

VCM Impact on Aerosol Retrievals: Feedback from Aerosol cal/val Team

Contributions from: Hongqing Liu (IMSG), Sid Jackson (NGAS), Jingfeng Huang (UMD-CICS),
Hai Zhang (IMSG)

Presented by: Shobha Kondragunta and Istvan Iaszlo

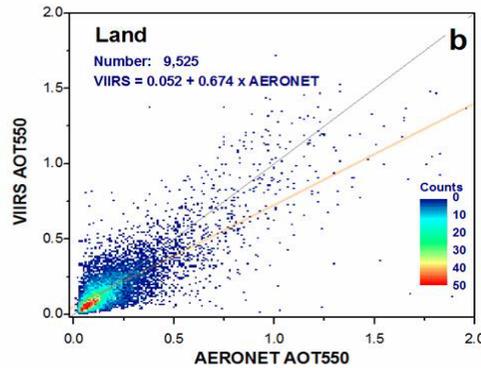
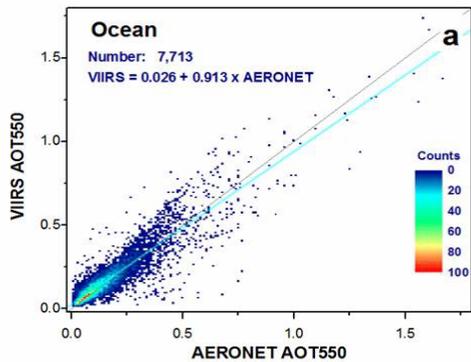
January 7-8, 2014

VCM EDR Stage 1 Validation Review



VCM Flags Used by Aerosol Algorithm

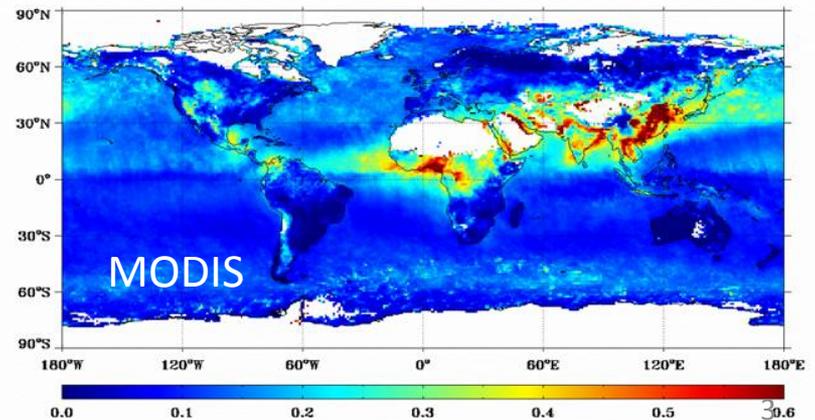
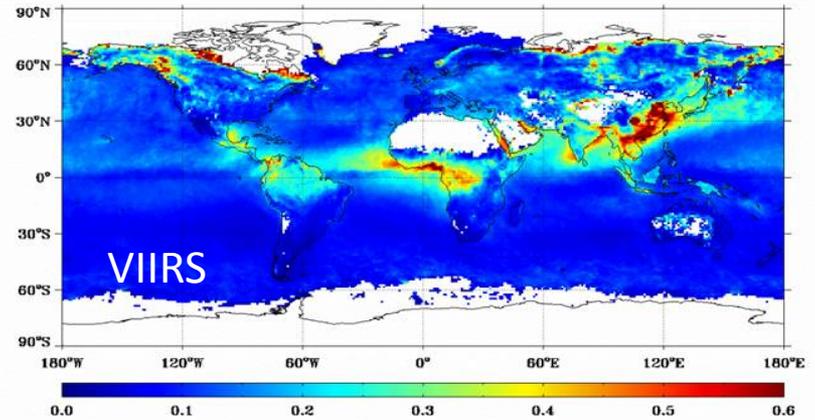
Flag description Key	Impact On Aerosol Retrieval	
Cloud Detection Result & Confidence Indicator	No retrieval if probably or confidently cloudy	Major Impact
Snow/Ice	No retrieval if snow/ice detected	
Sunlint	No retrieval over ocean if sunlint detected	
Fire detection	No retrieval if fire detected	
Heavy aerosol	Cloud mask is reset to confidently clear if heavy aerosol is detected and aerosol retrieval attempted	
Land/Water Background	Selecting retrieval path (land or ocean algorithm)	Marginal Impact
Shadow detected	Retrieval quality degraded if shadow detected	
Volcanic ash	Retrieval quality degraded if ash detected; set suspended matter type as ash	
Thin cirrus	Retrieval quality degraded if cirrus detected	



Comparison of VIIRS AOT to AERONET AOT showed that VIIRS AOT has a small positive bias over land but no obvious **major** issues with clouds.

- Comparison of global mean AOT maps of VIIRS and MODIS, however, did reveal a few issues with information from VCM:
 - Data artifacts (high AOTs) in the northern high latitudes due to snow/melting snow on the ground.

Mean AOT for February – May 2013



Issues Reported at VCM Provisional Review

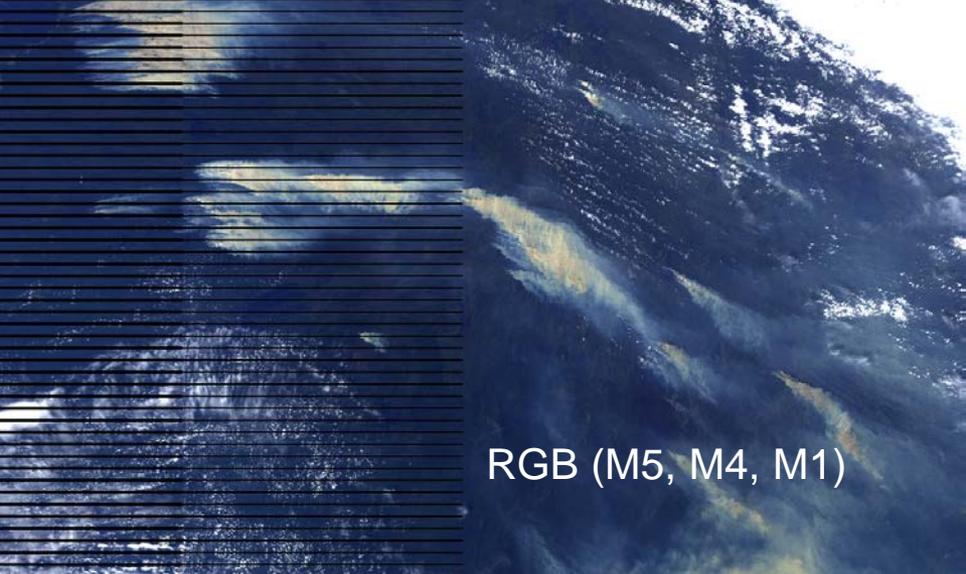
- Dust/cloud discrimination over land and ocean
- Data artifacts (high AOTs) due to snow/melting snow on ground not detected

Issues Reported at VCM Provisional Review

- Dust/cloud discrimination over land and ocean
 - No concrete solution identified
- Data artifacts (high AOTs) due to snow/melting snow on ground not detected
 - Aerosol team developed a new internal test based on spatial variability using M1 band to flag snow/cloud contaminated pixels.
 - NGAS also developed a new internal test based on I bands and improvements to NDSI.

VCM Issues Recently Identified

- Testing a modified version of the VIIRS Aerosol code which retrieves AOT up to 5 revealed three problems with the current VCM
 - Heavy smoke over land is not identified as heavy aerosol some times
 - Clouds detected by the M7 visible reflectance test over ocean (day) are not always classified as probably or confidently cloudy
 - The M1 reflectance test over desert and barren backgrounds is not fit to the proper function resulting in leakage and false detections under some viewing geometries
- These problems did not impact the current VIIRS Aerosol algorithm because most heavy smoke plumes and undetected clouds have a retrieved AOT > 2 and are not reported



RGB (M5, M4, M1)

Heavy Smoke Over Land Granule d20130704 t1647572

In the IDPS version of VCM, heavy smoke was identified as confidently cloudy. Heavy aerosol flag was NOT set due to which no AOT retrieval.

