

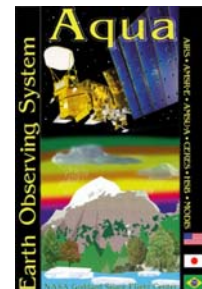


# MODIS Adaptive Processing System (MODAPS)

LP DAAC SAP Meeting  
January 7, 2006

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NASA GSFC Code 614.5





# Collection 4 Forward Processing (1 of 2)

- Over the last 3 months Terra and Aqua have averaged 1.1 and 1.2 days respectively behind real time; the largest lag was 2 days for Terra and 3 days for Aqua
  - ❑ All MODAPS production is performed from L0 input (complete Terra and Aqua now in MODAPS disk archive – >140 TB compressed)
  - ❑ The pacing item for Terra and Aqua production is the delivery of the NCEP/GDAS ancillary file which is delivered 24h behind real time. This is used as input to LSR.
  - ❑ For Terra, some recipes that are not dependent on LSR can be processed closer to real time (e.g. LST and L2G Sea Ice). This can not be done for Aqua that uses a 24h ephemeris file compared to the 2h Terra format.
  - ❑ The typical reasons for delays in MODAPS production are problems with the delivery of L0, ancillary, and ephemeris/attitude data to the GES DAAC. The incidence of these problems and the time required to correct them has reduced significantly in the last year.
  - ❑ The forward processing machine has a production capacity of approximately 2.7x and additional Linux processors can be moved on to the machine in the event of a serious production delay.



## Collection 4 Forward Processing (2 of 2)

- The average downtime on the forward processing machine has been 3% over the last 6 months
  - ❑ In the last year there has been only one instance of a production disk crash that resulted in minimal data loss
- Two Collection 5 land PGEs are presently running in forward processing and the products are shipped to the SCFs only: PGE72 (16-day VCC) and PGE88 (Monthly Snow CMG)
- In May 2005 following the TOVS failure, the ozone\_daily ancillary product used by LSR (PGE11) became unavailable and LSR converted to using the NCEP/GDAS product



# MODIS Land Products

## Energy Balance Product Suite

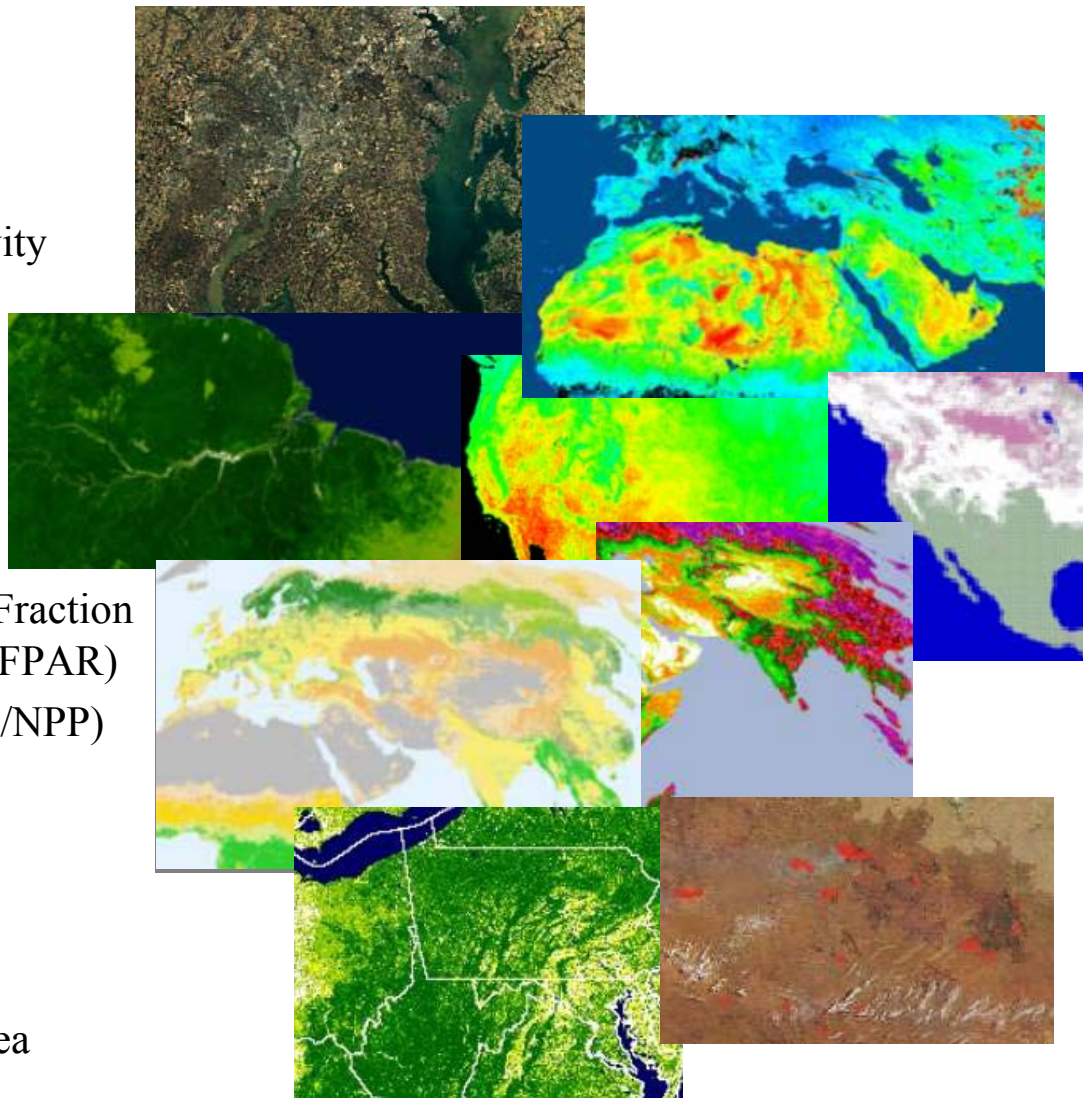
- Surface Reflectance
- Land Surface Temperature and Emmissivity
- Bi-directional Reflectance Distribution Function (BRDF) and Albedo
- Snow cover and sea-ice extent

