JPSS Risk Reduction Suspended-mater Algorithm

Pubu Ciren[1] and Shobha Kondragunta[2]

[1]IMSG@NOAA [2]NOAA/NESDIS/STAR

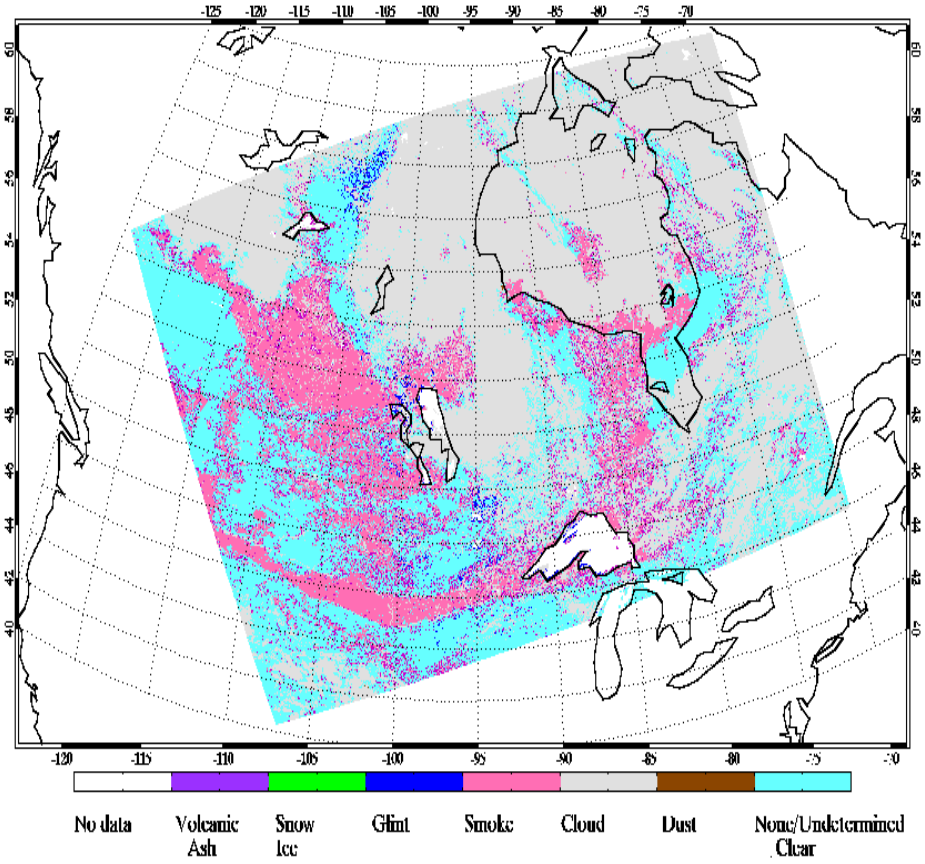
JPSS Annual Science meeting 2015
August 27, 2015

JPSS Risk Reduction SM Product

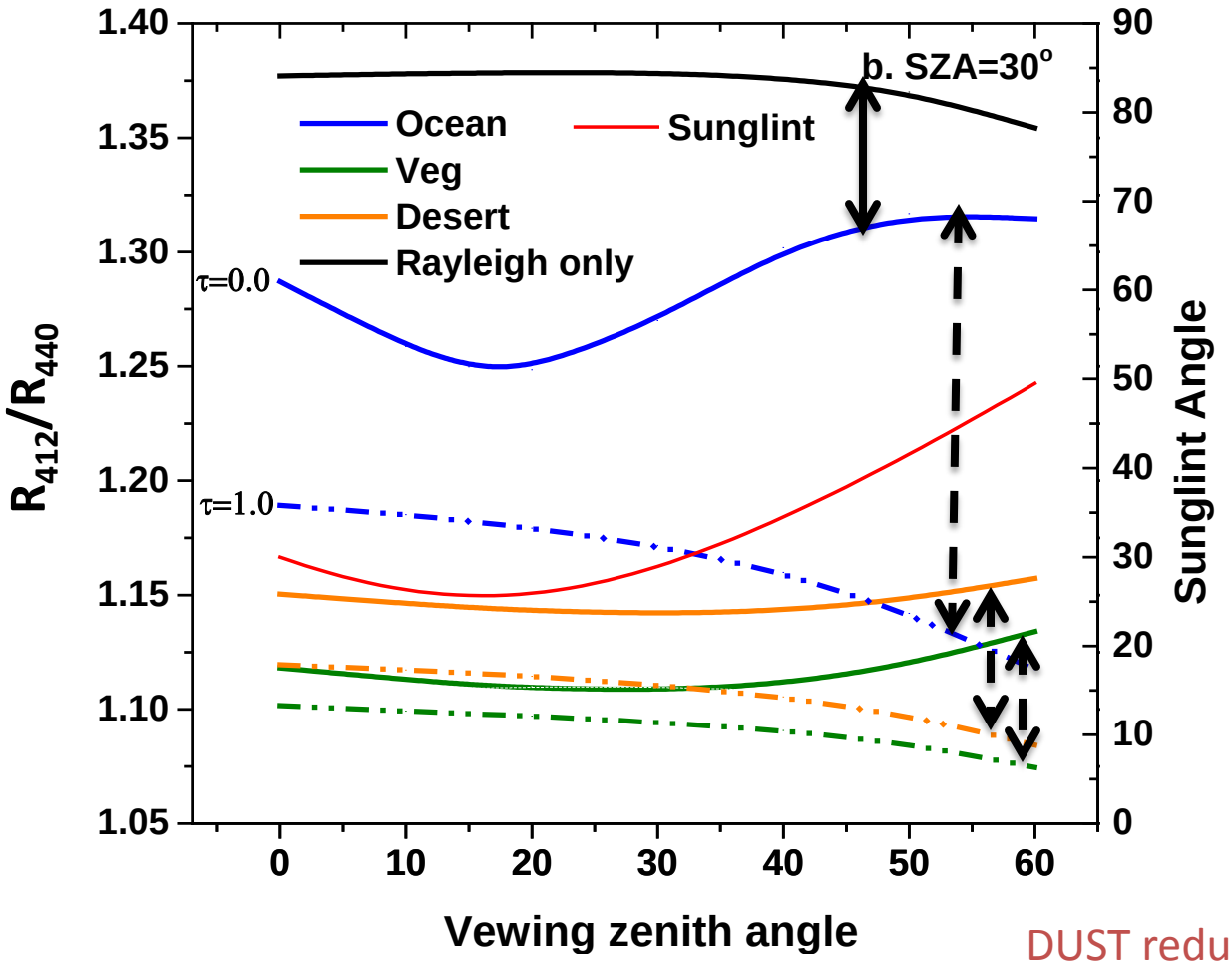
Output for each pixel(about 750m at nadir):

