Long-term AOD Retrieval from AVHRR Data over Land Surface

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Introduction

▼ AVHRR

▼ 16 satellites, over 35 years

▼ Morning and afternoon satellites

▼ Daily global coverage

SST, NDVI, albedo, aerosol…
✓ Long-term trend analysis

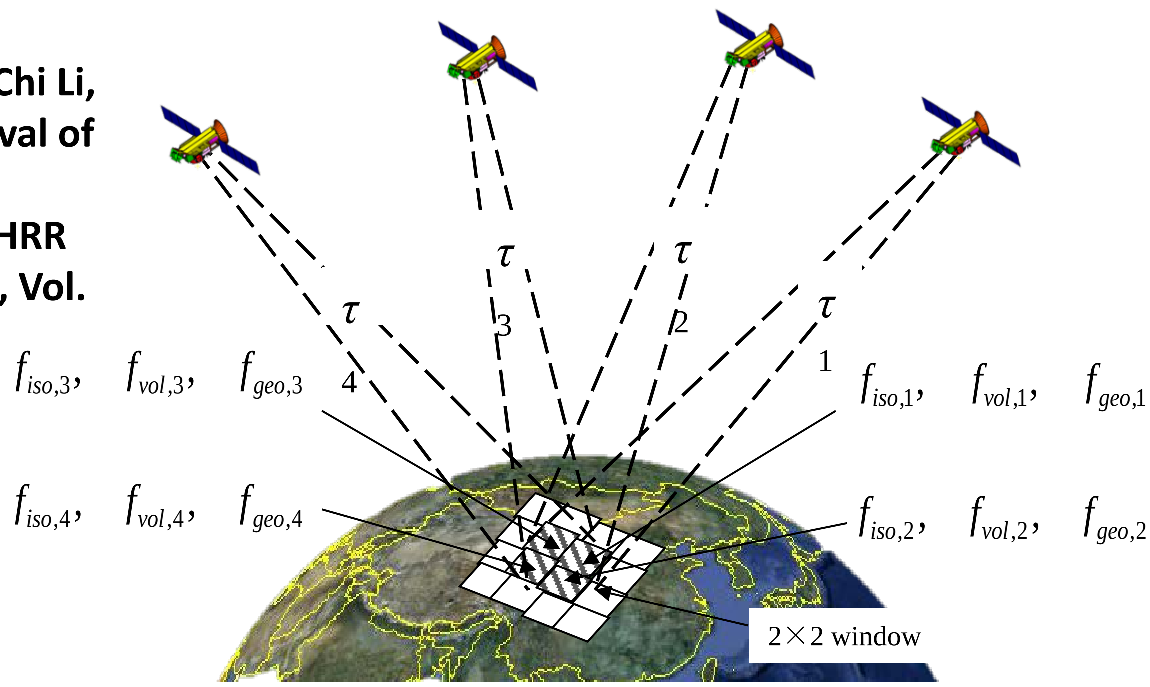
Satellite	Operational time	Equator passing time (ascending/descending)
TIROS-N	1978.10 - 1980.01	15:00/03:00
NOAA-6	1979.06 - 1986.11	19:30/07:30
NOAA-7	1981.04 - 1986.06	14:30/02:30
NOAA-8	1983.06 - 1984.06/ 1985.07 - 1985.11	19:30/07:30
NOAA-9	1985.02 - 1988.11	14:20/02:20
NOAA-10	1986.11 - 1991.09	19:30/07:30
NOAA-11	1988.11 - 1995.04	13:30/01:30
NOAA-12	1991.09 - 1998.12	19:30/07:30
NOAA-14	1995.04 - 2007.05	13:30/01:30
NOAA-15	1998.12 -	19:30/07:30
NOAA-16	2001.03 -	14:00/02:00
NOAA-17	2002.10 -	22:00/10:00
NOAA-18	2005.08 -	14:00/02:00
Metop-A	2006.11 -	21:30/09:30
NOAA-19	2009.06 -	14:00/02:00
Metop-B	2012.09 -	21:30/09:30

LABITS Algorithm

The top-of-atmospheric (TOA) reflectance obtained by satellite is

$$\rho^{TOA}(\theta_s,\theta_v,\varphi) = (f_{iso} + f_{vol}K_{vol} + f_{geo}K_{geo})\exp\left(-G\tau_a\right) + \frac{\omega P(\Omega_v,\Omega_s)}{4(|\mu_s|+\mu_v)}\left[1-\exp\left(-G\tau_a\right)\right]$$
$$+\frac{(1-g^2)(1+1.5\mu_v)\left[I^+_{ms}(0)-I^+_{ss}(0)\right] + g^2\delta(\mu_v-|\mu_s|)\left[I^+_{ms}(0)-I^+_{ss}(0)\right]}{2\pi\left[1-g^2(1-|\mu_s|)\right]}$$

Yingjie Li, Yong Xue, Gerrit de Leeuw, Chi Li, Leiku Yang, Tingting Hou, 2013, Retrieval of Aerosol Optical Depth and Surface Reflectance over Land from NOAA AVHRR Data. *Remote Sensing of Environment*, Vol. 133, Pages 1–20.



