

# The Evaluation of VIIRS Aerosol Retrievals Over Ocean

Ho-Chun Huang<sup>1,2\*</sup>, Shobha Kondragunta<sup>2</sup>, Istvan Laszlo<sup>2,3</sup>, Lorraine Remer<sup>4</sup>, Jingfeng Huang<sup>1,2</sup>, Hai Zhang<sup>2,5</sup>, and Alexander Smirnov<sup>6,7</sup>  
 \* ho-chun.huang@noaa.gov <sup>1</sup>CICS-MD/ESSIC/UMD <sup>2</sup>NOAA/NESDIS/STAR <sup>3</sup>DAOS/UMD, <sup>4</sup>JCET/UMBC, <sup>5</sup>IMSG, <sup>6</sup>Sigma Space Corp., <sup>7</sup>NASA GSFC

## VIIRS onboard Suomi-NPP and JPSS

- ❑ The Joint Polar Satellite System (JPSS) is the USA's next generation polar-orbiting operational environmental satellite system. JPSS will provide operational continuity of satellite-based observations and products currently obtained from the Suomi National Polar-orbiting Partnership (NPP) mission.
- ❑ Visible Infrared Imaging Radiometer Suite (VIIRS) is a multi-spectral scanning radiometer (22 bands between 0.4 $\mu$ m and 12 $\mu$ m) on-board the Suomi-NPP with spatial resolution for 16 bands at 750m and 5 bands at 325m. The spatial resolution of Intermediate Product (IP) output is 750 m at nadir. The spatial resolution of Environment Data Record (EDR) is 6 km at nadir compared to 10km at nadir for Moderate-Resolution Imaging Spectroradiometer (MODIS).
- ❑ The MODIS on-board Aqua and Terra are currently providing global aerosol coverage for research and operational activities in weather, climate, and air quality. The VIIRS on-board Suomi-NPP and future JPSS satellites are expected to continue daily global aerosol observations for operational and research communities.
- ❑ Separate algorithms are used for aerosol retrieval over land and ocean. The over-land aerosol algorithm is based on but a different scheme from MODIS Surface Reflectance algorithm (MOD09) and the over-ocean algorithm is derived from the MODIS Aerosol (MOD04 Collection 4) algorithm. In VIIRS, Aerosol Optical Thickness (AOT) and aerosol type are retrieved simultaneously by minimizing the difference between observed and calculated reflectance in multiple channels.

## VIIRS Aerosol Products

- VIIRS aerosol products include AOT, Aerosol Particle Size Parameter (APSP), and Suspended Matter (SM).
- The VIIRS AOT and APSP products reached Provisional maturity level and the SM product reached Beta maturity level on January 23, 2013.
- The VIIRS AOT and APSP (both EDR and IP) products are now publicly accessible from NOAA's Comprehensive Large Array-data Stewardship System (CLASS at <http://www.class.ngdc.noaa.gov>).

## Maritime Aerosol Network (MAN)

- MAN is a network of ship-borne aerosol optical thickness measurements using hand-held Microtops II sun photometers [Smirnov et al., 2009] with an uncertainty of AOT measurement no larger than 0.02.
- Collected MAN data follow AERosol RObotic NETwork (AERONET) protocol for data processing, [http://aeronet.gsfc.nasa.gov/new\\_web/maritime\\_aerosol\\_network.html](http://aeronet.gsfc.nasa.gov/new_web/maritime_aerosol_network.html).
- The cruise measurements available from MAN offer an unprecedented opportunity to validate the VIIRS AOT and APSP over open Ocean, far from coastlines and islands as that AERONET site.

## Comparisons between VIIRS Aerosol Retrievals and MAN Measurements

- Period from May 2, 2012 to February 28, 2014.
- MAN Level 2.0 Series Average Datasets.
- VIIRS AOT EDRs at three quality-flag (QF) levels;
  - High : used only high QF AOT.
  - Top2 : used both high and medium QF AOT.
  - All : used all retrieved AOT (QF = high, medium, and low).
- VIIRS APSP (Angstrom Exponent, AE) EDRs:
  - Used only high QF APSP.
  - AE computed at MAN's and MODIS's like wavelength pairs (445/865 versus 440/870 and 550/865 versus 500/870).
- Match-up criteria for VIIRS EDRs and MAN measurements:
  - The VIIRS-MAN match-up uses each MAN measurement as a reference point and finds the VIIRS retrievals within the spatial and temporal matching domain of 0.5° latitude-longitude and one hour time window centered on the MAN observation.
  - At least 12 (about 20%) selected quality VIIRS EDRs within the matching domain or any VIIRS EDR(s) within 3km of MAN measurements.
  - Multiple collocations within one-hour time window are averaged to a single match-up.
- Performance Statistics:
  - Accuracy : the mean difference between two datasets.
  - Precision : the standard deviation of the difference.
  - Separate AOT ( $\tau$ ) retrieval performance in the range of  $\tau < 0.3$  and  $\tau \geq 0.3$ .

