BGC Feedbacks Scientific Focus Area

Quantifying Feedbacks and Uncertainties of Biogeochemical Processes in Earth System Models

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Biogeochemistry–Climate Feedbacks SFA and Collaborating Projects participating in the

AGU FALL MEETING

San Francisco | 12–16 December 2016

American Geophysical Union (AGU) Fall Meeting
Moscone Center, San Francisco, California, USA
December 12–16, 2016

The BGC Feedbacks Scientific Focus Area (SFA) is identifying and quantifying the feedbacks between biogeochemical cycles and the climate system, and quantifying and reducing the uncertainties in Earth System Models (ESMs) associated with those feedbacks. The BGC Feedbacks SFA is contributing to the integration of the experimental and modeling science communities, providing researchers with new tools to compare measurements and models, thereby enabling DOE to contribute more effectively to future climate assessments by the U.S. Global Change Research Program (USGCRP) and the Intergovernmental Panel on Climate Change (IPCC).

Argonne National Laboratory | Berkeley Lab | Los Alamos National Laboratory | NCAR National Center for Atmospheric Research | Oak Ridge National Laboratory | UCI | Michigan

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Roser Matamala (Argonne National Laboratory) et al. 30

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Nathan G. McDowell (Los Alamos National Laboratory) et al. 30

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William W. Hargrove (USDA Forest Service) et al. 31

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Friday, December 16, 2016

2 Town Halls

Monday, December 12, 2016

TH13B: DOE's Strategic Developments at the Terrestrial-Aquatic Interface Under a Changing Climate

The terrestrial-aquatic interface is a highly dynamic component of the Earth system, developed from a near balance between terrestrial and aquatic conditions forming unique processes and community assemblages. This interfaces play a critical role in biogeochemical cycling with the potential to provide major feedbacks to the Earth system. However, we lack the adequate basic data and multiscale models to describe how a changing climate will influence the key processes related to feedbacks with the intent of model improvement. This town hall will highlight current developments on a coupled model-experimental approach related to DOE's strategic research priorities.

Monday, December 12, 2016 12:30–13:30
Moscone West 2004

Primary Contact:
Gerald L. Geernaert (U.S. Department of Energy)

Presenters:
Daniel B. Stover (U.S. Department of Energy)
Jared L. Deforest (U.S. Department of Energy)

TH13C: EMSL: A User Facility for Environmental Molecular Science Research — Expand your research possibilities

This townhall provides an introduction to capabilities and expertise available at EMSL, a DOE-BER funded user facility in Richland WA, that would be of interest to the AGU community. Hear first hand from EMSL users about their research experience at EMSL as well as from EMSL scientists describing state of the art facilities available at no cost through a peer-reviewed proposal process. Come tell us about the type of expertise and capabilities that you need to reach your research goals.

Monday, December 12, 2016 12:30–13:30
Moscone West 2006

Primary Contact:
Nancy J. Hess (Pacific Northwest National Laboratory)

Presenters:
Ljiljana Paša-Tolić (Pacific Northwest National Laboratory)
Timothy D. Scheibe (Pacific Northwest National Laboratory)
Kirsten S. Hofmockel (Pacific Northwest National Laboratory)

TH13D: Enabling Development of a Community-Based Cyberinfrastructure with Task-Oriented Working Groups

The increasing amount and diversity of data, along with the increasing interest in developing a predictive understanding that integrates data and models, is creating a need for community-based cyberinfrastructure and tools. In response to recent workshops and meetings, the Office of Biological and Environmental Research (BER) has established three working groups to address these cyberinfrastructure needs across its Climate and Earth Science division (CESD). These groups, which include, Data Management and Workflows, Model-Data Integration, and Software Engineering and Interoperability, are managed by an executive committee composed of leads from CESD projects. In this town hall we present the overarching goals of this community-based cyberinfrastructure, highlight the roles and activities of each working group, and seek input from the broader community on identifying new activities and ensuring the development of a sustainable and impactful capability.

Monday, December 12, 2016 12:30–13:30
Moscone West 2008

Primary Contact:
Gerald L. Geernaert (U.S. Department of Energy)

Presenters:
John D. Moulton (Los Alamos National Laboratory)
David P. Lesmes (U.S. Department of Energy)

TH15A: Highlights from the SPRUCE Project: Initial Results From an Ecosystem-scale Warming and Elevated-CO_2 Manipulation in a Northern Peatland

Northern peatlands are vulnerable to climate change, yet responses have not been well characterized at the ecosystem scale. Spruce and Peatland Responses Under Climatic and Environmental Change (SPRUCE) is a decadal, ecosystem-scale experiment examining the vegetation, microorganism, and biogeochemical responses to warming and elevated CO_2. SPRUCE manipulations were initiated in June 2014 with isolated deep peat heating. In August 2015, aboveground warming was added to yield whole-ecosystem warming, and in June 2016, elevated CO_2 was added to half the warming treatments. This town hall will present initial SPRUCE results and will provide a forum for discussions between AGU members and SPRUCE researchers.

Monday, December 12, 2016 18:15–19:15
Moscone West 2018

Primary Contact:
Paul J. Hanson (Oak Ridge National Laboratory)

Presenters:
Jessica Gutknecht (University of Minnesota)
Paul J. Hanson (Oak Ridge National Laboratory)
Avni Malhotra (Oak Ridge National Laboratory)
Jeff Warren (Oak Ridge National Laboratory)
Natalie Griffiths (Oak Ridge National Laboratory)
Alison L. Gill (Boston University)
Kirsten S. Hofmockel (Pacific Northwest National Laboratory)
Xiaofeng Xu (San Diego State University)
Daniel M. Ricciuto (Oak Ridge National Laboratory)

Wednesday, December 14, 2016

TH33H: Toward an interagency collaborative modeling framework for multi-sector, multi-stressor, multi-scale impacts and adaptation analysis

Understanding the dynamics of coupled human-environmental systems in a multi-stressor world is coming into focus as a crucial area of societal need. Feedbacks and dynamic changes in one sector or system can affect others and lead to cascading failures/events. Advances in climate, impacts, and integrated assessment modeling provide opportunities for closer coupling of tools to explore interactions across scales—from regional to global—and infrastructure and systems linked through flows of food, materials, energy, water, and other resources. The US Global Change Research Program (USGCRP) is developing a coordinated approach and integrated modeling and analysis framework built around Integrated Assessment (IA), Impact Adaptation and Vulnerability (IAV), and Earth System (ES) Models. Such a framework can be tailored to questions, scales, and complexities for different uses/needs, offering a repository of modeling tools of varying complexity — from coarser grid, longer time-horizon to higher-resolution shorter-term models of socioeconomic systems, infrastructure, and natural resources. During the Town Hall, presentations will outline the needs, rationale, design, and paths forward, including regional and topical test beds. Results from a workshop and supporting technical activities will be discussed. Importantly, a panel of invited agency representatives, e.g., DOE, DHS, EPA, NASA, USDA, NSF, and USACE, will address Q&A's.

Wednesday, December 14, 2016 12:30–13:30
Moscone West 2005

Primary Contact:
Gerald L. Geernaert (U.S. Department of Energy)

Presenters:
Robert Vallario (U.S. Department of Energy)

Thursday, December 15, 2016

TH43C: Developing the 2nd State of the Carbon Cycle Report – Interagency engagement opportunities with the community

Led by the U.S. Carbon Cycle Science Program, the '2nd State of the Carbon Cycle Report (SOCCR-2)', an ongoing interagency USGCRP Sustained Assessment activity, focuses on U.S. and North American carbon cycle processes, stocks, and flows and associated climate change impacts in managed and unmanaged systems, including soils, oceans, rivers, wetlands, coasts/blue carbon, urban areas, agriculture and forestry. Featuring SOCCR-2 updates and relevant carbon management science perspectives and tools for supporting and informing decisions, as pertinent to the White House Climate Action Plan, U.S. Carbon Cycle Science Plan and National Climate Assessment, this public engagement activity will brainstorm next steps in the report development, review and production process, including outreach and dissemination ideas with the AGU community.

Thursday, December 15, 2016 12:30–13:30
Moscone West 2006

Primary Contact:
Gyami Shrestha (U.S. Carbon Cycle Science Program)

Presenters:
Nancy Cavallaro (U.S. Department of Agriculture)
Zhiliang Zhu (U.S. Geological Survey)
Daniel B. Stover (U.S. Department of Energy)
Kathy A. Hibbard (NASA Headquarters)

TH43G: Requirements for improving coordination of ice sheet observation and modeling-based activities

Current activities involving ice sheet observation, modeling, and model validation will be presented by U.S. federal agency managers and project scientists from DOE, NASA and NSF. Major efforts to date, remaining uncertainties, and future plans will be discussed. Scientists from glaciological, modeling, and polar-climate disciplines are encouraged to attend to aid in identifying present gaps and priorities for future research.

Thursday, December 15, 2016 12:30–13:30
Moscone West 2005

Primary Contact:
Gerald L. Geernaert (U.S. Department of Energy)

Presenters:
Dorothy M. Koch (U.S. Department of Energy)
Thomas Paul Wagner (NASA Headquarters)

TH43H: The AmeriFlux Network: Celebrating its 20th anniversary

2016 is the AmeriFlux Network's 20th anniversary. Since it was launched in 1996 with 15 sites, more than 200 sites have joined the network, linking ecosystem-flux and process studies across the Americas. The DOE AmeriFlux Management Project serves the flux sites and data users, enhancing data quality, measurements and synthesis. Join the town hall to hear news about the network, exchange ideas, learn about the FLUXNET2015 data release, and 20th anniversary activities like the journal special issue.

