SNPP and NOAA-20 VIIRS Aerosol Product Update

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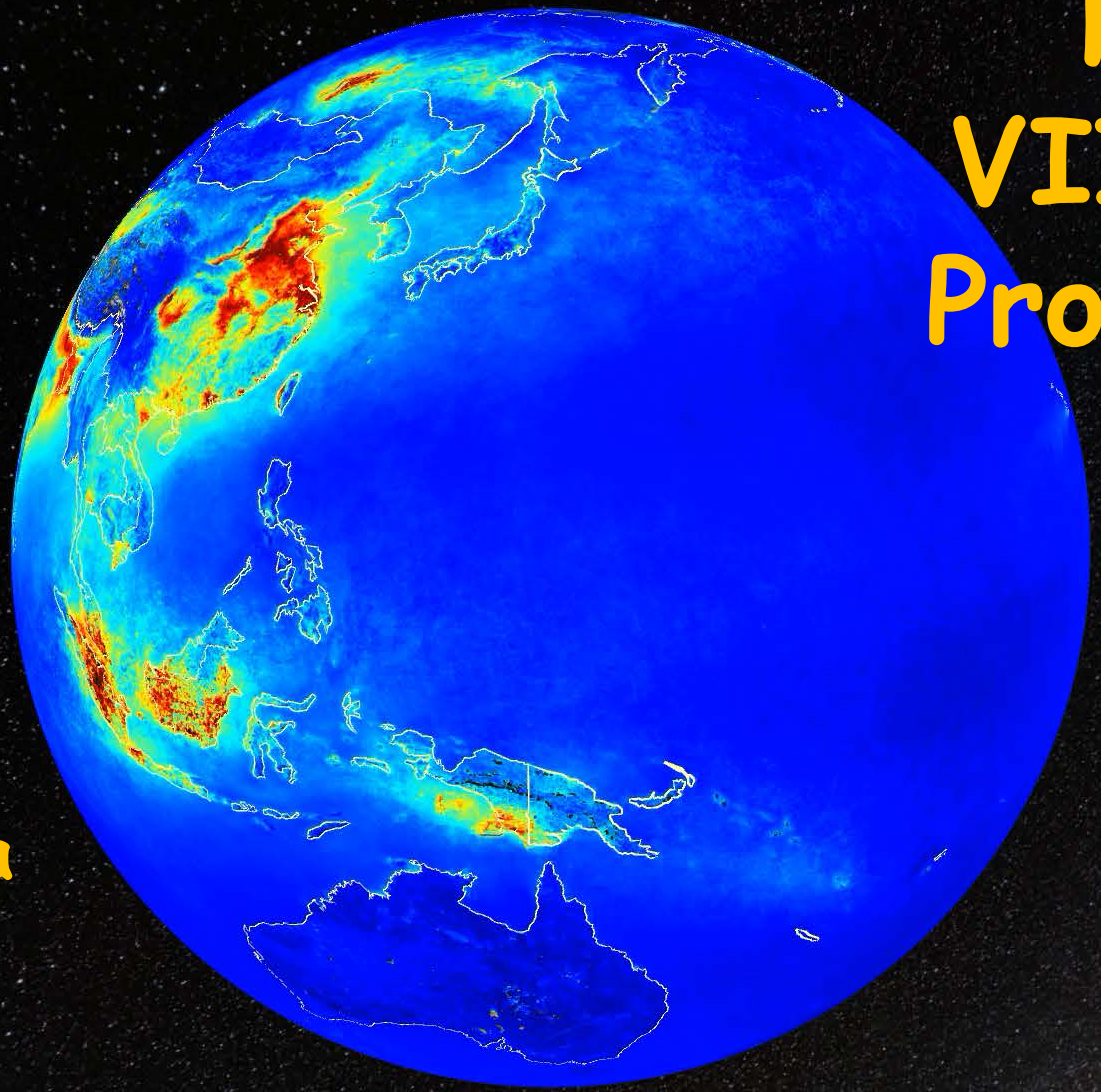


Shobha Kondragunta
NOAA/NESDIS/STAR

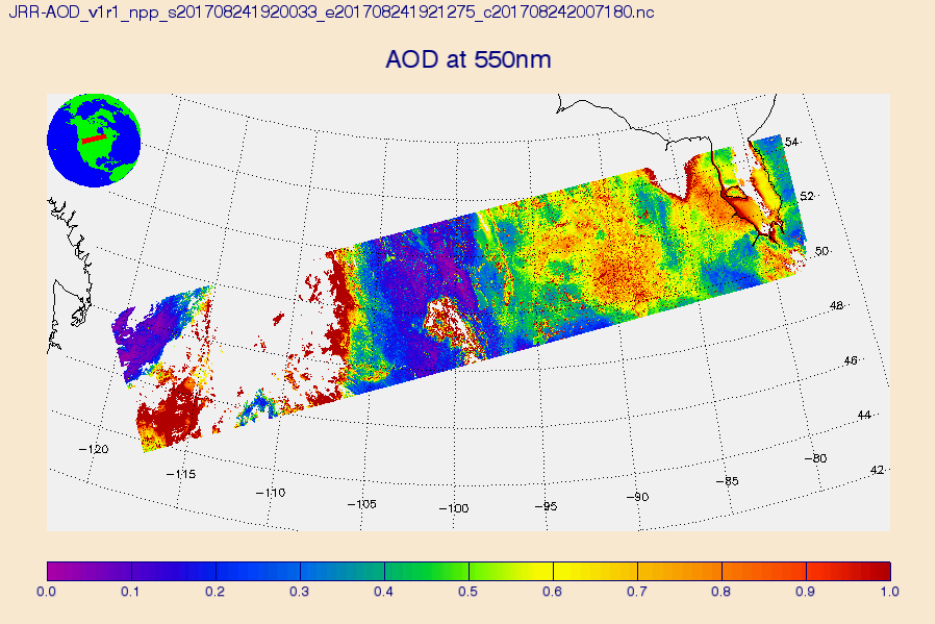
Playing

SHOBHA Dataset
Altitude: 6000 mi
NOAA's Earth System Research Laboratory

JPSS Aerosol Team

Name	Organization	Major Task
Pubu Ciren	IMSG	Aerosol detection product development and validation
Amy Huff	PSU	Product assessment & User (forecasters) feedback, outreach
Edward J. Hyer	NRL	Product validation, assimilation activities
Shobha Kondragunta	NOAA	Co-lead (PI for aerosol detection)
Istvan Laszlo	NOAA	Co-lead (PI for aerosol optical depth)
Hongqing Liu	IMSG	Algorithm development, validation, visualization
Lorraine A. Remer	UMBC	Documentation, liaison to Cloud Team
Arthur Russakoff	IMSG	Algorithm integration
Ivan Valerio	IMSG	Data management and monitoring
Hai Zhang	IMSG	Algorithm coding for and maintenance of eIDEA, AerosolWatch websites

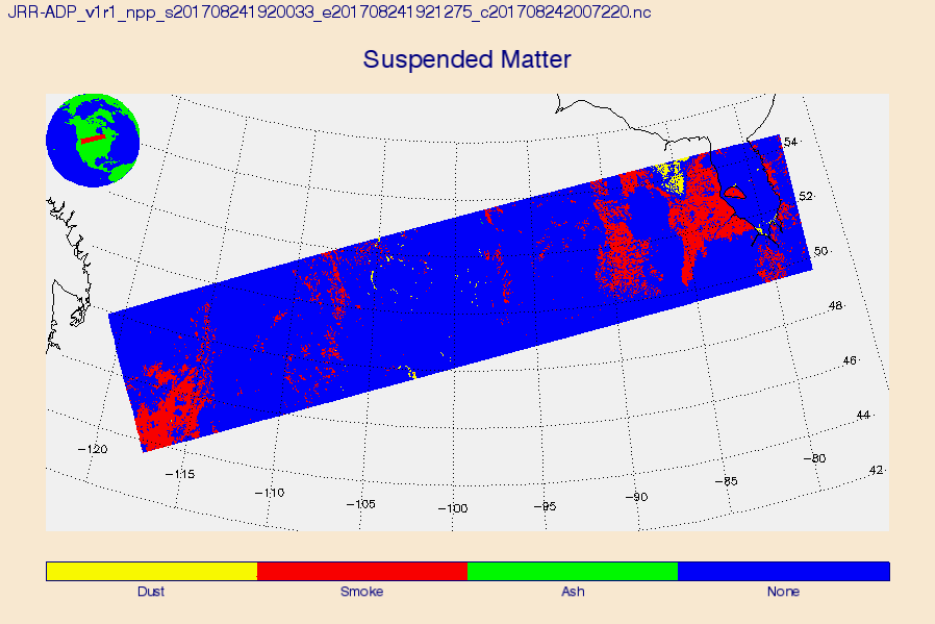
Aerosol Optical Depth (AOD)



- AOD: *quantitative* indicator of aerosol amount
- AOD is unitless; values typically range from 0 to 1 in the U.S.
- Higher AOD values correspond to higher aerosol concentrations
- AOD is not retrieved in cloudy regions
- Data are available as individual 86 seconds granule

- Multi-spectral aerosol retrieval algorithm
- Retrieval Coverage
  - Bright and dark surfaces except snow covered and glint regions
  - Product range -0.05 to 5.0
  - ~750 m resolution
- Extensive internal tests to throw away un-retrievable pixels

Aerosol Detection (smoke/dust/ash)



- ADP: *qualitative* indicator of aerosol type
- Smoke, dust, volcanic ash
- Absorbing Aerosol Index can be used as a proxy for intensity
- ADP is not retrieved in cloudy regions
- Data are available as individual 86 seconds granule

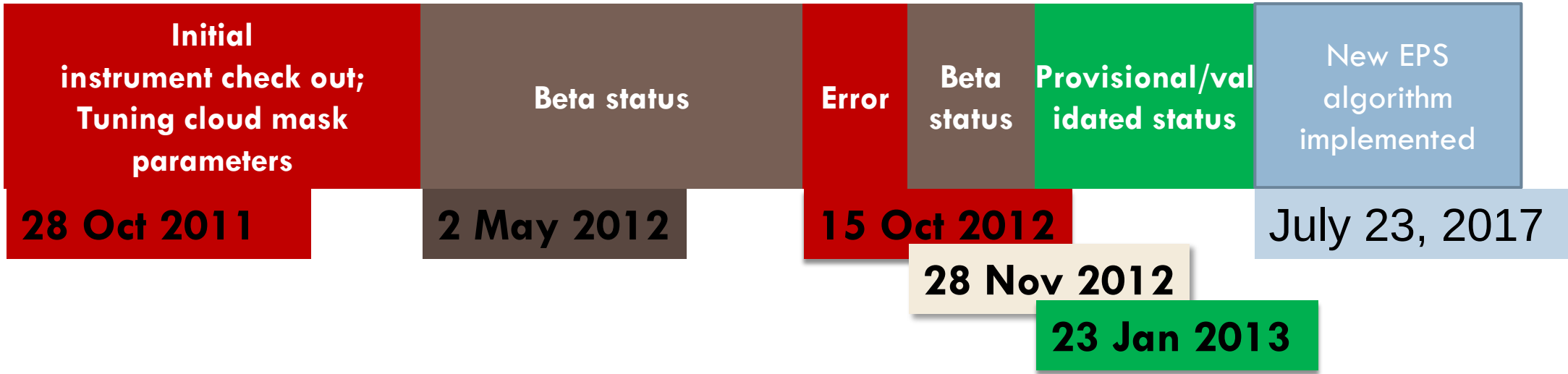
- Multi-path aerosol detection algorithm
  - Relies on absorbing aerosol index and dust smoke discrimination index derived using 412, 441, and 2250 nm
  - Uses spectral and spatial variability tests of various infrared bands
- Retrieval coverage
  - All surfaces except snow covered and glint regions
  - ~750 m resolution
- Future updates will include aerosol concentration

