Annual Progress Report and Research Plan for NASA Co-operative Agreement NNX12A05A

December 30th, 2022

ARC-CREST

Ames Research Center Co-operative for Research in Earth Science and Technology

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Report Period of Performance 3/1/22 to 2/28/23
Research Plan Period of Performance 3/1/23 to 2/28/24

Introduction

On page 16 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. In addition, supplement Number 0246 of the Cooperative Agreement (Statement of Collaboration, p.5) states that the recipient shall:

"…with input from NASA "generate the Annual Research Plan." In the Cooperative Agreement Notice (amended October 18, 2011) for this cooperative agreement, NASA stated, in Section 1.1.4, that: An Annual Research Plan (ARP) will be jointly developed by ARC and the Recipient to guide the work conducted under the agreement."

Accordingly, we present a progress report for the eleventh year (2022-23) of this Cooperative Agreement and an Annual Research Plan for 2023–24.

The primary task of ARC-CREST is to work cooperatively with NASA Ames Research Center's Earth Science Division and related groups to achieve NASA's strategic Earth Science objectives. These objectives include: (1) the conduct of research into fundamental questions related to the atmosphere, the oceans, the biosphere, and Earth's land masses; (2) the use of informational and computational sciences to visualize, analyze, and interpret Earth Science data; (3) the application of technology necessary for Earth Science research; and (4) the provision of outreach and education to the general public regarding Earth Science. 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 eleventh year of the ARC-CREST cooperative agreement.

For 2023–24, the ARC-CREST scientific team, working closely with the NASA Ames Earth Science Division, will participate in over 50 project areas covering the gamut of Earth Science research. Please find descriptions of each of the project's 2022–23 accomplishments as well as 2023–24 project goals in the following report.

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

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ARC-CREST Partners

Bay Area Environmental Research Institute
California State University at Monterey Bay
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Flight

Airborne Science Advanced Planning

Project Participants

BAERI: Brenna Biggs, Susan Schoenung
NASA: Matt Fladeland

Project Description

The Airborne Science Advanced Planning activity seeks to collect information on the needs of the NASA Earth Science community for support from NASA's Airborne Science Program (ASP). ASP provides flight services for Earth Science using NASA aircraft platforms, both manned and unmanned, operating out of several NASA Centers. ASP also provides payload integration services and mission assistance, including flight planning, data management, and communications. To ensure that the right capabilities are available and will be available for future science activities, Advanced Planning maintains an out-year schedule of mission plans and the assets and services required. Information is gathered from NASA Earth Science program and from the science community through workshops, conferences, and ongoing interactions.

Accomplishments

- Made monthly updates of ASP 5-year plan in Excel.
- Updated the monthly map of ASP airborne campaigns.
- Completed a semi-annual update of a 5-year plan in OmniPlan and PowerPoint.
- Published the NASA ASP FY21 Annual Report.
- Published the NASA ASP 2022 Needs Assessment.
- Published the Fall 2021, Spring 2022, and Fall 2022 ASP Newsletters.
- Participated in ESD and Decadal Survey community workshops.
- Participated in Ames Airborne Science division semi-monthly meetings.

Presentations

- Schoenung, Susan and Fladeland, Matt "NASA Airborne Science Program Contributions to Environmental Science," presented at The History of NASA and the Environment Symposium, Georgetown University, September 29-30, 2022

Project goals for 2023

- Assist ASP Director and Deputy Director in tasks to determine needed capabilities, and to document ASP fleet modifications for science and other historical material.
- Update the ASP 5-year plan, monthly, for ASP management.
- Prepare a monthly map of all ESD airborne missions for ASP management.
- Assist ASP and ESD team in highlighting science impacts of ASP activities for ASP Director and HQ R&A manager.
- Complete the ASP 2022 Annual Report and two semiannual newsletters.
- Draft the ASP 2023 Annual Report.
- Participate in various science team meetings related to NASA Earth Science missions to gather airborne requirements data.
- Support a High Altitude Long Endurance (HALE) aircraft project, including a HALE workshop and several associated conference presentations.

Earth Observing System (EOS)

Project Participants

BAERI: Rose Dominguez, Thomas Ellis, Conrad Esch, Eric Fraim, Jeff Grose, Dr. Edward Hildum, Dr. Gary Hoffmann, James Jacobson, Jeffrey Myers, Ethan Pinsker, Dr. Haiping Su, Paul Windham, 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 real-time payload communications systems 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 sat-com based payload communications systems are deployed on most of the NASA science aircraft and are a key element of the larger NASA Airborne Sensor Network, which allows scientists to view data from multiple instruments in real-time during science campaigns. 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 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.
- Coordinated the refurbishment of our large radiometric sphere, along with co-characterization with the Radiometric Calibration Laboratory at NASA Goddard.
- Worked with outside partners to calibrate instrumentation in the ASF Cal Lab for ongoing projects including NIRVSS and AIM for the VIPER lunar mission, AMS for ongoing USDA FS wildfire work, and the Mjolnir HySpex camera system for the USGS.

Project goals for 2023

- Build and test boards for the eMAS and MASTER instruments of the Airborne Sensor Facility and have boards ready for flight season in Palmdale.
- Complete the testing of the eMAS vacuum system and begin the process of instrument characterization, with the goal of being ready for engineering test flights later this FY (if there is ER-2 aircraft availability).
- Complete Critical Design Review of the PICARD case/G-V integration with input from Johnson Space Center (JSC) engineering and Airborne Science Program (ASP) management.
- Fabricate PICARD mk.2 Case and complete initial integration/test flights on the NASA G-V.
- Participate in the following airborne campaigns: Western Diversity Time Series (WDTS), Earth Mapping Resources Initiative (EMRI), PACE-PAX, FireSense, AEROMMA.
- Complete MASTER Fire Channel modifications (MASTER Port 3 Detector).
- Maintain and upgrade N-259 calibration laboratory instrumentation and capabilities to accommodate higher standards of measurement as well as increased capacity.

Earth Science Project Office (ESPO)

Project Participants

BAERI: Judy Alfter, Quincy Allison, Brad Bulger, Daisy Gonzalez, Mariangela Gross, Christine Harper, Erin Justice, Lynn Kennedy, Sam Kim, Andrian Liem, Sommer Nicholas, Ayuta Padhi, Stevie Phothisane, Michael Schroeder, Daniel Zhang
NASA: Marilyn Vasques, Jhony R Zavaleta

Project Description

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

Accomplishments

- Supported the following research campaigns under the ARC-CREST agreement:
  - **ACCLIP (Asian Summer Monsoon Chemical & CLimate Impact Project)** is a joint venture between NASA and 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 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 AB, Republic of Korea.
  - **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, USVI between 17 August – 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 from January-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 multi-year 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 in November of 2022. An open data workshop is slated for December of 2022. The third and final deployment (IOP-2) is planned for 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 with an open data workshop scheduled for December 2022. A hybrid science team meeting is scheduled for January 2023 in College Station, Texas to discuss the most recent findings.

- Supported the following meetings—meetings were hybrid except as noted:
  - CAMP^{2}Ex (Cloud, Aerosol and Monsoon Processes Philippines Experiment) Science Team Meeting, Pasadena, CA.
  - IMPACTS (Investigation of Microphysics and Precipitation for Atlantic Cost-Threatening Snowstorms) Science Team Meeting, Boulder, CO.
  - CPEX-CV (Convective Processes Experiment – Cabo Verde) Science Team Meeting, Pasadena, CA.
  - ICAP 10 (International Cooperative for Aerosol Prediction), Monterey, CA.
  - ESI SET meeting (Solid Earth Team Meeting and Early Career Workshop for the Earth Surfaces and Interior community), La Jolla, CA.
  - ACCLIP STM (Asian Summer Monsoon Chemical & Climate Impact Project) (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).

Project goals for 2023

- Support the following research campaigns under the ARC-CREST agreement:
  - **AEROMMA (Atmospheric Emissions and Reactions Observed from Megacities to Marine Areas)** is a comprehensive study led by NOAA's Chemical Sciences Laboratory to address emerging research needs in urban air quality, marine emissions, climate feedbacks, and atmospheric interactions at the marine-urban interface, and future satellite capabilities of monitoring atmospheric composition over North America. The NASA DC-8 is the flagship of AEROMMA. The research aircraft will base out of Palmdale to access the urban areas of Los Angeles together with regions where DMS chemistry is known to be active off the coast of Los Angeles and the Salton Sea. The second half of the mission will be based in the Eastern U.S. to survey major urban areas such as New York, Chicago, and Atlanta, together with agricultural regions in Wisconsin, Iowa and Illinois.
  - **BioSCape (Biodiversity: Marine, Freshwater, and terrestrial Biodiversity Survey of the Cape):** is a Biodiversity field campaign incorporating airborne imaging spectroscopy, lidar, and

field observations across South Africa's Greater Cape Floristic Region including surrounding coastal and marine environment. ESPO will be supporting the field campaign in late 2023, with planning well underway with the science team and the NASA G-V and G-III platforms.

- Manage the following Earth Venture Suborbital-3 (EVS-3) Missions:
  - **IMPACTS** (Investigation of Microphysics and Precipitation for Atlantic Coast-Threatening Snowstorms). 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). The pilot campaign was successfully completed in October 2021, followed by IOP-1 in October 2022. IOP-2 is planned for April-May 2023.
  - **DCOTSS** (Dynamics and Chemistry of the Summer Stratosphere). Management and science teams continue to meet on a regular basis, and data analysis is ongoing. An in-person science team meeting is slated for January 2023 in College Station, Texas.
- Support the following hybrid meetings during 2023:
  - CAMP^{2}Ex (Cloud, Aerosol and Monsoon Processes Philippines Experiment) Science Team Meeting, quarterly virtual meetings plus hybrid meeting, dates and location TBD.
  - IMPACTS (Investigation of Microphysics and Precipitation for Atlantic Cost-Threatening Snowstorms) Science Team Meeting, summer 2023, location TBD.
  - CPEX-CV (Convective Processes Experiment – Cabo Verde) Science Team Meeting, summer 2023, location TBD.
  - DCOTTS (Dynamics and Chemistry of the Summer Stratosphere) Science Team Meeting, January 2023, College Station, TX.
  - TEMPO (Tropospheric Emissions: Monitoring Pollution) Science Team Meeting, May 1-5, 2023, Huntsville, AL.
  - PBL (Planetary Boundary Layer), spring 2023, location TBD.
  - MACIE (Measurements of Aerosols, Clouds and their Interactions for ESMs) monthly meetings (Virtual).
  - AGAGE 67 (Advanced Global Atmospheric Gases Experiment) Technical Session, Bologna, Italy.
  - AGAGE 68 (Advanced Global Atmospheric Gases Experiment) Technical Session, Dedham, MA.
  - NDAAC (Network for the Detection of Atmospheric Composition Change) Steering Committee Meeting, Murnau, Germany.

GeoCarb

Project Participants

BAERI: Susan Kulawik
NASA: Berrien Moore

Project Description

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

Accomplishments

- Validated TROPOMI methane in the GeoCarb domain and globally using TCCON and GML aircraft profiles.
- Worked on acquiring EM27 contacts and data within the GeoCarb domain.

Presentations

- "Validation of TROPOMI CH4 in the GeoCarb domain" presented at GeoCarb Science Team Meeting, May 10-12, Norman, OK.
- "Validation of TROPOMI Methane in the GeoCarb Domain", Susan Kulawik, Alba Lorente, Sean Crowell, Colm Sweeney, Kathryn McKain, Edward J. Dlugokencky, Sebastien C. Biraud, John Miller, Paul O. Wennberg, Debra Wunch, Frank Hase, Coleen M. Roehl, Rigel Kivi, Nicholas M. Deutscher, Kei Shiomi, Voltaire A. Velazco, Thorsten Warneke, Kawakami Shuji, Laura T. Iraci, James R. Podolske, Joshua L. Laughner, 18th International Workshop on Greenhouse Gas Measurements from Space (IWGGMS-18), July 12-14 hosted online from Tsukuba, Japan.

Meteorological Measurement Systems (MMS)

Project Participants

BAERI: Cecilia S. Chang, Jonathan M. Dean-Day
NASA: T. Paul Bui

Project Description

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

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

Accomplishments

- Re-processed and re-submitted revised MMS data from 7 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 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, TX.
- 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 PI 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 Stratospheric Aerosol processes, Budget and Radiative Effects (SABRE) mission in early 2023. Identified ideal Mach and altitude flight conditions for MMS maneuvers during the campaign and examined science flight data for ongoing proper operation of MMS analog/digital sensors and inertia navigation systems.
- Responded to questions by researchers about the strengths and limitations of MMS turbulence data and calculation methods from prior field campaigns (e.g., FIREX, DCOTSS, and ACCLIP).

Publications

June, Nicole A., [et al., including Dean-Day, Jonathan M.] (2022), Aerosol size distribution changes in FIREX-AQ biomass burning plumes: the impact of plume concentration on coagulation and OA condensation/evaporation. *Atmos. Chem. Phys*., **22**, 12803-12825. https://doi.org./10.5194/acp-22-12803-2022.

Project goals for 2023

- Finalize calibration and correction of ER-2 #806 MMS data from the Dynamics and Chemistry of the Summer Stratosphere (DCOTSS) 2022 mission.
  - Reconstruct temperature probe response by statistically combining probe bath calibrations with laboratory amp measurements.
  - Apply calibrations to science data according to installed hardware.
  - Apply deicing compensation to Tslow temperature probe data as needed for data reduction.
  - Optimize selected use of inertial navigation system (INS) variables based on in-flight performance of CMIGITS and LTN-100G.
  - Use redundant measurements to reconstruct missing values.
  - Correct clock errors resulting from GPS reception dropouts.
  - Reprocess final data and archive 1 Hz and 20 Hz files.
- As part of the development, fabrication, and performance validation, analyze laboratory swing measurements to determine time delays of LTN-251 and CMIGITS INUs, along with a Paroscientific 15psia total/static pressure transducer.
  - Measure and compare time response of INU attitude, velocity, and acceleration variables.
  - Compare analog values sampled with or without RC filter processing.
  - Develop digital filters to reduce 100Hz raw measurements to 20Hz and validate the accuracy of filtered data values during sinusoidal swing oscillations.
- Perform remote data analysis and processing support during the Stratospheric Aerosol processes, Budget and Radiative Effects (SABRE) mission in early 2023.
  - Evaluate performance of sensors and components.
  - Examine frequency response of flow angle data from new PPT transducers.
  - Monitor reliability of INS measurements and adapt processing code to minimize impact of poor GPS reception.
  - Evaluate range, precision and thermal dependence of sensors to optimize MMS performance.
  - Compare air data sampled from PPT with Rosemount sensor probes.
  - Recommend flight conditions for aircraft maneuvers.
  - Update WB-57 MMS measurement calibrations during the deployment to maximize accuracy and scientific value of field measurements.
- Prepare for the Atmospheric Emissions and Reactions Observed from Megacities to Marine Areas (AEROMMA) campaign on the DC-8.
  - Adapt existing processing software to 100Hz raw data sampling of the new MMS2 instrument.
  - Compare time response of the aircraft LN-251with the CMIGITS INU during aircraft maneuvers during a series of test flights flown from Palmdale, CA to validate laboratory swing results.
  - Analyze and perform initial calibration of MMS2 data.
- Provide data analysis and processing support for AEROMMA and SARP-2022 during both early summer flights from Palmdale, and mid- to late-summer science flights based from Dayton, OH.
  - Evaluate performance of MMS2 instrument sensors during the mission and recommend flight conditions for aircraft maneuvers.
  - Begin ensemble calibration of MMS2 maneuvers and develop initial corrections for errant data during post-mission analysis.

- Evaluate data quality and calibrate WB-57 MMS measurements from the late-winter SABRE mission.
    - Combine MMS maneuver calibrations from ACCLIP-2022 and SABRE-2023 in order to update statistical functions characterizing instrument response throughout the WB-57 flight envelope for the dual campaigns.
    - Develop corrections to sensor errors from individual flights as needed.
    - Reprocess MMS data and submit revised 1 and 20 Hz files to the project archive.
- Prepare for the Airborne and Satellite Investigation of Asian Air Quality (ASIA-AQ) campaign on the DC-8.
    - Modify existing processing software to adapt to MMS2 hardware configuration.
    - Analyze and update calibration of MMS2 airborne maneuvers during test flights in early 2024.
- Review and help improve manuscripts of scientists utilizing MMS data.
    - Provide editorial comment and submit results of supportive analyses to primary authors during peer review.
- Provide guidance and consultation as needed with regard to developing an MMS customized for the new NASA Boeing 777, which is proposed to replace the DC-8 platform within the next few years.

NSRC Mission Operations

Project Participants

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

Project Description

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

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

NSRC went through several staff transitions between March 2022 and May 2022, including:

- Mar 2022: An NSRC Instrumentation Engineer left the organization.
- May 2020: An NSRC Senior Software/Electrical Engineer was brought onboard.

Accomplishments

DC-8 Specific Engineering and Data/Satcom System Accomplishments

- Worked with OE's to install additional cameras and environmental monitoring systems to mitigate cabin pressurization risk. Camera upgrades will also replace aging pit monitoring cameras.
- Worked with OE's to install similar external Wifi / LTE antenna as what is in use aboard the ER-2 to support enhanced connectivity during ground operations.
- Worked with OE's to install Iridium Certus antenna.
- Updated the mechanical design for the mid-cabin overhead to incorporate Iridium Certus, ADS-B, and WiFi/LTE systems/communications components, updated detail/installation drawing, and sent out new parts for fabrication.
- Updated the mechanical design for the Iridium filters assembly, updated detail/installation drawing, and sent out new parts for fabrication.
- Updated the electrical drawing for the antenna farm and nadir ADS-B antenna cabling.
- Updated the electrical drawing for the GPS antennas, splitters, and sidewall connectors.
- Updated the electrical drawing for the dropsonde UHF antenna, amplifier, and sidewall connectors.
- Modified the installation of the dropsonde UHF antenna amplifier.
- Completed network upgrades (VLAN Configuration).
- Completed extensive work on new pit and outflow valve cameras.
- Worked on ADS-B / CERTUS upgrade for DC-8.
- Worked with the aircraft team to implement cabin humidity monitoring.
- Continued work on finalizing drawings associated with mechanical and electrical modifications to support ASP missions.
- Engaged in extensive interaction with DC-8 program to close out all necessary activities prior to test flight of combined payload
- Supported all HIWC flight activities.
- Supported all SARP ground-based sonde launches, field campaigns, and activities.
- Installed new camera in cargo compartment.

ER-2 Specific Engineering and Data/Satcom System Accomplishments

- Completed significant cleanup of MVIS wiring, which was utilizing wiring and trays designed for a much more complex and obsolete camera system.
- Continued work to validate data system functionality during N806NA return to flight - verified NASDAT Inputs, completed troubleshooting of SATCOM issues, verified integrity of network wiring, and worked with crew to correct all issues.
- Continued work to upgrade INMARSAT canoe, build additional routers, and work towards a built-in LTE capability.
- Worked to restore PTZ camera to functionality—currently it is unable to hold its dry nitrogen purge and was fogged over for much of IMPACTS.
- Created EIP breakout cables and started building procedures to EIP tests.
- Completed upgrade to Gigabit ethernet for INMARSAT canoe.
- Continued work to validate data system functionality during N806NA return to flight - verified NASDAT Inputs, troubleshooting of SATCOM issues, verified integrity of network wiring, and worked with crew to correct it.
- Scanned the ER-2 datasystems for IT security.
- Contacted PACA experimenters regarding their specs for our data systems, to set up for the campaign which was subsequently canceled.
- Provided IMPACTS Support (SSH Accounts & Setting up upload).

P-3 Specific Engineering and Data/Satcom System Accomplishments

- Continued to work on P-3 Permanent Data System engineering, supported PER.
- Prepared and presented the Preliminary Engineering Review for the P-3 permanent data system modifications.
- Created detail/installation drawings for mechanical modifications.
- Continued work on structural analysis and associated reports for load center and overhead bins.
- Created design and installation drawing for a new L1/L2/L5/L-Band GPS antenna.
- Sent out new parts for fabrication for the P-3 antenna farm modifications (to add Iridium Certus and ADS-B antennas).
- Fabricated cable-end associated wiring of interface boxes, control panels, and load center in preparation for installation.
- Updated detail/installation drawings for electrical and mechanical modifications.
- Directly provided on-site support for the mechanical and electrical installation of hardware on the aircraft.
- Continued work on P-3 Permanent Data system at WFF.
- Completed final drawings and engineering analyses for installation.
- Directly provided on-site support for the mechanical and electrical installation of hardware on the aircraft.
- Continued work on specific requirement for SaSa.

G-V Specific Engineering and Data/Satcom System Accomplishments

- Completed AOD GV defogging data collection project. Provided technical oversight, drawing reviews, and mentorship.
- Supported GV NOAA Dropsonde Project. Wrote, tested, and installed automated file transfer software for dropsonde files on the GV's data system. Provided support for Delta TRR held on 22 Sep.

G III (LARC) Specific Engineering and Data/Satcom System Accomplishments

- Assisted in the installation of the CERTUS satellite communications system.

Overall ASP Data Management Activities

- Submitted ACTIVATE 2022 dataset to www-air (https://www-air.larc.nasa.gov/missions/activate/index.html) (~80 science flights). This is the navigation dataset for the UC-12/B200.
- IMPACTS 2022 (ER-2 (10 science) and P3 (11 science)) dataset is now available/staged at the GHRC DAAC.
- Updated DCOTSS 2022 (ER-2 (11 science)) dataset to www-air (https://www-air.larc.nasa.gov/missions/dcotss/index.html).
- Updated 2022 data management logs on SharePoint (currently in google drive).

- Began work on HIWC preliminary dataset.
- Provided CPEX-CV ground support (9/2-9/14), (including uploads of quick turn-around MetNav datasets for the DC-8 to the LaRC field archive);
- Provided CPEX-CV data system operation support (9/15-10/2); flew as primary operator for 7 research flights and 2 transits. Missed 1 research flight due to illness. (Included uploads of quick turn-around MetNav datasets for the DC-8 to the LaRC field archive.)
- Fully backed up the DC-8 datasystem (fully swept and cleaned the server).
- Generated "quick look" forward camera videos from select flights during CPEX-CV, work in progress.
- Supported the field archival for WDTS in the beginning of September (total of 5 flights); got set up to "quick-archive" the ER-2 data on asp-archive. No formal dataset generation required for this mission.
- Continuing to work on the HIWC-2022 public release dataset.
- Working to release SARP 2021 and SARP 2022 datasets before AGU 2022.
- Began the solicitation to IMPACTS for NSRC integration/networking support on the P3.
- Made a full copy of the DC-8 aircraft server and copied all the aircraft video.
- Worked to clean up asp-archive (adding some items to the archive from DCOTSS, working on the CPEX-CV fast video).
- Installed a new server for the MTS. Continued to configure and tweak that infrastructure. Work on virtualizing the NSRC infrastructure and finalizing the ASP security plan is ongoing.

Projects and Missions Supported by SMO Staff to Date

ACTIVATE (HU-25) - Winter 2022
- Monitored flights, provided technical support.
- Turned in 2021 data and started work on Winter 21/22.

LARGE AIRCRAFT
- Initiated working large aircraft preliminary requirements. Met with ASP weekly prior to 777 engineering kickoff meeting in Annapolis to develop requirements list and project plan. Continued preliminary design of various electrical, mechanical, and network/data systems.
- Worked with LaRC counterpart to develop agenda and delegate subsystems to team members. Started work on 777 SATCOM requirements.
- Began drafting 777 engineering project plan. Developed 777 site visit checklist for EE items.
- Initiated preliminary designs of various systems – network/power/RF. Laid IT groundwork for cross-center collaboration—added relevant NAMS requests for the whole team, set up fileshare permissions, and worked with local IT contractor to upgrade license servers.

SOA2RSE — November 2022
- Provided operator support for 4 SOA2RSE flights.

OCELOT (DC-8) — Dec2022
- Supported payload integration and data system requirements.
- Supported local flights out of PMD with both mission directors and data system operators.

DCOTSS (ER-2)— Spring 2022
- Initiated preparation for DCOTSS integration in April.
- Completed operator documentation and scheduling.
- Completed requirements confirmation.
- Attended multiple telecons.
- Reconfigured INMARSAT canoe for use on N806NA, updated OS to comply with Agency IT security.
- Completed all instrument checkouts.
- Integrated MVIS camera aboard N806NA.
- Continued work to get AVS camera to hold its purge.
- Configured N806NA NASDAT for DCOTTS.

- Created translator program to allow PALMS Command and control software to interface with ASPInterface system for instrument command and control.
- Created an outdoor test ring with INMARSAT canoe to allow early instrument checkouts while N806NA was down.
- Supported Kansas radar check flights.
- Made extensive effort to swap and troubleshoot NASDAT for X-Chat purposes.
- Completed preparation for DCOTSS deployment in May.
- Completed all planned data-system improvements.
- Installed improved PTZ camera.
- Supported deployment of the ER-2 to Salina, Kansas, and the return to PMD and subsequent local flights
- Supported instrument integration and configured all ground side data links.

SABRE Winter 2023
- Supported WB-57 NOAA mission.

WDTS August 2022
- Supported local ER-2 mission.

SARP Spring - Summer 2022
Twenty-eight outstanding undergraduate STEM student majors from across the United States traveled to southern California to participate in a unique internship experience, exposing them to NASA's Earth Science research and allowing them to participate in a short airborne science mission. SARP provided the students with a research experience like none other. This included data collection dispersed across the country, as well as the analysis of previously-collected aircraft, ground, and satellite data. Students flew on ASP's DC-8 aircraft on multiple science flights from Palmdale, California. They also participated in multiple ground measurement excursions around southern California and then utilized previously collected data along with these new measurements to generate original scientific analyses on climatological and human impacts in southern California. The students then relocated to UC Irvine for 2 months to complete their research and present their results.

Project goals and Upcoming Mission Support for 2023

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

BIOSCAPE: This mission is scheduled for October - December 2023 to South Africa. It is planned to fly on the G-V and G-III.

Asia-AQ: This mission is scheduled for multiple OCONUS sites during November - December 2023.

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

IMPACTS: This mission is being executed on the ER-2 and P-3. Science flights will take place in January-February 2023 with the P-3 flying locally out of Wallops Flight Facility, and the ER-2 flying out of a deployed location in Georgia.

AEROMMA: Mission planning underway with integration on the DC-8 in May, local Palmdale flights June - July 2023, and deployment to Ohio in July - August 2023.

SARP 2023: Local science flights on the DC-8 are planned in June 2023. This will be followed by several weeks of mentoring students in data analysis and report preparation at UC Irvine.

WDTS: Local science flights on the ER-2 are planned in March - May 2023.

ALOFT: Science flights on the ER-2 are planned in July - August 2023.

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

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

- Mission Support for missions as detailed above with on-board data system operation for the P-3 and DC-8 missions, along with on-site support for the ER-2 and as-needed for other platforms.
- Maintenance of onboard instrumentation, network, and SATCOM facilities:
    - Further development of ER-2 Camera Systems.
    - Upgrade of ER-2 INMARSAT Canoes to facilitate onboard processing.
    - Install External Wifi and LTE capabilities on the ER-2s, DC-8 and P-3.
    - Maintain instrument calibrations.
    - Install new instruments including DC-8 Pitot/Static Pressure Transducers.
    - Deploy Iridium CERTUS across the ASP Fleet.
    - Complete a permanent data system installation for the P-3.
    - Develop a NASDAT Next Generation system.

- Maintenance and development of new software for flight:
    - Develop an Inmarsat monitor and management program.
    - Develop Network Integrity Monitoring Tools.
    - Standardization of deployable file server.
    - Upgrade NSRC Data Acquisition software.
    - Upgrade NSRC Data Display Software.
    - Build a proactive network monitoring tool.
    - Modernize the data access API.
- Prepare all SARP laptops for remote distribution for SARP.
- Complete final mission data archive for: CPEX-CV, IMPACTS, and HIWC.
- Continue documentation of all analysis code.
- Continue the development of next-generation NASDAT for preliminary testing on the DC-8.

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

- Further development and refinement of the MTS infrastructure:
    - Increasing storage and backup capabilities.
    - Increased fault tolerance.
    - Adding 3D rendering capabilities.
    - Increasing computational capabilities.
    - Incorporating more data products as they become available from the FAA.
- Take lessons learned from MTS infrastructure and deploy similar in NSRC cloud infrastructure:
    - Further virtualize NSRC ground infrastructure.
    - Restructure the support and infrastructure for pre and post QC field data (asp-archive revamp).
        - Better organization of data, search capabilities, and data display.
    - Focus on increased fault tolerance and availability.
    - Lights out management for all ground side infrastructure allowing remote diagnostics/ troubleshooting/repair.
    - Increase the amount of time we can withstand from any fault until onsite repair is necessary.
- Decentralize and update our Iridium Short Burst Data Portal:
    - Rewrite/refactor using newer APIs and libraries not previously available.
    - Continue to investigate and experiment with alternative handheld/easily deployed asset tracking units that make use of the DOD/DISA Iridium gateway.
- Decentralize/rewrite/refactor TFR KML generation:

    - Bring back color coding.
    - Leverage MTS API.
    - Move to a different code base.
- Investigate viability of moving current Ames based cloud infrastructure into a different gov cloud instance.
    - Investigate cost/benefit, security/fault tolerance, and ease of use.

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

- Provide engineering support for the development of the Large Aircraft B777-200ER.
- Provide DC-8 payload and engineering support for the SARP 2023 mission.
- Provide DC-8 limited payload and engineering support for the AEROMMA mission.
- Provide DC-8 limited engineering support to AFRC for the OPALS instrument development.
- Provide mechanical engineering support for various DC-8 data and satcom systems installations, including: permanent IR/visible camera pod installation, Ethernet network upgrade, ADS-B systems (zenith and nadir), Iridium NEXT satcom, pitot-static pressure transducers, 2-channel TAT signal conditioner, touchscreens, and WiFi/LTE connectivity.
- Provide mechanical engineering support for integrating WiFi/LTE connectivity on other ASP platforms.
- Provide mechanical engineering support for the NextGen NASDAT development.

USFS Autonomous Modular Sensor

Project Participants

BAERI Edward Hildum
NASA: Donald Sullivan

Project Description

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

Accomplishments

- Collected and shared all existing instrument documentation with USFS via MS Teams repository.
- Updated and reviewed the existing operator's manual.
- Wrote new documents covering system optical design and operating system installation.
- Calibrated the instrument in the ASF lab.
- Advised USFS personnel on possible instrument improvements.
- Brought AMS to flight-ready status on new USFS/NIFC aircraft.

