Deep Blue Aerosol Products from SNPP VIIRS: Long-Term Data Continuity and New Products
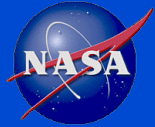
Photo taken from Space Shuttle: Fierce dust front over Libya

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# *Recent Progress on Deep Blue Aerosol Algorithm for VIIRS*

- *Expand coverage from arid and semi-arid regions into vegetated (SeaWiFS, MODIS C6, and VIIRS) areas as well as oceans (SeaWiFS and VIIRS only)*

- *Develop and employ non-spherical dust models for aerosol retrievals*

- *Improve cloud screening to distinguish heavy smoke plumes from clouds*

- *Account for the effect of water vapor in identifying strongly absorbing mineral dust using the IR channels*

VIIRS ocean retrieval algorithm

S-NPP VIIRS, 13:40 UTC 26 Jan 2014 · AOD at 550 nm · Aerosol model
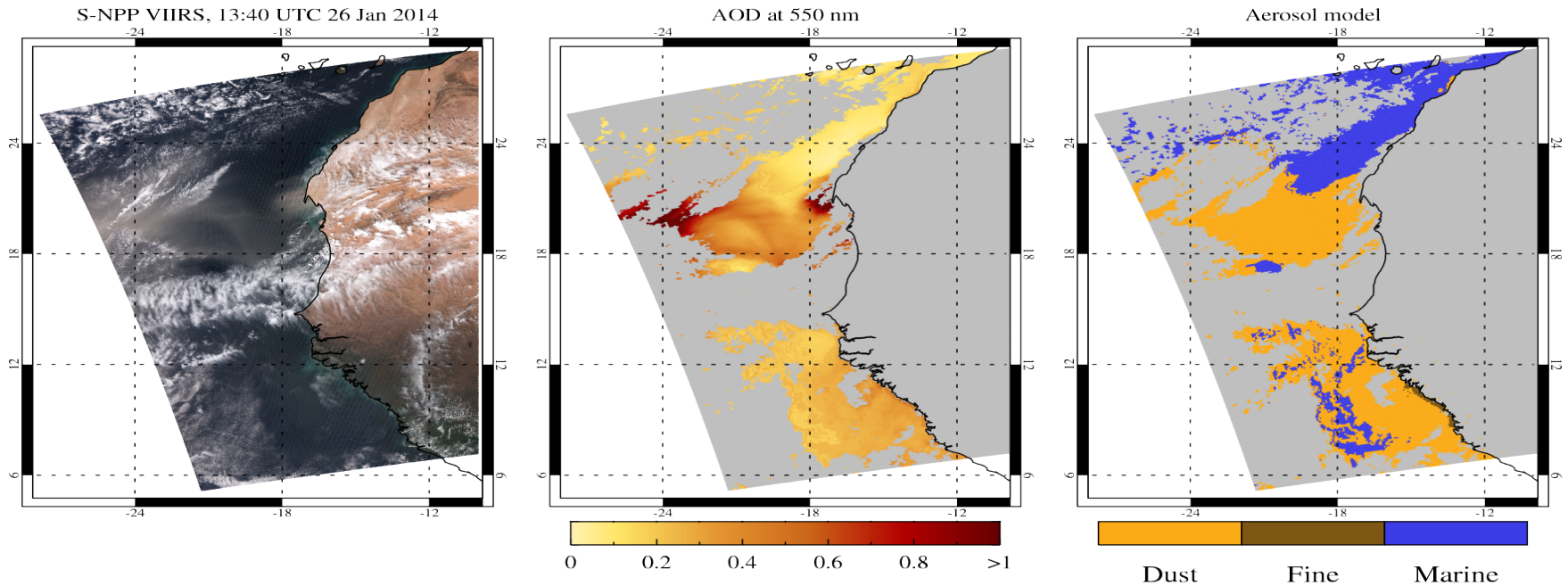
- The VIIRS ocean algorithm is an extension and improvement on our SeaWiFS algorithm
  - Similar in principle to other common approaches (e.g. MODIS) as well
- Retrieve AOD, fine mode fraction (Ångström exponent), aerosol type (from a selection of models)
  - Includes nonspherical dust model
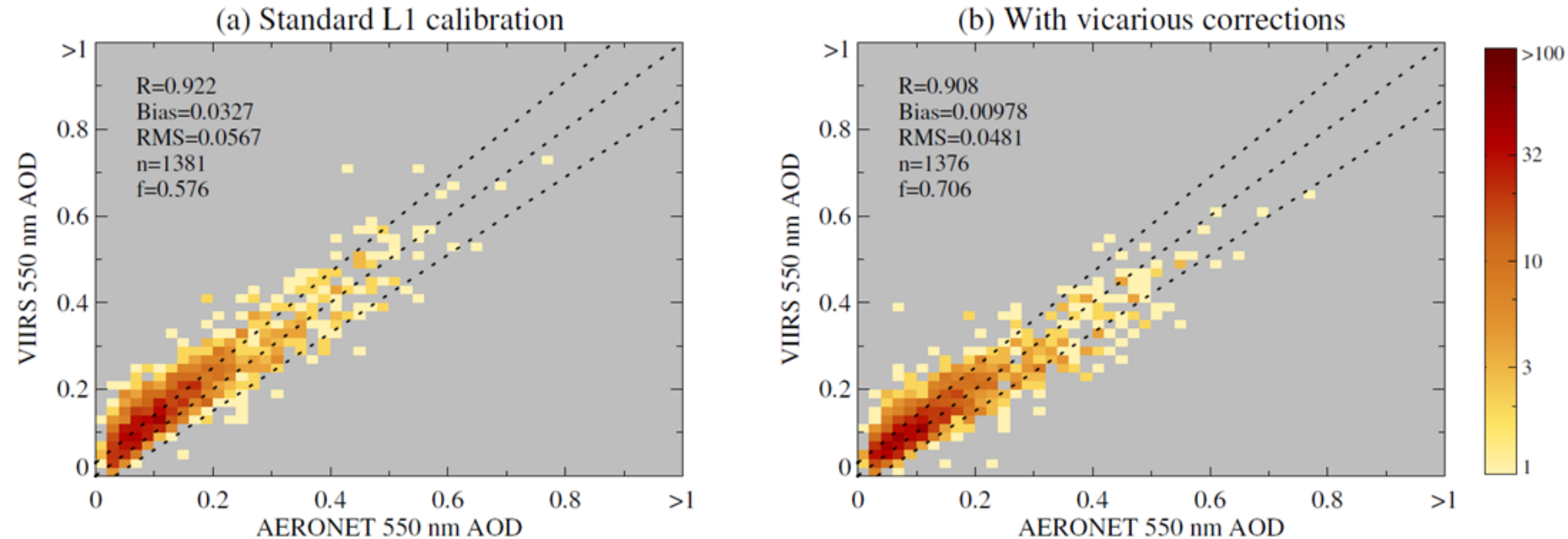- Cloud screening seems effective even in cases of heavy aerosol loading

