Next-Generation Ecosystem Experiments

NGEE Arctic

Participation in the December 10-14, 2018

American Geophysical Union (AGU) Meeting in Washington, DC




Organized Oral and Poster Sessions

Poster and Presentation Abstracts

Funded by the United States Department of Energy, Office of Science, Biological and Environmental Research

This project is a joint Project led by the Oak Ridge National Laboratory in partnership with Lawrence Berkeley National Laboratory, Los Alamos National Laboratory, Brookhaven National Laboratory, and the University of Alaska Fairbanks.

Sessions Organized by Participants in the NGEE Arctic Project for the 2018 American Geophysical Union (AGU) Meetings

Characterizing Spatial and Temporal Variability of Hydrological and Biogeochemical Processes across Scales

Bhavna Arora and Haruko Wainwright

Lawrence Berkeley National Laboratory, Berkeley, CA

Biogeochemical processes are often spatially discrete (hotspots) and temporally restricted (hot moments) due to variability in controlling factors like hydrologic fluxes, lithologic characteristics, microbial composition, vegetation, etc. Although this scale-dependence of biogeochemical processes accounts for a high percentage of nutrient cycling, the ability to identify and incorporate them into reactive transport models remains a significant challenge. This session invites contributions that identify spatial and temporal patterns in biogeochemical variables, implement such variability in reactive transport models, and/or document the extent that hot spots/moments influence larger-scale system functioning. This session will focus on exchanging ideas on (1) new techniques for identifying biogeochemical hotspots and hot moments across scales, (2) understanding the governing controls such as, soil-landscape features, flux-inputs, vegetation characteristics that leads to this emergent behavior, (3) incorporating this spatio-temporal variability in models and/or designing scale-aware parameterizations, and (4) quantifying the significance of incorporating this emergent behavior in reactive transport models.

Monday, 10 December 2018
16:00 - 18:00
Convention Center 146B

Tuesday, 11 December 2018
08:00 - 12:20
Convention Center - Hall A-C (Poster Hall)

Advances in the Remote Sensing of the Terrestrial Carbon Cycle

Holly Croft, Alemu Gonsamo, Tristan L. Quaife, and Shawn Serbin

University of Toronto, Toronto, Ontario
University of Reading, Reading, Berkshire, England
Brookhaven National Laboratory, Upton, NY

Despite technical progress in the monitoring and modelling of the terrestrial carbon cycle, the spatially-explicit quantification of terrestrial carbon budgets remains uncertain. In part, this is because temporal and spatial variations in plant phenology, physiology and canopy structure are not well represented in most terrestrial ecosystem models. Recent advances in remote sensing techniques (e.g. solar-induced chlorophyll fluorescence, plant trait mapping), sensor capabilities (including the forthcoming BIOMASS and FLEX missions) and an increasing archive of legacy observations (e.g. AVHRR, Landsat) offer an unprecedented opportunity to forward understanding of terrestrial carbon cycle processes, from second to decadal scales. Such advances can provide a valuable insight towards assessing the spatial patterns, temporal variability and environmental controls on the terrestrial carbon cycle and source-sink activities.

Tuesday, 11 December 2018
13:40 - 15:40
Convention Center - 147B

Big Data in the Geosciences: New Approaches to Storage, Sharing, and Analysis

Cedric H. David, Forrest M. Hoffman, Hamed Alemohammad, Soo Kyung Kim, Michelle M. Gierach, and Jitendra Kumar

Jet Propulsion Laboratory, Pasadena, CA
Oak Ridge National Laboratory, Oak Ridge, TN
Radiant Earth Foundation, Washington, DC
Lawrence Livermore National Laboratory, Livermore, CA

Existing and future Earth system data are 1) increasingly large and complex – often representing high spatial/temporal/spectral resolution and dimensionality from remote sensing or model results — and are 2) growing at an unprecedented rate (e.g., NASA SWOT and NISAR missions), making such data difficult to store, download, analyze, visualize, interpret, and understand by traditional methods. Therefore, this session explores new approaches to processing, storage, exchange, and analysis of large geoscience data. Perspectives on cloud-based approaches (e.g., ready science data systems, cloud-optimized storage, cloud analytics engine, and use of cloud resources for scientific discovery), geoscientific data analytics approaches (statistical, data mining, assimilation, deep learning, etc.), parallel algorithms and software employing high performance computing resources for scalable analysis and novel applications of traditional methods on large geoscience data are strongly desired.

Wednesday, 12 December 2018
13:40-15:40
Convention Center 209A-C

Thursday, 13 December 2018
08:00-12:20
Convention Center Hall A-C (Poster Hall)

Integrated Understanding of Climate, Carbon, Nutrient Cycles, Human Activities, and Their Interactions in Terrestrial Ecosystems

Forrest M. Hoffman, Xiaojuan Yang, Danica L. Lombardozzi, Matthew P. Dannenberg, William Kolby Smith, Atul K. Jain, and Ana Bastos

Oak Ridge National Laboratory, Oak Ridge, TN
National Center for Atmospheric Research, Boulder, CO
University of Iowa, Iowa City, IA
University of Arizona, Tucson, AZ
University of Wisconsin, Madison, WI
University of Illinois at Urbana-Champaign, IL
Ludwig-Maximilians University of Munich, München, Germany

Assessments of coupled climate–carbon cycle simulations indicate that terrestrial carbon cycle feedbacks are highly uncertain and could significantly alter the rate of atmospheric CO_2 increase and, therefore, climate change over the next one hundred years. The terrestrial carbon cycle is directly affected by increasing atmospheric CO_2 levels and by climate change, and, further, is altered indirectly by feedbacks from potentially limiting nutrients (e.g., nitrogen and phosphorus). Changes in CO_2 concentration and climate can affect the availability of these nutrients, and anthropogenic disturbances—such as tropospheric ozone, nitrogen deposition, and land cover and land use changes—also influence the carbon cycle, nutrient cycles, climate change, and the strength of their interactions. This session will focus on an integrated understanding of carbon, nutrient cycles, climate change, human activities, and their interactions and feedbacks to climate in terrestrial ecosystems.

Wednesday, 12 December 2018
16:00-18:00
Convention Center 149AB

Thursday, 13 December 2018
08:00-12:20
Convention Center Hall A-C (Poster Hall)

Computational Methods and Tools for Model–Data Integration

Forrest M. Hoffman, Xingyuan Chen, Tianfang Xu, and Hyungjun Kim

Oak Ridge National Laboratory, Oak Ridge, TN
Pacific Northwest National Laboratory, Richland, WA
Utah State University, Salt Lake City, UT
University of Tokyo, Tokyo, Japan

The widening accessibility of computational resources and expanding volumes of Earth science data are fueling the rise in data-driven research and discovery in Earth system science. A growing number of open source tools are being developed and used for model–data fusion, data assimilation, visualization and visual analytics, model benchmarking, and multi-model ensemble prediction experiments. Such Earth science models and supporting languages, tools, and analytics software are being deployed on large workstations, clusters, dynamically provisioned cloud services, and supercomputers. This session highlights innovative computational methods, open source software tools and related cyberinfrastructure for model-data integration and their application to address research challenges in hydrology and biogeosciences. Examples might include methodology development for model-data integration (e.g., data assimilation, uncertainty quantification, and model-informed experimental design), application of machine learning methods, assimilation of remote sensing data, language features, data management standards, user interface and visualization capabilities, and novel use cases for Open Science applications.

Friday, 14 December 2018
08:00-12:20
Convention Center Hall A-C (Poster Hall)

Friday, 14 December 2018
16:00-18:00
Convention Center 154AB

Understanding Phenological Responses and Feedbacks in Terrestrial Vegetation: Patterns, Mechanisms, and Consequences

Jitendra Kumar, Xiantao Xu, Min Chen, and Jake F. Weltzin

Oak Ridge National Laboratory, Oak Ridge, TN
Harvard University, Cambridge, MA
Carnegie Institution for Science Stanford, Stanford, CA
US National Phenology Network, Tucson, AZ

Phenology is an integrated and sensitive indicator of ecosystem health and function that responds to growing conditions, disturbance, and climate change. Understanding phenological responses to environmental change across spatial and temporal scales is critical for forecasting shifts in species activity and associated changes in biogeochemical cycling, landscape dynamics, and ecological processes. This session features recent advances in characterizing the spatio-temporal patterns in vegetation phenology using a variety of methods (e.g., satellite, drones, webcams, in-situ); determining underlying mechanistic processes; developing accurate model representations of vegetation phenology; and investigating phenological implications to key land surface processes and society. The session will also feature contributions from the USA National Phenology Network (USA-NPN), which for a decade has provided data, tools and platforms designed to advance science, support decision making, and engage a diversity of audiences -- including scientists, educators, resource managers, policy-makers, and the public -- in this exciting and emerging field.

