Potential Solution to Resolving Data Artifacts in VIIRS Aerosol Detection Product over Land

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1. IMSG; 2. NOAA; 3. UMBC; 4. UMD

Outline

- VIIRS Aerosol Detection Product (ADP)
- Demonstration and analysis of the data artifacts in ADP dust detection
- Dust RGB images using IR bands
- Dust detection using IR bands based on dust RGB method

VIIRS Aerosol Detection Product (ADP)

- Detect smoke and dust using two aerosol indices:
  - Absorbing Aerosol Index (AAI)

$$AAI = -100\left[\log_{10}\left(\frac{R_{412}}{R_{440}}\right) - \log_{10}\left(\frac{R'_{412}}{R'_{440}}\right)\right]$$

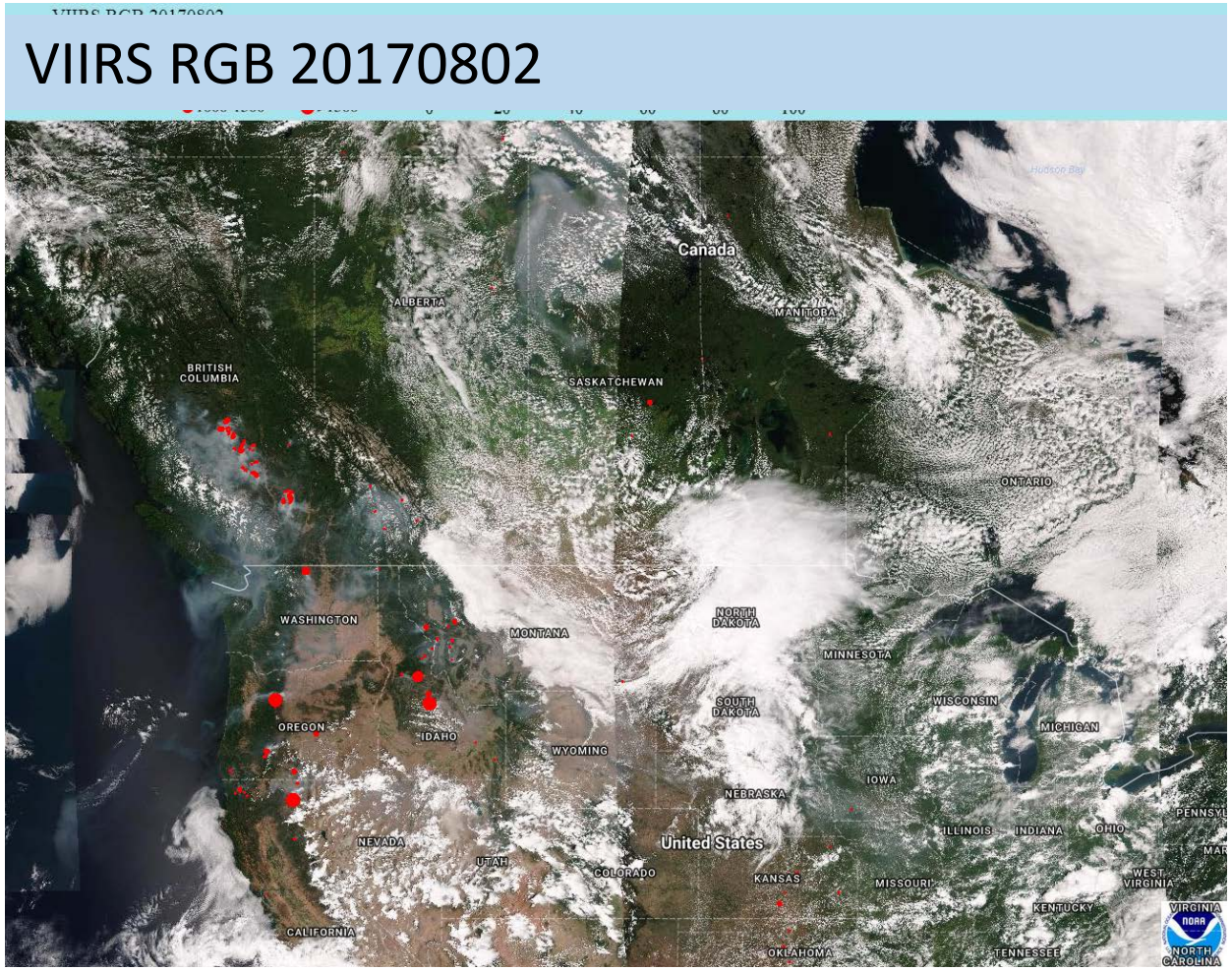
    - R_{412} and R_{440} : TOA reflectance at 412nm and 440nm bands
    - R'_{412} and R'_{440} : Rayleigh reflectance at 412nm and 440nm bands
  - Dust Smoke Discrimination Index (DSDI)
    - $DSDI = -10\ log_{10}(\frac{R_{412}}{R_{2130}})$
    - R_{412} and R_{2130} : TOA reflectance at 412nm and 2130nm bands

VIIRS Aerosol Detection Product (ADP)

- The detection is based on thresholds of AAI and DSDI, which are different over land and ocean

Surface type	Aerosol type	AAI thresholds	DSDI thresholds	Other
Land	Dust	> 10	≥ 0.0	
	Smoke	≥ 5.0 thin ≥ 9.0 thick	≤ -3.0 thin ≤ -2.0 thick	$0.2<R_{412}<0.4$ thick
Ocean	Dust	> 4.0	≥ -10.0	
	Smoke	≥ 4.5 thin ≥ 10.0 thick	≤ -10.0 thin ≤ -4.0 thick	$R_{2130} < 0.1$ thin

An example of smoke mask shown on eIDEA (https://www.star.nesdis.noaa.gov/smcd/spb/aq/eidea/)



The dust mask is not shown on eIDEA because of the problems in the following slides

Problems in dust detection over land

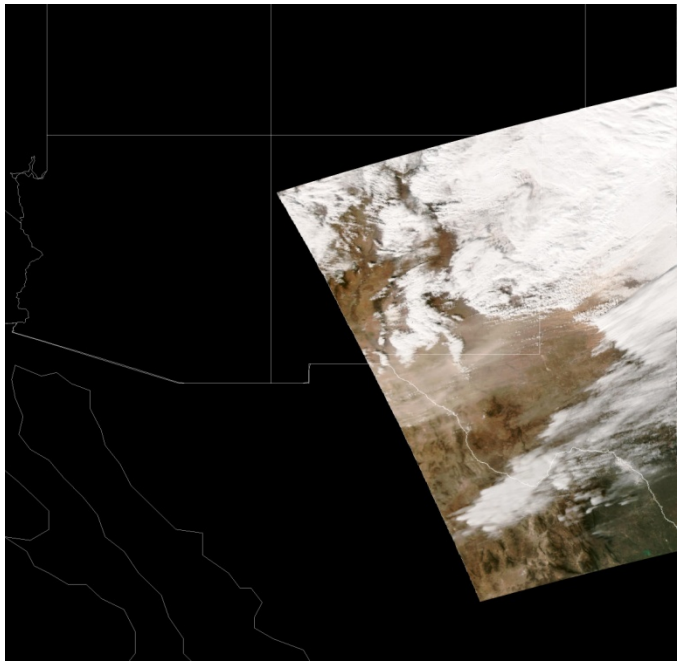
- False detection
- Undetected dust
- Geometry dependent
- Demonstrated in the following cases

1902 UTC

2043 UTC

VIIRS 20161217

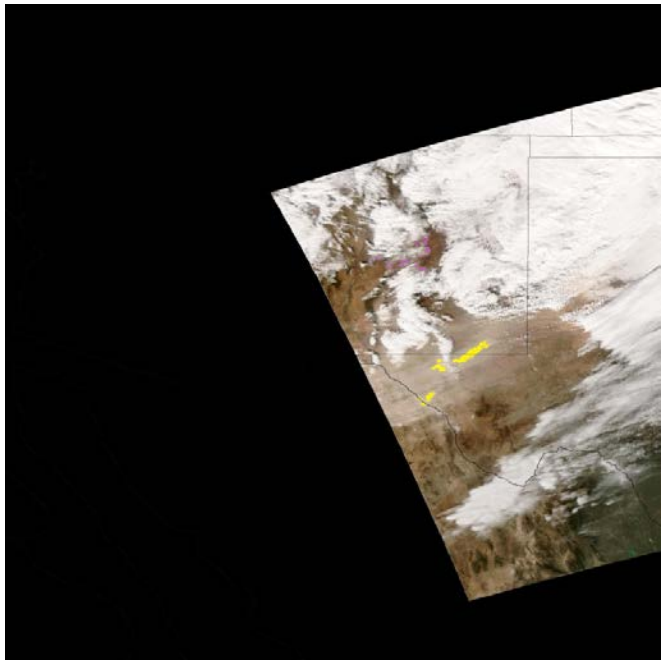
RGB

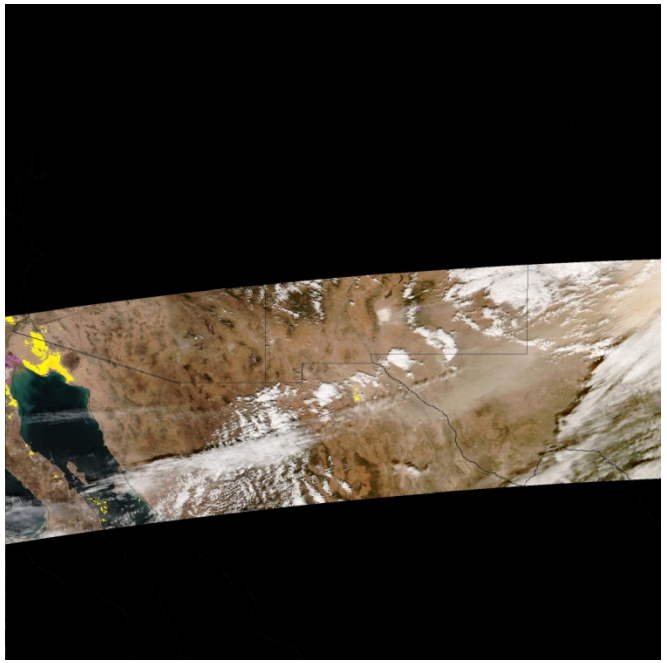


Dust storm near Texas/Mexico boundary

Two overpasses

RGB and dust mask (yellow)



