Ninth Year Progress Report for NASA Cooperative Agreement NNX12A05A

As amended January 26, 2021

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

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Period of Performance 3/1/20 to 2/28/21

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Introduction

The Cooperative Agreement creating the Ames Research Center Cooperative for Research in Earth Science and Technology ("ARC-CREST") provides on page 16 (Required Publications and Reports) that a progress report is due annually, 60 days prior to the anniversary date of the grant/cooperative agreement. Accordingly, we presented a report on December 31, 2020 for the ninth year of this Cooperative Agreement. This submission amends and expands that earlier report.

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. In the ninth year of the ARC-CREST cooperative agreement, the current participants, Bay Area Environmental Research Institute ("BAERI") and California State University Monterey Bay ("CSUMB") achieved each of these objectives despite the postponement of almost all earth science mission-related activity due to the COVID pandemic.

The ARC-CREST scientific team, working closely with the Ames Earth Science Division, participated in project areas covering the gamut of Earth Science research. Viewing the shutdown of NASA installations as an opportunity, ARC-CREST scientists used the time to sift through and analyze mountains of data collected in recent years. For example, our researchers analyzed data collected by NASA resources that measure atmospheric carbon dioxide. The solar physics program, not as affected, continued its strong work. ARC-CREST scientists also continued to develop and use cutting edge technology to advance Earth Science. The NASA Earth Exchange (NEX) project used NASA's supercomputing capability to provide online collaborative space to researchers around the world, providing dramatically increasing access to vast amounts of data collected by NASA satellites. In the Carbon Monitoring Systems (CMS) project, ARC-CREST scientists used the NEX computing capability and Landsat data to generate 1-m tree cover estimates across the continental U.S and then validated its results using state-wide Lidar data. Also ARC-CREST scientists have worked on the Indigenous Peoples Capacity Building Initiative and pathways for future international Indigenous collaborations. This effort was recognized by the NASA Administrator in his NASA Weekly Update of July 27, 2020.

ARC-CREST scientists also worked with NASA to use data collected for Earth Science Research on a range of projects that have practical applications. For example, The ARC-CREST partners also provided support to critical Earth Science activities at NASA Ames Research Center, including the Applied Sciences Program's Water Resources Program.

Finally, through the Student Airborne Research Program (SARP), an educational program run by the National Suborbital Research Center, and the Digital Earth Virtual Environment and Learning Outreach Project (DEVELOP), ARC-CREST participants worked with the NASA Ames Research Center to provide extensive educational and public outreach opportunities related to Earth Science.

Robert W. Bergstrom, Ph.D., J.D.
Director of Research

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NASA Ames Research Center – Earth Sciences Division

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Earth Science Focus Areas

A Framework for Mining and Analysis of Petabyte Sized Time-series on the NASA Earth Exchange (AIST-16-0137)

Project Participants

NASA: Ramakrishna Nemani, Eleanor Rieffel
BAERI: Thomas Vandal, Andrew Michaelis
InuTeq: Jeffrey Becker
University of Bristol: Max Willson

Project Description

Time-series analysis is key to understanding and uncovering changes in the Earth system. However, many currently available geospatial tools only provide easy access to the spatial rather than the temporal components. Because of this, there is a significant burden on researchers to correctly extract time-series data from multiple files for thorough temporal analysis. There are very few tools that enable easy time-series access, search, and analysis at scale. While large-scale temporal analysis of geospatial data is of course easily achievable on a small scale, searching for trends across multi-millions or billions of time-series using 100's of terabytes to petabytes of data can quickly become a huge undertaking for individual researchers. Apart from scaling the analysis algorithm itself, it often requires a significant effort with large-scale data transformations and processing, metadata, and data management. Finally, there are limited places where algorithms supporting novel time-series approaches can be easily tested and evaluated. Given the challenges and importance of time-series analysis to Earth sciences, we viewed this call as an opportunity to engage and bring together Earth science, machine learning, and data mining communities - an essential goal of the NASA Earth Exchange (NEX) project.

The overall goal of the project was to develop a platform for fast and efficient mining of time-series data from NASA's satellite-based observations, model output, and other derived datasets. The proposed effort sought to create a capability for the NASA Earth Exchange that would enable users to analyze long-term records without the excessive burden on individual researchers. By removing the burden of local storage management, large-scale data acquisition, metadata handling and cataloging, physical data transformations and or processing, the platform can significantly accelerate individual or group exploratory and analysis efforts focused on the temporal dimension. To accomplish our stated goals, we worked towards developing a framework for time-series indexing, time-series search, and domain-specific data compression.

Accomplishments

- Requested an augmentation of the core objectives for the project, and explored the concept of extending and integrating previous work developed at NASA's Quantum Artificial Intelligence Laboratory (NASA QuAIL). The team:
    - Conceptualized and assessed the potential of near-term Quantum Machine Learning (QML) architectures, methodologies, and techniques as applied to time-

series analysis in the Earth Sciences;
  - Conceptualized and assessed Earth Science specific data compression using quantum-based methodologies and techniques;
  - Conceptualized and assessed how QML and domain-specific data compression could complement each other for time-series analysis. That is, to encode our test data sources in a specific way in which it "improves" the QML time-series analysis both in execution times, accuracy, and uncertainty; and
  - Assessed the potential of the current D-wave system that is housed at ARC (annealer).

- Studied the real-world applicability of a QVAE by presenting a proof-of-concept for similarity search in late-scale high-dimensional datasets. Recent progress in quantum algorithms and hardware indicates the potential importance of quantum computing in the near future. For instance, Quantum Assisted Variational Autoencoders (QVAE) [2] have been proposed as a quantum enhancement to the discrete VAE. We showed how the latent space representation of a QVAE can be used to construct a space-efficient search index. We backed up our claims by experimental results which showed a correlation between the Hamming distance in the embedded space and the Euclidean distance in the original space on the MODIS NDVI [3] dataset. Further, we showed real-world speedups compared to linear search and demonstrate memory-efficient scaling to half a billion data points;

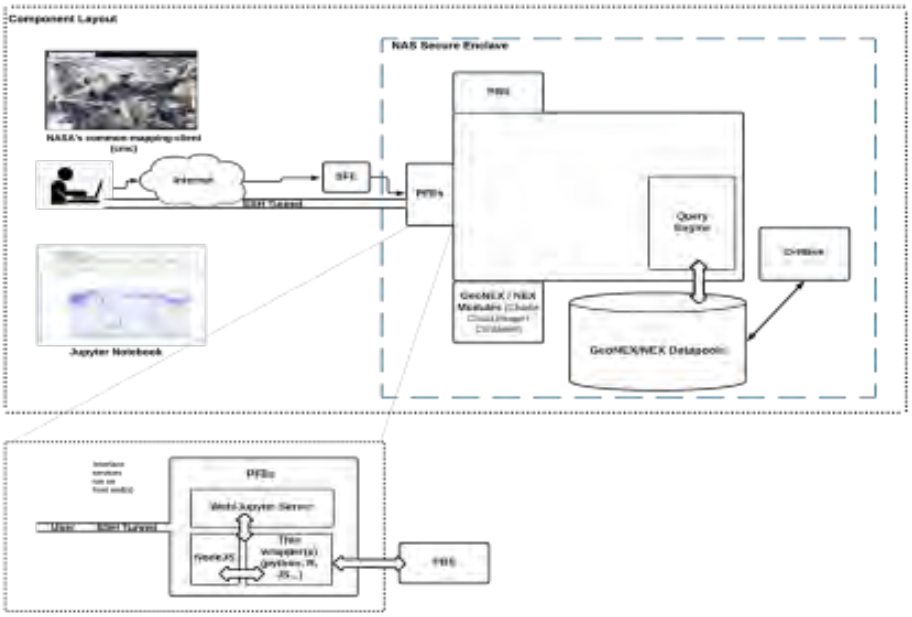
- Prototyped the Radius Sketch [4] algorithm for large-scale time series analysis in the High-Performance computing environment. The Radius Sketch method projects each time series onto a set of n random vectors, where n is substantially smaller than the length of each time series, leading to an overall reduction in the data size, relative to the original data. For similarity search queries, the resulting sketches are then compared using Euclidean distance with the shorter sketch lengths and reduced data size, which in turn reduces query times. We implemented Radius Sketch in Python, leveraging the Dask [5] and Xarray [6] libraries. We were able to test this on the Pleiades supercomputer at NAS, using a cluster of 50 or 100 nodes;

- Implemented and tested a prototype system within the NEX community, integrating various components such as the Radius Sketch search/query engine and software tools developed under past AIST investments; and

- Supported specific use cases, including:
  - Characterized inter-annual variability and trends of land productivity at an individual pixel level from satellite data at various resolutions (30m through 8km);
  - Enhanced the ability to query petabyte-scale data sets for identifying locations that are similar to a prescribed temporal profile (either from an area of interest or hypothetical);
  - Used time-series to characterize cohesiveness in the ecosystem behavior of an

area. For example, the investigation of changing community composition (tree structures/species) in the Amazon rainforest, which is not possible to quickly analyze when time-series are aggregated and need to be examined at the individual pixel level;

- Searched and classified significant events, such as changes in seasonal phenology, deforestation, fires, etc., across billions of time-series, and subsequently use the knowledge for forecasting and prediction; and
- Spatially constrained multivariate clustering.



An NAS/NEX user using SSH tunneling, a Charlie Cloud container bundle for the front-end, and the backend query engine with an API. Queries are submitted through a simple nodeJS [11] and python-based API wrapper, which can interact with the portable batch scheduler PBS.

Publications

Wilson, Max & Vandal, Thomas & Hogg, Tad & Rieffel, Eleanor. (2019). Quantum-assisted associative adversarial network: Applying quantum annealing in deep learning.

Presentations

Gao et al. “High-Dimensional Similarity Search with Quantum-Assisted Variational Autoencoder.” Submission to ACM International Conference on Knowledge discovery and data mining SIGKDD 2020.

Wilson, A.M., Michaelis, A., Rieffel, E., Nemani, R.R. and Vandal, T.J., 2018, December. Compressing Earth science datasets with quantum-assisted machine learning algorithms. In AGU Fall Meeting 2018. AGU.

Vandal et al. “Temporal Interpolation of Geostationary Satellite Imagery with Task Specific Optical Flow.” Submission to ACM International Conference on Knowledge discovery and data mining SIGKDD 2020.

Vandal, T. & Nemani, R. (2020). “Optical Flow for Intermediate Frame Interpolation of Multispectral Geostationary Satellite Data”. 19th Conference on Artificial Intelligence for Environmental Science. Boston, MA.

Vandal, T., Nemani, R.R., Wang, W. and Li, S., 2019, December. Transfer Learning to Generate True Color Images from GOES-16. In AGU Fall Meeting 2019. AGU.

Aerosol Modeling & Data Analysis

Project Participants

NASA: Mian Chin
BAERI: Qian Tan

Project Description

Aerosols, the small particles suspended in the air, can affect air quality and climate in many ways. As one of the major air pollutants, aerosols (or particulate matter) not only affect local air quality, it also can travel long distances. Dust is one of the dominant aerosol types over Africa and Asia. Dust outflow from Africa and Asia can be deposited into the Atlantic and Pacific Oceans and affect radiation balance and biogeochemical cycle.

We use both satellite measurements and model results to study the evolution of aerosol particles over the past decades. NASA satellites measure aerosol distribution and properties from different perspectives. Two Lidar systems are deployed to measure the vertical profile of aerosols. The spatial coverage of these systems' orbits provides a unique opportunity to study the polar-ward transport of aerosols from major aerosol source regions, both man-made and natural, to the high latitude. Combining this data with model-simulated aerosol distribution and NASA GMAO's MERRA-2 meteorological fields, we estimated the seasonal and regional averages of aerosol vertical profiles at major aerosol source regions and transport pathways.

Accomplishments

- Studied the aerosol back scatter and extinction measured by two Lidar systems. Since they have different spatial coverage, we sampled the data at different geographic locations and estimated their seasonal average and meridional transport;
- Evaluated seasonal aerosol vertical profiles at different geographic locations; and
- Compared satellite measurement with aircraft campaign measurements in places when their tracks overlap.

Publications

https://doi.org/10.1029/2019JD030822

Yu, H., Yang, Y., Wang, H., Tan, Q., Chin, M., Levy, R. C., Remer, L. A., Smith, S. J., Yuan, T., and Shi, Y.: Interannual variability and trends of combustion aerosol and dust in major continental outflows revealed by MODIS retrievals and CAM5 simulations during 2003–2017, Atmos. Chem. Phys., 20, 139–161, https://doi.org/10.5194/acp-20-139-2020, 2020.

Knobelspiesse, K., Barbosa, H. M. J., Bradley, C., Bruegge, C., Cairns, B., Chen, G., Chowdhary, J., Cook, A., Di Noia, A., van Diedenhoven, B., Diner, D. J., Ferrare, R., Fu, G., Gao, M., Garay, M., Hair, J., Harper, D., van Harten, G., Hasekamp, O., Helmlinger, M., Hostetler, C., Kalashnikova, O., Kupchock, A., Longo De Freitas, K., Maring, H., Martins, J. V., McBride, B., McGill, M., Norlin, K., Puthukkudy, A., Rheingans, B., Rietjens, J., Seidel, F. C., da Silva, A., Smit, M., Stamnes, S., Tan, Q., Val, S., Wasilewski, A., Xu, F., Xu, X., and Yorks, J.: The Aerosol Characterization from Polarimeter and Lidar (ACEPOL) airborne field campaign, Earth Syst. Sci. Data, 12, 2183–2208, https://doi.org/10.5194/essd-12-2183-2020, 2020.

Presentations

AGU Fall Meeting 2020:

- The Gigantic African Dust Intrusion to the Caribbean Basin and southern U.S. in June 2020: An analysis of MODIS and CALIOP remote sensing observations and GEOS model simulations. Hongbin Yu, Qian Tan, Lillian Zhou, Yaping Zhou, Huisheng Bian, Mian Chin, Dongchul Kim, Robert C Levy, Yingxi Rona Shi, Lorraine Remer, and Olga L Mayol-Bracero, link: https://agu.confex.com/agu/fm20/meetingapp.cgi/Paper/691983

- Monitoring Air Quality from Space: Perspectives from Modeling and Sub-orbital Measurements to Understand the AOD-PM2.5 Relationship on Different Time Scales Mian Chin, Qian Tan, Gao Chen, Huisheng Bian, Zhining Tao, Dongchul Kim, Hongbin Yu link: https://agu.confex.com/agu/fm20/meetingapp.cgi/Paper/682577

Panels & Committees

- NASA ROSES Proposal Review Panel, March 2020.

Agriculture, Health, and Marine Applied Sciences

Project Participants

NASA: Ramakrishna Nemani, Jennifer Dungan
CSUMB: Forrest Melton, Lee Johnson, Alberto Guzman, Isabel Zaragosa, Michael Hang, Tianxin Wang, Will Carrara
Student team members: Ryan Solymar (CSUMB), Conor Doherty (Stanford University)

Project Description

CSUMB personnel have a long history of participation and support of NASA research and applied science missions to apply satellite data to improve our understanding of environmental conditions and processes that affect agriculture, public health and vectorborne disease, and coral reefs and other marine ecosystems. Under this task, CSUMB conducts research and applied science activities in these areas in collaboration with the Ames Earth Science Division (AESD) and numerous collaborators in government agencies, non-profits 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:

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

During 2020, research activities focused solely on Objective 1 based on priorities and funding availability from NASA.

Left: CSUMB Student Researcher checks a flux tower in a celery field in Soledad, CA. Ryan is using the flux tower to collect ET measurements to assess the accuracy of satellite-based estimates of ET from the NASA Satellite Irrigation Management Support (SIMS) system.

Center: Forrest Melton works on a flux tower in a vineyard in Soledad, CA. Forrest and his lab are using the flux tower to collect ET measurements to assess the accuracy of satellite-based estimates of ET from the NASA Satellite Irrigation Management Support (SIMS) system.

Right: Tianxin Wang (left) and Michael Hang (right) prepare to collect multispectral and thermal data over a vineyard in Soledad, CA using a UAV. The data is being used to quantify the accuracy of satellite-based measurements of fractional cover over vineyards

Accomplishments

- Published 5 peer reviewed journal articles, 1 major interagency technical report, with 2 additional articles submitted and currently in review, and 3 currently in final preparation for a total of 11 papers prepared, of which 6 were published or in press in 2020. The team also has four other manuscripts currently in preparation. The team presented more than 17 scientific and technical talks/posters at science conferences and technical meetings. F. Melton also provided briefing for staff for seven U.S. Senate offices, three House offices, two House committees, the Oregon State Legislature Water Resources Committee, the American Farm Bureau Federation, the California Farm Bureau, and the U.S. Office of Management and Budget;

- Mentored one CSUMB student and one Stanford University student who worked with the SIMS and OpenET projects in 2020 (Ryan Solymar, Conor Doherty). Tianxin Wang (former intern) was accepted to a PhD program at UC Berkeley and began his program in Fall 2020. Will Carrara (former student research assistant) is now a software engineer with NASA ARC-CREST. Additional research internships will be offered in 2021;

- Secured an additional $500k million ($6 million in total funding to date) for the OpenET project from the Water Funders Initiative and the Walton Family Fund. 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 is one of the two technical co-leads for the project and continued to lead a team of >40 leading experts on remote sensing of ET. Co-Is Guzman and Johnson led the implementation of the NASA SIMS ET model on the Earth Engine platform and production of field-scale ET data for 17 western states to date. The team supported the soft launch of OpenET in September 2020 and OpenET was featured on nasa.gov and Forbes in September. Co-I A. Guzman was also featured in a profile on appliedscience.nasa.gov. A. Guzman and W. Carrara led the development of raster API for the OpenET project, and made key contributions to the development of the OpenET platform. The OpenET Data Explorer and API are currently being tested by project partners across the western US prior to the public launch during the first half of 2021. C. Wang also co-led the data review and footprint analysis for more than 150 Ameriflux stations, and the project team is currently co-leading the largest accuracy assessment and intercomparison of ET models conducted to date;

- Concluded work on the WesternET project, a ROSES supported project on evapotranspiration (ET) mapping in the western US in collaboration with Univ. Nevada/ Desert Research Institute. Co-PI Johnson and Sr. Software Engineer Guzman collaborated with DRI to apply SIMS and METRIC to map ET across four critically impacted basins spanning 6 western states. Project results are currently helping to support the OpenET effort;

- With support from the NASA Western Water Applications Office, completed and released an updated Application Programming Interface (API) for SIMS and used the API to integrate data from SIMS with the UCANR CropManage tool. This allows data from SIMS to be used operationally to support irrigation and fertilizer management decisions by more than 2,500 California growers. W. Carrara and A. Guzman also worked with HabitatSeven to redesign the SIMS website, which is being prepared for launch in early 2021. In addition, the project deployed and maintained flux towers in collaboration with Central Coast growers to support expansion of CropManage to include winegrapes and celery. T. Wang and R. Solymar 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. Results from this task were presented at the 2020 Fall AGU Meeting and are currently being prepared for publication;

- In partnership with USDA ARS in Salinas, CA, 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 development of crop canopies and fractional cover across multiple crops to verify and improve the SIMS algorithms. M. Hang used the UAV to map 6 research sites, 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;

- Continued field trials and research to quantify the value of SIMS and ET-based irrigation scheduling. The team deployed and maintained instrumentation at the West Side Research and Extension Center. Results to date further confirm the value of SIMS for reducing applied water by 20-40% relative to standard practice, and also demonstrate the ability to reduce nitrate leaching by 50-75% or more. The project team also conducted additional field trials in collaboration with UC Cooperative Extension and CSU Fresno on specialty crops to quantify the benefits of ET-based irrigation scheduling;

- Secured additional funding related to this task, which was available only to non-federal, California institutions;

- Johnson is Co-I on a proposal led by UC Cooperative Extension under the 2019 CDFA Specialty Crop Block Grants Program ($333k). He is helping to manage irrigation trials in artichoke and red cabbage being conducted at the USDA research station in Salinas. The project employs a student assistant (Javier Lopez), who recently graduated from the ag-business program at Hartnell and has since transferred to CSUMB.

- 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.

- Johnson is PI of a $445k concept proposal submitted to the 2021 CDFA-SCBGP and currently under peer-review. If accepted, the project would exercise OpenET and CropManage to address sustainability indicators identified by the State of California in response to declining groundwater levels, seawater intrusion, and degraded water quality.

- Johnson is in the final year of a $285k project sponsored by the CA Dept. of Water Resources to further develop and deliver an online calculator for agricultural water efficiency metrics.

- 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.

Publications

Pereira, L., P. Paredes, F. Melton, L. Johnson, M. Mota, T. Wang., 2021. Prediction of crop coefficients from fraction of ground cover and height. Practical application to vegetable, field and fruit crops with focus on parameterization. Agric. Water Mgt. (in press)

Wang, T., F. Melton, T. Thao, K. Post, L. Johnson, F. Cassel-Sharma, 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, 106533.

Pereira, L., P. Paredes, F. Melton, L., Johnson, T. Wang, R. Lapez-Urrea, J. Cancela, R. Allen, 2020. Prediction of crop coefficients from fraction of ground cover and height. Background and validation using ground and remote sensing data. Agricultural Water Management 241, 106197.

Ketchum, D., Jencso, K., Maneta, M.P., Melton, F., Jones, M.O. and Huntington, J., 2020. IrrMapper: A Machine Learning Approach for High Resolution Mapping of Irrigated Agriculture Across the Western US. Remote Sensing, 12(14), p.2328.

Lipschultz, F., Herring, D.D., Ray, A.J., Alder, J.R., Dahlman, L., DeGaetano, A.T., Fox, J.F., Gardiner, E.P., Herring, J., Hicks, J. and Melton, F., 2020. Climate Explorer: Improved Access to Local Climate Projections. Bulletin of the American Meteorological Society, 101(3), pp.E265-E273.

Lesmes, D., Moerman, J., Melton, F. (and 32 other co-authors), Community Coordinating Group on Integrated Hydro-Terrestrial Modeling (2020), “Integrated Hydro-Terrestrial Modeling: Development of a National Capability,” report of an interagency workshop held September 4-6, 2019 with support from the National Science Foundation, the U.S. Department of Energy, and the U.S. Geological Survey, https://doi.org/10.25584/09102020/1659275

In addition, the team currently has two additional papers in review and three papers in final preparation for submission

Presentations

- Melton, F., et al., 2020. OpenET: Filling the Biggest Data Gap in Water Management. 2020 American Meteorological Society Annual Meeting, Boston, MA, Jan. 15, 2020 (invited).

- Melton, F., et al., 2020. OpenET and Applications of Ameriflux for Water Management in the West. Ameriflux Annual Conference, Oct. 6, 2020 (invited).

- Johnson, L., M. Cahn, A. Guzman, D. Chambers, T. Lockhart, F. Melton, 2020. Landsat-based estimation of fractional cover for several Salinas Valley horticultural crops. AGU Fall Meeting, #SY035-0007. link

- Melton, F., et al., 2020. OpenET: Filling a Critical Gap in Water Data for the Western United States. AGU Fall Meeting , #H021-08 (invited) link

- Melton, F., et al., 2020. OpenET: Applications for Agricultural Water Management. Almond Board of California Annual Meeting (invited) link

- Rollison, D., et al., 2020. OpenET: Enabling Science-Based Water Management through Open Data Services and User-Driven Design. AGU Fall Meeting, #SY036-04 link

- Cassel, F., S. Ashkan, T. Thao, R. Brar, A. Garcia,D. Goorahoo, F. Melton, T. Wang, and L. Johnson, 2020. Lysimetric determination of crop water requirement for onions. CSU ARI PI meeting, 23 Oct.

- Melton et al., 2020. OpenET: Filling the Biggest Gap in Water Data for the Western U.S. Amer. Meterol. Soc. Annual Meeting, 34th Conference on Hydrology 12-16 Jan., Boston (invited) link

- Johnson, L., M. Cahn, D. Chambers S. Benzen, 2019. Evapotranspiration-based irrigation scheduling in Salinas Valley vegetable crops. AGU Fall Meeting, 9-13 Dec., San Francisco (#PA31G-1081) link

- Huntington, J., L. Johnson, et al., 2019. Operational Remote Sensing of Agricultural Water Use in Cooperation with Western State Water Resource Agencies for Improved Water Management AGU Fall Meeting, 9-13 Dec., San Francisco (#H21C-07) link

- Carrara, W., F. Melton, L. Johnson, A. Guzman, and C. Doherty, 2019. Rapid Operational Derivation of Surface Reflectances for Landsat & Sentinel Imagery. AGU Fall Meeting, 9-13 Dec., San Francisco (#B31N-2402) link

- Wang T., F. Melton, M. Cahn, L. Johnson, L. Hipps, L. .McKee, K. Alsted, 2019. Comparison of Evapotranspiration Estimates from Remote Sensing, Crop Coefficient Models, and Eddy Covariance Stations for Celery in California. AGU Fall Meeting, 9-13 Dec., San Francisco (#B31N-2391) link

- Guzman, A., L. Johnson, F. Melton, M. Cahn, I. Zaragoza, T. Wang, 2019. Supporting Advances in Agricultural Sustainability through Integration of NASA SIMS and CropManage for Irrigation Management Support. Colorado River Water Users Assn. Annual Meeting, Las Vegas, 11-Dec., Las Vegas.

- Johnson, L., et al., 2020. UCCE Irrigation & Nutrient Management Day (annual continuing-education event for growers and crop consultants)

- J. Huntington, L. Johnson, C. Morton, A. Guzman, M. Bromley, B. Daudert, J. Hansen, F. Melton. Operational remote sensing of agricultural water use in cooperation with western state water resource agencies for improved water management. NASA Applied Sciences Program, Water Resources Team Meeting, July 2020.

- Guzman, A., et al., 2020. Irrigation Management with SIMS and CropManage. 2020 NASA Applied Sciences Program, WWAO & Water Resources Team Meeting, July 2020.

- Martin, F., Hang, M., Meton, F. 2020. Remote sensing as part of an integrated program for management of soil borne diseases on strawberries and vegetable rotation system. American Phytopathological Society. Unmanned Aerial Vehicles For Making Plants Healthy—Do We Have a Winner?, November, 2020.

Panels or Committees

- SBG Applications Working Group (F. Melton)

- Integrated Hydroterrestrial Modeling Technical Committee (F. Melton)

- California Open Water Data Infrastructure Technical Working Group (F. Melton)

- EWRI ET in Irrigation and Hydrology Committee (L. Johnson)

- Western Water Applications Office Capabilities Working Group (L. Johnson)

- Participation in multiple NASA review panels (Applied Science, SBIR) by Johnson and Melton.