SNPP VIIRS Status

- SNPP launched on October 28, 2011
- AerosolWatch is providing the following products
  - AOD, True Color RGB, dust RGB, Fire hot spots, smoke/dust mask*, 48-hr trajectories
- CONUS and Alaska AOD data files are available via STAR FTP site but for historic data please go to CLASS at https://class.noaa.gov/

ftp://ftp.star.nesdis.noaa.gov/pub/smcd/hzhang/VIIRS_EPS_NRT

AOD



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ftp://ftp.star.nesdis.noaa.gov/pub/smcd/hzhang/VIIRS_EPS_NRT

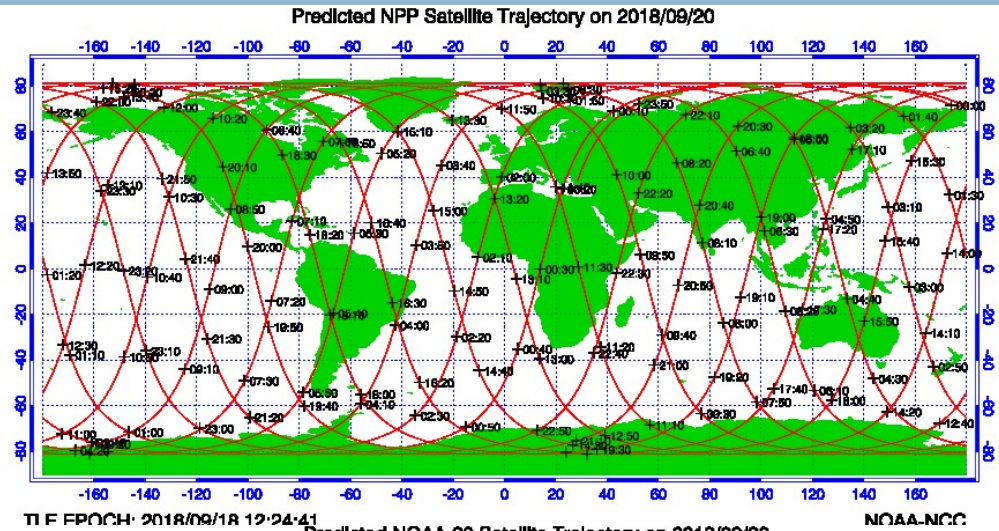
ADP

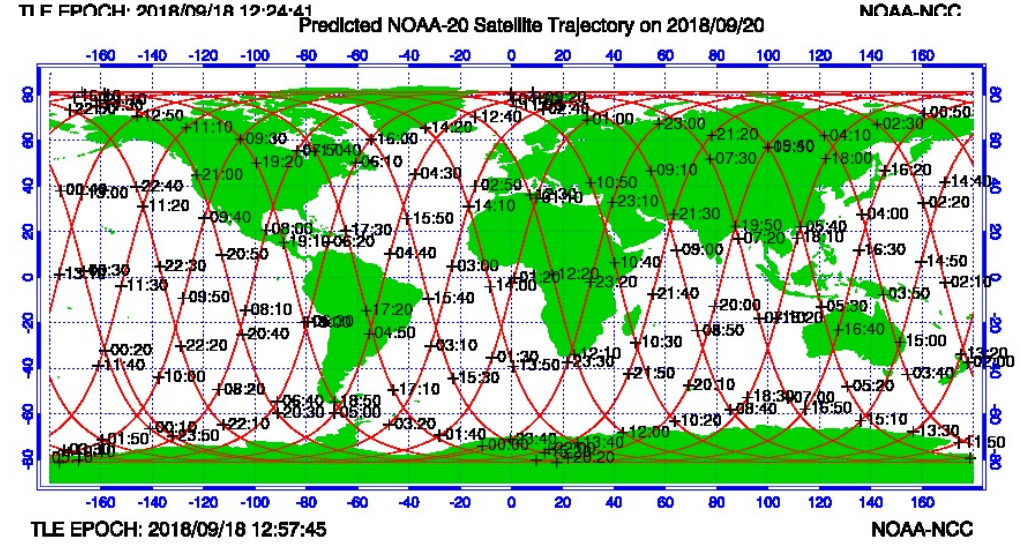
Initial instrument check out; Tuning cloud mask parameters	New EPS algorithm implemented
28 Oct 2011	July 23, 2017

NOAA-20 VIIRS Status

- SNPP launched on November 18, 2017
- NOAA-20 is in the same orbit as SNPP but 50 minutes behind
- AOD and ADP products have reached provisional status April 2018 but products are still not available at CLASS. Data availability TBD
- AerosolWatch is providing the following products
  - AOD, True Color RGB, dust RGB, Fire hot spots, smoke/dust mask*, 48-hr trajectories

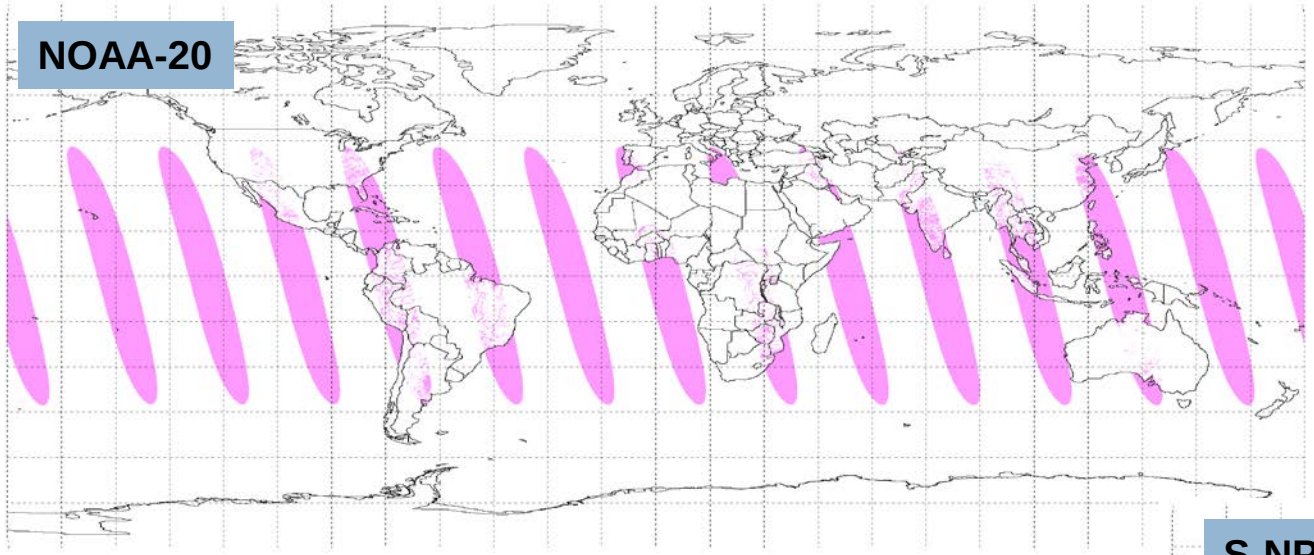
*algorithm updates will be implemented by end of September.
Product will have less false positives for dust



