MODIS Science Algorithms Lessons Learned

HyspIRI Symposium

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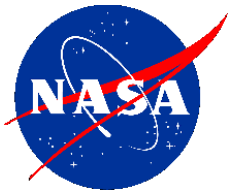


Outline

- Overall science algorithms
- Disciplines specific lessons learned
  - Oceans
  - Atmospheres
  - Land

MODIS Overall Lessons Learned

Team Leadership and Communication

- Good leadership and regular communication are needed
- Regular forums for information exchange
  - Weekly technical team meeting keeps everyone on same page
    - consists of team leader, discipline leads, instrument/calibration lead, data system leads and outreach lead
  - Full Science Team meetings
    - twice per year early in mission (once per year later)
  - Weekly calibration and data system meetings
- Science Team members funded before and through the life of the instrument – a long term commitment and experience base is critical
- Disciplines – Discipline Leads and a core full-time group built around the data systems with weekly discipline telecons
  - Close working relationship between data team and science team members is important
- Calibration – core calibration group working with discipline representation
  - Discipline representatives provide important feedback because they understand calibration and its impact on fundamental (upstream) science products (e.g. water leaving radiance, land surface temperature, land surface reflectance, aerosols)

Data Systems

- Science testing
  - Don’t bundle too many changes together – impacts of upstream algorithms are hard to untangle
  - Many iterations of testing are needed
  - Storage is needed for multiple baselines and changes
  - Carefully control for ancillary data dependencies
  - Maintain a basic set of science test days
- Reprocessing: It should be possible do a minimum of entire mission in 1 year
  - 2X forward plus more than 1X per mission-year
  - Ideally should be able process mission in 3 months or less (requires 10X to 100X)
  - Having Level 0 data on-line makes science testing and reprocessing much easier
  - Disciplines will have their own reprocessing schedules
  - So the reprocessing data system needs to be able to handle this
  - Multiple strings may be needed for individual disciplines
- Test system (separate string) should be minimum of 1X; ideally 4X to 10X
  - Can double as reprocessing string
- It was useful to have the same algorithms across multiple sensors
  - For Ocean Color, adapting the heritage SeaWIFS algorithm for Aqua made it possible to produce a good quality product

Algorithm Development, Integration and Testing

- ST members should play a key role in development and maintenance of code remain responsible
  - It is better to produce some experimental products at the Scientist Team Member's Computing Facility – but a method is needed for eventually bringing code into the primary production facility
- Science team led processing is needed to ensure that the best products are generated and reprocessed with a workable schedule
- Stable calibration and algorithms are needed to produce a good time series
  - Don't make changes in middle of reprocessing
  - Minimize changes in forward processing (after calibration and algorithms stabilize)
- Improved Aqua instrument characteristics made some products possible, e.g. Ocean Color, Deep Blue Aerosols
- Process for bringing in new products needs to be streamlined because of the current 3-year proposal cycle
  - Ocean group has developed a well-defined process that allows for community feedback

Quality Assurance

- Centralized QA activities for each discipline is invaluable
- Land group has the following functions:
  - Global browse and golden tiles
  - Subsets and QA database
  - Known issues pages
  - Initial point of contact for user's quality concerns
  - Help in tracking quality issues to source (sometimes in the upstream algorithm)
  - Coordination and feedback on science algorithm testing
- Atmosphere team makes available:
  - Projected granule browse of L1B and key atmosphere products
  - Images of hundreds of L3 global parameters including min, max, standard deviation fields
  - Collection highlights and known issues
  - Standard visualizations of all test data for the science team
- Ocean team offers similar capabilities

Distribution

- Key communities will need specialized products
  - Products in Climate Modeling Grid for climate modelers
  - Near Real Time products for applications users
  - Plan for additional formats and tailored products
  - One map projection (grid spacing, etc.) will not work for all users (or even a majority)
- Self document format (HDF) is useful – but additional formats are needed
  - Geographic information system users have community format standards (not HDF)
- Always have a full collection going forward
  - Reprocess the full mission in background
  - Give users time to switch over to new dataset
- On-line products (including Level 0) greatly increased distribution
  - Made getting data much easier and increased speed of fulfilling orders
  - Enables processing-on-demand for tailoring products as well as web services
  - Need to perform trade study between processing-on-demand vs. storing products on a product by product basis

Applications and Outreach

- Near Real Time (NRT) data system is needed for application users (MODIS Rapid Response experience)
  - Stand alone NRT system is needed to avoid gearing the entire production stream to the NRT constraints
  - Should be developed once the instrument has stabilized and data products are at Stage 1 Validation
  - Direct Broadcast (DB) versions of code make it easier for broad product uptake and use – increases standardization
  - DB encourages applications and regional algorithm development and has been a huge success with > 100 direct readout sites worldwide
  - Some products originally developed by application users (e.g. Polar Winds) could be considered as future standard products
- Targeted outreach program is needed
  - Imagery support is needed for outreach
  - Earth Observatory for one-stop shopping – must include good descriptions (captions) – this is a good way to deal with the Media

