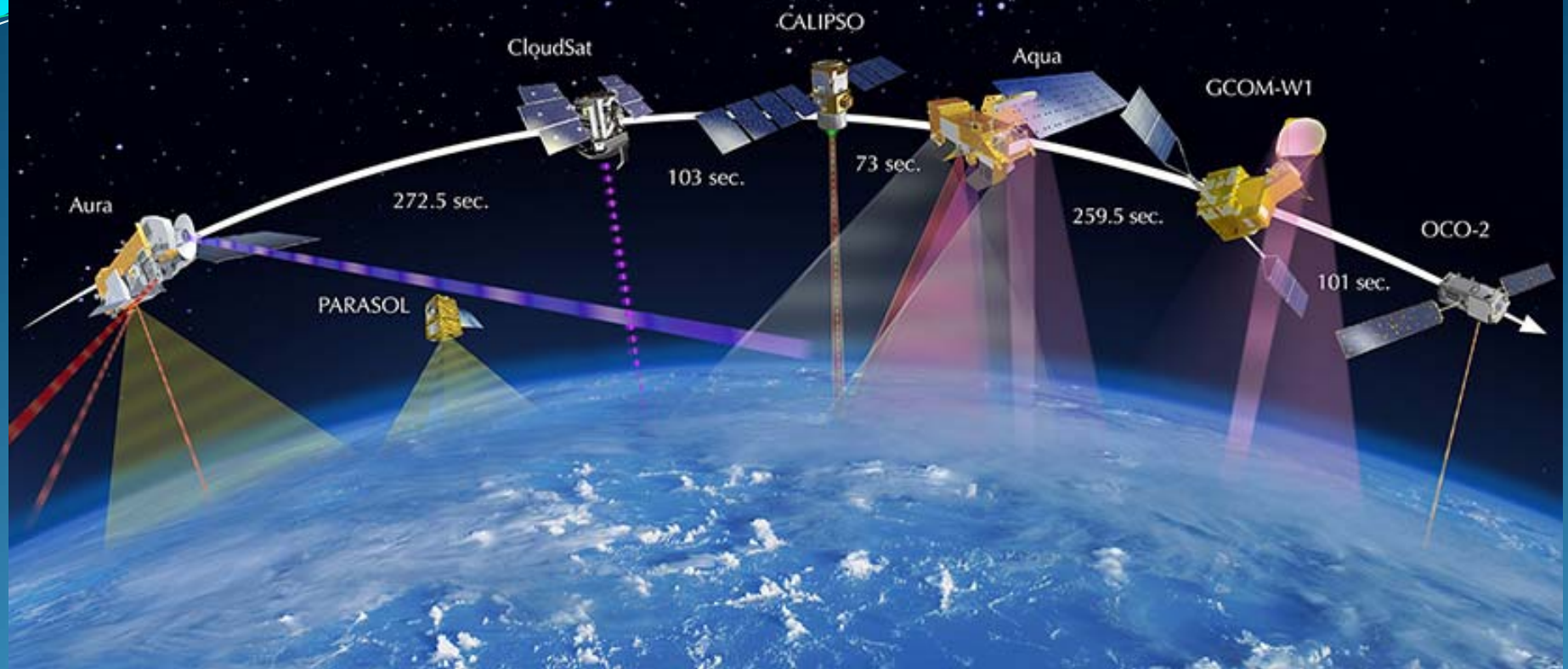


MET 611 – Satellite Data Applications



MODIS Land Overview

Jennifer D. S. Griswold



MODIS Granule over Southern Africa
(Sept 13, 2001, 8:45 to 8:50 GMT)

Red, Green, Blue MODIS top of
atmosphere reflectance

No atmospheric correction

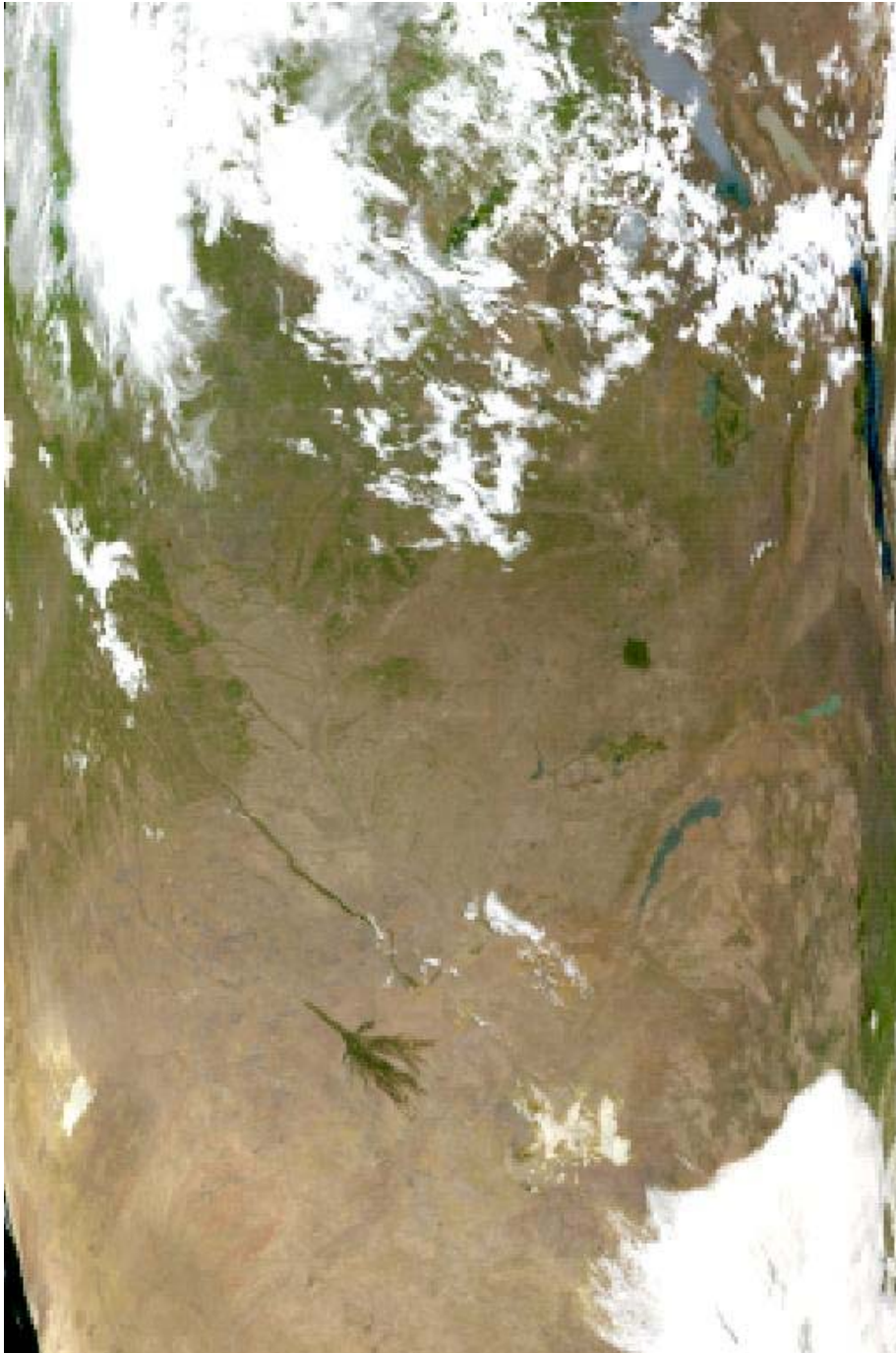
**Surface Reflectance: Atmospheric
effect has a strong impact on
remotely sensed data**

(GSE/GEOG-741-S01)

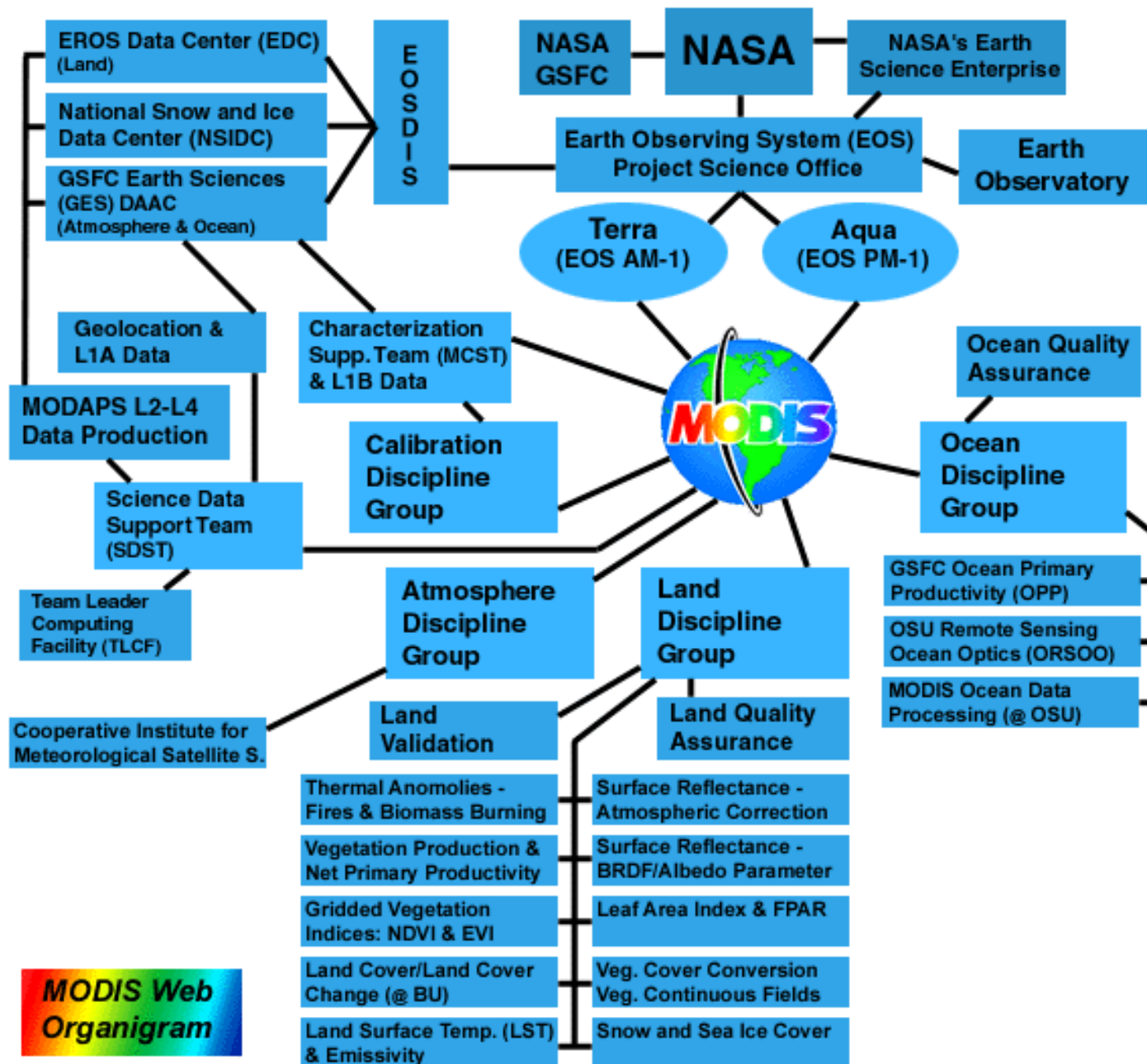
MODIS Granule over Southern Africa
(Sept 13, 2001, 8:45 to 8:50 GMT)

Red, Green, Blue MODIS surface
reflectance

With atmospheric correction



(GSE/GEOG-741-S01)

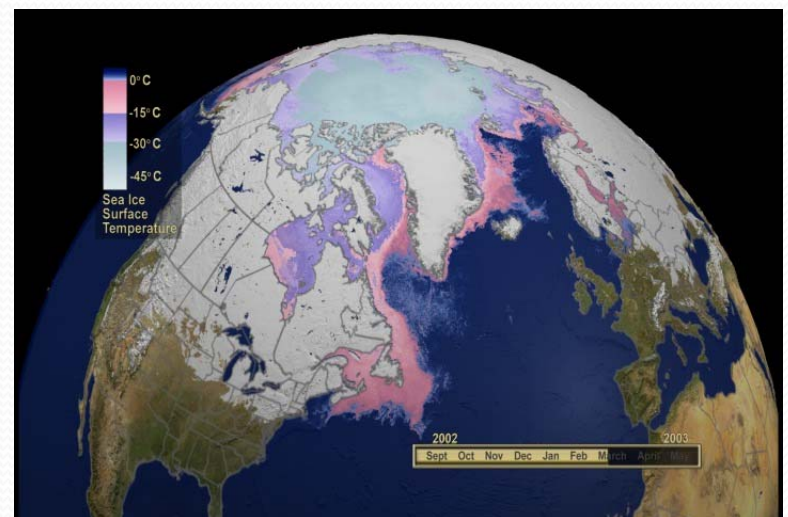
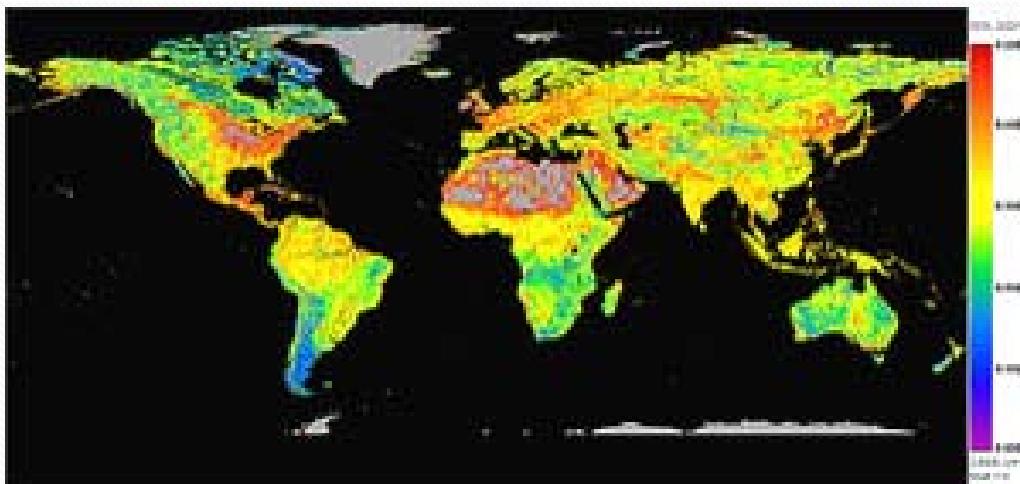


