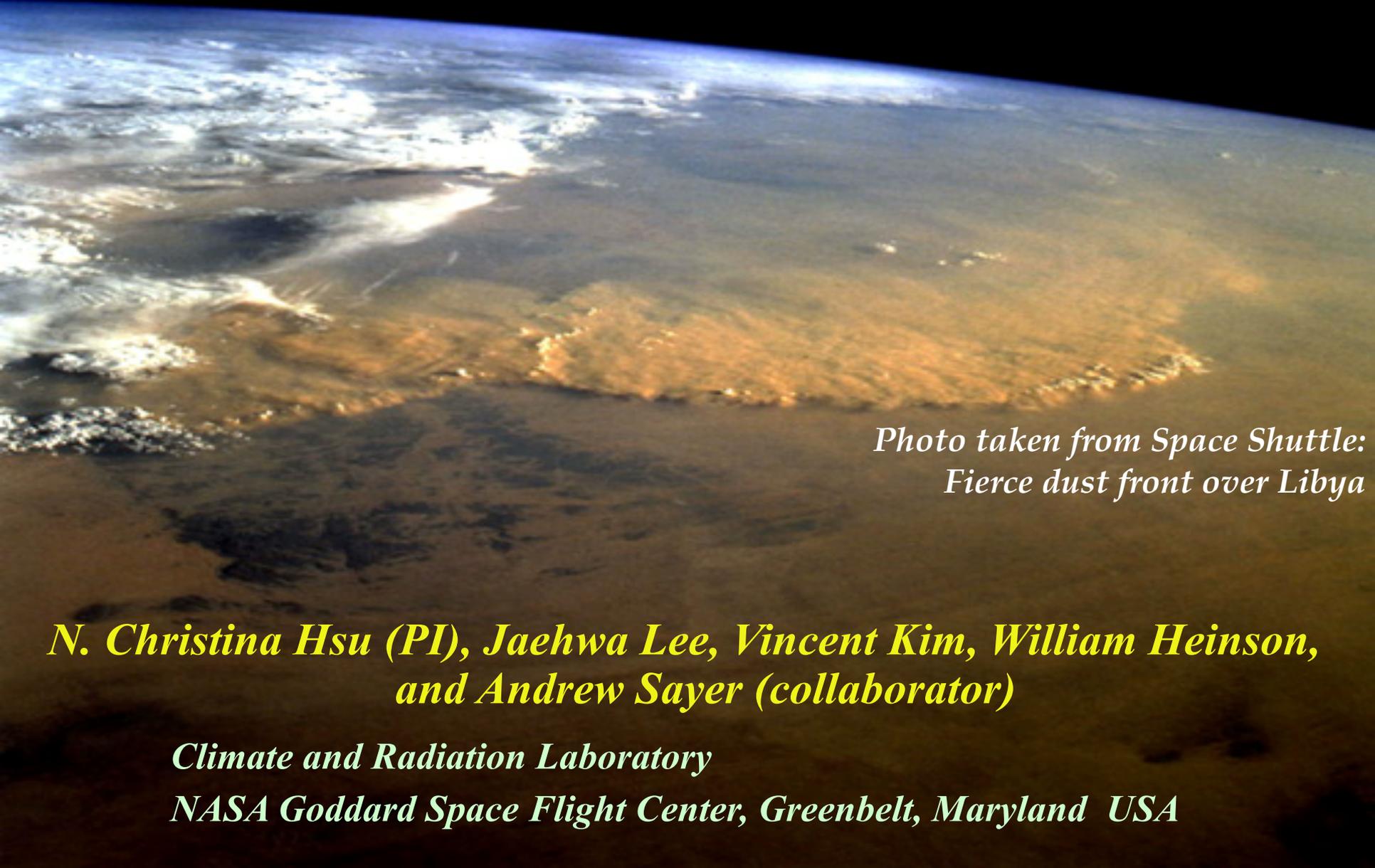


*Status Update and New Aerosol Products From MODIS and VIIRS  
Using Deep Blue Aerosol Algorithm*



*Photo taken from Space Shuttle:  
Fierce dust front over Libya*

*N. Christina Hsu (PI), Jaehwa Lee, Vincent Kim, William Heinson,  
and Andrew Sayer (collaborator)*

*Climate and Radiation Laboratory*

*NASA Goddard Space Flight Center, Greenbelt, Maryland USA*



# Multi-Sensor Long-Term Deep Blue Aerosol Products

## ➤ **Science Objectives:**

- Our primary goal is to produce consistent long-term aerosol climate data record using multiple satellite sensor data from **AVHRR** (historic) to **SeaWiFS** and **MODIS** (EOS-era) to **VIIRS** (JPSS-era) as well as latest **GEO** sensors (such as AHI and ABI) for diurnal cycle
- Our **VIIRS** and **GEO** aerosol products are generated based upon *Deep Blue* algorithm (over land) (previously applied to **AVHRR**, **SeaWiFS** and **MODIS**) and SOAR algorithm (over ocean) (applied to **AVHRR** and **SeaWiFS**)

