F.5 Future Investigators in NASA Earth and Space Science and Technology
SOLICITATION: NNH23ZDA001N-FINESST

The Science Mission Directorate (SMD) received a total of 1120 proposals that were submitted to the F.5 Future Investigators in NASA Earth and Space Science and Technology (FINESST) competition within the Notice of Funding Opportunity (NOFO) entitled “NASA Research Announcement: Research Opportunities in Space and Earth Sciences” (ROSES-2023)”. Five SMD divisions at NASA Headquarters, i.e., Astrophysics, Biological and Physical Sciences, Earth Science, Heliophysics, and Planetary Science, conducted/provided oversight for the review and selection process.

FINESST accepts proposals for graduate student-designed research projects that contribute to SMD’s science, technology, and exploration goals. The maximum, three-year total FINESST award amount is $150,000 and includes the reasonable, allowable, and allocable cost categories described in Title 2 of the Code of Federal Regulations (2 CFR §200), inclusive of any indirect, overhead, and facilities and administrative costs. The total funding amount does not exceed $50,000 per proposal year for all costs combined, i.e., stipend or other type of compensation paid to the FI, travel related costs (e.g., registration, airfare, meals and incidental expenses, ground transportation) in support of conferences, symposia, or collaborative meetings and/or research, fees/tuition, and other FI support costs (e.g., expendable laboratory supplies, page charges for journal articles, printing of a thesis, health insurance policy, textbooks, or other instructional supports), etc.

SMD's timeframe to communicate privately the selection or intent-to-award decisions is late June through late November. Most SMD Divisions release selection decisions first, followed by non-selections/declinations approximately 75 days later. The NASA Solicitation and Proposal Integrated Review and Evaluation System (NSPIRES) separately announces each decision via a system generated email sent to the PI and AOR. NSPIRES makes detailed documentation of the selection and declination decisions available for each reviewed proposal to both the Principal Investigator (PI) and Authorized Organization Representative (AOR).

Access to proposal-specific documentation requires logging in to NSPIRES and navigating to the submitted proposal. Normally, FIs, however, cannot access FINESST decisions or review results directly via NSPIRES and must rely on the PI and AOR to share results. If by December 1, the PI and/or AOR have not contacted the FI, then the FI should ask them 1) to log in to NSPIRES to see if the proposal status has changed and 2) and if the status has changed, to download and share the results.

For assistance with NSPIRES log in, please contact the NSPIRES Help Desk at (202) 479-9376 Monday – Friday, excluding Federal Holidays, (e.g., Labor Day September 2, 2024, etc.) between the hours of 8 AM to 6 PM Eastern Time or by email at nspires-help@nasaprs.com.

Table 1: FINESST-23 Proposal Data

Division	Proposals Received	Proposals Selected (Estimated)	NSPIRES Publication Date
Astrophysics	315	24	July 8, 2024
Biological and Physical Sciences	43	TBD	TBD, 2024
Earth Science	434	57	August 5, 2024
Heliophysics	75	TBD	TBD, 2024
Planetary Science*	253	TBD	TBD ,2024
Totals**	1120	TBD	November 29, 2024 (Date is Subject to Change)

NOTE For Selected PI-FI Teams: Once SMD receives selection acceptance, the FINESST proposal will be transferred to the NASA Shared Services Center (NSSC). NSPIRES cannot track the NSSC grant processing activities. A grant's status may be tracked via a web search on the PI's name (do not use the FI name or NSPIRES proposal number) at: https://www3.nasa.gov/centers/nssc/forms/grant-status-form, telephoning the NSSC at 1-877-NSSC123, or e-mailing nssc-contactcenter@nasa.gov.

Any pre-award costs incurred are at the proposer's risk. All new awards receive an automatic 90 days of pre-award spending approval on award, meaning that NASA has waived the requirement for FINESST award recipients to obtain written approval prior to incurring project costs up to 90 calendar days before NASA issues an award. Just because NASA gives a pre-award costing waiver doesn't mean that waiver is binding on the FI's institution. The awardee's written policies may overrule or take precedence from the NASA's waiver. Plus expenses incurred more than 90 calendar days before an award require prior written (i.e., email) approval from a Grants Officer at the NSSC.

NOTE for Non-Selected PI-FI Teams: SMD received a far greater number of proposals than available funds can support. In February 2024, SMD published draft, partial text for the next solicitation, NNH24ZDA001N-FINESST, as a cross-divisional appendix to ROSES-2024 at https://go.nasa.gov/FINESST24. In a major change from prior years, FINESST-24 will participate in SMD's Dual-Anonymous Peer Review (DAPR) process. For more information about DAPR visit https://science.nasa.gov/researchers/dual-anonymous-peer-review/.

Contingent on the final text of FINESST-24, a non-selected 2023 FINESST proposal may be eligible to be revised and resubmitted to the 2024 competition. Entirely new, eligible proposals also are welcome.

When the new FINESST solicitation (F.5) is published in final form it will be available at https://go.nasa.gov/FINESST24. Proposal intake will continue for an approximate minimum of 90 days from the release barring any unforeseen circumstances. In the interim, SMD's Cross Division FINESST team welcome general comments, comments on the draft FINESST-24 text, questions, and FINESST-improvement suggestions via email at: HQ-FINESST@mail.nasa.gov.

*Technical Note: *The Planetary Science Division (PSD) will make all notifications (selections and declines) available on NSPIRES at the same time in order to be consistent with other PSD program practices.*

***These totals may be different than what a selection letter may indicate due to administrative adjustments.*

EARTH SCIENCE Division Selection Summaries, (57, Alphabetical by PI Last Name)

Loren Albert (PI) / Charles Southwick (FI)
Oregon State University
23-EARTH23-0137: Testing Competing Hypotheses for Amazon SIF Seasonality

The possibility that the Amazon rainforest will reach a 'tipping point' under climate change is of pressing concern to Earth system scientists, policymakers, and the public. Some Earth system models suggest climate-change-induced forest dieback within Amazonia, whereas others suggest resilience. Remote sensing has revealed clues to how forests of the Amazon respond to increasingly dry conditions, such as evidence of a 'green-up' in the dry season. For over 15 years, scientists have debated whether this 'green-up' signifies increased Amazon photosynthesis during dry periods, seasonal changes in forest structure, or is simply an artifact. Solar-induced fluorescence (SIF) promises a more direct link to photosynthesis, and TROPOMI SIF has recently been shown to increase during the dry season in the Amazon. Yet, the mechanisms behind this increase remain unclear. We propose to test the hypothesis that SIF in the Amazon increases during the dry season due to seasonal changes in how the Amazon Forest interacts with light at the canopy, crown, and leaf spatial scales. We will combine a unique set of cross-scale approaches to enhance our understanding of the complex interplay between canopy structural complexity, phenological processes, and ecophysiological factors affecting Amazon radiative transfer.

The research strategy will test structural and physiological hypotheses for seasonal changes in SIF through three objectives: Obj. 1) testing the theory that satellite-scale leaf area index (LAI) is predictive of SIF throughout the annual cycle; Obj. 2) exploring the role of temporal variability in leaf angle (a strong driver of radiative transfer) in influencing dry season Amazon SIF; and Obj. 3) quantifying how leaf age-related physiology drives SIF responses during dry season leaf turnover.

We will address these objectives through 4 key tasks: Task 1 involves compiling basin-wide remote sensing datasets (TROPOMI and GEDI) to analyze the relationships between season, structure, and SIF (for Obj. 1). Task 2 quantifies leaf angle distributions, physiology, and phenology through extensive fieldwork at two sites in the Brazilian Amazon (for Objs. 2 & 3). Task 3 integrates canopy field data with DESIS hyperspectral satellite data using a processedbased model, enabling a sensitivity analysis of tropical forest radiative transfer to provide insights into the canopy-level relationship between leaf area index, leaf angle, and SIF (for Obj. 2). Finally, Task 4 seeks to characterize SIF and leaf age relationships by integrating leaf ecophysiological and phenological data (for Obj. 3).

The proposed methodology aligns with NASA Earth Science Strategic Plan objectives and vision for interdisciplinary discovery. The integrated approach fulfills Decadal Survey objectives, including quantifying functional traits, vegetation 3D structure, and terrestrial system physiological dynamics (Measurement Objectives E-1a,b,c), as well as quantifying the carbon fluxes into an ecosystem (E-3a). Overall, this proposal represents a multifaceted, cross-scale effort to shed light on the intricate mechanisms driving Amazon SIF seasonality. This proposal will advance appropriate use of SIF as a proxy for both drought stress and gross primary productivity, furthering our capacity to model and monitor the complex dynamics of Earth's vulnerable tropical forests.

Ernesto Alvarado (PI) / Maria Isabel Silva dos Santos (FI)
University of Washington, Seattle
23-EARTH23-0029: Analysis of Amazonian Forest Post Slash Fire: Understanding the Influence of Fire Severity on Regeneration

Global climate change associated with high levels of deforestation and fragmentation are causing prolonged drought periods in the Southern Amazon Forest, an area known as Arc of Deforestation. In this context, the agricultural conversion practice of forest slash and burn produces fires of increasing intensity that impact subsequent forest regeneration. Studies suggest that biomass accumulation occurs slowly for areas of higher fire severities, which directly impacts ecosystem services, biodiversity, and carbon uptake. Aside from that, current Earth Observation (EO) monitoring models do not account for those different recovery dynamics and underestimate the age after fire of areas of higher severity fires. Therefore, understanding how the burnt tropical areas recover from increased fire intensity is imperative for the future managing and monitoring of this ecosystem, as well as estimating terrestrial carbon (C) fluxes and modelling the global C cycle.

The main goal of this research project is to create a new secondary-forest monitoring model with increased accuracy to estimate years after fire and carbon uptake by incorporating historical fire intensity data to the model. This will be acomplished by integrating fuel consumption, calculated from EO data; chronosequences of secondary forests structure vs. fire severity, and geospatial analysis of biomass recovery.

First, EO data provided by NASA will be used to identify slash fires, estimate their fuel consumption, and characterize post-fire vegetation change at the field plots and wider Southern Amazon basin. A time-series of Landsat and MODIS imagery (2001+) will be used to identify the time of forest felling though analysis of vegetation phenological metrics. The MODIS active fire product (MOD14), will be used to identify the burn date. Precipitation between forest felling and fuel combustion will be measured using Tropical Rainfall Measuring Mission (TRMM) data. Regional slash fire fuel consumption estimates (2001-2023) will be derived using fire radiative energy (FRE). The next step to this study is the assessment of regeneration of similar plots that were subjected to a varied range of fire severities. The designated forest site encompasses eight plots of varying sizes, slashed-and-burned between 1997 and 2005. Since these plots were experimentally cleared and subjected to controlled burns, with their fire characteristics quantified, they offer a valuable contrast across known biomass fuel load and biomass fire consumption. This will facilitate a thorough comparison with remote sensing fire characterization data. For each plot, field measurements will include the assembling of a forest inventory and geospatial surveying using terrestrial laser scanning (TLS). Results will base the creation of chronosequences of successional trajectories for low and high fire severities. Finally, it will be possible to create a model to estimate age-after-fire and carbon uptake that considers both EO analysis, field data and terrestrial carbon models. Utilizing Google Earth Engine and MapBiomas, the study delineates secondary forest areas. Biomass recovery assessment will be performed using LandTrendr algorithm, forming the basis for a model capable of delineating secondary forests that were previously subjected to slash fires and estimate their age-after-fire and carbon uptake. Validation includes current SINTRAFOR inventories.

In summary, this project uses an integrative methodology to advance the understanding of post-fire forest regeneration in the Southern Brazilian Amazon. By integrating advanced EO technology, historical on-site measurements, and current on-site measurements, it aims to create a new, more accurate model to estimate years after fire and carbon uptake. Therefore, this large-scale model of an area so heavily deforested can inform restoration efforts in the region, and contribute to monitoring of land-cover, carbon stocks and the modeling of global carbon fluxes.

Robert Anderson (PI) / Andrew Gaier (FI)
City College of New York
23-EARTH23-0374: Predicting Species Composition and Extinction Risks for Montane Mammals Across Dynamic Patchy Environments

In light of increased rates of environmental change and habitat fragmentation, understanding biodiversity patterns across dynamic, patchy environments is crucial for ecological research and conserving nature and its services to humans. Forecasting how species will respond to future changes remains a central challenge to ecologists, including the often-quantified Essential Biodiversity Variable, "species distributions." Insular distribution functions (IDFs) have historically been key models in biogeography, aiming to predict how the size and connectivity of a habitat patch influence species extinctions. These models hinge upon estimations of patch size and isolation, but traditional methods of quantifying these variables are simplistic, and they only reflect current environmental conditions. Fortunately, recent advancements in remote sensing, landscape ecology, and species distribution models (SDM) now offer powerful tools for improving the predictive power of IDFs. Remote sensing technologies can provide detailed information about climate and landcover, and landscape ecology offers ecologically realistic ways to quantify connectivity, area, and habitat quality. SDMs are the bridge: they integrate that ex situ environmental data with in situ species occurrence data to estimate habitat suitability maps, which then can be used to calculate the modern landscape ecology metrics. Complementarily, a new biogeographic model provides the framework to consider not only the effects of present environments but also past ones, as drivers of current presence or absence on patches. Hence, by modernizing IDFs and integrating both current and past environmental data, researchers would be better able to assess the factors influencing biodiversity and refine predictive models for future scenarios.

The proposed research aims to do so, modernizing classic methods in biogeography, with mammals of the Great Basin of western North America as a study system. This data-rich region, characterized by isolated mountain peaks or "sky islands," provides an excellent opportunity to investigate how habitat availability and spatial connectivity have influenced the extinction and colonization processes of species since the last glacial maximum (LGM). In this potentially transformative research, the future investigator will utilize NASA data on current climate, landcover, and reconstructions of past climate. These datasets will allow cutting-edge characterizations of present and past patterns of habitat availability and connectivity in the Great Basin. He proposes to 1) modernize IDFs using remotely sensed data and SDMs, 2) make and test predictions of mammal presence or absence on patches based on present patterns of species-specific area and connectivity, and 3) determine how past habitat availability and connectivity influenced present patterns in patch occupancy. He will assemble data for a pool of species inhabiting the larger source habitats adjacent to the Great Basin. Using present day quantifications of area and isolation from SDMs, he will build IDFs and test how well they predict the species known to inhabit each sky-island. He then will assess the influence of past environmental patterns (at the LGM and mid-Holocene) again via IDFs and test their predictions for current known patterns. This research will advance understanding of how biodiversity in fragmented landscapes responds to environmental change, ripe for application in diverse systems to inform future conservation and management strategies. By doing so, it advances NASA missions and GEOBON goals, enabling copious other studies relevant to NASA programs in Ecological Forecasting and Biodiversity.

Susan Anenberg (PI) / Soo-Yeon Kim (FI)
George Washington University
23-EARTH23-0260: Application of Satellite Observations in Estimating NO2 Concentrations, Mortality Burdens, and Inequities

This research project aims to estimate surface-level nitrogen dioxide (NO2) concentrations, attributable mortality burdens, and inequities in the continental US (CONUS), leveraging recent satellite NO2 observations with high spatiotemporal resolutions. By using NASA Earth Observations to identify NO2 pollution, NO2-attributable mortality, and related disparities, this project will contribute to the increase of our understanding of NO2 pollution and provide valuable insights to guide future actions in the air quality and public health sectors.

We will address this objective in three specific research aims. First, we will estimate annual surface-level NO2 and NO2-attributable mortality for all CONUS census tracts using a new land-use regression (LUR) model that incorporates TROPOMI NO2 observations as a predictor variable, which is under development by our research group and is expected to be completed before this project starts. Second, we will characterize disparities in surface-level NO2 and associated health impacts at the census tract level across area-level sociodemographic factors, including percent of racial/ethnic minority, median household income, poverty rate, percent with a high school degree or higher, and percent unemployed. Both absolute and relative metrics of disparities will be used to quantify NO2 disparities. Third, we will explore the additional value of daytime hourly geostationary satellite observations for estimating NO2 disparities. Here, we will first check the overall agreement between TEMPO columnar NO2 and surface-level NO2, and compare census tract-level NO2 disparities from TEMPO columnar NO2 and LUR-derived NO2 concentrations.

Results from this research will support evidence-based decision making on NO2 pollution at national and sub-national scale. To support the informed decision making by end-users, we will work with NASA and other partners of our research group (e.g., National Oceanic and Atmospheric Administration, Environmental Defense Fund, and US EPA). Also, this project will disseminate the most up-to-date knowledge on NO2 pollution and relevant disparities. To maximize the societal impacts of these results, we will engage the public by disseminating our results on our research group's website. Finally, as this project will be among the first empirical applications of TEMPO in identifying NO2 pollution and relevant disparities, this project will provide insights for future applications of TEMPO and encourage future research on NO2 disparities using TEMPO.

Emily Bernhardt (PI) / Spencer Rhea (FI)
Duke University
23-EARTH23-0330: Clearing Blackwaters: Satellite Detection of Saltwater Intrusion in Coastal Rivers

Sea level rise and saltwater intrusion (SWISLR) threaten the structure and function of coastal ecosystems. Although remote sensing has been used to understand how SWISLR impacts terrestrial ecosystems, the consequences for coastal river ecosystems are uncertain. Combining data from the Landsat and Sentinel satellites with in-situ measurements of salinity, this proposal will develop and test a novel approach to estimate the salinity of coastal blackwater rivers. Because saltwater intrusion removes dissolved organic matter from the water column, it may be possible to estimate salinity through the changing color of water. Once a model is developed to estimate salinity, the drivers of saltwater intrusion and the consequences for river ecosystem productivity will be evaluated using a combination or in-situ and remotely sensed datasets. This proposal will further our understanding of not only the spatial and temporal extent of saltwater intrusion but also the drivers and consequences of saltwater intrusion in coastal river ecosystems.

Emmanuel Boss (PI) / Charlotte Begouen Demeaux (FI)
University of Maine, Orono
23-EARTH23-0327: Effects of Cloudiness on Estimates of Phytoplankton Biomass and Primary Production in the Ocean

On an average day, 72% of the ocean is veiled by drifting clouds.

To quantify remote sensing-based oceanic net primary productivity (NPP) in cloudy pixels, it is common practice to interpolate the needed inputs (e.g., Chlorophyll a (Chl a) and particulate backscattering (bbp)) from adjacent non-cloudy pixels (e.g., the Cloud-Fill Algorithm from the Ocean Productivity group). Alternatively, inputs can be extracted from several-day/monthly sunny sky composites. The retrieved inputs are subsequently combined with a cloud-attenuated Photosynthetically Available Radiation (PAR) and then fed into NPP algorithms available in NASA's NPP Suite. Effectively this translates to the assumption that primary production in the ocean is not affected by the presence of clouds other than by the associated decrease in PAR. However, this present-day assumption has yet to be validated with in-situ data and given the extensive cloud cover, could introduce a notable bias in global estimates of oceanic NPP.

