Evaluation of the VIIRS Land Algorithms at the Land PEATE

NOAA CDR Workshop – April 5, 2011

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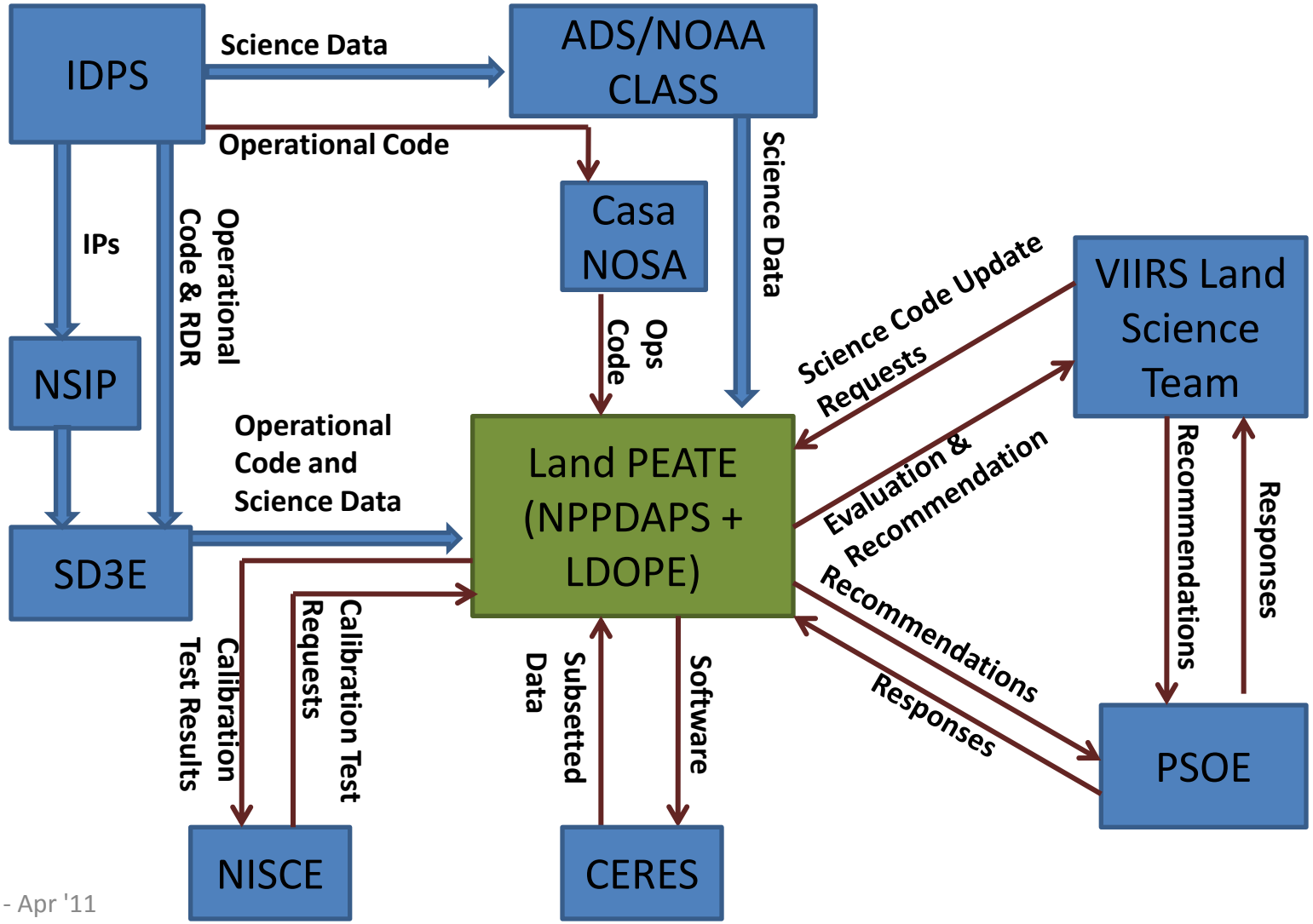
Based on an IGARSS 2010 presentation with co-authors Sadashiva Devadiga, Gang Ye, Ed Masuoka and Bob Schweiss

Land Product Evaluation and Algorithm Test Element

- **Component of NASA's Science Data Segment (SDS) of the NPOESS Preparatory Project (NPP)**
  - Assess the quality of the Visible Infrared Imaging Radiometer Suite (VIIRS) Land Products made by the Interface Data Processing System (IDPS)
  - Recommend improvements to the VIIRS Land science algorithms.
- **Uses NPP Data Processing System (NPPDAPS) for production of data and Land Data Operational Product Evaluation (LDOPE) for evaluation of the data products.**
  - NPPDAPS is a version of the MODIS Adaptive Processing System (MODAPS) modified to make products from the IDPS operational code and software provided by the science teams.
  - LDOPE Team adopts the MODIS Land QA approach to evaluate the quality of the VIIRS Land Products.
- **Uses VIIRS Proxy data (based on MODIS/Aqua) as input in the pre-launch testing of the algorithms.**
- **MODIS and other data is used for comparison in the NPP post-launch era.**

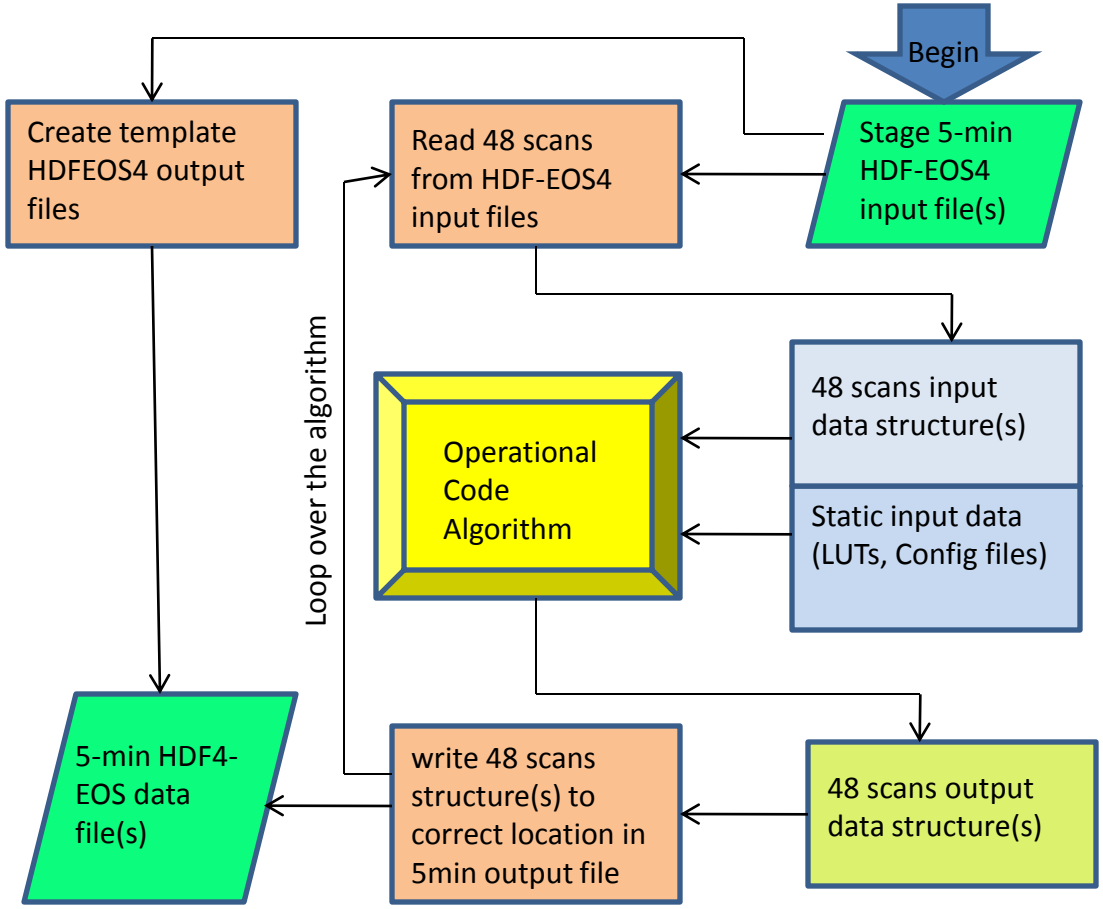
Interface of Land PEATE with SDS Elements and External Segments



IDPS OPS Code Integration at Land PEATE

- **2 types of algorithms integrated to NPPDAPS**
  - IDPS Operational code (OPS) developed at the IDPS by porting the Science code developed by the Northrop Grumman Aerospace Systems (NGAS) science algorithm team to run on IDPS – moving to JPSS project and NOAA STAR
  - Science Team (ST) code developed by the VIIRS Land science teams.
- **Coarse Resolution Product**
  - A shared code integrated to every L2 and L3 PGEs generates coarse spatial resolution product at 5km resolution.
  - Used to generate global browse images from one full day of data.
- **Diagnostic Data Records**
  - VIIRS equivalent of the MODIS Level 3 daily and multi-day gridded products.
  - MODIS C5 code modified to use VIIRS xDRs (Sensor Data Records, Environmental Data Records)
  - Facilitates comparison and trending between the two instruments.
- **Subset data for use in validation**

IDPS OPS Code Integration at Land PEATE



Operational Code Wrapping

- OPS Codes are designed to run on a large shared memory system, reading and writing data entirely in memory.
- Land PEATE adds wrapper software to each module that writes intermediate products to disk so that the OPS code can run on small Linux servers with limited memory.
- Performs aggregation of 48 scans to approx. 5 min granules.
- Outputs are HDF4 files (an HDF5 version of wrapper is available from the direct readout group)

