Validation of Suomi NPP VIIRS Aerosol Optical Thickness and Particle Size Parameter with AERONET

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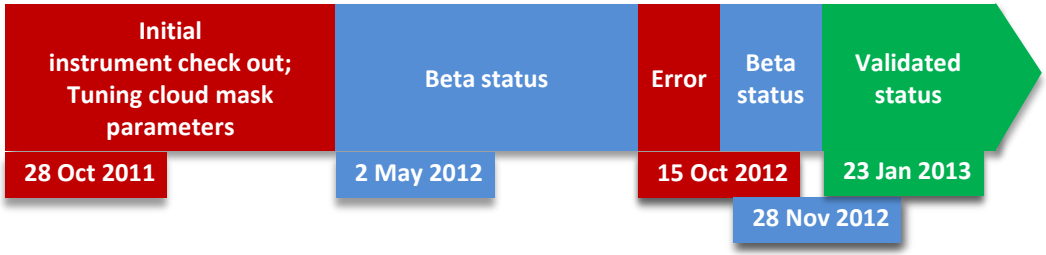
Introduction

- VIIRS aerosol products, AOT and APSP (AE), are derived from 412 - 2,250 nm VIIRS M bands.
- Preliminary evaluation of AOT for May 2, 2012/Jan 23, 2013 - Sep 1,2013 aerosol data is in Liu et al. (2014):
  - Global biases: 0.01 over ocean and -0.01 over land
  - 64% (land) and 71% (ocean) of retrievals fall within the expected uncertainty range established by **MODIS** (!) [ocean: ±(0.03 + 0.05AOT); land: ±(0.05 + 0.15AOT)]
- This presentation extends the period to Dec 31, 2014 and establishes expected error range from VIIRS AOT & APSP.
- **Outline**
  - Aerosol data used
  - Matchup protocol
  - Results

Aerosol Data



- **VIIRS:**
  - *Aerosol Optical Thickness (AOT)* Environmental Data Record (EDR) (6 km): best quality AOT at 550 nm;
  - *Aerosol Particle Size Parameter (APSP)* EDR over ocean (6 km) reported as the Ångström Exponent (AE) : calculated from AOTs at 865 nm and 1610 nm;
  - *Time period:* Jan 23, 2013 to Dec 31, 2014 (land) and May 2, 2012 to Dec 31, 2014 (except Oct 15, 2012 to Nov 27, 2012) (ocean).
- **AERONET:**
  - Level 2.0 AERONET Direct Sun Algorithm AOT wavelengths 380-870 nm, and at 1640 nm (Holben et al., 1998; Smirnov et al., 2000)
  - AERONET AOTs are interpolated to VIIRS wavelengths using a 2nd order polynomial fit in logarithmic coordinates. (Eck et al., 1999; Remer et al., 2005; Levy et al., 2010, Kahn et al., 2010)