## Vegetation Parameters Suite

- Vegetation Indices
- Leaf area index and Fraction (LAI) and Fraction of Photosynthetically Active Radiation (FPAR)
- Gross and Net Primary Production (GPP/NPP)

## Land Cover/Land Use Suite

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



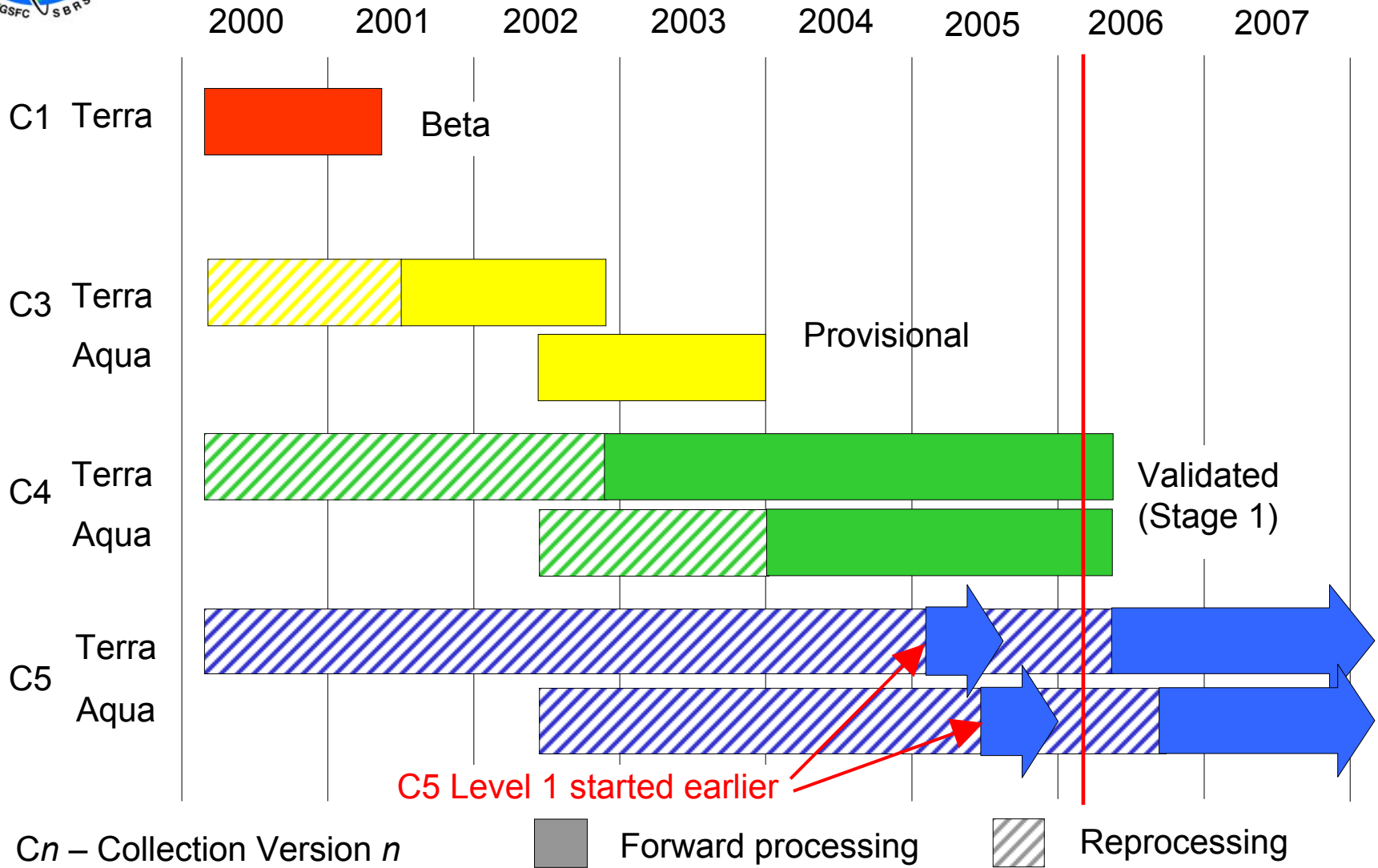


## Science Team – Phase 2

- Overall – Phase 1 Land Team intact and strengthened
  - ❑ Separate funding for Validation Coordination and Rapid Response
- Larger Science Team (27 total)
  - ❑ Algorithm Maintenance and Validation Team (10)
  - ❑ EOS Science – Data Users (17)
  - ❑ Four new/improved Land products: Plant Water Content, Evaporation, Improved Surface Reflectance, Physical Based Continuous Fields and Land Cover
- Discipline Leader: Dr. Chris Justice, UMD



