SeaWiFS-derived Ocean Color and Aerosol in the Western Equatorial Pacific Ocean :Validation and Comparison

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Abstract

Observation of aerosol optical thickness and spectral water-leaving radiance are carried out onboard R/V MIRAI in the western equatorial Pacific Ocean during the international observation project of Nauru99 (MR99-K03 cruise) and the continuing MR00-K04 cruise. In situ data are taken with synchronized SeaWiFS overpasses and the SeaWiFS-derived aerosol optical thickness and normalized water-leaving radiance products are validated against the in situ data. By using the archived NOAA and SeaWiFS-derived aerosol optical thickness and other products in the western equatorial Pacific Ocean in situ aerosol optical thickness data for two cruises are compared with not only each other but also temporal and spatial variability of archived satellite-derived datasets. Based on these comparisons it was found out that the in situ aerosol optical thickness data are corresponded to the low values of aerosol optical thickness in the seasonal variability.

1. Introduction

The western equatorial Pacific Ocean is known as "warm pool"[1] where the most active air-sea interaction is taken place in the world. During the last two years R/V MIRAI of Japan Marine Science and Technology Center (hereafter called JAMSTEC) extensively surveyed this region in order to clarify the mechanism of various air-sea interactions[2]. We joined these cruises for observing aerosol optical thickness and spectral water-leaving radiance onboard R/V MIRAI synchronized with SeaWiFS overpasses in order to make it clear how aerosol optical thickness affects spectral water-leaving radiance which is known as ocean color. In this study in situ aerosol optical thickness and spectral water-leaving radiance are not only validated against the SeaWiFS-derived products but also compared with NOAA-derived aerosol optical thickness for annual and seasonal variability.

2. Method

The study area is shown in Fig.1. MR99-K03 cruise is carried out around Nauru Island as an international cooperation project called Nauru99 during the period from June 17 to July 17, 1999. MR00-K04 cruise is conducted north of New Guinea Island during the period from June 12 to July 6, 2000. During these cruises radiation observation onboard R/V MIRAI synchronized with SeaWiFS overpasses are carried out to characterize aerosol optical properties and their impacts on SeaWiFS-derived ocean color in the western equatorial Pacific Ocean. SeaWiFS is an abbreviation of Sea-viewing Wide Field-of-view Sensor onboard the SeaStar launched in 1998. The sensor has eight bands in the visible and near infrared wavelength and the tilt mechanism to avoid sun glitter as shown in Table 1[3].

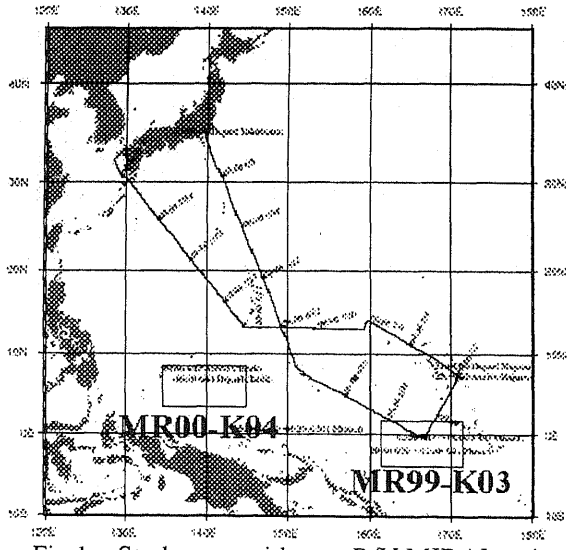

Fig.1 Study area with two R/V MIRAI cruises.
(Solid line shows the observation line of MR00-K03.)

Table 1. Specification of SeaWiFS

Band No.	wavelength(nm)
1	402-422
2	433-453
3	480-500
4	500-520
5	545-565
6	660-680
7	745-785
8	845-885
Equator Crossing	Local Noon(±20min), descending
Orbit type	Sun Synchronous at 705km
Spatial resolution	1.13km(LAC), 4.5km(GAC)
Swath width	2801km(LAC), 1502km(GAC)
Scan Plane Tilt	+20° ,0° , -20°

Table 2. Specifications of MSR7000,FPR5000,PSR1000

MSR7000	
Wavelength	400-1000nm
Wavelength resolution	1nm
Field of view	2 deg.
Detector	Silicon photo diode, photo multiplier

FPR5000, PSR1000	
Channel	Wavelength (band width)
0	443nm (20nm)
1	490nm (20nm)
2	565nm (20nm)
3	670nm (20nm)
4	765nm (40nm)
5	865nm (40nm)
Detector	Silicon photo diode
Polarizer	Glan Thompson prism
Field of view	2 deg.

