Annual Progress Report

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July 31, 2024

ARC-CREST

Ames Research Center Cooperative for Research in Earth Science and Technology

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Report Period of Performance 10/1/23–9/30/24

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California State University at Monterey Bay
NASA Ames Research Center—Earth Sciences Division

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Other Partners

California State Parks, Division of Boating and Waterways (DBW)	Caudill, Jeffrey Gustafson, Guphy Hard, Edward
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Desert Research Institute	Giordano, Marco Wilcox, Eric
Impossible Sensing	Hyman, Cody Rehnmark, Fredrik Sobron, Pablo
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Jet Propulsion Laboratory	Altinok, Alphan Davidson, Mark Fasson, Renato Granger, Stephanie Hobbs, Jon Jenkins, Amber Laughner, Josh Liu, Junjie McDuffie, James Natraj, Vijay Nelson, Rob Nguyen, Hai

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Woods Hole Oceanographic Institute (WHOI)	Bell, Tom Houskeeper, Henry

INTRODUCTION

On page 14 of the Cooperative Agreement for the Ames Research Center Cooperative for Research in Earth Science and Technology (ARC-CREST), the Required Publications and Reports section states that a progress report is due annually, 60 days prior to the anniversary date of the grant/cooperative agreement.

Accordingly, we present a progress report for the first year (2023–24) of this Cooperative Agreement.

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. As shown in this report, the current ARC-CREST participants, the Bay Area Environmental Research Institute and California State University Monterey Bay, achieved each of these objectives during the first year of the renewed ARC-CREST cooperative agreement.

For 2023–24, the ARC-CREST scientific team, working closely with the NASA Ames Earth Science Division, will participate in nearly 50 project areas covering the gamut of Earth science research. Below, please find descriptions of each of the project's 2023–24 accomplishments.

Robert W. Bergstrom, Ph.D., J.D.
Director of Research, Bay Area Environmental Research Institute

FLIGHT

AirSHARP3

Project Participants

BAERI: Samuel LeBlanc, Kristina Pistone, Ivan Sirio

Project Description

This project supports the PACE (Plankton, Aerosol, Cloud, ocean Ecosystem) Validation Science Team (PVST) by deploying an airborne radiometer package. The radiometers, 4STAR+C-AIR (Sky-Scanning, Sun Tracking Atmospheric Radiometer; Coastal Airborne In-situ Radiometers), will produce repeated validation measurements of the Hyperspectral Aerosol Optical Depth, its derived properties,- and water leaving radiances spanning a range of atmospheric conditions and optical water types. We intend to deploy this airborne sensor package on the Naval Postgraduate School Twin Otter (NPS TO) platform along with the aligned field instrumentation for robust PACE Ocean Color Instrument (OCI) and advanced data products from OCI and polarimeter validation over relevant aquatic targets. Access to relevant matching/demonstrated field instrumentation for aquatics (e.g., University of California Santa Cruz (UCSC) Compact Optical Profiling System (C-OPS) and Hyperspectral Profiling Radiometer (HyperPro) with in-water sampling from a vessel), and atmospheric (AErosol RObotic NETwork (AERONET), rooftop Cimel at ARC, and Microtops II) will coincide with airborne overflights and PACE overpassess +/- 1 hr. The study area is along the California coast that has been covered in past NASA Coastal and Ocean Airborne Science Testbed (COAST), Hyperspectral Infrared Imager (HyspIRI), Ocean Color Ecosystems Assessment using Novel Instruments and Aircraft (OCEANIA), and Coastal High Acquisition Rate Radiometers for Innovative Environmental Research (C-HARRIER) campaigns (Kudela et al. 2015, Guild et al., 2020; Hooker et al., 2020, Houskeeper et al., 2021).

This portion of the project supports the 4STAR implementation on board the Twin Otter, the data collection efforts, and the data archive for PACE product validation.

Accomplishments

- Start of project, planning, and scheduling
- 4STAR (A+B) radiance calibration at the Airborne Sensor Facility
- 4STAR-B fiber optic clamping refinement and instrument upgrade
- Successful deployment of 4STAR (A+B) at Table Mountain Facility (TMF) operated by the Jet Propulsion Lab in Southern California for direct irradiance calibration (Langleys)
- Start of airworthiness process with student intern - Ivan Sirio

Outreach and Community Service

Summer intern calibration experience at TMF, for Fire & Air (a Multidisciplinary drifting Observatory for the Study of Arctic Climate (MOSAIC) program) students (Eddy Alderete, Allen Rosales) from California State University at Stanislaus (CSUStan), led by Kristina Pistone

ASP Advanced Planning

Project Participants

BAERI: Brenna Biggs, Gary Ash
NASA: Matt Fladeland

Project Description

Airborne Science Program (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, science value compilations, and other internal reports.

Accomplishments

- Made monthly updates of ASP 5-year plan, and developed individual plans for each Earth Science Division (ESD) Program.
- Sent weekly updates regarding ASP activities.
- Published the NASA ASP FY23 Annual Report.
- Published the NASA ASP 2022 Needs Assessment.
- Published the Fall 2023 and Spring 2024 ASP Newsletters.
- Participated in Earth Science Division (ESD) and Decadal Survey community workshops.
- Participated in Ames Airborne Science division semi-monthly meetings.

Earth Observing System (EOS)

Project Participants

BAERI: James Jacobson, Dr. Edward Hildum, Rose Dominguez, Paul Windham, Thomas Ellis, Jeff Grose, Jason Chang, Nikolas Gibson, 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/).

Accomplishments

- Participated in field activities for the Western Diversity Time Series (WDTS) Spring 2023 mission, observing California's ecosystems and providing critical information on natural disasters such as volcanoes, wildfires, and drought. It will provide a benchmark on the state of the ecosystems against which future changes can be assessed. The MODIS/ASTER Airborne Simulator (MASTER) collected 111 flight tracks over 12 field sorties for this mission.
- Participated in field activities for the Geological Earth Mapping Experiment/Earth Mapping Resources Initiative (GEMx/EMRI) Summer 2023 mission to map critical minerals over much of the western United States. MASTER collected 102 flight tracks over 11 field sorties for this mission.
- Participated in field activities for the FireSense 2023 mission as part of a larger NASA-wide Wildland Fire Initiative involving the Science Mission Directorate (SMD), the Aeronautics Research Mission Directorate (ARMD), and the Space Technology Mission Directorate (STMD) to provide unique Earth science and technological capabilities to operational agencies, striving towards measurable improvement in US wildland fire management. MASTER collected 174 flight tracks over 11 field sorties for this mission.
- Successfully integrated MASTER onto a new airborne platform, the NASA B-200 (#801), in support of the NASA FireSense mission
- Participated in field activities for the WDTS Spring 2024 mission, observing California's ecosystems and providing critical information on natural disasters such as volcanoes, wildfires, and drought. It will provide a benchmark on the state of the ecosystems against which future changes can be assessed. MASTER collected 39 flight tracks over 4 field sorties for this mission.
- Participated in field activities for the GEMx/EMRI Spring 2024 mission to map critical minerals over much of the western United States. MASTER collected 245 flight tracks over 26 field sorties for this mission.
- Coordinated the co-characterization of the ASF Calibration lab with the Radiometric Calibration Laboratory at NASA Goddard.

- Spectrally and radiometrically characterized the Pushbroom Imager for Cloud and Aerosol Research (PICARD) instrument with the Radiometric Calibration Laboratory at NASA Goddard, resulting in more comprehensive understanding of PICARD spectral response functions

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 (SMD) 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 Earth Observing System 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.

Accomplishments

- Supported the following research campaigns under the Ames Research Center Cooperative for Research in Earth Science and Technology (ARC-CREST) agreement:
    - ACCLIP (Asian Summer Monsoon Chemical & CLimate Impact Project) is a joint venture between NASA and the National Center for Atmospheric Research (NCAR). Two aircraft (the NASA WB-57 and the NCAR G-V), outfitted with state-of-the-art sensors, and approximately 80 scientists from the US and other international research organizations participated in the ACCLIP deployment from Osan Air Base in South Korea in the summer of 2022. Integration and test flights were successfully completed at NASA Johnson Space Center (JSC) in the summer of 2022. NASA WB-57 completed 16 science flights and NCAR G-V completed 14 science flights. The field campaign was successfully completed in September 2022 at Osan Air Base.

- CPEX-CV (Convective Processes Experiment – Cabo Verde) is a continuation of the truncated CPEX–Aerosols and Winds (CPEX-AW) field program flown out of St. Croix, US Virgin Islands, between 17 August and 10 September 2021. As in CPEX-AW, CPEX-CV flew the NASA DC-8 medium-altitude aircraft equipped with a suite of remote sensors and dropsonde-launch capability that allowed for the measurement of tropospheric aerosols, winds, temperature, water vapor, and precipitation. CPEX-CV operated out of Sal Island, Cabo Verde, the location originally intended for CPEX-AW, between 1 and 30 September 2022. The overarching goal of CPEX-CV is to investigate atmospheric dynamics, marine-boundary-layer properties, convection, the dust-laden Saharan Air Layer, and their interactions across various spatial scales to improve understanding and predictability of process-level lifecycles in the data-sparse tropical East Atlantic region.

- Managed the following Earth Venture Suborbital-3 (EVS-3) Missions:

  - IMPACTS (Investigation of Microphysics and Precipitation for Atlantic Coast–Threatening Snowstorms) is a multi-NASA-center project studying the formation of snow bands in East Coast winter storms in order to improve forecasts of extreme weather events. This study involves flights of NASA's ER-2 and P-3 aircraft over the northeastern United States. Deployments were successfully completed out of Pope Army Airfield and Wallops Flight Facility (WFF) from January to March, 2022. This second-year field campaign had been scheduled for 2021 but was postponed to 2022 because of the COVID-19 pandemic. The team is currently planning to deploy the ER-2 out of Dobbins Air Reserve Base in Georgia, and the P-3 will operate out of NASA WFF in early 2023 for the final year of the field campaign.

  - S-MODE (Sub-Mesoscale Ocean Dynamics Experiment) is a multiyear project exploring the potentially large influence that small-scale ocean eddies have on the exchange of heat between the ocean and the atmosphere. The experimental region is located in the San Francisco Bay Area, with NASA aircraft operations based at Moffett Field at Ames Research Center. The first deployment (Pilot Campaign) was completed in November 2021. The participating platforms were the NASA AFRC B-200, a Twin Otter, the Research Vessel Oceanus, as well as ocean surface drifters, wave gliders, and saildrones. Most of the mission-planning and control-center operations were done remotely, showcasing the team's resiliency. The team completed IOP-1 (intensive observation period-1) in November of 2022. An open data workshop was conducted in December of 2022. The third and final deployment (IOP-2) took place in Spring 2023.

  - DCOTSS (Dynamics and Chemistry of the Summer Stratosphere) is a five-year NASA project investigating how strong summertime convective storms over North America can change the chemistry of the stratosphere. Aircraft operations were based in Salina, Kansas, with the NASA ER-2 aircraft. The first deployment was successfully completed in the summer of 2021 after a yearlong postponement because of the COVID-19 pandemic. The second and final deployment was in the spring and summer of 2022. The science teams are heavily engaged in data analysis, and an open data workshop took

place in December 2022. A hybrid science team meeting took place in January 2023 in College Station, Texas, to discuss the most recent findings.

- Supported the following meetings—meetings were hybrid except as noted:
- CAMP2Ex (Cloud, Aerosol and Monsoon Processes Philippines Experiment) Science Team Meeting, Pasadena, California.
- IMPACTS (Investigation of Microphysics and Precipitation for Atlantic Coast–Threatening Snowstorms) Science Team Meeting, Boulder, Colorado.
- CPEX-CV (Convective Processes Experiment–Cabo Verde) Science Team Meeting, Pasadena, California.
- ICAP 10 (International Cooperative for Aerosol Prediction), Monterey, California.
- ESI SET (Earth Surfaces and Interior, Solid Earth Team) meeting and early career workshop, La Jolla, California.
- ACCLIP (Asian Summer Monsoon Chemical & Climate Impact Project) STM (Virtual).
- S-MODE (Sub-Mesoscale Ocean Dynamics Experiment) (Virtual).
- TEMPO (Tropospheric Emissions: Monitoring Pollution) Science Team Meeting (Virtual).
- MACIE (Measurements of Aerosols, Clouds and their Interactions for ESMs) monthly meetings (Virtual).
- AGAGE 65 (Advanced Global Atmospheric Gases Experiment) Technical Session, Dübendorf, Switzerland.
- NDAAC (Network for the Detection of Atmospheric Composition Change) Steering Committee Meeting, Paris, France.
- NASA SMD Wildfire Stakeholder Engagement Workshop (Virtual).

Meteorological Measurement System (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 (P), static temperature (T), and 3D winds on a number of NASA airborne research platforms, including the unmanned aerial vehicles Global Hawk and Sierra, and the aircraft 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 the 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.

Accomplishments

- Re-processed and re-submitted revised MMS data from seven flights of the Dynamics and Chemistry of the Summer Stratosphere (DCOTSS) 2021 mission to the NASA Langley data archive. On the remaining flights, no revision was necessary.

- Calibrated MMS maneuvers and Stratospheric Aerosol processes from the Asian Summer Monsoon Chemical and Climate Impact Project (ACCLIP), and completed the test flight series for the Stratospheric Aerosol processes, Budget and Radiative Effects (SABRE) project. This included four ACCLIP flights from August 2021 and seven SABRE flights from February 2022, flown on the WB-57 aircraft based out of Ellington Field near Houston, Texas.

- Determined ideal Mach and altitude flight conditions for MMS maneuvers during DCOTSS-2022, based on common ER-2 flight patterns executed during the 2021 campaign. The quality of maneuvers was evaluated in real time to assess the necessity of repeat execution, and we updated calibration constants for the 2022 campaign. Analysis of MMS temperature data helped determine whether glitch storms were generated by the Tfast probe, its attached amplifier, or by a faulty wiring harness within the aircraft body.

- Identified ideal Mach and altitude flight conditions for MMS maneuvers during ACCLIP, based on WB-57 flight patterns executed during the ACCLIP-2021 and SABRE test flight series. We identified glitch storms in temperature data on a subset of science flights flown from Osan, South Korea, and developed filtering algorithms to mitigate impact on temperature accuracy.

- Analyzed in-flight calibration maneuvers of WB-57 MMS data from the ACCLIP mission, and updated statistical modeling of individual flight calibrations in order to determine continuous calibration functions needed through the flight envelope. Applied redundant measurements to reconstruct missing or errant data, and reprocessed and archived final MMS data to the Langley project data archive.

- Evaluated laboratory data obtained from immersed bath calibration of four Rosemount fast temperature probe/amp assembly pairs at an Armstrong Flight Research Center (AFRC) test facility. Checked experimental data for self-consistency and discussed results with the Primary Investigator as needed. Obtained and analyzed corrected bath values and applied curve fits to produce accurate voltage-to-temperature conversions for later data reduction of DCOTSS-2022 flight temperature data.

- Monitored WB-57 MMS data quality during the SABRE mission in early 2023. Identified ideal Mach and altitude flight conditions for MMS maneuvers during the campaign. Examined science flight data for ongoing proper operation of MMS analog/digital sensors and inertia navigation systems.

- Responded to researcher questions about the strengths and limitations of MMS turbulence data and calculation methods from prior field campaigns (e.g., Fire Influence on Regional to Global Environments Experiment-Air Quality (FIREX-AQ), DCOTSS, and ACCLIP).

NSRC

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

The National Suborbital Research Center (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 (ASP). 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. NSRC also supports the ASP with engineering expertise in a variety of areas, currently in support of ASP's new Boeing 777 platform.

- Communications and Training

The ASP 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.

Accomplishments

Boeing 777- Specific Engineering and Data/Satellite Communications (Satcom System) Accomplishments:

- Continued support on multiple electrical and mechanical subsystem designs
- Continued to pursue information about APN-232 (a solid-state radar altimeter system) refurbishment
- Complete design of CEIP; fabrication initiated
- Completed 777 network patch panel design
- Continued design effort on 777 XCS - Need some vendor and fabrication information and more clarity on oxygen system
- Establishing methodology to publish parts to the Vault Content Center
- Completed power distribution final engineering review
- Completed data system final engineering review
- Scope of Work for XCS/conference table fabrication is currently in work
- Supported dry-run and final engineering review of the integrated circuits (ICs)
- Continued effort on 777 XCS design
- Completed working Change Order (CO) process for the 777 Vault
- Supported ongoing wiring installation
- Completed network patch panel designs currently being fabricated
- Completed cargo bay wall CEIP interface design. Made a prototype and test fitted. Talked to Langley Research Center (LaRC) maintainers about installation
- Interfaced with FMS regarding housekeeping rack design; provided feedback and recommendations
- Interfaced with HII, the contractor installing wiring bundles and associated hardware in the 777, about disconnect panels and wire routing for XCS
- Working with Wallops Flight Facility (WFF) software personnel to resolve some issues with the Vault release process impacting 777 drawings
- Supported radio frequency (RF) FER dry run
- Supported 777 forward fuselage viewport NRE kickoff with L3Harris, the contract provider

- Supported laser scan of forward cargo compartment and main cabin window areas to facilitate structural analysis of proposed nadir ports and window modifications to accommodate existing interface hardware currently flown on the DC-8
- Attended viewport system requirements review (SRR) at L3
- Helped HII and others to resolve questions as they arose
- Resolved issue of the network patch panels missing some components that hadn't been ordered
- Tried to get overlays/decals made, surprisingly difficult but developed a solution
- Completed MPA disconnect design, now released and ready for fab
- Developed solutions for the conference table and updated XCS design
- Interfaced with HII, updated drawings as required
- Network patch panel production complete. Finally got those overlays figured out. Should've been way easier than it was
- Went to LaRC, participated in nadir viewport cloud detection and response (CDR), visited the Makerspace, took some measurements for XCS/conference table (oxygen tank mounting and routing). Suggested redesign of viewport Shutter Control Panel user interface
- Updated design of conference table to use commercial orbital transportation services (COTS) legs. Redesigned floor adapter plates to be smaller pieces that dovetail together.
- Updated XCS design to use panel sizes that FMS has in stock, and also to reduce assembly complexity to match FMS capabilities. Added some more space on the Dzus rails, and the middle screen is now larger
- Revised MPA overhead disconnect design to make it more manufacturable for our vendors
- Revised WAP mounting plate to add labels. Plate is now being manufactured
- Helped LaRC figure out the transfer to the LaRC Vault server
- Assisted multiple engineers with Engineering Orders and releases
- Kicked off XCS analysis and fabrication contract
- Contributed design suggestions for HK Rack Preliminary Engineering Review (PER), analysis now underway
- Helped relocate 777 Vault from the WFF server to the LaRC server. Still making ongoing changes and working out the kinks

- Multiple LaRC activities on infrastructure including interfacing with HII contractor and helping with Network Patch Panel installation
- Participated in bi-weekly engineering meetings along with various engineering reviews
- Redesigned floor adapter plates to be smaller pieces that dovetail together

Arctic Radiation-Cloud-Aerosol-Surface-Interaction Experiment (ARCSIX) support:

- Sent the NSRC data requirements to each instrument team prior to anticipated upload (25 March)
- Loaned Spec Inc. a Certus antenna
- Coordinated with SPEC to consider satellite jpegs/radar data from their aircraft to help coordinate flights. Lear radar is a Ka-Band precip radar from ProSensing
- Near Real Time latency—the latency for Moderate Resolution Imaging Spectroradiometer (MODIS)/Visible Infrared Imaging Radiometer Suite (VIIRS) is actually 1–2 hours (it was higher last year but I believe they've now moved fully/mostly to the cloud) so definitely worth looking into
- Utilize weather radar data at Pituffik, Villum, and Svalbard
- Accommodate in-flight changes; worked to determine how we can have folks on the ground help communicate/redirect aircraft
- On site at WFF every week during ongoing payload installations
- Continued to prepare for the ARCSIX airborne campaign this summer in Pituffik, Greenland. Deployment dates: 5/24–6/17/2024 and 7/22 – 8/16/2024.

P-3 aircraft Specific Engineering and Data/Satcom System Accomplishments

- Reinstalled all associated NSRC equipment in the P-3 following major maintenance

Miscellaneous & ASP Data Management Activities

- Extensive work to relocate NSRC equipment from Palmdale to other locations
- Worked to remove NSRC equipment from the DC-8 following return from Airborne and Satellite Investigation of Asian Air Quality (ASIA-AQ) mission prior to aircraft being excessed
- Deployed sentinel one to all computers in prep for dropping symantec
- Working to archive and kill modem servers
- Replaced dead hard drive on aspfaa00
- Initiated and continued plan for rack-redesign

- Initiated and continue moving asp-interface container into production
- Worked with the C-20 to ease their transition into a commercial Iridium contract for their 9575 handset (phone)
- Started work on porting archiver code to containerized archiver model
- Continued working to move from hardware to container asp-archive
- Rebuilding staff member laptop
- Recertified an engineer for harness fabrication and soldering
- Killed modem servers
- Continued work on porting archiver code to containerized archiver model
- Updated IT equipment in accordance with Canadian Space Agency (CSA) duties
- Installed remote management access to allow for remote login at the console as well as power systems on and off
- Supporting ER-2 aircraft remotely for the Airborne Multiangle SpectroPolarimetric Imager (AirMSPI) and Airborne Hyper-Angular Rainbow Polarimeter (AirHARP) campaign
- Supported NASA Biodiversity field campaign in the Greater Cape Floristic Region of South Africa (BioSCape) as required
- Working with Armstrong Flight Research Center (AFRC) to facilitate the transfer of property from Palmdale (PMD)
- Finished an Ubuntu Auto-Installer for Dell Servers
- Installed a NASA Advanced Supercomputing (NAS) for Mission Tools Software (MTS) to effect backups and deep storage. This increases the storage available for MTS to 56TB of Redundant Arrays of Inexpensive Disks (RAID) and six protected hard disk drives (HDD) storage
- Installed the tape robot for NSRC/ASP, the robot is not yet configured, but it's in the rack. This tape robot has been a long time in coming but we haven't had physical space for it until recently. It'll hold 27-12TB tapes and act as a deep backup for all of our storage
- Preparing to transfer all Student Airborne Research Program (SARP) related equipment and supplies to the new project manager
- Submitted Investigation of Microphysics and Precipitation for Atlantic Coast–Threatening Snowstorms (IMPACTS) ER2 aircraft Navigation dataset to Global Hydrometeorology Resource Center (GHRC)
- Working ASP 2023 inputs

- Wrapped up presentation for American Geophysical Union (AGU)
- Submitted multiple recommendation letters for SARP 2023 students
- Got an updated NextGen NASDAT image running on the DC-8 backup NASA Airborne Science Data and Telemetry System (NASDAT); conducted initial testing
- Finally got the forward-looking infrared (FLIR) Nadir camera working reasonably well. Several lessons learned to carry forward to the 777 installation
- Spent a ridiculous amount of time determining that the lack of Iridium connectivity in Thailand was due to RF jamming from neighboring Myanmar. Several lessons learned with regard to Bluesky technical support and online RF jamming maps
- Getting situated into main campus at Edwards Airforce Base (EDW) from PMD
- CSA patching continues
- SARP campaign occurs 6/24–7/3 between Wallops Flight Facility and Ontario, California, flying on the P-3 with the ARCSIX payload and a Dynamic Aviation C-12
- Disassembled Reveal Boxes
- Took apart the DC8 Housekeeping rack
- Major effort in identifying equipment/aircraft components in PMD for excess or transfer to other centers
- Software research with ext4 mounting on Windows
- Wired second smart power and data units (PDU) into NSRC rack at ARC
- Load balanced the electrical load across two whips, across two uninterruptible power supply (UPS), across two PDUs
- Physically moved all but one MTS server into NSRC rack
- Updated an MTS server to most recent operating system (OS) allowed by NASA
- Compliance stuff across the board
- Continued effort on ASP Space Station Program (SSP)
- Worked to get Personal Identity Verification-Secure Shell (PIV-SSH) remote access working for Geological Earth Mapping Experiment (GemX)
- Pulled old modem server out of the rack and made space

- Rearranged power in NSRC rack so everything has one plug on either smart PDU allowing remote power on/off by logging into both PDUs and turning independent power supplies on/off
- Had an issue with asp-archive not wanting to spin up a disk, fixed the disk
- Started development on a modernization effort for our container system
- Got an updated NextGen NASDAT image running on the DC-8 backup NASDAT, conducted initial testing.
- Gained access to EDW hanger and completed hydrazine training
- Working with Pat to get our systems compliant (no network block)
- Continued working usual Ames power outage and other facility issues
- Continuing education on our container system to modernize development operations architecture for MTS (will trickle into ASP as well)
- P-3 stress analysis re-do is complete

Projects and Missions Supported by Service Management Office (SMO) AEROMMA Support

- Supported all flights with data system operator
- Wrapped up Atmospheric Emissions and Reactions Observed from Megacities to Marine Areas (AEROMMA) campaign
- Working on fixing IG1 Timestamps
- Working data management, reporting, and archiving issues
- Continuing to correct the forward aircraft video from AEROMMA/EcoDemonstator (EcoD) aircraft

ARCSIX support

- Coordinated data requirements for each instrument team prior to anticipated upload (25 March)
- Loaned SPEC a Certus system
- Worked with SPEC to consider satellite jpegs/radar data from their aircraft to help coordinate flights. Lear radar is a Ka-Band precip radar from ProSensing
- Worked near real-time latency - the latency for MODIS/VIIRS is actually 1–2 hours
- Utilize weather radar data at Pituffik, Villum, and Svalbard

- Accommodate in-flight changes; worked to determine how to have folks on the ground help communicate/redirect aircraft
- Coordinated ARCSIX integration prep. Convened meetings with experimenters to resolve questions they had regarding the data system and requirements
- Verified the P-3 experimenter interface panels were reinstalled correctly on the aircraft
- The USB to Ethernet dongles that we have in the WFF lab only support Windows OS, so purchased a spare network adapter
- Prepared for Langley Aerosol Research Group Experiment (LARGE) and discovery and systems health (DASH) installation
- On site at WFF every week during ongoing payload installations
- Continued to prepare for the ARCSIX airborne campaign this summer in Pituffik, Greenland. Deployment dates: 5/24 – 6/17/2024 and 7/22 – 8/16/2024

Integration activities

- Began program requirements gathering back in Jan/Feb; continued during integration window
- Installed NASDAT SN002 onto the P3
- Reconfigured NASDAT software to properly ingest ARINC-429 (data transfer system) and App development challenge (ADC)
- Routine housekeeping on the P3 data system
- Instrument/aircraft network checks
- Met with Chief Information Security Officer (CISO) IT Security point of contact who visited Wallops to meet with David and Ryan
- ARINC-429 signal to Solar Spectral Flux Radiometer (SSFR) instrument rack
- Resupplying the NSRC fly-away kit and packing instrumentation/data system spares for Greenland
- Built some RJ45 cables proving that we can build cables that work
- Verified the Skylink Voice over internet protocol (VoIP) procedure; generated a “how to” guide for WFF support
- Coordinated ARCSIX integration prep. Convened meetings with experimenters to resolve questions they had regarding the data system and requirements
- Verified the P-3 experimenter interface panels that were reinstalled correctly on the aircraft