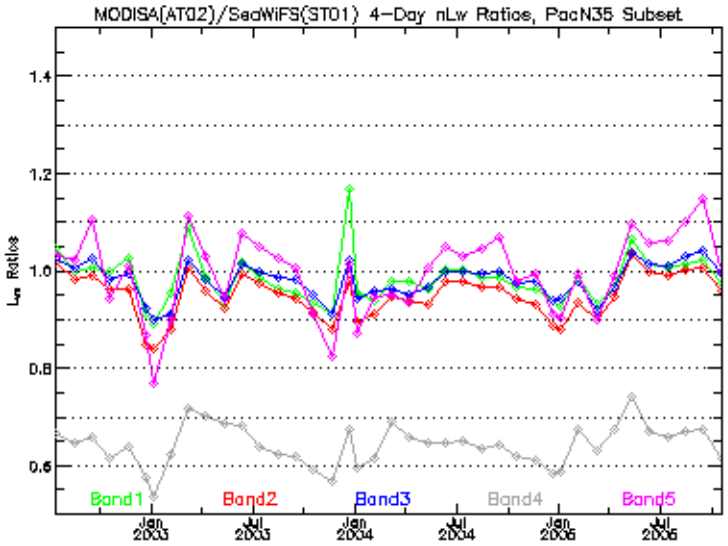
MODIS Ocean Lessons Learned

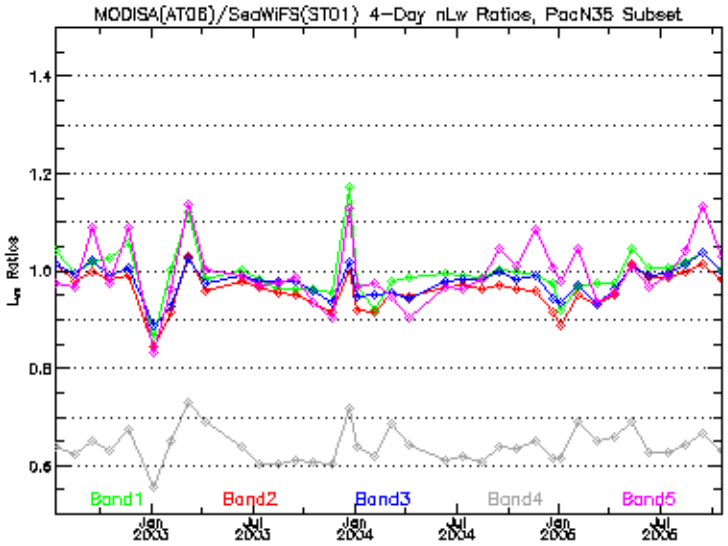
Source: Fred Patt, OCDPS

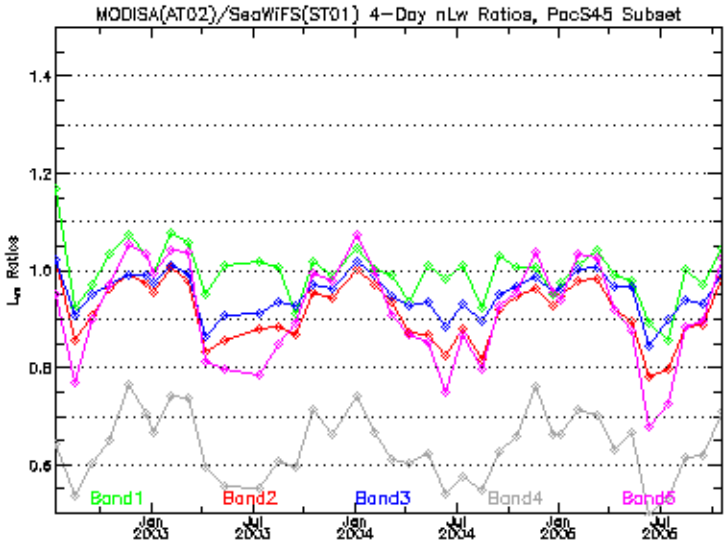
Summary of MODIS Ocean Lessons Learned

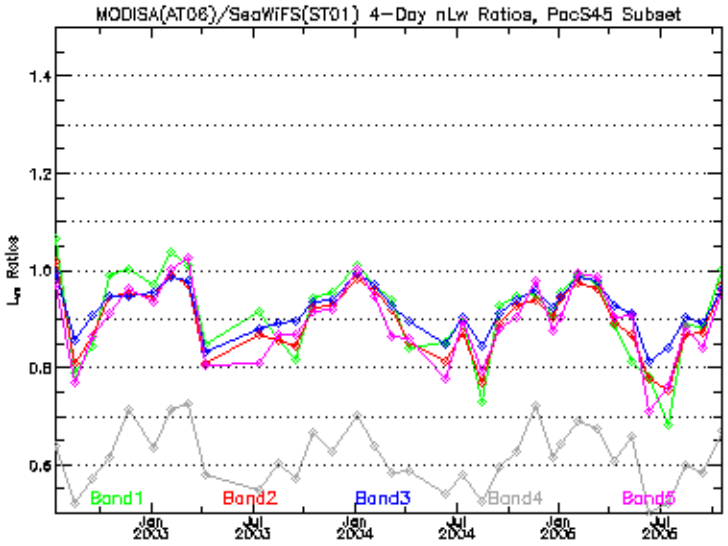
- Overall success of the effort depends critically on collaboration between the Ocean and Calibration teams and on a robust Calibration and Validation program.
- Development of Climate Data Records (CDRs) from multiple instruments is best performed in discipline-specific measurement-based systems.
- Products should be developed and validated in stages, with the initial products validated and mature before the downstream products
- A well-defined, rigorous process is needed for adding new products in cooperation with external team members.
- Data system needs to be flexible to accommodate both regular algorithm updates and continual technology advancements
- Effort needs to be visible and linked to the external science community.

Improvements in MODIS/SeaWiFS nLw Comparisons Resulting from Revised Polarization Correction



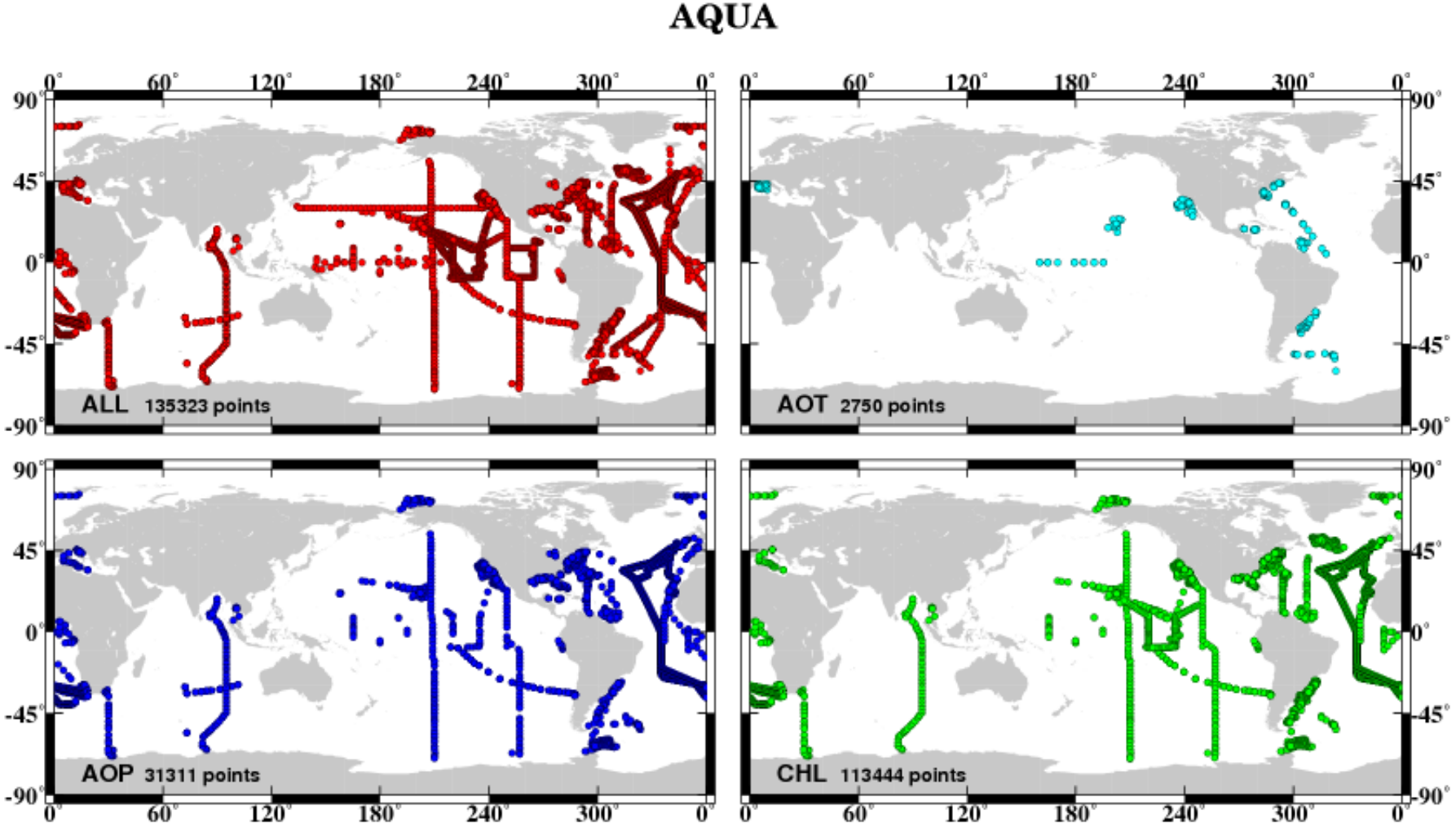




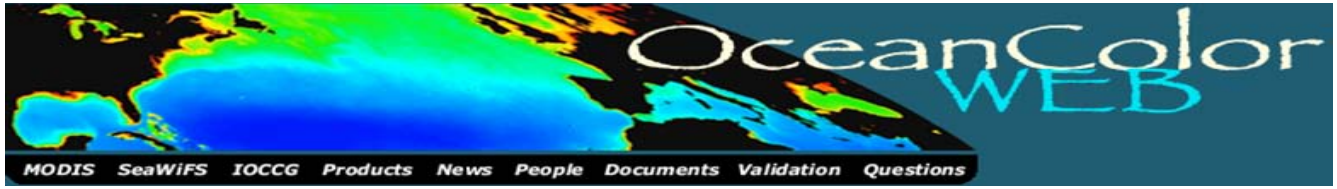


Before **After**

The SeaWiFS Bio-Optical Storage System (SeaBASS) – *In situ* Data Submission, Archive and Search