# MODIS Collections







# MODIS Land Collection 5 Changes

- Use improved Land/Water mask and new Land Cover map based on 3 years of Collection 4 data.
- Refine surface reflectance by adopting a dynamic aerosol model in atmospheric correction and implement adjacency effect correction scheme.
- Reduce size (250 to 110 GB/day), number of files (7 to 2 per tile) and complexity of daily L2G product.
- Improve quality of the Land Surface Temperature by revising the day/night algorithm and improving the detection and filtering of cloud contaminated observations.
- Increase resolution of BRDF/Albedo product to 500m.
- Interpolate ancillary data to remove artifacts in the NPP product.
- Refine LAI/FPAR LUTs to improve numerical accuracy of the radiative transfer simulations.
- Add burned area product.



## Collection 5 Science Testing (1 of 2)

- Collection 5 Science Testing started in July 2004 and 35 tests have been conducted to date
  - ❑ 33 of the tests were for Terra
  - ❑ Approximately half the tests were major tests involving 16+ test days (a 16-day global test generates 13TB of data products). Most of the remaining tests were rapid-response ad hoc tests in direct support of a specific developer
  - ❑ The most recent 33-tile time-series test for 2003 required 45 days to complete and generated 15TB of compressed data products
  - ❑ 4 more Terra and 5 more Aqua tests are planned before Collection 5 reprocessing starts; the Aqua tests are not critical path
  - ❑ For the most recent tests, the Land Archive and Distribution System (LADS) has been used to distribute test products to the developers





## Collection 5 Science Testing (2 of 2)

- Four more Terra and one Aqua science tests are planned before the start of the Collection 5 Terra reprocessing:
  - ❑ A 16-day global Terra test.
  - ❑ A 48-day Aqua test for LST only.
  - ❑ A Terra 3-month time-series test for 6 tiles. February through April 2003 is planned
  - ❑ A second Terra 3-month time-series test for 6 tiles. July through September 2003 is planned. The tiles will be different than those used in the prior test
  - ❑ A final Terra PGE patch test



# Land Plans for Collection 5 Reprocessing

- Terra reprocessing is planned for a late-March, 2006 start date
  - ❑ The reprocessing will proceed on a single machine at approximately 3.6x
  - ❑ The Terra-only interval will be completed by early-November 2006
- The Terra/Aqua period will be processed using two machines both of which will process Terra and Aqua in order to expedite the generation of combined products
  - ❑ The odd years will be processed on one machine and the even years on the second machine; the total production rate will be 7.2x
  - ❑ The Collection 5 reprocessing will be completed by December 2007
- Hardware upgrades are being considered to enable faster reprocessing
- Forward processing chain will be updated to Collection 5 when both Aqua and Terra codes are available; estimated to be Aug. 2006



# Land Processing Summary

- Forward Processing
  - ❑ Most of the time this is as close to real time as possible; the occasional lags are corrected in 1-2 days
- Science Testing
  - ❑ A significant part of the Terra Collection 5 testing has been completed
  - ❑ 5 tests remain to be run and evaluated in the next 2 months
- Production and Archival
  - ❑ The Terra and Aqua Collection 5 reprocessing will be a 20 month proposition



# MODAPS Evolution

- Transition processing, archive and distribution of MODIS data from GES DAAC to MODAPS
  - ❑ Level 1 and Atmosphere data
  - ❑ Store all Atmosphere products on-line (data-pool)
    - Faster access to products from on-line storage
  - ❑ 30-day rolling archive for Level 1 forward processing
  - ❑ Process other Level 1 data on-demand
  - ❑ Reduces archive growth due to on-demand processing
  - ❑ Provides a starting point for improvements in delivering data to the North American Carbon Program (NACP) modelers



# Land and Atmospheres Archive and Distribution System (LAADS)

- LAADS will provide the Level 1 and atmospheres science communities with simple and rapid access to large volumes of MODIS data products.
- Functionality:
  - ❑ The ability to perform simple searches (e.g. browse, geographical, temporal and metadata) and orders with quick response (within seconds) to users.
  - ❑ The ability to perform complex post-processing activities (e.g. mosaicing, subsetting, and reprojection) with delayed response (minutes to hours) to users. This functionality is designed to increase the efficacy of MODIS data usage in a variety of communities including the modeling community.
  - ❑ The ability to perform Processing-On-Demand (POD) for any Level 1 data products that are not archived in LAADS.
- A key element to the LAADS approach is that the evolution in the system capabilities is driven exclusively by requirements specified by the MODIS atmospheres and land discipline science users.
- LAADS is presently being used to support the MODIS algorithm developers in generating the science codes to be used for the Collection 5 reprocessing. By mid-2006, approximately 10 data-years of atmosphere and Level 1 products will be available through LAADS.



