GOES-R AWG Aerosol, Air Chemistry, and Air Quality Application Team: Aerosol Detection (Smoke/Dust detection)

June 8, 2010

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Outline

- Executive Summary
- Algorithm Description
- ADEB and IV&V Response Summary
- Requirements Specification Evolution
- Validation Strategy
- Validation Results
- Summary

Executive Summary

- ABI Aerosol Detection Algorithm generates Option 1 Aerosol Detection (including smoke/dust) Product (ADP)
- Version 5 code and ATBD (100%) is on track for a July delivery. Will include ABI cloud tests.
- Preparing for System Readiness Review in July 2010.
- Improvements to smoke detection over water and dust over land.
- Comparisons with CALIPSO Vertical Feature Mask Product (VFM), MODIS RGB and AOD product indicate ADP spec compliance.

Algorithm Description

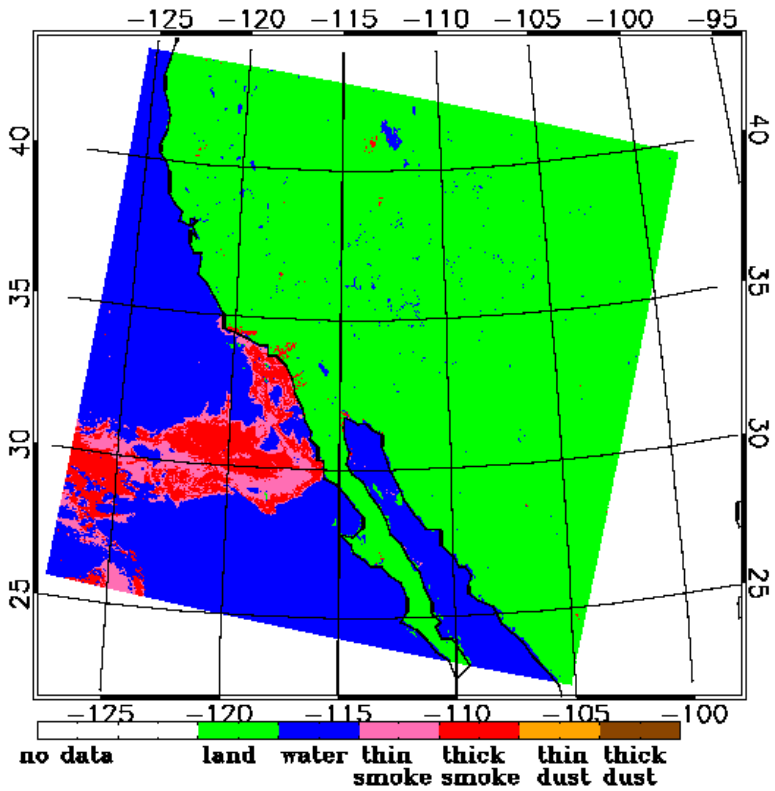
- Aerosol detection algorithm uses visible, near-IR, and thermal IR spectral contrast and variability tests.
- Key features:
  - » Cloud-free radiances and reflectances at different wavelengths are used.
  - » Dust/Smoke detection depends on bright land surface test, blue channel test over water, and various other spectral threshold tests
  - » Dust/Smoke detection over water relies heavily on visible channels.
  - » Currently runs on 1 km MODIS data. Algorithm will be tuned for ABI bands and for spatial resolution.
  - » Depends on ABI cloud and snow/ice mask.
  - » Provides binary information on aerosol (dust/smoke) mask.
  - » Based on University of Wisconsin – Madison algorithm for MODIS.
- Algorithm not yet tested for:
  - » Dependence of product accuracy to aerosol loading and height
  - » Robustness of spectral thresholds for different viewing geometries

Algorithm Assumptions and Limitations

- **Assumptions:**
  - » Spectral thresholds are insensitive to viewing geometry
  - » Information on neighboring pixels is available for spatial variability tests
  - » Striping is minimal (striping will adversely affect the texture input parameters)
  - » Spectral shifts are minimal (spectral shifts will adversely affect the BTD input parameters)
  - » ABI data have been corrected for parallax
  - » Cloud and other input ancillary data are available
- **Limitations:**
  - » Only for daytime
  - » Smoke detection over land is limited to dark surface
  - » Not optimal for optically thin smoke and dust
  - » Threshold dependent and hence frequent tuning needed if instrument experiences calibration errors etc.
  - » Product accuracy sensitive to aerosol loading and height