Spectral water-leaving radiance is observed by a spectroradiometer MSR7000 and solar irradiance is measured by multi-polarimeter FPR5000 and PSR1000. Specifications of these radiometers are shown in Table2. Raw data derived from FPR5000 is converted to aerosol optical thickness using the algorithm developed by Masuda et al[4].

3. Validation and comparison

3.1 Spectral water-leaving radiance

An example of spectral water-leaving radiance derived from SeaWiFS and MSR7000 during the MR00-K04 cruise is shown in Fig.2. Spectral radiance values from SeaWiFS are normalized, which means that the sun is at the zenith and the atmosphere is absent[5]. The difference of radiance between SeaWiFS and MSR7000 is getting increase as the wavelength is getting shorter. Since the radiance from MSR7000 includes the contribution from the reflection of sea surface, these differences are partly accounted for.

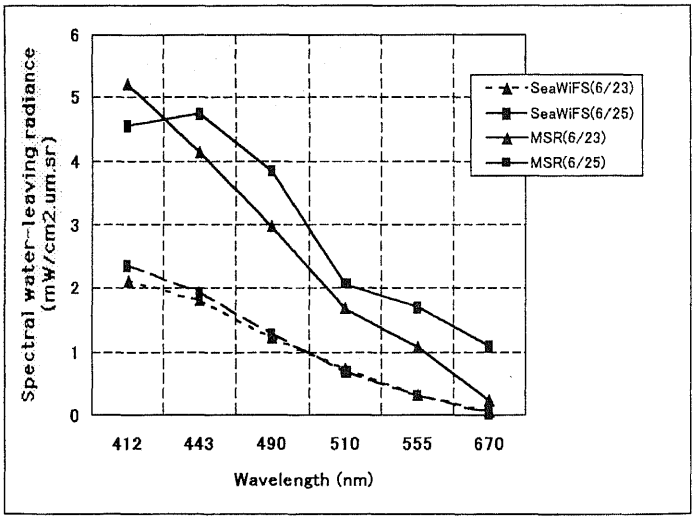

Fig.2 Spectral water-leaving radiance from SeaWiFS and MSR7000 at June 23 and 25, 2000 during the MR00-K04 Cruise.

3.2 Aerosol optical thickness

Aerosol optical thickness is observed by FPR5000 in 1999 and by PSR1000 in 2000. Since the number of matched observation between the in situ and synchronized SeaWiFS is small especially during the MR00-K04 cruise, an attempt is made to compare with archived aerosol optical thickness derived from NOAA/AVHRR[6]. More detailed discussion on operational aerosol products using NOAA/AVHRR is found in Stowe et al[7]. Fig.3 shows the comparison of aerosol optical thickness derived from satellites (NOAA/AVHRR and SeaWiFS) and in situ sensors (FPR5000 and PSR1000). Aerosol optical thickness from NOAA/AVHRR (indicated as average) is the mean value from 5 degrees south to 10 degrees north latitude at 150 degrees east longitude. During the period of two years aerosol optical thickness from NOAA/AVHRR clearly indicates the seasonal variability in which the low values dominates from June to October and high values from December to April. It is found out that SeaWiFS and in situ aerosol optical thickness values during the two cruises correspond to the low values in the seasonal variability.