Friday, 14 December 2018
08:00-12:20
Convention Center Hall A-C (Poster Hall)

Friday, 14 December 2018
13:40-15:40
Convention Center 147B

Friday, 14 December 2018
16:00-18:00
Convention Center 147B

Advancing Understanding of Cold Climate Hydrologic and Geomorphic Systems in a Warming Climate

Jill A. Marshall, Moritz Langer, Bob Bolton, and Cathy J. Wilson

University of Arkansas, Fayetteville, AR
Humboldt University of Berlin, Berlin, Germany
University of Alaska, Fairbanks, AK
Los Alamos National Laboratory, Los Alamos, NM

In cold settings, such as polar and alpine environments, the complex and nonlinear multi-phase behavior of water exerts a primary control on hydrology, geomorphology, vegetation, biogeochemistry, and associated ecosystem fluxes. As a result, liquid and frozen water availability is a key driver of periglacial Critical Zone architecture and processes such as surface and subsurface hydrological response, physical rock weathering, and sediment transport. As global mean air temperatures continue to increase, permafrost is expected to degrade, altering the availability of liquid and frozen water and hence hydrologic and geomorphic processes throughout cold regions. Despite the importance and rapidly changing nature of ground ice, surprisingly little is known about its occurrence such that processes related to ground ice melt are usually disregarded in modeling exercises. Novel remote sensing techniques, field-based investigations and experiments, and new model approaches aim to fill these gaps and inform critical zone processes in the cryosphere.

Friday, 14 December 2018
08:00 - 12:20
Convention Center - Hall A-C (Poster Hall)

Friday, 14 December 2018
13:40 - 15:40
Convention Center - Salon H

Friday, 14 December 2018
16:00 - 18:00
Convention Center - Salon H

Coupled Human–Natural Systems and Global Environmental Change: Innovative Interdisciplinary Approaches

Erwan Monier, Jessica Gephart, Jory S. Hecht, Deeksha Rastogi, Mallory Ladd, and Charles Rouge

Massachusetts Institute of Technology, Cambridge, MA
University of Virginia, Charlottesville, VA
University of Vermont, Burlington, VT
Oak Ridge National Laboratory, Oak Ridge, TN
University of Sheffield, Sheffield, South Yorkshire, England

Understanding the complex interactions among human and natural systems is essential for informing sustainable responses to global environmental changes. This session focuses on innovative approaches for developing predictive understanding of coupled human-Earth system dynamics across spatial and temporal scales. This could include, for example, interactions across the energy-water-land nexus, the influence of extreme events on critical infrastructure systems, connections between climate and human activities, or feedbacks associated with population dynamics and human health. Approaches for simulating these and related interactions range from global models that account for many processes at coarse resolution, to coupled modeling frameworks that focus on a particular subset of systems with high process fidelity. New methods for exchanging information across sectors and scales, as well as data and approaches for calibrating and validating these modeling approaches, are a key research need.

Tuesday, 11 December 2018
10:20 - 12:20
Convention Center - Salon A

Signatures of Climate Change in Surface Processes

Anastasia Piliouras, Carli A. Arendt, Diana Karwan, and Colin B. Phillips

Los Alamos National Laboratory, Los Alamos, NM
North Carolina State University, Raleigh, NC
University of Minnesota Twin Cities, Minneapolis and Saint Paul, MN
Northwestern University, Evanston, IL

Climate change affects the physical, biological, and geochemical processes that shape landscapes. These effects are manifest in myriad multiscale problems in a range of environments, and include altering the magnitude, frequency, and/or intensity of innumerable natural processes. Signatures of climate change are observed at all scales, where modifications of natural processes, such as changes in flood magnitudes, sea level rise, the timing of snowmelt, wildfire, drought, or permafrost thaw can have profound impacts. This session welcomes submissions investigating manifestations of climate change in physical, biological, and geochemical surface processes. We encourage studies using experimental, modeling, field, and/or remote sensing techniques, including interpretations of past climate change in the stratigraphic record. We aim to create a diverse, interdisciplinary session representing the broad range of research into the impacts of climate change on the Earth's surface.

Friday, 14 December 2018
10:20 - 12:20
Convention Center - 147A

Seeing Is Believing: Advances in Understanding of Root–Rhizosphere Dynamics

Jeff Warren, Keita F. DeCarlo, and Colleen Iversen

Oak Ridge National Laboratory, Oak Ridge, TN
Princeton University, Princeton, NJ

In recent years, compilation of a global fine-root ecology trait database (*FRED*) highlighted gaps in our understanding of belowground plant traits that limits our ability to project plant responses to changing environmental conditions (*Iversen et al. 2017 doi:10.1111/nph.14486*). 'Root *functional* traits' are key to understanding root dynamics, but only 3% of root trait observations are related to function. Even less is known about root-rhizosphere dynamics, which operate in a unique environment with myriad microbes, altered soil structure, moisture, hydraulic conductivity and nutrient availability. Advances in our understanding of root-rhizosphere dynamics will improve management systems and help refine model predictions of future ecosystem function. We invite presentations on new ways to conceptualize and observe root traits, root physiology and the interaction of roots with the surrounding rhizosphere. Field, laboratory, advanced imaging, meta-analysis, modeling and cross-disciplinary studies across scales are highly encouraged.

Tuesday, 11 December 2018
13:40 - 18:00
Convention Center Hall A-C (Poster Hall)

Unmanned Aircraft Systems (UAS) in Geosciences: Research and Development

Peter W. Webley, Sebastien Biraud, David C. Piere, and Misha Krassovski

University of Alaska, Fairbanks, AK
Lawrence Berkeley National Laboratory, Berkeley, CA
NASA Jet Propulsion Laboratory, Pasadena, CA
Oak Ridge National Laboratory, Oak Ridge, TN

Originating mostly from military applications, unmanned aircraft systems (UAS) use in geoscience research is continuing to expand, given their flexibility and usability. Even now advanced sensors are being miniaturized and developed specifically for use on a UAS. High precision observations can be used to track volcanic gases, map forest fires, measure river-ice breakup, monitor critical infrastructure, and measure vegetation health. The aim of this session is to bring together geosciences to present on the newest UAS, payloads, and research. We invite contributions including those in formal and applied science, system and sensor development and UAS integration into manned airspace as well as in developing new missions and ongoing campaigns to collect geoscience data. The session will bring together leading experts in all aspects of UAS planning, regulations, operations, data collection, processing, and analysis to initiate discussions and share experiences for fostering cross-disciplinary research and knowledge-transfer across the sciences.

Tuesday, 11 December 2018
13:40 - 18:00
Convention Center - Hall A-C (Poster Hall)

Abstracts Submitted by Participants in the NGEE Arctic Project for the 2018 American Geophysical Union (AGU) Meetings

Geomorphic Feedbacks Enhance the Stability of High-Centered Polygons

Charles Abolt, Michael Young, Adam L. Atchley, Dylan R. Harp, and Ethan T. Coon

University of Texas at Austin, Austin, TX
Los Alamos National Laboratory, Los Alamos, NM
Oak Ridge National Laboratory, Oak Ridge, TN

Pan-Arctic ice wedge degradation has accelerated abruptly in the past 30 years, driving widespread formation of high-centered polygons (HCPs) across tundra landscapes. This rapid geomorphic transformation alters near-surface hydrologic processes and influences the mobilization of soil organic carbon. However, the pathways by which ice wedges degrade are incompletely understood, causing high levels of uncertainty in projections of future landscape function. Here we use the Advanced Terrestrial Simulator, a physics-based modeling framework for surface and subsurface hydrologic and thermal processes in porous media, to explore the influence of geomorphic feedbacks during ice wedge degradation and re-stabilization. Our model simulates the thermal regime of the active layer in radially-symmetric polygons, using soil physical parameters inferred from field samples and validated using historic meteorological data and observed ground temperature. By varying microtopography and trough inundation among simulations, we isolate the influence of these variables on active layer development in conditions representing various stages of thermokarst. Our results indicate that ice wedge degradation is influenced by a mix of positive and negative feedbacks associated with trough subsidence and inundation, but that negative feedbacks predominate at almost all stages. Impoundment of water in deepening troughs modestly enhances thawing processes, but this effect is counteracted by the concurrent destruction of rims, which diminishes a conductive heat flux toward the ice wedge in summer. In most cases, rates of soil accumulation in the trough during thermokarst are sufficient not only to re-stabilize the ice wedge, but to increase the thickness of a protective layer of frozen soil atop it several-fold compared to pre-thermokarst conditions. Overall, these results imply that currently observed development of surface water bodies in degrading ice wedge troughs is intrinsically limited. Because partially-degraded ice wedges become more stable than those unaffected by thermokarst, we forecast that HCPs are durable landscape features, which will exert a long-term influence on soil moisture, runoff generation, and rates of carbon export as CO_2, CH_4, and dissolved organic carbon in a warmer future.

