STAR JPSS 2015 Annual Science Team Meeting

The JPSS Risk Reduction Aerosol Optical Thickness Algorithm

Hongqing Liu and Istvan Laszlo

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Objectives

- Algorithm updates
  - Extend the range of aerosol optical thickness to [-0.05, 5.0]
  - Adopt MODIS aerosol models
  - Revise the spectral relationship of land reflectance
  - Combine the VIIRS-like and MODIS/ABI-like retrieval schemes over land
  - Refine the internal tests
  - Revise the quality control
- Cross-platform consistency
  - Apply a single algorithm on both JPSS and GOES-R

Algorithm Comparison (Over Water)

	IDPS	NOAA
Internal Tests	Turbid water; Sun glint; Sea ice	Bright cloud; Cirrus; Sea ice; Spatial homogeneity; Turbid/shallow water; Heavy aerosol
Aerosol Models	MODIS C4	MODIS C5
Surface Reflectance	$R_f+R_u+R_s$	$R_f+(1-R_f)R_u+(1-W)R_s$ [Koepke, 1984]
AOT Range	[0.0, 2.0]	[-0.05, 5.0]
Channel Used	0.67, 0.74(saturation), 0.86, 1.24, 1.61, 2.25 μm	**0.55**, 0.67, 0.74(saturation), 0.86, 1.24, 1.61, 2.25 μm
Residual	$\sum_{\lambda=1}^{n}\left(\rho_\lambda^m-\rho_\lambda^{LUT}\right)^2$	$\sqrt{\sum_{\lambda=1}^{n}\left(\frac{\rho_\lambda^m-\rho_\lambda^{LUT}}{\rho_\lambda^m-\rho_\lambda^{Ray}+0.01}\right)^2}\Big/n$
Ångström Exponent	0.86 vs. 1.61 μm	0.55 vs. 0.86 μm 0.86 vs. 1.61 μm
Inland Lakes	No retrievals	Included

Algorithm Comparison (Over Land)

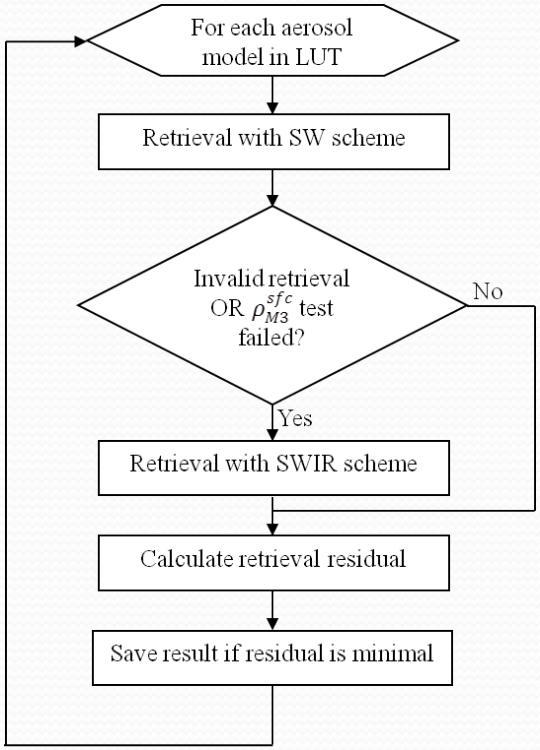
	IDPS	NOAA
Internal Tests	Cirrus; Sunglint; Fire; Snow; Ephemeral water	Cloud; Cirrus; Snow; Spatial homogeneity; Ephemeral water; Heavy aerosol
Aerosol Models	AERONET	MODIS C5
Surface Reflectance Spectral Relationship	Constant ratios	Linear relationship as functions of $NDVI_{SWIR}$, scene redness, and glint angle
AOT Range	[0.0, 2.0]	[-0.05, 5.0]
Reference Channels	0.48 and 0.67 μm	0.48 and 0.67 μm (SW scheme) 0.48 and 2.25 μm (SWIR scheme)
Residual	$\sum_{\lambda=1}^{n}\left(\alpha_{\lambda}^{corr}-\alpha_{\lambda}^{est}\right)^2$	$\sqrt{\sum_{\lambda=1}^{n}\left(\frac{\rho_{\lambda}^{m}-\rho_{\lambda}^{LUT}}{\rho_{\lambda}^{m}-\rho_{\lambda}^{Ray}+0.01}\right)^2}\Big/n$