Effects of New Dust Optical Models
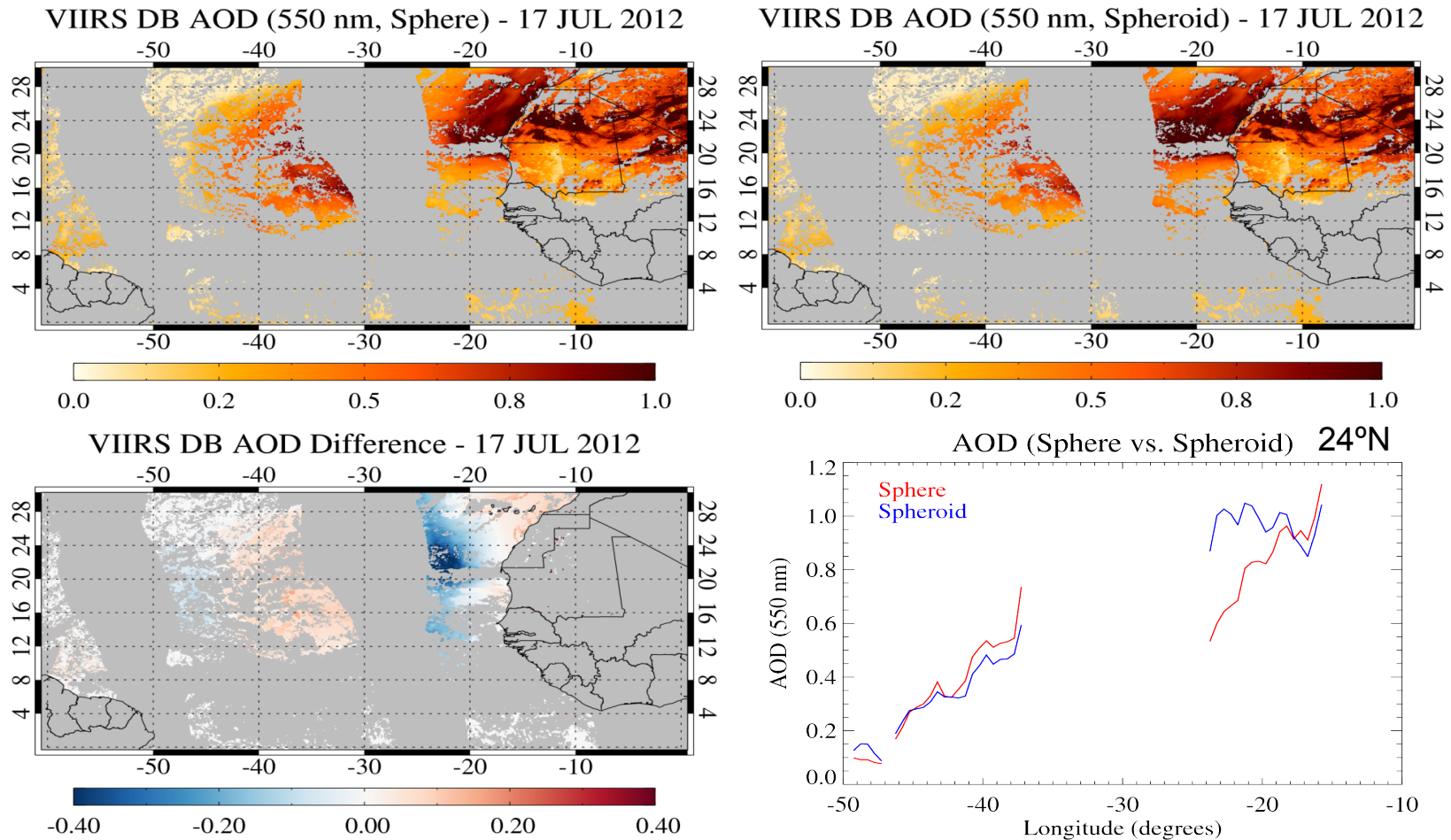
- **Implementation of the new nonspherical dust model substantially improves the angular dependence of retrieved AOD bias (up to 40%) as well as Angstrom exponent**