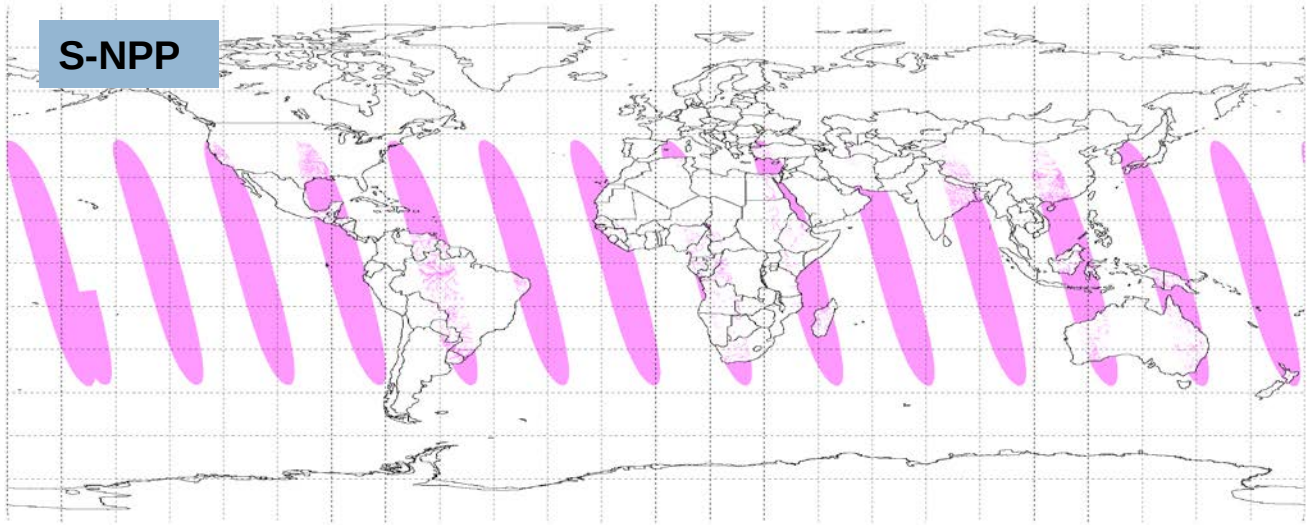


https://ncc.nesdis.noaa.gov/VIIRS/index.php

SNPP vs. NOAA-20 VIIRS



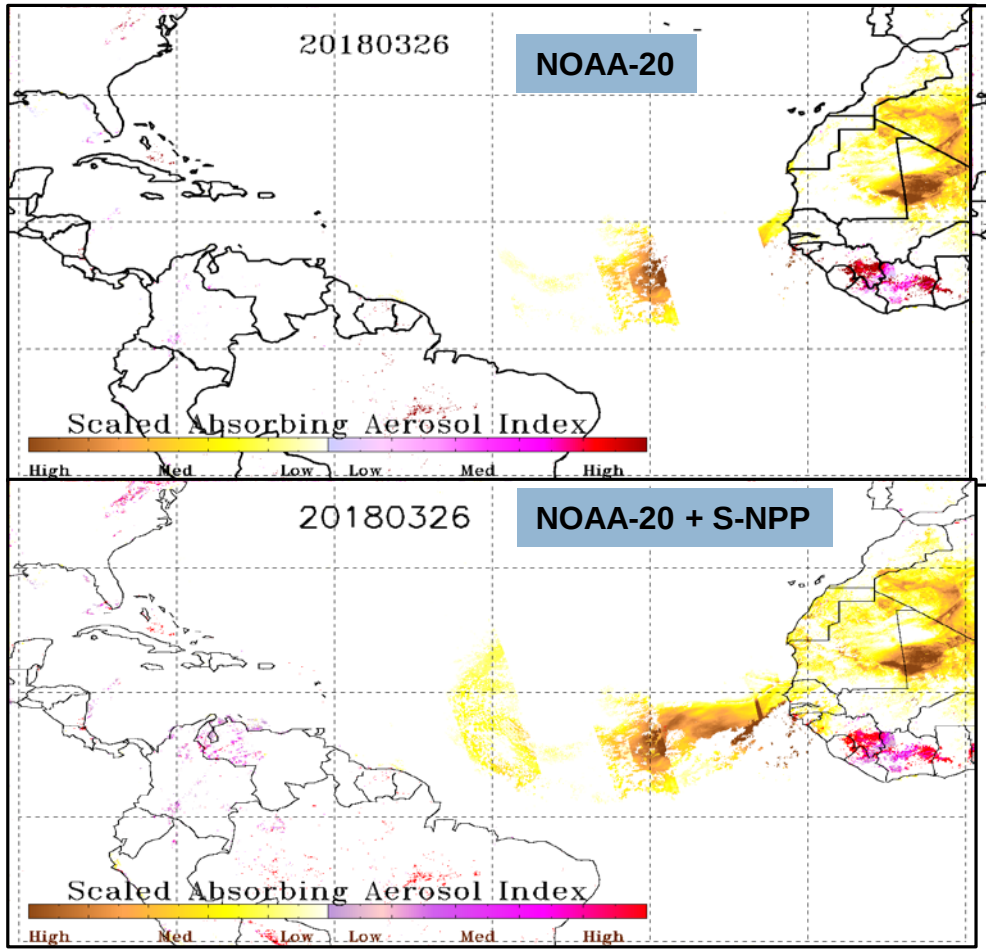
$0 < \eta < 40^0$



$\mathrm{Cos}(\eta) = \mathrm{Cos}(\theta_0)*\mathrm{Cos}(\theta)+\mathrm{Sin}(\theta_0)*\mathrm{Sin}(\theta)*\mathrm{Cos}(180-\varphi)$

η is the sunglint angle; θ_0 is the solar zenith angle
θ is the satellite zenith angle; φ is the relative azimuth angle

SNPP vs. NOAA-20 VIIRS



By combining ADP from NOAA-20 with ADP from S-NPP will increase the coverage

S-NPP/N-20 Product(s) Overview

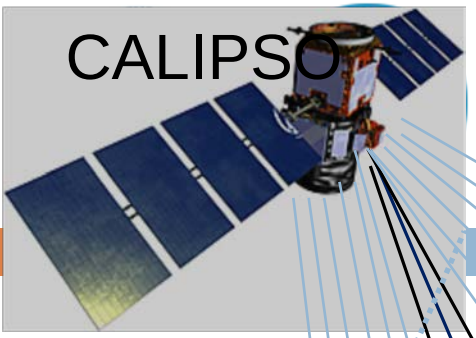
- Product(s) Performance Summary (1/7/2018 - 8/4/2018)

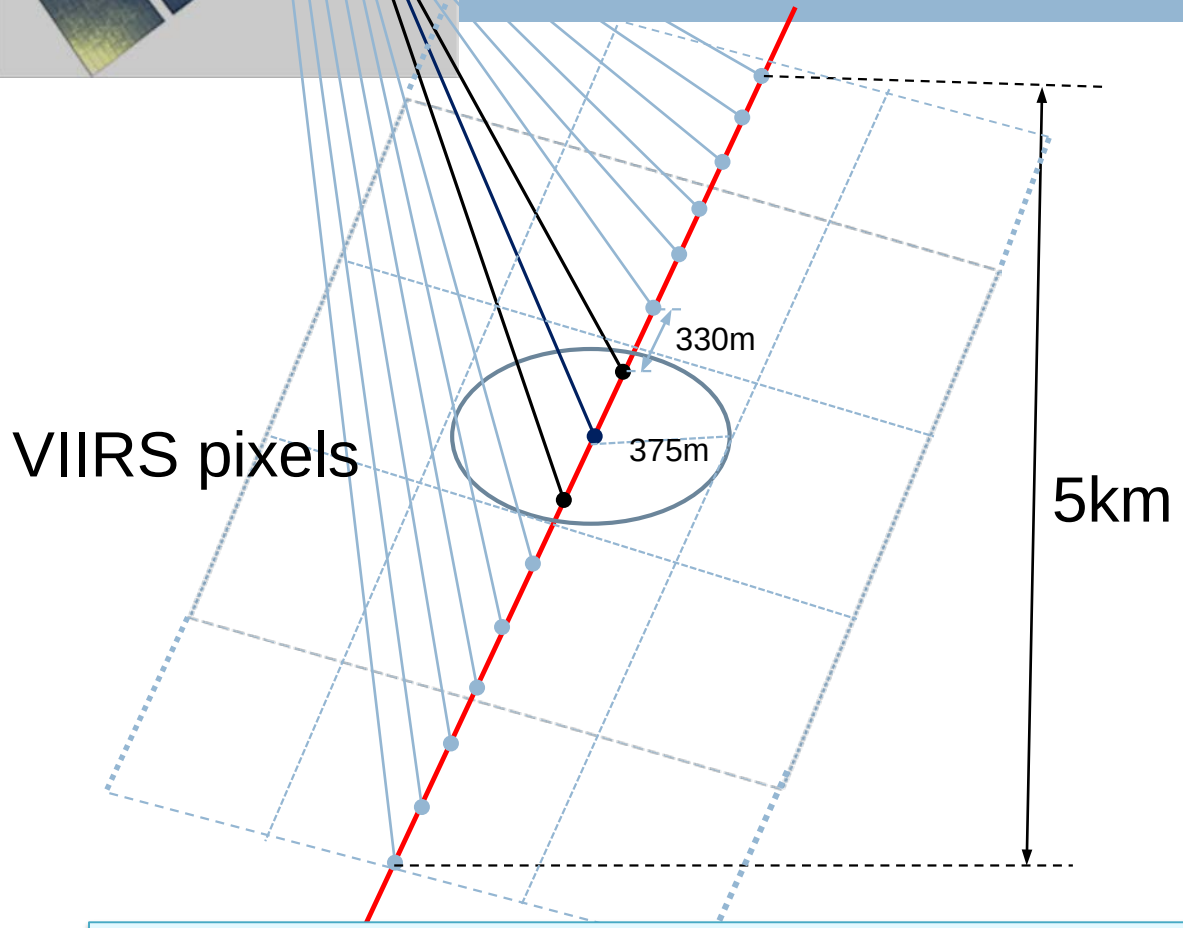
AOD	L1RDS A(P)	S-NPP	N-20
LAND			
AOD < 0.1	0.06 (0.15)	0.01 (0.05)	0.01 (0.05)
0.1 ≤ AOD ≤ 0.8	0.05 (0.25)	-0.04 (0.11)	-0.04 (0.11)
AOD > 0.8	0.20 (0.45)	-0.19 (0.34)	-0.18 (0.35)
WATER			
AOD < 0.3	0.08 (0.15)	0.02 (0.04)	0.01 (0.04)
AOD >= 0.3	0.15 (0.35)	-0.01 (0.11)	-0.03 (0.13)

APS	L1RDS A(P)	S-NPP	N-20
WATER			
550-860 nm	0.3 (0.6)	0.07 (0.39)	0.03 (0.45)
860-1610 nm	0.4 (0.6)	-0.04 (0.33)	0.01 (0.32)

Only High quality AOD and APS were used

Validation (VIIRS vs. CALIPSO)