Land Aerosol Algorithm

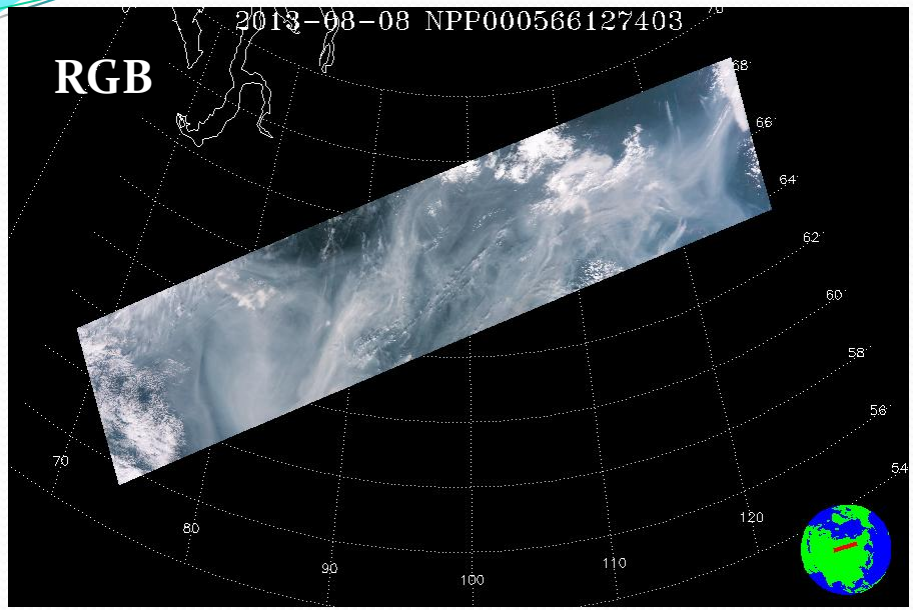
- IDPS VIIRS (SW scheme)
  - Surface reflectance at 0.48μm is estimated from 0.67μm
  - Pros: robust spectral surface reflectance relationship
  - Cons: strong atmospheric effect
  - Better performance at low AOTs
- MODIS (SWIR scheme)
  - Surface reflectance at 0.48μm is estimated from 2.25μm
  - Pros: relatively transparent atmosphere for most aerosols at 2.25μm
  - Cons: uncertain spectral surface reflectance relationship
  - Better performance at high AOTs
- JPSS Risk Reduction Aerosol Algorithm (NOAA VIIRS)
  - SW scheme as the first choice
  - Apply SWIR algorithm if
    - Invalid retrievals from SW scheme
    - Surface reflectance at 0.48μm is out of uncertainty range
  - Surface spectral reflectance relationship are linear functions of TOA redness ratio (TOA M5/M4 reflectance ratio), $NDVI_{SWIR}$ (TOA M8-M11/M8+M11) and glint angle (G)

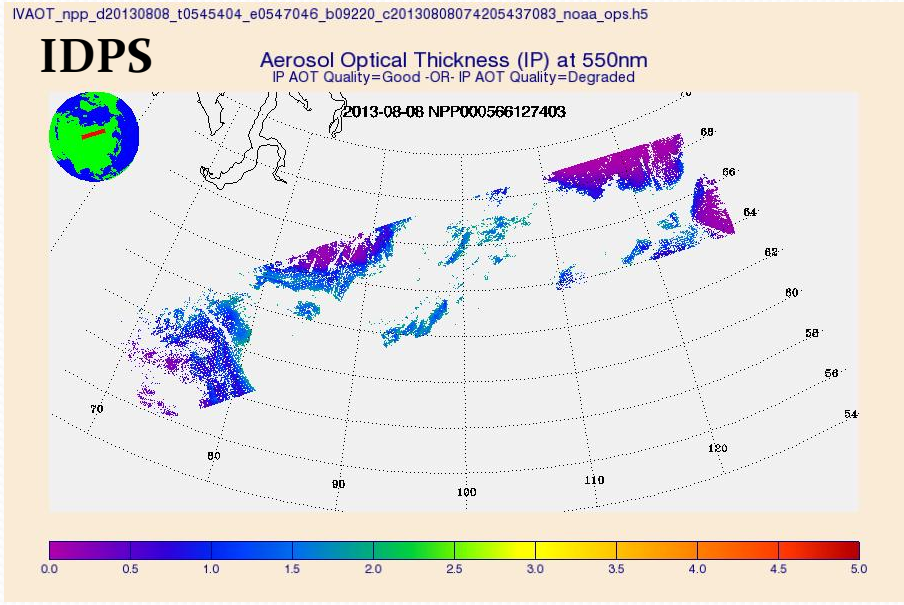
    $Y = (c_1+c_2*Redness+c_3*NDVI_{SWIR}+c_4*G) + (c_5+c_6*Redness+c_7*NDVI_{SWIR}+c_8*G)*X$

