Eighth Year Progress Report for NASA Co-operative Agreement NNX12A05A

December 31, 2019

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

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Period of Performance 3/1/19 to 2/28/2020

Table of Contents

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. We presented our report for the eighth year of this co-operative agreement on December 31, 2019. This document amends that Eighth Year 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 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 eighth year of the ARC-CREST cooperative agreement, the current participants, Bay Area Environmental Research Institute ("BAERI") and California State University Monterey Bay ("CSUMB") worked to achieve each of these objectives.

The ARC-CREST scientific team, working closely with the Ames Earth Science Division, participated in project areas covering the gamut of Earth Science research. ARC-CREST scientists used NASA resources to measure atmospheric carbon dioxide, coastal ocean biology, solar physics, and synthetic biology. They 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 predictions of maximum forest height for forested areas across the continental U.S.

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, through the Ecological Forecasting project, there were important accomplishments in agricultural productivity, water management, earthquake response, and many other important areas.

The ARC-CREST partners also provided support to critical Earth Science activities at NASA Ames Research Center, including the Earth Science Project Office; the Applied Sciences Program's Water Resources Program; the Meteorological Measurement System; and the Airborne Science Program (including payload integration engineering, data display and networking, and facility instrumentation for NASA's fleet of research aircraft). Development of NASA's capabilities in using Unmanned Aerial Vehicles for Earth Science projects continued to be a particular focus.

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

ARC-CREST Partners

- Bay Area Environmental Research Institute
- California State University at Monterey Bay
- NASA Ames Research Center, Earth Science Division

ARC-CREST Staff

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CSUMB

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Scargle, Jeff
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Vasques, Marilyn
Worden, John

Earth Science Focus Areas

Aerosol Modeling

Project Participants

NASA: Hongbin Yu, Mian Chin
BAERI: Qian Tan

Project Description

Aerosols, the small particles suspended in the air can affect the 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. Among all components, dust is one of the dominant aerosol types over Africa and Asia. Dust outflow from Africa and Asia can be deposited to Atlantic and Pacific Ocean and affect radiation balance and biogeochemical cycle.

Accomplishments

- Studied and quantified dust deposition along the trans-Atlantic pathways from the outflow of dust emitted from northern African deserts; and
- Analyzed the trans-Pacific transport of Asian dust using both satellite observation and simulation from various models.

Publications

Kim, D., M. Chin, H. Yu, X. Pan, H. Bian, Q. Tan, R. Kahn, K. Tsigaridis, S. Bauer, T. Takemura, L. Pozzoli, N. Bellouin, M. Schulz, Asian and trans-Pacific Dust: A multi-model and multi-remote sensing observation analysis, Journal of Geophysical Research: Atmospheres, under review.

Yu, H., Q. Tan, M. Chin, L. A. Remer, R. A. Kahn, H. Bian, D. Kim, Z. Zhang, T. Yuan, et al, Estimates of African dust deposition along the trans-Atlantic transit using the decade-long record of aerosol measurements from CALIOP, MODIS, MISR, and IASI. Journal of Geophysical Research: Atmospheres, 124, 2019

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 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
- Submitted a paper to The Bulletin of the American Meteorological Society (BAMS) for publication. Dr. Knobelspiesse is the lead author of the paper, Dr. Tan is one of co-authors.

Publications

Knobelspiesse, K., Q. Tan, C. Bruegge, B. Cairns, J. Chowdhary, B. van Diedenhoven, D. Diner, et al. 2019. Intercomparison of airborne multi-angle polarimeter observations from the Polarimeter Definition Experiment (PODEX), Applied Optics, 58: 650-669, https://doi.org/10.1364/AO.58.000650,

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

The overarching goal of this project is to develop a scalable software framework to compress and search large volumes of time-series data. In particular, we are interested in searching for MODIS vegetation data over the continental United States for regions with similar characteristics. Our work has focused on using Radius Sketch, a distributed searching algorithm, with High Performance Computing (HPC) tools for scalability. We are exploring the applicability of quantum annealing for compression using the D-Wave 2000Q system at NASA Ames Research Center. While the quantum architecture limits model complexity, we have found that quantum annealing is able to compress time-series at a smaller scale with reasonable accuracies. We are currently exploring how the quantum annealing algorithms compare with the distributed HPC approach.

Accomplishments

- Implemented the radius sketch algorithm for compression and search of time-series. We found that this model has tighter theoretical bounds than the proposed iSAX2 methodology;
- Scaled radius sketch to search MODIS at 500m spatial resolution over the continental United States on NASA HPC and currently testing on lower resolution datasets;
- Implemented spatial compression with a quantum assisted discrete variational auto-encoder on the GIMMs vegetation dataset; and
- Developed a quantum-assisted associate adversarial network to generate realistic looking handwritten digits on the MNIST dataset. A paper has been submitted for review.

Publications

Duffy, K. M., T. Vandal, S. Li, S. Ganguly, R. Nemani, and A.R. Ganguly. 2019. DeepEmSat: Deep Emulation for Satellite Data Mining. Frontiers in Big Data, 2: 42.

Vandal, T., and R. Nemani. 2019. Optical Flow for Intermediate Frame Interpolation of Multispectral Geostationary Satellite Data. arXiv preprint arXiv:1907.12013 (In submission).

Wilson, M., T. Vandal, T. Hogg, and E. Rieffel. 2019. Quantum-assisted associative adversarial network: Applying quantum annealing in deep learning. arXiv preprint arXiv:1904.10573 (In review).

Duffy, K., T. Vandal, W. Wang, R. Nemani, and A.R. Ganguly. 2019. Deep Learning Emulation of Multi-Angle Implementation of Atmospheric Correction (MAIAC). arXiv preprint arXiv:1910.13408 (In review).

Presentations

Vandal, T., R. Nemani, W. Wang, and S. Li. 2019. Transfer Learning to Generate True Color Images from GOES-16. AGU Fall Meeting, Dec. 9-13, San Francisco, CA.

Duffy, K., T. Vandal, S. Li, R. Nemani, and A.R. Ganguly. (2019, December). Deep Learning Emulation of Atmospheric Correction for Geostationary Sensors. In AGU Fall Meeting 2019. AGU.

Li, S., W. Wang, H. Hashimoto, T. Vandal, J. Yao, and R. Nemani. 2019. Surface Reflectance Product from Geostationary Satellite. AGU Fall Meeting, Dec. 9-13, San Francisco, CA.

Vandal, T., K.Duffy, and R. Nemani. 2019. Deep Learning and Uncertainty Quantification For Climate Resilience. INFORMS Annual Meeting. Oct. 20-23, Seattle, WA.

Vandal, T. and R. Nemani. 2019. Estimating Optical Flows in Satellite Imagery, Space Lidar Winds Working Group Meeting, National Institute for Aerospace, Mar. 21-23, Hampton, VA.

Vandal, T., R. Nemani and S. Ganguly. 2019. Enhancing Climate Data with Deep Learning, First Workshop on Leveraging AI in the Exploitation of Satellite Earth Observations and Numerical Weather Prediction, April 23-25, NOAA Center for Weather and Climate Prediction, College Park, MD.

Panels or Committees

Vandal, T., Committee on Artificial Intelligence Applications to Environmental Science for the American Meteorological Society

Ganguly, S. and T. Vandal, Scaling Machine Learning in the Earth Sciences". Earth Science Information Partners (ESIP) Winter Meeting, Jan. 15-17, Bethesda, MD.

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
Student team members: Will Carrara (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:

- Apply satellite data, airborne data, flux towers and other ground-based instrumentation to model and map agricultural productivity, evapotranspiration and crop water demand;
- Apply satellite data, climate models, and ecological models to map habitat for disease vectors and model vector-borne disease transmission risk; and
- 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 2019, research activities focused solely on Objective 1 based on priorities and funding availability from NASA.

Accomplishments

- Published 1 conference proceedings paper, 1 article in an industry trade journal, and 7 additional articles currently in preparation;
- Presented more than 15 scientific and technical talks/posters at science conferences and technical meetings, including an invited presentation at the Western Governors' Association Annual Meeting;
- Presented (F. Melton) an overview of applications of NASA satellite data and technologies for water management directly to six governors of western states at the WGA Annual Meeting in 2019;
- Mentored one CSUMB student and one Stanford University student who worked with the SIMS and Fallowed Area Mapping projects in 2018 (Will Carrara, Conor Doherty). Additional research internships will be offered in 2020;

- Secured an additional $2 million ($5.5 million in total funding to date) for the OpenET project from the Gordon and Betty Moore Foundation, the Walton Family Fund and the Telluray Foundation. 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 >25 leading experts on remote sensing of ET. 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 11 western states to date. The OpenET annual meeting in August in Reno, NV was attended by 23 scientists and technical experts and more than 60 partners and stakeholders from the Western Water Management community. The beta version of OpenET web data explorer featured data from the USGS operational Simplified Surface Energy Balance (SSEBop) model and the NASA SIMS model, facilitating an extremely well-received demonstration of the OpenET user interface at the annual meeting. Alberto Guzman also used the SIMS implementation on Earth Engine to process multiple years of data for OpenET use cases with project partners working to support implementation of the Sustainable Groundwater Management Act in California. C. Wang also co-led the data review and footprint analysis for more than 100 Ameriflux stations, and the project team is currently preparing to co-lead the largest accuracy assessment and intercomparison of ET-models conducted to date.
- Continued work on the WesternET project, a ROSES supported project on evapotranspiration (ET) mapping in the western US in collaboration with DRI. Johnson and Sr. Software Engineer Guzman are working with DRI on an effort to leverage SIMS and METRIC to map ET across four critically impacted basins spanning 6 western states. Johnson and Guzman worked with DRI to complete an implementation of the pySIMS model which is currently being prepared for release as open source software. The project team also made multiple improvements to the SIMS model, including expansion to include a soil water balance model that runs at Landsat scales (led by C. Doherty), support for irrigated rice fields, and options to use reference ET datasets from CIMIS or GRIDMET. pySIMS was also applied to create 10 year data records for the Harney Basin in Oregon providing a critical data resource for the Oregon Department of Water Resources.
- Successfully developed, with support from the NASA Western Water Applications Office, an 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 2,000 California growers. In addition, the project deployed and maintained flux towers in collaboration with Central Coast growers to support expansion of CropManage to include winegrapes and celery. T. Wang led the deployment and operation of eddy covariance instrumentation in commercial fields and vineyards and is currently using the data to evaluate ET data and irrigation recommendations from CropManage for these crops. T. Wang also developed automated python workflows for processing and analysis of the flux tower data. The SIMS API has also been provided to commercial partners, including Ceres Imaging, for testing and use in commercial applications. W. Carrara also completed a study of atmospheric correction options for the Sentinel-2 data, facilitating integration of this valuable data source into SIMS. Results from this student research will be presented at the 2019 Fall AGU Meeting in December;
- Acquired, in partnership with USDA ARS in Salinas, CA, a DJI Matrix 600 hexacopter UAV platform and Micasense Altum camera. The project team (F. Melton, PI; M. Hang Co-I) secured a five-year cooperative agreement with USDA ARS ($500k total funding) to conduct joint research on use of UAV data to identify and map plant pathogen presence in strawberries and other high value specialty crops. M. Hang obtained his FAA Part107 pilot's license and developed data calibration and georegistration workflows for the UAV data, as well as algorithms for mapping disease presence, plant counts, fractional cover and plant health. The project team is currently using these capabilities to monitor 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;

- Led (Isabel Zaragosa) field campaigns to collect additional ground validation data in Nevada and Washington to allow the project team to complete modification of algorithms to support mapping of land fallowing during drought events in these states. The project team developed training materials for CA DWR, the Washington Department of Agriculture, and the Nevada State Engineer's Office to facilitate final transition of capabilities for satellite mapping of land fallowing in California, Washington State and Nevada. The project team is currently finalizing the algorithms for these states and plans to complete transition to operational use in 2020 in partnership with these three state agencies;
- Continued field trials and research to quantify the value of SIMS and ET-based irrigation scheduling;
- Deployed and maintained instrumentation on one commercial farms in Firebaugh, CA in partnership with growers in the Central Valley;
- Collaborated with partner growers on data analysis and manuscripts for publication. 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;
- Conducted additional field trials in collaboration with UC Cooperative Extension and CSU Fresno on cabbage and onions to quantify the benefits of ET-based irrigation scheduling;

Publications

Cahn, M., and L. Johnson, 2019. Using weather data to optimize crop water management. American Vegetable Grower, Sept. 2019. (circulation ~60,000; non-refereed).

Cahn, M., L. Johnson, and R. Smith, 2019. Using the CropManage Decision Support Tool for Improving Irrigation and Efficiency of Coastal Vegetables. Proceedings ASA California Plant and Soil Conference, pp. 55-59, 5-6 February, Fresno.

2019 was a relatively light year for this task for publications relative to past years. However, the team is currently serving as the lead or a senior co-author on 7 manuscripts that are being prepared for submission over the next 3 months.

Presentations

Cahn, M., L. Johnson, S. Benzen, Z. Qin, and D. Chambers. 2019. Optimizing Water Management in Celery Using Weather Based Scheduling, American Society for Horticultural Science (ASHS) Annual Conference, 22-25 July, Las Vegas, NV.

Fulton A., L. Johnson, et al. 2019. Evaluation of crop coefficients and evapotranspiration in English walnut (Invited). California Crop Coefficient (3C) Science Collaborative, 3 April 2019, Davis, CA.

Cahn, M., L. Johnson, and S. Benzen. 2019. Optimizing water management in celery using ET weather-based scheduling. Univ. California Cooperative Education (UCCE) Irrigation and Nutrient Management Meeting, 26 Feb., Salinas, CA.

Melton, F., L. Johnson, A. Guzman, T. Wang, I. Zaragosa, M. Cahn, T. Temesgen, and R. Trezza. 2019. Integrating Satellite and Surface Sensor Networks for Irrigation Management Decision Support in California. California Water and Environmental Modeling Workshop, April 24, 2019, Sacramento, CA.

Carrara, W. et al. 2019. Quantifying the benefits of evapotranspiration-based irrigation management. California State University Agricultural Research Institute Workshop for the California Legislature, October 24, Sacramento, CA.

Guzman, A., F. Melton, L. Johnson, T. Wang, I. Zaragosa, M. Cahn, B. Temesgen, R. Trezza, and S. Eching. 2019. Integrating SIMS and CropManage to Advance Data-Driven Irrigation Management. NASA Water Resources Annual Meeting, July 17, 2019, Portland, OR.

Melton, F., A. Guzman, I. Zaragosa, T. Wang, L. Johnson, J. Huntington, and C. Morton. 2019. Satellite Mapping of Agricultural Land Fallowing for Drought Impact Assessment and Decision Support. NASA Water Resources Annual Meeting, July 17, 2019, Portland, OR.

Melton, F., et al., 2019. Remote sensing applications for vineyard management. National Grape Research Alliance Annual Meeting, November 12, Sacramento, CA.

Johnson co-organized UCCE Field Day for about 40 cauliflower growers in Salinas, CA and presented on results of field trials and integration of data from SIMS in CropManage, Salinas, CA.

Panels or Committees

- SBG Applications Working Group (F. Melton)
- Scientific Committee for the 2019 IEEE International Geoscience and Remote Sensing Symposium (L. Johnson)
- Western Water Applications Office Capabilities Working Group (L. Johnson)
- Participation in multiple NASA review panels (Applied Science, SBIR) by Johnson and Melton.

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, CO2, methane and meteorological parameters. Ms. Yates identifies science questions, designing and planning flights, data analysis (IDL, python), maintaining instruments and scientific writing and presentations. Since 2016, she has been responsible for facilitating collaborations through setting up a new laboratory of atmospheric instruments (CO2, CO, carbonyl sulphide, C-isotopes) and making them available for use within the wider scientific community. To date, the project has been awarded four grants to deploy instrumentation on a UAS in Alaska, in a vehicle, and an 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 (in review).

Leifer, I., C. Melton, R. Chatfield, X. Cui, M.L. Fischer, M. Fladeland, W. Gore, D.L. Hlavka, L. Iraci, J. Marrero, J.-M. Ryoo, T. Tanaka, E. Yates, and J. Yorks. 2019. Air pollution inputs to the Mojave Desert by fusing surface mobile and airborne in situ and airborne and satellite remote sensing: A case study of interbasin transport with numerical model validation, Atmospheric Environment, https://doi.org/10.1016/j.atmosenv.2019.117184.

Ryoo, J.-M., L.T. Iraci, T. Tanaka, J.E. Marrero, E.L. Yates, I. Fung, A.M. Michalak, J. Tadi'c, W. Gore, T.P. Bui, J.M. Dean-Day, and C.S. Chang. 2019. Quantification of CO2 and CH4 emissions over Sacramento, California, based on divergence theorem using aircraft measurements, Atmospheric Measurement Techniques, 12,2019, doi: 10.5194/amt-12-2949-2019

Presentations

Yates, E.L., et al. 2019. Investigating the Processes Affecting Surface Air-Quality in California's Sierra Nevada Mountain Range, AGU Fall Meeting, Dec. 9-13, San Francisco, CA.

