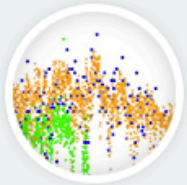
Welcome to
NASA Applied Remote Sensing Training (ARSET)
Webinar Series

Introduction to NASA Earth Science Data Products, Portals, and Tools

Course Dates: 16, 23, 30 September and 7, 14 October 2014


ATMOSPHERE


CALIBRATED RADIANCE AND SOLAR RADIANCE


CRYOSPHERE


HUMAN DIMENSIONS


LAND


OCEAN

ARSET

Applied Remote SEnsing Training
A project of NASA Applied Sciences

Important Information

Presentations URL:

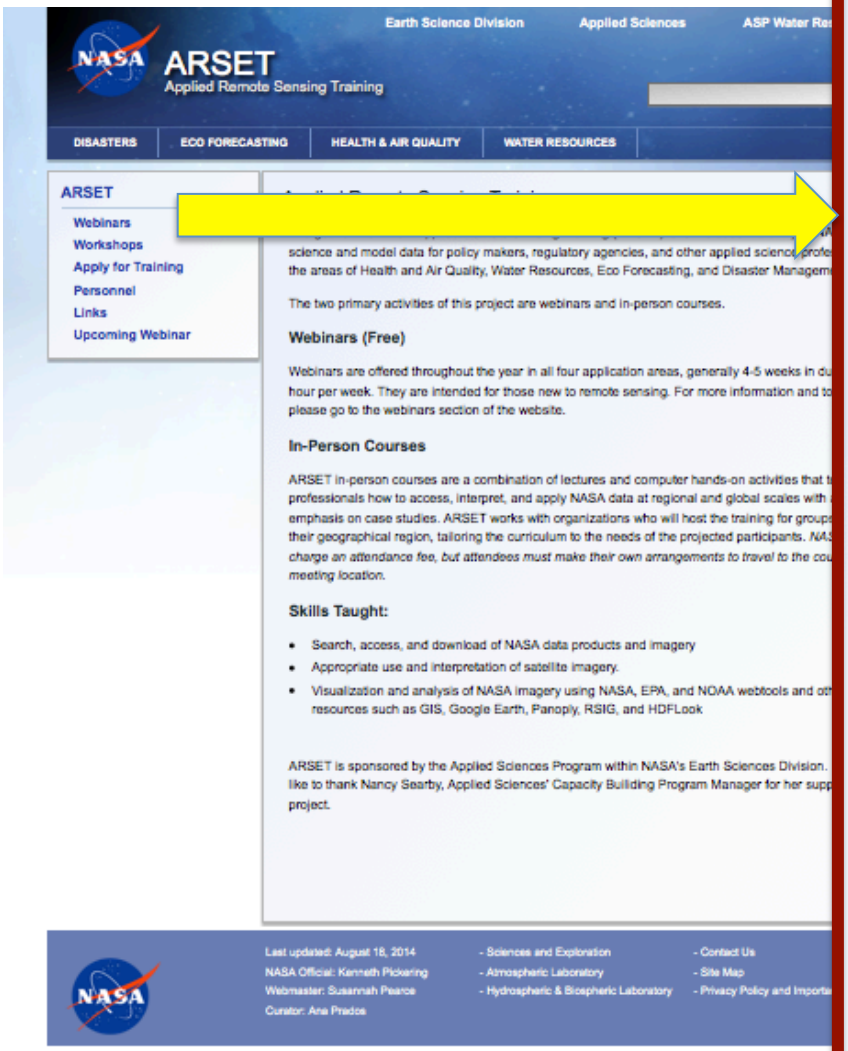
http://arset.gsfc.nasa.gov/

Contact for Requesting Recorded Link for the Webinars:

Marines Martins : marines.martins@ssaihq.com

ARSET Web Page

http://arset.gsfc.nasa.gov



Introduction to NASA Earth Science Data Products, Portals, and Tools

09/16/2014 to 10/14/2014

Times: Tuesdays (5 one-hour sessions), 8-9 AM U.S. Eastern Standard Time (13 PM UTC)

GIS: True

Keywords: **Satellite Imagery, Tools**

Instruments: **Aqua, Landsat, Terra, TRMM**

Webinar Information

Presentations and Recordings

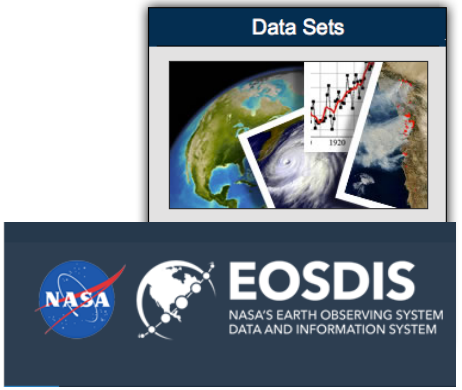
Week	Date	Title	Presentation	Recording	Assignment
1	Sept. 16, 2014	NASA Earth Science: *Research and Applications to Decision Support*	**Session-1 (click)**	**View**	N/A
2	Sept. 23, 2014	Overview of NASA Earth Science Data Products: Remote Sensing and Earth System Modeling Data			N/A
3	Sept. 30, 2014	NASA Data Centers and Data Access Tools			N/A
4	Oct. 7, 2014	NASA Data and GIS Applications: Air Quality, Water Resources			N/A
5	Oct. 14, 2014	NASA Data and GIS Applications: Disasters, Agriculture and Ecology			N/A

Course Outline

Week 1

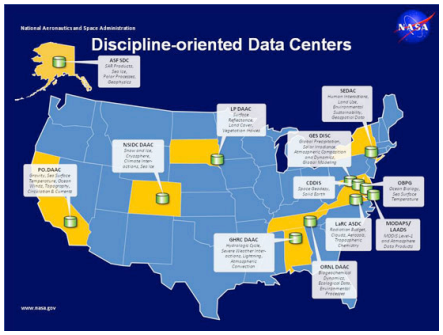
NASA Earth Science

Week 2



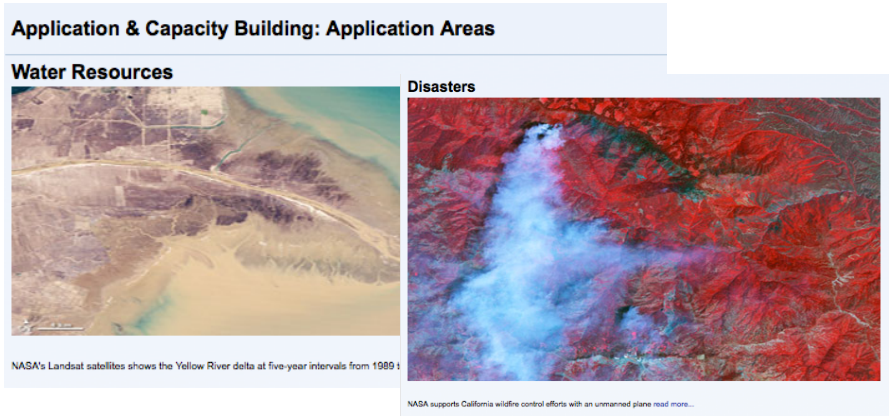
NASA Data Products

Week 3



NASA Data Centers and Tools

Weeks 4 & 5



NASA Data Applications with GIS

NASA Earth Sciences Data

There are **6861** Unique Data Sets!

EOSDIS FY2013 Metrics (Oct. 1, 2012 to Sept. 30, 2013)	
Unique Data Sets	6,861
Distinct Users of EOSDIS Data and Services	1.7 M
Web Site Visits	2.5 M
Average Archive Growth	8.5 TB/day
Total Archive Volume	9.8 PB
End User Distribution Products	839 M
End User Average Distribution Volume	22 TB/day

Week 2: Outline

- **Summary Lists of NASA Earth Science Data Parameters**
- **Data for Environmental Applications :**

  (Products, Sources, Attributes)

  - *Air Quality*
  - *Disasters*
  - *Eco-forecasting and Land Management*
  - *Water Resources*

- **How to Search for Data?**

Earth Science Data Parameters

For Details visit: https://earthdata.nasa.gov/

NASA Earth Observing System Data and Information System (EOSDIS)

EOSDIS

https://earthdata.nasa.gov/

Atmospheric Data

- Atmospheric temperature
- Atmospheric humidity
- Winds (wind speed, wind direction, vertical air motions, upper air winds)
- Precipitation
- Lightning (events, area, flash structure)
- Aerosol Properties
- Tropospheric Chemistry(ozone, precursor gases, carbon dioxide)
- Stratospheric chemistry (Ozone, ClO, BrO)
- Cloud properties (amount, optical properties, height
- Radiative Energy Fluxes(Top of atmosphere, surface)

