STAR Algorithm and Data Products (ADP) Beta Review

Suomi NPP Surface Reflectance IP ARP Product

Alexei Lyapustin

Surface Reflectance Cal-Val Team

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STAR ADP Surface Reflectance
ARP Team Member Goals

- Alexei Lyapustin (NASA GSFC)
  - SR IP Cal-Val Science Team Lead
- Yujie Wang (UMBC/JCET)
  - Product validation and analysis
- Eric Vermote (UMD/Geography)
  - MODIS heritage algorithm; VCM liaison

Background of Surface Reflectance IP

- Represents **continuity** with NASA EOS **MODIS** and NOAA POES **AVHRR** surface reflectance products
- SR IP is the basis for various VIIRS EDRs including vegetation index, snow/ice products and others. Based on extensive MODIS user base, this product would be used by **real-time resource and disaster management; ecosystem monitoring; climate studies** etc. provided its elevation to the status of EDR (the motion is underway).

Proposed L1RD Requirements (for SR EDR)

Surface Reflectance		
ATTRIBUTE	**THRESHOLD**	**OBJECTIVE**
a. Horizontal Cell Size		
1. Nadir	0.8 km (Radiometric)/0.4km (Imagery)	0.25 km
2. Worst case	1.6 km (Radiometric)/0.8km (Imagery)	0.5 km
b. Horizontal Reporting Interval	HCS	
c. Horizontal Coverage	Global Land	Global
d. Mapping Uncertainty, 3 sigma	Pixel Geolocation Uncertainty	
e. Measurement Range	0 to 1 (can be >1 over snow at certain angles)	0 to 1.0
f. Measurement Uncertainty	0.005+0.05 ρ	0.003+0.03 ρ
g. Refresh	At least 90% coverage of the globe every 24 hours (monthly average)	N/A
h. Latency	NA	NA

Currently, SR has status of the Intermediate Product (IP). The work is underway, led by I. Csizar and J. Privette (NOAA), to change the status of SR to EDR.

Current SR IP was designed to satisfy derived requirements from the downstream EDRs. The proposed L1RD requirement table is compliant with the derived requirements.

Overview of Surface Reflectance ARP

- Removal of Atmospheric Scattering and Absorption Effects in cloud-free daytime conditions in VIIRS VIS-SWIR bands
  - The algorithm is based on a heritage MODIS C5 atmospheric correction algorithm
  - Ancillary Data: VCM; aerosol properties (AOD and model); DEM; NCEP Ozone and WV; Land-Water Mask, Snow/Ice Mask;
  - Assumptions: Lambertian reflectance model; Aerosol Climatology over bright surfaces;
- Assumption for ARP validation is that the **VIIRS SDR is calibrated**.
  - Pre-beta and beta versions of SDR have been used to help **algorithm and instrument assessments** during EOC and the early stages of ICV
  - Team provided **feedback to SDR team** to assess the impact of the post-launch calibration degradation in the Red-NIR bands due to mirror coating problem

Evaluation Approaches

- Visual evaluation of SR IP in different world regions

  (analysis was conducted using data from both Land PEATE (NASA) and IDPS (NOAA). The results from both systems were found to be in agreement. As the quality of Surface Reflectance is a function of performance of the VIIRS Cloud Mask (CM) and aerosol algorithms, the joint analysis of the three products was conducted).

- Validation based on the AERONET-based Surface Reflectance Validation Network (ASRVN)

VIIRS SR IP Quality Flag (QF)

- Cloud Mask Quality
- Cloud detection & Confidence
- Day/night
- Low Sun Mask
- Sun glint
- Land/water back ground
- Cloud shadow mask
- Heavy aerosol mask
- Thin cirrus reflective
- Thin cirrus emissive
- M-band SDR data quality (band 1,2,3, 4,5,7,8,10,11)
- I-band SDR data quality (band 1,2,3)
- Overall AOT quality
- Missing AOT input data
- Missing AM input data
- Missing PW input data
- Missing OZ input data
- Missing SP input data
- Overall quality of M-band SR (band 1,2,3,4,5,7,8,10,11)
- Overall quality of I-band SR (band 1,2,3)