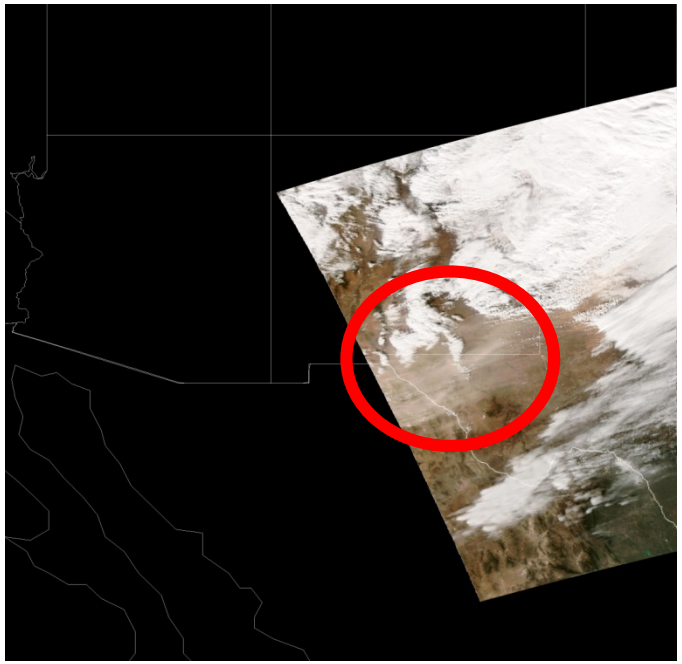


1902 UTC

2043 UTC

VIIRS 20161217

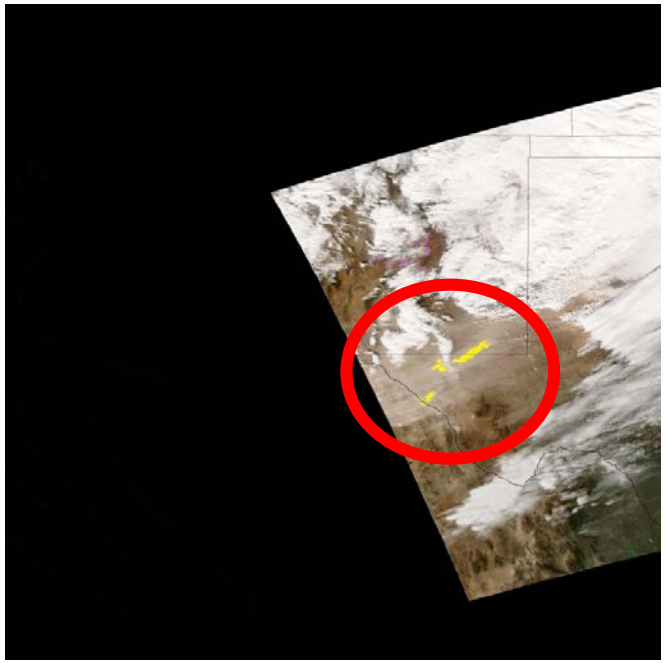
RGB

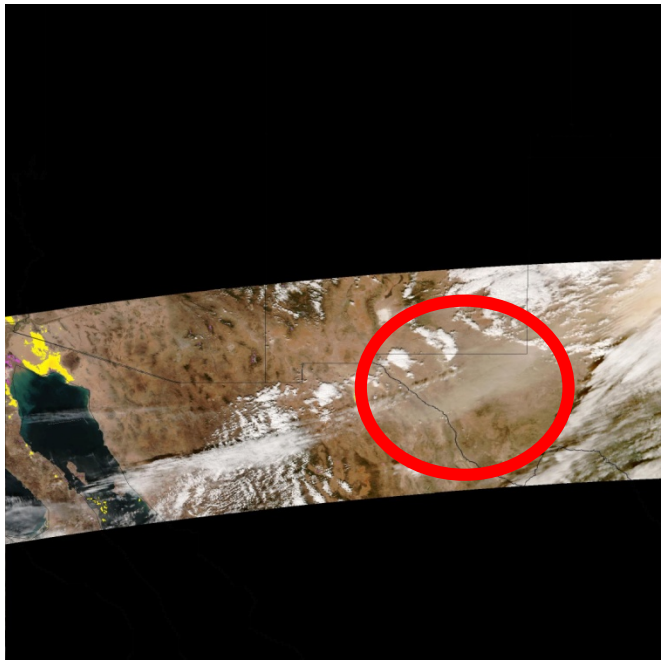


Dust storm near Texas/Mexico boundary

Two overpasses

RGB and dust mask (yellow)





NPP track for 20161217

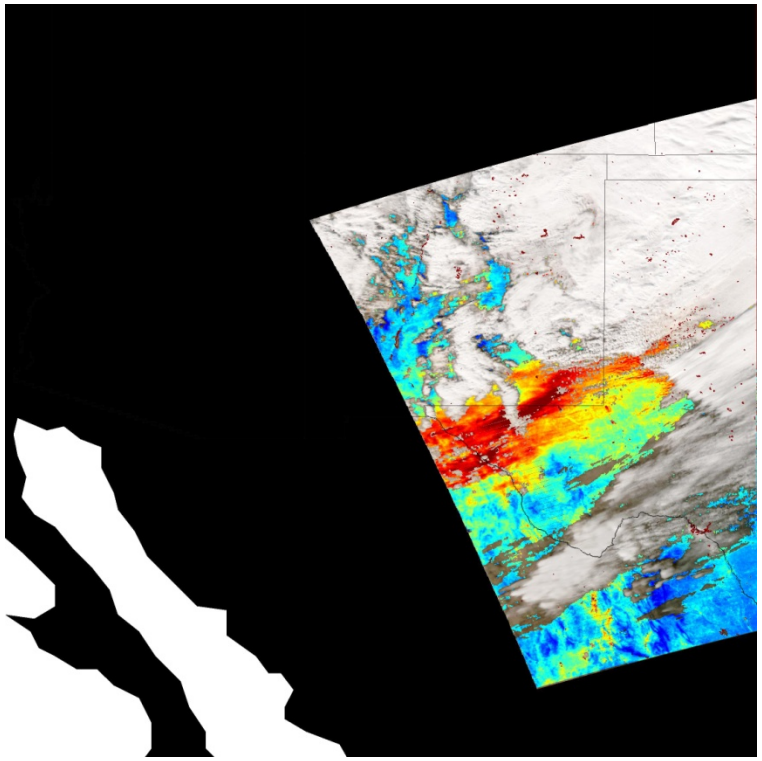
Since the sun is to the west of the nadir, the overpass at 1902 is in forward reflection geometry and the overpass at 2043 is in backward reflection geometry.

