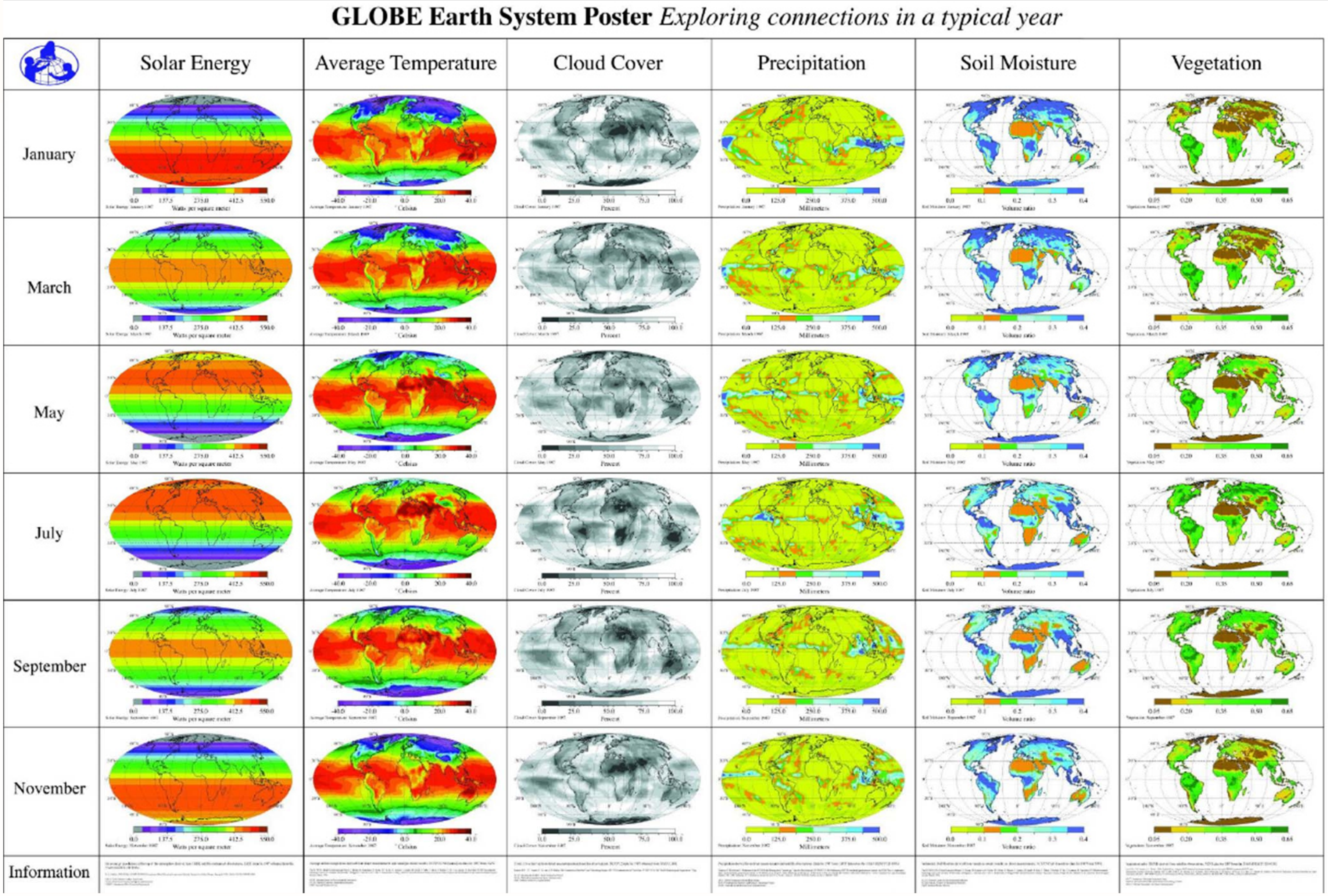
Earth System Science Poster Update: Interactive Satellite Data Exploration

Lin Chambers
NASA LaRC

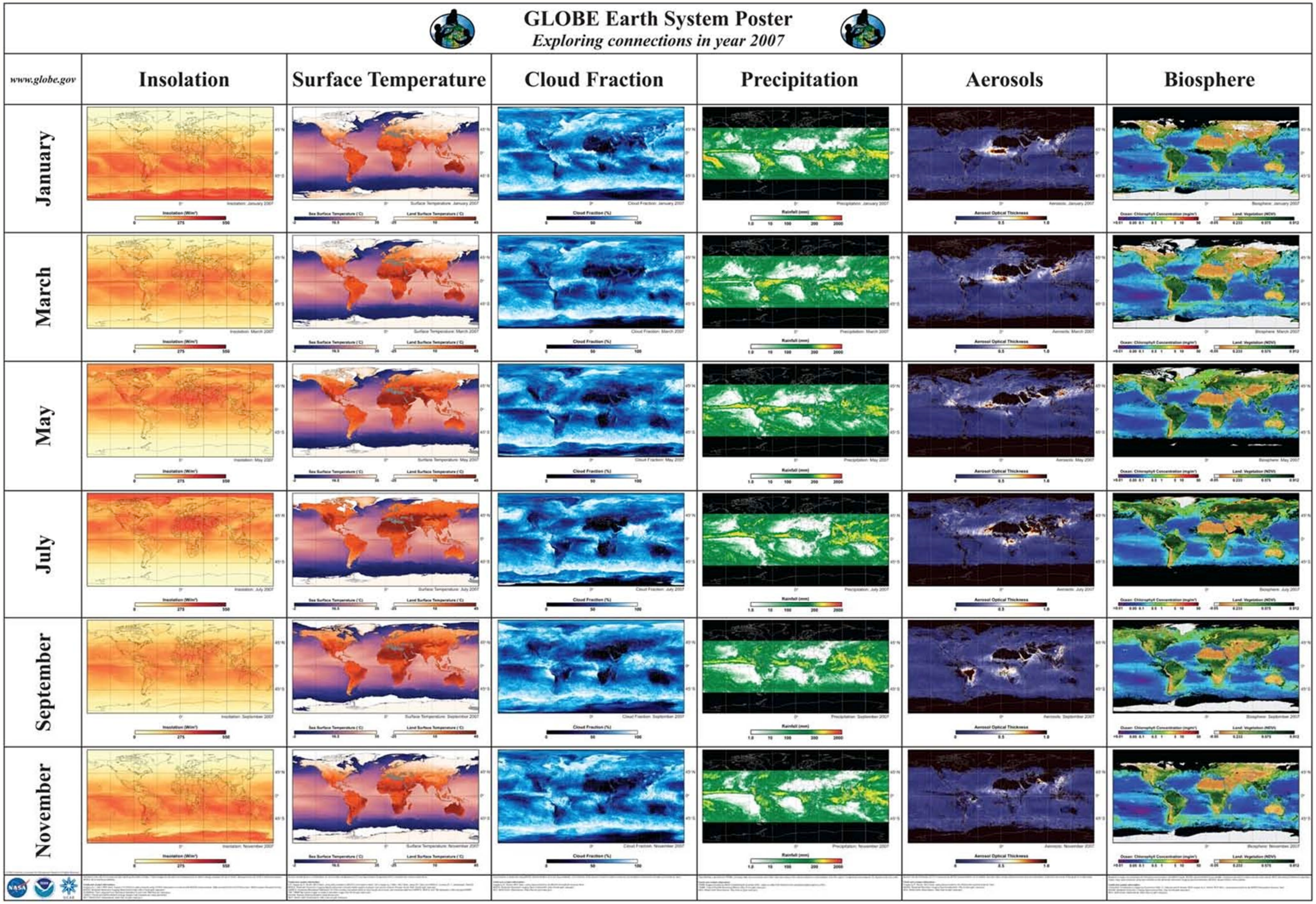
Outline

- The traditional GLOBE Earth System poster and activity
- New! Interactive Earth System poster
- Connecting GLOBE Protocols to Satellite Data
- Friday tour

1987 Version

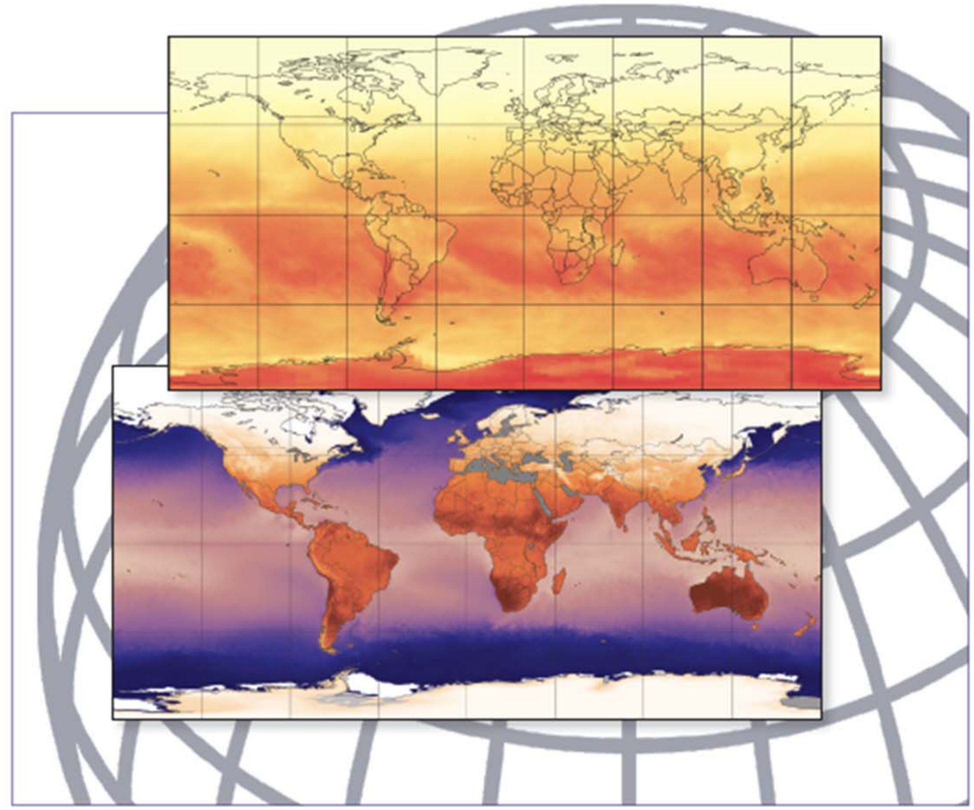


2007 Version



2007 Version

The GLOBE Earth System Poster Learning Activities



Activities to accompany the GLOBE Earth System Poster
"Exploring Connections in Year 2007"

The Science Directorate at NASA's Langley Research Center

2013 Version – The concept

- Leverage the MY NASA DATA Project
- Provide easy access to several years of monthly data for each parameter

Demo

http://mynasadata.larc.nasa.gov/globe-earth-systems-digital-poster-demo/

http://mynasadata.larc.nasa.gov/globe-earth-systems-digital-poster-demo/

Demo

2013 Version – The concept

- Watch this site for developments

http://mynasadata.larc.nasa.gov/globe-earth-systems-digital-poster-demo/

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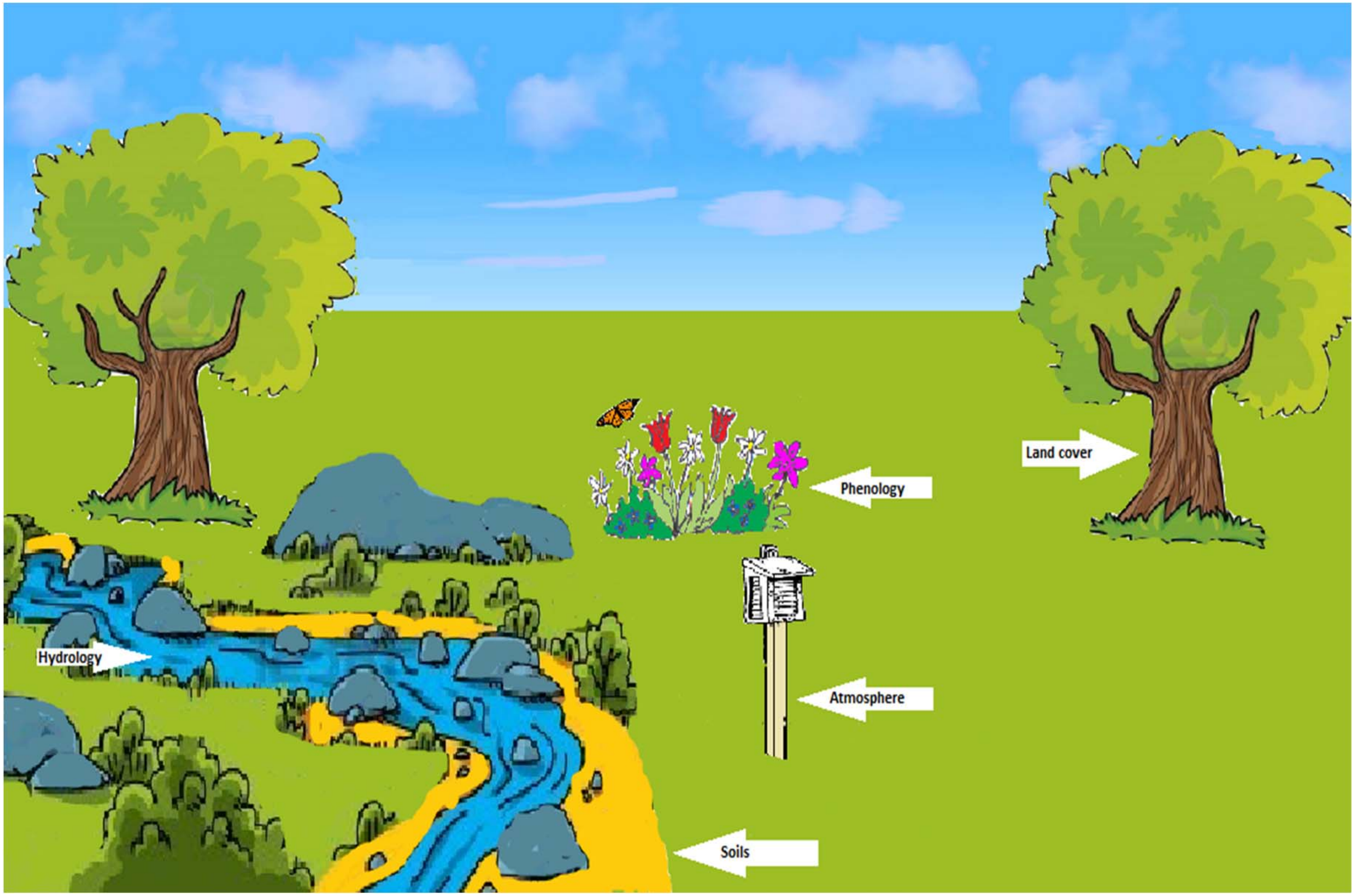
NASA Connections
Instrument loan program
Training slides

Connecting NASA to GLOBE

- Atmosphere
- Soils
- Hydrology
- Land cover
- Phenology



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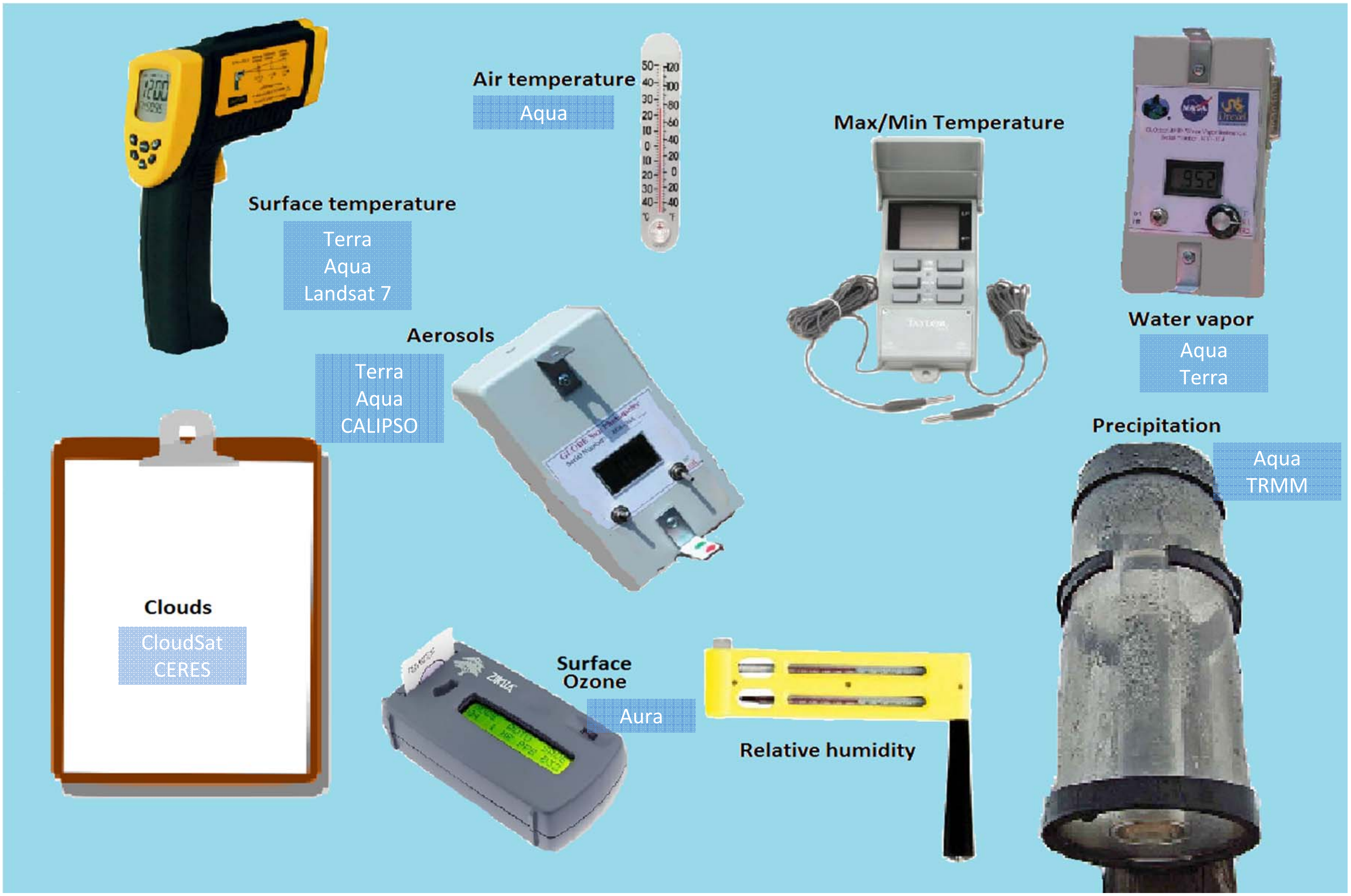
Atmosphere Protocols