Agile Satellites for Flood Observation and Modeling

Project Participants

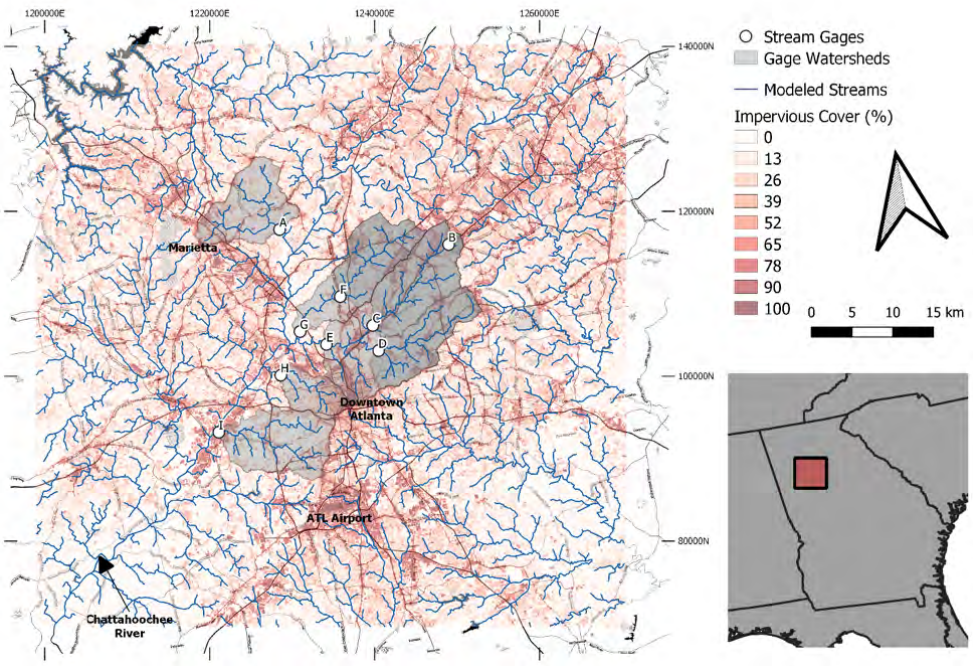
BAERI: Alan Li

Project Description

Agile satellites offer new opportunities to track and monitor fast changing, dynamical events on Earth from orbit with limited ground-based support. This project proposes to utilize machine learning and LSTMs to model flood risk of stream flows within a predefined area. By varying the number of observations and their frequencies, we show that onboard machine learning models can quickly update flood risk in near real time to understand which areas need the most urgent monitoring.

Accomplishments

- Tested multiple LSTM models to model flood risk, from 2D grid-based to 1D stream-based;
- Settled on 1D temporal stream flows for simplicity and quick runtimes; and
- Compared those flows to high fidelity models such as WRF-Hydro for comparison.



Flood map of Atlanta region of interest

Alpha Jet Atmospheric Experiment (AJAX)

Project Participants

NASA: Laura Iraci
BAERI: Emma Yates

Project Description

The Alpha Jet Atmospheric eXperiment (AJAX) team takes airborne measurements of ozone, formaldehyde, CO_2, methane and meteorological parameters. BAER's role includes identifying science questions, designing and planning flights, data analysis (IDL, python), maintaining instruments, and scientific writing and presentations. Since 2016, BAER 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 aircraft, to measure COS uptake from coastal Redwood forests.

Publications

Yates, E.L., L.T. Iraci, L.W. Tarnay, J. Burley, C. Parworth, and J-M. Ryoo. 2019. The effect of an upwind non-attainment area on ozone in California's Sierra Nevada Mountains, *Atmospheric Environment*, Volume 2030, 2020.

Accomplishments

• Submitted 2 ROSES proposals (one as PI); and

• Participated in a panel for NASA Earth Science call.

TRopospheric Ozone and its Precursors from Earth System Sounding (TROPESS)

Project Participants

NASA-JPL: Kevin Bowman
BAERI: Susan Kulawik

Project Description

TRopospheric Ozone and its Precursors from Earth System Sounding (TROPESS) will produce long term, Earth Science Data Records (ESDRs) with uncertainties and observation operators pioneered by the Aura-TES mission and enabled by the MUlti-SpEctra, MUltiSpEcies, Multi-SEnsors (MUSES) retrieval algorithm and ground data processing system.

The Tropospheric Emission Spectrometer (TES) was an infrared spectrometer on the Aura satellite. Its high spectral resolution enabled it to vertically resolve ozone in the Troposphere and measure concentrations of many chemical constituents in our atmosphere including: temperature, water, HDO, methane, ozone, carbon monoxide, carbon dioxide, methanol, ammonia, formic acid, HCN, and PAN.

Accomplishments

- Building off expertise gained from TES, AIRS, OMI, and OCO-2, developed a standardized and extensible set of trace gas products; and

- Produced long-term records and fields campaign support for FIREX, ORACLES, and WE-CAN for CrIS CO, AIRS-CH4, AIRS-OMI-O3, and AIRS-HDO.

Publications

Kulawik, S. S., Worden, J. R., Payne, V. H., Fu, D., Wofsy, S. C., McKain, K., Sweeney, C., Daube Jr., B. C., Lipton, A., Polonsky, I., He, Y., Cady-Pereira, K. E., Dlugokencky, E. J., Jacob, D. J., and Yin, Y.: Evaluation of single-footprint AIRS CH4 Profile Retrieval Uncertainties Using Aircraft Profile Measurements, Atmos. Meas. Tech. Discuss., https://doi.org/10.5194/amt-2020-145, in review, 2020.

Herman, R. L., Worden, J., Noone, D., Henze, D., Bowman, K., Cady-Pereira, K., Payne, V. H., Kulawik, S. S., and Fu, D.: Comparison of optimal estimation HDO⁄H2O retrievals from AIRS with ORACLES measurements, Atmos. Meas. Tech., 13, 1825–1834, https://doi.org/10.5194/amt-13-1825-2020, 2020.

Kuai, L., Bowman, K. W., Miyazaki, K., Deushi, M., Revell, L., Rozanov, E., Paulot, F., Strode, S., Conley, A., Lamarque, J.-F., Jöckel, P., Plummer, D. A., Oman, L. D., Worden, H., Kulawik, S., Paynter, D., Stenke, A., and Kunze, M.: Attribution of Chemistry-Climate Model Initiative (CCMI) ozone radiative flux bias from satellites, Atmos. Chem. Phys., 20, 281–301, https://doi.org/10.5194/acp-20-281-2020, 2020.

Aerosol Cloud Ecosystem Polarimeter Working Group (ACEPWG)

Project Participants

NASA: Kirk Knobelspiesse
BAERI: Qian Tan

Project Description

Atmospheric aerosols have large impacts on both air quality and climate. A polarimeter can provide more critical information about atmospheric aerosols' properties than current optical instruments and satellites used to monitor aerosols. Measurements from polarimeters can be used to derive the aerosol particles' size and shape. Those parameters are very important for accurately estimating the aerosol's radiative perturbation on climate.

The Aerosol Cloud Ecosystem (ACE) mission was recommended by the National Research Council in their 2007 Earth Science Decadal Survey. One of the proposed ACE instrument payloads is a passive polarimeter intended for the measurement of aerosol and cloud optical properties. As part of the ACE mission's pre- formulation studies, aircraft polarimeter prototypes have been developed and deployed in several field campaigns. The intent of these efforts is to help determine the optimal ACE mission objectives and instrument characteristics; therefore, the purpose of the ACE Polarimeter Working Group (ACEPWG) is to help organize this endeavor.

Accomplishments

- Analyzed the observations from various polarimeters in the Polarimeter and Lidar (ACEPOL) airborne field campaign in 2017; and

- Submitted a paper to Earth Systems Science Data for publication. Dr. Knobelspiesse is the lead author of the paper, Dr. Tan is one of co-authors.

Publications

Knobelspiesse, K., Barbosa, H. M. J., Bradley, C., Bruegge, C., Cairns, B., Chen, G., Chowdhary, J., Cook, A., Di Noia, A., van Diedenhoven, B., Diner, D. J., Ferrare, R., Fu, G., Gao, M., Garay, M., Hair, J., Harper, D., van Harten, G., Hasekamp, O., Helmlinger, M., Hostetler, C., Kalashnikova, O., Kupchock, A., Longo De Freitas, K., Maring, H., Martins, J. V., McBride, B., McGill, M., Norlin, K., Puthukkudy, A., Rheingans, B., Rietjens, J., Seidel, F. C., da Silva, A., Smit, M., Stamnes, S., Tan, Q., Val, S., Wasilewski, A., Xu, F., Xu, X., and Yorks, J.: The Aerosol Characterization from Polarimeter and Lidar (ACEPOL) airborne field campaign, Earth Syst. Sci. Data, 12, 2183–2208, https://doi.org/10.5194/essd-12-2183-2020, 2020.

Carbon Monitoring Systems (CMS)

Project Participants

NASA: Ramakrishna Nemani
BAERI: Taejin Park

Project Description

There are currently three projects funded under the NASA CMS program.

Project 1: NASA CMS 2017 (Vargas) Carbon monitoring systems across Mexico to support implementation of REDD+: maximizing benefits and knowledge. The objective of this research is to implement a machine learning algorithm on the Landsat Web-enabled Landsat Data (WELD) composites to generate a yearly forest cover map for Mexico. In addition, the project will implement algorithms to generate biophysical parameters like Leaf Area Index (LAI), Fraction of Photosynthetically Active Radiation (FPAR) and General Purpose Parameters (GPP) using the already established Terrestrial Observation and Prediction Systems (TOPS) framework on NEX to model biomass, Net Primary Productivity, and carbon flux.

Project 2: NASA CMS 2017 (Hurtt) High-Resolution Carbon Monitoring and Modeling: Continued Prototype Development and Deployment to Regional and National Scales. This project will implement machine learning algorithms for generating forest cover maps from the 1-m National Agricultural Imagery Program (NAIP) data, and high-resolution climate variables for input to the UMD ED-2 modeling framework. The machine learning pipelines are part of the broader NEX-Artificial Intelligence (AI) unified modeling and inference framework. In addition, the NEX supercomputing facility will be used to run the ED model and prepare a workflow for Lidar processing in support of the NASA Global Ecosystem Dynamics Investigation (GEDI) mission.

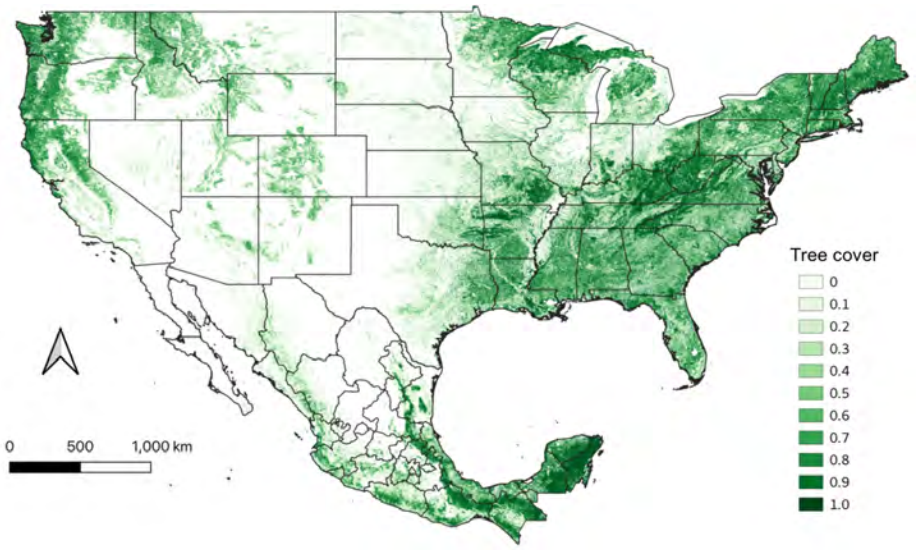
Project 3: Project: NASA CMS (Saatchi) Annual GHG Inventory and MRV System for the US Forestlands. This project is responsible for producing annual percent tree cover maps from Landsat and NAIP which will serve as an important input to the annual greenhouse gas (GHG) assessment for the Continental US. The project leverages our current NEX-AI workflow pipelines with benchmarked algorithms for land cover classification.

Accomplishments

- Validated the NEX tree cover product using state-wide Lidar based 1-m tree cover estimates;

- Performed inter-comparison of the NEX tree cover using independent existing tree cover product, i.e., NLCD and MODIS product;

- Disseminated the tree cover product to JPL and University of Delaware; and
- Enhanced collaborative research activities with CMS project team members (see publications & presentations).



Landsat based tree cover estimate in 2018 over the contiguous United States and Mexico.

Publications

Piao, S., Wang, X., Park, T., Chen, C., Lian, X., He, Y., Bjerke, J.W., Chen, A., Ciais, P., Tømmervik, H. and Nemani, R.R., 2020. Characteristics, drivers and feedbacks of global greening. Nature Reviews Earth & Environment, pp.1-14. https://doi.org/10.1038/s43017-019-0001-x

Kim, M., Ham, B.Y., Kraxner, F., Shvidenko, A., Schepaschenko, D., Krasovskii, A., Park, T. and Lee, W.K., 2020. Species-and elevation dependent productivity changes in East Asian temperate forests.
Environmental Research Letters. https://doi.org/10.1088/1748-9326/ab71a2

Li, W., Ciais, P., Stehfest, E., Van Vuuren, D., Popp, A., Arneth, A., Di Fulvio, F., Doelman, J., Humpenöder, F., B Harper, A. and Park, T., 2020. Mapping the yields of lignocellulosic bioenergy crops from observations at the global scale. https://doi.org/10.5194/essd-12-789-2020

Xu, B., Li, J., Park, T., Liu, Q., Zeng, Y., Yin, G., Yan, K., Chen, C., Zhao, J., Fan, W. and Knyazikhin, Y., 2020. Improving leaf area index retrieval over heterogeneous surface mixed with water. Remote Sensing of Environment. https://doi.org/10.1016/j.rse.2020.111700

Peano, D., Hemming, D., Materia, S., Delire, C., Fan, Y., Joetzjer, E., Lee, H., Nabel, J.E., Park, T., Peylin, P. and Wårlind, D., 2020. Plant phenology evaluation of CRESCENDO land surface models–Part I: start and end of growing season. Biogeosciences Discussions, https://doi.org/10.5194/bg-2020-319.

Hemming, D. L.; Garforth, J.; Park, T.; Richardson, A. D.; Rutishäuser, T.; Sparks, T. H.; Thackeray, S. J.; Myneni, R. 2020. Phenology of primary producers. Bulletin of the American Meteorological Society, 101(8), S95-S98. https://www.ametsoc.org/index.cfm/ams/publications/bulletin-of-the-american-meteorological-society-bams/state-of-the-climate/

Presentations

- Vargas, R., Nemani, R., Park, T., Carbon monitoring systems across Mexico to support implementation of REDD+: maximizing benefits and knowledge. NASA Carbon Monitoring System Science Team Meeting 2020. Virtual Meeting. November 17-19, 2020.

- Wang, W., Hashimoto, H., Michaelis, A., Park, T., Nemani, R., Wang, Y., Lyapustin, A., Kalluri, S., Uncertainty Analysis of the GeoNEX Top-of-Atmospheric Reflectance Products Generated from the Third-Generation Geostationary Satellite Sensors. American Geophysical Union 2020 Fall Meeting, Virtual Meeting. December 1-17, 2020.

- Vandal, T., Nemani, R., Wang, W., Michaelis, A., Dungan, J., Hashimoto, H., Park, T., Duffy, K., Geostationary Satellites and Deep Learning. Earth Science Technology Forum 2020, Virtual Meeting. June 23-25, 2020.

Decadal Record of Lower Tropospheric Methane From Satellite Measurements of Total Column and Free-Tropospheric Methane Concentrations

Project Participants

BAERI: Susan Kulawik

Project Description

Our objective is to develop a twelve-year record (2005-2016) of lower tropospheric and free-tropospheric/stratospheric methane concentrations in support of the proposal call to “Develop new or significantly improved Level 2 data that are not supported by the Aura project core data analysis budget.” The free-tropospheric record is based on the Aura TES measurements with observation gaps filled by processing AIRS methane radiances using the state-of-the art Aura TES composition retrieval algorithm.

Accomplishments

- Received acceptance by the Atmospheric Measurement Techniques (“AMT”) journal of a paper summarizing Dr. Kulawick’s work on this project. This publication presents the results and characterization of the first single-footprint methane product from AIRS.

Publications

Kulawik, S. S., Worden, J. R., Payne, V. H., Fu, D., Wofsy, S. C., McKain, K., Sweeney, C., Daube Jr., B. C., Lipton, A., Polonsky, I., He, Y., Cady-Pereira, K. E., Dlugokencky, E. J., Jacob, D. J., and Yin, Y.: Evaluation of single-footprint AIRS CH4 Profile Retrieval Uncertainties Using Aircraft Profile Measurements, Atmos. Meas. Tech. Discuss., https://doi.org/10.5194/amt-2020-145, in review, 2020.

Presentations

- “Evaluation of single-footprint AIRS CH4 Profile Retrieval Uncertainties Using Aircraft Profile Measurements”- presentation at Virtual_AIRS_STM, May, 2020

Delta Region Areawide Aquatic Weed Project (DRAAWP)

Project Participants

NASA: Dave Bubenheim
BAERI: Greg Schlick

Project Description

Invasive aquatic plants impact waterways throughout the world with ecological, economic, and social impacts. The California Delta, involving the San Francisco Bay and San Joaquin and Sacramento River watersheds, is seriously affected by increasing presence of aquatic invasive plants, threatening ecological integrity of the region and water management. Invasive aquatic plants are affecting resource management, ecosystem services, aquatic habitats and food webs, economic pursuits in the Delta region, as well as 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. In response, the Delta Region Areawide Aquatic Weed Project (DRAAWP) was initiated as a comprehensive and multi-disciplinary effort to develop science-informed, adaptive management support systems. The DRAAWP provided for development, gap filling science, and demonstration of how science and remote sensing-based tools can be fused to support adaptive management decisions in a complex aquatic ecosystem with a wide range of stakeholder pressures and regulatory oversight.

DRAAWP includes the USDA-ARS, NASA-Ames Research Center, University of California Davis, and State of California – Division of Boating and Waterways (DBW). NASA-ARC focuses on remote sensing to map and track floating aquatic invasive plant communities in the Delta, including validation of location and estimation of biomass, and definition of invasive aquatic species to environmental variations, including water quality and flow as impacted by land use and climate change. The project relies heavily on BAER personnel operating controlled environment growth chamber facilities at ARC to support gap filling science and in validating performance of sensing tools. Learn more: https://ucanr.edu/sites/DRAAWP/

Accomplishments

- Selected by the society of Aquatic Plant Management as the recipient of The Outstanding Technical Contribution to the Field Award for 2020;

- Awarded by the Federal Lab Consortium as the 2020 Outstanding Federal Agency Collaboration;

- Provided all the research growth chamber complex (including all work that happens within them at Ames Research Center) and all the field validation of remote sensing techniques in the field for the DRAAWP project; and

- Took sole responsibility for maintaining this facility and all efforts at Ames Research Center during the COVID closure, including maintaining live cultures and capabilities of these systems.

Earth System Data Records CO_2

Project Participants

NASA-JPL PI: Vineet Yadav
BAERI: Susan Kulawik

Project Description

The Earth Science Data Records (ESDR) project supports the NASA Earth Science Data Systems Program. One component of the ESDR Program, the ESDR Uncertainty Analysis, seeks to extend and enhance Earth system data records used by NASA communities, including climate data records, through rigorous estimation of errors.

This project develops long term CO_2 products from OCO-2, GOSAT, and AIRS CO2 satellite observations, both independently and fusing observations from the above satellite. Dr. Kulawik's participation in the project is to provide guidance on the biases and sensitivity of the different satellite products and validate the fused products.

Accomplishments

- Participated in bi-weekly telecons; and
- Evaluated fused products compared with TCCON observations.

5STAR/Eng-Sci

Project Participants

NASA: Stephen Dunagan, Roy Johnson, Meloë Kacenelenbogen
BAERI: Kristina Pistone, Samuel LeBlanc, Conrad Esch, Scott Venancio, and Ali-Imram Tayeb
CSUMB: Bob Dahlgren
USRA: Stephen Broccardo

Project Description

The ARC (Ames Research Center) Sun-photometer/Satellite group supports a variety of instruments with a specific focus on airborne sun photometers that provide measurements of tropospheric aerosols (i.e. low-level atmospheric particles, such as from smoke, dust, or pollution) and trace gases. The ARC SunSat team is funded to maintain existing instruments (2STAR, 3STAR, 4STAR) and develop the next generation instrument (5STAR, muSSTAR). This set of instruments (collectively termed nSTAR) depend on precision radiometer and spectrometer detectors and include a variety of both 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 into the stratosphere.

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. ARC Internal Research And Development (IRAD) funding was awarded this year to further reduce SWAP to enable measurements from a heavy lift hex- or octa-copter platform (muSSTAR: miniature unmanned airborne Sunphotometer for Sun-Tracking Atmospheric Research), opening up a new domain for experimental design.

5STAR adopts a new means of sun-tracking, miniature fiber spectrometers, and custom circuitry. The design includes a wide-range camera for sun-tracking purposes in place of a quadrant detector which its predecessor 4STAR uses. It also includes custom circuitry to thermally stabilize both silicon and InGaAs photodiodes at discrete wavelengths in addition to custom boards to amplify the data. First flights are planned to be on the Sensor Integrated Environmental Remote Research Aircraft (SIERRA). Designs are also being created to further miniaturize the instrument to allow flight on multi-rotor drone platforms.

Presentations

Broccardo, S. P., S. E Dunagan, R. P. Dahlgren, R. Johnson, L. Fahey, C. Esch, S. Venancio, S. E LeBlanc, K. Pistone, M. S Kacenelenbogen, Michal Segal-Rosenhaimer, A. Mazzulla, S. Zuninga, R. Kolyer, M. Stewart, C. Flynn and J. Redemann, The 5STAR airborne tracking sunphotometer on the NASA SIERRA UAS, AGU Fall meeting, December 2020, A012-035

Follow the photochemistry: Harnessing new observations of PAN to learn how changes in emissions are impacting the global atmosphere

Project Participants

JPL: Vivienne Payne
BAERI: Susan Kulawik

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 proposal 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

- Generated PAN observations for a 45-day period of summer wildfires in 2018, and matched WE-CAN aircraft campaign and PAN observations to ATom aircraft validation data. These results were analyzed by other group members and are resulting in two publications; and

- Prepared two publications:
  - “Satellite measurements of peroxyacetyl nitrate from the Cross-Track Infrared Sounder: Comparison with ATom aircraft measurements”, Vivienne H. Payne, Susan. S. Kulawik, Emily V. Fischer, Jared Brewer, L. Gregory Huey, Kazuyuki Miyazaki, Kevin. W. Bowman, Steve Wofsy, James Elkins, Eric Hinsta and Fred Moore
  - “Evolution of PAN in wildfire smoke plumes detected by the Cross-Track Infrared Sounder (CrIS) over the western US during summer 2018.”, Julieta Juncosa Calahorrano, Susan S. Kulawik, Frank Flocke, Teresa Campos, Vivienne H. Payne, and Emily V. Fischer.

4STAR and Satellite Data Analysis

Project Participants

BAERI: Samuel LeBlanc, Kristina Pistone, Michal Segal-Rozenhaimer, Yohei Shinozuka, Scott Venacio

Project Description: 4STAR Project Overview

The 4STAR Sunsat project has multiple tasks associated with it:

- ORACLES (ObseRvations of Aerosols above CLouds and their intEractionS)
- ISFM (Internal Science Funding Model) - Radiation Science Program (RSP)
- ISFM - Atmospheric Composition Program (ACP)
- IRAD (Internal Research And Development) - muSSTAR
- Canada's NRC (National Research Council) COSR (Canadian Oil Sands Regions, experiment).

Broadly, the 4STAR (Sky-scanning, Sun-tracking Atmospheric Research) project quantifies solar light transmission through the atmosphere, including aerosol, trace gases, and clouds. We use measurements obtained from the 4STAR instrument, either from airborne or ground-based platforms, 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, its predecessor AATS-14, and the in-development muSSTAR and 5STAR) 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 columns. We also 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. The new muSSTAR instrument concept and 5STAR instrument broaden the types of usable aircraft, and add the additional measurement capabilities of high accuracy, multi-decade amplitude diodes to supplement and increase the stability of spectrometers similar to those within 4STAR, while reducing size, weight, and power for greater flexibility.

ORACLES (ObseRvations of Aerosols above Clouds and their intEractionS)

Project Description

The ORACLES experiment is a five-year project funded as a NASA Earth Venture - Suborbital (EV-S) mission, consisting of three airborne intensive operating periods during 2016, 2017, and 2018. ORACLES focused on the South East Atlantic Ocean off the African coast, an area with some of the largest inter-model differences in aerosol forcing assessments on the planet. ORACLES provides multi-year airborne observations over the complete vertical column of the key parameters that drive aerosol-cloud interactions. Following the final field deployment in September-October 2018, the focus has been on data processing, scientific analysis, and preparation and submission of peer-reviewed scientific manuscripts based largely on the measurements obtained by 4STAR in collaboration with many other scientists.

Accomplishments

- Worked on final archival and some revisions of field campaign data for 4STAR (Q1), now as part of the archive: ORACLES Science Team (2019), Moffett Field, CA, NASA Ames Earth Science Project Office (ESPO), Accessed at doi: 10.5067/Suborbital/ ORACLES/P3/2018_V1;

- Co-authored multiple papers on ORACLES;

- Published a paper on ORACLES above cloud aerosol optical depth (Q1);

- Attended the ORACLES science team meeting remotely in May 2020, and at AGU 2020. Gave oral presentation:
    - LeBlanc, S., Pistone, K., Flynn, C., Schmidt, K. S., Cochrane, S., Mallet, M., Direct Aerosol Radiative Effect of Aerosol Above Cloud, ORACLES Science Team meeting 2020, May 14th.

- Participated in review panels for NASA Post-doctoral Program (2x);

- Participated in Department of Energy, SBIR review panel; and

- Completed 13-week course for proposal writing at NASA (L'SPACE NPWEE).

Presentations

- LeBlanc, S. E., S. Schmidt, S. Cochrane, H. Chen, J. Redemann, C. J. Flynn, K. Pistone, M. Segal-Rosenhaimer, M. S Kacenelenbogen, Y. Shinozuka, S. P Broccardo and M. Mallet, Direct Aerosol Radiative Effect Above Clouds in the Southeast Atlantic from Airborne Measurement, AGU fall meeting, A135-06, December 11th, 2020

Publications

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ISFM (Internal Science Funding Model) - Radiation Science Program (RSP) & ISFM - Atmospheric Composition Program (ACP)

Project Description

ISFM - RSP & ACP supports 4STAR/sunsat scientists and the continued science readiness of airborne instrumentation. For RSP, we continue the evolution of science related to 4STAR during ORACLES, and support the development of the next instrument 4STARB, a version of the 4STAR instrument that increases stability through an improved light path from the sensor head to the spectrometers.

The ISFM ACP continues the development of the science related to the KORUS-AQ (Korean-US Air Quality) field campaign that occurred in South Korea during May-July 2016. This campaign sampled the atmospheric constituents over the Korean peninsula and surrounding waters in order to quantify the impact on Korean air quality from both local sources and from neighboring large industrial regions.

Accomplishments

ISFM - RSP

- Worked on the calculation of direct aerosol radiative effect from above cloud aerosol impacts during ORACLES. (Q1-Q2), in preparation for the International Radiation Symposium (Meeting postponed until 2021);

- Continued evaluation of retrieval of cloud properties from zenith hyperspectral radiances measured during ORACLES (Q1-Q2);

- Helped as co-author on task related to aerosol radiative impacts during ORACLES (Q1-Q2). Still in progress:
    - Ian Y. Chang, I. Y., Gao, L., Burton, S. P., Chen, H., Diamond, M., Ferrare, R. A., Flynn, C., Kacenelenbogen, M., LeBlanc, S. E., Meyer, K., Pistone, K., Schmidt, K. S., Segal-Rosenhaimer, M., Shinozuka, Y., Wood, R., Zuidema, P., Redemann, J., Christopher, S. A., Spatiotemporal heterogeneity of aerosol and cloud properties over the southeast Atlantic: An observational analysis, In prep. for GRL

- Worked on draft of 4STARB instrument paper, and started the process for calibration at Mona Loa in September (Postponed until TBD); (Q2-Q3)

- Co-mentored intern (CAARE: Brendan Cornelison from University of Houston) for study on review paper on results of AOD from global airborne sunphotometry field campaigns; (Q2, Q3, Q4)

- Migrated and categorized the entire 4STAR/AATS historical and current database of measured data onto the NASA Ames' HIGH-END COMPUTING CAPABILITY (NAS - HECC); (Q3-Q4) and

- Analyzed preliminary data taken at NASA Ames rooftop during the west coast forest fires (Q3-Q4).

