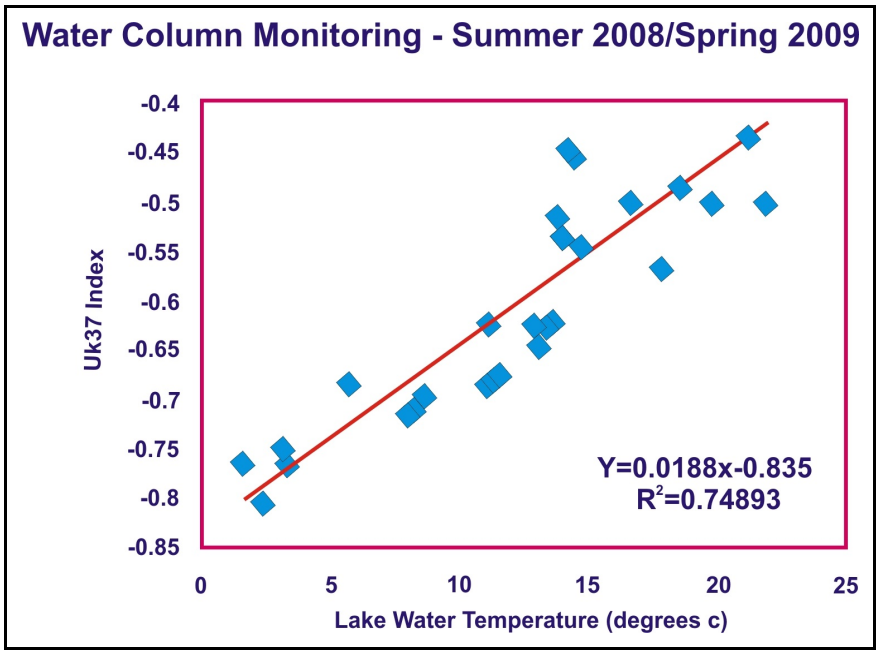
Long-term Rainfall Variations Linked to Solar Forcing at Lake George (Salt Lake), Streeter, ND

Jaime Toney, Geological Sciences, Brown University, RI

Paleolimnologists have been interested in studying Northern Great Plains lakes for decades in order to understand climate change. One of the greatest challenges has been to separate out the effects of temperature versus those of precipitation in order to identify drought periods. Lakes are the best archive of past change for this region, but confounding issues with groundwater overprinting and lake level changes make it difficult to overcome local influences and generate a regional scale climate picture.

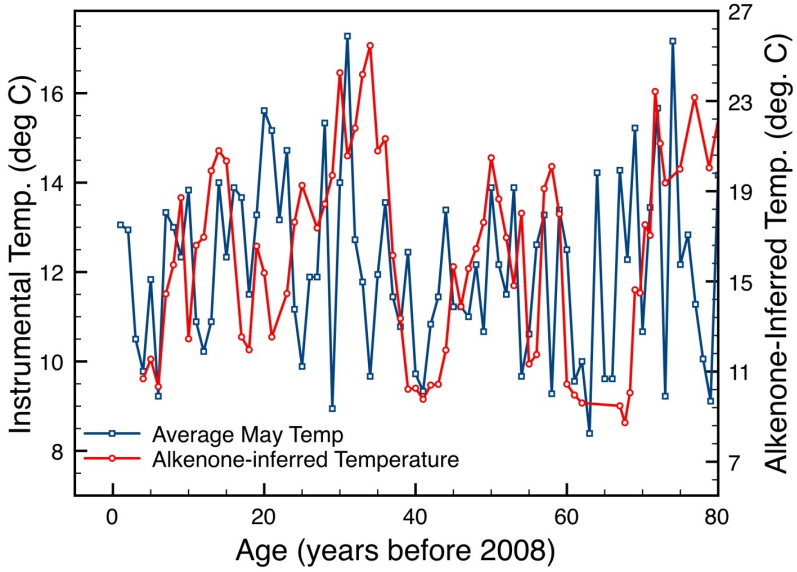
The ongoing research at Lake George, Streeter, ND is allowing us to test new ways to separate temperature and precipitation signals recorded in the sediments. Our research objectives are to use compounds produced by algae (alkenones) to determine if surface temperature change is correlated to drought prior to the instrumental period and to use the hydrogen isotope values of plant leaf waxes to reconstruct precipitation change throughout the Holocene (past 8,200 years). Ultimately, a high-resolution record of temperature and rainfall from Lake George will allow us to relate the causes of drought to global-scale climate patterns and potentially improve models designed to predict drought for the region.

We have now surveyed 74 lakes in the prairies of Nebraska, South Dakota, North Dakota and Canada and have found 23 lakes that contain alkenones. Lake George is our target site, because it is deep, seasonally stratified, has laminated sediments, high concentrations of alkenones, and is located adjacent to the NDSU Central Grasslands Agricultural Research Center. Paul Nyren and Rick Bohn from the Research Center have collected and filtered multiple water column samples over the course of the past two summers. From the organic compounds in these samples, we have derived a calibration between the alkenone compounds and lake water temperature. There is a strong linear correlation (r^2 = 0.75), which allows us to infer average May temperature. (Toney et al. 2009 GCA doi:10. 1016/j.gca.2009. 11.021).