Disaster

Water Resources, Eco/Land Surface

Air Quality

Data List from Jennifer Brennan (EOSIDS)

Ocean Data

- Surface temperature(SST)
- Phytoplankton and Dissolved Organic Matter
- Surface Wind Fields
- Heat Flux
- Ocean Surface Topography (height, waves, sea level, tide models)
- Sea Ice
- Gravity

Climate monitoring, Coastal Water Quality/Eco system

Global Water Balance

Data List from Jennifer Brennan (EOSIDS)

Cryospheric Data

Water Resources, Climate monitoring

- Land ice (ice sheet topography, ice sheet volume, ice sheet volume change, glacier change)
- Sea ice (Extent, concentration, motion, temperature)
- Snow Cover (extent, water equivalent, depth)

Land Processes Data

- Land Cover and Land Use Change
- Vegetation Dynamics
- Surface Temperature
- Surface Topography(Elevation, slope, DEMs)
- Fire Occurrence (Extent, thermal anomalies)
- Volcanic Effects (Frequency of occurrence, thermal anomalies, impact
- Soil moisture
- Gravity/Ground Water

Data List from Jennifer Brennan (EOSIDS)

Human Dimensions Data

- Population and Land Use
- Biodiversity and Ecosystems
- Human and Environmental Health
- Climate Change

Eco/Land management

Health

Data List from Jennifer Brennan (EOSIDS)

Data for Environmental Application Areas

Data Sources
for
Air Quality, Disasters, Eco/Land Management, Water Resources

Satellites/Sensors **Environmental Models**

Data Sources : Satellites

Air Quality	Water Resources/ Disasters*	Eco/Land Management
Terra	TRMM	Landsat
Aqua	GPM	Aqua
Aura	Terra	Terra
CALIPSO Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations	Aqua	
NPP (National Polar-Orbiting Partnership)	GRACE	
	Landsat	

*Extreme Precipitation, Flooding/Droughts, Storms, Landslides, Fire

Satellites/Sensors for Air Quality Parameters

Satellite	Sensors	Quantities
Terra and Aqua	MODerate Resolution Imaging Spectroradiometer (MODIS)	Aerosol Optical Depth (AOD)
Terra	Multi-angle Imaging SepctroRadiometer (MISR)	(AOD) Particle Type
Aqua	Atmospheric Infrared Sounder (AIRS)	Trace Gases
Aura	Ozone Monitoring Instrument (OMI)	Ozone, Sulphur Dioxide, Nitrogen Dioxide AOD
Suomi-NPP*	**V**isible **I**nfrared **I**maging **R**adiometer **S**uite (VIIRS)	Aerosol Optical Depth (AOD) Particle Type
CALIPSO	LIDAR	Aerosol Profile

*National Polar-orbiting Partnership

Satellites/Sensors for Disasters, Land and Water Resources Parameters

Satellite	Sensors	Quantities
TRMM	Precipitation Radar (PR) TRMM Microwave Imager (TMI) Visible Infrared Scanner (VIRS)	Rain Rate, Vertical Rain Rate Profile, Accumulated Rain, Soil Moisture
Terra and Aqua	MODerate Resolution Imaging Spectroradiometer (MODIS)	Snow Cover, Vegetation Index, Leaf Area Index, Land Cover , Clouds
Aqua	Atmospheric Infrared Sounder (AIRS) Advanced Microwave Scanning Radiometer for EOS (AMSR-E)	3-dimensional Atmospheric Temperature and Humidity, clouds Snow Water Equivalent, Sea Ice, Soil Moisture, Rain Rate
Landsat	(Enhanced) Thematic Mapper (ETM)	Vegetation Index, Leaf Area Index, Land Cover
Grace	K-Band Ranging Assembly	Terrestrial Water

Data Sources: Models

- MERRA: Modern Era Retrospective-analysis for Research and Application
- GLDAS : Global Land Data Assimilation System
- NLDAS : North American Land Data Assimilation System

NASA Models Data
For Water Resources and land Management

Models	Quantities
MERRA	3-dimensional Winds, Temperature, Humidity, Clouds, Rain Rate ,Snow Mass, Snow Cover, Snow Depth, Surface Snowfall Rate, Evapotranspiration
GLDAS/NLDAS	Evapotranspiration, Multi-layer Soil Moisture, Rainfall, Snowfall Rate, Snow Melt, Snow-Water Equivalent, Surface and Sub-surface Runoff

Data Attributes

For Satellites and Earth System Models

Data Attributes (Remote Sensing and Models)

Spatial Resolution
Spatial Coverage
Temporal Resolution
Temporal Coverage
Data Format
Data Latency
Data Accuracy
Data Strengths/Limitations

Data Access
Data Analysis/Visualization

Remote Sensing Data Attributes

Spatial and Temporal Resolution of Satellite Measurements

Depends on the satellite orbit configuration and sensor design

- **Spatial Resolution:**

  Decided by its pixel size -- pixel is the smallest unit measured by a sensor

- **Spatial Coverage:**

  The geographical area covered by a satellite

- **Temporal resolution:**

  How frequently a satellite observes the same area of the earth

- **Temporal Coverage:**

  Time span or life-time of a satellite for which measurements are available

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Sensor Types

Satellite Sensors

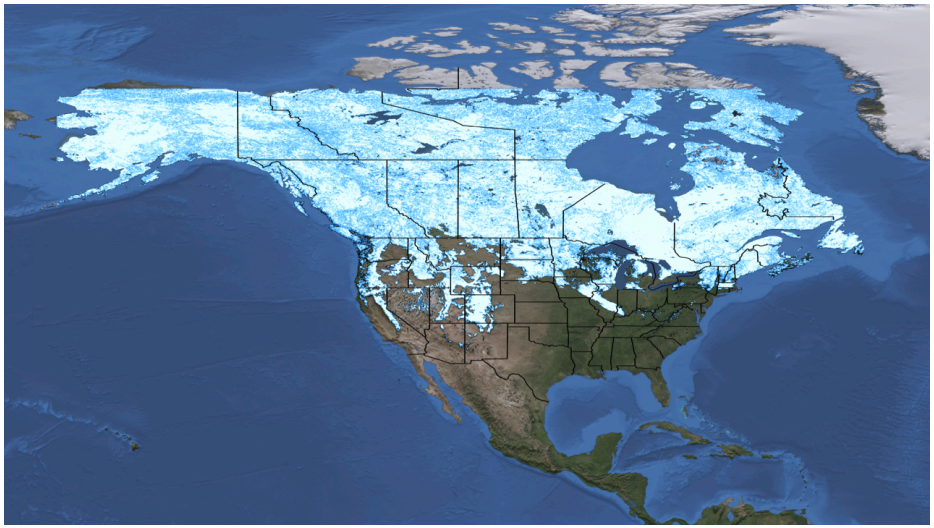
Passive remote sensors measure radiant energy reflected or emitted by the earth-atmosphere System

Radiant energy is converted to geophysical quantities such as temperature, humidity, clouds, precipitation, soil moisture

Examples:

MODIS, AIRS

MODIS Snow Cover on March 5, 2012



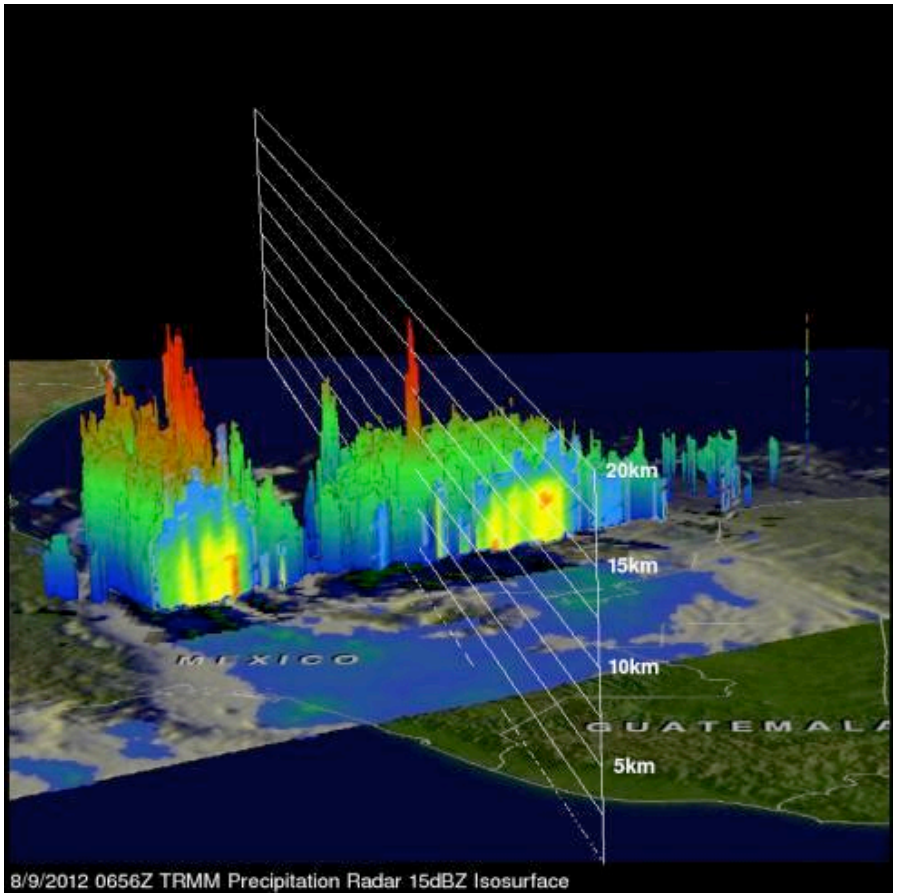
Satellite Sensors

Active remote sensors ‘throw’ beams of radiation on the earth-atmosphere system and measure ‘back-scattered’ radiation