Heavy Aerosol Flag from updated VCM
(ADL testing by NGAS)

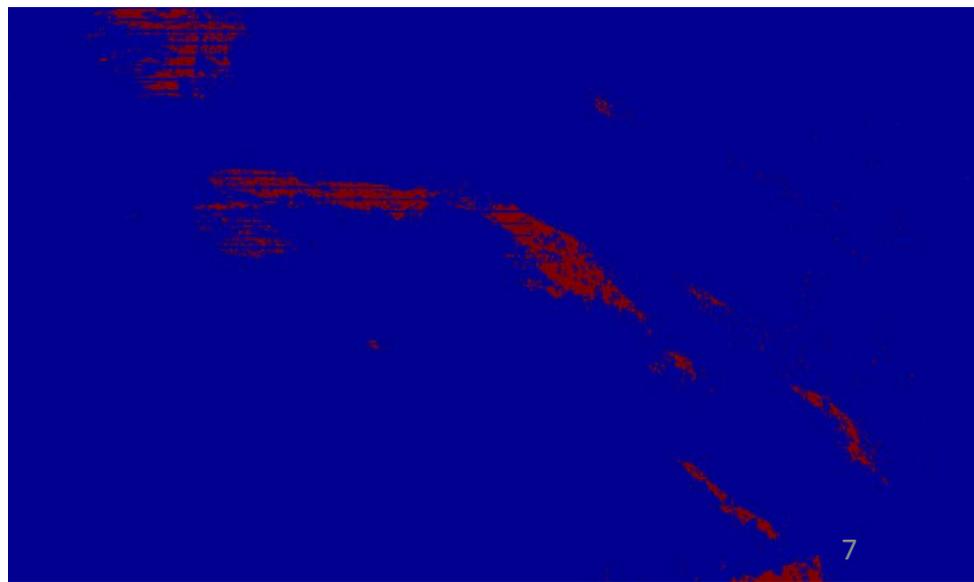
$$M1 < 0.4$$

$$M1/M5 < 0.9 \text{ and } M7 < 0.15 \text{ and } M11 < 0.1$$

$$M7/M5 < 0.9 \text{ and } M11/M5 < 0.45$$

$$M11 < 0.25 \text{ and } M11/M5 < 0.45$$

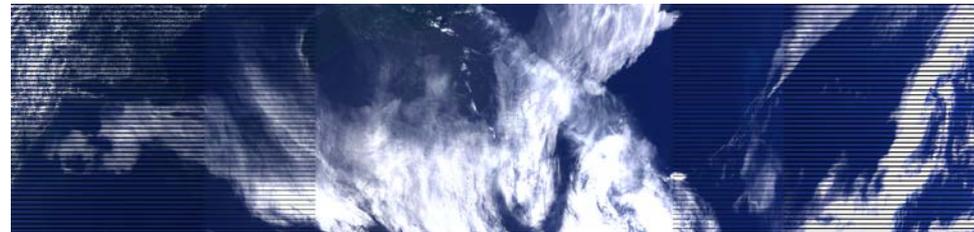
$$M7 < 0.45 \text{ and } M7/M5 < 0.95$$



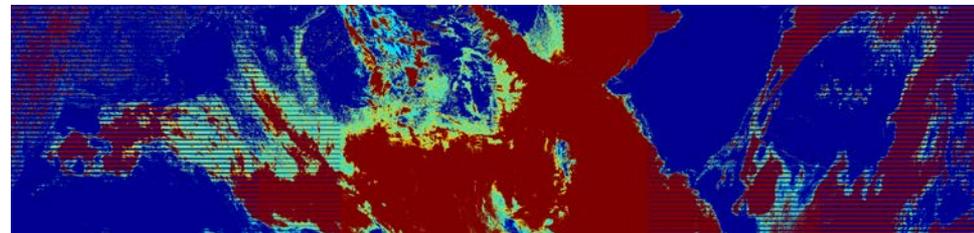
Cloud Confidence for Day / Ocean is Confidently Clear Despite Detection by the M7 Reflectance Test

Day time clouds over Ocean are some times set to confidently clear because thermal IR tests are not catching these low level clouds that do not have a large thermal contrast. Recommend the use of M7 reflectance test for low-level water clouds over Ocean.

RGB

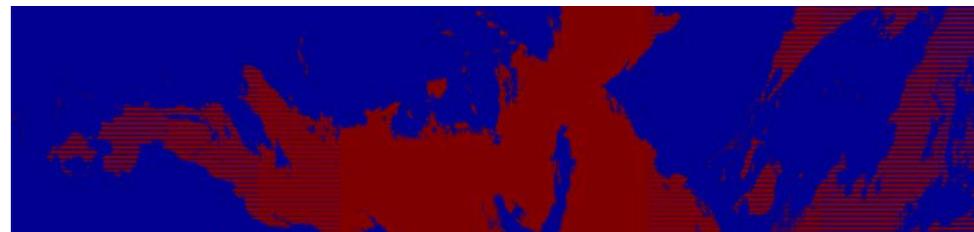


Cloud confidence

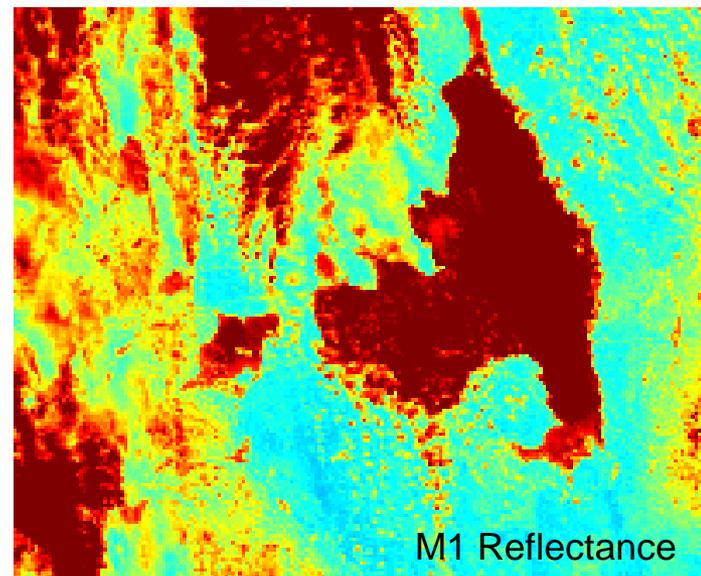
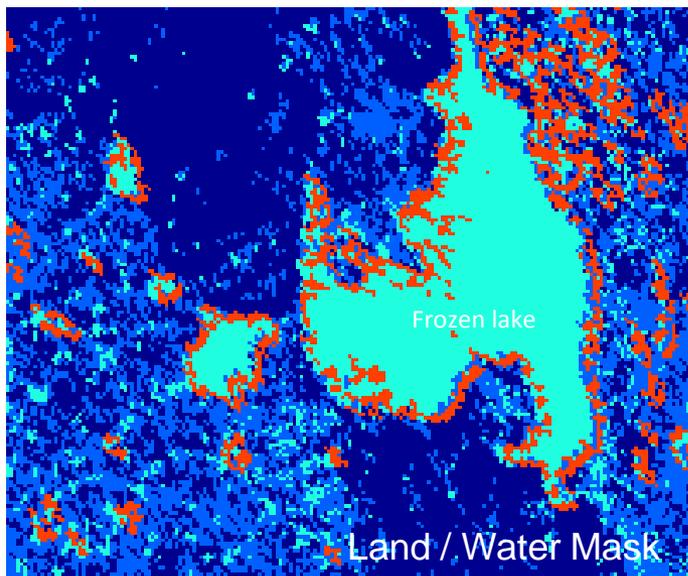
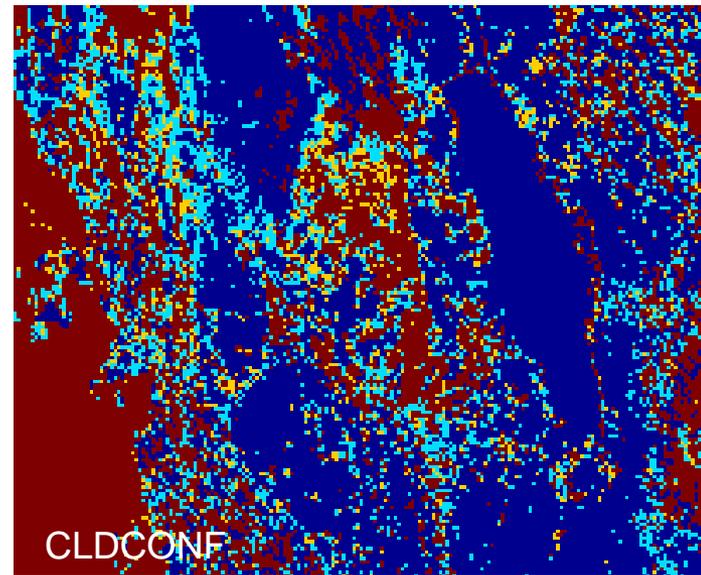
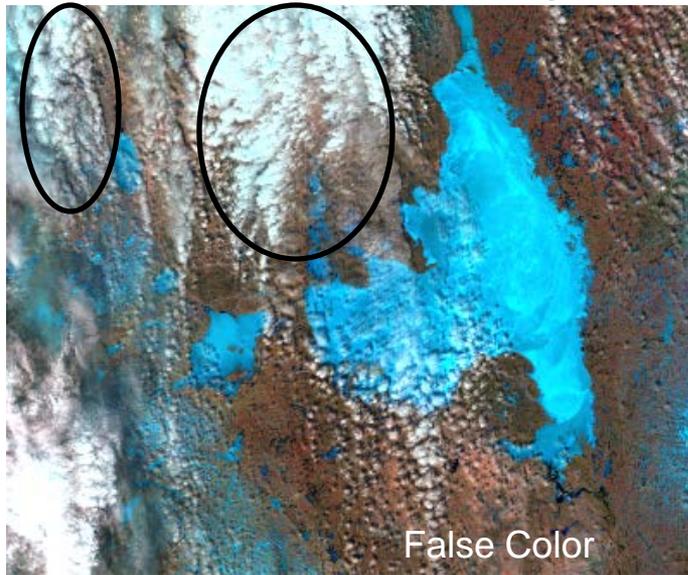