MODIS Web Organigram

MODIS Land Product Overview

Radiation Budget Variables

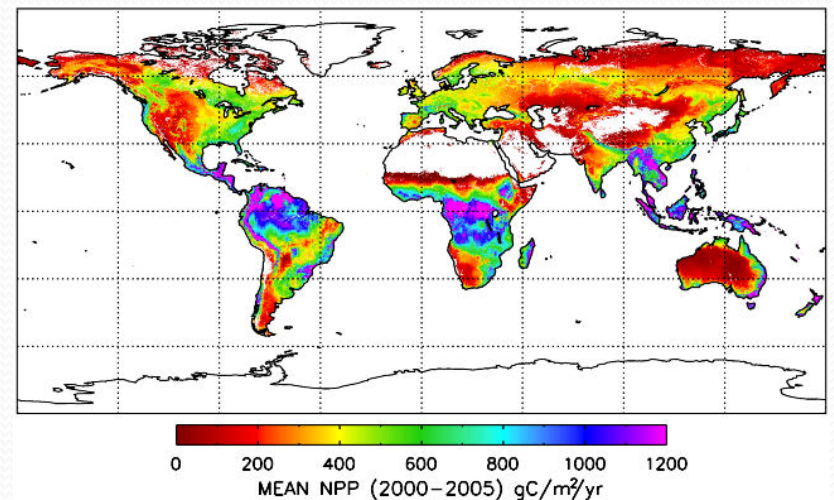
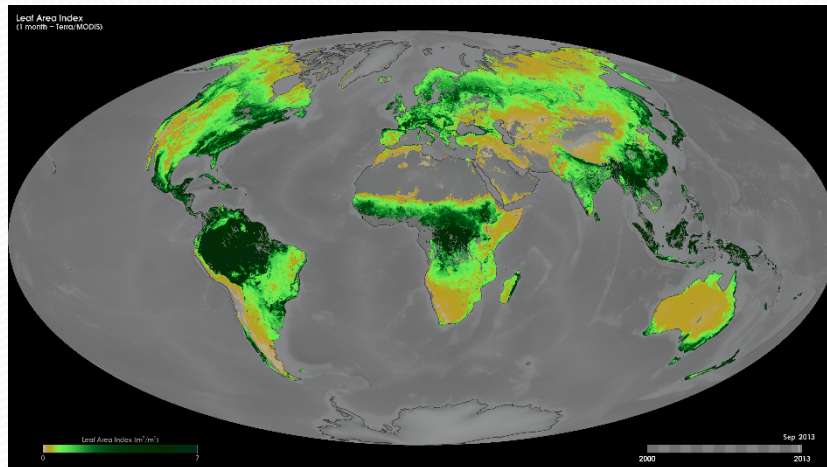
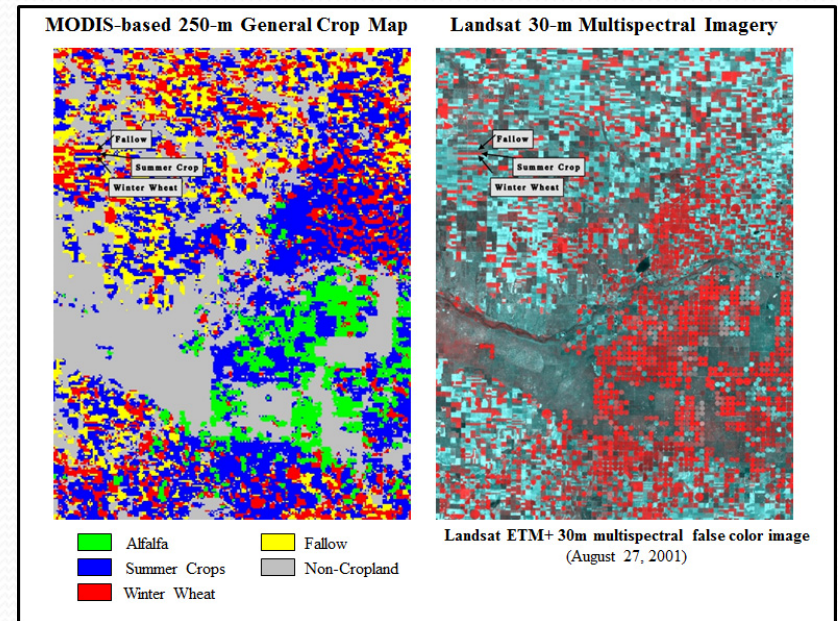
- Surface Reflectance
- Surface Temperature and Emissivity
- Snow and Ice Cover
- BRDF and Albedo



MODIS Land Product Overview

Ecosystem Variables

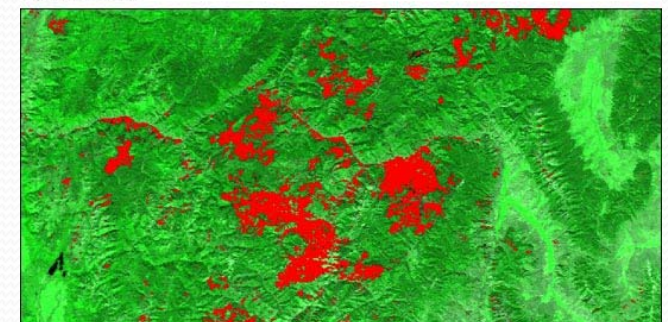
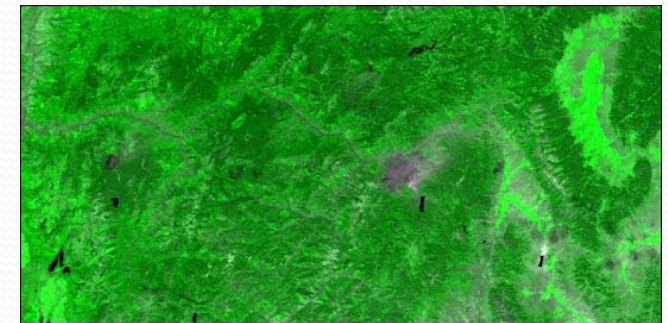
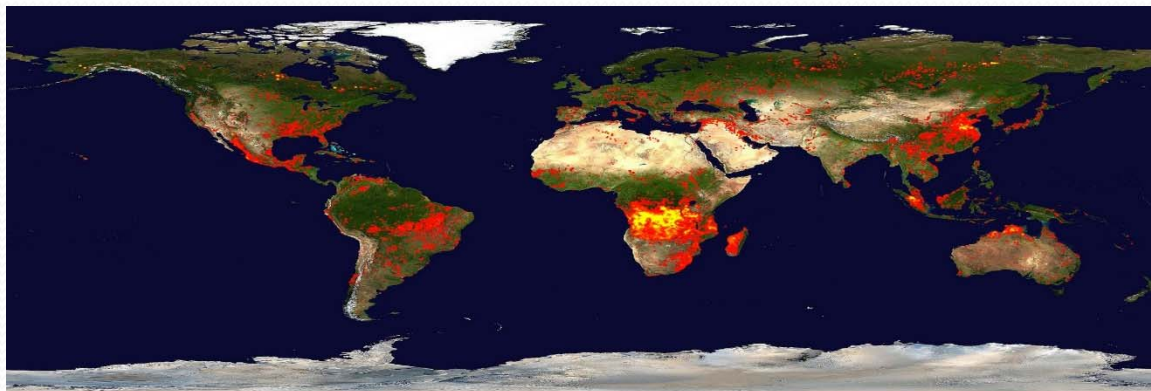
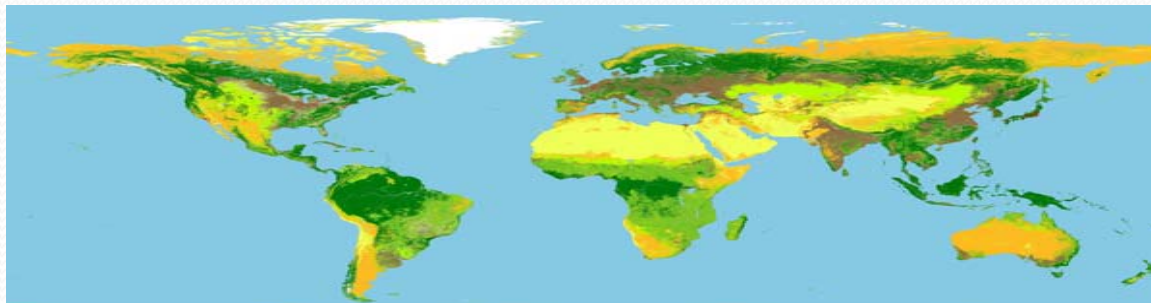
- Vegetation Indices
- Leaf Area Index (LAI) and Fractional Photosynthetically Active Radiation (FPAR)
- Vegetation Production
- Net Primary Productivity (NPP)



MODIS Land Product Overview

Land Cover Characteristic

- Fire and Thermal Anomalies
- Land Cover
- Vegetation Cover Conversion



Scale (km)
0 25

List of MODIS Land Products

https://lpdaac.usgs.gov/dataset_discovery/modis/modis_products_table

MOD01	Level-1A Radiance Counts	MOD23	Suspended-Solids Conc, Ocean Water
MOD02	Level-1B Calibrated Relocated Radiances	MOD24	Organic Matter Concentration
MOD03	Relocation Data Set	MOD25	Coccolith Concentration
MOD04	Aerosol Product	MOD26	Ocean Water Attenuation Coefficient
MOD05	Total Precipitable Water	MOD27	Ocean Primary Productivity
MOD06	Cloud Product	MOD28	Sea Surface Temperature
MOD07	Atmospheric profiles	MOD29	Sea Ice Cover
MOD08	Gridded Atmospheric Product (Level-3)	MOD31	Phycoerythrin Concentration
MOD09	Atmospherically-corrected Surface		
Reflectance			
MOD10	Snow Cover	MOD35	Cloud Mask
MOD11	Land Surface Temperature & Emissivity	MOD36	Total Absorption Coefficient
MOD12	Land Cover/Land Cover Change	MOD37	Ocean Aerosol Properties
MOD13	Vegetation Indices	MOD39	Clear Water Epsilon
MOD14	Thermal Anomalies, Fires & Biomass Burning	MOD43	Albedo 16-day L3
MOD15	Leaf Area Index & FPAR	MOD44	Vegetation Cover Conversion
MOD16	Surface Resistance & Evapotranspiration	MODISALB Snow and Sea Ice Albedo	
MOD17	Vegetation Production, Net Primary		
Productivity			
MOD18	Normalized Water-leaving Radiance		
MOD19	Pigment Concentration		
MOD20	Chlorophyll Fluorescence		
MOD21	Chlorophyll_a Pigment Concentration		
MOD22	Photosynthetically Active Radiation (PAR)		

Current MODIS Land Products

MODIS Products Table

These links will direct you to specific information and access points for each of the MODIS Land Products distributed from LP DAAC.

- ✦ [Radiation Budget Variables](#)
- ✦ [Ecosystem Variables](#)
- ✦ [Land Cover Characteristics](#)

Thermal Anomalies and Fire

Version 4 - 5.5

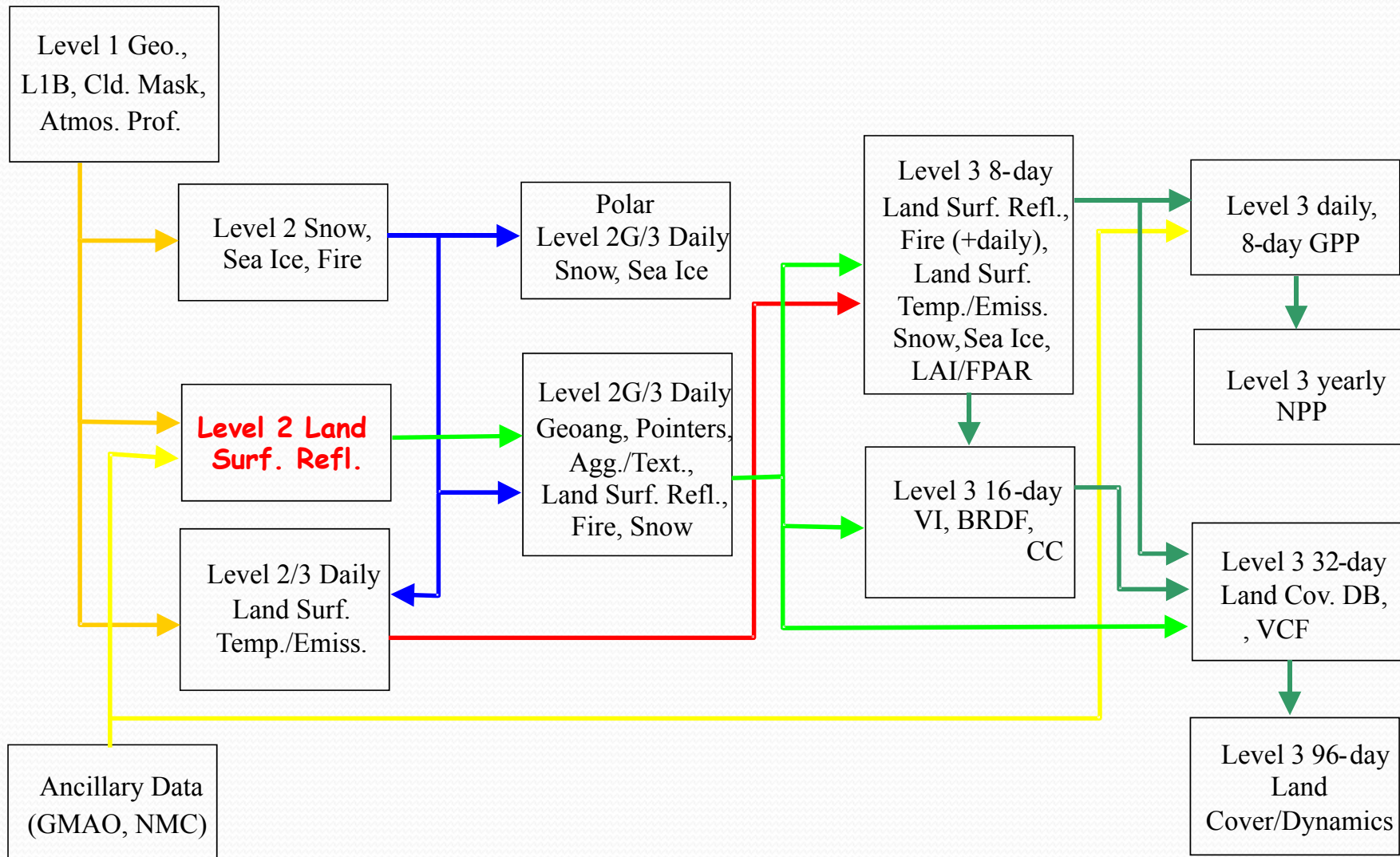
Version 6

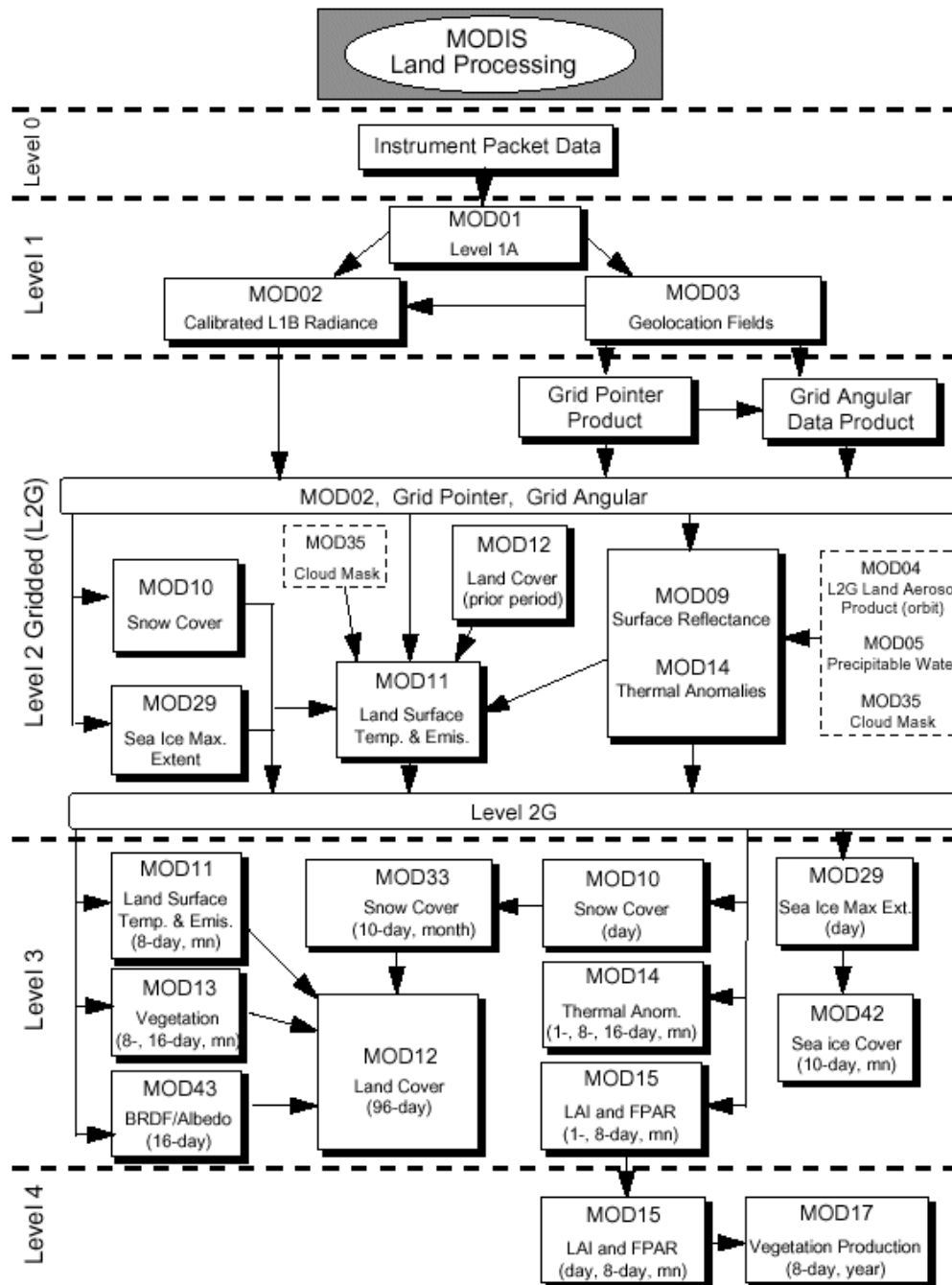
Search:

