Title: Use of HICO Imagery for Regional Monitoring of the Biogeochemical Conditions of Inland Lakes

Study Area: Select sites in Minnesota, USA

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Abstract

Regional lake water clarity assessment using remote sensing has become routine in many regions using broad band multispectral imagery such as Landsat. Higher spectral resolution systems such as MERIS for large lakes and airborne hyperspectral systems for lakes and rivers have been used for more comprehensive biophysical assessments of variable such as chlorophyll, suspended material, turbidity and colored dissolved organic matter. This project will investigate the higher spectral resolution of HICO imagery for chlorophyll, water clarity and suspended material assessment of inland lakes in Minnesota. Routine ground-based sampling efforts by state and local agencies will provide calibration data for chlorophyll, suspended solids, and water clarity. Best-fit relationships will be developed between these in situ data and various combinations of the spectral radiance data.. This project will investigate the utility of the additional spectral band for more comprehensive water quality assessment than can be accomplished with typical multispectral imagery.

Project Description

The Upper Great Lakes region includes tens of thousands of inland lakes, and their importance to the region can hardly be exaggerated. Land use and climate change are threatening the supply and quality of the waters of these lakes in many ways, with eutrophication being the most pervasive problem. To help manage the continued health of the region's lakes, a variety of federal (USGS, EPA), and state agencies monitor water

quality by an assortment of in-situ sampling programs. However, due to the large number of lakes involved and the limits on agency budgets and personnel, it is impossible to adequately sample more than a small fraction of the lakes in any given year.

The potential benefits of satellite monitoring of these inland lakes are enormous. Under the auspices of our NASA RESAC project, we developed a standardized protocol for monitoring lake water clarity, which has been applied on a systematic basis across our entire three-state region (Olmanson et al., 2001). This protocol involves the extraction of lake spectral data from Landsat TM/ETM+ imagery using ERDAS Imagine, and the analysis of these data in combination with field observations collected by networks of citizen volunteers and others, and compiled in the EPA's STORET system. The Landsat-based regional approach used in the RESAC project successfully resulted in the first systematic, consistent, wide-scale assessment of water clarity for more than 20,000 lakes in Minnesota, Wisconsin and Michigan (Kloiber et al., 2002; Chipman et al., 2003 Olmanson et al., 2008). We also have applied the approach to MERIS and MODIS imagery with similar success for water clarity and chlorophyll assessment of larger lakes (Olmanson et al. 2011), with IKONOS and QuickBird for water clarity of small lakes and ponds (Sawaya et al. 2003) and with airborne hyperspectral imagery for water clarity, chlorophyll and suspended solids in optically complex river waters (Olmanson et al. submitted).

To investigate the retrieval of additional water quality variables in inland lakes we propose the use of HICO imagery. The HICO imagery will be processed, and used to derive estimates of selected physical-chemical parameters for inland lakes. Initially, these parameters will include Secchi disk transparency and other measures of water clarity, such as suspended solids concentration and turbidity. Further research will be conducted to develop robust models utilizing the improved spectral characteristics of HICO to estimate other parameters, such as chlorophyll *a* concentration and colored dissolved organic matter (CDOM) to the extent practicable for application to the range of lakes (oligotrophic to hypereutrophic) in the region.

The imagery will be processed in the University of Minnesota Remote Sensing and Geospatial Analysis Laboratory using Intergraph ERDAS Imagine and Esri ArcMap software. To develop models and validate the resulting products, we will work with field data collected by a network of collaborating groups and agencies. These include field data collected by state natural resource agencies, data from local government programs and other groups. These programs are well established and have provided ample data for image calibration in our previous projects. Sites will be selected throughout Minnesota in areas with diverse lake types and water quality conditions. Assuming we are successful in acquiring clear imagery we will develop algorithms for water quality maps and validate HICO products for regional water quality assessments in Minnesota. More information

about our research and links to our LakeBrowser application can be found at water.umn.edu.

References

Chipman, J.W., Lillesand, T.M., Schmaltz, J.E., Leale, J.E., & Nordheim, M.J. (2004). Mapping lake water clarity with Landsat images in Wisconsin, USA. Canada Journal of Remote Sensing, 30, 1-7.

Kloiber, S.M., Brezonik, P.L., and Bauer, M.E. (2002b). Application of Landsat imagery to regional-scale assessments of lake clarity. Water Research 36, 4330-4340.

Olmanson, L.G., Bauer, M.E., and Brezonik, P.L. Airborne Hyperspectral Remote Sensing to Assess Spatial Distribution of Water Quality Characteristics in Large Rivers: the Mississippi River and its Tributaries in Minnesota . Submitted to *Remote Sensing of Environment*.

Olmanson, L. G., P. L. Brezonik, and M. E. Bauer (2011), Evaluation of medium to low resolution satellite imagery for regional lake water quality assessments, Water Resources Research, 47, W09515, doi:10.1029/2011WR011005.

Olmanson, L.G., M.E. Bauer and P.L. Brezonik. 2008. Development and analysis of a 20-year Landsat water clarity census of Minnesota.s 10,000 lakes. *Remote Sensing of Environment*, special issue on Monitoring Freshwater and Estuarine Systems.

Olmanson, L.G., Kloiber, S.M., Bauer, M.E., and Brezonik, P.L. 2001. Image processing protocol for regional assessments of lake water quality. Water Resources Center and Remote Sensing Laboratory, University of Minnesota, St. Paul, MN, 55108, October 2001.

Sawaya, K., Olmanson. L., Heinert, N., Brezonik. P., and Bauer, M. 2003. Extending satellite remote sensing to local scales: Land and water resource monitoring using high-resolution imagery. *Remote Sensing of Environment* 88: 144-156.