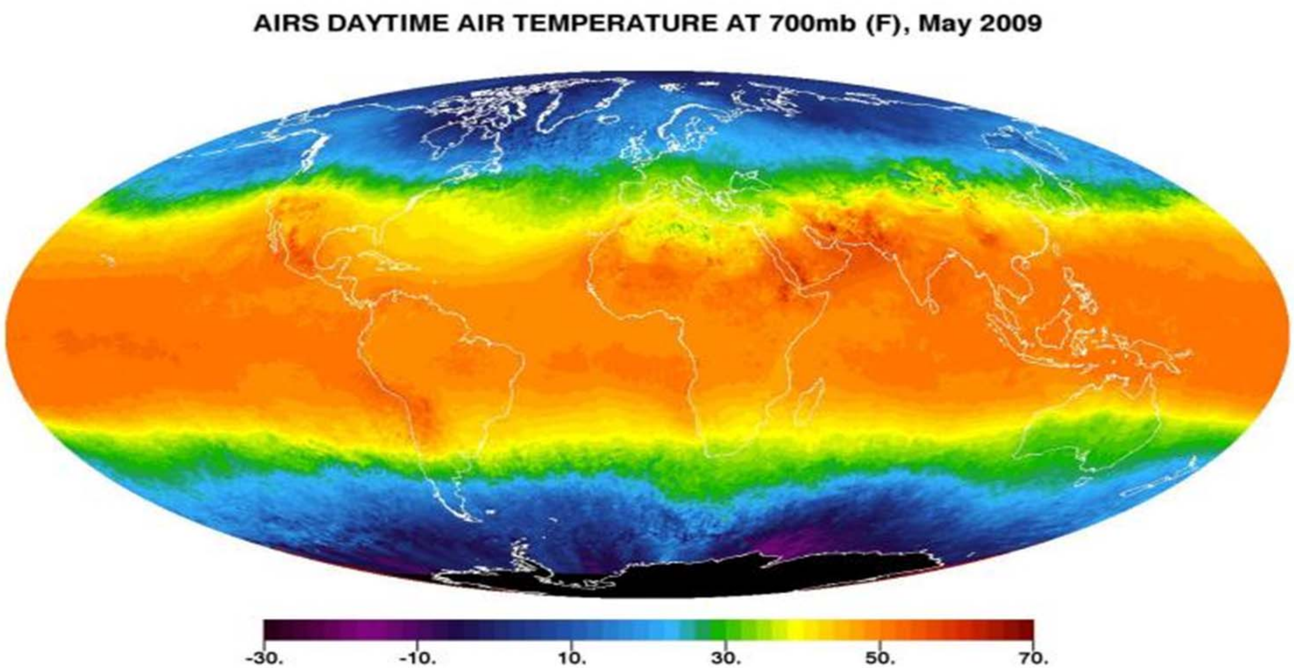
- NASA Connections
- Air Temperature
- Max/Min Temperature
- Precipitation
- Clouds
- Surface Ozone
- Barometric Pressure
- Relative Humidity
- Aerosols
- Water Vapor
- Surface Temperature



Atmosphere Protocol: Air Temperature

Atmosphere
Air Temperature
Max/Min Temperature
Precipitation
Clouds
Surface Ozone
Barometric Pressure
Relative Humidity
Aerosols
Water Vapor
Surface Temperature

Aqua Satellite: Atmospheric Infrared Sounder (AIRS)



The image above was captured by Atmospheric Infrared Sounder (AIRS) instrument located on NASA's Aqua (http://aqua.nasa.gov/) spacecraft. AIRS is able to make observations all the way to Earth's surface, even with the presence of clouds. AIRS, in conjunction with Advanced Microwave Sounding Unit (AMSU), creates a global map of atmospheric temperature, precipitation, cloud amounts and heights, and other atmospheric phenomena. The mission was launched in 2002 and is managed by NASA's Jet Propulsion Laboratory in Pasadena, CA. This image shows average daytime air temperature in May, 2009 found at the atmospheric pressure of 700 millibar. This occurs at approximately 3,000 meters altitude, which is located in the lower troposphere. Deep reds represent warm air and deep blues and purple represent below freezing

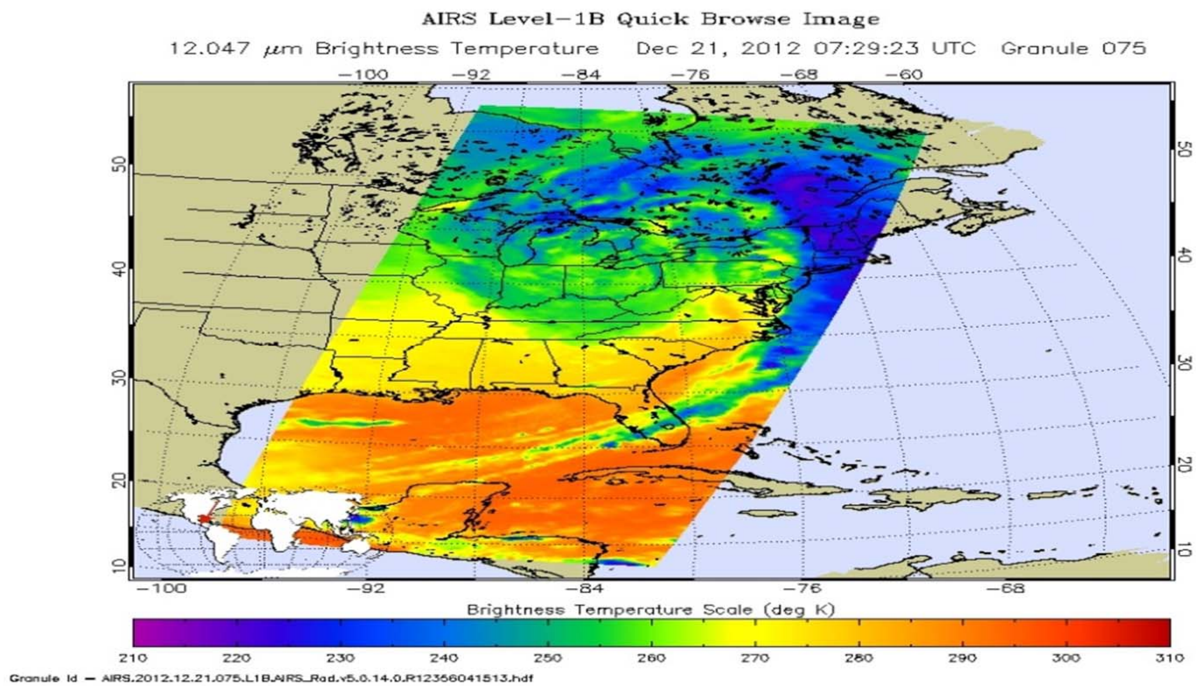
Atmosphere Protocol: Max/Min Temperature

Unfortunately, satellite data is unavailable for min/max air temperatures due to current orbital paths. In order for this measurement to be collected from space, a geostationary satellite would be required in order to take constant measurements of temperature throughout the day. The best place to obtain this data point for verification would be from local ground stations. Student data collection is extremely important in this instance since resources are limited.

Atmosphere Protocol: Precipitation

Atmosphere
Air Temperature
Max/Min Temperature
Precipitation
Clouds
Surface Ozone
Barometric Pressure
Relative Humidity
Aerosols
Water Vapor
Surface Temperature

Aqua Satellite: Atmospheric Infrared Sounder (AIRS)



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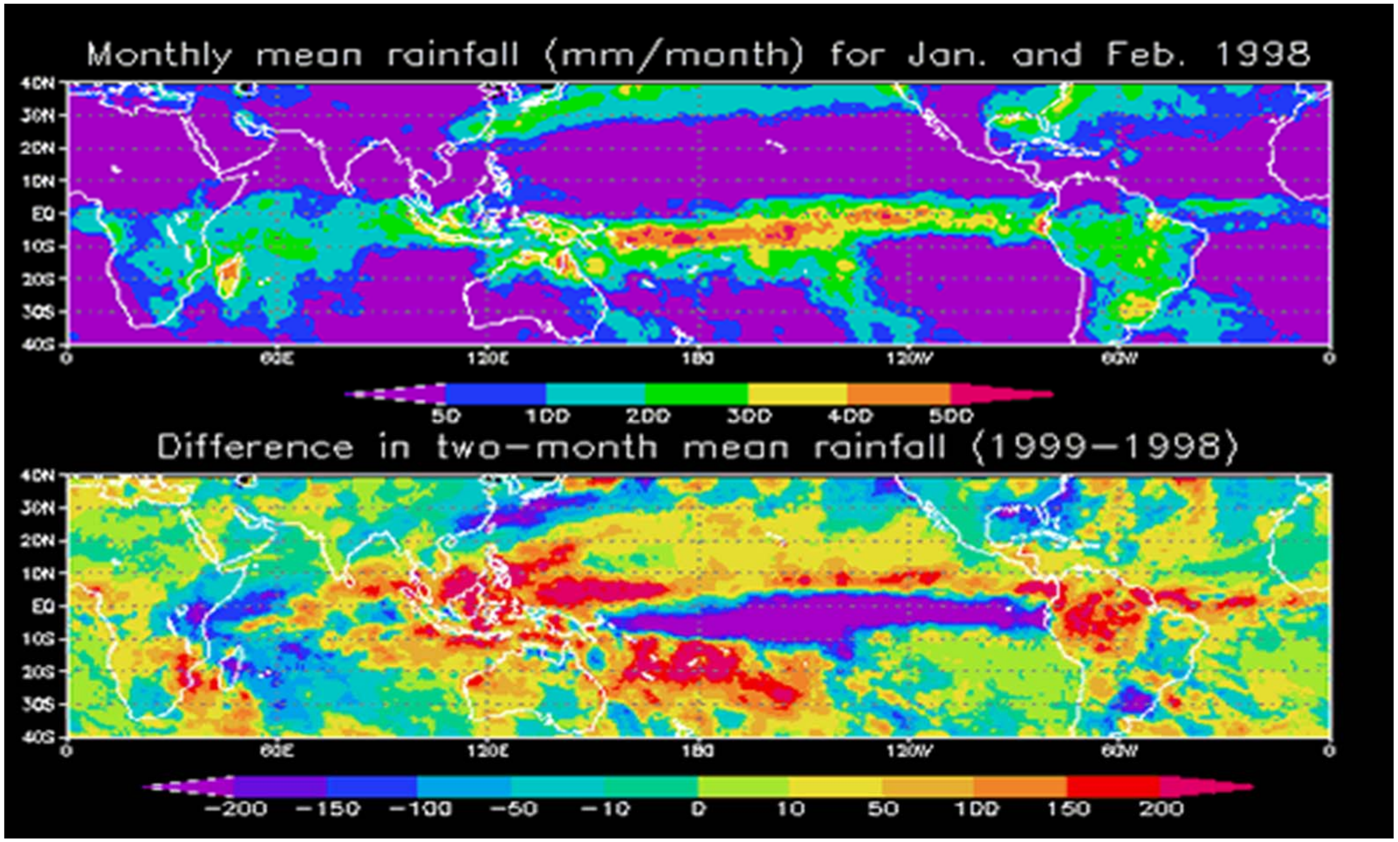
AIRS also records monthly precipitation anomalies for more direct measurements of precipitation:
http://disc.sci.gsfc.nasa.gov/AIRS/rusfiresimages2010/AirsPrecipAnom.png (image download)
http://disc.sci.gsfc.nasa.gov/featured-items/airs-observes-russian_fires (description/source)

TRMM (Tropical Rainfall Measuring Mission

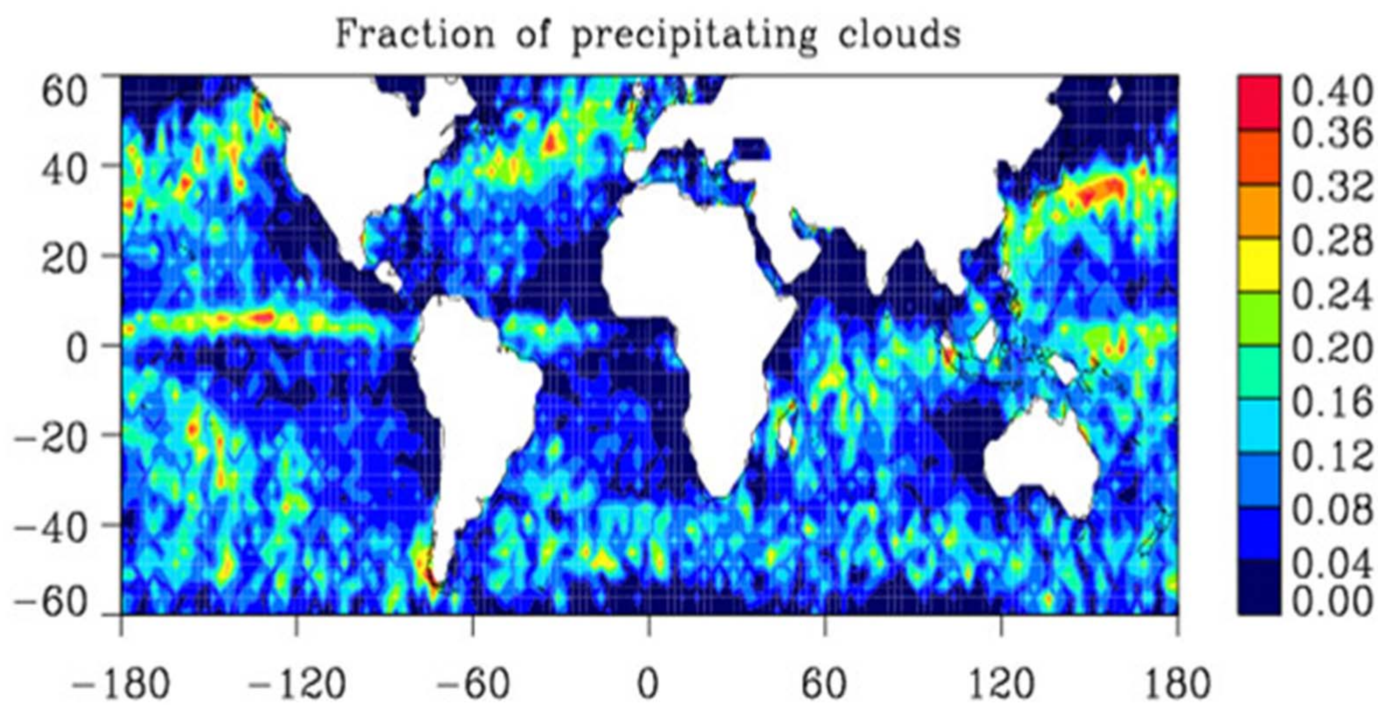


The image above was captured by the Tropical Rainfall Measuring Mission (TRMM) (http://trmm.gsfc.nasa.gov/) by its precipitation radar (PR) instrument. TRMM is a joint mission between NASA and the Japan Aerospace Exploration Agency (JAXA) to improve our understanding of distribution of precipitation in the tropics and how it contributes to climate. Although the data range is limited to tropical and subtropical regions of the earth, it plays a critical role in tropical cyclone forecasting, weather prediction, and precipitation climatologies that influence the globe. A key component to the TRMM project is ground validation by ground-based radars and rain gauges. Primary sites for ground validation in the United States include Houston, TX and Melbourne, FL. Other students in subtropical regions can increase the ground validation database by following the precipitation protocols and uploading data to the GLOBE website.
Why TRMM is important: http://trmm.gsfc.nasa.gov/overview_dir/why-hs.html

Atmosphere Protocol: Clouds

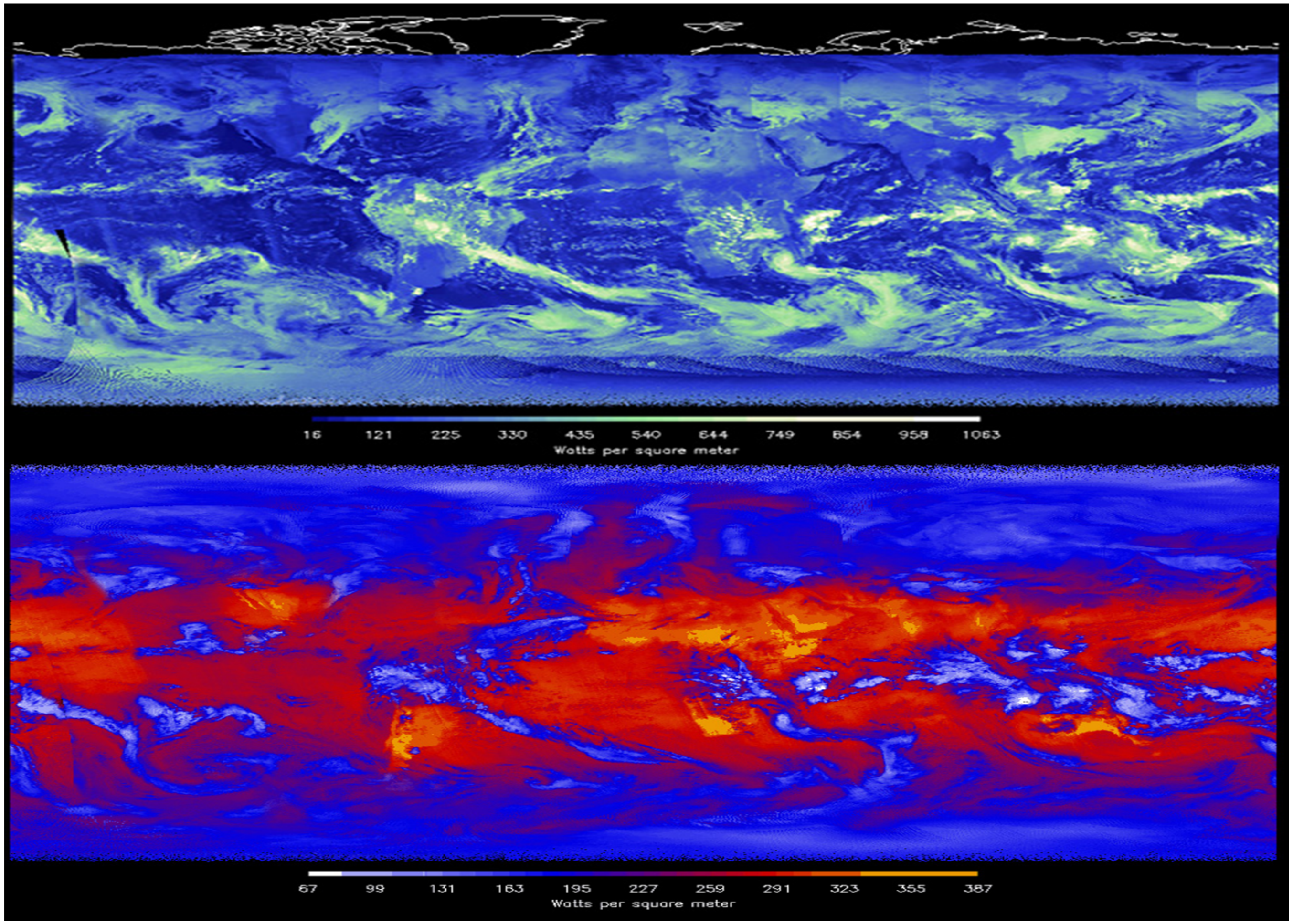
Atmosphere
Air Temperature
Max/Min Temperature
Precipitation
Clouds
Surface Ozone
Barometric Pressure
Relative Humidity
Aerosols
Water Vapor
Surface Temperature