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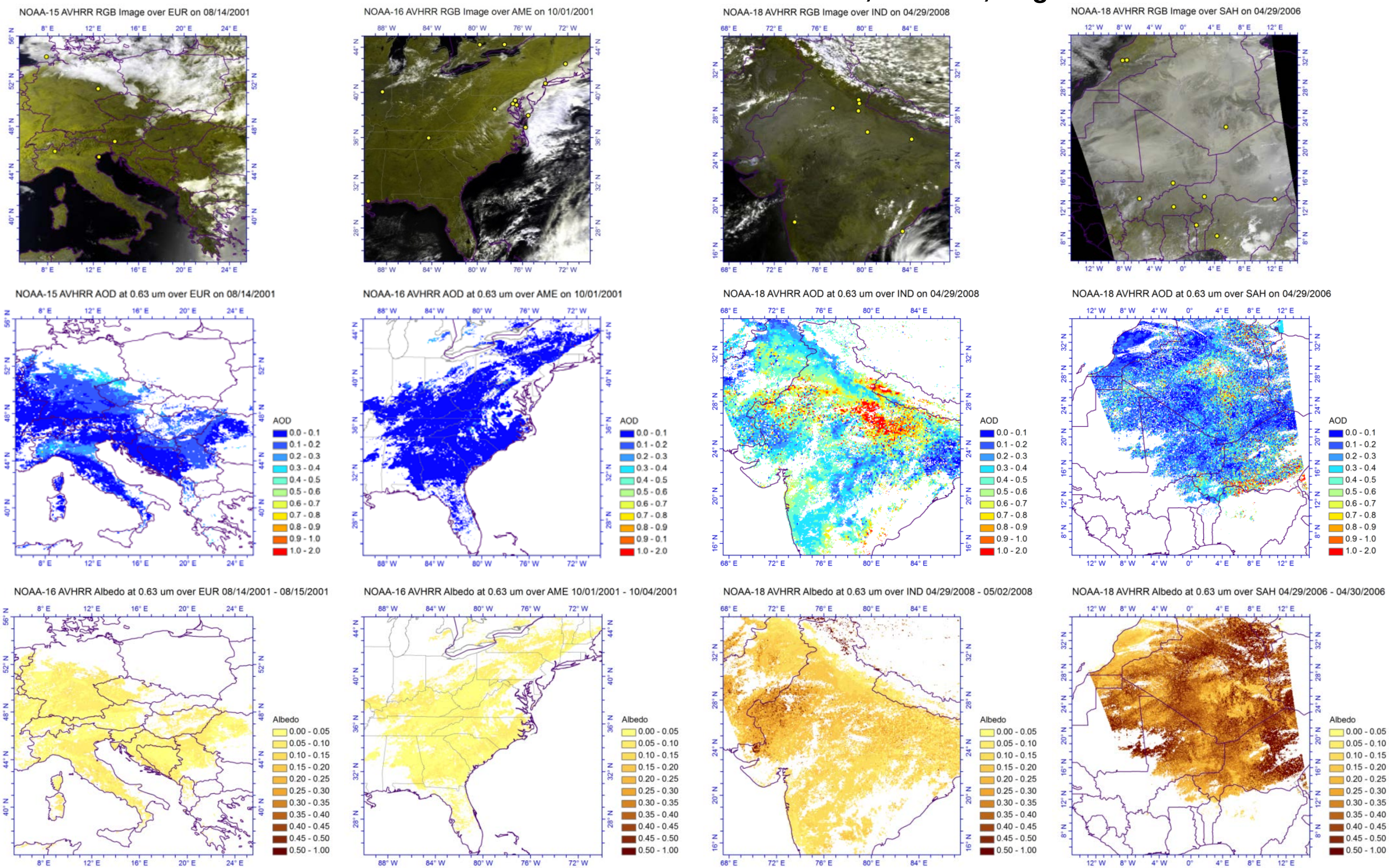