IDPS OPS Code Integration Status

- **Production Environment is up and running**
- **Completed integration and testing of IDPS Build1.4 (Spring 2008) and Build 1.5.0.25 (Fall 2009)**
- **Integration of Build 1.5.0.48 done (Dec. 2010)**
  - SDR/RDR/GEO Code, CERES subsetter
  - Level 2 Products (including intermediates) – 16 Algorithms
  - Level 3 Gridded Intermediate Products – 7 Algorithms
  - VIIRS Grid → Granulation – 7 Algorithms
  - Land PEATE DDRs – 12 algorithms (5 more in next build – last ones)
  - Coarse Browse Products – For all L2 products and DDRs
  - HDF5 → 4 Conversion/Aggregation – For all SDRs and most L2 products
- **Integration of IDPS Mx4 (1.5.4.0) Build underway**
  - Expect to complete in June

Chain Testing of Land Algorithms

- **Algorithms Used in the Chain Tests**
  - OPS B25 (1.5.0.25) – 51 day global test
  - OPS B48 (1.5.0.48) – 16 and 51 day global test
  - Land PEATE Adjusted (LPA) version of OPS Algorithms
    - Relax certain constraints (e.g. retrieval of surface reflectance under cloudy condition)
    - Use alternative algorithm paths (e.g. use of single split window as main algorithm instead of the dual split window approach to retrieve LST)
- **Test Input**
  - MODIS Proxy data – MODIS/Aqua data mapped to VIIRS bands in VIIRS sensor geometry
  - 16-day global data (2003/193 – 2003/208)
  - 51-day global data (2003/170 – 2003/222)
- **Objective of Chain Tests**
  - Integration testing of IDPS OPS PGEs
  - Identify algorithm issues and communicate issues to science teams
  - Track issues to identify algorithm improvements
  - Assess algorithm performance by comparing VIIRS product to heritage MODIS products
- ***Note: Examples presented for illustration only. Final version of algorithm will not be available until after post-launch calibration and validation period.***

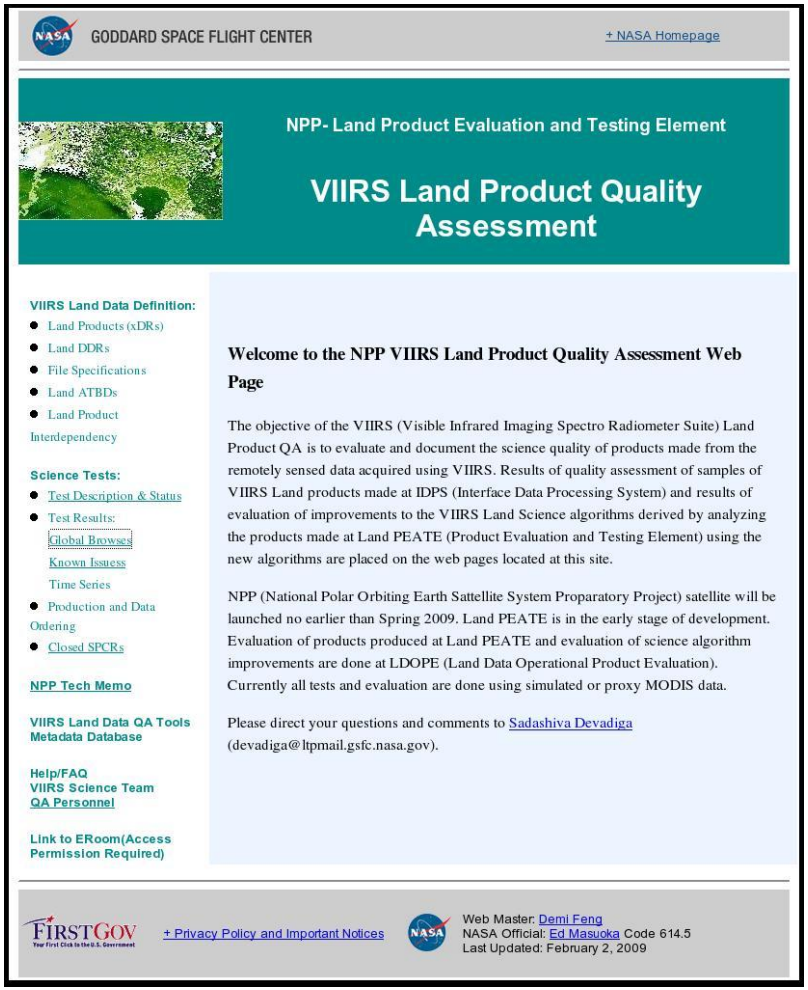
LDOPE's Approach to Quality Assessment

- **Generic QA**
  - Sample data granules by examination of Global Browses, golden tile browses, animation, and time series.
  - Identify and analyze granules with poor data quality.
  - Use product interdependency and check for propagation of error
    - Top down approach (L1 -> cloud Mask/Aerosol -> surface reflectance -> VI)
    - Bottom up approach (LST -> cloud mask -> L1)
- **Assessment of VIIRS Land Algorithm**
  - Comparison of different algorithm versions
  - Comparison to MODIS products
- **Dissemination of QA result**
  - Test status, and evaluation results posted on a QA web site.
- **Develop and Maintain QA tools**
  - Generic and transparent to products from different instruments

VIIRS Land Product QA Web Page

http://landweb.nascom.nasa.gov/NPP

- NPP VIIRS QA Page
  - Access limited to VIIRS Land Program participants
  - NASA ST, IPO, NOAA, DOD, NGST



GODDARD SPACE FLIGHT CENTER

+ NASA Homepage

NPP- Land Product Evaluation and Testing Element

VIIRS Land Product Quality Assessment

VIIRS Land Data Definition:
- Land Products (xDRs)
- Land DDRs
- File Specifications
- Land ATBDs
- Land Product Interdependency

Science Tests:
- Test Description & Status
- Test Results:
  - Global Browses
  - Known Issues
  - Time Series
- Production and Data Ordering
- Closed SPCRs

NPP Tech Memo

VIIRS Land Data QA Tools
Metadata Database

Help/FAQ
VIIRS Science Team
QA Personnel

Link to ERoom(Access Permission Required)

Welcome to the NPP VIIRS Land Product Quality Assessment Web Page

The objective of the VIIRS (Visible Infrared Imaging Spectro Radiometer Suite) Land Product QA is to evaluate and document the science quality of products made from the remotely sensed data acquired using VIIRS. Results of quality assessment of samples of VIIRS Land products made at IDPS (Interface Data Processing System) and results of evaluation of improvements to the VIIRS Land Science algorithms derived by analyzing the products made at Land PEATE (Product Evaluation and Testing Element) using the new algorithms are placed on the web pages located at this site.

NPP (National Polar Orbiting Earth Sattellite System Proparatory Project) satellite will be launched no earlier than Spring 2009. Land PEATE is in the early stage of development. Evaluation of products produced at Land PEATE and evaluation of science algorithm improvements are done at LDOPE (Land Data Operational Product Evaluation). Currently all tests and evaluation are done using simulated or proxy MODIS data.

Please direct your questions and comments to Sadashiva Devadiga (devadiga@ltpmail.gsfc.nasa.gov).

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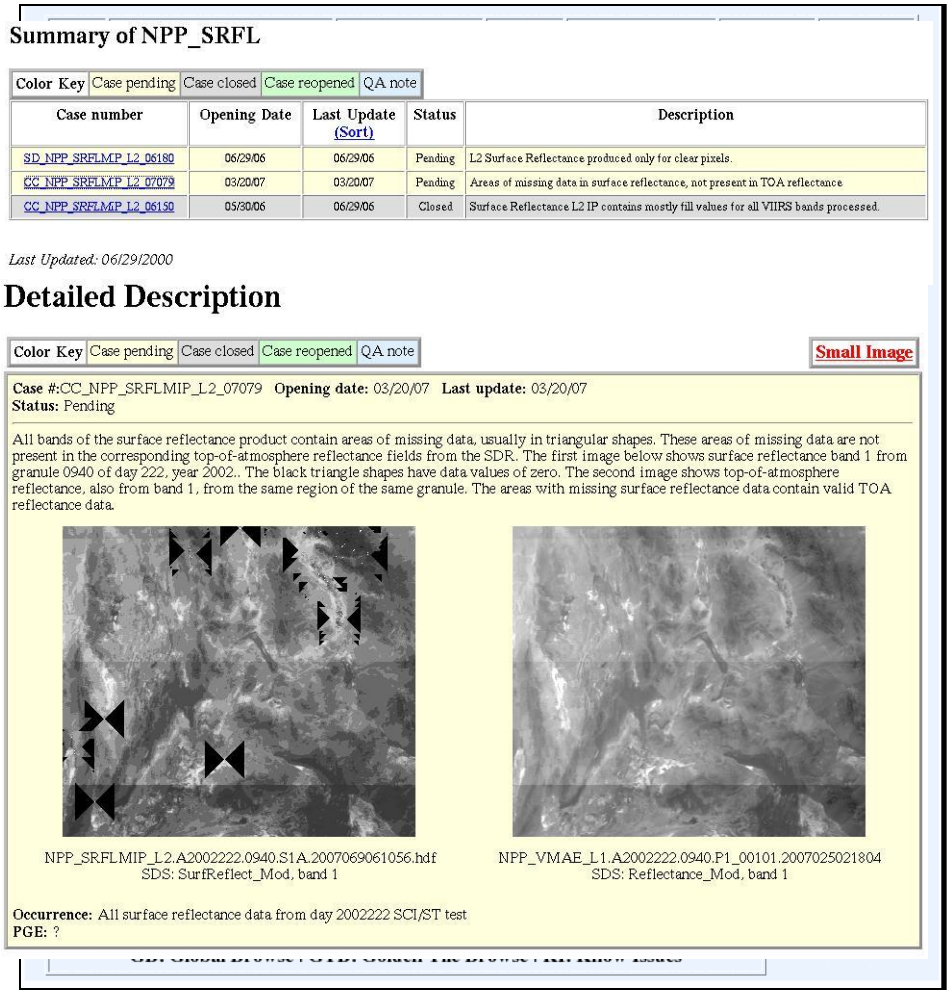
Web Master: Demi Feng
NASA Official: Ed Masuoka Code 614.5
Last Updated: February 2, 2009

- Science Test Status web Page
- Product Known Issue Page



Summary of NPP_SRFL

Color Key	Case pending	Case closed	Case reopened	QA note

Case number	Opening Date	Last Update (Sort)	Status	Description
SD_NPP_SRFLMP_L2_06180	06/29/06	06/29/06	Pending	L2 Surface Reflectance produced only for clear pixels.
CC_NPP_SRFLMP_L2_07079	03/20/07	03/20/07	Pending	Areas of missing data in surface reflectance, not present in TOA reflectance
CC_NPP_SRFLMP_L2_06150	05/30/06	06/29/06	Closed	Surface Reflectance L2 IP contains mostly fill values for all VIIRS bands processed.