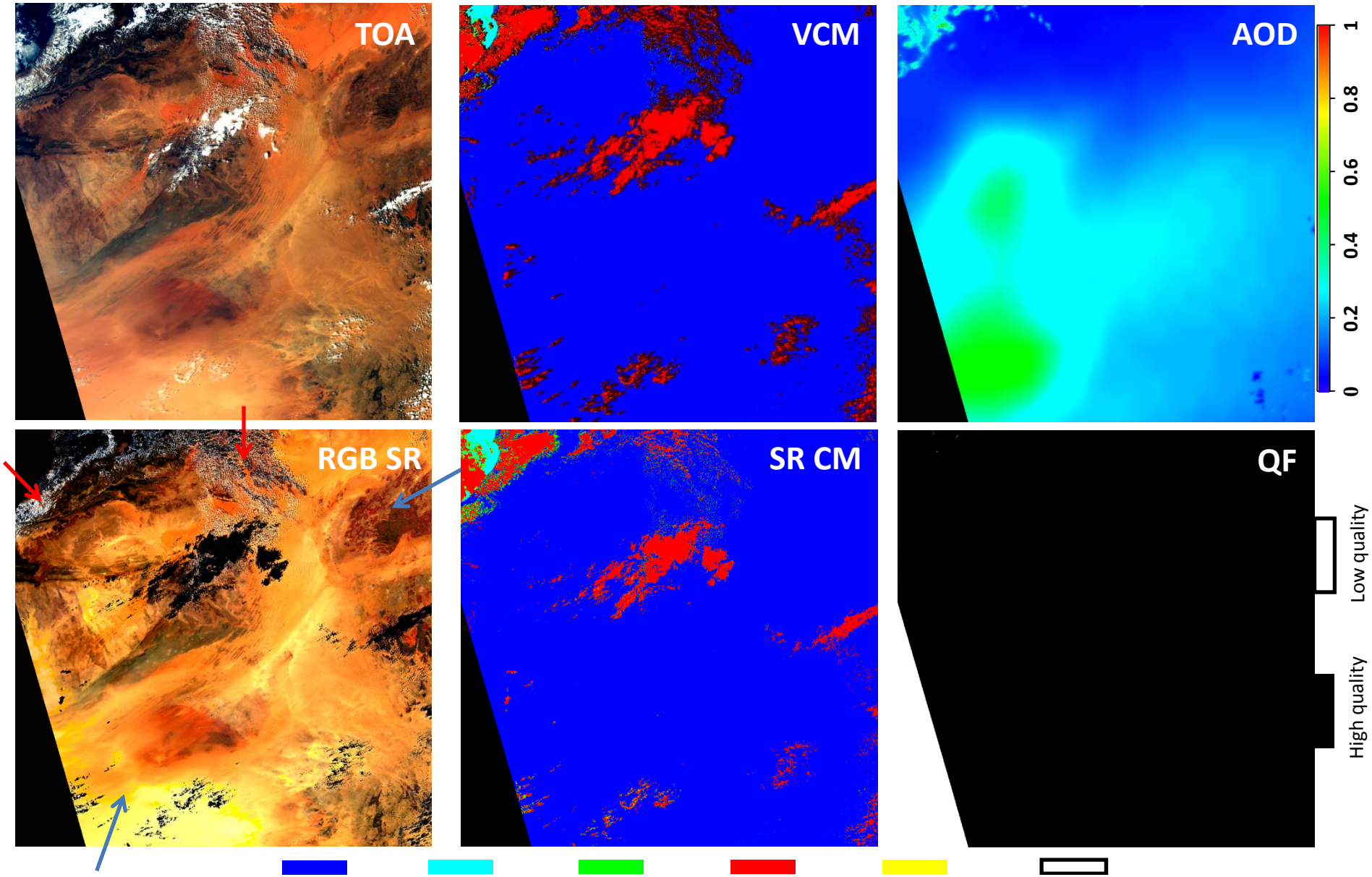
VIIRS SR IP Quality Flag Analysis

The general structure of QF is close to comprehensive and easy to follow. Two issues were found:

1. M-band and I-band QFs are coded together while being at a different resolution. This implies that QF is only provided at the M-band resolution, which should be stated upfront.

2. The "Overall quality of M/I-band SR" bit does not reflect the exclusion conditions. For instance, this bit has a "Good" value in areas with detected clouds (where SR is not produced) and under high aerosol level conditions. This is counter-intuitive to the common logic. We recommend to add the exclusion conditions into the "Overall quality of SR" bit, which then can be considered by the users as the "summary" quality flag.