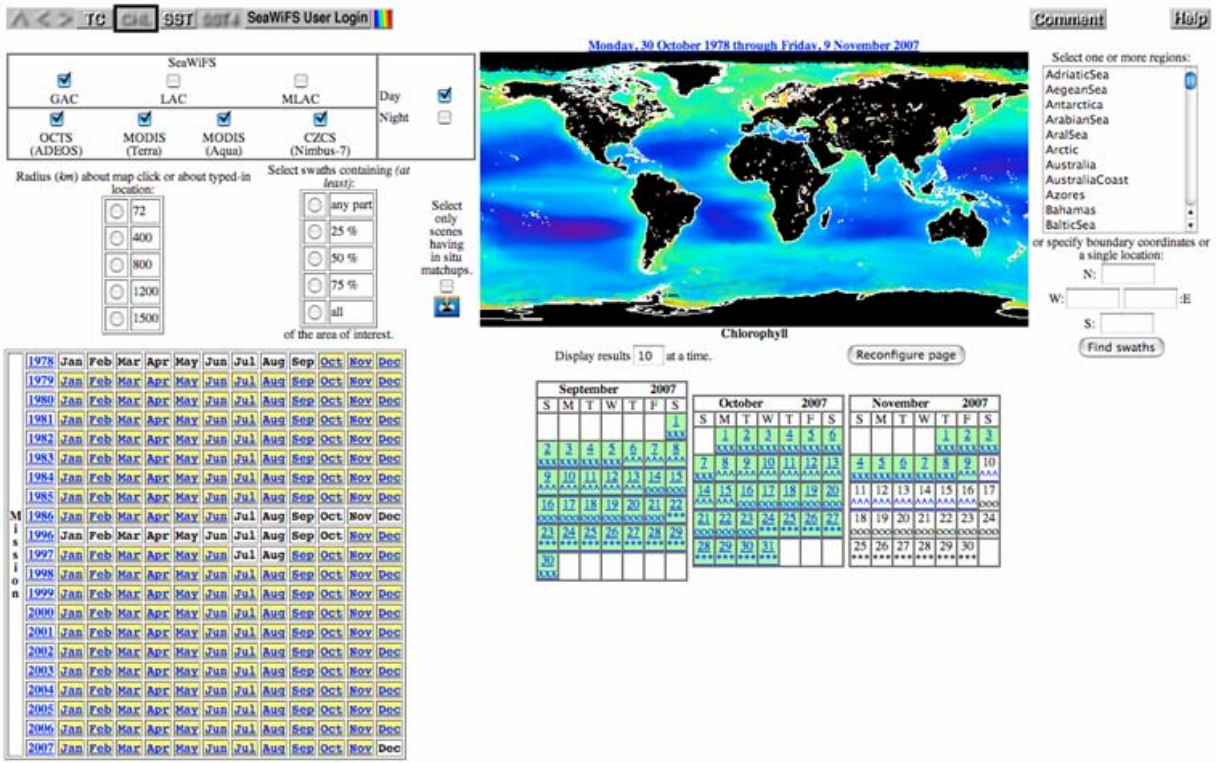
Ocean Color Web Site – One-stop Shopping for NASA Ocean Data Products



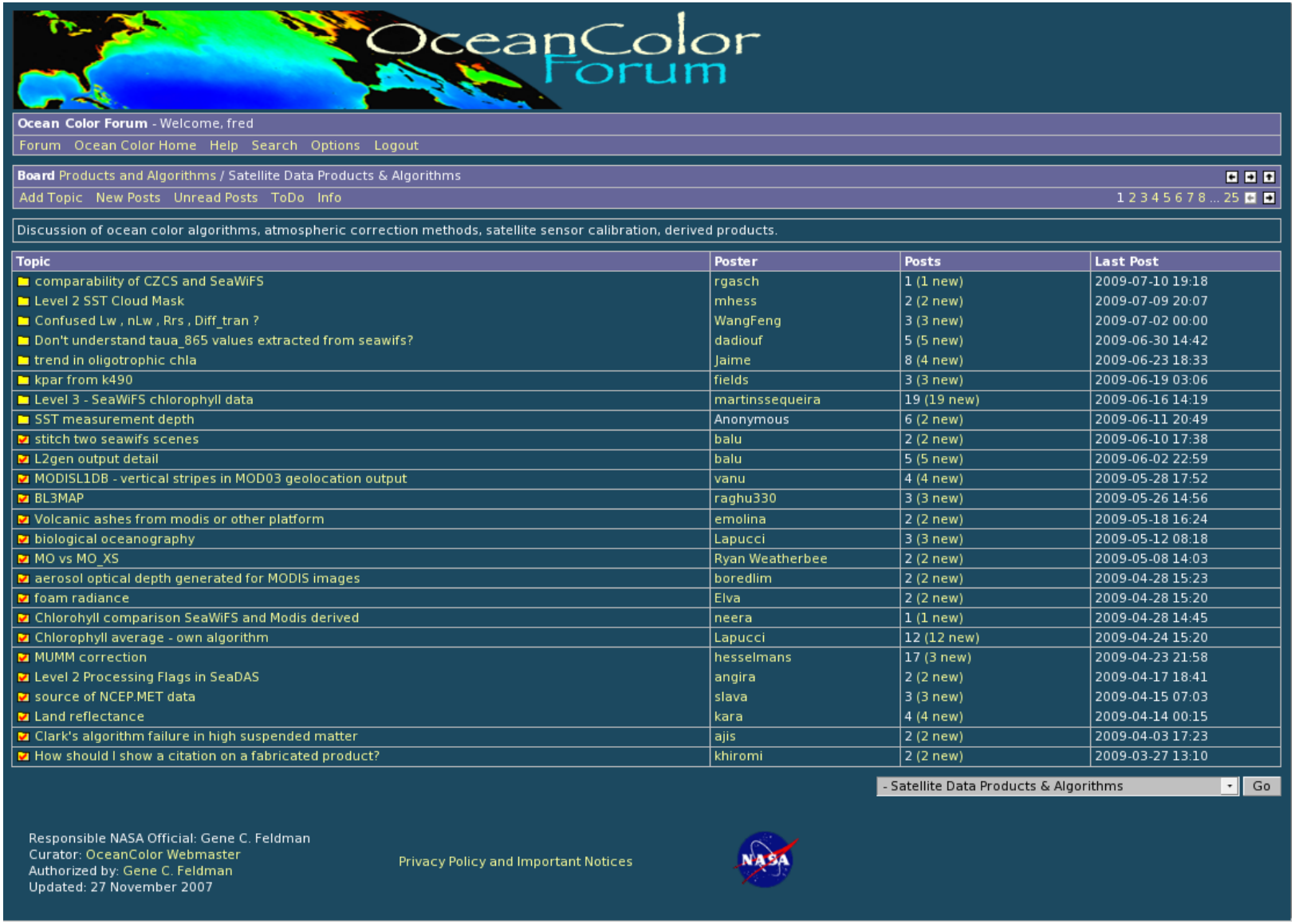
oceancolor.gsfc.nasa.gov

MISSIONS SUPPORTED

- MODIS (Terra and Aqua): 2000 – present
- SeaWiFS: 1997 – present
- CZCS/Nimbus-7: 1978 – 1986
- OCTS/ADEOS-I: 1996 – 1997
- Glory data system prototype: 2009 launch
- Aquarius/SAC-D: May 2010 launch*
- VIIRS/NPP: January 2011 launch
- Community Processing & Analysis Software SeaDAS (1991-present)