The proposed research aims to investigate and quantify the impact of cloud cover on remote sensing-derived estimates of oceanic primary production at the global scale. I suggest two main investigation avenues to answer this question:

First, investigate the photoacclimation of phytoplankton to cloud presence by modulating their pigment concentration in response to lower light (i.e., the Chl: C ratio). Preliminary results in the Mediterranean Sea show a similar photoacclimation in cloudy vs. sunny conditions. This suggests that the current interpolation methods underestimate NPP, as they do not account for phytoplankton photoacclimating to reduced light under clouds.

Secondly, assess if NPP is impacted beyond what can be predicted solely based on a reduced PAR due to cloud coverage. This includes considering changes in atmospheric conditions throughout the day (i.e., the diel variability), as well as how the light fields' directionality can potentially affect light attenuation with depth.

Once the magnitude of the impact is characterized, I plan on developing a corrected NPP remote-sensing product. To do so, I will consider previous findings and design an NPP under-cloud remote sensing product that will 1) Adjust the Chl: C ratio based on adjacent sunny pixels, the extent of cloud cover, and the previous light history of the pixel, 2) Correct PAR for diel variability in the atmospheric conditions, and 3) Adjust the attenuation coefficient of light to the directionality of impinging radiation.

This research is of importance as it will improve our understanding of the global carbon cycle by more accurately quantifying oceanic primary production. Indeed, NPP is a crucial parameter when trying to estimate the ocean ecosystem contributions to the global carbon cycle notably when quantifying the amount of atmospheric carbon dioxide sequestered by the ocean. An accurate characterization of NPP is also relevant to improving our understanding of likely ocean ecosystem responses to climate change, as well as informing fisheries management. This new NPP characterization will be shared with the scientific community to provide insight and a valuable tool for future carbon export studies. It inscribes itself in NASA's Earth Science Mission Directorate by "improving the ability to predict climate changes by better understanding the roles and interactions of the ocean, atmosphere, land, and ice in the climate system".

W Buck (PI) / Emily Glazer (FI)
Columbia University
23-EARTH23-0064: Using ICESat-2 Elevation Profiles and Viscoelastic Modeling to Constrain Ice-Shelf Rheology and Calving Potential

Floating ice shelves surround 75% of the Antarctic coastline and play an important role in controlling the mass balance of the ice sheet. Ice shelves exert buttressing forces against inland glaciers, helping mitigate sea-level rise by slowing the flow of grounded ice. Ice shelves lose approximately half of their mass to iceberg calving, and though mechanisms of calving are uncertain, it is highly likely that shelf-bending-induced stresses contribute.

Standard models predict that ice shelves should bend downward at the front, but NASA ICESat and ICESat-2 elevation data reveals upward bending profiles at many ice-shelf fronts, including along 74% of the Ross Ice Shelf. Upward flexure is dually dangerous for ice-shelf stability because it induces stresses at the base of the ice, which can lead to calving, and creates topographic depressions, which can lead to surface meltwater accumulation. Both effects can contribute to rifting and potential disintegration. This upward flexure is widely attributed to ice-front melting near the waterline, which leads to a submerged ice bench and consequent additional buoyant force at the front.

We have shown through numerical modeling that adding vertical variations in ice viscosity, or stiffness, can lead to upward flexure even in the absence of a bench, for shelves with cold surface temperatures. Variations in viscosity are expected because ice flow is temperature dependent. By utilizing ICESat-2 data, we can constrain viscosity parameters, which are known to vary in observations and lab experiments, greatly influencing ice-mass loss projections.

In this work, we propose using ICESat-2 elevation profiles of Antarctic ice-shelf fronts and two-dimensional viscoelastic models of ice-shelf flexure to (1) constrain the rheology of ice in these critical regions, and (2) inform predictions of how ice shelves will calve in a changing climate.

The internal moment and ice bench mechanisms suggest different induced stresses at the base, so disentangling them through examination of ICESat-2 data will improve calving predictions. Additionally, the modeled range of possible ice-sheet mass loss due to the uncertainty in rheologic parameters is on the same order of magnitude as the increase in mass loss due to atmospheric warming, so constraining these parameters is a crucial problem. By better parameterizing both calving potential and ice flow at shelf fronts, my results will help inform sea-level-rise predictions, improve ice-flow models, and answer NASA ESD's research question: What changes are occurring in the mass and extent of Earth's ice cover?

Diego Cerrai (PI) / Brian Filipiak (FI)
University of Connecticut, Storrs
23-EARTH23-0294: Refinement of Snow Microphysics and Density Forecasting Using GPM Ground Validation Observations and NU-WRF

This proposal's key objective is to test and refine NASA's high resolution weather modeling capabilities of winter storms through utilizing its ground validation instrumentation from Global Precipitation Measurement (GPM) mission deployments. Forecasting snow amounts is a difficult problem because it requires understanding of how much liquid water of snow will occur in one location and then converting it using the snow's density to get a snowfall amount. While many methods have been tested previously, there has not been a significant advancement in the last 10 years and many of these methods rely on environmental conditions rather than physical processes. To improve upon this, physical processes occurring in the microphysics schemes in numerical weather simulations guided by GPM ground instrumentation can help inform a physically based approach to forecasting snow density, which will ultimately help snowfall forecasts.

To accomplish this, field observations of snow microphysics will be used from up to 4 different GPM ground validation missions in the mid-latitudes. Instrumentation for observations will include ground-based radars, weighing rain gauges, laser and video disdrometers which will provide information about precipitation amount and rate, particle size and fall speed, and atmospheric conditions of the lower atmosphere. These observations will first be used to validate NASA's Unified Weather Research and Forecasting model (NU-WRF); this validation will include a set of experiments testing how different microphysics schemes within NU-WRF represent precipitation amounts and structure.

Upon learning about NU-WRF's sensitivities and the generation of accurate simulations, focus will be given to NASA's Goddard microphysics scheme, which will be used in the NU-WRF simulations. The Goddard microphysics scheme is an important component of numerical weather simulations as it parameterizes the different types and amounts of hydrometeors in each grid cell of the simulation. To parameterize snow hydrometeors, the Goddard scheme applies several key relationships like a snow size density mapping, diameter fall speed relationship, and mass-diameter relationships; these assumptions have not been validated in winter campaigns before. Validation of these relationships will occur using ground instrumentation such as the Precipitation Imaging Package (PIP), a NASA design video disdrometer. Upon verification of these relationships, adjustments and refinements may be needed, and if so, they will be implemented.

The refined Goddard microphysics scheme can be used as the basis for the explicit snow density forecast. The goal will be to apply different techniques with physical basis to forecast snow density. This will include the application of solving for the quantity using the prognostic variables within the model, physically based post processing algorithms and artificial intelligence. The explicit snow density algorithm will be validated both against the PIP's density measurements, as well as manual observations from humans.

This work will align with NASA Earth Science Division's goal to improve weather and air quality forecasts and prediction of extreme events. Improving snow microphysics will aid models to resolve winter storms better, and while the focus is on NASA modeling components and observations, the work will impact multiple agencies besides NASA. Also, the use of ground instrumentation from NASA field campaigns will provide new applications for some of the instruments, like the PIP. By learning more about the physical processes the govern snow properties, they can be applied to other areas of NASA research like satellite operations and algorithms. Overall, this proposed project's main goal is to validate both NASA modeling systems and components using ground observations collected by NASA instrumentation and use the findings to develop a new, physically based method of forecasting snow density.

Don Chambers (PI) / Sara Jean Reinelt (FI)
University of South Florida, Tampa
23-EARTH23-0194: Revealing the Role of Mesoscale Eddies for Carbon Ventilation and Sequestration in the Southern Ocean

This research proposal aims to enhance understanding of the impact of mesoscale eddies within on air-sea CO2 flux in the Southern Ocean. The Southern Ocean is integral in global carbon regulation, with the Antarctic Circumpolar Current (ACC) playing a critical role in the transport of physical, biological, and chemical properties. However, the region remains undersampled due to its dangerous nature, especially during the austral winter, so understanding of the role of mesoscale features on CO_2 flux is limited. This study proposes using satellite altimetry and data from the Surface Water and Ocean Topography (SWOT) mission along with older nadir altimeter satellites in conjunction with biogeochemical Argo float data to analyze eddy-induced dynamic CO_2 flux. By combining satellite and in situ observations, the project will classify eddy types, assess their impact on CO_2 flux, and investigate variations in carbon signals based on eddy strength, season, and zonal and meridional region. The research contributes to addressing the challenges of limited carbon sampling in the Southern Ocean and strives to advance our knowledge of the complex processes shaping global climate through improved understanding of mesoscale eddies' influence on carbon dynamics in the Southern Ocean.

Chengbin Deng (PI) / Faezeh Najafzadeh (FI)
University of Oklahoma, Norman
23-EARTH23-0401: Coupling Multi-Source Earth Observation Data with Artificial Intelligence to Update Local Climate Zone in Cities of the Global South

Currently, over half of the global population resides in urban areas, which is predicted to increase to over two-thirds by the year 2050. The population's growth has been accompanied by a tendency toward urbanization. This phenomenon is primarily characterized by rapid changes in land use in urban areas. Uncontrolled urbanization, especially in developing countries, leads to various negative effects such as increased fuel consumption, higher temperatures in cities, heat island formation, urban climate change, and a range of environmental and health issues. The significance of monitoring urban changes from various aspects such as socio-economic development and urban climate changes in urban management and planning cannot be overstated. Local Climate Zone (LCZ), globally standardized land cover classification system, is considered a critical physical characteristic of urban morphology. LCZ allows for more comprehensive thermal properties of the urban environment. Despite the widespread application of the LCZ scheme across diverse urban sciences, the lack of accessible and consistent LCZ data elucidating the morphology and function of cities has hindered advancements in urban climate sciences. Existing LCZ mapping efforts have signification limitation, (1) only available in a singular year, and (2) not readily available for cities in the Global South. Even the 2018 global LCZ data by Demuzere and colleagues provides global coverage, its availability at a singular point of time limits a wider application as it fails to capture the dynamic nature of cities, especially those undergoing rapid development. Cities experience continuous changes in land use, infrastructure, and population density, which significantly influence their microclimates. Cities experience continuous changes in land use, infrastructure, and population density, which significantly influence their microclimates.

Here, we propose a comprehensive framework to update LCZ information, with an emphasis on data-scarce cities in the Global South. These cities usually experience fast development but lack timely data for sustainable urban planning. With this framework, we aim to use AI-based approaches and multi-source remote sensing data to update LCZ information in three rapidly developing metropolitans. In this regard, the research contains three main stages. The first stage is to develop a model for generating Normalized Digital Surface Models (nDSM) using satellite images (i.e., Landsat, Sentinel-1, Sentinel-2) as AI model inputs, and spaceborne lidar datasets (i.e., GEDI and ICESat-2) as reference data of building/canopy height. The next step involves developing an AI-based model to produce and update the LCZ map in different years using the generated nDSM from Stage 1, along with land use land cover change from optical earth observations. After updating the LCZ data, comparisons before and after the LCZ updates will be made, and future urban climate will be modeled by using WRF-urban (Weather Research & Forecasting) model with the predicted LCZ data under different Shared Socioeconomic Pathways (SSPs). With the modeled results, it has a great potential to help inform urban planning and design strategies to promote sustainable development and climate resilience, and accordingly, to improve livability and quality of life of human beings.

Larry Di Girolamo (PI) / John Lundstrom (FI)
University of Illinois, Urbana-Champaign
23-EARTH23-0383: Quantitative Evaluation of Atmospheric Tomography with 3D Radiative Transfer for Advancement in Cloud and Aerosol Retrievals Using Terra and CAMP2EX Data and in Future Mission Design

Among the objectives of NASA's Earth Science Division is to enhance scientific discovery using existing space-based, airborne, and ground-based observations and to develop cutting edge technologies for future Earth science missions. The wealth of information from the many Earth Observing System instruments has contributed significantly to the depth of knowledge on the Earth system. However, there are known limitations in the remote sensing of cloud and aerosol properties from passive instruments; namely, the use of 1D radiative transfer in the interpretation of radiance data leads to biases that depend on cloud regime and sun-view geometry. Moreover, retrieved quantities, such as cloud droplet effective radius, lack information of the in-cloud vertical structure of microphysics, which is critically needed for advancements in cloud physics to climate predictions. Overcoming these biases is well recognized as a crucial area for improvement for monitoring the Earth. Recent developments in Atmospheric Tomography with 3D Radiative Transfer (AT3D) eliminate the bias caused by using 1D radiative transfer and retrieves the highly desired 3D distribution of cloud and aerosol microphysical and optical properties through multi-view angle observations. The tomographic technique has the potential to achieve the goals of the Earth Science Division by producing new scientific insight to cloud and aerosol processes from existing observations and by informing cutting-edge technology for future mission design.

The current state of investigation into AT3D includes an in-depth error analysis of retrievals in idealized synthetic conditions and an initial application to a single high-resolution scene from AirMSPI. All investigations thus far point to the success of the method. Preliminary results from using AT3D to retrieve cloud properties using observations from the Multi-angle Imaging SpectroRadiometer (MISR) aboard the Terra satellite are encouraging and motivate this proposal.

It is the goal of this investigation to inform potential future satellite missions that are designed specifically for tomographic retrievals of cloud and aerosol properties and to assess the applicability of AT3D to observations from current missions. This will be done in three parts. In the first part, I will quantify retrieval errors caused by the radiative horizontal boundary conditions used in the 3D radiative transfer forward model, the sensor spatial resolution, and their dependence on the sun-view geometry. This will be done with a large set of synthetic simulations. Second, I will apply AT3D to existing observations from the Terra satellite and assess its applicability. I will explore the possibility of integrating observations from MISR, the Advanced Spectral Thermal Emission and Reflection Radiometer (ASTER), and the Moderate Resolution Imaging Spectroradiometer (MODIS) and validate retrievals using data from the Cloud, Aerosol and Monsoon Processes Philippines Experiment (CAMP2Ex) field campaign. I will also explore the applicability of AT3D to imagers aboard the NASA P-3 aircraft during the CAMP2Ex field campaign with validation from active sensors and in-situ sampling. Finally, in the third part, I will explore the possibility of retrieving near-cloud aerosols, which is of significant scientific interest in studies of aerosol-cloud interactions.

This work will aid in the definition of requirements for future earth observing missions that target clouds and aerosols. It will also enhance the scientific value of NASA's investments in the EOS-Terra mission and CAMP2Ex field campaign. The goals and objectives of this work align well with the goals of the Earth Science Division to drive cutting edge technology and leverage existing observations to enhance scientific investigation for monitoring the Earth system.

Christopher Doughty (PI) / Benjamin Wiebe (FI)
Northern Arizona University
23-EARTH23-0411: Mapping Tropical Forest Vulnerability to High-Temperature Extremes Using Satellite Thermal Measurements and Imaging Spectroscopy

Forests worldwide are under increasing threat from anthropogenic climate change. Recent work by Doughty (PI), Wiebe (FI), and colleagues found that tropical forests worldwide are already operating dangerously close to the upper-temperature limits of photosynthesis. However, while the threat of increasing climate extremes to tropical forests is known, no study has yet mapped thermal risk to forests at any scale, let alone at regional or global levels. We propose using novel satellite data from NASA instruments aboard the International Space Station (ISS) and recent modeling techniques to map two main constituent components of tropical forest vulnerability at regional and global scales. We will then use these data products to assess drivers of variability at regional and global scales.

First, we will build upon results by Wiebe and Doughty suggesting that leaf thermal tolerance can be predicted using leaf spectroscopy, a method of predicting traits through measurements of narrow wavelength bands. Uncertainty in the distribution of leaf thermal tolerance is one of the main aspects limiting accurate thermal risk assessment in tropical forests. We will use an airborne imaging spectrometer (NEON AOP) to bridge leaf-level measurements collected in a limited field campaign with satellite-scale spectroscopy (NASA EMIT) to predict leaf thermal tolerance across Puerto Rico. We will use a recently validated methodology (2023) for scaling from airborne to satellite spectroscopy. This work will provide critical foundations for future global mapping of thermal tolerance with the upcoming NASA Surface Biology and Geology (SBG) mission.

Next, we propose a novel approach for high-resolution mapping of upper temperatures experienced by tropical forests around the world. To do this, we will use a recent physics-based data fusion approach (2022) to combine high-resolution thermal data from NASA's ECOSTRESS with lower-resolution, high-frequency data from geostationary satellites to resolve diurnal temperature cycles at high spatial resolution. We will extract peak temperatures from these cycles to create a first-of-its-kind map of maximum temperatures experienced by canopies around the tropics.

Combined, these efforts promise to allow spatially explicit estimates of thermal risk across broad areas of tropical forest, and to inform forest management, conservation and policy. This work directly contributes to goals articulated by the National Academy's 2027 Decadal Survey and adopted by NASA's Science Mission Directorate (SMD), including mapping key terrestrial vegetation functional traits, and identifying thresholds in ecosystem carbon storage. Additionally, this work establishes key theoretical and methodological foundations for future cutting-edge research using NASA SBG.

Iryna Dronova (PI) / Eric Romero (FI)
University of California, Berkeley
23-EARTH23-0094: Wetland Resilience: Remote Sensing Strategies for Nature-Based Carbon-Subsidence Solutions in the San Francisco Estuary

This work aims to determine the key mechanisms driving carbon fluxes across diverse wetlands in the San Francisco Estuary. Wetland carbon fluxes have been shown to directly influence vertical land motion in coastal areas, making wetland productivity through restoration a leading strategy to combat sea-level rise. A better understanding of wetland carbon fluxes will create knowledge to help develop ecosystem restoration and management strategies focused on carbon capture to increase vertical land motion. This knowledge will have a positive impact on ecosystem restoration and management in estuaries around the world as sea level continues to rise.

This study will combine observations from multiple satellites using visible and infrared light, temperature, and radar measurements. Field instrument measurements of comparable environmental variables will also be used, including greenhouse gas exchanges, water depth and salinity, temperature, and vegetation structure measurements. Field measurements will be used (1) for validation of satellite data and (2) to develop a machine learning model to measure the ability of wetlands to capture and store atmospheric carbon. The data produced by the machine learning model will be used alongside satellite data and field measurements to determine the optimal environmental conditions and ecosystem restoration designs for wetland carbon capture and storage. This will be accomplished using structural equation models, an advanced statistical technique that can determine the role of variables in complex environmental systems.

The goals of this research are directly relevant to NASA's Earth Science Division through the Terrestrial Ecology Program and Carbon Monitoring System Initiative. The knowledge created by this work will improve understanding of the carbon-based function of coastal wetland ecosystems and the impact of their land use change and restoration succession through the development of spatial carbon flux models. These advancements will clarify the role of Estuary wetlands in land-atmosphere carbon cycling and quantify the carbon sink strength of these ecosystems. The knowledge and tools produced by this work will build upon current and future

NASA missions like Landsat and NISAR to benefit natural resource managers and policymakers focused on wetland monitoring and restoration as a natural climate solution for carbon sequestration, long-term carbon storage, and land subsidence reversal.

