MODIS Land Products Overview

Land Remote Sensing Data Access Workshop
March 13-14, 2012

MODIS Land Products Overview

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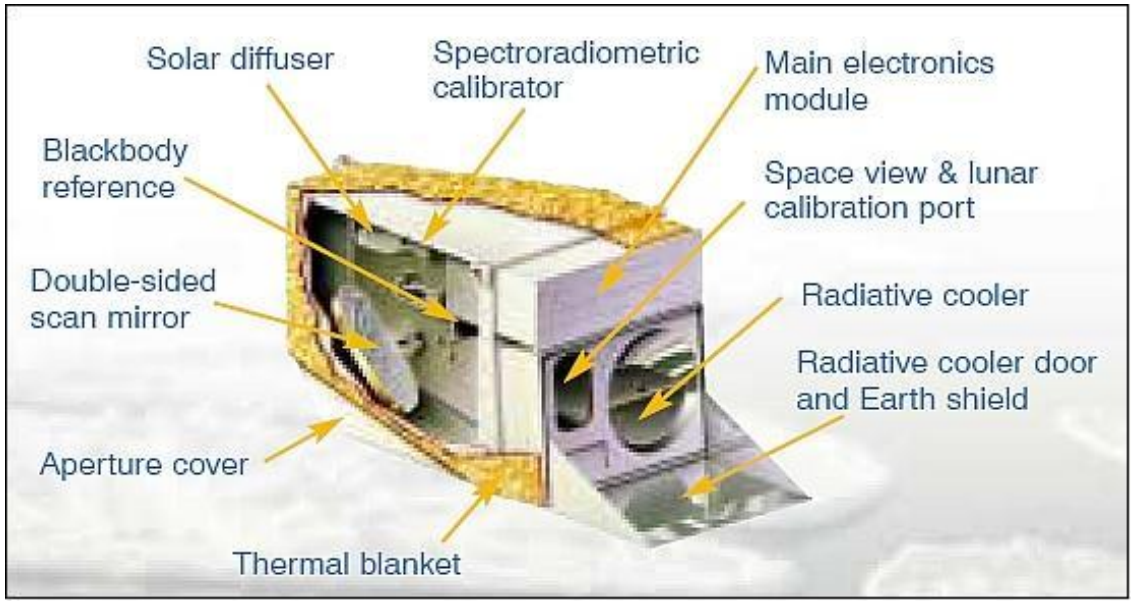
MODIS Mission Components (1/4)

MODIS stands for Moderate resolution Imaging Spectroradiometer, an instrument designed to measure large-scale global dynamics across land, oceans, and the atmosphere



The two almost identical MODIS instruments (aboard the Terra and Aqua platforms) generate daily, continuous, global, multispectral, multitemporal data that help build a holistic record of our Earth's parameters

MODIS Mission Components (2/4)

- The MODIS instrument is a multispectral, cross-track scanning radiometer that acquires continuous, global data at moderate resolutions between 250 m and 1000 m
- Terra MODIS passes from N to S across the equator in the morning (10:30)
- Aqua MODIS passes from S to N across the equator in the afternoon (13:30)

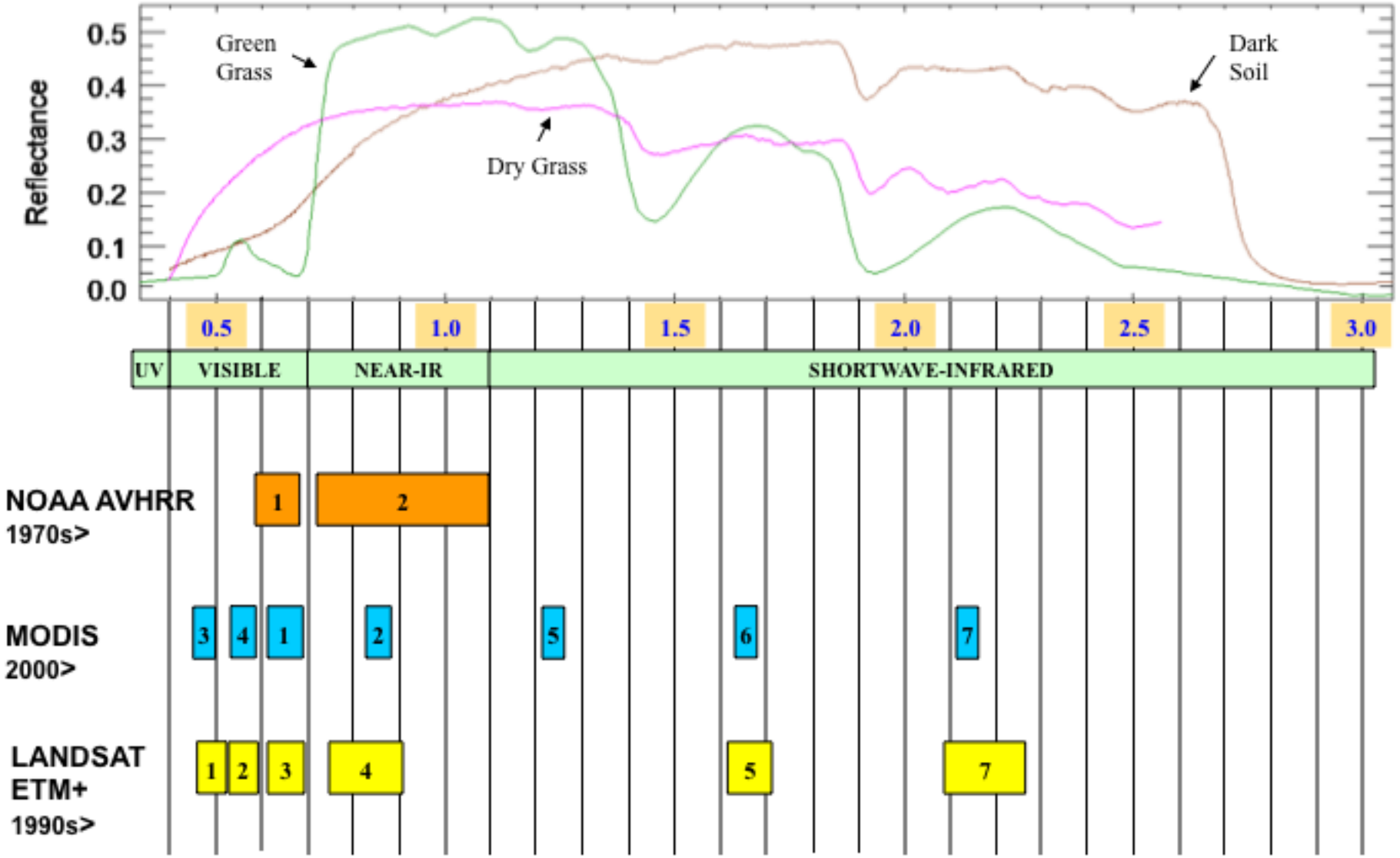
MODIS flies in a 705 km Sun-synchronous orbit with a ±55° off-nadir field-of-view, which produces a swath width of 2330 km in a single pass. This allows MODIS to observe any location twice daily in the mid to high latitudes (one daytime and one nighttime pass)

MODIS Mission Components (3/4)

MODIS Spectral Coverage

Band	(μm)	Res. (m)	Band	(μm)	Res. (m)	Band	(μm)	Res. (m)
1	0.62-0.67	250	13	0.662-0.672	1000	25	4.482-4.549	1000
2	0.841-0.876	250	14	0.673-0.683	1000	26	1.360-1.390	1000
3	0.459-0.479	500	15	0.743-0.753	1000	27	6.535-6.895	1000
4	0.545-0.565	500	16	0.862-0.877	1000	28	7.175-7.475	1000
5	1.230-1.250	500	17	0.890-0.920	1000	29	8.400-8.700	1000
6	1.628-1.652	500	18	0.931-0.941	1000	30	9.580-9.880	1000
7	2.105-2.155	500	19	0.915-0.965	1000	31	10.780-11.280	1000
8	0.405-0.420	1000	20	3.660-3.840	1000	32	11.770-12.270	1000
9	0.438-0.448	1000	21	3.929-3.989	1000	33	13.185-13.485	1000
10	0.483-0.493	1000	22	3.929-3.989	1000	34	13.485-13.785	1000
11	0.526-0.536	1000	23	4.020-4.080	1000	35	13.785-14.085	1000
12	0.546-0.556	1000	24	4.433-4.498	1000	36	14.085-14.385	1000

Spectral Sensitivity (AVHRR, MODIS, & Landsat)



Characteristics of MODIS Land Products (1/9)

Temporal	1-, 8-, 16-, 32-day, quarterly, yearly
Spatial	250 m, 500 m, 1000 m, 5600 m
Level-2	Derived geophysical variables at the resolution and location as the level-1 source data
Level-2G	Level-2 data mapped on uniform space-time grid scales
Level-3	Variables mapped on uniform space-time grid scales in derived spatial and/or temporal resolutions
Level-4	Model outputs or results from analyses of lower-level data

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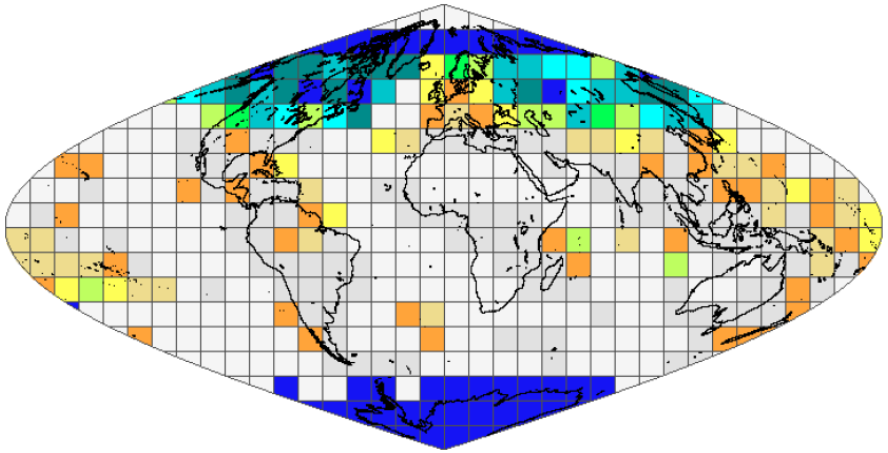
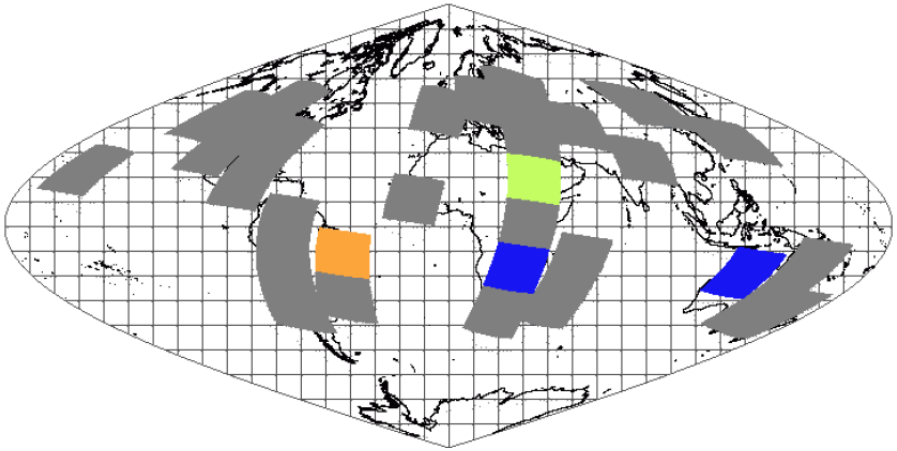
Grid-Tiled and Swath Product Structures (2/9)

MODIS L2G, L3, L4 Tiled Products



- daily, 8-day, 16-day, 32-day, monthly and yearly products
- defined in geolocated, fixed, non-overlapping, earth-located tiles
- each tile has an area of approximately 1200 x 1200 km (10° x 10° at the equator)
- 326 tiles contain land
- Sinusoidal + Lambert Azimuthal Equal-area (sea-ice products) map projections

MODIS L2 Swath Products



- retrieved geophysical parameters
- same swath location as the MODIS Level 1 instrument data
- not geometrically corrected into a grid
- 5 minutes of MODIS sensing, ~2000km x 2340km
- 288 granules/day

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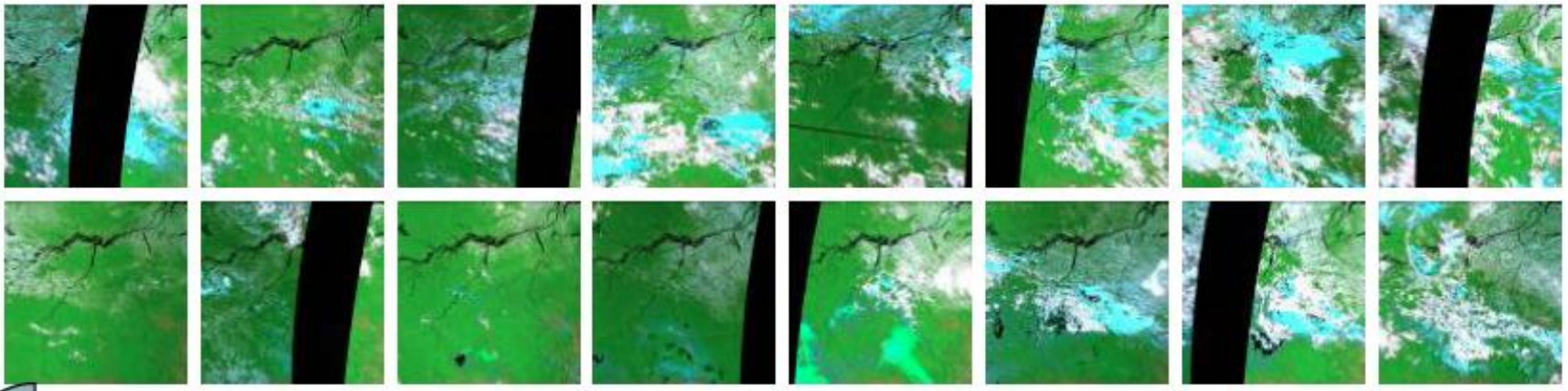
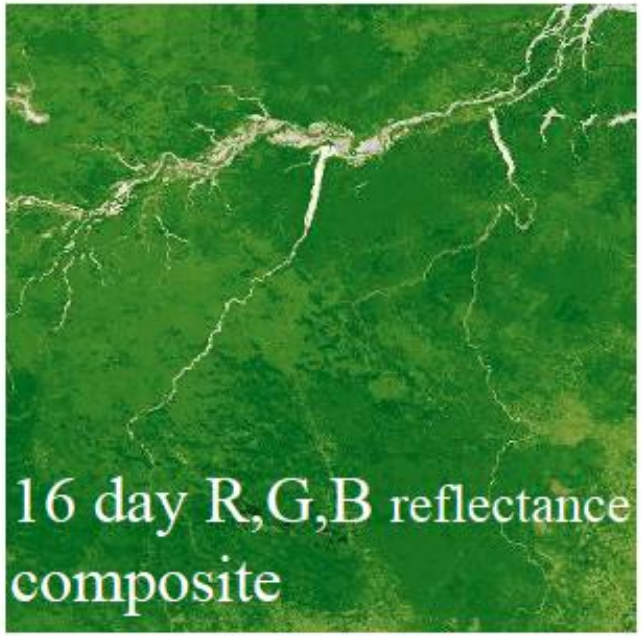
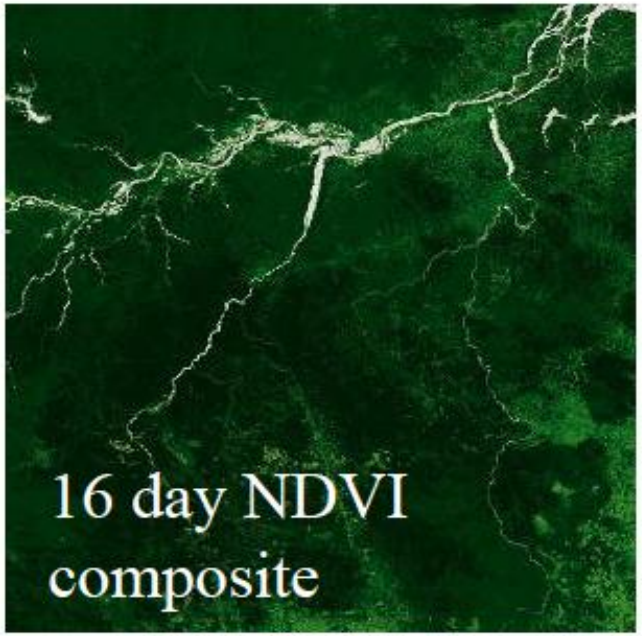
MODIS Land Product Composites (3/9)

