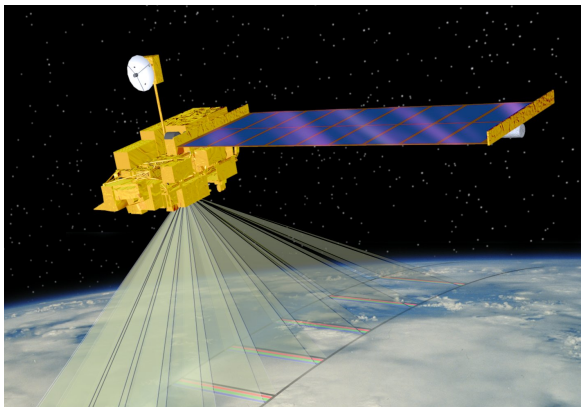
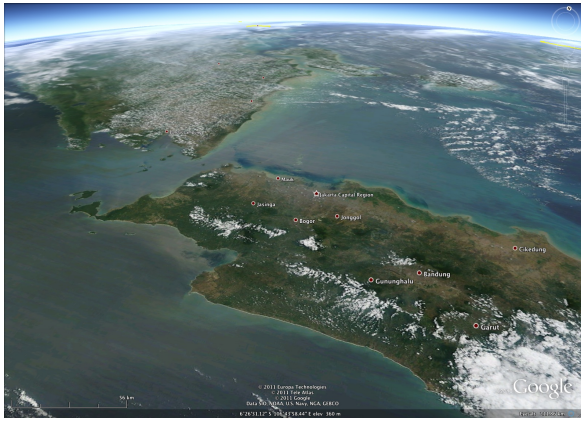
Introduction to the MODIS Sensor and Products Continued



RA-V Training Workshop on Satellite Applications for Meteorology and Climatology
Citeko, Bogor–Indonesia
19 – 27 September 2011



Kathy Strabala and Liam Gumley
Space Science And Engineering Center
University Of Wisconsin-Madison

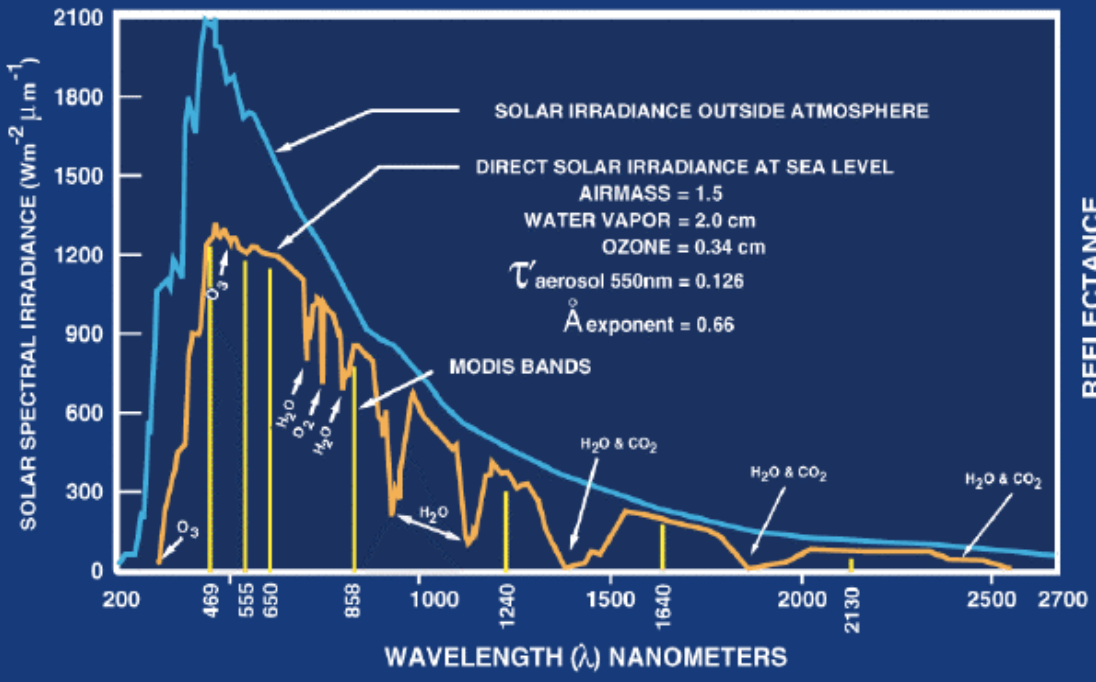
SSEC

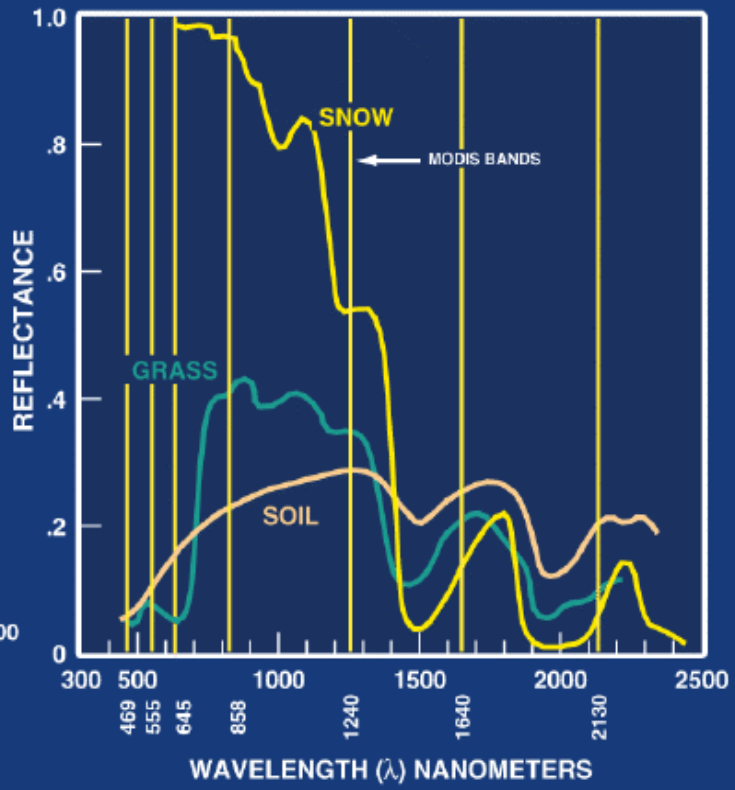
MODIS Land Products

MODIS Land Products

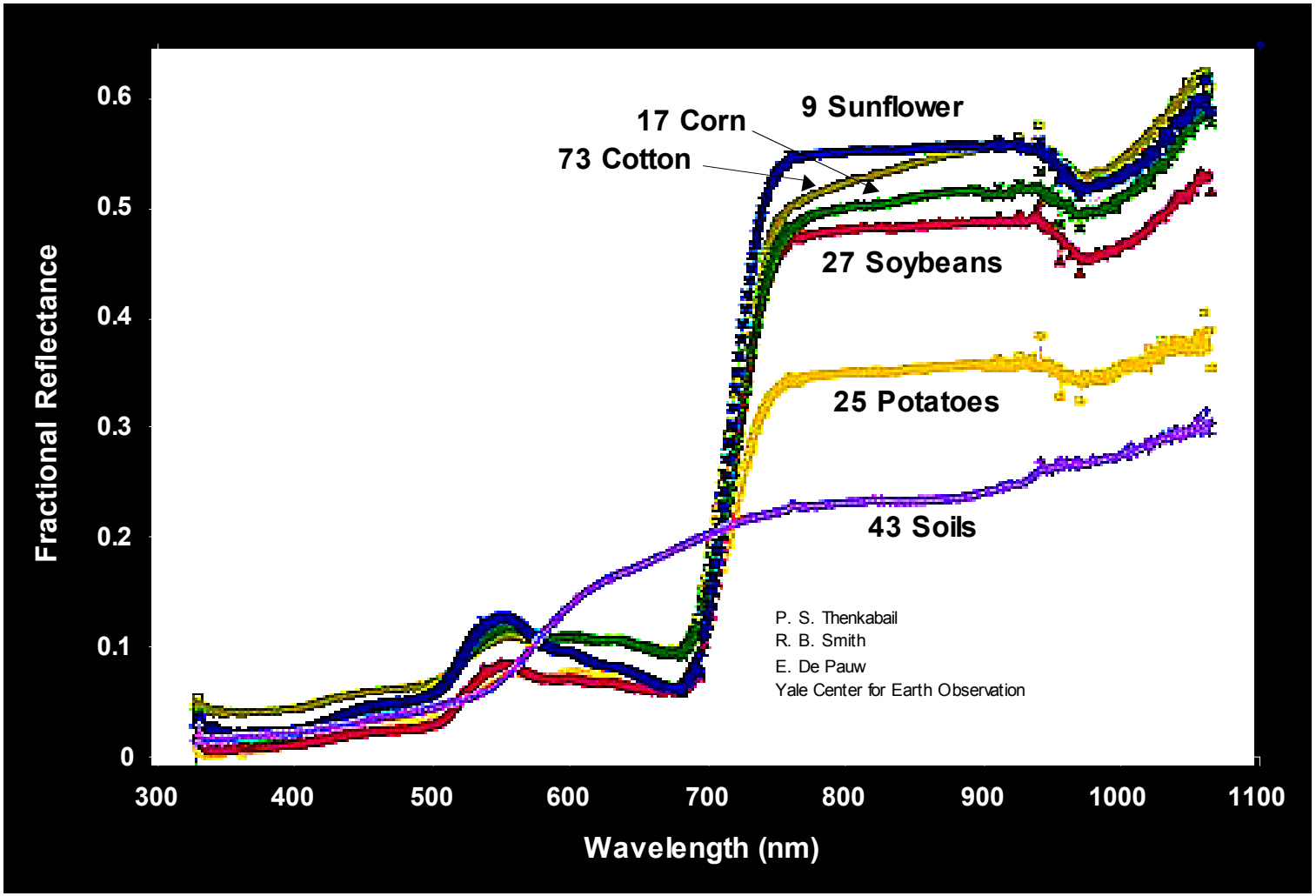
MOD 09 - Land Surface Reflectance
MOD 10 - Snow Cover
MOD 11 - Land Surface Temperature & Emissivity
MOD 12 - Land Cover/Land Cover Change
MOD 13 - Gridded Vegetation Indices (NDVI & EVI)
MOD 14 - Thermal Anomalies (Fires)
MOD 15 - Leaf Area Index & FPAR
MOD 16 - Evapotranspiration
MOD 17 - Net Photosynthesis and Primary Productivity
MOD 29 - Sea Ice Cover
MOD 43 - Bidirectional Reflectance Distribution Function (BRDF)
MOD 44 - Vegetation Cover Conversion

LAND-SOLAR RADIATION





Soil and crop reflectance



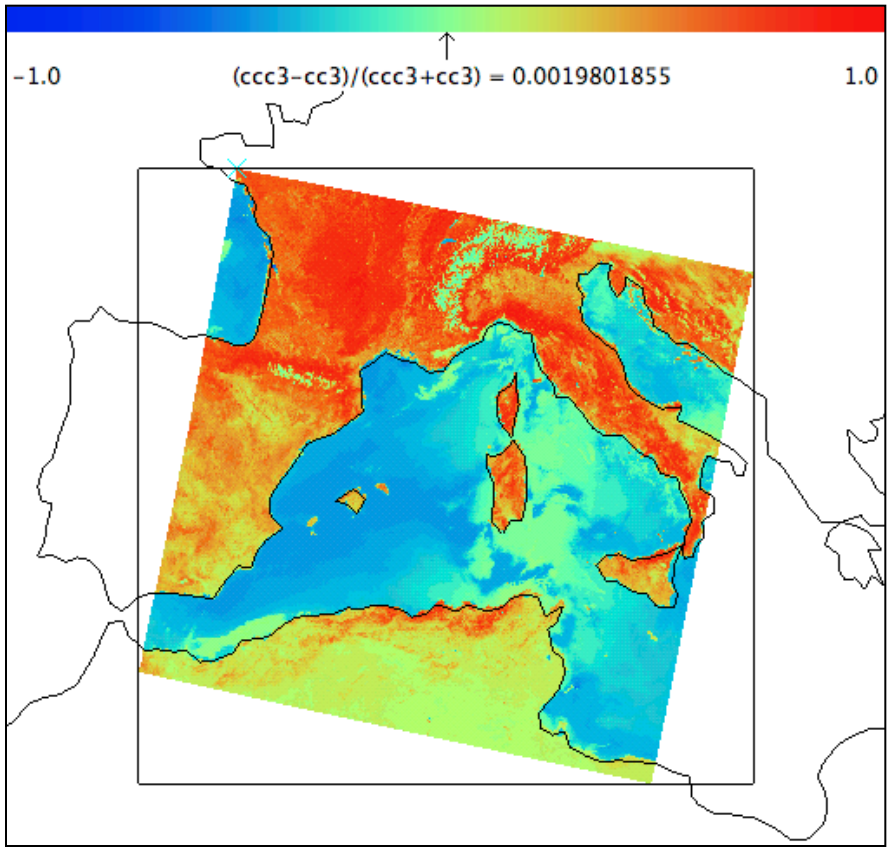
Normalized Difference Vegetation Index (NDVI)

Defined as the ratio

$$(r_{.86} - r_{.68})/(r_{.86} + r_{.68})$$

Correlated with:	
Plant Biomass	Crop Yield
Plant Nitrogen	Plant Dhlorophyll
Water Stress	Plant Diseases
Insect Damage	

Applications:	
Vegetation Monitoring	Agricultural Activities
Drought studies	Landcover Change
Public Health Issues (mosquitos)	Climate Change Detection
Net Primary Production	Carbon Balance



How does DB VI version differ from the MOD13 product?

- DB VI product uses the corrected reflectance, but not the MODIS surface reflectance MOD09 product
  - Corrected reflectance product removes the effects of the small particle scattering (Rayleigh scattering), but not the Mie scattering (includes aerosols)
  - NASA VI product (MOD13) uses the BRDF (Bidirectional Reflectance Distribution Function) product as input

Surface Reflectance (MOD09)

The surface reflectance product is defined as the reflectance that would be measured at the land surface if there were no atmosphere.

Surface Reflectance

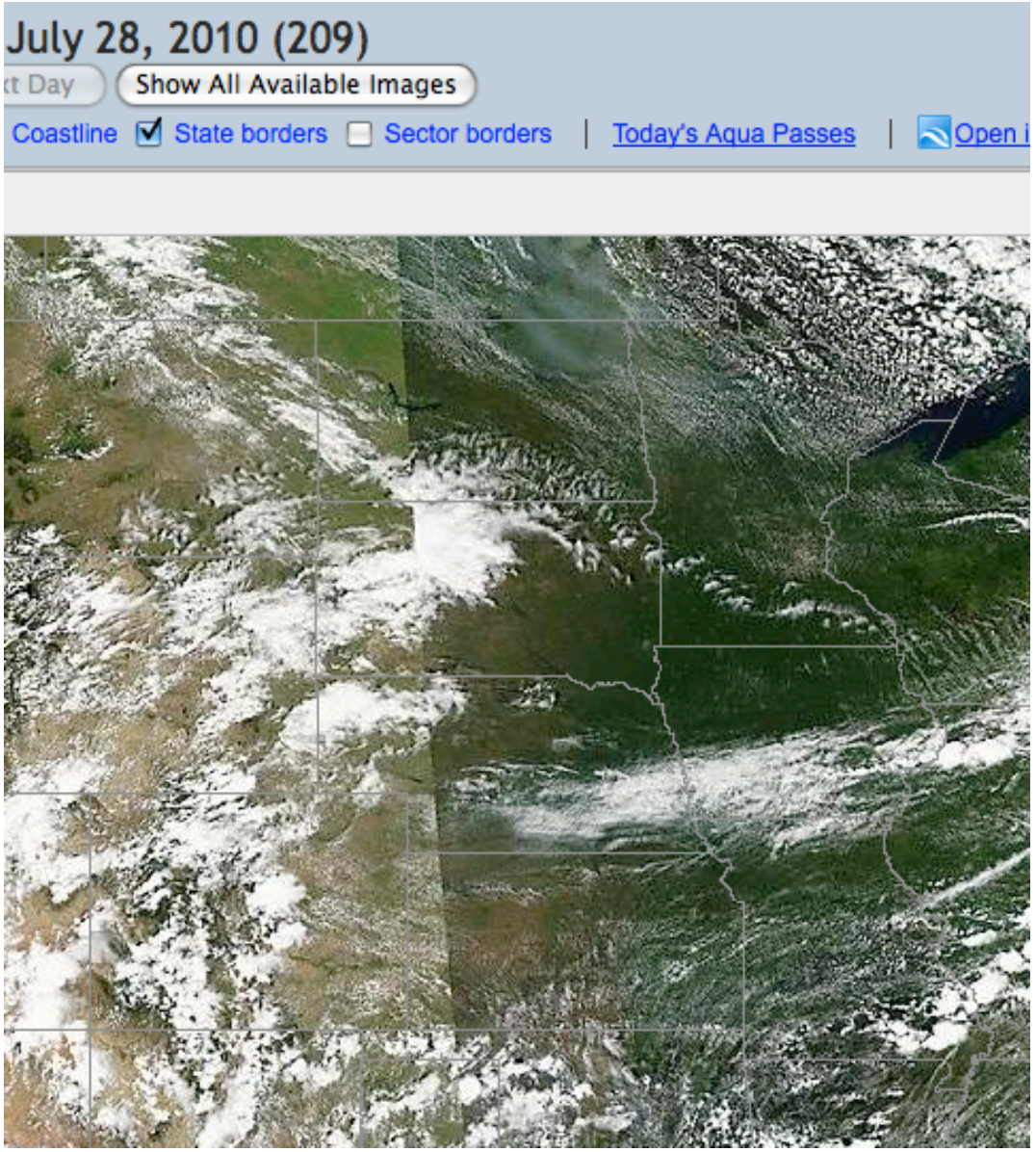
$$\rho_{TOA} = \mathrm{Tg}(O_3, O_2, CO_2)\left[\rho_R + (\rho_{R+A} - \rho_R)\mathrm{Tg}(U_{H_2O}/2) + T_{R+A}\frac{\rho_s}{1 - \rho_s S_{R+A}}\mathrm{Tg}(U_{H_2O})\right] \quad ($$

ρ_{TOA} is the reflectance observed at the top of the atmosphere,
T_g refers to gaseous transmission,
ρ_R is the molecular scattering intrinsic reflectance,
ρ_{R+A} is the intrinsic reflectance of the molecules and aerosols,
T_{R+A} is the transmission of the molecules and aerosols and
S_{R+A} is the spherical albedo.

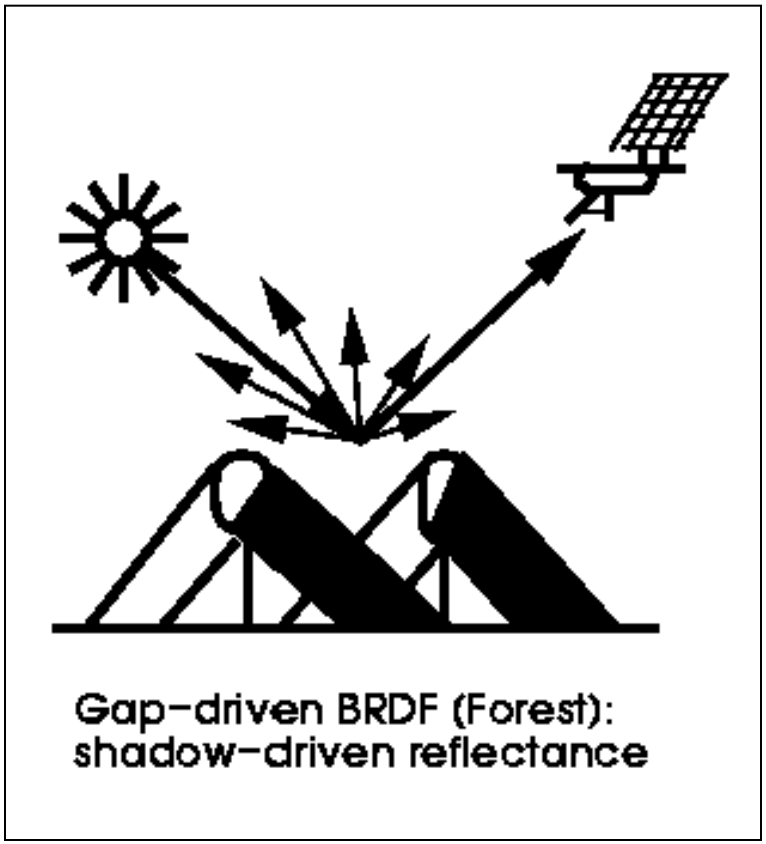
Example from MODIS Today web site

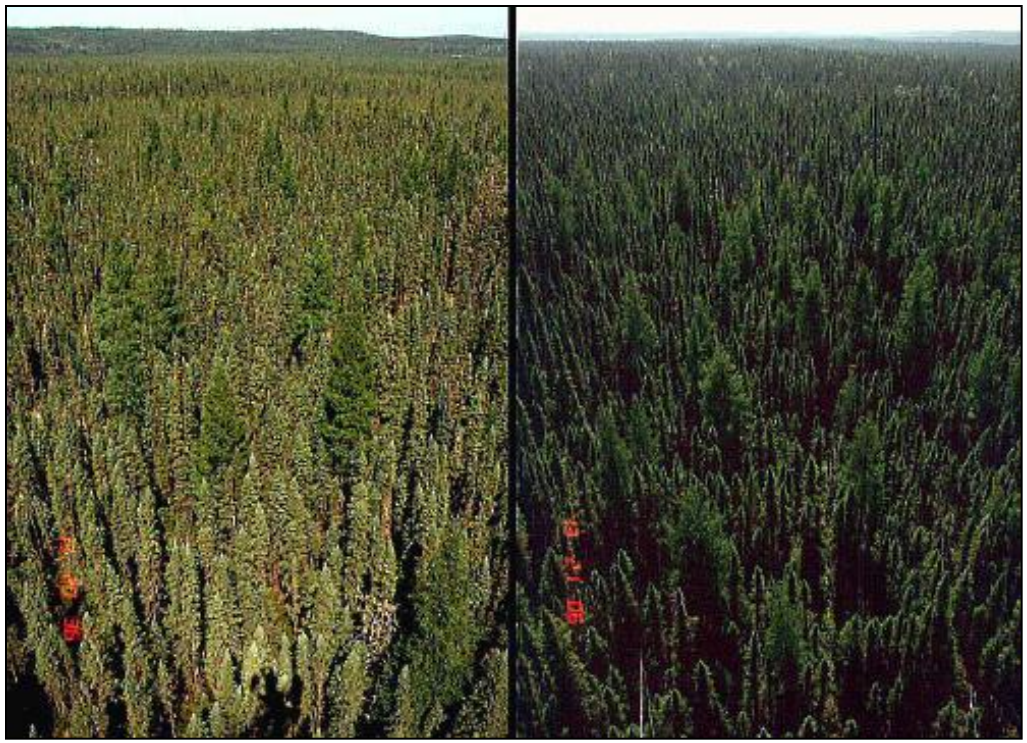
The effects of atmospheric and surface reflection are not uniform across a scan

This will affect your retrievals



BRDF (Bi-directional Reflectance Distribution Function)