The back-scattered radiation is converted to geophysical quantities

Examples: Precipitation Radar, LIDAR

TRMM satellite – **Precipitation Radar, an active sensor,** measuring 3-dimensional reflectivity converted to rain rates for Hurricane Ernesto (August 9, 2012)



Satellite Sensors

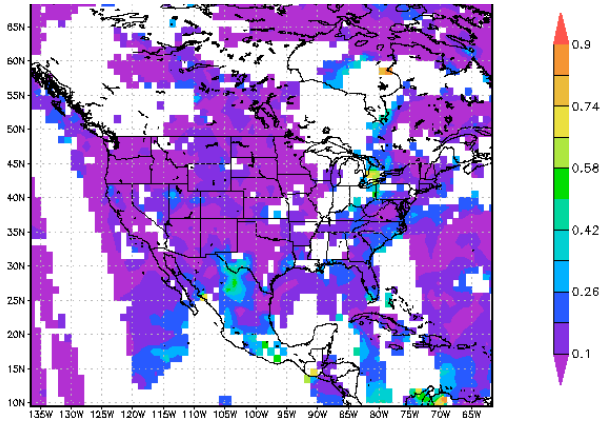
Imagers: Create Images

Examples: MODIS, TMI

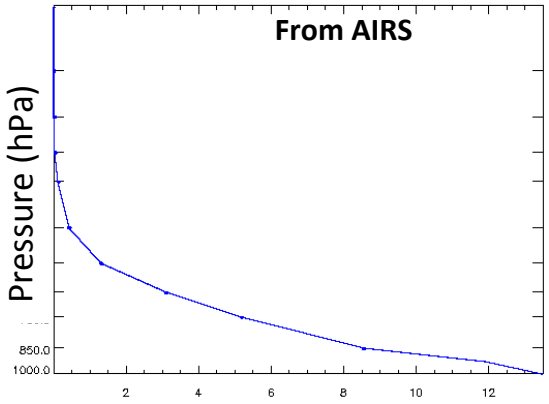
Sounders: Provide vertical profiles

Examples: AIRS

MODIS Aerosol Optical Depth
September 1, 2014



Water Vapor Profile Averaged over Central US for July 2012



g of water vapor per kg of dry Air

Spatial Resolution of NASA Satellite Data Products

- **High Spatial resolution**
  30x30 m, 250x250 m; 500x500 m; 1x1 km; 4x4 km
  Example: Landsat, MODIS True Color Imagery (RGBs), TRMM Radar

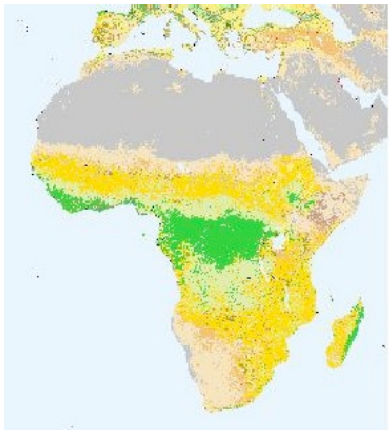
- **Moderate Spatial Resolution**
  0.125x0.125 to 0.25x0.25 degrees
  Example: GLDAS, TRMM precipitation products.

- **Low Spatial Resolution (Level 3)**
  Primarily at 1 x 1 degree - derived from each data set's native resolution product
  Example: Aqua/AIRS surface air temperature, model data

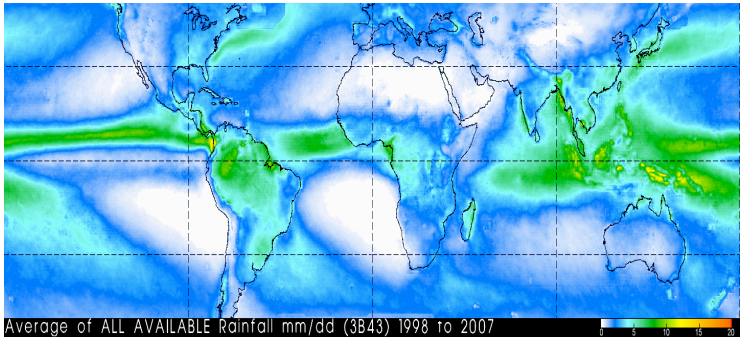
NASA Satellites Measurements with Different Spatial Resolution

Landsat Image of Philadelphia
Spatial resolution: 30 m

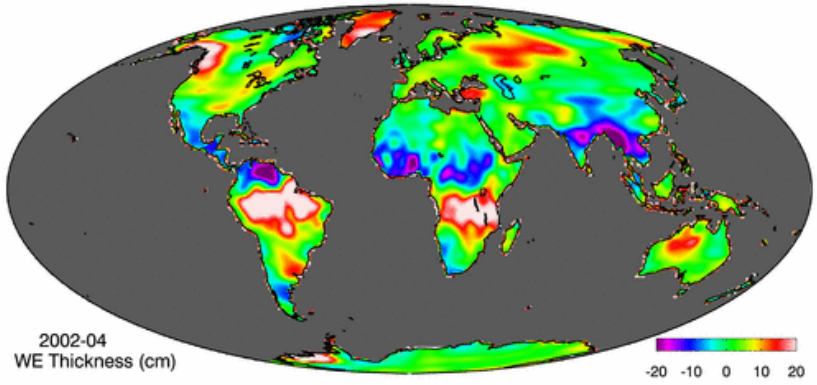
Land Cover from Terra/MODIS:
Spatial resolution: 1 km²
(From: http://gislab.jhsph.edu/)



Rain Rate from TRMM
Spatial resolution: 25 km²



Terrestrial Water Storage Variations from GRACE: Spatial resolution: 150,000 km² or coarser **(**Courtesy: Matt Rodell, NASA-GSFC)



Spatial Coverage and Temporal Resolution of Satellite Measurements

Depends on the satellite orbit configuration and sensor design

- **Spatial Resolution:**

  Decided by its pixel size -- pixel is the smallest unit measured by a sensor

- **Spatial Coverage:**

  The geographical area covered by a satellite

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  How frequently a satellite observes the same area of the earth

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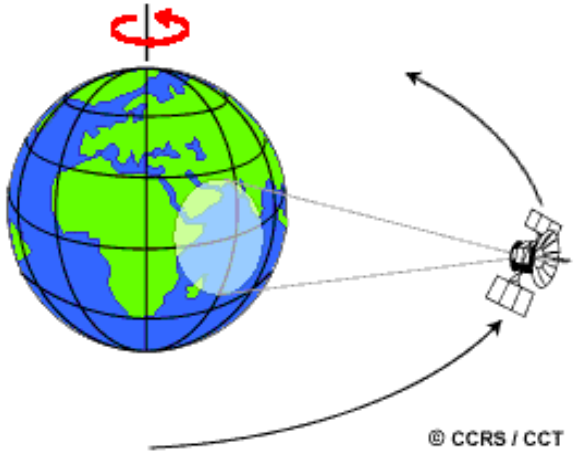
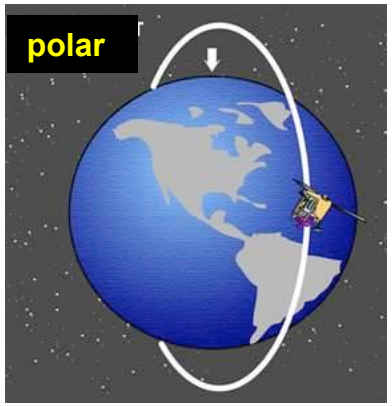
Types of Satellite Orbits

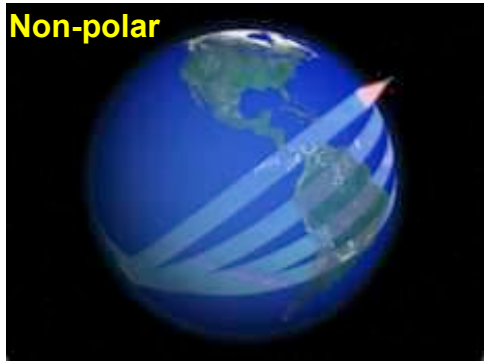
Geostationary orbit



Satellite is at ~36,000 km above earth at equator. Same rotation period as earth's. Appears 'fixed' in space.

