Status of Land Surface Product Development for the US GOES-R Satellite Mission

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Outlines

- GOES-R Mission
- AWG Land Team
- GOES-R Land Products
- Accomplishments
- Validation Efforts

GOES-R Overview

GOES Satellite Mission

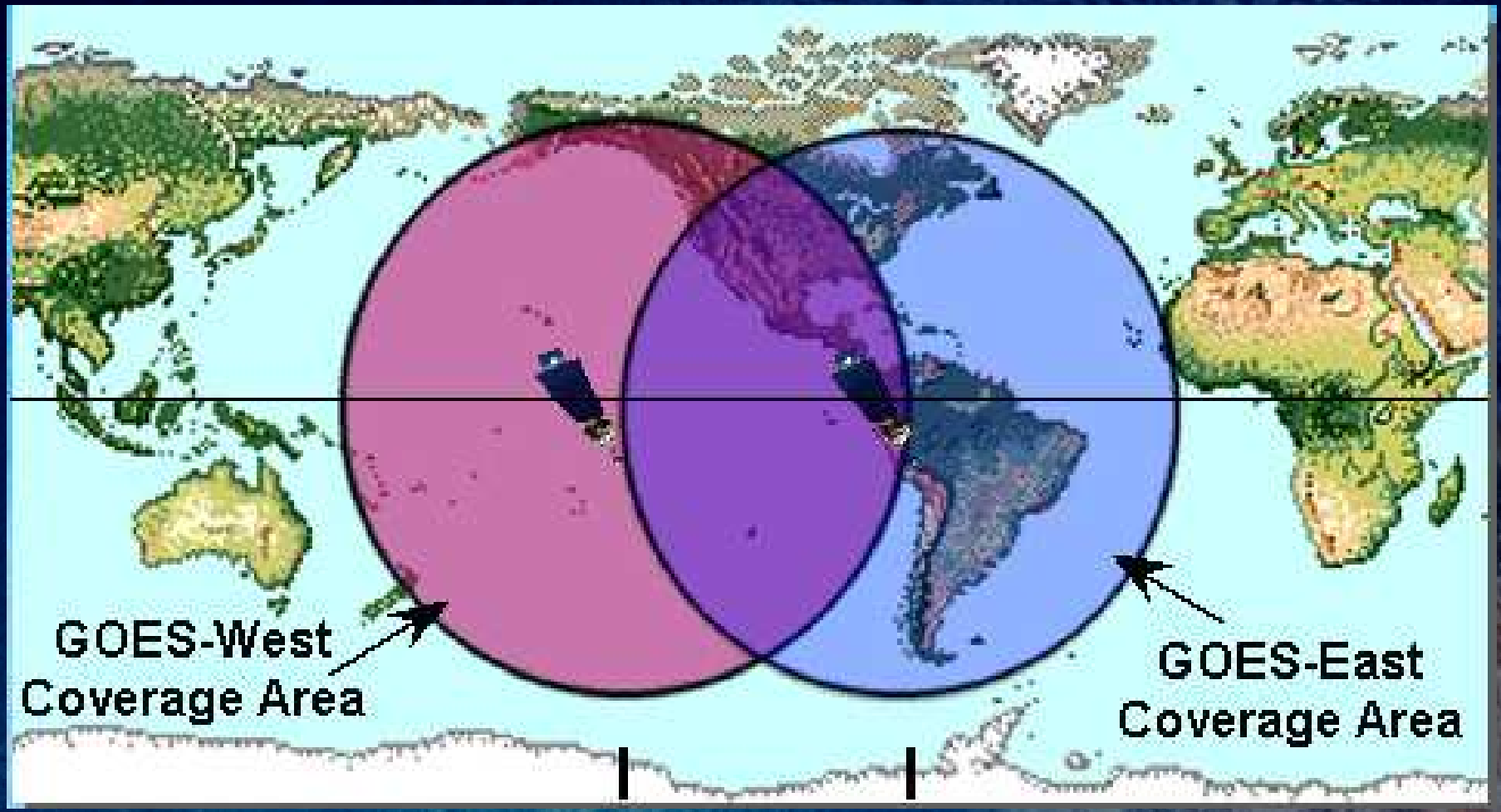
- **National operational environmental observations for 24-hour of weather and Earth's environment**
- **The GOES-R system provides an observation system that produces reliable data on atmosphere, terrestrial, fresh water, and ocean ecosystems data and will be one of the primary U.S. systems networked into the Global Observing System led by the World Meteorological Organization and that was set as a goal at the Earth Observation Summit (July 2003)**
- **Support storm-scale weather forecasting and numerical modelers**
  - *To meet requirements, GOES continuously maintains operational satellites at two locations (75º West and 135º West)*
- **On-orbit spare ready in case of failure**
  - *currently operational : GOES-10 (K), -11(L), -12(M); -13(N), -14 (O), -P (N series)*
  - *GOES-R Series is the follow-on continuity program to GOES-N Series* ***(New Generation GOES Satellites)***

GOES-R AWG program is a government-led effort to

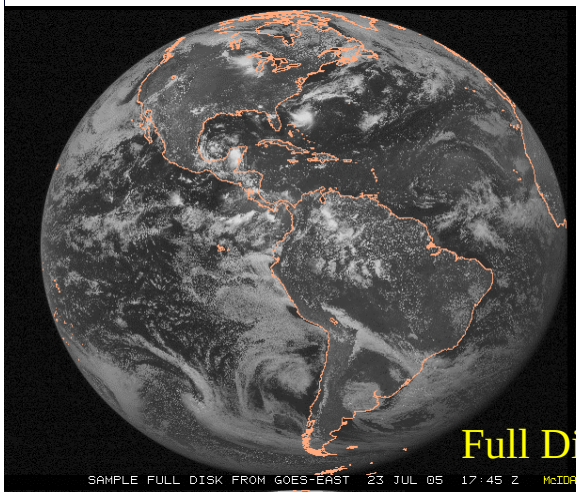
- broker algorithms between government, academic and commercial sources;
- support the prototyping and demonstration of algorithm performance including algorithm/product metadata generation techniques, standards, and formats;
- provide algorithm software, test data sets, and benchmarks as potential solutions for the product generation functions, and
- review and assess applicable GOES Incident Reports (GIRs).