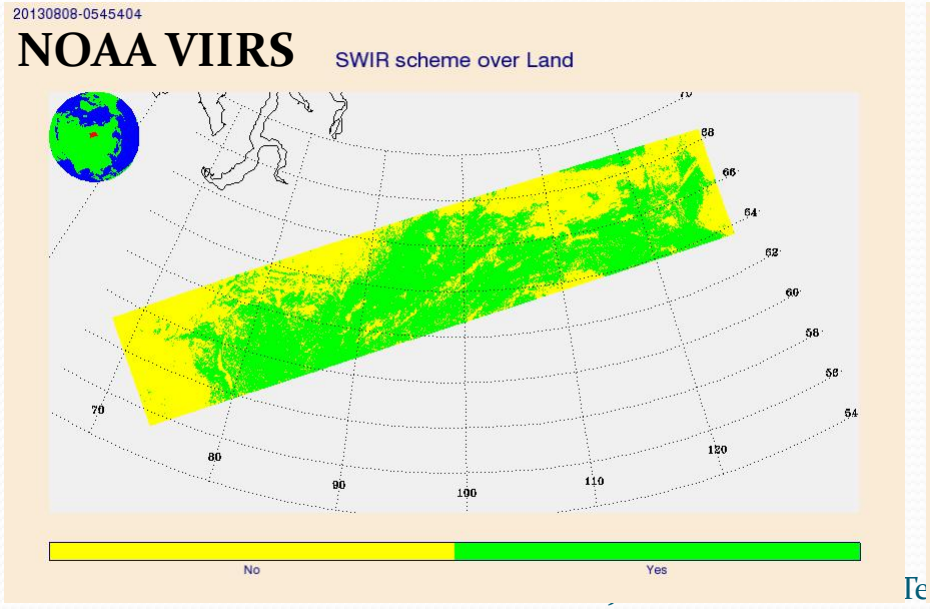
    where Y is the surface reflectance at band M5, M3, M1, M2; and X is the surface reflectance at M11, M5, M3, M3, respectively.

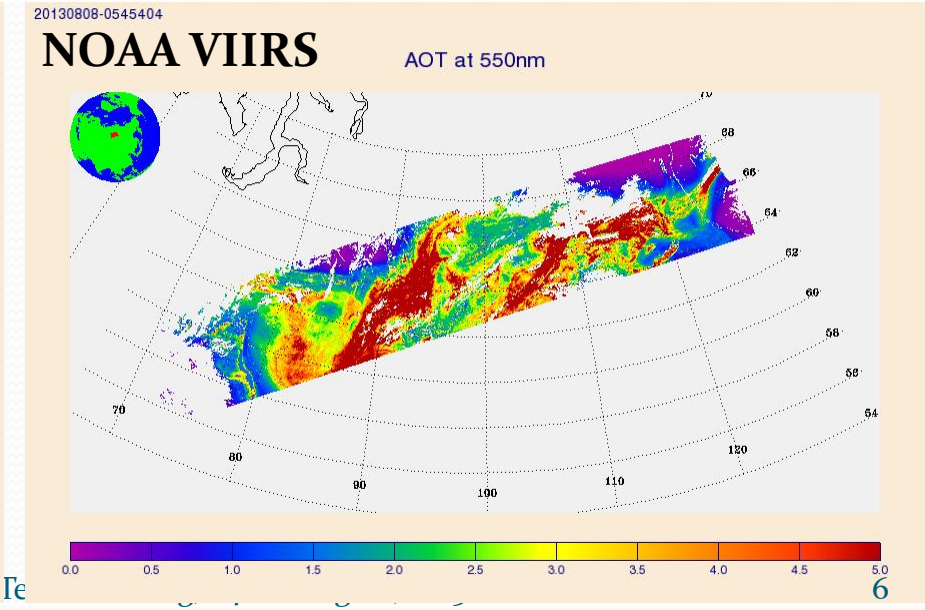


Land Aerosol Algorithm (Example)