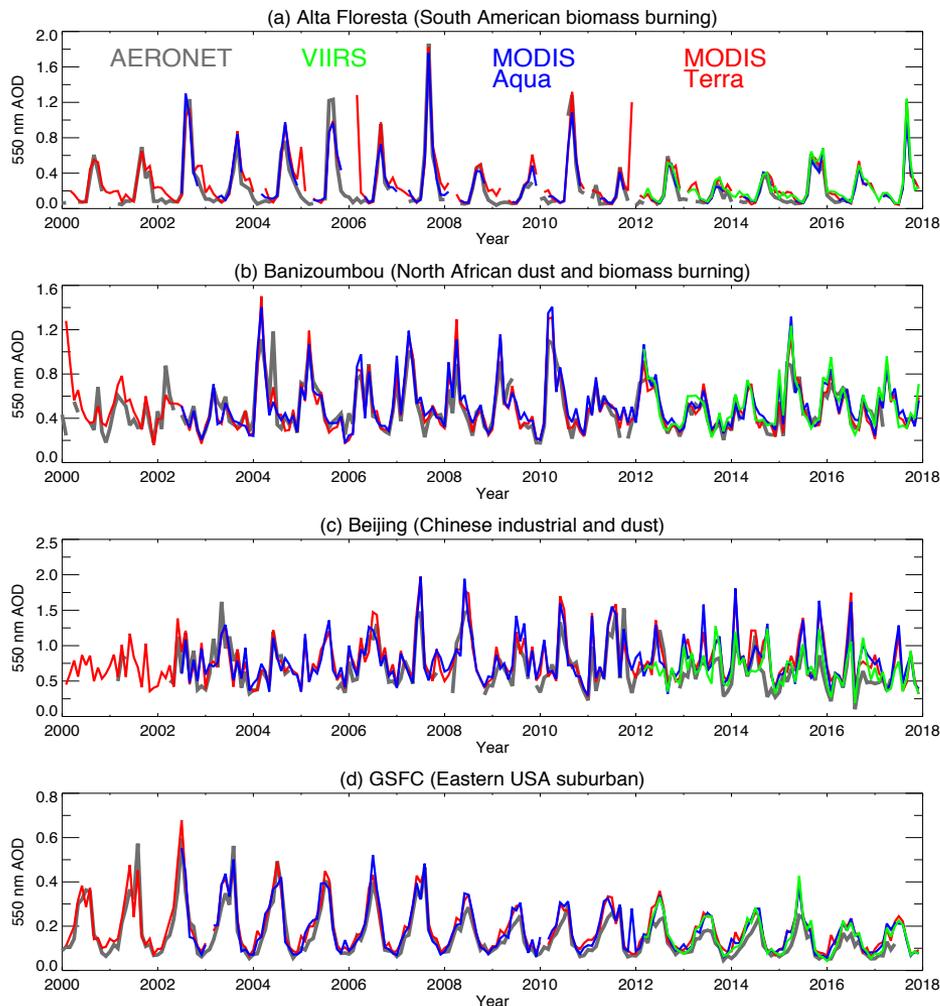
## ➤ **Status of the VIIRS Deep Blue aerosol products:**

- ✓ **Standard VIIRS L2 and L3** Version 1 Deep Blue products have been operational and available at **LAADS** since late 2018.
- ✓ **NRT VIIRS** Deep Blue products also officially became operational in 2019 via **LANCE**. The imagery is now available at **Worldview**.
- ✓ **VIIRS Version 1.1** Deep Blue algorithm is finalized and the products will be processed at SIPS soon. Compared to V1.0, the changes made in V1.1 include the improvement of AOD retrieval during the extreme fire events and a few minor bug fixes.
- ✓ Preparation of implementing new aerosol product retrieval such as **aerosol height and AOD retrieval over cloud** in the **VIIRS V2.0** algorithm has started.



