

<https://svs.gsfc.nasa.gov/4493>

# Applications of Remote Sensing for Monitoring The Water Budget Within River Basins

Amita Mehta and Sean McCartney

13 March 2019



# Training Objectives

Become familiar with:

- Remote sensing and Earth system modeling data relevant for river basin management
- Estimation of surface water budgets and their temporal variability in sub-watersheds within river basins using data access tools and QGIS



# Training Outline

13 March 2019

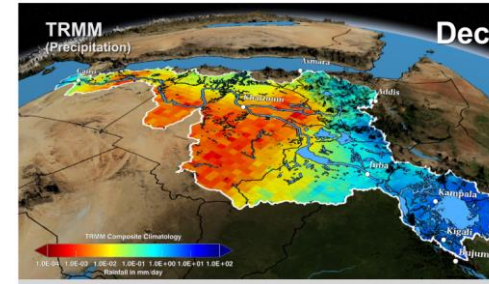
Overview of Remote Sensing Data  
For River Basin Monitoring



<http://wwf.hu/en/the-river-basin-management-plan>

20 March 2019

Applications of Remote Sensing for River  
Basin Monitoring: Nile Basin



<https://svs.gsfc.nasa.gov/4044>

27 March 2019

Applications of Remote Sensing for River  
Basin Monitoring: Mekong Basin



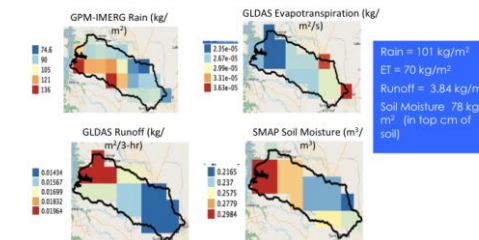
<https://earthobservatory.nasa.gov/images/91761/a-new-reservoir-in-cambodia>

3 April 2019

Surface Fresh Water Budget Estimation

Monitoring Water Resources Over Sao Francisco Verdeiro  
Watershed in Brazil - September 2017

<https://arset.gsfc.nasa.gov/water/workshops/brazil17>



<https://arset.gsfc.nasa.gov/water/workshops/brazil17>

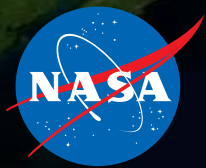


# Homework and Certificate

- Homework will be available after Sessions 2 and 4 from:  
<https://arset.gsfc.nasa.gov>
  - Answers must be submitted via Google Form
  - Due dates: 4 April (Homework 1) & 17 April (Homework 2)
- Certificate of Completion will be awarded to those:
  - Attend all webinars
  - Complete homework assignments
- You will receive certificates approximately two months after the completion of the course from: [marines.martins@ssaihq.com](mailto:marines.martins@ssaihq.com)

# Session-1 Outline

- About ARSET
- River basin monitoring and management: importance and approach
- Overview of remote sensing data sources relevant for river basin monitoring and management
  - River basin delineation
  - Surface water budget components
- Demonstration river basin delineation



# About ARSET



# NASA's Applied Remote Sensing Training Program (ARSET)

<http://arset.gsfc.nasa.gov/>

- Part of NASA's Applied Sciences Capacity Building Program
- Empowering the global community through remote sensing training
- Goal to increase the use of Earth science in decision-making through training for:
  - policy makers
  - environmental managers
  - other professionals in the public and private sector

Topics for trainings include:



# ARSET Trainings



100 trainings



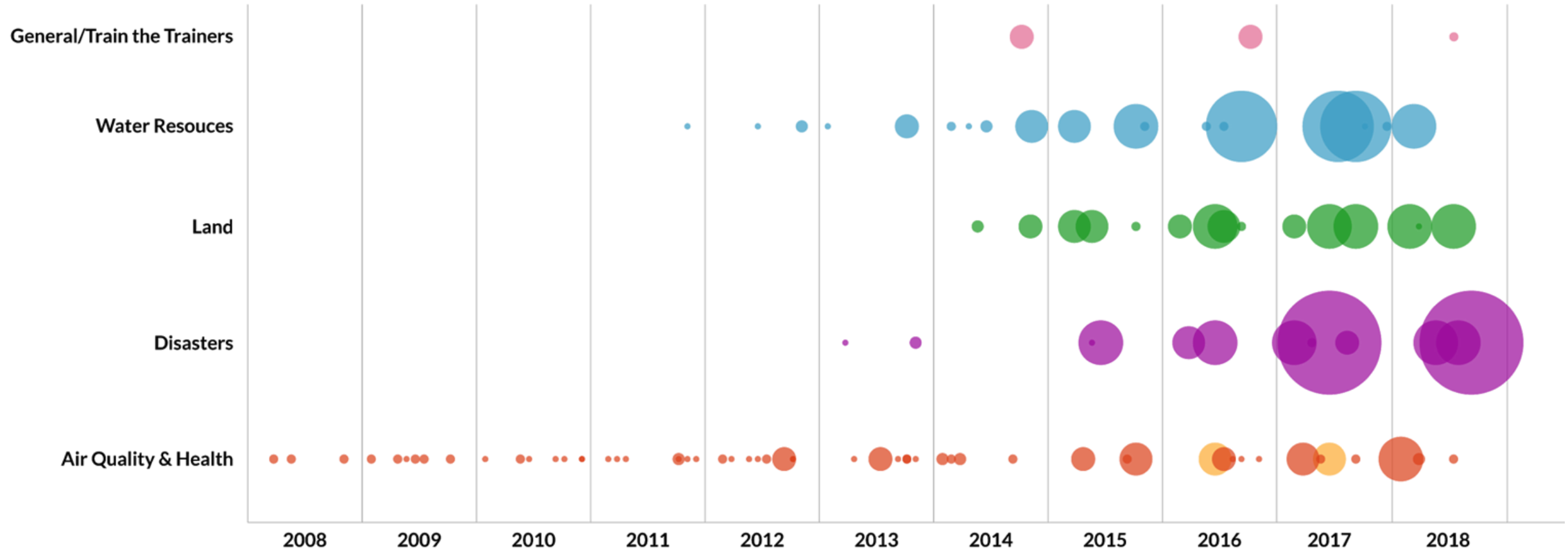
13,000+ participants



160+ countries



3,700+ organizations



\* Size of bubble corresponds to number of attendees





# ARSET Team Members

## Program Support

- Ana Prados, Program Manager (GSFC)
- Brock Blevins, Training Coordinator (GSFC)
- David Barbato, Spanish Translator (GSFC)
- Annelise Carleton-Hug, Program Evaluator (Consultant)
- Elizabeth Hook, Technical Writer/Editor (GSFC)
- Marines Martins, Project Support (GSFC)
- Selwyn Hudson-Odoi, Training Coordinator (GSFC)
- Stephanie Uz, Program Support (GSFC)

## Acknowledgement:

- We wish to thank Nancy Searby for her continued support

## Disasters & Water Resources

- Amita Mehta (GSFC)
- Erika Podest (JPL)
- Sean McCartney (GSFC)

## Land & Wildfires

- Cynthia Schmidt (ARC)
- Amber Jean McCullum (ARC)

## Health & Air Quality

- Pawan Gupta (MSFC)
- Melanie Cook (GSFC)



# ARSET Training Formats

## Online

Typically offered via the internet  
2-5 weeks long  
1-2 hours a week  
Available at all skill levels  
Live & recorded  
Materials available in English & Spanish  
Free

## In-Person

Hosted with a partner  
Typically in a computer lab  
2-7 days long  
Focus on locally-relevant case studies  
Certain topics can be presented in Spanish

## Train the Trainers

Online or in-person  
Designed for individuals and organizations looking to develop their own applied remote sensing trainings



# ARSET Training Levels

## Advanced (Level 2)

Requires level 1 training or equivalent knowledge

In-depth and highly focused topics

*Advanced Webinar: SAR Image and Data Processing*

## Basic (Level 1)

Requires level 0 training or equivalent knowledge

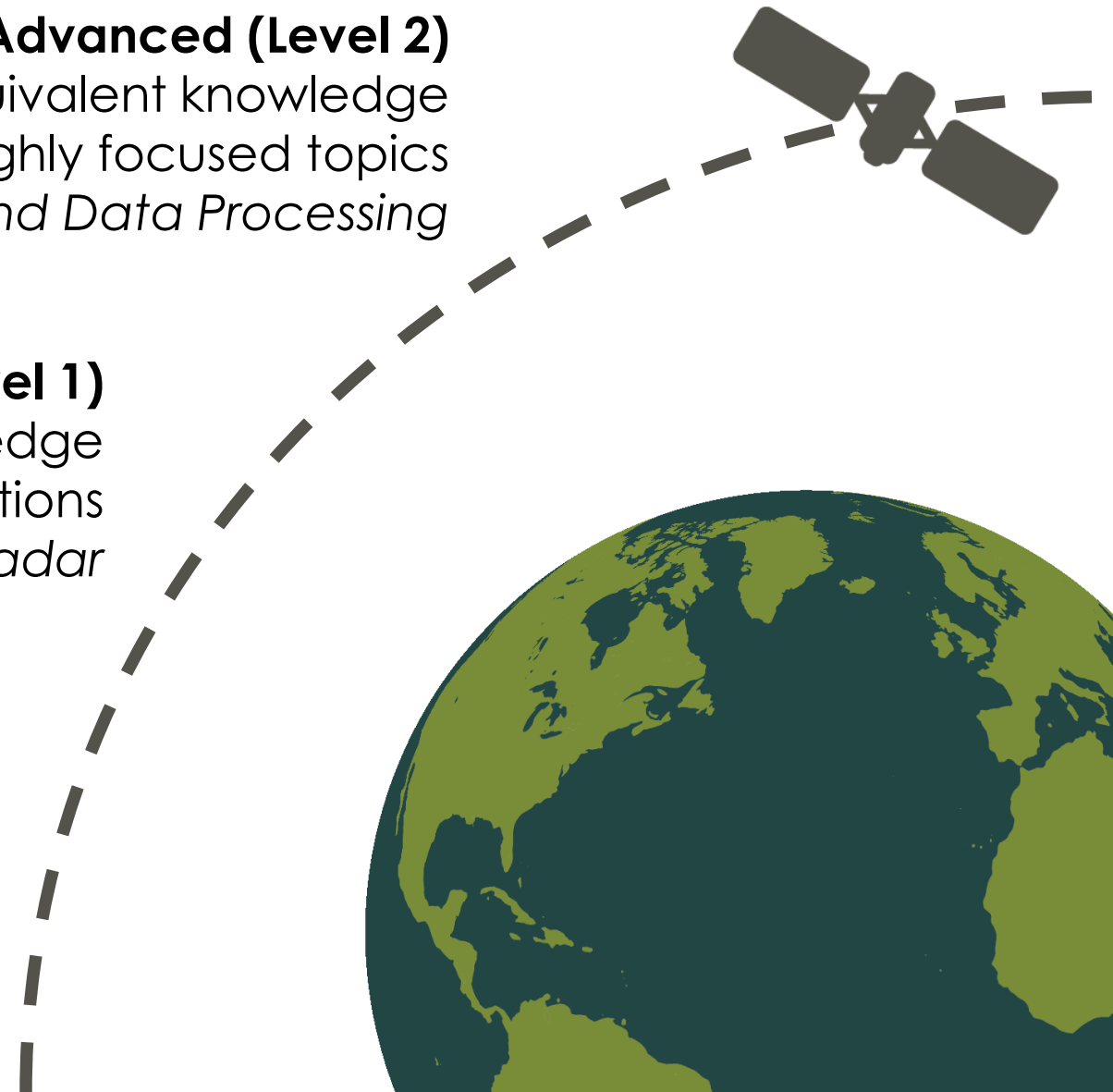
Covers specific applications

*Introduction to Synthetic Aperture Radar*

## Fundamentals (Level 0)

Assumes no prior knowledge of remote sensing

*Fundamentals of Remote Sensing*

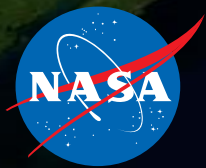


# Learn More About ARSET

<http://arset.gsfc.nasa.gov/>

The screenshot displays the ARSET website interface. At the top, the NASA logo and 'ARSET Applied Remote Sensing Training' are visible, along with navigation links for 'Earth Sciences Division', 'Applied Sciences', and 'ASP Water Resources'. A search bar and a Twitter icon are also present. A navigation menu includes 'Home', 'About', and 'Trainings'. The 'Trainings' menu is open, showing options for 'Fundamentals', 'Disasters', 'Health & Air Quality', 'Land', and 'Water Resources'. The 'Disasters' option is selected, leading to a featured training event: 'Introduction to Remote Sensing of Harmful Algal Blooms'. The event details include the dates 'Tuesdays, Sep 5-26, 2017' and times '11:00-12:00 or 21:00-22:00 EDT (UTC-4)', with a 'Register Now' button. The background of this section is a satellite image of a coastal area with greenish water. Below the event details are navigation arrows '<<' and '>>'. On the right side, a sidebar titled 'ARSET' contains links for 'Online Trainings', 'In-Person Trainings', 'Sign up for the Listserv' (highlighted with a red circle and a mouse cursor), 'Tools Covered', 'Suggest a Training', 'Personnel', and 'Resources'. Below the sidebar, there is a section for 'Upcoming Training' with a sub-section for 'Water' and a link for 'Satellite Observations of Water Quality for'.





# River Basin Monitoring and Management: Importance and Approach



# What is a River Basin?

- An area of land that drains water into a river and its tributaries
- A river basin usually has multiple drainage catchments or watersheds separated by ridges and hills called the drainage divide
- Each watershed in a river basin collects rain and/or snow water and drains to a common outlet such as a stream, tributary, lake, or wetland – eventually contributing water to the river
- A river basin consists of surface water and also underlying groundwater

<https://water.usgs.gov/edu/watershed.html>

## Colorado River Basin



<https://www.americanrivers.org/river/upper-basin-colorado-river/>



# Importance of River Basins

- River Basins:
  - connect rivers with surrounding land hydrology, ecology, and socio-economic components within basins
  - are dynamic spatially and temporally, and affect availability of freshwater in the river
- Rivers:
  - are a major source of freshwater for drinking and agricultural activities
  - support a variety of aquatic and terrestrial ecosystems
  - provide means of transportation and hydropower generation

[https://wwf.panda.org/our\\_work/water/rivers/irbm/](https://wwf.panda.org/our_work/water/rivers/irbm/)



# Importance of River Basins: The Major Source of Water

04



Source: United Nations Environment Programme (UNEP); World Conservation Monitoring Centre (WCMC); World Resources Institute (WRI); American Association for the Advancement of Science (AAAS); *Atlas of Population and Environment*, 2001.