1. **SM type flags**: (1-presence;0-Absence)
   - ***Volcanic ash flag passed on from Cloud mask***
   - ***Dust flag***
   - ***Smoke flag***
   - ***Others (none/unknown/clear)***
   - ***Cloud flag***
   - ***Snow/ice flag***
2. **Dust/smoke aerosol index values**
3. **quality flags (00/01/11)**

low, medium and high quality for SM type



6S Radiative Transfer Simulations

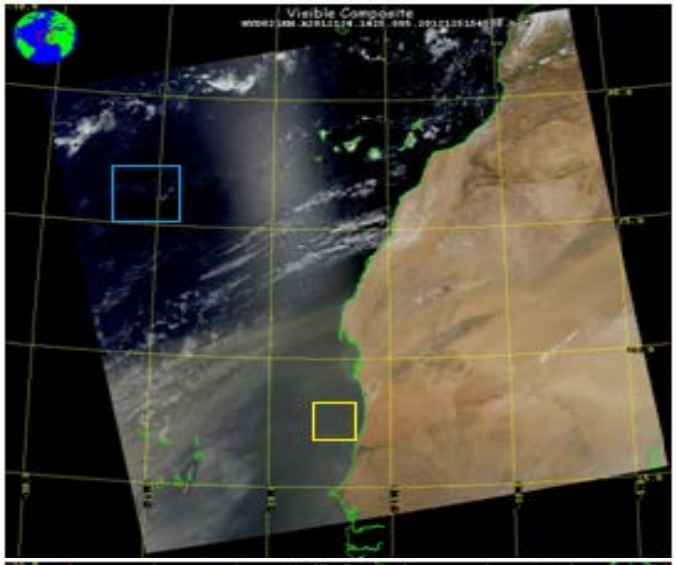


6S Simulations:

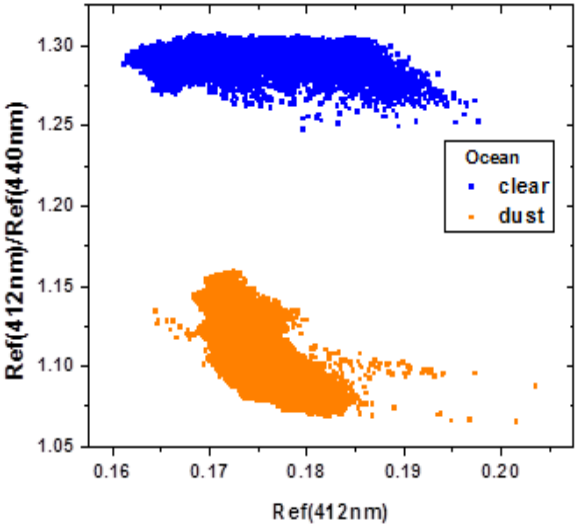
1. MODIS C5 dust aerosol model used
2. Desert, vegetation, ocean BRDF with easterly wind speed of 6 m/s are used to represent surfaces in 6S

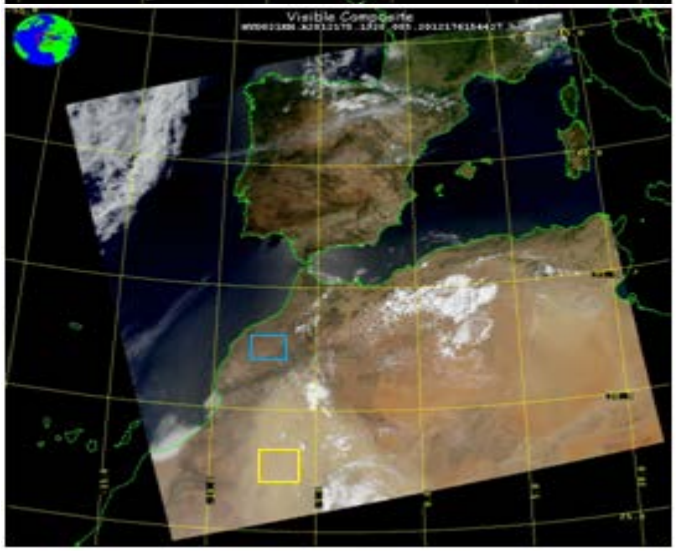
DUST reduces the contrast between 412nm and 440 nm as absorption by dust increases with decreasing wavelength.

