We dedicate this conference in memory of Jianwu (“Jim”) Tang, MBL scientist who passed away in December 2022.

Jim received a B.S. and M.S. from Peking University in China, and a Ph.D. in ecosystem sciences from the University of California, Berkeley in 2003. Following his degree program, he was a research associate at the University of Minnesota. Prior to joining the MBL faculty, he was a research scientist at the Chicago Botanic Garden and adjunct assistant professor at Northwestern University.

Studying ecosystem biogeochemistry, soil-plant-atmosphere interactions, and global change ecology, Jim’s work focused on the impacts of climate change and human activities on ecosystem processes and functions, in particular greenhouse gas emissions from agro-ecosystems and wetlands and their responses to management and disturbance. He had numerous projects in the Arctic, at Harvard Forest, and in salt marshes on Cape Cod and Plum Island.

Jim’s expertise included the development of new instrumentation and in 2015 he and Yuki Hamada (Argonne National Laboratory) received a Frank R. Lillie Research Innovation Award from the University of Chicago and the MBL to develop a novel approach to measure plant photosynthesis and other ecosystem functions that could be used to quantify the impacts of environmental change on ecosystems and agricultural systems.

Jim’s steadfast curiosity and gentle collegiality will be sorely missed. He leaves his wife, Lisa, and two sons, Lawrence, a student at the University of Chicago, and Alex, a high school student at Shanghai American School.

Cover: Forest image credit, David C. Powell, F14-SO-WP-SILV-10 (2012)
Dear Conference Attendee:

Welcome to the 1st Annual Eastern Regional Dynamic Global Vegetation Conference (ER-DGVM-C). We hope this inaugural meeting March 24-26, 2023, will be the beginning of a tradition to forge closer ties among those of us working on different vegetation models. This conference also is intended to connect the modelers and those acquiring the critical field measurements for parameterizing and validating the models, assembling the satellite data products that help constrain them, and everyone seeking to advance our understanding about the Earth’s ecosystems, how they came to be as they are, and where they are going amid climate change, with human activities now integral to the dynamics of the global system.

This year’s theme, “From Leaf to Globe, Seconds to Centuries: Scaling Up For Climate Change”, of course, encompasses the wide range of research that is necessary for the development and evaluation of DGVMs to enable them to address the complex scientific questions surrounding the role of vegetation in the Earth System. The conference presentations this year span leaf-level measurements, to wide-scale field analyses of phenology, to global scale coupled climate simulations with satellite boundary conditions; physical process on the scale of seconds, to seasonal variation, and decadal to century scale climate change. We hope that over years collaborations forged at the ER-DGVM-C will help advance connections across these multiple scales.

We would like to thank our sponsors, Li-COR, SpectraVista, Spectral Evolution, and Picarro, for their generous support. Their instruments have served our community extensively in characterizing the physiology and behavior of vegetation, and their properties that might be discerned by satellite remote sensing.

We would also like to thank the Analysis, Integration, and Modeling of the Earth System (AIMES) global research network of Future Earth. AIMES brings together Earth system scientists and scholars that work across disciplines to advance innovative, interdisciplinary ways to understand the complexity of the natural world and its interactions with human activities. We thank AIMES for their support of the research community through integrative working groups, outreach activities, and workshops like this one.

Thank you to all attendees and sponsors for helping us start up this new conference. We hope you will take away from it new insights, collaborations, and friendships.

Nancy Y. Kiang
Conference Chair
NASA Goddard Institute for Space Studies

Hannah Liddy
AIMES Executive Officer
Center for Climate Systems Research
Columbia University
Table of Contents

CONFERENCE PROGRAM 2

ORAL & POSTER SCHEDULE 3

ORAL PRESENTATION ABSTRACTS 5

POSTER LIST 20

POSTER ABSTRACTS 21

LIST OF PARTICIPANTS 28

Thank you to our Sponsors:
1st Annual Eastern Regional Dynamic Global Vegetation Modeling Conference (ER-DGVM-C)

CONFERENCE PROGRAM

FRIDAY, MARCH 24, 2023
4:00-6:00 pm Check-in, set up posters
6:00-7:00 pm Dinner in dining hall
7:00-7:10 pm Welcome and Opening Remarks
7:10-8:45 pm FRIDAY EVENING ORAL SESSION: DYNAMICS, DATA & DEMOGRAPHY
8:45 pm - late POSTERS MIXER SESSION

SATURDAY, MARCH 25, 2023
7:00-8:15 am Breakfast in dining hall
8:15-10:00 am SATURDAY MORNING ORAL SESSION: PHENOLOGY & TEMPERATURE
10:00-10:10 am Group photo
10:10-10:30 am Coffee break
10:30-12:00 noon SATURDAY MORNING BREAKOUT SESSION: GROUP MIP ACTIVITY
12:00-1:00 pm Lunch in dining hall
1:00-3:45 pm FREE TIME for impromptu meetings, walks, soccer, etc.
3:45-4:00 pm Pre-talk snacks by POSTERS
4:00-5:00 pm SATURDAY AFTERNOON ORAL SESSION 1: DATA ASSIMILATION
5:00-5:50 pm SATURDAY AFTERNOON ORAL SESSION 2: MODEL PARAMETERIZATION
6:00-7:30 pm Dinner in dining hall
SATURDAY EVENING SESSION: POSTER MIXER
7:30-late pm POSTERS MIXER SESSION

SUNDAY, MARCH 26, 2023
7:00-8:15 am Breakfast in dining hall
8:15-9:25 SUNDAY MORNING ORAL SESSION 1: HUMAN-NATURAL INTERACTIONS
9:25-9:40 SUNDAY MORNING ORAL SESSION 2: REMOTE SENSING OF VEGETATION
9:40-9:55 COFFEE BREAK
9:55-10:55 SUNDAY MORNING ORAL SESSION 2 continued
10:55-11:10 am Student and postdoc presentation awards, announcement of next co-chairs and date
11:10-12:00 pm Conference feedback and general discussion
12:00-1:00 pm Lunch in dining hall
Conference End
# ORAL & POSTER SCHEDULE

All talks will be held in the Meigs Room, next to the Dining Hall of the Swope Center, MBL.