Yates, E.L., et al. 2019. The Alpha Jet Atmospheric EXperiment (AJAX): Past, Present, and Future Airborne Measurements, May 21-22, Boulder, CO.

Accomplishments

- Focused primarily on data analysis of historic AJAX data due to aircraft down-time, this has resulted in a paper submitted to Atmospheric Environment and currently in review and an oral presentation at the AGU.

- Prepared another paper for planned submission in early 2020;
- Performed data analysis of AJAX data for the CABOTS team, a funded project through CARB. The final AJAX CABOTS report was submitted to CARB in December;
- Worked to extend collaborations and work of other trace gases on various platforms;
- Awarded a proposal from SAFIRE (scientific Aviation) to fly the COS instrument in spring/summer next year. Significant time has been spent analyzing the instrument's performance in the laboratory and chamber tests. Modifications are required in order to fly the instrument to control temperature;
- Carried out significant testing on a CO instrument, again in the laboratory and chamber, with the hope to fly it onboard the ER-2 next summer; and
- Worked on analysis and data and field deployment of a methane sensor on a small Unmanned Aerial Vehicle (s-UAV) to assess its performance with the overall aim of deriving methane fluxes.

Aura TES

Project Participants

NASA-JPL: Kevin Bowman
BAERI: Susan Kulawik

Project Description

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. Based analysis from the GEOCAPE project and other analyses, the TES team developed and routinely processes a combined UV (e.g. from OMI, tropOMI, OMPS) and thermal infrared observations (e.g. TES, AIRS, IASI, or CrIS). Even though AIRS and OMI individually each have one or less degree of freedom in the Troposphere, combined OMI+AIRS observations have similar sensitivity to TES and are used to continue the TES record of tropospheric ozone measurements. The TES-heritage processing system, called MUSES, contains the ability to process TES, AIRS, CrIS, OMI, and OCO-2, and the system now processes CrIS PAN (ROSES-funded project, Vivienne Payne, PI), AIRS CH_4 (ROSES-funded project, John Worden, PI), CrIS CO (ROSES-funded project, Helen Worden, PI), AIRS HDO (Herman et al., 2019), and CrIS NH3 (working with Karen Cady-Pereira, AER. Dr. Kulawik was one of the key developer of the MUSES system, along with Dejian Fu (JPL), John Worden (JPL), Helen Worden (NCAR), and Kevin Bowman (JPL).

Award

Dr. Kulawik received the 2019 NASA Exceptional Public Achievement Medal “for exceptional achievement in atmospheric remote sensing, enabling development of new atmospheric composition products and algorithmic advances across NASA missions.”

Accomplishments

- Worked with Qui Chau to transition from the current codebase in the proprietary IDL environment to a codebase in python (open source) and with Valentin Kantchev to transition the code to git and github;
- Completed significant updates to improve processing of CrIS and AIRS satellite observations for PAN, HDO, and CH_4;
- Developed significant improvements in the output product content; and
- Validated TES HCN and CO_2 products.

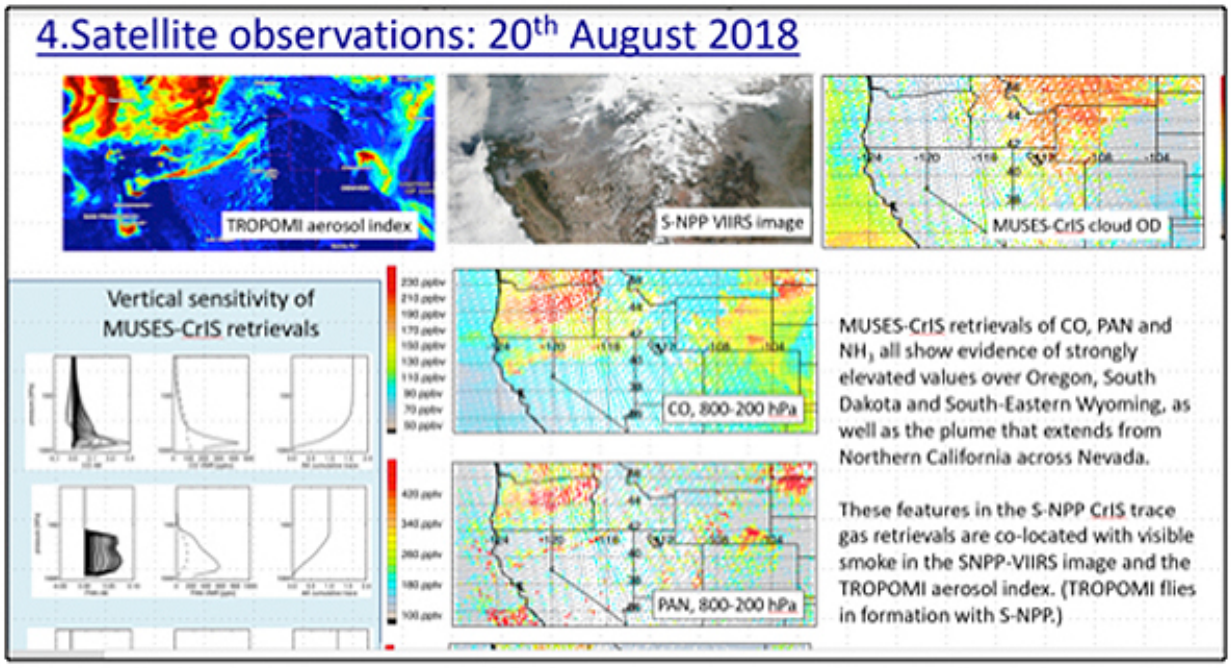


Figure from the poster presented at the Aura Science Team meeting in Pasadena, CA, in August, 2019 showing how retrieving linear PAN improves TES results.

Publications

Worden, J.R., S.S. Kulawik, D. Fu, V.H. Payne, A.E. Lipton, et al. 2019. Characterization and evaluation of AIRS-based estimates of the deuterium content of water vapor, Atmospheric Measurement Techniques, 12 (4): 2331–2339. https://doi.org/10.5194/amt-12-2331-2019.

Miyazaki, K., T. Sekiya, D. Fu, K.W. Bowman, S.S. Kulawik, et al. 2019. Balance of Emission and Dynamical Controls on Ozone During the Korea-United States Air Quality Campaign From Multiconstituent Satellite Data Assimilation, Journal of Geophysical Research: Atmospheres, 124 (1): 387-413. https://doi.org/10.1029/2018JD028912

Fu, D., S.S. Kulawik, K. Miyazaki, K.W. Bowman, et al. 2018. Retrievals of tropospheric ozone profiles from the synergism of AIRS and OMI: methodology and validation, Atmospheric Measurement Techniques, 11 (10): 5587-5605. https://doi.org/10.5194/amt-11-5587-2018

Presentations

Kulawik, S.S., V. Payne, E. V. Fischer, K.W. Bowman. 2019. Improved Aura-TES PAN retrievals for increased sensitivity to low PAN values, Aura meeting, Aug. 27-29, Pasadena, CA.

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 yearly forest cover map for Mexico. In addition, the project will also 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.

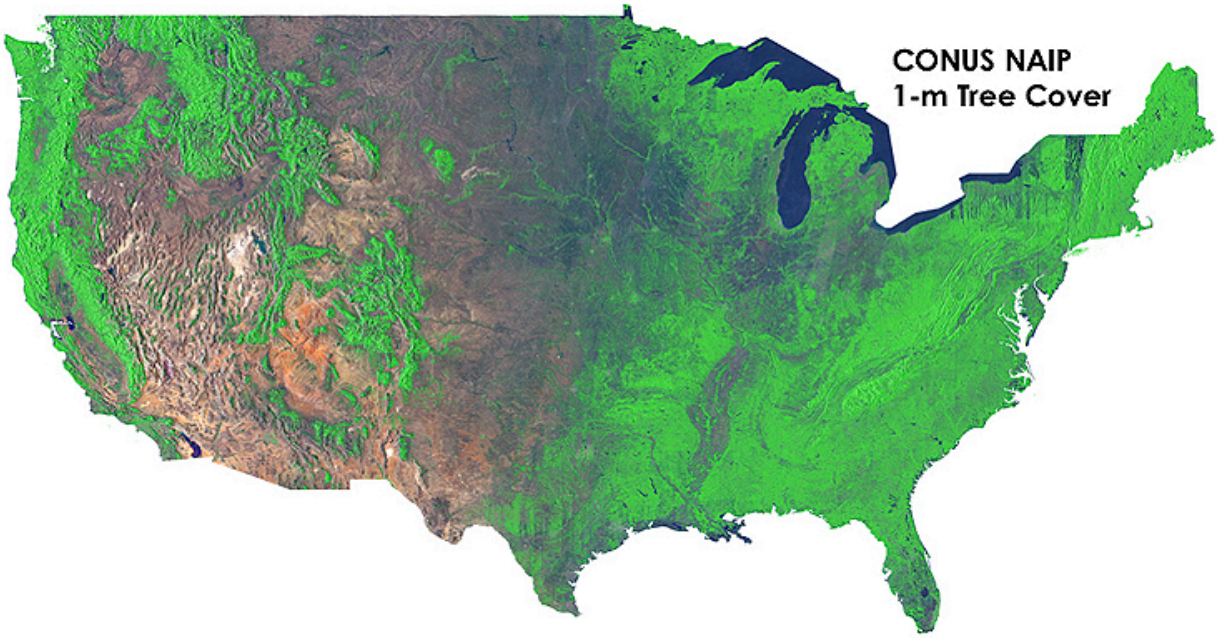
Project 2: NASA CMS 2017 (Hurtt) High-Resolution Carbon Monitoring and Modeling: Continued Prototype Development and Deployment to Regional and National Scales. This project will implement machine learning algorithms for generating forest cover maps from the 1-m National Agricultural Imagery Program (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: 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

- Created and delivered 30-m Landsat-based forest/non-forest maps (See figure below). This serves as a critical input to the Aboveground Biomass (AGB) model from the Jet Propulsion Laboratory (JPL) and for further estimation of net carbon flux. The algorithm for generating the forest masks is based on a deep learning-based artificial intelligence model that has been originally trained and modeled at the 1-m spatial resolution using the NAIP imagery;
- Generated a high resolution dataset of climate variables which are now being ingested by the ED model - this model is critical to the UMD biomass modeling effort and is going to be a key input to the ED model that will run on data provided by the new GEDI mission;

- Performed final validation and quality checks for the beta version of the NAIP 1-m tree cover data product, which will then be disseminated to Oak Ridge National Lab Distributed Active Archive Center (ORNL DAAC);
- Presented a number of algorithmic model architectures and related CMS studies at AGU and CMS Science Team Meeting; and
- Published a number of peer reviewed articles including a high-profile journal.



Publications and Presentations

Park, T., C. Chen, F. Macias, M. Fauria, H. Tømmervik, S. Choi, A. Winkler, U.S. Bhatt, D.A. Walker, S. Piao, V. Brovkin, and R. Nemani. 2019. Changes in timing of seasonal peak photosynthetic activity in northern ecosystems. Global Change Biology, 25 (7): 2382-2395. https://doi.org/10.1111/gcb.14638

Liu, Q., S. Basu, S. Ganguly, S. Mukhopadhyay, R. DiBiano, M. Karki, and R. Nemani. 2019 DeepSat V2: Feature Augmented Convolutional Neural Nets for Satellite Image Classification, Remote Sensing Letters, 11 (2). DOI: 10.1080/2150704X.2019.1693071

Duffy, K.M., Vandal, T., Li, S., Ganguly, S., Nemani, R. and Ganguly, A.R., 2019. DeepEmSat: Deep Emulation for Satellite Data Mining. Frontiers in Big Data, 2: 42. https://doi.org/10.3389/fdata.2019.00042

Chen, C., T. Park, X. Wang, S. Piao, B. Xu, R.K. Chaturvedi, R. Fuchs, V. Brovkin, P. Ciais, R. Fensholt, and H. Tømmervik. 2019. China and India lead in greening of the world through land-use management. Nature Sustainability, 2 (2):122.

Tømmervik, H., J. W. Bjerke, T. Park, F. Hanssen, and R.B. Myneni. 2019. Legacies of Historical Exploitation of Natural Resources Are More Important Than Summer Warming for Recent Biomass Increases in a Boreal–Arctic Transition Region. Ecosystems, 22(7):1512-1529.

Tharammal, T., G. Bala, N. Devaraju, and R. Nemani. 2019. A review of the major drivers of the terrestrial carbon uptake: model-based assessments, consensus, and uncertainties. Environmental Research Letters, 14(9): 093005.

Rao, A.S., Bala, G., Ravindranath, N.H. and Nemani, R., 2019. Multi-model assessment of trends, variability and drivers of terrestrial carbon uptake in India. Journal of Earth System Science, 128 (4): 99.

Tharammal, T., G. Bala, D. Narayanappa, and R. Nemani. 2019. Potential roles of CO2 fertilization, nitrogen deposition, climate change, and land use and land cover change on the global terrestrial carbon uptake in the twenty-first century. Climate Dynamics, 52(7-8): 4393-4406.

Presentations

Park, T., S. Ganguly, S. Li, and R. Nemani. 2019. Tree cover delineation for CONUS from 1-m NAIP imagery, NASA CMS Science Team Meeting, Nov. 12-14, La Jolla, CA.

Park, T., R. B. Myneni, and Y. Knyazikhin. 2019. Disturbance, cultivation, and climate drive a widespread North American vegetation greening. AGU Fall Meeting, Dec. 9-13, San Francisco, CA.

Chen, C., T. Park, X. Wang, S. Piao, B. Xu, R.K. Chaturvedi, R. Fuchs, V. Brovkin, P. Ciais, R. Fensholt, and H.A. Tømmervik. 2019. Greening of global lands from twenty-year satellite observation. AGU Fall Meeting, Dec. 9-13, San Francisco, CA.

Melendy, L., S.C. Hagen, S. Saatchi, Y. Yu, G.M. Domke, B.F. Walters, R. Nemani, S. Ganguly, A. Bloom, S. Li, S. and Y. Yang. 2019. Net Carbon Change: Emissions and Attribution for US Forests in 2005-2016. AGU Fall Meeting, Dec. 9-13, San Francisco, CA.

Duffy, K., T. Vandal, S.Li, R. Nemani, and A.R. Ganguly. 2019. Deep Learning Emulation of Atmospheric Correction for Geostationary Sensors. AGU Fall Meeting, Dec. 9-13, San Francisco, CA.

Yu, Y., S. Saatchi, G.M. Domke, B.F. Walters, S. Li, R. Nemani, S. Hagen, L. Melendy, and R.E. McRoberts. 2019. Monitoring Changes in Aboveground Biomass Across U.S. Forestlands Using Satellite Observations and Forest Inventory Data. AGU Fall Meeting, Dec. 9-13, San Francisco, CA.

Vargas, R., S. Li, and R. Nemani. 2019. Validation of tree cover maps across Mexico. AGU Fall Meeting, Dec. 9-13, San Francisco, CA.

Xu, B., L. Jing, T. Park, O. Liu, Y. Zeng, G. Yin, K. Yan, C. Chen, J. Zhao, W. Fan, and Y. Knyazikhin. 2019. Improving leaf area index retrieval over heterogeneous surface mixed with water. AGU Fall Meeting, Dec. 9-13, San Francisco, CA.

Cross-track Infrared Sounder Observations of Peroxyacetyl Nitrate (CrIS PAN)

Project Participants

NASA-JPL: Vivienne Payne, Emily Fisher
BAERI: Susan Kulawik

Project Description

This 3-year ROSES-funded project develops Cross-track Infrared Sounder (CrIS) peroxyacetyl nitrate (PAN), to create a thermal-infrared PAN Earth data record from 2004 through the present, continuing the PAN record from Aura-TES (Fischer et al., 2018), which began in 2004. This project's science goal is to provide new constraints on the impacts of fires on air quality and the nitrogen cycle from CrIS observations. PAN plays a critical role in long-range pollution transport, atmospheric chemistry, and in the redistribution of tropospheric nitrogen.

This has been instrumental in developing the single-pixel processing of non-cloud-cleared CrIS observations, a unique product which will be incorporated into the Sounder SIPS processing. This team has also participated in the development of additional CrIS species, including atmospheric temperature, water, HDO, methane, ozone, carbon monoxide, carbon dioxide, methane, and ammonia, in collaboration with Aura-TES and other ROSES-funded projects (working with Helen Worden, NCAR on CO; Karen Cady-Pereira, AER, on NH3; working with Kevin Bowman, JPL, on O_3; John Worden, JPL, on HDO).

Accomplishments

- Finalized CrIS PAN retrieval strategy and quality screen;
- Compared PAN results to aircraft observation from ATom (https://daac.ornl.gov/ATOM/campaign/);
- Processed ~500,000 CrIS PAN observations matching the WE-CAN observation domain in the western United States for 7/24/2018 through 9/13/2018; and
- Presented PAN results at the Aura meeting in August, 2019 (by Dr. Kulawik) and at the AGU fall meeting in December, 2019 (by Dr. Payne).