Last Updated: 06/29/2000

Detailed Description

Color Key | Case pending | Case closed | Case reopened | QA note

Small Image

Case #:CC_NPP_SRFLMIP_L2_07079 **Opening date:** 03/20/07 **Last update:** 03/20/07
Status: Pending

All bands of the surface reflectance product contain areas of missing data, usually in triangular shapes. These areas of missing data are not present in the corresponding top-of-atmosphere reflectance fields from the SDR. The first image below shows surface reflectance band 1 from granule 0940 of day 222, year 2002.. The black triangle shapes have data values of zero. The second image shows top-of-atmosphere reflectance, also from band 1, from the same region of the same granule. The areas with missing surface reflectance data contain valid TOA reflectance data.

NPP_SRFLMIP_L2.A2002222.0940.S1A.2007069061056.hdf
SDS: SurfReflect_Mod, band 1

NPP_VMAE_L1.A2002222.0940.P1_00101.2007025021804
SDS: Reflectance_Mod, band 1

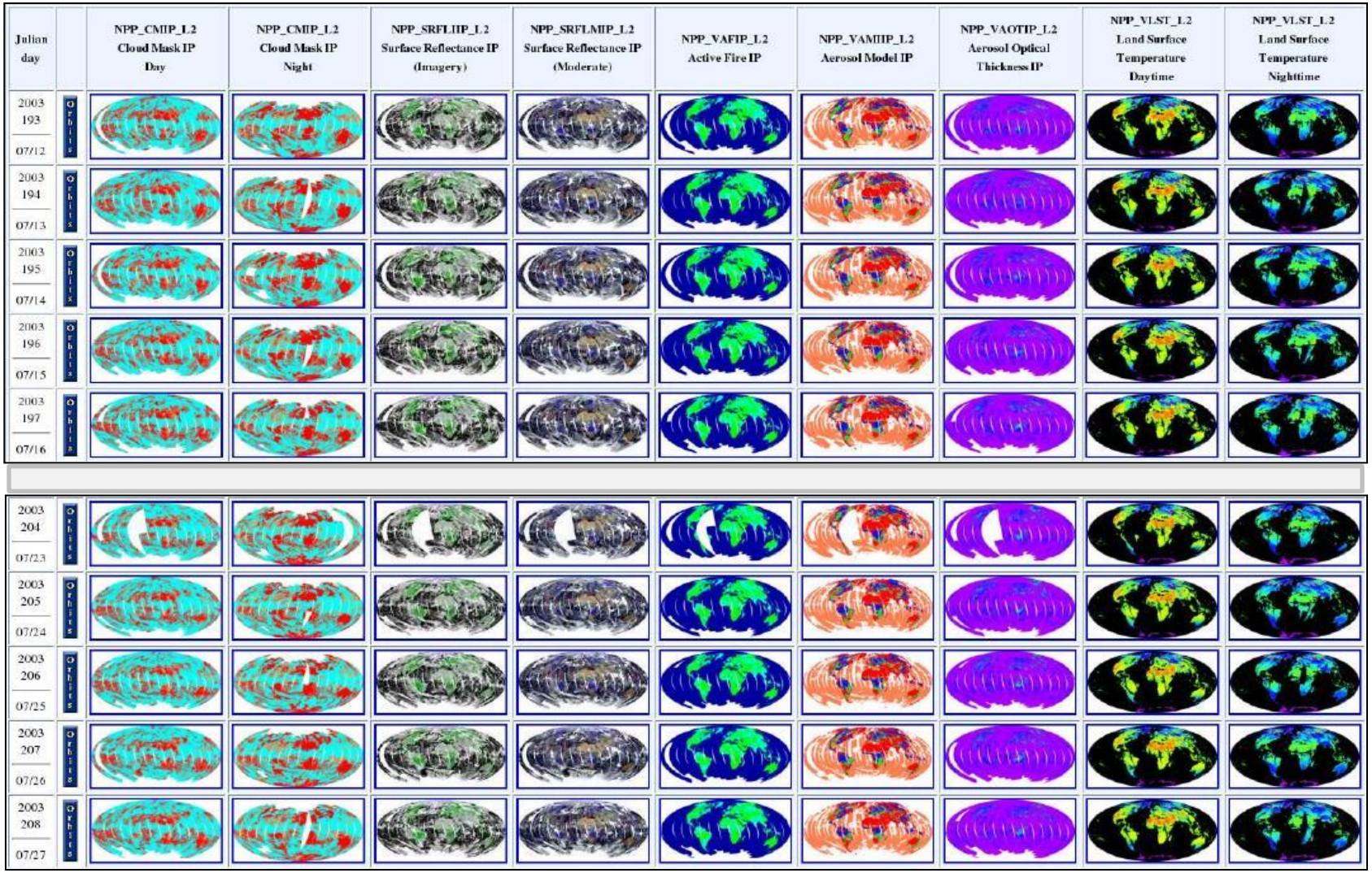
Occurrence: All surface reflectance data from day 2002222 SCI/ST test
PGE: ?

Global Browses

- All PGEs use a shared source code to generate coarse spatial resolution version of the products (5 km) using appropriate aggregation schemes (subsample, average, classification, …)
- Selected science data sets are projected into a global coordinate system
- The global browses displayed on the VIIRS Land QA web page to facilitate synoptic QA of Land products
- The browse images are generated in JPEG/GIFF format with fixed contrast stretching and color LUTs to enable
  - consistent temporal comparison.
  - comparison of products from different versions of the algorithm
- The web interface supports interactive selection of browse products and zooming and panning at 5km resolution.

Global Browses

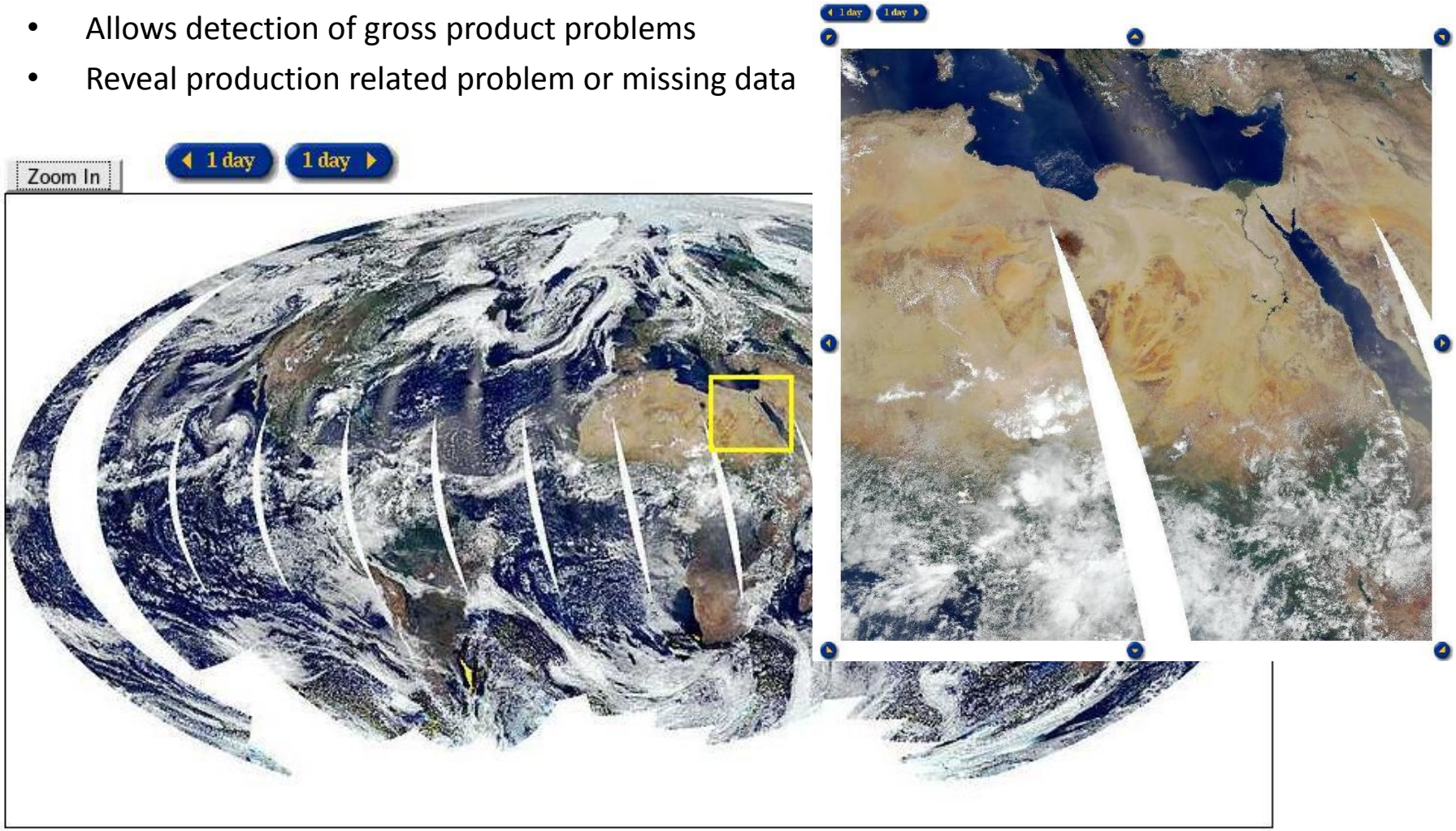
Global Browse of Test Results from the B48 Algorithms Chain Test