Visual Analysis (West Sahara, DOY 270, 2012)



Found Issues

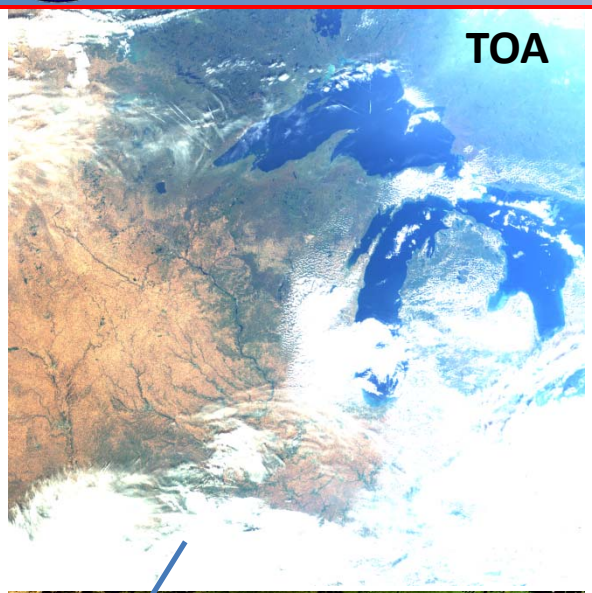
1. RGB SR image show areas of cloud leakage (red arrows) and color distortions (blue arrows).

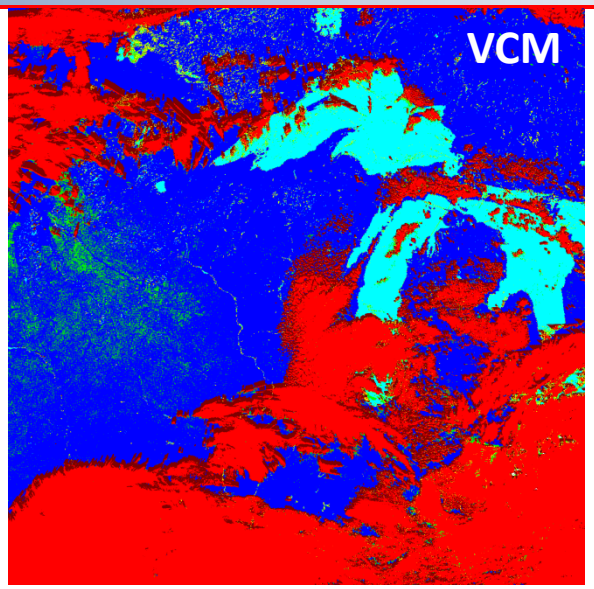
2. “Cloud leakage” is observed where SR CM (Cloud Confidence) disagrees with VCM (Cloud Confidence + Cirrus Flag). The Cirrus Flag combines “Cirrus” and “Brightness Temperature” tests, the latter detecting small and less bright clouds. Currently, the Cloud Confidence flag does not include Cirrus flag. We recommend to include Cirrus Flag into Cloud Confidence Flag which can then be considered as a “summary” VCM flag.

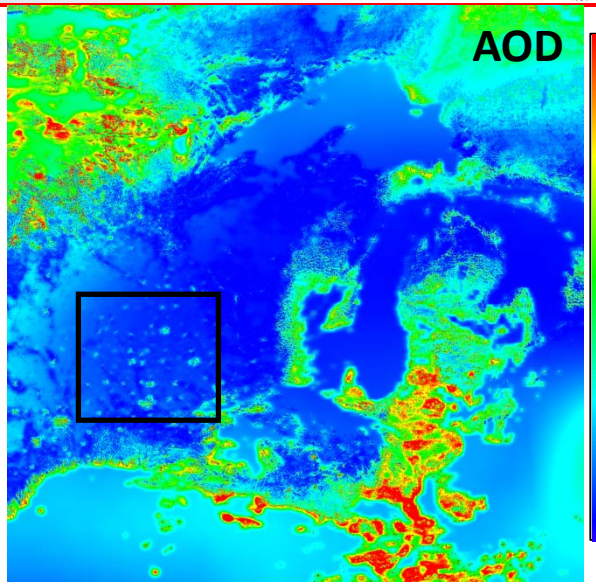
3. AOD is reported for the exclusion conditions (under clouds).