Low Earth Orbit (LEO)





Circular orbit constantly moving relative to the Earth at 160-2000 km. Can be in Polar or non-polar orbit

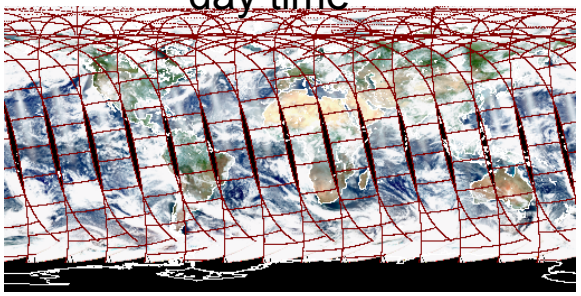
Spatial Coverage and Temporal Resolution

Polar orbiting satellites: global coverage - but one to two or less measurements per day per sensor. Orbital gaps present. Larger Swath size, higher the temporal resolution.

Non-Polar orbiting satellites: Less than one per day. Non-global coverage. Orbital gaps present. Larger Swath size, higher the temporal resolution.

Geostationary satellites: multiple observations per day, but limited spatial coverage, more than one satellite needed for global coverage.

Aqua ("ascending" orbit) day time



TRMM Image

GOES Image

Temporal Resolutions

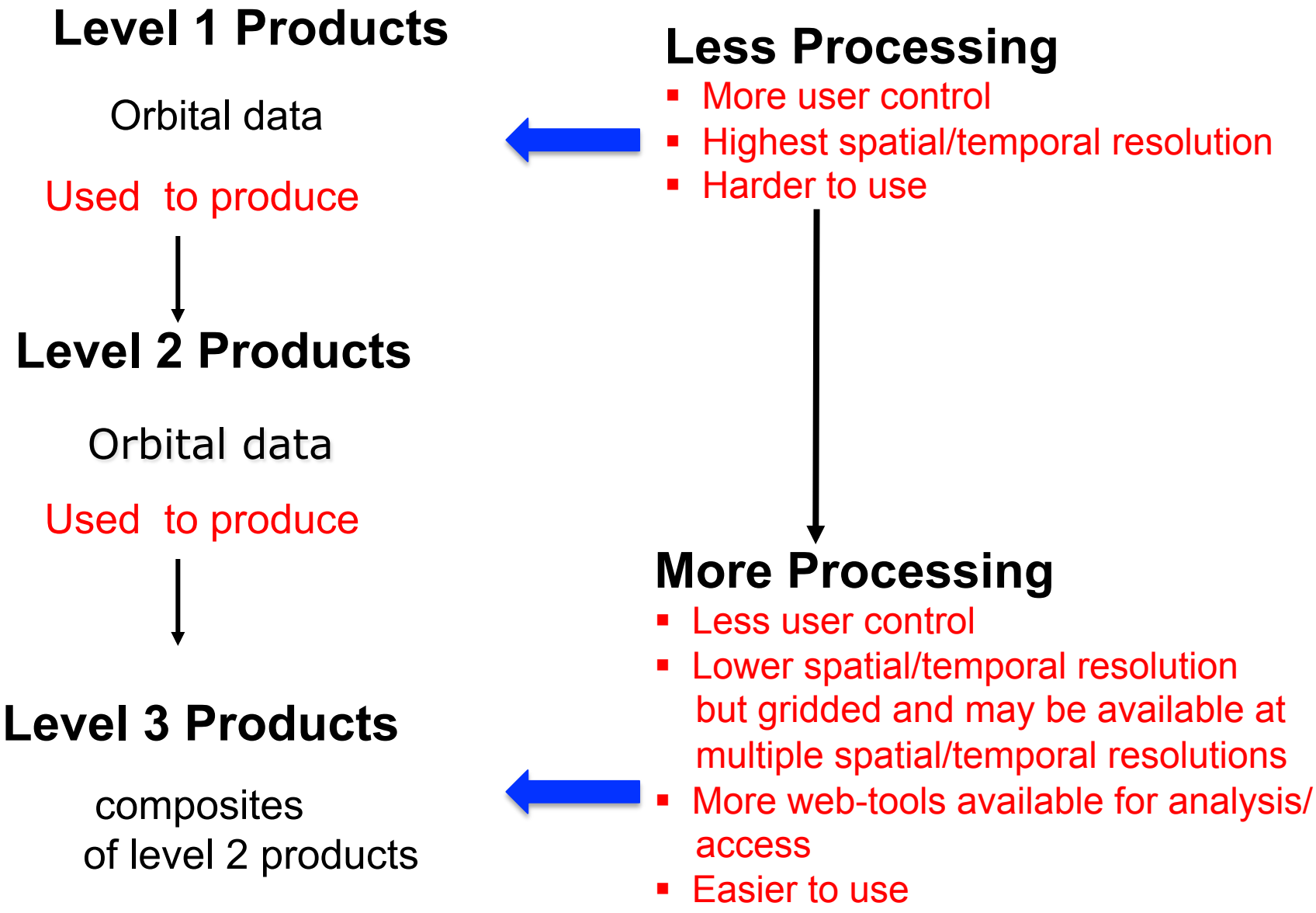
Sun Synchronous, Polar Orbiting Satellites
Less than 1 to 2 measurements per day

Aqua
Aura
CALIPSO
Landsat
NPP
Terra
SMAP

Non-sun Synchronous Satellites
Less than 1 measurement per day

TRMM
GPM

Levels of Remote Sensing Data Processing



Model Data Attributes

Spatial and Temporal Resolution and Coverage of Model Data

(Less Rigid than Remote Sensing Data)

Depends on the model configuration

- **Spatial Resolution:**

  Defined by the grid size, generally provided in degrees of latitude-longitude. Models provide data on vertical levels in the atmosphere, ocean, and land

- **Spatial Coverage:**

  The geographical area covered by a model (regional or global)

- **Temporal resolution:**

  How frequently model parameters are written out and saved

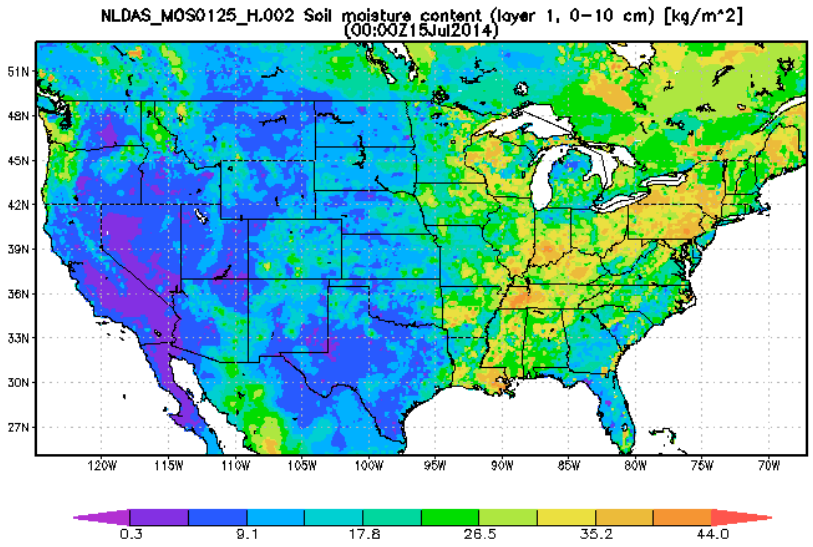
- **Temporal Coverage:**

  Time span over which the model runs are conducted

Examples of Model Data Resolutions

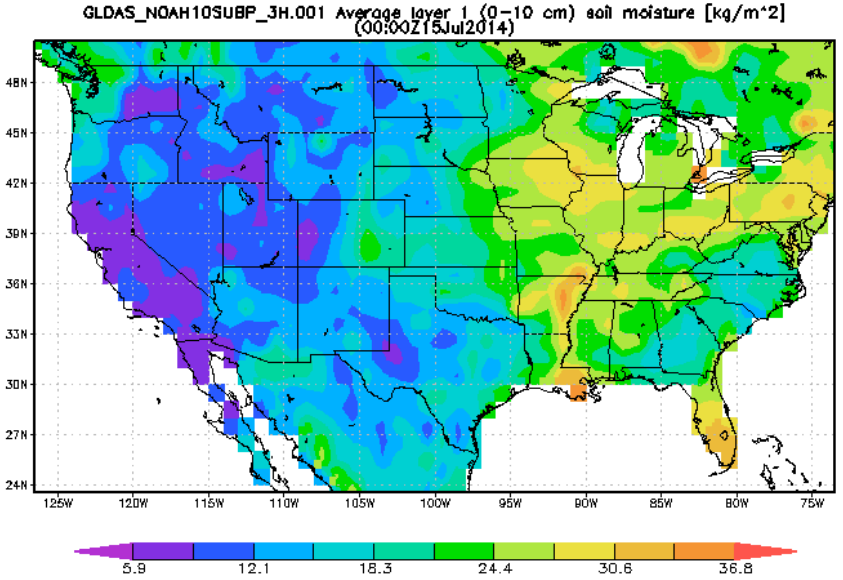
Soil Moisture (0-10 cm) at 0 UTC on 15 July 2014