Thursday, December 15, 2016 12:30–13:30
Moscone West 2004

Primary Contact:
Sébastien Biraud (Lawrence Berkeley National Laboratory)

Presenters:
Sébastien Biraud (Lawrence Berkeley National Laboratory)

3 Sessions Organized

Friday, December 16, 2016

B51E: New Mechanisms, Feedbacks, and Approaches for Improving Predictions of Global Carbon Cycles in Earth System Models I Posters

Friday, December 16, 2016 08:00–12:20
Moscone South Posters 0449–0465

Swirl: Soils

Primary Convener:
Forrest M. Hoffman (Oak Ridge National Laboratory)

Co-conveners:
James T. Randerson (University of California Irvine)
Atul K. Jain (University of Illinois Urbana Champaign)
J. Keith Moore (University of California Irvine)

Chairs:
Forrest M. Hoffman (Oak Ridge National Laboratory)
J. Keith Moore (University of California Irvine)

Index Terms:
0428 Carbon cycling
0439 Ecosystems, structure and dynamics
1615 Biogeochemical cycles, processes, and modeling
1622 Earth system modeling

B54C: New Mechanisms, Feedbacks, and Approaches for Improving Predictions of Global Carbon Cycles in Earth System Models II

Friday, December 16, 2016 16:00–18:00
Moscone West 2006

Swirl: Soils

Primary Convener:
Forrest M. Hoffman (Oak Ridge National Laboratory)

Co-conveners:
James T. Randerson (University of California Irvine)
Atul K. Jain (University of Illinois Urbana Champaign)
J. Keith Moore (University of California Irvine)

Chairs:
Atul K. Jain (University of Illinois Urbana Champaign)
James T. Randerson (University of California Irvine)

Index Terms:
0428 Carbon cycling
0439 Ecosystems, structure and dynamics
1615 Biogeochemical cycles, processes, and modeling
1622 Earth system modeling

4 Presentation Abstracts

Monday, December 12, 2016

B11J-08: Understanding the representativeness of FLUXNET for upscaling carbon flux from eddy covariance measurements

Eddy covariance data from regional flux networks are direct in situ measurement of carbon, water, and energy fluxes and are of vital importance for understanding the spatio-temporal dynamics of the the global carbon cycle. FLUXNET links regional networks of eddy covariance sites across the globe to quantify the spatial and temporal variability of fluxes at regional to global scales and to detect emergent ecosystem properties. This study presents an assessment of the representativeness of FLUXNET based on the recently released FLUXNET2015 data set. We present a detailed high resolution analysis of the evolving representativeness of FLUXNET through time. Results provide quantitative insights into the extent that various biomes are sampled by the network of networks, the role of the spatial distribution of the sites on the network scale representativeness at any given time, and how that representativeness has changed through time due to changing operational status and data availability at sites in the network. To realize the full potential of FLUXNET observations for understanding emergent ecosystem properties at regional and global scales, we present an approach for upscaling eddy covariance measurements. Informed by the representativeness of observations at the flux sites in the network, the upscaled data reflects the spatio-temporal dynamics of the carbon cycle captured by the in situ measurements. This study presents a method for optimal use of the rich point measurements from FLUXNET to derive an understanding of upscaled carbon fluxes, which can be routinely updated as new data become available, and direct network expansion by identifying regions poorly sampled by the current network.

Monday, December 12, 2016 09:45–10:00
Moscone West 2004

Authors:
Jitendra Kumar (Oak Ridge National Laboratory)
Forrest M. Hoffman (Oak Ridge National Laboratory)
William W. Hargrove (USDA Forest Service)
Nathan Collier (Oak Ridge National Laboratory)

GC12A-08: The effect of atmospheric sulfate reductions on diffuse radiation and photosynthesis in the eastern United States

Aerosol optical depth (AOD) has been shown to influence ecosystem carbon uptake by increasing the fraction of diffuse light, which increases photosynthesis over a greater fraction of the vegetated canopy. Several modeling studies have hypothesized that this effect may be a significant driver of the historical terrestrial carbon sink, and may therefore be an important climate feedback associated with changing air quality. In this study, we quantify the impact of anthropogenic aerosols on gross primary production (GPP) in the eastern United States. We focus on the eastern U.S. because 1) rapid decreases in SO_2 emissions over the past two decades create an opportunity to examine the effects of reduced SO_4 mass and aerosol optical depth; 2) SO_2 emissions in the United States have been well quantified; 3) carbon fluxes within temperate ecosystems in the eastern United States have been well observed. We use accurate SO_2 emission data for 1995–2013 in the Community Earth System Model (CESM) to determine trends in AOD, surface radiation, and photosynthesis.

Between 1995 and 2013, U.S. SO_2 emissions declined by over 70%, coinciding with observed AOD reductions of $3.0 \pm 0.6\%\,y^{-1}$ over the eastern U.S. In the Community Earth System Model (CESM), these trends cause diffuse light to decrease regionally by almost $0.6\%\,y^{-1}$, leading to declines GPP of $0.07\%\,y^{-1}$. Integrated over the analysis period and domain, this represents 0.5 Pg C of omitted GPP. A separate upscaling calculation that used published relationships between GPP and diffuse light agreed with the CESM model results within 20%. The agreement between simulated and data-constrained upscaling results strongly suggests that anthropogenic sulfate trends have a small impact on carbon uptake in temperate forests due to scattered light.

Monday, December 12, 2016 12:05–12:20
Moscone West 2020

Authors:
Gretchen Keppel-Aleks (University of Michigan Ann Arbor)
Rebecca A. Washenfelder (NOAA Boulder)

B13C-0599: The contribution of particulate carbon to arctic rivers from river bank erosion of floodplains

Rivers actively exchange sediment and particulate carbon with floodplains. Carbon is exported from rivers to floodplains by lateral accretion as channels migrate and by overbank deposition during flood events. Sediment and carbon may enter rivers through the erosion of the floodplain surface but the dominant flux results from the lateral erosion of river banks. Fluxes of particulate carbon and sediment measured at river mouths quantify the integrated results of land-river exchanges throughout the watershed upstream. These measurements, however, provide limited insight on magnitude of exchanges occurring between rivers and floodplains above their deltas. Using the most extensive analysis of arctic river bank erosion rates assembled to date, we estimate the flux of particulate carbon from floodplains into rivers across the Arctic. We used remotely sensed imagery to quantify floodplain erosion and accretion rates of approximately 4,000 km of 10 arctic rivers. The rivers range in drainage area from 12,000 to 2.5 million km^2 and cover regions of discontinuous to continuous permafrost. We use the results of these 10 rivers to develop a statistical model for river bank erosion based on basin size, river slope, climatology, and permafrost extent. Using this model, we estimate erosion rates for segments of other major arctic rivers with detectable floodplains. These area-based erosion estimates are then multiplied by estimates of soil organic carbon content in the upper 3 m of arctic floodplains. Preliminary results suggest that arctic-wide tens of terragrams (Tg) of particulate carbon enter rivers from floodplains annually. Comparison of fluxes on individual rivers to POC measured just upstream of deltas suggest that inputs of floodplain soil carbon equal or exceed the amount reaching the ocean. The fate of the carbon entering rivers is presently unknown, a fraction of it may reach the ocean while the rest may either be lost to the atmosphere in-stream or it may be redeposited onto the floodplain downstream of where it was eroded.

Monday, December 12, 2016 13:40–18:00
Moscone South Poster 0599

Authors:
Joel C. Rowland (Los Alamos National Laboratory)
Jordan D. Muss (Los Alamos National Laboratory)
Eitan Shelef (University of Pittsburgh)
Sophie J. Stauffer (Los Alamos National Laboratory)

Umakant Mishra (Argonne National Laboratory)
Nicholas A. Sutfin (Los Alamos National Laboratory)

B13D-0624: Soil moisture drives microbial controls on carbon decomposition in two subtropical forests

Soil microbes play a dominant role in soil carbon (C) cycling. However, the temporal variations in microbes influenced by environmental conditions (e.g. soil temperature and moisture) are not adequately modelled owing to limited available microbial observations and the lack of model parameterization against data beyond the laboratory scale, which constrains our understanding of the trend for soil C sink under climate change. Here we incorporated soil moisture responses into the Microbial-ENzyme Decomposition (MEND) model and parameterized MEND against the observed heterotrophic respiration (R_H) and microbial biomass C (MBC) from a three-year field experiment in a young pine forest (PF) and an old-growth broadleaf forest (BF) in subtropics. The observed variability in R_H and MBC were well simulated by the MEND model. Both R_H and MBC in the two forests were more sensitive to soil moisture than temperature, and the R_H in BF was more susceptible to soil moisture than that in PF. The R_H increased to a larger extent in the wet season by inducing a greater active fraction of microbial biomass in BF than PF. Our results suggest that soil microbes and C in the old-growth forest would be more vulnerable than the young forest under a drought-prone environment.

Monday, December 12, 2016 13:40–18:00
Moscone South Poster 0624

Authors:
Gangsheng Wang (Oak Ridge National Laboratory)
Wenjuan Huang (Iowa State University)
Guoyi Zhou (South China Botanical Garden, Chinese Academy of Sciences)
Melanie A. Mayes (Oak Ridge National Laboratory)

B14C-01: Integrating statistical and expert knowledge to develop phenoregions for the Continental United States (Invited)

Vegetated ecosystems exhibit unique phenological behavior over the course of a year, suggesting that remotely sensed land surface phenology may be useful for characterizing land cover and ecoregions. However, phenology is also strongly influenced by temperature and water stress; insect, fire, and weather disturbances; and climate change over seasonal, interannual, decadal and longer time scales. Normalized difference vegetation index (NDVI), a remotely sensed measure of greenness, provides a useful proxy for land surface phenology. We used NDVI for the conterminous United States (CONUS) derived from the Moderate Resolution Spectroradiometer (MODIS) every eight days at 250 m resolution for the period 2000–2015 to develop phenological signatures of emergent ecological regimes called phenoregions. We employed a "Big Data" classification approach on a supercomputer, specifically applying an unsupervised data mining technique, to this large collection of NDVI measurements to develop annual maps of phenoregions. This technique produces a prescribed number of prototypical phenological states to which every location belongs in any year. To reduce the impact of short-term disturbances, we derived a single map of the mode of annual phenological states for the CONUS, assigning each map cell to the state with the largest integrated NDVI in cases where multiple states tie for the highest frequency of occurrence. Since the data mining technique is unsupervised, individual phenoregions are not associated with an ecologically understandable label. To add automated supervision to the process, we applied the method of Mapcurves, developed by Hargrove and Hoffman, to associate individual phenoregions with labeled polygons in expert-derived maps of biomes, land cover, and ecoregions. We will present the phenoregions methodology and resulting maps for the CONUS, describe the “label-stealing” technique for ascribing biome characteristics to phenoregions, and introduce a new polar plotting scheme for processing NDVI data by localized seasonality.

