ASSESSING WATER QUALITY IN THE ROCHESTER EMBAYMENT USING MODIS IMAGES AND DATA ASSIMILATION A. Vodacek, Y. Zhu, and A. J. Spivey, Digital Imaging and Remote Sensing Laboratory, Center for Imaging Science, Rochester Institute of Technology, Rochester, NY 14623, vodacek@cis.rit.edu, yaz0405@cis.rit.edu, alvin.spivey@gmail.com

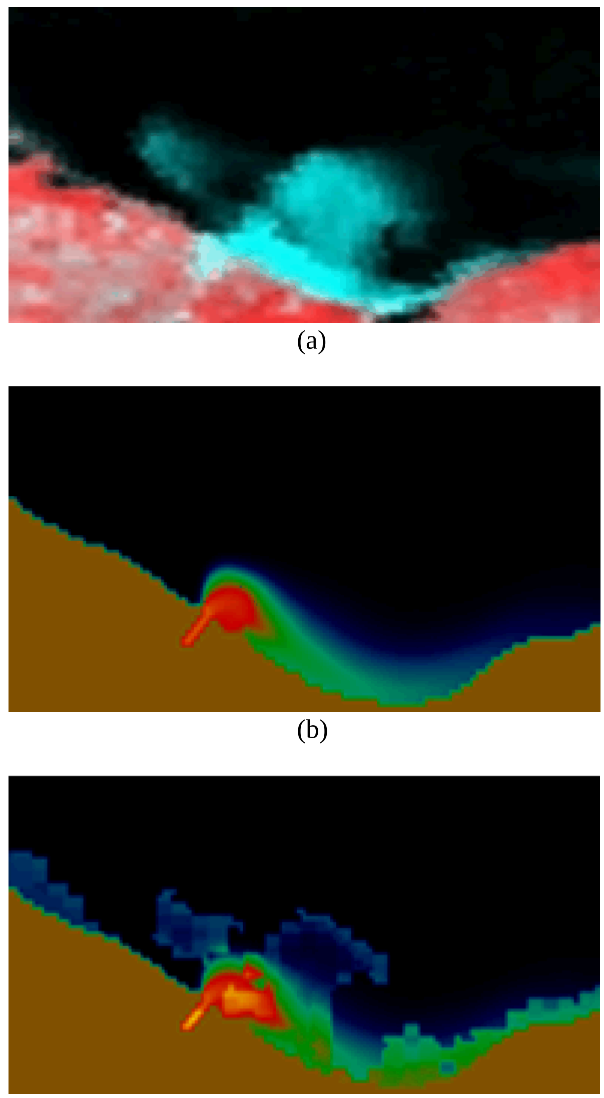
Introduction: Ontario Beach in Rochester, NY is often closed during the summer swimming season due to poor water quality. The Monore County Health Department has a set of criteria for determing beach closures that include coliform counts, turbidity, and magnitude of flow from the Genesee River. Due to high nutrient and suspended sediment loads, the fate of the Genesee River plume is quite important in determining parameters related to beach closings. A system for forecasting beach closures at Ontario Beach is under development. The system couples hydrologic and hydrodynamic information with weather data to predict the transport of sediment in the Genesee River plume in the Rochester Embayment. Satellite data sensitive to sediment load are used to adjust the hydrodynamic simulation results on cloud-free days. The predicted sediment concentration in front of the beach correlates well with actual beach closure decisions.

Modeling System: The modeling system is described fully in the Ph.D. dissertation by Li [1]. The system consists of a hydrodynamic model, a radiative transfer model, and a program for assimilating MODIS reflectance data.

The hydrodynamic model. The heart of the modeling system is the three dimensional hydrodynamic model that simulates the flow of the Genesee River plume in the Rochester Embayment. The hydrodynamic model used was specifically designed for matching to remote sensing data [2]. Inputs to the hydrodynamic model include weather data, river discharge, and river sediment content. A low resolution simulation of the whole of Lake Ontario (1.5 km grid spacing) provides lake current boundary conditions so that the high resolution plume simulation (135 m grid spacing) responds to the overall pattern of currents in the lake.

The radiative transfer model. The distribution of suspended sediment predicted by the hydrodynamic simulation serves as input to a radiative transfer code that is used to predict the water reflectance in the embayment [3]. The radiative transfer model predicts the water reflectance based on the concentrations of materials in the water, the absorption and scattering properties of those materials, and the bottom reflectance. The radiative transfer model is run for each horizontal node of the hydrodynamic model to create a synthetic reflectance image of the embayment with 135 m pixel size. This synthetic image is then resampled to match the 250 m pixel size of the MODIS reflectance image.

Assimilating MODIS data. The MODIS reflectance image is compared to the synthetic image output of the radiative transfer model using an Ensemble Kalman Filter. The Ensemble Kalman Filter was developed to improve environmental models by incorporating real observations into the simulation [4,5]. The statistical properties of the modeling system are found by running the simulation multiple times (the ensemble).



(a) (b) (c)

Figure 1. (a) MODIS reflectance image of the Rochester Embayment on July 29, 2003. This false color image (RGB = nir, red, red) is derived from the 250 m red (band 1) and near infrared (band 2) surface reflectance data product (MOD09GQ).

Results:

Data assimilation assessment. Figure 1 shows the MODIS image (a), the direct simulation result (b), and the simulation result after the Ensemble Kalman Filtering process (c). The simulation results were assessed two ways. First, for the duration of the modeled time span, the root mean squared error between the measured sediment concentration in the river (USGS station 431510077363501) and the sediment concentration predicted at the river mouth following the MODIS data assimilation was calculated. This value was smaller than the error over the same time span for any of the ensemble of simulations without the use of data assimilation. Second, the root mean squared error was calculated for the spatial distribution of predicted reflectance. In this case the MODIS data is assumed to be correct. A large reduction in error was observed over the time span of the simulation when the spatial distribution of the plume is assessed. The good fit for the spatial assimilation result is illustrated well by comparing Fig. 1 (b) and (c) to Fig. 1 (a).

Assessing the relationship between turbidity at the beach and the beach closure decision. The average sediment concentration for eight grid points in front of the beach was calculated for each day of the simulation. By comparing the sediment concentration to the beach closure decision, it was found that when a sediment concentration threshold of 45 gm^{-3} was exceeded, a beach closure decision could be made with 80% accuracy.

Discussion: We are continuing the development and assessment of the modeling system for other years. We can add to the system by incorporating a hydrological model that can provide river discharge and sediment and dissolved organic matter concentrations. We also plan to add to the data sources by using night time MODIS thermal data for monitoring the river plume and placing turbidity and fluorescence sensors in the river for real-time monitoring of suspended sediment and dissolved organic matter.

References: [1] Li Y. (2007) *Ph.D. dissertation*, RIT. [2] Garrett A. J. et al. (2000) *Photogram. Eng. Remote Sens. 66*, 329-335. [3] Mobley C. D. and Sundman L. K. (2000) *HYDROLIGHT 4.1 USER Guide.* Sequoia Sci. [4] Natvik L.-J. and Evensen G. (2003) *J. Mar. Sys. 40-41*, 127-153. [5] Natvik L.-J. and Evensen G. (2003) *J. Mar. Sys. 40-41*, 155-169.