NLDAS: resolution 0.125°x0.125°



More Detailed and small-scale variations captured by high-resolution data

GLDAS: resolution 1°x1°



Spatial Resolution and Temporal Resolutions of Model Data Products

- **MERRA**
  2/3x1/2 degree, hourly; 1.25x1.25 degree, 42 level, hourly and monthly

- **GLDAS**
  0.125x0.125 degree, 6 soil levels, 3-hourly and monthly; 1x1 degree, 3-hourly and monthly

- **NLDAS**
  0.125x0.125 degree, 3 soil levels, hourly and monthly

Remote Sensing and Model Data Formats

- **Text/ASCII**
- pros: easy to read and examine the data right away (can read with used tools such as excel and GIS software)
  cons: large data files, not always available.
- **Binary – HDF, NetCDF**
- pros: takes less space, more information (metadata, SDS)
  cons: need specific tools or code to read the data
- **KML or KMZ (zipped KML)**
  pros - easy 2D and 3D visualization of the data through free tools such as Google Earth. Data are very low volume
- **Shapefiles/Geotiff**: GIS Applications. May or may not work with open source

Data Latency

Time between data production/observation and dissemination/availability to users

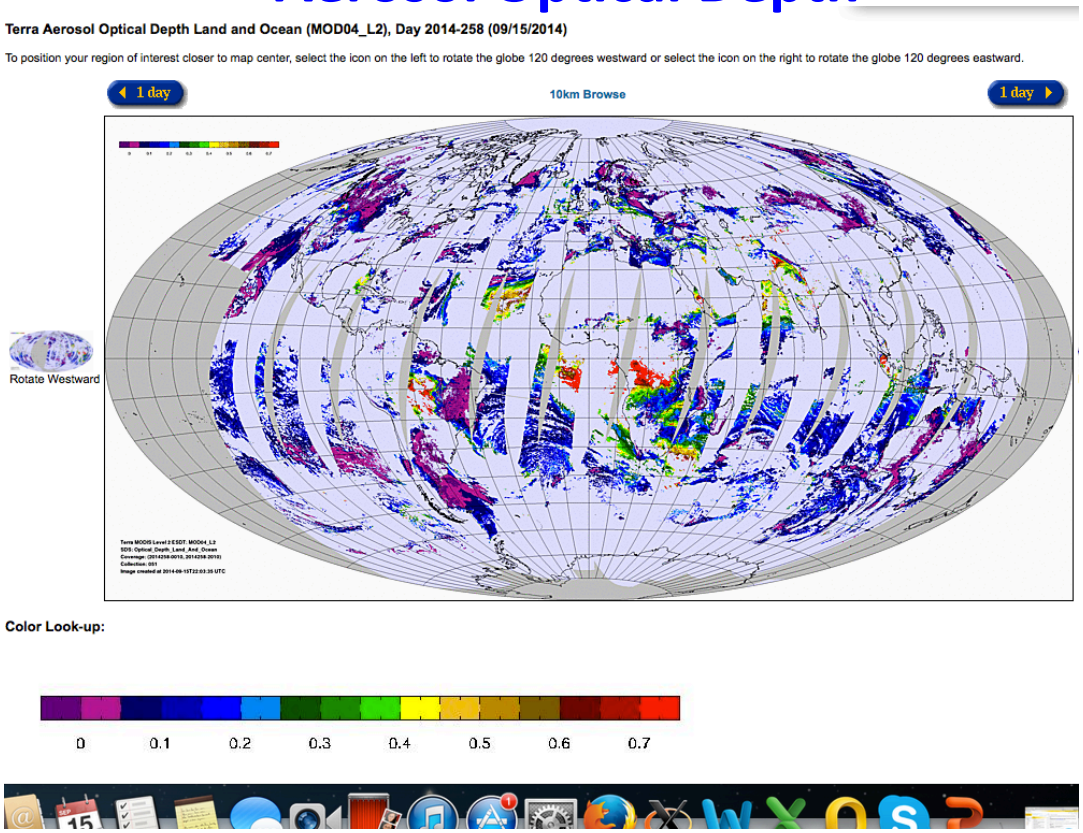
Ranges from Near-Real Time (NRT) data with less than 3 hour latency to up to 3 months latency (Level 3 data)

Examples of NRT Data

http://lance-modis.eosdis.nasa.gov/

- MODIS Radiances, Cloud/Aerosols, Water Vapor, Fire, Snow Cover, Sea Ice, Land Surface Reflectance, Land Surface Temperature: 90 –125 minutes

Aerosol Optical Depth

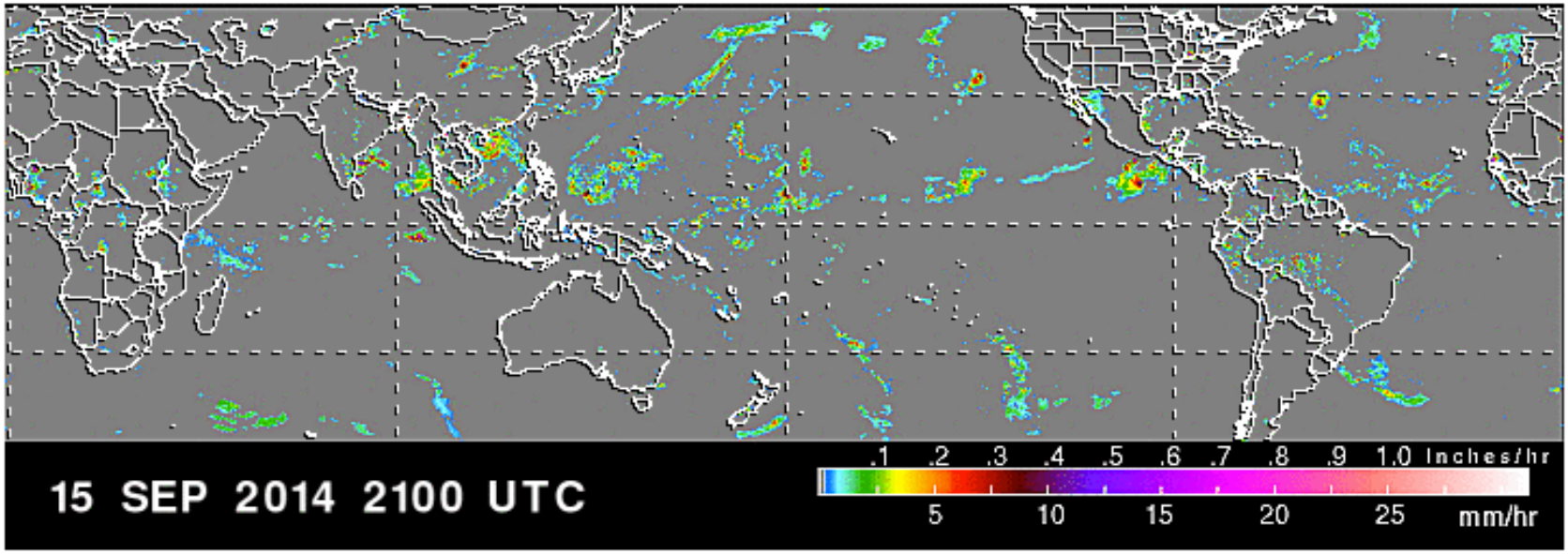


Examples of NRT Data

http://trmm.gsfc.nasa.gov/affinity/affinity_3hrly_rain.html

- TRMM and Multi-satellite Merged Data: Rain Rate (3-6 hour latency) -- used in monitoring heavy rain, flooding, landslides, tropical storms

Rain Rate in mm/hr



Latest 3 Hourly Global Rainfall _ Click to See a Medium [1.7 MB] Animation

Although TRMM has less than 1-day temporal resolution, combined with other satellites NRT data are derived that are used for monitoring floods and landslide