For ISFM - ACP

- Worked on a draft paper on the spatial and spectral changes in AOD measured during the KORUS-AQ field campaign by 4STAR. This is the current paper draft citation:
    - LeBlanc, S. E., Segal-Rosenheimer, M., Redemann, J., Flynn, C., Shinozuka, Y., Livingston, J., Altitude, spectral, and source dependence of airborne aerosol optical depth during KORUS-AQ, In Preparation for Atmos. Chem. Phys., expected publication end of 2020.

- Co-mentored summer intern (CAARE: Scott Dillworth from San Jose State University) for study on impacts of COVID-19 on urban NO2 column as measured from Pandora at NASA Ames. (Q2, Q3, Q4).

IRAD (Internal Research And Development) - muSSTAR

Project Description

The Internal Research and Development (IRAD) project called muSSTAR (miniature unmanned airborne Sunphotometer for Sun-Tracking Atmospheric Research) is the development of the plan and improvement on the subsystems to build a prototype small airborne sunphotometer. The sun photometer will be hosted on an unmanned aerial system, and will profile the lower atmospheric boundary layer over land and near the coast. This will enable scientific applications such as air

and water quality assessment and prediction. Such a system would be used to investigate the vertical profile of aerosol optical depth. This system is aimed at quantifying a measurement gap in atmospheric science between ground based observations and large airborne field campaigns where research aircraft are bound to minimum altitudes above the measurable lower layer.

The major goal of this project is to build, in a small package, the radiometer electronics for multi-decade, low noise amplifier circuitry, enabling highly accurate measurements of sunlight direct beam and scattered sky-light.

The muSSTAR project has enabled co-development of the larger next evolution airborne sunphotometer : 5STAR (ultra-Stable Spectrometers for Sky-Scanning, Sun-Tracking Atmospheric Research). The main amplifier circuitry will be used by both muSSTAR and 5STAR. 5STAR is an overall toughened instrument, with many more channels and spectrometers.

Accomplishments

- Formulated Science questions and science traceability matrix for determining the requirements of the project; (Q1-Q2)

- Co-managed project with Dr. Steve Dunagan, managing junior BAERI engineers Scott Venancio and Conrad Esch. (Q1-Q4). Managed them to bring together the next generation of size reduced multi-decade radiometric sensors for sun and sky light measurements;

- Helped draft proposal to NASA HQ (RSP) for 5STAR evolution based on muSSTAR project; (Q2 and Q4) and

- Analyzed newest data obtained from the prototype amplifier circuitry boards. (Q3-Q4)

Presentations

Broccardo, S. P., S. E Dunagan, R. P. Dahlgren, R. Johnson, L. Fahey, C. Esch, S. Venancio, S. E LeBlanc, K. Pistone, M. S Kacenelenbogen, Michal Segal-Rosenhaimer, A. Mazzulla, S. Zuninga, R. Kolyer, M. Stewart, C. Flynn and J. Redemann, The 5STAR airborne tracking sunphotometer on the NASA SIERRA UAS, AGU Fall meeting, December 2020, A012-035

Canada's NRC (National Research Council) COSR (Canadian Oil Sands Regions, experiment)

Project Description

The COSR experiment was an airborne sampling experiment based out of Fort McMurray, Alberta, Canada in June-July 2018. The focus was on sampling the outflow and transformation

of aerosol and aerosol precursors in the oil sand mining and transformation regions. This experiment was led by Environment and Climate Change Canada (ECCC), through collaboration with Canada's National Research Council (NRC).

During this campaign, the 4STAR instrument was integrated onto the NRC's Convair 580, and focused on aerosol transformation and quantifying the oil sand region's emissions. To better understand the regional aerosol burden, data was gathered focused on forest fire emissions, and the resulting biomass burning aerosol. Through this contracted work, 4STAR data products have been delivered, with ongoing analysis work.

In this work, we found that the airborne measurements of the vertical extinction due to aerosols (aerosol optical depth, AOD) obtained in the Athabasca Oil Sands Region (AOSR) can significantly exceed ground-based values usually taken as a reference for the region. This can have an effect on estimating the AOSR radiative impact and is relevant to satellite validation based on ground-based measurements. We also show that the AOD can marginally increase as the plumes are being transported away from the source and the new particles are being formed.

This is part of the 4STAR project, and while directly funded by NRC in 2019, it may be considered part of the ISFM-RSP package for 2020.

Accomplishments

- Contributed to the Lab report:
  - Baibakov, Konstantin, LeBlanc, Samuel, Molani, Kian, Wolde, Mengistu, Pistone, Kristina, Flynn, Connor, … Johnson, Roy. (2019, July 29). 4STAR hyperspectral sunphotometry measurements during the Oil Sands 2018 campaign near Fort McMurray, Alberta. Zenodo. http://doi.org/10.5281/zenodo.3517172

- Contributed analysis and reviews for the manuscript:
  - Baibakov, K., LeBlanc, S. E., Ranjbar, K., O'Neill, N. T., Wolde, M., Redemann, J., Pistone, K., Li, S.-M., Liggio, J., Chan, T. W., Wheeler, M. J., Nichman, L., Flynn, C., Johnson, R., Airborne and ground-based measurements of aerosol optical depth of freshly emitted anthropogenic plumes in the Athabasca Oil Sands region, Submitted to Atmos. Chem. Phys. acp-2020-1218, Nov. 2020.

GeoCarb

Project Participants

NASA: Berrien Moore, PI
BAERI: Susan Kulawik

Project Description

GeoCarb, an Earth Venture Class mission, will advance our understanding of the global carbon cycle by mapping concentrations of key carbon gases from a new vantage point: geostationary orbit. The mission, launching in 2022, will measure carbon cycle constituents, carbon dioxide, carbon monoxide, methane, as well as solar induced fluorescence (SIF) to answer key questions about the carbon cycle.

Figure:"GeoCarb Intensive Scans". GeoCarb will observe 4 locations intensively multiple times per day, allowing GeoCarb to quantify the diurnal cycle and intensively observe particular cities, forests, farmland, and methane-producing regions.

Accomplishments

- Passed CDR. Kulawik is the L2 validation lead and has a finalized L2 validation plan.

Improving Arctic Re-analyses and Seasonal Forecasts: Boundary Layer Clouds and Surface Radiative Flux Assessment with Airborne Observations and Model Simulations

Project Participants

BAERI: Michal Segal Rozenhaimer

Project Description

Observationally based estimates of surface radiative fluxes in the Arctic are scarce. Yet they are crucial for better predictions of sea-ice melt and re-freeze in short-term and long-term climate modeling. While climate models and satellite observations complement each other in achieving long-term, regional coverage of the Arctic climate system, large discrepancies between them remain in the characterization of boundary layer (BL) atmospheric stability, accurate surface properties, and BL clouds, which are intimately linked to the surface energy balance and the sea-ice melt.This project utilizes unique observational data sets from two NASA airborne campaign over the Arctic: ARISE (Arctic Radiation IceBridge Sea&Ice Experiment – Fall 2014) and OIB (Operation Ice Bridge – Spring and 2014/2015 and Summer 2016) to quantify the differences between models and observations, and to improve prediction of BL clouds and SRF in Arctic reanalyses and forecast models.

Accomplishments

- Submitted a final report for the NASA NIP program; and
- Submitted to following manuscript to GRL: “Sub-grid variability of total water PDF over the Arctic Ocean from Airborne observations.”

Publications

Chen, H., S. Schmidt, M.D. King, G. Wind, A. Bucholtz, E.A. Reid, M. Segal-Rozenhaimer, W.L. Smith, P.C. Taylor, S. Kato, and P. Pilewskie. 2019. Shortwave Radiative Effect of Arctic Low-Level Clouds: Evaluation of Imagery-Derived Irradiance with Aircraft Observations, *Atmos. Meas. Tech. Discuss.*, https://doi.org/10.5194/amt-2019-344, in review

Presentations

- Segal Rozenhaimer, M., R. Cullather, D. Barahona, and A. Molod. 2019. Utilization of airborne observations to assess model parametrizations of critical RH profiles in the Arctic Ocean and their effect on surface radiative budget predictions, GC13H-1255. AGU Fall Meeting, Dec. 9-13, San Francisco, CA.

Kulawik OCO-2 Subcontract

Project Participants

BAERI: Susan Kulawik

Project Description

The goal of the collaboration is to assess the value added for joint retrievals of multiple OCO-2 and OCO-3 observations.

Accomplishments

- Made several presentations regarding these observations; and
- Prepared paper discussing findings that multiple observation retrievals will significantly reduce CO2 errors, however some updates (e.g. additional albedo parameters) are needed in order to utilize the additional information.

Presentations

- “Albedo error propagation into XCO2 in the near infrared”: iposter at OCO2/3 virtual meeting.

NASA Earth Exchange (NEX) / Ecological Forecasting

Project Participants

NASA: Rama Nemani, Jennifer Dungan, Ved Chirayath, Piyush Mehrotra, Andrew Michaelis
BAERI: Taejin Park, Alan Li, Thomas Vandal, Wen Yip, Andrew Michaelis (resigned 2020), Subodh Kalia
CSUMB: Weile Wang, Alberto Guzman, Hirofumi Hashimoto, Forrest Melton, Will Carrara
InuTeq: Jeff Becker

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 develop and 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). 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, and monitor biomass at local to continental scales. 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, as well as large-scale visualizations for data from NASA's Earth Observing System Data and Information System (EOSDIS).

The NEX team continues to support the GeoNEX initiative, a collaborative effort among scientists from NASA, NOAA, JAXA (Japan Aerospace Exploration Agency) and KARI (Korean Aerospace Research Institute) in exploring the feasibility of producing operational land surface products similar to those from MODIS/VIIRS using GeoStationary satellites, such as GOES16, and GOES17. Research from this activity not only derives more value from the current operational GeoStationary platforms, it also feeds into NASA's long term goals supporting new geostationary platforms due to launch in the coming years.

The NEX team continues to support the OpenNEX initiative in collaboration with Carnegie Mellon University. OpenNEX strives to support science education through lectures by experts and community challenge events, such as the space Apps Challenges (https://www.spaceappschallenge.org/).

The team will work to:

- Continue to support NASA's "Earth Science Research from Operational Geostationary Satellite Systems" ROSES call NNH19ZDA001N-ESROGSS
- Continue to support the geostationary remote sensing research community with GeoNEX L1b (TOA) products and software tools.
- Continue to Support NASA DO studies, such as SBG and other related projects (e.g., GeoCarb, TEMPO, Glimr)
- Continue to tune the MAIAC atmospheric correction algorithm for Himawari AHI, GOES16/17 ABI and the Geo-Compsat-2A AMI sensors
- Acquire and manage Landsat collection 2 in support of current and future NEX projects.
- Acquire and manage Sentinel 1 A/B in support of current and future NEX projects.
- Refine the framework for Geo-LEO (MODIS/VIIRS, etc.) inter-comparison and synergy.
- Facilitate community developed GeoNEX protype products including
- Continue to publish GeoNEX related papers on peer-reviewed journals (including the Remote Sensing special issue) and technical documents (e.g., user-guides) for community support.
- Process several epochs of Landsat collection 2 under the WELD project (MEaSUREs program)
- Improve NEX data discovery and data indexing, and data distribution through the data portal (https://data.nas.nasa.gov/geonex/data.php).

Accomplishments

- Selected for ROSES: "Quantifying Earth Process Dynamics with Optical Flow on Geostationary Satellite Imagery." NASA Research Opportunities in Space and Earth Science (ROSES), Earth Science Research From Operational Geostationary Satellite Systems (9 of 83 selected). Aug 2020- July 2023;

- Awarded Best Spotlight Presentation, 1st ACM SIGKDD Workshop on Deep Learning for Spatiotemporal Data, Applications, and Systems, 2020; and

- Had paper accepted into 26th ACM SIGKDD Conference on Knowledge Discovery and Data Mining Research track with a 17% acceptance rate.

NEX/GeoNEX Accomplishments

- Supported NASA's research calls by facilitating the use of NASA state-of-the-art supercomputing, large data archives and providing relevant software and support;

- Organized a session on Geostationary Earth Remote Sensing at the AGU2020 Fall Meeting;

- Completed a special Issue with the peer-reviewed journal Remote Sensing on the theme of Geostationary Earth Monitoring;

- Formally released NEX-GDM dataset, distributed at data.nas.nasa.gov/geonex;

- Refined, extended and distributed the GeoNEX L1G products, which are radiometric calibration with residual georegistration and topographic errors removed, with accurate illumination/view geometry-dependent bi-directional reflectance factors provided. The products are projected onto a global common grid to facilitate inter-satellite comparisons and are available at data.nas.nasa.gov/geonex (Fig. 1);

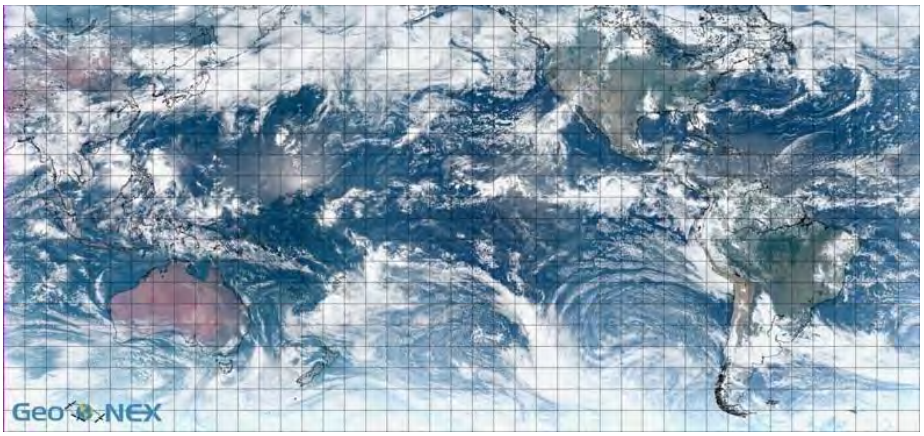

Figure 1
Example of GeoNEX L1G TOA reflectance composited with data from Himawari-8/AHI, GOES-17/ABI and GOES16/ABI.

- Initiated the research on the fusion of GEO-LEO satellite datasets across multiple spatial and temporal resolutions that is expected to synergistically leverage advantages of different platforms to improve global land surface monitoring (Fig. 2);

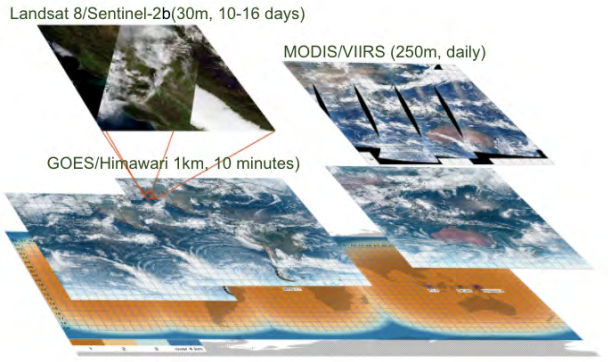

Figure 2
Data fusion of GEO-LEO satellite data across various spatio-temporal resolutions based on the GeoNEX common grid.

- Built, maintained, and developed NASA MAIAC software package for atmospheric correction and the production of aerosol optical thickness (AOT) and surface reflectance (SR) datasets;

- Distributed provisional surface reflectance products with customized MAIAC algorithm to collaborators for science investigations over Asia, Oceania, and North/South America;

- Implemented a machine learning based framework to generate Landsat based yearly percent tree cover maps for the conterminous United States and Mexico. Collaborated with the JPL team to produce national scale carbon pool and flux products. An example of the datasets in tree cover estimation over the US and Mexico is shown in Fig. 3;

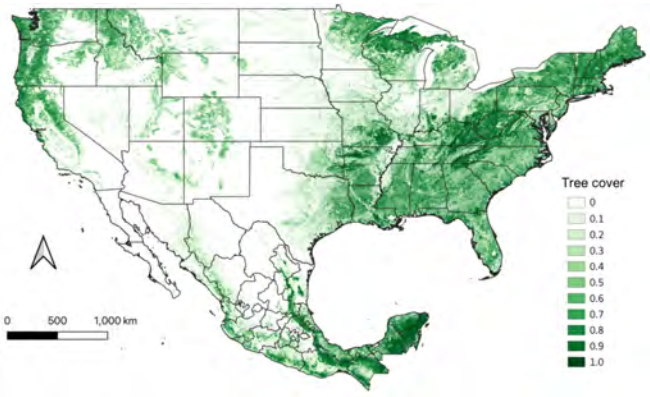

Figure 3
Landsat based tree cover estimate in 2018 over the contiguous United States and Mexico.

- Collaborated with Boston University team on Leaf Area Index (LAI) and Fraction of Absorbed Photosynthetically Active Radiation (FPAR) product development with Machine Learning algorithms;

- Phenology Product: collaborated with South Dakota State University team on product development;

- Collaborated with University of Michigan and South Dakota State University to create and distribute Global WELD Landsat products; and

- Implemented Python-based software tools to automatically generate full color animations of GOES-16/17 data using unsupervised spectral synthesis for satellite-to-satellite translation method.

OpenNEX Accomplishments

- Participated in the SpaceApps Challenge 2020 as owners of the Spot That Fire V3.0 challenge. This challenge was to develop an application to detect, predict, and assess the economic impacts from actual or potential wildfires by leveraging high-frequency data from a new generation of geostationary satellites, data from polar-orbiting environmental satellites, and other open-source datasets. (https://2020.spaceappschallenge.org/challenges/confront/spot-fire-3/details);

- Held 5 seminars and labs and posted 4 talks on the OpenNEX YouTube Channel; and

- Presented NEX at science meetings and workshops to engage the stakeholder community.

SBG Accomplishments

- Lead the Task 4 of the SBG Modeling Group, Emulating Global Surface Hyperspectral Reflectance from Multi-Band Remote Sensing Data, and developed algorithms to generated global synthetic hyperspectral datasets based on MODIS data and pre-selected spectral libraries (Fig. 4); and

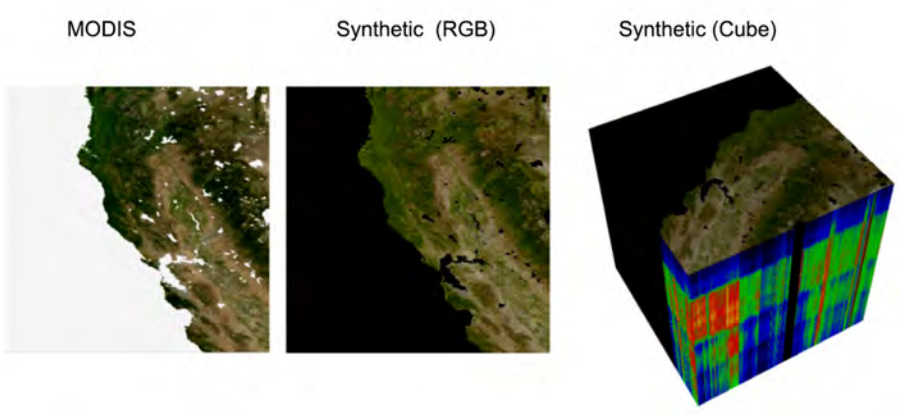

Figure 4

Example of synthetic hyperspectral images generated from broad-band satellite (MODIS) data and a pre-selected spectral library with an algorithm based on non-negative-least-square (NNLS) regressions.

- Obtained and deployed software packages including MODTRAN, LibRadtran, Atrem, ISOFIT, and Hypertrace on NEX for implementing/testing the processing pipeline of the SBG-SISTER project.

Data Acquisition & Management

- Acquired and managed several hundred terabytes of Landsat Collection 1 and Collection 2 data for several active NEX projects;

- Acquired and managed several hundred terabytes of MODIS, MAIAC, ECOSTRESS, GEDI data for the GeoNEX activity;

- Acquired and managed GOES16, GOES17, Himawari 8 and GEO-KOMPSAT-2A datasets to enable the GeoNEX activity in support of the Earth Science Research from Operational Geostationary Satellite Systems solicitation (NNH19ZDA001N);

- Improved data acquisition automation, data management, and data distribution for GeoNEX/NEX data products;

- Acquired Hyperion data from USGS for several active NEX projects;

- Acquired SSURGO soils data, NLCD landcover data, and SRTM elevation data; and

- Obtained daily surface temperature and precipitation data until 2100 from all climate projection models using the NASA Earth Exchange Global Daily Downscaled Projections (NEX-GDDP) dataset to assist in conducting world-wide climate change studies.

Proposals Submitted

NEX is virtual collaborative that brings scientists together. At least one member of the NEX team participated in the following proposals:

- Synergistic use of GEO-LEO-ISS observations to study diurnal and seasonal changes in photosynthetic activity of Amazon rainforests (NNH20ZDA001N-CARBON)

- Carbon monitoring system across Mexico: continued development and application at the national scale (NNH20ZDA001N-CMS)

- High-Resolution Forest Carbon Monitoring and Modeling: Continued Prototype Development and Deployment to National and Global Scales and Science Team Lead (NNH20ZDA001N-CMS)

- Fieldwork be damned: Using very high-resolution satellite imagery and deep learning to monitor beaver activity across the broader northwest U.S. (NNH20ZDA001N-CSDA)

- Monitoring and forecasting large-scale patterns of forest structure and carbon dynamics using field, remote sensing, and process-based models (NNH20ZDA001N-GEDIST)

- Prototyping Fractional Land Cover from Multi-Scale Data Fusion and Deep Learning: Case Studies in Partial Timber Harvest and Wildland-Urban Interface (NNH20ZDA001N-LCLUC)

- How Specific Environmental Conditions Favor Covid-19 Spatial Transmission, a Case Study In Italy (NNH20ZDA001N-RRNES)

- Data-Driven Wildfire Analytics and Intelligent Prediction Using Earth Science Data (NNH19ZDA001N-ACCESS)

- Science Middleware for Analysis Ready Data in OpenNEX (NNH19ZDA001N-ACCESS)

- An Investigation of the Formation and Evolution of Midlatitude Mixed-phase Clouds (NNH19ZDA001N-ESROGSS)

- Developing a High Frequency Product Suite of Biophysical Variables from Geostationary Satellite Systems to Monitor Vegetation Dynamics (NNH19ZDA001N-ESROGSS)

- Developing the Land continuous Variable Estimator for Geostationary satellite data (LoVE-G) (NNH19ZDA001N-ESROGSS)

- Generating global downward shortwave radiation and photosynthetically active radiation products over land surfaces by integrating the new-generation geostationary data with polar-orbiting satellite data (NNH19ZDA001N-ESROGSS)

- Increasing Useful XCO2 and XCH4 Obs: Sizing Cloud Gaps for Best Scattering Corrections (NNH19ZDA001N-ESROGSS)

- Quantifying Earth Process Dynamics with Optical Flow on Geostationary Satellite Imagery (NNH19ZDA001N-ESROGSS

- Reconstructing daily maps of aerosol optical depth from geostationary satellites over major metropolitan areas (NNH19ZDA001N-CROSS)

- Using a geostationary perspective to improve understanding and modeling of photosynthesis (NNH19ZDA001N-ESROGSS)

- Development of limb-corrected and inter-calibrated multispectral composites from the constellation of geostationary satellites (NNH19ZDA001N-ESROGSS)

- Development of MAIAC processing for Geostationary Observations NNH19ZDA001N-ESROGSS)

- A Scalable Machine Learning based Data Compression Algorithm and utility (solicitation - Cross-disciplinary use case for Artificial Intelligence / Machine Learning (AI/ML) by the SMD Strategic Data Management Working Group (SDMWG).

- EyeTracker: An Interactive Tropical Cyclone Monitoring Framework using Machine Learning, NASA's Earth Exchange (NEX), and Common Mapping Client (CMC) (NNH19ZDA001N-ACCESS)

- Integrating data-driven and physics-based predictive modeling tools to investigate the impacts of urbanization on hydrometeorology (NNH19ZDA001N-IDS)

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- Benjamin Poulter, Kerry-Anne Cawse-Nicholson, Michelle Gierach, Glynn C Hulley, David Schimel, Shawn Serbin, Alexey N Shiklomanov, David R Thompson, Philip A Townsend, Weile Wang, Anh Nguyen and Shannon Kian Zareh (2020), Modeling to Support End-to-End Traceability of Reflectance to Algorithms for the Surface Biology

and Geology Designated Observable (MEET-SBG), Dec 2020, Online, AGU 2020

- Erickson, Adam; Poulter, Benjamin; Thompson, David; Okin, Gregory; Serbin, Shawn; Wang, Weile; Schimel, David (2020), A software framework for optimizing the design of spaceborne hyperspectral imager architectures, 22nd EGU General Assembly, held online 4-8 May, 2020

- Hirofumi Hashimoto, Ramakrishna Nemani, Weile Wang, Andrew Michaelis, Hideaki Takenaka, Atsushi Higuchi. (2020): "Hourly GPP estimation in Australia using Himawari-8 AHI products" IEEE International Geoscience and Remote Sensing Symposium, IGARSS 2020, 26th September – 2nd October, Virtual Symposium.

- Hirofumi Hashimoto, Weilie Wang, Jennifer L Dungan and Ramakrishna R Nemani (2020), Detecting short term drought impact in the Southwest US using GOES-16 ABI data, Dec 2020, Online, AGU 2020

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- Ramakrishna R Nemani, Weile Wang, Andrew Michaelis, Satya Kalluri, Tsengdar J Lee, Alexei Lyapustin, Atsushi Higuchi, Hideaki Takenaka, Jia Zhang and Jennifer L Dungan (2020), GeoNEX: A Geostationary Earth Observatory, Dec 2020, Online, AGU 2020

- Vandal, T. & Nemani, R. (2020). "Optical Flow for Intermediate Frame Interpolation of Multispectral Geostationary Satellite Data". 19th Conference on Artificial Intelligence for Environmental Science. Boston, MA.

- Vandal, T. & Nemani, R. (2020). "Optical Flow for Intermediate Frame Interpolation of Multispectral Geostationary Satellite Data". 1st ACM SIGKDD Workshop on Deep Learning for Spatiotemporal Data, Applications, and Systems (Best Spotlight Presentation).

- Vargas, R., Nemani, R., Park, T., Carbon monitoring systems across Mexico to support implementation of REDD+: maximizing benefits and knowledge. NASA Carbon Monitoring System Science Team Meeting 2020. Virtual Meeting. November 17-19, 2020.

- Weile Wang, Hirofumi Hashimoto, Andrew Michaelis, Shuang Li, Hideaki Takenaka,

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- Weile Wang, Hirofumi Hashimoto, Andrew Michaelis, Taejin Park, Ramakrishna R Nemani, Yujie Wang, Alexei Lyapustin and Satya Kalluri (2020), Uncertainty Analysis of the GeoNEX Top-of-Atmospheric Reflectance Products from the Third Generation Geostationary Satellite Sensors, Dec 2020, Online, AGU 2020

- Xiaoyang Zhang, Yu Shen, Yongchang Ye, Jianmin Wang and Weile Wang (2020), Fusion of Time Series of Geostationary Satellite and VIIRS Observations for Detecting Land Surface Phenology, Dec 2020, Online, AGU 2020

Panel or Committees

- SIAM International Conference on Data Mining, 2021

- AI for Earth Workshop at NeurIPS

- SIGKDD Workshop on Fragile Earth Data Science for a Sustainable Planet, 2020

- ICDM Workshop on Data Mining in Earth System Science, 2020

- Weile Wang, Panelist on NASA Remote Sensing Theory (RST) Proposal Review Panel, May 27-29, 2020

- Weile Wang, Co-lead on the Modeling Working Group of NASA Surface Biology & Geology (SBG) Study

- Weile Wang, Convener of session on “Earth Observations from Geostationary Satellites: Applied Research and Applications” at AGU 2020 Fall Meeting.