MODIS Observations: Dust vs. Clear Sky

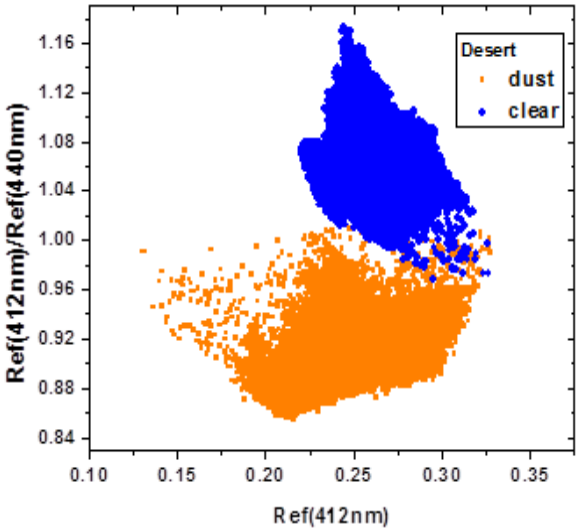


Over water

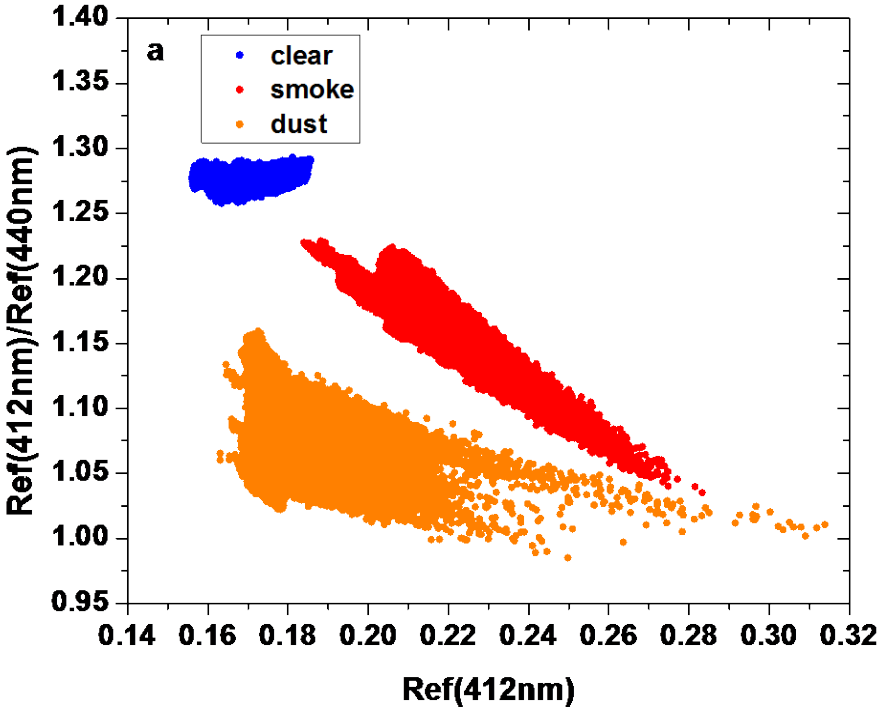


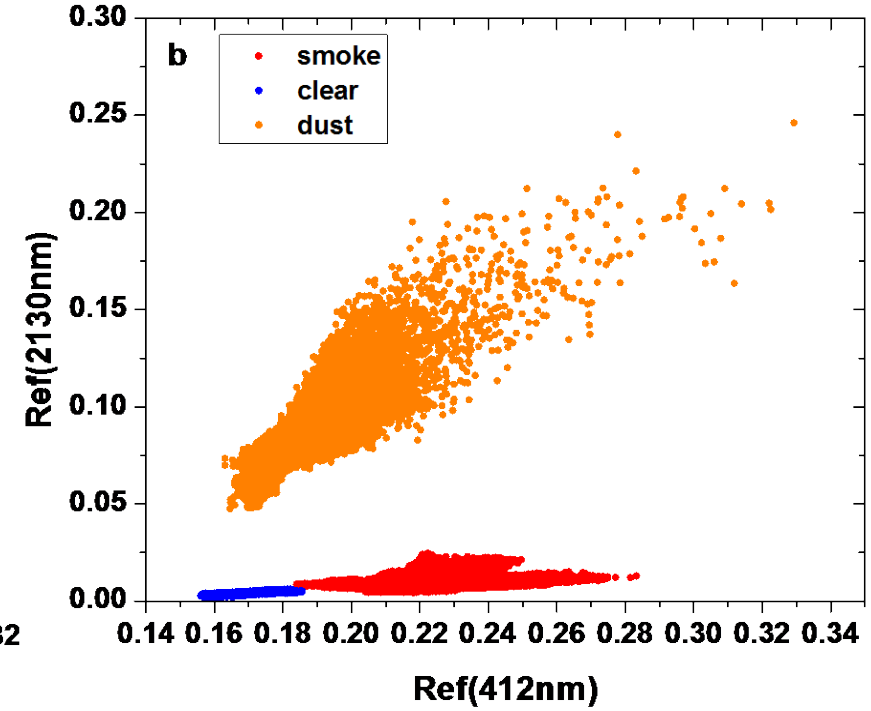


Over land



Smoke and dust vs. Clear Sky





Smoke:

- Has the similar effect as dust in terms of reduction of the contrast between 412nm to 440nm
- Difference in particle size enables us to pick-out the smoke by introducing short-wave IR channel (2.13 µm)

Dust Aerosol Index (DAI)

$$DAI = -100*[\log_{10}(R_{412nm}/R_{445nm})-\log10(R'_{412nm}/R'_{445nm})]$$
$$NDAI = -10*[\log_{10}(R_{412nm}/R_{2250nm})]$$

R' -- reflectance from Rayleigh scattering

Detection will not be performed for the following conditions:

- **Clouds**
  - **screened by using R_{412nm} and cloud mask**
- **Residual Clouds**
  - **over water:**

    screened by using 860nm spatial variability test.
  - **Over land:**

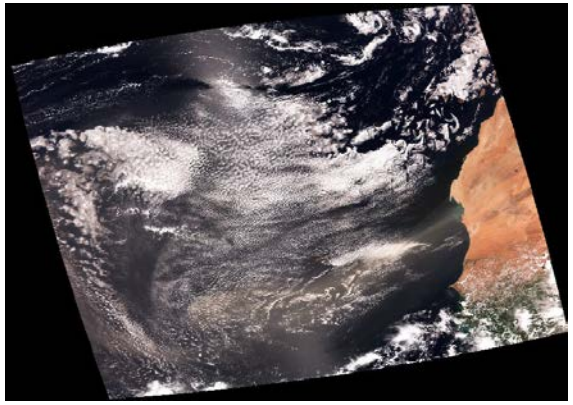
    screened by 412nm spatial variability test.
- **Bright surfaces**

  screened by using bright pixel index (normalized difference of 1.24 μm and 2.25 μm).
- **Turbid water**

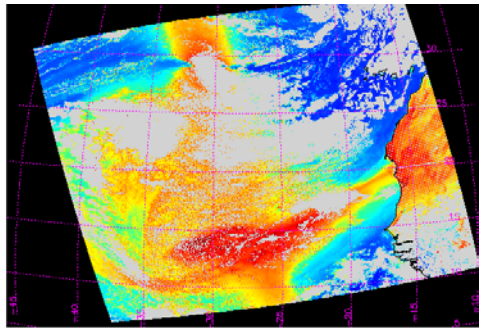
  Screened with test based on Shi and Wang(2007) uses 746 nm and 1.24 μm measurements.
- **Sunglint (for dust only), snow/ice, fire hot spots**

  screened based on different tests (geometry, spectral etc.)

JPSS SM Dust Detection



DAI after cloud screening



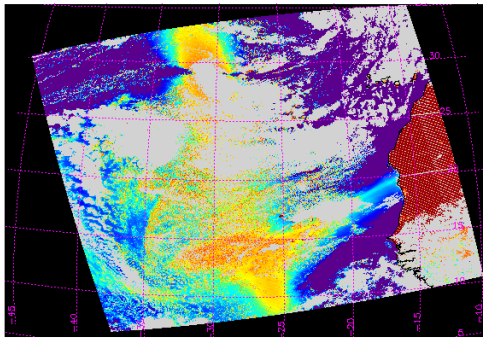
Dust is detected If DAI and NDAI pass these tests:

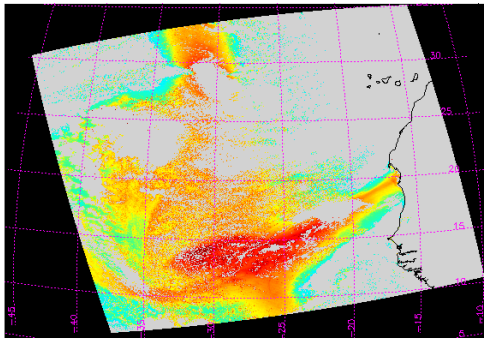
- **Water**: DAI ≥ 4 and NDAI ≥ -10
- **Land**: DAI ≥ 11.5 and NDAI ≥ 0