Product QA using Global Browses

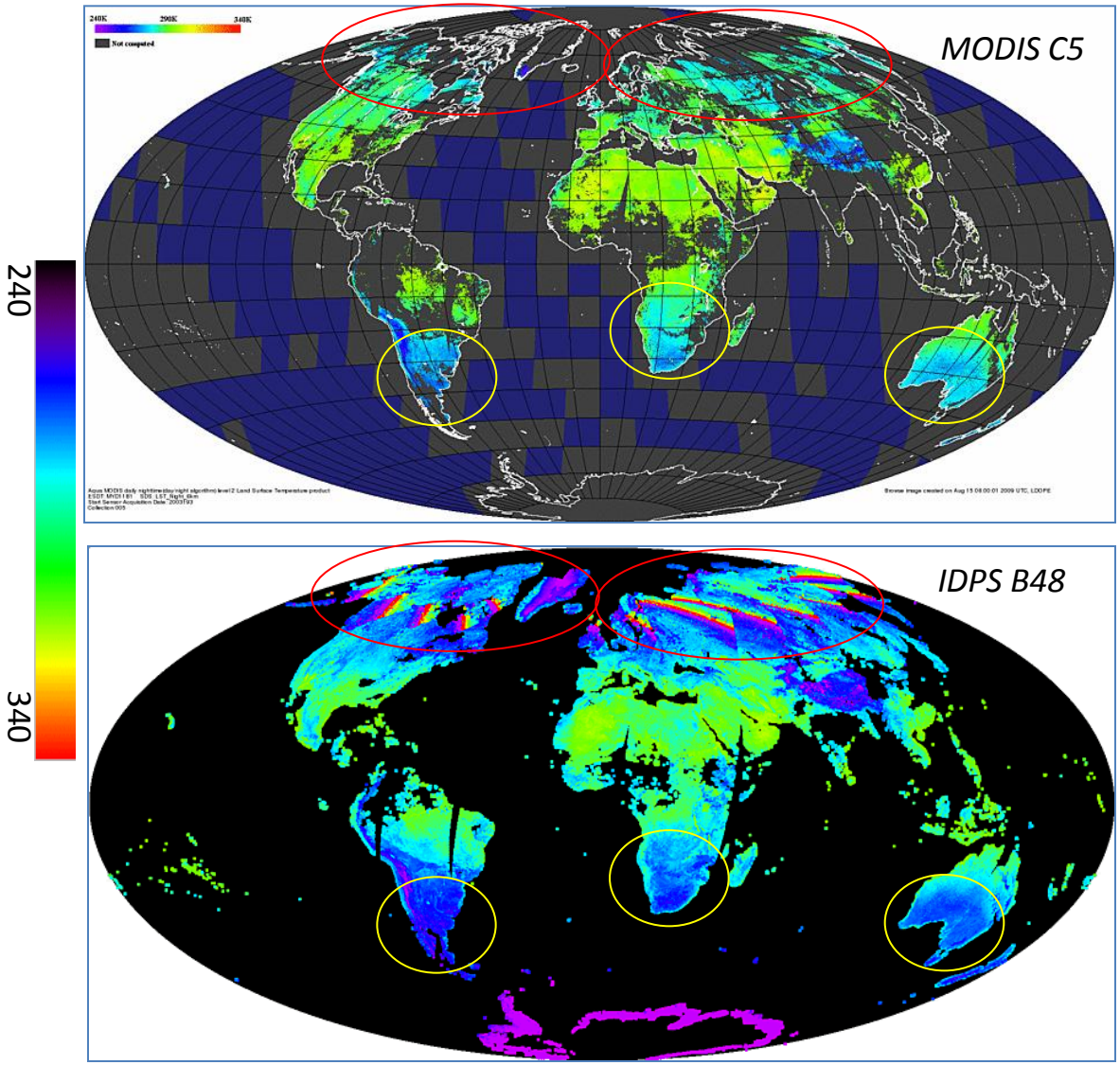
Surface Reflectance from Day 2003/193 (LPA of OPS B25)

- Instrument sensing geometry and cloud cover visible
- Allows detection of gross product problems
- Reveal production related problem or missing data



Product QA using Global Browses

Example: Night LST from Day 2003/193

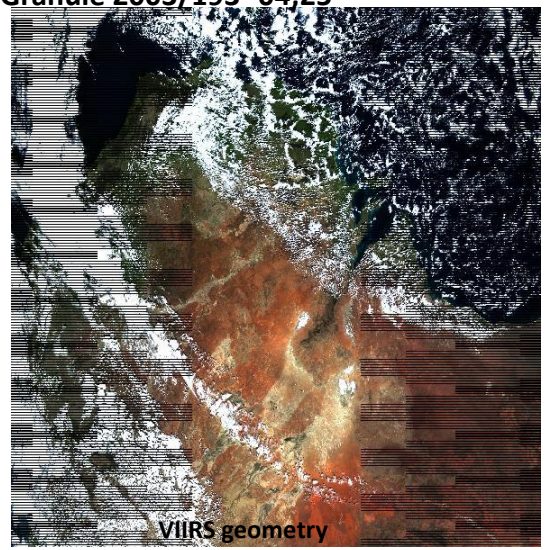


- Visual inspection of browse of LST from the IDPS B48 algorithm indicate product quality problem at high latitude – possibly at the day night boundary
- Comparison of browses of LST from the IDPS B48 to the MODIS C5 indicates possible underestimation of LST by the IDPS algorithm.
- More retrieval in VIIRS compared to MODIS.

Assessment of Algorithm Improvement

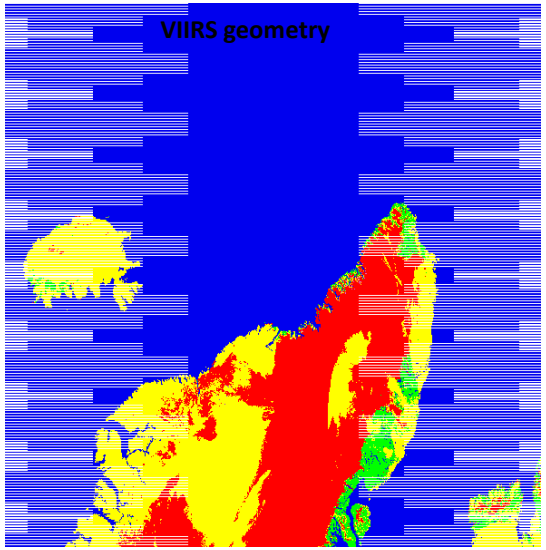
Mapping MODIS products to VIIRS sensor geometry

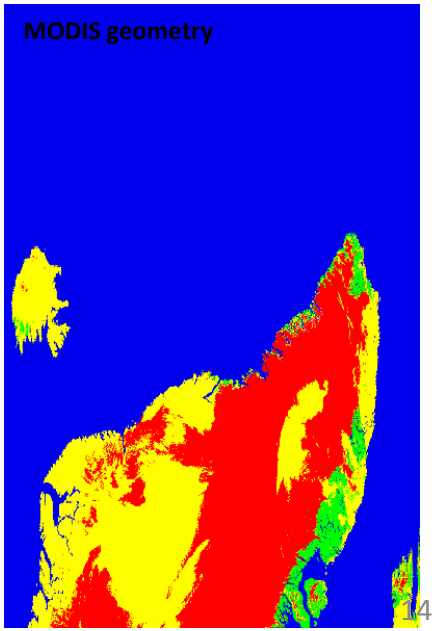
MODIS Surface Reflectance: Granule 2003/193- 04;25



- The MODIS L2 products are mapped to VIIRS geometry to facilitate pixel level comparison of MODIS and VIIRS L2 products
- Pixel deletions (bow-tie) are introduced during the resampling of the L2 product.