Research and Analysis

4STAR and Satellite Data Analysis

Project Participants

BAERI: Stephen Broccardo, Samuel LeBlanc, Kristina Pistone

Project Description

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

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

Accomplishments

- Completed Langley calibration of 4STAR/4STAR-B & 5STAR prototype at Mauna Loa Observatory. This was a successful calibration campaign, with 4STAR showing < 0.6% variability and 4STAR-B < 0.45% variability from day-to-day, for a combined set of 7 sunrises and sunsets.
- Deployed 4STAR-B on the NASA P-3 during the SaSa flight campaign. One test flight and 5 research flights were completed successfully. Aerosol optical depth data from SaSa flights are under QC and will be archived on the NASA Langley DAAC.
- Published software packages:
    - LeBlanc, S. and millercommamatt: samuelleblanc/fp: Moving Lines labels color, bug fixes, and scroll to zoom, v1.29, https://doi.org/10.5281/zenodo.5838962, 11 January 2022.
    - LeBlanc, S. and millercommamatt: samuelleblanc/fp: Moving lines: excel spreadsheet flight path update for pilots, v1.30, https://doi.org/10.5281/zenodo.5975513, 4 February 2022.
    - Samuel LeBlanc: samuelleblanc/LeBlanc_2022_KORUSAQ: KORUS-AQ Science code analysis release for LeBlanc et al., 2022, ACP: "Airborne observation during KORUS-AQ show aerosol optical depths are more spatially self-consistent than aerosol intensive properties," [code] https://doi.org/10.5281/zenodo.6965167, 5 August 2022.
- Completed 4STAR A &B fiber-optic path repair and improvements to fiber mechanical constraint within the instrument head.
- Completed radiometric and spectral calibration for 4STAR A & B at the Airborne Sensor Facility calibration lab.
- Analyzed 4STAR (A&B) rooftop NO2 measurements and comparisons to Pandora.
- LeBlanc was selected for leadership support for ARCSIX.
- Analyzed 2 years of AERONET, Pandora, OMI, and TROPOMI NO2 at California surface sites.
- Continued work with collaborators at OU on processing and optimizing 4STAR sky scans from ORACLES 2017/2018.
    - Standardized archived ORACLES sky scans so that the 2017-2018 results are consistent with the ORACLES 2016 sky scans which used 5 wavelengths (400, 500, 675, 870, 995nm). This was due to the irregularities observed in 2017/18 in the 400nm radiances.
    - Analysis and processing of sky scan data is ongoing, including QC and collocation with other ORACLES aerosol instrumentation, and multi-year analysis of the aerosol intensive properties.

Presentations

- LeBlanc: San Jose State University - Meteorology & Climate Science. SJSU Spring 2022 Seminar Series - Looking up from airplanes: understanding impact of aerosol and cloud on transmitted sunlight.
- LeBlanc: Presentation for Ames' Wildfire interest group on: "Aerosol vertical information from Oxygen-A band" (2022-03-14).
- LeBlanc: Presentation during SGG branch meeting on: "Aerosol optical depth is more consistent than aerosol size over large distances during KORUS-AQ" (2022-02-28).
- Pistone: Invited Talk: Hampton University Atmospheric and Planetary Sciences seminar series, October 2022: "Observations of biomass burning aerosol over the southeast Atlantic Ocean and the meteorological context: Results from ORACLES."
- Presentation at SGG branch meeting: "4STAR in SaSa" (2022-10-04).
- Invited presentation at AOGS-2022: LeBlanc et al., Measuring aerosol optical depth from aircraft during KORUS-AQ reveals higher consistency than aerosol size, AOGS, August 2022, AS09-A037, invited oral presentation.
- Contributions to student-led 4STAR work:
    - Mitchell et al. " Subseasonal Variability of Biomass Burning Aerosol Radiative Properties Retrieved by 4STAR during the ORACLES 2016-2018 Campaigns", AMS Collective Madison Meeting, August 2022.
- To be presented at AGU Fall meeting December 2022:
    - LeBlanc et al., Aerosol above cloud and optical depth in the southeast Atlantic and their use in continuity NASA products, AGU, Session A073. Models, In situ, and Remote sensing of Aerosols (MIRA), Accepted as Oral.
    - Broccardo et al., Evaluating the impact of absorbing aerosol on space-based NO2 retrievals using AERONET and Pandora in California, AGU Fall meeting A085 - Remote Sensing of Fire Processes and Biomass Burning Emissions poster session.

Publications

LeBlanc, S. E., Segal-Rozenhaimer, M., Redemann, J., Flynn, C., Johnson, R. R., Dunagan, S. E., Dahlgren, R., Kim, J., Choi, M., da Silva, A., Castellanos, P., Tan, Q., Ziemba, L., Lee Thornhill, K., and Kacenelenbogen, M.: Airborne observations during KORUS-AQ show that aerosol optical depths are more spatially self-consistent than aerosol intensive properties, Atmos. Chem. Phys., 22, 11275–11304, https://doi.org/10.5194/acp-22-11275-2022, 2022.

Norgren, M. S., Wood, J., Schmidt, K. S., van Diedenhoven, B., Stamnes, S. A., Ziemba, L. D., Crosbie, E. C., Shook, M. A., Kittelman, A. S., LeBlanc, S. E., Broccardo, S., Freitag, S., and Reid, J. S.: Above-aircraft cirrus cloud and aerosol optical depth from hyperspectral irradiances measured by a total-diffuse radiometer, Atmos. Meas. Tech., 15, 1373–1394, https://doi.org/10.5194/amt-15-1373-2022, 2022.

Cochrane, S. P., Schmidt, K. S., Chen, H., Pilewskie, P., Kittelman, S., Redemann, J., LeBlanc, S., Pistone, K., Segal Rozenhaimer, M., Kacenelenbogen, M., Shinozuka, Y., Flynn, C., Ferrare, R., Burton, S., Hostetler, C., Mallet, M., and Zuidema, P.: Biomass burning aerosol heating rates from the ORACLES (ObseRvations of Aerosols above CLouds and their intEractionS) 2016 and 2017 experiments, Atmos. Meas. Tech., 15, 61–77, https://doi.org/10.5194/amt-15-61-2022, 2022.

Chang, I., Gao, L., Flynn, C. J., Shinozuka, Y., Doherty, S. J., Diamond, M. S., Longo, K. M., Ferrada, G. A., Carmichael, G. R., Castellanos, P., da Silva, A. M., Saide, P. E., Howes, C., Xue, Z., Mallet, M., Govindaraju, R., Wang, Q., Cheng, Y., Feng, Y., Burton, S. P., Ferrare, R. A., LeBlanc, S. E., Kacenelenbogen, M. S., Pistone, K., Segal-Rozenhaimer, M., Meyer, K. G., Ryoo, J.-M., Pfister, L., Adebiyi, A. A., Wood, R., Zuidema, P., Christopher, S. A., and Redemann, J.: On the differences in the vertical distribution of modeled aerosol optical depth over the southeast Atlantic, Atmos. Chem. Phys. Discuss. [preprint], https://doi.org/10.5194/acp-2022-496, in review, 2022.

Committees and Service

- LeBlanc:
  - DOE SBIR review panel member.
  - Initial development of FireSense meeting.
  - AOS Suborbital.
  - EarthCare sub-orbital cal/val.
- Pistone:
  - NASA ROSES review panel member.
  - CLOUD GAZE Science Steering Committee (May 2021-present), science advisory on development of a new community science platform as part of NASA's GLOBE program.
  - NASA ARC Science Directorate Diversity and Inclusion Advisory Committee (April 2021-present).
  - Earth Science Seminar Committee, NASA ARC (January 2021-present).
  - NASA Technical Review Committee for MUREP (Minority University Research and Education Project) Center for Advanced Measurements in Extreme Environments (CAMEE) project (June 2020-present), including review of COVID-related 2y funding extension.
  - American Geophysical Union Fall Meeting Program Committee (June 2020-present), Atmospheric Sciences section.
- Broccardo:
  NASA SBIR review panel member.
  NASA ROSES review panel member.
  AGU Fall Meeting 2022 Student Presentation Judge.

Project goals for 2023

ISFM Radiation Science Program

- Assess and improve the AOD repeatability, calibration stability, and UV-wavelength performance of 4STAR-B through a comprehensive series of tests, characterization and calibration.
- Assess and improve the trace-gas column measurements from 4STAR by comparisons with the NASA Ames Pandora instrument.
- Improve the accuracy of 4STAR skyscan products sampled during the ORACLES airborne campaign (https://espo.nasa.gov/ORACLES/content/ORACLES) to inform on aerosol microphysical properties of biomass burning aerosol above clouds over the southeast Atlantic in 2016-2018.
- Provide support to keep 4STAR/4STARB instruments operational and ready for potential deployments, including compilation of data into archives.
- Prepare papers for publication:
  - "Is there a Physical Difference in Aerosol as a distance to the coastline for a few key airborne campaigns? [Conrelison et al., in Prep]" - A compilation of legacy airborne aerosol optical depth measurements in a cohesive publication.
  - "Above Cloud Direct Aerosol radiative effect and diurnal variations from airborne measurements in the southeast Atlantic" [LeBlanc et al., in Prep.]
  - Engineering Paper describing advancements in 4STARB [Broccardo et al., in Prep].
  - Sky scan analysis paper: "Aerosol intensive properties of biomass burning smoke measured by an airborne sun photometer over the southeast Atlantic, 2016-2018" to the ORACLES ACP special issue [Pistone].

ISFM Atmospheric Composition Program (ACP)

- Assess atmospheric trace gas and aerosol observations in northern California, includes analysis of NASA ARC Pandora instrument (installed in November 2019).
- Continue data analysis linking satellite and ground based NO2 and Aerosol observations, with potential publication: "OMI-vs-Pandora-AERONET comparison using instruments on rooftop at Ames" [Broccardo et al].

- Prepare papers for publication:
  - OMI NO2 bias under various aerosol conditions [Segal-Rozenhaimer et al., in Prep] - Addressing the measurements during KORUS-AQ airborne mission.
  - Spatial autocorrelation of aerosol intensive and extensive properties during KORUS-AQ [LeBlanc et al., submitted] - Aerosol optical depth from airborne sampling during KORUS-AQ.

5STAR/Eng-Sci

Project Participants

BAERI: Stephen Broccardo, Conrad Esch
NASA: Stephen Dunagan

Project Description

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

The 5STAR (ultra-Stable Spectrometers for Sky-Scanning Sun-Tracking Atmospheric Research) 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

- Incorporated temperature control into the ground prototype.
- Developed a software state-machine architecture in Labview to enable arbitrary instrument mode changes and pointing sequences based on a “recipe” file to enable solar aureole and sky-radiance measurements.
- Developed camera-based sun-tracking software in the Linux/ROS environment.
- Completed a first calibration test of the engineering prototype at Mauna Loa Observatory.

Project goals for 2023

- Investigate and demonstrate credible ultrasonic window-cleaning systems for the flight instrument based on triple-offset butterfly valve geometry.
- Diagnose and improve the photodiode and amplifier temperature stabilization on the prototype.
- Integrate amplifier/filter/routing circuitry developed by the SeaSTAR project into the 5STAR prototype.
- Update the CAD model to incorporate new geometries and new circuitry.
- Transition the 5STAR prototype software from Windows/Labview to Linux/ROS, to maximize technology sharing between 5STAR (airborne) and SeaSTAR, and address security concerns around Windows-based instruments.
- Improve stray-light control through the use of ultra-black coatings inside the entrance optics, similar to the Pandora instruments.
- Test and address issues with the photodiode boards and transimpedance amplifiers.
- Test radiometer wavelength and radiometric response in a calibration lab.
- Propose to ROSES A.25 Airborne Instrument Technology Transition.

ACCDAM

Project Participants

BAERI: Kristina Pistone
DRI: Marco Giordano, Eric Wilcox

Project Description

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

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

Accomplishments

- Extended the results of Pistone et al. (2021) to examine all three ORACLES deployments, including analysis of an additional atmospheric chemistry reanalysis (CAMS). Despite the differing locations and season of each deployment, we find that there continues to be good agreement between the airborne ORACLES dataset and large-scale reanalyses, specifically the ECMWF ERA5 and CAMS reanalyses. Other reanalyses (specifically NASA's 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.

- Made progress on the follow-on to Pistone et al., 2021 (https://doi.org/10.5194/acp-21-9643-2021), including all of the above and tentatively titled "Seasonal changes in atmospheric vertical structure over the Southeast Atlantic," for submission in the ORACLES ACP special issue. Pending coauthor comments, I hope to submit this in the first quarter of 2023.
- In progress: analyzing the broader radiative and dynamical implications of these results for conditions of aerosols overlying stratocumulus clouds. Began running radiative transfer calculations based on the above canonical profiles, working towards an integrated radiative heating calculation for the region.

Presentations

- Invited Talk: Hampton University Atmospheric and Planetary Sciences seminar series, October 2022: "Observations of biomass burning aerosol over the southeast Atlantic Ocean and the meteorological context: Results from ORACLES."
- Talk: American Meteorological Society, Collective Madison Meeting, August 2022: K. Pistone et al., "Variation and evolution of atmospheric structure over the SEA BB season as seen from aircraft and reanalysis."
    - Also chaired session: "Challenges in the Understanding of Absorbing Aerosol and Its Impacts on Clouds, Radiation, and Climate" at CMM.

Publications

In prep: Pistone et al., "Vertical structure of a springtime smoky and humid troposphere over the southeast Atlantic from aircraft and reanalysis."

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.
- CLOUD GAZE Science Steering Committee (May 2021–present), science advisory on development of a new community science platform as part of NASA's GLOBE program.
- NASA ARC Science Directorate Diversity and Inclusion Advisory Committee (April 2021–present).
- Earth Science Seminar Committee, NASA ARC (January 2021–present).
- NASA Technical Review Committee for MUREP (Minority University Research and Education Project) Center for Advanced Measurements in Extreme Environments (CAMEE) project (June 2020–present).
- American Geophysical Union Fall Meeting Program Committee (June 2020–present), Atmospheric Sciences section.
- NASA GLOBE Subject Matter Expert on aerosols and clouds (videos and webinars for educators and students) (2020–present).
- 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.

Project goals for 2023

- Complete the manuscript for peer review (see above), currently titled "Seasonal changes in atmospheric vertical structure over the southeast Atlantic," for submission in the ORACLES ACP special issue. With this paper, we plan to extend the prior analysis to all three deployment periods rather than just 2016 and present the new good agreement with CAMS as well as the meteorological regimes.
- Lead additional paper(s) that will focus on the radiative transfer results above and what they can tell us

about the relative importance of each component to overall heating both separately and as they coincide in these meteorological regimes.

- Present results from this work at the Radiation and Climate Gordon Research Conference in July 2023 and the American Geophysical Union Fall Meeting in December 2023.
- Expand our SEA analysis to the SEP profiles as well, including classification into atmospheric regimes based on vertical structure of aerosols and water vapor. Hopefully, we will verify and then use the verified agreement between observations and the CAMS reanalysis to quantify the overall incidence for this other region.
- Begin to characterize satellite-observed cloud fractions associated with different aerosol and water vapor conditions in both regions.

ACCLIP

Project Participants

BAERI: Levi Golston, Emma Yates
NASA: Jim Eilers, Laura Iraci, Roy Johnson, Jim Podolskie

Project Description

ACCLIP (Asian Summer Monsoon Chemical & CLimate Impact Project) aims to investigate the impacts of Asian gas and aerosol emissions on global chemistry and climate via the linkage of Asian Summer Monsoon (ASM) convection and associated large-scale dynamics. Main deployment: July – August, 2022, Osan AFB, South Korea. Test flights: July - August 2021, Houston, Texas. COMA (Carbon mOnoxide Measurement from Ames) will play a valuable role in determining CO and N2O mixing ratios in the stratosphere, both of which are tracers of surface influence/pollution and will be used in most future data analyses.

Accomplishments

- Successfully deployed COMA instrumentation: June-July 2022, Houston, TX (test flights).
- Successfully deployed COMA instrumentation: July – August, 2022, Osan AFB, South Korea.
- Completed data analysis of field campaign data.
- Conducted pre- and post-deployment laboratory testing and calibrations.
- Uploaded preliminary COMA field campaign data to the DAAC.

Project goals for 2023

- Conduct continuous operation and testing of the COMA instrument at Ames in the laboratory to finalize COMA data from ACCLIP. We need a good understanding of the operational uncertainties (precision, linearity, limit of detection etc) and to cross-compare standards (NOAA vs Matheson).
- Produce finalized COMA data and upload to DAAC (Mar 2023).
- Complete data analysis of field campaign data. Findings will be presented at conferences, and written up into a research paper.

Aerosol Modeling & Data Analysis

Project Participants

BAERI: Qian Tan
NASA: Hongbin Yu

Project Description

Aerosols, the small particles suspended in the air, can affect air quality and public health on a global scale. In this study, we quantified the premature deaths that are attributable to the long-term exposure of PM2.5, i.e. the aerosol particles that have diameter smaller than 2.5um. PM2.5 concentrations are from NASA's MERRA-2 Reanalysis, and the relative risk of various diseases are from the integrated exposure model (IRM) developed by the World Health Organization (WHO). Based on our analyses, PM2.5 contributes to ~2.89 million premature deaths globally. PM2.5-induced ischaemic heart disease causes more deaths than other diseases. The highest mortality occurs in Asia, due to both high PM2.5 concentration and high population density. Among all PM2.5 components, mineral dust contributes to ~22% of aerosol related mortality.

Accomplishments

- Completed estimates of the meridional circulation pattern in major dust and aerosol outflow regions, and around the Arctic using NASA MERRA-2 reanalysis.
- Estimated the fluxes of dust and other aerosol components in selected regions around the globe using both CALIOP measurements and MERRA-2 reanalysis.
- Collected and analyzed measurements of aerosol chemical properties and optical properties made at the same location in both the United States and Asia from various field missions and ground networks.
- Analyzed CO measurements from three satellites (MLS, MOPITT and AIRS).

Publications

Yang A, Tan Q, Rajapakshe C, Chin M and Yu H (2022), Global premature mortality by dust and pollution PM2.5 estimated from aerosol reanalysis of the modern-era retrospective analysis for research and applications, version 2. Front. Environ. Sci. 10:975755. doi: 10.3389/fenvs.2022.975755.

Project goals for 2023

- Study the relationship between surface PM2.5 and particle scattering as a function of its chemical compositions during NASA field missions in both the United States and Asia.
- Study the relationship between surface PM2.5 and column aerosol optical depth as a function of aerosol chemical composition and meteorological conditions.
- Evaluate modeled surface PM2.5 vs AOD relationship via available observations.
- Quantify meridional transport of aerosols using CALIPSO measurements in different seasons.

Alpha Jet Atmospheric Experiment (AJAX)

Project Participants

BAERI: Emma Yates
NASA: Laura Iraci

Project Description

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

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

Accomplishments

- Served as co-investigator on an accepted proposal: NASA EARTH SCIENCE DIVISION, Atmospheric Composition Campaign Data Analysis and Modeling, ROSES 2020 Program Element A.23, NNH20ZDA001N-ACCDAM. Proposal Title**:** Solving the Mystery of the Disappearing Low Ozone Values: Attributing Ozone Trends over the Eastern Pacific Ocean and Western North America.
- Maintained, calibrated, and serviced AJAX wing pod instruments, which are now ready for return to flight status (approvals still needed from Ames/airfield management).
- Used AJAX wing pod instruments to cross- calibrate a number of low-cost sensors (built by NPP Okon), which are deployed across the Bay Area and within the greater LA region.
- Converted AJAX data to ICARRT format for upload to the DAAC.
- Participated in a review panel for NASA Earth Sciences.
- Submitted an IRAD proposal: "*Constraining Uncertainties in GHG Ocean-Atmosphere Exchange in the California Current System*" PI: Iraci.

Presentations

- E.L. Yates et al., "*The unusual case of AJAX: Archiving a multi-year, multi-objective, multi-instrument data set*" NASA Airborne and Field Data Workshop, March 2022.

Publications

LT Iraci, CL Parworth, EL Yates, JE Marrero, JM Ryoo, *A Collection of Airborne Measurements and Analyses of Trace Gases Emitted From Multiple Fires in California*, Earth and Space Science 9 (4), e2021EA002116.

Project goals for 2023

- Resume efforts to restart AJAX flights (we are still waiting on NASA legal/management in order to proceed. In the meantime we continue to keep AJAX flight instruments operational and well calibrated so we have a good track record of instrument uncertainty if/when we can proceed).
- Finalize AJAX data overview paper (to be submitted late 2022/early 2023).
- Ensure our ACCDAM proposal commitments are met — this is a study looking at ozone coming into the western US. Upon completion of the proposal we expect publication(s) and presentations.
- Submit to other funding calls, including ROSES.
- Complete other trace gas work, including the continued set-up of our laboratory to enable air from outside to be sampled, and to align this with the current rooftop instrumentation on N-245.

- Collaborate with NPP Orken on the INSTEP project, using low cost sensors to measure trace gasses.
- Receive feedback on IRAD proposal "*Constraining Uncertainties in GHG Ocean-Atmosphere Exchange in the California Current System*" PI: Iraci.
- Work towards a research study/paper publication using AJAX data to validate lowermost tropospheric satellite products from OCO-2 and GOSAT.

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.

The project's objectives are to:

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

Accomplishments

- Developed a Day-Night (diurnal) cloud type prediction model from 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:
    - IR-based model is more stable than VIS-based model, and allows diurnal predictions of cloud MCC type (Fig. 1).

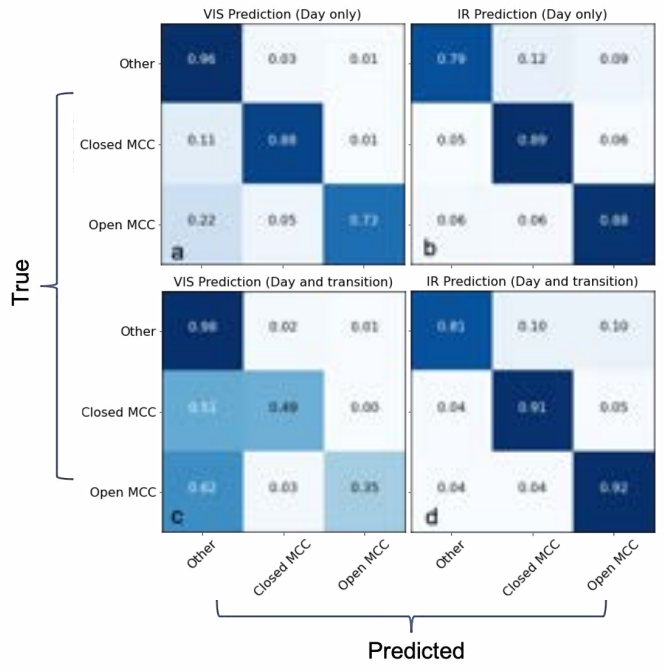


Figure 1: (a) confusion matrix results from visible imagery model predictions during day-time only, (b) confusion matrix results from infrared imagery model predictions during day-time only (c) similar to (a) but for day and transition (early morning and late afternoon) times, and (d) similar to (b)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

- MCC clouds 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).

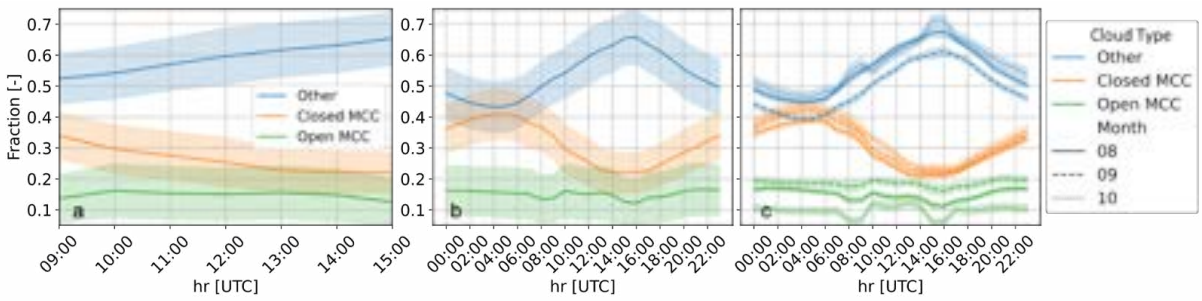


Figure 2: (a) time of day (daytime only) fractional amount (where fraction represents the amount of pixels classified by a certain cloud type relative to the entire pixels over the research domain) for Closed, Open and Other cloud types, (b) same as (a) but for the entire diurnal cycle, where shaded 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).

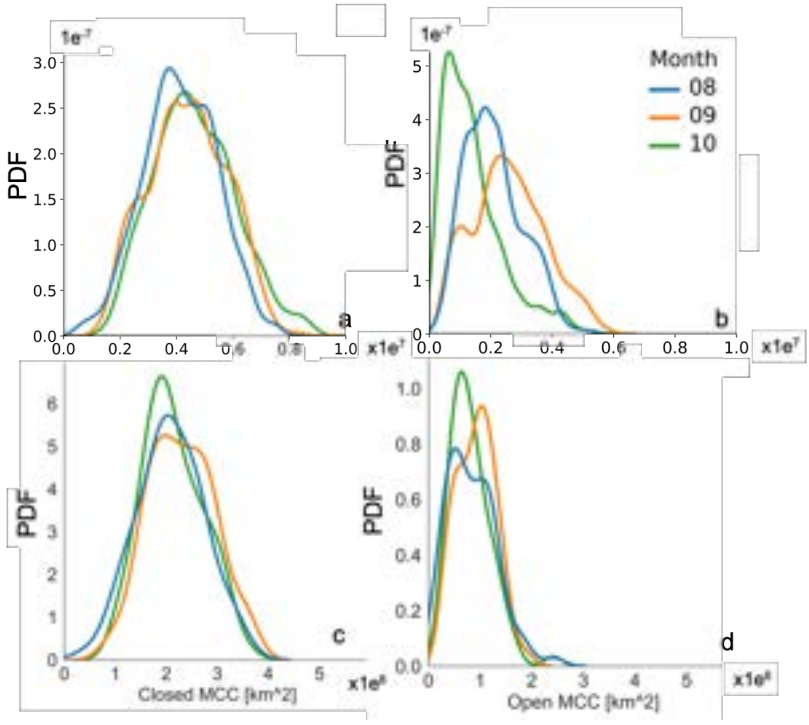


Figure 3: normalized probability density plots for (a) Closed MCC, and (b) Open MCC derived by the current algorithm from SEVIRI (integrating 30-min. predictions), (c) Closed MCC, and (d) Open MCC derived by Yuan et al. (2020) algorithm for MODIS daytime over pass.

- 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).

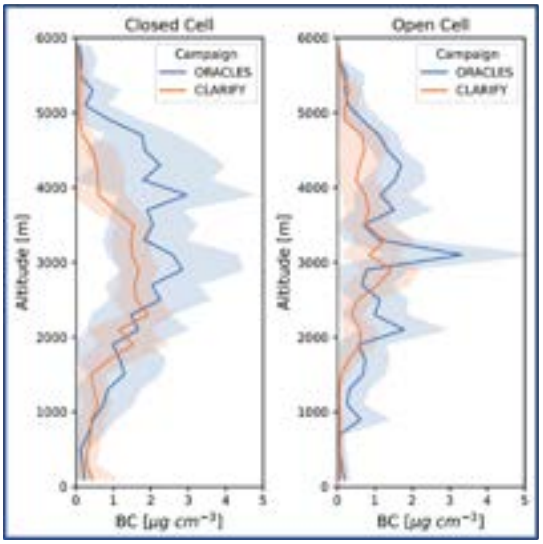


Figure 4:Black Carbon (BC) concentration along the vertical column from ORACLES airborne observations, collocated with cloud MCC type using Segal-Rozenhaimer et al. (in prep.) algorithm.

- Expanded the algorithm and successfully applied it on 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 the biomass-burning (Objective 2, manuscript II in prep).

Presentations

- Feb-27-Mar-2-2023, 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.
- October, 23, 2022, 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.
- January 27, 2022 – AMS Annual Meeting (online), 21st conference on Artificial Intelligent 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.

Publications

Michal Segal-Rozenhaimer, David Nukrai, Haochi Che, Robert Wood, Zhibo Zhang, Cloud Meso-scale Cellular Classification and Diurnal Cycle from the Geostationary SEVIRI satellite using Convolutional Neural-Network (CNN) (in prep. For Remote Sensing).

Michal Segal-Rozenhaimer,, Haochi Che, Robert Wood, Zhibo Zhang, Aerosol and Thermodynamic vertical composition affect cloud meso-scale types over the South-East Atlantic (in prep. For GRL).

Project goals for 2023

- Finalize the writing and submission of the algorithm manuscript (title: “Cloud Meso-scale Cellular Classification and dynamics from the Geostationary SEVIRI satellite using Convolutional Neural-Network (CNN)”), which is in prep for Remote Sensing of the Environment (*RSE)*.
- Overlay cloud and aerosol properties from satellites and MERRA-2 with our diurnal classified clouds to investigate their interactions and correlations, and finalize a short manuscript describing these relationships during the ORACLES campaign time-period (2016-2018).

Atmosphere Observing System (AOS)

Project Participants

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

Project Description

The AOS mission, planned to launch around 2030, is working towards 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-SATT Team, Aerosol, and CCP algorithm working groups, as well as organizer of cross-ESO (Earth System Observatory) to be held at NASA Ames in 2023.
- Samuel LeBlanc is the Ames representative in AOS Sub-orbital science meeting.

Project goals for 2023

- Continue work on suborbital project plan for Key Decision Point.
- Continue to work on Aerosol and CCP (Cloud, Precipitation, Convection) Algorithms teams to design cloud mask product
- Coordinate synergistic science efforts among the ESO mission components, and help to plan and lead a workshop at NASA Ames for cross-ESO deliverables.

Carbon Monitoring Systems (CMS)

Project Participants

BAERI: Taejin Park

Project Description

Mexico is a high-biodiversity country with nearly 40% of its territory forested. During the last decade the scientific capacity of Mexican scientists has rapidly increased, and state-of-the-art measurements on carbon (C) dynamics are available at representative landscapes and at the national level; Mexico is recognized to be one of the few non-Annex I countries capable of implementing REDD+. This proposal builds on previous work supported by NASA CMS to improve monitoring, reporting and verification (MRV) for implementation of Reducing Emissions from Deforestation and Forest Degradation (REDD+) in Mexico.

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

This project supports NASA C cycle research through:

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

Accomplishments

- 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 (Figure 1).

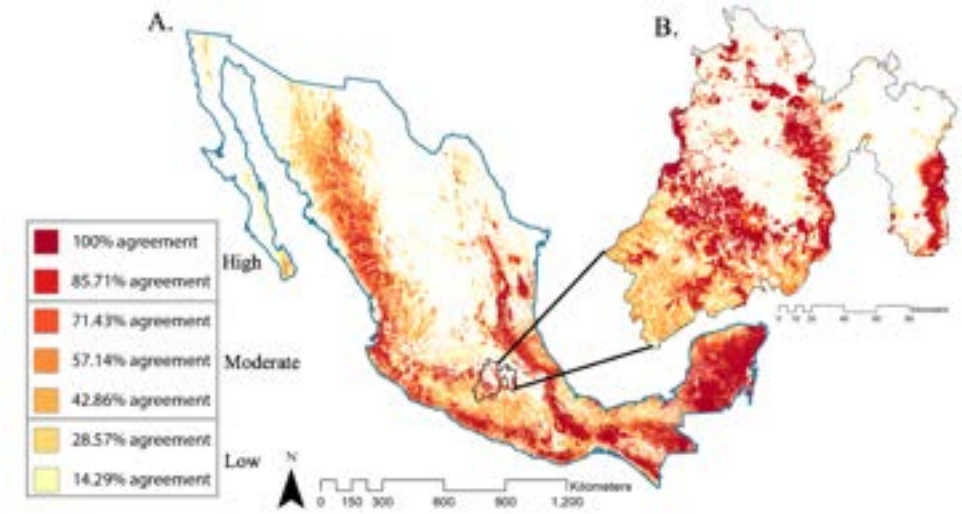
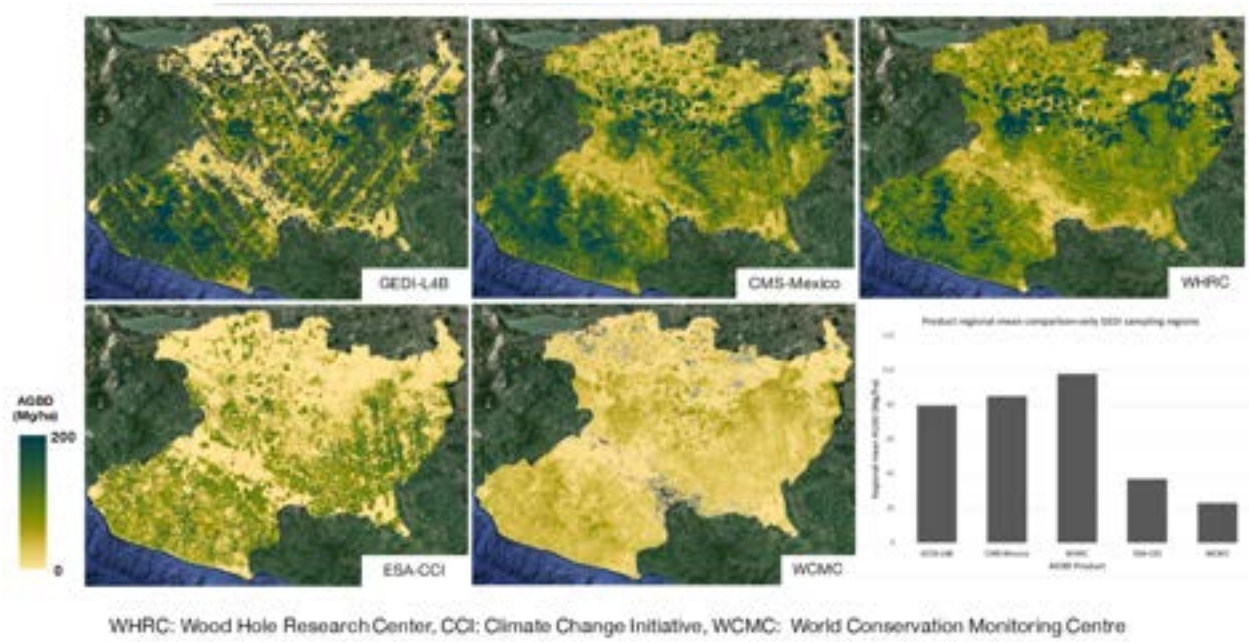


Figure 1: A. Hybrid uncertainty heat map showing the percent agreement across the 7 products. The percentage represents how many products identified each pixel as being forested. B. Closeup of the state of Mexico.