VIIRS-AERONET AOT Matchup

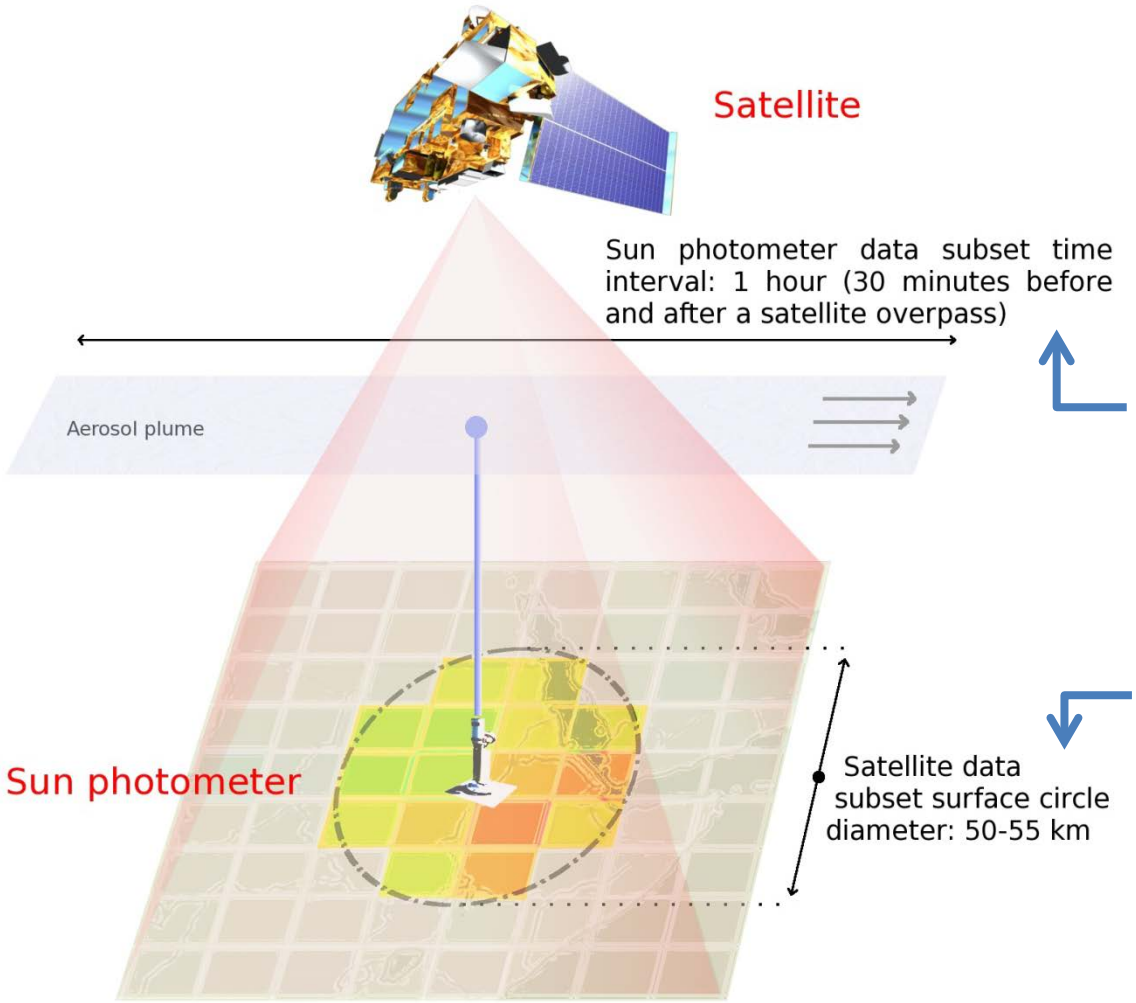


Figure credit of NASA GSFC MAPSS Group, P. Maksym & C. Ichoku (http://disc.sci.gsfc.nasa.gov/aerosols/services/mapss/)

Matchup Protocol:

Follows Multi-sensor Aerosol Products Sampling System (MAPSS)

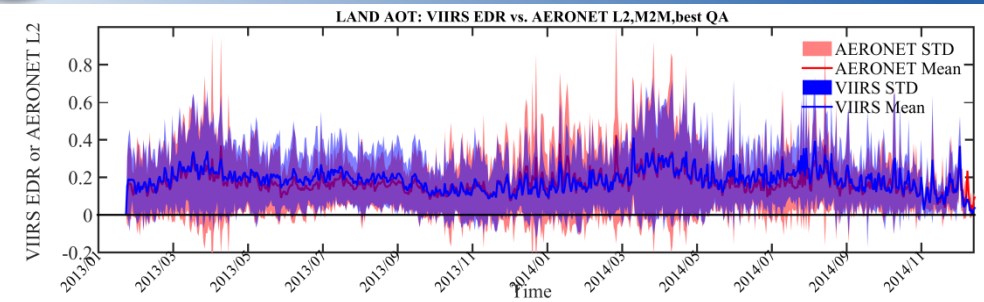
Matchup Criteria:

- At least 2 AERONET L2.0 measurements are available within time window;
- At least 20% of VIIRS best quality AOT retrievals are available within spatial domain.