# LAADS Capabilities (1 of 2)

- LAADS capabilities have evolved over the last year driven by the significant input that has been received from the MODIS land and atmospheres science communities. The initial system, version 1.3 released in December 2004, has been used extensively to support the MODIS algorithm developers in developing and refining the codes to be used for Collection 5 atmospheres and land reprocessing. This version featured: simple browse, geographic, temporal, and day/night granule searches, geographic and parameter subsetting and direct ftp access to data.
- In the present system (version 2.0), the following capabilities have been added: limited metadata searches, mosaicing (generating a single file from a specified list of contiguous or non-contiguous granules or tiles), tile and granule reprojection (user-specified from a list of 15 projections) and reformatting into the GeoTIFF format, Processing-On-Demand, and user push in addition to pull.



# LAADS Capabilities (2 of 2)

- The next version for release early this spring year (Version 3.0) will include comprehensive metadata searches, recurring temporal searches, pixel-level searches, a shopping cart.
- Subsequent versions for release during 2006 will include
  - ❑ subsampling, masking (using irregular shaped geographic regions such as states to filter archived or post-processed data sets)
  - ❑ the ability to include test land products for NPP VIIRS
  - ❑ links to ECHO to enable continue cross-instrument search and ordering
  - ❑ machine-to-machine interface through DODS and McIDAS servers
  - ❑ functionality that will facilitate access to MODIS products by the NACP community. Also, includes:
- The development of LAADS has relied on the re-use of pre-existing software such as MODAPS (the primary production system for MODIS), HSE (the Univ. of Alabama, Huntsville, HDF-EOS Subsetting Engine), MRT (LP DAAC's MODIS Reprojection Tool), hrepack (from NCSA) and HDFlook (USTL - Lille, France).





# Intuitive Interface (1 of 5)

The home page includes links to the main sections: Data, Images, Tools, and Help.

The screenshot shows the AADS Web homepage. At the top left is the NASA logo and 'GODDARD SPACE FLIGHT CENTER'. To the right is a link '+ Visit NASA.gov'. Below this is a banner with three satellite images and the text 'AADS Web Atmosphere Archive and Distribution System'. A navigation bar contains links: '- HOME', '+ DATA', '+ IMAGES', '+ TOOLS', and '+ HELP'. The main content area includes a welcome message, a 'NEWS' section with a link '+ View News Archives', and sections for 'Data', 'Images', 'Tools', and 'Help', each with a brief description. At the bottom, there is a 'FIRST GOV' logo, a link '+ NASA Privacy, Security, Notices', the NASA logo, and contact information for the webmaster and NASA official.



# Intuitive Interface (2 of 5)

The Level 2 Browser allows the user to view a global composite image for the selected satellite, date, collection, and parameter. The user may use the yellow "rubber band" to select an area of interest and view the granule browse images for that area.

+ HOME    + DATA    - IMAGES    + TOOLS    + HELP

### Level 2 Browser

Satellite: Terra    Month: Mar    Day: 19    Year: 2005    Parameter: Cloud Optical Thickness  
Date: March 19, 2005  
Aqua:     Terra:     Collection: 5 - Col 5 reprocessing (TERRA and AQUA)    Update  
Parameter: Cloud Optical Thickness  
Collection: 5    Combined:

+ Previous    + Next    + View Help

Cloud Optical Thickness 2005 078

Specify Bounding Box Coordinates as:  
North, West, East, South

North: 51.84  
West: -130.32    East: -69.84  
South: 21.58

Get Granule Images

+ View high resolution image of Terra MODIS Cloud Optical Thickness for March 19, 2005



All of the granule browse images in the area of interest are displayed in the granule view of the Level 2 Browser. The user may order the product files associated with the granule browse images by clicking on the file's checkbox.

+ HOME	+ DATA	- IMAGES	+ TOOLS	+ HELP
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### Level 2 Browser

**Satellite:** Terra      **Satellite:**  Terra:  Combined:   
**Date:** March 19, 2005      **Month:** Mar   **Day:** 19   **Year:** 2005      **Parameter:** Cloud Optical Thickness  
**Parameter:** Cloud Optical Thickness  
**Collection:** 5  
**Spatial:** N: 52, S: 22, E: -70, W: -130      **Collection:** 5 - Col 5 reprocessing (TERRA and AQUA)     

Click on the thumbnail image to view a higher resolution image. [+ View Help](#)

Displaying results 1 - 4 of 11. [1](#) | [2](#) | [3](#) | [Next](#) | [View All](#)

March 19, 2005 15:25

MOD06\_L2.A.2005078.1525.005.2005286064041.hdf

March 19, 2005 15:30

MOD06\_L2.A.2005078.1530.005.2005286065623.hdf

March 19, 2005 15:35

MOD06\_L2.A.2005078.1535.005.2005286062618.hdf

March 19, 2005 17:05

MOD06\_L2.A.2005078.1705.005.2005286072813.hdf



# Intuitive Interface (4 of 5)

The files selected on the granule view of the Level 2 Browser may be ordered in the order view. The files may be ordered as is or the user may also select parameter or geographic subsetting.

+ HOME
+ DATA
- IMAGES
+ TOOLS
+ HELP

## Level 2 Browser

**Browse Parameters**

**Product:** MOD06\_L2  
**Temporal:** 2005-078 00:00 - 2005-078 23:59  
**Collection:** 5  
**Spatial:** N: 52, S: 22, E: -70, W: -130

**Browse Results** [+ View Help](#)

A total of **3 files (112 MB)** match the selected parameters.

