Welcome to

NASA Applied Remote Sensing Training Program (ARSET)

Webinar Series

13 November 2012 : Week-2

Introduction to Remote Sensing Data for Flood and Drought Monitoring

Course Dates: Every Tuesday, November 6 - December 4, 2012

ARSET

Applied Remote SEnsing Training

A project of NASA Applied Sciences

Announcements

- **Fourth Week of course (November 27th)**
  - There will be no 8 AM EST session
  - You will be sent a link for a recorded version
  - A limited number of seats are available for the live session at 2 pm EST. If interested in joining that session, send email to:

    marines.martins@ssaihq.com

Webinar Presentations can be found on:

http://water.gsfc.nasa.gov/webinars/

For Webinar Recording Link :

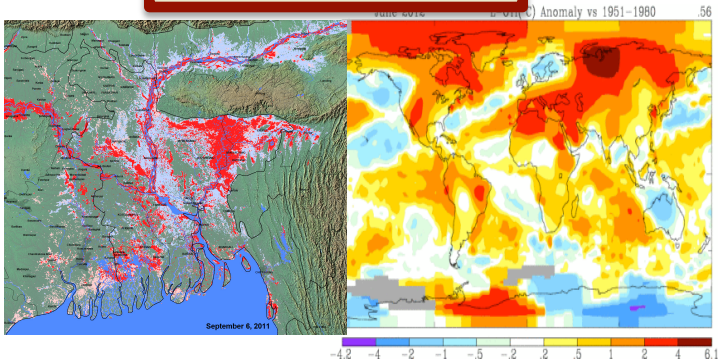
Contact : Marines Martins
Email: marines.martins@ssaihq.com

Course Outline

Week 1

Intro. & Background: Satellite Remote Sensing

Week 2

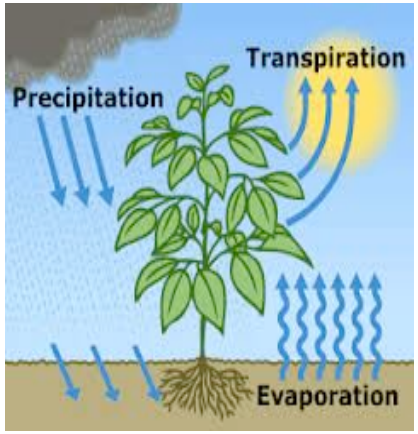


Flood and Drought [Rainfall, Weather and Climate Data]

Week 3

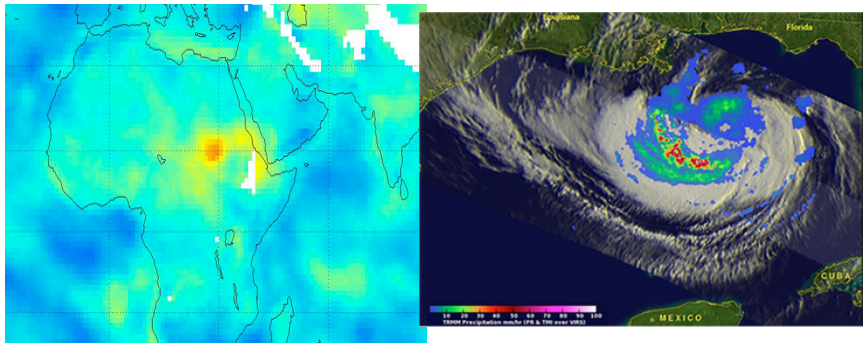
Web-tools

Week 4



Evapotranspiration

Week 5



Data Applications/ Case Studies

Week 2: Introduction to Rain, Temperature, Humidity, and Wind Data

- Useful for flood and drought monitoring – *3-hourly to decade long coverage*
- Useful as inputs to hydrology/land use models

Week 2: Introduction to Rain, Temperature, Humidity, and Wind Data

- Brief overview of satellites and sensors for rain, temperature, humidity observations
- Brief overview of model-derived temperature, humidity, and wind data
- Examples of data applications

NASA Remote Sensing/Model Quantities for Flood/Drought Monitoring

Satellite	Sensors	Quantities
TRMM	Precipitation Radar (PR) TRMM Microwave Imager (TMI) Visible Infrared Scanner (VIRS)	**Rain Rate, Vertical Rain Rate Profile, Accumulated Rain**
Terra and Aqua	MODerate Resolution Imaging Spectroradiometer (MODIS)	**Land Cover**
Aqua	Atmospheric Infrared Sounder (AIRS)	**3-dimensional Atmospheric Temperature and Humidity, Clouds**
Model		**Quantities**
MERRA		**3-dimensional Atmospheric Temperature, Humidity, Wind**

Before talking about specific satellite data you need to learn about ……..

Satellite Data Levels of Processing and Formats

Levels of Data Processing

Level 1	Source Data: L1a are raw radiance counts and L1b are calibrated radiances
Level 2	Derived geophysical variables at the same resolution and location as Level 1 source data
Level 2G	Level 2 binned data mapped on a uniform space-time grid
Level 3	Geophysical variables mapped on a uniform space-time grid in derived spatial and/or temporal resolutions

Levels of Data Processing

Level 1 Products

Orbital data

Used to produce

Level 2 Products

Orbital data

Used to produce

Level 3 Products

composites
of level 2 products

Less Processing

- More user control
- Highest spatial/temporal resolution
- Harder to use

More Processing

- Less user control
- Lower spatial/temporal resolution but gridded and may be available at multiple spatial/temporal resolutions
- More web-tools available for analysis/ access
- Easier to use

Rain

NASA Rain Data Sources

- Global Precipitation Climatology Project (GPCP)

- Tropical Rainfall Measuring Mission (TRMM) satellite observations

The TRMM Multi-satellite Precipitation Analysis (TMPA): Quasi-Global, Multiyear, Combined-Sensor Precipitation Estimates at Fine Scales

NASA Rain Data : GPCP
http://precip.gsfc.nasa.gov/

National and international multiple satellites and surface rain gauge measurements merged together:

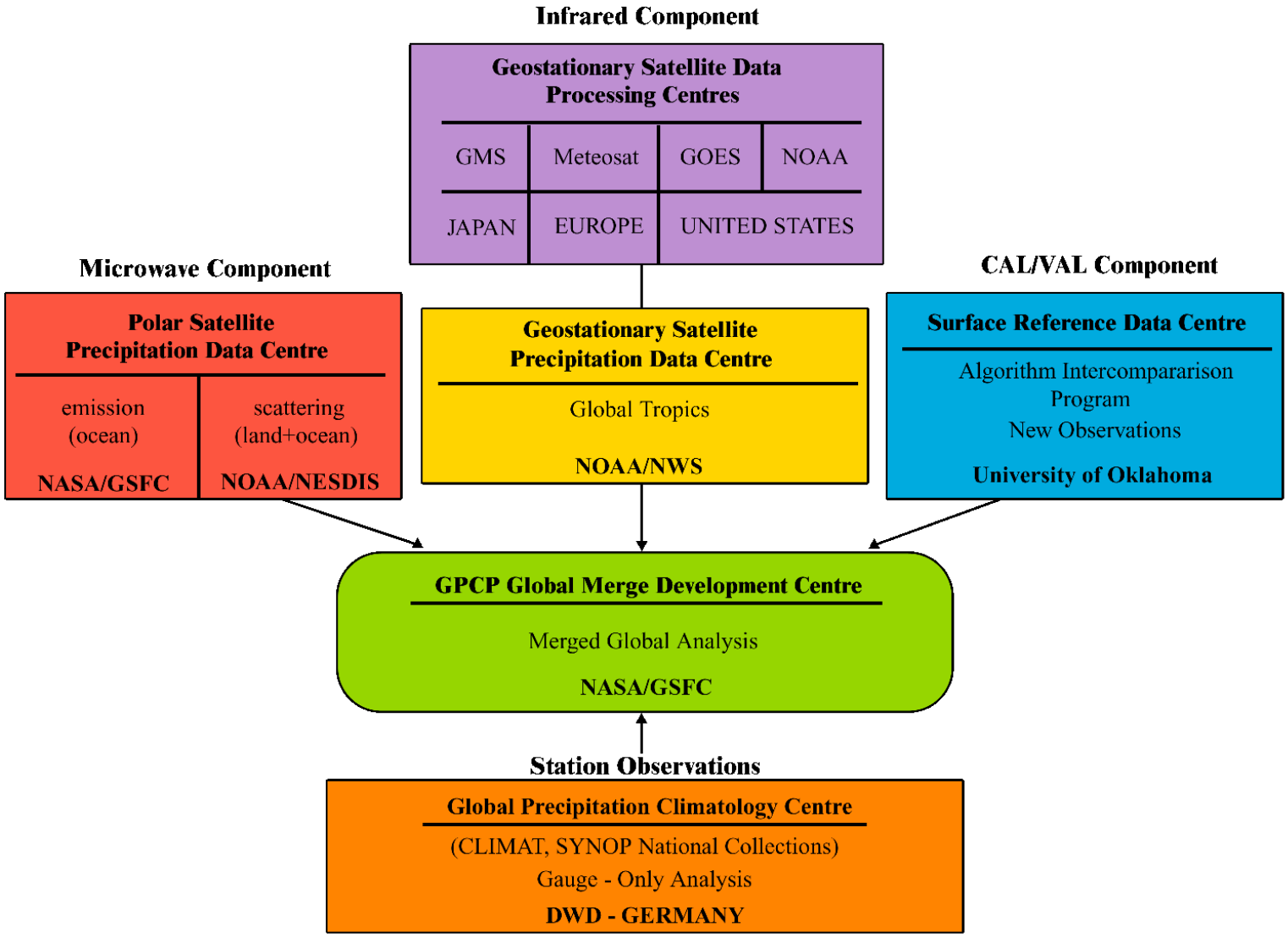
- **Rain measurements from over 6,000 global rain gauge stations**

- **Rain retrievals from satellites**: geostationary and low-orbit infrared, passive microwave, and infrared sounding observations

Spatial Resolution:	2.5°x2.5° latitude-longitude
Spatial Coverage:	Global
Temporal Resolution:	Daily, Monthly
Temporal Coverage:	1979-present

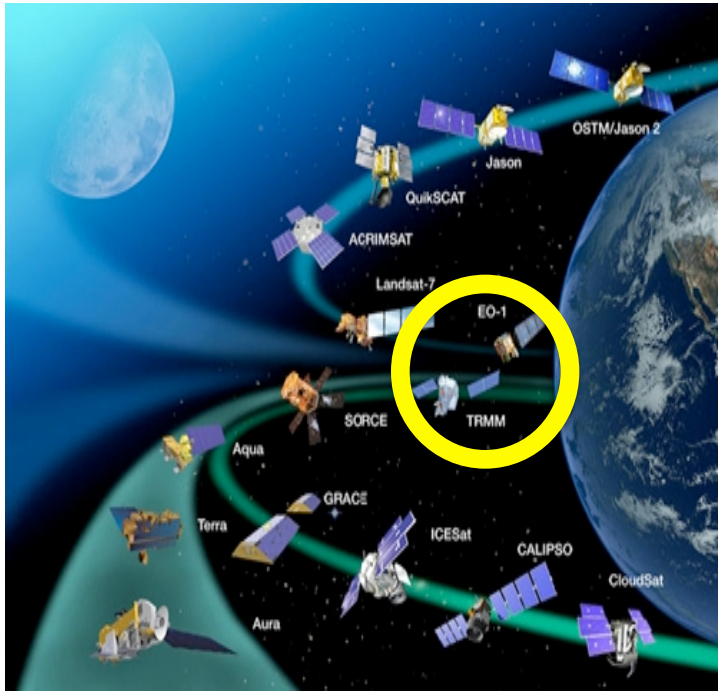
NASA Rain Data : GPCP

For Large-scale and Climate Applications



TRMM: Tropical Rainfall Measuring Mission
http://trmm.gsfc.nasa.gov

- The first satellite mission **dedicated to measuring tropical and subtropical rainfall** - Launched on 27 November 1997
- First satellite to carry a microwave Precipitation Radar
- Predecessor to Global Precipitation Measurement (GPM) mission to be launched in 2013-14.