CloudSat Satellite: Cloud Profiling Radar



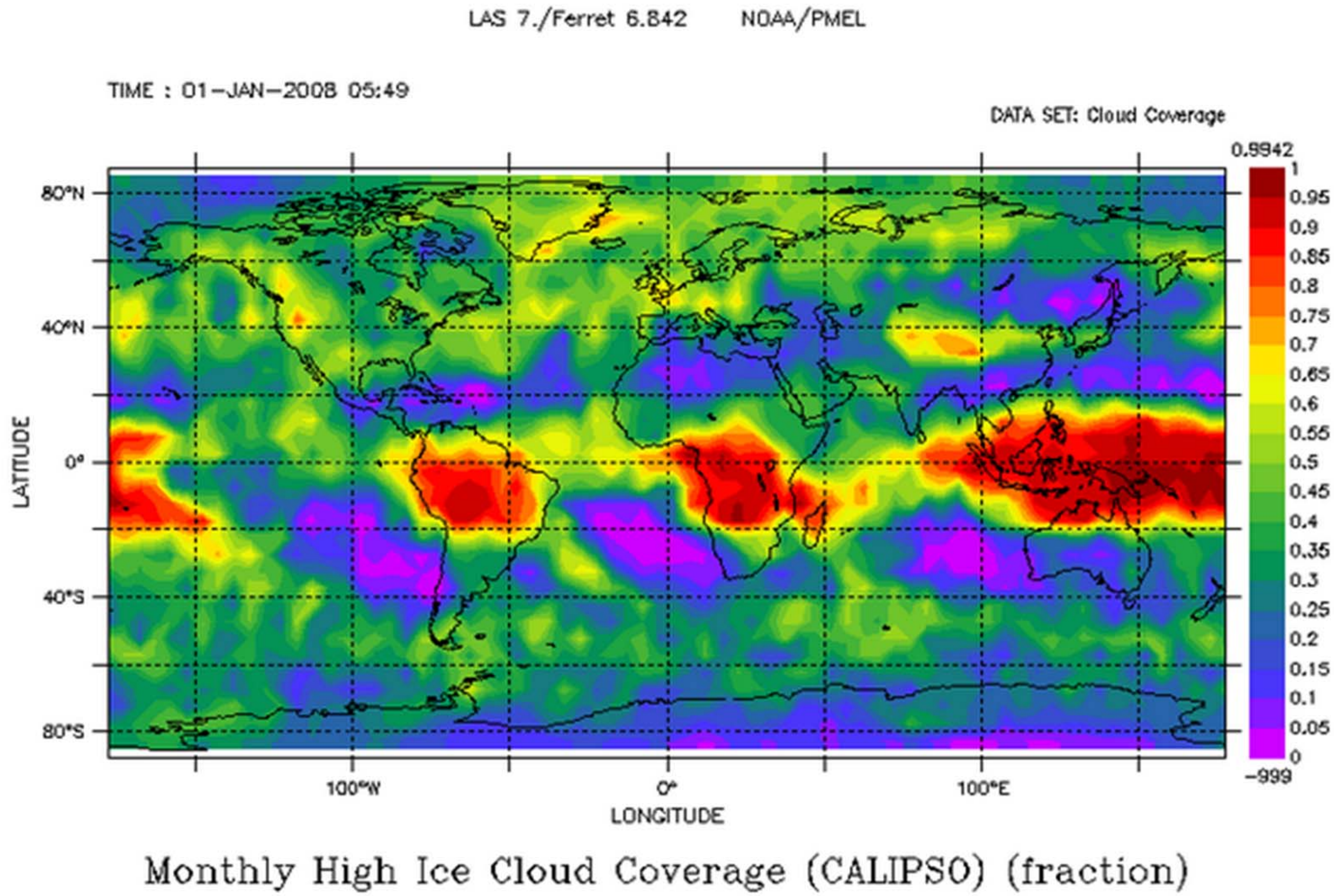
The image above was captured by NASA's CloudSat (http://cloudsat.atmos.colostate.edu/) spacecraft by its cloud profiling radar (CPR). The mission was launched in April, 2006 in order to study the structure and composition of clouds. The goal of the mission is to study the role that clouds play in regulating the Earth's weather, climate, and air quality. CloudSat is one of the first satellites to study clouds on a global basis by using CPR to slice through clouds to see their vertical structure. The data from the image shows that 13% of clouds observed over the Earth's oceans at any time are producing rain that reach the surface. Yellows and reds indicate a higher percentage.

Suomi NPP Satellite: CERES instrument



The images shown above were obtained by Clouds and the Earth's Radiant Energy System (CERES) (http://ceres.larc.nasa.gov/) instrument onboard NASA's Suomi National Polar-orbiting Partnership (Suomi NPP) Earth-observing satellite. Other CERES instruments are located TRMM, Terra, and Aqua Satellites. CERES on Suomi NPP was launched in October, 2011 and began taking measurements in January, 2012. CERES conducts cloud properties estimates and produces both solar-reflected and Earth-emitted radiation images in order to understand the impact clouds have on incoming and outgoing energy. In the images shown the relationship between solar-reflected and Earth-emitted radiation can be seen. On the left, the white and light blue represent more incoming solar energy being reflected back to space. On the right, the red and yellow areas represent where more Earth-emitted radiation is escaping to space. By comparing and contrasting the images, it can be determined that in areas of higher solar reflectance (greater cloud cover) less Earth-emitted radiation is released.

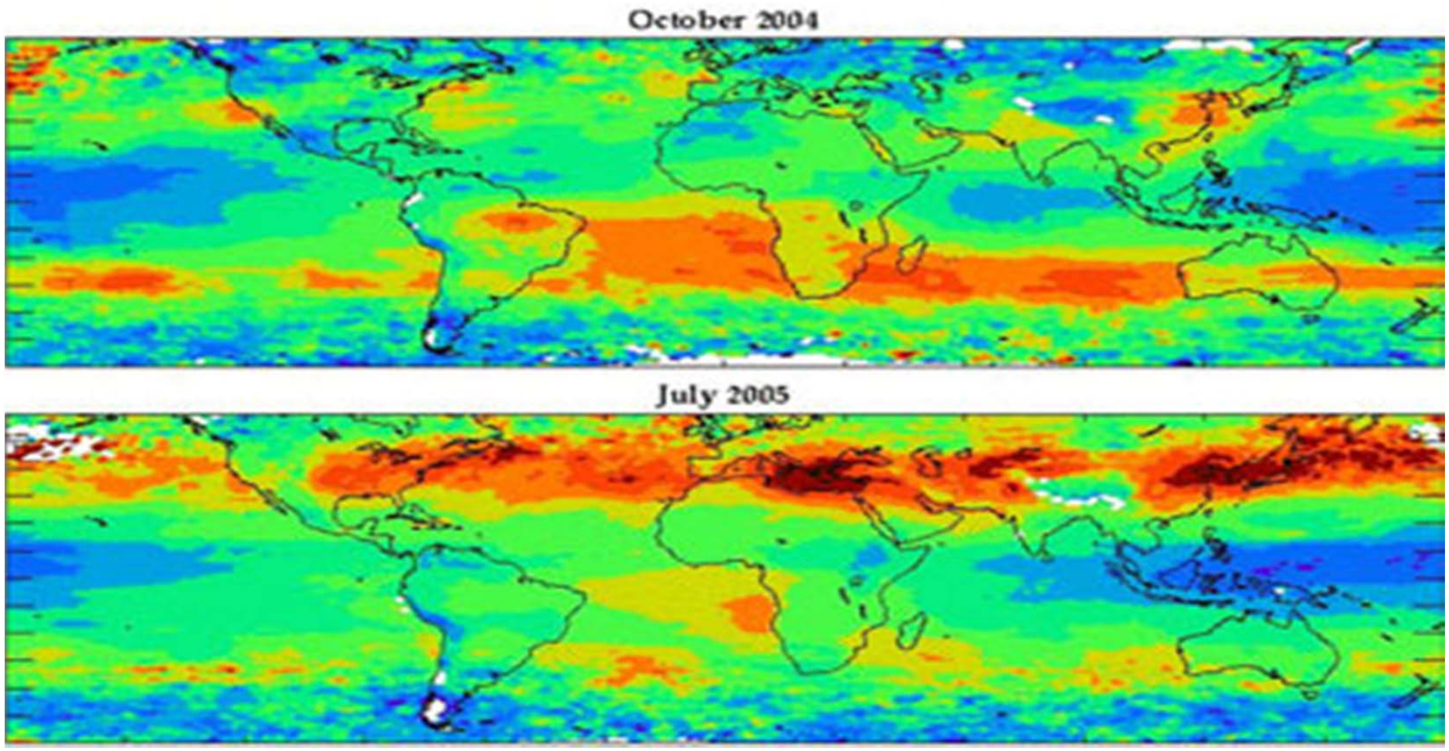
CALIPSO Satellite: Active Lidar Instrument



The image above was captured by NASA's Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO) (http://www.nasa.gov/mission_pages/calipso/main/) satellite. CALIPSO provides insight into the role clouds and aerosols play in regulating Earth's weather, climate, and air quality. CALIPSO was launched in April, 2006 alongside CloudSat. This image from MY NASA DATA's Live Access Server shows global High Ice Cloud coverage for January 2008.

Atmosphere Protocol: Surface Ozone

Aura Satellite: Ozone Monitoring Instrument



The image above was captured by NASA's Aura (http://aura.gsfc.nasa.gov/) satellite by the ozone monitoring instrument (OMI). The OMI is capable of distinguishing between aerosol types such as smoke, dust, and sulfates. In total, it measures cloud pressure and coverage which provides data to derive tropospheric ozone. It helps to monitor the recovery of the ozone layer as well as studying ground-level ozone. The images pictured show how pollutant created in one region of the globe can travel great distances. The top image shows ozone created from burning biomass. As it traveled, the ozone levels increased in concentration. It is important to note that air quality in one area is not limited, but instead creates a much larger effect.

Atmosphere Protocol: Barometric Pressure

Atmosphere
Air Temperature
Max/Min Temperature
Precipitation
Clouds
Surface Ozone
Barometric Pressure
Relative Humidity
Aerosols
Water Vapor
Surface Temperature

There are no current satellite missions that are capable of measuring the pressure at the surface of the Earth. Pressure changes with height, which causes an issue in regards to satellite data collection. In situ data collection of pressure may even vary from floor to floor of a building. With current technology, satellites are unable to account for the pressures at all levels of the atmosphere. Students are encouraged to collect their own data and to go to local ground data stations for data verification.

Atmosphere Protocol: Relative Humidity

Atmosphere
Air Temperature
Max/Min Temperature
Precipitation
Clouds
Surface Ozone
Barometric Pressure
Relative Humidity
Aerosols
Water Vapor
Surface Temperature

Relative humidity is not measured by satellites; however water vapor data can be used to calculate relative humidity for an area.

Relative humidity=$\frac{Actual\ vapor\ density}{Saturation\ vapor\ density} * 100$

Saturation vapor density can be determined using standard charts based on the temperature at the time of data collection

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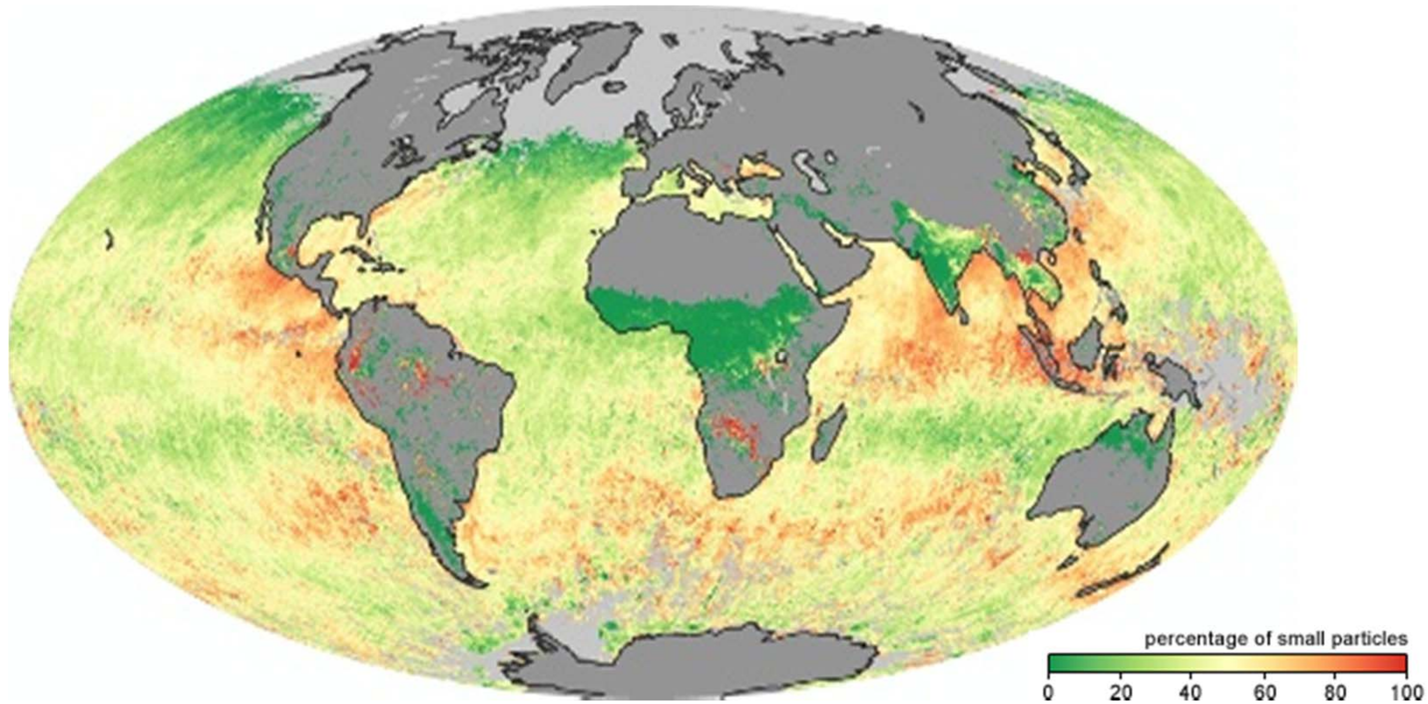
Atmosphere Protocol: Aerosols

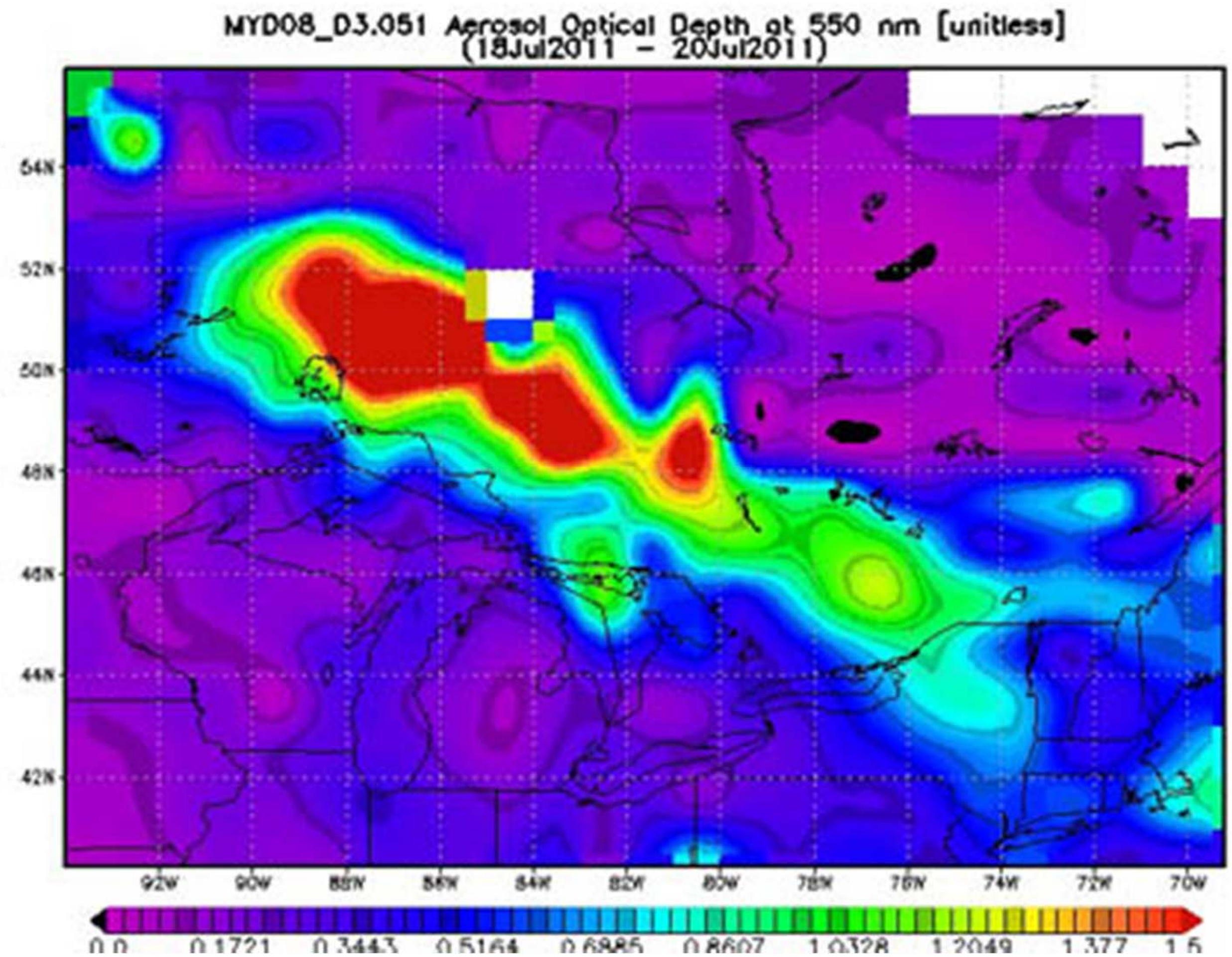
- Atmosphere
- Air Temperature
- Max/Min Temperature
- Precipitation
- Clouds
- Surface Ozone
- Barometric Pressure
- Relative Humidity
- Aerosols
- Water Vapor
- Surface Temperature