16 days of MODIS daily surface reflectance product





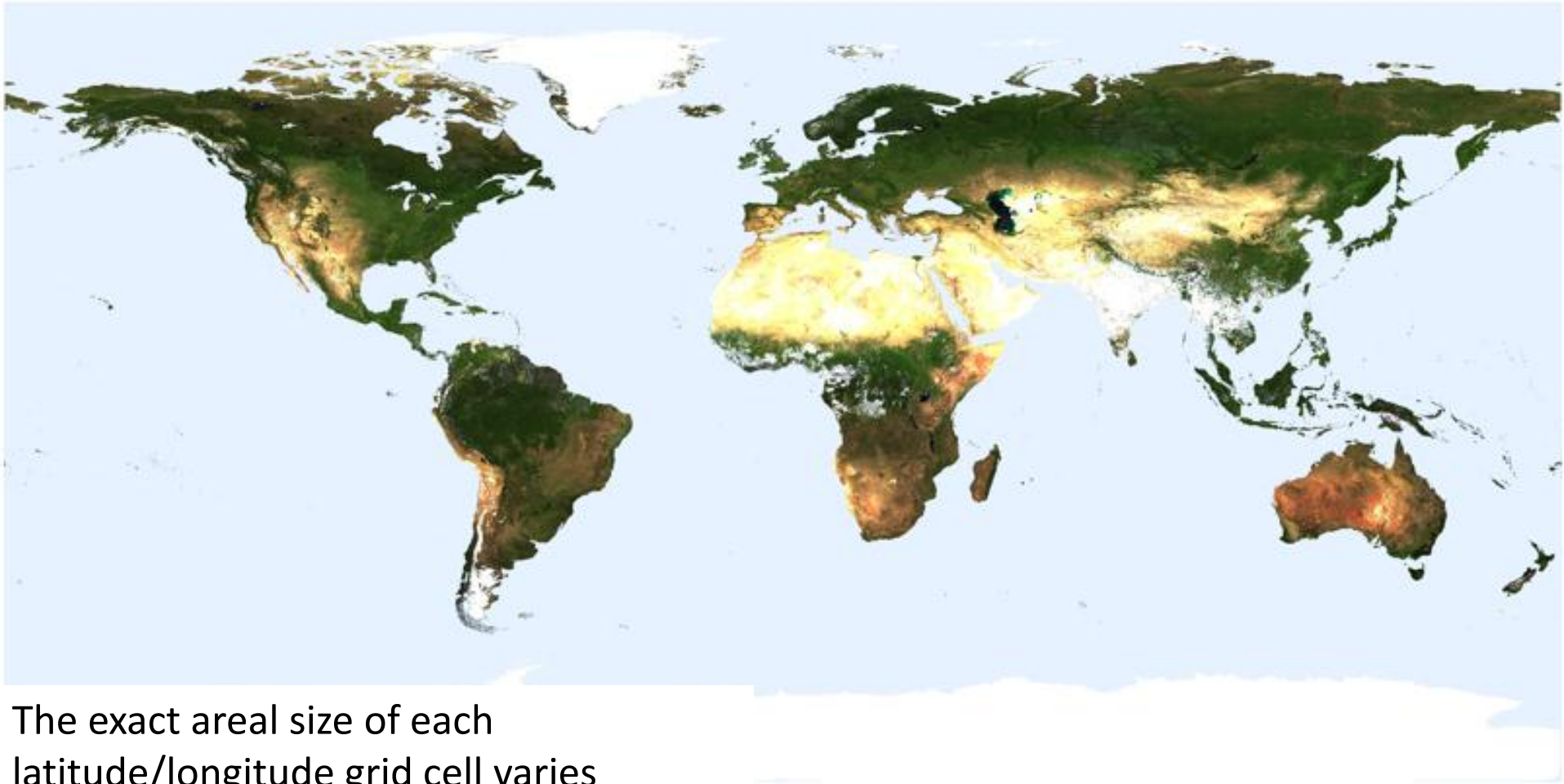


[Credit: D. Roy/SDSU]

[Source: A. Huete & K. Didan/UA]

Climate Modeling Grid Product Structure (4/9)

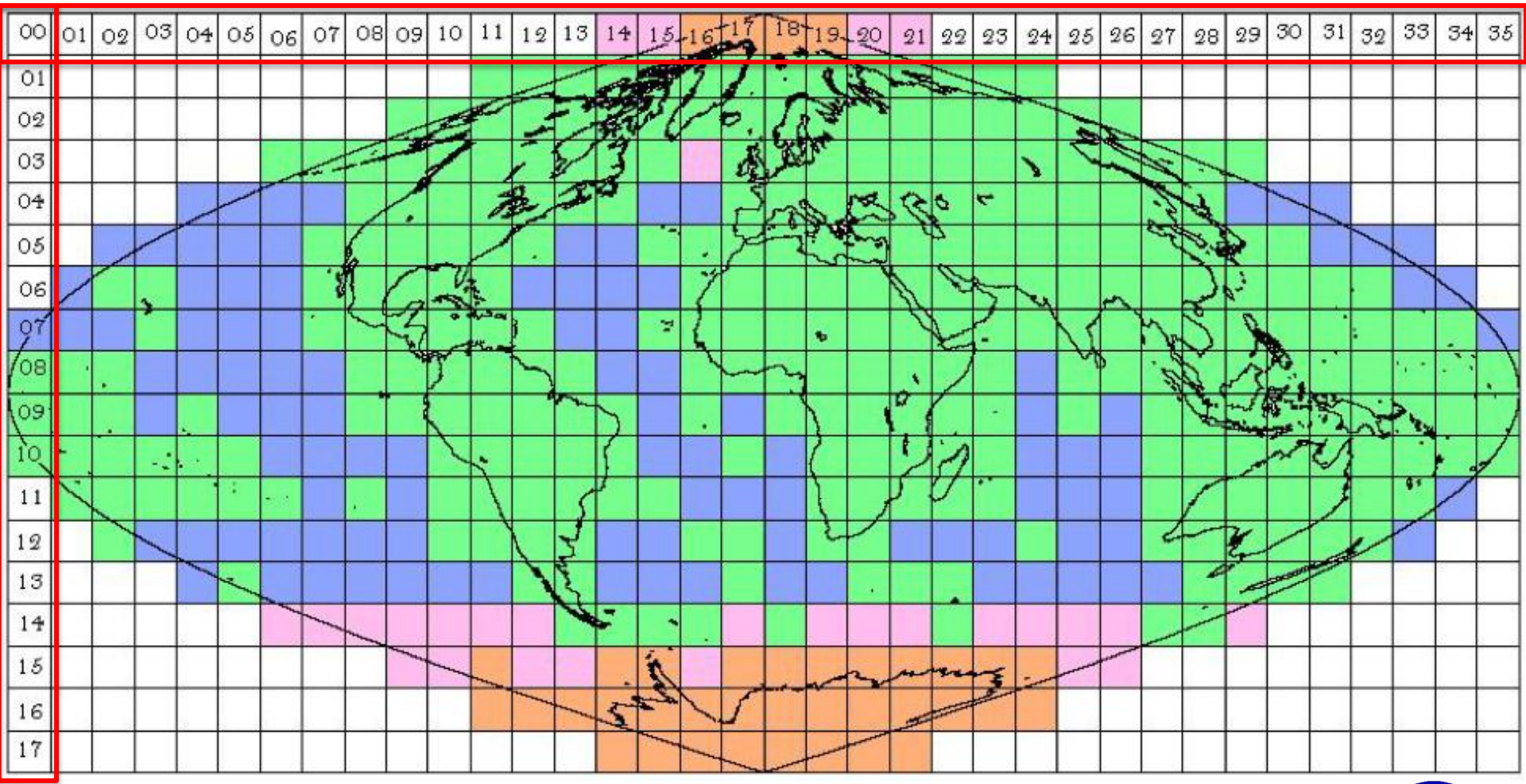
MODIS L3 Climate Modeling Grid Product



The exact areal size of each latitude/longitude grid cell varies with latitude. It measures 0.05˚ (5600 m) at the equator

Unique Features of the MODIS Land Products (5/9)

MODIS Tile Grid



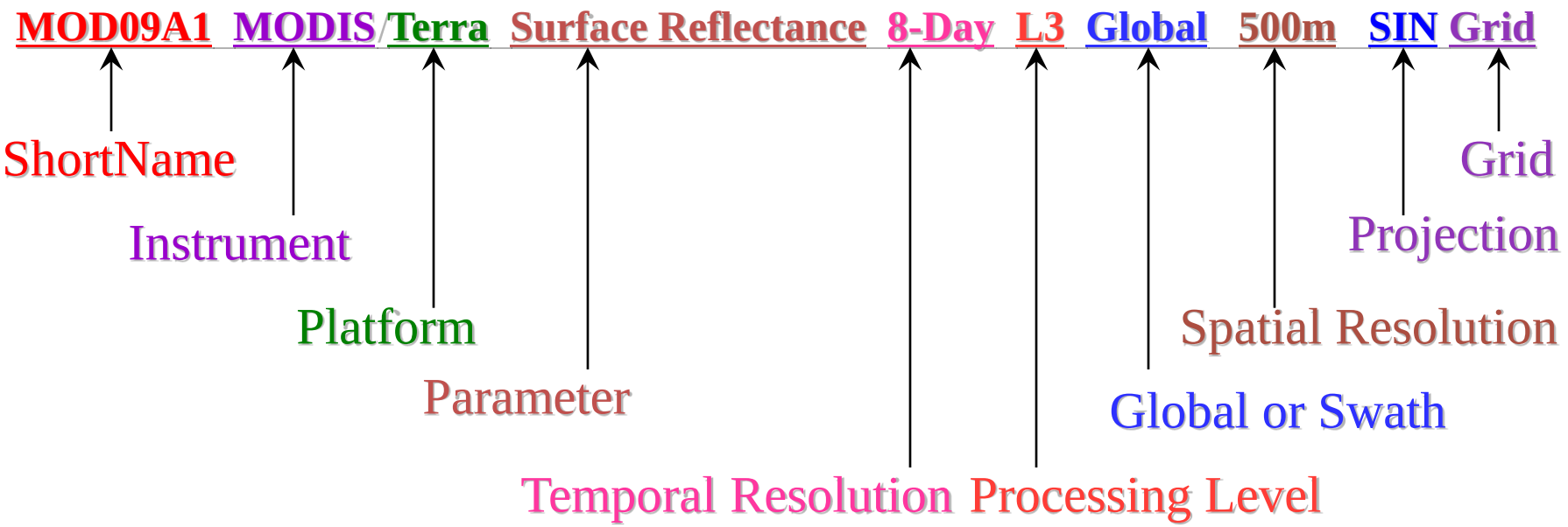
Unique Attributes of the MODIS Land Products (6/9)

HDF-EOS Data Format

- All MODIS land products are distributed in the Hierarchical Data Format – Earth Observing System (HDF-EOS) format. This data format is the standard version of HDF with EOS conventions, data types, and metadata added
- The principal distinction of HDF-EOS lies in its specification of three geolocation data types — swath, grid, and point — which allow querying the file contents by Earth coordinates and time
- Each HDF file contains several layers of data called **Science Data Sets** (SDS). The tree-like structure of SDSs in an hdf file allows the ability to store various kinds of data in separate files along with the actual geophysical values of the primary data product