## VIIRS and MAN Match-up

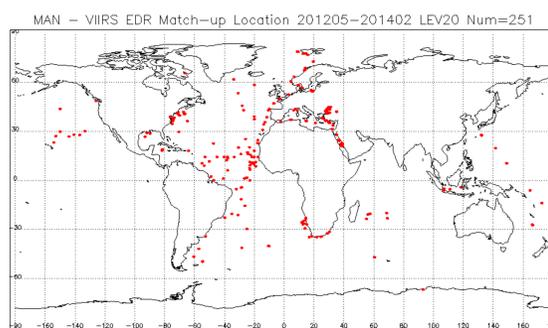


Figure 1 Locations of MAN measurements where match-ups were found with high quality VIIRS AOT EDRs during selected period.

## VIIRS APSP EDR Performance

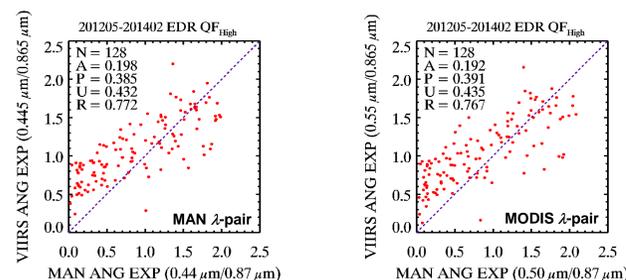


Figure 2 Comparisons between VIIRS high quality APSP EDRs and MAN measurements. Left panel shows the scatter plot of AE computed at MAN-like wavelength( $\lambda$ )-pair and right panel shows the scatter plot of AE computed at MODIS-like  $\lambda$ -pair. N : number of match-ups, A : accuracy, P : precision, U : uncertainty, R : correlation coefficient

Attribute	QF Level	APSP $\lambda$ -pair	VIIRS APSP Measurement	JPSS EDR Threshold	Achieved
Accuracy	High	MAN-like	0.20	0.3	✓
		MODIS-like	0.19		✓
Precision	High	MAN-like	0.39	0.6	✓
		MODIS-like	0.44		✓

Table 1 The performance statistics of VIIRS high quality APSP EDRs against JPSS requirement threshold at two AE  $\lambda$ -pairs.

## VIIRS AOT EDR Performance

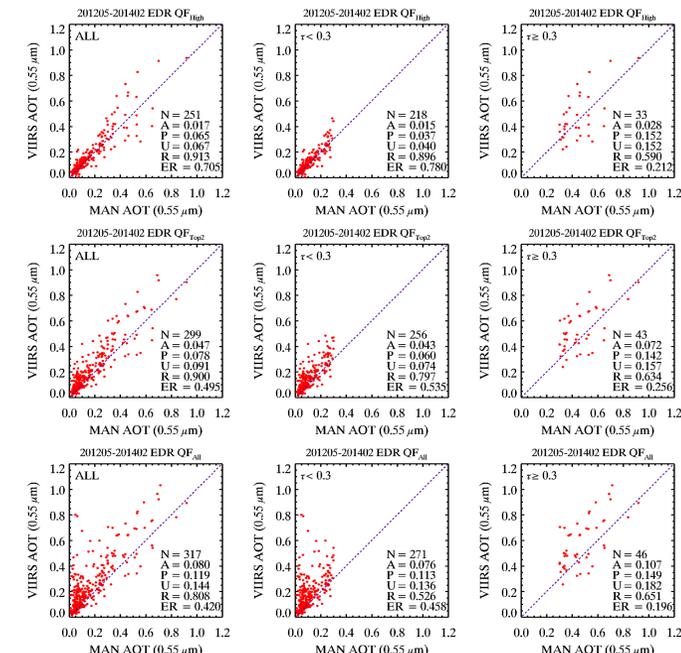


Figure 3 Comparisons between VIIRS AOT EDRs and MAN measurements. Figures in left, middle, and right columns are scatter plots of all match-ups, match-ups where MAN  $\tau < 0.3$ , and match-ups where MAN  $\tau \geq 0.3$ , respectively. Figures in upper, middle, and bottom rows are scatter plots of quality level equals to High, Top2, and All, respectively. N : number of match-ups, A : accuracy, P : precision, U : uncertainty, R : correlation coefficient, and ER : percentage of match-ups within MODIS expected error bars ( $\pm 0.03 \pm 0.05\tau$ ).

Attribute	QF Level	$\tau$ -range	VIIRS AOT Measurement	JPSS EDR Threshold	Achieved
Accuracy	High	$\tau < 0.3$	0.02	0.08	✓
			0.04		✓
			0.08		✓
Precision	High	$\tau \geq 0.3$	0.03	0.15	✓
			0.07		✓
			0.11		✓
Accuracy	Top2	$\tau < 0.3$	0.04	0.15	✓
			0.06		✓
			0.08		✓
Precision	High	$\tau \geq 0.3$	0.15	0.35	✓
			0.14		✓
			0.15		✓

Table 2 The performance statistics of VIIRS AOT EDRs against JPSS requirement threshold at three quality levels.

## Summary

- VIIRS AOT EDRs meet JPSS AOT thresholds at all three QF levels. It still needs some improvements to achieve the objective goal of 1% for both accuracy and precision at all  $\tau$  values.
- VIIRS high quality APSP EDRs meet JPSS thresholds for APSP. It also needs improvements to achieve the objective goal of 0.1 unit for both accuracy and precision.
- Comparisons between VIIRS AOT and APSP over the land can be seen from poster session presented by J. Huang et. al., "Spatial and Temporal Characterization of the Difference between Multi-Sensor Aerosol Retrievals and AERONET measurements".

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