- The USB to Ethernet dongles that we have in the WFF lab only support Windows OS, so purchased a spare network adapter
- On site every week during ongoing payload installations.

ecoDemonstrator (ecoD) Support

- Gathering customer requirements for the DC-8 data system
- Worked scripting for recording data
- Continued gathering ongoing customer requirements as payload arrived for integration for the DC-8 data system
- Added new requirements for pilot and customer displays
- Supported mechanical integration to support customer needs
- Updated the plume prediction software for aircrew utilization
- Completed customer payload requirements for DC-8 data system
- Improved Tradespace Analysis Tool (TAT) data support with new hardware
- Validated both new pilot and customer displays
- Validated scripting for recording data
- Integrated customer payload interface requirements into the aircraft system including preparing the data servers to manage experimenter requirements
- Finalized payload mechanical integration to support customer needs
- Received laudatory feedback on the utility of the plume prediction software
- Installed multiple improved camera systems on the aircraft to enhance aircrew situational awareness during formation flight with both nadir and 45-degree cameras
- Prepared our data server to handle all experimenter requirements
- Provided on-aircraft data system operation and quick dataset release support for all 11 ecoDemonstrator flights
- Prepared EcoD videos for public distribution
- FireSense Support
- Purchased equipment; creating software to enable x-chat and tracking for LaRC, AFRC, Dynamic Aviation’s C-12 as well as the C-20 during the mission
- Completed design and initiated fabrication of units

- Geological Earth Mapping Experiment (GEM-X) Support
- Verified network and data system integrity following GEM-X
- Reconfigured Inmarsat canoe
- Configured Skylink
- Worked payload interfacing
- Configuring instrument telemetry
- Migrating instrument teams to PIV SSH
- Supported all flights with data system operator
- Worked issues with global positioning system (GPS) timing
- Replaced NASDAT at first available opportunity to resolve issue
- Continued working Skylink issues
- Resolved ongoing interface issues
- Tested NASDAT network time protocol (NTP) to fix time
- Set up network packets for Airborne visible/infrared imaging spectrometer (AVIRIS) and the MODIS/Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) Airborne Simulator (MASTER)
- Debugged NASDAT and tracker issues
- PIV authentication to asp-interface
- Security scan of 809 systems

High Altitude Water Cherenkov Observatory (HAWC) Support

- The HAWC campaign consisted of two instruments, aerosol limb imager (ALI) and Spatial Heterodyne Observations of Water (SHOW). Airborne Multiangle SpectroPolarimetric Imager-2 (AIRMSPI-2) and Airborne Scanning Microwave Limb Sounder (A-SMLS) were not able to participate due to technical issues with their instruments. AIRMSPI-2 is expected to make a return with ALI as a piggyback
- ALI/SHOW concluded the HAWC campaign with three successful science flights. Post-flight aircraft data has also been submitted to them
- Networking issues resolved
- An uplink was set up for ALI/SHOW. This requires local forwarding via SSH

- Supported all flights
- Actively worked all Satcom data interface issues as they arose during or post-flight

ASIA-AQ support

- Assisted in aircraft load plan including payload layout for customer items in cargo bay to assist Earth Science Project Office (ESPO) in planning shipping needs to overseas locations
- Worked payload integration and data systems requirements
- Worked staffing plan including support and travel planning
- Resolved forward camera issues that appeared during ecoD
- Removed UPS for check prior to deployment
- Extensive exchange with multiple organizations to resolve requirements associated with the export of laptops Outside Contiguous United States (OCONUS)
- Supported installation of multiple payloads including fabrication of custom hardware
- Set up the PostGres database for experimenter packet downlink and uplink
- Worked with experimenters to ensure that packet definitions are of the correct format to send to our servers
- Flew on the initial test flight to establish issues that may occur. Corrected the parameter table and found the hygrometer was outputting incorrect data
- Worked Satcom, camera, and payload issues on flights from PMD to Hawaii and on subsequent flights to Guam and Clark Air Force Base
- Extensive ongoing support for all flight activities
- Rotating operators in/out of countries as required to support continued flight operations
- Routine exchange with multiple organizations to resolve ongoing payload requirements
- Continued working with experimenters to ensure that packet definitions are of the correct format to send to our servers
- Flew on all data flights and resolved issues as they occurred
- Resolving on-board camera issues to improve data quality and system utility
- ASIA-AQ ground-side mission support as necessary
- Security rollouts/updates/etc.

- Successfully created a mission Freeze for ASP systems for the duration of ASIA-AQ keeping us from having to update/reboot critical systems at inopportune times
- Requested plan of action and mitigation (POA&M) for several laptops while resolving necessary OS upgrades for Windows computers.
- Troubleshooting failure with an MTS server, pursuing resolution through Dell
- Extensive ongoing support for all flight activities in both Korea and Thailand
- Routine exchange with multiple organizations to resolve ongoing payload requirements

RESEARCH AND ANALYSIS

5STAR/Eng-Sci

Project Participants

BAERI: Conrad Esch, Stephen Broccardo

Project Description

The Ames Research Center (ARC) 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 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.

Accomplishments

Temperature stabilization of the InGaAs photodiodes and associated circuitry is critical to achieving consistent photodiode dark-current and measurement stability. Thermoelectric cooling was implemented on a metal block encasing the photodiodes and circuit board and tested in the laboratory. Disposal of waste heat from the measurement head was found to be an obstacle, and a heat pipe and water-cooling system was implemented. Different models of photodiodes with different spectral response characteristics were tested. For the long-wavelength (peak response 2.3 microns) photodiodes, dark currents were found to be related to system temperature by an exponential function, allowing corrections to be made to the measurement based on the measured temperature of the system. Photodiodes sensitive to shorter wavelengths (peak response 1.75 microns) show a linear relationship between dark current and temperature. This relationship is shown in the figure below left. The system was tested at two different temperatures (20.1°C and 22.4°C) using an integrating sphere, and corrections were made according to the modeled dark current. This correction scheme appears to work, as shown in the figure below right.

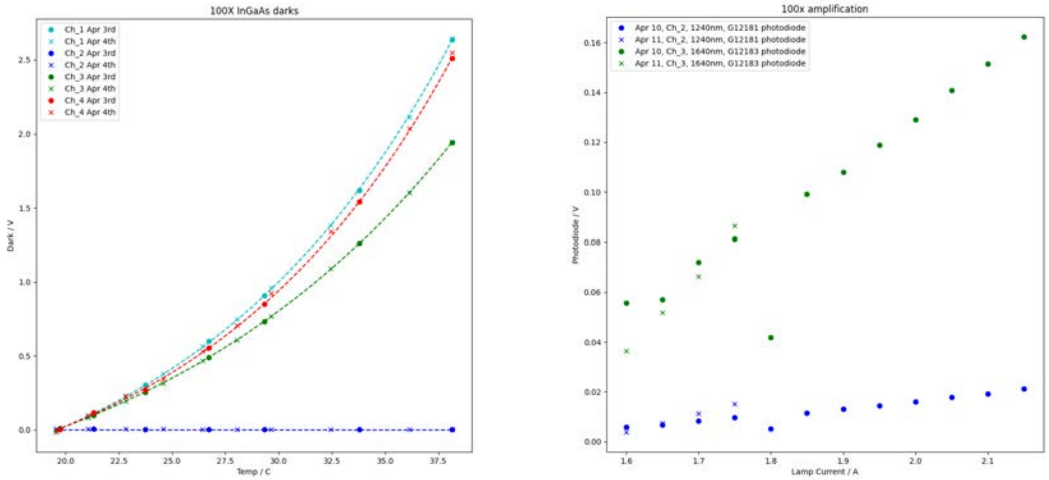


Figure 1: (Left): Dark current vs. temperature for two models of photodiode—green, red, cyan indicate photodiodes sensitive at 2.3 microns; blue indicates a photodiode sensitive at 1.75 microns. (Right): Response tests of the two models of photodiode on different days at different temperatures, indicate our ability to correct the measurements for changing dark currents.

ACCDAM Bio

Project Participants

BAERI: Kristina Pistone
Desert Research Institute (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 ObseRvations of Aerosols Above CLouds and their IntEractionS (ORACLES) airborne campaign in the SouthEast Atlantic (SEA) between 2016 and 2018 to observationally quantify the impact of water vapor under different aerosol conditions. The SEA stratocumulus clouds are seasonally subjected to biomass burning (BB) emissions advected from springtime agricultural fires in southern Africa, and the ORACLES campaigns saw a humid layer co-located with the BB plume. Studies of these two major atmospheric components, separately and 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 to gain a better understanding of the impacts of water vapor on cloud properties in the SEA stratocumulus regime, 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.

Accomplishments

- Extended the results of Pistone et al. (2021) to examine all three ORACLES deployments, including analysis of an additional atmospheric chemistry reanalysis (Copernicus Atmosphere Monitoring Service (CAMS)). Despite the differing locations and season of each deployment, we find that good agreement between the airborne ORACLES dataset and large-scale reanalyses continues, specifically the European Centre for Medium-Range Weather Forecasts reanalysis version 5 (ECMWF ERA5) and CAMS reanalyses. Other reanalyses (specifically NASA's Modern Era Retrospective—Analysis for Research and Applications 2 (MERRA-2)) preserved the observed correlation between meteorology and BB conditions, but were frequently displaced spatially, relative to the observations.

- Extended the results beyond BB tracers to consider reanalysis aerosol properties in CAMS and MERRA-2.

- Because of the good CAMS/ORACLES agreement, we examined multi-year seasonal patterns and trends beyond the three months with available aircraft data. We found distinct variations between each month/deployment in terms of vertical smoke distribution and correlation to atmospheric specific humidity, due to changing conditions over the BB season. Using k-means clustering of climatological data, we identified six canonical atmospheric profile types of varying total atmospheric humidity and vertical structure and described their overall incidence and spatial/temporal changes throughout the region and season.

- In progress: analyzing the broader radiative and dynamical implications of these results for conditions of aerosols overlying stratocumulus clouds. Radiative transfer calculations have been run based on the above canonical profiles, working towards an integrated radiative heating calculation for the region, and writing a publication by the end of the year (led by M. Giordano).

- In progress: identifying resulting cloud property distinctions between each of the canonical atmospheric profiles (both for water vapor and for BB tracer) across the region and the season.

Outreach and Community Service

- American Geophysical Union Local Science Partners (2021–present): AGU program to facilitate relationship-building between science experts and local policymakers https://thebridge.agu.org/2021/12/10/agu-welcomes-first-cohort-of-local-science-partners/.
- Sustainability Commissioner, Sunnyvale Sustainability Commission (June 2021–present), volunteer advisory position to city council regarding sustainability issues in the city of Sunnyvale. Media:
    - Engineers & Scientists Acting Locally: https://esal.us/climate-scientist-tackles-global-aerosols/.
    - BAERI podcast: https://medium.com/bay-area-environmental-research-institute/kristina-pistone-on-what-its-like-to-work-as-a-climate-scientist-d08410faffe6.
- NASA ARC Science Directorate Diversity and Inclusion Advisory Committee (April 2021–present).
- Earth Science Seminar Committee, NASA ARC (January 2021–July 2023).
- NASA Technical Review Committee for MUREP (Minority University Research and Education Project) Center for Advanced Measurements in Extreme Environments (CAMEE) project (June 2020–December 2022).
- American Geophysical Union Fall Meeting Program Committee (June 2020–January 2024), Atmospheric Sciences section. Chair, 2022–2023.
- Letters to a Pre-Scientist (Aug 2018–present): one-on-one pen-pal mentorship program for science classrooms in low-income schools.
- Skype a Scientist (May 2017–present): virtual interactions with groups and classes of K–12 students regarding atmospheric/climate science and scientific careers.

Aerosol Modeling & Data Analysis

Project Participants

BAERI: Qian Tan
NASA: Hongbin Yu

Project Description

Particulate matter (PM) or aerosol particles have large impacts on public health and climate. Aerosol particle size determines its health impacts, i.e., how far they can penetrate into the human respiratory system. Aerosol size is difficult to measure since each particle has a different size and an irregular shape. In the PM2.5 measurements, most instruments use a PM2.5 cyclone which is measured aerodynamically. In the aerosol models, its size is based on the

geometric measurement. In order to do a more consistent comparison, we reprocessed NASA Modern Era Retrospective—Analysis for Research and Applications 2 (MERRA-2) PM2.5 calculation based on the aerodynamic assumption. Comparison with EPA's global ground network at US Embassies yields better agreements in the dusty regions. This update will be useful to the public health community for estimating the PM2.5 impact on respiratory and pulmonary diseases.

Accomplishments

- Generated global PM2.5 dataset with both aerodynamic and geometric diameter for 2001–2023 based on NASA MERRA-2 simulation.
- Evaluated PM2.5 simulation with US Embassy measurements around the globe.
- Collected satellite measurements for fine and coarse dust analysis.

Aerosol Rapid Analysis Combined Entry Probe/Sonde Technology (AERACEPT)

Project Participants

BAERI: Caroline Dang
NASA: Diana Gentry, Andrew Mattioda, Laura Iraci
Impossible Sensing: Pablo Sobron, Cody Hyman, Fredrik Rehnmark

Project Description

AERACEPT (Aerosol Rapid Analysis Combined Entry Probe/Sonde Technology) is an early-stage technology that enables a single aeroshell body to act both as an entry vehicle and aerosol-sampling passive descent sonde. AERACEPT reduces the mass, volume, and complexity of planetary aerosol sampling by eliminating the need for heat shield separation, deployable parachutes, or other descent control. These features are well suited to a small spacecraft Venus cloud mission, where the particles of greatest interest are within the subsonic part of the descent. My project goal is to validate instrument viability for analyzing Venus aerosols.

Accomplishments

- Analyzed a suite of Venus aerosol analogs with Raman micro spectrometry
- Analyzed a suite of Surface Enhanced Raman Spectrometry (SERS) substrates for Raman
- Tested thermal and chemical stability of substrates
- Developed Python script for a region of interest and histogram analysis of images for Impossible Sensing Ultraviolet (UV) Fluorescence Instrument
- Onboarding Impossible Sensing Laser Induced Breakdown Spectroscopy (LIBS) instrument

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 (Interactive Data Language, Python), maintaining instruments, and scientific writing and presentations.

Since 2016, BAERI has been responsible for facilitating collaborations by 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. The project has been awarded four grants to deploy instrumentation on an Unmanned Air System (UAS) in Alaska, in a car, and on an aircraft, and to measure COS uptake from coastal redwood forests.

Accomplishments

- Co-investigator on NASA Earth Science Division, Atmospheric Composition Campaign Data Analysis and Modeling, Research Opportunities in Earth and Space Science (ROSES) 2020 Program Element A.23, NNH20ZDA001N-ACCDAM. Project Title: Solving the Mystery of the Disappearing Low Ozone Values: Attributing Ozone Trends over the Eastern Pacific Ocean and Western North America.
- Submitted a Notice of Intent for Virtual Institute for Carbon Cycle (VICC) call, title: "California current system: LInking Carbon Ocean-Atmosphere exchange (CALICOA)"
- Primary investigator for submitted NASA ROSES proposal NNH24ZDA001N-CSESP, A.50 Citizen Science for Earth Systems Programs title: "Ozone Measurements from General Aviation: Supporting TEMPO (Tropospheric Emissions: Monitoring Pollution) Satellite Validation and Addressing Air Quality Issues in California's San Joaquin Valley with Citizen Science."
- Maintained, calibrated, and serviced AJAX and Trace Gas Group (TGGR) instruments.
- Used AJAX wing pod instruments to cross-calibrate a number of low-cost sensors (Kristen Okorn, BAERI).
- Asian Summer Monsoon Chemical & CLimate Impact Project (ACCLIP) data analysis and manuscript preparation
- Total Carbon Column Observing Network (TCCON): maintenance, operation, and data analysis of the TCCON Armstrong site.

Arctic Observing Network (AON)

Project Participants

BAERI: Cindy Schmidt
NASA: Emily Sylak-Glassman

Project Description

The US Arctic Observing 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.

Accomplishments

- Attended monthly AON Board meetings.
- Connecting AON leadership with relevant NASA projects including the Arctic Boreal Vulnerability Experiment (ABoVE), the Indigenous Peoples program, the Ocean Biology and Biogeochemistry program.

Arctic Radiation Cloud Aerosol Surface Interaction Experiment (ARCSIX)

Project Participants

BAERI: Samuel LeBlanc

Project Description

The overarching goal of the Arctic Radiation Cloud Aerosol Surface Interaction Experiment (ARCSIX) is to quantify the contributions of surface properties, clouds, aerosol particles, and precipitation to the Arctic summer surface radiation budget and sea-ice melt during the early melt season (May through mid-July). This science-question-led mission will be based at Pituffik Space Base, (formerly Thule), in Greenland. Three aircraft, NASA P-3, NASA G-III, and the Spec Inc. Learjet, provide airborne platforms focusing on sampling sea ice, clouds, aerosols, and radiation in the Arctic Circle.

This project supports the ARCSIX field campaign with customized flight planning strategies for the airborne sampling platforms, NASA P-3, NASA G-III, and Spec Inc. Learjet, in coordination with satellite, ship-, and ground-based observing platforms.

Accomplishments

- Completed nine new software versions of the moving lines flight planning software.

- Added new capabilities to the bocachica server, to enable web map service for forecasted fields of meteorological parameters, and sea ice (European Centre for Medium-Range Weather Forecasts (ECMWF), Goddard Earth Observing System Forward Processing (GEOS-FP), Bremen sea-ice, NOAA Regional Arctic System Model (RASM).
- Completed Phase 1 of the ARCSIX deployment, May 24–June 17, 2024.
- Completed dry-run exercises (NASA Langley Research Center, July 2023; University of Colorado at Boulder, May 2023).

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) Meso-scale Cellular convection (MCC) cloud cells.

The project's objectives were to:

- Develop a new algorithm to classify MSC cloud cover and MCC 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 South-East Atlantic and South-East Pacific regions during the ObseRvations of Aerosols Above CLouds and their IntEractionS (ORACLES) and Vertiport Assessment and Mobility Operations (VAMOS) Ocean-Cloud-Atmosphere-Land Study Regional Experiment (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.

Accomplishments

- Developed a Day-Night (diurnal) cloud-type prediction model from The Spinning Enhanced Visible and InfraRed Imager (SEVIRI) Geostationary Imagery over the South-East Atlantic Ocean (Objective 1, manuscript I in prep.).

- Made key findings to be presented in paper publication, including:
    - Infrared (IR)-based model is more stable than Visible Infrared Spectrum (VIS)-based model and allows diurnal predictions of cloud MCC type (Fig. 1)

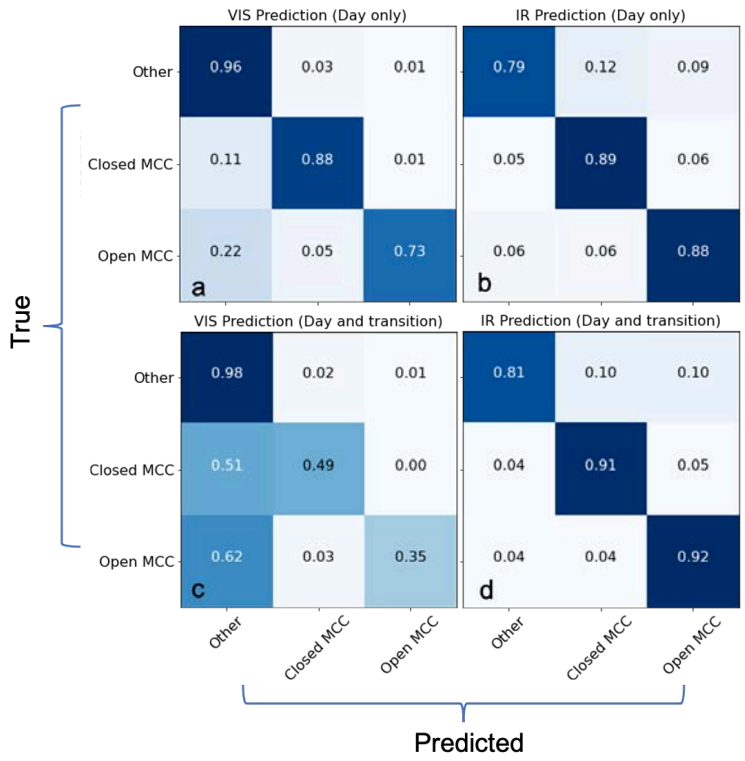


Figure 1: (a) confusion matrix results from visible imagery model predictions during day-time only, (b) confusion matrix results from infrared imagery model predictions during day-time only (c) similar to (a) but for day and transition (early morning and late afternoon) times, and (d) similar to (b) but for day and transition (early morning and late afternoon) times.

- MCC cloud variability during daytime is relatively small—more variability was observed for specific periods within the BB season (i.e. October is showing less Open MCC), and larger during night (Fig. 2)

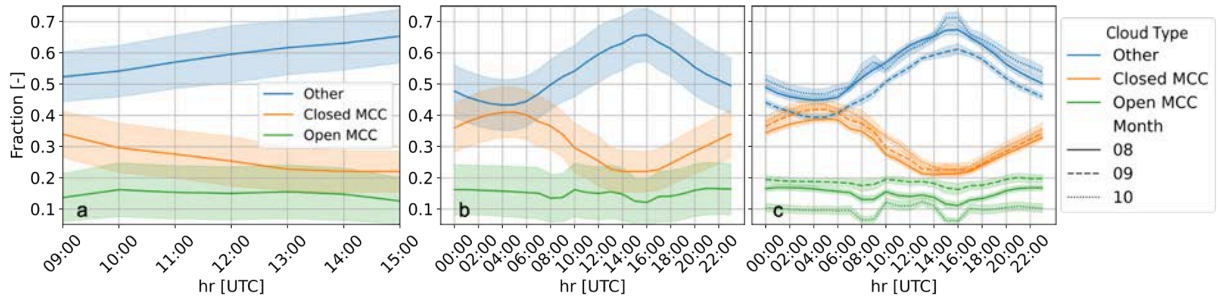


Figure 2: (a) time of day (daytime only) fractional amount (where fraction represents the number of pixels classified by a certain cloud type relative to the entire pixels over the research domain) for Closed, Open, and Other cloud types, (b) same as (a) but for the entire diurnal cycle, where shaded area represents the 95% confidence interval margin based on the data standard deviation per each class, and (c) diurnal variability similar to (b) but parsed for each month (class color is similar to previous panels and months marked by different line types).

- MCC cloud cover area generated by the new algorithm corresponds well in trends with previous observations but allows more clouds to be detected, compared to previous algorithms (Fig. 3)

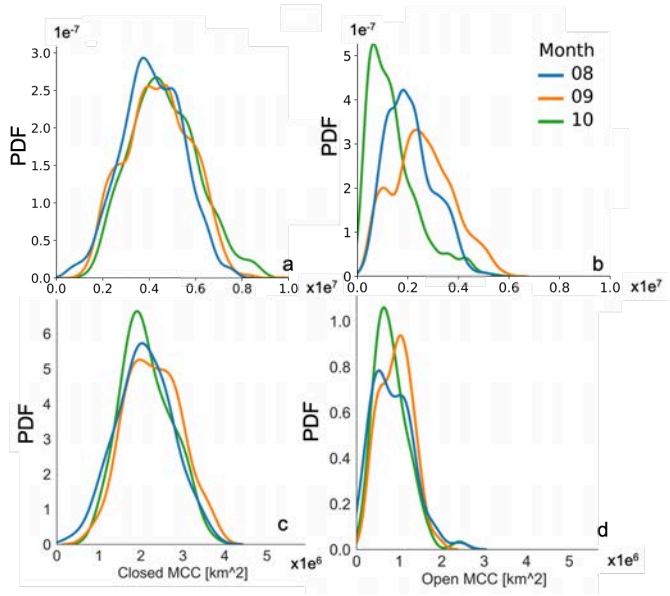


Figure 3: normalized probability density plots for (a) Closed MCC, and (b) Open MCC derived by the current algorithm from SEVIRI (integrating 30-min. predictions), (c) Closed MCC, and (d) Open MCC derived by Yuan et al. (2020) algorithm for Moderate Resolution Imaging Spectroradiometer (MODIS) daytime overpass.

- Vertical examination of collocated black carbon (BC) airborne measurements from ORACLES with our MCC cloud type classification over the South-East Atlantic is revealing a higher BC amount above Closed MCC types (Fig. 4)

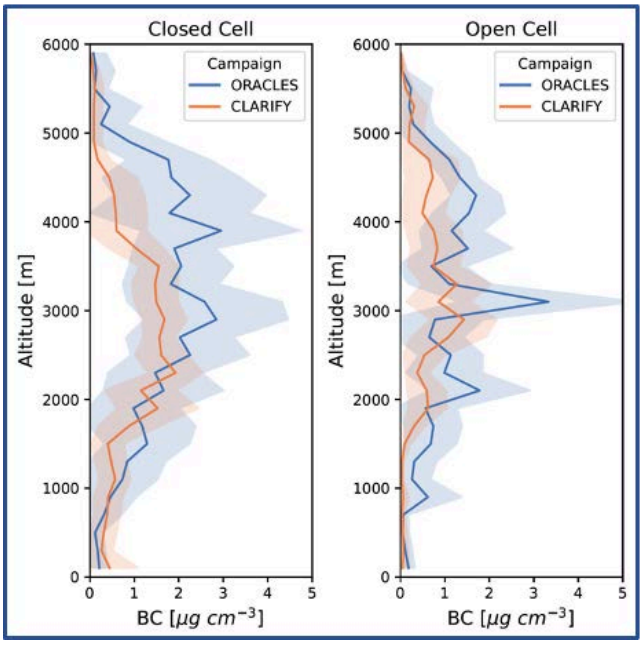


Figure 4:Black Carbon (BC) concentration along the vertical column from ORACLES airborne observations, collocated with cloud MCC type using Segal-Rozenhaimer et al. (in prep.) algorithm.

- Expanded the algorithm and successfully applied it on Geostationary Operational Environmental Satellite (GOES) imagery over the South-East Pacific Ocean (Objective 1, manuscript I in prep.).
- Used the algorithm in conjunction with the NASA ORACLES airborne campaign to study the link between cloud type and aerosol during biomass burning (Objective 2, manuscript II in prep.).

Atmosphere Observing System (AOS)

Project Participants

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

Project Description

The Atmosphere Observing System (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.

Accomplishments

- Designed and presented AOS suborbital workgroup slides for Mission Critical Review.
- Advocated for and defended the inclusion of an aerosol component as part of the planned suborbital effort.
- Joined Earthcare team on validation and lessons learned.

Panels or Committees

- Michal Segal Rozenhaimer is a science member of the AOS Science Applications and Transition Team (SATT), Aerosol, and Cloud, Convection, Precipitation (CCP) algorithm working groups, as well as organizer of cross-ESO (Earth System Observatory) held at NASA Ames in 2023.
- Samuel LeBlanc is the Ames representative in AOS Sub-orbital science meetings.