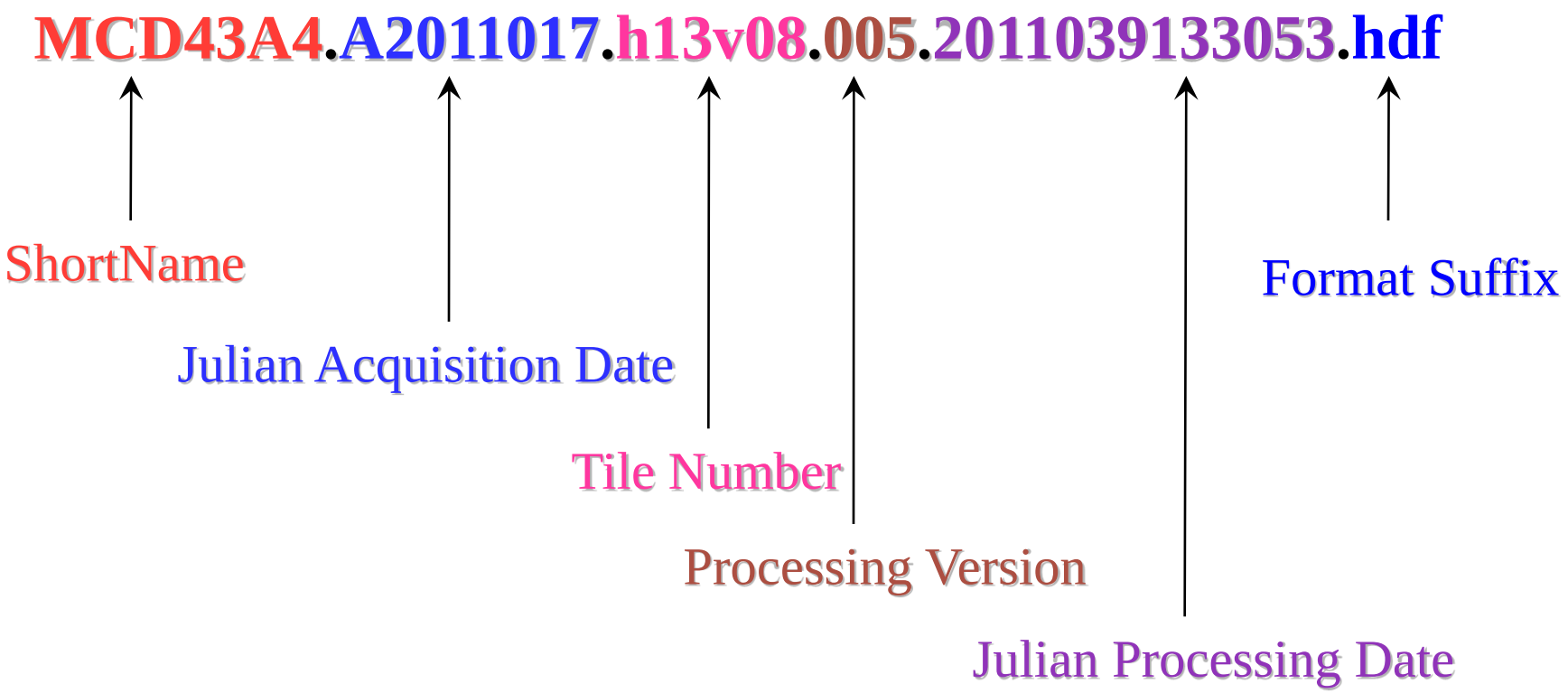
Unique Attributes of the MODIS Land Products (7/9)

Parsing a MODIS Product's Long Name



Unique Attributes of the MODIS Land Products (8/9)

Parsing a MODIS Dataset File Name



Unique Attributes of the MODIS Land Products (9/9)

MODIS Land Product Suite Identifiers

MOD/MYD 09	Land Surface Reflectance
MOD/MCD 43	BRDF & Albedo
MOD/MYD 11	Land Surface Temperature
MOD/MYD 14	Thermal Anomalies & Fire
MOD/MCD 12	Land Cover & Dynamics
MOD/MYD 13	Vegetation Indices
MOD/MYD/MCD 15	Leaf Area Index & FPAR
MOD/MYD 17	Gross & Net Primary Productivity
MOD 44	Vegetation Continuous Fields
MCD 45	Burned Area

MOD = Terra **MYD = Aqua** **MCD = Combined**

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MODIS Land Products & Applications (1/37)

MODIS Land Product Suites

Radiation Budget Variables	Ecosystem Variables	Land Cover Characteristics
Land Surface Reflectance	Vegetation Indices	Land Cover and Vegetation Dynamics
Land Surface Temperature and Emissivity	Leaf-Area Index/Fraction of Photosynthetically Active Radiation	Thermal Anomalies, Fire, and Burned Area
Bi-directional Reflectance Distribution Function/Albedo	Gross Primary Productivity/Net Primary Production	Vegetation Continuous Fields

MODIS Land Products & Applications (2/37)

Radiation Budget Variables

Satellite-derived remote sensing data provide fundamental measurements of surface radiance and brightness temperature. The surface radiation family includes the following product suites:

- **Land Surface Reflectance**
- **Land Surface Temperature & Emissivity**
- **Bi-directional Reflectance Distribution Function & Albedo**
- **Snow & Sea-Ice Cover**

MODIS Land Products & Applications (3/37)

Land Surface Reflectance (MOD09)

- MODIS land surface reflectance is an estimate of the surface spectral reflectance for each band as measured at ground level in the absence of atmospheric scattering or absorption. The effects of atmospheric gases and aerosols are also corrected
- Surface reflectance is a seven-band product derived from the MODIS level-1B land bands 1–7

MODIS Land Products & Applications (4/37)

LSR as a primary input for higher-level products

- The most basic remotely sensed surface parameter, surface reflectance provides the primary input to derive essentially all higher-level surface geophysical parameters, including VI, BRDF/Albedo, LAI/FPAR, Burned Area, Land Cover, Thermal Anomalies, and Snow Cover

MODIS Land Products & Applications (5/37)

Land Surface Temperature & Emissivity (MOD11)

- MODIS land surface temperature (LST) measures the thermal radiation emitted by the Earth's land surface derived from satellite observations. Also called "skin temperature," LST is different from "air" or "meteorological" temperature
- LST refers to the canopy in vegetated areas or soil surface in bare areas
- LST products exist as a sequence from daily swath (5-min) through daily, 8-day, and monthly global grid-tiled and CMG products

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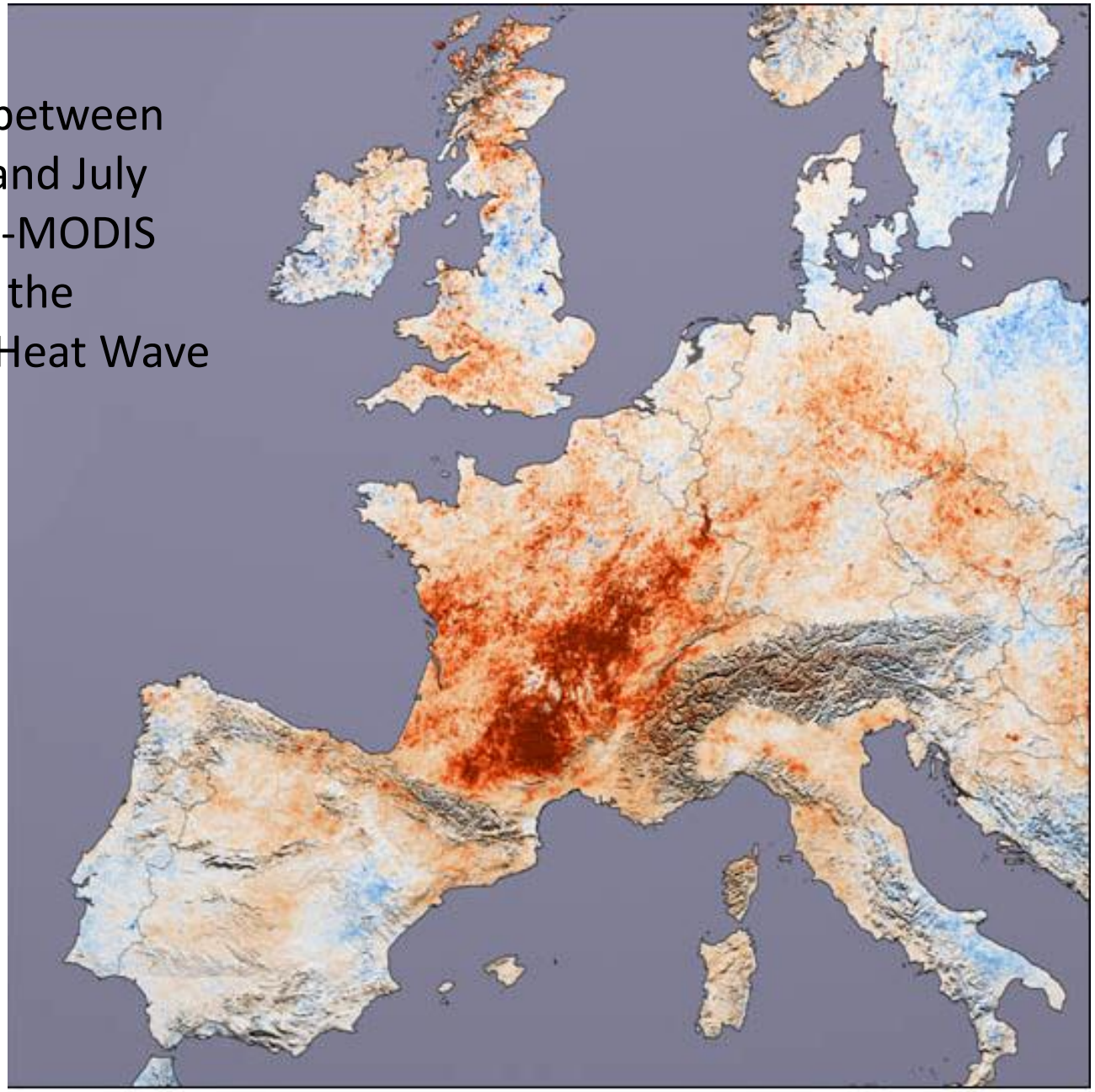
Contrasts between July 2001 and July 2003 Terra-MODIS LST during the European Heat Wave



MODIS Land Products & Applications (7/37)

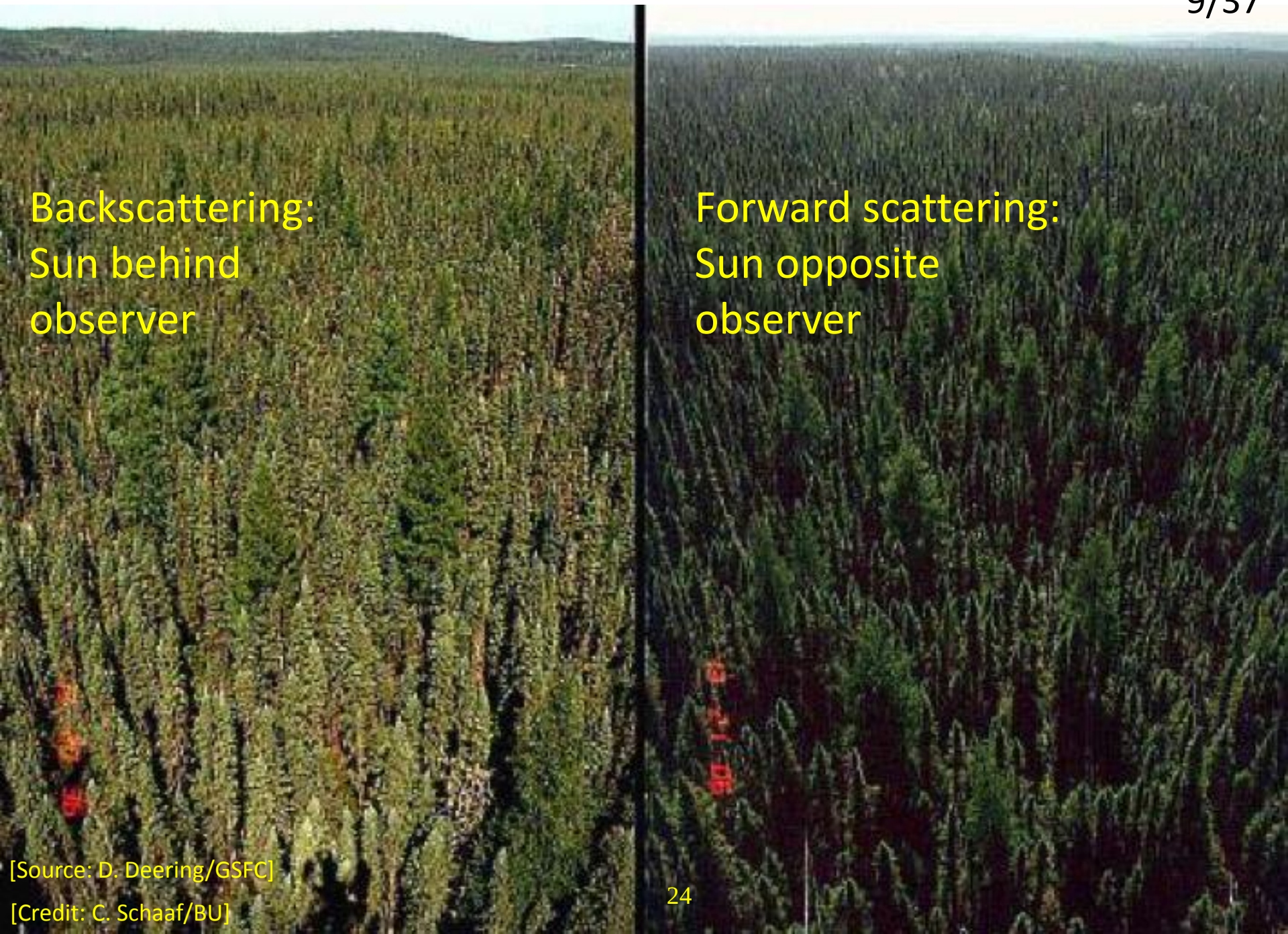
Application Relevance of LST Products

- The multi-year daytime & nighttime LSTs help us understand the spatial & temporal distribution of the warming & cooling of the land surface in response to regional & global climate changes
- LSTs also help us better understand surface-atmosphere interactions and energy fluxes between the atmosphere and Earth's surface

MODIS Land Products & Applications (8/37)

BRDF & Albedo (MCD43)

- BRDF simply describes what we generally observe daily: Objects look differently when viewed from different angles, and when illuminated from different directions
- BRDF explains why painters and photographers explore the appearance of trees and other objects of interest under varying illumination conditions (sunlight, shadows, etc.)
- BRDF describes how light is reflected from an opaque surface as a function of illumination and viewing geometries. Dependent on wavelength, BRDF is determined by the structural and optical properties of the target's surface