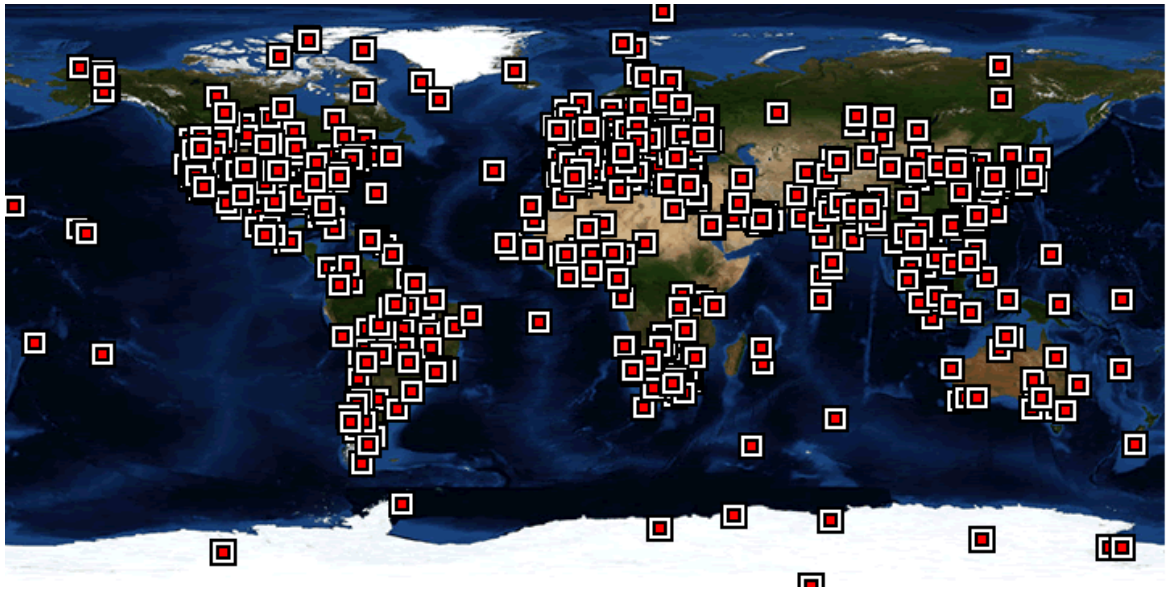


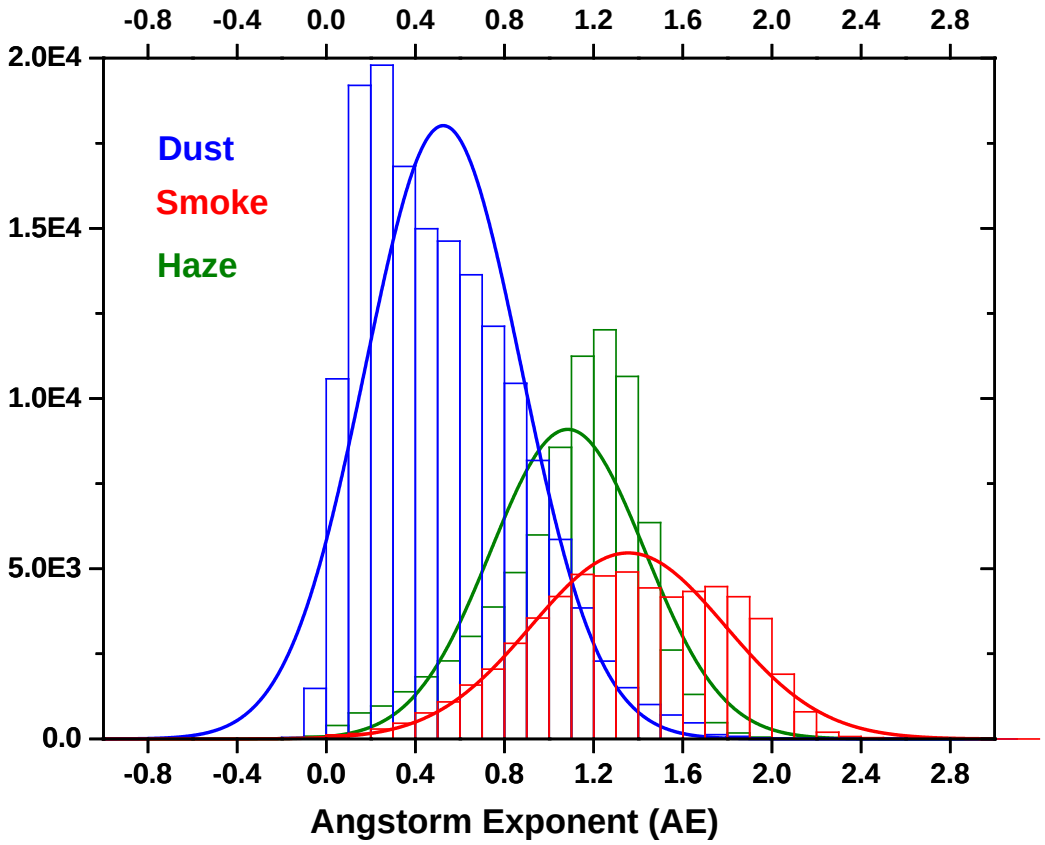
- Time difference: ±2 minutes
- Spatially , VIIRS pixels within ± 375m of the middle CALIPSO profile are selected.
- Middle three profiles are used to determine aerosol type in the column
  - All three profiles need to be cloud-free;
  - Dominant aerosol type is determined through the calculation of dust (or smoke) fraction (i.e., no of dust (or smoke) layers divided by the no. of aerosol layers from surface to 12km.
- VIIRS ADP data are filtered for high quality.

True Positive (TP): VIIRS and CALIPSO say dust
True Negative(TN): VIIRS and CALIPSO say no dust
False Negative(FN): VIIRS says no dust but CALIPSO says dust
False Positive(FP): VIIRS says dust when CALIPSO says no dust

POCD = TP/(TP+FN)
Accuracy = (TP+TN)/(TP+TN+FP+FN)
POFD = FP/(FP+TP)

Validation (VIIRS vs. AERONET)

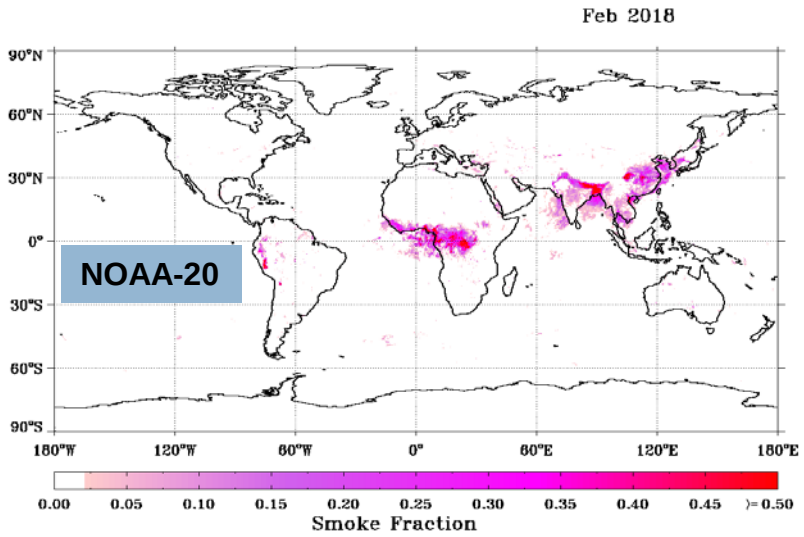


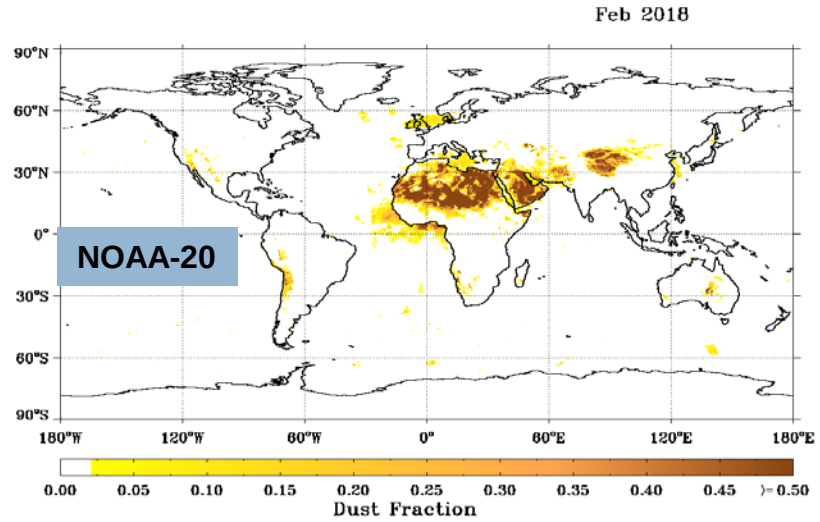


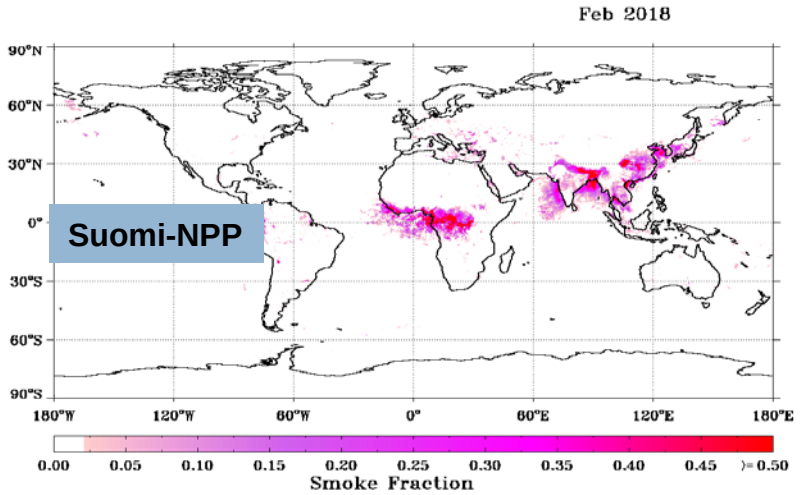
AERONET Smoke: AOD > 0.2 and Angstrom Exponent > 1.0
AERONET Dust: AOD > 0.2 and Angstrom Exponent < 0.5

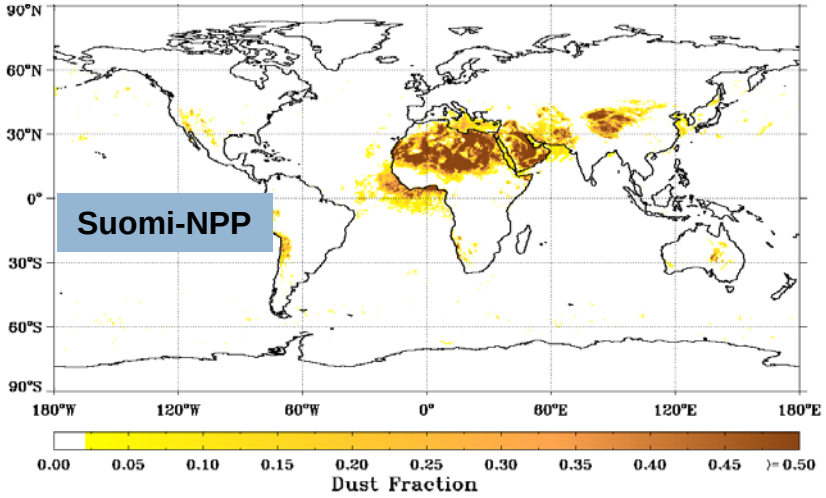
AERONET and NOAA-20 within ±30 min
NOAA-20 VIIRS > 750 pixels within 27.5 km radius of AERONET

VIIRS Smoke and Dust Fractions for February 2018 (0.25º x 0.25º)

