ANNUAL RESEARCH PLAN FOR ARC-CREST COOPERATIVE AGREEMENT RENEWAL (80NSSC23M0230) FOR 2023–24

ARC-CREST (Ames Research Center Cooperative for Research in Earth Science and Technology) (80NSSC23M0230)

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ARC-CREST Project Research Plans 2023–2024

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Introduction

Page 7 of the Award Terms and Conditions for the Notice of Award for the Renewal of the Ames Research Center Cooperative for Research in Earth Science and Technology ("ARC-CREST") Cooperative Agreement, NASA states that an Annual Research Plan will "provide a detailed plan of research activities to meet specific research objectives" and requires the recipient to prepare the plan.

Having consulted with Ames Research Center, we present the following plan for research under this Cooperative Agreement for 2023–24.

The primary task of ARC-CREST is to work cooperatively with NASA Ames Research Center's Earth Science Division and related groups to achieve NASA's strategic Earth science objectives. These objectives include: (1) the conduct of research into fundamental questions related to the atmosphere, the oceans, the biosphere, and Earth's land masses; (2) the use of informational and computational sciences to visualize, analyze, and interpret Earth science data; (3) the application of technology necessary for Earth science research; and (4) the provision of outreach and education to the general public regarding Earth science. For 2023–24, the current participants for this agreement (Bay Area Environmental Research Institute (BAERI), California State University Monterey Bay (CSUMB), and San José State University (SJSU) will continue working toward achieving each of these objectives.

This year, the ARC-CREST scientific team, working closely with the NASA Ames Earth Science Division, will participate in over 40 different project areas covering the gamut of Earth science research. Set out below, please find descriptions of each of the projects as well as this year's project goals.

4STAR and Satellite Data Analysis

Project Participants

BAERI: Samuel LeBlanc, Kristina Pistone, Stephen Broccardo

Project Description

The 4STAR (Sky-scanning, Sun-tracking Atmospheric Research) project quantifies solar light transmission through the atmosphere, including aerosols, trace gases, and clouds. We use airborne measurements obtained from the 4STAR instruments, as well as from other airborne and ground-based instruments (e.g., AERONET and Pandora), to study the microphysical properties of the atmospheric constituents and their impact on the radiative environment, and consequently on climate.

We analyze measurements from these instruments (4STAR, 4STAR-B, and their predecessor AATS-14) to yield atmospheric aerosol optical depth and extinction spectra, aerosol size distributions, aerosol absorption and refractive index, cloud optical depth and microphysical properties, water vapor columns and profiles, and ozone column density. We have used the sun photometer instruments to validate measurements from 12 satellite instruments, two airborne simulators of satellite instruments, and several airborne and ground-based lidars.

During this next year, the project is in evolution, with less emphasis on 4STAR and more on the Pandora/AERONET system analysis, and support for upcoming ARCSIX field campaigns. This project is now supported only by the ISFM Radiation Science Program and no longer part of the ISFM Atmospheric Composition Program (ACP).

Plans for 2023–2024

<u>ISFM Radiation Science Program</u>

- Support deployment of ARCSIX with research flight planning. (LeBlanc)
- Provide support to keep 4STAR/4STAR-B instruments operational and ready for potential deployments, including compilation of data into archives.
- Assess and improve the trace-gas column measurements from 4STAR by comparisons with the NASA Ames Pandora instrument, AERONET, and combination thereof.
- Continue to assess and improve the AOD repeatability, calibration stability, and UV-wavelength performance of 4STAR-B through a comprehensive series of tests, characterization, and calibration.
- Improve the accuracy of 4STAR skyscan products sampled during the ORACLES airborne campaign (https://espo.nasa.gov/ORACLES/content/ORACLES) to inform on aerosol microphysical properties of biomass burning aerosol above clouds over the southeast Atlantic in 2016–2018.
- Continue the preparation of these papers for publication:
    - “Is there a physical difference in aerosol as a distance to the coastline for a few key airborne campaigns? [Conrelison et al., in prep]”—A compilation of legacy airborne aerosol optical depth measurements in a cohesive publication.

- "Above cloud direct aerosol radiative effect and diurnal variations from airborne measurements in the southeast Atlantic" [LeBlanc et al., in Prep].
- Engineering paper describing advancements in 4STAR-B [Broccardo et al., in Prep].
- Sky scan analysis paper: "Aerosol intensive properties of biomass burning smoke measured by an airborne sun photometer over the southeast Atlantic, 2016–2018" to the ORACLES ACP special issue [Pistone].

5STAR/Eng-Sci

Project Participants

BAERI: Conrad Esch, Stephen Broccardo

Project Description

The ARC (Ames Research Center) Sun-photometer/Satellite group supports a variety of instruments with a specific focus on airborne sun photometers that provide measurements of tropospheric aerosols (i.e., low-level atmospheric particles, such as from smoke, dust, or pollution) and trace gases. ARC maintains the existing instruments 4STAR-A and -B, and is developing the next generation instrument: 5STAR (ultra-Stable Spectrometers for Sky-Scanning Sun-Tracking Atmospheric Research). 5STAR (as well as the ship-based variant SeaSTAR, funded separately) depends on precision radiometers and spectrometer detectors and includes a variety of transmissive, diffractive, and diffusive optical elements, including fiber optic light path technology. Robotics technology is required for sun tracking and sky scanning functionality in the aircraft environment, with the detector head exposed to free stream environmental conditions up to the tropopause.

The 5STAR airborne instrument (in development) is the next-generation instrument that will present improvements over the current instruments in terms of reducing measurement uncertainty and improving calibration stability, all with smaller weight and power (SWAP) packaging enabled by modern sensor and digital processing technology. 5STAR adopts a new means of sun-tracking, miniature fiber spectrometers, and custom circuitry. The design includes a camera for sun-tracking purposes in place of the quadrant detector used by 4STAR. It also includes custom circuitry to thermally stabilize both silicon and InGaAs photodiodes at discrete wavelengths, in addition to custom boards, to amplify the signal.

Plans for 2023–2024

- Transition the 5STAR prototype software from Windows/Labview to Linux/ROS to maximize technology sharing between 5STAR (airborne) and SeaSTAR, and address security concerns around Windows-based instruments.
- Improve spatial stray-light control through the use of tailored geometry and ultra-black coatings inside the entrance optics, similar to the Pandora instrument.
- Test improvements in Gershun-tube to optical fiber coupling using a miniature integrating sphere developed in 2023.

ACCDAM

Project Participants

BAERI: Kristina Pistone
DRI: Eric Wilcox, Marco Giordano

Project Description

The climatological effects of atmospheric aerosol particles are primarily regional in scale, yet are of global importance. Aerosols alter cloud properties by changing cloud microphysics (e.g., droplet size), macrophysics (e.g., thickness or altitude), the total cloud amount, or the local atmospheric dynamics. Stratocumulus clouds, by covering large regions of the subtropical oceans, are a large component of global albedo, and changes in the reflectivity of these regions may thus have global impacts. We use observations from the NASA ORACLES airborne campaign in the southeast Atlantic (SEA) between 2016 and 2018 and the multi-platform VOCALS-REx campaign in the southeast Pacific (SEP) in 2008 to observationally quantify the impact of water vapor under different aerosol conditions. The SEA stratocumulus are seasonally subjected to biomass burning (BB) emissions advected from springtime agricultural fires in southern Africa; in contrast, the SEP is largely influenced by local anthropogenic sulfate aerosol. The regions also differ in water vapor context: while VOCALS saw very low above-cloud water vapor content, ORACLES saw a humid layer co-located with the BB plume. Studies of these two regions together can thus provide valuable insights into the complex radiative and dynamic interactions between water vapor, aerosols, and clouds in current and future climate.

In this project, we seek to explain how atmospheric water vapor governs aerosol effects on stratocumulus clouds, and establish how cloud-top radiative fluxes vary with above-cloud humidity and aerosol, and how this affects cloud macrophysics (specifically, cloud liquid water and cloud fraction). Our analysis will use a combination of observations from suborbital field campaigns, satellite data, and reanalysis products over two stratocumulus regions. We will use the ORACLES and VOCALS observations of aerosol and cloud properties and atmospheric state to gain a better understanding of the impacts of water vapor on cloud properties in these stratocumulus regimes, how water vapor varies with aerosol loading, and the radiative and dynamic effects of this covariance. We will incorporate vertically-resolved and geostationary satellite observations and large-scale reanalysis to understand the conditions preceding and following aircraft measurements and to capture the range of variability in water vapor and aerosol conditions over the two regions. Finally, we will use this understanding to quantify the relative radiative effects of atmospheric humidity and aerosol in these regions. By better understanding the importance of water vapor to the radiative and dynamic processes that control aerosol effects on stratocumulus clouds, we will ultimately be able to better quantify direct, semi-direct, and indirect aerosol effects in the present-day and future climate.

Plans for 2023–2024

- The first manuscript “Vertical structure of a springtime smoky and humid troposphere over the southeast Atlantic from aircraft and reanalysis” has been submitted in the

ORACLES ACP special issue, and we hope to successfully guide it through peer review in the next several months.

- The DRI collaborators are drafting at least one additional paper focused on the radiative transfer results above and what they can tell us about the relative importance of each component to overall heating, both separately and as they coincide in these meteorological regimes.
- In progress for the AGU December meeting as of this writing is characterization of satellite-observed and reanalysis cloud properties (fraction, liquid water, and height) associated with different aerosol and water vapor classes in both regions. Of particular interest is how the different atmospheric structures intersect with one another and the cloud properties predominant in those conditions.
- Having focused on a more comprehensive understanding of the SEA and a robust analysis framework, in the remaining time on this project, we will expand that analysis to the SEP, including classification into atmospheric regimes based on vertical structure of aerosols and water vapor. We hope to verify and then use the verified agreement between observations and the CAMS reanalysis to quantify the overall incidence for this other region.

Agriculture, Health, and Marine Applied Sciences

Project Participants

CSUMB: Adam J. Purdy, Lee Johnson, Pam Hansen, Alberto Guzman, Will Carrara, Michael Hang, Ryan Solymar, Michael Biedebach, Kristen Burroughs
NASA: Forrest Melton (ARC), Ian Brosnan (ARC), Jessica McCarty (ARC), Jacquelyn Shuman (ARC)
Student team members: Manuel Villa Alvarado, Marie Tolteca, Ronnie Lazaro, Jason Pham

Project Description

CSUMB personnel have a long history of participation and support of NASA research and applied science missions to apply satellite data to improve our understanding of environmental conditions and processes that affect agriculture, public health and vectorborne disease, and coral reefs and other marine ecosystems. Under this task, CSUMB conducts research and applied science activities in these areas in collaboration with the Ames Earth Science Division (AESD) and numerous collaborators in government agencies, nonprofits and NGOs, and the commercial sector. This task applies remote sensing data; agricultural models; ecological and weather models; and epidemiologic, vector, and pathogen models to advance the ability of US and international institutions to understand and manage these processes. Activities under this task include analysis of satellite data, management of airborne and field campaigns to collect data, and development of models and decision support systems.

The primary objectives of this task are to:

1. Apply satellite data, airborne data, flux towers, and other ground-based instrumentation to model and map agricultural productivity, evapotranspiration, and crop water demand.
2. Apply satellite data, climate models, and ecological models to map habitat for disease vectors and model vector-borne disease transmission risk.
3. Apply satellite multispectral and airborne hyperspectral data, coupled with field measurements of biological data, to contribute to research on ecosystem health, ecological structure, and benthic habitat biodiversity of coral reefs and associated biotopes.

Plans for 2023–2024

- OpenET:
    - Provide leadership for the OpenET Consortium and conduct joint planning activities with NASA, USGS, and other partners to facilitate planning for long-term operational support for OpenET.
    - Continue to lead software engineering activities for the OpenET user management systems and open data services/application programming interfaces.
    - Continue to support ongoing daily and monthly data production for the western US and Mississippi River Basin.
    - Contribute to the quality control and quality assurance review of historic data.
    - Contribute to the organization of the OpenET science team, including the coordination and planning of the OpenET science team meeting.
    - Provide user support for more than 10,000 users of OpenET in the water resources management and agricultural communities.
    - Provide support for thousands of agricultural producers and local, state, tribal, and federal water management agencies on the publicly released OpenET API.
    - Develop additional outreach and training materials for agricultural producers on working with ET data.
    - Complete and publicly release the OpenET Custom Reporting Tools.
    - Integrate data from OpenET into irrigation scheduling tools developed by cooperative extension, USDA NRCS, and commercial sector partners.
    - Conduct outreach and training workshops with cooperative extension agency partners throughout the West.
    - Work with the OpenET Science Team and partners to submit grant proposals, complete state contracting agreements, and work with NASA HQ and federal partners to secure and distribute funding to support the OpenET Consortium.
    - Publish manuscripts describing the OpenET accuracy and intercomparisons.
    - Develop automated effective precipitation and consumptive use workflows.
    - Analyze and quantify errors associated with meteorological data inputs in remotely sensed ET models.
- Irrigation Management and Scheduling/Satellite Irrigation Management Support:

    - Expand geographic coverage for SIMS and CropManage and continue to provide user support for an expanding user base.
    - Modify CropManage and other irrigation scheduling apps to import/use OpenET daily data and forecasts.
    - Conduct outreach to additional potential agricultural partners.
    - Conduct collaborative research with the Natural Resources Conservation Service, University of California Cooperative Extension, agricultural companies, and other partners to expand use of satellite-based, data driven approaches for irrigation scheduling and management.
    - Conduct additional accuracy assessment studies and demonstration projects.
- CDFA-SCBGP:
    - Continue publication of results from vegetable crop irrigation trials.
    - Continue assisting Cooperative Extension with evaluation of CropManage for use in vineyards, by comparison with data from OpenET and eddy covariance systems.
    - Analyze relationships between ET and applied water in vineyards and cool-season vegetables.
- Crop pathogen and yield mapping:
    - In collaboration with NASA and USDA Agricultural Research Service, conduct applied research on use of NASA satellite and UAS data, with an emphasis on hyperspectral and multispectral data, to quantify crop pathogen presence and density and forecast crop yields.
    - Develop information products that are interpretable and actionable by agricultural partners, including data products on plant counts, plant conditions, disease presence indicators, and improved crop yield forecast models.
- Wildfire Applications:
    - In coordination with the Wildfire Task and FireSense program, conduct applied research on applications of OpenET and other NASA satellite and UAS data for quantification of fuel moisture, vegetation evapotranspiration and water stress, and impacts of forest management practices on wildland fire risk and behavior.
    - Support the FireSense implementation team tasks, including identification of current barriers of scientific data integration and identification of collaborative partnerships and research priorities within pre-, active, and post-fire management.
    - Conduct outreach to regional, state, and national forestry and fire management organizations on applications of OpenET and other NASA data for decision support to reduce fire risk and respond to wildland fire events.

Alpha Jet Atmospheric Experiment (AJAX)

Project Participants

BAERI: Emma Yates
NASA: Laura Iraci

Project Description

The Alpha Jet Atmospheric eXperiment (AJAX) team takes airborne measurements of ozone, formaldehyde, CO_2, methane, and meteorological parameters. BAERI's role includes identifying science questions, designing and planning flights, data analysis (IDL, python), maintaining instruments, and scientific writing and presentations.

Since 2016, BAERI has been responsible for facilitating collaborations through setting up a new laboratory of atmospheric instruments (CO_2, CO, carbonyl sulfide (COS), C-isotopes) and making them available for use within the wider scientific community. To date, the project has successfully been awarded four grants to deploy instrumentation on a UAS in Alaska, in a car, and on aircraft, to measure COS uptake from coastal Redwood forests.

Plans for 2023–2024

- Work towards a research study/paper publication using AJAX data to validate lowermost tropospheric satellite products from OCO-2 and GOSAT.
- Ensure SNAAX data is made publicly available through collaboration with DAAC personnel.
- Ensure our ACCDAM proposal commitments are met—this is a study looking at ozone coming into the western US. Upon completion of the proposal, we expect publication(s) and presentations.
- Submit to other funding calls, including ROSES.
- Complete other trace gas work, including the continued setup of our laboratory to enable air from outside to be sampled, and to align this with the current rooftop instrumentation on N-245.
- Collaborate with NPP Orken on the INSTEP project, using low-cost sensors to measure trace gases.
- Operation and maintenance of the NASA Armstrong TCCON site. Explore avenues for data analysis.

Autonomous Modular Sensor USFS

Project Participants

BAERI Edward Hildum
NASA: Donald Sullivan

Project Description

This project's focus is to prepare documentation for and facilitate the integration of the Autonomous Modular Sensor (AMS) onto new US Forest Service aircraft and investigate noise reduction in its infrared spectral channels.

Plans for 2023–2024

- Enhance AMS engineering and operational documentation.
- Investigate noise reduction in AMS infrared channels.
- Possibly install new operating system on AMS computers.
- Bring AMS to flight-ready status on new USFS/NIFC aircraft.

Applied Remote Sensing Training (ARSET)

Project Participants

BAERI: Sativa Cruz, Britnay Beaudry
NASA Civil Servant: Juan Torres-Pérez

Project Description

As part of the Capacity Building Program, the Applied Remote Sensing Training Program, or ARSET, conducts online and in-person training sessions that are designed with the user in mind. We have a variety of application areas, such as training focused on water resources, disasters, health and air quality, and land management. The Ecological Conservation team here at NASA Ames focuses on land and wildfire training. We have training on change detection, wildfire detection, tracking deforestation, freshwater monitoring, time series analysis, and more. Participants can build skills and grow through ARSET. Participants are introduced to the fundamentals of remote sensing, they learn how to find and download NASA data, and they learn to process and analyze data using geospatial software to aid in decision-making. All of our materials are freely available in both English and Spanish on the ARSET website: https://arset.gsfc.nasa.gov/.

These courses are for beginners and advanced practitioners alike. Since 2009, the program has reached over 40,000 participants from 170 countries and more than 8,500 organizations worldwide. The ARSET team at NASA Ames focuses on the application area of Land Management.

Plans for 2023–2024

For the ARSET Ecological Conservation Application area here at Ames, we are conducting four trainings in FY24:

Field Spectroscopy Hands-On Training for Airborne Image Validation (April 2024)
This in-person training will provide hands-on experiences on the use of hyperspectral in-situ field spectroradiometers for land and water targets as well as a first view of some of the hyperspectral imagery collected during the BioSCape campaign. Participants will be able to use in-situ spectral data as a means for validation of airborne imagery. We will also explore aspects for consideration when working with airborne data such as sunglint, sun angle, aircraft (pitch, row, yaw) factors, among others and how these impact the image analysis. Participants will also explore differences between in-situ and image spectral signatures and how these differences are affected by image spatial resolution.