Reference: *Lee et al.*, 2017, JGR, "Effects of nonspherical dust optical models on the VIIRS Deep Blue over-water aerosol product"

# Effects of VIIRS Vicarious Calibrations on AOD retrievals

(a) Standard L1 calibration

R=0.922
Bias=0.0327
RMS=0.0567
n=1381
f=0.576

(b) With vicarious corrections

R=0.908
Bias=0.00978
RMS=0.0481
n=1376
f=0.706

➢ **Cross-calibration against collocated MODIS Aqua pixels over dark water scenes with common geometry**
  ➢ **Sensor-to-sensor differences accounted for in radiative transfer calculations**
  ➢ **Technique is independent of the AOD retrieval algorithm**
  ➢ **Stability of both sensors over the 2012-2016 time series seems (mostly) good**
➢ **Applying these corrections removes the bulk of the AOD bias over water**
  ➢ **Suggest MODIS absolute calibration is closer to the truth than VIIRS**
 ➢ **We are currently repeating this procedure using VIIRS version 2 L1B data**

Reference: Sayer et al., 2017, AMT, "Cross-calibration of S-NPP VIIRS moderate resolution reflective solar against bands MODIS Aqua over dark water scenes"

> **Improved VIIRS heavy smoke/cloud detection scheme significantly increases the spatial coverage of the retrieved AOD compared to MODIS C6 over major smoke plumes**
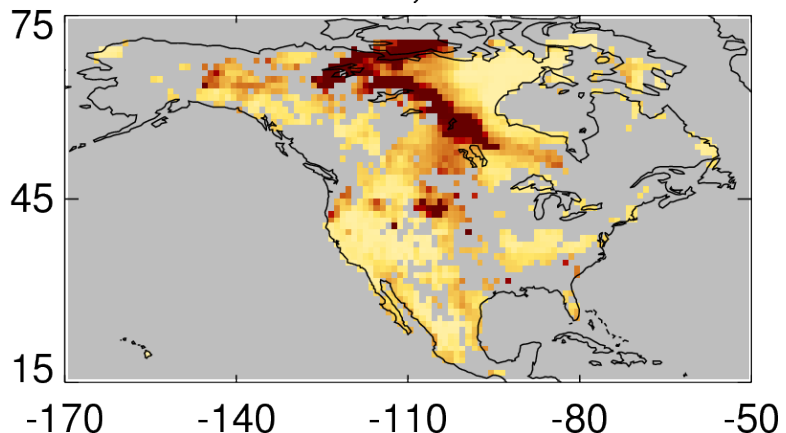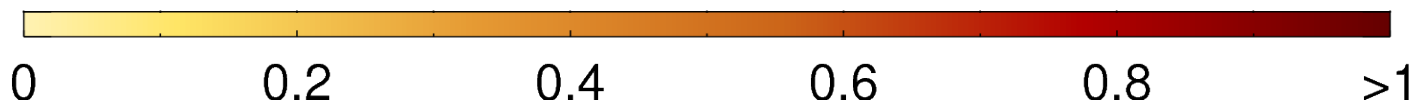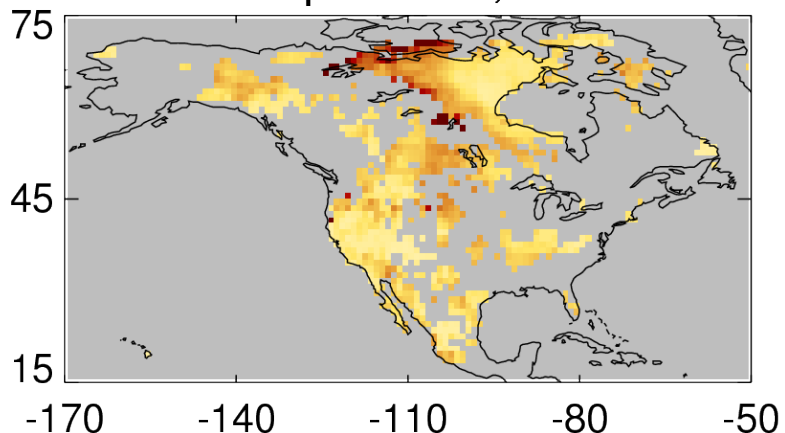
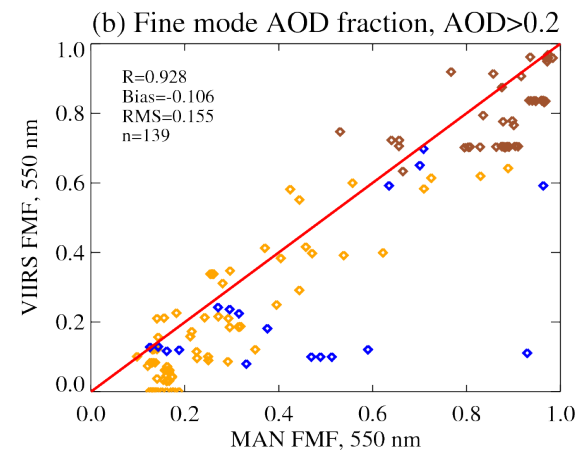VIIRS AOD, 20130704
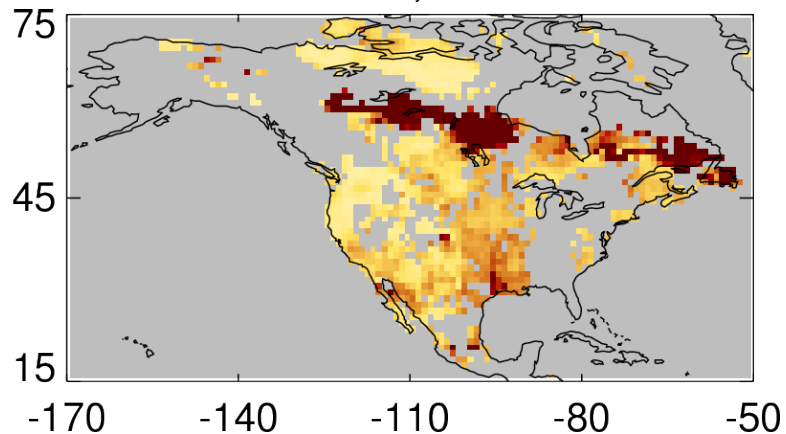
MODIS Aqua AOD, 20130704
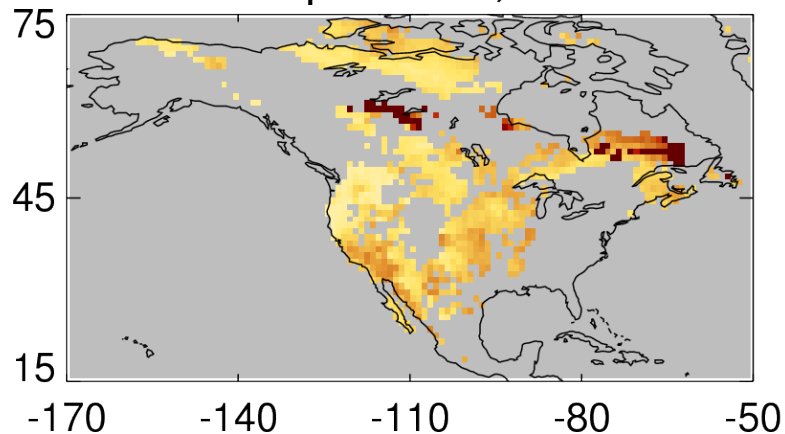
VIIRS AOD, 20130814