Friday, 14 December 2018
17:15 - 17:30
Convention Center, Salon H

Estimation of Polygonal Tundra Soil Properties by Coupled Inversion of ERT and Hydrothermal Data

Adam L. Atchley, Elchin E. Jafarov, Dylan R. Harp, Ethan T. Coon, Baptiste Dafflon, Anh Phuong Tran, Susan Hubbard, and Cathy J. Wilson

Los Alamos National Laboratory, Los Alamos, NM
Oak Ridge National Laboratory, Oak Ridge, TN
Lawrence Berkeley National Laboratory, Berkeley, CA

Observations of the spatial and temporal evolution of thaw and soil moisture changes are needed to understand thermo-hydrologic dynamics in periglacial regions and to inform models that forecast changes in permafrost hydrology under future climatic conditions. However, obtaining spatially and temporally distributed observations of thaw depth and moisture content is difficult. An indirect approach to achieve this information is Electrical Resistivity Tomography (ERT). ERT is sensitive to many parameters such as grain size, porosity, water phase, and chemical concentrations and therefore requires site data and expert interpretation to extract the ERT response of interest. Complimentary site data can constrain ERT sensitivity that then allows for higher ERT interpretation confidence. Here, we investigate the use of sparsely collected borehole measurements of temperature and moisture content to augment ERT surveys. To accomplish this, we combine the Arctic Terrestrial Simulator (ATS) with the Boundless ERT (BERT) simulator to model ERT response to parameter combinations. Petrophysical relationships are used to convert the ATS simulated temperatures and saturations into spatially distributed electrical resistivities. The BERT simulator then uses the petrophysically-derived, distributed electrical resistivities to simulate the ERT survey response (i.e., the ERT survey that would be collected given the petrophysically-derived, distributed resistivities), which can be compared for consistency with the measured ERT survey. We implement a gradient based parameter estimation approach to infer permafrost soil properties based on the consistency of simulated temperature, moisture contents, and resistivities to observations. We tested our inverse approach with data from a continuously recording ERT transect and co-located temperature and soil moisture measurements at a polygonal tundra site near Utqiaġvik, Alaska. The results indicate that the inverse approach applied to data from this type of environment can identify porosities and thermal conductivities. The use of this approach with co-located ERT surveys and point measurements has the potential to significantly increase the spatial coverage of hydrothermal property estimates in permafrost environments.

Friday, 14 December 2018
08:00 - 12:20
Convention Center, Hall A-C (Poster Hall)

Simulation of Landscape Changes on the Alaskan Arctic Coastal Plain with the Alaska Thermokarst Model

Bob Bolton, Genet Helene, Mark J. Lara, Vladimir E. Romanovsky, and William J. Riley

University of Alaska, Fairbanks, AK
University of Illinois, Champaign-Urbana, IL
Lawrence Berkeley National Laboratory, Berkeley, CA

Landscape change in permafrost regions, caused by thermokarst, can result in profound impacts on the water, energy, and carbon fluxes; wildlife habitats; and infrastructure. Changes in the landscape due to thermokarst occurs when ice-rich permafrost thaws and the land surface subsides due to volume loss when ground-ice transitions to water. The important processes affected by thermokarst include changes in surface ponding, topography, vegetation composition, soil moisture and drainage patterns, and related erosion and biogeochemical turnovers. The Alaska Thermokarst Model (ATM) is a large-scale, state-and-transition model designed to simulate transitions between landscape units affected by thermokarst disturbance. The ATM using a frame-based methodology to track cohorts (unique landscape representations) transitions and their respective proportions within each model grid cell. In the arctic tundra environment, the ATM tracks thermokarst related transitions among wetland tundra, graminoid tundra, shrub tundra, and lakes. The transition from one cohort are initiated by pulse disturbance (i.e. extreme heat, large precipitation events, or wildfires) or by gradual active layer deepening that eventually results in penetration of the protective layer. The results of our research will be used to inform resource managers to better inform decision making. Further, the frame-based methodology of tracking transitions between landscape units is conceptually consistent with the watershed delineation approach being developed the Department of Energy’s E3SM (Energy Exascale Earth System Model) land model. We will utilize and apply the recent approaches to translate the intermediate-resolution modeling results into functional responses applicable for integration into the E3SM framework. This model integration will improve the representation of landscape changes and its consequences on hydrological, biogeochemical and energy processes in the Arctic region. This study will present our results to date on the Alaskan Arctic Coastal Plain and our plans moving forward into the near future.

Friday, 14 December 2018
08:00 - 12:20
Convention Center - Hall A-C (Poster Hall)

Temporal Variance in Arctic Polygonal Ground Surface Water Sources

Nathan A. Conroy, Brent D. Newman, Cathy J. Wilson, and Stan D. Wullschleger

Los Alamos National Laboratory, Los Alamos, NM
Oak Ridge National Laboratory, Oak Ridge, TN

Surface water samples were collected at the Barrow Environmental Observatory (BEO, Barrow Alaska) during and after the snowmelt period in the late spring and summer of 2013. Deuterium and oxygen-18 ratios were assayed, in addition to a suite of inorganic ions. Geographic variability during the snowmelt period was evident, as well as temporal variability within a site selected for more intensive study. Distinct deuterium/hydrogen and oxygen-18/oxygen-16 ratios were observed, and were correlated to the snowmelt period, active-layer melt period, and recent precipitation events. Stable hydrogen and oxygen isotopes were used to estimate the timing and duration of the snowmelt and active layer thaws, as well as the relative contributions of snowmelt, active layer water, and recent precipitation to the surface waters. Consequently, measured concentrations of inorganic ions could be correlated to changes in the predominant source of surface water at a given time. These data and correlations will inform the development of improved hydrological and biogeochemical models of Arctic polygonal ground.

Friday, 14 December 2018
08:00 - 12:20
Convention Center, Hall A-C (Poster Hall)

Exploring the Interactions Between Thermal Hydrology, Soil Structure, and Dynamic Topography in Warming Polygonal Tundra

Ethan Coon, Ahmad Jan, Julie D. Jastrow, Scott L. Painter, and Cathy J. Wilson

Oak Ridge National Laboratory, Oak Ridge, TN
Argonne National Laboratory, Lemont, IL
Los Alamos National Laboratory, Los Alamos, NM

Observations of warming Arctic polygonal tundra suggest significant changes in hydrology and geomorphology at multiple scales. The magnitude and pattern of these changes are fundamentally affected by ground ice and thermal and hydrologic properties of the landscape, potentially affecting both the water and energy balances. Answering seemingly simple questions like, "will a warmer Arctic be wetter or dryer than current conditions?" and "will carbon stored in polygonal tundra decompose into methane or carbon dioxide?" requires a careful consideration of the interplay of these processes. Such basic understanding is critical to predict the fate of carbon stored in thawing soils, infrastructure stability, and water fowl habitat. In coastal regions like Barrow, Alaska, systematic geomorphic change has been observed, including both subsidence across scales of 100s-1000s of meters and local polygon degradation at scales of 1s-10s of meters. As soils warm, ground ice thaws and soils subside and compact. The active layer gains new soil, but porosity decreases, changing where and how much water is stored in the soil column. As polygons degrade, poorly connected low centers that store significant snowmelt become well-connected high centers, resulting in significant increase in runoff and less potential for infiltration. The tradeoffs between these and other considerations are difficult to understand. We present a mechanistic model coupling permafrost thermal hydrology to a simple soil subsidence representation based upon grain consolidation. This model is parameterized by data derived from entire cross-polygon profiles (3m deep) at Barrow (reconstructed from analyses of soil horizons sampled via trenching and coring). A multi-decade regional subsidence record at Barrow is used to evaluate one-dimensional, regional subsidence simulations, and 100-year projections are explored. Finally, a first-of-a-kind, multiscale model integrates these columns through a dynamic parameterization capturing the impacts of polygon degradation on lateral flow. Predictions are made of how these processes interact to determine the fate of polygonal tundra under a warming climate.

Friday, 14 December 2018
17:45 - 18:00
Convention Center - Salon H

Development and use of a Distributed Temperature Profiling (DTP) System to Estimate Arctic Soil Thermohydrology and Depth to Permafrost, and their Relationships with Geomorphological and Vegetation Properties

Baptiste Dafflon, Hunter Akins, Jack Lamb, Emmanuel Leger, Craig Ulrich, Sebastian Uhlemann, Ian Shirley, John E. Peterson, Sebastien Biraud, and Susan Hubbard

Lawrence Berkeley National Laboratory, Berkeley, CA

A substantial improvement in our ability to quantify and monitor soil and permafrost thermohydrology is important for improving our prediction of Arctic ecosystem feedbacks to climate under warming temperatures. Understanding the relationships between soil thermal and hydrological behaviors, soil physical properties (incl. fraction of soil constituents, bedrock depth, permafrost characteristics), and landscape properties could greatly improve our predictive understanding of the subsurface storage and fluxes of water, carbon and nutrients in permafrost environments. However, obtaining such information is extremely challenging using conventional measurement approaches. We developed a novel approach called Distributed Temperature Profiling (DTP) to address this measurement challenge. This system involves a network of vertically-resolved thermistor probes (>10 thermistors/probe) with an accompanying data acquisition system to autonomously sense the temperature regime at numerous depths and locations. The DTP system has been developed with an extraordinarily low production and assembly cost; uses automated data acquisition, management and transfer; and leverages open source software and hardware to encourage community-based development and deployment. Here, we describe the new DTP system and its joint use with electrical resistivity tomography (ERT) datasets, soil sample analysis, soil moisture data, and UAV-inferred vegetation indexes, digital surface elevation models and snow thickness to investigate the characteristics of and controls on permafrost processes in a watershed on the Alaskan Seward Peninsula. Together, the various datasets allowed us to distinguish shallow permafrost from deep permafrost with an overlying perennially thawed layer (i.e., suprapermafrost talik) implying year-round subsurface fluid flow and transport. In addition, relationships between the subsurface permafrost/soil characteristics, the topography, the snow thickness and vegetation distribution were identified. Finally, spatial and temporal variations in DTP and ERT, both showing strong lateral variations over a few meters, indicate the presence of preferential flow paths to depths of ~20m.