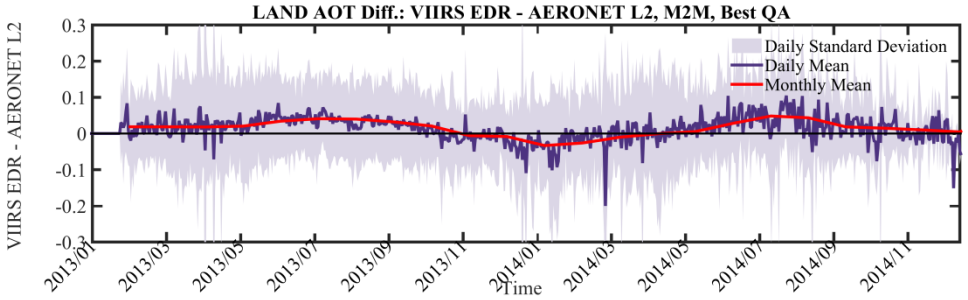
Averages of AOTs are saved in matchup.

VIIRS vs. AERONET Time Series

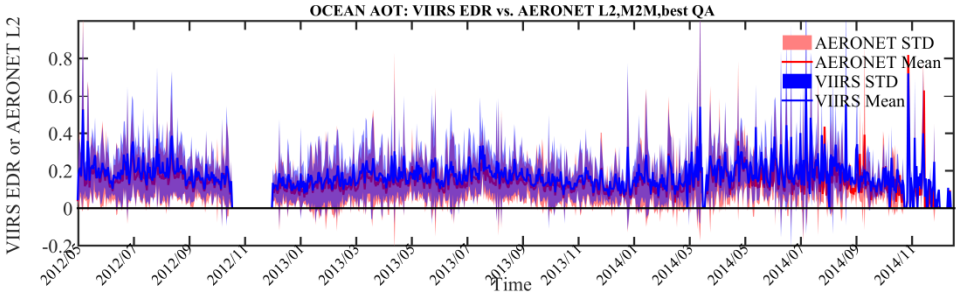
(a)



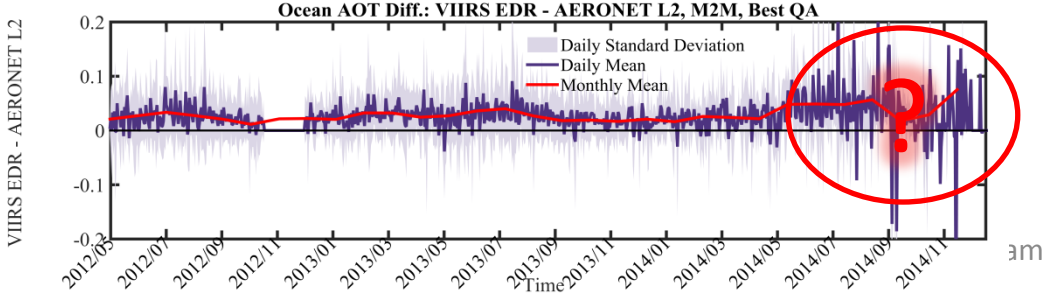
(b)



(c)