Black spruce forest in Canada.
Left, sun behind camera
Right, sun opposite

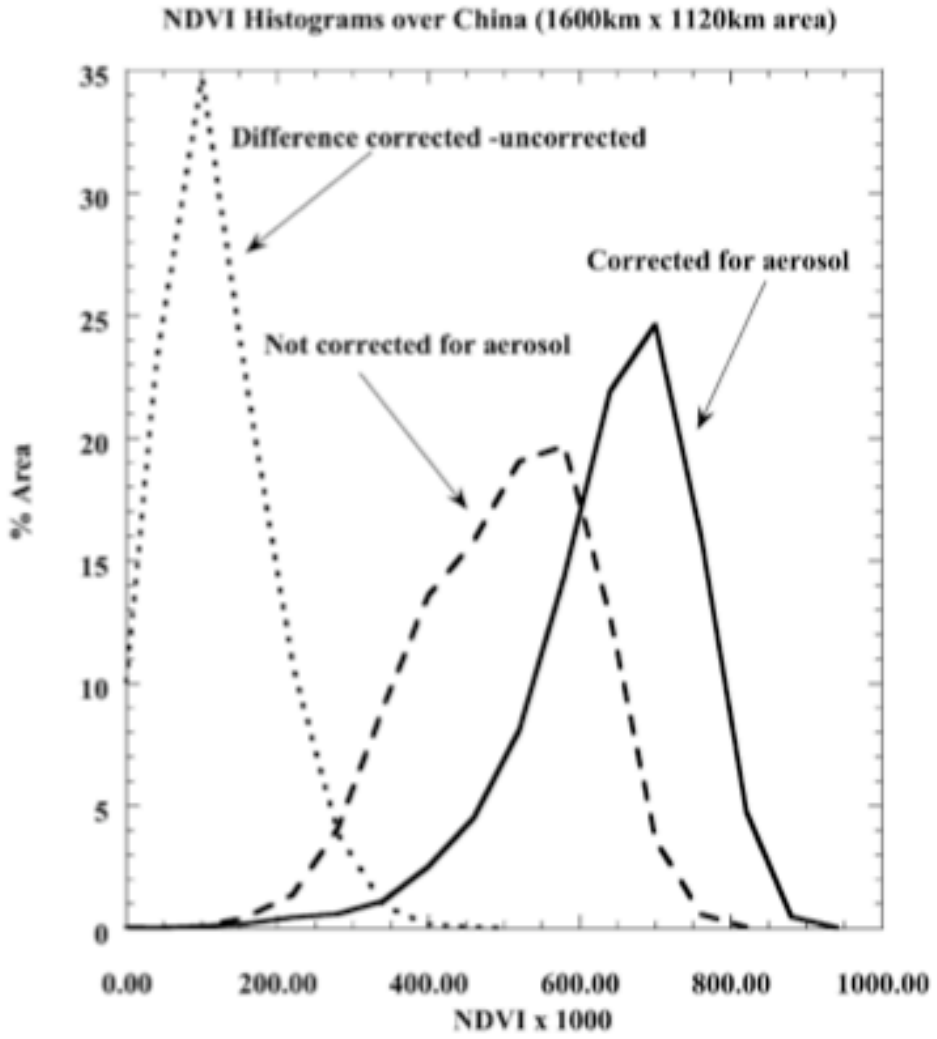


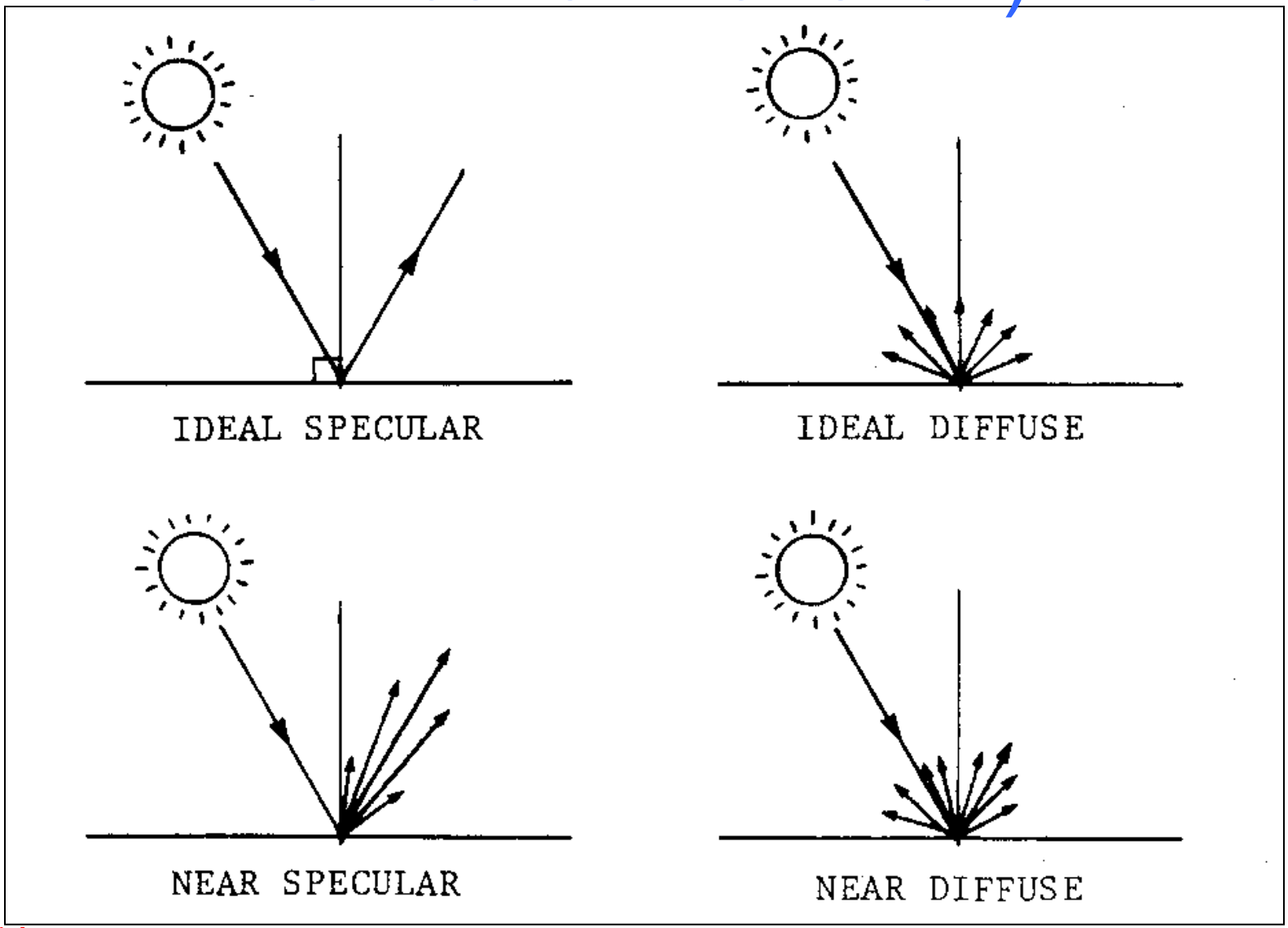
Fig. 4. Comparison of histograms of NDVI (corrected for aerosol and uncorrected for aerosol) observed over China (area of 1600 × 1120 km), the solid curve corresponds to the aerosol corrected data, the dashed one to the uncorrected and the small dash to the difference between uncorrected and corrected NDVI.

Importance of aerosol correction when retrieving NDVI (Example over China)

Reference

- E.F. Vermote, Nazmi Z. El Saleous, Christopher O. Justice, “Atmospheric correction of MODIS data in the visible to middle infrared: first results”. Remote Sensing of the Environment 83. (2002), 97–111.

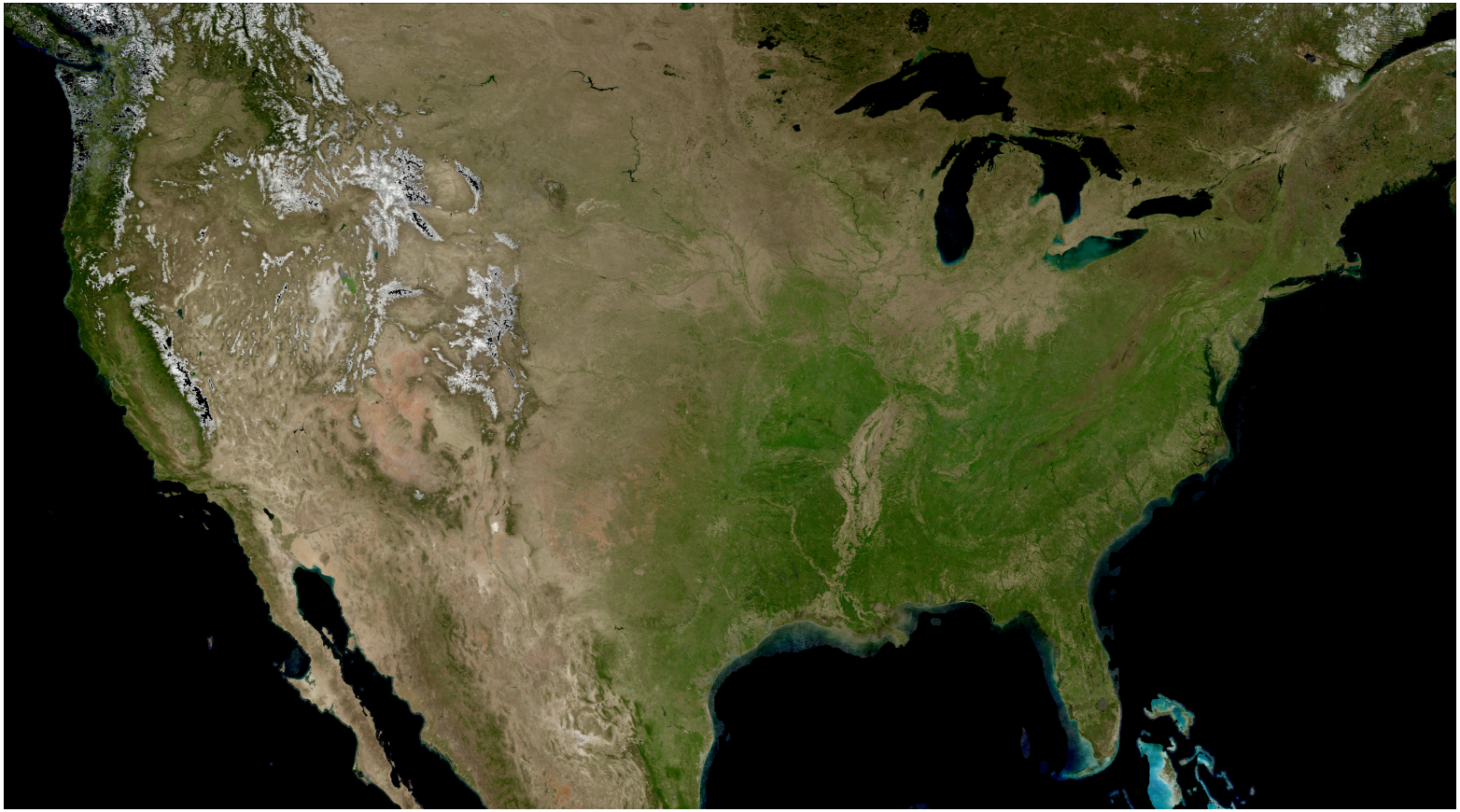
BRDF (Bi-directional Reflectance Distribution Function)



Wolfgang Lück

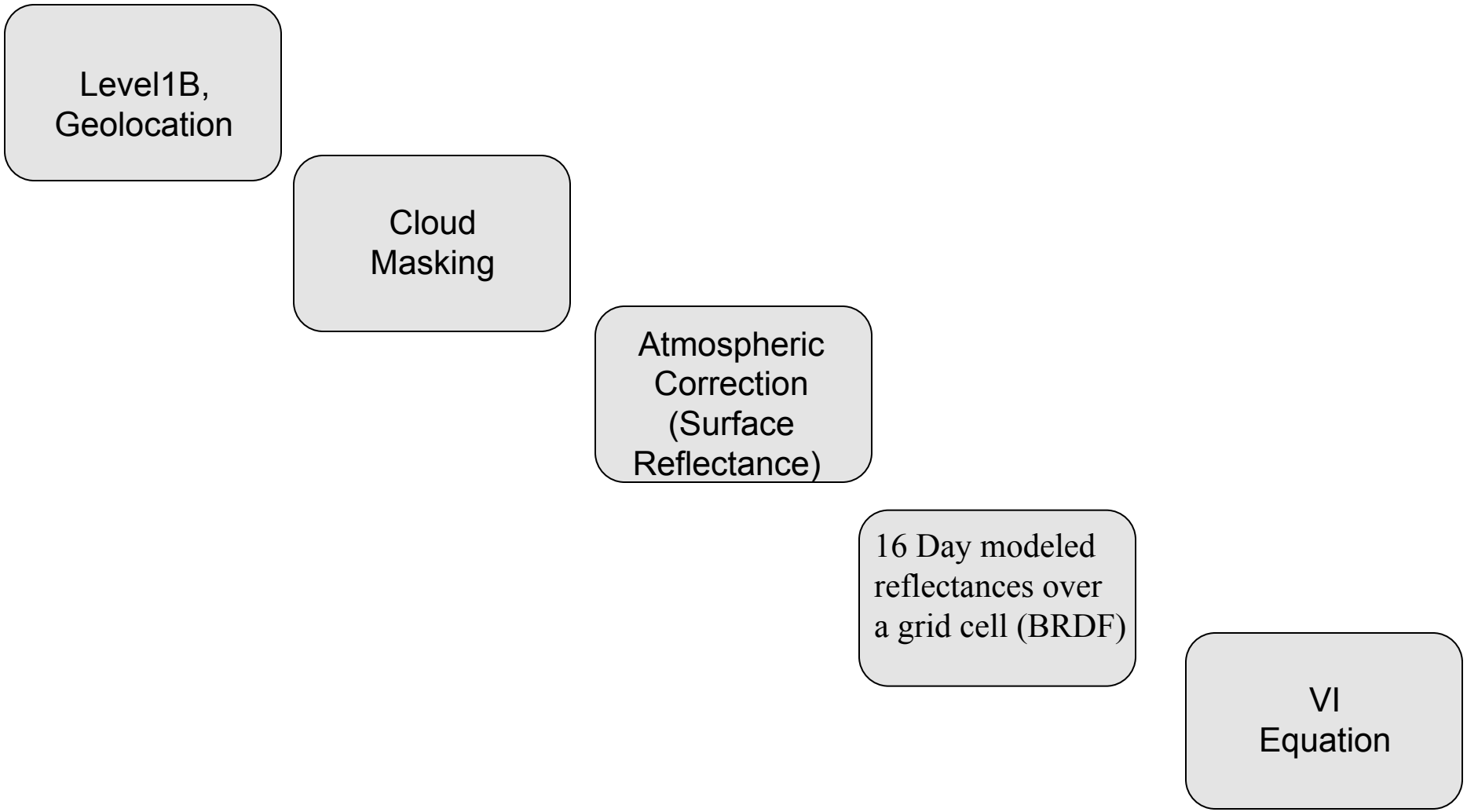
BRDF product

BRDF modeled refectances
16 days of UW MODIS DB data



18 April 2010

Inputs and Processing Chain for MODIS VI Production



BRDF References

- Shuai,Y., C. B. Schaaf, A. H. Strahler, J. Liu, Z. Jiao, Quality assessment of BRDF/albedo retrievals in MODIS operational system, Geophys. Res. Lett., 35, L05407, doi: 10.1029/2007GL032568,2008.
- Schaaf, C. B., F. Gao, A. H. Strahler, W. Lucht, X. Li, T. Tsang, N. C. Strugnell, X. Zhang, Y. Jin, J.-P. Muller, P. Lewis, M. Barnsley, P. Hobson, M. Disney, G. Roberts, M. Dunderdale, C. Doll, R. d'Entremont, B. Hu, S. Liang, and J. L. Privette, and D. P. Roy,First Operational BRDF, Albedo and Nadir Reflectance Products from MODIS, Remote Sens. Environ., 83, 135-148, 2002.

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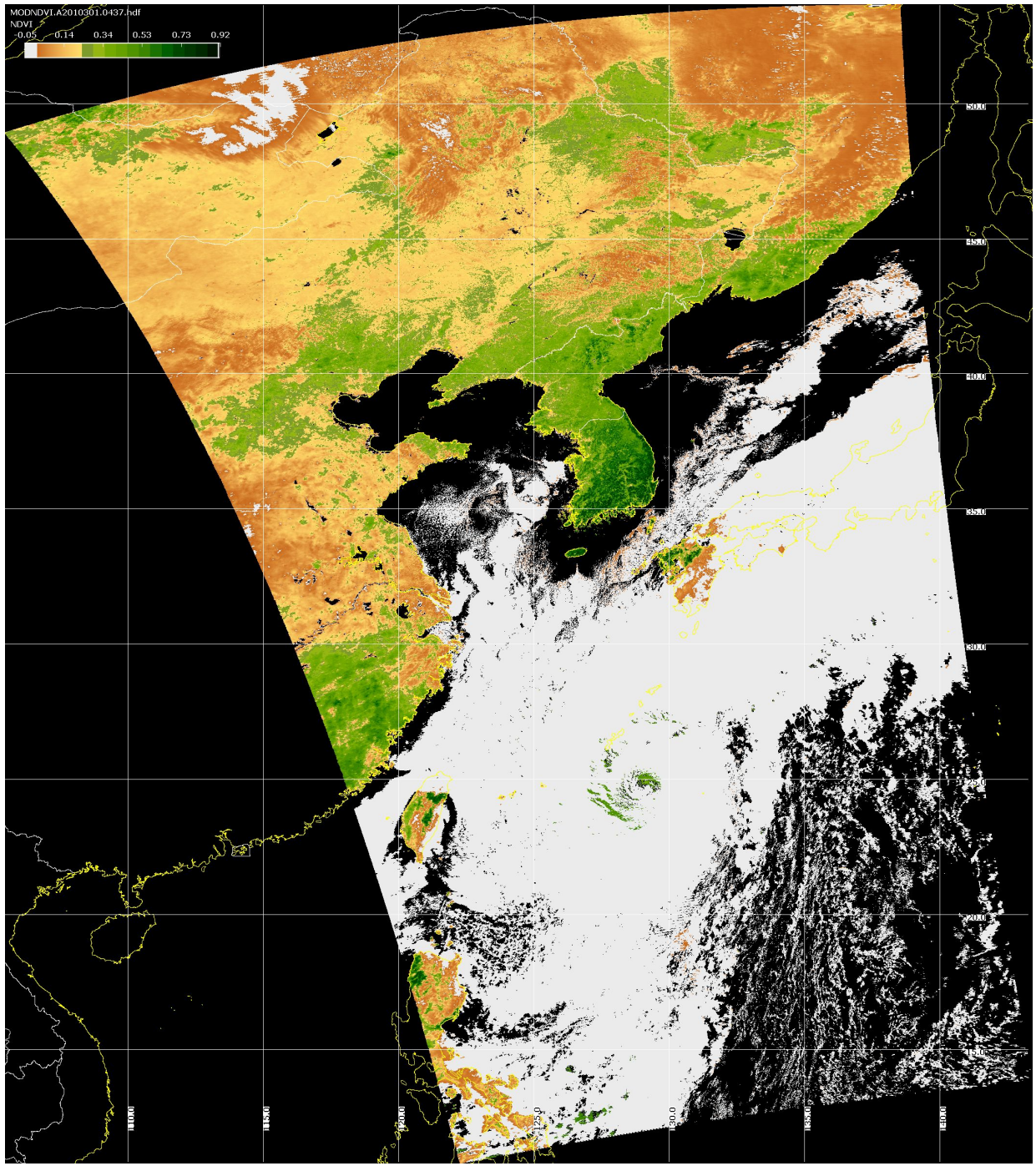
- Ramachandran, Bhaskar, Justice, Christopher O., Abrams, Michael J., Huete, Alfredo, Didan, Kamel, Leeuwen, Willem, Miura, Tomoaki and Ed Glenn. MODIS Vegetation Indices, Land Remote Sensing and Global Environmental Change, Remote Sensing and Digital Image Processing: 2011. Springer New York, 978-1-4419-6749-7, Physics, 579-602.
- Huete, A., K. Didam, T. Miura, E.P. Rodiguez, X. Gao and L.G. Ferreira: 2002. Overview of the radiometric and biophysical performance of the MODIS vegetation indices: 2002. *Remote Sensing of the Environment*, **83**, 195-213.
- Algorithm Theoretical Basis Document (ATBD)

  http://modis.gsfc.nasa.gov/data/atbd/atbd_mod13.pdf

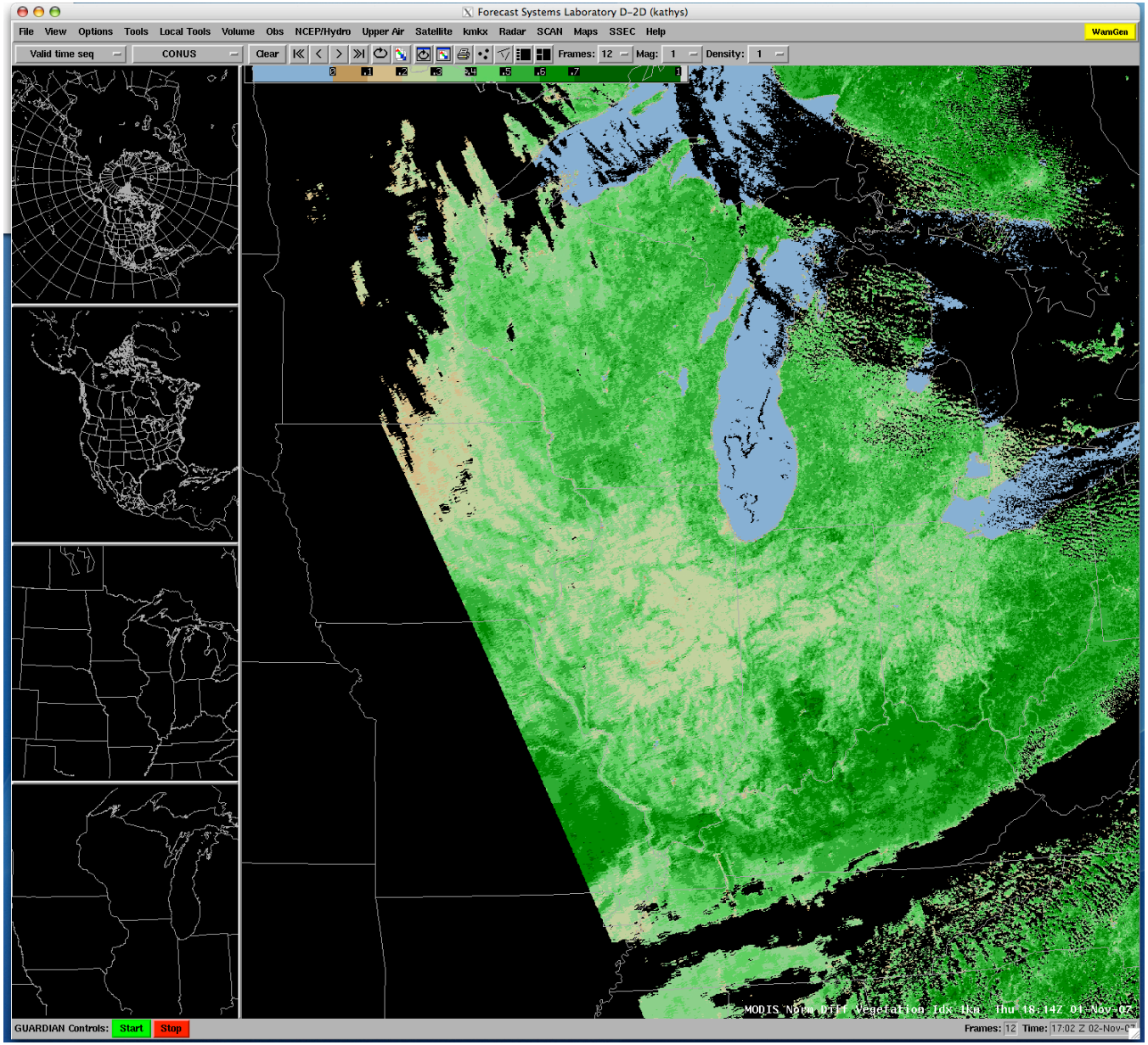
Applications

- Monitoring of seasonal, inter-annual, and long term variations of vegetation structure and biophysical parameters
- Climate Studies - Model input
- Famine Early Warning - Drought
- Epidemiology
- Correlated with Net Primary Production
- Fire Potential - US National Weather Service Forecasters



MODIS NDVI Product from ECNU 28 October 2010

Example of MODIS NDVI product viewed by US Operational Forecasters in AWIPS 1 November 2007



National Weather Service Weather Forecast Office

Milwaukee/Sullivan, WI

Home | Site Map | News | Organization

Local forecast by "City, St" or Zip Code

City, St Go

XML RSS Feeds

Current Hazards
Watches/Warnings
Outlooks
Submit Report

Current Conditions
Observations
Radar
Satellite
Observed Precip

Forecasts
Forecast Discussion
Activity Planner
Aviation Weather
Fire Weather
Marine Weather
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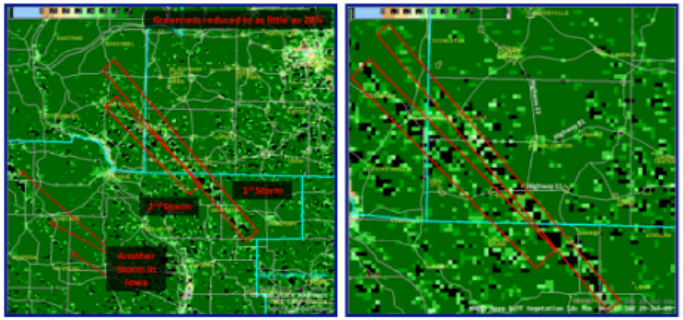
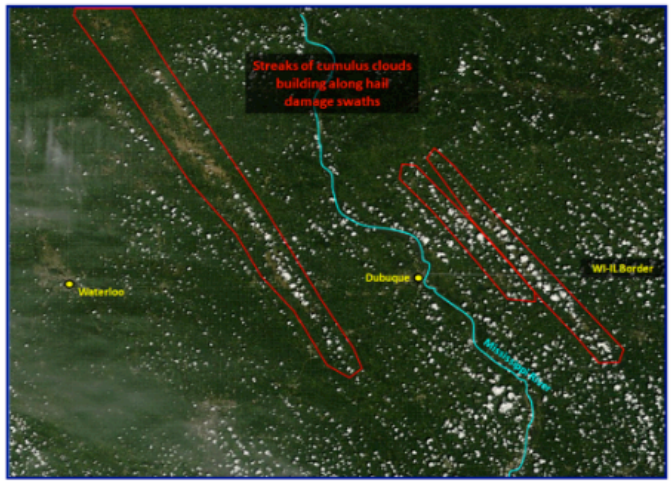
Hail Scars Visible On Satellite Imagery

On Friday July 24, 2009, multiple significant hail storms moved southeastward across northeast Iowa, southwest Wisconsin, and northwest Illinois. These hail storms produced extremely large hail, and copious amounts of hail, which led to some concentrated swaths of damage to vegetation. In some areas, most of the crops were severely damaged or destroyed. For a complete write-up on the situation, **click here**.

