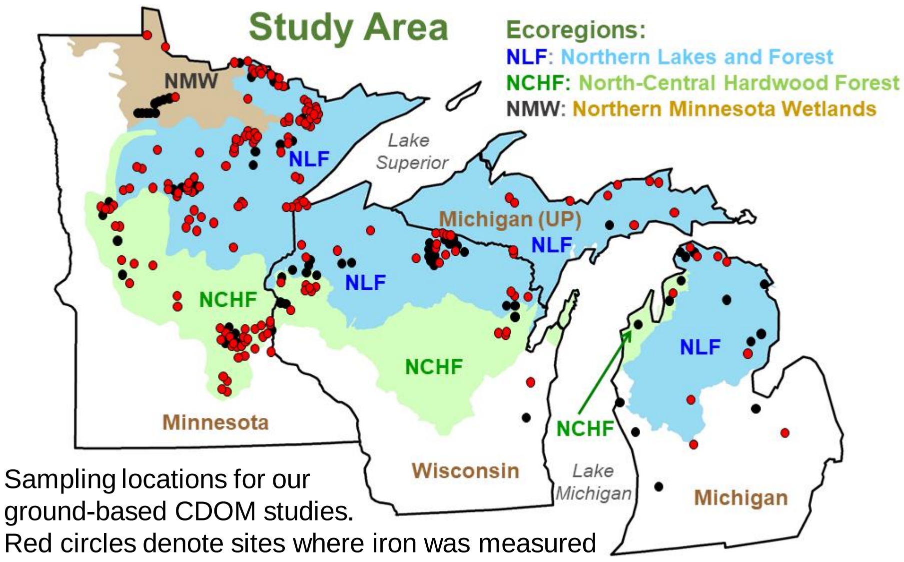
CDOM: Field-based studies

In addition to mapping CDOM by remote sensing, we have used our field data (see map at right for 2014-2017 sampling sites), coupled with lab measurements and experiments, to address three questions related to the role of CDOM in aquatic ecosystems. Here we present some findings from recently published papers on these topics.

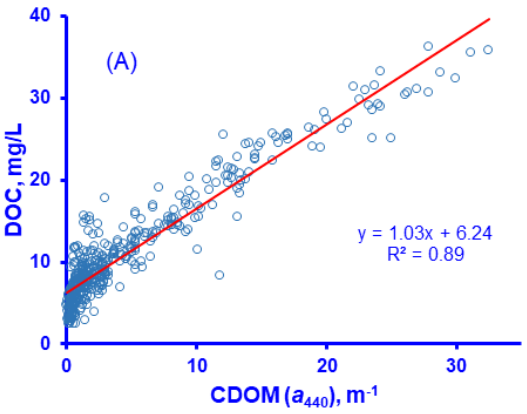


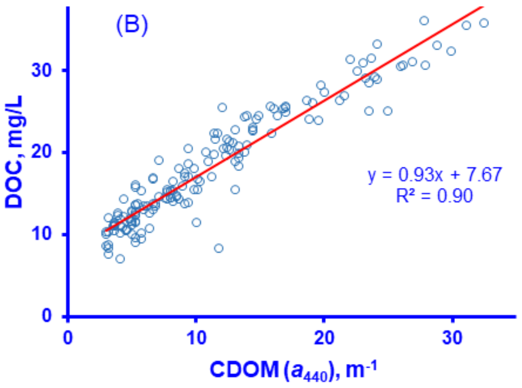
Sampling locations for our ground-based CDOM studies.
Red circles denote sites where iron was measured in addition to DOC, CDOM, SD chlorophyll and other water quality parameters that were measured at all sites.

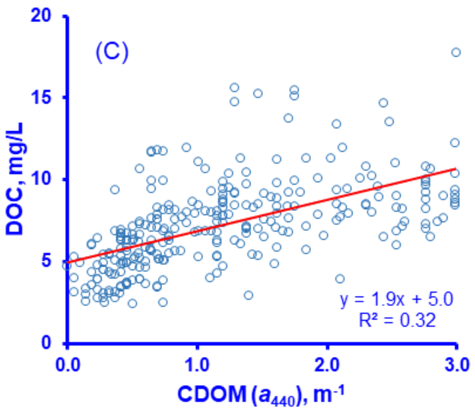
1. DOC-CDOM relationships

(A) DOC and CDOM (measured as a_{440}) are strongly correlated across the lakes of the Upper Great Lakes states, especially (B) in visibly stained lakes (a_{440} > ~ 3 m^{-1}).