## FRIDAY, MARCH 24, 2023

### FRIDAY EVENING ORAL SESSION: DYNAMICS, DATA & DEMOGRAPHY

<table>
<thead>
<tr>
<th>Time</th>
<th>Presenter(s)</th>
<th>Title</th>
<th>Affiliation</th>
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<tbody>
<tr>
<td>7:00</td>
<td>Nancy Kiang, Hannah Liddy</td>
<td>Welcome and opening remarks</td>
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</tr>
<tr>
<td>7:10</td>
<td>Ben Poulter</td>
<td>Maintaining process in a data-driven world: Applications to dynamic global vegetation modeling, examples with LPJ-wsl</td>
<td>CS, NASA/GSFC</td>
</tr>
<tr>
<td>7:35</td>
<td>Nancy Kiang</td>
<td>Let there be light: physics-based canopy radiative transfer for coupling with vegetation demography and carbon</td>
<td>CS, NASA/GISS</td>
</tr>
<tr>
<td>7:55</td>
<td>Jennifer Holm (KEYNOTE)</td>
<td>Demographic vegetation models for capturing forest regrowth and carbon sink solutions</td>
<td>Staff scientist, LBL</td>
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<tr>
<td>8:40</td>
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<td>POP-UP TALKS</td>
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<td>8:45 till late</td>
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<td>FRIDAY EVENING POSTER SESSION &amp; MIXER</td>
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## SATURDAY, MARCH 25, 2023

### SATURDAY MORNING ORAL SESSION: PHENOLOGY & TEMPERATURE

<table>
<thead>
<tr>
<th>Time</th>
<th>Presenter(s)</th>
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<th>Affiliation</th>
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<tbody>
<tr>
<td>8:15</td>
<td>Minkyu Moon (KEYNOTE)</td>
<td>Observing and modeling vegetation phenology using remote sensing and data-driven model</td>
<td>Staff Scientist, Boston University</td>
</tr>
<tr>
<td>9:15</td>
<td>Xiaoting Li</td>
<td>Empirical methods underpredict temperature sensitivity compared with warming experiments and mechanistic modeling over alpine grassland</td>
<td>Graduate student, Cornell University</td>
</tr>
<tr>
<td>9:30</td>
<td>Jen Diehl</td>
<td>Opportunities Using Thermal Imaging</td>
<td>Graduate student, Northern Arizona University</td>
</tr>
<tr>
<td>9:45</td>
<td>Jiangong Liu</td>
<td>Widespread Evidence for the Thermal Acclimation of Canopy Photosynthesis</td>
<td>Postdoc, Columbia University</td>
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<tr>
<td>10:10</td>
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<td>GROUP PHOTO</td>
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<td>10:10</td>
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<td>COFFEE BREAK</td>
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<tr>
<td>10:30-12:00 pm</td>
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<td>SATURDAY MORNING BREAKOUT SESSION: GROUP MIP ACTIVITY</td>
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<tr>
<th>Time</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Interactive MIP activity</td>
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</table>
# SATURDAY AFTERNOON ORAL SESSION 1: DATA ASSIMILATION

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Title</th>
<th>Institution</th>
</tr>
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<tbody>
<tr>
<td>3:45</td>
<td>PRE-TALK SNACK BREAK BY POSTERS</td>
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<tr>
<td>4:00</td>
<td>Natasha MacBean (KEYNOTE)</td>
<td>15 Years of Development of the ORCHIDEE Data Assimilation System: Progress and Future Directions</td>
<td>Assistant Professor, Western University</td>
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</table>

# SATURDAY AFTERNOON ORAL SESSION 2: MODEL PARAMETERIZATION

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Title</th>
<th>Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>5:00</td>
<td>Yanlan Liu</td>
<td>Large Divergence of Projected Arctic Plant Composition and Productivity due to Functional Trait Uncertainty</td>
<td>Assistant Professor, Ohio State University</td>
</tr>
<tr>
<td>5:15</td>
<td>Xiangtao Xu</td>
<td>Constraining simulated tropical tree growth sensitivity to CO₂ fertilization and climate variability by integrating tree ring records</td>
<td>Assistant Professor, Cornell University</td>
</tr>
<tr>
<td>5:35</td>
<td>Nicolas Venjean</td>
<td>Invasive Species Monitoring With UV-Vis-NIR Spectroscopy</td>
<td>Spectral Evolution</td>
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<tr>
<td>5:50</td>
<td>POP-UP Talks</td>
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<tr>
<td>7:30-late</td>
<td>SATURDAY EVENING POSTER SESSION &amp; MIXER</td>
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# SUNDAY, MARCH 26, 2023

## SUNDAY MORNING SESSION 1: HUMAN-NATURAL INTERACTIONS

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Title</th>
<th>Institution</th>
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<tbody>
<tr>
<td>8:15</td>
<td>Elena Shevliakova (INVITED)</td>
<td>Why would an Earth System Model benefit from a vegetation dynamics component? Some insights from the NOAA/GFDL ESM4.1</td>
<td>Staff Scientist, GFDL</td>
</tr>
<tr>
<td>8:35</td>
<td>Kathy Hibbard (INVITED)</td>
<td>Terrestrial Ecology now and models of the future: a helicopter view from HQ</td>
<td>Program Manager, NASA ESD/Terrestrial Ecology</td>
</tr>
<tr>
<td>8:50</td>
<td>Sonali McDermid (INVITED)</td>
<td>Eating our cake without losing it: exploring sustainability in agriculture and food security with land modeling</td>
<td>Associate Professor, NYU</td>
</tr>
<tr>
<td>9:10</td>
<td>Levente Klein</td>
<td>Urban Forests for Carbon Sequestration and Heat Island Mitigation</td>
<td>Staff Scientist, IBM</td>
</tr>
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## SUNDAY MORNING SESSION 2: REMOTE SENSING OF VEGETATION

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
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<th>Institution</th>
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</thead>
<tbody>
<tr>
<td>9:25</td>
<td>Wenge Ni-Meister (INVITED)</td>
<td>Quantifying aboveground biomass and vertical photosynthetically active radiation (PAR) transmission and absorption in forest canopies using Lidar measurements</td>
<td>Professor, CUNY Hunter College</td>
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<tr>
<td>9:40</td>
<td>COFFEE BREAK</td>
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<tr>
<td>10:55</td>
<td>Student and postdoc presentation awards, announcement of next co-chairs and date</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11:10-noon</td>
<td>Conference feedback and general discussion</td>
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Oral Presentation Abstracts

MAINTAINING PROCESS IN A DATA-DRIVEN WORLD: APPLICATIONS TO DYNAMIC GLOBAL VEGETATION MODELING, EXAMPLES WITH LPJ-wsl

Ben Poulter¹, Andres Baresch², Leo Calle², Bryce Currey³, Andrew Feldman², Brenden Femal⁴, Qing Ying², Zhen Zhang²

¹NASA Goddard Space Flight Center, Greenbelt, MD; benjamin.poulter@nasa.gov
²University of Maryland, Earth System Science Interdisciplinary Center (ESSIC), Riverdale Park, MD
³Montana State University, Bozeman, MT
⁴University of Maryland, Baltimore County, GESTAR-II