# Constructing Consistent Long-Term Aerosol Climate Data Record

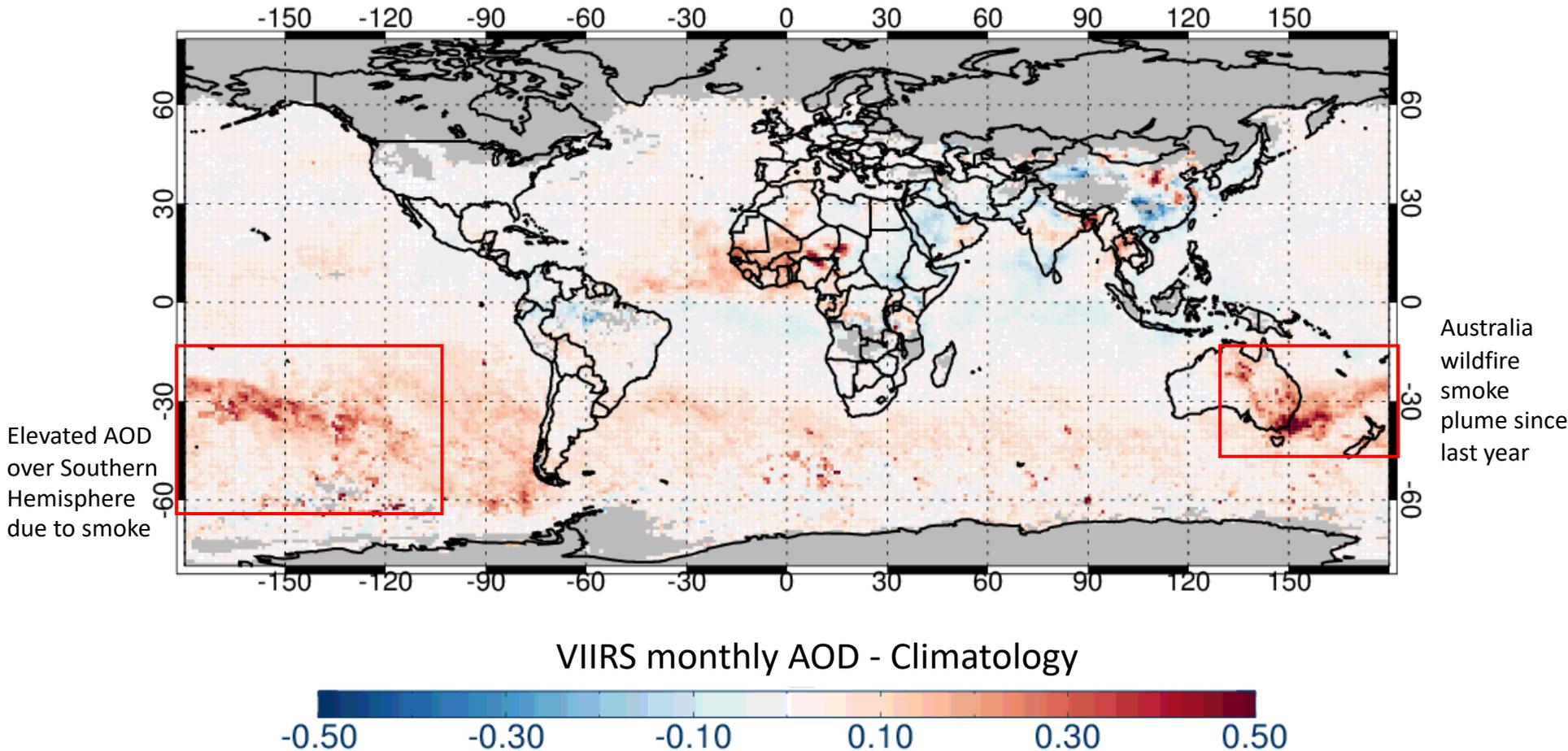
## Time Series of Monthly Mean AOD from Multi-satellite Deep Blue data at select AERONET sites



This comparison shows multi-year (2002-2018) quantitative consistency of the VIIRS AOD in comparison with our heritage MODIS and SeaWiFS results, as well as AERONET validation data. These VIIRS AOD data are generated using corrected VIIRS L1B files after we assessed the calibration of S-NPP VIIRS against MODIS Aqua and developed a cross-calibration correction for VIIRS, which was shown to decrease the uncertainty in retrieved AOD and make VIIRS results more comparable to MODIS .