Short Video Series (Intermittent 2024)
This series of short videos will provide participants with the ability to access data, utilize regular online platforms, and perform necessary calculations for remote sensing. These concepts will be contained within shorter, hands-on videos that learners can access with less time commitment than traditional ARSET trainings. These videos can further enhance the knowledge and abilities of the audience to engage with the more advanced and longer-form ARSET training. Each video will assist remote sensing newcomers to relevant remote sensing resources and best practices.

Invasive Species Monitoring with Remote Sensing (July 2024)
Invasive species cost the U.S. economy billions of dollars a year and can cause declines in ecosystem health. NASA data can be used to identify the impacts of invasive species including the extent, potential distribution, and impacts to affected species. With improvements to the temporal, spatial, and spectral resolution of data alongside cloud-based computing, there are new opportunities to apply NASA data, products, and tools to landscape management. This course will provide participants with an overview of typical NASA satellites and sensors used to map invasives such as Landsat, MODIS, and VIIRS, as well as innovative or upcoming data and missions such as the Global Ecosystem Dynamics Investigation (GEDI), HyMap, the Surface Biology and Geology (SBG) mission, and the Geosynchronous Littoral Imaging and Monitoring Radiometer (GLIMR). This training will highlight project-based applications of remote sensing for species of interest such as tamarisk, cheatgrass, kudzu, pepperweed, and more, with a lens towards innovative uses of hyperspectral data for additional invasives. Participants will also learn approaches for image processing and inclusion of data into species distribution models for mapping future spread of invasive species via Google Earth Engine (GEE).

Fire Risk Mapping for Vulnerable Habitats (September/October 2024)
Increasing frequency and severity of fires has continued to alter ecosystems worldwide, including significant changes to habitats, vegetation, soil properties, watersheds, and atmospheric conditions. This training will highlight uses of NASA Earth Observations (EO) for pre-fire habitat/species distribution mapping and remote sensing techniques to develop a fire

risk assessment for a given study area. Participants will also evaluate post-fire conditions for land management considerations related to restoration planning. This training includes hands-on exercises for using NASA EO for these assessments within QGIS.

ASP

Project Participants

BAERI: Brenna Biggs, NSRC (Director Gary Ash)
NASA: Susan Schoenung, Matt Fladeland

Project Description

ASP Advanced Planning will continue to create two newsletters for the airborne community each year along with an annual report detailing the accomplishments of the year. Additionally, the team interviews NASA affiliates (project managers, project scientists, instrument operators, instrument developers, etc.) to understand the needs of the community and to draft plans for outgoing years. This culminates in an annual five-year plan as well as auxiliary documents like needs assessments and science value compilations.

In addition to science, ASP also does outreach for K–12 schools, occasionally teaming up with the GLOBE program to host students to collect their own scientific data concurrently with an airborne campaign. Many schools are connected to the scientists virtually through Mission Tools Suite, but as we return to more in-person opportunities, students have a chance to connect with scientists face-to-face as well.

Plans for 2023–2024

- Facilitate outreach for multiple schools in Cape Town, South Africa, for BioSCape. (Fall 2023)
- Host ASP table at NASA booth at AGU 2023 conference in San Francisco, CA. (December 2023)
- Complete Gulfstream class needs-assessment report. (late 2023)
- Complete the 2023 ASP Annual Report. (early 2024)
- Facilitate outreach for multiple schools in Asia for ASIA-AQ. (Winter 2024)
- Complete Spring 2024 ASP Newsletter. (Summer 2024)
- Complete Fall 2024 ASP Newsletter. (Winter 2024, FY 2025)

Atmosphere Observing System (AOS)

Project Participants

BAERI: Michal Segal Rozenhaimer, Samuel LeBlanc
NASA: Charles Gatebe

Project Description

The AOS mission, planned to launch around 2030, is working toward the goal of making new state-of-the-art cloud and aerosol measurements. The project is now in its design stages—system architecture, geophysical variables, and product algorithms are currently in development. The role of the NASA Ames team is to help with guidance on cloud and aerosol products, suborbital mission planning, and validation efforts. In addition, the team is co-leading the overarching science goals for the Earth System Observatory (ESO), and the synergistic efforts of other ESO missions.

Plans for 2023–2024

- Continue work on suborbital project plan for Key Decision Point.
- Continue to work on Aerosol and CCP (Cloud, Precipitation, Convection) Algorithms teams to design aerosol and cloud algorithm products. Specifically for this task, we are developing a new physics informed neural-network (PINN) based framework, which will be designed to perform both forward radiative transfer (RT) and inverse-modeling (retrieval) at the same time. Specific tasks for the upcoming year:
    - Adapt the developed PINN framework, which operates for radiances in plane-parallel atmosphere to polarized radiances in spherical atmospheres for the purpose of improving computation time and accuracy of polarized and 3D scenes.
    - Continue to develop the PINN framework to allow the concurrent operation of an end-to-end retrieval flow including the forward RT and the inverse modeling at the same pass-through, focusing on aerosol canonical cases as defined by the AOS SIT-A.
    - Compare the approach to existing algorithms in terms of speed and accuracy.
- Work on the EarthCare best practices for suborbital validation document - which serves as a template for AOS Suborbital.

Atmospheric Composition: Modeling and Analysis Program (ACMAP)

Project Participants

BAERI: Michal Segal-Rozenhaimer

Project Description

Our goal is to gain a better understanding of the link between aerosols, Marine Stratocumulus Clouds (MSC), and their radiative effects, and how those interactions impact the capabilities of

global climate model (GCM) prediction by developing a novel technique of cloud type classification for open (precipitating) and closed (non-precipitating) MCC cloud cells.

The project's objectives are to:

- Develop a new algorithm to classify MSC cloud cover and MCC (Meso-scale Cellular convection) cell types from multi-spectral satellite imagery on a finer spatial and temporal scale than what is available to-date, using a powerful image-based machine learning technique (semantic segmentation and texture classification via convolutional neural network).
- Utilize the new algorithm to generate high spatial and temporal cloud mask and MCC cell type maps over the southeast Atlantic and southeast Pacific regions during the ORACLES and VOCALS airborne campaigns and compare these two different aerosol-laden regions. Between these two regions, we will compare their MCC type cloud microphysical properties (e.g., cloud droplet number concentrations, effective radius, precipitation rate) and macrophysical properties (e.g., cloud albedo, cloud coverage), as well as their diurnal cycle and radiative effects under comparable meteorological conditions, to better assess how MSC cloud cell properties change in response to variations in aerosol conditions.
- Compare our campaign-derived cloud mask, cell types, and their properties with cloud fields and properties derived by GCM. We will use various sub-grid parameterization schemes to evaluate how these schemes (or lack thereof) affect radiative budget estimations due to MSC clouds in climate models. We will explore the differences in the models' predictions under the different aerosol conditions that prevail in the two selected regions of investigation.

Plans for 2023–2024

We are currently working on our second publication, which utilizes the detection algorithm and applies it to the entire three-year BB season measured during ORACLES (2016–2018). We are working to collocate cloud properties from satellite data with our defined cloud classes to study the effect of biomass-burning aerosol on the different cloud regimes (closed cells-non precipitating, and open cells-precipitating). Our planned timeline is to publish this second paper during Q2 of 2024.

Carbon Monitoring Systems (CMS)

Project Participants

BAERI: Taejin Park

Project Description

Mexico is a high-biodiversity country with nearly 40% of its territory forested. During the last decade, the scientific capacity of Mexican scientists has rapidly increased, and state-of-the-art measurements on carbon dynamics are available at representative landscapes and at the national level; Mexico is recognized to be one of the few non-Annex I countries capable of

implementing Reducing Emissions from Deforestation and Forest Degradation (REDD+). This proposal builds on previous work supported by NASA CMS to improve monitoring, reporting, and verification (MRV) for implementation of REDD+ in Mexico.

This project will increase the ARLs of ongoing CMS prototypes and develop new CMS prototypes with the ultimate aim of supporting implementation of REDD+ across Mexico. In this project, our specific commitment is to adapt CMS prototypes developed from other NASA efforts for testing, validation, and improvement across Mexico. Specifically, we will adapt and develop CMS prototypes for improving MRV of forest structure and carbon dynamics at the national scale (ARLs 4-6).

This project supports NASA carbon cycle research through:

- Validation of CMS-related applications.
- Advancement of remote sensing-based approaches for MRV and local-to-global carbon dynamics.
- Supporting implementation of international REDD+ projects.
- Working with stakeholders and sharing value added products and information derived from this proposal.

Plans for 2023–2024

In this project year, we will focus on developing a continuous forest structure and aboveground biomass mapping approach by leveraging Landsat time series and spaceborne lidar observations.

- Implement the Continuous Change Detection and Classification (CCDC) algorithms to reconstruct spatiotemporally consistent Landsat time series.
    - Create nationwide synthetic Landsat surface reflectances and seasonality variables using available all Landsat observations.
    - Use the synthetic Landsat time series and GEDI L4A (Aboveground biomass density, AGBD) data to map historical AGBD change maps in Mexico.
    - Evaluate the AGBD estimates using independent validation data (national forest inventory & lidar) and available other CMS AGBD products.
    - Investigate trends and drivers of historical AGBD changes in Mexico.
- Create wall-to-wall tree canopy delineation maps using high resolution imagery.
    - Build individual tree crown (ITC) training and validation samples using airborne lidar data and other data sources.
    - Develop and evaluate a set of convolutional neural network (CNN) models (e.g., Mask R-CNN, Unet-id, etc.) for ITC detection.
- Attend CMS Monthly and annual Science Team meetings and publish peer-reviewed publications and presentations.

USDA-ARS California Delta Areawide Project for Integrated Resource Management

Project Participants

California State Parks, Division of Boating and Waterways: Edward Hard, Jeffrey Caudill, Guphy Gustafson
CSUMB: Vanessa Genovese
NASA Ames: David Bubenheim, Greg Schlick

Project Description

This project is a collaboration between NASA, the USDA-ARS and California State Parks, Division of Boating & Waterways (DBW) to map invasive aquatic vegetation throughout the SF Delta region using satellite data to assist with environmental mitigation projects. Specifically, we are mapping invasive aquatic species of Water Hyacinth and Water Primrose as well as submerged vegetation.

Plans for 2023–2024

- Advise the CA DBW on new vegetation maps and on the continued development of the dashboard.
- Work on verification of Hyacinth and Primrose species maps.
- Run invasive plant growth models to simulate plant growth under varying management and climate scenarios.
- Work on identifying submerged aquatic vegetation (SAV) throughout the Delta.

California State University at Monterey Bay (CSUMB) Educational Program

Project Participants

CSUMB: Susan Alexander
Students: Brandon Alexander, Kristen Burroughs, Emily Haydis, Ronnie Lazaro, Jason Pham, Marie Tolteca, Manuel Villa Alvarado

Project Description

The Department of Applied Environmental Science at CSUMB offers a Bachelor of Science degree in Environmental Science, Technology, and Policy (ESTP) and a Master of Science degree in Environmental Science (ENSCI). These interdisciplinary programs emphasize the critical thinking and technical skills necessary to develop workable solutions to complex environmental problems. Our curriculum integrates training in science, technology, economics, and policy that focus on marine, coastal, and watershed systems.

Among its many components, the CSUMB mission emphasizes an educational approach that fosters in students distinctive technical and educational skills, the experience and abilities to start a successful career, the critical thinking abilities to be productive citizens, and the entrepreneurial spirit needed for innovation and success. Because our knowledge and

understanding of the Earth system and its processes are increasingly dependent on advanced technologies for acquiring, analyzing, and visualizing geospatial information about our planet, expertise in geospatial applications is one of the most sought-after skill sets for students pursuing Earth system science careers.

The MS in ENSCI offers two degree options: PSM and thesis. Within their chosen option, students elect an emphasis in marine or watershed science. Advanced technology training is integrated throughout the applied environmental science and policy curriculum. The PSM option within ENSCI emphasizes professional skill sets that will distinguish students as they enter the workforce, including advanced technologies for acquiring, analyzing, modeling, and visualizing spatially explicit environmental data; professional and scientific communication; scientific ethics; and environmental economics and policy analysis. Within the PSM option, skills learned in the classroom are matured by students through professional internships. The program satisfies a demand for highly skilled professionals within environmental technology and applied science-based companies, governmental agencies, and non-profit organizations.

The team will apply its educational, scientific, and technological expertise to train the next generation of Earth system scientists and to reach out to the public about the project. Specifically, we will work to:

- Offer programs and career development opportunities within the Science, Technology, Engineering, and Mathematics (STEM) fields that specifically foster the identification, recruitment, and success of Hispanic and other under-represented and low-income students.
- Provide hands-on training for undergraduate and graduate students in Earth science research activities including participation in field campaigns, internships, apprenticeships, and other research experiences.
- Lead educational activities aimed at K–12 students, college and graduate students, and the general public utilizing NASA-developed technologies and results.
- Communicate results of our scientific activities through community outreach events, conferences, publications, and other venues.

Plans for 2023–2024

- Facilitate research collaborations between ENSCI graduate students, ESTP and biology senior undergraduate students, ARC-CREST Research Scientists, CSUMB Faculty, and NASA PIs on ARC-CREST funded projects.
- Promote student research and internship opportunities at NASA Ames Research Center related to the Cooperative Agreement (e.g., DEVELOP, CAARE).

D-SHIELD: Distributed Spacecraft with Heuristic Intelligence to Enable Logistical Decisions

Project Participants

BAERI: Sreeja Roy Singh, Vinay Ravindra, Ryan Ketzner

Collaborators

NASA Ames Research Center and KBR Wyle Services, LLC: Richard Levinson
San Jose State University: Adam Kochanski
United States Geological Survey, SD: Kurtis Nelson
University of Colorado, Boulder: Jan Mandel
University of Southern California: Mahta Moghaddam
University of Utah: Derek Mallia

Project Description

D-SHIELD is a suite of scalable software methods and frameworks that helps schedule payload operations of large constellations, with multiple payloads per and across spacecraft, such that the collection of observational data and their downlink, constrained by the constellation constraints (orbital mechanics), resources (e.g., power) and subsystems (e.g., attitude control), results in maximum science value for a selected use case. Constellation topology, spacecraft, and ground network characteristics can be imported from design tools or existing constellations and can serve as elements of an operations design tool. The framework includes a science simulator to inform the scheduler of the predictive value of observations or operational decisions.

We are developing D-SHIELD in the context of wildfire response with remote-sensing from Global Navigation Satellite System Reflectometry (GNSS-R) satellites. Alongside our collaborators, we shall develop an adaptive, intelligent, responsive observation strategy, which shall produce actionable intelligence to incident management teams from GNSS-R derived fire data products feeding into fire-danger and active fire prediction models. The system will demonstrate how that autonomous tasking of satellite observations and downlinks can be used to optimize data collection needed in operational fire modeling systems and provide important tools needed for monitoring wildfires responsively in near real time.

Plans for 2023–2024

- Work alongside collaborators in the development of the fire-related data products from GNSS-R and its subsequent application in fire-danger and active fire prediction models.
- Develop a higher fidelity GNSS-R coverage calculator which considers an ellipsoidal Earth model and frequent Two-Line Element (TLE) updates.
- Develop a statistical wildfire activity predictor over CONUS for driving satellite observations and in general for efficient resource utilization.

- Integrate all basic satellite operations (observations, data handling, maneuvering, power handling) scheduling into a single planning framework.
- Format the D-SHIELD planning tool as an open-source package for utilization by a general user.

These goals fit within the 2017 Decadal Survey's Global Hydrologic Cycles and Water Resources Panel and seeks to answer H4, i.e., *"How does the water cycle interact with other Earth system processes to change the predictability and impacts of hazardous events and hazard chains, e.g. floods, wildfires…?"* The committee also concluded that fire is *"one of the biggest unknowns for the future"* and that any prioritized program *"strategy requires a combination of space-based observations, and expansion of aircraft and ground-based observations."* We partner with USGS for this effort on civil Earth observations from space. Our work products are expected to be academically sound and operationally useful to emergency personnel, thereby supporting *"rapid transition from science to applications."*

DEVELOP

Project Participants

BAERI: Participation anticipated in 2024 (see below)
NASA: Diana Ly, Morgan Gilmour, Juan L. Torres-Perez

Project Description

The Applied Sciences' Capacity-Building DEVELOP National Program addresses environmental and policy issues through interdisciplinary research projects that apply NASA Earth Observations to community concerns around the globe. DEVELOP bridges the gap between NASA Earth Science and society, building capacity in both its participants and partner organizations to better prepare them to handle the challenges that face our society. DEVELOP builds the capacity of young professionals from diverse academic backgrounds (undergraduates, graduates, and recent graduates) in the use of remote sensing and GIS to assess environmental problems.

Plans for 2023–2024

- For 2024, DEVELOP ARC already has lined up two projects for spring 2024 and three projects for summer 2024. Most likely, two additional projects will be completed in the fall 2024 for a total of seven 2024 projects, potentially engaging around 28 participants.
- DEVELOP ARC will continue engaging with local, national, and international partners and end-users on potential project ideas for 2024 and onwards.
- To the extent possible, we will try to engage a BAERI employee to participate in DEVELOP activities. As such, this person will support science advising, proposals writing, evaluation of potential participants, and managing duties.

Disaster Management

Project Participants

CSUMB: Vincent Ambrosia, A.J. Purdy
NASA: Michael Falkowski, Forrest Melton

Project Description

The Disaster Task is composed of two principal elements: 1) Staffing (Associate Program Management (APM)) to support the NASA Earth Action Program (EAP) - Wildland Fires Program, 2) Supporting a similar role in the new NASA FireSense Project.

Between 2013 and 2023, V. Ambrosia served as an Associate Program Manager and managed a portfolio of projects within the ASP-Wildfire Program. He retired in late 2023 and continues to support transition of those APM efforts to a yet-to-be-identified EAP Wildland Fires/FireSense replacement.

NASA EAP Support:
The EAP portfolio management includes the development of NASA EAP Wildland Fires topical solicitations, as well as organizing and managing the review panels and selection of NASA proposals to those solicitations; supporting scientific oversight of the program goals and objectives; budgetary management of the funded efforts; metrics monitoring for the investigations; interactions with partner agencies involved in the projects; and serving as a supporting NASA representative on regional, national, and international wildland fire science and applications panels and boards. Additional activities include organization and planning of national and international symposia and forums, participating and collaborating in workshops and webinars, and highlighting the EAP Wildland Fire Program area and the FireSense Project efforts to access/operationalize Earth observations (EO) data/information to support wildfire science and applications by the community.