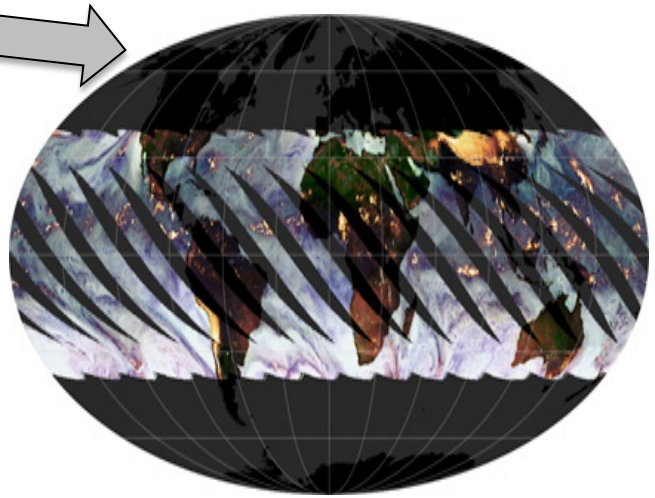
TRMM

- A non-polar, low inclination orbit
  Revisit time ~11-12 hours, but time of observation changes daily

- One active and two passive rain sensors

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

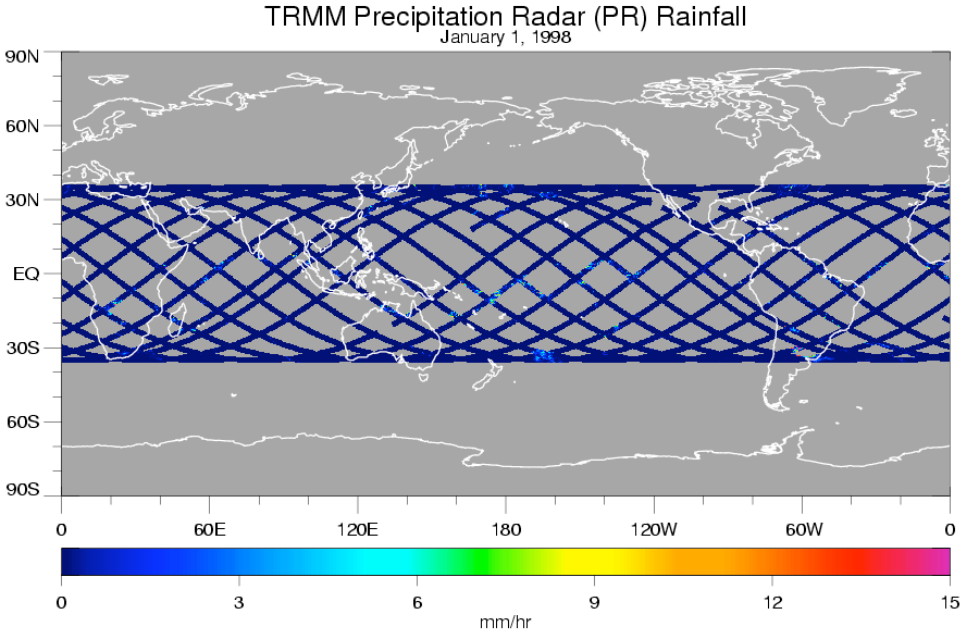
- Multiple rain products available from individual sensors, at varying spatial resolutions, (details given in Appendix)

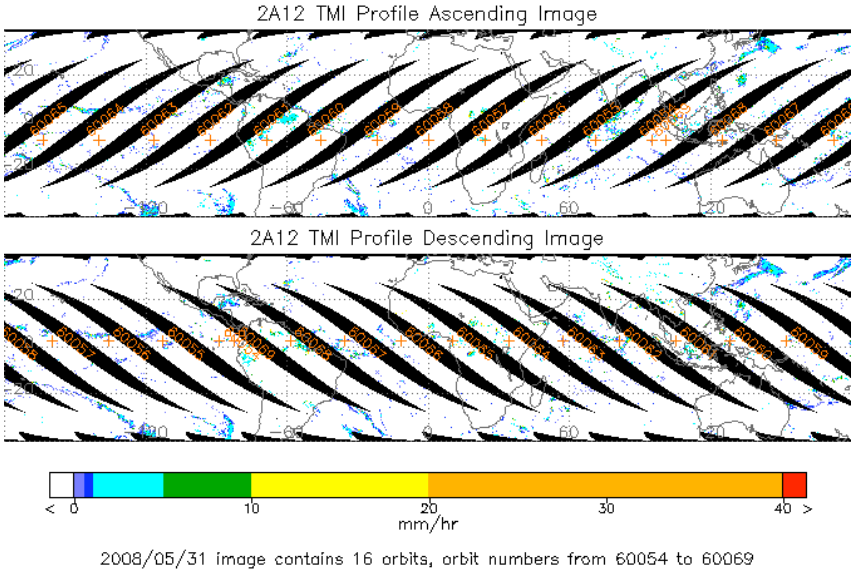


There are 16 TRMM orbits a day **covering global tropics between 35° S to 35°N latitudes**

Altitude - of approximately 350 Km, raised to 403 Km after 23 August 2001

TRMM PR and TMI Rain Data





PR: Swath = 220 km (247 km)
Pixel Size: 5 km

TMI: Swath = 760 km (870 km)
Pixel Size : 5 to 45 km
(channel-dependent)

Strength: High pixel resolution, Accurate measurements
Limitation: No global coverage on daily basis

TRMM Multi-satellite Precipitation Analysis (TMPA)

Product Name 3B42

(Used for flood/drought monitoring applications)

TRMM 3B42:

Combines PR and TMI rain rates

Inter-calibrates passive microwave rain rates from **SSM/II, AMSR** and **AMSU-B** satellite sesors

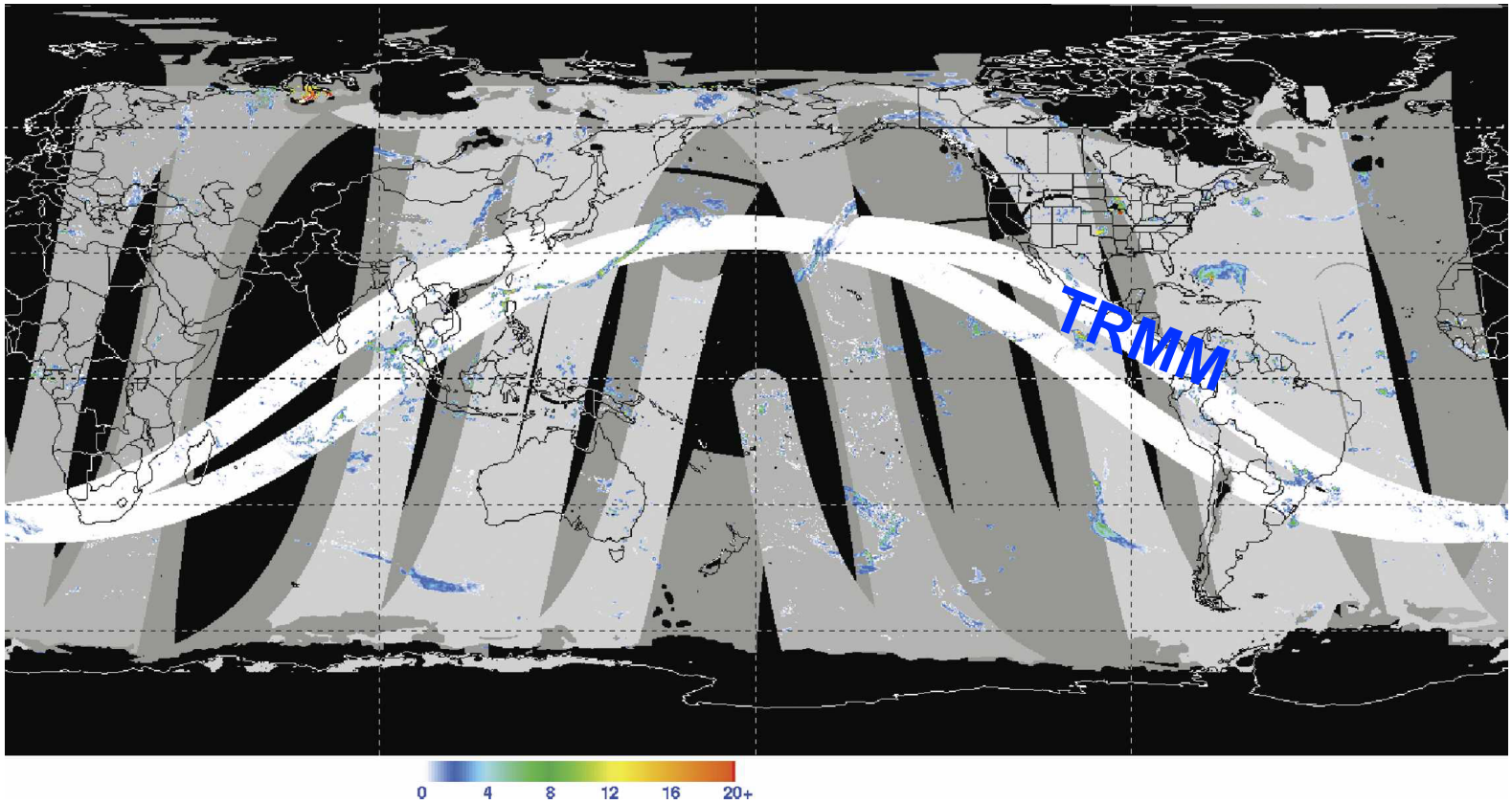
Inter-calibrates with national and international **geostationary and NOAA low earth orbiting satellites infrared measurements** by using **VIRS**

Final rain product is calibrated with rain gauge analyses on a monthly time scale.

SSM/I: Special Sensor Microwave Imager
AMSR: Advanced Microwave Scanning Radiometer
AMSU: Advanced Microwave Sounding Unit

The TRMM Multi-satellite Precipitation Analysis (TMPA) Combined Microwave Estimates

(From Huffman et al. 2006, J. of Hydrometetorology)



Combined microwave precipitation estimate for the 3-h period centered at 0000 UTC 25 May 2004 in mm/h h1. Blacked-out areas denote regions that lack reliable estimates

TMPA uses accurate PR/TMI rain rates to calibrate rain rates from other sensors to essentially increase temporal resolution from 12 hours to 3 hours

TRMM TMPA Surface Rain Rate Data

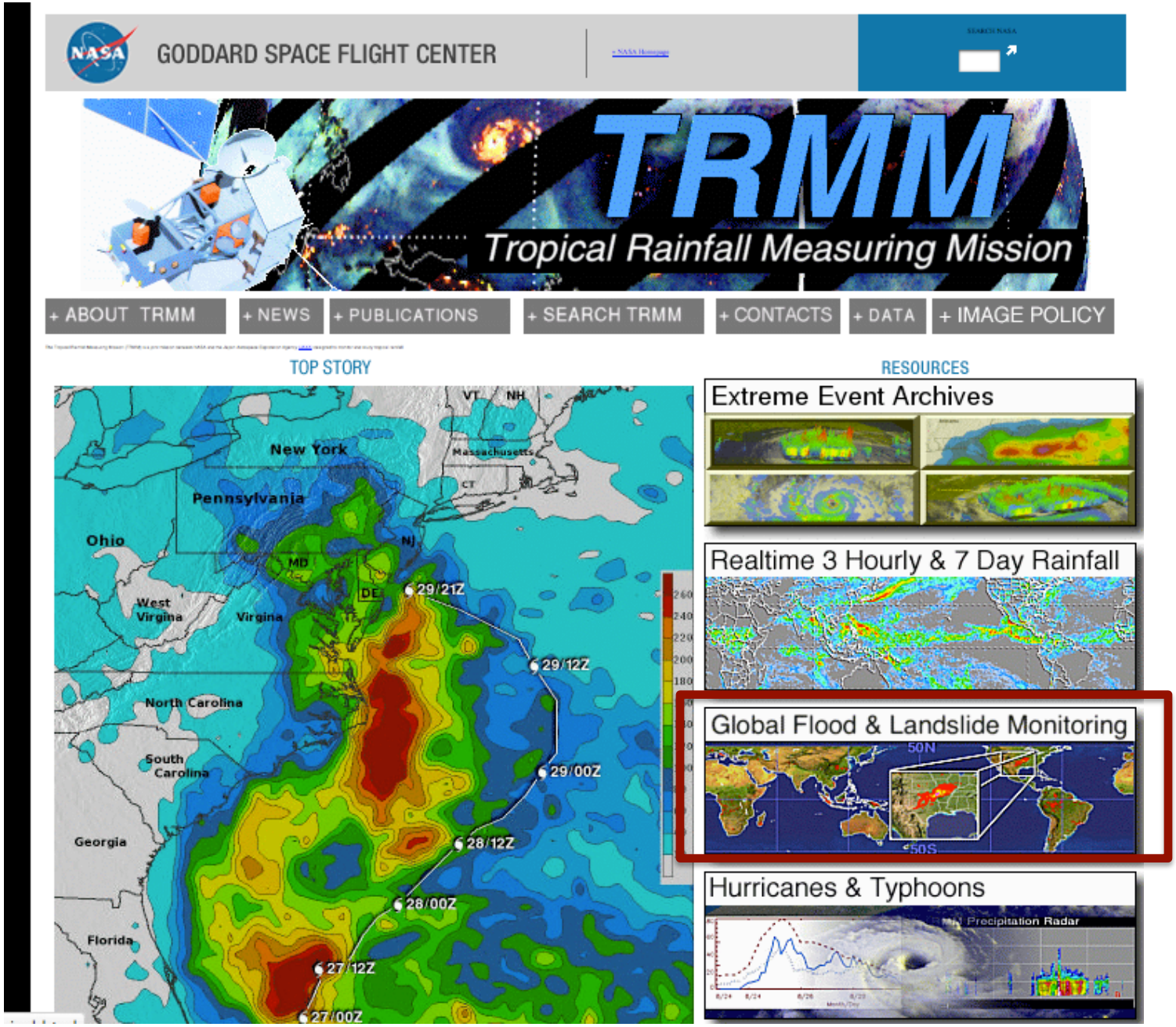
TRMM 3B42RT : Near-Real Time

TRMM 3B42 : Adjusted with surface rain gauge measurements on monthly basis

Spatial Resolution: 0.25°x0.25° latitude-longitude
Spatial Coverage: 50° S to 50° N, Global
Temporal Resolution: 3-hourly,Daily,
Temporal Coverage: 1998 to present

TRMM 3B43 : Monthly Mean

http://pmm.nasa.gov/TRMM



TRMM Rainfall Data Applications

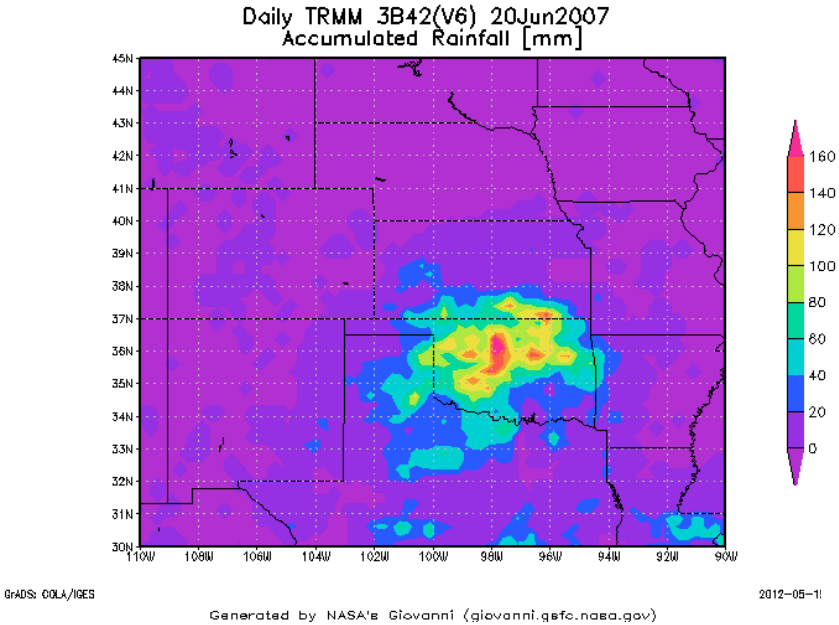
- Monitor near-real time rainfall – including extreme rain events
- Monitor regional wet/dry periods
- Input/forcing to hydrological models that are used in many applications, such as for example mapping flood and landslide potential