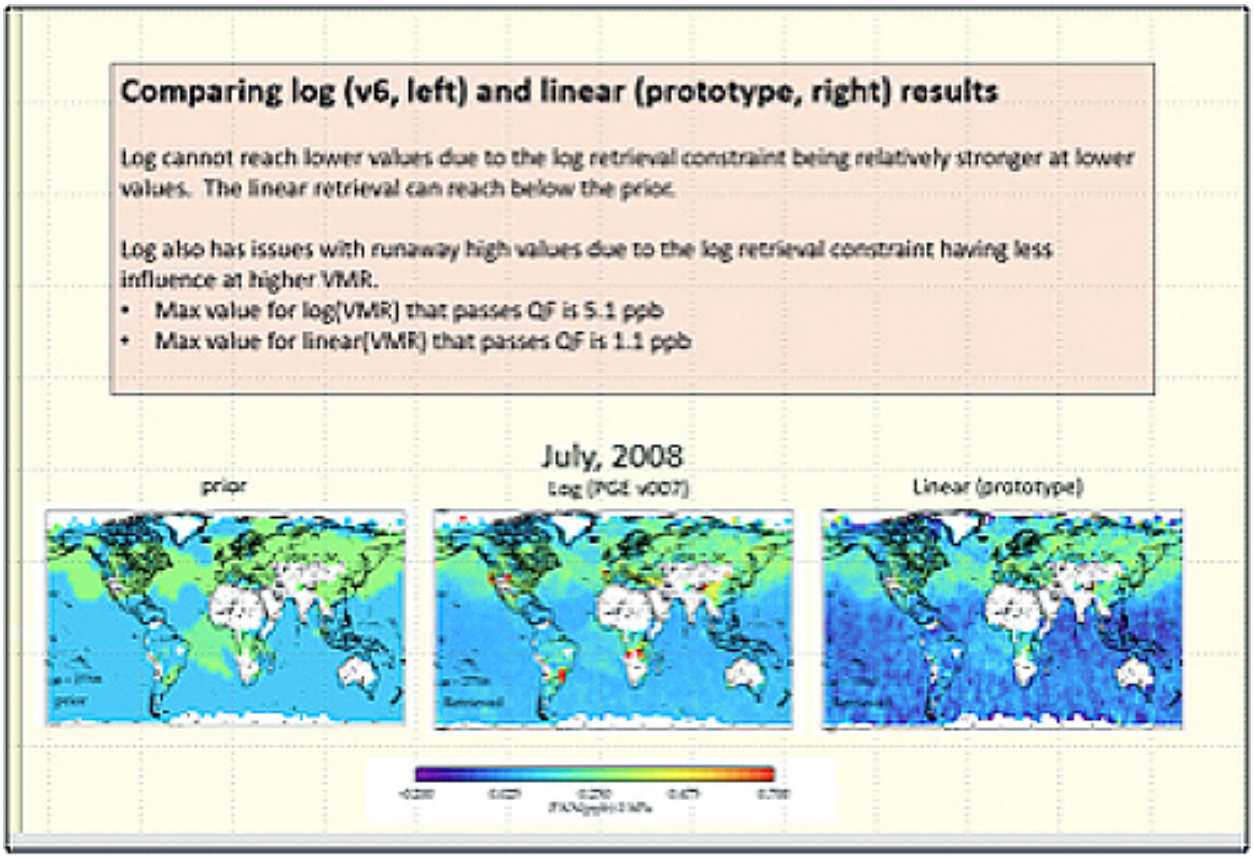


Figure from the poster presented at fall AGU, A43J-2957, "Observations of atmospheric composition in fire plumes over the Western United States in summertime from the Cross-Track Infrared Sounder." Authors:V. Payne, S. S. Kulawik, et al.

Presentations

Payne, V., S. Kulawik, E.V. Fischer, K.W. Bowman, H.M. Worden, G.L Francis, et al. 2019. Observations of atmospheric composition in fire plumes over the Western United States in summertime from the Cross-Track Infrared Sounder. AGU Fall Meeting, Dec. 9-13, San Francisco, CA.

Earth System Data Records CO_2

Project Participants

NASA-JPL PI: Vineet Yadav
BAERI: Susan Kulawik

Project Description

The satellite observation record of carbon dioxide includes SCIAMACHY (2001), AIRS (2002), ACE (2003), TES (2004), GOSAT (2009), OCO-2 (2014), and OCO-3 (2019). Generation of a harmonized long-term CO_2 satellite data record is essential to understanding carbon dioxide responses to interannual variations, like El Nino, land-use changes, and emission trends, The Earth Science Data Records (ESDR) project supports the NASA Earth Science Data Systems Program, which seeks to extend and enhance Earth system data records used by NASA communities, including climate data records. This project develops a long term CO_2 record from OCO-2, GOSAT, and AIRS CO2 satellite observations, both independently and fusing observations from different satellites.

Dr. Kulawik provides guidance on the biases and sensitivity of the different satellite products, and validates the fused products.

Accomplishments

- Produced initial fused OCO-2 products; and
- Compared the fused products 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.

SeaSTAR is a related project that adapts 5STAR detector technology and packages it into an instrument tailored for the marine environment. This includes the adaptation of a tilt nod tracking system that is better suited for the type of motion encountered by seagoing platforms.

Accomplishments

- Completed design, fabrication, and testing of custom printed circuit boards for the 5STAR radiometer package including:
  - ✦ InGaAs detector thermo-electric coolers (Rev 2);
  - ✦ 4-channel InGaAs detector dual gain amplifier board (Rev 4);
  - ✦ 5-channel Si detector dual gain amplifier board (Rev 2); and
  - ✦ National Instruments 6218 OEM ACD interface board (Rev 1).
- Completed design fabrication and testing of light collection and optical filtering systems for 9 radiometer channels;

- Integrated and tested above optical and electronic components. Performed lab diagnostics as required to maximize signal to noise ratio output from amplifiers;
- Developed slip-ring configuration to provide power and high speed digital signal across rotating interfaces;
- Fabricated test fixture to evaluate integrating sphere optical collector as a means to achieve flatter field-of-view;
- Specified, purchased, and tested new OEM spectrometer hardware consistent with performance requirements for muSSTAR miniaturization; and
- Developed new light-weight, low-power, low-backlash drive concepts for sun tracking motors, input to spectrometer.

Presentations

Broccardo, S.P., S.E. LeBlanc, S.E., Dunagan, M. Segal-Rosenheimer, M. Kacenelenbogen, C. Flynn, K. Pistone, and J. Redemann. 2019. NASA's next-generation airborne sunphotometer (5STAR): science drivers and requirements. Proceedings, Optics and Photonics for Sensing the Environment, June 25-27, San Jose, CA. Paper# JW3A.33.

Dahlgren, R.P., S.E. Dunagan, R. Johnson, S.P. Broccardo, A.I. Tayeb, and C. Esch. 2019. NASA's next-generation airborne sunphotometer (5STAR): engineering challenges and advances, Optics and Photonics for Sensing the Environment, June 25-27, San Jose, CA. Paper# JW3A.11

Dunagan, S., and S. LeBlanc. 2019. muSSTAR: miniature unmanned airborne Sunphotometer for Sun-Tracking Atmospheric Research, Ames Research and Technology Showcase Poster Session, Aug. 19, Moffett Field, CA.

Johnson, R., S. P. Broccardo, S. Muvva, and C. S Chang, 2019. The Seagoing sky-scanning Sun Tracking Atmospheric Research Radiometer: automated sunphotometry from ships, AGU Fall Meeting, Dec. 9-13, San Francisco CA.

4STAR and Satellite Data Analysis

Project Participants

BAERI: Kristina Pistone
UC San Diego, Scripps Institute: I. Eisenmann, V. Ramanathan

Project Description

During recent decades, there has been dramatic Arctic sea ice retreat. This has reduced the top-of-atmosphere albedo, adding more solar energy to the climate system. There is substantial uncertainty regarding how much ice retreat and associated solar heating will occur in the future. This is relevant to future climate projections, including the timescale for reaching global warming stabilization targets. We use satellite observations to estimate the amount of solar energy that would be added in the worst-case scenario, the complete disappearance of Arctic sea ice throughout the sunlit part of the year. Assuming constant cloudiness, we calculate a global radiative heating of 0.71 W/m2 relative to the 1979 baseline state. This is equivalent to the effect of one trillion tons of CO_2 emissions. These results suggest that the additional heating due to complete Arctic sea ice loss would hasten global warming by an estimated 25 years.

The write-up and publication of this work in mid-2019 was made possible by the directed funding provided to the 4STAR group.

Publications

K. Pistone , I. Eisenman, V. Ramanathan. 2019. Radiative Heating of an Ice-free Arctic Ocean, Geophysical Research Letters, 46. doi:10.1029/2019GL082914 .

Presentations

Pistone, K. , I. Eisenman, and V. Ramanathan. 2019. Radiative impacts of Arctic sea ice melt. Talk: 32nd CERES Science Team Meeting, Oct. 29-31, Lawrence Berkeley National Laboratory, Berkeley, CA.

Pistone, K., I. Eisenman, and V. Ramanathan. 2019. Radiative impacts of Arctic sea ice melt: using observations to inform future climate effects. Talk: AGU Fall Meeting, Dec. 9-13, San Francisco, CA.

***Part Two** - 4STAR-A and 4STAR-B instrument development -- Airborne Instrument Technology Transition (AITT), data analysis and flight operation (field campaigns: ORACLES, NAAMES and KORUS-AQ, see resp. Projects 2, 5 and 6).*

Project Participants

NASA: Meloë Kacenelenbogen
BAERI: Kristina Pistone, Samuel LeBlanc, Michal Segal-Rozenhaimer
USRA: Stephen Broccardo, Yohei Shinozuka

Project Description

The ObseRvations of Aerosols above CLouds and their intEractionS (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 these 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 by both BAERI team members and external collaborators.

In April, Pistone and LeBlanc also attended a joint workshop between ORACLES team and the CLARIFY (UK), AEROCLO-sA (France), and LASIC (US DoE ARM program) teams, all of which were making measurements between 2016 and 2017 in the southeast Atlantic Ocean. As described in the ongoing work, continued scientific collaborations within the ORACLES team and with other teams will be an important task in the coming year.

Accomplishments

- Completed final archive of ORACLES-2018 4STAR direct beam (AOD) data;
- Added ORACLES-2016 4STAR quality-controlled sky scan retrievals (and input sky radiances) into the ORACLES archival. Input sky radiances were also included for ORACLES-2016, 2017, and 2018;
- Organized the joint ORACLES-CLARIFY-AEROCLO-LASIC presentation and discussion session on measurements of aerosol properties (Pistone);
- Co-convened a poster and oral session at the AGU 2019 Fall Meeting (LeBlanc);
- Published three peer-reviewed papers; 4 more manuscripts currently in review (listed below); and
- Awarded NASA Group Achievement award for ORACLES.

Publications

Sayer, A.M., N.C. Hsu, J. Lee, W.V. Kim, S. Burton, M.A. Fenn, R.A. Ferrare, M. Kacenelenbogen, S. LeBlanc, K. Pistone, J. Redemann, M. Segal-Rozenhaimer, Y. Shinozuka, and S.-C. Tsay. 2019. Two decades observing smoke above clouds in the south-eastern Atlantic Ocean: Deep Blue algorithm updates and validation with ORACLES field campaign data, Atmospheric Measurement Techniques, 12, 3595-3627, doi:10.5194/amt-12-3595-2019.

Pistone , K., J. Redemann, S. Doherty, P. Zuidema, S. Burton, B. Cairns, S. Cochrane, R. Ferrare, C. Flynn, S. Freitag, S. G. Howell, M. Kacenelenbogen, S. LeBlanc, X. Liu, K.S. Schmidt, A.J. Sedlacek III, M. Segal-Rozenhaimer, Y. Shinozuka, S. Stamnes, B. van Diedenhoven, G. Van Harten, and F. Xu. 2019. Intercomparison of biomass burning aerosol optical properties from in-situ and remote-sensing instruments in ORACLES-2016, Atmos. Chem. Phys., 19, 9181-9208, doi:10.5194/acp-19-9181-2019.

Cochrane, S. P., K.S. Schmidt, H. Chen, P. Pilewskie, S. Kittelman, J. Redemann, S. LeBlanc, K. Pistone, M. Kacenelenbogen, M. Segal Rozenhaimer, Y. Shinozuka, C. Flynn, S. Platnick, K. Meyer, R. Ferrare, S. Burton, C. Hostetler, S. Howell, S. Freitag, A. Dobracki, and S. Doherty. 2019. Above-cloud aerosol radiative effects

based on ORACLES 2016 and ORACLES 2017 aircraft experiments, Atmos. Meas. Tech., 12, 6505–6528, https://doi.org/10.5194/amt-12-6505-2019.

Daniel, J. M., M. Segal-Rozenhaimer, K. Knobelspiesse, J. Redemann, B. Cairns, M. Alexandrov, B. van Diedenhoven, and A. Wasilewski. 2019. Low-level liquid cloud properties during ORACLES retrieved using airborne polarimetric measurements and a neural network algorithm, Atmos. Meas. Tech. Discuss., https://doi.org/10.5194/amt-2019-327.

LeBlanc, S.E., J. Redemann, C. Flynn, K. Pistone, M. Kacenelenbogen, M. Segal- Rosenheimer, Y. Shinozuka, S. Dunagan, R.P. Dahlgren, K. Meyer, J. Podolske, S.G. Howell, S. Freitag, J. Small-Griswold, B. Holben, M. Diamond, P. Formenti, S. Piketh, G. Maggs-Kölling, M. Gerber, and A. Namwoonde. 2019. Above Cloud Aerosol Optical Depth from airborne observations in the South-East Atlantic, Atmos. Chem. Phys. Discuss. , https://doi.org/10.5194/acp-2019-43, in review.

Shinozuka, Y., P. Saide, G. Ferrada, S. Burton, R. Ferrare, S. Doherty, K. Longo, M. Mallet, H. Gordon, Y. Feng, D. Noone, A. Dobracki, S. Freitag, S. Howell, S. LeBlanc, C. Flynn, M. Segal-Rosenhaimer, K. Pistone, J. Podolske, E. Stith, J. R. Bennett, G. Carmichael, A. da Silva, R. Govindaraju, R. Leung, Y. Zhang, L. Pfister, J.-M. Ryoo, J. Redemann, R. Wood, and P. Zuidema. 2019. ORACLES model inter comparison, https://doi.org/10.5194/acp-2019-678

Shinozuka et al. 2019. Aerosol optical depth above low-level clouds is similar to that in adjacent clear skies at the same height: airborne observation above the southeast Atlantic, Atmos. Chem. Phys. Discuss. Submitted.

LeBlanc, S. E., J. Redemann, M. Segal-Rosenheimer, C. Flynn, M. Kacenelenbogen, K. Pistone, K. Sebastian Schmidt, H. Chen, and S. Cochrane. 2019. Quantifying Cloud Radiative Effects with Overlying Aerosol using Hyperspectral Transmitted Light, Optical Sensors and Sensing Congress (ES, FTS, HISE, Sensors), OSA Technical Digest (Optical Society of America), paper HW5C.3, doi: 10.1364/HISE.2019.HW5C.3.

Presentations

Pistone, K. 2019. When there are different types of smoke in the sky it changes how the sun light goes through the sky? (Talk: Up-Goer Five Science Communication Challenge session), AGU Fall Meeting, Dec. 9-13, San Francisco, CA.

LeBlanc, S., et al. 2019. Aerosol above cloud, optical depth, and direct radiative effect in the southeast Atlantic, Session A11N: Cloud-aerosol-radiation-climate interactions in the southeast Atlantic II Posters, AGU Fall Meeting, Dec. 9-13, San Francisco, CA.

Pistone, K., et al. 2018. Aerosol optical properties from 4STAR sky scans, 2016-2018. Talk: ORACLES Science Team Meeting, May 14-15, Miami, FL.

LeBlanc, S., et al. 2019. Above cloud AOD changes between 2016, 2017, and 2018, ORACLES Science Team Meeting, May 14-15, Miami, FL.

Pistone, K., et al. 2019. Intercomparison of biomass burning aerosol properties from in-situ and remote-sensing instruments in ORACLES-2016. Talk: European Geophysical Union General Assembly, April 7-12, Vienna, Austria.

LeBlanc S., et al. 2019. Airborne Observations Above Cloud Aerosol Optical Depth in the Southeast Atlantic during biomass burning seasons over 3 years. Session AS1.41: Aerosols, radiation and clouds over the southeast Atlantic, European Geophysical Union General Assembly, April 7-12, Vienna, Austria.

