Climate/Earth Systems Seminar Presentations Agenda
Wednesday, September 26, 2018

Reinhard Friedel, CSES 5min 1:00-1:05 pm
Introduction to CSES Climate Focus Area Presentations

Daniella Ulrich, B-11 10min 1:05-1:20 pm (5 min discussion time)
CSES Emerging Ideas R&D project
Title: Advancing forest carbon and water modeling with plant physiology

Kurt Solander, EES-16 15min 1:20-1:40 pm (5 min discussion time)
CSES Emerging Ideas R&D project
Title: The expansion of the wildfire season in the western US as seen through FIRETEC

Mavendra Dubey, EES-14 20 min 1:40-2:10 pm (10 min discussion time)
CSES Student Fellow project
Title: Emission Ratios Parameterizations to Predict Biomass Burning Aerosol Optical Properties

BREAK 10min 2:10-2:20 pm

Anastasia Piliouras, EES-14 10min 2:20-2:35 pm (5 min discussion time)
CSES Emerging Ideas R&D project
Title: Sea ice sediment entrainment from riverine outflows

Alexandra Jonko, EES-16 20min 2:35-3:05 pm (10min discussion time)
CSES Emerging Ideas R&D project
Title: Examining sensitivity of modeled fire behavior to small perturbations in initial conditions through the lens of Chaos theory

Tirtha Banerjee, EES-16 15min 3:05-3:25 pm (5 min discussion time)
Ex CSES Chick Keller Postdoc continuing work
Title: Ecosystem disturbance modeling: a systems approach

Advancing forest carbon and water modeling with plant physiology

<u>Danielle E. Marias Ulrich</u> (B-11), Tirtha Banerjee (EES-16), Sanna Sevanto (EES-14)

This project advances model predictions of ecosystem carbon and water fluxes by incorporating plant drought response strategies. Climate change threatens vegetation worldwide. Society depends on earth system models to project future climate and inform land management strategies and policy decisions. Traditionally, vegetation is represented in models as plant functional types (e.g. evergreen, deciduous). However, grouping vegetation in this way does not yield accurate model predictions given the large variability in environmental stress responses of co-occurring plant species that inhabit the same ecosystem (e.g. pinyon, juniper). Drought sensitivities are measured along the isohydric-anisohydric continuum that describes drought responses of stomata, small pores on leaves that regulate water loss through transpiration and carbon gain for photosynthesis (e.g. piñon pine=isohydric, juniper=anisohydric). Thus, stomatal strategy substantially influences ecosystem water and C fluxes, and models must account for vegetation composed of species with contrasting stomatal strategies to accurately predict C and water fluxes. We test the utility of incorporating species with contrasting strategies into a plant biophysics model that predicts ecosystem C and water fluxes. We parameterize the model using extensive eddy flux, meteorological, and plant physiological data sets collected at TA-51 and the SUMO (Survival-Mortality) field site (TA-49) with co-occurring juniper and piñon. This is a major advancement for modeling ecosystem C and water fluxes because current efforts not only struggle to account for contrasting stomatal strategies but also lack a well-instrumented site of co-occurring iso-anisohydric species equipped with long term datasets to test such a model.

The expansion of the wildfire season in the western US as seen through FIRETEC

Kurt Solander, EES-16

The recent string of devastating wildfires impacting California year-round provides evidence that the seasonality of wildfires in the western US is changing. Driven by warmer temperatures, fuels are drying to moisture content levels that are more typical of the historical peak wildfire season at times before and after this period, causing the wildfire season to lengthen. Although a number of studies have looked at how changes in the climate will create conditions more favorable for wildfires outside of the historical norm, the actual effect that these seasonal changes will have on wildfire behavior remains poorly understood. We address this shortcoming by running sensitivity experiments for a Ponderosa Pine forest in the southwest US using the fully coupled atmospheric dynamics wildfire behavior model known as HIGRAD/FIRETEC. Given that forests are simultaneously expected to experience greater rates of mortality due to more severe and more frequent droughts, we explore the sensitivity of wildfire behavior to both vegetation density and fuel moisture using the full range of feasible parameter space for these variables. Additional model simulations are conducted using the most likely changes in fuel moisture and vegetation density to determine a likely outcome for the targeted forest. We focus our efforts on understanding future changes in fuel moisture for the months immediately before and after the historical peak wildfire season for this area. Preliminary results indicate that wildfire burn area and intensity is more sensitive to changes in fuel moisture except where a threshold vegetation density is reached, given as 50-75% of the baseline density used in our analysis. These results can be used to better understand how the pending wildfire season expansion will impact wildfire behavior at critical times of the year, which has implications for wildfire fighting techniques resource allocation as well as improved forestry management practices to better cope with these changes.

Emission Ratios Parameterizations to Predict Biomass Burning Aerosol Optical Properties

Manvendra Dubey, Joseph Schlosser (UofArizona, Grad student), Allison Aiken, Kip Carrico (NMT) and Armin Sarooshian (UofArizona)

Biomass burning has a significant impact on the overall inventory of aerosols that have both radiative and adsorptive properties. Past research has focused on characterizing biomass burning effects based on EC and OC properties as well as MCE and AAE. This study shows that AAE can be used to predict both absorptive EC/BC and POM[LA1] effects. Data was collected from laboratory biomass burning as well as ground based measurement of ambient biomass burning events using SP2 (BC), Picarro (CO), and PASS-3 (absorption) instruments. Linear fits were used to calculate emission ratios (β/ΔCO and BC/ΔCO), and curve fitting techniques were used to correlate emission ratios to AAE. Measured Absorption and BC emission ratios are reported for several fuel types and ignition methods. (EQUATIONS HERE) [LA2] shows the resulting correlation of absorption emission ratios to AAE at 781nm, 532nm and 405nm. (EQUATION HERE) [LA3] shows the correlation of BC and POM[LA4] emission ratios to AAE. This analysis shows that as AAE increases, the emission ratio of total absorption decreases in all spectra. It also shows that the contribution of POM's to the total absorption emission ratio is significant at all AAE values, but dominates at higher AAE values.
These correlations will allow for the prediction of BC and POM emissions from biomass burning by using AAE and CO measurements alone. The results of this study allow for simpler and potentially more accurate predictions of the climate forcing potential of biomass burning events as compared to core-shell analyses done in the past.

