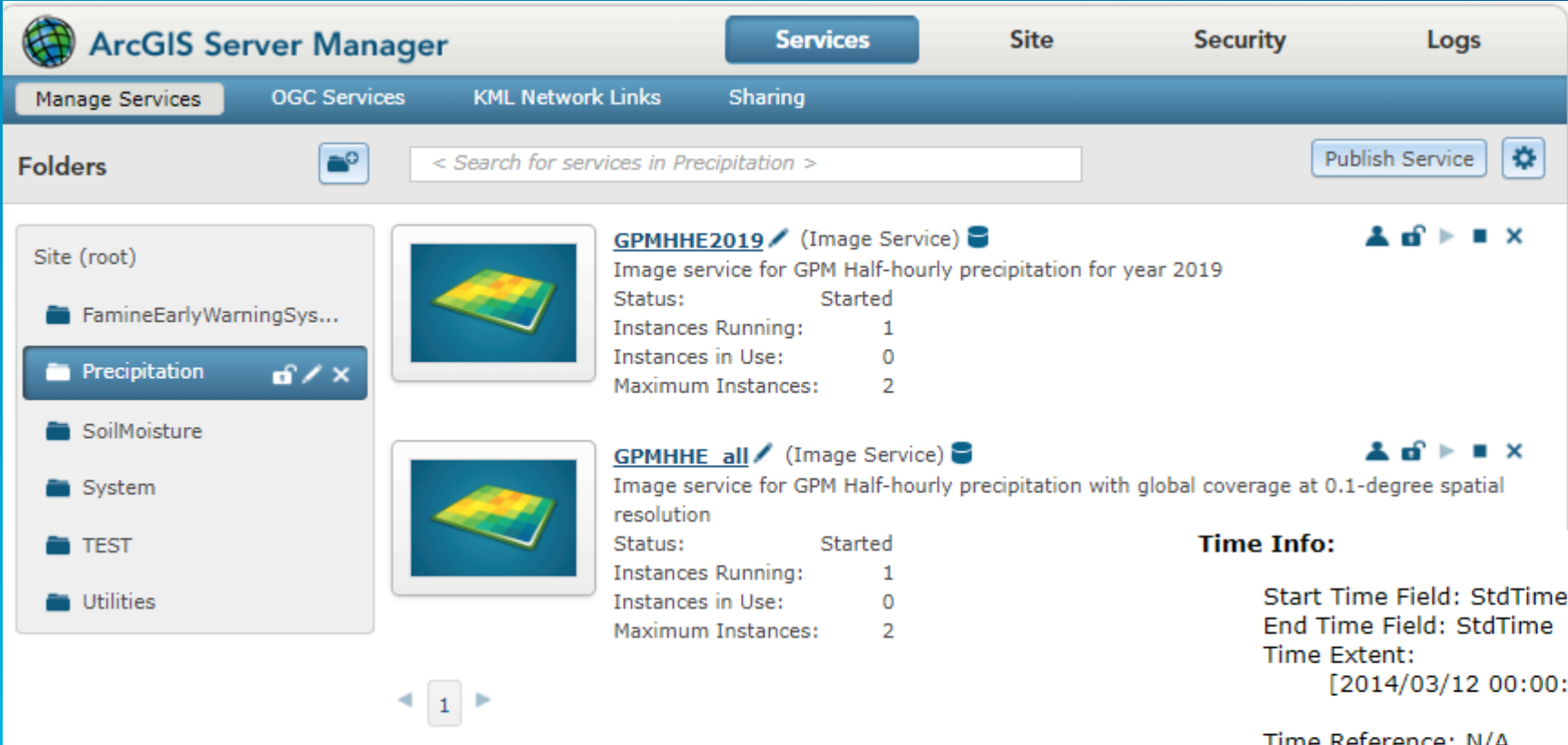
# TRMM/GPM Precipitation Missions

- GES DISC is the official TRMM/GPM data archive and distribution center
- Complex mission datasets: **178 Products** through data holdings (<https://disc.gsfc.nasa.gov/datasets?project=GPM>)



Source: Precipitation Measurement Missions (PMM), [pmm.nasa.gov](http://pmm.nasa.gov)

# Image Services for Precipitation Data



The screenshot shows the ArcGIS Server Manager interface. The top navigation bar includes 'Services', 'Site', 'Security', and 'Logs'. Below this, there are tabs for 'Manage Services', 'OGC Services', 'KML Network Links', and 'Sharing'. The 'Folders' pane on the left shows a tree structure with 'Site (root)' at the top, followed by 'FamineEarlyWarningSys...', 'Precipitation' (selected), 'SoilMoisture', 'System', 'TEST', and 'Utilities'. The main content area displays two image services under the 'Precipitation' folder. The first service is 'GPMHHE2019' (Image Service), described as 'Image service for GPM Half-hourly precipitation for year 2019'. Its status is 'Started', with 1 instance running, 0 instances in use, and a maximum of 2 instances. The second service is 'GPMHHE\_all' (Image Service), described as 'Image service for GPM Half-hourly precipitation with global coverage at 0.1-degree spatial resolution'. It also has a status of 'Started', with 1 instance running, 0 instances in use, and a maximum of 2 instances. To the right of the services, a 'Time Info' section provides details: 'Start Time Field: StdTime', 'End Time Field: StdTime', 'Time Extent: [2014/03/12 00:00:00 UTC, 2019/05/01 23:30:00 UTC]', and 'Time Reference: N/A'. Below the time info, the 'Pixel Size X' and 'Pixel Size Y' are both listed as 0.09999999660727316.