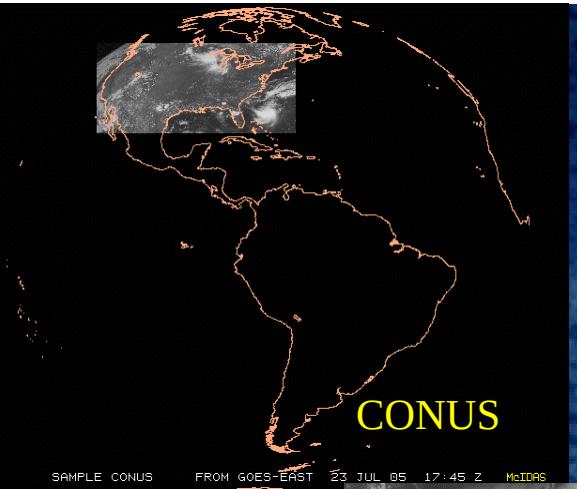
GOES-R Mission

US GOES Imager Coverage

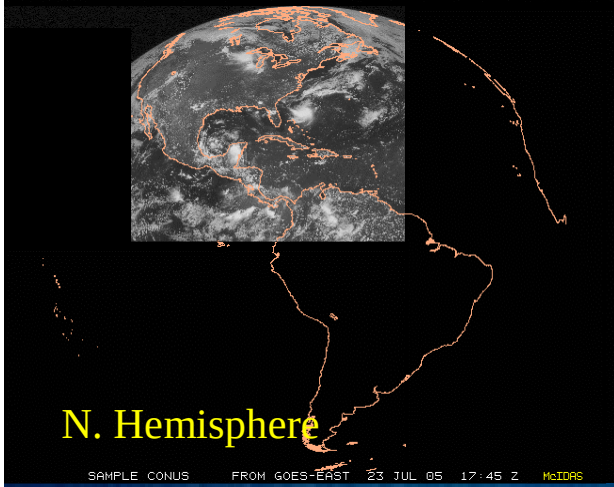


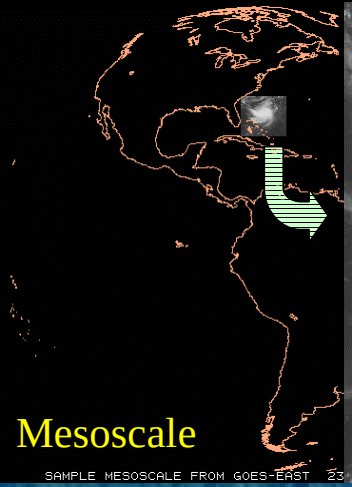
Advanced Baseline Imager
-- Scan Mode

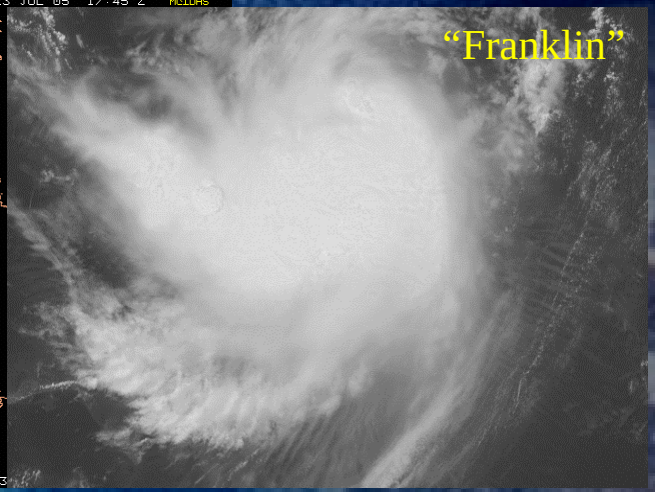




ABI scans about 5 times faster than the current GOES imager







There are two anticipated scan modes for the ABI:

- Full disk images every 15 minutes + 5 min CONUS images + mesoscale
- Or, Full disk every 5 minutes

ABI Sensor
-- Channels

ABI Band	Wavelength Range (μm)	Central Wavelength (μm)	Central Wavenumber (cm-1)	sub-satellite IGFOV (km)	Land Product Use
1	0.45 – 0.49	0.47	21277	1	Albedo
2	0.59 – 0.69	0.64	15625	0.5	**Fire, albedo, NDVI/GVF Flood**
3	0.846 – 0.885	0.865	11561	1	**Albedo, NDVI/GVF, Flood**
4	1.371 - 1.386	1.378	7257	2	**Albedo**
5	1.58 - 1.64	1.61	6211	1	**Albedo**
6	2.225 - 2.275	2.25	4444	2	**Fire, Albedo**
7	3.80 - 4.00	3.90	2564	2	**Fire**
8	*5.77 - 6.6*	*6.19*	*1616*	*2*	
9	*6.75 - 7.15*	*6.95*	*1439*	*2*	
10	*7.24 - 7.44*	*7.34*	*1362*	*2*	
11	*8.3 - 8.7*	*8.5*	*1176*	*2*	
12	*9.42 - 9.8*	*9.61*	*1041*	*2*	
13	10.1 - 10.6	10.35	966	2	**Fire**
14	10.8 - 11.6	11.2	893	2	**LST, Fire, Flood**
15	11.8 - 12.8	12.3	813	2	**LST Fire, Flood**
16	*13.0 - 13.6*	*13.3*	*752*	*2*	

GOES-R Algorithm Working Group

Product(s) Team	NOAA Collaborator (Team Chair)
Air Quality/Aerosol	Shobha Kondragunta (NOAA/STAR)
Aviation	Ken. L. Pryor (NOAA/STAR)
Calibration/Validation	Changyong Cao (NOAA/STAR)
Clouds	Andrew Heidinger (NOAA/STAR)
Cryosphere	Don Cline (NOAA/NWS)
Hydrology	Bob Kuligosky (NOAA/STAR)
Land Surface	*Yunyue Yu (NOAA/STAR)*
Ocean Color	Menghua Wang (NOAA/STAR)
Sea Surface Temperature	Alexander Ignatov (NOAA/STAR)
Proxy Data	Fuzhong Weng (NOAA/STAR)
Radiation Budget	Istvan Laszlo (NOAA/STAR)
Soundings	Chris Barnet (NOAA/STAR)
Space Weather	Steven Hill (NOAA/SEC)
Winds	Jaime Daniels (NOAA/STAR)
Algorithm Integration	Walter Wolf (NOAA/STAR)

AWG Land Team and Products

AWG Land Team Chair : Yunyue (Bob) Yu

- Normalized Difference Vegetation Index[2]
  - ***Peter Romanov (Lead)***
  - *Hui Xu*
  - *Dan Tarpley*
  - *Bob Yu*
  - *Kevin Gallo*
  - *Felix Kogan*
  - *Wei Guo*
- Land Surface Temperature[1]
  - **Bob Yu (Lead)**
  - Dan Tarpley
  - Hui Xu
  - Ming Chen
  - Konstantin Vinnikov
  - Kevin Gallo
- Fire/Hot Spot Characterization[1]
  - **Chris Schmidt (Lead)**
  - Ivan Csiszer
  - Wilfrid Schroeder
  - Bob Yu
  - Hui Xu
- Clear Sky Radiance*
  - **Peter Romanov (Lead)**
  - Hui Xu
  - Dan Tarpley

Software Development

- **Hui Xu (Lead)**
- Aiwu Li (AIT)
- Shuang Qiu (AIT)
- Ming Chen
- Wei Guo

- Flood/Standing Water[1]
  - **Donglian Sun (Lead)**
  - Bob Yu
  - Rui Zhang
  - Hui Xu
- Albedo/Reflectance[2]
  - **Shunlin Liang (Lead)**
  - Dongdong Wang
  - Bob Yu
  - Tao He
  - Hongyi Wu
- Green Vegetation Fraction[2]
  - ***Peter Romanov (Lead)***
  - *Yuhong Tian (co-Lead)*
  - *Bob Yu*
  - *Felix Kogan*
  - *Dan Tarpley*
  - *Hui Xu*
  - *Felix Kogan*

[1] baseline products; [2] option 2 products

*Activities on this product are not described in this review

GOES-R Land Product and Schedules

Baseline Products:

- *Land Surface Temperature* (LST)
- *Fire Detection and Characterization* (FDC)

Option 2 Products:

- *Normalized Difference Vegetation Index* (NDVI)
- *Land Surface Albedo* (LSA)
- *Flood and Standing Water* (FSW) *monitoring*
- *Green Vegetation Fraction* (GVF)

Major Milestone	LST	NDVI	FDC	LSA	FSW	GVF
Algorithm Design Review	12/21/2006	12/21/2006	12/21/2006	6/9/2009	6/9/2009	6/9/2009
Algorithm development	04/2010	04/2010	04/2010	06/2011	06/2011	06/2011
Critical Design Review	5/8/2008	5/8/2008	5/8/2008	2/18/2010	2/18/2010	2/18/2010
ATBD draft	6/27/2008	6/27/2008	6/27/2008	8/15/2008	8/15/2008	8/15/2008
Test Plan Review	3/23/2009	3/23/2009	3/23/2009	9/8/2010	9/8/2010	9/8/2010
Validation Plan (draft)	3/31/2009	3/31/2009	3/31/2009	11/5/2010	11/5/2010	11/5/2010
ATBD (80% readiness)	6/26/2009	6/26/2009	6/26/2009	8/23/2010	8/23/2010	8/23/2010
ATBD (100% readiness)	6/21/2010	6/21/2010	6/21/2010	8/5/2011	8/5/2011	8/5/2011
Software Package ready	4/21/2010	4/21/2010	4/21/2010	6/13/2011	6/13/2011	6/13/2011

