Limnological Studies - Peter Doran and Cristina Takacs-Vesbach

Lakes are the only perennial liquid water environments in the MDV; they maintain biological activity year-round with food webs dominated by phytoplankton and bacteria (Priscu et al.1999; Vick et al. 2013; Kong et al. 2012). Perennial ice-cover limits turbulent mixing and most lakes are strongly stratified by temperature and salinity (Spigel and Priscu 1998). The major influences on the chemical composition of lakes are their landscape positions and climate history (Lyons et al. 2000; Dore and Priscu 2001).

Autonomous monitoring equipment and lake hydrology surveys

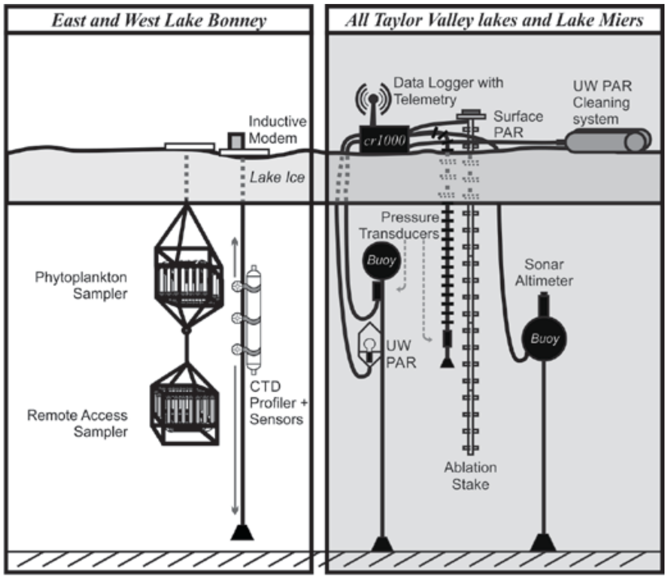

Fig. 1. Schematic showing autonomous sampling (left) and monitoring (right) equipment deployed in MCM LTER lakes

We maintain year-round equipment: stage, ablation (mass loss from lake ice by melt or sublimation), ice thickness, surface PAR and under-ice PAR data continuously (Fig. 1). In addition we conduct surveys during the summer field season to manually measure lake levels and surface ablation against established benchmarks. This past year, PhD student Hilary Dugan published the long term lake ablation record, which established the summer ablation rates of 0.2–0.7 mm w.e.d^{-1} and winter rates of 5–31 mm w.e.d^{-1}. The up-to-date lake level record is shown in Fig. 2.

Through an equipment grant from NASA, an EAGER award from NSF, and logistics co-ordination with the MCM, we installed new Autonomous Lake Profiling and Sampling (ALPS) stations in both lobes of Lake Bonney this season. The ALPS stations will profile the lakes year-round at regular intervals (currently every other day) measuring temperature, conductivity, photosynthetically available radiation, chlorophyll-a fluorescence, phytoplankton pigment diversity, turbidity, dissolved oxygen, methane, and carbon dioxide. The stations also have automated water filtration samplers to collect and preserve samples from regions of peak biomass for geomicrobiological analysis over the year (at a minimum, collections will be made every other week, which is less than the doubling time of the organisms). Filtered lake water will be analyzed for dissolved organic carbon, dissolved inorganic N and P species, and ion chemistry. The particulate matter on the glass filters will be analyzed for particulate organic C, and N. Metabolic and phylogenetic diversity will be assayed using metagenomic and metatranscriptomic methods on filter concentrated and preserved samples.

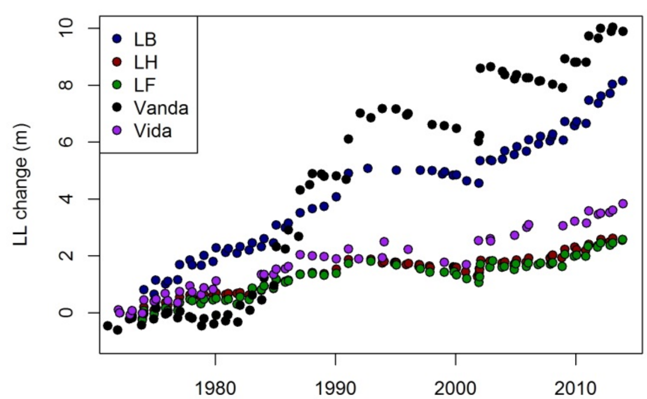

Fig. 2. Lake level changes documented by the MCM LTER.

Limno Runs

At least twice a summer lakes are visited for an exhaustive assessment of water column physical, chemical and biological rates (a regularly updated manual detailing our sampling and analyses protocols is available here: http://www.montana.edu/priscu/DOCS/LTER%20methods%20web%20page/Method_Manual_AC_23_Feb_2011.pdf). Given the addition of Lake Miers to our monitoring program during MCM4, we carefully evaluated our lake monitoring activities and reduced the frequency of limno runs in the Taylor Valley lakes and have reduced sampling efforts at Lake Hoare. We continue to conduct limno runs at Lake Bonney and Lake Fryxell.