Dynamics and Chemistry of the Summer Stratosphere (DCOTSS)

Project Participants

BAERI: Ju-Mee Ryoo
NASA: Rei Ueyama

Project Description

BAERI's Ju-Mee Ryoo will support implementation and forecasting activities in the NASA Arctic Radiation-Cloud-Aerosol-Surface-Interaction Experiment (ARCSIX) mission, assisting the NASA Ames Forecast Lead (Rei Ueyama) with flight planning and data analysis. The ARCSIX mission will be performed during the summer of 2024. The Plankton, Aerosol, Cloud, ocean Ecosystem Postlaunch Airborne eXperiment (PACE-PAX) mission will be performed during the fall of 2024. Ju-Mee Ryoo will generate meteorological forecasting plots to support forecasting activities during deployment.

Additionally, Ju-Mee Ryoo will conduct research and data analysis on the relationship between atmospheric rivers (ARs) and overshooting convection observed during DCOTSS, as well as on climatological data. The expected deliverables are a conference presentation and a peer-reviewed journal publication.

Accomplishments

- Generated and updated the website for the ARCSIX mission.

    - Completed support for the first ARCSIX mission and preparing for the second mission in summer 2024.

- Maintained website resources and forecasting products for the PACE-PAX mission.
- Provided timely forecasting products and support for the ARCSIX and PACE-PAX missions.
- Presented the DCOTSS project results at professional conferences, including the American Geophysical Union (AGU) and DCOTSS Science Team Meeting (STM).

FNR

Project Participants

BAERI: Jia Jung

Project Description

We have witnessed pronounced improvements in satellite remote-sensing platforms 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 (NO2) and formaldehyde (HCHO) column retrievals, underpin so many of scientific capacities potentially demonstrating spatiotemporal changes in NO2, HCHO, and ozone (O3) production sensitivity regimes using the ratio of HCHO and NO2 (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 (O3) production sensitivity regimes. Therefore, in this project, we constrain the bottom-up emission inventories with multiple NO2 and HCHO column retrievals and analytical joint-species/sensor inversion over the Continental United States (CONUS) between 2019–2023. We use a suite of numerical modeling, the Weather Research and Forecasting (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 NOx and Non-Methane Volatile Organic Compounds (NMVOC) emissions with a rich legacy of satellite retrievals from 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 the ratio of HCHO and NO2 (FNR).

Progress

- We produced monthly averaged maps of NO2 and HCHO column retrievals of OMI and TROPOMI for 2019–2021.
- WRF-CMAQ air quality model configuration and input data was prepared:
    - Meteorological input was prepared using the Weather Research and Forecasting (WRF) model.

    - Model-ready emissions consist of anthropogenic emission (EPA NEI 2017, mapped to other years preserving day of the week), biogenic emission (Biogenic Emission Inventory System v3.6.1), biomass burning emission (Fire Inventory from NCAR v2.5), lightning emission (World Wide Lightning Location Network), and aviation emission (CEDS aircraft emission v1).
    - Chemical boundary conditions (BCs) are from the Community Atmospheric Model with Chemistry (CAM-Chem) with emission adjustment during COVID-19. In addition, CO and O3 concentrations in BCs are scaled based on the comparison with Clean Air Status and Trends Network (CASTNET) O_3 measurement and ObsPack GLOBALVIEW plus CO product.

- We developed an inverse modeling framework that reads satellite vertical column density (VCD) information, calculates the corresponding VCD simulated by the CMAQ modeling system, and conducts an inversion of nitrogen oxide (NOx) and NMVOCs emissions, considering uncertainty of observations and model components.
- We have produced preliminary results of the inverse modeling of NOx and NMVOC emissions for May 2019 with TROPOMI.

Heliophysics

Project Participants

BAERI: Andrew Ngo
NASA: Irina N. Kitiashvili, Spyros Kasapis

Project Description

We aim to identify and analyze the movement and lifetime of supergranulation and “banana cells” on the sun in efforts to improve solar activity predictions. We also analyze data from polar regions.

Accomplishments

- Developed pipeline for supergranule identification.
- Created visualization identifying supergranulation around polar regions.

Intelligent Long Endurance Observing System (ILEOS)

Project Participants

BAERI: Vinay Ravindra
JHU Applied Physics Laboratory, Maryland: William Swartz
NASA Ames Research Center: Meghan Chandarana, Jeremy Frank, Richard Levinson, Eugene Turkov, Douglas Caldwell
NASA Goddard Space Flight Center, Maryland: Bryan Duncan, Sarah Strode

United States Geological Survey, California: Kristen Manies

Project Description

Intelligent Long Endurance Observing System (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.

Accomplishments

We have developed semi-automated science activity planning system and conducted simulation based studies 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.

MEaSUREs

Project Participants

JPL: Vineet Yadev (PI), Jon Hobbs, Hai Nguyen, Junjie Liu
BAERI: Susan Kulawik
CIRA: David Baker

Project Description

The Making Earth System Data Records for Use in Research Environments (MEaSUREs) Program aims to create a long-term record of CO2 (2009–present) by fusing data from Orbiting Carbon Observatory (OCO)-2, The Greenhouse gases Observing SATellite (GOSAT), and Cross-track Infrared Sounder (CrIS) CO2 observations to create a 1 degree gap-filled product that reduces data volume and random error. This works off the methodology developed by co-investigator Nguyen (Nguyen, Hai, Cressie, Noel, and Braverman, Amy (2017). “Multivariate Spatial Data Fusion for Very Large Remote Sensing Datasets,” Remote Sensing, 9, p. 142.).

Accomplishments

- Fused, 1 degree gap-filled OCO-2 and GOSAT products are publicly available here: MEaSUREs OCO-2: gap-filled product, obtained from fusing level-2, bias-corrected, XCO2 retrievals from OCO-2: https://disc.gsfc.nasa.gov/datasets/OCO2GriddedXCO2_3/summary?keywords=OCO-2%20XCO2

- MEaSUREs OCO-2 and GOSAT: a gap-filled product obtained from fusing level-2, bias-corrected XCO2 retrievals from OCO-2 and ACOS-GOSAT: https://disc.gsfc.nasa.gov/datasets/MultiInstrumentFusedXCO2_3/summary?keywords=MultiInstrumentFusedXCO2_3

Panels or Committees

- Served on the Carbon Monitoring Systems (CMS) review panel in May 2024.

NASA Earth Exchange (NEX) / Ecological Forecasting

Project Participants

NASA Ames Research Center (ARC): Ian Brosnan, Donovan Mathias, Andrew Michaelis, Weile Wang, Muge Komurcu, Morgan Gilmour, Matthew S. Johnson, Kazuyuki Miyazaki, Kevin Bowman
BAERI: Taejin Park, Wen Yip, Arthur Mizzi, Aishwarya Raman, Sepideh Khajehei, Claire Teitelbaum, Kyle Kabasares, Bridget Thrasher
California State University at Monterey Bay (CSUMB): Alberto Guzman, Hirofumi Hashimoto, Will Carrara
Morgan State University: K. Emma Knowland
National Center for Atmospheric Research: Rajesh Kumar
NOAA Chemical Sciences Laboratory: Brian McDonald
NASA Postdoctoral Program (NPP): Conor Doherty, Aakash Chhabra

Collaborators

NASA ARC: Matthew Johnson
NASA Short-term Prediction Research and Transition (SpoRT): Aaron Naeger
NASA Global Modeling and Assimilation Office (GMAO): Zhining Tao

National Oceanic and Atmospheric Administration (NOAA) Chemical Sciences Laboratory (CSL): Brian McDonald
The Cooperative Institute for Research in Environmental Sciences (CIRES): Chia-Hua Hsu, Congmeng Lyu, Siyuan Wang
University of Colorado (CU) Boulder: Daven Henze
National Center for Atmospheric Research (NCAR): Rajesh Kumar
University of Wisconsin-Madison: Min Chen, Hangkai You
University of Delaware: Rodrigo Vargas, Pinki Mondal; Manan Sarupria
University of Texas: Akash Awasthi
University of Connecticut: Zhe Zhu

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 (NAS) facility at NASA Ames research center, using the NEX virtual collaborative, and having select NASA datasets readily available, scientists and engineers can ask big science questions, execute on 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 (ESD), 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, and for monitoring and modeling natural disasters such as wildfires and emerging public health threats. Additionally, NEX supports the production of global long-term data records and products for NASA's Making Earth System Data Records for Use in Research Environments (MEaSUREs) program, NASA's Carbon Monitoring System (CMS) program, Global Ecosystem Dynamics Investigation (GEDI) program, National Climate Assessment (NCA), geostationary satellite remote sensing research, the Advanced Information Systems Technology (AIST) program, Earth Action (formerly Applied Sciences) programs, as well as large-scale visualizations for data from NASA's Earth Observing System Data and Information System (EOSDIS) and the new Earth Information Center. NEX also supports several Earth System Observatory missions in formulation, including Surface Biology and Geology (SBG), Internet of Animals, and Planetary Boundary Layer (PBL)

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, Shared Socioeconomic Pathways (SSP)126, 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 (NCCS), https://doi.org/10.7917/OFSG3345 and was recently released on Amazon Web Services (AWS), 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

The team is also exploiting NEX-GDDP-CMIP6. They have developed visualizations and derived climate indices for the new Earth Information System, and partnered with the Finnish Meteorological Agency to complete an evaluation of NEX-GDDP-CMIP6 output in Northern Europe. They also used the NEX-GDDP-CMIP6 data to assess global fire weather conditions using the Canadian Fire Weather Framework (Fig. 1). This data has the potential to be broadly used not only for wildfire risk assessment, but also for various future climate change impact assessments and preparedness. The data (https://doi.org/10.25966/p394-qc98) and source codes (https://doi.org/10.5281/zenodo.10433232) are publicly available.

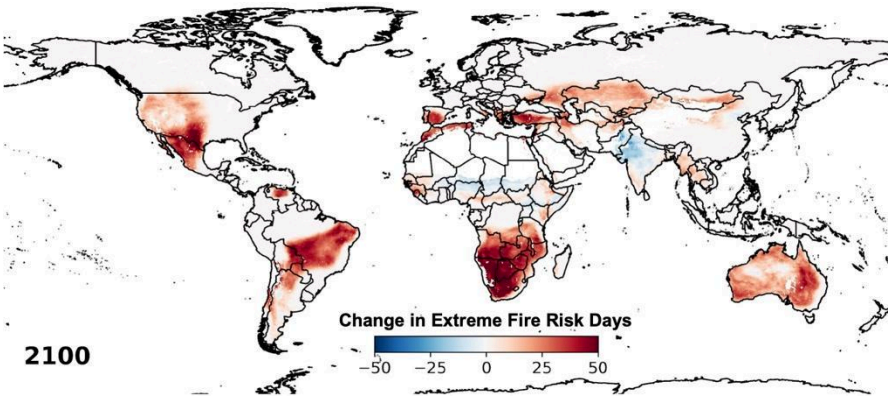


Figure 1: Changes in extreme fire risk days (number of days Fire Weather Index (FWI)>30) between baseline (1950-1979) and the end of 21st century under SSP2-4.5 scenario.

In 2024, the team also completed an update of the NEX-(Downscaled Climate Projections) DCP30 product to incorporate the CMIP6 output, which has been released via the NAS Data Portal. A publication describing the dataset has also been submitted.

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 Geostationary Operational Environmental Satellite (GOES)-16/17 Advanced Baseline Imager (ABI), the Himawari-8/9 Advanced Himawari Imager (AHI), GK2A Advanced Meteorological Imager (AMI), 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 it has significant influences on the downstream products. In addition to the existing efforts for ABI and AHI, the team built a processing pipeline for geolocation correction and orthorectification. The team successfully produced GeoNEX AMI L1G products (Fig. 2).

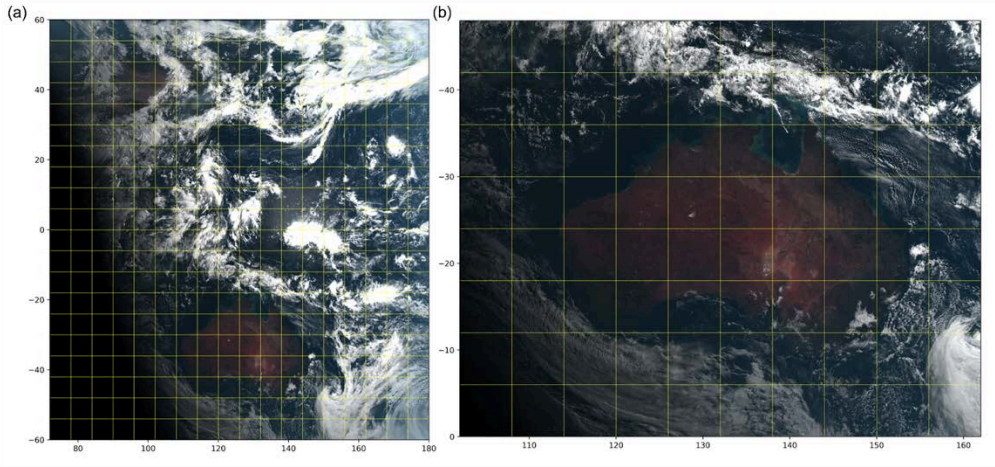


Figure 2. Example natural color Red-Green-Blue (RGB) composite of GeoNEX GK2A AMI L1G product.

Prototype GeoNEX Level 2 products were developed, including atmospheric aerosol optical depth and surface reflectance/ bi-directional reflectance distribution function (BRDF) for Himawari 8/9 AHI and GOES16/17 ABI data sets (Fig. 3). The BRDF describes the fundamental optical property of a surface and therefore has been retrieved from both geostationary (GEO) and polar-orbiting (or Low-Earth Orbit, LEO) satellite observations. In theory, although GEO and LEO observations feature different illumination-view geometries, they reflect the same physical property and the retrieved BRDF should be mutually consistent. We investigated the idea by comparing Terra/Aqua Moderate Resolution Imaging Spectrometer (MODIS) and GOES16/17 ABI surface BRDF retrieved with the Multi-Angle Implementation of Atmospheric Correction (MAIAC) algorithm. The results indicated both agreements and discrepancies. In particular, the GEO BRDF seems to have a stronger volumetric scattering component in the tropical region. Further research is being conducted to identify the sources of the discrepancies between GEO and LEO BRDFs.

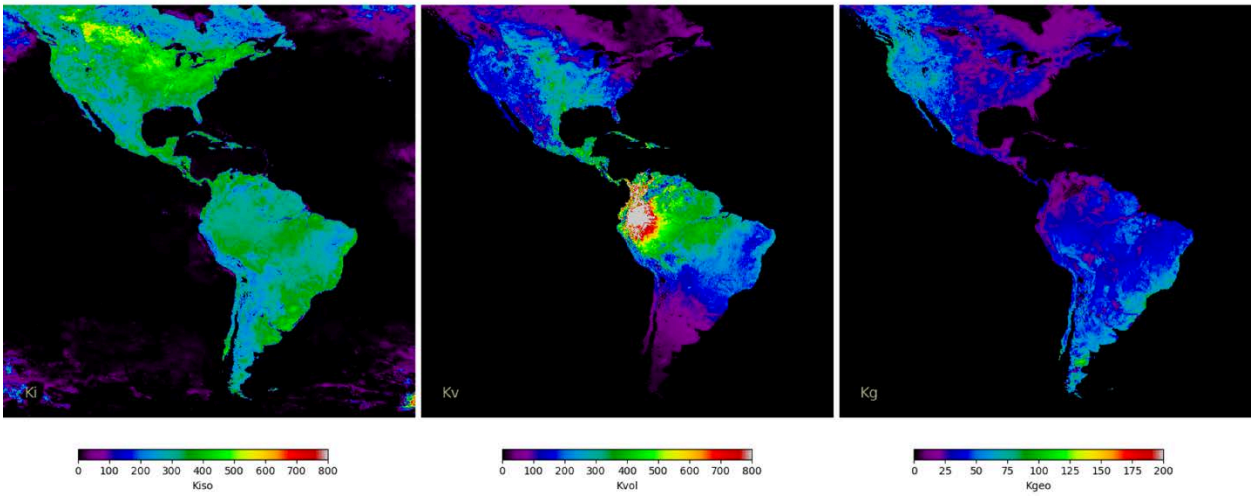
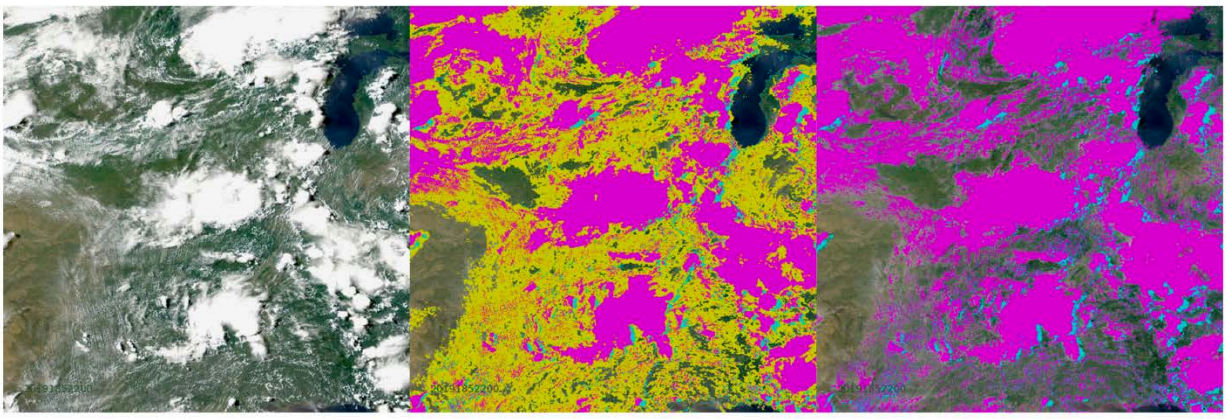


Figure 3 Example of GeoNEX L2G Surface BRDF components retrieved from GOES-16/ABI on 2019/07/15: (left) isotropic component, Kiso; (middle) volumetric component, Kvol; (right) geometric component. Values shown are scaled by 1000.

Analyses of the current MAIAC outputs indicate that the algorithm tends to overestimate cloudy pixels (i.e., false positives), which introduces more than expected data gaps in the L2G products, especially in the tropics. This motivated us to develop a new cloud detection algorithm that takes full advantage of the high temporal resolution of the GEO observations. The algorithm combines the roughness/smoothness index we developed for the GeoNEX time series processing with well-known computer vision and image processing techniques to classify TOA images in three categories: clear, cloud, and shadow pixels. We eliminate the traditional “partial cloud/partial clear” category in our algorithm so that the classification is firm and can be readily used by the MAIAC algorithm.



(a) Preprocessed TOA Image (b) 4-Category Cloud Mask (c) 3-Category Cloud Mask

Figure 4 Example of GeoNEX Cloud Mask retrieved from GOES-16/ABI on 2019/07/02, 22:00UTC. The yellow color in (b) indicates the “partial cloud/partial clear” category in traditional 4-category cloud mask algorithms. This category is eliminated in the new 3-category algorithm (c), which has only categories for clear, cloud, and shadow pixels.

The new cloud detection algorithm can be further extended to include a temporal compositing component (Fig. 5). For Geostationary data, compositing TOA data allows us to obtain the clearest diurnal cycle of the surface at regular (e.g., monthly) time steps. These data are very useful in calibrating the atmospheric correction algorithm. They can also be used as surface prior information for cloud detection in the next time steps.

Figure 5 Composited Clear-Sky TOA images of GOES16 observations in July of 2019: (left) 13:00UTC; (right) 16:00UTC.

Several experimental level-3 data products were prototyped using a GEO-LEO approach. 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 Imager (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. An emulated Land Surface Temperature (LST) was prototyped using convolutional neural networks. This novel approach was used to predict land surface temperature with improved spatial and temporal resolution compared to standard product. While multiple satellite types provide data to monitor surface temperature, geostationary (GEO) sensors provide near-continuous, continental-scale observations which can better capture the diurnal variability of land surface temperature (LST) 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 resolution. 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.

We want to apply GEO observations in addressing global ecology challenges faced by the science community. With their 10-minute temporal resolutions, GEO satellites can have 50-100 times more opportunities than LEO satellites to get a clear view of the surface. Because the time series are so dense, we can accurately fill the data gaps by interpolation and other more advanced techniques. With the help of radiative transfer models, we can further estimate solar radiation and land surface temperature under cloud covers. As such, GEO observations help us generate gap-filled continuous data sets to model diurnal ecosystem fluxes of carbon, water, and energy (Fig. 6). We are actively working on this project.

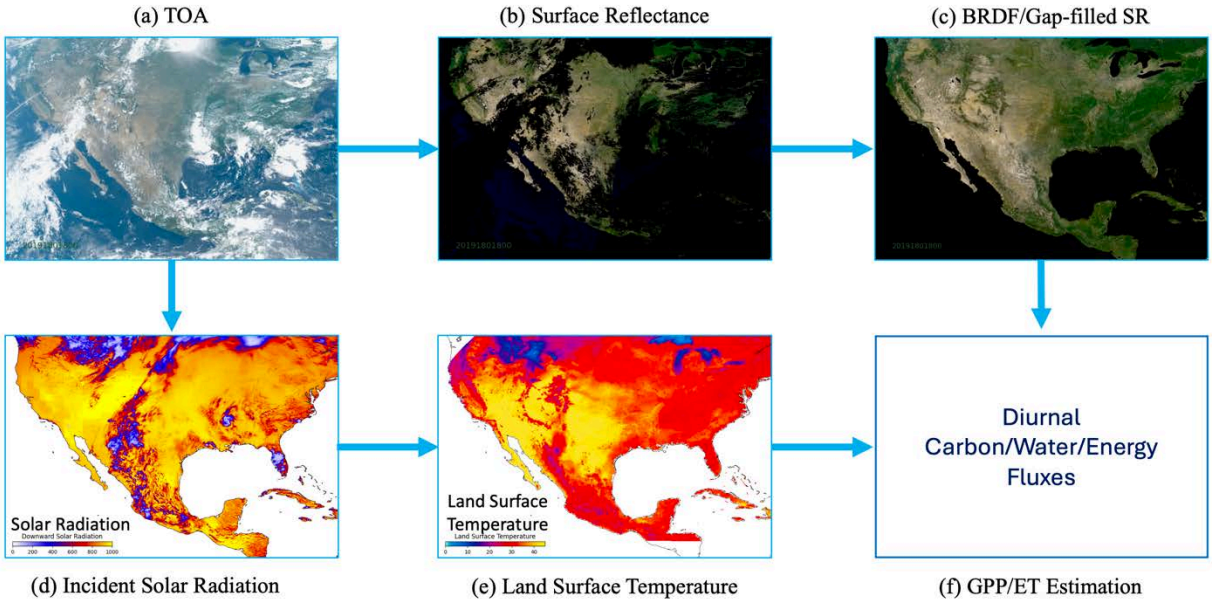


Figure 6 Processing Diagram that use GEO observations to generate gap-filled, continuous data sets and model diurnal ecosystem processes

We teamed up with the AmeriFlux data management team to build a visualization webpage within the AmeriFlux website. This webpage provides a quick overview of a suite of GeoNEX products, including vegetation indices, land surface temperature (LST), downwelling solar radiation, and more. We expect this data dissemination will promote GeoNEX and open new scientific areas for the community to contribute.

Carbon Monitoring System (CMS) and Global Ecosystem Dynamics Investigation (GEDI)

As part of the Carbon Monitoring System (CMS) project, we implemented a machine learning-based framework to generate Landsat-based yearly percent tree cover maps for Mexico, and evaluated uncertainty of the existing seven different tree cover products (Fig. 7). Based on the uncertainty evaluation practice, an area of 288,749 km^2 is identified as very likely forested (identified as forested by 6 or 7 products), while an area of 340,661 km^2 is identified as potential forest (identified as forested by 3-5 products at forested). This represents a significant

area of uncertainty, most of which falls within the tropical dry forest and subtropical mountain system – and represents up to 1.8 Gt aboveground biomass, around half of the total aboveground biomass estimated for Mexico. These findings quantify the uncertainty surrounding various forest cover estimates in Mexico and identify critical ecozones where additional ground data and research is needed.

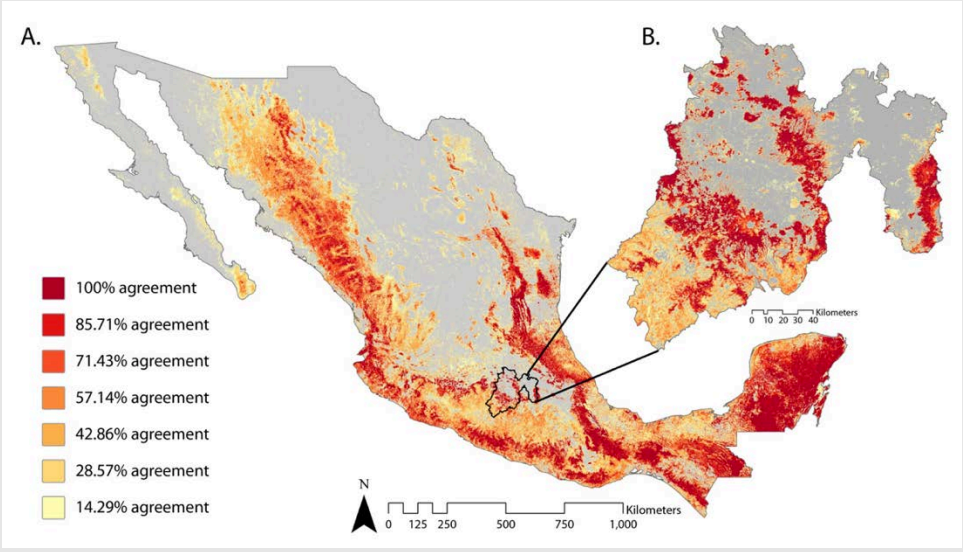


Figure 7 A. Hybrid uncertainty heat map showing the percent agreement across the 7 products. The percentage represents how many products identified each pixel as being forested. B. Closeup of the state of Mexico.

The NEX team also has built and tested a remote sensing-based aboveground biomass estimation framework using Landsat and Sentinel-1 and 2), Global Ecosystem Dynamics Investigation (GEDI), and Continuous Change Detection and Classification (CCDC) algorithm over Mexico. The CCDC algorithm uses all available satellite observations and fits piecewise harmonic regression models to identify the timing and location of statistically significant breaks. The algorithm can provide a spatiotemporal database of model breaks and harmonic regression coefficients for producing smoothed, interpolated synthetic reflectance data at each pixel. The CCDC-based synthetic reflectance data is extremely useful in reconstructing time series of surface reflectance when only few and temporally inconsistent observations are available. GEDI is capable of providing high-resolution 3D canopy structural and aboveground biomass information of various forest ecosystems. By synergistically integrating Landsat, GEDI, CCDC, and a machine learning approach, the team plan to create a long-term aboveground biomass product (1984-present) at 30 m spatial resolution and support local stakeholders in implementing Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (REDD+) across Mexico.