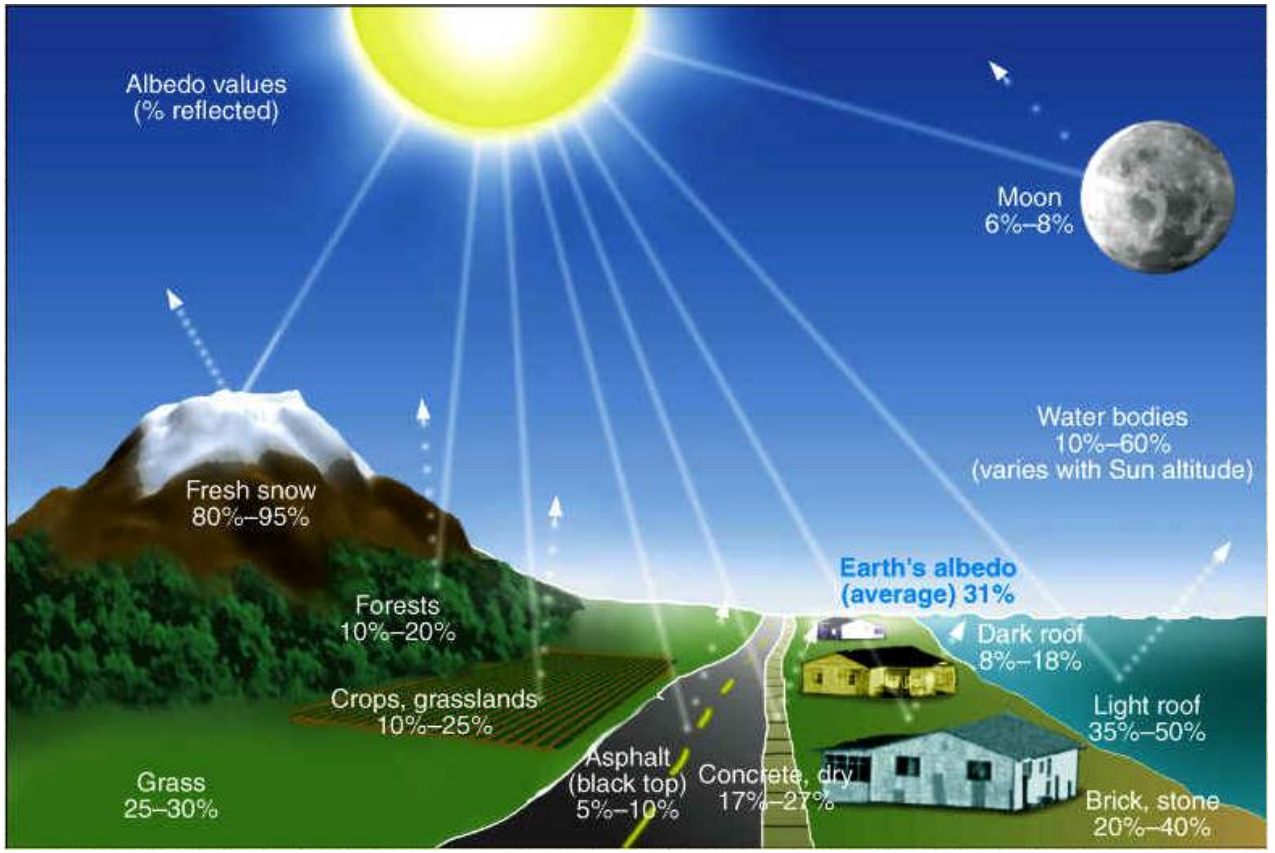
[Source: D. Deering/GSFC]

[Credit: C. Schaaf/BU]

MODIS Land Products & Applications (10/37)

Albedo

Albedo is the fraction of solar energy reflected back from Earth into space, and is a measure of the Earth surface's reflectivity



The nature of illumination (direct vs. diffuse) determines two kinds of albedo: directional hemispherical & bi-hemispherical

MODIS Land Products & Applications (11/37)

Application Relevance of BRDF & Albedo Products

- BRDF & Albedo products help us better understand how the Earth uses solar energy. For example, observation patterns of bright snow and dark vegetation through the winter months provide additional clues to understand and improve our climate prediction models
- BRDF models play a key role in the inference of land surface parameters (LAI, FPAR etc.) at regional & global scales by helping us better understand the transfer of energy and mass between terrestrial ecosystems and the atmosphere
- Albedo-informed global surface reflectance is very useful to monitor annual growth cycles of crops and vegetation besides evaluating drought conditions

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MODIS Land Products & Applications (12/37)

Ecosystem Variables

Remote sensing technology has enabled us to study plant physiology from a global perspective; previously, it was only possible to study such phenomena in response to local dynamics and local environmental changes. MODIS science provides three product suites that contribute to a global perspective on vegetation ecology:

- **Vegetation Indices**
- **Leaf Area Index & Fraction of Photosynthetically Active Radiation**
- **Gross Primary Production & Net Primary Productivity**

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MODIS Land Products & Applications (13/37)

Vegetation Indices (M*D 13)

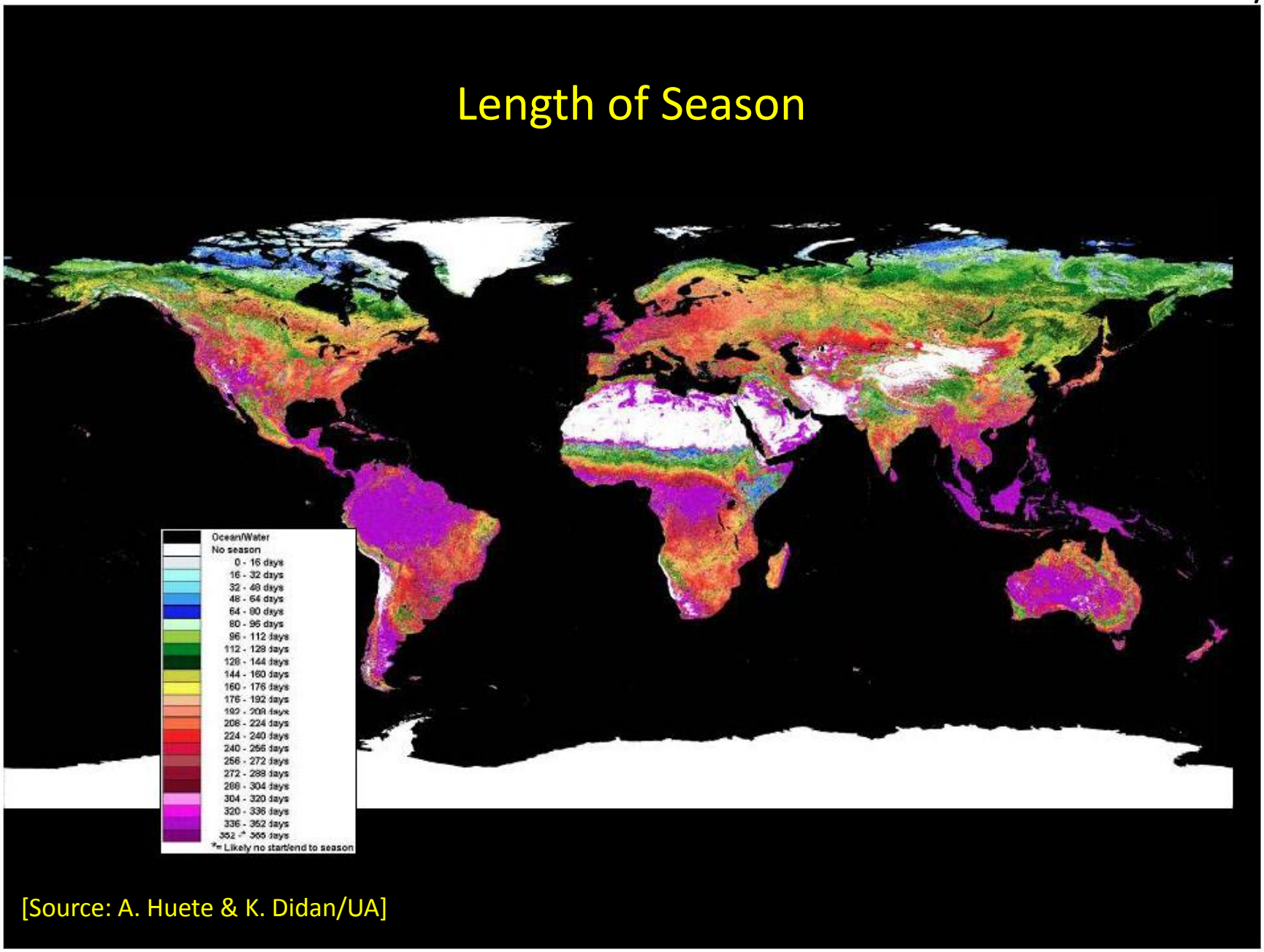
- Vegetation Indices (VI) are optical remote sensing data-derived measures of vegetation greenness. Although not intrinsic physical quantities, VIs are useful as proxies to assess a number of canopy properties & biophysical processes
- Canopy properties include Leaf Area Index (LAI), Fraction of absorbed Photosynthetically active Radiation (FPAR), Chlorophyll content, & Green vegetation fraction
- Canopy biophysical variables include photosynthesis and transpiration

MODIS Land Products & Applications (14/37)

Vegetation Indices (M*D 13)

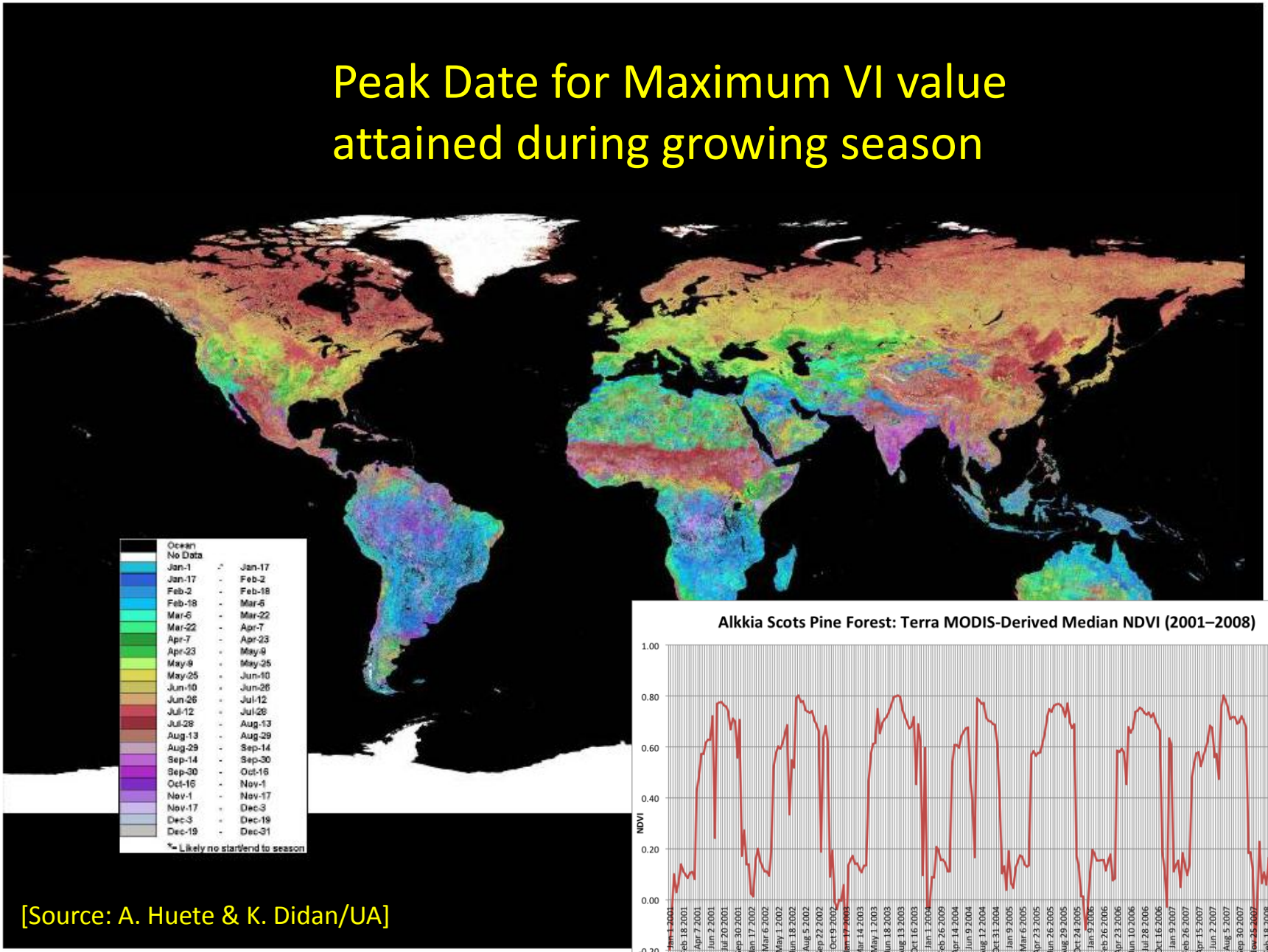
- One of the most common applications of VI products is to study phenology
- Phenology is the study of the timing associated with periodic plant and animal life-cycle events, and their relationship with seasonal and interannual variations in climate
- The following two slides provide examples of VI applications to derive length of season, and peak VI values attained during growing season

Length of Season



[Source: A. Huete & K. Didan/UA]

Peak Date for Maximum VI value attained during growing season

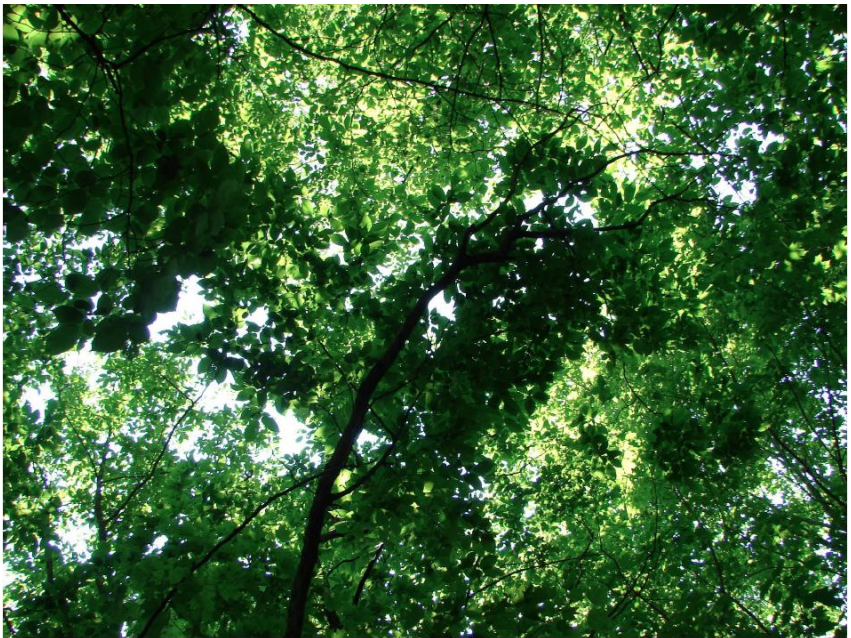


[Source: A. Huete & K. Didan/UA]

MODIS Land Products & Applications (17/37)

LAI & FPAR (M*D15)