You may modify your order by selecting or clearing each file's checkbox. You may also select or clear the checkboxes for all files by clicking "Select All Checkboxes" or "Clear All Checkboxes".

Time	Product	File Name	Size	Online	Order	Browse
2005-078 15:25	MOD06_L2	MOD06_L2.A2005078.1525.005.2005286064041.hdf	50 MB	Yes	<input checked="" type="checkbox"/>	<a href="#">+ View Effective Particle Radius</a> <a href="#">+ View Cloud Fraction</a> <a href="#">+ View Cirrus Reflectance</a> <a href="#">+ View Cloud Optical Thickness</a> <a href="#">+ View Cloud Top Pressure</a> <a href="#">+ View Cloud Top Temperature</a>
2005-078 15:30	MOD06_L2	MOD06_L2.A2005078.1530.005.2005286065623.hdf	39 MB	Yes	<input checked="" type="checkbox"/>	<a href="#">+ View Effective Particle Radius</a> <a href="#">+ View Cloud Fraction</a> <a href="#">+ View Cirrus Reflectance</a> <a href="#">+ View Cloud Optical Thickness</a> <a href="#">+ View Cloud Top Pressure</a> <a href="#">+ View Cloud Top Temperature</a>
2005-078 15:35	MOD06_L2	MOD06_L2.A2005078.1535.005.2005286062618.hdf	22 MB	Yes	<input checked="" type="checkbox"/>	<a href="#">+ View Effective Particle Radius</a> <a href="#">+ View Cloud Fraction</a> <a href="#">+ View Cirrus Reflectance</a> <a href="#">+ View Cloud Optical Thickness</a> <a href="#">+ View Cloud Top Pressure</a> <a href="#">+ View Cloud Top Temperature</a>

Select All Checkboxes
Clear All Checkboxes

**Post Processing Selection (optional)**

Please choose whether or not to post-process the data products in your order. If you choose post-processing, you will be required to submit additional order information defining your post-process criteria. Post-processing is not required. [+ View Help](#)

Order data without additional post processing  
 Post process and order data

Order





# Intuitive Interface (5 of 5)

A side by side comparison with the granule browse images of other parameters may be done in the comparison view of the Level 2 Browser.

+ HOME    + DATA    - IMAGES    + TOOLS    + HELP

### Level 2 Browser Parameter Comparison

Satellite: Terra    Parameter: Cirrus Reflectance  
Date: March 19, 2005 15:25  
Collection: 5    Update

Click on an image to view a high resolution image. Please note that this will open a new browser window.

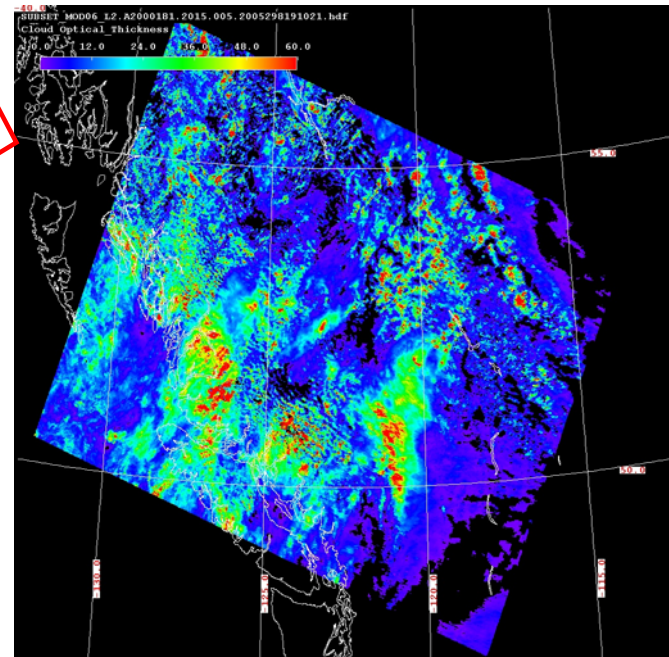
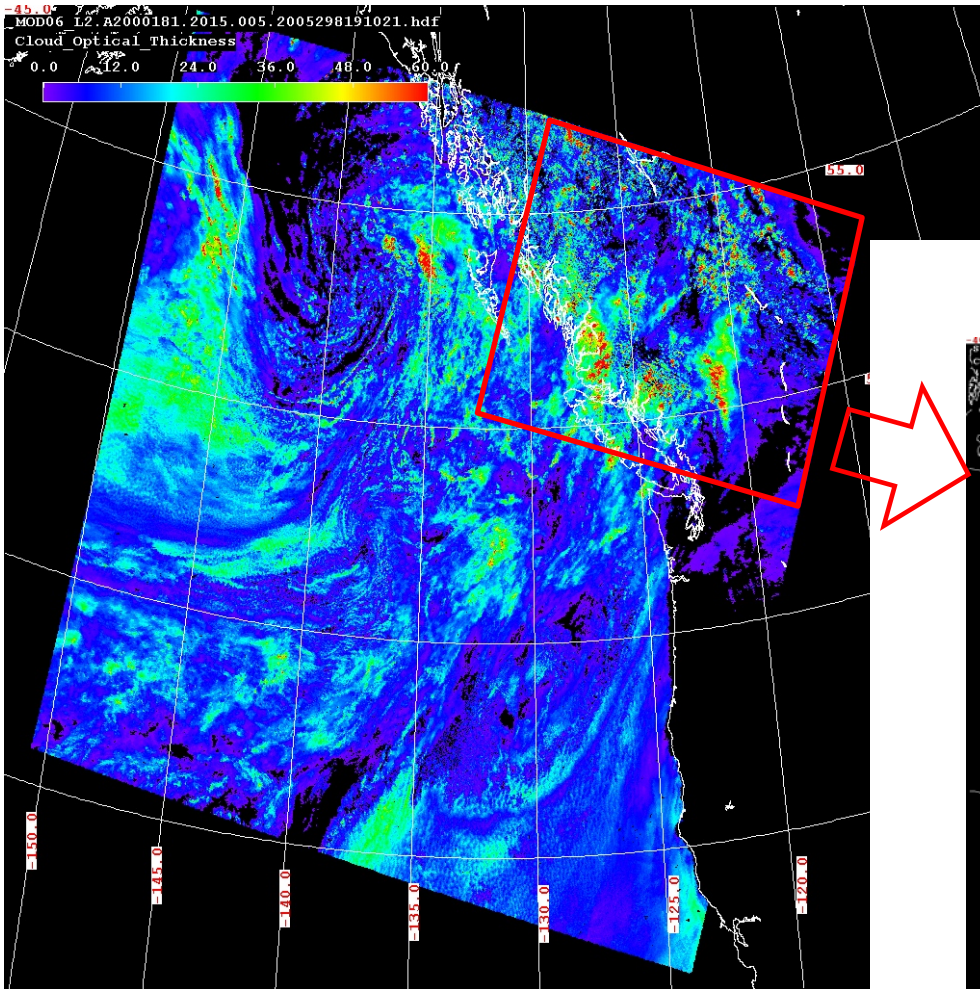
Cloud Optical Thickness    Cirrus Reflectance