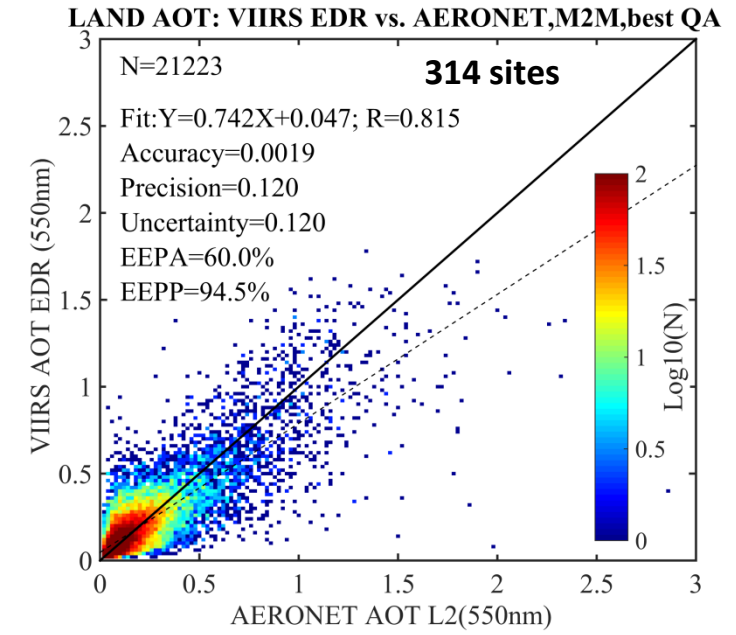


(d)



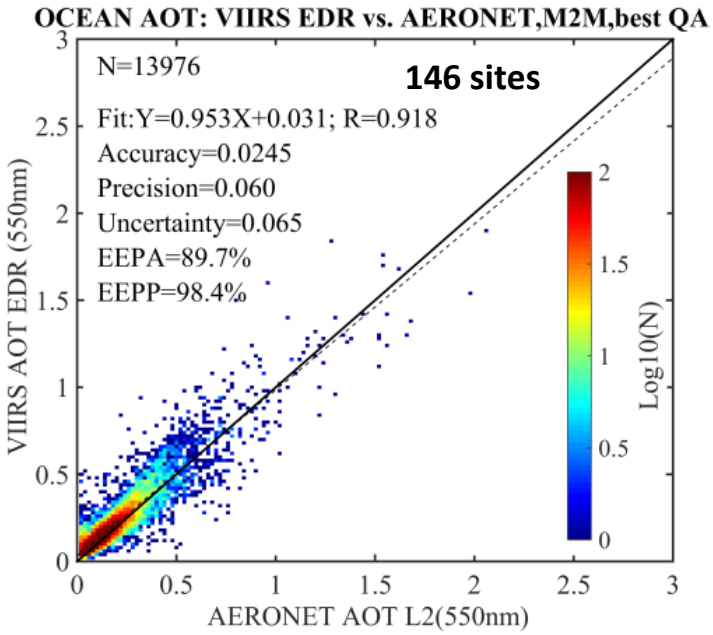
- Daily AOTs (**a, c**), daily and monthly mean AOT differences (**b, d**) over land and ocean.
- Day-to-day variability (**a, c**) is similar.
- Large seasonal dependence of bias over land (**b**); >0 during NH summer, <0 NH winter. (Because of constant surface reflectance ratios ?)
- No significant seasonal variability of bias over ocean, but persistent positive bias is present (**d**).