(C) The DOC-a_{440} relationship is weaker in low colored lakes (a_{440} < 3 m^{-1}) likely because low-colored organic matter from human sources (e.g., wastewater effluent, urban runoff) contributes varying amounts to the DOC pool but not the CDOM pool. Easily measured CDOM thus is useful as a surrogate (predictor) of DOC. For details on CDOM relationships with DOC and other properties of DOM, see Griffin et al. ***Water Research*** 144: 719 (2018).

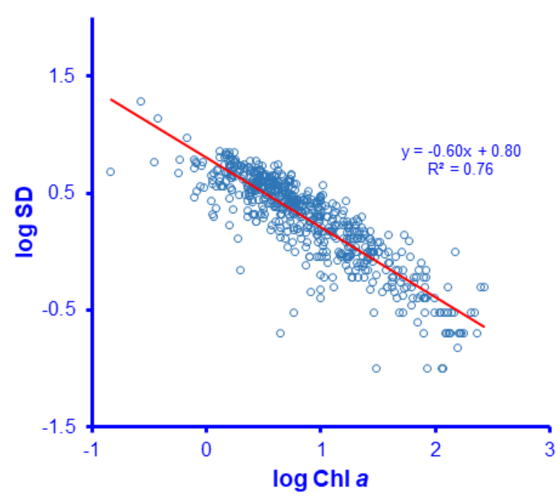




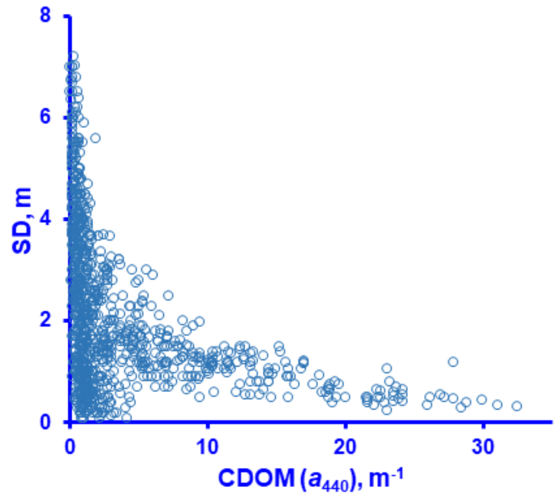


2. CDOM effects on Secchi depth (SD)

In most lakes SD is controlled by algal density, commonly measured as chlorophyll *a* concentration. In highly colored lakes, CDOM is the main controlling factor for SD. This means that SD is not a good indicator of trophic state in highly colored lakes.

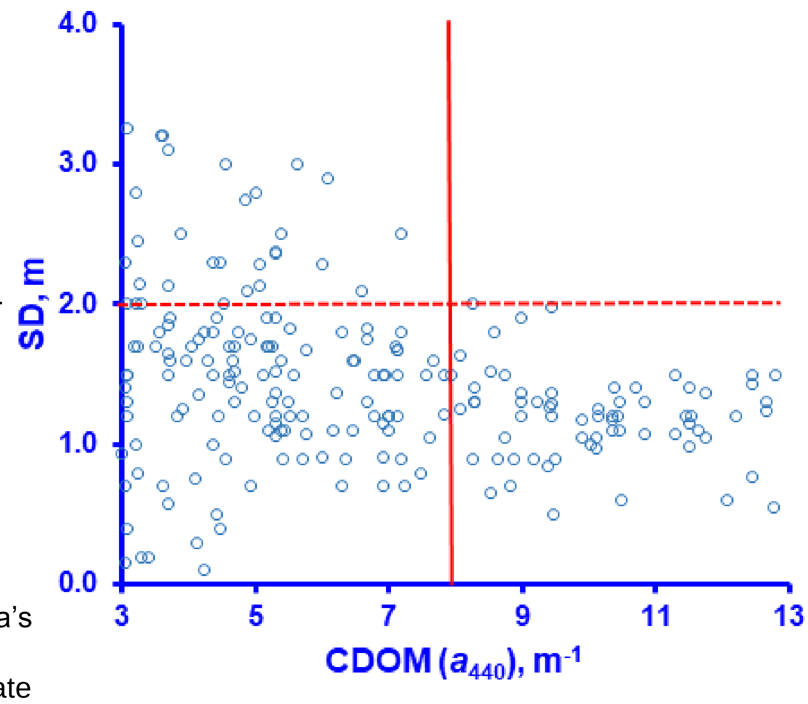


The strong relationship in the log-log plot of SD vs. chlorophyll for low-color Minnesota lakes suggests that chlorophyll (algal density) is a primary controlling factor for SD in these lakes.