Two side-by-side satellite images showing data from the Terra satellite. The left image is titled "Cloud Optical Thickness" and the right image is titled "Cirrus Reflectance". Both images show a map of the Earth with a color scale at the top. The color scale ranges from blue (low values) to red (high values). The images show a large area of high values (red and yellow) in the central part of the map, indicating high cloud optical thickness and cirrus reflectance.



# Post-processing (1 of 2)

Geographic subsetting allows the user to subset an HDF file over a given spatial domain.



*Subset of MODIS Cloud Optical Thickness (29 June 2000, 17:15 GMT)*

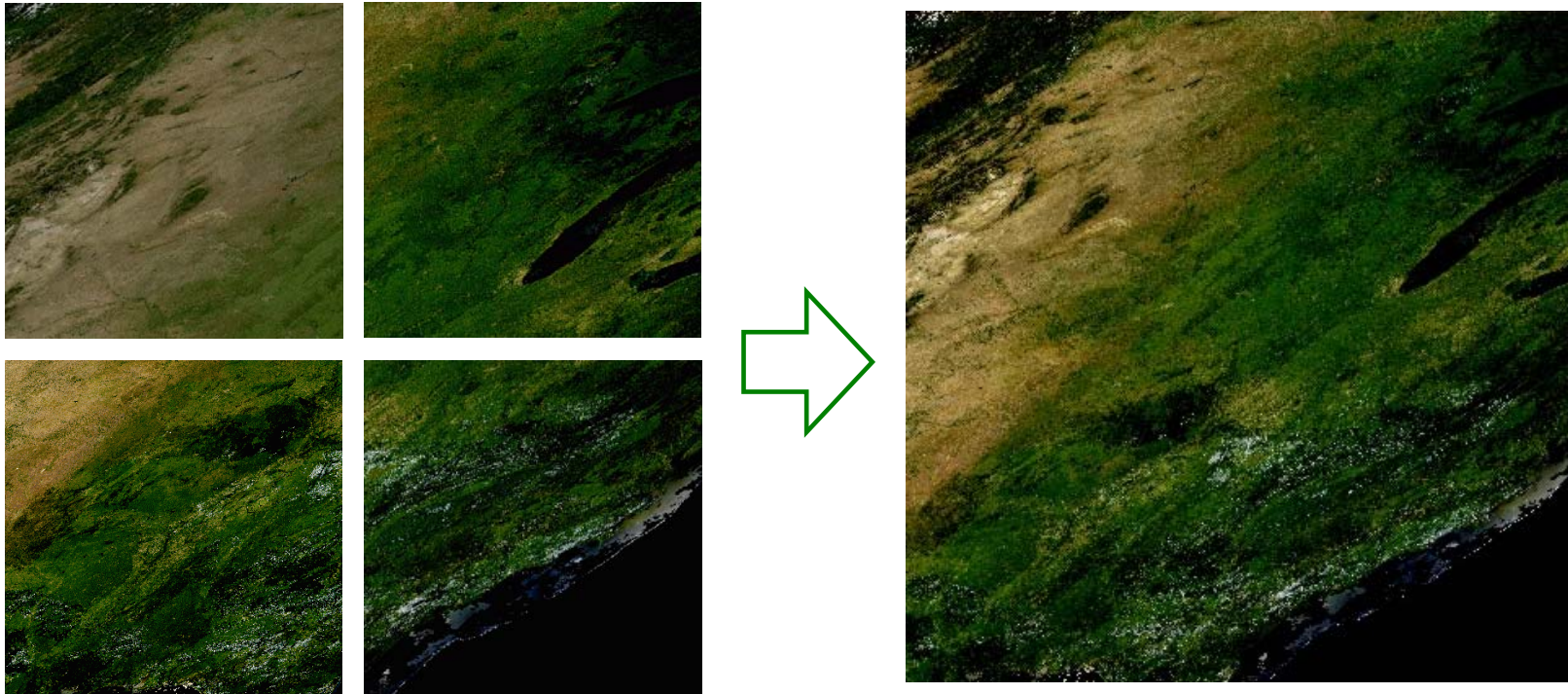




# Post-processing (2 of 2)

Mosaicing allows multiple land product tiles to be ordered as a single product.

*Mosaic of four tiles of 8-day Surface Reflectance over US east coast (12-19 July 2003).*



Multiple operations can be performed sequentially (e.g., mosaicing followed by reprojection).





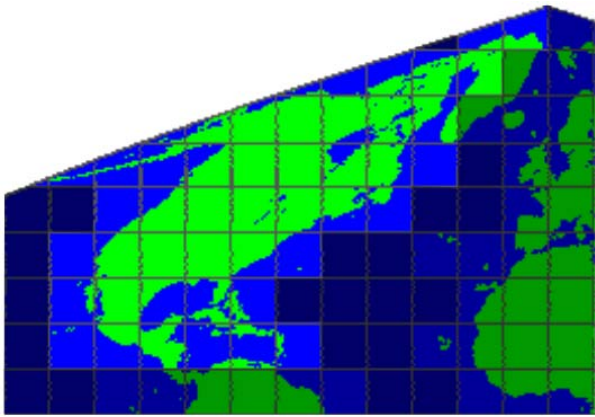
# LAADS Schedule

- The present version of LAADS (Version 2.0) will provide access to MODIS data products from the Terra and Aqua Collection 5 atmospheres near-real time forward processing and reprocessing. The reprocessing started in December 2005 at Terra first-light and data products will be immediately available through LAADS. The reprocessing will be completed by August 2006 with 10 data-years of products archived in LAADS. There will be no restrictions upon data access.