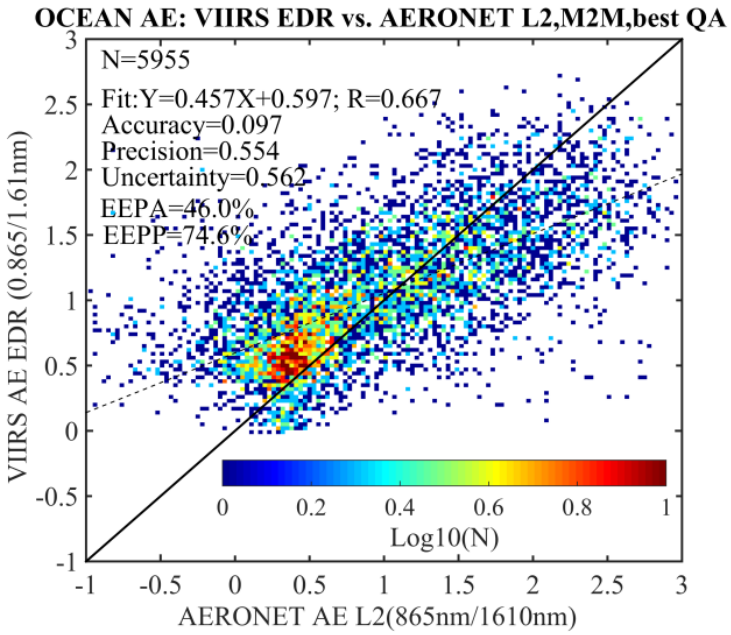
Scatter Plots



Land: Large scatter, but small overall bias (due to cancellation of errors). High AOT is underestimated.

Ocean: Smaller scatter, but overall positive bias (doubled wrt. Liu at al., 2014). Smaller/larger particles from VIIRS when AERONET suggest larger/smaller particles





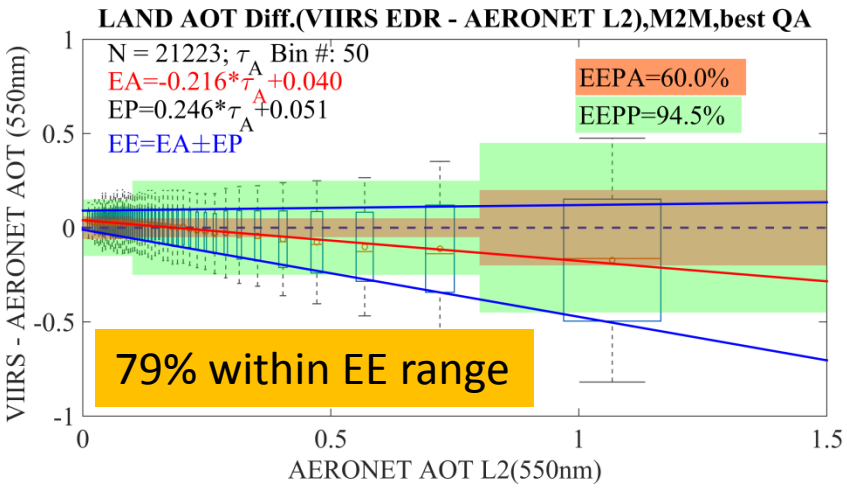
EDR vs. JPSS L1RD Requirements

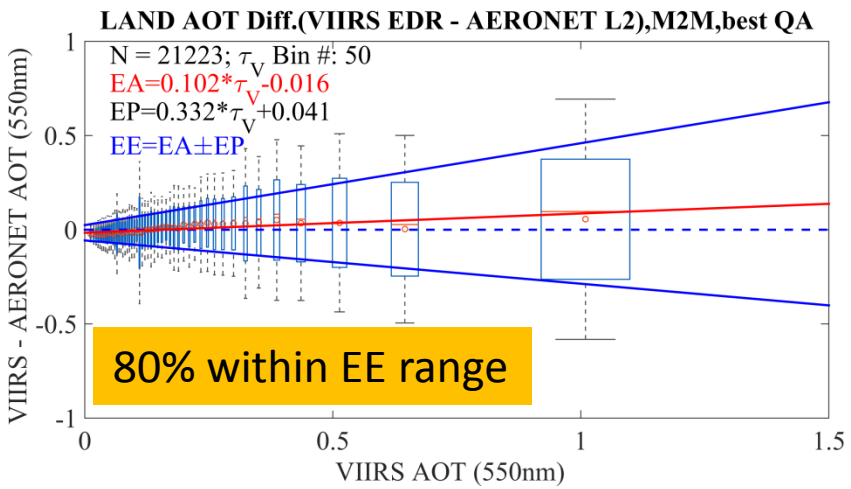
AOT range	Accuracy		Precision	
	Specs	VIIRS	Specs	VIIRS
LAND AOT (01/23/2013-12/31/2014)				
AOT < 0.1	0.06	**0.03**	0.15	**0.07**
0.1 ≤ AOT ≤ 0.8	0.05	**-0.01**	0.25	**0.12**
0.8 < AOT≤ 2.0	0.20	**-0.19**	0.45	**0.34**
OCEAN AOT (05/02/2012-12/31/2014, excluding 10/15/2012-11/27/2012)				
AOT < 0.3	0.08	**0.03**	0.15	**0.04**
0.3 ≤ AOT ≤ 2.0	0.15	**0.02**	0.35	**0.13**
OCEAN AE (05/02/2012-12/31/2014, excluding 10/15/2012-11/27/2012)				
865nm/1610nm	0.30	**0.10**	0.60	**0.55**