MODIS Snow Cover: Granule 2003/193 – 14:45



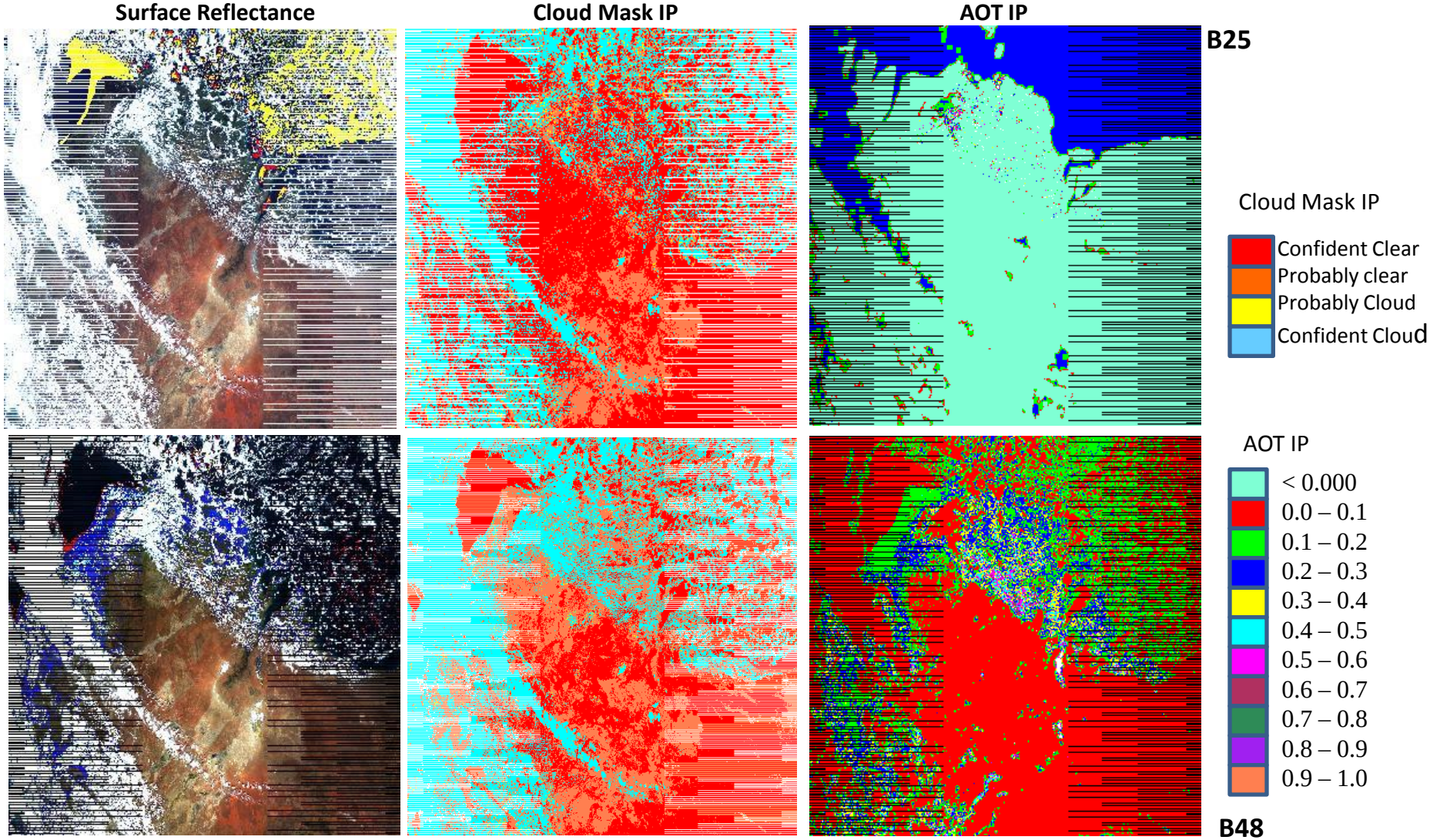


Snow
Cloud
Water
Clear land
Lake ice

Assessment of Algorithm Improvement

Surface Reflectance, Cloud Mask IP and AOTIP

Granule 2003/193-04:25

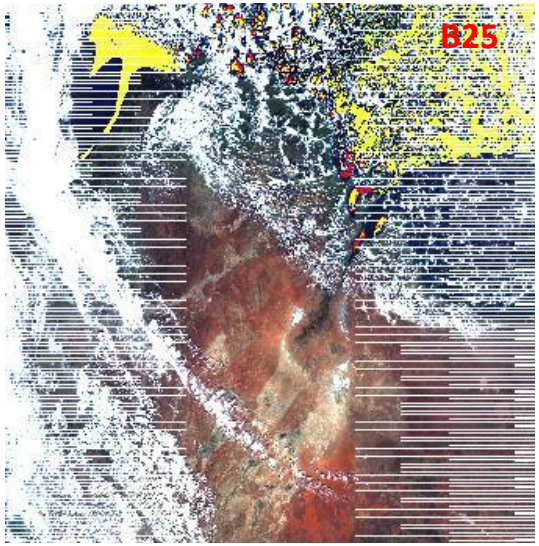


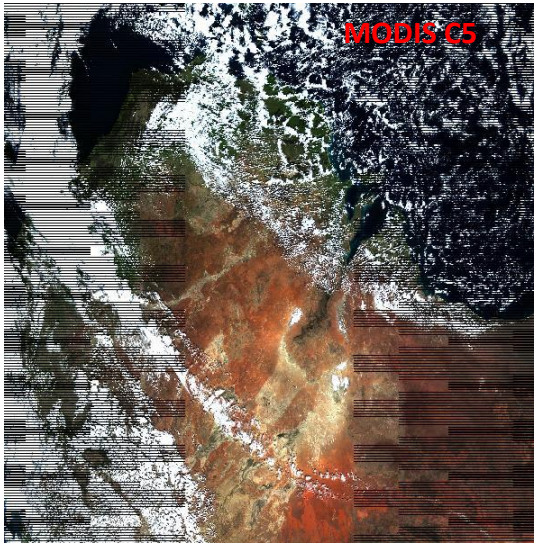
There seems to be some improvement in Cloud Mask, but AOT in B48 is good,

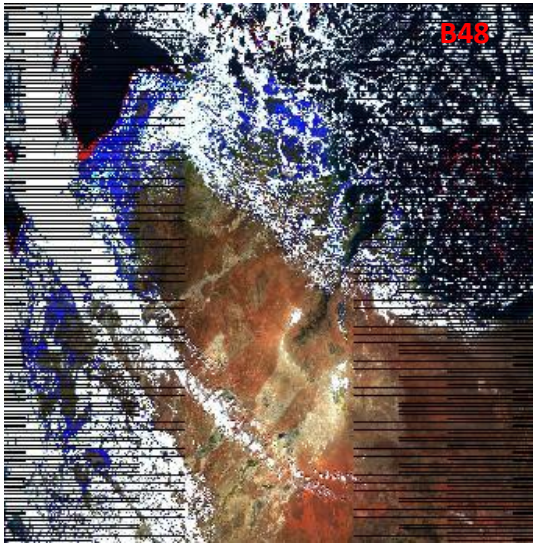
Assessment of Algorithm Improvement

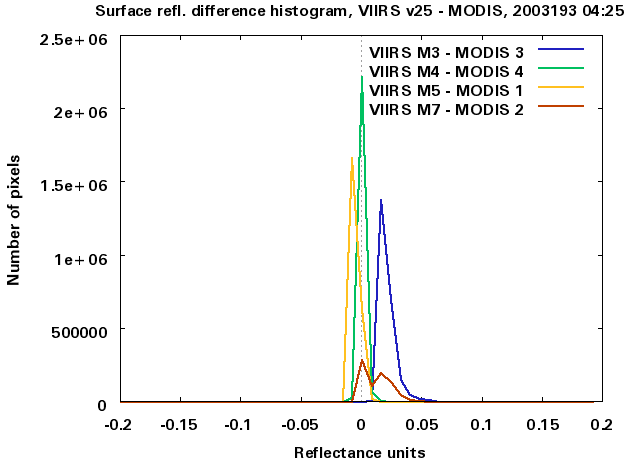
Histogram of Pixel Level Difference in Surface Reflectance

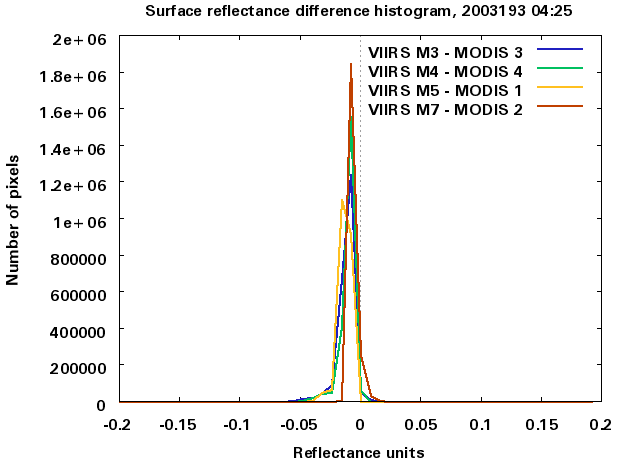
Granule: 2003/193-04:25







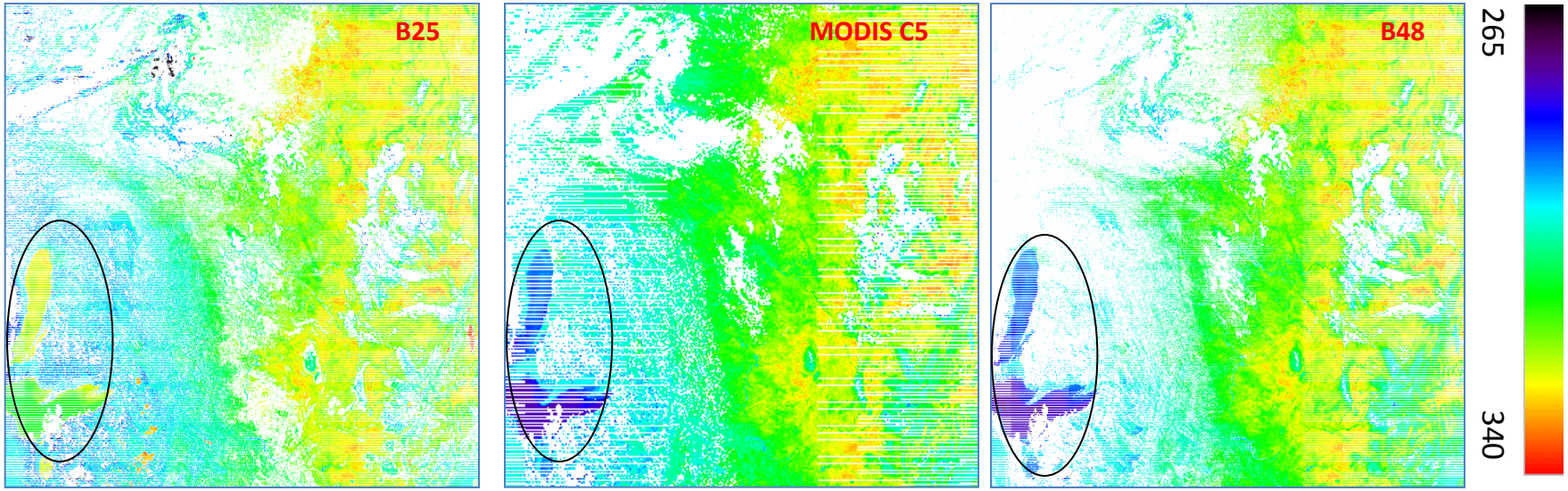


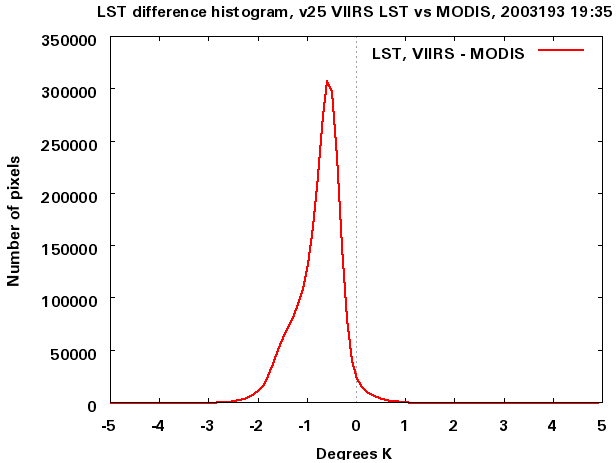


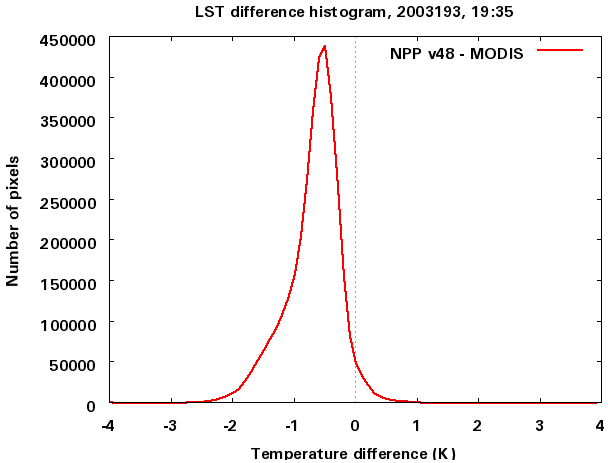
- **AOT in B25 is mostly negative. In the LPA version of SR algorithm the AOT was set to a low value.**
- **In B48 version the retrieved AOT was good and was used by the B48 IDPS SR algorithm.**
- **No difference in the LSR algorithm.**
- **Land PEATE test may be using VIIRS LUT**