Laura Duncanson (PI) / Paromita Basak (FI)
University of Maryland, College Park
23-EARTH23-0212: Analyzing Spatial Co-Benefits of Carbon and Structural Diversity in South East Asia with GEDI

The terrestrial biomes of Earth host a diverse array of ecoregions pivotal for preserving biodiversity and potentially helping mitigate climate change through carbon storage and sequestration. Biomass and biodiversity in these ecoregions are strongly correlated and need to be protected from further loss. In this research, high carbon areas in ecoregions that overlap with high local structural diversity, termed 'co-benefit' areas, will be identified, focusing on South East Asia (SEA). The vulnerability of these key co-benefit areas to anthropogenic activities will be assessed, and their conservation potential will be analyzed. The research is structured around three primary objectives. First, NASA's Global Ecosystem Dynamics Investigation (GEDI) lidar data will be used to identify high carbon and structural diversity co-benefit areas in SEA. For Objective 2, quantification will be done on the proportion of these conservation priority co-benefit areas that are under protection versus those that remain unprotected in each ecoregion within SEA. Finally, for Objective 3, the focus will be on assessing the extent of risk for vegetation loss within and around Protected Areas (PAs) and with a specific emphasis on quantifying anthropogenic impact (i.e., biomass disturbance) on identified key co-benefit areas. Fusion with different remote sensing products on deforestation and land cover change will be used here to calculate rates of AGBD loss over recent time periods in and around the previously identified co-benefit areas. The analysis and results of this research will provide much needed insights on the above ground carbon-rich co-benefit areas in the SEA region which can be conservation priority zones, and can inform spatial planning for future efforts such as the goal to protect 30% of terrestrial land by 2030.

Matthew Fagan (PI) / Anisha Jayadevan (FI)
University of Maryland Baltimore County
23-EARTH23-0096: Assessing the Extent and Carbon Sequestration Potential of Massive Afforestation Projects in Semi-Arid Open Natural Ecosystems

The proposed work critically assesses the expansion of tree plantations across the drylands of western India. Government policies have favored tree planting in savannas there for decades, but the extent and impact of these policies on tree cover and carbon sequestration is unclear. This research will use satellite data to map tree plantations in the region and will use a combination of satellite and field data to map planted tree carbon gains (or losses) across the region. I will also interview Indian Forest Service officials and local people to understand the full costs of planting trees, both in terms of carbon price and impacts on local livelihoods.

John Gardner (PI) / Gabriella Zuccolotto (FI)
University of Pittsburgh
23-EARTH23-0314: Advancing Harmful Algal Bloom Detection and Understanding In Rivers

Harmful algal blooms (HABs) occur when algae or cyanobacteria grow out of control and release toxins. These events can have significant consequences for ecological, economic, and human health. HABS are well studied in lakes, and while HABs have anecdotally observed in major rivers around the world, our understanding of where, when, and why these HABs are occurring in rivers is limited. Phycocyanin (PC) is a pigment found in toxin-producing cyanobacteria that can be captured by sensors on spaceborne satellites. By quantifying the relationship between concentrations PC and Chlorophyll-a (a general proxy for alga) and surface reflectance signature captured by satellites, and applying that relationship across many satellite images, we can analyze how river HAB activity is changing over time and space.

Our overarching goal is to map and understand HABs in rivers, but first we need new methods for detecting HABs in rivers. We will test and compare the performance of various single and multi-task machine learning models that predict PC and Chl-a in the Illinois River Basin using different satellite products (Landsat and PlanetScope SuperDove). Using these models, we will generate a high-resolution database of PC and Chl-a for the basin over the last decade to quantify the magnitude, frequency, and extent of HABs. Lastly, we will identify the drivers of rivers HABs over in the Illinois River Basin using high-frequency in-situ observations of hydrologic and environmental conditions. Our training data will be specific to the IRB; however, our code will be open-source and easily replicated for other large rivers. Our research approach will allow for cross-model comparisons and provide insight on the advantages and limitations of SR products and ML approaches for PC detection.

This research will support NASA's Science Mission Directorate within the Earth Science Division. Along with using NASA's satellite products to complete this research (i.e. Landsat), we are also supporting their Commercial Smallsat Data Acquisition Program by developing comparable models of Landsat and Planet data. The SMD goals that we will support within the Water and Energy Cycle topic area are to 1) enable better assessment and management of water quality and quantity to accurately predict how the global water cycle evolves in response to climate change, and 2) further the use of Earth system science research to inform decisions and provide benefits to society. This research also directly contributes to the priority research objective "H-3a: Develop methods and systems for monitoring water quality for human health and ecosystem services" outlined in NASA's 2018 decadal survey. Our data products and insights will be an asset to river management, where HAB indicators are used to initiate drinking water and recreation advisories. The high spatial resolution of our databases will identify at-risk areas and patterns of bloom occurrences that may not be captured with in-situ sensors. Identifying drivers of HABs is important for flow regulation (e.g., USCACE reservoir releases) as water residence time has been shown to influence HAB proliferation in regulated rivers.

Cynthia Gerlein-Safdi (PI) / Katie Stephens (FI)
University of California, Berkeley

23-EARTH23-0145: Enhancing Methane Emission Estimates from Boreal Wetlands: Illuminating Insights from Cutting-Edge GNSS-R-Based Inundation Maps

The purpose of this work is to leverage data from a new satellite system, the Berkeley-RWAWC algorithm, and a global wetland methane emissions model (WetCHARTs v1.3.1) to improve wetland inundation maps and global methane emission predictions. The overarching goals of this project are: (1) determine the accuracy of current estimates of boreal wetland extent, sub-seasonal variability, and locations ; (2) model local methane emissions from inundation maps generated from achieving goal 1 ; (3) evaluate the implications of refined methane model estimations generated from goal 2 in relation to the global methane budget.

To achieve these three goals, the FI will test three corresponding hypotheses: Hypothesis 1: current estimations of boreal wetland extent are not accurate due to a lack of information, and fast-changing, year-to-year increase in thawing caused by increasing surface temperatures. Hypothesis 2: boreal wetland coverage area and their corresponding methane emission rates are larger than current reported values, but we do not know to what extent. Hypothesis 3: the rise in global methane emissions is predominantly attributed to fluxes in tropical wetlands, but wetlands in northern latitudes are contributing more to the global methane budget than previously estimated as a direct result of climate change.

The project will be divided into three tasks, matching the three goals and hypotheses: Task 1: adapt the Berkeley-RWAWC computer vision algorithm to be capable of processing GNSS-R data sourced from Spire Global Inc. GNSS-R satellite constellation, validate the algorithm in comparison to CYGNSS data, and generate procedures to mitigate false positives and negatives. Task 2: Utilize results from Task 1 to generate high-latitude water masks and substantiate inundation maps with direct comparisons to the Surface Water Microwave Product Series (SWAMP) and Wetland Area and Dynamics for Methane Modeling (WAD2M) data sources. Task 3: Estimate consequences of updated wetland extent and variability data generated from Task 1 & 2 on carbon cycling by utilizing the WetCHARTs v1.3.1 model.

Our proposed methodology is an extension of the technique developed by the PI, which leverages the spatial and temporal information contained in CYGNSS surface reflectivity data and applies the random walker algorithm (Berkeley-RWAWC) to separate water and land. We will create a reliable parameter and threshold selection system that applies to the Spire data across various domains. Additionally, we will integrate surface topography data with the computer vision algorithm to enhance image segmentation through spatial analysis.

The proposed work will directly address NASA's Earth Science Division's (ESD) mission to advance scientific knowledge of Earth System Science to answer questions about how our planet is changing now, and how Earth could change in the future to provide societal benefit. The proposed work demonstrates relevance to support the Research and Analysis (R&A) Program from ESD as it uses satellite observations and computer modeling to turn measurements into understanding of the Earth system and interaction between processes in the following focus areas: Climate Variability and Change, Water and Energy Cycle, as well as Carbon Cycle and Ecosystems.

Hamed Gholizadeh (PI) / M. Ny Aina Rakotoarivony (FI)
Oklahoma State University
23-EARTH23-0237: Assessing the Impacts of Invasive Plants on Ecosystem Characteristics Using Multi-Scale Imaging Spectroscopy

Grasslands cover about 40% of Earth's land surface and have significant ecologic, economic, and social importance. However, grasslands are among the most threatened ecosystems, with biological invasions being among the primary threats. Although previous studies have assessed the potential impacts of biological invasions on ecosystems, quantifying such impacts is rather challenging, primarily due to inconsistency in sampling methods and the context-dependency of the impacts of biological invasions on various ecosystems. Further, most studies focusing on the impacts of biological invasions have been based solely on small-scale experimental studies. There exists, therefore, a critical need to develop approaches to study the ecological impacts of invasive plants across various spatial scales. Advances in remote sensing technology have provided opportunities for studying invasive plants across large spatial domains. The ultimate goal of this proposal is to use imaging spectroscopy and develop a holistic understanding of the ecological impacts of invasive plants on above- and belowground characteristics of grasslands across various spatial scales. I will focus on Lespedeza cuneata (hereafter, L. cuneata), an invasive legume threatening grassland ecosystems of the U.S. Southern Great Plains. Due to its competitive nature, allelopathic effects, and ability to grow in different soil and weather conditions, L. cuneata can negatively impact grassland ecosystems.

I will harness the potential of remote sensing, particularly imaging spectroscopy, to study the impacts of the invasive L. cuneata on ecosystem characteristics both above- and belowground. My central hypotheses are that (1) invasive and native plants have significantly different aboveground characteristics, which in turn affect remotely-sensed spectral signals, (2) there are linkages between aboveground and belowground ecosystem characteristics; remote sensing can estimate belowground ecosystem characteristics because of these above- and belowground linkages as suggested by the optical surrogacy hypothesis -- that optical data are proxies of ecosystem characteristics at different levels, and (3) the perceived impacts of invasive plants on ecosystem characteristics are scale-dependent and vary with spatial resolution. I am proposing a 3-year project with the following hypotheses and objectives:

Hypothesis 1. Invasive and native plants have significantly different aboveground characteristics, which in turn affect remotely-sensed spectral signals.
Objective 1. Use in situ data and airborne imaging spectroscopy to determine the impacts of L. cuneata on aboveground characteristics, here defined as plant functional traits and biomass.

Hypothesis 2. There are linkages between aboveground and belowground ecosystem characteristics. Remote sensing can be used to map belowground characteristics because of the above- and belowground linkages as suggested by the optical surrogacy hypothesis.
Objective 2a. Use in situ data to determine the aboveground-belowground linkages.
Objective 2b. Use airborne imaging spectroscopy to assess the impacts of L. cuneata on belowground characteristics, including soil properties and microbial biomass, based on the linkages between aboveground and belowground characteristics.

Hypothesis 3. The perceived impacts of invasive plants on ecosystem characteristics are scale-dependent and vary with spatial resolution.
Objective 3a. Assess the capability of Surface Biology and Geology (SBG)-like imagers in determining the ecological impacts of L. cuneata invasion on grassland ecosystems through the fusion of coarse spatial resolution spaceborne hyperspectral data from DLR's DESIS sensor and fine spatial resolution spaceborne multispectral data from PlanetScope.
Objective 3b. Determine the scale-dependence of the impacts of L. cuneata on ecosystem characteristics using unoccupied aircraft systems (UAS)-based imaging spectroscopy.

Colin Gleason (PI) / Fiona Bennitt (FI)
University of Massachusetts, Amherst
23-EARTH23-0165: Revealing the Hydrosphere: Mapping Widths and Heights of Narrow Rivers with SWOT

Narrow rivers (< 50 m wide) constitute over 90% of the total length of global rivers, but unlike headwater streams or larger rivers, they are severely understudied. Limited-resolution optical data cannot detect many narrow rivers, nor can it capture crucial stream gradients needed for hydraulic models. DEM-based streams can be appended to optically derived maps to map very small streams and reveal their topography, but DEMs are frequently inaccurate and strongly tied to the surface condition at the time of their creation. The NASA/CNES Surface Water and Ocean Topography Mission (SWOT) is designed specifically to detect rivers. SWOT uses synthetic aperture radar and interferometry to obtain the location and height of rivers, but SWOT data products are only available for rivers wider than 50 m. However, early SWOT data clearly show very narrow (~10 m) rivers. This exciting development suggests that SWOT might be a viable tool for mapping narrow rivers currently poorly represented in global hydrography, but it is currently unknown what is possible with SWOT. I will extract narrow rivers from the SWOT Single Look Complex interferograms and then use the SWOT Hydrology processing pipeline to produce a vector product mapping narrow rivers.

I will pursue the following objectives:

1. What is the smallest river visible from SWOT?

2. What is the smallest river that can give us reliable heights from SWOT?

3. What can SWOT reveal about global narrow rivers?

The project will utilize a mix of radar processing, geospatial analysis, computer vision, and machine learning techniques. I will extract narrow rivers from the SWOT Single Look Complex interferograms and then use the SWOT Hydrology processing pipeline to produce first a pixel cloud and then a vector product mapping these rivers. River widths will be validated using an external database of river widths for North America and heights will be validated using river gauge data and field measurements sampled opportunistically by the SWOT Calibration and Validation field team.

This project has high risk, but early SWOT returns detailed herein suggest that rivers 15-50 m should be reliably mapped with unknown height errors. Given the unprecedented spatiotemporal resolution, this project will thoroughly alter our understanding of narrow rivers. This project will further the goal of the NASA Terrestrial Hydrology--Water and Energy Cycle Focus Area to enhance "our understanding of the transfer and storage of water and energy in the Earth system" as well as the NASA's Earth Science Research Program's aim "to understand the naturally occurring & processes that drive the Earth system, and to improve our capability for predicting its future evolution".

Scott Goetz (PI) / Danielle Salganek (FI)
Northern Arizona University
23-EARTH23-0149: Remote-Sensing Resilience: An Exploration of Caribou Winter Habitat in the Changing Arctic Environment

In recent decades, the Arctic warmed nearly four times faster than the global average. As the Arctic becomes warmer, the landscape is changing quickly and observably. Vegetation distribution and abundance are shifting, especially with expansions of tundra shrubs and declines of ground-covering lichen. Wildfires have become more intense and frequent on the tundra and in boreal regions adjacent to the Arctic tundra. Snow cover is changing in duration, snowpack is decreasing, and winter rain-on-snow events are becoming more prevalent, creating ice crusts within the snowpack. These landscape transformations have far-reaching ecological consequences, particularly for barren-ground caribou (Rangifer tarandus), a species that is integral to Arctic ecosystems and Indigenous cultures, including as a subsistence food source for many communities across the North American Arctic.

Caribou in the warming Arctic are navigating a new, unprecedented landscape. Lichen decline and snow conditions that limit access of forage may require that caribou adopt new habitat selection and space-use strategies to acquire adequate winter nutrition. Habitat selection and space-use studies that take full advantage of remotely sensed satellite data at high spatial resolution and temporal frequency are necessary for capturing caribou spatiotemporal response to changing vegetation community and inter-annual snow conditions in the Arctic.

This study establishes four research objectives: 1) Produce daily SnowModel outputs for North Slope of Alaska at 90m spatial resolution for the years 2004-2024 (temporal coverage corresponds to caribou GPS-collar data). 2) Develop a resource selection function to describe caribou winter habitat selection using temporally dynamic snow metric and annual vegetation fractional cover data and determine threshold levels of snow depth and crust avoided by caribou. 3) Investigate the effects of interannual snow variability and lichen abundance on both caribou winter range fidelity and winter range size. 4) Quantify terricolous lichen decline throughout the range of North Slope caribou herds. Investigate impacts of caribou grazing by comparing low vs. high winter use.

The proposed research addresses NASA's Earth Science Carbon Cycle and Ecosystems (CC&E) Focus Area and the Applied Sciences' Ecological Conservation Program objectives by contributing to efforts to monitor ecosystem response to changing climates and using NASA Earth observations to monitor, analyze, and forecast these changes. Specific science questions addressed from the CC&E Focus Area include:

1. How are ecosystems changing around the globe, and what mechanisms, processes, and feedbacks contribute to this change?

This study aims to unravel the reciprocal relationship between the rapidly transforming Arctic environment and the adaptive responses of caribou in terms of habitat selection and space utilization. By investigating how the changing Arctic landscape influences caribou behavior, and conversely, how caribou's space-use patterns contribute to the alterations in the Arctic vegetation cover, I seek a comprehensive understanding of this dynamic interplay.

2. What are the consequences of land cover and land use change for human societies and the sustainability of ecosystems?

Barren-ground caribou are one of the most ecologically, economically, and culturally important species across Arctic ecosystems and previous work suggests climate change and associated changes in snow regimes and vegetation communities will have a largely negative effect on caribou populations. By understanding ecological feedbacks on the North Slope, researchers, managers, and conservationists can co-develop strategies to safeguard caribou populations, ecosystems, and the Indigenous communities that rely on them amidst the challenges posed by climate change.

Brian Hornbuckle (PI) / Kyle DeLong (FI)
Iowa State University, Ames
23-EARTH23-0219: Crop Water Overhaul: Interpreting Microwave Remote Sensing with a Model that Accounts for Water Hydraulics

This project mainly focuses on understanding the water cycle within the center of the soil-plant-atmosphere continuum. Although a relatively small portion of the global water balance, water used and stored in plants, especially crops, can significantly affect how mass and energy move in Earth's system. Notably, crops we grow to support civilization, such as corn, have major economic and land-use impacts in not only the US but the world. These crops will be "happy" when they have enough plant-available water to fill the deficit of photosynthesis and leakage via transpiration, which is driven by the atmosphere's "thirst." Therefore, our long-term goal is to better understand the movement and storage of water in crops, especially corn, which is a crop that is important in both the US and the world, to better observe this portion of the water cycle and to provide more information on crop health.

Investigating water in crops is time-intensive and expensive. Therefore, (1) there is a lack of high-quality biophysical data to investigate these crops. Models can be useful for estimating phenomena like drought stress, but current ecohydrological models typically employ a soil moisture limiting function to make the plant "unhappy" or stressed. Thus, (2) models essential to understanding plant behavior and productivity neglect plant water hydraulics and mainly depend on soil moisture. A popular method for identifying crop stress via remote sensing is utilizing instruments sensitive to visible or infrared spectral bands. However, (3) visible and infrared instruments require cloud-free observations.

We have three objectives that ultimately tackle the three target problems, respectively.

(1) To quantify a multi-layer crop canopy water budget for corn through high-quality biophysical in situ measurements at various canopy heights.

(2) Validate an ecohydrological model at multiple heights using data from Objective 1.

