# C6 MODIS Land Algorithm Change Testing and Reprocessing Status

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## Overview: Purpose / Timeframe

The MODIS (Moderate Resolution Imaging Spectroradiometer) Adaptive Processing System (MODAPS), has been processing the earth view data acquired by the MODIS instrument aboard the Terra (EOS AM) and Aqua (EOS PM) satellites to generate a suite of land and atmosphere data products using the science algorithms developed by the MODIS Science Team. These data products are used by diverse users in research and other applications from both government and non-government agencies around the world. These validated global products are also being used in interactive Earth system models able to predict global change accurately enough to assist policy makers in making sound decisions concerning the protection of our environment. An increased emphasis is being placed on generation of high quality consistent data records from the MODIS data through reprocessing of the records using improved science algorithms.

Since the launch of Terra in Dec 1999, MODIS land data records have been reprocessed four times. The Version 6 (V6) reprocessing of Atmosphere products started in Dec 2013 and reprocessing of land products is scheduled to start in July 2014. At the current processing rate of 30-40x the atmosphere reprocessing is expected to complete in summer of 2014 and land in summer of 2015. The V6 products are expected to be released to the public from the Distributed Active Archive Centers (DAAC's) within a month after the start of the reprocessing. To facilitate user acquaintance with products from the new version and independent evaluation of V6 by comparison of two versions, MODAPS plans to continue generation of products from both Versions for at least a year upon completion of the V6 reprocessing, after which V5 processing will be discontinued.

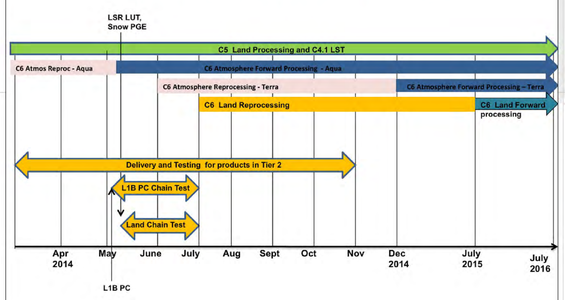
## Improvements in Land Products from V6 Changes

- Improvement in all land products from improvement in V6 L1B from Calibration, Cloud Mask, Geolocation, Land Water Mask and multi-year Land Cover seed input.
- Improvement in Land Surface Reflectance, Land Surface Temperature, Active Fire, Snow and BRDF/Albedo from product specific algorithm changes.
- LAI/Fpar and GPP/PSNnet produced at 500m resolution.
- VI suite of products generated from 8-day composite reflectance product (MOD09A1/MYD09A1)
- BRDF/Albedo produced daily at 500m resolution, global CMG of all datasets at 15 arc sec.

New products in C6:
- 8-day and monthly LST tiled 6km resolution products (MO[Y]D11B2, MO[Y]D11B3).
- Two new snow cover daily products – cloud clear daily snow, reflectance based snow
- New L2G-lite daily products – Snow, Ocean bands, and thermal bands
- MAIAC (Multi-Angle Implementation of Atmospheric Correction), (MO[[Y]D19)
- New Land surface temperature and emissivity product (MO[Y]D21) from JPL
- 8-day, monthly and yearly Evapotranspiration (MOD16) product from NTSG. Montana

## C6 Science Testing - Status

### C6 Land and Atmosphere Testing and Reprocessing TimeLine




## C6 Reprocessing Plan

- Land Reprocessing will include two tiers of processing with first tier of processing currently projected to start in June/July 2014.
  - **First tier of reprocessing will generate most of L2/L2G and L3 products – suite of LSR (MxD09), Fire(MxD14), Snow(MxD10), sea-ice(MxD29), LST(MxD11), VI(MxD13), LAI/FPAR (MxD15), GPP/PSNnet (MxD17) and BRDF/Albedo (MCD43).**
  - **Second tier of reprocessing will generate new land products – MAIAC (MOD19), Simon's LST (MOD21), Evapotranspiration (MOD16) and other L3/L4 products like Burned Area (MCD45A1), VCF (MOD44B), LC (MCD12Q1 and MCD12Q2).**
- Reprocessing will start from the beginning of the Terra mission, and will include Aqua and combined processing when the processing reaches the beginning of the Aqua mission in 2002.
- At 30x processing rate the first tier of reprocessing could take 8-12 months to complete reprocessing of the entire mission.
- MODAPS will process the second tier products as C6 algorithms become available.
- C6 products will be released to the public after review of the data from the initial period of reprocessing by the science team (~ 3 months after start of reprocessing).
- C5 land reprocessing will continue for a year after the completion of the C6 reprocessing and data products from both versions will be available to the public during this period.

