WELCOME TO
NASA APPLIED REMOTE SENSING TRAINING (ARSET)
WEBINAR SERIES

Water Resources Management Using NASA Earth Science Data

COURSE DATES: EVERY Tuesday, October 13, 20, 27; November 3, 10
TIME: 10 TO 11 AM AND 2 TO 3 PM Eastern US Time
(UTC-4 Hours for October and UTC-5 Hours for November)

Applied Remote Sensing Training

Objective

To provide information about availability and access to global freshwater data from NASA remote sensing observations and land-atmosphere models to facilitate applications and decision support activities in planning **water allocation, flood and drought management, agricultural management, and reservoir/dam management**

Webinar Outline

Week 1

NASA Remote Sensing Data and Applications for Water Resources Management

Week 2

Precipitation and Soil Moisture Data Access and Applications

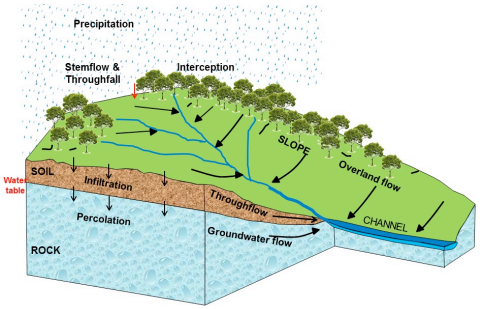
Week 3

Run off, Streamflow and Reservoir Level Data Access and Applications

Week 4

Evapotranspiration and Ground Water Data Access and Applications

Week 5



Land Data Assimilation for Water Budget Estimation and Case Studies with GIS Applications

Training Team

Instructors:

- Amita Mehta (ARSET): amita.v.mehta@nasa.gov
- Cynthia Schmidt (ARSET): cynthia.l.schmidt@nasa.gov (Week-4)
- Brock Blevins (ARSET): bblevins37@gmail.com

Guest Speakers:

- Eni Njoku(NASA-JPL): eni.g.njoku@jpl.nasa.gov (Week-2)
- Brian Thomas (NASA-JPL): Brian.F.Thomas@jpl.nasa.gov (Week-4)
- Sujay Kumar (NASA-GSFC): sujay.v.kumar@nasa.gov (Week-5)

Spanish Translation:

- David Barbato (ARSET): barbato1@umbc.edu

General Inquiries about ARSET:

- Brock Blevins (ARSET) bblevins37@gmail.com
- Ana Prados (ARSET) aprados@umbc.edu

Important Information

Certificate of Completion (upon request):
You must attend all 5 live sessions
You must submit the homework assignments
(homework assignment links will be provided after Week-1 and Week-5)

Contact : Marines Martins
Email: marines.martins@ssaihq.com

Agenda for Week-1
NASA Satellite Missions and Land-Atmosphere Models Relevant to Water Resources Management

- About Applied Remote Sensing Training (ARSET) Program
- Water Resources Management
- Satellites and Earth Science Models Useful for Water Resources Management
- Water Resources Data Search, Access, Analysis, and Visualization Tools
- Water Resources Data Applications

About ARSET

ARSET is a Capacity Building Program of NASA Applied Sciences

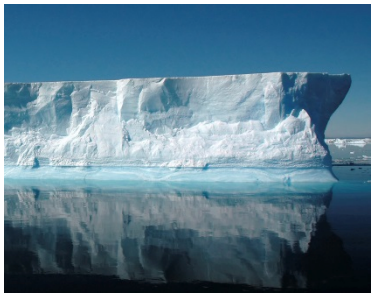
Disasters

Ecological forecasting

Health and Air Quality

Water Resources

Agriculture



Climate

Energy

Oceans

Meteorology

NASA Applied Sciences Themes

ARSET Capacity Building Training Areas

Disasters

Ecological forecasting

Health and Air Quality

Water Resources

Agriculture

Climate

Energy

Oceans

Meteorology

Applied Remote SEnsing Training (ARSET)

http://arset.gsfc.nasa.gov

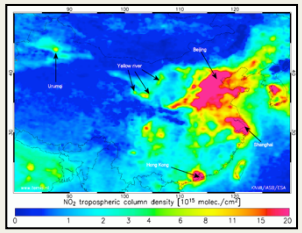
- **GOAL**: To increase utilization of NASA observational and model data for decision-support through training activities for environmental professionals.
- **Online Trainings**: Live and recorded, 4-6 weeks in length. Include demos on data access
- **In person Trainings**: In a computer lab, 2- 4 days. Large focus on data access
- **Train the Trainers**: Courses and training manuals for those interested in conducting their own remote sensing training.
- **Application Areas:** water resources, disasters, health/air quality, and land management

Accomplishments (2008 – 2015)

- 53 trainings completed
- 4000+ participants worldwide
- 1400+ organizations
- 130+ countries

Applied Remote Sensing Training (ARSET)

Health (Air Quality)

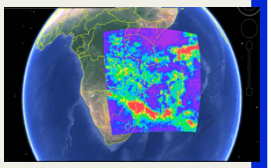


- 2008 – present
- 33 Trainings
- 1000+ end-users
- Analysis of dust, fires and urban air pollution.
- Long range transport of pollutants
- Satellite and regional air quality model inter-comparisons.
- Support for air quality forecasting and exceptional event analysis

Water Resources and Flood Monitoring

- April 2011 – present
- 11 Trainings
- 1200+ end-users
- Flood/Drought monitoring
- Severe weather and precipitation
- Watershed management
- Climate impacts on water resources
- Snow/ice monitoring
- Evapotranspiration (ET), ground water, soil moisture, and runoff.

Satellite derived precipitation

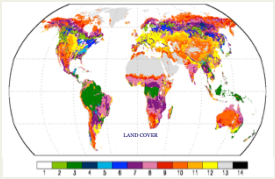


Inundation mapping

Land Management

- Launched in 2014
- 2 Trainings, +300 end-users
- GIS Applications
- Vegetation indices
- Fire products (beginning in 2015)

Land Cover



Train the Trainers (Starting in 2015)

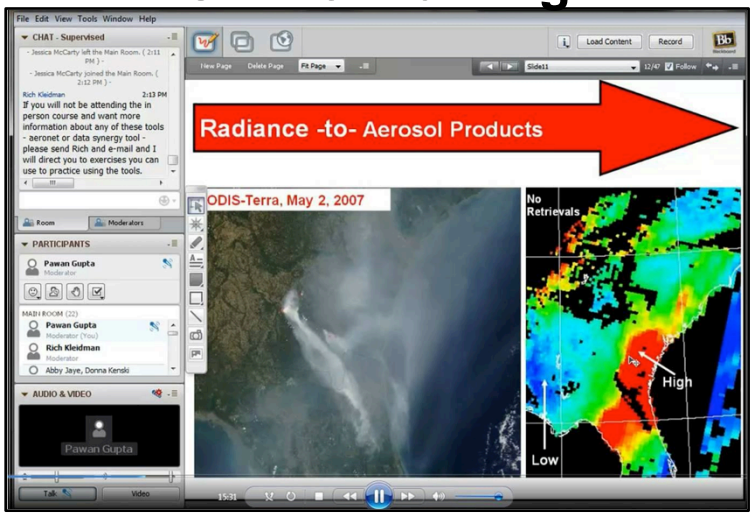
- Courses and guidance on how to design and develop, *YOUR OWN* online and/or computer based remote sensing training
- How to develop effective presentations and exercises.

Gradual Learning Approach

Basic Training
Webinars
Hands-on
Assumes no prior knowledge of RS

Advanced Training
Hands-on
Webinar course generally required
Focused on a specific application/ problem/Data: for example flood monitoring in a specific country or region