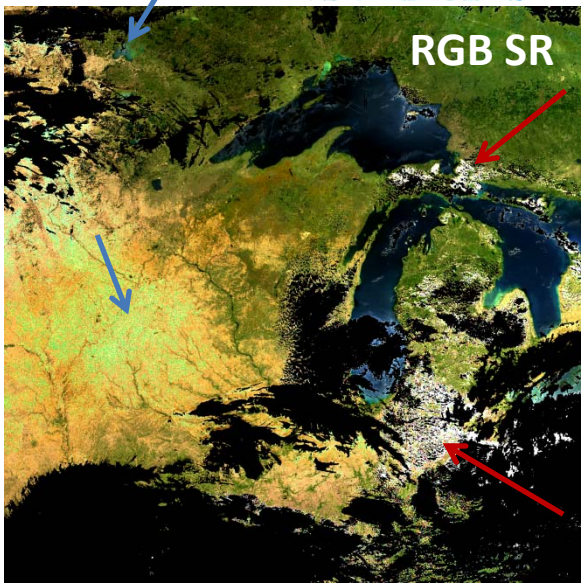
4. The “Overall quality SR” (QF) does NOT show exclusion conditions such as clouds. Over 99% pixels of the above image have a “Good” quality.

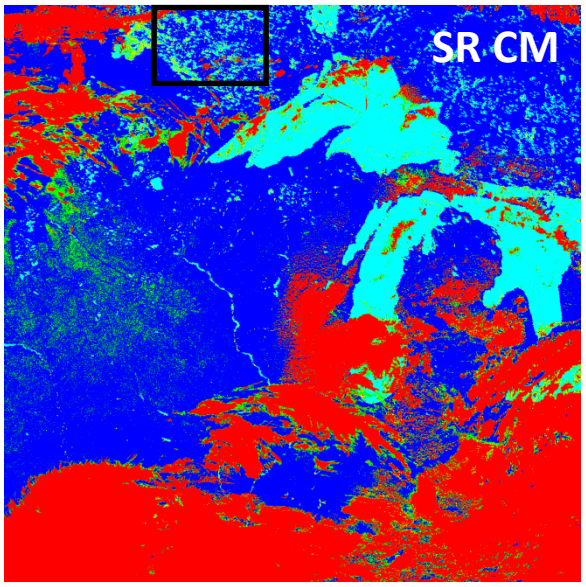
Great Lakes, DOY 274, 2012

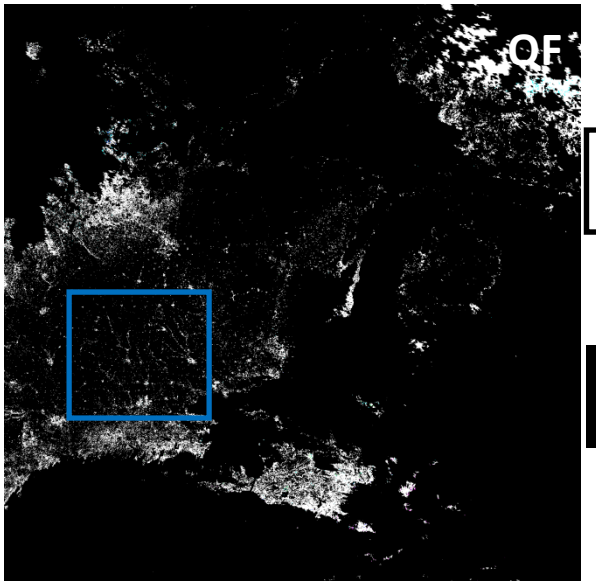












Clear over land | Clear over water | Possible clear | Confident clouds | Possible clouds | Clear over snow