## Leading baseline Changes:

In addition to the improvements from product specific changes to algorithms, the V6 products will also see significant improvement from :

- Change in approach to L1B TOA reflectance and radiance from MCST
- More accurate Geolocation
- Improvements to Cloud Mask
- Improved Land Water Mask
- New Land Cover seed input
- Correction to Terra polarization sensitivity

## Land Cover Seed Input:

- V6 reprocessing will use the new multi-year LC generated based on 3 years of MODIS data as opposed to using single global LC product for the entire mission in V5 processing.
- Multi-year land cover products available at 1km (MCDLC1KM) and 500m (MCDLCHKM) resolution for years 2001, 2004 and 2007.

## Land Water Mask:

- Shows improvement in definition of small inland water features, lakes, shorelines and improvement in definition of rivers.
- A new dataset "water present" included in the Geolocation (MOD03) file – an indicator of percentage water in a 1km resolution pixel.

### Differences between C5 and C6 water mask for MODIS

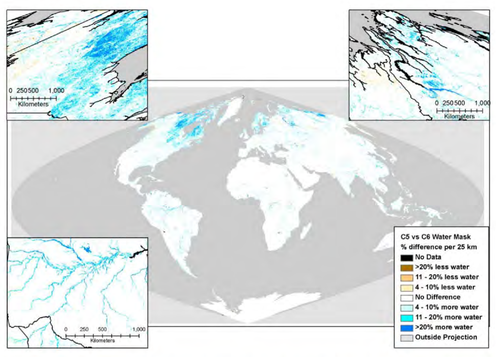



Figure 4 The differences between the Collection 5 vs the Collection 6 water mask for MODIS. Differences are represented as percent difference per 25km grid cell for visibility with more water shown in shades of blue and less water shown in shades of brown.

## Summary of Science Tests and Evaluation on the LDOPE QA web page

### 1. C6 Test website

- C6 Algorithm changes and the science test plans are posted on the QA web site at http://landweb.nascom.nasa.gov/cgi-bin/QA_WWW/newPage.cgi?fileName=sciTestMenuC6
  Science tests are listed for individual products and as chain tests of one or more dependent products in the land production chain.

### 2. Select a C6 product test

**C6 LSR Test**

**Updated:** 03/20/2014

| Test Name | Description | AS# | PGE Version | Run Status | Evaluation Status |
|---|---|---|---|---|---|
| LSR Test | L2G-lite 1 year surface reflectance test for tile h10v05 (Test Plan). | 982 | See Test plan | Completed-03-20-2014 | On going GTB |
| | 1-day global test of Terra and Aqua for PGE11 V6.1.6 (Test detail) | 916 875 | PGE11 6.1.6 | Completed-08-08-2013 | On going GB |
| | Repeat of previous C6.1.4 test, using tile h18v04, year 2005-2009 | 885 5 | PGE11/12/13 | Completed-07-20-2013 | On going GTB/DIFF |
| | L2G-lite surface reflectance test for tile h31v11. (C6.1.4) | 852 5 | PGE11/12/13 | Completed-04-16-2013 | On going GTB/DIFF |
| | C6 PGE11/75 Test (C6.2.8) | 24(Terra) 22(Aqua) 5 | Terra, PGE11 6.0.12 PGE75 6.0.6 Aqua PGE11 6.0.10 PGE75 6.0.5 | On going | On going GB |
| | To evaluate the most recent updates to the C6 PGE11 (LSR, version 6.0.13) and its effect on the downstream land products (except for LST, fire, snow and sea_ice). (C6.2.7 New LSR Chain Test) | 808 557 | PGE11 6.1.1 | Completed-09-20-2012 | On going GB/DIFF GTB/DIFF (n-day only) |
| | | 808 556 | | | On going GB/DIFF GTB/DIFF (n-day only) |

- Most science tests generated products globally from two 16-day periods, one summer (starting day 193) and one winter period (starting day 001) of year 2003.
- The Baseline data is generated using C6 L1B geolocation, cloud mask, and C5 land algorithms. The Test data is generated using C6 land algorithms.