# Satellite products can provide global and regional pictures of aerosol variabilities for climate and air quality studies

## AOD anomaly for **January** 2020 related to climatology



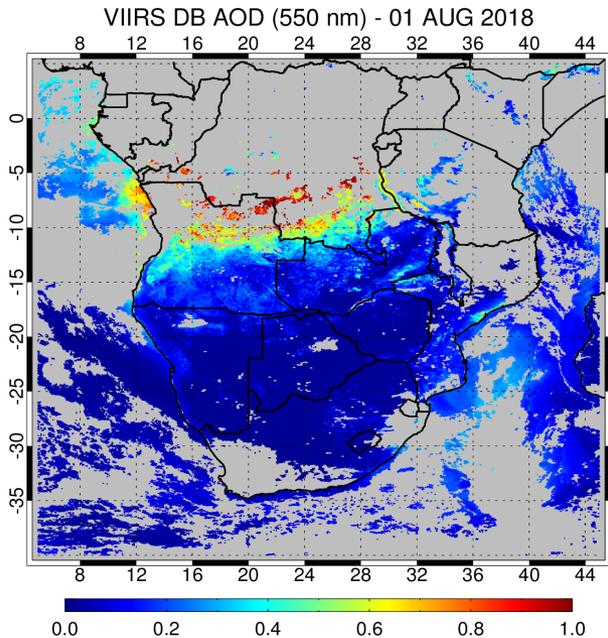
# Planning for VIIRS Version 2 Deep Blue Aerosol Products

Major changes include:

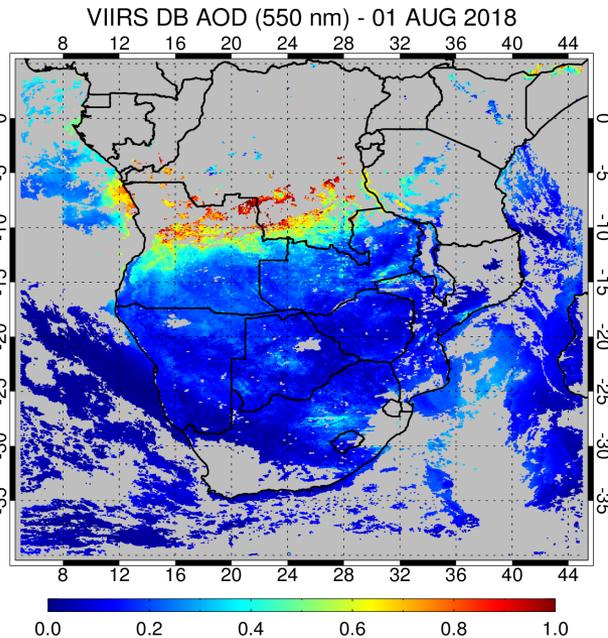
- Improved surface reflectance estimate and aerosol retrievals over high elevation regions
- Better aerosol models
- Implementation of new aerosol products, including aerosol height and AOD retrieved above clouds