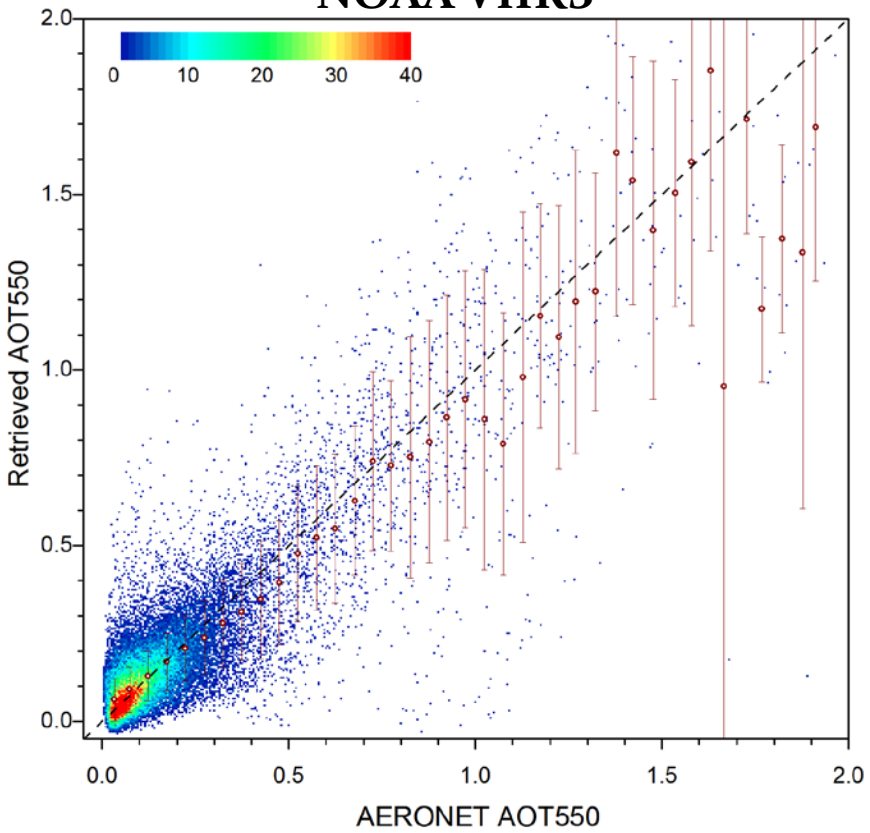




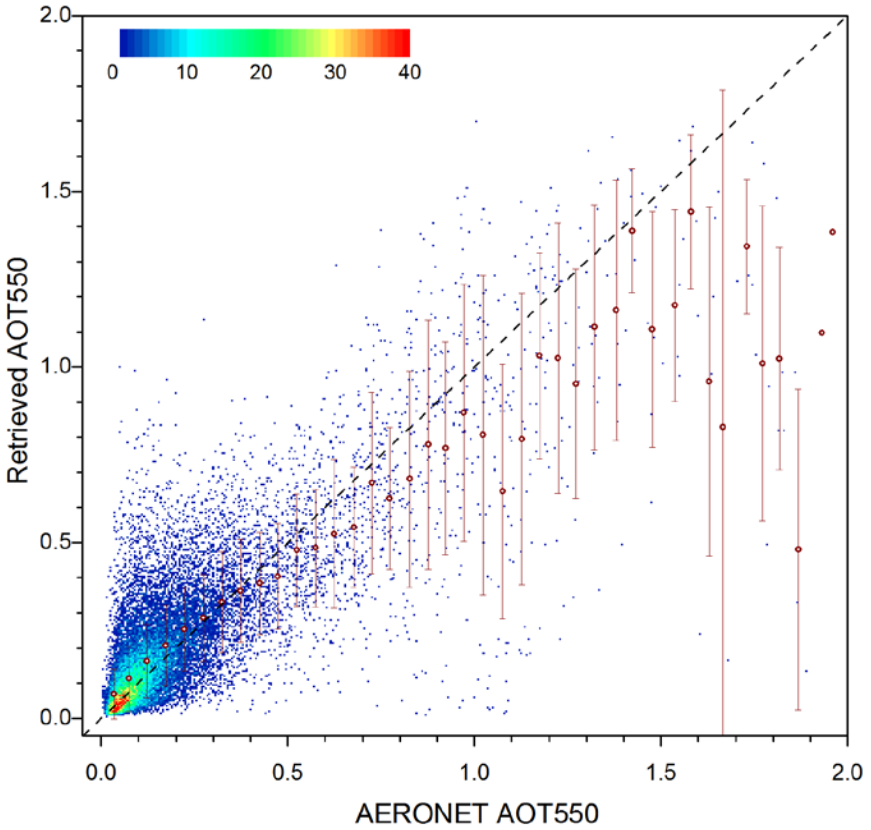
Validation over Land

- Time period: Jan. 23, 2013 – Dec. 31, 2014
- High quality retrievals over AERONET stations
- 20-km radius (at least 400 retrievals), and 1-hr window (at least two measurements) for match-up
- AERONET L1.5 ground measurements

NOAA VIIRS



IDPS VIIRS



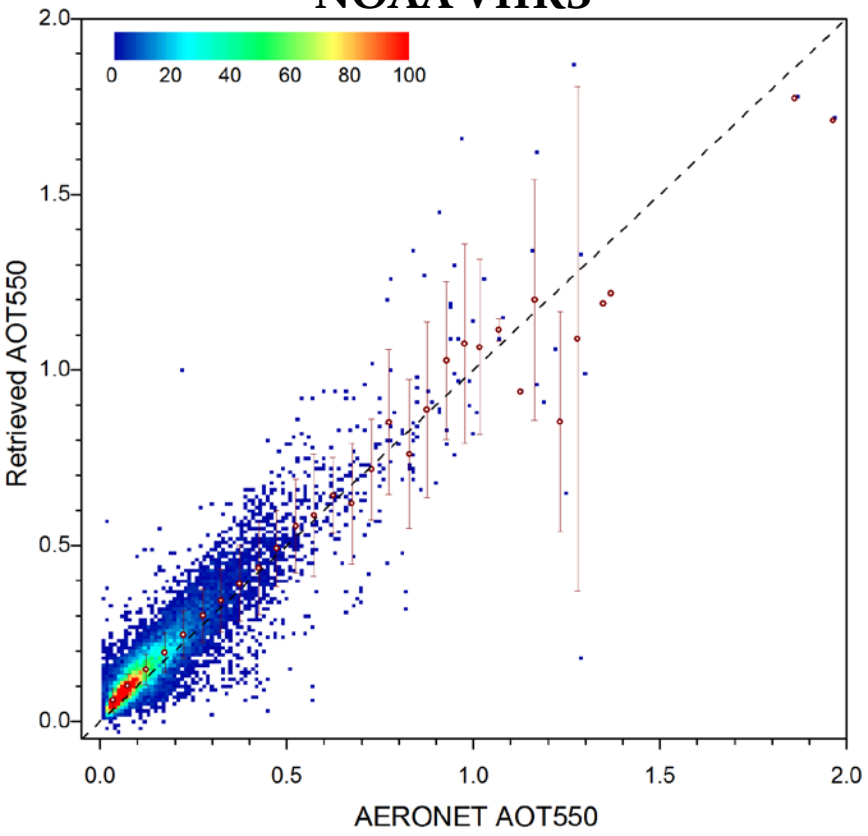
Statistics

LAND		NOAA-VIIRS	IDPS-VIIRS	Requirement
<0.1	Accuracy	0.02	0.04	0.06
	Precision	0.06	0.09	0.15
	Number	17,451	9,563	
[0.1, 0.8]	Accuracy	-0.01	0.02	0.05
	Precision	0.11	0.13	0.25
	Number	15,187	11,344	
>0.8	Accuracy	-0.11	***-0.26***	0.20
	Precision	0.41	***0.46***	0.45
	Number	539	454	
All	Accuracy	0.003	0.021	
	Precision	0.103	0.136	
	Number	33,177	21,361	