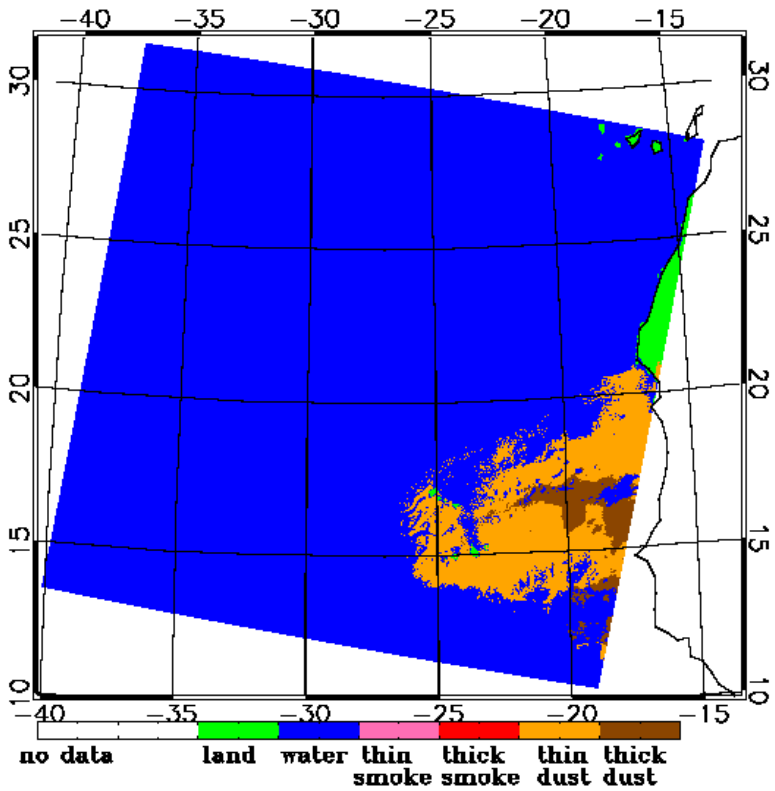
Examples of ADP Output

Smoke plume



October 27, 2001 UTC 1825

Dust storm



May 18, 2010, UTC 1230

Algorithm Changes from 80% to 100%

- Improved smoke detection over water and dust over land
- Quality flags added
- Diagnostic flags added

Algorithm Changes from 80% to 100%

- Major changes for smoke detection over water
  - » Spectral contrast test (different Channel selections)

V3: R_1= Refl_Ch1/Refl_Ch2 V5 : R_1= Refl_Ch1/Refl_Ch4

R_2= Refl_Ch3/Refl_Ch2 R_2= Refl_Ch6/Refl_Ch4

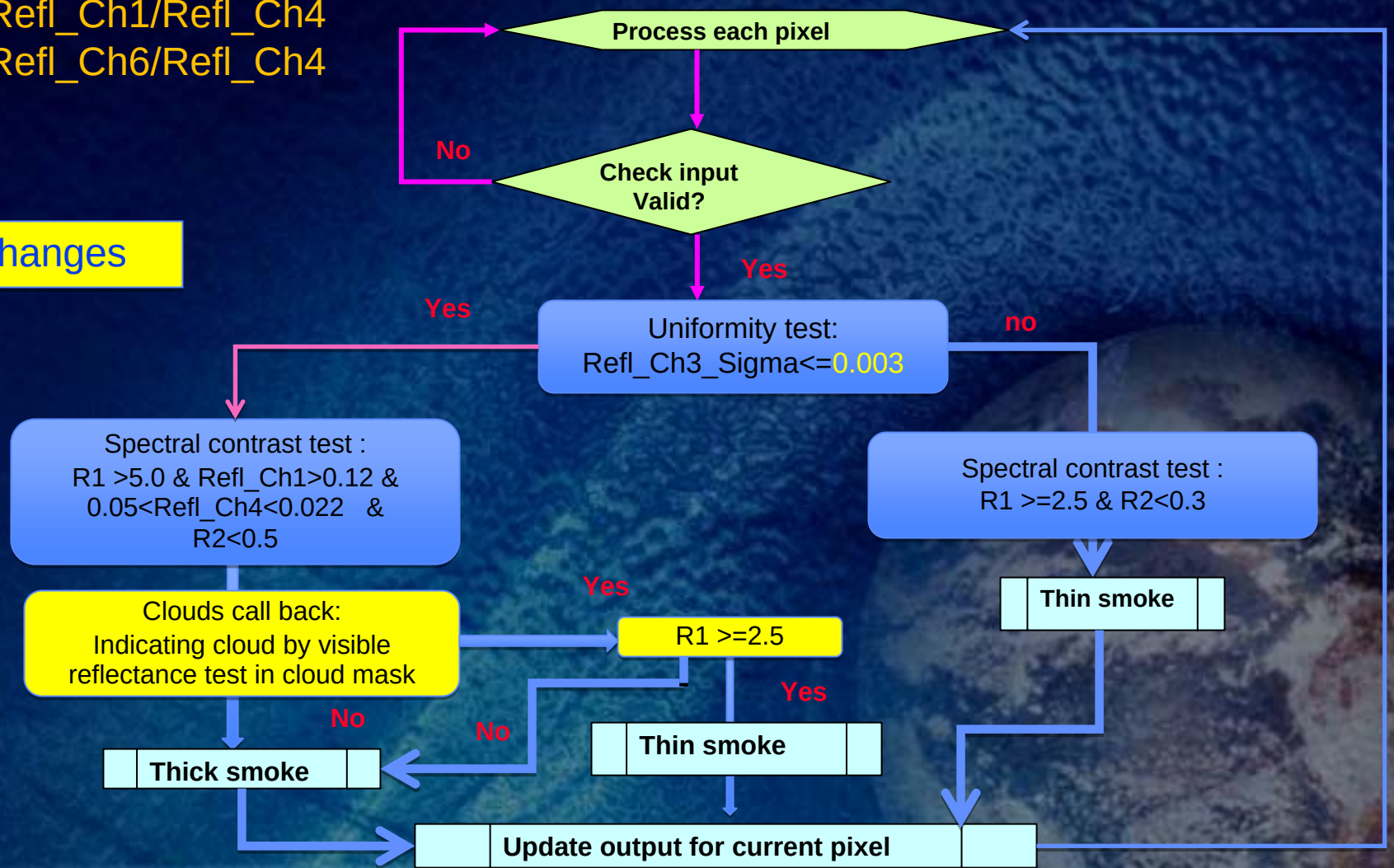
- Major changes for dust detection over land
  - » 3.75 -11µm test: 20K (V3) to 15K (V5) to include thin dust layers.
  - » 11-12 µm test : -0.5K (V3) to -0.2K (V5)

