Introduction to NASA Water Products

NASA Remote Sensing Training
Norman, Oklahoma
June 19-20, 2012

ARSET

Applied Remote SEnsing Training

A project of NASA Applied Sciences

Objective

To present an overview of NASA water resource products from satellites and models

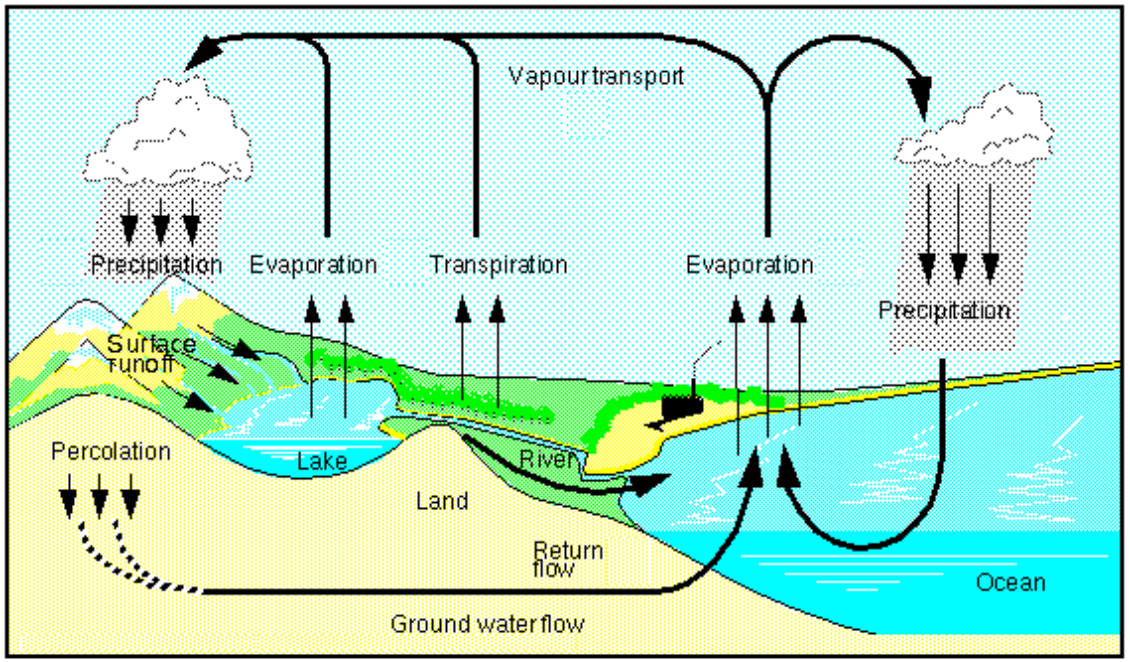
Part 1 :
Overview of Remote Sensing and Modeling Approaches

Part 2 :
Brief Description of Water Products from Various Sources

NASA Applied Sciences Program
Water Resources site: http://wmp.gsfc.nasa.gov/

NASA Water Products

- Rain
- Snow/Ice
- Water Vapor
- Clouds
- Soil Moisture
- Ground Water
- Snow/Ice
- Rain, Clouds, Water Vapor
- Soil Moisture
- Evaporation/Transpiration
- Run off