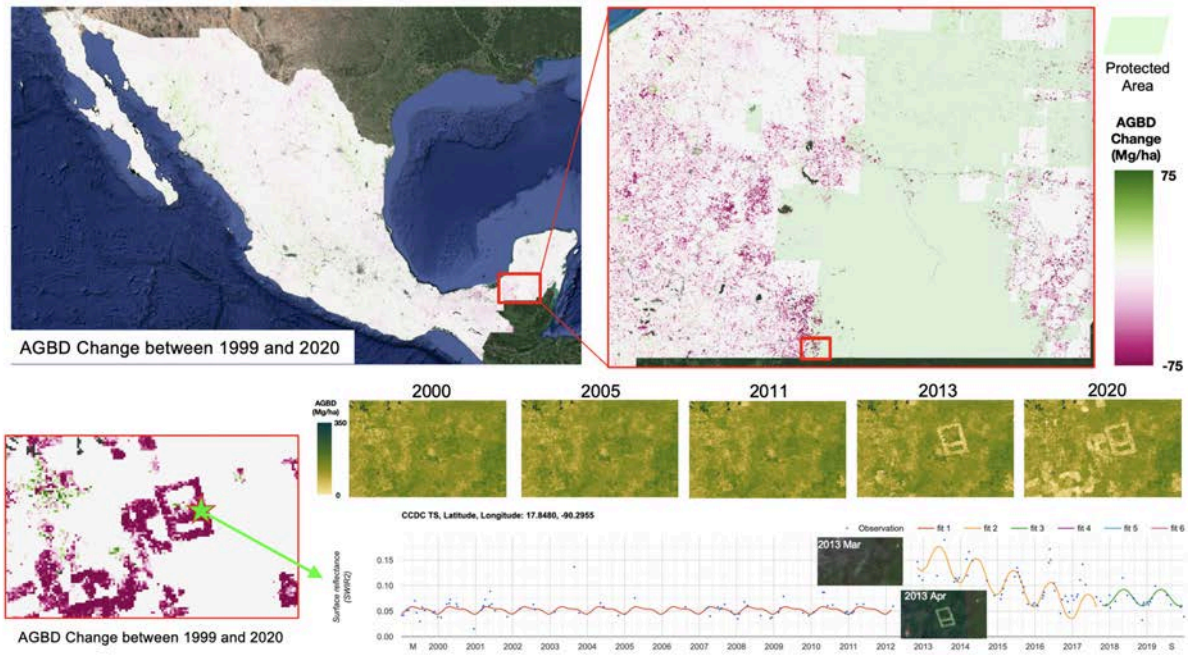


Figure 8. Spatial distribution of aboveground biomass density (Mg/ha) changes during the period between 1999 and 2020.

The NEX team has built a lidar processing workflow which can ingest airborne lidar point cloud data to produce important 3D data for topography, vegetation, and built structure (Fig. 9). This processing workflow will be used to produce state-wide lidar-derived 3D metrics.

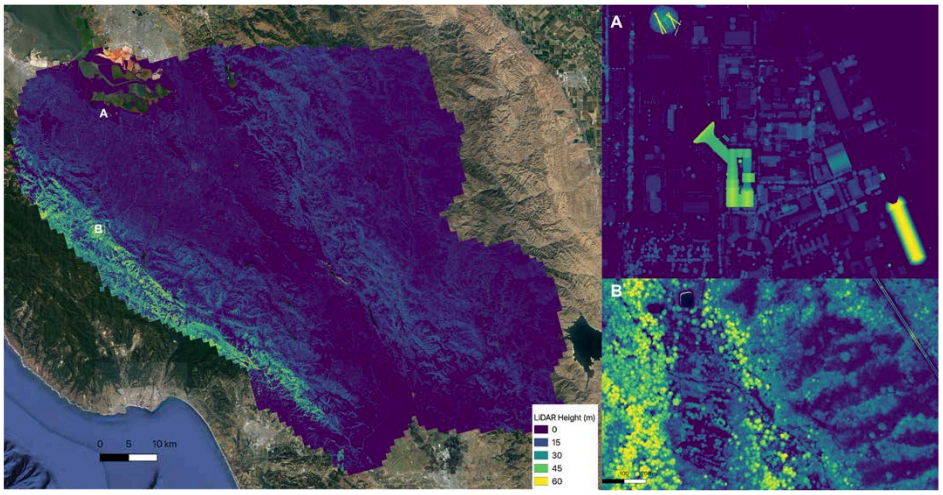


Figure 9. Example lidar canopy height model over the Santa Clara county (A: Ames research center, B: Redwood forest near city of Saratoga)

Surface Biology and Geology (SBG)

In 2018, NASA initiated a new study for the Surface Biology and Geology (SBG) Designated Observable, identified in the National Academies of Sciences, Engineering and Medicine (NASEM) 2017 Decadal Survey. SBG is entering Phase A in mission formulation and the NEX team are contributing tools for algorithm development and science data system engineering. The NEX team have developed the Ames Global Hyperspectral Synthetic Data (AGHSD) algorithm based on the spectral invariant theories and Monte-Carlo Ray-Tracing simulation results. The algorithm emphasizes that hyperspectral surface BRDF Real-Time Location System (RTLS) parameters can be accurately approximated by the weighted sum of the spectra of soil surface reflectance, leaf single albedo, and the canopy scattering coefficient. Fig. 10 shows some examples of the AGHSD Surface BRDF dataset based on MODIS data and pre-selected spectral libraries over the Continental United States (CONUS).

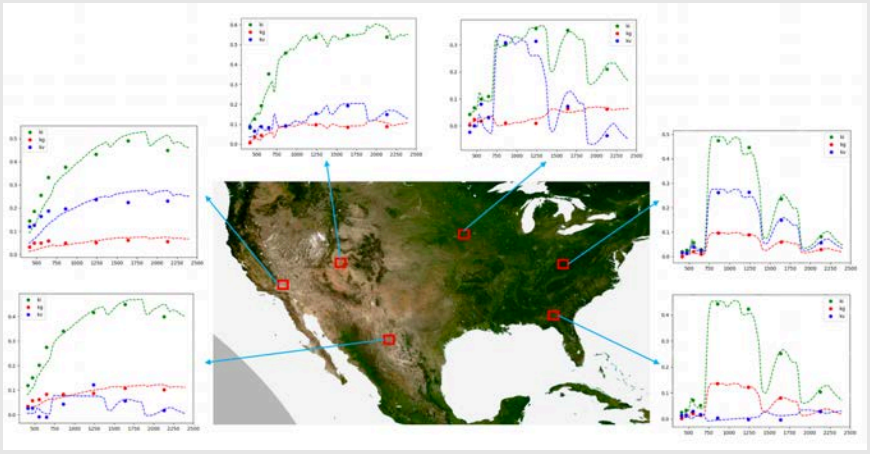


Figure 10. Comparison between the synthetic hyperspectral BRDF RTLS parameters (lines) with the corresponding MODIS data (dots) at the chosen sites over CONUS.

Using MODIS/AGHSD datasets as priors, we expanded our radiative transfer modeling capabilities developed for GeoNEX to perform atmospheric correction for hyperspectral sensors like PRISMA, EnMAP, EMIT, and future SBG (Fig. 11). This algorithm is based on the assumptions that: (1) atmospheric aerosol optical depth varies at relatively large spatial scales (e.g., 50km); (2) observations of moderate resolution satellite (like MODIS/VIIRS/GOES ABI) provide prior information to retrieve surface reflectance from the high resolution (e.g., 30m) hyperspectral sensors. We applied the algorithm to process PRISMA/EnMAP data and submitted our results to the third atmospheric correction intercomparison experiment (ACIX-III). This study is still ongoing.

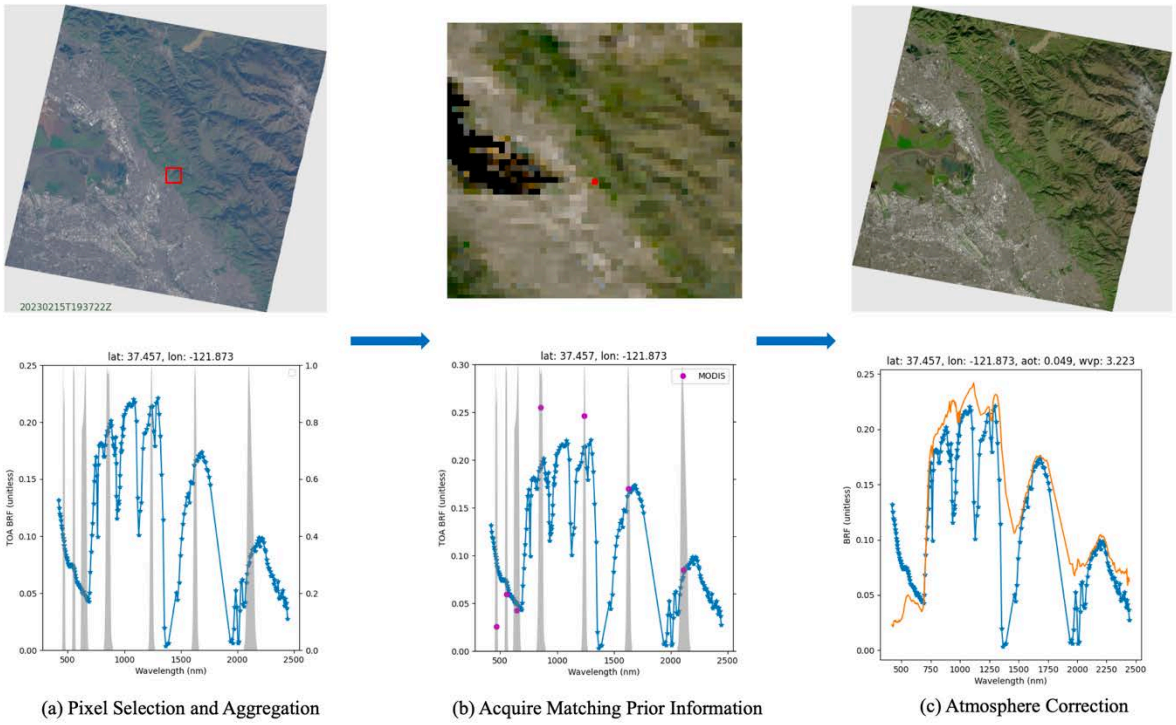


Figure 11. Diagram of GeoNEX Atmospheric Correction Algorithm for Hyperspectral Sensors.

WRF-Chem/DART

WRF-Chem/DART is a regional, ensemble, atmospheric composition (AC) forecast / assimilation / emissions inversion system based on integrating the Weather Research and Forecasting model (WRF) with 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 US government for air quality (AQ) forecasting research and operations. DART is an ensemble data assimilation system based on the Ensemble Adjustment Kalman Filter (EAKF) 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 to include, or applied WRF-Chem/DART as follows:

- Assimilation of OMI O3, NO2, SO2, HCHO; TROPOMI CO, O3, NO2, SO2, HCHO, CH4; TES CO, CO2, O3, NH3, CH4; CrIS CO, O3, NH3, CH4, PAN; GOME2a NO2, SCIAMACHY NO2; MLS O3, HNO3, and TEMPO O3, NO2 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 associate 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 find that the assimilation of geosynchronous (GEO) satellite observations (synthetic TEMPO NO2 tropospheric column retrievals) can recover the COVID period NO2 emissions over the continental US (CONUS) more accurately and more quickly than the assimilation of low earth orbiting (LEO) satellite observations (synthetic TROPOMI NO2 tropospheric column retrievals). This work is being done and sponsored in collaboration with NOAA and the University of Colorado at Boulder (CUB).
- Participating in the NASA Data Assimilation Working Group.
- Participating as a NASA representative to the US Department of State Wildfire Study Group.
- Participating on the NASA FireSense Implementation Team.

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 Tracking Aerosol Convection Interactions ExpeRiment (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 of April-September. For the forecast and assimilation system, we use the Weather Research and Forecasting model with Chemistry (WRF-Chem) as integrated in the Data Assimilation Research Testbed (DART) as modified to include chemical data assimilation and emissions estimation (Chem-DART; collectively called WRF-Chem/Chem-DART). We interface WRF-Chem/Chem-DART with Jet Propulsion Laboratory (JPL)'s Multi-model Multi-constituent Chemical data assimilation (MOMO-Chem)

dataset to supply chemical initial and boundary conditions. We have added various forward operators for satellite AC observations into Chem-DART to enable a seamless analysis of AC in TRACER-I. 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. The deliverables from TRACER-I will be a 20-yr (2005 – 2024; April – September) survey of the concentrations, emissions, and uncertainties for the criteria pollutants (excluding PM) and selected trace gasses across the CONUS.

Internet of Animals (IOA)

The Internet of Animals (IOA) 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 compiles 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. Data are being analyzed from over 4,000 individual tracked birds from 30 species, with data derived from 79 studies. Preliminary results show that habitat composition and human population density are two key determinants of waterfowl movement, more so than weather or vegetation variables.

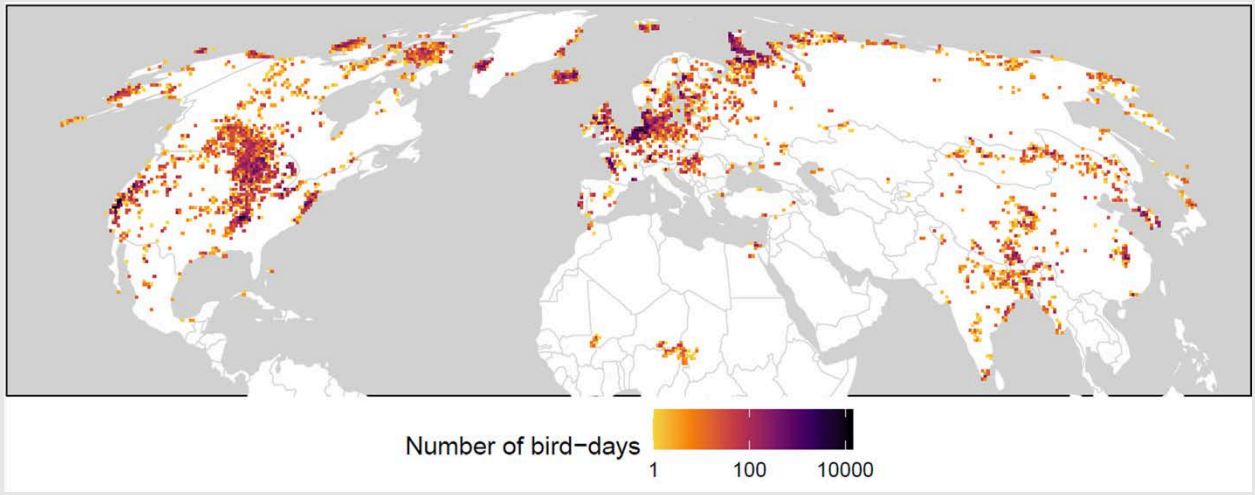


Figure 12: Locations from 79 studies of 30 species included in global waterfowl telemetry data sets. Data sets include GPS and Argos telemetry from diving ducks, dabbling ducks, geese, swans, and shelducks tracked between 2004 and 2023. Only winter and breeding season data are shown (i.e., migration is excluded).

- 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 for species distribution modeling with disease applications, but that disease ecologists could benefit from more critically appraising remote sensing products and from using more modern, advanced approaches. This manuscript will be submitted in the coming month.

- Palmyra Bluewater Research: This is a collaborative project with The Nature Conservancy, the United States Geological Survey (USGS), the National Oceanic and Atmospheric Administration (NOAA), UC Santa Barbara, San Jose State University, Stanford University, the University of Hawaii, and the University of Washington. Marine protected areas (MPAs) 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 combined remote sensing and 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 39% of the area where species traveled and on average, 73% of the MPA contained highly suitable habitats. The sizes of suitable habitats both increased and decreased under two climate scenarios for all species.

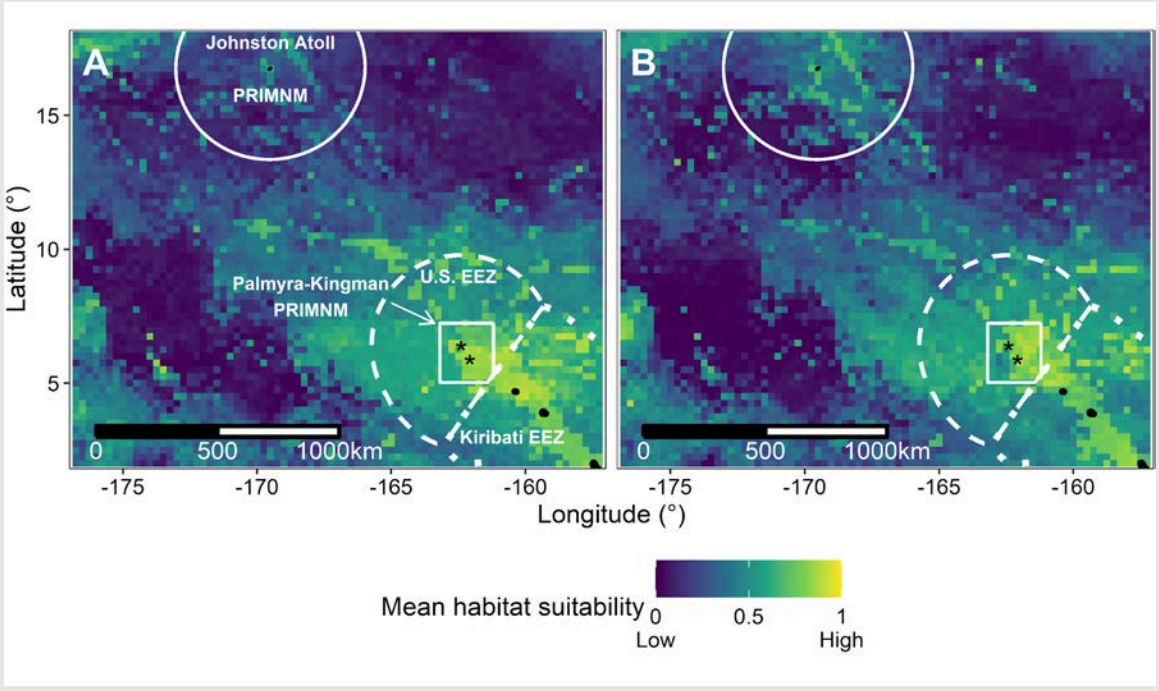


Figure 13: Mean habitat suitability within and outside the Palmyra unit of the Pacific Remote Islands Marine National Monument (rectangle) and U.S. exclusive economic zone (EEZ; dashed lines) for eight marine species that include seabirds, manta rays, reef sharks, tuna, and cetaceans for A) summer and 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 4000 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 continuing 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.

Proposals (Submitted / Selected)

- A Bird's Eye View: Integrating remote sensing and animal telemetry to assess waterbird distributions, dispersal, and diversity in dynamic environments. (24-BIODIV24-0011, submitted).

- FATE: The drifting Fish Aggregating device (dFAD) TrajEctory modeling tool for marine protected area management. (NNH22ZDA001N-ECON, selected).

- Pathogen spillover at the terrestrial-marine interface: drivers of cross-species transmission of avian influenza (NSF EEID).
- Windybird: Animal-borne wind velocity measurements at the planetary boundary layer (NASA ARC CIF, submitted).
- Novel technology for revealing climate change signals through space-based animal tracking (SPACE BAT) (NASA ECI, submitted).
- SPACE BAT: A prototype biologger to measure planetary boundary layer height though space-based animal tracking (NASA ARC IRAD, submitted).
- Great frigatebirds as a novel inclusion to planetary boundary layer assimilation efforts (24-MAP24-0009, submitted).
- Improving numerical weather forecasts with more representative land surface modeling: Implementation of updated satellite-derived land cover and land use change maps (NNH24ZDA001N-LCLUC, submitted).
- Using Satellite-driven High-resolution Wildland Fire Emissions to Connect Fire Behavior with Pre-Fire Risk Conditions (NNH24ZDA001N-WF, submitted).
- Embracing CSDA-Supported Spaceborne SAR Data in NASA FireSense Airborne Campaigns (NNH23ZDA001N-CNVOE, selected).
- Eco-evolutionary modeling of tropical vegetation transitional dynamics with fire and climate changes in GISS ModelE (NNH24ZDA001N-MAP:A.15 Modeling, Analysis, and Prediction, submitted).
- Leveraging the Satellite Record to Build a Better Model (NNH24ZDA001N-MAP:A.15 Modeling, Analysis, and Prediction, submitted).
- Toward Improved Land-Earth System Digital Twins: Representing Wildland-Urban-Interface Characteristics for Improved Land-Surface-Boundary-Layer-Cloud Interactions in Climate Simulations (NNH24ZDA001N-LCLUC:A.2 Land Cover/Land Use Change, submitted).
- Improving numerical weather forecasts with more representative land surface modeling: Implementation of updated satellite-derived land cover and land use change maps (NNH24ZDA001N-LCLUC:A.2 Land Cover/Land Use Change, submitted).
- Improved Fire Weather Forecasting with Continuous and Efficient Monitoring (NNH24ZDA001N-WF:A.47 Earth Action: Wildland Fires, submitted).
- Using Satellite-driven High-resolution Wildland Fire Emissions to Connect Fire Behavior with Pre-Fire Risk Conditions (NNH24ZDA001N-WF A.47 Earth Action: Wildland Fires, submitted).

Partnerships (proposed / ongoing)

- Wildfire, Ecosystem Resilience & Climate Monitoring & Assessment Initiative (WERC) - California Natural Resource Agency.

- Urgent computing using a hybrid Cloud-HPC architecture for streaming satellite data analysis and event-driven modeling (BAERI; 80NSSC22M0158, 22-NUP2022-0046) – synergies with ARC-CREST NEXFire work.

- Integrating machine learning and remote sensing for dynamic forest mapping (New Zealand MBIE & NASA Catalyst program).

- Morgan Gilmour (SGE) has accepted an invitation to be a member of the Editorial Advisory Board at the journal Regional Environmental Change.

- Dr. Arthur Mizzi was asked by the Tropospheric Emissions: Monitoring of Pollution (TEMPO) Mission to join the Ozone Validation Team. He will work with early release of TEMPO ozone profiles and attempt to evaluate whether these have the near-surface sensitivity they are assumed to have.

- Dr. Arthur P. Mizzi Collaborate with NOAA/CSL, Maintain and develop Chem-DART as necessary, and Assist with applying Chem-DART to greenhouse gas (GHG) and wildfire emissions estimation observing system simulation experiments (OSSEs).

  As part of the: (i) NASA Data Assimilation Working Group, (ii) NASA/NOAA collaboration, and (iii) Ames Research Center (ARC) support of the development and application of the Joint Effort for Data Assimilation Integration (JEDI) we pursued the following:

- Getting the Community Multi-Scale Air Quality (CMAQ) model coupled with JEDI (CMAQ/JEDI) installed and running on the NASA ARC Pleiades computing system. (Mr. Andrew Michaelis did the associated work).

- Integrating CMAQ into Chem-DART (the NCAR Data Assimilation Research Testbed (DART) system as modified to include chemical data assimilation and “top-down” emissions estimation) (CMAQ/Chem-DART). (Dr. Arthur P. Mizzi did the associated work. This project is still in progress. The focus recently changed from incorporating CMAQ into Chem-DART to modifying EPA’s CMAQ-to-WRF-Chem/WRF-Chem-to-CMAQ output converters to make CMAQ output look like WRF-Chem output for input to Chem-DART).

- Expanding Chem-DART to include forward operators for TROPOMI methane (CH4) and formaldehyde (HCHO), and CrIS carbon monoxide (CO), ozone (O3), CH4, and peroxyacyl nitrates (PAN). (Dr. Arthur P. Mizzi did the associated work. This project is still in progress).

- Modifying Chem-DART so that the atmospheric constituent (AC) and emissions perturbation error correlations patterns are species independent. (Dr. Arthur P. Mizzi did the associated work. This project is winding down.

- Assisting researchers at the NOAA/Chemical Systems Laboratory (CSL) and NOAA/Global Modeling Laboratory (GML), California Air Resources Board (CARB), and National

Autonomous University of Mexico (UNAM) with setting up, running, and applying WRF-Chem/Chem-DART. (Dr. Arthur P. Mizzi did the associated work for all these projects.)

- NOAA/CSL and NOAA/GML are running observing system simulation experiments (OSSEs) with WRF-Chem/Chem-DART to try to recover GHG emissions. NOAA/CSL is conducting a CH4 emissions estimation OSSE (Dr. Mizzi is advising Dr. Islam Nazrul – a NOAA/CSL/CIRES junior scientist for this project), and NOAA GML is conducting a CO2 emissions estimation OSSE. (Dr. Mizzi is advising Dr. Michael Trudeau—a NOAA/GML research scientist for this project.)
- NOAA/CSL is conducting a wildfire OSSE to recover plume injection heights from assimilation of height dependent aerosol optical depth (called aerosol layer heights (ALHs)). (Dr. Mizzi is advising Dr. Congmeng Lyu – a NOAA/CSL/CIRES post-doctoral researcher for this project.)
- CARB is conducting a CH4 emissions estimation OSSE over California. (Dr. Mizzi is advising Dr. Yuyan Cui—a CARB research scientist for this project.)
- UNAM is applying WRF-Chem/Chem-DART over Mexico with higher resolution over the Mexico City megalopolis for internally funded projects and in preparation for NASA's Earth Venture Suborbital-3 field program called Hemispheric Airborne Measurements of Air Quality (HAMAQ) (Dr. Mizzi is advising Prof. Victor Almanza Veloz—a UNAM/Institute for Atmospheric Chemistry and Climate Change junior faculty member and his post-doctoral researcher Dr. Gilberto Maldonado for this project.)

Advising Mr. Chia-Hua Hsu at the University of Colorado at Boulder Paul Rady Department of Mechanical Engineering (CUB Mec-E) with his application of WRF-Chem/Chem-DART for the COVID OSSE as part of his doctoral research. This research is published as Hsu, C.-H., et al., 2024: An observing system simulation experiment analysis of how well geostationary satellite trace-gas observations constrain NO_x emissions in the US. *Journal of Geophysical Research: Atmospheres*, 129, e2023JD039323, https://doi.org/10.1029/2023JD039323.

- Served on the Research Preliminary Exam and Comprehensive Exam committees for Mr. Chia-Hua Hsu and Mr. Worapop Thingsame doctoral students in CUB Mec-E.
- Additional professional service activities:
  - EPA Methane Emissions Estimation Workshop: invited speaker and moderator.
  - NASA FireSense Implementation Team: invited member.
  - US State Department Facilities Smoke Impact Assessment: invited expert.
  - Joint Science Meeting for TEMPO, GeoXO ACX, and TOLNET, Air Quality Modeling: invited panelist.
  - International Research Station Workshop on Mathematical Approaches for Chemical Data Assimilation and Inverse Modeling, Chemical Data Assimilation: invited speaker.

- NASA Chemical Data Assimilation Working Group: member.