MODIS Aqua AOD, 20130814
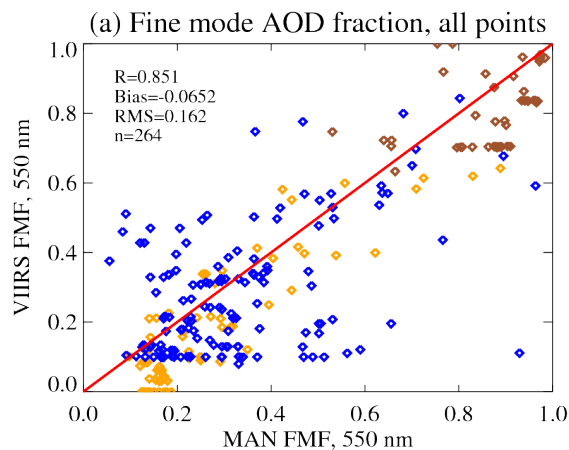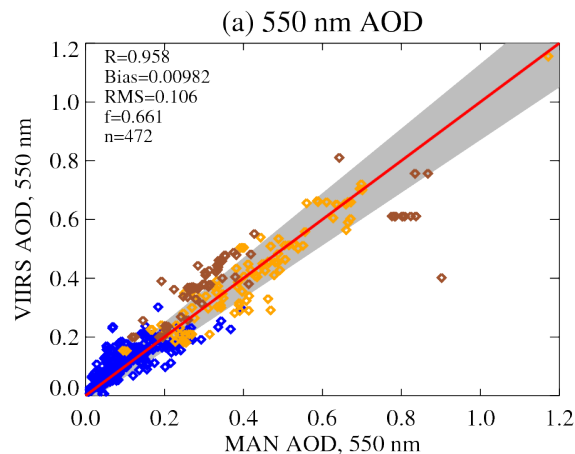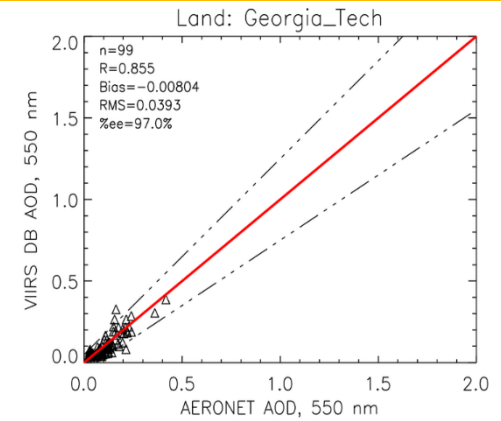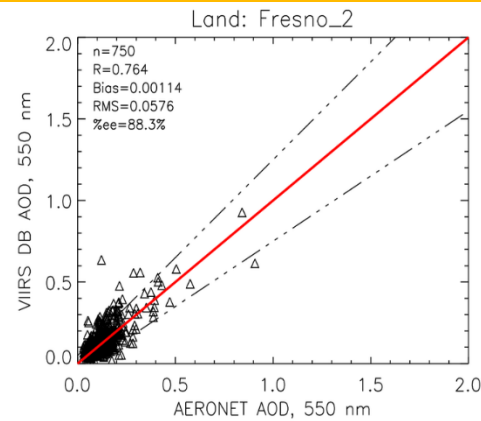
Comparisons of VIIRS over-ocean products with Maritime Aerosol Network (MAN)