Courtesy Erich Roeckner, Max Planck Institute for Meteorology

Water Cycle Components

Products in red - derived from satellite measurements

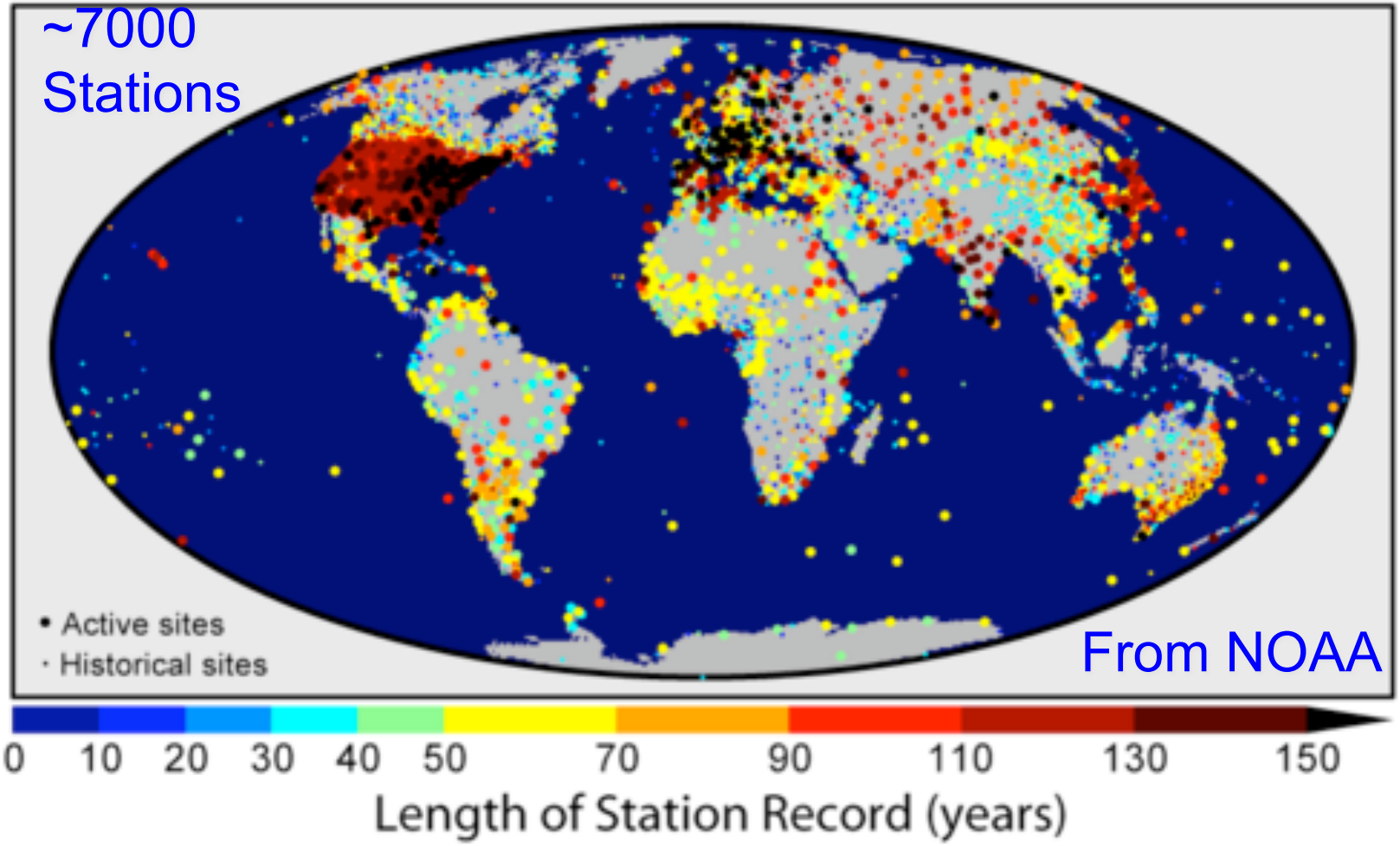
Products in blue - derived from atmospheric/land surface models in which satellite measurements are assimilated

NASA Water Products

- Water critical for food, health, and energy
- Water in all forms is controlled by weather and climate and also impacts weather and climate
- A major focus of NASA satellite missions and modeling efforts is to
  - develop improved water cycle observation capabilities,
  - enhance understanding of weather and climate related water cycle variability
  - make water products available to end-users for water resource management
  - help train end-users in accessing, interpreting, and using water products
  - **Upcoming Missions: Global Precipitation Measurement (GPM) and Soil Moisture Active Passive (SMAP)**

Why Use Satellites and Models to Monitor/Study Water Resources ?

Global Historical Climate Network



Why use Satellites and Models to Study Water Resources ?