<https://www.grida.no/resources/5782>

**World Atlas - the Rivers of the World**

**The major rivers of the world**

Click a river name here below and display its location with its mouth and the crossed states and its length:

Aldan	Essequibo	Kolyma	Okavango	Tapajos
Amazon	Euphrates	Krishna	Olenyok	Tarim
Amur	Fly	Kura	Olyokma	Tennessee
Anadyr	Fraser	Kuskokwim	Orange	Tiete
Angara	Gambia	Kwango	Orinoco	Tigris
Arkansas	Ganges	Leha	Ottawa	Tobol
Athabasca	Gila	Liao	Paraguay	Tocantins
Belaya	Godavari	Lland	Parana	Tunguska Stony
Beni	Grande do Brazil	Limpopo	Pechora	Ubangi Uele
Benue	Green	Loire	Pecos	Ural
Bermejo	Guapore	Lomami	Pilcomayo	Uruguay
Brahmaputra	Guaviane	Lower Tunguska	Purus	Vaal
Brazos	Helmand	Mackenzie	Putumayo	Vilyuy
Canadian	Huallaga	Madeira-Mamore	Red River Southern	Vistula
Cauca	Huang He	Madre de Dios	Rhine	Vitim
Chenab	Squazu	Magdalena	Rhone	Volga
Chindwin	Ili	Maranon	Rio Grande	Vyatka
Churchill	Indigirka	Mekong	Saint Lawrence	Vychegda
Colorado	Indus	Mississippi	Salado Northern	White
Colorado Texas	Irin	Missouri	Salween	Xi Jiang
Columbia	Irrawaddy	Murray	Sankuru	Xingu
Congo	Irtys	Narmada	Sao Francisco	Yalong
Danube	Ishim	Negra	Senegal	Yamuna
Daugava	James	Nelson-Saskatchewan	Sepik	Yangtze
Desna	Jialing	Nen	Shire	Yellowstone
Dnieper	Jurua	Niger	Snake	Yenisei
Dniester	Juruena	Nile	Songhua	Yukon
Don	Kama	Nile Blue	Sukhona	Zambezi
Donets	Kapuas	Ob	Sutlej	Zeya
Dvina Northern	Kasai	Ohio Allegheny	Syr Daria	
Eibe	Khaper	Oka	Tagus	

Conditions of Use    Privacy Notice    Contact    EurAtlas - 2001-2012

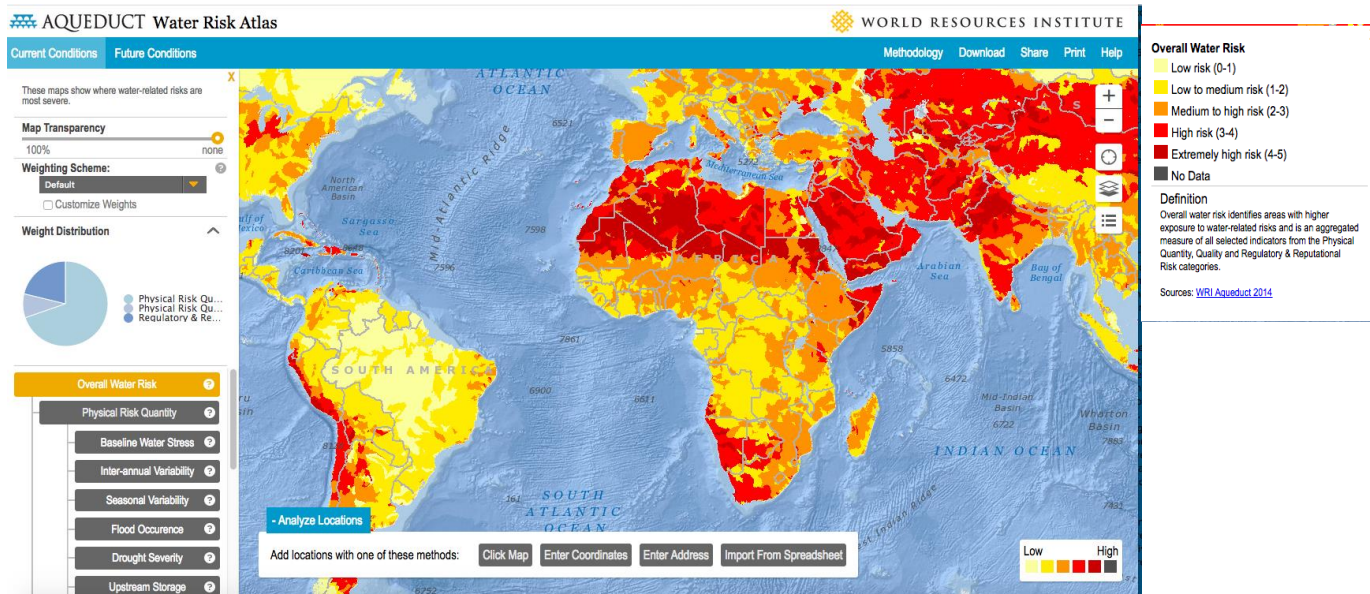
<https://www.euratlas.net/geography/world/rivers/index.html>





# Importance of River Basin Management

- Water stress, flood occurrence, and drought severity are increasing in many parts of the world



- For water allocation, distribution, and sharing among states/regions within a country or among various countries in the same river basin, river basin management is crucial

<http://www.wri.org/applications/maps/aqueduct-atlas/#x=8.00&y=0.40&s=ws!20!28!c&t=waterrisk&w=def&g=0&i=BWS-16!WSV-4!SV-2!HFO-4!DRO-4!STOR-8!GW-8!WRI-4!ECOS-2!MC-4!WCG-8!ECOV-2!&tr=ind-1!prj-1&l=3&b=terrain&m=group>

<http://www.unwater.org/water-facts/transboundary-waters/>



# Importance of River Basin Management: Transboundary Rivers

<http://www.unwater.org/water-facts/transboundary-waters/>

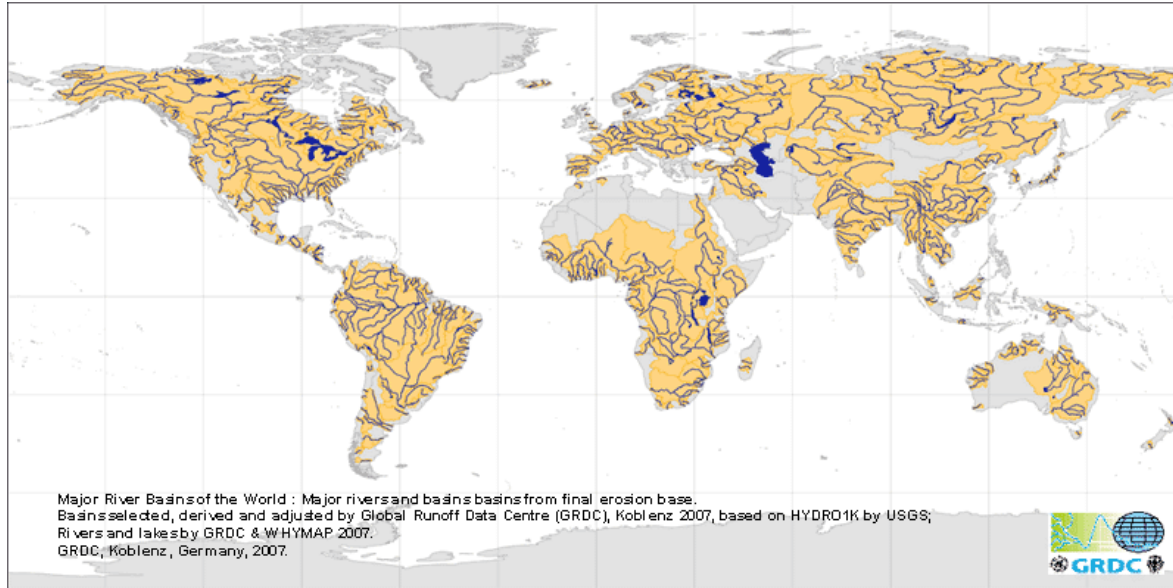
- There are 263 transboundary river basins covering about half the Earth's surface
- 145 states have territory within transboundary lake or river basins, and 30 countries lie entirely within them
- Since 1948, 37 incidents of acute conflict over water have occurred, and approximately 295 international water agreements have been negotiated and signed.



<http://www.unwater.org/app/upload/2018/10>



# Importance of River Basin Management



“River systems are the life blood of our planet, an integral part of the global climate system. As such they feed back to many geophysical processes on local, regional and global scales”

- River basin management involves policies and decisions at the river basin scale, which guide actions at sub-basin levels including:
  - Sustainable water supplies for all stakeholders (domestic, industrial, and agricultural)
  - Flood and drought management
  - Improved land and ecosystem management
  - Improved sanitation

[https://www.bafg.de/SharedDocs/Bilder/Bilder\\_GRDC/major\\_rivers\\_and\\_basins.gif?\\_\\_blob=poster](https://www.bafg.de/SharedDocs/Bilder/Bilder_GRDC/major_rivers_and_basins.gif?__blob=poster)

[https://wwf.panda.org/our\\_work/water/rivers/irbm/](https://wwf.panda.org/our_work/water/rivers/irbm/)



# River Basin Management

[http://www.unece.org/fileadmin/DAM/env/water/publications/WAT\\_Good\\_practices/2015\\_P\\_CCP\\_Flyer\\_Good\\_Practices\\_LIGHT.pdf](http://www.unece.org/fileadmin/DAM/env/water/publications/WAT_Good_practices/2015_P_CCP_Flyer_Good_Practices_LIGHT.pdf)

Some factors for good river basin management practices:

- Multi-level involvement of stakeholders

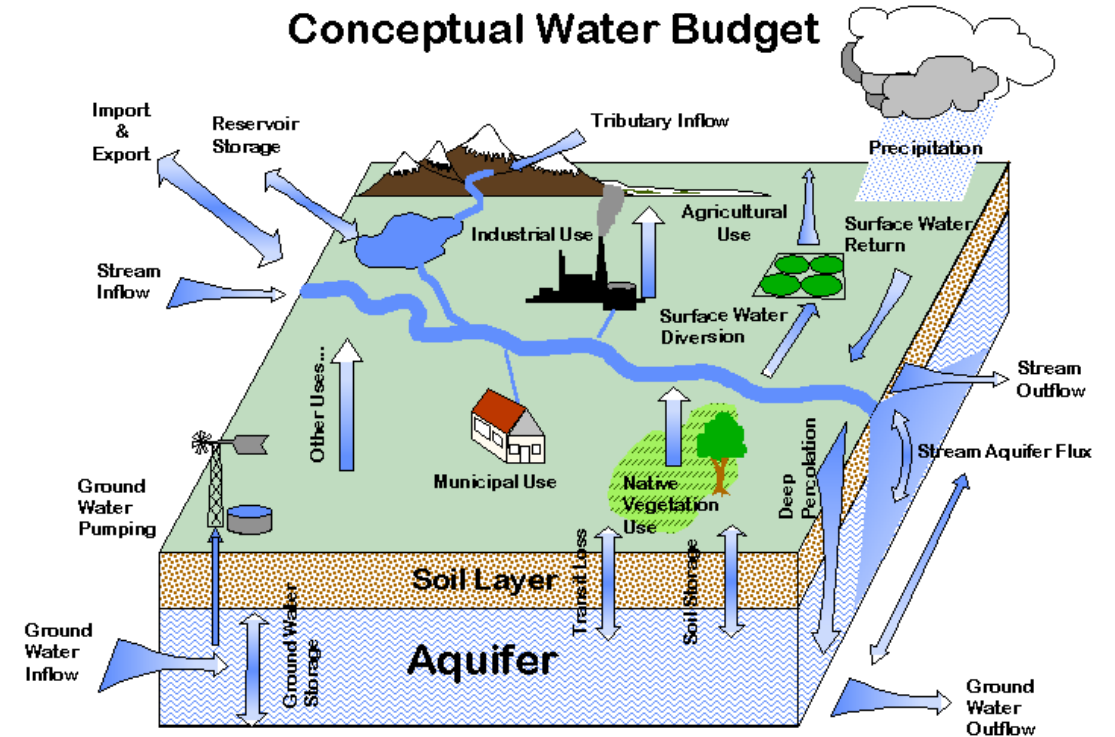
- **Data and information** - basin level organization is needed in order to implement Integrated Water Resource Management

- Human right to water is key in addressing access to drinking water
- Trust between stakeholders
- Capacity building of stakeholders



# River Basin Management

- River Basin Management primarily requires monitoring water availability and demand in the basin
- Water availability depends on basin hydrology and ecology, and is influenced significantly by weather and climate
- Monitoring water availability within a river basin is crucial for efficient and effective basin management\*



<https://www.water-research.net/index.php/the-hydrological-cycle-water-budgets>

\* Water quality monitoring also is an important part of river basin management. This webinar focuses on data relevant for monitoring water quantity



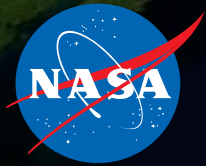
# River Basin Management

Also requires:

- Accurate identification and delineation of watersheds and stream channels within a basin based on terrain and slope
- Characteristics of the basin – soil and vegetation, lakes and reservoirs, aquifer/groundwater storage
- Information about water demand – residential, agricultural, and industrial – in the basin

This webinar will focus on the application of remote sensing-based data for access to river networks and assessing surface water budget components in river basins





