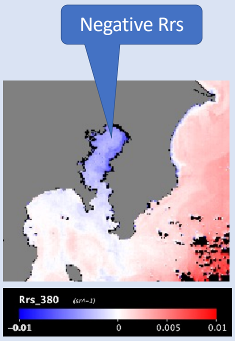
Absorptive aerosol reflectance correction for GCOM-C/SGLI

Mitsuhiro Toratani (Tokai University)

Background and objective

In Tokyo Bay, negative remote sensing reflectance(Rrs) sometimes occur. In areas with high CDOM and detritus, such as Tokyo Bay, a slight overestimation of aerosol reflectance can easily produce negative Rrs because of the small water-leaving reflectance. In addition, where anthropogenic aerosols are abundant, the effect of absorptive aerosols such as soot is likely to be present.

The objective of this study is to eliminate the negative Rrs.



Radiative transfer model

The atmospheric correction for SGLI is based on the radiative transfer model of Gordon and Wang (1994).

$$\rho_T(\lambda) = \rho_M(\lambda) + \rho_A(\lambda) + \rho_{MA}(\lambda) + T(\lambda)[\rho_G]_N(\lambda) + t(\lambda)[\rho_{WC}]_N(\lambda) + t(\lambda)[\rho_w]_N(\lambda)$$

ρ_T : Satellite observed reflectance
ρ_M : Reflectance due to gas molecules
ρ_A : Reflectance due to aerosol particles
ρ_{MA} : Reflectance due to molecule-aerosol interact.
$[\rho_G]_N$: Normalized reflectance due to sunglint.
$[\rho_{WC}]_N$: Normalized reflectance due to whitecap
$[\rho_w]_N$: Normalized reflectance of water body
t: Diffuse transmittance between sea surface and satellite
T: Direct transmittance between sea surface and satellite

Definitition of Reflectance

$$\rho \equiv \frac{\pi \cdot L}{F_0 cos\theta_0}$$

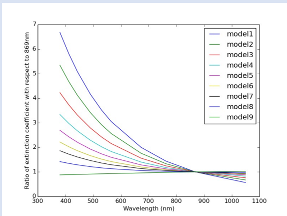
ρ: Reflectance
L : Radiance
F_0: Extraterestrial solar irradiance
θ_0: Solar zenith angle

The overestimation of aerosol reflectance in the atmospheric correction results in an underestimation of water-leaving reflectance, which is negative.

Estimation of aerosol reflectance

Aerosol reflectance is calculated by radiative transfer simulations, using aerosol model selection and aerosol optical thickness estimation from satellite data.
The model is based on the Yoshida (2021) model, which has nine levels of volume mixing ratios of large and small particles.

Aerosol model



Model	Aerosol volume ratio	
	Fine mode	Coarse mode
1	1	0
2	0.71	0.29
3	0.50	0.50
4	0.35	0.65
5	0.25	0.75
6	0.18	0.82
7	0.13	0.87
8	0.07	0.93
9	0	1

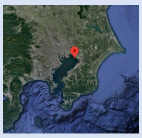
The soot type was added as an absorbent aerosol. The volume ratio of soot was set to 0.05 increments from 0 to 0.3.

A comparison was made for SGLI Ver.2 (Toratani et al., 2020) and Ver.3 atmospheric correction (Toratani et al., 2021) for Ver. 2 with and without absorbing aerosols..
The following three cases of aerosol reflectance calculation are compared.

1. Ver.2 without absorptive aerosol correction
   In the standard Ver.2 atmospheric correction, the aerosol model does not take into account absorbent aerosols.
2. Ver.2 with absorptive aerosol correction
   The Ver.2 atmospheric correction aerosol model with absorbent aerosol (soot) was used.
3. Ver.3 without absorptive aerosol correction
   The standard Ver.3 atmospheric correction does not consider absorbent aerosols in the aerosol model. However, when the Rrs becomes negative, the aerosol model is reselected to avoid negative Rrs.