- All atmosphere L2 through L3 products will be archived including cloud mask/profiles, L2 and L3 products and global browse. LAADS will also contain Collection 4 L3 data products. L1B and geolocation products will not be archived but will be available through a rolling data pool or by POD.
- Subsequent releases of LAADS are planned for 2006 that will include additional functionality requested by users, will expedite access to MODIS products by the North American Carbon Program, and will provide limited access to NPP VIIRS science test products.



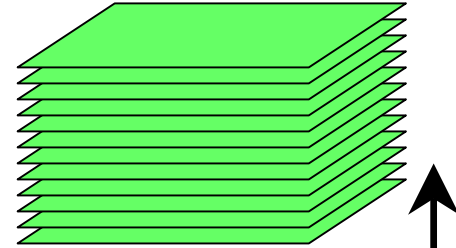
# MODIS NACP ACCESS Project

- Project: Improving access to Land and Atmosphere science products from Earth Observing Satellites: helping NACP investigators better utilize MODIS data products.
- For: Advancing Collaborative Connections for Earth-Sun System Science (ACCESS)
- Two year project with possible one year extension
- Leverages MODIS production facility and LAADS to serve the remote sensing needs of the North American Carbon Program as a: “Data and Information Systems Support for Science Focus Areas and Applications”.



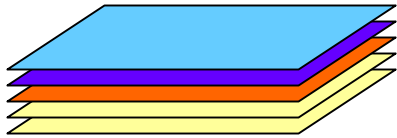
# Typical Data Flow

**Product that meets researcher's needs:**  
 Data through time  
 User-defined area  
 One data set, appropriately filtered by the associated QA layer

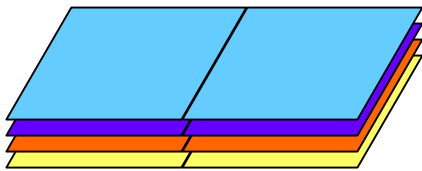


## 1. Order Data

Six years over North America implies:  
 7314 files, 1.013GB, ~20 8-hour days to order

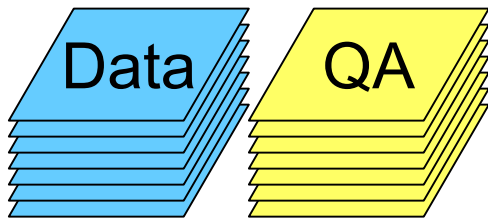


**Current MODIS granule:**  
 one time step  
 Several "bands" or science data sets  
 One or more associated QA layers  
 Fixed area (1200km x 1200km)