## Overview of Remote Sensing Data Sources Relevant for River Basin Monitoring and Management

- River Basin Delineation
- Surface Water Budget Components

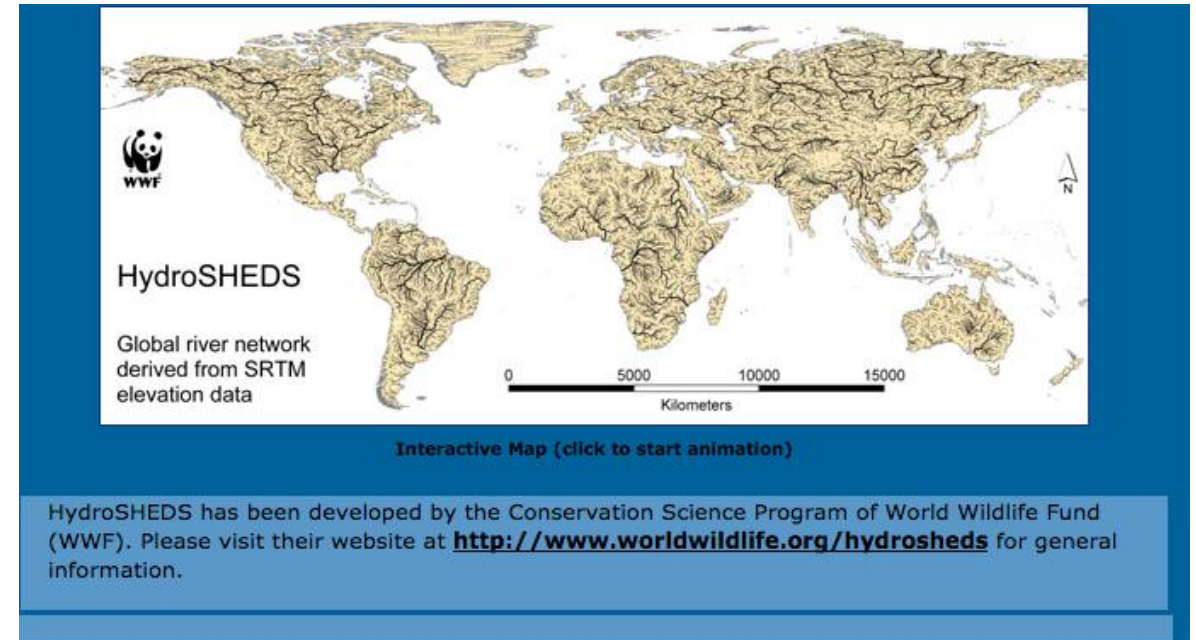


# River Basin Network Based on Remote Sensing

<https://www.hydrosheds.org/> <https://hydrosheds.cr.usgs.gov>

- **Hydrological** data and maps based on **SHuttle Elevation Derivatives** at multiple **Scales (HydroSHEDS)** provides data sets of stream networks, watershed boundaries, drainage directions, flow accumulations, distances, and river topology information
- HydroSHEDS uses digital elevation data from the Shuttle Radar Topography Mission (SRTM)\*, a C-band (5.6 cm) radar, carried on-board the Space Shuttle Endeavour

\*See Appendix slides for more information on SRTM





# River Basin Network Based on Remote Sensing

<https://hydrosheds.cr.usgs.gov/datasets.php>

- HydroSHEDS data set development: details, quality check, format, and download information
  - Data void filling
  - Stream identification and hydrologic conditions derived using GIS
  - Removing spurious features
  - Coastal zone “weeding” to reduce the impact of mangroves and vegetation on digital elevation data
  - Stream “burning” to enforce known river courses onto an elevation surface
  - Modeling valley courses to improve river delineation in low lying areas
  - Quality checking – more uncertainty in flat and vegetated areas



**USGS**  
science for a changing world

**HydroSHEDS**

Data Produced by:  


Home  
Overview  
Data Sources  
Data Set Development  
Quality Assessment  
Data Availability  
Data Formats  
Notes for Users  
References  
Disclaimer

Resources:  
DATA DOWNLOAD  
LEAFLET  
DOCUMENTATION

Acrobat® Reader is needed to view and print a PDF.

In Partnership with:

## Data set development

With all digital geospatial data sets, users must be aware of certain characteristics of the data, such as resolution, accuracy, method of production and any resulting artifacts, in order to better judge its suitability for a specific application. A characteristic of the data that renders it unsuitable for one application may have no relevance as a limiting factor for its use in a different application (NASA/JPL 2005).

This section provides an overview of the applied processing steps for the generation of HydroSHEDS and discusses some key technical specifications in order to allow the user to better estimate the suitability of the data set for a specific application. Additional data validation details are addressed in section 4. Please also refer to the flowchart of Appendix A in the **technical documentation**.

**3.1 Combination of unfinished SRTM-3 and finished DTED-1 data**  
**3.2 Void-filling**  
**3.3 Sink identification**  
**3.4 Hydrologic conditioning**  
**3.5 Manual corrections**  
**3.6 Upscaling**  
**3.7 Derived products**

**3.1 Combination of unfinished SRTM-3 and finished DTED-1 data**

**3.1.1 Combining SRTM-3 and DTED-1 original data**

For the generation of HydroSHEDS, the performance of the publicly available SRTM-3 and DTED-1 versions of SRTM at 3 arc-second resolution have been tested. Due to their specific characteristics, each data set showed both advantages and disadvantages for hydrological applications.



# River Basin Data Availability from HydroSHEDS

<https://hydrosheds.cr.usgs.gov/dataavail.php>

- Data are available for download with the following filename convention:  
**Extent\_DataType\_Resolution**

## Extent

Identifier	Continent
Af	Africa
As	Asia
Au	Australasia
Eu	Europe
Na	North America
Sa	South America

## Resolution

Identifier	in sec/min	in degree	in meters/km
3s	3 arc-second	0.000833333333333333	approx. 90 m at the equator
15s	15 arc-second	0.004166666666666667	approx. 500 m at the equator
30s	30 arc-second	0.008333333333333333	approx. 1 km at the equator
5m	5 minute	0.083333333333333333	approx. 10 km at the equator

## Data Type

Identifier	Type of data
DEM	Digital elevation model (void-filled)
CON	Hydrologically conditioned elevation
DIR	Drainage directions
ACC	Flow accumulation (number of cells)
RIV	River network (stream lines)
BAS	Drainage basins (watershed boundaries)

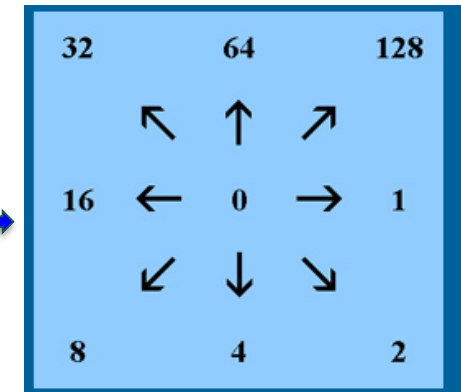


# River Basin Data Layers and Format from HydroSHEDS

<https://hydrosheds.cr.usgs.gov/data.php>

- Data are available in ESRI vector and raster\* format in WGS84

Layer Name	Format	Data	Resolution
DEM Void-filled Digital Elevation Model	Raster	Elevation in meters	3 arc-sec 15 arc-sec
CON Hydrologically Conditioned Elevation	Raster	Elevation in meters	3 arc-sec
DIR Drainage Direction	Raster	ESRI direction numbers	3 arc-sec 15 arc-sec
ACC Flow Accumulation	Raster	Number of upstream cells draining into each cell	15 arc-sec
RIV River Network	Vector	Unique identifier and maximum flow accumulation number of cells	15 arc-sec
BAS Drainage Basin	Vector	Unique identifier and surface area in km <sup>2</sup>	15 arc-sec



\*Raster data are also available in binary images in Band Interleaved by Line (BIL) format



# Monitoring Water Availability in River Basins

- Monitoring water availability in a basin – water flow in streams within the basin – requires information/observations/modeling of water budget components in the basin
- Water flow in a stream/river depends on the following components in the watershed contributing to the flow:
  - Precipitation
  - Evaporation and Transpiration
  - Infiltration
  - Surface water: soil moisture, reservoirs, and groundwater storage
  - Runoff



# Monitoring Water Availability in River Basins

- Water flow in a stream/river depends on the following components in the watershed contributing to the flow:
  - Precipitation
  - Surface Water: soil moisture, reservoirs, and groundwater storage
  - Evaporation and Transpiration
  - Infiltration: soil characteristics, soil moisture, terrain and slope
  - Runoff

Can be obtained from surface-based and remote sensing observations

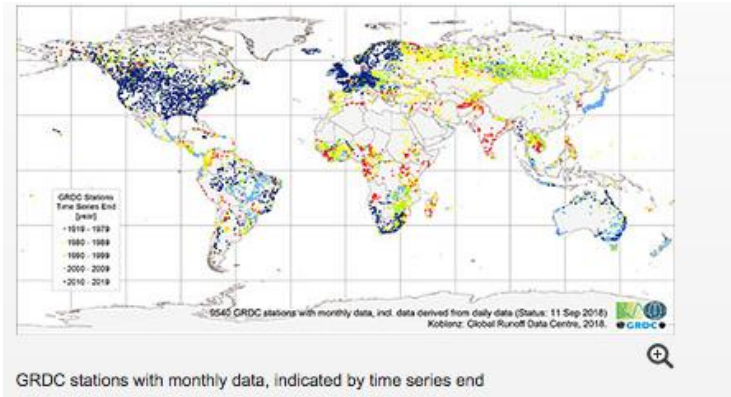
Can be calculated based on other observable geophysical parameters

Can be calculated based on a water balance equation



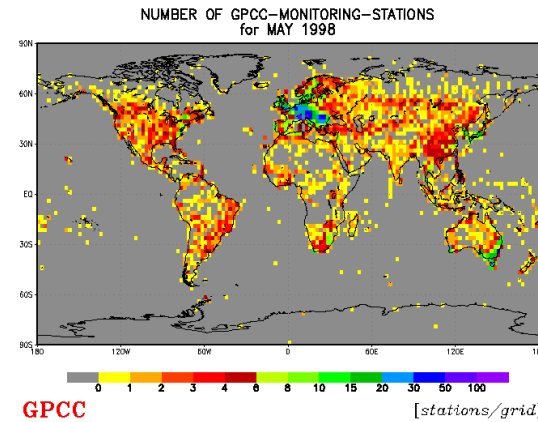
# Monitoring Water Budget Components: Surface-Based Observations

## River Discharge



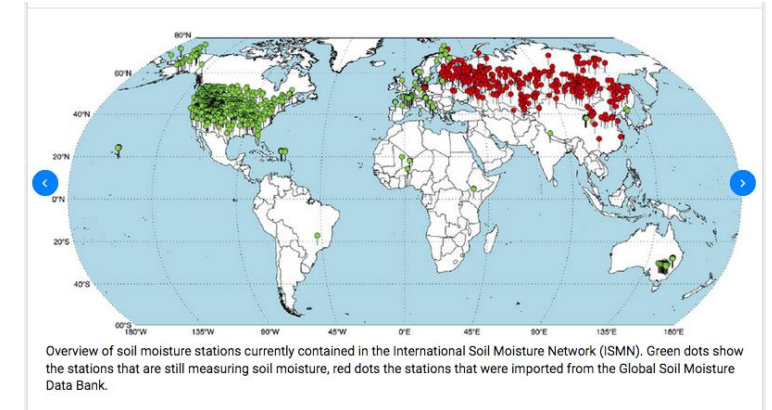
[https://www.bafg.de/GRDC/EN/02\\_srvcs/21\\_tmsrs/riverdischarge\\_node.html](https://www.bafg.de/GRDC/EN/02_srvcs/21_tmsrs/riverdischarge_node.html)

## Precipitation



GPCP  
Number of rain gauges per grid box. These boxes are 2x2 degrees. (Source: Global Precipitation Climatology Project)

## Soil Moisture



[https://www.geo.tuwien.ac.at/insitu/data\\_viewer/](https://www.geo.tuwien.ac.at/insitu/data_viewer/)

## Evapotranspiration

Eddy Covariance System




Lysimeters



Surface measurements are very important, **but** are point measurements, have non-uniform coverage, and data void regions



# Monitoring Water Budget Components: Remote Sensing-Based Observations

Water Budget Component	Satellites	Earth System Model
Rain	TRMM, GPM	GLDAS
Evapotranspiration	Landsat, Terra, Aqua	
Soil Moisture	SMAP	
Runoff		
*Groundwater	GRACE, GRACE-FO	
*Reservoir Height	Jason 1,2,3	

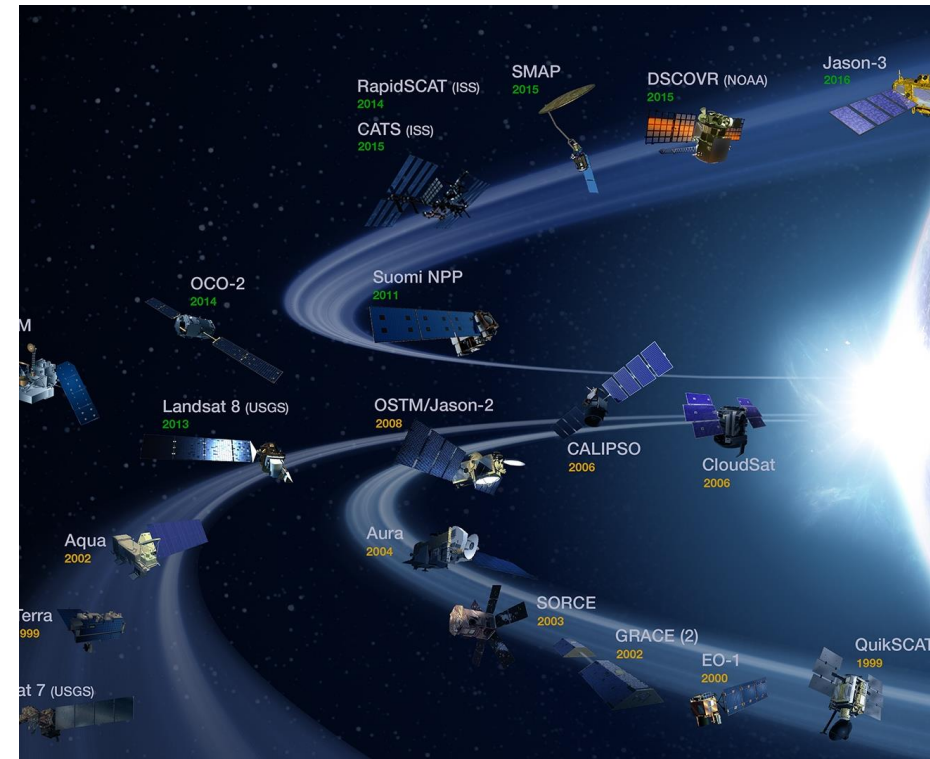
\* We will focus primarily on precipitation, evapotranspiration, soil moisture, and runoff. Groundwater and reservoir height data information is provided in the Appendix