LeBlanc, S., et al. 2019. Quantifying Cloud Radiative Effects with Overlying Aerosol using Hyperspectral Transmitted Light, Hyperspectral Imaging and Sensing of the Environment, paper HW5C.3, June 25-27, San Jose, CA.
Presentations (selected 4STAR co-authored)

Cochrane, S. P., et al. 2019. The Dependence of Direct Aerosol Radiative Effects on the Underlying Albedo and Aerosol Properties: Results from the 2016 and 2017 ORACLES Field Campaigns (oral presentation), AGU Fall Meeting, Dec. 9-13, San Francisco, CA.

Cochrane, S.P., et al. 2019. Aerosol Radiative Effects Above Clouds Derived from ORACLES Measurements (oral presentation), NASA ORACLES Science Team Meeting, May 14-15, Miami, FL.

Chang, I., et al. 2019. Observational and model inter-comparisons of aerosol and cloud properties during NASA ORACLES (poster presentation), AGU Fall Meeting, Dec. 9-13, San Francisco, CA.

Chang, I., et al. 2019. Observation and model intercomparisons of aerosol and cloud properties during the NASA ORACLES field campaign (poster presentation), Gordon Research Conference: Bioorganic Chemistry, June 9-14, Bates College, Lewiston, ME.
Chang, I., et al. 2019. Satellite retrieval and aircraft validation of above-cloud biomass burning aerosols and cloud properties in the southeast Atlantic (oral presentation). Progress in Electromagnetics Research Symposium, June 17-20, Rome, Italy.

Chang, I., et al. 2019. Observation-model intercomparisons of aerosol properties (oral presentation), NASA ORACLES Science Team Meeting, May 14-15, Miami, FL.

Chang, I., et al. 2019. Aircraft, satellite, and model intercomparisons of aerosol and cloud properties during NASA ORACLES (poster presentation), European Geosciences Union General Assembly, April 7-12, Vienna, Austria.

Part Three:- *NAAMES (North Atlantic Aerosols and Marine Ecosystems Study)*

Project Participants

BAERI: Kristina Pistone, Samuel LeBlanc

Project Description

The North Atlantic Aerosols and Marine Ecosystems Study (NAAMES) is an interdisciplinary Earth Venture Suborbital campaign consisting of 4 deployments of ship-based and aircraft-based instrumentation, in October-November 2015, April 2016, August-September 2017, and March-April 2018. The goal of this campaign was to resolve key processes controlling ocean system function, their influences on atmospheric aerosols and clouds, and their implications for climate. The NAAMES observations, targeted during different seasons with different ocean ecosystem characteristics, will enable improved predictive capabilities of Earth system processes and will inform ocean management and assessment of ecosystem change. These observations are critical to resolving the key processes controlling marine ecosystems and aerosols that are essential to our understanding of Earth system function and future change.

We participated with the 4STAR instrument in the first phase, AATS-14 in the second, and the 4STAR-B in the final two, although the fourth NAAMES aircraft deployment (March-April 2018) was scrubbed after the outbound transit flight due to multiple mechanical failures of the C-130 aircraft. The Aerosol Optical Depth (AOD) flight data of the participating instruments of all deployments have been delivered to the NAAMES-3 archive, along with below-cloud zenith mode radiances for 4STAR and 4STAR-B at applicable flight times.

Accomplishments

- Prepared for archival below-cloud zenith-mode radiances from the 4STAR and 4STAR-B deployments;
- Incorporated 4STAR data into the analysis of other teams, specifically the Research Scanning Polarimeter (RSP) and the Geostationary Coastal and Air Pollution Events Airborne Simulator (GCAS), to correct for atmospheric aerosol and cirrus cloud effects in their retrievals
- Attended (K. Pistone) the NAAMES Science Team Meeting in June 2019 to further collaboration and promote the use of our data to ship- and aircraft-based research teams; and
- Received NASA Group Achievement Award (externally nominated by NASA Langley).

Presentations

- Pistone, K., S. LeBlanc, R. Johnson, Y. Shinozuka, and J. Redemann. 2019. Spectral distinction of aerosol loading versus cloud from airborne sun photometry, NAAMES Science Team Meeting, NASA Langley Research Center, June 17-19, Hampton, VA.

Part Four: *-KORUS-AQ (Korea-US Air Quality)*

Project Participants

BAERI: Michal Segal-Rozenhaimer, Samuel LeBlanc, Kristina Pistone
USRA: Stephen Broccardo

Project Description

The KORUS-AQ campaign took place in April-June 2016 in South Korea. Science goals of the campaign were focused on the local Korean air quality issues, in terms of survey monitoring (i.e. repeated flight patterns in Seoul), source characterization (urban outflow, power plants), and the effect of long-range transport that interacts with the local pollution. An additional goal was to explore how very high pollution of aerosols and gases might affect total column retrievals of Aerosol Optical Depth (AOD) and trace gases from space.

4STAR was selected to fly on this campaign as tier 1 instrument and supplied total AOD, columnar water vapor, O3 and NO2 amounts under various conditions. Ongoing analysis has been supported through NASA's internal science funding structure as part of the tropospheric composition program (TCP). As part of the ongoing KORUS-AQ analysis, 2 tasks have been outlined: assessment of OMI retrievals of NO2 within regions of high aerosol loading; and aerosol optical depth characterization and source attribution in the Korean peninsula.

Accomplishments

- Supported install of Pandora instrument at NASA Ames and deepened links to Pandora community;
- Continued analysis on Aerosol Optical Depth and source attribution in the Korean Peninsula during KORUS-AQ (LeBlanc);
- Worked on preparing paper comparing OMI NO2 retrievals to 4STAR column gas retrievals (Segal-Rozenhaimer), in collaboration with NASA Post-doctoral Program Fellow, Stephen Broccardo; and
- Collaborated on paper: "Spatial and Temporal Variations of Aerosol Optical Properties during KORUS-AQ" (external lead: Yongjoo Choi)

Part Five: *National Research Council – Canadian Oil Sands Region (NRC-COSR)*

Project Participants

BAERI: Samuel LeBlanc, Kristina Pistone

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 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.

Ongoing Work:

- Publication in preparation: Baibakov et al., "Aerosol Optical Depth in the Oil Sand region, climatology and airborne observations" In preparation.
- Quantification of Direct Aerosol Radiative Effect from the Oil sand mining and processing.

Presentations

Baibakov, K., S. LeBlanc, K. Molani, K. Pistone, M. Wolde, C. Flynn, J. Redemann, and R. Johnson. 2019. 4STAR hyperspectral sunphotometry measurements during the Oil Sands 2018 campaign near Fort McMurray, Alberta. NRC-CNRC Aerospace Portfolio Internal reports, LTR-FRL-2018-0116, Ottawa, July 2019.

Baibakov, K., et al. 2019. 4STAR AOD during Oils Sands campaign, Environment and Climate Change Canada symposium, Toronto, Ontario, Canada, July 2018.

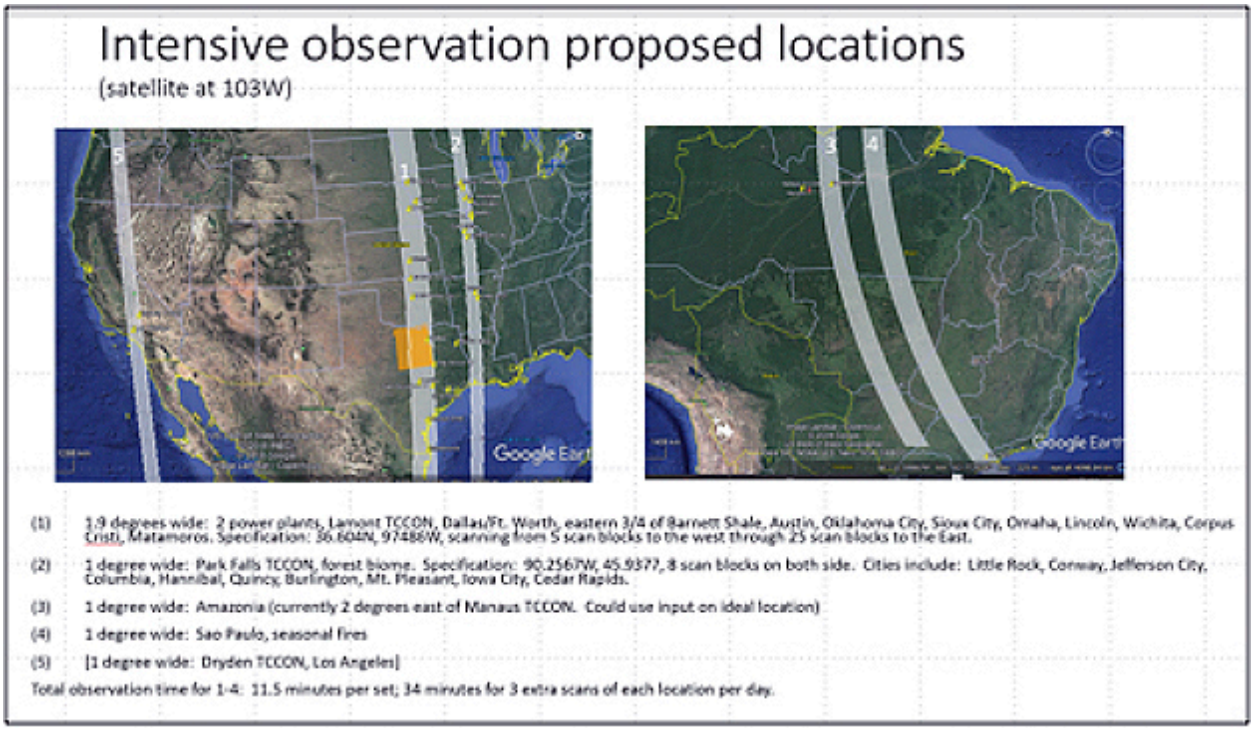
GeoCarb

Project Participants

NASA: Berrien Moore, PI
BAERI: Susan Kulawik

Project Description

GeoCarb, an Earth Venture Class mission, will significantly advance our understanding of the global carbon cycle by mapping concentrations of key carbon gases from geostationary orbit. The mission, launching in 2022, will measure carbon cycle constituents, carbon dioxide, carbon monoxide, methane to answer key questions about the carbon cycle. In addition to the above trace gases, the satellite will observe Solar Induced Fluorescence (SIF), an important metric of plant health.



GeoCarb Intensive Scans 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

Finalized the GeoCarb Validation plan and participated in GeoCarb telecons and meetings.

Presentations

Kulawik, S. 2019. GeoCarb Intensive Scans, GeoCarb breakout meeting. 15th International Workshop on Greenhouse Gas Measurements from Space, June 3-5, Sapporo, Japan.

Kulawik, S. 2019. Intensive Scans over Dallas, GeoCarb breakout meeting, U.S. Climate and Variability and Predictability, Oct. 1-3, Boulder, CO.

Modeling Methane Emissions from Natural Wetlands, Lakes, and Reservoirs

Project Participants

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

Project Description

Wetlands, lakes, and reservoirs (WLR) are the largest natural sources of the world's methane (CH4) emissions contributing ~30% of annual emissions. Wetlands are the dominant focus of studies of CH_4 emission from natural sources; lakes have received much less study and no spatially-explicit studies of CH_4 emission from reservoirs exists. These sources are of critical importance because their emissions respond to interannual and longer-term climate variability, and the direction of their responses to climate change is unknown. The many wetland-modeling studies published to date reveal substantial differences in magnitude, seasonality and distribution of emissions that hamper robust understanding of the role of wetlands (lakes and reservoirs) in atmospheric CH_4 variations and the overall carbon cycle. A primary contributor to divergent wetland-model emissions is differences in wetland representation. All but a few models define wetlands (or methane-producing areas using surface inundation data that 1) include, but do not distinguish among, flooded wetlands, lakes, reservoirs, rivers, irrigated rice, and other unidentified aquatic features and 2) fail to capture non-flooded wetlands which account for ~80% of the total. In contrast to the widespread use of one inundation data set for wetland studies, lake data used in methane studies reveal substantial differences in area, abundance and size of lakes, especially for small lakes with the highest fluxes per unit area. No spatially-explicit data on reservoir types, or modeling studies of their emissions, exists at all. Lastly, in situ measurements confirm that CH_4 fluxes vary with wetland, lake and reservoir types but very few methane models explicitly consider relevant types.

Accomplishments

Nearly finalized global foundational data sets of natural wetlands, of lakes and of reservoirs. They are unique in that they are mutually exclusive allowing, for the first time, for independent estimates of methane emission from these sources.

Presentations

Genovese, V., E. Matthews, and M. Johnson. 2019. New Global Datasets for Methane Modeling: Natural Wetlands, Lakes, and Reservoirs, AGU Fall Meeting, Dec. 9-13, San Francisco, CA.

Matthews, E., M. Johnson, V. Genovese, and C. C. Treat. 2019. Methane from high-latitude wetlands, lakes and reservoirs: Mutually-exclusive source data and emissions, AGU Fall Meeting, Dec. 9-13, San Francisco, CA.

NASA Earth Exchange (NEX)

Project Participants

NASA: Rama Nemani, Jennifer Dungan, Ved Chirayath, Piyush Mehrotra, Cameron Houser
BAERI: Sangram Ganguly (resigned 2019), Andrew Michaelis, Alan Li, Shuang Li (resigned 2019), Jun Xiong (resigned 2019), Thomas Vandal, Wen Yip
CSUMB: Alberto Guzman, Hirofumi Hashimoto, Forrest Melton, Weile Wang

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 collaborate with scientists in NASA Ames Earth Science Division, as well as 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. Natural disasters, such as wildfires, and emerging public health threats are also supported. Additional, 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 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 development, maintenance, and administration of the OpenNEX platform ongoing. The website can be found at https://www.opennex.org.

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, GOES17. Research from this activity not only derives more value from the current operational GeoStationary platforms, it also feeds into NASA long-term goals supporting new geostationary platforms due to launch in the coming years.

Accomplishments

- Our team published 6 peer review publications in 2019, with additional publications in preparation.
- GeoNEX Activity:
  - Organized a Special Issue with the peer-reviewed journal Remote Sensing on the theme of Geostationary Earth Monitoring;
  - Organized a session on Geostationary Earth Remote Sensing at the AGU2019 Fall Meeting;
  - Prepared top of Atmosphere (TOA) Reflectance Product (Version 2): Himawari-8 AHI (2016/01-2019/08), GOES-16 ABI (2018/01 - 2019/08), GOES-17 ABI (2019/01 – 2019/09);
  - Produced Surface Reflectance Product with customized MAIAC algorithm (provisional): Himawari-8 AHI (2016/01-2019/08) and GOES-16 ABI (2018/01 - 2019/08);
  - Compared AHI TOA with corresponding MODIS products with the ray-matching method;
  - Built and maintained NASA MAIAC software package for atmospheric correction and the production of AOT and SR data;
  - Evaluated Atmospheric Optical Thickness Surface Reflectances Product;
  - Worked on Leaf Area Index (LAI) and Fraction of Absorbed Photosynthetically Active Radiation (FPAR) with Machine Learning algorithms (collaborating with Boston University team)
  - Collaborated on development of Phenology Product with South Dakota State University;
  - Collaborated with University of Montana team on development of Gross/Net Primary Production (GPP/NPP) products;
  - Built prototype processing pipeline on AWS to generate the near-realtime ABI fire products with a time latency less than 5 minutes (collaborating with NOAA team)
  - Collaborated with JAXA scientists on generating Surface Incoming Solar Radiation Product;
  - Built the GeoNEX website (https://www.nasa.gov/geonex) for community engagement; and
  - Deployed initial version of the GeoNEX data products (https://data.nas.nasa.gov/geonex/data.php/).
- Collaborating on NASA CMAC projects:
  - Climate Model Diagnostic Analyzer Services on NASA Earth Exchange Platform (JPL)
  - Multi-Resolution Investigation of Climate Model using NASA's High-End Computing

Resources: A Parallel Version of Regional Climate Model Evaluation System Enhanced by HEALPix

- (Open)NEX Development and maintenance:
  - Developed collaborative tools (MATA) for management and discovery of science data and workflow components both internal and external to NEX;
  - Produced 8 new lectures and labs for the OpenNEX YouTube Channel; and
  - Present NEX at science meetings and workshops to engage the stakeholder community.
- Data management:
  - Acquired 300 additional terabytes of Landsat Collection 1 data for the WELD project;
  - Acquired 150 additional terabytes of MODIS and MAIAC data for GeoNEX activity; and
  - Acquired additional GOES16, GOES17 and Himawari 8 datasets to enable the GeoNEX activity

Publications

Chen, Y., K. Sun, C. Chen, T. Bai, T. Park, W. Wang, R. Nemani, and R. Myneni. 2019. Generation and evaluation of LAI and FPAR products from Himawari-8 Advanced Himawari Imager (AHI) data. Remote Sensing, 11 (3) https://doi.org/10.3390/rs11131517.