(3) Determine if retrievals of crop water made with microwave remote sensing (which is unaffected by clouds) can be used to indicate crop stress in the US Midwest. This approach will be evaluated with the model output data from Objective 2.

Our overarching approach is to (1) collect in situ and sampling data during the growing season at a highly monitored agricultural research farm in Iowa, (2) use the collected data to validate an ecohydrological model that incorporates plant water hydraulics at multiple canopy heights, and (3) retrieve microwave signals (unaffected by clouds) using a ground-based radiometer to detect crop stress and evaluate it with the ecohydrological model output.

This project and its overall objectives will address the priorities of the Science Mission Directorate's Division A, the Earth Science Research Program. Specifically, we address the Research and Analysis and Earth Action programs in the Water and Energy Cycle focus area. Our objectives aim to (1) develop a relatively long-term biophysical dataset, (2) validate an ecohydrological model to demonstrate the effectiveness of incorporating plant water hydraulics when modeling crop water fluxes and storage, and (3) use microwave radiometry to better understand water in crops and determine the ability of microwave sensing platforms to detect crop stress.

David Johnston (PI) / Brandon Hays (FI)
Duke University
23-EARTH23-0356: Impacts of Rebounding Asian Elephant Populations on Forest Structure and Carbon Storage

Elephants shape forest composition and structure by dispersing seeds, selectively browsing saplings, and dispersing nutrients through dung (Poulsen et al. 2018). The loss of elephants has been shown to shift rain forests in the Afrotropics from a structure dominated by fewer large, carbon-dense trees to a structure dominated by many smaller trees with low carbon density, thereby reducing above ground carbon storage by 7% (Berzaghi et al. 2019). Elephants inhabit ~30% of tropical rain forests storing ~16% of global carbon (Xu et al. 2021), thus they have a substantial impact on global carbon cycling. But studies on the impacts of Asian elephants on tropical forest structure and carbon storage at large scales have not yet been conducted. Understanding the consequences of losing elephants is important both for our understanding of Asian tropical forests, and for our understanding of global carbon cycles and climate change. Rebounding elephant populations in Eastern Thailand are both a source of high human wildlife conflict and an opportunity to study the density dependent effects of elephants on forest structure. Khao Ang Rue Nai Wildlife Sanctuary has seen elephant populations rise from 5-15 in 1980 to greater than 300 today. I propose to use a combination of ground, aerial, and satellite based remote sensing to measure forest structure in Khao Ang Rue Nai in the present, as well as camera trapping to estimate elephant populations. Then, I will measure past forest densities using archived satellite data and historic elephant populations by combining previous reports with extrapolated population growth rates from demographic analyses. By studying the impacts of rebounding elephant populations on forest structure over time, I will enhance our understanding of tropical forest carbon dynamics and of the reversibility of the effects of large herbivore losses.

Trevor Keenan (PI) / Huiqi Wang (FI)
University of California, Berkeley
23-EARTH23-0074: Quantifying the Role of Vegetation Structure in Regulating Forest Responses to Soil Water Availability

Forests play a crucial role in absorbing fossil fuel emissions but are under threat from increasing droughts and loss of biodiversity. Understanding how forests react to changes in soil water availability (a primary determinant of plant health) is essential yet very complicated, as do the underlying driving factors. The role of ecosystem diversity, especially structural diversity that offers more direct assessment of niche space, in enhancing forest resilience to water stress is recognized but remains poorly understood, in particular at large spatial scales. As the structural diversity can be readily measured remotely (e.g., using GEDI or airborne LiDAR), it paves the way for testing structural diversity effects on ecosystem sensitivity to environment change at both broad and fine scale. Given the global initiative to expand forest areas, a comprehensive understanding of forest response to water availability and structural diversity's impact becomes crucial and urgently needed for guiding effective forest restoration and management strategies.

This study aims to deepen our understanding of forests' responses to soil water changes and the critical role of structural diversity in enhancing ecosystem resilience. I will utilize a blend of ground observations (Ameriflux and NEON) along with NASA satellite data (MODIS, OCO-2, SMAP, GEDI) to assess the forest's response to soil water changes and the role of vegetation structural diversity. Specifically, I will: (1) develop a dynamic linear model framework to quantify the sensitivity of forest productivity to soil water variations over time, using both satellite-based estimates (MODIS, SMAP, etc) and in-situ measurements from eddy covariance towers. (2) apply advanced machine learning techniques to investigate the role of structural diversity in forest responses to soil water, utilizing LiDAR data from both GEDI and NEON. (3) integrate our functional relationship obtained from the observational analysis into the International Land Model Benchmarking (ILAMB) framework and evaluate the accuracy of existing Earth System Models in capturing ecosystem vulnerability to water deficits and the structural effects.

This proposed research directly contributes to the priorities of NASA's Earth Sciences Division and Carbon Cycle and Ecosystems Focus Area by characterizing the relationship between soil water availability and forest ecosystem function. In addition, by quantifying the role of structural diversity on ecosystem resilience, this work will advance the understanding of diversity effects from a new perspective and might contribute to the long-term debate surrounding the diversity-stability relationship, informing climate mitigation and adaptation management. Further, by incorporating our results into ILAMB, I expect that in the long-term, our improved benchmarks promise lasting benefits for multiple NASA and partner projects far beyond this award' duration.

Pierre-Emmanuel Kirstetter (PI) / Aimee Matland-Dixon (FI)
University of Oklahoma, Norman
23-EARTH23-0397: Advancing Precipitation Process Retrievals within Convection with Orbital and Suborbital Radar Observations

Radar observations are key to improving the physical understanding of atmospheric processes and their representation in global cloud resolving models, such as the coupled process continuum of clouds, convection and precipitation, a priority "designated observable" identified in the 2017 Earth Science Decadal Survey. Because atmospheric microphysical observations associated with clouds, convection, and precipitation are constrained by the capabilities of the instruments used to measure them, there is a need to understand the information content that can be extracted from active ground-based and spaceborne sensors to optimize the usage of current networks and constellations, the design of future instruments, and their synergistic combination. The proposed work will explore this information content by using a simulation framework involving multiple active instruments (both orbital and suborbital) including satellite radars and S-band ground-based radars: the GPM Dual-frequency Precipitation Radar (DPR; Ku-Ka band) targeting precipitation, the INCUS train of three scanning Ka-band radars designed for convective mass fluxes, the AOS W- and Ku-band Doppler radars for precipitation processes within convection, and the ground-based S-band 1988 Doppler Weather Surveillance Radar (WSR-88D) and future phased-array radar

This work will develop retrievals predicting precipitation process-rates, fluxes, and vertical motion from simulated radar returns from individual and combined instruments that builds upon current work on PAR precipitation rate retrievals. By quantifying the observation capability differences (e.g., resolution, frequency, sensitivity, and orientation) as applied to microphysical properties (e.g., hydrometeor size, shape, phase) and processes (e.g. evaporation, melting, drop-breakup, and collision-coalescence) from the instruments and their synergistic use, this work will address a fundamental need to characterize atmospheric processes from current and future ground- and spaceborne instruments. Probabilistic retrievals of microphysical fluxes, process rates, and precipitation rates that account for uncertainty will be developed to quantify the information from radar returns from both individual instruments and joint instrument observations at their beam intersections. It will also help to quantify the contribution of suborbital observations to supplementing space-based observations.

Meredith Kupinski (PI) / Jaclyn John (FI)
University of Arizona
23-EARTH23-0083: Thermal Polarimetry of Ice Crystals: Cloud Top Observations and Growth Chamber Studies

Uncertainty in ice-cloud microphysical properties, such as ice water path (IWP) and the orientation of ice crystals, is a significant source of error in global climate models. Our FINESST Goddard collaborator has demonstrated that up to a 30% error in IWP retrieval would be caused by neglecting cloud ice polarization. The lack of precise knowledge of cloud ice leads to uncertainty about the role of cloud processes within the atmosphere. The 2017 Earth Science Decadal Survey recommended submillimeter wave (sub-mm) and LWIR radiometers for cirrus ice cloud measurements. No existing space platforms measure longwave infrared (LWIR) polarization. To address this need, the Infrared Channeled Spectro-Polarimeter (IRCSP) was developed as a subsystem of the Sub-mm Wave and IR Polarimeter (SWIRP) project out of Goddard Space Flight Center. As an undergraduate, the FI participated in the IRCSP development. This effort was funded by a 2016 ESTO Instrument Incubator Program to measure linear Stokes parameters with a 1 μm resolution between 8-12 μm.

The PI and FI co-authored the publication of IRCSP results from the first high-altitude balloon (HAB) piggyback in 2021. Our work demonstrated the instrument's operation at altitudes over 30 km and produced the first known measurements of downward viewing polarized thermal radiation from the Earth's atmosphere. The IRCSP observed brightness temperatures (BT) from 250-285 K with an uncertainty of 1.5 K and polarization magnitudes typically in the 1.0-2.0% range. The IRCSP has an upcoming long-duration HAB flight opportunity in New Zealand.

The FINESST Co-PI has found that model settings for ice microphysics can alter simulated cloud radiative heating rates by a factor of four. Horizontally oriented ice crystals affect cloud albedo and the life stage of storms. Ice clouds with horizontally oriented ice crystals have been theoretically shown to have a greater long wave radiative effect than clouds with randomly oriented crystals. Ice crystal orientation is not a globally available data product since polarimetry would be required. The Co-PI has constructed a crystal growth chamber to study ice nucleation, morphology, and orientation. The facilities of the PI and Co-PI, combined with the FI's expertise in polarimetric calibration and measurements, create an opportunity for unprecedented studies of the thermal polarization signature radiated by ice particles. This FINESST project will further investigate the scientific relevance of LWIR polarimetry through increased quantity of high-altitude observations, engineering improvements, and controlled laboratory studies.

The goals of this FINESST are: 1. thermal polarimetric measurements of chamber-grown ice crystals and 2. improve IRCSP thermal management that will stabilize the focal plane temperatures and allow differentiation between 1% and 2% polarization magnitudes. The expected outcomes are: 1. observations of polarized emission for ice crystal samples with well-characterized morphology and orientation 2. HAB observations of thermal polarization with uncertainty in BT reduced to 0.5K. These observations are intended to inform future NASA instruments targeting IWP and ice crystal orientation retrievals.

Laifang Li (PI) / Yifei Fan (FI)
Pennsylvania State University
23-EARTH23-0193: Explore the Role of Cloud Radiative Forcing on the Formation and Future Evolution of the North Atlantic Warming Hole

In contrast to global warming, the subpolar North Atlantic has experienced a significant long-term cooling trend since industrialization. This unique local cooling, namely the North Atlantic warming hole (NAWH), has been shown to influence the ability of the ocean to uptake excessive heat from anthropogenic activities, disturb large-scale atmospheric circulation, reduce transient global warming, and thus impact global and regional climate. Despite the significant climatic impacts of the NAWH, the mechanism driving the NAWH in the past century and its evolution in the future remains a matter of debate. My preliminary analysis of the global climate model (GCM) simulations found that, in addition to the Atlantic Meridional Overturning Circulation, cloud radiative forcing provides a significant cooling mechanism to observed NAWH. Addressing the synergy of cloud radiative forcing and large-scale ocean circulation in modulating the NAWH under different climates is the overarching goal of my proposed study.

Synergistically using NASA's remote sensing of Earth's radiative fluxes and cloud properties, reanalysis products, ocean observations, CMIP6 model output, and idealized numerical experiments, I aim to achieve three objectives: (1) Explore the relationship between cloud radiative forcing, the AMOC, and subpolar North Atlantic SST variability; (2) Apply observational records of clouds and AMOC to narrow down the uncertainties in the NAWH mechanisms simulated by GCMs; and (3) Project the future evolution of the NAWH and the roles cloud radiative forcing and the AMOC will play. These objectives hinge on three hypotheses: (1) Cloud radiative forcing plays a critical role in the subpolar SST variability. As the AMOC weakens, the congruent increase in cloud fraction provides an equally important cooling mechanism to the NAWH compared with ocean heat transport; (2) Remote sensing of clouds and recently launched AMOC measuring programs provide an unprecedented opportunity to constrain simulated physical processes relevant to the NAWH and to further narrow down uncertainties in the NAWH mechanism; and (3) The way the NAWH evolves in response to anthropogenic greenhouse gases is dependent on the response of clouds and the rate of AMOC slowdown, both of which change with the background climate.

The proposed research will be performed toward my Ph.D. degree at PSU in the Spring of 2027. The successful completion of the project will lead to a significant step forward in understanding the complicated air-sea interaction and climate variability/change mechanisms in the subpolar North Atlantic, a region critical for decadal climate prediction, ocean heat and carbon uptake, and abrupt climate change. Thus, my project is closely aligned with the NASA Earth Science SMD in Earth's energy balance and Climate Variability and Change.

The outcome of this project will be disseminated to the broader community through peer-reviewed publications and presentations at conferences and workshops. The project will contribute to the education of next-generation scientists by mentoring one undergraduate research fellow per year through the Research Experience for Undergraduates (REU) program at PSU's climate site, for which I have mentored two fellows since 2022.

Zhong Lu (PI) / Vamshi Karanam (FI)
Southern Methodist University, Inc
23-EARTH23-0153: Characterizing the Role of Faults, Geology and Hydrocarbon Production Induced Stress Changes on Surface Deformation in Permian Basin Using InSAR Analysis and Poroelastic Modeling

The Permian Basin is a major source of oil and natural gas accounting for more than 40% of the oil production in the United States. With the recent advancements in petroleum extraction methods such as hydraulic fracturing and horizontal drilling, production skyrocketed. Such rapid developments, along with the disposal of wastewater back into the subsurface, have caused significant changes in the stress regime of the region's subsurface resulting in the activation of faults, earthquakes, and leakage of hydrocarbons into the groundwater and air. The fluids introduce pore fluid pressure to the subsurface, reducing solid-solid contact. In addition, the faults act as barriers/conduits that control the hydrocarbon fluid flow. Such stress changes in the subsurface are often manifested as surface deformation. Such a complex combination of multiple driving factors with a wide array of implications makes it essential for a detailed analysis of the stress and strain dynamics in the region to address the potential impacts of these processes on the local infrastructure and environment.

The proposed study aims to understand the role of faults, geologic material properties, and oil extraction and injection activities in inducing the subsurface stress changes, and their impact on the surface deformation in the Permian basin. The first objective is to map the evolution of surface deformation in the entire Basin over the last two decades (2007 - 2025) using advanced InSAR processing of ALOS PALSAR -1/2 (L band), Sentinel 1 A/B (C band), and the upcoming NISAR (L band) datasets using a combination of Distributed Scatterer and persistent Scatterer techniques. The second objective is to model the contribution of petroleum production and injection activities using poroelastic principles. For this, the subsurface will be divided into small elements using the Finite Element Method (FEM) for the modeling. Third, unmapped faults will be located using deformation gradient maps, earthquake locations, and existing geology data. Fault orientation, fault width, and proportion of shale content will be used to estimate the fault's permeability and the barrier/conduit property. Finally, the newly identified faults will be added to the model to estimate the injection and extraction-induced deformation in the presence of faults.

The proposal focuses on NASA's Strategic Objective 1.1 "Understand the Earth system and its climate", in particular, on the goal of "characterizing the dynamics of the Earth's surface and interior, improving the capability to assess and respond to natural hazards and extreme events". The use of existing SAR datasets together with the soon-to-be-available NISAR data will explore the potential of the NISAR mission. This study will provide valuable insights for planning authorities and key stakeholders to understand the threats to the region's petroleum industry and help formulate policies and regulations to mitigate negative effects. Within the scientific community, the proposed work will improve the understanding of the impacts of faults on fluid flow and surface deformation. Finally, this research will help hydrocarbon industries in empowering the public by guaranteeing a safe, dependable, and constant source of hydrocarbons to meet their demands.

Troy Magney (PI) / Francis Ulep (FI)
University of California, Davis
23-EARTH23-0156: Smoke and Optics - Assessing Ecosystem Productivity in the Presence of Fire-Related Aerosols Through a Scaled Remote Sensing Approach

As climate change intensifies, wildfire frequency and severity are forecasted to follow suit, releasing unprecedented quantities of carbon into the atmosphere. Consequently, plant exposure to wildfire emissions will also increase, and the influence of these emissions on vegetation's ability to sequester carbon needs to be better understood. Persistent smoke cover affects plant productivity by reducing light availability and influencing photosynthetic activity. To date, smoke is one of the most understudied plant physiological stressors. This project will investigate how plants respond and recover from fire-derived smoke at different scales. The proposed project has three compounding objectives: (1) track vegetation response under high-smoke conditions through a greenhouse experiment, (2) incorporate an optical remote sensing approach to monitor site-level productivity in the presence of prescribed burns aerosols, and (3) integrate remotely sensed data at the tower and satellite scale to inform fluctuations in ecosystem productivity.

Hyperspectral reflectance (400-2500nm) at the leaf and plant scale for the greenhouse experiment will be collected for information on plant physiological response after exposure to different durations and PM concentrations using handheld and tower-mounted spectrometers. Following the experiment, the same tower-based system will be deployed to monitor surrounding vegetation downwind from prescribed burns. The model developed based on the greenhouse experiment data will validate site and canopy level measurements from this investigation stage. NASA satellite remote sensing data with archived tower-based data will be used to assess the ability to track smoke response and recovery at the landscape and ecosystem levels and understand the overall sensitivity of fluctuations in reflectance over time within naturally occurring wildfire scenarios.

This investigation will collect and use existing high spatiotemporal resolution measurements to understand PM's short-term (e.g., sub-daily to days) and long-term (e.g., weeks to seasons) impacts on trees to make informed connections across fine and regional spatial scales. Furthermore, it incorporates multiple datasets ranging from space-borne instruments, ground-based RS platforms, and in situ observations to assess how climate-driven abiotic changes affect primary productivity. These goals and methods align with the goals of NASA's 2022 Strategic Objective 1.1 and the Earth Science Focus Area: Carbon Cycle and Ecosystems.

Hilary Martens (PI) / Matthew Swarr (FI)
University of Montana, Missoula
23-EARTH23-0236: Investigating the Effect of Earth's 3D Structure on Load-Induced Surface Displacement

Astronomical- and climate-driven variations in the distribution of mass stored within the spheres of the Earth system produce measurable changes in the solid Earth's figure and gravity field. As the spatiotemporal characteristics of environmental loading vary broadly, observations of the solid Earth's displacement response using modern geodetic techniques, such as the Global Navigation Satellite Systems (GNSS), are subject to variations in the elastic and density structure of the Earth across varying depth ranges. While predictions derived from 1D spherical Earth models offer a good approximation, apparent sensitivities to features such as surface topography and lateral variations in structure drive the need for a new generation models used to estimate the solid Earth's surface loading response. To improve the current understanding of the Earth's dynamic response to variations in surface loading and explore the potential use of surface loading displacements to probe the 3D elastic and density structure of the Earth, we propose extending the open-source finite-element code PyLith (Aagard et al., 2023) to simulate the solid Earth's ocean tidal loading (OTL) displacement response while considering arbitrary 3D heterogeneities of the Earth.