- Built and tested a landsat-based biomass estimation framework using landsat, GEDI, and Continuous Change Detection and Classification algorithm (Figure 2).



WHRC: Wood Hole Research Center, CCI: Climate Change Initiative, WCMC: World Conservation Monitoring Centre

Figure 2: Spatial distribution of AGBDs from CMS-Mexico, GEDI-L4B, Wood Hole Research Center, ESA-Climate Change Initiativ, and World Conservation Monitoring Centre.

- Attended CMS Science Team meeting virtually on September 26–28, 2022. Presented progress on our CMS project and discussed potential collaborations for CMS (Figure 3).

Figure 3: CMS Science Team Meeting in Washington DC on September 26–28, 2022.

- Co-advised a Master's student (Dustin Braden) from the University of Delaware.

Presentations

- Braden, D., Mondal, P., Park, T., Vargas, R., Identifying Variability in Forest Cover Estimates in Mexico by Comparing Multiple Satellite-Derived Data Products. Dec 2022, AGU 2022.
- Ryoo, J.M., Park, T., Characterizing Seasonal Atmospheric Rivers, Climate, and Wildfire Patterns over the Western United States. Dec 2022, AGU 2022.
- Spiegel, M.P., Volkovitskiy, A., Terekhina, A., Forbes, B.C., Park, T., Macias-Fauria, M., Top-down regulation by reindeer herbivory limits climate-driven Arctic vegetation change. Dec 2022, AGU 2022.
- Ko, Y., Park, T., Kim, M., Hong, M., Choi, G., Lee, W.K., Son, J., Identifying Forest Soil information based on Machine learning for South Korea. Dec 2022, AGU 2022.
- Park, T., Vargas, R., Brosna, I., Nemani, R., Mapping national forest aboveground biomass in Mexico by integrating GEDI, Sentinel1 and Sentinel2 data. Dec 2022, AGU 2022.
- Madrazo, M.K., Lee, H., Khodayari, A., Wan, W., Park, T., The impact of climate change on fire danger over the contiguous United States. Dec 2022, AGU 2022.
- Vargas, R., Park, T. NASA Carbon Monitoring System Science Team Meeting and Applications Workshop, September 26–28, 2022.

Publications

Yu, Y., Saatchi, S., Domke, G.M., Walters, B., Woodall, C., Ganguly, S., Li, S., Kalia, S., Park, T., Nemani, R. and Hagen, S.C., 2022. Making the US national forest inventory spatially contiguous and temporally consistent. Environmental Research Letters, 17(6), p.065002.

Dunn, R.J. . et al. including (Park, T.), 2022. Global Climate. Bulletin of the American Meteorological Society, 103(8), pp.S11-S142.

Thoman, R.L. et al. including (Park, T.), 2022. The Arctic. Bulletin of the American Meteorological Society, 103(8), pp.S257-S306.

G.V. Frost, M.J. Macander, U.S. Bhatt, L.T. Berner, J.W. Bjerke, H.E. Epstein, B.C. Forbes, S.J. Goetz, M.J. Lara, T. Park, G.K. Phoenix., 2021, Arctic Report Card 2021: Tundra Greenness.

Braden, D., Mondal, P., Park, T., Vargas, R., Quantifying uncertainty of forest extent estimates in Mexico by comparing satellite-derived land and tree cover products. Environmental Research Letters, under review.

Project goals for 2023

In this project year, we will focus on refining machine learning algorithms by leveraging existing CMS efforts and airborne lidar datasets.

- Refine machine-learning algorithms and generate Landsat Tree Cover time series.
    - Leverage existing CMS efforts and other NASA/USGS airborne lidar campaigns (e.g., G-LiHT, 3DEP) over CONUS to complement more representative training samples to improve NEX-TC for Mexico.
    - Build a lidar processing pipeline at the NASA Earth eXchange (NEX) to generate large-scale high-resolution forest structure metrics from the airborne lidar point cloud data.
- Retrieve forest structure variables from airborne and spaceborne lidar data over Mexico.
    - Acquire and process airborne lidar data collected over Mexico from Instituto Nacional de Estadística y Geografía.
    - Process GEDI footprint datasets (tree cover, plant area index, biomass) over Mexico.
    - Validate the retrieved forest structure variables against ground observations.
- Attend CMS Monthly and Annual Science Team Meetings and publish peer-reviewed publications and presentations.

CyanoSCape

Project Participants

BAERI: Jeremy Kravitz (beginning Feb 2023)
NASA: Liane Guild

Project Description

The overarching goal of CyanoSCape is to characterize phytoplankton and the floating aquatic vegetation (FAV) community composition in example freshwater systems of the Greater Cape Floristic Region of South Africa. CyanoSCape will utilize satellite multispectral and airborne hyperspectral data, with recently developed and next-generation algorithms, to determine the biodiversity of freshwater systems phytoplankton assemblage with emphasis on genus level distinction, including potentially toxic cyanobacteria, and monitor the prevalence and diversity of FAV that favor these environments. This work has implications for understanding how natural phytoplankton assemblages, including harmful cyanobacteria and invasive FAV, are changing in a warming climate.

Project goals for 2023

- Design and coordinate the field plan concept and methodology for the airborne campaign.
- Build upon existing satellite time series of data over aquatic sites and review seasonality of phytoplankton and floating aquatic vegetation.
- Actively participate in South African (Cape Town area) airborne campaign field sampling (~Sept/Oct 2023), instrument deployment, and subsequent data analysis.
- Develop and maintain relevant bio-optical synthetic datasets.
- Provide development, training, and validation of machine learning retrieval models.
- Lead the uncertainty quantification analyses.
- Aid in manuscripts and presentations.

GEDI

Project Participants

BAERI: Taejin Park

Project Description

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

The objectives of this work are to:

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

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

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

Accomplishments

- Built and tested a remote-sensing based aboveground biomass estimation framework using landsat (Sentinel-½), GEDI, and Continuous Change Detection and Classification (CCDC) algorithm (Figure 1).

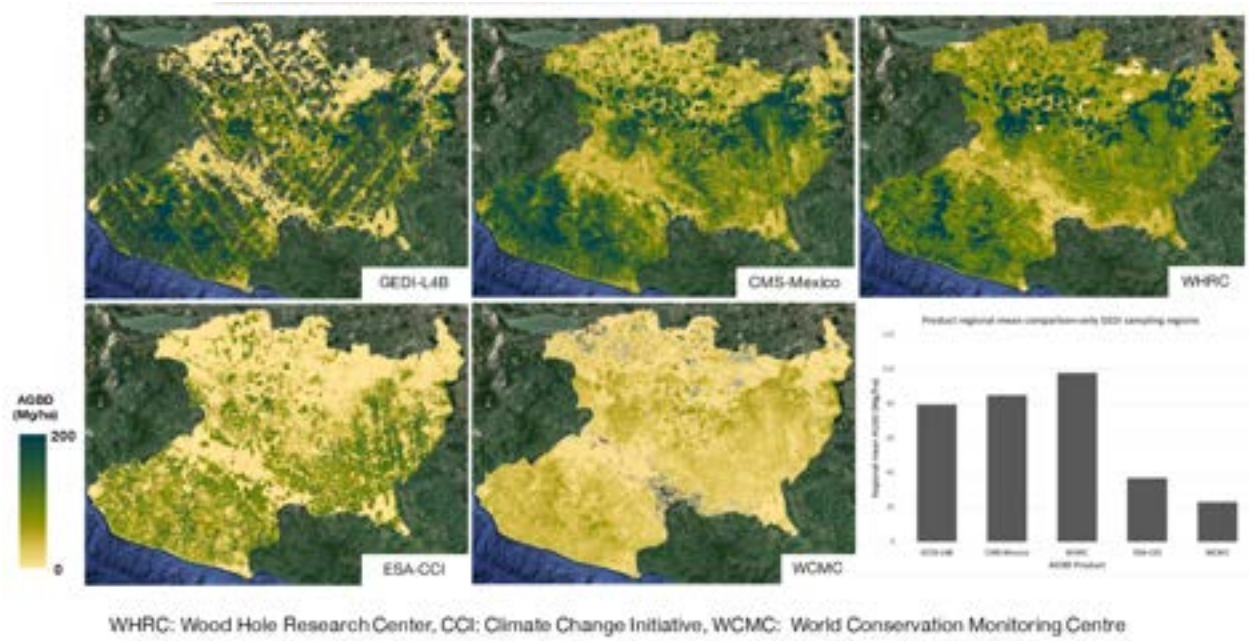


Figure 1: Spatial distribution of AGBDs from CMS-Mexico, GEDI-L4B, Wood Hole Research Center, ESA-Climate Change Initiative, and World Conservation Monitoring Centre.

- Used an integrative approach to investigate changes in forest carbon stocks in South and North Korea during the last two decades. Landsat-based tree cover change, GEDI canopy height, and national forest inventory data were used to generate decadal forest carbon stock maps shown below (Figure 2).

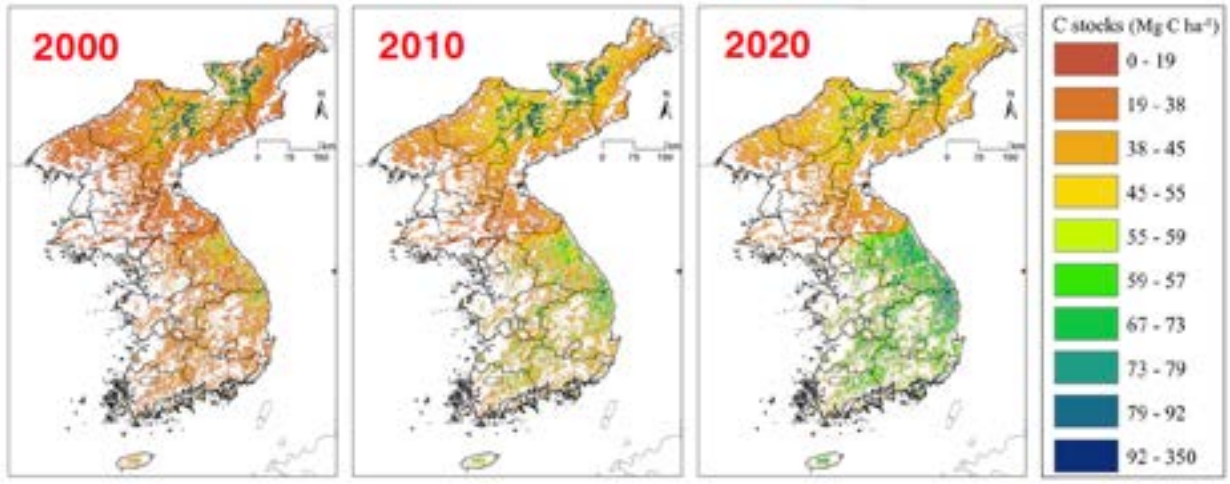


Figure 2: Carbon stock changes in 2000, 2010, and 2020. Data is from Landsat, GEDI, and national forest inventory.

- Tested a machine learning approach to estimate site index and stand age from climate, topography, and GEDI-based canopy height data (Figure 3).

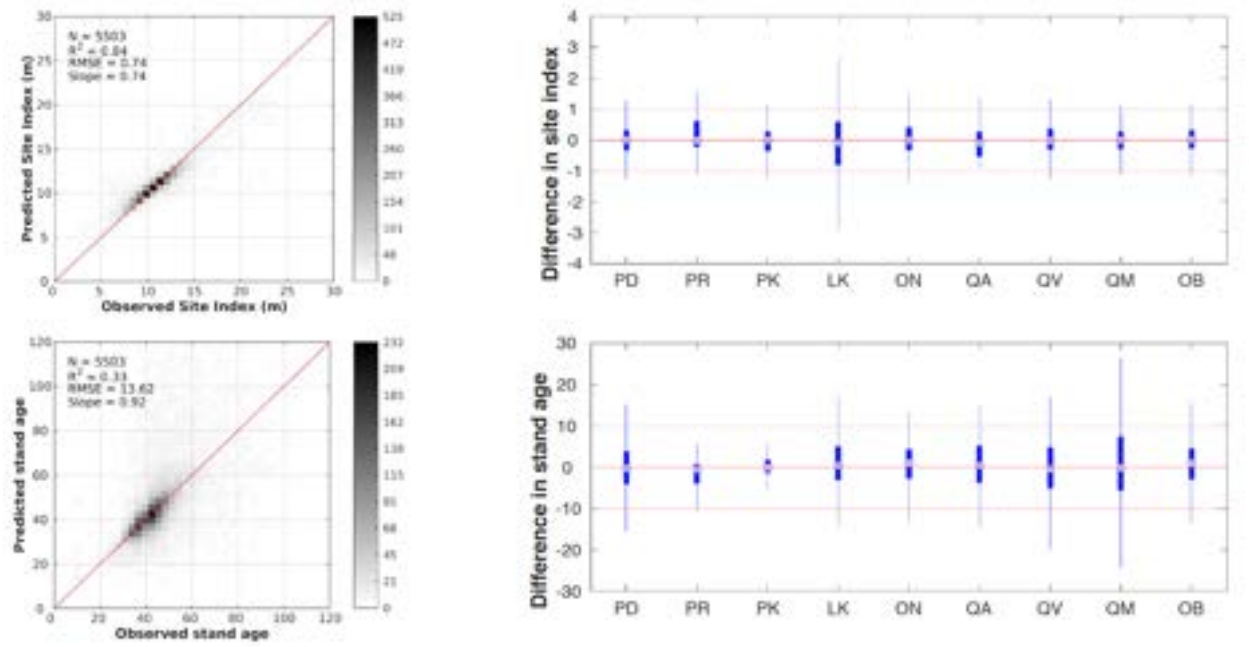


Figure 3: Comparison between observed and predicted site index (upper panels) and stand age (lower panels).

- Attended 2nd year GEDI Science Team meeting held in Washington DC on November 15-17, 2022. Presented progress on our GEDI project and discussed potential collaborations for GEDI and CMS (Figure 4).

Figure 4: GEDI Science Team Meeting in Washington DC on November 15-17, 2022.

Presentations

- Park, T., Vargas, R., Brosna, I., Nemani, R., Mapping national forest aboveground biomass in Mexico by integrating GEDI, Sentinel-1 and Sentinel-2 data. Dec 2022, AGU 2022.
- Park, T., Vargas, R., Kim, M., Nemani, R., Myneni, R. Monitoring and forecasting large-scale patterns of forest structure and carbon dynamics using field, remote sensing, and process-based models. Global Ecosystem Dynamics Investigation (GEDI) Science Team Meeting. November 15-17, 2022.

Publications

Yu, Y., Saatchi, S., Domke, G.M., Walters, B., Woodall, C., Ganguly, S., Li, S., Kalia, S., Park, T., Nemani, R. and Hagen, S.C., 2022. Making the US national forest inventory spatially contiguous and temporally consistent. Environmental Research Letters, 17(6), p.065002.

Park, T., Sim, S. Biophysical controls on burn severity measured by multi-temporal Landsat and NEON LiDAR data: 2016 Chimney Tops 2 fire. Frontiers in Remote Sensing. Under review.

Project goals for 2023

- Improve current ASRL model:
  - Update the ASRL model with varying metabolic scaling and tree geometry parameters.
  - Change input climatic variables from annual to monthly data for realistic whole-plant energy balance estimation.
  - Incorporate Landsat and other ancillary disturbance history data (i.e. forest stand ages) into the model framework.
- Continue to build a lidar processing pipeline at the NASA Earth eXchange (NEX) to generate large-scale high-resolution forest structure metrics from the airborne lidar point cloud data (e.g., USGS 3DEP).
- Continue to expand the ASRL model for total aboveground biomass estimation.
  - Develop a total biomass estimation module by taking into account two key relations: (a) the allometry between the h and biomass of individual trees and (b) the size-frequency distribution of trees.
- Continue research collaboration with colleagues in South Korea to develop empirical forest growth models with GEDI forest height and Landsat land surface history data.
  - Develop an integrative approach combining national forest inventory, remote sensing, and empirical forest growth models.
  - Estimate annual forest carbon stock and sequestration rate over Korea, and validate the estimation using independent inventory and existing global biomass products.
- Attend GEDI Monthly and Annual Science Team Meetings and publish peer-reviewed publications and presentations.

NASA Earth Exchange (NEX) / Ecological Forecasting

Project Participants

BAERI: Kate Duffy, Arthur Mizzi, Taejin Park, Thomas Vandal, Wen Yip
CSUMB: Will Carrara, Alberto Guzman, Hirofumi Hashimoto, Forrest Melton
InuTeq: Jeff Becker
NASA ARC: Ian Brosnan, Piyush Mehrotra, Andrew Michaelis, Weile Wang

Collaborators

CIRES: Chia-Hua Hsu, Congmeng Lyu, Siyuan Wang
NASA ARC: Matthew Johnson
NASA GMAO: Zhining Tao
NASA SpoRT: Aaron Naeger
NCAR: Rajesh Kumar
NOAA CSL: Brian McDonald
University of Colorado (CU) Boulder: Daven Henze

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, utilizing 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, as well as with the broader NASA science community, to apply NEX capabilities to analyze long-term and emerging trends in ecosystem conditions, conduct simulations of climate and land-use change impacts on terrestrial and aquatic ecosystems, map patterns in biodiversity, monitor biomass at local to continental scales, project future climate conditions, and retrieve emissions for air quality forecasting. The NEX team supports applied science activities, such as the development of information products to support land managers, agricultural producers, and water managers throughout the U.S. for the monitoring and modeling of natural disasters such as wildfires, and emerging public health threats. Additionally, NEX supports the production of global long-term data records for NASA's MEaSUREs program, NASA's Carbon Monitoring System (CMS) program, Global Ecosystem Dynamics Investigation (GEDI) program, national climate assessment (NCA), geostationary research, Advanced Information Systems Technology (AIST) program, and Applied Sciences program, as well as large-scale visualizations for data from NASA's Earth Observing System Data and Information System (EOSDIS).

National Climate Assessment

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

This dataset was made available at the NASA Center for Climate Simulation (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 (Fig. 1)

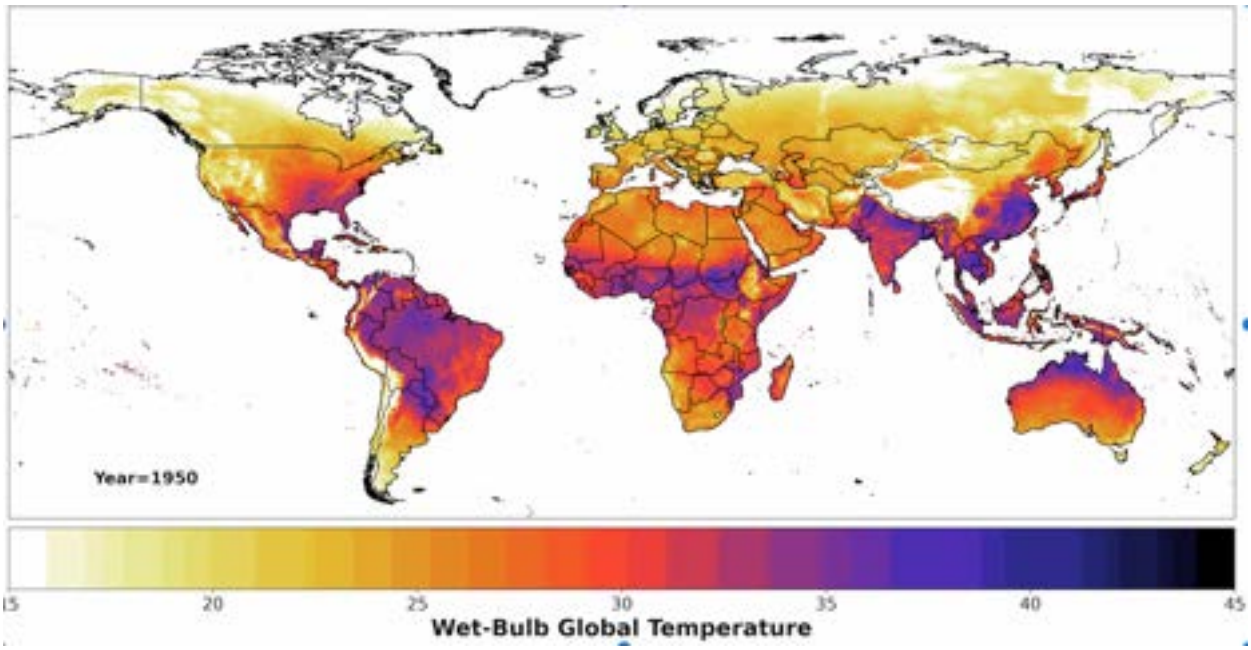


Figure 1: Global map of wet-bulb global temperature from NEX-GDDP-CMIP6 data.

GeoNEX

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

The team developed a new atmospheric correction algorithm, GeoNEX-AC, that exploits the high frequency of the GeoNEX time series to accurately detect cloud-free observations, quantify atmospheric aerosol optical depth, and retrieve surface reflectance and bi-directional reflectance distribution function (BRDF) (Fig. 2).

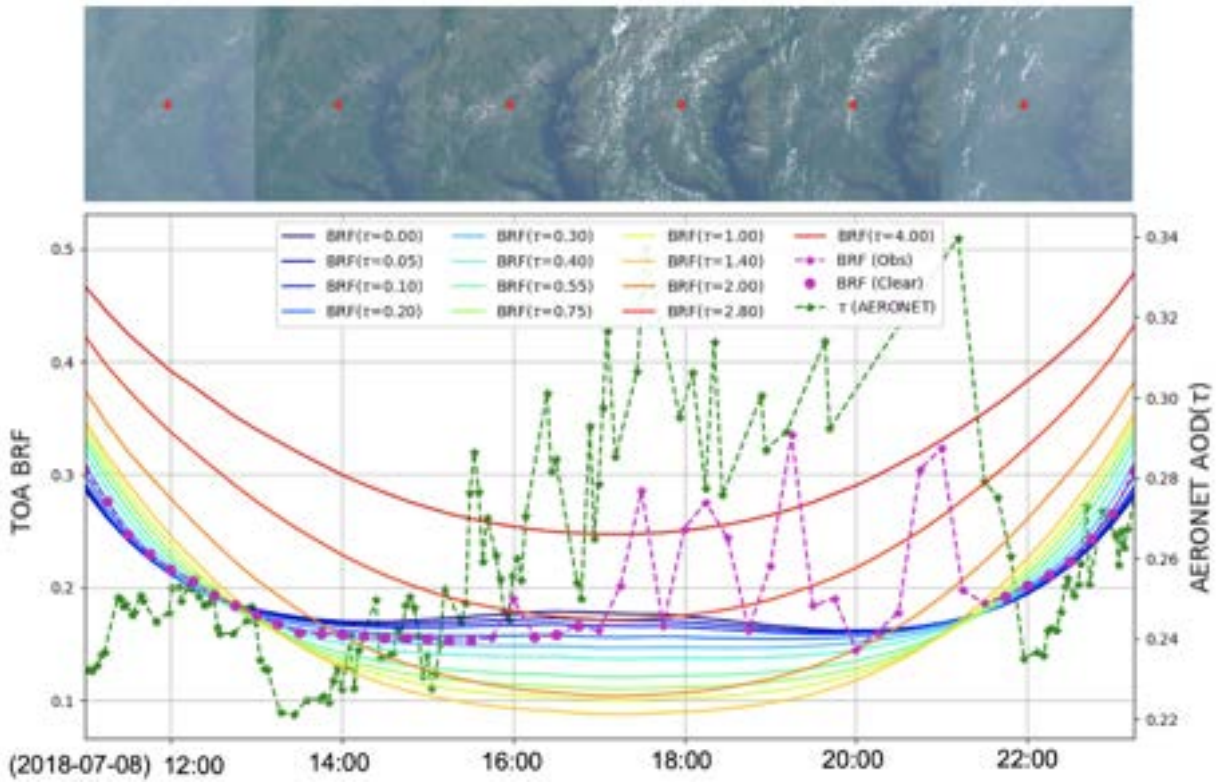


Figure 2: An illustrative example of the GeoNEX-AC algorithm that exploits the high frequency time series of GeoNEX data in simultaneously retrieving AOD and surface reflectance.

The team developed prototype GeoNEX Level 2 products, including atmospheric aerosol optical depth and surface reflectance/BRDF for Himawari 8/9 AHI and GOES16/17 ABI data sets (Fig. 3). The products are distributed on the GeoNEX data portal (data.nas.nasa.gov/geonex) for public access by the science community. We are also collaborating with the community to systematically evaluate the scientific quality of the data sets, and develop applications in air quality and public health studies.

Figure 3: Example of GeoNEX L1G (TOA) and L2G (Surface) BRDF-enhanced reflectance with data from GOES-16/ABI collected over CONUS on 2018/06/18, 19:00UTC.

The team initiated research on the fusion of GEO-LEO satellite datasets across multiple spatial and temporal resolutions, which is expected to synergistically leverage advantages of different platforms to improve global land surface monitoring (Fig. 4).

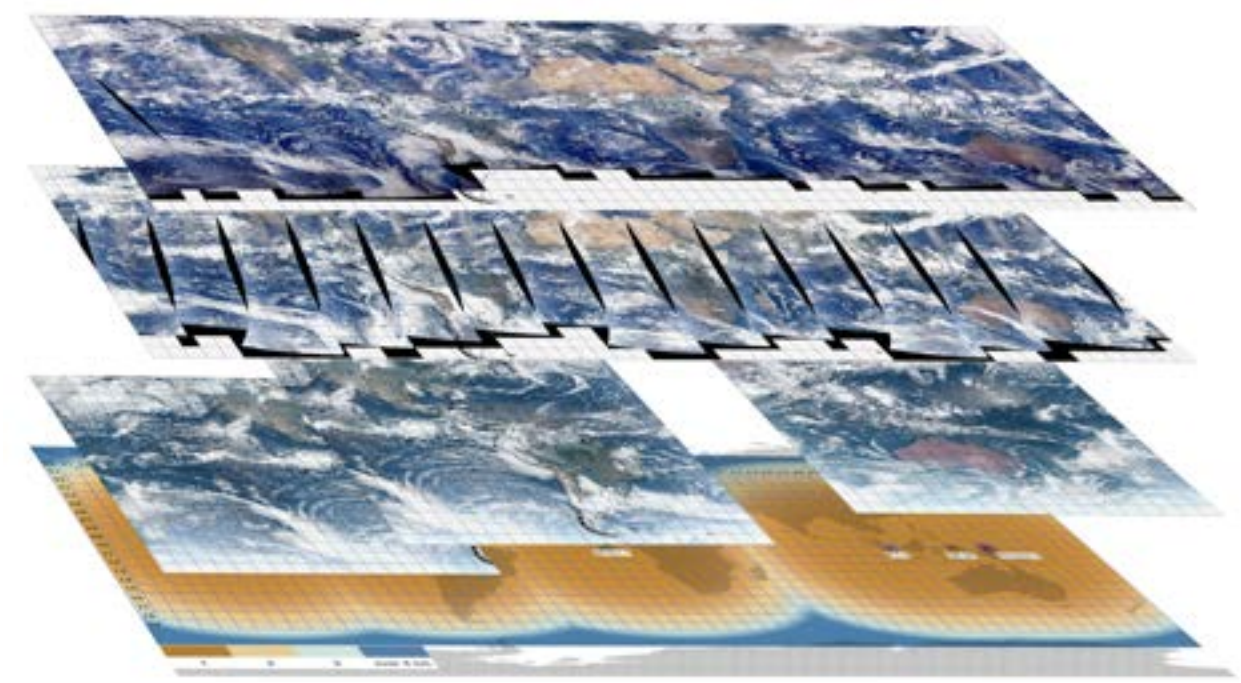


Figure 4: Data fusion of GEO-LEO satellite data across various spatio-temporal resolutions based on the GeoNEX common grid.

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

The team prototyped a land surface phenology (LSP) product, in collaboration with South Dakota State University. The LSP was 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. The result indicates that BI can provide ~3 times more high-quality observations than HLS (Fig. 5).

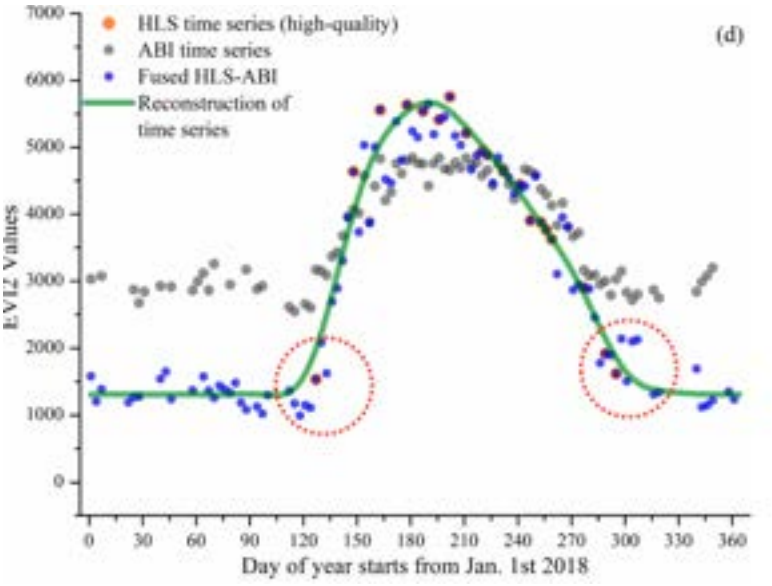


Figure 5.

The team prototyped an emulated Land Surface Temperature (LST) using convolutional neural networks. This novel approach was used to predict land surface temperature with improved spatial and temporal resolution compared to the 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 (Fig. 6).