Meeting JPPS requirements

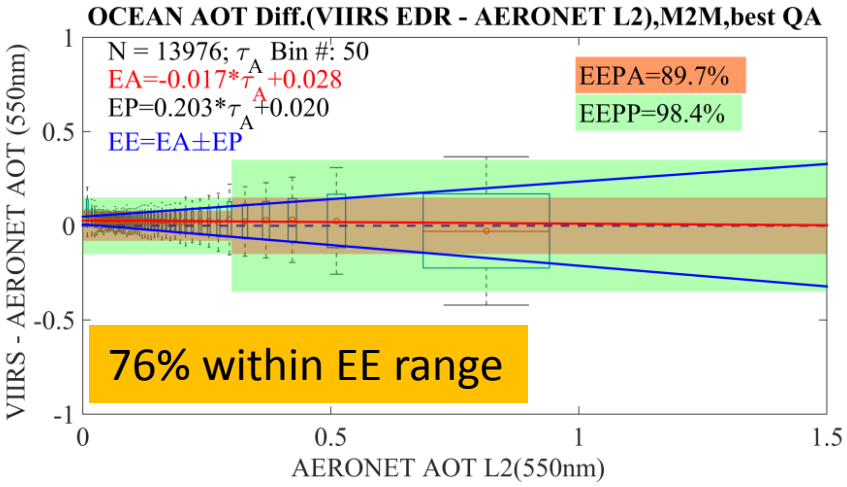
Expected Error Estimates

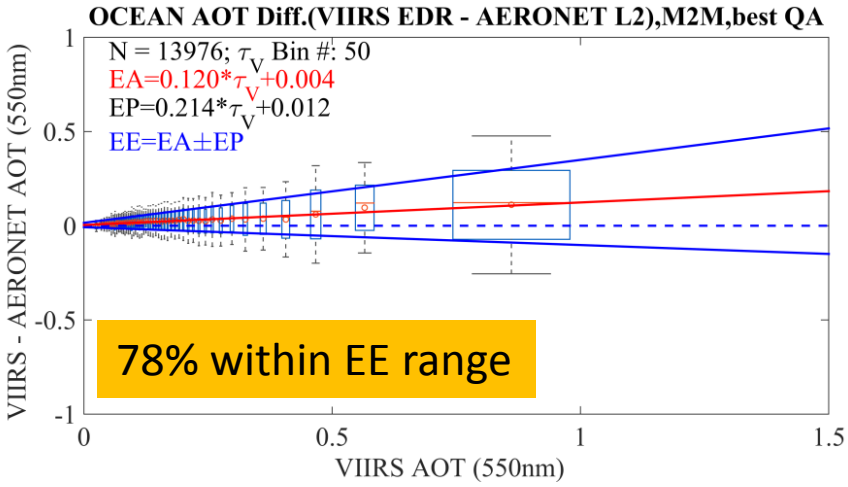
- Bin VIIRS-AERONET differences according to AERONET (VIIRS) AOT
- Calculate mean bias (circle) and (1 σ) standard deviation (box) for each bin.
- Linearly fit bin values of mean bias (**EA**) and standard deviation (**EP**) as function of AERONET (VIIRS) AOT.
- **Expected Error: EE = EA ± EP**