Terra Satellite: Moderate Resolution Imaging Spectroradiometer (MODIS)



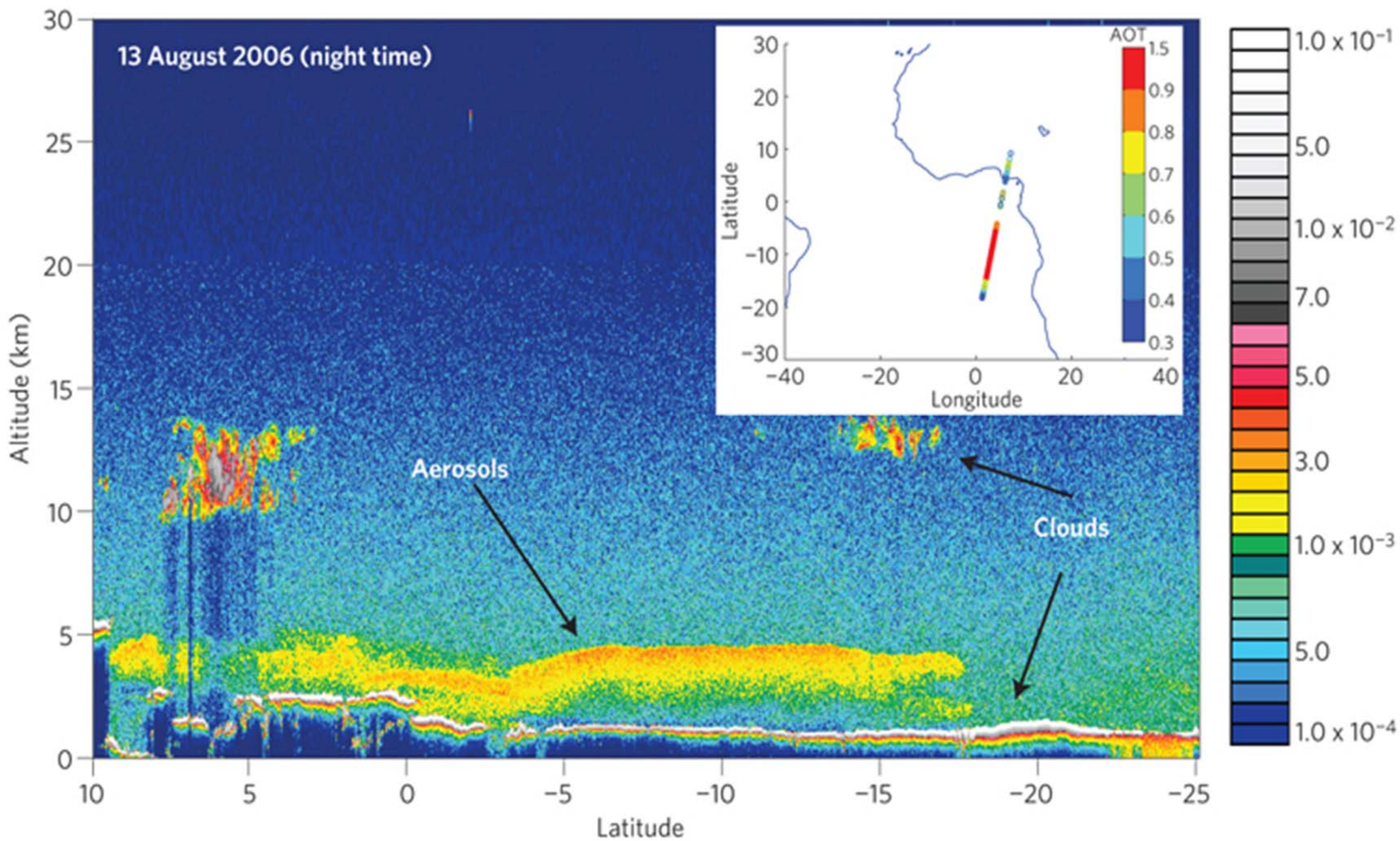
The image above was captured by NASA's Terra (http://www.nasa.gov/mission_pages/terra/index.html#.UgTz55LqmFk) satellite through the use of MODIS. Terra was launched in December 1999 with the purpose of studying global climate. The MODIS Aerosol Product monitors the ambient aerosol optical thickness over the oceans and the continents globally. Aerosol size distribution is derived over the oceans, whereas aerosol type is derived over the continents. The image displayed shows size distribution of aerosols. Green areas show plumes dominated by large particles and red areas show plumes dominated by small particles. Aerosol particles of natural origin tend to be larger in size than human produced aerosols. Red areas indicating human produced aerosols on this map are located on or near continents as expected. AERONET is a global network of sun photometers that measures aerosols from the ground to validate MODIS aerosol data. Further data collection by students is encouraged.

Aqua Satellite: Moderate Resolution Imaging Spectroradiometer (MODIS)



The image above was captured by the MODIS instrument located on NASA's Aqua (http://aqua.nasa.gov/) spacecraft. The MODIS Aerosol Product monitors the ambient aerosol optical thickness over the oceans and the continents globally. Aerosol size distribution is derived over the oceans, whereas aerosol type is derived over the continents. MODIS can also detect heat signatures and can identify hot spots where fires are still burning. The Aqua mission was launched in 2002 and is managed by NASA's Jet Propulsion Laboratory in Pasadena, CA. The image displayed covers western Ontario where smoke from wildfires streamed towards the Great Lakes. Red areas have higher aerosol optical depth value. Higher aerosol optical depth indicated decreasing light transmission or increased aerosols. In this instance, the aerosols would be composed largely of soot particles.

CALIPSO Satellite: Active Lidar Instrument



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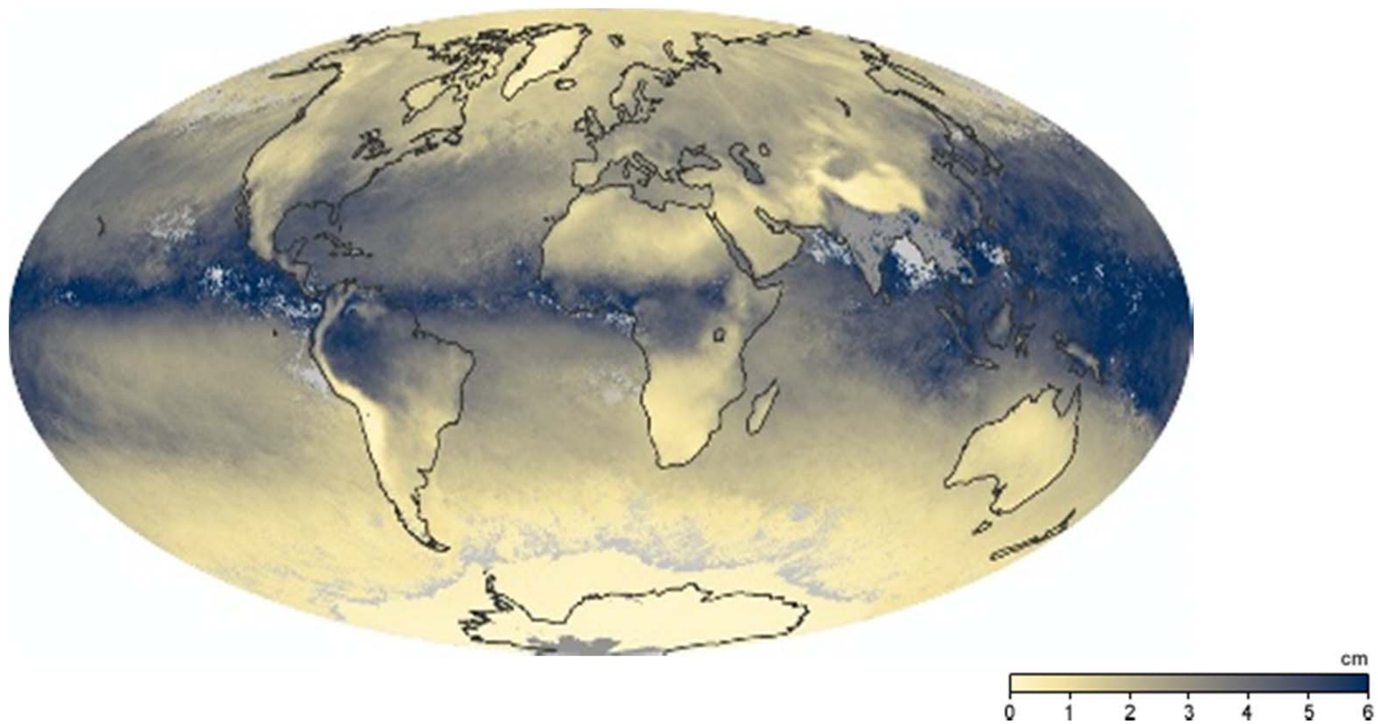
Atmosphere Protocol: Water vapor

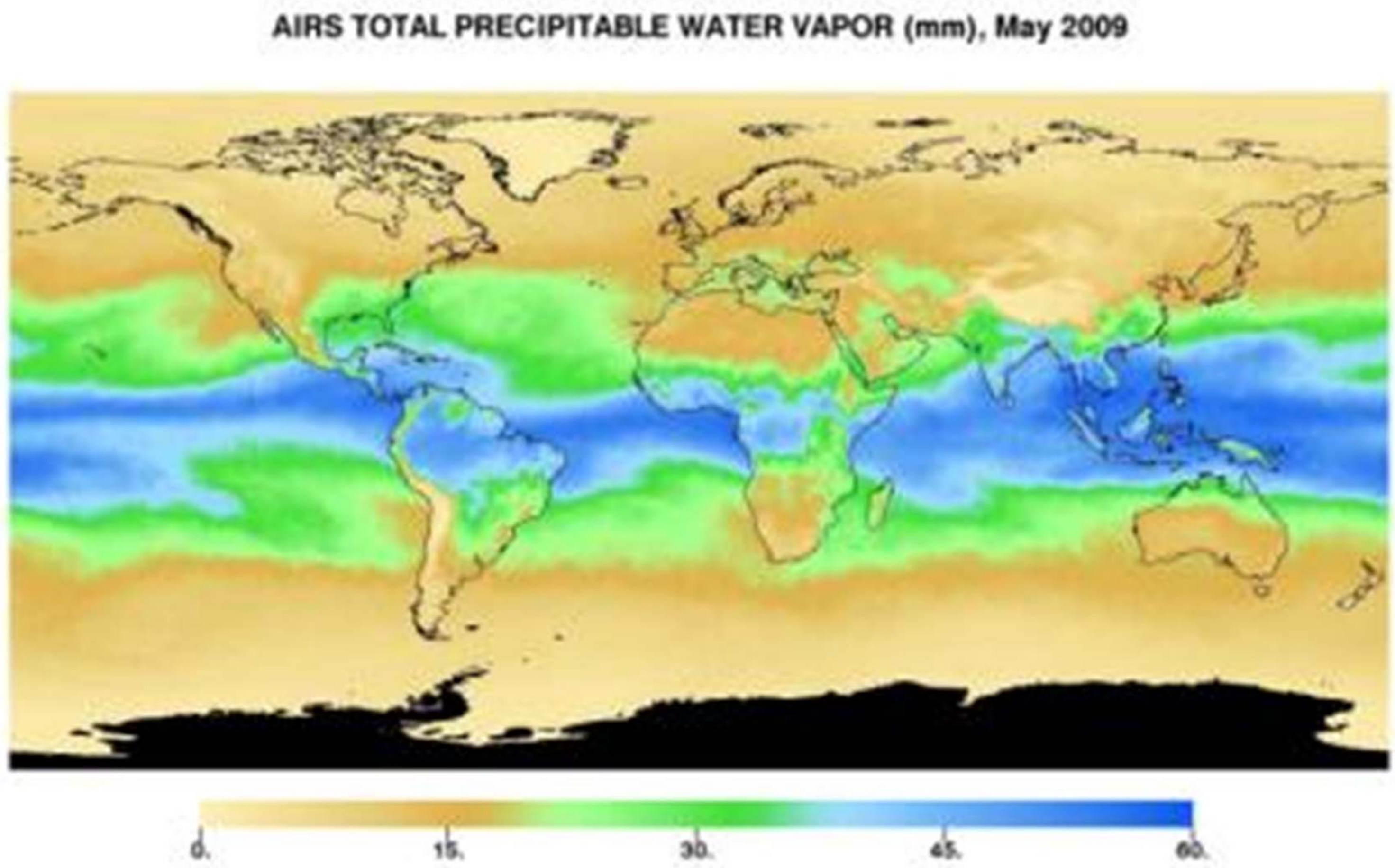
Atmosphere
Air Temperature
Max/Min Temperature
Precipitation
Clouds
Surface Ozone
Barometric Pressure
Relative Humidity
Aerosols
Water Vapor
Surface Temperature

Terra Satellite: Moderate Resolution Imaging Spectroradiometer (MODIS)



The image above was captured by NASA's Terra (http://www.nasa.gov/mission_pages/terra/index.html#.UgTz55LqmFk) satellite through the use of MODIS. Terra was launched in December 1999 with the purpose of studying global climate. The MODIS precipitable water product calculates columnar water-vapor amounts. Water vapor is one of the most important greenhouse gases in the atmosphere because they radiate heat in all directions. The image displayed shows the average amount of water vapor in a column of the atmosphere. The units are in centimeters which is equivalent to if all the water vapor in the column were to condense. The highest amounts of water vapor appear dark blue. The band of extremely humid air tends to move north and south of the equator as the seasons change. This band is part of the Intertropical Convergence Zone. Away from the equator, water vapor concentrations are higher in the hemisphere experiencing summer.

Aqua Satellite: Atmospheric Infrared Sounder (AIRS)



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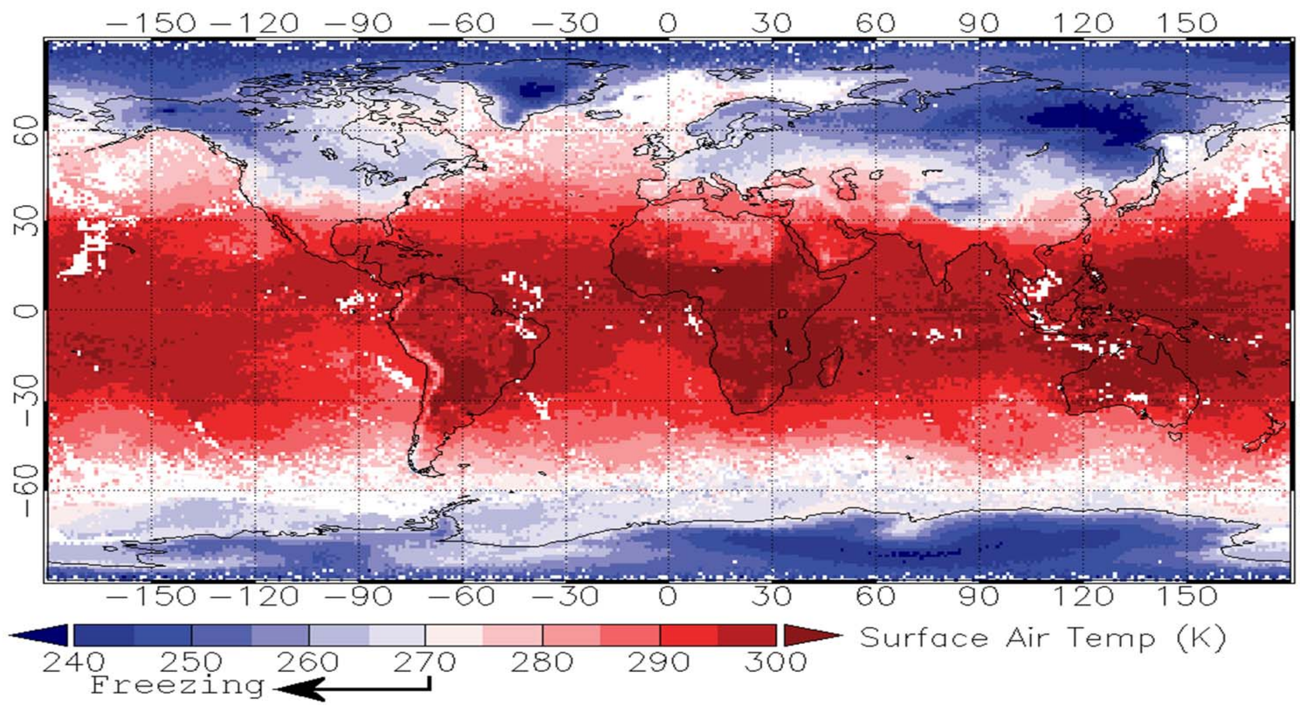
Atmosphere Protocol: Surface temperature