Name	Dataset	Product	Pixel Size	Temporal Granularity
MCD64A1	Combined MODIS	Thermal Anomalies and Fire	500	Monthly
MOD14	Terra MODIS	Thermal Anomalies and Fire	1000	5 Minute
MOD14A1	Terra MODIS	Thermal Anomalies and Fire	1000	Daily
MOD14A2	Terra MODIS	Thermal Anomalies and Fire	1000	Composites
MYD14	Aqua MODIS	Thermal Anomalies and Fire	1000	5 Minute
MYD14A1	Aqua MODIS	Thermal Anomalies and Fire	1000	Daily
MYD14A2	Aqua MODIS	Thermal Anomalies and Fire	1000	Composites

https://lpdaac.usgs.gov/dataset_discovery/modis/modis_products_table

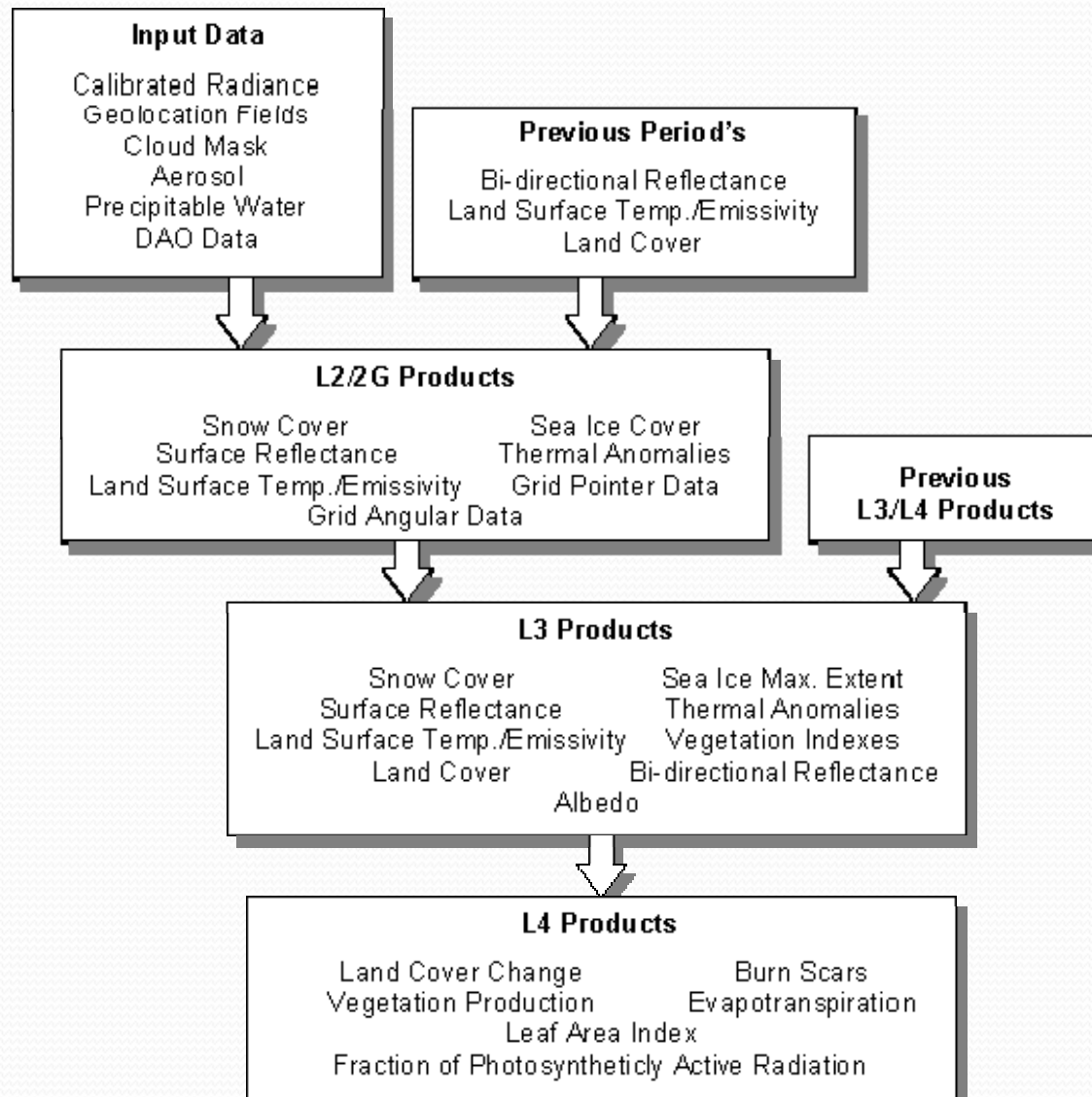
MODIS Land Production Processing Chart Atmospheric Correction Product (MOD09) crucial input to the MODIS land products





Flow Diagram Showing Interrelationship of MODIS Land Products.

MODIS Land Data Processing Overview



Level 1 - Level 4 Data

Level 1B

- = Raw, Un-calibrated Swath Data (Scene), Not projected
- = Includes radiometric and calibration coefficients and parameters, but not applied

Level 2

- = Derived geophysical variables at the same resolution and location as the Level 1 source data

Level 2G

- = Calibrated, IS Map Projection*, Tiled
 - = Multiple Coincident Swaths (e.g. overlapping pixels)
- *Integerized Sinusoidal*

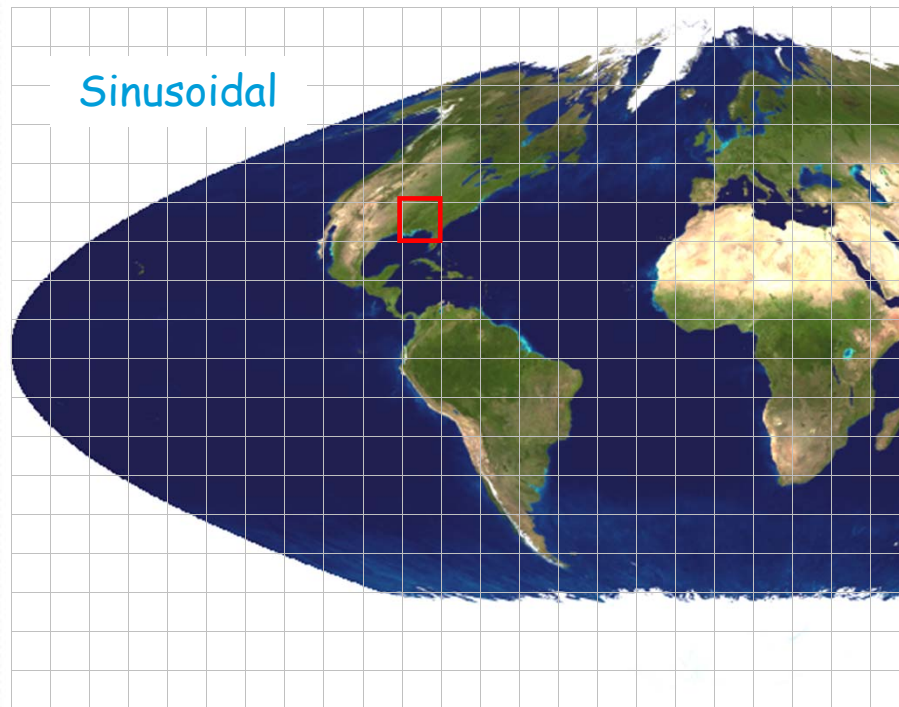
Level 3 Data

- = Variables mapped on uniform space-time grid scales
- = “MODIS Land End User”
- = Usually composite data
- = Tiled, IS Projection, “Best” pixel selection (e.g. one value/pixel)

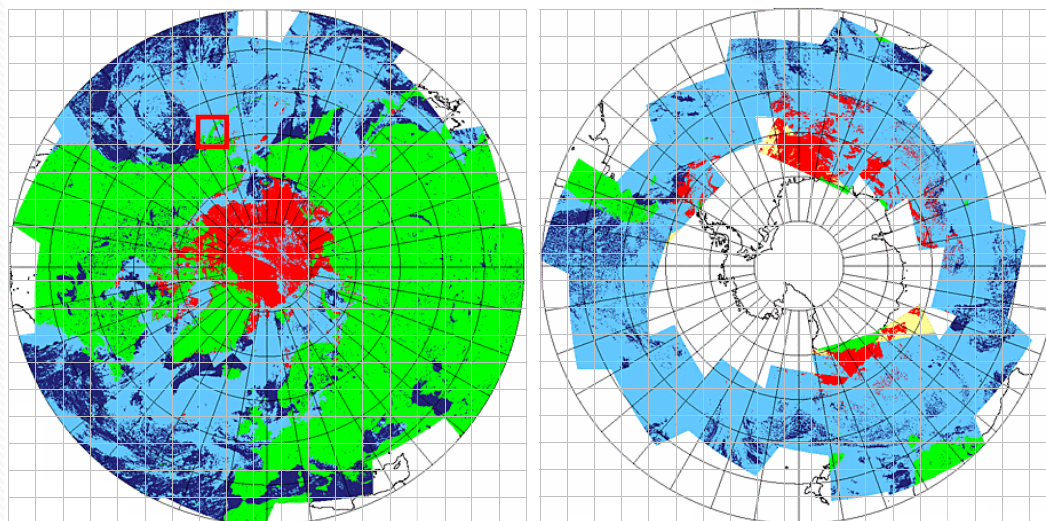
Level 4 Data


- = Model output or results from analysis of lower level data
- = LAI/FPAR, PSN/NPP

Level 2G, 3 and 4 Products (fine resolution)



Lambert
Azimuthal
Equal Area
(LAEA)



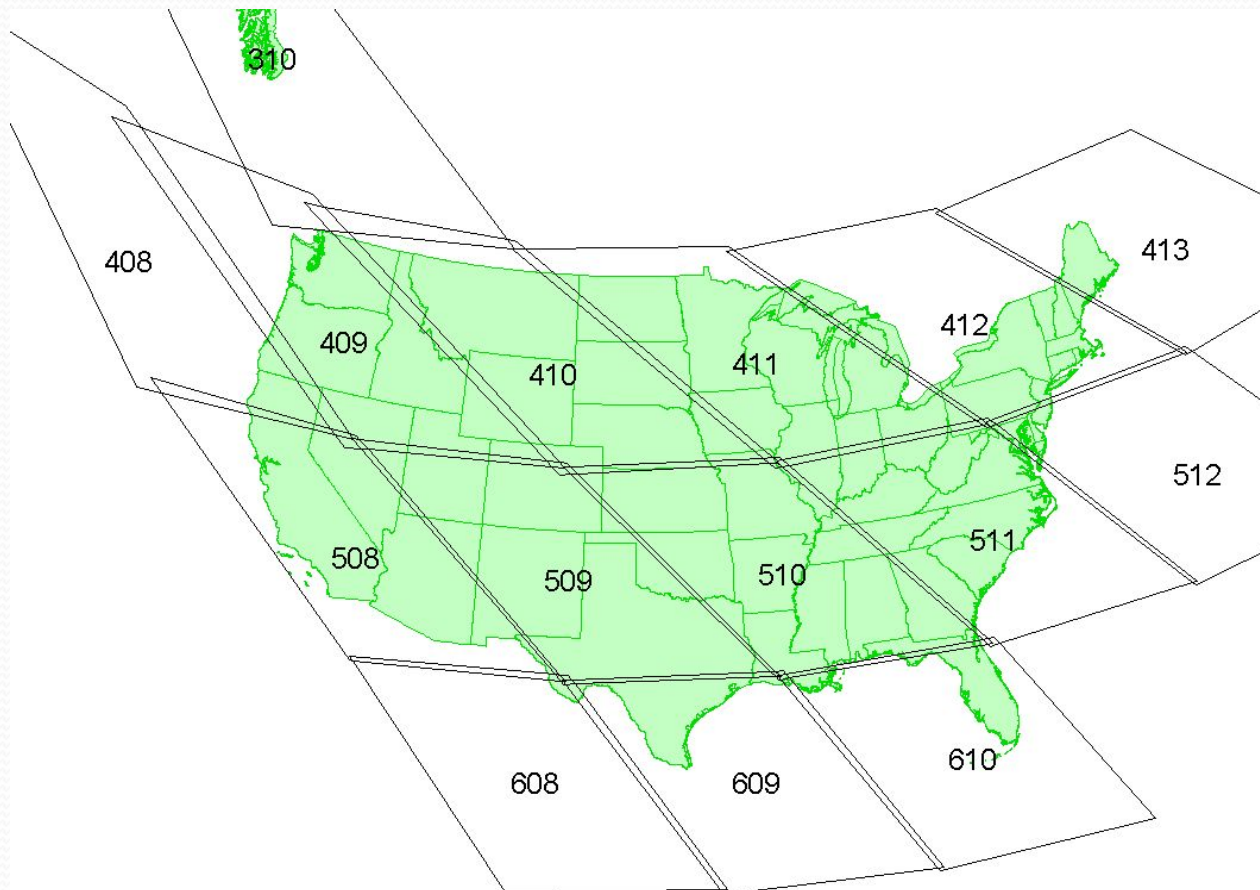
- Level 2G/3: earth-gridded geophysical parameters
- Level 4: earth-gridded model outputs
- Daily, 8-day, 16-day, 32-day, monthly and yearly products
- $10^\circ \times 10^\circ$ Tiles ()
- Sinusoidal (equatorial); 7.5, 15 and 30 arcsec. resolution (roughly 250m, 500m and 1 km)
- LAEA (sea-ice products, polar projection)