NASA FireSense Support:
The NASA Science Mission Directorate (SMD) FireSense project (https://cce.nasa.gov/firesense/index.html) is focused on delivering NASA's unique Earth science and technological capabilities to operational agencies, striving towards measurable improvement in US wildland fire management. The NASA SMD FireSense project is part of a larger NASA-wide Wildland Fire Initiative involving SMD, the Aeronautics Research Mission Directorate (ARMD), and the Space Technology Mission Directorate (STMD). The FireSense project will include an airborne science component (annual campaigns) where improved capabilities and technologies will be developed, evaluated, and ultimately demonstrated to agency stakeholders in a large capstone airborne campaign in year five of the project (2027–2028).

MedRIN Support:
Assist in managing/transitioning coordination role of the NASA Land-Cover/Land-Use Change Program (LCLUC), Mediterranean Regional Information Network (MedRIN) effort. The tasks

include coordination of annual meetings and workshops with regional coordinators from the Mediterranean countries, with a focus on dynamic land/biosphere changes common to the area, and also participation in the NASA LCLUC Annual Team Meeting. The 2024 annual MedRIN meeting is currently planned for June 2024 at the MAICH (Mediterranean Agronomic Institute of Chania), Chania, Crete, Greece. V. Ambrosia will also assist in the transition of MedRIN coordination to staff at NASA-ARC, through the leadership of F. Schwandner (NASA ARC Earth Science Division Chief)

Plans for 2023–2024

- Support the structuring and development of the renamed NASA Earth Action Program (EAP), Wildland Fire Program and the FireSense Project, including the development of the programmatic direction, development of future ROSES solicitations, and transitioning management of the Associate Program Manager roles to the new Program Manager and new APM position(s).
- Transition the role of the Co-Organizer/Chair of the NASA/USFS Tactical Fire Remote Sensing Advisory Committee (TFRSAC) to a new representative from NASA (ARC). Assist/support M. Falkowski in TFRSAC role transition through 2025, if necessary. Support the organization for the TFRSAC spring 2024 and fall 2024, specifically the logistics management of the spring 2024 meeting, tentatively scheduled for a NASA ARC venue.
- APM role could include supporting coordination with the ESD FireSense PM, the FireSense Project Scientist, FireSense Systems Engineer, the NASA ARMD, and the NASA Science Mission Directorate (SMD) in the development of the new NASA FireSense Project and subsequent workshops and engagements between the wildfire management community and various NASA Directorates.
- Continue to develop, manage, and support the various elements of the Group on Earth Observations (GEO)—Global Wildfire Information System (GWIS) Initiative (identified in the 2023–2025 GEO Work Programme document (https://earthobservations.org/organization/work-programme). These activities include supporting workshops, webinar, and outreach components, including international outreach (conference workshops) to increase utilization of the NASA co-developed GWIS by under-served entities/organizations/nations.
- Manage/transition coordinator role of the Mediterranean Regional Information Network (MedRIN) of the NASA LCLUC Program (HQ PM: G. Gutman). Also assist in coordination of the 2024 annual MedRIN meeting, currently planned for June 2024 at the MAICH (Mediterranean Agronomic Institute of Chania), Chania, Crete, Greece. Assist in the transition of MedRIN coordination to staff at NASA-ARC, through the leadership of F. Schwandner (NASA ARC Earth Science Division Chief).
- Maintain involvement representing the NASA Earth Science Division on regional, national, and international professional scientific committees (includes GEO, USGEO, and CEOS Working Group: Disasters).
- Serve as programmatic peer reviewer of NASA Earth Science Program solicitation proposals (including LCLUC program, Future Investigators/Early Career Investigators

program (FINESST), Ecological Forecasting, Disaster Management, RRNES, and EPSCoR).
- Continue to support the scientific community by serving as a peer-reviewer for other federal agency/department solicitations (including USDA-FS SBIR Program, NSF Solicitation Reviewer, etc.).
- Continue as international scientific journal peer-reviewer/SME.
- Support the development of the NASA/USFS Interagency Agreement (IAA) Space Act Agreement (SAA), to collaborate on use/integration of EO for resource management issues, including wildland fire.
- Support and advise various NGO groups on use of EO to support wildland fire management (i.e., Moore Foundations, etc.).
- Provide outreach and education of NASA EAP directions to various community groups, including lecturing at universities, providing seminars at other scientific organizations, and wildfire management training exercises and workshops.
- Support workshops and working group meetings as speakers and reviewers of uses of new technologies to improve wildland fire management; these organizations include the IDGA, USGS, etc.

Disaster Support

Project Participants

BAERI: Cindy Schmidt
NASA: Shanna McClain

Project Description

The Disasters program area uses Earth observations and applied research to improve the prediction of, preparation for, response to, and recovery from global hazards and disasters. Before, during, and after disasters strike, the team coordinates with decision makers and local governments to provide actionable data to recover from disaster impacts and build resilient communities. The program has two main components: The Disaster Response Coordination System (DRCS), which is run by NASA Langley, and ROSES solicitations, which will address disaster risk and resilience. Schmidt will be advising the Program Manager on stakeholder engagement and capacity building issues and developing strategic activities around these topics.

Plans for 2023–2024

- Work with the new Ames Center Disaster Coordinators to identify critical tasks and integrate with the rest of the DRCS team.
- Advise the Program Manager and the DRCS on best practices around engaging with Indigenous peoples.
- Help design stakeholder engagement workshops for the new web-based Disaster portal.

Earth Observing System (EOS) / Airborne Sensor Facility (ASF)

Project Participants

BAERI: James Jacobson, Dr. Edward Hildum, Rose Dominguez, Paul Windham, Thomas Ellis, Jeff Grose, Ethan Pinsker, Conrad Esch, Roy Vogler, Eric Fraim, Dr. Gary Hoffmann, Dr. Haiping Su, Jian Zheng

Project Description

The Airborne Sensor Facility (ASF) at NASA Ames supports a variety of airborne research activities for the NASA Earth Science Division. It conducts engineering development of remote sensing instrumentation and supports their operational use on science field campaigns. The ASF maintains a suite of facility instruments that are made available for use by NASA-approved research projects, with all resulting data being made available free of charge through public archives. These data are typically used for fundamental Earth science process studies, satellite calibration and validation, development of retrieval algorithms, and disaster response. The ASF includes elements for sensor engineering, optical and infrared sensor calibration, and data processing. (See https://asapdata.arc.nasa.gov/).

Plans for 2023–2024

- Build and test boards for the eMAS and MASTER instruments of the ASF and have boards ready for flight season.
- Complete the testing of the eMAS vacuum system and begin the process of instrument characterization, with the goal of being ready for engineering test flights later this FY (if there is ER-2 aircraft availability).
- Fabricate PICARD mk.2 Case and complete initial integration/test flights on the NASA G-V and ER-2
- Participation in the following airborne campaigns: Western Diversity Time Series (WDTS), Earth Mapping Resources Initiative (EMRI/GEMx), PACE-PAX, and FireSense.
- Complete MASTER Fire Channel characterization/calibration (MASTER Port 3 Detector).
- Maintain and upgrade N-259 calibration laboratory instrumentation and capabilities to accommodate higher standards of measurement as well as increased capacity.
- Work with US Forest Service to update AMS airborne imager for fire operations.
- Conduct monthly calibration stability analysis to track changes in N-259 calibration sources.
- Conduct yearly “Round-Robin” characterization of Radiometric sources in collaboration with GSFC RCL.
- Produce PICARD “white paper”/technical memo for science and PI instrument user community.
- Collaborate with Andrea Gabrielli on PICARD/AVIRIS comparison study.

Earth Science Project Office (ESPO)

Project Participants

BAERI: Judy Alfter, Quincy Allison, Eric Arguello, Brad Bulger, Daisy Gonzalez, Lynn Kennedy, Sam Kim, Andrian Liem, Ayuta Padhi, Stevie Phothisane, Michael Schroeder, Jaden Ta
NASA: Marilyn Vasques, Jhony R Zavaleta

Project Description

The Ames Earth Science Project Office (ESPO) provides project management for NASA's Science Mission Directorate field research. ESPO provides planning, implementation, and post-mission support for large, complex, multi-agency, national, and international field missions, especially airborne missions. ESPO has a long history of managing successful field missions, beginning in 1987 with the Stratosphere-Troposphere Exchange Project and the Airborne Antarctic O3 Expedition experiments. More recently, ESPO's NASA customers have included the Atmospheric Chemistry and Modeling Analysis Program, the Tropospheric Chemistry Program, the Radiation Sciences Program, Atmospheric Dynamics and Remote Sensing, the Suborbital Science Program, and the EOS satellite validation program. Annually, the ESPO team manages the deployment of between six and ten major field missions and continues to provide support to the science team, airplane team, and the larger scientific community for previous years' missions. Finally, the ESPO team plays a critical role in planning for future missions, interfacing with NASA Headquarters, NASA and university scientists, crew members of airborne platforms, local support staff, and the larger scientific community. The unique work done by the ESPO team makes NASA Earth Science's core mission of collecting Earth science data from airborne platforms with global coverage possible.

Plans for 2023–2024

Support the following research campaigns under the ARC-CREST agreement:

- **ASIA-AQ (Airborne and Satellite Investigation of Asian Air Quality)** is an international cooperative field study designed to address local air quality challenges. Specifically, ASIA-AQ will contribute to improving the integration of satellite observations with existing air quality ground monitoring and modeling efforts across Asia. Satellite air quality observations are evolving with new capabilities from South Korea's Geostationary Environment Monitoring Spectrometer (GEMS). Traditional satellite measurements from low earth orbit (LEO) are only available once per day. GEMS measures hourly to provide a new view of air quality conditions from space that both complements and depends upon ground-based monitoring efforts of countries in its field of view. NASA will contribute three research aircraft (AFRC DC-8, LaRC G-III, JSC G-V) to the study, with the potential to conduct flights in February–March 2024 over The Philippines, South Korea, Malaysia and Thailand.
- **ARCSIX (Arctic Radiation Cloud Aerosol Surface Interaction Experiment)** is an airborne investigation planned to take place during early summer based from Northern

Greenland and possibly Svalbard. It is driven by the need to: 1) Understand how coupling between radiative processes and sea ice surface properties influence summer sea ice melt; 2) Understand processes controlling the predominant Arctic cloud regimes and their properties; and 3) Improve our ability to monitor Arctic cloud, radiation, and sea ice processes from space. NASA will deploy WFF P-3 and LaRC G-III aircraft.

- **PACE-PAX (The Plankton, Aerosol, Cloud, Ocean Ecosystem Postlaunch Airborne eXperiment)** is a field campaign to gather data for the validation of the upcoming PACE mission. PACE-PAX will be conducted in September 2024, roughly nine months after the launch of PACE. The operational area will be Southern and Central California and nearby coastal regions. Sixty flight hours are planned each for the NASA ER-2 and the CIRPAS Twin Otter. Both will be based in their home airports at NASA Armstrong Flight Research Center and Marina Municipal Airport, respectively. Flights will be coordinated between the aircraft, with PACE overflights, and with surface-based observations including ship-based measurements and floats. Data will be made available within six months following the conclusion of the campaign.

- **FireSense—**The NASA Science Mission Directorate (SMD) FireSense project is focused on delivering NASA's unique Earth science and technological capabilities to operational agencies, striving towards measurable improvement in US wildland fire management. The NASA SMD FireSense project is part of a larger NASA-wide Wildland Fire Initiative involving SMD, the Aeronautics Research Mission Directorate (ARMD), and the Space Technology Mission Directorate (STMD).The FireSense project will include an airborne science component (annual campaigns), where improved capabilities and technologies will be developed and evaluated and ultimately demonstrated to agency stakeholders in a large capstone airborne campaign in year five of the project (2027–2028).

  Through initial stakeholder engagement activities, the FireSense project will begin by focusing on four uses-cases focused on characterization and measurement of (1) pre-fire fuels conditions; (2) active fire dynamics; (3) post fire impacts and threats; and (4) air quality impacts and forecasting, each co-developed with identified stakeholders.

- **SARP (Student Airborne Research Program)** is an eight-week summer internship program for junior undergraduate students to acquire hands-on research experience in all aspects of a scientific campaign using one or more NASA Airborne Science Program flying science laboratories (aircraft used for SARP have included the DC-8, P-3B, C-23, UC-12B, and ER-2).

Support the following hybrid meetings, in addition to Science Team meetings for the missions listed above, during 2024:

- CAMP2X STM (Cloud, Aerosol, and Monsoon Processes Philippines Experiment) Science Team Meeting, February 27-29, 2024, Pasadena, CA.
- DSI PBL Community Meeting (Decadal Survey Incubation Planetary Boundary Layer) Spring 2024, Pasadena, CA.

- AGAGE69 (Advanced Global Atmospheric Gases Experiment): June 3–7, 2024, Bristol, England.
- QOS 2024 (Quadrennial Ozone Symposium), Boulder, CO, July 15–19, 2024.
- IMPACTS (Investigation of Microphysics and Precipitation for Atlantic Coast-Threatening Snowstorms) Science Team Meeting, August 2024, location TBD.
- GEMS/TEMPO Joint Science Team Workshop, August 26–30, 2024, Hawaii.
- NDACC (Network for the Detection of Atmospheric Composition Change) Steering Committee Meeting, early November 2024, Santiago, Chile.
- AGAGE70 (Advanced Global Atmospheric Gases Experiment): December 2–6, 2024, La Jolla, CA.

Ecological Conservation

Project Participants

BAERI: Cindy Schmidt
NASA: Woody Turner, Keith Gaddis

Project Description

As an associate program manager for the NASA Applied Science Ecological Forecasting program, Schmidt tracks projects in the Ecological Conservation portfolio, supports strategic planning activities, helps coordinate annual program review meetings, and participates in interagency activities and meetings as required by the program managers. She will manage nine projects for the program in FY24.

Plans for 2023–2024

Meetings/conferences:

- Plan and attend the Biodiversity and Ecological Conservation team meeting in May (Washington, DC). Tasks include helping to develop the agenda and organizing and running several breakout sessions.
- Attend and present at the Ecological Society of America conference in August.
- Attend project team meetings in Africa, Colombia, Idaho, Montana, and California. Attend other project team meetings and project mid-term reviews either virtually or in-person as they become organized.
- Continue duties as Applications Liaison for the BioSCape project, which will include attending project meetings in Cape Town, South Africa.
- Organize biodiversity and conservation sessions at AGU 2024.
- Organize and attend Ecological Conservation team retreat in Florida in January.

Other:

- Present project status updates at Earth Action Program reviews as requested.
- Participate in the Applied Science Guidebook working group to provide guidance on the guidebook content.
- Help develop a new Catalyst program in California.
- Participate in ROSES Ecological Conservation and FINESST panel reviews.

Equity & Environmental Justice

Project Participants

BAERI: Emma Yates, Nikki Tulley
NASA GSFC: Sabrina Delgalo Arias
NASA HQ: Shobhana Gupta, Owen Hooks
NASA LARC: Lauren Childs-Gleason

Project Description

As an associate program manager for the NASA Applied Science Equity and Environmental Justice (EEJ) program, Yates will be providing science management support for work with EEJ communities through the ROSES-21 A.49 Project Portfolio. This project is tasked with tracking west-coast-based projects in the EEJ portfolio, supporting strategic planning activities, helping coordinate annual program review meetings, and participating in interagency activities and meetings as required by the program managers.

Plans for 2023–2024

- Continually track eight projects in the EEJ portfolio.
- Support strategic planning activities.
- Help coordinate annual program review meetings.
- Participate in interagency activities and meetings as required by the program managers.

FNR Trends and NOX/VOC

Project Participants

BAERI: Jia Jung

Project Description

We have witnessed pronounced improvements in satellite remote-sensing platforms, so that we can anticipate advanced spatiotemporal resolution, reduced noise, and higher accuracy in satellite retrievals. These improvements in newer satellites, together with a rich legacy of nitrogen dioxide (NO_2) and formaldehyde (HCHO) column retrievals, underpin many scientific capacities potentially demonstrating spatiotemporal changes in NO_2, HCHO, and ozone (O_3) production sensitivity regimes using the ratio of HCHO and NO_2 (FNR). However, uncertainties in the bottom-up emission inventories associated with the poor classification of emission sources and the limited knowledge of emission factors often result in significant bias in the results of the chemical transport model and misclassification of ozone (O_3) production sensitivity regimes. Therefore, in this project, we constrain the bottom-up emission inventories with multiple NO_2 and HCHO column retrievals and analytical joint-species/sensor inversion over the CONUS between 2019–2023. We use a suite of numerical modeling, the Weather Research and Forecasting model (WRF) and Community Multiscale Air Quality Modeling System (CMAQ), and analytical data-driven emissions estimates using the direct decoupled method (DDM). Top-down estimates of NO_x and NMVOC emissions with a rich legacy of

satellite retrievals from the Ozone Monitoring Instrument (OMI), Ozone Mapping and Profiler Nadir Mapper (OMPS-NM), TROPOspheric Monitoring Instrument (TROPOMI), and upcoming Tropospheric Emissions: Monitoring of Pollution (TEMPO) will shed a light on trends of ozone precursor emissions, along with the trend of FNR.

Plans for 2023–2024

- Produce monthly averaged maps of NO_2 and HCHO column retrievals of multiple satellite platforms.
- Assist in the analysis of spatiotemporal changes in NO_2 and HCHO column retrievals and FNR.
- Perform model simulation and validation of the output.
    - Prepare model input data, including meteorology, emissions, boundary conditions, etc.
    - Work on validation of the output with various measurement data (e.g., in-situ, remote-sensed, ozone zone, flight measurement, etc.).
- Demonstrate statistical comparison of modeled FNR before and after constraining bottom-up emissions with multiple satellite retrievals.
    - Work on preparation of various model input data such as meteorology, multi-source emission inventory, boundary conditions.
    - Calculate error covariance before and after the inversion.
    - Provide optimized NO_x and NMVOC emissions.
    - Analyze the changes in NO_x and NMVOC emissions and FNR.

GEDI

Project Participants

BAERI: Taejin Park, Ramakrishna Nemani

Project Description

The aim of this project is to map and project current (circa 2020) and future (circa 2100) forest height, aboveground biomass, and carbon sequestration potential over the continental USA (CONUS) using a theory-based integrative approach. This research will synergistically use a biophysical model, called Allometric Scaling and Resource Limitation (ASRL), with spaceborne/airborne remote sensing data including foundational GEDI lidar altimetry data to generate large-scale and continuous patterns of forest height and aboveground biomass. The model has been developed on the basis of metabolic scaling theory and water-energy balance equations. Local resource availability (i.e., water, light, and temperature) and disturbance history are explicitly implemented in the model to predict maximum forest growth. The biophysical mechanism integrated within the model enables prognostic applications, in contrast to conventional black-box approaches.