TRMM Applications: Monitoring extreme rain events and seasonal variability

TRMM Monitoring of Extreme Weather

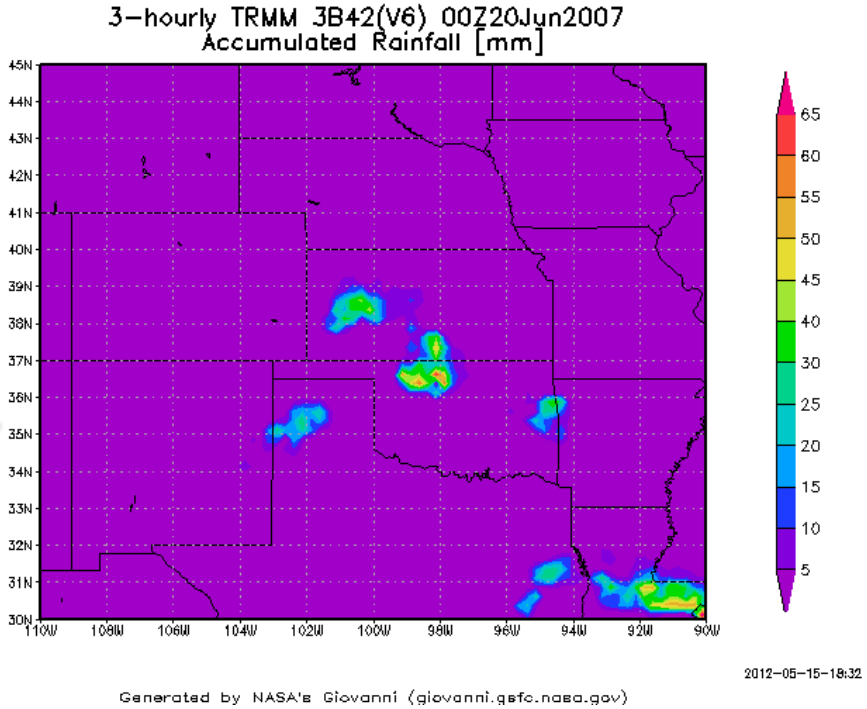
Analysis and visuals created by using the NASA Giovanni web-tool

http://disc.sci.gsfc.nasa.gov/giovanni/overview/index.html



Extreme Rain Event of June 20, 2007

3-hourly Rainrate



Floods paralyze Manila (Philippines)

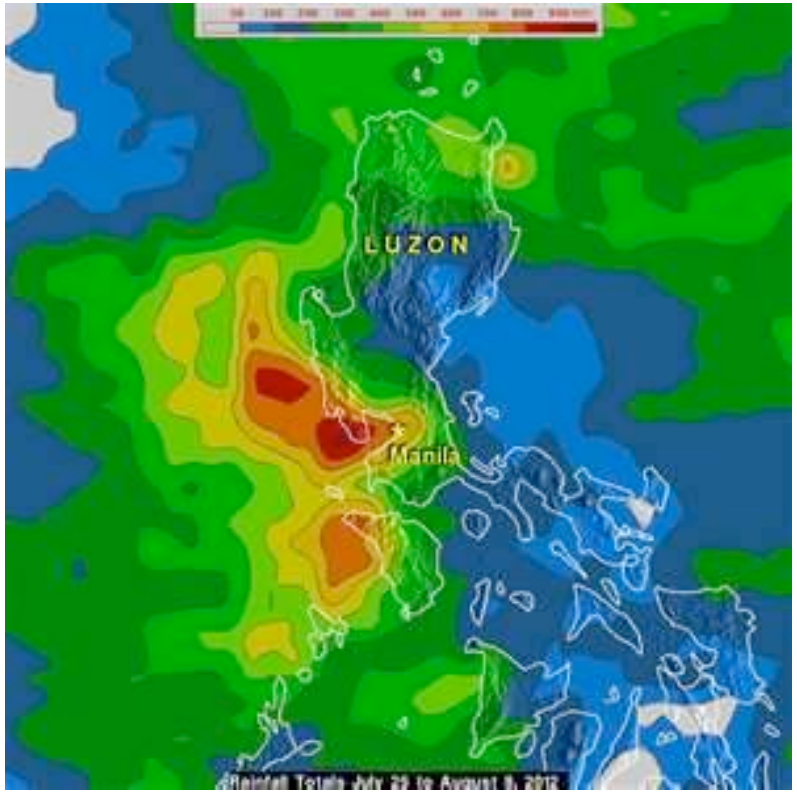
BBC's Kate McGeown: "Roads have been turned into rivers"

At least nine people have been reported dead as torrential rain caused flooding that paralysed most parts of the Philippine capital, Manila.

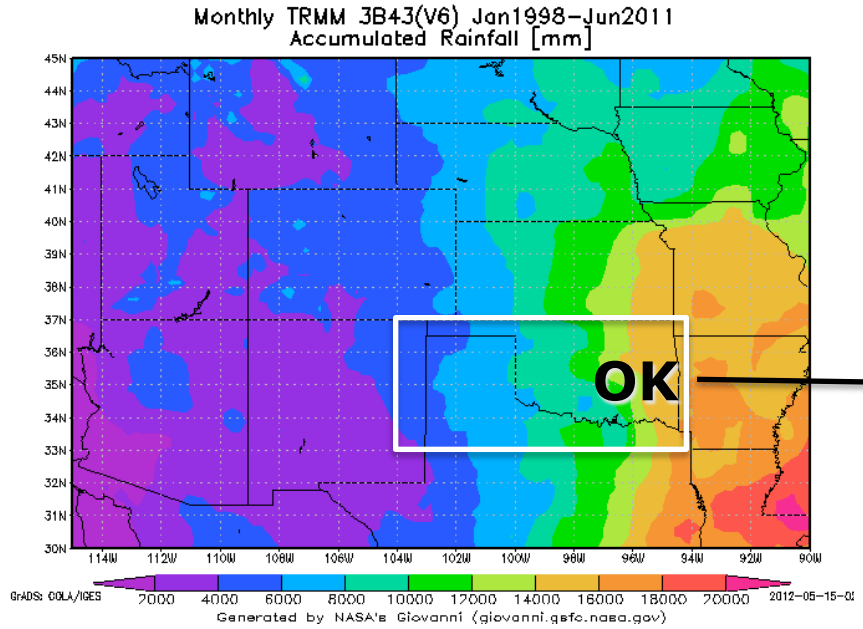
Monsoon, Tropical Cyclones Bring Massive Flooding to Manila

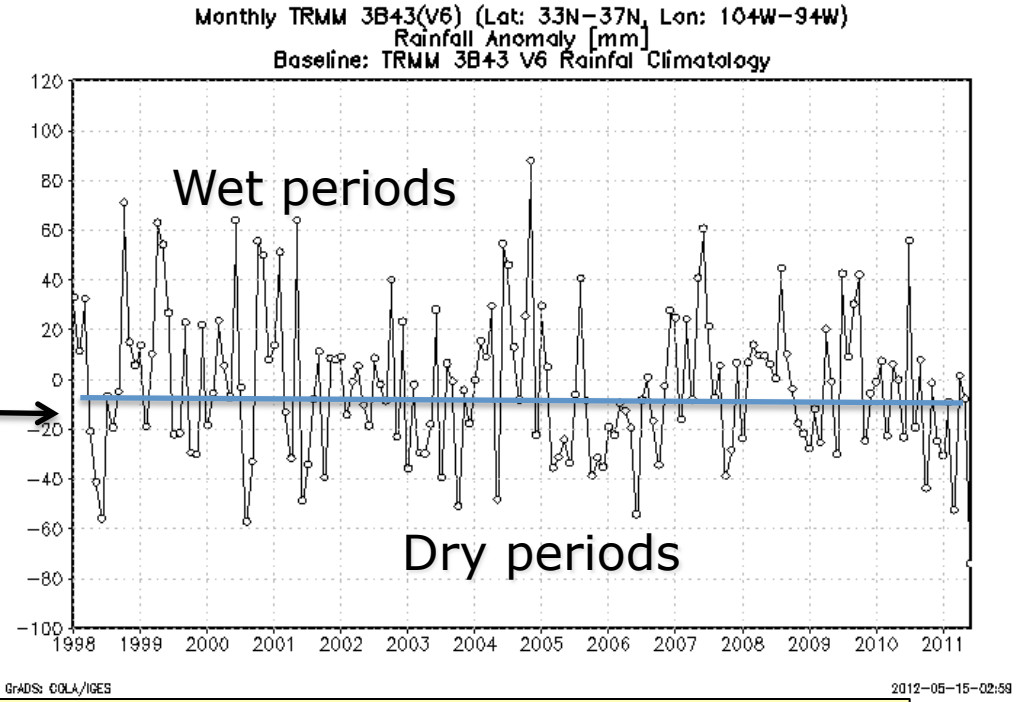
From: http://pmm.nasa.gov

TRMM Rainfall Amount
25 July - August 9, 2012

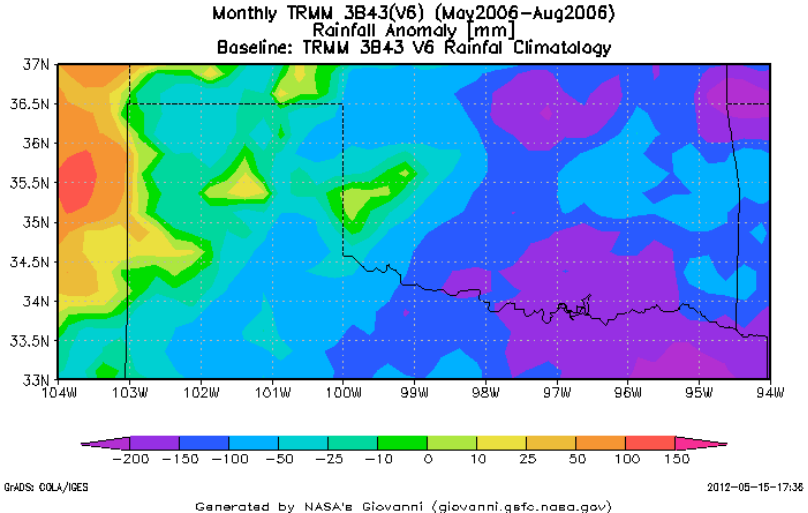


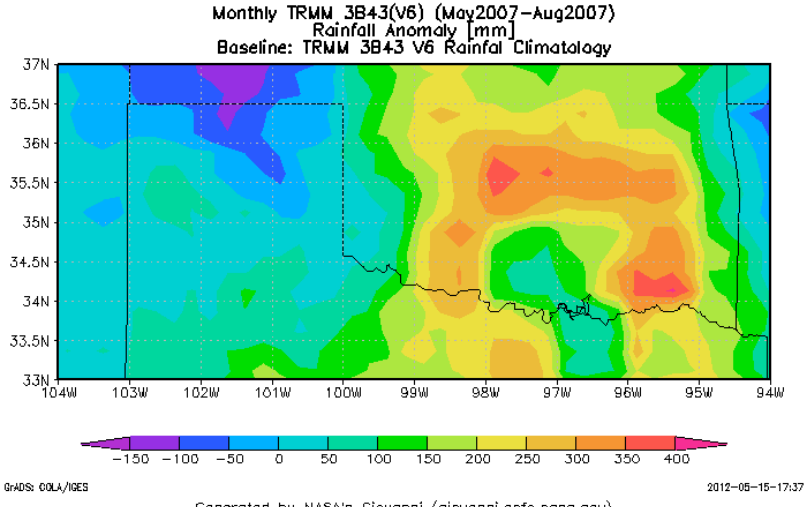
TRMM Data for Dry/Wet Seasonal Monitoring





Anomalies are defined as deviation from long-term average values





TRMM Applications: Hydrological Modeling

CREST: A Distributed Hydrologic Model designed to take advantage of 4-D remote sensing data: Used at Global or Regional Projects

Wang and Hong et al. 2011

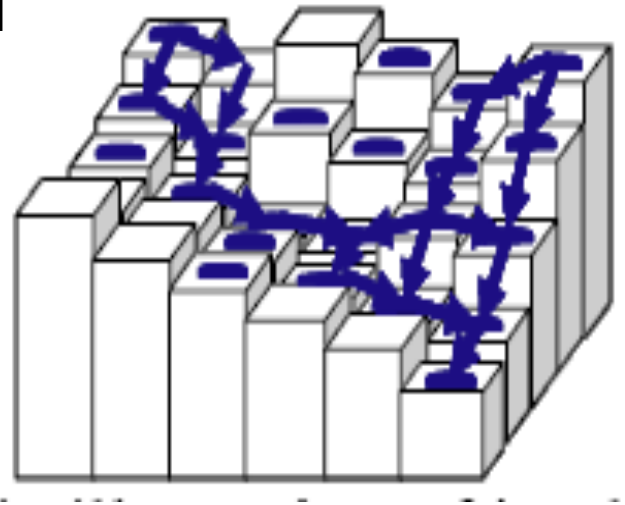
Coupled Routing and Excess STorage (CREST):

- Three soil layers.
- Distributed, fully coupled runoff generation and routing model
- Simulates water and energy fluxes and storage on a regular grid

2 Forcings
17 Parameters
9 Outputs

Spatial Resolution 1 km

Cell-to-Cell Flow Routing



Step I: Rainfall-infiltration Partitioning (distributed and time-variant)