# Planned Improvements over High Elevation Areas for VIIRS and MODIS

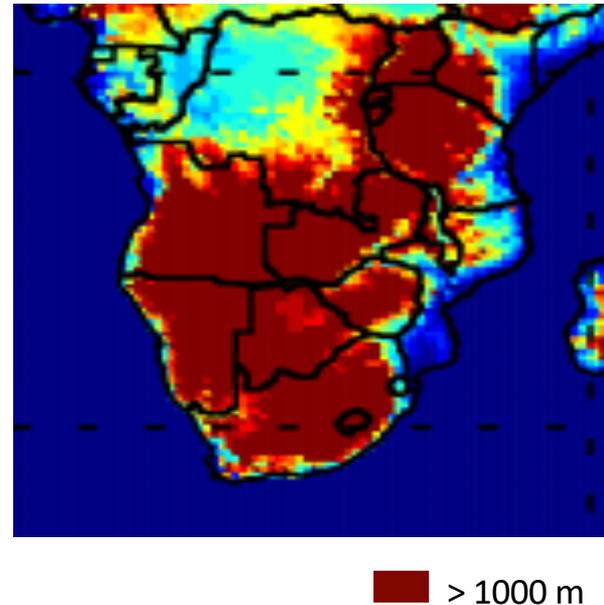
VIIRS version 1



VIIRS version 2



Surface elevation



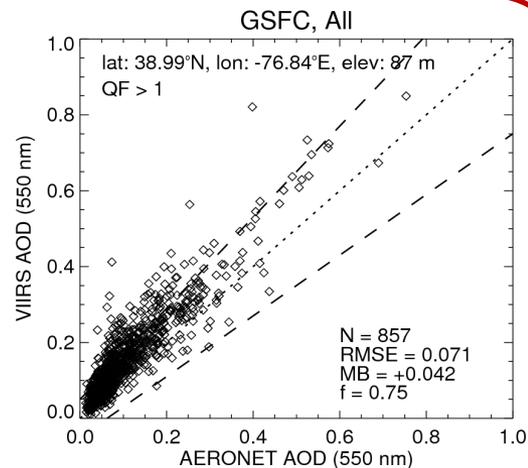
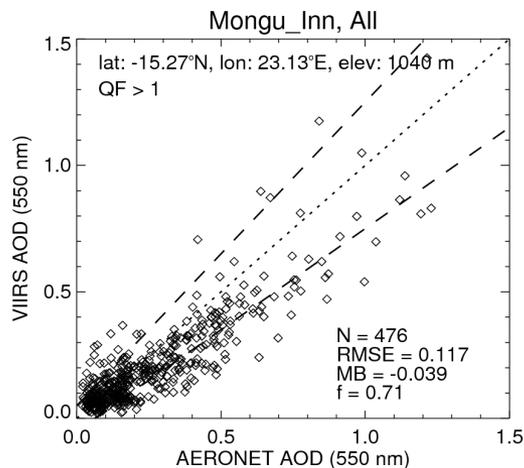
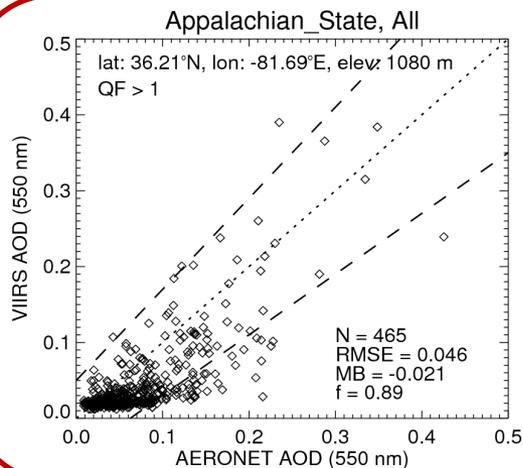
- The DB surface reflectance database has been revised by better accounting for the effects of surface elevation, resulting in improvements of low bias in retrieved AOD over high elevation regions.

# Planned Improvements for VIIRS V2 and MODIS C7

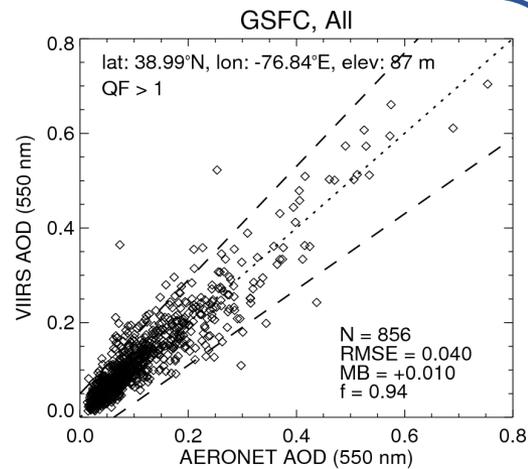
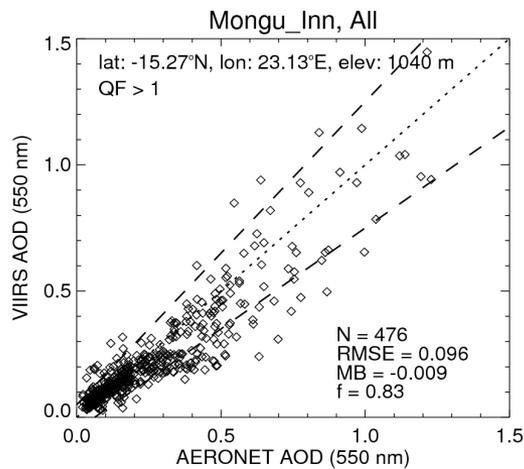
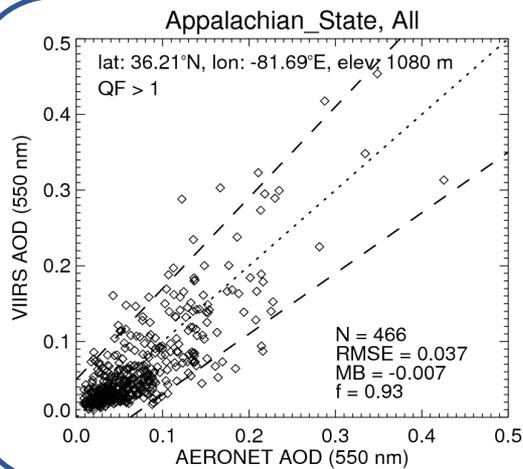
## High Elevation