2043 overpass

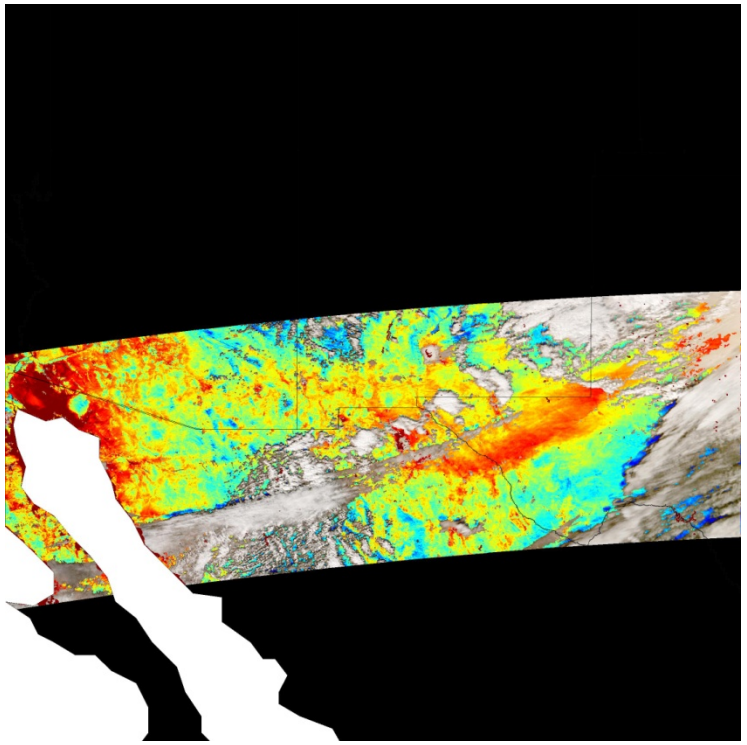
1902 overpass

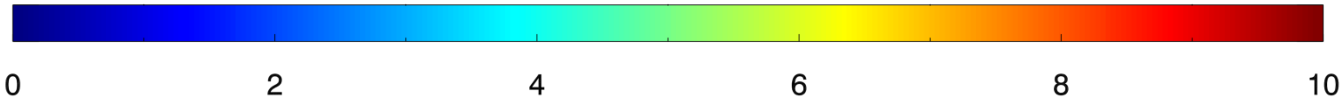
VIIRS AAI 20161217

1902 UTC



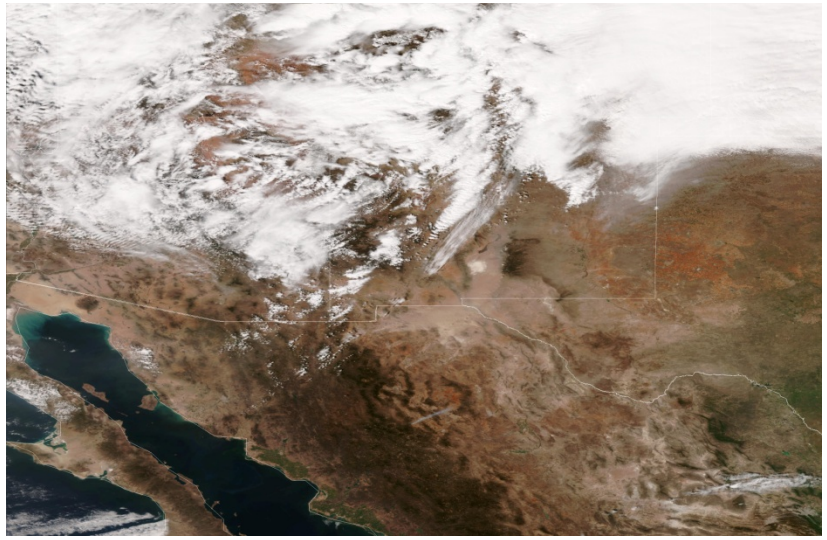
2043 UTC

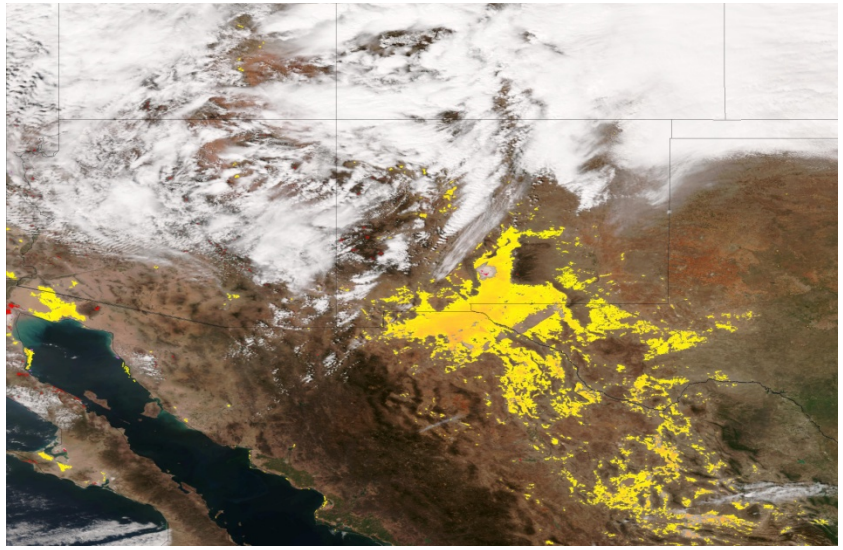




- AAI is lower in the backward reflection geometry than that in the forward reflection geometry

An example with the area close to the center of the granule (20170331)

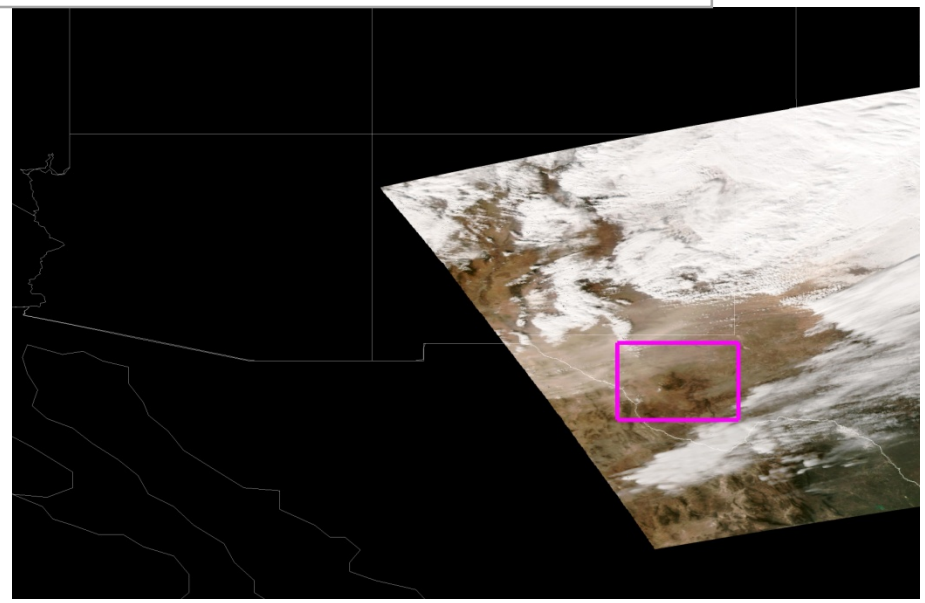


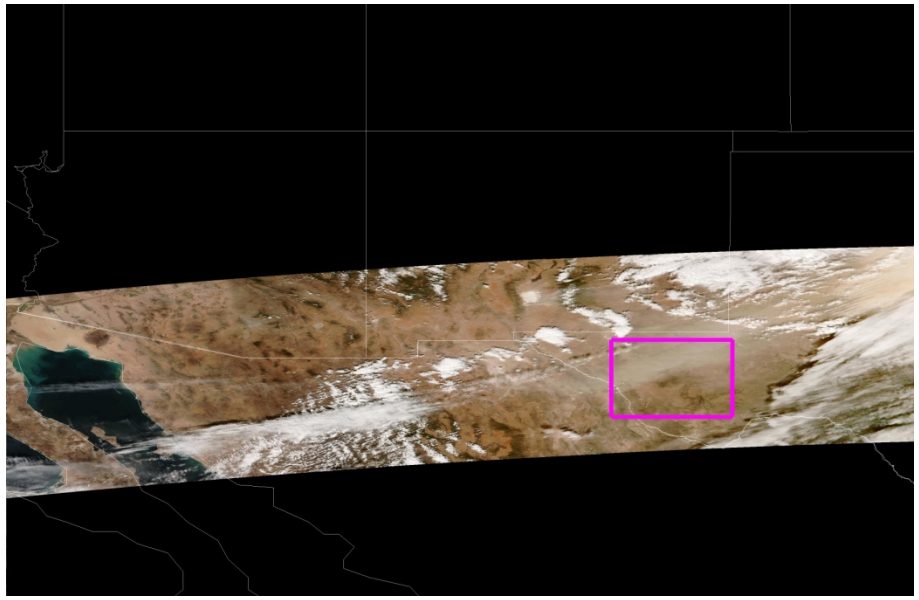


The false detection is more serious in the areas close to the nadir

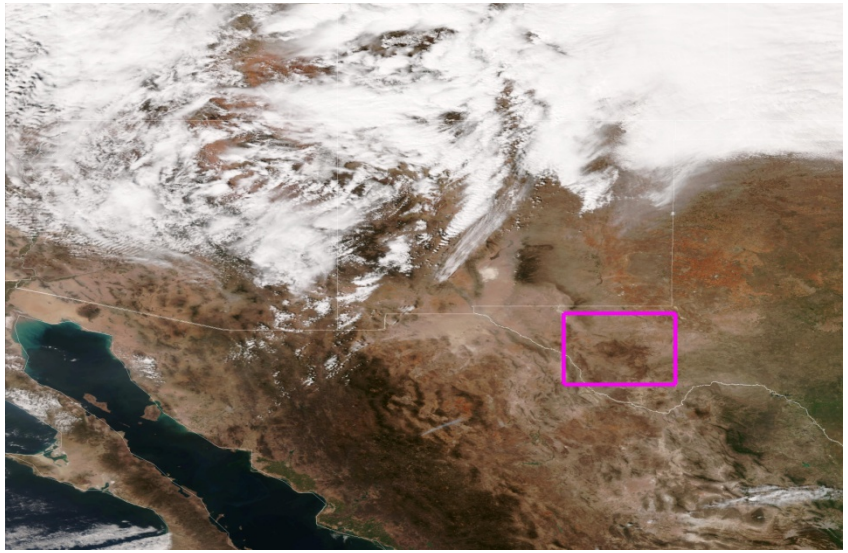
Simulation study of AAI vs aerosol load in the three geometries

20161217





20170331



- Obtain the geometries in the boxes (same area in the three cases)
- Obtain the surface reflectance from surface reflectance database (built from multi-year VIIRS data)