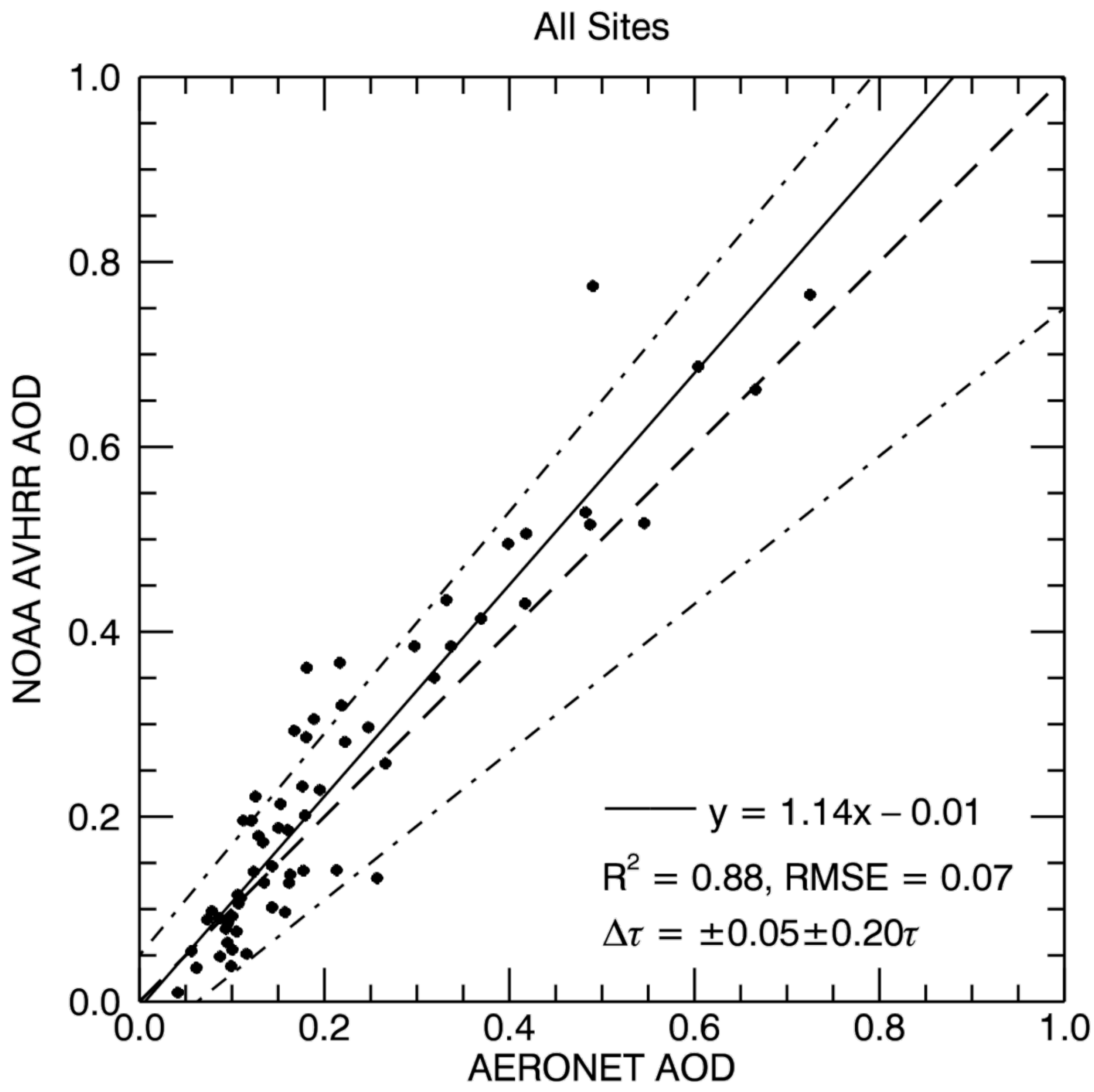
Long-term (30 yrs) AOD data from AVHRR Data