Hayatbini, N., B. Kong, K.-L. Hsu, P. Nguyen, S. Sorooshian, G. Stephens, C. Fowlkes, R. Nemani, and S. Ganguly. 2019. Conditional generative adversarial networks (cGANs) for near real-time precipitation estimation from multispectral GOES-16 satellite imagries — PERSIANN-cGAN. Remote Sensing, 11 (19), https://doi.org/10.3390/rs11192193.

Li, S., W. Wang, H. Hashimoto, J. Xiong, T. Vandal, J. Yao, L. Qian, K. Ichii, A. Lyapustin, Y. Wang, and R. Nemani. 2019. First provisional land surface reflectance product from geostationary satellite Himawari-8 AHI. Remote Sensing (in press).

She, L., H. Zhang, W. Wang, and Y. Wang (2019). Evaluation of the Multi-angle Implementation of Atmospheric Correction (MAIAC) aerosol algorithm for Himawari-8 data. Remote Sensing (in press).
Hashimoto, H., R. Nemani, G. Bala, L. Cao, A. Michaelis, S. Ganguly, et al. 2019. Constraints to Vegetation Growth Reduced by Region-Specific Changes in Seasonal Climate. Climate, 7 (2): 27.

Hashimoto, H., W. Wang, F. Melton, A. Moreno, S. Ganguly, A. Michaelis, and R. Nemani. 2019. High-resolution mapping of daily climate variables by aggregating multiple spatial data sets with the random forest algorithm over the conterminous United States. International Journal of Climatology, 39 (6): 2964–2983. https://doi.org/10.1002/joc.5995

Hashimoto, H., R. Nemani, G. Bala, L. Cao, A. Michaelis, S. Ganguly, et al. 2019. Constraints to Vegetation Growth Reduced by Region-Specific Changes in Seasonal Climate. Climate, 7(2), 27.
Chen, Y., K. Sun, C. Chen, T. Bai, T. Park, W. Wang, R. Nemani, and R. Myneni. 2019. Generation and evaluation of LAI and FPAR products from Himawari-8 Advanced Himawari Imager (AHI) data. Remote Sensing, 11 (3). https://doi.org/10.3390/rs11131517.

Hayatbini, N., B. Kong, K.-L. Hsu, P. Nguyen, S. Sorooshian, G. Stephens, C. Fowlkes, R. Nemani, and S. Ganguly. 2019. Conditional generative adversarial networks (cGANs) for near real-time precipitation estimation from multispectral GOES-16 satellite imagries — PERSIANN-cGAN. Remote Sensing, 11 (19). https://doi.org/10.3390/rs11192193.

Li, S., W. Wang, H. Hashimoto, J. Xiong, T. Vandal, J. Yao, L. Qian, K. Ichii, A. Lyapustin, Y. Wang, and R. Nemani. 2019. First provisional land surface reflectance product from geostationary satellite Himawari-8 AHI. Remote Sensing (in press).

She, L., H. Zhang, W. Wang, and Y. Wang. 2019. Evaluation of the Multi-angle Implementation of Atmospheric Correction (MAIAC) aerosol algorithm for Himawari-8 data. Remote Sensing (in press).

Presentations

Park, T., R.B. Myneni, and Y. Knyazikhin. 2019. Disturbance, cultivation, and climate drive a widespread North American vegetation greening. AGU Fall Meeting, Dec. 9-13, San Francisco, CA.

Chen, C., T. Park, X. Wang, S. Piao, B. Xu, R.K. Chaturvedi, R. Fuchs, V. Brovkin, P. Ciais, R. Fensholt, and H.A. Tømmervik. 2019. Greening of global lands from twenty-year satellite observation. AGU Fall Meeting, Dec. 9-13, San Francisco, CA.

Chen, Y., K. Sun, C. Chen, T. Park, W. Wang, R. Nemani, and R. Myneni. 2019. Generating LAI and FPAR Products from GOES-16 Advanced Baseline Imager (ABI) Data. AGU Fall Meeting, Dec. 9-13, San Francisco, CA.

Poulter, B., S. Serbin, and W. Wang. 2019. The SBG modeling working group report, SBG Community Workshop, June 12-14, Washington DC.

Hirofumi, H., W. Weile, J. Dungan, S. Li, J. Xiong, A. Guzman, H. Takenaka, A. Higuchi, R. Myeni, and R. Nemani. 2019. GOES ABI high frequency data for understanding Amazon vegetation dynamics, AGU Fall Meeting, Dec. 9-13, San Francisco, CA.

Wang, W., R. Nemani, J. Xiong, S. Li, S. Ganguly, A. Lyapustin, Y. Wang, P. Meyer, S. Kalluri, and G. Stark. 2019. Near real-time fire dection on OpenNEX with Geostationary data, LANCE UWG Meeting. April 17, Boulder, CO.

Weile, W., S. Li, H. Hirofumi, T. Hideaki, J. Dungan, K. Satya, and R Nemani. 2019. Generating Accurate and Consistent Top-of-Atmosphere Reflectance Products from the New Generation Geostationary Satellite Sensors, AGU Fall Meeting, Dec. 9-13, San Francisco, CA.

Vandal, T., S. Li, W. Wang, and R. Nemani. 2019. Transfer Learning to Generate True Color Images from GOES-16, AGU Fall Meeting, Dec. 9-13, San Francisco, CA.

Jun, X., Y. Jiang, A. Michaelis, S. Malek, W. Wong, S. Kalluri, J. Zhang, J. Dunagan, and R. Nemani. 2019. GeoNEX: A Cloud Gateway for Near Real-time Processing of Geostationary Satellite Products, AGU Fall Meeting, Dec. 9-13, San Francisco, CA.

Shuang, L., W. Weile, H. Hirofumi, T. Vandal, Y. Jing, and R. Nemani. 2019. Surface Reflectance Product from Geostationary Satellite, AGU Fall Meeting, Dec. 9-13, San Francisco, CA.

Wang, W., R. Nemani, J. Xiong, S. Li, S. Ganguly, A. Lyapustin, Y. Wang, P. Meyer, S. Kalluri, and G. Stark. 2019. Near real-time fire dection on OpenNEX with Geostationary data. April 17, Boulder, LANCE UWG Meeting.

Poulter, B., S. Serbin, and W. Wang. 2019. The SBG modeling working group report. SBG Community Workshop, June 13, Washington D.C.

Panel or Committees

- Wang, Co-lead on the Modeling Working Group of NASA Surface Biology & Geology (SBG) Study.
- W. Wang, Guest Editor for MDPI Remote Sensing Journal, Special Issue on "Land Monitoring from A New Generation of Geostationary Satellites".
- W. Wang, Convenor of session on “Remote Sensing of Land, Ocean and Atmosphere from the New Generation fo Geostationary Satellites” at AGU 2019 Fall Meeting

Awards

NASA’s agency wide Group Achievement Award for the GeoNEX Team: “For innovative reuse of NASA’s terrestrial Earth Observing System algorithms for imagery and data from new geostationary satellite sensors to extend long-term Earth monitoring.” Signed by NASA Administrator Jim Bridenstine.

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 opensource 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. www.nemonet.info

Version1 (Michal Segal Rozenhaimer): Presently, NeMO-Net exploits active learning and data fusion of mmscale remotely sensed 3D images of coral reefs captured using high resolution imaging systems from the NASA Laboratory of Advanced Sensing (LAS) and lower-resolution remote sensing from commercial and governmental satellite data to determine coral reef ecosystem coverage and vitality. The project utilizes machine learning methods that apply image processing algorithms to determine the marine habitat classes, including corals, sand, seagrass etc..

Version 2 (Juan L. Torres-Perez): The Neural Network for Global Coral Reef Assessment (NeMO-Net) aims at developing accurate algorithms for the identification of coral reef organisms at different taxonomical levels using remotely-sensed data. As part of the project, a citizen science tool was developed for classification of reef benthic scenes using 2D and 3D data in an iPad application.

Accomplishments

(Juan L. Torres-Perez):

- Completed successful field campaigns in Puerto Rico and Guam;
- Released the beta version of the NeMO-Net app for iPads and iPhones;
- Invited to attend multiple conferences/meetings to present the project findings;
- Conducted a seagrass workshop at NASA Ames to discuss ideas on how to integrate seagrass data into the tool;
- Completed a field guide for reef benthic components identification which will be incorporated into the final version of the NeMO-Net app;
- Completed multiple reef characterizations using the beta version of the NeMO-Net app; and

- Worked on several manuscripts to be submitted for publication in early 2020.

Publications

Segal-Rozenhaimer, M., A. Li, K. Das, and V. Chirayath. 2019. Cloud detection algorithm for multi-modal satellite imagery using convolutional neural-networks (CNN),Remote Sensing of Environment, 237, 2020, 111446, ISSN 0034-4257, https://doi.org/10.1016/j.rse.2019.111446.

Presentations

Chirayath, V., J.L. Torres-Perez, A. Li, M. Segal-Rozenhaimer, K. Das, and J. Van Den Bergh. 2019. NeMO-Net: The fluid lending neural network for global coral reef assessment. Presented at 41st USCRTF meeting, Sept. 9-13, Koror, Republic of Palau.

Chirayath V, J.L. Torres-Perez, A. Li, M. Segal-Rozenhaimer, K. Das, and J. Van Den Bergh. 2019. NeMO-Net: The fluid lensing neural network for global coral reef assessment. Presented at the NASA Biodiversity and Ecological Forecasting Meeting, May 21-23, Washington, D.C.

Li., A., V. Chirayath, J. van den Bergh, K. Das, M. Segal Rozenhaimer, and J.L. Torres-Perez. 2019. MeMO-Net: The Neural Multi-Modal Observation and Training Network for Global Coral Reff Assesment (B13A-08), AGU Fall Meeting, Dec. 9-13, San Francisco, CA.

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 Ph.D. 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.

Awards

2019 Ames Honor Award: NASA NeMO-Net Field Campaign Team, Nov. 7, 2019.

NeMO-Net team members receiving Group Achievement Award. (Left-Right: Carol Caroll, Ames Deputy Center Director, Ved Chirayath, Jarrett van den Burgh, Jonas Jonsson, Juan Torres-Perez, and Eugene Tu, Ames Center Director.

Pertinent Information: NeMO-Net will go into a no-cost extension until March 2020. A follow-up proposal (NeMO-Cast) was submitted to the 2019 AIST call but was rejected despite having very good feedback/ comments from the reviewers. We will look for additional opportunities to re-submit an improved version of the proposal based on the reviewers' comments.

ObseRvations of Aerosols above CLouds and their intEractionS (ORACLES)

Project Participants

Kirk Knobelspiesse
BAERI: Michal Segal-Rozenhaimer

Project Description

We are developing a neural network (NN) based algorithm for the retrieval of liquid low-level marine stratocumulus cloud microphysical property parameters (cloud optical depth, cloud droplet size effective radius and variance) from airborne multi-angle polarimetric measurements. Additionally, we are developing a combined algorithm for getting both aerosol (Aerosol optical depth) with cloud properties for aerosols above clouds scenes.

Accomplishments

- Completed the development and processing of the cloud retrieval algorithm. One paper was published in 2018, describing the method, and the second paper, published in 2019 (see above) discusses the improvement of the initial cloud algorithm and provides an overview of another dataset that was analyzed.
- Archived all of ORACLES 2016-17-18 cloud retrieval data. We started working on the aerosol above cloud algorithm and presented our initial results in the polarimetry conference APOLO, in November 2019.

Publications

Miller, D.J., M. Segal-Rozenhaimer, K. Knobelspiesse, J. Redemann, B. Cairns, M. Alexandrov, B. van Diedenhoven, and A. Wasilewski. 2019. Low-level liquid cloud properties during ORACLES retrieved using airborne polarimetric measurements and a neural network algorithm, Atmos. Meas. Tech. Discuss., https://doi.org/10.5194/amt-2019-327 (in review).

Presentations

Knobelspiesse, K.D., D. J. Miller, M. Segal Rozenhaimer, B. Cairns, and M. Alexandrove. 2019. ORACLES field campaign observations of clouds and aero-sols above cloud by the Research Scanning Polarimeter, APOLO 2019 conference, Nov. 4-7, Lille, France.

Orbiting Carbon Observatory-2 Errors/Profiles (OCO-2 E/OCO-2 P)

Project Participants

NOAA: Sourish Basu PI
BAERI: Susan Kulawik

Project Description

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). Vertically resolved carbon dioxide is likely to reduce the effect of model transport error, a large contributor of error during assimilation of satellite data. This project continues a previous ROSES proposal to develop vertically resolved CO2 from the GOSAT instrument. The 2017 decadal survey described how vertically resolved CO2 can be useful for finer resolution of carbon dioxide fluxes: "Day-to-day variability in XCO2 is strongly influenced by synoptic weather patterns, obscuring signatures of surface fluxes. Kulawik et al. (2016) have recently developed a method for separately estimating lower- and upper-tropospheric partial column CO2 with GOSAT data, and comparisons with aircraft measurements demonstrate the potential for this approach." (https://essp.nasa.gov/essp/files/2018/02/2017-Earth-Science-Decadal-Survey.pdf). The current project utilizes the previously developed on-line bias correction and an initial study to determine the vertical quantity least sensitive to model transport error, then will develop and assimilate the new vertical quantity.

Accomplishments

- Presented at the fall AGU, 2019, a comparison of 5 different models to evaluate model transport error and select the optimal vertical quantity that minimizes model transport error;
- Developed preliminary lowermost tropospheric OCO-2 product following the method of Kulawik et al. (2017). The entire OCO-2 record for lowermost troposphere OCO-2 is archived on Zenodo (https://zenodo.org/record/3568428#.XfuvutVKg2w).
- Worked with the OCO-2 project to link to the preliminary lowermost tropospheric OCO-2 product from co2.jpl.nasa.gov; and
- Published validation results in Kulawik et al. (2019) in review in the AMTD journal.

Publications

Kulawik, S., S. Crowell, D. Baker, J. Liu, K. McKain, et al. 2019. Characterization of OCO-2 and ACOS-GOSAT biases and errors for CO2 flux estimates, Atmospheric Measurement Techniques Discussions, https://doi.org/10.5194/amt-2019-257, in review, 2019.

Presentations

Basu, S., F. Chevallier, J. Liu, P. Kumar Patra, S. S. Kulawik, and D. Baker. 2019. Is there an Optimal CO2 Partial Column for Flux Inversions? AGU Fall Meeting, Dec. 9-13, San Francisco, CA.

Iraci, L.T., E.L. Yates, C. Parworth, A. Kuze, N. Kikuchi, F. Kataoka, K. Shiomi, H. Suto, S. Kulawik, and S. Basu. 2019. Vertical Profiles of Greenhouse Gases Collected over Land and Water in the Western US in Support of Partial Column Validation Efforts, AGU Fall Meeting, Dec. 9-14, San Francisco, CA.

Basu, S., and S. Kulawik. 2019. Vertically resolved OCO-2, OCO-2 Science Team Meeting, Oct. 28, Boulder, CO.

U.S. Coral Reef Task Force (USCRTF)

Project Participants

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

Project Description

Torres-Perez is a coral reef biologist interested in understanding the effects of humans on the health and resilience of reefs, particularly those in the Caribbean. As a member and one of the NASA representatives in the US Coral Reef Task Force (CRTF), he continues to participate in monthly coordination calls of the CRTF Steering Committee, Watershed Partnership Initiative, and the Climate Change Working Group. He has also participated in the CRTF's two annual meetings.

Accomplishments

- Participated in monthly conference calls of the CRTF Steering Committee, Watershed Partnership Initiative, and the Climate Change Working Group;
- Attended the CRTF's two annual meetings; and
- Provided input on aspects related to the ecology and biology of coral reef ecosystems on a global and local scales.

Presentations

Hernandez, W., J.L. Torres-Perez, R. Armstrong, O. Lopez, and R. Viqueira. 2019. Combination of very high resolution (VHR) satellite and drone imagery for benthic habitat mapping: A case study for Guánica, Manatí and Vega Baja in Puerto Rico. Presented at 41st USCRTF meeting, April 1-4, 2019, Washington, D.C.

Worsham, M., Collin, E. Davis, A. Markarian, and J.L. Torres-Perez. 2019. Evaluating the impacts of land cover and water quality changes in American Samoa to improve watershed management. Presented at 41st USCRTF meeting, Sept. 9-13, Koror, Republic of Palau.

Chirayath, V., J.L. Torres-Perez, A. Li, M. Segal-Rozenhaimer, K. Das, and J. Van Den Bergh. 2019. NeMO-Net: The fluid lending neural network for global coral reef assessment. Presented at 41st USCRTF meeting, Sept. 9-13, Koror, Republic of Palau.

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, Robert Dahlgren

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). The description of the two major components of the Disaster Task are presented below:

Disaster Element Task 1 (Ambrosia)

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.

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 workshop with regional coordinators from the region (Mediterranean) with a focus on dynamic land/biosphere changes common to the area.