IS Projection

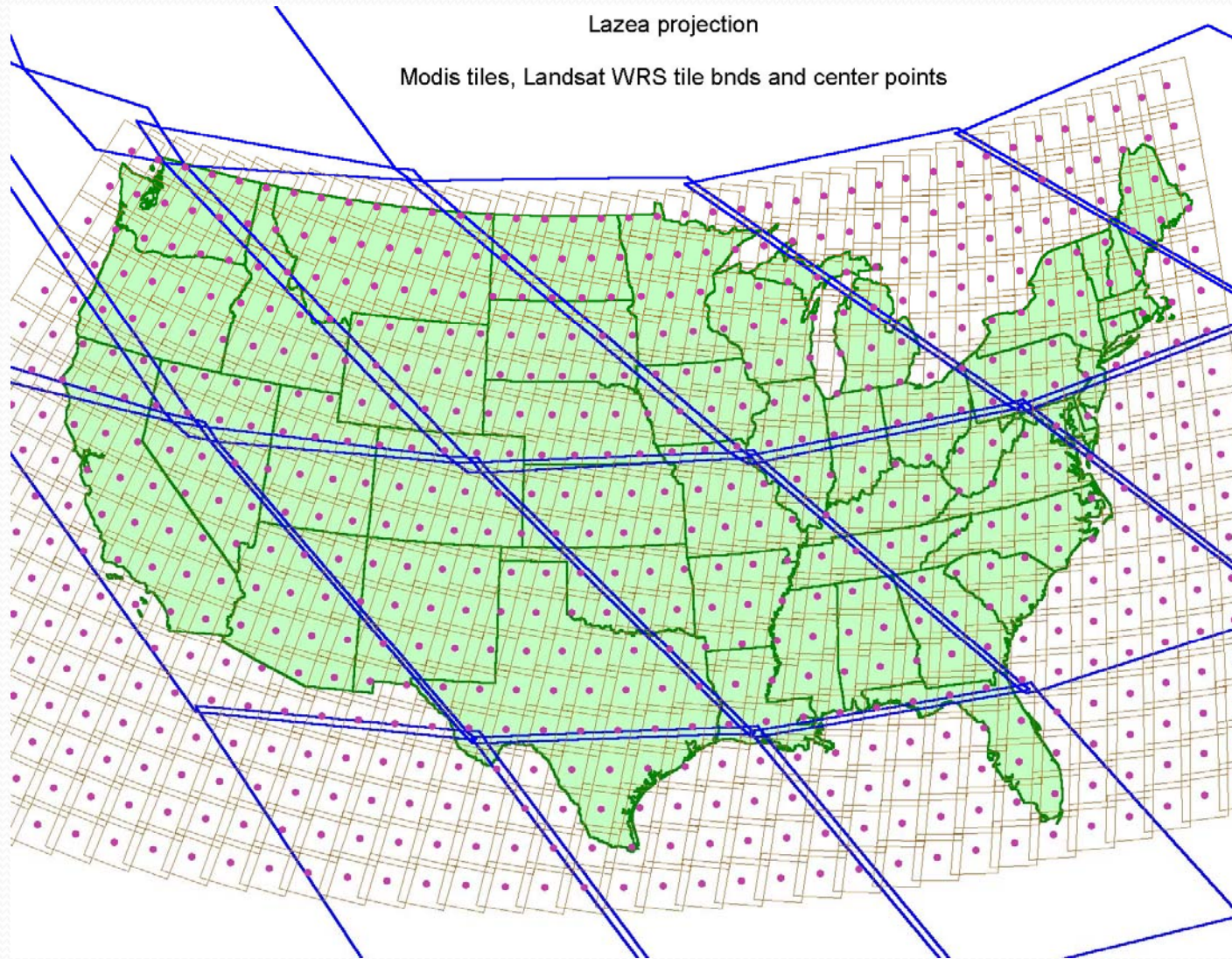
1 km tile = 1200 x 1200
500 m tile = 2400 x 2400
250 m tile = 4800 x 4800

MODIS Land Tiles for U.S.

Lambert Azimuthal Equal Area



Relationship of MODIS tiles to TM scenes

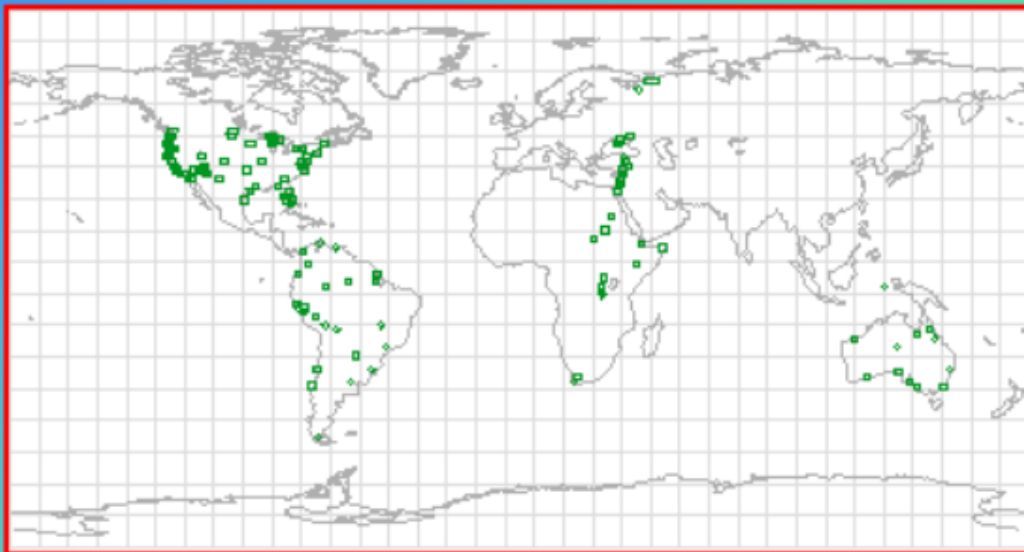


MODIS Land Bands

<i>Band</i>	<i>Spatial Resolution</i>	<i>Wavelength, nm</i>
1	250 m	654–664
2	250 m	860–870
3	500 m	465–475
4	500 m	550–560
5	500 m	1234–1246
6	500 m	1632–1648
7	500 m	2120–2140

MODIS Geolocation

- ***Geolocation accuracy specification is 300 m (2σ) and goal is 100 m (2σ) at nadir***
- ***Geolocation goal driven by Land 250 m change product requirements***
- ***Goal is currently being met***



Ground Control Points—Land

← Land: 550 CPs
from 126 TM Scenes

Ocean: 4600 island
points from SeaWifs
library

IGBP Land Cover Units (17)

- ***Natural Vegetation (11)***

- Evergreen Needleleaf Forests
- Evergreen Broadleaf Forests
- Deciduous Needleleaf Forests
- Deciduous Broadleaf Forests
- Mixed Forests
- Closed Shrublands
- Open Shrublands
- Woody Savannas
- Savannas
- Grasslands
- Permanent Wetlands

- ***Developed and Mosaic Lands (3)***

- Croplands
- Urban and Built-Up Lands
- Cropland/Natural Vegetation Mosaics

- ***Nonvegetated Lands (3)***

- Snow and Ice
- Barren
- Water Bodies

International
Geosphere-Biosphere
Programme

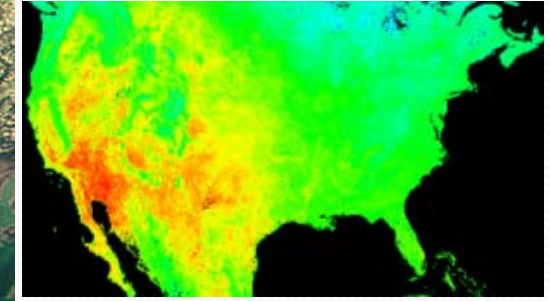
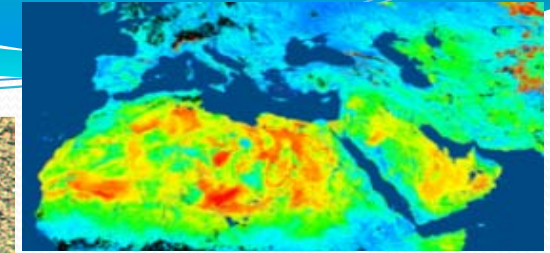
Land Cover Input Database

- **242 Features From MODIS:**
 - *Temporal and spectral information; 16-day composites*
- **Uses Surface Reflectance (NBAR)**
 - *View-angle corrected surface reflectance, 7 land bands*
- **And Enhanced Vegetation Index (EVI)**
- **Plus (in the future)....**
 - **Spatial Texture from 250-m Band 2**
 - **Standard deviation-to-mean ratio in Band 2 (near-infrared)**
 - **Snow Cover**
 - **MODIS Snow Cover Product, number of days with snow cover**
 - **Land Surface Temperature**
 - **MODIS Land Surface Temperature, maximum value composite**
 - **Directional Information**
 - **Bidirectional reflectance information from BRDF product**

MODIS Land Products

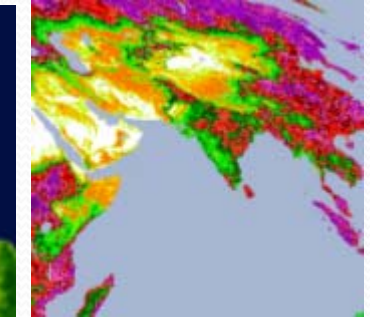
Energy Balance Product Suite

- Surface Reflectance
- Land Surface Temperature, Emmissivity
- BRDF/Albedo
- Snow/Sea-ice Cover



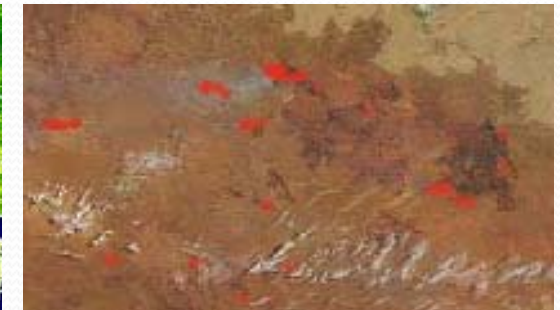
Vegetation Parameters Suite

- Vegetation Indices
- LAI/FPAR
- GPP/NPP



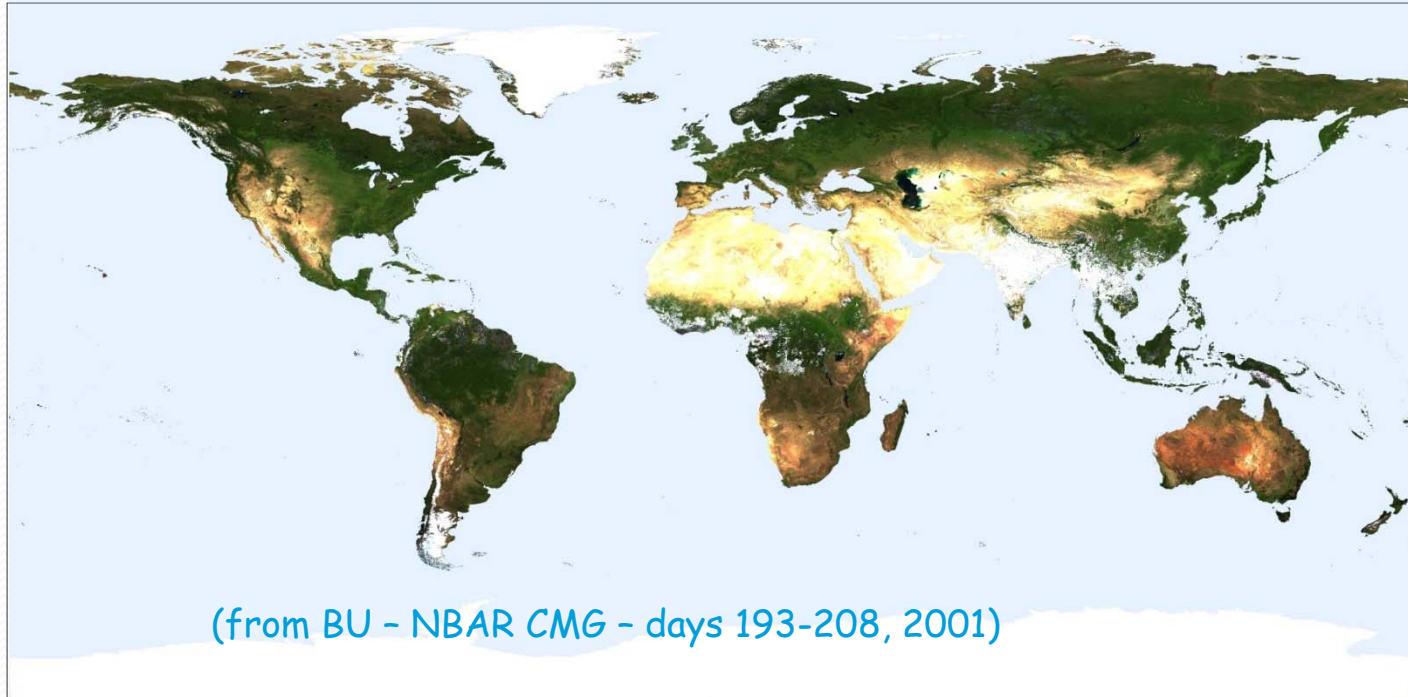
Land Cover/Land Use Suite

- Land Cover/Vegetation Dynamics
- Vegetation Continuous Fields
- Fire and Burned Area



Climate modeling grid products

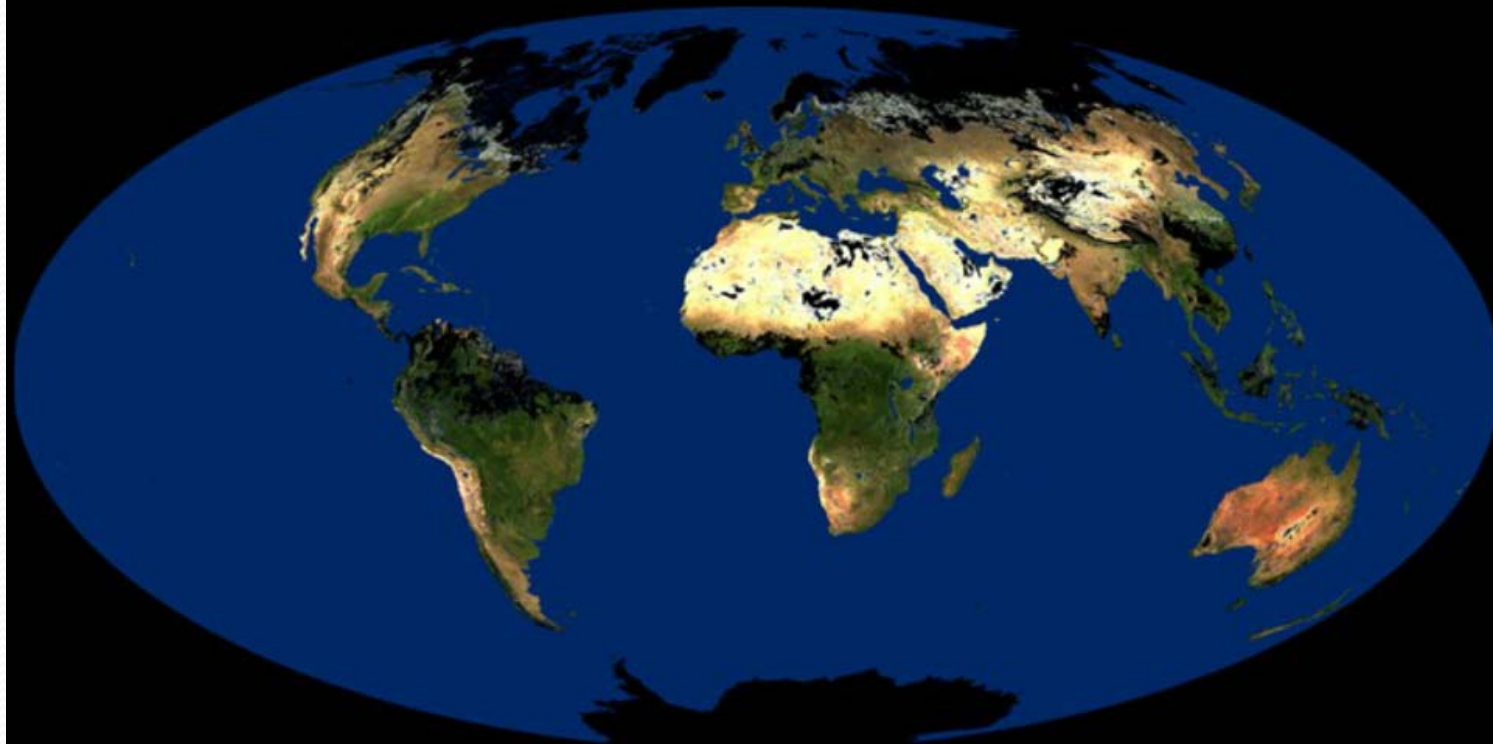
- The land products were driven in large part by the modeling community through ATBD (Algorithm Theoretical Basis Documents) review
 - At the outset most 'land' models were not using satellite data
- Resolution: 0.05° and 0.25° degrees
- Almost all products are lat/long
 - sea-ice is current exception – in polar grid (snow in C5)