The objectives of this work are to:

- Refine and expand the current form of ASRL model to predict tree height, aboveground biomass, and carbon sequestration potential by accounting for specific biophysical parameters in different disturbance histories.
- Test a theory-based integrative approach using independent and comparable measurements.
- Map and project changes in forest height, biomass, and carbon sequestration potential over the CONUS with different climate scenarios.

In this research, input geo-predictors to the model are topography, climate variables, and nutrients. Lidar and optical observations such as NASA's GEDI, ICESat-2, LVIS, MODIS, and Landsat will produce current patterns of forest structure, which are used to initialize model parameters regarding tree metabolism, crown geometry, and resource accessibility and use efficiency. We will utilize NASA's NEX CMIP6 climate projection to project changes in forest height, biomass, and carbon sequestration potential. Model evaluation and uncertainty estimation will incorporate independent in-situ, FLUXNET, and remote sensing data.

This research directly responds to the 2020 NASA "Global Ecosystem Dynamics Investigation Science Team (NNH20ZDA001N-GEDIST)" call and carbon science program, which both aim at characterizing, quantifying, understanding, and predicting the evolution of global carbon sources/sinks through spaceborne, airborne, and field monitoring. The proposed research will not only facilitate the current NASA Carbon Monitoring and Terrestrial Ecology Programs, but also support ongoing NASA space missions including GEDI and ICESat-2.

Plans for 2023–2024

- Continue to build a lidar processing pipeline at the NASA Earth eXchange (NEX) to generate large-scale high-resolution forest structure metrics from the airborne lidar point cloud data (e.g., USGS 3DEP).
- Continue to expand the ASRL model for total aboveground biomass estimation.
    - Develop a total biomass estimation module by taking into account two key relations: (a) the allometry between the *h* and biomass of individual trees and (b) the size-frequency distribution of trees.
- Assess forest edge effect on global forest structure and aboveground biomass density.
    - Collaborate with colleagues at University of Wisconsin to quantify the impact of increase in global forest edge on forest structure and aboveground biomass density.
- Continue research collaboration with colleagues in South Korea to develop empirical forest growth models with GEDI forest height and Landsat land surface history data.
    - Develop an integrative approach combining national forest inventory, remote sensing, and empirical forest growth models.
    - Estimate annual forest carbon stock and sequestration rate over Korea, and validate the estimation using independent inventory and existing global biomass products.
- Attend GEDI Monthly and Annual Science Team Meetings, and publish peer-reviewed publications and presentations.

GeoCarb

Project Participants

BAERI: Susan Kulawik
NASA: Berrien Moore

Project Description

GeoCarb, an Earth Venture Class mission, will advance our understanding of the global carbon cycle by mapping concentrations of key carbon gases from a new vantage point: geostationary orbit. The mission, planned to launch in the early 2020s, will measure carbon cycle constituents, carbon dioxide, carbon monoxide, methane, and solar induced fluorescence to answer key questions about the carbon cycle.

Plans for 2023–2024

The funding for this has been re-allocated from science and software testing to instrument building and testing. If in the future, there is funding to launch this instrument, we will use the remaining funding to do the analysis of the thermovac data comparisons of GeoCarb to TCCON.

ILEOS: Intelligent Long Endurance Observing System

Project Participants

BAERI/NASA Ames Research Center: Vinay Ravindra
JHU Applied Physics Laboratory, MD: William Swartz
NASA Ames Research Center: Meghan Chandarana, Jeremy Frank, Richard Levinson, Eugene Turkov, Douglas Caldwell
NASA Goddard Space Flight Center, MD: Bryan Duncan, Sarah Strode
United States Geological Survey, CA: Kristen Manies

Project Description

ILEOS is a science activity planning system to enable new observing strategies (NOS) consisting of satellites and High Altitude Long Endurance (HALE) Unmanned Aerial System (UAS)-mounted instruments. Observation targets for UAS are generated by fusing coarse-grained satellite data and near real-time environmental (e.g., wind, weather, airspace constraints) forecast data. *Explainable* plans are generated for optimal fine-grained spatio-temporal resolution data collection. It is designed for human operators to ensure science mission planners understand all key choices made while generating targets and plans.

IMPACT: Reduced cost for Earth observations in environments ranging from arctic to urban to offshore (some previously inaccessible) regions.

The objectives of this project are:

- Development of a novel automated target generation technology.
- State-of-the-art automated planning and scheduling algorithms.
- Innovative techniques for user control and review of decision making.

Plans for 2023–2024

The science activity planning system shall be developed for the following two science cases:

Monitoring of offshore Nitrogen Oxides (NOX) emissions (a harmful pollutant) over the Gulf of Mexico due to ships, oil rigging platforms, and miscellaneous sources. This work would allow for the estimation of these emission sources, e.g., point (large rigs), line (shipping lanes) and area (small wells, support ships).

Monitoring for Methane (CH4) (a greenhouse gas (GHG)) emissions over interior Alaska. CH4 is emitted over large areas of the Arctic-Boreal zone, especially from wetlands, at a rate which is strongly influenced by water table level and air temperature. The data may be used for scientific modeling and to pinpoint sources needing migration for safety reasons.

Indigenous Peoples Initiative

Project Participants

BAERI: Amber McCullum, Nikki Tulley, Sativa Cruz, Victoria Ly
NASA: Tom Wagner

Project Description

The Indigenous Peoples Initiative (IPI), within NASA's Capacity Building Program Area, seeks to support and cultivate efforts within Indigenous communities and NASA to increase the use of Earth Observations (EO) to inform decisions, policies, and actions. The IPI team is uniquely positioned to foster respectful and reciprocal relationships between NASA and Indigenous communities to sustainably co-develop trainings, projects, and tools. The pillars of this work are centered on place-based remote sensing training, community engagement, and creating diverse Earth science opportunities. IPI is dedicated to building lasting relationships with Indigenous communities by creating a trusted, reliable, and Indigenous-centric geospatial community with a focus on environmental justice and climate issues on Indigenous lands and territories. We aim to strengthen the relationships between NASA and Indigenous communities through meetings and knowledge-sharing activities, as well as co-developing a global Indigenous geospatial community of practice through the Group on Earth Observations (GEO), particularly the GEO Indigenous Alliance, US GEO and AmeriGEO. Through dialogue and discussion focused on Indigenous needs and priorities, our remote sensing trainings provide participants with the data and resources needed to address specific natural resource issues facing their lands. https://appliedsciences.nasa.gov/what-we-do/capacity-building/indigenous-peoples-initiative

Plans for 2023–2024

Regional needs assessments around the use of EO in Indigenous communities

We have been tasked with assisting in NASA's compliance with the CHIPS Act in the dissemination and summary of an Earth Observations (EO) needs assessment to States, Tribes, and Territories. Our new needs assessment hire will work in collaboration with CFI Group on a series of in-depth-interviews, needs assessment workshops, and the creation and dissemination of the online survey. Tasks will include:

- Identify the Indigenous-relevant needs assessments regions.
- Identify stakeholders (POCs) for in-depth online or phone call interviews (IDIs) around landscape monitoring and management needs.
- Conduct one-hour interviews with each of the POCs.
- Summarize the interviews.
- Ensure proper protocols are conducted regarding ethical pathways for Institutional Review Board (IRB) requirements.
- Work with CFI Group to create list of relevant questions around the needs and use of EO data in tribal communities based on the interviews.
- Create tribal contact list for online survey to be disseminated.
- Collaborate with CFI Group to create relevant, inclusive, and respectful questions to be included in the online survey for tribal groups.
- Work with CFI Group to create summary report from online survey.
- Create invitation list for each of the eight (or so) regions for each in-person needs assessment.
- Conduct pre-workshop webinar for each of the regions.
- Conduct eight (or so) regional in-person needs assessment workshops over the span of two years.
- Provide summary report from each of the eight regional needs assessment workshops.

Support Indigenous-focused EEJ A.49 projects

- Team member to act as an associate for four projects.
- Assist project leads with NASA reporting and project progress.
- Assist project leads with capacity building.

Trainings/workshops

- Geo for Good, October 4–6, 2023 (workshop, in-person)
    - Will present a talk on our collaborations with Google, USGS, America View, and WWF on the creation of the Navajo Mother Earth as Art App and subsequent community event.
- Tribal GIS, Spring 2024 (training, in-person)

    - Will provide 1–2 day in-person training on the use of EO for Indigenous land monitoring. This will also likely include a dialogue session around tribal needs and EO to support the Regional Needs Assessment activities.

- Indigenous Mapping Workshop, TBD 2023 (training, in-person)

    - Will provide a 2–4 day in-person training on the use of EO for Indigenous lands, including floods and droughts and potentially additional topics, such as wildlife monitoring or wildfire mapping upon request. This will continue to support our collaborations with the Canadian Space Agency (CSA) and our strong partnerships with Google, ESRI, and Indigenous organizations Firelight Group and Winyama. There is potential for a US-based IMW in the next year.

- ITEP Tribes and Climate Change Program Meeting: September 2024 in Anchorage

    - Will provide 1–2 day in-person training on the use of EO for Indigenous land monitoring. This will also likely include a dialogue session around tribal needs and EO to support the Regional Needs Assessment activities.

- EO Tools for Indigenous Forest Stewardship, Date TBD, online and self-paced

    - In collaboration with the United Nations Development Programme's (UNDP) Learning for Nature and NASA ARSET, our IPI team will assist in content creation, use case development of EO with our tribal partners, marketing/branding, and connections with the GEO Indigenous Alliance. This course will contain multiple modules on the role of Indigenous people in forest stewardship, the basics of forest mapping, mapping tools, data governance and advocacy. It will be self-paced and freely available online via the Learning for Nature platform.

Support of GEO and US GEO Indigenous engagement

- Attend the GEO Week Ministerial Summit, November 6–10, Cape Town, South Africa.
- Provide support to GEO Indigenous Alliance as needed, which may include connections to Learning for Nature course and/or the GEO Indigenous Alliance Summit.
- Continue to attend US GEO meetings and assist in strategic planning around a US GEO Indigenous Alliance as needed.

Relationship building and outreach to communities

Continue to hold meetings with tribal natural resource management personnel around opportunities for the use of remote sensing on tribal lands:

- These will include continued connections with tribes such as the Karuk, the Yurok, the Blue Lake Rancheria (a connection that came from the Tribal Consultation meeting in Jan 2023) and additional connections that our team makes through conferences/meetings, etc.

- Our team has already made progress in this area in FY23. Specifically, we have connected managers from the Karuk DNR with multiple NASA scientists at Ames and JPL. We have also connected employees from the Blue Lake Rancheria to the Carbon Monitoring System and POWER groups and have provided additional resources.

- Connect tribes with data, tools, and NASA scientists as requested for support of their land-management needs.

- Attend relevant conferences (ITEP workshops, Native Earth to Sky, and others as they are identified).

- Identify Indigenous-focused uses of EO and potential for supporting activities with groups such as ITEP and AIHEC.

- Continue to connect with regional tribal groups (e.g., the Western Regional Partnership and Native American Fish and Wildlife Society), private organizations (Google and ESRI), and nongovernmental organizations (Firelight group), in support of the increased use of EO for Indigenous communities.

Relationship building and in-reach to NASA

Engage with NASA Ames Native American Advisory Committees (NAACs) and Natives at NASA.

- Continue to connect with other CBP+ elements on projects and efforts related to EEJ, DEIA, Apps and Challenges, which could include an Indigenous hackathon and/or Indigenous focused DEVELOP projects.
    - Our team is currently fostering a relationship with the Southwest Indian Polytechnic Institute and DEVELOP for a potential summer 2024 project.
- Continue engagement with NASA MAIANSE through internship opportunities and shared goals.
- Connect with relevant ASP projects and efforts, such as WWAO and FireSense, as they work with Indigenous communities.
- Support the creation of a NASA HQ- or ASP-level Tribal Liaison.

Collaboration with the CSA on Turtle Island Activities

- These strong connections will continue through our bi-monthly meetings, IMW involvement (noted above in the training activities), knowledge sharing activities, such as webinars and meetings with US tribal and Canadian First Nations communities, cross-boundary projects, and the potential for collaborative internship opportunities. While the IMW activities will continue, we would need additional resources to support the secondary activity—a cross-boundary Indigenous-led project.

Communications

- Update website.

- Create communications materials, such as ArcGIS Storymaps.
- Continue to work with NASA communications personnel for articles and social media posts.

Impact and future planning

- Catalog participants who take trainings and those who engage in needs assessment workshops in order to cultivate network of Indigenous geospatial personnel.
- Hold a team retreat for reflections and future visioning.

Meteorological Measurement Systems (MMS)

Project Participants

BAERI: Jonathan M. Dean-Day, Rajesh Poudyal, Kristen Okorn, Cecilia S. Chang, T. Paul Bui
NASA: Charles Gatebe

Project Description

The Meteorological Measurement System (MMS) provides in situ measurements of static pressure, static temperature, and 3D winds on a number of NASA airborne research platforms, including the Global Hawk UAV, Sierra UAV, DC-8, ER-2, WB-57F, and the H211 Alpha Jet. These measurements are useful to chemistry studies, which rely on our basic state measurements to compute reaction rates of atmospheric pollutants; to microphysical studies, which focus on the formation and growth of ice crystals in cirrus clouds; and to large scale transport studies, which rely on our data to initialize back trajectories. The data are also useful for characterizing advection of pollutants in the planetary boundary layer and the structure and morphology of mesoscale waves, which modulate the freeze-drying process of air rising through the tropical tropopause layer into the lower stratosphere.

The MMS is a fast-response (20 Hz) system capable of measuring fine scales of turbulence and thus is useful for computing fluxes of heat and momentum, as well as chemical contaminants, when high-rate in situ chemistry instruments are also operating. It is also highly accurate (P, T, and 3-D winds are accurate to +/- 0.3 hPa, 0.3K, and 1 m/s), making it superior to the usual "facility"-type navigation instruments, which may provide similar data, but with much degraded accuracy and reliability. This research focuses on maintaining the scientific validity of the MMS data and on performing basic research with the measurements as time allows.

Plans for 2023–2024

- Finalize calibration and correction of ER-2 #806 MMS data from the Dynamics and Chemistry of the Summer Stratosphere (DCOTSS) 2022 mission.
    - Reconstruct temperature probe response by statistically combining probe bath calibrations with laboratory amp measurements.
    - Apply calibrations to science data according to installed hardware.
    - Apply deicing compensation to Tslow temperature probe data as needed for data reduction.

    - Optimize selected use of inertial navigation system (INS) variables based on in-flight performance of CMIGITS and LTN-100G.
    - Use redundant measurements to reconstruct missing values.
    - Correct clock errors resulting from GPS reception dropouts.
    - Reprocess final data and archive 1 Hz and 20 Hz files.
- Finalize calibration and correction of DC-8 MMS data from the Stratospheric Aerosol processes, Budget and Radiative Effects (SABRE) mission.
    - Reconstruct temperature probe response by statistically combining probe bath calibrations with laboratory amp measurements.
    - Apply calibrations to science data according to installed hardware.
    - Apply deicing compensation to Tslow temperature probe data as needed for data reduction.
    - Optimize selected use of inertial navigation system (INS) variables based on in-flight performance of CMIGITS and LTN-100G.
    - Use redundant measurements to reconstruct missing values.
    - Correct clock errors resulting from GPS reception dropouts.
    - Reprocess final data and archive 1 Hz and 20 Hz files.
- Finalize calibration and correction of DC-8 MMS data from the Megacities to Marine Areas (AEROMMA) mission.
    - Reconstruct temperature probe response by statistically combining probe bath calibrations with laboratory amp measurements.
    - Apply calibrations to science data according to installed hardware.
    - Apply deicing compensation to Tslow temperature probe data as needed for data reduction.
    - Optimize selected use of inertial navigation system (INS) variables based on in-flight performance of CMIGITS and LTN-100G.
    - Use redundant measurements to reconstruct missing values.
    - Correct clock errors resulting from GPS reception dropouts.
    - Reprocess final data and archive 1 Hz and 20 Hz files.
- As part of the development, fabrication, and performance validation, analyze laboratory swing measurements to determine time delays of LTN-251 and CMIGITS INUs, along with a-Paroscientific 15psia total/static pressure transducer.
    - Measure and compare time response of INU attitude, velocity, and acceleration variables.
    - Compare analog values sampled with or without RC filter processing.
    - Develop digital filters to reduce 100Hz raw measurements to 20Hz and validate the accuracy of filtered data values during sinusoidal swing oscillations.

- Prepare for the Airborne and Satellite Investigation of Asian Air Quality (ASIA-AQ) campaign on the DC-8.
    - Modify existing processing software to adapt to MMS2 hardware configuration.
    - Analyze and update calibration of MMS2 airborne maneuvers during test flights in early 2024.

- Perform remote flight data analysis and processing support during the Airborne and Satellite Investigation of Asian Air Quality (ASIA-AQ) in early 2024.
    - Evaluate performance of sensors and components.
    - Examine frequency response of flow angle data from new PPT transducers.
    - Monitor reliability of INS measurements and adapt processing code to minimize impact of poor GPS reception.
    - Evaluate range, precision, and thermal dependence of sensors to optimize MMS performance.
    - Compare air data sampled from PPT with Rosemount sensor probes.
    - Recommend flight conditions for aircraft maneuvers.
    - Develop corrections to sensor errors from individual flights as needed.
    - Update DC-8 MMS measurement calibrations during the deployment to maximize accuracy and scientific value of field measurements.
- Review and help improve manuscripts of scientists utilizing MMS data.
    - Provide editorial comment and submit results of supportive analyses to primary authors during peer review.
- Provide guidance and consultation as needed with regard to developing an MMS customized for the new NASA Boeing 777, which is proposed to replace the DC-8 platform within the next few years.