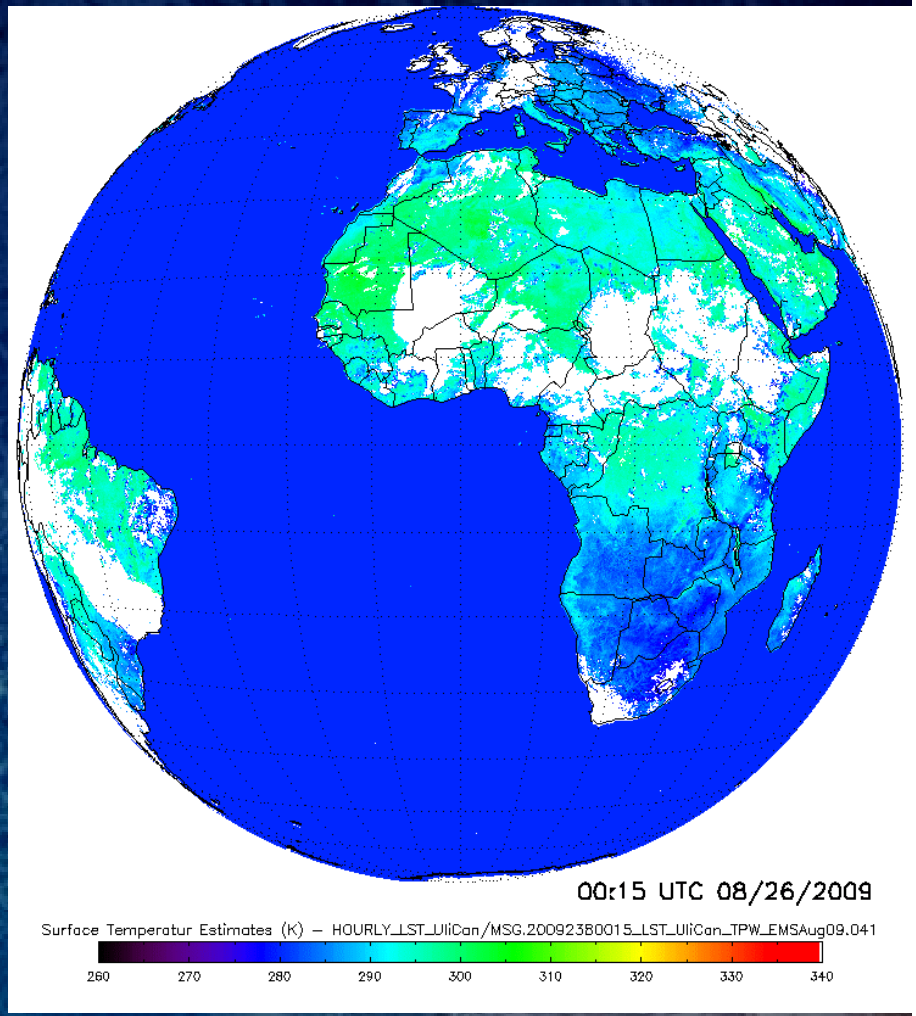
Land Surface Temperature (LST)

Current status

- A TIR split window, explicit emissivity application algorithm was developed for the LST retrieval.
- Examined using a comprehensive simulation dataset.
- Tested using current GOES Imager and SEVIRI datasets.
- Evaluated using *in situ* LST estimation from SURFRAD stations.
- Critical design review, test readiness review have been done
- 100% readiness ATBD and software have been delivered.

Planned accomplishment

- Collecting more ground LST and satellite data for comprehensive *in situ* validation
- Development for validation system/tools



LST Algorithm Tested Using MSG/SEVIRI Data Sample
data time: Aug 26, 2009,.

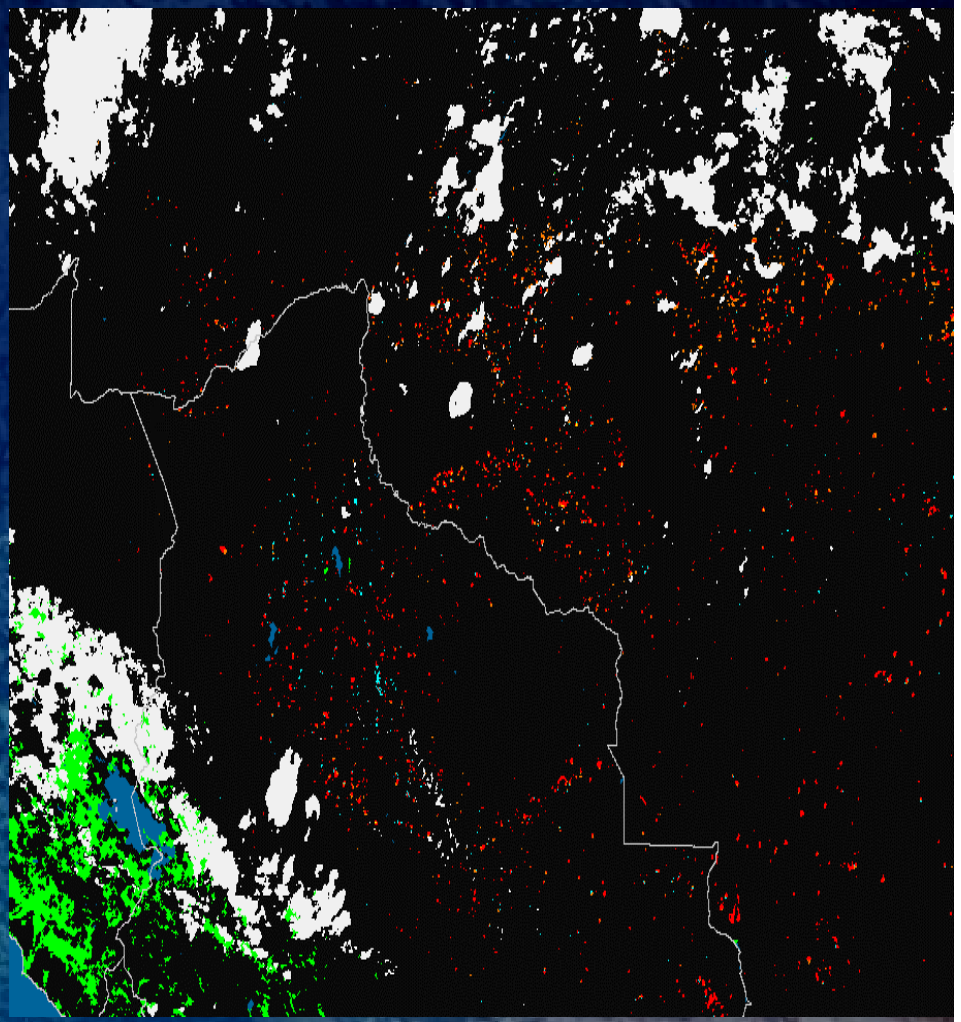
Fire Detection and Characterization (FDC)

Current status

- Adapted wildfire automated biomass burning algorithm (WA_ABBA): a dynamic, multi-spectral, thresholding contextual algorithm using visible and infrared bands to locate fires and characterize sub-pixel fire characteristics.
- Examined using a comprehensive simulation dataset from proxy satellite data via a point spread function (PSF)
- Tested using MODIS data and SEVIRI data.
- Critical design review, test readiness review have been done
- 100% readiness ATBD and software have been delivered.

Planned accomplishment

- Collecting ground Fire and satellite data for comprehensive *in situ* and multi-satellite validation
- Development for validation system/tools



GOES-R WF_ABBA Fire Mask tested using MODIS data on Sept. 7, 2004, at 17:50 UTC.