[LA1]POM may include gasses

[LA2]Will be updated as results are acquired.

[LA3]Will be updated as results are acquired.

[LA4]POM may include gasses

Sea ice sediment entrainment from riverine outflows

Anastasia Piliouras, Postdoctoral Research Assistant, EES-DO

Entrainment of fine sediment into sea ice results in lower sea ice albedo. This drastically impacts rates of ice melting, which in turn influences land-ocean interactions at the coast, especially during seasonal floods when fluxes to the coast are high. Increasing sea ice sediment content not only changes the spatial patterns of fine sediment deposition in the ocean, but also influences biogeochemical production within and below the ice and the transport of nutrients and/or pollutants throughout the ocean. Thus, to better understand these important processes, further investigation of sediment entrainment into sea ice is needed. Here we present preliminary results from modeling experiments examining the potential to incorporate sediment into sea ice during spring flood conditions when a freshwater riverine plume flows between overlying ice cover and underlying sea water. We compare the rate of freshwater freezing to the rate of sediment settling from the freshwater plume to determine the proportion of suspended sediment entrained into ice for various freshwater discharges, temperatures, sediment concentrations, and ice roughness values. The results of this study will be used to determine if the proportion of suspended sediment entrained into sea ice during spring floods is substantial and may therefore need to be considered as a control on ice albedo or ice biogeochemistry along Arctic coasts.

Examining sensitivity of modeled fire behavior to small perturbations in initial conditions through the lens of Chaos theory

Alexandra Jonko[1], EES-16, Juliana Conley[1,2], Kara Yedinak[3], Rod Linn[1], and Russell Parsons[4]

2017 was an exceptionally busy year for wildland fires with an estimated 9.8 million acres burned, highlighting the pressing need to better anticipate, prepare for, and manage wildland fire behavior. Wildland fires serve as both an ecological process essential for maintaining species diversity and a hazard to human lives, infrastructure and activities. Fire managers' ability to anticipate fire behavior is key to maximizing ecological value of fire while simultaneously minimizing negative impacts, and predictive models are critical to this task. However, prediction of fire behavior and development of extreme fire scenarios is complicated by the fact that small changes in environmental conditions can have large impacts on wildfire outcomes, i.e. they are chaotic systems. Here, we investigate sensitivities of wildfire behavior to these small changes in environmental conditions using LANL's process-based, computational fluid dynamics model of fire-atmosphere interactions, FIRETEC. We consider perturbations in the turbulent wind field as well as the distribution of fuels. To this end, we perform four sets of ensemble simulations, using four different sets of fuel beds. We begin with homogenous grass (1), then add a canopy consisting of Ponderosa pine at low (2), moderate (3) and high (4) levels of fuel aggregation. For each fuel bed, we run 27 simulations with slightly different turbulent wind conditions. In order to characterize the sensitivity of fire behavior to these perturbations in wind and fuel aggregation, we examine several fire behavior metrics, including rate of growth, total area burned and fuel consumption, which approximates fire intensity. We quantify the overall spread in metrics, and look for clustering, which would suggest the presence of stable states between which wildfires transition.

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Ecosystem disturbance modeling: a systems approach.

Tirtha Banerjee, Director's Postdoctoral Fellow, (Previously Chick Keller Postdoctoral Fellow), Computational Earth Sciences, EES-16

Forests cycle more energy, water and carbon dioxide (CO_2) than any other ecosystems and currently are the largest carbon sinks in the world. Whether they remain net carbon sinks or switch to being net carbon sources will define tipping points in the Earth system. Forests in the tropics and other regions, including the semi-arid forests of the US Southwest, play key roles in regional meteorology, precipitation and hydrology. Disturbances such as drought, insect outbreaks, flooding, wildfires and harvesting as well as elevated CO_2 levels, rising temperatures and changing precipitation patterns can change the energy and resource balances that govern forest productivity and thus exacerbate or dampen vulnerability of these ecosystems. However, poor representation of coupling between micrometeorological and forest canopy processes responsible for mass, momentum and energy exchange between forests and atmosphere, as well as plant physiological responses to micrometeorological shifts currently prevents characterization of the feedbacks and identification of potentially disastrous tipping points. To identify the ecosystem/atmospheric feedbacks that dictate forest resilience, a novel modeling framework is developed through the coupling of a plant biophysics model with a computational fluid dynamics (CFD) tool. In this new model paradigm, plant physiological response is captured at the leaf scale, accounting for plant hydraulics and photosynthesis as well as the economics of carbon uptake and water loss under stomatal regulation, which govern the mass and energy exchange between foliage and the atmosphere. Actual canopy structural data collected from field campaigns are used to simulate forested landscapes, where turbulent flow-fields are resolved through heterogeneous vegetation at sub-meter scales. This will enable simulating high- resolution three-dimensional effects of canopy disturbance-induced (natural or anthropogenic) forest structure changes on the critical forest/atmosphere exchange processes. Current top-down Earth and climate-system models do not capture the leaf-to-landscape-scale processes in fine enough detail to account for evolving heterogeneities. Thus, the proposed bottom up modeling framework will bridge a major science gap.