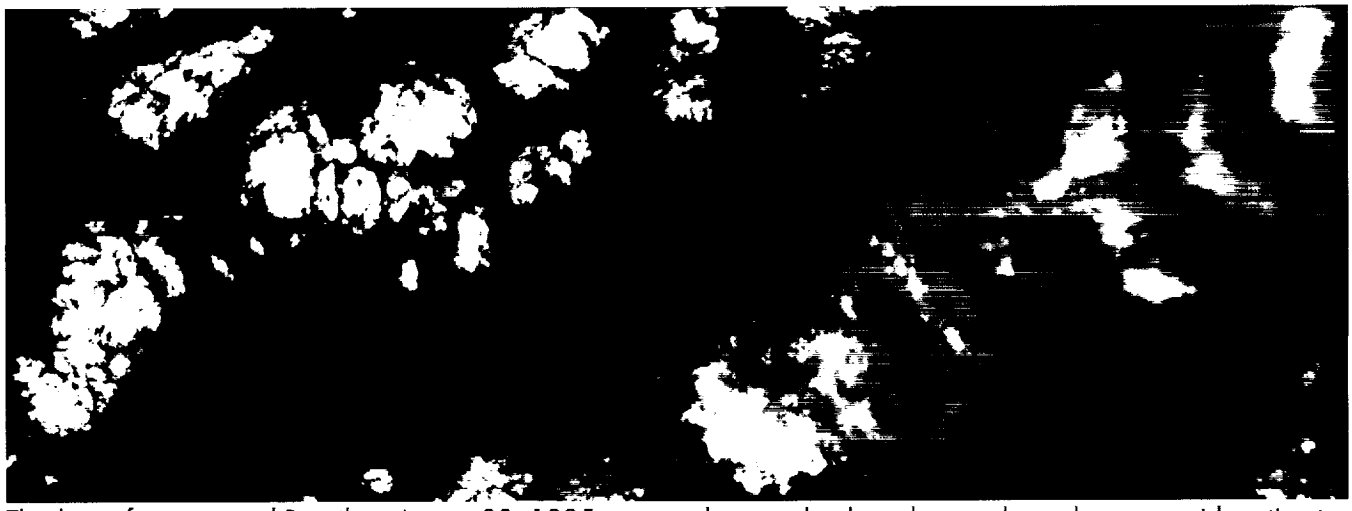
Moderate-Resolution Imaging Spectroradiometer (MODIS)

Data from the Goddard DAAC

April 1999



This large fire in central Brazil on August 23, 1995, was imaged by the MODIS airborne simulator. The fire shows up well in thermal infrared (11 μm.) MODIS will provide data on clouds and aerosols, and even provide estimates of emissions from biomass burning.

Two new ocean products from MODIS will be primary productivity and sea surface temperature. The ability to measure multiple related parameters at the same time, combined with unprecedented calibration accuracy, gives MODIS researchers the tools necessary to unravel the complexities of the global climate.

Introduction to MODIS

This century, especially in the last few decades, Earth's history was marked by intense study and concern about our environment and how we affect it. Scientific studies show that the level of carbon dioxide in the atmosphere is rising, the ocean's productivity is changing, and the average global temperatures have risen by 0.5°. What we do not completely understand is: What fraction of this variation is due to human interference with the environment? What fraction is due to natural phenomena? How do these changes correlate with each other?

In order to obtain a better understanding of how land, atmosphere and ocean interact to produce changes on Earth's climate and how human intervention affects these changes, NASA started planning for the Earth Observing System (EOS) in the early 1980's. As a result, a series of satellites will be sent into orbit to monitor the Earth for the next 18 years, providing scientists with necessary data to help them answer these questions.

Productivity Index P2 (x100gCm^{-2}yr^{-1})

Simulated from SeaWiFS • September 1997–August 1998

Sea Surface Temperature (°C)

Simulated from AVHRR • August 1998

MODIS (Moderate-resolution imaging spectroradiometer) instrument is planned to be launched on board the EOS TERRA (previously EOS AM-1), the first in the series of satellites, in July of 1999. It is also planned to fly on a later mission, aboard the satellite EOS PM-1. MODIS will give continuity to the line of Earth-observing instruments such as the Advanced Very High Resolution Radiometer (AVHRR), the High Resolution Infrared Sounder (HIRS), the Coastal Zone Color Scanner (CZCS) and the Sea-viewing Wide Field-of-view Sensor (SeaWifs). MODIS represents an improvement over previous instruments in terms of signal-to-noise ratio, temporal coverage, spectral resolution, spatial resolution and spatial coverage.