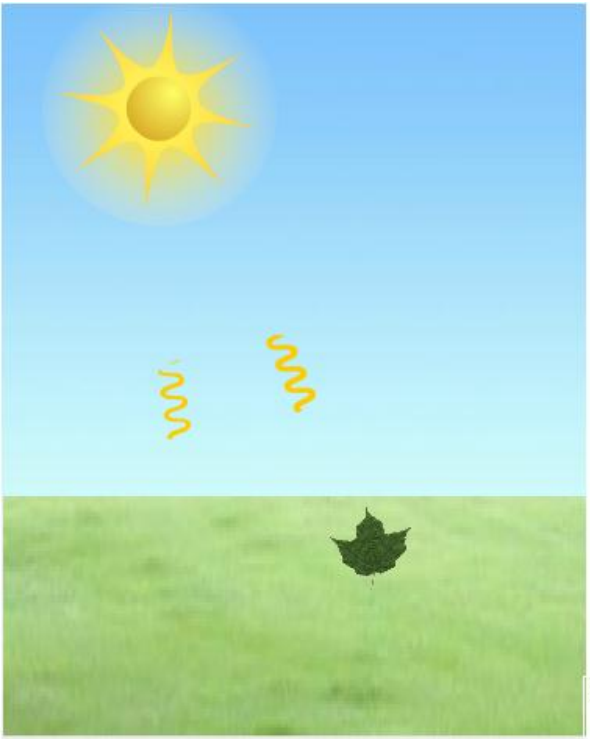
- Leaf Area Index (LAI) is a dimensionless variable defined as the total one-sided area of green leaves in a vegetation canopy relative to a unit ground area. LAI ignores canopy details such as leaf angle distribution, canopy height or shape
- The fundamental difference between LAI & FPAR is that LAI is a structural variable while FPAR is a radiation-derived variable

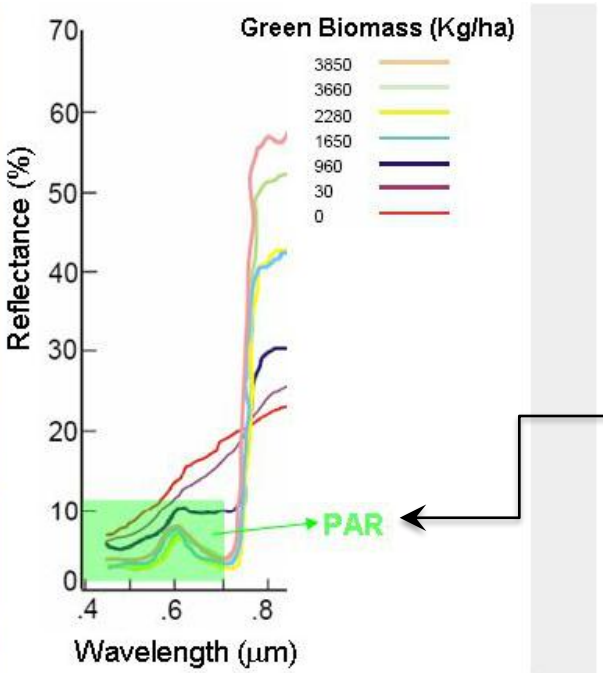


MODIS Land Products & Applications (18/37)

FPAR

Fraction of Photosynthetically Active Radiation absorbed by vegetation (FPAR) is also a dimensionless variable defined as the fraction of the photosynthetically active radiation absorbed by vegetation. FPAR is directly related to the primary productivity function of photosynthesis, and therefore, used to estimate the assimilation of CO_2 in vegetation





Spectral behaviour of materials with different green biomass quantities (Adapted from Jensen, J. R., 2000).

Solar radiation incident on the surface in the 0.4 – 0.7µm spectral window is called photosynthetically active radiation (PAR)

MODIS Land Products & Applications (19/37)

Application Relevance of VI, LAI and FPAR Products

- VI products are used to monitor vegetation dynamics, landscape phenology, and productivity
- LAI represents the amount of leaf material within an ecosystem, and therefore an important link between the biosphere and atmosphere, and as a parameter to predict primary production
- FPAR helps evaluate the exchange of carbon between the atmosphere and terrestrial vegetation, which provides valuable inputs to analyze global carbon budgets

MODIS Land Products & Applications (20/37)

GPP and NPP (M*D17)

- Gross Primary Production: GPP is the total amount of carbon dioxide captured and stored (in an ecosystem) through photosynthesis in a given time period
- Photosynthesis is a chemical process driven by sunlight energy, which converts carbon dioxide into organic compounds, especially sugars, by reducing CO_2 to carbohydrates
- Net Primary Productivity: NPP is the remaining fraction of biomass produced after accounting for energy spent due to cellular respiration and maintenance of plant tissue
- Thus, **NPP = GPP – respiration**

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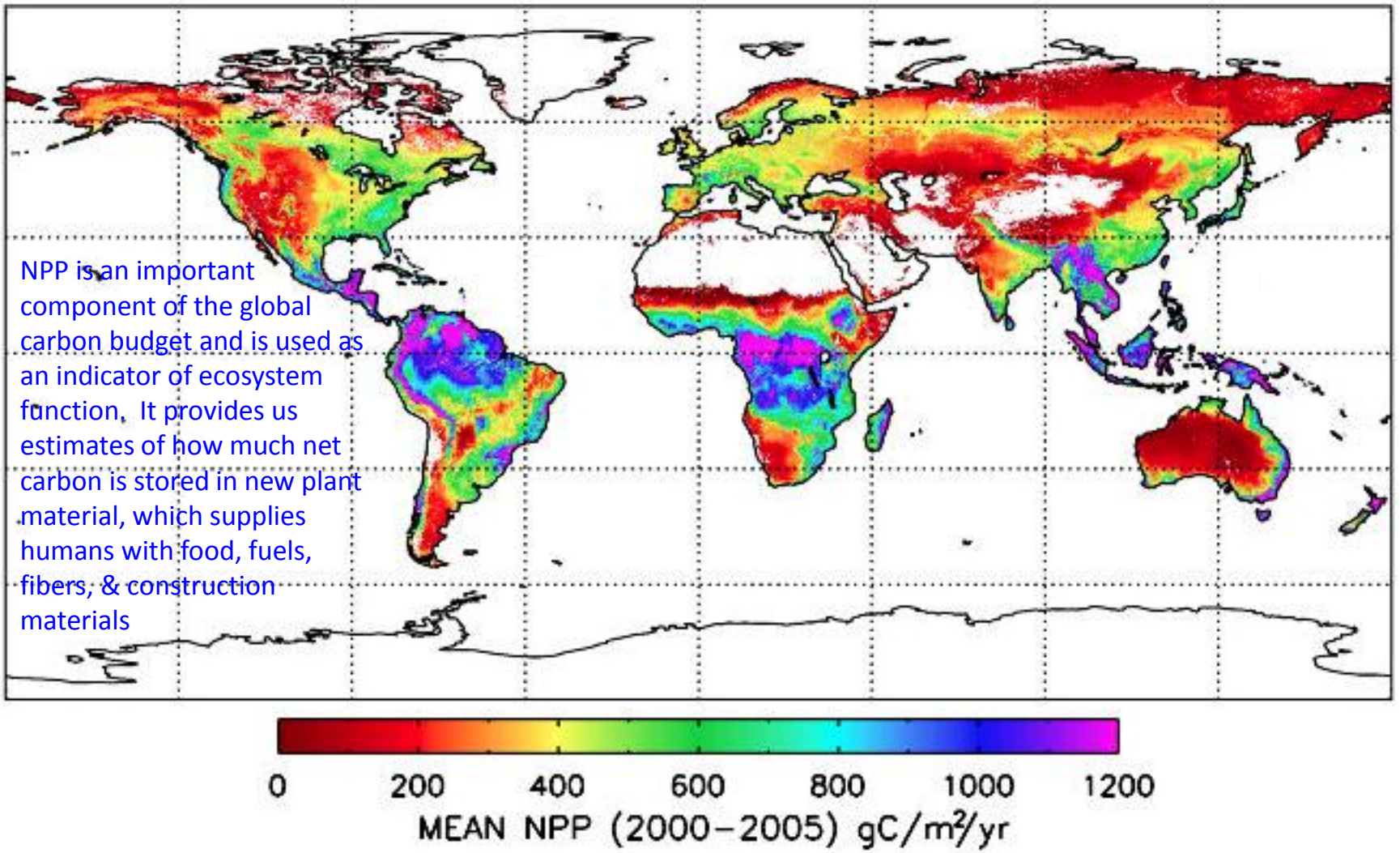
Global Mean NPP (21/37)



[Source: Numerical Terradynamic Simulation Group/UMT]

MODIS Land Products & Applications (22/37)

Application Relevance of GPP & NPP Products

- NPP products help delineate environmental changes that include deforestation, desertification, fires, insect outbreaks, and impacts of pollution and climate change on ecosystem health and services
- MODIS GPP data have been used to predict deer mice population densities at known trapping sites. These rodent populations are a primary host for the Sin Nombre virus, which is the infectious disease agent for Hantavirus pulmonary syndrome

MODIS Land Products & Applications (23/37)

Land Cover Characteristics

The impact of human activities in transforming Earth's surface is constantly felt by ecosystems across the globe. The consequences highlight on the strong linkages between land cover, energy exchange & dynamics, and the biogeochemical cycles. Three MODIS products suites address these concerns:

- **Land Cover & Vegetation Dynamics**
- **Thermal Anomalies, Fire, & Burned Area**
- **Vegetation Continuous Fields**

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MODIS Land Products & Applications (24/37)

Land Cover Type (MCD12Q1)

- Land cover is defined as the biophysical state (including biotic & abiotic properties) of the land surface
- The MODIS Land Cover Type product contains five classification schemes, which describe land cover properties derived from observations spanning a year's input of Terra and Aqua data

The five land cover classification schemes include:

1. Land Cover Type 1: IGBP global vegetation classification scheme
2. Land Cover Type 2: Univ. of Maryland (UMD) scheme
3. Land Cover Type 3: MODIS-derived LAI/FPAR scheme
4. Land Cover Type 4: MODIS-derived NPP scheme
5. Land Cover Type 5: Plant Functional Type scheme

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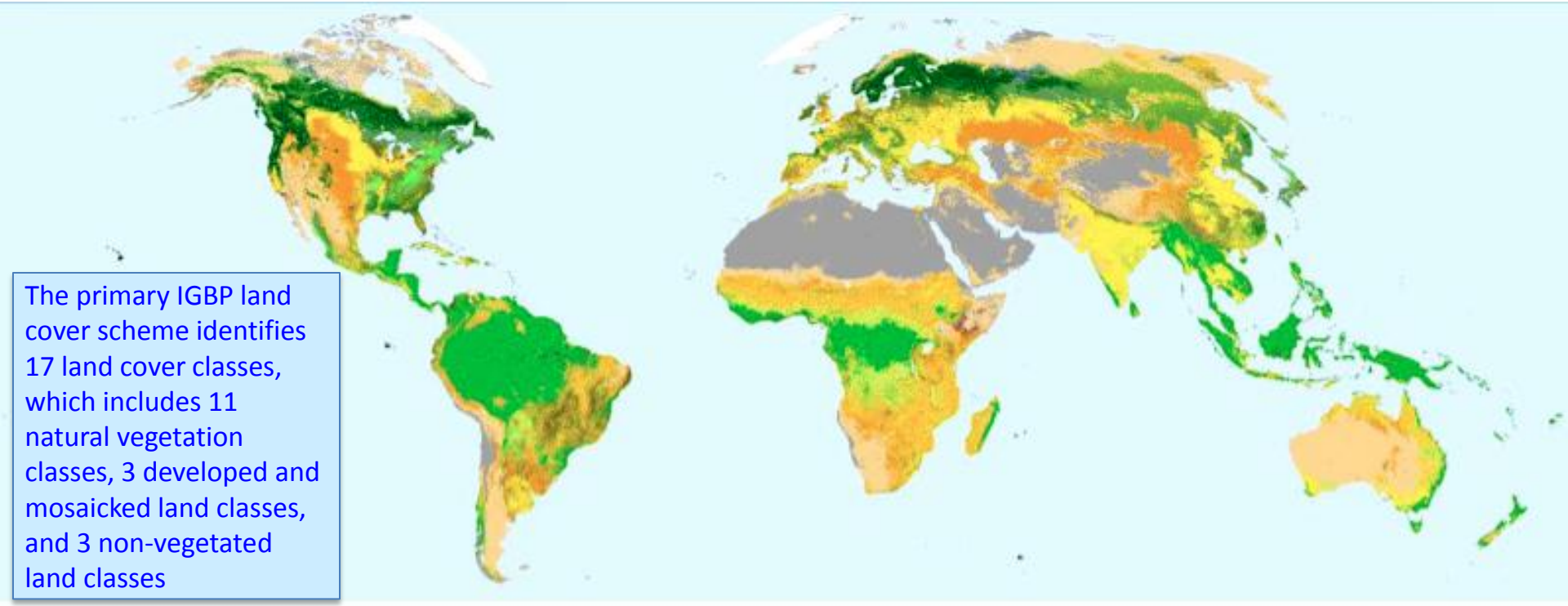
MODIS Land Products & Applications (25/37)

MODIS Land Cover Type, 2002

The primary IGBP land cover scheme identifies 17 land cover classes, which includes 11 natural vegetation classes, 3 developed and mosaicked land classes, and 3 non-vegetated land classes



[Source: A. Strahler & M. Friedl/BU]

IGBP Land Cover Classes

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

MODIS Land Products & Applications (26/37)

Application Relevance of Land Cover Type Products

- Land cover strongly influences the biosphere–atmosphere interactions, and hence, accurate land cover information proves essential to parameterize land surface processes in regional to global scale Earth system models
- Global land cover dynamics presents important implications for all aspects of an ecosystem's health and sustainability from local to global scales especially because human-induced land use and land cover modifications remain among the most significant agents of environmental change