Online Training



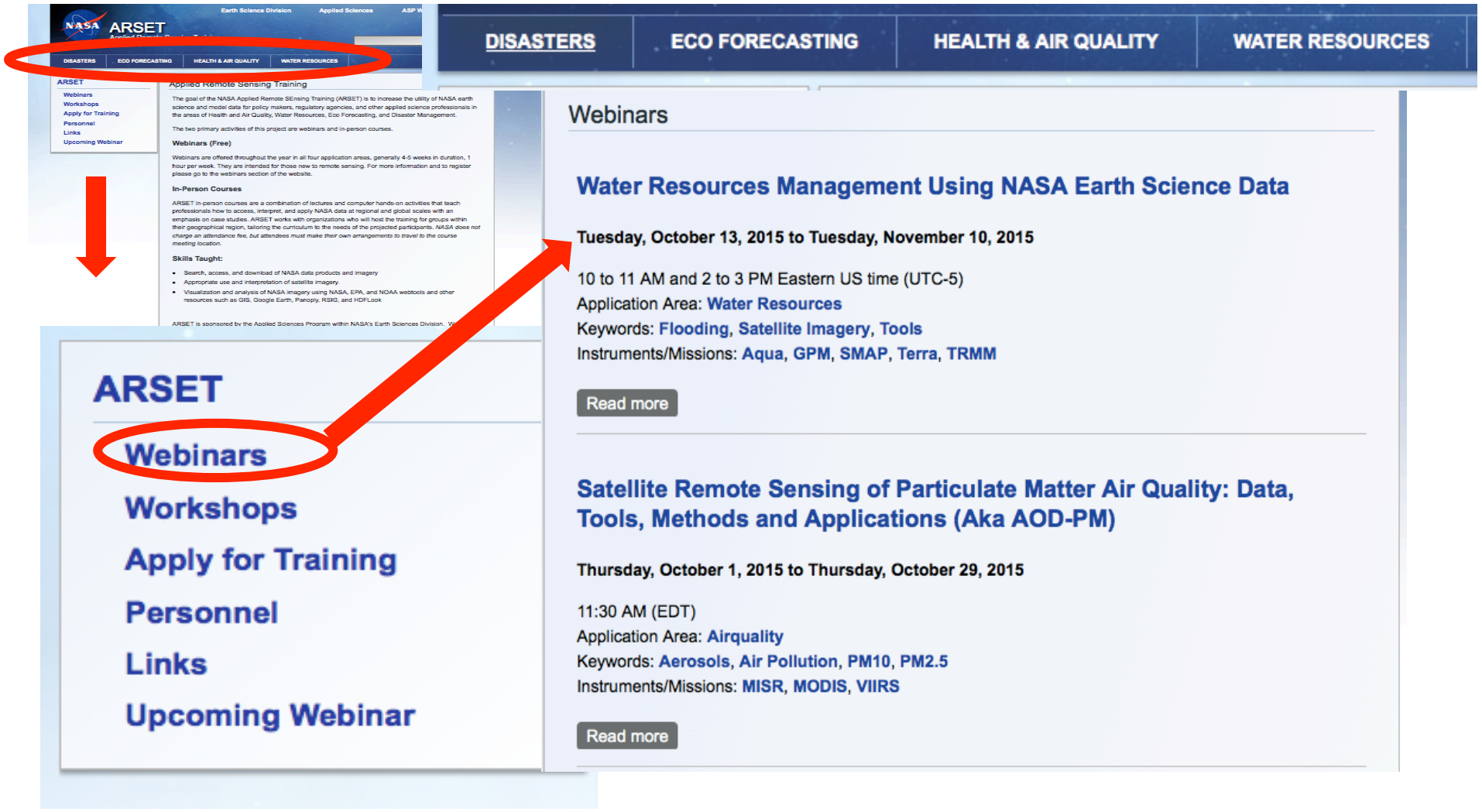
In-Person Training

ARSET Website

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

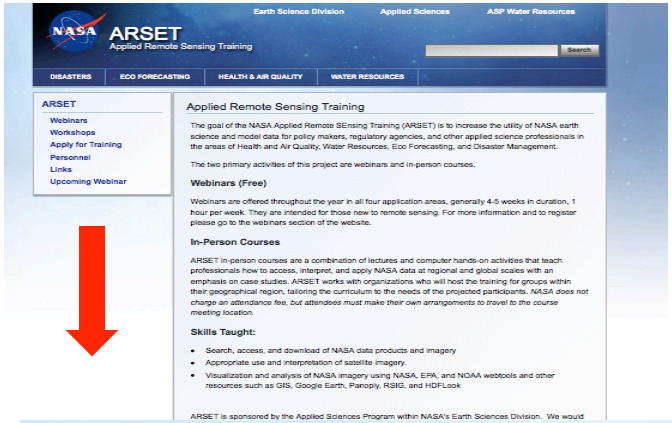
Access to ARSET Trainings

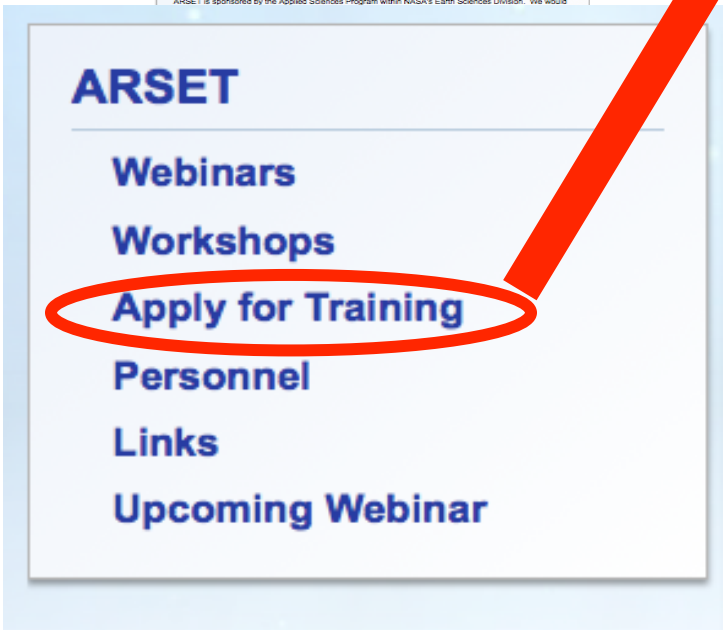
http://arset.gsfc.nasa.gov



Request a Training

http://arset.gsfc.nasa.gov





Apply for Training

The NASA Applied Remote Sensing Training Program provides webinars and in-person courses. The goal of these training activities is to build the capability and skills to utilize NASA earth science observations and model data for environmental management and decision-support. Courses are primarily intended for applied science professionals and decision makders from local, state, federal agencies, NGOS, and the private sector. ARSET also offers a Train the Trainers program, which is recommended for establishing or growing your organizations' capacity in applied remote sensing.

ARSET trainings are NOT designed for research but for operational and application driven organizations.

To apply for a training email Ana Prados at **Ana.I.Prados@nasa.gov**

The program offers four types of courses. For in-person courses, applicants must provide a computer laboratory or similar facility.

1. Overview webinar course: held over a period of 4-5 weeks, 1 hour per week
2. Basic hands-on: In person applied remote sensing course for those new to remote sensing. Generally 2-3 days in length held. It is highly recommended that attendees first take the webinar course.
3. Advanced hands-on: In person applied remote sensing course that builds the skills to use NASA data for a specific environmental management problem. Intended for those who have already taken the basic course or have previous experience using NASA data and resources. Generally 1-2 days in length.
4. Train the Trainers: In person applied remote sensing course intended for existing remote sensing/geospatial trainers within the organization/institution/agency.

ARSET ListServ

For information on upcoming courses and program updates, sign up to the listserv

https://lists.nasa.gov/mailman/listinfo/arset

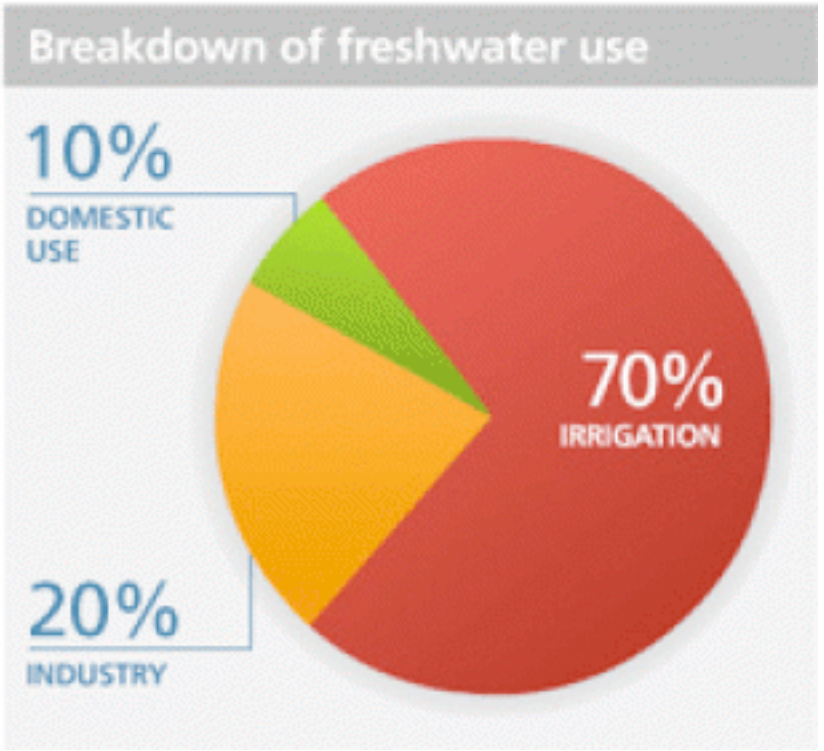
Water Resources Management

Water Resources Management

- Requires balancing availability and consumption of freshwater
- Planning for water allocation among various sectors
- Planning for disasters (droughts, floods)

Major Challenges:

- Regional and temporal imbalances in freshwater availability and usage
- Increasing demands -- population increase, agricultural and industrial demands
- Cross-boundary water sharing issues
- Climate variability and change

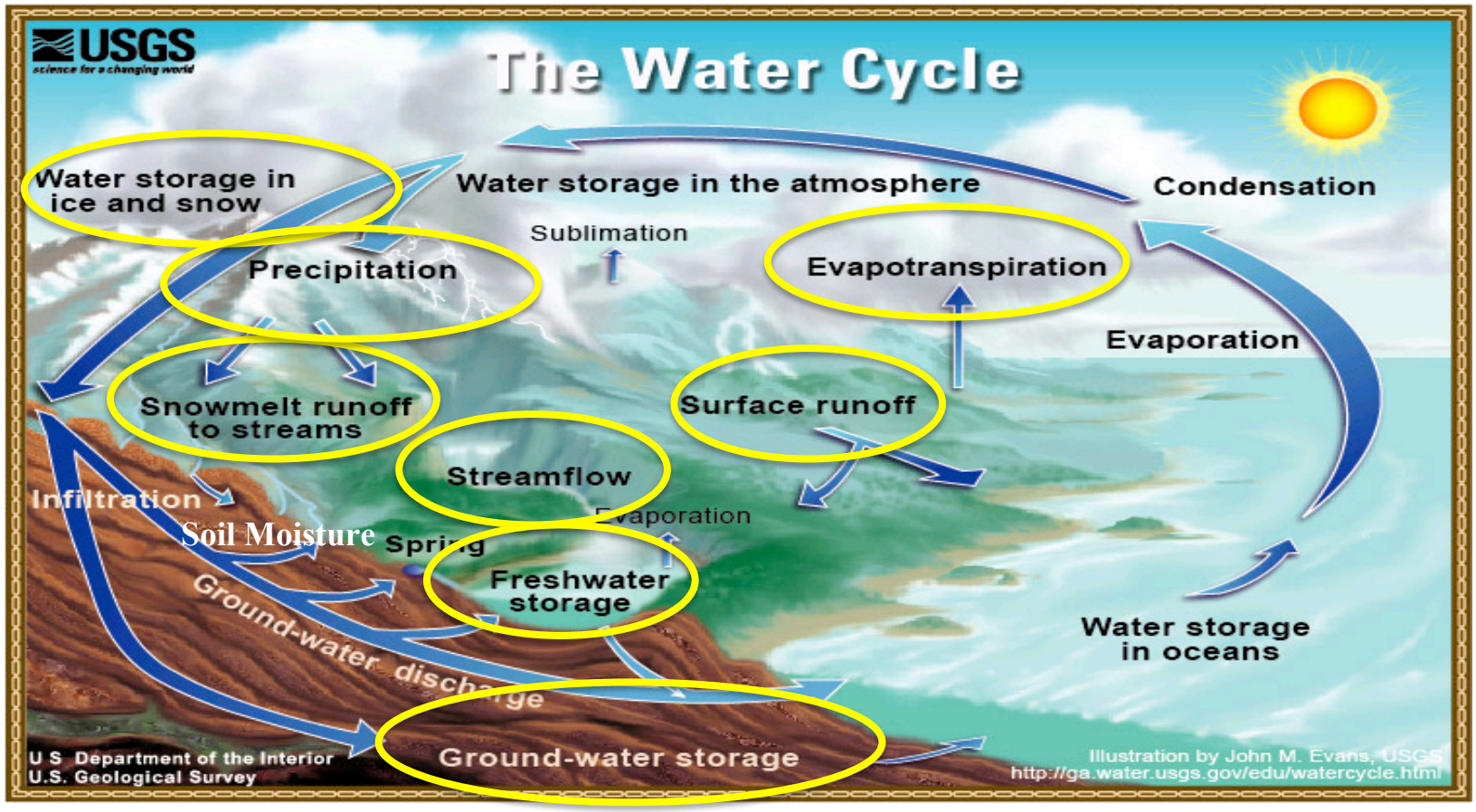


www.unwater.org

The definition of freshwater is water containing less than 1,000 milligrams per liter of dissolved solids, most often salts (http://water.usgs.gov/edu/watercyclefreshstorage.html)