Yingjie Li, Yong Xue, Gerrit de Leeuw, Chi Li, Leiku Yang, Tingting Hou, 2013, Retrieval of Aerosol Optical Depth and Surface Reflectance over Land from NOAA AVHRR Data. *Remote Sensing of Environment*, Vol. 133, Pages 1–20.





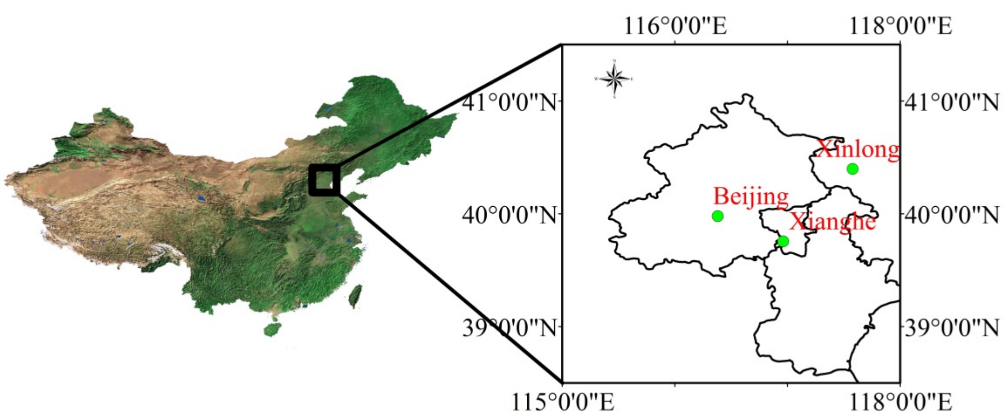
AOD Validation over the ROIs of EUR, AME, IND and SAH

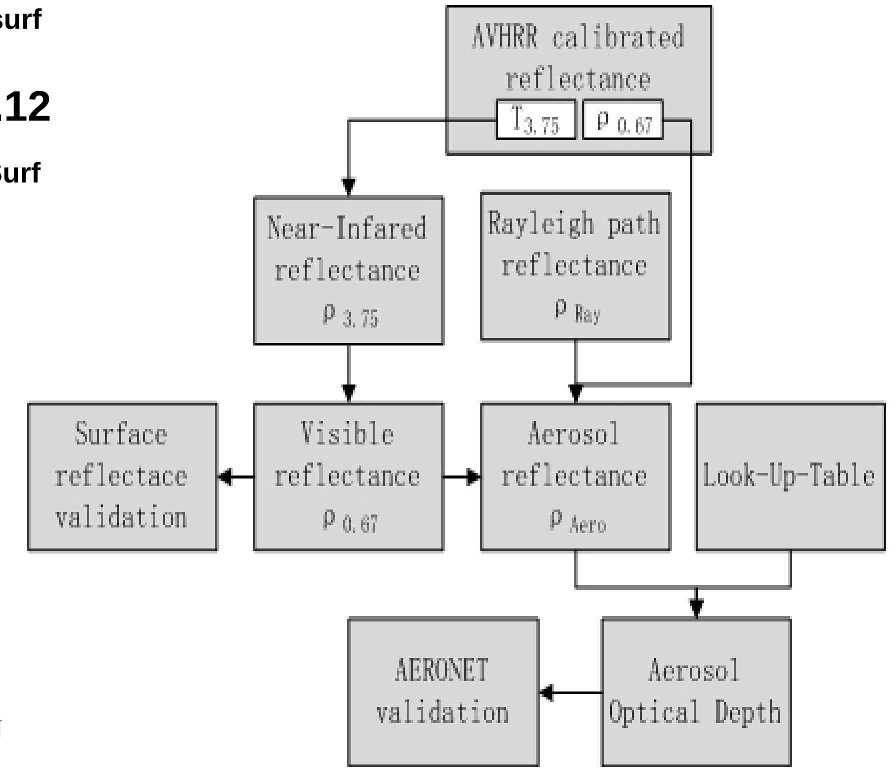
Retrieval of aerosol optical depth over land surfaces from AVHRR data

Based on the statistical relationship between R_{surf} (3.75 μm) and R_{Surf} (2.12 μm) and the empirical relationship between R_{Surf} (0.64 μm) and R_{Surf} (2.12 μm) used in the MODIS dark-target algorithm R_{Surf} (0.64 μm)=0.5×R_{Surf} (2.12 μm), we obtain

$$R_{\mathrm{Surf}}(0.64\ \mu\mathrm{m}) = 2.5 \times a \times R_{\mathrm{Surf}}(3.75\ \mu\mathrm{m}) + 2.5 \times b + c,$$