NASA IDS-New Global Datasets for Methane Modeling

Project Participants

NASA: Matthew Johnson
BAERI: Elaine Matthews
CSUMB: Vanessa Genovese

Project Description

Current methane models vary widely in their emissions estimates due to wide differences in defining and characterizing water bodies and wetlands globally. The NASA-IDS Methane Modeling project goal is to be able to more accurately estimate methane emissions globally by creating detailed global natural methane source datasets, which are then summarized at a global scale for the methane modeling efforts.

This work was completed in 2020 and is now being published. The first of several manuscripts has been published and the other are several others still in draft form.

Accomplishments

- Finalized and published our new 0.25 degree global dataset of lakes, reservoirs and wetlands as well as the final methane emission modeling results.

Publications

Matthews, E., Johnson, M.S., Genovese, V. et al. Methane emission from high latitude lakes: methane-centric lake classification and satellite-driven annual cycle of emissions. Sci Rep 10, 12465 (2020). https://doi.org/10.1038/s41598-020-68246-1

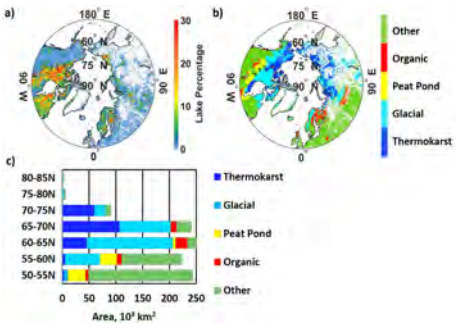


Figure 1. (a) Lake percentage, (b) classification of lake types, and (c) latitudinal areas by lake type. Total lake area is 1,095 × 103 km2. White areas in Figs. (a) and (b) denote zero lake percentage. All maps are at 0.25°lat/lon resolution.

NASA Surface Biology and Geology Study-Modeling Working Group

Project Participants

NASA: Jennifer Dungan, Ben Poulter
CSUMB: Vanessa Brooks Genovese, Weile Wang

Project Description

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

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

The study has been broken into four Research & Applications working groups: Applications, Algorithms, Modeling and Calibration / Validation. Our group at NASA Ames is working as a subtask of the modeling working group (MEET-SBG).

For 2021, we will continue to evaluate and compare our synthetic data products to existing datasets of similar scale and evaluate the pathways to process, store, and distribute future SBG data.

Accomplishments

- Began work, as part of the MEET-SBG modeling working group, to generate synthetic data products to emulate the possible scale of future SBG data (60m, global, hyperspectral) products and evaluate the pathways to process, store, and distribute this data.

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

Project Participants

NASA: Mike Little, Woody Turner, Ved Chirayath
BAERI: Alan Li, Michal Segal Rozenhaimer, Jarrett Van Den Bergh, Kamalika Das (former staff), Juan L. Torres-Perez

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 this April 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.

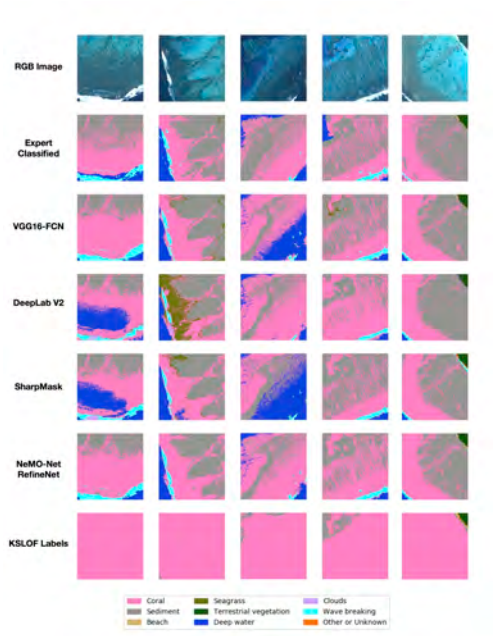
Accomplishments

- Released a web-based citizen science application. So far, there have been about 43,000 downloads with more than 71,000 image classifications completed for Pacific and Caribbean coral reefs. The user App Store ratings are 4.9/5.0 showing the success of this app with citizen scientists;

- Gave multiple presentations, mostly by the project PI, in different venues including IEEE and AGU;

- Acknowledged by NASA HQ, the Ocean Biology and Biochemistry Program, the Biodiversity and Ecological Forecasting Program, among others;

- Released public iOS version of NeMO-Net game on app store and online; and
- Finalized partnership with Living Oceans Foundation for additional coral data.



Comparison between different classifications and methods over a number of 256×256 WV-2 patches taken the Fiji Islands.

Publications

A. S. Li, V. Chirayath, M. Segal-Rozenhaimer, J. L. Torres-Pérez and J. van den Bergh, “NASA NeMO-Net’s Convolutional Neural Network: Mapping Marine Habitats with Spectrally Heterogeneous Remote Sensing Imagery,” in IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, vol. 13, pp. 5115-5133, 2020, doi: 10.1109/JSTARS.2020.3018719.

Asanjan, A.A., K. Das, A. Li, V. Chirayath, J. Torres-Perez, and S. Sorooshian. 2020. Learning instrument invariant characteristics for generating high-resolution global coral reef maps. KDD ‘20: Proc. 26th ACM SIGKDD Int. Conf. Knowledge Discovery and Data Mining. 2617-2624.

Michal Segal-Rozenhaimer, Alan Li, Kamalika Das, Ved Chirayath, Cloud detection algorithm for multi-modal satellite imagery using convolutional neural-networks (CNN), Remote Sensing of Environment, Volume 237, 2020, 111446, ISSN 0034-4257, https://doi.org/10.1016/j.rse.2019.111446.

Presentations

Asanjan, A.A., K. Das, A. Li, V. Chirayath, J. Torres-Perez, and S. Sorooshian. 2020. Learning instrument invariant characteristics for generating high-resolution global coral reef maps. KDD ‘20: Proc. 26th ACM SIGKDD Int. Conf. Knowledge Discovery and Data Mining. August 2020.

AGU Presentation: “Expanding NeMO-Net Machine Learning Capabilities for Citizen Science”.

Awards

NASA Ames Award Ceremony 2019 - Group Achievement Award for NeMO-Net Field Campaign.

NOAA Coral Reef Conservation Program - Protectores de Cuencas - Puerto Rico

Project Participants

BAERI: Juan L. Torres-Perez

Project Description

This project aims at conducting an in situ and remotely-sensed assessment of the current situation of the coral reefs located southeast and east of Guánica Bay in southwest Puerto Rico, with the purpose of proposing the expansion of the Guánica Forest (a Biosphere site) to include these reefs.

Originally, a series of diver-operated underwater transects were planned as specified in the project proposal. Due to the occurrence of numerous earthquakes in southwest Puerto Rico, particularly in Guánica and its surrounding areas, we modified the data collection methodology to one where an underwater drop-off camera was submerged from the boat and allowed to collect 1-2 min video transects. Later, 4-10 frames from each video transect were frozen and analyzed for benthic cover. A written report was provided to the Protectores de Cuencas Executive Director as agreed in the Scope of Work of the project.

Left: Entrance of Guánica Bay in southwest Puerto Rico; Right: drop-off camera for video transects collection

Accomplishments

- Conducted a modified field campaign in January 2020;
- Submitted a final report to Protectores de Cuencas at the end of the project (September 2020); and
- Analyzed results, and we expect to submit a peer-reviewed paper by the beginning of 2021.

Atmospheric Composition: Modeling and Analysis Program (ACMAP)

Project Participants

NASA: Kirk Knobelspiesse
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 prediction.

The project's objectives are to:

- Develop a new algorithm to classify MSC cloud cover and MCC cell types from multi-spectral satellite imagery on a finer spatial and temporal scale than what is available to-date, using a powerful image-based machine learning technique (semantic segmentation and texture classification via convolutional neural network).

- Utilize the new algorithm to generate high spatial and temporal cloud mask and MCC cell type maps over the South-east Atlantic and South-east Pacific regions, during the 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) effect radiative budget estimations due to MSC clouds in climate models. We will explore the differences in the model's predictions under the different aerosol conditions that prevail in the two selected regions of investigation.

Accomplishments

- Generated training for SE Atlantic using SEVIRI data from 2016-2018;

- Developed several machine learning algorithm approaches to predict MCC cloud types;

- Performed predictions of MCC cloud fields over the ORACLES domain and improved algorithmic approaches;
- Derived climatology of low-level clouds over SE Atlantic from SEVIRI; and
- Evaluated MSC simulations in the CMIP6 GCMs.

Presentations

Marine Stratocumulus Cloud Type Classification from SEVIRI using Convolutional Neural-Network and their Diurnal Cycle over the South-East Atlantic Ocean during ORACLES. Michal Segal Rozenhaimer, NASA Ames Research Center/BAERI, Mountain View, CA, Israel; Tel-Aviv University, Tel-Aviv, Israel; and D. Nukrai, T. Shalev, Z. Zhang, A. Denagamage, R. Wood, and J. Riedi

Reducing the Impact of Model Transport Error on Flux Estimates Using CO2 Profile Information from OCO2 in Concert with an Online Bias Correction

Project Participants

NOAA: Sourish Basu PI
BAERI: Susan Kulawik

Project Description

This project develops a bias-corrected lower tropospheric product from OCO-2.

The goal of this project is to develop vertically resolved OCO-2 products to better estimate locations and amounts of emitted carbon dioxide (e.g. from fires, combustion) and locations and amounts of carbon dioxide uptake (e.g. forests, oceans). This project utilizes the previously developed on-line bias correction (estimating biases in parallel with fluxes) and an initial study to determine the vertical quantity least sensitive to model transport error.

Accomplishments

- Assessed the optimal vertical quantity which will minimize model transport error;
- Developed a bias corrected preliminary product which is hosted on Zenodo for the OCO-2 v9 record, at: https://zenodo.org/record/3568428#.X9RmVthKiUk; and
- Found that bias correction modifies the averaging kernel, and therefore changed the online bias correction approach.

Presentations

- “Bias correction and its effect on the Averaging Kernel” - OCO-2/3 virtual meeting, October, 2020.
- “TCCON for CO2 satellite validation”, TCCON virtual meeting, May, 2020.
- “Characterization of OCO-2 and ACOS-GOSAT biases and errors for flux estimates”, OCO-2/3 virtual meeting, March, 2020.

U.S. Coral Reef Task Force (USCRTF)

Project Participants

NASA: Paula Bontempi, Joe Coughlan, Liane Guild
BAERI: Juan L. Torres-Perez

Project Description

The US Coral Reef Task Force (CRTF) is an interagency entity dedicated to promote the research, restoration and conservation of coral reefs and associated coastal and marine ecosystems within the US jurisdictions that have these magnificent ecosystems. NASA is one of the agencies that participates in the CRTF. I am a coral reef biologist mostly interested in understanding the effects of humans on the health and resilience of reefs, particularly those in the Caribbean, and am one of NASA's representatives within the CRTF.

I participate in the CRTF Steering Committee, Climate Change Working Group and the Watershed Working Group's monthly meetings. During a normal year, the CRTF meets in person twice a year — we meet in February in Washington DC, and in the Summer/Fall in one of the jurisdictions. During these meetings, I provide updates on coral reef-related projects funded by NASA. This year, because of the current COVID-19 situation, we had a virtual meeting where Dr. Laura Lorenzoni, the current Ocean Biology and Biogeochemistry Program Scientist, provided the update based on information provided by myself and Dr. Liane Guild from Ames.

Accomplishments

- Participated in regular monthly meetings of the CRTF Steering Committee, Watershed Working Group and the Climate Change Working Group;

- Provided updates on NASA-funded projects with coral reef themes such as the EVS-CORAL, NeMO-Net, and several short term projects conducted through the NASA DEVELOP Program; and

- Participated in the virtual meeting that took the place of the task force's regular in-person bi-yearly meeting.

Panels or Committees

Torres-Pérez continues to be an invited reviewer in a number of peer-review journals as well as proposal panel reviews. Torres-Pérez is also part of two PhD graduate committees of two students from the University of Puerto Rico, one in the Department of Marine Sciences and the

other in the Department of Environmental Sciences.

Earth Science

Applied Sciences Program

Disaster Management

Project Participants

NASA: Lawrence Friedl
CSUMB: Vincent Ambrosia

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 mission 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 development of NASA Applied Science Wildland Fire topical solicitations, as well as organizing and managing review panels and selection of NASA proposals to those solicitations; scientific oversight of the program goals and objectives, budgetary management of the funded efforts of disparate organizations and investigators, metrics monitoring for the investigations, interactions with partner agencies involved in the projects and servings 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 assumed an additional role / task as the 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 (2020--virtual).

Our 2021 project goals are to:

- Continue to support the NASA Applied Science Program – Wildfire Program in the capacity of Associate Program Manager with management oversight of the NASA ROSES-16, A.50 Group on Earth Observations (GEO) Work Programme; 3.3.7 Global Wildfire Information System (GWIS) projects (three projects). Manage the budgetary and scientific metric of those project teams through the solicitation /program life-cycle (to FY22);

- Develop, manage, and support the workshop, webinar and outreach components of the GEO-GWIS program element, including international outreach (conference workshops) to increase utilization of the system by under-served entities / organizations / nations;

- Manage the Mediterranean Regional Information Network (MedRIN) of the NASA LCLUC Program (HQ PM: G. Gutman) to develop collaborations of nations in eastern Mediterranean region with NASA Earth Sciences Program;

- Continue as NASA representative on Group on Earth Observations (GEO) GWIS Initiative (WP 2020-2022), Coordination Advisory Board;

- Maintain involvement, representing the NASA Earth Science Division on regional, national, international professional scientific committees (includes GEO);

- Continue as website content manager for the NASA Applied Science Program - Wildland Fire Program contributions to the Disaster Program Website and Disaster Portal;

- Serve as programmatic peer reviewer of NASA Earth Science Program solicitation proposals;

- Continue support to the scientific community by serving as a peer-reviewer for other Federal agency / departments solicitations (including USDA-FS SBIR Program, NSF Reviews, etc.);

- Continue as international scientific journal peer-reviewer;

- Continue service on the External Advisory Board of "EXCELSIOR" (ERATOSTHENES: Excellence Research Center for Earth Surveillance and Space-Based Monitoring Of the Environment), an European Commission (EC) WIDESPREAD-04-2017: Teaming Phase 2, HORIZON 2020 Work Programme 2018-2019 "Spreading Excellence and Widening Participation" effort. This 7-year funded initiative will develop an eastern Mediterranean Region Center of Excellence (CoE) in Remote Sensing at the Cyprus Technology University (CTU). Role of Ambrosia is to serve as a Board Member on the CoE Advisory Board to the University President and the Board of Directors;

- Develop (co-author) and support the USFS Annex to the NASA / USDA Inter-agency Agreement (IAA to collaborate on use / integration of EO for resource management issues, including wildland fire);

- Support and advise various NGO groups on use of EO to support wildland fire management, including the CA. League of Women Voters Wildfire Issues Committee, and the NASA Space Portal Wildfire Issue;

- Provide outreach and education of NASA ASP directions to various community groups including lecturing at Universities, providing seminars at other scientific organizations and wildfire management training exercises and workshops;

- Support workshops and working group meetings as invited speaker and reviewer on uses of new technologies to improve wildland fire management; these organizations include the IDGA, USGS, etc;

- Support the International Conference on Remote Sensing and Geoinformation of Environment (RSCy) as a member of the Conference Organizing Committee and the Scientific Committee; and

- Serve as Scientific Committee / Organizing Committee member of ISRSE for 2022 Symposium (Hanoi, VN, Spring 2022).

Accomplishments

- Managed the NASA ROSES16 A.50-Group on Earth Observations (GEO) Work Programme; 3.8 Global Wildfire Information System (GWIS) projects (2018-2022), including development of the solicitation, organizing and managing the peer-review panel for selection, and serving as Associate PM of the GWIS program projects (3) in that solicitation. Management includes development of project progress metrics, organizing and participating in workshops and trainings at regional and international fire conferences / meetings;

- Co-Lead the 2020 Tactical Fire Remote Sensing Advisory Committee (TFRSAC), which also entails co-hosting the twice-annual workshop in November. Management efforts included planning agendas, budgetary control of the meeting expenses, contracting services, organizing speakers, development of breakout sessions, securing meeting facilities and securing A/V support to meetings, and archiving / sharing of meeting presentations;

- Continued management of the NASA LCLUC Program (HQ PM: G. Gutman), Mediterranean Regional Information Network (MedRIN). As NASA Lead of MedRIN, developed collaborations with international EO partners in the eastern Mediterranean region with the NASA Earth Sciences Program. Worked with two European MedRIN Chairs to facilitate collaborative science, and organize regional workshops that enhance the use of NASA Earth Observation data for land change dynamics;

- Co-organized the Joint MedRIN / SCERIN (South Central Europe Regional Information Network) Workshop, Thessaloniki, Greece (June 2020), which was postponed to 2021 due to COVID-19 meeting / travel restrictions;

- Represented NASA Applied Science Program on inter-agency, regional, national, and international science panels focused on wildfire assessment, including the USGEO / GEO Global Wildfire Information System (GWIS) Committee;

- Briefed NASA HQ management on programmatic goals and metrics of the Wildfire Program during quarterly ASP Programmatic Reviews;

- Participated as member of Technical and Scientific Panel of international remote sensing conferences, including the 2020 International Conference on Remote Sensing and Geoinformation of Environment (RSCy-2020), which was canceled due to COVID-19 meeting / travel restrictions;

- Served on numerous journal peer-review panels; provided scientific peer review of four (4) manuscripts submitted to journals in 2020;

- Served as Scientific Panel reviewer for NASA Earth Science Division (HQ) solicitation proposal submissions (ROSES-19; LCLUC Program);

- Reviewed Panel for USDA SBIR submissions for fire science support in 2020;

- Collaborated with NASA HQ Comms Department on a series of wildfire science / apps videos, NASA TV features, and web documentaries in 2019 and 2020;

- Served as content manager of the NASA Applied Science Program - Wildfire website;

- Contributed to NASA Applied Science Program – Disaster Program, Wildland Fire element 2019 and 2020 Annual Program Report;

- Authored GEO-GWIS component and NASA Fire Applications elements of the NASA Applied Science Program – Disaster 2018 Annual Report; and

- Served as external Advisory Board Member of the *"EXCELSIOR" (ERATOSTHENES: Excellence Research Center for Earth Surveillance and Space-Based Monitoring Of the Environment)*, Center of Excellence (CoE) at the Cyprus Technology University (CTU), Limassol, Cyprus

Presentations

- Ambrosia, V.G., 2020. *NASA Contribution to the Eastern Mediterranean Region, EXCELSIOR Project, & the MedRIN Network*, 1st Virtual EXCELSIOR International Technical Workshop, CUT ERATOSTHENES Centre of Excellence, Lemasol, Cyprus, 15 July 2020.

- Ambrosia, V.G., 2020. *Collaboration on the Global Wildfire Information System (GWIS),* Wildfire Management Summit 2020, Institute for Defense and Government Advancement (IDGA), (Virtual meeting), Sacramento, CA., 4 June 2020.

- Hadjimitsis, D., G. Schreier, H. Kontoes, A. Ansmann, G. Komodromos, K. Themistocleous, K. Neocleous, S. Michaelides, R. Mamouri, I. Papoutsis, J. Bühl, E. Schwarz, S. Tziortzis, C. Danezis, A. Nisantzi, C. Mettas, C. Papoutsa, G. Melillos, M. Tzouvaras, E. Evagorou, A. Agapiou, A. Christofe, M. Prodromou, V. Lysandrou, T. Polydorou, P. Kyriakidis, N. Kyriakides, E. Akylas, V. Ambrosia, M. Maranesi, P. Zeil,

  L. Halounova, D. Barok, 2020. *The ERATOSTHENES Centre of Excellence (ECoE) as a Digital Innovation Hub for Earth Observation*, Proc. SPIE 11418, Detection and Sensing of Mines, Explosive Objects, and Obscured Targets XXV, 114180F (24 April 2020); doi: 10.1117/12.2567070.

- Ambrosia, V.G., 2020. *Global Wildfire Information System (GWIS) Web Mapping Services*, Aerial Firefighting North America – 2020 Conference & Exhibition, Sacramento, CA., 5 March 2020.

- Seminar: *NASA Missions: Earth Observations*. California State University – Monterey Bay, School of Natural Sciences Seminar Series, Seaside, CA., 27 January 2020.

Panels or Committees

External Advisory Board (EAB) Member, *EXCELSIOR (ERATATOSTHENES: Excellence Research Center for Earth SurveiLlance and Space-Based MonItoring Of the EnviRonment)*, WIDESPREAD-01-2018-2019: Teaming Phase 2, Horizon 2020 Program, Cyprus University of Technology (CUT), Lemasos, Cyprus.

Ambrosia served as a Scientific Panel Reviewer for two national programmatic solicitations:
- NASA ROSES-2019: A.2**;** Land-Cover/Land-Use Change (LCLUC) Review Panel (June 2020; virtual).
- USDA-National Institute of Food & Agriculture; SBIR 8.1, Forests and Related Resources (March 31 – April 2, 2020).

NASA Representative on the Group on Earth Observations (GEO), Global Wildfire Information System (GWIS) committee; GEO Work Plan 2011-2015, 2016-2020, and 2020-2022.

2020 Scientific Peer-Review Journal Reviewer for: International Journal of Wildland Fire, Remote Sensing, Remote Sensing of Environment, and Science of Remote Sensing.

Co-Chair: NASA Tactical Fire Remote Sensing Advisory Committee (TFRSAC); a USFS / NASA committee focused on technology development and EO in support of wildland fire management (since 2003).

Other Information

Community Outreach
Vince Ambrosia serves as a member of the External Advisory Board for the Cyprus University of Technology (CUT), EXCELSIOR Center of Excellence (CoE) (2018-2027). The EXCELSIOR CoE is designed to create a new Mediterranean region remote sensing, earth observations and Geomatics Center to develop research, applications, and technology transfer of geospatial tools to greater use in the community. The European Commission (EC) supports the EXCELSIOR CoE effort.

Professional Societies, Committees, and Boards

- American Society for Photogrammetry and Remote Sensing (ASPRS)
- Institute of Electrical and Electronics Engineers (IEEE)
- European Assoc. of Remote Sensing Laboratories (EARSeL) Forest Fires Special Interest Group (FF-SIG), Science Team Member (2001-present); Technical Committee (2009-present)
- American Institute for Aeronautics and Astronautics (AIAA)
- American Geophysical Union (AGU)

Ecological Forecasting

Project Participants

NASA: Woody Turner
BAERI: Cindy Schmidt

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 10 projects for the program.

Accomplishments

- Attended the 16th Global Forest Observation Initiative Regional Workshop in the Americas: How is REDD+ data used for management, policy and other reporting mechanisms in Latin America. I gave presentations on the Ecological Forecasting projects in Colombia, Ecuador and Peru as well as a presentation on Earth Observations for Sustainable Development Goals;

- Participated in all-day Applied Science program reviews in March, May, July, September and November. Participation included presenting on Ecological Forecasting projects and contributing to the Applied Science strategic planning process; and

- Conducted a remote sensing training for conservation as part of the Society for Conservation GIS annual conference. This training was co-taught with a colleague from UC Berkeley's Geospatial Innovation Lab.

Presentations

- "Remote Sensing for Biodiversity and Conservation", Cal State University Monterey Bay GIS class, August 2020

- "Remote Sensing for Biodiversity and Conservation", UC Berkeley GIS class, October 2020

Panels or Committees

- Co-chair for AGU 2020 session: Earth Observations for Sustainable Development Goals

Indigenous Knowledge

Project Participants

NASA: Lawrence Friedl
BAERI: Cindy Schmidt, Amber McCullum

Project Description

The NASA Applied Science Capacity Building Indigenous Peoples initiative seeks to better understand the needs and data gaps in the use of geospatial data, particularly NASA Earth science data and products, within Indigenous communities globally, but particularly tribes in the United States. This program also builds the capacity of indigenous communities and organizations to use geospatial data through in-person and online trainings and workshops. In addition to better understanding the needs and data gaps of Indigenous groups, this effort also seeks to understand how indigenous knowledge can inform NASA Earth Science activities.

The pillars of this work include community engagement and the co-production of place-based remote sensing trainings specific to 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

- Completed the Indigenous Peoples Capacity Building Initiative, led by Cindy Schmidt and Amber McCullum, in partnership with the United Tribes Technical College, an all-virtual “Introduction to Remote Sensing for Tribal Lands” training series, held each Tuesday and Thursday in October. Each week, we focused on a different tribal region in the U.S. with guest speakers from the Navajo Nation, the Sault Ste. Marie Band of Chippewa Indians, the Rosebud Sioux tribe, and the Tulalip Tribes. The training had 276 registrants, from a variety of organizations (130 academic, 77 tribal, 40 govt., 19 private, and 10 NGO). 100% of the survey respondents said the course either met or exceeded their expectations. One respondent noted: “Cynthia and Amber have excellent presentation skills, knowledge, and thorough explanations on each of the webinars. Thank you both and for NASA to make this program possible for real world application!” Another respondent mentioned “virtually training is so good to get involved without physically [being] in the united states, this means a lot to our tribe […] thank you so much for offering this, the course explain very well and it is very useful in real-life setting particularly for tribal land management!” More information can be found at the

course website here: https://appliedsciences.nasa.gov/join-mission/training/english/introduction-remote-sensing-tribal-lands;

- Participated in the Indigenous Mapping Workshop (IMW 2020), held online from November 17-19th, 2020. We offered 9 training sessions as part of the Indigenous Mapping workshop. This workshop was organized by the indigenous-led and owned Firelight Group out of Canada, and featured training sessions by other collaborators such as Google, ESRI, and Mapbox. The workshop had over 800 people registered and included panels and presentations from Indigenous leaders and elders from Canada, Australia, New Zealand and the US. Additional information can be found here: https://www.indigenousmaps.com/2020imw/;

- Featured on StoryCorps: A discussion with Amber McCullum, titled "Community-based Science and Capacity Building with NASA and the Navajo Nation." This interview was led by Luke Gezovich, a CAARE communications intern working with Kassie Perlongo. In this interview, Amber highlighted her work as a coordinator for NASA's Indigenous People's Capacity Building Initiative (IP), which is led by Dr. Cindy Schmidt. The goals of the IP centers around community, listening, and relationship building. One of the primary objectives is to provide remote sensing trainings to the indigenous community through a focus on place-based approaches. The IP also seeks to increase indigenous representation and knowledge systems at NASA. Amber also discussed her role as the lead for a project focused on drought reporting in collaboration with the Navajo Nation, including project outcomes and further connections with the Navajo Nation;

- In celebration of International Day of the World's Indigenous Peoples on Sunday August 9, 2020 the Group on Earth Observations (GEO) announced via Twitter that they published the report from last month's high-level forum. During this forum, Amber McCullum presented on the Indigenous Peoples Capacity Building Initiative and pathways for future international Indigenous collaborations. This side event was a collaborative effort led by 19 contributors from CANEUS, FILAC, GEO, NASA, Conservational International, Agvesto, and others, representing Indigenous representatives as well as key actors in the field of EO and Information and Communications Technology (ICT) design. It served as a platform for Indigenous Peoples to discuss opportunities and challenges for increasing Indigenous Peoples engagement with other stakeholders in the co-development, creation and use of culturally relevant EO data and tools;

- Participated in the Group on Earth Observation Indigenous Peoples Summit by presenting information about the online trainings we conducted in October; and

- Acknowledged and featured on nasa.gov and space.com:
  - https://www.nasa.gov/feature/blending-science-and-tradition-sharing-remote-sensing-technologies-with-indigenous
  - https://www.space.com/earth-observation-for-native-american-tribes.html

Presentations

- Amber McCullum participated as a panel speaker and representative for NASA's Indigenous Peoples Capacity Building Program at the United Nations High-level Political Forum on Sustainable Development side event titled "Indigenous Peoples-led Use of Earth Observations" held virtually on July 9th, 2020. During this event, a panel of experts discussed key challenges and opportunities for inclusive engagement of Indigenous Peoples to advance the use, application, and co-development of tools that use Earth Observations for conservation, land management, and sustainable development. Contributors to this event included Indigenous leaders from around the world, the Group on Earth Observations (GEO) Secretariat, members of the GEO Indigenous Alliance, and international non-governmental organizations such as Conservation International.