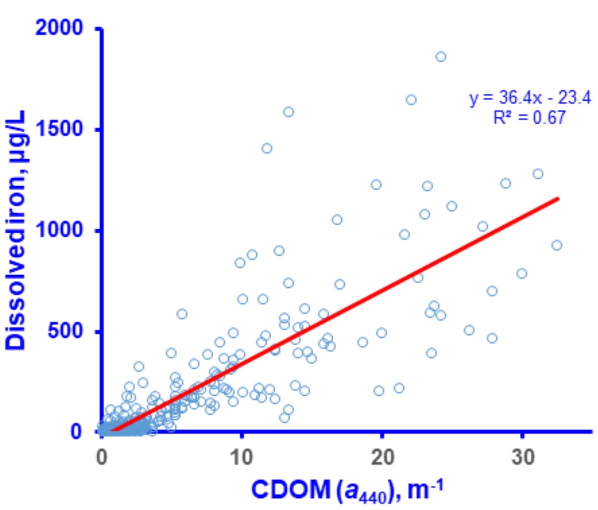
SD values have a wide range in low-color lakes, largely reflecting how much chlorophyll is present, but high colored lakes have low SD because of the light-absorbing properties of CDOM.

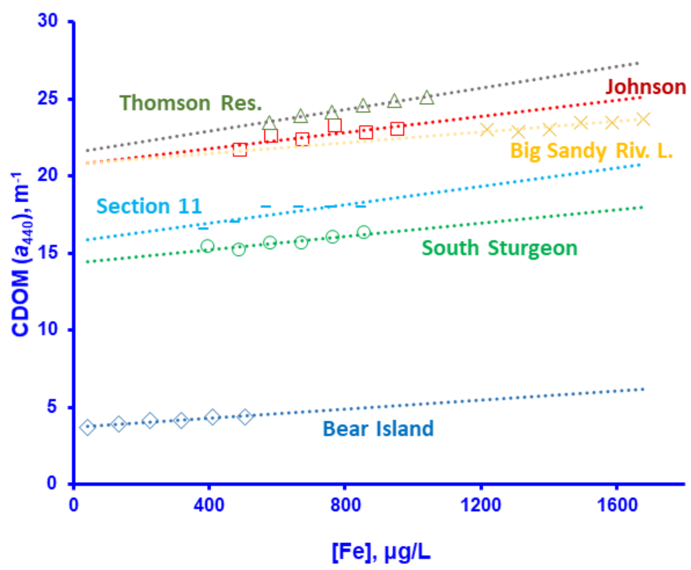
Using a data set of 1460 samples from our ground-based sampling (2014-17) and monitoring data from the MN Pollution Control Agency (2015-17), we found that no lake with CDOM (a_{440}) > 8 m^{-1} had a SD > 2 m (see plot at right). Further statistical analyses showed that CDOM starts to affect SD at a_{440} > ~ 4 m^{-1}. A SD of 2 m is Minnesota's water quality standard indicative of trophic state impairment for warm/cool-water lakes in the NLF ecoregion. For more details on this subject, see Brezonik, Bouchard, et al. ***Ecol. Appl.*** e01871 (2019).