- AOD retrieval quality similar to, or better than, standard MODIS product

- Ångström exponent (AE) and fine mode AOD fraction compare favorably to MAN data, even when the AOD is not high

- Colors indicate aerosol optical model: retrieved, not prescribed

  - Either **marine**, **dust**, or **fine-dominated**

(a) 550 nm AOD

R=0.958
Bias=0.00982
RMS=0.106
f=0.661
n=472

(b) AE

R=0.812
Bias=-0.105
RMS=0.369

(a) Fine mode AOD fraction, all points

R=0.851
Bias=-0.0652
RMS=0.162
n=264

(b) Fine mode AOD fraction, AOD>0.2

R=0.928
Bias=-0.106
RMS=0.155
n=139
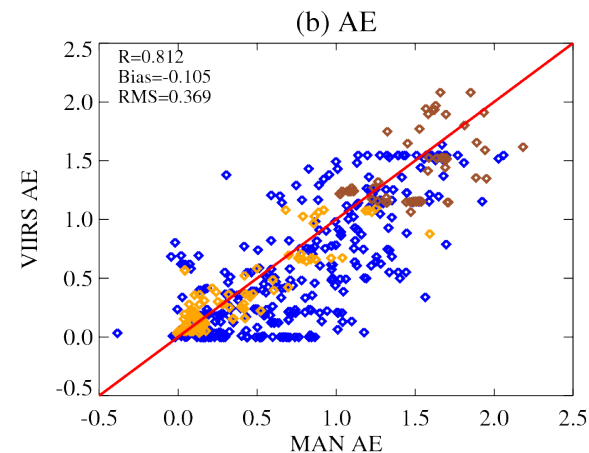
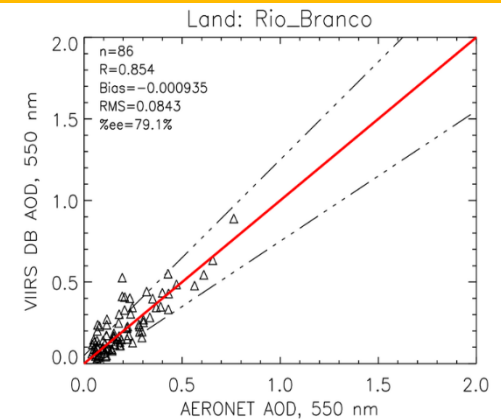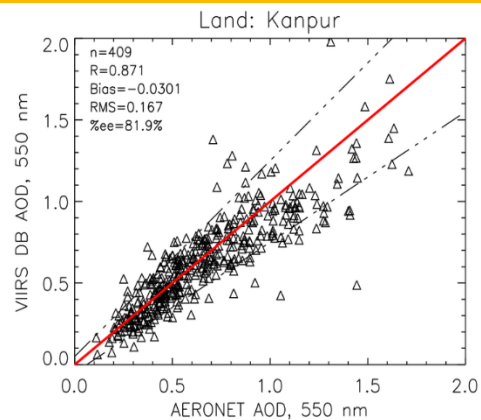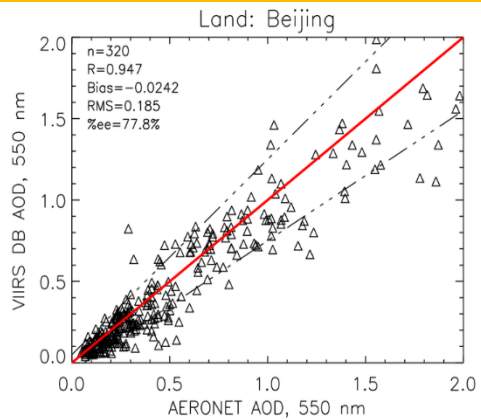# VIIRS Comparisons with AERONET AOT over Land

Urban Pollution
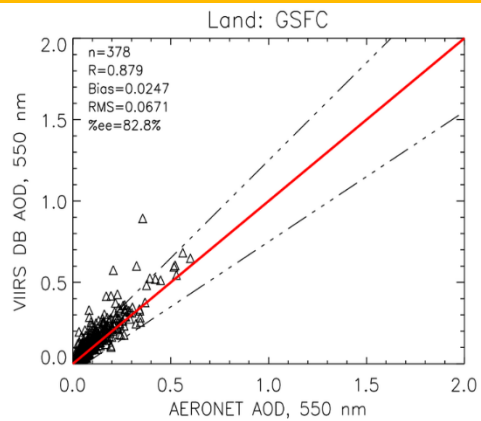
Urban Pollution, Dust, Smoke