Algorithm Changes from 80% to 100%

smoke detection over ocean

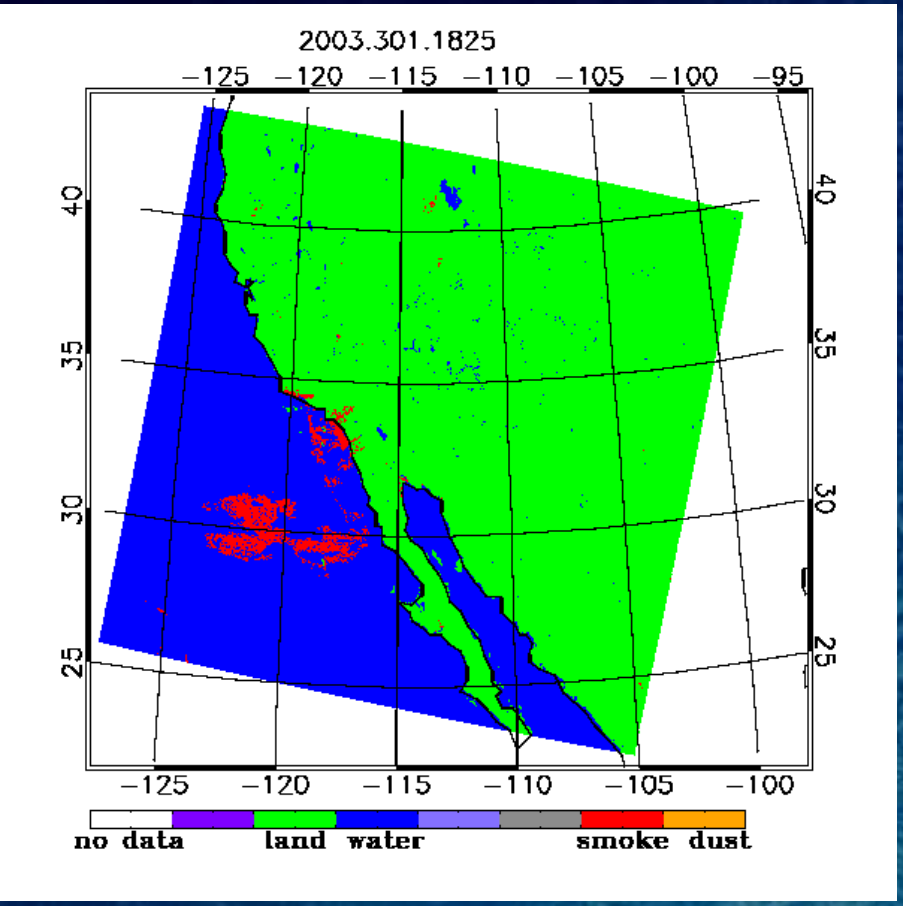
R_1= Refl_Ch1/Refl_Ch4
R_2= Refl_Ch6/Refl_Ch4