**Acronyms are defined in subsequent slides**



# Current Satellite Missions for Water Budget Components

- Tropical Rainfall Measuring Mission (TRMM): 11/1997 - 04/2015
- Global Precipitation Measurement (GPM): 02/2014 - present
- Landsat 7: 04/1999 - present
- Landsat 8: 02/2013 - present
- Terra: 12/1999 - present
- Aqua: 05/2002 - present
- Soil Moisture Active Passive (SMAP): 01/2015 - present
- Gravity Recovery and Climate Experiment (GRACE): 03/2002 - 10/2017
- GRACE Follow-on (GRACE FO): 05/2018 - present
- Jason 2: 06/2008 - present
- Jason 3: 01/2016 - present





# Satellites and Sensors for Water Budget Components

Satellites	Sensors	Spectral Measurements	Water Budget Component
TRMM & GPM	Microwave Radiometer and RADAR TMI, PR GMI, DPR	TMI: 10-85 GHz GMI: 10-183 GHz PR and DPR (Ku and Ka)	Precipitation
Terra & Aqua	MODIS	Visible, Near IR, Middle IR	Snow Cover, Evapotranspiration
Landsat 7, 8	TM, ETM+, OLI	Visible, Near IR, Middle IR, Thermal IR	Evapotranspiration
SMAP	Microwave Radiometer	L-Band	Soil Moisture
GRACE & GRACE-FO	Microwave Radar	K-Band	Groundwater
Jason 2, 3	Altimeter	C-Band and Ku-Band	Reservoir Height

TMI : TRMM Microwave Imager  
 PR Precipitation Radar  
 GMI: GPM Microwave Imager  
 DPR: Dual-frequency Precipitation Radar

MODIS: MODERate Resolution Imaging Spectroradiometer  
 TM: Thematic Mapper  
 ETM+: Enhanced Thematic Mapper  
 OLI: Operational Land Imager

For details see **Session 2B** on <https://arset.gsfc.nasa.gov/webinars/fundamentals-remote-sensing>



# Precipitation From TRMM and GPM: Multi-Satellite Algorithms

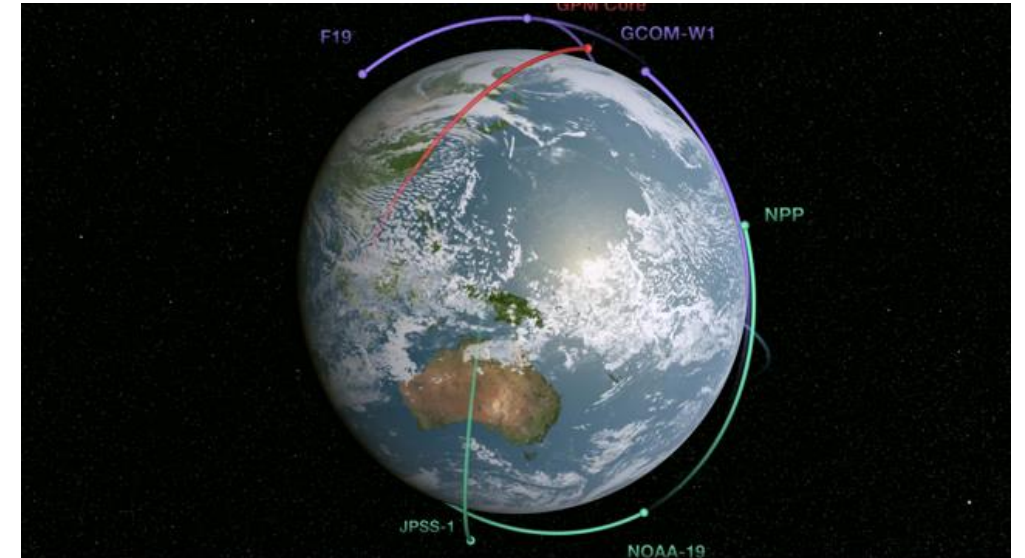
<http://pmm.nasa.gov/science/precipitation-algorithms>

- TRMM & GPM core satellites are used to calibrate microwave observations from a constellation of national and international satellites
- Allow improved spatial and temporal coverage of precipitation data
- TRMM Multi-satellite Precipitation Analysis (**TMPA**)
- TMPA will be extended to match Integrated Multi-satellitE Retrievals for GPM (**IMERG**)
- Widely used for applications



# Precipitation From Integrated Multi-satellite Retrievals for GPM (IMERG)

- Multiple runs accommodate different user requirements for latency and accuracy
  - “Early” – 5 hours (flash flooding)
  - “Late” – 12 hours (crop irrigation)
  - “Final” – 3 months (research data)
- Spatial resolution:  $0.1^\circ \times 0.1^\circ$ , from  $60^\circ\text{N}$  -  $60^\circ\text{S}$  (will be  $90^\circ\text{N}$  -  $90^\circ\text{S}$ )
- Temporal resolution: Native time intervals are **half-hourly** and monthly (final only)
  - Value-added products at 3 hours, 1, 3, and 7 days are available



# TMPA and IMERG

	TMPA	IMERG
Spatial Resolution	0.25° x 0.25°	0.1° x 0.1°
Spatial Coverage	Global, 50°S - 50°N	Global, 60°S - 60°N (will be extended from pole to pole)
Temporal Resolution	3 hours	30 minutes
Temporal Coverage	12/1997 – present*	2/27/2014 – present <sup>+</sup>

\* After April 8, 2015, TRMM climatological calibration is being used to generate TMPA

<sup>+</sup> TMPA and IMERG combined data will be available in 2019 at IMERG data resolution

TMPA is widely used for hydrologic and flood modeling and IMERG will replace it in the near future



# Precipitation Data Access

<https://pmm.nasa.gov/data-access>

**Data Access**

- Extreme Weather News
- ▼ Data Downloads & Documentation
  - TRMM
  - GPM
  - Ground Validation
- Data Sources
- Data Recipes
- Data News
- Google Earth
- NASA Worldview
- Using the PPS FTP
- Training
- Data FAQ

**Connect With Us**

- Twitter
- Facebook
- Youtube

**Need Help?**

- View Frequently Asked Questions
- View the PMM Glossary

**How to Access TRMM & GPM Precipitation Data**

Precipitation data from the GPM and TRMM missions is made available free to the public in a variety of formats from several sources at [NASA](#) Goddard Space Flight Center. This section outlines the different types of data available, the levels of processing, the sources to download the data, and some helpful tips for utilizing precipitation data in your research.

- **GPM Data Downloads & Documentation**
- TRMM Data Downloads & Documentation
- Explanation of GPM & TRMM Data Sources
- Data Processing "Recipes"
- Precipitation Data in Google Earth
- Frequency Asked Questions (FAQ)

**GET DATA**  
GLOBAL PRECIPITATION MEASUREMENT  
New Users Start Here

**Use of the PPS FTP and STORM requires you to first register your email address. Click here to register.**

- All about GPM data
  - Including updates, news, and FAQ
- Quick data access links and user registration
- For more information about GPM and data access visit: <https://pmm.nasa.gov/training>



# Precipitation Data Access and Analysis Using Giovanni

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

The screenshot shows the Giovanni web interface with several red callout boxes highlighting key features:

- Analysis and plot options:** A box pointing to the "Select Plot" section, which includes radio buttons for "Maps: Time Averaged Map", "Comparisons: Select...", "Vertical: Select...", "Time Series: Select...", and "Miscellaneous: Select...".
- Temporal and spatial search:** A box pointing to the "Select Date Range (UTC)" and "Select Region (Bounding Box or Shape)" sections. The date range is set to "00 : 00" to "23 : 59" with a "Valid Range: 1948-01-01 to 2018-04-16". The region selection is empty.
- Search data by keyword:** A box pointing to the search bar in the "Select Variables" section, which shows "Number of matching Variables: 0 of 1901" and "Total Variable(s) included in Plot: 0".
- Plot data:** A box pointing to the "Plot Data" button at the bottom right of the interface.

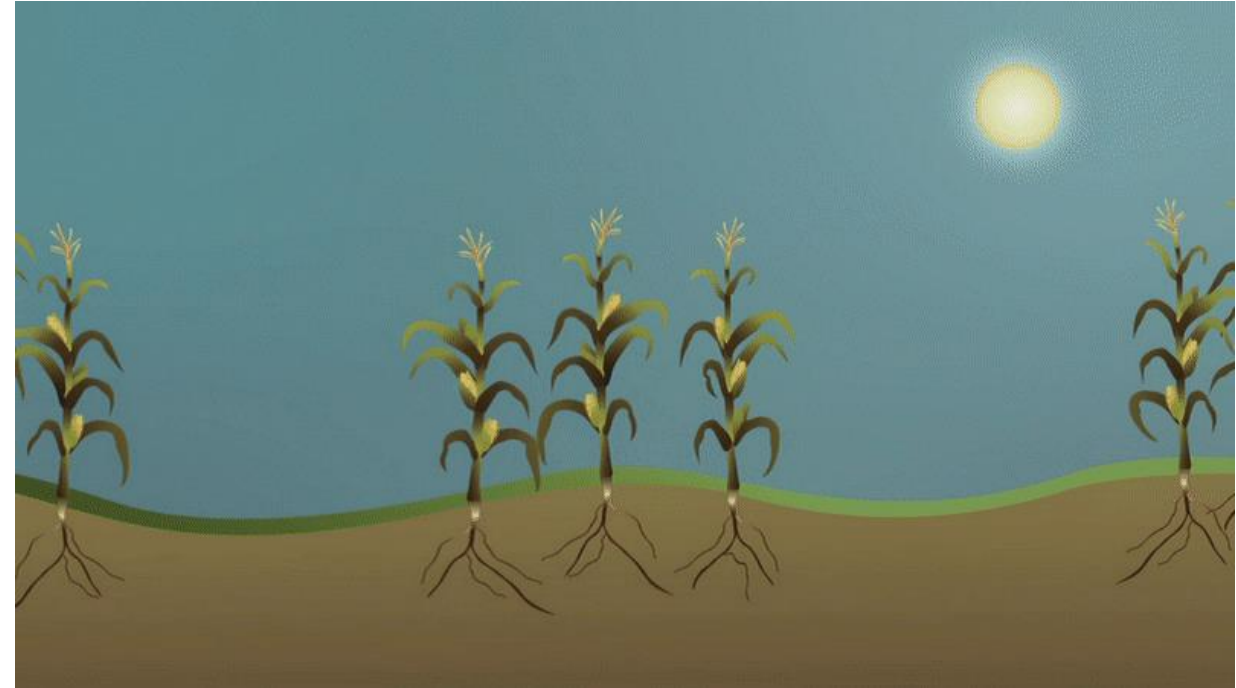
The "Select Variables" section is expanded to show a list of disciplines and measurements:

- Disciplines:**
  - Aerosols (187)
  - Atmospheric Chemistry (75)
  - Atmospheric Dynamics (418)
  - Cryosphere (13)
  - Hydrology (1115)
  - Ocean Biology (59)
  - Oceanography (61)
  - Water and Energy Cycle (1199)
- Measurements:**
  - Aerosol Index (5)
  - Aerosol Optical Depth (87)
  - Air Pressure Anomaly (1)
  - Air Pressure (57)
  - Air Temperature Anomaly (2)
  - Air Temperature (101)
  - Albedo (25)



# Evapotranspiration (ET)

- The sum of evaporation from the land surface, plus transpiration from plants
- ET transfers water from the surface to the atmosphere in vapor form
- Energy is required for ET to take place (for changing liquid water into vapor)



# Challenges in Estimation of ET

- ET depends on many variables:
  - solar radiation at the surface
  - land and air temperatures
  - humidity
  - surface winds
  - soil conditions
  - vegetation cover and types
- Highly variable in space and time

There are multiple ET products based on the MODIS vegetation index, thermal infrared bands from MODIS, Landsat-8, and global geostationary satellites

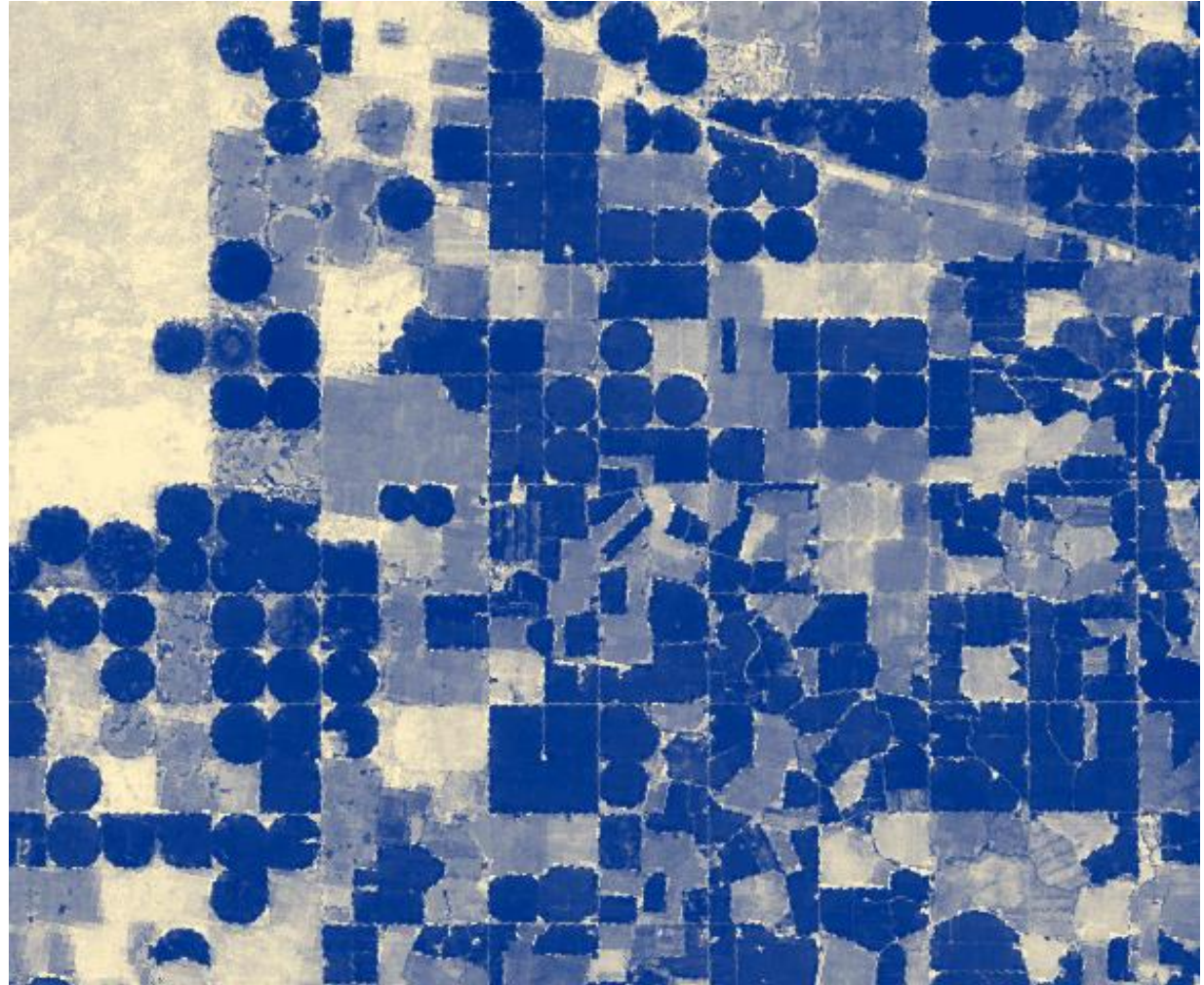


Image Credit: NASA Earth Observatory, Robert Simmon, based on data from the Idaho Department of Water Resources





# ET From MODIS

<https://lpdaac.usgs.gov/node/1191>

## MOD16A2: MODIS/Terra Net Evapotranspiration 8-Day L4 Global 500 m SIN Grid V006

### Description

The MOD16A2 Version 6 Evapotranspiration/Latent Heat Flux product is an 8-day composite product produced at 500 meter pixel resolution. The algorithm used for the MOD16 data product collection is based on the logic of the Penman-Monteith equation, which includes inputs of daily meteorological reanalysis data along with MODIS remotely sensed data products such as vegetation property dynamics, albedo, and land cover.

