SeaWiFS and MODIS-derived Product Verification using Normalized Water-leaving Radiance Model in the Western Equatorial Pacific Ocean

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Abstract : The purpose of the study is to verify the SeaWiFS and MODIS-derived normalized water-leaving radiances and chlorophyll-a concentrations based on in situ sea surface spectral radiance observation. Utilizing ship's shadow for estimating sky radiance in the normalized water-leaving radiance model, we estimated normalized water-leaving radiance and compared with SeaWiFS and MODIS-derived corresponding products. It was found that SeaWiFS and MODIS-derived normalized water-leaving radiances and chlorophyll-a concentrations show good agreements with corresponding parameters derived from in situ spectral radiance observation.

Keywords : Western equatorial Pacific Ocean , Normalized water-leaving radiance , Chlorophyll-a concentration ,Sky radiance ratio

1. INTRODUCTION

In order to accurately extract chlorophyll-a as important indices of water quality and primary production, it is necessary to estimate upward radiances below the sea surface without an influence of surface reflectance. However the conventional in situ measurement of sea surface reflectance is not accurately enough to estimate chlorophyll-a concentration based on the spectral reflectance of the sea surface. The purpose of the study is to verify the SeaWiFS and MODIS-derived normalized water-leaving radiances and chlorophyll-a concentrations based on in situ sea surface spectral radiance observation during the cooperative air-sea interaction research cruise of R/V MIRAI belonging to JAMSTEC.

2. DATA AND METHOD

R/V MIRAI stationed at 138.5 degrees East and 2 degrees North from March 3 to 15, 2004 in the western equatorial Pacific Ocean. (Fig.1) During the research cruise we carried out in situ measurements of upward spectral radiance from sea surface using a spectral radiometer GER1500 with 512 bands ranging from 350 to 1050 nm and chlorophyll-a concentration synchronized with SeaWiFS and MODIS overpasses. Measurement times are 4 times a day (10, 11, 13, 14 hours (local time)). In order to estimate normalized water-leaving radiance (nLw) normalized water-leaving radiance model is used as follows[1)].

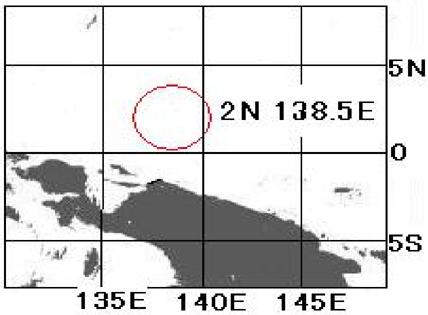

Fig. 1. R/V MR04-01 Stationary point within the circle. (Feb.22-Mar.22,2004)

$$nLw(\lambda) = R_L(\lambda)F_0(\lambda) \quad (1)$$

$$R_L(\lambda) = \frac{S_w(\lambda) - \rho(\theta)S_{sky}(\lambda)}{\pi S_G(\lambda)\rho_G(\theta,\lambda)} \quad (2)$$

$$S_{sky}(\lambda) = S_w(\lambda) * SR(\lambda) \quad (3)$$

$F_0(\lambda)$ is defined as an mean spectral solar irradiance, $S_w(\lambda)$, $S_{sky}(\lambda)$, $S_g(\lambda)$ are in situ spectral radiances from sea surface, sky and standard white board respectively. $\rho(\theta)$ and $\rho_G(\lambda)$ are Fresnel reflection coefficient and reflection coefficient of standard white board. $SR(\lambda)$ is the ratio between sky radiance and solar radiance. This ratio is defined based on upward spectral radiance from sea surface and the same radiance observed under shadowed sea surface, which is solely illuminated by sky radiance. Spectral sky radiance ratio is shown in Fig.2.

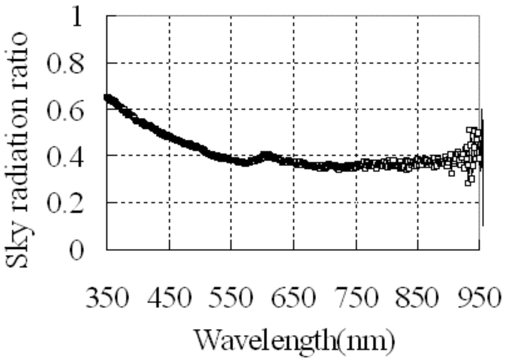

Fig.2 Spectral sky radiance ratio.

3. RESULTS AND DISCUSSION

Fig.3 shows the results of estimated nLw(λ) based on the nLw model above. Magnitude of nLw reaches maximum around 410 nm and shows minimum at the wavelength longer than 750 nm. Comparing with the nLw(λ) products derived from SeaWiFS and MODIS, the result of comparison is shown in Fig.4. Solid points are based on model-derived nLw and the ones derived from SeaWiFS and MODIS. White points are based on upward spectral radiance without using the nLw model[2]. Model-derived nLw shows good agreement with SeaWiFS and MODIS-derived nLw.