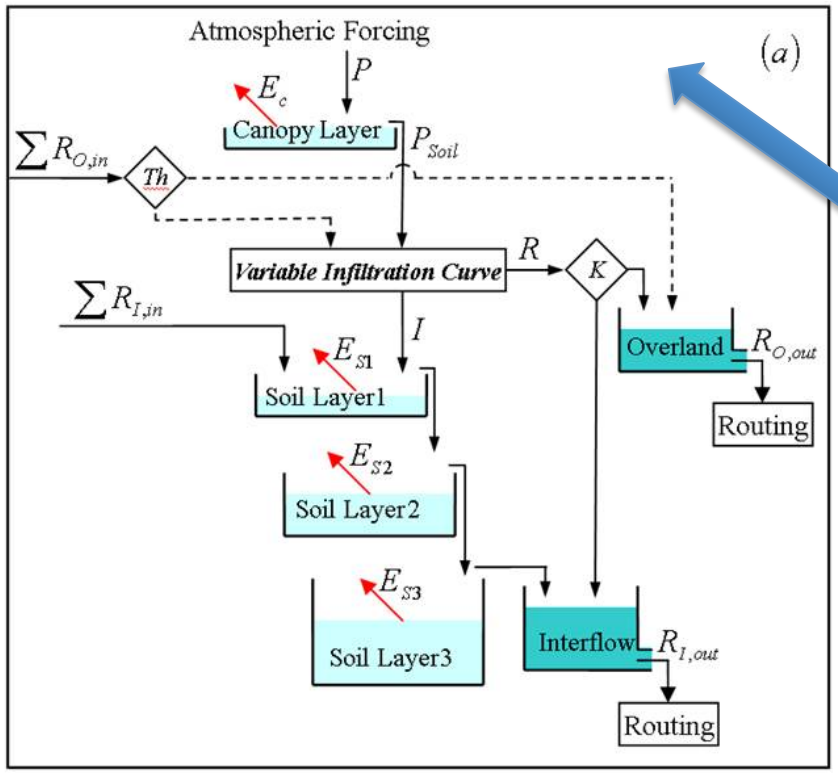
Step 2: Flow Routing using Macro-scale Cell-to-Cell Algorithm

Step 3: Grid Point Hydrographs--Flood Inundation Mapping

From: J. J. Gourley, University of Oklahoma

CREST Hydrology Model Forcing Data: Satellite TMPA RT and Forecast

CREST



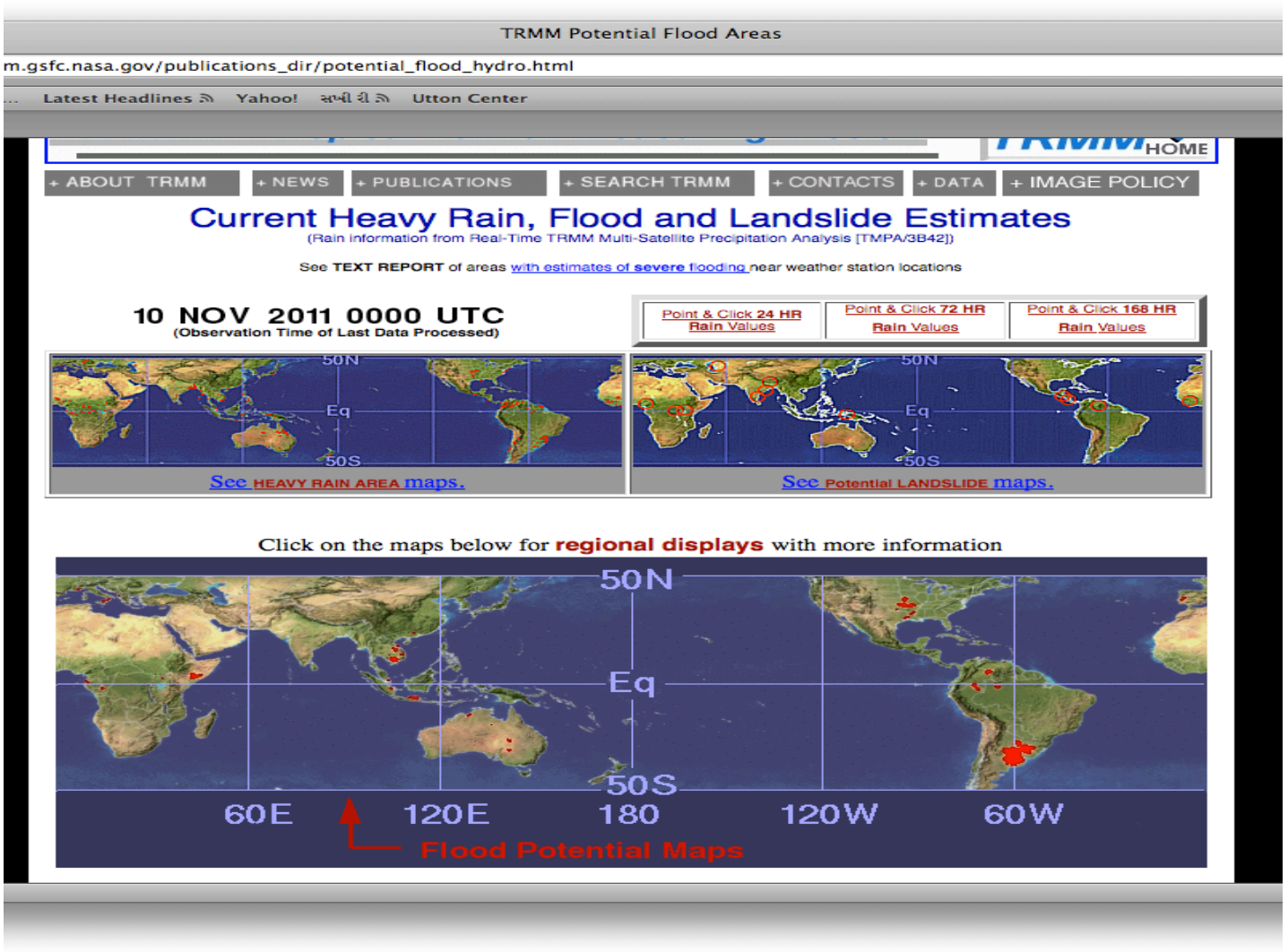
Atmospheric Forcing for CREST

1. **TMPA 3B42RT**
2. NCEP Global Ensemble Forecast System (1-5 day forecast)
3. NASA GEOS-5 (1-5 day forecast)
4. Regional: WRF 1-5 day Forecast

From: J. J. Gourley, Universit of Oklahoma

TRMM Near-real Time Flood and Landslide Information Tool

(http://trmm.gsfc.nasa.gov/publications_dir potential_flood_hydro.html)



Based on the CREST Hydrological Model

SERVIR-Africa Flood Warning System (funded by USAID/NASA)

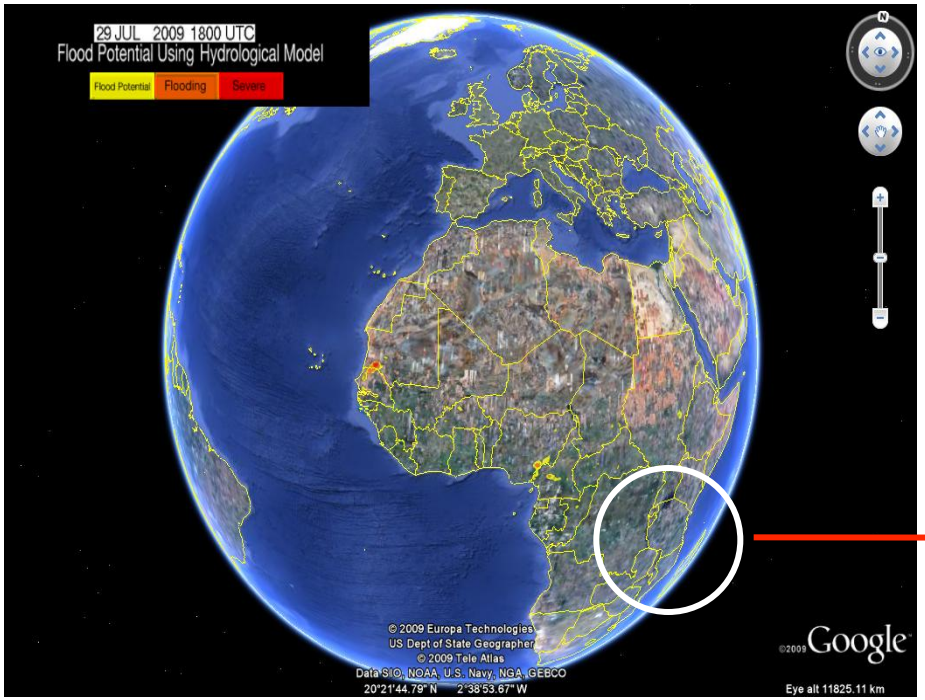
https://www.servirglobal.net/

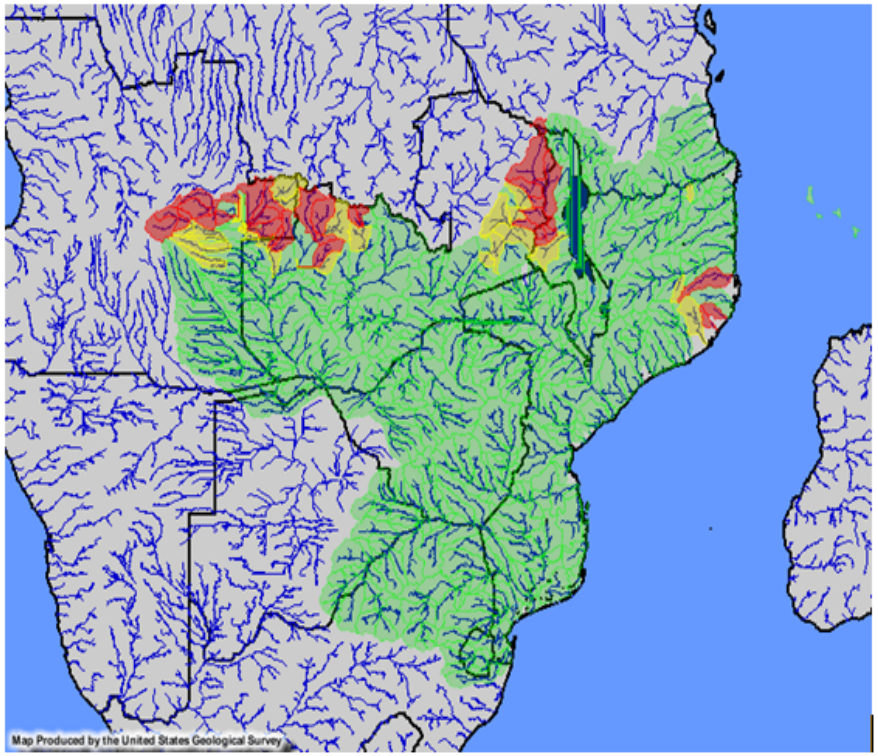
Color-coded Flood Prediction by the OU-NASA distributed CREST Model

Green: safe (Go)

Red: No Go

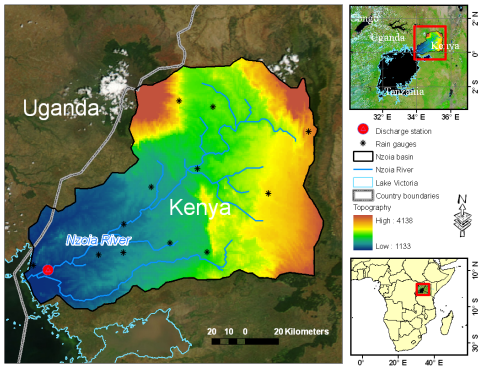
Yellow: Watch



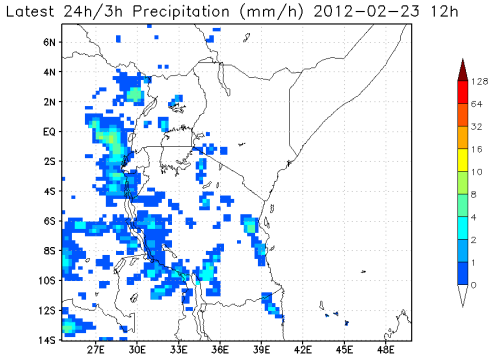


From: J. J. Gourley, Universiyt of Oklahoma

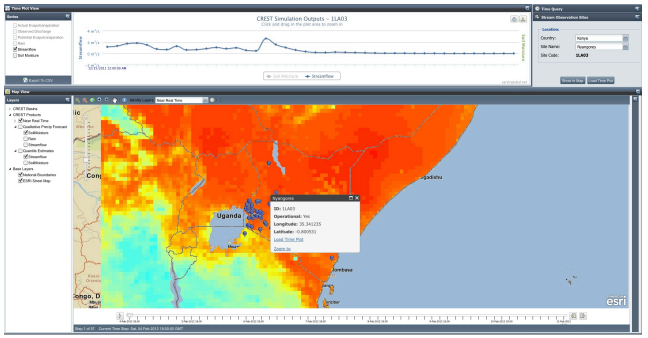
Hydrologic Model CREST Developed for Single Watershed in Kenya



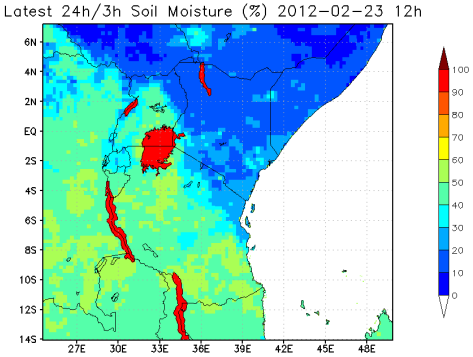
Near Real Time NASA Satellite Rainfall Data



Engaged Kenya Department of Water Resources to help monitor floods

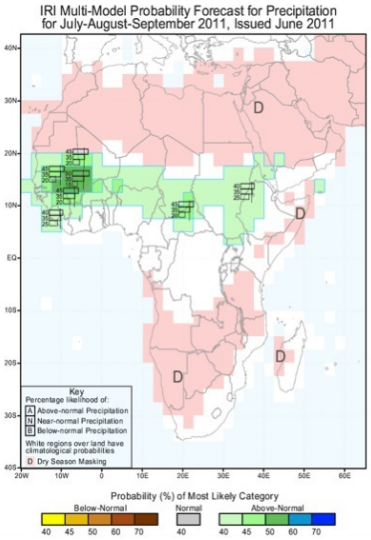


Soil Moisture

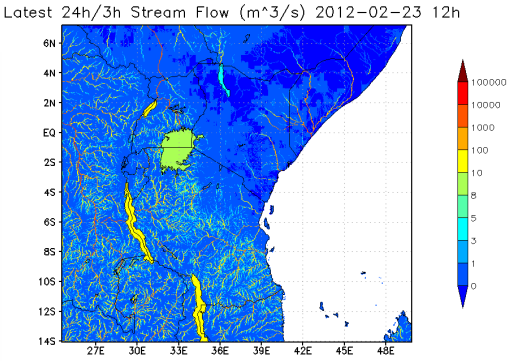


Hydrologic Modeling in East Africa with Active Engagement with End Users

Working on seasonal hydrologic forecasts at the request of Kenya and Tanzanian Ministries of Water Resources