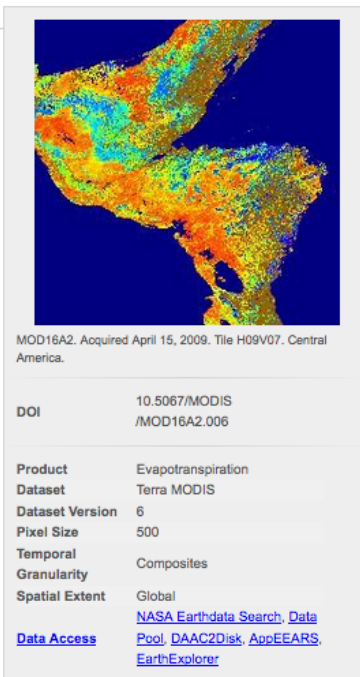
Provided in the MOD16A2 product are layers for composited Evapotranspiration (ET), Latent Heat Flux (LE), Potential ET (PET) and Potential LE (PLE) along with a quality control layer. Two low resolution browse images are also available for each MOD16A2 granule, (1) ET and (2) LE.

The pixel values for the two Evapotranspiration layers (ET and PET) are the sum of all eight days within the composite period and the pixel values for the two Latent Heat layers (LE and PLE) are the average of all eight days within the composite period. Note that the last 8-day period of each year is a 5 or 6-day composite period, depending on the year.

Validation at [Stage 1](#) has been achieved for MODIS Evapotranspiration products.

### Improvements/Changes from Previous Versions

- Spatial resolution of Version 6 products increased to nominal 500 meters from nominal 1,000 meters in Version 5.
- Version 5 data products were previously distributed by the Numerical Terradynamic Simulation Group at the University of Montana. The Version 6 products are a continuation of this project.
- Operational Version 6 data products have had additional cloud/aerosol screening applied for the end of the year in which the previous full year of MODIS Leaf Area Index/FPAR ([MOD15A2H](#)) and Albedo ([MCD43A3](#)) data are available. See Section 3.2.1 of the [User Guide](#) for more information.



- Available from MODIS on Terra (MOD16A2) and Aqua (MYD16A2)
- Spatial resolution: 500 m
- Temporal resolution: 8 days
- Temporal coverage: 2010 - present

Reference: Running, S., Mu, Q., Zhao, M. (2017). MOD16A2 MODIS/Terra Net Evapotranspiration 8-Day L4 Global 500m SIN Grid V006 [Data set]. NASA EOSDIS Land Processes DAAC. doi: 10.5067/MODIS/MOD16A2.006



# MOD16A2 Data Access Using NASA Earthdata

<https://earthdata.nasa.gov>

Temporal and spatial search

Product name

Product name: MOD16A2 V006

Start: 2010-01-01 00:00:00 Stop: 2019-01-08 23:59:59

Rectangle: SW: 38.8125,-86.0625 NE: 41.0625,-83.8125

826 Granules

Download All 826 Granules

Granule ID	START	END
MOD16A2.A2018345.h11v05.006.2019003.155331.hdf	2018-12-11 00:00:00	2018-12-18 23:59:59
MOD16A2.A2018345.h11v04.006.2019003.155459.hdf	2018-12-11 00:00:00	2018-12-18 23:59:59
MOD16A2.A2018337.h11v05.006.2018353.164543.hdf	2018-12-03 00:00:00	2018-12-10 23:59:59
MOD16A2.A2018337.h11v04.006.2018353.164548.hdf	2018-12-03 00:00:00	2018-12-10 23:59:59
MOD16A2.A2018329.h11v05.006.2018344.222830.hdf	2018-11-25 00:00:00	2018-12-02 23:59:59

ET data granules

NASA Earthdata requires user registration



# ET From Landsat

<https://arset.gsfc.nasa.gov/sites/default/files/water/ET-SMAP/week4.pdf>

## Mapping and EvapoTranspiration at high-Resolution with Internalized Calibration (METRIC)

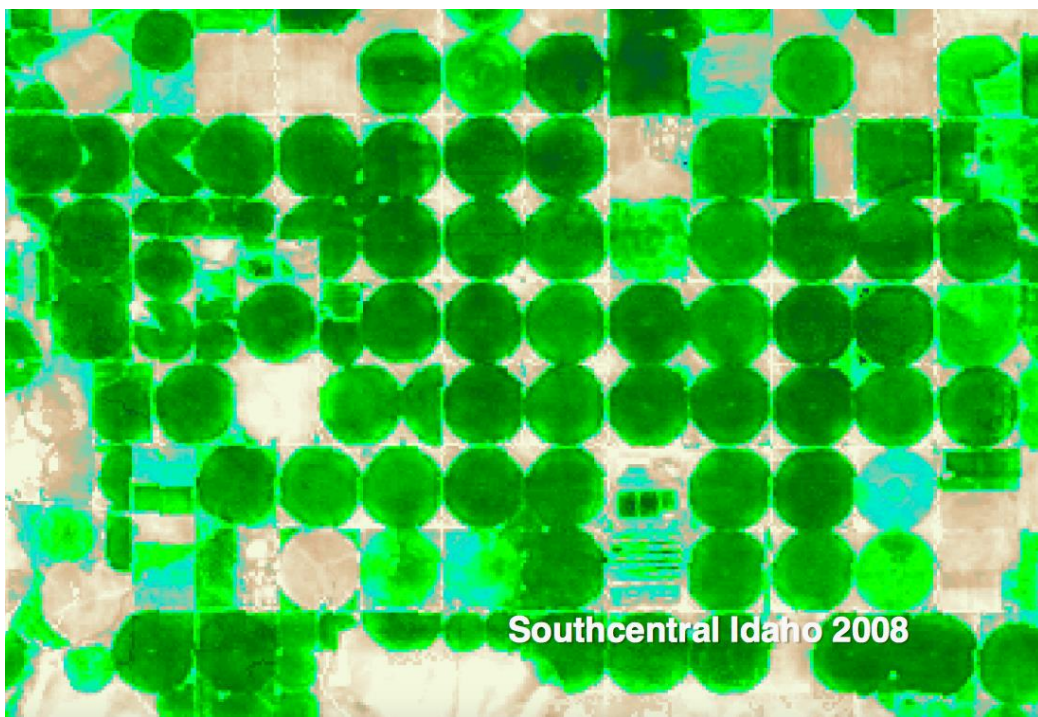


Image Credit: Richard Allen, University of Idaho

- Spatial resolution: 30 m
- Temporal resolution: 16 days
- Temporal coverage: 2011 - present

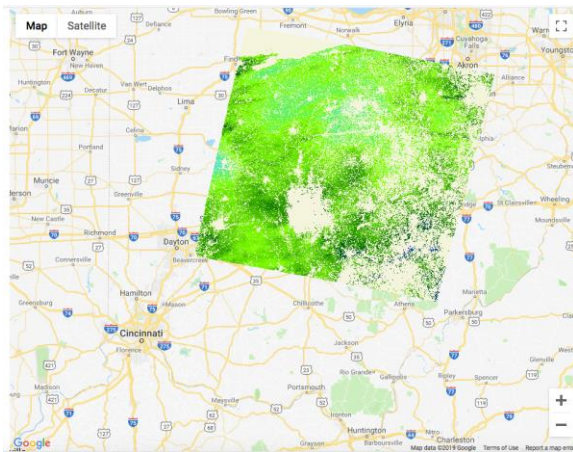
Allen R., T. Masahiro, R. Trezza, 2007: Satellite-Based Energy Balance for Mapping Evapotranspiration with Internalized Calibration (METRIC)—Model , Journal of irrigation and drainage Engineering, 133, 733-943. -- [https://doi.org/10.1061/\(ASCE\)0733-9437\(2007\)133:4\(380\)](https://doi.org/10.1061/(ASCE)0733-9437(2007)133:4(380))



# METRIC ET Data Access Using EEFlux

<https://eeflux-level1.appspot.com/>

## Google Earth Engine Evapotranspiration Flux (EEFlux)



SELECT YOUR LANDSAT IMAGE ▾

2018-10-16 / LE70190322018289EDC00 / Cloud 24% / Ti
2018-12-19 / LE70190322018353EDC00 / Cloud 61% / Ti
2019-01-04 / LE70190322019004EDC00 / Cloud 64% / Ti
2018-10-23 / LE70200322018296EDC00 / Cloud 3% / Tier
2018-11-01 / LE70190322018305EDC00 / Cloud 100% / T
2018-11-17 / LE70190322018321EDC00 / Cloud 87% / Ti
2018-12-03 / LE70190322018337EDC00 / Cloud 100% / T
2018-11-08 / LE70200322018312EDC00 / Cloud 83% / Ti
2018-10-24 / LC80190322018297LGN00 / Cloud 19% / Ti
2018-11-25 / LC80190322018329LGN00 / Cloud 53% / Ti
2018-12-11 / LC80190322018345LGN00 / Cloud 1% / Tier
2018-12-27 / LC80190322018361LGN00 / Cloud 100% / T
2018-11-09 / LC80190322018313LGN00 / Cloud 100% / T

**EEFlux**

This is version 0.10.4 of EEFlux. Automated calibration of ET<sub>F</sub> is still evolving. The last calibration update was Jun. 20, 2018. See the FAQ regarding the version numbers.

[Instructions](#) [FAQ](#)

Date Search

Please change the date range

2018-10-10 to 2019-01-08

Location Information

Please drag the marker on the map to select the Landsat location of interest. Latitude and Longitude values are in decimal degrees. Latitude and longitude -->

39.889061854439284

-83.10953445732594

[SEARCH FOR IMAGES](#)

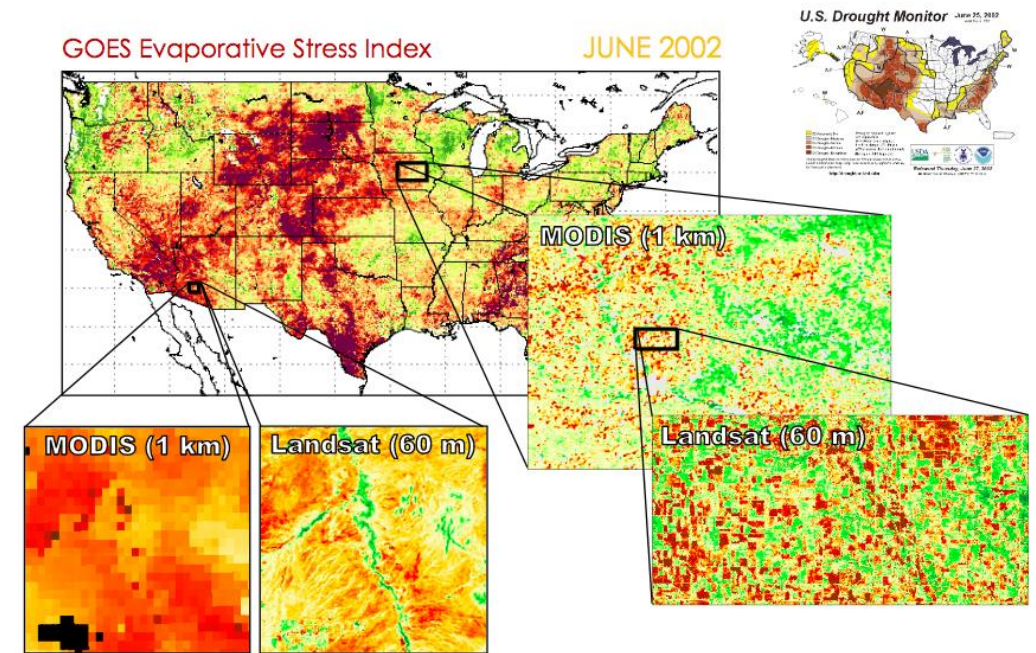


# Multi-satellite ET from The Atmosphere-Land EXchange Inverse (ALEXI)

<https://www.hydrol-earth-syst-sci.net/15/223/2011/hess-15-223-2011.pdf>

- ALEXI ET is derived by using an energy balance model
- Land Surface Temperature is obtained from global geostationary satellites; in addition, MODIS and Landsat are also used in a version of ALEXI
- For more details:

<https://arset.gsfc.nasa.gov/sites/default/files/water/ET-SMAP/week5-1.pdf>



Reference: Anderson et al., 2011, Hydrol. Earth Syst. Sci., 15, 223–239, 2011, doi:10.5194/hess-15-223-2011



# ALEXI Data Access

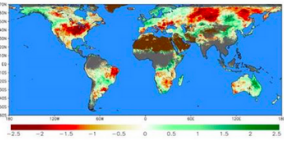
[http://catalogue.servirglobal.net/Product?product\\_id=198](http://catalogue.servirglobal.net/Product?product_id=198)

SERVIR GLOBAL | PRODUCT CATALOGUE DOWNLOAD FACTSHEET

## EVAPORATIVE STRESS INDEX

This new global geospatial dataset reveals regions of drought where vegetation is stressed due to lack of water, capturing early signals of drought without using observed rainfall data; this is critical in developing regions and other parts of the world lacking sufficient ground-based observations of rainfall.