- Provides consistent, global information
- Complements ground-monitoring networks or provides information where there are no ground-based measurements
- Advance warning of impending environmental events and disasters such as flooding
- Models provide parameters which are not directly observable, for example, 3-D winds and water vapor movement in the atmosphere
- Models help understand processes associated with cycling of water in the climate system and provide prediction capability

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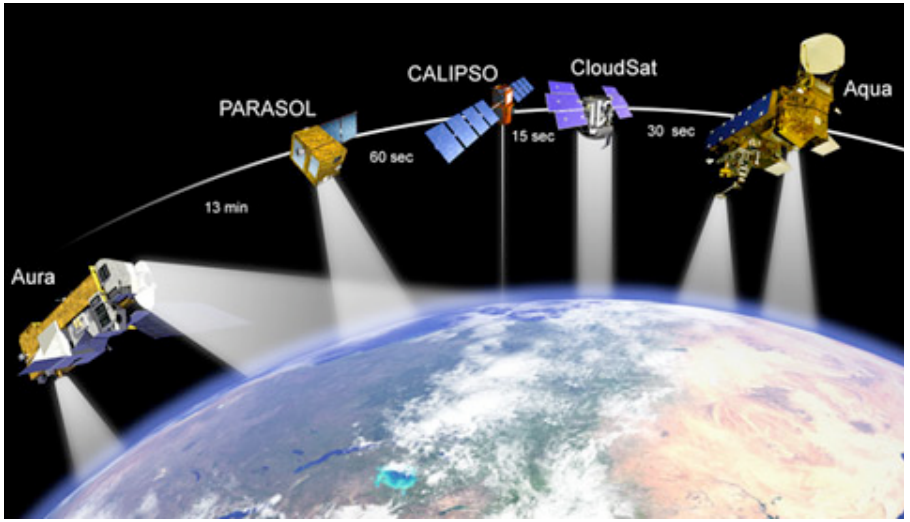
Satellite Remote Sensing

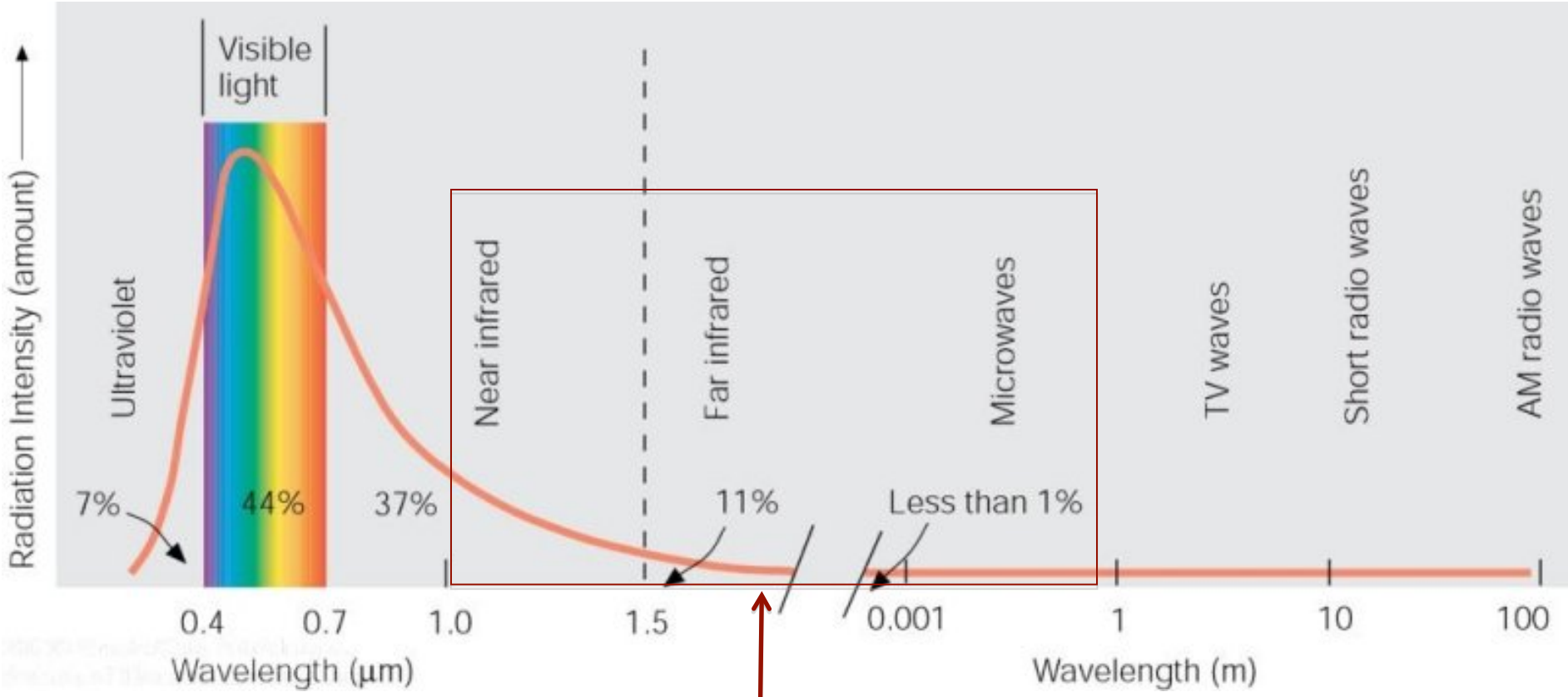
Remote Sensing : measurement of a quantity associated with an object by a device not in direct contact with the object