Ocean Color Forum – A Tool for User Support and Community Interaction



OceanColor Forum

Ocean Color Forum - Welcome, fred

Forum Ocean Color Home Help Search Options Logout

Board Products and Algorithms / Satellite Data Products & Algorithms

Add Topic New Posts Unread Posts ToDo Info 1 2 3 4 5 6 7 8 ... 25

Discussion of ocean color algorithms, atmospheric correction methods, satellite sensor calibration, derived products.

Topic	Poster	Posts	Last Post
comparability of CZCS and SeaWiFS	rgasch	1 (1 new)	2009-07-10 19:18
Level 2 SST Cloud Mask	mhess	2 (2 new)	2009-07-09 20:07
Confused Lw , nLw , Rrs , Diff_tran ?	WangFeng	3 (3 new)	2009-07-02 00:00
Don't understand taua_865 values extracted from seawifs?	dadiouf	5 (5 new)	2009-06-30 14:42
trend in oligotrophic chla	Jaime	8 (4 new)	2009-06-23 18:33
kpar from k490	fields	3 (3 new)	2009-06-19 03:06
Level 3 - SeaWiFS chlorophyll data	martinssequeira	19 (19 new)	2009-06-16 14:19
SST measurement depth	Anonymous	6 (2 new)	2009-06-11 20:49
stitch two seawifs scenes	balu	2 (2 new)	2009-06-10 17:38
L2gen output detail	balu	5 (5 new)	2009-06-02 22:59
MODISL1DB - vertical stripes in MOD03 geolocation output	vanu	4 (4 new)	2009-05-28 17:52
BL3MAP	raghu330	3 (3 new)	2009-05-26 14:56
Volcanic ashes from modis or other platform	emolina	2 (2 new)	2009-05-18 16:24
biological oceanography	Lapucci	3 (3 new)	2009-05-12 08:18
MO vs MO_XS	Ryan Weatherbee	2 (2 new)	2009-05-08 14:03
aerosol optical depth generated for MODIS images	boredlim	2 (2 new)	2009-04-28 15:23
foam radiance	Elva	2 (2 new)	2009-04-28 15:20
Chlorohyll comparison SeaWiFS and Modis derived	neera	1 (1 new)	2009-04-28 14:45
Chlorophyll average - own algorithm	Lapucci	12 (12 new)	2009-04-24 15:20
MUMM correction	hesselmans	17 (3 new)	2009-04-23 21:58
Level 2 Processing Flags in SeaDAS	angira	2 (2 new)	2009-04-17 18:41
source of NCEP.MET data	slava	3 (3 new)	2009-04-15 07:03
Land reflectance	kara	4 (4 new)	2009-04-14 00:15
Clark's algorithm failure in high suspended matter	ajis	2 (2 new)	2009-04-03 17:23
How should I show a citation on a fabricated product?	khiromi	2 (2 new)	2009-03-27 13:10

- Satellite Data Products & Algorithms Go

Responsible NASA Official: Gene C. Feldman
Curator: OceanColor Webmaster
Authorized by: Gene C. Feldman
Updated: 27 November 2007

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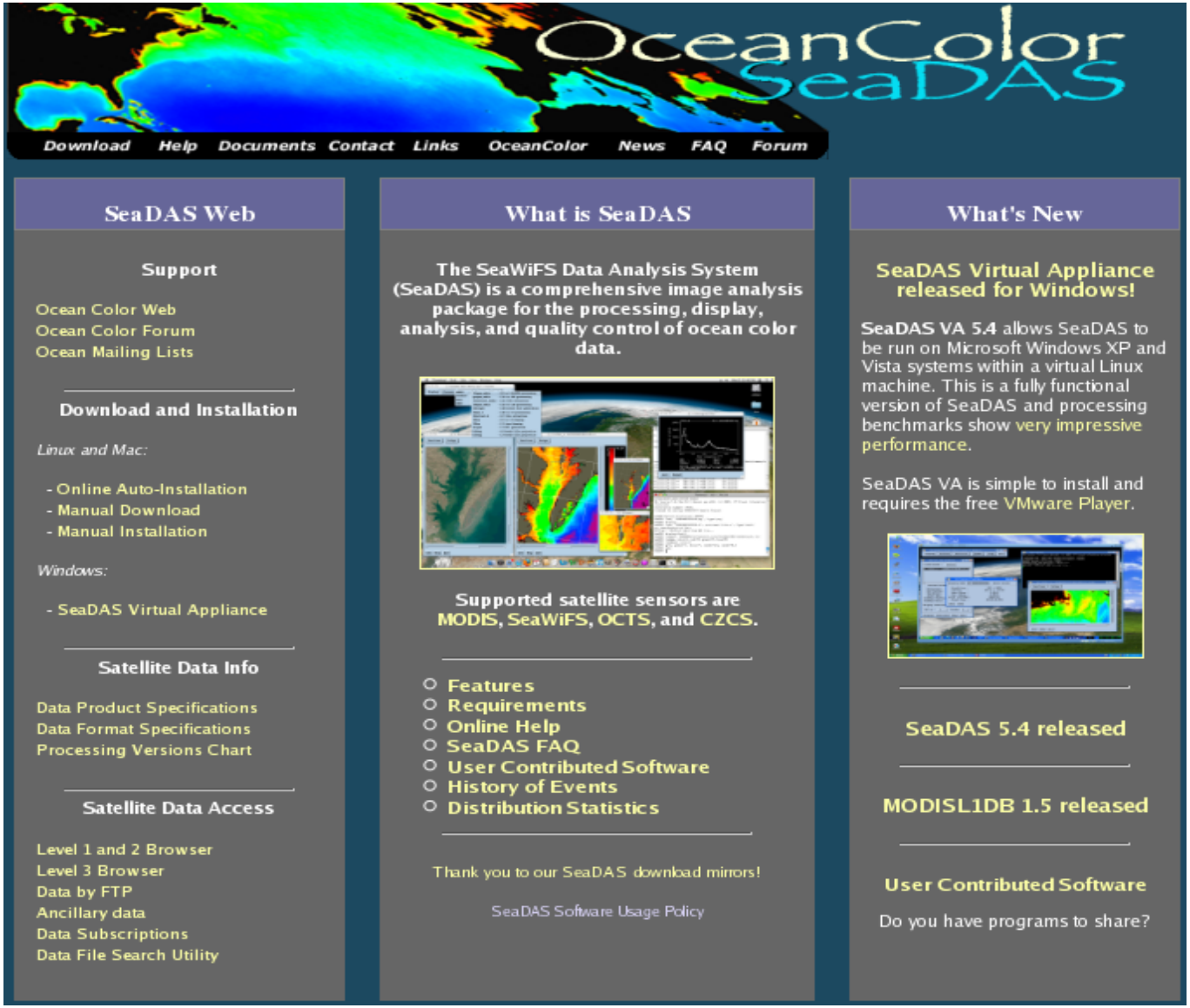
SeaWiFS Data Analysis System (SeaDAS) – Desktop Ocean Data Processing and Analysis