Millions of people in the developing world depend on agriculture for their livelihoods. However, uncertainties in weather patterns and water availability pose a serious challenge to reliable crop production. Officials in charge of water resources need to know where vegetation is stressed due to lack of water so they can more accurately monitor and/or forecast drought, while providing farmers with actionable information related to mitigating the effects of water stress (e.g., irrigation) leading to more informed decisions impacting agriculture and food security.



**Application Purpose**

The new global dataset, called the Evaporative Stress Index (ESI), available online and produced weekly at 5-kilometer resolution for the entire globe, reveals regions of drought where vegetation is stressed due to lack of water, enabling agriculture ministries to provide farmers with actionable advice about irrigation. The ESI can capture early signals of "flash drought," a condition brought on by extended periods of hot, dry, and windy conditions leading to rapid soil moisture depletion. Reduced rates of water loss can be observed through the use of land surface temperature before it can be observed through decreases in vegetation health or "greenness." The ESI describes soil moisture across the landscape without using observed rainfall data. This is critical in developing regions and other parts of the world lacking sufficient ground-based observations of rainfall. The ESI is based on satellite observations of land surface temperature, which are used to estimate water loss due to

- Spatial resolution: 5 km
- Spatial coverage: Global
- Temporal resolution: 4-week and 12-week composites
- Temporal coverage: 2001 - present
- Visualization of data available in ArcGIS and Google Earth

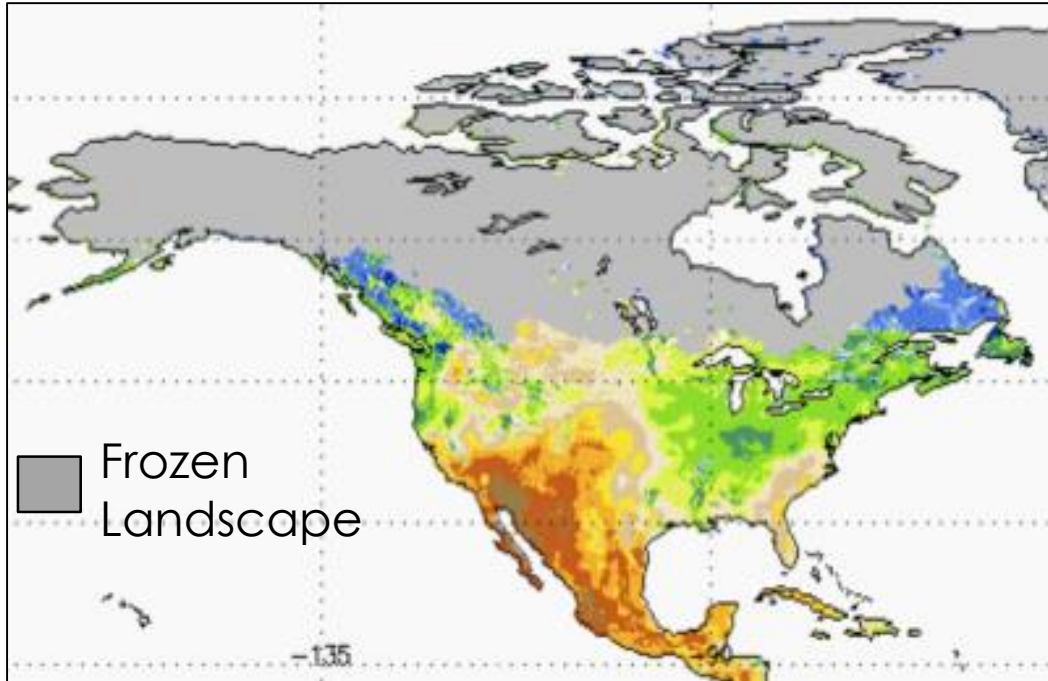
## Access Product

- To **analyze** Evaporative Stress Index (ESI) data, go to <http://ClimateSERV.servirglobal.net>, choose Get Started, draw a polygon or choose a feature on the map, and then select Evaporative Stress Index (ESI) as your Data Source.
- To **download** Evaporative Stress Index (ESI) data as tif files:  
<https://gis1.servirglobal.net/data/esi/>
- To **visualize** Evaporative Stress Index (ESI) data in a WMS, see ArcGIS REST Service:  
[https://gis1.servirglobal.net/arcgis/rest/services/Global/ESI\\_4WK/MapServer](https://gis1.servirglobal.net/arcgis/rest/services/Global/ESI_4WK/MapServer)  
[https://gis1.servirglobal.net/arcgis/rest/services/Global/ESI\\_12WK/MapServer](https://gis1.servirglobal.net/arcgis/rest/services/Global/ESI_12WK/MapServer)



# Soil Moisture From SMAP

<http://smap.jpl.nasa.gov/>



- Measures moisture in the top 5 cm of soil
- Soil moisture derived from L-band radiometer
- Radar, designed to work as Synthetic Aperture Radar (SAR), stopped operating after July 7, 2015
- Currently SAR data from Sentinel-1 (European Space Agency [ESA] satellite) are used together with the passive radiometer on board SMAP
- Spatial resolution: 36 km, 9 km
- Temporal resolution: 3 days
- Temporal coverage: March 2015 - present



# SMAP Data Access From NSIDC

<http://nsidc.org/data/search/#keywords=soil+moisture/>

The National Snow & Ice Data Center:

NSIDC National Snow & Ice Data Center

DATA RESEARCH NEWS ABOUT

SEARCH Web pages

Soil Moisture Active Passive Data (SMAP)  
NASA SMAP data at the NSIDC DAAC. [Read more...](#)

Scientific Data for Research

Glaciers Ice Sheets Ice Shelves Permafrost Sea Ice Soil Moisture Snow Search for more

Showing 1-25 of 236 Data Sets

Sort by: Relevance (highest to lowest) Per page: 25

**Parameter**

Filter Parameters

- Active Layer (20)
- Aerosols (2)
- Air Temperature (40)
- Albedo (4)
- Altitude (2)
- Antenna Temper... (1)
- Atmospheric Ch... (4)
- Atmospheric Pre... (18)
- Atmospheric Pro... (28)

**Spatial Coverage**

- Show Global Only (25)

**Temporal Duration**

- < 1 year (164)
- 1+ years (68)
- 5+ years (32)
- 10+ years (22)
- Not specified (4)

**Format**

- ASCII Text (128)
- Binary (25)
- Documents (13)
- ESRI Shapefile (3)
- GRIB (1)

**SMAP L3 Radar Global Daily 3 km EASE-Grid Soil Moisture**

Temporal Coverage: 2015-04-13 to 2015-07-07

Parameter: Sigma Nought | Soil Moisture

Data Format: HDF5

Summary: This Level-3 (L3) soil moisture product provides a composite of daily estimates of global land surface conditions retrieved by the Soil Moisture Active Passive (SMAP) radar as ...More Detail

**SMAP L2 Radar Half-Orbit 3 km EASE-Grid Soil Moisture**

Temporal Coverage: 2015-04-13 to 2015-07-07

Parameter: Sigma Nought | Soil Moisture

Data Format: HDF5

Summary: This Level-2 (L2) soil moisture product provides estimates of global land surface conditions retrieved by the Soil Moisture Active Passive (SMAP) active radar during 6:00 a.m. ...More Detail

**SMAP L3 Radiometer Global Daily 36 km EASE-Grid Soil Moisture**

Temporal Coverage: 2015-03-31 to continuous

Parameter: Brightness Temperature | Soil Moisture

Data Format: HDF5

Summary: This Level-3 (L3) soil moisture product provides a composite of daily estimates of global land surface conditions retrieved by the Soil Moisture Active Passive (SMAP) passive ...More Detail

**SMAP L2 Radiometer Half-Orbit 36 km EASE-Grid Soil Moisture**

Temporal Coverage: 2015-03-31 to continuous

Parameter: Brightness Temperature | Soil Moisture

Data Format: HDF5

Summary: This Level-2 (L2) soil moisture product provides estimates of global land surface conditions retrieved by the Soil Moisture Active Passive (SMAP) passive microwave radiome ...More Detail

**SMAP L4 9 km EASE-Grid Surface and Root Zone Soil Moisture Geophysical Data**

Level 2 to Level 4 data





# SMAP Data Access Using AppEEARS

<https://lpdaacsvc.cr.usgs.gov/appeears>

Application for **Extracting** and **Exploring** **Analysis** **Ready** **Samples** (**AppEEARS**) /

Extract Area Sample

Enter a name to identify your sample

Area Sample name

Upload a file or draw a polygon using the or icon

Drop a vector polygon file containing the area feature(s) to extract or click here to select the file.

Supported file formats:

- ESRI Shapefile (.zip including .shp, .shx, and .dbf files)
- GeoJSON (.json or .geojson)

Start Date: MM-DD-YYYY

End Date: MM-DD-YYYY

Is Date Recurring?

Select the layers to include in the sample

Search for a product

Selected file

To clear a polygon, draw a new polygon or

Select a dataset below to list the products that are currently available in AppEEARS.

Selected layers

Select the layers to include in the sample

Output Options

File Format: GeoTiff

Projection: Search for a projection

NOTE: Be aware that any reprojection of data from its source projection to a different projection will inherently change the data from its original format. All reprojections use GDAL's `gdalwarp` function in combination with the PROJ.4 `string` listed above. For additional information, see the AppEEARS help documentation.

Submit Cancel

Extract data by custom shapefile

Temporal selection

Data & layer selection

Data format

Submit data extraction request

Extract data within a box or polygon shapefile

- ARD
- Combined MODIS
- DAYMET
- eMODIS Smoothed NDVI
- Global WELD
- GPW
- S-NPP NASA VIIRS
- SMAP**
- SRTM
- SSEBop ET
- Terra MODIS
- WELD



# Global Land Data Assimilation System (GLDAS) for Water Budget Data

<http://ldas.gsfc.nasa.gov/gldas/>

A water and energy balance model with assimilation of remote sensing data

## Inputs:

- Rainfall: TRMM and multi-satellite based data
- Meteorological data: global reanalysis and observations-based data from Princeton University
- Vegetation mask, Land/Water mask, Leaf Area Index (LAI): MODIS (GLDAS-2)
- Clouds and Snow (for surface radiation): NOAA and DMSP satellites

## Integrated outputs include:

- Soil Moisture
- Evapotranspiration
- Surface/Sub-surface runoff
- Snow water equivalent

Reference: Rodell, M., P. R. Houser, U. Jambor, J. Gottschalck, K. Mitchell, C.-J. Meng, K. Arsenault, B. Cosgrove, J. Radakovich, M. Bosilovich, J. K. Entin, J. P. Walker, D. Lohmann, and D. Toll, 2004. The Global Land Data Assimilation System. *Bulletin of the American Meteorological Society*, 85(3):381–394.



# Water Budget Data Access From GLDAS Using Giovanni

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

**Giovanni User Support unavailable during government shutdown ...** [1 of 1 messages] [Read More](#)

**Select Plot**

Maps: Time Averaged Map
  Comparisons: Select...
  Vertical: Select...
  Time Series: Select...
  Miscellaneous: Select...

**Select Date Range (UTC)**      **Select Region (Bounding Box or Shape)**

YYYY-MM-DD      HH:mm      Format: West, South, East, North  
 -   :  to  -   :

Valid Range: 1948-01-01 to 2019-01-08

Please specify a start date.

**Select Variables**

**Disciplines**  
 Atmospheric Dynamics (1)  
 Hydrology (216)

Number of matching Variables: 217 of 1981      Total Variable(s) Included in Plot: 0

Please select at least 1 variable

Keyword:            

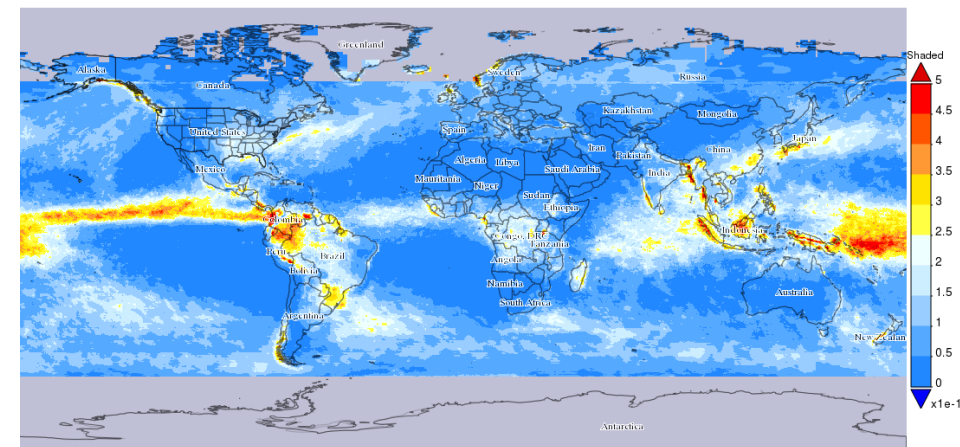
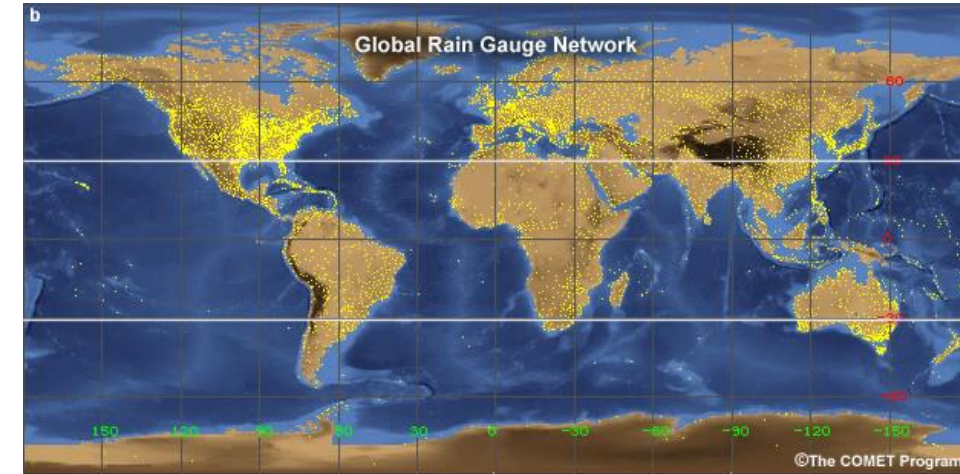
- Spatial resolution: 0.25° x 0.25°
- Temporal resolution: 3 hourly, monthly
- Temporal coverage: 2000 - present

