Landsat Images Applied for Analyzing Spatial Flow and Water Quality Patterns in a Korea Estuary Dam

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ABSTRACT : This paper presents the results of Landsat-TM imagery applications for detecting spatial variations of the water environments in the Saemankeum (STLR) project areas. The simulated tidal flow patterns from a two-dimensional hydro-dynamic model and water quality data from STRL project were used for relationships with the satellite data. Unsupervised classification of the tidal water body reflects the overall flow patterns at a flooding tide. Regressive equations for water quality parameters were derived and used for supervised classifications. The results were found to be useful to synoptically evaluate the water environments during the construction stages of the STLR project.
Keywords: Hydrodynamic modeling, Supervised classification, Tidal flow and water quality, Sea-dike construction

1. Introduction

This paper presents the results of applying Landsat-TM imagery for spatially analyzing and synoptically viewing the flow and water quality variations at the Saemankeum Tidal Land Reclamation (STLR) Project in the mid-west Korean coast. The STLR project which has been implemented since 1991 is to construct 33 km long sea dikes and reclaim tidal flats and estuary of 410 km^2 for agricultural lands, freshwater reservoir, and other land uses. Over eighty percent of the sea dikes have been constructed as of November, 2003.

The use of satellite image data which have the features of wideness, simultaneity, and periodicity, can be the most effectively utilized in evaluating the changes of water environments resulting from sea dike construction in the STLR project areas. The paper attempts to adopt the remote sensing technology as a supplemental tool to expand the results from hydrodynamic modeling and water quality monitoring for understanding the changes of the water environments during the construction.

2. Data and Image Analyses

Among several recent Landsat-TM images, the ones taken at 1:44:27 October 6, 1997 and at 1:30:13, October 30, 2000 were selected and used in this study (Fig. 1). The 10-30-2000 image

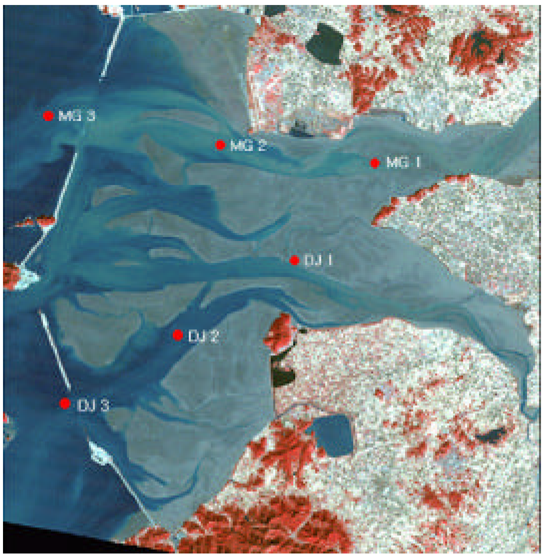

Fig. 0 Landsat-TM image of the Saemankeum areas and water quality sampling sites (October 30, 2000)

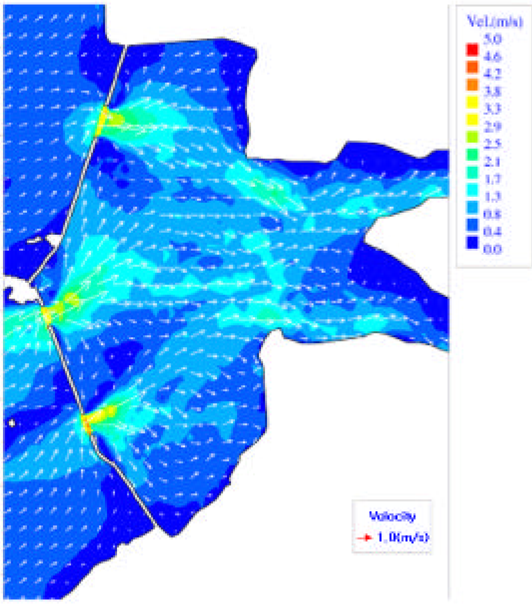

Fig. 0 Hydrodynamic simulation results for flooding tide used for the 10-30-2000 images

was used to developed for the relationships for water quality parameters, and the 10-6-1997 used for the validation. The tidal currents in the STLR areas at the times of Landsat-TM passage were in a flooding stage, but no field measurements were made. The results from a two-dimensional hydrodynamic modeling for the construction stage IV of STLR were used [1]. Fig. 2 is the tidal current vector map, showing that rapid tidal currents passing through the gaps command the flow patterns inside of the constructing dikes. The boundary conditions for the Landsat scene may be different from the conditions used in the modeling. However, it has been documented that tidal flows are very much similar in general tidal circulations within the STLR project areas. No additional hydro-dynamic modeling was justified to obtain the exact flow patterns at the times of the passage.