Satellite Remote Sensing: measurements of earth-atmosphere system's properties from space

Numerous satellites are currently orbiting earth



Electromagnetic Radiation

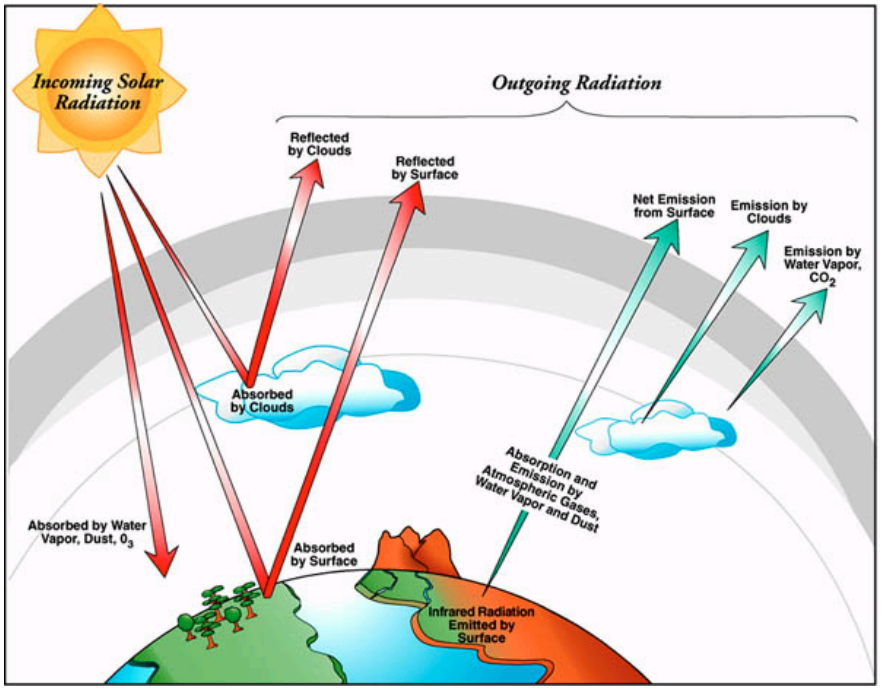


Shortwave or Solar Radiation

Longwave or Terrestrial Radiation

Radiation at the Top of Atmosphere

Parameters influencing the amount of radiation at the top of earth-atmosphere systems:



Solar radiation

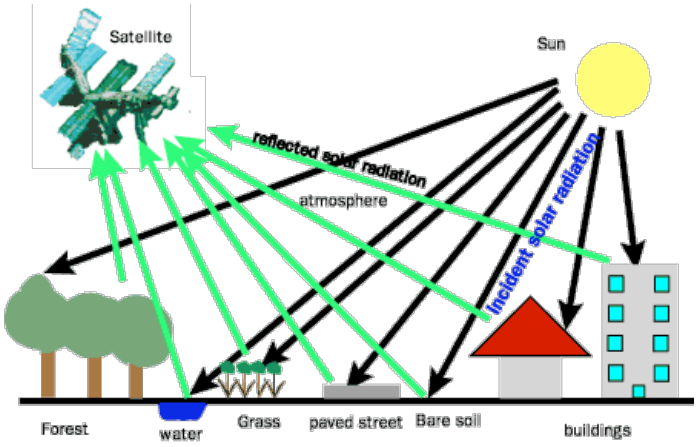
*surface type – e.g. vegetation, soil, **snow/ice, clouds**, aerosols*