Disaster Element Task 2 (Dahlgren)

Airborne systems (UAS for Environmental and Disaster Monitoring and Science Support)

The task objective is to lowering the cost of remote sensing using small unmanned aerial systems (UAS) as low-altitude platforms to host payloads such as sensing instruments. This work includes the integration of payloads that often require significant effort for electrical, aerodynamic, electromagnetic, structural, and system engineering development. Some of the applications of these aircraft will be volcanic plume observation, magnetometer surveys, wildlife census, and emergency response. Mapping applications include the study of marsh erosion, post-wildfire recovery, inundation, landslide hazard, mudflat, geological surveys, and other data collection campaigns. This includes development and construction of specific instruments

such as sun photometer, sun glint sensor, and polarization-based optical sensors. We provide electrical engineer support for payload integration onto the SIERRA-B aircraft at the NASA Ames Research Center noted for excellence in optical sensor physics, gyroscopes/accelerometers, lasers, and electromagnetic testing. We research ice accretion on UAS vehicles, wing sections, and sensors at the NASA Glenn Research Center's Icing Research Tunnel (IRT). Some of the applications of this work will be better models to simulate ice accretion at the low airspeeds that small UAS typically fly, improved knowledge where to apply de-icing strategies.

Accomplishments

Disaster Element Task 1 (Ambrosia)

- Managed the NASA ROSES16 A.50-Group on Earth Observations (GEO) Work Programme; 3.8 Global Wildfire Information System (GWIS) projects, including writing the solicitation, organizing and leading the panel review selection, and serving as manager of the GWIS program projects (3) in that solicitation for 2018 through 2022; Management includes development of project progress metrics, organizing and participating in workshops and trainings census, and emergency response. Mapping applications include the study of marsh erosion, post-wildfire recovery, inundation, landslide hazard, mudflat, geological surveys, and other data collection campaigns.
- Workshop and scientific meeting development in 2018 in support of the NASA Applied Science Program- Wildfire Program. These workshops and meetings 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.
- Managed the start of the Mediterranean Regional Information Network (MedRIN) of the NASA LC-LUC Program (HQ PM: G. Gutman) to develop collaborations of nations in eastern Mediterranean region with NASA Earth Sciences Program; Work with two European MedRIN Chairs to facilitate collaborative science, organize regional workshops that enhance the use of NASA Earth Observation data for land change dynamics.
- Supported the development of the Gordon and Betty Moore Foundation “Workshop on Fire Immediate Response System”, and assisted in editing the white paper findings document; April 24-26, 2019;
- 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 of programmatic goals and metrics of the Wildfire Program during quarterly ASP Programmatic Reviews.
- Sit on Technical and Scientific Panel of international remote sensing conferences, including the ISRSE 2019 meetings, and the RSCy2019 and 2020 meetings.
- Program Organizer Committee of RSCY2019 & 2020;
- Guest Editor duties of two e-journal remote sensing periodicals;
- Chair of the Remote Sensing Data Enhancement session, in the 3rd International Electronic Conference on Remote Sensing, May 22 – June 5, 2019;
- Session Chair of “Earth Observations for Disaster Assessment and Response” Pecora 21 / ISRSE 38, Baltimore, MD, 8 October 2019.
- Sit on numerous journal peer-review panels; provided scientific peer review of 5 manuscripts submitted to journals in 2019.
- Scientific Panel reviewer for NASA Earth Science Division (HQ) solicitation proposal submissions;

- Reviewer for two USDA SBIR submissions for fire science support.
- Collaborated with NASA HQ PA / Comms Department on a series of wildfire science / apps videos, NASA TV features, and web documentaries;
- Content manager of the NASA Applied Science Program - Wildfire website.
- Prepared NASA Applied Science Program - Wildland Fire 2018 Annual Program Report;
- Authored GEO-GWIS component and NASA Fire Applications elements of the NASA Applied Science Program – Disaster 2018 Annual Report;
- Serve (7-year term) on the External Advisory Board of project: "EXCELSIOR" (ERATOSTHENES: Excellence Research Center for Earth Surveillance and Space-Based Monitoring Of the Environment), a project supported under the European Commission: WIDESPREAD-04-2017: Phase 2 (Develop of a CoE), HORIZON 2020 Work Programme 2016-2017 "Spreading Excellence and Widening Participation". This project supports collaboration with the Cyprus Technology University (CTU) in a role as advisor to the development of a Center of Excellence (CoE).

Disaster Element Task 2 (Dahlgren)

- Ice testing of UAS, especially the continued writing a manuscript to report the results of the 2018 testing. The co-authors include multiple Federal agencies (USCG, NOAA, DOE, NASA) and industrial partners (Navmar, Griffon, Pemdas, CU); the manuscript is 75% complete.
- Receiving airworthiness certification for SIERRA-B in 2018, continuing electrical engineering support, payload integration and R&D on medium-class UAVs. Accomplishments include electrical rescue (SAR) payload. Attendance at regional and international fire conferences / meetings, including the GOFC-GOLD Fire IT Meeting / 4th GWIS Workshop in Rome, Italy (Oct. 2019), and the 7th International Wildland Fire Conference (Campos Grande, Brazil);
- Continuing engineering support for 4STAR and working on airworthiness matters, including the architecture of a new photometer circuit, and a companion error budget model in Excel to estimate noise, offset, and gain errors - and ultimately accuracy, trueness and precision.
- Sampling fog water to examine fog-borne life such as bacteria, protozoa, and other microbial life forms. Accomplishments include co-authoring two presentations in 2019.
- Directing move of UAS lab from Bldg. N245 room 26 to Bldg. N248 room 118.
- Presenting at CSUMB professional development meeting.

Presentations

Disaster Element Task 1 (Ambrosia)

Ambrosia, V.G., J. S. M. Ayanz, L. Boschetti, L. Giglio, and R. Field. 2019. The GEO Global Wildfire Information System (GEO-GWIS), AGU Fall Meeting, Dec. 9-13, San Francisco, CA.

Ambrosia, V.G. 2019. The GEO Global Wildfire Information System (GEO-GWIS), AGU Fall Meeting, Dec. 9-13, San Francisco, CA.

Ambrosia, V.G., J. Ayanz, L. Boschetti, L. Giglio, and R. Field. 2019. NASA Applied Science Program and NASA GEO-GWIS Program. Seventh International Wildland Fire Conference, October 29, Campos Grande, Brazil.

Ambrosia, V.G., J. Ayanz, L. Boschetti, L. Giglio, and R. Field. 2019. GEO Global Wildfire Information System (GEO-GWIS). Pecora 21 / ISRSE 38, Oct. 8, Baltimore, MD.

Ambrosia, V.G. 2019. NASA Update: ASP Wildland Fire Element, 4th Global Wildfire Information System & Global Observation of Forest Cover - Global Observation of Land Dynamics (GOFC-GOLD) Fire Implementation Team Meeting, Oct. 1-2, Consiglio Nazionale delle Ricerche, Rome, Italy.

Hinkley, E. and V.G. Ambrosia, 2019. The View From Above: Satellites and Aircraft Are Wildfire Multi-Taskers. Natural History, August 2019.

Ambrosia speaking at “EXCELSIOR” conference, Nov. 6, 2019, at Cypress University of Technology.

Ambrosia, V.G. 2019. UAS / RPAS Supporting the Wildland Fire Community: History, Accomplishments, Opportunities and Obstacles. AIAA Aviation Forum, June 19, Dallas, TX.

Ambrosia, V.G. 2019. Remote Sensing Data Enhancement – Section Chair of Web Conference, SCIFORUM 3rd International Electronic Conference on Remote Sensing (IECRS), Sponsored by MDPI/Remote Sensing, May 22 –June 5, online.

Ambrosia, V.G. NASA Support to the MedRIN: The Concept & the Digital Presence, LC-LUC Mediterranean Regional Information Network (MedRIN) First Meeting, RSCY2019, Mar. 20, Paphos, Cyprus.

Ambrosia, V. G. 2019. NASA Missions: Earth Observations and Applications. Seventh International Conference on Remote Sensing and Geoinformation of Environment, Mar. 19, Paphos, Cyprus.

Disaster Element Task 2 (Dahlgren)

Jared, D.W., R. Sagaga, R.J. Comstock, S.J. Lam, M. M. Fladeland, R.C. Strawn, and R.P. Dahlgren. 2019. A Comparison of Lift-Drag Predictions for the US Army’s Raven RQ-11 using Helios and STAR-CCM+, AIAA Aviation and Aeronautics Forum, June 17-21, Dallas TX.

Dahlgren, R.P., S.E. Dunagan, R. Johnson, S.P. Broccardo, A.I. Tayeb, and C. Esch. 2019. NASA's next-generation airborne sunphotometer (5STAR): engineering challenges and advances, OSA Sensing Congress, June 25-27, San Jose, CA.

Dahlgren, R. 2019. Experimental and Simulated Ice Accretion on Small UAS, Federal UAS Conference, May 14-16, Moffett Field, CA.

Cahill, S., A. Mazzulla, Z. Young, R. Kolyer, R. Dahlgren, S. Zuniga, M. Fladeland, D. Satterfield, M. Sumich, M. Irish, T. Lynn, J. Martin, N. Schultz, P. Schuyler, B. Marsh, and E. Uribe. 2019. NASA SIERRA-B Capability Returns to Flight, Federal UAS Conference, May 14-16, Moffett Field, CA.

Vanderbilt, V., C. Daughtry, and R. Dahlgren. 2019. Polarization to Estimate Leaf Surface Reflectance, SPIE Conference (Proc. SPIE. 11132), Polarization Science and Remote Sensing IX, Sept. 6, San Diego, CA.

Gentry, D., and R. P. Dahlgren. 2019 Venus Aerosol Sampling Considerations for In Situ Biological Analysis, The Venera-D Landing Sites and Cloud Layer Habitability Workshop, Oct. 2-5, Moscow, Russia.

Daughtry, C.S.T., V. Vanderbilt, R. Dahlgren, and E.R. Hunt. 2019. Leaf Surface Structures Alter Polarization of Incident Light (B-51B-07), AGU Fall Meeting, Dec. 9-13, San Francisco CA.

Gentry, D., A. Navazo, A. Wong, D. Arismendi, and R. Dahlgren. 2019. Sampling Strategy Concerns for Atmospheric Microbiology, AGU Fall Meeting, Dec. 9-14, San Francisco CA.

Panels or Committees

Disaster Element Task 1 (Ambrosia)

Ambrosia served as an Expert Scientific Panel Member for the California Council of Science & Technology (CCST) Forum Briefing on “Emerging Technologies for Real-Time Response to Wildfires” at the California State Capitol Building, Sacramento, California on 6 February 2019. (https://ccst.us/ccst-expert-briefing-to-discuss-emerging-technologies-for-real-time-wildfire-response-at-state-capitol/);

Editorship: Guest Editor: New Trends in Forest Fire Research Incorporating Big Data and Climate Change Modeling. Southeastern Europe Journal of Earth Observations and Geomatics, Thematic Issue, Vol. 8, No. 1S, 2019; Guest editors: Dr. Chariton Kalaitzidis, Prof. Ioannis Gitas, Dr. Vincent Ambrosia, Dr. Thomas Katagis, Mr. Mustapha Lateb.

Section Chair: Remote Sensing Data Enhancement, in 3rd International Electronic Conference on Remote Sensing, May 22 – June 5, 2019.

Session Chair / Moderator: Session 6-5, Earth Observations for Disaster Assessment and Response. Pecora 21 / ISRSE 38, Baltimore, MD, 8 October 2019

Scientific Peer Review Panels:

- Ambrosia served as a NASA Scientific Panel Reviewer for two programmatic solicitations:

- ROSES-18 A.37 Earth Science Applications: Disaster Risk Reduction and Response;
- Future Investigators in NASA Earth and Space Sciences and Technology (FINESST) NNH19ZDA005K; a
- USDA (USFS) Small Business Innovative Research (SBIR) Grant solicitation – 2019.

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;

2019 Scientific Peer-Review Journal Reviewer for International Journal of Wildland Fire, Remote Sensing, *Remote Sensing of Environment*;

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).

Disaster Element Task 2 (Dahlgren)

- Co-Convenor, Natural Hazards Sessions NH14A and NH21B "Autonomous Unmanned Systems, Geoscience Research Platforms for the 21st Century, and Automated Natural Hazard Detection, Recognition, and Characterization," American Geophysical Union (AGU) 2019 Fall Meeting, (San Francisco CA).
-
- Member, Program Committee, "Symposium on Optical Components and Materials," SPIE Photonics West (San Francisco CA).
-
- Member, USCS Baskin Alumni Advisory Council Santa Cruz CA).

Awards

Disaster Element Task 1 (Ambrosia)

2019: *Remote Sensing Journal*, 10-Year Anniversary 'Best Paper' award for "Considerations for the Use of Unmanned Aircraft Systems in Remote Sensing and Scientific Research", March 2019 (article published in 2012).

Other Information

Disaster Element Task 1 (Ambrosia)

Community Outreach:

- Ambrosia, V.G., 2019. NASA Missions: Earth Observations, "First Friday" Chabot Space and Science Center, Oakland CA, 6 Sept. 2019.

  The above open community lecture was presented in the observatory of the Chabot Space and Science Center during the "First Friday" evening lecture series. The lecture focused on exposing the community to the Earth science work that NASA performs and the benefits of such to society. (https://chabotspace.org/great-outdoors-first-friday-schedule/)

Professional Societies, Committees, and Boards:

- American Society for Photogrammetry and Remote Sensing (ASPRS)
- Institute of Electrical and Electronics Engineers (IEEE-GRS)
- 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

Schmidt provides support to the NASA Applied Sciences Ecological Forecasting program by tracking projects in the Ecological Forecasting portfolio, supporting strategic planning activities, helping coordinate annual program review meetings, and participating in interagency activities and meetings as required by the Program Manger for Ecological Forecasting. Schmidt currently manages 10 projects for the program.

Accomplishments

Participated in the following:

- Forest Integrity Project science team meeting, Bozeman, Montana, February 2019
- Life on Land Inception workshop and project kick of meeting, Ecuador, April 2019
- Belize water quality project kick off meeting, Belize, May 2019
- Biodiversity and Ecological Forecasting annual team meeting, Washington DC, May 2019
- Remote sensing for conservation management on BLM lands project workshop, Denver, CO, October 2019
- Mapping Nature for People and Planet workshop, organized by the UN Development Programme, Costa Rica, October 2019

Presentations

Schmidt, C., et al. 2019. Panel Discusion: The Role of GIS in Land Acknowledgement. Earth Observations for Conservation, 22nd Annual Society for Conservation GIS Conference, July 15-17, Pacific Grove, CA.

Schmidt, C. 2019. Earth observations for global biodiversity monitoring ,The GEO Biodiversity Observation Network, PECORA Conference, Baltimore, MD, October 6-11, Baltimore, MD.

Panels or Committees

Earth Observations for Sustainable Development Goals committee meeting, United Nations HQ, New York, August 2019.

Indigenous Knowledge

Project Participants

NASA: Lawrence Friedl
BAERI: Cindy Schmidt, Amber McCullum

Project Description

The NASA Applied Science Capacity Building program 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 in North America and South and Central America. Tribal members and other long-term residents of particular areas have developed extensive knowledge that includes deep understanding of local environments and adaptive processes passed down through generations. That knowledge, referred to as “indigenous knowledge” is typically orally passed down through generations, and holistic in having cultural and spiritual components. Indigenous knowledge encompasses the relation of living beings with each other and the surrounding environment. 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.

Accomplishments

- In March, Schmidt attended a workshop in Cambridge, UK organized by UN Environment-World Conservation Monitoring Centre and World Wildlife Fund for Nature on mapping Indigenous Peoples territories.
- In September, the team attended the GEO for Good Summit at Google HQ in Sunnyvale and formed a collaboration with Google and the Indigenous Mapping Network based in Canada. This collaboration will result in participation in the Indigenous Mapping workshop in Spring 2020 in Canada to incorporate Earth observations into Indigenous mapping efforts.
- In November, the team organized a key side event at the Group on Earth Observations (GEO) Ministerial Summit in Canberra, Australia called "Earth Observations and the Worlds' Indigenous Peoples". The side event included a panel of representatives from indigenous communities in Ecuador, Kenya, Australia and the United States. The side event resulted in the development of an Indigenous Community of Practice within GEO.
- In December, the team participated in a Capacity Building exchange in Huntsville, AL. This exchange focused on developing strategies and best practices for SERVIR hubs to build the capacity for countries to use Earth observations for natural resource management.

Presentations

Murray, B., A. McCullum, and K. Sousa. 2019. Cross-Cultural Scientific Investigation: Connecting Indigenous Knowledge with Satellites, National Adaptation Forum, April 23-25, Madison WI.

Schmidt, C., and A. McCullum. 2019. Web-based Climate Adaptation Planning Tools, NASA’s Tribes and Resilience Resources, Tribal Leaders Summit, Sept. 3-5, Bismarck, ND.

Schmidt, C., and A. McCullum. 2019. Connecting NASA’s Capacity Building Program to Indigenous Communities, SACNAS Annual Meeting, Oct. 21-Nov.2, Honolulu, HI.