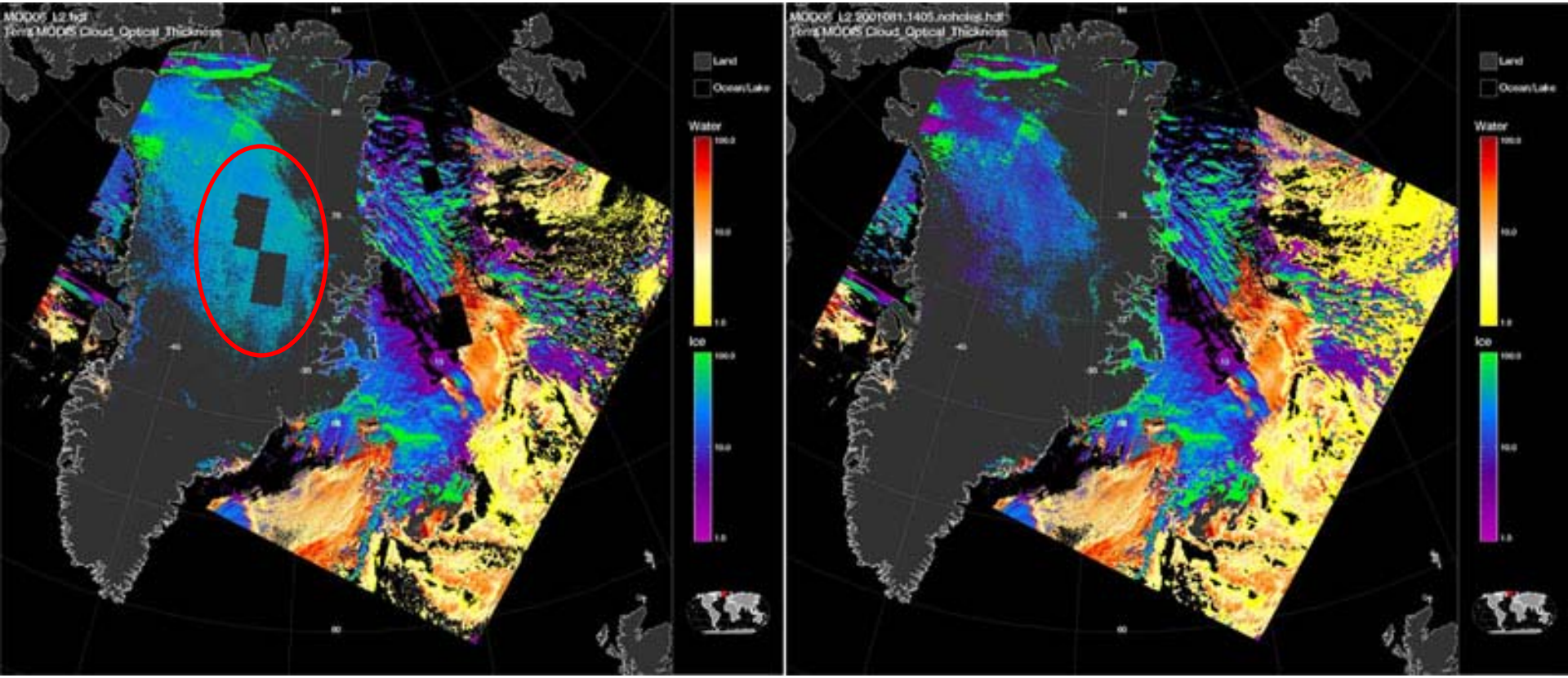
MODIS Atmosphere Lessons Learned

Source: Bill Ridgway

Summary of MODIS Atmosphere Lessons Learned

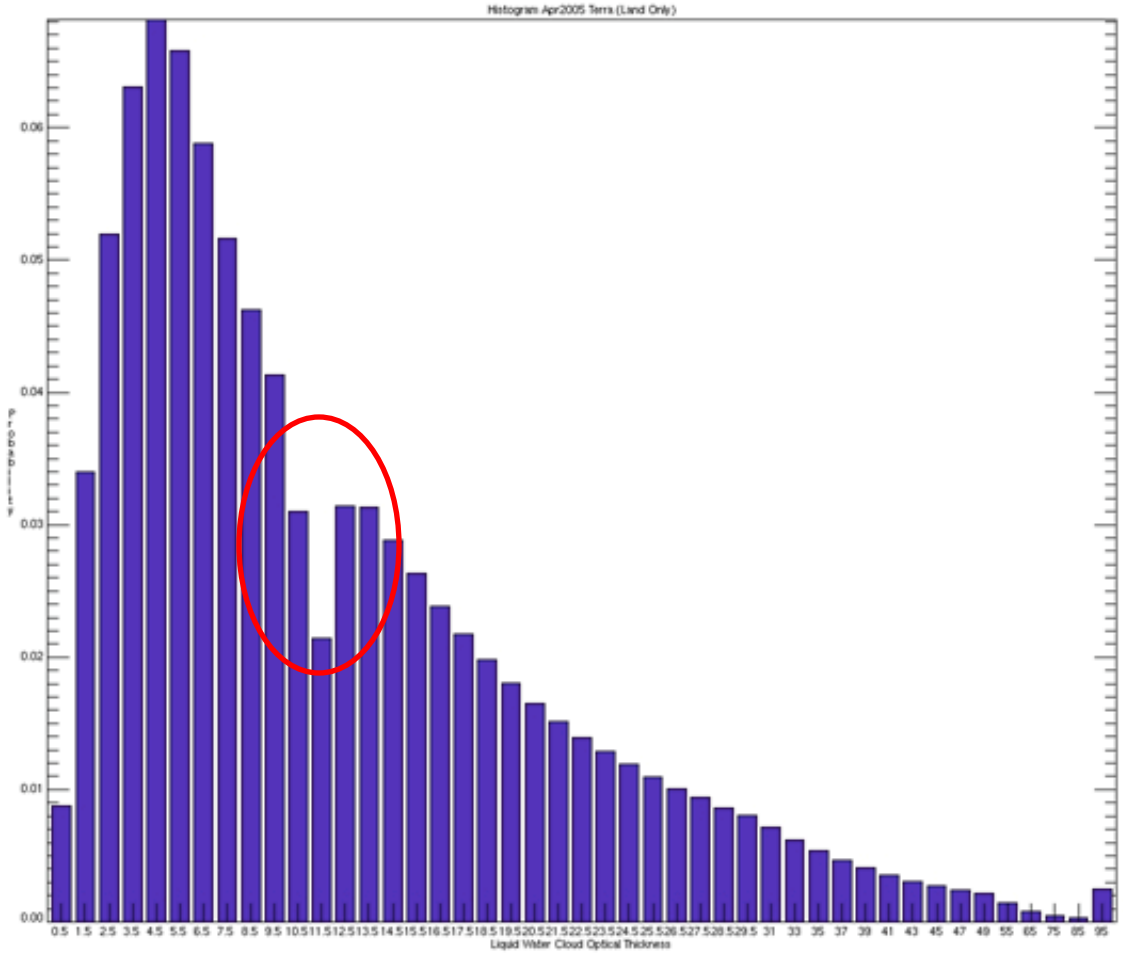
- Atmospheric parameters are very dynamic, requiring validation at varying time and distance scales.
- AERONET ground stations are critical in validating MODIS aerosol retrievals. We provide cut-outs of retrieved parameters near AERONET surface stations (both HDF and spreadsheet formats).
- Product packaging bundles parameters into five products at Level 2 including important imbedded diagnostics: cloud mask, atmospheric profiles, aerosol, water vapor and cloud parameters.
- It's important to make extensive use of embedded QA flags and diagnostic parameters such as cloud particle phase and multi-layer cloud flags. Aerosol diagnostics include path radiance, angstrom exponent, mass concentration, and pixels used per retrieval.
- We produce approximately 800 global single-parameter images per day (each platform) to support QA and product quick looks.