Data Accuracy

- Data validation and accuracy assessment are conducted by comparing satellite and model data parameters with land-based measurements, and/or aircraft field campaign measurements
- Conducted for each data product individually
- Accuracy varies with platforms satellite/sensors, models) and may vary geographically
- Available from published literature and/or from data production team
- NASA Earth Sciences funds projects for regional validation through proposal solicitation

Remote Sensing Data
Strengths and Limitations

Data Void in Station-based Measurements

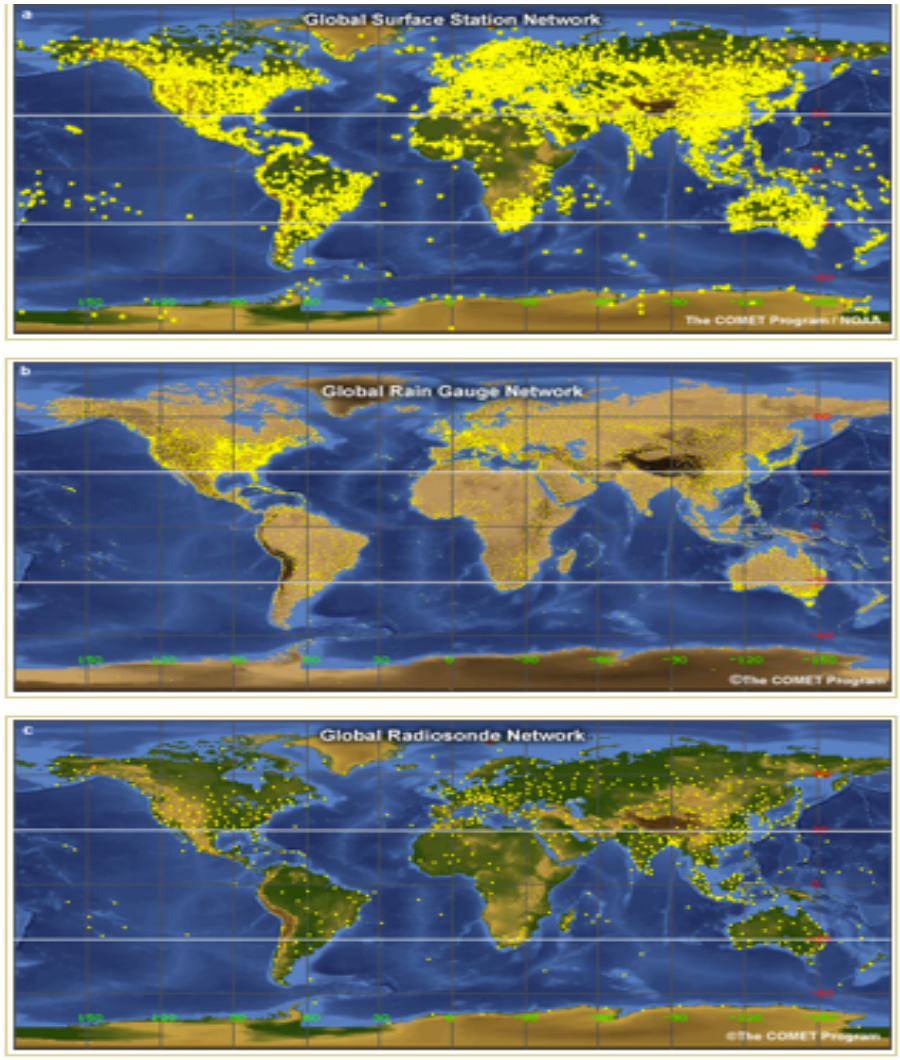
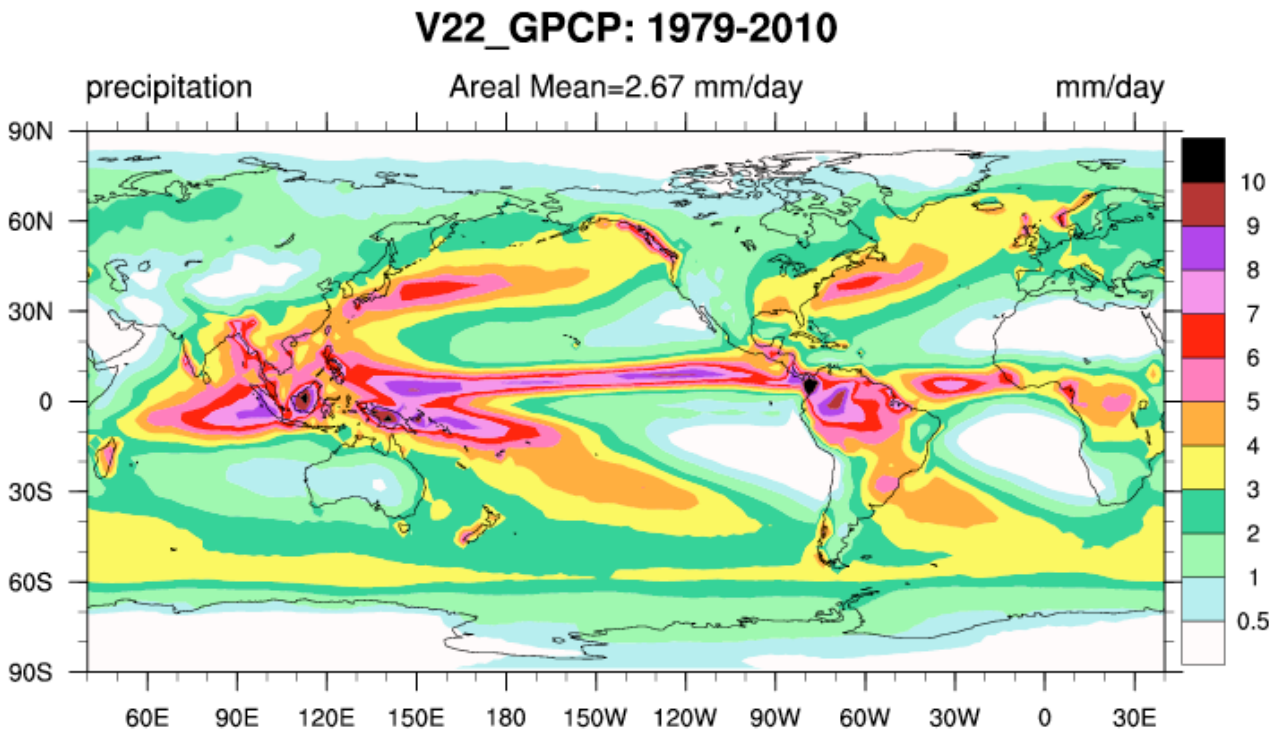


Fig. 2.1. Global network of (a) regular surface stations, (b) rain gauge stations, and (c) radiosonde stations. White lines mark ±30° latitude.

From NOAA/COMET

Remote Sensing observations



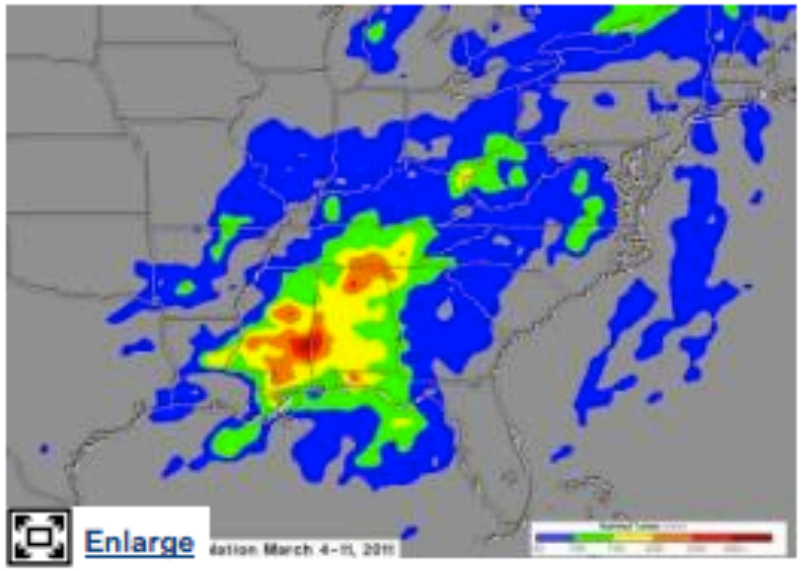
Rainfall Estimates Combined from Multiple International Satellites

- Provide information where there are no ground-based measurements, including over oceans
- Provide consistent observations over global/large areas

Remote Sensing observations provide large scale perspective

TRMM maps flooding along US East Coast from massive storm

March 14, 2011



The analysis indicated that the greatest total rainfall for the past week was over 300 mm (~11 inches) and was located over Alabama and Mississippi (in dark red). Some of the extremely heavy rainfall in this area was associated with tornado spawning thunderstorms. Much of the eastern United States was affected by rainfall totals of over 50 mm (~2 inches). Credit: NASA/SSAI, Hal Pierce