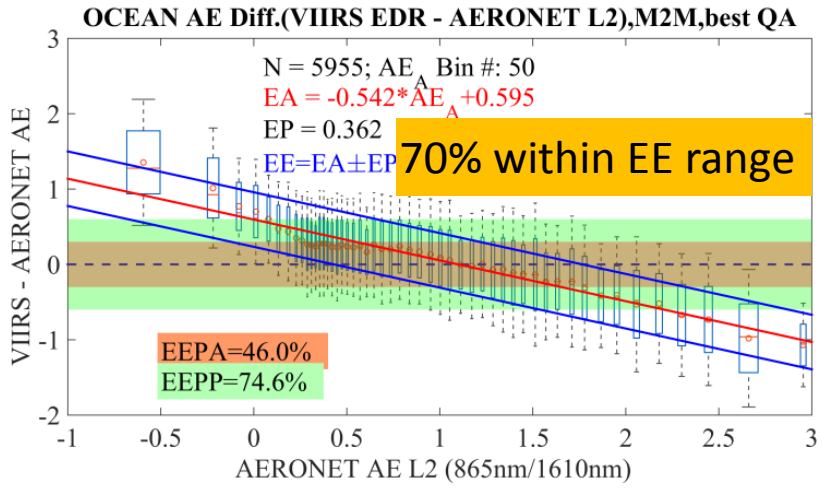


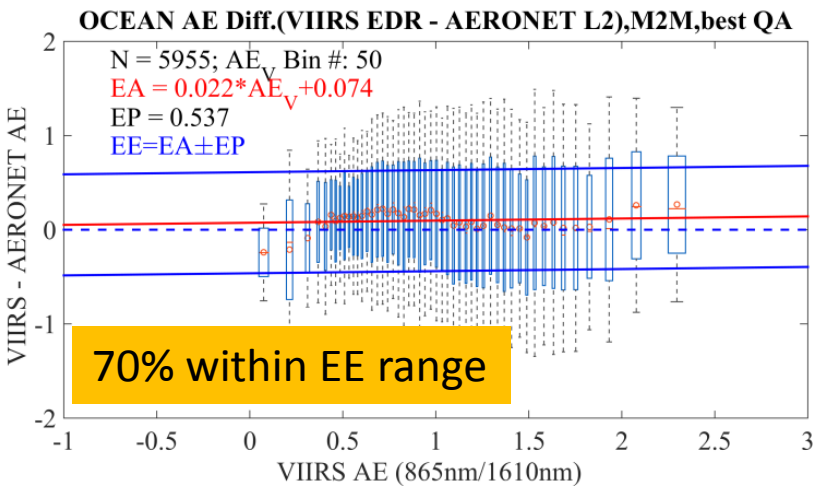


Expected Error Estimates

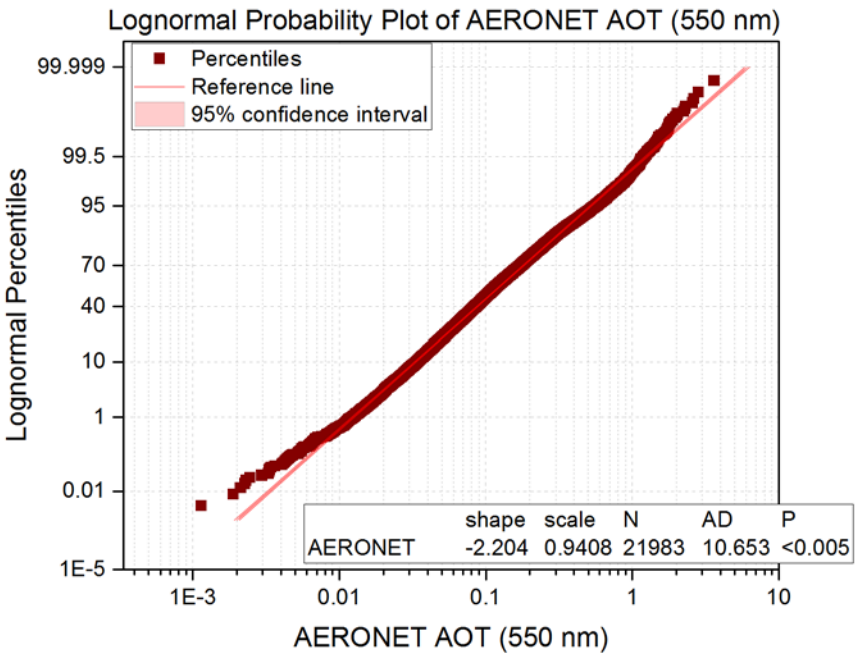


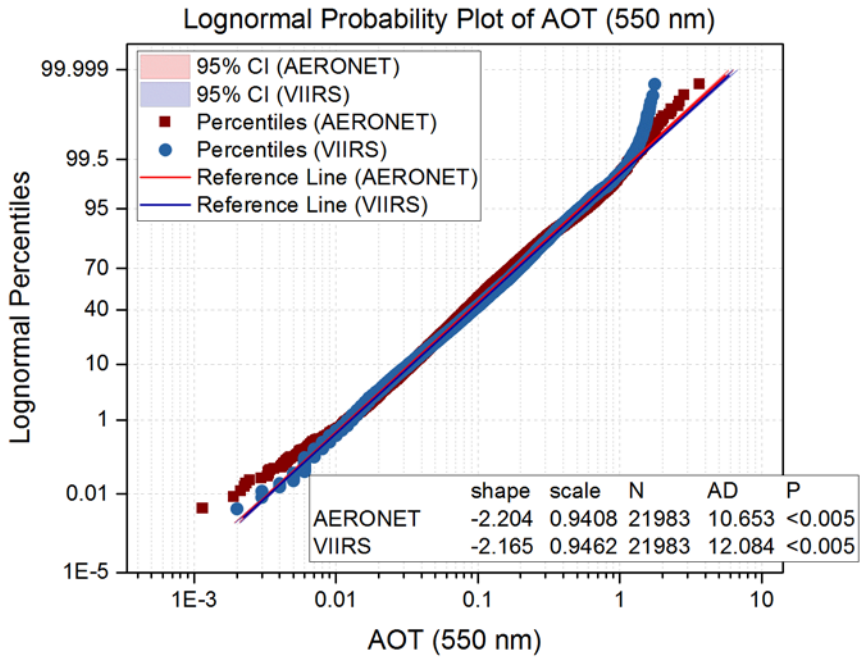






A different look





Motivation: AERONET and VIIRS AOTs are samples of the AOT "population"; should have similar PDFs

- Assume the samples follow a *lognormal distribution* [O'Neill et al., 2000] and display them on a Probability plot (CDF; Benard median score was used)
  - VIIRS **empirical** CDF can be compared to AERONET CDF **fit**.
  - (If true the fit could be used to (objectively) detect outliers.)
- Actually, they do **not**! But still can be used for comparison.
  - VIIRS and AERONET fit parameters (shape and scale) are similar

Summary

- Accuracy, Precision and Expected Errors of VIIRS AOT and APSP EDRs are estimated from a 2+ year record of VIIRS retrievals and AERONET L2 data.
- Bias over land/ocean is smaller/larger than that in the shorter time period in Liu et al. (2014), but still within JPSS specs.

	Land AOT	Ocean AOT	Ocean AE
Sample Size	21223	13976	5955
Accuracy	0.002	0.025	0.097
Precision	0.120	0.060	0.554
Uncertainty	0.120	0.065	0.562
Corr. Coef.	0.815	0.918	0.667
Slope	0.742	0.953	0.457
Intercept	0.047	0.031	0.597
EEPA	60.0%	89.7%	46.0%
EEPP	94.5%	98.4%	74.6%