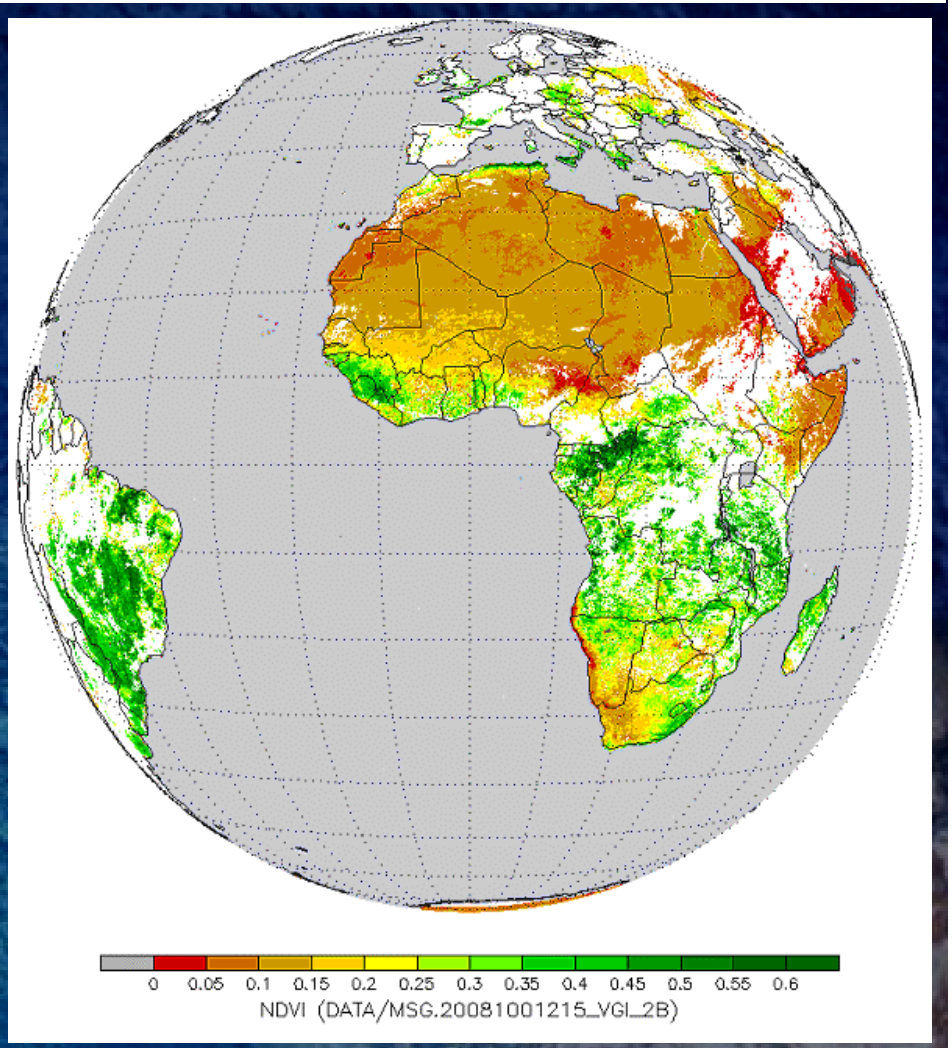
Normalized Difference Vegetation Index (NDVI)

Current status

- A maximum-value composite algorithm is determined for the NDVI generation.
- Examined cloud contamination effect
- Tested using a comprehensive proxy satellite dataset including MODIS and SEVIRI datasets
- Critical design review, test readiness review have been done
- 100% readiness ATBD and software have been delivered.

Planned accomplishment:

- Analyzing anisotropic effect and its impact to the NDVI product
- Perform multi-satellite data comparison
- Collecting and perform *in situ* data comparison
- Development for validation system/tools



GOES-R NDVI Product: example NDVI map from 12:15 UTC April 9, 2008 produced from SEVIRI on Meteosat-8 .

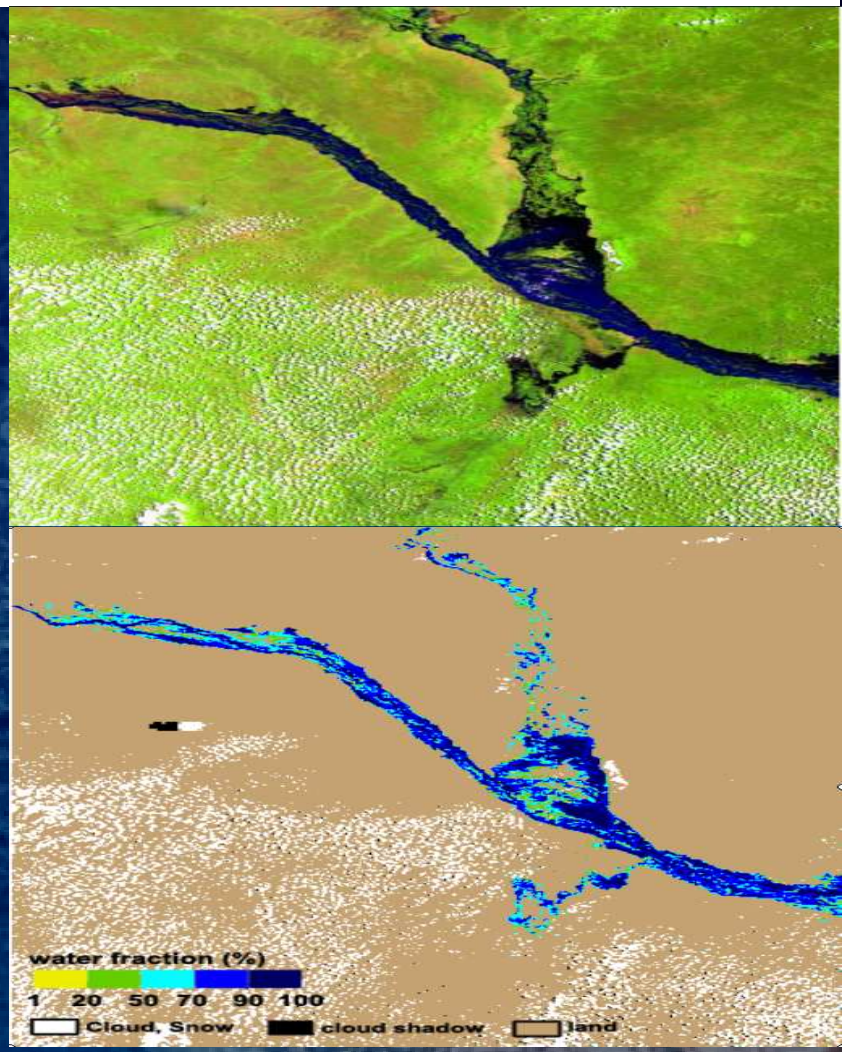
Flood and Standing Water (FSW)

Current status

- A decision tree algorithm is determined for detecting the flood/standing water area
- A ratio (visible and short wave infrared bands) comparison algorithm is applied for estimating sub-pixel water fraction.
- Algorithm is primarily tested using MODIS data and SEVIRI data.
- Algorithm design review was done in 2009.
- Algorithm Critical Design Review was done in 2010.
- 80% readiness ATBD was delivered in 2010.

Planned accomplishment

- Collecting/generating ground database for *in situ*, multi-satellite comparisons.
- Further testing the decision tree algorithm/ procedure and optimizing threshold values applied
- 100% readiness ATBD and software delivery
- Development for validation system/tools



Top: SEVIRI RGB image in Namibia on Feb. 4, 2008
Bottom: water fraction calculated using the FSW algorithm

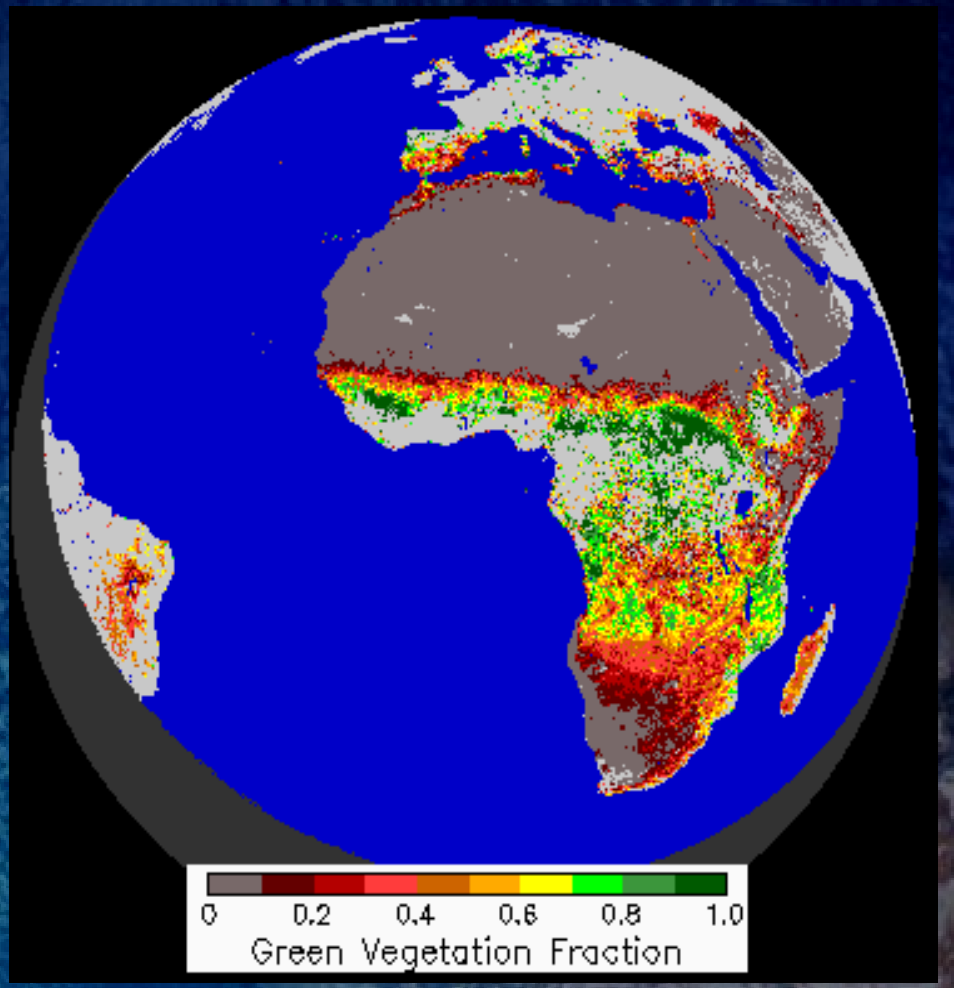
Green Vegetation Fraction (GVF)