With a relatively clear day today, some of the scarring is visible on satellite images. First, the MODIS Vegetation Index which is a 1km resolution product designed to pick up on areas of greenness in the vegetation:

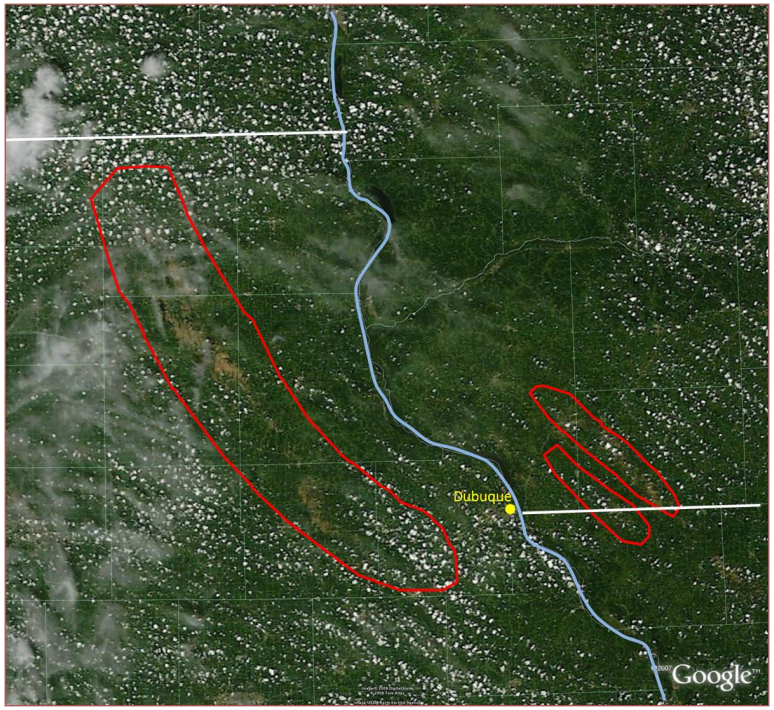


A minimum of about 28% greenness is evident just south-southeast of Belmont, which is not surprising given that is where some of the worst crop damage was observed. Corn stalks were completely stripped and sheared off to a height of less than 2 feet. These damaged areas of vegetation now absorb more radiation from the sun, thereby allowing the surface to heat faster. This phenomenon is evident in the MODIS 250m resolution satellite image from below. Cumulus clouds fired in greater abundance on the Wisconsin hail swaths, which makes them less distinguishable than the Iowa hail swath.



The below image is from a few days later, a little earlier in the day so fewer cumulus clouds. The hail scars are more clearly visible over southwest Wisconsin as well as in northeast Iowa.

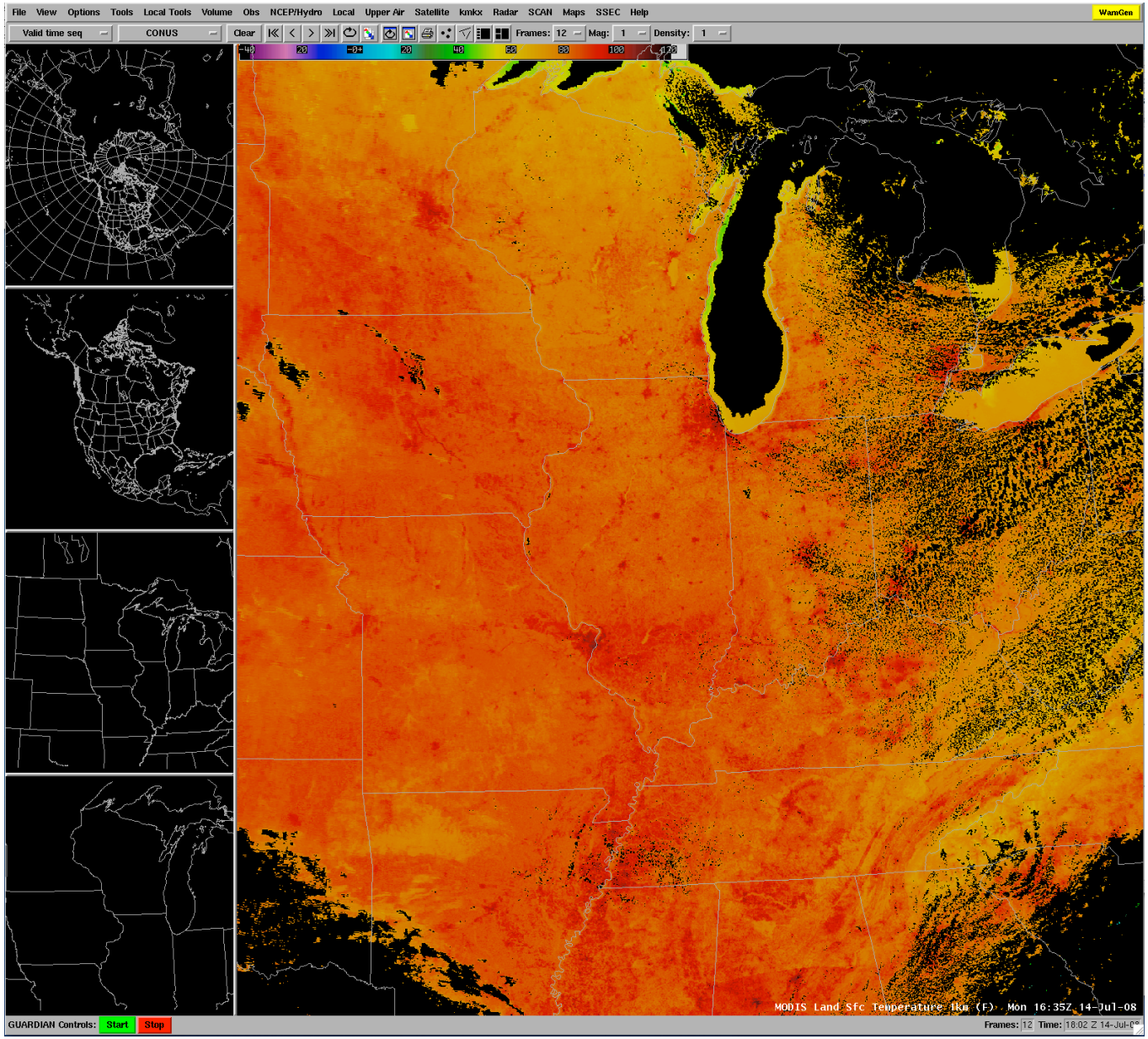
MODIS NDVI product used to determine extent of hail damage July 2008



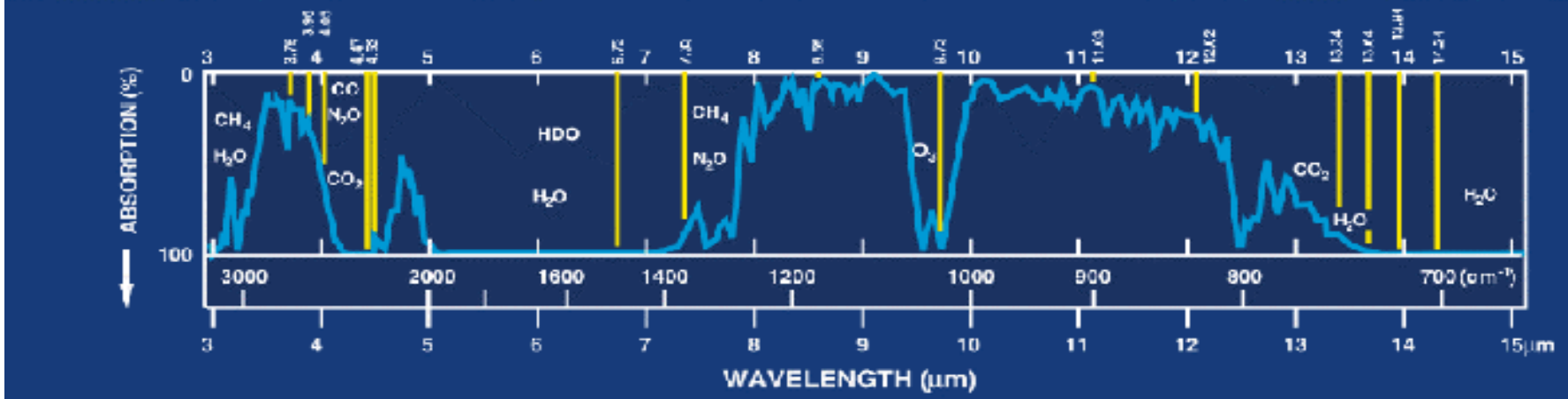
NASA SSEC NOAA National Oceanic and Atmospheric Administration U.S. Department of Commerce

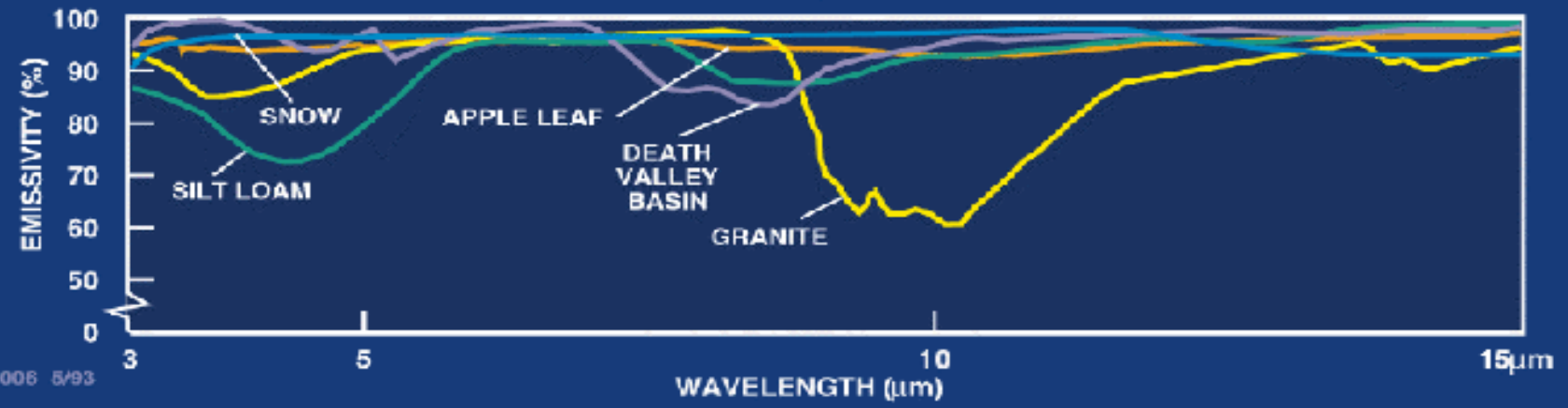
Land Surface Temperature and Emissivity

Land Surface Temperature



LAND - THERMAL RADIATION





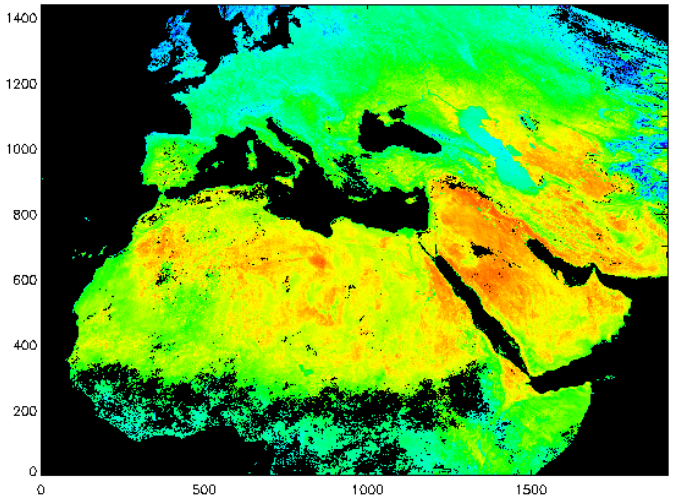
C351.006 5/93

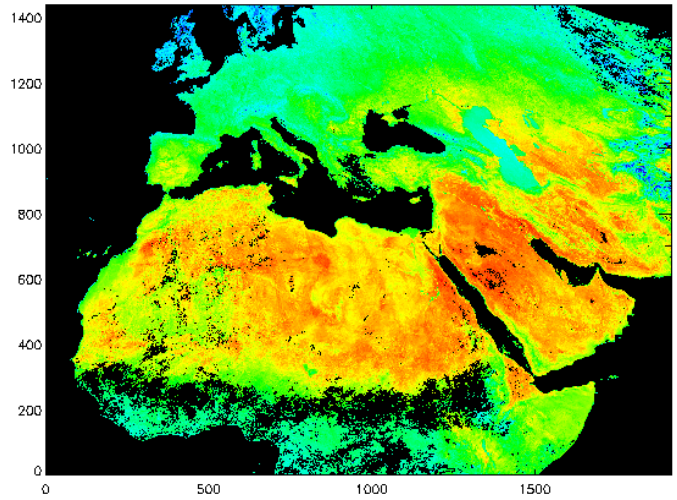
LSTs retrieved from Terra and Aqua MODIS data

on data days 176-177 and 185-190 (06/25-26 & 07/4-9)

to show spatial distribution of the diurnal variation

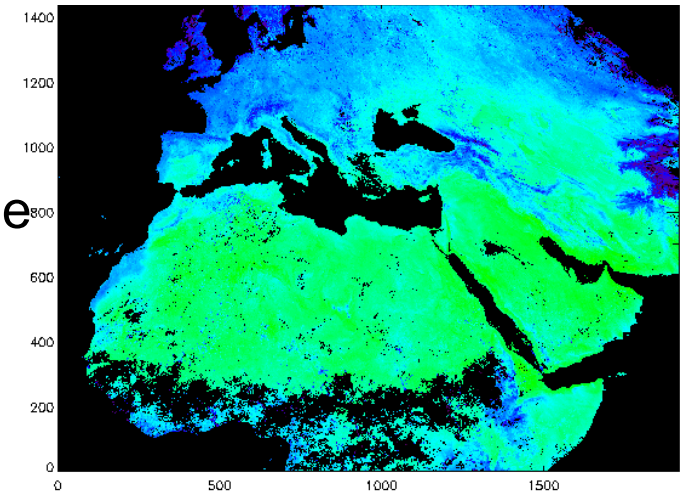
daytime Terra

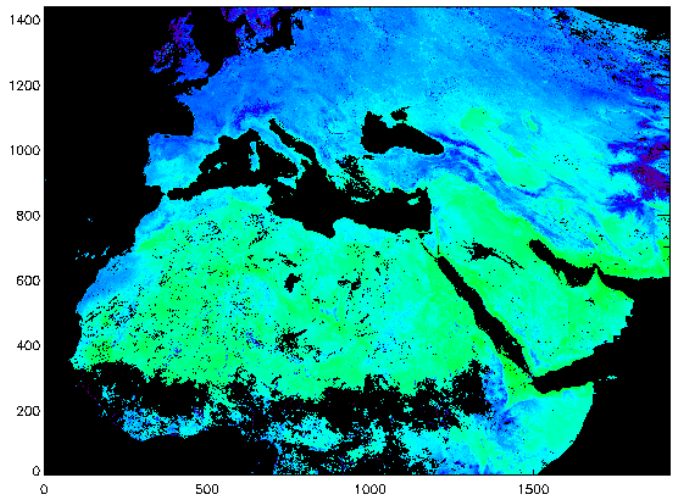




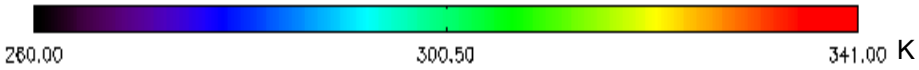
daytime Aqua

nighttime Terra





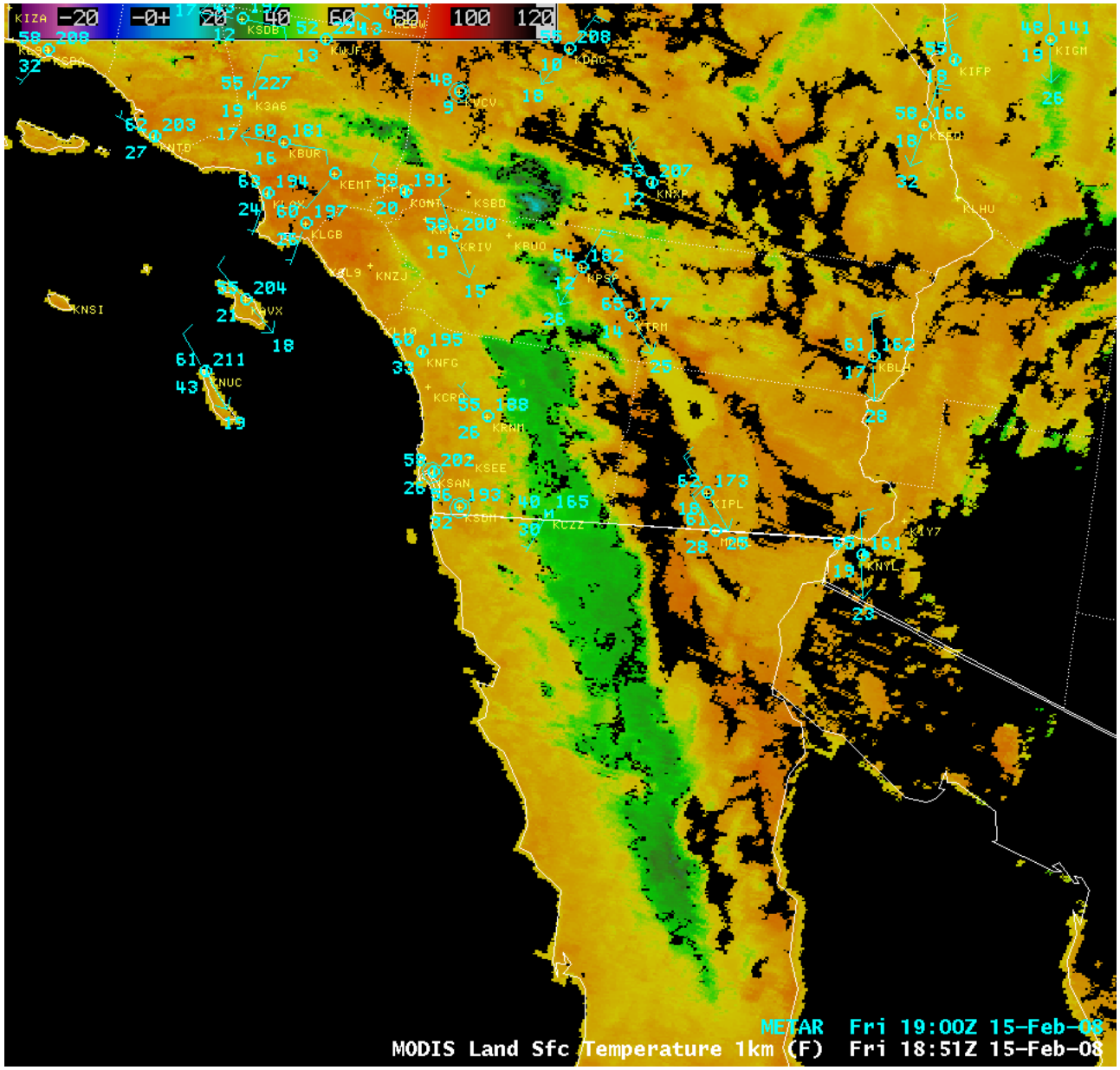
nighttime Aqua



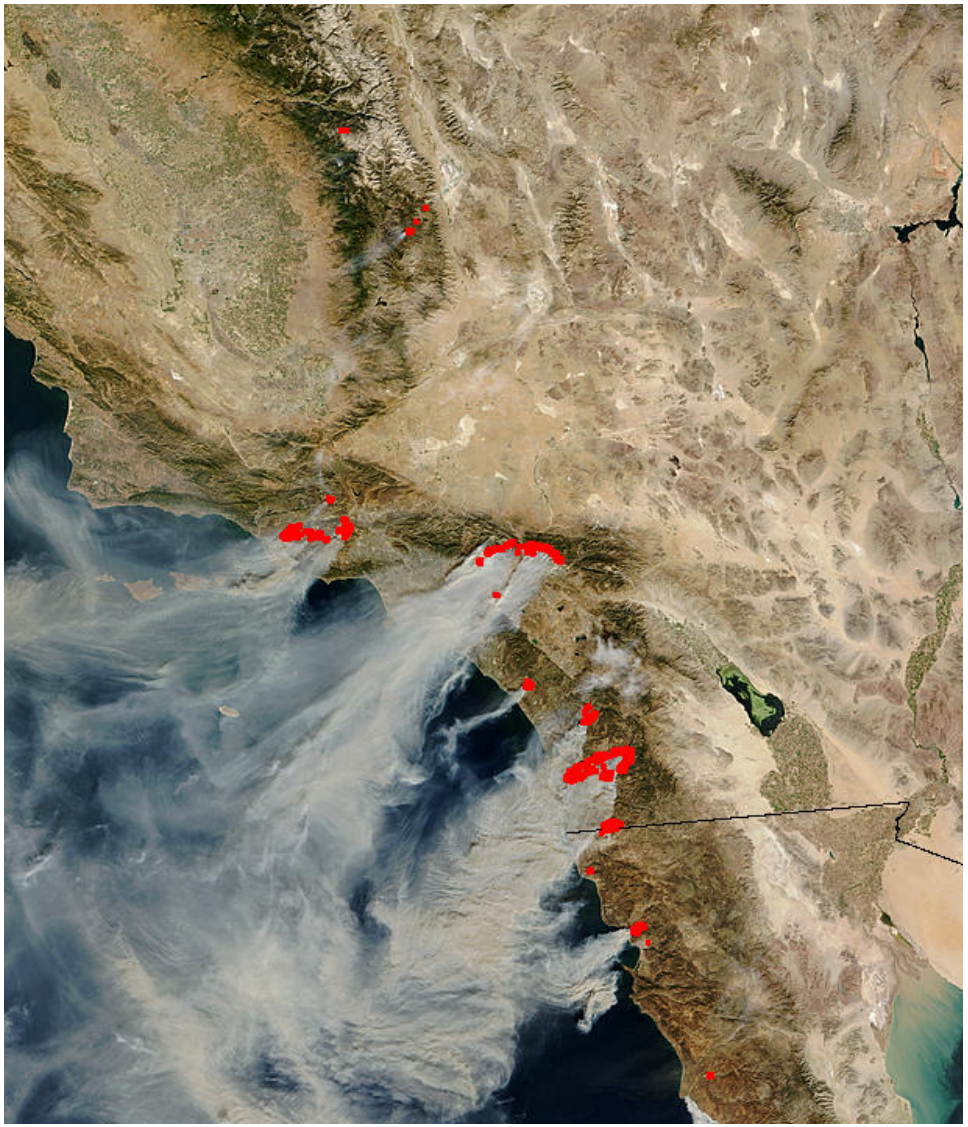
ICESS Institute for Computational Earth System Science University of California, Santa Barbara

MODIS True Color

MODIS Land Surface Temperature



MODIS Active Fire Detection



California – 10/26/03

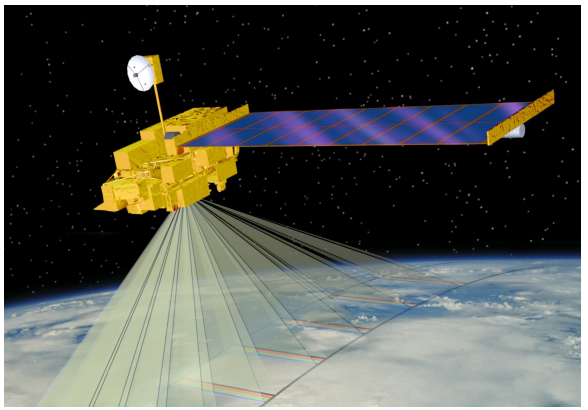
- The algorithm considers the spectral signature (in middle and thermal infrared) of each pixel and compares it to the non-burning surrounding pixels
- The natural variability of the surrounding background is taken into account
- Fewer false detections than traditional threshold-based algorithms
- Sensitive enough to detect small fires

Other Products Saved for Tomorrow

- Fires
- Aerosols

End of Part One

MODIS Direct Broadcast Software and Products



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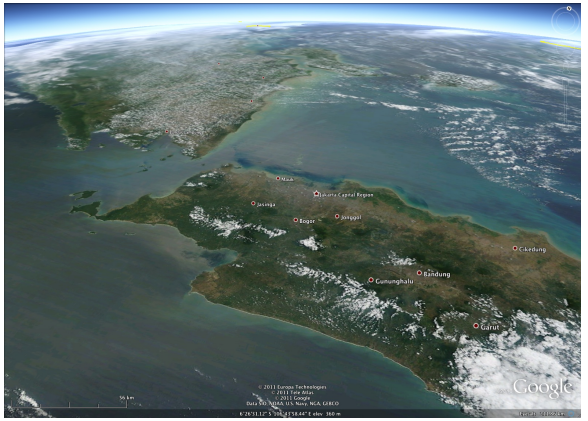


Kathy Strabala and Liam Gumley
Space Science And Engineering Center
University Of Wisconsin-Madison

SSEC

Outline

1. What is MODIS **Direct Broadcast** (DB)?
2. MODIS DB **Image** Products
3. MODIS DB **Atmosphere** Products
4. MODIS DB **Land** products
5. MODIS DB **Ocean** products
6. Software for **interpreting** MODIS DB products
7. **Downloading** MODIS data from the Web

What is Direct Broadcast?