V5 Changes

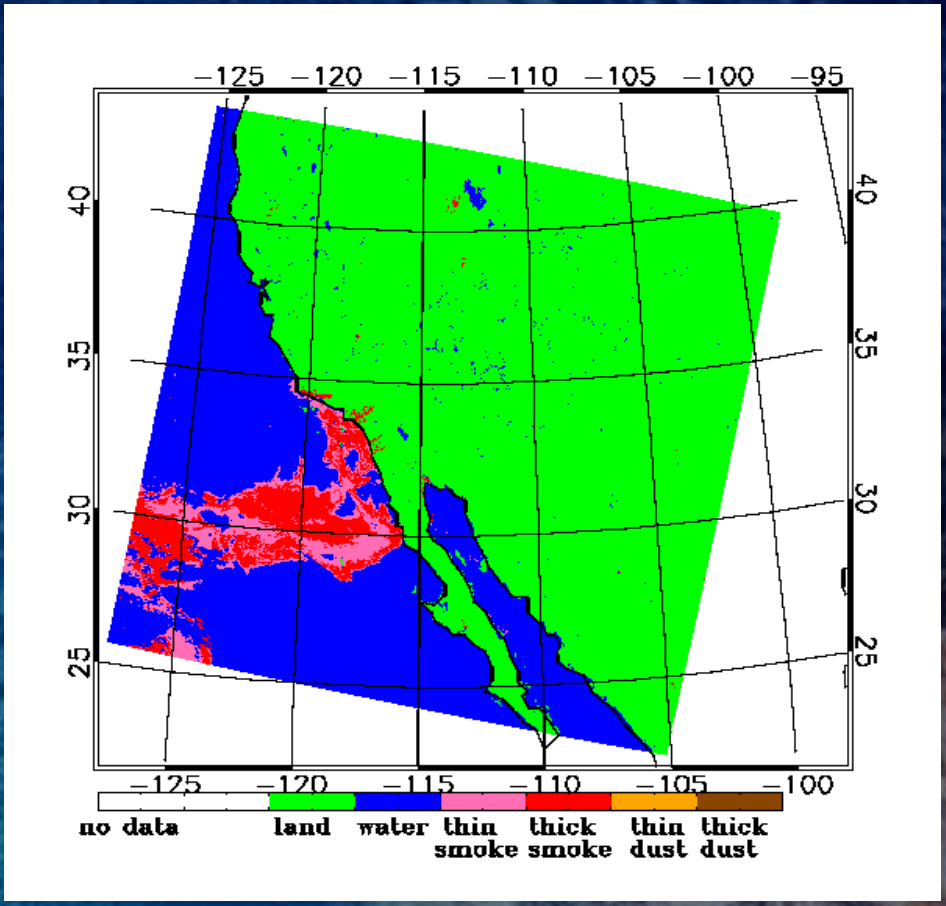


Algorithm Changes from 80% to 100%

Version 3

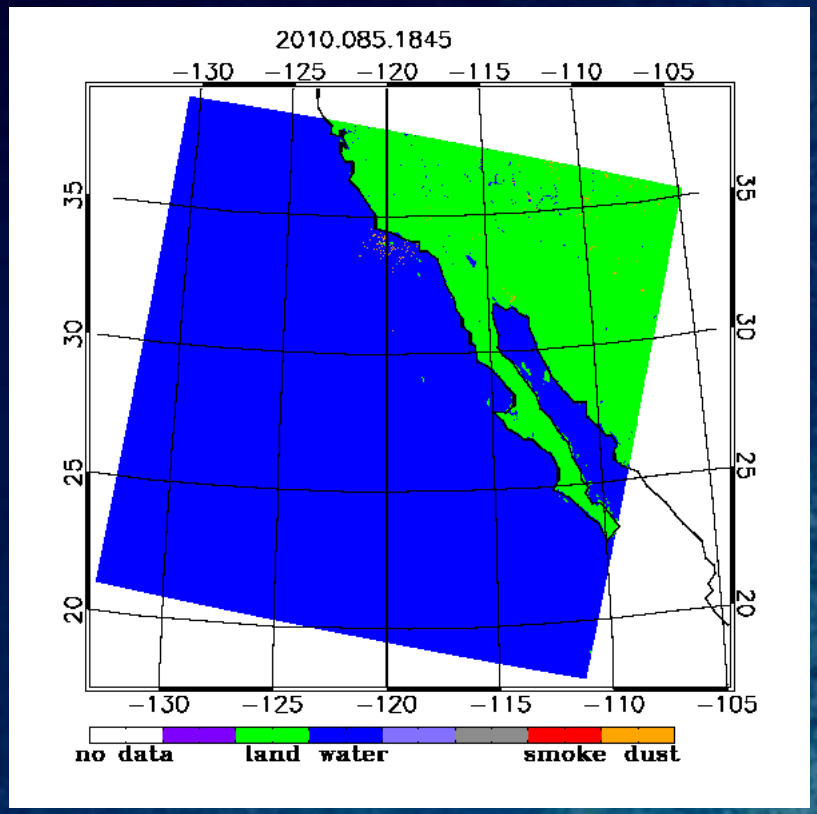


Version 5

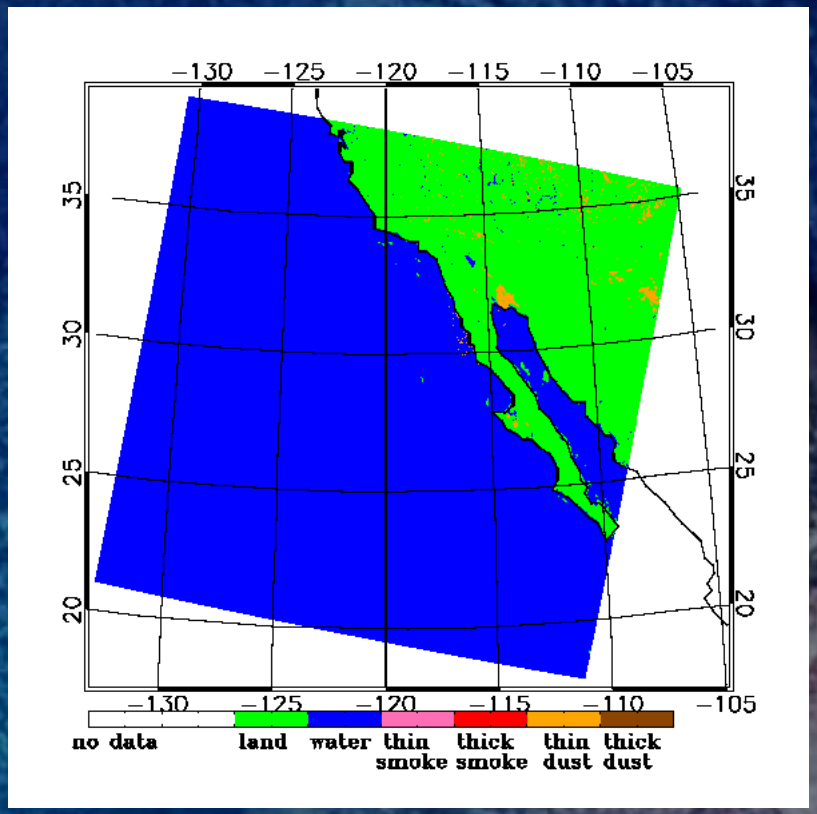


Algorithm Changes from 80% to 100%

Version 3



Version 5



ADEB and IV&V Response Summary

Main Comments:

- Formula used to compute accuracy includes “no aerosol (clear-sky) cases” and therefore leads to high values of accuracy.
  - » Agree with the comment but that is the guidance given to the teams. Information on “Hit Rate” and “Miss Rate” are now included in the validation approach to make the validation results more realistic.
- Use supervised Image classification algorithms.
  - » MODIS RGB imagery that uses image classification algorithms are used in our validation work. Plans are to adapt similar techniques for ABI aerosol imagery in the future.
- SEVIRI data not used in algorithm development work
  - » No 2.1 um channel on SEVIRI. But the dust detection algorithm (imagery product) developed for SEVIRI is being tested on MODIS. Parts of this algorithm could be adapted for ABI in future versions.
- Interaction with cloud team
  - » Working with cloud team to ensure cloud tests are consistent with ADP algorithm requirements.

Requirements

Name	User & Priority	Geographic Coverage (G, H, C, M)	Vertical Res.	Horiz. Res.	Mapping Accuracy	Msmnt. Range	Msmnt. Accuracy	Latency Refresh Rate/Coverage Time Option	Vendor-Allocated Ground	Product Measurement Precision
Aerosol Detection (including Smoke and Dust)	GOES-R	C	Total Column	2 km	1 km	Binary yes/no detection above threshold 0.2 (for AOT)	Dust: 80% over land and water Smoke: 80% over land, 70% over water	15 min	15 min	N/A
Aerosol Detection (including Smoke and Dust)	GOES-R	FD	Total Column	2 km	1 km	Binary yes/no detection above threshold 0.2 (for AOT)	Dust: 80% over land and water Smoke: 80% over land, 70% over water	15 min	806 sec	N/A
Aerosol Detection (including Smoke and Dust)	GOES-R	M	Total Column	2 km	1 km	Binary yes/no detection above threshold 0.2 (for AOT)	Dust: 80% over land and water Smoke: 80% over land, 70% over water	15 min	806 sec	N/A

Qualifiers

These are made with the following qualifiers.

- Sensor zenith angle < 65 degrees
- Cloud (aerosol) optical thickness > 1(0.2)
- Cloud mask and cloud type available

Validation Approach

- ABI Aerosol Detection 10-Week Run:
  - » 2006: August 1-31
  - » 2007: February 1-13, April 1-13, October 1-13
- Validation Data:
  - » CALIPSO Vertical Feature Mask (VFM) product
    - – Co-located CALIPSO with MODIS (Aqua) observations for the 10-week analysis period.
  - » MODIS RGB Images with smoke/dust plumes tagged and accompanied by AOD greater than 0.2 (criteria to detect smoke/dust)
  - » Ground-based AERONET observations

Detection	ABI	Truth
True Positive Detect ion (TPD)	Yes	Yes
False Positive Detection (FPD)	Yes	No
True Negative Detection (TND)	No	No
False Negative Detection (FND)	No	Yes

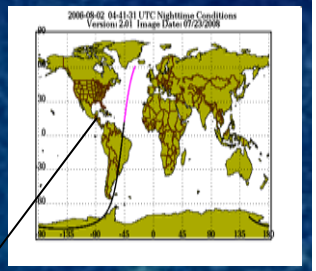
$$Accuracy = \frac{(TPD+TND)}{(TPD+TND+FPD+FND)} * 100$$

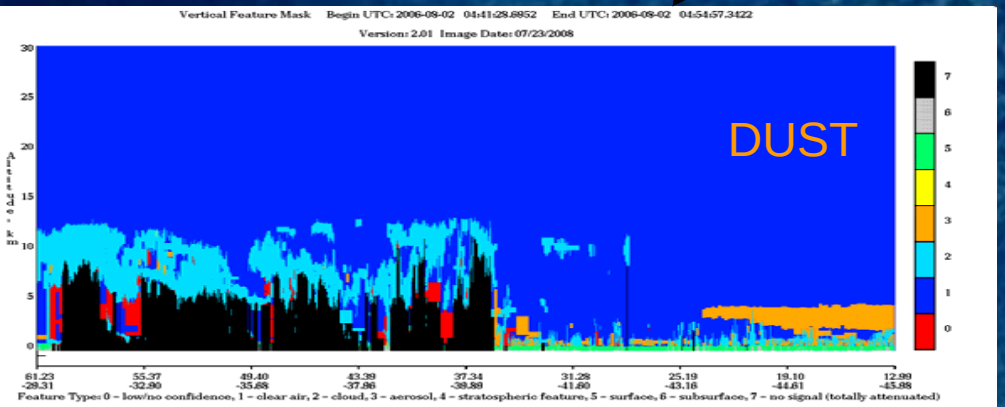
$$HitRate = \frac{(TPD)}{(TPD+FPD)} * 100$$