Water Resources Management

For sustainable water management, it is critical to have accurate estimates of water cycle components



Water Resources Management
Freshwater Components

Over a watershed, river basin, or region:

- **Precipitation (rain, snow)** is the main source of Fresh Water; regionally, **runoff**/**streamflow, lakes, soil moisture, and ground water** also contribute to available Fresh Water

- **Evaporation and Evapotranspiration** through the loss of water to the atmosphere and **runoff** outflow contribute to the depletion of available Fresh Water

- Surface Fresh water availability W is largely controlled as follows:

  W= (Precipitation + Runoff in the region) minus
  (Evaporation/Evapotranspiration + Runoff Outflow + Infiltration)

Freshwater Information

- Not all water cycle components can easily be measured directly (e.g. evapotranspiration, runoff, water vapor transport)

- NASA Satellites and Earth Systems Models measure/calculate all water cycle components

Overview of Satellites and Earth Science Model Data for Water Resources Management

NASA Satellites and Earth Systems Models

Provide global-scale water cycle quantities on hourly, daily, seasonal, and multi-year time scales useful for water resources management

- Rain
- Temperature
- Humidity
- Winds
- Soil Moisture
- Snow/Ice
- Clouds
- Terrain
- Ground Water
- Vegetation Index
- Evapotranspiration
- Runoff

Water Resources Management:

Rain Amount, Snowmelt Amount
Runoff
Soil Moisture
Evapotranspiration
Ground Water

Hydrology Modeling Inputs:

Rain Amount, Snowmelt Amount
Surface Temperature, Wind, Humidity
Terrain, Land Cover
Solar and Terrestrial Radiation at the Surface

All other quantities are available from satellite observations as well as from models
Quantities in green are derived from satellite observations
Quantities in red are from atmosphere-land models in which satellite observations are assimilated

NASA Satellites for Water Resources Monitoring

TRMM: Tropical Rainfall Measuring Mission
GRACE: Gravity Recovery and Climate Experiment
GPM: Global Precipitation Measurements
SMAP: Soil Moisture Active Passive

Landsat (07/1972-present)

TRMM (11/1997-04/2015)

GPM (2/27/2014-present)

Terra (12/1999-present)

Aqua (5/2002-present)

SMAP (1/31/2015-present)

GRACE (3/2002-present)

Jason-1&2 (12/2001-present)

Fundamentals of Satellite Remote Sensing

To use satellite observations, it is important to understand principles of remote sensing and attributes of satellite data:

- What is Remote Sensing? What is Measured?
- Types of Satellite Orbits
- Types of Satellite Sensors/Instruments, Spectral Bands
- Conversion from Sensor Measurements to Geophysical Quantities (i.e. Temperature, Rain, Soil Moisture, Carbon Dioxide etc.)
- Spatial and Temporal Resolutions and Coverage
- Spectral and Radiometric Resolutions
- Levels of Satellite Data Products
- Strengths and Limitations of Remote Sensing Data

The following link provides concepts and definitions about the above topics that will be used through out this webinar series:
https://arset.adobeconnect.com/fundrssession1/event/registration.html

NASA Satellites for Water Resources Monitoring

- Each satellite carries one or more sensors/instruments with specific spectral channels to observe specific geophysical quantities
- Sensors most useful for the water resources data will be described in this training

Landsat (07/1972-present)

TRMM (11/1997-04/2015)

GPM (2/27/2014-present)

Terra (12/1999-present)

Aqua (5/2002-present)

SMAP (1/31/2015-present)

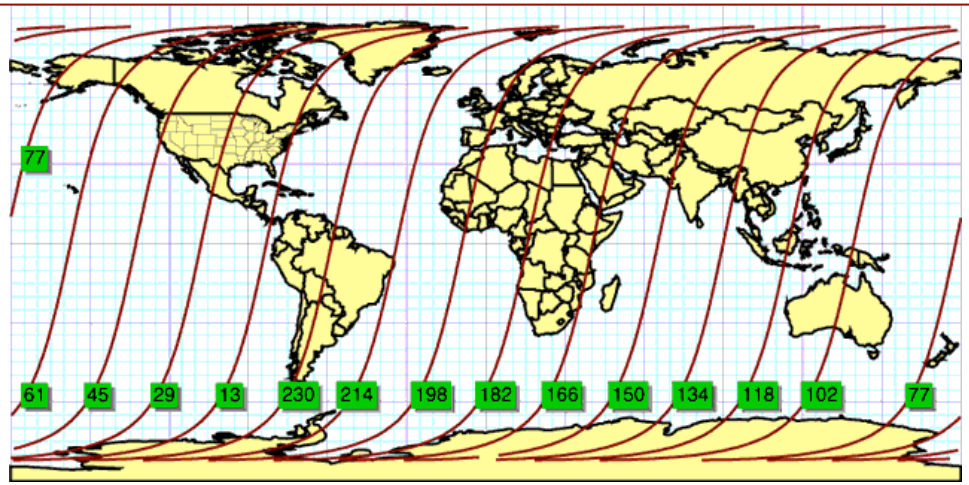
GRACE (3/2002-present)

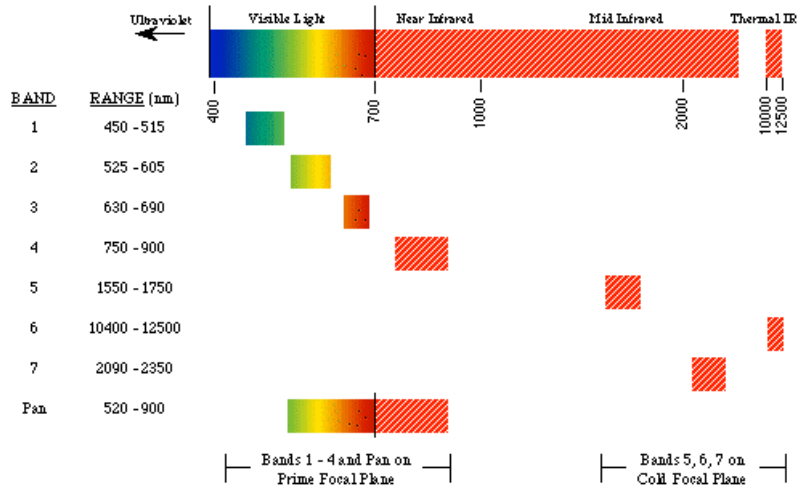
Jason-1&2 (12/2001-present)

Landsat (07/1972 – Present)

http://landsat.gsfc.nasa.gov/

Continuous mission with multiple satellites, Landsat-1 launched in July 23, 1972





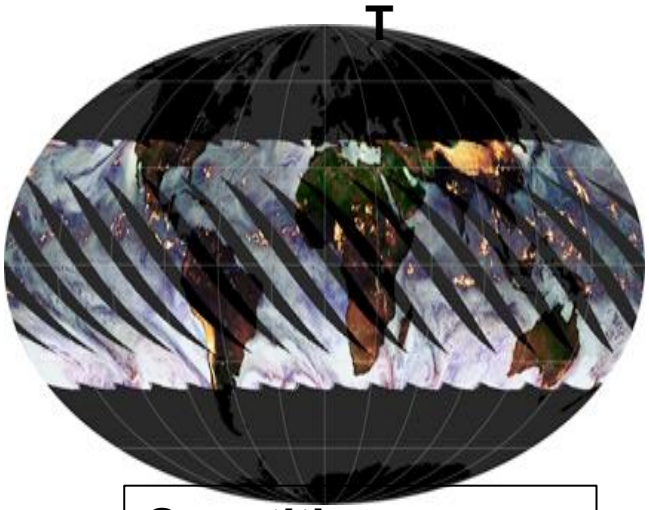
- Near-polar orbit, 10 am equator-crossing time
- Global coverage
- July 1972- Present, 16-day revisit time
- Sensors: *MSS,TM, ETM+,OLI, TIRS*

Quantities:
Land Cover

TRMM (11/1997 – 4/2015)

http://trmm.gsfc.nasa.gov

TRMM stopped collecting data in April 2015



Quantities:
Surface Rainfall
Rainfall Profiles
Latent Heating

- **A non-polar, low inclination orbit**
  Revisit time ~11-12 hours, but time of the observation changes daily
- There are 16 TRMM orbits a day **covering global tropics between 35° S to 35°N latitudes**
- Sensors

  *Precipitation Radar (**PR**)**
  *TRMM Microwave Imager (**TMI**)*
  *Visible and Infrared Scanner (**VIRS**)*

Important Note:
The TRMM mission was terminated in April 2015 but near-real time TRMM-calibrated rainfall from other satellites are available until GPM data become available in near-real time

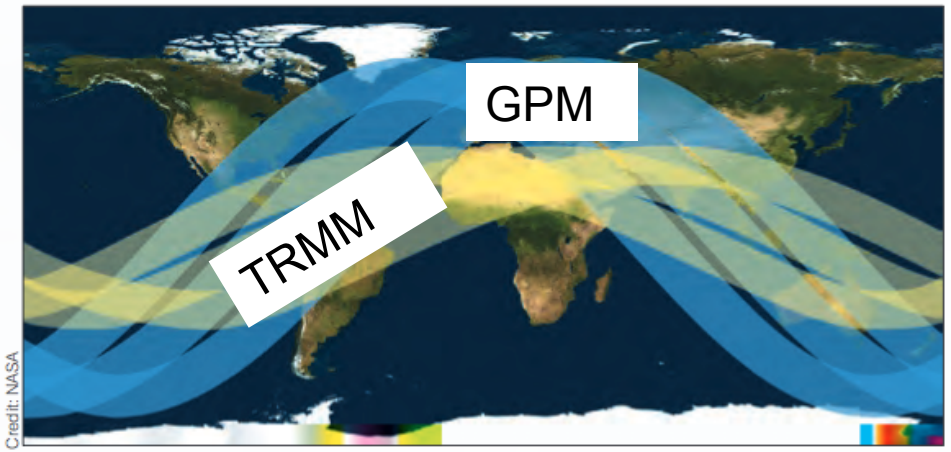
TRMM data from 1997-2014 are widely used for weather, climate, and hydrology applications and will be used in this training