Satellite-based Drought Reporting on the Navajo Nation

Project Participants

NASA: Lawrence Friedl
BAERI: Henrietta Marks, Amber McCullum, Nikki Rae Tulley

Project Description

Without water, we cannot survive. Without the tools needed to understand the patterns of water availability, it is difficult to make decisions about how to manage water and provide resources to regions that need it most. On the Navajo Nation (NN), in the four corners of the southwestern U.S., there is a need for data-driven management of water resources. Water is scarce, highly variable, and drought declarations are common. Paired with in-situ rain gauge data, satellite-based remote sensing of precipitation, vegetation, and drought indices on the Navajo Nation may improve upon the ability to monitor and report drought conditions. This project has created a cloud-based web application, the Drought Severity Evaluation Tool (DSET), for improved drought reporting that integrates remotely-sensed, modeled, and in-situ data on the NN. This tool harnesses the capabilities of Google Earth Engine (GEE), specifically through a partnership with the Desert Research Institute (DRI) and ClimateEngine.org, to conduct drought and land assessments. Tool development has been an engaged and iterative process with project partners at the NNDWR and beyond to ensure usability of the tool post-development. This engagement has included regular meetings and an in-person training with Navajo partners and others, that culminated in a feedback session for tool improvements. DSET provides insight for the use of additional drought metrics and reporting mechanisms that can assist in updating the Navajo Nation Drought Contingency Plan.

Accomplishments

- Created the DSET Tool: https://app.climateengine.org/dset;

- Acknowledged through a feature article posted to the NASA Science website on Friday 3/20/2020 highlighting project partner Carlee McClellan, from the Western Water Applications Office (WWAO) Navajo Drought project: https://science.nasa.gov/earth-science/applied-sciences/making-space-for-earth/carrying-water-for-his-community-carlee-mcclellan-navajo-nation. This human-interest piece chronicles Carlee's life and career path alongside the current partnerships with NASA (PI Amber McCullum) and the Desert Research Institute (collaborators Justin Huntington and Britta Daudert). The article was also featured on NASAEarth's Twitter page for World Water Day (3/22/2020);

- Featured as the image of the day on the Earth Observatory website on Monday 4/20/2020: The Western Water Applications Office (WWAO) Navajo Drought project. This includes multiple images and a brief story about the project and relevance to Applied Sciences. View the posting at: https://earthobservatory.nasa.gov/images/146565/tracking-water-for-the-navajo-nation;

- Featured on StoryCorps: A discussion with Amber McCullum, titled "Community-based Science and Capacity Building with NASA and the Navajo Nation." This interview was led by Luke Gezovich, a CAARE communications intern working with Kassie Perlongo. In this interview, Amber highlighted her work as a coordinator for NASA's Indigenous People's Capacity Building Initiative (IP), which is led by Dr. Cindy Schmidt. The goals of the initiative are centered on community, listening, and relationship building. One of the primary objectives is to provide remote sensing trainings to the indigenous community through a focus on place-based approaches. The initiative also seeks to increase indigenous representation and knowledge systems at NASA. Amber also discussed her role as the lead for a project focused on drought reporting in collaboration with the Navajo Nation, including project outcomes and further connections with the Navajo Nation;

- Featured in an article on NASA.gov about blending science and tradition: The WWAO Navajo Nation Drought project. The article was mentioned in Administrator Bridenstien's weekly update email;

- Featured on the NASA Earth Twitter account on August 8th, 2020 to highlight the 'Space for US' series: The Navajo Drought Severity Evaluation Tool (DSET). This series highlights a NASA Earth Science project from each state, with this tool being the highlight for Utah; and

- Secured funding from the S.D. Bechtel, Jr. Foundation for continued development of the Drought Severity Evaluation Tool (DSET), as well as expansion of the partnership to use remotely sensed Evapotranspiration (ET) data from OpenET. This project will begin in early FY21 and will continue to sustain the relationship with NASA and the Navajo Nation through the co-development of satellite-based water management tools, capacity building, and an internship opportunity for a student within the Dine community. The funding will also support the continued transition of operations from NASA to the Navajo Nation.

Publications

McCullum, A.J.K., C. McClellan, B. Daudert, J. Huntington, R. Green, V. Ly, A.R.G. Marley, N.R. Tulley, C. Morton, K.C. Hegewisch, J.T. Abatzoglou,D. McEvoy, Satellite-based Drought Reporting on the Navajo Nation, Journal of the American Water Resources Association. In press.

Presentations

- On Friday August 28th, from 10:00 to 11:30 am Pacific, Nikki Rae Tulley of the Navajo Nation Drought Project presented for the Western Regional Partnership Tribal Engagement Working Group in a featured presentation titled, “From land to space: Understanding water on the Navajo Nation”. She was joined by Dr. Crystal Tulley-Cordorva, the Principal Hydrologist from the Navajo Nation Dept. of Water Resources to provide an overview of the Hydromet Network and the connections of this work to the NASA-funded project.

- Upcoming: SY038: Science to Action: Enabling science- and data- driven water management, https://agu.confex.com/agu/fm20/prelim.cgi/Session/104795, The Drought Severity Evaluation Tool: A collaboration of Sovereignty and Science for the Navajo Nation, Nikki Tulley1, Amber McCullum2, and Crystal Tulley-Cordova3

Embedded links to some of the articles, etc. in the Google Doc here: https://docs.google.com/document/d/1mQetVAV6AHv_AmVjqTTRBCajAsqBoUdLj7lT1vOdm2s/edit

Water Resources Program

Project Participants

CSUMB: Forrest Melton, Pam Hansen

Project Description

The primary objectives of this task are to:

- Support the NASA Applied Sciences Program, 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; and

- Conduct outreach and engage and support the NASA Applied Sciences Water Resources stakeholder community.

Future goals are to:

- Continue to support NASA HQ through program management and community leadership activities;

- Continue to maintain contact with PI's and projects for which I am responsible, and report progress at ASP Program Reviews;

- Organize the 2021 Water Resources PI Meeting (P. Hansen, F. Melton);

- Co-organize Remote Sensing Applications sessions at AGU, AMS and other scientific conferences;

- Continue to maintain and improve program website and communication material;

- Attend additional stakeholder meetings and workshops to represent the NASA ASP Water Resources program element; and

- Organize at least 1 additional meeting or event for the NASA Applied Science Water Resources 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. Supported the project formulation process for multiple projects being supported by WWAO in the Columbia River Basin. Co-led the development of the WWAO Program Strategy for FY21. Supported the WWAO Needs Assessments for the Rio Grande River Basin and the Missouri River Basin. Co-authored the WWAO RFI for the Columbia River Basin. Oversaw technical progress on six project supported by WWAO;

- Organized and co-led the annual NASA Applied Sciences Program (ASP) Water Resources and Western Water Applications Office Meetings. Planned all logistics for the meeting to be held in Salt Lake City, UT and reorganized the meeting and agenda to allow the meeting to be held virtually over four days from July 20-23. Organized all meeting logistics and agenda for a meeting with over 110 participants. Organized panels on special topics for the NASA Water Resources Community;

- Served as the NASA Representative to WESTFAST and the NIDIS Applications Working Group, which are federal interagency coordinating organizations;

- Co-led the organization of the WWAO Technology Transition Workshop with the Western States Water Council (WSWC) and WestFAST in Irvine, CA, scheduled for May, 2020. Worked with the WWAO team and the WSWC to develop the workshop objectives and agenda. This workshop has been postponed until 2021; and

- Continued to lead the organization of a program initiative with the Bechtel Foundation, Moore Foundation, the Walton Family Funding, Google, EDF and the Water Funders Initiative on remote sensing of evapotranspiration (ET). Secured $6 million in funding to date from multiple private foundations for the OpenET effort, which involves six PIs from the ASP Water Resources Community. Co-organized a workshop for 90 participants in Reno, NV in August 2019 for the project kick-off events.

Presentations

- Melton, F., 2020. Remote Sensing of Cover Crops. Report and presentation prepared for the Walton, Family Foundation, Jun 25, 2020.

- During 2020, Forrest Melton provided briefings for 7 U.S. Senate Offices, 3 House of Representative Offices, staff for 2 House Committees and the American Farm Bureau Federation and the California Farm Bureau.

Panels or Committees

- F. Melton is serving as a guest editor on a special issue of the Journal of the American Water Resources Association in 2020.
- NSF Integrated Hydro-Terrestrial Modeling committee.
- Western Federal Agency Support Team (WESTFAST).
- California Department of Water Resources Open Water Information Architecture Technical Committee.
- California State Water Resources Control Board Open Data Technical Advisory Committee.
- NIDIS Applications Working Group.

Heliophysics

Interactive Database of Atmospheric Radiation Dose Rate

Project Participants

NASA: Nagi Mansour
BAERI: Irina Kitiashvili, Viacheslav Sadykov

Project Description

The Earth's radiation environment is a subject of primary importance in the study of Space Weather from scientific, operational, and commercial points of view. A decision-impacting example of using advanced scientific knowledge to improve human safety is to obtain accurate estimates of the radiation doses received during aircraft flights. The goal of the project is to develop a convenient, user-friendly and reliable infrastructure that will provide dynamical intuitive access to measurements of the solar radiation flux in the Earth atmosphere at high altitudes, obtained with the ARMAS device (Tobiska et al., 2015-2018), and based on the HelioPortal Web platform.

The team has developed a Radiation Portal Database – an interactive web-based application for convenient search and visualization of in-flight radiation measurements and exploration of various properties related to the radiation environment. The application provides dynamic intuitive access to measurements of the radiation dose rates in the Earth atmosphere at avionic altitudes obtained with the Automated Radiation Measurements for Aerospace Safety (ARMAS) experiment (Tobiska et al. 2018), together with quick analysis and visualization tools. The application also links the ARMAS measurements to the observations of the solar activity (soft X-ray radiation and energetic proton fluxes) by the Geostationary Operational Environmental Satellite (GOES).

Accomplishments

- Implemented and tested the fully-functional database and the web-based application at the local server. The application search engine contains a variety of filters (flight location and timing, environmental and dosimetric properties), allowing a user to customize the flight selection;

- Initiated using the Google Charts API, the search process accompanied by dynamic histograms of the flight parameters. The visualization shows the statistics for user-selected flights as well as the properties of each selected flight (route and measurements). The dynamical web-based visualization has been implemented using the Google Charts and OpenLayers map API;

- Set up the MySQL relational database, which contains the ARMAS flight measurements and GOES satellite observations. The integration of the GOES data with the ARMAS measurements has been optimized for fast data retrieval. A set of scripts for the database

updates and the inclusion of new ARMAS and GOES measurements has been developed and tested;

- Developed the Application Programming Interface (API) and related Python routines. They provide users with the capability to retrieve database records directly and efficiently, without interaction with the web interface; and

- Initiated the Radiation Data Portal deployment in the NAS Data Portal environment (https://data.nas.nasa.gov/) and is currently transferring the codes to the NAS team.

Publications

Sadykov, V.M., Kitiashvili, I.N., Tobiska, W.K., Guhathakurta, M. “Radiation Data Portal: Integration of Radiation Measurements at the Aviation Altitudes and Solar-Terrestrial Environment Observations”. 2020. Space Weather Journal, in press.

Presentations

- Sadykov, V.M. et al. “Radiation Portal: Connection of Radiation Measurements on Airplane Flights with Observations of Solar-Terrestrial Environment”. 2020, AGU Fall Meeting 2020. Online, December 1-17, 2020.

- NASA Frontier Development Lab 2020 Big Think Workshop: Sadykov V.M., Kitiashvili I.N., Tobiska W.K., Mertens C., Cruz A. “Machine Learning-driven Prediction of Radiation Doses Received during Airplane Flights.”

Interaction of Quiet-Sun Magnetic Fields with the Chromosphere

Project Participants

NASA: Nagi Mansour, Alan Wray
BAERI: Irina Kitiashvili, Viacheslav Sadykov

Project Description

Where and how solar magnetic fields are generated and how they affect the structure and dynamics of the solar surface and atmosphere are questions that are fundamental to our understanding of solar activity and variability. High-resolution observations and 3D simulations suggest that, in addition to the “global dynamo” which operates deep in the convection zone and is responsible for the solar cycles, there is a separate “small-scale dynamo” which operates near the surface and produces ubiquitous small-scale magnetic elements, thus contributing to the magnetic carpet in the photosphere and to the magnetic structure and dynamics of the solar atmosphere. Observations from the NASA space mission IRIS have revealed finely structured, multi-temperature high-speed plasma dynamics in the upper chromosphere, rapidly varying in space and time. Recent discoveries of the rich and intense plasma motions of the quiet-Sun atmosphere have raised new questions about the physical mechanisms behind the fine structuring observed in the chromosphere and about the effects of these dynamics. It appears that the primary drivers in the energetics and dynamics of the chromosphere and transition region are small-scale, previously unresolved, quiet-Sun magnetic fields.

In this study the traditional force-free and potential models of the quiet-Sun magnetic carpet and chromospheric loops are replaced with radiative MHD models that describe the properties and dynamics of the photosphere, chromosphere and corona more realistically. The realistic simulations are capable of reproducing various known magnetic features (loops, vortices, jets, oscillations), and also can predict new phenomena, which can be then investigated observationally. Understanding the origin and dynamics of small-scale magnetic fields in the quiet-Sun atmosphere is the main goal of this research. In the new picture emerging from recent observations and simulations, the atmospheric dynamics is no longer controlled by relatively regular magnetic loops and their occasional reconnections but rather is characterized by an extremely turbulent magnetized medium where multi-scale reconnections occur continuously and plasma eruptions are driven through processes of magnetic self-organization. Making this descriptive transformation requires deep understanding of how the chromospheric dynamics observed with IRIS is linked to the photospheric fields. This knowledge can be provided by complementary data from Hinode observations and numerical simulations.

Accomplishments

- Developed new hydrodynamic models extended to the solar corona and subsurface (up to 20,000km high and 5,000 km deep);

- Analyzed characteristics of the UV emission, and dynamics of the solar atmosphere from the photosphere to the corona using a 3D MHD radiative model obtained with the StellarBox code;

- Obtained synthetic observations of Mg II and C II lines observed by IRIS, and EUV emission observed by SDO/AIA, synthesized using RH radiative transfer code and temperature response functions;

- Generated series of the full Stokes profiles for nine spectral lines (4305A, 5247A, 5250.2A, 5260.6A, 6173A, 6301A, 6302A, 15648A, and 15652A) from two sets of small-scale high-resolution dynamo models obtained with the StellarBox code. Synthesis of each line computed for six distances from the disk: 0, 30, 45, 60, 70, and 80 degrees. The synthetic Stokes profiles are obtained for two independent small-scale dynamo models with a spatial resolution of 12.5km and temporal resolution of five and thirty seconds. Each dynamo model includes at least 1 hour of the data;

- Detected manually 18 total shock wave patterns across the computational domain. Quantitative characteristics of changes of physical parameters of the atmosphere and the synthesized UV emission were derived for each shock wave. It was found that the Doppler velocity jumps of the C II 1334.5 Å IRIS line, and relative enhancement of SDO/AIA 335 Å emission, are the best proxies for the enthalpy deposited by shock waves into the corona. The synthetic emission of the lines and extreme ultraviolet passbands are correlated with each other during the shock wave propagation. Also, all studied shocks are mostly hydrodynamic (i.e., the magnetic energy carried by horizontal fields is <2.6% of the enthalpy for all events) and have Mach numbers > 1.0-1.2 in the low corona;

- Tested the detection of the shockwaves in numerical simulations using supervised machine learning (ML) techniques using two approaches: a classical binary classification, and similarity-based prediction of the shock wave presence at each considered location of the simulation domain. The statistical study of properties of the shocks detected with ML is in progress; and

- Generated the synthetic data of the FeI line (6173A), which corresponds to an operational wavelength of the Helioseismic and Magnetic Imager on-board the NASA Solar Dynamics Observatory for the solar disk center (0°), 30°, and 60° latitude. The data have been made publicly available through the NAS Data Portal.

Publications

Kitiashvili I.N., Wray A.A., Sadykov V.M., Kosovichev A.G., Mansour N.N. 2020. Realistic 3D MHD modeling of self-organized magnetic structuring of the solar corona. Proceedings of the International Astronomical Union, Volume 15 / Issue S354, pp 346 - 350.

Kitiashvili I.N. 2020. Global evolution of solar magnetic fields and prediction of activity cycles. Proceedings of the International Astronomical Union, Volume 15 / Issue S354, pp 147 - 156.

Nita G., Georgoulis M., Kitiashvili I. etc. White paper: Machine Learning in Heliophysics and Space Weather Forecasting: A White Paper of Findings and Recommendations. arXiv: 2006.12224

Kitiashvili, I.N. et al. “Realistic 3D MHD modeling of self-organized magnetic structuring of the solar corona”. 2020, Proceedings of the International Astronomical Union, Volume 354, pp. 346-350

Sadykov V. M., Kosovichev A. G., Kitiashvili I. N., Kerr G. S. Response of SDO/HMI Observables to Heating of the Solar Atmosphere by Precipitating High-energy Electrons. The Astrophysical Journal, Volume 893, Issue 1, id.24, 10 pp. (2020)

Huang N., Sadykov V. M., Xu Y., Jing J., Wang H. Comparison of Enhanced Absorption in He I 10830A Observations and Modeling during the Early Phase of a Solar Flare. 2020. The Astrophysical Journal Letters, 897, L6.

Sadykov V. M., Kitiashvili I. N., Kosovichev A. G., Wray A. “Connecting Atmospheric Properties and Synthetic Emission of Shock Waves Using 3D RMHD Simulations of Quiet Sun”. 2020, The Astrophysical Journal, under review.

Presentations

- Kitiashvili, I.N. Global Solar Activity Forecast using AI/ML and Data Assimilation. Workshop on machine Learning, data Mining and data Assimilation in Geospace (LMAG2020), September 21-24, 2020.

- Kitiashvili, I.N. Use Case: 3D Realistic Modeling of the Sun. HEC Needs Assessment Workshop, June 2020.

- Sadykov, V.M. “Connecting Atmospheric Properties and Synthetic Emission of Shock Waves in 3D RMHD Simulations of Quiet Sun”. 2020. Virtual seminar at the National Solar Observatory (NSO), August 4th, 2020.

- Sadykov, V.M., Kitiashvili I.N. Modeling observations of NASA Heliophysics Missions from Realistic 3D Simulations of the Sun. 2020, NASA@SC2020 virtual exhibit.

- Kitiashvili I.N., Zhao J., Sadykov S.M., Criscuoli S., Kosovichev A.G., Wray A.A. 2020. Multi-Wavelength Modeling and Analysis of the Center-to-Limb Effects of Solar Spectroscopy and Helioseismology. AGU Fall meeting (virtual), December 7-11, 2020.

Frequency-Dependent Helioseismic Analysis on Solar Meridional Flow, Center-to-Limb Effect, and Sunspots

Project Participants

BAERI: Thomas Hartlep

Project Description

The Sun is filled with acoustic oscillations that can be detected on the solar surface by observing Doppler shifts. Similar to seismic waves on Earth, these waves can be used to infer the structure and dynamics of the solar interior. In this project, we study how helioseismic waves travel in the solar interior using numerical simulations in order to develop, improve, and validate observation technique applied on solar observations.

Accomplishments

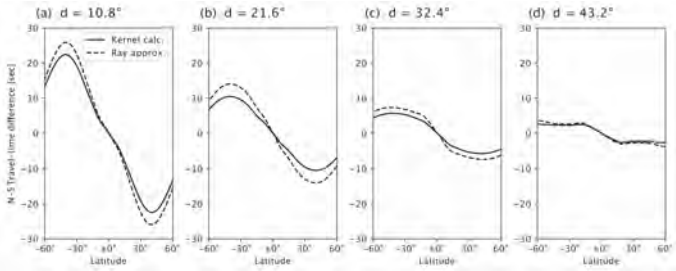
- Completed development of a new technique for computing realistic, 3D, spherical sensitivity kernels for horizontal flows inside the Sun. Such sensitivity kernels allow inferring flow speeds inside the Sun by measuring the travel time of waves observable on the solar surface;

- Computed such kernels for many different wave travel-distance and multiple wave frequencies;

- Performed self-consistency checks and validation of the new kernels;

- Submitted a paper (and revision) to the Astrophysical Journal on sensitivity kernels for horizontal flows inside the Sun; and

- Performed numerical simulation of wave propagation through small radial flow perturbations in the Sun; from it derived select sensitivity kernels for radius.



Travel-time difference between north- and south-traveling waves on the Sun caused by the solar meridional flow (circular that is poleward near the solar surface). The panels show results from our modeling for a particular flow model for 4 different wave travel distances. By measuring such travel-time difference observationally, the flow speed inside the Sun can be inferred.

Publications

Thomas Hartlep & Junwei Zhao “Computing Helioseismic Sensitivity Kernels for the Sun’s Large-Scale Internal Flows using Global-Scale Wave-Propagation Simulations” Submitted to the *Astrophyiscal Journal* (ApJ), revision just submitted following the initial referee’s report.

NAS SDO Data Service: AI Model to Predict the Emergence of Solar Magnetic Flux

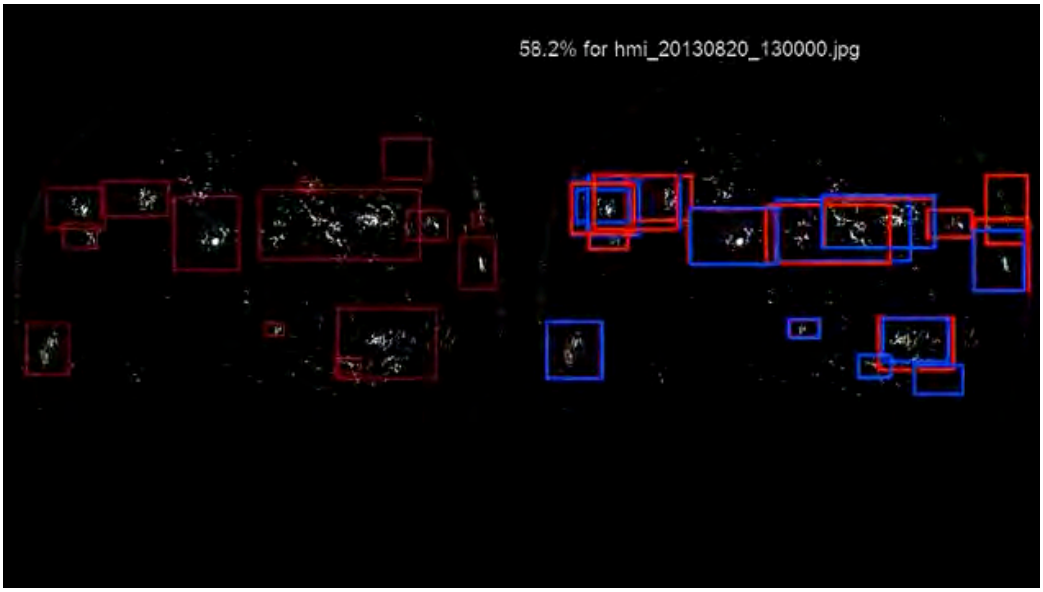
Project Participants

NASA: Mark Cheung, Nagi Mansour, Herbert Yeung, Art Amezcua
BAERI: Will Barnes & Graham Mackintosh
Stanford University: Phil Scherrer, Monica Bobra

Project Description

The emergence of solar magnetic flux is the first stage of an “active region” on the surface of the Sun, something we typically call a sunspot. These areas, in turn, can grow in size and volatility until they can cause a solar flare, which are very sudden high-energy solar particle events. These events can be harmful to spacecraft, and potentially deadly to astronauts in space. It would be very helpful to be able to predict the first step in this potentially dangerous sequence of events - namely, the first emergence of an area of elevated magnetic flux on the Sun’s surface.

We aim to do this by using historical records of solar active regions and the corresponding images of the Sun at that time to train a neural net model to learn what the Sun looks like when active regions first appear. Hopefully, we can use that training to have the model predict when it thinks the emergence of a new active region is imminent. This would help to forecast the Sun’s activities and give astronauts and mission controllers more time to take precautions if potentially severe solar events are looming.



Still from an example of retinanet active region prediction video using SDO HMI data

Accomplishments

- Implemented complete data pipeline to extract solar images and active region data from JSOC remote repository for local processing within the NASA Advanced Supercomputer system;

- Completed a complete rewrite of the longitudinal “gap filling” algorithm to find the best possible temporal substitute for missing SDO observations, thereby offering a near seamless time series of images with configurable time steps, start/stop framing and maximum permitted substitution temporal distances;

- Developed image pre-processing routines for AIA and HMI images that included brightness, sharpness and contrast with configuration options that can be included in deep learning hyperparameter settings;

- Implemented and documented a command line interface suitable to integration into other projects that supports over 40 processing options and switched;

- Developed multi-threaded code to rapidly transform images and data from the NASA Solar Dynamics Observatory into source-target image pairs suitable for cGAN (pixel to pixel) image mapping—a key data requirement for predicting active region emergence;

- Used the distributed process SDO pipeline to implement a high performance pix2pix neural net model and training/testing module that ingests the image pairs mentioned above, and outputs a video of actual images of the Sun paired with a visual representation of predicted active regions; and

- Implemented a retinanet SDO data pipeline and image classifier and bounding box generator to ingest the image pairs mentioned above, and output bounding box predictions of future active regions classified by predicted changes in size (e.g. “growing”, “shrinking”).

Biology

Raman Spectroscopy as a Viral Sensor

Project Participants

BAERI: Rocco Mancinelli

Project Description

The goal of this work is to evaluate the feasibility of developing a reusable viral sensor. This sensor will be designed to be used by crew members as a medical diagnostic tool, and for monitoring the spacecraft environment, such as recycled or stored water supplies. This proposal was awarded in late 2020 and funding was received in April after the COVID shut down at ARC began. As a result, this proposed laboratory demonstration project became a paper concept study.

Accomplishments

- Literature search – Completed during COVID shut down.
- Protocol development – Completed during COVID shut down.

Airborne Science

and Mission Support

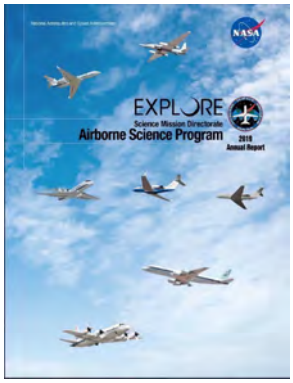
Airborne Science Advanced Planning

Project Participants

NASA: Matt Fladeland
BAERI: Susan Schoenung

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.



Airborne Science Program 2019 Annual Report

Accomplishments

- Updated the ASP 5-year plan, monthly, for ASP management;
- Prepared a monthly map of all ESD airborne missions for ASP management;
- Prepared a draft Airborne Science Program Needs Assessment, which is currently in HQ review;
- Prepared the ASP 2019 Annual Report and one ASP newsletter;

- Participated in various science team meetings related to NASA Earth Science missions to gather airborne requirements data; and

- Participated in ASP strategic planning with new ASP deputy directors by sharing archived data.