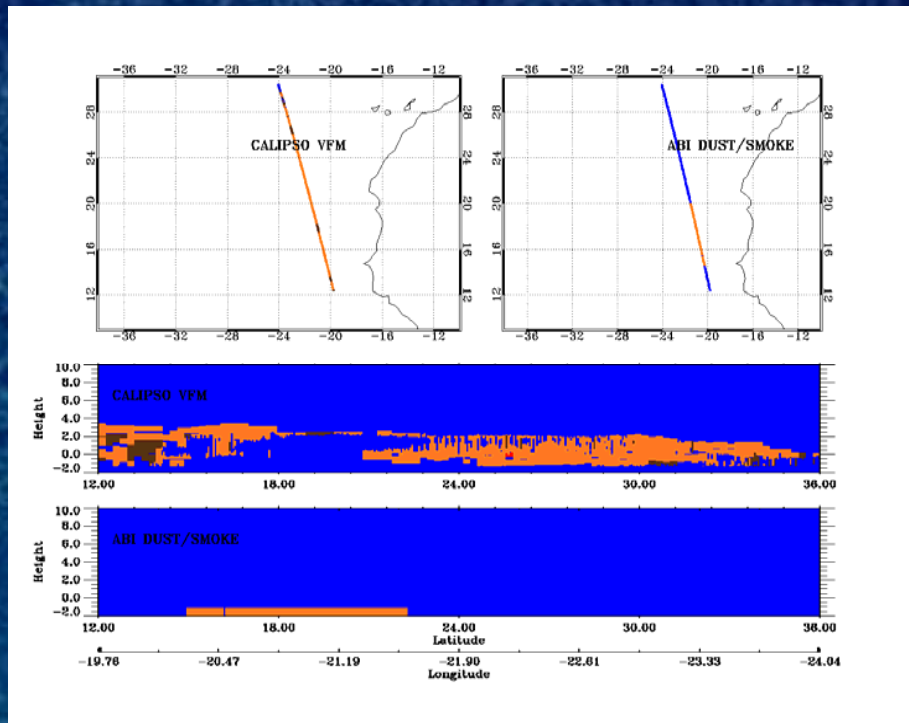
$$MissRate = \frac{(FND)}{(TND+FND)} * 100$$

Validation Approach -CALIPSO VFM

- VFM product provides the vertical and horizontal distribution of aerosol type (including smoke and dust). For each cloud-free but aerosol-loaded CALIPSO pixel (5km), smoke/dust is identified by subtype of aerosol.
- By matching up with ADP (1km) on the track of CALIPSO observations, performance of ADP are evaluated.



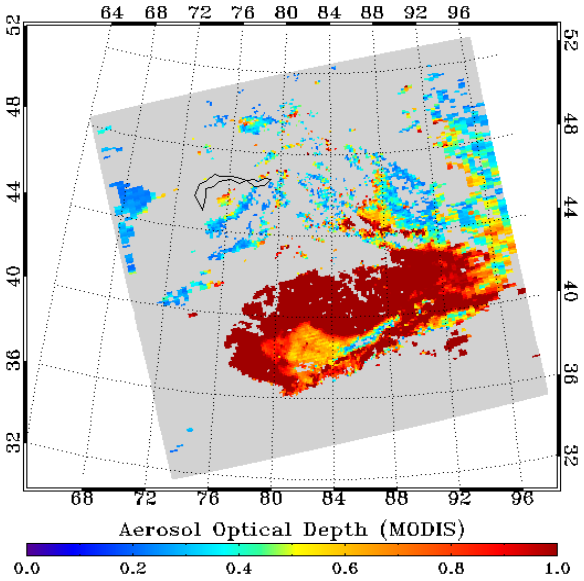




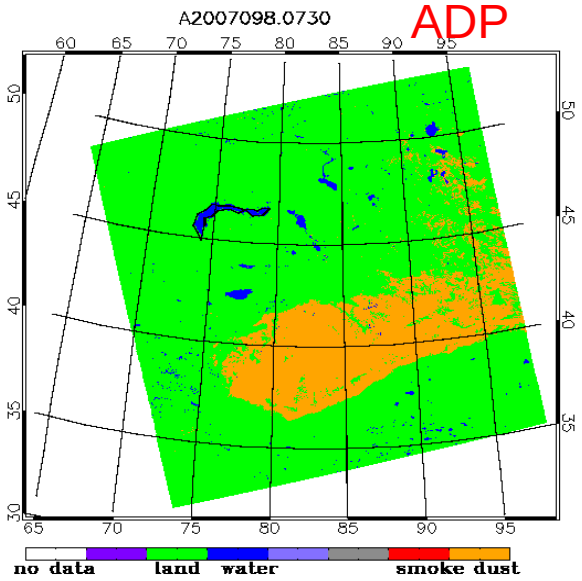
Validation Approach -Independent MODIS Retrievals

- Smoke/dust events are identified by the MODIS Rapid response system and NASA Natural Hazard system.
- MODIS granules containing either smoke or dust event are selected. Pixels with AOD (MODIS-C5) >0.2 are considered as smoke/dust laden. Pixels with AOD<0.2 is taken as smoke/dust free (clear-sky).