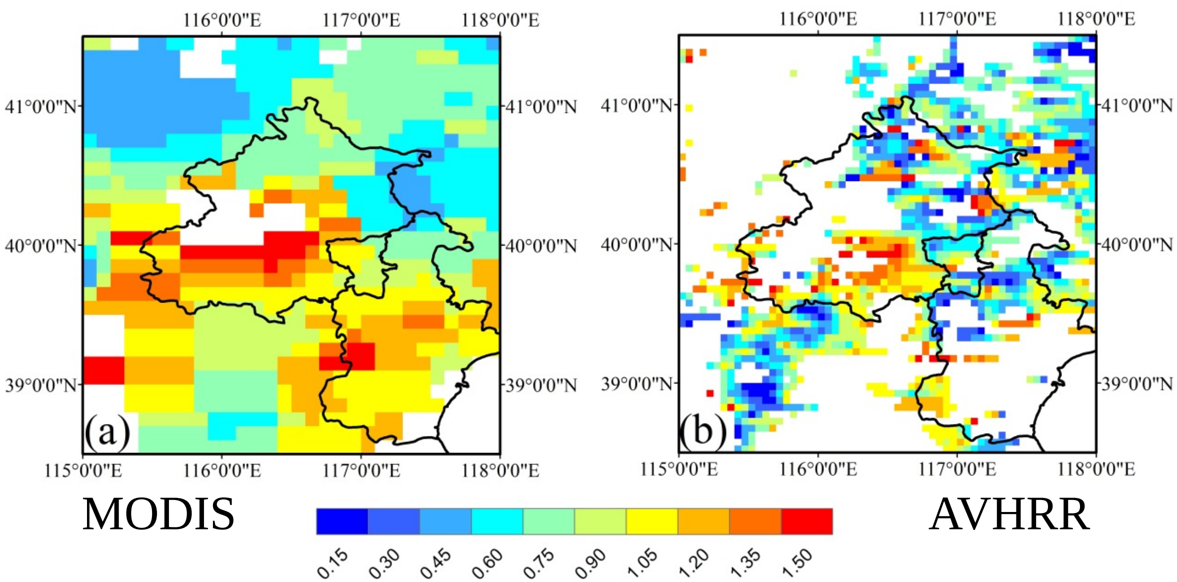
where a and b are functions of the normalised difference vegetation index (NDVI) and c is a correction part for scattering angle, which is similar to that proposed by Holzer-Popp et al. (2009).



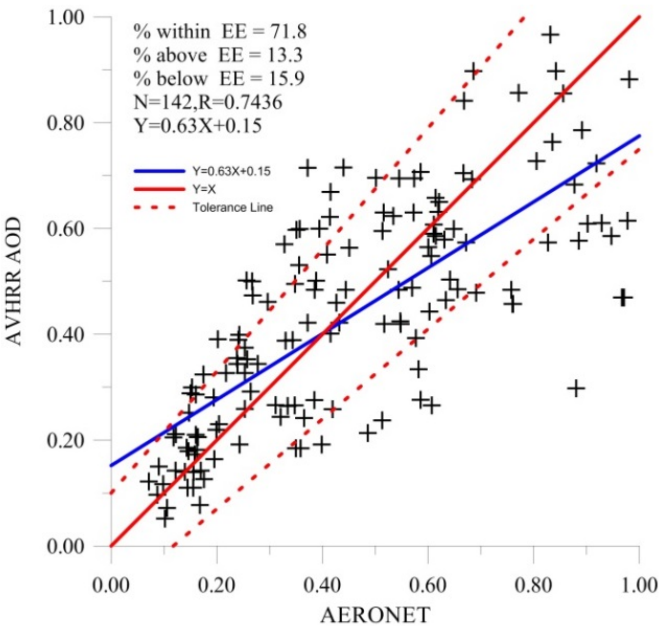


Mei, L., Xue, Y., Kokhanovsky, A. A., von Hoyningen-Huene, W., de Leeuw, G., and Burrows, J.P.: Retrieval of aerosol optical depth over land surfaces from AVHRR data, 2014, *Atmospheric Measurement Techniques*, 7, 2411–2420.

Retrieval of aerosol optical depth over land surfaces from AVHRR data



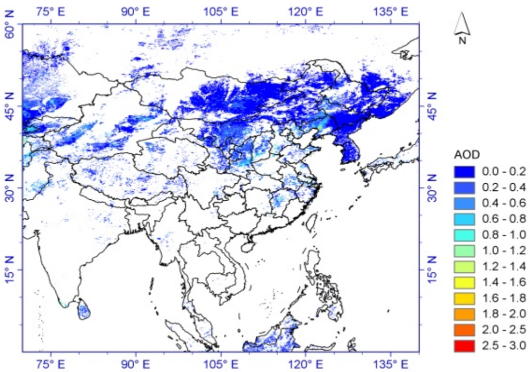
(a) MODIS 0.55 μm AOD product (Collection 5) and
(b) AVHRR-derived 0.64 μm AOD



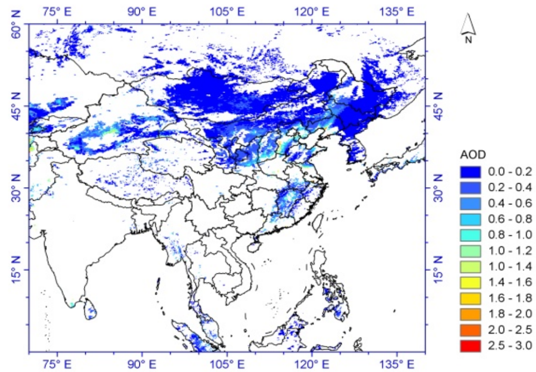
Scatter plot of AVHRR-derived AOD (0.64 μm) versus AERONET AOD for 0.64 μm. Text at the top describes the number of collocation (N), the regression curve, correlation (R), and the tolerance line of ±(0.1+15 %).