Ccloud Pcloud Pclear Cclear

M7 reflectance test



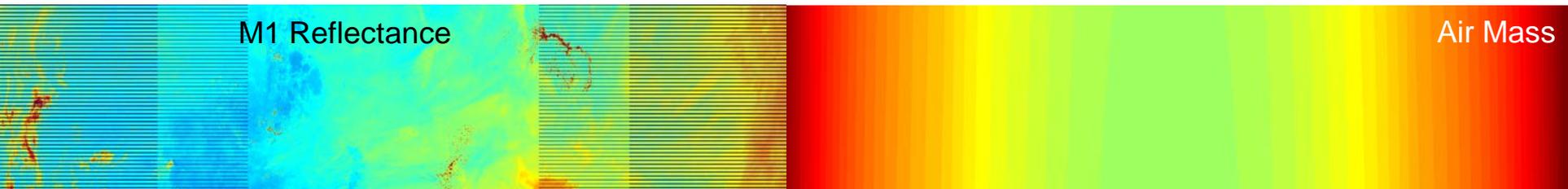
M1 Reflectance Test Day / Desert Fails to Detect Obvious Optically Thick Water Clouds



M1 Reflectance Test Day / Desert is a Function of Scattering Angle Rather than Air Mass Resulting in False Alarms



False Alarms at edge of scan are the result of the M1 reflectance threshold being a function of scattering angle rather than air mass.

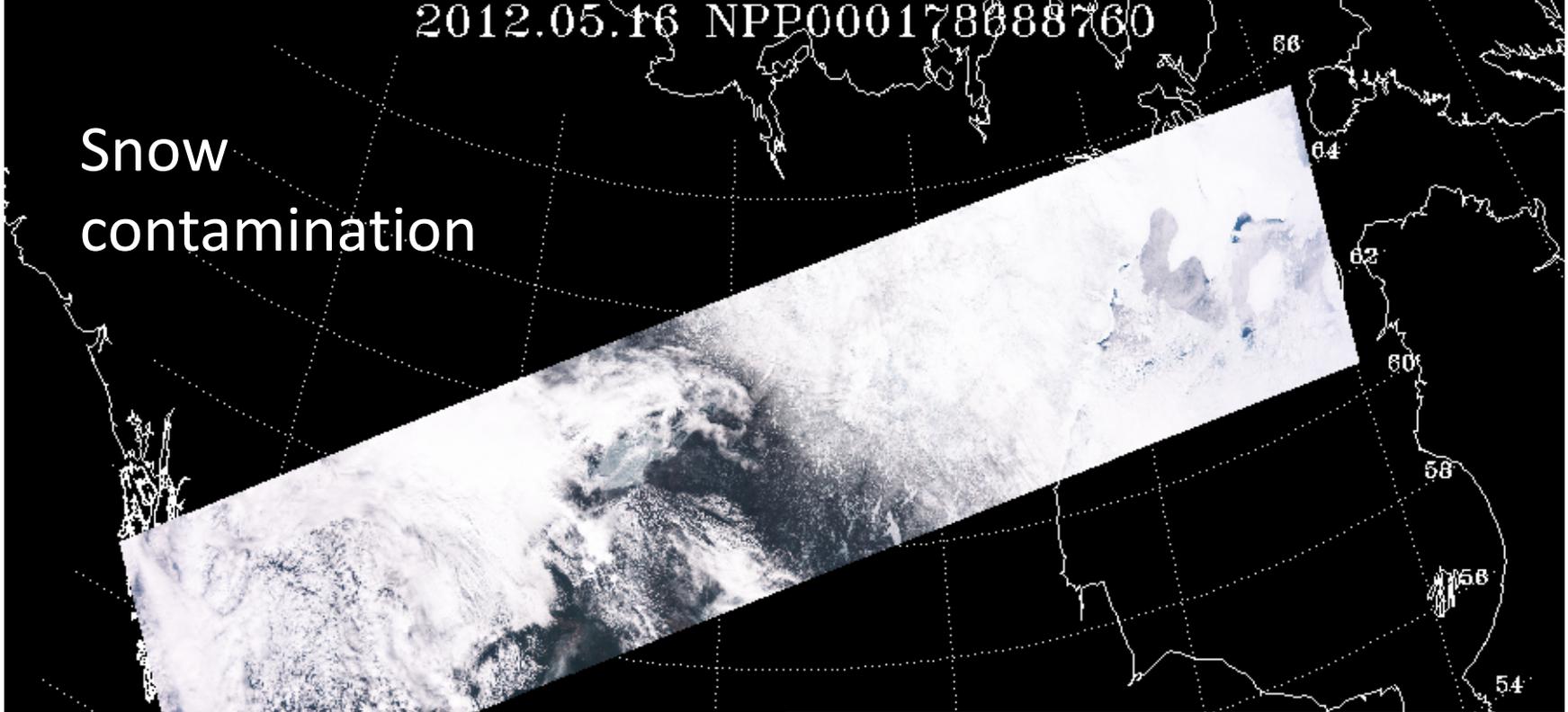


Potential Solutions

- Heavy smoke over land
 - Alternate algorithm currently being run in an ADL version of the code
 - Requires additional testing to verify that the amount of clouds misidentified as heavy smoke is acceptable
- Cloud confidence set to Confidently Clear for Day / Ocean despite detection by M7 reflectance test
 - Change logic in VCM so that cloud confidence is a least probably cloudy when a single test positively identifies a pixel as cloudy
- Leakage and false alarms over Day / Desert result from incorrect functional for the M1 reflectance test
 - Change functional form of threshold from scattering angle to air mass