(from BU - NBAR CMG - days 193-208, 2001)

Nadir Bidirectional Reflectance Distribution Function

Global Composite Map of Nadir BRDF-Adjusted Reflectance (NBAR)
April 7–22 2001



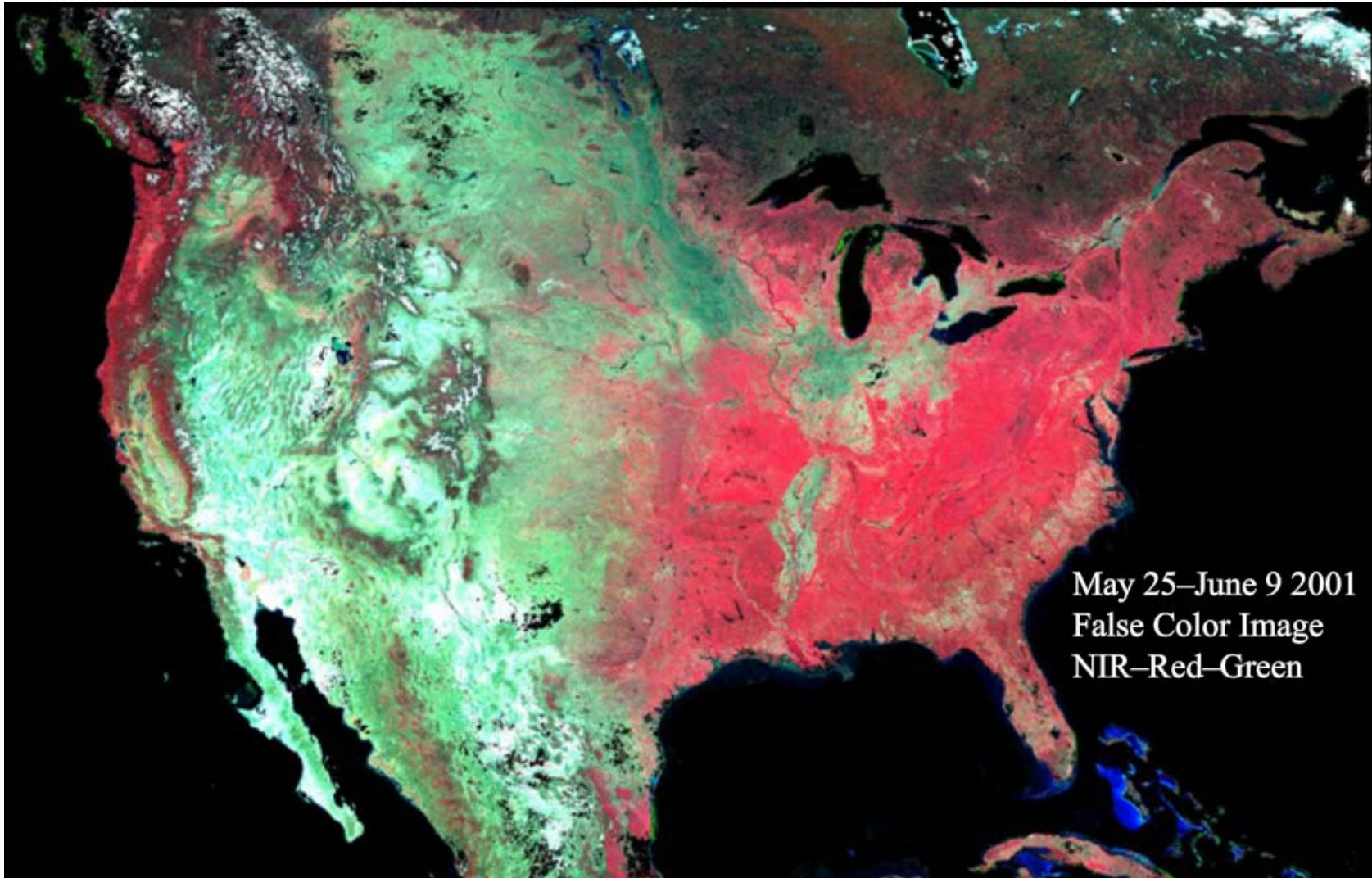
□ No data

True color, MODIS Bands 2, 4, 3

10 km resolution, Hammer-Aitoff projection,
produced by MODIS BRDF/Albedo Team

MODLAND/Strahler et al.

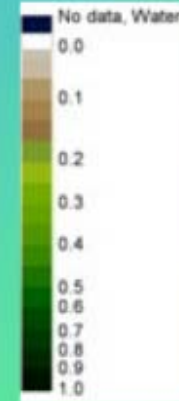
MODIS Nadir BDRF-Adjusted Reflectance



MODIS 500 m Vegetation Indices



NDVI



**MOD13A1 16 day
Composite**

EVI



NDVI

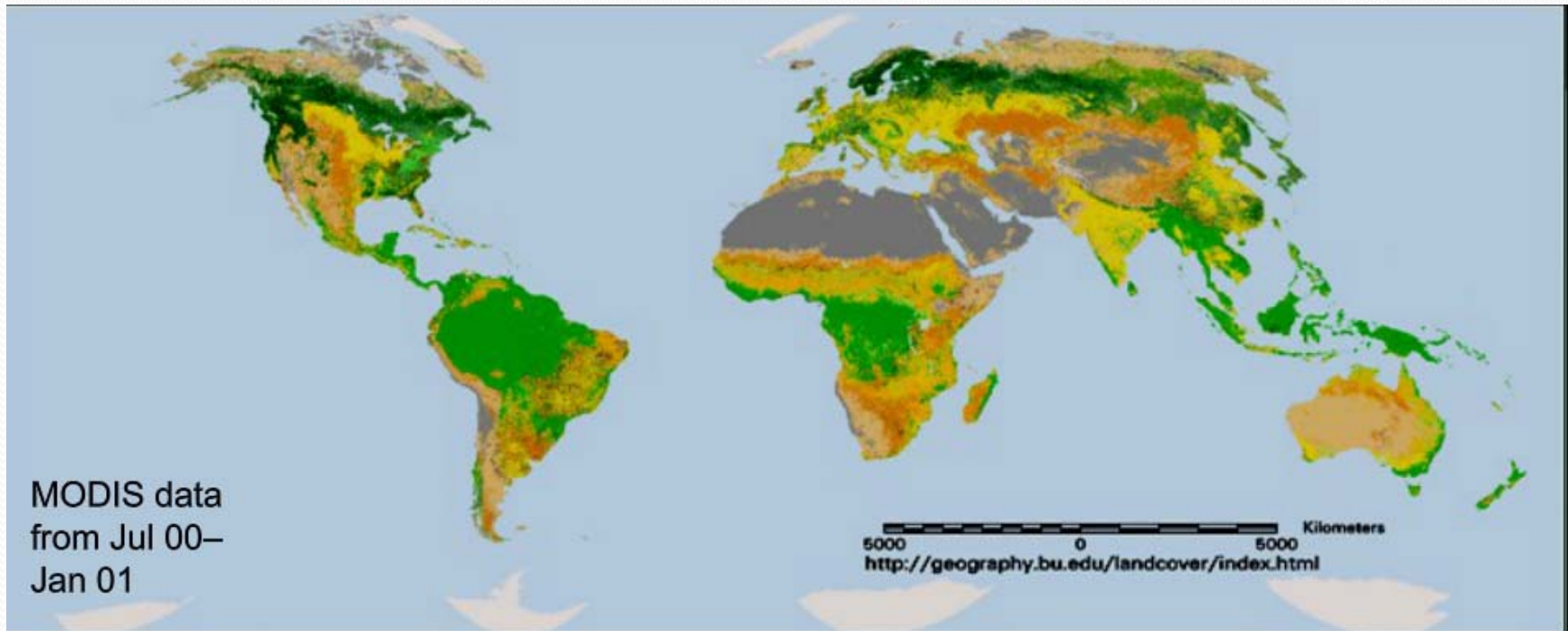


EVI



EVI shows better dynamic range, less saturation

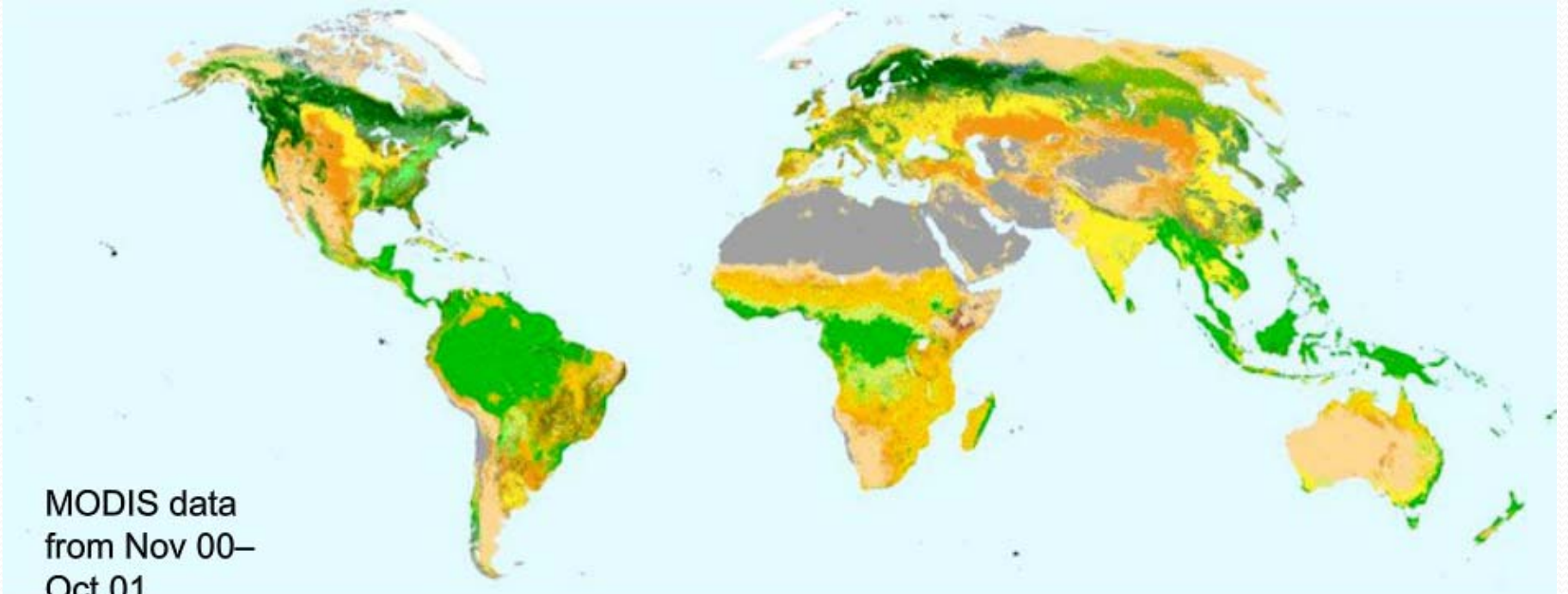
Provisional Land Cover Product



TERRA/MODIS MOD12Q1 2001001 IGBP Land Cover Classes

0 Water	6 Closed Shrublands	12 Croplands
1 Evergreen Needleleaf Forest	7 Open Shrublands	13 Urban and Built-Up
2 Evergreen Broadleaf Forest	8 Woody Savannas	14 Cropland/Natural Vegetation Mosaic
3 Deciduous Needleleaf Forest	9 Savannas	15 Snow and Ice
4 Deciduous Broadleaf Forest	10 Grasslands	16 Barren or Sparsely Vegetated
5 Mixed Forests	11 Permanent Wetlands	