- Direct Broadcast is the real-time transmission of earth observation data from the spacecraft to the ground (via X-band on Terra and Aqua)
- On Terra, only MODIS is broadcast
- On Aqua, all data is broadcast
- Data are free and clear with no encryption

- All you need is an antenna and receiver!
- “Terra and Aqua are a great gift to the world” *(Vladimir Gershenzon, ScanEx)*

Terra

Launched: Dec. 18, 1999

10:30 am descending

ASTER: Hi-res imager

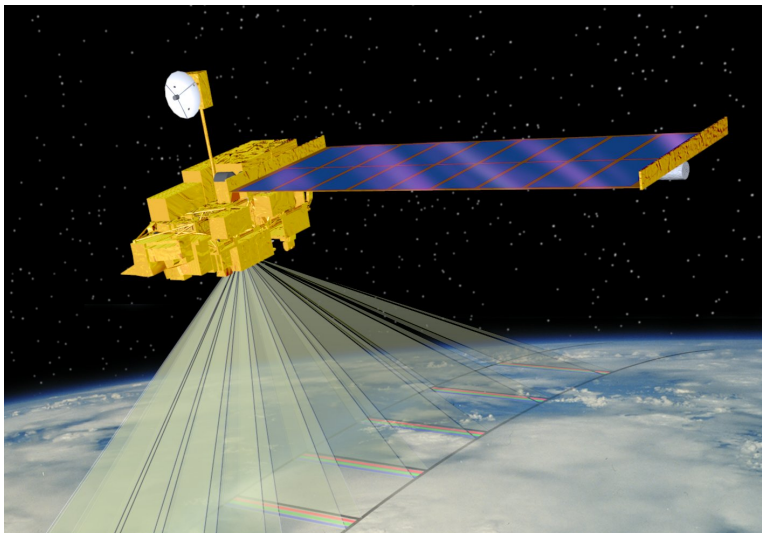
CERES: Broadband scanner

MISR: Multi-angle imager

MODIS: Multispectral imager

MOPITT: Limb sounder

Only MODIS is available by DB



Aqua

Launched: May 4, 2002

1:30 pm ascending

AIRS: Infrared sounder

AMSR-E: Microwave scanner

AMSU: Microwave scanner

CERES: Broadband scanner

HSB: Microwave sounder

MODIS: Multispectral imager

All sensors are available via DB

How do I get Direct Broadcast?

- Direct Broadcast X-band ground stations are available from a number of vendors
- Cost is around $100-300K USD
- There are many other stations around the world

There are other ways to get MODIS data…

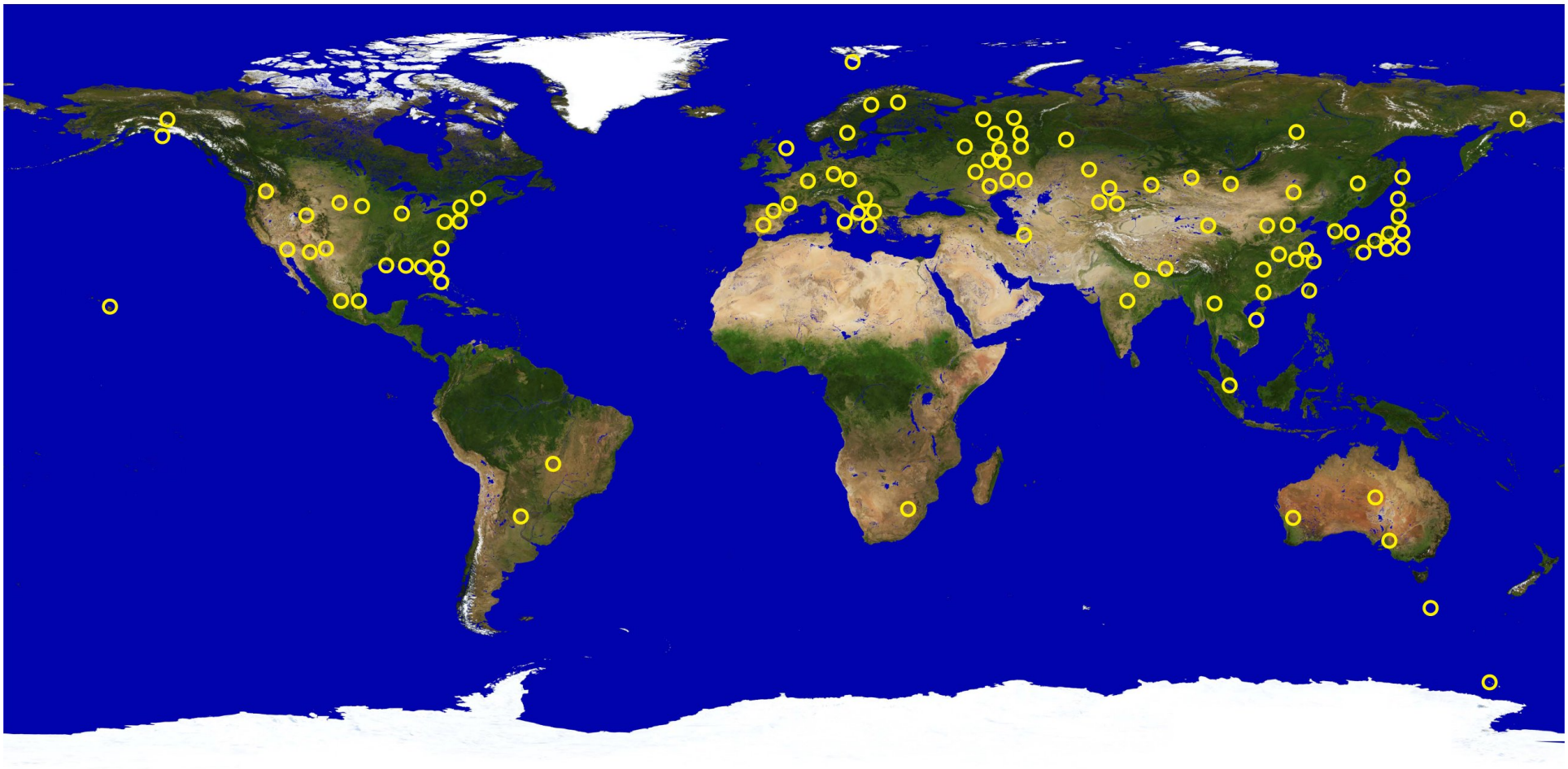
Shanghai, China

Moscow, Russia
27/11/03 12:58

Madison, USA

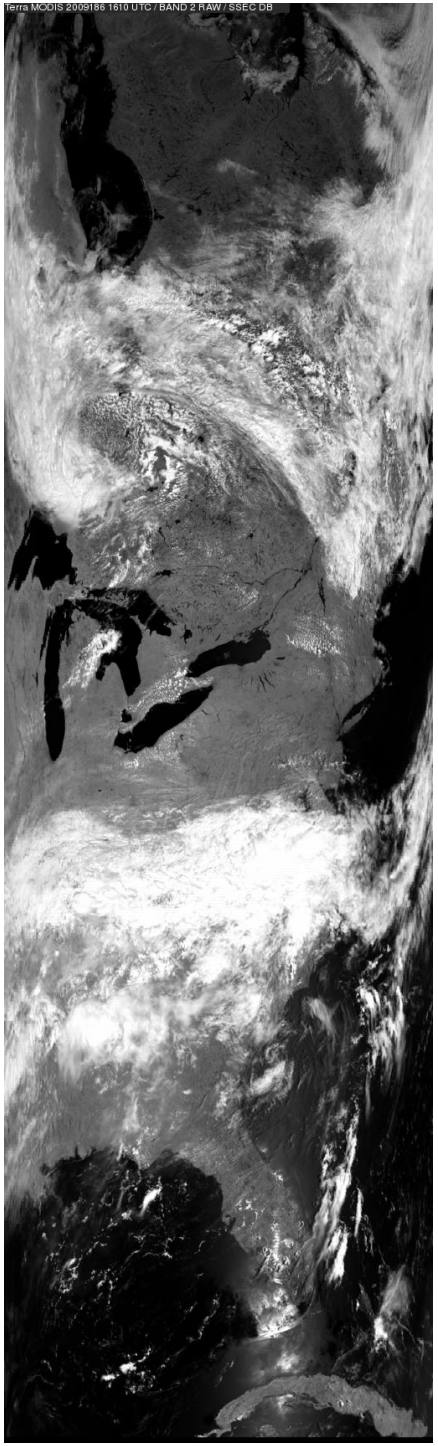
Benevento, Italy

EOS Direct Broadcast Sites Worldwide



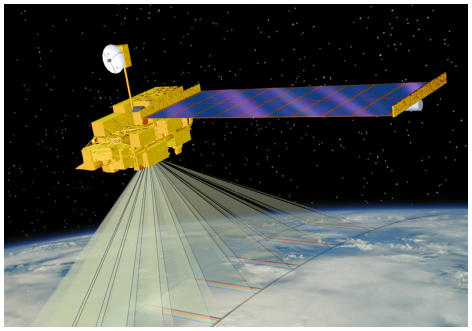
DB Coverage from Madison, WI

Terra, 2009/07/05

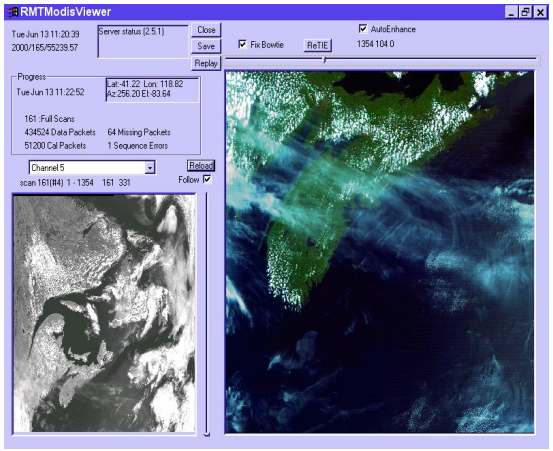


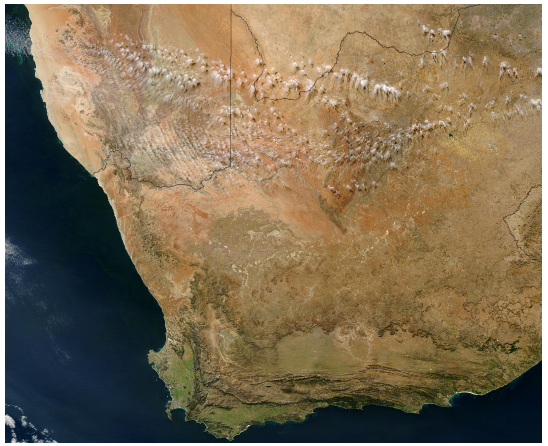
Advantages of DB

Satellite



- Local control gives users the freedom to tailor operations to suit local needs
- Timeliness for responding to natural hazards and providing information for decision makers
- Local researchers are free to develop and refine algorithms tuned for local conditions





Ground Station

Processing Software

Products and Applications

Terra and Aqua DB Product Suite

MODIS Level 1B Products (MODISL1DB)
Level 0 quicklook images (visible and infrared)
Level 1B 1KM, HKM, and QKM radiances and geolocation
Destriping corrections for Level 1B 1KM infrared radiances

MODIS Atmosphere Level 2 Products (IMAPP)
Cloud Mask
Cloud Top Pressure, Phase, Emissivity, Optical Depth
Aerosol Optical Depth
Temperature and Water Vapor Profiles
Total Column Precipitable Water Vapor
Total Column Ozone
Level 2 browse images for all Atmosphere Products

MODIS Land Products (DRL)
Corrected Reflectance 1KM, HKM, QKM
Fire Detection / Thermal Anomalies
Land Surface Temperature (LST)
Normalized Difference Vegetation Index (NDVI)
Enhanced Vegetation Index (EVI)
Land Surface Reflectance

MODIS Ocean Products (SeaDAS)
Chlorophyll-A Concentration
Sea Surface Temperature (SST)

MODIS Images (HDFLook)
Level 1B browse images (visible, infrared, true color)
Level 2 Land browse images (NDVI, LST)
Level 2 Ocean browse images (Chlorophyll-A, SST)

MODIS Google Earth KML (IMAPP)
MODIS 250 meter resolution true color JPEG images and KML

AIRS Level 1 and Level 2 (IMAPP)
Level 1B data (including AIRS IR, AIRS VIS, and AMSU)
Level 2 retrievals of temperature and moisture

AMSR-E Level 1 and Level 2 (IMAPP)
Geolocated and calibrated antenna temperatures
Rain Rate
Soil Moisture
Snow Water Equivalent

Outline

1. What is MODIS **Direct Broadcast** (DB)?
2. MODIS DB **Image** Products
3. MODIS DB **Atmosphere** Products
4. MODIS DB **Land** products
5. MODIS DB **Ocean** products
6. Software for **interpreting** MODIS DB products
7. **Downloading** MODIS data from the Web

MODIS DB Level 1 Image Products

Software: **MODISL1DB**

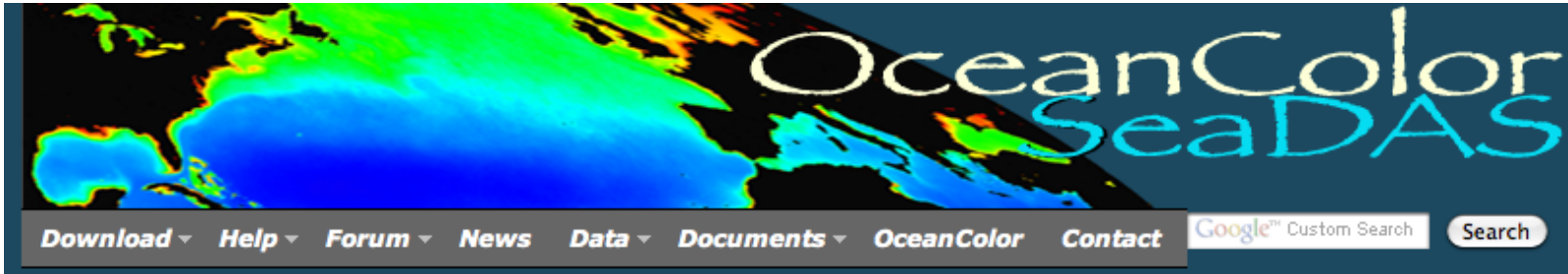
Developers: MODIS Characterization Support Team, MODIS Science Team, NASA Ocean Biology Processing Group

Distributor: NASA Ocean Biology Processing Group

Platforms: Linux, OS X, Windows (VM)

http://oceancolor.gsfc.nasa.gov/seadas/modisl1db/

Free Download



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MODISL1DB 1.7 (Released January 5, 2011)

MODISL1DB is a MODIS Level-1 Direct Broadcast software package capable of processing MODIS Aqua and Terra Level 0 data to Level 1A and Level 1B.

This software is a culmination of various efforts made by the MODIS Science and Calibration Teams, including the latest processing source codes from the MODIS Science Data Support Team (SDST), the MODIS Characterization Support Team (MCST), and the Ocean Biology Processing Group (OBPG). Thanks also goes out to SSEC for continued support.

Processing MODIS data with MODISL1DB will result in identical products to those produced by the OBPG if the same calibration LUTs are used.

Notable changes in this release are:

- Updated to the l1agen and geogen programs
- Added 64bit Linux support
- Processing scripts have been modified:
  - modis_L0_to_L1A_GEO.csh -> modis_L1A.csh (GEO creation removed)
  - modis_L1A_to_GEO.csh -> modis_GEO.csh
  - modis_L1A_to_L1B.csh -> modis_L1B.csh

For more details see the Version History.

The main MODISL1DB user support medium is the **MODIS Direct Broadcast Support Forum** (one of the Ocean Color Forums). If you would like to contact us directly, please feel free to send questions or comments to seadas at seadas.gsfc.nasa.gov.

What does MODISL1DB do?

Purpose: **Convert raw MODIS telemetry files to calibrated and geolocated Level 1B image products**

Input Data: **Level 0 CCSDS Packet Files containing APID 64 (MODIS) for Terra and Aqua; and APID 957 (GBAD) for Aqua**

Output Data: **MODIS Level 1B 1KM, HKM, QKM, and Geolocation (HDF4 format)**

MODIS Level 1B Data

- MODIS Level 1B data contains calibrated and geolocated radiance or reflectance values observed by the instrument (top of atmosphere)
- MYD02 is the Aqua product ID (Terra=MOD02)
- MYD021KM = 1000 meter resolution

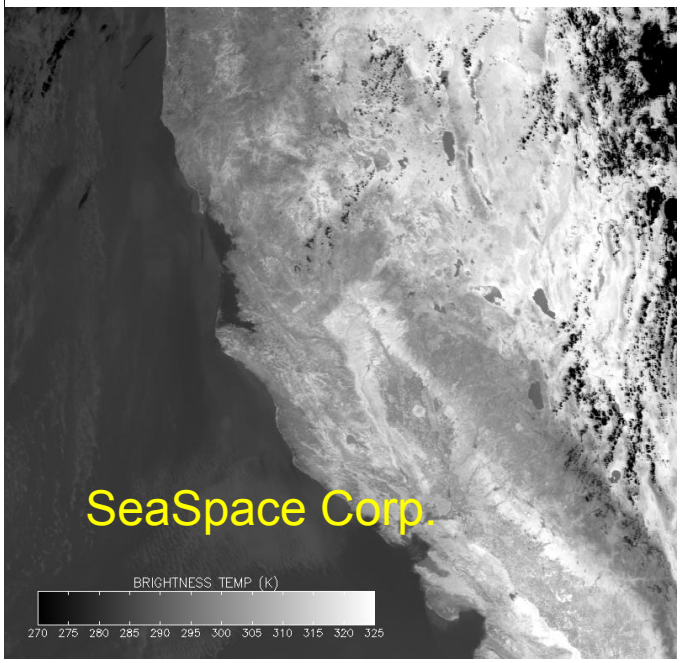
  (1354 pixels across track by 2030 pixels along track for a standard 5-minute granule or scene)
- MYD02HKM = 500 meter resolution (2708 x 4060)
- MYD02QKM = 250 meter resolution (5416 x 8120)

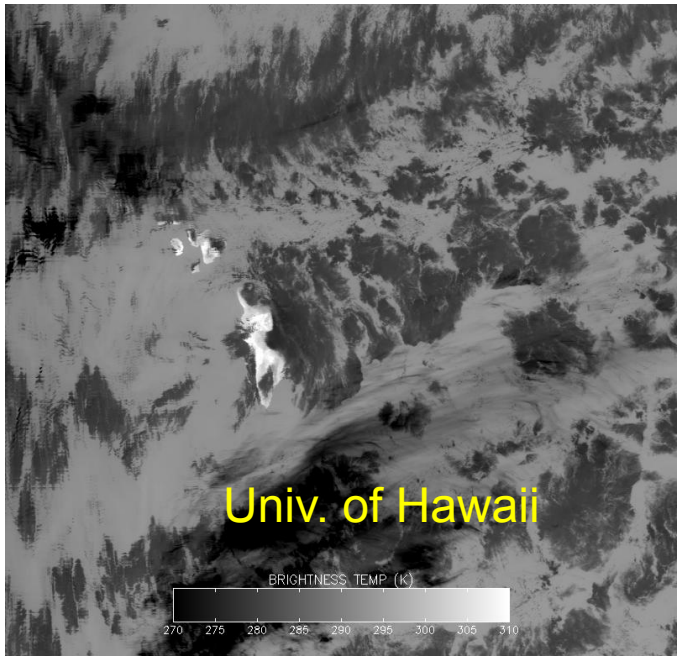
DB granules may be larger (up to 14 minutes long)

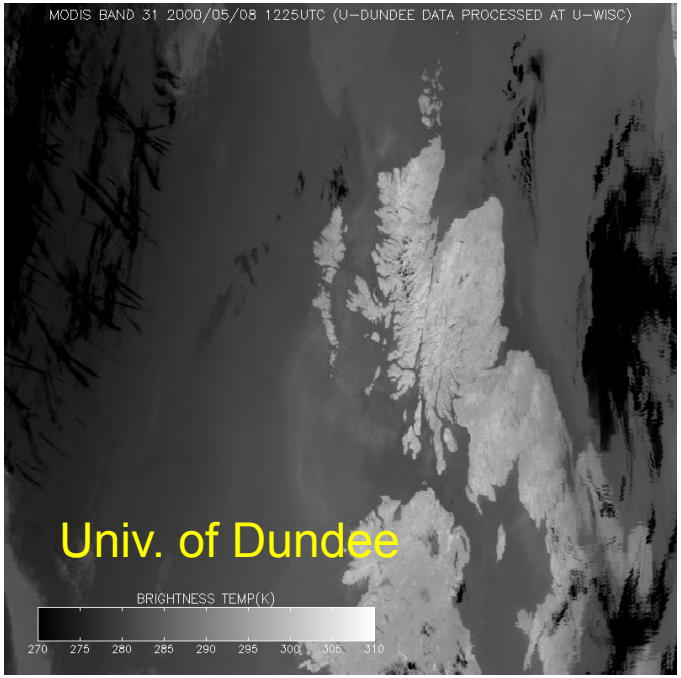
MODIS Level 1B Contents

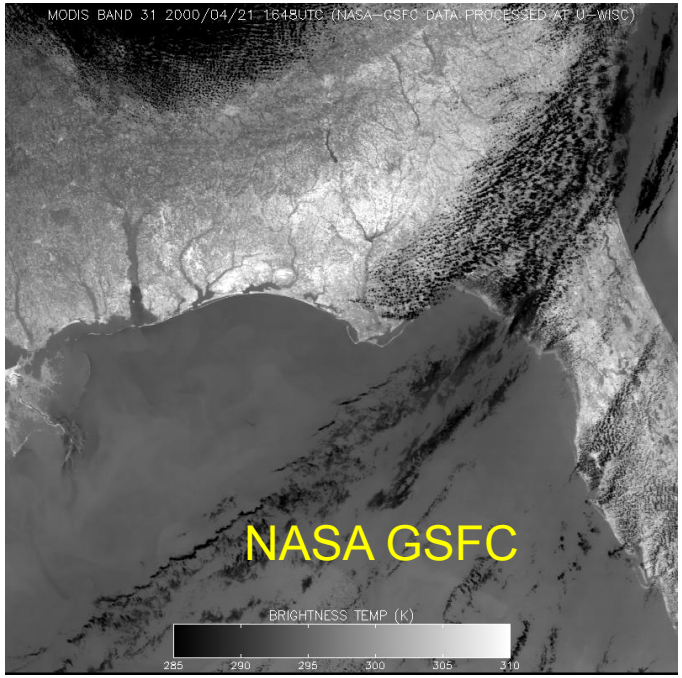
- Format is Hierarchical Data Format v4 (HDF4)
- Image data are stored as scaled integers, with linear slope and intercept to convert to calibrated radiance or reflectance
- Geolocation data at 1000 meter resolution are stored in a separate file (MYD03), along with sensor viewing geometry and solar geometry
- Daytime 1KM granules contain all 36 bands at 1000 meter resolution
- Nighttime 1KM granules contain bands 20-36 only
- HKM and QKM granules are daytime only

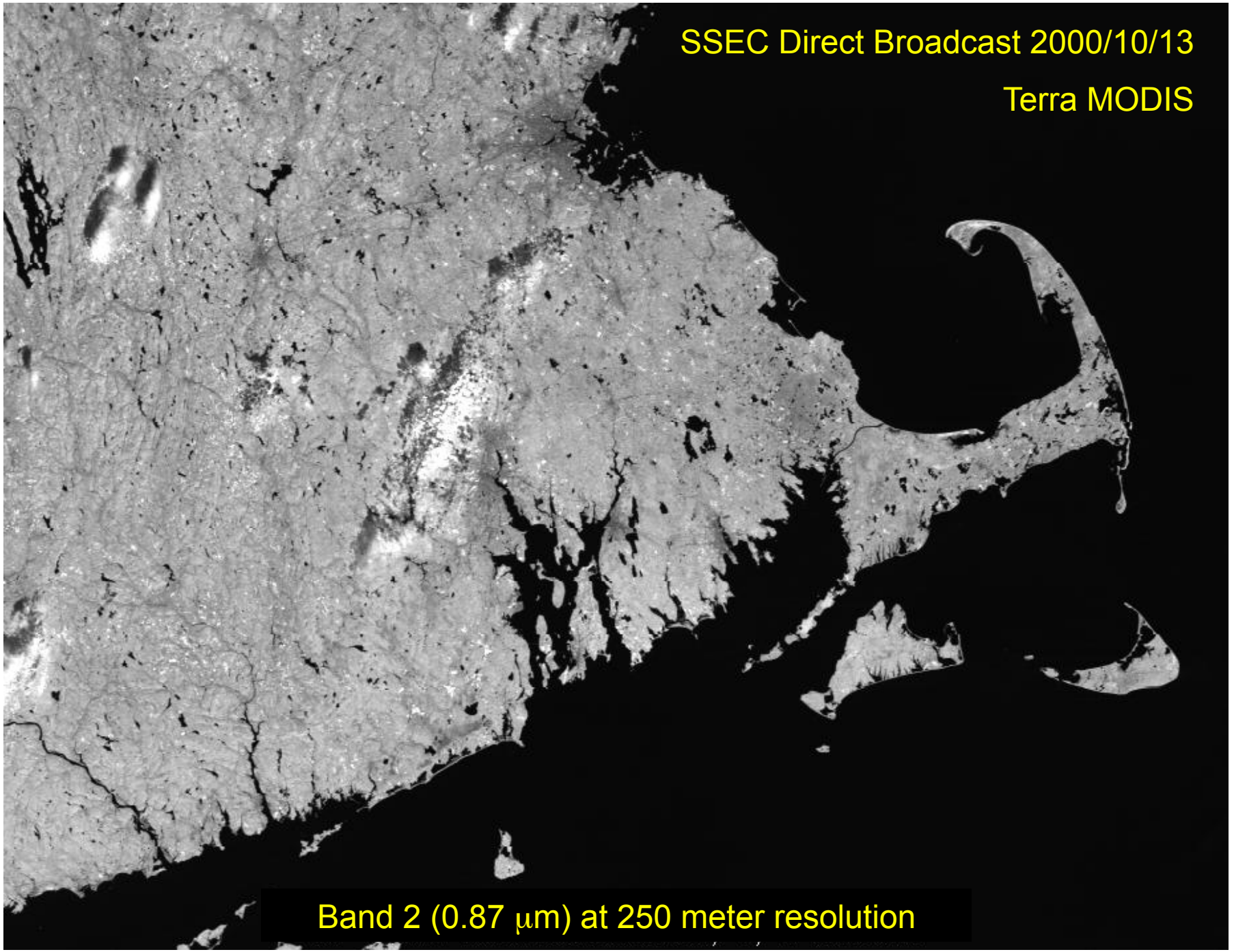
MODIS Band 31, Acquired by four different DB ground stations









