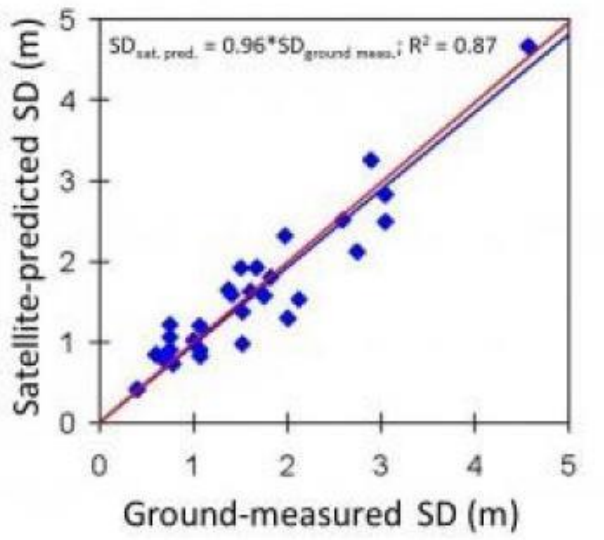
Water clarity of lakes across the Twin Cities metro area

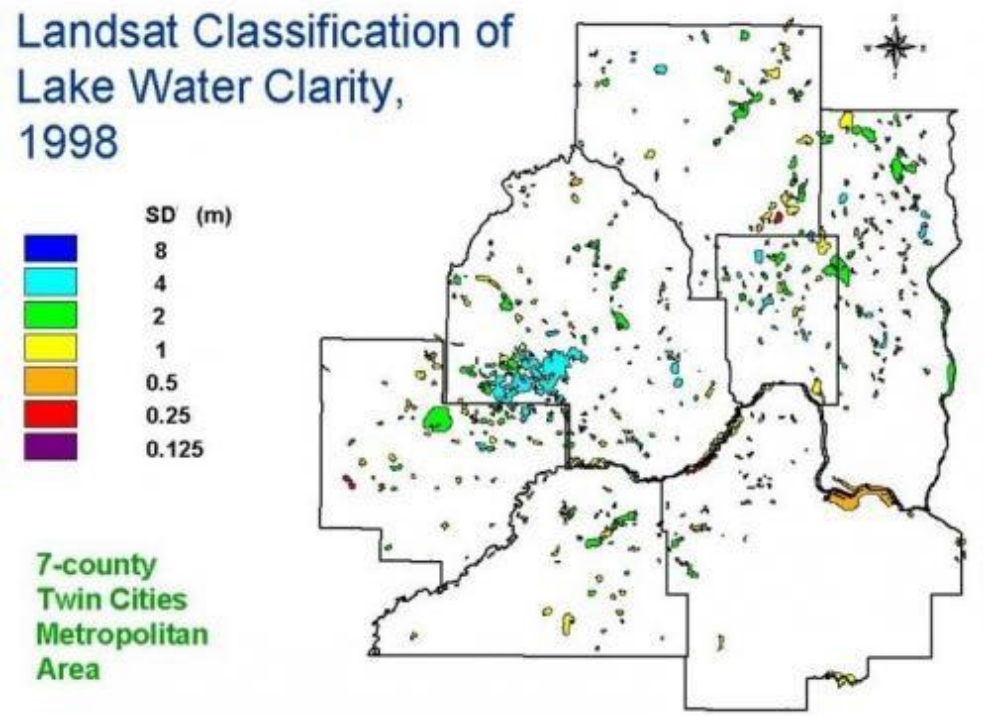
Our work using satellite imagery to measure water quality began as an M.S. paper (Olmanson, 1997) focused on water clarity of lakes in the seven-county Twin Cities (Minneapolis and St. Paul) Metropolitan Area (TCMA). This initial study led to a multi-year effort funded by the Metropolitan Council's Environmental Services division to examine spatial patterns and temporal trends in lake clarity across the TCMA, a 7,800 km^2 area with more than 600 small and medium-sized lakes. The study focused on developing a regional-scale image-processing procedure (Olmanson et al. 2001; Kloiber et al. 2002a) and applying it to map the water clarity of lakes in the region (Kloiber et al. 2002b). To develop the method, we needed to address several issues:

- Defining timing and frequency requirements for an assessment program
- Selecting satellite images
- Data extraction from images
- Selecting ground observation data
- Developing an appropriate estimation model



To create water clarity maps for TCMA lakes, we used Landsat images obtained from the USGS EROS Center in Sioux Falls, SD and obtained Secchi depth (SD) data from a database managed by the Minnesota Pollution Control Agency. A companion study analyzed seasonal water quality data for lakes in the region and showed that the period late July to mid-September was a useful "index period" for region-wide assessments of water clarity because SD values were relatively stable and at minimum seasonal levels during this period (Stadelmann et al. 2001; Kloiber et al. 2002b). Spectral signatures of lakes for which we had SD data were extracted to model water clarity for all lakes in the region. As with the city-scale study using IKONOS imagery, we used the band 1:3 ratio and band 1 as the independent variables and the natural log of SD as the dependent variable in the retrieval model. The agreement between the Landsat data and SD measurements was very good ($R^2 = 0.87$).

We used the image-processing procedure to create a long-term database of water clarity in more than 500 TCMA lakes. From the archive of available images, we selected 13 Landsat TM and MSS images from the period 1973 to 1998. The images were from years with relatively normal climatic conditions except for one dry year (1988) and one wet year (1993). Four images from 1991 (June - September) also were analyzed to measure seasonal variability in SD, and TM and MSS images from September 4, 1991 were acquired to evaluate the compatibility of the two sensors. Lake water clarity results for TCMA lakes in 1998 are shown in the map at the left. Analysis of long-term trends based on the processed imagery shows that in spite of large land use changes in the region over the study period, only about 10% (49) of the lakes had significant temporal trends in SD, and more lakes had increasing SD (34) than decreasing SD (15). For more details on the results of this study, see Kloiber et al. (2002b).



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