<input type="checkbox"/>	<a href="#">Snow_melt</a> (GLDAS_NOAH025_3H.v2.1)	kg m-2	GLDAS Model	3-hourly	0.25 °	2000-01-01	2018-11-30
<input type="checkbox"/>	<a href="#">Soil_temperature (0 - 10 cm underground)</a> (GLDAS_NOAH025_3H.v2.1)	K	GLDAS Model	3-hourly	0.25 °	2000-01-01	2018-11-30
<input type="checkbox"/>	<a href="#">Soil_moisture_content (40 - 100 cm underground)</a> (GLDAS_NOAH025_3H.v2.1)	kg m-2	GLDAS Model	3-hourly	0.25 °	2000-01-01	2018-11-30
<input type="checkbox"/>	<a href="#">Downward_shortwave_radiation_flux</a> (GLDAS_NOAH025_3H.v2.1)	W m-2	GLDAS Model	3-hourly	0.25 °	2000-01-01	2018-11-30
<input type="checkbox"/>	<a href="#">Sensible_heat_net_flux</a> (GLDAS_NOAH025_3H.v2.1)	W m-2	GLDAS Model	3-hourly	0.25 °	2000-01-01	2018-11-30
<input type="checkbox"/>	<a href="#">Albedo</a> (GLDAS_NOAH025_3H.v2.1)	%	GLDAS Model	3-hourly	0.25 °	2000-01-01	2018-11-30
<input type="checkbox"/>	<a href="#">Soil_moisture_content (100 - 200 cm underground)</a> (GLDAS_NOAH025_3H.v2.1)	kg m-2	GLDAS Model	3-hourly	0.25 °	2000-01-01	2018-11-30
<input type="checkbox"/>	<a href="#">Baseflow-groundwater_runoff</a> (GLDAS_NOAH025_3H.v2.1)	kg m-2	GLDAS Model	3-hourly	0.25 °	2000-01-01	2018-11-30
<input type="checkbox"/>	<a href="#">Soil_temperature (10 - 40 cm underground)</a> (GLDAS_NOAH025_3H.v2.1)	K	GLDAS Model	3-hourly	0.25 °	2000-01-01	2018-11-30
<input checked="" type="checkbox"/>	<a href="#">Evapotranspiration</a> (GLDAS_NOAH025_3H.v2.1)	kg m-2 s-1	GLDAS Model	3-hourly	0.25 °	2000-01-01	2018-11-30
<input type="checkbox"/>	<a href="#">Storm_surface_runoff</a> (GLDAS_NOAH025_3H.v2.1)	kg m-2	GLDAS Model	3-hourly	0.25 °	2000-01-01	2018-11-30
<input type="checkbox"/>	<a href="#">Soil_moisture_content (0 - 10 cm underground)</a> (GLDAS_NOAH025_M.v2.0)	kg m-2	GLDAS Model	Monthly	0.25 °	1948-01-01	2010-12-31
<input type="checkbox"/>	<a href="#">Snow_depth_water_equivalent</a> (GLDAS_NOAH025_M.v2.0)	kg m-2	GLDAS Model	Monthly	0.25 °	1948-01-01	2010-12-31
<input type="checkbox"/>	<a href="#">Transpiration</a> (GLDAS_NOAH025_M.v2.0)	W m-2	GLDAS Model	Monthly	0.25 °	1948-01-01	2010-12-31
<input type="checkbox"/>	<a href="#">Snow_depth</a> (GLDAS_NOAH025_M.v2.0)	m	GLDAS Model	Monthly	0.25 °	1948-01-01	2010-12-31



# Advantages of Remote Sensing & Modeling Data

- Remote sensing-based data provide near-global to global coverage compared to surface-based, spatially non-uniform point measurements
- Provide data where surface-based measurements are unavailable
- Earth systems models integrate surface-based and remote sensing observations and provide uniformly gridded, frequent information of water budget components
- Earth system models provide parameters that aren't directly observed by satellites (e.g. runoff, ET)
- **Data are free and there are web-based tools to subset, download, analyze, and visualize data**
- **Data are available in near-real time for the last 10+ years**



Top: Global rain gauge locations. Credit: Introduction to Tropical Meteorology, The COMET Program

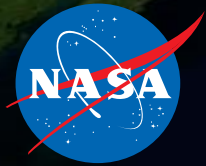
Bottom: Annual Precipitation (2015) from NASA GPM



# Challenges in Using Remote Sensing & Modeling Data

- All freshwater components are measured by different satellites and sensors with varying spatial and temporal resolutions, coverage, and quality
- Satellite and model data files are large and in different data formats, and available from different portals—training is required to learn how to access them
- While the data are generally validated with selected surface measurements, regional and local assessment is recommended
- Often additional processing is needed for specific applications





## Demonstration of Data Access

- HydroSHEDS



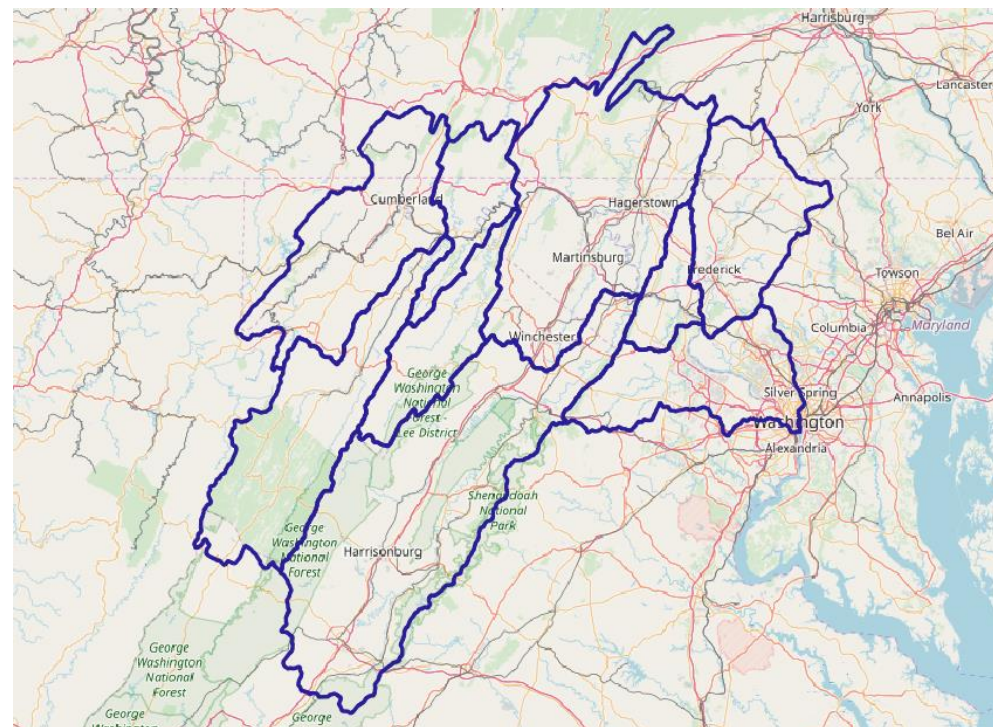
# River Basin Network from HydroSHEDS

<https://www.hydrosheds.org/> <https://hydrosheds.cr.usgs.gov>

## Parana River Basin



## Potomac River Basin

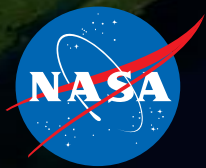




**Thank You**







# Appendix

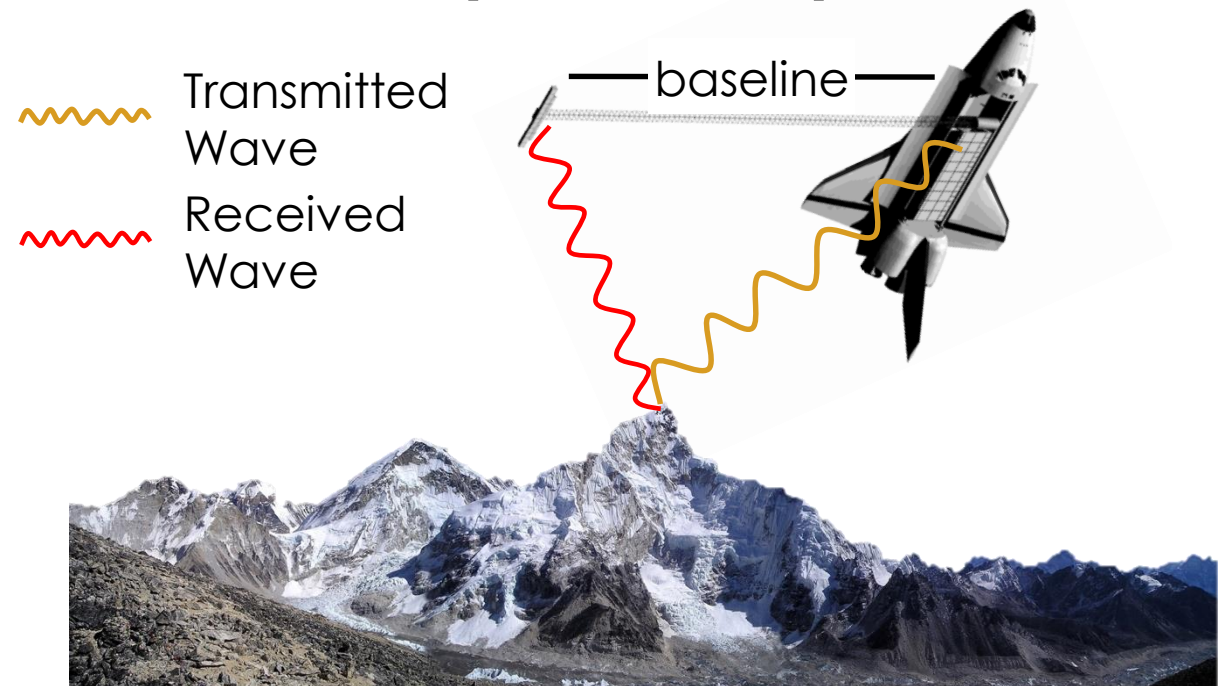


# Terrain Data from Shuttle Radar Topography Mission (SRTM)

<https://www2.jpl.nasa.gov/srtm/mission.htm>

- C-band (5.6 cm) SAR mission
- NASA Space Shuttle Endeavour
- Completed in February 2000
- 176 orbits around Earth in 11 days
- Generated digital elevation maps of all land between 60°N-56°S latitude
- ~80% of Earth's total land mass
- SRTM used interferometry to generate topographic (elevation) maps
- For detailed information see: [https://arset.gsfc.nasa.gov/sites/default/files/water/Brazil\\_2017/Day3/S6P2.pdf](https://arset.gsfc.nasa.gov/sites/default/files/water/Brazil_2017/Day3/S6P2.pdf)

**Radar signals being transmitted and received on the SRTM mission (not to scale)**



Spatial resolution: 30 m



# SRTM Elevation Data Access from Global Data Explorer (GDEx)

<http://gdex.cr.usgs.gov/>

The screenshot displays the Global Data Explorer (GDEx) interface. At the top, there are navigation menus for 'EARTHDATA', 'Data Discovery', 'DAACs', 'Community', and 'Science Disciplines'. The main header features the USGS logo and 'LP DAAC'. A toolbar contains various map navigation icons: zoom in (+), zoom out (-), pan (hand), bounding box (red dashed box), state/country selection (USA flag), lat/long input (XY), and refresh (circular arrow). A 'Download' icon (floppy disk) is also present. A callout box labeled 'Zoom' points to the zoom in icon. Another callout box labeled 'Define region of interest by bounding box, state, country, or lat/long' points to the bounding box, state/country, and lat/long icons. A third callout box labeled 'Refresh' points to the refresh icon. A fourth callout box labeled 'Download' points to the download icon. The main map area shows a topographic map of the United States and Mexico. On the right, the 'Map Layers' panel is visible, listing layers such as 'ASTER Global DEM', 'NASA Blue Marble', 'Data Coverage', 'ASTER Global DEM V2', 'NGA SRTM 1 arcsec', 'NGA SRTM 3 arcsec', 'NASA SRTM 1 arcsec', 'NASA SRTM 3 arcsec', 'World Boundaries', 'Country', and 'State/Province'. A legend and a locator map are also shown.