Monday, December 12, 2016 16:05–16:25
Moscone West 2004

Authors:
Forrest M. Hoffman (Oak Ridge National Laboratory)
Jitendra Kumar (Oak Ridge National Laboratory)
William W. Hargrove (USDA Forest Service)
Steven P. Norman (USDA Forest Service)
Bjørn-Gustaf J. Brooks (USDA Forest Service)

Tuesday, December 13, 2016

B21I-0538: Changes in belowground C that accompany ecosystem shifts: An approach to constraining depth, timing, and magnitudes of soil change

Emerging databases for soil profiles offer an approach for exploring changes in belowground C that accompany ecosystem shifts. We used steady state models, soil data for bulk and fractionated soil stocks, and radiocarbon data to calculate changes in soil C based on measurements from detrital (free light), aggregate-bound (occluded) and mineral associated (complexed or chemically bound) carbon pools and for bulk soil at incremental soil depths. We explored a space-for-time sequence of increasingly warmer soils from Alaskan Black Spruce permafrost (Gelisols; Mean Annual Temperature at 50 cm depth −1.5°C), Alaskan Black Spruce non permafrost (Inceptisols; MAT at 50 cm +3°C), and Iowa Prairie (Mollisols; MAT at 50 cm +9°C) developed on similar geologic substrates (loess). These temperature ranges were also representative of 50 cm temperatures from model output by CLM for Yr 2014, Yr 2100, and Yr 2300 for Interior Alaska. The space-for-time concept assumes that the soil will step instantaneously from one ecosystem state to another, with adjustments of input and loss captured by steady state models. Fitting an exponential equation to depth trends in soil C within 2 m depths and exploring model output of these fits, we found that e-folding depths were related to depths of rooting and changes in bulk density. The direction and magnitude of the C loss or gain was dictated by the C stocks of initial and final ecosystems. The timing of the loss/gain was dictated by the distribution and turnover time of C in the fractions. Thawing from Gelisol to Inceptisol in loess parent materials resulted in only very small net changes to soil C over 100 years, reflecting both loss of detrital and gain into occluded C forms. Further warming and shifts to the Mollisol resulted in net increases (CO_2 sink) , mainly to the detrital C pool from deep roots. These methods enable analysis of large datasets where depth profiles of soil report bulk density, organic C, and have some data or proxy information on C fractions, their turnover times. Without fraction data, these methods provide constraints for changes in belowground net C stocks upon ecosystem shifts, but the timing of changes must be constrained by other methods or assumptions.

Tuesday, December 13, 2016 08:00–12:20
Moscone South Poster 0538

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C22B-01: Permafrost in Earth System Models: Recent Progress and Future Challenges (Invited)

Permafrost is a crucial component of the Earth system, representing a key intersection point of soil physical and carbon cycle dynamics, yet has been poorly represented in Earth system models. None of the ESMs of the CMIP5 generation included permafrost carbon dynamics, and many had poor representation of soil thermal dynamics. Subsequent to CMIP5, a number of key improvements have been made to address these shortcomings, including strategies for including permafrost carbon dynamics in models, as well as methods and datasets for benchmarking both the physical and biogeochemical components of the models. I will discuss recent progress and outstanding challenges that remain in understanding and quantifying the role that permafrost soils may play as feedback agents in the Earth system.

Tuesday, December 13, 2016 10:20–10:35
Moscone West 3005

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GC22A-08: Enhancing the global carbon sink: A key mitigation strategy

Earth's terrestrial ecosystems absorb about one-third of all anthropogenic CO_2 emissions from the atmosphere each year, greatly reducing the climate forcing those emissions would otherwise cause. This puts the size of the terrestrial carbon sink on par with the most aggressive climate mitigation measures proposed. Moreover, the land sink has been keeping pace with rising emissions and has roughly doubled over the past 40 years. But there is a fundamental lack of understanding of why the sink has been increasing and what its future trajectory could be. In developing climate mitigation strategies, governments have a very limited scientific basis for projecting the contributions of their domestic sinks, and yet at least 117 of the 160 COP21 signatories stated they will use the land sink in their Nationally Defined Contribution (NDC). Given its potentially critical role in reducing net emissions and the importance of UNFCCC land sinks in future mitigation scenarios, a first-principles understanding of the dynamics of the land sink is needed.

For expansion of the sink, new approaches and ecologically-sound technologies are needed. Carefully conceived terrestrial carbon sequestration could have multiple environmental benefits, but a massive expansion of land carbon sinks using conventional approaches could place excessive demands on the world's land, water, and fertilizer nutrients. Meanwhile, rapid climatic change threatens to undermine or reverse the sink in many ecosystems. We need approaches to protect the large sinks that are currently assumed useful for climate mitigation. Thus we highlight the need for a new research agenda aimed at predicting, protecting, and enhancing the global carbon sink. Key aspects of this agenda include building a predictive capability founded on observations, theory and models, and developing ecological approaches and technologies that are sustainable and scalable, and potentially provide co-benefits such as healthier soils, more resilient and productive ecosystems, and more carbon-neutral bioenergy. Better scientific understanding of the sink provides more options for policy design, enables mitigation strategies that capture co-benefits, and increases the chances that global mitigation commitments will be met.

Tuesday, December 13, 2016 11:50–12:05
Moscone West 3003

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and others

C22B-08: Snow in Earth system models: Recent progress and future challenges (Invited)

Snow is the most variable of terrestrial boundary conditions. Some 50 million km^2 of the Northern Hemisphere typically sees periods of accumulation and ablation in the annual cycle. The wonderous properties of snow, such as high albedo, thermal insulation and its ability to act as a water store make it an integral part of the global climate system. Earliest inclusions of snow within climate models were simple adjustments to albedo and a moisture store. Modern Earth Syetem Models now represent snow through a myriad of model architectures and parameterizations that span a broad range of complexity. Understanding the impacts of modeling decisions upon simulation of snow and other Earth System components (either directly or via feedbacks) is an ongoing area of research. Snow models are progressing with multi-layer representations and capabilities such as complex albedo schemes that include contaminants. While considerable advances have been made, numerous challenges also remain. Simply getting a grasp on the mass of snow (seasonal or permanent) has proved more difficult than expected over the past 30 years. Snow interactions with vegetation has improved but the details of vegetation masking and emergence are still limited. Inclusion of blowing snow processes, in terms of transport and sublimation, is typically rare and sublimation remains a difficult quantity to measure. Contemplation of snow crystal form within models and integration with radiative transfer schemes for better understanding of full spectrum interations (from UV to long microwave) may simultaneously advance simulation and remote sensing. A series of international modeling experiments and directed field campaigns are planned in the near future with the aim of pushing our knowledge forward.

Tuesday, December 13, 2016 12:05–12:20
Moscone West 3005

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T23C-2953: Scalable algorithms for clustering large geospatiotemporal data sets on Manycore architectures

The increasing availability of high-resolution geospatiotemporal data sets from sources such as observatory networks, remote sensing platforms, and computational Earth system models has opened new possibilities for knowledge discovery using data sets fused from disparate sources. Traditional algorithms and computing platforms are impractical for the analysis and synthesis of data sets of this size; however, new algorithmic approaches that can effectively utilize the complex memory hierarchies and the extremely high levels of available parallelism in state-of-the-art high-performance computing platforms can enable such analysis. We describe a massively parallel implementation of accelerated k-means clustering and some optimizations to boost computational intensity and utilization of wide SIMD lanes on state-of-the art multi- and manycore processors, including the second-generation Intel Xeon Phi ("Knights Landing") processor based on the Intel Many Integrated Core (MIC) architecture, which includes several new features, including an on-package high-bandwidth memory. We also analyze the code in the context of a few practical applications to the analysis of climatic and remotely-sensed vegetation phenology data sets, and speculate on some of the new applications that such scalable analysis methods may enable.

Tuesday, December 13, 2016 13:40–18:00
Moscone South Poster 2953

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B23I-01: Soil organic matter (de)stabilization — New experiments needed to inform soil biogeochemistry modules in Earth system models (Invited)

To better predict soil carbon climate feedbacks, the next generation of soil biogeochemistry modules in Earth System Models (ESMs) demand new types of experiments, and a more appropriate use of existing observations. For example, we highlight soil incubations and how they have been misinterpreted when inferring pseudo-first order turnover times and decomposition temperature and moisture sensitivities. Further, for existing pseudo first-order modules, and the new microbial- and mineral-explicit generation of biogeochemistry modules, there is often a mismatch between temporal and spatial observations and how they are used by modelers.
Observation periods should be longer, from annual to decadal, and include transitions, e.g., induced by climate or management. Key observations to better structure and parameterize processes that are important for carbon-climate feedbacks include i) mineral surface interactions, ii) microbial dynamics and activity, including effects of soil temperature and moisture, iii) erosion and export, iv) landscape scale process heterogeneity, and v) the effect of land use change, such as clear cut and changes in tillage. Recent insights and knowledge gaps from traditionally disconnected scientific

fields (such as geophysical modeling, agricultural soil science, geomorphology, and soil biogeochemistry) will be discussed in the context of informing ESM-scale terrestrial biogeochemistry models.

Tuesday, December 13, 2016 13:40–13:55
Moscone West 2006

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GC23K-17: The future of the North American carbon cycle — Projections and associated climate change

Approximately half of anthropogenic emissions from the burning of fossil fuels is taken up annually by carbon sinks on the land and in the oceans. However, there are key uncertainties in how carbon uptake by terrestrial, ocean, and freshwater systems will respond to, and interact with, climate into the future. Here, we outline the current state of understanding on the future carbon budget of these major reservoirs within North America and the globe. We examine the drivers of future carbon cycle changes, including carbon–climate feedbacks, atmospheric composition, nutrient availability, and human activity and management decisions. Progress has been made at identifying vulnerabilities in carbon pools, including high-latitude permafrost, peatlands, freshwater and coastal wetlands, and ecosystems subject to disturbance events, such as insects, fire and drought. However, many of these processes/pools are not well represented in current models, and model intercomparison studies have shown a range in carbon cycle response to factors such as climate and CO_2 fertilization. Furthermore, as model complexity increases, understanding the drivers of model spread becomes increasingly more difficult. As a result, uncertainties in future carbon cycle projections are large. It is also uncertain how management decisions and policies will impact future carbon stocks and flows. In order to guide policy, a better understanding of the risk and magnitude of North American carbon cycle changes is needed. This requires that future carbon cycle projections be conditioned on current observations and be reported with sufficient confidence and fully specified uncertainties.