Sahel

Land: GSFC
n=378
R=0.879
Bias=0.0247
RMS=0.0671
%ee=82.8%

Land: Fresno_2
n=750
R=0.764
Bias=0.00114
RMS=0.0576
%ee=88.3%

Land: Georgia_Tech
n=99
R=0.855
Bias=−0.00804
RMS=0.0393
%ee=97.0%

Land: Beijing
n=320
R=0.947
Bias=−0.0242
RMS=0.185
%ee=77.8%

Land: Kanpur
n=409
R=0.871
Bias=−0.0301
RMS=0.167
%ee=81.9%

Land: Rio_Branco
n=86
R=0.854
Bias=−0.000935
RMS=0.0843
%ee=79.1%

Land: Banizoumbou
n=486
R=0.878
Bias=−0.0213
RMS=0.160
%ee=74.9%

Land: IER_Cinzana
n=480
R=0.894
Bias=−0.00821
RMS=0.131
%ee=72.1%

Land: Ilorin
n=140
R=0.845
Bias=0.0378
RMS=0.232
%ee=72.1%

Comparisons of VIIRS Deep Blue Daily AOD Product with the Newly Developed MODIS C6.1 Deep Blue Product

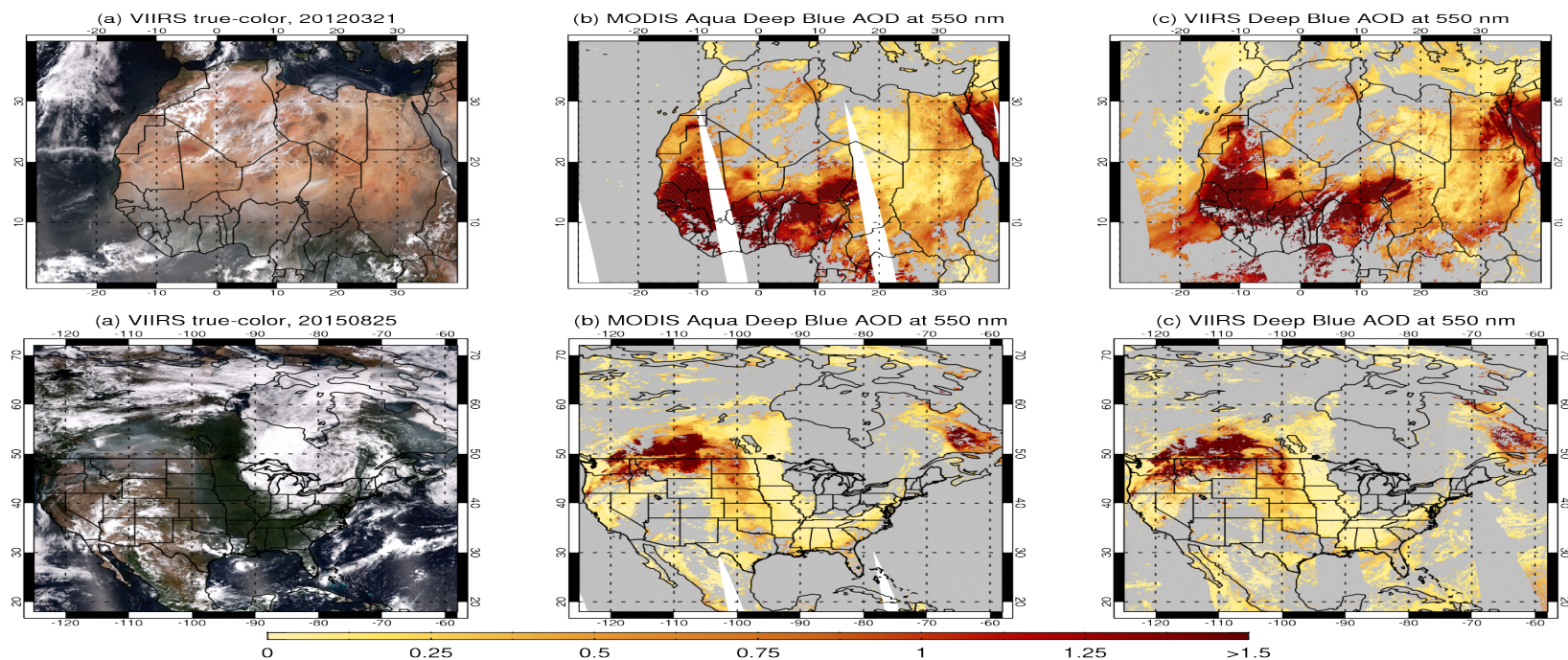The VIIRS Deep Blue AOD product shows good continuity with the MODIS Collection 6.1 Deep Blue product, in terms of both AOD magnitude and efficacy of cloud screening. Examples of daily MODIS/VIIRS comparisons are depicted in the upper panels for a Saharan dust outbreak over North Africa, and in the lower panels for extensive smoke plumes over North America.