Current status

- The algorithm will use NDVI product with pre-determined maximum and minimum NDVI values as references of full and zero vegetation fractions, respectively.
- Algorithm for determining global maximum and minimum NDVI values have been tested using 4-year SEVIRI data (as proxy)
- Impact of anisotropic effect in NDVI data is analyzed, resulting that surface BRDF information will significantly improve the GVF product.
- Algorithm is primarily tested using MODIS data and SEVIRI data.
- Algorithm design review was done in 2009.
- Algorithm Critical Design Review was done in 2010.
- 80% readiness ATBD was delivered in 2010.

Planned accomplishment

- Develop a approach for the BRDF correction
- 100% readiness ATBD and software delivery
- Development for validation system/tools



GOES-R GVF tested using SEVERI data, in the week of 2007155-2007161

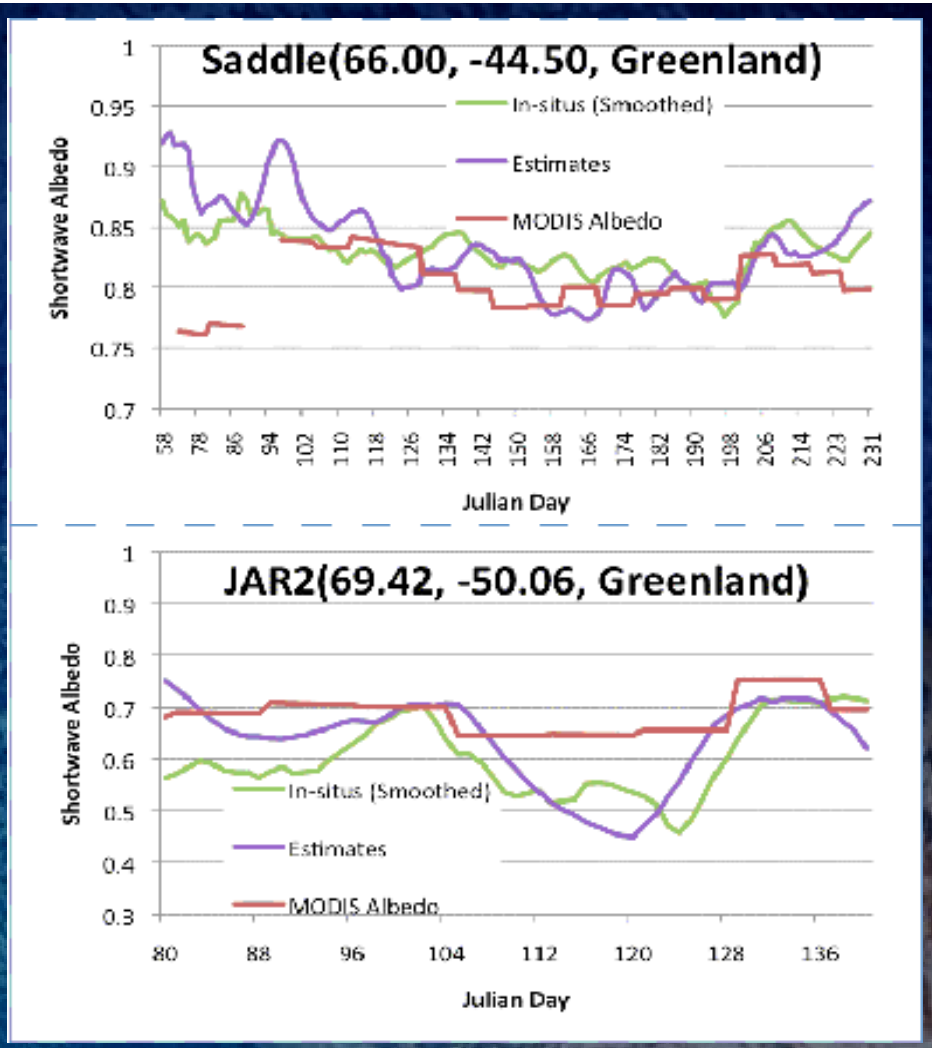
Land Surface Albedo (LSA)

Current status

- A regression analysis approach is determined for estimating the surface albedo from TOA radiances.
- Three-kernal model is applied for determining the surface BRDF characters.
- The broad band albedo is estimated from narrow band albedos from visible to short wave infrared channels), through a pre-determined linear combination formula, which is inherited from MODIS and VIIRS approaches.
- Surface reflectance determined from the BRDF characters is available as bypass product.
- The algorithm is tested using MODIS data and SEVIRI data.
- Algorithm design review was done in 2009.
- Algorithm Critical Design Review was done in 2010.
- 80% readness ATBD was delivered in 2010.