Tuesday, December 13, 2016 15:15–15:21
Moscone West 3007

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GC24B-01: The Land Use Model Intercomparison Project (LUMIP) contribution to CMIP6: Rationale and experimental design

Human land-use activities have resulted in large changes to the Earth surface, with resulting implications for climate. The Land Use Model Intercomparison Project (LUMIP) aims to further advance understanding of the impacts of land-use and land-cover change (LULCC) on climate, specifically addressing the questions: (1) What are the effects of LULCC on climate and biogeochemical cycling (past-future)? (2) What are the impacts of land management on surface fluxes of carbon, water, and energy and (3) Are there regional land-management strategies with promise to help mitigate against climate change? LUMIP will also address a range of more detailed science questions to get at process-level attribution, uncertainty, data requirements, and other related issues in more depth and sophistication than possible in a multi-model context to date. Foci will include separation and quantification of the effects on climate from LULCC relative to all forcings, separation of biogeochemical from biogeophysical effects of land-use, the unique impacts of land-cover change versus land management change, modulation of land-use impact on climate by land-atmosphere coupling strength, and the extent that CO_2 fertilization is modulated by past and future land use. LUMIP involves three sets of activities: (1) development of an updated and expanded historical and future land-use dataset, (2) an experimental protocol for LUMIP experiments, and (3) definition of metrics that quantify model performance with respect to LULCC. LUMIP experiments are designed to be complementary to simulations requested in the CMIP6 DECK and historical simulations and other CMIP6 MIPs including ScenarioMIP, C4MIP, LS3MIP, and DAMIP. LUMIP includes idealized coupled and land-only model simulations designed to advance process-level understanding of LULCC impacts on climate. LUMIP also includes simulations that allow quantification of the historic impact of land use and the potential for future land management decisions to aid in mitigation of climate change. We will present the experimental protocol in detail, explain the rationale, outlines plans for analysis, and describe a new subgrid land-use tile data request for selected variables (reporting model output data separately for primary and secondary land, crops, pasture, and urban land-use types).

Tuesday, December 13, 2016 16:00–16:15
Moscone West 3001

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Wednesday, December 14, 2016

B31G-0550: Separating the effects of tropical Atlantic and Pacific SST-driven climate variability on Amazon carbon exchange

Amazon forests store an estimated 25% percent of global terrestrial carbon per year, but the responses of Amazon carbon uptake to climate change is highly uncertain. One source of this uncertainty is tropical sea surface temperature variability driven by teleconnections. El Niño-Southern Oscillation (ENSO) is a key driver of year-to-year Amazon carbon exchange, with associated temperature and precipitation changes favoring net carbon storage in La Niña years, and net carbon release during El Niño years.
To determine how Amazon climate and terrestrial carbon fluxes react to ENSO alone and in concert with other SST-driven teleconnections such as the Atlantic Multidecadal Oscillation (AMO), we force the atmosphere (CAM5) and land (CLM4) components of the CESM(BGC) with prescribed monthly SSTs over the period 1950–2014 in a Historical control simulation. We then run an experiment (PAC) with time-varying SSTs applied only to the tropical equatorial Pacific Ocean, and repeating SST seasonal cycle climatologies elsewhere.
Limiting SST variability to the equatorial Pacific indicates that other processes enhance ENSO-driven Amazon climate anomalies. Compared to the Historical control simulation, warming, drying and terrestrial carbon loss over the Amazon during El Niño periods are lower in the PAC simulation, especially prior to 1990 during the cool phase of the AMO. Cooling, moistening, and net carbon uptake during La Niña periods are also reduced in the PAC simulation, but differences are greater after 1990 during the warm phase of the AMO. By quantifying the relationships among climate drivers and carbon fluxes in the Historical and PAC simulations, we both assess the sensitivity of these relationships to the magnitude of ENSO forcing and quantify how other teleconnections affect ENSO-driven Amazon climate feedbacks. We expect that these results will help us improve hypotheses for how Atlantic and Pacific climate trends will affect future Amazon carbon carbon cycling.

Wednesday, December 14, 2016 08:00–12:20
Moscone South Poster 0550

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GC31F-1154: Non-robust numerical implementations impact global carbon and water cycle simulations: a demonstration with two ESM land models

Numerically robust land modeling is essential for making good predictions of climate change, yet sufficient attention is still due to the quality of numerical methods in land modules of Earth System Models (ESMs). Using CLM (Community Land Model) and ALM (ACME land model), we show through examples that the "popular" sequential coupling approach (SCA) can lead to large predictive errors due to numerically generated pseudo physics. The first example is about the coupling between water movement in roots and soil for simulating the hydraulic root redistribution in CLM. The SCA obtained better simulation of evapotranspiration (ET) at the Blodget Forest site in California as compared to that from the tight coupling approach (TCA) and the two performed equally well for simulating ET at the Tapajos Forest site in Amazon. This result may mislead one to assert that the SCA should be preferred for calibration and prediction. However, SCA led to extreme time step size sensitivity, whereas TCA did not. In global simulations, SCA overestimated ET by as much as 3.5 $\mathrm{mm\,d^{-1}}$ in some tropical sites, suggesting large land-atmosphere feedbacks could

be triggered due to numerical error. The second example focused on the coupling between carbon and nitrogen dynamics in ALM. SCA assumed that the newly mineralized nitrogen is not available for plant and microbe uptake until the next numerical time step. In both site and global simulations, SCA resulted in larger nitrification rates and ecosystem nitrogen losses as compared to those from TCA that tightly couples nitrogen mineralizers and immobilizers. In particular, for long-term simulations driven by the RCP8.5 atmospheric CO_2 trajectory, SCA overestimated (compared to the tight coupling approach) global land-atmosphere CO_2 exchange by as much as 440 ppmv CO_2 equivalent over 300 years. Further considering uncertainty in initial conditions led to a difference as large as 890 ppmv CO_2 equivalent. These differences are as large as that across the CMIP5 model predictions, suggesting that land model developers need to pay as much attention to the numerical implementation of processes as they do to model structure and parametrizations.

Wednesday, December 14, 2016 08:00–12:20
Moscone South Poster 1154

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GC31F-1155: Uncertainty quantification of extratropical forest biomass in CMIP5 models over the Northern Hemisphere

Simplified representations of processes driving global forest biomass in Earth system models contribute to large uncertainty and variability among climate predictions, in particular for the simulations of biomass magnitude, allocation, and the responses of biomass to changing climatic conditions. In this study, we evaluated forest biomass from the historical runs of eight coupled Earth system models in the Coupled Model Intercomparison Project Phase 5 (CMIP5) archive, using a recent data product synthesized from remote sensing and ground-based observations across northern extratropical latitudes (30°N–80°N). Compared to this data product, all models excluding two Hadley Centre's models overpredicted global forest biomass in wood by $166\% \pm 153\%$ whereas biomass in roots was underestimated by $-82\% \mp 2\%$ in all models except the IPSL models ($133\% \pm 46\%$). In addition, the IPSL models had the largest biases in total forest carbon mass estimates ($154\% \pm 51\%$), which was attributed mainly to the overestimated wood component ($163\% \pm 56\%$). Nevertheless, the allocation of modeled forest biomass in roots (21%) and in wood (76%–77%) found in the IPSL models was more consistent with observations (22% for roots and 73% for wood). Our results also demonstrated that both observed and modeled forest biomass was positively correlated with precipitation variations in most regions, while surface temperature was as important as precipitation at higher latitudes. Moreover, small differences in forest biomass between the pre-industrial period and the modern time period implied that the biases in forest biomass may have been introduced at the beginning of the simulations. Our work suggests that caution should be exercised for (1) allocating carbon mass to forest components, (2) apportioning vegetation types within modeled gridcells, and (3) reducing the uncertainty in vegetation inputs for Earth system models with correct vegetation parameterizations during the spin-up processes.

Wednesday, December 14, 2016 08:00–12:20
Moscone South Poster 1155

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B32C-04: Human-induced greening of the northern extratropical land surface

Significant land greening in the northern extratropical latitudes (NEL) has been documented through satellite observations during the past three decades. This enhanced vegetation growth has broad implications for surface energy, water and carbon budgets, and ecosystem services across multiple scales. Discernible human impacts on the Earth's climate system have been revealed by using statistical frameworks of detection–attribution. These impacts, however, were not previously identified on the NEL greening signal, owing to the lack of long-term observational records, possible bias of satellite data, different algorithms used to calculate vegetation greenness, and the lack of suitable simulations from coupled Earth system models (ESMs). Here we have overcome these challenges to attribute recent changes in NEL vegetation activity. We used two 30-year-long remote-sensing-based leaf area index (LAI) data sets, simulations from 19 coupled ESMs with interactive vegetation, and a formal detection and attribution algorithm. Our findings reveal that the observed greening record is consistent with an assumption of anthropogenic forcings, where greenhouse gases play a dominant role, but is not consistent with simulations that include only natural forcings and internal climate variability. These results provide the first clear evidence of a discernible human fingerprint on physiological vegetation changes other than phenology and range shifts.