Assessment of Algorithm Improvement

Histogram of Pixel Level Difference in Day Time Land Surface Temperature – Granule 2003/193 19:35



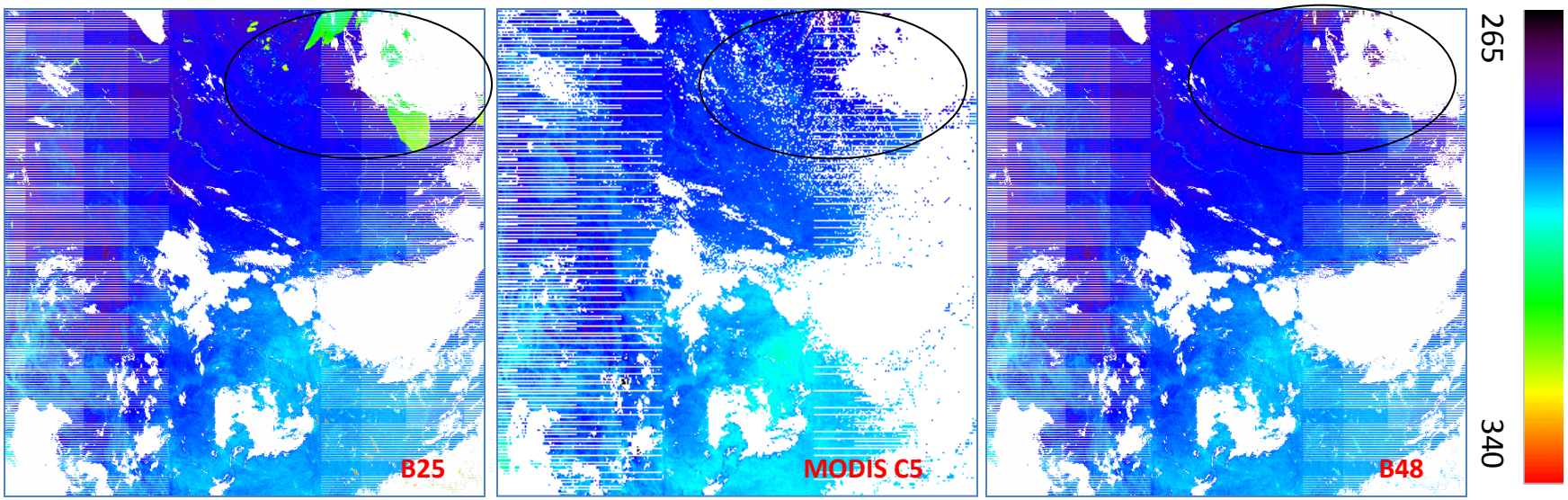


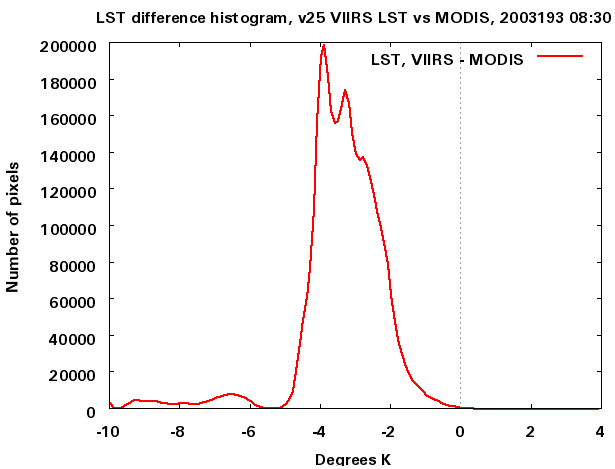


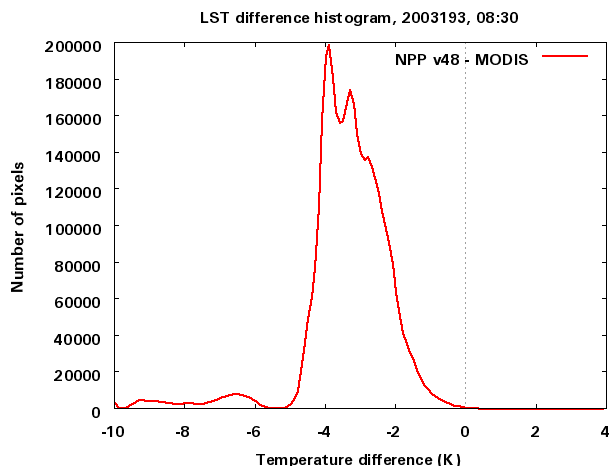
- LST algorithm may not have changed.
- Difference in histogram is due to difference in cloud mask.
- LST retrieval over inland water bodies fixed in B48.

Assessment of Algorithm Improvement

Histogram of Pixel Level Difference in Day Time Land Surface Temperature – Granule 2003/193 08:30





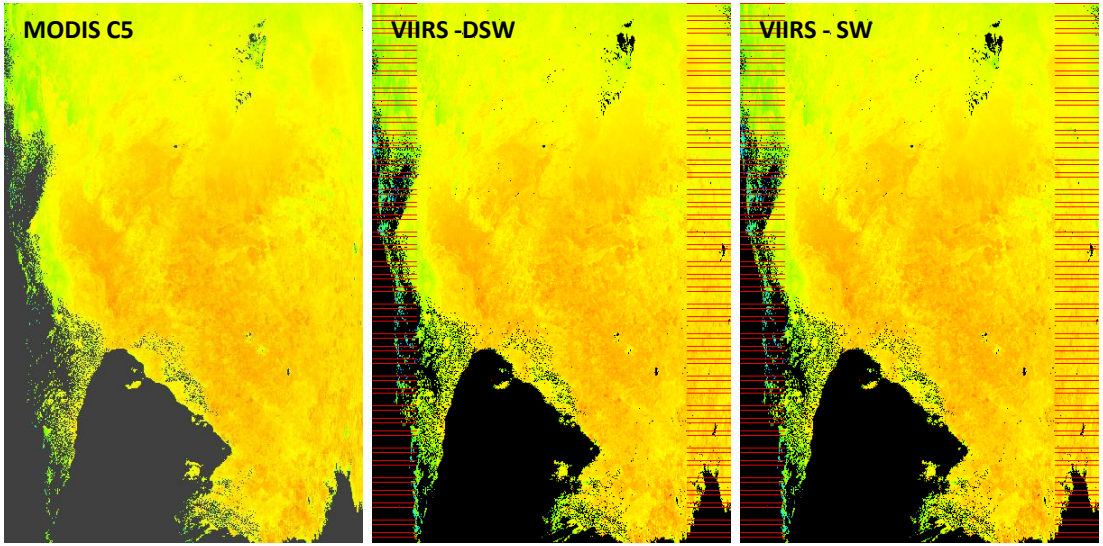


- **Night time LST and the night time cloud mask algorithm didn't change, except for the fix to retrieve LST over water area in B48.**
- **Night time LST is largely underestimated**

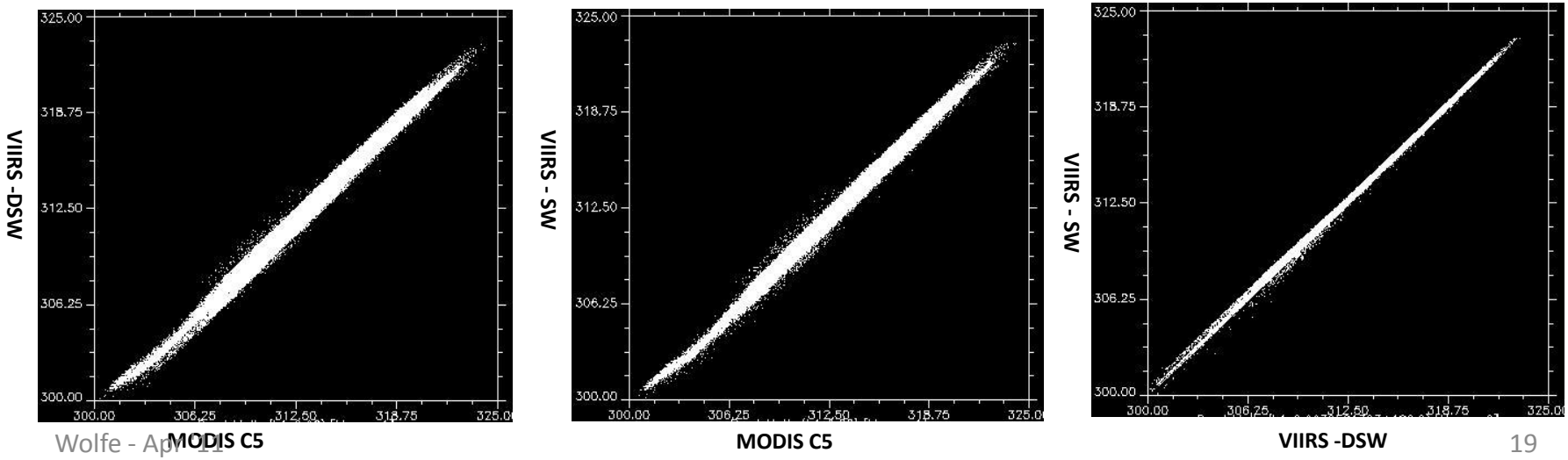
Assessment of Algorithm Improvement

Evaluating the Alternate Algorithm Paths

Granule 2002/222 04:30



- VIIRS LST uses dual split (main) and split window algorithm (back up)
- OPS algorithm modified to use Split window as main algorithm replacing the dual split window algorithm.
- Two algorithms retrieve nearly the same LST.