NDAI after cloud screening

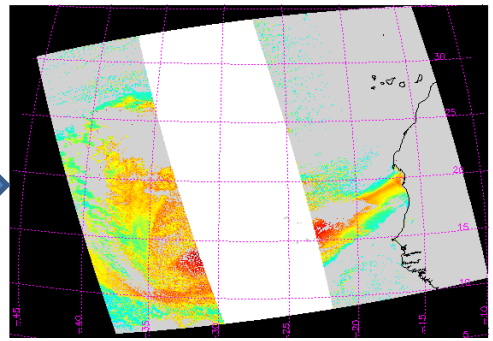
Dust flag

Final dust flag



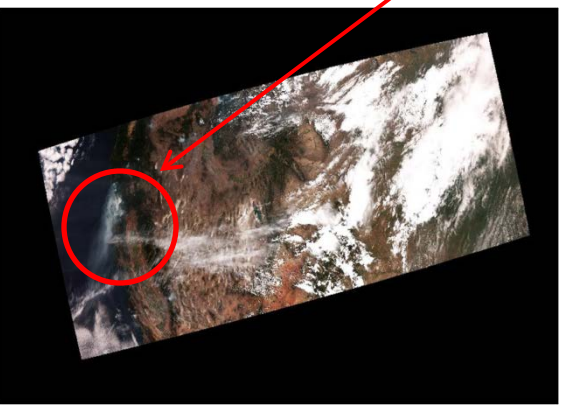


Sunglint flag

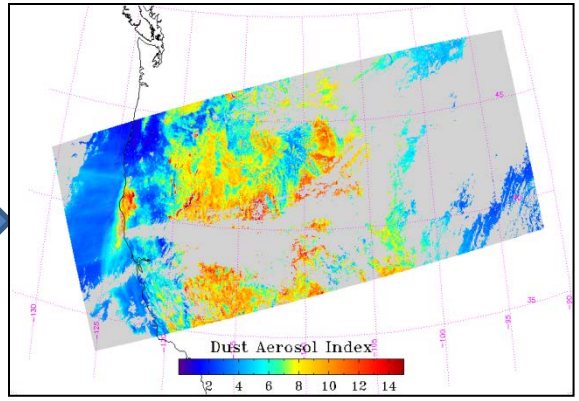


JPSS SM Smoke Detection

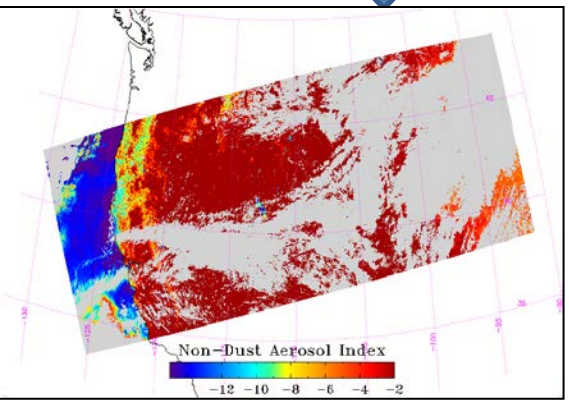
smoke



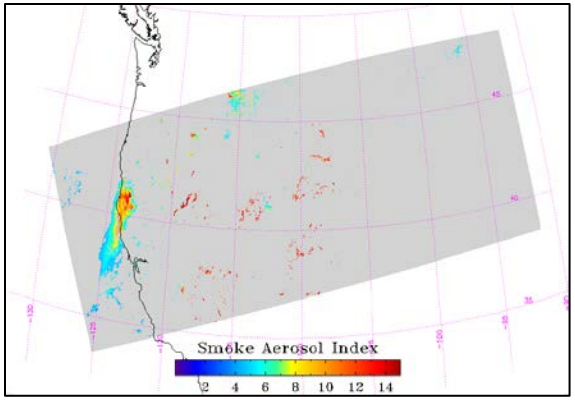
DAI after cloud screening



NDAI after cloud screening



Smoke flag



Smoke is detected If DAI and NDAI pass these tests:

– **Water:**

thin smoke:

DAI ≥ 4.0 and NDAI ≤ -10.0 and R_{410} < 0.1

thick smoke:

DAI ≥ 9.0 and NDAI ≤ -4.0

– **Land:**

thin smoke

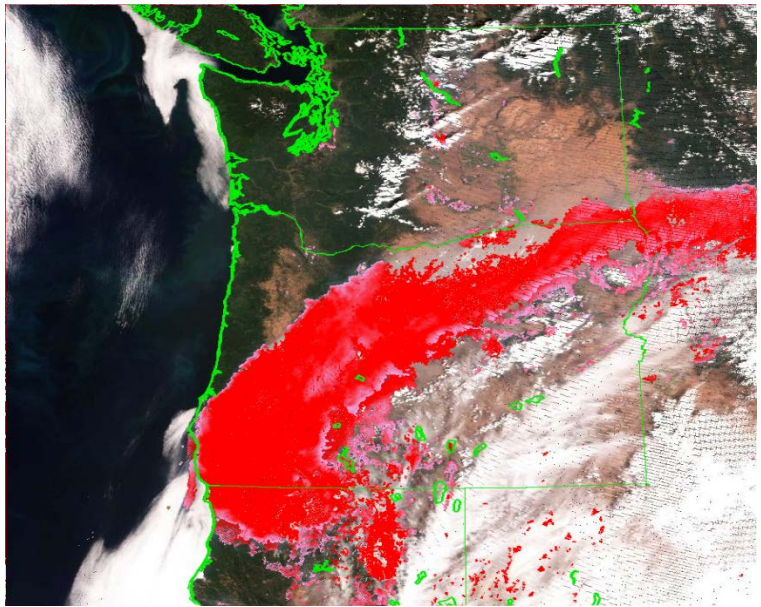
DAI ≥ 5.0 and NDAI ≤ -2.0

thick smoke:

DAI ≥ 9.0 and NDAI ≤ -2.0 and 0.2<R_{410} < 0.4

Dust and Smoke Detection Examples

Smoke plume shown in the VIIRS RGB image on August 3, 2014 Over west coast of U.S.