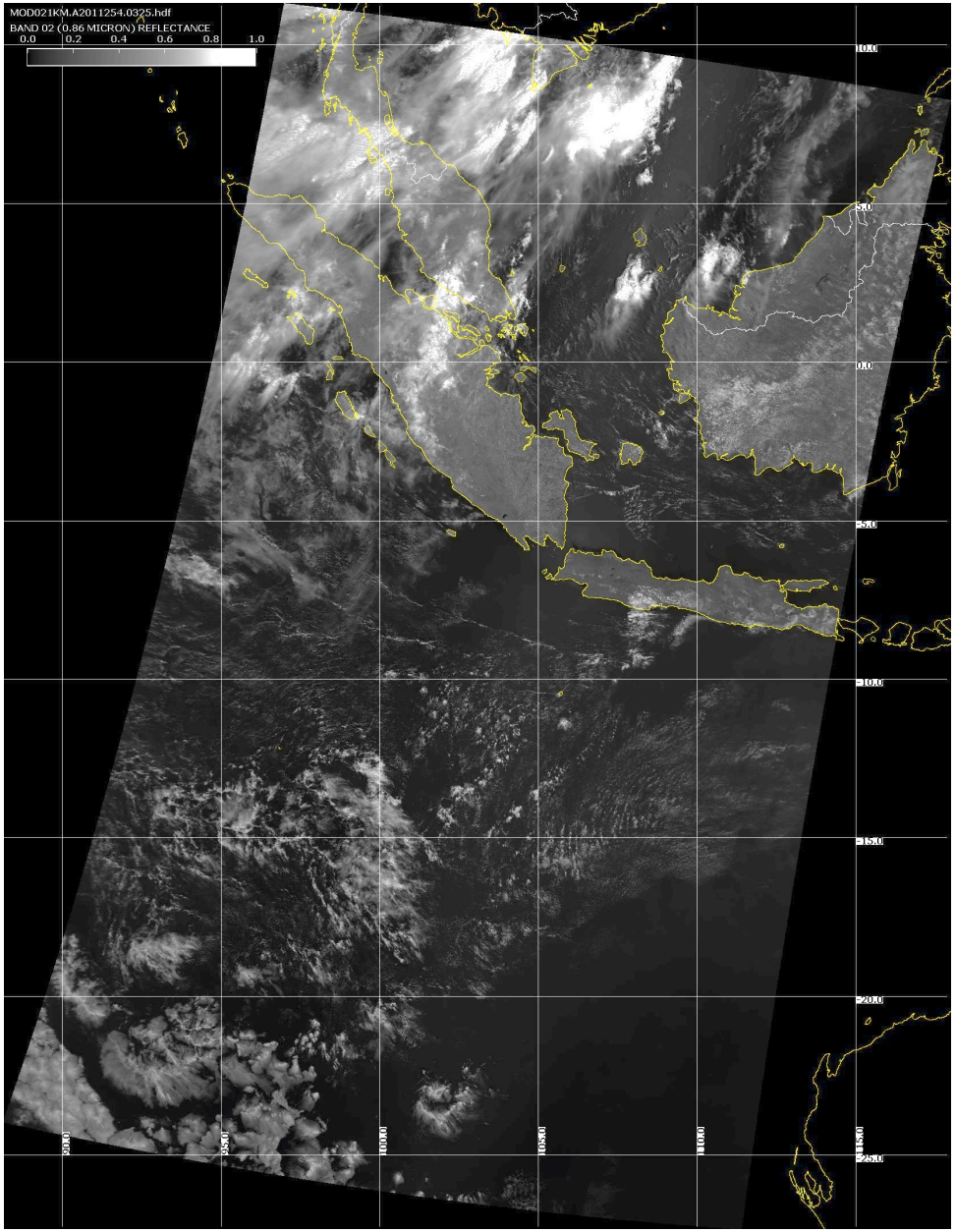

SSEC Direct Broadcast 2000/10/13
Terra MODIS
Band 2 (0.87 μm) at 250 meter resolution

Band 2 (visible)

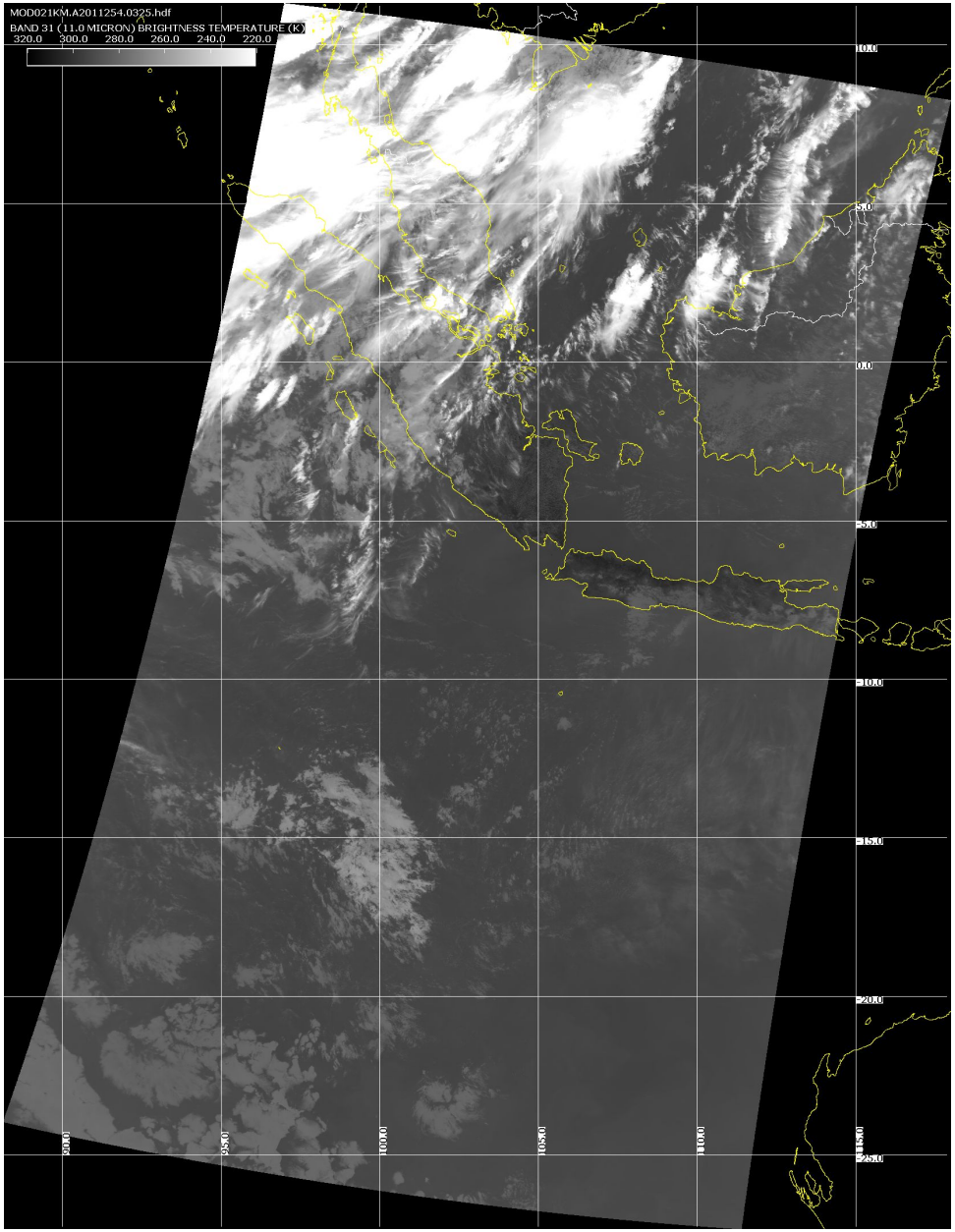
Terra MODIS

2011/09/11

03:25 UTC



Band 31 (infrared)

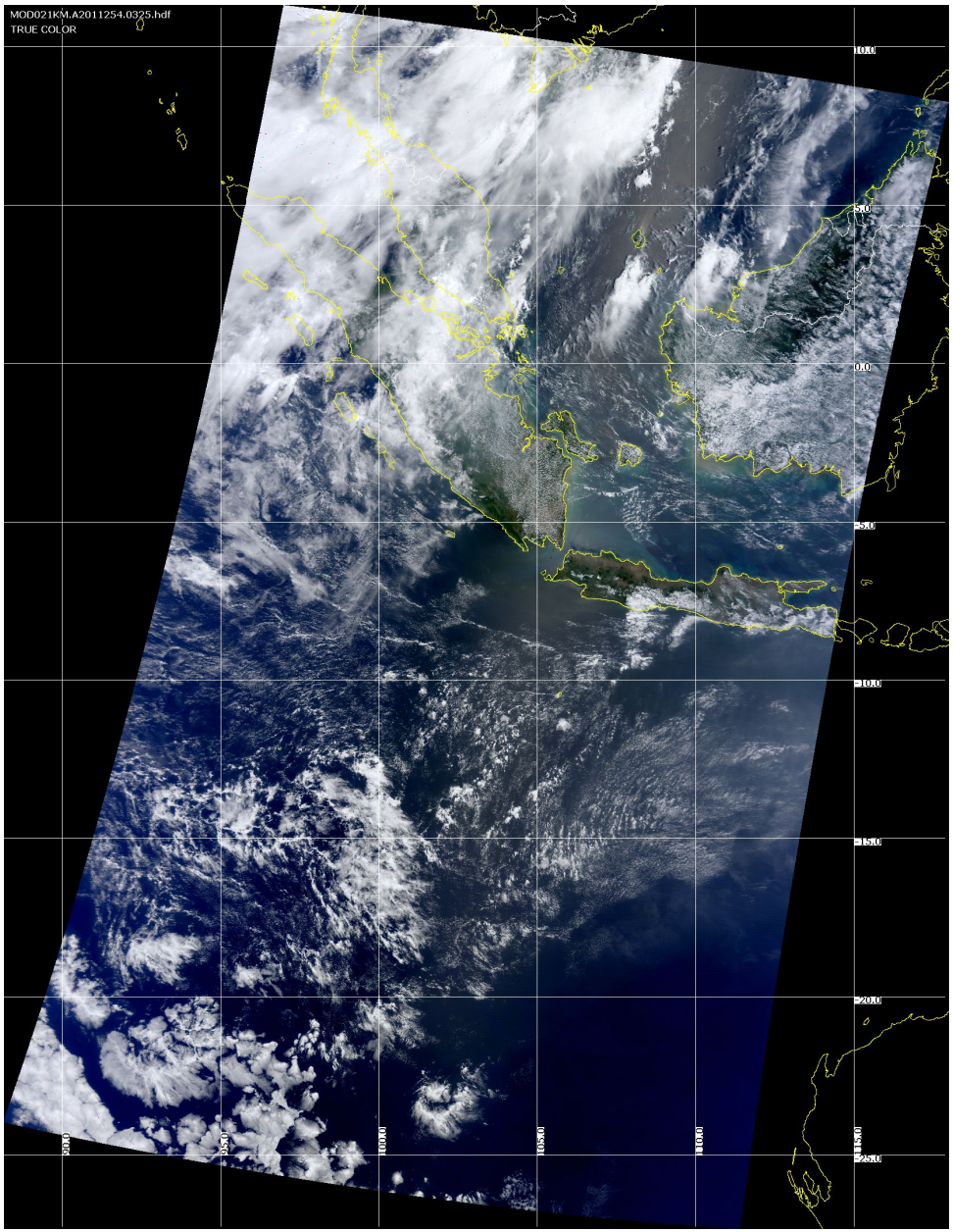


Terra MODIS

2011/09/11

03:25 UTC

True Color



Terra MODIS

2011/09/11

03:25 UTC

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MODIS DB Atmosphere Products

Software: **International MODIS/AIRS Processing Package (IMAPP)**

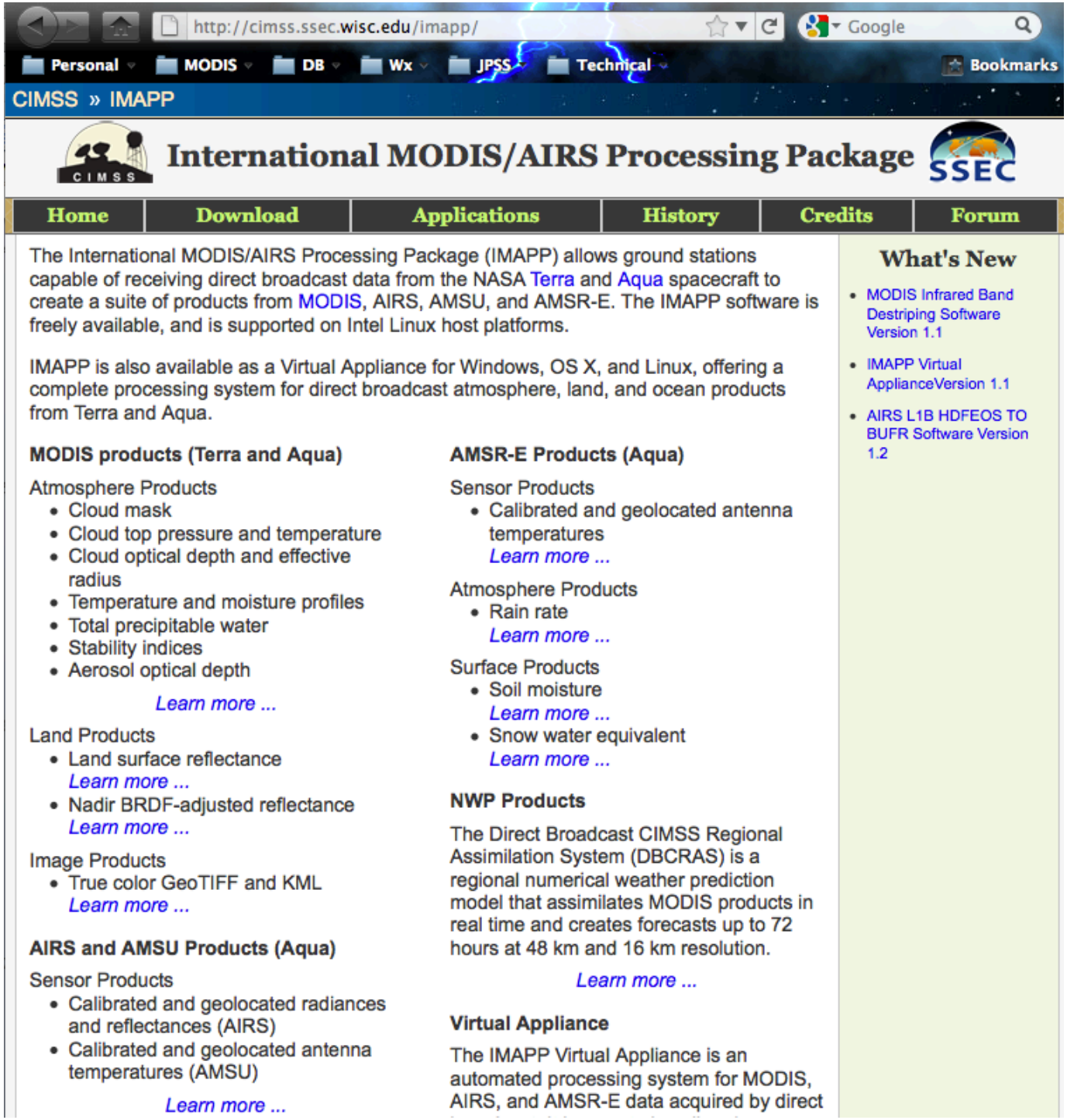
Developers: University of Wisconsin-Madison, MODIS Science Team, Remote Sensing Systems, Free University of Berlin

Distributor: University of Wisconsin-Madison

Platforms: Linux, (OS X, Windows) - VM

Website: http://cimss.ssec.wisc.edu/imapp/

Free Download


http://cimss.ssec.wisc.edu/imapp/
Google
Personal
MODIS
DB
Wx
JPSS
Technical
Bookmarks
CIMSS » IMAPP
International MODIS/AIRS Processing Package
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Forum
The International MODIS/AIRS Processing Package (IMAPP) allows ground stations capable of receiving direct broadcast data from the NASA Terra and Aqua spacecraft to create a suite of products from MODIS, AIRS, AMSU, and AMSR-E. The IMAPP software is freely available, and is supported on Intel Linux host platforms.
IMAPP is also available as a Virtual Appliance for Windows, OS X, and Linux, offering a complete processing system for direct broadcast atmosphere, land, and ocean products from Terra and Aqua.
MODIS products (Terra and Aqua)
Atmosphere Products
Cloud mask
Cloud top pressure and temperature
Cloud optical depth and effective radius
Temperature and moisture profiles
Total precipitable water
Stability indices
Aerosol optical depth
Learn more ...
Land Products
Land surface reflectance
Learn more ...
Nadir BRDF-adjusted reflectance
Learn more ...
Image Products
True color GeoTIFF and KML
Learn more ...
AIRS and AMSU Products (Aqua)
Sensor Products
Calibrated and geolocated radiances and reflectances (AIRS)
Calibrated and geolocated antenna temperatures (AMSU)
Learn more ...
AMSR-E Products (Aqua)
Sensor Products
Calibrated and geolocated antenna temperatures
Learn more ...
Atmosphere Products
Rain rate
Learn more ...
Surface Products
Soil moisture
Learn more ...
Snow water equivalent
Learn more ...
NWP Products
The Direct Broadcast CIMSS Regional Assimilation System (DBCRAS) is a regional numerical weather prediction model that assimilates MODIS products in real time and creates forecasts up to 72 hours at 48 km and 16 km resolution.
Learn more ...
Virtual Appliance
The IMAPP Virtual Appliance is an automated processing system for MODIS, AIRS, and AMSR-E data acquired by direct
What's New
MODIS Infrared Band Destriping Software Version 1.1
IMAPP Virtual ApplianceVersion 1.1
AIRS L1B HDFEOS TO BUFR Software Version 1.2

IMAPP Product List

MODIS Products:
Cloud Mask (MOD35)
Cloud Top Properties (MOD06CT)
Atmospheric Profiles (MOD09)
Aerosol Optical Depth (MOD04)
Sea Surface Temperature
Near Infrared Water Vapor
Level 1B Destriping
True Color Images for Google Earth
Nadir BRDF Adjusted Reflectance

Other Products:
AIRS/AMSU Level 1B Calibrated And Geolocated Radiances
AIRS/AMSU JPL Atmospheric Profiles
AIRS UW Single FOV Atmospheric Profiles (Clear Sky Only)
AIRS/MODIS Single FOV Atmospheric Profiles (Clear and Cloudy)
AMSR-E Level 2 Geophysical Products
AMSR-E Snow Water Equivalent
DBCRAS Numerical Weather Prediction Model

What does IMAPP do?

Purpose: **Creates MODIS atmosphere, utility, and image products (and AIRS, AMSU, AMSR-E)**

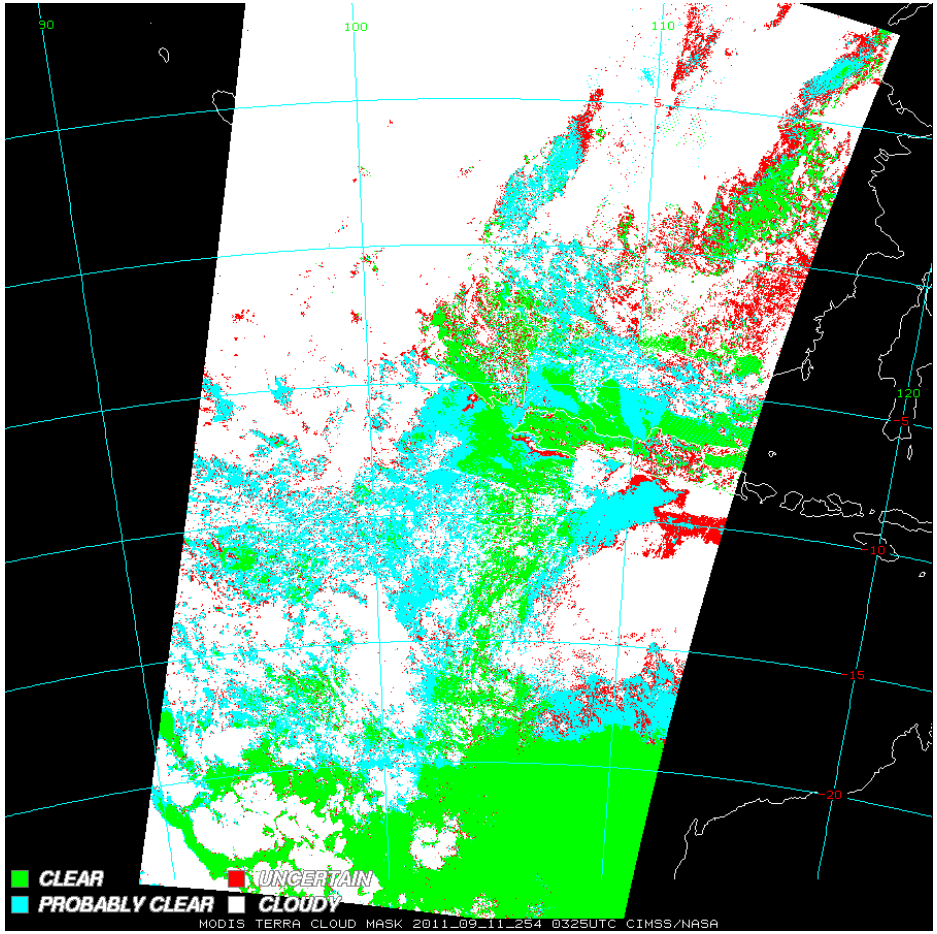
Input Data: **MODIS Level 1B 1KM, HKM, QKM, and Geolocation (HDF4 format)**

Output Data: **MODIS Level 2 Cloud Mask, Cloud Top Properties, Atmospheric Temperature and Water Vapor Profiles, Total Ozone, Total Precipitable Water Vapor (HDF4 format)**