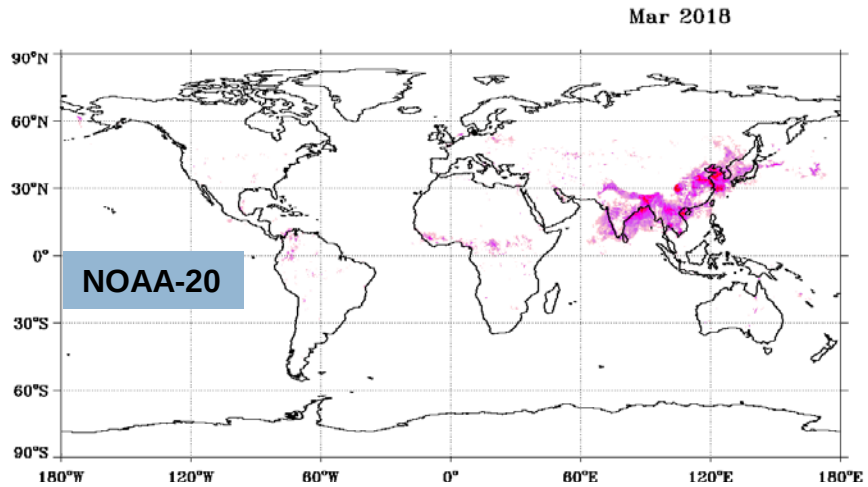


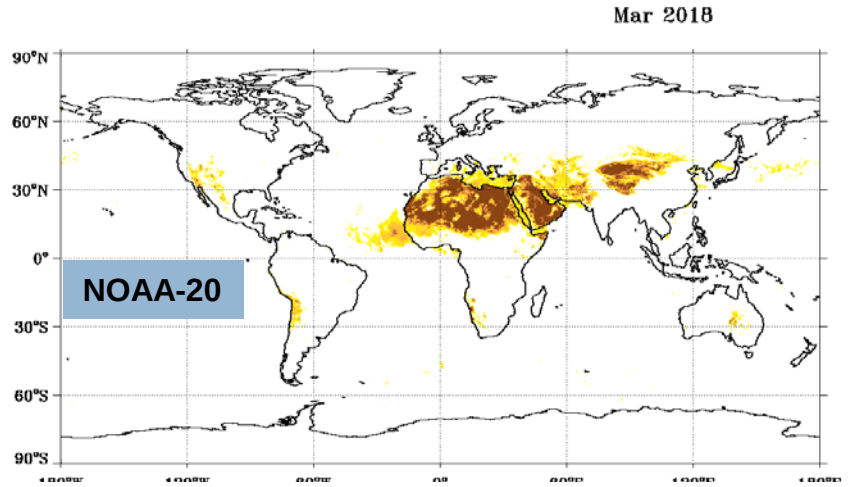


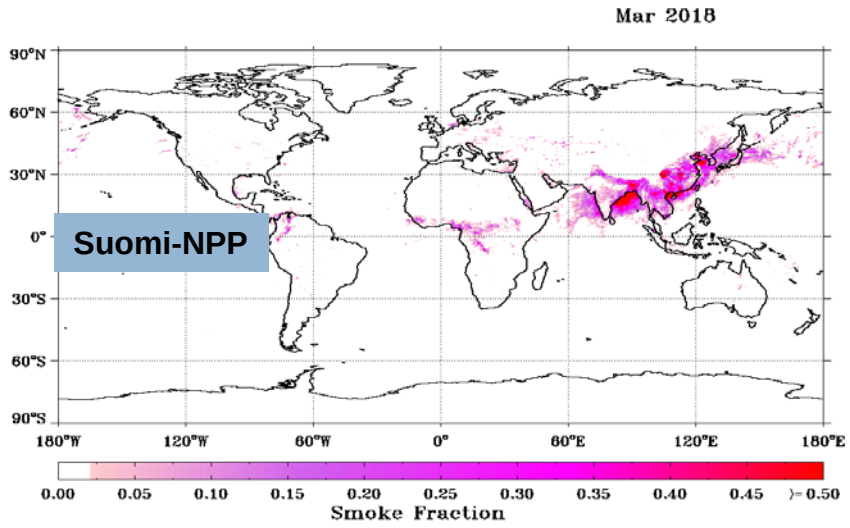


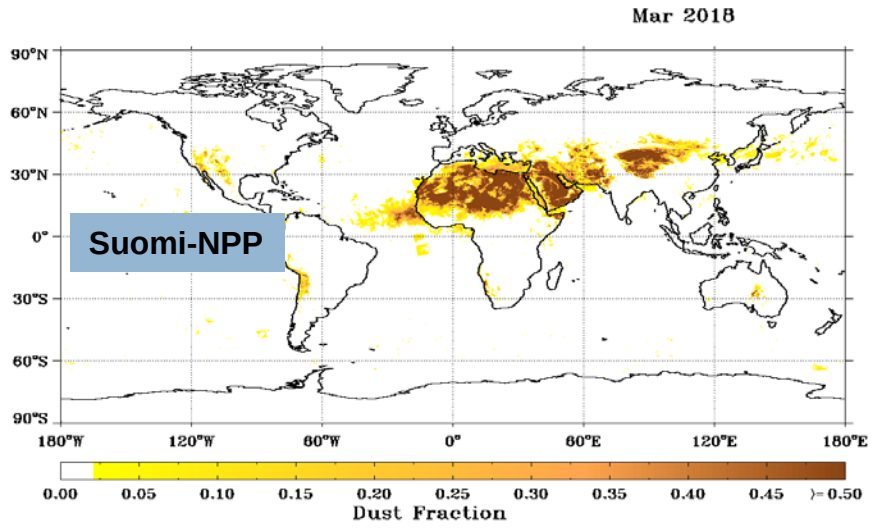


VIIRS Smoke and Dust Fractions fo March 2018 (0.25° x 0.25°)