Found Issues

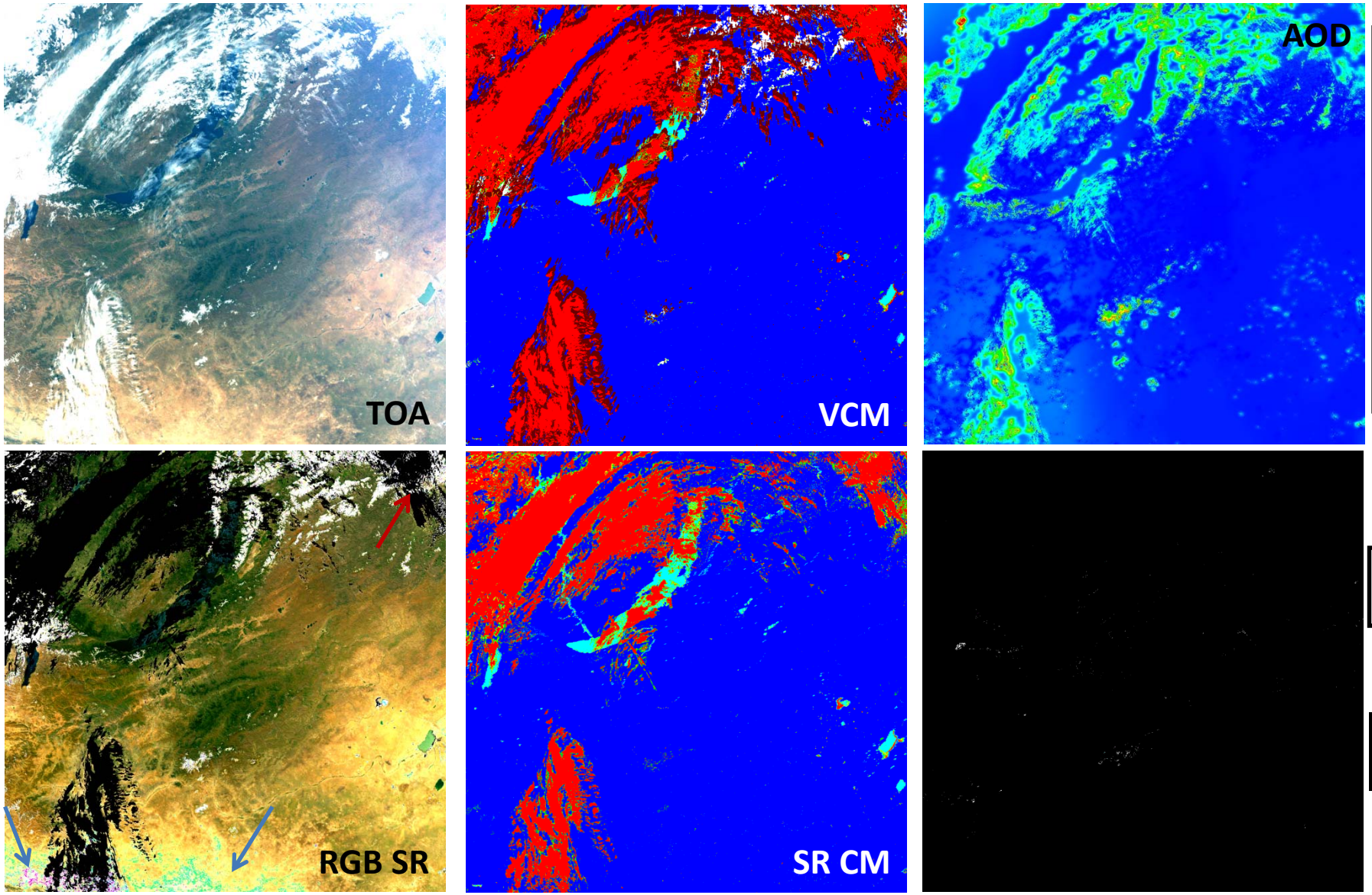
1-4. The same as above (slide 12).

5. The AOT image shows that AOT is correlated with the surface brightness. The region enclosed by the black rectangle shows relatively high AOT values over urban centers and major roads. This known deficiency of the aerosol retrieval algorithm is correctly masked in the QF (the same region marked by the blue rectangle).

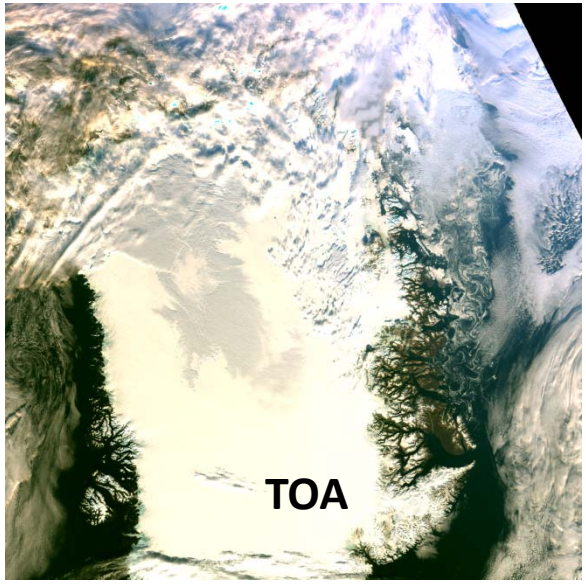
6. A new issue can be seen in the comparison of the SR CM and VCM. The black box shows that SR CM marks many more land pixels as water as compared to the VCM.