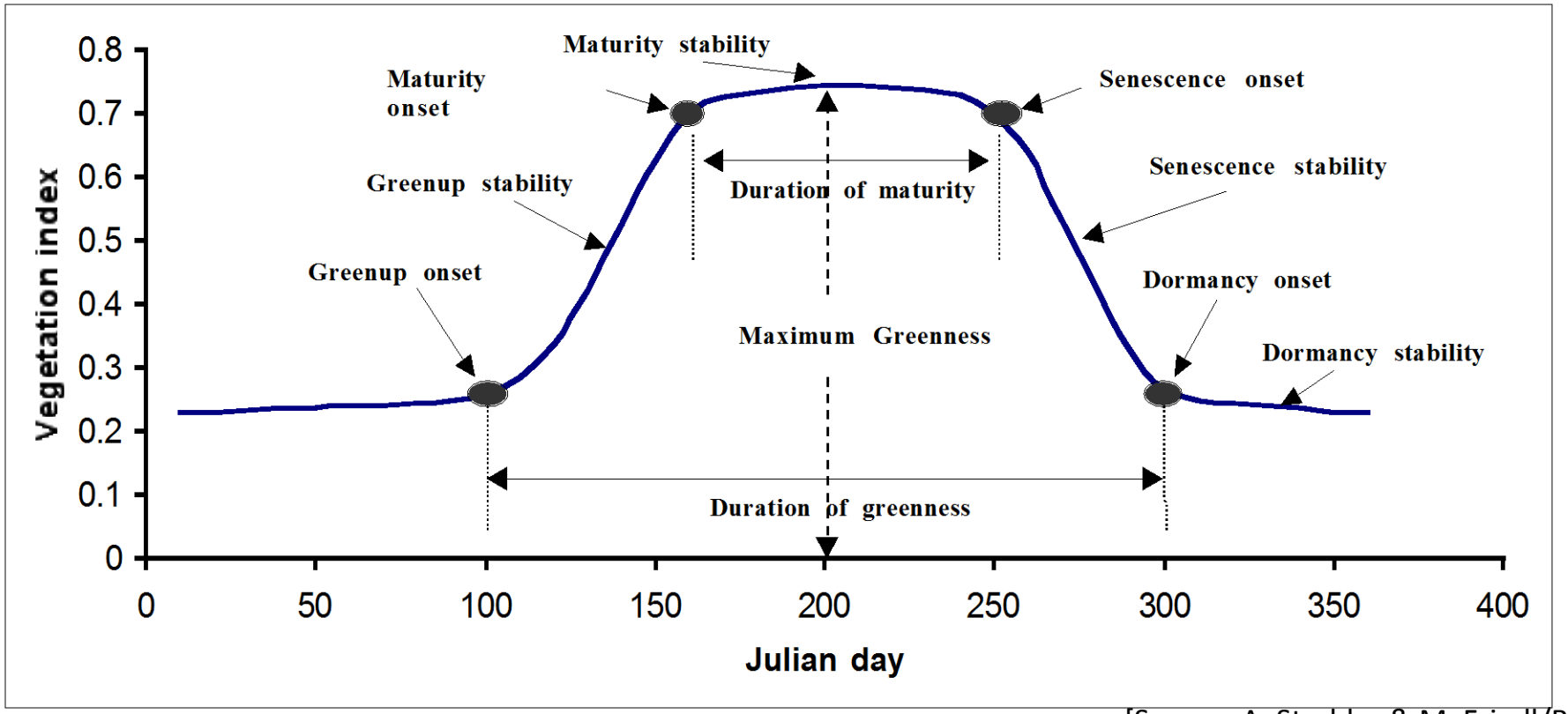
MODIS Land Products & Applications (27/37)

Land Cover Dynamics (MCD12Q2)

- The MODIS land cover dynamics product identifies transition dates, which define key phenological phases of vegetation at yearly time scales. Phenology is the study of periodic plant life cycle events, and how they are influenced by seasonal and interannual climate variations
- The land cover dynamics product is generated bi-annually to capture differences in phenological seasonality in the northern and southern hemispheres

MODIS Land Products & Applications (28/37)

Land Cover Dynamics: Defining Phenological Attributes



[Source: A. Strahler & M. Friedl/BU]

MODIS Land Products & Applications (29/37)

Application Relevance of Land Cover Dynamics Products

- An accurate understanding of land surface phenology contributes to quantifying inputs to surface energy fluxes and global carbon cycle dynamics that define Earth system models
- The very nature of this product, characterizing seasonal variation in land cover dynamics, significantly contributes to a wide range of ecological applications. They include regional and global carbon modeling, ecological assessment, and agricultural monitoring

MODIS Land Products & Applications (30/37)

Thermal Anomalies and Fire (M*D14)

- The MODIS Thermal Anomalies & Fire suite provides snapshots of both actively burning fires and burned areas globally
- The Active Fire product characterizes, on a daily basis, actively burning locations at satellite overpass time at 1 km pixel size
- It provides a Fire Mask and a Fire Pixel table for each fire pixel. The Fire Pixel table characterizes 19 attributes including “Fire Radiative Power”
- As the name suggests, other thermal anomalies like volcanic signatures are also detected

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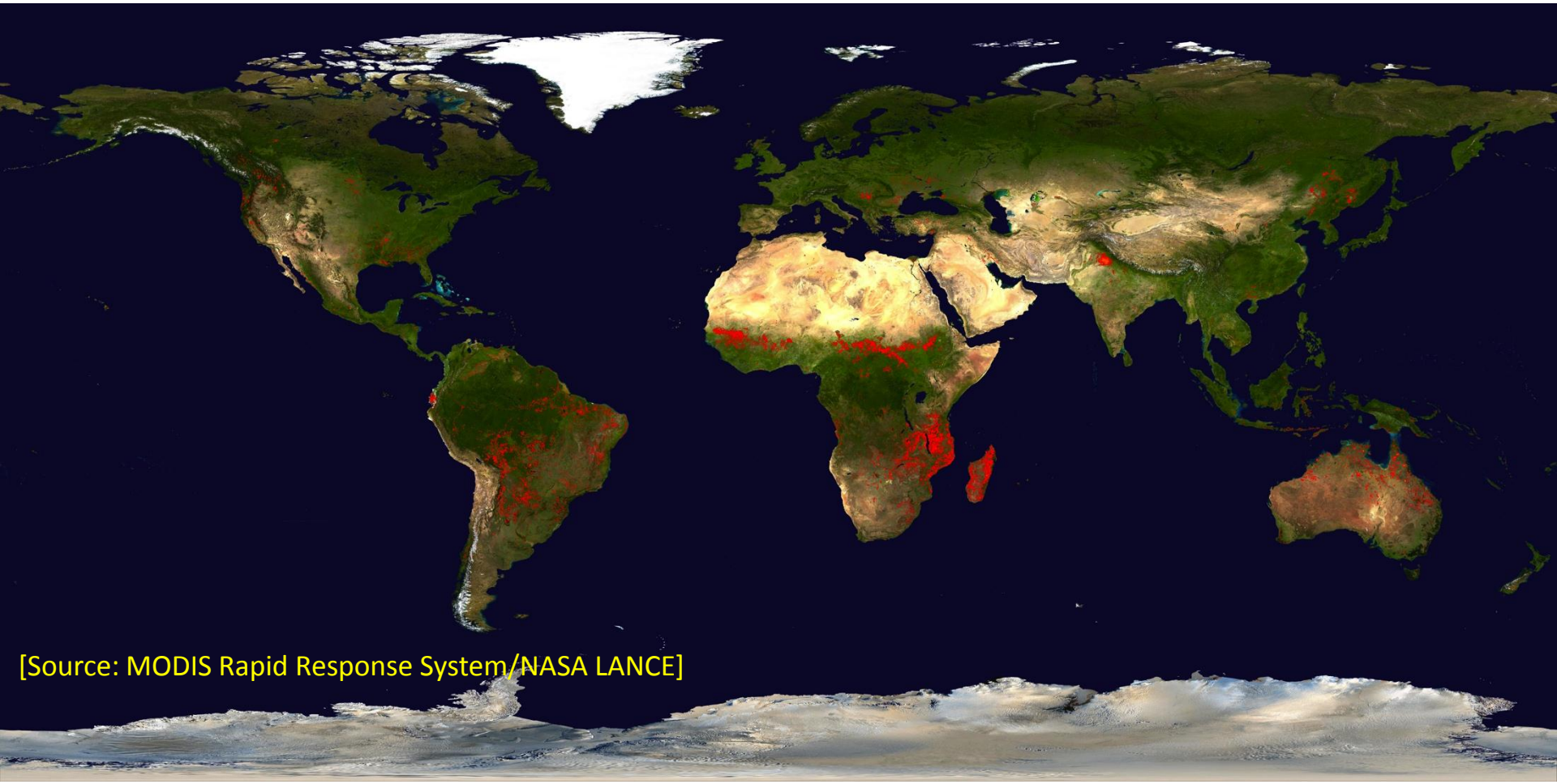
MODIS Land Products & Applications (31/37)

Global Fire Map (2011-301 – 2011-310)



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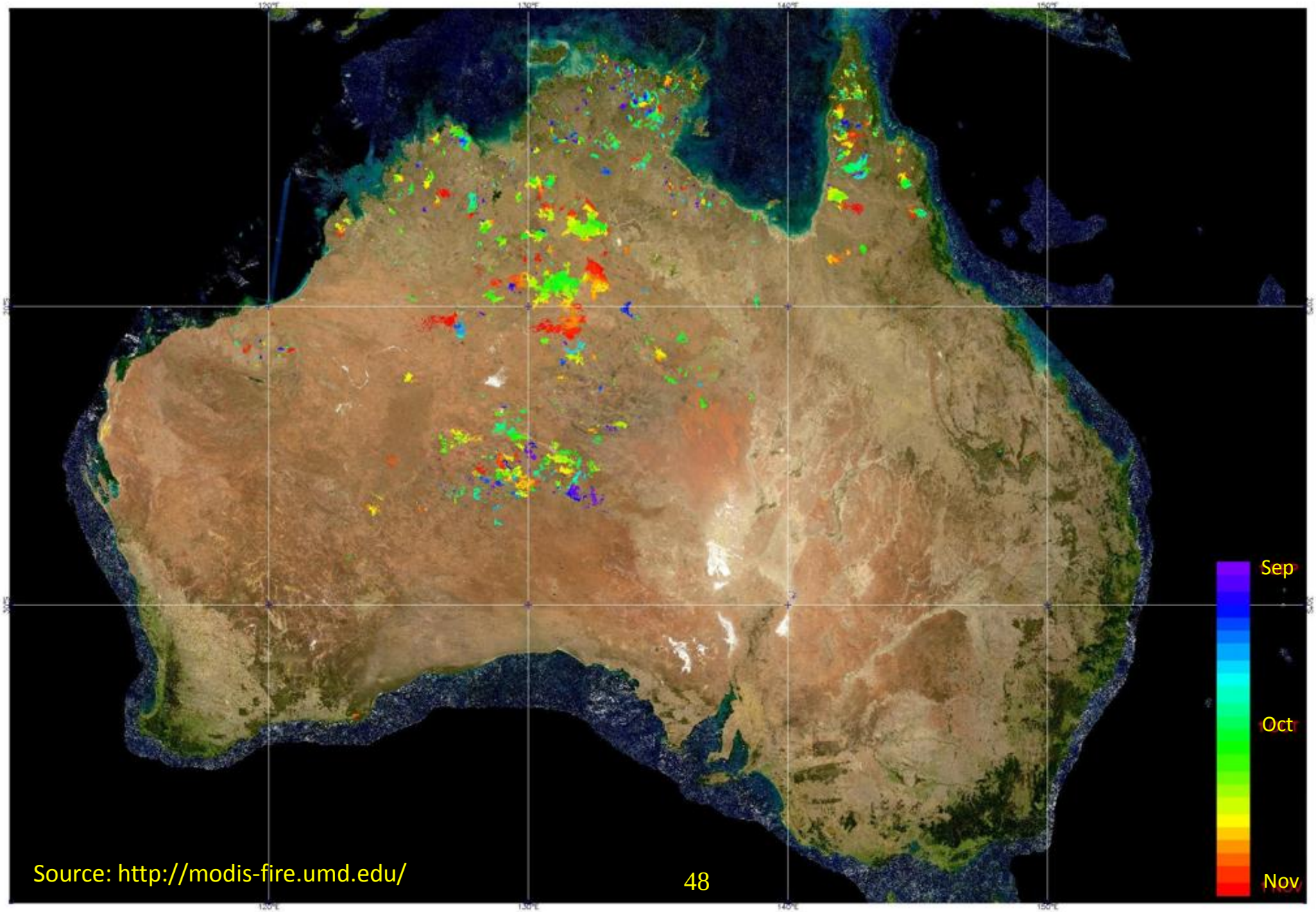
MODIS Land Products & Applications (32/37)

Burned Area (MCD45A1)

- The Terra & Aqua MODIS Burned Area product is a monthly L3 gridded 500-meter product, which contains burning and quality information on a per-pixel basis
- It analyzes daily surface reflectance dynamics to locate rapid changes, & uses that information to detect the approximate date of burning, and maps the spatial extent of recent fires only
- The algorithm uses a BRDF model-based change detection approach to handle angular variations in the data. It further uses a statistical measure to identify change probability from a previously observed state

Burned Areas in Australia (Sep. – Nov. 2002)



Source: http://modis-fire.umd.edu/

MODIS Land Products & Applications (34/37)

Application Relevance of Active Fire & Burned Area Products

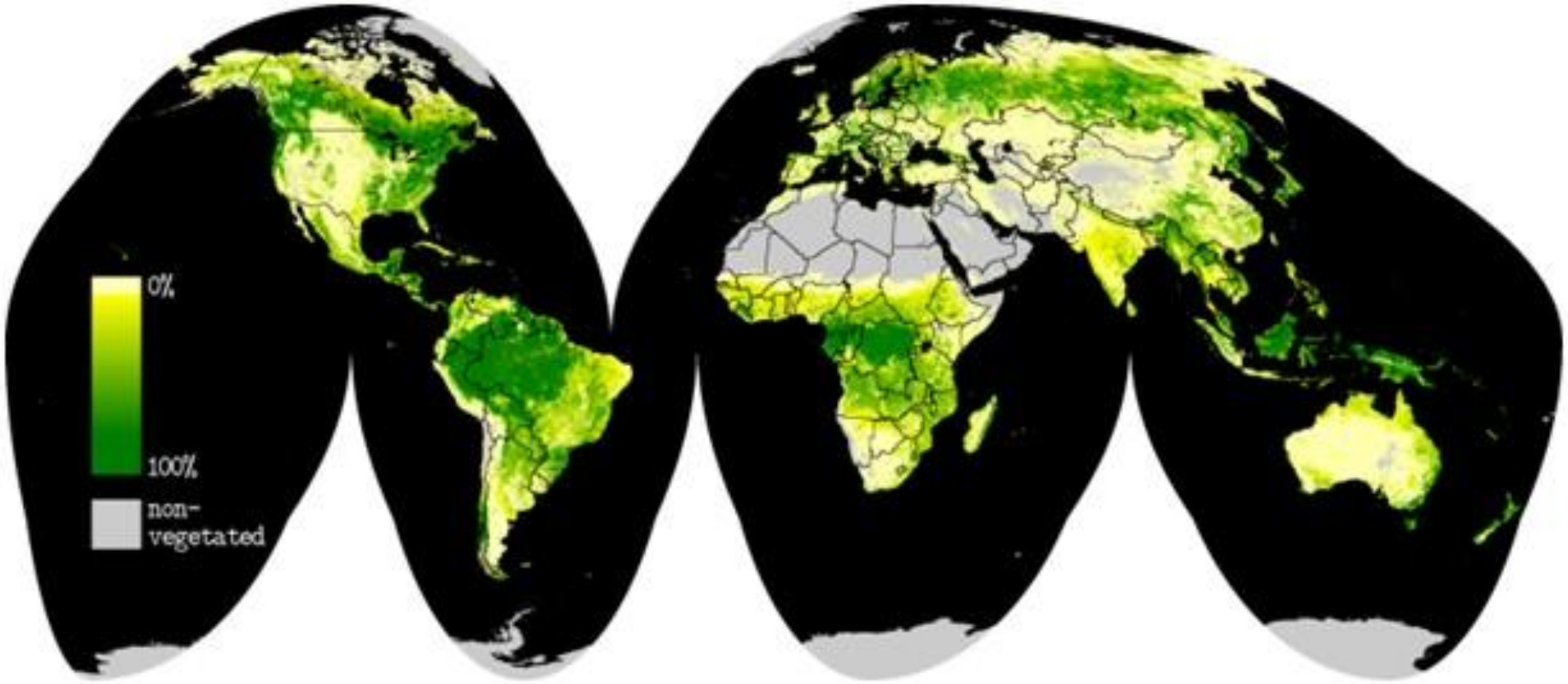
- The natural resource management and global climate change research communities are two significant users of the fire products
- Agencies with operational fire monitoring & management responsibilities benefit through near-real-time data provided by the following:
  - MODIS Rapid Response System:
    - http://lance-modis.eosdis.nasa.gov/cgi-bin/imagery/firemaps.cgi
  - NASA's Fire Information for Resource Managers System (FIRMS):
    - http://maps.geog.umd.edu/firms