Atmosphere
Air Temperature
Max/Min Temperature
Precipitation
Clouds
Surface Ozone
Barometric Pressure
Relative Humidity
Aerosols
Water Vapor
Surface Temperature

Aqua Satellite: Atmospheric Infrared Sounder (AIRS)



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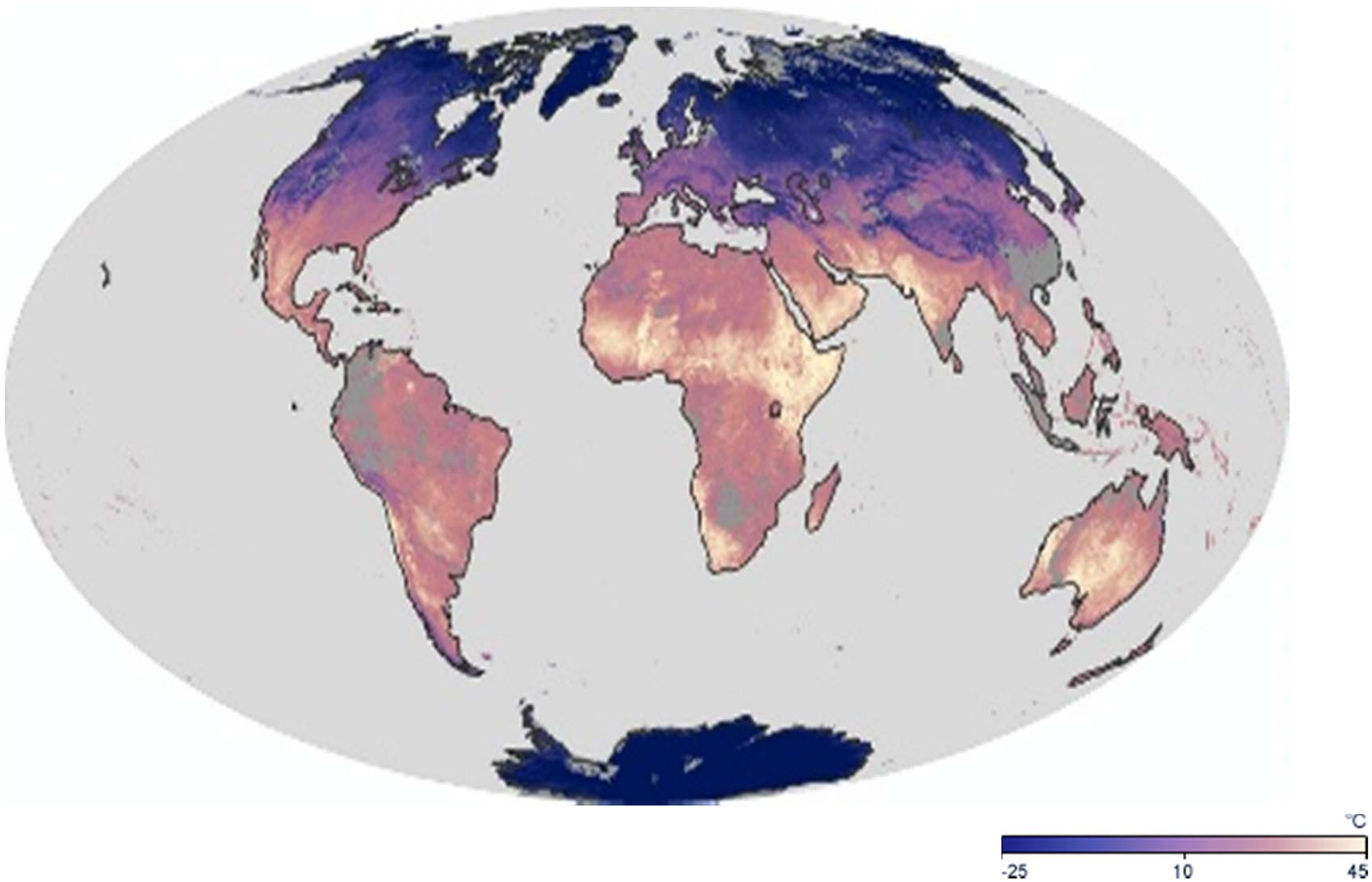
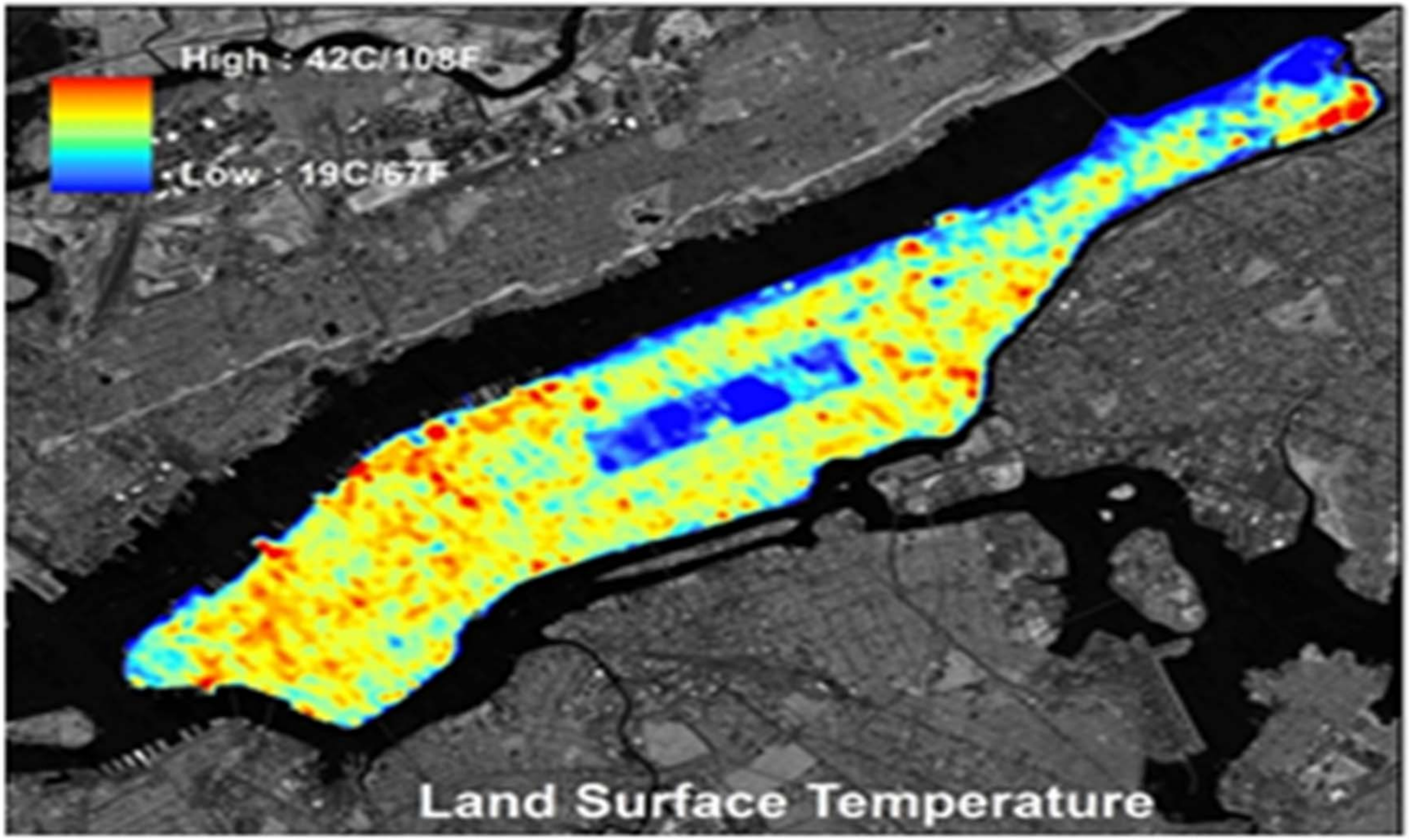
Terra Satellite: Moderate Resolution Imaging Spectroradiometer (MODIS)



The image above was captured by NASA's Terra (http://www.nasa.gov/mission_pages/terra/index.html#.UgTz55LqmFk) satellite through the use of MODIS. Terra was launched in December 1999 with the purpose of studying global climate. The MODIS Land Surface Temperature (LST) and Emissivity product is responsible for producing surface temperature data. LSTs data is whatever the surface would feel like if you were to touch it. Surfaces measured range from ice to building tops. The image shown here shows warm temperatures near the equator and the southern hemisphere and cold temperatures in the northern hemisphere, which is to be expected in February. Areas located near the equator maintain the warm temperatures throughout the year, whereas the northern and southern hemispheres change with the seasons. It can also be seen that altitude plays a role in surface temperature. Mountain ranges appear colder than other locations at the same latitude due to

Landsat 7 Satellite: Enhanced Thematic Mapper (ETM+)

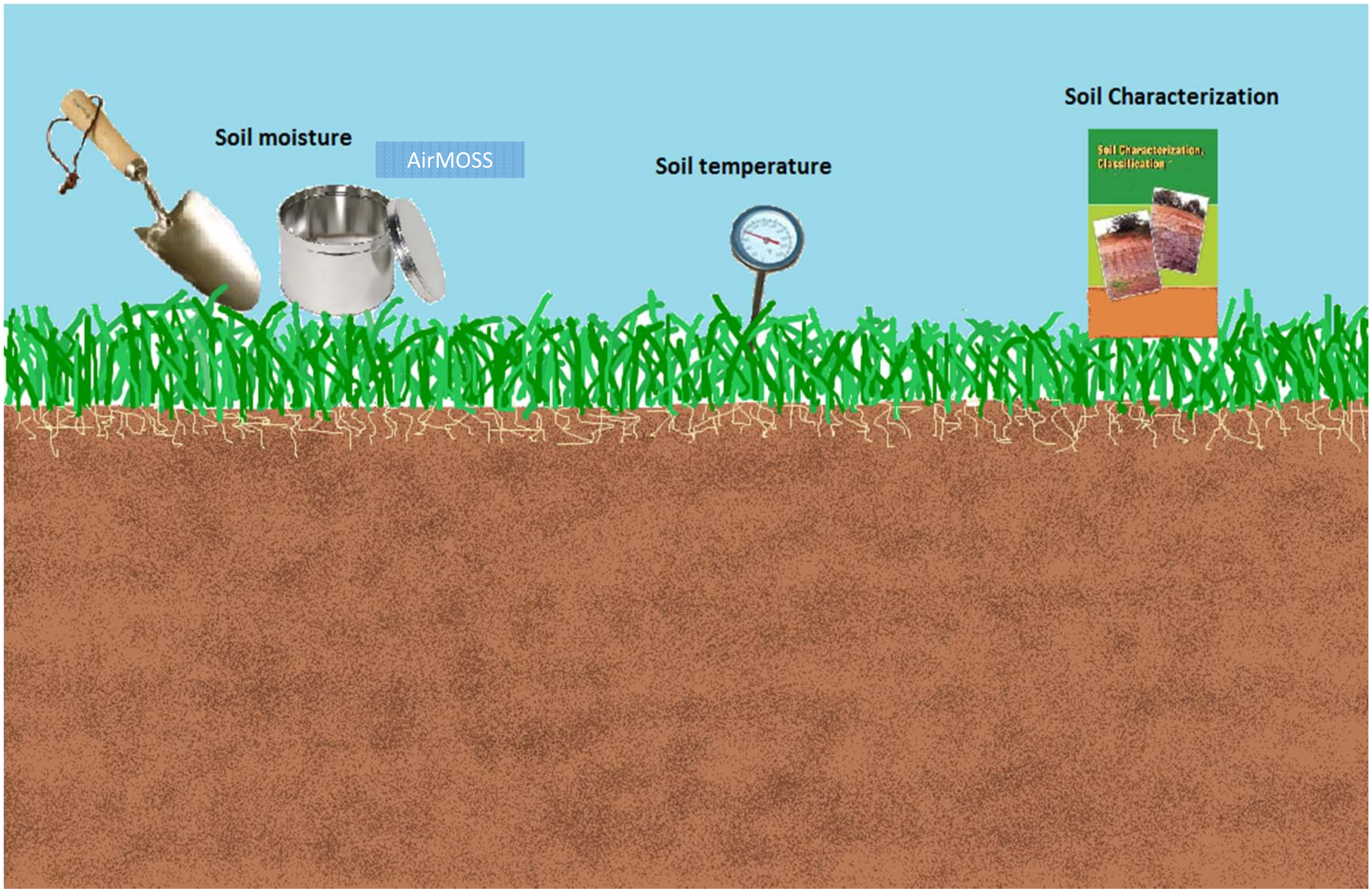


The image above was captured by the Enhanced Thematic Mapper (ETM+) on NASA's Landsat 7 (http://landsat.gsfc.nasa.gov/) satellite. The mission was launched in April, 1999. The ETM+ has enhanced features that make it more versatile and efficient for global change studies and land cover monitoring than previous thematic mappers. The ETM+ has a variety of bands specializing in various areas.

The image displayed shows data extracted from the ETM+ thermal band. To obtain land surface temperature (LST) the land surface emissivity (LSE) of the study area must be accounted for. LSE is the quantification of the intrinsic ability of a surface in converting heat energy into above-surface radiation. It relies on the physical properties of the surface and on observation conditions. The varying temperatures shown in this image account for the physical properties of the surfaces from which the

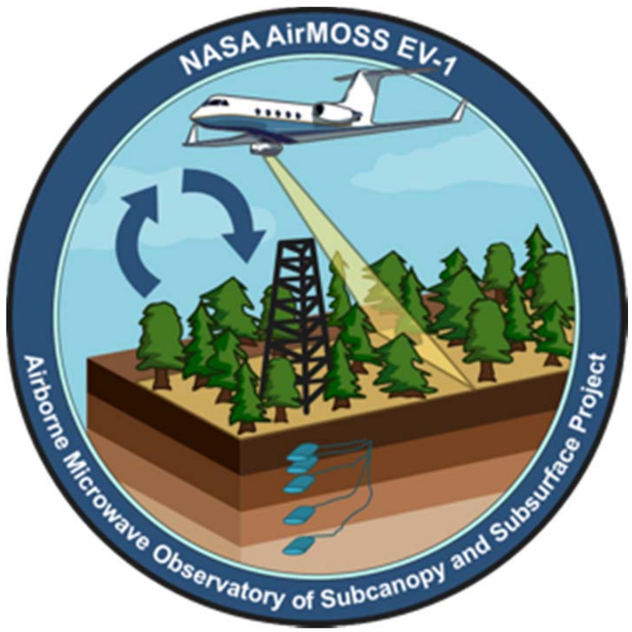
Soils Protocols

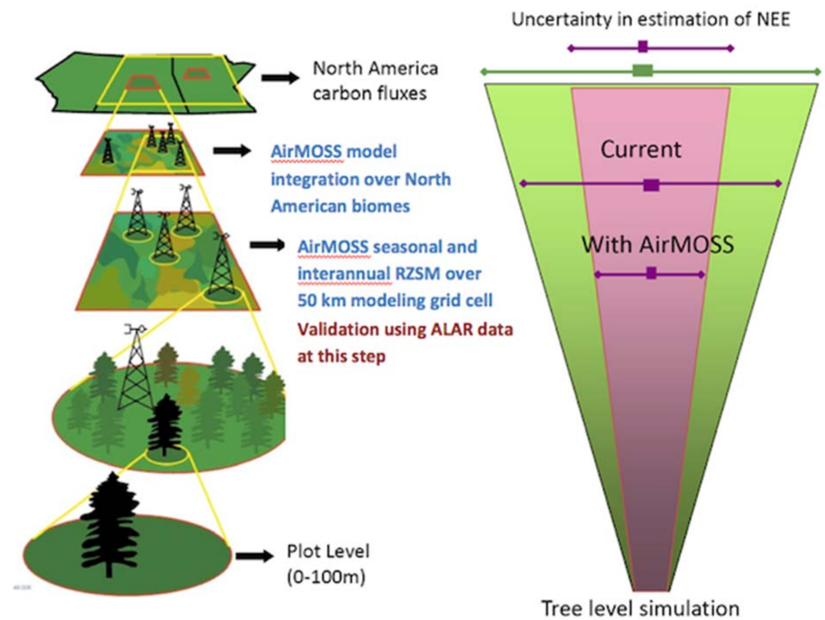
NASA Connections
Soil Moisture
Soil temperature
Soil characterization



Soils Protocol: Soil moisture

NASA Connections
Soil Moisture
Soil Temperature
Soil Characterization





AirMOSS data is currently unavailable as flight campaigns have just started in Spring 2013. For more information visit: http://airmoss.jpl.nasa.gov/ Follow the flight campaign calendar to view where it's going next.

AirMOSS uses an ultra-high frequency synthetic aperture radar which is capable of penetrating through vegetation canopies and a soil depth of up to 1.2 meters. This airborne campaign will provide high-resolution observations of root-zone soil moisture over regions representing each of the major biomes in North America. In addition, the data measured will help to quantify the impact of soil moisture variation on regional carbon fluxes.

NASA's Uninhabited Aerial Vehicle Synthetic Aperture Radar (UAVSAR) is being flown on a Gulfstream-III aircraft. Along with the aircraft measurements will be taken in-situ on the ground and by towers.

Soils Protocol: Soil temperature

NASA Connections
Soil Moisture
Soil Temperature
Soil Characterization

Currently, satellites and airborne campaigns are unable to measure soil temperature. There are multiple missions that study surface temperature, however they are unable to penetrate the surface. This data point is best measured in situ. Ground data is necessary in order to monitor trends involving soil temperature. Students can play a large role in adding to the soil temperature data base through the use of protocols.

Soils Protocol: Soil characterization

Soil characterization involves observing soil structure, color, consistence, texture, root and rock presence, and checking for the presence of carbonates. These observations cannot be done via satellite or airborne campaign as they involve human senses to detect. Student data collection is essential to keeping databases updated.