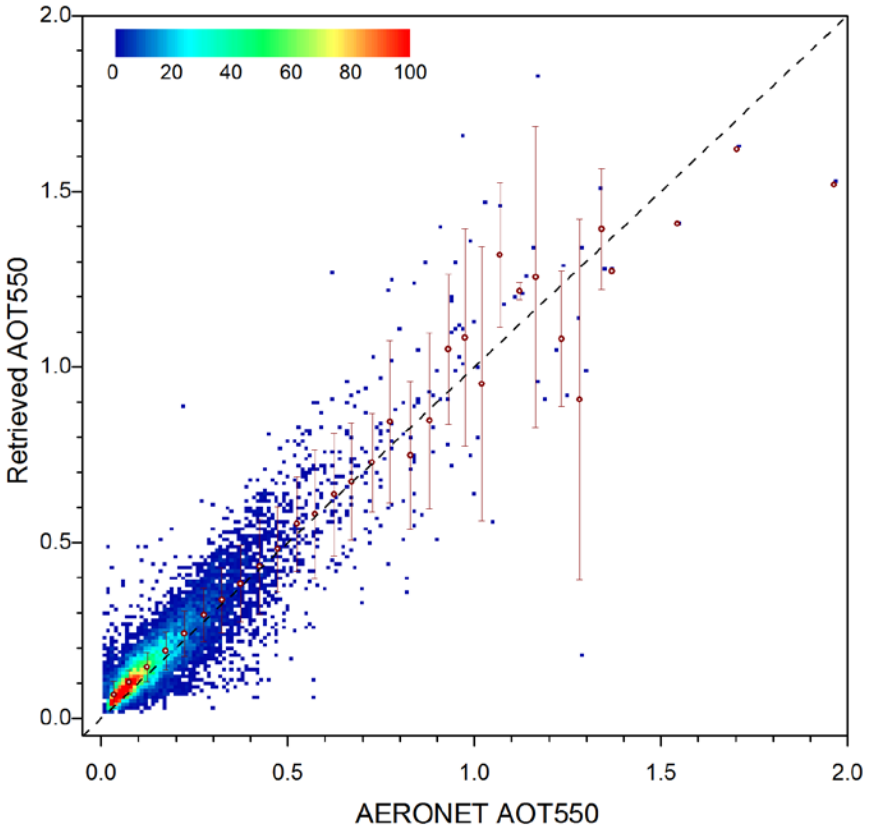
Validation over Ocean

- Time period: Nov. 27, 2012 – Dec. 31, 2014
- High quality retrievals over AERONET stations
- 20-km radius (at least 200 retrievals), and 1-hr window (at least two measurements) for match-up
- AERONET L1.5 ground measurements

NOAA VIIRS



IDPS VIIRS



Statistics

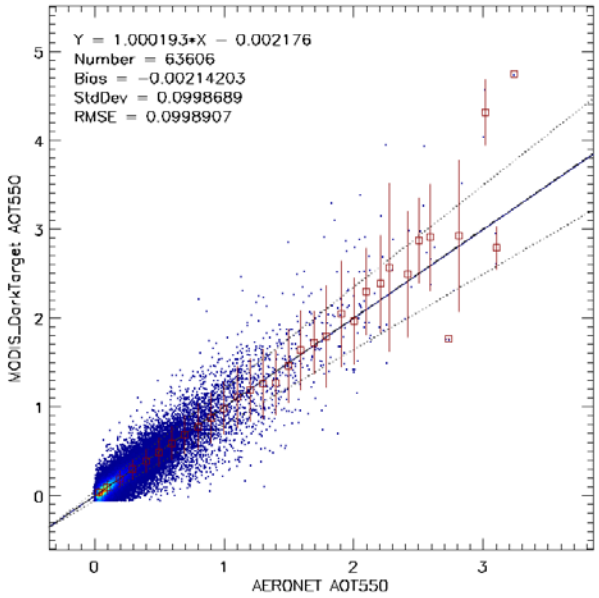
Ocean		NOAA-VIIRS	IDPS-VIIRS	Requirement
<0.3	Accuracy	0.03	0.03	0.08
	Precision	0.04	0.05	0.15
	Number	13,254	11,991	
>=0.3	Accuracy	0.01	0.01	0.15
	Precision	0.13	0.14	0.35
	Number	1,315	1,301	
All	Accuracy	0.025	0.024	
	Precision	0.058	0.061	
	Number	14,569	13,292	