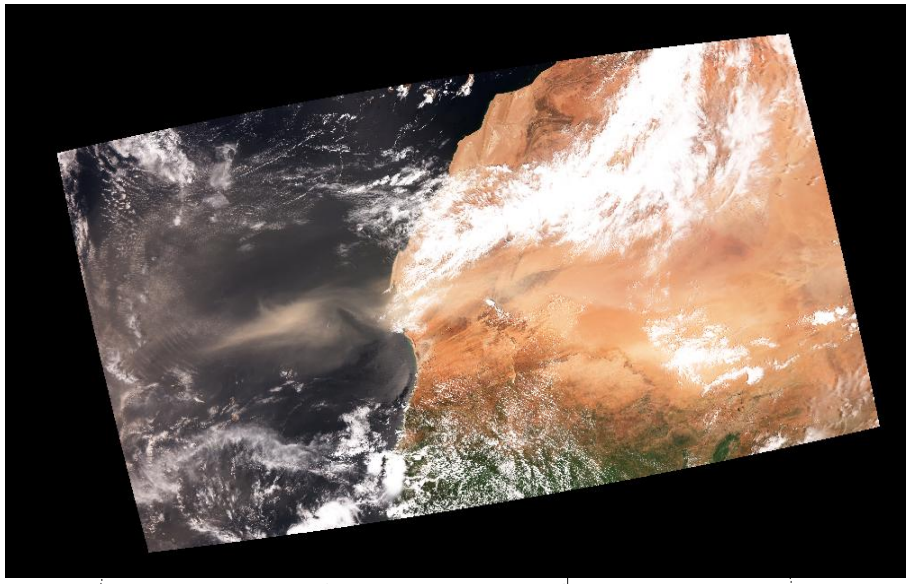


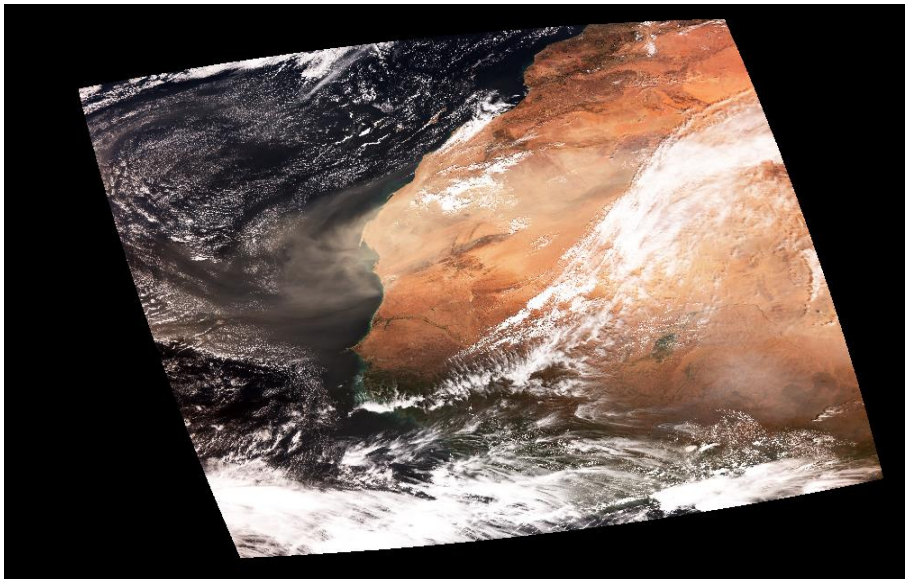
VIIRS smoke detection algorithm identifies the smoke plumes including the one removed from fire hot spots