Infrared radiation

surface temperature, greenhouse gases (water vapor, carbon dioxide, methane, ozone) and clouds

Microwave radiation

Surface temperature and type (snow/ ice, soil moisture), rain, water vapor, clouds

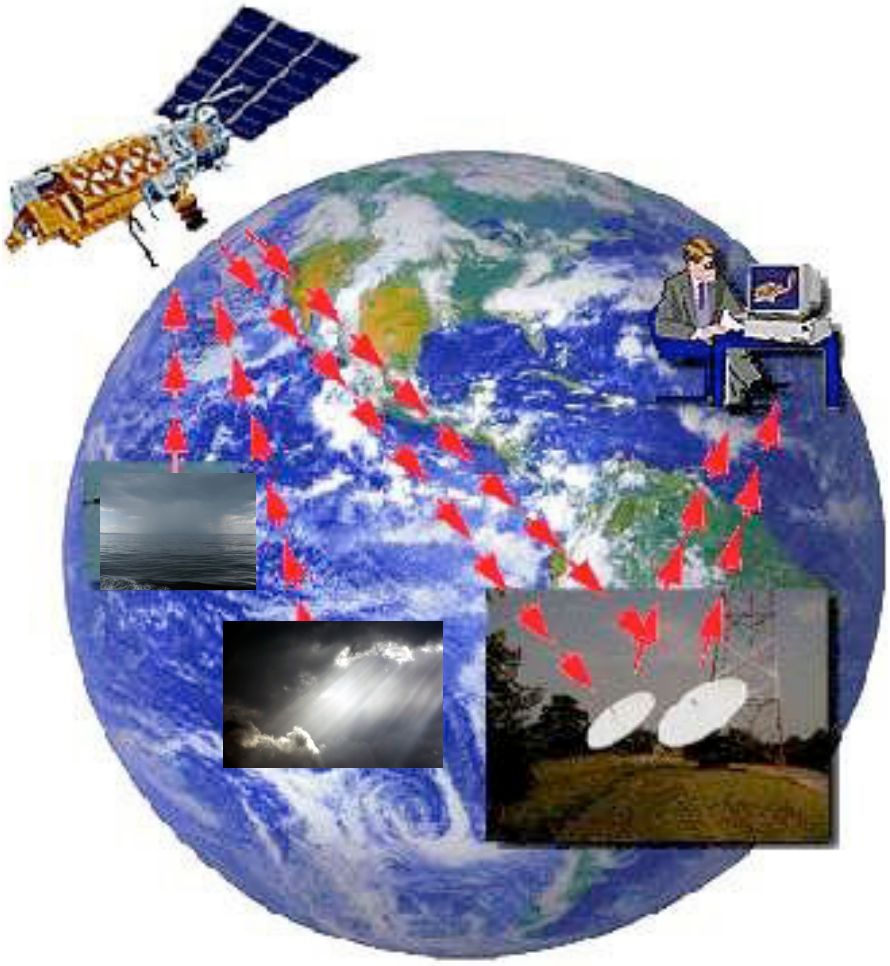


Principles of Remote Sensing

Satellites carry a variety of instruments to measure electromagnetic radiation reflected or emitted by the earth-atmosphere system

In **'passive'** remote sensing satellites measure naturally reflected or emitted radiation

In **'active'** remote sensing satellites 'throw' beams of radiation on the earth-atmosphere system and measure 'back-scattered' radiation