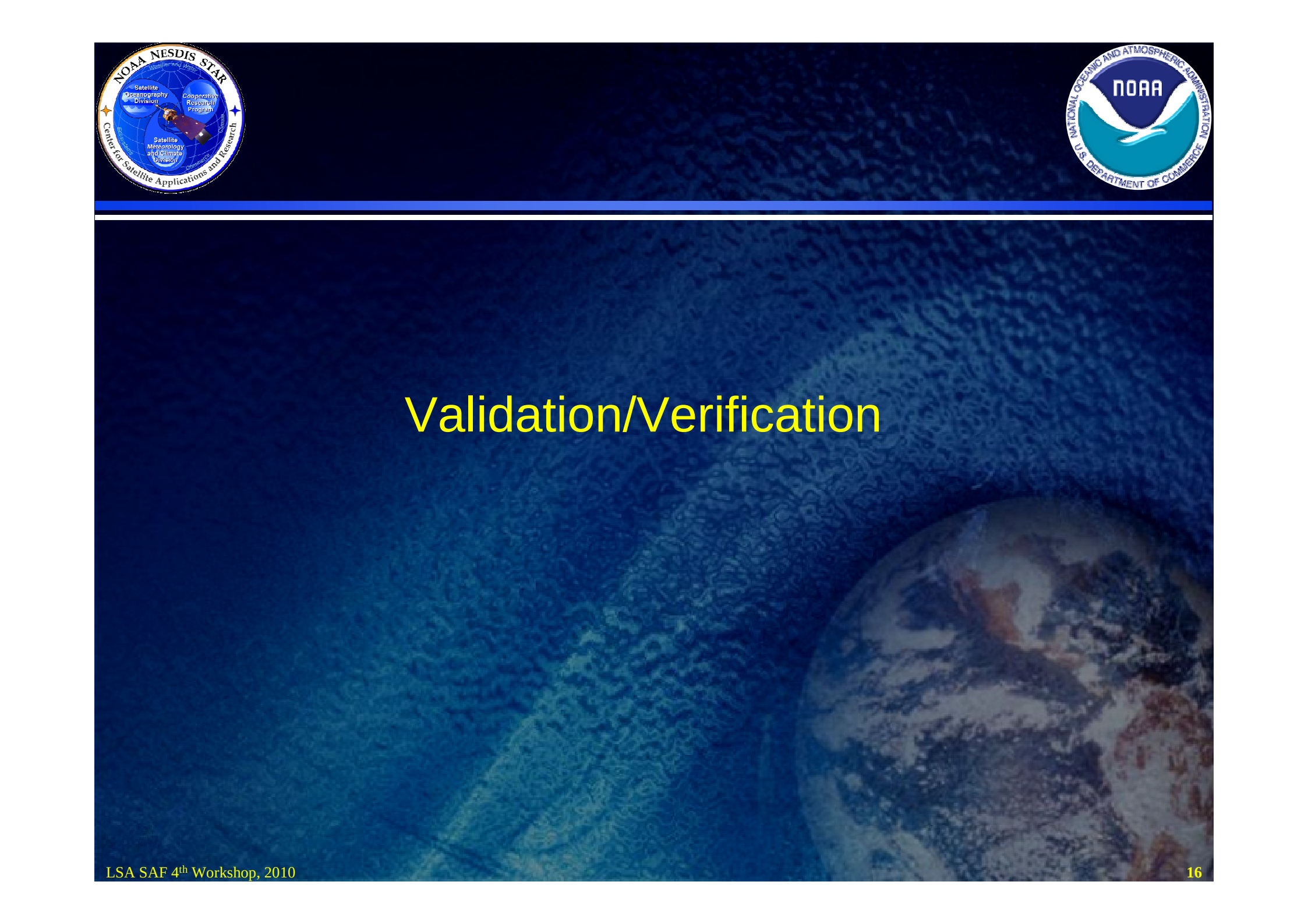
Planned accomplishment

- Cross comparison using different satellite data
- More simulation and proxy data analyses for improving the regression coeffs
- 100% readiness ATBD and software
- Development for validation system/tools



GOES-R Albedo Product Tested using SEVIRI data; compared to MODIS data and in situ data.

Validation/Verification



LST Evaluation and Validation

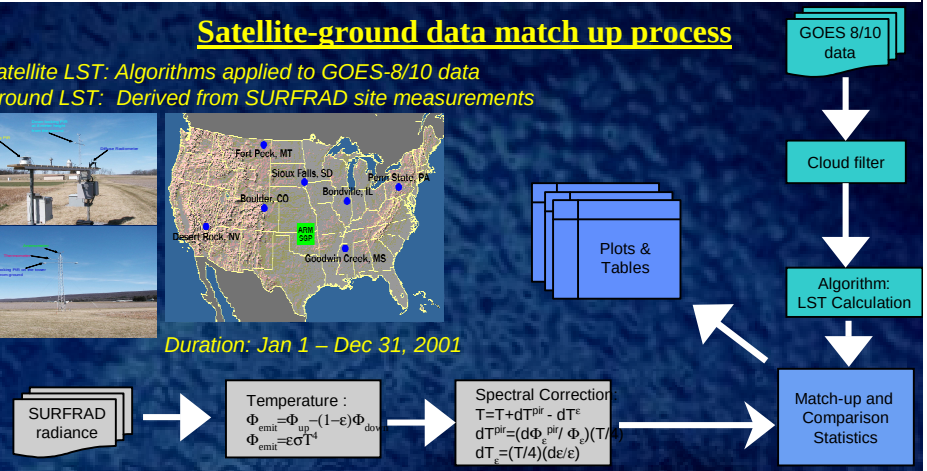
Current status

- A satellite-ground data match up tool has been developed, which includes a stringent cloud filtering processes.
- A large set of *In situ* data has been collected covering areas in the U.S. and Europe.
- A site characterization model is developed for estimating measurement difference between the satellite pixel and the *in situ* spot.
- Validation plans have been set up.

Satellite-ground data match up process

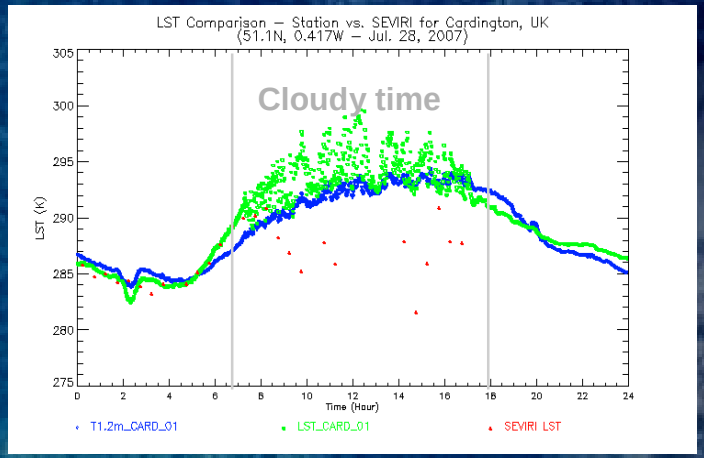
Satellite LST: Algorithms applied to GOES-8/10 data
Ground LST: Derived from SURFRAD site measurements

Duration: Jan 1 – Dec 31, 2001



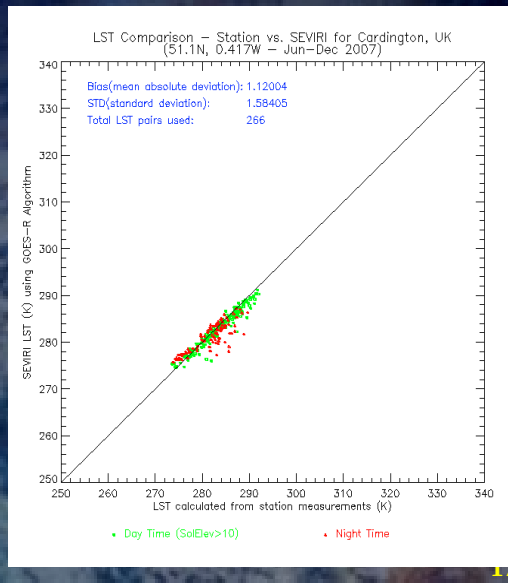
Planned accomplishment

- Collecting more *in situ* data and corresponding satellite data for better temporal and spatial representativities.
- Selecting proper *in situ* sites for high quality validation process.
- Development for validation system/tools



Above: Cloudy data are filtered using in situ data.

Below: LST validation using in situ data.



LSA Evaluation and Validation

Current status

- Ground data (upwelling and downwelling irradiances) were collected from six SURFRAD stations and four AmeriFlux stations.
- MODIS and SEVIRI data were collected as the ABI proxies for the product testing.
- Point-to-point comparisons performed
- Simulation data analysis performed
- 2D images generation for testing the operational ability.

Planned accomplishment

- Prepare a comprehensive pre-launch and post-launch validation plan
- Collecting more *ground measurement* data and corresponding satellite data for better temporal and spatial representativities.
- Selecting proper *in situ* sites for high quality validation process.
- Set up and conduct validation plan.
- Development for validation system/tools