2012.05.16 NPP000178688760

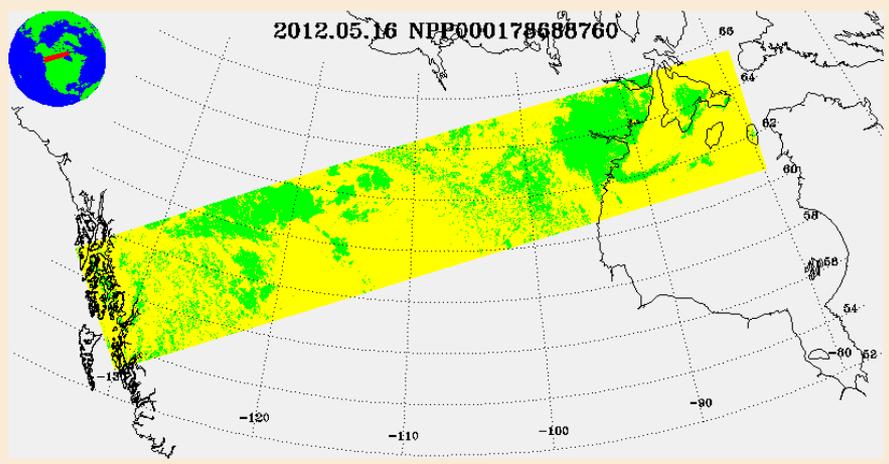
Snow contamination



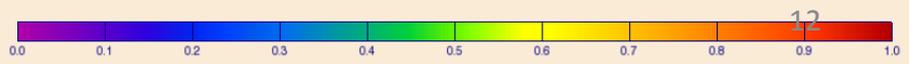
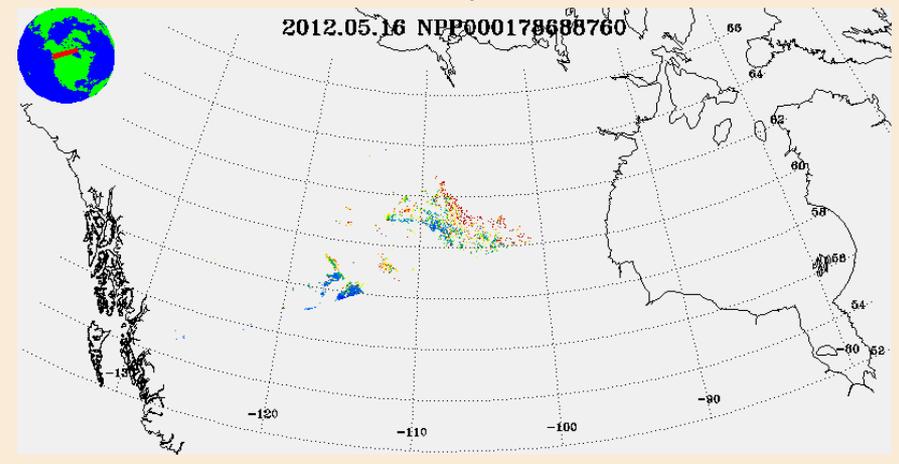
VAOT_npp_d20120516_t1934363_e1936004_b02856_c20120516220101493799_noaa_ops.h5

VAOT_npp_d20120516_t1934363_e1936004_b02856_c20120516220101493799_noaa_ops.h5

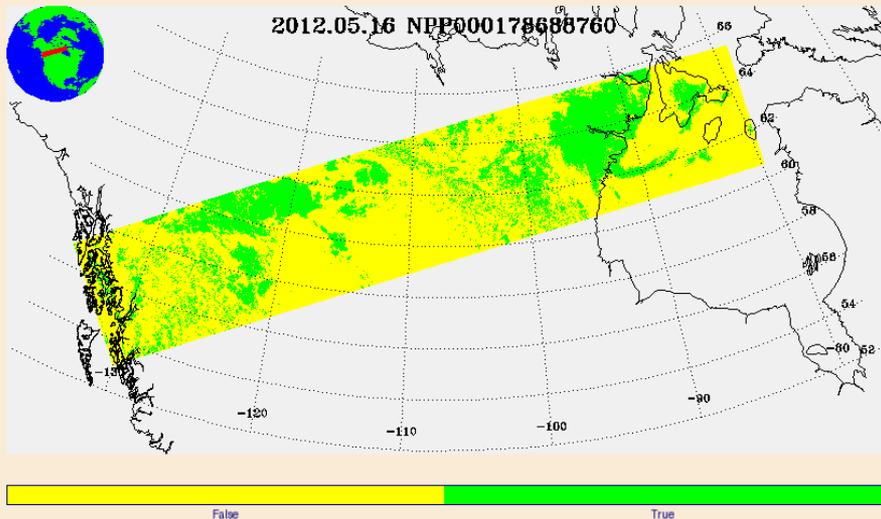
IP Snow/Ice



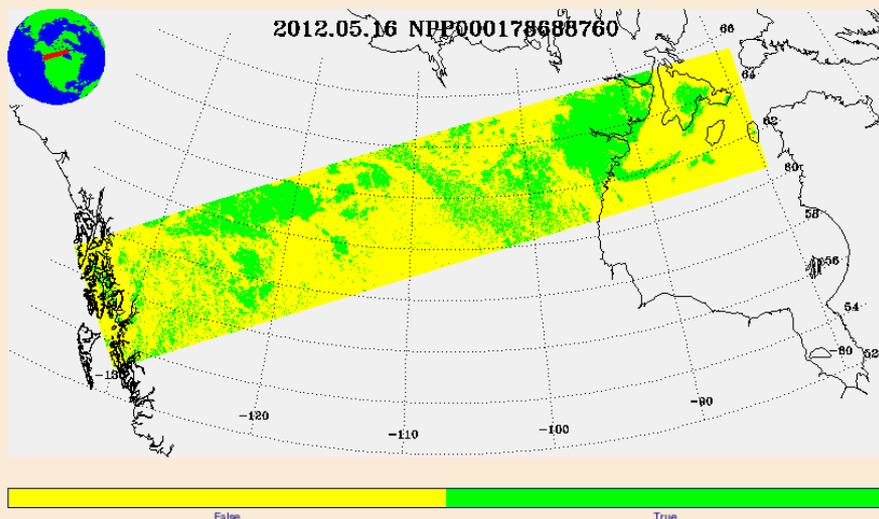
Aerosol Optical Thickness (IP) at 550nm
IP AOT Quality=Good