Abstract. Dynamic global vegetation models (DGVMs) were developed in an era where the data landscape was poor and theory was high. Thirty-years later, DGVM modelers find themselves facing the opposite situation, an era rich in data that arguably overwhelms theoretical investments. Data-science initiatives are critical to advance discovery on massive data volumes, assist in data access and equity, and to expand data transparency, yet, a process understanding remains a necessary component of model development and applications to attribution and forecasting. The Lund-Potsdam-Jena (LPJ) DGVM was one of the early models to couple biogeochemistry and vegetation demography using scaling principles that drive soil, leaf, and disturbance processes. Our team has continually developed LPJ (which we call LPJ-wsl) to include new processes related to wetland area and methane emissions, tiling-schemes to represent post-disturbance forest recovery, land-use change, stable and radio-isotope tracers, dynamic plant traits, and simulations of surface reflectance. These developments have enabled LPJ-wsl to contribute to global assessments of the carbon cycle led by the Global Carbon Project, i.e., Trendy V1 through V11, the Global Methane Budget (2017, 2020, and 2023), model intercomparison projects for flux tower networks, and more recently, supporting hyperspectral and greenhouse-gas satellite mission requirements. Throughout the model developments are adaptations to include the exponential availability of data, though data-assimilation, model parameterization, and model benchmarking. An update of these developments and applications to Earth systems challenges will be reviewed for discussion.
LET THERE BE LIGHT:
PHYSICS-BASED CANOPY RADIATIVE TRANSFER FOR COUPLING WITH VEGETATION DEMOGRAPHY AND CARBON

Nancy Y. Kiang\textsuperscript{1}, Wenge Ni-Meister\textsuperscript{2}, Anastasia Romanou\textsuperscript{1}, Paul Lerner\textsuperscript{3}, Igor Aleinov\textsuperscript{3}

\textsuperscript{1}\textit{NASA Goddard Institute for Space Studies}, New York, NY; nancy.y.kiang@nasa.gov
\textsuperscript{2}\textit{City University of New York, Hunter College}, New York, NY; wnimeist@hunter.cuny.edu
\textsuperscript{3}\textit{Columbia University}, New York, NY; anastasia.romanou@nasa.gov

Abstract. The interception of light for photosynthesis and remote sensing observation of plant canopy elements obey the same physics: the radiative transfer of photons, their absorption and scattering. Dynamic global vegetation models that couple with Earth System Models (ESMs) are tasked with simulating the biophysics of canopy gas and energy exchange with the atmosphere as well as the dynamic change in canopy structure with seasonality, competition, and disturbance, all within computational and data constraints at the global scale. Early purely biophysical models began with simple “big leaf” representations of canopies, and have evolved further to represent the vertical extinction of light through a canopy and the distinction between shaded vs. light-saturated sunlit leaves in light use efficiency. The assumptions about the spatial distribution of light-scattering elements in a canopy at the time did not require consideration of the individualistic nature of plants in the ecological dynamics that drive ecosystem change. Now with demographic DGVMs, modelers have sought to introduce ways to represent canopy heterogeneity, more often from ecologists’ perspectives. I review some of these approaches, and then present the coupled model results of sensitivity to diffuse radiation for a geometrical optical radiative transfer (GORT) representation via the Analytical Clumped Two-Stream (ACTS) canopy model in the Ent Terrestrial Biosphere Model (Ent TBM) coupled to the NASA Goddard Institute for Space Studies (GISS) ESM ModelE2.1. A first-order, single-cohort vegetation demography global data set was derived from ICESat/GLAS and MODIS data. Transient historical simulations with some updates to Coupled Model Intercomparison Project 6 (CMIP6) forcings show significance of the response of global gross primary productivity to the aerosol effect on diffuse radiation. The simulations provide a model quantification of the net ecosystem response to the Pinatubo eruption in 1991.
KEYNOTE TALK

DEMOGRAPHIC VEGETATION MODELS FOR CAPTURING FOREST REGROWTH AND CARBON SINK SOLUTIONS

Jennifer A. Holm

Climate and Ecosystem Sciences Division, Lawrence Berkeley National Laboratory, Berkeley CA, USA
jaholm@lbl.gov

Abstract. Global terrestrial vegetation plays a vital role in sustaining biogeochemical and water cycles, but is being altered by anthropogenic global change drivers including land-use change, altered disturbance regimes, and climate change. Better representation of vegetation demography and mechanistic plant competition in Earth System Models (ESMs) is at the forefront of modeling more realistic interactions between biologically driven feedbacks with future climate change. To advance this research we have integrated fine-scale demographic processes into the Energy Exascale Earth System Model’s (E3SM) Land Model (ELM) via the Functionally-Assembled Terrestrial Ecosystem Simulator (FATES). In order to represent ecosystem response from competing vegetation dynamics FATES was used to simulate the growth, reproduction, and mortality of individual trees varying in size- and age-structure, multi-layered canopies, and across many plant functional traits. This enables the land surface model, ELM, to model the fine-scale environmental heterogeneity associated with disturbance and recovery processes. Demographic vegetation models, like FATES, can be pivotal resources in quantifying accurate forest regrowth and carbon sink potential in forests recovering on degraded lands. Unmanaged logging has the potential to be a widespread threat to tropical forests, reducing carbon storage and causing carbon emissions. On the other hand, tropical reforestation on logged or degraded land is a major, ongoing land cover change occurrence, with the potential to store carbon and conserve biodiversity. This presentation will highlight examples of these multiple use-cases of demographic, dynamic vegetation process-based modeling.
KEYNOTE TALK

OBSERVING AND MODELING VEGETATION PHENOLOGY USING REMOTE SENSING AND DATA-DRIVEN MODEL

Minkyu Moon

Department of Earth and Environment, Boston University, Boston, MA; mkmoon@bu.edu

Abstract. Vegetation phenology plays an important role in controlling seasonal variation in ecosystem processes and land-atmosphere exchanges, such as the timing and magnitude of carbon, water, and energy fluxes. As the only viable source providing time series of vegetation activity at local to global scales, and from days to decades, remote sensing has provided invaluable records in vegetation phenology over the last decades. Recently, new sources of remote sensing imagery collected at moderate to high spatial resolutions have dramatically expanded the scope and quality of data available for phenological research using remote sensing. In parallel, modeling studies using data-driven approaches have provided different perspectives compared to results from studies using conventional process-based models, in terms of how vegetation phenology will change in a changing climate. In this talk, I will synthesize findings from our recent studies focusing on two dimensions. First, I will introduce recent progress in observing vegetation phenology using remote sensing, especially from moderate (i.e., from Landsat and Sentinel-2 at 30 m) to high (i.e., from commercial PlanetScope imagery at 3 m) spatial resolution satellite imagery. Second, I will present results from model-based studies using a Bayesian approach that exploits remote sensing to improve understanding of how bioclimatic forcings control the start and end of the growing season.