McClellan, C., A. McCullum, and C. Schmidt. 2019. Navajo Storytelling and NASA Earth Science, AGU Fall Meeting, Dec. 9-13, San Francisco, CA.

Satellite-based Drought Reporting on the Navajo Nation

Project Participants

NASA: Lawrence Friedl
BAERI: Henrietta Marks

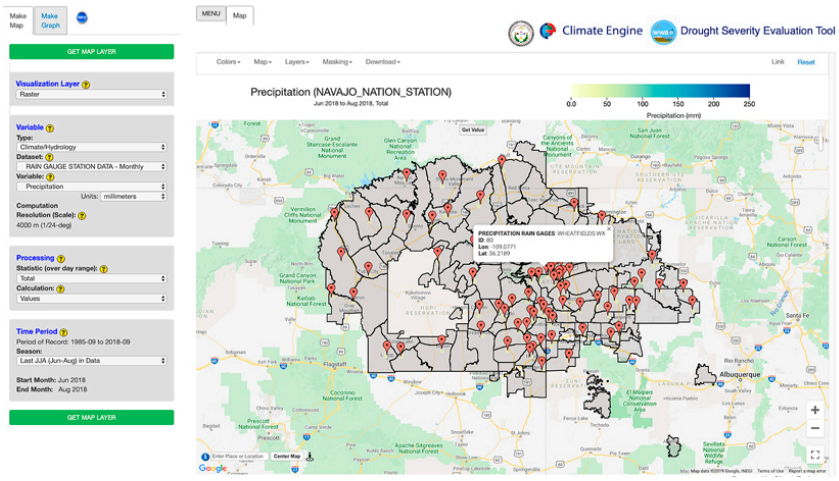
Project Description

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,

The DSET tool with the 6-month SPI displayed.

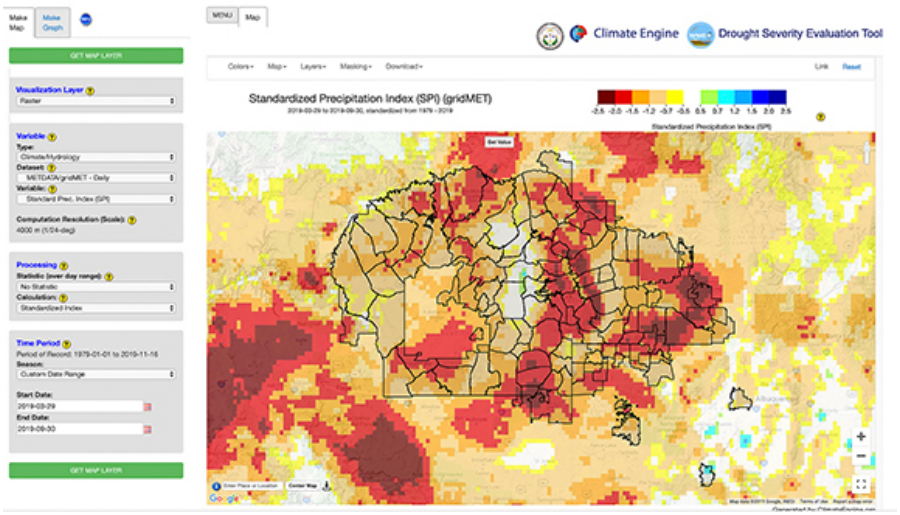
and drought declarations are common. Paired with in-situ rain gauge data, satellite-based remote sensing of precipitation, vegetation, and drought indices on the NN may improve upon the ability to monitor and report drought

Water Tank located on the Navajo Nation that depicts the arid landscape of the region. Photo Credit: Carlee McClellan, NNDWR partner.



Drought Severity Evaluation tool with the 85 Navajo Nation rain gauges displayed.

conditions. This project, funded under NASA's Western Water Applications Office or WWAO, 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.



The DSET tool with the 6-month SPI displayed.

Presentations

McCullum, A., R. Green, and C. McClellan. 2019. Satellite-based Drought Reporting on the Navajo Nation, NASA Water Resources Annual Meeting, July 16-19, Portland, OR.

McCullum, A., C. McClellan, B. Daudert, and J. Huntington. 2019. Satellite-based Drought Reporting on the Navajo Nation, ASPRS Annual Meeting, Oct. 6-11, Baltimore, MD.

McClellan, C., A. McCullum, and C. Schmidt. 2019. Navajo Storytelling and NASA Earth Science, AGU Fall Meeting, Dec. 9-13, San Francisco.

McCullum, A., C. McClellan, J. Huntington, and B. Daudert. 2019. Drought characterization on the Navajo Nation via a web-based remote sensing tool, AGU Annual Meeting, Dec. 9-13, San Francisco, CA.

McCullum, A., C. McClellan, J. Huntington, and B. Daudert. 2019. A partner-driven water resource management tool on the Navajo Nation, AGU Fall Meeting, Dec. 9-13, San Francisco, CA.

Marley, A., A. McCullum, and C. McClellan. 2019. A partner-driven water resource management tool on the Navajo Nation. AGU Fall Meeting, Dec. 9-13, San Meeting, Dec. 9-13, San Francisco, CA.Water Resources Program Francisco, CA.

McClellan, C., A. McCullum, and C. Schmidt. 2019. Navajo Storytelling and NASA Earth Science, AGU Fall Meeting, Dec. 9-13, San Francisco, CA

NavajoTrainingGroup: Training participants from DSET workshop in Flagstaff AZ.

Water Resources Program

Project Participants

NASA: Pam Hansen
CSUMB: Forrest Melton

Project Description

We support the NASA Applied Sciences Program, Water Resources application area as an Associate Program Manager for Water Resources, and as the Program Scientist for the NASA Western Water Application Office. We 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. Additionally, we conduct outreach by engaging and supporting the NASA Applied Sciences Water Resources stakeholder community.

Accomplishments

- Tracked and coordinated 12 ASP Water Resources projects. Monitored financial and technical progress and engagement with partners and stakeholders. Communicated regularly with project PIs to identify and resolve issues. Reported project progress to ASP PMs and Associates at five ASP Program Reviews.
- Participated in weekly meetings with WWAO and bi-weekly meetings with NASA HQ. Supported the project formulation process for multiple projects being supported by WWAO in the Colorado River Basin. Co-led the development of the WWAO Program Strategy for FY20.
- F. Melton and P. Hansen organized and co-led the annual NASA Applied Sciences Program (ASP) Water Resources and Western Water Applications Office Meetings held in Portland, OR, July 16-19, 2019. Organized all meeting logistics and agenda for a meeting with over 90 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-organized the NASA Western Water Applications Office workshop on Stakeholders Needs Assessment for the Columbia River Basin, with more than 30 participants from water resource management organizations in the Columbia River Basin. Worked with the WWAO team and SPF Consultants to develop meeting objectives, plan the meeting agenda, and develop questions for the breakout groups. Presented overviews of NASA capabilities and the WWAO portfolio of projects, and led breakout groups on topics related to evapotranspiration and agricultural water management. Edited the workshop report and prepared a summary of the workshop findings for NASA HQ.
- Co-led the organization of the WWAO Technology Transition Workshop with the Western States Water Council (WSWC) and WestFAST in Irvine, CA, August 7-9, 2019. Worked with the WWAO team and the WSWC to develop the workshop objectives and agenda. Presented an overview of successful project supported by the NASA ASP Water Resources Application Area and led discussion sessions and breakout groups. Co-authored and edited the workshop report prepared for NASA HQ and the WSWC.
- 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 $5.5 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. Organized and led a workshop for the technical team (25 leading scientists in the field of remote sensing of ET) to

develop and plan the architecture for OpenET in Monterey, CA, Nov 13-16, 2018, as well as multiple workshops to plan development and implementation of key components of the OpenET architecture.

Presentations

Melton, F. et al., 2018. OpenET: Filling the biggest gap in water data for the Western U.S. AGU Fall Meeting, Dec. 10-14, Washington, D.C.

Melton, F., B. Doorn, J. Bolten, C. Lee, and B. Brennan. 2019. Applications of remote sensing for water resources management (invited). Western Governors' Association Annual Meeting, June 10-12, Vail, CO.

Melton, F., B. Doorn, J. Bolten, C. Lee, C., and B. Brennan. 2019. Applications of remote sensing for water resources management, Western Regional Partnership Briefing, August 27 (webinar).

Melton, F., 2019. Applications of satellite data for agricultural water management (invited). National Grape Research Alliance Annual Meeting, Nov. 12, Sacramento, CA.

Melton, F., 2019. NASA Western Water Applications Office: Remote Sensing Solutions for Water Management. WWAO-WSWC Technology Transfer Workshop, Aug. 7, Irvine, CA.

Six additional presentations on OpenET via webinars and outreach events with water management partners in the western U.S.

Preparation of materials for a presentation by the Administrator Bridenstine to the World Ag Expo, Feb. 12, Tulare, CA.

Panels or Committees

- F. Melton is serving as a guest editor on a special issue of the Journal of the American Water Resources Association, 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

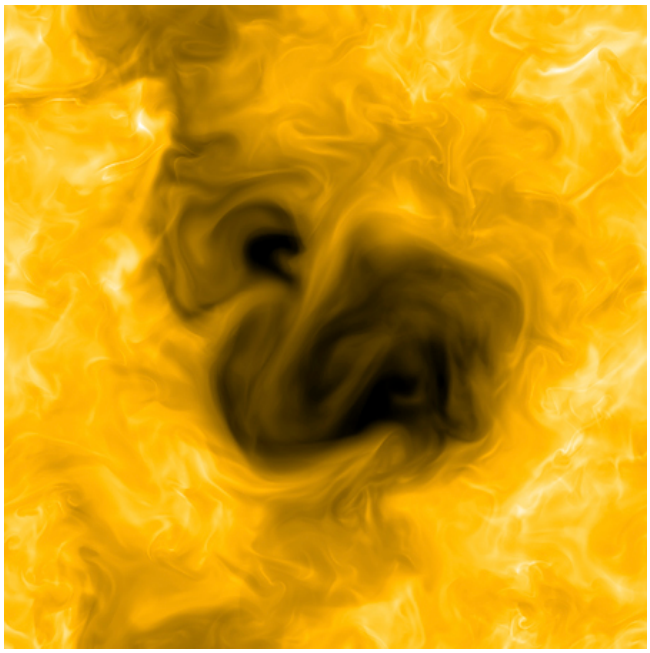
Interactive Database of Atmospheric Radiation Dose Rate

Project Participants

NASA: Nagi Mansour
BAERI: Irina Kitiashvili, Viacheslav Sadykov

Project Description

The project goal 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 Automated Radiation Measurements for Aerospace Safety (ARMAS) device (Tobiska et al., 2015-2018) together with quick analysis and visualization tools based on the HelioPortal Web platform (https://helioportal.nas.nasa.gov/) originally developed as a multi-instrument database of solar flares (Sadykov, et al., 2017).



Synthetic emission ofAIA instrument (17A channel) inboard of the Solar Dynamics Observatory computed from 3D radiative MHD simulations.

Accomplishments

- Developed the initial design of the radiation database and the database prototype.

Presentations

Kitiashvili, I., C. M. Cheung, M. Guhathakurta, and N. Mansour. 2019. Machine Learning and Data Assimilation as Emerging Tools for Characterization and Forecasting of Solar Variability and Space Weather Events, AGU Fall Meeting, Dec. 9-13, San Francisco, CA.

Heliophysics Modeling and Simulation (HMS)

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 effects of this 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. The synergy of the advanced realistic MHD modeling and multiwavelength observations primary with IRIS, SDO and Hinode is the basic methodology of this project.

Accomplishments

- Dynamical effects of solar magnetoconvection span a wide range spatial and temporal scales that extends from the interior to the corona and from fast turbulent motions to the global-Sun magnetic activity. To study the solar activity on short temporal scales (from minutes to hours), we use 3D radiative MHD simulations that allow us to investigate complex turbulent interactions that drive various phenomena, such as plasma eruptions, spontaneous formation of magnetic structures, funnel-like structures and magnetic loops in the corona, and others. In particular, we focus on multi-scale

processes of energy exchange across the different layers, which contribute to the corona heating and eruptive dynamics, as well as interlinks between different layers of the solar interior and atmosphere.

- During this year we worked on 1) improving StellarBox code to improve modeling results of the solar chromosphere, 2) analysis existing simulation results, and 3) working on new models with corona. Details are:
- During this year the team included new capabilities into the StellarBox code, such as added flexibility of used vertical mesh, capability to expand computational domain in all directions, developed a new approach to compute two-temperature of solar plasma in NLTE regime, included capability to drive the bottom boundary conditions to model magnetic flux emergence from global simulations

Analysis of the currently available modeling and observational is performed. In particular, we analyzed 3D radiative MHD simulations of solar magnetoconvection with a self-organized pore-like magnetic structure, and identified more than 600 individual acoustic events both inside and outside this structure. By performing a case-by-case study, we found that acoustic sources surrounding the magnetic structure are associated with downdrafts. Their depth correlates with downdraft speed and magnetic field strength. The sources often can be transported into deeper layers by downdrafts. The wave front shape, in the case of a strong or inclined downdraft, can be stretched along the downdraft. Inside the magnetic structure, excitation of acoustic waves is driven by converging flows. Frequently, strong converging plasma streams hit the structure boundaries, causing compressions in its interior that excite acoustic waves. Analysis of the depth distribution of acoustic events shows the strongest concentration at 0.2-1 Mm beneath the surface for the outside sources and mostly below 1 Mm inside the magnetic region, that is, deeper than their counterparts outside the magnetic region.

A significant amount of time within the project was dedicated to study of properties of shockwaves in numerical quiescent Sun simulations. Connection of shockwave properties to the properties of synthesized spectral lines (Mg II and C II ultraviolet lines observed by the Interface Region Imaging Spectrograph, IRIS) and extreme ultraviolet emission of the corona (observed by the Atmospheric Imaging Assembly onboard the Solar Dynamics Observatory, SDO/AIA) is of special interest because it potentially provides diagnostics possibilities from remote sensing observations. The modeling of the quiescent Sun is done with the "StellarBox" code which solves the fully compressible MHD equations with radiative transfer solved by ray tracing and opacity binning techniques. We analyzed the computational domain of 12.8 x 12.8 x 15.2 Mm including a 10 Mm layer from the photosphere to the corona, with 25 km horizontal spatial resolution. From the 3D realistic model we generated synthetic time-series of Mg II and C II lines observed by IRIS (using RH radiative transfer code) and SDO/AIA emission (using known temperature response functions).
We developed procedure to identify the shock waves in the synthetic data, which manifest themselves as sudden enhancements in SDO/AIA running difference images. The identified shock waves have been used to extract variations of local physical properties variations (energy flux transport to the corona, local variations in velocity field associated with shock wave propagation, etc), and properties derived from the synthetic emission (Doppler velocity jumps of IRIS lines, relative enhancements of SDO/AIA emission, etc.). We performed the correlation analysis to develop procedure for indentification of the shock waves in observations and extract thermodynamical properties of the solar plasma. One of our findings is that Doppler velocity fluctuations in the C II 1334.5 Å (IRIS line), and relative enhancement of 335 Å emission (SDO/AIA channel), are the best proxies for the energies deposited by shockwaves into the corona. The paper describing relationships between the shockwaves and synthesized IRIS and SDO/AIA emission is in

preparation now. Currently testing detection of the shockwaves in numerical simulations using unsupervised machine learning techniques.

During analysis of synthetic data some discrepancies between model results and observations have been identified and solved. In particular it was found that discrepancies in emission flux for IRIS lines, and unrealistic line profile H_alpha relates to high plasma density in the solar chromosphere and corona. To resolve this issue we performed series of simulations to optimize the model parameters. In addition, it was found that too shallow layer of the solar corona prevents us to generate a realistic description of the solar chromosphere and corona. Currently we are preparing hydrodynamic models with extension of the computational domain deeper (upto 50Mm) into the solar interiors and higher into atmosphere (upto 20Mm).

Publications

Kitiashvili I., A.G. Kosovichev, N. Mansour, A. Wray, and T. Sandstrom. 2019. The Origin of Deep Acoustic Sources Associated with Solar Magnetic Structures. The Astrophysical Journal, 872 (1), article id. 34. https://iopscience.iop.org/article/10.3847/1538-4357/aafac1/meta

Kitiashvili I. N. 2019. Application of Synoptic Magnetograms to Global Solar Activity Forecast. Cornell University-Astrophysics, eprint arXiv:1910.00820. https://arxiv.org/abs/1910.00820

Huang, N., Y. Xu, V.M. Sadykov, J. Jing, and H. Wang. 2019. Spectral Diagnosis of Mg II and Hα Lines during the Initial Stage of an M6.5 Solar Flare. The Astrophysical Journal Letters, 878 (1), article id. L15. https://iopscience.iop.org/article/10.3847/2041-8213/ab2330/pdf

Sadykov, V.M., A.G. Kosovichev, I. Kitiashvili, and G.S. Kerr. 2019. Response of SDO/HMI observables to heating of the solar atmosphere by precipitating high-energy electrons. Cornell University-Astrophysics, eprint arXiv:1906.10788. https://arxiv.org/abs/1906.10788

Sadykov V.M., A.G. Kosovichev, I.N. Sharykin, and G.S. Kerr. 2019. Statistical Study of Chromospheric Evaporation in Impulsive Phase of Solar Flares. The Astrophysical Journal, 871 (1): , article id. 2, 13 pp.