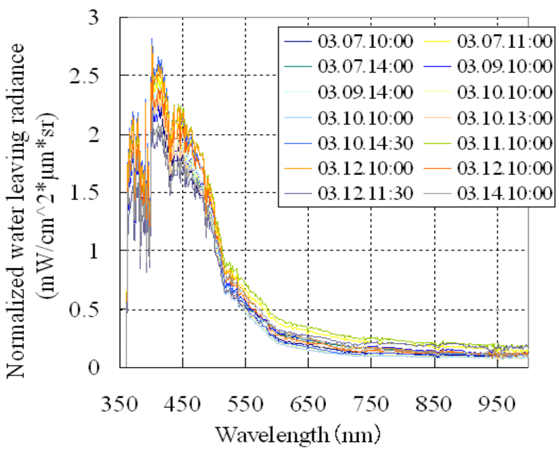

Fig. 3 Estimated normalized water-leaving radiance at the stationary point (Mar-7-14,2004).

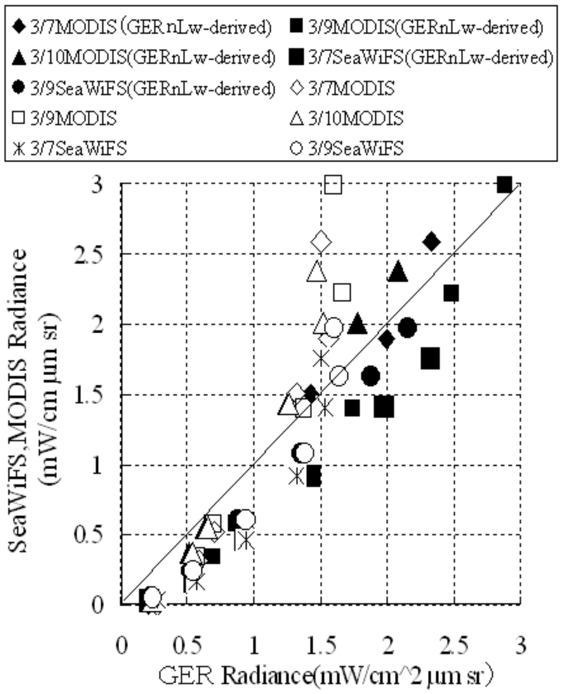

Fig. 4 Comparison between estimated normalized water-leaving radiance by GER-derived upwelling radiance and SeaWiFS and MODIS-derived normalized water-leaving radiance. (Solid points are based on model-derived nLw and the ones derived from SeaWiFS and MODIS. White points are based on upward spectral radiance without using the nLw model[2].)

As far as the comparison of chlorophyll-a is concerned, the result of comparison between nLw-model-derived chlorophyll-a and chlorophyll-a without the nLw model is shown in Fig.5. Both concentrations are calculated based on OC4v4 algorithm[3] which is the operational algorithm of SeaWiFS. OC4v4 algorithm is expressed as follows.

$$C=10.0\^(0.366-3.067R_{4S}+1.930R^2_{4S}+0.649R^3_{4S}-1.532R^4_{4S}) \quad (4)$$

$$R_{4S}=\log_{10}(R^{443}_{555}>R^{490}_{555}>{}^{510}_{555}) \quad (5)$$

where C is chlorophyll-a concentration (mg/m^3), R_{4S} is defined as the logarithm of maximum ratio between radiances from two bands of SeaWiFS.

Chlorophyll-a derived from nLw model shows better agreement with the ones from SeaWiFS and MODIS (solid triangles and squares in Fig.5.) compared with the ones without using nLw model (cross marks).

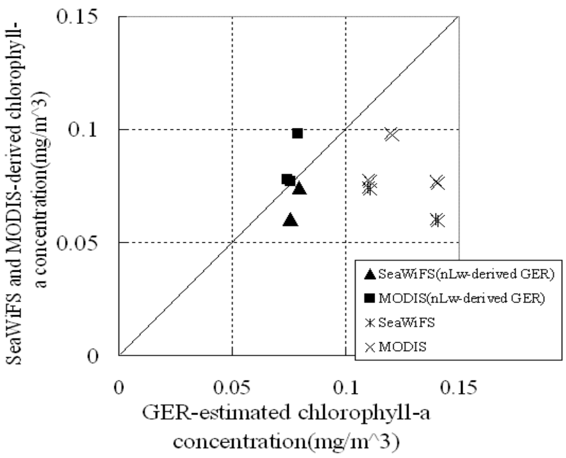

Fig. 5 Comparison between GER estimated chlorophyll-a concentration (solid triangles and squares: nLw model-derived chlorophyll-a, cross marks (x, ∗): chlorophyll-a without using nLw model) and SeaWiFS and MODIS-derived chlorophyll-a concentration

４．SUMMARY

By combining the normalized water-leaving radiance model with in situ spectral radiance observation utilizing the shadowed sea surface, we verified the normalized water-leaving radiance and chlorophyll-a products derived from SeaWiFS and MODIS.

It was found that SeaWiFS and MODIS-derived normalized water-leaving radiances and chlorophyll-a concentrations show good agreements with corresponding parameters derived from the normalized water-leaving radiance model with in situ spectral radiance observation.

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