Activities

- NEX researchers have received a patent for MATA, an AI-powered research assistant that can answer questions on earth science data (https://technology.nasa.gov/patent/TOP2-288).
- Dr. Taejin Park served as a SME for pre- and post-fire focus areas in the FireSense implementation team.
- Dr. Taejin Park served as a SME for "Agriculture and Forestry" during the National Earth Observation Assessment. He participated in drafting the report which provides a quantitative assessment of the Nation's then-current portfolio of Earth observations for each Societal Benefit Area.
- Dr. Taejin Park participated in a workshop "Remote Sensing and Fluxes Upscaling for Real-world Impact" at UC Berkeley and discussed potential GeoNEX-relevant collaboration opportunities with international FluxNET communities.
- Dr. Taejin Park was interviewed by the Bay Area's ABC 7 News to describe how NASA Ames is helping agencies in California manage fires, July 4, 2024.
- Dr. Weile Wang was a co-organizer of the 2st Expert Workshop on Advancing International Constellation of Geostationary Satellites for Terrestrial Monitoring, Seoul National University at Seoul, South Korea. His co-organizers included Dr. Kazuhito Ichii (Chiba Univ.) and Dr. Yougryel Ryu (Seoul National Univ).
- A new study published in NATURE Water, "Assessing the accuracy of OpenET satellite-based evapotranspiration data to support water resource and land management applications." rigorously documented the accuracy of the OpenET data, described implications of the accuracy assessment for the OpenET user community, and described future priorities for applied research to further increase the accuracy of the OpenET data. From Ames, Forrest Melton, Lee Johnson, Will Carrara, Conor Doherty, Alberto Guzman, and AJ Purdy are among the authors. https://www.nature.com/articles/s44221-023-00181-7
- GeoNEX team co-hosted the 2nd Geostationary satellite community workshop (June 28-29, 2024) in South Korea and exchanged current research activities and future collaboration opportunities with international collaborators (Fig. 8).

Figure 8. Group photo of the 2nd Geostationary satellite community workshop participants.

- Research conducted by the Internet of Animals project has been featured in several media outlets
    - BBC Radio4 “Tracking the Planet” https://www.bbc.co.uk/programmes/m001x54g/episodes/guide
    - NASA podcast “Small Steps, Giant Leaps” https://appel.nasa.gov/podcast
    - NASA story “Surfing NASA’s Internet of Animals: Satellites Study Ocean Wildlife” https://www.nasa.gov/general/surfing-nasas-internet-of-animals-satellites-study-ocean-wildlife
    - AGU Newsroom “Great frigatebirds wearing backpacks map the atmosphere” https://news.agu.org/press-release/great-frigatebirds-wearing-backpacks-map-the-atmosphere/

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

Project Participants

BAERI: Justin Fain
NASA: Juan Torres-Perez

Project Description

The (Ocean Community Engagement and Awareness using NASA Earth Observations and Science for Hispanic/Latino Students) OCEANOS project centers on the following hypothesis: 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 can be used to monitor water quality in areas that affect coastal shallow-water marine ecosystems in Caribbean waters.

PACE-PAX

Project Participants

BAERI: Samuel LeBlanc

Project Description

The Plankton, Aerosol, Cloud, ocean Ecosystem Postlaunch Airborne eXperiment (PACE-PAX) will be 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 Center for Interdisciplinary Remotely Piloted Aircraft Studies (CIRPAS) Twin Otter aircrafts.

The project aim is to support the PACE-PAX field campaign with customized flight planning strategies for the airborne sampling platforms in coordination with the PACE satellite and ship- and ground-based observing platforms. This project is a subset of the larger meteorological forecasting support project for PACE-PAX.

Accomplishments

- Supported the September 2023 dry run
- Supported the March 2024 dry run of flight and mission planning
- Prepared multiple options for NASA ER-2 and Naval Postgraduate School (NPS) Twin Otter flight paths to satisfy mission objectives
- Help develop next version of mathematical framework for evaluating the success function of the mission

Peroxyacetyl nitrate (PAN) from AIRS

Project Participants

BAERI: Susan Kulawik
Colorado State University: Emily Fischer
JPL: Vivienne Payne, Josh Laughner

Project Description

While total anthropogenic Nitrogen Oxide (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.

Accomplishments

- Developed a strategy to retrieve PAN from AIRS that produces reasonable PAN columns over land (Josh). Over ocean, low, warm clouds are interfering with PAN retrievals in some cases, causing spurious high PAN values. Therefore the initial product will be land-only.
- The next step is to develop a quality flag system over land that flags bad AIRS PAN retrievals. After exploring many options, we have decided to focus on machine learning (ML) to accomplish this, by training on CrIS-AIRS matched PAN results and screening out AIRS results that are significantly different from what CrIS would retrieve. We will then (a) use the structure of the ML model to guide selection of quality filtering criteria, or (b) implement the output from the ML model itself as part of the quality flag. This approach requires a sufficiently broad set of AIRS and CrIS retrievals for the same days to use as a training set, which has already been generated (Josh).

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
Colorado State University: Chris O'Dell

Project Description

The project seeks to improve Orbiting Carbon Observatory (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%.

Accomplishments

- Implemented 3D-clouds into the Reusable FRamework for Atmospheric Composition (ReFRACtor) radiative transfer system (James).
- Implemented piecewise linear albedo into ReFRACtor radiative transfer system (James).
- Implemented 3D-cloud and additional albedo parameter retrievals (Susan).

- Ran retrievals with new parameters on the synthetic observations (Susan).
- Ran Moderate Resolution Imaging Spectroradiometer (MODIS)-based Education and Research 3D Radiative Transfer Toolbox (EAR3T) and began preparing publication on the results (Sebastian and graduate student Yu-wen).
- Finalized temperature and water principle component retrievals (Rob).

Panels or Committees

- Served on the Arctic Radiation-Cloud-Aerosol-Surface-Interaction Experiment (ARCSIX) review panel in March 2022.

Remote-sensing oUtgassing Magma Movement Before Large Eruptions (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 Research Opportunities in Space and Earth Sciences (ROSES) interdisciplinary science proposal, and aims to make measurements of degassing fluxes from a volcano in Costa Rica (e.g., Turrialba, Rincón de la Vieija) using the Orbiting Carbon Observatory-3 (OCO-3) and ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station (ECOSTRESS) instruments on the International Space Station. These will be combined with ground-based measurements made during intensive observation periods to inform a geophysical subsurface 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 AErosol RObotic NETwork (AERONET) sunphotometer to Costa Rica and do the interpretation of flux measurements.

Accomplishments

Efforts focused on a machine-learning based retrieval of aerosol optical depth from OCO-2/3, led by JPL/Caltech. Coincident measurements of Cloud-Aerosol Lidar and Infrared Pathfinder

Satellite Observations (CALIPSO) aerosol and cloud optical depth, and spectral measurements from OCO-2 and OCO-3 in proximity to volcanoes were used to train a machine-learning model. Good performance was achieved by the machine-learning model, as shown by the preliminary results in figure 1 below.

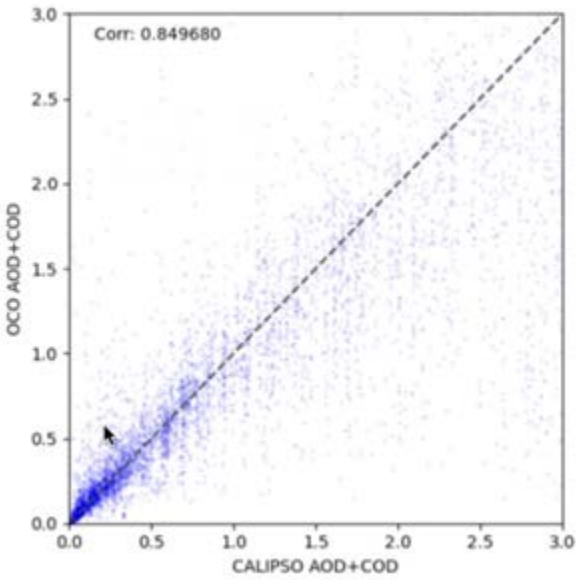


Figure 1: Aerosol and cloud optical depth measured by CALIPSO compared with the same quantities predicted by the machine-learning model from OCO spectra.

Atmospheric modeling efforts have focused on the Mauna Loa eruption in November 2022. An enhancement of XCO2 downwind of the volcano was observed in the OCO-3 standard products. Preliminary modeling results are shown in figure 2 below.

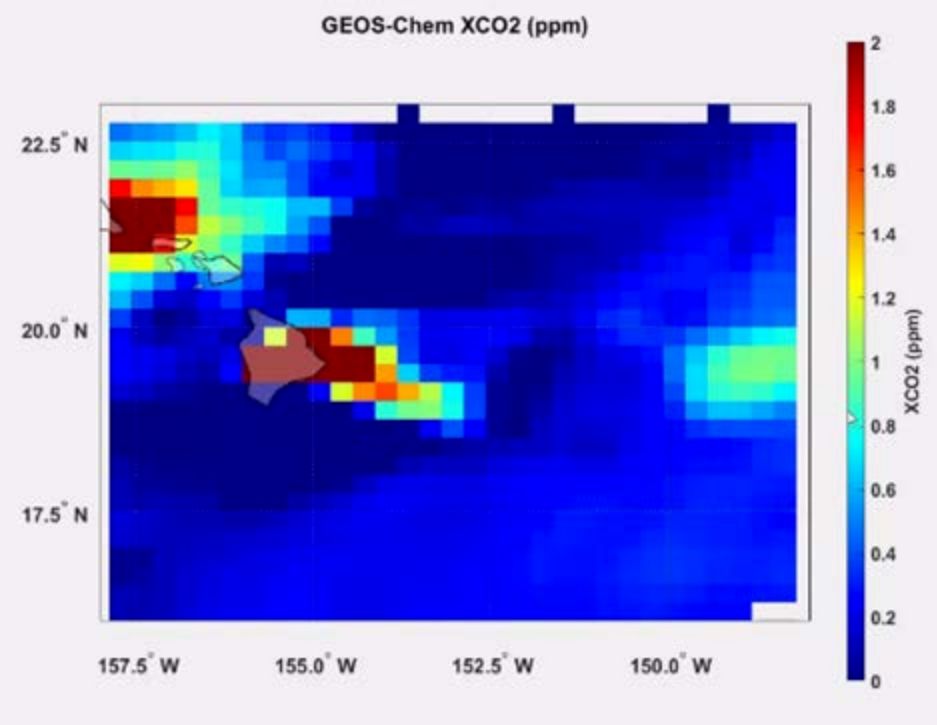


Figure 2: GEOS-Chem model of XCO2 for 30 November 2022 around Mauna Loa volcano on Big Island, Hawaii.

Sea-going Sky-Scanning Sun-Tracking Advanced Robotic Research Radiometer (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's 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 for compensation of the movement of the vessel while making sky- and ocean-radiance measurements.

Accomplishments

- Continued with integration of electro-optics into the measurement head.

- Improvements to the mechanical design of the measurement head, to incorporate custom-made quartz windows and water-cooling.
- Developed feed-forward motion compensation based on the output from an inertial measurement unit (IMU).
- Developed feedback-loop sun-tracking based on a camera image of the sun.
- Developed a state machine to home the robot, acquire the sun based on IMU output, and start sun-tracking.
- Developed ancillary software for performance measurement and tuning.
- Improved performance of communication with the servomotors.
- Began development of a model predictive controller (MPC) to enhance sun-tracking and sky-scanning performance.

Terra-Aqua Suomi-National Polar-orbiting Partnership (TASNPP)

Project Participants

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

Project Description

This project enables the Moderate Resolution Imaging Spectroradiometer (MODIS) and Visible Infrared Imaging Radiometer Suite (VIIRS) continuity products for aerosol above clouds using the light absorption by aerosol measured during ObseRvations of Aerosols Above CLouds and their IntEractionS (ORACLES). 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) Top-Of-Atmosphere (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 Near Infrared (NIR) through the Visible Infrared Spectrum (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 southeast Atlantic Ocean 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. Global Climate Model (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 Short Wave Infrared (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 (Land, Atmosphere Near-real-time Capability for EOS (Earth Observing System)) operational production environment for near real-time MODIS retrievals to support in-field operations and science analysis; LANCE Near Real-Time (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 Above Cloud Aerosol Optical Depth (ACAOD) retrievals are comparable to those from other passive satellite techniques (e.g., Ozone Measuring Instrument (OMI), Polarization and Directionality of the Earth's Reflectances (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 Terra-Aqua Suomi-National Polar-orbiting Partnership (TASNPP) science team, is led by Dr. Kerry Meyer at Goddard Space Flight Center. It aims to produce 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 Suomi National Polar-orbiting Partnership (SNPP)/NOAA-20 VIIRS; this includes refining a quality assurance scheme and initializing the Algorithm Theoretical Basis Document (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.

Accomplishments

- STAR ORACLES measurements from 2016 to build statistics of spectral above cloud AOD for new radiative transfer calculations used in retrieval of Above cloud AOD.
- ExtrapolateStarted comparisons of MODIS ACAOD products to ORACLES, Sky-scanning, Sun-tracking Atmospheric Research (4STAR) and High-Spectral-Resolution Lidar–Generation 2 (HSRL-2) ACAOD, and preliminary comparisons delivered to Dr. Meyer.
- Continued refinement of MODIS and VIIRS ACAOD products binned comparisons to ORACLES measured ACAOD.
- Started publication draft.
- Delivered case study products and overall statistics on aerosol-intensive properties (campaign representative single scattering properties–small slope approximation (SSA), asymmetry parameter, phase function), which were measured by 4STAR during ORACLES 2016, to the Primary Investigator for incorporation into retrieval products.
- Used 4d over wavelength range the intensive aerosol properties using Mie radiative transfer calculations.

Panels or Committees

- NASA Research Opportunities in Earth and Space Science (ROSES) review panel member (LeBlanc, Pistone).
- Department of Energy (DOE) Small Business Innovation Research (SBIR) review panel member (LeBlanc).
- CLOUD GAZE Science Steering Committee (May 2021–present), science advisory on development of a new community science platform as part of NASA's Global Learning and Observations to Benefit the Environment (GLOBE) program (Pistone).
- NASA Ames Research Center (ARC) Science Directorate Diversity and Inclusion Advisory Committee, April 2021–present (Pistone).
- Earth Science Seminar Committee, NASA ARC, January 2021–present (Pistone).
- NASA Technical Review Committee for Minority University Research and Education Project (MUREP) Center for Advanced Measurements in Extreme Environments (CAMEE) project (June 2020–present). Including review of COVID-related second year funding extension (Pistone).
- American Geophysical Union Fall Meeting Program Committee (June 2020–present), Atmospheric Sciences section (Pistone).

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 (DA) 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 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 AQ policy measures.

The TRACER-1 project aims to build a high-resolution, 20-year (2005–2024) regional AC reanalysis 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 (WRF-Chem) as integrated in the Data Assimilation Research Testbed (DART) as modified to include chemical data assimilation and emissions estimation (Chem-DART; collectively called WRF-Chem/Chem-DART). We interface WRF-Chem/Chem-DART with Jet Propulsion Laboratory's (JPL's) Multi-model Multi-constituent Chemical (MOMO-Chem) data assimilation dataset to supply chemical initial and boundary conditions. We have added various forward operators for satellite AC observations into Chem-DART to enable a seamless analysis of AC in TRACER-I. 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 AQ trends across the CONUS, investigate the influence of emission variations on regional AQ, and evaluate the effects of DA on regional DA increments for correlated chemical species. The deliverables from TRACER-I will be a 20-year (2005–2024; April–September) reanalysis of the concentrations, emissions, and uncertainties for the criteria pollutants (excluding particulate matter [PM]) and selected trace gases across the CONUS.

Accomplishments

- Developed and tested WRF-Chem/Chem-DART for the TRACER-1 domain using the chemical mechanism and WRF-Chem settings used by NOAA.
- WRF-Chem/Chem-DART has been improved to include chemical data assimilation for additional satellite platforms and retrieval types to support the TRACER-I reanalysis effort.
- Developed and tested an interface between JPL's TCR-2 (Tropospheric Chemical Reanalysis) and WRF-Chem/Chem-DART for chemical initial and boundary conditions, in conjunction with initial and boundary conditions from NAM (North American Mesoscale) forecasts.
- Comprehensively tested all forward operators for the TRACER-I reanalyses.
- Coordinated with NOAA/CSL (Chemical Sciences Laboratory) to develop the anthropogenic emissions to be input to WRF-Chem/Chem-DART for 2005, 2015, and 2019. These years will be used to do initial testing for the TRACER-1 production simulations.

APPLIED SCIENCES

Agriculture, Health, and Marine Applied Sciences

Project Participants

CSUMB: Adam J. Purdy, Lee Johnson, Alberto Guzman, Will Carrara, Jon Detka, Michael Hang, Ryan Solymar, Michael Biedebach, Kristen Burroughs, Pam Hansen
NASA Ames: Forrest Melton, Conor Doherty, Ian Brosnan, Jessica McCarty, Jacquelyn Shuman
CSUMB student team members: Marie Tolteca, Trent Taylor, Jon Logie, Jason Pham, Robin Fishman, Brandon San Luis

Project Description

CSUMB personnel have a 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 vector-borne 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 NASA 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. The activities under this task include analysis of satellite data, management of airborne and field campaigns to collect data, development of numerical and statistical models, and development/evaluation of 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.

Accomplishments

- Published four peer reviewed journal articles, along with two book chapters, two additional articles that were submitted and currently in review, and three currently in final preparation for a total of nine papers and two book chapters prepared.
- Presented more than 25 scientific and technical talks/posters at science conferences and technical meetings. A. Purdy and W. Carrara also provided training to support the adoption and use of OpenET data to a number of state and federal agencies including: Oregon Water

Resources Department, the United States Bureau of Reclamation, the Colorado River Authority of Utah, the Montana Department of Natural Resources and Conservation, and the United States Geological Survey among others.

- Building on the success of the OpenET data explorer, the OpenET consortium launched OpenET API and Farm and Ranch Management Support system (FARMS) to accelerate and support OpenET data adoption and use by water managers in the western US. The API launch was coordinated with NASA HQ and featured on nasa.gov. Approx. 5,500 users, the majority of whom are self-identified professional practitioners, actively use OpenET as of July 2024. The OpenET API has satisfied almost 150,000 data requests since its launch last October. The OpenET team is currently working with USGS and NASA HQ on a transition plan for OpenET to sustain operational data production for the long term.
    - As a result of the success and impacts to date on water resources management, the House Committee on Appropriations, Subcommittee on Interior, Environment, and Related Agencies included $3.5 million per year for the Department of the Interior to support a national ET mapping system based on OpenET. The funding would provide support for USGS, working in partnership with the OpenET consortium and others, to develop an operational ET mapping system for the US.
- Mentored seven CSUMB students (Marie Tolteca, Trent Taylor, Jon Logie, Jason Pham, Robin Fishman, and Brandon San Luis). Marie Tolteca and Trent Taylor have contributed to research exploring the impact of reference surface quality on surface meteorology observations. Jon Logie is supporting fuel moisture data collection and applications of hyperspectral observations to support fire risk assessments in addition to supporting eddy covariance tower deployment and maintenance. Jason Pham has been supporting fuel moisture data collection, curation, and analysis. Robin Fishman is supporting ET and ETo forecasting analysis and assessment. Brandon San Luis is supporting eddy covariance tower deployment and data analysis. Additional research internships will be offered in 2024–25.
- Secured an additional ~$2.5 million from competitively awarded grants to support research activities related to the OpenET project from the CSU-Agricultural Research Institute (ARI), California Department of Food and Agriculture (CDFA), USGS, and the USDA (awards are detailed below). The OpenET project is advancing the availability of field scale information on ET via open web data services and APIs. OpenET is a partnership among three NASA Centers (Ames Research Center (ARC), Jet Propulsion Laboratory (JPL), Marshall Space Flight Center (MSFC)), Environmental Defense Fund, Google, the Desert Research Institute, USDA, USGS, and several university research teams. A. Purdy supports F. Melton in the coordination of >35 leading experts on remote sensing of ET. F. Melton serves as the NASA Project Scientist for OpenET and technical lead for a team. Purdy and Co-Investigators Guzman, Carrara, Johnson, and Doherty (NASA postdoctoral fellow) have led the implementation and improvement of the NASA Satellite Irrigation Management Support (SIMS) ET model on the Earth Engine platform, development and implementation of a sub-model for deriving effective precipitation and corresponding ET of applied water and

production of field-scale ET data for 17 western states to date. Carrara and Guzman continue to lead development of the OpenET API to support ongoing data production and have made multiple key contributions to the development of the OpenET platform.

  - Purdy (PI) was awarded a CSU-ARI Campus Grant for Mapping Fuel Moisture in Coastal California to inform Fire Risk Mitigation Strategies. The award primarily supports student involvement in field activities and data analysis. (Two years ~ $25K).

  - Purdy (PI) and Johnson (Co-I) were awarded a USGS Cooperative Ecosystem Studies Units (CESU) grant for OpenET: Cooperative Agreement for CESU-affiliated Partner with Californian Cooperative Ecosystem Studies Unit. Funding source: (Two years ~ $1M).

  - Purdy (PI) and Johnson (Co-I) were awarded a USDA National Institute of Food and Agriculture (NIFA) Grant for Applications of OpenET and satellite-based ET information to advance data-driven water management in the Southwest and Southern Plains Regions. Funding source: (Three years ~ $1M).

  - Johnson (PI) and Purdy (Co-I) were awarded a 2023 Specialty Crop Block Grant Program—Grant Proposal. Funding source: CDFA Specialty Crop Block Grant Program (Three years ~ $490K).

  - Johnson (Campus PI) and Purdy (Co-I) are co-investigators on a five-year $10M proposal to the USDA Sustainable Agriculture Systems led by Dr. Susan Metzger at Kansas State University to support agricultural systems in the Southern Great Plains in adapting to climate change and enhancing resilience. (In review).

  - Additionally, through OpenET, CSUMB has been able to secure funding through the contracts or awards from Oregon Water Resources Department, the United States Bureau of Reclamation, the Colorado River Authority of Utah, the Montana Department of Natural Resources and Conservation, and the Walton Family Foundation among others to support ongoing activities related to the advancement and applications of ET data through OpenET.

- Completed a working beta version of the FARMS system to ease the adoption and application of OpenET. The FARMS user interface allows people to upload geometries and retrieve automated reports from OpenET. The OpenET FARMS user interface has also been undergoing working groups to incorporate multiple extension agencies. This advancement and work on the OpenET API has facilitated integrations with the University of California Agriculture and Natural Resources (UCANR) CropManage tool. With support from NASA's Water Resources Applied Science Program, Johnson, in collaboration with UCANR has been working to integrate OpenET data and forecasted data into the CropManage tool. This allows data from OpenET, including the SIMS model, to be used operationally to support irrigation and fertilizer management decisions by more than 1,000 California growers in the Salinas Valley and beyond.

- Helped organize and conduct an OpenET Applications Conference that attracted >300 professionals and academics. The two-day meeting featured presentations from the

OpenET team and users involved with a variety of applications, as well as training workshops. All presentations and trainings were recorded and are publicly available for online viewing.

- Continued to set up eddy covariance flux towers in collaboration with Central Coast growers to measure ET from select fields and enhance understanding of crop water requirements in high-value Salinas Valley crops and provide a basis for further evaluation of output from OpenET and the CropManage decision support system operated by UC Cooperative Extension. R. Solymar and M. Biedebach have led the deployment and operation of eddy covariance instrumentation in commercial fields and vineyards in the past year and provided key support for data post-processing. The data from these flux towers are currently being used to evaluate ET values from OpenET and irrigation recommendations from CropManage. Additionally, the field team has been able to collect valuable ET observations at the UC WestSide Research and Extension Center (WSREC) to support instrument intercomparisons and develop an ET dataset for fallowed fields.

- In partnership with USDA ARS in Salinas, California, the project team continued to use an Unmanned Aerial Vehicle (UAV) platform and Micasense Altum camera to collect imagery over agricultural fields in the Salinas Valley. The project team of Melton (Collaborator) and Hang (Co-I) recently completed joint research with USDA ARS under a five-year cooperative agreement with USDA ARS ($500k total funding) to identify and map plant pathogen presence in strawberries and other high value specialty crops. The project received a follow-on agreement that allowed the team to hire a postdoctoral scholar (J. Detka) to support manuscript preparation and complete one more field campaign. The CSUMB team assesses the development of crop canopies and fractional cover across multiple crops. M. Hang used the UAV to map a research site in 2023, and J. Detka has an automated data processing workflow to transform tens of thousands of UAV images into plant locations, fractional canopy cover, and canopy condition. J. Detka and M. Hang are currently working with USDA partners to incorporate data on crop yields and pathogen density into the analysis.

- Collected one year of live fuel moisture in Carmel Valley, California, to support regional applications of fire risk assessment. In collaboration with the CAL-FIRE San Benito-Monterey Unit, the team continues to collect fuel moisture samples on the Santa Lucia Preserve and Monterey Peninsula Regional Park District lands. On October 5, 2023, A.J. Purdy and M. Biedebach, with support from CSUMB students, led simultaneous fuel and soil moisture data collection under three NASA aircraft as part of the 2023 FireSense Field Campaign. The field collection included nine additional CSUMB students. Preliminary results were presented at the 2023 international fire congress. A.J. Purdy is mentoring J. Logie on the use of hyperspectral and synthetic aperture radar data processing and applications for live fuel moisture and vegetation composition and condition mapping. With support from NASA Firesense project and the CSU-ARI campus award, the team (A.J. Purdy, M. Biedebach, and J. Logie) continues to collect fuel moisture data in 2024 to support regional fire risk assessment.

Panels or Committees

- A.J. Purdy and L. Johnson participated in NASA's. Western Water Application Office Annual Meeting, Boulder, Colorado. May 2024.
- A.J. Purdy attended NASA Jet Propulsion Laboratories A-Team Study Wildfire Research to Operations Project to support NASA's FireSense project, Virtual. May 2024
- A.J. Purdy co-convened Session 4: Re/Insurance and the Business of Water at the AGU Chapman Conference on Remote Sensing of the Water Cycle, Honolulu, Hawaii. February 2024
- A.J. Purdy attended the California Irrigation Institute Annual Meeting. Fluid Futures: Adapting to Extremes (to represent NASA's Western Water Application Office), Sacramento, California. February 2024
- A.J. Purdy attended and facilitated NASA's Western Water Application Office Needs Assessment Workshop for the Arkansas Red-White River Basin, Oklahoma City, Oklahoma. June 2024
- A.J. Purdy attended and co-convened Session: OpenET: Satellite-Based Evapotranspiration Data to Support Advances in Hydrology and Water Resources Management at the AGU Water Sci Conference, St. Paul, Minnesota. June 2024
- A.J. Purdy attended NOAA's Workshop for Building Drought Resilience in a Changing Climate with Upper Columbia and Missouri Basin Tribes (to represent NASA's Western Water Application Office), Missoula, Montana. September 2023
- A.J. Purdy attended and participated in the NASA's Western Water Applications Office Annual Retreat, Pasadena, California. October 2023
- A.J. participated in NASA review panels (Applied Sciences).
- C. Doherty gave a presentation on the development and use of effective precipitation data during a plenary session of the OpenET Applications Conference, Albuquerque, New Mexico. February 2024
- W. Carrara gave a presentation on upcoming features and functionalities during a plenary session of the OpenET Applications Conference, Albuquerque, New Mexico. February 2024
- L. Johnson moderated a breakout session on integration of OpenET into decision-support tools. OpenET Applications Conference, Albuquerque, New Mexico. February 2024.
- L. Johnson was a Scientific Committee member for the 2024 IEEE IGARSS Symposium.