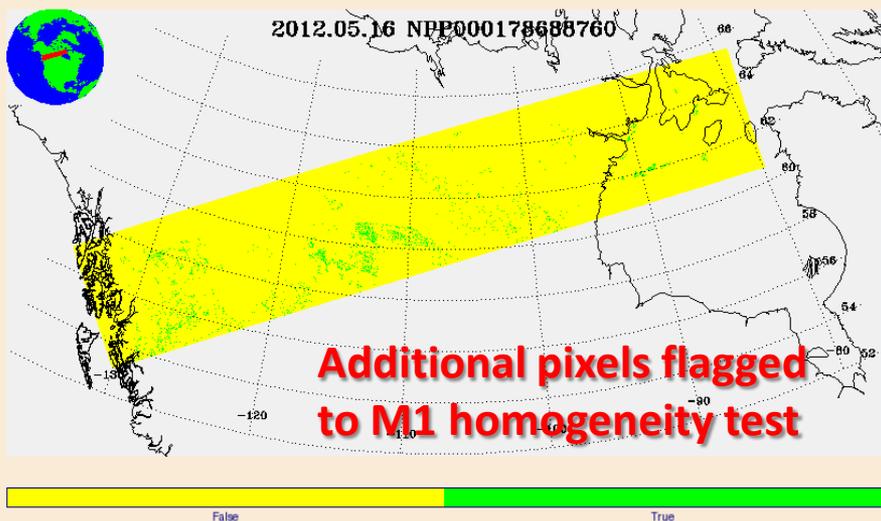
IP Snow/Ice



IP Snow/Ice



IP Homogeneity Test

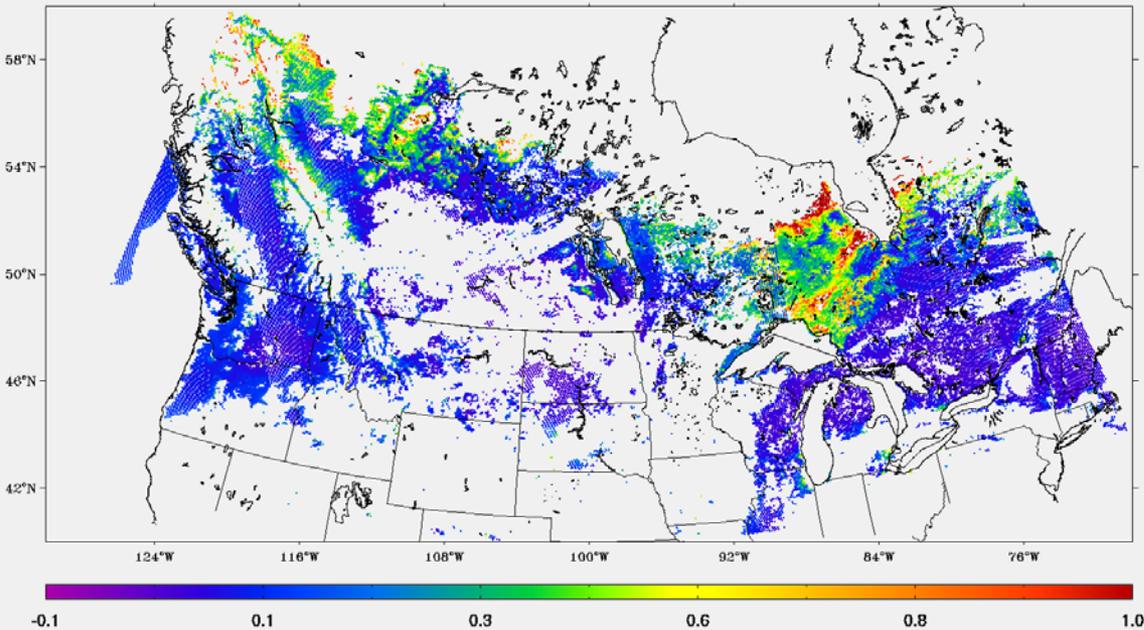


$$\frac{(\rho_{M7} - \rho_{M8})}{(\rho_{M7} + \rho_{M8})} > 0.01$$

$$BT_{M15} < 285K$$

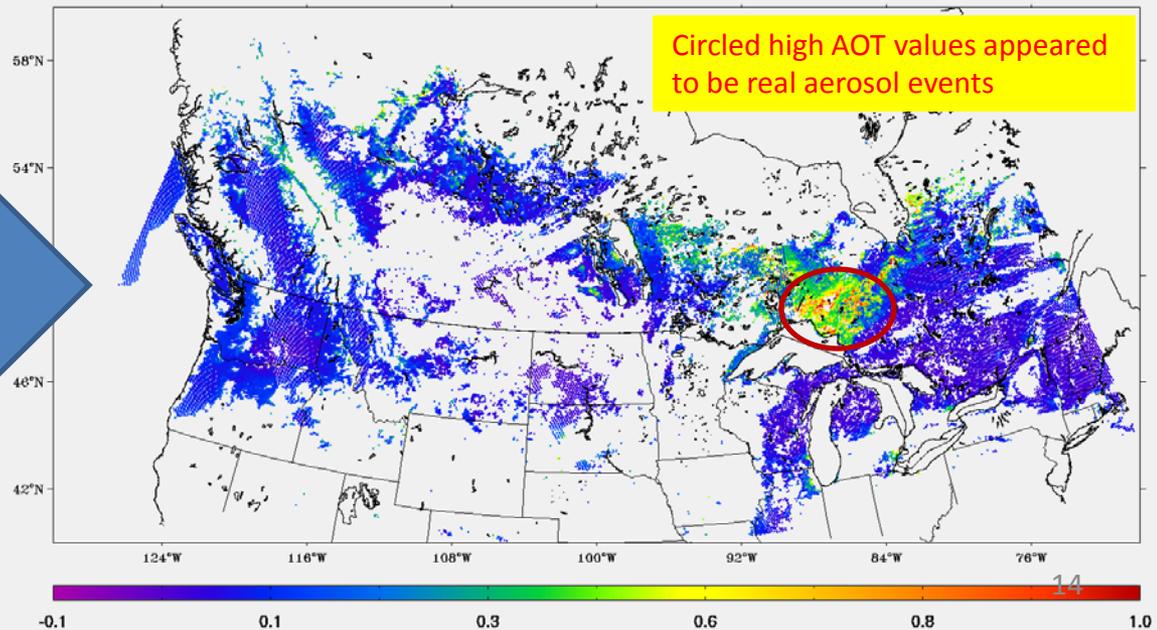
$$\sigma_{M1} < 0.05$$

20130507 Best QF AOD 550nm



Best QF AOD
from the
Baseline Run
with VIIRS
snow test

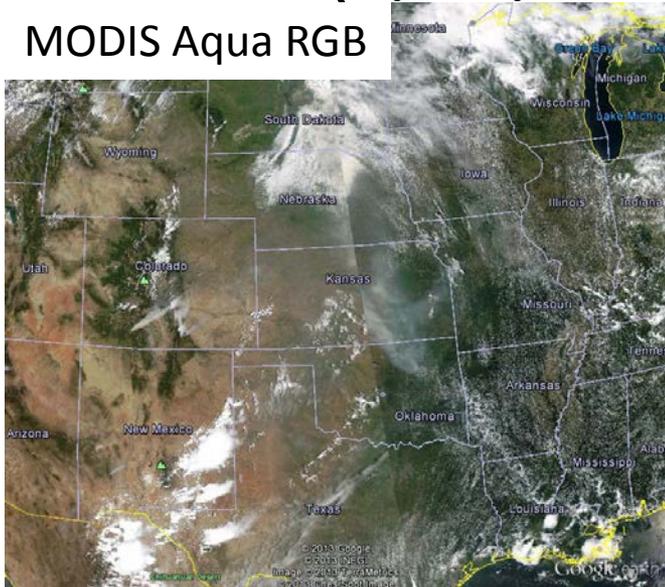
20130507 Best QF AOD 550nm



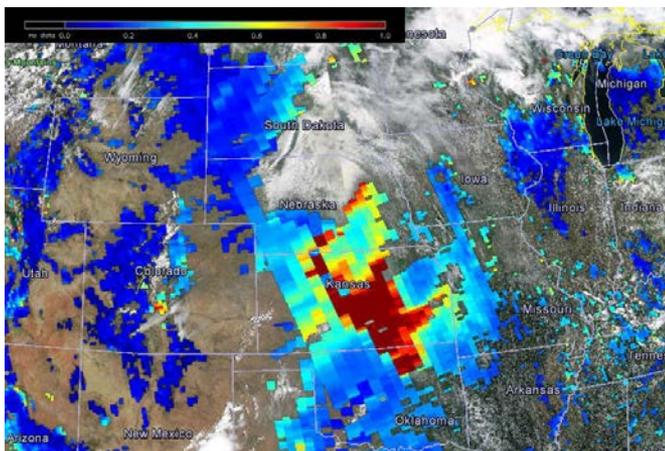
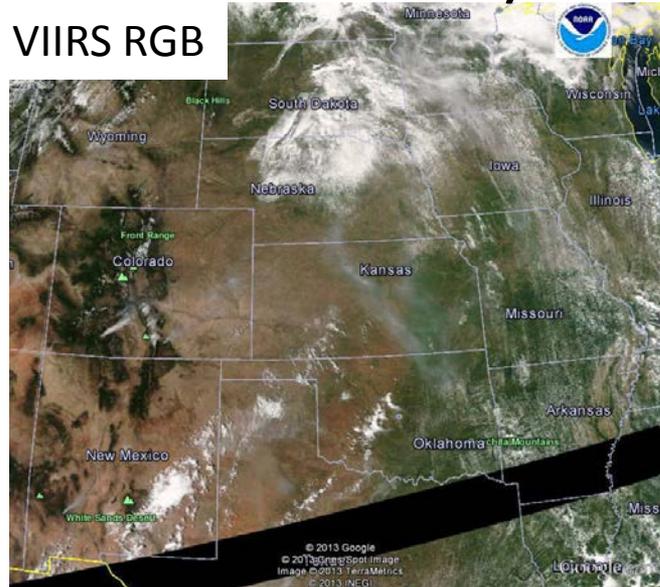
Best QF AOD
from the run
with MODIS
snow test and
M1 spatial filter