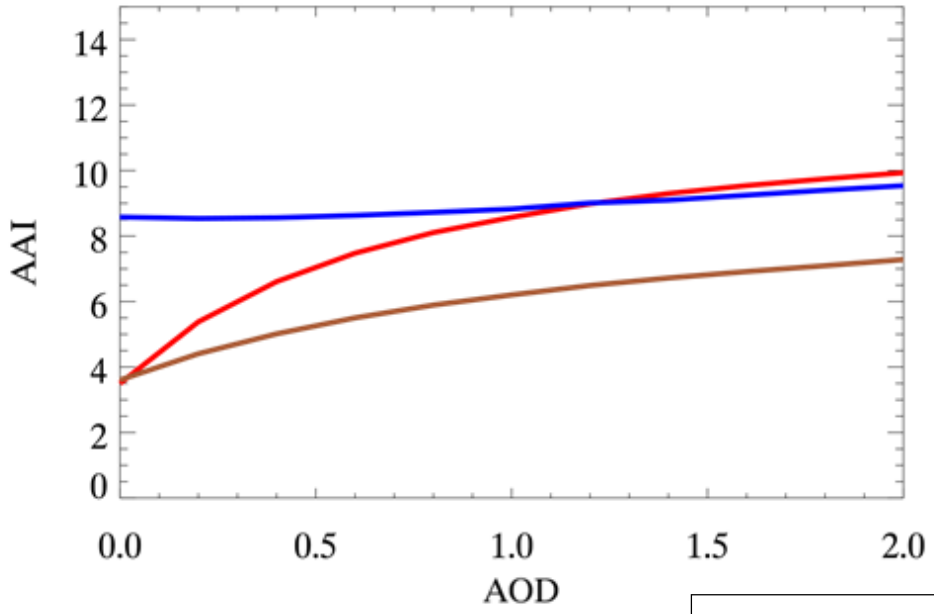
Parameters for the three cases

Case number	description	Lat,lon bound	geometry (sza, vza,azi)	Surface reflectance M1,M2, M3, M5, M11
1	20161217 overpass 1	Lat 29.8N-31.8N Lon 105W-103W	forward (54.27, 65.26, 110.86)	0.05, 0.056, 0.067, 0.126, 0.196
2	20161217 overpass2		backward (60.37, 57.52, 55.80)	0.070, 0.081, 0.098, 0.185, 0.275
3	20170331		nadir (29.11, 13.29, 128.71)	0.076, 0.087, 0.103, 0.182, 0.269

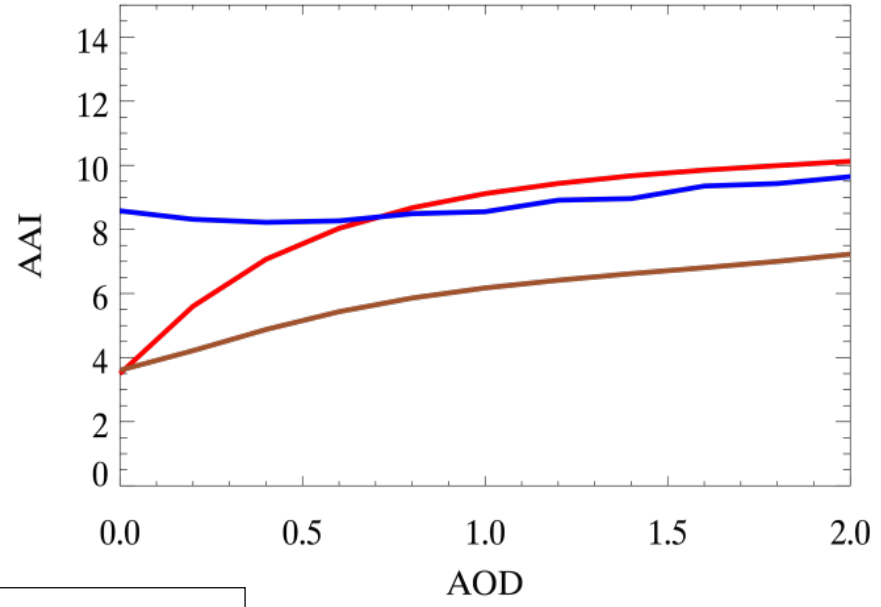
Simulated AAI vs AOD (using LUT in Enterprise AOD algorithm)

$$AAI = -100\left[\log_{10}\left(\frac{R_{412}}{R_{440}}\right) - \log_{10}\left(\frac{R'_{412}}{R'_{440}}\right)\right]$$

Dust



Smoke



Red: forward (20161217 p1)
Brown: backward (20161217 p2)
Blue : nadir (20170331)

- Good sensitivity in forward direction, some sensitivity in backward direction, no sensitivity near nadir
- Dust and smoke are similar in AAI

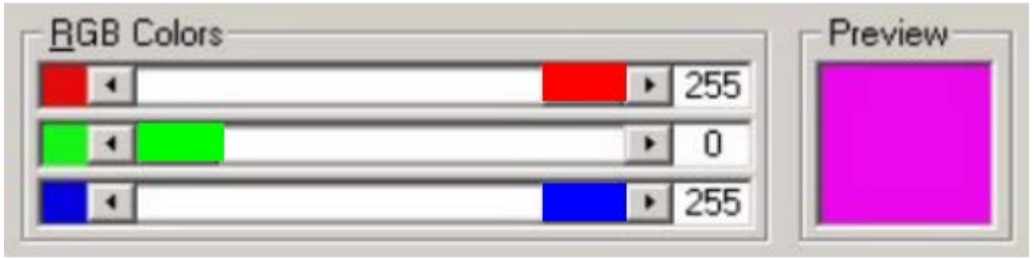
Dust RGB

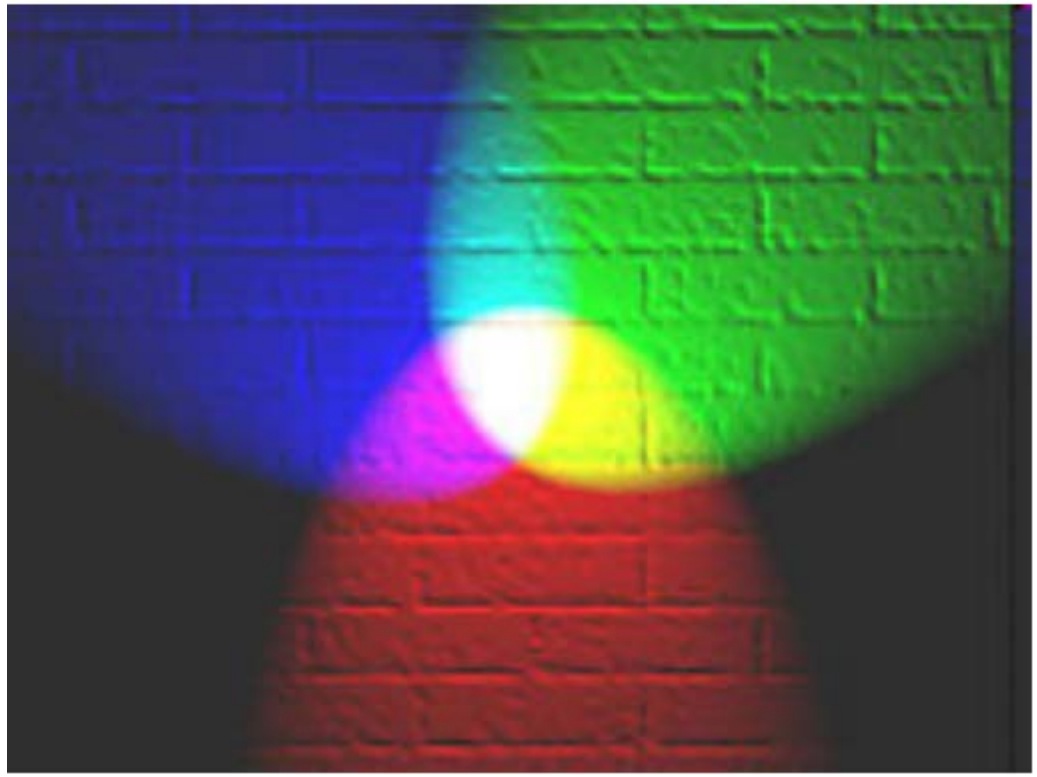
- Used by EUMETSAT (European Organization for Meteorological Satellites) on MSG (Meteosat Second Generation) (https://www.eumetsat.int/website/home/Data/Training/TrainingLibrary/DAT_2042669.html?lang=EN)
- Three IR bands are used: IR8.7, IR10.8 and IR12.0
  - Brightness temperature at IR10.8 is less than that at IR12.0
    - Surface emissivity in 10.8 µm is similar to that in 12 µm
    - More absorption for dust in 10.8 µm than in 12 µm
  - Brightness temperature is close in IR10.8 and in IR8.7
    - Surface emissivity in 10.8 µm is higher than that in 8.7 µm
    - More absorption for dust in 8.7 µm than in 10.8 µm