Airborne Sensor Facility

Project Participants

NASA: Matt Fladeland
BAERI: Ethan Pinsker
USRA: Jefferey Myers

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 is staffed by the Universities Space Research Association (USRA) under the NASA Academic Mission Services (NAMS) contract. It includes elements for sensor engineering, optical and infrared sensor calibration, and data processing. (see https://asapdata.arc.nasa.gov/)

Accomplishments

- Wrote software for in-lab sensor used for instrument calibration;
- Prototyped new revision of head power supply board for the eMAS payload; and
- Built and tested new revision for Long Wave Infrared Sensor array amplifiers.

Autonomous Scheduling of Earth-orbiting Satellite Constellations

Project Participants

BAERI: Sreeja Nag, Vinay Ravindra, Alan Li
JPL: Marc Sanchez Net, Kar-Ming Cheung
UGA: Rod Lammers, Brian Bledsoe

Project Description

This research involves designing distributed spacecraft and their autonomous operations. One theme focuses on distributed spacecraft autonomy, which is looking at how multiple spacecraft in orbit talk to each other and make reactive science decisions. If a spacecraft sees something of interest on the ground it would be able to make inferences and predictions based on its observations. The spacecraft can then broadcast that knowledge to other spacecraft in the form of actionable metadata so they can change their observation control strategies accordingly. Dynamic control based on inter-spacecraft coordination can maximize existing space assets because they can adaptively reconfigure their instrument orientations, channels, data collection rates, and integration times.

Another theme focuses on distributed operator autonomy. We co-lead the communication navigation group under the UAV (unmanned aerial vehicle) traffic management project. That project will inform how the government will manage thousands of drones that will be flying in the skies very soon. The UAV project taught us new ideas to build an automated framework so that different entities controlling vehicles could interact with one another in a more efficient way and to share the skies safely. We are now applying that same concept to space traffic management to automate interactions between -currently disjointed- spacecraft operators and providers of services such as space situational awareness, conjunction assessment, space weather forecasts.

Essentially, one half of our endeavor is creating technology by which we can fly sensor webs of multiple satellites, and the other half is creating technology so these satellites don’t collide or radio-interfere.

Publications

Le Moigne, J,J,, J.C. Adams, and S. Nag. 2019. A New Taxonomy for Distributed Spacecraft Missions, *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, accepted, with minor revisions.

Ravindra, V., and S. Nag. 2019. Fast Methods of Coverage Evaluation for Tradespace Analysis of Constellations, *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, DOI:10.1109/JSTARS.2019.2952531

Presentations

Nag, S., A.S. Li, V. Ravindra, M. Sanchez Net, K.M. Cheung, R. Lammers, and B. Bledsoe. 2019. Autonomous Scheduling of Agile Spacecraft Constellations with Delay Tolerant Networking for Reactive Imaging, International Conference on Automated Planning and Scheduling SPARK Workshop, July 11-15, Berkeley, CA.

Nag, S., P. Dabney, V. Ravindra, and C. Anderson. 2019. Planning a Reference Constellation for Radiometric Cross-Calibration of Commercial Earth Observing Sensors, International Workshop on Planning and Scheduling for Space, July 11-15, Berkeley CA.

Slavinskis, A., S. Nag, and J. Mueting. 2019. An Initial Analysis of the StationkeepingTradespace for Constellations, IEEE Aerospace Conference, Mar. 2-9, Big Sky, Montana.

Nag, S., D. Murakami, N. Marker, M. Lifson, and P. Kopardekar. 2019. Prototyping Operational Autonomy for Space Traffic Management, International Astronautical Congress, Oct. 21-25, Washington D.C.

Murakami, D., S. Nag, M. Lifson, and P. Kopardekar. 2019. Space Traffic Management with a NASA UAS Traffic Management (UTM) Inspired Architecture, AIAA Science and Technology Forum and Exposition (AIAA SciTech), Jan. 7-11, San Diego, CA.

Cabrera, J., S. Nag, and D. Murakami. 2019. An Initial Analysis of Automating Conjunction Assessment and Collision Avoidance Planning in Space Traffic Management, 29th AAS/AIAA Space Flight Mechanics Meeting, Jan. 13-17, Ka'anapali, HI.

Awards

NASA Advanced Information Systems Technology Grant as Principal Investigator, for "D-SHIELD: Distributed Spacecraft with Heuristic Intelligence to Enable Logistical Decisions", in 2019-21

Panels/Committees

Planning Committee Member, IWPSS - International Workshop on Planning and Scheduling for Space (peer-reviewed), to review and select papers for publication in IWPSS bi-annually

Panelist and Engineering Expert, NASA Heliophysics Technology Demonstration Mission of Opportunity , to review and submit recommendations for Small Complete Missions to demo innovative medium Technology Readiness Level (mid-TRL) technologies that enable significant advances in NASA's Heliophysics Science Objectives and Goals.

Also served as the Engineering Expert in the NASA Heliophysics Science Demonstration Mission of Opportunity, a PI-led science investigation with TRL 6 technologies by PDR. Access to space will be in the form of a secondary payload opportunity on the Evolved Expendable Launch Vehicle planned for NASA's STP-5 mission—Interstellar Mapping and Acceleration Probe.

Panelist and Reviewer, NASA Early Career Faculty (ECF) Research Grants to review and submit recommendations for awards for the Space Technology ECF grants on the topic of 'Intelligent Calibration of Constellations of Sensors'. ECF funds untenured Assistant Professors on the tenure track at U.S. universities to conduct innovative low-TRL research, that increases knowledge and capabilities in response to new questions and requirements, stimulates innovation, and allows more creative solutions to problems in fundamental research.

Panelist and Engineering Expert, NASA Heliophysics Technology and Instrument Development for Science (H-TIDeS) Program to review and submit recommendations for Cubesat flight missions proposed nationally to the NASA H-TIDeS solicitation, in the capacity of the review engineering expert. The H-TIDeS program seeks to investigate key Heliophysics science questions by addressing the best possible science and/or technology investigations that can be carried out with instruments flown on suborbital sounding rockets, stratospheric balloons, CubeSats or other platforms.

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

Project Participants

BAERI: Ryan Ketzner **&** Vinay Ravindra

Project Description

D-SHIELD is a suite of scalable software tools that helps schedule payload operations of a large constellation, 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. D-SHIELD will include a science simulator to inform the scheduler of the predictive value of observations or operational decisions. Autonomous, realtime re-scheduling based on past observations needs improved data assimilation methods within the simulator.

OrbitPy is a Python application for satellite constellation design and analysis, used in support of the larger D_SHIELD project. We have been working on a new tool for OrbitPy to produce simulated sensor observations; the field of view of a sensor is discretized, projected onto the surface of the earth, and overlaid with simulated science data. Alongside this simulated imaging tool, I have also been developing a novel algorithm for rapid satellite coverage simulations to be implemented in the OrbitPy coverage module.

Accomplishments

- Developed a tool to simulate orbits and instruments which will be made open-source by the end of 2020;
- Developed a test suite for the OrbitPy coverage module, verifying coverage simulation output against a wide range of STK and GMAT scenarios; and
- Implemented several features of the new simulated sensor observation tool in the application, and testing is underway.

Publications

V. Ravindra, S. Nag, A.S. Li, “Ensemble Guided Tropical Cyclone Track Forecasting for Optimal Satellite Remote Sensing”, IEEE Transactions on Geoscience and Remote Sensing (TGRS), July 2020, DOI: 10.1109/TGRS.2020.3010821

V. Ravindra, S. Nag, “Instrument Data Metrics Evaluator for Tradespace Analysis of Earth Observing Constellations”, IEEE Aerospace Conference, Big Sky, Montana, March 2020 (pdf)

S. Nag, M. Sanchez Net, A. S. Li, V. Ravindra, “Designing a Disruption Tolerant Network for Reactive Spacecraft Constellations”, AIAA ASCEND Conference, Las Vegas, November 2020

S. Nag, M. Moghaddam, D. Selva, J. Frank, V. Ravindra, R. Levinson, A. Azemati, A. Aguilar, A. Li, R. Akbar, “D-SHIELD: Distributed Spacecraft with Heuristic Intelligence to Enable Logistical Decisions”, IEEE International Geoscience and Remote Sensing Symposium, Hawaii USA, July 2020

Presentations

- S. Nag, A. Aguilar, R. Akbar, A. Azemati, J. Frank, R. Levinson, A. Li, M. Moghaddam, V. Ravindra, D. Selva, “D-SHIELD: Distributed Spacecraft with Heuristic Intelligence to Enable Logistical Decisions”, NASA Earth Science Technology Forum, Dulles Virginia, June 2020

- V. Ravindra, S. Nag, A.S. Li, “Optimal Sensing of Tropical Cyclones (TCs) by Constellation of Low Earth Orbiting Satellites, Guided by Numerical Weather Prediction Model Ensemble Track Forecasts and Assimilation of Observed/ Missed TC Center Position Measurements”, AGU 2020.

- S.Nag, V. Ravindra, et al., “Distributed Spacecraft with Heuristic Intelligence to Enable Logistical Decisions (D-SHIELD) for Soil Moisture Monitoring”, AGU 2020.

- M.S. Net, S. Nag, A.S. Li, V. Ravindra, “Designing a Disruption Tolerant Network for Reactive Spacecraft Constellations”, AGU 2020.

Earth Science Project Office (ESPO)

Project Participants

NASA: Marilyn Vasques, Bernadette Luna
BAERI: Judy Alfter, Quincy Allison, Brad Bulger, Katja Drdla, Erin Justice, Susan McFadden, Caitlin Murphy, Sommer Nicholas, Ayuta Padhi, Stevie Phothisane, Leslie Ryan, Alex Stanfill, Katie Stern, and Brent Williams.

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

In 2020, the NASA-ARC-based ESPO team supported the following research campaigns under the ARC-CREST agreement:

- **EXPORTS (EXport Processes in the Ocean from RemoTe Sensing)** is a five year ocean biology project. The field campaign is designed to advance the capability of satellite-based NASA ocean color products to predict how changes in ocean primary production will impact the global carbon cycle. The first very successful deployment took place August and September of 2018. Data submission and planning for the 2020 deployment continued. EXPORTS has been postponed until spring of 2021 because of the COVID-19 pandemic.

- **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 will participate in the ACCLIP deployment from Osan Air Base in South Korea in the summer of 2021. The field campaign was initially planned for Naha, Okinawa in the summer of 2020, but was postponed because of the COVID-19 pandemic.

- **CPEX-AW (Convective Processes Experiment – Aerosols & Winds)** is a joint effort between NASA and ESA with the primary goal of conducting post-launch calibration and validation activities of the Atmospheric Dynamics Mission-Aeolus (ADM-AEOLUS) Earth observation wind Lidar satellite in Sal, Cabo Verde. CPEX-AW is a follow-up to the Convective Processes Experiment (CPEX) field campaign which took place in the summer of 2017. In addition to joint calibration/validation of ADM-AEOLUS, CPEX-AW will study the dynamics and microphysics related to the Saharan Air Layer, African Easterly Waves and Jets, Tropical Easterly Jet, and deep convection in the InterTropical Convergence Zone (ITCZ). The field campaign was initially planned for Sal, Cabo Verde in the summer of 2020, but was postponed until the summer of 2021 because of the COVID-19 pandemic. Planning for the field campaign continues, and the deployment location may change.

- **SHARC (SCIFLI-Hayabusa Airborne Re-entry observation Campaign)** is a joint effort between NASA and JAXA. The ESPO team will be supporting the observations of the re-entry of the Hayabusa2 Sample Return Capsule out of Adelaide, Australia. Using the LaRC and JSC G-IIIs and multiple instruments, the objective is to acquire data from a flight experiment of an atmospheric entry system. The data from the observation are radiometric and spectroradiometric emission signatures of the re-entry fireball.

ESPO is managing 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 will involve flights of NASA's ER-2 and P-3 aircraft over the northeastern United States. Deployments were successfully completed out of Hunter AFB and Wallops Flight Facility from January-March, 2020. The second year field campaign was scheduled to resume in fall 2020 but was postponed until fall 2021 because of the COVID-19 pandemic.

- **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. ESPO will support the San Francisco Bay Area based research project, with aircraft operations based at Moffett Field at NASA Ames Research Center. The project will utilize the NASA B-200 and G-

III, a Twin Otter, a research vessel, as well as ocean surface drifters, wave gliders, and floats. The first deployment was scheduled for April 2020, but was postponed for March-April 2021 because of the COVID-19 pandemic.

- **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. The project will be based in Salina, Kansas with the NASA ER-2 aircraft. The first deployment was scheduled to start in March 2020 with ER-2 integration and test flight activities, but has been postponed for March 2021 because of the COVID-19 pandemic.

In 2020, the NASA-ARC-based ESPO team supported the following virtual meetings:

- CAMP^{2}Ex (Cloud, Aerosol and Monsoon Processes Philippines Experiment) Science Team Meeting
    - Planetary Boundary Layer Community Workshop

- AGAGE 61 and AGAGE 62 (Advanced Global Atmospheric Gases Experiment) Meeting
    - TEMPO (Tropospheric Emissions: Monitoring Pollution) Science Team Meeting

- ORM 11 (Ozone Research Managers of the parties to the Vienna Convention for the Protection of the Ozone Layer Eleventh Meeting, part I)

- NDAAC (Network for the Detection of Atmospheric Composition Change) Steering Committee Meeting

Meteorological Measurement Systems (MMS)

Project Participants

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

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, as well as 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 some similar data, but with much degraded accuracy and reliability. Mr. Dean-Day’s research focuses on maintaining the scientific validity of the MMS data and in performing some basic research with the measurements as time and opportunity allow.

Accomplishments

- Completed calibration and revised final MMS data for FIREX-AQ, after incorporating new laboratory bath calibrations of the temperature sensor and updating aerodynamic calibration to account for shifts in true airspeed. Updated an algorithm for substitution of redundant temperature data during soot contamination events;

- Investigated differences between MMS and Housekeeping Static Temperature data from the DC-8 during ATom, SARP-2018, and FIREX missions, due to an unexpected shift that happened between ATom-4 and SARP. MMS changed its source for bath calibration of temperature probes to the AFRC cal lab following FIREX-AQ, but after examining differences between multiple MMS probes, it appears that the source of the error is likely caused by Housekeeping changing its primary temperature probe. Investigated drifting yaw offsets in our DC-8 data and examined whether we could use heading data instead of yaw to calibrate vertical winds. DC-8 MMS attack angle data ATom was examined to

determine why a shift was apparent during sea surface runs from ATom-4; apparently the pilots flew at lower true airspeed. Helped to evaluate strategies for obtaining pressure measurements from MMS flow angle probes during the upcoming ACCLIP mission on the WB-57;

- Compared WB-57 Housekeeping and MMS data from part of the 2015 Volcanic-plume Investigation Readiness and Gas-phase and Aerosol Sulfur (VIRGAS) mission to determine altitude- and temperature-dependent differences in static and dynamic pressure measurements. Statistical relationships between simultaneously sampled data streams will be later used to estimate missing MMS pressure values and reconstruct 1 Hz data during the first week of the mission;

- Acted as one of the referees during peer review of a manuscript involving remote sensing data analysis, submitted to Atmos. Chem. and Physics. Reviewed three Phase-I proposals for the Department of Energy's Small Business Innovative Research (SBIR) program; and

- Developed and updated mission software for DCOTSS and ACCLIP. Developed MMS next generation data acquisition software system.

Publications

Ryoo, J.-M. et al. (J. Dean-Day, one of 11 co-authors), 2020. Terrain Trapped Airflows and Precipitation Variability during an Atmospheric River Event. J. Hydrometeor., 21 (2): 355-375. https://doi.org/10.1175/JHM-D-19-0040.1

Cuchiara, G.C. et al. (J. Dean-Day, one of 24 co-authors), 2020. Vertical Transport, Entrainment and Scavenging Processes Affecting Trace Gases in a Modeled and Observed SEAC4RS Case Study. J. Geophys. Res., 125 (11). https://doi.org/10.1029/2019JD031957

NSRC Mission Operations

Project Participants

NASA: Matt Fladeland
BAERI: Melissa Yang Martin, Adam Webster, David Van Gilst, Sebastian Rainer, Ryan Bennett, Pat Finch

Project Description

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

1. 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.

2. 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 November 2019 and October 2020, including:

- April 2020: The NSRC Mechanical Design Engineer left the organization. The position was advertised in May and a new Mechanical Design Engineer is pending selection.

- May 2020: The NSRC Instrumentation Engineer left the organization. The position will not be filled immediately, pending the successful coordinated support from the Ames Crosscutting team to assist in the following: Documentation of instrument performance over time, keeping a thorough calibration and maintenance record, environmental testing of new equipment, troubleshooting of measurements with the NSRC Data Manager, and consultation during all flights. Additional duties include writing an operational/ troubleshooting document for all the NSRC facility instruments, and providing hands-on training to operators who will be staffing field deployments.

- June 2020: The NSRC Senior Software Engineer left the organization. The position will not be filled immediately, pending the successful coordinated support from NASA Johnson Space Center.

- September 2020: The NSRC Program Director Melissa Yang Martin left the organization to continue supporting the NASA Airborne Science Program (ASP) from a NASA HQ position as the ASP Deputy Director and EVS-3 Mission Manager. She continues to support NSRC in a reporting role until a new NSRC Program Director has been selected. In the interim, Adam Webster is the Acting NSRC Program Director. Initial knowledge transfer included basic NSRC director duties training, including financial costing/ accounting procedures, budgeting, MPC estimates, etc.

Staff Accomplishments

- Emily Schaller, Steven Schill, Ryan Bennett, and Melissa Yang Martin attended the 2019 Fall AGU meeting in San Francisco, CA. Activities included the following:
  - NSRC staff worked at the airborne science booth every day.
  - Networked with people within the science community and others in support of the airborne science program.
  - Advocated the Student Airborne Research Program (SARP) to increase applicant pool and interest in the program.
  - Attended science team meetings for several missions supported through the year.
  - Ryan Bennett gave the invited talk titled “An Assessment of Uncertainty in Atmospheric State Measurements on Airborne Platforms.”
  - Emily Schaller gave the talk titled “NASA Operation IceBridge In-Flight K-12 Classroom Connections.”
  - Emily Schaller, along with 2 SARP alumni (S. Freeman, 2013 and K. Zigner, 2015) gave a presentation titled “High-Flying Interns: The NASA Student Airborne Research Program” at the Hyperwall in the NASA booth.

- Melissa Yang Martin and Adam Webster attended the National Academy of Science DC-8 study virtual workshop discussions.

- All NSRC employees completed the SATERN training to be considered Certified Systems Administrators at NASA. This gives each NSRC employee the administrative rights of their non-ACES/EUSO machines. Pat Finch was designated the NSRC CSA who will oversee all IT security for NSRC.

Aircraft Specific Engineering Accomplishments

DC-8 Specific Engineering and Data/Satcom System Accomplishments

- Ramped-up activity on the following hardware redesign items, intended for install after

the DC-8 Heavy Maintenance Check (CY 2021):

- Full upgrade and re-design of DC-8 Ethernet Network.
- Automated Power-up/Power-down for basic services.
- Replacement of power strips for better current protection.
- Removal of equipment from aircraft in anticipation of heavy check.

- Continuation of work towards network and instrumentation upgrades to be completed during/after heavy check period.

- Debugging and system evaluation of software tools for working with 4K Cameras.

- Development of small tools for ease of interaction with new camera, with an eye towards low-bandwidth remote operation.

- Created design, drawing, and analysis of a blank off plate for the APU bleed air plumbing.

- Repair/replacement of faulty wingtip pylon electrical connector discovered during FIREX-AQ campaign.

- Performed a redesign of the seatbelt attachment bracket on the DC-8 swivel seats.

- Acquisition of DC-8 gauge and Multi-Function Display (MFD) camera replacements.

- Provided DC-8 science modification design data to aid in defining structural inspections for upcoming heavy maintenance check.

- Support of investigation into damaged UPS batteries discovered during heavy check preparation activities.

- Completed redlines and documentation package for an upgrade to the DC-8 Housekeeping analog signal wiring.

ER-2 Specific Engineering and Data/Satcom System Accomplishments
Note: NSRC supports ER-2 operations in conjunction with the Airborne Sensor Facility (ASF) team

- Worked on Miniature Video Imaging System (MVIS) “Network Video Recorder.”

- Installed software for pilot access to camera.

- Worked on creating pilot access to IRC chat capabilities.

- Created new revision of ER-2 Inmarsat system installation drawing and structural analysis.

- Created ER-2 Inmarsat system router assembly drawing.

P-3 Specific Engineering and Data/Satcom System Accomplishments
***Impacted by the COVID-19 Pandemic ***

The P-3 lavatory/galley overhaul in conjunction with the NSRC permanent data system installation was originally planned to be completed in 2020. Unfortunately, due to travel restrictions and health concerns, it was impossible for the onsite work to continue as planned. The goal is to continue doing design and engineering work remotely to the best extent possible, and install hardware between scheduled missions, when aircraft availability permits.

The NSRC mechanical engineering and data system teams conducted brief visits to NASA WFF in 2019 and 2020 to work on two major projects:

- NSRC Permanent Data System installation on the P-3 aircraft
  - Temporarily installed some new equipment (listed below) on P-3 for testing in temporary location prior to permanent installation.
    - New data server
    - New VLAN segmented switching arrangement
    - Labjack A/D recording device
  - Performed preliminary P-3 permanent data installation CAD work and equipment research.
  - Finalized individual component selection and overall layout.
  - Continued detailed modeling/design of aircraft structure and data system installations.

- P-3 Lavatory and Galley Overhaul
  - Gathered applicable engineering details on the P-3.
  - Evaluated appliances previously purchased by WFF for suitability and began researching substitutes where required.
  - Documented the existing lavatory and galley areas on the aircraft, including adjacent wiring, ductwork, electronics, and various structure.

G-V Specific Engineering and Data/Satcom System Accomplishments

- Built up server for installation on JSC G-V.

- NSRC staff traveled JSC to install a configured Adlink data server on the aircraft, enabling onboard displays and IRC chat capabilities.

- Configured ground infrastructure to receive real-time data from the G-V system.

Overall ASP Development Work

- Provided design guidance to the VIPR radar team to help with their instrument development.
    - Sent detailed information and CAD models of the planned pressure box configuration, determined design/test load factors to apply to their radome design, and provided general electrical design information.

- Provided some design guidance to the Korean B1900 team to help with the installation of PMS canister probe pylons on their aircraft.
    - Provided some guidance regarding damage found on optical window to be used by the AFRC B200 program in support of the upcoming S-MODE mission. Also provided guidance in determining appropriate environmental test values to use for optical window testing related to B200 installation.

- Provided detailed design info to ND-MAX team on “scoop” inlet that was used for the primary aerosol sampling inlet during that campaign.

- Provided guidance and history in support of the “Legacy” review of the DC-8 Zenith #1, Nadir #2, and Nadir #7 ports and associated hardware.

- Provided design guidance to the NAST-I instrument team regarding their new thermoelectric cooling system design.

- Created a detailed historical summary of past DC-8 missions in support of the National Academy of Sciences DC-8 replacement study.

- Provided the ATHOS instrument team with detailed information on the DC-8 cameras to help interpret their FIREX-AQ research results.

- Supported a preliminary design review for the OPALS instrument optical cell and provided feedback on the design.

- Supported multiple design review meetings with the AirMASTR team to provide feedback on their instrument design. Also created and provided updated CAD models of the DC-8 pressure box configuration/installation that will be used by the instrument and determined the various cable lengths necessary for their various primary components.

Development Tasks

- Transitioned Inmarsat Traffic to a VPN-secured solution; greatly improving security, reducing the attack surface for Inmarsat operations, and simplifying interactions with the Inmarsat government networking team. This included conducting a successful initial

end-to-end test from the Inmarsat system on the aircraft to the NASA ARC ground infrastructure via VPN.

- Began development of a more advanced Inmarsat monitoring solution, including the following features:
  - A more advanced remote control, allowing for simpler inflight diagnostic via Iridium satcom, in the event that Inmarsat is not functioning.
  - Development of a better real-time accounting solution, providing a better record of data used during flight.

- Began construction of a ground rig to test MultiPath TCP (MPTCP) software. This will be used to further investigate minor issues that appeared with the MPTCP software stack during the ACTIVATE campaign.

- Ensured that all servers are NASA ITSEC compliant.

- Performed disaster recovery practice and training with containers for the (Misstion Tools Suite) MTS network.

- Officially moved the hosting of MTS away from Amazon Web Services to in-house hosting on our container networks.

- Continued development on remote satcom management tools.

- Continued development on containerized infrastructure for aircraft servers.

- Continued revamp of data access API.

- Started rebuild of ER-2 Inmarsat routers, with planned enhancements.

- Provided input and support in the development of the System Security Plan.

- David Van Gilst was designated the lead for the development of the NextGen NASA Airborne Science Data and Telemetry System (NASDAT).
  - Developed outline of requirements
  - Created GitLab accounts for team members
  - Performed research on various COTS solutions

- IRC Chat
  - Started Evaluation of the UnrealIRCd 5.x branch as a replacement for UnrealIRCd 4.x in the NSRC-maintained IRC/XChat infrastructure.
  - Began Improvements to the channel-logging infrastructure by implementing a bot to provide a searchable index of chat logs, so that they are retrievable via the

web. This was in response to requests from a number of mission scientists who have been using the IRC chat system to keep their notes used to generate flight reports.

- NASA ARC Server Upgrades
  - Installed second Uninterruptible Power Supply (UPS).
  - Installed Network Attached Storage (NAS) system.
  - Initiated the first phases of moving our data from asp-archive to the NAS.
  - Configured one of our container hosts.
  - Set up three containers: the ASP Science Data Portal, one to take the place of asp-interface-2, and one to act as the chat server for NSRC.
  - Brought our second container host online.
  - Set up a locally- hosted Jira container in our new container infrastructure, eliminating this will allow us to spin down the existing NSRC cloud-hosted ticketing system and mitigate potential concerns about SBU data.
  - Performed architectural advances on the MTS backend via containers.
  - New web host for the MTSv2 transition (mts2.nasa.gov) with user migration to MTSv2
  -

Missions Supported by SMO Staff

FIREX-AQ (DC-8) — May 2019 - November 2019

- Completed publication data submittal

- Worked with Paul Bui and Gao Chen to identify the source of discrepancies between NSRC and MMS reported temperatures during the mission. The discrepancy was ultimately traced to carbon fouling/contamination of the MMS Total Air Temperature (TAT) element due to the high smoke environment.

CAMP2Ex (P-3) — June 2019 - October 2019

- Final submission of 1Hz and 10Hz Data.

- Worked with Lee Thornhill and Gao Chen to identify the source of discrepancies between temperature measurements from NSRC instrumentation and those from the TAMMS instrument.

- Updated intercomparisons between LWC and TAMMS.

- Quality-controlled, processed, and archived video products.

- Completed the CAMP2EX V1.0 README document covering Meteorological & Navigation (MetNav) data.

AirLusi (ER-2/N809NA) — November 2019

- Provided ER-2 data system support for some of the AirLUSI flights.

IMPACTS (P-3) — November 2019 - February 2020

- Installed new wiring for the KT-19 pyrometer, electrically isolating it from the aircraft systems.

- Installed deiced TAT probe and digital signal conditioner in anticipation of likely IMPACTS flight conditions.

- Gathered test data from the P-3 weather radar data stream.

- Created/presented critical design review material, finalized installation/detail drawings, created structural analysis report for review, and manufactured/assembled components for Rosemount 858 flow angle probe installation on P-3.

- Provided available information and data on the Nevzorov probe to WFF in support of their investigation into the probe's in-flight failure.

- Configured AVAPS, TAMMS, and WISPER data to transfer it to the ground.