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 2024, 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.

Ambrosia continued his support of the management transitioning tasks of the NASA Global Observations of Forest Cover and Land-use Dynamics (GOFC-GOLD) Mediterranean Regional Information Network (MedRIN). He was a co-coordinator of MedRIN with two European co-coordinators. His activities are being transitioned to Dr. F. Schwandner (NASA Ames Research Center (ARC) Earth Science Division Chief), and he will advise on MedRIN workshops and coordination for the near term on an “as-needed” basis.

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 participation in the NASA LCLUC Annual Team Meeting. The 2024 annual MedRIN workshop was recently completed (July 2024) at the MAICH (Mediterranean Agronomic Institute of Chania), Chania, Crete, Greece. The workshop was coordinated with the South-Central European Regional Information Network (SCERIN). V. Ambrosia will also assist in the further transition of MedRIN coordination to staff at NASA-ARC, through the leadership of F. Schwandner (NASA ARC Earth Science Division Chief).

Accomplishments

- Co-hosted/Chaired the Tactical Fire Remote Sensing Advisory Committee (TFRSAC) virtual meetings and supported the restructuring of the charter documents for the group and the inclusion of new co-coordinators on the steering committee (now including NASA, United States Forest Service (USFS), NOAA, and USGS).
- Supported the monthly NASA Center Leads Wildfire Meetings, providing guidance on collaborations with the wildfire management community and helping define goals and objectives for the NASA-wide program.
- Served as technical reviewer for the 2023–2024 USDA-National Institute of Food and Agriculture (USDA-NIFA) Small Business Innovative Research (SBIR) program proposals.
- Served on the FirEUrisk Scientific Forum Board; a European Commission (EC)-funded trans-European wildfire program, led by University of Coimbra (Portugal) and University of Alcala (Spain), 2019–2025. Participated in virtual meetings and annual progress reviews.
- Served as an External Advisory Board (EAB) member—EXCELSIOR Program (ERATOSTHENES: Excellence Research Centre for Earth Surveillance and Space-Based Monitoring of the Environment), Cyprus University of Technology (CUT), Limasos, Cyprus (2019–2027). Participated in virtual and in-person meetings and reviews.
- Served as member of the External Advisory Committee (EAC) for Nevada's National Science Foundation (NSF) Established Program to Stimulate Competitive Research (EPSCoR) Research Infrastructure Improvement (RII) project, "RII Track 1: Harnessing the Data Revolution for Fire Science." Participated in virtual and in-person annual reviews with NSF review staff.

- Peer-reviewed submissions for scientific journals, including Remote Sensing, Fire, Forests, Journal of Applied Earth Observations, Science of Remote Sensing, Sensors, and Remote Sensing Applications Journal.

Ecological Forecasting

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 is managing 10 projects for the program in FY24.

Accomplishments

- Attended project team workshop in Kasane, Botswana, in October.
- Attended project team meeting in Boise in November.
- Attended American Geophysical Union (AGU) in December. Co-convened a Biological Diversity oral session.
- Mentored NASA HQ student intern on developing outreach materials for the Ecological Conservation and Biodiversity programs.
- Organized and attended Ecological Conservation team retreat in Florida in January.
- Developed an agenda and helped organize Ecological Conservation and Biodiversity programs team meeting in Washington, DC, in May.
- Participated in Future Investigators in NASA Earth and Space Science and Technology (FINESST) proposal review in May.
- Participated in proposal panel review for Ecological Conservation in July.

Panels or Committees

- Review committee for Applications Guidebook.
- Board member for UC Berkeley Geospatial Innovation Lab.

Equity and Environmental Justice (EEJ)

Project Participants

BAERI: Emma Yates, Nikki Tulley
NASA GSFC: Sabrina Delgalo Arias
NASA LARC: Edil Sepulveda Carlo
NASA HQ: Michelle Hawkins Aguilar

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 and ROSES-23 A.47 project portfolios. 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.

Accomplishments

- Involved in the organization and running of NASA review panel for Research Opportunities in Earth and Space Science (ROSES) solicitation A.47 Earth Action: Community Action for Equity and Environmental Justice (June 2024).

Partnerships

Project Participants

BAERI: Cindy Schmidt
NASA: 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 Earth Science Division (ESD) remote sensing data and research and advances natural-resource management, including natural-capital accounting and ecosystem-health assessment. FY24 efforts for one team have been focused on mapping blue carbon in Eastern Africa, particularly mangroves and sea grasses. The second team is focused on mapping global riparian zone ecosystems and helping determine where those ecosystems can play an important role in nature-based solutions.

Accomplishments

- Organized bi-monthly meetings with the riparian team to obtain project updates with NASA team members and Conservation International (CI).

- Participated in bi-weekly and quarterly review meetings with the Blue Carbon team to obtain project updates with NASA team members and CI.
- Reporting all successes and challenges to Lawrence Friedl in preparation to reassess all the ESD partnerships in late FY24.
- Attended riparian project workshop at CI offices in Arlington, VA, in March.
- Working closely with Lawrence Friedl to develop a partnership strategy for NASA's ESD.

Plant Physiology

Project Participants

BAERI: Greg Schlick
NASA: David Bubenheim

Project Description

Invasive aquatic plants have ecological, economic, and social impacts on waterways throughout the world. The California Delta, which involves the San Francisco Bay and San Joaquin and Sacramento River watersheds, is seriously affected by the increasing presence of aquatic invasive plants, which threaten the water management and ecological integrity of the region. Invasive aquatic plants are affecting resource management, ecosystem services, aquatic habitats and food webs, as well as the primary agricultural production and water supply to 25 million people in California. Added challenges include unpredictable climate and environmental variations, unknown biological response to those variations, and changing regulatory rules, stakeholder needs, and regional US water-resource distribution and management policy.

The Delta Region Areawide Aquatic Weed Project (DRAAWP) was launched as a comprehensive and multi-disciplinary response effort to develop science-informed, adaptive management support systems. DRAAWP includes the USDA's Agricultural Research Service (ARS), the NASA Ames Research Center, the University of California, Davis, and the State of California's Division of Boating and Waterways (DBW).

Accomplishments

- Completed an entire year/season of sampling in the delta for floating aquatic vegetation (FAV), and provided biomass and leaf-area data for mapping.
- Provided data to fill in gaps of biomass for treated areas of FAV.
- Worked closely with the State of California DBW and California State Parks to identify sample collection sites for FAV and submerged aquatic vegetation (SAV), and validate satellite imagery.
- Added several SAV sites for satellite imagery.

- Maintained and increased culture ability from FAV, and added significant SAV collection to the panel.
- Added CO2 to the culture systems to optimize cultures as well as add the capability of manipulating dissolved CO2 concentrations that are consistent with water flows in the delta.
- Defined a potentially new method for looking at respiration in SAV and LiCor, which is helping build a test unit.
- Maintained and improved the controlled environment agriculture (CEA) facility, and increased capabilities to include respiration and plant development.
- Ran the plant science facility at Ames, and kept the facility operational and up to code with regulatory entities.

USDA-ARS California Delta Areawide Project for Integrated Resource Management

Project Participants

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

Project Description

This project is a collaboration between NASA, the USDA-Agricultural Research Services (ARS), and the California State Parks, DBW to map invasive aquatic vegetation throughout the San Francisco Delta region using satellite data to assist with environmental mitigation projects. In addition, we have developed an ArcGIS dashboard as a mapping interface for the DBW field operators to use.

Accomplishments

- Continued creating mapping products using Sentinel 2 data for the DBW management dashboard.
- Creation of algorithm and code for identifying individual invasive plant species.

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 a science team member for NASA's Western Water Application Office (WWAO).
- Engage and support WWAO project teams in identifying and resolving project issues and coordinate the WWAO science team.
- Conduct outreach and engage and support the NASA Applied Sciences Water Resources stakeholder community.

Accomplishments

- Participated in meetings with WWAO. Monitored project progress and provided strategic advice for multiple projects being supported by WWAO in the Columbia Basin and the Rio Grande Basin. Supported technical progress on projects supported by WWAO.
- A.J. Purdy facilitated NASA's WWAO Needs Assessment Workshop for the Arkansas Red-White River Basin by providing technical expertise related to agriculture use-cases. The needs assessment was held in Oklahoma City, Oklahoma, in June 2024.
- Assisted with organization and planning for the NASA presence at multiple meetings and conferences. A.J. Purdy attended NOAA's Workshop for Building Drought Resilience in a Changing Climate with Upper Columbia and Missouri Basin Tribes to represent WWAO in Missoula, Montana, in fall 2023. A.J. Purdy attended the California Irrigation Institute Annual Meeting—Fluid Futures: Adapting to Extremes to represent WWAO Sacramento, California, February 2024, in addition to representing WWAO during additional workshops, meetings, and conferences.
- P. Hansen organized and supported the annual 2023 NASA Water Resources Team Meeting in Huntsville, Alabama, from September 26–28, 2023; the annual 2024 NASA Water Resources and WWAO meeting in Boulder, Colorado, from April 30–May 2, 2024; and the in-progress 2024 NASA Water Resources Team Meeting in Boston, Massachusetts, to be held from September 17–19, 2024. Hansen vetted potential venue locations (hotel block, catering, conference venue, A/V support), organized all meeting logistics, facilitated on-line and in-person attendance, created all meeting materials, and organized and facilitated all meeting communication and post-meeting analysis and outreach.
- A.J. Purdy joined the WWAO and participated in the WWAO Annual Retreat to provide input on the strategic plan. The meeting was held in Pasadena, California, in October 2023.

Panels or Committees

- A.J. Purdy participated in NASA review panels (WWAO and NASA Applied Sciences).

- A.J. Purdy co-convened Session 4: Re/Insurance and the Business of Water at the AGU Chapman Conference on Remote Sensing of the Water Cycle. Honolulu, HI, February 2024
- A.J. Purdy attended and co-convened Session: OpenET: Satellite-Based Ev*apotranspiration Data to Support Advances in Hydrology and Water Resources Management* at the AGU Water Sci Conference. St. Paul, MN, June 2024

WWAO

Project Participants

BAERI: Amber McCullum
CSUMB: A.J. Purdy
NASA Headquarters: Erin Urquhart
JPL: Stephanie Granger, Alphan Altinok, Amber Jenkins, Sharon Ray, Mark Davidson, Colleen Schroeder, Renato Fasson
NASA Goddard Space Flight Center: Bailing Li, Amita Mehta

Project Description

Water challenges in the western US have made enhanced resource management solutions with NASA's Earth-observation capabilities pivotal. In addressing this multifaceted paradigm, it is crucial to have a science-based understanding of water resource issues and to match those with NASA's capabilities. Moreover, fostering user-driven approaches to water management and decision-making is essential for effective and sustainable solutions. NASA's Western Water Applications Office (WWAO) has identified six critical areas in water management, each containing various needs that could benefit from NASA Earth science observations and capabilities. These include water availability, use, quality, and infrastructure; extreme events; and watershed health and management. The goal of WWAO is to increase use of NASA Earth Observations (EO) by water organizations in the western US and maximize the impact of NASA Earth observations and capabilities to improve water management in these complex water management environments. WWAO was established to further the Earth Action Water Resources Program Area goals by leveraging the broader Water Resources Program and contributing to Earth Science Division achievements. The program aims to engage both water managers and scientists to identify and co-develop promising EO-informed solutions, and partner with organizations to transition these solutions into operations. Amber McCullum serves as the Impact and Transition Lead for the WWAO Program Office.

Accomplishments

- Developed an annual plan that outlines the general responsibilities of the Impact and Transition Lead and provides a detailed timeline for actions and deliverables.
- Developed thought leadership in Application Transition and Research to Operations (R2O).
    - Created a list of leaders in R2O within federal agencies and academic institutions that can be used for seeking guidance and establishing a community of practice.

    - Connected with other program elements within Earth Action to discuss successes, challenges, and pathways toward R2O.
    - Held a town hall at the American Geophysical Union (AGU) Annual Meeting around Research to Operations in water management on December 14, 2023.
- Developed resources to assist WWAO projects (PIs and partners) in Application Transition.
    - Created and communicated a transition guideline document for WWAO project leads
    - Held separate post-project conversations with project PIs and partners to identify lessons learned, best practices, and future needs around transition.
    - Followed up with project partners on an as-needed basis should the need for “final-mile” transition support be identified.
- Supported WWAO program office in Application Transition and R2O.
    - Identified WWAO and Earth Action water resource projects that may be candidates for additional transition support.
    - Reviewed transition concepts from project partners and collaborated with program managers to secure funding for transition projects.
- Developed WWAO project resources to increase impact.
    - Provided projects with impact reporting templates at project start.
    - Held meetings at the beginning of each project to identify which impact metrics were tracked and cadence for reporting.
    - Created impact stories/communications with the water resources community.
- Supported and participated in the WWAO Annual Retreat in Pasadena, CA on October 12–13, 2023.
- Supported and participated in the WWAO Annual Meeting in Boulder, CO on April 30–May 2, 2024.
- Supported and participated in the WWAO Arkansas White Red River Basin Needs Assessment in Oklahoma City on June 11–13, 2024. Engaged with water users in the Arkansas White Red River Basin to generate multiple use cases for relevant applications of NASA’s remote sensing data for water management issues. Outcomes from this workshop will be used by WWAO for future solicitations for NASA-funded projects.

EARTH SCIENCE TECHNOLOGY

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

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, Angel Farguell Caus
United States Geological Survey (USGS), South Dakota: Kurtis Nelson
University of Colorado, Boulder: Jan Mandel
University of Southern California: Mahta Moghaddam, Amer Melabari, Archana Kannan
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 will develop an adaptive, intelligent, and responsive observation strategy, which will 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.

Progress

- Developed a Monte Carlo Tree Search (MCTS) approach for scheduling satellite-observation and downlink operations, with simulation studies for pre-fire monitoring over the Continental US (CONUS) region.
- Currently streamlining and enhancing the fidelity of mission operations simulation software (EO-Sim). Created and adapted an Earth Observing Systems Engineering API: EOSE API.
- Ongoing development of data products using GNSS-R (Cyclone Global Navigation Satellite System (CYGNSS) data) for wildfire applications. This includes creating a burned-area

product, enhancing the USGS Fire Danger product, and joint retrievals of soil moisture and vegetation water content.

- Continuing progress in developing a wildfire-severity predictor for the CONUS region. This tool will aid in driving satellite observations and optimizing resource utilization.

EDUCATION, OUTREACH, AND WORKFORCE DEVELOPMENT

Applied Remote Sensing Training Program (ARSET)

Project Participants

BAERI: Sativa Cruz, Britnay Beaudry, Justin Fain
NASA: 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 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 at NASA Ames focuses on land and wildfire training, including 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 to process and analyze data using geospatial software to aid in decision-making. 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.

Accomplishments

- Delivered training series: Using Earth Observations for Pre- and Post-Fire Monitoring. (https://appliedsciences.nasa.gov/join-mission/training/english/arset-using-earth-observations-pre-and-post-fire-monitoring)
    - This training occurred on January 18 and 20, 2022, and consisted of two sessions with hands-on exercises and lab time, where participants completed exercises. Instructors were available online to answer questions as they arose. The first session reviewed pre-fire risk assessment by investigating land surface variables (e.g., vegetation type and height, fuel regimes, fuel moisture, and topography) and climate variables (e.g., temperature and precipitation). In the second session, we conducted post-fire mapping of burned area and burn severity using vegetation indices such as the Normalized Burn Ratio (NBR). Methods included the use of open-source tools such as Google Earth Engine and NASA-supported platforms such as the SERVIR Global Service Catalog for analyzing imagery. The training had a large turnout with **1,028 participants** in attendance from **107 countries, 37 states, and 500 organizations**. Training materials were provided in both English and Spanish to increase accessibility across a broader audience.

- Delivered training series: Using the UN Biodiversity Lab to Monitor the Pulse of the Planet. (https://appliedsciences.nasa.gov/join-mission/training/english/arset-using-un-biodiversity-lab-monitor-pulse-planet)
    - This five-part, trilingual training occurred from April 14 to May 4, 2022, and focused on using remote sensing and geospatial data within the NASA-supported UN Biodiversity Lab (UNBL) to take action on national conservation and sustainable development priorities. With 400+ of the world's best global data layers on biodiversity, ecosystem services, and sustainable development, UNBL enables decision-makers and policymakers to access essential global data, upload national datasets, and calculate dynamic indicators for any area of interest—all without any background in remote sensing and GIS. This training was organized by ARSET trainers Amber McCullum (ARC) and Juan Torres-Pérez (ARC) and delivered by guest speakers Annie Virnig (United Nations Development Programme (UNDP)), Di Zhang (UNDP), Osgur McDermott-Long (United Nations Environmental Programme World Conserving Monitoring Centre (UNEP-WCMC)), Marion Marigo (UNDP), Casandra Llosa (UNDP), Lauren Weatherdon (UNEP-WCMC), and Scott Atkinson (UNDP). In attendance were 958 participants from 121 countries and 23 US States. Approximately 400 organizations were represented.
- Delivered training series: Monitoring Aquatic Vegetation with Remote Sensing. (https://appliedsciences.nasa.gov/join-mission/training/english/arset-monitoring-aquatic-vegetation-remote-sensing)
    - This introductory-level training combined basic information on the remote sensing of aquatic vegetation and spectrometry of aquatic/coastal vegetation and a demonstration of the NASA-funded Floating Forests citizen science tool. The training reached 813 participants from ~400 organizations across 95 countries and 30 US States.
- Delivered training series: Evaluating Ecosystem Services with Remote Sensing. (https://appliedsciences.nasa.gov/join-mission/training/english/arset-evaluating-ecosystem-services-remote-sensing)
    - This introductory-level training outlined the basics of ecosystem services and natural capital accounting and provided an overview of how Earth Observations (EO) can support global frameworks and initiatives, such as standards set by the United Nations System of Environmental-Economic Accounting (UN-SEEA). The training reached 1,668 participants from ~800 organizations across 120 countries and 42 US States.
- Produced FY23 Training Plan
- Prepared for training series: Connecting Citizen Science with Remote Sensing.
    - This introductory-level training, occurring in January 2023, provided attendees an overview of citizen science efforts that use Earth Observations, and how to engage with community members in a supportive and meaningful manner to achieve project goals. Attendees were provided with case-study examples of successful citizen science

projects, in particular those funded under NASA's Applied Sciences Program. We highlighted projects like NeMO-Net (Neural Multimodal observation and training network for global coral reef assessment): a global coral reef classification with a 2D and 3D image application combined with machine learning; Floating Forests: a Giant Kelp monitoring platform where participants classified kelp in Landsat images; Snapshot Wisconsin: a project that uses images of wildlife from trail cameras to assist with habitat mapping; Soundscapes to Landscapes, where bird diversity in California is monitored by identifying specific species through sound recordings; and the Global Learning and Observations to Benefit the Environment program (GLOBE) Observer Mosquito Habitat Mapper: an application that pairs satellite-based observations of temperature, water, and vegetation with sites where citizen scientists report potential mosquito habitat and presence of mosquito larvae.

ASP Communications

Project Participants

BAERI: Brenna Biggs, Gary Ash

Project Description

In addition to science, the Airborne Science Program (ASP) does outreach for K–12 schools, occasionally teaming up with the Global Learning and Observations to Benefit the Environment program (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 gather support for more in-person opportunities, students have a chance to connect with scientists face-to-face as well. I also attend NASA SMD Communications meetings weekly.

Accomplishments

- 2024 NASA Group Achievement Award – Sub-Mesoscale Ocean Dynamics Experiment (S-MODE)
- 2024 NASA Group Achievement Award – Investigation of Microphysics and Precipitation for Atlantic Coast—Threatening Snowstorms (IMPACTS)
- 2024 Award for Outstanding Support of the NASA S-MODE Mission
- Hosted 4 30-minute virtual science club meetings for 6th grade students at Roberts Street Elementary School in Canastota, NY in May and June, 2024.
- Created and delivered 26 in-person (2,812 students in 3 countries: Philippines, Thailand, and South Korea) and 30 virtual (2,285 students in 12 countries) presentations reaching over 96 schools during the 2024 Airborne and Satellite Investigation of Asian Air Quality (ASIA-AQ) campaign. Bilingual interpretation offered. Students also collected 71 GLOBE Atmosphere: Clouds observations and 40 Whole Air Sampling canisters to contribute to the campaign dataset.

- For the 15th Annual Student Airborne Research Program (SARP) in 2023 - coached 24 undergraduate students to communicate effectively as scientists through an hour-long presentation and one-on-one follow-up discussions to prepare them to present their internship data to their peers, faculty, and NASA representatives.
- Provided school outreach for Biodiversity Survey of the Cape (BioSCape) in 2023. Created and delivered 8 in-person presentations to 169 students from 10 different schools near Cape Town, South Africa. Six of these schools were in townships—historically underprivileged areas created because of apartheid. Over 50 data points about the atmosphere and hydrosphere were collected using standardized GLOBE protocols. Also facilitated a two-day workshop for 17 participants representing 2 South African government agencies, 1 non-profit organization, and 1 environmental consulting firm to become certified in GLOBE protocols. Over 90 data points about the atmosphere and biosphere were collected using standardized GLOBE protocols.
- Continued to update the ASP website with News and Current Activities.

CSUMB Educational Program

Project Participants

CSUMB: Susan Alexander
Students: Brandon Alexander, Kristen Burroughs, Noe Cabrera, Robin Fishman, Emily Haydis, Ronnie Lazaro, Jonathan Logie, Jason Pham, Brandon San Luis, Trent Taylor, 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: (Professional Science Master's) 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.

Accomplishments

- Students participated in the CSUMB ARC-CREST Ag, Health, Marine, and Water Resources task, including being co-authors on several publications and presentations.

Fire&Air

Project Participants

BAERI: Samiah Moustafa, Kristina Pistone
NASA: Chris Potter, Jessica McCarty, Matthew Johnson

Project Description

The Fire&Air project aims to enhance diversity and inclusion in wildfire and atmospheric sciences by providing tailored mentoring and research opportunities to underrepresented groups (URGs) at California State University, Stanislaus (CSUStan). Recognizing the historical and systemic barriers faced by URGs, the initiative seeks to foster an equitable STEM environment aligned with NASA's diversity, equity, inclusion, and accessibility (DEIA) goals. The project leverages CSUStan's diverse student body and its strategic location in California's

Central Valley, a region deeply affected by wildfires and pollution. By connecting students with NASA scientists and resources, Fire&Air offers comprehensive support through a two-year program that includes yearlong mentorship, hands-on research experiences, and professional development. This initiative aims to empower students, facilitate their entry into STEM careers, and contribute to innovative research that addresses critical environmental challenges.

Accomplishments

- Developed a Program Schedule for Summer 2024 and Related Curriculum.
- Developed a program website in collaboration with NASA Ames Research Center.
- Directly mentored four undergraduate student researchers, in collaboration with two NASA Subject Matter Experts (SMEs) and two faculty mentors at CSUStan, through research projects in wildfire and air quality, from start to finish.
- Developed an eight-week summer research program at NASA Ames Research Center and CSUStan.

FireSage

Project Participants

BAERI: Samiah Moustafa
NASA: Hiro Hashimoto, Weile Wang, Jessica McCarty, Juan Torres-Perez
UC Santa Cruz: Bo Yang
SJSU: Kate Wilkin, Julia Gaudinski

Project Description

Geosciences, encompassing Earth, Ocean, and Atmospheric Sciences, is notably lacking in diversity and has historically excluded underrepresented groups. The White House's Office of Science and Technology Policy aims to break down these barriers, fostering greater innovation and participation in STEM. Effective mentoring for these groups requires a shift from traditional hierarchical models to adaptive, multi-mentor approaches. FireSage, a collaborative effort between San Jose State University (SJSU) and NASA Ames Research Center (ARC), addresses this by combining Wildland Fire Science research with a robust mentoring program. This initiative trains and inspires students from diverse backgrounds, preparing them for careers in STEM and NASA. FireSage employs a sustained mentoring model with multiple mentors, providing students with comprehensive support and opportunities to engage in high-performance computing and AI research. The program's ultimate goal is to diversify the field of Wildland Fire Science, STEM education, and the NASA workforce by creating a scalable, impactful mentoring and research framework.

Accomplishments

- Developed a Program Schedule for Summer 2024 and Related Curriculum.

- Developed a program website in collaboration with NASA ARC.
- Directly mentored two undergraduate and four graduate student researchers, in collaboration with two NASA Subject Matter Experts (SMEs) and two faculty mentors at SJSU, through research projects in wildfire and artificial intelligence, from start to finish.
- Developed a 10-week summer research program at NASA ARC and SJSU.

Indigenous Peoples Initiative (IPI)

Project Participants

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

Project Description

The Indigenous Peoples Initiative (IPI), within NASA's Capacity Building Program Area (CBP), 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 trainings, 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

Accomplishments

- December 6–8, 2023, 10th International Fire Ecology and Management Congress in Monterey, CA. Victoria attended the Indigenous Fire track of this conference and cultivated relationships built in the Institute for Tribal Environmental Professionals' (ITEP) fire workshop in September.
- February 1, 2024, FireSense and Community Engagement. Amber and Victoria met with NASA's FireSense group to discuss engaging with Indigenous communities. This activity supports collaborating between Earth science application areas and application of R&A.

- February 8, 2024, CHIPS Qualitative Report Submitted. Part of a White House mandate related to the CHIPS and Science Act of 2022, NASA's IPI team held a series of discussions with Tribal users of NASA EO.
- February 2023, 2024, CBP+ Retreat, Asheville NC.
- February 21–22, 2024, Indigenous Co-Stewardship of Public Lands Workshop. Victoria attended and connected with Indigenous communities in California.
- February 27–28, 2024, OpenET Applications Workshop. Participation in this event was as an attendee. The opportunity to network was ample and new connections were made with Navajo Agricultural Products Industry (NAPI) and members of new hires with the Navajo Nation (NN) Water Management Branch.
- February 28, 2024, NAFWS Webinar. Sativa presented NASA and Indigenous Communities: Fostering Earth Action alongside Cindy Schmidt for a webinar hosted by the Native American Fish and Wildlife Society (NAFWS). This presentation also featured collaborative components from the Land Processes Distributed Active Archive Center (LPDAAC) and the Ecological Conservation Applications Area. Together they introduced participants to the fundamentals of EO; gave an overview of NASA's Earth Action and CBPs; provided examples of EO used for fish, wildlife, habitat, and environmental justice applications; and shared opportunities to connect in the future.
- March 5–7, 2024, IPI Retreat, Santa Fe, NM.
- March 19, 2024, Navajo Nation Earth Observation Brainstorming Session, virtual. As part of the EO Collective, a joint effort with USGS, WWF, ESRI, and others, the IPI held the virtual Navajo Nation Earth Observation Brainstorming Session. This session was part of the continued relationship building and outlining future project ideas following the April 2023 Nihima Nahasdzaan The Art of Mother Earth event held on the Navajo Nation. This included representatives from multiple Navajo Nation Natural Resources Mgmt. departments including Water Resources, Agriculture, and Forestry.
- April 15–17, 2024, Auburn, Washington. Nikki participated in a panel discussion at the Affiliated Tribes of Northwest Indians 2024 National Tribal Leaders Climate Summit: Honoring Traditions, Shaping Futures. https://www.bia.gov/news/attend-2024-national-tribal-leaders-climate-summit
- April 19, 2024, Pablo, Montana. Nikki and Amber, as part of the EO Collective, participated in the Confederated Salish Kootenai Tribes Earth Day Event being held at the Salish Kootenai College, which engaged community members around the use of EO for landscape monitoring, mapping, and storytelling.
- April 29–May 2, 2024, Tribal GIS, Albuquerque, NM. Nikki and Sativa attended Tribal GIS as conference participants.