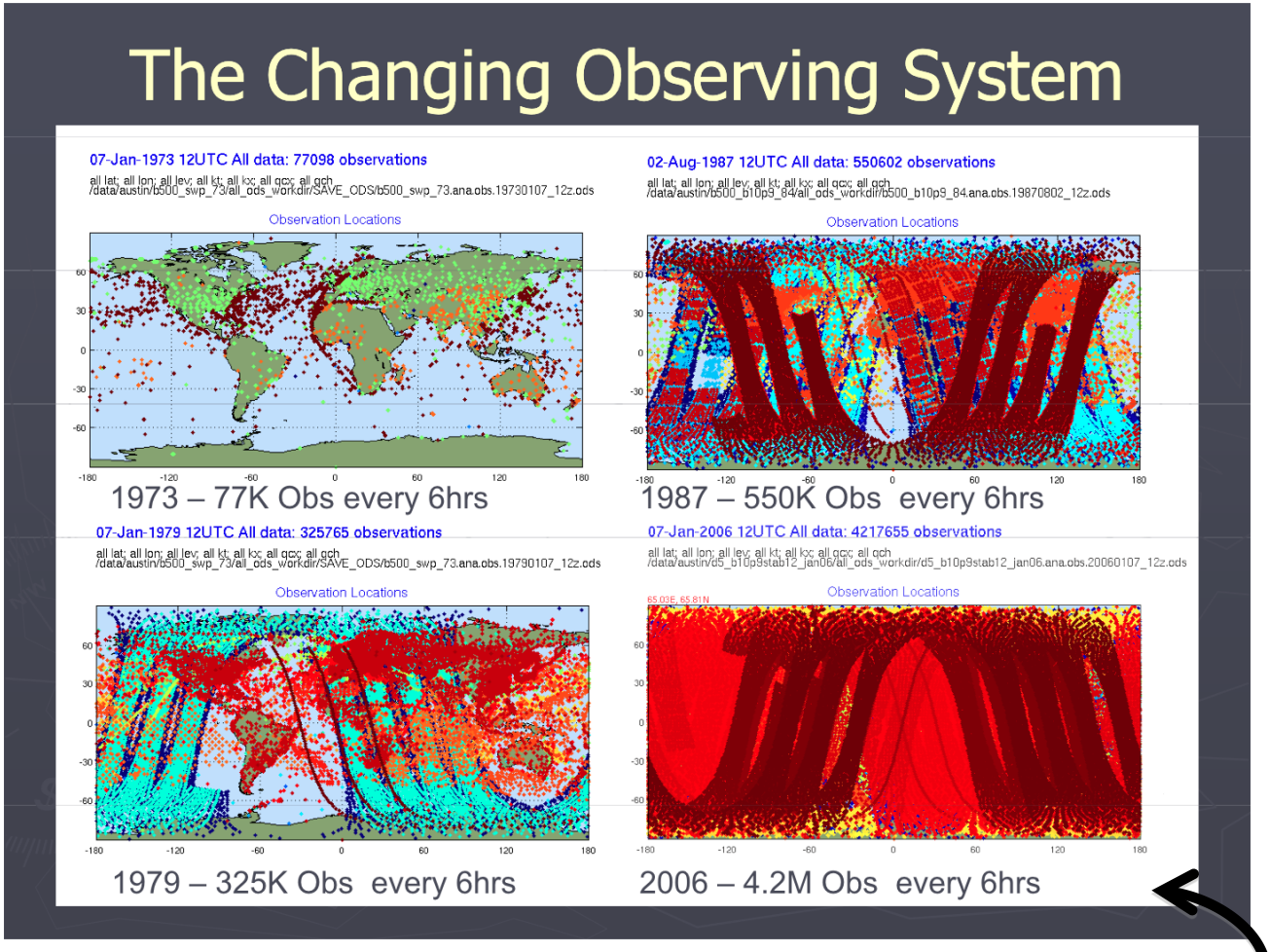
The massive rain storm that stretched from New York to Florida last week dropped some record rainfall and NASA's Tropical Rainfall Measuring Mission (TRMM) satellite measured that rainfall from space. Those rainfall totals were

Remote Sensing Observations : Trade Offs

- It is very difficult to obtain extremely high spectral, spatial, temporal and radiometric resolution at the same time
- Several sensors can obtain global coverage every one to two days because of their wide swath width
- Higher spatial resolution polar/non-polar orbiting satellites may take 8 – 16 days to attain global coverage
- Geostationary satellites obtain much more frequent observations but can only cover 1/3rd of the earth
- Large amount of data with varying formats
- Data applications may require additional processing, visualization and other tools

Model Data
Strengths and Limitations

Blends the vast quantities of observational data

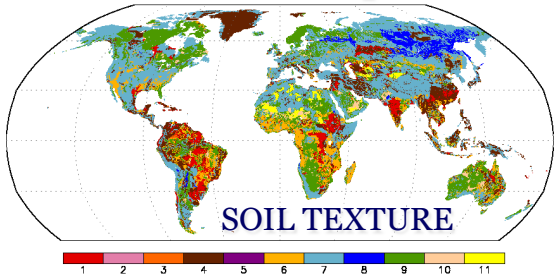


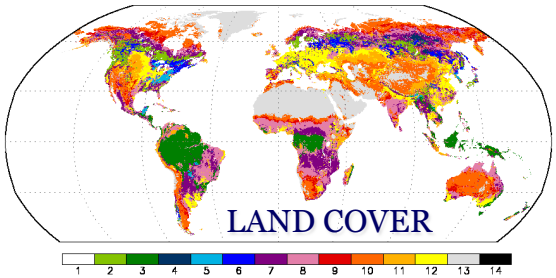
Current satellite coverage assimilated in MERRA

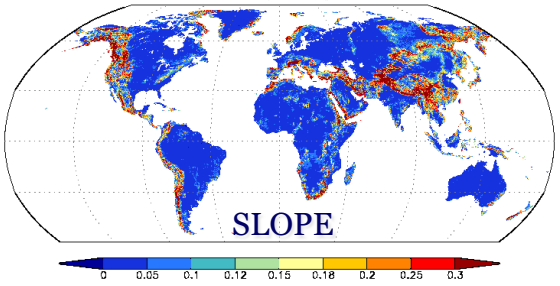
Provide Integrated Output (Example GLDAS)

GOAL: Integrate ground and satellite observations within sophisticated numerical models to produce physically consistent, high resolution fields of land surface states (e.g., snow) and fluxes (e.g., evaporation)

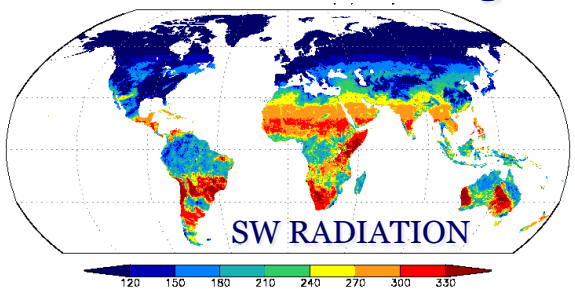
Parameter Inputs

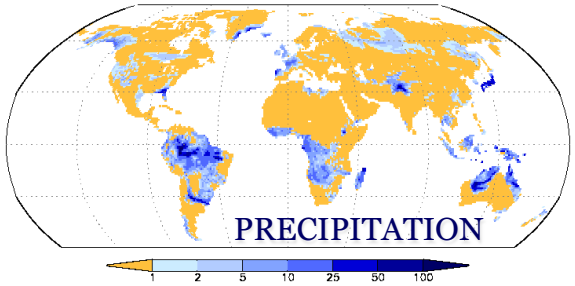






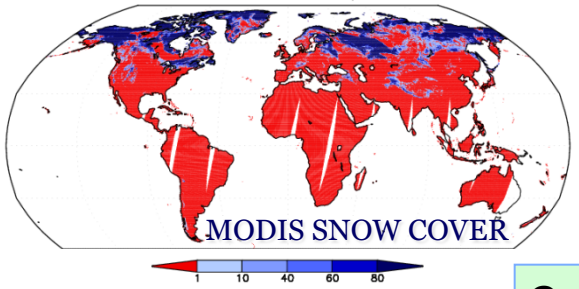
Satellite Based Forcing





AVAILABILITY: Output from 1979-present simulations of Noah (1/4°; 1°), CLM (1°), and Mosaic (1°), and VIC (1°), at http://disc.gsfc.nasa.gov / hydrology/index.shtml

Assimilated Observations



USES: Weather and climate forecast initialization studies, water resources applications, hydrometeorological investigations

Integrated Output

Soil Moisture
Evapotranspiration
Runoff
Snow Water Equivalent

Courtesy Matt Rodell, NASA-GSFC

Model-derived Quantities: Trade-offs

- Help blend remote sensing and in situ observations – provide geophysical variables on uniform spatial latitude-longitude grids, and at regular intervals.