Wednesday, December 14, 2016 11:05–11:20
Moscone West 2008

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B32E-06: Quantifying environmental controls on stocks, uncertainties, and scaling of soil organic carbon (Invited)

Large uncertainties exist in estimating equilibrium soil carbon storage and predicting its future change at regional and global scales. Several efforts are being made to investigate environmental controls of soil organic carbon (SOC) storage, its uncertainties, and scaling behavior. We used soil observations, secondary information of soil-forming factors (climate, topography, land cover types, and surficial geology), and geospatial approaches to predict the spatial heterogeneity of SOC stocks and its uncertainties (95% confidence intervals) across State of Alaska, USA. We also investigated how these soil-forming factors control the scaling behavior of SOC stocks. Our results showed non-stationary environmental controls on SOC stocks across the study area. Among the investigated variables, land cover showed most heterogeneous and elevation showed least heterogeneous control on SOC stocks. The magnitude of uncertainties varied across space. Spatial predictions of SOC stocks were least uncertain in Coastal Rain Forests, and most uncertain in Bering Tundra ecoregions. We found different environmental factors to be statistically significant predictors of SOC stocks at different spatial scales. Among the investigated factors, only elevation, temperature, potential evapotranspiration, and land cover were significant predictors at all investigated scales (50 m to 10 km). The strengths of control of these four environmental variables on SOC stocks decreased with increasing scale, and were accurately represented using mathematical functions ($R^2 = 0.83$–0.97). Our findings can inform towards improving understanding of large scale SOC dynamics, quantifying uncertainties in observations, and representing observed spatial heterogeneity of SOC in large scale models.

Wednesday, December 14, 2016 11:35–11:50
Moscone West 2006

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B32C-07: Greening of the Earth and its drivers

Global environmental change is rapidly altering the dynamics of terrestrial vegetation with consequences for the functioning of the Earth system and provision of ecosystem services. Yet how global vegetation is responding to the changing environment is not well established. Here we use 3 long-term satellite leaf area index (LAI) records and 10 global ecosystem models to investigate four key drivers of LAI trends during 1982–2009. We show a persistent and widespread increase of growing season integrated LAI (greening) over 25 to 50% of the global vegetated area, whereas less than 4% of the globe shows decreasing LAI (browning). Factorial simulations with multiple global ecosystem models suggest that CO_2 fertilization effects explain 70% of the observed greening trend, followed by nitrogen deposition (9%), climate change (8%) and land cover change (LCC) (4%). CO_2 fertilization effects explain most of the greening trends in the tropics, while climate change resulted in greening of the high latitudes and the Tibetan Plateau. LCC contributed most to the regional greening observed in Southeast China and Eastern United States. The regional effects of unexplained factors suggest that the next generation of ecosystem models will need to explore the impacts of forest demography, differences in regional management intensities for cropland and pastures, and other emerging productivity constrains such as phosphorus availability.

Wednesday, December 14, 2016 11:50–12:05
Moscone West 2008

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B33E-0657: Redefining plant functional types for forests based on plant traits

Our ability to predict forest mortality is limited by the simple plant functional types (PFTs) in current generations of Earth System models (ESMs). For example, forests were formerly separated into PFTs only based on leaf form and phenology across different regions (arctic, temperate, and tropic areas) in the Community Earth System Model (CESM). This definition of PFTs ignored the large variation in vulnerability of species to drought and shade tolerance within each PFT. We redefined the PFTs for global forests based on plant traits including phenology, wood density, leaf mass per area, xylem-specific conductivity, and xylem pressure at 50% loss of conductivity. Species with similar survival strategies were grouped into the same PFT. New PFTs highlighted variation in vulnerability and physiological adaptation to drought and shade. New PFTs were better clustered than old ones in the two-dimensional plane of the first two principle components in a principle component analysis. We expect that the new PFTs will strengthen ESMs' ability on predicting drought-induced mortality in the future.

Wednesday, December 14, 2016 13:40–18:00
Moscone South Poster 0657

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B33E-0658: Constraining the Q_{10} of respiration in water-limited environments

If the current rate of greenhouse emissions remains constant over the next few decades, projections of climate change forecast increased atmospheric temperatures by a least 1.1°C by the end of the century. Warmer temperatures are expected to largely influence the exchange of energy, carbon and water between plants and the atmosphere. Several studies support that terrestrial ecosystems currently act as a major carbon sink, however warmer temperatures may amplify respiration processes and shift terrestrial ecosystems from a sink to a source of carbon in the future. Most Earth System Models incorporate the temperature dependence of plant respiration (Q_{10}) to estimate and predict respiration processes and associated carbon fluxes. Using a temperature and precipitation manipulation experiment in natural conditions, we present evidence that this parameter is poorly constrained especially in water-limited environments. We discuss the utility of the Q_{10} framework and suggest improvements for this parameter along with trait-based approaches to better resolve models.

Wednesday, December 14, 2016 13:40–18:00
Moscone South Poster 0658

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B33E-0669: Leaf structural acclimation amplifies simulated climate warming in response to elevated carbon dioxide

Many plants undergo structural acclimations, or changes in trait morphology, in response to elevated carbon dioxide in field and greenhouse manipulation experiments. These structural acclimations can alter plant functioning — changes in which, taken at the global scale, have been shown to dramatically impact climate. Vegetation modifies Earth's climate by controlling the fluxes of carbon, water, and energy. Of critical importance is a better understanding of how vegetation responses to climate change will feedback on climate. Yet, the climate impacts of plant structural acclimation remain to be tested and quantified. Here we show that one plant structural acclimation — a one third increase in leaf mass per area in response to elevated carbon dioxide in C3 plants globally — significantly impacts climate in Earth system model experiments. Consideration of leaf structural acclimation decreases global net primary productivity (−6 Pg C/yr) compared to the control

climate change simulation, representing a flux of carbon dioxide to the atmosphere of similar magnitude to current annual fossil fuel emissions (8 Pg C/yr). Additional terrestrial warming (+0.3°C globally), especially of the northern extratropics (+0.4°C), results from reduced evapotranspiration and enhanced absorption of solar radiation at the surface. Structural acclimation drives the productivity and evapotranspiration declines by decreasing the leaf area growth associated with carbon fertilization, as greater leaf mass per area increases the cost of building leaf area and productivity fails to fully compensate. Our results suggest that plant structural acclimations, such as leaf mass per area, should be considered in climate projections and provide additional motivation for ecological and physiological experiments that determine plant responses to environment.

Wednesday, December 14, 2016 13:40–18:00
Moscone South Poster 0669

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B34C-01: Amazon storm-driven tree mortality (Invited)

While intrinsic factors such as tree competition and soil nutrients have commonly been proposed to explain the observed patterns of tree mortality in Amazonia, we show in this study that windthrows act as important exogenous contributors to those observed patterns. Windthrows are more frequent in areas with no dry season, but are spatially and temporally variable across the basin. Regionally, Northwestern Amazonia (NWA) is more vulnerable to windthrows than Central Amazonia (CA). More frequent and severe convective storms in combination with soil characteristics in NWA may explain this vulnerability. In a demographic model using observed rates of tree mortality of 1% in CA and ∼2% in NWA, we confirmed higher productivity but lower biomass in NWA compared to CA, primarily through forest composition and higher disturbance. Over the next century, projected increases in extreme rainfall events may produce a dramatic increase in windthrows across the basin. Our modeling results suggest that species composition in CA is more sensitive to a doubling of mortality rates than in NWA, leading to a larger decrease in biomass in CA. Our study emphasizes the importance of including exogenous factors in model simulations for reliable predictions of the carbon cycle.

Wednesday, December 14, 2016 16:00–16:12
Moscone West 2004

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Thursday, December 15, 2016

B41G-0527: Attribution of disturbances causing tree mortality for the Continental U.S.

Broad-scale tree mortality has been frequently reported and documented to increase with warming climate and human activities. However, there is so far no general method to quantify the relative contributions of different disturbances on observed broad-scale tree mortality. In this study, we presented a framework to investigate the contribution of various disturbances causing tree mortality for 2000–2014 in the continental US. Our work is based on the high-resolution forest-loss data developed by Hansen et al. (2013). Firstly, fire-driven mortality was determined using the data from Monitoring Trends in Burn Severity (MTBS) project. Secondly, a landscape-pattern-recognition approach focusing on the differences of boundary complexity caused by natural and anthropogenic disturbances was developed to attribute harvest-driven mortality patches. Then, a drought threshold was determined through conducting an intensive literature survey for attribution of drought-driven mortality. Our results showed that we can correctly attribute 85% harvest-driven mortality as compared to Forest Inventory and Analysis (FIA) data. Based on Evaporative Stress Index (ESI), our literature survey suggests that most mortality events happened at extreme drought (37.7%), then severe (31.4%) and moderate (23.4%) drought. In total, 92.6% of drought-induced mortality events observed during 2000–2014 occurred at drought conditions of moderate or worse with corresponding ESI values ranging from $-0.9 \sim -2.49$. Therefore, -0.9 will be used as the threshold to attribute drought-driven tree mortality. Overall, these results imply a great potential for using these methods to identify and attribute disturbances driving tree death at broad spatial scales.

Thursday, December 15, 2016 08:00–12:20
Moscone South Poster 0527

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GC41B-1087: Vegetation–rainfall feedbacks across the Sahel: A combined observational and modeling study

The Sahel rainfall is characterized by large interannual variability. Past modeling studies have concluded that the Sahel rainfall variability is primarily driven by oceanic forcings and amplified by land–atmosphere interactions. However, the relative importance of oceanic versus terrestrial drivers has never been assessed from observations. The current understanding of vegetation's impacts on climate, i.e. positive vegetation–rainfall feedback through the albedo, moisture, and momentum mechanisms, comes from untested models. Neither the positive vegetation–rainfall feedback, nor the underlying mechanisms, has been fully resolved in observations.

The current study fills the knowledge gap about the observed vegetation–rainfall feedbacks, through the application of the multivariate statistical method Generalized Equilibrium Feedback Assessment (GEFA) to observational data. According to GEFA, the observed oceanic impacts dominate over terrestrial impacts on Sahel rainfall, except in the post-monsoon period. Positive leaf area index (LAI) anomalies favor an extended, wetter monsoon across the Sahel, largely due to moisture recycling. The albedo mechanism is not responsible for this positive vegetation feedback on the seasonal–interannual time scale, which is too short for a grass–desert transition. A low-level stabilization and subsidence is observed in response to increased LAI — potentially responsible for a negative vegetation–rainfall feedback. However, the positive moisture feedback overwhelms the negative momentum feedback, resulting in an observed positive vegetation–rainfall feedback.