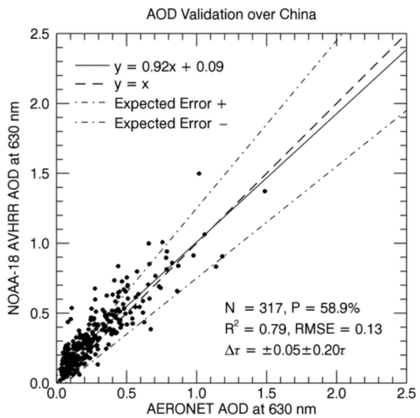
Long-term AOD data from AVHRR Data

NOAA-18 AVHRR AOD at 0.63 um over China
on 08/04/2008

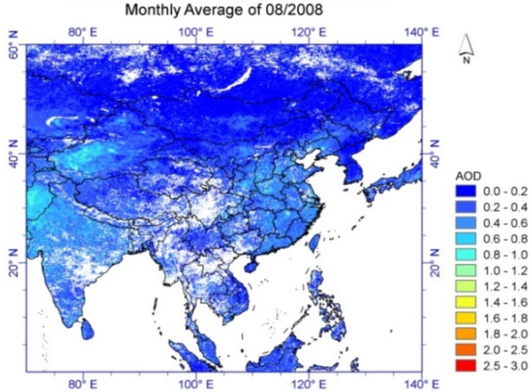


Aqua MODIS AOD at 0.66 um (DT & DB) over China
on 08/04/2008

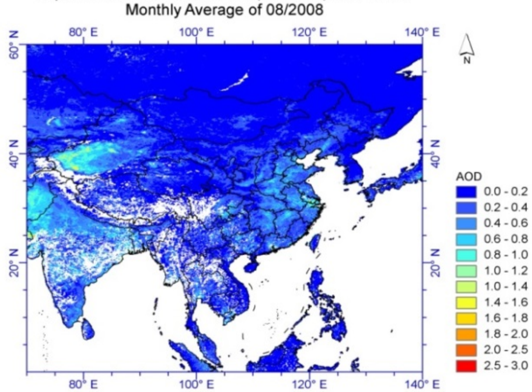


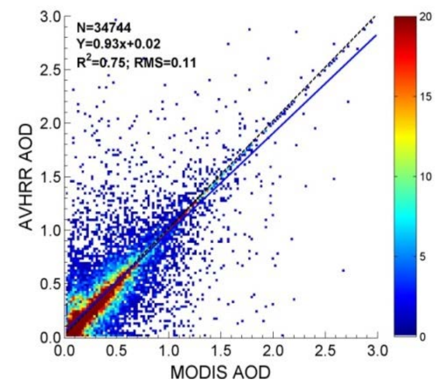


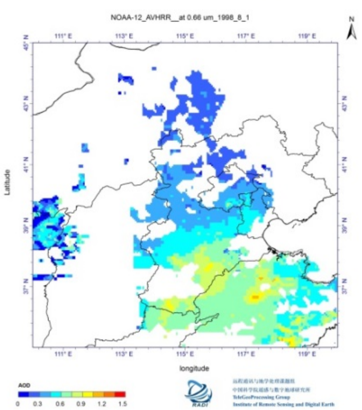
NOAA-18 AVHRR AOD at 0.63 um over China
Monthly Average of 08/2008

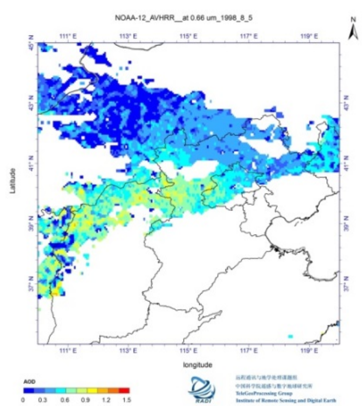


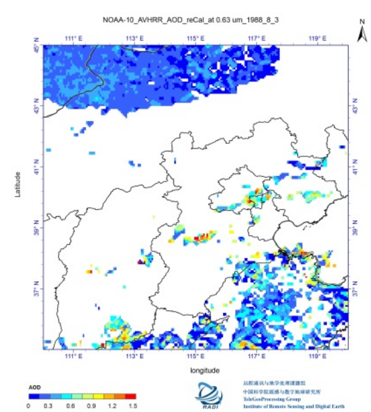
Aqua MODIS AOD at 0.66 um (DT & DB) over China
Monthly Average of 08/2008