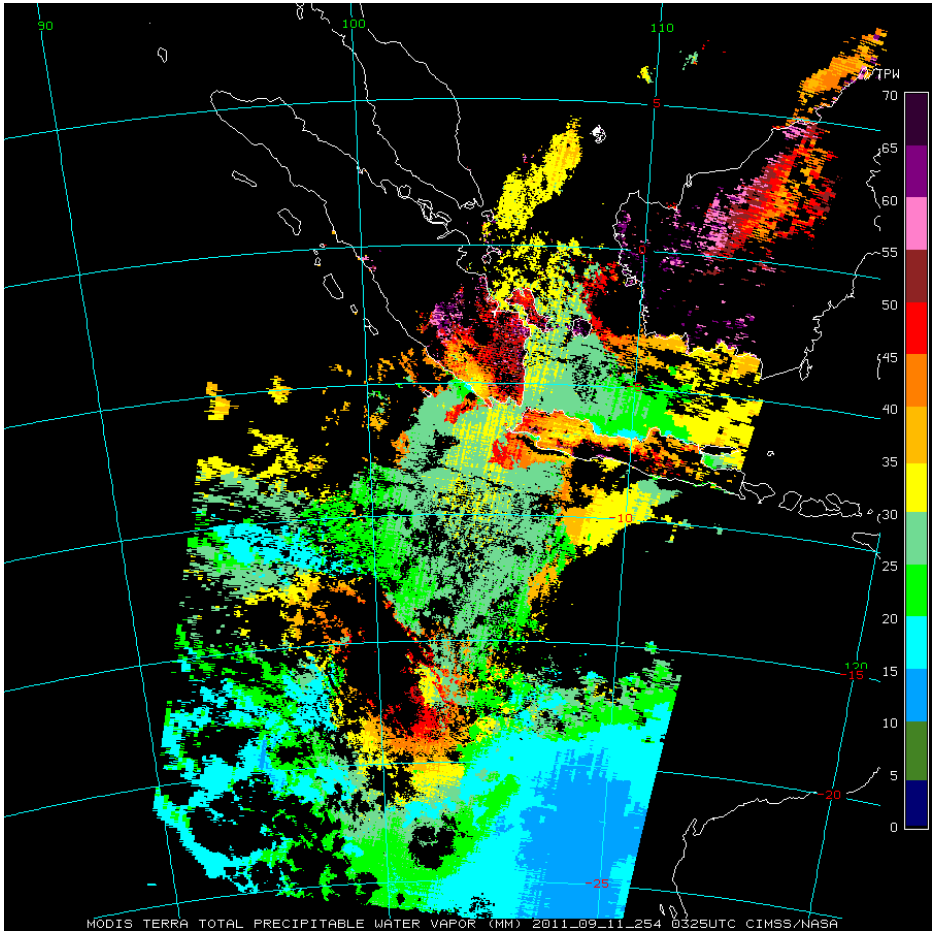
MODIS Atmosphere Products

2011/09/11 03:25

Cloud Mask



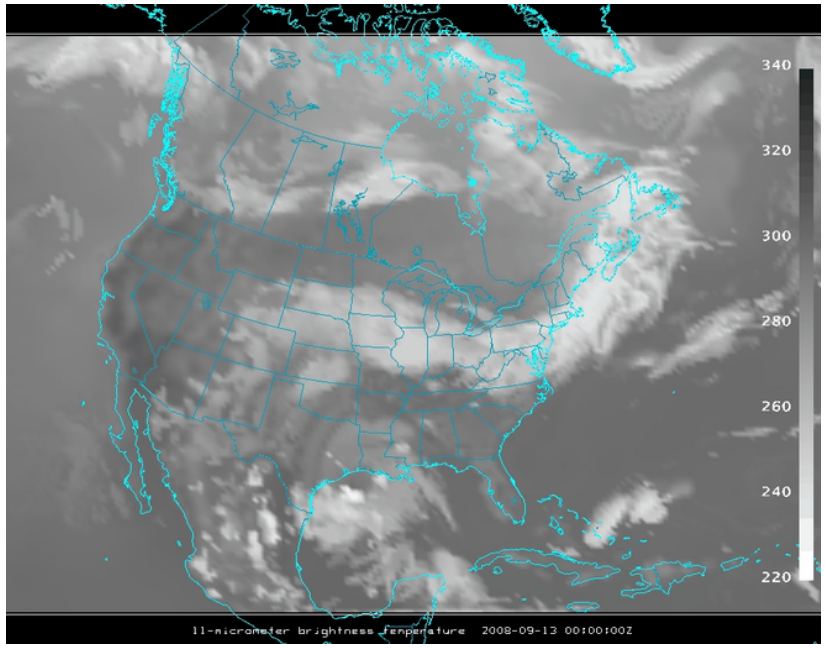
Water Vapor



DBCRAS NWP Model

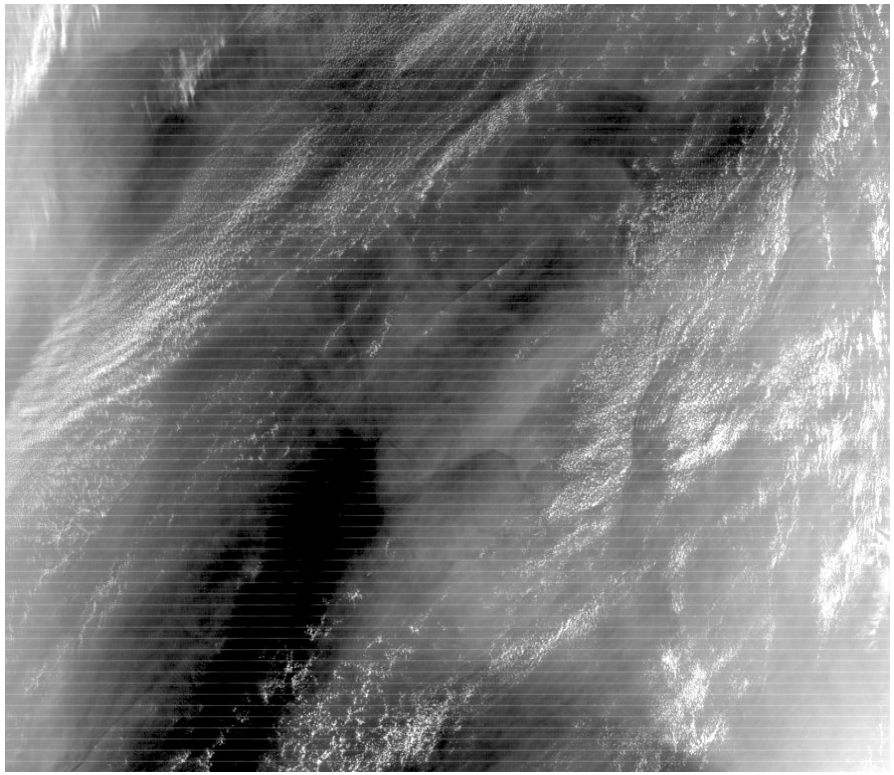
- Easy to install and easy to execute on modest PCs
- NWP domain centered on your DB location
- Assimilates IMAPP MOD07 TPW and MOD06CT Cloud Top Pressure and Cloud Effective Emissivity in order to adjust the cloud and moisture fields in the GFS.
- Output is standard meteorological parameters in GRIB2
- Creates forecast satellite imagery

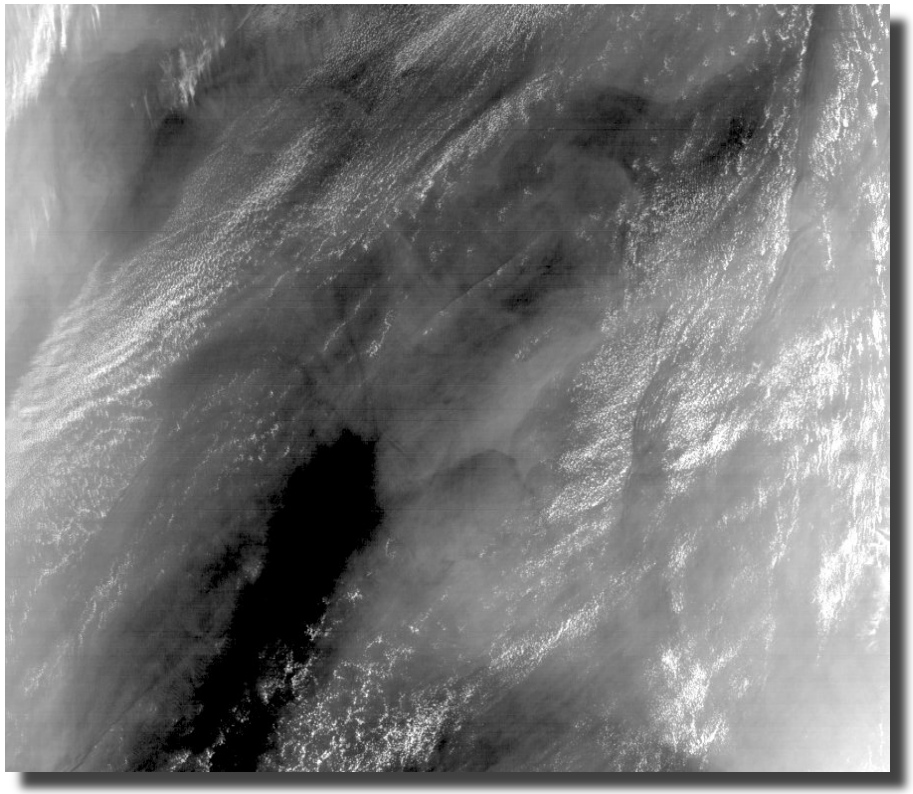
72 hour forecast of 11 micron brightness temperature (3 hour time step)



Level 1B 1KM Destriping

- Removes stripes from 1KM thermal infrared bands
- Each detector is adjusted to match a reference detector
- Destriping is recommended before creating IMAPP Atmosphere Products (e.g., Cloud Mask)





Terra MODIS L1B 1KM, 2003094 06:05, Band 29

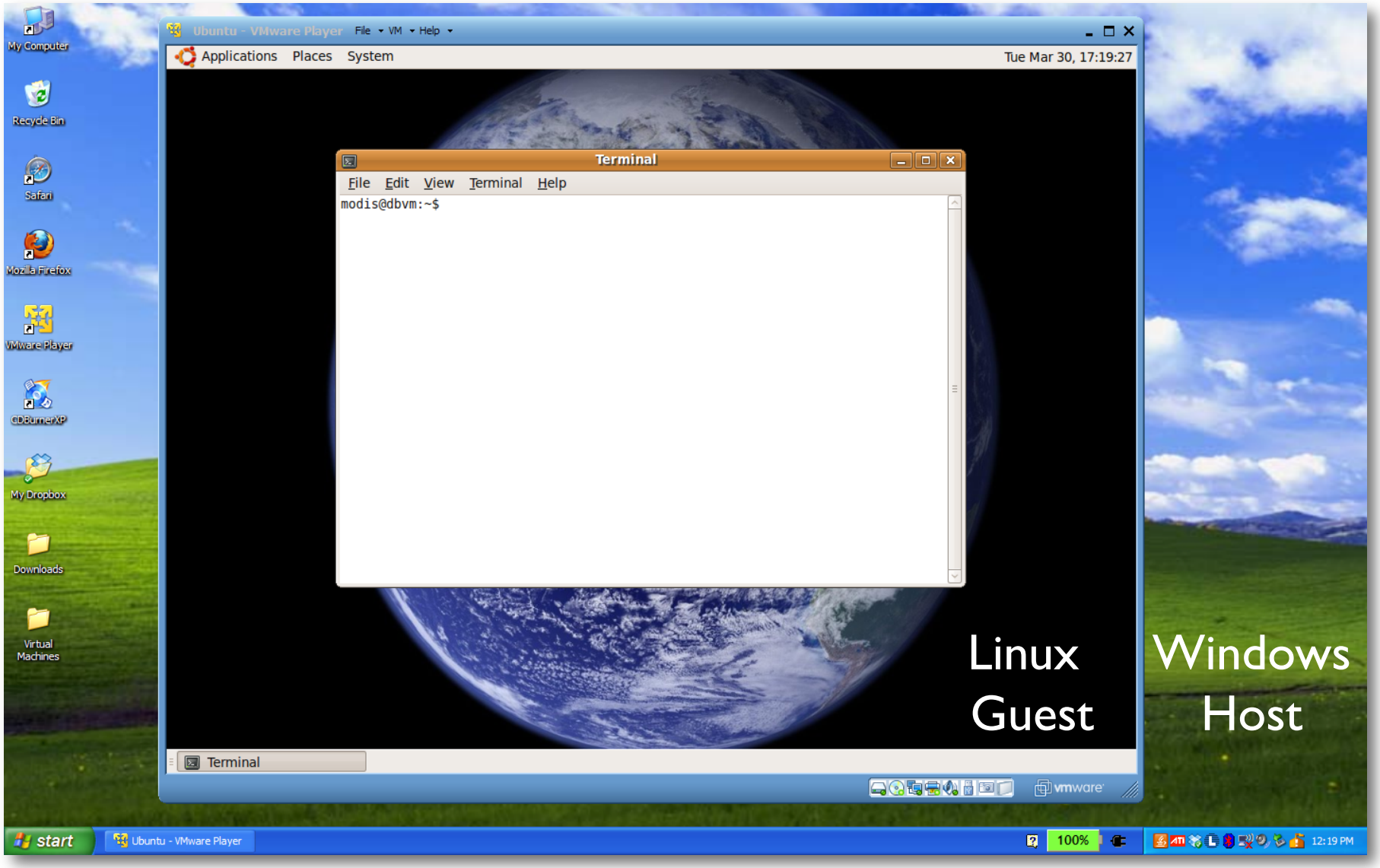
True Color Images for Google Earth

Images can be ready within 30 minutes of acquisition

IMAPP Virtual Appliance

The IMAPP VA makes it simple to install and run a DB processing system to create a range of atmosphere, land, and ocean products from the MODIS sensor onboard Terra and Aqua, and the AIRS, AMSU, and AMSR-E sensors onboard Aqua.

- Supports Windows (XP, Vista, 7), Apple OS X, Linux
- Install and run within 10 minutes
- Easy to configure (e.g., turn on MODIS Land, turn off AIRS)
- Easy to maintain (automated lookup table updates)
- Designed for simplicity (no DBMS, no Java, no COTS; just Bash scripts)
- Allow reliable automated processing
- Use only open source software packages (e.g., IMAPP, SeaDAS, etc.)
- Software package downloads are automated as part of the install process
- Easy to add user-created processing software


My Computer
Recycle Bin
Safari
Mozilla Firefox
VMware Player
CDBurnerXP
My Dropbox
Downloads
Virtual Machines
Ubuntu - VMware Player
File
VM
Help
Applications
Places
System
Tue Mar 30, 17:19:27
Terminal
File Edit View Terminal Help
modis@dbvm:~$
Terminal
Linux Guest
Windows Host
start
Ubuntu - VMware Player
100%
12:19 PM

IMAPP VA Installation (Windows)

1. Download and run IMAPP VA self-extracting archive
2. Download and install VMware Player (free)
3. Start VMware Player and select IMAPP VA

MODIS Level 1 and Atmosphere processing packages are pre-installed.

Other packages can be added by editing a configuration file, and running an installer script.

Version 1.1 is now available on the IMAPP website

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MODIS DB Land Products

Software: **Science Processing Algorithms (SPA)**

Developers: MODIS Science Team

Distributor: NASA Direct Readout Laboratory

Platforms: Linux, Windows (VM)

Website: http://directreadout.sci.gsfc.nasa.gov/

Free Download

DRL Software/Algorithms

DOWNLOADS

- TECHNOLOGY

+ DATA

+ NEW USER

+ DOWNLOAD GUIDELINES

DRL Highlights

L2GEN_SPA V5.9.7 Released
H2G_SPA V1.5a Released
CRECBuilder V1.0 Released
IMAPP_SPA V2.0
L2GEN_SPA V5.8.9
Simulcast V4.1 Released
MODLST_SPA V4.14
L2GEN_SPA V5.8.3
MOD09_SPA V5.3.18
MODISL1DB_SPA V1.5
IPOPP Alpha Test Program
GBAD_SPA V2.6 Released
RT-STPS V4.1 Released
CREFL_SPA V1.4.2
Simulcast V4.0 Released
IMAPP_SPA V2.0 Released
RT-STPS V4.0 Released
MSL12_SPA V5.7.1
MODISL1DB_SPA V1.4
MODIS Product Gallery
NDVIEVI_SPA V2.2
MOD14_SPA V5.0.1
MODLST_SPA V4.13
MODISL1DB_SPA V1.3

Category	Software Name	Description	Platform	Version
Level 1 (GEO/CAL)	AIRS	AIRS processes downlinked data from the AIRS, AMSU-A and HSB instruments on the Aqua spacecraft from RAW packets in PDS format to Level 1-B calibrated radiances.	Linux, Sun	5.2
Protocol Processing / Level 0	Construction Record Lister	Prints the contents of a PDS/EDS Construction Record.	Linux, Windows	1.01
Utilities	CRECBuilder	The CRECBuilder utility is a Java application that reads a MODIS Level-0 packet file and recreates the corresponding Production Data Set (PDS) (packet file + construction record/metadata file).	Linux	1.0
Level 2	CREFL_SPA	The crefl_SPA processes MODIS Aqua and Terra Level 1B DB data into the MODIS Level 2 Corrected Reflectance product. The algorithm performs atmospheric correction with MODIS visible and near-infrared bands (bands 1 - 7), and it also corrects for molecular scattering and gaseous absorption.	Linux	1.4.2
Protocol Processing / Level 0	GBAD_SPA	The Aqua GBAD Ephemeris and Attitude Data Converter (GBAD) SPA creates ephemeris and attitude files.	Linux	2.6
		The H2G_SPA is specially designed for		

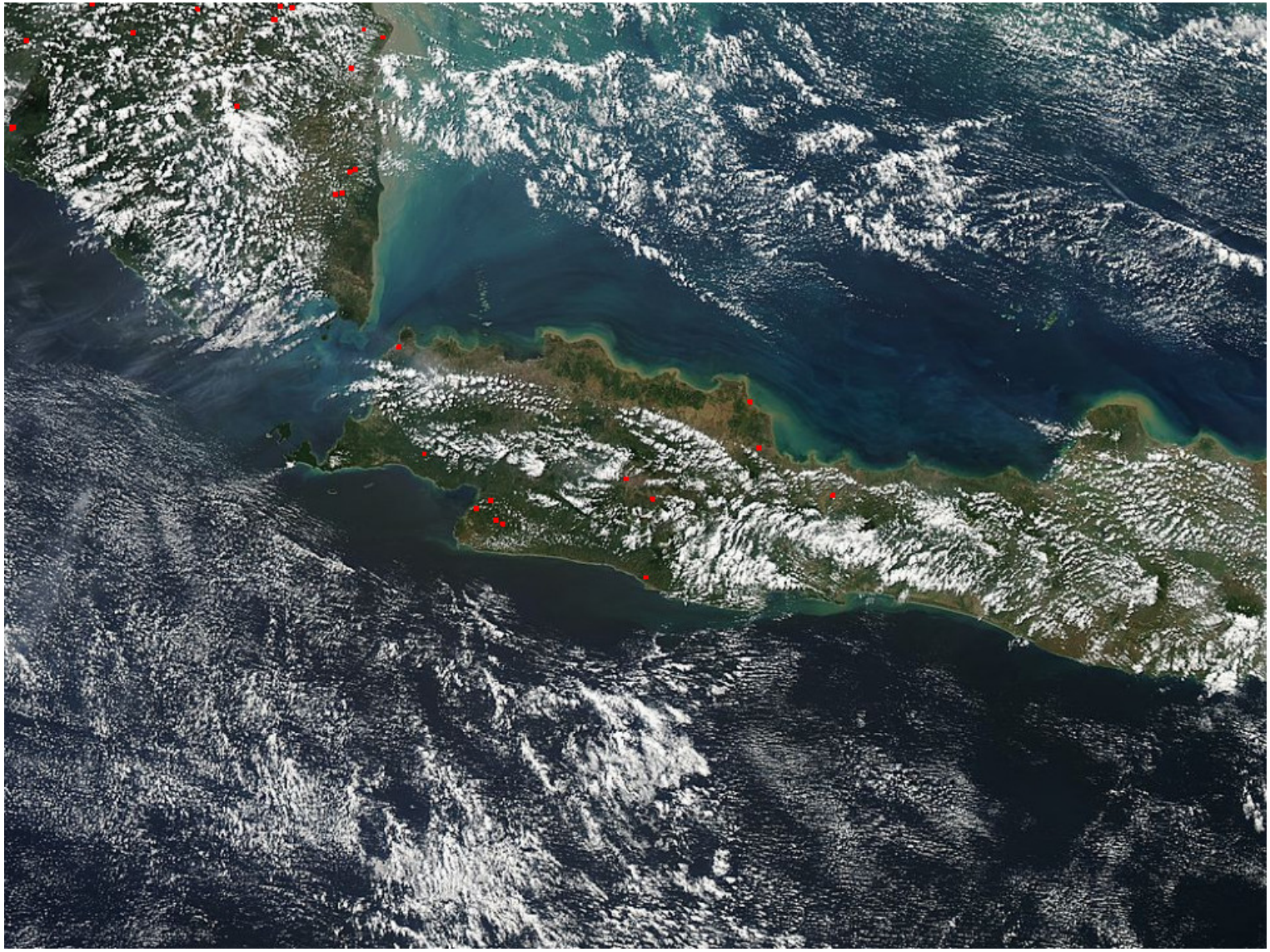
What does SPA do?

Purpose: **Creates DB customized Land products**

Input Data: **MODIS Level 1B 1KM, HKM, QKM, and Geolocation (HDF4 format)**

Output Data: **MODIS Level 2 Active Fires, Corrected Reflectance, NDVI, EVI, Land Surface Temperature, Land Surface Reflectance (HDF4 format)**