**Global Precipitation with 30-minute temporal and 10km spatial resolution from 2014 to present.**

**Time Info:**  
Start Time Field: StdTime  
End Time Field: StdTime  
Time Extent:  
[2014/03/12 00:00:00 UTC, 2019/05/01 23:30:00 UTC]  
Time Reference: N/A  
Pixel Size X: 0.09999999660727316  
Pixel Size Y: 0.09999999660727316

# Why Cyclone Idai is one of the Southern Hemisphere’s most devastating storms

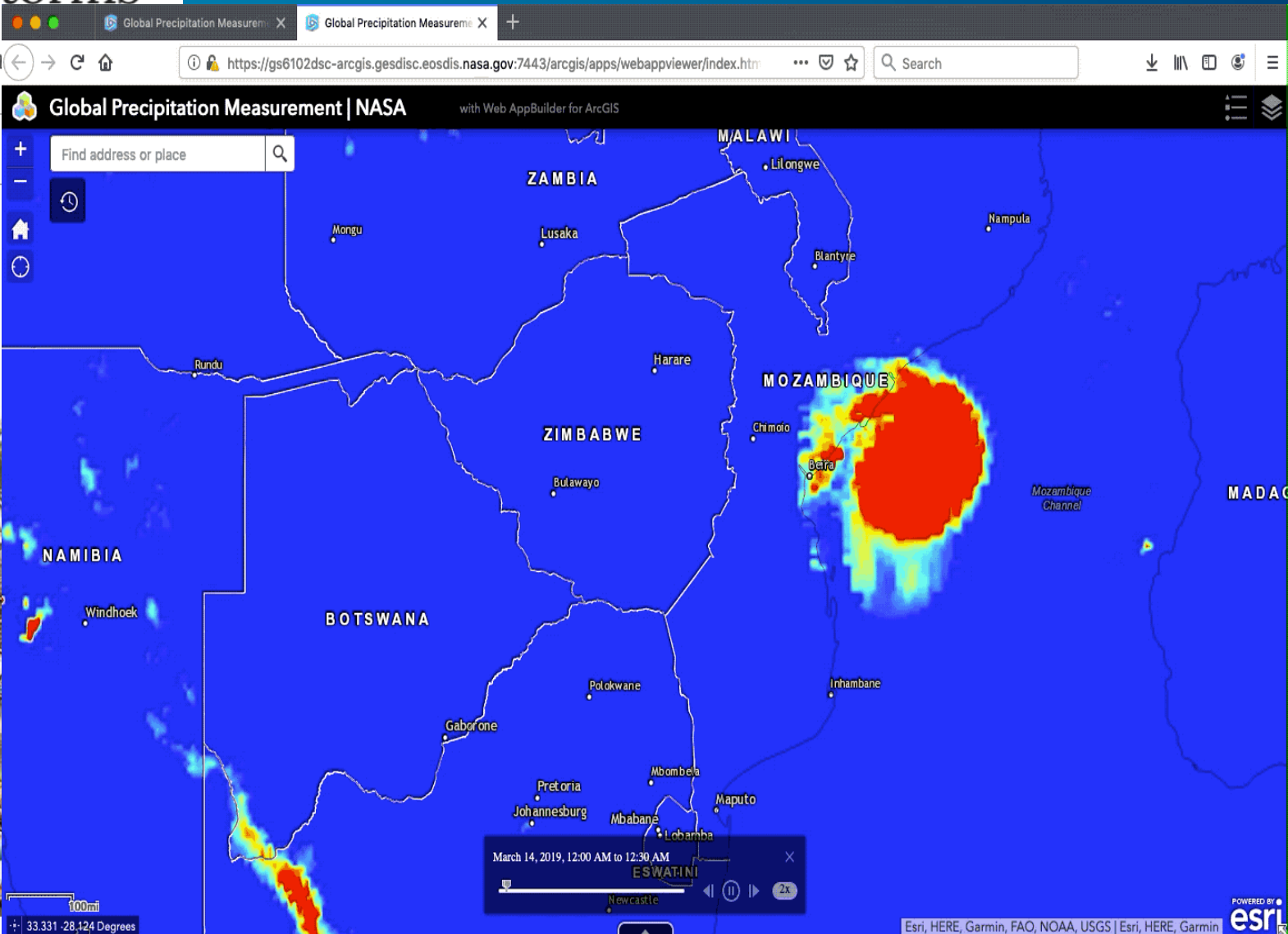
The catastrophic storm has affected nearly 2 million people in

Matthew Warren



Cyclone Idai has destroyed the city of Beira in Mozambique, where it made landfall. Credit: Denis Onyodi/IFRC via ZUMA Wire

# Use GPM Half-hourly Precipitation Rate Data to Track Cyclone Idai



# Potential Issues of Image Service for EO Data

- Separate statistics and fillvalues for different variables served in one image service
- Unit information be included in science variable
- Multi-level folders for easy grouping for variables from multiple sources (currently only one-level folder)

# Upcoming GIS Data Support

- Add data layers products based on users demand
- Experiment ArcGIS Feature Service (for non-gridded swath data)
- User community/theme/event portals
  - Perform hotspot mapping to identify hotspots of extreme events
  - Identify the Spatial and temporal shift
- Experiment ArcGIS Geoprocessing Service
  - Spatial auto correlation or clustering to identify climate regions and spatial dependency
  - Zonal statistics which can summarize data at specific administrative level
  - Time series analysis and rate of change of temperature

**Tell us know what you need!**

# Please help us to help you!

- Videos on **You Tube** subscribe “NASAGESDISC”
- Twitter  @NASA\_GESDISC, @NASA\_Giovanni
- How-To's

Download

Case Study

Visualization

- Feedback:
- Help Desk: [gsfc-help-disc@lists.nasa.gov](mailto:gsfc-help-disc@lists.nasa.gov)

*Feedback*