Friday, 14 December 2018
08:00 - 12:20
Convention Center, Hall A-C (Poster Hall)

Understanding Controls on Arctic Soil Moisture Using In-Situ Soil Moisture and Thaw Depth Observations and Airborne SAR Data at Barrow and Seward Peninsulas, Alaska

Julian Dann, Bob Bolton, Lauren Charsley-Groffman, Elchin E. Jafarov, Emma Lathrop, Dea Musa, Stan D. Wullschleger, and Cathy J. Wilson

Los Alamos National Laboratory, Los Alamos, NM
University of Alaska, Fairbanks, AK
Oak Ridge National Laboratory, Oak Ridge, TN

The DOE Office of Science Next-Generation Ecosystem Experiments, NGEE-Arctic project is a multi-lab effort working to improve the representation of arctic terrestrial processes in Earth System Models. By co-analyzing in-situ and remote sensing data at multiple sites, we aim to extend local observations to regional scales. Here we present an analysis of in-situ measurements of soil moisture and thaw depth collected during the summer of 2017 coincident with airborne overflights of L and P-band SAR instruments in collaboration with the NASA Arctic Boreal Vulnerability Experiment (ABoVE) project's Airborne SAR Campaign. We examine how local geomorphology, topography, climate and vegetation properties interact with thaw depth and soil moisture across a range of field sites and settings near Utqiaġvik, AK and Nome, AK. In Utqiaġvik, in-situ data were collected at high-center, flat-center, and low-center polygons during the June SAR P-band and September L-band overflights. At all sites on the Seward Peninsula, in-situ data were collected in May and August, coincident with P-band overflights. At each field site the same measurement techniques were used including the establishment of multiple 100m by 100m plots designated for SAR ground-truthing. Within each “SAR plot” two 60 meter transects were established along which both soil moisture and thaw depth measurements were taken. This configuration is consistent with the ABoVE protocols which enables proper averaging of multiple pixels for airborne or spaceborne SAR data. Moisture data was collected using a Hydrosense-II soil-water sensor and data logger which relies on the dielectric properties of the soil to estimate volumetric moisture content (VMC). Soil moisture and thaw depth are key factors controlling subsurface biogeochemistry and surface ecosystem type and function. Our observations and analysis provide a unique benchmark dataset with which to test predictions of spatial variation and temporal evolution of soil moisture in local and regional permafrost models.

Wednesday, 12 December 2018
08:00 - 12:20
Convention Center - Hall A-C (Poster Hall)

Modeling the Response of Permafrost Affected Mesoscale Watersheds to Long-Term Warming

Matvey Debolskiy, Vladimir A. Alexeev, Dmitry Nicolsky, Regine Hock, Vladimir E. Romanovsky, Alexander I. Shiklomanov, and Richard B. Lammers

University of Alaska, Fairbanks, AK
University of New Hampshire, Durham, NH

Recently observed increase in the Arctic river runoff and subannual reshaping of the hydrographs demand an explanation of processes responsible for these changes. Theoretical models of heat and water dynamics in the ground material suggest a non-linear response of permafrost to increase in air temperature. In this work, we employ a distributed water-balance model WaSiM to investigate how a synthetic mesoscale watershed reacts to changes in the air temperature on a millennial timescale. All case studies are completed using the same precipitation forcing for Alaska. The change in temperature we apply is based on the observed trend for the same area. We analyze the sensitivity of the present-day steady state and its potential responses to different levels of warming and to soil parameters within the watershed such as the van Genuchten soil retention parameter, hydraulic conductivity and the anisotropy of soil properties. In addition, we investigate how roughness and steepness of the watershed terrain affect the permafrost and water-balance responses to the warming on the millennial timescale. Furthermore, we analyze changes in the water-balance components: evapotranspiration, river runoff and groundwater recharge as well as changes in the runoff components: surface flow, interflow, and baseflow. Preliminary results suggest that timing and severity of an increase in the baseflow and an associated decrease in the interflow strongly depend on the physical parameters of the ground material and occur on the millennial timescale, whereas the surface flow and evapotranspiration responses are triggered almost immediately.

Friday, 14 December 2018
08:00 - 12:20
Convention Center - Hall A-C (Poster Hall)

Soil pH Controls on Anaerobic Microbial Activity and Organic Carbon Transformations in Arctic Polygon Tundra

David E. Graham, Jianqiu Zheng, Elizabeth Herndon, Megan Dillon, Neslihan Tas, Ji-Won Moon, Baohua Gu, and Stan D. Wullschleger

Oak Ridge National Laboratory, Oak Ridge, TN
Kent State University, Kent, OH
Lawrence Berkeley National Laboratory, Berkeley, CA

Soil acidity directly affects pore water biogeochemical speciation and microbial community composition and interactions. Organic carbon-rich Arctic soils and permafrost vary significantly in pH, which is expected to influence the thermodynamics of dominant anaerobic processes of soil organic matter (SOM) hydrolysis and fermentation, methanogenesis, and anaerobic respiration through iron reduction. While ecosystem models usually consider pH as a fixed parameter, hydrologic changes and biogeochemical activities can cause changes in pH gradients through the soil column. We measured the buffering capacity of polygon tundra soil and permafrost from Utqiaġvik (formerly Barrow), Alaska, which was significantly lower than the values reported from soils in temperate regions. Predominant quartz minerals identified in Arctic soils by X-ray diffraction have minimal contribution to buffering capacity or cation exchange. Iron (Fe) K-edge X-ray absorption spectroscopy and extended X-ray absorption fine structure analyses identified Fe(II) and Fe(III) in the soils as organic-bound or poorly crystalline iron (oxyhydr)oxides, which contributed to buffering capacity at low pH. We developed a simple representation of proton-binding characteristics of SOM using a selective range of proton binding constants from organic acids and lignin derivatives commonly found in soil, which explained a large portion of pH buffering capacity in these soils. Substantial pools of iron (oxyhydr)oxides also buffered pH via simulated dissolution/precipitation reactions and formation of complexes. Anoxic incubation experiments using soils buffered at acidic and alkaline pH identified changes in methanogenesis and iron reduction that illustrate differences in pH response factors for anaerobic processes and their potential feedbacks on soil pH. Molecular analyses of microbial community composition changes in these incubations describe organismal feedbacks on key biogeochemical processes. Separate parameterizations of pH response functions for fermentation, iron reduction and methanogenesis in a biogeochemical kinetic model improved the simulation of pH evolution, including the initial pH drop due to organic acid accumulation caused by fermentation and then a pH increase due to iron reduction and methanogenesis.

Wednesday, 12 December 2018
08:00 - 12:20
Convention Center - Hall A-C (Poster Hall)

Modelling Climate Change Impacts on an Arctic Polygonal Tundra: Changes in CO_2 and CH_4 Exchange Depend on Rates of Permafrost Thaw as Affected by Changes in Vegetation and Drainage

Robert F. Grant, Zelalem Mekonnen, William J. Riley, Bhavna Arora, and Margaret S. Torn

University of Alberta, Edmonton, Alberta
Lawrence Berkeley National Laboratory, Berkeley, CA

Model projections of CO_2 and CH_4 exchange in Arctic tundra during the next century diverge widely. Here we used *ecosys* to examine how climate change will affect CO_2 and CH_4 exchange in troughs, rims and centers of a coastal polygonal tundra landscape at Barrow AK. The model was shown to simulate diurnal and seasonal variation in CO_2 and CH_4 fluxes associated with those in air and soil temperatures (T_a and T_s) and soil water contents (q) under current climate in 2014 and 2015. During RCP 8.5 climate change from 2015 to 2085, rising T_a, atmospheric CO_2 concentrations (C_a) and precipitation (P) increased NPP from 50 – 150 g C m^{-2} y^{-1}, consistent with current biometric estimates, to 200 – 250 g C m^{-2} y^{-1}. Concurrent increases in R_h were slightly smaller, so that net CO_2 exchange rose from values of -25 (net emission) to +50 (net uptake) g C m^{-2} y^{-1} to ones of -10 to +65 g C m^{-2} y^{-1}. Large increases in R_h with thawing permafrost were not modelled. Increases in net CO_2 uptake were largely offset by increases in CH_4 emissions from 0 – 6 g C m^{-2} y^{-1} to 1 – 20 g C m^{-2} y^{-1}, reducing gains in NEP. These increases in net CO_2 uptake and CH_4 emissions were modelled with hydrological boundary conditions that were assumed not to change with climate. Both these increases were smaller if boundary conditions were gradually altered to increase landscape drainage during model runs with climate change.