Evaluation with MODIS Data

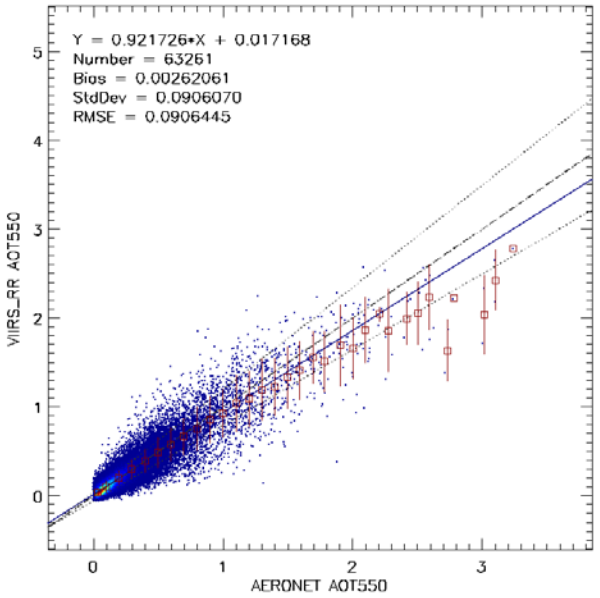
- Comparing different algorithms with same inputs
- VIIRS algorithms (IDPS and Risk-Reduction) are adapted to MODIS (Aqua) reflectance data available from Collection-6 Level-2 aerosol products
  - Create lookup tables with MODIS spectral response functions
  - Revise band-dependent coefficients
  - Derive spectral relationship of surface reflectance
- Match up with AERONET Level-2 measurements
  - MODIS 10km pixels within 50x50km domain
  - One-hour time window for ground measurements
  - Jul. 2002 – Dec. 2013