GPM (2/2014 – Present)

http://pmm.nasa.gov/GPM

- Non-polar, low inclination orbit with 16 orbits per day
- **GPM observes global region between 65°S to 65°N latitudes**
- Sensors:

  *Dual frequency Precipitation Radar (**DPR**)*
  *GPM Microwave Imager (**GMI**)*

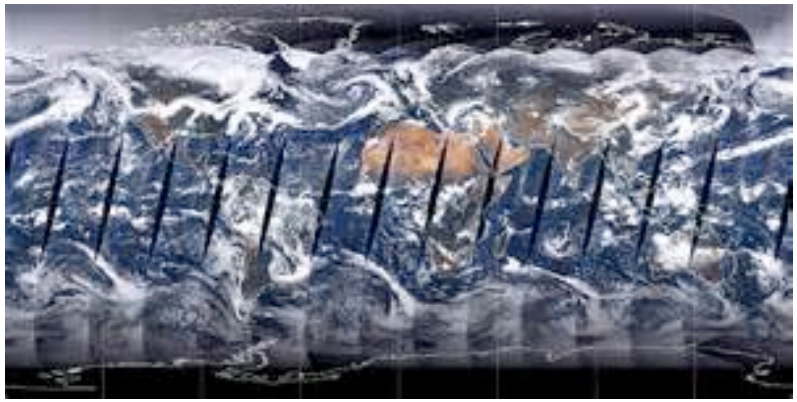


the area covered by three TRMM orbits [yellow] versus orbits of the GPM Core Observatory [blue]

Quantities:
Surface Precipitation (Rain and Snow)
Precipitation Profiles

Terra (12/1999 – Present)

http://terra.nasa.gov



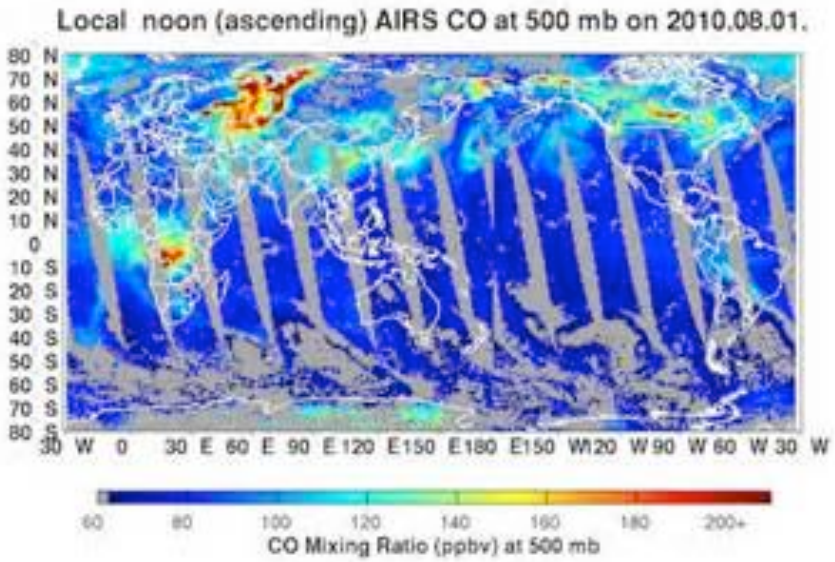
Quantities:
Land Cover
Snow Cover
Clouds
Water VApor
Radiative Fluxes
Aerosol Information
Digital Elevation

- Polar, Sun-Synchronous Orbit, Global Coverage
- Twice-daily Observations **10:30 AM/ PM** Descending Orbits
- Sensors:
  - *Moderate Resolution Imaging Spectroradiometer* ***(MODIS)***
  - *Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER)*
  - *Clouds and Earth's Radiant Energy System (CERES)*
  - *Multi-angle Imaging Spectroradiometer (MISR)*
  - *Measurements of Pollution in the Troposphere (MOPITT)*

Aqua (5/2002 – Present)

http://aqua.nasa.gov

- Polar, Sun-Synchronous Orbit, Global Coverage
- Twice-daily Observations **1:30 AM/ PM** Descending Orbits
- Sensors:
  - *Moderate Resolution Imaging Spectroradiometer* ***(MODIS)***
  - *Atmospheric Infrared Sounder (AIRS)*
  - *Advanced Microwave Sounding Unit (AMSU-A)*
  - *Advanced Microwave Scanning Radiometer for EOS (AMSR-E)*
  - *Clouds and the Earth's Radiant Energy System (CERES)*

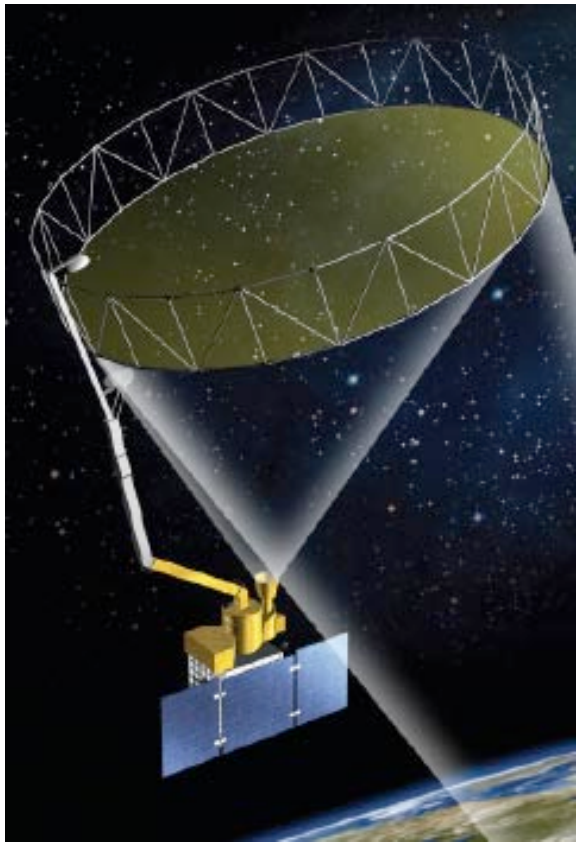


Quantities:

Land Cover
Snow Cover
Clouds
Temperature, Humidity
CO_2, CO, CH_4, O_3
Radiative Fluxes
Aerosol Information

SMAP (1/2015 – Present)

http://smap.jpl.nasa.gov

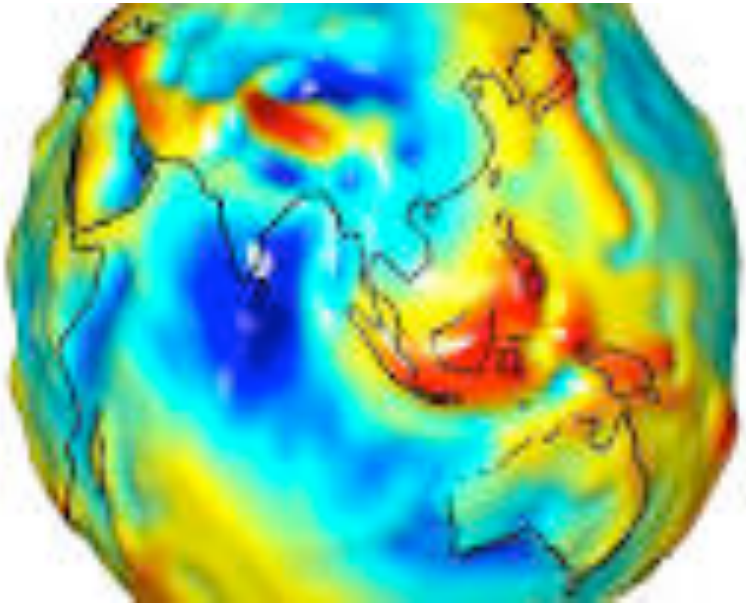


- Polar, Sun-Synchronous Orbit, Global Coverage
- Twice-daily Observations **6:00 AM/ PM** Equator Crossing
- Sensors:
  Microwave Radiometer
  Microwave Radar

Quantities:
Soil Moisture
Freeze-Thaw State

GRACE (3/2002 – Present)

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

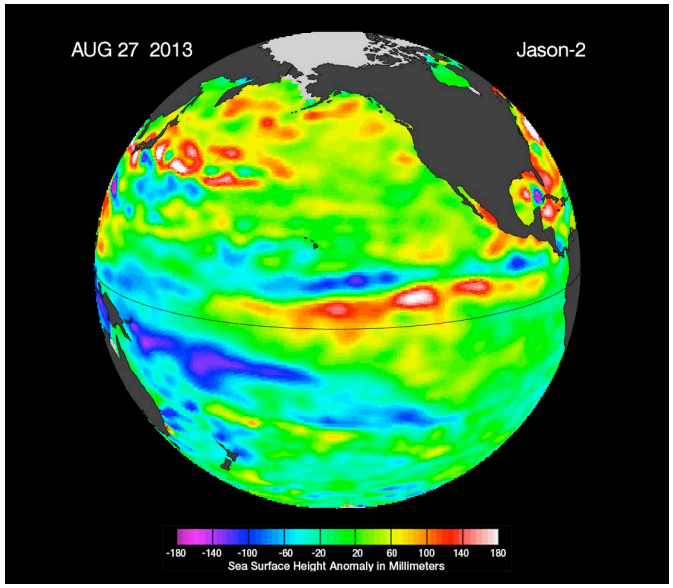


- Polar, Sun-Synchronous Orbit, Global Coverage
- 250 gravity profiles per day
- Sensors:
  - *Microwave K-band ranging instrument*
  - *Accelerometers*
  - *Global Positioning System Receivers*

Quantity:
Terrestrial Water

Jason-1 (12/2001 – 7/2013) & Jason-2 (6/2008-Present)