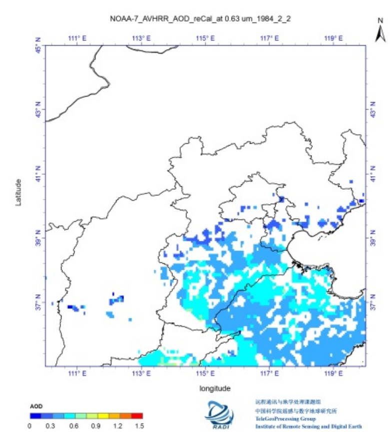












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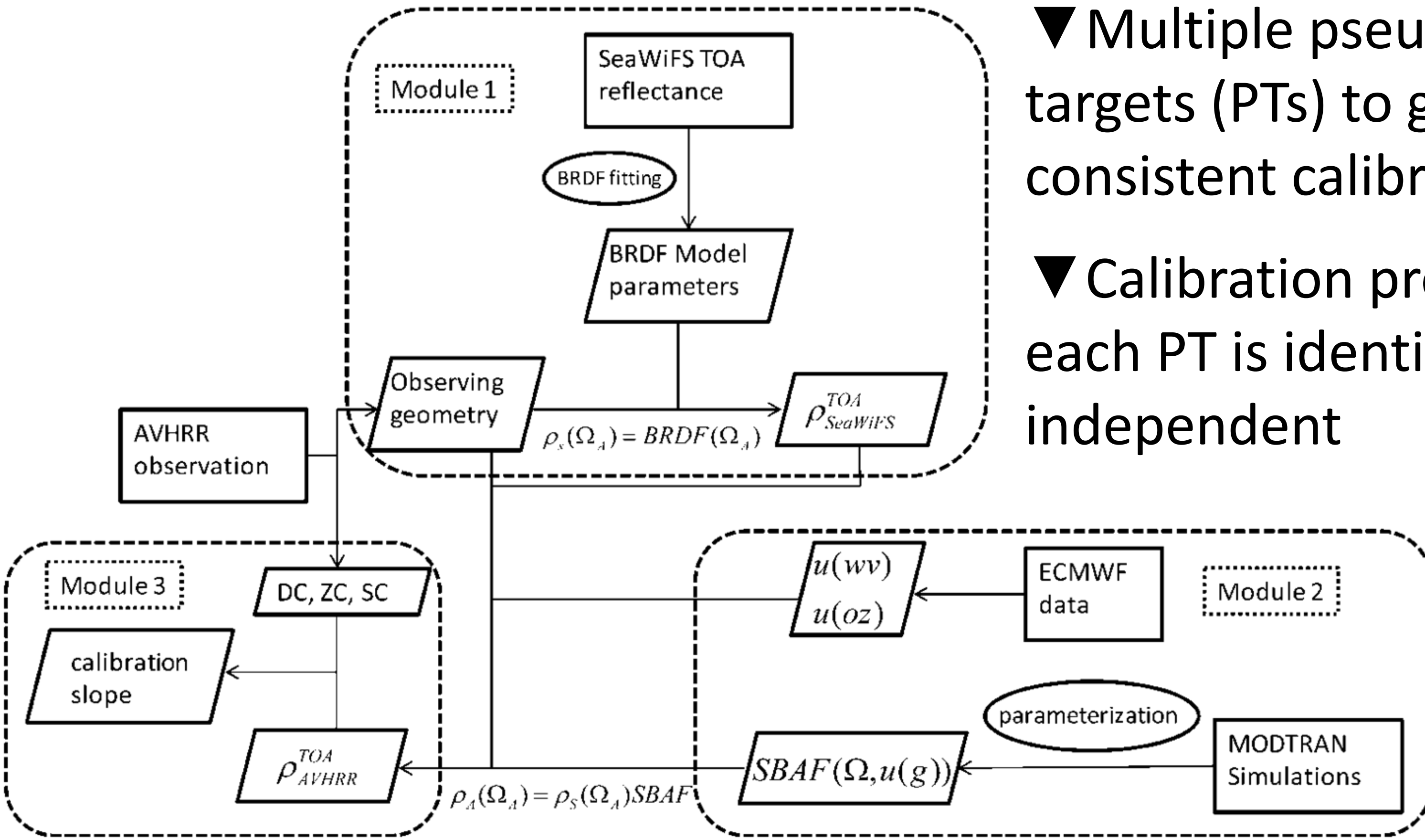
Calibration Methodology

▼ A multi-site calibration method using SeaWiFS data



▼ Multiple pseudo-invariant targets (PTs) to generate a consistent calibration result