Understand Algorithm Dependencies and Track Known Issues



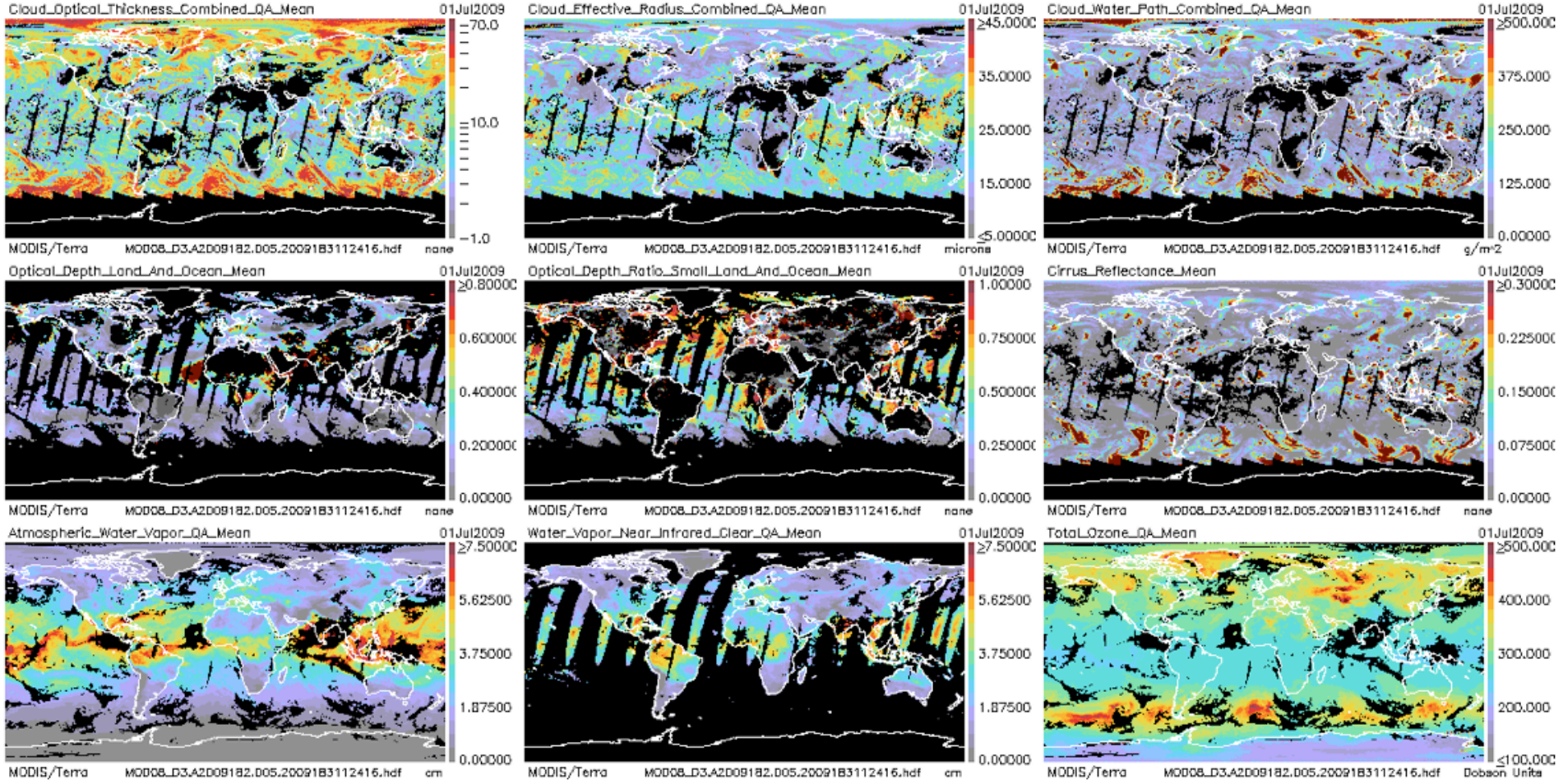
Missing Blocks (Retrieval Failure) in Cloud Optical Properties. Rectangular holes (**Left Image**) result from fill values in the 3-hour GDAS ancillary data set that cause Cloud Top Properties retrievals to abort. Cloud optical properties are dependent on prior cloud top temperature and pressure retrievals.

Algorithm Flaws Show Up in Histograms. So, Compute Many.



Liquid water optical thickness over land was found to be flawed in early retrievals due to coding errors in the Rayleigh correction algorithm. Above is the probability distribution for liquid water optical thickness with values from 0-30 microns. The flaw appears as a deficiency at 12 microns.

Visualize Many Parameters



Daily atmosphere product maps support QA and are posted for general use by product users (above are 9 of 792 parameters).

MODIS Land Lessons Learned

Summary of MODIS Land Lessons Learned

- Close interaction between the science team and the Science Data Support Team (SDST) allowed for timely decisions to be made on the production priorities and adjustments to be made to the production schedule so that early understanding of the product quality could be made while the data system was being improved.
- Centralized QA group expedited handling a large number of interdependent algorithm changes by investigating quality problems and coordinating the geographically dispersed science team members.
- Recognized the importance of validation and set up a centralized activity to coordinate validation of the Land products.