Fig. 1 also shows the six water quality sampling sites in the STRL project areas. The water quality data consisted of seven parameters: The salinity, pH, secchi disk transparency, suspended sediment (SS), total nitrogen (TN), total phosphorus (TP), and chemical oxygen demand (COD).

The Landsat-TM images were pre-processed and classified in the following steps [2]: 1) The geometric correction for converting the image data to the UTM coordinate, 2) atmospheric correction to remove the distortion by atmospheric effects, but the results not applied in later processes due to the less apparent views from the corrections as compared to the original scene, 3) unsupervised classification for terrestrial areas and masking them to get water-only image, 4) unsupervised classification of water only image, 5) area-of-interest positioning and the signature acquisition, 6) regression analysis of flow and water quality parameters as related to Landsat data, 7) creation of the flow and the water quality parameter maps.

3. Results and Discussions

The tidal flow patterns in the STRL areas as simulated using the hydrodynamic modeling were found to be similar to the unsupervised Landsat images. The supervised flow map using the regression relationship contains some irregularities in tidal flow patterns. This may be partly due to the fact that the flow simulation results were not at the exact time the satellite passed over. Thus, relationships between the simulated flow patterns and unsupervised classifications were developed and used for the flow pattern map of the STRL areas. The classified flow patterns look in a similar trend, and the coefficient of determination (R^2) was 0.56 between the classified and simulated flow velocities.

A stepwise regression analysis was applied to get the predictive equations for water quality parameters as related to the Landsat data. Regression coefficients for all the water quality parameters including those which are not visible from the reflectance such as pH, TN, and TP were greater than 0.90. An example of the

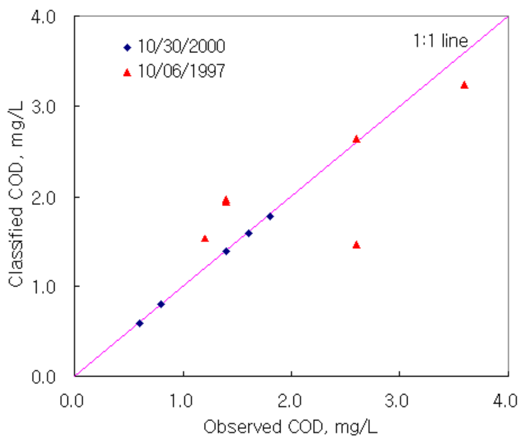

Fig. 3 Classified and observed CODs for 10-30-2000 and 10-06-1997 images

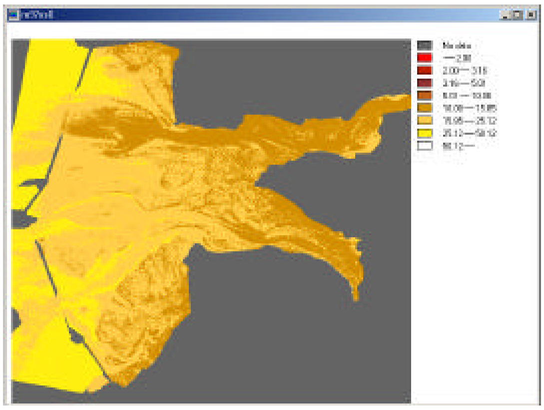

Fig. 4 Classified suspended sediment concentrations for the 10-06-1997 images

comparison between the measured and classified COD is shown in Fig. 3, which presents a close agreement between the two values. And the supervised classification map for SS is shown in Fig. 3.

The reflectance of a Landsat image is often different from other images. Retaining the same bands, the regression equations were developed for 10-6-1997 image. The statistical analyses indicated poorer R^2 values than 10-30-2000 image, but the classification results appear reasonably good.

The good results from regression analyses for the water quality constituents may be attributed to the following: 1) The water quality in the STRL areas is mainly governed by the bathymetry of the tidal prisms, 2) the sampling sites in the areas are limited to relatively deep areas, and no sampling was taken at coastal zones and tidal flats where the turbulence by wind waves may contribute significantly to high concentrations of suspended sediment. In cases further validation is needed, sampling should be made at several points in tidal flats and applied the previous steps. Nevertheless, the results like in Fig. 4 offer the information on the spatial variations of water quality in the areas which may not otherwise be possible without remote sensing applications.

4. Conclusions

The supervised classifications of Landsat-TM images based on hydrodynamic modeling and several in-situ water quality monitoring provided the conditions of the water environments in the STRL areas. The classified results were consistent and accurate for water quality constituents. The information is valuable to the environmental assessment of STRL projects under construction. The technique is also only a tool available to offer better insight into wide ranges of the waters for the project. And periodic updating of the classifications is planned for future water quality assessment for the different construction stages.

References

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