[Accessibility](#) [FOIA](#) [Privacy](#) [Policies and Notices](#)

U.S. Department of the Interior | U.S. Geological Survey  
URL: <https://gdex.cr.usgs.gov/gdex/>  
Page Contact Information: [LPDAAC@usgs.gov](mailto:LPDAAC@usgs.gov)  
Page Last Modified: 01/27/2017

[User Guide](#) | [GMU](#) | [CSISS](#) | [About GeoBrain](#) | [Contact](#)

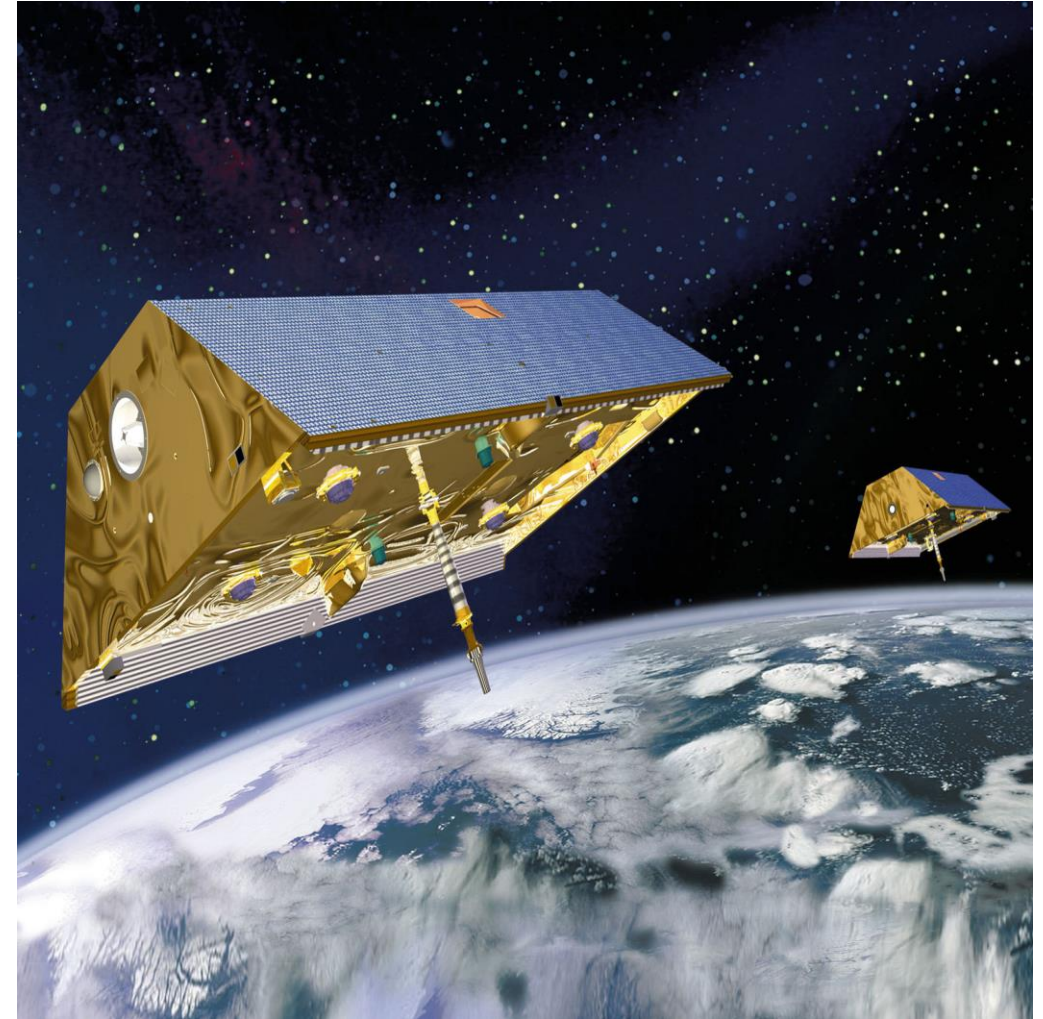


# GRACE and GRACE-FO

- Polar, sun-synchronous orbit
- Twin satellite system
- Spatial coverage and resolution:
  - Global
  - Resolution:  $1^\circ \times 1^\circ$
- Temporal Coverage and Resolution:
  - March 17, 2002 - present
  - 250 gravity profiles per day

**Note:** GRACE-FO currently is still in In-Orbit-Checkout (IOC) phase. Data will be available mid-2019

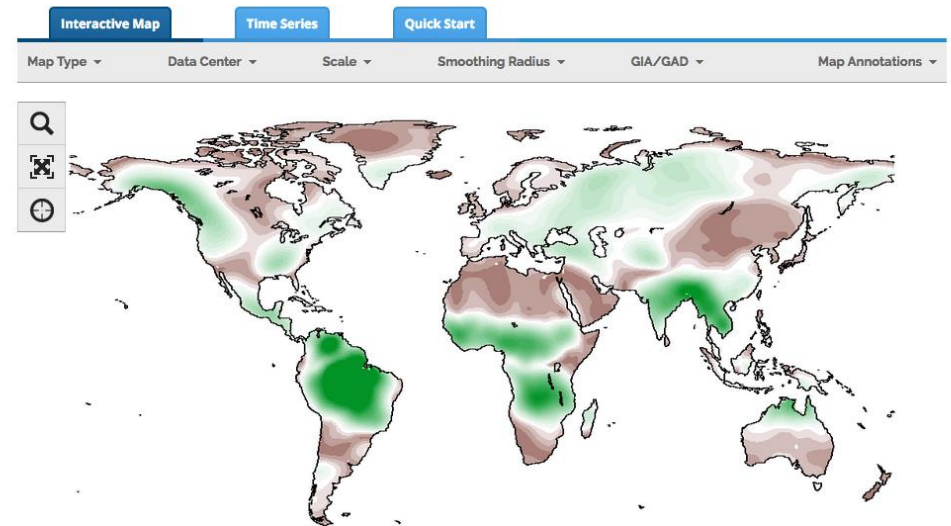
<http://www.jpl.nasa.gov/missions/details.php?id=5882>



# GRACE and GRACE-FO Data Access

- Level-0 to Level-2
  - <ftp://podaac.jpl.nasa.gov/allData/grace/>
  - <http://www.csr.utexas.edu/grace/>
  - <https://isdc.gfz-potsdam.de/grace-isdc/>
  - <https://isdc.gfz-potsdam.de/grace-fo-isdc/>
- Level 3
  - <http://grace.jpl.nasa.gov/data/>
  - <http://geoid.colorado.edu/grace/>
  - <https://podaac.jpl.nasa.gov/GRACE-FO>

\\ CU GRACE Data Portal



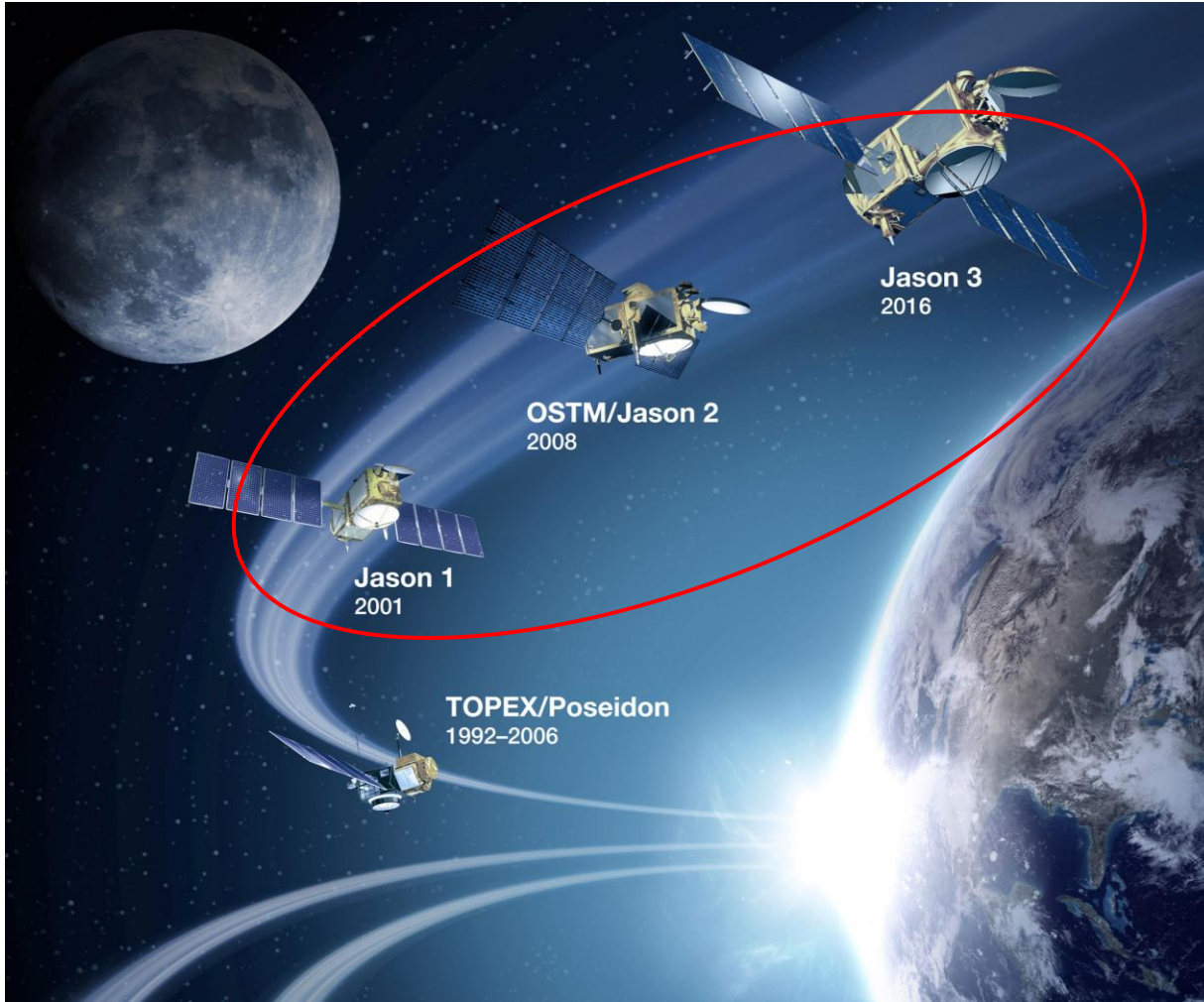
GRACE Interactive Data Analysis and Download Portal:

<http://geoid.colorado.edu/grace/>



# Jason 1, 2, and 3

<http://sealevel.jpl.nasa.gov/missions/>



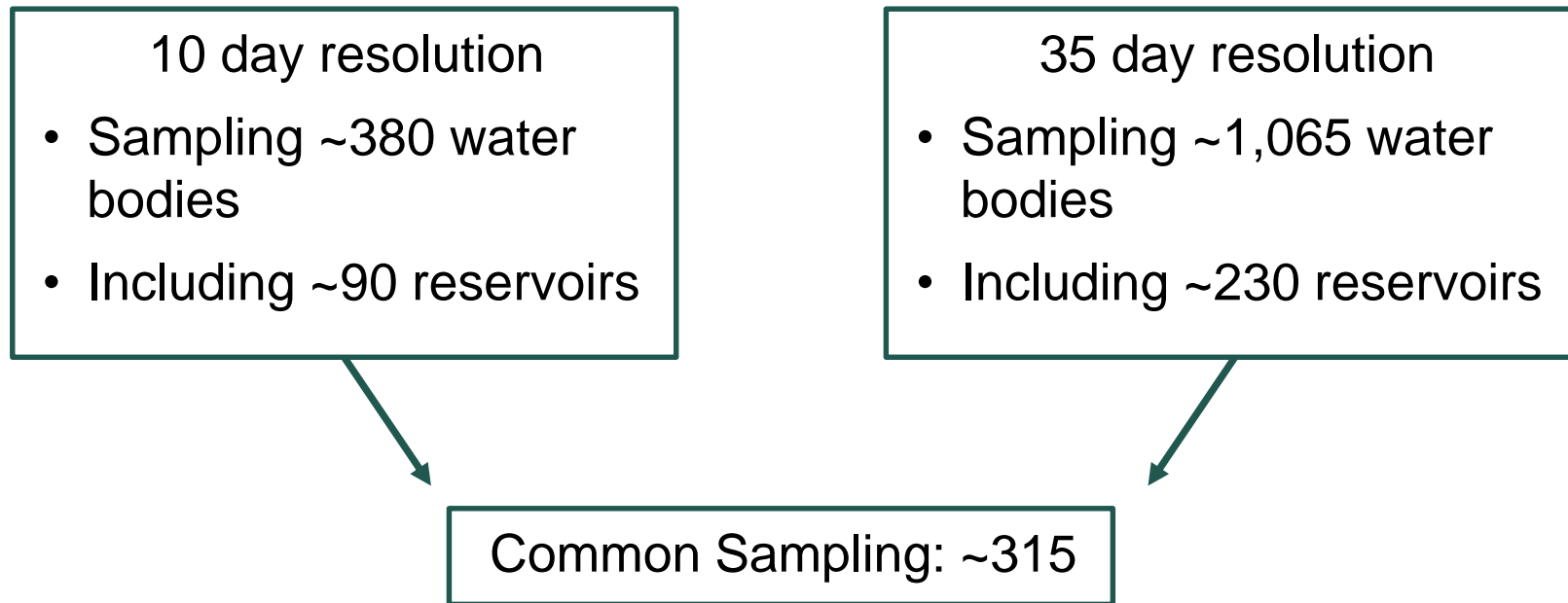
- Non-polar orbit
- Spatial Coverage:
  - Covers 95% of the world's oceans
  - 66°N-66°S latitude
- Temporal Coverage:
  - Revisit time: 10 hours
  - Jason-1: 12/2001 - 7/2013
  - Jason-2: 06/2008 - present
  - Jason-3: 01/2016 - present
- Sensors:
  - Poseidon altimeter
  - Advanced Microwave Radiometer (AMR) and DORIS

NASA, NOAA, CNES, and EUMETSAT Joint Missions



# Jason 2 & 3 Data for Reservoir Heights

- Current satellite radar altimeters only view a certain proportion of the world's largest water bodies, with a trade-off between temporal and spatial resolution



Acknowledgement: Charon M. Birkett, Earth System Science Interdisciplinary Center, University of Maryland, College Park



# Jason Reservoir Height Data Access

USDA Crop Explorer

U.S. Department of Agriculture  
Foreign Agricultural Services

[http://www.pecad.fas.usda.gov/cropexplorer/global\\_reservoir/](http://www.pecad.fas.usda.gov/cropexplorer/global_reservoir/)

USDA United States Department of Agriculture  
Foreign Agricultural Service

Crop Explorer

Toolbox

Latest Product News

October 8th 2015 - Upgrades and New Products

- The surface water level variation products have recently been upgraded (from TPJO.1.1 to TPJO.1.3 and TPJO.2 to TPJO.2.3). They have been re-calculated based on updated altimetric parameters and a revised reference datum. End users are advised not to mix the old/new product versions.
- The upgraded products now include correction factors in the `esdl` text file header which will enable end users to translate the satellite-based time series into various orthometric frames (approximating mean sea level). At the lake product level there is also the option (left-hand panel) to view the reference and geoid height profiles which were used to determine these correction factors. Details can be found in the Q&A link.
- Additional lake products displaying variations from 2008 to the present day at 10-day resolution are also now available..

NOTE !!!

- End users must consider the location of the satellite ground track AND the section of track used to create the products. This is particularly important for complex and drought-prone lakes and reservoirs, where height variability may be location dependent. See the product headers.
- End users must also note that the graphs/products associated with the filtered time series are provided as a visualization aid only.

10-day Near Real Time products with datum based on a single satellite overpass (1 day)

Map Satellite

Global Reservoir and Lake Monitor: 10-day resolution

10-day Status products with datum based on a 9 year (1993-2001) mean