**New C6 LSR Chain Test**

**Updated:** 09/05/2012

**Test Objective:** To evaluate the most recent updates to the C6 PGE11 (LSR, version 6.0.13) and its effect on the downstream land products (except for LST, fire, snow and sea_ice).

**Test Time Interval:** Two 16-day periods of Aqua and Terra

2003001 - 2003024

2003193 - 2003216

All daily and n-day products within this test periods must be produced. Additional Aqua days should be included to account for any 8-day shift in the Aqua processing stream.

**Machine/Archive Set:**

**Related Test(s):** LAADS archive tests 315, 409, 5, 557

**Baseline DataSet:** LAADS AS 315, 409, 557

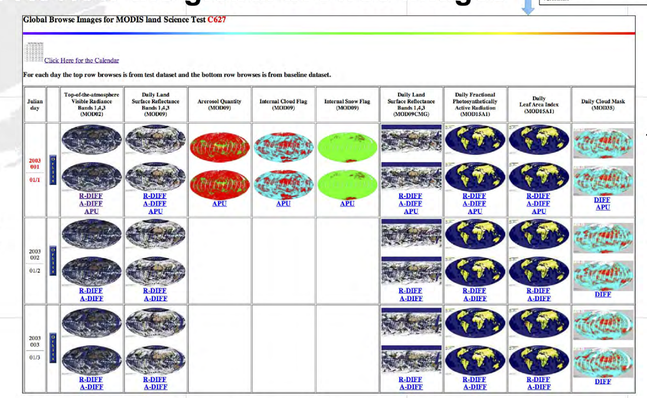
**Input DataSet:** Terra and Aqua L0

**Ancilliary data:** should use the same ancillary used in AS 315 (presumably same as in AS 409)

**Recipes/PGEs to be tested:**

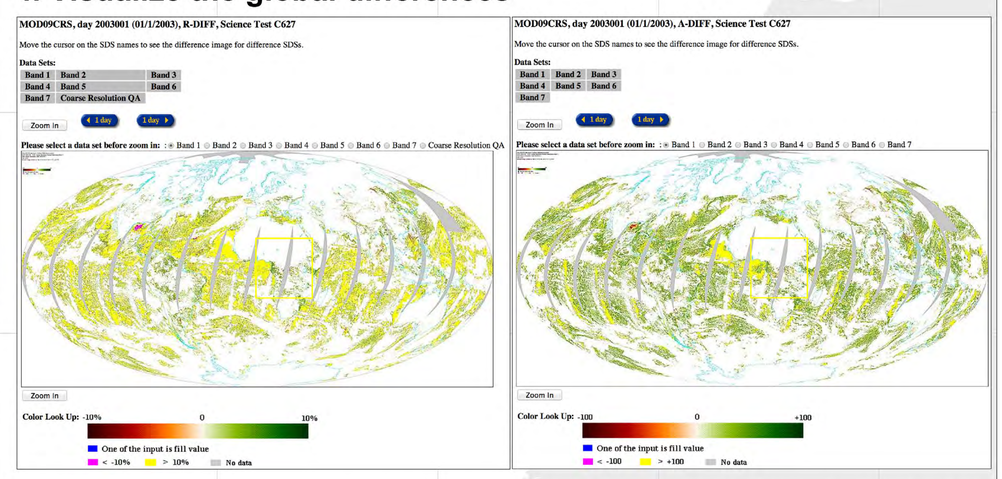
Aqua Recipes and PGE Versions (extracted from AS 409 â€" Update this with more recent PGE01, PGE02, PGE03 for C6) â€" Please remove PGEs generating any of the LST, Snow, sea_ice and Fire product. For LSR PGE11, PGE75 and PGE21 use the current baselined C6 versions.

### 3. Review the global browse images




- For each science test, the table contains the test plan, LAADS archive set containing the baseline and the test, and the images of data products and results from analysis of the data products generated in the science test.

### 4. Visualize the global differences




- To facilitate quick and easy comparison of products from the test to the baseline, global browse images of products from the two versions are created using identical stretching and the same set of LUTs.
- Global browse image of difference (relative and absolute) between the corresponding datasets in the baseline and test data are posted to visualize the spatial variation of difference from the algorithm change.