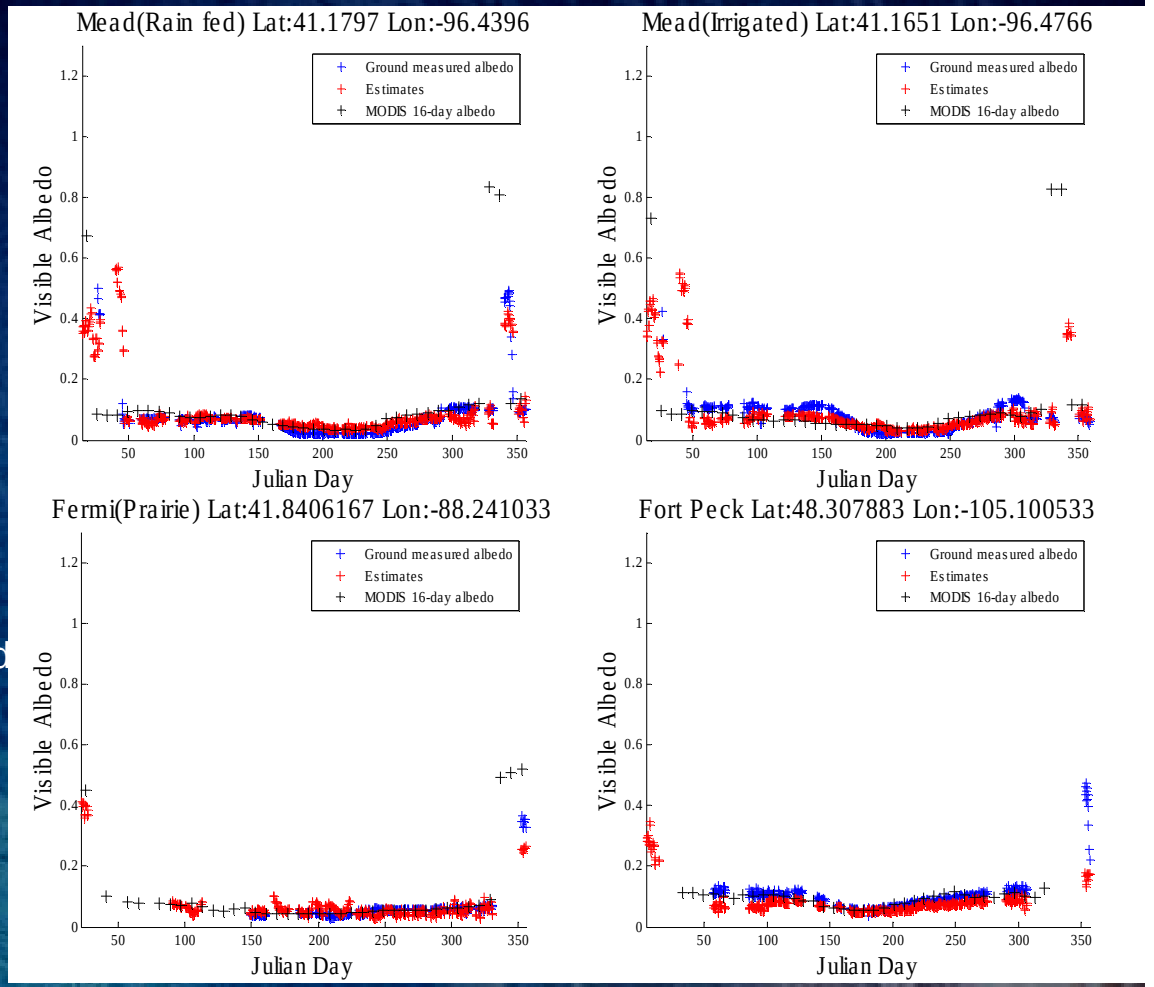


Figure .Time series of validation results of the LSA algorithm using MODIS as proxy data in 2005 over four AmeriFlux sites.

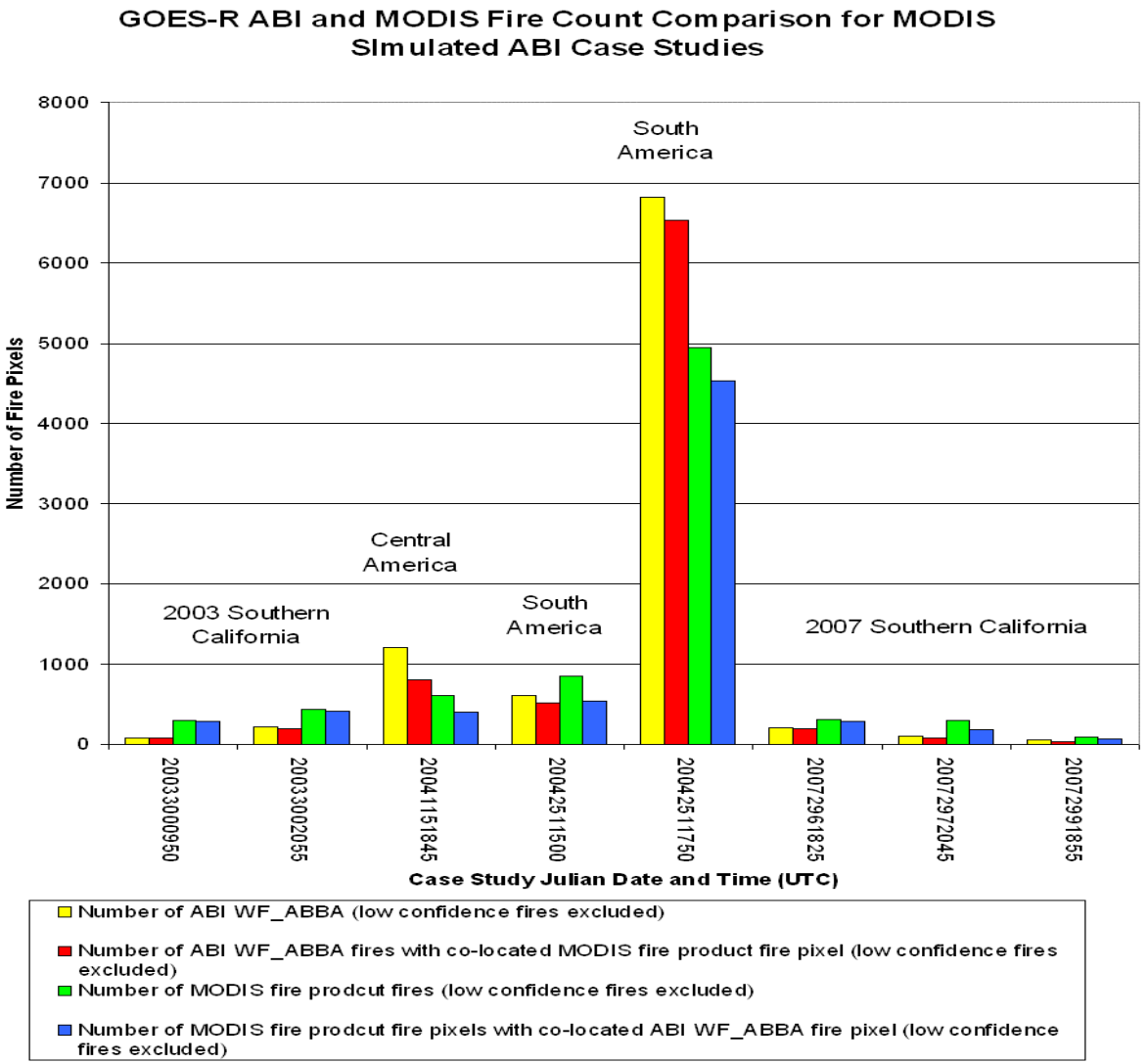
FDC Evaluation and Validation

Current status

- Algorithm has been tested using simulation dataset, proxy dataset , at UW-Madison CIMSS.
- MODIS, GOES, SEVIRI data were used as the ABI proxy.
- Eight cases of fire events (mostly in California) were studied, under the MODIS observations, for the algorithm evaluation..

Planned accomplishment

- Applications to a large set of model simulation dataset in CONUS and central America.
- Collecting and applying Terra ASTER data and Landsat 7 ETM+ data for comparison.
- Airborne observation data collection from existing programs for the validation.