Keywords: vegetation phenology; remote sensing; data-driven model
Empirical methods underpredict temperature sensitivity compared with warming experiments and mechanistic modeling over alpine grassland
Xiaoting Li¹, Xiangtao Xu¹

¹Department of Ecology and Evolutionary Biology, Cornell University, Ithaca, NY; xl688@cornell.edu, xx286@cornell.edu

Abstract. Spring phenology is one of the most sensitive indicators of climate change and a critical aspect of ecosystem functioning, especially in the cold and temperature-sensitive Tibetan Plateau (TP) which has undergone greater warming than the global average. Evaluating how spring events change with climate variation (here, defined as phenological sensitivity) is often achieved with statistical testing and experimental manipulations. As the number of methods used to infer phenological sensitivity increases, assessing the predictive accuracy of different approaches has become necessary. For the first time, we have compared the sensitivity of spring phenology inferred from parameter-rich correlative regression (e.g., Partial Least Square Regression, PLSR) and mechanistic phenology models with experimental studies and widely used apparent sensitivity by using long-term field observations and satellite-derived spring onset of alpine grasslands in the TP. We show that mechanistic identified phenological sensitivity is the most comparable to warming experiments at the same site, while empirical methods underestimate the temperature sensitivity by 1.78-2.70 days °C⁻¹ and 4.04-4.14 days °C⁻¹ in field observations and satellite-derived data, respectively, despite a comparable predictive accuracy in near-future prediction. Nevertheless, the sensitivity to precipitation appears to be relatively consistent across various methods and scales. Our findings indicate that in colder and wetter regions of the plateau, spring onset is more sensitive to temperature increases. Additionally, we have observed an intriguing relationship between temperature sensitivity and precipitation sensitivity; both mechanistic and empirical approaches revealed a significant negative correlation between these factors. These are among the first results highlighting differential spring phenological responses of alpine grasslands among different methods used and across scales. They provide a predictive and quantitative understanding of phenological sensitivity and its spatial patterns for better representing alpine ecosystems in Earth system models.

Key words: phenological sensitivity; alpine grassland; phenological models.
Abstract. Leaf temperature is central to every canopy-atmosphere exchange and plant function. Yet, the evaluation of how current global vegetation models parameterize leaf temperature is limited. Here, we provide an overview of two long-term thermal imaging datasets available to help constrain models. One site is a mixed temperate forest in Massachusetts (Harvard Forest) and the other is a subalpine conifer forest in Colorado (NIWOT Ridge). We also review whether more readily available flux data (i.e., longwave radiation) may be used as a proxy in models for leaf temperature.
WIDESPREAD EVIDENCE FOR THE THERMAL ACCLIMATION OF CANOPY PHOTOSYNTHESIS

Jiangong Liu\textsuperscript{1,2}, Youngryel Ryu\textsuperscript{2,3*}, Xiangzhong Luo\textsuperscript{4}, Benjamin Dechant\textsuperscript{5}, Trevor F. Keenan\textsuperscript{6,7}, Pierre Gentine\textsuperscript{8,9}, Xing Li\textsuperscript{2}, Bolun Li\textsuperscript{2}, Iain Colin Prentice\textsuperscript{8,10}, Benjamin D. Stocker\textsuperscript{11,12}, Sandy P. Harrison\textsuperscript{10,13}

\textsuperscript{1} Department of Earth and Environmental Engineering, Columbia University, NY 10027, USA; bruce.jiangong.liu@gmail.com
\textsuperscript{2} Research Institute of Agriculture and Life Sciences, Seoul National University, Seoul, Republic of Korea
\textsuperscript{3} Department of Landscape Architecture and Rural Systems Engineering, Seoul National University, Seoul, Republic of Korea
\textsuperscript{4} Department of Geography, National University of Singapore, 1 Arts Link, Singapore 117570
\textsuperscript{5} German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig, Leipzig, Germany
\textsuperscript{6} Climate and Ecosystem Sciences Division, Lawrence Berkeley National Laboratory, 1 Cyclotron Road, Berkeley, CA 94720, USA
\textsuperscript{7} Department of Environmental Science, Policy, and Management, University of California, Berkeley, CA 94720, USA
\textsuperscript{8} Earth Institute, Columbia University, New York, NY 10025, USA
\textsuperscript{9} Georgina Mace Centre for the Living Planet, Department of Life Sciences, Imperial College London, Silwood Park Campus, Buckhurst Road, Ascot SL5 7PY, United Kingdom
\textsuperscript{10} Department of Earth System Science, Ministry of Education Key Laboratory for Earth System Modeling, Institute for Global Change Studies, Tsinghua University, Beijing 100084, China
\textsuperscript{11} Department of Environmental System Science, ETH, Universitätsstrasse 2, Zürich CH-8092, Switzerland
\textsuperscript{12} Swiss Federal Institute for Forest, Snow and Landscape Research WSL, Zürcherstrasse 111, Birmensdorf 8903, Switzerland
\textsuperscript{13} School of Archaeology, Geography and Environmental Sciences (SAGES), University of Reading, Reading RG6 6AH, United Kingdom

Abstract. Most plant leaves acclimate to warming by adjusting their photosynthetic capacities over weeks to months. However, there is little evidence for photosynthetic thermal acclimation at the canopy scale. This study derives the maximum ecosystem-scale light-saturated photosynthetic rates ($A_{\text{max}}$) across over 200 eddy covariance sites. The correlations ($r$) between the light-standardized $A_{\text{max}}$($A_{\text{max},3000}$) and their growth temperature are explored. Evidence of thermal acclimation, indicated by positive $r$, is widely detected across different schemes of concurrent temperature and canopy foliage amount, as well as single flux sites. The evolution of $r$ with the time length for growth temperature suggests 21 days as the most relevant time scale. The average apparent thermal acclimation rate across all ecosystem types reaches $0.51 \pm 0.76 \ \mu\text{mol} \ \text{m}^{-2} \ \text{s}^{-1} \ ^\circ\text{C}^{-1}$, with well-watered ecosystems and evergreen broadleaf forests showing the largest and least acclimation capabilities, respectively. Satellite-based observations demonstrate that canopy structures are potentially attributable to thermal acclimation. The estimated acclimation rate under the framework of a biochemical model indicates that leaf photosynthetic capacities necessarily increase with higher growth temperature to reproduce the pattern observed from FLUXNET2015 sites. The improved canopy $A_{\text{max}}$, corresponding to a higher growth temperature, implies a potential increase in the ecosystem photosynthetic capacity under continued global warming.
15 YEARS OF DEVELOPMENT OF THE ORCHIDEE DATA ASSIMILATION SYSTEM: PROGRESS AND FUTURE DIRECTIONS

Natasha MacBean¹, Cedric Bacour², Philippe Peylin², Vladislav Bastrikov², Nina Raoult³, Fabienne Maignan², Catherine Ottlé²

¹Department of Geography and Environment & Department of Biology, Western University, London, ON, Canada.
²Laboratoire des Sciences du Climat et de l’Environnement, Gif-sur-Yvette, France.
³Department of Mathematics and Statistics, University of Exeter, Exeter, UK.

Abstract. Predicting the fate of land ecosystem carbon and water budgets and their sensitivity to climate change and land use/management strongly relies on our ability to accurately model carbon and water fluxes exchanged with the atmosphere. However, simulated carbon and water fluxes remain subject to large uncertainties, partly because of unknown or poorly calibrated parameters.