### 5. Evaluate the magnitude of difference with APU

**APU Metrics**

- Accuracy (Mean Difference, Bias)

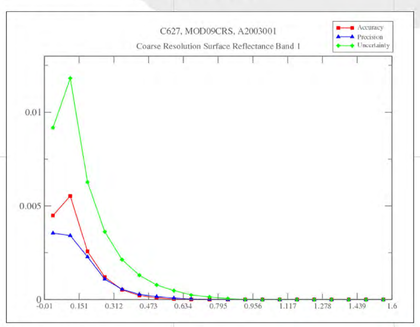
$$A = \frac{1}{N}\sum_{i=1}^{N}\left(X_{V6,i} - X_{V5,i}\right)$$

- Precision (Standard Deviation)

$$P = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}\left(X_{V6,i} - \bar{X}_{V6}\right)^2} \quad \text{where} \quad \bar{X}_{V6} = \frac{1}{N}\sum_{i=1}^{N} X_{V6,i}$$

- Uncertainty (Root Mean Square Error)

$$U = \sqrt{\frac{1}{N}\sum_{i=1}^{N}\left(X_{V6,i} - X_{V5,i}\right)^2}$$

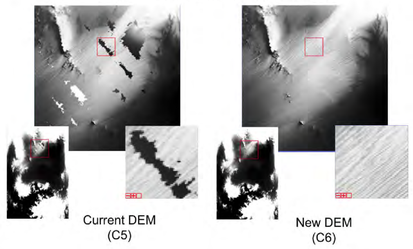



- Accuracy, Precision and Uncertainty metrics are computed for datasets in the product by using the baseline as the reference and these APU plots are posted.

## Geolocation:

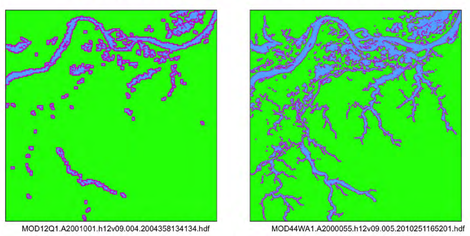
### Old vs. New Digital Elevation Model (DEM)

**MODIS Geolocation Height (data-day 2010/221)**




- New C6 DEM (Source: USGS and NGA, Danielson et al.)
- Being used at 15 arc-sec (~500m)
- Better data available for gap filling
- Using best available approach to reducing resolution and gap filling.

### Difference in C5 vs C6 LW Mask




- The spatial subset of the tiles above show the Amazon river in Northern Brazil.
- There is a significant improvement in defined rivers and streams.

00: shallow ocean
01: land
02: ocean coastlines and shorelines
03: shallow inland water
05: deep inland water
06: continental / moderate ocean
07: deep ocean

Table 2 Confusion matrix comparing C5 vs C6 water mask. Class 4, Ephemeral water, is not populated in either mask so has been omitted from the table.

| | C5 Mask | 0 | 1 | 2 | 3 | 5 | 6 | 7 | |
|---|---|---|---|---|---|---|---|---|---|
| C6 Mask | | Shallow Ocean | Land | Shoreline | Shallow Inland | Deep Inland | Mod. Ocean | Deep Ocean | Total |
| 0 | Shallow Ocean | 66,064,777 | 2,494,034 | 3,179,627 | 165,235 | 809 | 45,889,107 | 956,637 | 118,750,226 |
| 1 | Land | 541,970 | 646,883,341 | 4,862,811 | 1,204,525 | 8,095 | 16,423 | 192 | 653,517,357 |
| 2 | Shoreline | 545,582 | 12,370,392 | 2,519,087 | 895,621 | 984 | 6,010 | 379 | 16,338,055 |
| 3 | Shallow Inland | 72,016 | 5,411,904 | 2,366,318 | 5,893,698 | 623,283 | 43 | - | 14,367,262 |
| 5 | Deep Inland | 123 | 558 | 915 | 614,639 | 245,001 | - | - | 861,236 |
| 6 | Mod. Ocean | 5,270,037 | 86,763 | 211,545 | 3,962 | - | 36,370,514 | 7,586,840 | 49,529,661 |
| 7 | Deep Ocean | 1,814,187 | 5,129 | 12,196 | 57 | - | 7,540,884 | 836,966,734 | 846,348,187 |
| | Total | 74,308,692 | 667,252,121 | 13,152,499 | 8,777,737 | 878,172 | 89,831,981 | 845,510,782 | |