Given our more than 20 years of accumulated limnological data and evidence of changing lake levels, we are integrating the long-term physical, chemical, and biological data from the lakes to understand the role that increased connectivity has on ecosystem function. These closed-basin lakes are reservoirs of history, integrating many centuries of autochthonous and allochthonous inputs. We have recently shown that there is a coincident change in lake heat contents and volumes (Fig. 3). There was a general loss of volume during the cooling trend before 2001, and since then, a general increase in volume and heat content of all lakes. Mean lake temperature trends through time suggest that the lakes are potentially receiving more water directly from glaciers (relative to streams) as mean water temperatures cool, but heat and water mass increase.

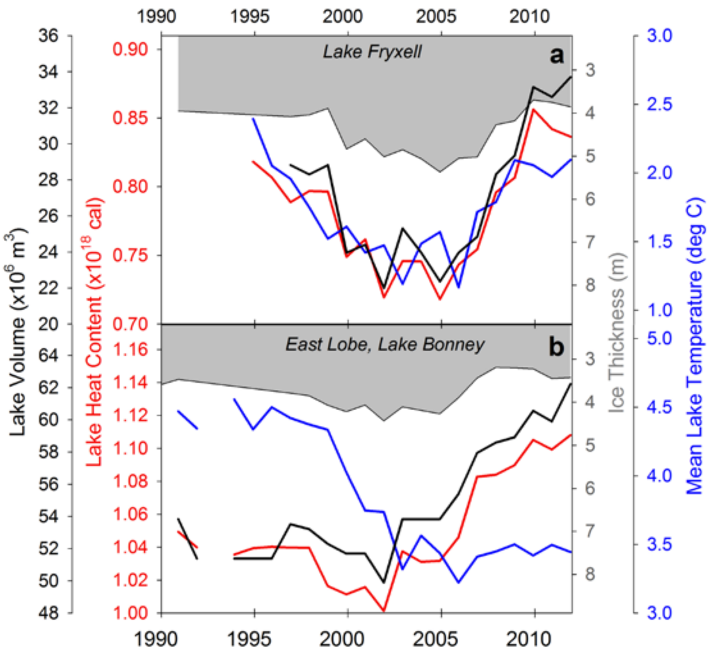

Fig. 3. Decadal changes in lake volume, heat content, ice thickness (gray fill), and volume-weighted mean temperature for (a) lake Frxyell and (b) East Lobe of Lake Bonney.

Lake Integrative Connectivity Experiment (Lake ICE)

Lakes represent the most biologically productive landscape unit in the MDV and respond to processes occurring valley wide. We conducted the lake experiment described in the proposal to address our overarching hypothesis that climate warming in the MDV will amplify connectivity among landscape units leading to enhanced coupling of nutrient cycles, increased productivity, and biodiversity (Takacs-Vesbach et al. in prep). The Lake Integrative Connectivity Experiment (LakeICE) was designed specifically to quantify the effect of increased MDV connectivity on lake autotrophic and heterotrophic productivity and community composition (hypotheses 1-3). We expect lakes to experience increased input from streams, cryoconites, aeolian sediments, and fluvially deposited algal/cyanobacterial mats, and an overall increase in nutrient input. Surface water (1 m below the bottom of the ice cover) from East Lobe Lake Bonney was amended experimentally with material from the surrounding basin (aeolian sediment collected from the surface of Lake Bonney, wetted sediments from the surrounding soils, *Nostoc* mats from ponds in the basin, cryoconite material collected from the Canada Glacier, and stream water) to simulate increased material transport resulting from potentially increased melt within the MDV ecosystem. These materials were encased in 12,000 Dalton dialysis tubing and incubated in 10 L microcosms of lakewater for 2 days to approximate a pulsed event. The dialysis tubing ensured that only macromolecules or exudates from the materials would be leached into the lake water microcosms. Biological productivity, biological diversity and selected chemical parameters were then monitored in microcosms incubated over 6 days under simulated temperature and light. Primary productivity increased in the microcosms in response to the cryoconite and aeolian treatments only, whereas bacterial productivity responded to all treatments, and was accompanied by enhanced uptake of inorganic N and P. At the same time, bacterial 16S rRNA gene richness initially increased in all treatments relative to the controls, but then decreased in nearly every treatment by the end of the experiment. Changes in community composition were largely attributed to variations in the relative abundance of members of the Bacteroidetes, Proteobacteria, and Cyanobacteria. Data from the LakeICE experiment show that lake productivity, diversity, and community composition can respond rapidly to increased nutrients input resulting from climate induced connectivity in the MDV.