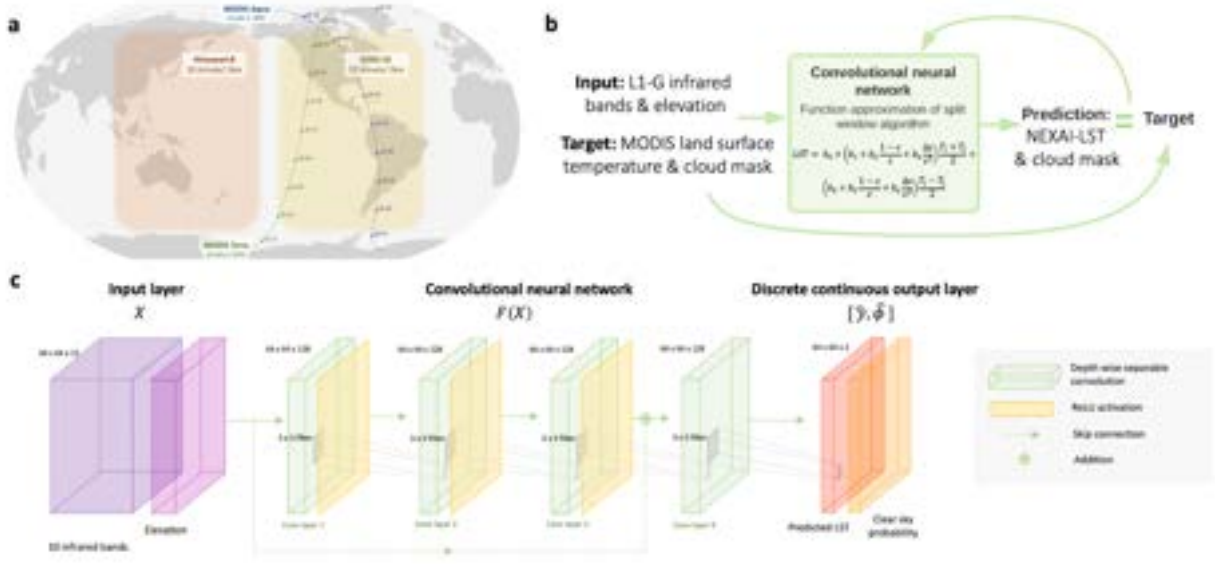


Figure 6: Datasets, problem setup, and deep learning architecture for LEO-GEO algorithm emulation

Global WELD

In collaboration with the University of Michigan and South Dakota State University, the team created and distributed a Global WELD Landsat product.

Carbon Monitoring System (CMS)

As part of the 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). An area of 288,749 km ^{2} is identified as very likely forested, based on the uncertainty evaluation practice (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). 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.

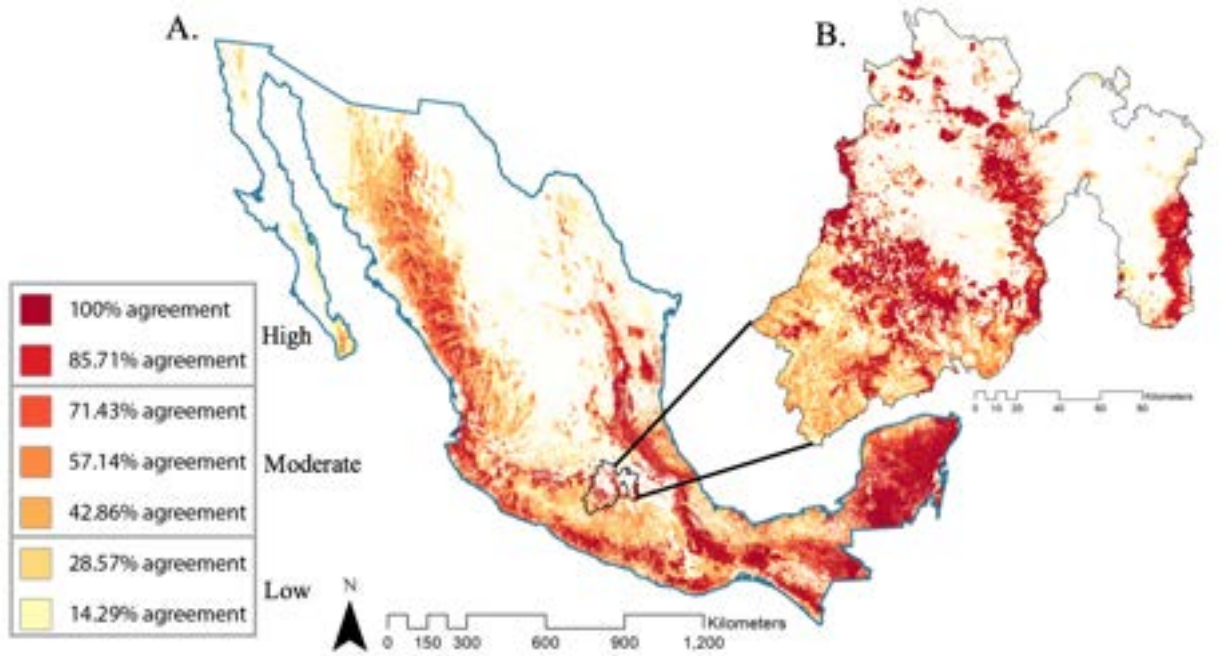


Figure 7: A. Hybrid uncertainty heat map showing the percent agreement across the 7 products. The percentage represents how many products identified each pixel as being forested. B. Closeup of the state of Mexico.

The NEX team also has built and tested a remote-sensing based aboveground biomass estimation framework using Landsat and Sentinel-1 and -2, 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 plans to create a long-term aboveground biomass product (1984-present) at 30 m spatial resolution and support local stakeholders in implementing REDD+ across Mexico (Fig. 8).

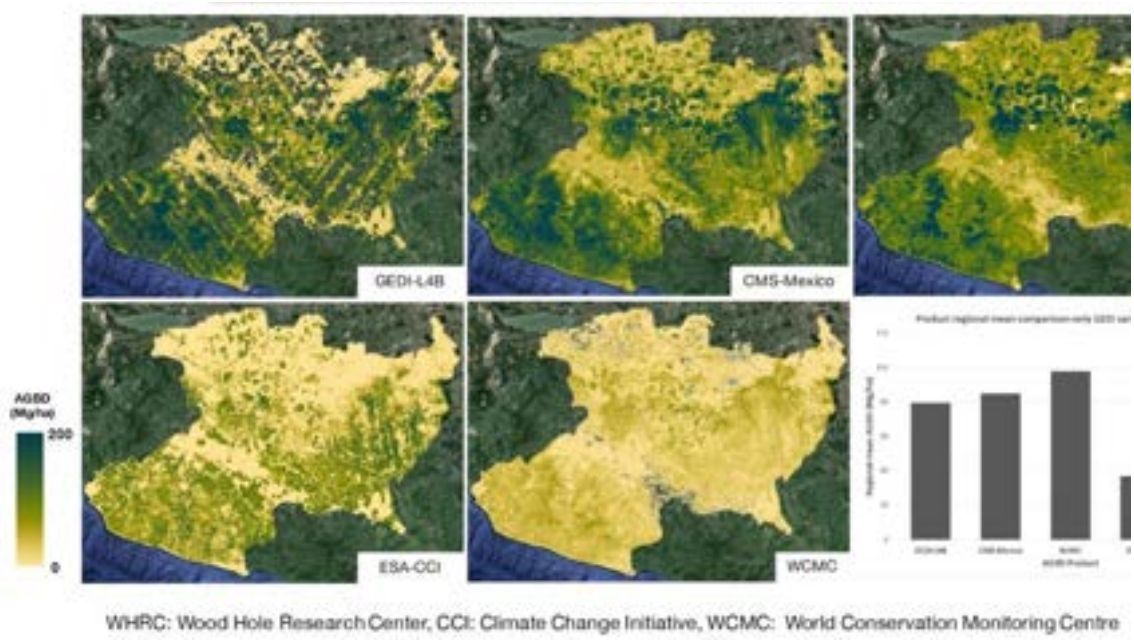


Figure 8: Spatial distribution of aboveground biomass density (Mg/ha) from CMS-Mexico, GEDI-L4B, WHRC, ESA-CCI, and WCMC (WHRC: Wood Hole Research Center, CCI: Climate Change Initiative, WCMC: World Conservation Monitoring Centre).

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 of mission formulation, and the NEX team is contributing tools for algorithm development and science data system engineering. The NEX team has 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 (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. 9). Additionally, the NEX team has completed the first systematic reprocessing of the Hyperion EO-1 data to L1, and is actively working on L2 processing that will make Hyperion data interoperable with SBG and contemporary hyperspectral imaging satellites in the international program of record.

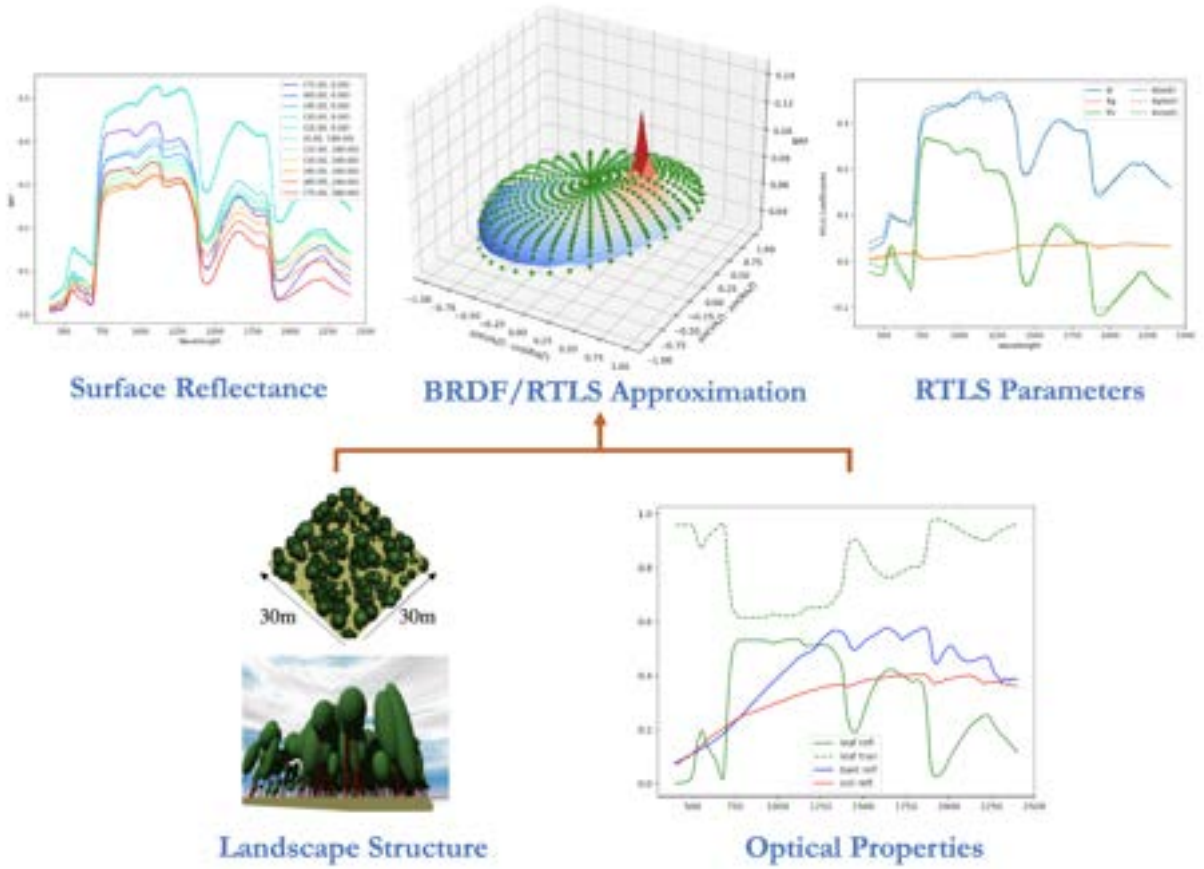


Figure 9: The AGHSD algorithm illustrates that hyperspectral surface BRDF (RTLS) parameters can be accurately approximated by the weighted sum of the spectra of soil surface reflectance, leaf single albedo, and the canopy scattering coefficient.

In support of the work, we obtained and deployed software packages including MODTRAN, LibRadtran, Atrem, ISOFIT, and Hypertrace on NEX for implementing and testing the processing pipeline of the SBG-SISTER project.

NEX-Fire/AQ, WRF-Chem/DART

NASA ARC scientists and their collaborators are using WRF-Chem/DART— a regional, ensemble, atmospheric composition (AC) forecast/assimilation/emissions estimation system developed by Dr. Mizzi, and advanced under funding from NASA and NOAA. WRF-Chem/DART is a state-of-the-science system based on integrating the Weather Research and Forecast (WRF) model with online chemistry (WRF-Chem) into the ensemble Kalman filter based Data Assimilation Research Testbed (DART). NASA ARC scientists and their collaborators have advanced WRF-Chem/DART to include the assimilation of OMI O_3, NO_2, and SO_2, TROPOMI CO, O_3, NO_2, and SO_2, and TEMPO proxy O_3 and NO_2 total/partial column and profile retrievals. They have applied WRF-Chem/DART to the following projects:

- Joint assimilation of multiple satellite retrievals with dynamic emissions estimation at medium (12 km grid spacing in the Front Range Air Pollution and Photochemistry Experiment (FRAPPE) application) and high (4 km grid spacing in the Colorado application) resolutions. The FRAPPE application demonstrates that the joint assimilation *in situ* and satellite observations improves forecast skill in the lower to mid-troposphere (lower tropospheric improvements due to *in situ* observations and mid-tropospheric improvements due to satellite observations), and that dynamic emissions estimation provides additional forecast skill improvements in the lower troposphere. The Colorado application demonstrates that we can obtain similar

adjustments (presently we have no validation data for the Colorado application, so we do not know whether these adjustments are improvements) at high spatial resolutions and that we are ready for assimilation of TEMPO O_3 and NO_2 observations as soon as they become available. In support of these applications, we advanced WRF-Chem/DART to include a simple bias correction algorithm and upper boundary conditions (BCs) for O_3 to enable the assimilation of O3 retrievals.

- Based on the success of the joint assimilation experiments, we entered a collaboration with NOAA CSL, CU Boulder, and CIRES to apply WRF-Chem/DART to a COVID period 'observing system simulation experiment' (OSSE) to test whether dynamic emissions estimation can recover the 'true' COVID emissions from the 'business as usual' (BAU) emissions. For this application we integrated NOAA CSL's WRF-Chem model into WRF-Chem/DART and used the COVID emissions to generate the 'nature run' (NR). Then we used the NR and known TEMPO and TROPOMI NO_2 observation errors to generate proxy TEMPO and TROPOMI tropospheric column NO_2 retrievals. These proxy retrievals were assimilated in two multi-model experimental runs: (i) the TEMPO EX run where the model initial and BCs (ICs/BCs) were the same as in the NR, and we assimilated TEMPO proxy NO_2 retrievals, and (ii) the TROPOMI EX run, which was the same as TEMPO EX except we assimilated TROPOMI proxy retrievals (instead of TEMPO retrievals). The results show that the independent assimilation of TEMPO and TROPOMI retrievals recover the 'true' emissions, but that TEMPO EX recovers the 'true' emissions in half the time it takes TROPOMI EX. The results also show that after convergence, the emissions correction factors remain constant with time and do not change during the weekend.
- Based on the success of the COVID OSSE, we are expanding our collaboration with NOAA CSL and CIRES to include a set of wildfire (WF) OSSEs. The WF OSSEs are the subject of two of our pending proposals (Dr. Mizzi's NASA-ESROGSS proposal, and Dr. Wang's NOAA-OAR-CPO proposal—see below).
- Finally, as part of a collaboration between NASA ARC, NASA JPL, and GMAO, we are coupling WRF-Chem/DART with the NASA JPL and GMAO global modeling systems. We will use the coupled system to study the: (i) sensitivity of the regional model solutions and emissions estimates to characteristics of the global model, e.g., the spatiotemporal resolution of the initial, lateral, and upper boundary conditions, global chemical data assimilation, and global emissions estimation; (ii) impact of geostationary satellite atmospheric composition observations on regional analyses and/or forecasts; and (iii) wildfire emissions estimation and smoke transport forecasting.

Presentations

- Kate Duffy presented a guest lecture on machine learning applications in remote sensing to a graduate level Time Series and Geospatial Data Sciences class at Northeastern University (2022, March).
- Duffy, K., and Vandal, T. J. (2022, January). LEO sensor to GEO sensor algorithm transfer models for land surface temperature. American Meteorological Society Annual Meeting.
- Duffy, K., Vandal, T. J., and Nemani, R. R. (2021, December). Communicating metrics of land surface temperature variability using multi-sensor machine learning. American Geophysical Union Fall Meeting.
- Vandal. T, Duffy, K, McCarty, W., Sewnath, A., Das, P., Michaelis, A., and Nemani, R. (2022) Deep Learning System for Efficient Processing of Geostationary Satellite Imagery. 21th Conference on Artificial Intelligence for Environmental Science, AMS Winter Meeting, Houston, TX.
- Weile Wang presented at the NASA booth in programmatic FireSense discussions. (The 2022 International Fire & Climate conference, held in Pasadena CA the week May 23-27, 2022).
- Weile Wang (SGE) organized a session "Earth Monitoring from Operational Geostationary Satellites" at Asian Oceania Geosciences Society 19th Annual Meeting (2022, August).
- Alberto Guzman presented a talk on OpenET at World Water Week in Stockholm, Sweden in a session on "Achieving food and nutrition targets by 2030 through water security" (2022, August).
- Will Carrara presented "OpenET: *Mapping of Evapotranspiration over the Western U.S.*" at NASA Ames for UC Berkeley Visit (2022, September).
- Thomas Vandal presented at 28th SIGKDD Conference on Knowledge Discovery and Data Mining with the topic "Dense feature tracking of atmospheric winds with deep optical flow" (2022, August).
- Taejin Park presented "Role of Atmospheric Rivers Affecting Vegetation and Fire Patterns over the Western U.S. during Wet and Dry years" together with Ju-Mee Ryoo at the 4th International Atmospheric

Rivers Conference (2022, October).

- Braden, D., Mondal, P., Park, T., Vargas, R., Identifying Variability in Forest Cover Estimates in Mexico by Comparing Multiple Satellite-Derived Data Products. Dec 2022, AGU 2022.
- Ryoo, J.M., Park, T., Characterizing Seasonal Atmospheric Rivers, Climate, and Wildfire Patterns over the Western United States. Dec 2022, AGU 2022.
- Spiegel, M.P., Volkovitskiy, A., Terekhina, A., Forbes, B.C., Park, T., Macias-Fauria, M., Top-down regulation by reindeer herbivory limits climate-driven Arctic vegetation change. Dec 2022, AGU 2022.
- Ko, Y., Park, T., Kim, M., Hong, M., Choi, G., Lee, W.K., Son, J., Identifying Forest Soil information based on Machine learning for South Korea. Dec 2022, AGU 2022.
- Park, T., Vargas, R., Brosna, I., Nemani, R., Mapping national forest aboveground biomass in Mexico by integrating GEDI, Sentinel1 and Sentinel2 data. Dec 2022, AGU 2022.
- Madrazo, M.K., Lee, H., Khodayari, A., Wan, W., Park, T., The impact of climate change on fire danger over the contiguous United States. Dec 2022, AGU 2022.
- Park, T., Wang, W., Dungan, J.L., Genovese, V., Shinozuka, Y., Poulter, B., Brosnan, I., Development of the Ames Global Hyperspectral Synthetic Dataset. Dec 2022, AGU 2022.
- Park, T., Vargas, R., Kim, M., Nemani, R., Myneni, R. Monitoring and forecasting large-scale patterns of forest structure and carbon dynamics using field, remote sensing, and process-based models. Global Ecosystem Dynamics Investigation (GEDI) Science Team Meeting. November 15-17, 2022.
- Vargas, R., Park, T. NASA Carbon Monitoring System Science Team Meeting and Applications Workshop, September 26–28, 2022.
- Mizzi, A., Hsu, C.-H., Lyu, C., Johnson, M., McDonald, B., Naeger A., Henze, D., Kumar, R., and Anderson, J. (2022): Improving regional air quality forecasting through chemical data assimilation with dynamic emissions estimation, NASA Ames Research Center, Earth Science Division Seminar, Moffett Field, CA, March 3, 2022.
- Hsu, C.-H., Henze, D., Mizzi, A., and McDonald, B. (2022): How well can assimilation of geostationary trace-gas observations constrain NOx emissions in the US, International Symposium on Data Assimilation, Colorado State University, Fort Collins, CO, June 10, 2022.
- Mizzi, A., Johnson, M., McDonald, B., Naeger A., Hsu, C.-H., Henze, D., Kumar, R., and Anderson, J. (2022): Joint assimilation of multiple satellite retrievals and dynamic emissions estimation with WRF-Chem/DART, International Symposium on Data Assimilation, Colorado State University, Fort Collins, CO, June 10, 2022.
- Mizzi, A., Hsu C.-H., Lyu, C., Johnson, M., Naeger, A., McDonald, B., and Henze, D. (2022): The potential for satellite-based anthropogenic/wildfire emissions estimation with WRF-Chem/DART, NASA Ames Research Center, NASA/USGS Symposium, Moffett Field, CA, September 29, 2022.
- Hsu, C.-H., Mizzi, A., Henze, D., and McDonald, B. (2022): How well can assimilation of geostationary trace-gas observations constrain NOx emissions in the US, NASA Ames Research Center, Earth Science Division Seminar, Moffett Field, CA, September 30, 2022.
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Project goals for 2023

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

GeoNEX and Remote Sensing

- Continue to support NASA's "Earth Science Research from Operational Geostationary Satellite Systems" and MEaSUREs ROSES solicitations.
- Facilitate community-developed GeoNEX prototype products.
- Continue to support the geostationary remote sensing research community with GeoNEX L1b (TOA) products and software tools.
- Continue to tune the MAIAC atmospheric correction algorithm for Himawari AHI, GOES16/17 ABI, and the Geo-Compsat-2A AMI sensors.
- Acquire and manage Earth observation data (such as Landsat Collection 2 and Sentinel 1 A/B) in the NEX data pool and other platforms in support of current and future NEX projects.
- Refine the framework for Geo-LEO (MODIS/VIIRS, etc.) inter-comparison and synergy.
- Continue to support NASA's development and application of joint global/regional atmospheric composition modeling/data assimilation/emissions estimation—e.g., global/regional model resolution, boundary conditions, and emissions dependencies.
- Continue to support NASA ARC's development and application of regional atmospheric composition modeling/data assimilation/emissions estimation—e.g., air quality forecasting, tropospheric atmospheric composition and emissions reanalysis, and wildfire emissions estimation/smoke transport forecasting.

NCA

- Support National Climate Assessment and climate resilience activities.
- Continue to develop and refine downscaled climate projections, including NEX-GDDP and community development LOCA datasets.
- Develop scientific applications of NEX datasets to evaluate the impact of climate-change extremes on human health and the environment.

NEXFire

- Support the NASA FireSense Project Office.
- Advance wildfire research, and facilitate innovation across the wildfire community for pre-fire, active, and post-fire challenges.
- Understand and characterize fire potential for current and future climate scenarios.

Flight-missions

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

Technology Innovations

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

OCEANOS

Project Participants

BAERI: Britnay Beaudry
NASA: Juan Torres-Pérez

Project Description

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

Project goals for 2023

- Recruit and train low-income Hispanic/Latino (Puerto Rican) High School and undergraduate students on ocean color data acquisition and analysis of remotely sensed freely available imagery.
- Plan and coordinate OCEANOS Summer Internship activities.
- Participate in monthly or bi-monthly meetings with OCEANOS Co-I's.
- Develop an educational training module on basic image analysis with Google Earth Engine (GEE).
- Travel to Puerto Rico in the Summer 2023 to conduct an in-person training on the use of GEE with internship participants.

OCEMOD

Project Participants

BAERI: Casey Smith Schine
NASA: Dan Whitt

Project Description

This project examines the impact of climate variability on marine ecosystem dynamics in the North Atlantic using a combination of remote sensing and modeling. The goal of the project is to understand the mechanisms behind trends in surface chlorophyll in the North Atlantic. We are looking at the role of nutrient delivery, as well as at changes in horizontal and vertical circulation. We are looking specifically at trends in chlorophyll represented in both the satellite remote sensing record and the ECCO-Darwin model. We are then using both model and observational datasets to investigate the mechanisms behind observed trends in chlorophyll.

Accomplishments

- Examined the ability of the ECCO-Darwin model to recreate trends and interannual variability in chlorophyll similar to what is seen in the satellite remote sensing record in the North Atlantic. The model performs very well in certain regions—the subtropics in particular—and recreates the seasonal cycle, interannual variability, and long-term trends similar to those observed in the satellite chlorophyll record. The model does not perform as well in other regions—the subpolar region is unfortunately one of these. We spent a lot of time on model validation, and looked in depth at how grouping regions by biome or latitude impacts the data distribution observed in the satellite chlorophyll record and the ECCO-Darwin model chlorophyll output.
- Identified some interesting stories to explore using the ECCO-Darwin model to dig deeper into the impacts of light and nutrient delivery and the mechanisms that impact light and nutrient availability.

Project goals for 2023

- Assess the potential use of the ECCO-Darwin model in the subpolar region, given the issues observed in recreating the seasonal cycle, interannual variability, and long-term trends in chlorophyll.
- Look at the mechanisms controlling the long-term chlorophyll decline in the Atlantic oligotrophic gyre. This trend is represented in both satellite chlorophyll and model chlorophyll data. We will be examining changes in nutrient distribution and mixed layer depth (in both observational and model data) as potential mechanisms for the observed decline in chlorophyll. We will also be examining what influences the interannual variability in chlorophyll in this region.
- Use the ECCO-Darwin model to look at changes in AMOC and the relationship with surface production within the model.

OCO-2 Profile

Project Participants

BAERI: Susan Kulawik
NASA/GSFC: Sourish Basu

Project Description

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

Accomplishments

- Assimilated 1.5 years of lowermost tropospheric (LMT) OCO-2 product (Sourish).
- Validated the OCO-2 LMT product versus NOAA Global Monitoring Laboratory aircraft observations (Susan).

Project goals for 2023

- Publish a paper on the lowermost tropospheric (LMT) OCO-2 product assimilation and validation.
- Publish OCO-2 v10 LMT product to the DAAC.
- Apply methodology to look at the LMT of OCO-3.

Peroxyacetyl nitrate (PAN) from AIRS

Project Participants

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

Project Description

While total anthropogenic NOx emissions have remained approximately constant over the last 15 years, this time period has been marked by dramatic changes in the distribution of these emissions. While there have been large decreases in the emissions of NOx in North America, Chinese emissions have risen and subsequently dropped, and rapid urbanization is creating new emission hot spots in parts of the world where anthropogenic NOx emissions have typically been small. Peroxyacetyl nitrate (PAN) plays a fundamental role in the distribution of tropospheric ozone via its role as a reservoir for NOx. This project aims to improve our ability to predict how global oxidation capacity responds to changes in NOx emissions via the new PAN record from the Aura satellite (2004-2013), the CrIS instrument (2012-present), and the GEOS-Chem global model.

Accomplishments

- Updated the code and algorithms from IDL to run in python to align with the TROPESS processing system (Susan, Josh).
- Updated and tested the algorithms to utilize the new CAMEL thermal infrared emissivity database (Josh).
- Studied different window configurations and selected the best windows for AIRS (Josh, Susan, and Vivienne).

Presentations

- Joshua Laughner, Vivienne Payne, Susan Kulawik, Emily Fischer, "Retrievals of Peroxyacetyl Nitrate from AIRS", The 2022 AIRS/Sounder Science Team Meeting, May 10, 2022 - May 12, 2022, Jet Propulsion Laboratory, Pasadena, CA

Project goals for 2023

- Implement the ability to process TES data into the python TROPESS processing system and process TES Megacity data to compare to AIRS. The TES-heritage TROPESS processing system has lost the ability to process TES observations, and we want to re-process TES with a consistent algorithm to AIRS for comparison to AIRS (Lead: Susan).
- Implement time-dependence for trace interferences such as CFC11, CCL4, CFC22. These gasses currently have no annual dependence, but have varied significantly (e.g. 20%) over the AIRS 20-year record (Susan and Vivienne).
- Compare AIRS to CrIS and TES PAN and write up validation of PAN (Lead: Josh).
- Analyze PAN in fire-impacted and background conditions (Lead: Emily).

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

Project Description

The project seeks to improve OCO-2/3 regional biases by adding 3-d 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 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 MODIS-based EAR3T and began preparing publication on the results (Sebastian and graduate student Yu-wen).
- Finalized temperature and water principle component retrievals (Rob).

Presentations

- 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.
- "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.
- "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.

Panels or Committees

- Served on the ARCSIX review panel in March, 2022.

Project goals for 2023

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

RUMMBL

Project Participants

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

Project Description

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

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

Accomplishments

- Performed a second season of ground-degassing field measurements at Turrialba volcano (done by the MTU team), which brought the total number of ground degassing measurements to ~950.
- Continued the development of an aerosol optical depth retrieval using OCO-3 measurements. We are currently pursuing a machine-learning approach using a combination of MODIS and OCO-2/3.
- Improved the location of the AERONET site in San Jose Costa Rica to enable a clearer view of the horizon. The AERONET instrument is operating nominally.
- Continued development of a numerical model of volcanic degassing, using a finite-element approach based on COMSOL multiphysics. Initial modeling considers mass conservation, Darcy's flows for CO2 and SO2, gas-matrix energy transfer, pressurized magma reservoirs, elastic and visco-elastic crust, and different geometries and magma injections into the reservoir.

Presentations

- Broccardo S.P. et al: Enabling more routine monitoring of volcanic CO_2 degassing from space, *in OCO Science Team Meeting, local/urban breakout sessio*n, online, 2022-03-09.
- Chen et al: Utilizing SAM data over volcanoes: a report of the in-progress work, *in OCO Science Team Meeting, Local/Urban breakout session*, Boulder CO and online, 2022-10-13
- Broccardo S.P. et al: RUMMBLE (Remote-sensing Underground Magma Movement Before Large Eruptions) Enabling routine volcano monitoring from space, *in NASA Earth Surface and Interior Solid Earth Science Team Meeting*, La Jolla, 7 Nov 2022
- Nelson K.M. et al: Improving the Total CO2 Budget Estimate for and Active Stratovolcano in Costa Rica, *in NASA Earth Surface and Interior Solid Earth Science Team Meeting*, La Jolla, Nov 2022

Project goals for 2023

- Continue the development of CO2 retrieval from OCO-[2,3] (JPL/Caltech team) and its application to space-based observations of volcanoes.

- Apply a validation strategy using surface, suborbital, and space-based assets to our custom OCO retrieval products (Ames/BAERI team).
- Develop a numerical physics-based model of volcanic degassing, based on subsurface magma flows (University of Alaska, Fairbanks).
- Complete the interpretation of ground-based flux measurements at Turrialba volcano (Michigan Tech team).
- Begin a synthesis of the space-based, surface degassing, and subsurface modeling results (whole team).

SeaSTAR

Project Participants

BAERI: Stephen Broccardo, Conrad Esch

Project Description

The project aims to develop a ship-based robotic sun/sky photometer for the quantification and characterization of marine aerosol particles. We will integrate radiometer technology that was developed for Ames' next-generation airborne sunphotometer (5STAR) with a new high-performance 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

- Developed and tested two hardware revisions of an interface and signal conditioning board for the photodiode amplifiers.
- Built the two-axis robot frame, incorporating improved servo gearboxes. It is ready to begin testing camera feedback, sun-tracking, and IMU-based motion compensation.
- Modified the airborne sunphotometer test table to incorporate a second motorized axis so that the motion of a ship can be more closely simulated.
- Took the 5STAR prototype to Mauna Loa Observatory, and produced promising initial Langley calibrations from selected wavelength channels.