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



Quantity:
Sea Level Height

- Polar, Sun-Synchronous Orbit, Global Coverage
- 10-day Repeat Time
- Focus on Ice-free Oceans
- Sensors:
  Poseidon Altimeter (C- and Ku-band)
  Jason Microwave Radiometer (JMR) (Jason-1)
  Advance Microwave Radiometer (AMR) (Jason-2)
  DORIS Doppler tracking antenna
  Global Positioning System
  Laser Retroreflector *array*

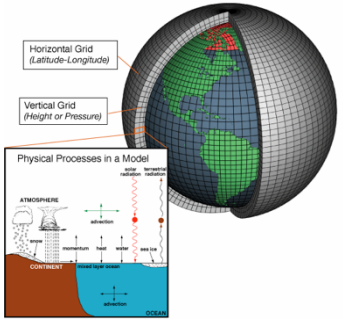
Altimeter Data used to observe Lake Levels

Earth System Models Provide Value-added Information

Remote Sensing + Surface Observations + Numerical Models

Satellite Data

Surface Measurements and In-Situ Data



Numerical Models

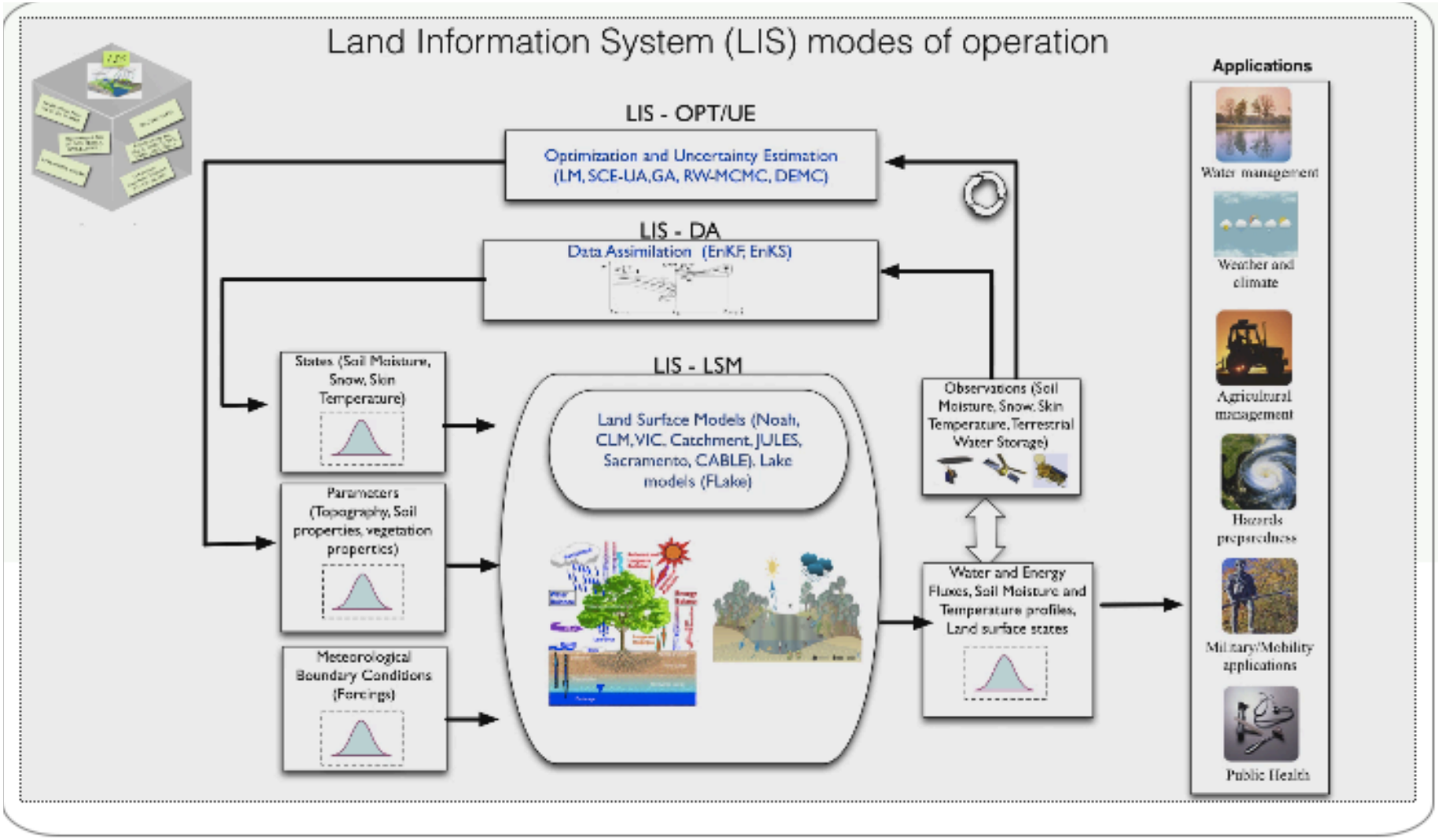
NASA Models Useful for Water Resources Management

(Atmosphere-Ocean-Land Models)

- GEOS-5 : The Goddard Earth Observing System Version 5
- MERRA: Modern Era Retrospective-analysis for Research and Application
- GLDAS : Global Land Data Assimilation System
- NLDAS : North American Land Data Assimilation System

Land Information System (LIS)

http://lis.gsfc.nasa.gov



Global Land Data Assimilation System(GLDAS)
North American Land Data Assimilation System (NLDAS)

http://ldas.gsfc.nasa.gov/

Integrate ground and satellite observations within sophisticated numerical models to produce physically consistent, high resolution fields of land surface states and fluxes

GLDAS and a Version of NLDAS use LIS with Different Sources of Inputs

Meteorological Analysis
Surface Solar Radiation
Precipitation
Soil Texture
Vegetation Classification and Leaf Area Index
Topography

Integrate Output for Water Resources

Soil Moisture
Evapotranspiration
Surface/Sub-surface Runoff
Snow Water Equivalent

Satellite Data used in LDAS: MODIS, TRMM ,GOES

This Training will Focus on the Following Satellites and Models for Monitoring Freshwater Components

❑ Rain Amount	(TRMM, GPM)
❑ Snow Cover	(Terra and Aqua MODIS)
❑ Soil Moisture	(SMAP, NLDAS/GLDAS)
❑ Evapotranspiration	(Terra and Aqua MODIS, Landsat, NLDAS/GLDAS)
❑ Runoff/Streamflow	(TRMM,GPM, NLDAS/GLDAS)
❑ Lake Level Height	(Jason-2)

This Training will Focus on the Following Satellites and Models for Monitoring Freshwater Components

- Rain Amount (TRMM, GPM)
- Snow Cover (Terra and Aqua MODIS)
- Soil Moisture (SMAP, NLDAS/GLDAS)
- Runoff/Streamflow (TRMM,GPM, NLDAS/GLDAS)
- Lake Level Height (Jason-1 and -2)
- Evapotranspiration (Terra and Aqua MODIS, Landsat, NLDAS/GLDAS)
- Terrestrial Water (GRACE)
- Regional Water Budget (NLDAS/GLDAS)

Week-2 **Week-3** **Week-4** **Week-5**

This Training will Focus on the Following Satellites and Models for Monitoring Freshwater Components

- Rain Amount (TRMM, GPM)
- Snow Cover (Terra and Aqua MODIS)
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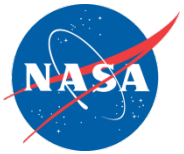
- Terrestrial Water (GRACE)
- Regional Water Budget (NLDAS/GLDAS)

Week-2 **Week-3** **Week-4** **Week-5**

Data Search, Access, Analysis, and Visualization Tools

There are Multiple Web-based Tools for Water Resources Data Search, Analysis, and Download



Mirador http://mirador.gsfc.nasa.gov	Precipitation, LDAS -Run Off, Soil Moisture, ET
Reverb-ECHO http://reverb.echo.nasa.gov/reverb	Selected Water Resources Data
Giovanni-4 http://giovanni.gsfc.nasa.gov/giovanni	**Geospatial Interactive Online Visualization And aNalysis Infrastructure --** Selected Data Access [Precipitation, LDAS – Run Off, Soil Moisture, ET]
PPS-STORM https://storm.pps.eosdis.nasa.gov/storm	**Precipitation Processing Systems - Science Team On-Line Request Module** [Precipitation]
NSIDC, JPL Snow Server http://nsidc.org http://snow.jpl.nasa.gov/portal/data/map/	Snow Cover
GFMS **http://flood.umd.edu/**	Global Flood Monitoring System [Run Off/Streamflow]
USDA **Crop Explorer** http://www.pecad.fas.usda.gov /cropexplorer/global_reservoir	Reservoir Height

Water Resources Data Applications

Water Resources Data Applications

Freshwater components crucial for the following Activities

Water Allocation

Water Budget including all the freshwater components

Agricultural and Irrigation Management

Precipitation
Soil Moisture
Evapotranspiration

Flood/Drought Management

Precipitation
Runoff/ Streamflow
Soil Moisture
Evapotranspiration
Ground Water

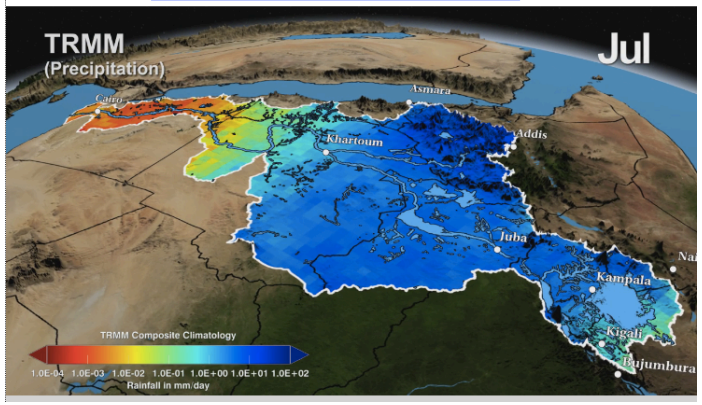
Reservoir/Dam Management

Reservoir Height
Precipitation
Runoff/ Streamflow

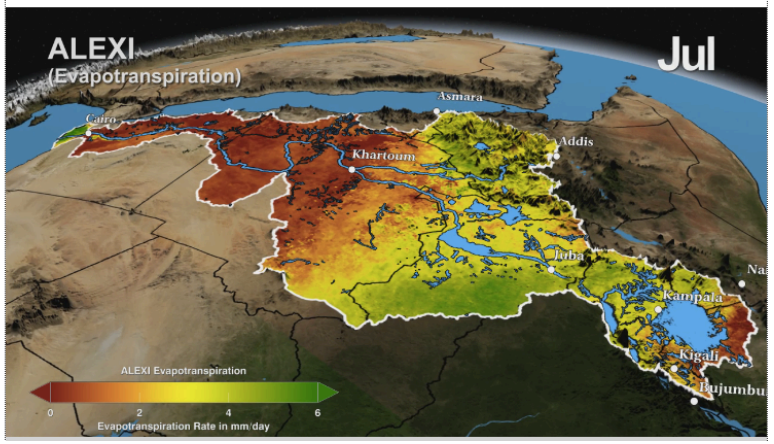
NASA Observations and Modeling Systems Offer Capabilities to Monitor Water Balance in the Nile Basin