To assess the individual impact of 3D features of the Earth (e.g., surface topography, lithosphere structure) we will simulate the Earth's OTL-induced displacement response using high-resolution ocean tide models along with 3D tomographic models from seismology to parameterize the Earth's structure and quasi-spherical geometry. Similarly, through comparison of the predictions produced from our simulations which consider 3D variations in structure with

GNSS observed OTL displacements we will shed light on potential improvements to the accuracy of predicted OTL-induced displacement relative to models which rely on a 1D characterization of the Earth's elastic and density structure. Furthermore, to explore the potential of using observed OTL-induced displacements to constrain the 3D elastic and density structure of the Earth through a geophysical inversion, we will carry out sensitivity analyses using adjoint methods to construct 3D sensitivity kernels which quantify the sensitivity of the solid Earth's displacement response to perturbations of the bulk modulus, shear modulus, and density structure of the Earth's interior. Equipped with the sensitivity kernels, we will then formulate a fully probabilistic inverse problem to solve for 3D perturbations of the elastic moduli and density of a chosen reference Earth model (e.g., PREM) through comparison of observed and predicted OTL-induced surface displacement. Using the published OTL-induced displacements from Martens et al. [2016], we aim to constrain the 3D elastic and density structure of the South American craton.

This work aims to contribute to advancing knowledge of the Earth as a system by providing a new tool to predict deformation of the Earth's surface produced by the redistribution of solid and fluid mass within the Earth system while considering a realistic 3D representation of the Earth's topography and interior structure. Additionally, by using observations of the Earth's OTL response to probe the 3D elastic and density structure of the Earth we aim to provide valuable constraints on the density distribution within the Earth's interior, improving our understanding of the solid Earth's formation and evolution.

Dev Niyogi (PI) / Trevor Brooks (FI)
University of Texas, Austin
23-EARTH23-0422: Climate Harmony: Studying and Informing Urban Climate Efforts in Central Texas Through the Development of a Regional Climate Atlas

This proposal seeks to fill in the gaps between city-city learning and comparisons through the creation of a Central Texas Regional Climate Atlas. Urban growth brings with it different pressures that are exacerbated by the effects of global climate change. These negative effects are also often unequally distributed with residents who experience low income, the elderly, racial minorities, and women bearing a disproportionate impact from these stressors compared to their counterparts. Often, if a city is left on their own to address these inequities, they find themselves without the proper resources or expertise resulting in the "loudest" groups within a city to be able to attract much of the resources. To remedy this issue many cities have begun engaging in what is known as a reflexive co-production process where cities, academics, and local community members/ organizations form strong partnerships to facilitate more equitable remedies for the stressors related to urban expansion and climate change. The issue with many of these projects is that they tend to only look internally within their own city and do not compare the efforts happening across different municipalities in their region. This results in a siloed workflow for regions and can cause difficulties when cities do try to communicate best practices with one another as these projects lack scalability or were not made with scalability in mind. This proposal aims to resolve part of this issue through the development of a regional climate atlas for the Central Texas area (Austin, San Antonio, and College Station). Each area is experiencing different levels of urbanization and growth while also having the appropriate mechanisms for reflexive coproduction to take place (strong university presence, willing city officials, and residents feeling pressures from increased urbanization).

This project will create an atlas that aims to examine the climatic stressors of air quality and extreme urban heat through the integration of localized climate data (through NASA products such as the novel TEMPO), lived experiences, and city know-how to develop localized and regional decision-making tools. The atlas will also include a section for the Central Texas region on the response to extreme cold as extreme cold snaps are expected to become more frequent in the region. The atlas also intends to examine the various pilot projects oriented towards climate change adaptation around the region and compare the efforts between Austin, San Antonio, and College Station and their use (if any) of NASA products. This atlas will require various data sources from NASA such as the TEMPO dataset when it gets released for air quality, Landsat data for the development of local climate zones and the examination of landcover change over time, and Lidar data to assist in the development of the UTCI to create high resolution thermal comfort maps (per the H3I method). This atlas will require various inputs from local governance experts and community organizations from the various municipalities in Central Texas to meet the rigorous standards of reflexive co-production as the goal of this atlas is not only to produce high-impact publications but to also make climate information usable and useful for the communities.

This approach aligns with many of NASA's goals meeting both strategies 1.3 and 1.4 in the Science 2020-2024 plan. The plan will also help NASA meet various executive orders as the project is inherently focused on EEJ principles and the leveraging of Earth and social science data to advance the interests of vulnerable communities. This regional climate atlas will serve as a facilitator for much needed city-city learning to ensure that the Central Texas region continues to develop in a way that results in an equitable climate for all rather than just a few.

Mitchio Okumura (PI)/ Megan Woods (FI)
California Institute of Technology
23-EARTH23-0403: Water's Influence on SOA Formation via Criegee Intermediates and Hydrogen Peroxides

Secondary Organic Aerosols (SOA) play a significant role in Earth's health and climate. However, models exhibit a systematic 5-fold discrepancy from observed data in NASA's ACE-Asia campaign, a trend prevalent throughout the Northern Hemisphere. While contemporary models show improved agreement with organic aerosol concentrations from NASA ATom observations, they are in fortuitous agreement and may underestimate an important pathway for SOA formation. A recent field, modeling, and laboratory study identified atmospheric trace species Criegee Intermediates (CI) as critical precursors to SOA formation (Caravan, 2024). The study demonstrated that CI may rapidly react with hydrogen peroxides (ROOH) in the gas phase, with reaction products growing until they condense into the particle phase and form SOA. Despite this observation, Caravan et al. (2024) showed that current atmospheric models only capture a small portion of CI signatures observed in the field.

A hypothesis to explain the discrepancy in field observations and models is that gas-phase water vapor (H2O) can catalyze the reaction of CI and ROOH. Preliminary measurements done at JPL observed a 20% increase in the kinetic coefficient of the simplest CI (CH2OO) and hydrogen peroxide (H_2O_2) in the presence of H_2O. Modeling the preliminary data using GEOS-Chem, the enhanced rate coefficient led to an increase of up to 2 μg m^{-3} in SOA formation. This result suggests that rate enhancements by H_2O of CI reactions could be a significant, previously unrecognized source of SOA in the lower troposphere.

This proposal aims to measure rate coefficients of functionalized ROOH that are pertinent to the troposphere, as a function of temperature and H_2O using the ultraviolet-visible (UV-vis) spectroscopy setup in the photochemistry and kinetics group at JPL. The newly measured rate coefficients are then implemented into GEOS-chem to assess how CI+ROOH+H_2O impacts ROOH lifetimes, as well as HOx, NOx, and SOA formation globally and in the United States. Overall aiming to constrain uncertainties in the formation pathways and unaccounted-for mass of SOA.

Results from the proposal align with the Earth Science Division and the atmospheric research and analysis program, addressing how atmospheric composition is changing and responding to global environmental change. In addition, the proposed study addresses the gap in understanding SOA formation, providing insights into unexplored CI chemistry and the catalytic role of H_2O. The newly elucidated kinetic coefficients and models will offer insight into a formation pathway of SOA not previously considered. Overall, this strongly supports NASA's upcoming MAIA mission, as well as current TEMPO missions. The proposed work aligns with NASA's objective 1.1 to understand the Earth system and its climate and addresses NASA's 2022-2024 Earth Science strategy of reducing climate uncertainty and informing societal response, positioning itself as a valuable contribution to understanding Earth's health and climate and ultimately improving life for all people.

Elsa Ordway (PI) / Anna Ongjoco (FI)
University of California, Los Angeles
23-EARTH23-0082: Uncovering Water and Carbon Tradeoffs in Three California Oak Species with Hyper Spectral Remote Sensing

Changes to the interactions of the global carbon and water cycle is of great interest to Earth scientists and plant ecophysiologists, especially as the intensity and frequency of droughts continues to exacerbate water scarcities. As water availability continues to diminish, prolonged water stress of trees can lead to physiological damage and large-scale tree mortality. This has been seen in California, killing an estimated 129 million trees across the state. Due to logistical constraints, traditional metrics of water stress (e.g., plant water potential, a physiological diagnostic of water status) and carbon metabolism (e.g., non-structural carbohydrates or NSCs, indicates carbon storage and physiological performance) to understand carbon and water tradeoffs in the field have been difficult to accomplish across space and time. Given increased availability of advanced airborne and spaceborne hyperspectral visible-to-shortwave infrared (VSWIR) imaging sensors (AVIRIS-NG and EMIT), we are well-poised to improve monitoring and modeling capabilities to understand the future of these forests spatially and temporally. The objective of my proposed research is to determine: 1) how we can use remote sensing tools to further understand water and carbon use strategies beyond the individual leaf and tree scale, 2) if remote sensing datasets can serve as proxies for plant water and carbon metrics measured in the field and 3) investigate if ground measurements are comparable to what we see from airborne and spaceborne VSWIR imagery. This research will be using existing ground-based leaf trait data and maps of traits derived from VSWIR imagery obtained from the 2022 SBG High-Frequency Time Series (SHIFT) campaign that included Sedgwick Reserve (located in southern California and part of the University of California Natural Reserve System) and utilized the Airborne Visible-Infrared Imaging Spectrometer - Next Generation (AVIRIS-NG). In addition, future ground-based measurements of plant water potential and NSCs will be collocated with NASA's Earth Surface Mineral Dust Source Investigation (EMIT) imaging spectrometer on the International Space Station to extend my time series and evaluate the scalability of these metrics. I will also compare these time series to ecosystem trends using traditional vegetation indices retrieved from spaceborne data via Harmonized Landsat/Sentinel 2 (HLS). This research will determine the importance of more detailed estimates of plant response and function and their tradeoffs from airborne and spaceborne remote sensing metrics and ground measurements. Integrating next-generation sensors from airborne and spaceborne platforms that go beyond traditional greenness indices will allow us to explore more direct measures of plant response related to carbon- and water-use strategies. Finally, this research has the potential to provide unprecedented insight to the intra- and inter-specific variation of oaks and more accurately reflect physiological responses to drought stress.

Paola Passalacqua (PI) / Eleanor Henson (FI)
University of Texas, Austin
23-EARTH23-0071: Local Calibration, Global Implementation- Developing a Nutrient Model Applicable to Deltas Across Earth

This proposal emphasizes the need for the integration of remotely-sensed data to better understand the transport of both water and nutrients in river deltas. Fertilizer application in agricultural landscapes has continually increased in recent decades to account for the growing global food demand. Nutrients in fertilizers, such as nitrate, have been increasingly flushed into river systems and ultimately to river deltas. Excess nitrate has caused hypoxia and eutrophication in coastal systems, resulting in significant economic and ecological losses. This proposal seeks to better understand nitrate and water transport in deltas to answer the question, "Can deltas be last-ditch effort sites of nitrate processing before entering the ocean?".

The NASA Delta-X mission campaign emphasized the usefulness of remotely-sensed data in deltas to evaluate soil accretion and loss in the Mississippi River Basin. This proposal expands this campaign further by utilizing the high-resolution remotely-sensed data acquired during airborne campaigns of two NASA instruments, AirSWOT and NISAR, to better understand nitrate transport in Wax Lake Delta (WLD) of coastal Louisiana. Specifically, the first goal of this proposal is to develop a nitrate transport model in WLD to pair with a calibrated ANUGA hydrodynamic model and the particle transport model dorado.

Recent advances in modeling deltaic nutrient transport have benefited from a mathematical perspective known as graph theory, where river channel networks are extracted as a series of nodes (junctions) and links (channels). The second goal of this research is to apply an updated graph-based framework to the nitrate model to gain insights into transport dynamics through an interactive and visually appealing mathematical tool. The beauty of utilizing a graph-based approach is its ability to be applied globally and incorporate a diverse set of inputs from various sources (i.e. remote-sensing instruments). Recent research has confirmed the beneficial use of the graph-based approach in delta networks, but the accuracy of such work has been limited by not accounting for mass losses within the channel network. This proposal will improve application of the graph-based approach in deltas by incorporating a novel index of channel leakiness.

The third goal of this proposal is to apply the improved graph-based framework to deltas around the world, with initial application to the Lena and Mekong Deltas. This task leverages another unique attribute of the Delta-X campaign data- the AirSWOT and UAVSAR instruments are prototypes for mature NASA missions SWOT (launched) and NISAR (soon to be launched in 2024). SWOT discharge values and NISAR water surface fluctuations will be used to calculate novel estimates of channel leakiness, which are critical for improving understanding of both water and nitrate transport dynamics around the globe. Section 1.7 of the proposal outlines alternative remotely-sensed data sources if necessary.

This project not only intends to promote the usage of past, current, and future NASA satellite data but will also directly advance goals outlined for programs in the NASA Earth Science Division (ESD). A broadly applicable model of water fluxes alone would improve predictions of global delta evolution and water surface elevation changes. Including constituents such as nitrate would revolutionize quantitative measures of our global nitrate budget. There is potential for the developed methodology to be utilized with other constituents and provide insights into the global carbon budget. These accomplishments would directly benefit the Research and Analysis program's focus areas "Carbon Cycle and Ecosystems" and "Water and Energy Cycle". Lastly, the Earth Science Technology Office would benefit from the development of an open-source, freely accessible global nitrate model and an updated graph-based mathematical framework for deltas.

Claire Pettersen (PI) / Jack Richter (FI)
University of Michigan, Ann Arbor
23-EARTH23-0013: Leveraging Global Precipitation Measurement Mission Assets to Evaluate Atmospheric River Snowfall Properties

Atmospheric rivers (AR) can produce extreme snowfall events that have different characteristics compared to snowfall events independent from ARs (NoAR). This proposal aims to utilize a plethora of NASA assets, including long-term NASA ground validation (GV) instruments sites, targeted field campaign observations (ground-based and airborne), and the Global Precipitation Measurement Mission (GPM) spaceborne Dual-Frequency Precipitation Radar (DPR) to evaluate snowfall properties during ARs. These NASA assets enable observations of snowfall in diverse environments and from multiple perspectives that will allow us to characterize AR snowfall and lend insight into the related snowfall processes. Three science questions (SQ) are introduced that outline the approach to better characterize AR snowfall:

SQ1) What are the micro- and macro-physical differences between AR and NoAR snowfall properties? This SQ will analyze observations from two long-term NASA GV sites to determine distinct micro- and macro-physical properties of AR snowfall.

SQ2) Are there differences in GPM-DPR observations of AR and NoAR snowfall? This SQ will build on SQ1 and evaluate GPM-DPR retrievals in conjunction with the long-term GV sites and targeted field campaigns to connect the spaceborne perspective of AR snowfall to the surface measurements.

SQ3) What are the characteristics of AR snowfall in the northern hemisphere as shown by DPR? This last SQ will further expand the results from SQ1 and SQ2 and characterize AR snowfall properties in the entire northern hemisphere using more than 10 years of GPM-DPR observations.

Improved characterization of AR snowfall is important because both ARs and extreme snowfall are projected to become more frequent in a warming climate. Accordingly, the proposed study is relevant to the NASA Earth Sciences Division, of which a primary objective is "...to advance knowledge of Earth as a system in order to meet the challenges of environmental change and to improve life on our planet." Additionally, the proposed work follows key scientific goals of the NASA Precipitation Measurement Missions (PMM) Science Team: "(1) advancing precipitation observations from space; (2) improving knowledge of precipitation systems, water cycle variability".

Laura Prugh (PI) / Benjamin Sullender (FI)
University of Washington, Seattle
23-EARTH23-0039: Integrating Climate Projections into Snow-Mediated Habitat Selection for Carnivores and Ungulates

Snow dynamics influence a suite of biotic processes including wildlife movement patterns, predator-prey interactions, and species distributions in ecosystems worldwide. However, seasonal snow remains sparsely studied in wildlife ecology, mainly due to the complex physical processes that determine biologically significant shifts in snowpack, challenges developing snow data products at wildlife-relevant scales, and the truly interdisciplinary nature of snow ecology itself. As researchers have gained new capabilities to estimate where, how much, and how long snow persists, emerging findings reveal that snowpacks are changing dramatically worldwide. Coupling these rapidly shifting baselines with forecasted changes further adds to this complexity, as increased temperatures and altered precipitation patterns shift snow dynamics. Leveraging prior NASA-funded work, this project will integrate a unique animal location dataset (>1.5 million GPS locations of 5 large mammal species) with remotely sensed snow data, physically-based snow modeling, and downscaled climate projections to quantify how changing snowpacks will affect wildlife.

I will achieve this broad goal through three main approaches. First, I will evaluate the effect of snow cover on migratory patterns of ungulates by linking MODIS snow cover data with locations from GPS-collared mule deer, white-tailed deer, and elk in Washington (Obj. 1). Second, I will quantify the role of snow depth and density in habitat selection of ungulates and carnivores by pairing a physically-based snowpack model (SnowModel) with locations from GPS-collared mule deer, white-tailed deer, elk, wolves, and cougars (Obj. 2). Finally, I will assess how snow-mediated habitat suitability is likely to change in future climate scenarios by forcing SnowModel with meteorological data from NASA Earth Exchange Downscaled 30 Arc-Second CMIP5 Climate Projections to quantify spatial and temporal changes in suitable winter habitat (Obj. 3).

Together, these three lines of inquiry will improve our understanding of how snow shapes the life histories of wildlife that in turn sustain ecosystems in the Pacific Northwest and the broader Northern Hemisphere.

This proposal builds directly on several prior research efforts, including an expiring NASA Interdisciplinary Research in Earth Science grant and a multi-year partnership with the Washington Department of Fish & Wildlife. Through these initiatives, we developed a parallelized version of SnowModel in NASA's Land Information System that will greatly improve computational efficiency of the proposed work. My FINESST proposal addresses questions that are directly relevant to NASA's Earth Action Program (via the Ecological Conservation Climate Resilience element) and the Research and Analysis Program (via Cryospheric Science and Modeling, Analysis, and Prediction).

Outcomes from my proposed project are societally relevant and stand to benefit multiple groups, including snow scientists, ecologists, resource managers, stakeholders, community members, and the general public. Recent reintroductions and recolonizations of large carnivores across western North America have attracted intense public interest, but there is significant uncertainty about how and where climate change may shift these predators on the landscape. Additionally, these predators structure habitat use and migration patterns for their prey, including three ungulate species of critical importance to regional hunting economies and community harvest. This knowledge will represent an important contribution towards developing conservation plans to enhance climate resilience in the western US and beyond.