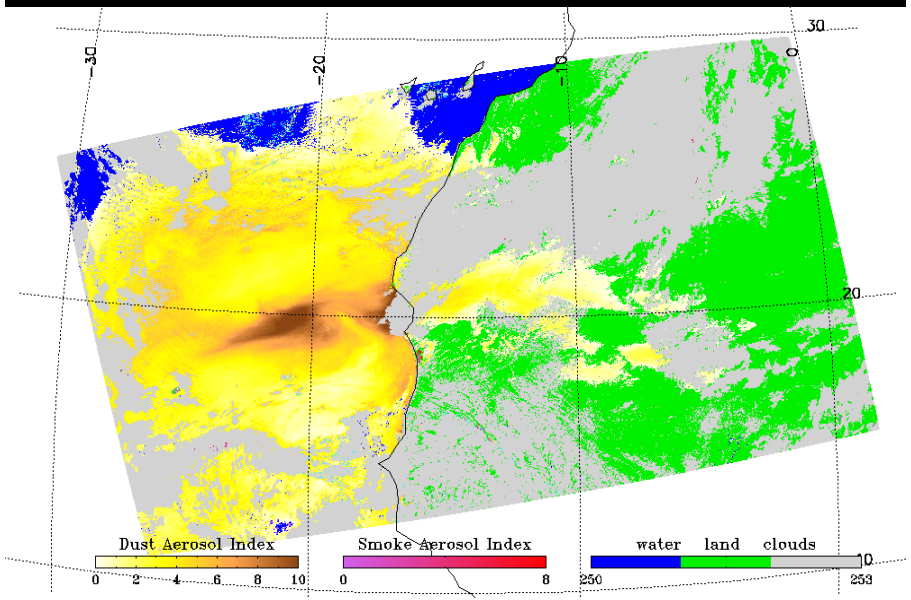
Sahara dust outbreaks

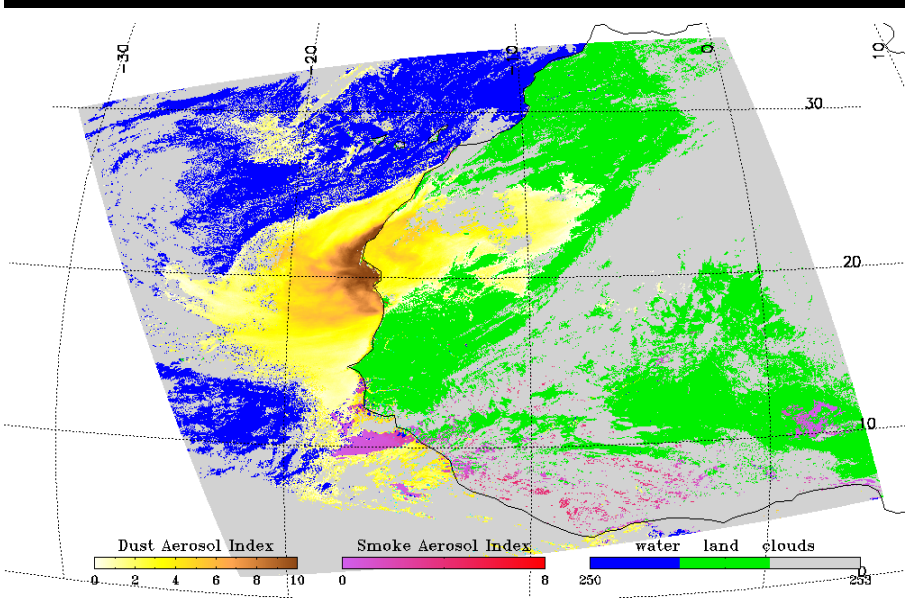
September 14, 2013

December 14, 2013



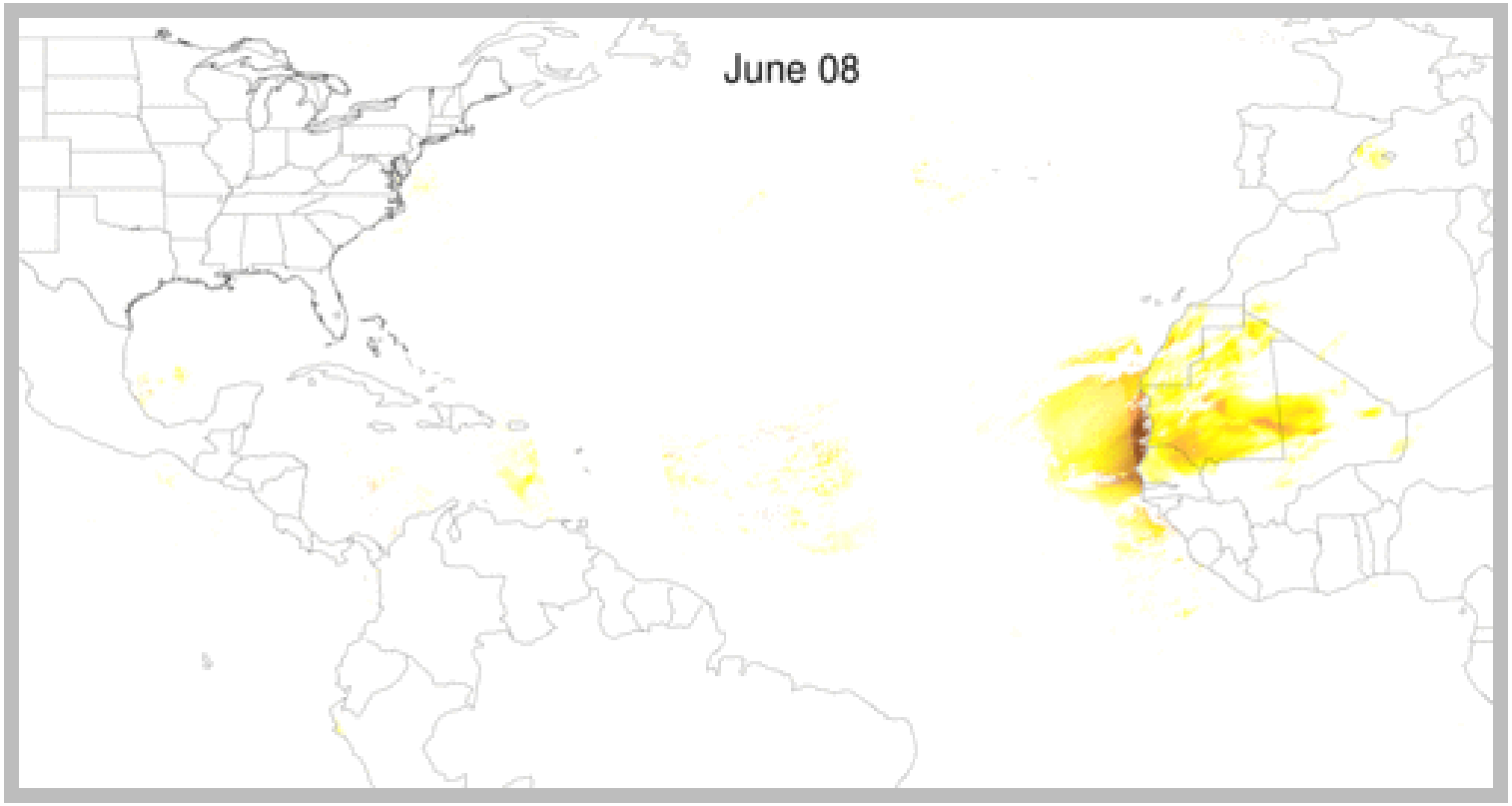






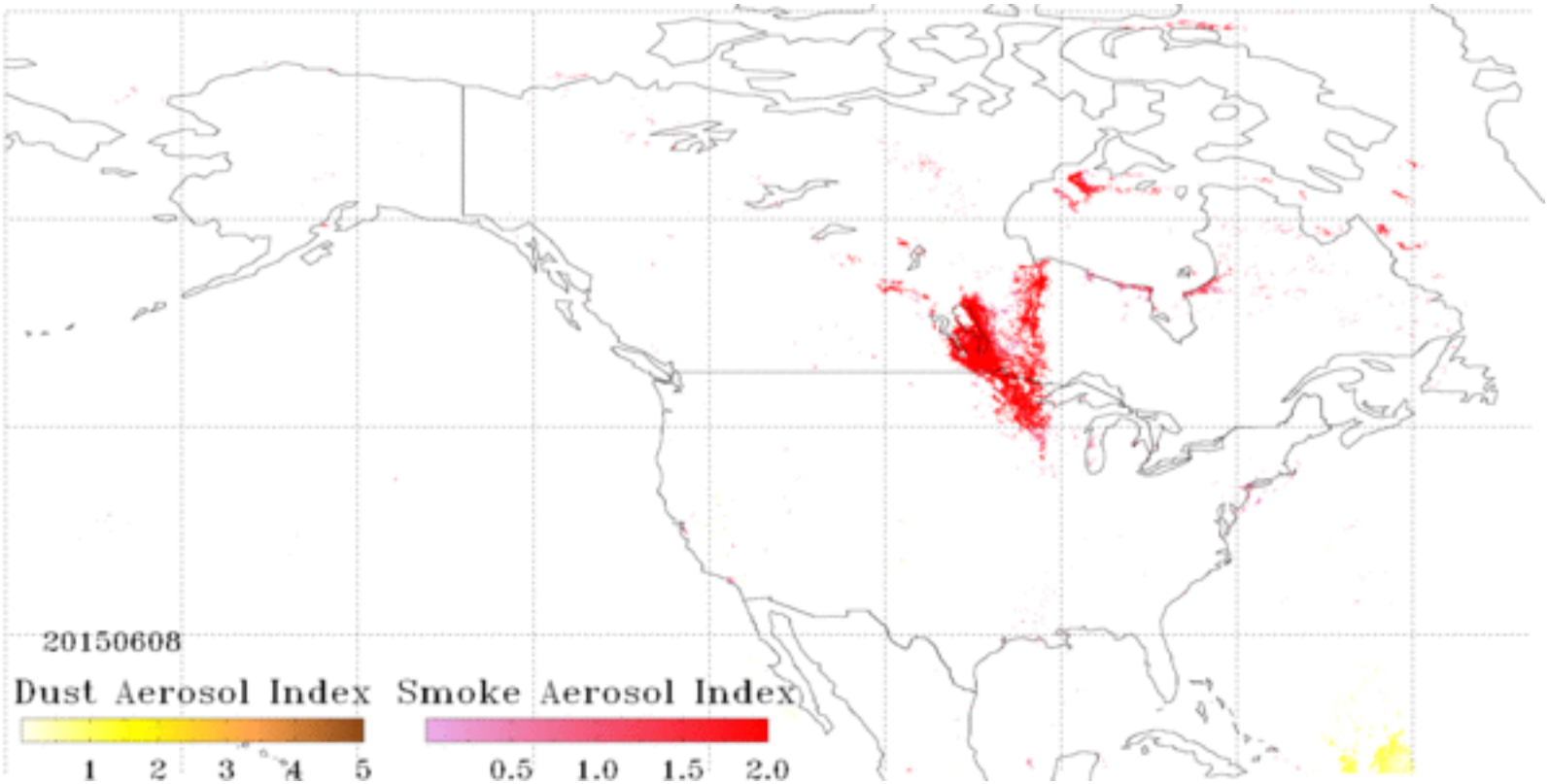
Transatlantic dust transport

Year of 2014



Smoke outbreak over U.S.