Validation over Land

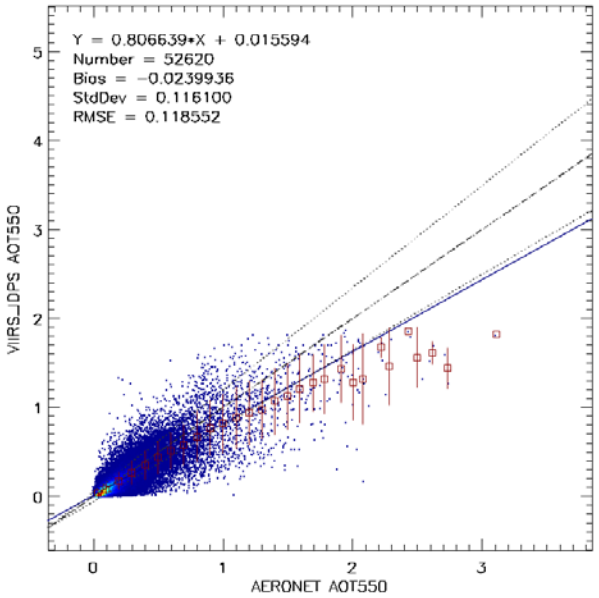
MODIS



NOAA VIIRS



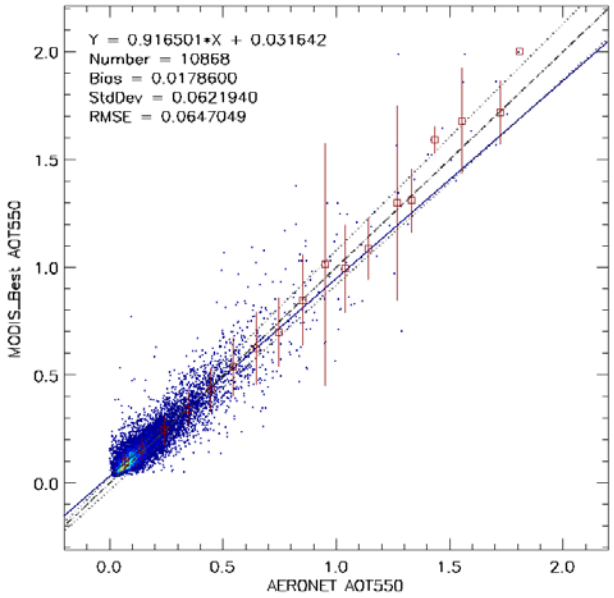
IDPS VIIRS



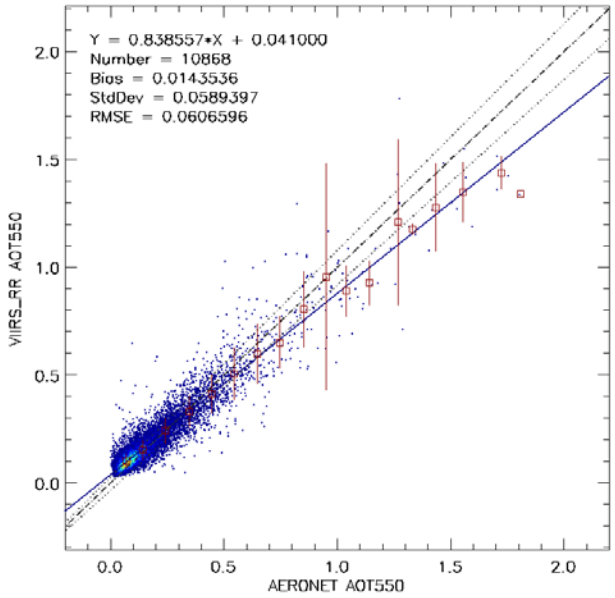
Statistics	MODIS	NOAA-VIIRS	IDPS-VIIRS
Accuracy	-0.002	0.003	-0.024
Precision	0.100	0.091	0.116
#Match-ups	63,606	63,261	52,620
Correlation	0.901	0.907	0.842
%inUncRange	70.83	79.28	72.78

Validation over Ocean

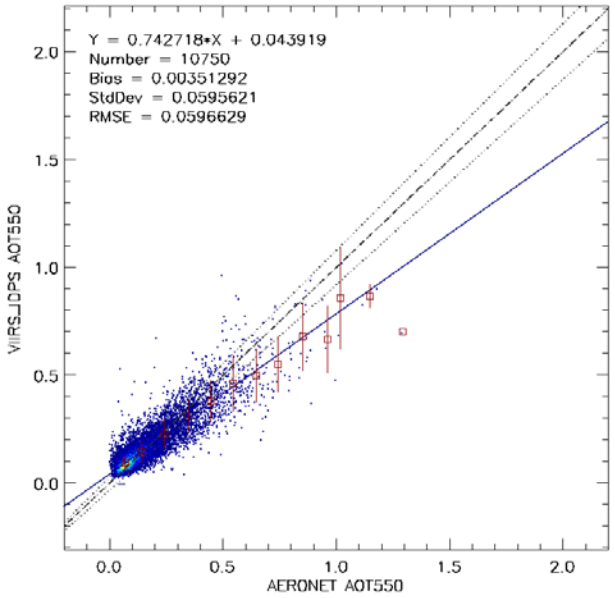
MODIS



NOAA VIIRS



IDPS VIIRS



Statistics	MODIS	NOAA-VIIRS	IDPS-VIIRS
Accuracy	0.018	0.014	0.004
Precision	0.062	0.059	0.060
#Match-ups	10,868	10,868	10,750
Correlation	0.916	0.922	0.878
%inUncRange	60.49	60.83	61.16

Summary

- JPSS Risk Reduction Aerosol Algorithm was developed.
  - Single algorithm applied to both VIIRS and ABI
  - More functionalities with less number of line of code than the IDPS algorithm (~3500 vs. ~5600)
  - Wider spatial coverage than IDPS
  - More retrievals over significant aerosol events
  - Wider AOT range [-0.05, 5.0]
- Evaluation with AERONET shows better performance than IDPS over land.
- Evaluation with MODIS data shows comparable performance.