Wednesday, 12 December 2018
08:00 - 12:20
Convention Center - Hall A-C (Poster Hall)

Characterizing Rooting Depth Distribution and Nitrogen Acquisition by Dominant Tundra Plant Species

Colleen M. Iversen, Ingrid Slette, Victoria L. Sloan, Joanne Childs, Richard J. Norby, William J. Riley, Verity G. Salmon, Holly M. Vander Stel, Stan D. Wullschleger, and Qing Zhu

Oak Ridge National Laboratory, Oak Ridge, TN
Colorado State University, Ft. Collins, CO
University of Bristol, Bristol, UK
Lawrence Berkeley National Laboratory, Berkeley, CA
Michigan State University, Ann Arbor, MI

Rooting depth distributions are an important factor controlling competition for water and nutrients among plant species in Arctic tundra. Permafrost thaw and degradation resulting from climate warming may alter the thickness of the active soil layer and the vertical distribution of plant-available nutrients. Species with root distributions that provide better access to nutrients in an altered soil profile may gain a competitive advantage. However, little is known about the rooting depth distributions and nutrient acquisition strategies of the dominant plant species in tundra ecosystems. We conducted a ^{15}N isotope tracer experiment to assess the vertical distribution of soil nutrient acquisition among three dominant species representing important plant functional types on the Barrow Environmental Observatory in Alaska, USA. We injected a solution of $^{15}NH_4Cl$ into the soil in either the organic soil horizon, the mineral soil horizon, or at the permafrost boundary beneath plots located in homogeneous patches of *Carex aquatilis* (sedge), *Eriophorum angustifolium* (sedge), or *Salix rotundifolia* (deciduous shrub) and quantified the uptake and distribution of ^{15}N one week later. Vertical patterns of nutrient acquisition varied among the plant species. The shrub species acquired ^{15}N primarily from the organic soil layer, while both sedge species acquired more ^{15}N from the mineral soil layer; across all three species, very little ^{15}N was acquired from near the permafrost boundary. The roots of the shrub were located almost exclusively in the organic horizon, which is consistent with the patterns of nutrient acquisition for this species. Contrastingly, the roots of the sedges extended throughout the soil profile, suggesting that root density does not entirely explain the patterns of nutrient acquisition for these species. Instead, a nutrient competition model (N-COM) that incorporated rooting depth distribution, as well as species-specific differences in nutrient uptake kinetics and the greater plant-microbe nutrient competition in surficial organic soils, was able to faithfully reproduce the observed patterns. Minimal plant ^{15}N uptake from near the permafrost boundary may limit the impact of climate warming-induced nutrient release from previously frozen soils.

Monday, 10 December 2018
13:40 - 13:55
Convention Center - 150B

Modeling the Role of Preferential Snow Accumulation in Through Talik Development and Hillslope Groundwater Flow in a Transitional Permafrost Landscape

Elchin E. Jafarov, Ethan T. Coon, Dylan R. Harp, Cathy J. Wilson, Scott L. Painter, Adam L. Atchley, and Vladimir E. Romanovsky

Los Alamos National laboratory, Los Alamos, NM
Oak Ridge National laboratory, Oak Ridge, TN
University of Alaska, Fairbanks, AK

Through taliks – thawed zones extending through the entire permafrost layer – represent a critical type of heterogeneity that affects water redistribution and heat transport, especially in sloping landscapes. The formation of through taliks as part of the transition from continuous to discontinuous permafrost creates new hydrologic pathways connecting the active layer to sub-permafrost regions, with significant hydrological and biogeochemical consequences. At hilly field sites in the southern Seward Peninsula, AK, patches of deep snow in tall shrubs are associated with higher winter ground temperatures and an anomalously deep active layer. To better understand the thermal-hydrologic controls and consequences of through taliks, we used the coupled surface/subsurface permafrost hydrology model ATS (Advanced Terrestrial Simulator) to model through taliks associated with preferentially distributing snow. We simulated a synthetic hillslope domain to explore the conditions under which large shrub patches would drive through-talik formation. The model was forced with detrended meteorological data with snow preferentially distributed at the mid-slope of the domain to investigate the potential role of vegetation-induced snow trapping in controlling through talik development under conditions typical of the current-day Seward Peninsula. We simulated thermal hydrology and talik development for five permafrost conditions ranging in thickness from 17m to 45m. For the three thinnest permafrost configurations, a through talik developed, which allowed water from the seasonally thawed layer into sub-permafrost waters, increasing sub-permafrost groundwater flow. These numerical experiments suggest that in the transition from continuous to discontinuous permafrost, through taliks may appear at locations that preferential trap snow and that the appearance of those through taliks may drive significant changes in permafrost hydrology.

Friday, 14 December 2018
17:30 - 17:45
Convention Center - Salon H

Impacts of Microtopography on the Evolution of Polygonal Tundra Hydrology in a Warming Climate

Ahmad Jan, Ethan T. Coon, and Scott L. Painter

Oak Ridge National Laboratory, Oak Ridge, TN

The soil thermal hydrology in permafrost regions is characterized by strong coupling among thermal and hydrologic processes on the surface and in the subsurface, making it difficult to assess how hydrological condition will evolve in a warming climate. For polygonal tundra, microtopography (heterogeneities in the surface elevation below the scale of an ice wedge polygon) is an important factor influencing hydrological processes because it determines the flow direction, liquid storage, drainage networks and greatly affects surface/subsurface interactions. We explore the consequences of microtopographic features on the evolution of polygonal tundra using a recently developed integrated surface/subsurface permafrost thermal hydrology simulator, the Advanced Terrestrial Simulator. Our model is calibrated to field observations of soil temperature, soil moisture and evaporation, and can efficiently capture critical microtopographic features and thaw-induced subsidence in large-scale integrated models. We present 100-year projections of the integrated thermal hydrology system in stochastically generated landscapes comprising high- and low-centered ice wedge polygons and explore how warming climate can affect surface flow and active layer evolution.

Thursday, 13 December 2018
13:40 - 18:00
Convention Center - Hall A-C (Poster Hall)

Cryoplanation Terraces at the Seward Peninsula: Mechanisms of Origin and Influence on Subsurface Hydrology on the Local Scale

Alexander L. Kholodov, Matvey Debolskiy, and Kelsey E. Nyland

University of Alaska, Fairbanks, AK
Michigan State University, Ann Arbor, MI

Slope terraces are widespread feature at the Seward Peninsula. Many researches identify these landforms as solifluction lobs. But in fact, the solifluction is the process of the flowage of the soil of active (seasonally frozen) layer oversaturated with water down a steep slope. So it is strongly associated with permafrost. At the same time, we notice these feathers not only on the north facing slopes, underlined by permafrost but as well on the south slopes where permafrost is detached from the seasonally frozen layer where surface soil layer is undersaturated. We assume that in this region within the areas where permafrost absence close to ground surface these features originated in result of solifluction during the cold epochs now days are subject to development of the novel processes i.e. influence of perennial or late-lying snow patches. These landforms control the redistribution of snow during winter seasons and, thus controls soil temperature and moisture regime. In September of 2017 we established the 70 meters long observation transects across one of the slope terraces at the milepost 28 of the Teller road. We installed temperature sensors at the ground surface and the depths of 20, 50 and 120 cm in three points located in the rear, central and front parts of the terrace. We also conducted vegetation, soil and snow surveys along the transect. In according to our results at the spring time of the 2018 snow thickness across the terrace decreases from the 1.8 m in the rear part to less than 30 cm at the front. It provides the conditions for permafrost preservation at the front part, while at the rear we observe only shallow (about 30 cm) seasonal freezing. This thin seasonally frozen layer thaws completely soon after the melting of snow cover that allows melted water and precipitation to infiltrate to deeper horizons during the summer. Presence of permafrost close to the ground surface at the frontal parts of these terraces creates series of “frozen dumbs” across the slope. These dumbs make longer the paths of downhill flow of ground water and sometimes can event create local water catchments.

Tuesday, 11 December 2018
08:00 - 12:20
Convention Center - Hall A-C (Poster Hall)

The Influence of Vegetation on Shallow Soil and Air Temperature Coupling: A Pan-Arctic Data Synthesis

Heather Kropp, Michael M Loranty, Susan Natali, Alexander L. Kholodov, Benjamin Abbott, Jakob Abermann, Elena Blanc-Betes, Daan Blok, Gesche Blume-Werry, Julia Boike, Amy L. Breen, Sean M.P. Cahoon, Casper Christiansen, Thomas A Douglas, Bo El berling, Howard E Epstein, Eugenie S Euskirchen, Gerald Frost, Mathias Goeckede, Laura Gough, Monique Heijmans, Jan Hjort, Toke Thomas Hoye, Elyn Humphreys, Colleen M. Iversen, Hiroki Iwata, Benjamin M Jones, Torre Jorgenson, Inge Juszak, Yongwon Kim, Peter Lafleur, James Laundre, Magnus Lund, Steven Mamet, Marguerite Mauritz, Anders Michelsen, Isla H Myers-Smith, Jon O'Donnell, David Olefeldt, Gareth K Phoenix, Adrian V Rocha, Vladimir E Romanovsky, Verity G Salmon, Britta Sannel, Gabriela Schaepman-Strub, Sharon L Smith, Oliver Sonnentag, Ken D Tape, Margaret S Torn, Lydia Smith Vaughn,
Mathew Williams, and Cathy J. Wilson

Colgate University, Hamilton, NY
Multiple Universities, Institutes, and Organizations

Shallow soil temperatures influence ecosystem carbon cycling and the temperature of deeper soil layers where permafrost thaw occurs. Vegetation affects shallow soil temperatures via impacts on the surface energy balance, hydrology, and soil characteristics. Vegetation may influence the degree to which soil temperatures rise with increases in air temperature under global climate change. However, variability in vegetative influences on soil temperature are not well quantified at a pan-Arctic scale. We compiled data from 235 sites across high latitude permafrost regions to examine the influence of air temperatures and vegetation on shallow soil temperatures. Annual thermal regimes varied across vegetation types characterized by dominant plant functional cover. The overall magnitude of soil temperature maxima and minima varied across plant functional types. Ecosystems dominated by vegetation with tall statured canopies such as evergreen needleleaf boreal forests and tall shrub tundra tended to have warmer soil warmer temperatures than tundra sites dominated short statured vegetation such as graminoid or short shrub species. Soil temperatures increased with air temperature similarly within tundra vegetation types, and rising air temperatures from global climate change may result in similar increases in soil temperatures regardless of vegetation type in the tundra. Soil temperatures were highly variable and decoupled from air temperature in boreal forest sites.

