The Atmospheric Correction of ROCSAT-1 OCI Imagery using near infrared radiance

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Abstract

Basically, radiance coming from the sea surface is very little in the near infrared channels. In particular, water-leaving radiance in the near infrared channels in clear water areas can be assumed to be almost zero. The SeaWiFS Data Analysis System (SeaDAS) uses the radiance in last two near infrared channels (765 and 865nm) to estimate the aerosol scattering radiance. OCI sensors have two near infrared channels, 670 and 865nm. In these two channels, the major component of the total radiance received by the satellite sensors will be the Rayleigh and aerosol scattering radiance. Since the 765nm channel is absent, the SeaWiFS atmospheric correction algorithm can not be directly used for the OCI data. We use the difference between the total radiance and the Rayleigh scattering radiance at 670 and 865nm channel to determine the air mass character used in estimating the aerosol scattering radiance and the water-leaving radiance for all channels in every pixel. The results indicate a high correlation between estimates using this algorithm and the SeaDAS model. In the future, in situ data about the aerosol optical thickness over the ocean will be collected and used to ascertain the accuracy of OCITRAN with radiative transfer theorem and algorithm.

(Key words: water-leaving radiance, aerosol, OCI)

I. Introduction

Taiwan's first satellite, ROCSAT-1, was launched successfully at a 600km high low-orbit in January of 1999. This satellite carries three main scientific experimental payloads, one of which is the Oceanic Color Imager (OCI). The OCI experiment is designed to map the ocean surface water color, and then these observation data can be used to further examine the ocean dynamic, marine biochemistry, global change, marine environmental change, fishing resource preservation, etc. The OCI consists of a push-broom scanner with a 700km field of view with 896 sampling pixels. The OCI provides six channels located in the visible and the near-infrared regions. Their center frequencies are at 443、490、510、555、670 and 865nm(Li, et.al.,1999).

Basically, the OCI channels are similar to the SeaWiFS channels, but lack the 412 and 765nm channels. Because the 765nm channel can be used as an indicator for atmospheric correction, the operational SeaDAS model for the atmospheric correction of ocean color data can not be implemented on OCI data. Therefore, a modified model, OCITRAN, was developed for OCI data, and is applied to two SeaWiFS data sets, and be compared with the SeaDAS model result and to evaluate the OCITRAN model.

II. Methodology

The satellite observed upwelling radiance from a cloud-free ocean surface includes several components. Based on the CZCS result (Gordon and Wang, 1994), the upwelling radiance (L_t) can be expressed as the sum of the Rayleigh scattering (L_r), the aerosol scattering (L_a) and the water-leaving radiance after atmospheric attenuation ($t\,L_w$). As well, the sun glint (L_g) should also be counted, because the OCI does not provide a function for avoiding sun glint effects. The complete equation can then be written as,

$$L_t(\lambda) = L_r(\lambda) + L_a(\lambda) + L_g(\lambda) + t(\lambda)L_w(\lambda), \quad (1)$$

where $t(\lambda)$ is the diffuse transmittance from the ocean surface to the top of the atmosphere,

$$t(\lambda) = \exp\left[-\left(\frac{\tau_r(\lambda)}{2} + \tau_{oz}(\lambda)\right)\left(\frac{1}{\cos\theta}\right)\right], \quad (2)$$

where $\tau_r(\lambda)$ and $\tau_{oz}(\lambda)$ are the optical thickness of the Rayleigh and ozone, respectively, θ is the satellite zenith angle and λ is the wavelength.

Before ocean color mapping, the cloud-free ocean area pixels must be identified. In the other words, both cloud and land pixels are need to be masked first. Meanwhile, pixels affected by sun glint radiance also need to be picked out and discarded. In this study, pixels having a sun glint probability at greater than 1.5 are discarded because this value implies that the sun glint would contribute greater radiance than any water-leaving radiance, which is what we want to assess (McClain and Yeh, 1994). A detail OCITRAN atmospheric correction procedure has been developed by Liu et al. (1999).

In this study, the algorithm proposed by Gordon et al. (1988) was employed to compute the Rayleigh multi-scattering radiance, using single scattering approximation algorithm to compute the aerosol scattering. For cloud-free atmospheric conditions over the open ocean, this single approximation generally obtains satisfactory results. The air mass character (Gathman, 1983) used for the aerosol scattering radiance is determined by the radiance difference between the satellite observed total radiance and the Rayleigh scattering radiance. Finally, the water-leaving radiance can be estimated after the other components become known, and the chlorophyll concentration can be estimated by using a bio-optical algorithm.

III. Results

Two SeaWiFS data sets covering the Taiwan area and the northern South China Sea were acquired at 0423Z, March 25 and 0414Z, April 16, 1999 are used in this study. The ground resolution was about 1.1x1.1km at nadir. Meanwhile, two sets of OCI images covering the East China Sea were acquired at 0528Z, March 31 and 0236Z, April 7, 1999, and two other sets, covering the northern South China Sea (near Luzon) were acquired at 0630Z, February 11 and 0705Z, March 15, 2000 and are also used.