Over the past fifteen years, we have developed a carbon and water cycle data assimilation system to investigate the benefit of assimilating multiple data streams into the ORCHIDEE terrestrial biosphere model (TBM), the land surface component of the Institut Pierre Simon Laplace Earth System Model. These datasets have included FLUXNET eddy covariance data (net CO₂ flux and latent heat flux) to constrain hourly to seasonal time-scale carbon and water fluxes, satellite-derived solar induced chlorophyll fluorescence (SIF) measurements to constrain gross C uptake, remote sensing of the vegetation activity (MODIS NDVI/FAPAR) to constrain the leaf phenology, global atmospheric CO₂ concentrations to provide a large-scale constraint on the land carbon sink. Furthermore, we have investigated technical issues related to multiple data stream assimilation and choice of optimization algorithm. This has provided a wide-ranging perspective on the challenges we face in constraining TBM parameters, particularly when using a variety of different observations to quantify and reduce uncertainty in future global vegetation, carbon, and water cycle projections.

We review our past studies in terms of the impact of the optimization on key characteristics of the ecosystem to global carbon cycling and explore differences in global carbon budgets depending on the DA experiment configuration in comparison to atmospheric inversion estimates. We highlight the need for global scale constraints on long-term trends in carbon stocks to accurately simulate the terrestrial carbon sink and its partitioning between northern extratropical versus tropical regions. We further discuss our work in the context of the abovementioned challenges, and propose solutions for the modelling and land DA communities going forward, including: i) how to address questions of scale; ii) the need to account for, or remove, inconsistencies or biases between the model and observations and between different data streams; and iii) the potential from recent studies assimilating new observations (e.g., soil moisture, atmospheric carbonyl sulphide (COS) concentrations, tree ring isotope data, and upcoming satellite biomass and canopy height estimates).

Key words: Terrestrial Biosphere Model, Data Assimilation, Global Carbon Cycle, Water Cycling, Vegetation Dynamics, Satellite Data.
Large Divergence of Projected Arctic Plant Composition and Productivity
due to Functional Trait Uncertainty

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Abstract. Vegetation shifts have been widely recorded in northern-high latitudes and are expected to continue due to rapidly changing climate. Future vegetation change directly controls carbon sink strength and climate feedbacks but remains challenging to predict. Vegetation change arises from the interplay of chronic climate trends such as warming and transient demographic processes of recruitment, growth, competition, and mortality. While most data-driven predictive models focus on the impacts of chronic climate trends, the roles of demographic dynamics—which are controlled by plant functional traits—remain largely unknown. Here, we simulate vegetation demographic dynamics at the Next Generation Ecosystem Experiments - Arctic Kougarok Hillslope field site in Alaska under historical (1960–2010) and future climates (2051–2100) using the E3SM Land Model coupled with the Functionally Assembled Terrestrial Ecosystem Simulator (ELM-FATES). To evaluate the roles of plant functional traits, we parameterize the model with 5312 trait combinations representing diverse strategies of recruitment, photosynthesis, allometry, and mortality. Our results show 542 trait combinations can reproduce in situ observations of biomass composition of plant functional types (PFTs), suggesting significant diversity in trade-offs across traits. In addition, the trait combinations that reproduce the current observation lead to drastically different compositions and productivity under future climate. Notably, the trait-induced uncertainties of projected PFT composition and net primary productivity are 6.5 and 2.7 times that induced by climate, respectively. The variation in PFT composition resulting from across-PFT competition, is primarily explained by traits controlling seed germination, seedling establishment, allometry, maximum carboxylation rate, and freeze-induced mortality. Our findings highlight that neglecting or under-constraining demographic dynamics will likely induce large uncertainties in projected vegetation change. Observational constraints on key functional traits and demographic processes will facilitate better prediction of vegetation change and the carbon sink in northern-high latitudes.

Key words: Arctic vegetation change, ecosystem productivity, FATES modeling, functional traits

Figure 1. Uncertainties of projected net primary productivity (NPP) and biomass due to function traits exceed climate-induced change at an Arctic site.
Constraining simulated tropical tree growth sensitivity to CO\textsubscript{2} fertilization and climate variability by integrating tree ring records

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Abstract

Woody growth in tropical forests has been a major contributor to the land carbon sink in the past decades. Yet, estimates on the strength, potential, and resilience of this tropical carbon sink under ongoing environmental changes are highly uncertain across Earth system models. One critical process is the sensitivity of tree woody growth, the fraction of plant productivity allocated to carbon pools with relatively longer turnover rate, to various environmental factors, especially increasing atmospheric CO\textsubscript{2}. However, constraints on long-term model predictions of tree growth beyond the scale of CO\textsubscript{2} enrichment experiment are lacking, particularly in mature tropical forests. Here, we address this question by leveraging unique tree ring records from a South Asian tropical forest that provide information on woody growth and water use efficiency during the past century. Particularly, we combined the tree ring records with ED-2.2-hydro, a terrestrial biosphere model with explicit vegetation demography that allows for extraction of simulated tree rings.

After model calibration, we conducted numerical experiments including or excluding historical atmospheric CO\textsubscript{2} increase and compared simulated and observed tree ring records. We found that the model can reasonably capture the observed long-term increase of inter-cellular CO\textsubscript{2} concentration (~50-70 ppm per century, estimated from carbon isotope) but strongly overestimated tree growth sensitivity to CO\textsubscript{2}, especially for the fast-growing, low wood density plant functional type. Significant downregulation (over 50\%) of aboveground woody carbon allocation in our model is necessary to match the observed growth sensitivity to CO\textsubscript{2}. The simulated annual tree growth also shows much higher sensitivity to inter-annual climate variability, likely caused by the simplistic source-driven woody growth scheme. Altogether, our findings highlight the importance of woody growth ecophysiology in predicting long-term forest changes and provide novel quantitative constraints on tropical aboveground woody growth that will help to reduce uncertainty in carbon sequestration predictions in the tropics.
**INVASIVE SPECIES MONITORING WITH UV-VIS-NIR SPECTROSCOPY**

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Abstract. The hemlock woolly adelgid, or HWA, is an insect of the order Hemiptera native to East Asia. It feeds by sucking sap from hemlock and spruce trees and is causing widespread death and decline of hemlock trees in the Eastern United States. Its seasonal appearance in the spring and fall at the Harvard forest in Massachusetts is hard to see and monitor due to the height of the Hemlock canopies. This study investigates the use of UV-Vis-NIR spectroscopy for the detection of infested trees. The impact of the spectral resolution of the UV-Vis-NIR spectroradiometer on the detection threshold is also discussed.

*Key words:* invasive species; hemlock; adelgid; spectroscopy.