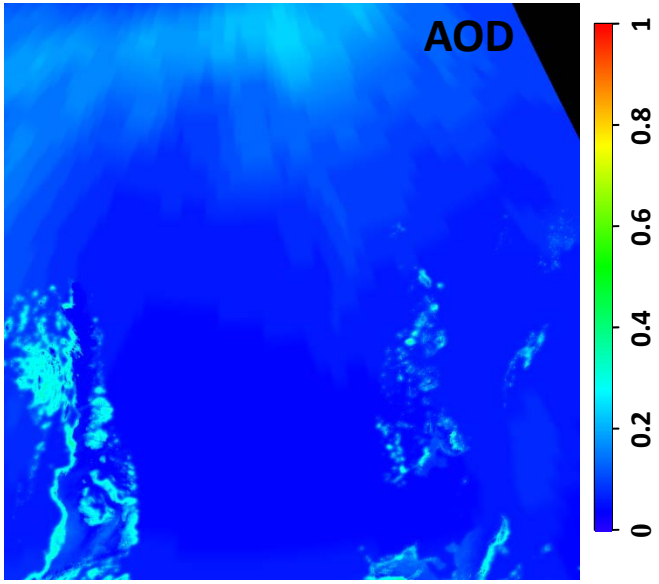
Issues (1-4) in the region of Lake Baikal and Greenland (next 2 slides).