## Better Surface Reflectance

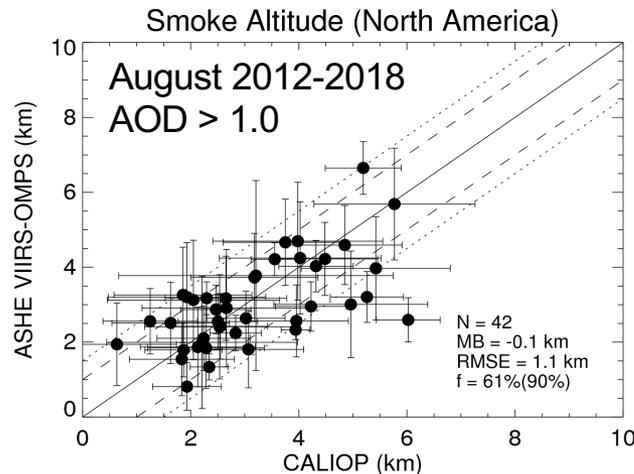
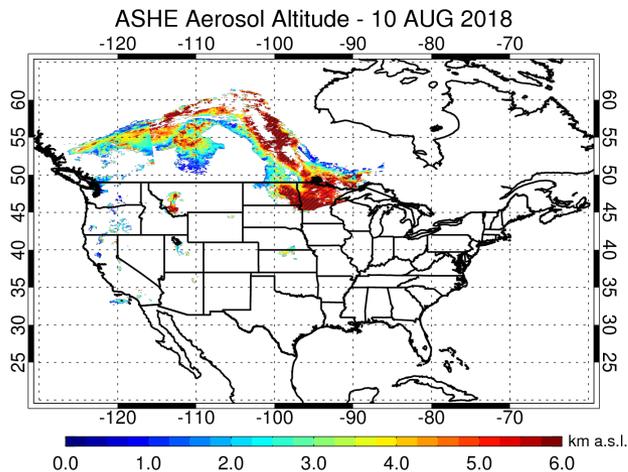
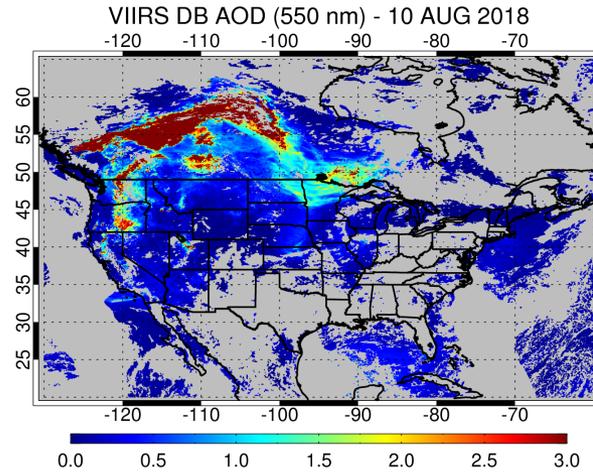
V1



V2



# New Deep Blue Aerosol Layer Height from VIIRS and OMPS-NM



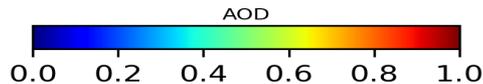
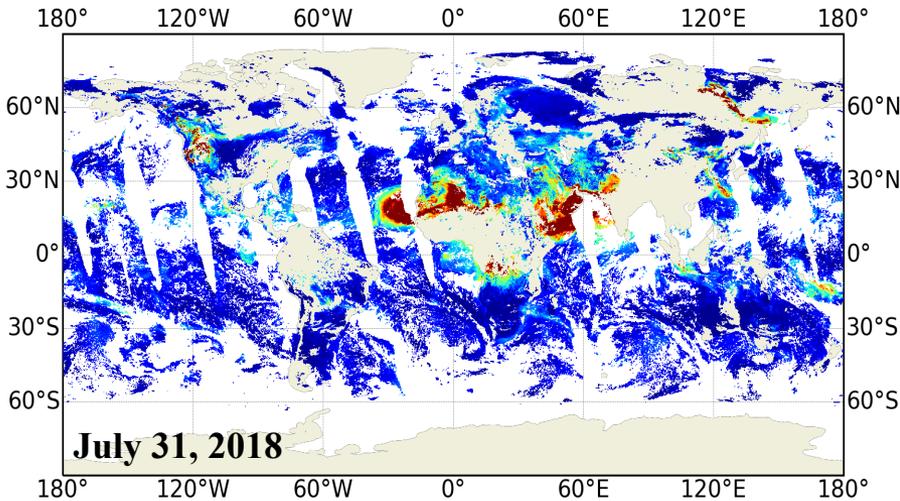
An operation-ready Aerosol Single-scattering albedo and Height Estimation (ASHE) algorithm has been implemented in the VIIRS Deep Blue aerosol algorithm suite to provide the height of absorbing aerosols from synergistic use of VIIRS and OMPS, both onboard the S-NPP satellite. With extensive spatial coverage, the data set can contribute to better understanding of the effects of aerosol layer height on long-range transport and surface air quality. **The data product will be available as part of the Version 2 VIIRS Deep Blue products.**

**Publication:** Lee, *et al.*, 2020, Aerosol layer height with enhanced spectral coverage achieved by synergy between VIIRS and OMPS-NM measurements, *IEEE Geo. and Remote Sens. Lett.*, doi: 10.1109/LGRS.2020.2992099.