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**WHY WOULD AN EARTH SYSTEM MODEL BENEFIT FROM A VEGETATION DYNAMICS COMPONENT?**

**SOME INSIGHTS FROM THE NOAA/GFDL ESM4.1**

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Abstract. For the Coupled Model Intercomparison Project, phase 6 (CMIP6) NOAA/GFDL developed a new Earth System Model ESM4.1 that includes new land component LM4.1 capable of representing age-height structured vegetation dynamics following the Perfect Plasticity Approximation Approach. In LM4.1, vegetation dynamics is fully integrated with the land surface energy, water, and carbon exchanges via a multi-layer canopy structure with the prognostic prediction of temperature, stomatal conductance, and canopy water storage for each vegetation cohort. The state of vegetation is affected by changes in climate, wildfire disturbances, and land use land cover changes via CMIP6 historical reconstructions and SSP scenarios. Analysis of CMIP6 and other ESM4.1 simulations suggest that vegetation dynamics could play a non-trivial role in shaping future responses of climate and land carbon cycle to increases of atmospheric GHGs and direct land use forcings.
Abstract. NASA Terrestrial Ecology research addresses changes in Earth’s carbon cycle and ecosystems using space-based observations. The goals of NASA’s Terrestrial Ecology research are to improve understanding of the structure and function of global terrestrial ecosystems, their interactions with the atmosphere and hydrosphere, and their role in the cycling of the major biogeochemical elements and water. This program of research addresses variability in terrestrial ecosystems, how terrestrial ecosystems and biogeochemical cycles respond to and affect global environmental change, and future changes in carbon cycle dynamics and terrestrial ecosystems. The research approach combines (i) use of remote sensing to observe terrestrial ecosystems and their responses; (ii) field campaigns and related process studies to elucidate ecosystem function; and (iii) ecosystem and biogeochemical cycle modeling to analyze and predict responses. Research to establish a theoretical and scientific basis for measuring Earth surface properties using reflected, emitted, and scattered electromagnetic radiation and to develop the methodologies and technical approaches to analyze and interpret such measurements is an important component of the Terrestrial Ecology research program.

Eating Our Cake Without Losing It: Exploring Sustainability in Agriculture and Food Security with Land Modeling

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Abstract. Global agriculture has transformed ~40% of Earth’s land surface, consuming copious inputs including water, fertilizer, and land. While we are currently producing more than we ever have, this has not meant food and nutrition security for all and, furthermore, agriculture and associated land use is now a major contributor to climate change, exceedance of biogeochemical flows, biodiversity loss, and water over-extraction. By the same token, climate change and extremes increasingly threatens agriculture and food security. In response to these challenges, interest in sustainable food system transformations is growing, and a large emphasis has been placed on improving agricultural production. Emerging efforts (and carbon markets) are even pursuing agriculture as a “nature-based” climate solution via increasing soil and agroecosystem carbon sequestration. Land systems modeling is a crucial tool to understanding agriculture as both a driver of global environmental change as well as its vulnerabilities to these changes. Both must be better understood - and better modeled - in order to meet the combined goals of global food security and global environmental change mitigation into the future. My talk will provide a brief overview of agriculture-Earth systems interactions and identify key questions for modeling agriculture in a land and Earth systems framework. In doing so, I will flag key uncertainties/limitations to our current approaches, and highlight important efforts for coordinated and cross-disciplinary Earth system modeling centered around agriculture and land use.
With the majority of globe population projected to live in urban areas, mitigation of urban heat islands effects that directly impact human health and wellbeing is of primary importance. Traditionally urban heat islands were assessed based on statistically assembled weather parameters but frequent remote sensing data like surface temperature and land use can support strategies like integration of vegetation, parks and urban design to mitigate urban heat islands. We developed an image processing tool to assess tree detection from high resolution National Agriculture Imagery Program (NAIP). The NAIP data consist of Red, Green, Blue and Near Infrared band at 0.5 m resolution. Using image segmentation and land use classification, individual trees are delineated, and the height is estimated based on crown diameter. Models are calibrated using a small sample of LiDAR data. Dependent on the tree species, the biomass of individual tree can be estimated considering tree shape and wood density. These trees serve both as a carbon sequestration pool and heat island mitigation tool. Climate change will increase the frequency and severity of urban heat islands. Thus, new urban planning strategies demand our attention. Based on multimodal, remotely sensed data, we map the tree density, its carbon sequestered, and its impact on urban heat islands for New York City, NY and Dallas, TX. Using local climate zones, we investigate concepts of urban planning through optimized tree planting and adjusting building designs to mitigate urban heat islands.
QUANTIFYING ABOVEGROUND BIOMASS AND VERTICAL PHOTOSYNTHETICALLY ACTIVE RADIATION (PAR) TRANSMISSION AND ABSORPTION IN FOREST CANOPIES USING LIDAR MEASUREMENTS

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Abstract This study presents our current activities of using lidar measurements to estimate terrestrial aboveground biomass (AGB) and photosynthetic active radiation (PAR) transmission and absorption in forest canopies. We developed a physically based AGB density model that directly uses lidar waveform measurements instead of derived height metrics. We applied this biomass model to estimate aboveground biomass at the continental U.S. using the spaceborne Global Ecosystem Dynamics Investigation (GEDI) lidar waveform measurements. We estimated the above-ground biomass at each GEDI footprint, and compared the aggregated the biomass with FIA biomass at hexagon (64,000 Ha hexagon) scale with good accuracy. The model outperforms current available GEDI biomass products significantly. This study demonstrates the capability of this model to estimate aboveground biomass at the continental scale using spaceborne GEDI waveform measurements. In this talk, I also demonstrate the use of lidar measurements to estimate light transmission and absorption for photosynthesis to demonstrate the capability to link vegetation structure measurements from lidar for modeling land surface biophysics processes.

Key words: biomass; PAR, lidar waveforms; GEDI
REMOTE SENSING OF TERRESTRIAL ECOSYSTEMS AND THE DEVELOPMENT OF A PREDICTIVE SCIENCE OF THE BIOSPHERE

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Abstract. Remote sensing measurements of terrestrial vegetation have been integral to the development of earth system models. The interplay between terrestrial biosphere models and remote sensing measurements has, however, entered a new, more complex, and more challenging era because modern-day terrestrial biosphere models are integrating predictions of short-term carbon, water, and energy fluxes into corresponding predictions of long-term changes in ecosystem composition and structure. In this presentation, I show how remote-sensing measurements of plant canopy structure and composition can be used to constrain and improve terrestrial biosphere model simulations of current and near-term carbon, water and energy fluxes, and accompanying vegetation dynamics. Analyses in temperate and tropical ecosystems indicate that there are significant long-term, large-scale legacies of canopy structure and composition on predictions of ecosystem change over the coming century. The findings demonstrate the importance of canopy structure and composition to predictions about how ongoing human activities are altering terrestrial ecosystems and their biogeochemical and biophysical dynamics.
## Poster List

(in alphabetical order by last name)