MODIS science data products

MODIS science data products will be distributed to the scientific community through the Goddard Space Flight Center (GSFC) Distributed Active Archive Center (DAAC) and other DAACs across the country. Some of the data products available for distribution from the GDAAC are as follows:

level 1 radiance counts (Level-1A). These are the basic raw data. Calibrated and geolocated radiances are derived from Level-1A data, which contains counts from all 36 channels, for all times, resolutions, and detector views, plus all engineering and ancillary data. This data product also contains a quality indicator to mark missing or bad data and an indicator of instrument observing modes.

calibrated, geolocated radiances (Level-1B). These data sets are calibrated and geolocated for all 36 channels. Radiance data have units of W m^(-2) µm^(-1) sr^(-1). Quality flags, error estimates and calibration data are also provided.

geolocation data set (Level-1B). Determined by the attitude and orbit of the satellite, instrument telemetry and a digital elevation model, this data set supplies geodetic coordinates, ground elevation, solar and satellite zenith, and azimuth angle for MODIS 1-km samples. Higher level data are produced using this and the previous Level 1 data sets.

Ocean

MODIS data will be validated and calibrated by the MODIS Ocean Discipline Group.

Among the data products produced by this group are:

water-leaving radiance. This Level 2 and Level 3 data collection contains ocean water-leaving radiances for 7 of the 36 wavelengths/spectral bands (Band 8 through 14, 412 through 681 nm) known as ocean bands. The Level 2 product is provided daily at 1-km resolution for cloud-free pixels. Water leaving radiances are essential information for the production of higher level MODIS ocean products. They are derived from satellite images of the oceans by applying atmospheric correction to the data.

chlorophyll concentration. This is a Level 2 and Level 3 data collection. It contains ocean chlorophyll-a pigment concentration for Case 1 waters and Case 2 waters at 1-km resolution, daily and weekly products for cloud-free pixels, and the weekly composite is an average of cloud-free acquisitions for each ocean pixel. The observation of chlorophyll-a concentration is of importance to the study of oceanographic features because it allows the scientist to trace oceanographic currents, jets and plumes. Chlorophyll-a concentration is also important factor in determining the ocean's primary productivity.

primary productivity. This Level 4 data collection contains an estimate of the Ocean Primary Productivity on a weekly and annual basis. Primary productivity is the time rate of change of phytoplankton biomass. It is related to the result of photosynthesis integrated over a water column. This parameter is valuable in the study of interannual variability of ocean productivity and for comparison with global biochemical models, among others.

chlorophyll fluorescence. The observation of sun-stimulated chlorophyll fluorescence provides information on fluorescence line height, which is the relative measure of the amount of radiance leaving the sea surface at 683nm. It also provides a relative measure of the absorption and emission of PAR (photosynthetically active radiation), called fluorescence efficiency. The measurement of chlorophyll fluorescence is utilized to estimate the ocean's primary productivity. This data collection will be produced at Levels 2 and 3. Level 3 will be gridded and produced daily and weekly.

coccolith concentration. A coccolith is an external scale made of calcium carbonate found on small (on the scale of micrometers) marine phytoplankton called coccolithophores. Despite their small size, coccoliths are the largest source of calcium carbonate on Earth. Their production is an important part of the biogenic carbon cycle on Earth. This data collection will be produced at Levels 2 and 3.

phycoerythrin concentration. Phycoerythrin is a chlorophyll accessory pigment and serves to receive photosynthetically usable light in the 480 - 505 nm and 540 - 560 nm ranges. It is used to infer the global extent of phycoerythrin-bearing phytoplankton such as

cyanobacteria which are nitrogen-fixing and thus provide information on the nitrogen cycle. Used in conjunction with phytoplankton chlorophyllous pigment, the apparent species diversity of the oceans can be inferred. This data collection will be produced at Levels 2 and 3.

clear water epsilons. The normalized spectral ratios of aerosol radiances at 531nm and 667nm are called clear water epsilons. This product identifies blue-absorbing aerosols over clear waters. These aerosols are likely to transport about 5% iron from land into the ocean. It is believed that iron-rich aerosols could be an important source of iron to plants in parts of the ocean that are poor in nutrients. The Level 2 product is produced daily and the Level 3 product is produced daily and weekly, all at 1 km spatial resolution.

sea surface temperature. The study of sea surface temperatures will help the understanding of the El Niño phenomenon, the way it affects the ocean waters, the phytoplankton population and ultimately the fishing industry. These data sets are produced at Levels 2 and 3, and contain sea surface temperature at 1-km resolution over the global oceans. Level 2 product is produced daily and consists of global day and night coverage every 24 hours.

Atmosphere

MODIS data will be evaluated by the MODIS Atmosphere Discipline Group.