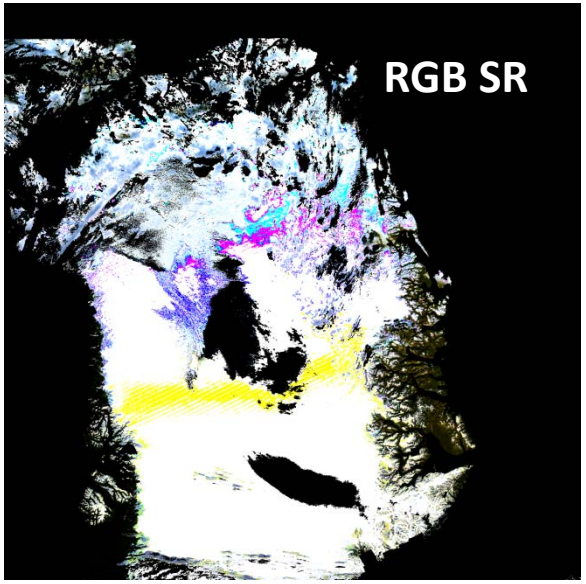
Lake Baikal, DOY 272, 2012

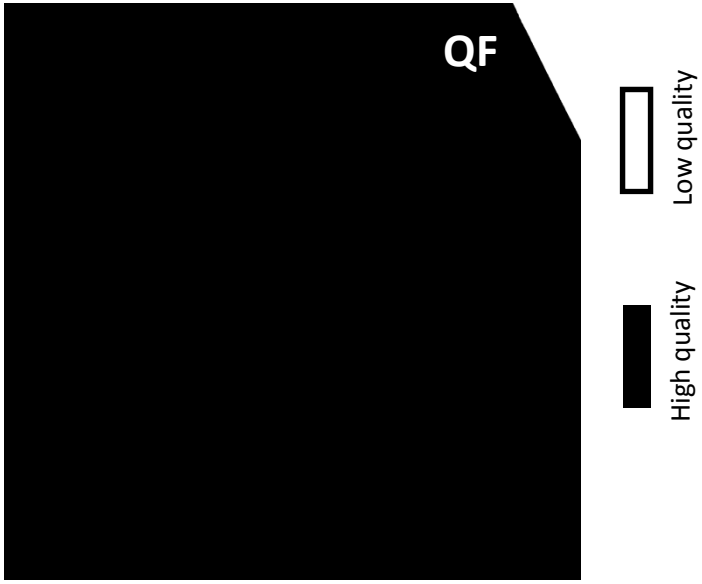


Greenland, DOY 270, 2012









Summary of Known Issues - Recommendations

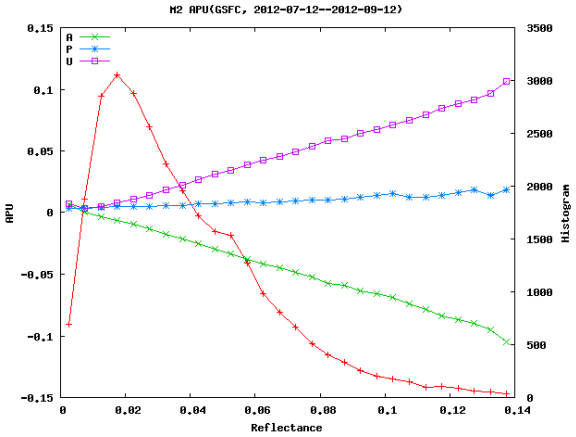
Recommendations (easy fixes leading to significant improvement of SR IP quality and convenience of QF)

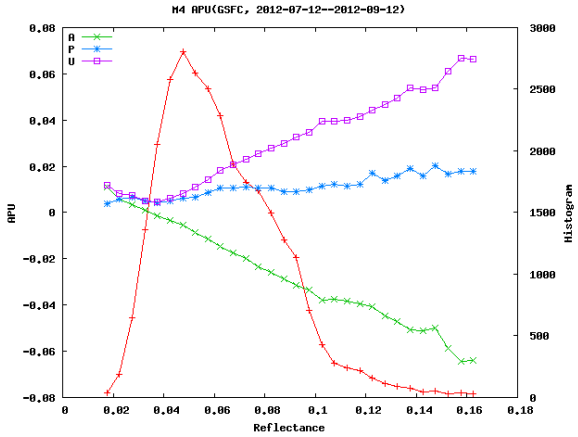
- Add exclusion conditions (e.g. clouds, high AOD) into the "Overall quality of SR" bit
- Include Cirrus Flag into Cloud Confidence Flag which can then be considered as a “summary” VCM flag

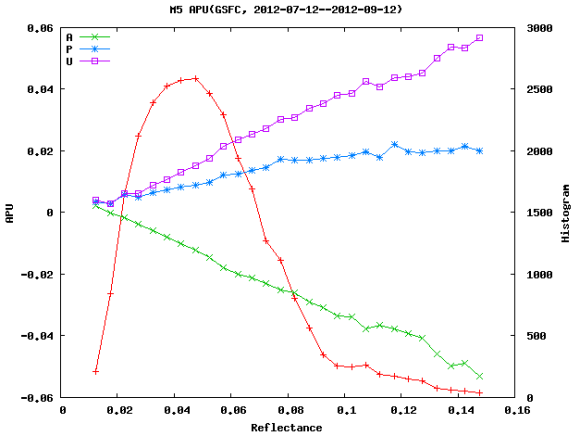
Other reported issues (e.g. spectral distortions) require further analysis of the atmospheric correction algorithm.

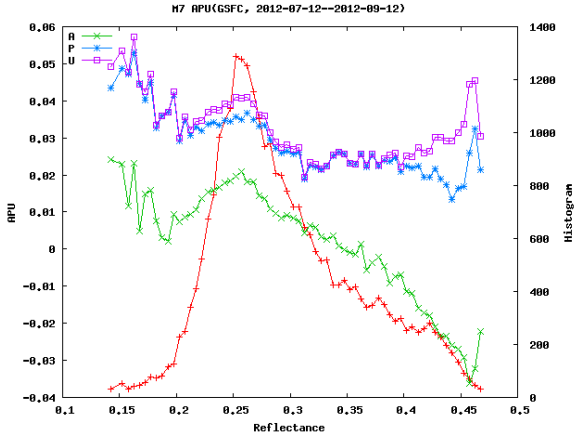
ASRVN Validation Analysis

An APU analysis of VIIRS SR was conducted for many AERONET sites for M1, M2, M4, M5, M7, M8, M10 and M11. Generally, VIIRS SR algorithm underestimates surface reflectance showing negative bias in visible bands. The bias is spectrally dependent, generally being largest in the blue band and reducing with wavelength. This result agrees with analysis of aerosol team which reported overestimation of AOD over land.









An example of APU plots in bands M2, M4, M5, M7 for the GSFC site.