Time Series of Monthly Mean AOD from Multi-satellite Deep Blue data at select AERONET sites
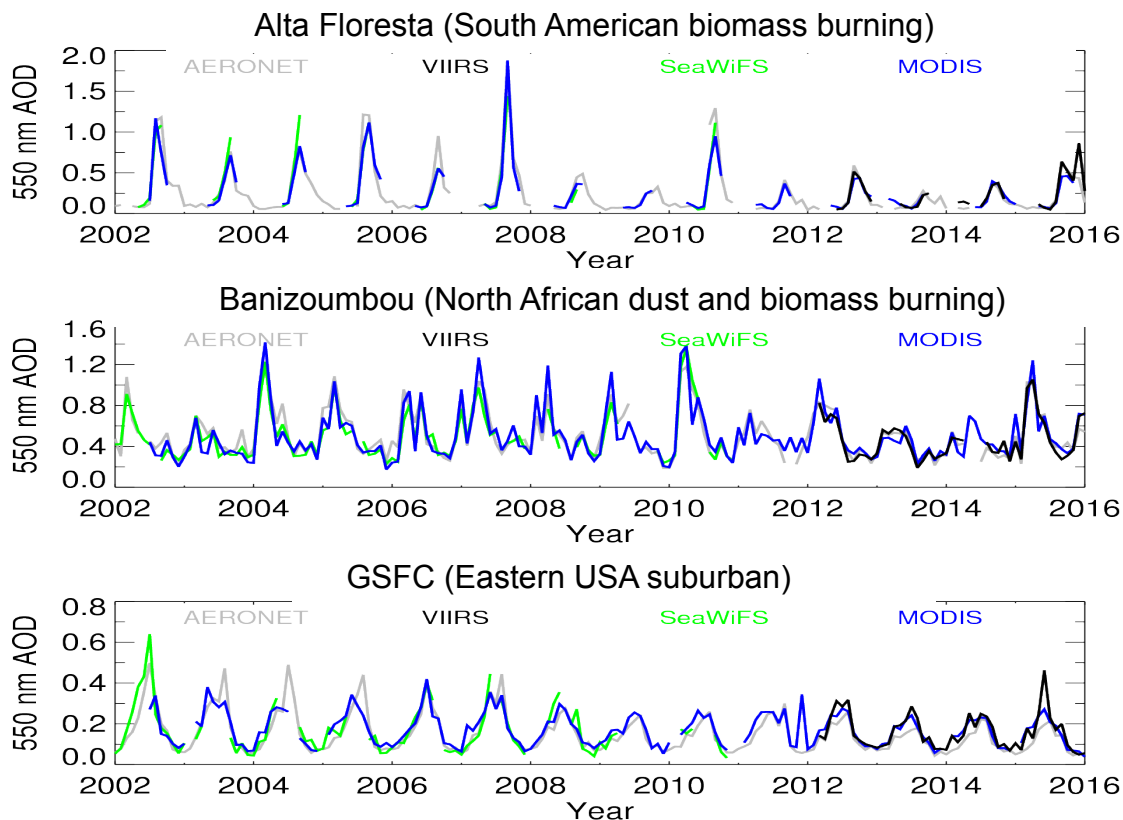
This comparison shows multi-year (2002-2015) quantitative consistency of the VIIRS AOD in comparison with our heritage MODIS and SeaWiFS results, as well as AERONET validation data.

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 .