- Configured IR and NEXRAD image upload/overlays for situational awareness.

- Provided Data System support at NASA Wallops Flight Facility for the duration of the mission.
    - Sebastian Rainer staffed IMPACTS flights from January 12 through February 1, supporting a total of 10 flights.
    - Provided 24-hour housekeeping data and quality controlled final data archive for all flights.

- Attended "Virtual" Science Team Meeting.

- Submitted RA MetNav data to GHRC DAAC.

IMPACTS (ER-2/N809NA) — November 2019 - February 2020

- Supported instrument integration and configured all ground side data links.

- Engaged in extensive troubleshooting of the Inmarsat system.
- Developed software to display MVIS Imagery to the pilot.
- Developed software to display IRC Chat to the pilot.
- Integrated the Network Video Recorder to the Stratus Wi-Fi, allowing pilot access to video without having to switch Wi-Fi networks.
- Successfully pivoted to provide MVIS imagery via a standalone access point.
- Supported instrument telemetry and data access requirements through asp-interface.arc.nasa.gov.
- MVIS images were sent to the ground and displayed in MTS in near real-time. Video was posted after each flight to asp-archive.
- Submitted ER-2 navigation data to project archive from ASF, including documentation which was provided to the project archive.
- Provided Data System support for the duration of the mission.
    - Eric Stith staffed ER-2 IMPACTS flights, supporting a total of 6 flights.
    - Provided 24-hour housekeeping data and quality controlled final data archive for all flights.

ACTIVATE (HU-25 and UC-12) — January 2020 - September 2020

- David Van Gilst traveled to LaRC in January 2020 to install and test telemetry systems on the two LaRC aircraft.
- Equipped the UC-12 with a simplified NSRC data system to provide IWG1 housekeeping data for tracking and instrument purposes. The system also includes a 4-Channel ARINC 429 device used to record aircraft systems data and a Honeywell PPT pressure transducer for measuring cabin pressure.
- Reconfigured a Multichannel Iridium System for the UC-12 to provide telemetry via three MPTCP-bonded modems, and for the first time routed traffic through the NASA ARC modem servers (rather than relying on the no-longer-funded infrastructure at NASA GRC).
    - Primary services were aircraft tracking, IRC Chat and instrument telemetry for the HSRL, AVAPS, and RSP instruments.
    - Secondary services are providing IWG1 data for the AVAPS system and providing a simplified set of displays.

- Completed configuration of the data system for the HU-25 Falcon.
    - Configured and tested the AVIATOR 200 Inmarsat system .
    - Configured several telemetry streams for onboard instruments to allow monitoring from the ground.
    - Configured a ChemWAD data stream for science situational awareness.

- Supported communications checks and provided remote data system support of flights .

- Reprocessed recorded aircraft systems and Applanix data into ICARTT format and submitted data to archive.

Inmarsat Router/Display system on the LaRC HU-25 Aircraft in support of ACTIVATE

SARP 2020 — May 2020 - August 2020
***Impacted by the Covid-19 Pandemic ***

Since 2009, the NASA Student Airborne Research Program (SARP) internship has brought ~30 outstanding undergraduate STEM students majors from across the United States to 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. In 2020, the COVID-19 pandemic prevented travel for the program. Although SARP was effectively grounded, it still continued to the fullest extent possible, and was able to provide the students with a virtual research experience like none other. This included at-home data collection dispersed across the country, as well as the analysis of previously-collected aircraft, ground and satellite data. During 2020, the project:

- Completed populating NASA LaRC Airborne Science Data for Atmospheric Composition (ASDAC) archive with all platform data from SARP 2009 through SARP 2019.

- Configured/imaged and supported 32 laptops for SARP participants.

- Found solutions to ensure that each student had access to an adequate internet connection in their lockdown locations, including deploying/supporting Wi-Fi hotspots.

- Uploaded data from prior SARP missions to shared server and distributed rugged external disks as required.

- Planning was performed to delay the SARP 2020 flight sequence to December 2020, but was ultimately again postponed to June 2021, due to safety risks associated with COVID-19.

- Ryan Bennett continued to provide meteorological support and data analysis support for the duration of SARP, including the following:
    - Enrichment lecture to students demonstrating use of the NOAA HYSPLIT model to determine air mass trajectories/transport/dispersion/etc.
    - Office hour sessions.
    - Individual meetings with more than 10 students working on projects.
    - Meeting with Gao Chen to discuss hosting archive products on ASDAC.
    - Developed SARP remote sensing flight summaries for the archive.
    - Performed data retrieval from ASF/JPL, as requested by students and faculty.
    - Contributed to a SARP project overview article for the Bulletin of the American Meteorological Society (BAMS) (cooperative effort with Emily Schaller, et al.).
    - Continued data analysis in support of the Fall AGU meeting, including SARP 2020 WAS sampling trajectories.

- SARP final presentations took place on August 5th and 6th. Attendees included SARP alumni, Research Faculty, NASA personnel and NSRC staff. Six student research projects were chosen to present at the 2021 Fall AGU meeting.

- Wrote a SARP project overview article for the Bulletin of the American Meteorological Society (BAMS) (Emily Schaller, Ryan Bennett, et al.).

CPEX-AW (P-3) — May 2020 - August 2020
***Impacted by the COVID-19 Pandemic*

The CPEX-AW project was planned to deploy on the P-3 to the Cape Verde Islands in July 2020. Unfortunately, due to travel restrictions and health concerns, it was impossible for the mission to continue as planned. In March 2020, the decision was made to postpone CPEX-AW to 2021, with the mission now scheduled to integrate and deploy on the DC-8. The items listed below highlight the effort of working towards supporting the mission on the P-3 aircraft in 2020.

- Adam Webster was identified as the lead integration engineer for both CPEX-AW and SARP on the P-3, traveling to WFF and LaRC for instrument integration planning and design.

- Helped finalize the planned SARP instrument complement by determining what the aircraft can accommodate, including performing an evaluation to add the HAMSR and AirHARP instruments to the payload.

- Created a combined CPEX-AW/SARP instrument floor plan, with a major overhaul to the legacy floor plan format.

- Created a detailed 3D model of the main cabin of the P-3, in order to determine precise placement of the DAWN instrument and required adjacent equipment.

- Created the DAWN optical window installation design, detail/installation drawings, and manufacturing files.

- Provided design guidance, CAD models, etc. in support of the design of ground support equipment required for loading/assembling the DAWN instrument.

- Finalized the CAFE/Picarro/UH inlet installation design, created detail/installation drawings, and created component manufacturing files.

- Worked out details of updated HALO structural analysis and WFF review.

- Performed a detailed review and update of the Payload Information Form (PIF) for each instrument, using the included information to create the payload instrument matrix.

- Created a CAD model of the existing P-3 two-position compressed gas cylinder mount, made modifications to fix/improve the original design, created detail/installation drawings, and created component manufacturing files.

- Finalized the design of the WAS equipment rack reconfiguration components, created detail drawings, and created component manufacturing files.

- Created design, detail drawings, and component manufacturing files for the LARGE scroll pump shelf installation.

HyspIRI (ER-2/N809NA) — August 2020 - September 2020

- Supported network testing on ER-2 and began work on SNMP-based continuous monitoring for ER-2 network faults.

- Worked with the vendor to return two failed Inmarsat components for repair.

SHARC (JSC G-III and LaRC G-III) — September 2020 - December 2020

- Created 3D CAD model for JAXA to determine field of regard analysis of their planned trajectory reconstruction instrumentation (Note: this was in support of the originally planned DC-8 installation, before the program shifted to the two backup G-III platforms).

- Developed a 6-channel MPTCP Iridium satcom system, combining it with a standard NSRC situational awareness data server.

- Performed installation and testing of system at AFRC and JSC, sustaining data transfer rates of 1600-1800 bytes (a new high benchmark for the various ASP multichannel Iridium systems).

- Successfully added a DHCP server to the system using only Iridium connectivity after JSC had to switch to a non-DHCP supplying network switch.

- In the midst of a pandemic, David Van Gilst traveled to LaRC to install a standard NSRC Data server on LaRC G-III, and to JSC to troubleshoot the MPTCP Iridium system on the JSC G-III.

- Developed software to manage a Dropbox into which SHARC staff will place files that will be pushed either through the MPTCP Iridium system (JSC G-III) or the NASDAT (LaRC G-III) and then automatically emailed to personnel on the ground to aid in rapid recovery of the reentry vehicle.

IMPACTS II (P-3 and ER-2) — November 2020 - February 2021
Impacted by the COVID-19 Pandemic

The Project made a “no-go” decision on Nov 2nd, 2020 to deploy this winter and will postpone the deployment to winter 2021/2022. The project considered all of the factors and risks surrounding a winter 2020/2021 deployment, including the recent significant increase in cases nationally, the risk of new cases after the holiday season, and the odds of potentially disruptive impacts of someone contracting COVID-19 or even showing potential symptoms that might force a last-minute cancelation or lengthy shut downs of operations during the campaign. This project:

- Gathered requirements for the upcoming science campaign.

- Redesigned TAMMS sideslope flow angle sensor probe installation, fabricated parts and performed final assembly of components.

- Continued logistical and technical preparations for deployment.

- Virtually attended IMPACTS Data Conference meeting.

- Prepared upgraded server for P-3 Rack install.

FUTURE MISSIONS — 2021 and Beyond

DCOTSS (ER-2) — Spring 2021 - Summer 2021
Impacted by the COVID-19 Pandemic

The DCOTSS project was planned to deploy in 2020. Unfortunately, due to travel restrictions and health concerns, it was impossible for the mission to continue as planned. The project was postponed one year to 2021. The items listed below highlight the effort of working towards supporting the mission in 2020:

- Virtually attended science team meeting.

- Engaged in one-on-one discussions with several groups about specific communications requirements.

- Supported UCATS and MMS pre-integration fit and network testing.

ACTIVATE (HU-25 and UC-12) — Winter 2021 - Summer 2021
Note: This mission is an EVS mission with multiple recurring flight sequences over the course of several years.

SARP (DC-8 or P-3) — Summer 2021
Note: This is an annual mission done each summer. Depending on aircraft schedules, it may be hosted on either the DC-8 or P-3 in 2021.

CPEX-AW 2021 (DC-8) Summer 2021
Note: This mission was originally planned for 2020, but was postponed to 2021 due to the COVID-19 pandemic.

- Created the DC-8 instrument floor plan for CPEX-A, including the SARP and HIWC III instrumentation suites to evaluate the feasibility of combining all three payloads simultaneously.

- Performed a preliminary estimate of the instrument integration schedule (Note: this will have to be revisited if SARP and/or HIWC is loaded simultaneously) and fabrication costs.

- Worked on details required for adapting HALO instrument move from Nadir #9 to the Nadir #5 port .

- Began looking at options for potential inclusion of the PICARD and S-HIS instruments,

including locating the major components of the legacy “ESMR” fairing, which could possibly be repurposed to accommodate one of the instruments.

- Performed an initial evaluation regarding potential inclusion of the CloudCube instrument.

- Outlined a detailed plan to move forward with development of the OPALS Version 2 instrument, which may “piggyback” on the CPEX-AW flights.

IMPACTS II (P-3 and ER-2) — Winter 2021/2022
Note: This mission was originally planned for 2020/2021, but was postponed to 2021/2022 due to the COVID-19 pandemic.

Communications and Training Task Accomplishments

- Completed a successful 2020 Student Airborne Research Program (SARP) with 28 undergraduate students, 5 graduate student/postdoc mentors and 5 faculty members.
  - 291 SARP applications were received from 175 different schools in 44 states and Puerto Rico (highest applicant number ever received).

- Represented the NASA Airborne Science Program (ASP) in the Earth Communications, Earth Expeditions communications campaigns, AGU NASA Booth planning meetings.

- Attended the NASA Science Mission Directorate (SMD) Communications Meeting in Washington D.C.

- Staffed NASA booth at the Dec 2019 Fall AGU meeting to promote SARP and K-12 mission communication activities and coordinated the SARP alumni reunion.
  - NSRC staffed the ASP section of the NASA booth for 24 hours total.
  - Emily Schaller, along with 2 SARP alumni (S. Freeman, 2013; and K. Zigner, 2015) presented at the NASA Hyperwall in the NASA booth: “High-Flying Interns: The NASA Student Airborne Research Program.”
  - More than 30 SARP alumni gave presentations at the AGU meeting.
  - The SARP alumni reunion drew over 60 people including alumni, mentors, faculty and NASA administrators.
  - Emily Schaller gave an oral presentation in a polar education session about Operation IceBridge outreach.

- Provided and added frequent content about missions to the Airborne Science Program and Earth Expeditions webpages and social media accounts.

Missions Supported by C&T Staff

OIB Fall 2019 Mission on the G-V — November 2019

- Utilizing the Mission Tools Suites for Communications, coordinated 14 virtual classroom chats (reaching 988 students grades 2-12) with mission personnel onboard the NASA G-V flying out of Hobart, Tasmania.

- From 2012-2019, NSRC coordinated a total of 492 virtual educational chats and flight-following during OIB (Arctic and Antarctic) missions, directly reaching over 11,000 K-12 students in 110 schools and 9 foreign countries (Argentina, Australia, Canada, Chile, Ghana, Mexico, South Africa, Togo) and in 31 different US states.

Map of school locations reached during OIB educational chats 2012-2019

IMPACTS 2020 Mission on the P-3 — January 2020 - February 2020

- Coordinated 3 live classroom chats with the Mission Tools Suites for Communications with Mission Personnel onboard the NASA P-3, reaching 61 students and 3 teachers in New York and Florida.

SARP 2020 Mission Goes Virtual June to August 2020
Impacted by the COVID-19 Pandemic

Every summer since 2009, the NASA Student Airborne Research Program (SARP) internship has brought about ~30 outstanding undergraduate STEM students majors from across the United States to California for a unique internship experience that exposes them to NASA's Earth Science research in the Earth Sciences and flies them on a research aircraft. This year with the COVID-19 pandemic, travel was not an option for the SARP. However, while SARP was

grounded, we were able to still provide the students with a virtual research experience like none other. It included at-home data collection across the country, as well as the analysis of previously collected aircraft, ground, and satellite data.

SARP 2020 was a unique year for the program as it remained completely virtual amidst the COVID-19 pandemic. The entire program was facilitated through the use of the Zoom web conferencing platform. The SARP Zoom was accessible to students for 11 hours each day to accommodate students in all US time zones. Students worked with their faculty advisors and mentors daily through the use of Zoom breakout rooms. Faculty and mentor lectures, one-on-one research time, guest lectures (including from a NASA astronaut), and daily social activities were enabled through the use of Zoom breakout rooms. Project accomplishments include:

- Management of the 2020 Student Airborne Research Program including program design, faculty recruitment, participant recruitment, selection, and logistics.

- Completed selection of 28 students from 291 applications (from 175 different schools in 44 states and Puerto Rico).

- 28 students were accepted from 28 different colleges and universities in 21 different states.
    - 14 new schools for SARP
    - 3.71 Average GPA
    - A mix of small schools and large research universities
    - A mix of biology, chemistry, physics, astronomy, environmental science, atmospheric science, meteorology, engineering, geography, and mathematics majors

- 5 Distinguished Faculty:
    - Don Blake (UC Irvine)
        - Whole Air Sampling of California Central Valley and Los Angeles pollution
    - Dr. Roya Bahreini (UC Riverside) & Dr. Andreas Beyersdorf (CSU San Bernardino)
        - Aerosol Research
    - Dr. Raphe Kudela (UC Santa Cruz)
        - Remote Sensing of the Coastal Ocean
    - Dr. Dar Roberts (UC Santa Barbara)
        - Remote Sensing of Vegetation and Fires

- SARP at-home Whole Air Sampling (WAS) was performed by individuals involved in SARP. It included 44 boxes (of 24 evacuated canisters each) mailed to students, mentors and faculty across the US. Each sample analyzed for nearly 100 different gases. Preliminary scientific results to be presented at AGU 2020.

- SARP at-home aerosol measurements through a partnership with the Citizen Enabled Aerosol Measurements for Satellites (CEAMS), a NASA-funded citizen science program at Colorado State University. 30 Aerosol Mass Optical Depth sensors were mailed out to SARP participants across the US which enabled them to measure PM2.5 and aerosol optical depth.

- Selection of the top student presentations for participation at the 2021 AGU conference.

- SARP participants presented about their experiences as NASA interns to the STEM Enhancement in Earth Sciences (SEES) high school internship program at the University of Texas (online).

- NSRC staff organized the conclusion of SARP 2020 with final student presentations which were held via zoom and attended by several NASA Program Managers.

- SARP Press Release (May 7): https://www.nasa.gov/feature/nasa-airborne-science-interns-gathering-data-at-home.

- Preparations to participate in staffing the virtual NASA booth for the Fall AGU meeting.

- Organized virtual SARP alumni reunion via zoom on Dec 18, 2020.

Education and Outreach Activities

Applied Remote Sensing Training (ARSET)

Project Participants

BAERI: Zach Bengtsson, Amber McCullum, 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 many more. Participants can build skills and grow through ARSET. Participants are introduced to the fundamentals of remote sensing, learn how to find and download NASA data, and 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. Because of the COVID-19 situation, all trainings in 2020 were conducted remotely.

Accomplishments

We conducted five trainings in FY20:

1. New Sensor Highlight: ECOSTRESS (November 2019)
2. Introductory Webinar: Using the UN Biodiversity Lab to Support National Conservation and Sustainable Development Goals (March 2020)
3. Advanced Webinar: Forest Mapping and Monitoring with SAR Data (May 2020)
4. Introductory webinar: Tracking Vegetation Phenology with Remote Sensing (July 2020)
5. Monitoring Coastal Ecosystems Using Remote Sensing (August 2020)

Lightning Webinar: New Sensor Highlight: ECOSTRESS

This lightning webinar focused on a NASA instrument that was launched and installed on the International Space Station in the summer of 2018. Designed to study terrestrial ecosystems and plant water stress from the ISS, ECOSTRESS can also be used to better understand crop health, volcanoes, urban heat, wildland fires, coastal systems, and much more: Training Website: https://appliedsciences.nasa.gov/join-mission/training/english/new-sensor-highlight-ecostress

Introductory Webinar: Using the UN Biodiversity Lab to Support National Conservation and Sustainable Development Goals

Live sessions with Q&A were offered in English, Spanish, and, for the first time, French. These sessions combined netted a record-breaking 1,700 online participants from over 125 countries and 1,000 different organizations. This introductory-level training came as the result of a collaboration between ARSET and the UN Development Programme (UNDP), and trains participants on the use of the new UN Biodiversity Lab interface in relation to conservation goals. Training website: https://appliedsciences.nasa.gov/join-mission/training/english/using-un-biodiversity-lab-support-national-conservation-and

Advanced Webinar: Forest Mapping and Monitoring with SAR Data

This was the first training offered by our Land Management team focused on SAR data and will highlight the advantages of SAR data, especially in cloud-prone tropical forests. This advanced webinar series will introduce participants to:

- SAR time series analysis of forest change using Google Earth Engine (GEE).
- Land cover classification with radar and optical data with GEE.
- Mapping mangroves with SAR.
- Forest stand height estimation with SAR.

Training Website: https://appliedsciences.nasa.gov/join-mission/training/english/forest-mapping-and-monitoring-sar-data

Introductory Webinar: Tracking Vegetation Phenology with Remote Sensing

This training highlighted multiple NASA-funded tools to observe and study phenology across a range of scales. Attendees were exposed to the latest in phenological observatory networks and science, and how these observations relate to ecosystem services, the carbon cycle, biodiversity, and conservation. The training had over 1,700 participants globally. Training website: https://appliedsciences.nasa.gov/join-mission/training/english/understanding-phenology-remote-sensing

Introductory Webinar: Monitoring Coastal Ecosystems Using Remote Sensing

This introductory-level, three-part training series was offered in both English and Spanish. Topics covered included satellites and sensors used for ocean color and shallow water ecosystem characterization, identification of water column components, water column corrections, and remote sensing of shorelines and beaches. In attendance were 2,933 participants from 114 countries and 42 US states. Around 1,900 unique organizations were represented. Training website: https://appliedsciences.nasa.gov/join-mission/training/english/remote-sensing-coastal-ecosystems

Upcoming Trainings

We are currently planning the FY21 portfolio of ARSET trainings, which will include webinars on hyperspectral remote sensing, Google Earth Engine, and Wildfires, among others. The ARSET eco team has successfully planned the hyperspectral training series and is near completion of all training materials. We expect to have it ready to go by the end of the year.

Hyperspectral Data for Land and Coastal Systems (FY21)

Hyperspectral data presents a unique opportunity to characterize specific vegetation types and biogeochemical processes across the land and oceans. Applications of hyperspectral data include plant species identification, invasive species management, assessment of phytoplankton functional types, mapping of wetlands and shallow benthic communities, and detection of harmful algal blooms (HABs). The ability of hyperspectral data to characterize chemical, physiological, and morphological traits allows decision-makers to better understand critical components of ecosystem dynamics such as invasive species encroachment, forest decline and pest infestation, and ocean dynamics. This training is also an opportunity to build capacity in a large user community prior to the launch of the highly anticipated global hyperspectral SBG mission. Website link: https://appliedsciences.nasa.gov/join-mission/training/english/hyperspectral-data-land-and-coastal-systems

California State University at Monterey Bay (CSUMB) Educational Program

Project Participants

CSUMB: Susan Alexander
CSUMB Students: Sahana Bojorquez, Josue Duque, Javier Lopez, Patrick Lopez, Nicole Lykfers, Israel Mandujano Olivera, and Ryan Solymar
Stanford University Student: Conor Doherty

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.

Our 2021 goals:

- We will 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.

- We will promote student research and internship opportunities at NASA Ames Research Center related to the Cooperative Agreement (e.g. DEVELOP, CAARE).

Accomplishments

We continue to facilitate research collaborations between ENSCI graduate students, ESTP and Biology senior undergraduate students, Cooperative Agreement Research Scientists, CSUMB faculty, and NASA PIs at Ames Research Center on the following projects:

- ESTP and ENSCI students Josue Duque, Javier Lopez, and Ryan Solymar conducted research and assisted with field activities under the mentorship of ARC CREST Senior Scientists Forrest Melton and Lee Johnson and ARC CREST Research Scientists.

- The team provided mentorship of students who worked with the SIMS and OpenET projects (described in detail in the Agriculture / Health / Marine Applied Science Task report) in 2020 (Ryan Solymar, Conor Doherty). Tianxin Wang (a former student intern) was accepted to a PhD program at UC Berkeley and began his graduate program in Fall 2020. Will Carrara (former student research assistant) is now a software engineer with NASA ARC-CREST. Additional research internships will be offered in 2021.

- Johnson is Co-I on a proposal led by UC Cooperative Extension under the 2019 CDFA Specialty Crop Block Grants Program ($333k). He is helping to manage irrigation trials in artichoke and red cabbage being conducted at the USDA research station in Salinas. The project employs a student assistant (Javier Lopez), who recently graduated from the ag-business program at Hartnell and has since transferred to CSUMB.

- Biology students Sahana Bojorquez, Patrick Lopez, Nicole Lykfers, and Israel Mandujano Olivera assisted with laboratory and field activities under the mentorship of CSUMB Associate Professor Dr. Arlene Haffa.

- ENSCI graduate student Liana Solis was a member of the Pacific Northwest Wildfire Team through her Summer 2020 DEVELOP internship at NASA ARC under the supervision of Dr. Juan Torres-Perez : https://develop.larc.nasa.gov/2020/summer/PacificNorthwestHAQ.html

Presentations

Student-only presentations, AGU 2020:

- SY029-01 Building Capacity for Policy-makers in a Virtual Setting: Providing Tools to Analyze Wildfire Smoke Plumes and Their Impacts Ani Matevosian1, Taylor Orcutt2, Danielle Ruffe3 and Liana Solis2,
- NASA DEVELOP Program - SSAI, Ames Research Center, Moffett Field, CA, United States, (2)NASA DEVELOP Program - SSAI, Ames Research Center, Moffett Field, United States, (3)The University of Texas at Austin, Department of Geography and the Environment, Austin, TX, United States

Student co-authors:

- Melton, F., et al., 2020. OpenET: Filling a Critical Gap in Water Data for the Western United States. AGU Fall Meeting , #H021-08 (invited)
- Rollison, D., et al., 2020. OpenET: Enabling Science-Based Water Management through Open Data Services and User-Driven Design. AGU Fall Meeting, #SY036-04 link

DEVELOP

Project Participants

NASA: Joseph Coughlan
BAERI: Juan L. Torres-Perez

Project Description

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

Accomplishments

Projects during the past year have comprehended a wide range of themes including plume detection, disaster analysis in Washington state, and the analysis of potential oceanographic conditions leading to the bloom of a nuisance benthic algae in the Northwestern Hawaiian Islands.

Typically, 5-7 projects are conducted at Ames each year during normal conditions. Three projects were conducted this year due to the limitations of conducting such projects remotely.

Due to COVID-19, this year's Spring term was moved to remote learning and was completed online. The Summer and Fall terms were also conducted remotely.

Presentations

All projects were presented remotely via the DEVELOP National Program Office.

Publications and Presentations

Publications

A. S. Li, V. Chirayath, M. Segal-Rozenhaimer, J. L. Torres-Pérez and J. van den Bergh, "NASA NeMO-Net's Convolutional Neural Network: Mapping Marine Habitats with Spectrally Heterogeneous Remote Sensing Imagery," in IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, vol. 13, pp. 5115-5133, 2020, doi: 10.1109/JSTARS.2020.3018719.

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"Characterization of OCO-2 and ACOS-GOSAT biases and errors for flux estimates", OCO-2/3 virtual meeting, March, 2020.

"Evaluation of single-footprint AIRS CH4 Profile Retrieval Uncertainties Using Aircraft Profile Measurements"- presentation at Virtual_AIRS_STM, May, 2020

"Remote Sensing for Biodiversity and Conservation", Cal State University Monterey Bay GIS class, August 2020

"Remote Sensing for Biodiversity and Conservation", UC Berkeley GIS class, October 2020

"TCCON for CO2 satellite validation", TCCON virtual meeting, May, 2020.

Ambrosia, V.G., 2020. NASA Contribution to the Eastern Mediterranean Region, EXCELSIOR Project, & the MedRIN Network, 1st Virtual EXCELSIOR International Technical Workshop, CUT ERATOSTHENES Centre of Excellence, Lemasol, Cyprus, 15 July 2020.

AGU Presentation: "Expanding NeMO-Net Machine Learning Capabilities for Citizen Science".

Amber McCullum participated as a panel speaker and representative for NASA's Indigenous Peoples Capacity Building Program at the United Nations High-level Political Forum on Sustainable Development side event titled "Indigenous Peoples-led Use of Earth Observations" held virtually on July 9th, 2020. During this event, a panel of experts discussed key challenges and opportunities for inclusive engagement of Indigenous Peoples to advance the use, application, and co-development of tools that use Earth Observations for conservation, land management, and sustainable development. Contributors to this event included Indigenous leaders from around the world, the Group on Earth Observations (GEO) Secretariat, members of the GEO Indigenous Alliance, and international non-governmental organizations such as Conservation International.