Consistent Year Land Cover Product

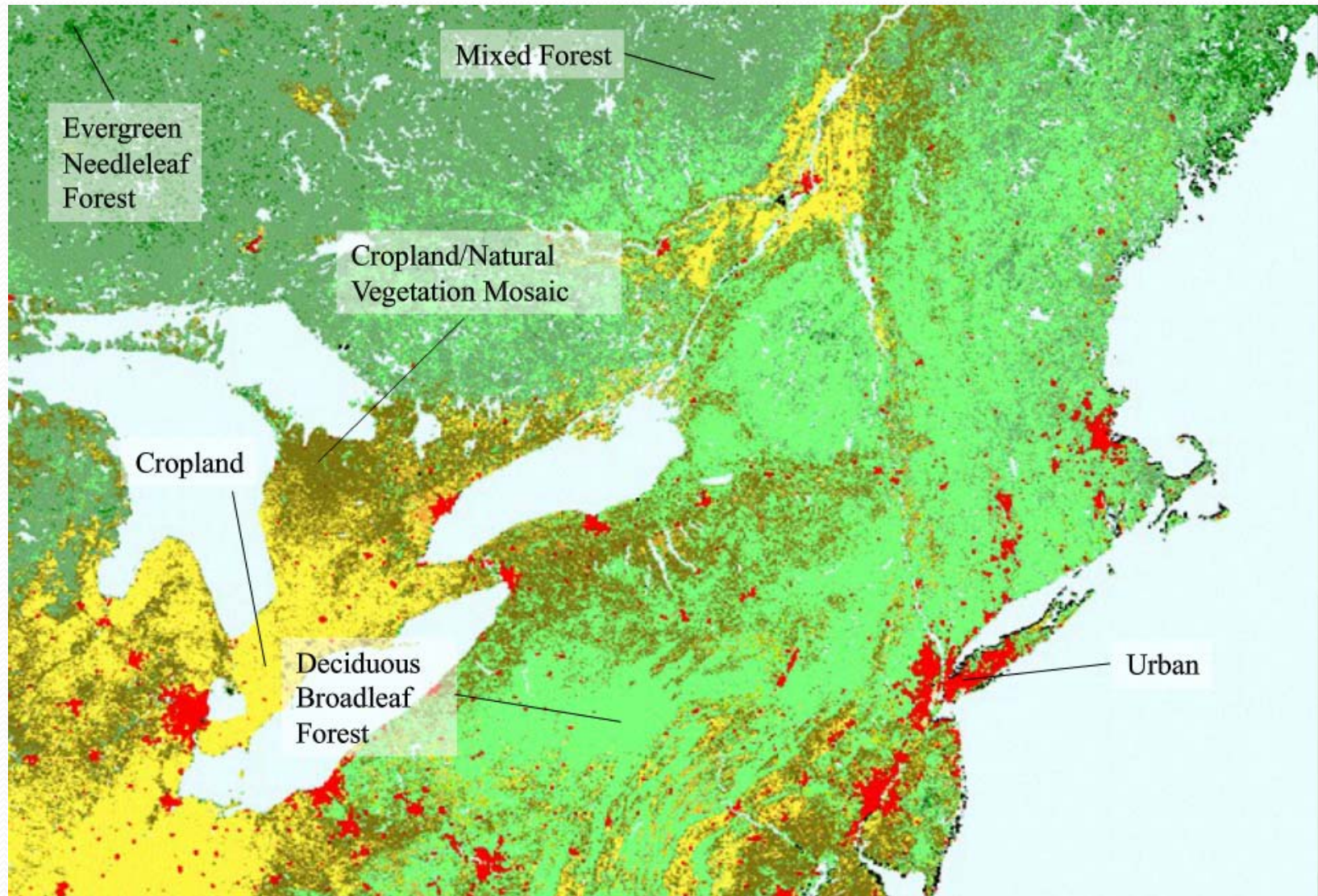


MODIS data
from Nov 00–
Oct 01

IGBP Land Cover Classes

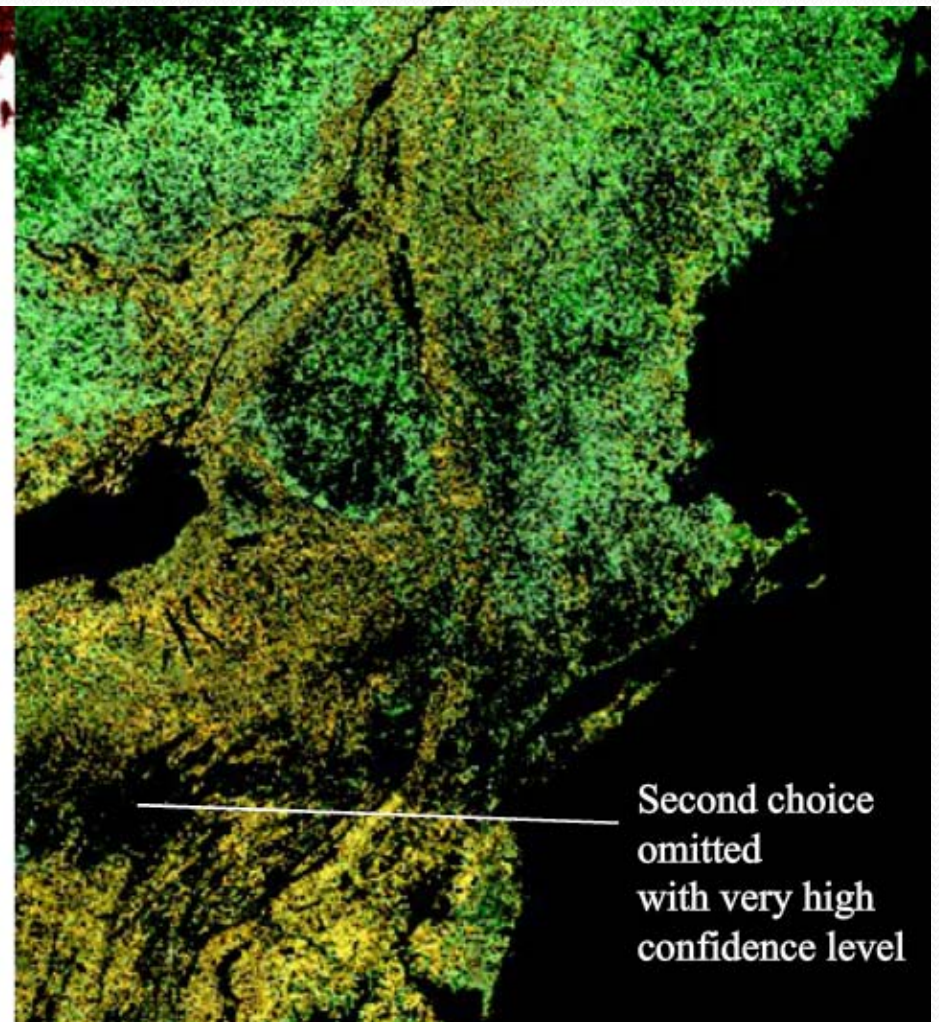
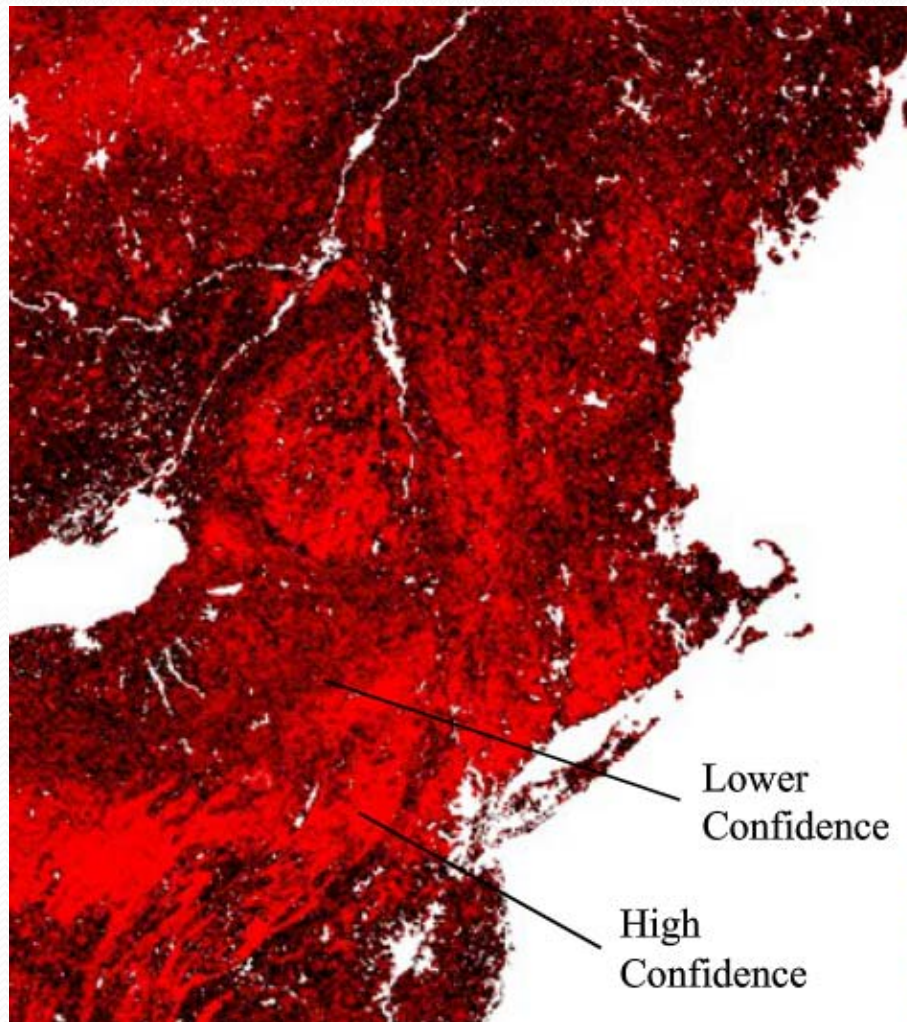
0 Water	6 Closed Shrublands	12 Croplands
1 Evergreen Needleleaf Forest	7 Open Shrublands	13 Urban and Built-Up
2 Evergreen Broadleaf Forest	8 Woody Savannas	14 Cropland/Natural Vegetation Mosaic
3 Deciduous Needleleaf Forest	9 Savannas	15 Snow and Ice
4 Deciduous Broadleaf Forest	10 Grasslands	16 Barren or Sparsely Vegetated
5 Mixed Forests	11 Permanent Wetlands	254 Unclassified

Consistent Year Land Cover Product

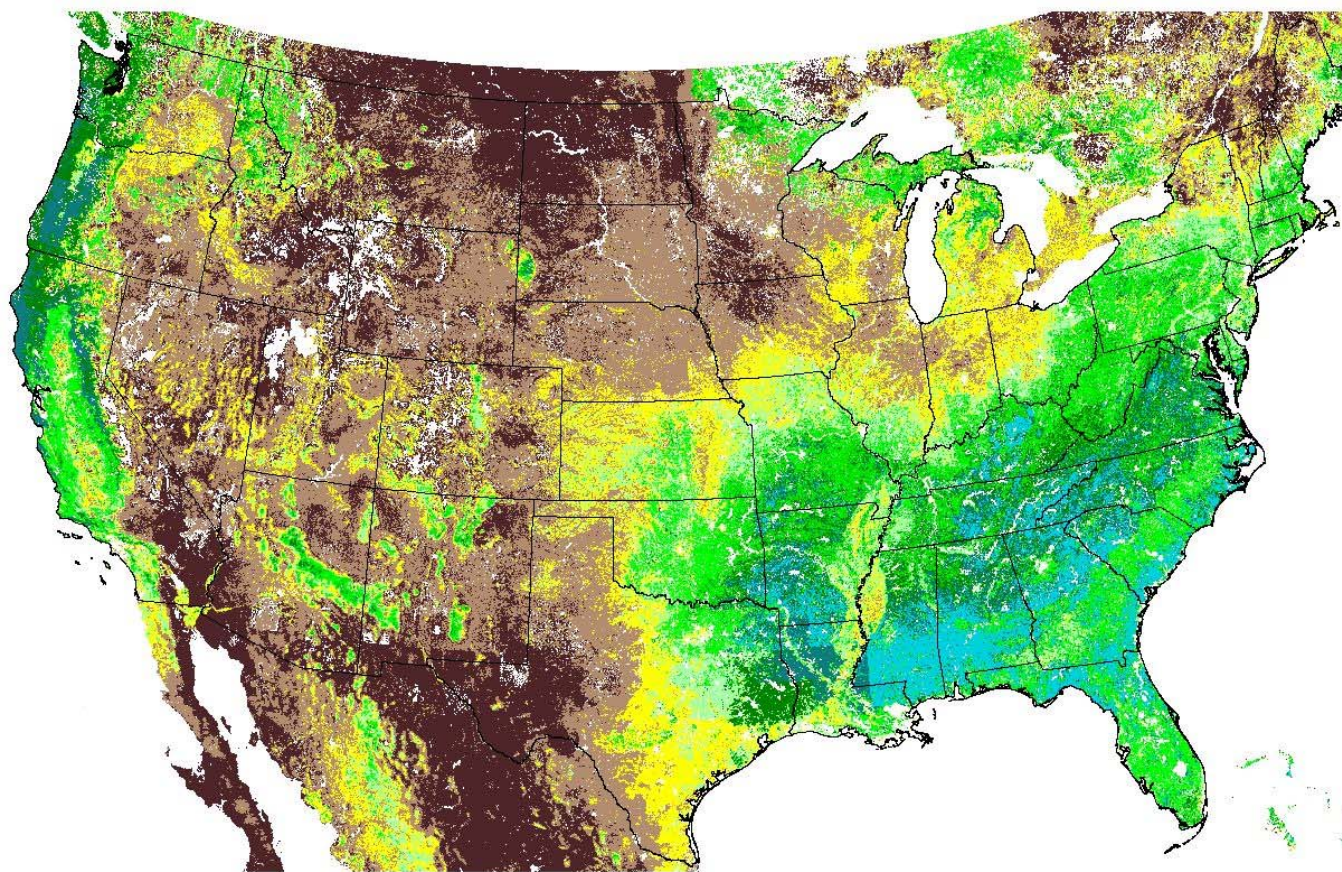


Classification Confidence Mask

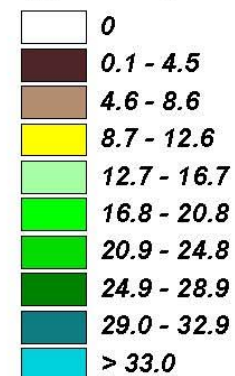
Second Most- Likely Class



United States MODIS Land Gross Primary Production 16 day total, March 26 - April 10, 2000



16 day total GPP
(gC / m²)