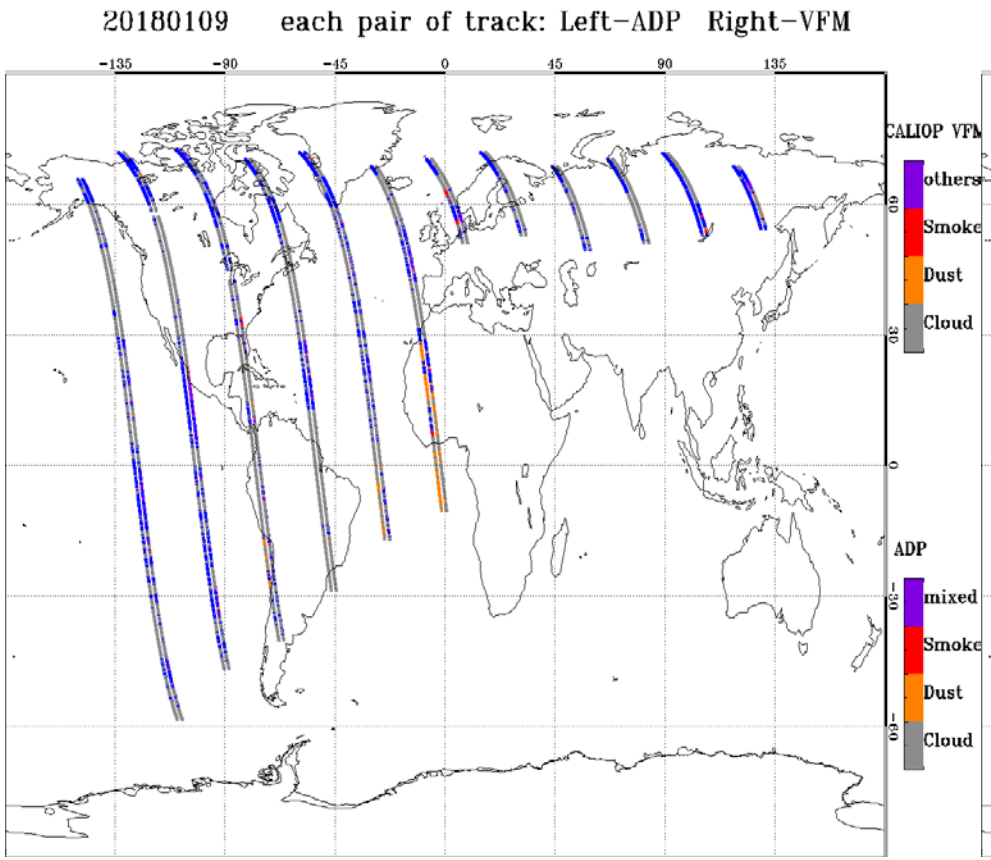




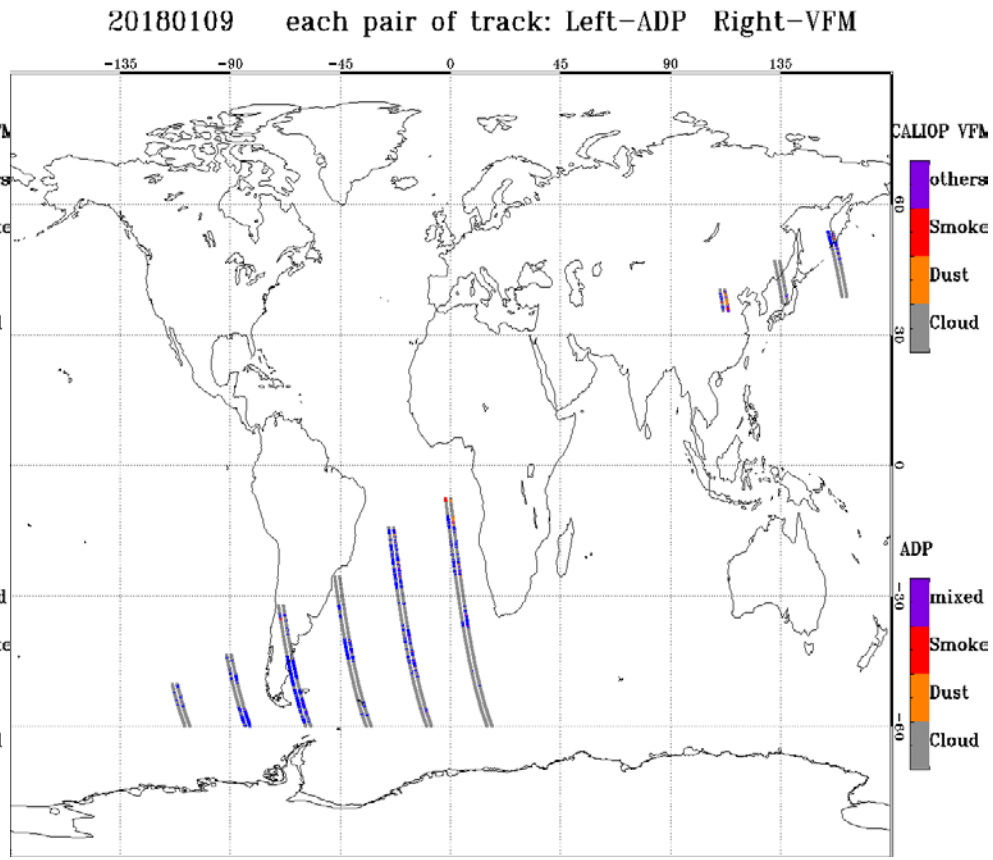


Validation (VIIRS ADP vs. CALIPSO VFM

NOAA-20 vs. CALIPSO VFM

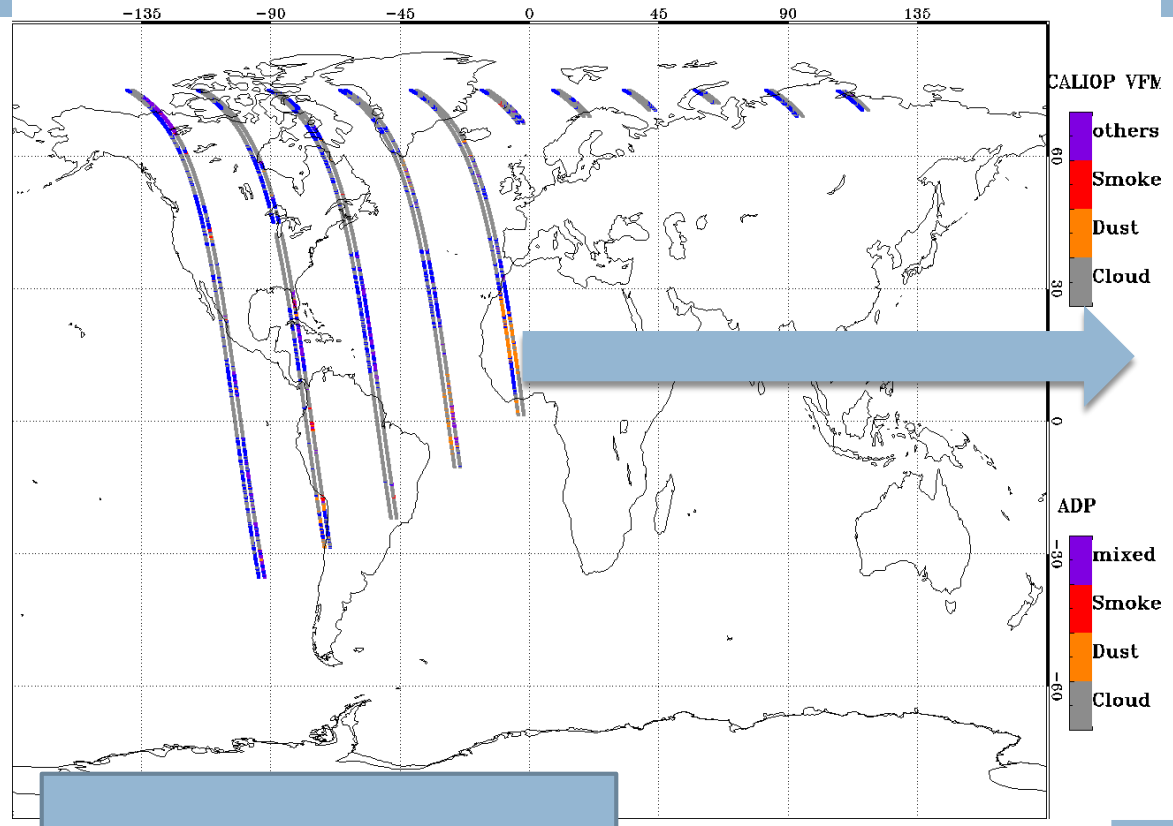


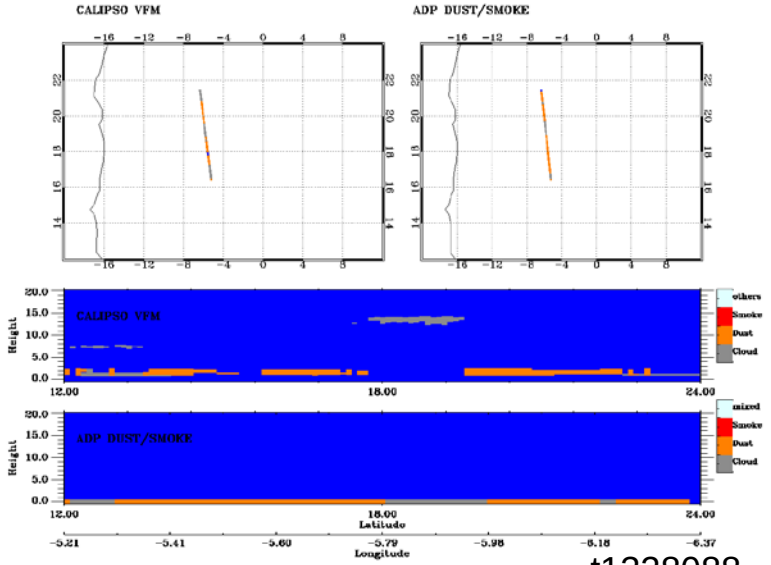
S-NPP vs. CALIPSO VFM



Validation (NOAA-20 VIIRS ADP vs. CALIPSO VFM)

Feb 10, 2018





For each pair of track:
Left: ADP right: CALISPO VFM

Accuracy	93%
POCD	89%

NOAA-20 and SNPP VIIRS ADP Validation Summary

January 9 – March 31, 2018

Smoke

Satellite	True positive	False positive	False negative	True negative	Accuracy	POCD	POFD
NOAA-20	103	39	21	2750	97.9	83.1	27.4
S-NPP	167	23	30	3804	98.6	84.7	12.1

Dust

Time Period	True positive	False positive	False negative	True negative	Accuracy	POCD	POFD
NOAA-20	7586	5202	603	22057	83.6	92.6	40.1
S-NPP	11312	7895	901	31229	82.9	92.6	41.1

Requirement of Correct Detection

Dust 80% over land; 80% over ocean
Smoke 80% over land; 70% over ocean

SNPP VIIRS ADP Validation Summary

Smoke

Satellite	True positive	False positive	False negative	True negative	Accuracy	POCD	POFD
S-NPP (NDE)	1589	316	64	25758	98.6	96.1	16.6

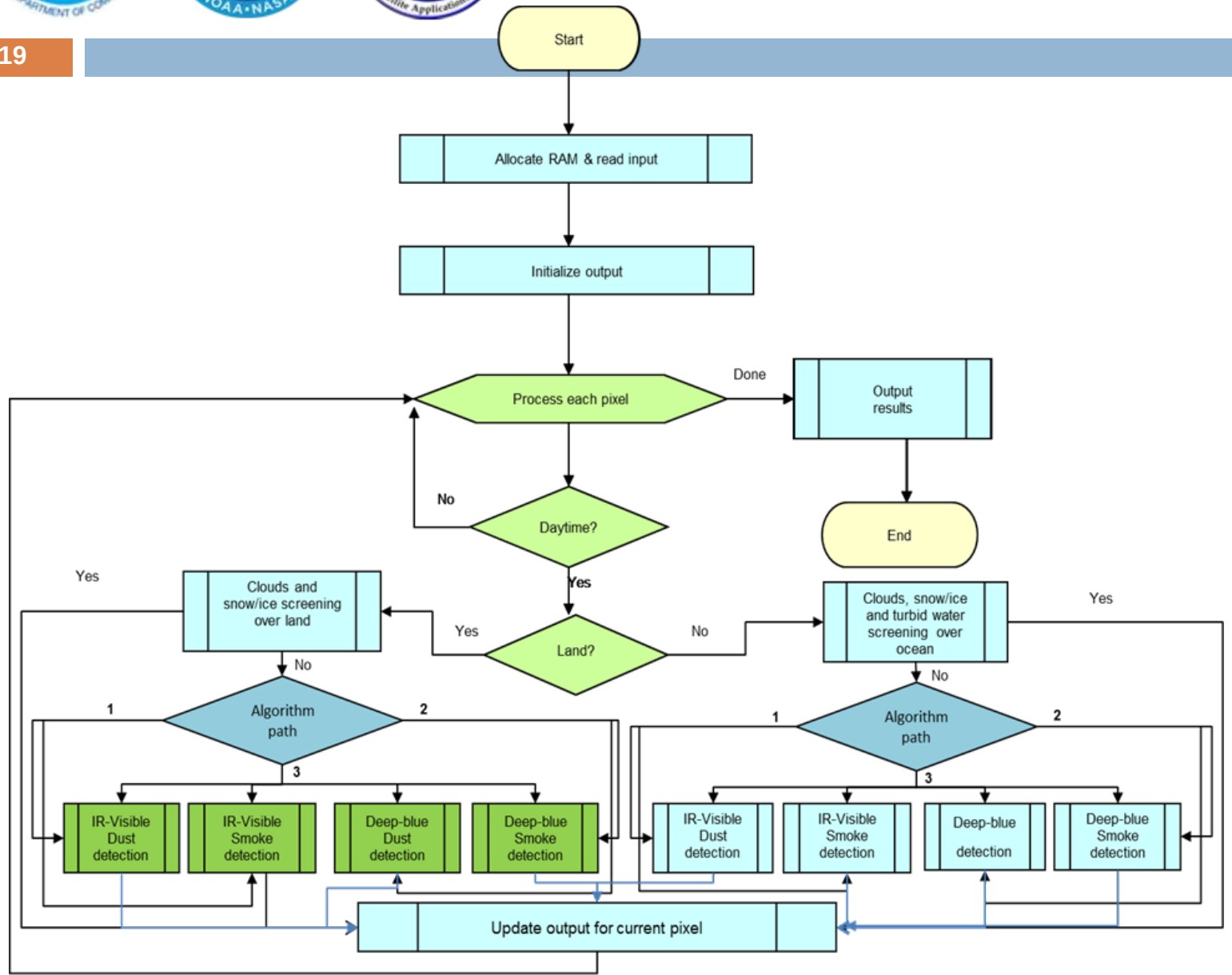
Dust

Time Period	True positive	False positive	False negative	True negative	Accuracy	POCD	POFD
S-NPP (NDE)	34051	21418	2666	86947	83.4	92.7	38.6