http://svs.gsfc.nasa.gov/cgi-bin/details.cgi?aid=4044

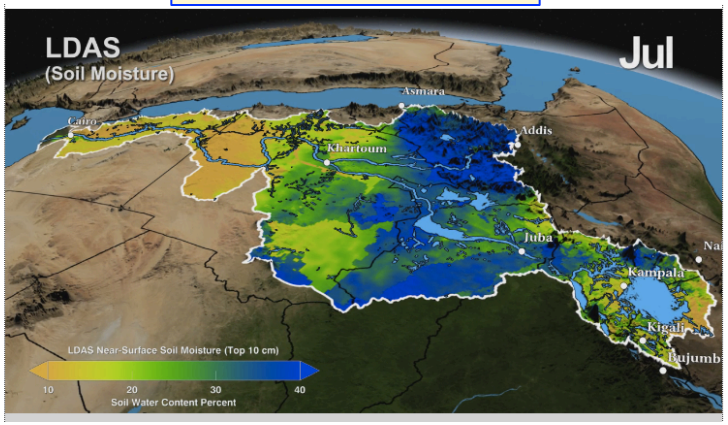
Precipitation



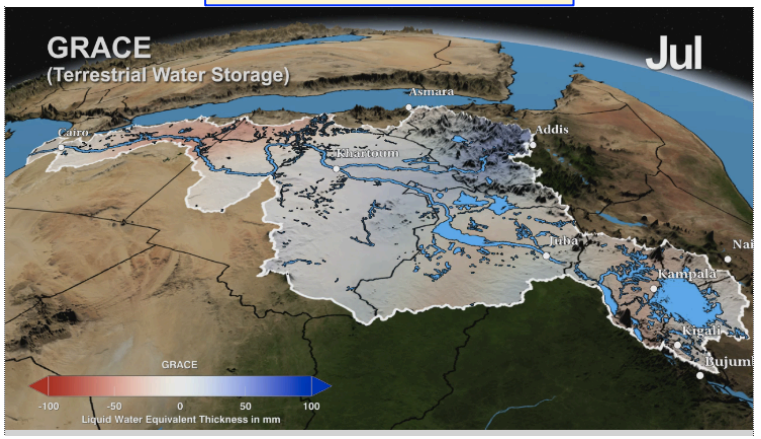
Evapotranspiration



Soil Moisture

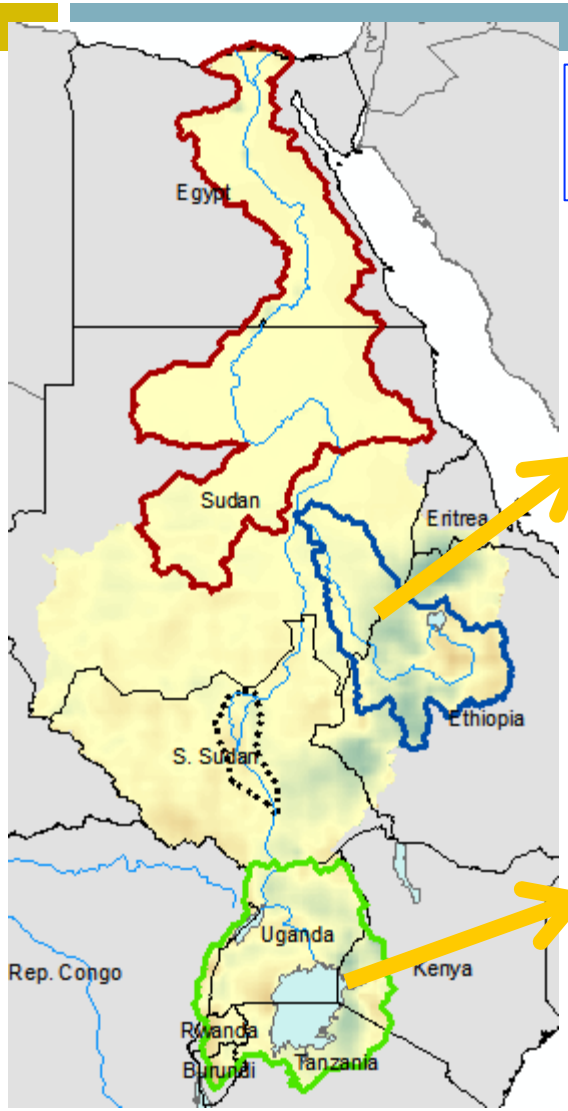


Terrestrial Water

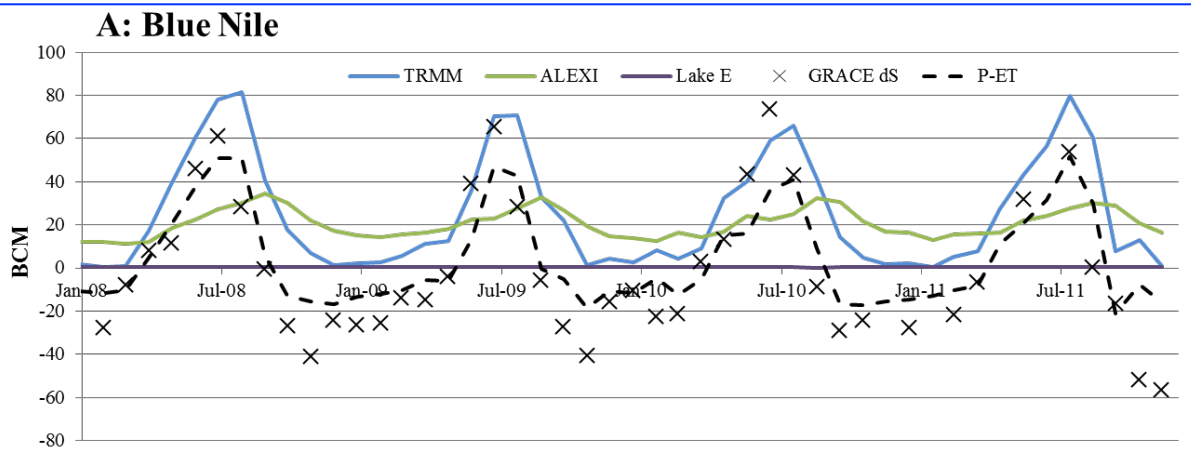


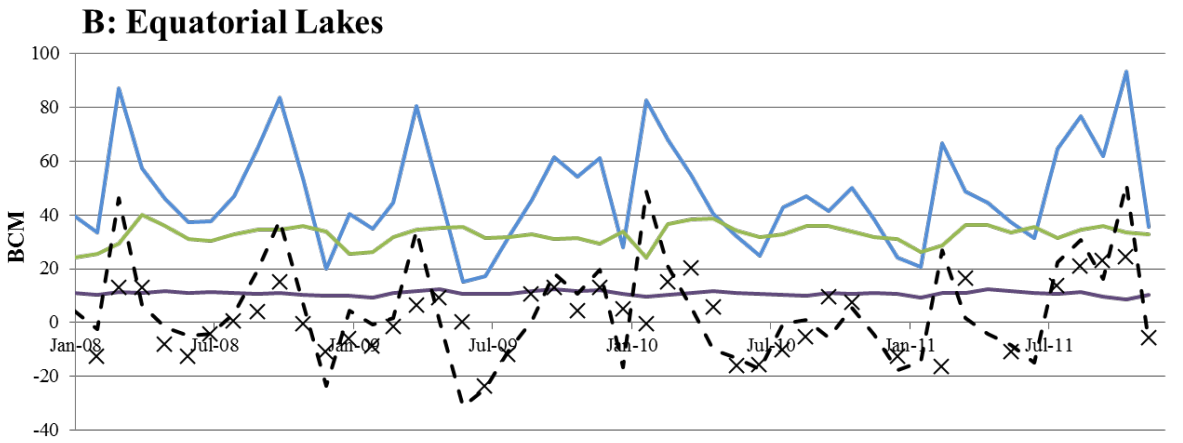
Applied Sciences Project Scientist: Ben Zaitchik (Johns Hopkins University)

Nile - Basin Scale Water Balance



Collaborators and Stakeholders: Egyptian Ministry of Water Resources and Irrigation, Cairo, Egypt; Water Resource Planning and Management Project, The Nile Basin Initiative, Addis Ababa, Ethiopia; Arab Water Council, Cairo, Egypt; The World Bank