MODIS Land Products & Applications (35/37)

Vegetation Continuous Fields (VCF)

- The Terra MODIS VCF product is a sub-pixel-level representation of surface vegetation cover estimates globally
- Designed to continuously represent Earth's terrestrial surface as a proportion of basic vegetation traits, it provides a gradation of three surface cover components:
  - percent tree cover,
  - percent non-tree cover, and
  - percent bare

MODIS Land Products & Applications (36/37)



Global Vegetation Continuous Fields percent tree cover for 2001. Darker greens indicate denser tree cover, pale colors indicate light tree cover, and gray indicates completely bare. [Credit: M. Carroll/GSFC]

USGS

NASA

MODIS Land Products & Applications (37/37)

Application Relevance of VCF Products

- The Vegetation Continuous Fields product, by virtue of its continuous representation of ground cover as a proportion of basic vegetation traits, provides improved spatial detail than discrete classifications
- VCF's sub-pixel characterizations of vegetation help map ecotones and disturbance areas more accurately
- The greater thematic detail contributes to better parameterization of models addressing change dynamics.
- The VCF product provides a novel alternative to traditional land cover classification schemes

USGS

NASA

MODIS Land Products QA & Validation (1/5)

MODIS Quality Assurance (QA)

- All MODIS land products include quality assurance information designed to help users understand and make best use of the data that comprise each product
- The Land Data Operational Product Evaluation (LDOPE) facility at GSFC is responsible for the overall coordination of the QA activities
- LDOPE evaluates & documents the science quality of all the MODIS land products, and incorporates them in the operational production code. QA information resides within the products (at the pixel-level), and their metadata (at the file-level)

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MODIS Land Products QA & Validation (2/5)

File-level QA

- File-level QA refers to the associated metadata that exist for any given product, and may include additional granule-level attributes, QA statistics, & QA flags metadata returned as part of the search & discovery process. This information mainly aids in the data screening & selection processes

Pixel-level QA

- Pixel-level QA is most valuable for applications that rely on consistent use of particular MODIS land products
- All MODIS land products contain one or more Science Data Sets (SDS) devoted to QA among the multiple HDF arrays. These SDSs are critical to understand, parse, and interpret pixel-level QA
- Pixel-level QA provides information for each science parameter through a binary representation of bit combinations that characterize particular quality attributes

★ LP DAAC MODIS Land Product QA Tutorial:
https://lpdaac.usgs.gov/media/files/one_pager_files modis_land_products_quality_assurance_tutorial_part_1

MODIS Land Products QA & Validation (3/5)

EOS MODIS Land Validation (http://landval.gsfc.nasa.gov/)

- Validation is the process of determining the accuracy of satellite data-derived land products by independent means
- MODIS land products are validated through various techniques:
  - Through direct comparisons with in-situ field data collected at EOS core sites & scientific observation networks
  - Through comparisons with data from higher spatial resolution sensor products
  - Through inter-comparisons of trends derived from independently obtained reference data and derived products

MODIS Land Products QA & Validation (4/5)

EOS MODIS Land Validation (http://landval.gsfc.nasa.gov/)

All MODIS land product suites are evaluated as part of the validation process, & assigned one of four stages in the validation hierarchy:

- **Stage-1 Validation**: Product accuracy is estimated using a small number of independent measurements obtained from selected locations/time periods, and ground-truth/field program efforts
- **Stage-2 Validation**: Product accuracy is estimated over a significant set of locations and time periods by comparison with reference in-situ or other suitable reference data
- **Stage-3 Validation**: Uncertainties in the product and its associated structure are well quantified from comparison with reference in-situ or other suitable reference data. Uncertainties are characterized in a statistically robust way over multiple locations and time periods representing global conditions
- **Stage-4 Validation**: Validation results for stage-3 are systematically updated when new product versions are released, and as the time-series expands

USGS

NASA

MODIS Land Products QA & Validation (5/5)

Current Validation Status of MODIS Land Products

Product Name (Collection Version)	Validation Stage
Land Surface Reflectance (V5)	Stage-2
Land Surface Temperature (V4.1 & V5)	Stage-2
BRDF & Albedo (V5)	Stage-2
Vegetation Index (V5)	Stage-3
LAI & FPAR (V5)	Stage-2
Gross Primary Production (V4)	Stage-3
Land Cover & Dynamics (V5)	Stage-2
Fire (V5)	Stage-3
Burned Area (V5)	Stage-2
Vegetation Continuous Fields (V5)	Stage-1
Snow & Ice Cover (V5)	Stage-2

http://landval.gsfc.nasa.gov/

USGS

NASA

References (1/3)

The NASA EOS MODIS mission offers a new generation of remote sensing-derived land products to support various aspects of Earth & environmental science applications

Understanding all aspects related to MODIS land products and learning how to use them is an incremental process. Besides the LP DAAC's Web site

(https://lpdaac.usgs.gov/products/modis_products_table),

there is an array of online as well as published resources available to learn about all aspects related to the use and application of MODIS land products

References (2/3)

Special Issues of Journals dealing with MODIS:

- **IEEE Transactions on Geoscience and Remote Sensing**, Vol. 36, (1998)
- **Remote Sensing of Environment**, Vol. 83 (2002)

Special Issue on Global Land Product Validation:

- **IEEE Transactions on Geoscience and Remote Sensing**, Vol. 44 (2006)

Search for MODIS application papers through Indexing Services:

- Web of Science
- Scopus
- Science Direct
- ProQuest
- Scholar.google.com

USGS

NASA

References (3/3)

MODIS Land Discipline-Specific Resources

Relevant Site	URL
MODIS Land Team	http://modis-land.gsfc.nasa.gov
MODIS Land Data Quality Assessment	http://landdb1.nascom.nasa.gov/cgi-bin/QA_WWW/newPage.cgi
MODIS Land Validation	http://landval.gsfc.nasa.gov
MODIS Land Global Browse Images	http://modland.nascom.nasa.gov/cgi-bin/browse/browse.cgi
MODLAND Developers	http://landdb1.nascom.nasa.gov/developers
MODIS Land Products Subsets	http://daac.ornl.gov/MODIS/modis.shtml
MODIS Characterization Support Team	http://mcst.gsfc.nasa.gov
MODIS Tools	https://lpdaac.usgs.gov/tools
The HDF Group	http://www.hdfgroup.org
NASA Earth Observatory	http://earthobservatory.nasa.gov

Questions?

Backup Slides

Introduction to the Earth Observing System

- NASA initiated the Mission to Planet Earth in the early 1990s, which later became the Earth Science Enterprise (ESE), primarily to study and understand all interacting components of Earth as a dynamic system
- NASA's Earth Observing System (EOS) mission, the centerpiece of ESE, is a 15-year effort to collect and analyze a multisensor, multitemporal data stream across all elements of the Earth's life-support systems
- The EOS mission consists of the following:
  - a space-based Earth observing system,
  - a data and information system (EOSDIS), and
  - a scientific research program

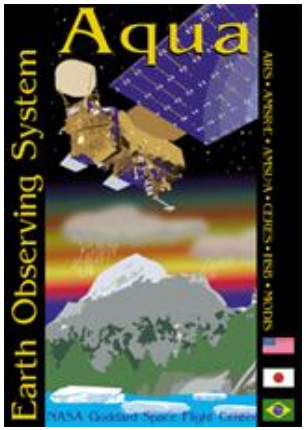
Introduction to the Earth Observing System

Three EOS satellite platforms were launched successfully between December 1999 and July 2004, and remain operational to date. Each platform carries a specialized payload of remote sensing instruments

1999

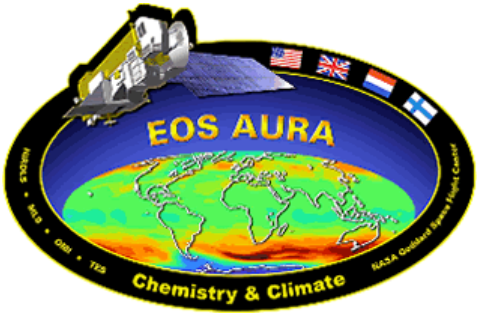
- **ASTER**
- CERES
- MISR
- **MODIS**
- MOPITT