Dust RGB

- R: bt12 – bt10.8 (bt– brightness temperature)
- G: bt10.8-bt8.7
- B: bt10.8

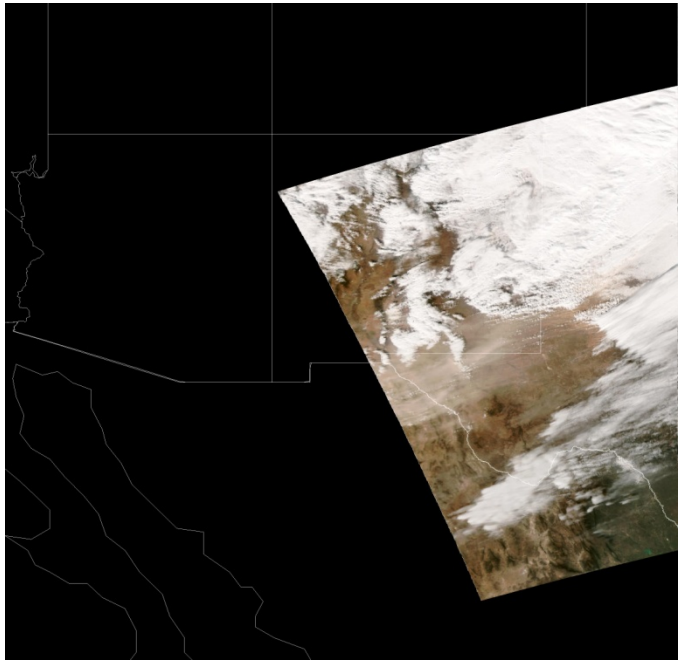
- Using this method, dust shows as magenta color over desert

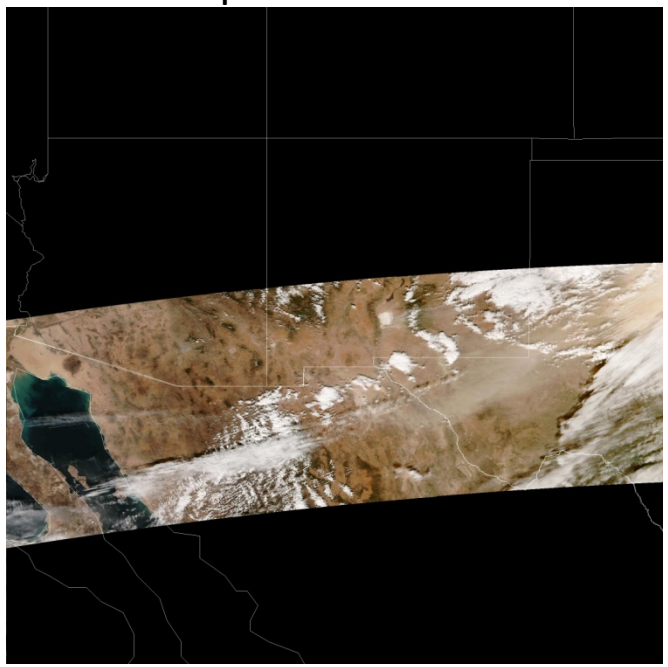


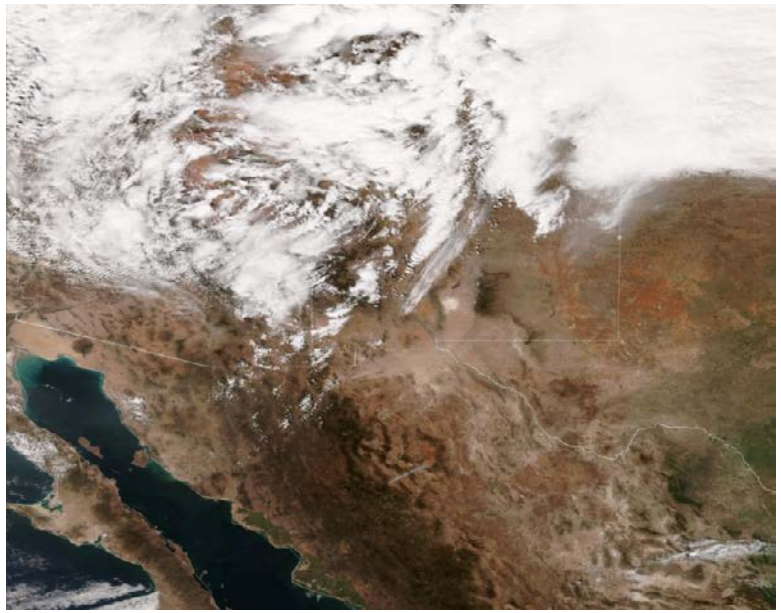


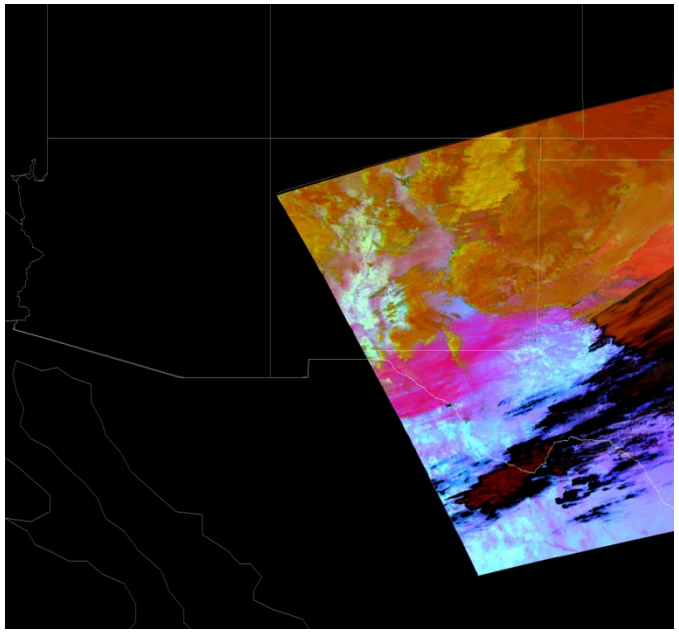
https://www.eumetsat.int/website/home/Data/Training/TrainingLibrary/DAT_2042669.html?lang=EN

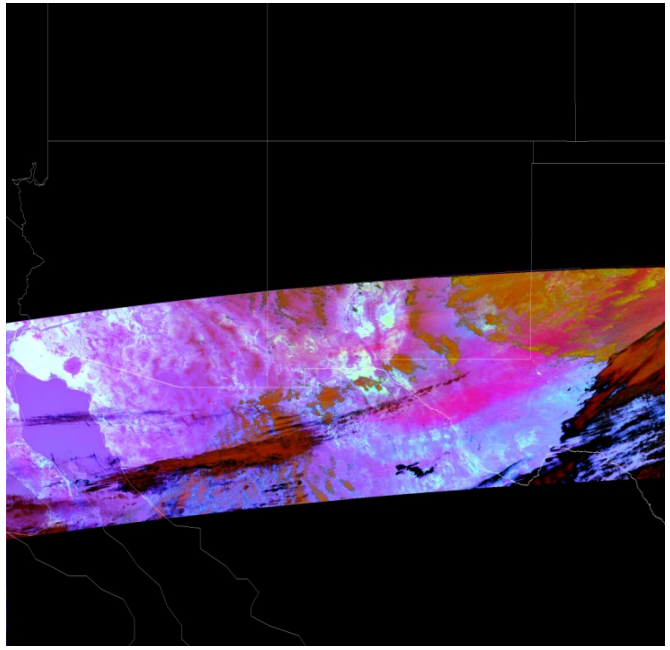
The three cases plotted in dust RGB image