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LeBlanc, S. E., S. Schmidt, S. Cochrane, H. Chen, J. Redemann, C. J. Flynn, K. Pistone, M. Segal-Rosenhaimer, M. S Kacenelenbogen, Y. Shinozuka, S. P Broccardo and M. Mallet, Direct Aerosol Radiative Effect Above Clouds in the Southeast Atlantic from Airborne Measurement, AGU fall meeting, A135-06, December 11th, 2020

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Monitoring Air Quality from Space: Perspectives from Modeling and Sub-orbital Measurements to Understand the AOD-PM2.5 Relationship on Different Time Scales Mian Chin, Qian Tan, Gao Chen, Huisheng Bian, Zhining Tao, Dongchul Kim, Hongbin Yu link: https://agu.confex.com/agu/fm20/meetingapp.cgi/Paper/682577

NASA DEVELOP Program - SSAI, Ames Research Center, Moffett Field, CA, United States, (2)NASA DEVELOP Program - SSAI, Ames Research Center, Moffett Field, United States, (3)The University of Texas at Austin, Department of Geography and the Environment, Austin, TX, United States

NASA Frontier Development Lab 2020 Big Think Workshop: Sadykov V.M., Kitiashvili I.N., Tobiska W.K., Mertens C., Cruz A. “Machine Learning-driven Prediction of Radiation Doses Received during Airplane Flights.”

Nemani, Ramakrishna, Tsengdar Lee, Satya Kalluri, Weile Wang, Hirofumi Hashimoto, Andrew Michaelis, Thomas Vandal, Alexei Lyapustin, Jia Zhang, Hideaki Takenaka, Atsushi Higuchi, Kazuhito Ichii, Shuang Li, Jong-Min Yeom. (2020). "GeoNEX: A Geostationary Earth Observatory at NASA Earth Exchange: Earth Monitoring From Operational Geostationary Satellite Systems" IEEE International Geoscience and Remote Sensing Symposium, IGARSS 2020, 26th September – 2nd October, Virtual Symposium.

On Friday August 28th, from 10:00 to 11:30 am Pacific, Nikki Rae Tulley of the Navajo Nation Drought Project presented for the Western Regional Partnership Tribal Engagement Working Group in a featured presentation titled, “From land to space: Understanding water on the Navajo Nation”. She was joined by Dr. Crystal Tulley-Cordorva, the Principal Hydrologist from the Navajo Nation Dept. of Water Resources to provide an overview of the Hydromet Network and the connections of this work to the NASA-funded project.

Ramakrishna R Nemani, Weile Wang, Andrew Michaelis, Satya Kalluri, Tsengdar J Lee, Alexei Lyapustin, Atsushi Higuchi, Hideaki Takenaka, Jia Zhang and Jennifer L Dungan (2020), GeoNEX: A Geostationary Earth Observatory, Dec 2020, Online, AGU 2020

Rollison, D., et al., 2020. OpenET: Enabling Science-Based Water Management through Open Data Services and User-Driven Design. AGU Fall Meeting, #SY036-04

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S. Nag, A. Aguilar, R. Akbar, A. Azemati, J. Frank, R. Levinson, A. Li, M. Moghaddam, V. Ravindra, D. Selva, "D-SHIELD: Distributed Spacecraft with Heuristic Intelligence to Enable Logistical Decisions", NASA Earth Science Technology Forum, Dulles Virginia, June 2020

S.Nag, V. Ravindra, et al., "Distributed Spacecraft with Heuristic Intelligence to Enable Logistical Decisions (D-SHIELD) for Soil Moisture Monitoring", AGU 2020.

Sadykov, V.M. “Connecting Atmospheric Properties and Synthetic Emission of Shock Waves in 3D RMHD Simulations of Quiet Sun”. 2020. Virtual seminar at the National Solar Observatory (NSO), August 4th, 2020.

Sadykov, V.M. et al. “Radiation Portal: Connection of Radiation Measurements on Airplane Flights with Observations of Solar-Terrestrial Environment”. 2020, AGU Fall Meeting 2020. Online, December 1-17, 2020.

Sadykov, V.M., Kitiashvili I.N. Modeling observations of NASA Heliophysics Missions from Realistic 3D Simulations of the Sun. 2020, NASA@SC2020 virtual exhibit.

Segal Rozenhaimer, M., R. Cullather, D. Barahona, and A. Molod. 2019. Utilization of airborne observations to assess model parametrizations of critical RH profiles in the Arctic Ocean and their effect on surface radiative budget predictions, GC13H-1255. AGU Fall Meeting, Dec. 9-13, San Francisco, CA.

Seminar: NASA Missions: Earth Observations. California State University – Monterey Bay, School of Natural Sciences Seminar Series, Seaside, CA., 27 January 2020.

SY029-01 Building Capacity for Policy-makers in a Virtual Setting: Providing Tools to Analyze Wildfire Smoke Plumes and Their Impacts Ani Matevosian1, Taylor Orcutt2, Danielle Ruffe3 and Liana Solis2,

The Gigantic African Dust Intrusion to the Caribbean Basin and southern U.S. in June 2020: An analysis of MODIS and CALIOP remote sensing observations and GEOS model simulations. Hongbin Yu, Qian Tan, Lillian Zhou, Yaping Zhou, Huisheng Bian, Mian Chin, Dongchul Kim, Robert C Levy, Yingxi Rona Shi, Lorraine Remer, and Olga L Mayol-Bracero, link: https://agu.confex.com/agu/fm20/meetingapp.cgi/Paper/691983

Upcoming: SY038: Science to Action: Enabling science- and data- driven water management, https://agu.confex.com/agu/fm20/prelim.cgi/Session/104795, The Drought Severity Evaluation Tool: A collaboration of Sovereignty and Science for the Navajo Nation, Nikki Tulley1, Amber McCullum2, and Crystal Tulley-Cordova3

V. Ravindra, S. Nag, A.S. Li, "Optimal Sensing of Tropical Cyclones (TCs) by Constellation of Low Earth Orbiting Satellites, Guided by Numerical Weather Prediction Model Ensemble Track Forecasts and Assimilation of Observed/ Missed TC Center Position Measurements, AGU 2020.

Vandal et al. “Temporal Interpolation of Geostationary Satellite Imagery with Task Specific Optical Flow.” Submission to ACM International Conference on Knowledge discovery and data mining SIGKDD 2020.

Vandal, T. & Nemani, R. (2020). “Optical Flow for Intermediate Frame Interpolation of Multispectral Geostationary Satellite Data”. 19th Conference on Artificial Intelligence for Environmental Science. Boston, MA.

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Vandal, T., Nemani, R., Wang, W., Michaelis, A., Dungan, J., Hashimoto, H., Park, T., Duffy, K., Geostationary Satellites and Deep Learning. Earth Science Technology Forum 2020, Virtual Meeting. June 23-25, 2020.

Vandal, T., Nemani, R.R., Wang, W. and Li, S., 2019, December. Transfer Learning to Generate True Color Images from GOES-16. In AGU Fall Meeting 2019. AGU.

Vargas, R., Nemani, R., Park, T., Carbon monitoring systems across Mexico to support implementation of REDD+: maximizing benefits and knowledge. NASA Carbon Monitoring System Science Team Meeting 2020. Virtual Meeting. November 17-19, 2020.

Vargas, R., Nemani, R., Park, T., Carbon monitoring systems across Mexico to support implementation of REDD+: maximizing benefits and knowledge. NASA Carbon Monitoring System Science Team Meeting 2020. Virtual Meeting. November 17-19, 2020.

Wang T., F. Melton, M. Cahn, L. Johnson, L. Hipps, L. .McKee, K. Alsted, 2019. Comparison of Evapotranspiration Estimates from Remote Sensing, Crop Coefficient Models, and Eddy Covariance Stations for Celery in California. AGU Fall Meeting, 9-13 Dec., San Francisco (#B31N-2391) link

Wang, W., Hashimoto, H., Michaelis, A., Park, T., Nemani, R., Wang, Y., Lyapustin, A., Kalluri, S., Uncertainty Analysis of the GeoNEX Top-of-Atmospheric Reflectance Products Generated from the Third-Generation Geostationary Satellite Sensors. American Geophysical Union 2020 Fall Meeting, Virtual Meeting. December 1-17, 2020.

Weile Wang, Hirofumi Hashimoto, Andrew Michaelis, Shuang Li, Hideaki Takenaka, Atsushi Higuchi, Satya Kalluri, Ramakrishna Nemani (2020). "An Introduction To The GeoNEX Level-1G Products: Top-Of-Atmosphere Reflectance and Brightness Temperature" IEEE International Geoscience and Remote Sensing Symposium, IGARSS 2020, 26 September – 2 October, 2020, Virtual Symposium.

Weile Wang, Hirofumi Hashimoto, Andrew Michaelis, Taejin Park, Ramakrishna R Nemani, Yujie Wang, Alexei Lyapustin and Satya Kalluri (2020), Uncertainty Analysis of the GeoNEX Top-of-Atmospheric Reflectance Products from the Third Generation Geostationary Satellite Sensors, Dec 2020, Online, AGU 2020

Wilson, A.M., Michaelis, A., Rieffel, E., Nemani, R.R. and Vandal, T.J., 2018, December. Compressing Earth science datasets with quantum-assisted machine learning algorithms. In AGU Fall Meeting 2018. AGU.

Xiaoyang Zhang, Yu Shen, Yongchang Ye, Jianmin Wang and Weile Wang (2020), Fusion of Time Series of Geostationary Satellite and VIIRS Observations for Detecting Land Surface Phenology, Dec 2020, Online, AGU 2020

Glossary

3C — California Crop Coefficient

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

AATS - Ames Airborne Tracking Sun-photometer

ABI – Advanced Baseline Imager

ACCLIP — Asian Summer Monsoon Chemical & CLimate Impact Project

ACE — Aerosol Cloud Ecosystem

ACEPOL — The Aerosol Characterization from Polarimeter and Lidar

ACEPWG — Aerosol Cloud Ecosystem Polarimeter Working Group

ACES — Agency Consolidated End-User Services

ACM — The Association for Computing Machinery

ACOS — Atmospheric CO2 Observations from Space

ACP — Atmospheric Composition Program

ACTIVATE — Aerosol Cloud meTeorology Interactions oVer the western ATlantic Experiment

ADM-AEOLUS — Atmospheric Dynamics Mission-Aeolus

AESD - Ames Earth Science Division

AFRC - Armstrong Flight Research Center

AGAGE — Advanced Global Atmospheric Gases Experiment

AGU - American Geophysical Union

AI – Artificial Intelligence

AIA – Atmospheric Imaging Assembly

AIAA — American Institute of Aeronautics and Astronautics

AirHARP — The Airborne Hyper-Angular Rainbow Polarimeter

AirLUSI — The airborne Lunar Spectral Irradiance Instrument

AIRS - Atmospheric Infrared Sounder

AIST - Advanced Information Systems Technology

AJAX - Alpha Jet Atmospheric eXperiment

AMT – Atmospheric Measurement Techniques

AOD – Aerosol Optical Depth

AOSR — Athabasca Oil Sands Region

API – Application Programing Interface

ARC – Ames Research Center

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

ARISE - Arctic Radiation-IceBridge Sea and Ice Experiment

ARMAS - Automated Radiation Measurements for Aerospace Safety

ARSET — Applied Remote Sensing Training

ASDAC — Airborne Science Data for Atmospheric Composition

ASP - Applied Sciences Program

ASPRS — American Society for Photogrammetry and Remote Sensing

ATHOS — Airborne Tropospheric Hydroxodes Sensor

ATom - Atmospheric Tomography Mission

ATRA – Advanced Technology Research Aircraft

AVAPS — The Advanced Vertical Atmospheric Profiling System

BAER or BAERI – The Bay Area Environmental Research Institute

BAMS — Bulletin of the American Meteorological Society

BIA - Bureau of Indian Affairs

BL — Boundary Layer

BLM – Bureau of Land Management

CA DWR — California Department of Water Resources

CAARE – Center for Applied Atmospheric Research and Education

CALIOP - Cloud-Aerosol Lidar with Orthogonal Polarization

CAM — Community Atmosphere Model

CAMP^{2}Ex — Cloud, Aerosol and Monsoon Processes Philippines Experiment

CDFA — California Department of Food and Agriculture

CDWR - California Department of Water Resources

CEAMS — Citizen Enabled Aerosol Measurements for Satellites

CIMIS — California Irrigation Management Information System

CMIP5 - Coupled Model Intercomparison Project Phase 5

CMIS – Compact Micro-Imaging Spectrometer

CMS - Carbon Monitoring Systems

CN - Communications and Navigation

CNN — Convolutional Neural Network

CoE — Center of Excellence

COMEX - CO_2 and Methane Experiment

CONUS – Continental United States

COSR – Canadian Oil Sands Region

COTS — Commercial Off-The-Shelf

CPEX-AW — Convective Processes Experiment – Aerosols & Winds

CrIS – Cross-track Infrared Sounder

CRTF – Coral Reef Task Force

CSU — California State University

CSUMB - California State University at Monterey Bay

CSUMB SNS - California State University at Monterey Bay, School of Natural Sciences

CTMs - Chemical Transport Models

CTU – Cypress Technology University

D-ATRA – DLR Airbus A320-232

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

DAAC – Distributed Active Archive Center

DARE - Direct Aerosol Radiative Effects

DASC – Digital Avionics Systems Conference

DASH-SP Differential Aerosol Sizing and Hygroscopicity Spectrometer Probe

DBW – Department of Boating and Motorways

DCOTSS — Dynamics and Chemistry of the Summer Stratosphere

DEVELOP - Digital Earth Virtual Environment and Learning Outreach Project

DHCP — Dynamic Host Configuration Protocol

DLR - Deutsches Zentrum für Luft- und Raumfahrt (German Aerospace Center)

DOAS - Differential Optical Absorption Spectroscopy

DOE – Department of Energy

DRAAWP – Delta Region Area-wide Aquatic Weed Project

DRI — Desert Research Institute

DSA – Distributed Spacecraft Autonomy

DSET — Drought Severity Evaluation Tool

EAE - Extinction Angstrom Exponent

EARSeL — European Association of Remote Sensing Laboratories

ECCC — Environment and Climate Change Canada

ECF — Early Career Faculty

ECOSTRESS – ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station

EDF — Environmental Defense Fund

EFB – Electronic Flight Bag

EMC – Electromagnetic Compatibility

ENSCI – Environmental Science (CSUMB)

ENSCI — Environmental Science

EO — Earth Observation

EOS – Earth Observing System

EOSDIS - Earth Observing System Data and Information System

EPSCoR – Established Program to Stimulate Competitive Research

ESA - European Space Agency

ESD – Earth Science Division

ESDR - Earth Science Data Records

ESMR — Electrically Scanning Microwave Radiometer

ESPO - Earth Science Project Office

ESTO – Earth Science Technology Office

ESTP – Environmental Science, Technology and Policy

ET — Evapotranspiration

Eu:CROPIS - Euglena and Combined Regenerative Organic-food Production in Space

EUSO — End User Service Office

EUV — Extreme Ultraviolet

EV-S — Earth Venture - Suborbital

EWRI — Environmental & Water Resources Institute

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

EXPORTS — EXport Processes in the Ocean from RemoTe Sensing

FAA - Federal Aviation Administration

FALC – Fast Lagrangian Analysis of Continuity

FASMEE - Fire and Smoke Model Evaluation Experiment

FAU — Friedrich Alexander University

FAV – Floating Aquatic Vegetation

FCC – Federal Communications Comissions

FDL – Frontiers Development Lab

FF-SIG — Forest Fires Special Interest Group

FIREX — Fire Influence on Regional to Global Environments Experiment

FOV - Field-of-view

FPAR – Fraction of Absorbed Photosynthetically Active Radiation

FTS - Fourier Transform Spectrometer

GCMs - Global Climate Models

GDDP – Global Daily Downscaled Projections

GDM – Generalized Dissimilarity Models

GEDI – Global Ecosystem Dynamics Investigation

GEE — Google Earth Engine

GEO – Global Environment Outlook

GEO — Geosynchronous Equatorial Orbit

GEO — Group on Earth Observations

GEO-CAPE - GEOstationary Coastal and Air Pollution Events Mission

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

GEOS-Chem — A global 3-D model of atmospheric chemistry driven by meteorological input from the Goddard Earth Observing System (GEOS) of the NASA Global Modeling and Assimilation Office

GHG – Greenhouse Gas(es)

GHOC – Global Hawk Operations Center

GHRC — Global Hydrology Resource Center

GIBS - Global Imagery Browse Services

GIS – Geographic Information System

GLAS - Geoscience Laser Altimeter System

GMAO — Global Modeling and Assimilation Office

GOCI - Geostationary Ocean Color Imager

GOES – Geostationary Operational Environmental Satellite

GOSAT - Greenhouse gases Observing Satellite

GPP – General Purpose Parameters

GPP/NPP – Gross/Net Primary Production

GPS – Global Positioning System

GRC — Glenn Research Center

GRIDMET — Gridded Surface Meteorological Dataset

GRL — Geophysical Research Letters

GSOC — German Space Operations Center

GWIS - Global Wildfire Information System

H-Q2O - High-Quality Optical Observations

H-TIDeS — Heliophysics Technology and Instrument Development for Science

HABs — Harmful Algal Blooms

HALO – High Latitude Lidar Observatory

HAMSR — The High Altitude MMIC Sounding Radiometer

HCN – Hydrogen cyanide

HEALPix – Hierarchical Equal Areal isoLatitude Pixelization

HEC — High-End Computing

HIAPER - High-performance Instrumented Airborne Platform for Environmental Research

HICE-PR - Human Impacts to Coastal Ecosystems in Puerto Rico

HIPPO - HIAPER Pole-to-Pole Observations

HIWC – High Ice Water Content

HMI - Helioseismic and Magnetic Imager

HSRL — High Spectral Resolution Lidar

HyspIRI - Hyperspectral Infrared Imager

HYSPLIT — The Hybrid Single-Particle Lagrangian Integrated Trajectory

IARPC - Interagency Arctic Research Policy Committee

ICAART — International Consortium for Atmospheric Research on Transport and Transformation

ICDM — International Conference on Data Mining

ICES - Innovation Center for Earth Science

ICESat - Ice, Clouds, and Land Elevation Satellite

ICT — Information and Communications Technology

IDGA — Institute for Defense and Government Advancement

IDL — Interactive Data Language

IDS — Interdisciplinary Research

IECRS – Indian Environment Consulting and Research Services

IEEE – Institute of Electrical and Electronics Engineers

IGARRS - International Geoscience and Remote Sensing Symposium

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

InGaAs — Indium Gallium Arsenide

InVEST - In-Space Validation of Earth Science Technologies

IOP – Intensive Observation Period

IRAD — Internal Research and Development

IRC – Internet Relay Chat

IRIS – Interface Region Imaging Spectrograph

IRT – Icing Research Tunnel

ISFM — Internal Science Funding Model

ISRSE – International Symposium on Remote Sensing of the Environment

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ISS — International Space Station

ITCZ — InterTropical Convergence Zone

ITSEC — The Information Technology Security Evaluation Criteria

IUCN - International Union for Conservation of Nature and Natural Resources

IWPSS — International Workshop on Planning and Scheduling for Space

JAXA – Japan Aerospace Exploration Agency

JPEG – Joint Photographics Expert Group

JPL – Jet Propulsion Laboratory

JSC – Johnson Space Center

KARI — Korean Aerospace Research Institute

KOMPSAT-2A — (also known as Arirang-2) was an Earth-imaging/environmental Korean satellite which launched on 28 July 2006 and remains operational.

KORUS-AQ — Korea U.S.-Air Quality

LAI – Leaf Area Index

LaRC — Langley Research Center

LARGE - Langley Aerosol Research Group Experiment

LCLUC — Land-Cover and Land-Use Change

LEO – Low Earth Orbit

LibRadran — library for radiative transfer

LIDAR - Light Detection and Ranging

LSTM — Long short-term memory

LTE – Long Term Evolution

LWIR – Long Wave Infrared

MAIAC – Multi-Angle Implementation of Atmospheric Correction

MDPI – Molecular Digital Publishing Institute

ME – Mechanical Engineering

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

METRIC – Mapping EvapoTranspiration at high Resolution with Internalized Calibration

MFAM - Micro Fabricated Atomic Magnetometer

MFD — Multi-Function Display

MHD – Magnetohydrodynamic

MJPEG – Motion JPEG

MMS - Meteorological Measurement System

MOC – MODIS OMI CALLIOP

MODERN — MODerate resolution atmospheric TRANsmission

MODIS – Moderate Resolution Imaging Spectroradiometer

MPTCP – Multi-Path Transmission Control Protocol

MSC — Marine Stratocumulus Clouds

MSFC — Marshall Space Flight Center

MSI - MultiSpectral Instrument

MTS - Mission Tools Software

MUSES — Multi-Spectra, Multispecies, Multi-sensors

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

MVIS — Miniature Video Imaging System

MWIR – Mid-Wave Infrared

NAAMES - North Atlantic Aerosols and Marine Ecosystems Study

NAIP - National Agriculture Imagery Program

NAS – NASA Ames Supercomputing

NAS — Network Attached Storage

NASA ACCES – Advancing Collaborative Connections for Earth System Science

NASA QuAIL - NASA’s Quantum Artificial Intelligence Laboratory

NASA-CASA NASA-Carnegie-Ames-Stanford Approach

NASDAT — NASA Airborne Science Data and Telemetry System

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NCA – National Climate Assessment

NCAR — National Center for Atmospheric Research

NCEAS - National Center for Ecological Analysis and Synthesis

NDAAC — Network for the Detection of Atmospheric Composition Change

NDVI - Normalized Difference Vegetation Index

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

NeurIPS — Neural Information Processing Systems

NEX - NASA Earth Exchange

NGO — Non-Governmental Organization

NIDIS — National Integrated Drought Information System

NIR – Near Infrared

NLCD — National Land Cover Database

NLTE – Non Local Thermodynamical Equilibrium

NN — Navajo Nation

NNDWR — Navajo Nation Department of Water Resources

NOAA - National Oceanic and Atmospheric Administration

NOx — Nitrogen Oxides

NPWEE — NASA/MSFC Proposal Writing and Evaluation Experience

NRC - National Research Council

NSERC - National Suborbital Education and Research Center

NSF — National Science Foundation

NSRC — National Suborbital Research Center

NSTC - National Science & Technology Council

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

OIB - Operation Ice Bridge

OLI – Operational Land Imager

OMI - Ozone Measuring Instrument

OPALS — Optical PAyload for Lasercomm Science

ORACLES - ObseRvations of Aerosols Above CLouds and their IntEractionS

ORM — Ozone Research Managers

ORNL – Oak Ridge National Laboratory

OSTP - Office of Science & Technology Policy

PALMS - Particle Analysis by Laser Mass Spectrometry

PAN – Peroxyocetyl nitrate

PBS — Portable Batch Scheduler

PECORA – ISRSE sponsored symposia named after named after William T. Pecora, the USGS Director who helped initiate the Landsat program in the 1960s.

PI — Principal Investigator

PICARD — Pushbroom Imager for Cloud and Aerosol Research

PIF — Payload Information Form

PM — Particulate Matter

POSIDON - Pacific Oxidants, Sulfur, Ice, Dehydration, and cONvection Experiment

PSM – Professional Science Masters

QML — Quantum Machine Learning

QVAE — Quantum Assisted Variational Autoencoders

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

RF – Radio Frequency

RFI — Request for Information

ROSES – Research Opportunities in Earth and Space Science

RSCy — Remote Sensing and Geoinformation of Environment

RSP — Radiation Science Program

RST — Remote Sensing Theory

S-HIS — Scanning High-Resolution Interferometer Sounder

S-MODE — Sub-Mesoscale Ocean Dynamics Experiment

SACNAS – Society for Advancing Chicanos/Native Americans in Science

SAR — Synthetic-aperture radar

SARP - Student Airborne Research Program

SATERN – System for Administration, Training, and Educational Resources for NASA

SBG – Surface Biology and Geology

SBIR – Small Business Innovation Research

SCBGP – Specialty Crop Block Grant Program

SCERIN — South Central Europe Regional Information Network

SCIAMACHY - Scanning Imaging Absorption Spectrometer for Atmospheric CHartographY

SCMC - Specified Clustering and Mahalanobis Classification

SDO - Solar Dynamics Observatory

SDR - Subcommittee on Disaster Reduction

SEAC4RS - Studies of Emissions, Atmospheric Composition, Clouds and Climate Coupling by Regional Surveys

SEES — STEM Enhancement in Earth Sciences

SEVIRI — The Spinning Enhanced Visible and InfraRed Imager

SGMA – Sustainable Ground water Management Act

SHARC — SCIFLI-Hayabusa Airborne Re-entry observation Campaign

SHINE - Solar Atmospheric and Interplanetary Environment

SHOUT - Sending Hazards with Operational Unmanned Technology

SIAM — Society for Industrial and Applied Mathematics

SIERRA — Sensor Integrated Environmental Remote Research Aircraft

SIF — Solar Induced Flourescence

SIGKDD — The Association For Computing Machinery’s Special Interest Group on Knowledge Discovery and Data Mining

SIMS – Satellite Irrigation Management Support

SLAP – Scanning L-band Active/Passive

SMD — Science Mission Directorate

SMT - Spectral Matching Techniques

SNMP — Simple Network Management Protocol

SNS – School of Natural Science

SP2 - Single-Particle Soot Photometers

SPOT – Satellite Pour l'Observation de la Terre (Fr., trans: Satellite for Observation of the Earth)

SR – Surface Reflectance

SRTM — Shuttle Radar Topography Mission

SSA - Single Scattering Albedo

SSAI — Science Systems and Applications, Inc

SSEBop – (operational) Simplified Surface Energy Balance

SSH — Secure Shell

SSURGO — Soil Survey Geographic Database

STAR — Sun-tracking Atmospheric Research

STEM - Science, Technology, Engineering, and Mathematics

STM – Space Traffic Management

sUAS - small Unmanned Aerial Systems

SWIR – Short Wave Infrared

SWRCB – State Water Resources Control Board

TAT - Total Air Temperature

TCCON - Total Carbon Column Observing Network

TCL - Technology Capability Levels

TEC – Thermoelectric Cooler

TEK - Traditional Ecological Knowledge

TES - Tropospheric Emission Spectrometer

TESS – Triennial Earth Sun Summit

TFRSAC – Tactical Fire Remote Sensing Advisory Committee

TGRS — Transactions on Geoscience and Remote Sensing

TOA – Top of Atmosphere

TOAR - Total Ozone Assessment Report

TOPS – Terrestrial Observation and Prediction Systems

TRL — Technology Readiness Level

TROPESS — Tropospheric Ozone and its Precursors from Earth System Sounding

UAS – Unmanned Air Systems

UAV – Unmanned Aerial Vehicle

UCANR — University of California Agriculture and Natural Resources

UCCE – University of California Cooperative Extension

UCSC - University of California, Santa Cruz

UMD ED-2 – University of Maryland Ecosystem Demography model

UNA-UK – United Nations United Kingdom

UNDP — UN Development Programme

UNFCCC - UN Framework Convention on Climate Change

UPS — Uninterruptible Power Supply

USCG – U.S. Coast Guard

USCRTF — U.S. Coral Reef Task Force

USDA — U.S. Department of Agriculture

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

USDA-FS — United States Department of Agriculture, Forest Service

USGEO — The U.S. Group on Earth Observations

USGS — United States Geological Survey

UTLS - Upper Tropospheric and Lower Stratospheric

UTM – Urchin Tracking Module

VIIRS – Visible Infrared Imaging Radiometer Suite

VIPIR Radar — Volumetric Imaging and Processing of Integrated Radar

VIRGAS - Volcano-plume Investigation Readiness and Gas-phase and Aerosol Sulfur

VLAN — Virtual Local Area Network

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

VPN – Virtual Private Network

WAS — Whole Air Sampling

WELD - Web-enabled Landsat Data

WESTFAST - Western States Federal Agency Support Team

WF-ABBA – Wildfire Automated Biomass Burning Algorithm

WFF – Wallops Flight Facility

WFST TF - Wildland Fire Science and Technology Task Force

WGA — Western Governors' Association

WIT - Wildfire Implementation Team

WSWC — Western States Water Council

WUI – Wildland Urban Interface

WWAO – Western Water Applications Office

XML API - an event-driven online algorithm for parsing XML documents