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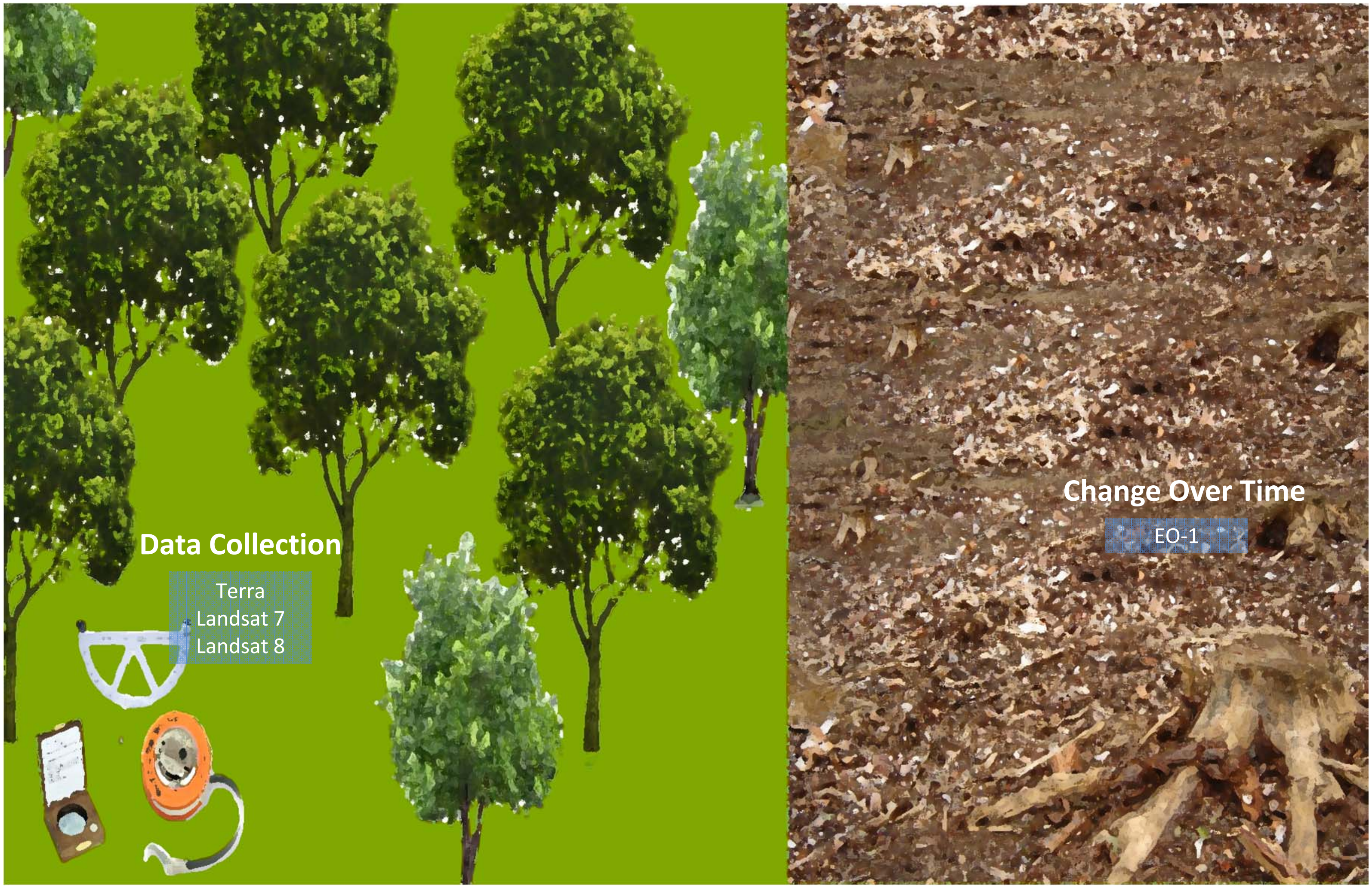
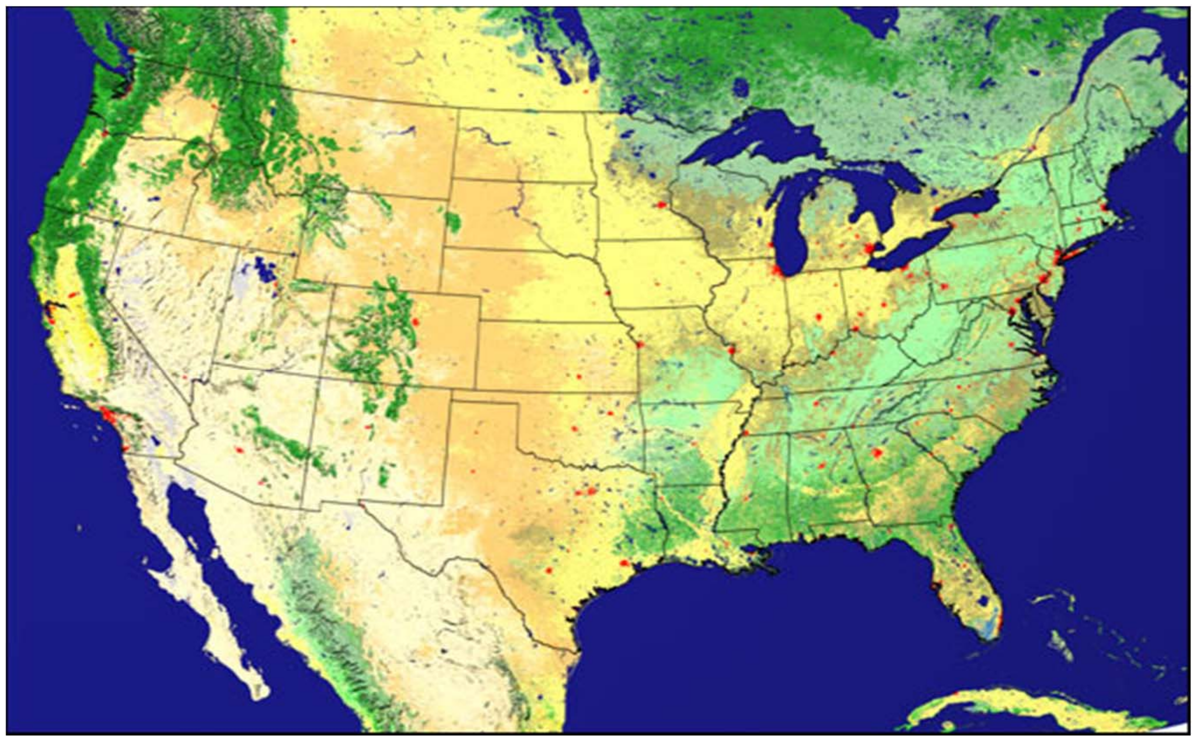
Land Cover Protocols

- NASA Connections
- Data collection
- Change over time



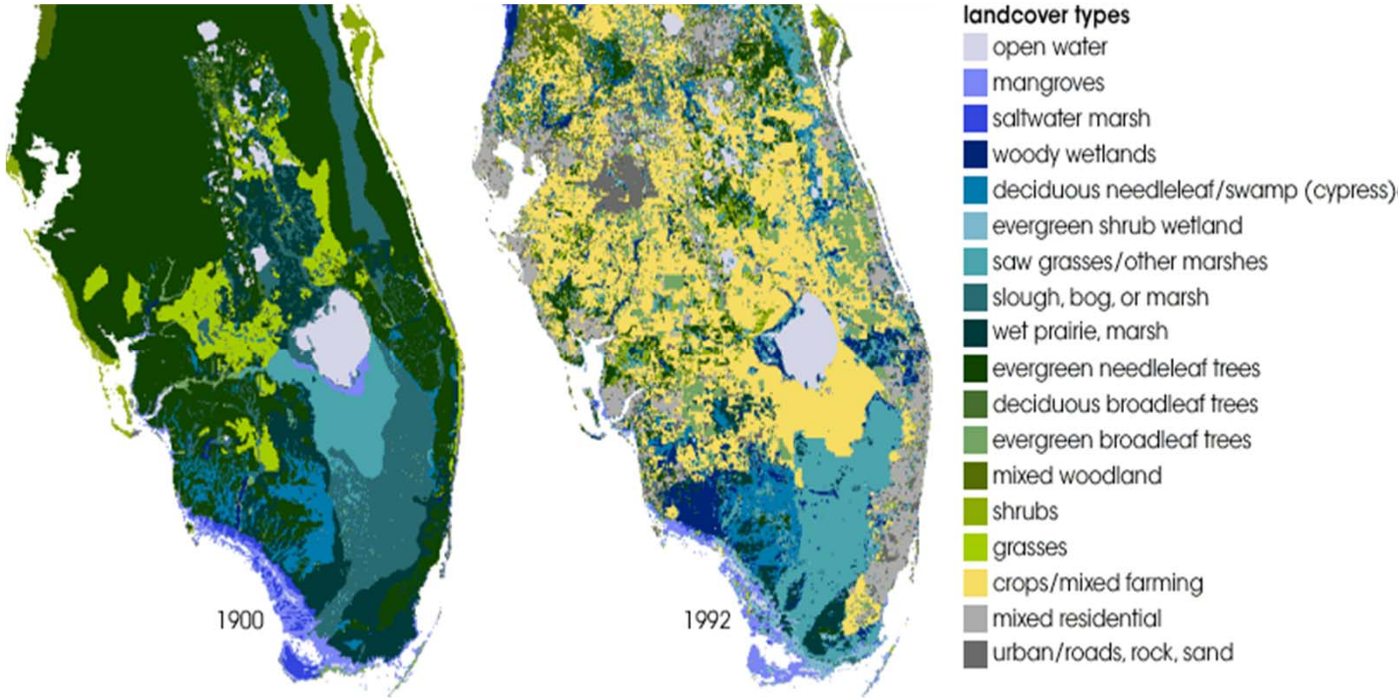
Land Cover Protocol: Data collection

Terra Satellite: Moderate Resolution Imaging Spectroradiometer (MODIS)



Terra (http://www.nasa.gov/mission_pages/terra/index.html#.UgTz55LqmFk) was launched on December 18, 1999 as the flagship of the Earth Observing System (EOS) series of satellites. The image shows the land cover of the United states, represented by a variety of colors. Each land cover type plays a distinct role in the carbon cycle. Northern forests are long-term sinks for carbon whereas agricultural lands. Land cover data helps to develop an understanding of the Earth as an integrated system in its reactions to both human and natural induced changes.

Landsat 7 Satellite: Vegetation Continuous Fields (VCF)



The image shows land cover transformation due to land conversion (croplands and cities). The land conversions resulted in diminished marshland and mangrove forests. Landsat 7 (http://landsat.gsfc.nasa.gov/) was launched on April 15, 1999 featuring the Enhanced Thematic Mapper Plus (ETM+). Landsat 7 provides up to date cloud free images of land cover.

Landsat 8 Satellite: Operational Land Imager

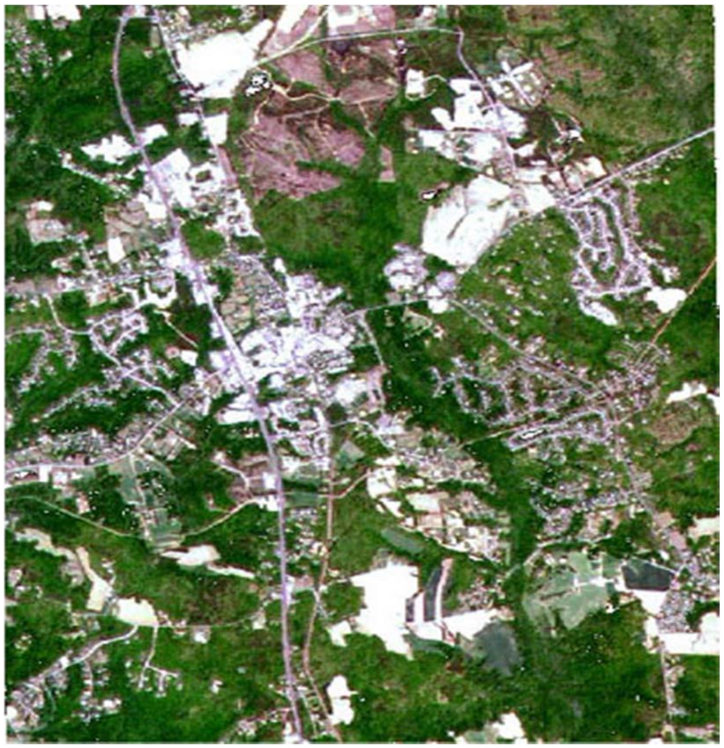
The image above was created on the Landsat Look Viewer (http://landsatlook.usgs.gov). Scene selections and selection of parameters allow the users to focus Landsat's products on their area of interest. Landsat 8 (http://www.nasa.gov/mission_pages/landsat/main/index.html#.UgT1HZLqmFk) was formerly called the Landsat Data Continuity Mission (LDCM). It plays a critical role in monitoring and understanding Earth's natural resources. Landsat 8 is a collaboration between NASA and the U.S. Geological Survey (USGS). After launch, operations were handed over to the USGS for management.

Landsat Tree Cover dataset information: http://landcover.org/data/landsatTreecover/

Land Cover Protocol: Change over time

NASA Connections
Data Collection
Change Over Time

Earth Observing-1 (EO-1) Satellite: Advanced Land Imager



La Plata, MD (before tornado) April 24, 2002

La Plata, MD (after tornado) May 1, 2002

Although this image displays a very short time scale, it shows drastic differences between land cover due to a natural phenomenon. The tornado destroyed trees and changed the land cover type wherever it crossed. Images were captured by the Advanced Land Imager (ALI) onboard NASA's Earth Observing-1 (EO-1) (http://eo1.gsfc.nasa.gov/) Global maps on Earth Observatory is a good place to see global change over the years. The EO-1 mission was launched in November, 2000 as a part of New Millennium Program to develop and validate a number of instruments and spacecraft technologies. The mission includes three advanced land imaging instruments: the Hyperion, the Advanced Land Imager, and the Linear Etalon Imaging Spectral Array.

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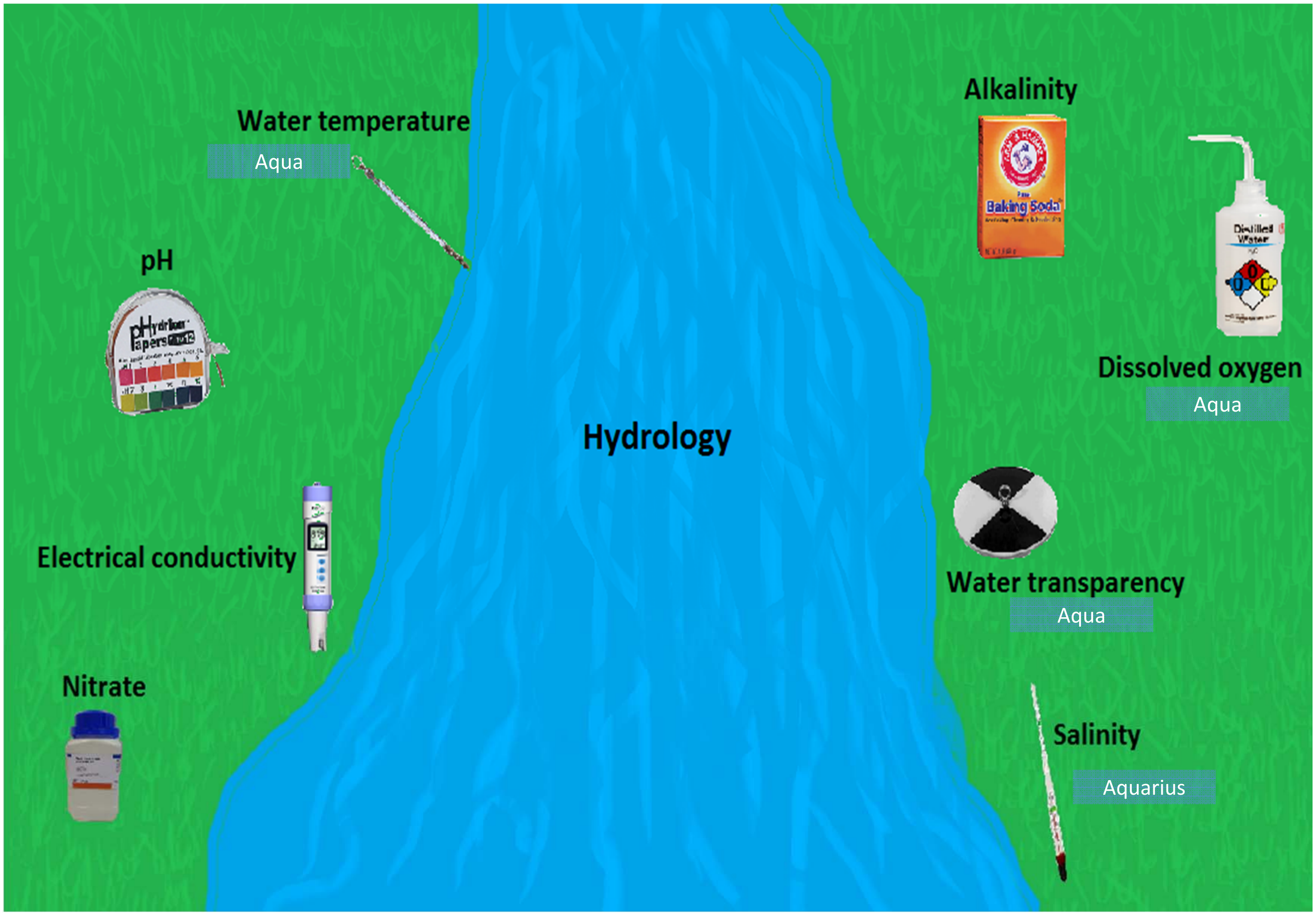
Hydrology Protocols

- NASA Connections
- Water Transparency
- Water Temperature
- Dissolved Oxygen
- Electrical Conductivity
- Salinity
- pH
- Alkalinity
- Nitrate