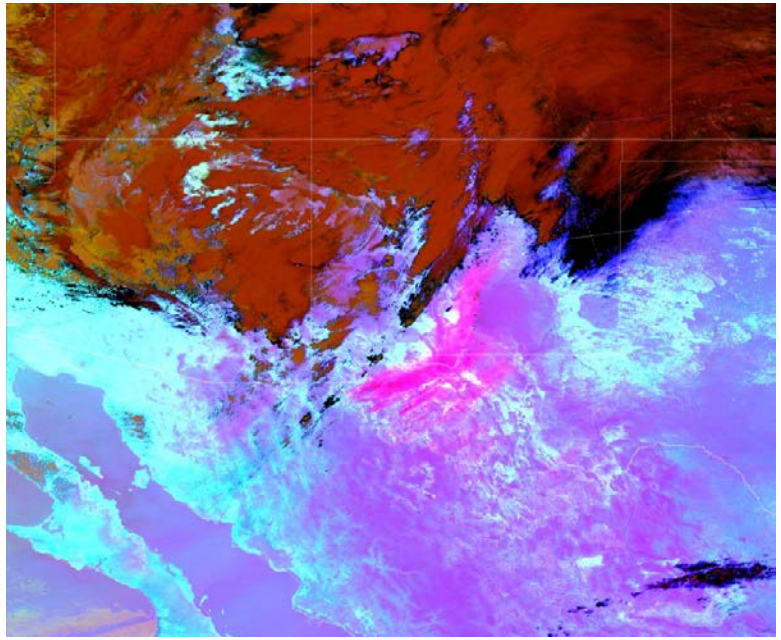










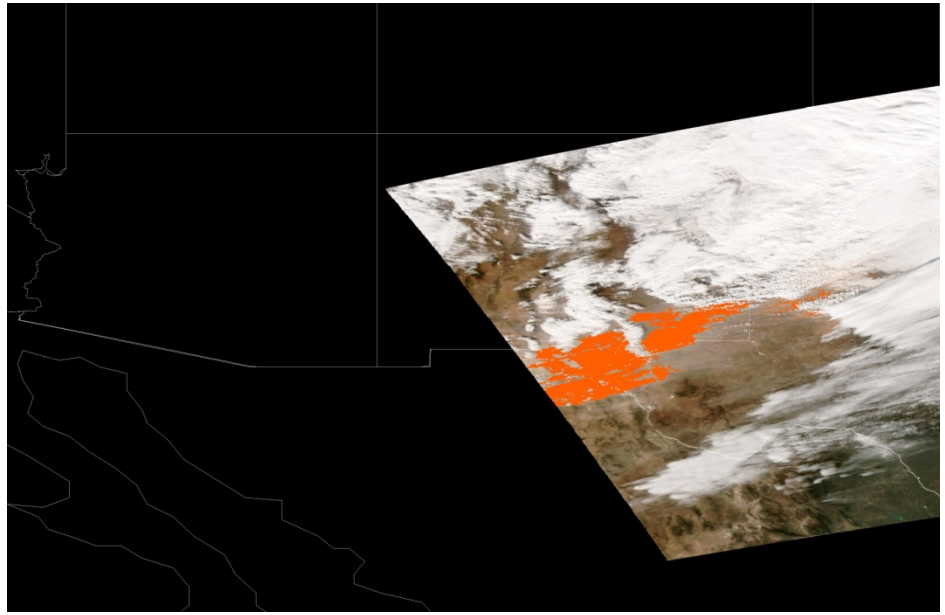


Use thresholds to detect dust in IR bands

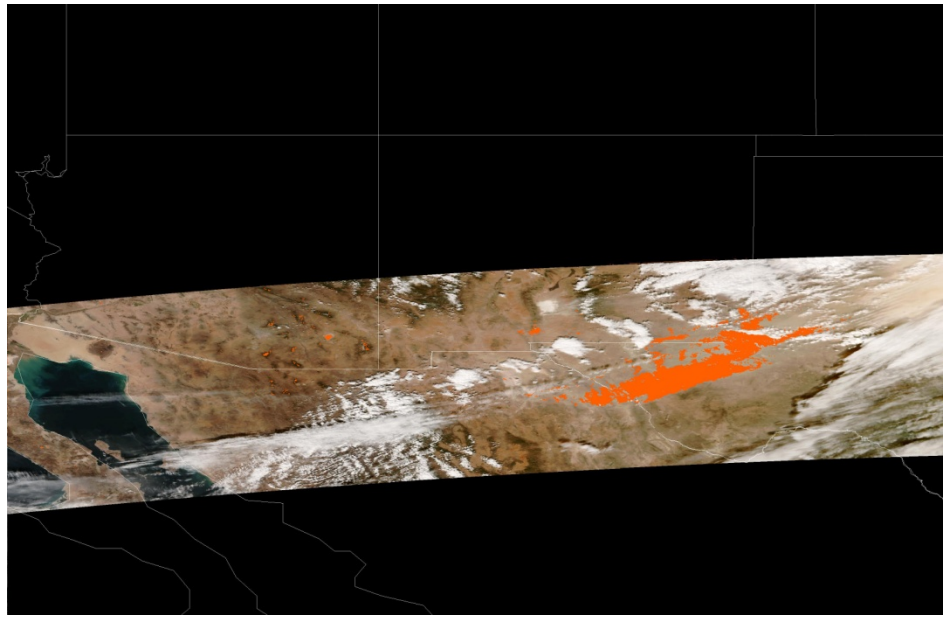
Determine thresholds through visual inspection of the dust cases

	thresholds
R: bt12 – bt10.8	> 0
G: bt10.8-bt8.7	< 0.5 in North America < 4 in North Africa and Arabian Peninsula
B: bt10.8	> 273