Training and Capacity Building

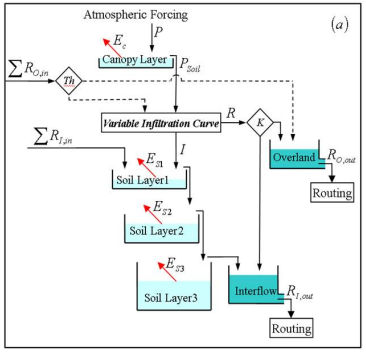


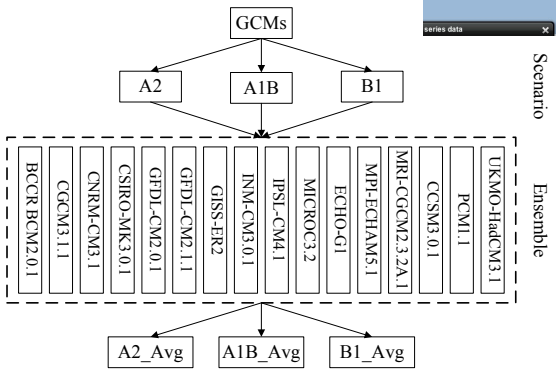
Real Time, Historic and Seasonal Streamflow

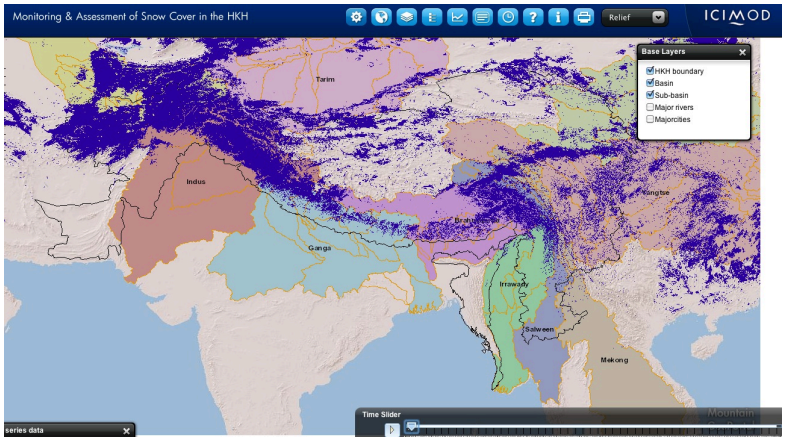
From: Dan Irwin (SERVIR)

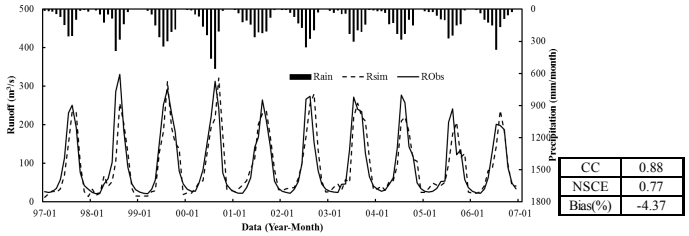
From: Dan Irwin (SERVIR)

Satellite Derived Snow Cover Datasets help Decision Makers with Real time snowpack conditions



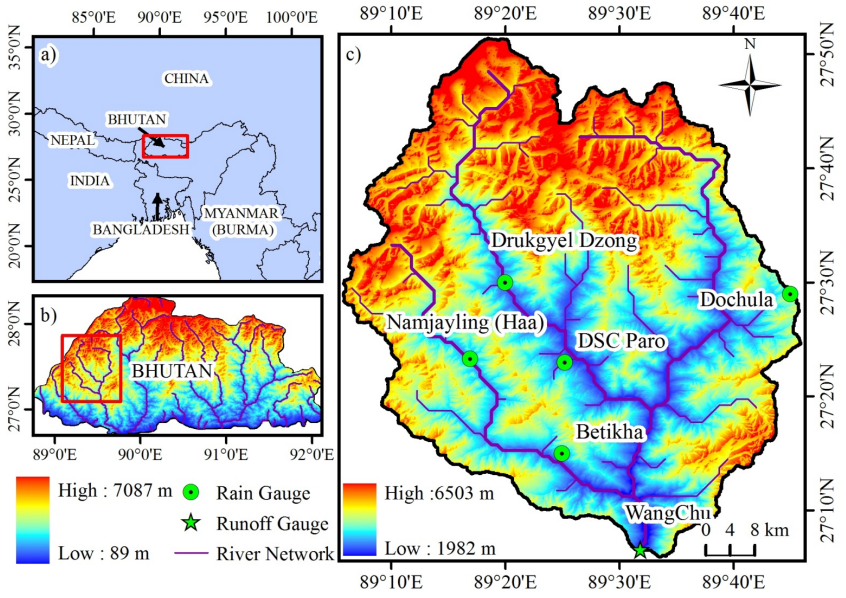


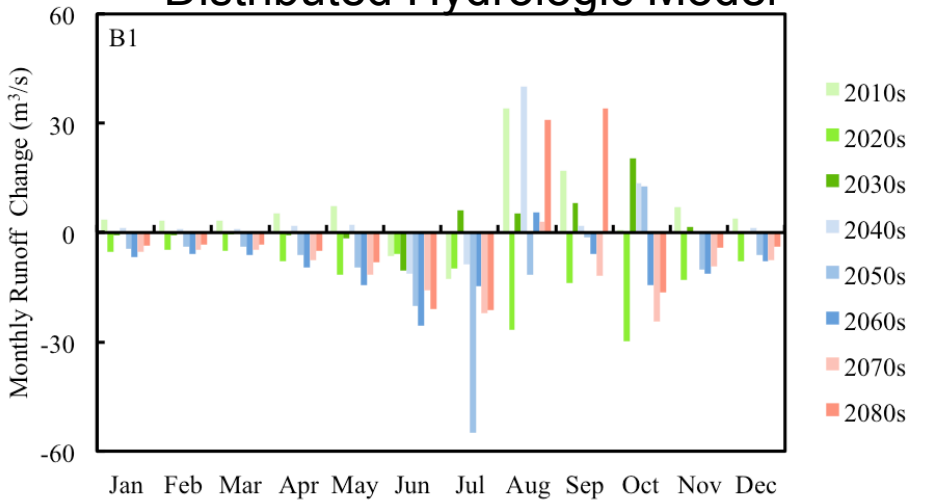




CC	0.88
NSCE	0.77
Bias(%)	-4.37

Bhutan Water Resource Assessment using IPCC Climate Change Scenarios and a Distributed Hydrologic Model

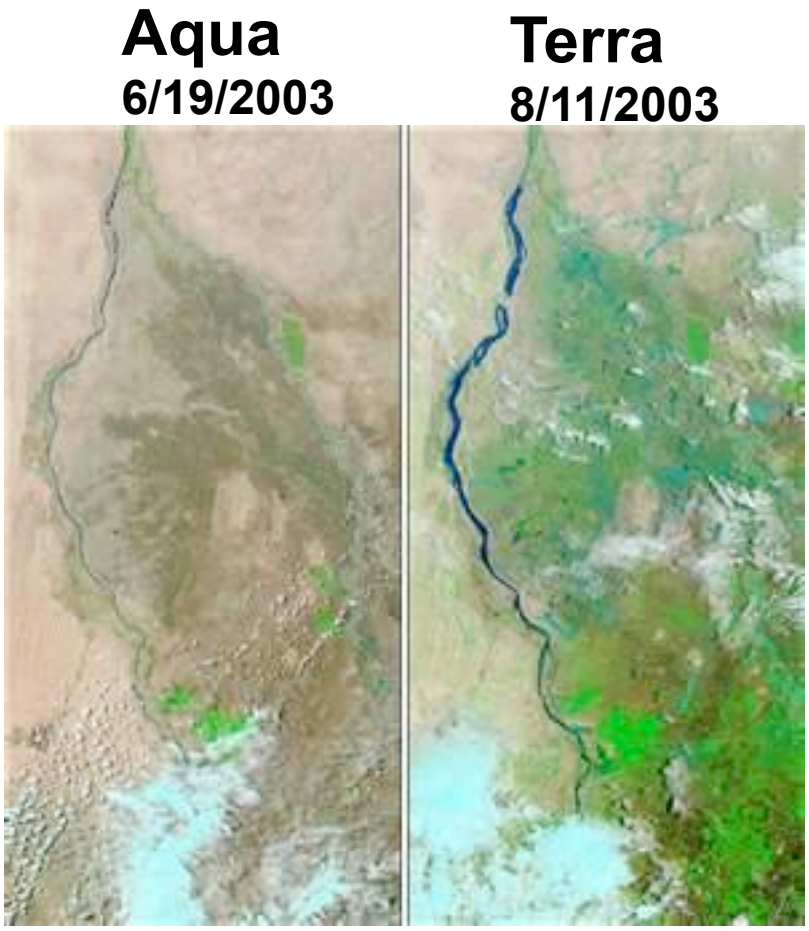




MODIS Applications: Flood Mapping

MODerate Resolution Imaging Spectroradiometer (MODIS)
http://modis.gsfc.nasa.gov

- Flying on-board Terra and Aqua – polar orbiting satellites
- Global measurements, 2 times per day
- 36 spectral bands observing atmosphere, ocean, and land properties
- Measurement footprints vary from about **250 m to ~1 km**



Flooding along the White **Nile**, Sudan
From : Natural Hazards
earthobservatory.nasa.gov

MOSDIS Data for Inundation Mapping

MODIS Data:

Reflectance in Optical Bands 1, 2, and 7

Spatial Resolution:	250 m x250m
Spatial Coverage:	Global
Temporal Resolution:	Daily, 8-day, 16-day
Temporal Coverage:	1998 to present

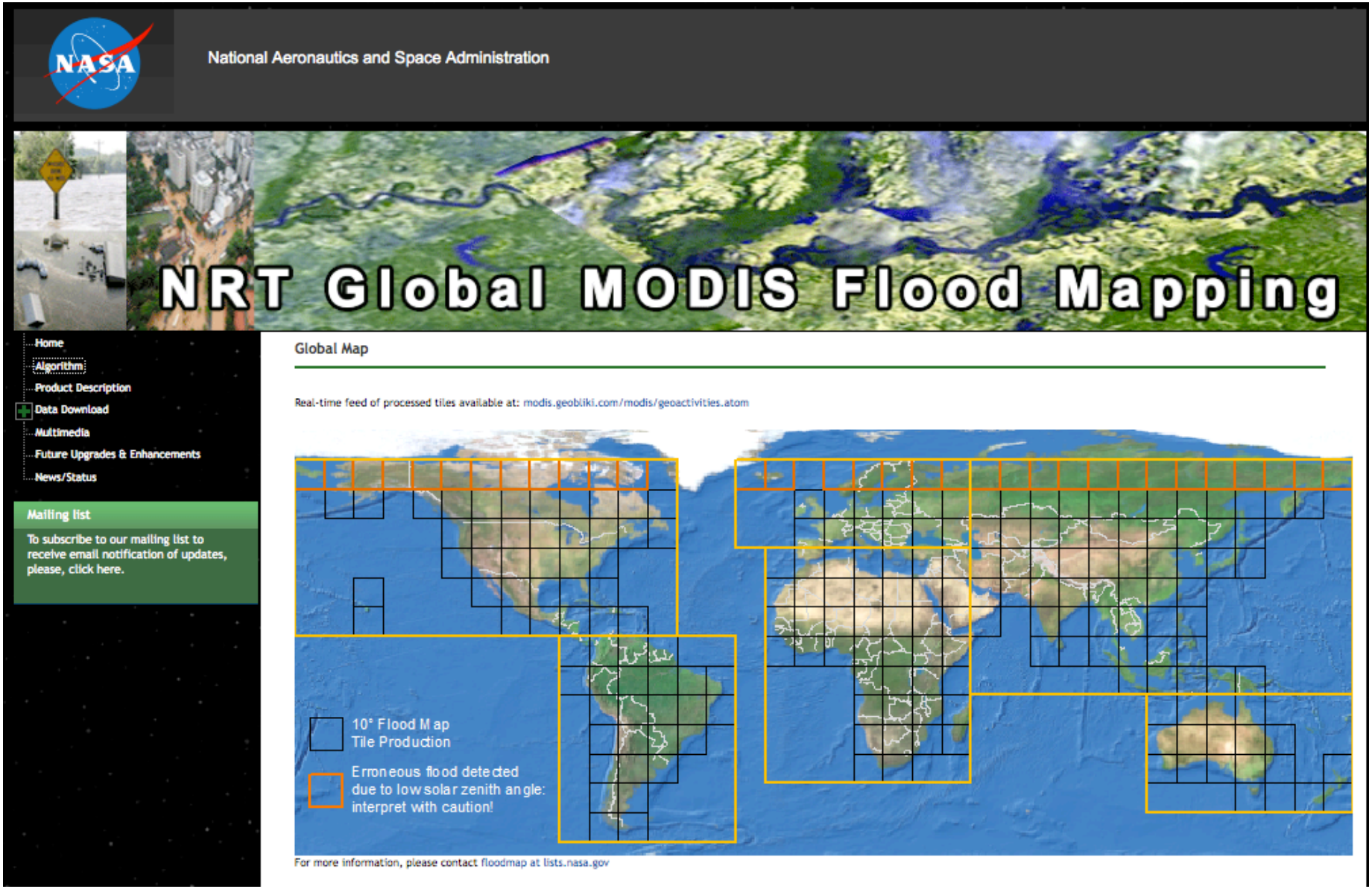
Note: MODIS also provides observations of vegetation indices