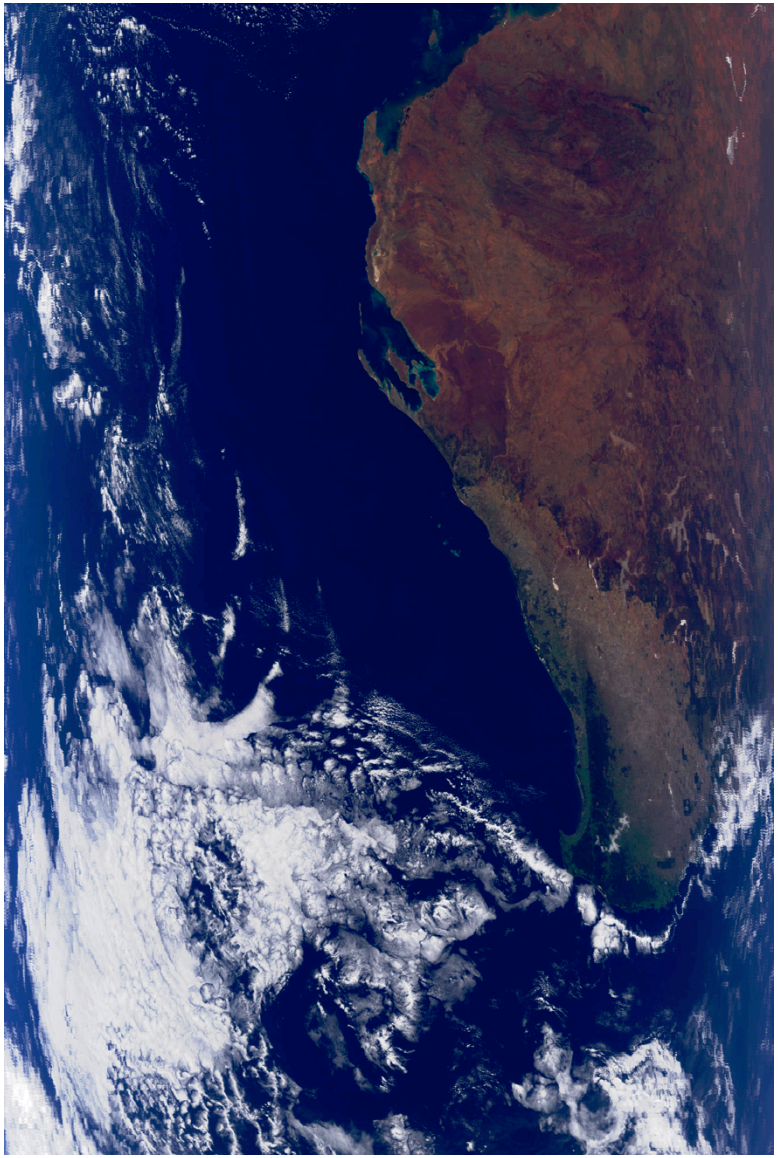
Active Fires



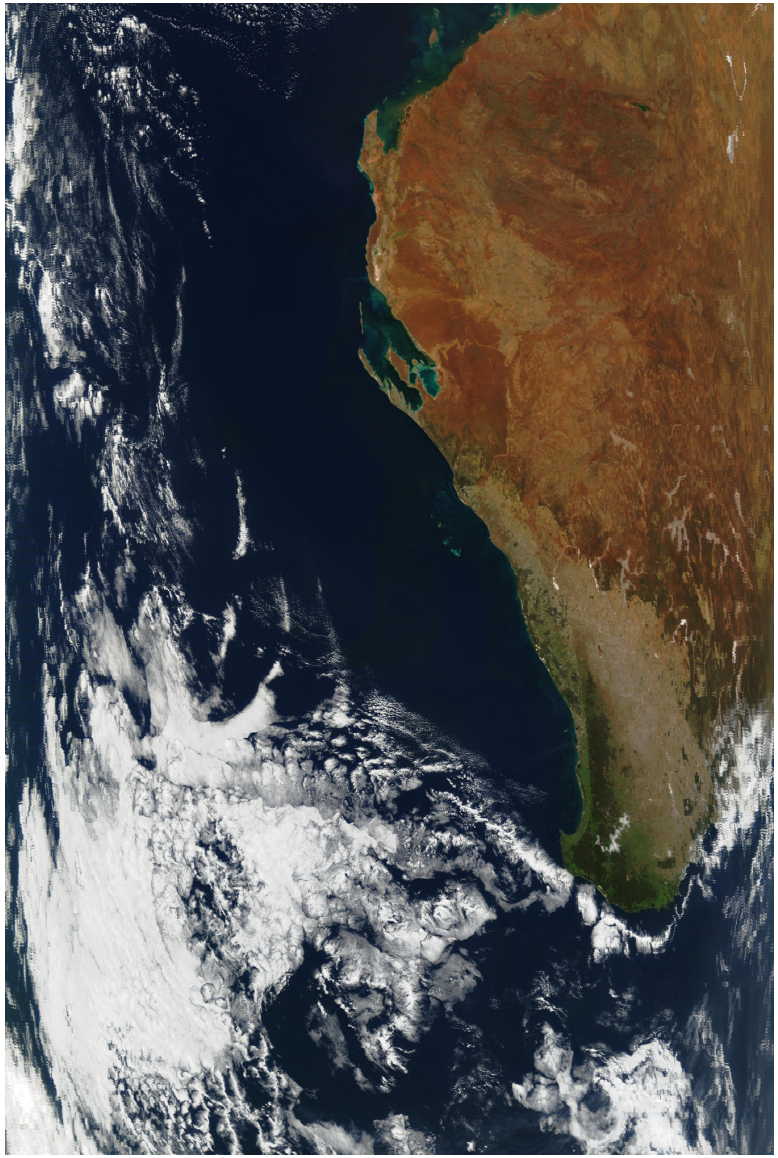
2011/08/01 Aqua MODIS

MODIS Corrected Reflectance

Before



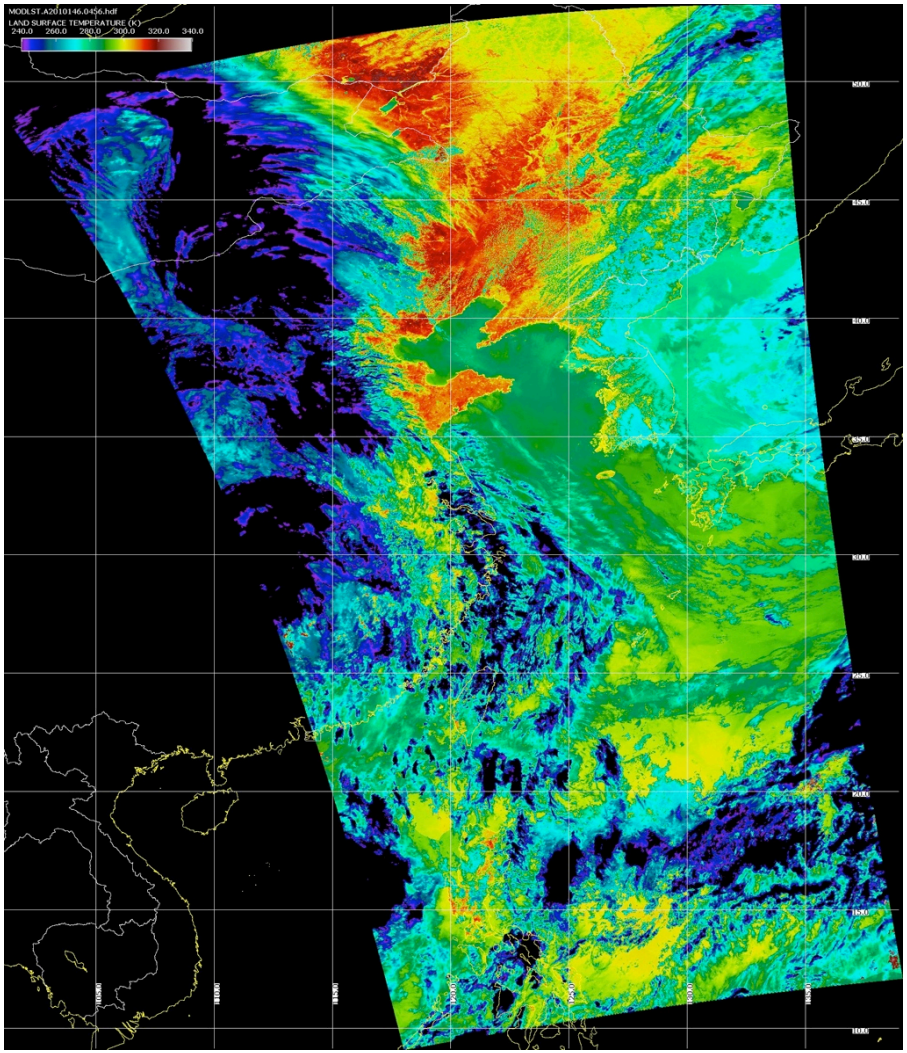
After



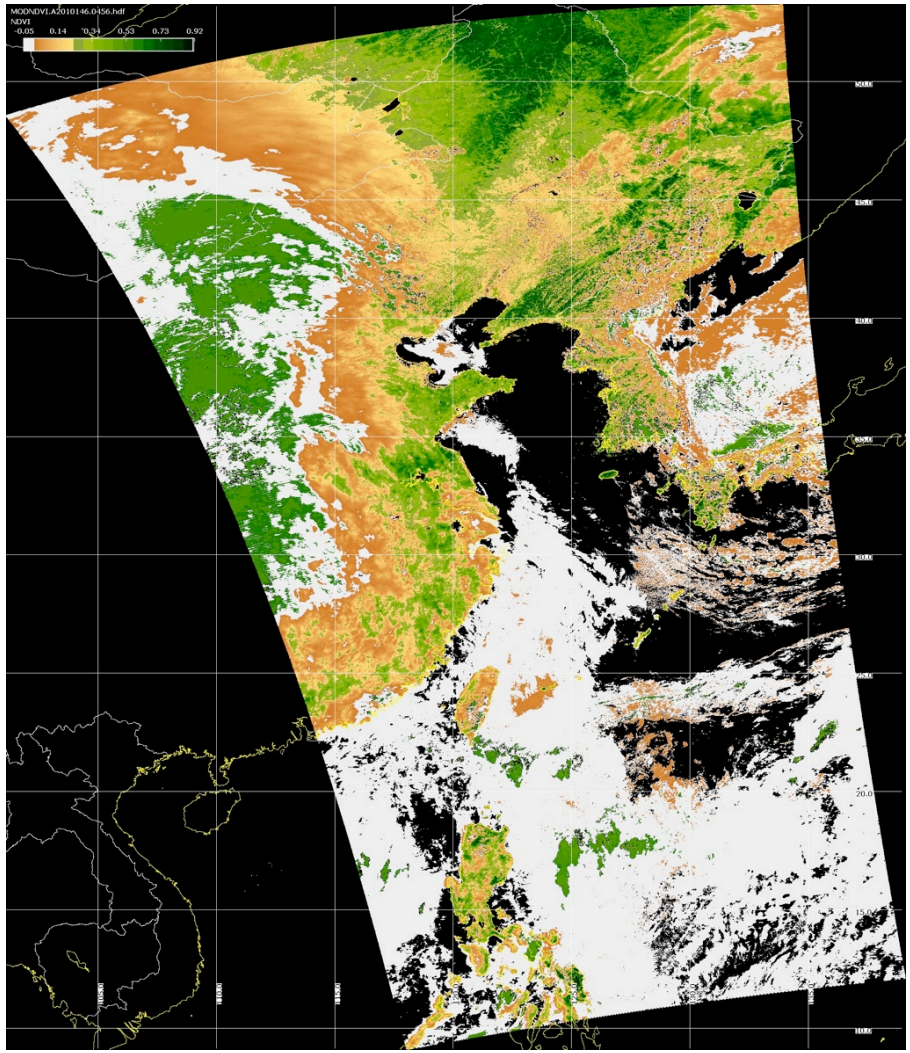
MODIS Land Products (China)

Aqua MODIS 2010/05/26 04:56

Land Surface Temperature



Vegetation Index

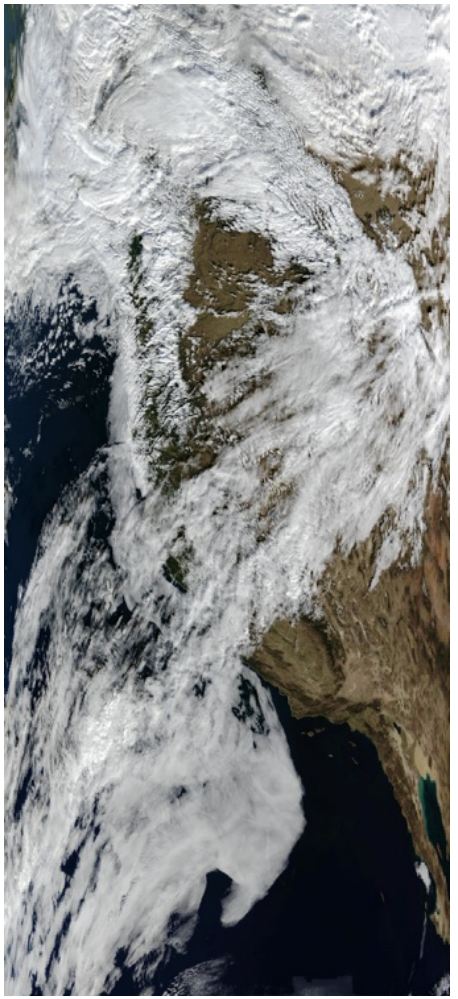


Land Surface Reflectance

MODIS Land Surface Reflectance Algorithm (MOD09) code was adapted for DB by Eric Vermote and Jim Ray. Standard HDF4 format with metadata is created.

Changes for DB included:

- Code pre-compiled for 32-bit Intel Linux; source code is also available
- Handles arbitrary granule sizes
- Able to use NCEP GFS forecast data instead of NCEP GDAS analysis data
- Automatically discovers and downloads required ancillary data at runtime
- Handles bad geolocation data
- Night granules are handled gracefully in wrapper script

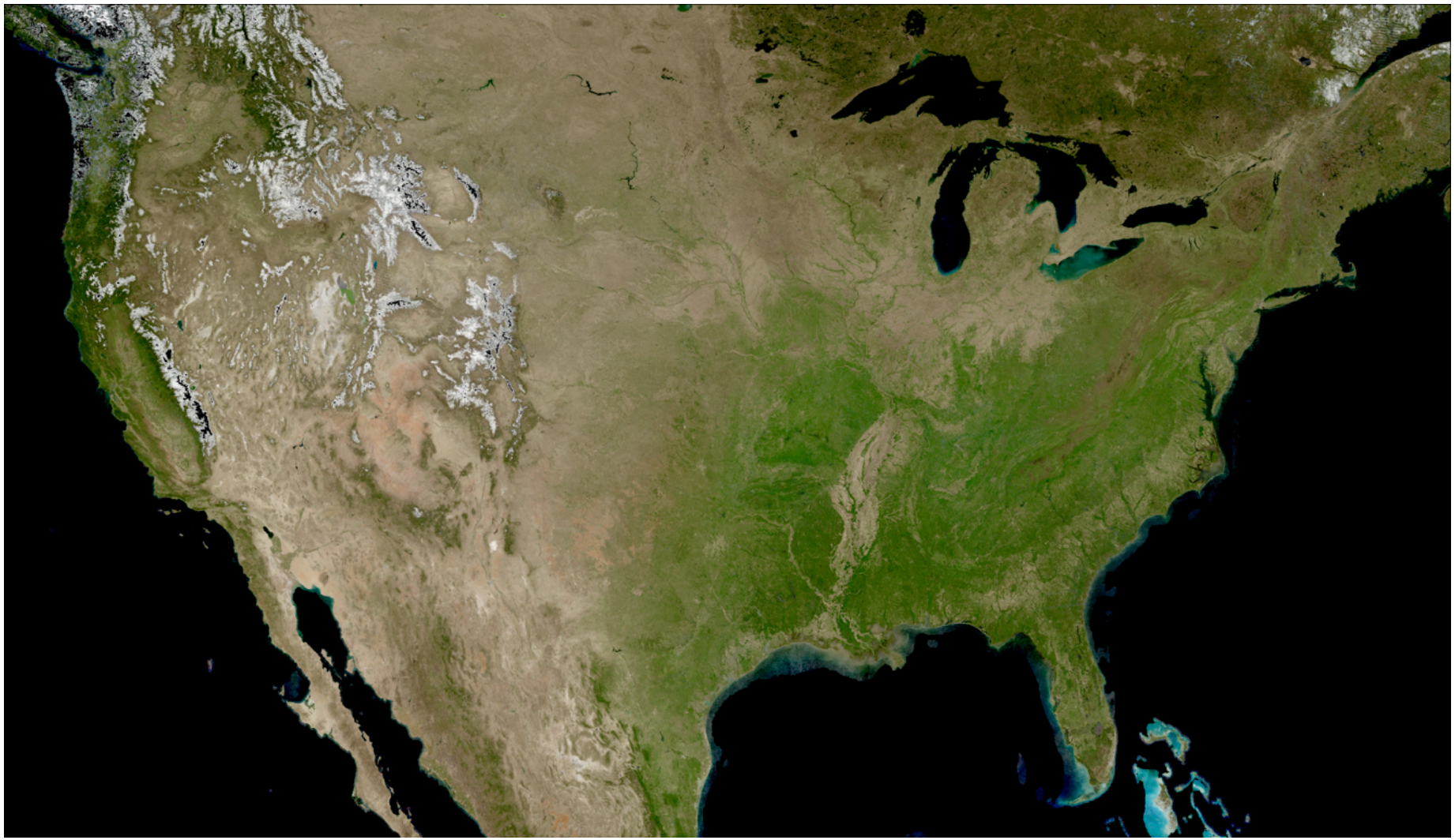


MOD09 True Color
Aqua DB

MODIS BRDF

- MOD43B4 Nadir BRDF-Adjusted Reflectance (NBAR) Product is computed for MODIS spectral bands (1-7) at the mean solar zenith angle of each 16 day period.
- View angle effects are removed from the directional reflectances.
- Applications include vegetation indices, land cover change, and burned area mapping.

16-day Composite from DB NBAR Algorithm (True Color) visualized by HDFLook



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MODIS DB Ocean Products

Software: **SeaDAS**

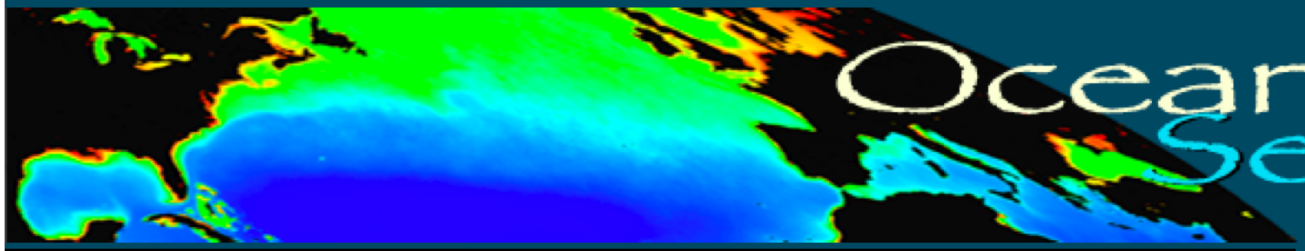
Developers: NASA Ocean Biology Processing Group, MODIS Science Team

Distributor: NASA Ocean Biology Processing Group

Platforms: Linux, OS X, Windows (VM)

Website: http://oceancolor.gsfc.nasa.gov/seadas/

Free Download



SeaDAS Web

Support

Ocean Color Web
Ocean Color Forum
Ocean Mailing Lists

Download and Installation

Linux and Mac:

- Online Auto-Installation
- Manual Download
- Manual Installation

Windows:

- SeaDAS Virtual Appliance

Satellite Data Info

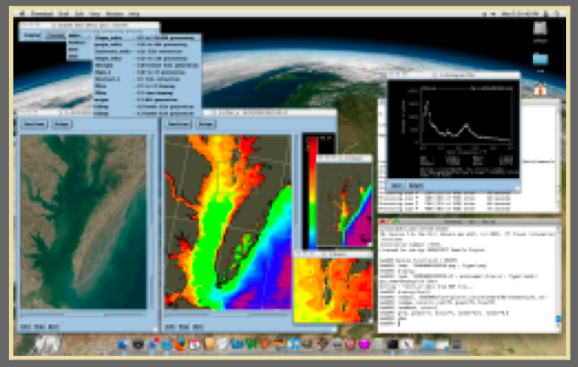
Data Product Specifications
Data Format Specifications
Processing Versions Chart

Satellite Data Access

Level 1 and 2 Browser

What is SeaDAS

The SeaWiFS Data Analysis System (SeaDAS) is a comprehensive image analysis package for the processing, display, analysis, and quality control of ocean color data.



Supported satellite sensors are MODIS, SeaWiFS, OCTS, and CZCS.

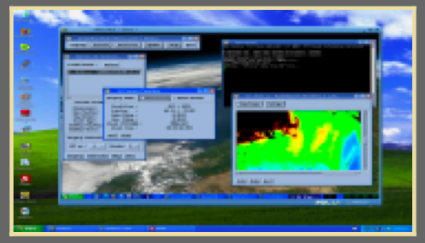
- Features
- Requirements
- Online Help
- SeaDAS FAQ
- User Contributed Software

What's New

SeaDAS Virtual Appliance released for Windows!

SeaDAS VA 5.4 allows SeaDAS to be run on Microsoft Windows XP and Vista systems within a virtual Linux machine.
This is a fully functional version of SeaDAS and processing benchmarks show very impressive performance.

SeaDAS VA is simple to install and requires the free VMware Player.



User Contributed Software

Do you have programs to share?

What does SeaDAS do?

Purpose: **Creates standard ocean color and ocean temperature products. Allows interactive display and analysis of ocean products.**

Input Data: **MODIS Level 1B 1KM, HKM, QKM, and Geolocation (HDF4 format)**

Output Data: **MODIS Level 2 Water Leaving Radiance, Chlorophyll concentration, Sea Surface Temperature (HDF4 format)**

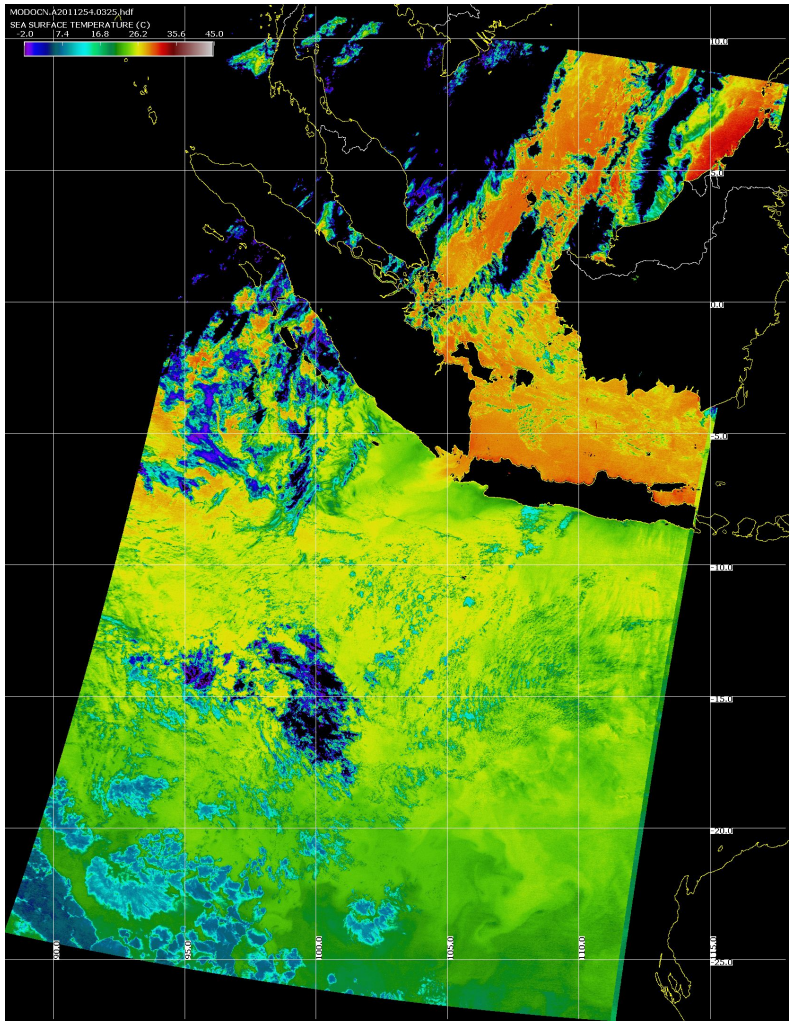
SeaDAS Standard Products

Geophysical Parameter Name	Description
nLw_412	Normalized water-leaving radiance at 412 nm
nLw 443	Normalized water-leaving radiance at 443 nm
nLw_488	Normalized water-leaving radiance at 488 nm
nLw_531	Normalized water-leaving radiance at 531 nm
nLw_551	Normalized water-leaving radiance at 551 nm
nLw_667	Normalized water-leaving radiance at 667 nm
Tau_869	Aerosol optical thickness at 869 nm
Eps_78	Epsilon of aerosol correction at 748 and 869 nm
Chlor_a	OC3 Chlorophyll a concentration
K490	Diffuse attenuation coefficient at 490nm
Angstrom_531	Angstrom coefficient, 531-869 nm
SST	Sea Surface Temperature: 11 micron
SST4	Sea Surface Temperature: 4 micron (night only)

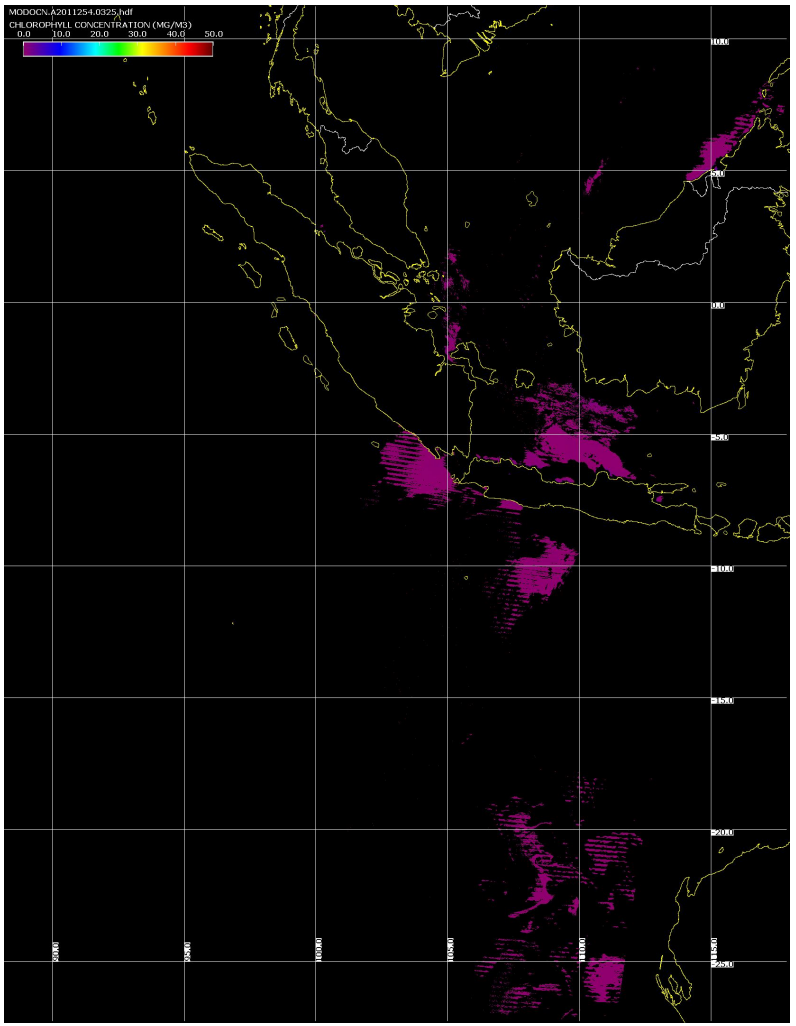
SeaDAS MODIS Products

Terra MODIS 2011/09/11 03:25

Sea Surface Temperature



Chlorophyll-A



Outline

1. What is MODIS **Direct Broadcast** (DB)?
2. MODIS DB **Image** Products
3. MODIS DB **Atmosphere** Products
4. MODIS DB **Land** products
5. MODIS DB **Ocean** products
6. Software for **interpreting** MODIS DB products
7. **Downloading** MODIS data from the Web

Software for Interpreting DB Products

- MODIS products are stored in a specialized format named Hierarchical Data Format (HDF) version 4.
- Some of the MODIS products (e.g., Level 1B) have complex internal structures
- Specialized software is required to read and interpret the HDF4 format correctly
- Software is designed for (a) Interactive Display, (b) Quantitative Analysis, or (c) Both
- Software is either (a) Free; or (b) Expensive

Software from Univ. of Wisconsin

- **Hydra** is a free application for MODIS, AIRS, and SEVIRI data exploration in classroom settings
  - http://www.ssec.wisc.edu/hydra/
- **Mc-LITE** is a free application for automated generation of MODIS image products (available as an add-on to IMAPP)
- **McIDAS-V** is a free application for interactively exploring MODIS and many other satellite and meteorological data products
  - http://www.ssec.wisc.edu/mcidas/software/v/

Free Software

- **MRTSwath** is a Linux application for reprojecting MODIS Level 1B and Level 2 products to a map grid (removes bowtie artifacts)
- **HDFLook** is a Linux application for interactive and automated display and reprojection of MODIS Level 1B and Level 2 products
- **MS2GT** is a Linux application for reprojecting MODIS Level 1B data and any other satellite imager data (AVHRR, MERSI, VIIRS)

Just Google the names…

Commercial Software

- **ENVI** is a Windows/Linux/OSX application interactive display and analysis of many satellite products, including MODIS Level 1B and Level 2
- **IDL and Matlab** are Windows/Linux/OSX interactive programming environments for quantitative analysis, and they can read MODIS Level 1B and Level 2 products in HDF4 format

Just Google the names…

HDF4 Application Programming Interface (API)