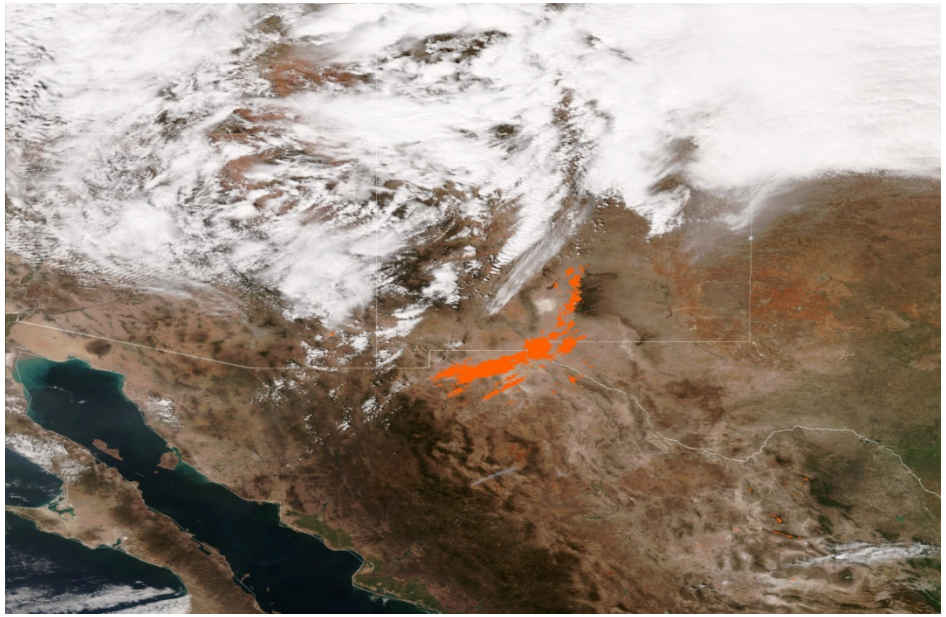
20161217 1902



20161217 2043

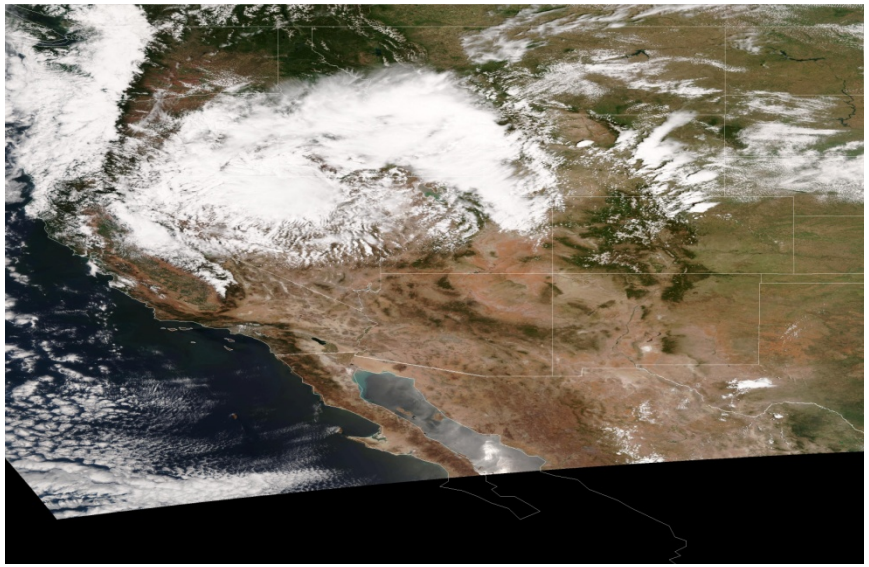


20170331

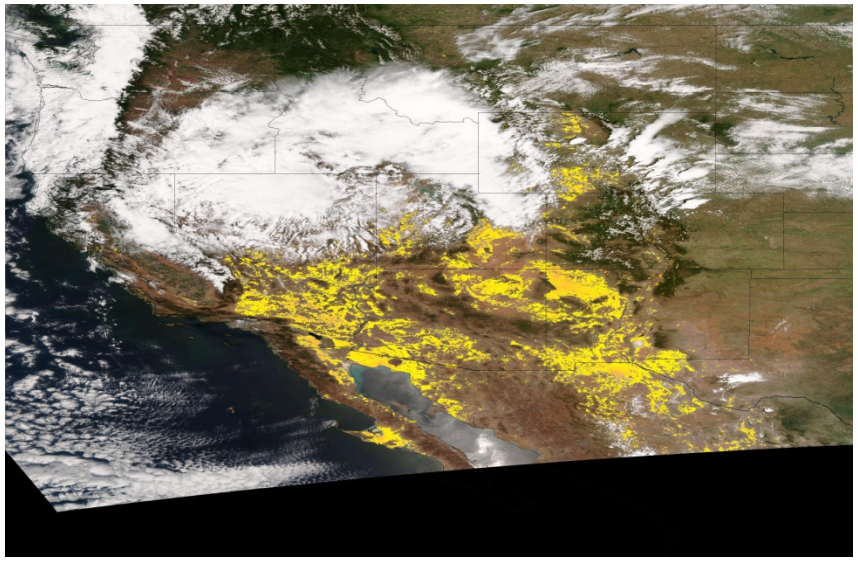


Dust mask (brown color regions) using IR bands for the three cases

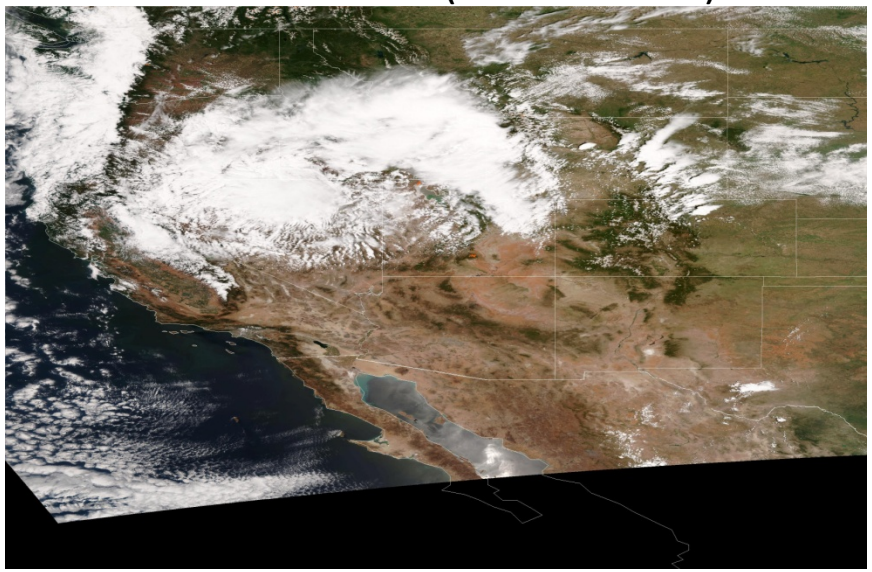
20170612 RGB



20170612 RGB ADP



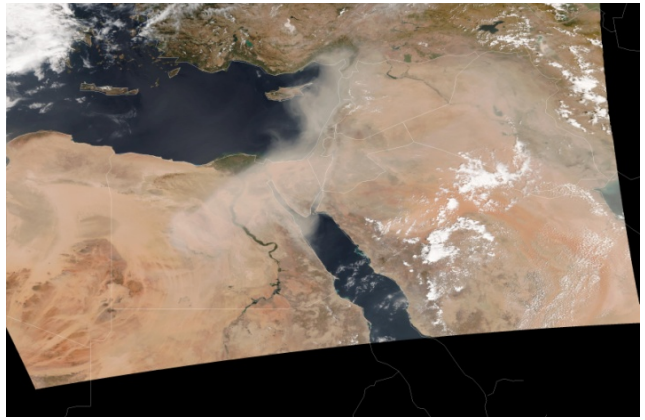
20170612 RGB IRDM (IR dust mask)



