第29回日本情報地質学会講演会 講演要旨集 037-038頁 2018年

Correlating geologic properties of tidal flat sediments with reflectance spectra for remote sensing-based environmental monitoring from a case study of Van Uc estuary (Vietnam)

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Key words: Remote sensing, Sediment properties, Reflectance spectra, Van Uc estuary

1. Introduction

Tidal flat is an important part of the coastal zone with many functions such as storage capacity, protect estuaries ecological system and also the filters of pollutant contaminant from land-based discharge. Several researches have addressed a significant relationship of composition with different sediment types (Zhang, 2001; Duquesne *et al.*, 2006). As the results, grain-size sediment property was specified as an important factor to understand the intertidal environment as well as monitor the environmental change in the estuary area. According to Ngoc *et al.* (2013), there is a strong correlation between the grain-size property and the reflectance spectra, and this correlation can be estimated from the satellite images such as ALOS-AVNIR. Furthermore, Sentinel 2A (S2A), one of satellites of an Earth observation mission in the Copernicus Programme developed by the European Space Agency has a multi-spectral imager including 13 spectral bands spanning from the blue to shortwave infrared (SWIR) region, with high quality image at 10, 20, and 60 m ground resolutions. It is suitable to apply the images to estimate the change in grain-size of surface sediment in the tidal flat of Van Uc estuary with high accuracy.

2. Materials and methods

The Van Uc estuary belonging to Thai Binh river is situated in the northern part of the Red River Delta coastal zone, the second most important flat plain in Vietnam. As the discharged area of the Thai Binh river system, this area has complex environment components with mangrove and intertidal eco-systems (Fig. 1).

Total 20 sediment samples were taken from the tidal flat of Van Uc estuary on 17 December 2017 by spoon, preserved in plastic bags under cool condition after measuring their reflectance spectra by the field spectrometers RS^3. In the laboratory, the Laser Particle Size Analyzer MODEL LA-950V2 of laser scattering method was used to identify the grain-size properties of all samples and transform them into soil types by the method of Wentworth (1922).

The S2A image used in this study was acquired at 17:46 GMT on 25 September 2016 at the UTM zone 48N with 10, 20, and 60 m resolutions. Level-1C (L1C) MSI dataset was downloaded from the Copernicus Open Access Hub, which contained orthorectified, georeferenced and radiometrically calibrated top-of-atmosphere (TOA) reflectance in the UTM projection with the WGS84 datum. The S2A Toolbox in the Sentinel Application Platform (SNAP) ver. 5.0 on Windows 10 was used to resample the images at the 10 m resolution. Then, a traditional empirical line method (ELM) was applied as an atmospheric correction to the S2A scene. Finally, the distribution map of grain size was generated by the density slicing tool of ENVI 5.3 and ArcGIS 10.5.

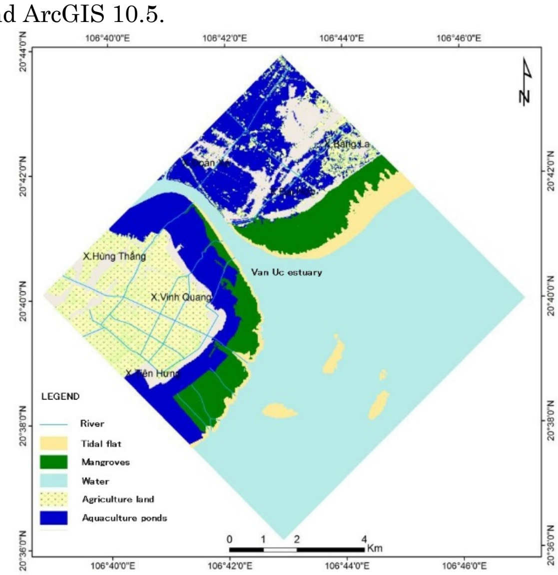

Figure 1. Land covers in the Van Uc estuary in which mudflat area is colored yellow.

3. Results

The measured grain-size of the total 20 sediment samples in the Van Uc estuary were ranged in wide value, from 78.22 % of the maximum silt content to 1% of the minimum sand content. As the average, the highest and lowest proportions were silt content (mean 60.84%) and clay content (mean 17.25%), respectively.

The measured reflectance spectra of all the sediment samples were in the range from visible to SWIR region. By focusing on the relationship between the reflectance spectra and the soil type of sediment, there seemed small correlation between all kinds of grain-size and the simulated S*2*A band reflectance in the total wavelength range, because their Pearson coefficients (*R*) were 0.1, 0.2, and 0.3 for the clay, sand, and silt content, respectively.

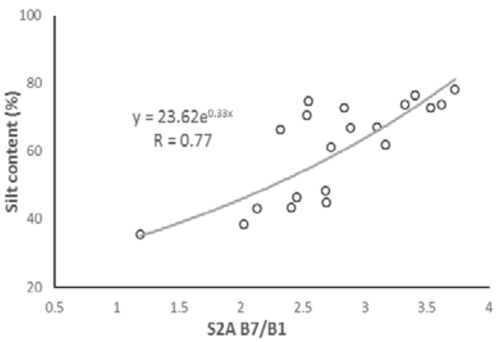

Figure. 2 Cross-relationship of *in-situ* silt content with simulated S2A ratio band reflectance.