Volker Radeloff (PI) / Akash Anand (FI)
University of Wisconsin, Madison
23-EARTH23-0190: Explainable AI to Model Avian Hierarchical Habitat Selection, and Accurately Predict Their Distribution and Richness

Our world is experiencing rapid change, with human activities significantly altering ecosystems and biodiversity by transforming natural landscapes. Birds, integral to many ecosystems, are not exempt from these changes. Establishing a relationship between avian behavior, distribution, and response to the local ecosystem can provide crucial knowledge about ecosystem change, resilience, and overall biodiversity. My research aims to determine how different bird species select their habitat, their distribution, and identify hotspots within ecosystems. I intend to utilize remote sensing data and novel AI methods to address three key questions: (i) How effectively can CNN models predict species distribution compared to other SDMs? (ii) How can multi-scale avian hierarchical habitat selection be explained with explainable AI? (iii) How well can NISAR map forest structure, and does it complement optical data in mapping bird richness?

First, I will present evidence on how well CNNs can predict species distributions compared to conventional SDMs, with a particular focus on assessing their performance with limited sample training data--a common challenge in conservation science. The tested CNNs will help determine optimal scenarios for utilizing shallow or deep CNN architectures and assess the effectiveness of data augmentation in predicting species with limited data.

Second, I will use explainable AI methods to understand what spatial scale is important for the individual species and how they interact with the local habitat. This approach is novel in applying explainable AI techniques to ecological questions, providing insights into the multiscale hierarchical habitat selection in birds.

Third, I will investigate the synergy between SAR-based vegetation structure indices and DHIs to predict bird richness. NISAR's L-band exhibits great promise for biodiversity studies, when combined with optical data, it will enhance the assessment of species' habitat and distribution, contributing to more accurate and informed ecological models.

My results will show evidence of how deep learning models can both predict and explain avian biodiversity better. The proposed approach will add transparency to deep learning models used by ecologists and build trust among policymakers and the scientific community. The outlined research is directly aligned with NASA's Earth Science Division's strategic objective to "advance knowledge of Earth as a system in order to meet the challenges of environmental change and to improve life on our planet" and the Carbon Cycle and Ecosystem science goal to "Detect and predict changes in Earth's ecosystems and biogeochemical cycle, including land cover, biodiversity, and the global carbon cycle".

Volker Radeloff (PI) / Elbegjargal Nasanbat (FI)
University of Wisconsin, Madison
23-EARTH23-0177: Grassland Degradation Patterns and Causes, and the Effectiveness of Protected Areas in Mongolia

Mongolia has some of the most intact remaining grasslands globally. However, Mongolia's grasslands are threatened by degradation due to climate change, overgrazing and disturbances such as wildfires and Brandt's voles. Degradation can manifest itself both as a loss of vegetation cover, or as a change in vegetation communities. Monitoring degradation is challenging though and requires new remote sensing approaches, such as cumulative endmember fractions, and community classifications based on convolutional neural networks. Better degradation estimates in turn allow to identify the role of disturbances for degradation. Protected areas can safeguard grassland biodiversity, but only if they are effective, and novel degradation measures can be used to measure their effectiveness.

The overarching goal of my proposed research is to map and assess the patterns of grassland degradation in Mongolia with medium-resolution Landsat imagery, both in terms of vegetation cover and vegetation communities, link the observed degradation to wildfire and vole disturbance while accounting for grazing and climate, and assess if protected area have been effective in stopping or even reversing grassland degradation.

My project has four major objectives:

(a) estimate the long-term trends in grassland degradation from the full Landsat archive (1987 -- 2023) based on cumulative endmember fractions parameterized with field spectroradiometer measurements and validated with biomass and vegetation cover field data,

(b) quantify change in grassland vegetation communities associations based on convolutional neural networks (CNNs), by capitalizing on phenological differences of dry versus wet years,

(c) assess the role of disturbances on grassland degradation focusing on wildfires and Brandt's voles,

(d) investigate the effectiveness of protected grassland areas that are important for plant biodiversity and migrating ungulates in stopping or even reverting grassland degradation.

Scientifically, I will contribute new knowledge by identifying the role of disturbances on grassland degradation such as wildfires and as Brandt's voles, which are part of the natural ecosystems, but exacerbated by overgrazing.

Methodologically, my project will be the first to parameterize cumulative endmember fraction analyses with field Spectro-Radiometer data, and validate fractions with field biomass and vegetation cover data. I will analyze data from a range of NASA assets, focusing on Landsat, and also MODIS data, and use novel trend analysis methods (remotePARTS) for satellite data.

In terms of management and conservation, I will provide base-line data for sustainable livestock management, and assess the effectiveness of Mongolia's growing protected area network, and of large herbivore habitat.

With my proposed research, I will contribute to NASA strategic objective to advance the knowledge of Earth as a system, and provide answers to key science questions, such as "How is the global Earth system changing?", "What causes these changes?, and "How can Earth system science provide societal benefit?"

Adrian Rocha (PI) / Rachel Badzoich (FI)
University of Notre Dame
23-EARTH23-0331: A Novel Way to Sense Post-Fire Impacts on Arctic Permafrost and Ecosystem Vulnerability with NASA Observatories and Computer Learning

The proposed work will advance understanding of post-fire impacts on Arctic permafrost and ecosystem vulnerability utilizing NASA observatories and innovative computer learning methods. Arctic fires have significant landscape impacts including increased permafrost thaw, increased surface subsidence, and changes to the landscape distribution of vegetation types. These processes are linked to increased microtopography that results from surface cracks that are visible in high resolution satellite imagery. I will develop computer vision models to automate the detection and quantification of these surface cracks and link their formation to land surface properties (i.e. burn severity, land cover, and soil edaphic properties) with machine learning models. This research will provide a novel metric to quantify post-fire surface cracking over space and time in the burn scar of the largest recorded tundra fire on the North Slope of Alaska, the 2007 Anaktuvuk River fire.

This project will leverage pre-existing computer vision techniques for detecting cracks on infrastructure. A deep convolutional neural network (CNN) will be trained for automated identification of surface cracks from <3m resolution multispectral imagery from the Maxar constellation of satellites. The CNN will quantify crack segments to produce maps of surface cracking density at 30-250m resolution. These maps will be the first to quantify the severity and distribution of post-fire surface cracking within the Anaktuvuk River fire scar across multiple years. The temporal trajectory of surface cracking will be characterized to provide insights into the underlying mechanisms and long-term implications for permafrost landscapes. Boosted regression tree machine learning models will be used to determine mechanistic relationships among surface cracking density, burn severity, land cover recovery, topography, and edaphic properties. Uncertainty analyses will be conducted using Monte Carlo sampling methods, simulating various scenarios and sources of uncertainty to determine the robustness and reliability of the models.

This project will significantly contribute to NASA's Earth Science Division objectives by advancing scientific knowledge related to Arctic ecosystems. The results will provide a better understanding of fire-accelerated permafrost degradation and its impacts on landscapes and ecosystems. Being awarded the NASA FINESST will support professional development through training on computer vision techniques at Washington University in St. Louis, the use of NASA's High Performance Computing, and funds to participate at annual NASA and LTER workshops and to present this research at international meetings such as the American Geophysical Union (AGU).

Mojtaba Sadegh (PI) / Amirhossein Montazeri (FI)
Boise State University
23-EARTH23-0033: Soil Burn Severity Prediction Using Remote Sensing and Machine Learning

This project's goal is to enhance post-fire mitigation and response through developing a predictive model of Soil Burn Severity (SBS) using satellite imagery. Wildfires have been increasingly impacting various regions worldwide with adverse impacts across spatial and temporal scales. A prime example of post-fire disasters is the 2018 Montecito debris flow in California that claimed 23 lives. Post-fire mitigation efforts heavily depend on the assessment of "burn severity". Burn severity is a broad term that refers to fire-induced ecosystem impacts as a result of change or loss of organic matter above and below ground. Vegetation Burn Severity (VBS) can be derived from satellite observations. However, Soil Burn Severity (SBS) assessment -- critical to allay hydrologic and geologic hazards -- requires costly and time-consuming field recalibration of VBS maps. SBS maps are only available for a small fraction of all fires in the western US, creating a data gap that this project will bridge. Furthermore, climate change-driven weather whiplash has narrowed the time interval between large fires and the ensuing precipitation event, requiring tools for rapid and accurate assessment of SBS without the need for laborious field recalibration of satellite-derived metrics.

This project will use multi-source data and advanced Machine Learning (ML) techniques to develop predictive understanding of how ecological, meteorological, climatic, geological, topographical processes prior to and during wildfires govern SBS outcomes. To this end, causality graphs will be developed to enlighten the pathways that wildfire covariates govern the SBS outcome. Through careful representation of causal pathways, this project will develop a physics-informed ML model of SBS that not only predicts wildfire impacts on soil and informs post-fire hazard mitigation, but also answers fundamental scientific questions about the strength of control of various processes on SBS outcomes. This project is directly aligned with Earth Science Research Program's goals of improving the capability to assess and respond to natural hazards, and furthering the use of Earth system science research to inform decision and provide benefits to the society.

Project objectives include:

1. Develop ML-ready dataset: A comprehensive dataset of all large fire incidents across the western US for which SBS maps have been developed will be paired with associated VBS maps as well as weather, fire danger indices, vegetation indices, climate, land cover, soil characteristics, and topographical factors based on the time and location of burn. Image texture metrics will also be calculated to preserve the spatial structure of the forcing data, before converting the data into tabular format for model training.

2. Develop predictive SBS models: Upon partitioning the historical data into train, validation, test and "extra test" sets, hyperparameters and parameters of a cohort of ensemble and deep learning models will be tuned. These models are trained regionally and for the entire western US (aka, "universal model"). Using soft and hard voting classifiers, predictions from various models will be fused to leverage the strengths of different model structures. This task will shed light on whether ML models can capture universal governing processes that modulate the SBS outcome. This investigation will answer the question of whether the herein developed western US model can be expanded to the entire globe.

3. Quantify the strength of control of fire covariates on SBS outcomes: Explainable Artificial Intelligence techniques will be used to quantify marginal contributions of each fire covariate to the SBS outcome. Furthermore, counterfactual scenario analyses using the predictive model will shed light on the thresholds that activate SBS change. These analyses will also reveal the strengths of control of various fire covariates on the SBS outcome across the environmental gradients in the western US.

Mike Sayers (PI) / Karl Bosse (FI)
Michigan Technological University
23-EARTH23-0192: Assessment of Hyperspectral Optical Closure in Optically Complex Freshwater Systems in Support of the NASA PACE Satellite

Satellite remote sensing has been used to study water quality for decades due to the improvements it provides over in situ sampling in terms of spatial and temporal coverage, with applications ranging from the study of primary production, sediment plume mapping, and harmful algal bloom detection. Nearly all of the satellite sensors used for these applications have been multispectral in nature, with a selection of bands in the visible and near-infrared targeting key environmental features. In February 2024, NASA will launch its new Plankton, Aerosol, Cloud, ocean Ecosystem (PACE) satellite, with the Ocean Color Instrument (OCI) sensor providing global hyperspectral imagery with 2-day repeat coverage. This new dataset is expected to provide a range of benefits, including an improved ability to monitor phytoplankton community composition, detect harmful algal blooms (HABs), and quantify levels of optically active constituents (OACs; i.e., chlorophyll, suspended sediments, and colored organic dissolved matter [CDOM]).

These parameters are all related to the inherent optical properties (IOPs) of the water, which are a measure of how light interacts with the water and are dependent only on the water itself (including its temperature and salinity) and its OACs. Because of their importance, many algorithms have been developed to derive the IOPs from satellite remote sensing including the

Color Producing Agents Algorithm (CPA-A) which was developed specifically for the Laurentian Great Lakes. The ability to monitor IOPs from space depends on the achievement of closure between measured IOPs and remote sensing reflectance (an apparent optical property, or AOP). Successful closure has been achieved across a range of conditions, including the optically complex freshwater Great Lakes. However, these historic assessments have been performed on a limited band set due to the unavailability of in situ hyperspectral backscattering measurements. While the existing closure analyses may be sufficient in case 1 oceanic waters where there is significant correlation between wavelengths, this knowledge gap is of particular concern in more complex waters like the Great Lakes where the OACs vary independently, resulting in less inter-band correlation.

The public release of the Hyper-bb instrument (Sequoia Scientific) in 2020 marked the first commercially available instrument for measuring hyperspectral backscattering. Since 2022, I have collected, along with my colleagues at Michigan Tech Research Institute (MTRI), Hyper-bb measurements throughout the Great Lakes alongside a suite of other hyperspectral optical measurements. The current dataset includes over 100 measurement suites spanning a range of optical conditions, primarily focused in the eutrophic waters of Saginaw Bay and Lake Erie where extreme sediment plumes and harmful algal blooms (HABs) are common. This dataset is unrivaled in its range of observed conditions, containing magnitudes and spectral shapes previously unreported in in situ data.

For this work, I propose to use MTRI's novel in situ optical dataset to perform hyperspectral optical closure experiments across the spectral range of 430 to 700 nm using the HydroLight (HL) radiative transfer (RT) modeling software. Through this proposed work, I will assess the ability to achieve closure between modeled reflectance (using our suite of in situ IOPs) and both measured in situ reflectance and PACE-generated reflectance measurements. These results will have a direct impact on the development and validation of hyperspectral IOP retrieval algorithms as well as the measurement and processing protocols for optical data.

Konrad Schmidt (PI) / Yu-wen Chen (FI)
University of Colorado, Boulder
23-EARTH23-0087: Satellite-Based Greenhouse Gas Retrieval in Partially Cloudy Regions -- From Quantification to Mitigation of Cloud-Induced Biases

The growing impact of climate change underscores the critical need for precise monitoring of greenhouse gases (GHGs) from space. Accurate observations of GHGs, particularly carbon dioxide (CO2), are vital for understanding the dynamics of GHG emissions and sinks. This knowledge is crucial for developing effective climate change mitigation strategies. NASA's Orbiting Carbon Observatory (OCO-2/3) satellites enable global monitoring of CO2 column mixing ratios (XCO2) and have propelled much research related to the carbon cycle. However, it has been noted that these XCO2 measurements can be affected by the presence of nearby clouds, referred to as the 3D cloud effect. This cloud-induced bias in XCO2 could pose an obstacle to carbon flux studies due to error propagation. Given that clouds cover more than 70% of the Earth's surface, addressing this challenge is imperative.

This proposal aims to develop a mitigation strategy that is compatible with the current XCO2 retrieval algorithm and applicable to most conditions. It will build upon our existing research that introduces a novel parameterization method to represent the 3D cloud effect in OCO-2 observations. Although initial results have been promising in specific cases, the global applicability of this approach remains unverified, necessitating further adaptation for widespread use. We plan to conduct a comprehensive analysis of cloud-induced XCO2 biases across various conditions, with the goal of refining our parameterization method for more general use.

This proposal is expected to enhance the accuracy of NASA OCO data, further contributing to carbon flux studies. This research aligns with the Earth Science Research and Analysis Focus Areas, particularly Carbon Cycle and Ecosystems. It also supports the "Carbon cycle, including carbon dioxide and methane" objective of the 2017 NASA Earth Science Decadal Survey. The methodologies developed through this project have the potential to not only improve current satellite CO2 monitoring techniques but also to benefit future GHG-related missions.

Courtney Schumacher (PI) / Ashley Sebok (FI)
Texas A&M University
23-EARTH23-0372: The Long-Term and Evolving Influence of Wildfire Burn Scars on Precipitation and Storm Characteristics

Wildfires are a global concern, with projected increases in number of fires and area burned in many regions in the coming decades. Land surface properties are well known to affect atmospheric processes, including boundary layer properties and storm occurrence, structure, intensity, and rainfall production. When the land surface is altered by wildfires, the atmosphere will respond, potentially resulting in changes to these storm characteristics. In addition, this atmospheric response will evolve as the ecosystem recovers, which often takes many years. The magnitude of and mechanisms impacting the burn scar-storm relationship are largely unknown. TRMM, GPM, and Terra/Aqua satellite measurements will be used to observationally quantify the changes to storm and precipitation parameters as burn scars undergo succession and to determine the mechanisms by which any observed changes occur. Environmental information from reanalysis will be used to assess the background state to further establish the cause of observed variations in storms and rainfall.

The TRMM precipitation radar (PR), GPM dual-frequency precipitation radar (DPR), TRMM/GPM IMERG, and Terra/Aqua MODIS products will be used in conjunction with MERRA-2 and ERA-5 reanalysis as the main observational data sets. MODIS will be used to identify wildfires and the scope of their resulting burn scars. MODIS will also be used to monitor vegetation recovery and identify possible canopy characteristic-based causes of storm parameter variations across regions. The PR/DPR measurements will be used to identify 3-D storm variables and the IMERG product will be used to provide high temporal and spatial rainfall measurements 3-5 years prior to the wildfire as a baseline and in the years following to monitor storm parameter changes as the ecosystem recovers. The overall outcome of this research will be a comprehensive and well-defined relationship between wildfire burns, vegetation, and precipitation/convection in both the tropics and extratropics. The information resulting from this study may be used to predict the likelihood of convective-induced flooding and debris flows post-fire and long-term precipitation trends over burn areas. This work is highly relevant to current NASA goals of "Understanding the Earth System and Climate" through "Research and Analysis" prescribed by the Earth Science Division. Specifically, NASA satellite data will be crucial in analyzing the evolution of Earth's landscape post-fire and the atmosphere's storm and precipitation response.

Robert Shriver (PI) / Elise Pletcher (FI)
University of Nevada, Reno
23-EARTH23-0388: Developing Multi-Scaled, Probabilistic Forecasts of Woodland Dynamics in the Great Basin

Achieving climate change mitigation goals requires accurately quantifying and predicting future shifts in vegetation structure. Vegetation monitoring data collected from satellite and historical aerial imagery are extremely useful tools for monitoring long-term changes in vegetation structure. But they also hold great potential for building forecasts to anticipate future vegetation change. Long-term observations can be used to develop and train models that can then be validated and updated when new data become available, creating the opportunity for testable predictions of future climate response. In recent years, drought has led to mass mortality and failing recruitment in several pinyon-juniper woodland tree species--an ecosystem that occupies 400,000 square kilometers of the western US. The ability to predict and anticipate future shifts in pinyon-juniper woodland structure will play a key role in meeting climate change mitigation goals. While remote sensing data collected onboard satellites allows for excellent opportunities for building forecasts of pinyon-juniper woodland changes across large spatial extents, these data also present unique challenges. For example, satellite-derived vegetation products contain large amounts of data noise that are unrelated to true shifts in vegetation structure from one time step to the next. Not accounting for such variation has the potential to lead to biased forecasts. Additionally, purely phenomenological forecasts may fail when we must predict change under novel environmental conditions. Forecasts that include underlying demographic mechanisms, on the other hand are likely to be more robust under expected novel climate conditions, because they capture processes that lead to changing responses to environment. Hierarchical Bayesian models are a powerful tool to partition and propagate different sources of uncertainty. For example, fitting a model within a hierarchical Bayesian framework makes it possible to account for both uncertainty in remotely sensed data (observation error) and uncertainty from ecological simplifications in the model (process error). The overarching goal of this project is to leverage satellite-derived land cover products and historical aerial imagery to develop forecasts of changes in woodland structure, abundance, and extent, while identifying, quantifying, and propagating key sources of uncertainty.