Smoke over land identified as cirrus cloud (6/20/2013 Kansas smoke case)

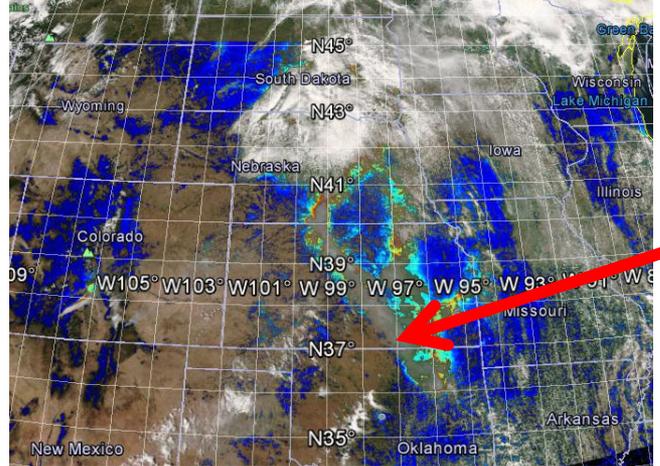
MODIS Aqua RGB



VIIRS RGB



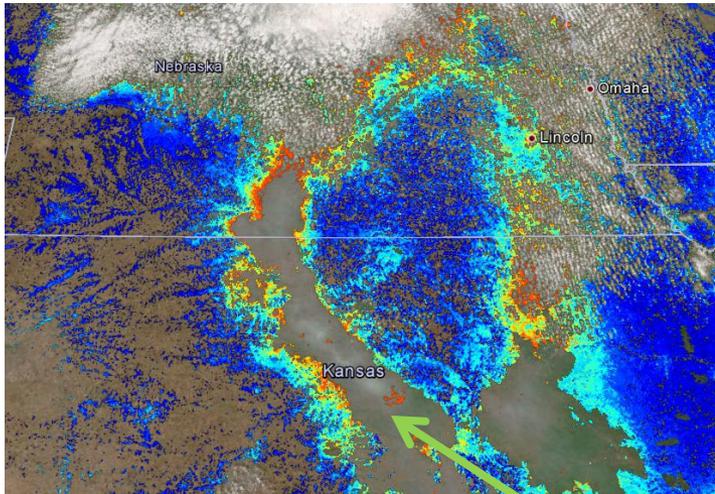
MODIS Aqua RGB & AOT



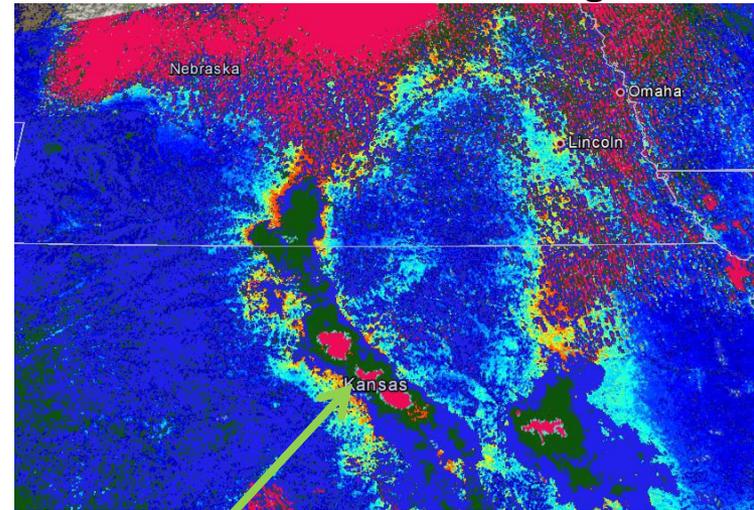
VIIRS RGB & IP AOT



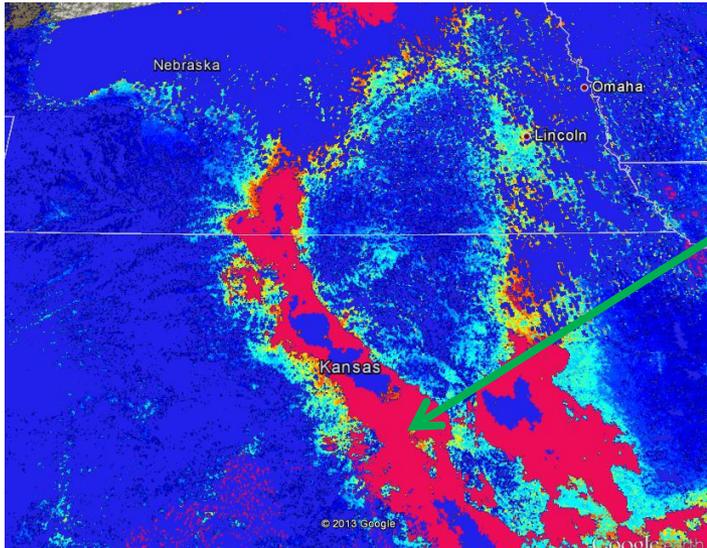
VIIRS IP AOT high quality with RGB background



with cloud mask background



VCM cirrus flag

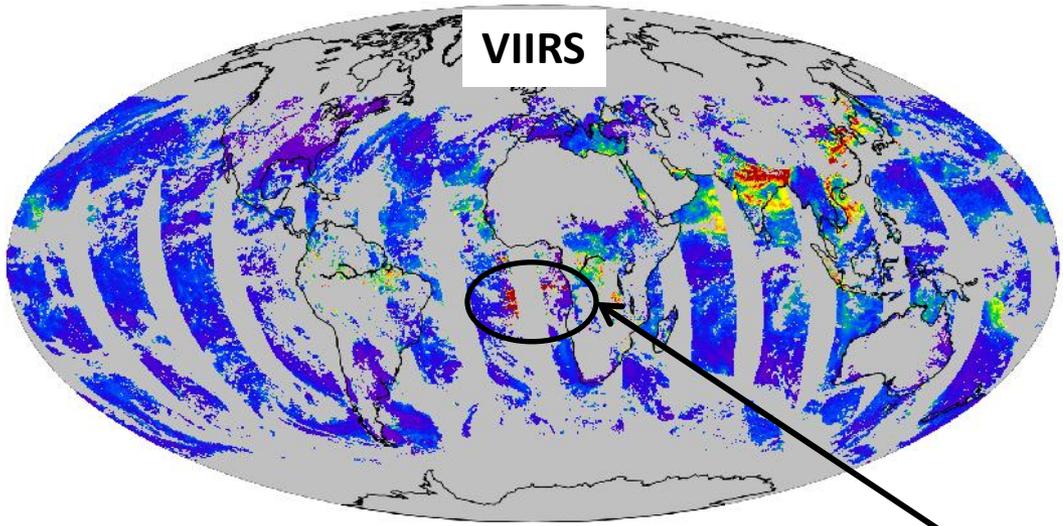


These areas do not have high quality IP AOT retrievals because the pixels are set as cirrus cloud in VCM