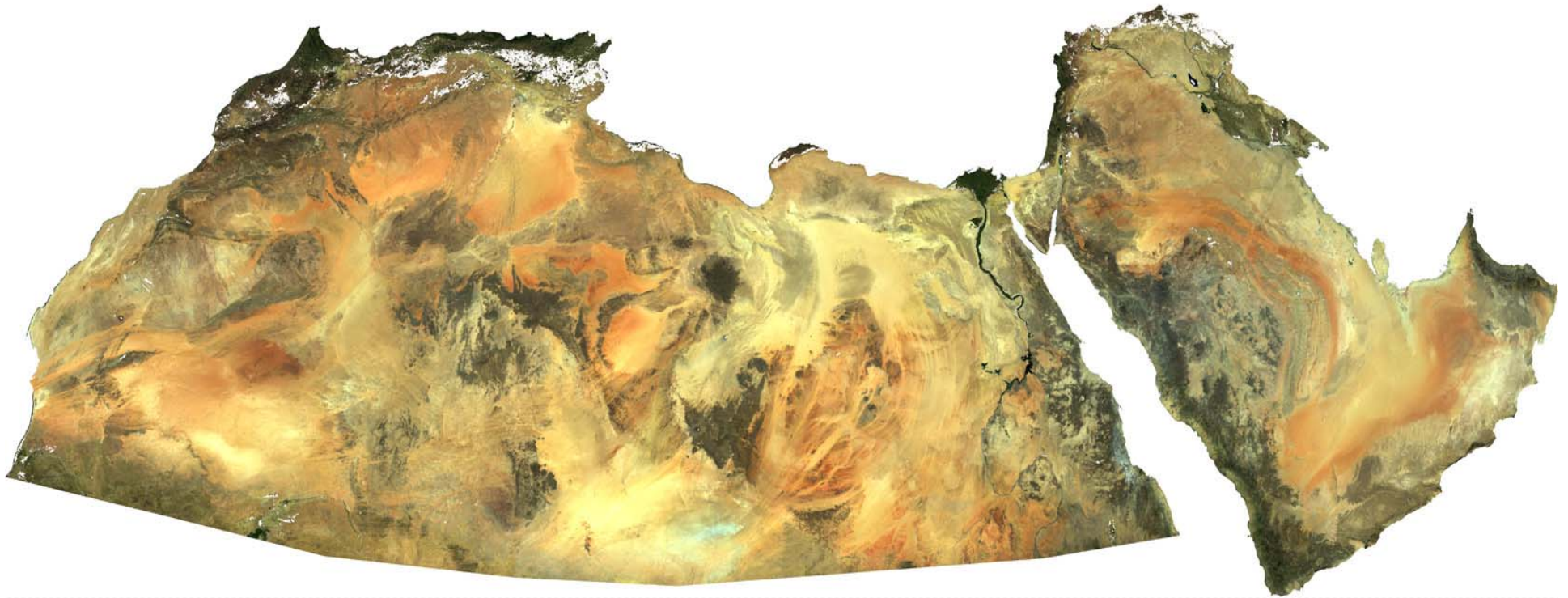


500 0 500 1000 1500 2000 Kilometers



University of Montana
MODIS-SCF / NTSG

Nadir BRDF-adjusted Reflectance (NBAR) North Africa



RGB true color

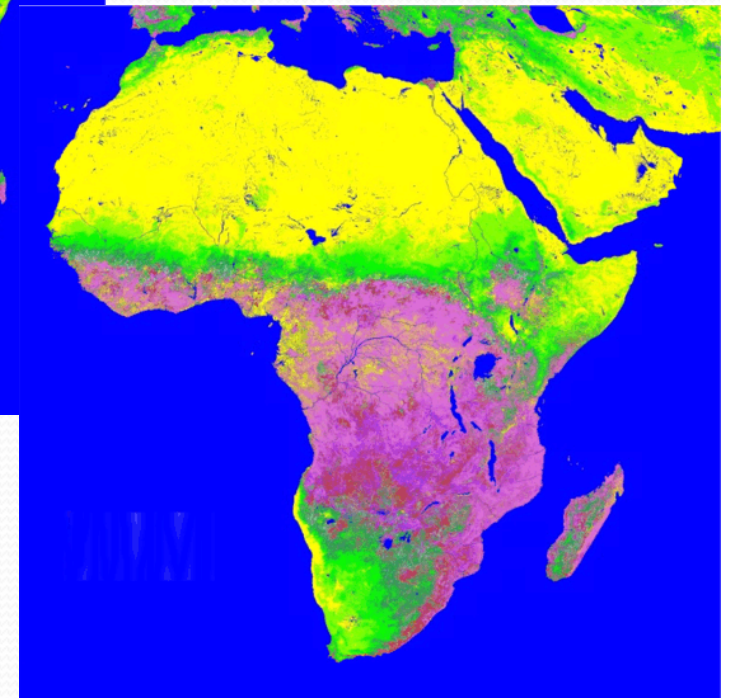
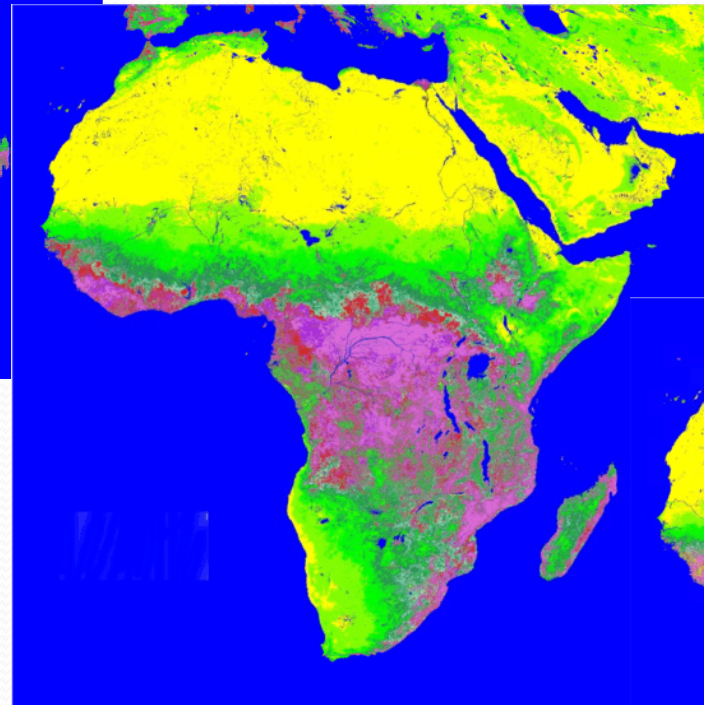
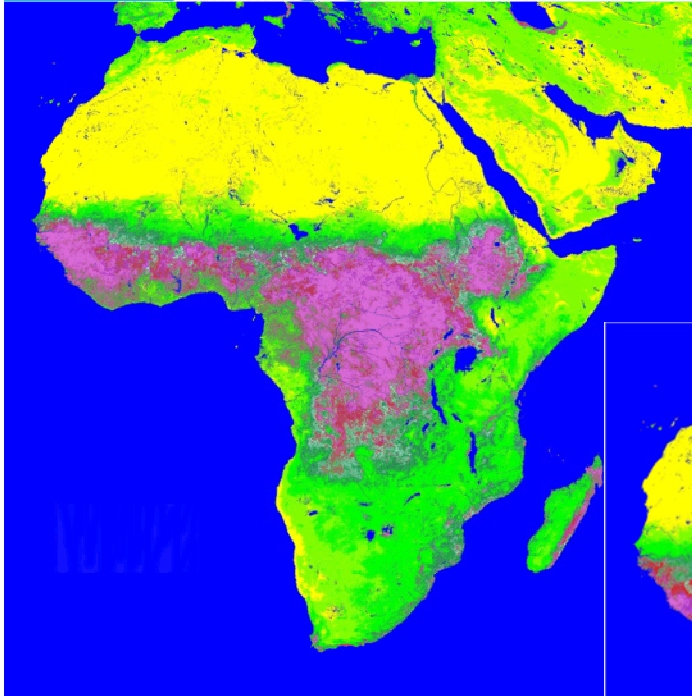
September 2000

MODIS Leaf Area Index

December 2000

Myneni et al

April 2001



0 3 6

Leaf area index is the biomass equivalent of FPAR, and is also a dimensionless ratio (m^2/m^2) of leaf area covering a unit of ground area.

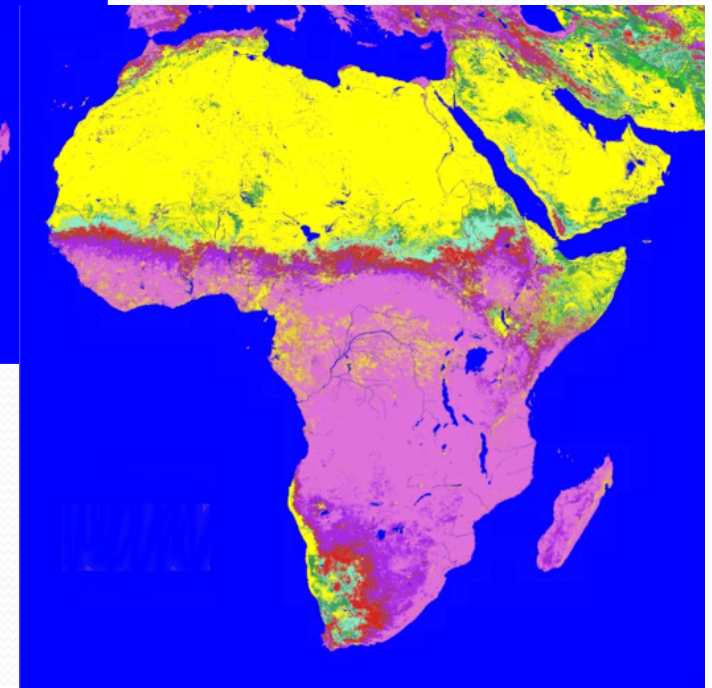
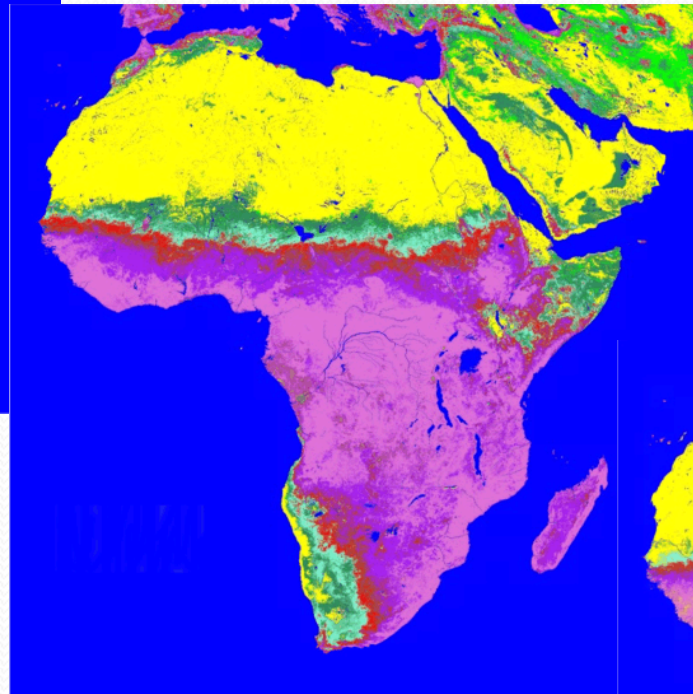
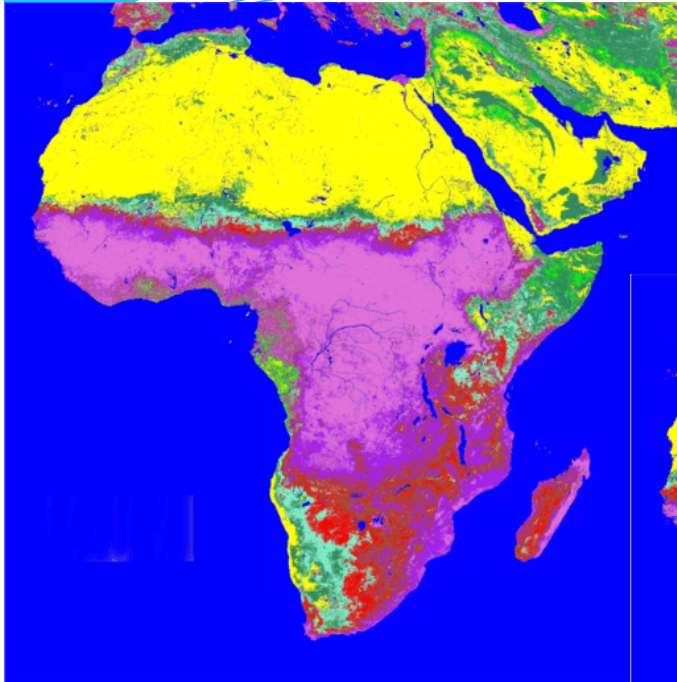
September 2000

MODIS FPAR

(Fraction of absorbed
Photosynthetically Active Radiation)

December 2000

April 2001

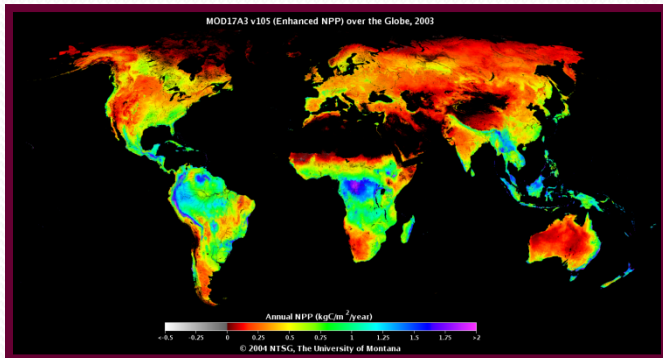


0 0.5 0.9

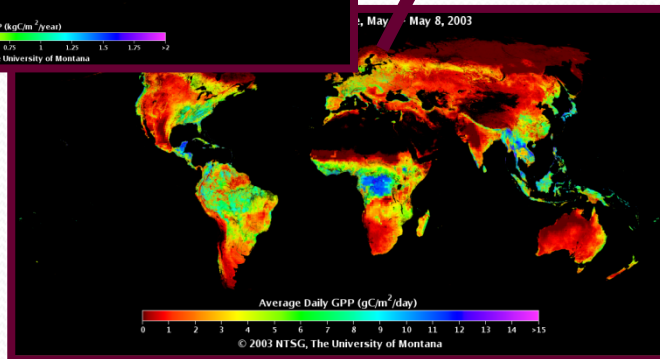
is expressed as a unitless fraction of
the incoming radiation received by
the land surface