Hydrology Protocol: Water transparency

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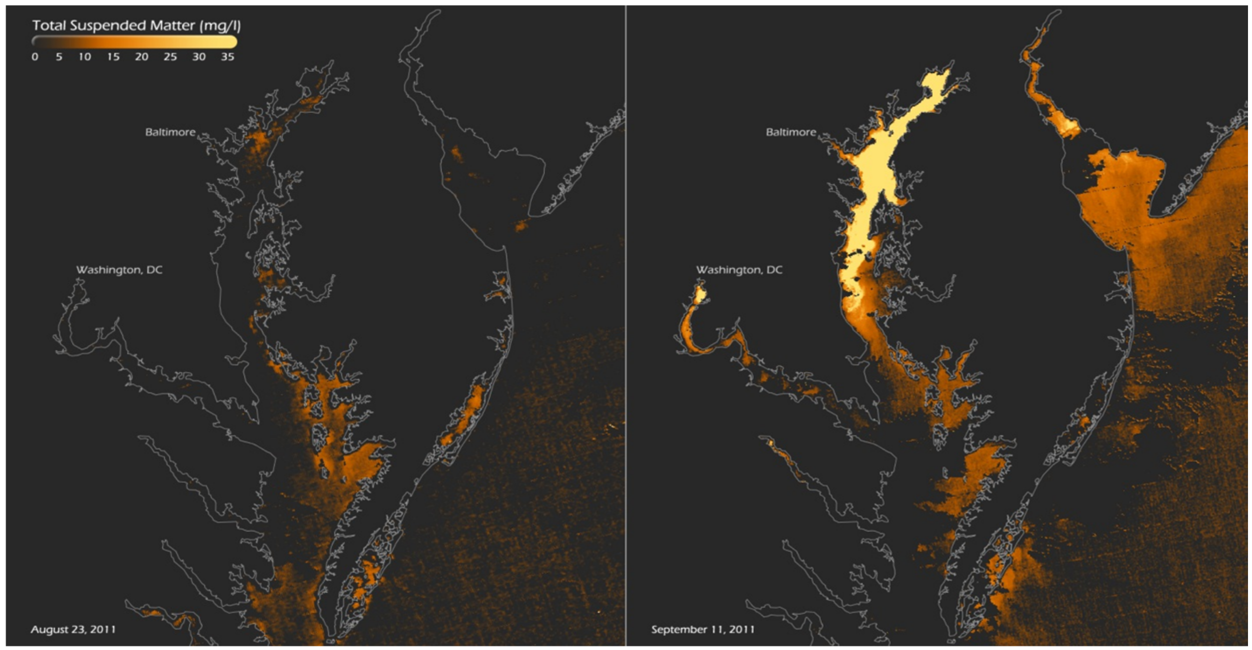
Aqua Satellite: Moderate Resolution Imaging Spectroradiometer (MODIS)



The image above shows the difference in total suspended matter (TSM) before and after the storms hit. There is a large increase shown in TSM after Hurricane Irene and tropical storm Lee hit the Chesapeake Bay area in 2011. The area received over 32 inches of rain between the two storms, in the course of two weeks. The result of this heavy rainfall was an extreme influx of polluted storm water into the Bay and its tributaries. The image was created using data acquired from NASA's Aqua (http://aqua.nasa.gov/) satellite. The image was converted using NOAA's CoastWatch to create this map of TSM. TSM is the total scattering of particles in the water column. It is determined by the backward scattering of light in the visible region. Clea lakes typically have between 0.3 to 2 mg/l whereas very turbid rivers have between 15 to 150 mg/l. The above image shows a large area in the Chesapeake Bay that would be considered extremely turbid. The Aqua satellite was launched on May 4, 2002. It holds six instruments on board and is part of the A-Train.

Hydrology Protocol: Water temperature

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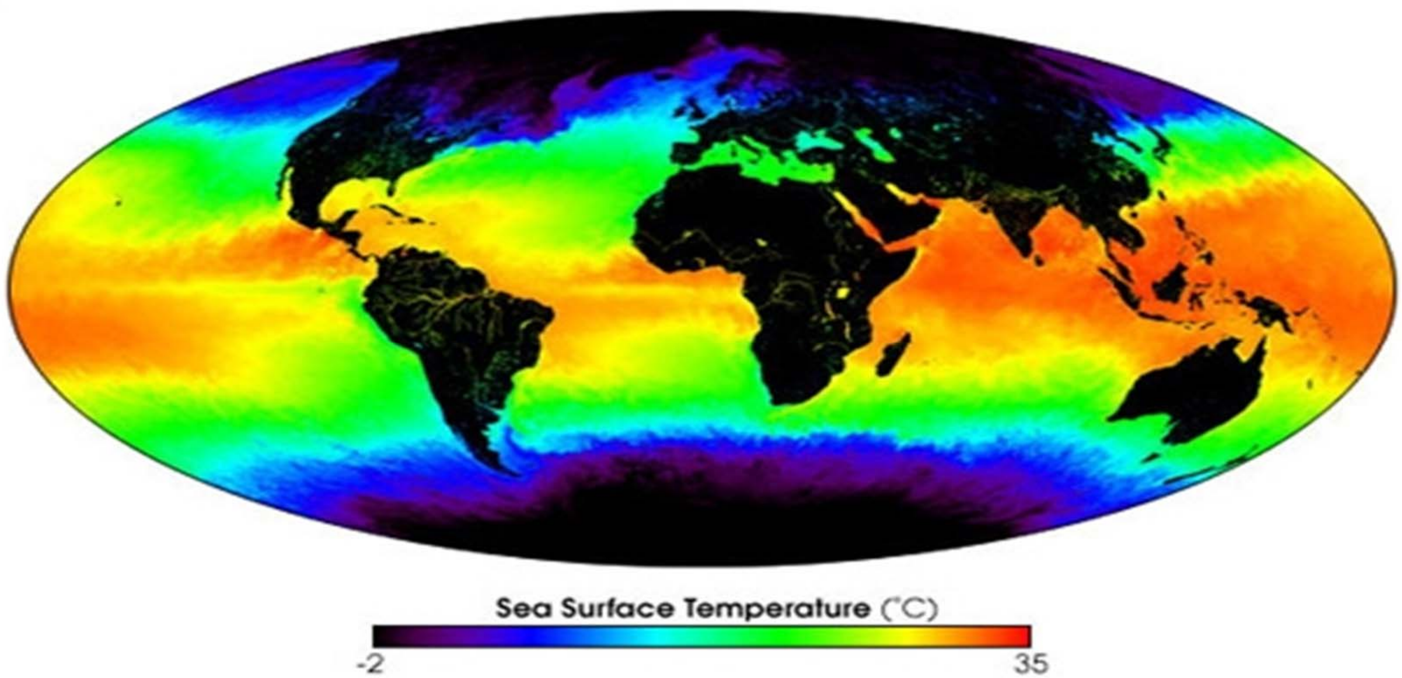
Aqua Satellite: Moderate Resolution Imaging Spectroradiometer (MODIS)



The image above shows a one month average of global sea surface temperature. Based on the color patterns displayed, the image reveals that cold water currents move from Antarctica northward along South America's west coast. In addition, warm currents from the Gulf Stream move up the United State's east coast, carrying the warm water toward Canada and across the Atlantic. The temperature at the surface tends to be zonal instead of longitudinal. The Aqua (http://aqua.nasa.gov/) satellite uses MODIS to measure sea surface temperature, however satellites are unable to gather temperature data below the surface of the land or water. In this case water temperature and surface temperature would be different, but the difference would be the smallest on the coast where water is shallow.

Hydrology Protocol: Dissolved Oxygen

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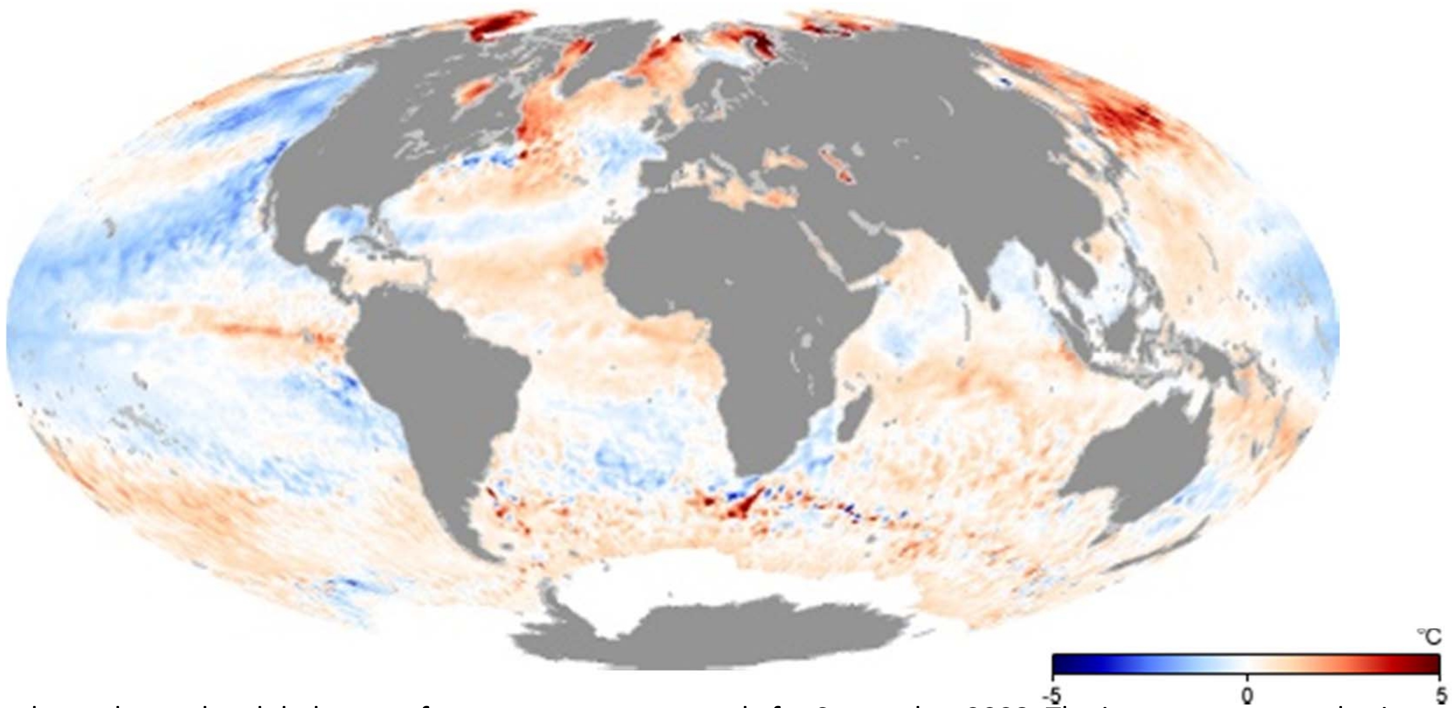
Aqua Satellite: Advanced Microwave Scanning Radiometer-EOS (ASMR-E)



The image above shows the global sea surface temperature anomaly for September 2008. The image was created using ASMR-E onboard NASA's Aqua (http://aqua.nasa.gov/) satellite. ASMR-E measures precipitation rate, cloud water, water vapor, sea surface winds, sea surface temperature, ice, snow, and soil moisture. It is not possible to determine the dissolved oxygen content of water by simply looking at it. Some other process must be done to measure it, such as adding distilled water to it as described in GLOBE protocols. However there is a correlation between temperature and dissolved oxygen. Warm water holds less dissolved oxygen. Therefore, it is possible to make a hypothesis of the general amount of dissolved oxygen present if the temperature of the water is known. When comparing direct measurements of dissolved oxygen to sea surface temperature anomalies, there is likely to be a similar pattern of variance from the average.

Hydrology Protocol: Electrical conductivity

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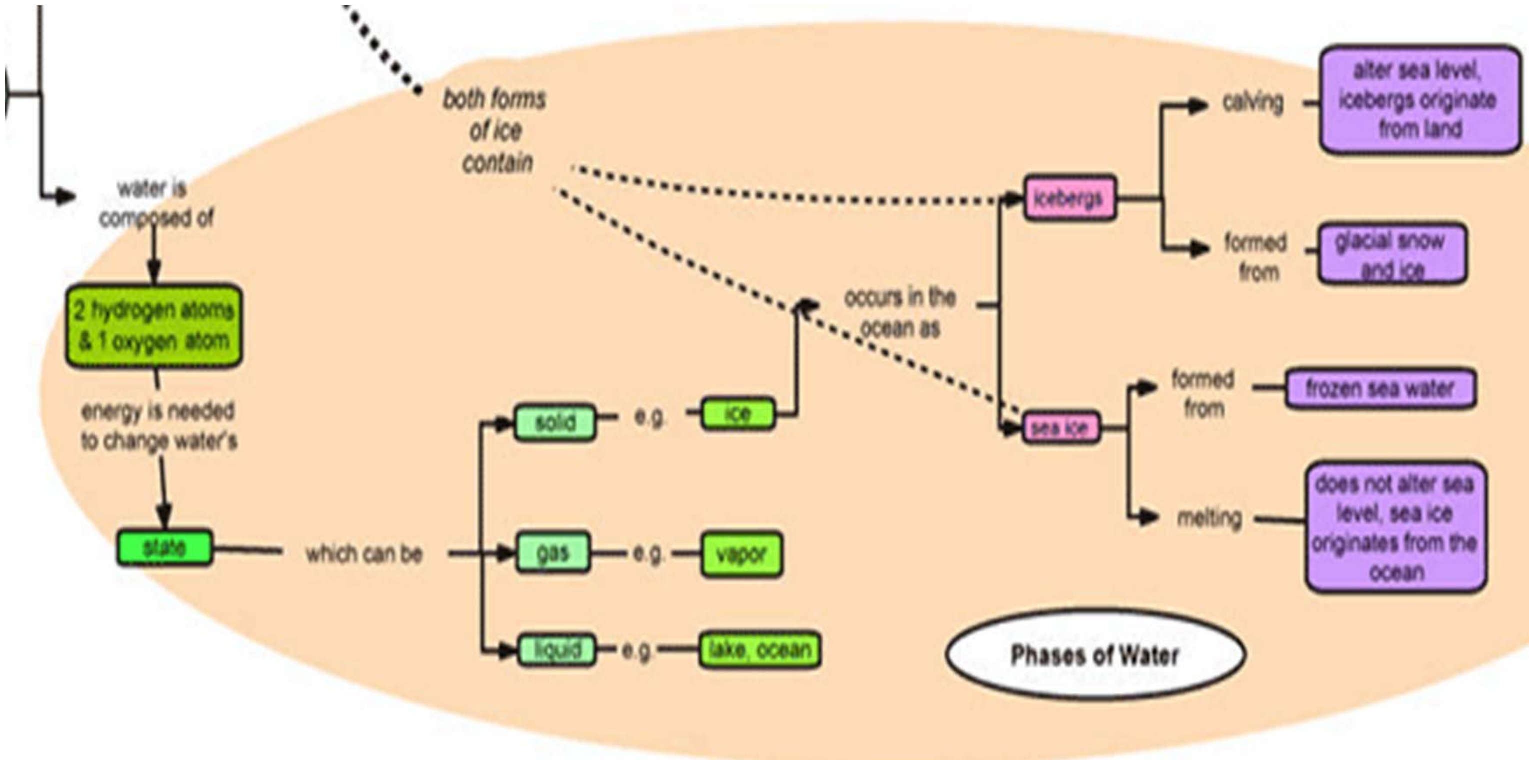

Absolutely pure water is a poor conductor of electricity. When dissolved salts and other solids are present in the solution, there is significant conductivity. The amount of minerals and salt dissolved in the water is known as the total dissolved solids (TDS). Salinity reflects the amount of TDS in a body of water, but there is no direct measurement.

This activity is targeted to help students understand electrolysis: http://aquarius.nasa.gov/electrolysis.html

Hydrology Protocol: Salinity

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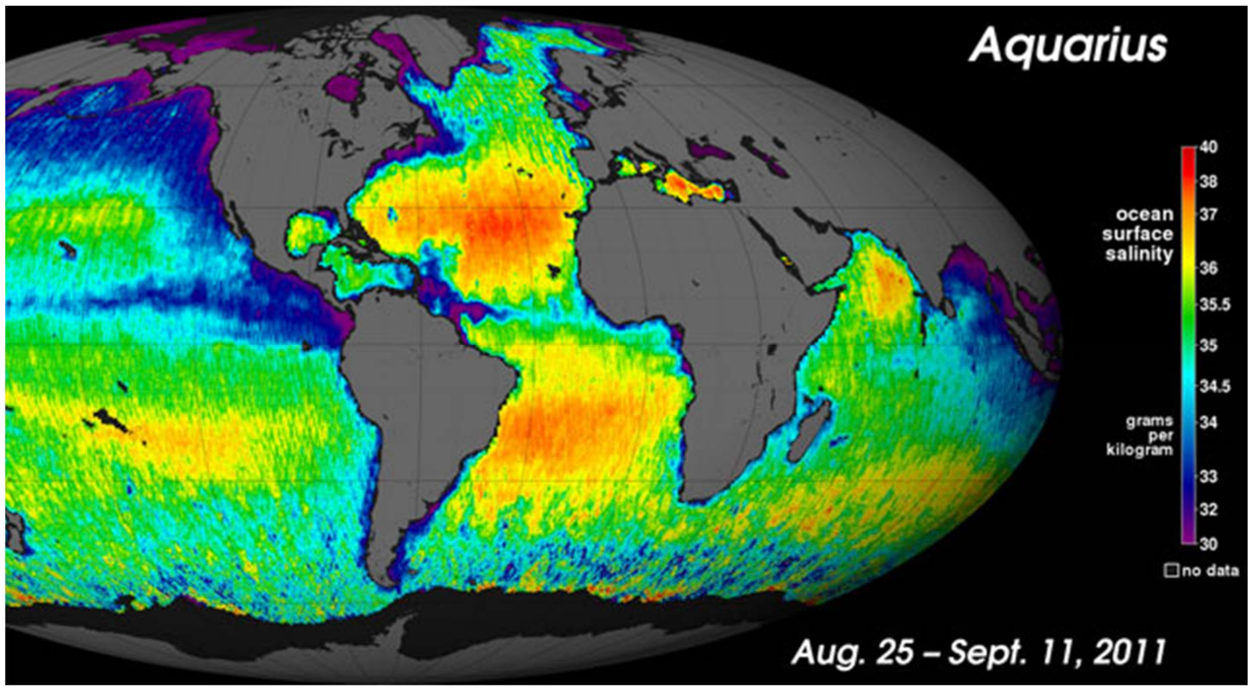
SAC-D (Argentinian Satellite): Aquarius Instrument



The image above is the first global map of the salinity of Earth's oceans produced by NASA's Aquarius instrument. The image reveals global salinity patterns and when compared to other months, it reveals the fluxes in these patterns. A video is available at http://aquarius.nasa.gov/index.html that shows changes in salinity throughout the year. The Aquarius instrument was launched on June 10, 2011 onboard Argentina's SAC-D satellite. It covers the Earth every seven days with an accuracy of 0.2 psu or the ability to detect a pinch of salt in a gallon of water. Users of Aquarius data should note that data is currently not available along the coastline (indicated by black line surrounding continents) and is not available inland. However, sea surface salinity is greatly influenced by other water ways and activities on land.