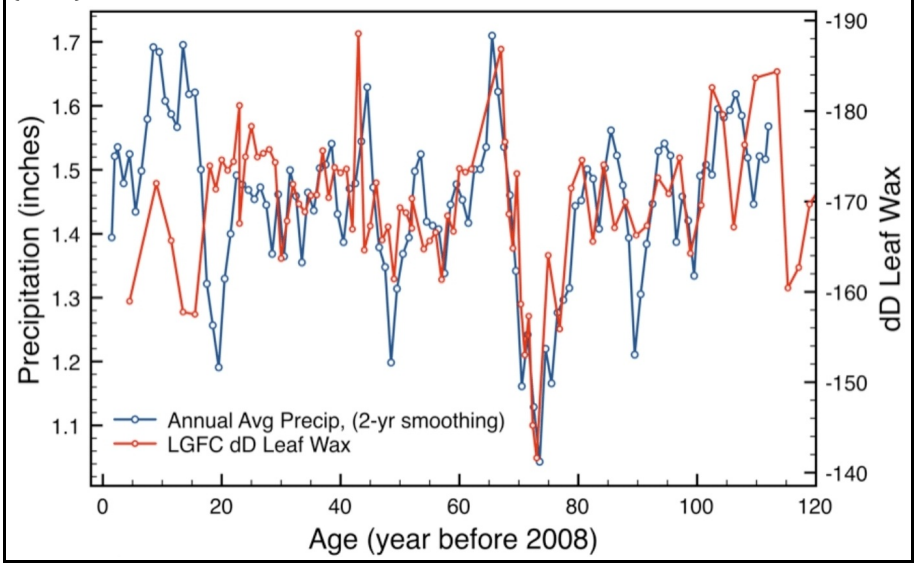
In February of 2009, Jaime Toney (Brown University, RI), Sheri Fritz (University of Nebraska, Lincoln), Paul Baker (Duke University), and Eric Grimm (Illinois State Museum) with the help of Rick Bohn retrieved a 13-meter long core from Lake George that dates back to 8,200 years ago. We also retrieved an 80-cm freeze core, which allows for annual sampling over the past 120 years. We are able to reconstruct average May temperature using alkenones and reproduce major temperate trends over the past 80 years.

Temperature Reconstruction (red) versus Instrumental Temperature Record (blue)



We also show that the hydrogen isotope value of terrestrial leaf waxes track changes in rainfall amount over the past 113 years as compared with the instrumental record from the Jamestown Weather Station, ND .

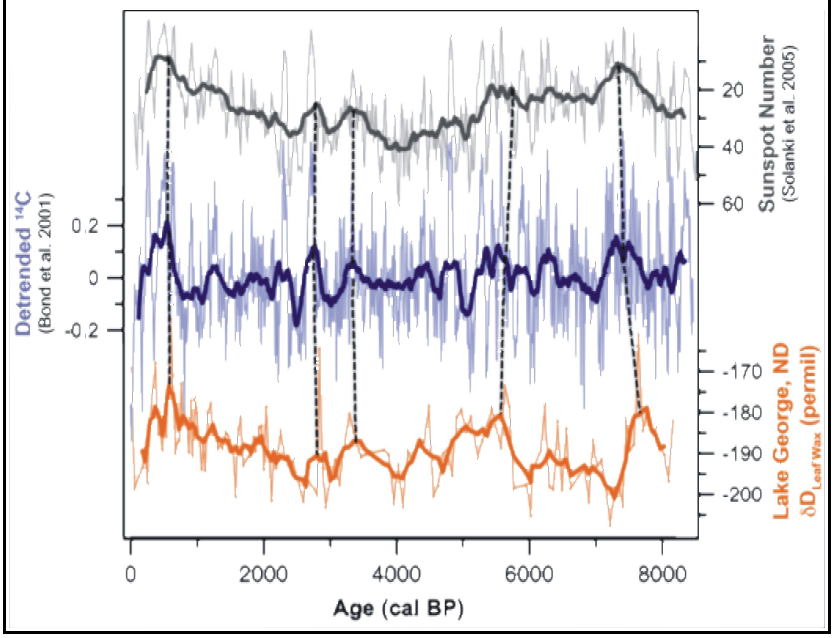
Rainfall Reconstruction (red) versus the Instrumental Rainfall Record (blue)



From the Holocene reconstruction we see a 4.9°C temperature increase since 8,200 years ago that has a similar trend to the global carbon dioxide rise over this time period (not shown). We also see enhanced spring warming begin at 2,000 years ago, when spring solar insolation began to increase from its Holocene minimum.

What is most exciting at this point is the rainfall reconstruction for the last 8,200 years shows a persistent drought from 8,000-7,500 years ago at the onset of the prairie period. Whereas, other records that infer drought from lake salinity show a sustained drought from ~7,500 to 3,000 years ago, we show relatively dry conditions, but much greater variability in precipitation amount. This indicates that we have developed a very sensitive recorder of precipitation. The large-scale trends match well with variations in the sunspot number and records of radiocarbon production, which is controlled by solar output. We show that centennial-scale precipitation is strongly related to solar output for the past 8,200 years.

Link Between Drought at Lake George (orange) and Solar Forcing (gray, blue)



In mid February 2009 a team of scientists from across the country met at Salt Lake (Lake George) located in Kidder County 10 miles NW of Streeter, ND, to take cores of the bottom sediment. The team included Ms. Jaime Toney, graduate student, Brown University, RI; Dr. Sheri Fritz, University of Nebraska; Dr. Paul Baker, Duke University, NC; and Dr. Eric Grimm, Illinois State Museum. Also present were Dr. Allan Ashworth, NDSU and several geology students.

Jaime Toney taking samples at Salt Lake in June 2009.