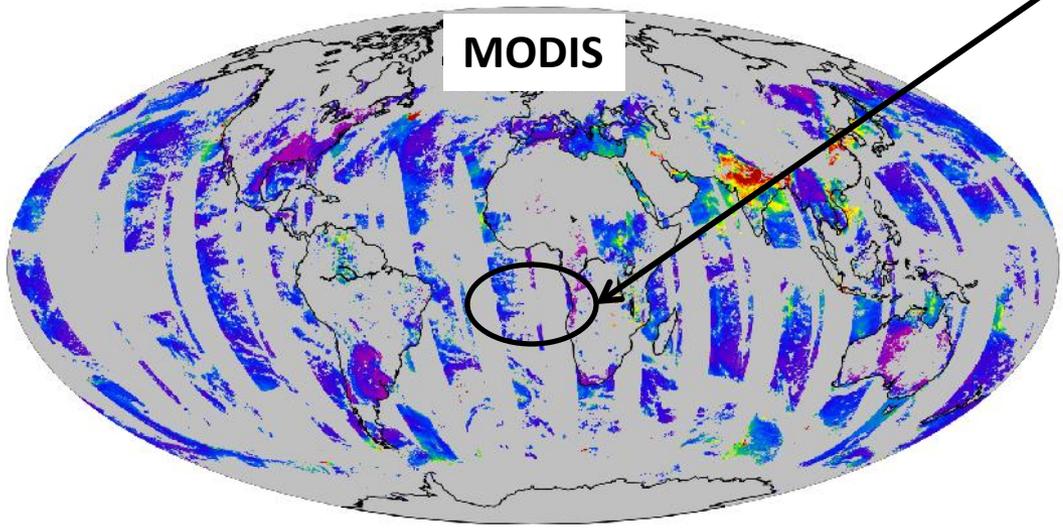
Concluding Remarks

- Cloud mask in general appears to perform well. But some cloud leakage and cloud contamination in aerosol product exists.
- Solutions for some problems reported here are in development/testing phase **by the aerosol team**. We have to ensure that these fixes do not deteriorate the product in other places.
 - As these tests mature, aerosol team will submit (if not submitted already) a DR and propose the changes.
- **Tuning out volcanic ash test (as of November 2, 2012) by VCM has impacted the Suspended Matter product.**
- **Aerosol team has not looked at a few other variables such as cloud shadows and ephemeral water to make a statement.**
- **Solar eclipse related issue identified (presented in the next set of slides).**

VIIRS & MODIS/AQUA AOT

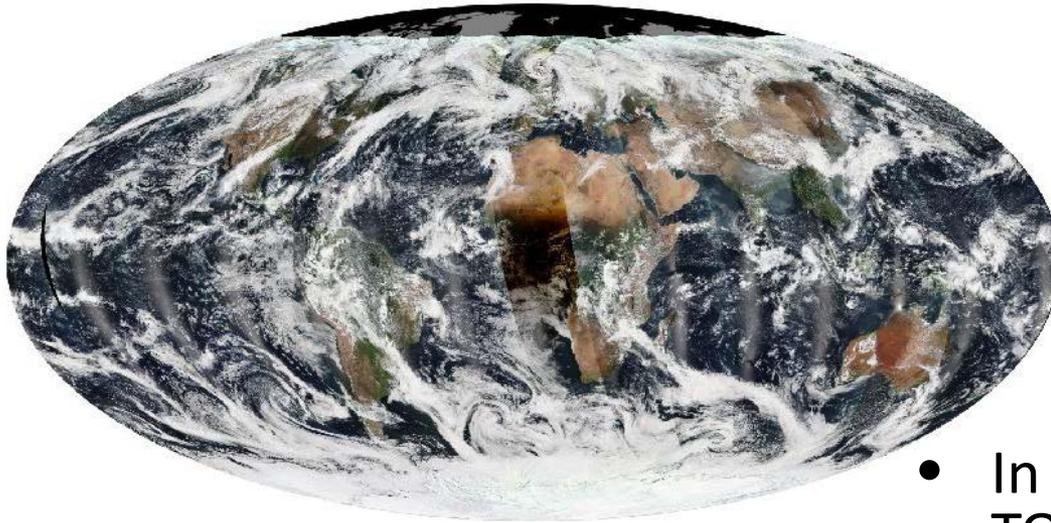


- Nov 3, 2013



- High AOT present in VIIRS is absent in MODIS/AQUA

Solar eclipse, Nov 3, 2013



VIIRS RGB (True Color) 2013-11-03

R : M05 (0.672 μm); G : M04 (0.555 μm); B : M03 (0.488 μm)

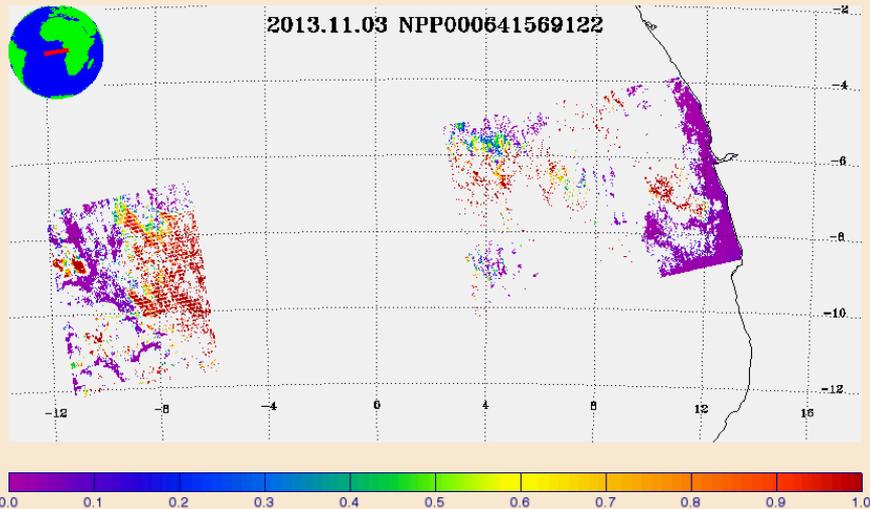


Solar eclipse
11/03/2013
13:22 UTC

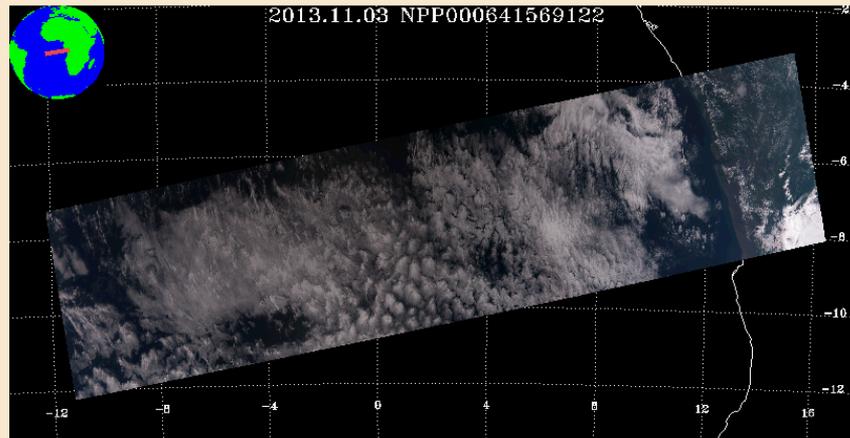
$$\rho = \frac{\pi L}{\mu_0 E_0 \left(\frac{d_0}{d} \right)^2}$$

- In eclipse, radiance, L and TOA irradiance, E_0 are reduced.
- But, conversion from radiance to reflectance, ρ still assumes E_0 is unchanged, so
- ρ is smaller than it actually is.
- Retrieved AOT is expected to be smaller than it actually is.
- But, AOT in VIIRS filed is high, not small!?

