Estimation of Chlorophyll-*a* Concentration from VIIRS Ocean Color Data in Cambodia

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ABSTRACT

A study on chlorophyll-*a* concentration on Cambodia water in the Gulf of Thailand was conducted using the Visible Infrared Imaging Radiometer Suite (VIIRS) to produce an estimation of global chlorophyll-*a* concentration. Field data was obtained from R/V Koyo-maru cruise No 49/2514 in 26 stations on November 2014 using calibration and validation. The study yielded results of a mean concentration of 1.467 mg/m^3, minimum concentration of 0.503 mg/m^3 and maximum concentration of 55.663 mg/m^3. The relationship between field data and satellite data is Y = 1.721x + 0.291, where Y is field chlorophyll-*a* concentration and x is concentration from VIIRS product. The coefficient of determination (R^2) is 0.245 which is lower than expected whereas RMSE from validation is 0.275 which is acceptable enough.

Keywords: Chlorophyll-*a* concentration, ocean color, Gulf of Thailand

INTRODUCTION

Chlorophyll-*a* is the main component of phytoplankton, which plays an important role in global climate system (Behrenfeld and Siegel, 2007; Sauer *et al*. 2012). Monitoring off shore distribution of chlorophyll-*a* concentration is costly and time consuming, especially for regular observations. Satellite based surface chlorophyll-*a* concentration estimation was introduced over 30 years ago when the Coastal Zone Colour Scanner (CZCS) aboard NASA Nimbus-7 satellite (1978-1986) first showed chlorophyll-*a* distribution following the Sea-viewing Wide Field-of-view Sensor (SeaWiFS) in 1997 (Gons *et al*., 2002). Until now Visible Infrared Imaging Radiometer Suite (VIIRS) aboard on Suomi NPP satellite on October 28, 2011 after Moderate Resolution Imaging Spectroradiometer (MODIS) that installed on NASA Aqua satellite had been on orbit in May 4, 2002 (Behrenfeld and Siegel, 2007). Current operational chlorophyll algorithm for SeaWiFS (OC4v4) was published in 2000 (Lee *et al*. 2006) and MODIS Chlorophyll algorithm (OC3) was published in 2004 for continuity of ocean color measurement (Franz *et al*, 2005). The OC3V algorithm has generated chlorophyll concentration

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Table 1. VIIRS sensor products from http://oceancolor.gsfc.nasa.gov

Products name	Acquired date	Period
V2014324054558.L2_NPP_OC.nc	20 November 2014	Daily
V2014325070638.L2_NPP_OC.nc	21 November 2014	Daily
V2014326064742.L2_NPP_OC.nc	22 November 2014	Daily
V2014327062847.L2_NPP_OC.nc	23 November 2014	Daily
V2014327063012.L2_NPP_OC.nc	23 November 2014	Daily
V2014328060951.L2_NPP_OC.nc	24 November 2014	Daily
V20143292014336.L3b_8D_NPP_CHL.nc	25 Nov – 2 Dec 2014	Eight day
V20143052014334.L3m_MO_NPP_CHL_chlor_*a*_4km.nc	1 Nov – 30 Nov 2014	Monthly

from VIIRS which was published in 2013, together with NOAA-MSL12 for level 2 data. Several successes in monitoring and estimation of chlorophyll concentration have been published, but no research work in the Gulf of Thailand has been done.

MATERIALS AND METHODS

Data

The study area covers Cambodia off-shore between 100° East to 106° East longitude and 8.80° North to 11.80 ° North latitude. All satellite images were from NASA Suomi National Polar-orbiting Partnership (Suomi-NPP) VIIRS sensors and accessed products at NASA ocean color website at http://oceancolor.gsfc.nasa.gov/ (Table 1).

The ground data from R/V Koyo-maru cruise no 49/2514, she was conducted around Cambodia off-shore in November 2014, 26 stations of Sea-Bird SBE Conductivity Temperature and Depth (CTD) device were operated. The surface chlorophyll concentration was also conducted.

Analysis method

From levels 2 & 3 (Daily and Monthly data) remotely sensed ocean color data, the Ocean Biology Processing Group (OBPG) serves as the Distributed Active Archive Center (DAAC) provides chlorophyll concentration estimated data from satellites, VIIRS were selected in this research.