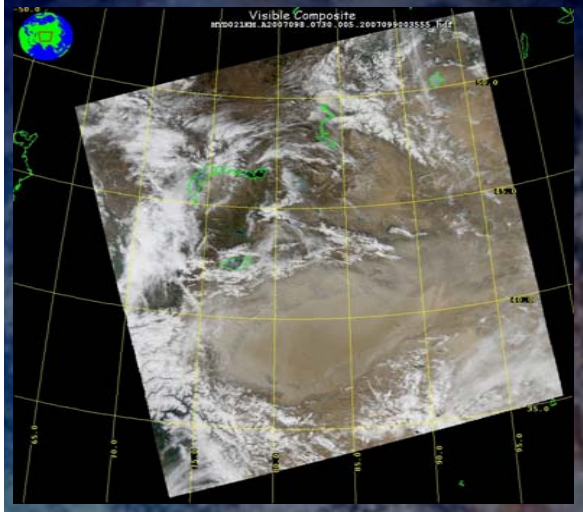
AOD >0.2



ADP

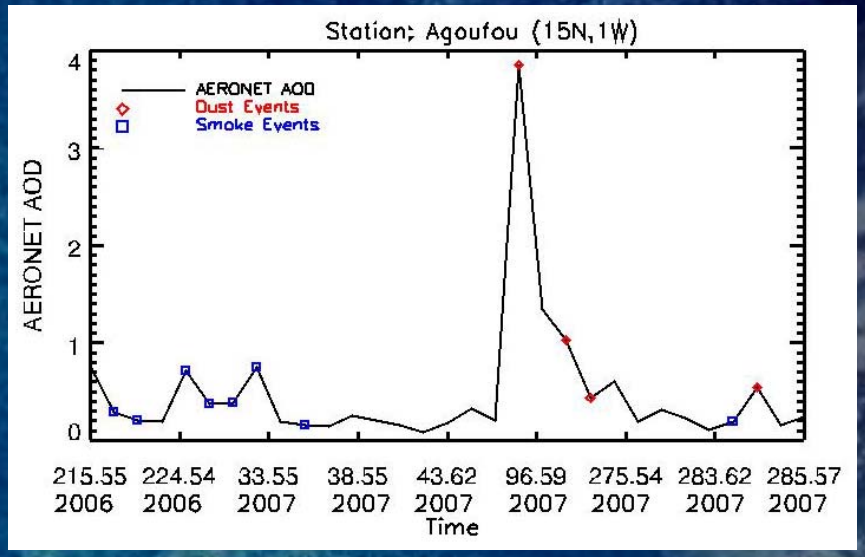


RGB



Validation Approach - AERONET observations

- AERONET observations provide measurements of Aerosol optical depth and Angstrom exponent. AOD>0.2 is used to indicate smoke/dust. Angstrom exponent indicates fine mode (smoke) or coarse (dust) aerosol.
- ADP is co-located with AERONET observations temporally (±60 minutes) and spatially (in 50 X50 km^2 box)
- Only Hit Rate calculated using AERONET Data



Summary of 10-Week Framework Run Validation Results

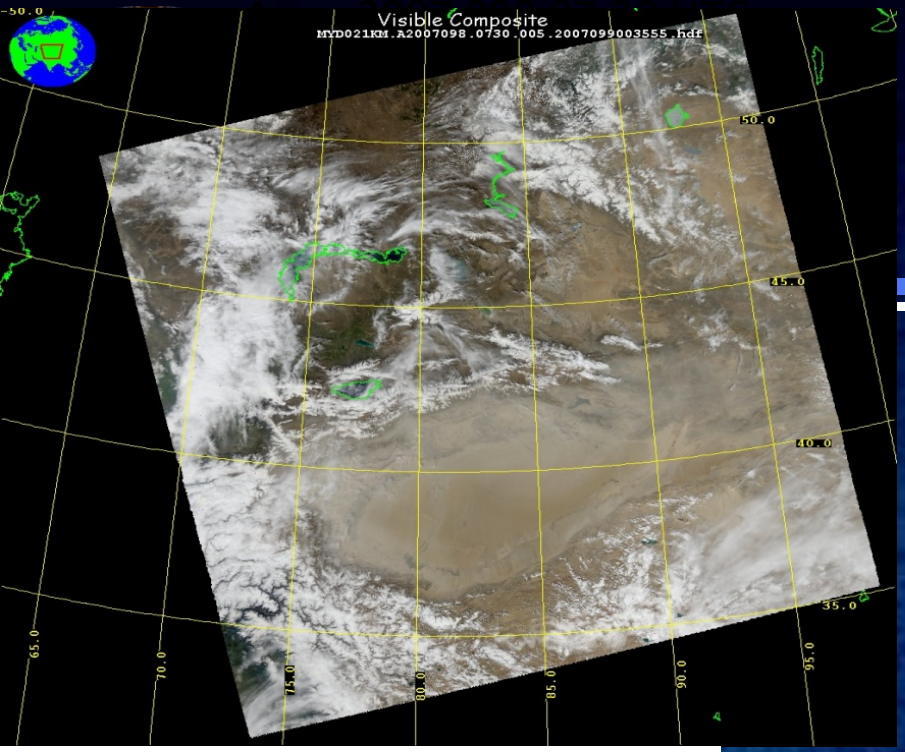
ABI Vs. CALIPSO			
Aerosol	**No. of Matchups**	**Accuracy (10-week run)**	**Accuracy (off-line, longer time period)**
Smoke	3	72%	75%
Dust	2	81%	81%