Presentations

- Broccardo S.P. et al: Robotic sunphotometry to enable over-ocean aerosol characterization, *in Advancement of Polarimetric Observations (APOLO),* Silver Spring MD, Aug 2022.

Project goals for 2023

- Complete the construction of the 3+1 axis robot, integrate 5STAR-derived radiometer circuitry and improved signal-conditioning board developed in Y1.
- Design the state-machine and adapt existing computer code for controlling the robot.
- Achieve sun-tracking with the robot for measuring multi-spectral aerosol optical depth.
- Achieve sky-scanning with the robot with IMU-based feed-forward motion compensation.
- Deploy on a boat/ship to demonstrate sun-tracking and sky-scanning.
- Begin development of aerosol property retrieval based on sky-scanning.
- Propose to the ROSES A.30 PACE Mission Validation call.

TASNPP

Project Participants

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

Project Description

Aerosols play a key role in the Earth-atmosphere radiative budget via interactions with solar radiation. Over dark surfaces (clear sky), aerosol scattering generally yields a negative (cooling) TOA direct radiative effect (DRE). Over bright surfaces (clouds), the TOA DRE can be negative or positive (warming) depending on underlying surface brightness and aerosol absorptivity; strongly absorbing above-cloud aerosols (biomass burning) yield local atmospheric warming and positive TOA DRE. Moreover, above-cloud aerosol absorption is problematic for passive satellite retrievals of the underlying clouds. Because aerosol absorption increases as wavelength decreases within the NIR through the VIS, cloud optical retrievals relying on VIS/NIR reflectance can be biased in the presence of above-cloud absorbing aerosols. For instance, MODIS cloud optical thickness (COT) retrievals, which assume a clean above-cloud atmospheric path (no aerosols), are biased low when above-cloud absorbing aerosols are present, having implications on downstream uses such as estimates of cloud and aerosol radiative effects.

Globally, there are several locations where absorbing aerosols are frequently observed above clouds. Foremost is the SE Atlantic basin. Here, smoke from extensive biomass burning in sub-Saharan Africa is often mixed with other regional emissions and transported off the continent over a semi-permanent stratocumulus cloud deck, creating a near-persistent aerosol over cloud condition from roughly June through October, with profound impacts on the regional radiative budget and passive imager cloud retrievals. GCM simulations have also been shown to have exceptional disagreement in the sign/magnitude of the aerosol radiative effects over this region, which are a function of the properties/distributions of both the aerosol and underlying clouds.

To address the above issues, a technique was developed to simultaneously retrieve above-cloud aerosol optical depth (AOD) and unbiased COT and cloud effective particle radius (CER) of the underlying clouds using VIS, NIR, and SWIR reflectance measurements. This technique, developed with regionally appropriate aerosol radiative models, has been applied to Terra and Aqua MODIS observations, and has enjoyed widespread use by the international cloud and aerosol remote sensing community, the atmospheric modeling community, and major field campaigns funded by NASA (ORACLES) and international partners (UK CLARIFY, France AEROCLO-SA). For ORACLES this MOD06ACAERO algorithm was implemented within the LANCE operational production environment for near real-time MODIS retrievals to support in-field operations and science analysis; LANCE NRT production continues to date. Because cloud forward model and ancillary assumptions are identical to MOD06, MOD06ACAER provides COT/CER retrievals consistent with MOD06 in aerosol-free cloud scenes, and its ACAOD retrievals are comparable to those from other passive satellite techniques (e.g., OMI, POLDER) and ORACLES field campaign observations. Moreover, the algorithm is sufficiently flexible to be applied to any passive sensor having the appropriate spectral channels (e.g., VIIRS).

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

In this project, we intend to:

- Build upon our MODIS LANCE capabilities to transition the algorithm to Standard Product status and extend to SNPP/NOAA-20 VIIRS; this includes refining a QA scheme and initializing the ATBD process.
- In parallel, 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

- Delivered case study products and overall statistics on aerosol intensive properties (campaign representative single scattering properties–SSA, asymmetry parameter, phase function), which were measured by 4STAR during ORACLES 2016, to the PI for incorporation into retrieval products.
- Used 4STAR ORACLES measurements from 2016 to build statistics of spectral above cloud AOD for new radiative transfer calculations used in retrieval of Above cloud AOD.
- Extrapolated over wavelength range the intensive aerosol properties using Mie radiative transfer calculations.
- Started comparisons of MODIS ACAOD products to ORACLES 4STAR and HSRL-2 ACAOD.

Presentations

- LeBlanc et al., Aerosol above cloud optical depth in the southeast Atlantic and their use in continuity NASA products, AGU, Session A073. Models, In situ, and Remote sensing of Aerosols (MIRA), Oral Presentation, AGU Fall Meeting, December 2022.

Panels or Committees

- NASA ROSES review panel member (Pistone).
- CLOUD GAZE Science Steering Committee (May 2021-present), science advisory on development of a new community science platform as part of NASA's GLOBE program (Pistone).
- NASA 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 MUREP (Minority University Research and Education Project) Center for Advanced Measurements in Extreme Environments (CAMEE) project (June 2020-present). Including review of COVID-related 2y funding extension (Pistone)
- American Geophysical Union Fall Meeting Program Committee (June 2020-present), Atmospheric Sciences section (Pistone).

Project goals for 2023

- Improve aerosol model in MOD06ACAERO.
    - The BAERI team will continue to process the 4STAR sky scans from ORACLES 2017 and 2018 in a way which is consistent with the 2016 data, to further refine the regional model.
- Complete and submit for peer review a paper currently titled "Aerosol intensive properties of biomass burning smoke measured by an airborne sun photometer over the southeast Atlantic, 2016-2018" to the ORACLES ACP special issue (Pistone).
- Submit "Samuel E. LeBlanc, Jens Redemann, Connor Flynn, Kristina Pistone, Stephen Broccardo, Michal Segal-Rosenheimer, Meloë Kacenelenbogen, Yohei Shinozuka, Roy Johnson, Stephen Dunagan, Richard Ferrare, Sharon Burton, Chris Hostetler, and Johnathan W. Hair, 'Airborne Observations Above Cloud Aerosol Optical Depth in the Southeast Atlantic during biomass burning season over 3 years,'" In prep for Atmos. Meas. Tech. (LeBlanc).

Applied Sciences

Agriculture, Health, and Marine Applied Sciences

Project Participants

CSUMB: Will Carrara, Alberto Guzman, Michael Hang, Lee Johnson, Forrest Melton, AJ Purdy, Ryan Solymar
CSUMB Students: Kristen Burroughs, Andrea Chiasky
Stanford University: Conor Doherty
NASA: Ian Brosnan

Project Description

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

The primary objectives of this task are to:

- Apply satellite data, airborne data, flux towers, and other ground-based instrumentation to model and map agricultural productivity, evapotranspiration, and crop water demand.
- Apply satellite data, climate models, and ecological models to map habitat for disease vectors, and model vector-borne disease transmission risk.
- 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 9 peer reviewed journal articles, including 2 student first-author papers, with 1 additional article submitted and currently in review, and 2 currently in final preparation for a total of 12 papers prepared.
- Presented more than 20 scientific and technical talks/posters at science conferences and technical meetings. F. Melton also provided briefing for staff of multiple U.S. Senate Office and House offices, the Kansas Farm Bureau, the Oregon State Legislature Water Resources Committee, the American Farm Bureau Federation, the California Farm Bureau, the Western States Water Council, the Upper Colorado River Commission, the Washington Hydrogeology Conference and multiple state and federal water management agencies.
- Launched OpenET, which was coordinated with NASA HQ and featured on nasa.gov. The public launch of the OpenET Data Explorer and corresponding NASA press release resulted in articles and press coverage in 400 U.S. and 60 international media outlets. More than 8,600 unique users have signed up for OpenET, and OpenET is providing data to thousands of water resource management professionals and agricultural producers on a daily basis. 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, OpenET Authorization Bills have been introduced in both the House and the Senate as bipartisan bills. The Senate version of the OpenET Authorization Bill S.2568 includes $14 million per year for 5 years for the Department of the Interior to establish a national ET mapping system based on OpenET. The bill would provide support for USGS, working in partnership with the OpenET consortium and others, to develop an operational ET mapping system for the United States. A version of the OpenET bill was included in the Wildfire Response and Drought Resiliency Act, H.R. 5118 (page 147), with funding budgeted at $23 million for each fiscal year for 5 years, but remains stalled in the Senate.

- Mentored two CSUMB students (Kristen Burroughs, Andrea Chiasky) and one Stanford University student (Conor Doherty) who worked with the SIMS and OpenET projects in 2022. Additional research internships will be offered in 2023.
- Secured an additional $3.2 million ($10.5 million in total funding to date) for the OpenET project from the Walton Family Fund, Lyda Hill Philanthropies, USGS, and the NASA Applied Sciences Program. The OpenET project is advancing the availability of field scale information on evapotranspiration (ET) via open web data services and APIs. The OpenET project is a partnership among 3 NASA Centers (ARC, JPL, MSFC), EDF, Google, the Desert Research Institute, USDA, USGS, and multiple university research teams. F. Melton serves as the NASA Project Scientist for OpenET, and technical lead for a team of >35 leading experts on remote sensing of ET. Co-Is Guzman, Carrara, Johnson, and Doherty have led the implementation and improvement of the NASA SIMS ET model on the Earth Engine platform, and production of field-scale ET data for 17 western states to date. Carrara and Guzman continue to lead development of the OpenET API and to support ongoing data production and have made multiple key contributions to the development of the OpenET platform. The API is currently being tested by more than 300 project partners across the western US prior to the public launch during the first half of 2023.
- Completed improvements to the Application Programming Interface (API) for SIMS, which is used to integrate data from SIMS with the UCANR CropManage tool, with support from the NASA Western Water Applications Office. This allows data from SIMS to be used operationally to support irrigation and fertilizer management decisions by more than 3,000 California growers. In addition, the project deployed and maintained flux towers in collaboration with Central Coast growers to support expansion of CropManage to include wine grapes and celery, and to conduct accuracy assessments of CropManage for lettuce. R. Solymar and K. Burroughs led the deployment and operation of eddy covariance instrumentation in commercial fields and vineyards. The data from these flux towers are currently being used to evaluate ET data and irrigation recommendations from CropManage for these crops. The SIMS API has also been provided to multiple commercial partners for testing and use in commercial applications. In addition, relationships were developed between satellite NDVI and crop fractional cover for several high-value crops.
- In partnership with USDA ARS in Salinas, CA, the project team continued to use a DJI Matrix 600 hexacopter UAV platform and Micasense Altum camera to collect imagery over agricultural fields in the Salinas Valley. The project team (F. Melton, PI; M. Hang Co-I) continued 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 team is currently monitoring multiple strawberry fields for plant pathogens, and assessing the development of crop canopies and fractional cover across multiple crops to verify and improve the SIMS algorithms. M. Hang used the UAV to map 3 research sites in 2022, developed an automated data processing workflow for tens of thousands of UAV images, and is currently working with USDA partners to incorporate data on crop yields and pathogen density into the analysis. The ultimate goal of this project is to provide an information tool that will support early detection of disease and targeted applications of fumigants in the strawberry industry.
- Secured additional funding related to this task, which was available only to non-federal, California institutions (some funding pending):
    - Johnson was Co-I on a proposal led by UC Cooperative Extension under the 2019 CDFA Specialty Crop Block Grants Program ($333k). He co-led irrigation trials in artichoke and red cabbage being conducted at the USDA research station in Salinas. The project concluded in June 2022.
    - Johnson is PI of a $386k project awarded by the CDFA-SCBGP in 2020 to work with UC Cooperative Extension offices in Monterey, San Luis Obispo, and Fresno Counties to adapt the CropManage-SIMS decision support tool for use in winegrape and tablegrape vineyards. Data acquisition and analysis is ongoing in several commercial vineyards in Salinas Valley and San Joaquin Valley.
    - Johnson is PI of a $445k project awarded through the 2021 SCBGP program. The joint project is using the OpenET and CropManage systems to address sustainability indicators identified by the State of California in response to declining groundwater levels, seawater intrusion, and degraded water quality. During 2022, monitored several Salinas Valley commercial vegetable fields and vineyards with flowmeters, soil moisture sensors, and eddy covariance systems. Data QAQC and analysis is ongoing.

- Johnson is PI of a $490k concept proposal to the 2023 SCBGP. The project would build on prior CDFA and ARI efforts by collecting eddy covariance data in an expanded number of specialty crop fields in Monterey County. Co-investigators include Dr. Adam Purdy (CSUMB) and Dr. Michael Cahn (UC Cooperative Extension). The concept proposal is in panel review as of Dec 2022.
- Johnson is Co-I on a NASA ROSES project selected for funding during 2022. The project is titled "Accelerating Adoption of Irrigation Scheduling with Satellite Based Evapotranspiration from OpenET." The work is led by Univ. Nebraska and additional collaborators include U.C. Cooperative Extension, Washington State Univ., and the Univ. Colorado Irrigation Innovation Consortium. The project will infuse OpenET data products into the domains of operational irrigation scheduling applications.
- Melton is a PI on a project awarded by the CSU Agricultural Research Institute in 2020 to apply remotely sensed ET data to support implementation of the Sustainable Groundwater Management Act ($400k). This project is mapping ET from high value specialty crops and invasive plants in the Salinas River Watershed to support implementation of the Groundwater Sustainability Plan for the Salinas Valley Basin.

Selected Presentations

- (Invited keynote) Melton, F., Carrara, W., Doherty, C., Guzman, A., Johnson, L., Solymar, R., et al., 2022. Operational Evapotranspiration Data for Water Management in the Western United States Washington Hydrogeology Conference, Tacoma, WA, May 11, 2022.
- Melton, F., Carrara, W., Doherty, C., Guzman, A., Johnson, L., Solymar, R., et al., 2022. OpenET: Operational Evapotranspiration Data for Water Management in the Western United States. ASPRS Pecora Conference, Denver, CO, October 27, 2022.
- Melton, F., Carrara, W., Doherty, C., Guzman, A., Johnson, L., Solymar, R., et al., 2022. OpenET: Operational Evapotranspiration Data for Water Management in Oregon. Oregon Water Resources Department / Oregon State University Evapotranspiration Workshops, Hemiston and Portland, OR, Sept 9-10, 2022.
- Purdy, A.J., Melton, F., Carrara, W., Doherty, C., Guzman, A., Johnson, L., et al., 2022, Supporting Sustainable Groundwater Management in the Salinas Valley with Satellite-based Evapotranspiration Data. California State University Agricultural Research Institute Annual Conference, Sacramento, CA, October 21, 2022.
- Bromley, M., Melton, F., Carrara, W., Doherty, C., Guzman, A., Johnson, L., et al., 2022. OpenET: Operational Evapotranspiration Data for Water Management in the Western United States. AGU Frontiers in Hydrology Conference, Puerto Rico, June 20, 2022.
- Martin, F., Fennimore, S.A., Matson, M., Racano, D., Putman, A.I., Melton, F., Hang, M., Magney, T., Earles, M., Goodhue, R. and Vougioukas, S., 2021, August. Site-specific soil pest management in strawberry & vegetable cropping systems. In PHYTOPATHOLOGY (Vol. 111, No. 10, pp. 115-115). 3340 PILOT KNOB ROAD, ST PAUL, MN 55121 USA: AMER PHYTOPATHOLOGICAL SOC.
- Racano, D., Martin, F., Fennimore, S., Putman, A., Matson, M., Melton, F., Goodhue, R., Henry, P., Vougioukas, S., Dorn, N. and Greer, C., 2021, September. Site-Specific Soil Pest Management in Strawberry and Vegetable Cropping Systems Using Crop Rotation and a Needs-Based Variable Rate Fumigation Strategy. In HORTSCIENCE (Vol. 56, No. 9, pp. S169-S169). 113 S WEST ST, STE 200, ALEXANDRIA, VA 22314-2851 USA: AMER SOC HORTICULTURAL SCIENCE.
- Grimm, R., Melton, F., Carrara, W., Doherty, C., Guzman, A., Johnson, L., Solymar, R., et al., 2022. OpenET: Filling the Biggest Data Gap in Western Water Management, World Water Week, Stockholm, Sweden, August 25, 2022.
- Melton, F., Carrara, W., Doherty, C., Guzman, A., Johnson, L., Purdy, A., Solymar, R., et al., 2022. OpenET. Presentations to the Western States Water Council, Colorado River Authority of Utah, Upper Colorado River Commission, Oregon Water Resources Department, California State Water Resources Control Board, American Farm Bureau Federation, USGS, Department of the Interior and other partners and stakeholders throughout 2022.
- Johnson, L., M. Cahn, F. Melton, 2022. CropManage Application for Vineyard Irrigation Decision-Support. ASEV National Conference, 19-21 June, San Diego.

- Cahn, M., L. Johnson, S. Benzen, 2022. Weather-Based Irrigation Scheduling of Artichoke and Red Cabbage. UCCE Irrigation and Nutrient Management Meeting, 23 Feb, Salinas, CA.

Publications

Melton, F., Huntington, J., Grimm, R., Herring, J., Hall, M., Rollison, D., Erickson, T., Allen, R., Anderson, M., Fisher, J., Kilic, A., Senay, G., volk, J., Hain, C., Johnson, L., Ruhoff, A., Blanenau, P., Bromley, M., Carrara, W., Daudert, B., Doherty, C., Dunkerly, C., Friedrichs, M., Guzman, A., Halverson, G., Hansen, J., Harding, J., Kang, Y., Ketchum, D., Minor, B., Morton, C., Ortega-Salazar, S., Ott, T., Ozdogon, M., Schull, M., Wang, T., Yang, Y., Anderson, R., 2021. OpenET: Filling a Critical Data Gap in Water Management for the Western United States. Journal of the American Water Resources Association, 2021 Nov 2. https://doi.org/10.1111/1752-1688.12956.

Cahn, M.D., Johnson, L.F. and Benzen, S.D., 2022. Evapotranspiration Based Irrigation Trials Examine Water Requirement, Nitrogen Use, and Yield of Romaine Lettuce in the Salinas Valley. *Horticulturae*, *8*(10), p.857.

Doherty, Conor T., Lee F. Johnson, John Volk, Meagan S. Mauter, Nicolas Bambach, Andrew J. McElrone, Joseph G. Alfieri et al. "Effects of meteorological and land surface modeling uncertainty on errors in winegrape ET calculated with SIMS." *Irrigation science* 40, no. 4 (2022): 515-530.

Wang, T., Melton, F.S., Pôças, I., Johnson, L.F., Thao, T., Post, K. and Cassel-Sharma, F., 2021. Evaluation of crop coefficient and evapotranspiration data for sugar beets from landsat surface reflectances using micrometeorological measurements and weighing lysimetry. *Agricultural Water Management*, *244*, p.106533.

Ahamed, A., Knight, R., Alam, S., Pauloo, R. and Melton, F., 2022. Assessing the utility of remote sensing data to accurately estimate changes in groundwater storage. *Science of The Total Environment*, *807*, p.150635.

Marston, L.T., Abdallah, A.M., Bagstad, K.J., Dickson, K., Glynn, P., Larsen, S.G., Melton, F.S., Onda, K., Painter, J.A., Prairie, J. and Ruddell, B.L., 2022. Water-Use Data in the United States: Challenges and Future Directions. *JAWRA Journal of the American Water Resources Association*.

Campana, P.E., Lastanao, P., Zainali, S., Zhang, J., Landelius, T. and Melton, F., 2022. Towards an operational irrigation management system for Sweden with a water–food–energy nexus perspective. *Agricultural Water Management*, *271*, p.107734.

Thrasher, B., Wang, W., Michaelis, A., Melton, F., Lee, T. and Nemani, R., 2022. NASA Global Daily Downscaled Projections, CMIP6. *Scientific Data*, *9*(1), pp.1-6.

Laipelt, L., Kayser, R.H.B., Fleischmann, A.S., Ruhoff, A., Bastiaanssen, W., Erickson, T.A. and Melton, F., 2021. Long-term monitoring of evapotranspiration using the SEBAL algorithm and Google Earth Engine cloud computing. ISPRS Journal of Photogrammetry and Remote Sensing, 178, pp.81-96.

Panels or Committees

- California Open Water Data Infrastructure Technical Working Group (F. Melton).
- IGARSS Scientific Committee (L. Johnson).
- Western Water Applications Office Capabilities Working Group (L. Johnson).
- Participation in multiple NASA review panels (Applied Sciences) by Melton.

Project goals for 2023

- OpenET:
    - Continue to support ongoing daily and monthly data production for the western U.S. and Mississippi River Basin.
    - Provide user support for more than 8,600 users of OpenET in the water resources management and agricultural communities.

    - Publicly release the OpenET API and provide support for thousands of agricultural producers and local, state, tribal, and federal water management agencies.
    - Develop additional outreach and training materials for agricultural producers on working with ET data.
    - Complete and publicly release the OpenET Custom Reporting Tools.
    - Integrate data from OpenET into irrigation scheduling tools developed by cooperative extension, USDA NRCS, and commercial sector partners.
    - Conduct outreach and training workshops with cooperative extension agency partners throughout the West.
    - Complete the OpenET Transition Planning process with NASA HQ and the USGS Water Availability and Use Science Program.
    - Work with the OpenET Science Team and partners to submit grant proposals, complete state contracting agreements, and work with NASA HQ and federal partners to secure and distribute funding to support the OpenET Consortium.
    - Publish manuscripts describing the OpenET Benchmark ET dataset and Phase II results.
- NASA-ROSES A.34:
    - Finalize irrigation scheduling user requirements definition.
    - Evaluate OpenET daily data output to meet irrigation scheduling requirements.
    - Modify CropManage and other irrigation scheduling apps to import/use OpenET daily data & forecasts.
    - Conduct outreach to additional potential partners.
    - Finalize testing strategy and identify primary test sites.
- CDFA-SCBGP:
    - Continue publication of results from vegetable crop irrigation trials.
    - Continue assisting Cooperative Extension with evaluation of CropManage for use in vineyards, by comparison with data from OpenET and eddy covariance systems.
    - Analyze relationships between ET and applied water in vineyards and cool-season vegetables.

Disaster Management

Project Participants

CSUMB: Vincent Ambrosia
NASA: Lawrence Friedl

Project Description

The Disaster Task is composed of two principal elements: 1) Staffing to support the NASA Applied Science Program (ASP) as Associate Program Manager - Wildfires, and 2) Supporting the development of airborne UAS and related sensor system technologies to enable improved science and applications data collection missions for NASA and partnering agencies and organizations. This element encompasses UAS systems development (and sensors) optimized for disaster support within the overall context of Earth science mission support.

Since 2013, Ambrosia has managed a portfolio of projects within the ASP-Wildfire Program. Portfolio management includes:

- Developing NASA Applied Science Wildland Fire topical solicitations, and organizing and managing the review panels and selection of NASA proposals to those solicitations.
- Providing scientific oversight of the program goals and objectives.
- Conducting budgetary management of the funded efforts of disparate organizations and investigators.
- Monitoring metrics for the investigations.
- Interacting with partner agencies involved in the projects.
- Serving as the NASA representative on regional, national, and international wildfire science and applications panels and boards.

Additional activities include organization and planning of national and international symposia and forums, as well as participating and collaborating in workshops and webinars, highlighting the ASP-Wildfire program and access/use of EO data to support wildfire science and applications by the community.

In 2019, Ambrosia took on the additional role/task of NASA Coordinator of the NASA Land-Cover/Land-Use Change Program, Mediterranean Regional Information Network (MedRIN). The tasks include coordination of annual meetings and workshops with regional coordinators from the Mediterranean countries with a focus on dynamic land/biosphere changes common to the area, and also to participate in the NASA LCLUC Annual Team Meeting (2022--virtual).

Accomplishments

- Supported NASA Applied Science Program in the review/technical evaluation of proposals submitted to the new NASA Wildfire Management Program in 2022.
- Co-hosted/Chaired the Spring 2022 Tactical Fire Remote Sensing Advisory Committee (TFRSAC) virtual meeting, and planned the 2022 Fal TFRSAC Meeting (Nov. 2022).
- 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 a technical reviewer for the 2022 NASA Small Business Innovative Research (SBIR) program proposals.
- Served as technical reviewer for the 2022 USDA-National Institute of Food and Agriculture (USDA-NIFA) Small Business Innovative Research (SBIR) program proposals.
- Participated in virtual meetings/progress reviews as a Scientific Advisory Board Member: European Commission (EC)-funded trans-European wildfire program (FirEURisk), led by University of Coimbra (Portugal) and University of Alcala (Spain).
- Participated in virtual meetings/progress reviews as an External Advisory Board 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).

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

Presentations

- Ambrosia, V.G., D. Green, M. Falkowski, B. Lefer, M. Seablom, P. Kopardekar, and L. Grindle, 2022. *NASA's New Wildland Fire Earth Observation Science & Applications Programmatic Developments,* 3rd International Conference on Fire Behavior and Risk (ICFBR-2022), Alghero, Sardinia, Italy, 4 May 2022.
- Ambrosia, V.G., D. Green, M. Falkowski, B. Lefer, M. Seablom,, P. Kopardekar, and L. Grindle, 2022. *NASA's New Wildland Fire Earth Observation Science & Applications Programmatic Developments,* 5th GOFC-GOLD Fire IT and Global Wildfire Information System (GWIS), Stresa, Italy, 21-23 June 2022.
- Ambrosia,V.G., D. Hadjimitsis, I. Gitas, 2022. *The Mediterranean Regional Information Network (MedRIN),* 5th GOFC-GOLD Fire IT and Global Wildfire Information System (GWIS), Stresa, Italy, 21-23 June 2022.

Publications

Ambrosia, V. G.; Green, D.; Falkowski, M. Lefer, B., Seablom, M.; Kopardekar, P.; Grindle, L. A., 2022. *NASA's New Wildland Fire Earth Observation Science & Applications Programmatic Developments*, Environ. Sci. Proc. 2022, 17(1), 71; https: Current Titles in Wildland Fire, September 2022 (9) 23 //doi.org/10.3390/ environsciproc2022017071.

Project goals for 2023

- Support the structuring, development, management of a portfolio of funded projects in the new NASA Applied Science Program, Wildland Fire Management Applications Program. This includes the development of the programmatic direction, development of a planned 2023 ROSES solicitation, and transitioning management of the Assoc. Program Manager roles to the new Program Manager and new Assoc. Program Manager position(s).
- Support and advise the structuring and development of the new (FY2023) NASA HQ Earth Science Division, FireSense Program.
- Continue to serve as the Co-Organizer/Chair of the NASA/USFS Tactical Fire Remote Sensing Advisory Committee (TFRSAC), and organize the twice-annual meeting (Spring and Fall 2023).
- Coordinate with the NASA Aeronautics Research Mission Directorate (ARMD) and the NASA Science Mission Directorate (SMD) in the development of the new NASA Wildfire Effort, and subsequent workshops and engagements between the wildfire and various NASA Directorates.
- Manage the Mediterranean Regional Information Network (MedRIN) of the NASA LCLUC Program (HQ PM: G. Gutman), and work to develop collaborations between nations in eastern Mediterranean region and NASA Earth Sciences Programs; Develop MedRIN workshop and meetings in collaboration with the MedRIN Co-Coordinators in Europe, particularly the Spring 2022 MedRIN Workshop (Cyprus/virtual) and the 2nd Joint MedRIN/SCERIN Workshop (tentative: Sophia, Bulgaria, 2023).
- Continue as NASA representative on the Group on Earth Observations (GEO) GWIS Initiative (WP 2023-2025), Coordination Advisory Board.
- Maintain involvement representing the NASA Earth Science Division on regional, national, and international professional scientific committees (includes GEO USGEO and CEOS Working Group: Disasters (CEOS WGDisasters)).
- Serve as programmatic peer reviewer of NASA Earth Science Program solicitation proposals (including LCLUC program, Future Investigators/Early Career Investigators program (FINESST), Ecological Forecasting, Disaster Management, RRNES, and EPSCoR).
- Continue to support the scientific community by serving as a peer-reviewer for other Federal agency/ department solicitations (including USDA-FS SBIR Program, NSF Solicitation Reviewer, etc.).
- Continue as an international scientific journal peer-reviewer/SME.
- Assist in development and support the new (2023) USFS/NASA Interagency Agreement (IAA to collaborate on use/integration of EO for resource management issues, including wildland fire) in 2023.

- Provide outreach and education to various community groups, including lecturing at Universities, providing seminars at other scientific organizations, and wildfire management training exercises and workshops.
- Support workshops and working group meetings as an invited speaker and reviewer on uses of new technologies to improve wildland fire management—organizations include the IDGA, USGS, etc.
- Continue service on the External Advisory Board of "EXCELSIOR" (ERATOSTHENES: Excellence Research Center for Earth Surveillance and Space-Based Monitoring Of the Environment).
- Continue role as a Scientific Advisory Board Member: European Commission (EC)-funded trans-European wildfire program (FirEURisk), led by University of Coimbra (Portugal) and University of Alcala (Spain) in 2023.

Disaster Program Support

Project Participants

BAERI: Cindy Schmidt
NASA: Shanna McClain

Project Description

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

Project goals for 2023

- Work with the newly formed DRCS to develop stakeholder engagement and capacity building strategies.
- Advise the Program Manager and the DRCS on best practices around engaging with Indigenous peoples.
- Help design workshops for the DRCS and the Disaster program coordinators at each center.

Ecological Forecasting Program Support

Project Participants

BAERI: Cindy Schmidt
NASA: Keith Gaddis, Woody Turner

Project Description

As an Associate program manager for the NASA Applied Science Ecological Forecasting program, Schmidt tracks projects in the Ecological Forecasting 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 currently manages 9 projects for the program.

Accomplishments

- Participated in FINESST proposal review in May.
- Developed an agenda and helped organize the annual Biodiversity and Ecological Forecasting team meeting in September.
- Attended project team meetings in Bogota, Colombia, Whitehorse, Yukon, and Logan, Utah.
- Developed and gave a Remote Sensing for Conservation virtual training for the Society for Conservation conference, in July.
- Co-mentored NASA HQ student intern on Private Sector Engagement and Sustainability.
- Developed agenda and helped organize Ecological Forecasting retreat in October.

Presentations

- Presented project summaries at Applied Science program reviews in May, July, October.
- Presented Applied Science overview to Karen St. Germain in July.
- Presented at the Canadian Space Agency Earth Observation Forum in September.
- Moderator and presenter of a session on Sustainable Development Goals for the Pecora Remote Sensing Symposium conference in Denver in October.

Panels or Committees

- US Arctic Observation Network board.
- Review committee for Applications Guidebook.
- Ames Code SG seminar committee.

Project goals for 2023

Meetings/conferences:

- Plan and attend the joint Carbon Cycle and Ecosystem meeting in May (Washington DC). Tasks include helping to develop the agenda and organizing and running several breakout sessions.
- Attend and present at the Ecological Society of America conference in August.
- Attend project team meetings in Africa, Colombia, Idaho and Montana. Attend other project team meetings either virtually or in-person as they become organized.
- Start duties as Applications Liaison for BioScape project, which will include attending project meetings in South Africa.
- Conducted a remote sensing workshop at the Society for Conservation GIS in July in collaboration with colleagues from UC Berkeley.
- Organize biodiversity and conservation sessions at AGU 2023.

Other:

- Present project status updates at bi-monthly Applied Science Program reviews.
- Participate in the Applied Science Guidebook working group to provide guidance on the guidebook content.
- Help develop a new Catalyst program in California.
- Continue to participate on the US Arctic Observation Network board.
- Participate in ROSES Ecological Conservation and FINESST panel reviews.

Equity & Environmental Justice

Project Participants

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

Project Description

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

Project goals for 2023

- Continually track 8 projects in the EEJ portfolio.
- Support strategic planning activities.
- Help coordinate annual program review meetings.
- Participate in interagency activities and meetings as required by the Program Managers.