ASRVN Summary Table

Table 1. Average surface reflectance and bias of VIIRS SR for selected sites with relatively low cloudiness and good AERONET record. The green color indicates a relatively good performance with the bias across all spectral bands below 0.01. The blue color indicates a marginal performance, and yellow color shows sites with poor performance (usually either bright surface or high AOD).

Site Name	M2		M4		M5		M7	
	Refl.	Bias	Refl.	Bias	Refl.	Bias	Refl.	Bias
GSFC	0.0377	-0.0257	0.0633	-0.0178	0.0531	-0.0193	0.2947	-0.0082
Railroad_Valley	0.1228	-0.0178	0.1831	-0.0153	0.2293	-0.0138	0.2734	-0.0102
KONZA_EDC	0.0387	-0.0042	0.0768	-0.0062	0.0836	-0.0068	0.3017	-0.014
Evora	0.058	-0.0044	0.1059	-0.0053	0.1569	-0.0065	0.3004	-0.0087
Ispra	0.0289	-0.0128	0.0552	-0.0088	0.0447	-0.0055	0.2974	-0.0055
Lille	0.0419	-0.0151	0.0809	-0.0105	0.0743	-0.0094	0.3553	-0.0012
UCSB	0.0416	-0.0071	0.0701	-0.0062	0.0838	-0.0051	0.2304	-0.0053
BONDVILLE	0.0268	-0.0097	0.0591	-0.0037	0.0517	-0.0051	0.348	0.0122
Alta_Floresta	0.0357	-0.0027	0.0784	-0.0045	0.0937	-0.0032	0.3208	-0.0076
Beijing	0.0577	-0.0321	0.0863	-0.0222	0.0857	-0.0218	0.255	-0.0091
CUIABA-MIRANDA	0.0325	0.0039	0.0687	0.0001	0.084	-0.0017	0.2537	-0.006
Hamburg	0.032	-0.0121	0.0711	-0.0109	0.0595	-0.0095	0.3447	-0.0068
TABLE_MOUNTAIN_CA	0.082	-0.0166	0.1233	-0.014	0.156	-0.0112	0.2502	-0.0083
Dakar	0.0789	-0.0279	0.1321	-0.0369	0.1473	-0.0277	0.3282	-0.0855
Banizoumbou	0.0657	0.0209	0.1735	-0.0054	0.2981	-0.0292	0.4666	-0.0494
XiangHe	0.039	-0.0186	0.0721	-0.0172	0.0615	-0.0108	0.326	-0.007

Beta Evaluation

Beta Definition	Artifacts (Deliverables)	Delivered Artifacts
Early release product:	N/A	N/A
Minimally validated:	Combined visual analysis of VCM, AOD and SR for >10 scenes (revealed several issues).	Examples of VIIRS analysis over Western Africa, USA, Siberia and Greenland included in this briefing
May still contain significant errors:	Narrative, listing and discussing found issues with correction recommendations.	Lack of exclusion conditions in QF; Cirrus Tests are not included in Cloud Confidence Flag. Illustration and narrative are provided.
Versioning not established until Beta establishes the baseline for this product:	Description of the development environment and algorithm used to generate the product validation materials.	Product validation materials are based on IDPS Mx5.3
Available to allow users to gain familiarity:	ADP STAR will request feedback from appropriate users for the product. The notification letter will include a Beta Maturity disclaimer.	SR IP
Product is not appropriate as the basis for quantitative scientific publications studies and applications:	Warning of potential non-reproducibility of results due to continuing calibration and code changes.	Disclaimer is included in separate CLASS "Readme" document.

Beta Considerations/Remaining Issues

- **Overall performance** of the Suomi NPP VIIRS SR IP is **good**
- Two recommendations to significantly improve SR data quality and QF "friendliness" are provided
- The main observed artifact of spectral distortions (usually over brighter surfaces and snow) will be further investigated and corrected.

Future Plans

- Near-term
  - January 2013
    - Conduct correlative analysis with MODIS spectral SR (MOD09)
    - Evaluation based on feedbacks from downstream EDRs (e.g. NDVI)
  - April 2013
    - Adapt science algorithm MAIAC for VIIRS and perform regional evaluation of SR with VCM/AOD analysis
    - With accumulation of VIIRS data, extend statistics of ASRVN analysis
- Mid- to long-term
  - Full evaluation of **updated science algorithm and code**
  - **Provisional status** by July 2013