NASA Earth Exchange (NEX) / Ecological Forecasting

Project Participants

BAERI: Taejin Park, Wen Yip, Arthur Mizzi, Aishwarya Raman, Sepideh Khajehei, Claire Teitelbaum, Jeremy Kravitz, Kyle Kabasares
CSUMB: Alberto Guzman, Hirofumi Hashimoto, Will Carrara
NASA ARC: Ian Brosnan, Piyush Mehrotra, Andrew Michaelis, Weile Wang, Muge Komurcu, Morgan Gilmour
NPP: Conor Doherty

Collaborators

CIRES: Chia-Hua Hsu, Congmeng Lyu, Siyuan Wang
NASA ARC: Matthew Johnson
NASA SpoRT: Aaron Naeger
NASA GMAO: Zhining Tao
NCAR: Rajesh Kumar
NOAA CSL: Brian McDonald
University of Colorado (CU) Boulder: Daven Henze
University of Connecticut: Zhe Zhu
University of Delaware: Rodrigo Vargas
University of Wisconsin-Madison: Min Chen

Project Description

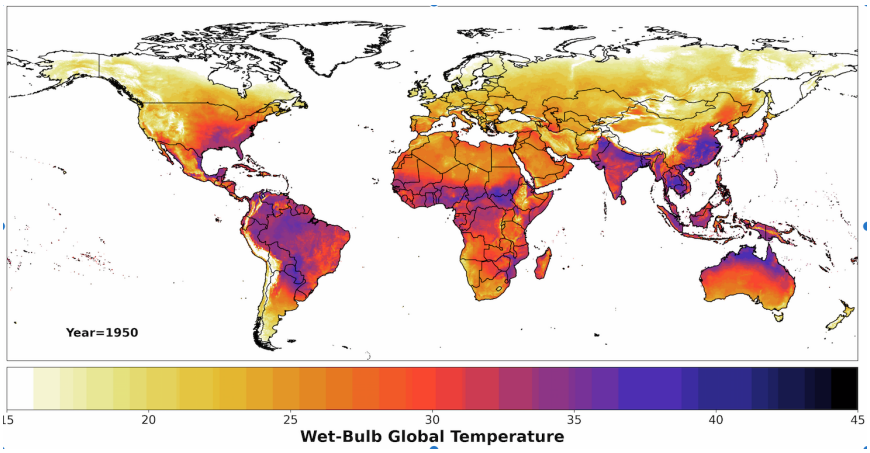
ARC-CREST scientists and software engineers, in collaboration with the NASA Ames Earth Science Division and the NASA Advanced Supercomputing (NAS) Division, continue to support the NASA Earth Exchange (NEX) project (Nemani et al., 2011). The primary objectives of the NEX project are to enable significant scientific discovery using data from NASA's satellite missions, and to foster scientific collaboration across a broad portfolio of researchers supported through Research Opportunities in Space and Earth Science (ROSES) and Flight Projects. NEX enables a community of researchers to answer meaningful science questions that require data, computing-intensive analyses, and modeling at regional to global scales. By leveraging NASA's advanced supercomputing facility at NASA Ames research center, utilizing the NEX virtual collaborative, and having select NASA datasets readily available, scientists and engineers can ask big science questions, execute large scale research, and share research results and knowledge with minimal burden.

ARC-CREST researchers closely collaborate with scientists in NASA Ames' Earth Science Division, as well as with the broader NASA science community, to apply NEX capabilities to analyze long-term and emerging trends in ecosystem conditions, conduct simulations of climate and land-use change impacts on terrestrial and aquatic ecosystems, map patterns in biodiversity, monitor biomass at local to continental scales, project future climate conditions, and retrieve emissions for air quality forecasting. The NEX team supports applied science activities, such as the development of information products to support land managers, agricultural producers, and water managers throughout the U.S. for the monitoring and modeling of natural disasters, such as wildfires, and emerging public health threats. Additionally, NEX supports the production of global long-term data records for nearly a dozen different programs.

National Climate Assessment
The latest version of the NASA Earth Exchange Global Daily Downscaled Projections (NEX-GDDP-CMIP6) was released in 2022. The archive contains downscaled historical and future projections for 1950–2100 based on output from Phase 6 of the Climate Model Intercomparison Project (CMIP6). The downscaled products were produced using a daily variant of the monthly bias correction/spatial disaggregation (BCSD) method and are at 1/4-degree horizontal resolution. Currently, eight variables from five CMIP6 experiments (historical, SSP126, SSP245, SSP370, and SSP585) are provided as procurable from thirty-five global climate models.

This dataset was made available at the NASA Center for Climate Simulation, https://doi.org/10.7917/OFSG3345 and was recently released on Amazon Web Services, https://registry.opendata.aws/nex-gddp-cmip6/, and the Microsoft Planetary Computer https://planetarycomputer.microsoft.com/dataset/nasa-nex-gddp-cmip6 to facilitate broader access by research and applications.

The team published the *NASA Global Daily Downscaled Projections, CMIP6* in Nature's *Scientific Data* journal. https://www.nature.com/articles/s41597-022-01393-4

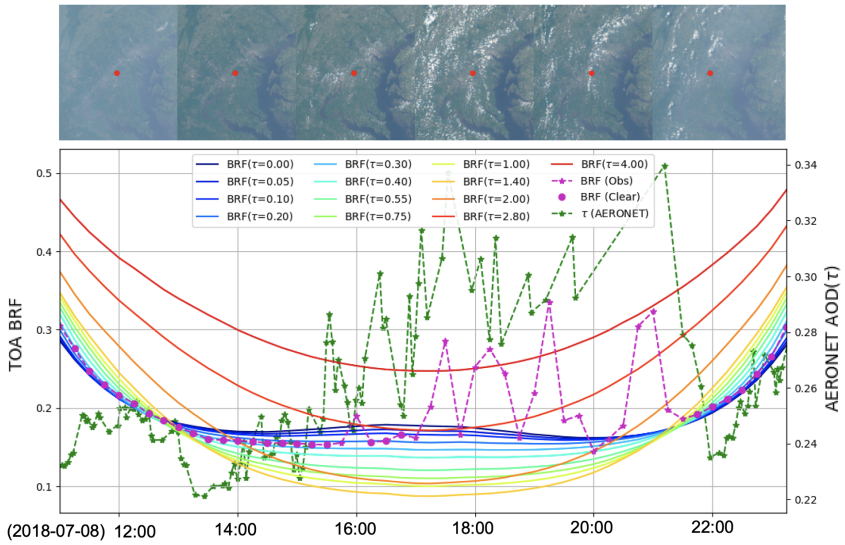


Global map of wet-bulb global temperature from NEX-GDDP-CMIP6 data.

GeoNEX

GeoNEX is a collaborative project led by scientists from NASA, NOAA, and many other institutes around the world to generate Earth monitoring products using data streams from the latest Geostationary (GEO) sensors including the GOES-16/17 Advanced Baseline Imager (ABI), the Himawari-8/9 Advanced Himawari Imager (AHI), and more. An accurate and consistent product of the Top-Of-Atmosphere (TOA) reflectance and brightness temperature is the starting point in the scientific processing pipeline and has significant influences on downstream products.

The team developed a new atmospheric correction algorithm, GeoNEX-AC, which exploits the high frequency of the GeoNEX time series to accurately detect cloud-free observations, quantify atmospheric aerosol optical depth, and retrieve surface reflectance and bi-directional reflectance distribution function (BRDF).

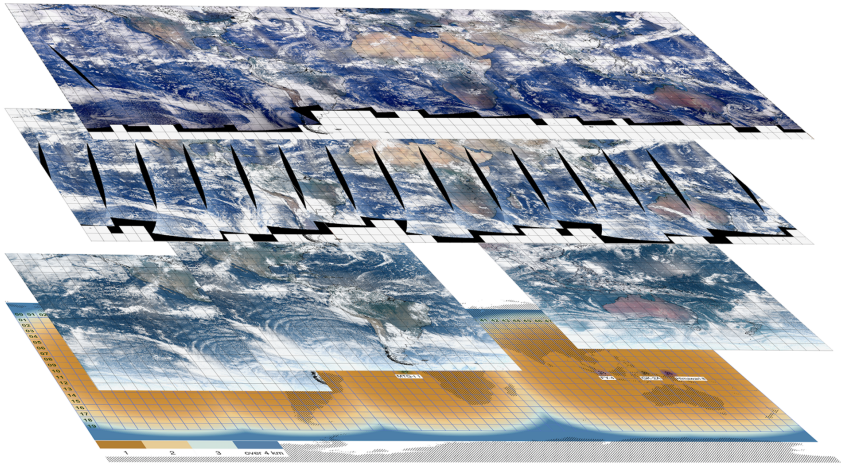


An illustrative example of the GeoNEX-AC algorithm that exploits the high frequency time series of GeoNEX data in simultaneously retrieving AOD and surface reflectance.

The team developed prototype GeoNEX Level 2 products, including atmospheric aerosol optical depth and surface reflectance/BRDF for Himawari 8/9 AHI and GOES16/17 ABI data sets. The products are distributed on the GeoNEX data portal (data.nas.nasa.gov/geonex) for public access by the science community. We are also collaborating with the community to systematically evaluate the scientific quality of the data sets and develop applications in air quality and public health studies.

Example of GeoNEX L1G (TOA) and L2G (Surface) BRDF-enhanced reflectance with data from GOES-16/ABI collected over CONUS on 2018/06/18, 19:00UTC.

The team has initiated research on the fusion of GEO-LEO satellite datasets across multiple spatial and temporal resolutions, which is expected to synergistically leverage advantages of different platforms to improve global land surface monitoring.

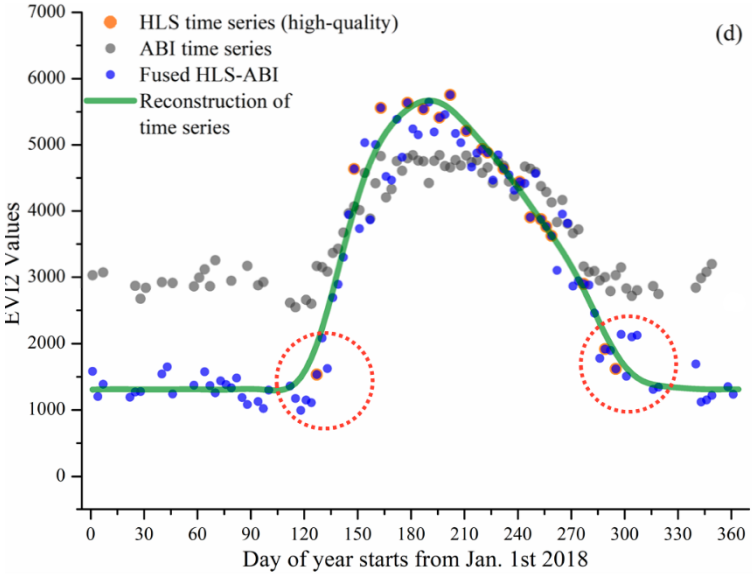


Data fusion of GEO-LEO satellite data across various spatio-temporal resolutions based on the GeoNEX common grid.

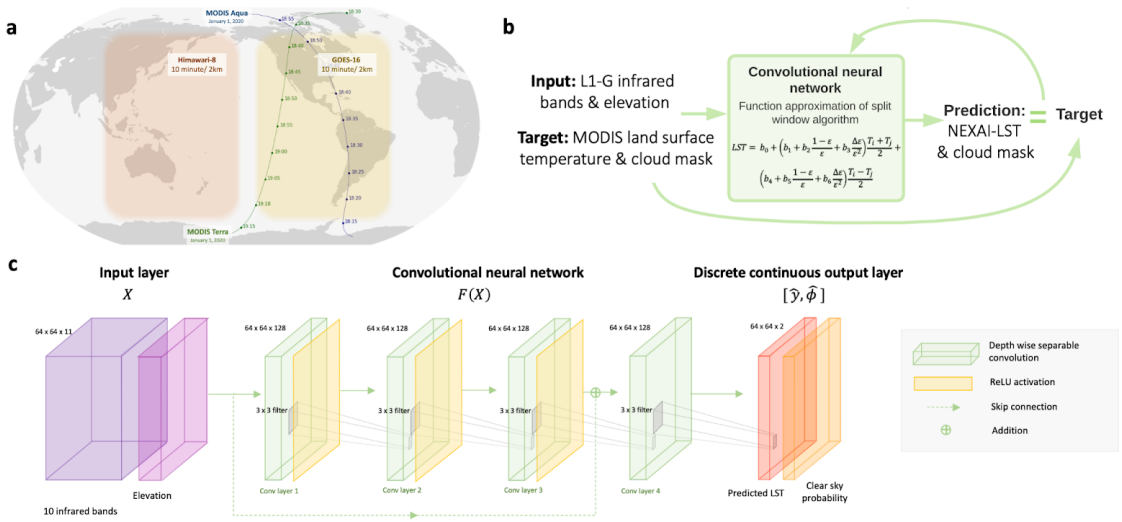
Additionally, several experimental level-3 data products were prototyped using a GEO-LEOapproach. The products are discussed below.

The team prototyped a land surface phenology (LSP) product, in collaboration with South Dakota State University. The LSP has been derived from Landsat-8 and Sentinel-2 time series (HLS), which provide detailed spatial patterns, but have relatively poor temporal resolution. With the availability of data from Advanced Baseline Imagers (ABI) onboard a new generation

of geostationary satellites that observe the Earth every 10–15 min, daily cloud-free time series are available. The LSP detections from HLS-ABI are compared with those from HLS or ABI alone and are further evaluated using PhenoCam observations. The result indicates that BI can provide ~3 times more high-quality observations than HLS.



The team prototyped an emulated Land Surface Temperature (LST) using convolutional neural networks. This novel approach was used to predict land surface temperature with improved spatial and temporal resolution compared to standard products. While multiple satellite types provide data to monitor surface temperature, geostationary (GEO) sensors provide near-continuous, continental-scale observations which can capture the diurnal variability of land surface temperature (LST) better than intermittent observations from low-earth orbit (LEO) sensors. However, standard products from GEO satellites are available at coarsened spatial and temporal resolutions compared to the native sensor resolutions. Using datasets from the NASA Earth Exchange, we leveraged co-located, co-temporal observations from LEO and GEO satellites to learn a data-driven mapping by means of a convolutional neural network.



Datasets, problem setup, and deep learning architecture for LEO-GEO algorithm emulation

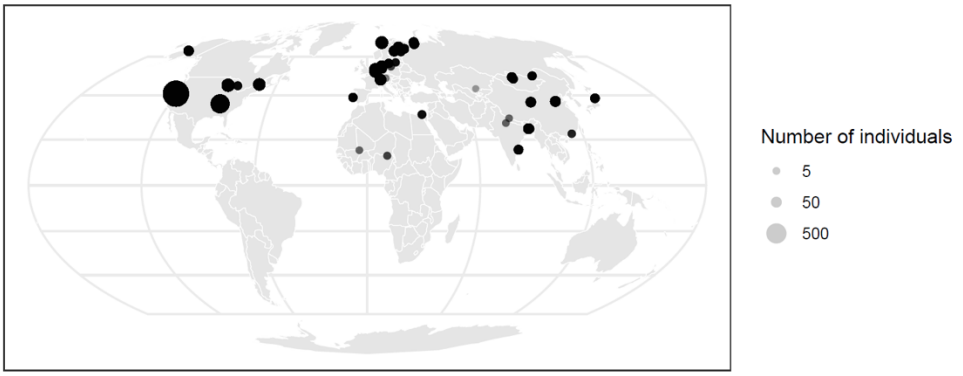
Carbon Monitoring System (CMS) and Global Ecosystem Dynamics Investigation (GEDI)
(see CMS report, pp. 19-20 and GEDI report, pp. 32-34)

Surface Biology and Geology (SBG)
(see SBG report, pp. 5-60)

NEX-Fire/AQ, WRF-Chem/DART
(see WRF-Chem/DART report, pp. 65-67)

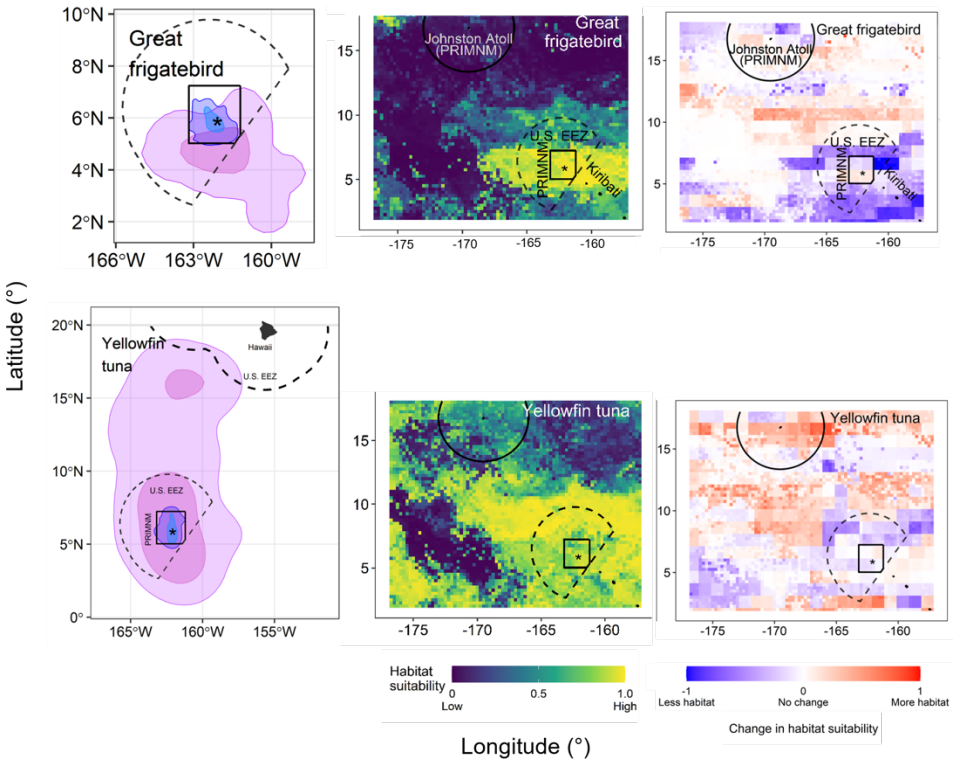
Internet of Animals (IOA)
The Internet of Animals project aims to combine animal telemetry data with Earth observations to better support applied ecological management, architect a next-generation space-based animal tracking system and develop technology that can link to biodiversity and habitats via remote sensing.

- Comparative analysis of waterfowl movement behavior: This project aims to compile global data sets on telemetry of waterfowl to study relationships between waterfowl movement behavior and environmental conditions, including landscape features, weather, and climate. Waterfowl are among the primary natural hosts of avian influenza viruses, so understanding the ecological drivers of their movement patterns can advance our understanding of how these zoonotic viruses spread in wild populations, and how these movements might shift under future climate and land-use change. To date, collaborations have been established with 14 scientists and research groups sharing data from a total of 57 studies. Movement metrics have been calculated for each individual and movement data has been annotated with environmental data derived from remote sensing and downscaled climate models.