Wednesday, 12 December 2018
08:00 - 12:20
Convention Center - Hall A-C (Poster Hall)

Landscape Structure and Heterogeneity Controls on Ecohydrological Processes in Arctic Tundra Ecosystem

Jitendra Kumar and Forrest Hoffman

Oak Ridge National Laboratory, Oak Ridge, TN

Biotic and abiotic complexity and heterogeneity of the landscape plays critical role in governing and influencing the ecohydrological processes on the landscape. These processes operate at a range of spatial and temporal scales, appropriate representation of which are critical for ecosystem modeling studies that focus on understanding the current and future state of the ecosystem. Capturing the subgrid heterogeneity and their affects across scales is important for understand the current and future state of the landscape in changing climate. However, characterizing and modeling these processes are especially hard in data limited and ungauged landscapes like Arctic tundra landscape at Seward Peninsula of Alaska where our study region is located. To characterize and model this topographically complex mountainous landscape we developed a physics-informed data-driven approach. We characterize the heterogeneity of the landscape using a multivariate approach to hierarchically segment the landscape units across spatial scales. Using physics-based hydrology models we simulate and analyze the dynamics of the complex heterogeneous landscape mosaic at and across various scales to understand. Goal of the study is to understand the landscape organization and their role and influence in modulating the ecohydrological processes to improve our ability to accurately model them in data poor Arctic tundra landscape.

Monday, 10 December 2018
16:15 - 16:30
Convention Center - 146B

Fire Driven Vegetation Dynamics and Rapid Carbon Turnover Cause a Decline in High-Latitude Soil Carbon Stocks Under Future Climate

Zelalem Mekonnen, William J. Riley, James T. Randerson, and Robert F. Grant

Lawrence Berkeley National Laboratory, Berkeley, CA
University California Irvine, Irvine, CA
University of Alberta, Edmonton, Alberta

The impact of recent and predicted changes in fire regimes on the carbon cycle of northern ecosystems is uncertain. Here we applied a well-tested mechanistic ecosystem model, *ecosys*, to examine the effects of complex interactions between fire and climate change on above and below ground carbon stocks across ecosystems of Alaska. Changes in surface litter and surface energy budgets following fire drove changes in soil temperature and nutrients. Warmer soil after fire deepened the active layer, hastened mineralization, and enhanced the growth of faster-growing deciduous vs. slower-growing evergreen plant functional types (PFTs). Enhanced microbial decomposition from increased litterfall of deciduous PFTs resulted in more rapid ecosystem carbon turnover. For a scenario to 2100 with expected fire increases across Alaska, fire induced ecosystem carbon losses were ~ 61 Tg C yr^{-1}, offsetting ~25% of ecosystem net biome productivity by 2100. Despite overall increases in aboveground biomass, soil organic carbon stocks declined by ~1.3 Pg C over the 21^{st} century. We conclude that the trajectory of vegetation change following fire strongly controls how aboveground biomass and the large soil carbon pool of northern ecosystems will change under future climate and fire regimes.

Wednesday, 12 December 2018
08:00 - 12:20
Convention Center - Hall A-C (Poster Hall)

High-Resolution Permafrost Modeling and Mapping in Alaska

Dmitry Nicolsky, Vladimir E. Romanovsky, Matvey Debolskiy, Lei Cai, Chris Bailey, Laurin Fisher, Reginald R Muskett

University of Alaska, Fairbanks, AK

We develop a series of ecotype-based permafrost dynamics models for the Alaska North Slope (30-m resolution), Seward Peninsula (500-m resolution) and Selawik National Wildlife Refuge (770-m resolution) regions. The developed models allow computations of the mean annual ground temperature (MAGT), active layer thickness (ALT) and talik thickness projections into the future for various climate scenarios. We demonstrated that the projections with the IPCC Representative Concentration Pathway (RCP) 4.5 and 8.5 scenarios will result in a drastic difference in the future near-surface ground temperature regimes in 2050s and 2090s. For the RCP 8.5 scenario, we find that ALT in the Alaska North Slope region, up to 0.5 m on average in 2000, increases by a factor of 2 by 2050. From 2050 to 2100, according to the RCP 8.5 scenario, ALT continues to increase and widespread taliks will start to form in the Alaska North Slope region. Development of the taliks will have serious implications for ecosystems, human activities (infrastructure and subsistence lifestyle), and potential feedbacks to climate change. On the other hand, for the RCP 4.5 scenario, the current model predicts only a modest increase in the near-surface. We plan to increase the spatial resolution of all developed models to 30-m for the community planners and engineers to understand potential hazards related to the permafrost degradation on the local scale near the relevant infrastructure. Using existing permafrost modeling capabilities for the community of Selawik, Alaska, we developed a stand-alone software package to compute and present various scenarios of permafrost degradation to local government agencies and to the residents of Selawik. To conduct the public outreach more effectively, we designed a publicly-downloadable application for iPhone to show how permafrost temperature might response to changes in air temperature, snow thickness and ground moisture.

Wednesday, 12 December 2018
13:40 - 18:00
Convention Center - Hall A-C (Poster Hall)

Stimulation of Anaerobic Organic Matter Decomposition by Subsurface Organic N Addition in Tundra Soils

Michael J. Philben, Jianqiu Zheng, Markus Bill, Jeffrey M. Heikoop, George Perkins, Stan D. Wullschleger, David E. Graham, and Baohua Gu

Oak Ridge National Laboratory, Oak Ridge, TN
Lawrence Berkeley National laboratory, Berkeley, CA
Los Alamos National Laboratory, Los Alamos, NM

Increasing nitrogen (N) availability in Arctic soils could stimulate the growth of both plants and microorganisms by relieving the constraints of nutrient limitation. We hypothesized that organic N addition to anoxic tundra soil would increase CH_4 production by stimulating the fermentation of labile substrates, which is considered the rate-limiting step in anaerobic C mineralization. We tested this hypothesis through both field and lab-based experiments. In the field experiment, we injected a solution of ^{13}C- and ^{15}N-labeled glutamate 35 cm below the soil surface in a tundra soil at a site near Nome on the Seward Peninsula, Alaska, and observed the resulting changes in porewater geochemistry and dissolved greenhouse gas concentrations. The concentration of free glutamate declined rapidly within hours of injection, and the ^{15}N label was recovered almost exclusively as dissolved organic N within 62 hours. These results indicate rapid microbial assimilation of the added N and transformation into novel organic compounds. We observed increasing concentrations of dissolved CH_4 and Fe(II), indicating rapid stimulation of methanogenesis and Fe(III) reduction. Low molecular weight organic acids such as acetate and propionate accumulated despite increasing consumption through anaerobic C mineralization. The laboratory soil column flow experiment using active layer soil collected from the same site further supported these findings. Glutamate recovery was low compared to a conservative bromide tracer, but concentrations of NO_3^- and NH_4^+ remained low, consistent with microbial uptake of the added N. Similar to the field experiment, we observed both increasing Fe(II) and organic acid concentrations. Together, these results support our hypothesis of increased fermentation in response to organic N addition and suggest that increasing N availability could accelerate CH_4 production in tundra soils.

Thursday, 13 December 2018
08:00 - 12:20
Convention Center - Hall A-C (Poster Hall)

Non-Growing Season Plant Nitrogen Uptake Affects Losses and Carbon Budgets in Tundra and Boreal Systems

William J. Riley, Zelalem Mekonnen, Robert F. Grant, Jinyun Tang, Nicholas Bouskill, and Qing Zhu

Lawrence Berkeley National Laboratory, Berkeley, CA
University of Alberta, Edmonton, Alberta
Purdue University, West Layfette, IN

The role of plant photosynthesis in maintaining high-latitude tundra C stocks is strongly limited by nutrient (N, P) availability. However, high-latitude plant representations in global land models remain uncertain and these models have fared poorly in recent confrontations with observations. We show here that one relevant factor may be plant nutrient acquisition during the non-growing season, a widely observed process ignored by many large-scale land models. To quantify nutrient acquisition across the North American tundra, we apply a mechanistic model of coupled plant, microbial, hydrological, and thermal dynamics (*ecosys*) that has been tested in many high-latitude systems and that explicitly represents nutrient acquisition based on competitor traits (e.g., fine-root biomass and transporter density, microbial V_{max} and affinity). Our results indicate that tundra plant uptake during the non-growing season ranges between ~20 and 50% of annual uptake, with large spatial variability and dependence on plant type. Asynchronous microbial and root uptake explain current patterns, but these interactions may change under expected warming over the next century. Model experiments excluding non-growing season nutrient uptake indicate substantial effects on nutrient losses, particularly during snowmelt periods, and subsequent growing season phenology and net primary production.