- Provide variables which are not directly observable, for example, 3-D humidity movement in the atmosphere, evapotranspiration, run off

- Help understand processes in the climate system and provide prediction capability

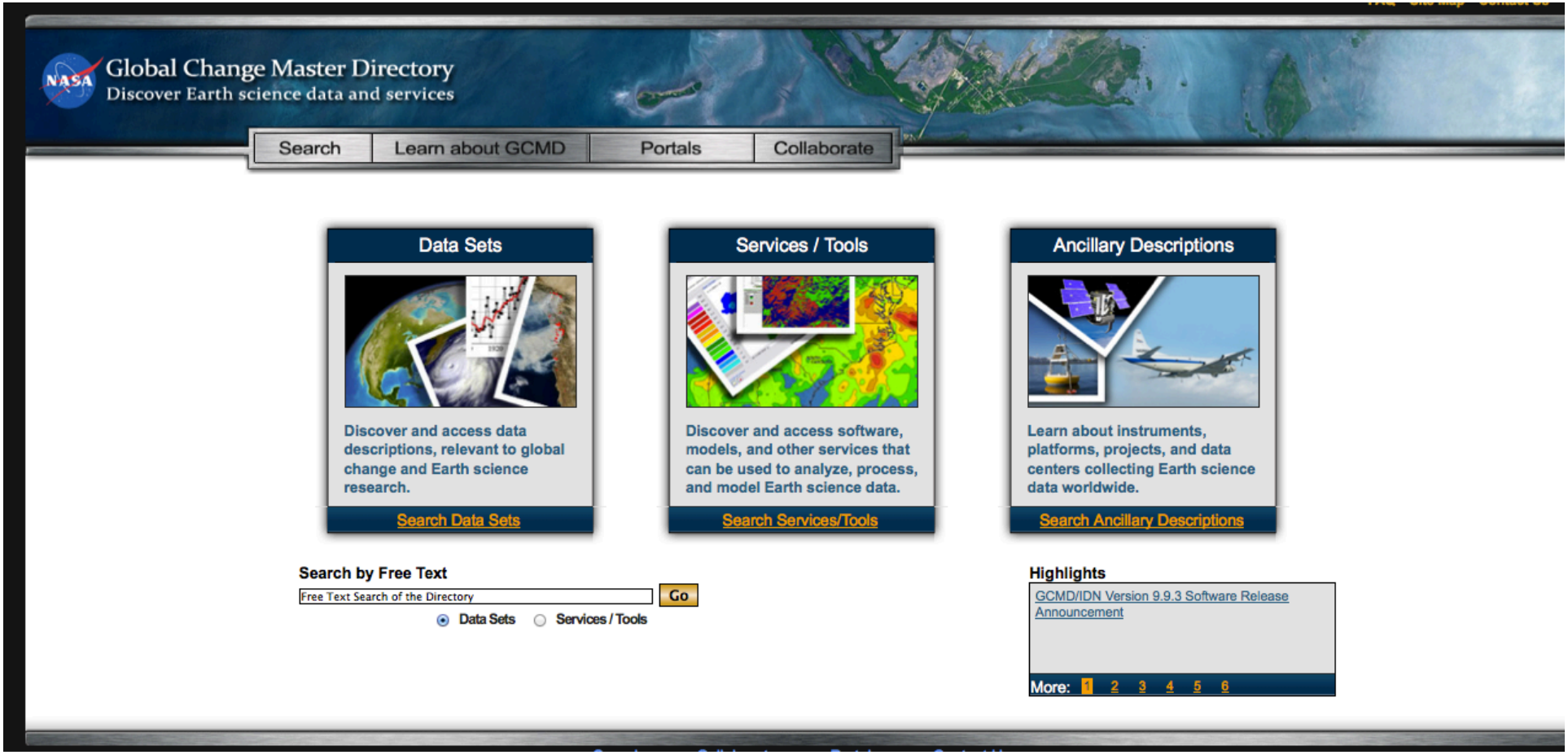
- Use many approximations and assumptions in representing physical processes – as good as our understanding

- There are multiple models, with varying spatial/temporal resolutions and accuracies.

How to Search for Data?

Global Change Master Directory

http://gcmd.gsfc.nasa.gov/index.html



Data Search Directory

Global Change Master Directory

http://gcmd.gsfc.nasa.gov/index.html

Data Search Directory

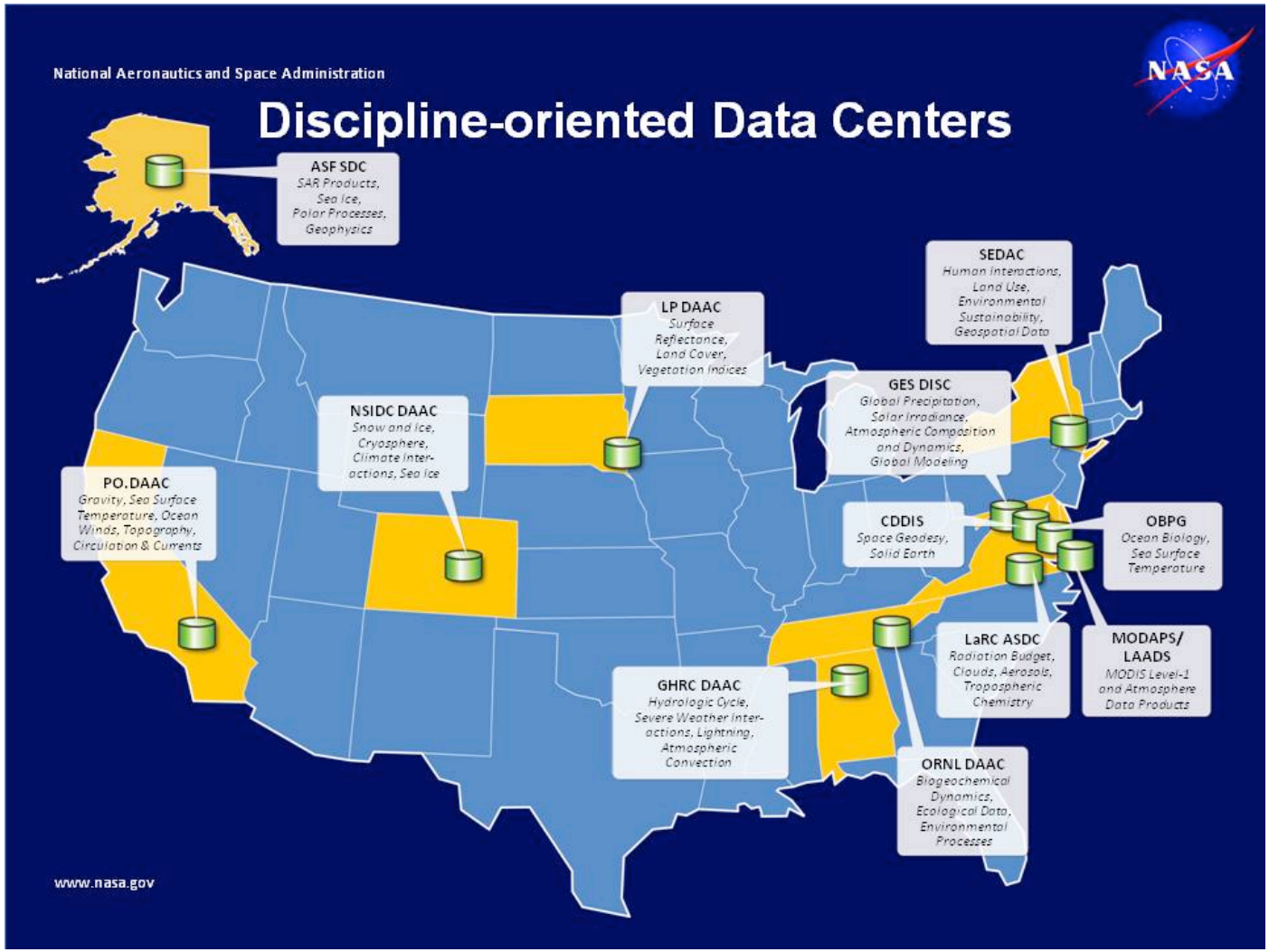
Live Demo of EOSDIS and GCMD Data Search

Coming Up Next Week --

Data Access, Analysis, Visualization

Coming Up Next Week --

NASA Data Centers and Data Access Tools



Thank You!

Amita Mehta **email: amita.v.mehta@nasa.gov**