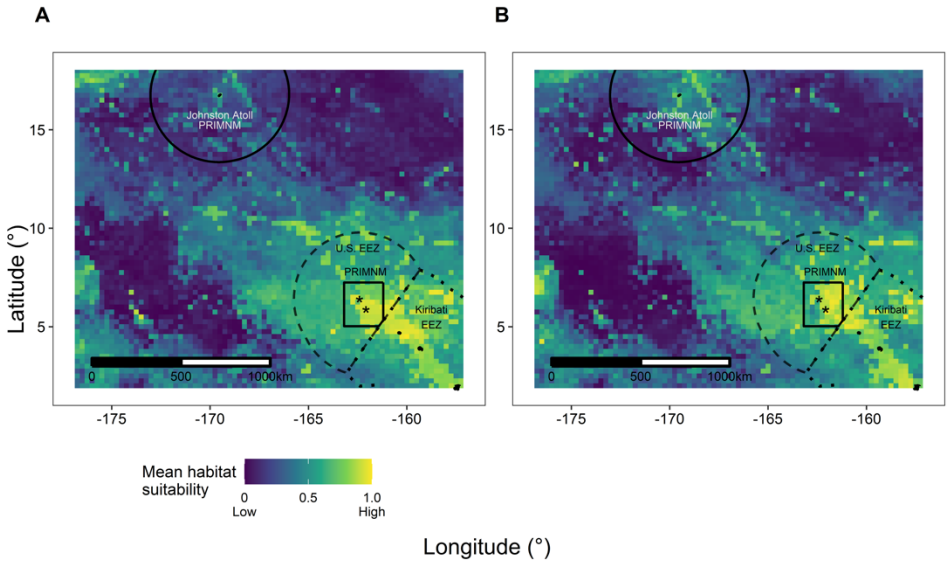


Tagging locations from 54 studies included in global waterfowl telemetry data sets. Data sets include GPS and Argos telemetry from diving ducks, dabbling ducks, geese, swans, and shelducks tracked between 2004 and 2023.

- Remote sensing in disease ecology: This project combines systematic and traditional review methods to characterize uses of remote sensing data in disease ecology and identify opportunities for future advancements. Disease ecology could benefit from the use of remote sensing data because many diseases are linked to environmental conditions and can be spread across large spatial scales, which makes it difficult to collect field data. The review identified that remote sensing data is commonly used in the study of tropical diseases and diseases of trees, but that disease ecologists would benefit from more critically appraising remote sensing products and from using more modern, advanced approaches.
- Palmyra Bluewater Research: This is a collaborative project with The Nature Conservancy, USGS, NOAA, UC Santa Barbara, San Jose State University, Stanford University, the University of Hawaii, and the University of Washington. Marine protected areas (MPA) are a conservation tool that has been applied widely to conserve marine resources and protect marine flora and fauna. However, once established, large remote MPAs, such as those in pelagic bluewater regions, are difficult to monitor. To address this issue, this study analyzed GPS and satellite animal telemetry data from nine marine megafauna species, including seabirds, cetaceans, tuna, sharks, and manta rays, to quantify movements and habitat use within the context of the boundaries of the Palmyra Atoll unit of the Pacific Remote Islands Marine National Monument under current conditions and under climate change scenarios. Overall, the MPA overlapped with 41% of the area where species traveled and on average, and 73% of the MPA contained highly suitable habitats. The sizes of suitable habitats both increased and decreased under two climate scenarios for all species.



Tracking data demonstrate how species (top: great frigatebird; bottom: yellowfin tuna) move in relation to boundaries of the Pacific Remote Islands Marine National Monument marine protected area (MPA) boundaries (left); Remote sensing environmental data describe species' habitats within the MPA (center), and how those habitats might change with climate scenarios (right).



Mean habitat suitability within and outside the Palmyra unit of the Pacific Remote Islands Marine National Monument (rectangle) and U.S. exclusive economic zone (EEZ; dashed lines) for eight marine species that include seabirds, manta rays, reef sharks, tuna, and cetaceans for A) summer and B) winter seasons. Habitat suitability was estimated via species distribution models that used remotely sensed data products.

- Assessment of planetary boundary layer height with seabird flight heights: Great frigatebirds are highly mobile and far-ranging tropical seabirds that use thermals and

wind to soar and glide across the ocean. Using this low-cost flight strategy, frigatebirds can reach altitudes of 4,000 meters, a height that coincides with the planetary boundary layer. Working with other NASA scientists, we are exploring frigatebirds' vertical movements and flight behaviors in relation to boundary layer dynamics.

- IOA group activities: The Internet of Animals group is beginning an assessment of the "community of practice" for animal telemetry within federal government agencies. Members are also participating in Remote Sensing for Animal Movement (RSAM), which is a gap analysis of remote sensing use in movement ecology.

Plans for 2023–2024

The team will work to perform and disseminate research in presentations at national and/or international technical meetings, and in publications in scientific journals in the following focus areas:

GeoNEX and Remote Sensing

- Continue to support the geostationary remote sensing research community with GeoNEX L1b (top-of-atmosphere) and L2 (surface) products and software tools.
- Continue to improve the MAIAC atmospheric correction algorithm for Himawari AHI, GOES16/17 ABI, the Geo-Compsat-2A AMI, and the European MTG FCI sensors.
- Adapt the NASA MAIAC algorithms to develop the data synergy that leverages complementary information in spectral, angular, spatial, and temporal dimensions from geostationary and polar-orbiting data streams to enhance the scientific quality of current (e.g., MODIS/VIIRS) satellite products and support future (e.g., TEMPO, SBG) Earth monitoring missions.
- Collaborate with the science community to adapt NASA EOS algorithms and use the atmospherically corrected Level 2 data to derive Level 3 and Level 4 science products for land/vegetation monitoring.
- Develop applications to investigate global water and carbon cycles with the hypertemporal GEO data streams, explicitly resolving the diurnal cycles of surface incident solar radiation, land surface temperature, and subsequently, water (ET) and carbon (GPP/NEE) fluxes.
- Continue to support NASA ARC's development and application of regional atmospheric composition modeling/data assimilation/emissions estimation—e.g., air quality forecasting, tropospheric atmospheric composition and emissions reanalysis, and wildfire emissions estimation/smoke transport forecasting.
- Continue to engage the science community in addressing science questions and building applications with GeoNEX data products.

National Climate Assessment (NCA)

- Develop a methodological framework for comprehensive evaluation of uncertainties of the downscaled climate dataset collections.
- Develop application examples based on NEX GDDP or downscaled climate datasets to showcase and promote their use in the climate resilience and adaptation communities.

- Sustain engagement with the NCA community to enable processing of downscaled climate products used by the NCA (e.g., LOCA2 and ESM-STAR) and understand emergent needs for NCA 6 that NEX can support.
- Engage with the new NASA Climate Resiliency program to identify needs and develop new climate products derived from NEX GDDP, etc., for use by the climate resilience and adaptation communities.
- Continue to provide support for NASA's Climate Adaptation Science Investigators program (CASI) by delivering requested GDDP and LOCA downscaled products.

NEXFire

- Support the NASA FireSense Project Office.
- Advance wildfire research, and facilitate innovation across the wildfire community for pre-fire, active, and post-fire challenges.
- Understand and characterize fire potential for current and future climate scenarios.
- Work with the community on the NEX platform to develop and distribute extensive, community-focused machine learning training datasets focused on wildfires.
- Continue to develop a machine learning pipelines concept that determines potential ignition events, active fire areas, with the notion of priority, given users' constraints or parameters. This work may evolve into a proposal.
- Continue to develop fire spread forecasting model orchestration work.

WRF-Chem/DART

(see report pp. 65-67)

CMS & GEDI

(see CMS report, pp. 19-20 and GEDI report, pp. 32-34)

Flight-missions

- Support development and execution of NASA Earth System Observatory (ESO) and cost-effective flight projects, such as SBG, FireSense, and the Internet of Animals.

Technology Innovations

- Advance new computing paradigms, including hybrid HPC-Cloud, through pilot projects such as NEXFire that advance ESD goals.
- Continue to support the development of technologies for forward-looking mechanisms for dynamic tasking with select space-based assets within a future constellation of observing systems using quantum-classical hybrid approaches.
- Advance optical modeling of global aquatic ecosystems to facilitate next generation algorithm development for water biogeophysics.

Internet of Animals

- Review paper: remote sensing in marine ecology. A systematic literature review will assess:
    - How remote sensing has been used to inform seabird movement ecology.
    - What remote sensing products may help move seabird ecology research forward.

NSRC Mission Operations

Project Participants

BAERI: Gary Ash, Adam Webster, David Van Gilst, Tu Phan, Terry Hu, Ryan Bennett, Pat Finch, Brenna Biggs, Tyler Thompson
NASA: Matt Fladeland

Project Description

NSRC is responsible for two tasks for the Airborne Science Program:

- Science Mission Operations
    - NSRC provides aircraft support across the centers within the Airborne Science Program. Aircraft support entails aircraft facility instrument operations and management, engineering support for payload integration, flight planning and mission management tools, flight navigation data hardware and software support, and flight data archiving and distribution.
- Communications and Training
    - The Airborne Science Program provides a suite of facility instrumentation and data communications systems for community use by approved NASA investigators. Currently available ASP instrumentation includes stand-alone precision navigation systems, and a suite of digital tracking cameras and video systems. Real-time data communications capabilities, which differ from platform to platform, are integral to a wider Sensor Network architecture. Access to any of these assets is initiated through the ASP Flight Request process.

Plans for 2023–2024

Large Aircraft: NSRC is taking the lead on several critical capabilities, including participation as deputy program manager.

BIOSCAPE: This mission was scheduled for October - December 2023 to South Africa. It flew the G-V and G-III.

ASIA-AQ: This mission is scheduled for multiple OCONUS sites January - April 2024.

ARCSIX: This mission is scheduled for the NASA P-3, NASA Gulfstream III, and Spec LearJet. Science flights are scheduled from May-June and August-September 2024 out of Thule, Greenland.

USGS EMRI: This mission is scheduled for October - November 2023 on the ER-2.

HAWC & SMLS: Science flights on the ER-2 are planned in November - December 2023.

SARP 2024: Science flights on the P-3 are planned for June/July 2024 out of Edwards AFB.

The Data System team will be focused on the following tasks:

- Provide mission support for missions as detailed above with on-board data system operation for the P-3 and DC-8 missions, along with remote support for the ER-2 and as-needed for other platforms.
- Complete the removal of NSRC maintained equipment from the DC-8 after ASIA-AQ.
- Conduct maintenance of onboard instrumentation, network, and SATCOM facilities:
    - Further development of ER-2 Camera Systems.
    - Upgrade of ER-2 INMARSAT Canoes to facilitate onboard processing.
    - Install External Wifi and LTE capabilities on the ER-2s, and P-3.
    - Maintain instrument calibrations.
    - Perform quality checks on pitot/static pressure transducers.
    - Deploy Iridium CERTUS across the ASP Fleet.
    - Develop a NASDAT Next Generation system.
- Do maintenance and development of new software for flight:
    - Develop an Inmarsat monitor and management program.
    - Develop Network Integrity Monitoring Tools.
    - Complete standardization of deployable file server.
    - Upgrade NSRC Data Acquisition software.
    - Upgrade NSRC Data Display Software.
    - Build a proactive network monitoring tool.
    - Modernize the data access API.
- Continue documentation of all analysis code.
- Continue the development of next-generation NASDAT for preliminary testing on the DC-8.

The IT Systems Engineering team will be focused on the following tasks:

- Further development and refinement of the MTS infrastructure:
    - Increase storage and backup capabilities.
    - Increase fault tolerance.
    - Add 3D rendering capabilities.
    - Increase computational capabilities.
    - Incorporate more data products as they become available from the FAA.
- Take lessons learned from MTS infrastructure and deploy in NSRC cloud infrastructure:
    - Further virtualize NSRC ground infrastructure.
    - Restructure the support and infrastructure for pre and post QC field data (asp-archive revamp), including better organization of data, search capabilities, and data display.
    - Focus on increased fault tolerance and availability.
    - Lights out management for all ground side infrastructure allowing remote diagnostics/troubleshooting/repair.
    - Increase the amount of time we can withstand from any fault until onsite repair is necessary.
- Decentralize and update our Iridium Short Burst Data Portal:

    - Rewrite/refactor using newer APIs and libraries not previously available.
    - Continue to investigate and experiment with alternative handheld/easily deployed asset tracking units that make use of the DOD/DISA Iridium gateway.
- Decentralize/rewrite/refactor TFR KML generation:
    - Bring back color coding.
    - Leverage MTS API.
    - Move to a different code base.
- Investigate viability of moving current Ames based cloud infrastructure into a different gov cloud instance.
    - Investigate cost/benefit, security/fault tolerance, and ease of use.

The Mechanical Engineering team will be focused on the following tasks:

- Provide engineering support for the development of the Large Aircraft B777-200ER.
- Provide DC-8 limited engineering support to AFRC for the OPALS instrument development.
- Provide mechanical engineering support for various DC-8 data and satcom systems installations, including permanent IR/visible camera pod installation, Ethernet network upgrade, ADS-B systems (zenith and nadir), Iridium NEXT satcom, pitot-static pressure transducers, 2-channel TAT signal conditioner, touchscreens, and WiFi/LTE connectivity.
- Provide mechanical engineering support for integrating WiFi/LTE connectivity on other ASP platforms.
- Provide mechanical engineering support for the NextGen NASDAT development.

OCEANOS

Project Participants

BAERI: Britnay Beaudry
NASA: Juan Torres-Perez

Project Description

The OCEANOS project centers on the hypothesis of: NASA observations and science coupled with low-cost in-water instrumentation can significantly increase STEM education and enthusiasm among low-income 1st generation Hispanic/Latino students, particularly in regard to oceanographic and coastal issues. Our goal is to use combined NASA ocean color data and in situ oceanographic parameters to improve the capacity and awareness among low-income students of how these together can be used to monitor water quality in areas that affect coastal shallow-water marine ecosystems in Caribbean waters.

Plans for 2023–2024

- Recruit and train low-income Hispanic/Latino (Puerto Rican) High School and undergraduate students on ocean color data acquisition and analysis of remotely sensed freely available imagery.
- Plan and coordinate OCEANOS Summer Internship activities.
- Participate in monthly or bi-monthly meetings with OCEANOS Co-I's.
- Develop an educational training module on basic remote sensing with Google Earth Engine or similar online platform.
- Travel to Puerto Rico in the Summer 2024 to conduct an in-person training with intern participants on the uses of Google Earth Engine for aquatic remote sensing.

OCO-2 Profile

Project Participants

BAERI: Susan Kulawik
NASA/GSFC: Sourish Basu

Project Description

This project is in support of the ROSES 17-OCO2-17-0013 project "Reducing the impact of model transport error on flux estimates using CO2 profile information from OCO2 in concert with an online bias correction," Sourish Basu, PI.

Plans for 2023–2024

- Publish a paper on the lowermost tropospheric (LMT) OCO-2 product for version 11.1.
- Archive OCO-2 v11.1 LMT product to the DAAC or Zenodo.
- Apply methodology to look at the LMT of OCO-3.

Peroxyacetyl nitrate (PAN) from AIRS

Project Participants

BAERI: Susan Kulawik
CSU: Emily Fischer
JPL: Vivienne Payne, Josh Laughner

Project Description

While total anthropogenic NOx emissions have remained approximately constant over the last 15 years, this time period has been marked by dramatic changes in the distribution of these emissions. While there have been large decreases in the emissions of NOx in North America, Chinese emissions have risen and subsequently dropped, and rapid urbanization is creating new emission hot spots in parts of the world where anthropogenic NOx emissions have typically been small. Peroxyacetyl nitrate (PAN) plays a fundamental role in the distribution of tropospheric ozone via its role as a reservoir for NOx. This project aims to improve our ability

to predict how global oxidation capacity responds to changes in NOx emissions via the new PAN record from the Aura satellite (2004–2013), the CrIS instrument (2012–present), and the GEOS-Chem global model.

Plans for 2023–2024

- Re-process parts of the TES PAN record with a consistent algorithm that was developed for AIRS PAN in order to compare the new AIRS PAN results to TES PAN.
- Test time-dependence for trace interferences such as CFC11, CFC12, CCL4, CFC22.
- Continue to develop AIRS PAN and write up validation of PAN.

Partnerships

Project Participants

BAERI: Cindy Schmidt
NASA: Shanna McClain, Lawrence Friedl

Project Description

NASA's Earth Science Division and Conservation International are collaborating on approaches for the assessment and monitoring of ecosystem health and natural capital flows to amplify the role of Earth observations and drive more sustainable decision making at national and regional scales. The partnership deepens the impact and application of NASA ESD remote sensing data and research, and advances natural resource management, including natural capital accounting and ecosystem health assessment. FY24 efforts for one team will be focused on mapping blue carbon in Eastern Africa, particularly mangroves and sea grasses. The second team will focus on mapping global riparian zone ecosystems and help determine where those ecosystems can play an important role in Nature-based solutions.

Plans for 2023–2024

Blue Carbon project:

- Identify where mangrove and seagrass loss is occurring so countries can focus on prioritizing restoration strategies.
- Help develop project success metrics for Phase 2 of the partnership.
- Organize and attend monthly project tag up meetings with NASA and Conservation International.

Riparian zone mapping project:

- Develop methods to map global riparian ecosystem zones.
- Work with Conservation International to understand country needs.

Both Projects:

- Coordinate activities and communication between Conservation International and NASA Headquarters.

- Update and renew the Space Act Agreements between NASA and Conservation International.
- Generate reports and highlights of the team's activities for NASA management.
- Attend monthly internal NASA tag up meetings and quarterly NASA review meetings, as well as NASA leadership review meetings.

Reducing OCO-2 Regional Biases through Novel 3D Cloud, Albedo, and Meteorology Estimation

Project Participants

BAERI: Susan Kulawik
JPL: James McDuffie, Rob Nelson
University of Colorado: Sebastian Schmidt, Yu-wen Chen

Project Description

The project seeks to improve OCO-2/3 regional biases by adding 3D clouds, additional albedo parameters, and temperature and water vapor vertical parameters to the OCO-2 retrieved state. We hope/expect to improve regional biases from ~0.6 to ~0.4 ppm, which should reduce OCO-2/3 flux errors by about 30%.

Plans for 2023–2024

- Publish results of the new 3D-cloud parameters on synthetic observations.
- Publish results on 3D-clouds with EAR3T system.
- Publish results on temperature and water principal component retrievals.
- Analyze actual OCO-2 observations with new 3D-cloud and albedo parameters with test sets outlined in the project proposal.