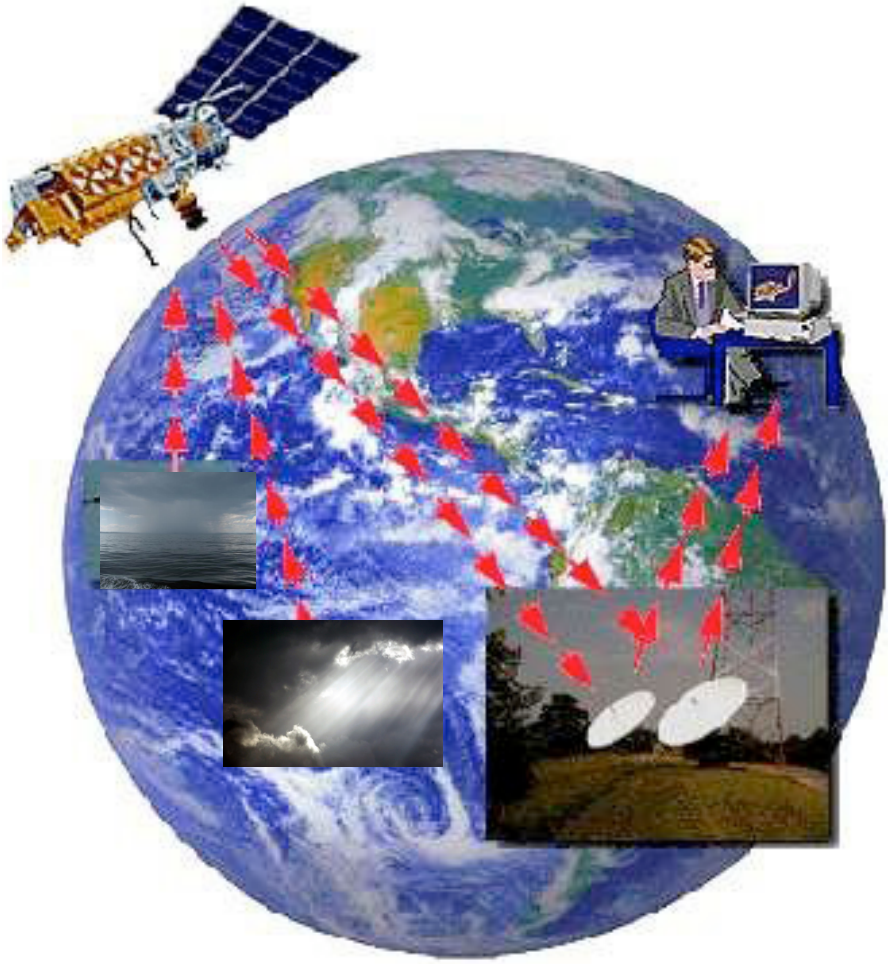


Principles of Remote Sensing

The measured radiant energy by satellites is recorded typically as digital counts on-board and transmitted to ground stations

The counts are processed and converted to appropriate geophysical quantities by using complex procedures (algorithms)

These ‘retrieved’ geophysical quantities are validated for accuracy by comparing them with ground-based and/or aircraft-based measurements



Remote Sensing of Water Quantities

For water quantities emitted infrared and microwave, and reflected solar radiation, either individually or together, are used

Infrared and solar-visible radiation can not measure rain directly as they can not penetrate clouds – but can sense water vapor and types and heights of clouds. The cloud information can then be statistically calibrated to surface rainfall

Microwave radiation can pass through rain and get scattered by Ice/snow and can be used to directly sense precipitation

A variety of satellites carrying various instruments measuring infrared, visible, and microwave radiation are currently in orbit

Remote Sensing of Water Products

NASA Satellites Measuring Water Quantities

TRMM (11/1997-present)

Terra (12/1999-present)

Aqua (5/2002-present)

GRACE (3/2002-present)

