THE SPECTRAL SHAPE MATCHING METHOD FOR THE ATMOSPHERIC CORRECTION OF LANDSAT IMAGERY IN SAEMANGEUM COASTAL AREA

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ABSTRACT:

Atmospheric correction over the ocean part is more important than that over the land because the signal from the ocean is very small about one tenth of that reflected from land. In this study, the Spectral Shape Matching Method (SSMM) developed by Ahn and Shanmugam (2004) is evaluated using Landsat imagery acquired over the highly turbid Saemangeum Coastal Area. The result of SSMM is compared with COST model developed by Chavez (1991 and 1997). In principle, SSMM is simple and easy to implement on any satellite imagery, relying on both field and image properties. To assess the potential use of these methods, several field campaigns were conducted in the Saemangeum coastal area corresponding with Landsat-7 satellite's overpass on 29 May 2005. In-situ data collected from the coastal waters of Saemangeum using optical instruments (ASD field spectroradiometer) consists of Chl, Ap, SS, a_{DOM}, F(d). In order to perform SSMM,we use the in-situ water-leaving radiance spectra from clear oceanic waters to estimate the the path radiance from total signal recorded at the top of the atmosphere (TOA), due to the reason that the shape of clear water-leaving radiance spectra is nearly stable than turbid water-leaving radiance spectra. The retrieved water-leaving radiance after subtraction of path signal from TOA signal in this way is compared with that estimated by COST model. The result shows that SSMM enabled retrieval of water-leaving radiance spectra that are consistent with in-situ data obtained from Saemangeum coastal waters. The COST model yielded significantly high errors in these areas.

KEY WORDS: Spectral Shape Matching Method (SSMM), COST model, Landsat-7 ETM+, Saemangeum

1. INTRODUCTION

For monitoring oceanic physical and biological features, there have been several studies that used satellite data from CZCS, SeaWiFS, MODIS, MERIS, OCM, and OSMI. However, these sensors provide images with 1 km spatial resolution, not enough to capture detailed characteristics of the highly dynamic coastal oceanic geophysical and biogeochemical variabilites. Therefore, for coastal area monitoring several studies attempted to make use the high spatial resolution satellite data from Landsat and SPOT (Froidfond, 2002 & 2004; Min, 2004 & 2005; Ahn et al, 2005).

Retrival of oceanic biogeochemical and geophysical variables from satellite data requires a method to correct the atmospheric effects in the satellite data resulting from scattered photons from aerosols and Raleigh particles and air-sea interface. Indeed 10-20% of the reflected radiance signal is from the ocean surface and remaining part results from the atmospheric path and air-sea interface (Ahn and Shanmugam, 2004), contributing to the TOA signal. To remove this path signal, there are classical atmospheric correction methods employed on the high spatial resolution satellite data, namely Dark Object Subtraction (DOS), Empirical Line Method (ELM), 6S Radiative Transfer Model. But these methods have some limitations for ocean applications. Thus, we need ocean specific atmospheric correction method to retrieve accurate water-leaving radiance signal from the total signal recorder at the TOA. Here we employ Spectral Shape Matching Method (SSMM) developed by Ahn and Shanmugam (2004) to perform accurate atmospheric correction of Landsat-7 ETM+ imagery and compare with COST model.

2. SSMM

2.1 Concept of SSMM

The idea behind this method is quite simple and easy to implement on any satellite imagery. The principal assumption of this method is that, there are some pixels in any given scene whose spectral shape of radiances or reflectance is quite stable and known for typical turbid or clear waters, leading to the extraction of the path signal from L_{TOA} by subtracting the known water-leaving radiance values obtained from the in-situ measurements as given below,

$$L_{path}(\lambda) = L_{TOA}(\lambda) - L_{insitu-ref}(\lambda) \quad (1)$$

where $L_{insitu-ref}(\lambda)$ is the typical in-situ reference spectra for clear or turbid waters. The atmospheric path signal ($L_{path}(\lambda)$) is the contribution of the photons, scattered and reflected between the sea surface and satellite sensor. The method of extracting path signal, in this manner, is also referred to as absolute calibration (Chavez, 1996). To retrieve L_w values from the satellite VIS/NIR imagery, with the assumption of constant diffuse transmittance (t_d = 1) and homogeneous distribution of aerosols and other particles, the $L_{path}(\lambda)$ is then subtracted from the $L_{TOA}(\lambda)$ measured at the TOA as below,

$$L_w(\lambda) = L_{TOA}(\lambda) - L_{path}(\lambda) \quad (2)$$

One can expect that the shape and magnitude of the retrieved water-leaving radiance spectra should approximately match with the in-situ spectrum over the same region. This atmospheric correction procedure is greatly significant in combination with SSMM, especially over turbid waters where most of the classical atmospheric correction algorithms fail. In contrast to path-extraction, SSMM performs even better for Case-II waters because L_w is not assumed to be zero ($L_{TOA} = L_{path} + t_d L_w$; $t_d = 1$, $L_w \neq 0$). The spectral normalization ($\widetilde{L}_{turbid-TM}$) of the retrieved (SSMM) and in-situ spectra is one of the models of comparison, which can be expressed as follows,

$$\begin{aligned} \{L_{TOA}(B1) - L_{path}(B1)\} / \{L_{TOA}(B2) - L_{path}(B2)\} &= \\ \widetilde{L}_{turbid-TM}(B1) \approx L_{insitu-ref}(B1) / L_{insitu-ref}(B2) & \\ \vdots \qquad\qquad & \quad (3) \\ \{L_{TOA}(B4) - L_{path}(B4)\} / \{L_{TOA}(B2) - L_{path}(B2)\} &= \\ \widetilde{L}_{turbid-TM}(B4) \approx L_{insitu-ref}(B4) / L_{insitu-ref}(B2) & \end{aligned}$$

One of the most significant problems in adopting the path-extraction and SSMM methods is that they may not reproduce water-leaving radiance spectra, when the distribution of aerosol loadings vary dramatically, and thus the assumption of spatial homogeneity aerosol loading of these methods will be violated.