PICARD-AVIRIS

Project Participants

BAERI: Robert Bergstrom (Acting)

Project Description

The PICARD-AVIRIS project aims at comparing L2 data products from the AVIRIS and PICARD instruments. The specific goals are to ready the PICARD L2 inversion algorithm and to generate several L2 PICARD data products. We want to produce reflectance maps and then normalized vegetation index maps using PICARD and AVIRIS (NDVI). We will also look at other L2 datasets that AVIRIS produces and use those in the comparison. We would like to have the L2 inversion algorithm ready for the end of November so that we may complete the higher level data products work by the end of the year.

Plans for 2023–2024

- Adapt the AVIRIS L2 algorithm to be able to process PICARD L2 datasets.
- Produce reflectance L2 data comparison between PICARD and AVIRIS.
- Generate normalized vegetation index L2 data comparison between PICARD and AVIRIS.
- Obtain methane L2 data comparison between PICARD and AVIRIS.

RUMMBL

Project Participants

BAERI: Stephen Broccardo
Caltech: Yuk Yung, Sihe Chen
Michigan Technological University: Chad Deering, Kate Nelson
NASA Ames: Matthew Johnson, Roy Johnson, Florian Schwandner
NASA GSFC: Meloe Kacenelenbogen
NASA JPL: Vijay Natraj, Rob Nelson
OVSICORI Costa Rica: Maarten de Moor
University of Alaska, Fairbanks: Tarsilo Girona
University of Costa Rica: Andres Diaz

Project Description

This project is funded by a 2020 ROSES Interdisciplinary Science proposal and aims to make measurements of degassing fluxes from a volcano in Costa Rica (i.e. Turriabla, Rincon de la Vieija) using the OCO-3 and ECOSTRESS instruments on the International Space Station. These will be combined with ground-based measurements made during intensive observation periods to inform a geophysical sub-surface model of magma evolution within the volcano.

JPL/Caltech will lead the development of a new XCO2 retrieval, and an SO2 column retrieval, taking aerosol particles into account. Michigan Technological University will perform field measurements, and the University of Alaska will do the geophysical modeling. NASA Ames and BAERI will conduct the deployment of an AERONET sunphotometer to Costa Rica, and do the interpretation of flux measurements.

Plans for 2023–2024

- Continue the development of the joint AOD & CO2 retrieval from OCO-[2,3] (JPL/Caltech team), and its application to space-based observations of volcanoes.
- Apply the new retrieval to a case-study of the recent eruption of Mauna Loa (NASA Ames team).
- Apply a distributed validation strategy using surface, suborbital, and space-based assets to our custom OCO retrieval products (NASA Ames/BAERI team).
- Continue development of a numerical physics-based model of volcanic degassing, based on subsurface magma flows (University of Alaska, Fairbanks team).

- Perform a synthesis of the space-based, surface degassing, and subsurface modeling results (whole team).

SARP West & SARP East

Project Description

The NASA Student Airborne Research Program (SARP) is an 8-week long internship that allows undergraduate students in Science, Technology, Engineering, and Mathematics (STEM) fields to conduct their own research in airborne science. Topics include whole air sampling, atmospheric aerosols, and remote sensing of terrestrial ecology and the ocean. A total of 48 students are selected, half for SARP West and half for SARP East. Each group of 24 is divided into four groups, each focusing on a different topic and led by faculty and graduate student mentors. The students attend rigorous lectures and receive training about tropospheric chemistry, climate change, coding, and instrumentation before they fly on scientific research flights, typically on the NASA DC-8 aircraft, based at NASA Armstrong Flight Research Center (AFRC).

Once the flights are completed, students travel to ground truthing locations to collect additional samples from the ground to validate those collected from the airplane. They spend the remainder of the summer at the University of California, Irvine analyzing data and executing their own individual research projects. Students continue to attend various presentations about coding and science throughout the summer. At the end of the program, students present their findings to their cohort, mentors, and NASA personnel. The students with the top four to six projects are fully funded to attend and present at the Fall American Geophysical Union (AGU) conference.

Plans for 2023–2024

- SARP East details: June 16 – Aug 9; Virginia; 24 students; 4 to 5 faculty from academia; 3 days of flights on the P-3 and DA B200.
- SARP West details: June 23 – Aug 16; California; 24 students; 4 to 5 faculty from academia; 3 days of flights on the P-3 and DA B200.
- SARP application is open: Dec 1, 2023 – Jan 31, 2024.

SeaSTAR

Project Participants

BAERI: Stephen Broccardo, Conrad Esch, Steven Tammes

Project Description

The project aims to develop a ship-based robotic sun/sky photometer for the quantification and characterization of marine aerosol particles. We will integrate radiometer technology that was developed for Ames' next-generation airborne sunphotometer (5STAR) with a robot platform that was developed using Ames Innovation Fair funds from 2018, and through the efforts of two student interns (Saketh Muvva in 2019 and Chaitu Nookala in 2020/2021).

We aim to develop an instrument which will make direct-sun absorption measurements, as well as polarized sky radiance measurements, to allow retrieval of aerosol particle optical properties. A third aim is to be able to make measurements of upwelling radiances from the sea surface. The robot will incorporate inertial measurement to enable compensation of the movement of the vessel while making sky- and ocean radiance measurements.

Plans for 2023–2024

- Complete the construction of the third robot axis.
- Complete integration of electro-optical subsystems into the instrument head.
- Design the state-machine, and integrate it with computer code developed in 2023 for controlling the robot.
- Achieve sun-tracking with the robot for measuring multi-spectral aerosol optical depth.
- Achieve sky-scanning with the robot, with IMU-based feed-forward motion compensation.
- Test on a simulation platform to demonstrate sun-tracking and sky-scanning.
- Begin development of aerosol property retrieval based on sky-scanning.

Surface Biology and Geology (SBG)

Project Participants

BAERI: Robert Bergstrom (Acting)
CSUMB: Vanessa Brooks Genovese, Yohei Shinozuka
NASA: Ian Brosnan, Jon Jenkins, Peter (“PT”) Tenenbaum, Bill Wohler, Andrew Michaelis, Jennifer Dungan, Weile Wang

Project Description

The NASA Surface Biology and Geology (SBG) study proposes a new set of missions to study the Earth with the following priorities:

- Terrestrial vegetation physiology, functional traits, and health.
- Inland and coastal aquatic ecosystems physiology, functional traits, and health.
- Snow and ice accumulation, melting, and albedo.
- Active surface changes (eruptions, landslides, evolving landscapes, hazard risks).
- Effects of changing land use on surface energy, water, momentum, and C fluxes.
- Managing agriculture, natural habitats, water use/quality, and urban development.

The study has been broken into four research & applications working groups: Applications, Algorithms, Modeling and Calibration/Validation. Our group at NASA Ames is working as sub-tasks of the modeling working group (MEET-SBG) and the Space-based Imaging Spectroscopy and Thermal pathfinder (SISTER).

Plans for 2023–2024

- Enable analyses of hyperspectral image data similar to those expected for SBG.
- Verify the results of the recently processed Hyperion hyperspectral satellite data.

- Apply additional programs to the Hyperion data.
- Execute the pipeline to reprocess the 55 TB data from the 17-year-long observations.
- Explore the NASA Ames Global Hyperspectral Synthetic Data to support the Earth sciences community as they develop algorithms to mine the huge dataset that SBG promises to deliver.
- Draft and submit a manuscript to JGR-Biogeosciences summarizing the NASA Ames Global Hyperspectral Synthetic Data.

TASNPP

Project Participants

BAERI: Kristina Pistone, Samuel LeBlanc
NASA GSFC: Kerry Meyer

Project Description

Aerosols play a key role in the Earth-atmosphere radiative budget via interactions with solar radiation. Over dark surfaces (clear sky), aerosol scattering generally yields a negative (cooling) TOA direct radiative effect (DRE). Over bright surfaces (clouds), the TOA DRE can be negative or positive (warming) depending on underlying surface brightness and aerosol absorptivity; strongly absorbing above-cloud aerosols (biomass burning) yield local atmospheric warming and positive TOA DRE. Moreover, above-cloud aerosol absorption is problematic for passive satellite retrievals of the underlying clouds. Because aerosol absorption increases as wavelength decreases within the NIR through the VIS, cloud optical retrievals relying on VIS/NIR reflectance can be biased in the presence of above-cloud absorbing aerosols. For instance, MODIS cloud optical thickness (COT) retrievals, which assume a clean above-cloud atmospheric path (no aerosols), are biased low when above-cloud absorbing aerosols are present, having implications on downstream uses such as estimates of cloud and aerosol radiative effects.
Globally, there are several locations where absorbing aerosols are frequently observed above clouds. Foremost is the SE Atlantic basin. Here, smoke from extensive biomass burning in sub-Saharan Africa is often mixed with other regional emissions and transported off the continent over a semi-permanent stratocumulus cloud deck, creating a near-persistent aerosol over cloud condition from roughly June through October, with profound impacts on the regional radiative budget and passive imager cloud retrievals. GCM simulations have also been shown to have exceptional disagreement in the sign/magnitude of the aerosol radiative effects over this region, which are a function of the properties/distributions of both the aerosol and underlying clouds.

To address the above issues, a technique was developed to simultaneously retrieve above-cloud aerosol optical depth (AOD) and unbiased COT and cloud effective particle radius (CER) of the underlying clouds using VIS, NIR, and SWIR reflectance measurements. This technique, developed with regionally appropriate aerosol radiative models, has been applied to Terra and Aqua MODIS observations, and has enjoyed widespread use by the international cloud and aerosol remote sensing community, the atmospheric modeling community, and major field

campaigns funded by NASA (ORACLES) and international partners (UK CLARIFY, France AEROCLO-SA).

For ORACLES, this MOD06ACAERO algorithm was implemented within the LANCE operational production environment for near real-time MODIS retrievals to support in-field operations and science analysis; LANCE NRT production continues to date. Because cloud forward model and ancillary assumptions are identical to MOD06, MOD06ACAER provides COT/CER retrievals consistent with MOD06 in aerosol-free cloud scenes, and its ACAOD retrievals are comparable to those from other passive satellite techniques (e.g., OMI, POLDER) and ORACLES field campaign observations. Moreover, the algorithm is sufficiently flexible to be applied to any passive sensor having the appropriate spectral channels (e.g., VIIRS).

This project, as part of the TASNPP (Terra-Aqua Suomi-NPP) science team, is led by Dr. Kerry Meyer at Goddard Space Flight Center, and is aimed at producing continuity products of Aerosol optical depth over cloud, and cloud optical and effective radius retrievals.

In this project, we intend to:

- Build upon our MODIS LANCE capabilities to transition the algorithm to Standard Product status and extend to SNPP/NOAA-20 VIIRS; this includes refining a QA scheme and initializing the ATBD process.
- Refine the regional aerosol radiative models using ORACLES campaign data as constraints, a critical effort towards assessing and constraining AOD retrieval uncertainty whose largest component is aerosol model uncertainty.
- Provide a means of assessing the biases of the MOD06 and MODIS-VIIRS continuity cloud products over regions known to have radiatively significant above-cloud absorbing aerosols.

Plans for 2023–2024

- Assess the improved MOD06ACAERO AOd retrievals with the new aerosol model based on 4STAR.
    - Compare MODIS and VIIRS retrievals to 4STAR and HSRL measurements during ORACLES.
    - Help prepare and present resulting comparisons.

- Complete and submit for peer review a paper currently titled “Aerosol intensive properties of biomass burning smoke measured by an airborne sun photometer over the southeast Atlantic, 2016-2018” to the ORACLES ACP special issue (Pistone) and/or contribute to the aerosol intensive properties analysis from ORACLES led by Logan Mitchell at University of Oklahoma.

- Submit “Samuel E. LeBlanc, Jens Redemann, Connor Flynn, Kristina Pistone, Stephen Broccardo, Michal Segal-Rosenheimer, Meloë Kacenelenbogen, Yohei Shinozuka, Roy Johnson, Stephen Dunagan, Richard Ferrare, Sharon Burton, Chris Hostetler, and Johnathan W. Hair, ‘Airborne Observations Above Cloud Aerosol Optical Depth in the

Southeast Atlantic during biomass burning season over 3 years,'" in prep for Atmos. Meas. Tech. (LeBlanc).

Tropospheric Regional Atmospheric Composition and Emissions Reanalysis (2005-2024) (TRACER-I)

Project Participants

BAERI: Arthur P. Mizzi, Aishwarya Raman
Morgan State University: K. Emma Knowland
NASA: Matthew S. Johnson, Kazuyuki Miyazaki, Kevin Bowman
National Center for Atmospheric Research: Rajesh Kumar
NOAA Chemical Sciences Laboratory: Brian McDonald

Project Description

Regional atmospheric composition (AC) and air quality (AQ) significantly impact tropospheric chemistry, climate change, and human health. Although in situ measurements of atmospheric composition offer valuable insights into long-term regional air quality trends, the observational content in these measurements is very limited in space and time for atmospheric gasses and aerosols with short lifetimes.

In recent years, global reanalysis products of AC have demonstrated the potential of combining information content from satellites with models, using chemical data assimilation techniques. Some of these studies have also optimized emissions along with chemical concentrations to understand the impact of improved emissions on air quality. However, we do not have a regional reanalysis dataset for the Continental United States that includes chemical data assimilation (DA) of satellite and in situ AQ observations and dynamic emission updates. A regional reanalysis is crucial for identifying the sources of criteria pollutants and implementing effective regional air quality policy measures.

The TRACER-1 project aims to build a high-resolution 20-year regional AC reanalysis (2005-2024) for the continental United States (CONUS), focusing on the months April-September. For the forecast and assimilation system, we use the Weather Research and Forecasting model with Chemistry and Data Assimilation Research Testbed (WRF-Chem/DART), and we interface WRF-Chem/DART with JPL's Multi-model Multi-constituent Chemical data assimilation (MOMO-Chem) dataset to supply chemical initial and boundary conditions. We port several forward operators for satellite AC observations and in situ air quality data into WRF-Chem/DART to enable a seamless analysis of AC. We use an ensemble Kalman filter technique that generates an optimized estimate of both chemical concentrations and emissions. We intend to leverage the TRACER-1 reanalysis dataset to understand the impact of a regional model with chemical DA in the analysis of tropospheric AC, discern air quality trends across the CONUS, investigate the influence of emission variations on regional air quality, and evaluate the effects of data assimilation on regional DA increments for correlated chemical species.

Plans for 2023–2024

- Develop and test WRF-Chem DART for the TRACER-1 domain using the chemical mechanism and WRF-Chem settings used by NOAA.
- Develop and test an interface between JPL's MOMO-Chem reanalysis and WRF-Chem/DART for chemical initial and boundary conditions, in conjunction with initial and boundary conditions from NAM forecasts.
- Conduct comprehensive testing of forward operators for satellite AC observations and in situ measurements, focusing on a prototype period from April 2005.
- Conduct validation of the analysis of surface and profile data for gas phase species, including CO, NOx, and Ozone for April 2005.
- Compare control experiments with no data assimilation with other experiments that include:
    - Meteorological data assimilation.
    - All chemistry assimilation without emission adjustment.
    - Meteorology and chemistry assimilation with emission adjustment.
- Prepare for TRACER-1 production simulations.

US Arctic Observation Network

Project Participants

BAERI: Cindy Schmidt
NASA: Emily Sylak-Glassman

Project Description

The US Arctic Observation Network (US AON) is an initiative to promote sustained and well-defined networks of Arctic observations through collaborative development across the US Federal agencies and other partners. These networks will provide high quality data and expertise in support of scientific understanding, stakeholder needs, and agency operations. Schmidt is on the US AON board representing NASA. She has been tasked with getting a complete understanding of NASA's role in the Arctic as well as identifying opportunities to bridge NASA's Research and Analysis program with its Earth Action program.

Plans for 2023–2024

- Attend monthly US AON board meetings.
- Work with US AON leadership to use the newly developed benefit tool to link observing system inputs to the societal benefit areas they support.
- Understand what NASA is doing in the Arctic by connecting with ABoVE, the IceSAT 2 team, Arctic-COLORS and other similar groups and projects.

Water Resources Program

Project Participants

CSUMB: A.J. Purdy, Pam Hansen
NASA: Forrest Melton (ARC), Ian Brosnan (ARC), Brad Doorn (HQ), Erin Urquhart-Jephson (HQ)

Project Description

The primary objectives of this task are to:

- Support the NASA Applied Sciences Program (ASP), Water Resources application area by serving as an Associate Program Manager for Water Resources, and as the Program Scientist for the NASA Western Water Application Office.
- Monitor progress across the project portfolio, engage and support project teams in identifying and resolving project issues, and coordinate the ASP Water Resources science community.
- Conduct outreach and engage and support the NASA Applied Sciences Water Resources stakeholder community.

Plans for 2023–2024

- Continue to support NASA HQ through program management and community leadership activities.
- Continue to maintain contact with PI's and projects for which I am responsible, and report progress at ASP Program Reviews.
- Organize the 2024 Western Water Applications Office and Water Resources PI Meetings and other meetings, including planning for all meeting logistics.
- Co-organize Remote Sensing Applications sessions at AGU, American Water Resources, AMS, and other scientific conferences.
- Continue to maintain and improve program website and communication material.
- Attend additional stakeholder meetings and workshops to represent the NASA ASP Water Resources program element and WWAO.

WRF-Chem/DART

Project Participants

BAERI: Arthur Mizzi

Project Description

WRF-Chem/DART is a regional, ensemble, atmospheric composition forecast/assimilation/emissions inversion system based on integrating the Weather Research and Forecasting model (WRF) with online chemistry (WRF-Chem) into the Data Assimilation Research Testbed (DART), with an expansion of DART to include chemical data assimilation and emissions estimation.

WRF-Chem and DART are state-of-the-science computational tools. WRF-Chem is a chemical transport model that contains online atmospheric chemistry. It is used internationally, domestically, and by the U.S. government for air quality (AQ) forecasting research and operations. DART is an ensemble data assimilation system based on the 'ensemble adjustment Kalman filter' of Anderson (2001; 2003). It is used internationally and domestically for various data assimilation applications. It includes adaptive inflation, physical and state space localization, and a non-Gaussian formulation.