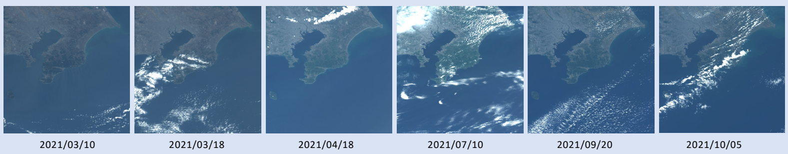
Comparison between satellite-derived Rrs and in-situ Rrs

AERONET-OC data (off-Kemigawa) was used as the in-situ observation data.The wavelengths used for comparison are 412, 443, 490, 560, and 667 nm.

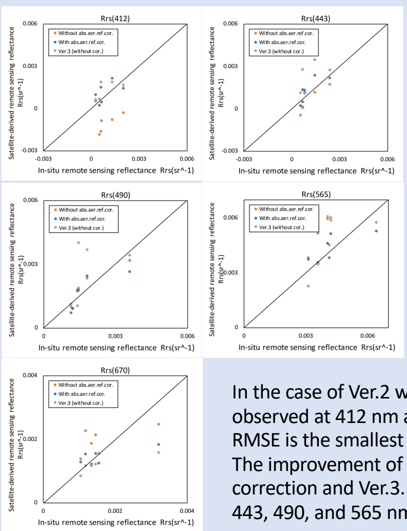



Aeronet-OC Off-Kemigawa site

SGLI data was used for the following six scenes.
Those are the scenes where the negative Rrs occurred.



Results



		RMSE	MAPE
Rrs(412)	Ver.2 without cor.	3.95E-06	229.96%
	Ver.2 with cor.	3.85E-07	85.78%
	Ver.3	3.33E-07	60.53%
Rrs(443)	Ver.2 without cor.	4.20E-07	73.50%
	Ver.2 with cor.	2.63E-07	51.64%
	Ver.3	1.42E-06	91.46%
Rrs(490)	Ver.2 without cor.	1.46E-07	22.23%
	Ver.2 with cor.	3.02E-07	27.69%
	Ver.3	1.66E-06	51.47%
Rrs(565)	Ver.2 without cor.	1.71E-06	28.88%
	Ver.2 with cor.	4.89E-07	13.61%
	Ver.3	1.32E-06	21.80%
Rrs(670)	Ver.2 without cor.	4.18E-07	37.78%
	Ver.2 with cor.	3.73E-07	21.55%
	Ver.3	4.76E-07	17.96%

In the case of Ver.2 without absorbing aerosols,negative Rrs were observed at 412 nm and 443 nm.
RMSE is the smallest for Ver.2 with the correction.
The improvement of MAPE is observed in both Ver.2 with the correction and Ver.3. The Rrs of Ver.3 tends to have larger errors at 443, 490, and 565 nm than Ver.2 with the correction.

Summary

Absorptive aerosol reflectance correction works well in Tokyo Bay.
The standard Ver.3 atmospheric correction does not take absorptive aerosols into account, but is as accurate as the Ver.2 with absorptive aerosol correction in Rrs(412). On the other hand, it tends to overestimate Rrs at 443-530nm.
For the global atmospheric correction algorithm, the reflectance correction for absorbent aerosols is not necessary and Ver.3 is sufficient. However, if you want to obtain Rrs more accurately in the area such as Tokyo Bay, it is better to include the absorbing aerosol reflectance correction as a local process.

Reference

Gordon and Wang (1994), Retrieval of water-leaving radiance and aerosol optical thickness over the oceans with SeaWIFS: a preliminary algorithm, *Applied Optics*, Vol.33, pp.443–452.
Toratani et al.(2020), Algorithm Theoretical Basis Document of atmospheric correction for ocean color ver.2, SGLI ATBD, https://suzaku.eorc.jaxa.jp/GCOM_C/data/ATBD/ver2/V2ATBD_O2AB_NWLR_Toratani_r4.pdf.
Toratani et al.(2021), Algorithm Theoretical Basis Document of atmospheric correction for ocean color ver.3, SGLI ATBD, https://suzaku.eorc.jaxa.jp/GCOM_C/data/ATBD/ver3/V3ATBD_O2AB_NWLR_toratani.pdf
Yoshida (2020), Algorithm Theoretical Basis Document of aerosol by non-polarization for GCOM-C/SGLI, SGLI ATBD, https://suzaku.eorc.jaxa.jp/GCOM_C/data/ATBD/ver2/V2ATBD_A3AB_ARNP_Yoshida.pdf.