3. METHOD

3.1 Study area and Satellite data used

The Saemangeum is situated in the western coastal part of Korea, where Mankyung and Dongjin rivers discharge fresh water. In this area, the 33 km Saemangeum tidal dyke is under the course of construction, and reclamation of shallow estuary is taking place for 41,000ha. Because of the high tidal range, high suspended and resuspended sediment materials characterize these waters as belonging to Case-II water type.

At present, the dyke is connected with Gogunsan-Gundo and separates this area into three regions; northwest, southwest and east (Saemangeum). The water in Saemangeum region is exchanged through two openings in the southern dyke. The SS concentration in the northwest region of the dyke is significantly lower than that in the southern part, mainly because of no exchange of water mass in this area. SS concentrations in the northwest region of the dyke are relatively high.

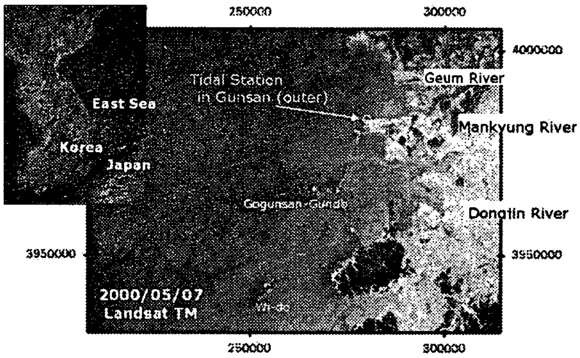

Figure 1. Landsat-5 TM (7 May, 2000) color composite image (RGB-321) at the Saemangeum coastal area.

3.2 Field measurements

To assess the potential use of these methods, several field campaigns were conducted in the Saemangeum coastal area.corresponded with the Landsat-7 satellite's overpass on 29 May 2005. In-situ observations were made from the coastal waters (at 29 May 2005) and land objects (at 28 May 2005) around the Saemangeum. At 10 locations we collected water samples for analyzing chlorophyll concentration (<chl>), suspended sediment concentration (<SS>), absorption coefficients of phytoplankton, and dissolved organic matter (DOM), along with simultaneous measurements of downwelling irradiance (E_d), water leaving radiance (L_w), sky radiance (L_{sky}) using ASD dual beam spectroradiometer.

4. RESULT AND DISCUSSION

Figure 2 shows the Standard spectral shape used in this study. The water-leaving radiance spectra for clear waters were collected during March 2000 from R/V EARDO cruise in the East Sea. The water-leaving radiance spectra for turbid waters were collected during March 2005 from a conventional boat operated in and around Saemangeum coastal area.

Atmospheric correction using SSMM was performed, and the results were compared with the in-situ data and those from COST model. We found that water-leaving radiance spectra estimated from SSMM is more consistent with in-situ spectra when compared to those from COST model.

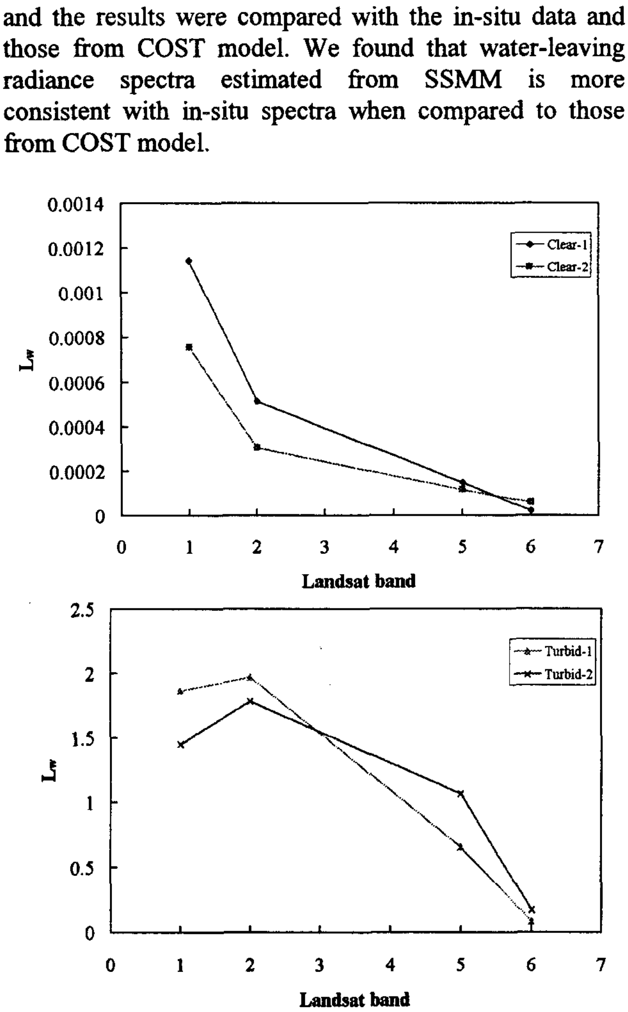

Figure 2. Standard Spectral Shape obtained from in-situ L_w measurements in clear waters (A) and turbid waters (B)

5. CONCLUSION

The Spectral Shape Matching Method (SSMM) seemed to be efficient atmospheric correction method when compared to other methods, however, for the effective use of this method we need to establish the spectral library for water-leaving radiance of having nearly stable spectral shape from both clear and turbid waters. So our future work will be to establish the spectral library for the effective use of SSMM for atmospheric correction. (A)

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