Strength: Globally consistent

Limitation: Data can not be retrieved when clouds are present

MOSDIS Data for Inundation Mapping

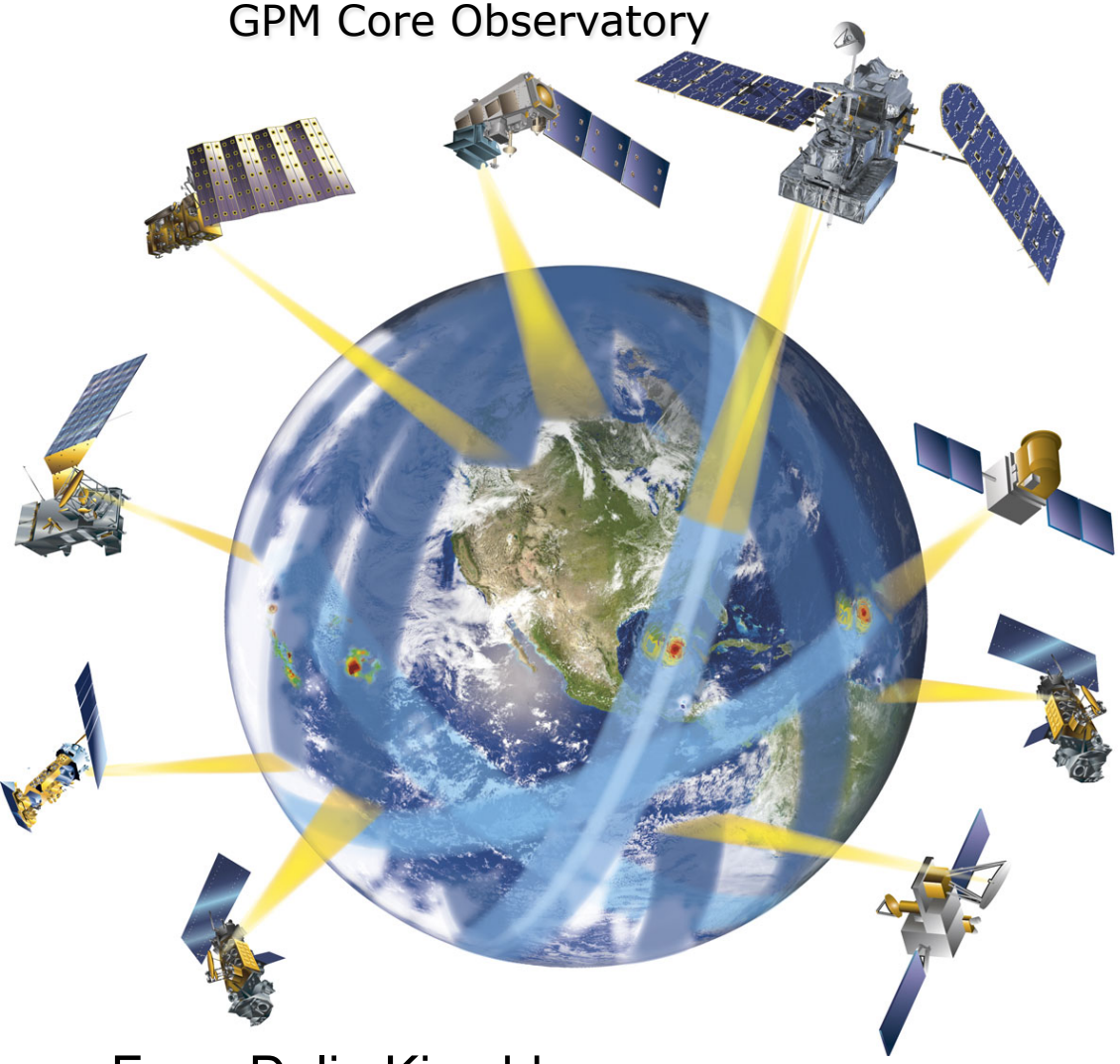
http://oas.gsfc.nasa.gov/floodmap/



Future NASA Mission for Precipitation Remote Sensing

Global Precipitation Measurement (GPM) Mission

GPM Core Observatory



GPM is an international mission co-led by NASA and JAXA and will use inputs from an international constellation of satellites to provide improved space and time coverage of precipitation (rain, snow) over the globe

Launch: February, 2014
Launch site: Japan

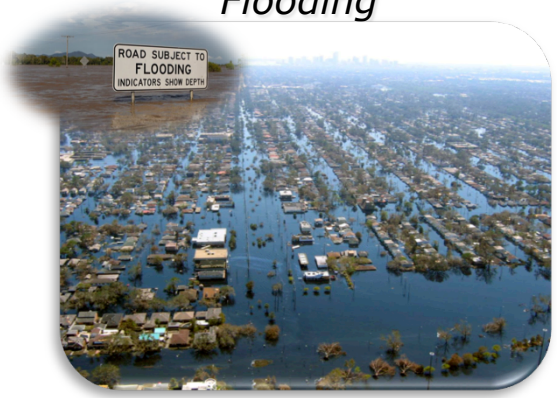
http://gpm.nasa.gov

From Dalia Kirschbaum

Why Global Precipitation Measurement?

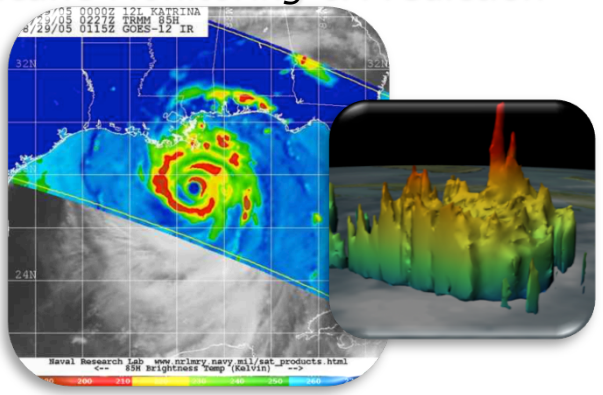
[From Dalia Kirschbaum]

Flooding

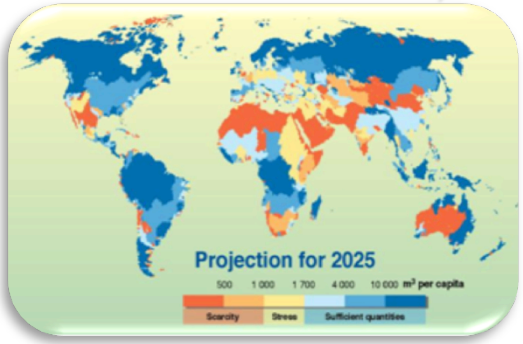


Landslides

Hurricane Monitoring & Prediction



Freshwater Availability



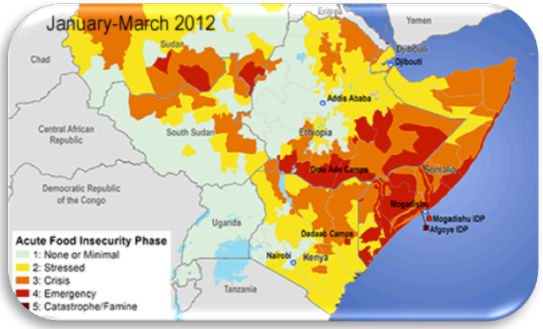
Extreme Snow Events

Global observations of precipitation every three hours at a 10 km spatial resolution.

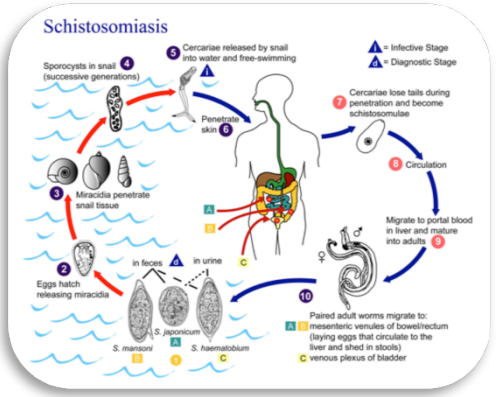
The rain and snow data will extend our capabilities to study a wide range of applications for scientific research and societal benefit.

http://pmm.nasa.gov

Agriculture/Famine Early Warning



World Health



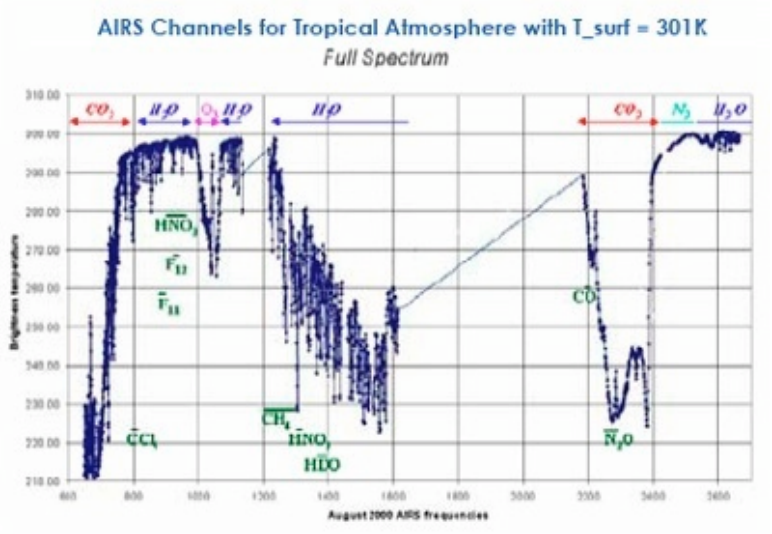
Temperature and Humidity

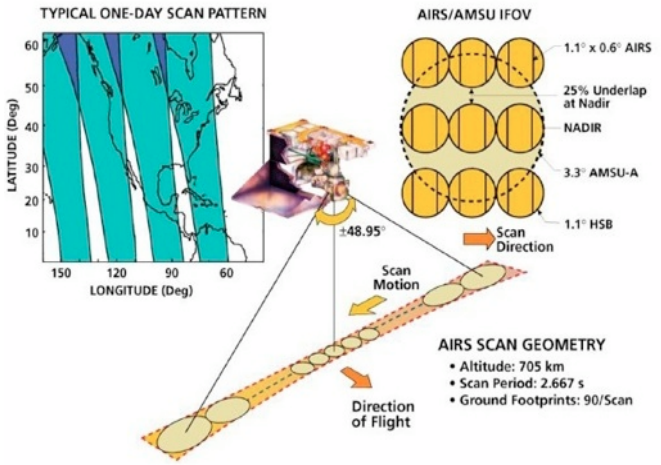
NASA Temperature and Humidity Data Sources

- Aqua/AIRS
- MERRA Atmospheric Model

Atmospheric Infrared Sounder (AIRS)
http://airs.jpl.nasa.gov/

- Flying on-board Aqua – polar orbiting satellite, launched on July 2002, in 705 km orbit.
- Global measurements, 2 times per day.
- Cutting-edge infrared technology with 2378 spectral bands in 0.5 to 15 micron wavelength.
- Measurement footprints vary from about **2.5 km to 40 km**
- Used in combination with AMSU and HSB (Humidity Sounder Brazil)





AIRS Temperature and Humidity

AIRS/AMSU Standard Data products:

Surface skin and Air Temperature
Temperature Profile
Humidity (Water Vapor) Profile
Column-integrated Water Vapor (Precipitable Water)
Cloud Cover and Height

Spatial Resolution:	50 kmx50 km and 1°x1° latitude-longitude
Spatial Coverage:	Global
Temporal Resolution:	Daily, 8-day mean, Monthly
Temporal Coverage:	2002 to present

Strength: Globally consistent, multiple atmospheric parameters

Limitation: Data can not be retrieved when clouds are present

Modern Era Retrospective-analysis for Research and Applications: MERRA

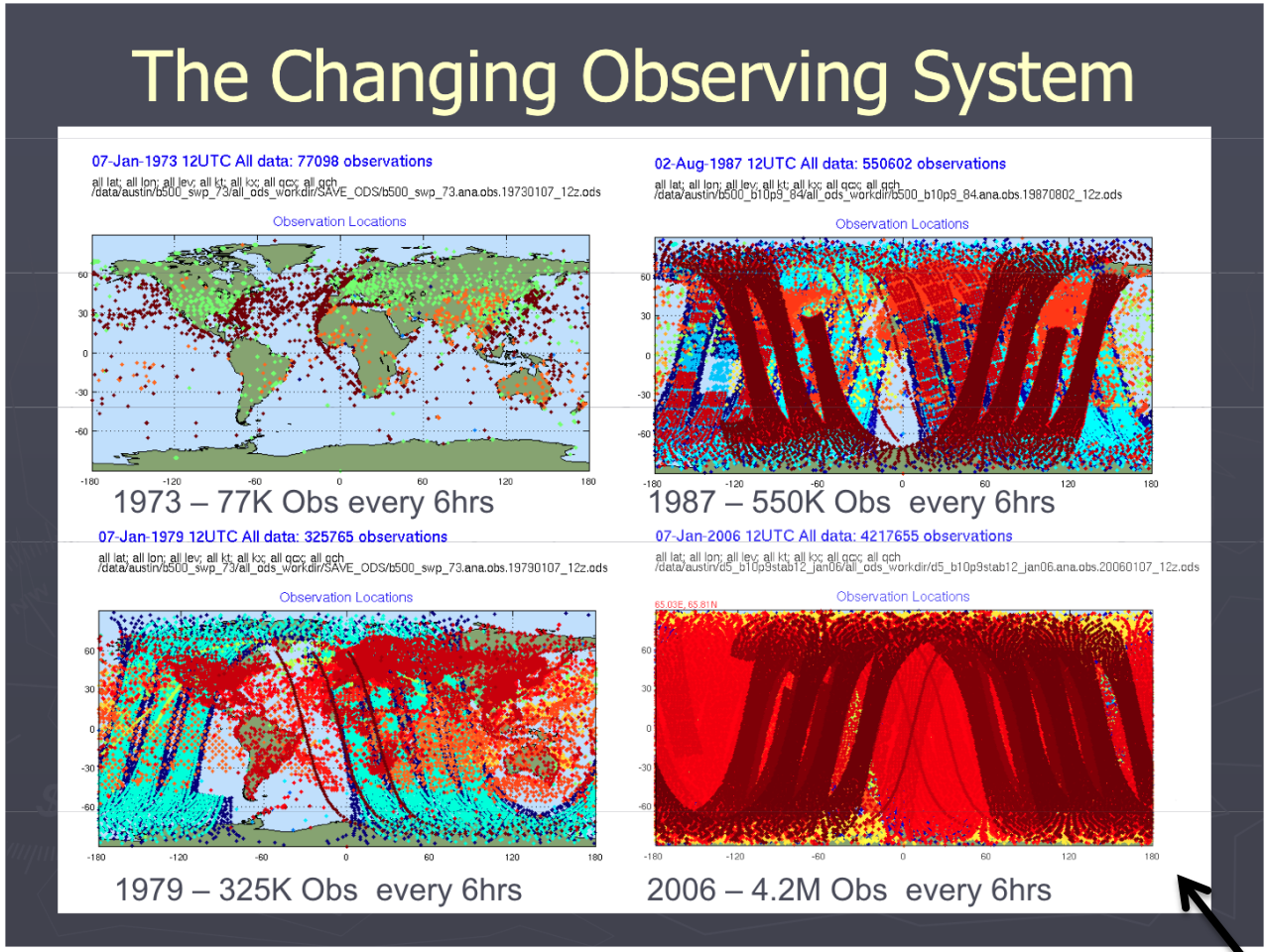
http://gmao.gsfc.nasa.gov/merra/

- Merges remote sensing and in-situ observations with the latest Earth systems models