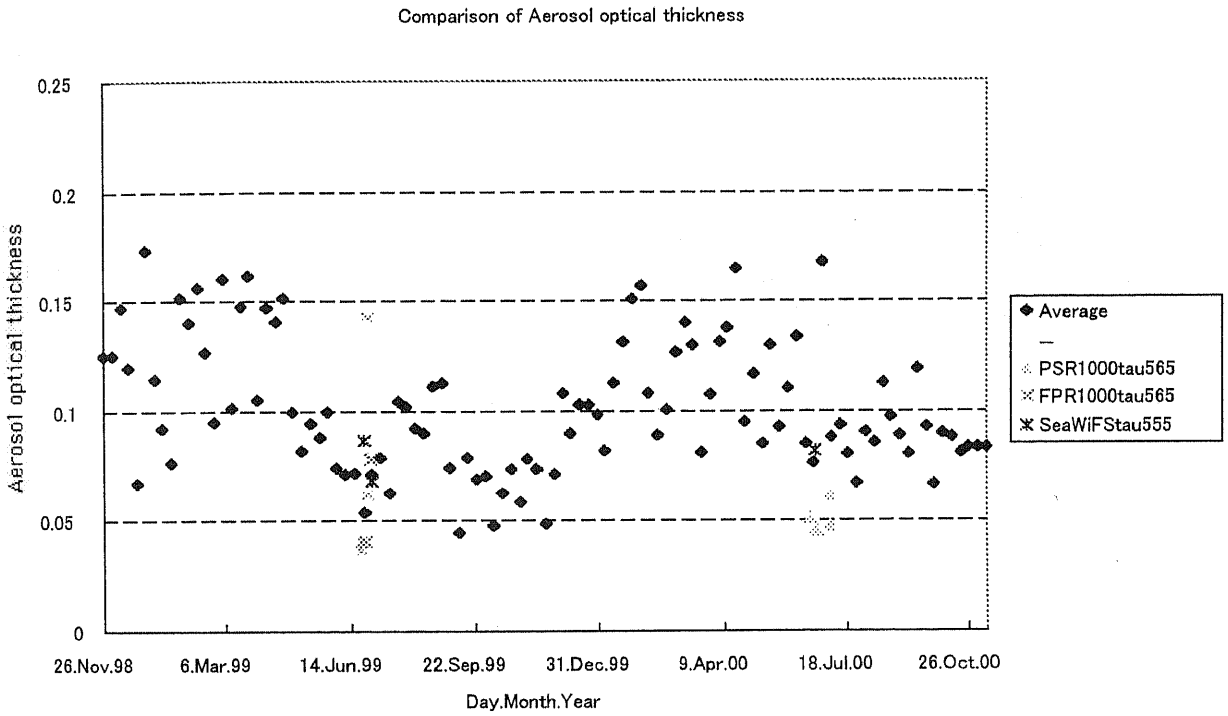

Fig.3 Comparison of aerosol optical thickness derived from satellites (NOAA/AVHRR indicated as average, SeaWiFS) and from in situ sensors (FPR5000 and PSR1000).

4. Summary

Based on the results and discussion above, the summary is described as follows.

(1) The difference of radiance between SeaWiFS and MSR7000 is getting increase as the wavelength is getting shorter. It is probably due to the fact that the radiance from MSR7000 includes the contribution from the reflection of sea surface.

(2) It is found out that SeaWiFS and in situ aerosol optical thickness values during the two cruises correspond to the low values in the seasonal variability derived from NOAA/AVHRR.

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References
1) Soloviev,A. and R.Lukas (1997): Observation of large diurnal warming events in the near-surface layer of the western equatorial Pacific warm pool. Deep-Sea Research I, 44, 6, 1055-1076.
2) Yoneyama,K. and M.Katsumata (2000): Overview of the R/V MIRAI Nauru99 Cruise. UMI TO SORA (J. of the Marine Meteorological Society) 76, 2, 59-63.
3) Hooker,S.B., W.E.Esaias, G.C.Feldman, W.W.Gregg and C.R.McClain (1992): An Overview of SeaWiFS and Ocean Color, Vol.1, SeaWiFS Technical Report Series, NASA Technical Memorandum 104566, 24p.
4) Masuda,K. and M.Sasaki (1997): A multi-spectral polarimeter for measurements of direct solar and diffused sky radiation: Calibration and measurements. Opt.Rev., 4, 498-501.
5) Gordon,H.R., O.B.Brown, R.H.Evans, J.W.Brown, R.C.Smith, K.S.Baker and D.K.Clark (1988): A Semianalytic Radiance Model of Ocean Color. J.Geophys.Res., 93, D9, 10909-10924.
6) URL: http://www.saa.noaa.gov/
7) Stowe,L.L., A.M.Ignatov and R.R.Singh (1997): Development, validation, and potential enhancements to the second-generation operational aerosol product at the National Environmental Satellite, Data, and Information Service of the National Oceanic and Atmospheric Administration. J.Geophys.Res.,102, D14, 16923-16934.