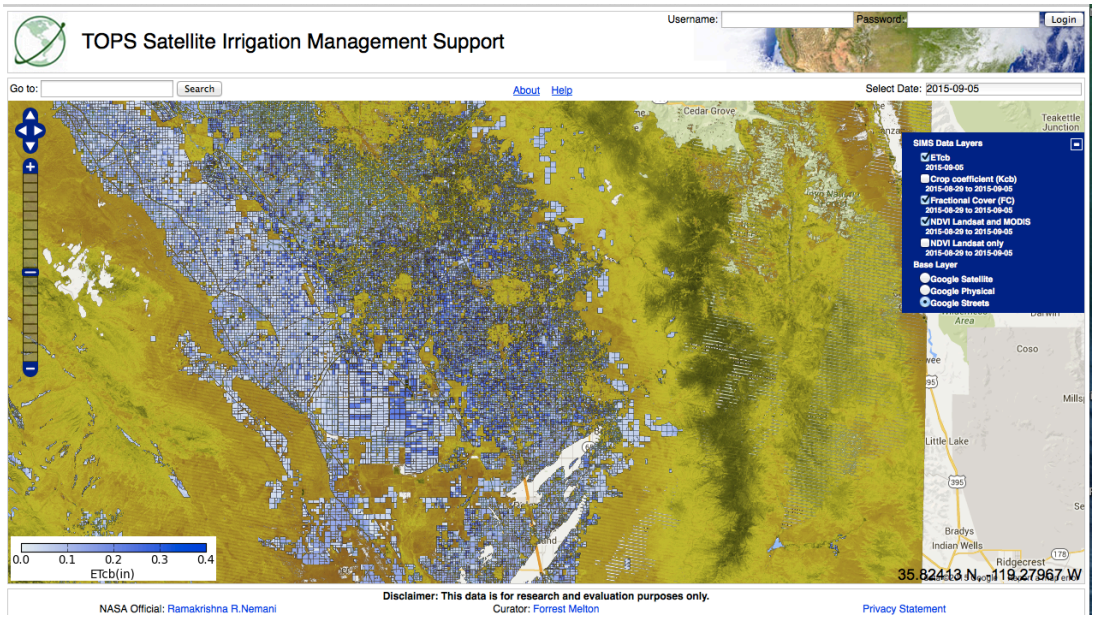


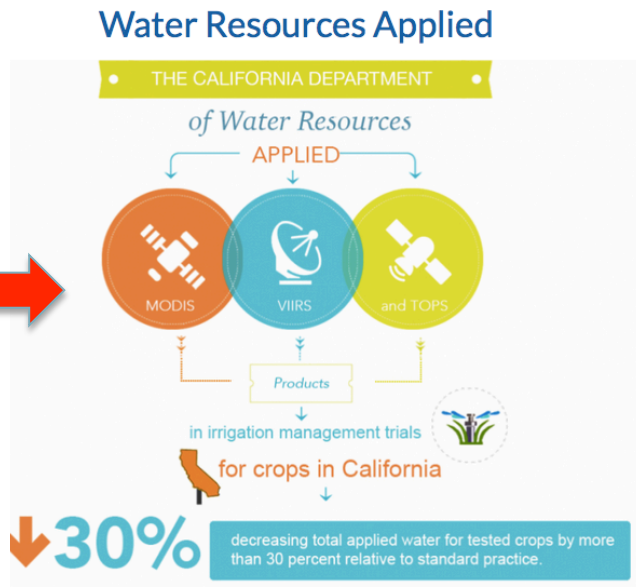
Courtesy: Ben Zaitchik (Johns Hopkins University)

Irrigation Management Using Satellite-based ET

http://ecocast.arc.nasa.gov/dgw/sims/

Collaborators and Stakeholders: California Department of Water Resources, Western Growers Association, University of California Cooperative Extension, USDA Agricultural Research Service, NOAA National Weather Service, Tanimura & Antle, Farming D Ranch, Pereira Bros. & Sons, Booth Ranches, Fresh Express, Ryan Palms Farms, Del Monte, Inc., Constellation Wines, E. & J. Gallo, Meyer Farms





30% Decrease in Water Usage for Selected crops

http://appliedsciences.nasa.gov/programs/water-resources-program

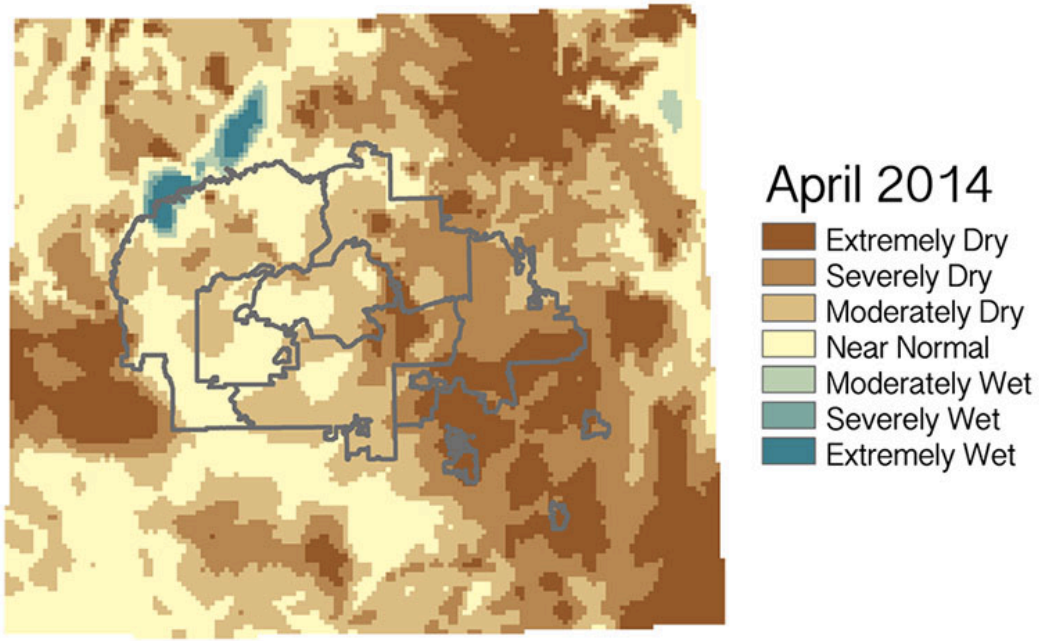
Project Scientist : Forrest Melton, NASA ARC-CREST / California State University

A Drought Monitoring Decision Support Tool for the Navajo Nation

http://develop.larc.nasa.gov/2015/summer_term/NavajoNationClimateII.html

Stakeholders: Navajo Nation

Based on Precipitation Index from TRMM and GPM



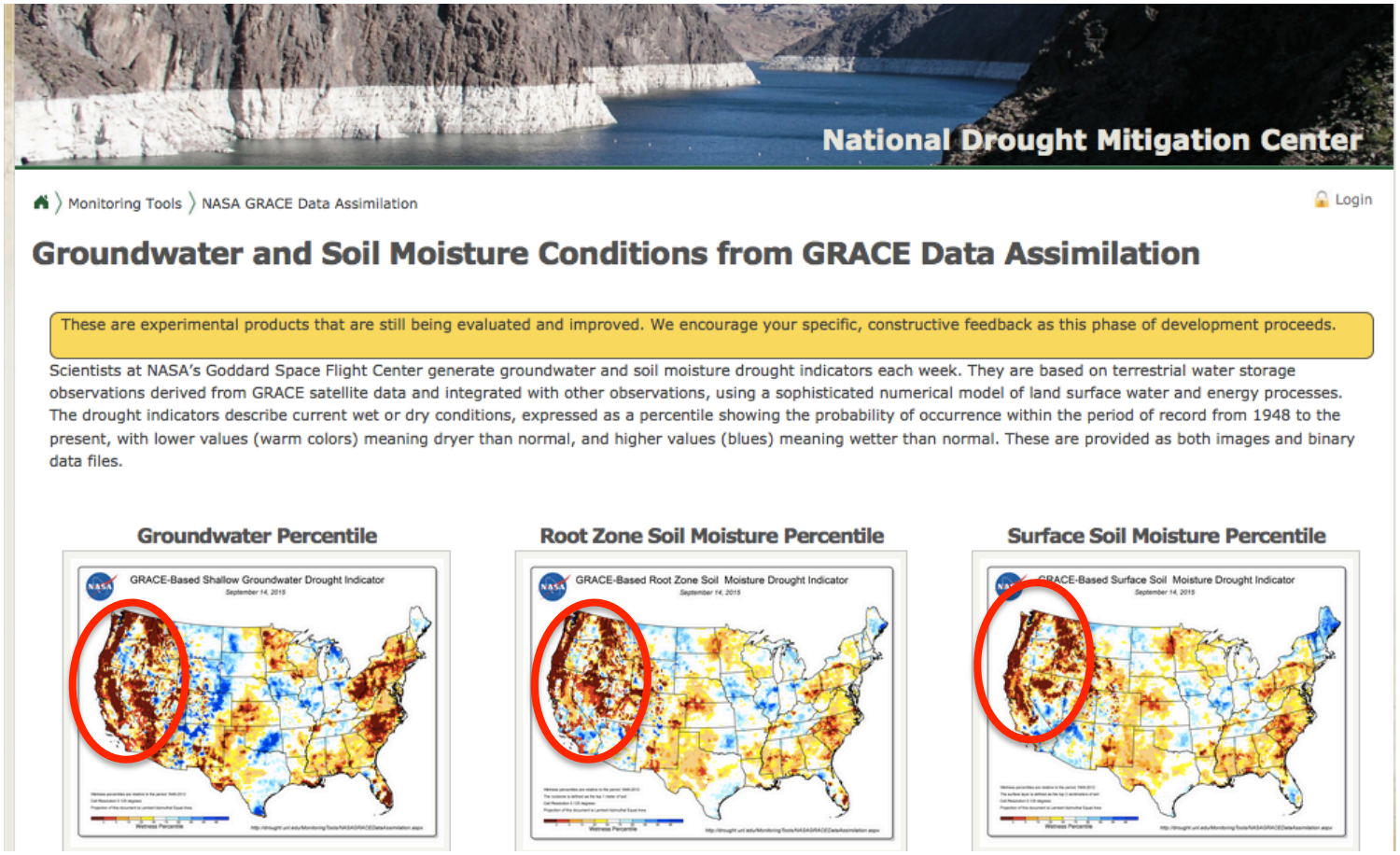
A Drought Monitoring Decision Support Tool for Customized Calculation of a Standardized Precipitation Index Value in the Navajo Nation

LOCATION
NASA Ames Research Center

NASA DEVELOP TEAM : Cheryl Cary (Project Lead), Michael Gao, Vickie Ly, Anton Surunis, Sophie Turnbull-Appell

National Drought Monitoring with GRACE Terrestrial Water Data

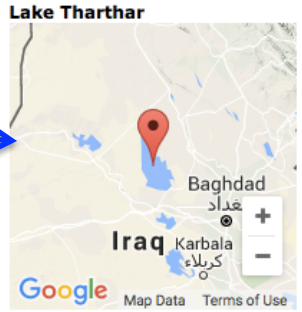
http://drought.unl.edu/MonitoringTools/NASAGRACEDataAssimilation.aspx