On the contrary, all sediment types were well correlated with the *in-situ* S2A band ratios with *R* larger than 0.5. The maximum *R* was specified for the relationship between the silt content and the ratio of the band in NIR (band 7, B7) versus the band in deep blue (band 1, B1) with $R = 0.77$ (Fig. 2). Accordingly, the most suitable equation to estimate the silt content from the ratio of S2A band 1 versus band 7 is expressed as:

$$S\,(\%) = 23.62e^{0.33\,(B7/B1)}$$

where S is the silt content in the surface sediment of tidal flats (%) and B7/B1 is ratio of S2A band 7 versus band 1.

Applying the above equation to the S2A image scene acquired on 25th September 2016, the distribution of silt content in surface sediment in the study area was mapped as shown in Fig. 3. It can be observed from the result that the silt content of surface sediment in the Van Uc estuary is wide in the range from 33.6 to 81.2%. The highest proportion of the silt content was detected near the shoreline and decrease to off-shore, the lowest level is located in the north tidal flat and two small areas in the middle estuary. Besides, the *in-situ* silt content data is totally fitted to the estimated silt content, which can demonstrate the highly accurate estimation of the silt content by satellite remote sensing technique.

4. Conclusion

A strong correlation was clarified between the *in-situ* reflectance spectra data and the sediment types of the surface sediment samples in the Van Uc estuary. Applying the correlated equation to the S2A image, the distribution map of silt content was generated. The result confirmed the potential of Sentinel 2A band ratio to estimate the distribution of grain-size properties in the surface sediment in tidal flat of the estuary. Furthermore, a high possibility of using satellite image for monitoring the change in grain-size components in the tidal flat is demonstrated.

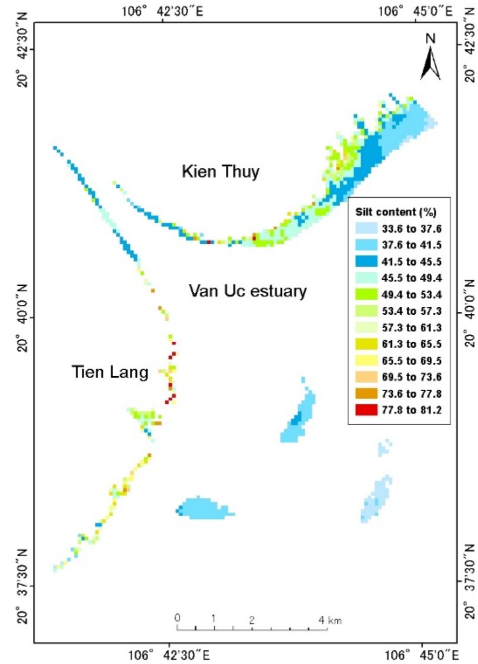

Figure. 3 Distribution map of silt content estimated from Sentinel 2A acquired on 25th September 2016 by a correlation equation.

References

Duquesne, S., Newton, L.C., Giusti, L., Marriott, S.B., Stark, H.J., Bird, D.J. (2006) Evidence for declining levels of heavy-metals in the Severn Estuary and Bristol Channel, UK and their spatial distribution in sediment. *Environmental Pollution*, 143, pp.187-196.

Mueller, J.L., Morel, A., Frouin, R., Davis, C., Arnone, R., Carder, K., Lee, Z.P., Steward, R.G., Hooker, S., Mobley, CD. (2003) Volume III: Radiometric Measurements and Data Analysis Protocols.

Mueller, J.L., Giulietta, S.F., McClain, C.R., eds. (2003) Goddard Space Flight Space Center: Greenbelt, MD, USA.

Ngoc, N.T., Koike, K., Tue, N.T. (2013) Correlating mass physical properties with ALOS reflectance spectra for intertidal sediments from the Ba Lat Estuary (northern Vietnam): an exploratory laboratory study. *Geo-Marine Letters*, 33, pp.273-284.

Ryu, J.H., Na, Y.H., Won, J.S., Doerffer, R. (2004) A critical grain size for Landsat ETM+ investigations into intertidal sediments: a case study of the Gomso tidal flats, Korea. *Estuarine, Coastal and Shelf Science*, 60, pp.491-502.

Small, C., Steckler, M., Seeber, L., Akhter, S.H., Goodbred, Jr.H., Mia, B., Imam, B. (2009) Spectroscopy of sediments in the Ganges-Brahmaputra delta: Spectral effects of moisture, grain size and lithology. *Remote Sensing of Environment*, 113, pp.342-361.

Zhang, W. (2001) China's Yangtze estuary: I. Geomorphic influence on heavy metal accumulation in intertidal sediments. *G Journal*, 41, pp.195-205.