Monday, 10 December 2018
13:40 - 13:55
Convention Center - 143A-C

Leaf to Landscape Scale Remote Sensing of Arctic Vegetation Structure and Function

Shawn Serbin, Andrew M. McMahon, Ran Meng, Daryl Yang, Wil Lieberman-Cribbin, Kim Ely, Wouter Hantson, Dan J. Hayes, Alistair Rogers, and Stan D. Wullschleger

Brookhaven National Laboratory, Upton, NY
Stony Brook University, Stony Brook, NY
Icahn School of Medicine at Mount Sinai, New York, NY
University of Maine, Orono, ME
Oak Ridge National Laboratory, Oak Ridge, TN

The inadequate representation of plant traits and trait variation across space and time in terrestrial biosphere models, including many that underlie the land-surface component of Earth System Models, is a key driver of uncertainty in model forecasts of terrestrial ecosystems. This is particularly relevant for the Arctic with sparse observational data availability. Uncertainty in the modeling of carbon uptake and associated processes and fluxes in the Arctic has been tied to the lack of key data on plant properties that regulate these processes. An approach is needed to bridge the scales between detailed ongoing in-situ observations in remote locations and the larger, landscape context needed to inform models on parameter variation in relation to biotic (e.g. structure) and abiotic drivers such as climate, soils, topography, and disturbance history. Remote sensing, particularly spectroscopy, high resolution imaging, and thermal infrared thermography, represent powerful observational datasets capable of scaling plant properties and capturing spatial and temporal dynamics in plant structure and functioning. We build on the success of scaling traits in temperate ecosystems and extend our approaches to the high Arctic to develop algorithms for mapping biochemical, morphological and physiological traits. Our work focuses on connecting a range of plant species and remote sensing data within our two core study areas within the Utqiaġvik and Seward Peninsula, Alaska regions. We link direct measurements of leaf chemistry and physiology, including leaf-level gas exchange, with measurements of leaf and canopy optical properties, TIR, and imagery from near-surface, unmanned aerial system (UAS) platforms, and NASA AVIRIS. We show how leaf-level spectra-trait models for Arctic vegetation are comparable with existing models from other biomes. Tram, UAS and AVIRIS platforms show a strong capacity to scale leaf-level traits to the larger landscape and capture patterns through time and across vegetation structure, derived using optical Structure from Motion (SfM). Despite strong variation in leaf and canopy structure we are finding a good potential for spectral models (i.e. R^2 between 0.50 and 0.89) to capture trait variation and highlight the possibility to map traits in the high Arctic.

Wednesday, 12 December 2018
10:50 - 11:05
Convention Center - 147B

Linking Surface and Subsurface Behaviors: UAV-based multi-spectral Imagery as Predictor of Soil Wetness, Thaw Depth and Soil Respiration in an Arctic Watershed

Ian Shirley, Baptiste Dafflon, Oriana Chafe, Hunter Akins, Sebastien Biraud, Chad V. Hanson, Margaret S. Torn, and Susan Hubbard

Lawrence Berkeley National Laboratory, Berkeley, CA
Oregon State University, Corvallis, OR

Arctic ecosystems are characterized by fine-scale heterogeneity of surface and subsurface structure, with differences in hydrological conditions, soil physical properties, and vegetation cover that strongly influence the distribution of soil carbon content and fluxes across a watershed. This spatial variation poses a unique challenge to upscale soil carbon content and flux measurements from the sub-watershed scale to the regional scales that are used in full-scale climate models. This study links surface and subsurface properties at a discontinuous permafrost site in a Seward Peninsula watershed near Council, AK. We performed a vegetation classification and hydrological stream flow analysis from, respectively, a multi-spectral mosaic and Digital Surface Model (DSM), both inferred from data obtained by a low-altitude Unmanned Aerial Vehicle (UAV). We also performed ground-based measurements of soil temperature using a Distributed Temperature Profiling (DTP) system, soil electrical conductivity (as a proxy for soil wetness) using an electromagnetic sensor, and of soil respiration using gas flux chambers at points across the site. Correlations between these ground-based and aerial measurements were explored with an emphasis on understanding linkages that will be useful for upscaling. We found that the remotely sensed products could be effectively used to distinguish between areas of significantly different subsurface and biogeochemical characteristics. Topography, plant type, and surface wetness are linked and can be used to predict significant differences in active layer depth, carbon dioxide, and methane emissions. The observed connections between surface and subsurface properties at this intermediate scale will be critical in future attempts to characterize entire watersheds in the Seward Peninsula with remotely sensed data products.

Friday, 14 December 2018
08:00 - 12:20
Convention Center - Hall A-C (Poster Hall)

A Method to Predict, Rather than Prescribe, Soil Heterotrophic Respiration Responses to Soil Moisture

Jinyun Tang and William J. Riley

Lawrence Berkeley National Laboratory, Berkeley, CA

Soil moisture and temperature impose equally significant influences on soil heterotrophic respiration (HR). However, current modeling approaches often derive the functional relationships between soil HR and soil moisture content from incubation experiments and then apply them to spatial-temporal extrapolation without considering uncertainty associated with this approach. In this study, we devised a theory based on how soil moisture modulates diffusive delivery of soluble carbon and oxygen to microbes and show that it is possible to predict how soil moisture change will affect soil HR. Our predictions suggest that soil physical properties, e.g., soil texture and mineral surface abundances, affect soil HR. High soil clay content will cause soil HR to peak at higher soil moisture content, whereas more mineral surface area will cause soil HR to peak at lower soil moisture content and the transition from aerobic to anaerobic soil HR to be smoother. Most importantly, our predictions suggest that there is no simple multiplicative soil moisture effect on HR, as is commonly assumed. Rather, moisture control of soil HR is an emergent response resulting from interactions between microbes, substrates, soil physical and chemical properties, and even atmospheric conditions. We evaluate biases associated with commonly applied approaches, and conclude that models would benefit from using our new approach to represent soil HR dependencies on soil moisture.

Tuesday, 11 December 2018
13:40 - 15:40
Convention Center 150B

Dealing with Structural and Parametric Uncertainty in an Earth System Model

Peter E. Thornton, Daniel M. Ricciuto, and Michele Thornton

Oak Ridge National Laboratory, Oak Ridge, TN

Earth system models depend on large and diverse collections of data, and represent broad syntheses of observation, experimentation, and theory. Each stage in the construction, parameterization, and execution of these complex coupled models is subject to multiple sources of uncertainty. Here we consider, as a working example, the Energy Exascale Earth System Model (E3SM v1), and its land ecosystem component (ELM). We examine model construction, estimation of parameters and mapped input datasets, and implementation of simulation experiments as three separate but connected stages in the Earth system modeling “workflow”. For each of these stages we describe the challenges associated with identifying and quantifying major sources of uncertainty, using examples specific to the ELM workflow. Model construction is considered from the perspective of motivating science questions. We show how selection of a model structure is constrained by the specific science questions it is designed to answer. We examine how complexity in model process representation relates to growth in or constraints on structural uncertainty, using representation of carbon, nitrogen, and phosphorus biogeochemistry in plants and soils as an example. Model parameterization and development of spatially-resolved model inputs present special challenges for global-scale models, since every ecosystem and geographic region must be included with some level of detail, while resources for development are always limited. We present examples of quantitative frameworks that can guide the allocation of effort to minimize uncertainty in the input parameter definitions, and in the model output fields. We present examples based on parameter sensitivity analyses and vegetation and soil organic matter model outputs. We conclude with a discussion of how model output uncertainty can depend on the design and implementation of simulation experiments. We emphasize the importance of careful model spin-up constraints, and the use of control and multi-factor simulations to isolate the model mechanisms contributing most strongly to variability and uncertainty.