I will forecast shifting woodland structure by incorporating varying levels of biological process and evaluate these forecasts to determine whether the inclusion of biological processes, such as demography, produce better forecasts. I will test two different modeling approaches across two study areas, one in central Oregon and one in western Nevada. First, I will use medium resolution fractional tree cover to forecast range expansion and contraction of woodland species across both study areas, while quantifying sources of observation and process uncertainty. Second, I will use abundance and size distribution data extracted from high resolution aerial imagery to forecast range expansion and contraction based on inferred demographic rates across the same study areas in central Oregon and western Nevada. Finally, I will assess performance of the two different models in forecasting shifts cover and abundance at different scales to determine whether adding biological level process (e.g., demography) improves forecast performance. This research project will contribute to the goal to "detect and predict changes in Earth's ecosystems and biogeochemical cycles" by testing approaches for both near and long-term forecasts of changes in woodland structure, abundance, and extent using remotely sensed data. Robust range-wide forecasts of woodland population dynamics can be incorporated into efforts to quantify future shifts in above ground biomass--an important component in the carbon cycle.

Andrew Stewart (PI) / Garrett Finucane (FI)
University of California, Los Angeles
23-EARTH23-0116: Parameterizing Ice Shelf Cavity Processes and Basal Melt in NASA Earth System Models

We propose to develop a new parameterization of Antarctic ice shelf basal melt and integrate it into the NASA GISS climate model to improve the capability of NASA to make predictions about key issues like sea level rise and sea ice extent.

The mass loss of Antarctic ice shelves has been accelerating for the past four decades. A large part of this mass loss has been attributed to ocean-driven basal melting. The melt water produced from basal melting changes not only the stratification around the ice shelves, but the conditions of the Southern Ocean, and the global climate. Global climate models used in multi-decadal runs contained in IPCC inter-comparisons do not have the resolution required to explicitly model the ocean circulation underneath ice shelf cavities, making them unable to capture the feedbacks between climate change and ice shelf melt. Low-order parameterizations of ice-shelf basal melt based on offshore oceanic conditions have been unable to adequately predict melt in coupled ice-ocean climate models and recreate observed melt rates from observations of the ocean conditions outside the shelves.

We propose to extend a newly developed parameterization of basal melt that has shown promise in the fastest melting ice shelf cavities to build a universal basal melt parameterization that works for ice shelf cavities around Antarctica. We will achieve this using a suite of idealized models to characterize the physics of ocean-driven melt in cavities predominantly filled with cold water. We will test the understanding we gain by predicting satellite-derived estimates of ice shelf melt from observations of the temperature and salinity of the ocean outside ice shelves and the ice shelves' shape.

We will then integrate this parameterization into the NASA GISS model with the help of our NASA Co-I. We will investigate melt response/feedbacks in the NASA GISS climate model by running simulations of the recent past and next century with our parameterization included. We will be re-running existing GISS simulations with the parameterization included to provide us with a direct point of comparison for the parameterizations effects. This would make the NASA GISS climate model the first global climate model to include an interactive Antarctic fresh water flux.

Sylvia Sullivan (PI) / Thabo Makgoale (FI)
University of Arizona

23-EARTH23-0019: Tracking Precipitation Biases from Simulated Mesoscale Convective Systems to Energetic and Dynamic Ice Processes

Tropical deep moist convection can organize into coherent structures that grow to scales larger than individual thunderstorms and persist for hours to days. Mesoscale Convective Systems (MCSs) represent one version of such organized tropical convection, with their thick anvil clouds spanning hundreds of kilometers. MCSs are the major source of accumulated precipitation in the tropics and associated with extreme precipitation events and severe winds.
Despite these impacts of MCSs, our models continue to struggle in simulating their convective precipitation, especially in the tropics, due in part to the range of involved scales. Sub-grid scale processes are those that cannot be resolved at the model grid spacing. Recent increases in computational power have permitted the development of storm-resolving models (SRMs) that run at much finer grid spacings than traditional global climate models (GCMs). SRMs can resolve the convective cores of MCSs explicitly, allowing us to focus on microphysical processes and internal dynamics. The proposed project will investigate how diabatic heating from ice phase processes contributes to model biases in MCS precipitation using the NASA Goddard Earth Observing System Model, Version 5 (GEOS-5) and the Integrated Multi-satellitE Retrievals (IMERG)Global Precipitation Measurement Mission (GPM) observations.
We propose to complete this work through four objectives that will 1) calculate and characterize MCS versus non-MCS precipitation efficiency from existing GEOS-5 output; 2) analyze energetic versus dynamic ice within these simulated MCSs; 3) evaluate simulated MCS precipitation relative to collocated GPM IMERG measurements; and 4) link precipitation efficiencies and energetic versus dynamic ice to MCS precipitation biases. In addition to our use of existing GEOS-5 nature runs at convection-permitting grid spacings, we will also run our own limited-duration, high-resolution GEOS-5 simulation, both to provide the FI with SRM experience and to include additional ice microphysical outputs as necessary.
We expect that our efforts will lead to a deeper understanding of MCS precipitation biases in the GEOS-5 model and other SRMs, as well as insight into the structure of latent and radiative heating rates within these high-impact storms. At a broader scale, the objectives of our project will contribute to the vision of NASA's Earth Science Division program, particularly the research and analysis program that aims to "advance our scientific understanding of Earth as a system and its response to natural and human-induced changes and to improve our ability to predict climate, weather, and natural hazards.

David Sutherland (PI) / Venezia Follingstad (FI)
University of Oregon
23-EARTH23-0435: Underwater Shape Matters: Characterizing Subsurface Ice Morphology at Tidewater Glaciers

Ice mass confined within ice sheets has become a looming threat to rising sea levels as global temperatures continue to rise with no end in sight. The Greenland Ice Sheet in particular has been subjected to warming oceanic and atmospheric conditions that have accelerated the rate of mass loss to the surrounding ocean. A significant amount of this mass loss is concentrated at tidewater glaciers (i.e., glaciers that terminate in the ocean/fjords), making them a key feature to study under changing atmospheric conditions. The frontal ablation of tidewater glaciers is composed of calving and submarine melt. While calving can be observed in the field and with remote sensing, submarine melting is extremely difficult to directly measure and observe due to the hazards of obtaining data so close to the dynamic terminus of these glaciers. In addition, the morphology of the glacier terminus is typically unknown, leaving models of frontal ablation and mass loss rates reliant on simplified vertical and undercut (i.e. protruding ice at surface with a receding grounding line due to subglacial discharge) terminus morphologies and submarine melt theory.

In this project, our goal is to address the widely unknown submarine terminus morphologies of tidewater glaciers throughout Greenland and Alaska. We will address this significant unknown in model parameters, and ultimately the resulting frontal ablation rates at tidewater glaciers, with the following objectives. We will process, develop, and analyze the most comprehensive quality-controlled dataset of subsurface tidewater glacier morphologies. We will primarily utilize multibeam sonar data from the NASA's Oceans Melting Greenland (OMG) field missions that is not currently incorporated into the bathymetry dataset available from this project. Combined with several other glacier morphologies published to date, we expect to produce 3-D terminus morphologies of roughly 15-20 glaciers that span Greenland and Alaska. Once this dataset is created and made publicly available, I will use data analysis, remote-sensing, and modeling techniques to 1) characterize typical glacier morphologies based on environmental conditions and geometrical parameters and 2) improve our understanding of how tidewater glaciers respond (e.g., calving multiplier effect) to submarine melting. Ultimately, these data will improve our ability to predict the rate of sea level rise.

My proposed research directly addresses specific goals of NASA and the Earth Science Division. I will use 'the vantage point of space to achieve a deep scientific understanding of our planet', as outlined in NASA's SMD, to validate terminus locations and observe velocity and stress fields with NASA's MEaSUREs product. Such observations, in conjunction with multibeam sonar data being rescued from the NASA OMG field missions, will make it possible for us to observe how this niche Earth system is changing, what is specifically causing these changes, as well as how they will continue to change.

Elizabeth Tellman (PI) / Lucas Belury (FI)
University of Arizona
23-EARTH23-0339: Flood Justice Utilizing Satellite Observations; Social Vulnerability, Capacity Building, and Impact Assessment

Floods affect more people than any hazard and low-income communities of color in the US are increasingly exposed to devastating floods. The Rio Grande Valley (RGV), at the southern tip of the Texas-Mexico border, is susceptible to floods due thousands of flood-vulnerable colonias. These peri-urban, informal, and Mexican/Mexican-American communities house the region's poorest residents and floods in these communities exacerbate poverty and poor public health outcomes. Unfortunately, inadequate flood data hinders community-based organizations (CBOs) in the RGV as they promote flood justice. NASA satellites are a powerful yet untapped resource to generate flood data and empower CBOs to promote flood justice in the RGV. To support these efforts, I co-produced a flood database by blending machine learning for flood detection with satellite imagery and grassroots activism. This database utilized machine learning algorithms developed by Dr. Beth Tellman's Social[Pixel] Lab across multiple satellites including Sentinel-1/2, Landsat 8, and PlanetScope. By Summer 2024 we will produce a flood database (2015-2023).

I proposed a participatory research project that assesses how this co-produced, remote sensing-based flood database, enriched with social vulnerability and housing indicators, and local advocates with the skillset to utilize this data, can challenge flood injustice. Within this research question I have three project objectives: 1) enriching this database with social vulnerability and housing indicators and exploring the relationship between these indicators and flooding 2) building institutional capacity with community partners to utilize this database, and remote sensing more broadly, as a tool for climate justice through on-the-ground training and 3) assessing the impact of this flood database and capacity building on environmental justice organizations.

To enrich the flood database with relevant indicators and analyze the relationship between these indicators and flooding (objective #1) I will create a flood risk index and analyze the connection between various social vulnerability and housing indicators. This analysis of flood risk and indicators will be based on the priorities of local partners. Next, I will build institutional capacity with CBOs to utilize remote sensing to address environmental injustice (objective #2). To build local capacity I will become a volunteer data consultant with these CBOs. In doing so, I will establish myself as a resource for data analysis and visualization while supporting the growth and utilization of the database we have built. I will also train CBO staff to utilize the flood database via adaptable training sessions developed from NASA's ARSET program. Finally, I will examine the utility of this flood database to address the priorities of community-partners to challenge flood injustice (objective #3). To do so, I will interview dozens of CBO staff and government officials and participate in pertinent organizational meetings. By examining how decision-makers utilize geospatial data I aim to understand the influence of satellite imagery for climate justice within frontline communities.

This project deepens our understanding of how satellite imagery can support climate justice. The impact of this scientific research includes 1) analyzing the connection between flooding and social vulnerability 2) deepening our understanding of how satellite imagery mitigates climate injustice and 3) filling a critical data gap in the RGV. This research is relevant to NASA's Earth Science Mission Directorate to "inform decisions and provide benefits to society". In addition, this project is relevant to NASA's 2022 Strategic Plan's priority to address "The climate crisis through space-based observation equipment, international partnerships, and data-sharing". This research project utilizes NASA earth observation data, including Landsat 8 and the CSDA Program's data (PlanetScope) to produce these flood maps.

Cesar Terrer (PI) / Jevan Yu (FI)
Massachusetts Institute of Technology
23-EARTH23-0181: Characterizing the Behavior and Carbon Cycle Implications of Southeast Asian Peat Fires

Peatlands in Southeast Asia have experienced large wildfires in recent decades, putting at risk a 70 Gt pool of carbon. Widespread soil drainage for human activities has reduced soil moisture and thus increased vulnerability to wildfires. These wildfires in Southeast Asian peatlands are important at the global scale because they release enormous amounts of carbon dioxide, in some cases as much as 5-10% of global annual fossil fuel emissions.

Despite continued scientific interest in Southeast Asian peat fires, significant uncertainties remain about their behavior and carbon cycle implications. First, the long-term fire regime in Southeast Asian peatlands remains poorly characterized. Much of this uncertainty stems from limited knowledge about the spread of peat fires and their resulting sizes. The unknown characteristics of peat fire spread inhibit rigorous emissions accounting and fire risk management.

In addition, the uncertainty in estimates of carbon emissions from Southeast Asian peat fires is large (~50%). Primarily, isolated and uncertain estimates of burn depth, a key parameter in emissions calculations, prevent accurate quantification of carbon emissions from peat fires on both yearly and decadal scales likely a meaningful component of recent emissions from terrestrial ecosystems to the atmosphere.

This study relies on NASA satellite data to address this gap. Using remotely sensed fire, hydrological, biogeophysical, climatic, and socioeconomic data as well as a meta-analysis of published emissions data, I aim to achieve three objectives:

Objective 1: I will quantitatively characterize the fire regime in Southeast Asian peatlands, including the ignitions, behavior, and sizes of fires, and their drivers. To do so, I will develop an algorithm to disentangle ignitions from spread in remotely sensed active fire data. I will then apply a model to understand the role of hydrology, climate, and humans in controlling ignitions and spread of peat fires. Finally, I will conduct a probabilistic assessment of peat fires to understand their hazard characteristics at the decadal scale.

Objective 2: I will quantify the role of burn history and soil moisture in regulating the carbon intensity of Southeast Asian peat fires. To do so, I will synthesize peat fire burn depth and emissions intensity data from published studies and harmonize it across space and time. I will then perform regression analysis to devise an explanation for the hydrological controls on peat fire carbon intensity. Allowing for spatial heterogeneity will significantly reduce uncertainties in the extrapolation of carbon intensities to the regional scale.

Objective 3: I will estimate carbon losses from Southeast Asian peat fires from 2012 to present. To do so, I will leverage the burned areas calculated in Objective 1 and the spatially explicit carbon intensities calculated in Objective 2 to estimate the amount of carbon released from Southeast Asian peat fires every month since 2012.

Achieving these three objectives will help shape our understanding of the causes, course, and consequences of tropical peat fires. The proposed research will provide a careful characterization of the Southeast Asian peat fire regime over the past decade or more, and will unravel the controls on fire ignitions and fire spread. Furthermore, it will substantially reduce uncertainties in estimates of carbon losses from Southeast Asian peat fires, and therefore in estimates of global fluxes of carbon from terrestrial ecosystems.

The proposed research falls squarely under the goals in NASA's Decadal Strategy to improve our understanding of (a) the connection between anthropogenic disturbance and wildfire, (b) the rate of turnover of terrestrial carbon pools, and (c) the fluxes of carbon dioxide from the land to the atmosphere. The proposal includes thorough plans for the Future Investigator to develop skills as an open-science researcher, communicator, and mentor.

Kristy Tiampo (PI / Quelyn Hayes (FI)
University of Colorado, Boulder
23-EARTH23-0351: Improved Characterization of Volcanic Eruptive Processes Using Commercial Satellite Data

This proposal uses satellite optical and radar data to provide improved constraints on volcanic eruption processes. More specifically, it will provide a processing sequence to map lava flow margins and height from the beginning of an eruption throughout its duration. This will be done by implementing three key components: high-resolution satellite optical data and commercial satellite X-band radar data, machine learning algorithms, and high-resolution digital surface models (DSMs). Utilizing commercial X-band radar data (i.e., Capella Space, with a pixel resolution of up to 0.5 meters) instead of radar data that has been used in the past (i.e., Sentinel-1 A/B C-band data, with a pixel resolution of up to 5 meters) provides a radar image with higher resolution, which results in higher accuracy for our calculations. We will employ a modified version of the building layover height algorithm developed by Liu et al., 2013, that detects building height on flat ground using C-band radar data. The building radar shadow is measured on the ground by the side-looking satellite as it flies overhead. The authors incrementally measure how far the shadow extends from where a known building outline is. We modify their algorithm for lava height by implementing this same process, but also incorporating high-resolution DSMs to account for changing terrain height and constrain lava boundaries using a coded loop function. We also will generate high resolution pre- and post-eruption DSMs to ground-truth our lava height and extent measurements, thus greatly reducing our measurement error.

A processing sequence to provide improved constraints on lava flow margins and height will allow scientists to integrate across the measured lava flow extent, which results in a better measurement of lava flow volume. This is significant as a lava volume measurement can tell scientists how much has been erupted at that point, and by proxy, provide an estimate on the remaining magma in a volcano chamber. When paired with other geophysical data, we can then better estimate the remaining duration of an eruption. Performing these updated calculations on a sub-daily basis and providing the information to the public can greatly enhance necessary evacuation efforts, and greatly reduce loss of life and property.

The objectives in the Earth Surface and Interior (ESI) division of the NASA Decadal Survey and the Science Traceability Matrix documents state that forecasting large-scale geologic hazards (including volcanic eruptions, earthquakes, and landslides) in a societally-relevant time frame, along with measuring the pre-, syn-, and post-eruption surface deformation of active land volcanoes on a time scale of days to weeks are both deemed as a most important priority. Additionally, the 2022 NASA Strategic Plan document outlines its need to partner with domestic and international commercial satellite partners in order to accomplish NASA's scientific goals. This proposal addresses all three of these objectives, in that we will utilize commercial satellite company Capella Space through a student partnership to obtain data pertaining to volcanic eruptions, we will create high-resolution DSMs pre- and post-eruption event, and we will produce a processing sequence to map lava flow extent and provide timely updates to the general public.

Morgan Tingley (PI) / Christopher Sayers (FI)
University of California, Los Angeles
23-EARTH23-0053: Sensing the Biodiversity Impacts of Gold Mining in the Peruvian Amazon

The tropics face numerous environmental disturbances that threaten the richest biological communities on Earth and hinder our capacity to achieve international goals for sustainable development. As a function of global market shifts, gold mining has rapidly expanded in river systems throughout the Amazon Basin as a promising economic opportunity for developing nations. However, this industry can compromise ecosystem health and function, human welfare, and biodiversity conservation via habitat degradation and mercury (Hg) pollution of terrestrial and aquatic ecosystems. While each of these stressors are important independent mechanisms of biodiversity loss, their relative impacts remain poorly understood because they potentially interact with and amplify one another within mining landscapes. The integration of ex-situ data from spaceborne remote sensing missions with in-situ data from fine-scale terrestrial observations presents a powerful opportunity to detect, quantify, understand, and predict the conservation externalities of this industry, with high potential to extrapolate findings at continental scales. Birds, as accessible and effective indicators of global change and ecosystem health, present an ideal focal organism for in-situ sensing. This research aims to isolate and quantify the impacts of gold mining on terrestrial biodiversity by monitoring the responses of avian populations and communities along disturbance gradients and among land-use classes in the Peruvian Amazon -- a global hotspot for both gold mining and biodiversity. I will integrate spaceborne remote sensing data from GEDI and Harmonized Landsat-Sentinel with bird banding and bioacoustics data to (1) ground-truth the relationship between habitat structure and avian Hg exposure, and (2) isolate and quantify the relative impacts of mining-induced deforestation, hydrological change, and Hg pollution on avian diversity. By accomplishing our primary aims and disentangling these stressors, this research will contribute to NASA's primary objective of understanding the Earth system as it relates to biodiversity responses to drivers of global change. Specifically, this research stands to (1) quantify how changes in habitat structure modulate the biogeochemical cycling and biotic exposure of anthropogenic Hg, (2) clarify mechanisms of ongoing biodiversity losses in Amazonia, (3) predict future biodiversity loss as a result of mining expansion, and (4) inform future opportunities for sustainable gold mining at local to global scales.