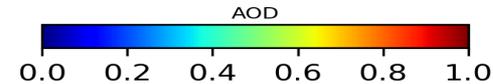
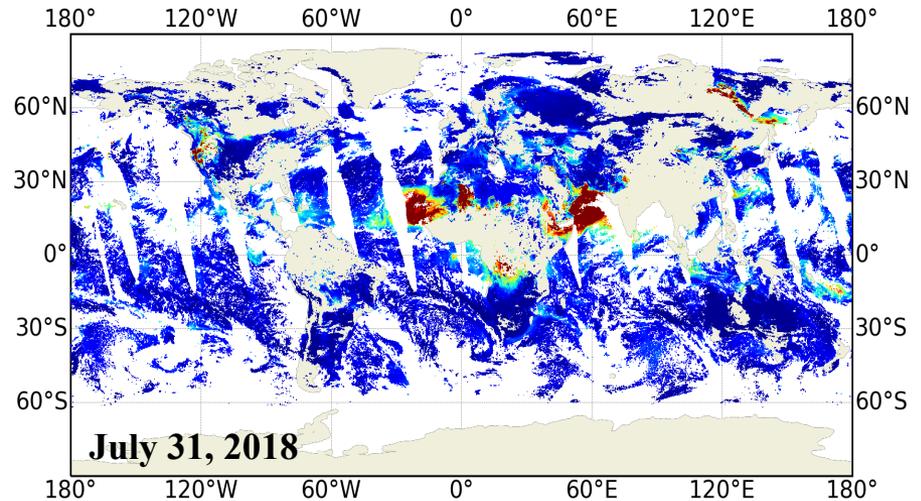


**The effort of applying SNPP VIIRS Deep Blue algorithm to NOAA-20 VIIRS is currently underway**

SNPP AOD

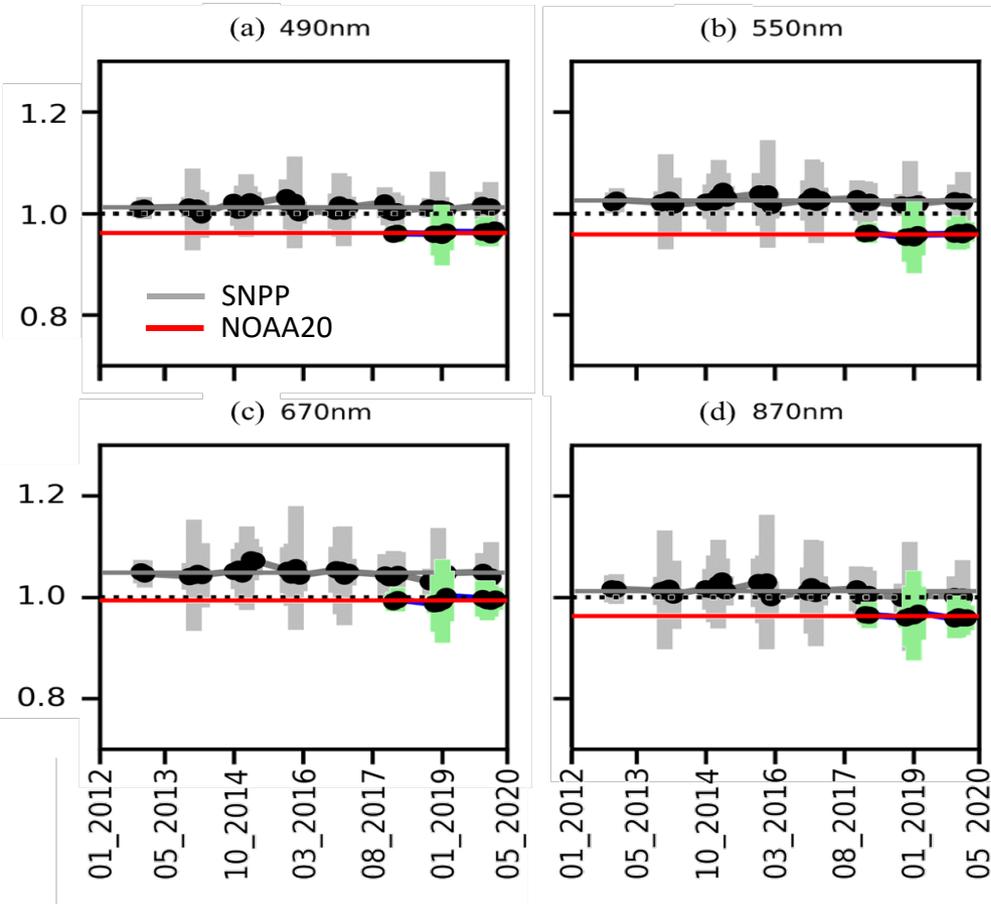


N20 AOD without any calibration adjustment



- NOAA-20 leads SNPP by a half orbit, or ~50 minutes. The VIIRS bands are similar between SNPP and NOAA-20.
- NOAA-20 AOD are in general lower than those for SNPP.