Requirement of Correct Detection

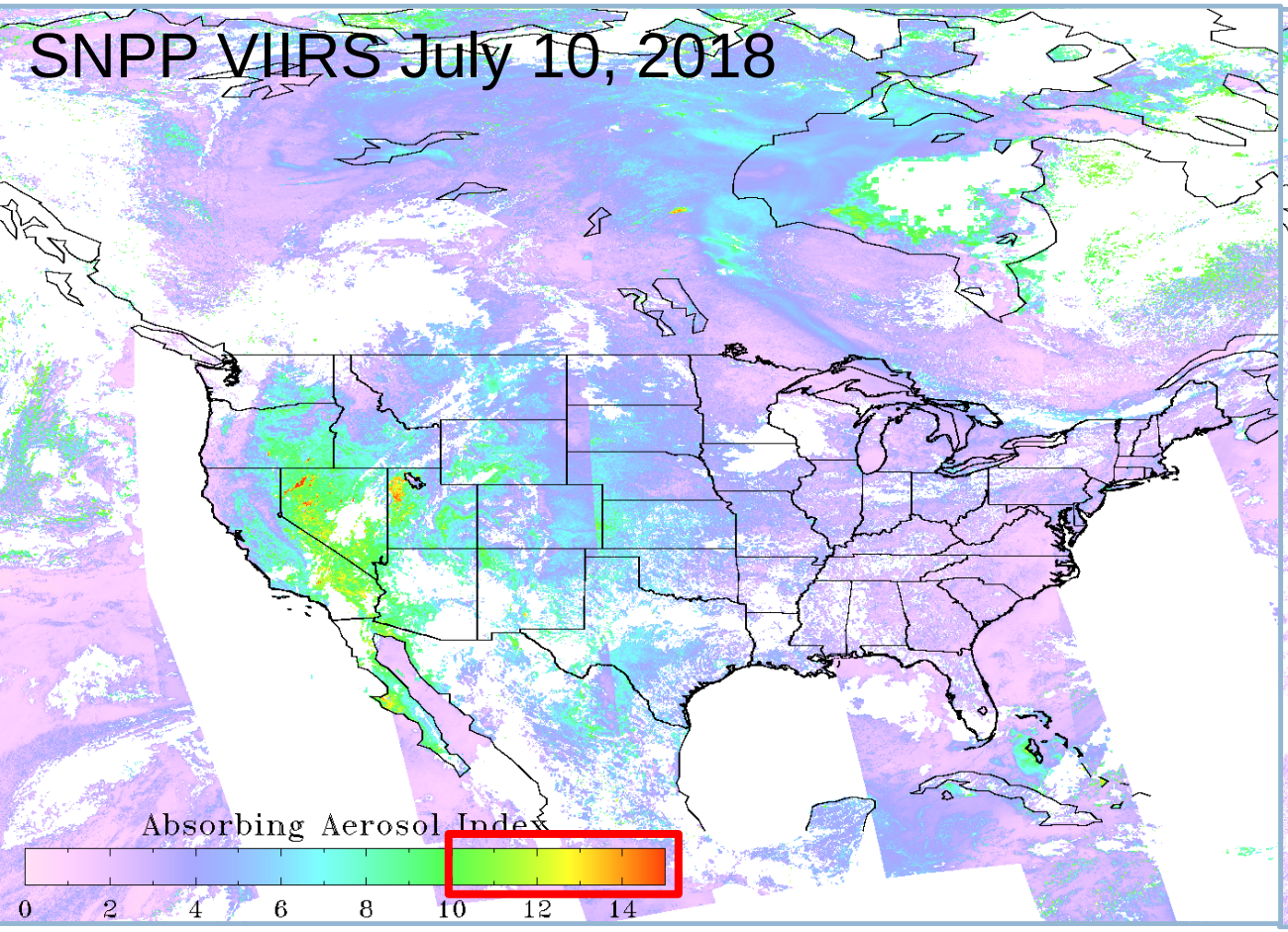
Dust 80% over land; 80% over ocean
Smoke 80% over land; 70% over ocean

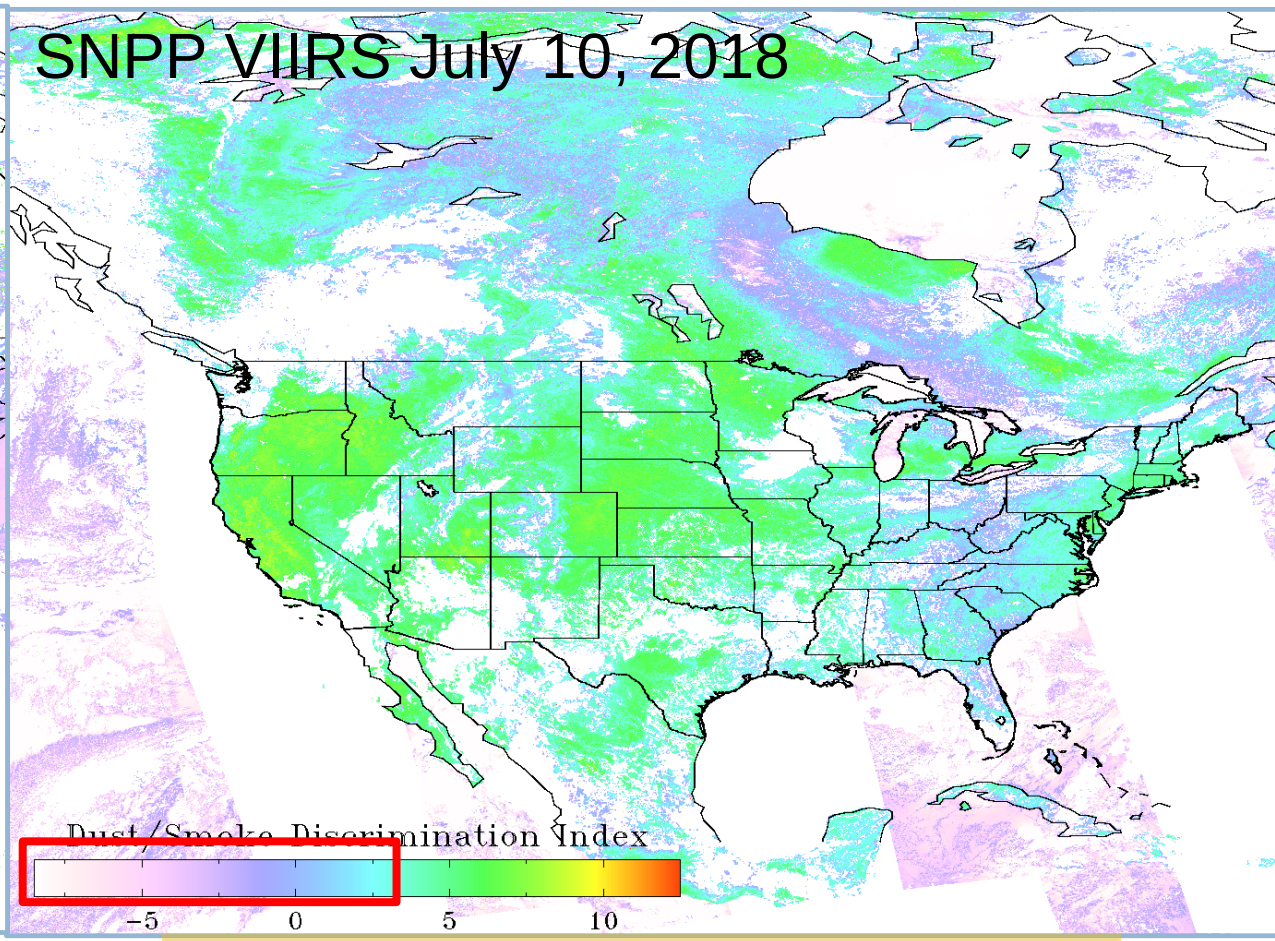
ADP Algorithm Flowchart



- Algorithm has two paths
  - Path that uses deep blue wavelengths to calculate aerosol indices
  - Path that uses IR-Visible wavelengths to derive dust/smoke mask using differential absorption features
- If dust or smoke detected by both paths, quality is set high.