The results show that the water leaving radiance estimated by the SeaDAS and OCITRAN models has a rather good consistency. For the first image pair, the correlation coefficients are 0.76 and 0.91 for the 490 and 555nm channels, respectively. For the second image pair, the coefficients are 0.89 and 0.96, respectively (Fig. 1). If we compare the chlorophyll concentrations estimated by the SeaDAS-derived and the OCITRAN-derived water-leaving radiance, the results also show a high correlation between them. The values are 0.91 and 0.92 for the two pairs, respectively (Fig. 2). This high consistency also exists in the two model-derived aerosol optical depth at 865nm. Their coefficients are 0.87 and 0.89, respectively (Fig.3). There is one notable difference found in the concentration map near the coastal zone. It shows part of pixels can appear obvious difference between two model results, and should be investigated further.

IV. Discussion

Because the total satellite-observed radiance at 865nm mainly comes from the aerosol and Rayleigh scattering radiance, and there is a close relationship between the aerosol amount and the air mass character for this channel, then the air mass character can be determined by using the radiance difference between the total and the Rayleigh radiance. This character can be used for OCITRAN input for OCI atmospheric correction pixel by pixel, to estimate the parameters, the optical depth, the water-leaving radiance and the chlorophyll concentration.

The comparisons of the SeaWiFS-derived results, processed by the OCITRAN and SeaDAS models, show that the correlation coefficients are 0.76, 0.91 and 0.87 for the derived-water-leaving radiance, the chlorophyll concentration and the optical depth at 865nm, respectively. This high correlation implies that the OCITRAN model can provide accurate and reliable atmospheric correlation results. Of course, more sea surface field measurements (such as the aerosol optical depth) and RTE modifications will be necessary in future studies to promote the accuracy of the OCITRAN model.

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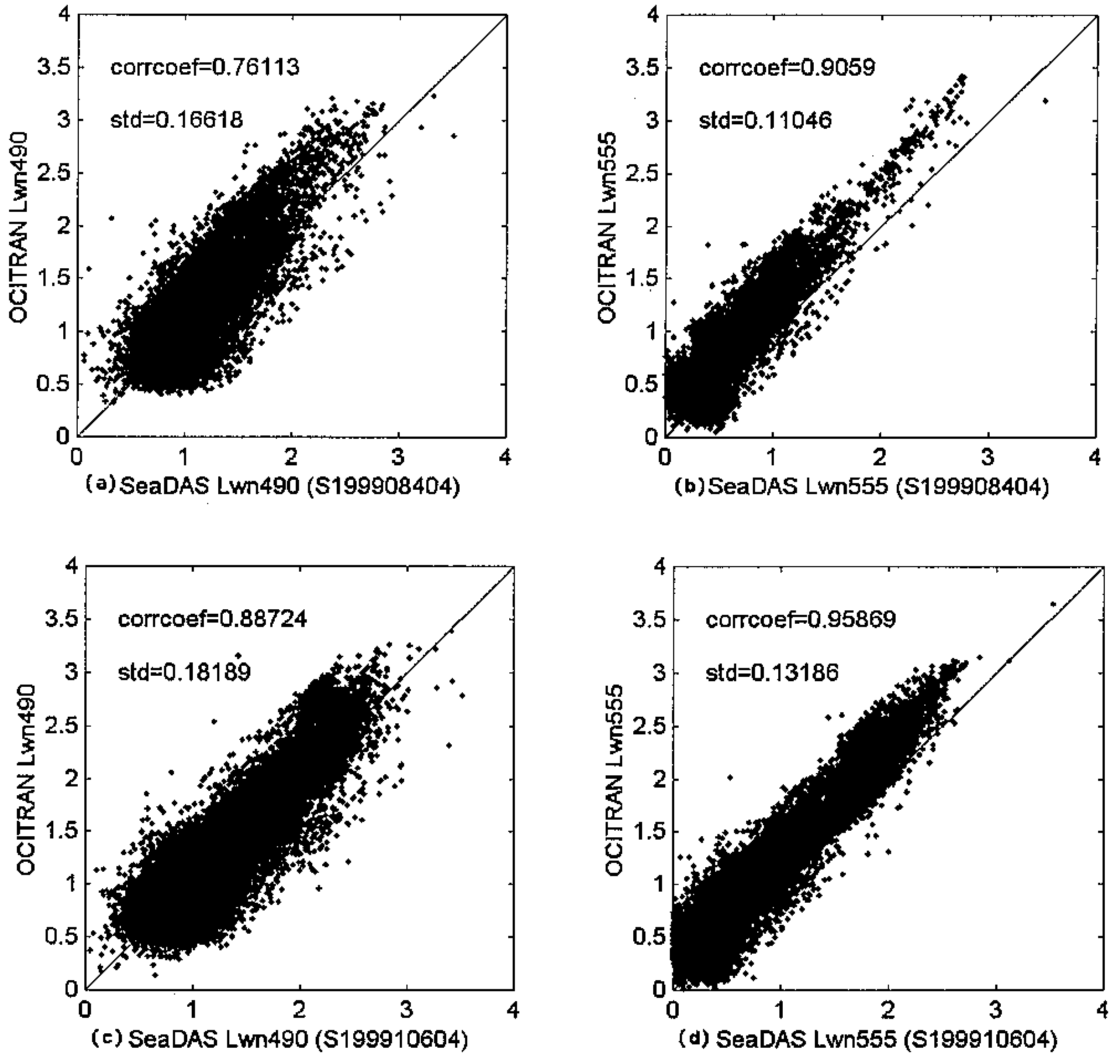