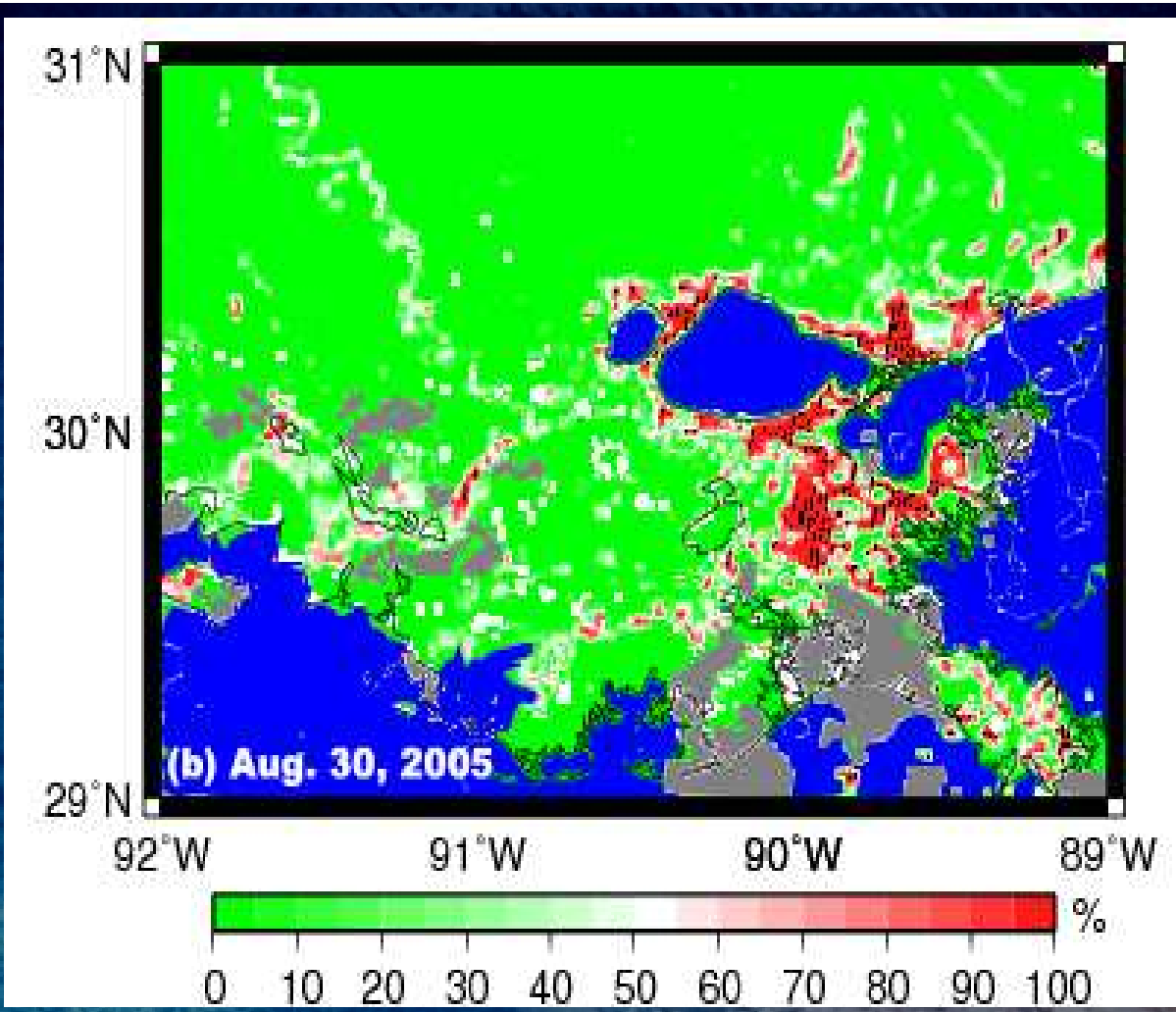
FSW Evaluation and Validation

Current status.

- MODIS, SEVIRI, and Simulation data are used as proxies for the algorithm test and evaluation.
- Cloud shadow detection is performed for better evaluation.
- The algorithm performance is compared with MODIS data and SEVIRI data for water/land classification.

Planned accomplishment

- Prepare a comprehensive pre-launch and post-launch validation plan.
- Validation method improvement – how to determine the permanent non-flood map reference?
- High resolution data ASTER and from ETM.
- Possible algorithm improvement -- DT structure and thresholds,



The derived flood map based on the difference of water fraction after (08/30/2005) and before (08/27/2005) flood

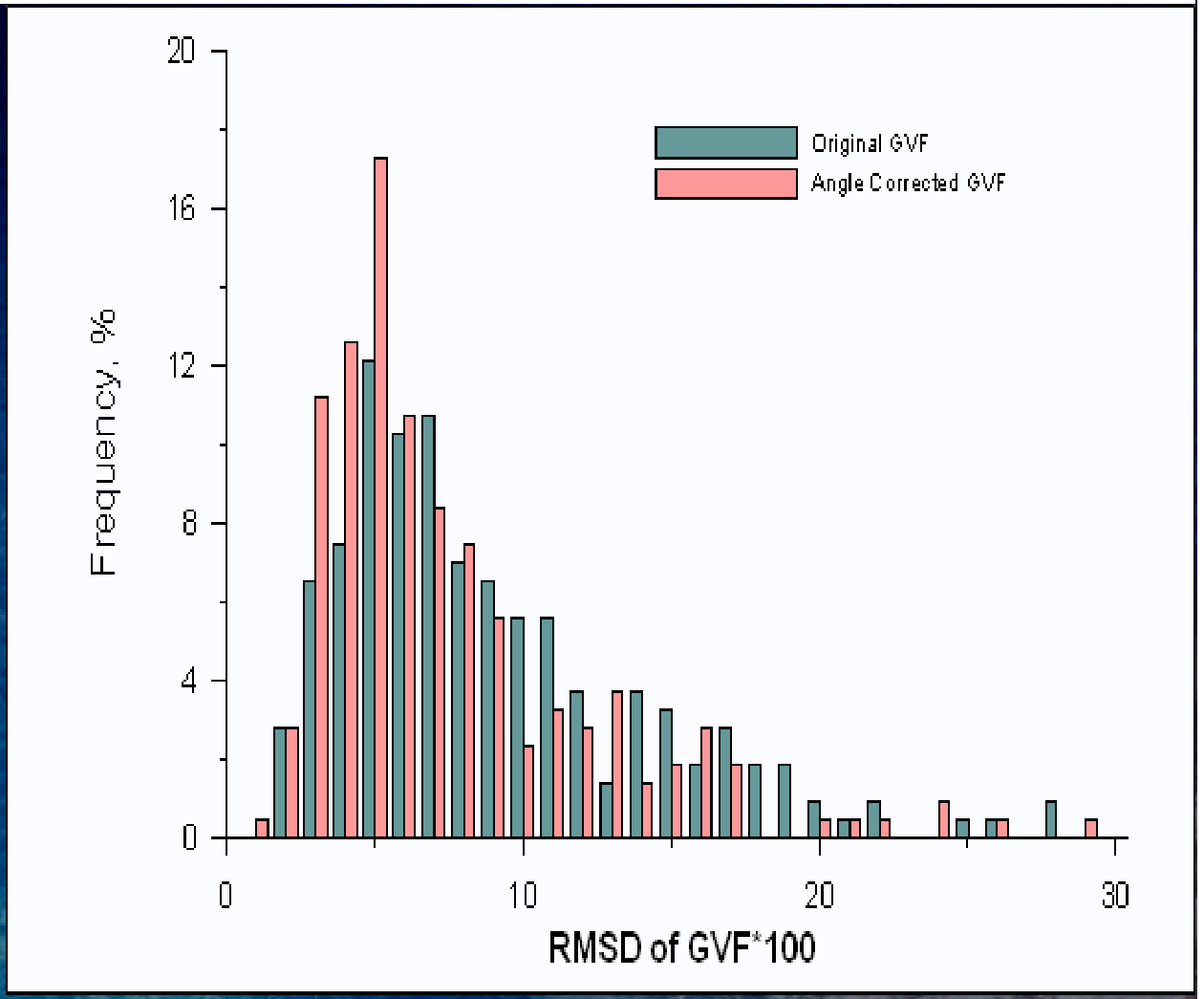
GVF Evaluation and Validation

Current status

- MODIS, SEVIRI, and Simulation data are used as proxies for the algorithm test and evaluation.
- Algorithm risk is analyzed – cloud and cloud shadow, snow cover, NDVI angular anisotropy, $NDVI_{min}$ variation, etc. performed for better evaluation.
- RMSD distribution analysis.
- Framework validation.

Planned accomplishment

- Prepare a comprehensive pre-launch and post-launch validation plan
- Consistency estimation using SEVIRI data as proxy.
- Further analysis and improvement on NDVI angular anisotropic effect.
- Improving cloud effect in the algorithm.



Frequency distribution of RMSD in daily GVF retrievals from 880 SEVIRI dataset. Clear sky data have been used. Observations with NDVI < 0.2 were not considered

Summary

- Critical Design Reviews (CDRs) for LST, FDC and NDVI were conducted and approved in 2008. The CDRs for GVF, LSA and FSW were done and approved in 2010.
- Algorithm readiness review (ARR) have been conducted and 100% readiness version of Algorithm Theoretical Basis Documents (ATBDs) have been delivered for LST, FDC and NDVI, through July to Sept. 2010,
- Test readiness review (TRR) have been conducted and 80% readiness version of the ATBDs have been delivered for GVF, LSA and FSW have been delivered, through July to September, 2010.
- Validation Plans for LST, FDC and NDVI are in performance; Validation Plans for GVF, LSA, and FSW are in preparation.