Luke Trusel (PI) / Mahsa Bahrami (FI)
Pennsylvania State University
23-EARTH23-0240: DeepLakes: Observing and Predicting Antarctic Supraglacial Lakes Through Deep Learning Architectures

The Antarctic ice sheet represents the most significant uncertainty in global sea level projections, influenced by our limited understanding of the dynamics of ice shelves. Supraglacial lakes are linked to ice shelf instability, as they can induce structural weakening in ice shelves through flexure and hydrofracturing, with the subsequent loss of ice shelf buttressing causing accelerated flow of land ice into the ocean. Uncertainties regarding supraglacial lakes can be reduced by leveraging advanced computational approaches and the diverse and extensive datasets available from satellite observations. This research aims to enhance predictive capacity within climate and ice sheet modeling frameworks like the forthcoming Ice Sheet Model Intercomparison Project for CMIP7 (ISMIP7), particularly in unraveling ice shelf surface hydrology and collapse.

To address the knowledge gaps in understanding the dynamics of supraglacial lakes and their impacts on ice shelf stability, we propose an innovative framework centered on deep learning approaches and novel remotely sensed supraglacial lake observations. We focus on two specific tasks: (1) Developing a comprehensive, multi-sensor dataset of supraglacial lakes in Antarctica with high spatial and temporal resolution, and (2) Utilizing deep learning to predict the evolution of supraglacial lakes driven by climatic factors and near-surface firn conditions. Our research will first harness the power of advanced deep learning techniques for the accurate detection of supraglacial lakes in optical and radar satellite imagery. The lakes identified through this process will then serve as ground truth data for training a deep learning model alongside state-of-the-art climate and firn models to predict the formation of supraglacial lakes under varied future climatic conditions. This innovative approach aims to bridge the gap between current observational capacities and modeling of hydrological processes relevant to the future evolution of the Antarctic ice sheet.

The objectives of this research are relevant to the goals of NASA's Earth Science Division by contributing to "improving the ability to predict climate changes by better understanding the roles and interactions of the oceans, atmosphere, land, and ice in the climate system". Additionally, this research aligns with key scientific priorities recently identified by the National Academy of Sciences, particularly focusing on the "impacts of Antarctica and the Southern Ocean on global sea level". The results of this research will be used to reduce the uncertainties associated with ice shelf dynamics and further refine sea level rise projections, which in turn, will be instrumental in formulating effective adaptation strategies for communities worldwide that are vulnerable to rising sea levels.

Maria Tzortziou (PI) / Britnay Beaudry (FI)
City College of New York
23-EARTH23-0126: Remote Sensing of Flood Risk and Water Quality, and Implications for Environmental Justice in a Vulnerable Urban Coastal System

Space-based remote sensing observations can uniquely capture the hydrological and biogeochemical connectivity of terrestrial and aquatic landscapes. Yet, there is still a major gap in studies linking remote sensing of flood risk and extreme inundation events in heavily urbanized coasts to remote sensing of key coastal hazards-- such as impaired water quality, eutrophication, undesirable algae and beach closures-- that severely impact the health and quality of life of coastal, including many underserved, communities. Addressing this challenge, the main objectives of this proposal are to: (1) analyze change in land use/cover over the Long Island subregion to better distinguish the change in impervious surfaces as it relates to flood risk, (2) apply, for the first time, HYDRAFloods (a remote sensing analysis tool created by NASA's SERVIR-Mekong Program) to monitor flood extent in the heavily urbanized NYC-Long Island Sound (LIS) region by incorporating in-situ tide gauge measurements, (3) link extreme flood events (e.g., duration, spatial extent, intensity) to changes in coastal water quality (e.g., water clarity, organic matter, and phytoplankton dynamics) using medium and high resolution sensors (Landsat/OLI, Sentinel-2/MSI, Sentinel-3/OLCI), and (4) identify historic, current, and potential vulnerable populations from through the Cadastral-based Expert Dasymetric System (CEDS) method and engage community members in coastal resiliency awareness through outreach events.

This project will help the scientific community and the Long Island community further understand the environmental factors affecting flooding in this area, and its impact on key ecosystem processes and water resources. To provide education, raise awareness, and promote preparedness within communities that are susceptible to flooding, this study will include outreach events within the Long Island subregion. These community-focused events will center on the intersection of flooding, water quality, remote sensing, and vulnerable populations. Understanding and addressing the needs of vulnerable populations is crucial in developing effective flood risk management strategies and ensuring that emergency response and impact mitigation plans are inclusive and equitable.

By using Sentinel-3, Landsat 7-9, Sentinel-2, and Harmonized Landsat-Sentinel data, this work will enhance our understanding of the Earth system and the various factors that impact coastal resiliency in the Long Island subregion. This study also benefits from the use of NASA-created sea-level predictions and flood extent tools and will examine their applicability on a regional scale. This cross-disciplinary project will link remote sensing observations over land to satellite retrievals of estuarine water quality, highlighting the hydrological and biogeochemical connectivity of coastal terrestrial and aquatic landscapes. Furthermore, this study aligns with the fourth Grand Challenge of the Ocean Biology and Biogeochemistry program's Science Vision, and the third focus area of NASA's 2022 Equity Action Plan. This work addresses the pressing need of providing information to decision makers and communities that are impacted by climate change. The NASA Earth Observations used within this study will be utilized to better identify vulnerable populations, and the knowledge and resources from this work will be shared at community outreach events. The utilization of traditional ecological knowledge through community partnerships combined with our flooding and water quality analyses will provide valuable insight for the development of community-focused coastal resiliency plans. Outcomes from this study will include capacity building, improved analysis of risk and resiliency, and environmental justice-- each an important focus within the Earth Action/Applied Sciences program.

Suniti Walimuni Devage (PI) / Dewan Mohammad Enamul Haque (FI)
Louisiana State University and A&M College
23-EARTH23-0347: Advancing Dynamic Multi-(Hazard-) Risk Assessment Method for a Massive Refugee Camp in Bangladesh

Globally, the rising number of forcibly displaced people has led to the establishment of refugee camps in hazard-prone areas, such as the Kutupalong Rohingya Refugee (KRC) Camp in Bangladesh. This camp, accommodating 1.1 million refugees within a geographically compact (15 km2) area, has undergone significant landscape changes, amplifying the potential of multi-(hazard-) risk (probability of hazard occurrence & likelihood of hazard consequence). We will advance dynamic multi-(hazard-) (landslides & flash flood) risk assessment method for this camp area utilizing earth observation and in-situ data to provide the answer: when, how large & where future disasters will be & whether appropriate mitigation measures have been implemented at the right place in a feasible manner.

Integration of scientific (earth science), social science, and engineering knowledge will form the basis of a sustainable and resilient decision support system. Effective decision-making based on scientific insights and computational analysis is imperative in an era of escalating refugee numbers. Our risk information generation approach will facilitate decision support systems and can be translated worldwide across settings. To do so, we will maximize the use of open-source earth observation data (satellite imagery). Research-derived outputs/outcomes, including crucial input data and developed codes, will be shared via Github to make it readily usable & to support NASA's open data policy.

My proposed research is aligned with two objectives of NASA's 2022 strategic plan: strategic objective 1.1- integrate and advance knowledge of Earth as a system to meet the challenges of environmental change and improve life for all people & strategic objective 1.3- ensure NASA's science data are accessible to all and produce practical benefits to society. My proposal also supports NASA's Earth Science plan (SCIENCE 2020-24: A Vision for Scientific Excellence), which aims to use Earth system science research further to inform decisions and benefit society.

The Government of Bangladesh & international donor agencies are investing hugely in reducing the terrain risk by implementing engineering & ecological mitigation measures at the KRC camp to ensure a safer abode for the refugee people. Funding our proposed research will contribute to maintaining and promoting America's global standing in this region in the context of benefitting society through scientific advancement.

Michael Ward (PI) / Wendy Dorman (FI)
University of Illinois, Urbana-Champaign
23-EARTH23-0292: Characterizing Habitat Requirements (Characteristics, Configurations, and Thresholds) of Grassland Birds in Illinois Through a Cross-Scale Remote Sensing Framework

The dramatic loss of grasslands, coupled with uncertainty in the locations and extent of grasslands and the unique and understudied habitat selection behavior of grassland birds have conspired to result in a conservation crisis, in which many grassland bird populations are experiencing dramatic and widespread population declines. A publicly available grassland landcover dataset does not exist at the scale needed for researchers and decision makers to develop species level management strategies and while grassland habitat requirements are expected to vary by species, these requirements are unknown for most grassland bird species. We will use cross-scale remote sensing (from ground, to airborne, to satellite) to quantify grasslands and their characteristics at a resolution relevant to grassland managers (3m), use multi-scale ecological modeling of bird-habitat relationships to analyze spatiotemporal trends, and use these data to determine what grassland configurations and thresholds are required to support robust populations of grassland birds.

The primary objective of this project is to identify the characteristics, quantities, and configurations of grasslands required to sustain robust populations of grassland birds. We will answer the following questions: (1) Where are the remaining grasslands? (2) What are the specific landscape and site-level grassland characteristics that most influence grassland bird species distribution and abundance? We will achieve this through:

Objective 1: Integrate cross-scale remote sensing data to effectively quantify grasslands and their characteristics at a resolution relevant to grassland managers (3m) using cross-scale remote sensing (from ground, to airborne, to satellite).

Objective 2: Determine what grassland configurations and thresholds are required to support populations of grassland birds using multi-scale ecological modeling of bird-habitat relationships to analyze spatiotemporal trends.

This project will produce a grassland modeling framework that can be replicated in other regions, the first high-resolution (3m) maps of grasslands in the Midwest, grassland bird associations with landscape factors, and species-specific grassland habitat thresholds. Using a cross-scale sensing framework we can bridge spatial discrepancies between field measurements from sampling plots to coarse-resolution satellite hyperspectral imagery. This work will use metrics via hyperspectral sensing that have not been used to investigate bird habitat selection before. The products of this research will provide the missing puzzle piece to directly inform conservation and management to determine which areas to prioritize for grassland conservation and/or creation to increase avian biodiversity, determine if sites are suitable for specific species, or provide them with the knowledge to make areas suitable.

This work supports the Earth Science Data Systems (ESDS) Program by using machine learning and big data to address Earth science questions, making the data more accessible to the public. It supports the Research and Analysis (R&A) Program by using satellite observations to make better landcover data available to the public and land managers. Finally, this project supports the Earth Action (EA) Program, application area Ecological Conservation, by helping conservation managers apply insights from satellite imagery to benefit the environment and increase biodiversity. Further, this work supports the vision expressed in the Decadal Survey of "understanding the complex, changing planet on which we live, how it supports life and how human activities affect its ability to do so." Grasslands are disappearing at an alarming rate largely due to agricultural demands. Understanding the present state of grasslands, their impact on grassland species, and the minimum amount of grassland required to support these species is a critical first step to mitigating the impacts of human-driven landcover change.

Park Williams (PI) / Melissa Ferriter (FI)
University of California, Los Angeles
23-EARTH23-0229: Predicting Ecosystem Change: Wildfire-Driven Forest Conversion in Mixed-Conifer Forests of the Sierra Nevada

Forest composition and structure shape ecosystem function, climate, and nutrient cycling -- tying the future of the earth system, in part, to the fate of forests. In the western US, these crucial ecosystems are being transformed by rapid shifts in climate and disturbance regimes. High fuel loads and increased fuel aridity are promoting larger, more severe forest fires, and rising temperatures and prolonged droughts have been linked to long-term forest decline. These compounding disturbances have the potential to catalyze vegetation type conversions (VTC), wherein the once dominant vegetation does not return to its pre-disturbance state. VTC occurs when a forest's resilience mechanisms are overwhelmed by disturbance -- for example, high-severity fire -- and a new vegetation type establishes and persists. The processes that promote VTC as a response to fire vary and can be associated with conditions that inhibit successional return to pre-fire vegetation or reinforce feedbacks that maintain new vegetation types. As trees struggle to re-establish after a fire, the competitive balance may shift to rapidly resprouting, flammable shrubs that then encourage more fire by creating continuous standing fuel. This positive feedback of VTC and fire can drastically increase the probability and intensity of future fires to further threaten forests. A growing body of work has attempted to disentangle post-fire forest conversions, but the magnitude and drivers of VTC remain poorly resolved since conversion is a slow and cumulative process. This work aims to remedy these knowledge gaps by quantifying past VTC, assessing the drivers of VTC, and estimating the sensitivity of VTC to future climate in California's Sequoia-Kings Canyon National Park (SEKI).

The work I propose here was developed in partnership with SEKI scientists and was designed around leveraging new Landsat-based maps of land cover and fire severity, downscaled NASA climate data, NASA's Shuttle Radar Topography Mission (SRTM) data, and Airborne Visible / Infrared Imaging Spectrometer (AVIRIS) imagery. My work will be guided by the following questions: (1) How much VTC has occurred across SEKI since 1985? (1) What are the drivers of post-fire VTC? (3) How does the probability of post-fire VTC change in response to anthropogenic climate change? I will develop statistical models using a Landsat-based land cover dataset in combination with climatic, topographical, and biophysical datasets to quantify VTC and clarify its drivers and sensitivity to climate change.

Park Williams (PI) / Qian He (FI)
University of California, Los Angeles
23-EARTH23-0234: How Do Compound Drought and Heatwave Events Influence Past and Future Vegetation and Wildfire in a Warming World?

Wildfire is a dynamic force in the Earth's system, impacting ecosystems, the carbon cycle, and society. Wildfires hinge on fuel, ignition, and weather conditions. Droughts and heatwaves, often co-occurring, intensify wildfire risks, as seen in Australia's 2019 megafires and the Pantanal 2020 wildfires. Compound drought-heatwave (CDHW) events, exacerbated by a warming climate, drive wildfires through fire weather and vegetation dynamics. Drought, heatwaves, and wildfires are interconnected but often studied in isolation, which ignores the compound effects of heat and aridity on the fuel and environment for fire. While studies have consistently highlighted the detrimental effects of drought and heat extremes on vegetation and wildfires, it is noteworthy that a warming climate does not universally lead to increased burned areas or reduced vegetation biomass. Importantly, the present and future roles of compound drought-heatwave (CDHW) events in influencing vegetation changes and impacting wildfire activities remain inadequately documented in a systematic manner. Additionally, existing studies usually use the Coupled Model Intercomparison Project Phase 6 (CMIP6) data to examine the future CDHW trends, which has a spatial resolution coarser than 1° and such resolution may omit some spatial heterogeneity across different regions. The NASA Earth Exchange (NEX) Global Daily

Downscaled Projections (GDDP) dataset, or NEX-GDDP-CMIP6 provide the opportunity to capture the variation more accurately through bias-corrected, high resolution (0.25°), and seamless daily climate projections.

The proposed research is motivated by the following question: To what extent will compound drought-heatwave (CDHW) events impact vegetation abundance and subsequently influence wildfire occurrence? The goal of this analysis is to evaluate the roles of CDHW events in as drivers of wildfire and vegetation change as well as interplay between wildfire and vegetation. I will focus on three specific aspects: 1) evaluating the historical roles of CDHW events on global-scale variations in vegetation and wildfire, 2) assessing the future impacts of CDHW on vegetation and wildfire dynamics (2020-2100) under different warming scenarios, and 3) examining the contributions of CDHW events to regional changes in fire and vegetation using process-based models, with a particular focus on the Western United States.

Daniel Wright (PI) / Kaidi Peng (FI)
University of Wisconsin, Madison
23-EARTH23-0172: Quantifying Satellite Precipitation and Hydrologic Model Parameter Uncertainties to Advance Flood Prediction in Ungauged Regions

Hydrologic model predictions are important for enhancing flood preparedness, particularly in data-sparse regions. Although satellite-based measurements of rainfall (e.g., NASA's IMERG) and streamflow (e.g., from SWOT) are increasingly available for use in ungauged regions, they often introduce large biases due to retrieval algorithms, sensor heterogeneity, and infrequent sampling. Forcing data uncertainty may result in erroneous model calibration, reducing the accuracy of streamflow predictions outside of the calibration period. Both meteorological forcing and model parameter uncertainties have been identified as significant factors that influence the accuracy of flood modeling. Limited rain gauge and streamflow data access further obfuscates where errors come from and how to fix them. These deficiencies could be mitigated by robust uncertainty characterization of satellite precipitation and hydrologic model parameters.

This project proposes to improve satellite-aided flood prediction by quantifying precipitation and parameter uncertainties in hydrologic modeling, developing a probabilistic prediction framework that conveys the uncertainty propagated from precipitation forcings and model parameters into flood predictions, and apply the proposed framework to ungauged regions. By leveraging satellite data, statistical models, and the widely-used Weather Research and Forecasting Hydrologic Model (WRF-Hydro), this project will foster the application of satellite data while characterizing the associated uncertainty.

This proposal would address these issues through three interconnected objectives:

Objective 1: Adapt the STREAM-Sat precipitation uncertainty methodology to blend IMERG observations and short-term forecasted precipitation to create "seamless" precipitation forcings and uncertainty estimates. These precipitation ensembles will include a one-day forecast horizon that mitigates the 4-hour latency of IMERG observations and improves upon the relatively coarse resolution of short-term global numerical precipitation forecasts.

Objective 2: Quantify precipitation and parameter uncertainties in flood predictions. Bayesian inference will be used to estimate WRF-Hydro model parameter uncertainty and simulate streamflow ensembles that convey both precipitation and parameter uncertainties. The relative importance of these two sources of uncertainty in flood predictions will be quantified

Objective 3: Provide a solution toward flood prediction in ungauged regions using SWOT data. With only satellite data as input, a more reliable Bayesian inference method will be proposed to solve the sparsity of SWOT overpasses and its potential high bias.

This proposal will fill scientific gaps in the deficiency of flood models to account for uncertainty in satellite precipitation data and hydrologic model parameters, thus improving flood prediction in ungauged regions. The approaches will be tested for historical flood events in gauged watersheds in the United States and South Africa. This proposal directly relates to the goals of NASA's GPM mission, such as "improving forecasting abilities for natural hazards, including floods, droughts, and landslides." This work will demonstrate the value of IMERG and forecasted precipitation uncertainty estimates (Objectives 1 and 2) and assess the applicability of SWOT discharge estimates (Objective 3) for supporting hydrologic model-based realtime flood prediction.