Hydrology Protocol: pH

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There are currently no NASA earth observing missions measuring pH. Even without satellite data, pH is one of the most commonly measured data points when studying water because it can be an indicator of contaminants and it can influence other processes. Student data collection aids in monitoring pH around the world.

Hydrology Protocol: Alkalinity

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Water Transparency
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There are currently no NASA earth observing missions measuring alkalinity. Alkalinity is the capacity of water to neutralize an acid. Alkalinity can only be measured on site by adding materials with high pH, such as baking soda, until a neutral pH of the solution is reached. Student data is necessary for recording this data on a global scale.

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Hydrology Protocol: Nitrate

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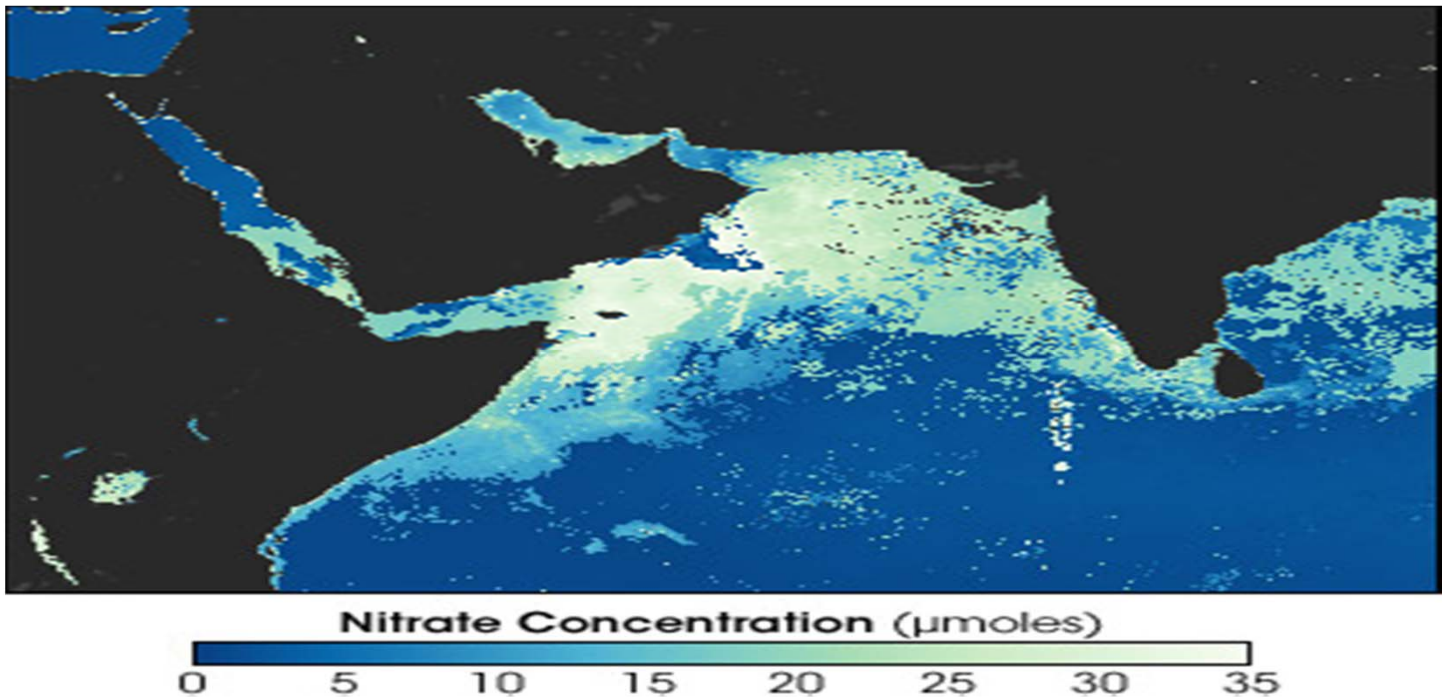
Aqua Satellite: Moderate Resolution Imaging Spectroradiometer (MODIS)



The image above shows nitrate concentration in the Arabian sea derived from chlorophyll and sea surface temperature data from NASA's Aqua (http://aqua.nasa.gov/) satellite. The Aqua satellite was launched on May 4, 2002. It holds six instruments on board and is part of the A-Train. The maps of nitrate concentrations in the world's oceans were developed by a team of researchers through NASA funding. There are no current earth observing missions that directly measures nitrate concentration. Student data is essential for filling in gaps and verifying estimates.

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Phenology Protocols

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- Green Up
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- Bud Burst

Phenology Protocol: Green up

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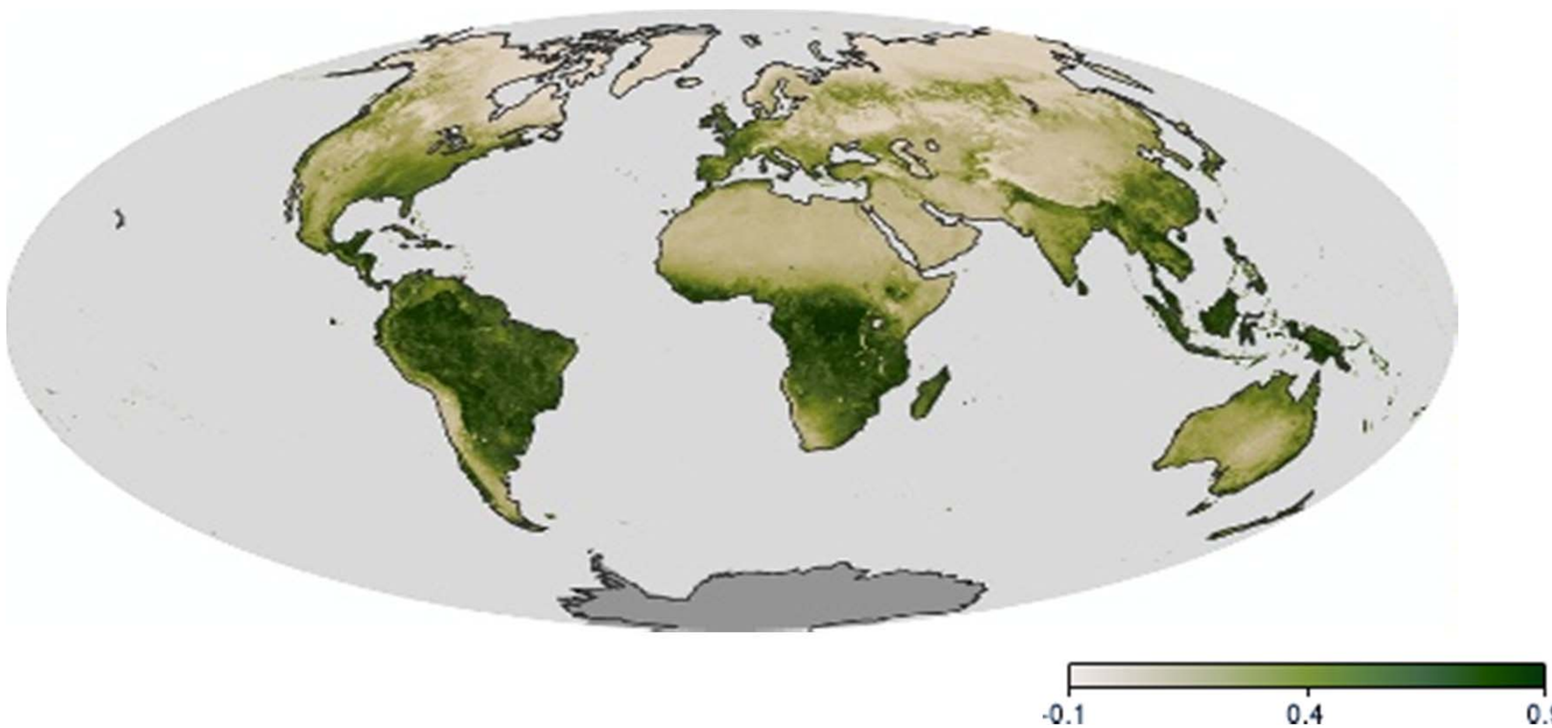
- Bud Burst

Terra Satellite: Moderate Resolution Imaging Spectroradiometer (MODIS)



The image above shows global greenness for March, 2006. Greenness is based on the number and type of plants, how leafy they are, and how healthy they are. In areas that appear dense or dark green, plants are growing quickly. Regions that have a low vegetation index are represented by a tan color. Vegetation greenness is high around the equator year round due to consistent temperatures, rainfall, and sunlight. In other regions, vegetation greenness rises and falls throughout the year. Terra (http://www.nasa.gov/mission_pages/terra/index.html#.UgTz55LqmFk) was launched on December 18, 1999 as the first Earth Observing System platform that provided global data in regards to the atmosphere, land, and oceans. MODIS calculates greenness using a Normalized Difference Vegetation Index (NDVI).

Phenology Protocol: Green down

NASA Connections
Green Up
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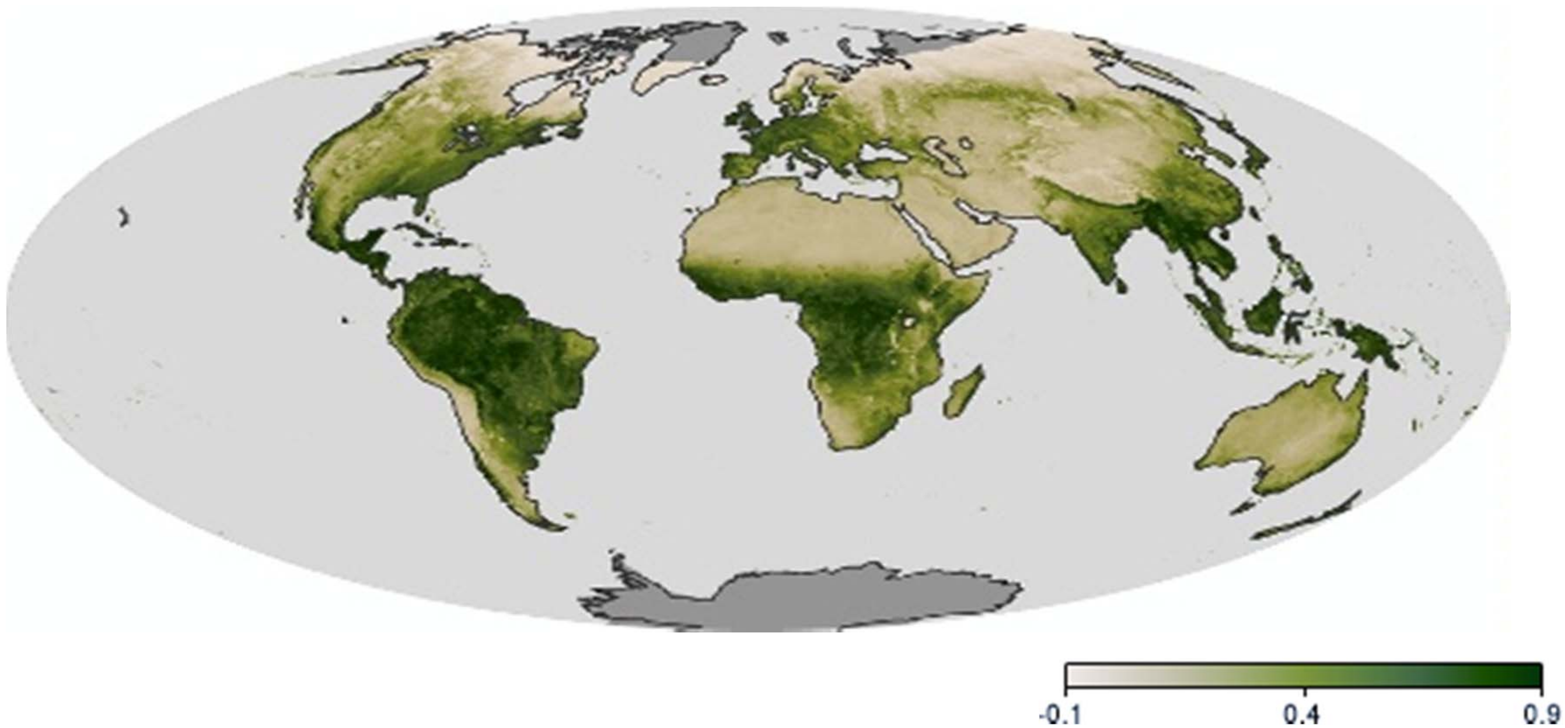
Bud Burst

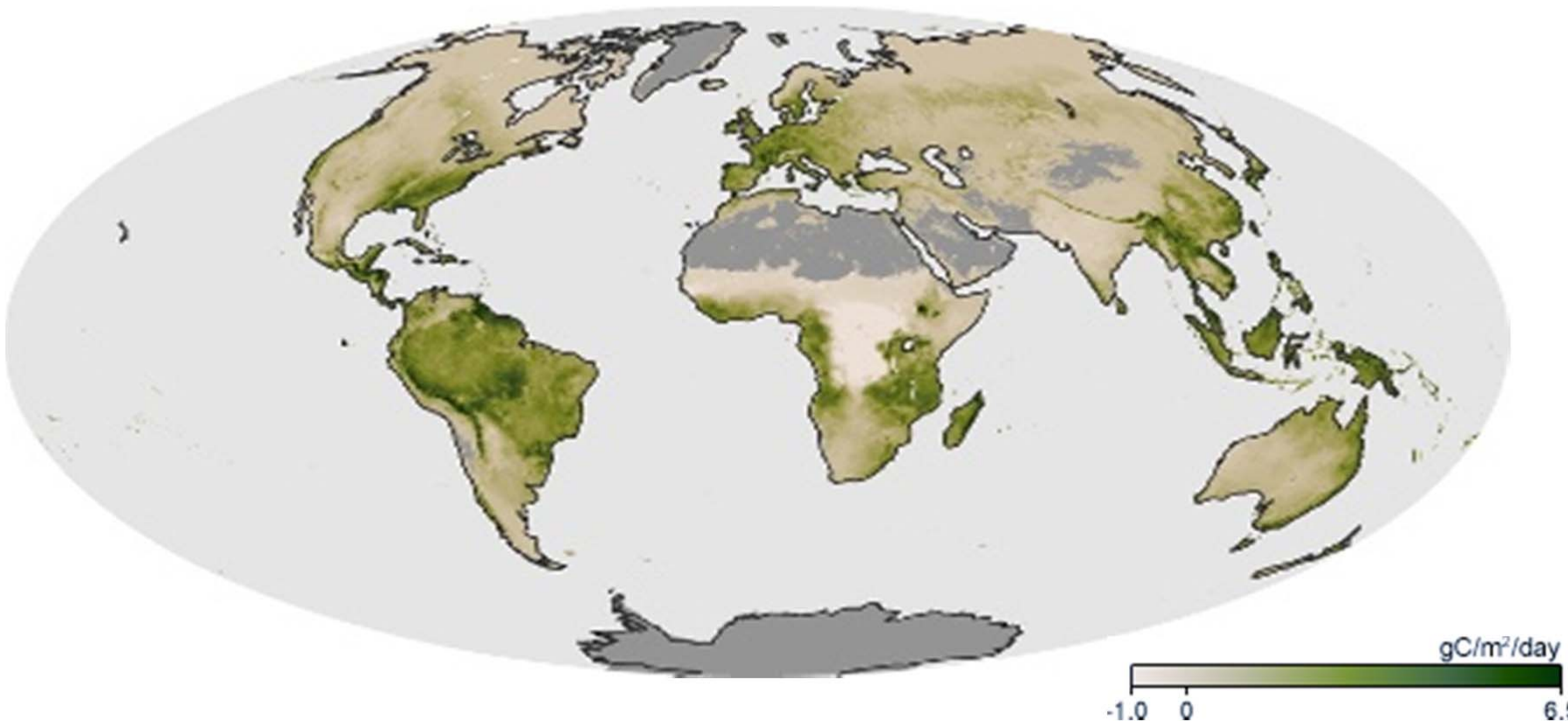
Terra Satellite: Moderate Resolution Imaging Spectroradiometer (MODIS)



The image above shows global greenness for November, 2006. Greenness is based on the number and type of plants, how leafy they are, and how healthy they are. In areas that appear dense or dark green, plants are growing quickly. Regions that have a low vegetation index are represented by a tan color. Vegetation greenness is high around the equator year round due to consistent temperatures, rainfall, and sunlight. In other regions, vegetation greenness rises and falls throughout the year. Terra (http://www.nasa.gov/mission_pages/terra/index.html#.UgTz55LqmFk) was launched on December 18, 1999 as the first Earth Observing System platform that provided global data in regards to the atmosphere, land, and oceans. MODIS calculates greenness using a Normalized Difference Vegetation Index (NDVI).

Phenology Protocol: Bud burst

Terra Satellite: Moderate Resolution Imaging Spectroradiometer (MODIS)



The image above shows global net primary productivity for March 2011. Primary productivity is how much carbon dioxide vegetation takes in during photosynthesis minus how much carbon dioxide the plants release during respiration. Plant productivity plays a major role in the global carbon cycle by absorbing some of the carbon dioxide released when humans burn fossil fuels. Productivity peaks in mid latitudes during the summer and slowly falls as winter approaches. In tropical areas, productivity remains high year round. Primary productivity is measured by MODIS onboard NASA's Terra