1A

Climate Change: Gasses, Clouds, Measurements

Session Moderator: Dennis Hartmann, Atmospheric Sciences
MGH 074
12:30 PM to 2:15 PM

* Note: Titles in order of presentation.

Greenhouse Gas Dynamics of Headwater Streams in Interior Alaska

Leana Lynn Axtell, Senior, Environmental Science & Resource Management
Mentor: David Butman, School of Environmental and Forest Sciences
Mentor: Matthew Bogard, SEFS

In the last 30 years temperature has risen 0.6C per decade in high latitude regions, twice as fast as the global average. This extreme warming is causing perennially frozen ground (permafrost) to thaw, thereby changing subsurface hydrology and exposing previously stored, deep millenial-aged soils to microbial activity. These changes are stimulating greater organic matter mineralization and emissions of potent greenhouse gases (GHG), carbon dioxide and methane (CO_2 and CH_4). The magnitude of soil carbon mobilization is poorly contained, in part because it is unclear what fraction of GHGs are emitted to the atmosphere directly, versus released to above ground aquatic networks. To better define the role of streams in the changing arctic carbon cycle, we explored headwater stream carbon chemistry in 10 individual catchments situated in a remote and understudied subarctic landscape of interior Alaska. We found an unexpected, positive relationship between CO_2 and CH_4 across streams, with concentrations peaking in the summer for CO_2, and fall for CH_4, suggesting stream emissions peaked when soil active layers were deepest and permafrost carbon layers were most hydrologically engaged. The positive relationship between surface water temperatures and the concentration of each gas reflected these strong seasonal shifts in stream GHG content. Organic carbon content in stream water was also linked to CO_2 but not CH_4, indicating potential differences in sources and sinks of each GHG that are currently being explored with ongoing stable isotope analyses. Taken together, our findings show that closer-than-expected coupling of CO_2 and CH_4 may make some streams much greater emissions hot-spots than others, and that accounting for seasonality is critical for understanding the greenhouse gas budget of individual streams.

Greenhouse Gas Dynamics Under Ice in Arctic and Boreal Lakes

Madeline O'dwyer, Senior, Environmental Science & Resource Management (Landscape Ecology & Conservation)
UW Honors Program
Mentor: David Butman, School of Environmental and Forest Sciences

The northern circumpolar landscape holds nearly twice as much carbon as the atmosphere, mostly as organic matter in perennially frozen (permafrost) circumpolar soils. Climatic warming may cause increased greenhouse gas emissions from arctic landscapes linked to thawing and mobilization of stored permafrost carbon. The role of circumpolar lakes in such climate-carbon feedbacks may be important, since lakes cover a disproportionately large fraction of the northern landscape, and emit carbon dioxide (CO2) and methane (CH4) to the atmosphere due to inputs of land-derived organic material. Yet northern lake carbon emissions are poorly characterized due to factors including limited sampling access and restricted sampling during prolonged inclement weather (winter and shoulder seasons). Here, we set out to define the environmental features most related to greenhouse gas build up in thirteen interior Alaskan lakes during winter ice cover, thereby providing information to better model lake emissions and identify hotspots across the regional landscape. We found that lakes with elevated CO2 tended to have elevated CH4 (with one exception), and that these patterns were predicted throughout the study region by variables that characterized the surrounding landscape, lake morphometry, and chemical properties of the lake. Shallow lakes at low elevation had the greatest concentrations of both gases, and also had the greatest quantities of organic matter readily available to fuel greenhouse gas production. Methane was mostly restricted to hypoxic conditions; whereas CO2 was found in both oxic and hypoxic conditions inversely pro-

portional to oxygen. Given the limited information available for northern lakes during winter, this survey provides key information to advance our understanding of the patterns and factors related to winter greenhouse gas buildup in lakes, currently a major unknown in arctic carbon research.

Understanding the Underlying Structural Differences and Mechanisms between Eastern and Western Tropical Anvil Clouds

Joshua Edson Driscol, Senior, Atmospheric Sciences: Climate, Atmospheric Sciences: Meteorology
Mary Gates Scholar
Mentor: Dennis Hartmann, Atmospheric Sciences

Recent studies like the Coupled Model Intercomparison Project Phase 5, or CMIP5, have sought to quantify how atmospheric variables will change due to climate change. Even from decades of rigorous study, it is still uncertain how cloud feedbacks will respond to a warming climate. However, it is possible to try and minimize this uncertainty in part by examining deep convection, and specifically anvil clouds, in the Tropical Pacific. Anvil clouds are not simulated well by the current generation of climate models, but by studying both large scale motions and small scale, local cloud structural evolution, Professor Hartmann and I seek in this study to determine the underlying mechanisms of the differences in vertical cloud structure in the Eastern and Western Pacific. I use the ERA-Interim, CloudSat, Calipso, and CMIP5 datasets in addition to climate model output from the Community Earth System Model (CESM) to analyze differences in cloud structure and model output. This is important work, because reducing uncertainty in an era of global warming can mean better advanced warning systems and more informed, ethical policy decisions moving forward.

Investigating Global Warming Impact on Phytolith Size

Kailyn M. (Kailyn) Zard, Senior, Biology (Molecular, Cellular & Developmental)
Mary Gates Scholar
Mentor: Camilla Crifo, Biology
Mentor: Caroline Stromberg, Biology

Plants take up silica over the course of their lives along with other essential nutrients in the water that they absorb through their roots. The silica becomes deposited within their tissues in the form of solid bodies (phytoliths); when the plant dies and decays, phytoliths are left in the soil where they can fossilize. Fossil phytoliths preserve the original morphology of plant cells and can be used to reconstruct past vegetation. The Middle Miocene Climatic Optimum (MMCO) was a major global warming event that happened ˜17-14.5 million years ago. Researcher have reconstructed the climate of the Santa Cruz Formation in Patagonia, Argentina during this period as warmer and drier. While we would expect the vegetation to become more open (i.e., grassy or shrubby versus forested), phytoliths from the Santa Cruz Formation tell a different story; in particular grass phytoliths (and therefore grass abundance) seem to decrease through time, but also become smaller. Some researchers have noticed that grasses tend to respond to reduced water availability with reduced cell size. Therefore, we hypothesize that the reduced size of grass phytoliths observed in the Santa Cruz Formation during the MMCO is due to increasing aridity. However, because this trend of decreasing cell size was only noticed by qualitative observation, we need to quantitatively assess significant changes in cell size. To do so, I studied and imaged grass phytoliths under a microscope, categorized them by subfamily/tribe based on their shape, and measured their size. I then statistically compared the phytoliths from younger and older strata to test whether there was a change in size through time. This work will be used to predict how our current global warming event may impact plant life based on the trends of the past.