Fig. 1 Comparison of water-leaving radiance derived from SeaWiFS data acquired on Mar. 25 and April 16, 1999 the OCITRAN and the SeaDAS models. Units are in $mw/cm^2/\mu m/sr$. The left panel is 490nm and the right panel is 555nm.

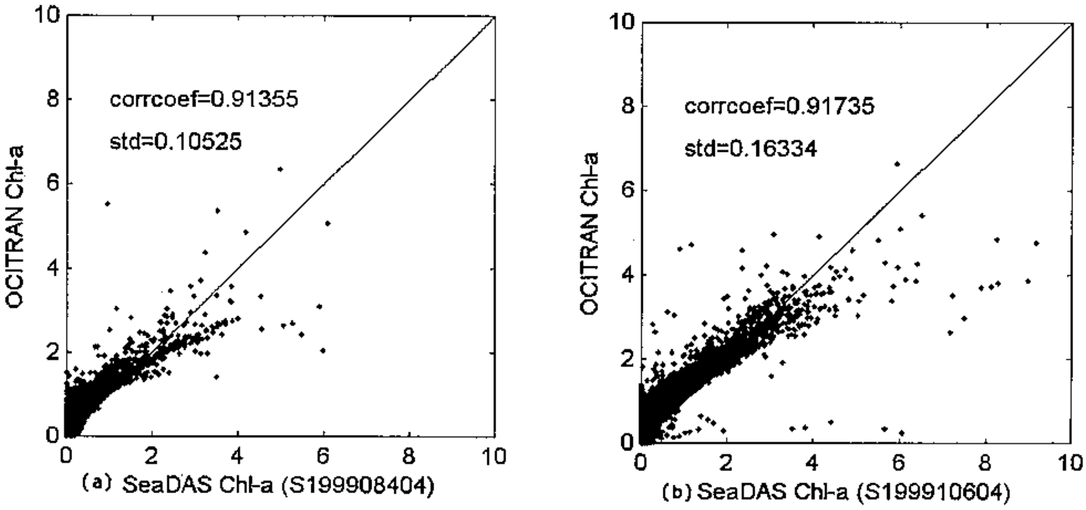

Fig. 2 Same as in Fig. 1, except showing the chlorophyll concentration.

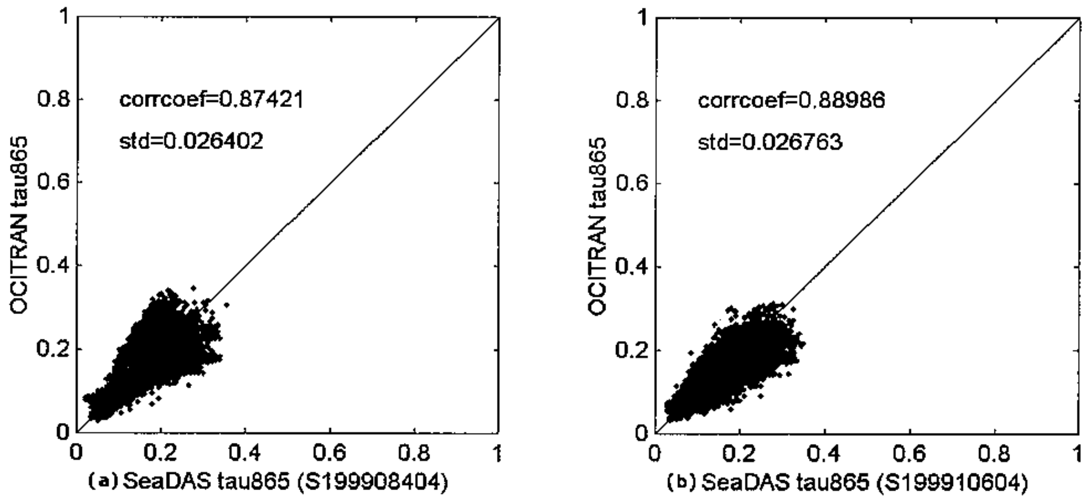

Fig. 3 Same as in Fig. 1, except showing the aerosol optical depth.