Under this and other non-BAERI projects, we have extended DART within the context of WRF-Chem/DART, or applied WRF-Chem/DART, as follows:

- Completed the assimilation of OMI O_3, NO_2, SO_2, HCHO; TROPOMI CO, O_3, NO_2, SO_2, HCHO, CH_4; TES CO, CO_2, O_3, NH_3, CH_4; CrIS CO, O_3, NH_3, CH_4, PAN; GOME2a NO_2, SCIAMACHY NO_2; MLS O_3, HNO_3, and TEMPO O_3, NO_2 total/partial column and/or profile retrievals.
- Streamlined and cleaned up the WRF-Chem/DART code and scripts to make the user interface, maintenance, and interface to the DART repository more efficient.
- Enhanced WRF-Chem/DART's use of the 'state augmentation method' for constraining emissions to enable assimilation cycle-based (dynamic) emissions estimation and demonstrated that dynamic emissions estimation improves forecast skill and predictability.
- Applied WRF-Chem/DART to joint assimilation of observations from multiple satellite and in situ platforms to constrain the forecast of all criteria pollutants and their associated emissions at medium (15 km) and high (4 km) spatial resolutions.
- Applied WRF-Chem/DART to an 'observing system assimilation experiment' (OSSE) for the COVID period (COVID OSSE) to determine whether the assimilation of geosynchronous satellite observations (synthetic TEMPO NO_2 tropospheric column retrievals) can recover the COVID period NO_2 emissions over the continental U.S. more accurately and more quickly than the assimilation of low earth orbiting satellite observations (synthetic TROPOMI NO_2 tropospheric column retrievals). This work is being done in collaboration with NOAA and the University of Colorado at Boulder.

Plans for 2023–2024

- Continue to pursue the goals of TRACER-I.
- Study the joint assimilation of 'compact phase space retrievals' (CPSRs) by:
    - Assimilating the same species from different satellite platforms with and without assimilation of in situ observations.
    - Assimilating different species from the same and/or different satellite platforms with and without assimilation of in situ observations.
    - Determining whether the assimilation of CPSRs can dynamically constrain emissions.
- Extend the COVID OSSE project to the assimilation of real satellite observations (TROPOMI, TEMPO, and/or other platforms) during the COVID period and/or the AEROMMA study period.
- Apply WRF-Chem/DART to a wildfire emissions OSSE in order to use the assimilation of synthetic height dependent AOD retrievals (and potentially other satellite observations) to constrain plume injection heights and other wildfire emissions parameters.
- Apply WRF-Chem/DART to a greenhouse gas emissions OSSE in order to use the assimilation of synthetic GOSAT-GW (or TROPOMI) and CriS CH_4 retrievals to recover oil and gas production CH_4 emissions over the Permian Basin.
- Conduct air quality forecasting/data assimilation/emissions over central Mexico with high resolution over Mexico City.
- Integrate online and offline versions of the Community Multiscale Air Quality Modeling System and/or UFS-Chem into WRF-Chem/DART. The goals of this effort are to:
    - Extend chemical data assimilation to the AC forecasting/emissions estimation system of the future.
    - Support regional chemical data assimilation within JEDI.
- Continue participating in the NASA Data Assimilation Working Group.
- Continue participating as a NASA representative to the U.S. Department of State Wildfire Study Group.
- Continue participating on the NASA FireSense Implementation Team.

Western Water Applications Office (WWAO)

Project Participants

BAERI: Amber McCullum
JPL, CSU Monterey Bay, etc.: Indrani Graczyk, Forrest Melton, Stephanie Granger, Amber Jenkins, Mark Davidson, Sharon Vasquez-Ray.

Project Description

The Western Water Applications Office (WWAO) is a NASA program focused on all things water. While physically headquartered at NASA's Jet Propulsion Laboratory in Pasadena, California, it is a cross-NASA initiative with a team that represents all of the NASA centers.

WWAO is part of a larger effort within NASA's Applied Sciences Program to help society through NASA's data, tools, and technology. It is part of NASA's Applied Sciences Program, which covers Earth science and encompasses five application areas: Health and Air Quality, Ecological Forecasting, Disasters, Wildfires, and Water Resources. WWAO forms a core part of the Water Resources application area. WWAO leverages decades of NASA investment in science and technology to deliver useful, actionable information to those on the ground making water decisions and shaping policies that potentially affect millions of people. Amber McCullum serves as the Impact and Transition Lead for the WWAO Program Office.

Plans for 2023–2024

- Develop an annual plan that outlines the general responsibilities of the Impact and Transition Lead and provides a detailed timeline for actions and deliverables.
- Develop thought leadership in application transition.
    - Create a summary document of past conversations with federal agency representatives around S2A to highlight multiple models for transition.
    - Create a list of leaders in S2A within federal agencies and academic institutions that can be used for seeking guidance and establishing a community of practice.
    - Connect with other program elements within Earth Action to discuss successes, challenges, and pathways towards S2A.
- Develop resources to assist WWAO projects (PIs and partners) in Application Transition.
    - Connect with other NASA programs (CalCIS, EIS, etc.) and outside agencies (NOAA, etc.) who are working on testbed approaches for sustained use of data and tools.
    - Create and communicate a transition guideline document for WWAO project leads.
    - Hold post-project conversations with project PIs and partners (separately) to identify lessons learned, best practices, and future needs around transition.
    - Follow up with project partners on an as-needed basis should the need for "final mile" transition support be identified.
    - Implement and support 1 "final mile" project as identified in post-project conversations.
- Support WWAO program office in Application Transition.
    - Identify WWAO or Earth Action water resources projects that may be candidates for additional transition support.
    - Review transition concepts from project partners and collaborate with program managers to secure funding for transition projects.
    - Attend meetings, retreats, conferences as needed for WWAO programmatic activities.
- Develop resources to assist WWAO projects with their impact.
    - Provide projects with impact reporting templates at the start of projects.
    - Hold meetings with each project at the start of the project to identify which impact metrics will be tracked and cadence for reporting.
    - Create impact stories/comms with the water resources community.

Acronym Glossary

3DEP—3D Elevation Program

4STAR—Sky-scanning, Sun-tracking Atmospheric Research

5STAR—ultra-Stable Spectrometers for Sky-Scanning Sun-Tracking Atmospheric Research

AATS—Ames Airborne Tracking Sun-photometer

ABI—Advanced Baseline Imager

ABoVE—Arctic-Boreal Vulnerability Experiment

ACCDAM—Atmospheric Composition Campaign Data Analysis and Modeling

ACMAP—Atmospheric Composition: Modeling and Analysis Program

ACP—Atmospheric Composition Program

AEROCLO-SA—AErosol, RadiatiOn and CLOuds in southern Africa

AEROMMA—Atmospheric Emissions and Reactions Observed from Megacities to Marine Areas

AERONET—AErosol RObotic NETwork

AATS—Ames Airborne Tracking Sun-photometer

AFRC—Armstrong Flight Research Center

AGAGE—Advanced Global Atmospheric Gases Experiment

AGBD—Aboveground biomass density

AFRC—Armstrong Flight Research Center

AHI—Advanced Himawari Imager

AIHEC—American Indian Higher Education Consortium

AIST—Advanced Information Systems Technology

AJAX—Alpha Jet Atmospheric eXperiment

AMS—American Meteorological Society

AMS—Autonomous Modular Sensor

AOD—Aerosol Optical Depth

AOS—Atmosphere Observing System

API—Application Programing Interface

APM—Associate Program Manage

ARC—Ames Research Center

ARC-CREST—Ames Research Center Cooperative for Research in Earth Science and Technology

ARCSIX—Arctic Radiation-Cloud-Aerosol-Surface-Interaction Experiment

Arctic-COLORS—Arctic-COastal Land Ocean inteRactions

ARL—Application Readiness Level metric

ARMD—Aeronautics Research Mission Directorate

ARSET—Applied Remote Sensing Training

ASF—Airborne Sensor Facility

ASIA-AQ—Airborne and Satellite Investigation of Asian Air Quality

ASP—Applied Sciences Program

ASP—Airborne Science Program

ASRL—Allometric Scaling and Resource Limitation

ATBD—Algorithm Theoretical Basis Document

AVIRIS—Airborne visible/infrared imaging spectrometer

BB—Biomass Burning

BCSD—Bias Correction/Spatial Disaggregation

BioSCape—NASA Biodiversity field campaign in the Greater Cape Floristic Region of South Africa

BRDF—Bi-directional Reflectance Distribution Function

CAARE—the Center for Applied Atmospheric Research and Education

CalCIS—California Climate Information System

CAMS—Copernicus Atmosphere Monitoring Service

CASI—Climate Adaptation Science Investigators

CBP—Capacity Building Program

CCDC—Continuous Change Detection and Classification

CEOS—Committee on Earth Observation Satellites

CER—Cloud Effective particle Radius

CHIPS Act—Creating Helpful Incentives to Produce Semiconductors

CIRES—The Cooperative Institute for Research in Environmental Sciences

CIRPAS—Center for Interdisciplinary Remotely Piloted Aircraft Studies

CMAQ—Community Multiscale Air Quality Modeling System

CMIGITS—Coarse/Acquisition - Miniature Integrated GPS/INS Tactical System

CMIP6—Climate Model Intercomparison Project Phase 6

CMS—Carbon Monitoring Systems

CNN—Convolutional Neural-Network

CONUS—Continental United States

COT—Cloud Optical Thickness

CPSR—Compact Phase Space Retrievals

CSA—Canadian Space Agency

CSU—California State University

CSUMB—California State University at Monterey Bay

D-SHIELD—Distributed Spacecraft with Heuristic Intelligence to Enable Logistical Decisions

DA—Data Assimilation

DAAC—Distributed Active Archive Center

DART—Data Assimilation Research Testbed

DBW—Division of Boating and Motorways

DCOTSS—Dynamics and Chemistry of the Summer Stratosphere

DDM—Direct Decoupled Method

DEIA—Diversity, Equity, Inclusion, Accessibility

DEVELOP—Digital Earth Virtual Environment and Learning Outreach Project

DISA—Defense Information Systems Agency

DNR—Division of Natural Resources

DOD—Department of Defense

DRCS—The Disaster Response Coordination System

DRE—Direct Radiative Effect

DRI—Desert Research Institute

DSI-PBL—Decadal Survey Incubation Planetary Boundary Layer

EAP—Earth Action Program

ECOSTRESS—ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station

EEJ—Equity and Environmental Justice

EIS—Earth Information System

eMAS—Enhanced MODIS Airborne Simulator

EMRI—Earth Mapping Resources Initiative

ENSCI—Environmental Science

EO—Earth Observations

EOS—Earth Observing System

EOSDIS—Earth Observing System Data and Information System

EPSCoR—Estab-lished Program to Stim-u-late Com-pet-i-tive Research

ESO—Earth System Observatory

ESPO—Earth Science Project Office

ESRI—Environmental Systems Research Institute. Esri is an international supplier of geographic information system software, web GIS and geodatabase management applications.

ESTP—Environmental Science, Technology and Policy

ET—Evapotranspiration

FCI—Flexible Combined Imager

FINESST—Future Investigators in NASA Earth and Space Science and Technology

FLUXNET—A global network of micrometeorological tower sites that use eddy covariance methods to measure the exchanges of carbon dioxide, water vapor, and energy between the biosphere and atmosphere.

FNR—formaldehyde (HCHO; a VOC species) to nitrogen dioxide (NO2; a component of NOx) concentration ratio

GCM—Global Climate Model

GDDP—Global Daily Downscaled Projections

GEDI—Global Ecosystem Dynamics Investigation

GEDIST—Global Ecosystem Dynamics Investigation Science Team

GEE—Google Earth Engine

GEMS—Geostationary Environment Monitoring Spectrometer

GEMx—Geological Earth Mapping Experiment

GEO-LEO—GEO-LEO is a virtual library for the specialty fields of mining, geography, maps, Earth sciences, and astronomy.

GEO—Geostationary

GEO—Group on Earth Observations

GHG—Greenhouse Gas(es)

GIS—Geographic Information System

GLIMR— Geosynchronous Littoral Imaging and Monitoring Radiometer

GLOBE—Global Learning and Observations to Benefit the Environment program

GMAO—Global Modeling and Assimilation Office

GNSS-R—Global Navigation Satellite System Reflectometry

GOES—Geostationary Operational Environmental Satellite

GOSAT—The Greenhouse gases Observing SATellite

GPP—General Purpose Parameters

GPS—Global Positioning System

GSFC—Goddard Space Flight Center

GWIS—Global Wildfire Information System

HALE—High Altitude Long Endurance

HAWC—High-altitude Aerosols, Water vapor and Clouds

HLS—Landsat-8 and Sentinel-2 time series

IAA—Interagency Agreement

ICESat-2—ICESat-2, part of NASA's Earth Observing System, is a satellite mission for measuring ice sheet elevation and sea ice thickness, as well as land topography, vegetation characteristics, and clouds.

IDGA—Institute for Defense and Government Advancement

IDI—In-depth Interviews

IDL—Interactive Data Language

ILEOS—Intelligent Long Endurance Observing System

IMPACTS—Investigation of Microphysics and Precipitation for Atlantic Coast-Threatening Snowstorms

IMW—Indigenous Mapping Workshop

INMARSAT—A British satellite telecommunications company

INS—Inertial Navigation System

INSTEP—Inexpensive Network Sensor Technology for Exploring Pollution

INU—Inertial Navigation Unit

IPI—The Indigenous Peoples Initiative

IRB—Institutional Review Board

ISFM—Internal Science Funding Model

ITC—Individual Tree Crown

ITEP—The Institute for Tribal Environmental Professionals

JPL—Jet Propulsion Laboratory

LaRC—Langley Research Center

LCLUC—Land-Cover and Land-Use Change

LEO—Low Earth Orbit

LIDAR—Light Detection and Ranging

LSP—Land Surface Phenology

LST—Land Surface Temperature

LVIS—Land, Vegetation, and Ice Sensor

MAIAC—Multi-Angle Implementation of Atmospheric Correction

MAIANSE—Minority University Research and Education Project (MUREP) for American Indian and Alaska Native Science, Technology, Engineering and Mathematics (STEM) Engagement

MAICH—Mediterranean Agronomic Institute of Chania

MASTER—The MODIS/ASTER Airborne Simulator

MCC—Meso-scale Cellular Convection

MEaSUREs—Making Earth System Data Records for Use in Research Environments

MedRIN—Mediterranean Regional Information Network

MMS—Meteorological Measurement System

MODIS—Moderate Resolution Imaging Spectroradiometer

MOMO-Chem—Multi-mOdel Multi-cOnstituent Chemical data assimilation

MPA—Marine Protected Areas

MRV—Measurement, Reporting, and Verification (Also: Monitoring, Reporting, and Verification)

MSC—Marine Stratocumulus Clouds

MTS—Mission Tools Software

NAAC—Native American Advisory Committee

NAS—NASA Advanced Supercomputing

NASA GSFC RCL—The NASA Goddard Space Flight Center (GSFC) Radiometric Calibration Laboratory (RCL)

NASDAT—NASA Airborne Science Data and Telemetry System

NCA—National Climate Assessment

NDAAC—Network for the Detection of Atmospheric Composition Change

NDVI—Normalized Difference Vegetation Index

NEX—NASA Earth Exchange

NGO—Non-Governmental Organization

NIFC—National Interagency Fire Center

NIR—Near Infrared

NMVOC—Non-Methane Volatile Organic Compound

NOAA—National Oceanic and Atmospheric Administration

NOS—New Observing Strategy

NOx—Nitrogen Oxides

NPP—National Polar-orbiting Partnership

NSRC—National Suborbital Research Center

OCEANOS—Ocean Community Engagement and Awareness using NASA Earth Observations and Science for Hispanic/Latino Students

OCO-2/3—Orbiting Carbon Observatory 2/3

OCONUS—Outside Contiguous United State

OMI—Ozone Measuring Instrument

OMPS-NM—Ozone Mapping and Profiler-Nadir Mapper

OMPS—Ozone Mapping and Profiler Suite

ORACLES—ObseRvations of Aerosols Above CLouds and their IntEractionS

OSSE—Observing System Simulation Experiment

PACE-PAX—Plankton, Aerosol, Cloud, ocean Ecosystem Postlaunch Airborne eXperiment

PACE—Plankton, Aerosol, Cloud, ocean Ecosystem

PICARD—Pushbroom Imager for Cloud and Aerosol Research

PINN—Physics Informed Neural-Network

PPT—Precision Pressure Transducer

PSM—A Professional Science Master's Degree

QGIS—Quantum GIS (open-source software)

QOS—Quadrennial Ozone Symposium

REDD+ —A voluntary climate change mitigation approach that has been developed by Parties to the UN Framework Convention on Climate Change (UNFCCC). It aims to incentivize developing countries to reduce emissions from deforestation and forest degradation, conserve forest carbon stocks, sustainably manage forests and enhance forest carbon stocks

ROSES – Research Opportunities in Earth and Space Science

RRNES—Rapid Response and Novel research in the Earth Sciences

RSAM—Remote Sensing of Animal Movements

RT—Radiative Transfer

SAA—Space Act Agreement

SABRE—Stratospheric Aerosol processes, Budget and Radiative Effects

SARP—Student Airborne Research Program

SATCOM—Satellite Communications

SAV—Submerged Aquatic Vegetation

SBIR—Small Business Innovation Research

SEA—South East Atlantic

SEP—South East Pacific

SISTER—Space-based Imaging Spectroscopy and Thermal pathfinder

SMD—Science Mission Directorate

STEM—Science, Technology, Engineering, and Math

STM—Science Team Meeting

STMD—Space Technology Mission Directorate

SWAP—Smaller Weight And Power

SWIR—Short Wave Infrared

TASNPP—Terra-Aqua Suomi-NPP

TCCON—Total Carbon Column Observing Network

TEMPO—Tropospheric Emissions: Monitoring Pollution

TFRSAC—Tactical Fire Remote Sensing Advisory Committee

TLE—Two Line Element

TOA—Top-Of-Atmosphere

TRACER—Tropospheric Regional Atmospheric Composition and Emissions Reanalysis

TROPOMI—The TROPOspheric Monitoring Instrument

UAS—Unmanned Air Systems

UNDP—United Nations Development Programme

US AON—United States Arctic Observation Network

USDA—U.S. Department of Agriculture

USDA-ARS—US Department of Agriculture, Agricultural Research Services

USDA-FS—US Department of Agriculture, Forest Service

USDA-NRCS—US Department of Agriculture Natural Resources Conservation Service

USFS—The United States Forest Service

USGS—United States Geological Survey

VIIRS—Visible Infrared Imaging Radiometer Suite

VIS—Visible Infrared Spectrum

VOC—Volatile Organic Compounds

VOCALS—VAMOS Ocean-Cloud-Atmosphere-Land Study Regional Experiment

WDTS—Western Diversity Time Series

WFF—Wallops Flight Facility

WRF-Chem/DART—Weather Research and Forecasting model coupled to Chemistry

WRF—Weather Research and Forecast

WWAO—Western Water Applications Office

WWF—World Wildlife Fund