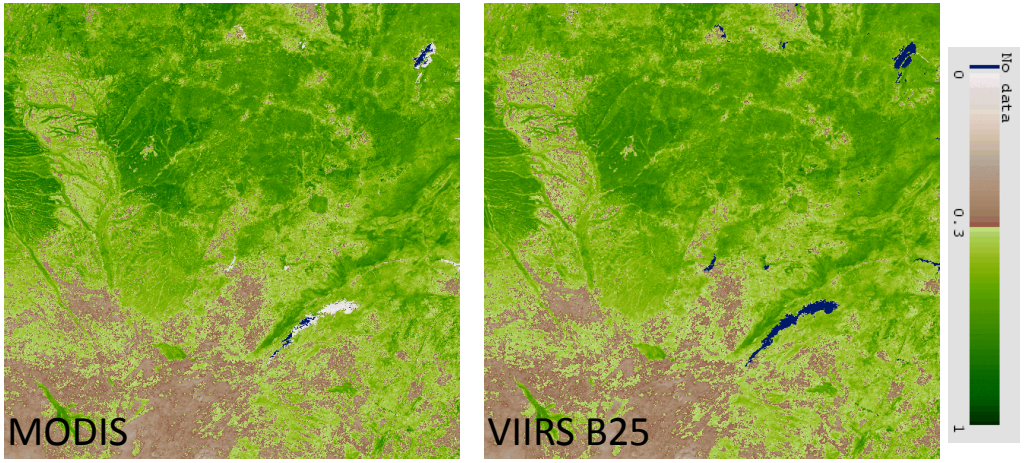
Diagnostic Data Records

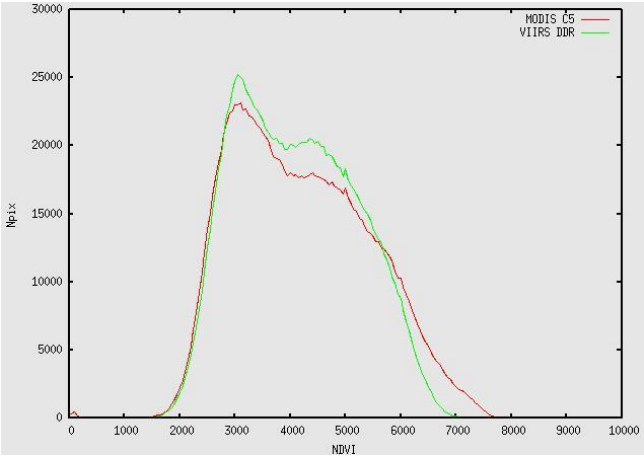
- Equivalent of the MODIS daily and n-day gridded products generated using the VIIRS L2 xDRs
- The products will be of MODIS tile size and resolution
- Current MODIS C5 algorithms are being modified to read the VIIRS xDRs with proper mapping of the spectral bands and the associated QA flags
- Facilitates comparison and trending between the two instruments.
- Examples
  - L2G daily LSR, LST, Snow, AF
  - L3 8-day LSR, LST, Snow,
  - L3 16-day VI
  - 16-day BRDF/Albedo
  - 8-day LAI/FPAR

Diagnostic Data Records – 16day VI

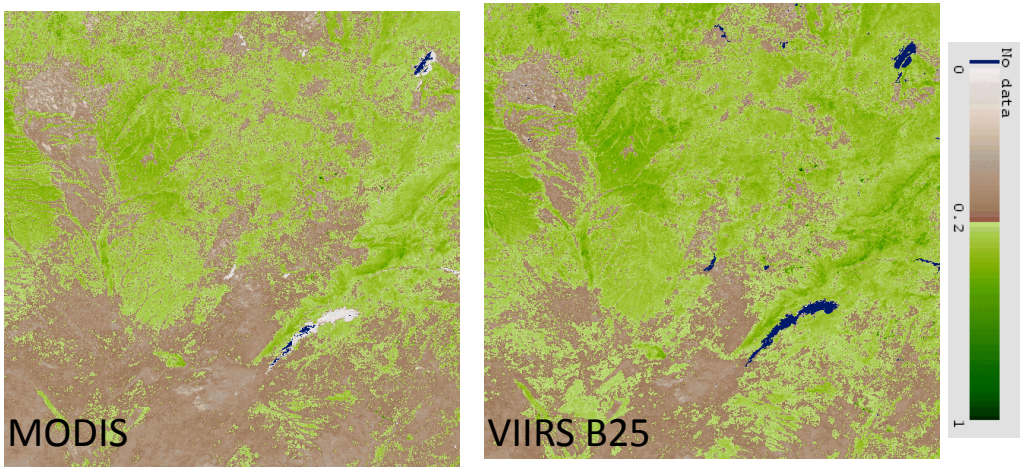
Africa-Botswana (Start-Day 2003193, Tile h20v10)

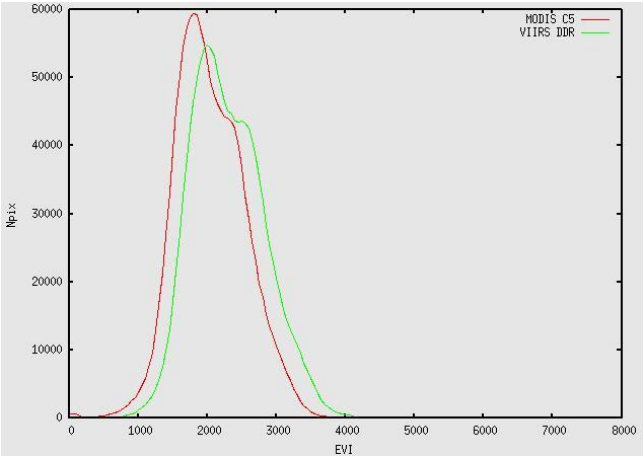
NDVI





EVI





Long Term Monitoring

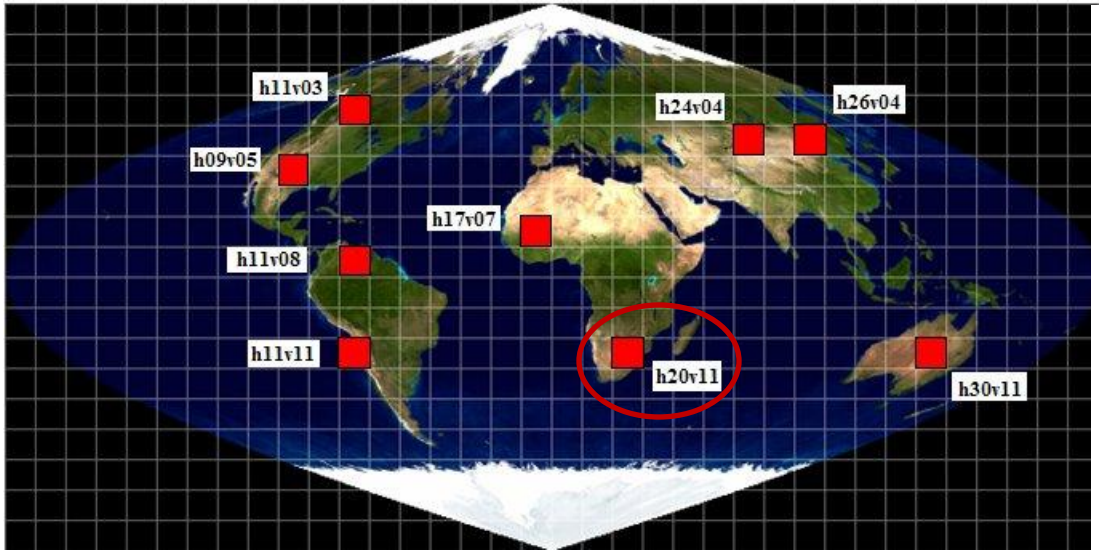
Golden Tile Browse and Time Series Analysis

- **Monitor product quality at fixed geographical locations of size 10 deg x 10 deg known as golden tiles.**
  - Examine full resolution browses
  - Derive time series summary statistics of science data
- **Summary statistics derived from all the gridded products.**
  - Statistics include mean, standard deviation, minimum, maximum and number of observations of good quality observations in the tile
  - Statistics derived separately for each biome, land cover and predetermined sites of 3 km x 3 km size.
- **Evaluation using time series**
  - Captures changes in the instrument characteristics and calibration, algorithm sensitivity to surface (e.g., vegetation phenology), atmospheric (e.g., aerosol loading) and remote sensing (e.g., sun-surface-sensor geometry) conditions that change temporally
  - Inter-comparison of time series from different instruments, different versions of the algorithm