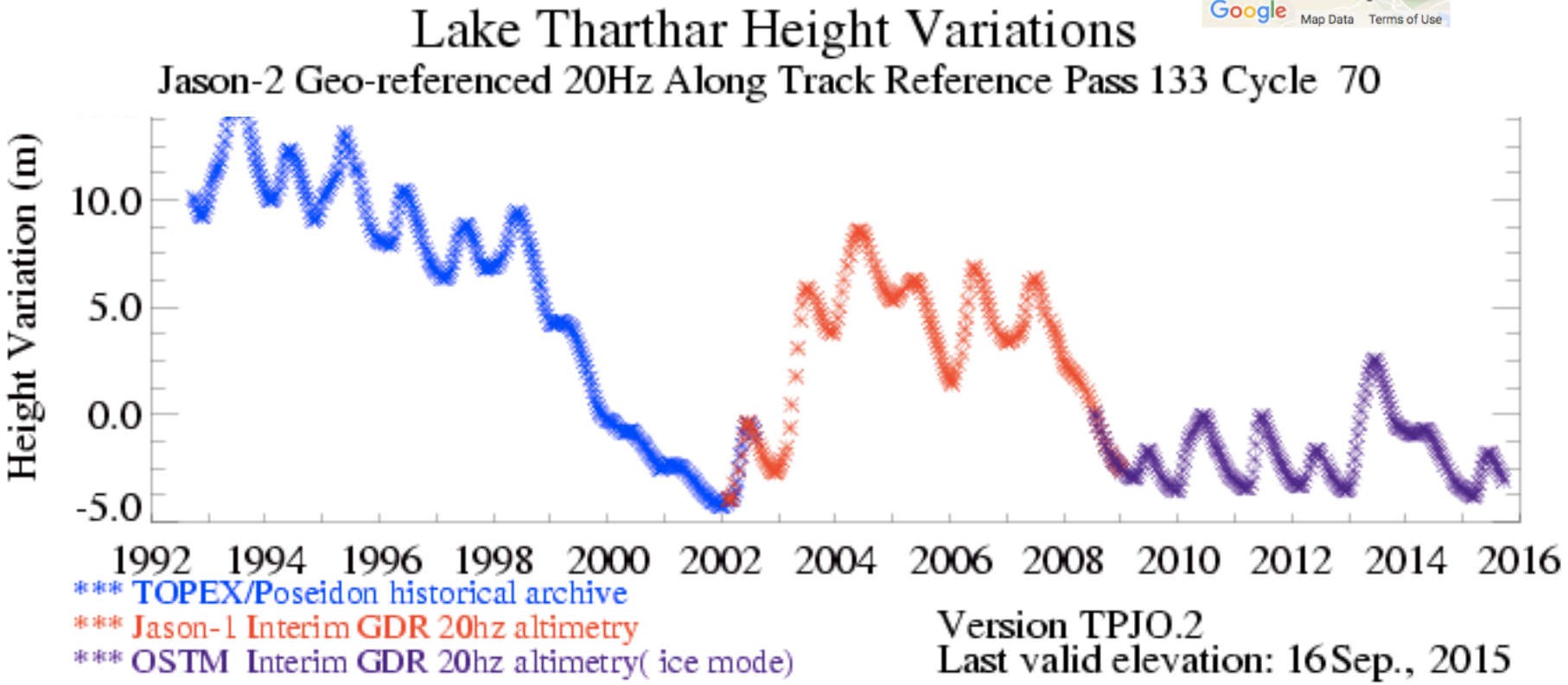


Products are currently being evaluated

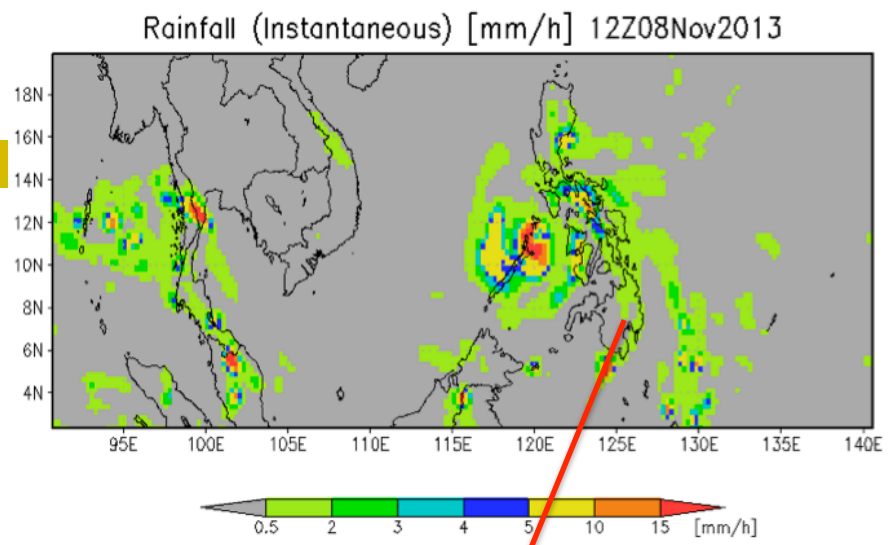
NASA Satellites Allow USDA to See World's Lakes Rise and Fall

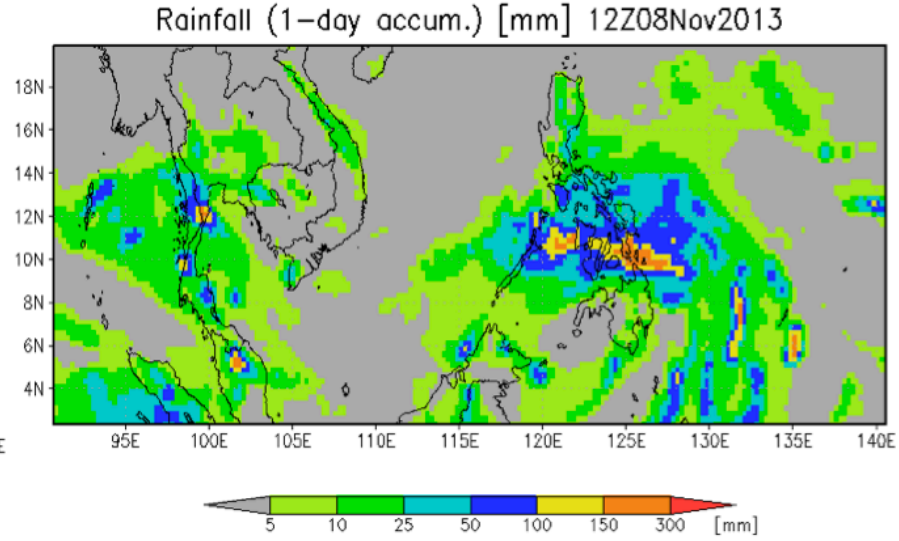
http://www.pecad.fas.usda.gov/cropexplorer/global_reservoir/

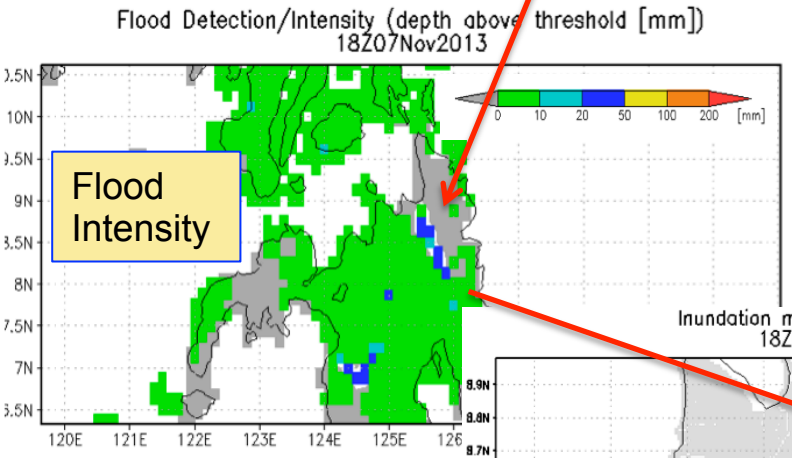


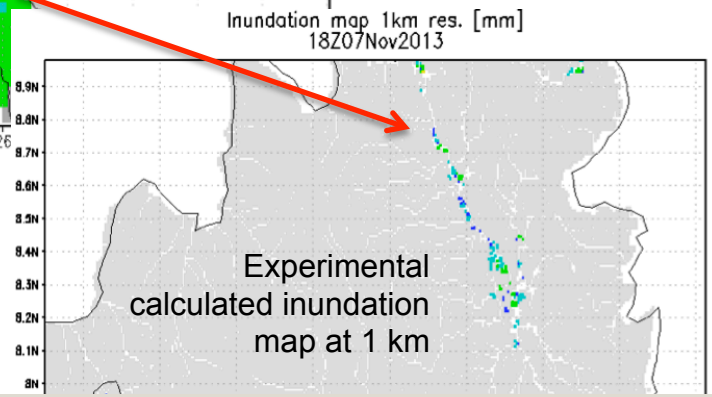


Streamflow Estimates, Flood Detection, Landslide Estimation



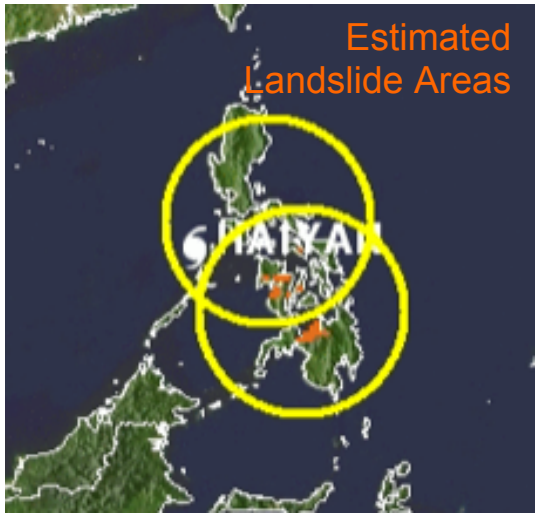






Using TRMM Precipitation in a Hydrological Model

Typhoon Haiyan produced rainfall up to about 300 mm. Flooding estimated from Haiyan and previous rainfall along with landslides. **GPM will enable high resolution (compared to TRMM) flood detection and mapping**.



flood.umd.edu

Adler/Wu
U. of Maryland

Courtesy: Dalia Kirschbaum, *GPM Applications Science Lead*

Home Work

Please review the presentation on **"Fundamentals of Remote Sensing"** before the next session:
https://arset.adobeconnect.com/fundrssession1/event/registration.html

Complete the following on-line Assignment by **November 15, 2015**:
https://docs.google.com/forms/d/1xDzBArgzUMsh3-JolBacWBw1I_QWZG6IrtKpkV-KDp0/viewform

Coming Up Next Week

- Overview of NASA Precipitation and Soil Moisture Data
- Live Demonstration of Precipitation and Soil Moisture Data Access

Thank You!

Amita Mehta

email: amita.v.mehta@nasa.gov