<table>
<thead>
<tr>
<th>Name</th>
<th>Title</th>
<th>Affiliation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Melissa Linares</td>
<td>Assessing the Impact of the ACTS Canopy Radiative Transfer Scheme on Land Surface Albedo Simulations in the NASA GISS Earth System Model</td>
<td>Graduate student, CUNY Hunter College</td>
</tr>
<tr>
<td>Melissa Linares</td>
<td>Impact of Wildfires on Land Surface Winter Climate in the Northern High-Latitudes: Insights on Vegetation Structure, Albedo Feedback, and Radiation Forcing</td>
<td>Graduate student, CUNY Hunter College</td>
</tr>
<tr>
<td>Yixin Ma</td>
<td>Light plasticity in multiple leaf traits regulates tropical forest structure and increases long-term biomass growth</td>
<td>Graduate student, Cornell University</td>
</tr>
<tr>
<td>Wenge Ni-Meister</td>
<td>Quantifying Aboveground Biomass In The Continental U.S. Using GEDI Waveform Measurements</td>
<td>Professor, CUNY Hunter College</td>
</tr>
<tr>
<td>Wenge Ni-Meister</td>
<td>Direct use of lidar measurements to simulate vertical photosynthetic active radiation (PAR) transmission and absorption in forest canopies through a canopy Geometric Optical and Radiative Transfer model</td>
<td>Professor, CUNY Hunter College</td>
</tr>
<tr>
<td>Joshua M. Rady</td>
<td>Climate Change and Forest Management Increase Loblolly Productivity and Yields in the 21st Century</td>
<td>Postdoc, Woodwell Climate Research Center</td>
</tr>
<tr>
<td>Xinyuan Wei</td>
<td>Biome correlation and time-dependent response of terrestrial ecosystem carbon fluxes to droughts</td>
<td>Postdoc, University of Maine</td>
</tr>
<tr>
<td>Ensheng Weng</td>
<td>Modeling demographic-driven vegetation dynamics and ecosystem biogeochemical cycling in NASA GISS’s Earth system model (ModelE-BiomeE v.1.0)*</td>
<td>Staff Scientist, Columbia University</td>
</tr>
</tbody>
</table>
Poster Abstracts

ASSESSING THE IMPACT OF THE ACTS CANOPY RADIATIVE TRANSFER SCHEME ON LAND SURFACE ALBEDO SIMULATIONS IN THE NASA GISS EARTH SYSTEM MODEL

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Abstract. This study evaluates the performance of the National Aeronautics and Space Administration (NASA) Goddard Institute for Space Studies (GISS) Earth System Model in simulating land surface albedo using its latest version. Specifically, we compare the model's surface albedo estimates with and without the Analytical Clumped Two-Stream (ACTS) canopy radiative transfer scheme developed for the Ent Terrestrial Biosphere Model (TBM). One of the differences between the new and old versions of the model is that in the ModelE with no Ent/ACTS, the vegetation cover is homogenous, while in the ModelE with Ent/ACTS, the vegetation cover accounts for gaps, resulting in more exposed surface, which can have an impact on snow dynamics. This difference in vegetation cover has implications for snow dynamics, as the exposed surface in the Ent/ACTS model allows for more snow accumulation and retention, affecting land surface albedo estimates. To assess the impact of the ACTS model on surface albedo estimates, we compare the results with the original snow mask algorithm during the winter months of 2004 (January, February, and March). We use MODIS observations to evaluate the accuracy of the models' estimates. The comparison reveals that the Ent/ACTS model predicts land surface albedo within 6.1%, 7.1%, and 6.7% RMSE of MODIS observations for January, February, and March, respectively. In contrast, the RMSE values for the current ModelE with no Ent/ACTS are 11.4%, 14.2%, and 13.5% for the same months. The findings suggest that incorporating a more realistic representation of vegetation cover in land surface models can improve the accuracy of simulations and further research in this area is warranted. However, the study also highlights the need for further investigation into the suitability of the model's snow masking of trees, which was tuned for the old model, for the ACTS model. Future work will involve adjusting this masking and running simulations with snow only under trees and no masking on top to improve the accuracy of the model's predictions. Overall, this study highlights the potential of the Ent/ACTS model to improve the accuracy of land surface albedo simulations and the need for ongoing research in this area.
IMPACT OF WILDFIRES ON LAND SURFACE WINTER CLIMATE IN THE NORTHERN HIGH-LATITUDES: INSIGHTS ON VEGETATION STRUCTURE, ALBEDO FEEDBACK, AND RADIATION FORCING

M. Linares¹, and W. Ni-Meister¹
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Abstract. Climate warming caused by human activity is increasing wildfires, leading to significant changes in the land surface winter climate in the northern high-latitudes. This study assesses the impact of wildfires on surface albedo, vegetation structure, and radiation forcing in central Alaska's boreal forest region using data from MODIS and the Monitoring Trends in Burn Severity program. The study found that all fire sites experienced a change in land cover after the fire, with the dominant land cover type shifting from high-stature to low-stature vegetation. The effects of fire severity depended on the land cover type. Post-fire, summertime leaf area index values recovered to pre-fire levels within 11 years, while winter values did not recover within the same timeframe. Surface albedo increased post-fire, with a more significant increase in wintertime albedo in higher-severity fires. In all nine burn sites, there was an increase in post-fire albedo, which persisted for an extended period, resulting in a negative radiative forcing to the atmosphere in the boreal region. The study also found that post-fire albedo and snow dynamics are driven by the loss of forest canopy, changes in land cover, and the amount of short and long-wave radiation reaching the surface. The findings suggest that fire severity, vegetation structure, and land cover change play a significant role in determining the post-fire albedo trajectory and vegetation recovery, which can dramatically alter the energy balance and climate. Therefore, future climate models should consider these factors to better understand the complex relationship between albedo feedback and radiation forcing.
LIGHT PLASTICITY IN MULTIPLE LEAF TRAITS REGULATES TROPICAL FOREST STRUCTURE AND INCREASES LONG-TERM BIOMASS GROWTH

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Abstract. Phenotypic plasticity is widely observed across organisms, and studies have shown that plasticity can increase individual fitness and promote population dynamics. However, previous research either have limited spatiotemporal scale or are unable to characterize ecosystem dynamics, and the impact of plasticity on community and ecosystem processes has yet to be evaluated. This knowledge is particularly crucial for tropical forests where plant traits can vary by ten folds within the same species, and plants may adaptively adjust to environmental changes and disturbances by this high trait plasticity. Here we combine trait-based modeling with in situ trait measurements of leaf gas exchange, specific leaf area, and leaf lifespan to quantify the plasticity impact across multiple ecological scales in a tropical moist forest. Our results show that light-driven plasticity in both photosynthetic and non-photosynthetic leaf traits greatly contribute to maintaining understory growth and survival. It also regulates forest structure including forest size structure and leaf area profile. In the long term, light plasticity substantially increases both biomass growth and total biomass during succession. Importantly, the plasticity effect cannot be compensated by increasing trait diversity across plant functional types. We provide the first evidence that changes in demographic rates induced by light-driven plasticity strongly regulate ecosystem structure and long-term carbon dynamics. Our results highlight that trait plasticity is required for trait-based predictions of vegetation dynamics under global change, and that future research should investigate the significance of phenotypic plasticity from a whole-ecosystem perspective.