- May 7, 2024, Adaptation and Response in Drylands (ARID) Stakeholder Workshop at University of New Mexico. Nikki attended to provide perspectives from Navajo/IPI.

- May 9, 2024, Code S presentation. Amber provided the NASA Ames Code S Seminar on NASA's Indigenous Peoples Initiative: Community Connections to Earth Observations.

- May 13–16, Native American Fish and Wildlife Society Annual Meeting. Sativa, Victoria, and Brianna Lind (USGS/LPDAAC) hosted a workshop on NASA Earth Observations for Habitat Monitoring. This in-person training focused on the use of NASA EO for landscape monitoring and mapping with a focus on buffalo habitat mapping and restoration. The NASA and USGS collaborative team also hosted a booth for the event to network and connect with the Indigenous wildlife and conservation biology community. https://www.nafws.org/product/2024-national-conference/

- May 28–30, CSA EO Forum. NASA's IPI (Amber and Nikki) co-organized a panel called "Sharing Stories about Indigenous Wisdom, Earth Observation and Mapping" for the Canadian Space Agency's (CSA) Earth Observation Forum at CSA HQ in Montreal, Canada. The session was also co-organized by the CSA smartEarth team and the Indigenous-owned Firelight Group. The panel explored pathways for linking traditional knowledge and EO capabilities around topics such as land management, coastal-marine issues, data sovereignty, EO data access, education, and training. The panel began with a welcome from Chief Cody Diabo of the Kahnawake Council and consisted of panelists from the Ya'thi Néné Lands and Resources Office, the Saskatchewan Aboriginal Lands Technicians, NASA's IPI, the Arctic Eider Society, and First Nations University.

- July 1–3, 2024, Karuk Needs Assessment and Fire Symposium. Sativa and Victoria attended/facilitated.

- July 17, 2024 ESRI User Conference Native Nations Summit, San Diego. Amber attended.

- July 29–30, 2024, Maori NZ Catalyst Project team visit at Ames. As a kickoff to the **Catalyst: Strategic – New Zealand – NASA Research Partnerships 2023**, the IPI will be hosting partners for the project Tātai Arorangi he kaiarataki—Integrating space-based observations into Maramataka at Ames Research Center and on the Navajo Nation. The visit will begin on July 29th with a 2-day knowledge exchange and EO training session around Connecting Land and Sky: Place-based storytelling with NASA data. On July 30th at 2:05pm in N232, room 103, the SGE Branch will host a special seminar highlighting the project. The New Zealand/IPI group will then travel to JPL on August 1st to visit with Native Engagement in Building a Unified Leadership Alliance (NEBULA) to discuss Indigenous knowledge systems and applications from the ERG's work within Earth Science. They will then be hosted by Nikki from August 3–5 to visit with her community near Blue Gap, AZ, and then in Window Rock, AZ, to meet with members from the Navajo Nation Department of Natural Resources to listen, learn, and discuss long-standing relationships with NASA's IPI.

- September 1–6, 2024, Indigenous Mapping Workshop (IMW) Australia. Perth, Multi-day training, Amber, Nikki.

- September 9–13, 2024, National Tribal Climate Change Conference. One-day training, SBG and UNBOUND collaboration, Victoria and Sativa.

SARP

Project Participants

BAERI: Rachel Wegener, Sam Kim
NASA: Bruce Tagg, Barry Lefer, Stephanie Olaya, Jack Kaye, Roy Johnson, Kristen Boogaard, Brian Hobbs, Thomas Matthews, Jasmine Tabla, Christina Zinger
UC Irvine: Donald Blake, Ann Marie Carlton
CSU, San Bernardino: Andreas Beyersdorf
Woods Hole Oceanographic Institute (WHOI): Henry Houskeeper, Tom Bell
San Diego State: Daniel Sousa
Virginia Commonwealth University: Chris Gough, Lisa Haber, Brandon Alveshere
Stony Brook University: Guanyu Huang
William & Mary: Dom Ciruzzi

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. Flights are based at the Wallops Flight Facility (WFF) on the East coast and Ontario International Airport on the West coast. 2024 flights utilized the P-3 and B200.

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 either the University of California, Irvine or Christopher Newport University 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 per coast are fully funded to attend and present at the Fall American Geophysical Union (AGU) conference.

Accomplishments

- Selected 27 students from across the United States from various academic and personal backgrounds to participate in the program.
- Recruited 12 faculty members and 10 graduate students to act as mentors for the duration of the program.

- Conducted 6 days of science flights to collect samples and data.
- Supported each of the 8 groups to conduct field trips to various locations for ground truthing: on the West coast the Whole Air Sampling and Atmospheric Aerosols Groups collected samples at the Salton Sea; the Oceans Remote Sensing Group collected samples in the Santa Barbara Channel, and the Terrestrial Ecology Group visited the Sedgwick Reserve. On the East coast the Atmospheric Science group collected samples alongside the Johns Hopkins Mobile Lab in Baltimore, MD; the Oceans group collected samples at the Virginia Coastal Reserve; the Terrestrial Fluxes group collected samples at the Rice Rivers Center, and the Hydroecology group collected samples near William and Mary University.
- Provided a diverse variety of speakers to share their experiences, science, and backgrounds with the goal of inspiring the students to attend graduate school and stay in STEM.
- Supported lodging and transportation for the students and mentors, as well as weekend enrichment activities, for the entirety of the summer.
- Hosted students in-person and virtually to present their final projects at the end of the program to their cohort and guests.

Presentations

AI4SPACE, 2nd workshop on AI for Space, in conjunction with ECCV, 2022: Keynote speaker (Invited): Michal Segal Rozenhaimer, AI from Space: Machine Vision Applications for Earth Sciences and Beyond. October 23, 2022.

AERACEPT (Aerosol Rapid Analysis Combined Entry Probe/sonde Technology: Design for Venus Aerosol Sampling. C. Espinoza, A. Norner, C. Dang, J.B. E. Meurisse, R. A. Miller, C. Naughton, J. Park, K. Simon, A. Cassell, S. Dhaniyala, L. T. Iraci, A. Mattioda, P. Sobron, E. Venkatapathy, A. Davila, D. M. Gentry. AbSciCon Presentation 5/2024.

AERACEPT (Aerosol Rapid Analysis Combined Entry Probe/Sonde Technology): Enabling In Situ Aerosol Science for Small Spacecraft Missions. D.M. Gentry, A. Borner, C. Dang, C. Espinoza, J.B.E. Meurisse, C. Naughton, J. Park, A. Cassell, S. Dhaniyala, L. Iraci, A. Mattioda, P. Sobron, E. Venkatapathy, A. Davila. IPPW presentation 6/2024.

AERACEPT (Aerosol Rapid Analysis Combined Entry Probe/sonde Technology):Enabling Technology for Missions to the Venus Clouds. D. Gentry, A.P. Borner, C. Dang, C. Espinoza, J. Meurisse, R. Miller, C. Naughton, K.H. Simon, J. Park, A. Cassell, S. Dhaniyala, L.T. Iraci, A. L. Mattioda, P. Sobron, E. Venkatapathy, A. F. Davila. AGU FAll Meeting Abstracts. P31G-3156

Affiliated Tribes of Northwest Indians 2024 National Tribal Leaders Climate Summit, Auburn, Washington. Nikki Tulley participated in a panel discussion at the Affiliated Tribes of Northwest Indians 2024 National Tribal Leaders Climate Summit: Honoring Traditions, Shaping Futures. April 15–17, 2024.

Ambrosia, V.G., F.M. Schwandner, D. Hadjimitsis, I. Gitas (2024), *The Mediterranean Regional Information Network (MEDRIN): An EO Partnership for Land Cover / Land Use Change*

Science, IEEE International Geoscience and Remote Sensing Symposium (IGARSS), IGARSS-2024, Athens, Greece, 12 July 2024.

American Geophysical Union Annual Meeting, December 2023: Poster. K. Pistone et al, “The seasonal evolution of atmospheric vertical structure of smoke and humidity over the Southeast Atlantic biomass burning region”

American Geophysical Uunion 2023: Poster. M. Giordano et al, “Simulations and Experiments using Satellite-retrieved Carbon Monoxide (CO) as a Speciated Proxy of Smoke Aerosol Layered Aerosol Optical Depth (AOD) for Radiative Transfer (RT) Model Studies”

AGU Fall Meeting. Amber McCullum attended AGU on behalf of IPI and presented Effective Engagement for Community Action with NASA’s Indigenous Peoples Initiative. December 11–15, 2023.

Ames Earth Day. Victoria Ly represented IPI at Ames Earth Day. This was a public facing and NASA outreach event and celebration. April 18, 2024.

AMS Annual Meeting (online), 21st Conference on Artificial Intelligence in Environmental Sciences, Oral Presentation: Michal Segal Rozenhaimer, David Nukrai, Robert Wood and Zhibo Zhang, Cloud Meso-scale Classification and dynamics from the Geostationary SEVIRI satellite using Convolutional Neural-Network. January 27, 2022.

ARC/MSFC Applications Virtual meeting. Amber McCullum presented on Earth Action at Ames for the ARC/MSFC Applications Virtual meeting. This included an overview of the IPI and facilitated connections between programs such as SERVIR, Earth Information System (EIS), Short-term Prediction Research and Transition (SpORT), and others. January 17, 2024.

ARCSIX flight planning overview. University of Colorado, Boulder, May 2023

ARCSIX Phase 1 update Samuel LeBlanc, NASA Ames Atmospheric Science (SGG) Branch meeting, July 9, 2024

ARCIS flights paths vs flown, ARCSIX science team meeting, June 8, 2024, Pituffik, Greenland

Biedebach, M., Purdy, A., Solymar, R., Johnson, L., Melton, F. 2024. Measuring ET rates in commercial lettuce and broccoli fields – Salinas Valley CA. Calif. Plant & Soil Conference, Fresno, CA, February 6–7, 2024

Biedebach, M., Purdy, A. J., Melton, F. On-ground Live Fuel Moisture Content Sampling Along California’s Central Coast: Santa Lucia Preserve—Carmel Valley, CA. 10th International Fire Ecology and Management Congress, Monterey, CA, December 5, 2024

Biggs, B., Forbes, C., Wilson, A., Slingsby, J., Hestir, E., Cardoso, A., … & Chen, A. (2023). Biodiversity Champions: Uniting with South African Students During the BioSCape Campaign. AGU Fall Meeting 2023. Poster.

Dr. Ian Brosnan presenting a merged NEX and NASA HPC Hyperwall presentation at 2023 AGU Fall Meeting (San Francisco, CA).

Canadian Symposium on Remote Sensing. Nikki Tulley provided a keynote presentation on IPI and a session presentation on IPI/CSA collaborations. June 10–13, 2024.

Carrara, W., Melton, F. Purdy, A.J., Guzman, A., Doherty, C., Johnson, L., et al., Building a scalable API ecosystem for OpenET. AGU Chapman Conference on Remote Sensing of the Water Cycle. Honolulu, Hawaii, February, 2024

Carrara, W., … Guzman, A., Purdy, A.J., Melton, F., et al., *Developing open & scalable data services for remotely-sensed evapotranspiration data with the OpenET API.* IGARSS, Athens, Greece, July 2024

Carrara, W. and Guzman, A. Training workshop for use of OpenET API and FARMS tool. OpenET Applications Conference, Albuquerque, New Mexico, February 27–28, 2024

Code S presentation. Amber McCullum provided the NASA Ames Code S Seminar on NASA's Indigenous Peoples Initiative: Community Connections to Earth Observations. May 9, 2024.

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 model predictions under the different aerosol conditions that prevail in the two selected regions of investigation.

Conducted remote sensing workshop at the South African Earth Observation Network (SAEON) Graduate Student Conference in Cape Town, South Africa, in October.

Conference on Cloud-climate Interactions across scales (Invited Speaker): Michal Segal-Rozenhaimer, Cloud Meso-scale Classification and dynamics over the South-East Atlantic Ocean, conference on Cloud-climate Interactions across scales, Eilat, Israel, 2023.

Connection to BIA Tribal Climate Resilience. The IPI team virtually presented NASA's Indigenous Peoples Initiative: NASA Data and Tools for Climate Adaptation to the Bureau of Indian Affairs (BIA) Branch of Tribal Climate Resilience (TCR). January 18, 2024.

Data Science in Earth Science class, virtual. Victoria Ly presented to a Data Science in Earth Science class at Columbia University and shared IPI and Capacity Building work as well as bridging between early career scientists and applying science to work in/support communities. April 4, 2024.

Duncan, Bryan Neal, Meghan Chandarana, Kate Bartlett, Douglass Caldwell, Jeremy Frank, Richard Levinson, Vinay Ravindra, Sarah A. Strode, William H. Swartz, and Eugene Turkov. "Intelligent Long Endurance Observing System." In 104th AMS Annual Meeting. AMS, 2024.

EEJ webinar. The IPI team presented NASA's Indigenous Peoples Initiative: Sharing Knowledge and Strengthening Communities as part of the Equity and Environmental Justice (EEJ)

Program's webinar on: Enabling Earth Observation-based Solutions with Indigenous Communities. The webinar highlighted EEJ A.49 Projects connected to Indigenous Communities. February 6, 2024.

EPA Regional Tribal Operations Committee for EPA Region 1, virtual. The IPI team alongside NASA MAIANSE, the Minority University Research and Education Project (MUREP) for American Indian and Alaska Native Science, Technology, Engineering and Mathematics (STEM) Engagement, presented, NASA and Indigenous Communities: Fostering Earth Action, during the EPA Regional Tribal Operations Committee for EPA Region 1 (New England). January 10, 2024.

Filmed two Earth Science episodes of Sunbeam Buddies, a new young kids' short form series on YouTube starring Miss Sunshine (Rachel Griffin). Episodes have not aired yet, but the show can be watched here.

Fladeland, M., Biggs, B. (2024). High Altitude Platform Systems (HAPS) and payloads to support STV Observing System Requirements. NASA STV Meeting. Poster.

Flight Planning for PACE-PAX. By LeBlanc, PACE-PAX science team meeting, NASA Ames Research Center, Moffett Field, CA, March 6, 2024.

Drs. Morgan Gilmour and Claire Teitelbaum presented an overview of the Internet of Animals at the annual Biodiviersty & Ecological Conservation meeting in Silver Spring, MD (May 2024). Dr. Teitelbaum also presented a poster about the Internet of Animals and Dr. Gilmour presented a poster about using birdborne observations to track dynamics of the planetary boundary layer.

Drs. Morgan Gilmour and Ian Brosnan presented a poster about using birdborne observations to track dynamics of the planetary boundary layer at the PBL Community Meeting in Pasadena, CA (April 2024).

Drs. Morgan Gilmour and Ian Brosnan were interviewed for an Audubon Society special issue on the use of animal biologging for studying the Earth system. This feature is expected to be published in the Winter issue of the Audubon Magazine.

Dr. Morgan Gilmour gave a talk about using animal telemetry and remote sensing data to characterize how a marine protected area protects seabirds at the Pacific Seabird Group annual meeting in Seattle, WA (February 2024).

Gordon Research Conference, Radiation and Climate, July 2023: Poster. K. Pistone et al, "Springtime SEA air is consistently both smoky and humid, but this relationship (and its radiative effects) varies spatially and seasonally"

Guest speaker (virtual) at the 3rd session of Going Uncurbed: A Webinar Series on Becoming a Digizen for the Environment. 55 attendees; all youth (~15-30 y/o) from the Philippines. Spoke about ASIA-AQ, GLOBE, and citizen science alongside guests from the Philippines Department of Natural Resources (DENR) and the Philippines Space Agency (PhilSA).

Guest speaker (in person) at the University of California, Irvine's Department of Ecology and Evolutionary Biology's panel, "What Can I Do with My PhD?" Panelists included Oxford Nanopore Technologies, USGS, and Ocean Science Trust. About 12 graduate school attendees.

Dr. Hirofumi Hashimoto presented during the 2024 Asia-Oceania Geocsiences Society meeting. The presentations include "Geonextool: a Tool of Geonex Geostationary Satellite Data for Carbon and Water Flux Modeling at Fluxnet Sites."

Dr. Hirofumi Hashimoto presented during the 2023 AGU fall meeting. The presentations include "G Mapping surface vapor pressure deficits from geostationary satellites for fire weather monitoring."

Invited Guest Speaker, 3rd Annual Institute of Electrical and Electronics Engineers (IEEE) TryEngineering STEM Summit, Oct. 25, 2023. Created and delivered a 45-minute virtual presentation to 82 participants titled, "Do-it-yourself: Empowering Students through Citizen Science with NASA and GLOBE," about citizen science opportunities with NASA Airborne Science and GLOBE.

Johnson, L., R. Solymar, A. Purdy, M. Biedebach, N. Cabrera, D. Chambers, M. Cahn, 2024. Use of OpenET for evaluation of irrigation efficiency in cool-season vegetables. AGU WaterSciCon, 24–27 June, St. Paul. MN

Johnson, L., N. Cabrera, D. Chambers, M. Cahn, 2024. Evaluation of lettuce irrigation application efficiency in the Salinas Valley during 2022–23. Calif. Plant and Soil Conf., 6–7 Feb., Fresno, CA

Johnson, L., Satellite estimates of crop water use on the Central Coast and OpenET. UCCE Irrigation and Nutrient Management Meeting, Salinas, CA (invited presentation), February 23, 2024

Johnson, L., *Overview of Two Decision-Support Systems for Vineyard Water Management*. 72nd Annual Lodi Grape Day, sponsored by UCCE San Joaquin County, California. (invited presentation). February 6, 2024

Johnson, L., and Cahn, M. Satellite-assisted Evaluation of Irrigation Application Efficiency for Lettuce in the Salinas Valley. AGU Fall Meeting, San Francisco. #H31S-1733. December 11–15, 2023

Johnson, L. (moderator), Allen, R., Cahn, M., Wang, C., Pearson, C., Kilic, A. Training workshop for comparison of OpenET to meter, eddy covariance, and other water use data. OpenET Applications Conference, Albuquerque, New Mexico. February 27–28, 2024

Susan S. Kulawik, Sebastian Schmidt, Yu-wen Chen, Rob Nelson, James McDuffie, Steve Massie, Chris O'Dell, Matthaeus Kiel, Kevin W. Bowman, "Reducing OCO-2 regional biases through novel 3D cloud, albedo, and meteorology estimation," presented at OCO-2/3 Science Team Meeting, March 2022, Pasadena, CA. Introduced project.

Susan S. Kulawik, Sebastian Schmidt, Yu-wen Chen, Rob Nelson, James McDuffie, Steve Massie, Chris O'Dell, Matthaeus Kiel, Kevin W. Bowman, "Reducing OCO-2 regional biases through novel 3D cloud, albedo, and meteorology estimation," presented at OCO-2/3 Science Team Meeting, October 2022, Boulder, CO. Showed results with simulation OSSE.

Joshua Laughner, Vivienne Payne, Susan Kulawik, Emily Fischer, "Progress and challenges in retrieving PAN from AIRS," The 2023 AIRS/Sounder Science Team Meeting, October 2023, Hyattsville, Maryland.

Melton, F., Grimm, R., Volk, J., et al. OpenET: Applications of Evapotranspiration Data for Water Resources Management in the Western United States. AGU Fall Meeting, San Francisco, California. #H13D-07. December 11–15, 2023

Melton, F. et al. OpenET: Applications of Evapotranspiration Data for Water Resources Management in the Western United States, AGU Chapman Conference on Remote Sensing of the Water Cycle, Honolulu, Hawaii. February 13–16, 2024

Melton, F. et al. OpenET: Applications of Evapotranspiration Data for Water Resources Management in the Western United States, AGU Water Sci Con, St. Paul, Minnesota, June 2024

Midwest Climate Resilience Conference in Duluth, MN. Victoria Ly presented with the larger NASA Capacity Building team (SERVIR, ARSET, DEVELOP) and represented IPI. October 25–27, 2023.

"Mitigation of OCO-2 Spectroscopy Retrieval Biases in the Vicinity of Clouds," Yu-wen Chen, Sebastian Schmidt, Steve Massie, Susan Kulawik, presented at the OCO-2/3 Science Team Meeting, October 2022, Boulder, CO.

NASA Ames Research Center (ARC) Internship Mini-Symposium 2024.

NASA SBG Collaborations Speaker Series, virtual. Nikki Tulley presented From Diné Bikéyah to NASA: An Indigenous Scientist's Journey, as part of NASA SBG Collaborations Speaker Series. March 1, 2024,

Navarro, I., Ashkan, S., Solorio, R., Purdy, A., Solymar, R., Melton, F., Hutmacher, R., Goorahoo, D., Johnson, L., Cassel-Sharma, F. Determining evapotranspiration and developing crop coefficients for forage sorghum using large weighing lysimeters. ARI PI Meeting, Sacramento, California. October 19, 2023

Optical Spectroscopy of Venus Aerosol Analogs. C. Dang, D. Gentry, L.T. Iraci, A.L. Mattioda, K.H. Simon, P. Sobron. AGU (American Geophysical Union) Fall Meeting Abstracts. 12/2023(3156), P31F-315

Optical Spectroscopy of Venus Aerosol Analogs and Substrate Survivability. C. Dang, L.T. Iraci, A. L. Mattioda, P. Sobron, K. Simon, D.V. Hoesen, A. Davila, D.M. Gentry. AbSciCon Presentation 5/2024.

Organized and participated in a panel during a town hall at AGU23, “Equitable Partnerships within Environmental Justice” (December 2023).

Dr. Taejin Park presented the newly developed downscaled global fire weather projection data at the International Fire Ecology and Management Congress on 4–7 December 2023. The title is Downscaled 21st century global fire weather projections.

Dr. Taejin Park represented ongoing efforts in Earth Science Division for NASA-New Zealand Catalyst program when NZ Prime Minister (Christopher Luxon) visited the Ames research center (12 July 2024).

Dr. Taejin Park presented an overview of current NEX efforts in NASA CMS, GEDI and WERC (NASA-CA partnership) when the Danish delegation visited the Ames research center.

Dr. Taejin Park gave a presentation “Continuous mapping of national forest aboveground biomass in Mexico by integrating GEDI and Landsat times series data” during the American Association of Geographers 2024 Annual Meeting.

Dr. Taejin Park presented two oral presentations during the 2024 Asia-Oceania Geosciences Society meeting. The presentations include “Greening of human-dominated ecosystems in India” and “Downscaled 21st century global fire weather projections.”

Dr. Taejin Park was a convener of a session at the 2024 Asia-Oceania Geosciences Society meeting in South Korea entitled “Research and Applications from Operational Geostationary Satellites.” His co-conveners were Dr. Kazuhito Ichii (Chiba Univ.), Dr. Yougryel Ryu (Seoul National Univ), Alfred Huete (Univ. of Technology Sydney), and Shi Chong (Chinese Academy of Sciences).

Pierret, Z., … Purdy, A.J., et al., Evaluation of ECOSTRESS Collection 2 Evapotranspiration, diurnal dynamics of carbon and water cycling, implications for Surface Biology and Geology Mission. Surface Biology and Geology Technical Interchange Meeting, Washington, DC. 2024

Pierret, Z., … Purdy, A.J., et al., Exploring Diurnal and Seasonal Dynamics of Water Use Efficiency U*sing Solar Induced Chlorophyll Fluorescence and Thermal Infrared Radiation*. AGU Fall Conference, San Francisco, California. 2024

Pierret, Z., … Purdy, A.J., et al., Scaling Diurnal and Seasonal Dynamics of Water Use Efficiency from the Site to the Globe. Global Energy and Water Exchanges Open Science Conference, Sapporo, Japan. 2024

Planning research flights for the upcoming suborbital airborne field campaigns PACE-*PAX and ARCSIX.* By LeBlanc, Schmidt, and Knobelspiesse, AGU Fall Meeting 2023, San Francisco, CA, December 11, 2023.

Poster presentation at the Asia Oceania Geosciences Society (AOGS) 2024 meeting, held in Pyeongchang, South Korea, on June 26, 2024. Title: “Quantifying the benefits of improved satellite remote-sensing observations for inverse modeling of NOx and NMVOC emissions”

Presentation at combined PVST+ Plankton, Aerosol, Cloud, ocean Ecosystem Postlaunch Airborne eXperiment (PACE-PAX) March meeting, NASA Ames, March 6th, 2024

Presentation for GeoByte American Society for Photogrammetry and Remote Sensing (ASPRS) webinar “Earth Observations for Environmental Justice: An Introduction to NASA’s Equity and Environmental Justice Program and Resources” (April 2024).

Purdy, A.J., et al., ECOSTRESS Collection 2 JET evaluation. ECOSTRESS Science Team Meeting, Ventura, California. October 2023

Purdy, A.J., et al., Mapping Fuel Moisture in Monterey County, California. 10th International Fire Ecology and Management Congress, Monterey, California. December 2024

Purdy, A.J., et al., Mapping Live Fuel Moisture Content along the Central California Coast, California, San Francisco, California. December 2024

Purdy, A.J., et al., OpenET overview, Northern California Water Association Managers Meeting, Virtual, February 2024.

Purdy, A.J., et al., Solar Farm Water Savings: A framework for evaluating potential water savings from solar farms with remotely sensed evapotranspiration. AGU Chapman Conference on Remote Sensing of the Water Cycle, Honolulu, Hawaii. February 2024

Purdy, A.J., et al., Using OpenET to Map Wildfire Risk. OpenET User Conference, Albuquerque, New Mexico. February 2024

Purdy, A.J., et al., OpenET Overview and Concluding Remarks. AGU Water Sci Conference, St. Paul, Minnesota. June 2024

Raman, A., Hsu, C. H., Mizzi, A. P., Harkins, C., Miyazaki, K., Kumar, R., Johnson, M. S., McDonald, B., Bowman, K. Knowland, K. E., Brosnan, I. G. (2024), “Advancing Regional Air Quality and Atmospheric Composition Analysis: Introducing the TRACER-1 Tropospheric Chemistry and Emissions Reanalysis,” talk presented at the Atmospheric Composition Modeling and Analysis Program (ACMAP) III session, 104th AMS Annual Meeting American Meteorological Society meeting, Baltimore, MD.