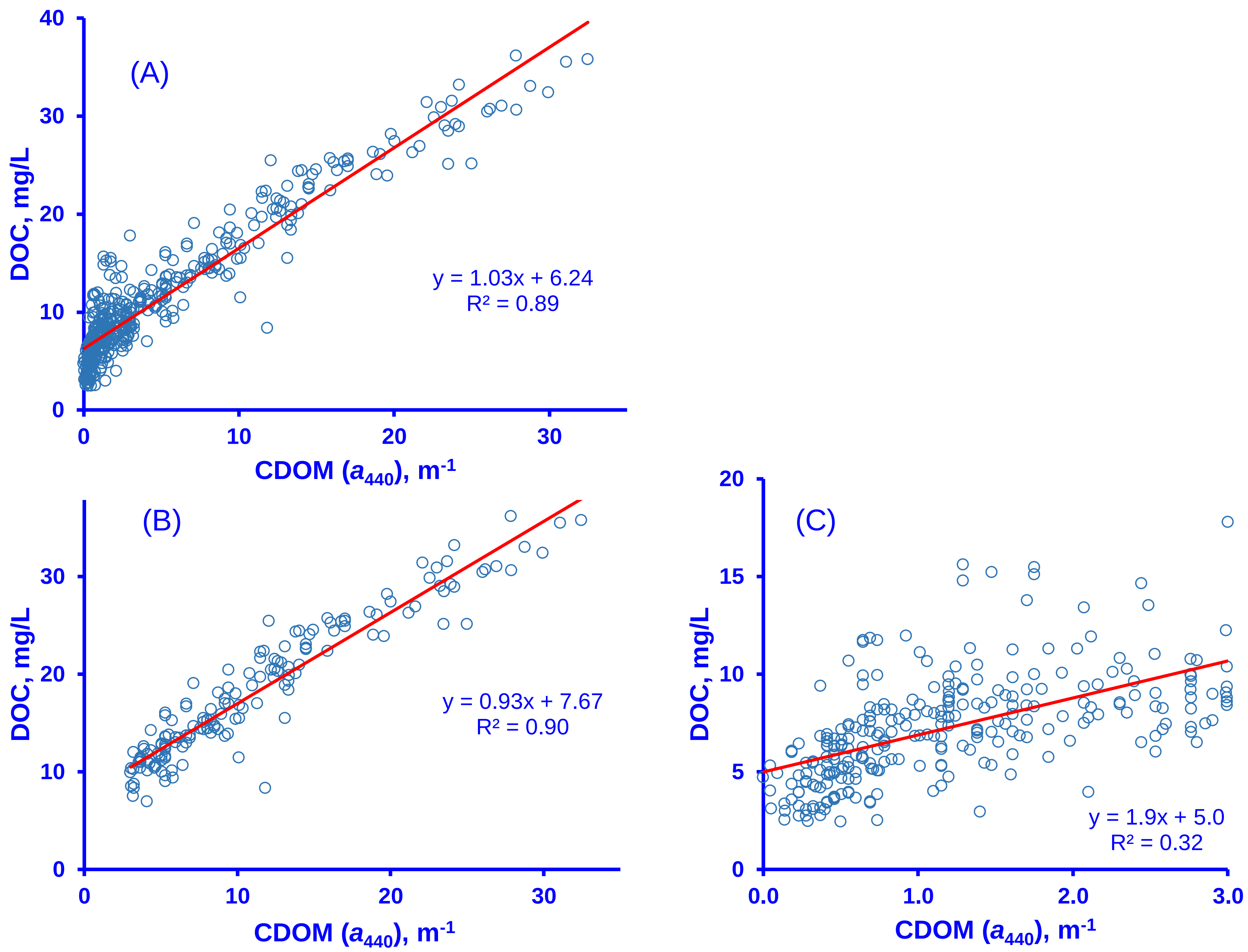


3. CDOM and Iron

CDOM levels and dissolved iron (Fe) concentrations are moderately associated with each other in Minnesota lakes (figure at left below) and elsewhere. In fact, anecdotal data suggest that many lake homeowners and lake users attribute the brown color of lakes to high Fe concentrations, and Scandinavian scientists have concluded that increasing dissolved Fe could explain the "browning" phenomenon (increases in brown color) commonly found in Scandinavian lakes (and elsewhere) in recent decades. Analysis of our field data, coupled with lab experiments in which controlled amounts of dissolved Fe were added to Minnesota lakes with varying CDOM levels, led us to conclude that dissolved Fe is not an important factor affecting apparent CDOM (i.e., a_{440}) in Minnesota and the surrounding region. Adding dissolved Fe to lake waters (see figure at right below) increased a_{440} only by very small amounts (average of only 0.24 m^{-1} per 100 µg/L of added Fe). Extrapolating the best-fit lines of a_{440} vs. added Fe back to zero ambient Fe showed that most of each lake's ambient a_{440} remained. Overall, DOM accounted for ~ 92 ± 5% of measured a_{440} for our lakes, and dissolved Fe accounted for the rest. For further information on this topic and other effects of Fe on DOM optical properties, see Brezonik, Finlay et al. ***PLOS ONE*** 14(2): e0211979 (2019).






(A)
DOC, mg/L
CDOM (a440), m-1
y = 1.03x + 6.24
R² = 0.89
0
10
20
30
40
0
10
20
30
(B)
DOC, mg/L
CDOM (a440), m-1
y = 0.93x + 7.67
R² = 0.90
0
10
20
30
0
10
20
30
(C)
DOC, mg/L
CDOM (a440), m-1
y = 1.9x + 5.0
R² = 0.32
0
5
10
15
20
0.0
1.0
2.0
3.0