Aerosol Indices





Absorbing Aerosol Index

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

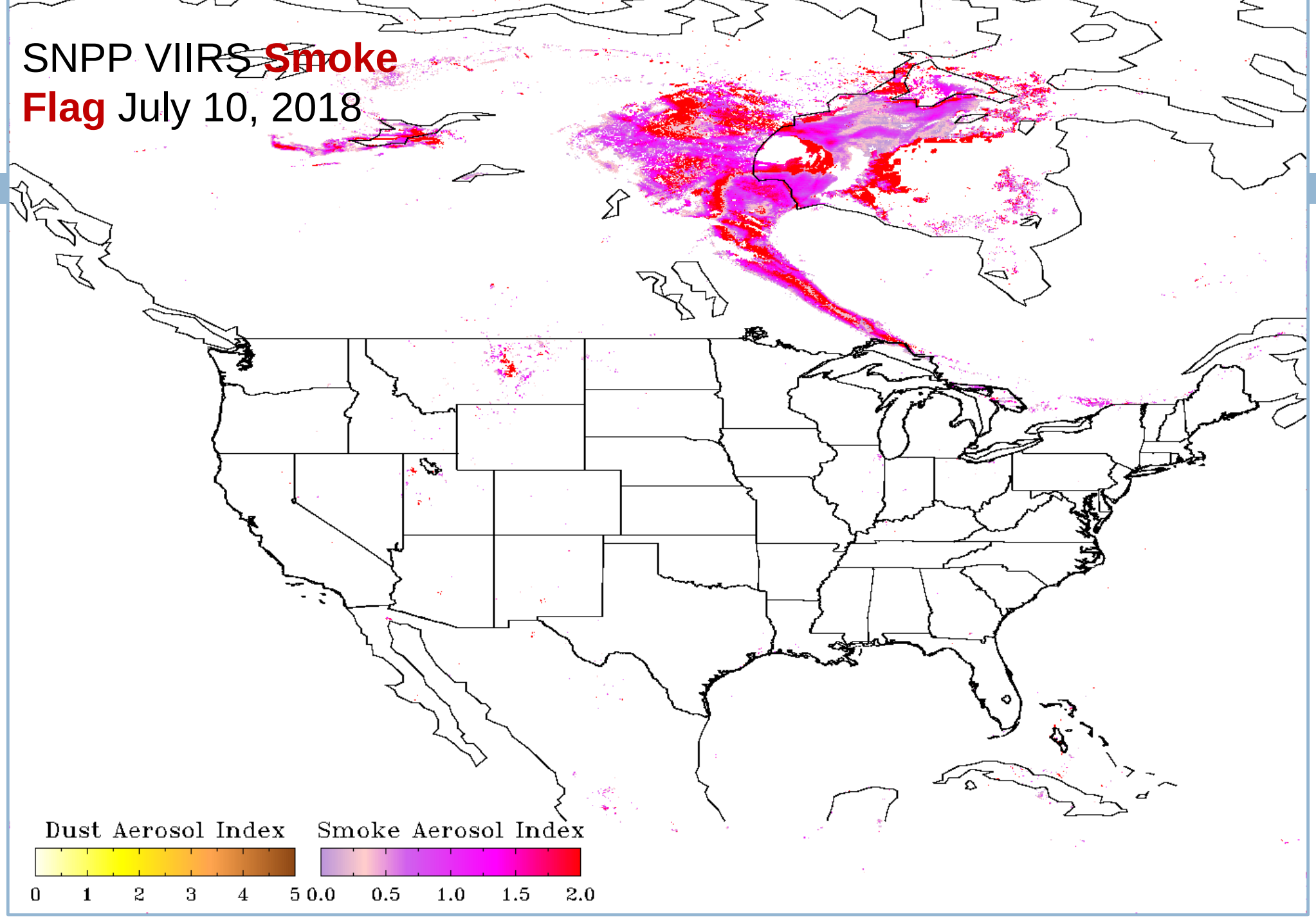
Dust Smoke Discrimination Index

$$DSDI = -10[\log_{10}(R_{412}/R_{2250})$$

Smoke detected if AAI > 10 and DSDI < 3

Dust detected if AAI > 10 and DSDI >0

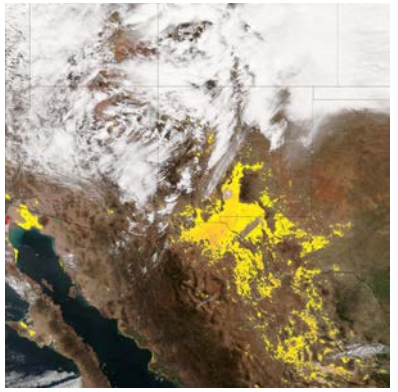
SNPP VIIRS **Smoke Flag** July 10, 2018



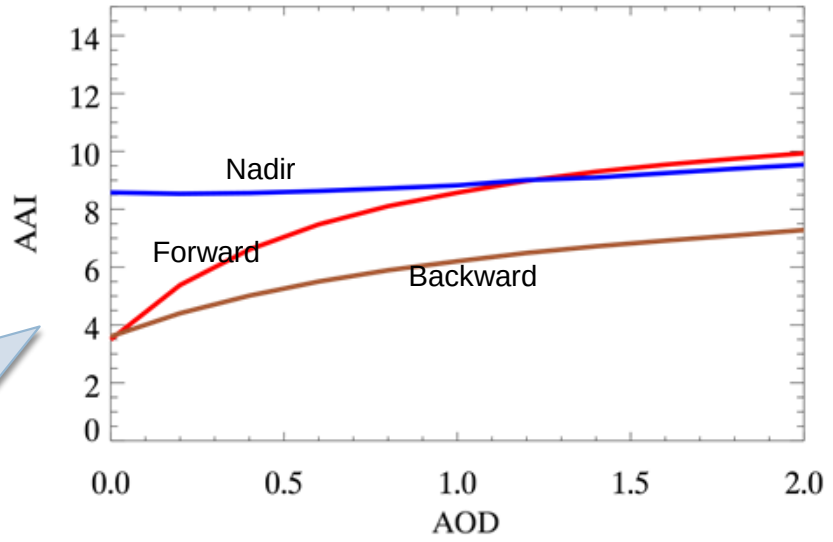
ADP Data Artifacts

$$AAI = -100\left[\log_{10}\left(\frac{R_{0.41}}{R_{0.44}}\right) - \log_{10}\left(\frac{R'_{0.41}}{R'_{0.44}}\right)\right]$$

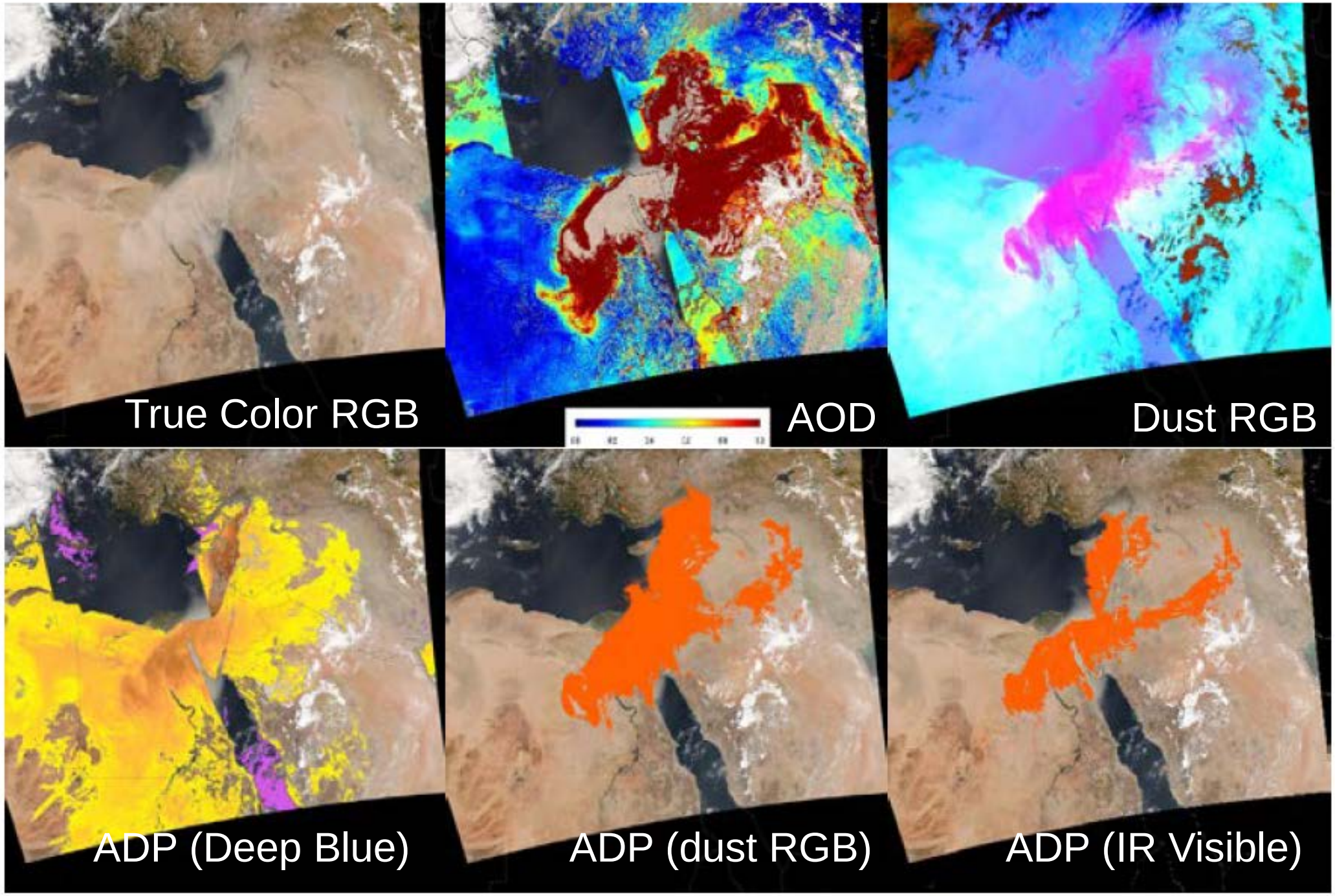
$$DSDI = -10\log_{10}\left(\frac{R_{0.41}}{R_{2.2}}\right)$$



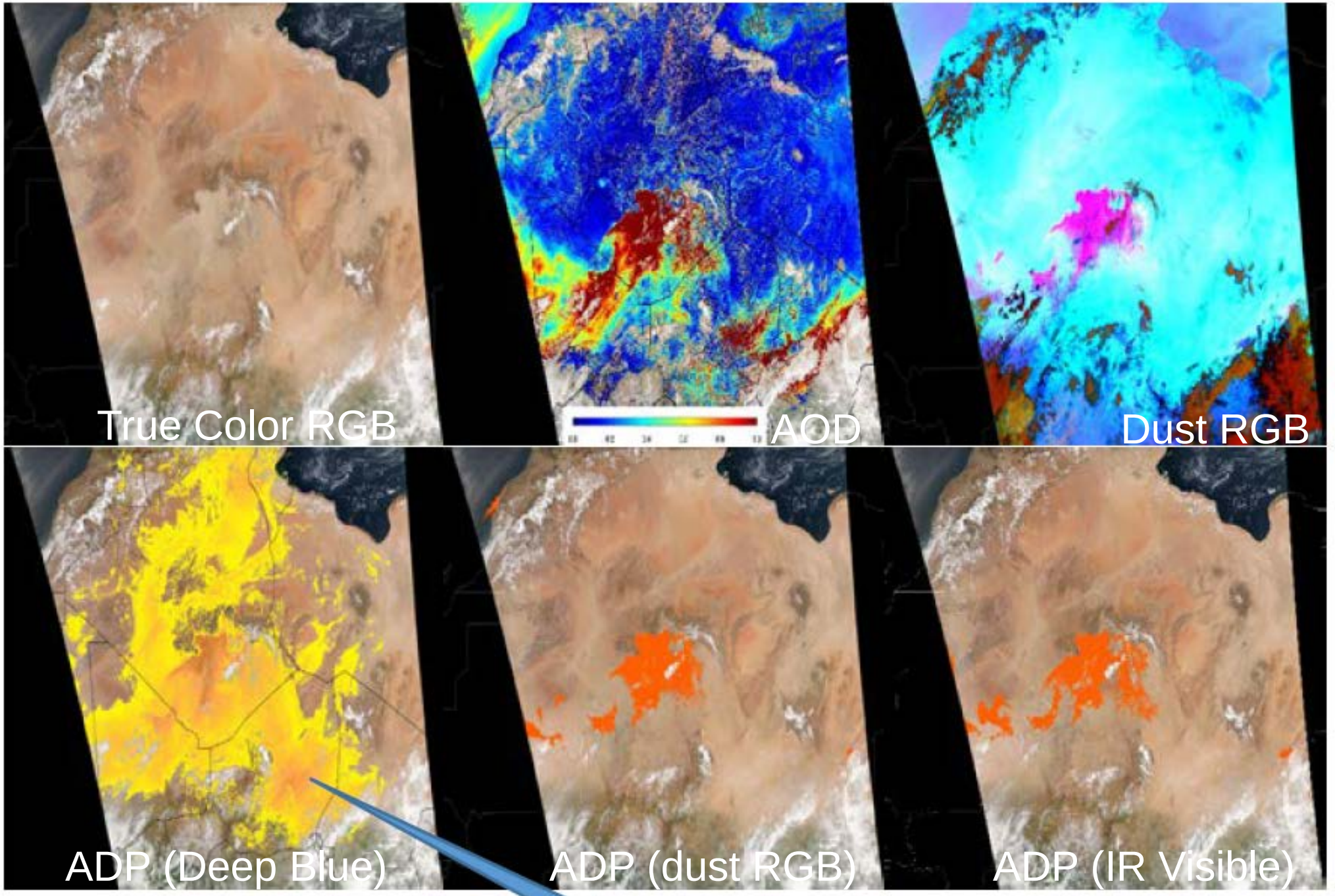
Theoretical calculations of AAI for three scenes corresponding to nadir, forward, backward scattering geometries



Zhang, Ciren, Kondragunta, Laszlo, Liu, An Evaluation of VIIRS Dust Detection Algorithm over Land, JARS, in press, 2018



Zhang et al., JARS, in press, 2018



Zhang et al., JARS, in press, 2018

Conclusions

- ADP algorithm continues to evolve. Latest updates to algorithm minimize false dust detections. Updates will be implemented in operations for SNPP and NOAA-20 December 2018
- CALIPSO continues to be a source for validation. AERONET classification based on Angstrom Exponent is an alternate approach
- NOAA-20 and SNPP overpass times are different and helps us fill in the gaps due to sunglint
- NOAA-20 data will be available on AerosolWatch after the latest updates go in and products go through reviews. Release date TBD.