06/08 to 07/15/2015



Validation Strategy

- Dust/smoke detection algorithm run on VIIRS data for the entire year of 2013 and 2014.
  - VIIRS smoke/dust detection matchup with AERONET Observations
  - VIIRS smoke and dust detection matchups with CALIPSO VFM
- Derive performance metrics
  - Accuracy
  - Probability of Correct Detection (POCD)
  - Probability of False Detection (POFD)

		TRUTH DATA: Yes	TRUTH DATA: No
VIIRS	Yes	A	B
	No	C	D

POCD = A/(A+C)

POFD = B/(A+B)

Accuracy* = (A+D)/(A+B+C+D)

VIIRS vs. CALIPSO

Year of 2013 and 2014

Land

Type	True positive	False positive	True negative	False Negative	Accuracy (%)	POCD (%)	FAR (%)
DUST	10669	170	5676	2840	84.4	80.0	1.6
SMOKE	307	159	19534	14	99.1	96.7	34.1

Water

Type	True positive	False positive	True negative	False negative	Accuracy (%)	POCD (%)	FAR (%)
DUST	297	11	139	10	95.4	96.4	3.3
SMOKE	601	507	7605	15	94.0	97.5	45.7

VIIRS vs. AERONET (DUST)

Stations		True positive	False positive	True negative	False negative	Accuracy	POCD	POFD
Darkar	2013	63	1	106	10	93.9	86.3	0.2
	2014	74	3	45	10	90.1	88.1	0.4
Solar_Village	2013	81	26	59	30	71.4	73.0	24.3
	2014	11	4	65	5	89.4	68.8	26.7
Capo_Verde	2013	44	0	56	3	97.1	93.6	0.0
	2014	53	1	17	1	97.2	98.1	0.2

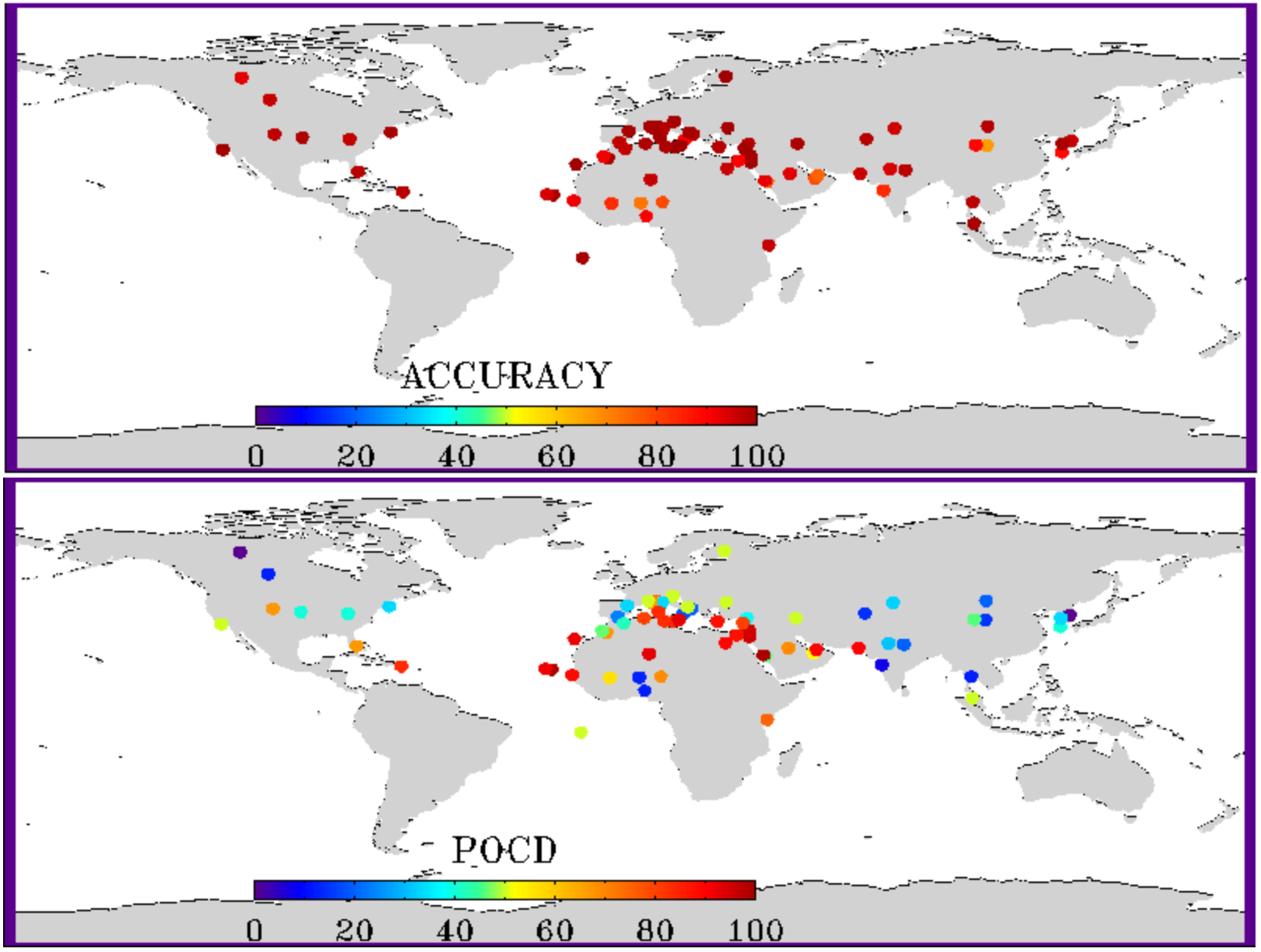
Over 440 AERONET stations	Accuracy	POCD	POFD
Year of 2013 and 2014	98.5	84.6	14.7

VIIRS vs. AERONET (Smoke)