- Weather, climate, climate variation for both research and applied decision making

MERRA

- Blends the vast quantities of observational data with output data of the Goddard Earth Observing System (GEOS) model [**1979-present**]



Current satellite coverage assimilated in MERRA

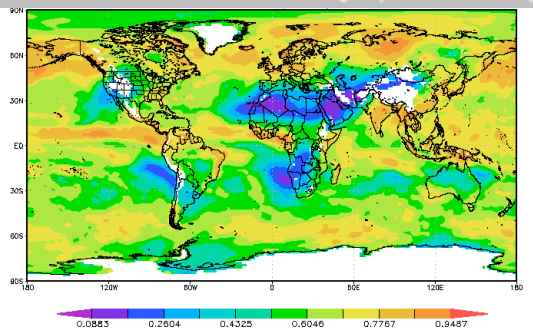
From: Michael Bosilovich, NASA-GSFC-GMAO

MERRA Reanalysis

- **Strength** – The processed data are globally continuous in space and time, and provide meteorological and climatological relevant fields

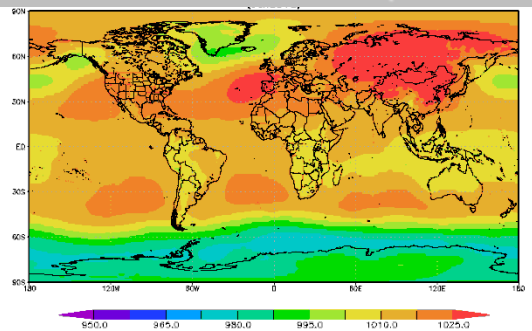
- **Weakness** – Earth system models represent the human knowledge of how the world works

Relative Humidity (fraction)

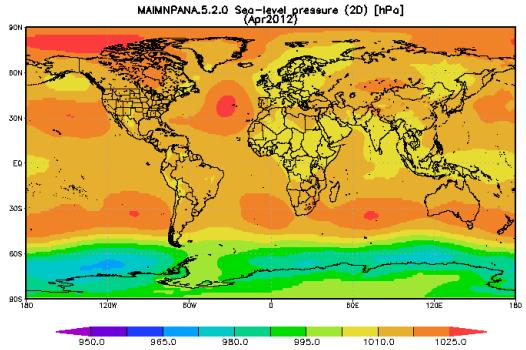


July 2011
(850 hPa)

Sea Level Pressure (hPa or mb)



January
2012



April
2012

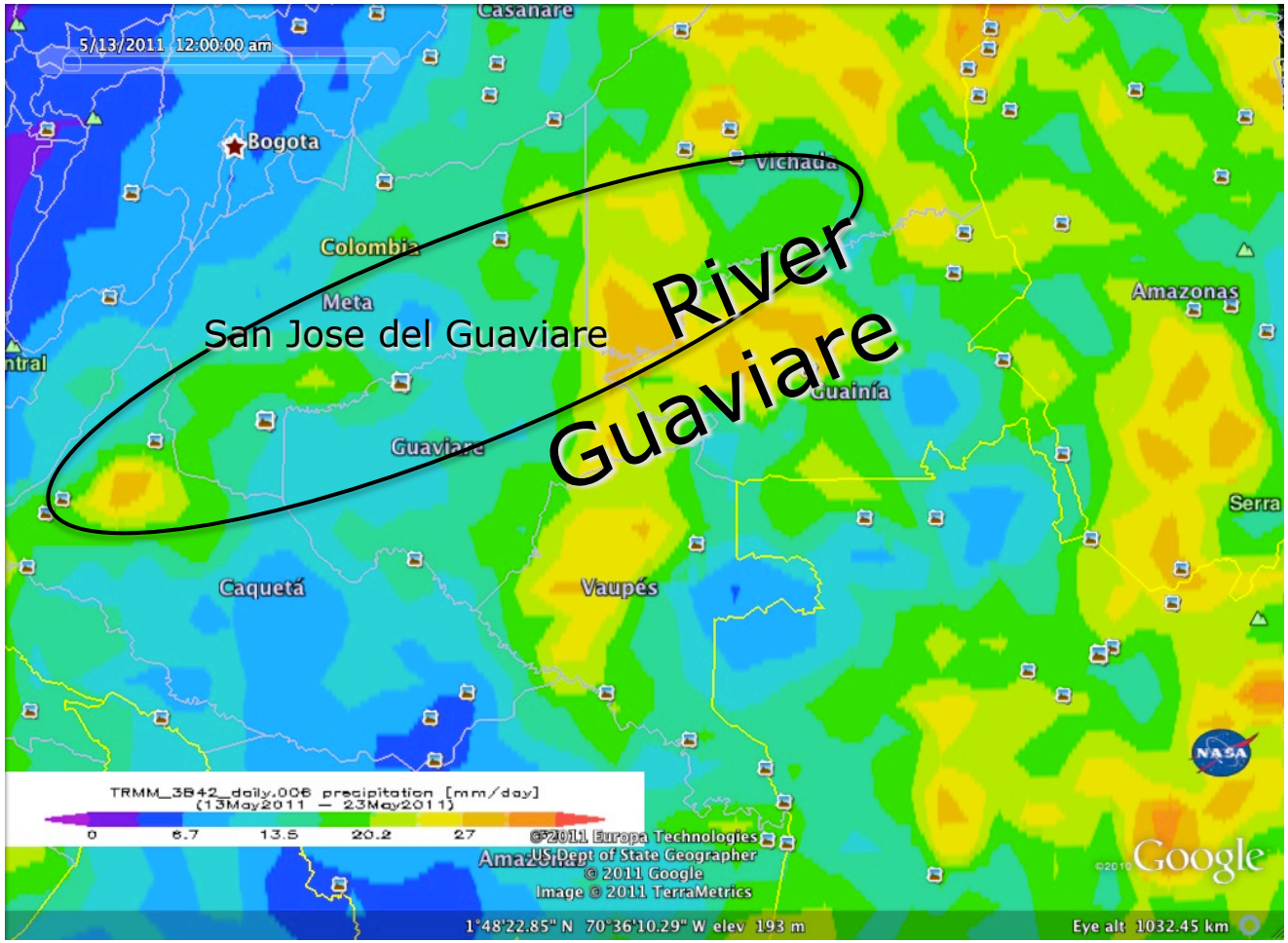
From: Michael Bosilovich, NASA-GSFC-GMAO

MERRA Temperature, Humidity, and Wind

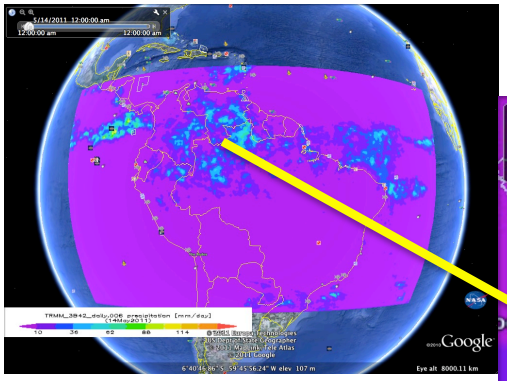
Surface skin and Air Temperature
Temperature Profile
East-West and North-South wind components
Humidity (Water Vapor) Profile
Column-integrated Water Vapor (Precipitable Water)

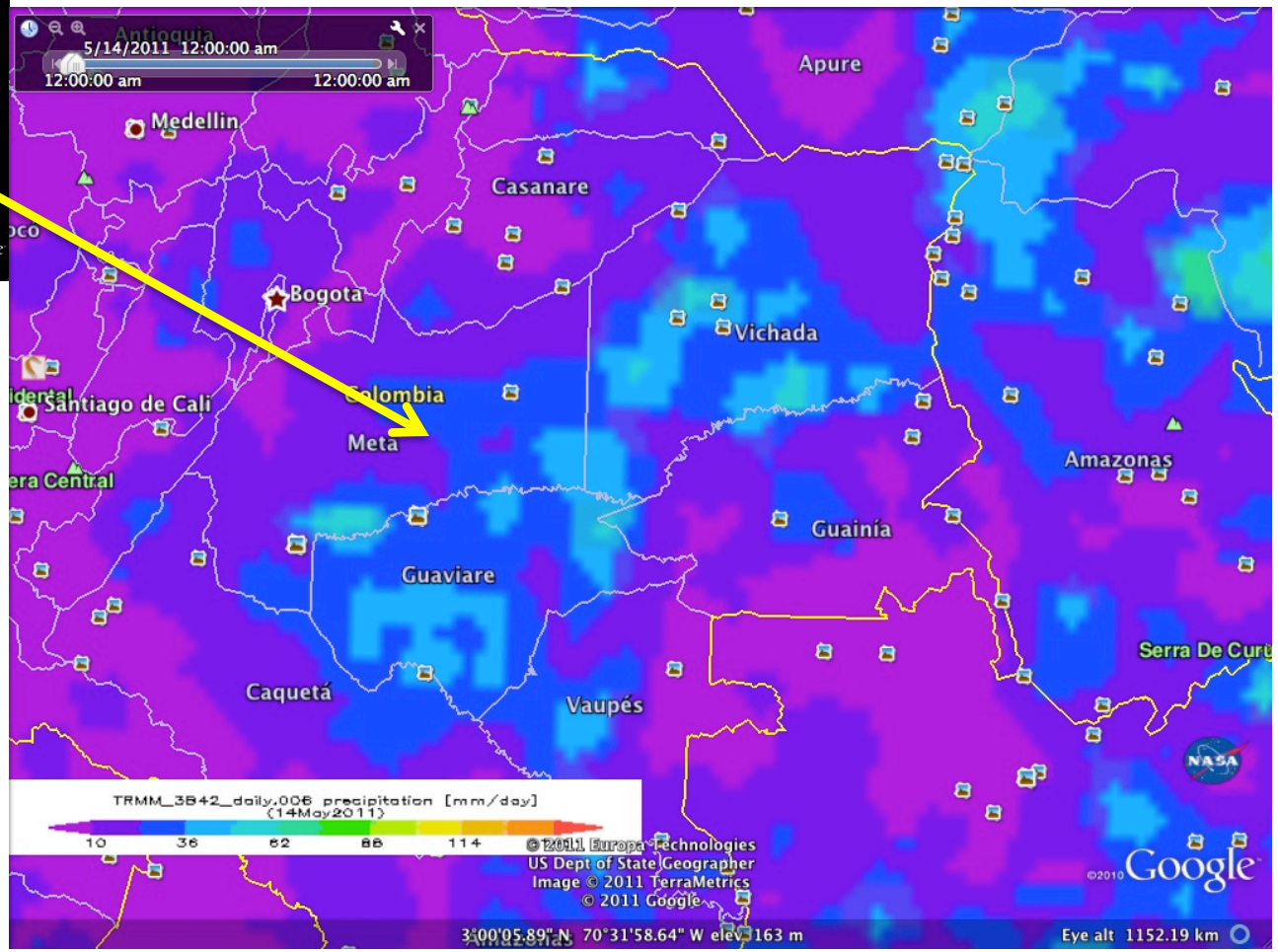
Spatial Resolution:	2/3°x1/2° latitude-longitude and 1.25°x1.25, 42 vertical levels
Spatial Coverage:	Global
Temporal Resolution:	Hourly, Daily, Monthly
Temporal Coverage:	1979 to present