Key words: light plasticity; leaf physiological traits; plant functional diversity; tropical forest; biomass; succession
DIRECT USE OF LIDAR MEASUREMENTS TO SIMULATE VERTICAL PHOTOSYNTHETIC ACTIVE RADIATION (PAR) TRANSMISSION AND ABSORPTION IN FOREST CANOPIES THROUGH A CANOPY GEOMETRIC OPTICAL AND RADIATIVE TRANSFER MODEL

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Abstract. Photosynthetically Active Radiation (PAR) is the most important limiting factor driving various ecological processes such as photosynthesis, evaporation, and CO2 uptake in forest canopies. Complex three-dimensional canopy structure controls the vertical distribution of light regimes in forest canopies. Spatial variation of complex vegetation structure leads to large spatial and temporal variation of radiation regimes in forests, thus photosynthesis and carbon uptake.

To study the impact of three-dimensional vegetation structure variation on the PAR environment in forests, we integrate lidar measurements with a canopy Geometric Optical and Radiative Transfer (GORT) model to simulate PAR transmission and absorptions. We use the discrete lidar data collected at the National Ecological Observatory Network (NEON) sites across the continental US to simulate the PAR transmission and absorption profiles at various forest sites. We compare the modeled PAR transmission and absorption with the NEON tower measurements. Our comparison results show that lidar-modeled PAR transmission and absorption agree reasonably well with tower measurements for forests with various vegetation structure characteristics. Our study demonstrates a quick, straightforward approach to using three-dimensional vegetation structure measurements from lidar to simulate vertical PAR transmission and absorption. Future work integrates the lidar vegetation structure measurements into ecosystem demography models to study the impact of vegetation structure on PAR transmission and absorption, photosynthesis, and the net atmosphere surface CO2 exchanges (NAE).

Key words: lidar; PAR; GORT
CLIMATE CHANGE AND FOREST MANAGEMENT INCREASE LOBLOLLY PRODUCTIVITY AND YIELDS IN THE 21ST CENTURY

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Abstract. Managed pine forests in the Southeastern United States (SEUS) make it one of the leading wood producing regions in the world. Climate change over the 21st century will alter the growth of these forests with implications for wood yields and plantation area. We used the CLM-FATES earth system model with the Vegetation Management Module to examine the influence of climate and forestry practices on loblolly pine (\textit{Pinus taeda}) plantations over the 21st century under Coupled Model Intercomparison Project Phase 6 (CMIP6) climate scenarios SSP1 RCP2.6 and SSP5 RCP8.5. We found that rising atmospheric CO\textsubscript{2} drives increases in SEUS loblolly productivity and wood yields. Planting density, age of harvest (rotation length), and mid-rotation stand thinning alter wood yields, with stand thinning having an effect comparable to climate change. Increasing productivity of Southern loblolly pine plantations could decrease the forest area needed to meet future societal wood demand, with unclear land cover and climate consequences. New work to advance predictive wildfire models in the northern permafrost zone with DVM-DOS-TEM is also introduced.

Key words: Forest Management; CLM-FATES, Climate Change; \textit{Pinus taeda}; DVM-DOS-TEM.
**Biome Correlation and Time-Dependent Response of Terrestrial Ecosystem Carbon Fluxes to Droughts**

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Abstract. The terrestrial biosphere plays an important role in the global carbon cycle, and droughts can have strong direct and indirect impacts on the key underlying ecological processes. Worldwide, droughts are becoming more frequent with increasing weather extremes, resulting in substantial impacts on land-atmosphere carbon exchange. However, the patterns of carbon fluxes in response to droughts differ across biomes and time scales due to variations in the adaptation and resilience of different plant species, soil properties, and available water and nutrients. In this study, we integrated results from an ensemble of terrestrial biosphere model simulations and examined the biome-scale spatial patterns in the response of carbon fluxes to droughts at different time scales. The results suggest that, globally, the direction and magnitude of terrestrial biosphere carbon fluxes were strongly correlated with droughts across all biomes. Tropical regions had the most robust correlation, while tundra areas had the weakest. Overall, carbon fluxes were most correlated with droughts at the 24-month time scale, but the magnitudes and effects varied from biome to biome. A new, categorical Drought Response Index was developed to characterize the effect of droughts on biome-scale net carbon exchange. The results indicate that droughts generally reduced terrestrial ecosystem carbon uptake and promoted carbon release; however, shorter droughts (≤ 6 months) might act to increase carbon uptake in portions of the arctic tundra and boreal forest biomes.
Modeling demographic-driven vegetation dynamics and ecosystem biogeochemical cycling in NASA GISS’s Earth system model (ModelE-BiomeE v.1.0)*

Ensheng Weng1,2, Igor Aleinov1,2, Ram Singh1,2, Michael J. Puma1,2, Sonali S. McDermid3, Nancy Y. Kiang2, Maxwell Kelley2, Kevin Wilcox4, Ray Dybzinski5, Caroline E. Farrior6, Stephen W. Pacala7, Benjamin I. Cook2

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Abstract. We developed a demographic vegetation model, BiomeE, to improve the modeling of vegetation dynamics and ecosystem biogeochemical cycles in the NASA Goddard Institute of Space Studies’ ModelE Earth system model. This model includes the processes of plant growth, mortality, reproduction, vegetation structural dynamics, and soil carbon and nitrogen storage and transformations. The model combines the plant physiological processes of ModelE’s original vegetation model, Ent, with the plant demographic and ecosystem nitrogen processes that have been represented in the Geophysical Fluid Dynamics Laboratory’s LM3-PPA. We used 9 plant functional types to represent global natural vegetation functional diversity, including trees, shrubs, and grasses, and a new phenology model to simulate vegetation seasonal changes with temperature and precipitation fluctuations. Competition for light and soil resources is individual-based, which makes the modeling of transient compositional dynamics and vegetation succession possible. Overall, the BiomeE model simulates, with fidelity comparable to other models, the dynamics of vegetation and soil biogeochemistry, including leaf area index, vegetation structure (e.g., height, tree density, size distribution, crown organization), and ecosystem carbon and nitrogen storage and fluxes. This model allows ModelE to simulate transient and long-term biogeophysical and biogeochemical feedbacks between the climate system and land ecosystems. Further, BiomeE also allows for the eco-evolutionary modeling of community assemblage in response to past and future climate changes with its individual-based competition and demographic processes.

## LIST OF PARTICIPANTS

<table>
<thead>
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<th>Affiliation</th>
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</tr>
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