We further applied GEFA to a fully-coupled Community Earth System Model (CESM) control run, as an example of evaluating climate models against the GEFA-based observational benchmark. In contrast to the observed positive vegetation–rainfall feedbacks, CESM simulates a negative vegetation–rainfall feedback across Sahel, peaking in the pre-monsoon season. The simulated negative feedback is largely due to the low-level stabilization caused by increased LAI. Positive moisture feedback is present in the CESM simulation, but an order weaker than the observed and weaker than the negative momentum feedback, thereby leading to the simulated negative vegetation–rainfall feedbacks.

Thursday, December 15, 2016 08:00–12:20
Moscone South Poster 1087

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GC41B-1095: Advancing a model-validated statistical method for decomposing the key oceanic drivers of observed regional climate variability and evaluating model performance: Focus on North African rainfall in CESM

North (N.) African rainfall is characterized by dramatic interannual to decadal variability with serious socio-economic ramifications. The Sahel and West African Monsoon (WAM) region experienced a dramatic shift to persistent drought by the late 1960s, while the Horn of Africa (HOA) underwent drying since the 1990s. Large disagreementregarding the dominant oceanic drivers of N. African hydrologic variability exists among modeling studies, leading to notable spread in Sahel summer rainfall projections for this century among Coupled Model Intercomparison Project models. In order to gain a deeper understanding of the oceanic drivers of N. African rainfall and establish a benchmark for model evaluation, a statistical method, the multivariate Generalized Equilibrium Feedback Assessment, is validated and applied to observations and a control run from the Community Earth System Model (CESM). This study represents the first time that the dominant oceanic drivers of N. African rainfall were evaluated and systematically compared between observations and model simulations.

CESM and the observations consistently agree that tropical oceanic modes are the dominant controls of N. African rainfall. During the monsoon season, CESM and observations agree that an anomalously warm eastern tropical Pacific shifts the Walker Circulation eastward, with its descending branch supporting Sahel drying. CESM and the observations concur that a warmer tropical eastern Atlantic favors a southward-shifted Intertropical Convergence Zone, which intensifies WAM monsoonal rainfall. An observed reduction in Sahel rainfall accompanies this enhanced WAM rainfall, yet is confined to the Atlantic in CESM. During the short rains, both observations and CESM indicate that a positive phase of tropical Indian Ocean dipole (IOD) mode [anomalously warm (cold) in western (eastern) Indian] enhances HOA rainfall. The observed IOD impacts are limited to the short rains, while the simulated impacts are year-round.

Thursday, December 15, 2016 08:00–12:20
Moscone South Poster 1095

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H41D-1359: Comparisons with observational and experimental manipulation data imply needed conceptual changes to ESM land models (Invited)

The land models integrated in Earth System Models (ESMs) are critical components necessary to predict soil carbon dynamics and carbon–climate interactions under a changing climate. Yet, these models have been shown to have poor predictive power when compared with observations and ignore many processes known to the observational communities to influence above and belowground carbon dynamics. Here I will report work to tightly couple observations and perturbation experiment results with development of an ESM land model (ALM), focusing on nutrient constraints of the terrestrial C cycle. Using high-frequency flux tower observations and short-term nitrogen and phosphorus perturbation experiments, we show that conceptualizing plant and soil microbe interactions as a multi-substrate, multi-competitor kinetic network allows for accurate prediction of nutrient acquisition. Next, using multiple-year FACE and fertilization response observations at many forest sites, we show that capturing the observed responses requires representation of dynamic allocation to respond to the resulting stresses. Integrating the mechanisms implied by these observations into ALM leads to much lower observational bias and to very different predictions of long-term soil and aboveground C stocks and dynamics, and therefore C–climate feedbacks. I describe how these types of observational constraints are being integrated into the open-source International Land Model Benchmarking (ILAMB) package, and end with the argument that consolidating as many observations of all sorts for easy use by modelers is an important goal to improve C–climate feedback predictions.

Thursday, December 15, 2016 08:00–12:20
Moscone South Poster 1359

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B41J-05: Using mid infrared spectroscopy to predict the decomposability of soil organic matter stored in Arctic tundra soils

The large amounts of organic matter stored in permafrost-region soils are preserved in a relatively undecomposed state by the cold and wet environmental conditions limiting decomposer activity. With pending climate changes and the potential for warming of Arctic soils, there is a need to better understand the amount and potential susceptibility to mineralization of the carbon stored in the soils of this region. Studies have suggested that soil C:N ratio or other indicators based on the molecular composition of soil organic matter could be good predictors of potential decomposability. In this study, we investigated the capability of Fourier-transform mid infrared spectroscopy (MidIR) spectroscopy to predict the evolution of carbon dioxide (CO_2) produced by Arctic tundra soils during a 60-day laboratory incubation. Soils collected from four tundra sites on the Coastal Plain, and Arctic Foothills of the North Slope of Alaska were separated into active-layer organic, active-layer mineral, and upper permafrost and incubated at 1, 4, 8 and 16 °C. Carbon dioxide production was measured throughout the incubations. Total soil organic carbon (SOC) and total nitrogen (TN) concentrations, salt (0.5 M K2SO4) extractable organic matter (SEOM), and MidIR spectra of the soils were measured before and after incubation. Multivariate partial least squares (PLS) modeling was used to predict cumulative CO_2 production, decay rates, and the other measurements. MidIR reliably estimated SOC and TN and SEOM concentrations. The MidIR prediction models of CO_2 production were very good for active-layer mineral and upper permafrost soils and good for the active-layer organic soils. SEOM was also a very good predictor of CO_2 produced during the incubations. Analysis of the standardized beta coefficients from the PLS models of CO_2 production for the three soil layers indicated a small number (9) of influential spectral bands. Of these, bands associated with O-H and N-H stretch, carbonates, and ester C-O appeared to be most important for predicting CO_2 production for both active-layer mineral and upper permafrost soils. Further analysis of these influential bands and their relationships to SEOM in soil will be explored. Our results show that the MidIR spectra contains valuable information that can be related to decomposability of soils.

Thursday, December 15, 2016 09:00–09:15
Moscone West 2004

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B42A-01: Knowledge and knowledge gaps in climate-induced tropical forest mortality (Invited)

Increasing tropical forest mortality is a significant risk and could have enormous consequences on the global carbon cycle, however, our understanding of mortality patterns, drivers, and mechanisms is currently insufficient to allow rigorous hypothesis testing or predictive simulation. Here we review the state of knowledge regarding tropical forest mortality and identify critical next steps to enable improved fundamental understanding and reduced model uncertainty. Limited observations in the tropics suggest many patterns, drivers, and mechanisms of tropical forest mortality are consistent with those found in temperate forests, with significant exceptions associated the high species diversity and unique climate of tropical forests. Accelerating mortality rates have been observed in the neo-tropics, and threshold mortality responses to drought and heat have been observed. However, the large species diversity may buffer tropical forests against drought and heat events relative to analogous responses in temperate forests. The importance of various drivers of tropical forest mortality are undocumented, but wind-induced mortality may play a larger role, drought and heat an equivalent role, and insects and pathogens a more minor role in mortality than in temperate zones. The relative importance of stress — versus productivity — (and CO_2 fertilization) accelerated mortality is a major science question, as is the threat of die-off (regional scale mortality event) thresholds. We conclude there is significant evidence to justify concern regarding the long-term carbon sink potential of tropical forests, but the state of predictive uncertainty is large relative to other forests globally. We outline a theoretical, empirical, and simulation based framework to surmount the challenge of understanding and predicting pan-tropical forest mortality rates under climate change.

Thursday, December 15, 2016 10:20–10:32
Moscone West 2020

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B42C-04: A polar approach for defining a spatially-explicit "phenological year" and quantifying the degree and date of seasonality for existing vegetation across the United States

Polar analysis of the annual distribution of NDVI allows for temporally seamless determination of vegetation seasonality, irrespective of the arbitrary human calendar. Evergreen vegetation appears as a perfect circle in such a polar graph presentation. Circular statistics can be used to calculate the mean resultant vector of the annual NDVI distribution over a number of years. The magnitude of this mean NDVI resultant vector describes how far "off-center" the center of mass of the NDVI distribution is, and therefore characterizes the degree of seasonality of the actual mixture of existing vegetation within each MODIS cell. The angle of the mean NDVI resultant vector indicates the Day-of-Year of the center of mass of the entire multi-year NDVI distribution (regardless of its form), and the anti-vector of mean vector NDVI divides the annual cycle into a beginning and ending at the antipode of greenness center-of-mass, creating a unique, vegetationally defined "phenological year" in every MODIS cell. Once the strength and mean date of seasonality are quantitatively defined, national maps can be drawn showing the nature of dominant vegetation seasonality. The polar phenology analysis approach is general and transferrable, and can also be applied to phenologies other than vegetation. Then avian seasonalities, for example, are directly commensurate with vegetation seasonalities, and shifts in the degree of synchrony or asynchrony between the two can be quantified and mapped.