MODIS Land Products

Energy Balance Product Suite

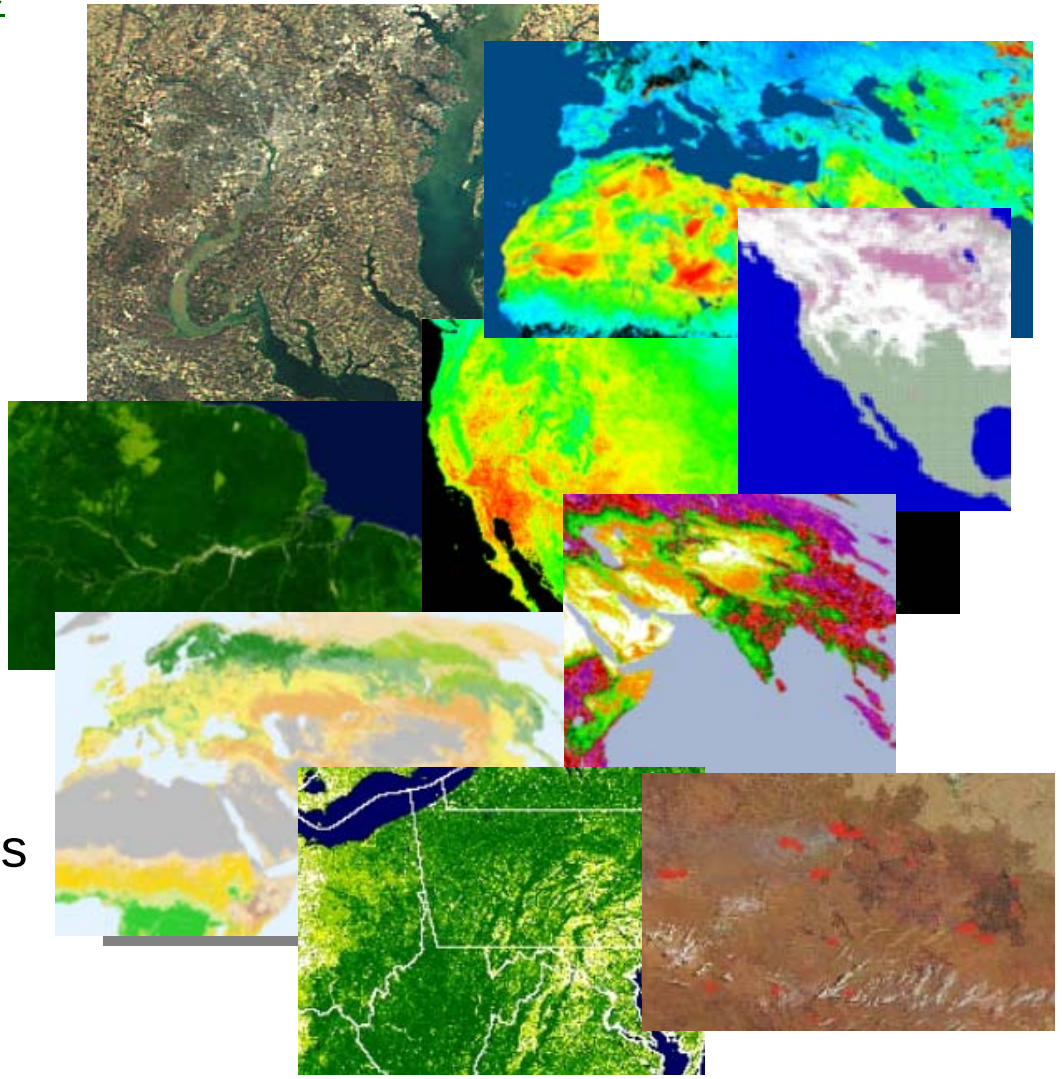
- Surface Reflectance
- Land Surface Temperature, Emmisivity
- BRDF/Albedo
- Snow/Sea-ice Cover

Vegetation Parameters Suite

- Vegetation Indices
- LAI/FPAR
- GPP/NPP

Land Cover/Land Use Suite

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



MODLAND QA

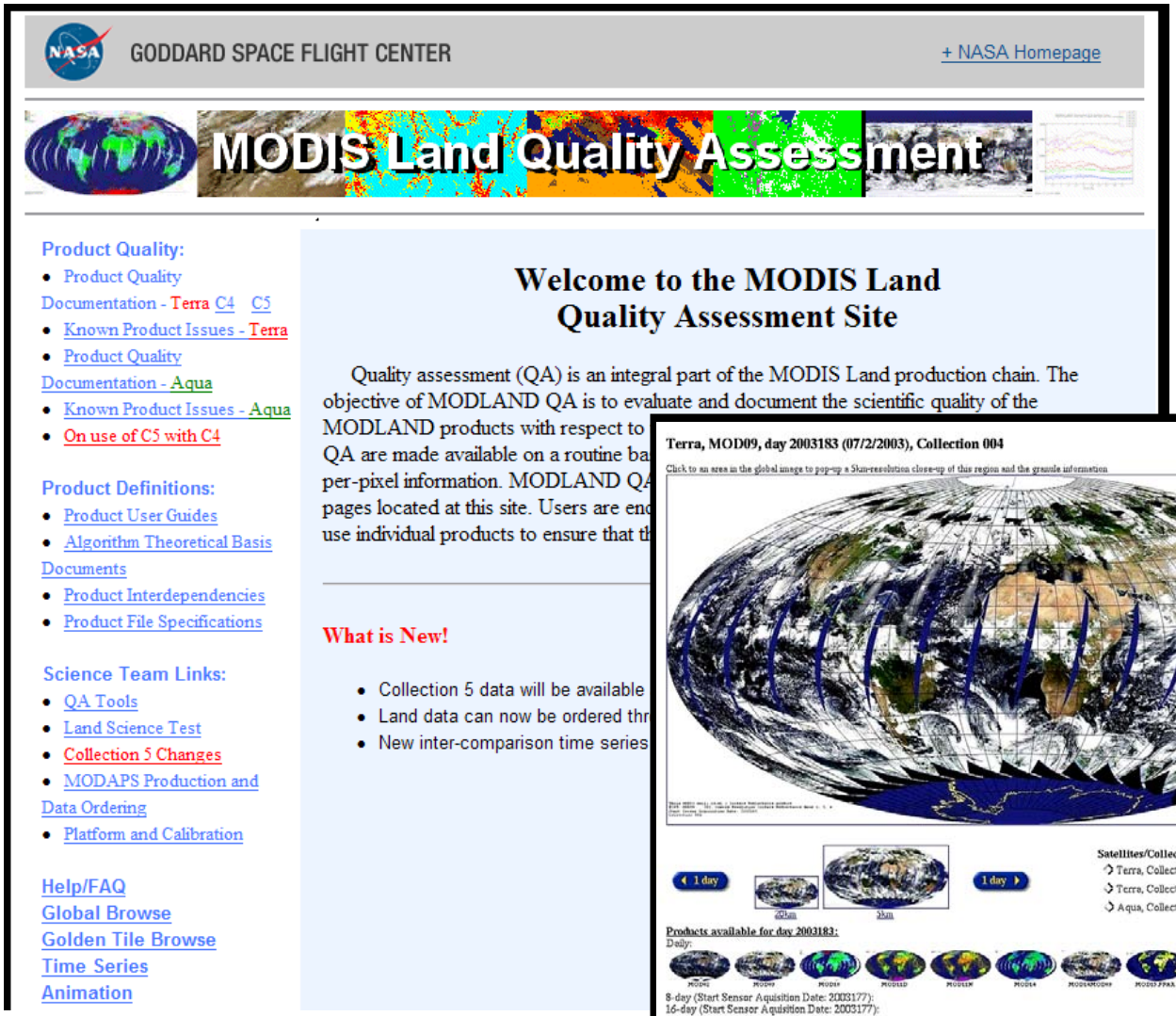
http://landweb.nascom.nasa.gov/cgi-bin/QA_WWW/newPage.cgi