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-ARS, the NASA Ames Research Center, the University of California at Davis, and the State of California – Division of Boating and Waterways (DBW).

Accomplishments

- Completed an entire summer 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 CA State parks to identify sample collection sites for FAV and SAV, and validate satellite imagery.
- Maintained and increased culture ability from FAV, and added significant SAV collection to the panel.
- Defined a potentially new method for looking at respiration in SAV and LiCor, which is helping build a test unit.
- Maintained and improved the 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.

Project goals for 2023

- Validate new remote sensing, satellite-based mapping and biomass estimation tool for Floating Aquatic Vegetation:
    - FAV sensing threshold and variability.
    - Biomass estimates accuracy and sensitivity.
    - Development effort to identify separate populations of 3 prominent FAV species in the California Delta.
    - Work collaboratively with the Cal Department of Boating and Waterway in evaluation of tools.
- Conduct controlled environment studies related to FAV response to environmental variation.
    - Fill gaps in modeling parameters.
    - Study gas exchange in FAV.
- Conduct controlled environment studies related to SAV response to environmental conditions and herbicides
- Use LI-7000 to define SAV respiration rates under varying environmental conditions.
- Maintain controlled environment facilities.
- Maintain cultures of all delta critical plants for evaluation.
- Increase SAV culture systems to maintain SAV cultures.

USDA-ARS California Delta Areawide Project for Integrated Resource Management

Project Participants

BAERI: Greg Schlick
CSUMB: Vanessa Genovese
California State Parks, Division of Boating and Waterways: Michael Cane, Edward Hard
NASA Ames: David Bubenheim

Project Description

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

Accomplishments

- Worked in conjunction with Michael Cane to develop an interactive ArcGIS dashboard to enable DBW management officers to use it in the field to inform their management practices.
- Created mapping products using Sentinel data for the dashboard.
- Analyzed various algorithms for specific plant species mapping.

Publications

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

Project goals for 2023

- Continue the development of the dashboard in collaboration with the CA DBW, as well as of the weekly Sentinel based invasive species maps for the Delta.
- Transfer processing of map generation to DBW.
- Continue to work on generation and verification of species maps.
- Continue the development of datasets for invasive plant growth models.

Water Resources Program

Project Participants

CSUMB: Pam Hansen, Forrest Melton

Project Description

The primary objectives of this task are to:

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

Accomplishments

- Tracked and coordinated 12 ASP Water Resources projects. Monitored financial and technical progress and engagement with partners and stakeholders. Communicated regularly with project PIs to identify and resolve issues. Reported project progress to ASP PMs and Associates at five ASP Program Reviews.
- Participated in weekly meetings with WWAO, and bi-weekly meetings with NASA HQ. Monitored project progress for multiple projects being supported by WWAO in the Columbia River Basin. Co-led the WWAO Program Review resulting in a successful 5-year renewal of WWAO. Supported the WWAO Needs Assessments for the Rio Grande River Basin and the Missouri River Basin. Oversaw technical progress on six projects supported by WWAO.
- Assisted with organization and planning for the NASA presence at the Commodity Classic conference. Attended the Commodity Classic to represent NASA at the request of Dr. Karen St. Germain. Also represented the NASA Applied Sciences Program at more than a dozen workshops, meetings and conferences.
- Supported Dr. St. Germain and Dr. Doorn as a Subject Matter Expert during the NASA Space for Ag Tour. Traveled through Nebraska and Kansas and conducted outreach with agricultural partners, participated in speaker panels, and answered questions about NASA's role in supporting agricultural producers.
- F. Melton and P. Hansen organized and co-led the annual 2022 NASA Applied Sciences Program (ASP) Water Resources and Western Water Applications Office Meetings in Salt Lake City, UT on Oct 3-7. Organized the meeting agenda, all meeting logistics, and chaired multiple technical sessions for a meeting with over 110 participants (70 in person and ~40 on-line). Organized and moderated stakeholder panels and presentations on special topics for the NASA Water Resources Community.
- Participated in the NASA Climate Strategy Working Group on behalf of the NASA Applied Sciences Program. Co-authored the NASA Climate Strategy, assisted the NASA Chief Scientist with planning for the NASA Climate Summit, and facilitated a breakout group on the topic of "NASA Data to Decisions" on Dec 9, 2022.

Presentations

- Melton, F., et al., 2022. The NASA Western Water Applications Office, American Society of Photogrammetry and Remote Sensing Pecora Conference, Denver, CO, October 27, 2022.
- Melton, F., et al., 2022. Operational Satellite Monitoring of Evapotranspiration for Precision Agriculture and Water Resources Management, Commodity Classic Conference, New Orleans, LA, Mar 10-12, 2022.

Publications

Cooley, S., Jenkins, A., Schaeffer, B., Bormann, K.J., Abdallah, A., Melton, F., Granger, S. and Graczyk, I., 2022. Paths to research-driven decision making in the realms of environment and water. *Technology in Society*, p.101994.

Panels or Committees

- Western States Water Council Western Federal Agency Support Team (WestFAST).
- NASA Climate Strategy Working Group.
- National Integrated Drought Information System Applications Working Group.

Project Goals for 2023

- Continue to support NASA HQ through program management and community leadership activities for the Water Resources and Agriculture application areas.
- Support the development of a strategy for the newly created Agriculture Application Area within the NASA Applied Sciences Program, working closely with NASA HQ and the new NASA Domestic Agriculture Consortium, and conduct additional outreach to the agricultural community in the U.S.
- Work with the NASA Chief Scientist to advance the implementation of the NASA Climate Strategy.
- Continue to maintain contact with PI's and projects for which we are responsible, and report progress at ASP Program Reviews.
- Organize the 2023 Water Resources PI Meeting (P. Hansen, F. Melton).
- Co-organize Remote Sensing Applications sessions at AGU, AMS, American Water Resources Association, and other scientific conferences.
- Continue to maintain and improve the program website and communication material.
- Attend additional stakeholder meetings and workshops to represent the NASA ASP Water Resources program element.

Western Water Applications Office (WWAO)

Project Participants

BAERI: Amber McCullum
CSUMB: Forrest Melton
JPL: Mark Davidson, Indrani Graczyk, Stephanie Granger, Amber Jenkins, Sharon Vasquez-Ray

Project Description

The Western Water Applications Office (WWAO) (wwao.jpl.nasa.gov) is a NASA program focused on all things water. While physically headquartered at NASA's Jet Propulsion Laboratory in Pasadena, California, it is a cross-NASA initiative with a team representing all of the NASA centers. WWAO is part of a larger effort within NASA's Applied Sciences Program to help society through NASA's data, tools, and technology. It is part of NASA's Applied Sciences Program (appliedsciences.nasa.gov), which covers Earth science and encompasses five application areas: Health and Air Quality, Ecological Forecasting, Disasters, Wildfires, and Water Resources. WWAO forms a core part of the latter of these thrusts: water resources. WWAO leverages decades of NASA investment in science and technology to deliver useful, actionable information to those on the ground making water decisions and shaping policies that potentially affect millions of people. Amber McCullum serves as the Impact and Transition Lead for the WWAO Program Office.

Accomplishments

- Assisted in the creation of the WWAO Annual Report.
- Assisted in the planning and delivery of the virtual Rio Grande Needs Assessment workshop, which took place on March 7-9, 2022. This included engaging with water users in the Rio Grande to generate multiple use cases for relevant applications of NASA remote sensing data for water management issues. Outcomes from this workshop will be used in future solicitations for NASA-funded projects through WWAO.
- Participated in the WWAO Annual Retreat to discuss program strategy on May 16.
- Participated in the Applied Sciences Water Resources Annual Meeting in Salt Lake City, October 4-7, 2022, and gave multiple presentations on WWAO programmatic activities.
- Continued collaboration with RTI on project work to conduct a large-scale economic assessment of the use of remote sensing for water applications. Current activities involve overseeing their work, which will generate multiple case-studies on the use of Earth Observations for water management and the quantitative value of those data products and tools to the community. A phase 1 report is expected in late November 2022, and a phase 2 full report expected in August 2023.
- Delivered a 5-year WWAO Program Impact Report that catalogs project impact metrics and summarizes programmatic impact for water management in the western U.S. The report will be made public by January 2023.
- Conducted programmatic planning for a Research to Operations workshops in collaboration with the National Academy of Sciences, which will occur in Spring 2023.
- Conducted programmatic planning for the Missouri River Basin Needs Assessment workshop, which will occur in March 2023.

Presentations

- WWAO Impact Assessment Updates, ASP Water Resources Annual Meeting, SLC, October 4-7, 2022.
- WWAO R2O Updates, ASP Water Resources Annual Meeting, SLC, October 4-7, 2022.

Project goals for 2023

- Facilitate ongoing Economic Valuation of Earth Observations for Freshwater Systems study.
    - Conducted by RTI International, the broad objective of the study is to conduct an analytical assessment of the economic and other values derived from Earth observation data (EOD) from space by U.S. and global systems that are in the NASA Applied Sciences Program scope. The

valuation study will assess the use, influence, and impact of these data across multiple sectors and decision contexts.

- Organize and host a Research to Operations meeting in Spring 2023.
    - Continue conversations with federal partners on research to operations pathways.
- Assist WWAO programmatic team on the Missouri River Basin Needs Assessment.
- Work with team leads to track and report project impacts such as: trainings, presentations, publications, products produced, number of users of tool/project outputs etc.
- Conduct assessments of viable projects for transition to stakeholder.
- Attend the ASP Water Resources meeting.
- Organize sessions for the AGU Annual Meeting.
- Attended weekly WWAO program office meetings.
- Attended multiple Western Regional Partnership meetings on behalf of the program office.

Earth Science Technology

Autonomous Scheduling of Earth-orbiting Satellite Constellations

Project Participants

BAERI: Vinay Ravindra, Sreeja Roy-Singh
JPL: Kar-Ming Cheung, Marc Sanchez Net
UGA: Brian Bledsoe, Rod Lammers

Project Description

Distributed Space Missions (DSMs), such as formation flight and constellations, are being recognized as important Earth Observation solutions to increase measurement samples over multiple spatio-temporal-angular vantage points. Larger numbers of smaller spacecraft also minimize launch and operational risks, and maximize evolution with time and technology. Small spacecraft (Cubesats up to 27U, ~40 kg in development) have the capability to host imager payloads and can slew to capture images within short notice, given the precise attitude control systems emerging in the commercial market. When combined with appropriate software, this can significantly increase response rate, revisit time, and coverage.

In prior work, we have demonstrated an algorithmic framework that combines orbital mechanics, attitude control, and scheduling optimization to plan the time-varying, full-body orientation of agile, small spacecraft in a constellation, such that they maximize observations for given imaging requirements and spacecraft specifications. The proposed schedule optimization would run autonomously at the ground station, and the resultant schedules would be uplinked to the spacecraft for execution. The algorithm is generalizable over small steerable spacecraft, control capability, sensor specs, and regions of interest.

In this project, we will modify the algorithm to run onboard small spacecraft, such that the constellation can make time-sensitive decisions to slew and capture images autonomously, without ground control. Upcoming technologies (such as inter-satellite links), will leverage onboard processing of images for intelligent decision making and onboard orbit prediction to reach consensus and coordinate execution among multiple spacecraft. Specifically, we will develop a communication module based on Delay/Disruption Tolerant Networking for onboard data management and routing among the satellites, which will work in conjunction with the other modules to optimize the schedule of agile communication and steering. We will then apply the developed software (for both ground-based and onboard autonomy) on representative constellations to simulate targeted measurements of multiple phenomena, organized by relevancy scenarios: (1) episodic precipitation events and subsequent floods, with varying requirements for data latency and reaction time; (2) cloud property assessment by tracking specific multi-angular geometries; and (3) Monitoring the spread of wildfires. The autonomous command and control efficiency of our agile algorithm, compared to static sensors, will be quantified with a very simplified observing system simulation per use case.

The proposed algorithms, partially tested on simulation software, will be integrated with University of Hawaii's COSMOS ground operations tool for software-in-the-loop verification. The onboard version of the algorithms will be integrated with NASAs Core Flight Software — an open source, project-independent framework used on flight missions such as MMS and GPM. It is expected to plan agile constellation operations, in terms of inter-satellite coordination and control, with minimum latency in a simulated environment, as verified in the cases above.

Accomplishments

- Completed the project and published a journal paper via a peer reviewed process as listed below.
- Gave an invited keynote talk at the DDDAS conference in Boston in October 2022.

Publications

R. Lammers, A.S. Li, V. Ravindra, S. Nag, "Prediction Models for Urban Flood Evolution for Satellite Remote Sensing", Journal of Hydrology 603 (2021), pp 127175, DOI:10.1016/j.jhydrol.2021.127175.

Awards

- Engineer of the Year, Aerospace and Robotics, American Society of Engineers of Indian Origin, February 2022.

Detecting extreme events in streaming satellite data

Project Participants

BAERI: Taejin Park
Syracuse University: Dr. Mohan Chilukuri, Subodh Kalia
University of Houston: Akash Aswathi, Dr. Hien Van Nguyen
NASA: Andrew Michaelis

Project Description

Detecting extreme events in streaming satellite data
Near real time detection of extreme or anomalous events such as wildfires, cyclones, or floods in satellite data is becoming crucial for managing disasters. Though there are several Earth observing satellites providing information about disasters, those in geostationary orbit provide data at intervals as frequent as every minute—practically a video from space. Analyzing these satellite data in the form of videos is very difficult due to the high volume of data. In this work, we developed a framework to detect and localize the wildfires in the satellite videos as described below.

Methodology
Anomaly detection is defined as the identification of the unexpected events. Therefore, predicting future frames based on the previous frames, and comparing the predicted frame with the ground truth is a better way of identifying the anomalous frames. In this study, we use the future frame prediction based anomaly detection technique to identify the anomalous frame. Our model is trained on the videos containing the normal frame, and tested on the mixture of normal and abnormal frames containing the fires. The main challenge here is to extract the video clips containing the normal frames. It can be done manually by identifying the clips from the pool of the video dataset, but we have used the pre-trained YOLOv5 to extract the abnormal and normal frames. Yolo stands for 'you look only once.' It is a family of object detection algorithms used to identify certain objects in the image. It divides the images into grids, and each cell in the grid is responsible for identifying the objects within itself. This is a transfer learning based method to identify normal and abnormal frames. The whole pipeline is divided into parts: Normal and abnormal frame extraction, and model training.

Normal and abnormal frame extraction
A raw dataset consists of the videos representing the climatic conditions of the different regions of the United States. For the current experiment, we have used the data of the North California region, and divided the videos into short clips. YOLOv5 is trained on publicly available fire images, and uses this pre-trained model to identify the short clips having the fire. This helps us to identify the clips that do not contain any fire, and these can be used as normal dataset for training the anomaly detection framework.

Accomplishments

- Project abstract accepted to AGU 2022 for an oral presentation.

Presentations

- Presenting at AGU 2022 Fall Meeting, Chicago, IL.

Project goals for 2023

- To extend this project and develop it for all kinds of anomalies other than fire, such as fog and hurricanes.
- To convert this research into a tool built for use by the community.
- Localize the anomalies in the video frames to understand which area is having the natural disaster using object localization or segmentation techniques.
- Continue to work on the paper to submit it to IEEE Transactions.

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

Project Participants

BAERI: Vinay Ravindra, Sreeja Roy-Singh

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.

Accomplishments

- Demonstrated D-SHIELD in an Observing System Simulation Experiment (OSSE) for a global soil moisture monitoring scenario using synthetic aperture radars (SARs) on agile satellites. To our knowledge, we have developed the first system to solve this complicated problem by integrating multiple s/cs with multiple heterogeneous sensors. The objective was to reduce the error in the knowledge of soil moisture from a (soil moisture) prediction model.
- Developed and evaluated novel heuristic search methods for integrating time-dependent target value and viewing-geometry/location-dependent observation quality. The presented methods may be extended to other geophysical variables and, more realistically, to consider multiple geophysical variables at once, since typically missions have multiple geophysical variables at focus.
- Provided a first glimpse of what adaptive sensing looks like in this new context, which may inform future mission design. For example, we have initial answers to questions such as:
    - How many observations can fit in a 6-hour horizon?
    - How much *knowledge error* will be reduced?
    - How much energy will be required for the observations and amount of time spent on maneuvers in a typical plan?

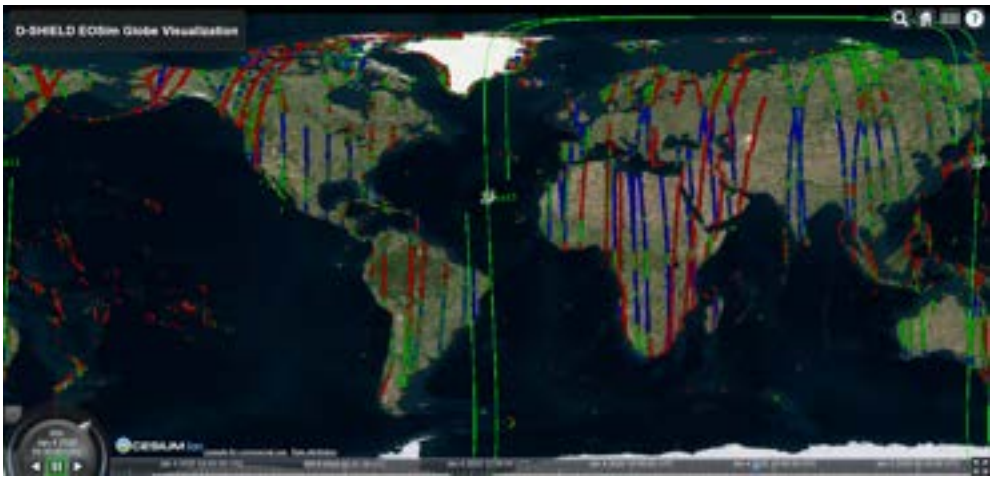

Figure 1: The executed spacecraft observation plan to monitor soil moisture. The scientific-value of the observations are color coded red, blue, and green to indicate low, moderate, and high values respectively.

Publications

R. Ketzner, V. Ravindra and M. Bramble, “A Robust, Fast, and Accurate Algorithm for Point in Spherical Polygon Classification with Applications in Geoscience and Remote Sensing,” Computers & Geosciences, Volume 167, 2022.

A. Melebari, S. Nag, V. Ravindra, M. Moghaddam, ”Soil Moisture Retrieval from Multi-Instrument and Multi-Frequency Simulated Measurements in Support of Future Earth Observing Systems”, IEEE International Geoscience and Remote Sensing Symposium, Kuala Lumpur, Malaysia, July 2022.

A. Kannan, G. Tsagkatakis, R. Akbar, D. Selva, V. Ravindra, R. Levinson, S. Nag, M. Moghaddam, ”Forecasting Global Soil Moisture using a Deep learning Model integrated with Passive Microwave Retrieval”, IEEE International Geoscience and Remote Sensing Symposium, Kuala Lumpur, Malaysia, July 2022.

Levinson, R., Niemoeller, S., Nag, S., Ravindra, V. (2022). Planning Satellite Swarm Measurements for Earth Science Models: Comparing Constraint Processing and MILP Methods. Proceedings of the International Conference on Automated Planning and Scheduling, 32(1), 471-479.

Project goals for 2023

- Extend New Observing Strategy (NOS) tools developed under AIST-18's D-SHIELD (Distributed Spacecraft with Heuristic Intelligence to Enable Logistical Decisions) to schedule satellite operations for observing optimal soil moisture to evaluate and monitor fast evolving phenomena like wildfires. D-SHIELD supports heterogeneous payloads on a spacecraft constellation, such that observations and downlinks maximize value for a customizable relevancy scenario, after constraining for resources (satellites, ground), orbit, and bus capacity (power, onboard data, attitude control). D-SHIELD’s Scheduler is informed by a Science Simulator that is based on a machine-learning model of the scientific phenomenon of interest. It assimilates data from past observations by the constellation and external sources, and predicts the quantitative value of future observations or operational decisions.
- D-SHIELD has been demonstrated in simulation on a global soil moisture monitoring scenario using synthetic aperture radars (SARs) and radiometers on agile satellites. We will develop “Rapid D-SHIELD” to:
    - Demonstrate the value of extending D-SHIELD to using soil moisture for improving wildfire predictions and monitoring. We will refine D-SHIELD architecture to reduce soil moisture uncertainty after transient events like rain and ignition. It will support faster cadence of iteration of assimilating data, tasking the agile components, and executing the tasks within a simulation of selected fire and rain events.
    - Extend the instrument module to include reflectometers (L and P band) that can improve soil moisture retrievals in addition to narrow swath SARs and coarse resolution radiometers.
    - Update satellite technology modules to support heterogeneous operations for retrieval using three types of spaceborne instruments applied to wildfire spread.
    - Fuse data from the new reflectometers using the soil moisture science simulator. We will apply for parallel funding to develop a new wildfire science simulator that uses soil moisture as input into development of pre fire products like live fuel moisture alongside ancillary data.
    - Update the scheduler to ingest new objectives and constraints, and produce efficient, soft real-time solutions onboard and on the ground station. We will also add new features such as compute characterization and resiliency to execution errors.

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

FLUID - Federated Learning Using In Space Data

Project Participants

BAERI: Graham Mackintosh
Hewlett Packard Enterprise: Mark Fernandez
Intel: Patrick Poley
USC: James Casaletto

Project Description

The FLUID project aims to develop and validate an architecture for training neural net models using data that is generated (and remains) in space, in conjunction with terrestrial data that is generated (and remains) on the ground. This will be an increasingly important capability as our cis-lunar and deep space missions—both crewed and robotic—generate ever more data while simultaneously operating at distances and environments that will severely challenge the data downlinks that would be needed for terrestrial analysis and AI modeling.

For example, a model to predict musculoskeletal degradation of astronauts living within a lunar habitat may need to be developed and subsequently fine-tuned using terrestrial data from ongoing animal studies, in conjunction with data obtained from routine health checks of lunar surface crews. That lunar-borne healthcare data may be too confidential and too large to downlink for machine learning on Earth using a traditional consolidated dataset. Yet the desired risk model would be more effective if all data could be virtually combined.

FLUID will solve this problem using a technique called federated learning, in which the system architecture trains model fragments in-situ with the data, and then the much smaller model components are transmitted and federated into a single neural network. Put another way, FLUID moves the model to the data instead of the data to the model, even when that data resides off-world.

Accomplishments

- Completed code on the FLUID platform—OpenFL and CRISP components are fully integrated.
- Completed full integration testing on NASA secure AWS cloud.
- Implemented a linux bash script "plug in" to simulate ISS communications outages, allowing more robust testing of FLUID prior to deployment as an ISS payload.

Project goals for 2023

- Complete FLUID platform testing, with a focus on performance and scalability.
- Assist the NASA Genelab team in the implementation of an AI model that will use the FLUID platform to use data on the ISS to assess the reproductive health of female astronauts during deep space missions.
- Work with the Ames chief medical officer to propose and secure funding for a program to use AI in order to enhance the capabilities of the NASA Ames E-Nose device for non-invasive health monitoring of astronauts using breath analysis.

NeMO-NET (Neural Multimodal observation and training network for global coral reef assessment)

Project Participants

BAERI: Michal Segal Rozenhaimer
NASA: Ved Chirayath (currently at University of Miami), Mike Little, Woody Turner

Project Description

NeMO-Net is a single player iPad game where players help NASA classify coral reefs by painting 3D and 2D images of coral. Players can rate the classifications of other players and level up in the food chain as they explore and classify coral reefs, and other shallow marine environments and creatures from locations all over the world. Data from the NeMO-Net game is fed to NASA NeMO-Net, the first neural multi-modal observation and training network for global coral reef assessment. NeMO-Net is an open-source deep convolutional neural network (CNN) that leverages NASA's Supercomputer, Pleiades, to use game data to classify and assess the health of coral reefs around the world.

Due to the massive amounts of sample data required to train machine learning algorithms, NeMO-Net includes an online classification application for mobile and desktop, which leverages the power of citizen science and active learning to generate accurate, high-resolution classification datasets. This application trains users to accurately identify coral reef families and semantically segment 3D coral reef scenes. The application also acts as an active learning framework, allowing users to rate and build off of other users' classifications.

NeMO-Net was released in April-2021 for desktop and iOS. To date, the application has had over 43,000 downloads and over 71,000 unique coral reef classifications, each filtered through a user-based rating and expert evaluation system. It is available to download at www.nemonet.info.

Accomplishments

- Trained and applied the NeMO-Net model on South-Pacific Island Regions.
- Began work to adopt the model to other regions of the world to produce global coral reef maps.
- Increased global usage of the app.

Presentations

- Ana M. Tarano, Ved Chirayath, Michal Segal-Rozenhaimer, Sam Purkis, Toward Global Coral Resilience and Biodiversity Assessments By Expanding NeMO-Net's Marine Habitat Mapping, in: B006: - Advances in remote sensing for monitoring biodiversity change: Integrating data and models across scales and technologies, AGU 2022

Publications

Segal Rozenhaimer Michal, Alan Li, Kamalika Das and Ved Chirayath, (2020), Cloud Detection Algorithm for Multi-Modal Satellite Imagery using Convolutional Neural-Networks (CNN), Remote Sensing of Environment, Remote Sensing of Environment 237 (2020) 111446.

Li, Alan, Ved Chirayath, Michal Segal-Rozenhaimer, Juan L. Torres-Perez, (2020), NASA NeMO-Net's Convolutional Neural Network: Mapping Marine Habitats through Spectrally Heterogeneous Remote Sensing Imagery, IEEE-Journal of Selected Topics in Applied Earth Observations and Remote Sensing, JSTARS-2020-00665.

Van den Bergh J, Chirayath V, Li A, Torres-Pérez JL and Segal-Rozenhaimer M (2021), NeMO-Net – Gamifying 3D Labeling of Multi-Modal Reference Datasets to Support Automated Marine Habitat Mapping. Front. Mar. Sci. 8:645408. doi: 10.3389/fmars.2021.645408.

Project goals for 2023

The project has been completed (as of February, 2022). The team is continuing to do work to make sure that the app can transition into use as an operational tool, both for United Nations Sustainability Goals (SDGs), as well as PICOGRAM and MarineVerse.

With that in mind, the remaining goals are to:

- Expand the NeMO-Net algorithm to cover the global dataset available on multiple platforms, including LOF, and other satellite datasets.
- Test and improve prediction accuracy matrixes over larger regional and global datasets.

Education, Outreach, and Workforce Development

Applied Remote Sensing Training (ARSET)

Project Participants

BAERI: Britnay Beaudry, Amber McCullum
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 trainings that are designed with the user in mind. We have a variety of application areas, such as trainings focused on water resources, disasters, health and air quality, and land management. The team here at NASA Ames focuses on land and wildfire trainings. We have trainings on change detection, wildfire detection, tracking deforestation, freshwater monitoring, time series analysis, and more. Participants can build skills and grow through ARSET. Participants are introduced to the fundamentals of remote sensing; they learn how to find and download NASA data; and, they learn to process and analyze data using geospatial software to aid in decision-making. All of our materials are freely available in both English and Spanish on the ARSET website: https://arset.gsfc.nasa.gov/

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

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 came up. During the first session, we 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 unique organizations**! The 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 over 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 (UNDP), Di Zhang (UNDP), Osgur McDermott-Long (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 unique 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, spectrometry of aquatic/coastal vegetation, and a demonstration of the NASA-funded Floating Forests citizen science tool. The training reached 813 participants from ~400 unique 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. It also provided an overview of how Earth Observations (EO) can be used to support global frameworks and initiatives such as standards set by the United Nation's System of Environmental Economic Accounting (UN-SEEA). The training reached 1,668 participants from ~800 unique 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, set to occur in January 2023, will provide 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 will also be provided with case-study examples of successful citizen science projects, in particular those funded under NASA's Applied Sciences Program. We will highlight projects like NeMO-Net: a global coral reef classification with 2D and 3D images application combined with machine learning; Floating Forests: a Giant Kelp monitoring platform where participants can classify 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 GLOBE Observer Mosquito Habitat Mapper: an application that pairs satellite-based observations of temperature, water and vegetation with sites where citizens scientists report potential mosquito habitat and presence of mosquito larvae.

Project goals for 2023

For the ARSET Land Management Application area here at Ames, we are conducting four trainings in FY23:

- **Connecting Citizen Science with Remote Sensing** (Bilingual, January 2023).
    - https://appliedsciences.nasa.gov/join-mission/training/english/arset-connecting-citizen-science-remote-sensing
- **Biodiversity Applications for Airborne Imaging** (March–April 2023).
    - This training series will first highlight the use of hyperspectral visible to Shortwave Infrared (VSWIR) imaging spectroscopy data, for example from AVIRIS-NG and PRISM instruments, for measuring and monitoring terrestrial and aquatic biodiversity (e.g., mapping plant or phytoplankton functional types). Next, the series will focus on using thermal and LiDAR data for characterizing the structure and function of ecosystems using airborne campaigns including the Hyperspectral Thermal Emission Spectrometer (HyTES) and NASA's Land, Vegetation, and Ice Sensor (LVIS). This training will also prepare participants for the use of data from upcoming NASA satellite missions and airborne campaigns such as the anticipated Surface Biology and Geology (SBG) mission and the NASA Biodiversity field campaign in the Greater Cape Floristic Region of South Africa (BioSCape).
- **Assessing the Impacts of Fires on Watershed Health** (cross-cutting with Disasters) (July 2023).
    - This advanced-level training will focus on using remote sensing observations for monitoring post-fire impacts on watershed health. Specifically, this training will highlight uses of NASA EO for pre-fire land cover mapping, watershed delineation and stream mapping, post-fire burn severity mapping, and pre- and post-fire riverine and freshwater water quality. This three-part training will highlight case studies that use remote sensing data for assessing the impacts of fires on watersheds. This training will also provide participants with hands-on exercises for using NASA EO for these assessments within the Soil Water Assessment Tool and Google Earth Engine.

- **Advanced Ecosystem Services with Remote Sensing** (September 2023).
    - This four-part training will provide participants with hand-on exercises for developing ecosystem extent maps for ecosystem accounting with the use of Google Earth Engine and R. Participants will be guided through analysis techniques for image composting and mosaicking, cloud and shadow masking, creating spectral indices, creating land cover classifications, and creating change detection maps. Guest speakers from the NASA-CI GDSA project will provide use cases for mapping land cover extent and change in Liberia and mangrove mapping in Guinea. In the second half of our series, participants will be guided through the Artificial Intelligence for Environment and Sustainability (ARIES) platform and the Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) models, two commonly used platforms for ecosystem accounting. These will assess the value of their data and determine how best to apply the data to decision-making.

California State University at Monterey Bay (CSUMB) Educational Program

Project Participants

CSUMB: Susan Alexander
Students: Kristen Burroughs, Andrea Cihasky, Conor Doherty, Samantha McCarrell, Katherine Tinsman

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

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

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

Accomplishments

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

Presentations

- (Invited keynote) Melton, F., Carrara, W., Doherty, C., Guzman, A., Johnson, L., Solymar, R., et al., 2022. Operational Evapotranspiration Data for Water Management in the Western United States Washington Hydrogeology Conference, Tacoma, WA, May 11, 2022.