Thursday, December 15, 2016 11:05–11:20
Moscone West 2008

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B42A-08: Development of a tropical ecological forecasting strategy for ENSO based on the ACME modeling framework

The El Niño Southern Oscillation (ENSO) is an irregular periodic climate fluctuation, occurring every eight to 12 years, that is driven by variations in sea surface temperatures (SSTs) over the tropical eastern Pacific Ocean and extending westward across the equatorial Pacific. El Niño, the warming phase of ENSO, has strong effects on the global carbon cycle. Strong drying conditions in the Asia-Pacific region and western South America during El Niño lead to reduced ecosystem productivity and increased mortality and fire risk. The intensity of the 2015–2016 ENSO event rivaled or exceeded that of the 1997–1998 event, which was the strongest well-observed El Niño on record. We performed a set of simulations using the U.S. Department of Energy's Accelerated Climate Modeling for Energy (ACMEv0.3) model, forced with prescribed sea surface temperatures, to study the responses and feedbacks of drought effects on terrestrial ecosystems induced by both of these events. The ACME model was configured to run with active atmosphere and land models alongside the "data" ocean and thermodynamic sea ice models. The Community Atmosphere Model used the Spectral Element dynamical core (CAM-SE) operating on the ne30 ($\sim1°$) grid, and the ACME Land Model (ALM) was equivalent to the Community Land Model with prognostic biogeochemistry (CLM4.5-BGC). Using Optimal Interpolation SSTs (OISSTv2) and predicted SST anomalies from NCEP's Climate Forecast System (CFSv2) as forcing, we conducted a transient simulation from 1995 to 2020, following a spin up simulation, and analyzed the ENSO impacts on tropical terrestrial ecosystems for the 5-year periods centered on these two strong ENSO events. During the transient simulation, we saved the resulting atmospheric forcing, which included prognostic biosphere–atmosphere interactions, every three hours for use in future offline simulation for model development and testing. We will present simulation results, focusing on hydroclimatic anomalies as compared with observations and the accompanying ecological responses, including changes in primary productivity, soil moisture, and stomatal conductance. In addition, we will discuss the potential utility of this modeling framework for ecological forecasting on seasonal to decadal scales,

Thursday, December 15, 2016 11:44–11:56
Moscone West 2020

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B43C-0626: Estimating potential damping of cryoturbation on permafrost carbon emissions using a perturbed parameters approach in a land surface model

Permafrost soils in the northern hemisphere contain about half of the world's total soil organic carbon (SOC), which has the potential to be a large carbon source as a consequence of anticipated climate changes. However, divergent estimates of the magnitude and the trend of soil carbon emission between different global land surface models with simple representation of permafrost processes highlighted the demand to understand the influence of processes that are most likely to affect the permafrost carbon cycle feedbacks (PCF), including cryoturbation, oxygen limitation and microbial dynamics. Here we use a land surface model, the Integrated Science and Assessment Model with one-dimensional soil biogeochemistry (ISAM-1DSB), to examine how the response of cryoturbation to a changing thermal and hydrological regime will affect the PCF under the IPCC RCP8.5 climate scenario. ISAM-1DSB contains an extended permafrost representation, a 1-D frost heave model that resolves ice lens formation and growth to represent cryoturbation and a gas diffusion model to estimate oxygen availability in poorly-drained soil. To validate the model's ability to capture the vertical variability of SOC profiles, ISAM-1DSB has been forced with CRU-NCEP reanalysis to build up quasi-equilibrium contemporary SOC storage and compared to a set of permafrost soil profiles from three different permafrost soil suborders: Histel, Turbel and Orthel. For the first time, soil $\Delta^{14}C$ profiles across the pan-arctic region has been utilized to constrain the key uncertain parameter linking ice lens velocity to the cryoturbation rate in the frost heave scheme by matching model estimated $\Delta^{14}C$ profiles with observations. The estimated range of the cryoturbation rate has been utilized to represent the uncertainty of the cryoturbation under future climate change. Finally, ISAM-1DSB has been forced with future climate projections from CMIP5 model outputs for the entire permafrost region to perform three simulation cases with the lower, the median and the upper bound of the parameter. These experiments estimate the permafrost carbon emission till 2100 to test a hypothesis: the accumulated permafrost SOC emission will be smaller with consideration of cryoturbation, but this trend will be enhanced once the cryoturbation stalls.

Thursday, December 15, 2016 13:40–18:00
Moscone South Poster 0626

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GC43C-1177: On the edge: The impact of climate change, climate extremes, and climate-driven disturbances on the food-energy-water nexus in the Colorado River Basin

The Colorado River Basin (CRB) is a critical watershed in terms of vulnerability to climate change and supporting the food-energy-water nexus. Climate-driven disturbances in the CRB—including wildfire, drought, and pests—threaten the watershed's ability to reliably support a wide array of ecosystem services while meeting the interrelated demands of the food-energy-water nexus. Our

work illustrates future changes for upper Colorado River headwater basins using the Variable Infiltration Capacity hydrologic model driven by downscaled CMIP5 global climate data coupled with pseudo-dynamic vegetation shifts associated with changing fire and drought conditions. We examine future simulated streamflow within the context of an operational model framework to consider the impacts on water operators and managers who rely upon the timely and continual delivery of streamflow. We focus on results for a large case study basin within the CRB—the San Juan River—showing future scenarios where this ecosystem is pushed towards the extremes. Our findings illustrate that landscape change in the CRB cause delayed snowmelt and increased evapotranspiration from shrublands, which leads to increases in the frequency and magnitude of both droughts and floods within disturbed systems. By 2080, coupled climate and landscape change produces a dramatically altered hydrograph resulting in larger peak flows, reduced lower flows, and lower overall streamflow. Operationally, this results in increased future water delivery challenges and lower reservoir storages driven by changes in the headwater basins. Ultimately, our work shows that the already-stressed CRB ecosystem could, in the future, be pushed over a tipping point, significantly impacting the basin's ability to reliably supply water for food, energy, and urban uses.

Thursday, December 15, 2016 13:40–18:00
Moscone South Poster 1177

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B43H-03: Next steps in understanding and predicting vegetation mortality under heat and drought (Invited)

Understanding and predicting vegetation dynamics under a warmer climate has advanced greatly in the last decade, yet many questions remain that must be addressed for us to maximize the accuracy of future predictions. False dichotomies are no longer driving our science, but predispositions to outcomes remain a challenge. Understanding the role of heat in particular must be at the forefront of our work, as warming is a gauranteed component of the climate system. Understanding the exact details of mortality is fascinating, but may not be essential (or feasible) to maximize predictive accuracy. Understanding the role of insect outbreaks and pathogens is lagging behind the physiological science but should catch up given the massive impact of insects. I will summarize some of these issues and outline a path forward for our society.

Thursday, December 15, 2016 14:10–14:25
Moscone West 2020

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Friday, December 16, 2016

B54C-08: The representation of non-equilibrium soil types in Earth system models and its impact on carbon cycle projections

Soils hold the largest reactive pool of carbon (C) on Earth. Global soil organic C stocks (0−−200 cm depth plus full peatland depth) are estimated to ∼2200 Pg C (adapted from Hugelius et al., 2014, Köchy et al., 2015 and Batjes, 2016). Soil C stocks in Earth system models (ESMs) can be generated by running the model over a longer time period until soil C pools are in or near steady-state. Inherent in this concept is the idea that soil C stocks are in (quasi)equilibrium as determined by the balance of net ecosystem input to soil organic matter and its turnover. The rate of turnover is sometimes subdivided into several pools and the rates are affected by various environmental factors. Here we break down the empirically based estimates of global soil C pools into equilibrium-type soils which current (Coupled Model Intercomparison Project, phase 5; CMIP5) generation ESMs are set-up to represent and non-equilibrium type soils which are generally not represented in current ESMs. We define equilibrium soils as those where pedogenesis (and associated soil C formation) is not significantly limited by the environmental factors perennial soil freezing, waterlogging/anoxia or limited unconsolidated soil substrate. This is essentially all permafrost-free mineral soils that are not in a wetland or alpine setting. On the other hand, non-equlibrium soils are defined as permafrost soils, peatlands and alpine soils with a limited fine-soil matrix. Based on geospatial analyses of state-of-the-art datasets on soil C stocks, we estimate that the global soil C pool is divided roughly equally between equilibrium and non-equlibrium type soils. We discuss the ways in which this result affects C cycling in ESMs and projections of soil C sensitivity under a changing climate.

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Köchy M. et al. (2015) *Soil*, 1, 351–365, doi:10.5194/soil-1-351-2015.

Friday, December 16, 2016 08:00–12:20
Moscone South Poster 0456

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B51E-0457: Towards improved predictions of global radiocarbon ($\Delta^{14}C$) through comparison between site observations and climate model outputs

Earth System Models (ESMs), such as the Accelerated Climate Modeling for Energy (ACME), are needed to understand feedbacks between the terrestrial carbon cycle and climate. Among many factors affecting the responses of the terrestrial carbon cycle to climate, the turnover time of soil organic carbon (SOC) depends on climate, soil properties, and vegetation type. However, estimating SOC turnover times at multiple spatial scales is challenging and subject to large uncertainty. As carbon turnover time can be reliably estimated from radiocarbon data, we strive to improve

global predication by comparing measured site-scale 10 and 50 cm depth $\Delta^{14}C$ values with large-scale ACME Land Model (ALM) predictions. Our goal is to identify the main factors causing discrepancies between simulated and observed values.
We first upscale site-scale measurements to large-scale ALM grids and then compare the upscaled and modeled $\Delta^{14}C$ values. At the large scale, we fit the mean observed values as a function of ALM outputs and large-scale surface features. Results show that plant functional type (PFT), soil order, and ground surface variations, such as average slope and standard deviation of elevation, are primary factors for explaining model-observed discrepancies at both depths. This suggests accurately representing PFT and soil order (e.g., by resolution refinement) may reduce discrepancies at the model grid scale. We also perform analysis on the residuals after removal of the mean effects to characterize the site-scale variability and find the $\Delta^{14}C$ residuals at both depths strongly depend on bulk density, mean annual temperature (MAT), and vegetation type. Since soil bulk density and its vertical profile are localized information, characterizing $\Delta^{14}C$ values at the site scale is more difficult and statistical models may play an important role. We finally use ALM to better understand how the global soil $\Delta^{14}C$ values are sensitive to those dominant factors.