The relationship between the 17 stations field chlorophyll concentrations and estimated chlorophyll-*a* concentration from OC3V algorithm (Equation 1) by using simple linear regression method were be analyzed. According to cloud cover information, there were no data from satellite product in certain area, therefore 10 stations were applied to validation.

$$\log (C) = \alpha_0+\alpha_1\chi+\alpha_2\chi^2+\alpha_3\chi^3+\alpha_4\chi^4$$

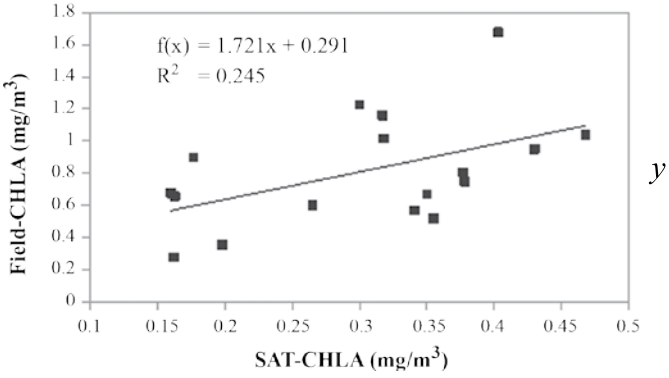
$$\chi = \log \left[\frac{\max (R_{rs}(443), R_{rs}(486))}{R_{rs}(550)}\right] \quad (1)$$

Where α_0, α_1, α_2, α_3, α_4, are 0.2228, -2.4683, 1.5867, -0.4275, -0.7768 respectively, and R_{rs} are normalized water leaving radiance for each VIIRS band.

RESULTS

The relationship between field chlorophyll-*a* concentration and estimated chlorophyll-*a* concentration from satellite is shown in Figure 1 and equation (2) with a coefficient of determination (R^2) of 0.245.

Apply the modification equation (2) to chlorophyll-*a* concentration monthly product in November 2014 (V20143052014334.L3m_MO_NPP_CHL_chlor_*a*_4km.nc). The result is shown in Figure 2. From ten validation stations, the root mean square error (RMSE) is 0.275 mean concentration is 1.467 mg/m^3, minimum concentration is 0.503 mg/m^3 and maximum concentration is 55.663 mg/m^3.



$$y = 1.721\,x + 0.291 \qquad (2)$$

Figure 1. Simple linear regression: y = field chlorophyll-*a* concentration (mg/m^3), x is estimated chlorophyll-*a* concentration from OC3V algorithm of VIIRS product (mg/m^3)

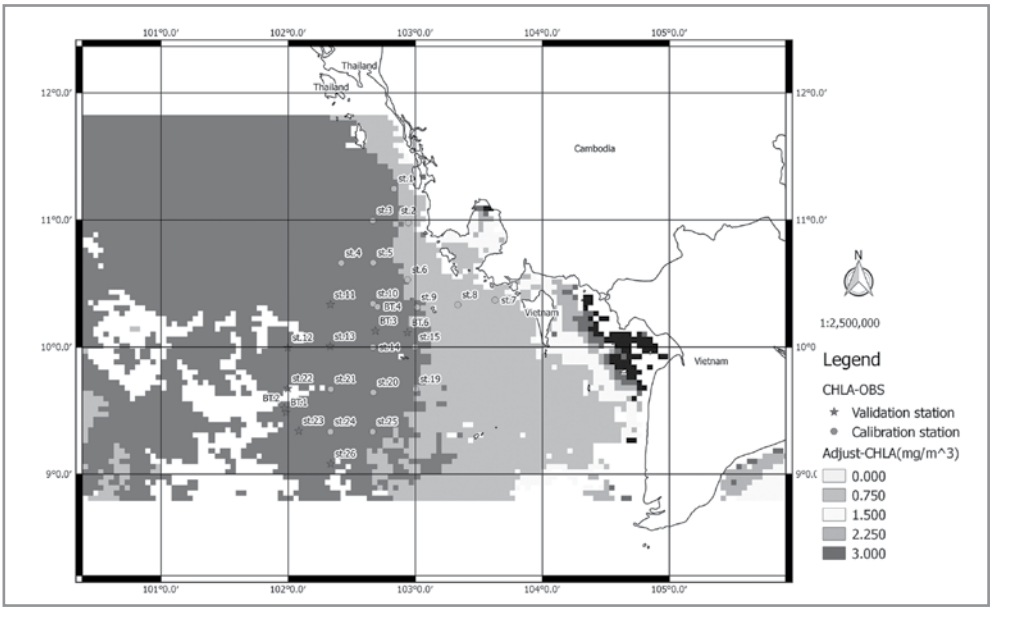


Figure 2. Estimation of Chlorophyll-*a* concentration by Suomi-NPP VIIRS around Cambodia off-shore, November 2014

CONCLUSION

There were several published papers shown useful of estimated chlorophyll-*a* concentration from satellite imagery (Sauer *et al*. 2012; Moses *et al*. 2009). However the results showing the origin OC3V algorithm from Suomi-NPP VIIRS are still not applicable in the Gulf of Thailand especially the Cambodia off-shore unless further adjustments will be done. From this research the R^2 of 0.245 is a bit low, it needs further research. Authors strongly recommend to develop our chlorophyll-*a* concentration algorithm for the Gulf of Thailand by need more field chlorophyll-*a* and using empirical methods to adjust co-efficiency value base on OC3-V algorithm.

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