New VIIRS Deep Blue Aerosol Product: Aerosol Plume Height
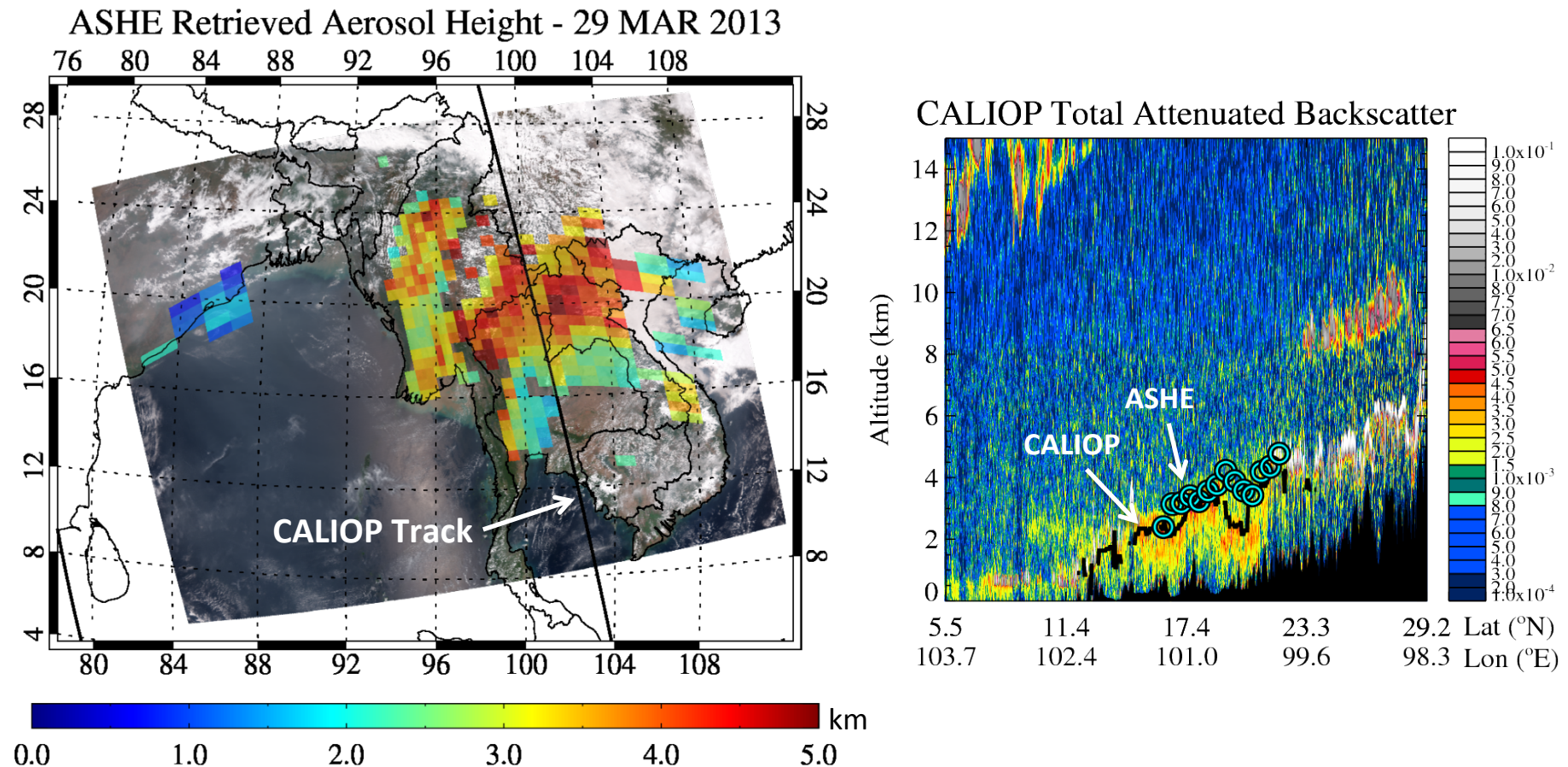
- Left panel shows retrieved aerosol height from our ASHE algorithm, for south-east Asian biomass burning.
- ASHE combines our VIIRS Deep Blue data with OMPS observations to determine aerosol height, which can not normally be retrieved using this type of sensor
- Validation with CALIOP profiles shows good agreement (right panel)
- If CALIOP is used as an optional additional input, we can also determine aerosol single scattering albedo
- We have also demonstrated the same capability using MODIS Aqua and OMI data

Summary

- **After applying comparable aerosol retrieval algorithm and additional calibration correction to VIIRS, the comparisons between MODIS and VIIRS Deep Blue AOD products indicate that the VIIRS Deep Blue product is able to continue the EOS long-term aerosol data record with good consistency.**

- **Based upon the comparisons with AERONET AOD global observations, the expected error for VIIRS DB at 6 km resolution is 0.05±20% over land and 0.03±10% over ocean, which is comparable to that for MODIS C6 and SeaWiFS DB.**

- **Thanks for the support from Atmosphere SIPS at Wisconsin, VIIRS version 1 DB aerosol products will be ready for release to the public in late 2017.**

VIIRS Deep Blue observations of dust storms originating in Algeria and the Bodélé Depression

VIIRS imagery, 20140226

VIIRS Deep Blue aerosol loading (AOD at 550 nm)

| 0 | 0.4 | 0.8 | 1.2 | 1.6 | >2 |
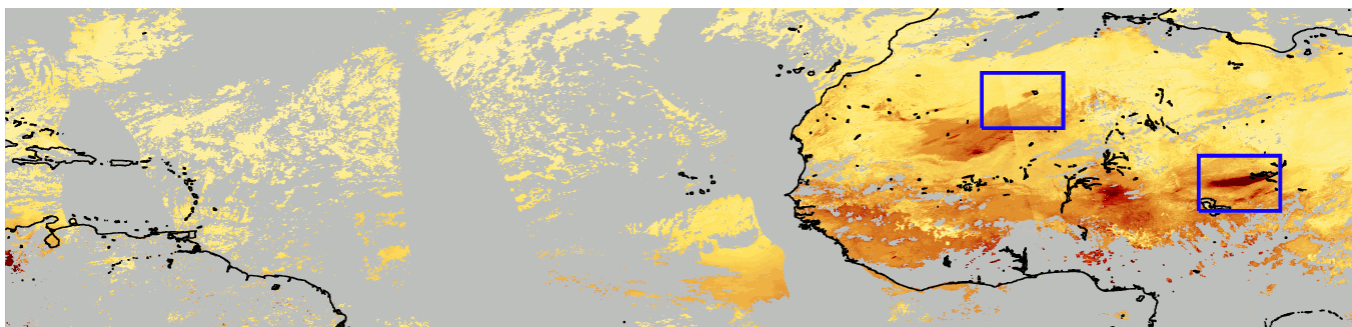
- Animation of VIIRS Deep Blue aerosol data from Feb 26 – Mar 06 2014
- We can observe the aerosol life cycle from source to sink, beginning with emission source regions (blue boxes) and ending with transport across the Atlantic and to South America
- Our product shows good continuity across land/ocean boundaries