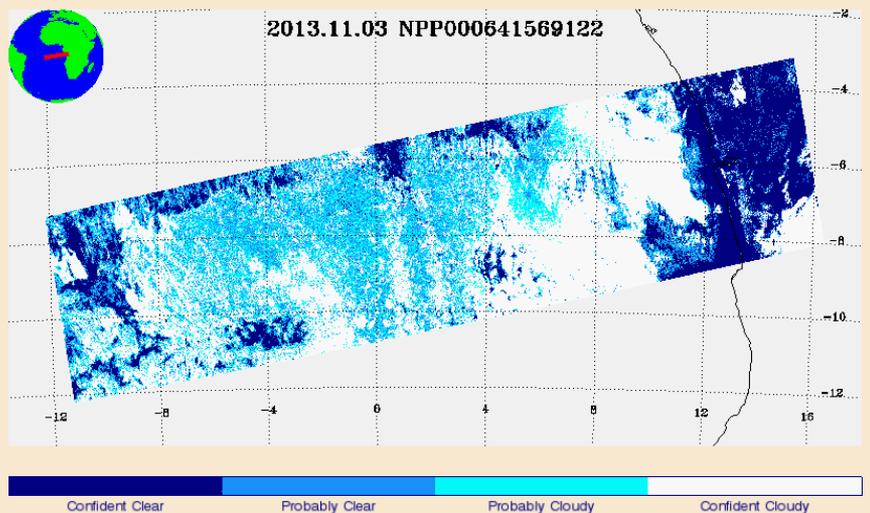
Aerosol Optical Thickness (IP) at 550nm
IP AOT Quality=Good



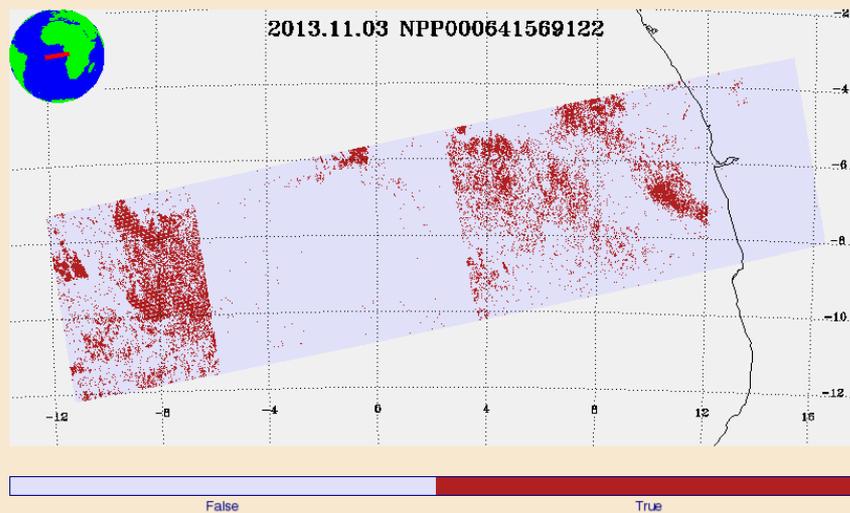
RGB Image [R=M5 (672 nm), G=M4 (551 nm), B=M3 (488 nm)]



VCM Cloud Detection Confidence

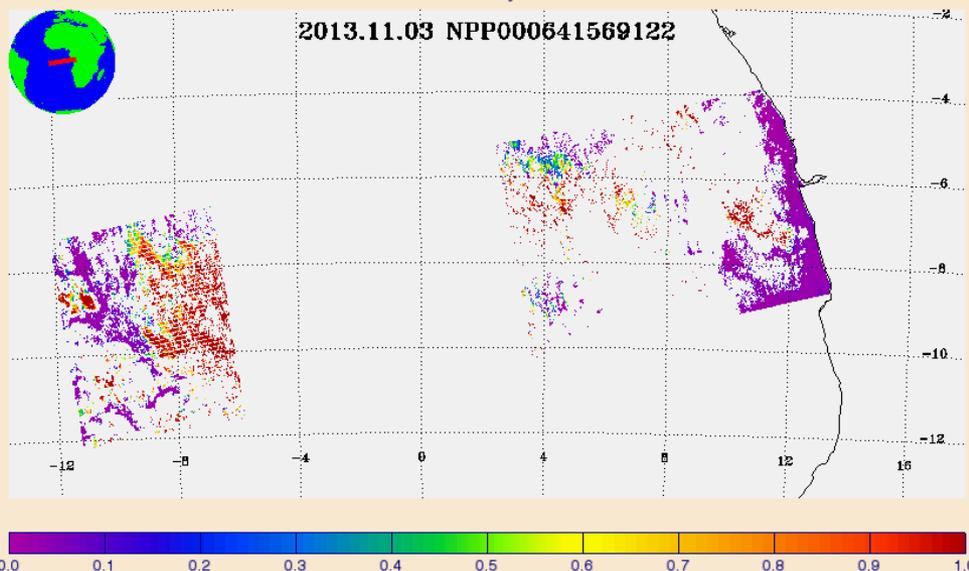


CM IP Heavy Aerosol

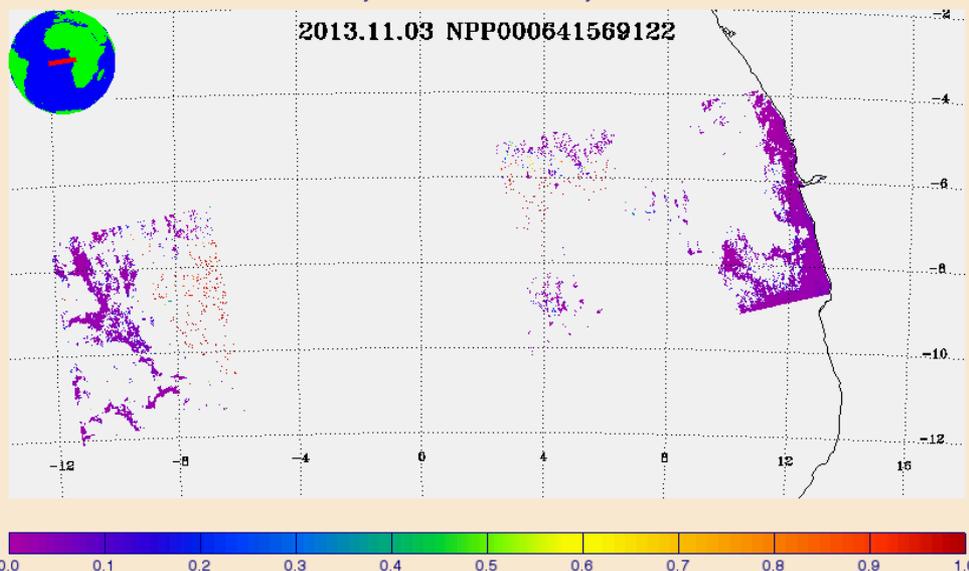


Area with high VIIRS AOT appears to be cloudy, but VCM Heavy Aerosol flag is on, so AOT retrieval is performed.

Aerosol Optical Thickness (IP) at 550nm
IP AOT Quality=Good



Aerosol Optical Thickness (IP) at 550nm
IP AOT Quality=Good -AND- VCM Heavy Aerosol=False



- Excluding pixels with heavy aerosol eliminates much of high AOT.
- Options:
 - use eclipse flag to skip processing of affected pixels;
 - correct reflectance of affected pixels.

Solar-eclipse-corrected reflectance

$$\rho_c = \frac{\pi L}{\mu_0(1-f)E_0\left(\frac{d_0}{d}\right)^2}$$

$$\rho_c = \frac{\rho}{(1-f)}$$

- Single pixel (Lat=9.13S; Lon=6.40W) example:
- VCM: cloudy, heavy aerosol, M5 reflectance test: clear
- **$\rho_{M5}=0.181$**
- Partial eclipse:
 - maximum at 13:16 UT
 - fraction of Sun covered by Moon, **$f=0.61$**
- **$\rho_{M5,c}=\rho_{M5}/(1-f)=0.464$**
 - May change heavy aerosol flag to *false* (?)