2002



- AIRS
- AMSR-E
- AMSU-A
- CERES
- **MODIS**
- HSB

2004

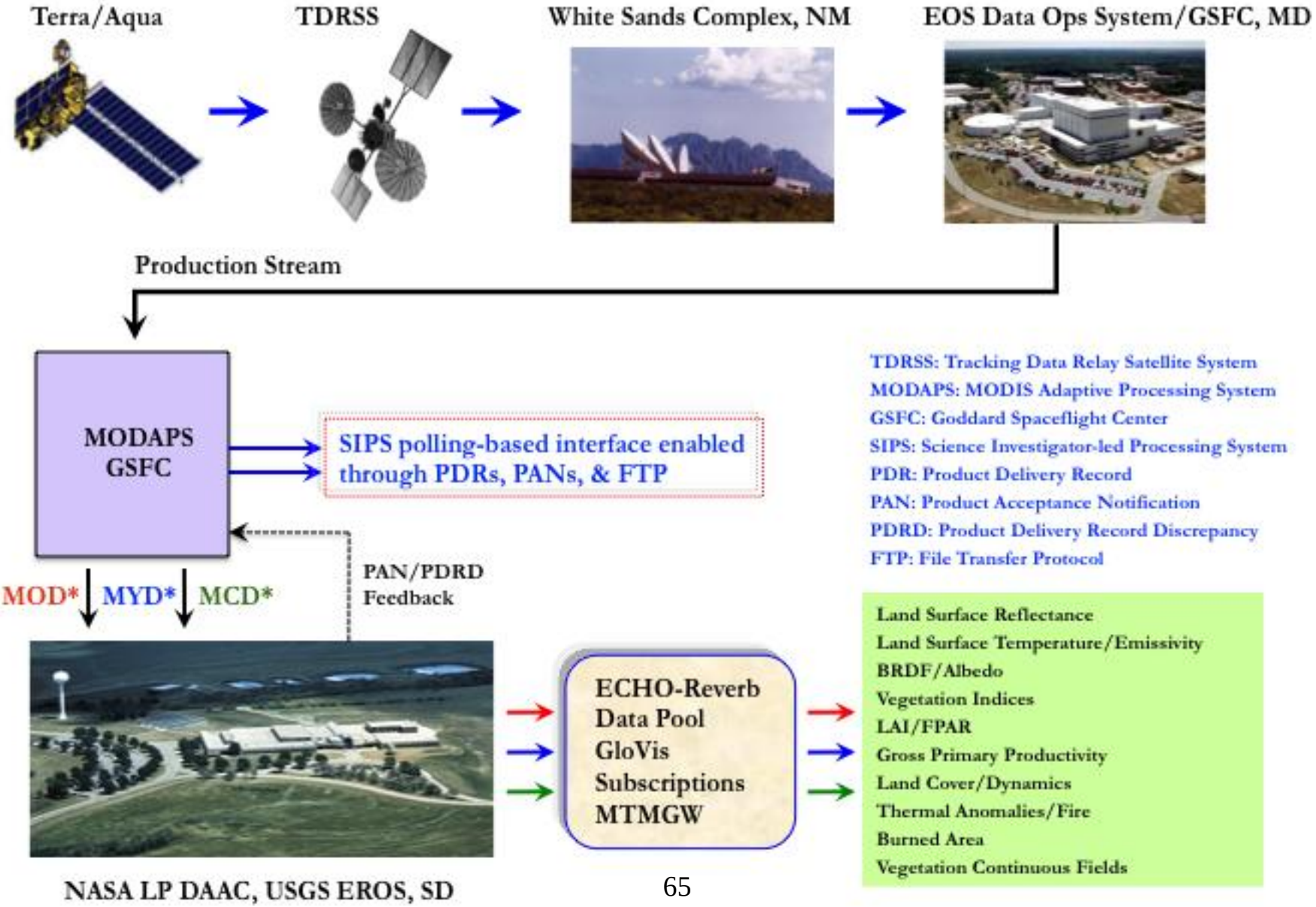


- HIRDLS
- MLS
- OMI
- TES

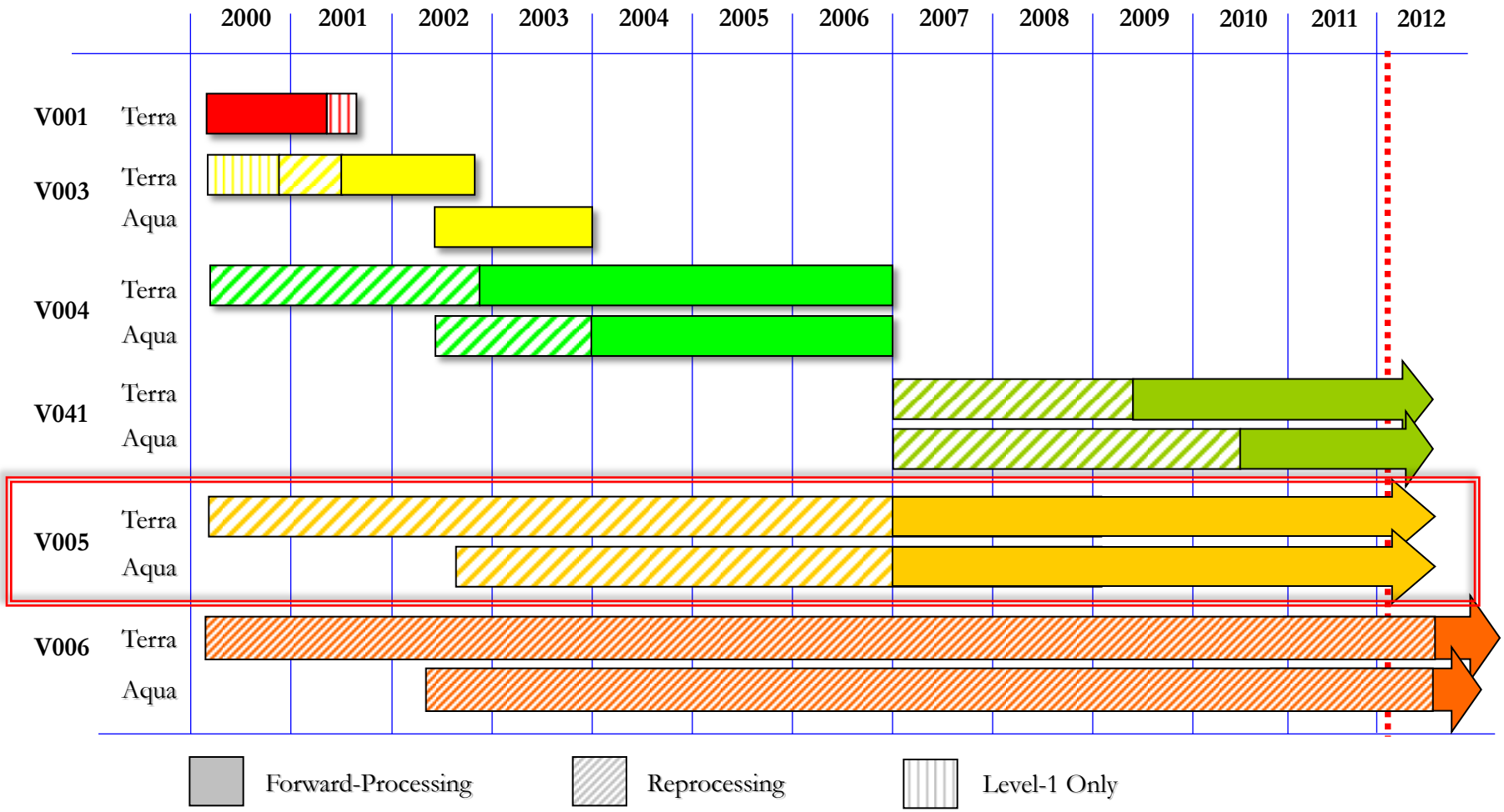
USGS

NASA

MODAPS TO LP DAAC MODIS DATA FLOW DYNAMICS

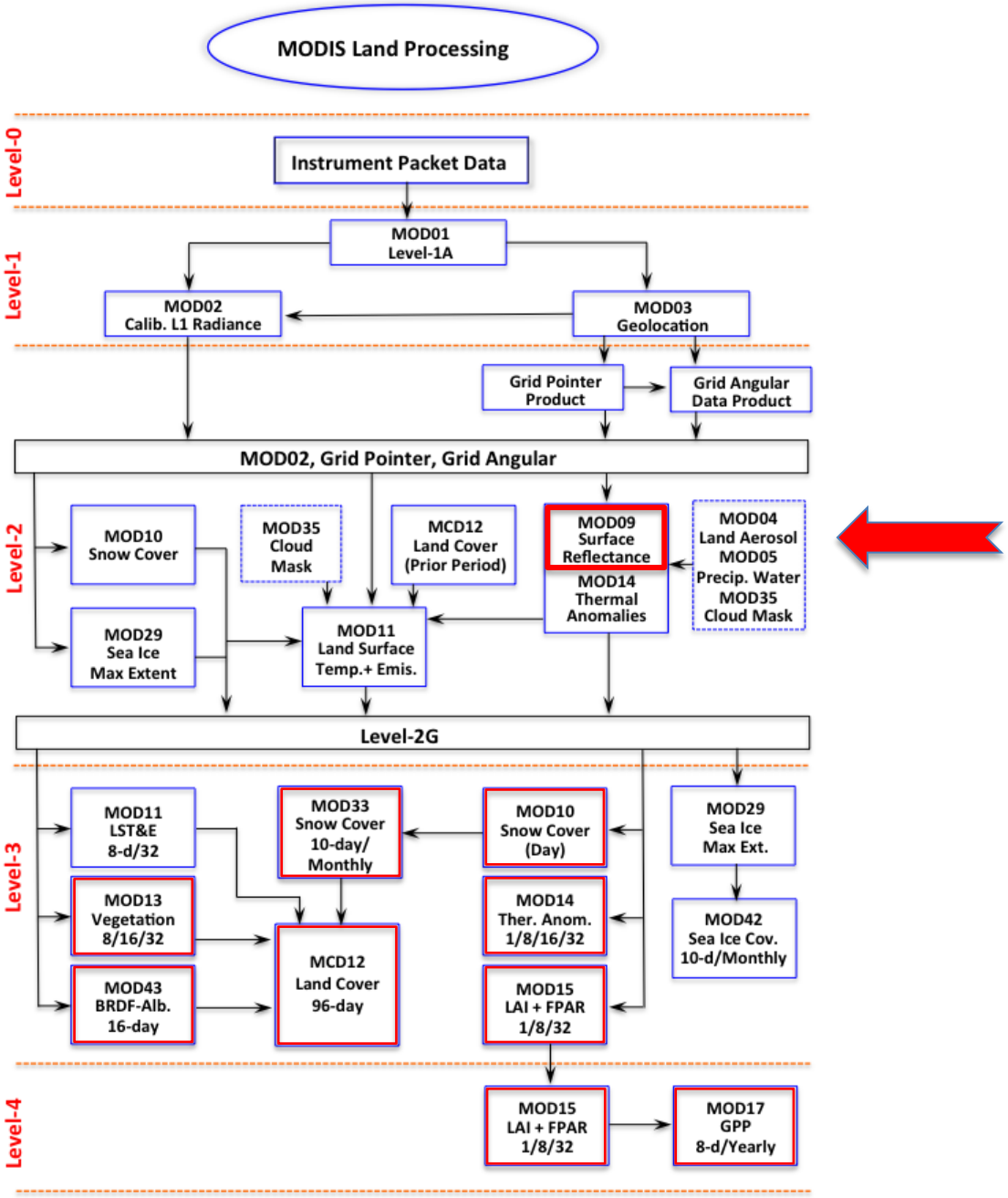


MODIS Product Collections at LP DAAC



V006 Collection is scheduled for release in early 2013

MODIS Land Processing Workflow

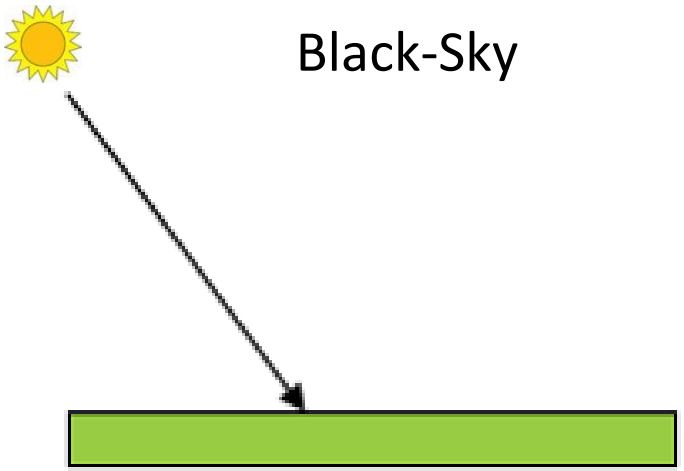


[Source: D. Deering/GSFC]

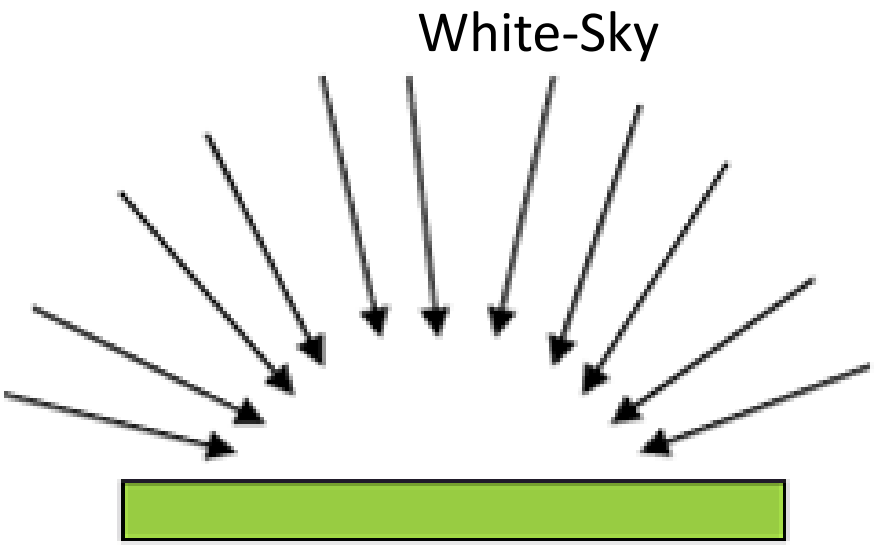
[Credit: C. Schaaf/BU]

MODIS Land Products & Applications

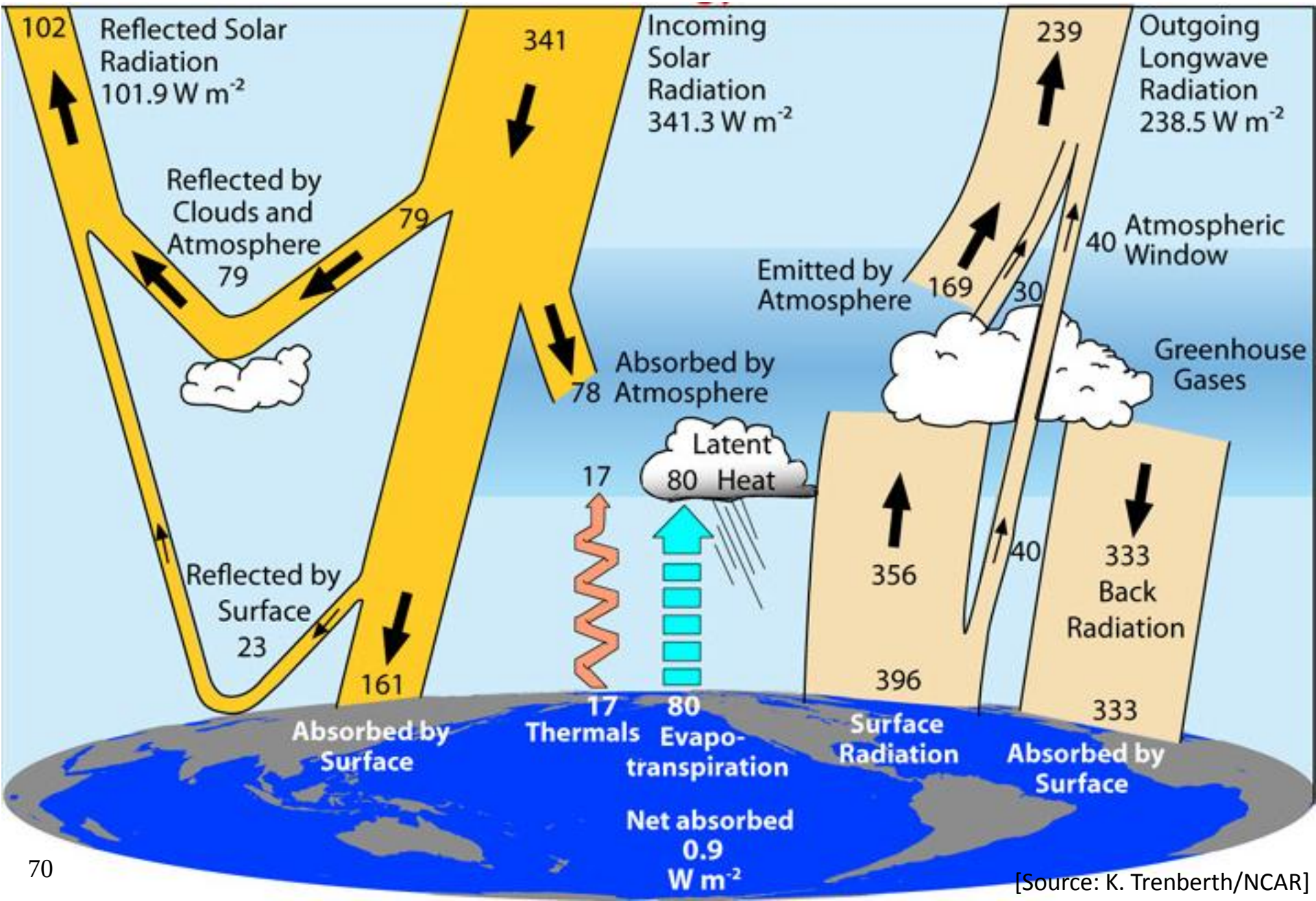
Directional-hemispherical reflectance is the reflectance of a surface under direct illumination (with no diffuse illumination component). Also called **black-sky albedo**, this forms the integral of BRDF over all viewing directions



Bi-hemispherical reflectance is the reflectance of a surface under diffuse or indirect light (with no direct illumination component). Also called **white-sky albedo**, this forms the integral of BRDF over all viewing and illumination directions of a hemisphere



Earth's Radiation Budget



[Source: K. Trenberth/NCAR]

GODDARD SPACE FLIGHT CENTER | + NASA Homepage

MODIS land team

Home | Core Sites | Val Status | Campaigns | Documentation

Announcements:

- MODIS Science Team Mtg, May 18-20, 2011, UMUC, College Park, MD. Registration now open.
- MODIS/VIIRS Science Team Meeting, Washington, D.C., Jan 26-28.
- MODIS validation case study presented at the 2009 ISRSE
- 4th Global Vegetation Workshop, Missoula, MT, June 2009
- The International Conference on Land Surface Radiation and Energy Budgets, Beijing, March, 2009
- MODIS Collection 5 changes
- ESDR White Papers - developed by the NASA Land Measurement Team
- TGARS Special Issue on Global Land Product Validation

MODIS News

The Committee on Earth Observation Satellites (CEOS), defines validation as the process of assessing, by independent means, the quality of the data products derived from the system outputs.

The MODIS Land Validation Strategy

MODIS Land (MODLAND) product quality is ensured by Calibration, Quality Assurance (QA) and Validation. The MODIS land validation effort will contribute to and leverage off of international validation activities, helping to establish standards and protocols through close coordination with the CEOS Land Product Validation (LPV) subgroup, under its Working Group on Calibration and Validation (WGCV).

MODLAND uses several validation techniques to develop uncertainty information for its products. These include comparisons with in situ data collected over a distributed set of validation test sites, comparisons with data and products from other sensors (e.g., ASTER, AVHRR, MISR, TM/ETM+), intercomparison of trends derived from independently-obtained reference data, and analysis of process model results.

MODLAND's primary validation technique includes the collection of field and aircraft data, and comparison with these and with products from other satellites. The infrastructure for these efforts has resulted in the establishment of a semi-permanent array of EOS Land Validation Core Sites, most of which include a flux tower for extended temporal measurement of terrestrial biophysical dynamics over a range of landcover types. Field data are archived in cooperation with the Oak Ridge DAAC's Mercury system. Results of all validation activities are conveyed to the end-user through both published literature and the MODLAND product Val Status pages.

Validation Hierarchy (updated Sept 2009)