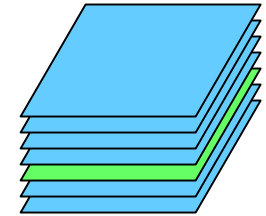


**2. Reproject & Mosaic tiles**  
 The "MODIS reprojection tool" is one tool available for this operation

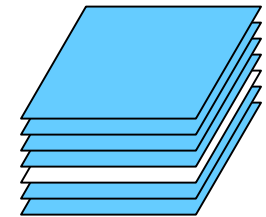
**3. Extract data layer of interest & its associated QA and "stack" through time**



**5. Fill gaps**  
 "TIMESAT" or other tools



**4. Filter data**  
 "LDOPE" tools can be used to interpret QA layers to filter out low quality data



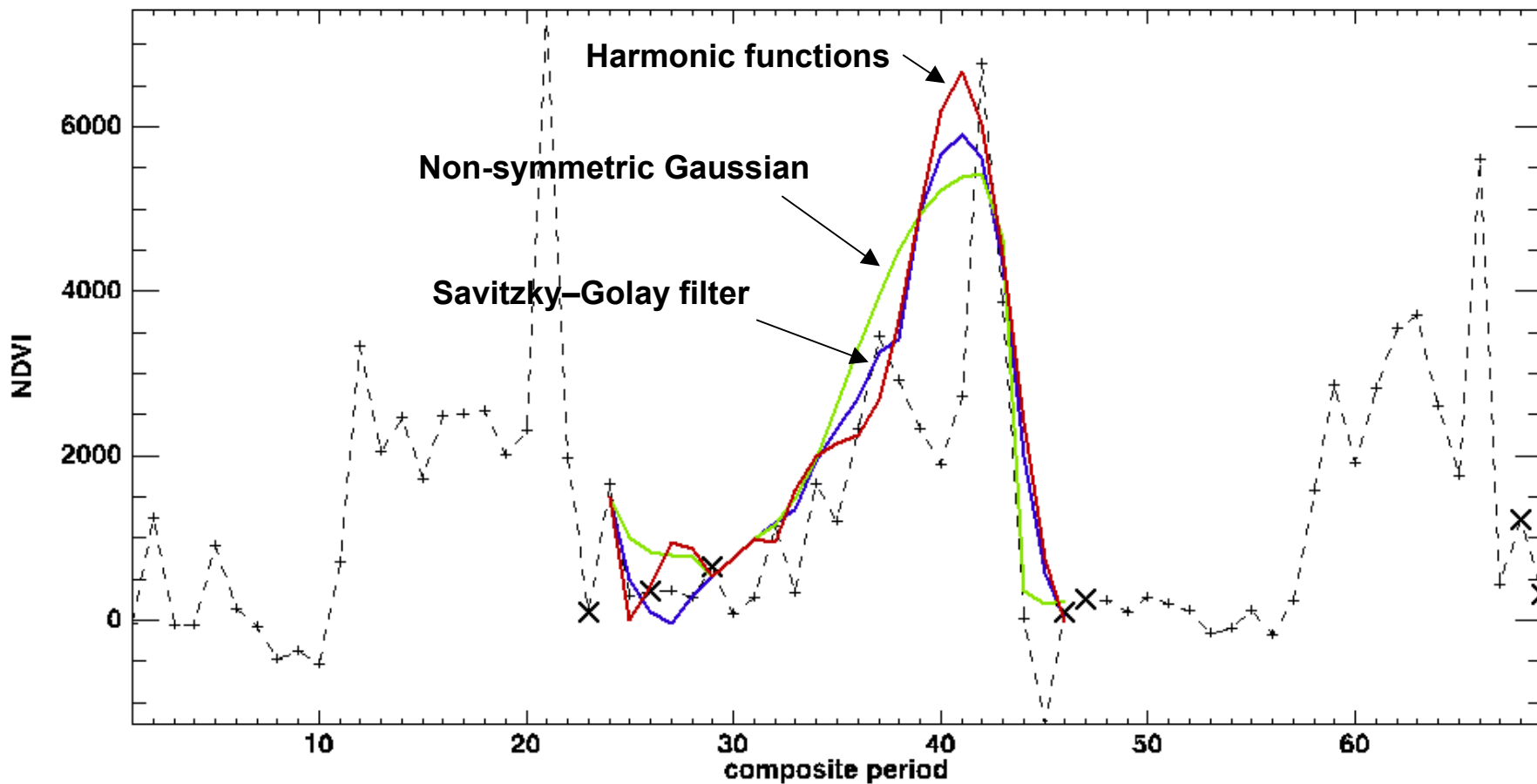
*In this diagram, we suppose this layer indicates low quality for this time step*





# Temporal filling and interpolation

MODIS NDVI time series 2001-2003



MODIS NDVI value with “poor quality” flag are marked are plotted as an X



# Product Delivery Options

- Options for MODIS Land and Atmosphere Products over NACP regional study area
  - ❑ Reprojection (to NACP regional map projection)
  - ❑ File format conversion (e.g., GeoTIFF, ASCII and Binary)
  - ❑ Mosaicing (from 10 x 10 deg. Tiles to Regional Coverage)
  - ❑ Resample (aggregate) spatial resolution (to coarser grid)
  - ❑ Modification of temporal composites (changing time steps)
  - ❑ QA filtering and gap filling (temporal and spatial)
  - ❑ Ancillary model data
  - ❑ Machine to machine requests (services)  
(LAADS capabilities)