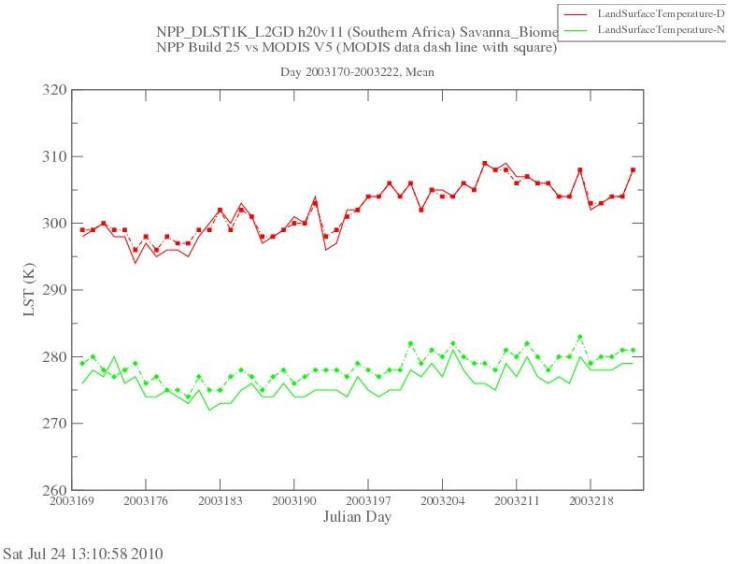
Long Term Monitoring

Golden Tile Browses and Time Series from IDPS B25
Day and Night LST from Tile h20v11 (VIIRS vs MODIS)

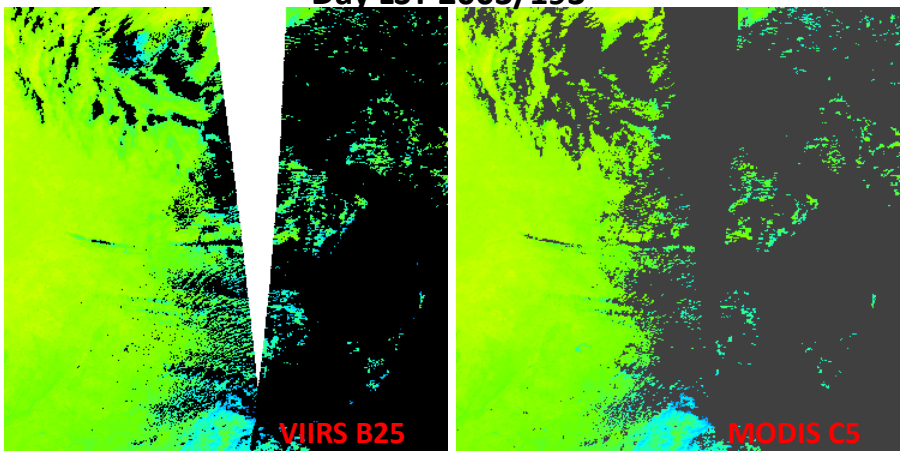
Golden Tiles used in the Time Series Analysis



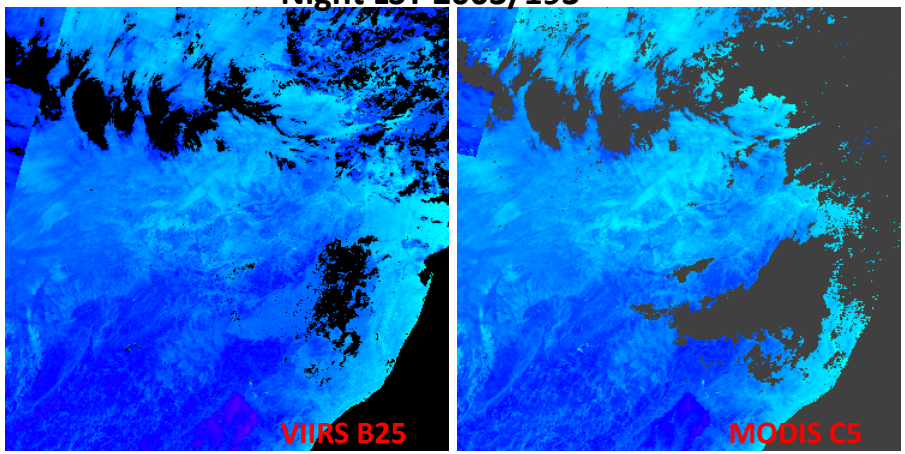
Time Series Plots of Day and Night LST (Savanna)



Day LST 2003/193



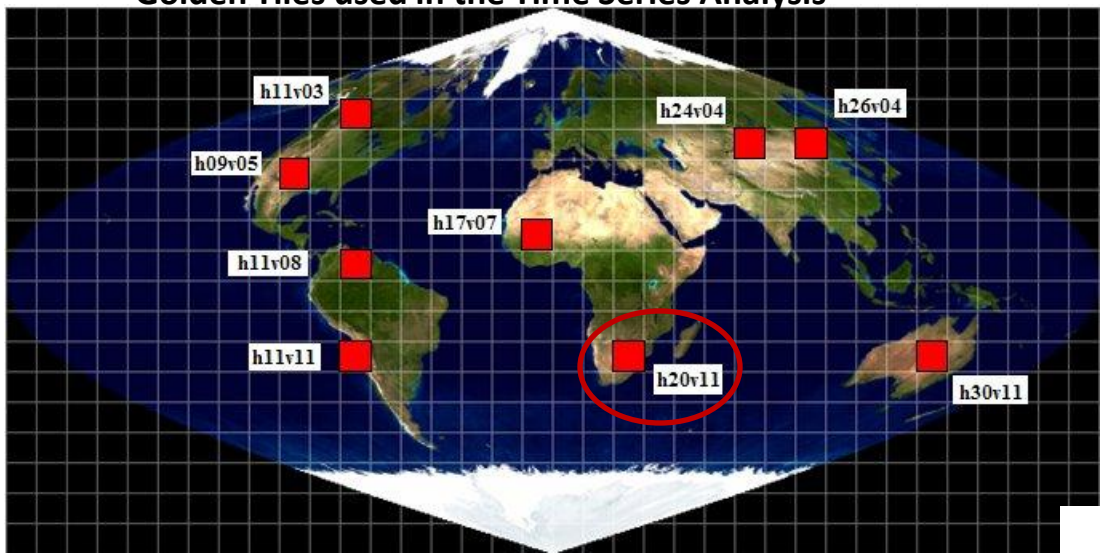
Night LST 2003/193



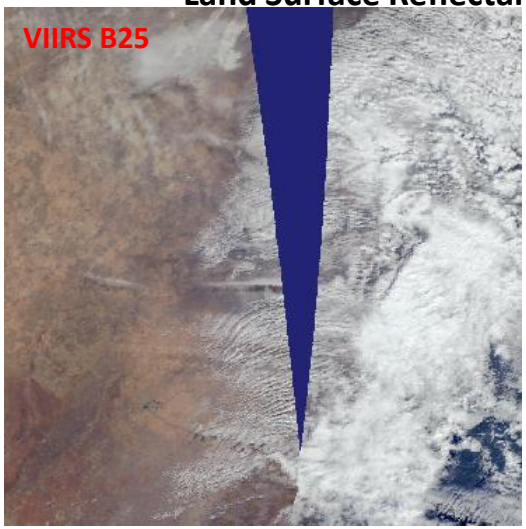
Long Term Monitoring

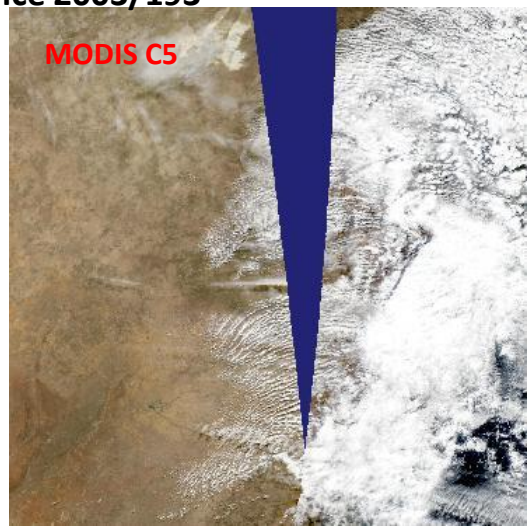
Golden Tile Browses and Time Series from IDPS B25 Land Surface Reflectance from Tile h20v11 (VIIRS vs MODIS)

Golden Tiles used in the Time Series Analysis

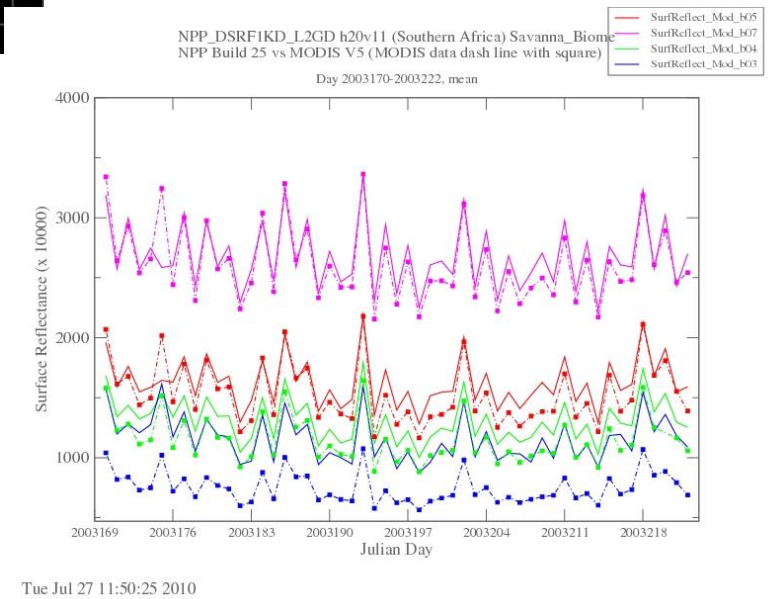


Land Surface Reflectance 2003/193





Time Series Plots of Land Surface Reflectance (for Savanna)
Bands: Red (0.620), NIR(0.841), Green (0.545) and Blue (0.459)



Summary

- Land PEATE has successfully integrated and tested 3 incremental build versions of the IDPS OPS algorithms.
- Chain tests run using the MODIS proxy as input.
- Test data evaluated at LDOPE by successfully adopting the MODIS QA approach to VIIRS products.
- Evaluation results are posted on LDOPE QA web site and communicated to the VIIRS science teams.
- Land PEATE is expected to meet all SDS requirements and be fully operational by launch.