- The HDF4 API is available for C, C++, FORTRAN-90, Java, and Python
- Documentation, binaries, and source code are available

http://www.hdfgroup.org/

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MODIS Products from NASA

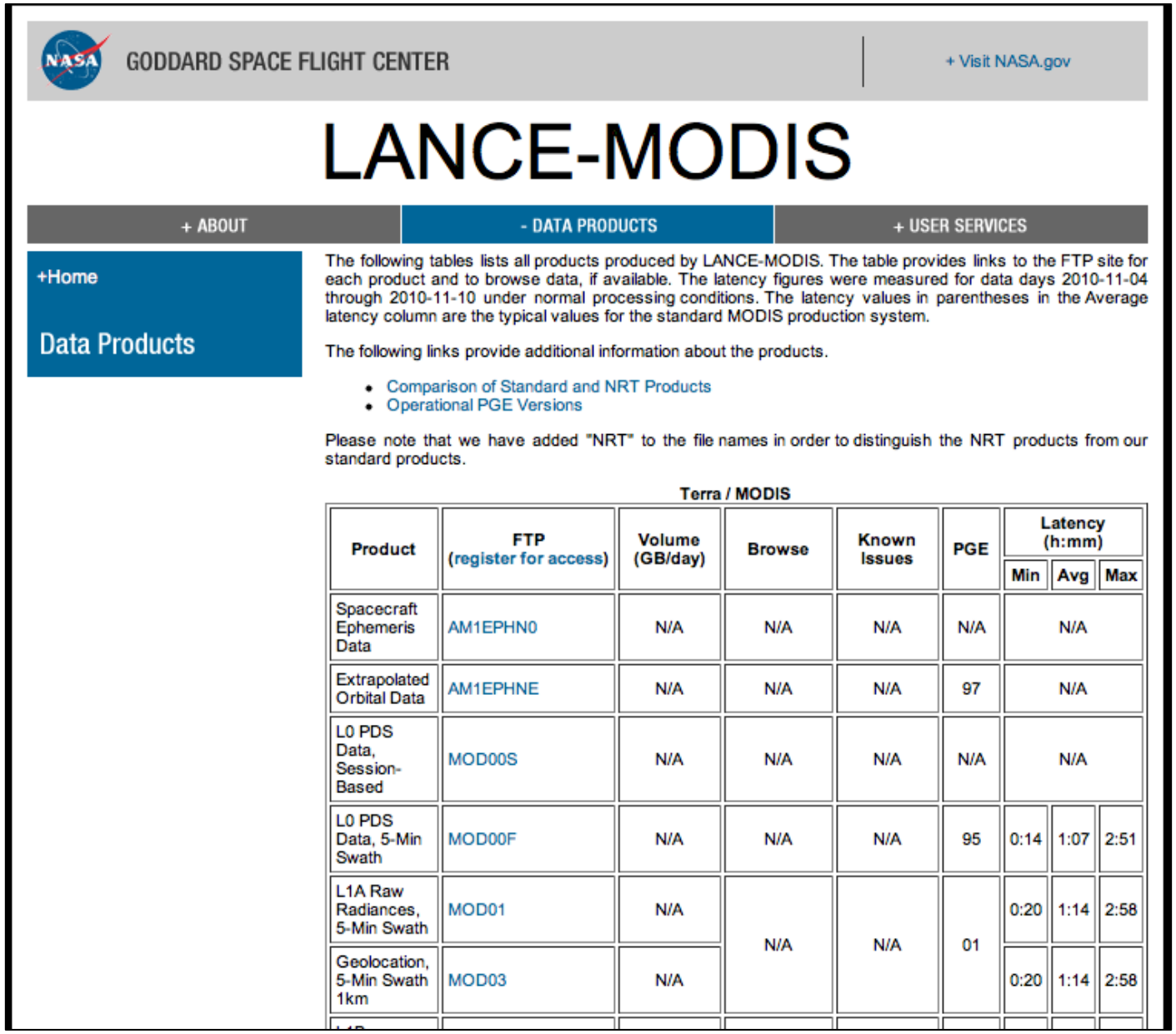
NASA provides MODIS Level 0, Level 1B, Land, Ocean and Atmosphere Products at no cost

Global near real-time products (about 90-120 minutes delay) are available from LANCE

Best for obtaining products in real-time; regional subscriptions are available.

Global long-term archive products (about 24 hours delay) are available from LAADS

Best for obtaining long-term historical data.



GODDARD SPACE FLIGHT CENTER

+ Visit NASA.gov

LANCE-MODIS

+ ABOUT | - DATA PRODUCTS | + USER SERVICES

+Home

Data Products

The following tables lists all products produced by LANCE-MODIS. The table provides links to the FTP site for each product and to browse data, if available. The latency figures were measured for data days 2010-11-04 through 2010-11-10 under normal processing conditions. The latency values in parentheses in the Average latency column are the typical values for the standard MODIS production system.

The following links provide additional information about the products.

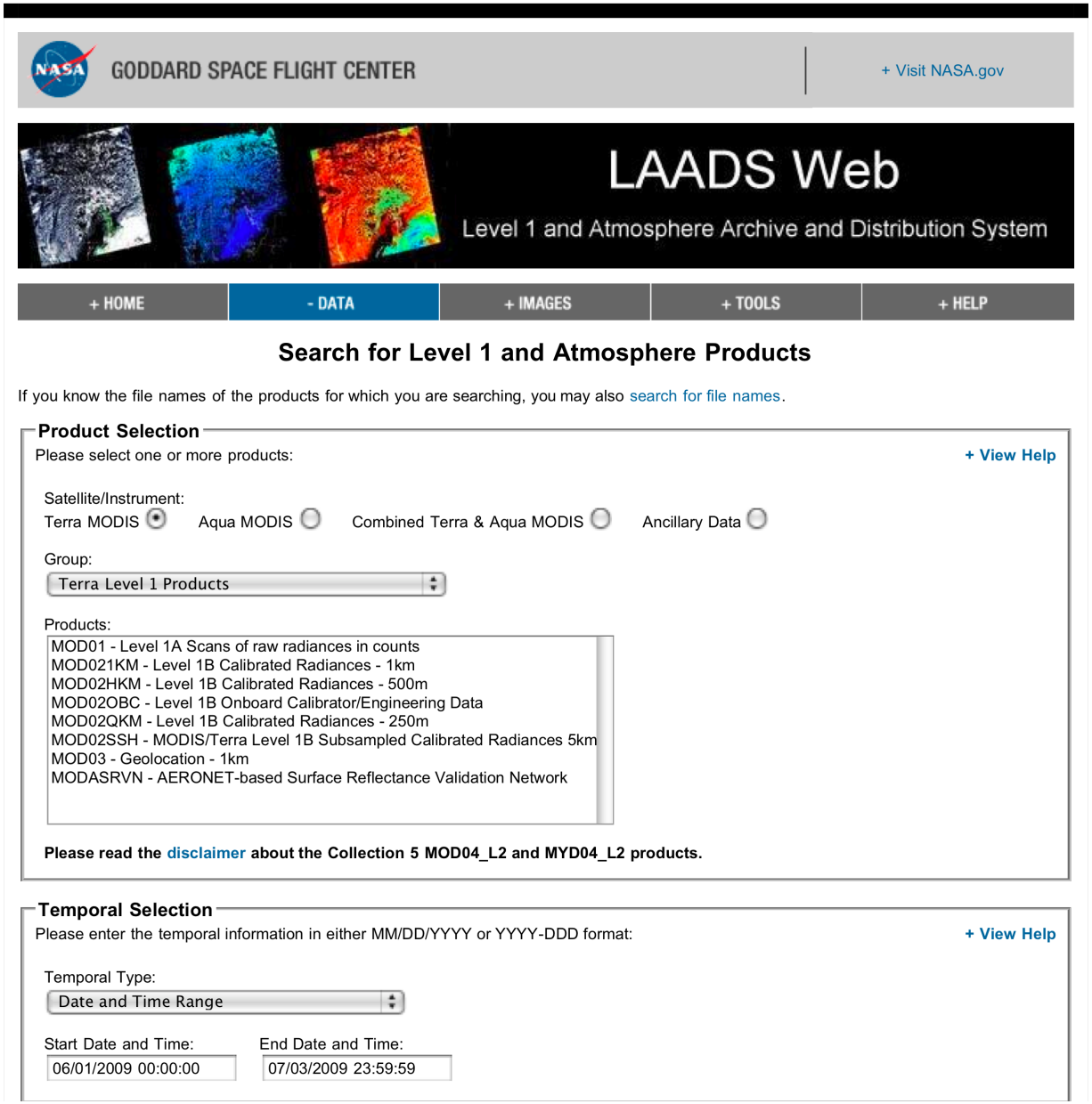
- Comparison of Standard and NRT Products
- Operational PGE Versions

Please note that we have added "NRT" to the file names in order to distinguish the NRT products from our standard products.

Terra / MODIS

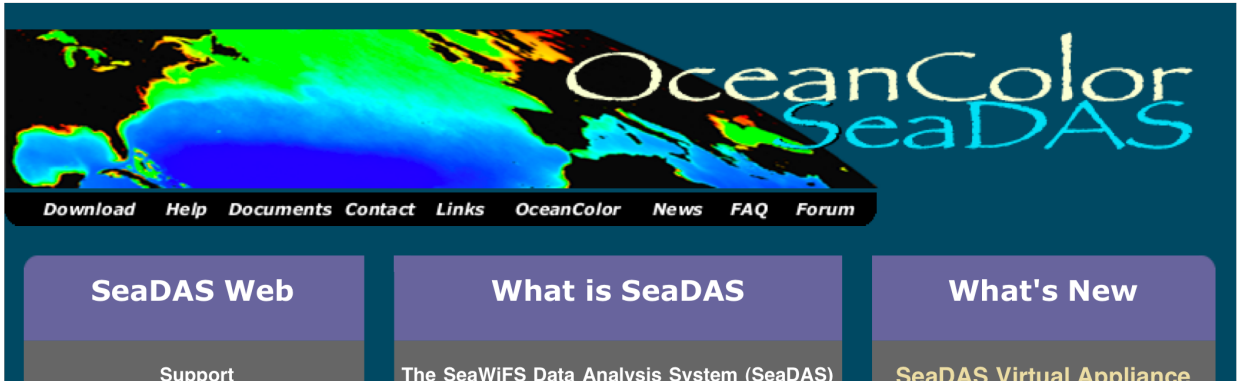
Product	FTP (register for access)	Volume (GB/day)	Browse	Known Issues	PGE	Latency (h:mm)		
						Min	Avg	Max
Spacecraft Ephemeris Data	AM1EPHN0	N/A	N/A	N/A	N/A	N/A		
Extrapolated Orbital Data	AM1EPHNE	N/A	N/A	N/A	97	N/A		
L0 PDS Data, Session-Based	MOD00S	N/A	N/A	N/A	N/A	N/A		
L0 PDS Data, 5-Min Swath	MOD00F	N/A	N/A	N/A	95	0:14	1:07	2:51
L1A Raw Radiances, 5-Min Swath	MOD01	N/A	N/A	N/A	01	0:20	1:14	2:58
Geolocation, 5-Min Swath 1km	MOD03	N/A				0:20	1:14	2:58

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

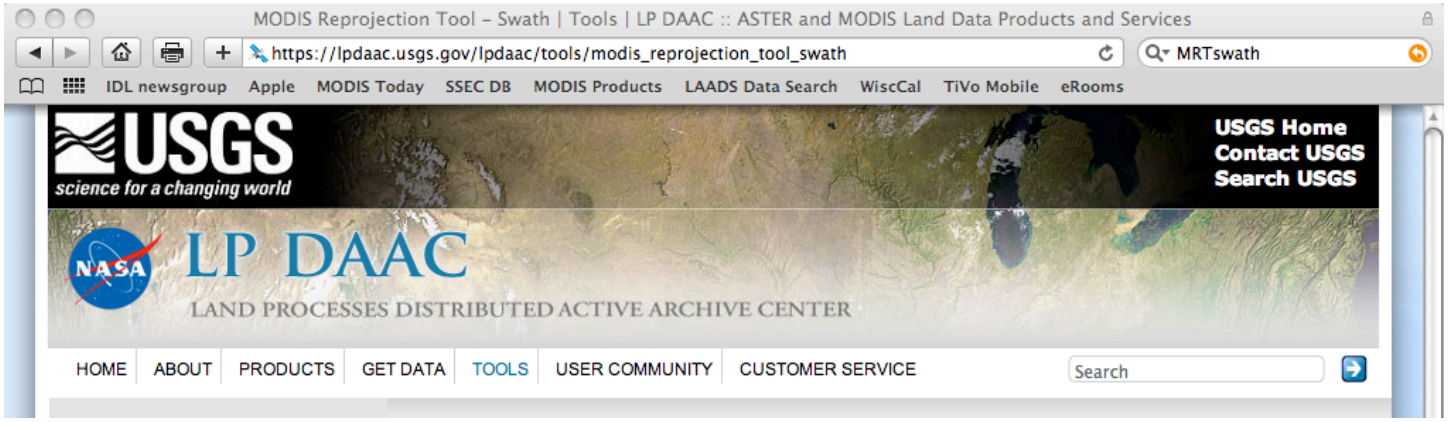


http://ladsweb.nascom.nasa.gov/data/search.html

MODIS Ocean Level 2 Products are available from http://oceancolor.gsfc.nasa.gov/

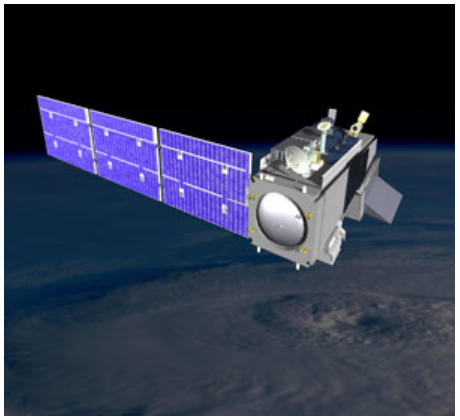


MODIS Land Level 2/3 Products are available from http://lpdaac.usgs.gov/



What Does the Future Hold?

Based on spacecraft fuel reserves, Terra and Aqua are expected to last until at least 2015.



NPOESS Preparatory Project (NPP) is a NASA mission scheduled to launch in October 2011 (afternoon orbit).

Joint Polar Satellite System (JPSS) is the successor to the canceled NPOESS program, and JPSS-1 (a clone of NPP) is planned to launch in 2014.

NPP Sensors

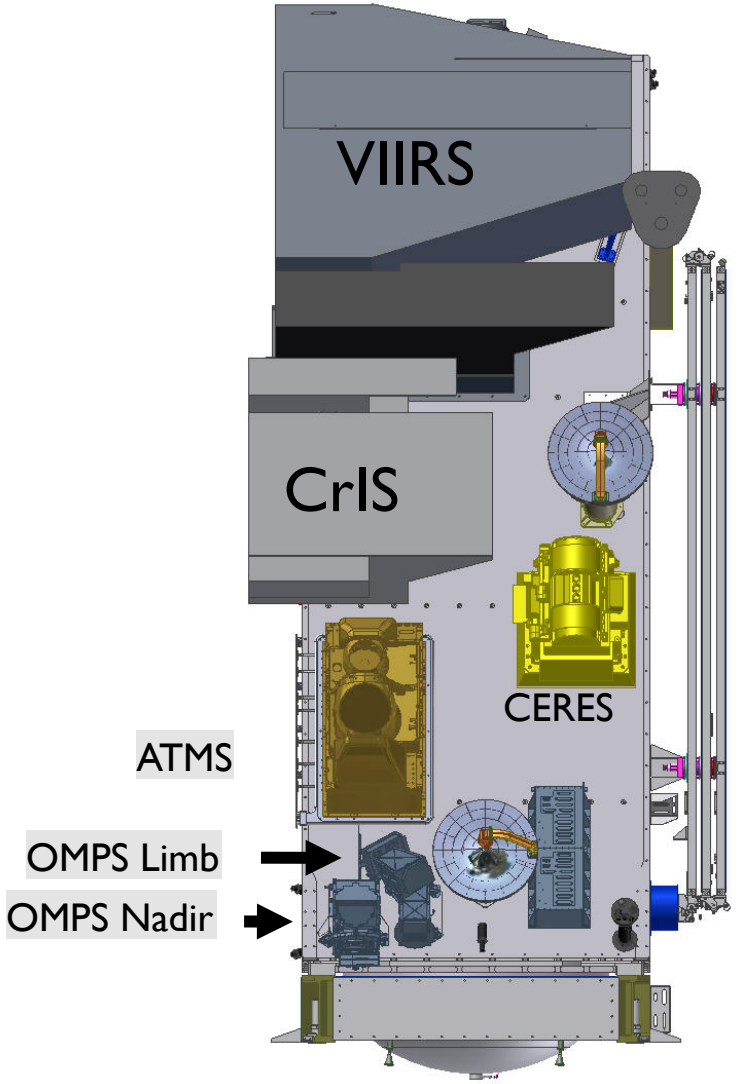
VIIRS – Medium Resolution Visible & Infra-red Imager

CrIS – Fourier Transform Spectrometer for IR Temperature and Moisture sounding

ATMS – Microwave sounding radiometer

OMPS – Total Ozone Mapping and Ozone Profile measurements

CERES - Earth Radiation Budget



Space Science and Engineering Center
University of Wisconsin-Madison

NPP at Ball Aerospace
July 2010

SSEC

VIIRS Spectral Bands

		Band No.	Wave-length (μm)	Horiz Sample Interval (km Downtrack x Crosstrack)		Driving EDRs	Radi-ance Range	Ltyp or Ttyp	Signal to Noise Ratio (dimensionless) or $NE^{\Delta}T$ (Kelvins)		
				Nadir	End of Scan				Required	Predicted	Margin
VIS/NIR FPA	Silicon PIN Diodes	M1	0.412	0.742 x 0.259	1.60 x 1.58	Ocean Color	Low	44.9	352	441	25%
						Aerosols	High	155	316	807	155%
		M2	0.445	0.742 x 0.259	1.60 x 1.58	Ocean Color	Low	40	380	524	38%
						Aerosols	High	146	409	926	126%
		M3	0.488	0.742 x 0.259	1.60 x 1.58	Ocean Color	Low	32	416	542	30%
						Aerosols	High	123	414	730	76%
		M4	0.555	0.742 x 0.259	1.60 x 1.58	Ocean Color	Low	21	362	455	26%
						Aerosols	High	90	315	638	102%
		I1	0.640	0.371 x 0.387	0.80 x 0.789	Imagery	Single	22	119	146	23%
		M5	0.672	0.742 x 0.259	1.60 x 1.58	Ocean Color	Low	10	242	298	23%
						Aerosols	High	68	360	522	45%
		M6	0.746	0.742 x 0.776	1.60 x 1.58	Atmospheric Corr'n	Single	9.6	199	239	20%
		I2	0.865	0.371 x 0.387	0.80 x 0.789	NDVI	Single	25	150	225	50%
		M7	0.865	0.742 x 0.259	1.60 x 1.58	Ocean Color	Low	6.4	215	388	81%
						Aerosols	High	33.4	340	494	45%
CCD		DNB	0.7	0.742 x 0.742	0.742 x 0.742	Imagery	Var.	6.70E-05	6	5.7	-5%
S/MWIR	PV HgCdTe (HCT)	M8	1.24	0.742 x 0.776	1.60 x 1.58	Cloud Particle Size	Single	5.4	74	98	32%
		M9	1.378	0.742 x 0.776	1.60 x 1.58	Cirrus/Cloud Cover	Single	6	83	155	88%
		I3	1.61	0.371 x 0.387	0.80 x 0.789	Binary Snow Map	Single	7.3	6.0	97	1523%
		M10	1.61	0.742 x 0.776	1.60 x 1.58	Snow Fraction	Single	7.3	342	439	28%
		M11	2.25	0.742 x 0.776	1.60 x 1.58	Clouds	Single	0.12	10	17	66%
		I4	3.74	0.371 x 0.387	0.80 x 0.789	Imagery Clouds	Single	270 K	2.500	0.486	415%
		M12	3.70	0.742 x 0.776	1.60 x 1.58	SST	Single	270 K	0.396	0.218	82%
		M13	4.05	0.742 x 0.259	1.60 x 1.58	SST	Low	300 K	0.107	0.063	69%
						Fires	High	380 K	0.423	0.334	27%
LWIR	PV HCT	M14	8.55	0.742 x 0.776	1.60 x 1.58	Cloud Top Properties	Single	270 K	0.091	0.075	22%
		M15	10.763	0.742 x 0.776	1.60 x 1.58	SST	Single	300 K	0.070	0.038	85%
		I5	11.450	0.371 x 0.387	0.80 x 0.789	Cloud Imagery	Single	210 K	1.500	0.789	90%
		M16	12.013	0.742 x 0.776	1.60 x 1.58	SST	Single	300 K	0.072	0.051	42%

MODIS vs. VIIRS

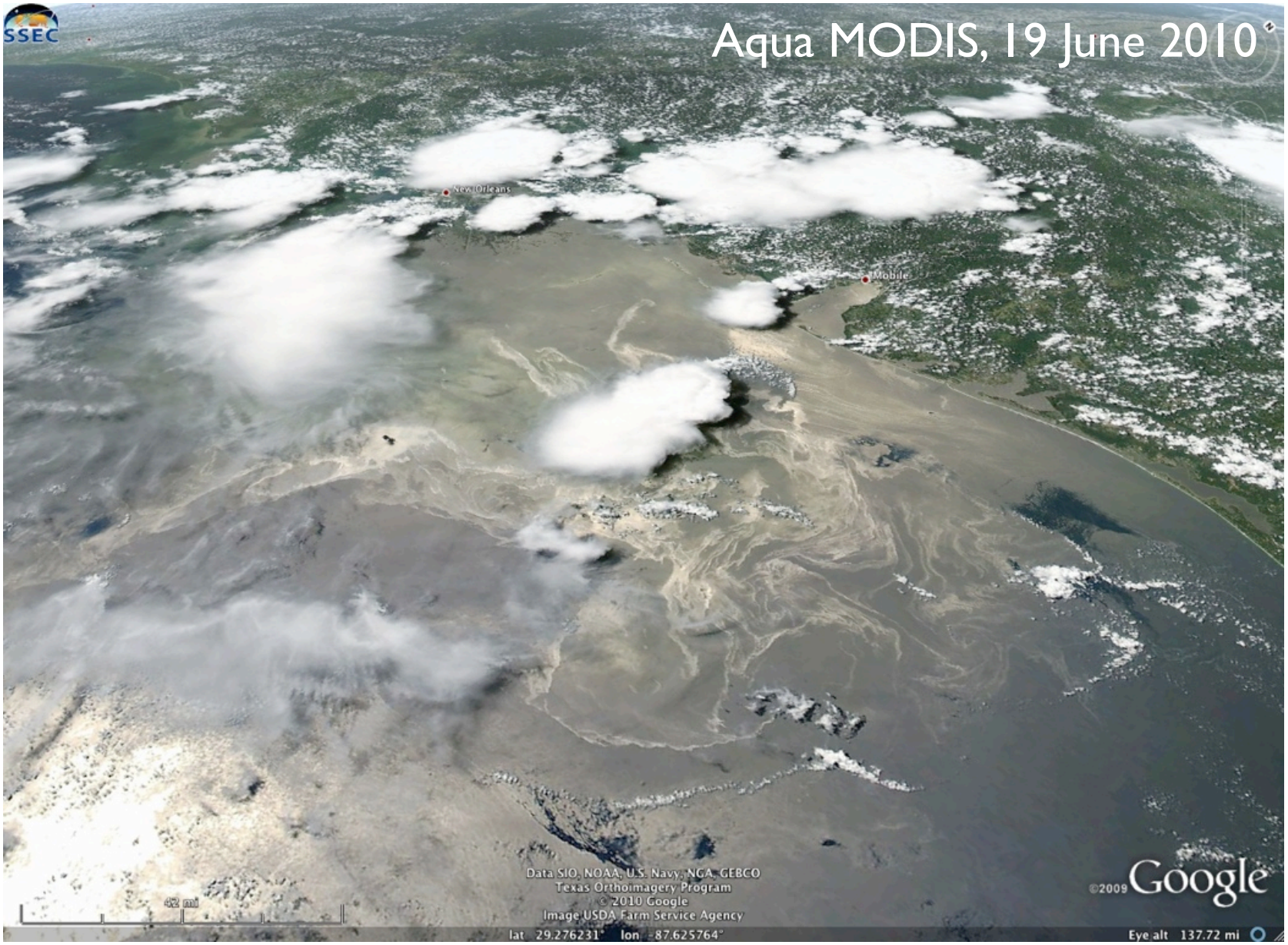
Similarities

- VIIRS supports all land surface imaging applications of MODIS (NDVI, LST, Burned Area, Snow/Ice, True Color, etc.).
- NPP and JPSS-1 will transmit all data to the ground in real-time via X-band direct broadcast (but not L-band).
- Software for real-time processing will be available (SSEC is funded from JPSS Project).

MODIS vs. VIIRS

Differences

- VIIRS native resolution is 375 and 750 meters (vs. 250 and 1000 meters for MODIS).
- VIIRS has 22 bands while MODIS has 36 bands.
- VIIRS has constant pixel size across the scan.
- VIIRS data format is HDF5.
- Redundant "bow-tie" pixels on VIIRS are not transmitted to the ground.



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