▼ Calibration processing for each PT is identical and independent

Chi Li, Yong Xue, Quanhua Liu, Jie Guang, Xingwei He, Jiahua Zhang, Tingkai Wang, Xinjie Liu, 2014, Post Calibration of Channels 1 and 2 of Long-term AVHRR Data Record Based on SeaWiFS Data and Pseudo-invariant Targets. *Remote Sensing of Environment,* Vol. 150, Pages 104–119. (DOI information: 10.1016/j.rse.2014.04.020)

Post Calibration of Channels 1 and 2 of Long-term AVHRR Data Record Based on SeaWiFS Data and Pseudo-invariant Targets

▼ Calculate calibration slopes

- ▼ Calculate S for two bands at each observation
- ▼ Dual-gain after NOAA-15 (Heidinger, 2002)

$$R = \frac{\rho_{AVHRR}^{TOA} \times \cos\theta_s}{d^2}$$

$$DC \le SC: 100 \times R = S_{low}(DC - ZC)$$

$$DC > SC: 100 \times R = S_{high}(DC - SC) + S_{low}(SC - ZC)$$

▼ Time series fitting

$$S = \sum_{i=0}^{2} C_i \times D^i$$

- C_i: fitted coefficients
- D: days since the January 1 of the beginning year with data availability

Satellite	Channel	Records	C_0	C_1	C_2
TIROS-N	band 1	556	0.098	3.931E-05	-1.077E-08
	band 2	571	0.144	-8.296E-05	9.682E-08
NOAA-6	band 1	496	0.105	4.397E-05	-3.454E-08
	band 2	478	0.098	9.885E-05	-7.337E-08
NOAA-7	band 1	2462	0.113	9.649E-06	1.376E-09
	band 2	2394	0.110	3.234E-05	-1.192E-08
NOAA-8	band 1	196	0.119	1.904E-05	-3.955E-10
	band 2	201	0.114	8.508E-05	-5.086E-08
NOAA-9	band 1	2798	0.106	1.776E-05	1.411E-09
	band 2	2742	0.113	1.512E-05	-4.218E-09
NOAA-10	band 1	1346	0.107	2.450E-05	-8.826E-09
	band 2	1101	0.129	1.262E-05	-4.548E-09
NOAA-11	band 1	4378	0.106	2.284E-06	6.052E-10
	band 2	4330	0.108	5.332E-06	-1.202E-09
NOAA-12	band 1	1277	0.113	1.938E-05	-4.382E-09
	band 2	928	0.134	1.608E-05	-3.073E-09
NOAA-14	band 1	4669	0.115	1.707E-05	-3.657E-09
	band 2	4649	0.140	7.249E-06	3.918E-10
NOAA-15	band 1	1923	0.122	-1.147E-06	1.427E-10
	band 2	1659	0.131	4.276E-06	-6.600E-10
NOAA-16	band 1_low	1290	0.054	1.871E-06	-9.302E-11
	band 2_low	982	0.055	2.370E-06	-2.251E-10
	band 1_high	782	0.161	6.442E-06	-4.290E-10
	band 2_high	980	0.166	7.032E-06	-7.007E-10
NOAA-17	band 1_low	979	0.055	1.811E-06	-7.676E-11
	band 2_low	1074	0.062	3.869E-06	-5.049E-10
	band 1_high	1061	0.164	6.078E-06	-4.973E-10
	band 2_high	943	0.184	1.301E-05	-1.879E-09
NOAA-18	band 1_low	973	0.054	1.415E-06	5.469E-11
	band 2_low	848	0.058	1.512E-06	1.176E-10
	band 1_high	1693	0.160	6.458E-06	-5.844E-10
	band 2_high	1753	0.173	7.983E-06	-8.688E-10
Metop-A	band 1_low	943	0.053	4.861E-06	-1.327E-09
	band 2_low	1197	0.063	1.077E-06	1.872E-10
	band 1_high	660	0.158	1.563E-05	-4.349E-09
	band 2_high	577	0.185	8.904E-06	-1.637E-09
NOAA-19	band 1_low	272	0.052	1.634E-06	-4.470E-10
	band 2_low	139	0.055	4.164E-06	-1.316E-09
	band 1_high	819	0.156	3.258E-06	-7.167E-10
	band 2_high	742	0.167	7.621E-06	-1.380E-09
Metop-B	band 1	103	0.104	-1.065E-05	1.616E-07
	band 2	74	0.105	3.576E-05	2.055E-08

Quadratic fit results of AVHRR calibration slope time series. Note that NOAA-15 and Metop-B are presented with equivalent single gain slopes.

Conclusions

- It is possible to derive AOD over land from AVHRR data in order to produce global AOD climatology (35 years ---) ?!

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