- Melton, F., Carrara, W., Doherty, C., Guzman, A., Johnson, L., Solymar, R., et al., 2022. OpenET: Operational Evapotranspiration Data for Water Management in the Western United States. ASPRS Pecora Conference, Denver, CO, October 27, 2022.
- Melton, F., Carrara, W., Doherty, C., Guzman, A., Johnson, L., Solymar, R., et al., 2022. OpenET: Operational Evapotranspiration Data for Water Management in Oregon. Oregon Water Resources Department / Oregon State University Evapotranspiration Workshops, Hemiston and Portland, OR, Sept 9-10, 2022.
- Purdy, A.J., Melton, F., Carrara, W., Doherty, C., Guzman, A., Johnson, L., et al., 2022, Supporting Sustainable Groundwater Management in the Salinas Valley with Satellite-based Evapotranspiration Data. California State University Agricultural Research Institute Annual Conference, Sacramento, CA, October 21, 2022.
- Bromley, M., Melton, F., Carrara, W., Doherty, C., Guzman, A., Johnson, L., et al., 2022. OpenET: Operational Evapotranspiration Data for Water Management in the Western United States. AGU Frontiers in Hydrology Conference, Puerto Rico, June 20, 2022.
- Grimm, R., Melton, F., Carrara, W., Doherty, C., Guzman, A., Johnson, L., Solymar, R., et al., 2022. OpenET: Filling the Biggest Data Gap in Western Water Management, World Water Week, Stockholm, Sweden, August 25, 2022.
- Melton, F., Carrara, W., Doherty, C., Guzman, A., Johnson, L., Purdy, A., Solymar, R., et al., 2022. OpenET. Presentations to the Western States Water Council, Colorado River Authority of Utah, Upper Colorado River Commission, Oregon Water Resources Department, California State Water Resources Control Board, American Farm Bureau Federation, USGS, Department of the Interior and other partners and stakeholders throughout 2022.

Publications

Melton, F., Huntington, J., Grimm, R., Herring, J., Hall, M., Rollison, D., Erickson, T., Allen, R., Anderson, M., Fisher, J., Kilic, A., Senay, G., volk, J., Hain, C., Johnson, L., Ruhoff, A., Blanenau, P., Bromley, M., Carrara, W., Daudert, B., Doherty, C., Dunkerly, C., Friedrichs, M., Guzman, A., Halverson, G., Hansen, J., Harding, J., Kang, Y., Ketchum, D., Minor, B., Morton, C., Ortega-Salazar, S., Ott, T., Ozdogon, M., Schull, M., Wang, T., Yang, Y., Anderson, R., 2021. OpenET: Filling a Critical Data Gap in Water Management for the Western United States. Journal of the American Water Resources Association, 2021 Nov 2. https://doi.org/10.1111/1752-1688.12956

Cahn, M.D., Johnson, L.F. and Benzen, S.D., 2022. Evapotranspiration Based Irrigation Trials Examine Water Requirement, Nitrogen Use, and Yield of Romaine Lettuce in the Salinas Valley. *Horticulturae*, *8*(10), p.857.

Doherty, Conor T., Lee F. Johnson, John Volk, Meagan S. Mauter, Nicolas Bambach, Andrew J. McElrone, Joseph G. Alfieri et al. "Effects of meteorological and land surface modeling uncertainty on errors in winegrape ET calculated with SIMS." *Irrigation science* 40, no. 4 (2022): 515-530.

Project Goals for 2023

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

Indigenous Peoples Initiative

Project Participants

BAERI: Sativa Cruz, Amber McCullum, Cindy Schmidt, Nikki Tulley
NASA: Lawrence Friedl

Project Description

The Indigenous Peoples Initiative (IPI), within NASA's Capacity Building Program Area, seeks to support and cultivate efforts within Indigenous communities and NASA to increase the use of Earth Observations (EO) to inform decisions, policies, and actions. The IPI team is uniquely positioned to foster respectful and reciprocal relationships between NASA and Indigenous communities to sustainably co-develop trainings, projects, and tools. The pillars of this work are centered around 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/indigenous-peoples-pilot.

Accomplishments

- Annual Retreat, January 25-28, 2022, at Ames Research Center:
  - During this time together we focused on team building, priority setting, and 5-year planning. Over the three days of reflection we discussed the IP initiative's intersection with EEJ with guidance from James Rattling Leaf Sr of the Rosebud Sioux Tribe. We began a Theory of Change informed by additional meetings with our colleagues in the CBP. There was mutual interest in collaboration between program elements and a lot of enthusiasm about possibilities. On our final day together we identified 4 core themes upon which to build our program's strategy.
- Capacity Building Program Retreat, January 31 - February 2, 2022, Virtual:
  - Attended the virtual annual Capacity Building Retreat, where we reported on our initiative's activities and engaged in strategic planning for the entire larger program.
- NASA ROSES A.49 Solicitation on Environmental Justice Tribal Preproposers Telecon, February 10, 2022:
  - Presented alongside CBP program managers for a proposers telecon for the NASA ROSES A.49 Solicitation on Environmental Justice and connections to tribal communities on January 10.
- Conducted ASP Program Review, February 15, 17 2022.
- Tribal Consultation Working Group, February 17, 2022, Meetings Ongoing:
  - Began engagement with this group, being led by Rebecca Klein, Federal Preservation Officer, Office of Strategic Infrastructure.
  - Attended bi-weekly and/or monthly planning meetings throughout 2022.
- WWAO Rio Grande Needs Assessment, March 7-9, 2022:
  - Engaged with water users in the Rio Grande to generate multiple use cases for relevant applications of NASA remote sensing data for water management issues. Outcomes from this workshop will be used in future solicitations for NASA-funded projects through WWAO. Our team participated to provide Indigenous perspectives.
- Provided a hands-on workshop titled: *From Earth Observations to Action: NASA data for natural resource monitoring and climate change* for the 12th annual Tribal GIS Conference in Albuquerque, NM on April 25, in collaboration with the Earth Science Data Systems (ESDS) Program, the Earth Science Data Systems GIS Team (EGIST) and the Transform to Open Science (TOPS) teams. This year's conference theme was *Geospatial Resilience in Indian Country* (https://ntgisc.regfox.com/12th-annual-tribal-gis-conference). This workshop introduced participants to the application of NASA remote sensing data and tools to monitor a variety of natural resource and climate change indicators, highlighting droughts and wildfires. The team

also facilitated a listening session on April 28 titled: *Open Science, Open Ears,* focusing on input about NASA's TOPS initiative and suggestions to improve tribal engagement. The team interacted directly with 28 participants from 13 states representing various tribal nations, such as the Pit River Tribe, the Hualapai Tribe, the Pueblo of Tesuque, the Salamatof Tribe, and others. Participants came from a variety of backgrounds including: tribal natural resource managers, students, federal agency employees, and more.

- Delivered training to the Karuk Dept. of Natural Resources, *An Introduction to Remote Sensing for Land and Wildfires*, on August 1. This was a full-day virtual workshop with KNDR staff and included guest presentations from FireSense intern Maya Saidel and NASA Ames/BAERI researcher Kristina Pistone. We had approximately 10 KNDR personnel in attendance.
- Delivered training for the National Tribal and Indigenous Climate Conference titled: *The aid of Natural Energy: Using NASA data for monitoring droughts and wildfires* on August 29. This was a 2-hour virtual training that highlighted DSET, FIRMS, and other NASA resources for tribes. We had 23 participants from regional tribal groups.
- Co-delivered a session titled: *Storying the Relationship Between Indigenous Wisdom and Earth Observation* (EO) with the Canadian Space Agency (Guy Aubé and Dirk Werle), and Melanie Goodchild (Anishinaabe/ University of Waterloo) for the 2022 National Forum on Earth Observations on Oct 4th. This session used a storytelling technique called "yarning" to explore pathways for linking traditional knowledge and Earth observation capabilities: A collective wisdom journey.
- Co-hosted a workshop at the National Adaptation Forum (nationaladaptationforum.org) on October 26, titled *Co-development of a U.S. Earth Observation (EO) enterprise engagement strategy with tribal nations for addressing climate change* alongside partners from NOAA, USGS, the Rosebud Sioux Tribe, and the Navajo Nation. The session featured lightning talks from the Geo Indigenous Alliance, NASA's IPI, and the South Central Climate Adaptation Center. The session concluded with discussion around enabling effective, respectful, and reciprocal relationship building among USGEO institutions and Tribal Nations.
- Organized multiple training sessions for the Indigenous Mapping Workshop held November 23-25, 2022 in Edmonton, Canada. These sessions include: (1) Introduction to Satellite Earth Observation, (2) Mapping the burn severity of a wildfire in ArcGIS Pro Part 1, (3) Mapping the burn severity of a wildfire in ArcGIS Pro Part 2, (4) Communicating wildfire impacts using StoryMaps, (5) Satellite Earth Observations in Practice: Sharing Stories and Experience Part 1, (6) Satellite Earth Observations in Practice: Sharing Stories and Experience Part 2, and (7) Satellite Earth Observations - Collective Turtle Island Storytelling.
- Assisted in coordinating a NASA Tribal Consultation forum. This will be a virtual forum and listening session hosted by NASA Administrator Bill Nelson on Wednesday, January 11, 2023. The goal of the forum is for NASA to hear suggestions from tribal leaders for actions the Agency could take to improve consultation and strengthen our relationships, and to learn how each Tribe's specific interests and activities overlap with NASA's existing programs and opportunities. NASA has created a website for tribal consultation and coordination: https://www.nasa.gov/tribal_affairs.
- Prepared for an in-person training with the Karuk Dept. of Natural Resources for Jan/Feb on the use of Earth Observations for wildfires and landscapes.
- Prepared for a Navajo Nation Nihimá Nahasdzáán – Art of Mother Earth – Gallery Event, and Navajo Nation Needs Assessment to occur in Feb 2023. These activities will feature a community-based evening event at the Navajo Nation museum showcasing the beauty of Earth Observations. The second-day event will focus on natural resource mgmt. needs and alignment with remote sensing technology.
- Created a draft 5-year Strategic Plan.

Presentations

- NASA's Indigenous Peoples Initiative, US GEO Annual Workshop, April 11-14, 2022.
- 2022 National Forum on Earth Observation, Oct 4-6:
  - Co-delivered with the Canadian Space Agency (Guy Aubé and Dirk Werle) and Melanie Goodchild (Anishinaabe/University of Waterloo) titled "Storying the Relationship Between Indigenous Wisdom and Earth Observation (EO)."
- Geo for Good Summit, Oct 4-6:
  - Plenary Talk: A collaboration of Sovereignty and Science for the Navajo Nation.
  - Panel Discussion: An Inclusive Future for the Geo for Good Community.
- AGU Fall Meeting: NASA EEJ Town Hall.

Project goals for 2023

- Conduct Regional Needs Assessments around the use of EO in Indigenous communities.
  - Collaborate with USGS and existing tribal networks (e.g., ITEP) for planning.
  - Coordinate 2 in-person workshops that will have a regional focus:
    - Southwest: Held in collaboration with the Navajo Nation (Spring 2023).
    - Great Plains: Held in collaboration with the Rosebud Sioux Tribe (Fall 2023).
  - Invite tribal leaders and tribal natural resource managers.
  - Provide training on remote sensing.
  - Cultivate dialogue about current uses of remote sensing and opportunities for future uses.
  - Obtain feedback about existing applications (e.g. those developed through ASP program elements), including uses, relevance, and improvements as they relate to Indigenous communities.
  - Generate workshop report.
  - Outline opportunities to continue needs assessments in FY24.
- Support Indigenous-focused EEJ A.49 Projects.
  - Team member to act as an associate for four projects.
  - Assist project leads with NASA reporting and project progress.
  - Assist project leads with capacity building.
- Plan and conduct trainings/workshops.
  - CSA's National Earth Observation Forum, October 4-6, 2022 (presentation, virtual).
  - Geo for Good, October 4-6, 2022 (workshop, in-person).
  - National Adaptation Forum, Oct 25-27, 2022 (workshop, in-person).
  - Indigenous Mapping Workshop, Nov 21-23, 2022 (training, in-person).
  - Tribal GIS, Spring 2023 (training, in-person).
  - Karuk/Yurok Remote Sensing for Wildfires and Landscapes, Spring 2023 (training, in-person).
  - Native American Fish and Wildlife Training at regional or national conference, Fall 2023 (training).
- Support of GEO and US GEO Indigenous Engagement.
  - Provide support to GEO Indigenous Alliance as needed.
  - Continue to attend US GEO meetings and assist in strategic planning around a US GEO Indigenous Alliance as needed.
- Continue relationship building and outreach to communities.
  - Continue to hold meetings with tribal natural resource management personnel around opportunities for the use of remote sensing on tribal lands.
  - Continue to collaborate with the Canadian Space Agency on trainings, projects, and cross-agency efforts to support Indigenous communities.
  - Connect tribes with data, tools, and NASA scientists as requested for support of their land management needs.
  - Attend relevant conferences.
  - Identify Indigenous-focused uses of EO and potential for supporting activities with groups such as ITEP and AIHEC.
  - Continue to connect with regional tribal groups (e.g., the Western Regional Partnership and Native American Fish and Wildlife Society), private organizations (Google and ESRI), and nongovernmental organizations (Firelight group) in support of the increased use of EO for Indigenous communities.
- Continue relationship building and in-reach with NASA.
  - Continue engagement with NASA Tribal Affairs group and consultation planning.
  - Engage with NASA Ames Native American Advisory Committees and Natives at NASA.
  - Continue to connect with other CBP+ elements on projects and efforts related to EEJ, DEIA, Apps and Challenges, which could include an Indigenous hackathon and/or Indigenous focused DEVELOP projects.
  - Continue engagement with NASA MAIANSE through internship opportunities and shared goals.
  - Connect with relevant ASP projects and efforts, such as WWAO and FireSense, as they work with Indigenous communities.
  - Begin work on a guidebook outlining lessons learned for respectful and reciprocal engagement strategies for NASA scientists working with Indigenous communities.

- Continue communications projects.
    - Update website.
    - Create communications materials such as ArcGIS Storymaps.
    - Continue to work with NASA communications personnel for articles and social media posts.
- Create a Theory of Change and update IPP long-term strategy as needed (Winter 2022).
- Catalog participants who take trainings and those who engage in needs assessment workshops in order to cultivate network of Indigenous geospatial personnel.

Partnerships

Project Participants

BAERI: Amber McCullum (off the partnerships work as of October 2022), Cindy Schmidt
NASA: Keith Gaddis, Shanna McClain

Project Description

NASA's Earth Science Division and Conservation International are collaborating on approaches for the assessment and monitoring of ecosystem health and natural capital flows to amplify the role of Earth observations and drive more sustainable decision making at national and regional scales. The partnership deepens the impact and application of NASA ESD remote sensing data and research, and advances natural resource management, including natural capital accounting and ecosystem health assessment. Efforts under this collaboration include development of ecosystem accounts for Liberia, Botswana, and Gabon, which contribute to the Gaborone Declaration for Sustainability in Africa (GDSA), as well as development of the Freshwater Health Index (FHI) in the Mekong region (southeast Asia) and the Okavango (Africa).

Accomplishments

- Organized bi-monthly meetings with the FHI team to obtain project updates with NASA team members and Conservation International (CI).
- Participated in bi-weekly and quarterly review meetings with the GDSA team to obtain project updates with NASA team members and CI.
- Organized project updates into highlight slides to capture impact.
- Updated the two NASA-CI Space Act Agreements for both projects.
- Developed end user questionnaire for GDSA countries: Liberia, Botswana, Gabon.

Project goals for 2023

GDSA project:

- Help develop capacity building materials for creating ecosystem maps for potential trainings in Liberia.
- Expand project to include Coastal ecosystems in Senegal.
- Attend bi-weekly tag up meetings and quarterly internal NASA review meetings, as well as NASA leadership review meetings.
- Coordinate activities and communication between CI and NASA Headquarters.
- Help develop project success metrics for Phase 2 of the partnership.
- Work with ARSET to develop a second Ecosystem Accounting online training.

FHI project:

- Organize monthly meetings with NASA and CI.
- Advise the FHI team on stakeholder engagement, in particular working with regional, government, and local communities.
- Develop capacity building materials for stakeholder trainings.
- Generate reports and highlights of the team's activities for NASA management.
- Expand the project to the La Plata River Basin in South America.
- Assist in developing assessment metrics for the FHI project.
- Attend regular meetings with the larger NASA partnerships team and report on progress.

SARP

Project Participants

BAERI: Gary Ash, Ryan Bennett (starting November 2022), Brenna Biggs (through October 2022), Pat Finch, Terry Hu, Tu Phan, Dave Van Gilst, Adam Webster
San Diego State: Daniel Sousa
UC Irvine: Donald Blake, Barb Chisholm
UC Riverside: Roya Bahreini
UC Santa Barbara: Andreas Beyersdorf
UC Santa Cruz: Raphael Kudela
NASA: Kristen Boogaard, Brian Hobbs, Jack Kaye, Barry Lefer, Melissa Yang Martin (through September 2022), Thomas Matthews, Jasmine Tabla, Bruce Tagg, Christina Zinger

Additional Instrument PIs and guests:
Please note, these often will change from year to year depending on payload. Postdocs and students not listed.
Howard University: Joseph Wilkins
St. Edwards University: Paul Walter
UC Irvine: Ann Marie Carlton
University of Houston: Sergio Alvarez, Jimmy Flynn
NASA LaRC: Glenn Diskin, Luke Ziemba
NASA GSFC: Glenn Wolfe
NASA JPL: Amin Nehrir

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. Twenty-eight students are selected and divided into four groups, each focusing on a different topic and led by faculty and graduate student mentors. The students attend rigorous lectures and receive training about tropospheric chemistry, climate change, coding, and instrumentation before they fly on scientific research flights, typically on the NASA DC-8 aircraft, based at NASA Armstrong Flight Research Center (AFRC).

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

Accomplishments

- Selected 28 students from across the United States (17 states and Puerto Rico) from various academic and personal backgrounds to participate in the program.
- Recruited 5 faculty members and 5 graduate students to act as mentors for the duration of the program.
- Separated the group of 28 students into 4 groups of 7 students: Whole Air Sampling, Ocean Remote Sensing, Terrestrial Ecology, and Atmospheric Aerosols. Each group was led by faculty and graduate student mentors.
- Conducted 2 days of science flights (3 total flights) out of NASA AFRC on the NASA DC-8 platform to collect samples and data.
- Provided additional science enrichment activities: ozonesonde preparations and launches (10 total) and mobile lab excursions (5 day-trips).
- Supported each of the 4 groups to conduct field trips to various locations for ground truthing: 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.
- Provided a diverse variety of speakers (38 formal lectures) 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.
- Selected and funded the top 4 students to present their SARP research at AGU 2022, along with the top 4 students from NASA SARP 2021.
- Featured in NASA Article, August 2, 2022: SARP Ozone Sondes Coincide with SAGE III/ISS Measurements | NASA
  - www.nasa.gov/feature/langley/sarp-ozone-sondes-coincide-with-sage-iiiiss-measurements/
- Featured in NASA Article, June 30, 2022: NASA Flies Students on DC-8 to Study Air Quality | NASA
  - www.nasa.gov/centers/armstrong/features/nasa-flies-students-on-dc8-to-study-air-quality.html
- Featured in NASA ASP Newsletter, Spring 2022: NASA ASP Spring 2022 Newsletter
  - airbornescience.nasa.gov/sites/default/files/documents/ASPnewsletterSPRING2022.pdf
- Featured in NASA ASP Newsletter, Fall 2022: NASA ASP Fall 2022 Newsletter
  - airbornescience.nasa.gov/sites/default/files/documents/ASPnewsletterFALL2022%20_Final_0.pdf

Presentations

- Brenna Biggs, to students in the Student Airborne Science Activation (SaSa) Program on July 19, 2022.
- Brenna Biggs, to junior undergraduate students in the "Introduction to the Geography Major" course at San Diego State University on September 26, 2022. Talk title: "Future NASA Internship Opportunities: NASA Student Airborne Research Program."

Upcoming:

- Ryan Bennett will host a Hyperwall presentation highlighting the accomplishments of SARP alumni at the AGU 2022 meeting in Chicago. Tentative title is the following: "High Flying Interns: NASA Student Airborne Research Program (SARP) 2009-2022."
- Ryan Bennett will host a Hyperwall presentation highlighting the accomplishments of SARP alumni at the AMS 2023 meeting in Denver. Tentative title is the following: "High Flying Interns: NASA Student Airborne Research Program (SARP) 2009-2022."
- Ryan Bennett will be presenting a poster at AGU 2022 about data resulting from the overpass of the SAGE III satellite during SARP 2022: "From the Ground Up: Stratospheric Aerosol and Gas Experiment III on the International Space Station(SAGE III/ISS) Comparison of Vertical Profiles with 2022 Student Airborne Research Program (SARP) In Situ Data."
- Brenna Biggs will be presenting about Mission Tools Suite (including how it was used for communication between students airborne and on the ground during SARP): "Development of a Virtual Tool to Connect Classrooms to NASA Airborne Science Missions."

Publications

Schaller, E. L., Bennett, J. R., Blake, D. R., Kudela, R. M., Lefer, B. L., Martin, M. Y., Roberts, D. A., ... & Kaye, J. A. (2022). High-Flying Interns: NASA's Student Airborne Research Program (SARP). *Bulletin of the American Meteorological Society*, *103*(4), E1061-E1077.

Project goals for 2023

- Select 28 students from across the United States from various academic and personal backgrounds to participate in the program.
- Separate the group of 28 students into 4 groups of 7 students: Whole Air Sampling, Ocean Remote Sensing, Terrestrial Ecology, and Atmospheric Aerosols. Each group will be led by faculty and graduate student mentors.
- Conduct 2 or 3 days of science flights out of NASA AFRC on the NASA DC-8 platform to collect samples and data for SARP 2023.

- Support each of the 4 groups to conduct field trips to various locations for ground truthing.
- Provide 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.
- Support lodging and transportation for the students and mentors, as well as weekend enrichment activities, for the entirety of the summer.
- Host students presenting their final projects at the end of the program to their cohort and guests, selecting 4 to 6 top students to present at AGU in the following year.
- Support the NASA booth efforts and internship outreach at AGU 2023 and AMS 2023.

Student Airborne Science Activation (SaSa)

Project Participants

BAERI: Samiah Moustafa, Kristina Pistone

Project Description

The overarching goals of the Student Airborne Science Activation (SaSa) project are to increase the number of STEM degrees from Minority Serving Institutions (MSIs), and prepare students from MSIs to enter the STEM workforce. To achieve these goals, the SaSa project engages students through NASA-related airborne campaigns—providing authentic engagement to students promises to raise the profile of the geoscience departments in MSIs among the relevant academic, research, and local communities. This will raise the science literacy in minority institutions, and align them perfectly with one of the primary NASA SciAct objectives: Improve U.S. Scientific Literacy.

To contribute to reaching the overarching goals, the specific objectives of the SaSa project are to:

- Create a student geoscience learning ecosystem (GLE) to enable effective student engagement with NASA scientists and engineers, academic advisors, peers, and the local communities.
- Provide students with new skills to work with NASA science equipment and real data from field/airborne campaigns and satellite imagery.
- Provide students with the opportunity to participate in the full life-cycle of a research project, from conception, to data collection and analysis, and to synthesis and reporting.

BAER Institute participants are involved in Project Management and Project Evaluation.

Accomplishments

- Developed a Program Schedule for Summer 2022: 2022 SaSa - Program Schedule (Student Version) last updated 7/26/2022 https://docs.google.com/spreadsheets/d/16N-bj7HDBTv4umADm8s1hSioNfScByzpRJjQr9Bje6Y/edit#gid=974394514.
- Implemented a Geoscience Learning Ecosystem (GLE) at 6 partner MSIs, and incorporated NASA content (data sets, derived products, and tools) into SaSa and non-SaSa faculty led undergraduate courses in Earth, Ocean, and Atmospheric Science departments (21 courses in Fall 2021, reaching 572 students; 18 courses in Spring 2022, reaching 320 students).
- Developed and distributed evaluation surveys, in collaboration with the Independent Evaluator (Kavita Mitapalli), to assess undergraduate students' perception of NASA content and knowledge as well as assess learning and content knowledge to promote the development of skills for STEM and Earth Science careers.
- Coordinated undergraduate and graduate student mentor recruitment, including outreach, and program advertisement. Recruited students on NASA Handshake app, Facebook, Instagram, Twitter, and LinkedIn, as well as via advertisements with partner and non-partner MSI institutions via email and Earth Science listserv distribution.
- Secured and reviewed 110 undergraduate applications and 35 graduate student mentor applications. Led the evaluation committee (group of 5 reviewers), developed a weight and rank criteria, developed protocol to minimize evaluation bias, reached consensus on application ranks, interviewed 16 graduate student mentors, distributed offer letters, and made phone calls to secure promising candidates for the inaugural SaSa summer program.
- Managed a cohort of 5 graduate student mentors for the SaSa Summer Program, including coordination of coding lectures, and panel discussions.
- Developed a SaSa promotional summer program video in collaboration with a videographer, including content development, script writing, editing, and final production released on YouTube and NASA social media channels.
- Developed and maintained a NASA SaSa webpage, including the coordination of public affairs, to develop student biographies, co-I and mentor profiles, and linked blog and communication materials.
- Planned, wrote, and organized science communication writing for publication on NASA website and social

media platforms about the SaSa program, including SaSa's undergraduate students, graduate mentors, and co-Is, in collaboration with NASA ARC Earth Science Division Science Communication Specialist, Science Activation Program, and Communications Strategist Science Mission Directorate at NASA Headquarters.

- Developed an 8-week summer research program for first- and second-year undergraduates from partner and non-partner MSIs interested in STEM and Geosciences, including an educational and evidence-based program schedule, planning, coordination, science activities, and logistics between 6 partner universities and 3 NASA centers (Langley Research Center, Goddard Space Flight Center, and Wallops Flight Facility), as well as enrichment activities (e.g., field trips; invited speaker and professional development series; science writing and communication exercises; community, social-building activities, and programming to develop students' confidence and identity in the Geosciences).
- Invited early-, mid- and senior-career and high visibility speakers in academia, industry, and government as part of the SaSa Summer Program weekly Professional Development Series.
- Organized a two-week (16 total flight hours) NASA Airborne Science research campaign for the SaSa Summer Program to collect atmospheric measurements, including the organization of science flight priorities and a science flight plan for 5 research flights; developed complementary student research projects centered on the use of NASA Earth Science Division assets, including ground, airborne, and satellite remote sensing; acted as a liaison between SaSa co-Is, the science planning team, NASA instrument teams, and the Airborne Science flight crew and pilots at Wallops Flight Facility.
- Coordinated special events for a Media Day during the SaSa Summer Program, including video and written documentation of the SaSa airborne science campaign, including NASA Office of Communications, university and public journalists, as well as a 6-day collaboration with a videographer to develop outreach, recruitment, and promotional video and media content of the SaSa program.
- Supported 24 undergraduate students throughout the 8-week summer research program, including the development of their research projects, and continued to advise a sub-set of 5 students into the Fall semester for poster presentations at the American Meteorological Society Student and Annual Conferences.

Presentations

- AGU 2022: NASA's Student Airborne Science Activation for Minority Serving Institutions: Inaugural Program, Educational Outcomes, and Lessons Learned.

Presentations

ACCDAM: Chaired session: “Challenges in the Understanding of Absorbing Aerosol and Its Impacts on Clouds, Radiation, and Climate” at CMM.

ACCDAM: Invited Talk: Hampton University Atmospheric and Planetary Sciences seminar series, October 2022: “Observations of biomass burning aerosol over the southeast Atlantic Ocean and the meteorological context: Results from ORACLES.”

AGU 2022: NASA’s Student Airborne Science Activation for Minority Serving Institutions: Inaugural Program, Educational Outcomes, and Lessons Learned.

Alberto Guzman presented a talk on OpenET at World Water Week in Stockholm, Sweden in a session on “Achieving food and nutrition targets by 2030 through water security” (2022, August).

Ambrosia, V.G., D. Green, M. Falkowski, B. Lefer, M. Seablom,, P. Kopardekar, and L. Grindle, 2022. NASA's New Wildland Fire Earth Observation Science & Applications Programmatic Developments, 3rd International Conference on Fire Behavior and Risk (ICFBR-2022), Alghero, Sardinia, Italy, 4 May 2022.

Ambrosia, V.G., D. Green, M. Falkowski, B. Lefer, M. Seablom,, P. Kopardekar, and L. Grindle, 2022. NASA's New Wildland Fire Earth Observation Science & Applications Programmatic Developments, 5th GOFC-GOLD Fire IT and Global Wildfire Information System (GWIS), Stresa, Italy, 21-23 June 2022.

Ambrosia,V.G., D. Hadjimitsis, I. Gitas, 2022. The Mediterranean Regional Information Network (MedRIN), 5th GOFC-GOLD Fire IT and Global Wildfire Information System (GWIS), Stresa, Italy, 21-23 June 2022.

Ana M. Tarano, Ved Chirayath, Michal Segal-Rozenhaimer, Sam Purkis, Toward Global Coral Resilience and Biodiversity Assessments By Expanding NeMO-Net’s Marine Habitat Mapping, in: B006: - Advances in remote sensing for monitoring biodiversity change: Integrating data and models across scales and technologies, AGU 2022

Braden, D., Mondal, P., Park, T., Vargas, R., Identifying Variability in Forest Cover Estimates in Mexico by Comparing Multiple Satellite-Derived Data Products. Dec 2022, AGU 2022.

Brenna Biggs will be presenting about Mission Tools Suite (including how it was used for communication between students airborne and on the ground during SARP): “Development of a Virtual Tool to Connect Classrooms to NASA Airborne Science Missions.”

Brenna Biggs, to students in the Student Airborne Science Activation (SaSa) Program on July 19, 2022.

Broccardo et al., Evaluating the impact of absorbing aerosol on space-based NO2 retrievals using AERONET and Pandora in California, AGU Fall meeting A085 - Remote Sensing of Fire Processes and Biomass Burning Emissions poster session.

Broccardo S.P. et al: Enabling more routine monitoring of volcanic CO2 degassing from space, in OCO Science Team Meeting, local/urban breakout session, online, 2022-03-09.

Broccardo S.P. et al: Robotic sunphotometry to enable over-ocean aerosol characterization, in Advancement of Polarimetric Observations (APOLO), Silver Spring MD, Aug 2022.

Broccardo S.P. et al: RUMMBLE (Remote-sensing Underground Magma Movement Before Large Eruptions) Enabling routine volcano monitoring from space, in NASA Earth Surface and Interior Solid Earth Science Team Meeting, La Jolla, 7 Nov 2022

Bromley, M., Melton, F., Carrara, W., Doherty, C., Guzman, A., Johnson, L., et al., 2022. OpenET: Operational Evapotranspiration Data for Water Management in the Western United States. AGU Frontiers in Hydrology Conference, Puerto Rico, June 20, 2022.

Cahn, M., L. Johnson, S. Benzen, 2022. Weather-Based Irrigation Scheduling of Artichoke and Red Cabbage. UCCE Irrigation and Nutrient Management Meeting, 23 Feb, Salinas, CA.

Chen et al: Utilizing SAM data over volcanoes: a report of the in-progress work, in OCO Science Team Meeting, Local/Urban breakout session, Boulder CO and online, 2022-10-13

Data Analytics: Presenting at AGU 2022 Fall Meeting, Chicago, IL.

Duffy, K., and Vandal, T. J. (2022, January). LEO sensor to GEO sensor algorithm transfer models for land surface temperature. American Meteorological Society Annual Meeting.

Duffy, K., Vandal, T. J., and Nemani, R. R. (2021, December). Communicating metrics of land surface temperature variability using multi-sensor machine learning. American Geophysical Union Fall Meeting.

E.L. Yates et al., "The unusual case of AJAX: Archiving a multi-year, multi-objective, multi-instrument data set" NASA Airborne and Field Data Workshop, March 2022.

Ecological Forecasting: Moderator and presenter of a session on Sustainable Development Goals for the Pecora Remote Sensing Symposium conference in Denver in October.

Ecological Forecasting: Presented Applied Science overview to Karen St. Germain in July.

Ecological Forecasting: Presented at the Canadian Space Agency Earth Observation Forum in September.