MODIS NPP = Annual GPP - Autotrophic Respiration

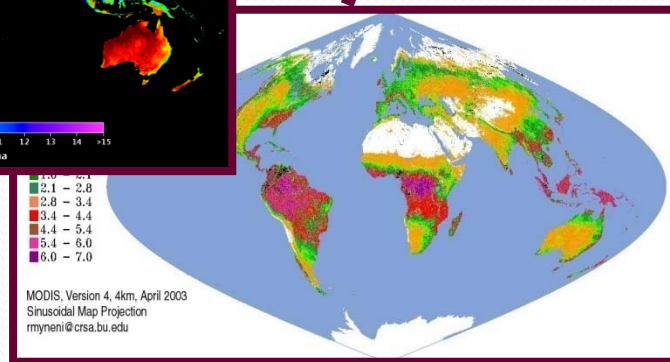
$$NPP = GPP - (R_m + R_g)$$



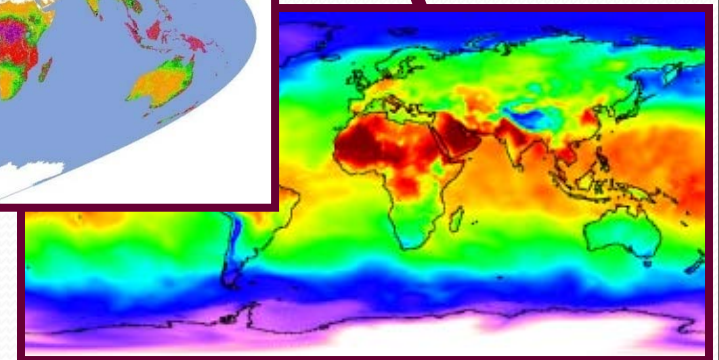
NPP



GPP



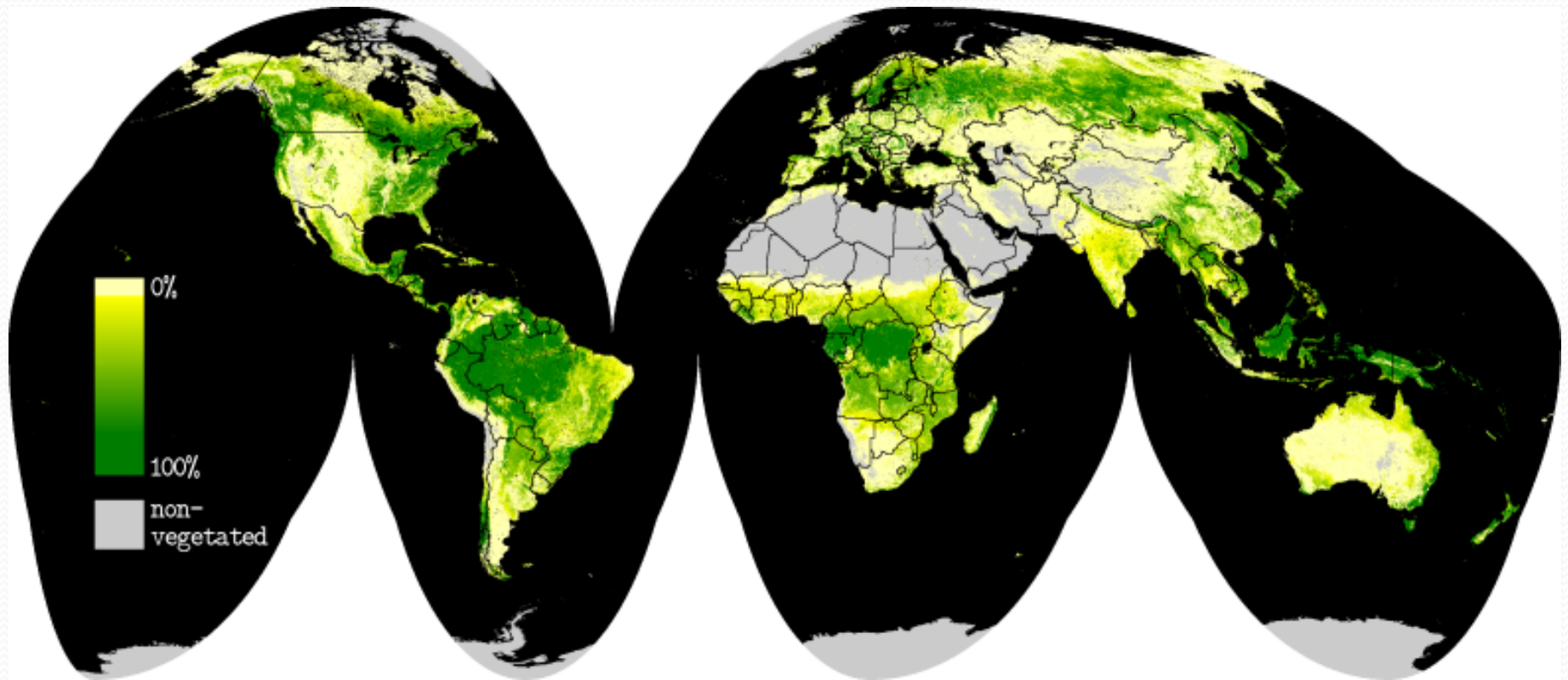
LAI



Temperature

Biome
Properties
Look-Up
Table

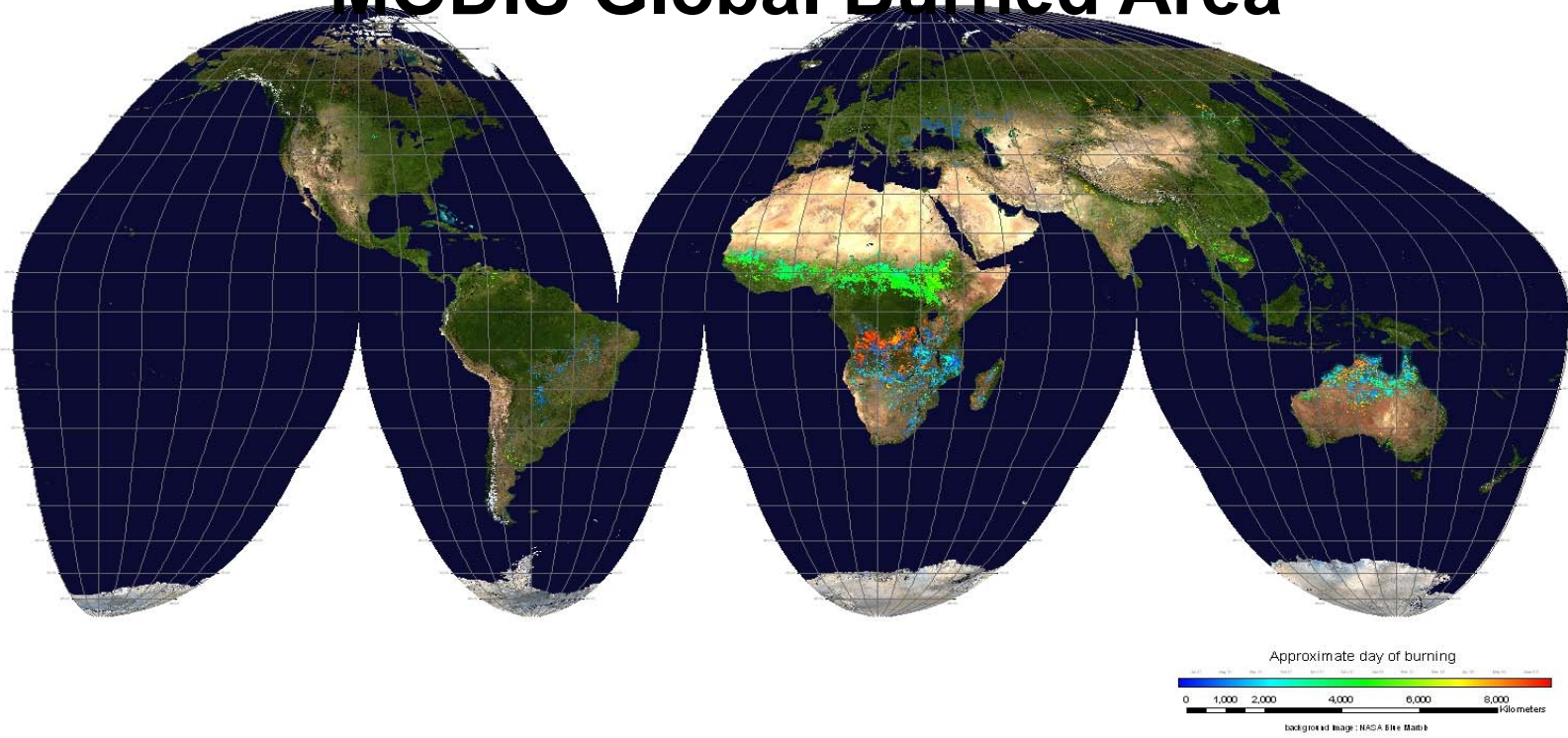
Vegetation Continuous Fields produced by year from MODIS at 250 m



Vegetation Continuous Fields Percent tree cover from MODIS year 2001.

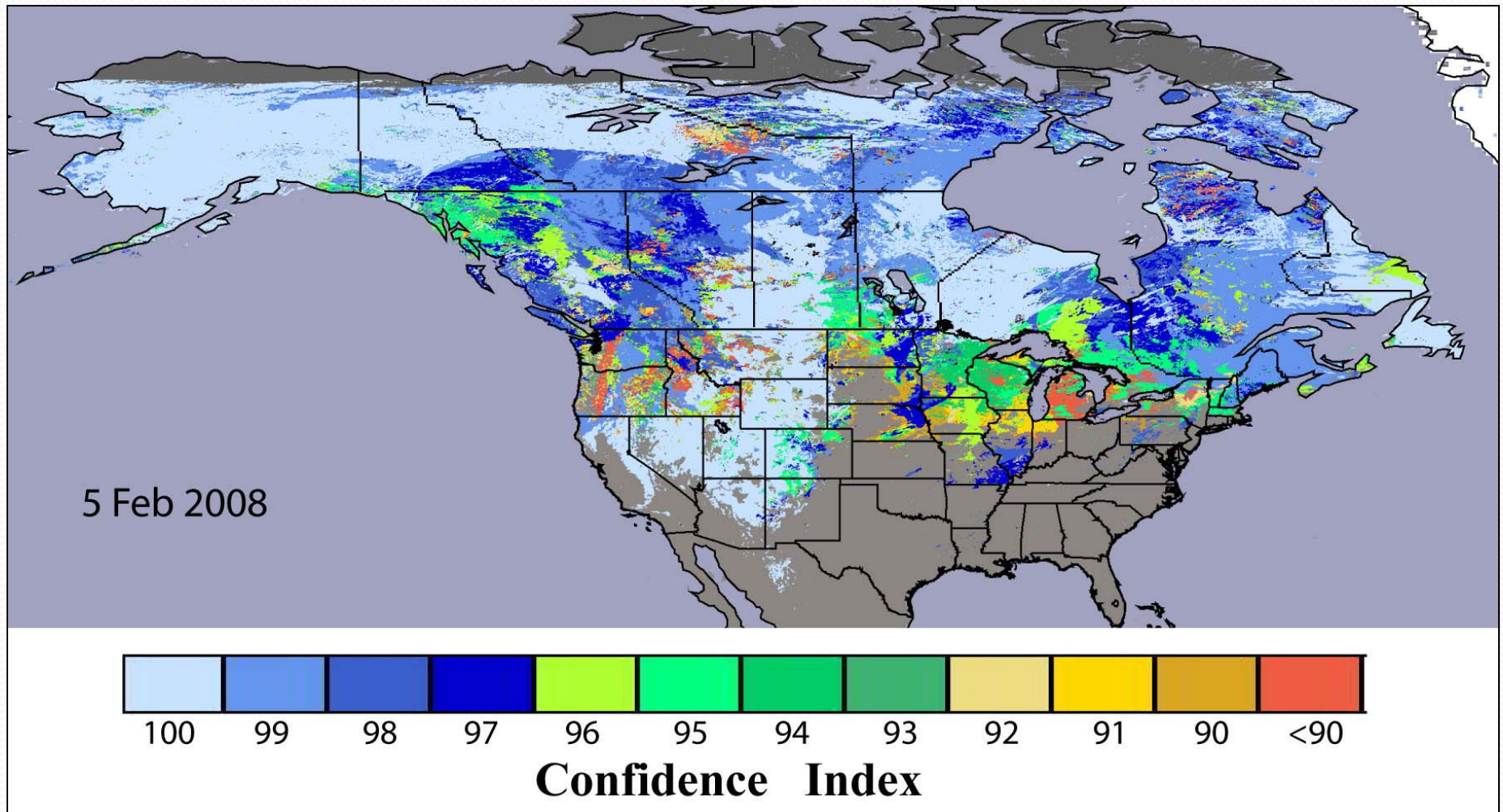
Slide from J. Townshend, UMD

MODIS Global Burned Area



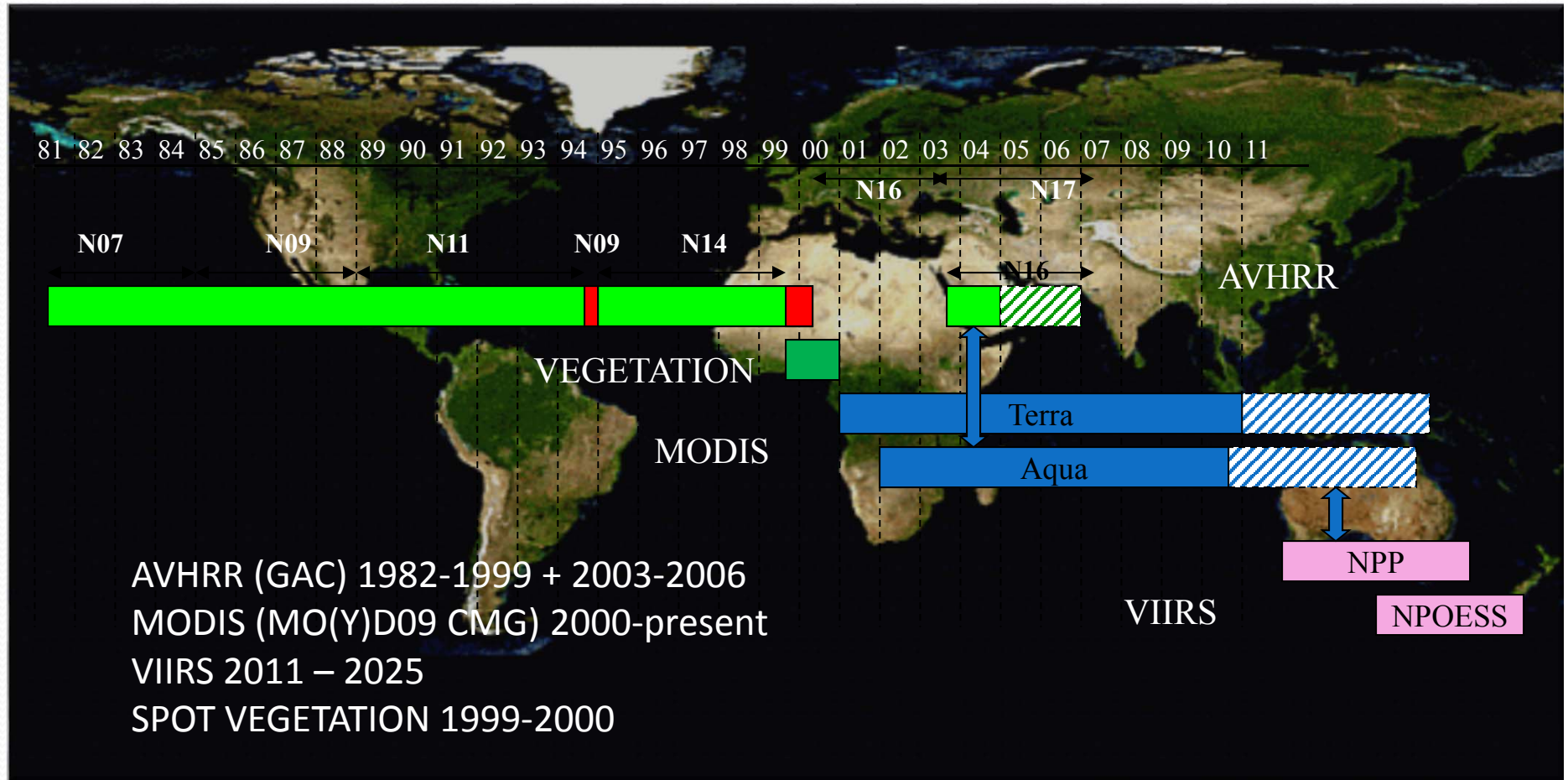
- Burned Area algorithm run **globally** for first time in MODIS C5 - purposefully running to map burned areas conservatively
- Burned areas are characterized by deposits of charcoal and ash, removal of vegetation, and alteration of the vegetation structure (Pereira et al. 1997, Roy et al. 1999).
- The MODIS algorithm used to map burned areas takes advantage of these spectral, temporal, and structural changes (Roy et al. 2005a).
- It detects the approximate date of burning at 500 m by locating the occurrence of rapid changes in daily surface reflectance time series data. The algorithm maps the spatial extent of recent fires and not of fires that occurred in previous seasons or years.

Snow Cover Cloud-Gap Filled (CGF) Product



Land Climate Data Record

Multi instrument/Multi sensor Science Quality Data Records used to quantify trends and changes



Emphasis on data consistency – characterization rather than degrading/smoothing the data

Eric Vermote et al.

Fire Information for Research Managers

The screenshot shows the NASA EarthData website interface. The browser address bar displays the URL: <https://earthdata.nasa.gov/earth-observation-data/near-real-time/firms>. The page header includes the EarthData logo, navigation links (ABOUT, DATA, COMMUNITY, RESOURCES), and a search bar. The main content area features a satellite map of the Pacific region with red dots indicating fire locations. Below the map, the page title is "Fire Information for Resource Management System (FIRMS)". The description states: "The Fire Information for Resource Management System (FIRMS) distributes Near Real-Time (NRT) active fire data within 3 hours of satellite overpass from both the Moderate Resolution Imaging Spectroradiometer (MODIS) and the Visible Infrared Imaging Radiometer Suite (VIIRS)." A dark blue button labeled "MODIS Active Fire Products" is visible. The left sidebar contains sections for "Data", "Disciplines", "Related Content", and "User Profile: Dave Johnson".

<https://earthdata.nasa.gov/earth-observation-data/near-real-time/firms>

<http://modis-fire.umd.edu/pages/ActiveFire.php?target=GetData>

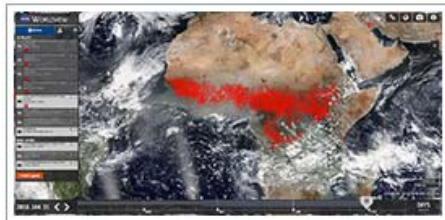
Active Fire Data Products:

<https://earthdata.nasa.gov/earth-observation-data/near-real-time/firms/active-fire-data>



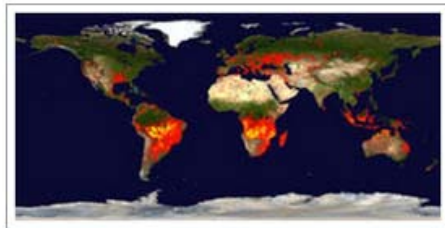
Interactively browse daily global MODIS and VIIRS fire locations and monthly MODIS burned areas through [Web Fire Mapper](#).

<https://firms.modaps.eosdis.nasa.gov/firemap/>



View MODIS and VIIRS active fire locations while interactively browsing global, full-resolution imagery in [Worldview](#).

<https://earthdata.nasa.gov/worldview>



Download [global 10-day fire maps](#) generated using the MODIS fire locations to represent the current fire activity around the world.

<https://lance-modis.eosdis.nasa.gov/cgi-bin/imagery/firemaps.cgi>