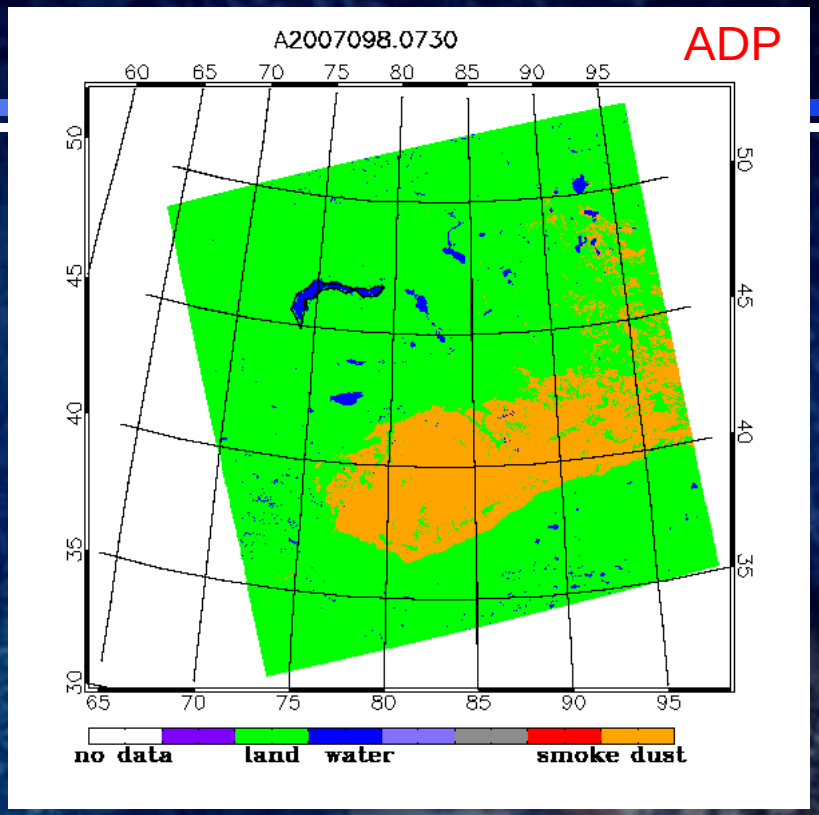
ABI vs. MODIS (10-week Run)				
Aerosol	**No. of Matchups**	**Accuracy**	**Hit Rate**	**Miss Rate**
Smoke	20	73%	53%	25%
Dust	4	85%	96%	15%

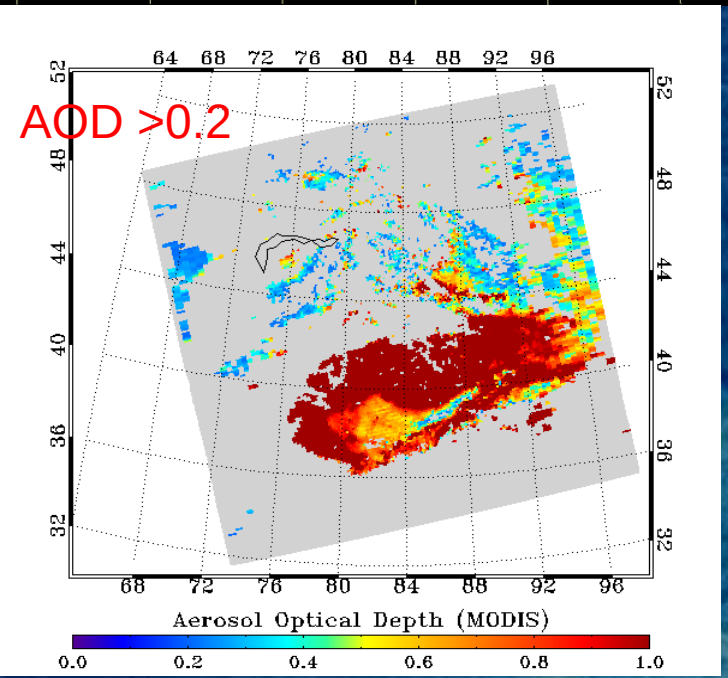
ABI vs. AERONET (10-week Run)		
Aerosol	**No. of Matchups**	**Hit Rate**
Smoke	8	31%
Dust	4	43%

F&PS Requirements: Dust (80%), Smoke (80% over land), Smoke (70% over ocean)

Aqua 2007 098 07:30 UTC







Accuracy	84.6%
Hit Rate	94.8%
Miss Rate	17.8%

Summary

- Testing of V3 algorithm delivered to AIT completed for a 10-week time period using MODIS radiances as proxy.
  - » Testing did not use ABI cloud tests.
- Dust detection for the 10-week run meets specification whereas smoke detection falls short of meeting specification.
  - » Very few matchups with truth dataset for this 10-week time period.
- V5 is expected to perform better than V3
  - » Code and ATBD ready to be delivered to AIT.