Ecological Forecasting: Presented project summaries at Applied Science program reviews in May, July, October.

Feb-27-Mar-2-2023, 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.

Grimm, R., Melton, F., Carrara, W., Doherty, C., Guzman, A., Johnson, L., Solymar, R., et al., 2022. OpenET: Filling the Biggest Data Gap in Western Water Management, World Water Week, Stockholm, Sweden, August 25, 2022.

Hsu, C.-H., Henze, D., Mizzi, A., and McDonald, B. (2022): How well can assimilation of geostationary trace-gas observations constrain NOx emissions in the US, International Symposium on Data Assimilation, Colorado State University, Fort Collins, CO, June 10, 2022.

Hsu, C.-H., Mizzi, A., Henze, D., and McDonald, B. (2022): How well can assimilation of geostationary trace-gas observations constrain NOx emissions in the US, NASA Ames Research Center, Earth Science Division Seminar, Moffett Field, CA, September 30, 2022.

Indigenous Knowledge: 2022 National Forum on Earth Observation, Oct 4-6:

Indigenous Knowledge: AGU Fall Meeting: NASA EEJ Town Hall.

Indigenous Knowledge: Co-delivered with the Canadian Space Agency (Guy Aubé and Dirk Werle) and Melanie Goodchild (Anishinaabe/University of Waterloo) titled "Storying the Relationship Between Indigenous Wisdom and Earth Observation (EO)."

Indigenous Knowledge: Geo for Good Summit, Oct 4-6:

Indigenous Knowledge: NASA's Indigenous Peoples Initiative, US GEO Annual Workshop, April 11-14, 2022.

Indigenous Knowledge: Panel Discussion: An Inclusive Future for the Geo for Good Community.

Indigenous Knowledge: Plenary Talk: A collaboration of Sovereignty and Science for the Navajo Nation.

January 27, 2022 – AMS Annual Meeting (online), 21st conference on Artificial Intelligent 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.

Johnson, L., M. Cahn, F. Melton, 2022. CropManage Application for Vineyard Irrigation Decision-Support. ASEV National Conference, 19-21 June, San Diego.

Joshua Laughner, Vivienne Payne, Susan Kulawik, Emily Fischer, "Retrievals of Peroxyacetyl Nitrate from AIRS", The 2022 AIRS/Sounder Science Team Meeting, May 10, 2022 - May 12, 2022, Jet Propulsion Laboratory, Pasadena, CA

Kate Duffy presented a guest lecture on machine learning applications in remote sensing to a graduate level Time Series and Geospatial Data Sciences class at Northeastern University (2022, March).

Ko, Y., Park, T., Kim, M., Hong, M., Choi, G., Lee, W.K., Son, J., Identifying Forest Soil information based on Machine learning for South Korea. Dec 2022, AGU 2022.

LeBlanc et al., Aerosol above cloud and optical depth in the southeast Atlantic and their use in continuity NASA products, AGU, Session A073. Models, In situ, and Remote sensing of Aerosols (MIRA), Accepted as Oral.

LeBlanc et al., Aerosol above cloud optical depth in the southeast Atlantic and their use in continuity NASA products, AGU, Session A073. Models, In situ, and Remote sensing of Aerosols (MIRA), Oral Presentation, AGU Fall Meeting, December 2022.

LeBlanc et al., Measuring aerosol optical depth from aircraft during KORUS-AQ reveals higher consistency than aerosol size, AOGS, August 2022, AS09-A037, invited oral presentation. Invited presentation at AOGS-2022.

LeBlanc: Presentation during SGG branch meeting on: “Aerosol optical depth is more consistent than aerosol size over large distances during KORUS-AQ” (2022-02-28).

LeBlanc: Presentation for Ames’ Wildfire interest group on: “Aerosol vertical information from Oxygen-A band” (2022-03-14).

LeBlanc: San Jose State University - Meteorology & Climate Science. SJSU Spring 2022 Seminar Series - Looking up from airplanes: understanding impact of aerosol and cloud on transmitted sunlight.

LT Iraci, CL Parworth, EL Yates, JE Marrero, JM Ryoo, A Collection of Airborne Measurements and Analyses of Trace Gases Emitted From Multiple Fires in California, Earth and Space Science 9 (4), e2021EA002116.

Madrazo, M.K., Lee, H., Khodayari, A., Wan, W., Park, T., The impact of climate change on fire danger over the contiguous United States. Dec 2022, AGU 2022.

Martin, F., Fennimore, S.A., Matson, M., Racano, D., Putman, A.I., Melton, F., Hang, M., Magney, T., Earles, M., Goodhue, R. and Vougioukas, S., 2021, August. Site-specific soil pest management in strawberry & vegetable cropping systems. In PHYTOPATHOLOGY (Vol. 111, No. 10, pp. 115-115). 3340 PILOT KNOB ROAD, ST PAUL, MN 55121 USA: AMER PHYTOPATHOLOGICAL SOC.

Melton, F., Carrara, W., Doherty, C., Guzman, A., Johnson, L., Purdy, A., Solymar, R., et al., 2022. OpenET. Presentations to the Western States Water Council, Colorado River Authority of Utah, Upper Colorado River Commission, Oregon Water Resources Department, California State Water Resources Control Board, American Farm Bureau Federation, USGS, Department of the Interior and other partners and stakeholders throughout 2022.

Melton, F., Carrara, W., Doherty, C., Guzman, A., Johnson, L., Solymar, R., et al., 2022. OpenET: Operational Evapotranspiration Data for Water Management in Oregon. Oregon Water Resources Department / Oregon State University Evapotranspiration Workshops, Hemiston and Portland, OR, Sept 9-10, 2022.

Melton, F., Carrara, W., Doherty, C., Guzman, A., Johnson, L., Solymar, R., et al., 2022. OpenET: Operational Evapotranspiration Data for Water Management in the Western United States. ASPRS Pecora Conference, Denver, CO, October 27, 2022.

Melton, F., Carrara, W., Doherty, C., Guzman, A., Johnson, L., Solymar, R., et al., 2022. Operational Evapotranspiration Data for Water Management in the Western United States Washington Hydrogeology Conference, Tacoma, WA, May 11, 2022. (Invited keynote).

Melton, F., et al., 2022. Operational Satellite Monitoring of Evapotranspiration for Precision Agriculture and Water Resources Management, Commodity Classic Conference, New Orleans, LA, Mar 10-12, 2022.

Melton, F., et al., 2022. The NASA Western Water Applications Office, American Society of Photogrammetry and Remote Sensing Pecora Conference, Denver, CO, October 27, 2022.

Mitchell et al. " Subseasonal Variability of Biomass Burning Aerosol Radiative Properties Retrieved by 4STAR during the ORACLES 2016-2018 Campaigns", AMS Collective Madison Meeting, August 2022.

"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.

Mizzi, A., Hsu C.-H., Lyu, C., Johnson, M., Naeger, A., McDonald, B., and Henze, D. (2022): The potential for satellite-based anthropogenic/wildfire emissions estimation with WRF-Chem/DART, NASA Ames Research Center, NASA/USGS Symposium, Moffett Field, CA, September 29, 2022.

Mizzi, A., Hsu, C.-H., Lyu, C., Johnson, M., McDonald, B., Naeger A., Henze, D., Kumar, R., and Anderson, J. (2022): Improving regional air quality forecasting through chemical data assimilation with dynamic emissions estimation, NASA Ames Research Center, Earth Science Division Seminar, Moffett Field, CA, March 3, 2022.

Mizzi, A., Johnson, M., McDonald, B., Naeger A., Hsu, C.-H., Henze, D., Kumar, R., and Anderson, J. (2022): Joint assimilation of multiple satellite retrievals and dynamic emissions estimation with WRF-Chem/DART, International Symposium on Data Assimilation, Colorado State University, Fort Collins, CO, June 10, 2022.

Mizzi, A., Johnson, M., McDonald, B., Naeger A., Hsu, C.-H., Henze, D., Kumar, R., and Anderson, J. (2022): Joint assimilation of multiple satellite retrievals and dynamic emissions estimation with WRF-Chem/DART, Tecnologico de Monterrey, Ciudad de México, MX, November 8, 2022.

Mizzi, A., Johnson, M., McDonald, B., Naeger A., Hsu, C.-H., Henze, D., Kumar, R., and Anderson, J. (2022): Joint assimilation of multiple satellite retrievals and dynamic emissions estimation with WRF-Chem/DART, Universidad Nacional Autónoma de México, Ciudad de México, MX, November 11, 2022.

Nelson K.M. et al: Improving the Total CO2 Budget Estimate for and Active Stratovolcano in Costa Rica, in NASA Earth Surface and Interior Solid Earth Science Team Meeting, La Jolla, Nov 2022

October, 23, 2022, 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.

Park, T., Vargas, R., Brosna, I., Nemani, R., Mapping national forest aboveground biomass in Mexico by integrating GEDI, Sentinel1 and Sentinel2 data. Dec 2022, AGU 2022.

Park, T., Vargas, R., Kim, M., Nemani, R., Myneni, R. Monitoring and forecasting large-scale patterns of forest structure and carbon dynamics using field, remote sensing, and process-based models. Global Ecosystem Dynamics Investigation (GEDI) Science Team Meeting. November 15-17, 2022.

Park, T., Vargas, R., Kim, M., Nemani, R., Myneni, R. Monitoring and forecasting large-scale patterns of forest structure and carbon dynamics using field, remote sensing, and process-based models. Global Ecosystem Dynamics Investigation (GEDI) Science Team Meeting. November 15-17, 2022.

Park, T., Wang, W., Dungan, J.L., Genovese, V., Shinozuka, Y., Poulter, B., Brosnan, I., Development of the Ames Global Hyperspectral Synthetic Dataset. Dec 2022, AGU 2022.

Pistone: Invited Talk: Hampton University Atmospheric and Planetary Sciences seminar series, October 2022: "Observations of biomass burning aerosol over the southeast Atlantic Ocean and the meteorological context: Results from ORACLES."

Presentation at SGG branch meeting: "4STAR in SaSa" (2022-10-04).

Purdy, A.J., Melton, F., Carrara, W., Doherty, C., Guzman, A., Johnson, L., et al., 2022, Supporting Sustainable Groundwater Management in the Salinas Valley with Satellite-based Evapotranspiration Data. California State University Agricultural Research Institute Annual Conference, Sacramento, CA, October 21, 2022.

Racano, D., Martin, F., Fennimore, S., Putman, A., Matson, M., Melton, F., Goodhue, R., Henry, P., Vougioukas, S., Dorn, N. and Greer, C., 2021, September. Site-Specific Soil Pest Management in Strawberry and Vegetable Cropping Systems Using Crop Rotation and a Needs-Based Variable Rate Fumigation Strategy. In HORTSCIENCE (Vol. 56, No. 9, pp. S169-S169). 113 S WEST ST, STE 200, ALEXANDRIA, VA 22314-2851 USA: AMER SOC HORTICULTURAL SCIENCE.

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

Ryan Bennett will be presenting a poster at AGU 2022 about data resulting from the overpass of the SAGE III satellite during SARP 2022: "From the Ground Up: Stratospheric Aerosol and Gas Experiment III on the International Space Station(SAGE III/ISS) Comparison of Vertical Profiles with 2022 Student Airborne Research Program (SARP) In Situ Data."

Ryan Bennett will host a Hyperwall presentation highlighting the accomplishments of SARP alumni at the AGU 2022 meeting in Chicago. Tentative title is the following: "High Flying Interns: NASA Student Airborne Research Program (SARP) 2009-2022."

Ryoo, J.M., Park, T., Characterizing Seasonal Atmospheric Rivers, Climate, and Wildfire Patterns over the Western United States. Dec 2022, AGU 2022.

SARP: Brenna Biggs, to junior undergraduate students in the "Introduction to the Geography Major" course at San Diego State University on September 26, 2022. Talk title: "Future NASA Internship Opportunities: NASA Student Airborne Research Program."

Schoenung, Susan and Fladeland, Matt "NASA Airborne Science Program Contributions to Environmental Science," presented at The History of NASA and the Environment Symposium, Georgetown University, September 29-30, 2022

Spiegel, M.P., Volkovitskiy, A., Terekhina, A., Forbes, B.C., Park, T., Macias-Fauria, M., Top-down regulation by reindeer herbivory limits climate-driven Arctic vegetation change. Dec 2022, AGU 2022.

Susan Kulawik, Alba Lorente, Sean Crowell, Colm Sweeney, Kathryn McKain, Edward J. Dlugokencky, Sebastien C. Biraud, John Miller, Paul O. Wennberg, Debra Wunch, Frank Hase, Coleen M. Roehl, Rigel Kivi, Nicholas M. Deutscher, Kei Shiomi, Voltaire A. Velazco, Thorsten Warneke, Kawakami Shuji, Laura T. Iraci, James R. Podolske, Joshua L. Laughner, "Validation of TROPOMI Methane in the GeoCarb Domain", 18th International Workshop on Greenhouse Gas Measurements from Space (IWGGMS-18), July 12-14 hosted online from Tsukuba, Japan.

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.

Taejin Park presented “Role of Atmospheric Rivers Affecting Vegetation and Fire Patterns over the Western U.S. during Wet and Dry years" together with Ju-Mee Ryoo at the 4th International Atmospheric Rivers Conference (2022, October).

Talk: American Meteorological Society, Collective Madison Meeting, August 2022: K. Pistone et al., “Variation and evolution of atmospheric structure over the SEA BB season as seen from aircraft and reanalysis.”

Thomas Vandal presented at 28th SIGKDD Conference on Knowledge Discovery and Data Mining with the topic “Dense feature tracking of atmospheric winds with deep optical flow” (2022, August).

"Validation of TROPOMI CH4 in the GeoCarb domain" presented at GeoCarb Science Team Meeting, May 10-12, Norman, OK.

Vandal. T, Duffy, K, McCarty, W., Sewnath, A., Das, P., Michaelis, A., and Nemani, R. (2022) Deep Learning System for Efficient Processing of Geostationary Satellite Imagery. 21th Conference on Artificial Intelligence for Environmental Science, AMS Winter Meeting, Houston, TX.

Vargas, R., Park, T. NASA Carbon Monitoring System Science Team Meeting and Applications Workshop, September 26–28, 2022.

Weile Wang (SGE) organized a session "Earth Monitoring from Operational Geostationary Satellites" at Asian Oceania Geosciences Society 19th Annual Meeting (2022, August).

Weile Wang presented at the NASA booth in programmatic FireSense discussions. (The 2022 International Fire & Climate conference, held in Pasadena CA the week May 23-27, 2022).

Will Carrara presented “OpenET: Mapping of Evapotranspiration over the Western U.S." at NASA Ames for UC Berkeley Visit (2022, September).

WWAO Impact Assessment Updates, ASP Water Resources Annual Meeting, SLC, October 4-7, 2022.

WWAO R2O Updates, ASP Water Resources Annual Meeting, SLC, October 4-7, 2022.

Publications

A. Kannan, G. Tsagkatakis, R. Akbar, D. Selva, V. Ravindra, R. Levinson, S. Nag, M. Moghaddam, ”Forecasting Global Soil Moisture using a Deep learning Model integrated with Passive Microwave Retrieval”, IEEE International Geoscience and Remote Sensing Symposium, Kuala Lumpur, Malaysia, July 2022.

A. Melebari, S. Nag, V. Ravindra, M. Moghaddam, ”Soil Moisture Retrieval from Multi-Instrument and Multi-Frequency Simulated Measurements in Support of Future Earth Observing Systems”, IEEE International Geoscience and Remote Sensing Symposium, Kuala Lumpur, Malaysia, July 2022.

Ahamed, A., Knight, R., Alam, S., Pauloo, R. and Melton, F., 2022. Assessing the utility of remote sensing data to accurately estimate changes in groundwater storage. Science of The Total Environment, 807, p.150635.

Ambrosia, V. G.; Green, D.; Falkowski, M. Lefer, B., Seablom, M.; Kopardekar, P.; Grindle, L. A., 2022. NASA’s New Wildland Fire Earth Observation Science & Applications Programmatic Developments, Environ. Sci. Proc. 2022, 17(1), 71; https: Current Titles in Wildland Fire, September 2022 (9) 23 //doi.org/10.3390/environsciproc2022017071.

Braden, D., Mondal, P., Park, T., Vargas, R., Quantifying uncertainty of forest extent estimates in Mexico by comparing satellite-derived land and tree cover products. Environmental Research Letters, under review.

Bubenheim, D., V. Genovese, J.D. Madsen, and E. Hard. "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.D., Johnson, L.F. and Benzen, S.D., 2022. Evapotranspiration Based Irrigation Trials Examine Water Requirement, Nitrogen Use, and Yield of Romaine Lettuce in the Salinas Valley. Horticulturae, 8(10), p.857.

Cahn, M.D., Johnson, L.F. and Benzen, S.D., 2022. Evapotranspiration Based Irrigation Trials Examine Water Requirement, Nitrogen Use, and Yield of Romaine Lettuce in the Salinas Valley. Horticulturae, 8(10), p.857.

Campana, P.E., Lastanao, P., Zainali, S., Zhang, J., Landelius, T. and Melton, F., 2022. Towards an operational irrigation management system for Sweden with a water–food–energy nexus perspective. Agricultural Water Management, 271, p.107734.

Chang, I., Gao, L., Flynn, C. J., Shinozuka, Y., Doherty, S. J., Diamond, M. S., Longo, K. M., Ferrada, G. A., Carmichael, G. R., Castellanos, P., da Silva, A. M., Saide, P. E., Howes, C., Xue, Z., Mallet, M., Govindaraju, R., Wang, Q., Cheng, Y., Feng, Y., Burton, S. P., Ferrare, R. A., LeBlanc, S. E., Kacenelenbogen, M. S., Pistone, K., Segal-Rozenhaimer, M., Meyer, K. G., Ryoo, J.-M., Pfister, L., Adebiyi, A. A., Wood, R., Zuidema, P., Christopher, S. A., and Redemann, J.: On the differences in the vertical distribution of modeled aerosol optical depth over the southeast Atlantic, Atmos. Chem. Phys. Discuss. [preprint], https://doi.org/10.5194/acp-2022-496, in review, 2022.

Cochrane, S. P., Schmidt, K. S., Chen, H., Pilewskie, P., Kittelman, S., Redemann, J., LeBlanc, S., Pistone, K., Segal Rozenhaimer, M., Kacenelenbogen, M., Shinozuka, Y., Flynn, C., Ferrare, R., Burton, S., Hostetler, C., Mallet, M., and Zuidema, P.: Biomass burning aerosol heating rates from the ORACLES (ObseRvations of Aerosols above CLouds and their intEractionS) 2016 and 2017 experiments, Atmos. Meas. Tech., 15, 61–77, https://doi.org/10.5194/amt-15-61-2022, 2022.

Cooley, S., Jenkins, A., Schaeffer, B., Bormann, K.J., Abdallah, A., Melton, F., Granger, S. and Graczyk, I., 2022. Paths to research-driven decision making in the realms of environment and water. Technology in Society, p.101994.

Doherty, Conor T., Lee F. Johnson, John Volk, Meagan S. Mauter, Nicolas Bambach, Andrew J. McElrone, Joseph G. Alfieri et al. "Effects of meteorological and land surface modeling uncertainty on errors in winegrape ET calculated with SIMS." Irrigation science 40, no. 4 (2022): 515-530.

Doherty, Conor T., Lee F. Johnson, John Volk, Meagan S. Mauter, Nicolas Bambach, Andrew J. McElrone, Joseph G. Alfieri et al. "Effects of meteorological and land surface modeling uncertainty on errors in winegrape ET calculated with SIMS." Irrigation science 40, no. 4 (2022): 515-530.

Douglas, E., Kirshen, P., et al. Climate Change Impacts and Projections for the Greater Boston Area: Findings of the Greater Boston Research Advisory Group Report (2022). UMass Boston.

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Glossary

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

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

AATS—Ames Airborne Tracking Sun-photometer

ABI—Advanced Baseline Imager

ACAOD—Above Cloud Aerosol Optical Depth

ACCDAM—Atmospheric Composition Campaign Data Analysis and Modeling

ACCLIP—Asian Summer Monsoon Chemical & CLimate Impact Project

ACMAP—Atmpsheric Composition: Modeling and Analysis Program

ACP—Atmospheric Composition Program

ACTIVATE—Aerosol Cloud meTeorology Interactions oVer the western ATlantic Experiment

ADIS—Algorithm Driven Information System

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

AERONET—AErosol RObotic NETwork

AESD—Ames Earth Science Division

AFB—Air Force Base

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

AIHEC—American Indian Higher Education Consortium

AIRS—Atmospheric Infrared Sounder

AIST—Advanced Information Systems Technology

AJAX—Alpha Jet Atmospheric eXperiment

AMOC—Atlantic Meridional Overturning Circulation

AMS—American Meteorological Society

AMS—Autonomous Modular Sensor

AOD—Aerosol Optical Depth

AOS—Atmosphere Observing System

ARC—Ames Research Center

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

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

ARMD—Aeronautics Research Mission Directorat

ARSET—Applied Remote Sensing Training

ASF—Airborne Sensor Facility

ASM—Asian Summer Monsoon

ASP—Airborne Science Program

ASP—Applied Sciences Program

ASRL—Allometric Scaling and Resource Limitation

ATBD—Algorithm Theoretical Basis Document

AVIRIS—Airborne visible/infrared imaging spectrometer

AWS—Amazon Web Services

BAU—Business As Usual

BB—Biomass Burning

BC—Black Carbon

BCs—Boundary Conditions

BCSD—Bias Correction/Spatial Disaggregation

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

BRDF—Bi-directional Reflectance Distribution Function

CAARE—The Center for Applied Atmospheric Research and Education

CALIOP—The Cloud-Aerosol Lidar with Orthogonal Polarization

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

CAMEE—Center for Advanced Measurements in Extreme Environments

CAMEL—Comprehensive Assessment of Models and Events based on Library tools

CAMP2Ex—Cloud, Aerosol and Monsoon Processes Philippines Experiment

CAMS —Copernicus Atmosphere Monitoring Service

CBP—Capacity Building Program

CCDC—Continuous Change Detection and Classification

CCI—Climate Change Initiative

CDFA—California Department of Food and Agriculture

CEOS—Committee on Earth Observation Satellites

CER—Cloud Effective particle Radius

CIRES—The Cooperative Institute for Research in Environmental Sciences

CMIP6—Climate Model Intercomparison Project Phase 6

CMS—Carbon Monitoring Systems

CNN—Convolutional Neural-Network

COMA—Carbon mOnoxide Measurement from Ames

CONUS—Continental United States

COSMOS—Comprehensive Open-architecture Solution for Mission Operations Systems

COT—Cloud Optical Thickness

CPEX—Convective Processes Experiment

CPEX-CV—Convective Processes Experiment-Cabo Verde

CPO—The Climate Program Office

CrIS—Cross-track Infrared Sounder

CSL—Chemical Sciences Laboratory

CSU—California State University

CSUMB—California State University at Monterey Bay

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

DAAC—Distributed Active Archive Center

DBW—Division of Boating and Motorways

DCOTSS—Dynamics and Chemistry of the Summer Stratosphere

DDDAS—Dynamic Data Driven Applications Systems

DEVELOP—Digital Earth Virtual Environment and Learning Outreach Project

DRAAWP—Delta Region Area-wide Aquatic Weed Project

DRCS—The Disaster Response Coordination System

DRE—Direct Radiative Effect

DSET—Drought Severity Evaluation Tool

DSMs—Distributed Space Missions

ECCO—Estimating the Circulation and Climate of the Ocean

ECMWF—European Centre for Medium-Range Weather Forecasts

ECOSTRESS—ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station

EEJ—Equity and Environmental Justice

EGIST—Earth Science Data Systems GIS Team

EIP—EtherNet/IP

EMRI—Earth Mapping Resources Initiative

ENSCI—Environmental Science

EO—Earth Observations

EOD—Earth Observation Data

EOS—Earth Observing System

EOSDIS—Earth Observing System Data and Information System

ERA5—ECMWF reanalysis version 5

ESD—Earth Science Division

ESI SET—Earth Surfaces and Interior, Solid Earth Team

ESO—Earth System Observatory

ESPO—Earth Science Project Office

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

ESROGSS—Earth Science Research on Operational Geostationary Satellite Systems

ESTP—Environmental Science, Technology and Policy

ET—Evapotranspiration

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

FAV—Floating Aquatic Vegetation

FHI—Freshwater Health Index

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

FLARE—The wildFire characteristics shaped by the integrated roLes of Atmospheric Rivers and their impacts on the Ecosystem

FLUID—Federated Learning Using In Space Data

FRAPPE—Front Range Air Pollution and Photochemistry Experiment

GCFR—Greater Cape Floristic Region

GCMs—Global Climate Models

GDDP—Global Daily Downscaled Projections

GDSA—Gaborone Declaration for Sustainability in Africa

GEDI—Global Ecosystem Dynamics Investigation

GEE—Google Earth Engine

GEO—Geostationary

GEO—Group on Earth Observations

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

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

GHRC DAAC—NASA's Global Hydrometeorology Distributed Active Archive Center

GIS—Georgraphic Information System

GLE—Geoscience Learning Ecosystem

GLOBE—Global Learning and Observations to Benefit the Environment program

GMAO—Global Modeling and Assimilation Office

GOES—Geostationary Operational Environmental Satellite

GOSAT—The Greenhouse gases Observing SATellite

GPM—Global Precipitation Measurement

GPS—Global Positioning System

GSFC—Goddard Space Flight Center

GWIS—Global Wildfire Information System

HALE—High Altitude Long Endurance

HIWC—High Ice Water Content

HLS—Landsat-8 and Sentinel-2 time series

HyTES—Hyperspectral Thermal Emission Spectrometer

IAA—Interagency Agreement

ICAP—International Cooperative for Aerosol Prediction

ICFBR—International Conference on Fire Behavior and Risk

IDL—Interactive Data Language

IDS—Interdisciplinary Science

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

INMARSAT—A British satellite telecommunications company

INS—Inertial Navigation System

INSTEP—Inexpensive Network Sensor Technology for Exploring Pollution

IOP—Intensive Observation Period

IPI—The Indigenous Peoples Initiative

IR—Infrared

IRAD—Internal Research and Development

IRM—Integrated Exposure Model

ISFM—Internal Science Funding Model

ISS—International Space Station

ITEP—The Institute for Tribal Environmental Professionals

JPL—Jet Propulsion Laboratory

JSC— Johnson Space Center

KNDR—Karuk Dept. of Natural Resources

LARC—Langley Research Center

LCLUC—Land-Cover and Land-Use Change

LFC—Lightning Flash Counts

LIDAR—Light Detection and Ranging

LMT—Lowermost Tropospheric

LOF—Living Oceans Foundation

LSP—Land Surface Phenology

LST—Land Surface Temperature

LVIS—Land, Vegetation, and Ice Sensor

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

MASTER—The MODIS/ASTER Airborne Simulator

MCC—Meso-scale Cellular Convection

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

MedRIN—Mediterranean Regional Information Network

MERRA—Modern Era Retrospective-Analysis for Research and Applications

MIRA— Models, In situ, and Remote sensing of Aerosols

MLS—Microwave Limb Sounder

MMS—Meteorological Measurement System

MODIS—Moderate Resolution Imaging Spectroradiometer

MODTRAN—A computer program designed to model atmospheric propagation of electromagnetic radiation for the 100–50,000 cm^{-1} spectral range.

MOPITT—Measurement of Pollution in the Troposphere

MRV—Measurement, Reporting, and Verification

MSC—Marine Stratocumulus Clouds

MSFC—Marshall Space Flight Center

MSIs—Minority Serving Institutions

MTS—Mission Tools Software

MUREP—Minority University Research and Education Project

MUSES—Multi-Spectra, Multi-Species, Multi-Sensors

MuSSTAR—Miniature unmanned airborne Sunphotometer for Sun-Tracking Atmospheric Research

MVIS—Miniature Video Imaging System

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

NeMO-NET—Neural Multimodal observation and training network for global coral reef assessment

NEX—NASA Earth Exchange

NIR—Near Infrared

NIRVSS—The Near Infrared Volatile Spectrometer Subsystem

NOAA—National Oceanic and Atmospheric Administration

NOS—New Observing Strategy

NOx—Nitrogen Oxides

NR—Nature Run

NRT—Near Real-Time

NSRC—National Suborbital Research Center

OAR—Oceanic and Atmospheric Research

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

OCONUS—Outside Contiguous United States

OE—Operations Engineer

OMI—Ozone Measuring Instrument

ORACLES—ObseRvations of Aerosols Above CLouds and their IntEractionS

OSSE—Observing System Simulation Experiment

PACE—Plankton, Aerosol, Cloud, ocean Ecosystem

PAN—Peroxyocetyl nitrate

Pandora—A small commercially available spectrometer

PBL—Planetary Boundary Layer

PER—Preliminary Engineering Review

PICARD—Pushbroom Imager for Cloud and Aerosol Research

PRISM—Panchromatic Remote-sensing Instrument for Stereo Mapping

PSM—A Professional Science Master's Degree

PTZ—Pan-Tilt-Zoom

QC—Quality Control

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

RFI—Request For Information

ROSES—Research Opportunities in Earth and Space Science

RSE—Remote Sensing of the Environment

RSP—Radiation Science Program

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

SAR—Synthetic Aperture Radars

SARP—Student Airborne Research Program

SaSas—Student Airborne Science Activation

SATCOM—Satellite Communications

SBIR—Small Business Innovation Research

SCBGP—Specialty Crop Block Grant Program

SDGs—Sustainable Development Goals

SEA—SouthEast Atlantic

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

SEP—SouthEast Pacific

SEVIRI—The Spinning Enhanced Visible and InfraRed Imager

SGE—NASA Ames Biosphere Science Branch

SIGKDD—Special Interest Group on Knowledge Discovery and Data Mining

SIMS—Satellite Irrigation Management Support

SISTER—Space-based Imaging Spectroscopy and Thermal pathfinder

STEM—Science, Technology, Engineering, and Math

SWAP—Smaller Weight And Power

SWAT—Soil Water Assessment Tool

SWIR—Short Wave Infrared

TASNPP—Terra-Aqua Suomi-NPP

TCCON—Total Carbon Column Observing Network

TEMPO—Tropospheric Emissions: Monitoring Pollution

TES—Tropospheric Emission Spectrometer

TESS—Triennial Earth Sun Summit

TFRSAC—Tactical Fire Remote Sensing Advisory Committee

TOA—Top-Of-Atmosphere

TOPS—Transform to Open Science

TROPESS—The TRopospheric Ozone and its Precursors from Earth System Sounding

TROPOMI—The TROPOspheric Monitoring Instrument

UAS—Unmanned Air Systems

UAV—Unmanned Aerial Vehicle

UHF—Ultra High Frequency

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

UNBL—UN Biodiversity Lab

UNDP—United Nations Development Programme

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

USDA-ARS—U.S. Department of Agriculture, Agricultural Research Services

USDA-NIFA—National Institute of Food and Agriculture

USDA-NRCS—U.S. Department of Agriculture Natural Resources Conservation Service

USDA—U.S. Department of Agriculture

USFS—The United States Forest Service

USGS—United States Geological Survey

USVI—United States Virgin Islands

VIIRS—Visible Infrared Imaging Radiometer Suite

VIPER—Volatiles Investigating Polar Exploration Rover

VIS—Visible Infrared Spectrum

VLAN—A virtual local area network

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

VSWIR—Visible ShortWave InfraRed

WDTS—Western Diversity Time Series

WELD—Web-enabled Landsat Data

WF—Wildfire

WFF—Wallops Flight Facility

WHO—World Health Organization

WHRC—Wood Hole Research Center

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

WRF—Weather Reserach and Forecast

WWAO—Western Water Applications Office

YOLO—You only look once