QA Summaries

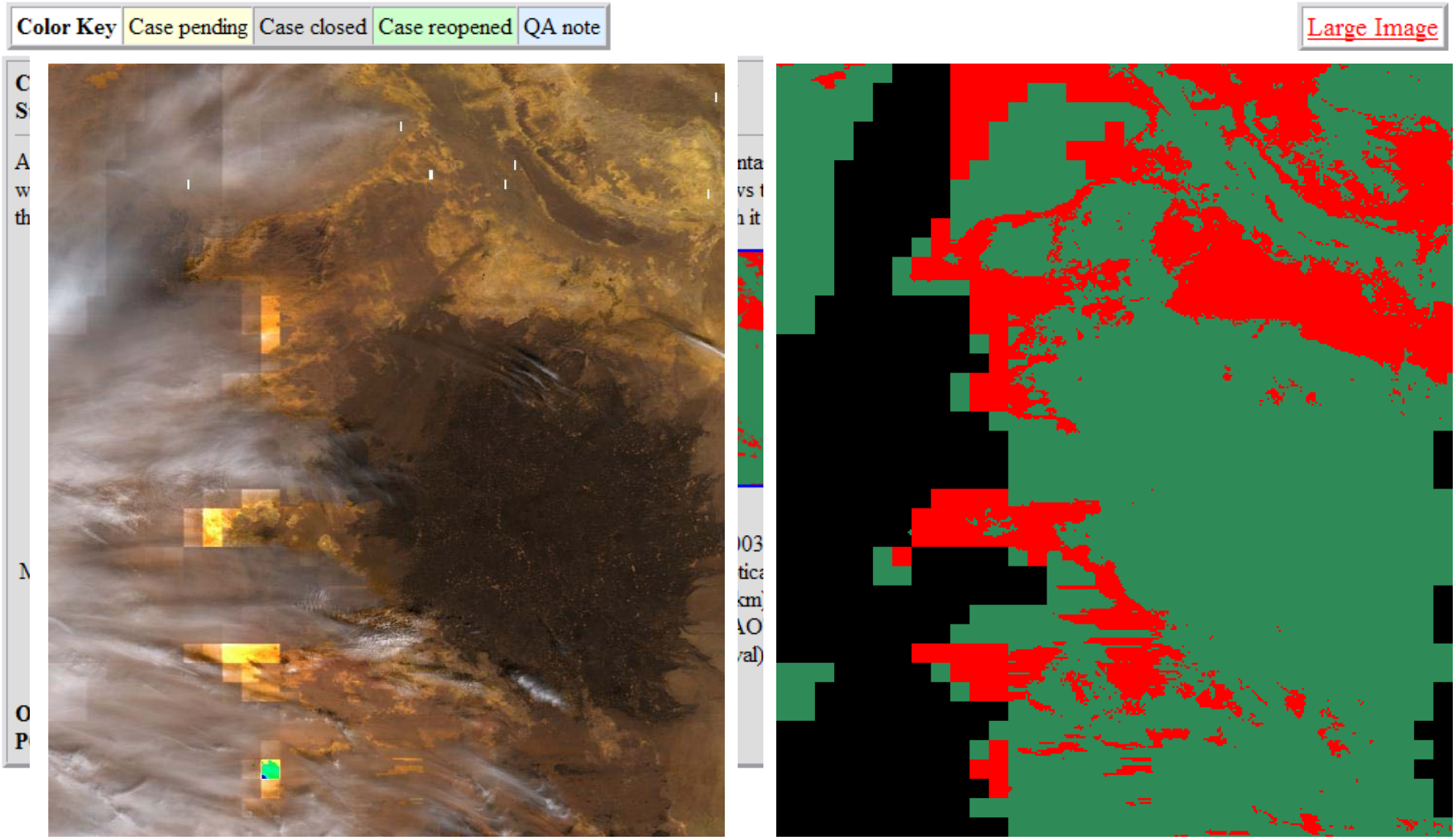
Known Issues

Global Browse

Time Series



Communicate Known Issues to team and community



Validation

- Should be funded as an integral part of the product development
- Some centralized validation coordination is needed
  - Makes effort more cost effective
- Five stage product maturity and validation approach works well
  - Beta, Provisional, Validated Stage 1 to 3
  - Helpful for provisional data to be available for community feedback
- Land: high resolution imagery and subsets for core validation sites were valuable
- Learned from Terra: “validation should not be too soon after launch” was applied to Aqua
  - Products need to be stable
  - Aqua products were more mature before validation occurred
- Useful to have Near Real Time images to support validation campaigns

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

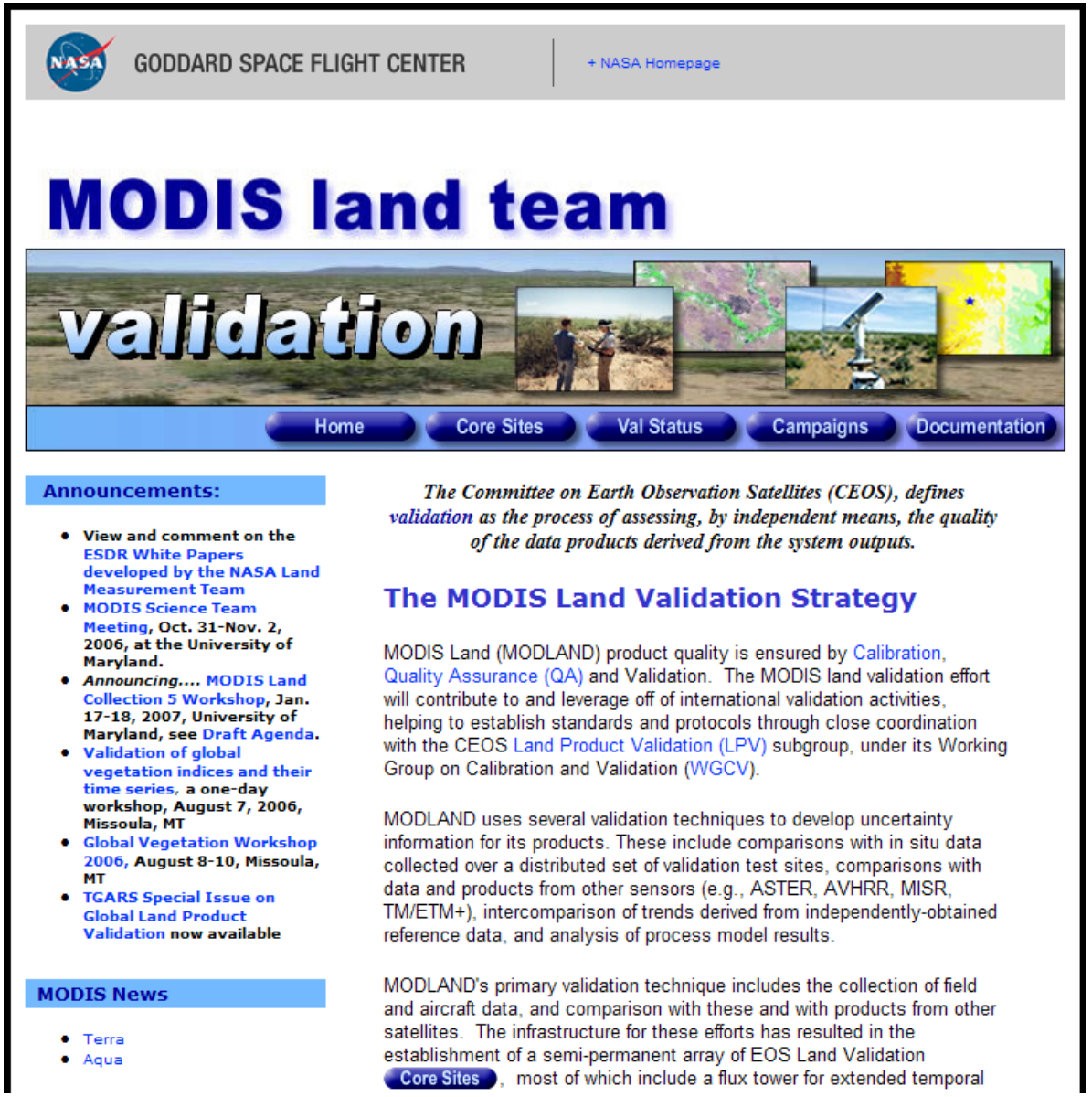
Val Summaries

EOS Core Sites

Major Campaigns

Val Metadata w. ORNL

MODIS Validation Data sub sets w. EDC



Conclusion

- Many lessons learned in processing data should be applied to future missions
  - Operational NPP/NPOESS VIIRS Sensors
  - NASA research sensors (e.g. HysplRI)
  - Similar international missions

Thank you!