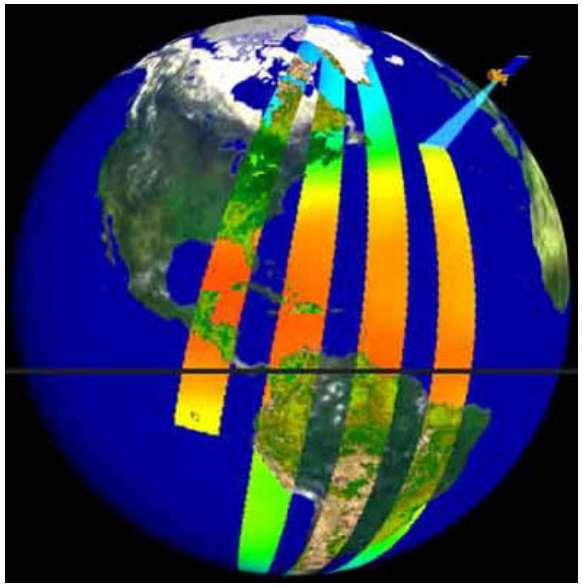
CloudSat (4/2006-present)

CALIPSO (4/2006-present)

ICESat (1/2003-8/2010)

TRMM: Tropical Rainfall Measuring Mission
GRACE: Gravity Recovery and Climate Experiment
CALIPSO: Cloud-Aerosol LIdar with Orthogonal Polarization
ICESat: Ice, Cloud,and land Elevation Satellite

NASA Satellites for Remote sensing of Water Products



Satellite	Products
> TRMM	Rain Rate, Rain Amount, Vertical Rain Rate Profile
> Terra	Fractional Snow Cover, Fractional cloud Cover, Cloud Top Pressure/Temperature
> Aqua	Fractional Snow Cover, Fractional cloud Cover, Cloud Top Pressure/Temperature Column Integrated Water Vapor, Vertical profile of Specific Humidity and Relative Humidity
GRACE	Ground Water
CloudSat	Cloud Water and Light Rain
CALIPSO	Cloud Profile
ICESat	Ice sheet mass, Cloud Heights

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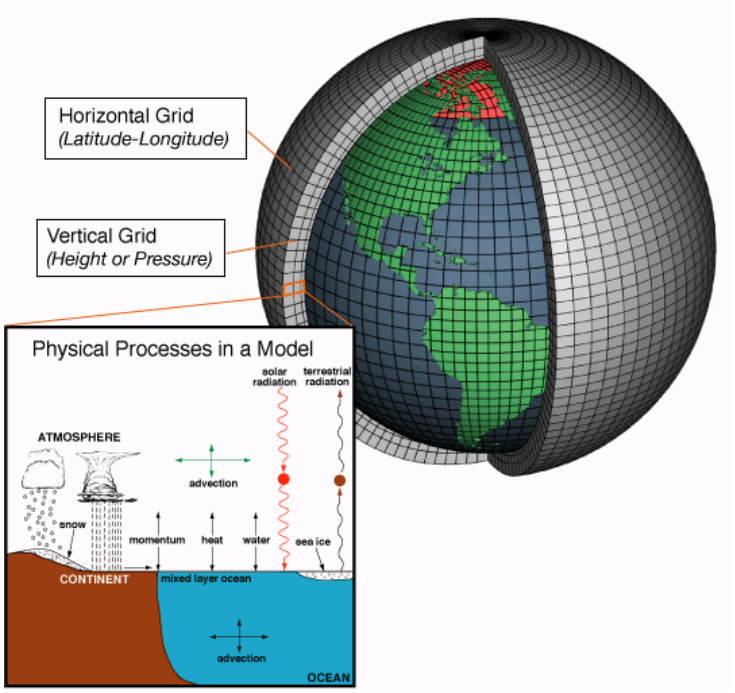
Modeling of the atmosphere-Land-Ocean Systems



- Models use laws of physics in terms of mathematical equations to represent atmosphere, ocean, land systems and changes occurring in them in space and time
- Models apply these mathematical equations, on horizontal and vertical grids by using numerical methods
- Models use observations to represent the atmosphere ocean-land system at a given time to deduct how the system will evolve over space/time
- Models ‘parameterize’ physical processes based on physical/statistical/empirical techniques derived or verified by using observed quantities

NASA Models for Water Products

(Atmosphere-Ocean-Land Models)