Accumulated Rainfall from NASA TRMM over 13-23 May 2011



Colombia Heavy Rain Event 14 May 2011

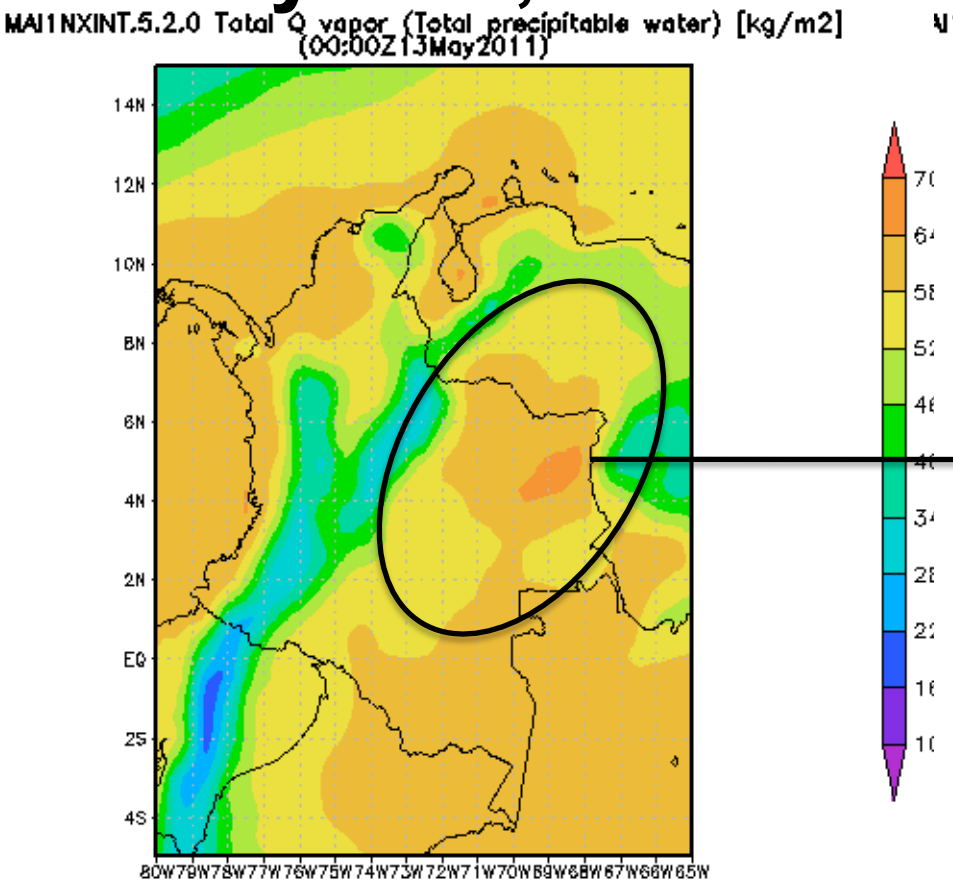




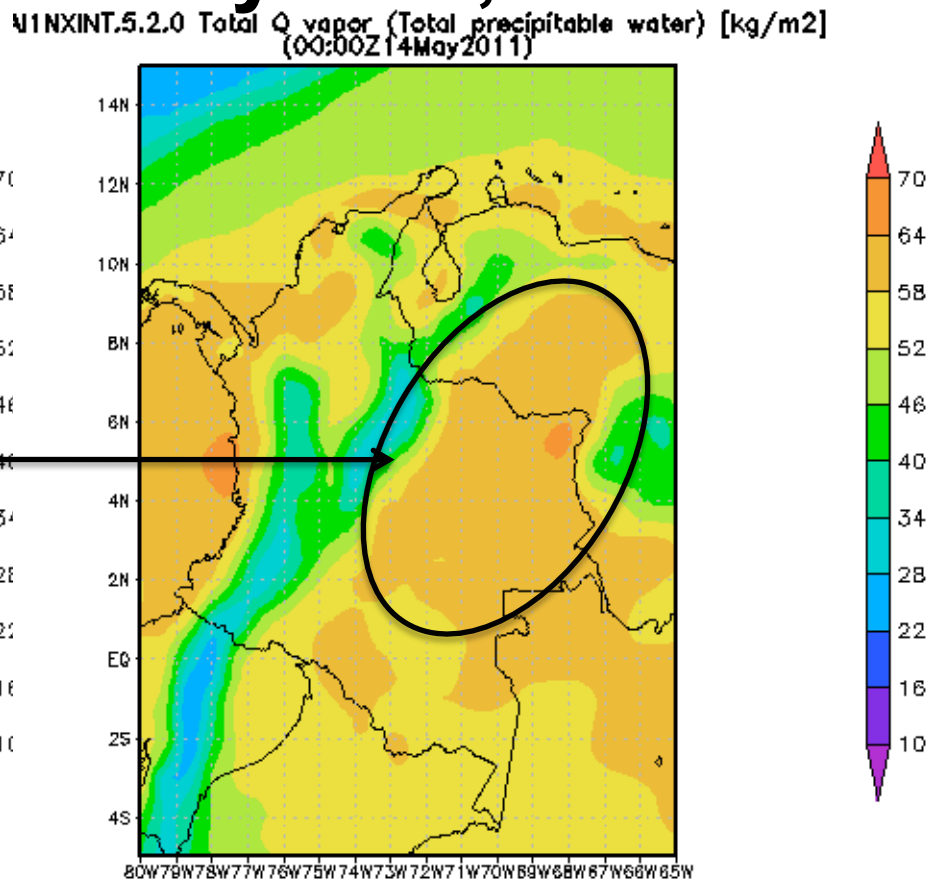
Heavy rainfall occurred over central and eastern Colombia on 14 May 2011

NASA MERRA Model Analysis Showing an Increase in the Amount of Moisture from the 13th to the 14th of May

May 13th , 2011



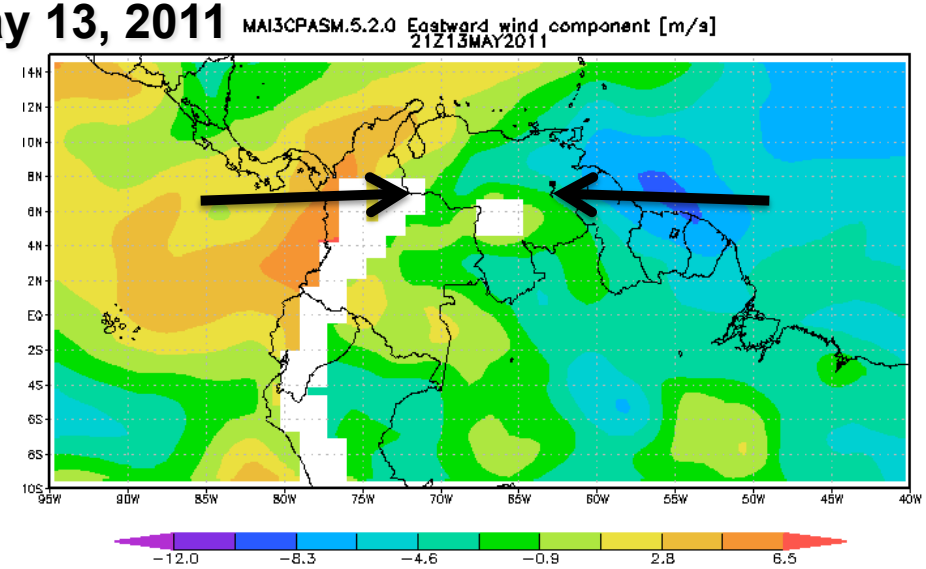
May 14th , 2011



Increase in amount of moisture

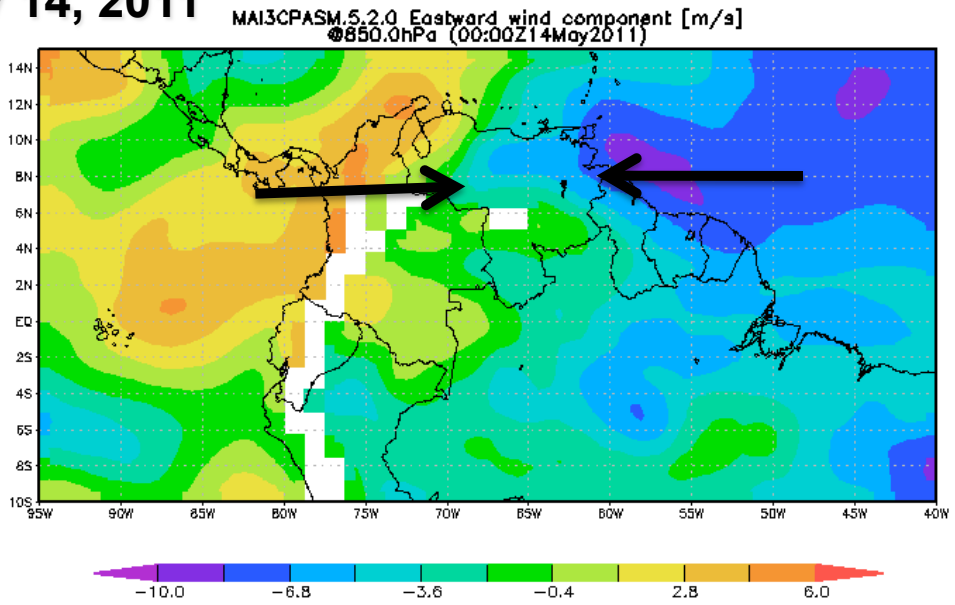
MERRA East-West Wind at 850 Mb

May 13, 2011



East-west wind from MERRA at 850 hPA

May 14, 2011



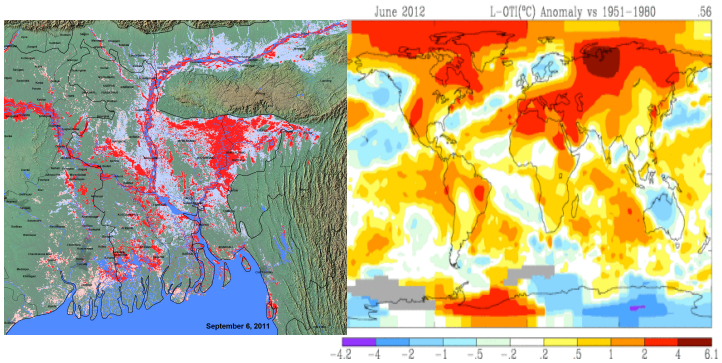
East-west winds converging over Colombia increase between 21Z on 13 May to 0Z 14 Z likely bringing more moisture that results in heavy rain at 0Z on 14 May

Course Outline

Week 1

Intro. & Background: Satellite Remote Sensing

Week 2

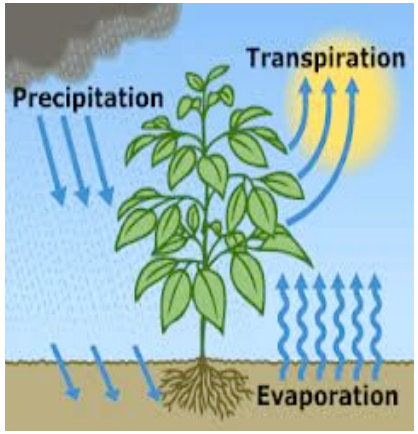


Flood and Drought [Rainfall, Weather and Climate Data]

Week 3

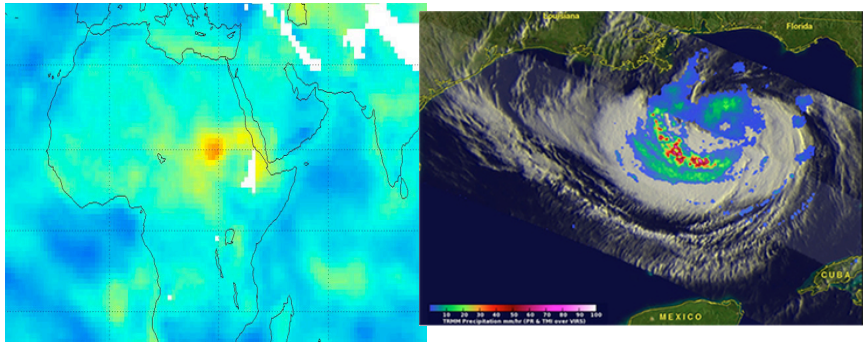
Web-tools

Week 4



Evapotranspiration

Week 5



Data Applications/ Case Studies

Next Q/A sessions: November 15 (2-3 p.m. EST)

Thank You!

Appendix
Information about Data Products

TRMM Data

Characteristic	Visible Infrared Scanner (VIRS)	TRMM Microwave Imager (TMI)	Precipitation Radar (PR)
Frequency/ Wavelength	0.63, 1.6, 3.75, 10.8, 12 µm Helps calibrate TRMM measurements with those of Polar Orbiting Environmental Satellites (POES) and Geostationary Operational Environmental Satellites (GOES)	10.65, 19.35, 37.0, 85.5 GHz dual polarization, 22.235 GHz vertical polarization	13.8 GHz horizontal polarization
Pixel Size	2.1 km	Ranges from 5 km at 85.5 GHz to 45 km at 10.65 GHz	4.3 km at nadir
Swath Width	720 km (833 km)	760 km (870 km)	220 km (247 Km)

TRMM Rain Data (Level 1 and 2)

Level	Visible Infrared Scanner	TRMM Microwave Imager	Precipitation Radar	PR and TMI Combined Products
Level 1	Visible & IR radiances	Microwave brightness temperatures **(1B11)**	Radar return power & reflectivity **(1B21, 1C21)**	NA
Level 2	NA	TMI profile for CLW, prec. water, cloud ice, prec. ice, latent heat, & **surface rain (2A12)**	PR surface cross-section & path attenuation (**2A21**), **rain type, storm, & freezing height;** (2A23) **PR profile for rain rate,** reflec., attenuation, & rain top/bottom height (**2A25**)	**Rain rate**, drop size dist. parameters, path integrated attenuation **(2B31)**

These data are available for each swath at pixel resolution

Rain product names are given in red

AIRS Data

Level	Geophysical Parameters
Level 1	AIRS Infrared Geolocated Radiances AIRS VIS/Near IR Geolocated Radiances **(AIRVBRAD)**
Level 2	AIRS/AMSU Standard Retrieval at **50km x50 km** **(AIRX2RET):** Surface Air Temperature, Temperature Profiles, Column Precipitable Water, Humidity (Water Vapor) Profile
Level 3	Global products binned into **1x1 degree** grid bins. Available in three temporal resolutions: daily **(AIRX3STD)**, 8-day (**AIRX3ST8)**, monthly (**(AIRX3STM)**: Surface Air Temperature, Temperature Profiles, Column Precipitable Water, Humidity (Water Vapor) Profile

Note: Precipitable water in a column is that if all the moisture turned into liquid. It is a measure of total humidity in the column.

Rain product names are given in red

MERRA Data

Type	Geophysical Parameters/Resolution
2-dimensional (hourly) 2/3°x1/2°	Surface Skin Temperature (**MAT1NXSLV.5.2.0**) Precipitable Water (**MAI1NXINT.5.2.0)**
3-dimesional (3-Hourly) 1.25°x1.25° and 42 vertical levels	Air Temperature, Relative Humidity, Specific Humidity Winds (zonal:east-west and meridional: north-south) **(MAI3CPASM.5.2.0)**
3-dimensional (Monthly) 2/3°x1/2° vertical levels 42	Temperature, Specific Humidity Winds (zonal:east-west and meridional: north-south) **(MAIMNPANA.5.2.0)**

Note: Precipitable water in a column is that if all the moisture turned into liquid. It is a measure of total humidity in the column.

Rain product names are given in red