Friday, December 16, 2016 08:00–12:20
Moscone South Poster 0457

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B51E-0461: Tropical carbon response to seasonal phasing and intensity of precipitation in CMIP5 Earth system models

Carbon cycling and water fluxes are connected over land. Understanding the current sensitivity of tropical ecosystems to climate drivers, such as precipitation, at short timescales is important for projecting future trends in the land sink of anthropogenic CO_2. Several recent studies have shown that interannual droughts in 2005 and 2010 reduced net carbon uptake in the Amazon rainforest. In 2011 Southern Hemisphere semi-arid regions, especially Australian ecosystems, were found to largely contribute to the above average increase in the land carbon sink following consecutive wet seasons under La Niña conditions.
Earth system models (ESMs) are able to simulate these sensitivities with varying degrees of fidelity, and ESMs also show a wide range of changes in precipitation phasing and intensity by 2100. Unsurprisingly, model projections of the land carbon sink also vary widely, with some simulations showing land becoming a CO_2 source to the atmosphere. To constrain projections of the tropical land carbon balance among an ensemble of ESMs, we analyzed seasonal and interannual precipitation–carbon relationships in Coupled Model Intercomparison Project Phase 5 (CMIP5) ESMs for the period from 1982–2006. The sensitivity of net biospheric production on land (NBP) to precipitation was quantified on seasonal and annual timescales, and NBP was spatially correlated to precipitation across tropical and subtropical regions ($\pm$30 degrees) within humid and semi-arid ecosystems. This analysis was expanded to soil moisture and drought metrics were used to distinguish between wet and dry seasons. Large scale precipitation was used to resolve Intertropical Convergence Zone (ITCZ) movement and convective precipitation was used to diagnose the short-term NBP response

within the wet season. Results revealed a spread in NBP sensitivity to precipitation intensity as well as how individual models simulated precipitation phasing across different tropical regions.

Friday, December 16, 2016 08:00–12:20
Moscone South Poster 0461

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B51E-0465: Modeling biogeochemical responses of vegetation to ENSO: Comparison and analysis on subgrid PFT patches

The El Niño Southern Oscillation (ENSO) is an important interannual climate variability and has significant consequences and impacts on the global biosphere. The responses of vegetation to ENSO are highly heterogeneous and generally depend on the biophysical and biochemical characteristics associated with model plant functional types (PFTs). The modeled biogeochemical variables from Earth System Models (ESMs) are generally grid averages consisting of several PFTs within a grid-cell, which will lead to difficulties in directly comparing them with site observations and large uncertainties in studying their responses to large scale climate variability. In this study, we conducted a transient ENSO simulation for the previoustwo decades from 1995 to 2020 using the DOE ACME v0.3 model. It has a comprehensive terrestrial biogeochemistry model that is fully coupled with a sophisticated atmospheric model with an advanced spectral element dynamical core. The model was driven by the NOAA optimum interpolation sea surface temperature (SST) for contemporary years and CFS v2 nine-month seasonal predicted and reconstructed SST for future years till to 2020. We saved the key biogeochemical variables in the subgrid PFT patches and compared them with site observations directly. Furthermore, we studied the biogeochemical responses of terrestrial vegetation to two largest ENSO events (1997–1998 and 2015–2016) for different PFTs. Our results show that it is useful and meaningful to compare and analyze model simulations in subgrid patches. The comparison and analysis not only gave us the details of responses of terrestrial ecosystem to global climate variability under changing climate, but also the insightful view on the model performance on the PFT level.

Friday, December 16, 2016 08:00–12:20
Moscone South Poster 0465

Authors:
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H51I-1635: Evaluating land–atmosphere moisture feedbacks in Earth system models with spaceborne observations

We have developed a set of metrics for measuring the feedback loop between the land surface moisture state and the atmosphere globally on an interannual time scale. These metrics consider both the forcing of terrestrial water storage (TWS) on subsequent atmospheric conditions as well as the response of TWS to antecedent atmospheric conditions. We designed our metrics to take advantage of more than one decade's worth of satellite observations of TWS from the Gravity Recovery and Climate Experiment (GRACE) along with atmospheric variables from the Atmospheric Infrared Sounder (AIRS), the Global Precipitation Climatology Project (GPCP), and Clouds and the Earths Radiant Energy System (CERES). Metrics derived from spaceborne observations were used to evaluate the strength of the feedback loop in the Community Earth System Model (CESM) Large Ensemble (LENS) and in several models that contributed simulations to Phase 5 of the Coupled Model Intercomparison Project (CMIP5). We found that both forcing and response limbs of the feedback loop were generally stronger in tropical and temperate regions in CMIP5 models and even more so in LENS compared to satellite observations. Our analysis suggests that models may overestimate the strength of the feedbacks between the land surface and the atmosphere, which is consistent with previous studies conducted across different spatial and temporal scales.

Friday, December 16, 2016 08:00–12:20
Moscone South Poster 1635

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B52A-01: The challenge of establishing decomposition functional types to estimate heterotrophic respiration at large scales (Invited)

Heterotrophic respiration (HR), the aerobic and anaerobic processes mineralizing organic matter, is a key carbon flux but one impossible to measure at large scales. This impedes our ability to understand carbon and nutrient cycles, benchmark models, or reliably upscale point measurements. Given that a new generation of highly mechanistic, genomic-specific global models is not imminent, we suggest that a useful step would be the development of "Decomposition Functional Types" (DFTs). Analogous to established plant functional types (PFTs) and proposed ecosystem functional types, DFTs would abstract and capture important differences in HR metabolism and flux dynamics, allowing modelers and experimentalists to efficiently group and vary these characteristics across space and time. DFTs should be developed using bottom-up, data-driven analyses that will depend heavily on established databases and remote sensing products. We present an example clustering analysis to show how annual HR can be broken into distinct groups associated with global variability in biotic and abiotic factors, and demonstrate that these groups are distinct from (but complementary to) already-existing PFTs. A similar analysis incorporating observational data could form the basis for future DFTs. Finally, we suggest next steps and critical priorities, all critical steps to build a foundation for DFTs in global models, thus providing the ecological and climate change communities with robust, scalable estimates of HR.

Friday, December 16, 2016 10:20–10:35
Moscone West 2006

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A53G-07: Local plant physiological responses to increasing CO_2 contribute to a zonally asymmetric pattern of precipitation change over tropical forests

Understanding how anthropogenic CO_2 emissions may impact future precipitation patterns is a critical question for Earth science and society, especially over tropical forests where changes affect drought conditions, ecosystem health, and the availability of freshwater. While there remains significant uncertainty about how tropical precipitation will change in the future, CMIP5 models robustly project a consistent zonally asymmetric pattern over land, amplifying differences between the Maritime Continent and Amazon. This pattern cannot be explained by mechanisms describing zonal mean changes to the hydrological cycle (e.g. Hadley strength, ITCZ shift, or wet-get-wetter response). Here we show, in CESM1(BGC), that the pattern is largely controlled by plant physiological responses to increased CO_2, which setup local dynamic anomalies over each continent, rather than global-scale radiative forcing. Regional precipitation and associated circulation changes that manifest with global CO_2 increases are also captured when CO_2 increases are isolated to the land-surfaces of individual continents. Increased CO_2 throttles stomatal conductance, reducing local transpiration and increasing sensible heating and surface temperature. Changes in heating over land drive regional circulations that influence vertical mixing and moisture fluxes over each continent, leading to greater moisture transport into the upper atmosphere and more precipitation over Indonesia, Central Africa and the west coast of South America, and less precipitation over the Amazon.

Friday, December 16, 2016 15:10–15:25
Moscone West 2022/2024

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B54C-01: Climatological temperature senstivity of soil carbon turnover: Observations, simple scaling models, and ESMs (Invited)

The projected loss of soil carbon to the atmosphere resulting from climate change is a potentially large but highly uncertain feedback to warming. The magnitude of this feedback is poorly constrained by observations and theory, and is disparately represented in Earth system models. To assess the likely long-term response of soils to climate change, spatial gradients in soil carbon turnover times can identify broad-scale and long-term controls on the rate of carbon cycling as a function of climate and other factors. Here we show that the climatological temperature control on carbon turnover in the top meter of global soils is more sensitive in cold climates than in warm ones. We present a simplified model that explains the high cold-climate sensitivity using only the physical scaling of soil freeze-thaw state across climate gradients. Critically, current Earth system models (ESMs) fail to capture this pattern, however it emerges from an ESM that explicitly resolves vertical gradients in soil climate and turnover. The weak tropical temperature sensitivity emerges from a different model that explicitly resolves mineralogical control on decomposition. These results

support projections of strong future carbon-climate feedbacks from northern soils and demonstrate a method for ESMs to capture this emergent behavior.

Friday, December 16, 2016 16:00–16:15
Moscone West 2006

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B54C-05: Representing carbon, nitrogen, and phosphorus interaction in the ACME Land Model v1: Model development and global benchmarking

Since nutrient limitations of the terrestrial carbon cycle have been rigorously demonstrated by field experiments (e.g., fertilization experiments), various Earth System Model (ESM) groups have spent substantial effort to incorporate nutrient sub-models in their terrestrial carbon cycle models (e.g., CLM-CNP, JSBACH-CNP, CABLE-CNP).
Here we report new developments in the Accelerated Climate Modeling for Energy (ACME) Land Model (ALMv1) regarding carbon-nutrient interactions. The development is based on (1) recent theoretical advances in understanding belowground multiple-consumer, multiple-nutrient competition; (2) a dynamic allocation scheme based on resources availability to balance whole system functioning; and (3) global datasets of plant physiological traits (e.g., TRY database). In addition to describing these developments, we compare them with representations in other ESM land models.
We demonstrate that these new ALMv1 developments accurately reproduce present terrestrial carbon dynamics under the constraints of nitrogen and phosphorus availability. We benchmark the new model using the International Land Model Benchmarking package (ILAMB) for major plant and soil carbon pools (total vegetation biomass, soil carbon content) and fluxes (GPP, NEP) and leaf area index (LAI). The results show that biases have been significantly reduced (e.g., GPP bias in boreal needle leaf forests, LAI bias in tropical broad leaf evergreen forests). The ILAMB benchmarks provide a unique opportunity to consistently track ongoing model development and simultaneously demonstrate improvements for multiple variables.
We further benchmark the new model transient response to nutrient perturbation, using nitrogen and phosphorus fertilization experiments at over 100 forest sites. We found that the plant productivity response ratio ($(\mathrm{NPP}_{\mathrm{fert}} - \mathrm{NPP}_{\mathrm{control}})/\mathrm{NPP}_{\mathrm{control}}$) could be captured only when the whole system functional balance is taken into account. Compared with other candidate models (e.g., fixed resource allocation), our results highlight the importance of self-regulation and adjustment of forest ecosystems in response to long-term resource supply imbalances (e.g., by CO_2, N, P) that are likely to occur over the next several decades.

Friday, December 16, 2016 17:00–17:15
Moscone West 2006

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Notes

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