Raman, A., Hsu, C. H., Mizzi, A. P., Harkins, C., Miyazaki, K., Kumar, R., Johnson, M. S., McDonald, B., Bowman, K. Knowland, K. E., Brosnan, I. G. (2024), “Advancing Regional Air Quality and Atmospheric Composition Analysis: Introducing the TRACER-1 Tropospheric Chemistry and Emissions Reanalysis,” poster presented at the 104th AMS Annual Meeting American Meteorological Society meeting, Baltimore, MD.

Raman, A., Mizzi, A. P., Hsu, C. H., Miyazaki, K., Kumar, R., Johnson, M. S., McDonald, B., Bowman, K. Knowland, K. E., Brosnan, I. G. (2023), “TRACER-1 Tropospheric Chemistry and Emissions Reanalysis,” poster presented at the Meteorology and Climate-Modeling for Air Quality Conference at UC Davis.

Solymar, R., A. Purdy, M. Biedebach, K. Burroughs, M. Tolteca, M. Villa Alvarado, M. Cahn, L. Johnson, F. Melton, 2023. Monitoring Crop Water Consumption in the Salinas Valley: 2023 Results. ARI PI Meeting, 19 Oct., Sacramento, CA

Solymar, R., Purdy, A., Johnson, L., Biedebach, M., Cahn, M., Melton, F., Lettuce Eat: Measuring Consumptive Water Use to Support America's Salad Bowl. AGU Fall Meeting, San Francisco, California. #H31S-1732. Dec 11–15, 2023

Support of PVST introduction meeting presentation

Dr. Bridget Thrasher hosted a NEX-GDDP-CMIP6 focused workshop at the ICRC-CORDEX 2023 International Conference on Regional Climate to enable attendees to compare bias-corrected Regional Climate Models (RCMs) with Empirical Statistical Downscaling (ESD) for robust future climate change projections.

Dr. Claire Teitelbaum presented a seminar and met with members of the Biology Department at the University of Massachusetts, Boston. Discussions focused on how remote sensing and animal tracking can be applied to diverse biological fields, including biodiversity monitoring, disease ecology, evolutionary biology, and global change ecology.

Vinay Ravindra, Sreeja Roy Singh, Mahta Moghaddam, Kurtis Nelson, Richard Levinson, Amer Melebari, Archana Kannan, "Distributed Spacecraft with Heuristic Intelligence to Enable Logistical Decisions for Global Navigation Satellite System Reflectometry (GNSS-R) of Wildfires," NASA Earth Science Technology Forum 2023. June 2023, Pasadena, United States.

Dr. Weile Wang served as featured speaker at San Jose State University's "RSCA in Five" on Climate Change and Adaptation.

"Water and Temperature SVD Estimates to Improve OCO-2 XCO2 Errors," Robert R. Nelson, Susan S. Kulawik, Christopher W. O'Dell, James McDuffie, American Geophysical Union Fall Meeting, December 12–16, 2022, Chicago, IL.

World Water Summit, Stockholm. Nikki Tulley (OpenET and Navajo Research Connection), Keynote. August 25–29, 2024.

WWAO R2O Updates, Applied Sciences Program Water Resources Annual Meeting, Salt Lake City, October 4–7, 2022.

WWAO Project Impacts Panel, WWAO Annual Meeting in Boulder, CO on April 30–May 2, 2024.

WWAO Program Overview, Marshall Space Flight Center (MSFC) Virtual Visit with Ames Earth Science, January 17, 2024.

Publications

Ahmad, S.K., Holmes, T.R., Kumar, S.V., Lahmers, T.M., Liu, P.W., Nie, W., Getirana, A., Orland, E., Bindlish, R., Guzman, A., Hain, C.R., Melton, F., Locke, K.A., Yang, Y. 2024. Droughts

impede water balance recovery from fires in the Western United States. *Nature Ecology & Evolution*, 8, 229–238 (2024). https://doi.org/10.1038/s41559-023-02266-8

Ambrosia, V.G., F.M. Schwandner, D. Hadjimitsis, I. Gitas. 2024. *The Mediterranean Regional Information Network (MEDRIN): An EO Partnership for Land Cover / Land Use Change Science*, Proceedings of the IEEE International Geoscience and Remote Sensing Symposium (IGARSS), IEEE Catalog No.: CFP24IGA-USB, ISBN: 979-8-3503-6031-8, pp.: 3325–3348; 2024, Athens, Greece, 7–13 July 2024.

Borges, D., S. Ramage, D. Green, C. Justice, C. Nakalembe, A. Whitcraft, B. Barker, I. Becker-Reshef, C. Balagizi, S. Salvi, V. Ambrosia, J. San-Miguel-Ayanz, L. Boschetti, R. Field, L. Giglio, L. Kuhle, F. Low, A. Kettner, G. Schumann, G. R. Brakenridge, R. Adler, H. Kontoes, H. De Boissezon, A. Eddy, D. Kirschbaum, R. Emberson, S. Cooley, S. Lloyd, C. Blake and K. Reichenbach. 2023. *Earth Observations into Action: The System Integration of Earth Observation Applications into National Risk Reduction Decision Structures*, Disaster Prevention and Management, Vol. 32 No. 1, pp. 163–185. https://doi.org/10.1108/DPM-09-2022-0186.

Braden, D., Mondal, P., Park, T., Alanís de la Rosa, J.A., Aldrete-Leal, M.I., Cuenca Lara, R.A., Mayorga Saucedo, R., Paz, F., Salas-Aguilar, V.M., Soriano-Luna, M.D.L.A., Vargas, R. 2023. Estimating forest extent across Mexico. *Environmental Research Letters* 19(1):13pp. [014083]. DOI 10.1088/1748-9326/ad193e

Bubenheim, D., V. Genovese, J.D. Madsen, and E. Hard. 2021. “Remote sensing and mapping of floating aquatic vegetation in the Sacramento-San Joaquin River Delta.” *J. Aquat. Plant Manage* 59 (2021): 46–54.

Cahn, M., Johnson, L., Benzen, S. Evapotranspiration-based irrigation management of cauliflower. Agricultural Water Management *(submitted May 2024).*

Doherty, C. T., Wang, W., Hashimoto, H., & Brosnan, I. G. 2024. *A Method for Quantifying Uncertainty in Spatially Interpolated Meteorological Data with Application to Daily Maximum Air Temperature*. https://doi.org/10.5194/egusphere-2024-1886

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GLOSSARY

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

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

A-SMLS—Airborne Scanning Microwave Limb Sounder

ABI—Advanced Baseline Imager

ABoVE—Arctic Boreal Vulnerability Experiment

AC—Atmospheric Composition

ACAOD—Above Cloud Aerosol Optical Depth

ACCDAM—Atmospheric Composition Campaign Data Analysis and Modeling

ACCLIP—Asian Summer Monsoon Chemical & CLimate Impact Project

ACIX—atmospheric correction intercomparison experiment

ACMAP—Atmospheric Composition: Modeling and Analysis Program

ACP—Atmospheric Composition Program

ACTIVATE—Aerosol Cloud meTeorology Interactions oVer the western ATlantic Experiment

ACX—Atmospheric Composition

ADC—App Development Challenge

ADS-B—Automatic Dependent Surveillance-Broadcast device

AERACEPT—Aerosol Rapid Analysis Combined Entry Probe/sonde Technology

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

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

AERONET—AErosol RObotic NETwork

AESD—Ames Earth Science Division

AFRC—Armstrong Flight Research Center

AGAGE—Advanced Global Atmospheric Gases Experiment

AGHSD—Ames Global Hyperspectral Synthetic Dataset

AGU—American Geophysical Union

AHI—Advanced Himawari Imager

AI—Artificial Intelligence

AI4SPACE—Artificial Intelligence for Space

AIHEC—American Indian Higher Education Consortium

Air-LUSI—Airborne Lunar Spectral Irradiance

AirHARP—Airborne Hyper-Angular Rainbow Polarimeter

AirMSPI—Airborne Multiangle SpectroPolarimetric Imager

AIRS—Atmospheric Infrared Sounder

AIST—Advanced Information Systems Technology

AJAX—Alpha Jet Atmospheric eXperiment

ALI—Aerosol Limb Imager

AMI—Advanced Meteorological Imager

AMS—American Meteorological Society

AMS—Autonomous Modular Sensor

AMT—Atmospheric Measurement Techniques

ANR—Agriculture and Natural Resources

AOD—Aerosol Optical Depth

AOGS—Asia Oceania Geosciences Society

AON—Arctic Observing Network

AOS—Atmosphere Observing System

API—Application Programming Interface

APM—Associate Program Management

AQ—Air Quality

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

ARC—Ames Research Center

ARCIS—novel code for the analysis of exoplanet transmission and emission spectra

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

ARMD—Aeronautics Research Mission Directorate

ARS—Agricultural Research Service

ARSET—Applied Remote Sensing Training

ASF—Airborne Sensor Facility

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

ASP—Airborne Science Program

ASP—Applied Sciences Program

ASPRS—American Society for Photogrammetry and Remote Sensing

ASTER—Advanced Spaceborne Thermal Emission and Reflection Radiometer

ATBD—Algorithm Theoretical Basis Document

AVIRIS—Airborne visible/infrared imaging spectrometer

AVS—Audiovisual Squadron

AWS—Amazon Web Services

BB—Biomass Burning

BC—Black Carbon

BCs—Boundary Conditions

BCSD—Bias Correction/Spatial Disaggregation

BIA—Bureau of Indian Affairs

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

BRDF—Bi-directional Reflectance Distribution Function

C-AIR—Coastal Airborne In-situ Radiometers

C-Harrier—Coastal High Acquisition Rate Radiometers for Innovative Environmental Research

C-OPS—Compact Optical Profiling System

CalCIS—California Climate Information System

CALICOA—California current system: Linking Carbon Ocean-Atmosphere exchange

CALIPSO—CloudSat and the Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation

CAM-Chem—Community Atmospheric Model with Chemistry

CAMEE—Center for Advanced Measurements in Extreme Environments

CAMP2Ex—Cloud, Aerosol, and Monsoon Processes Philippines Experiment

CAMS—Copernicus Atmosphere Monitoring Service

CARB—California Air Resources Board

CAS—Convergent Aeronautics Solutions

CASTNET—Clean Air Status and Trends Network

CCDC—Continuous Change Detection and Classification

CCP—Cloud, Precipitation, Convection

CDFA—California Department of Food and Agriculture

CDR—Cloud Detection and Response

CEA—Controlled Environment Agriculture

CER—Cloud Effective particle Radius

CESU—Cooperative Ecosystem Studies Units

CHIPS—Creating Helpful Incentives to Produce Semiconductors

CI—Conservation International

CIF—Center Innovation Fund

CIRA—Cooperative Institute for Research in the Atmosphere

CIRES—The Cooperative Institute for Research in Environmental Sciences

CIRPAS—Center for Interdisciplinary Remotely Piloted Aircraft Studies

CISO—Chief Information Security Officer

CLARIFY—CLoud–Aerosol–Radiation Interaction and Forcing: Year

CMAQ—Community Multiscale Air Quality

CMIP6—Climate Model Intercomparison Project Phase 6

CMS—Carbon Monitoring Systems

CNN—Convolutional Neural-Network

CNR-INO—Instituto Nazionale di Ottica (The National Institute of Optics)

CO—Change Order

COAST—Coastal and Ocean Airborne Science Testbed

CONUS—Continental United States

CoSMIR—Conical Scanning Millimeter-wave Imaging Radiometer

COT—Cloud Optical Thickness

COTS—commercial orbital transportation services

CPEX-AW—Convective Processes Experiment-Aerosols and Winds

CPEX-CV—Convective Processes Experiment-Cabo Verde

CPEX—Convective Processes Experiment

CrIS—Cross-track Infrared Sounder

CSA—Canadian Space Agency

CSDA—Commercial SmallSAT Data Acquisition

CSL—Chemical Sciences Laboratory

CSU-ARI—California State University Agricultural Research Institute

CSU—California State University

CSUMB—California State University at Monterey Bay

CSUStan—California State University at Stanislaus

CU—University of Colorado

CUB Mec-E—University of Colorado at Boulder Mechanical Engineering

CUB—University of Colorado at Boulder

CUT—Cyprus University of Technology

CYGNSS—Cyclone Global Navigation Satellite System

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

DA—Data Assimilation

DAAC—Distributed Active Archive Center

DART—Data Assimilation Research Testbed

DASH—discovery and systems health

DBW—Division of Boating and Motorways

DCOTSS—Dynamics and Chemistry of the Summer Stratosphere

DCP—Downscaled Climate Projections

DDM—Direct Decoupled Method

DEIA—Diversity, Equity, Inclusion, Accessibility

DENR—Philippines Department of Natural Resources

DEVELOP—Digital Earth Virtual Environment and Learning Outreach Project

dFAD—drifting Fish aggregating device

DISA—Defense Information Systems Agency

DOD—Department of Defense

DOE—Department of Energy

DRAAWP—Delta Region Areawide Aquatic Weed Project

DRE—Direct Radiative Effect

EAKF—Ensemble Adjustment Kalman Filter

EAP—Earth Action Program

EAR3T—Education and Research 3D Radiative Transfer Toolbox

EC—European Commission

ECCV—European Conference on Computer Vision

ECI—Early Career Initiative

ECMWF—European Centre for Medium-Range Weather Forecasts

EcoD—EcoDemonstrator aircraft

ECOSTRESS—ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station

EDW—Edwards Airforce Base

EEID—Ecology and Evolution of Infectious Diseases

EEJ—Equity and Environmental Justice

EEZ—Exclusive Economic Zone

EIP—Experimenter Interface Panels

EIS—Earth Information Systems

eMAS—Enhanced MODIS Airborne Simulator

EMRI—Earth Mapping Resources Initiative

ENSCI—Environmental Science

EO-Sim—Earth Observations Simulator

EO—Earth observations

EOS—Earth Observing System

EOSDIS—Earth Observing System Data and Information System

EOSE-API—Earth Observing Systems Engineering API

EPA—Environmental Protection Agency

EPSCoR—Established Program to Stimulate Competitive Research

ERA5—ECMWF reanalysis version 5

ERG—Employee Resource Group

ESD—Earth Science Division

ESD—Empirical Statistical Downscaling

ESI SET—Earth Surfaces and Interior, Solid Earth Team

ESO—Earth System Observatory

ESPO—Earth Science Project Office

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

ESSD—Earth System Science Data Journal

ESTP—Environmental Science, Technology, and Policy

ET—Evapotranspiration

ETo—Reference Evapotranspiration

EVS-3—Earth Venture Suborbital-3

EXCELSIOR-ERATOSTHENES—Excellence Research Center for Earth Surveillance and Space-based Monitoring of the Environment

FAA—Federal Aviation Administration

FARMS—Farm and Ranch Management Support system

FATE—drifting Fish Aggregating device (dFAD) TrajEctory

FAV—Floating Aquatic Vegetation

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

FIREX-AQ—Fire Influence on Regional to Global Environments Experiment-Air Quality

FLIR—Forward-Looking Infrared

FNR—Formaldehyde to Nitrogen Dioxide Ratio

FWI—Fire Weather Index

GCMs—Global Climate Models

GDDP—Global Daily Downscaled Projections

GEDI—Global Ecosystem Dynamics Investigation

GEMx—Geological Earth Mapping Experiment

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

GEO—Geostationary

GEO—Group on Earth Observations

GeoNEX—A collaborative effort for generating Earth monitoring products from the new generation of geostationary satellite sensors

GEOS-FP—Goddard Earth Observing System Forward Processing

GEOS—Goddard Earth Observing System

GeoXO—Geostationary Extended Observations

GHG—Greenhouse Gas

GHRC DAAC—Global Hydrometeorology Distributed Active Archive Center

GHRC—Global Hydrometeorology Resource Center

GIS—Geographic Information System

GISS—Goddard Institute for Space Studies

GLIMR—Geosynchronous Littoral Imaging and Monitoring Radiometer

GLOBE—Global Learning and Observations to Benefit the Environment program

GMAO—Global Modeling and Assimilation Office

GML—Global Modeling Laboratory

GNSS-R—Global Navigation Satellite System Reflectometry

GOES—Geostationary Operational Environmental Satellite

GOFC-GOLD—Global Observations of Forest Cover and Land-use Dynamics

GOSAT—The Greenhouse gases Observing SATellite

GPS—Global Positioning System

GSFC—Goddard Space Flight Center

GV—Gulfstream V aircraft

HALE—High Altitude Long Endurance

HAMAQ—Hemispheric Airborne Measurements of Air Quality

HAWC—High Altitude Water Cherenkov

HDD—Hard Disk Drive

HIWC—High Ice Water Content

HLS—Landsat-8 and Sentinel-2 time series

HPC—High-Performance Computing

HSRL-—High-Spectral-Resolution Lidar–Generation 2

HyMAP—Hydrological Model Parameter Processing

HyperPro—Hyperspectral Profiling Radiometer

HyspIRI—Hyperspectral Infrared Imager

ICAP—International Cooperative for Aerosol Prediction

ICs—Integrated Circuits

IDL—Interactive Data Language

IDS—Interdisciplinary Science

IEC—Indigenous Engagement Coordinator

IEEE—Institute of Electrical and Electronics Engineers

IGARSS—International Geoscience and Remote Sensing Symposium

ILEOS—Intelligent Long Endurance Observing System

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

IMU—Inertial Measurement Unit

IMW—Indigenous Mapping Workshop

Inmarsat—A British satellite telecommunications company

INSTEP—Inexpensive Network Sensor Technology for Exploring Pollution

IOA—Internet of Animals

IOP—Intensive Observation Period

IPI—The Indigenous Peoples Initiative

IR—Infrared

IRAD—Internal Research and Development

ITEP—The Institute for Tribal Environmental Professionals

JEDI—Joint Effort for Data Assimilation Integration

JET—JPL Evapotranspiration

JHU—John Hopkins University

JPL—Jet Propulsion Laboratory

JSC—Johnson Space Center

KML—Keyhole Markup Language

LANCE—Land, Atmosphere Near-real-time Capability for EOS

LARC—Langley Research Center

LARGE—Langley Aerosol Research Group Experiment

LCLUC—Land-Cover and Land-Use Change

LEO—Low-Earth Orbit

LIBS—Impossible Sensing Laser Induced Breakdown Spectroscopy

LIDAR—Light Detection and Ranging

LPDAAC—Land Processes Distributed Active Archive Center

LSP—Land Surface Phenology

LST—Land Surface Temperature

LTE—Long-Term Evolution

MACIE—Measurements of Aerosols, Clouds and their Interactions for ESMs

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

Mata—Sanskrit name for Earth

MBARS—Microwave Barometric Radar and Sounder

MBIE—Ministry for Business, Innovation, and Employment

MCC—Meso-scale Cellular Convection

MCTS—Monte Carlo Tree Search

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

MedRIN—Mediterranean Regional Information Network

MERRA-2—Modern Era Retrospective-Analysis for Research and Applications

MetNav—Meteorology and Navigation

ML—Machine Learning

MLS—Microwave Limb Sounder

MMS—Meteorological Measurement System

MODIS—Moderate Resolution Imaging Spectroradiometer

MOMO-Chem—Multi-model Multi-constituent Chemical

MOSAIC—Multidisciplinary drifting Observatory for the Study of Arctic Climate

MPA—Marine Protected Area

MPC—Model Predictive Controller

MSC—Marine Stratocumulus Clouds

MSFC—Marshall Space Flight Center

MSS—Magnetospheric Multiscale Mission

MTS—Mission Tools Software

MUREP—Minority University Research and Education Project

MVIS—Miniature Video Imaging System

NAAC—Native American Advisory Committees

NAFWS—Native American Fish and Wildlife Society

NAM—North American Mesoscale

NAMS—NASA Academic Mission Services

NAPI—Navajo Agricultural Products Industry

NAS—NASA Advanced Supercomputing

NASDAT—NASA Airborne Science Data and Telemetry System

NASEM—National Academies of Sciences, Engineering and Medicine

NBR—Normalized Burn Ratio

NCA—National Climate Assessment

NCAR—National Center for Atmospheric Research

NCCS—NASA Center for Climate Simulation

NDAAC—Network for the Detection of Atmospheric Composition Change

NEBULA—Native Engagement in Building a Unified Leadership Alliance

NeMO-NET—NEural Multimodal Observation and training NETwork for global coral reef assessment

NEX—NASA Earth Exchange

NIR—Near Infrared

NMVOC—Non-Methane Volatile Organic Compounds

NN—Navajo Nation

NOAA—National Oceanic and Atmospheric Administration

NOS—New Observing Strategies

NOx—Nitrogen Oxides

NPP—NASA Postdoctoral Program

NPS TO—Naval Postgraduate School Twin Otter

NRT—Near Real-Time

NSF—National Science Foundation

NSRC—National Suborbital Research Center

NTP—Network Time Protocol

OA—Organic Aerosol

OCEANIA—Ocean Color Ecosystems Assessment using Novel Instruments and Aircraft

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

OCI—Ocean Color Instrument

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

OCONUS—Outside Contiguous United States

OE—Operations Engineer

OMI—Ozone Measuring Instrument

OMPS-NM—Ozone Mapping and Profiler Suite-Nadir Mapper

OPALS—Optical Payload Lasercomm Science

OpenET—Open Evapotranspiration

ORACLES—ObseRvations of Aerosols Above CLouds and their IntEractionS

OS—Operating System

OSSE—Observing System Simulation Experiment

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

PACE—Plankton, Aerosol, Cloud, ocean Ecosystem

PALMS—Particle Analysis by Laser Mass Spectrometry

PAN—Peroxyocetyl nitrate

PBL—Planetary Boundary Layer

PDU—Power and Data Units

PER—Preliminary Engineering Review

PhilSA—Philippines Space Agency

PI—Primary Investigator

PICARD—Pushbroom Imager for Cloud and Aerosol Research

PINN—Physics Informed Neural-Network

PIV—Personal Identity Verification

PM—Particulate Matter

PMD—Palmdale Airport

POA&M—Plan Of Action and Mitigation

POLDER—Polarization and Directionality of the Earth's Reflectances

PPT—Precision Pressure Transducers

PSM—A Professional Science Master's Degree

PTZ—Pan-Tilt-Zoom

PVST—PACE Validation Science Team

R&A—Research and Analysis

R2O—Research to Operations

RAID— Redundant Arrays of Inexpensive Disks

RASM—Regional Arctic System Model

RCM—Regional Climate Model

REDD+—Reducing Emissions from Deforestation and Forest Degradation in Developing Countries. 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

ReFRACtor—Reusable FRamework for Atmospheric Composition

RF—Radio Frequency

RGB—Red-Green-Blue

RII—Research Infrastructure Improvement

ROSES—Research Opportunities in Earth and Space Science

RSAM—Remote Sensing for Animal Movement

RSCA—Research, Scholarship, and Creative Activity

RT—Radiative Transfer

RTLS—Real-Time Location System

RUMMBL—Remote-sensing oUtgassing Magma Movement Before Large Eruptions

S-MODE—Sub-Mesoscale Ocean Dynamics Experiment

SABRE—Stratospheric Aerosol processes, Budget and Radiative Effects

SAEON—South African Earth Observation Network

SAR—Synthetic Aperture Radars

SARP—Student Airborne Research Program

SATCOM—Satellite Communications

SAV—Submerged Aquatic Vegetation

SBG—Surface Biology and Geology

SBIR—Small Business Innovation Research

SCERIN—South-Central European Regional Information Network

SEA—SouthEast Atlantic

SeaSTAR—Sea-going Sky-Scanning Sun-Tracking Advanced Robotic Research Radiometer

SEP—SouthEast Pacific

SERS—Surface Enhanced Raman Spectrometry

SEVIRI—The Spinning Enhanced Visible and InfraRed Imager

SGE—NASA Ames Biosphere Science Branch

SGG—Atmospheric Science Branch

SHOW—Spatial Heterodyne Observations of Water

SIMS—Satellite Irrigation Management Support

SIT-A—Science Impact Team-Aerosols

SJSU—San Jose State University

SMD—Science Mission Directorate

SME—Subject Matter Experts

SMLS—Scanning Microwave Limb Sounder

SMO—Service Management Office

SNaX—Supernova X-Ray Database

SNPP—Suomi National Polar-orbiting Partnership

SOA2RSE—Synergies Of Active optical and Active microwave Remote Sensing Experiment

SPACE BAT—Space-Based Animal Tracking

SPoRT—Short-term Prediction Research and Transition

SRR—System Requirements Review

SSA—Small Slope Approximation

SSFR—Solar Spectral Flux Radiometer

SSH—Secure Shell remote access

SSP—Shared Socioeconomic Pathways

STEM—Science, Technology, Engineering, and Math

STM—Science Team Meeting

STMD—Space Technology Mission Directorate

STV—Surface Topography and Vegetation

SVD—Singular Value Decomposition

SWAP—Smaller Weight And Power

SWIR—Short Wave Infrared

TASNPP—Terra-Aqua Suomi-National Polar-orbiting Partnership

TAT—Tradespace Analysis Tool

TCCON—Total Carbon Column Observing Network

TCR-2—Tropospheric Chemical Reanalysis

TEMPO—Tropospheric Emissions: Monitoring Pollution

TES—Tropospheric Emission Spectrometer

TFR—Temporary Flight Restrictions

TFRSAC—Tactical Fire Remote Sensing Advisory Committee

TGGR—Trace Gas Group

TMF—Table Mountain Facility

TOA—Top-Of-Atmosphere

TOLNET—The Tropospheric Ozone Lidar Network

TRACER-1—Tracking Aerosol Convection Interactions ExpeRiment

TROPOMI—The TROPOspheric Monitoring Instrument

TRR—Test Readiness Review

UAS—Unmanned Air Systems

UAV—Unmanned Aerial Vehicle

UCCE—University of California Cooperative Extension

UCSC—University of California Santa Cruz

UHF—Ultra High Frequency

UN-SEEA—United Nation’s System of Environmental Economic Accounting

UNAM—National Autonomous University of Mexico

UNBL—UN Biodiversity Lab

UNBOUND—Understanding Needs to Broaden Outside Use of NASA Data

UNDP—United Nations Development Programme

UNEP-WCMC—United Nations Environmental Programme World Conserving Monitoring Centre

UPS—Uninterruptible Power Supply

URG—Underrepresented Groups

US AON—US Arctic Observing Network

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

USDA-NIFA—National Institute of Food and Agriculture

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

USDA—US Department of Agriculture

USFS—The United States Forest Service

USGS—United States Geological Survey

VAMOS—Vertiport Assessment and Mobility Operations

VCD—Vertical Column Density

VICC—Virtual Institute for Carbon Cycle

VIIRS—Visible Infrared Imaging Radiometer Suite

VIS—Visible Infrared Spectrum

VLAN— A virtual local area network

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

VOIC—Voice Over Internet Protocol

WDTS—Western Diversity Time Series

WERC—Wildfire, Ecosystem Resilience & Climate Monitoring & Assessment Initiative

WFF—Wallops Flight Facility

WHOI—Woods Hole Oceanographic Institute

WHyMSIE—Westcoast & Heartland Hyperspectral Microwave Sensor Intensive Experiment

WMS—Web Map Service

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

WRF—Weather Research and Forecasting

WSREC—WestSide Research and Extension Center

WWAO—Western Water Applications Office

WWF—World Wildlife Fund