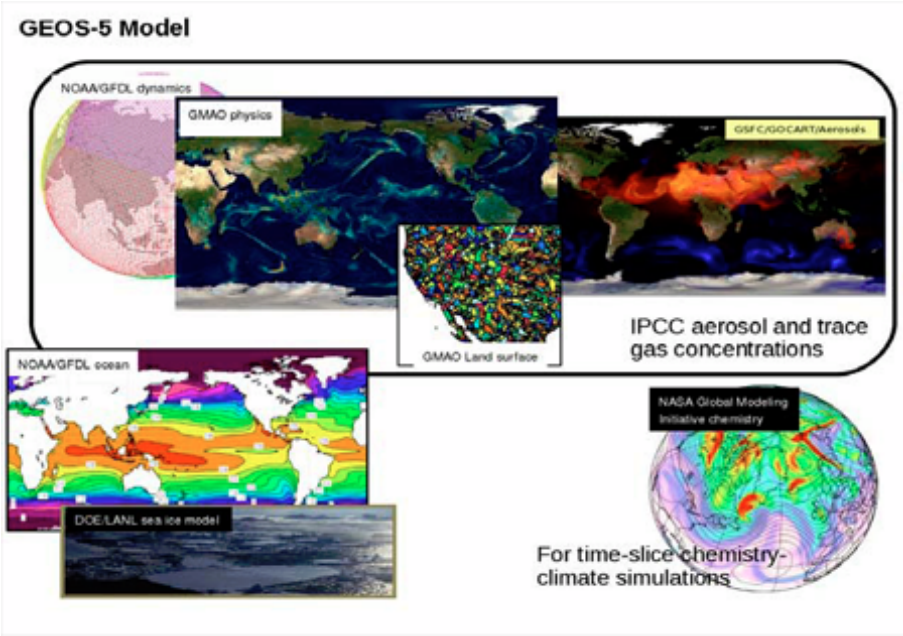
- **GISS GCM ModelE :** The Goddard Institute for Space Studies General Circulation Model II
- **GEOS-5 :** The Goddard Earth Observing System Version 5
- **MERRA:** Modern Era Retrospective-analysis for Research and Application
- **GLDAS :** Global Land Data Assimilation System
- **NLDAS :** North American Land Data Assimilation System

NASA Models for Water Products

Climate Models (Atmosphere-Ocean-Land Models)

- **GISS GCM ModelE and GEOS-5**

  Used for IPCC climate model projections, multi-decadal simulations with various climate conditions (greenhouse gases and aerosols)



Products: Rain, Snow and Ice, Water Vapor, Clouds, Soil Moisture

Relatively low spatial resolutions (100 – 300 square Km)

Used for climate variability and change studies

Regional validation required

NASA Atmosphere and Land Models for Water Products

Model	Products
MERRA	Clouds, Rain, Snow Mass, Snow Cover, Snow Depth, Surface Snowfall Rate, Surface Evaporation, Evapotranspiration, Water Vapor
GLDAS/NLDAS	Evapotraspiration, Multi-layer Soil Moisture, Snowfall, Snow Melt, Snow-Water Equivalent, Surface and Sub-surface Runoff

Model Products

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

Modeling of hydrological processes is complex due to presence of water in gaseous, liquid, and solid forms in the earth-atmosphere system

Models use many approximations and assumptions in representing physical processes

Rigorous validation with observations and model-to-model inter comparisons are conducted to assess accuracy of model products

Why use Satellites and Models to Obtain Water Products ?

- Provide consistent, global information
- Help understand processes associated with cycling of water in the climate system
- Complement ground-monitoring networks or provides information where there are no ground-based measurements
- Choices of products based on applications and usage

NASA water products are freely available and a number of web-based tools are available for their easy access, analysis, and visualization

NASA water resource products from satellites and models

Potential Data Usage:

- **Monitoring, Understanding, and Developing Strategies:**

  Extreme Rain Events and Floods

  Droughts

  Snow Amount and Snow Melt

- **Climate Variability/Change and Water Resources:**

  Seasonal to Inter-annual Changes in Rain, Soil Moisture, Evapotranspiration, Atmospheric Temperature, Humidity, Clouds, Winds

Accessing NASA Water Resource Data Products

- NASA water resource data have consistent coverage and global extent, and are **FREE**
- Many web-based applications are available for downloading data and imagery
- Tools for visualization and analysis of several of these data are also available

Thank You!

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