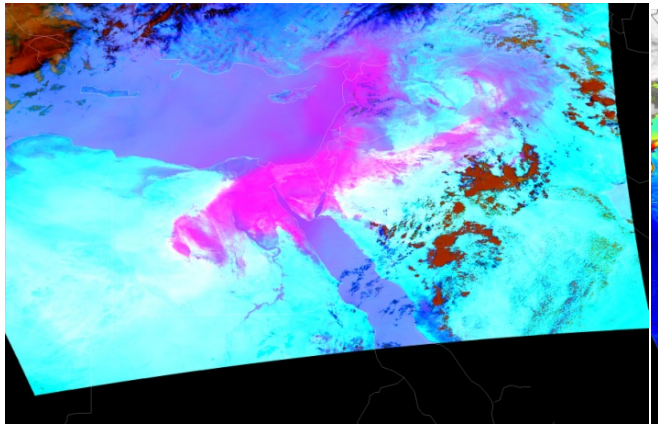
Another case with no dust

20150909 North Africa and Arabian Peninsula

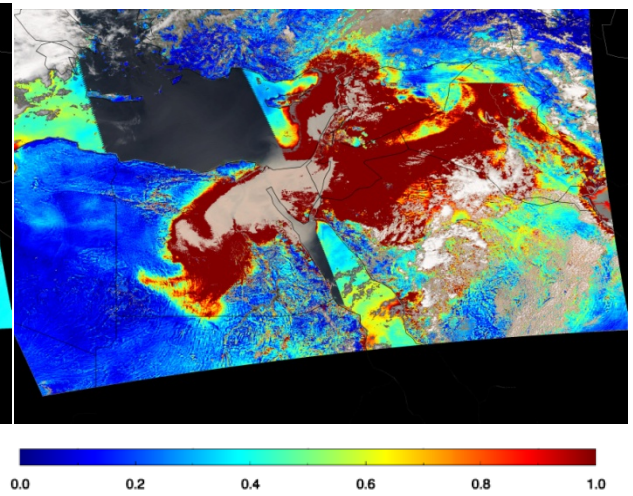
RGB



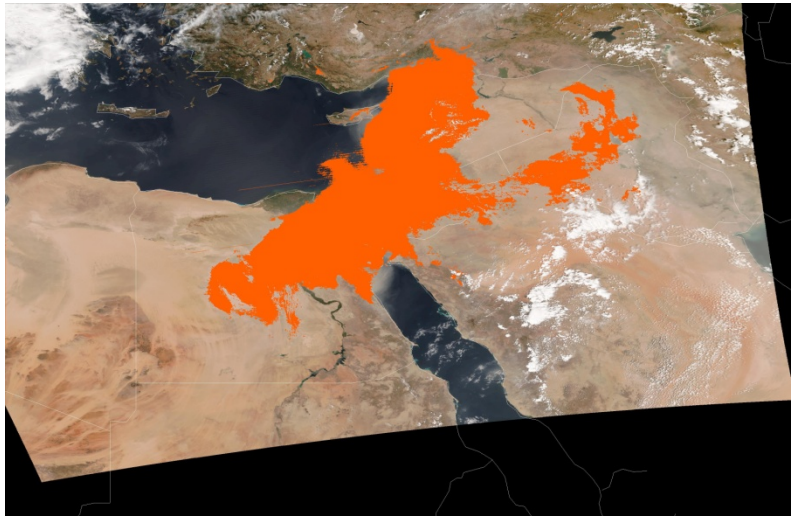
Dust RGB



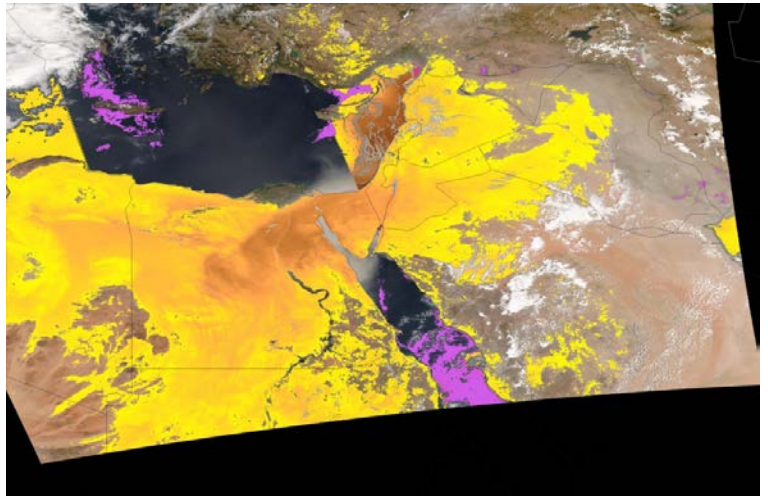
AOD



IRDM

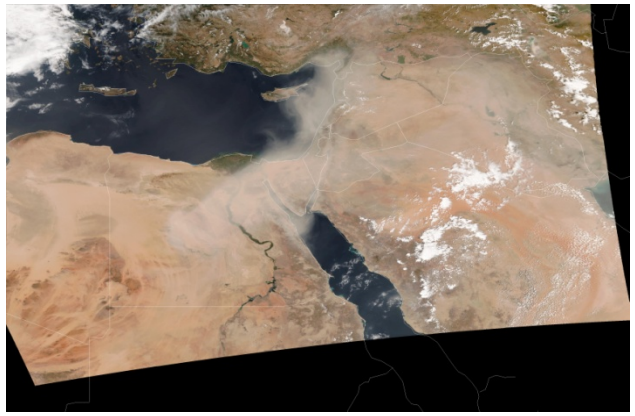


ADP

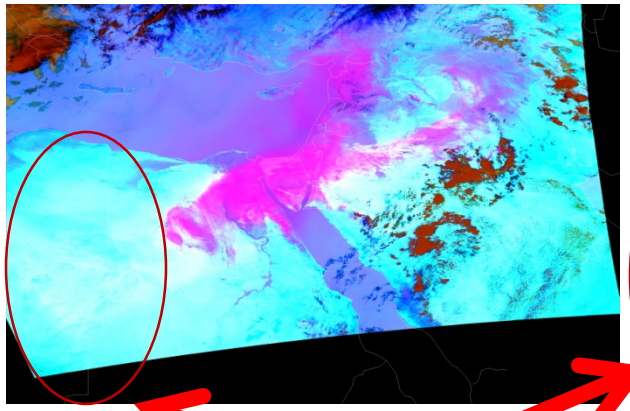


20150909 North Africa and Arabian Peninsula

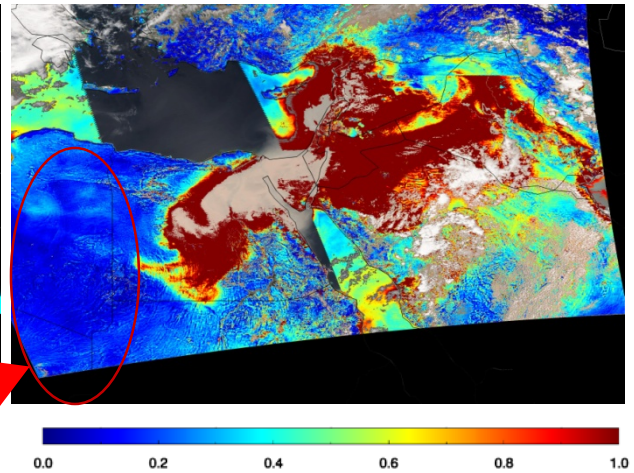
RGB



Dust RGB

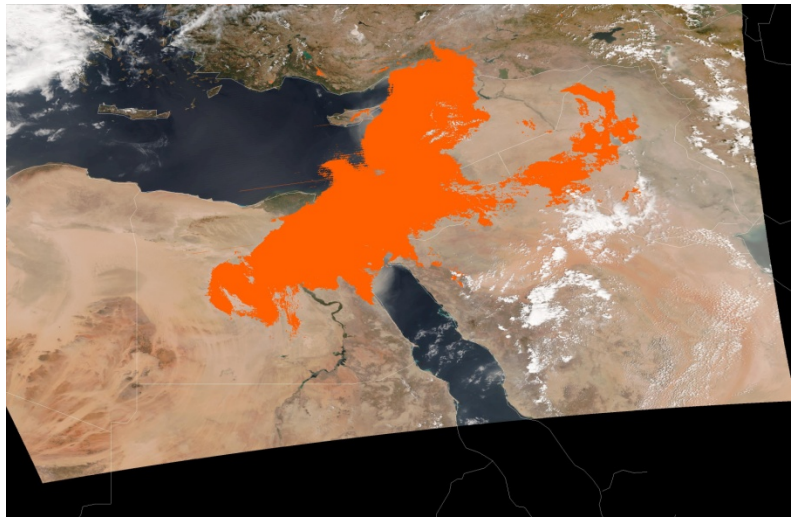


AOD

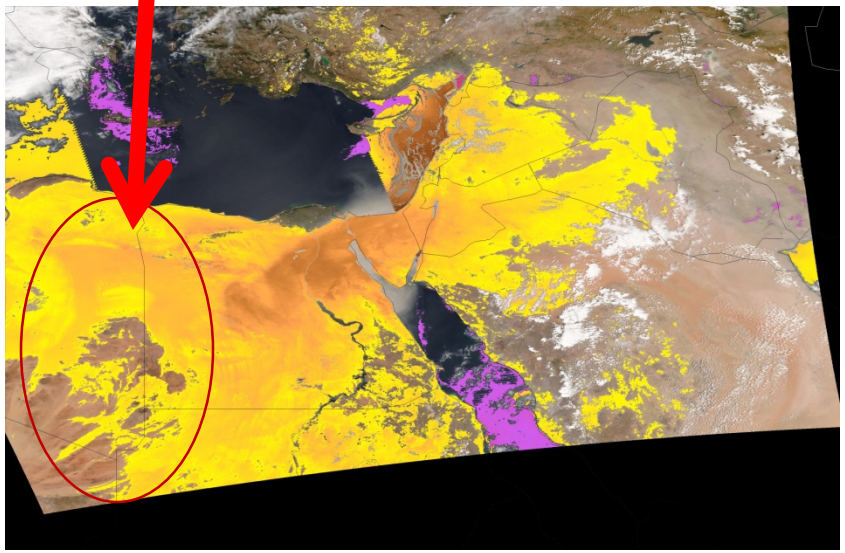


False detection in ADP

IRDM

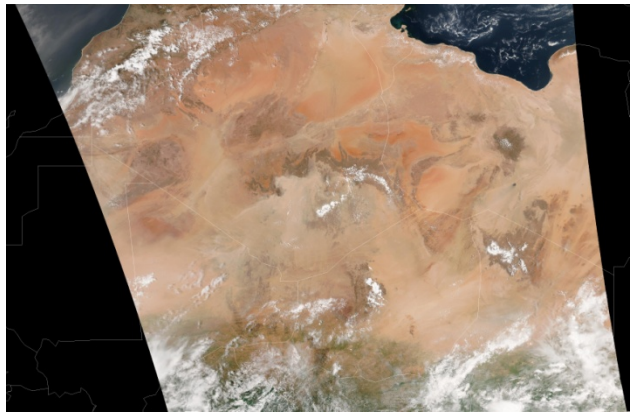


ADP

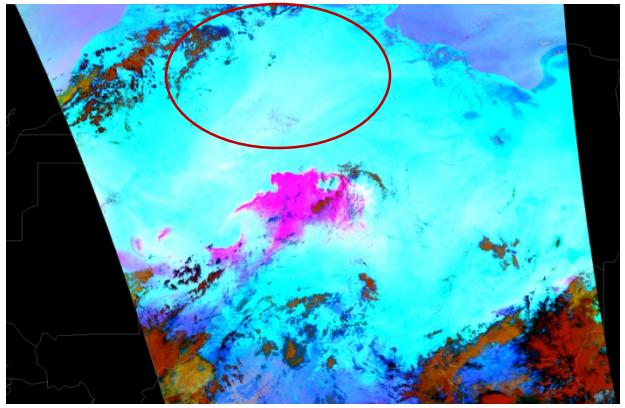


Another case in North Africa 20130823

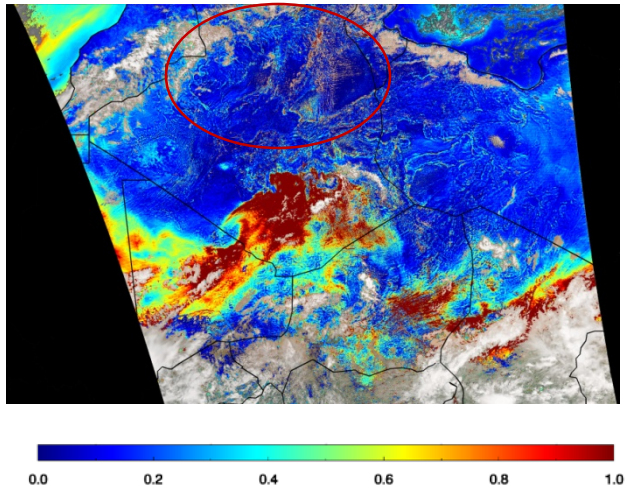
RGB



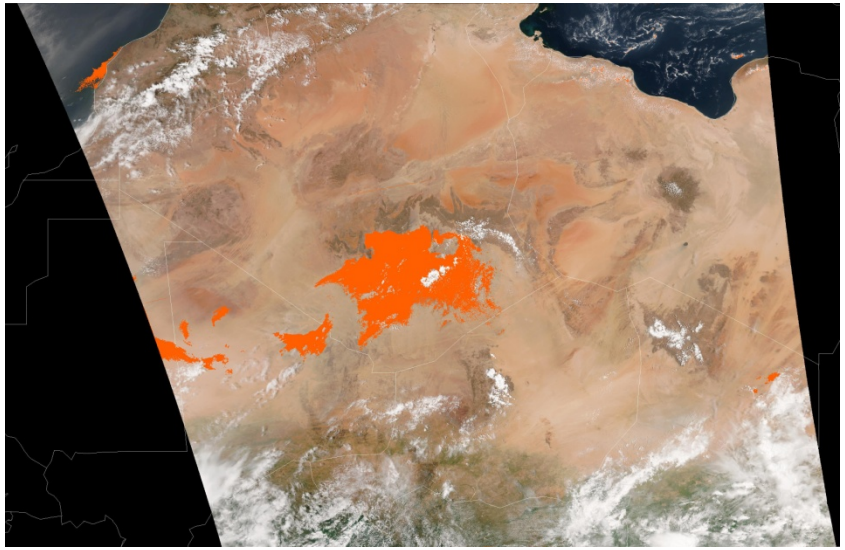
Dust RGB



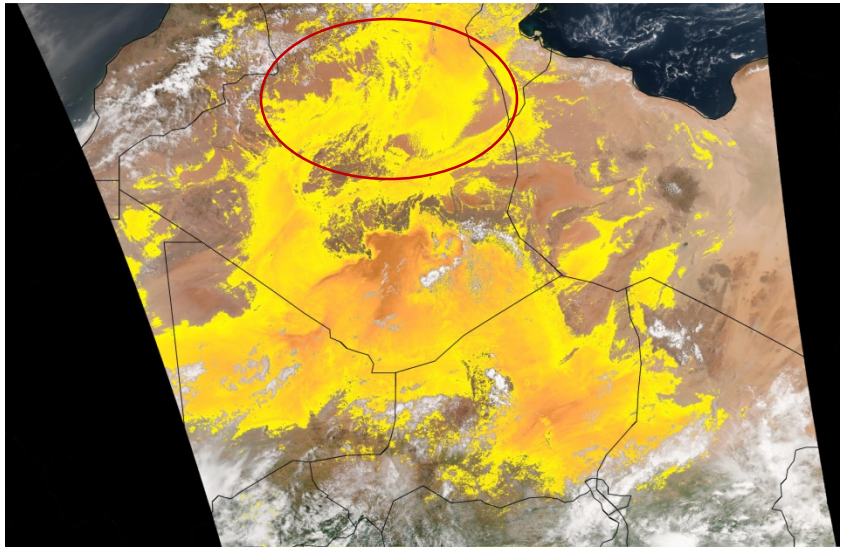
AOD



IRDM



ADP



Summary

- Current ADP dust detection over land using deep blue bands has many areas of false detections
  - Less or no sensitivity of AAI to the aerosol load in some geometries and surface conditions
- An alternative dust detection method based on IR bands is proposed
- Case studies show that using IR bands for dust detection can greatly reduce false detections