Keeping an eye on the Blue Marble: How NASA studies Earth’s weather, climate and hydrology from space

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3-27-2014

http://pmm.nasa.gov
What are we really studying?
NASA’s Water and Energy Satellites

Water Cycle Missions
- ICESat
  - Ice elevation
  - Cloud height
- GRACE
  - Column water-content
- TRMM and GPM
  - Global precipitation
- HYDROS
  - Surface wetness
  - Frozen soil
  (SMAP)

Water and Energy Cycle Missions
- EOS-Aura
  - Atmospheric humidity
  - Clouds
- EOS-Terra
  - Snow and ice
  - Vegetation
- CALIPSO
  - Cloud properties
- CloudSAT
  - Cloud profiler
- EOS-Aqua
  - Atmospheric humidity
  - Water storage
  - Clouds
  - Snow and ice

Energy Cycle Missions
- TOMS
  - Total column ozone
- SORCE
  - Total Irradiance measurements
- SAGE
  - Air quality
  - Climate change
- UARS
  - Carbon management
  - Air quality

Planned (not Approved)
- SWOT (Streamflow)
- SCLP (Snowpack)

Complementary Water and Energy Cycle Missions
- QuikSCAT
  - Sea-surface wind velocity
- EO-1 LANDSAT and NMP EO-1
  - Land cover
- NPOESS
  - Global environmental conditions
- GOES
  - Weather
- Aquarius
  - Global sea surface salinity
NASA Operating Missions

- OSTM/Jason 2 (NOAA)
- Landsat 8 (USGS)
- QuikSCAT
- TRMM
- EO-1
- Landsat-7 (USGS)
- ACRIMSAT
- SORCE
- GRACE (2)
- Calipso
- CloudSat
- Terra
- Aqua
- Aura
- S-NPP
Tropical Rainfall Measuring Mission (TRMM)

Science Objective:
Advance knowledge of global water and energy cycles through observed time and space distributions of tropical rainfall, hydrometeor structure and latent heating.

1981 - TRMM concept proposed
1988 - TRMM Steering Group
1988 - Phase A plan for TRMM

Instrument Payload:
TRMM Microwave Imager (TMI)
10, 19, 37, 86 GHz, conical scanning
Precipitation Radar (PR) [Japan]
14 GHz, cross-track scanning
Lightning Imaging Sensor (LIS) [MSFC]
Staring optical array
Visible IR Scanner (VIRS)
5-channel, cross-track scanning

TRMM Launched November 27th, 1997
TRMM’s legacy

TRMM Climatology in the tropics and subtropics. Now has 16+ years of data to evaluate daily to interannual cycles.

- 3-hour window with passive microwave information (gap filled with Geo-IR)
- Calibrated by TRMM

Near real-time product available ~6-12 hours after observation time.
Hurricane Sandy (Oct. 22-31st, 2012)

TRMM image on Oct. 28th

http://youtu.be/0_2pcVlJvBM
Introducing Global Precipitation Measurement (GPM)

TRMM versus GPM coverage animation: http://svs.gsfc.nasa.gov/goto?11165
GPM instrument animation: http://svs.gsfc.nasa.gov/goto?4016
Satellite Integration and Testing

Electromagnetic Interference/Compatibility

Vibration and Acoustic Testing

GPM Core Observatory in the Space Environmental Simulator at Goddard Space Flight Center

Mission Operations Control
Launched at 1:37 p.m. EST, Feb 27, 2014

On March 10, the Core Observatory passed over an extra-tropical cyclone about 1055 mi (1700 km) due east of Japan’s Honshu Island.

The storm contained heavy rain and snow and is the first time a satellite has been able to view an extratropical storm in 3D.

Dual-frequency Precipitation Radar view inside the extra-tropical cyclone observed on March 10, 2014

GMI instrument showing 13 channels, each sensitive to different types of precipitation

Societal Benefit Areas

**Extreme Events and Disasters**
- Landslides
- Tropical cyclones
- Floods
- Re-insurance

**Water Resources and Agriculture**
- Famine Early Warning System
- Water resource management
- Drought Monitoring
- Agricultural monitoring

**Weather, Climate & Land Surface Modeling**
- Numerical Weather Prediction
- Global Climate Modeling
- Land System Modeling

**Public Health and Ecology**
- Disease tracking
- Food Security
- Animal migration

GPM and TRMM applications: [http://pmm.nasa.gov/applications](http://pmm.nasa.gov/applications)
Oso Landslide
March 22nd, 2014

Cumulative Rainfall from Oct 1 - March 23 for 2000-2014, TMPA 3-hourly V7 RT

Above: Image from Landsat 8 pan-sharpened natural colour 15 m resolution data taken Sunday morning, March 23rd. Photo courtesy of Jesse Allan (Sigma Space Corp/NASA)
Impact of drought on California based on data from the Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA’s Terra and Aqua satellites, the map contrasts plant health from January 17 to February 1, 2014, against average conditions for the same period over the past decade.
Improved modeling capabilities

**Improving Weather Forecasts**
through assimilation of accurate global precipitation data

**Understanding precipitation’s role in a changing climate**

Global climate models predict significant changes in precipitation amount and intensity over the 21st century. We need global measurements to improve and validate these models.
Measuring Evaporation From Space

Landsat 7 and 8 data
Visible, Infrared, Thermal channels

Landsat: http://www.nasa.gov/landsat or http://landsat.usgs.gov/
The Gravity Recovery and Climate Experiment (GRACE) is a joint satellite mission of NASA and German Aerospace Center (DLR) that can measure changes in total, column-integrated Terrestrial Water Storage (TWS) from space.

- GRACE is unique in its ability to monitor water at all levels, down to the deepest aquifer.
- Provides a time-series of monthly time-variable gravity field estimates > mass changes in the ocean, of ice, and on land > affect the motion of all Earth satellites, including GRACE.

http://www.nasa.gov/grace
In 2014, for the first time in more than a decade, five NASA Earth science missions are launching to space in a single year. The first, the GPM Core Observatory, launched on Feb. 27 (above).

http://www.nasa.gov/earthrightnow
Set to launch in July, 2014

NASA’s first dedicated remote sensing satellite to study atmospheric carbon dioxide

Will be able to characterize CO$_2$ sinks and sources on a regional scale and quantify CO$_2$ seasonal variability

http://oco.jpl.nasa.gov/
Earth Right Now

ISS-RapidScat

- Set to launch in August (will be added to ISS)
- Measures ocean surface wind speed and direction
- To replace NASA’s QuikScat satellite, which stopped collecting data in 2009

http://winds.jpl.nasa.gov/missions/RapidScat/

Cloud Aerosol Transport System (CATS)

- Set to launch in September (will be added to the ISS)
- Measures the location, composition and distribution of pollution, dust, smoke, aerosols and other particulates in the atmosphere

Soil Moisture Active Passive (SMAP)

• Set to launch in November, 2014
• Global mapping of soil moisture and freeze/thaw state
• Soil moisture data will help scientists understand the processes that link the water, energy and carbon cycles, and improve weather and climate models and forecasting

http://smap.jpl.nasa.gov/
www.nasa.gov/GPM
Twitter:  @NASA_Rain
Facebook:  NASA.Rain
More GPM videos, data visualizations, and animations:
http://svs.gsfc.nasa.gov/Gallery/GPM.html