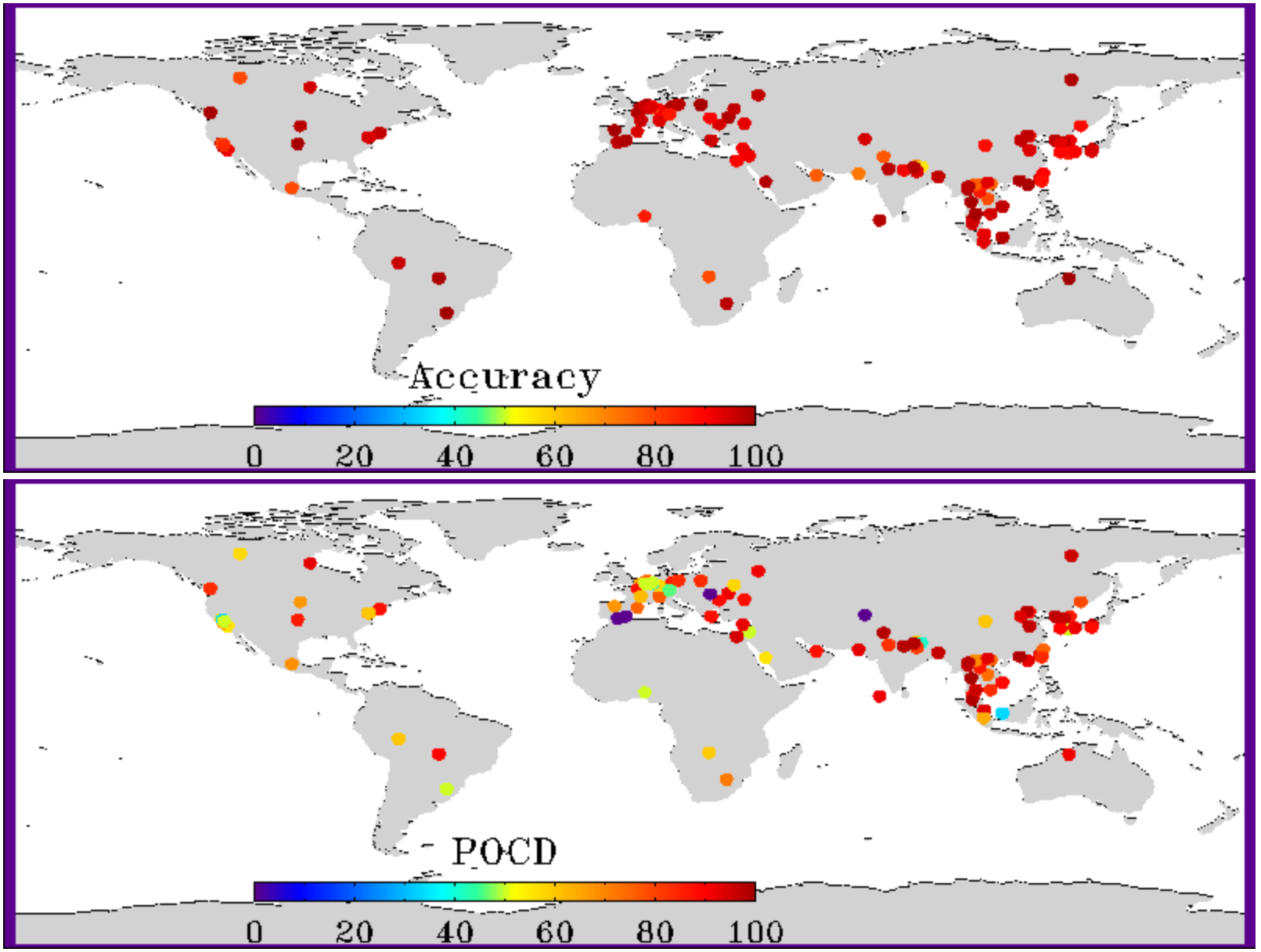
Stations (Biomass – burning)	True positive	False positive	True negative	False negative	Accuracy	POCD	POFD
Alta_Floresta	10	0	178	0	100.0	100.0	0.0
Bonanza_Creek	1	0	48	0	100.0	100	0.0
Jabiru	1	0	313	0	100.0	100.0	0.0
Moscow_MSU_MO	16	2	92	1	97.2	94.1	11.0
Tomsk_22	17	1	83	0	99.0	100.0	5.0
Yakutsk	22	1	88	1	98.2	95.6	4.3

Over 401 AERONET stations	Accuracy	POCD	POFD
Year of 2013 and 2014	97.5	91.6	18.5

VIIRS vs. AERONET (dust)

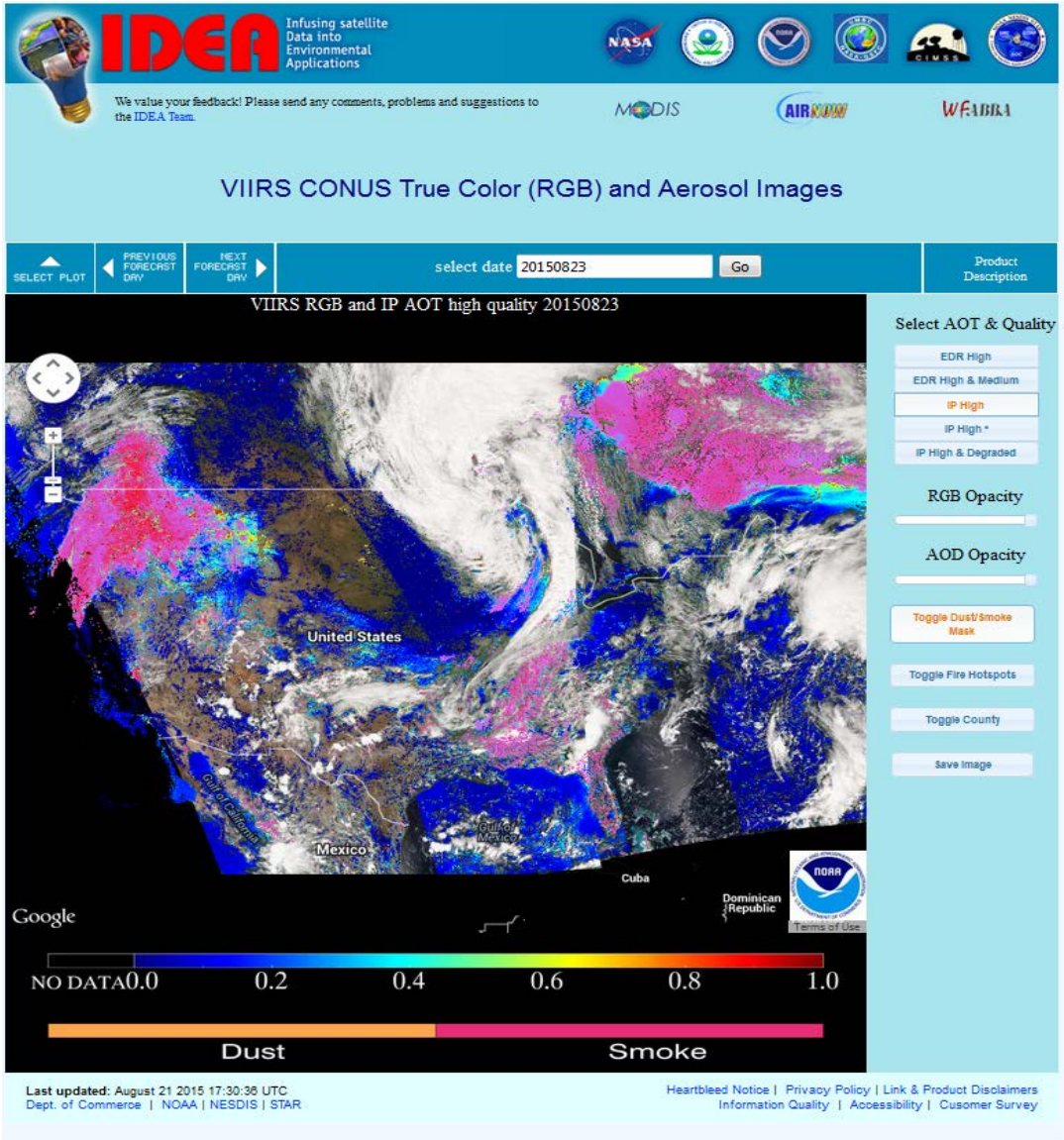


VIIRS vs. AERONET (smoke)



Near-real time run of JPSS SM algorithm on S-NPP VIIRS DB data

1. JPSS RR SM algorithm has been Implemented by using near-real time S-NPP VIIRS DB data over both CONUS and OCONUS
2. It provides daily monitoring of smoke/dust event OVER CONUS and Alaska



Summary

- JPSS RR Suspended Matter algorithm is simple, fast, and easy to be implemented operationally.
- Validation results indicated that Accuracy and POCD for dust and smoke detection can be as high as 90% and 80 %, respectively.
- Additional investigation of data artifacts (false detections) is required to enhance product accuracy.