Thursday, 13 December 2018
09:15 - 09:30
Convention Center - 209A-C

Permafrost Characterization Near Teller, Alaska, Using Petrophysical Joint Inversion of Seismic and Geoelectrical Data

Florian M. Wagner, Sebastian Uhlemann, Baptiste Dafflon, Craig Ulrich, John Peterson, Hunter Akins, Andreas Kemna, and Susan Hubbard

University of Bonn, Bonn, Germany
Lawrence Berkeley National Laboratory, Berkeley, CA

Imaging the spatiotemporal distribution of liquid water and ice is needed to improve our understanding of hydrological processes in permafrost systems and the parameterization of numerical models that simulate the dynamics and evolution of permafrost environments. Seismic and geoelectrical techniques are sensitive to the phase change of water between its liquid, frozen, and gaseous states and are therefore widely used in cryospheric geophysical applications. The combination of both methods offers opportunities for non-invasive and quantitative imaging of permafrost characteristics. Based on a recently developed joint inversion approach, we combine electrical resistivity and seismic refraction data acquired in a watershed near Teller, Alaska, during the summer of 2018. The complementary sensitivities of both methods are exploited by means of petrophysical coupling, enabling simultaneous inversion of both data sets for the volumetric fractions of liquid water, ice, and air. Due to the small contrasts between ice and bedrock in both acoustic and electrical properties as well as uncertainties in porosity, quantitative estimates of the pore-filling constituents remain ambiguous. Based on field data and analogous synthetic investigations, we demonstrate the value of adding non-tomographic ground truth data as constraints to the joint inversion framework (e.g., point measurements of soil water content), discuss the resulting uncertainty reduction, and give recommendations for future measurement strategies.

Thursday, 13 December 2018
11:20 - 11:35
Marriott Marquis - Marquis 12-13

Quantifying Cold Season Soil CO_2 Emissions in Alaska and Northwest Canada

Jennifer Watts, Susan Natali, Christina Minions, Sarah Ludwig, Brendan M. Rogers, Scott J. Goetz, Leah Birch, Oliver Sonnentag, Eugenie S. Euskirchen, Masahito Ueyama, Elyn Humphreys, Donatella Zona, Walter C. Oechel, Adrian V. Rocha, Kyle Andreas Arndt, Manuel Helbig, Hiroki Ikawa, Hideki Kobayashi, Rikie Suzuki, Gerardo Celis, David A. Risk, Peter Lafleur, Margaret S. Torn, Sigrid Dengel, Edward Schuur, John Kimball, Julie D. Jastrow, Scot Miller, Roisin Commane, Zhen Zhang, Benjamin Poulter, Yonghong Yi, and Stan D. Wullschleger

Woods Hole Research Center, St. Francis Xavier University, University of California Irvine, Northern Arizona University, Université de Montréal, University of Alaska Fairbanks, Osaka Prefecture University, Carleton University, San Diego State University, University of Notre Dame, McMaster University, Japan Agency for Marine-Earth Science and Technology, University of Florida, Trent University, Lawrence Berkeley National Laboratory, Northern Arizona University, University of Montana, Argonne National Laboratory, Johns Hopkins University, Columbia University, University of Maryland College Park, Montana State University, and Oak Ridge National Laboratory

As temperatures increase across the Arctic, particularly during the cold seasons, soil carbon may be increasingly vulnerable to microbial mineralization and transfer to the atmosphere as CO2. Loss of CO2 from soils during shoulder (autumn/spring) and winter seasons could greatly alter the annual net ecosystem carbon balance, yet the magnitude of these emissions is not well understood. This study incorporates new information gained from a NASA Arctic Boreal Vulnerability Experiment (ABoVE) network of CO_2 soil respiration sensors using Forced Diffusion (FD) flux chambers and eddy covariance tower observations across Alaska and northwestern Canada. These records show that CO2 loss rates can exceed 0.5 gC m^{-2} d^{-1} in midwinter and may reach >3 gC m^{-2} d^{-1}during the spring and autumn shoulder seasons. Ecosystem rates of loss depend greatly on soil temperature, surface radiation, soil texture and organic substrates, vegetation community type, and landscape moisture characteristics. We extrapolate the FD chamber and tower fluxes to the greater ABoVE domain ($5.9x10^5$ km^2) to obtain a full non-growing season (October 2016 through April 2017) CO2 flux budget using a generalized additive model (GAM) and information from multi-scale (visible-infrared, microwave) satellite remote sensing and ancillary inputs. We compare the 100-m resolution GAM results with estimates obtained from ecosystem models including the Community Land Model (CLM), the Lund–Potsdam–Jena Wald Schnee und Landschaft version (LPJ-wsl) and the Terrestrial Carbon Flux (TCF) model. These results indicate non-growing season soil emissions of > 180 TgC for the study domain. The considerable spatial variability observed in the regional flux estimates illustrates the importance of finer resolution flux monitoring and modeling efforts.

Wednesday, 12 December 2018
08:00 - 12:20
Convention Center - Hall A-C (Poster Hall)

Pathways to High Resolution Simulation of Land Surface Processes in Arctic Region: A Case Study on C & N Cycles Using PFLOTRAN Coupled E3SM Land Model (ELM)

Fengming Yuan, Gangsheng Wang, Shih-Chieh Kao, Jitendra Kumar, Verity G. Salmon, Colleen M. Iversen, Amy L. Breen, Peter E. Thornton, and Stan D. Wullschleger

Oak Ridge National Laboratory, Oak Ridge, TN
University of Alaska, Fairbanks, AK

In the Arctic, land surface processes are highly heterogeneous across scales. Accurate model representation of land features and processes under ongoing and projected climate conditions will require high resolution parameterization and data. In this study, we present an offline land surface simulation using the newly developed Energy Exascale Earth System Model's (E3SM) Land Model (ELM) simulation over high-latitude regions (>60oN) at half-degree spatial resolution. As a benchmark, ELM simulated C & N cycles associated with dynamical soil thermal-hydrology are described. Further improvement aiming to high resolution modeling via model development and data integration are explored. For this version of ELM, we have coupled its aboveground processes with a state-of-the-art massively parallel 3-D subsurface thermal-hydrology and reactive transport code, PFLOTRAN. As a preliminary experiment, the model is implemented for Pan-Arctic region in 1-D column mode (i.e., no lateral connection for large scale). The results show significant differences compared to stand-alone ELM, probably due to its fully representing soil N mobility relevant processes. The ELM-PFLOTRAN is also assessed using downscaled meteorological forcings (derived from 1km Daymet datasets) for the Next Generation Ecosystem Experiment-Arctic (NGEE Arctic) field intensive study sites at Seward Peninsula, AK. Analysis indicates that atmospheric forces alone appear not enough for high resolution simulation, requiring redistribution processes over heterogeneous landscape, e.g., snow/rainfall and other surface thermal-hydrological-biogeochemical mechanisms. Soils and vegetations always play critical roles across scales. Plant physiological parameters and vegetation distribution from field surveys are highly valuable to high resolution modeling, as demonstrated by incorporating field measurements into ELM. Identifying and integrating those physical and physiological properties and featuring them in model frameworks appropriately with spatial resolutions, is critical to capturing biosphere-atmosphere exchanges at various scales.

Tuesday, 11 December 2018
13:55 - 14:10
Convention Center - 150A

Evaluating the Spatial Representativeness of Eddy Covariance Towers Across the Arctic Alaska

Donatella Zona, Kassandra Reuss-Smith, Peter E. Levy, Walter C. Oechel, Craig E. Tweedie, Cathy J. Wilson, and Maria Santos

San Diego State University, San Diego, CA
University of Sheffield, Sheffield, England
Center for Ecology and Hydrology Penicuik, Edinburgh, UK
University of Texas at El Paso, El Paso, TX
Los Alamos National Laboratory, Los Alamos, NM
University of Zurich, Zürich, Switzerland

The Arctic is warming at twice the rate of the global mean, and this warming can stimulate methane (CH_4) emissions from northern wetlands and positively enhance greenhouse warming. Arctic wetlands are extremely heterogeneous, in terms of vegetation communities, microtopography, and hydrology, and therefore CH_4 fluxes can differ dramatically at the meter scale. This high variability of CH_4 emissions in both space and time confounds efforts to reduce uncertainty in baseline CH_4 emissions from arctic tundra landscapes. Eddy covariance is one of the most useful methods for estimating CH_4 fluxes in remote areas over long periods of time. However, if the footprint of these towers does not match the spatial and temporal scales at which the heterogeneity of the vegetation communities is expressed, modelling environmental controls of CH_4 emissions could be a source of substantial bias and limit capacities for upscaling site level results. In this study, we evaluated the effect of footprint variability on the CH_4 fluxes from two eddy covariance tower sites located in wetlands on the North Slope of Alaska. The local domain of each of these sites contains well developed polygonal tundra and their drainage channels. We found that the spatiotemporal variability of the land cover within the footprint, has a significant influence on the observed CH_4 fluxes, contributing to approximately 10 - 30 % of the unexplained variability in seasonal CH_4 fluxes. Multiple spatial indices were used to define spatial heterogeneity, and their importance varied depending on site and season, but the normalized differential water index (NDWI) had the most consistent explanatory power of CH_4 fluxes. A spatial bias (i.e. difference between the spatial indices in the area sampled by the tower and a wider 0.36 km^2 domain around the tower) of 18-51% suggests the need to consider the footprint when upscaling the fluxes to a wider region around the towers in these tundra ecosystems. This study highlights the challenge and solutions for using the eddy covariance method to infer the larger scale carbon balance from these highly heterogeneous polygonal tundra ecosystems.

Tuesday, 11 December 2018
13:40 - 18:00
Convention Center - Hall A-C (Poster Hall)

The Next-Generation Ecosystem Experiments (NGEE Arctic) project is supported by the Office of Biological and Environmental Research in the DOE Office of Science.