## The time series of ratio of VIIRS to MODIS Aqua TOA reflectance for both SNPP and NOAA20 over the Antarctic Dome C site



The observations of NOAA 20 and SNPP do not collocate so a direct comparison is not possible. However, both do have overlapping observations with Aqua MODIS and the use of their respective MODIS match files generated by Atmosphere SIPS provides a bridge to compare the two sensors.

Grey and red line represent the fit to the ratios of VIIRS to MODIS Aqua TOA reflectance for SNPP and NOAA20, respectively.

### MODIS-VIIRS match thresholds:

- View Zenith Angle  $\leq 3^\circ$
- Scatter Angle  $\leq 3^\circ$
- Time  $\leq 10$  min
- Distance from cloudy MODIS pixel  $\geq 5$ km

### The ratio of the grey and red line (SNPP/NOAA20)

412nm	490nm	550nm	670nm	870nm	1240nm	1610nm	2250nm
1.059	1.052	1.069	1.054	1.052	1.026	1.036	1.008

# Comparisons of retrieved VIIRS over-ocean AOD for SNPP and N20: Bias against AERONET

Data Time Period: 1-1-2018 to 7-1-2020

Sites	SNPP:		N20:
	No Cal Bias	SNPP-MODIS Bias	
Anmyon	0.0387	0.0412	0.0191
Ascension_Island	0.0284	0.0140	0.0106
ATHENS-NOA	0.0543	0.0310	0.0279
Cape_San_Juan	0.0416	0.0137	0.0103
Capo_Verde	0.0272	0.0159	0.0160
Dakar	0.0235	0.0221	-0.0076
Gangneung_WNU	0.0335	0.0194	0.0068
KAUST_Campus	0.0726	0.0536	0.0307
Santa_Cruz_Tenerife	0.0615	0.0357	0.0289
Shirahama	0.0811	0.0590	0.0470
Venise	0.0485	0.0400	0.0178

- Using original SNPP VIIRS L1B files, there are in general high bias in the VIIRS over-ocean retrieved AOD compared to AERONET.
- These high biases were improved by Andy Sayer's calibration correction used in the current VIIRS Deep Blue operational algorithm.
- However, these high biases seem to be further reduced in the NOAA20 VIIRS data.
- There is inconsistency between SNPP and NOAA20 retrieved AOD.

# **Fusing GEO with LEO Satellite Observations to Infer Diurnal Properties of Global Aerosols**

**New Deep Blue Geostationary Aerosol Products from Himawari-8 and GOES-16/17**

## Methodology:

- ➔ Employing modified Deep Blue (DB) algorithm by using hourly surface database
- ➔ Aerosol retrievals only perform when  $SZA < 84^\circ$  and  $VZA < 76^\circ$
- ➔ Using consistent aerosol models as in MODIS and VIIRS DB algorithms

## Products:

- ➔ AOD over both land and ocean, Level 2 spatial resolution: 8 km (4 x 4 aggregation of 2 km resolution data)
- ➔ Temporal coverage: every 10 minutes (AHI) and every 15 minutes (ABI) from Sunrise to Sunset (within retrieval angle ranges)



# Summary

- **Big Thanks for the supports from Atmosphere SIPS, LAADS and LANCE, standard and NRT VIIRS DB aerosol products are now available operationally, including daily imagery on Worldview.**
- ✓ **VIIRS Version 1.1 Deep Blue algorithm is finalized and the products will be processed at SIPS soon. Compared to V1.0, the changes made in V1.1 include the improvement of AOD retrieval during the extreme fire events and a few minor bug fixes.**
- ✓ **Preparation of implementing new aerosol product retrieval such as aerosol height and AOD retrieval over cloud in the VIIRS V2.0 algorithm has started.**
- ✓ **The calibration differences between SNPP and NOAA 20 VIIRS need to be addressed before data consistency can be achieved across the two sensors.**
- ✓ **Efforts of backporting all the improvements made in VIIRS to MODIS Collection 7 are also underway.**