

研 究 主 論 文 抄 録

論文題目

リモートセンシングと地球統計学の組み合わせによる沿岸域水質の時空間変動のモニタリング：北部ベトナム Tien Yen 湾への応用

Integrating remote sensing and geostatistics for monitoring spatio-temporal changes of coastal water quality: application to Tien Yen Bay (Northern Vietnam)

熊本大学大学院自然科学研究科 New Frontier Sciences 専攻 Life and Environmental Science 講座

(主任指導 Jun Shimada 教授)

論文提出者

グエン ティ ツウ ハ

Nguyen Thi Thu Ha

主論文要旨

《本文》

Coastal waters are important ecological systems and vital assets for many nations, particularly Vietnam where has more than 3200 km shoreline and approximately 3000 islands. Monitoring water quality parameters such as clarity, suspended sediment concentrations and presence of harmful algal blooms are main applications of ocean color remote sensing that gains better understanding of coastal processes for management decisions.

However, to apply remote sensing to a particular water monitoring application, especially within a dynamic coastal environment, there are challenges in finding appropriate reference materials and methods to gain an adequate understanding of remote sensing in a quick and effective manner. This study provides an example of identifying appropriate materials and methods for monitoring water quality in closed coastal waters through the case of Tien Yen Bay (Northern Vietnam). The combination of remote sensing and geostatistics in the study helps come-over challenges in traditional remote

sensing application due to limitation of orbit time and rough spatial resolution of satellite images.

Data of 40 sites sea truth measurement over Tien Yen Bay on 6 July 2010 were used to calibrate remote optical properties and in geostatistical analysis. MODIS imagery was selected for this study due to its advantages of high spectral resolution, short revisit period, free of charge and fast acquisition. Total suspended solids (TSS) and Chlorophyll-a concentrations are main selected indicators to understand water quality because of their special optical characteristics and important roles in coastal water cycle process.

Results from monitoring of seasonal change of TSS concentrations over Tien Yen Bay proved that the MODIS/Terra band 1 (visible red) data is high correlated with the *in situ* TSS concentrations and suitable for estimating TSS concentrations. A physical-based model for estimation of TSS concentrations from MODIS/Terra band 1 data was developed by an exponential function of the reflectance and showed high accurate estimated results. Results of 12 MODIS/Terra monthly scenes from November 2009 to October 2010 estimation indicated that the TSS concentrations in Tien Yen Bay waters become high during summer and low generally in fall and winter. Such trends were conformable to the hydrodynamics in Tien Yen Bay which control the strength of re-suspension of the seabed and/or coastal materials and the TSS concentrations over the bay consequently.

Results from monitoring eutrophication process in Tien Yen Bay proved a strong correlation of *in situ* Chl-a concentrations and ratios of green-blue bands. A semi-analytical model for estimation of Chl-a from MODIS data was developed and confirmed that relationship. Estimated Chl-a concentrations from 9 scenes of MODIS/Terra from late May to middle September 2010 using this model indicated that Tien Yen Bay waters are natural eutrophic with the minimum of Chl-a concentrations in summer over $10\text{mg}\cdot\text{m}^{-3}$. Chl-a in the bay waters created a peak of concentration in late summer (5 August 2010) as it is in common coastal waters. Monitoring of Chl-a concentrations over Tien Yen Bay also indicated that algae bloom did not occur in the bay during the summer 2010 because the highest concentration of Chl-a recorded ($27.2\text{mg}\cdot\text{m}^{-3}$) is far lower than that of algae bloom state ($100\text{mg}\cdot\text{m}^{-3}$).

Geostatistics methods, particularly ordinary kriging (OK), were proved the efficiency in monitoring coastal water quality by satellite imagery. OK was used to improve the spatial resolution of the MODIS/Terra image-based estimations and predict missing data due to covered clouds. OK prediction maps clarified the variation of water constituents (TSS and Chl-a) in detail and suggested influence factors associated with them. The maps produced by OK can contribute to the monitoring purpose on the change of water quality in coastal waters by user's operation on adjusting grid interval for OK with consideration of spatial resolution of the satellite image and the range of semivariogram.

The effective combination of remote sensing and geostatistics in this study may give a optimal lesson learned for monitoring water quality of hundreds closed coastal bays and lagoons in the world, where have similar geomorphologic condition as Tien Yen Bay. MODIS imagery and OK can be an appropriate material and method for water monitoring purpose.