Among the data products produced by this group are:

cloud mask. The MODIS Cloud Mask is a daily, global Level 2 product generated at the 1-km and 250-m (at nadir) spatial resolution. The algorithm employs a series of visible and infrared threshold and consistency tests to specify confidence levels that an unobstructed view of the Earth's surface is observed. An indication of shadows affecting the scene is also provided. The 250-m cloud mask flags are based on the visible channel data only. Radiometrically accurate radiances are required, so holes in the Cloud Mask will appear wherever the input radiances are incomplete or of poor quality. The determination of the Cloud Mask is essential to the correct evaluation of atmospheric parameters.

precipitable water. This Level 2 data collection contains derived precipitable column water vapor amounts, during daytime, using a near-infrared (IR) over clear land areas and above clouds over both land and ocean; water vapor estimates are provided over clear ocean areas. MODIS will be the first instrument to use near-IR bands combined with IR bands to determine the total precipitable water. The amount of precipitable water is of importance to the study of the climate, hydrological cycle, aerosol properties, and others.

atmospheric profiles. This MODIS Level 2 product refers to the measurement of some atmospheric parameters. These include: total ozone burden, total column estimate in the troposphere and stratosphere; atmospheric stability, determination of three stability indices, temperature profiles at 20 vertical levels, moisture profiles at 15 vertical levels, and atmospheric water vapor at 5x5 1-km pixel resolution when at least 9 Fields-of-View (FOVs) are cloud-free. This product provides a characterization of the atmosphere and will be used in many instances to correct atmospheric effects in other MODIS products.

aerosol product. These Level 2 data are produced at 1-km spatial resolution at nadir. MODIS will measure variations in aerosol optical thickness over land and over the ocean. For the measurements over the ocean the size distribution of aerosols will also be determined. This measurement is important to distinguish, for example, between desert dust and industrial aerosols. Aerosols represent one of the greatest uncertainties in climate modeling today.

cloud product. MODIS data from visible and near-IR bands will be utilized to detect clouds in different particle phases (ice vs. water, cloud vs. snow), and the effective cloud particle radius and cloud optical thickness. These two are essential parameters for the understanding of cloud radiative properties. Other products derived from the IR bands are height, effective emissivity, cloud top temperature, and cloud fraction. These will be produced during the day and at night at 5x5 1-km pixel resolution. An indication of cloud shadows affecting the scene will also provided. This data collection will be produced at Levels 2 and 3.

gridded atmospheric products. This Level 3 data collection contains 8-day and monthly gridded averages of infrared-derived precipitable water vapor, aerosol optical depth, aerosol size distribution, stability indices, and total ozone burden. One important point of information derived from this data product is the identification of cirrus clouds. It is essential in climate modeling to understand the role of cirrus clouds in the energy balance of the Earth. They allow solar radiation to reach the surface of the Earth but they reduce the emission of IR radiation into space. MODIS's 1.37μm channel will allow for the observation of thin cirrus clouds with great sensitivity. These clouds can later be 'subtracted' from the images to provide a clearer view of land or ocean scenes.

Cirrus Cloud Correction AVIRIS • 09/04/1992

Uncorrected (R=.66μm G=.86μm B=.47μm) | Cirrus Clouds (1.373μm) | Corrected (R=.66μm G=.86μm B=.47μm)

thermal anomalies – fires and biomass. This Level 2 data collection contains fire occurrence (day/night), and fire location retrieved daily at 1-km resolution. One of the first consequences of fires is that they change the physical aspect of the local vegetation and soil nutrients. Also, the gases and particles emanated from fires affect the chemical processes in the atmosphere, cloud development and their reflectivity. During the day, observation of fires will be made using the 3.9(m channel of MODIS, which saturates at 500K, and the 11(m channel, which saturates at 400K. At night, the 1.65(m and 2.15(m channels will also be used for observation of fires.

Land

MODIS data will be quantified and calibrated by the MODIS Land Discipline Group.

For information on MODIS land products please visit: **http://modarch.gsfc.nasa.gov/MODIS/LAND**

The Earth Resources Observation System (EROS) Data Center (EDC) DAAC will distribute MODIS Land products.

Visit their web site at: **http://edcwww.cr.usgs.gov/landdaac/**

MODIS data access and services at the GDAAC

The GDAAC will be distributing these and other MODIS data products.

Presently there are two ways to access data from the GDAAC:

Via the EOSDIS V0 IMS gateway, at: **http://lyta.gsfc.nasa.gov/~imswww/pub/imswelcome/**

Via the GDAAC, at: **http://daac.gsfc.nasa.gov/data/tutorial.html**

For more information on MODIS data products archived and distributed by the GDAAC, please visit: **http://daac.gsfc.nasa.gov**

For more information on MODIS ocean products: **http://modarch.gsfc.nasa.gov/MODIS/OCEANS**

For snow and ice cover please see the National Snow and Ice Data Center (NSIDC) DAAC at: **http://www-nsidc.colorado.edu/**

For more information on MODIS atmosphere products: **http://modarch.gsfc.nasa.gov/MODIS/ATM**

The Goddard DAAC
Code 902
Goddard Space Flight Center
Greenbelt, MD 20771
http://daac.gsfc.nasa.gov/

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