Hinkel, N., I. Kitiashvili, P. Young, and A. Youngblood. 2019. Stellar Characterization Necessary to Define Holistic Planetary Habitability. Astro2020: Decadal Survey on Astronomy and Astrophysics, science white papers, no. 435; Bulletin of the American Astronomical Society, 51 (3), id. 435.

Airapetian, V., I. Kitiashvili I., E.T. Wolf, et al. 2019. Reconstructing Extreme Space Weather From Planet Hosting Stars. Astro2020: Decadal Survey on Astronomy and Astrophysics, science white papers, no. 564; Bulletin of the American Astronomical Society, 51 (3), id. 564.

Rackham, B., I. Kitiashvili, E.V. Quintana, et al. 2019. Constraining Stellar Photospheres as an Essential Step for Transmission Spectroscopy of Small Exoplanets. Astro2020: Decadal Survey on Astronomy and Astrophysics, science white papers, no. 328; Bulletin of the American Astronomical Society, 51 (3), id. 328.

Wang Ji, I. Kitiashvili, M. Ulmer, et al. 2019. New Frontiers for Terrestrial-sized to Neptune-sized Exoplanets In the Era of Extremely Large Telescopes. Astro2020: Decadal Survey on Astronomy and Astrophysics, science white papers, no. 200; Bulletin of the American Astronomical Society, 51 (3), id. 200.

Fortney, J., I. Kitiashvili, L. Close, et al. 2019. The Need for Laboratory Measurements and Ab Initio Studies to Aid Understanding of Exoplanetary Atmospheres, Astro2020: Decadal Survey on Astronomy and Astrophysics, science white papers, no. 146.

Presentations

Kitiashvili I., A. Wray, A.G. Kosovichev, V.M. Sadykov, and N.N. Mansour. 2019. 3D Realistic Modeling of Chromospheric and Coronal Heating and Self-Organization. American Astronomical Society Meeting #234, id. 106.15. Bulletin of the American Astronomical Society, 51 (4).

Kitiashvili, I., and A.G. Kosovichev. 2019. Long-Term Prediction of Solar Activity Using Magnetogram Data and Ensemble Kalman Filter. American Astronomical Society Meeting #234, id. 401.01. Bulletin of the American Astronomical Society, 51 (4).

Kitiashvili, I.N. 2019. Application of Synoptic Magnetograms for Prediction of Solar Activity Using Ensemble Kalman Filter. Solar Atmospheric and Interplanetary Environment (SHINE 2019), Aug. 5-9, Boulder, CO. https://shinecon.org/CurrentMeeting.php, id.215

Sadykov, V. M., I. Kitiashvili, and A.G. Kosovichev. 2019. Cluster analysis of spectroscopic line profiles in RMHD simulations and observations of the solar atmosphere. Solar Atmospheric and Interplanetary Environment (SHINE 2019), Aug. 5-9, Boulder, CO. https://shinecon.org/CurrentMeeting.php, id.11

Sadykov, V. M. 2019. Multi-wavelength Investigation of Energy Release and Chromospheric Evaporation in Solar Flares. American Astronomical Society Meeting #234, id. 310.06. Bulletin of the American Astronomical Society, 51 (4).

Sadykov, V.M., A.G. Kosovichev, and I.N. Kitiashvili. 2019. Cluster analysis of spectroscopic line profiles and EUV emission in RMHD simulations and observations of the solar atmosphere. Data Mining Lab workshop at Georgia State University, Oct. 1-2, Atlanta GA.

Kitiashvili, I.N., and A.A. Wray. 2019. Modeling the Solar Corona to Study Sources of Space Weather Disturbances. Supercomputing conference, Nov. 17-22, Denver, CO.

Sadykov, V. 2019. Predicting Solar Flares Using Machine Learning: Advances and Challenges (SH34B-05). AGU Fall meeting, Dec. 9-13, San Francisco, CA.

Nita, G.M., V.M.Sadykov, A.G. Kosovichev, and V. Oria. 2019. A Generalized Spectral Kurtosis Solar Image Variability Descriptor. AGU Fall meeting, Dec. 9-13, San Francisco, CA.

Sadykov, V.M., I.N. Kitiashvili, and A.G. Kosovichev. 2019. Cluster Analysis of Spectroscopic Line Profiles in IRIS Observations and RMHD Simulations of the Solar Atmosphere (SH31E-3345). AGU Fall meeting, 9 – 13 December 2019, San Francisco, CA.

Kitiashvili, I.N., A.A. Wray, V.M. Sadykov, A.G. Kosovichev, and N.N. Mansour. 2019. Solar activity modeling: from subgranular scales to the solar cycles. AGU Fall meeting, 9-13 December 2019, San Francisco, CA.

Kitiashvili, I. 2019. Concepts of the Solar and Stellar Dynamos and Convection. IAU Symposium 354: Solar and Stellar Magnetic Fields: Origins and Manifestations, 30 June 30-July 6, 2019, Copiapo, Chile

Sadykov, V., A. Kosovichev, I. Kitiashvili. 2019. Enhancement of Binary and Probabilistic SWPC NOAA Flare Forecast by Using Machine Learning Algorithms. Space Weather Workshop, April 1-5, Boulder, CO.

Kitiashvili, I. 2019. Global Evolution of Solar Magnetic Fields and Prediction of Solar Activity Cycles. IAU Symposium 354: Solar and Stellar Magnetic Fields: Origins and Manifestations, June 30-July 6, Copiapo, Chile.

Kitiashvili, I., and A.A. Wray. 2019. Structure and Dynamics of the Overshoot Layer in a Rotating Main-Sequence Star a with Shallow Convection Zone. IAU Symposium 354: Solar and Stellar Magnetic Fields: Origins and Manifestations, June 30-July 6, Copiapo, Chile.

Kitiashvili, I., A. A. Wray, A.G. Kosovichev, V.M. Sadykov, and N.N. Mansour. 2019. 3D Realistic Modeling of Solar Turbulent Dynamics from Subsurface to the Chromosphere and Corona. IAU Symposium 354: Solar and Stellar Magnetic Fields: Origins and Manifestations, June 30-July 6, Copiapo, Chile.

Kitiashvili, I.N. 2019. Helical energy channels from the subsurface to the chromosphere. ISSI team meeting, The nature and physics of vortex flows in solar plasmas, Bern, Feb. 3-6, Bern, Switzerland.

Kitiashvili, I.N. 2019. Vortex Tube Formation and Dynamics in Quiet-Sun Regions. ISSI team meeting, The nature and physics of vortex flows in solar plasmas, Feb. 3-9, Bern, Switzerland.

Kitiashvili, I., A. Wray, V. M Sadykov, A. Kosovichev, and N. Nicolas Mansour. 2019. Solar activity modeling: from subgranular scales to the solar cycles, AGU Fall Meeting, Dec. 9-13, San Francisco, CA.

Kitiashvili, I., A. Wray, V. M. Sadykov, A. Kosovichev, and N. Mansour. 2019. Solar activity modeling: from subgranular scales to the solar cycles, AGU Fall Meeting, Dec. 9-13, San Francisco, CA.

Panels or Committees
Kitiashvili I. NCAR-Wyoming Supercomputer Center Steering Committee

Kitiashvili I. International Astronomical Union, Division E “Heliophysics” Steering Committee

Kitiashvili I. Leadership on monthly NASA HECC Heliophysics User Telecon

Kitiashvili I. Steering Committee @HDMIEC RCN: Towards Integration of Heliophysics Data, Modeling, and Analysis Tools, NSF EarthCube Project

Kitiashvili I. Leadership @HDMIEC RCN Working Group: Cross-Analysis and Validation of the Heliophysics Models, Laboratory Experiments, and Observations. NSF EarthCube Project

Kitiashvili I. Organization AGU Fall Meeting Session “SH31E: Machine Learning and Data Assimilation as Emerging Tools for Characterization and Forecasting of Solar Variability and Space Weather Events”

Sadykov V., Kitiashvili I. Organization SHINE session “Achievements and Challenges of Machine Learning and Data Assimilation for Analysis and Prediction of Solar Activity”, Boulder CO, August 5-9, 2019.

Upton L., Munjoz-Jaramillo A., Kitiashvili I., Metcalfe T. Organization SHINE session “Long-Term Solar/Stellar Variability: Closing the Rift Between Models and Observations”. Boulder CO, August 5-9, 2019.

Sadykov V. NASA Frontier Development Lab 2019, Review panel

Kitiashvili I.N. NASA Frontier Development Lab 2019, Review panel

Kitiashvili I. NASA & NSF panels reviewer

Others

NASA press-release: Irina Kitiashvili, “Solar Activity Forecast for the Next Decade”

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 helioseismic waves travel in the solar interior using numerical simulations in order to develop, improve and validate observation technique applied on solar observations.

Accomplishments

- Derived so-called sensitivity kernels that relate flow velocities inside the Sun with wave travel-time variations that are observable on the solar surface. This effort is a major breakthrough in the numerical method that allowed us to compute such kernels in significantly improved resolution and for much larger distances as before.
- Continued worked on a publication of the work on sensitivity kernels. The manuscript is nearly complete and will be submitted in the near future.
- Computed sensitivity kernels for a single wave frequency. We plan a redo to expand these calculations to other frequencies.
- Made detailed comparisons of our new realistic kernels with the kernels commonly used in the community that are based on ray and born approximation.
- Developed a multi-frequency inversion technique for large-scale flows in the Sun.
- Prepared a paper on using our new sensitivity kernels for inferring the Sun's meridional circulation pattern from wave travel times measured from the Sun.

Publications

Hartlep, T., and J. Zhao. 2019. Computing Helioseismic Sensitivity Kernels through global-scale wave-propagation simulations. To be submitted to the Astrophysical Journal.

Presentations

Zhao, J., and T. Hartlep. 2019. Deriving Three-Dimensional Sensitivity Kernels for Large-Scale Solar Interior Flows Using Wavefield Simulations, American Astronomical Society Meeting #234, June 9-13, St. Louis, MO.

Hartlep, T., and J. Zhao. 2019. Realistic, three-dimensional sensitivity kernels for measuring solar interior flows, AGU Fall Meeting, Dec. 9-13, San Francisco, CA.

NAS SDO Data Service: AIA Data Analysis at Scale with Python on NASA Pleiades

Project Participants

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

Project Description

The Atmospheric Imaging Assembly (AIA) instrument on the Solar Dynamics Observatory spacecraft produces an image of the Sun in multiple ultraviolet wavelengths every twelve seconds. This amounts to about 2 TB of data per day. Extracting scientific results from this large volume of data is challenging. Using NASA's high performance computing resources, we are developing software to analyze data from AIA on thousands of computing cores. Thus far, we have shown that this new paradigm for interactive analysis accelerates current workflows and enables new studies that would be prohibitively slow or impossible on desktop machines.

Accomplishments

- Worked on developing software tools for analyzing SDO data at scale on NASA Pleiades(see https://gitlab.com/wtbarnes/aia-on-pleiades and https://gitlab.com/wtbarnes/aiacube); and
- Worked on developing a software package for analyzing AIA data in Python (see https://gitlab.com/LMSAL_HUB/aia_hub/aiapy)

Presentations

Barnes, W., et al. 2019. Building an Interactive Data Analysis Platform for the Solar Dynamics Observatory on NASA Pleiades, lightning talk, Pangeo Community Meeting (www.pangeo.io), Aug. 21-23. Online.

Barnes, W., C.M. Cheung, and M. Bobra. 2019. The Sun at Scale: Interactive Analysis of High Resolution EUV Imaging Data on HPC Platforms with Dask (poster), AGU Fall Meeting, Dec. 9-13, San Francisco, CA.

Biology

SynBio Radiocatalysis

Project Participants

BAERI: Rocco Mancinelli

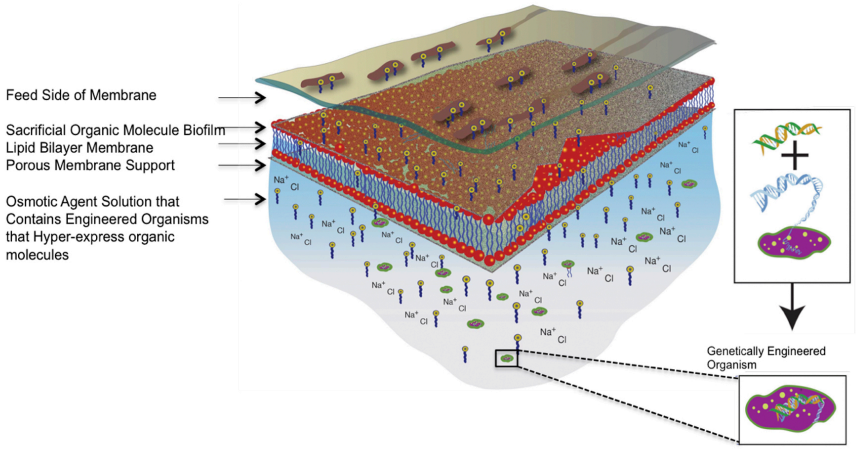
Project Description

Capability Need/Knowledge Gap: NASA's new Gateway mission will develop a cislunar habitat that will be occupied intermittently with long periods of dormancy. Maintaining sterility of the water distribution system during these periods of dormancy is a key challenge to the operation of the Gateway facility.

Objectives: The objective of this work is to evaluate the use of X-ray/gamma ray catalyst coatings to passively produce hydroxyl radicals that will maintain sterility of water systems using the cislunar radiation environment as an energy source.

Cislunar space is characterized by the presence of galactic and solar radiation. This radiation can serve as a biocide in water system by producing hydroxyl radicals. However, the activation energy of these reactions is high and radiation within a radiation protected spacecraft will not be high enough to produce significant quantities of hydroxyl radicals .

What is needed is a radiocatalytic nanoparticle that will reduce the activation energy and allow the low internal radiation environment of the space craft to produce enough hydroxyl radicals to maintain sterility of the water system.



Technical Approach: This work evaluated X-ray and gamma ray catalysts to produce hydroxyl radicals to insure the sterility of the water distribution system in the Gateway habitat during periods of dormancy. These biocompatible radiocatalytic nanoparticles will be integrated into coating materials that can be used on the internal surfaces of pipes, tanks, pumps, etc. These catalytic coatings will then passively produce low levels

of hydroxyl radicals using the ambient space radiation environment as an energy source. hydroxyl radicals are one of the highest oxidation potential species known to exist and are an excellent biocide.

The mechanism of radiocatalysis in this case comes from the reaction of adsorbed water molecules with excited conduction band electrons and valence band holes to produce hydroxyl radicals. Electron-hole pairs yields of 100 per keV absorbed radiation for typical semiconductors is common.

One of the most common radiocatalyts is gold coated with acetate. This material is fabricated into nanoparticles. These biocompatible particles are used in cancer radiation therapy where x-rays are used to produce hydroxyl radicals in oxygen starved tumor cells. This work tested the performance of gold coated with acetate for use in the radiation environment of the internal surfaces of the Gateway habitat water system. The results suggest that the radiation environment needs to be higher than that anticipated on the Gateway facility.

Elucidating the Nitrogen Cycle of Eu:CROPIS Euglena: Combined Regenerative Organic-food Production In Space

Project Participants

BAERI: Rocco Mancinelli

Project Description

Nitrogen is an essential element for life. It is present in all living systems, occurring in several important molecules including proteins and nucleic acids. Without nitrogen life as we know it could not exits. Thus, the nitrogen cycle is important to supporting life whether it is on Earth, in space, or on other planets or moons. Because only Earth has a 1 x g environment understanding how the nitrogen cycle operates as a function of gravity is key to sustaining life off of Earth. To change the gravity levels the spacecraft will be maneuvered (by spinning) to produce three different gravity regimes during the courser of the mission. The three gravity regimes will be 0.01 x g - 0.1-x g (essentially microgravity); 0.16 x g (Moon gravity) and 0.38 x g (Mars gravity). Each gravity regime will last for six months. Eu:CROPIS will be used in reducing organic waste and in the development of efficient life support systems. Its core element is a microbiological trickling filter of lava rock – the habitat of a multitude of microorganisms that purify and decontaminate water. The development aims at a wet composting system that may be used in closed life support systems such as waste water recovery. A key component of the system is the nitrogen cycle. So, modeling the nitrogen cycle of the system is essential to understanding how the system functions. It will be the first time nitrogen-transformation reactions will be measured as a function of gravity.

Presentations

Mancinelli, R. L., M. Cortesao, and R. Mowller. 2019. Microbes in Space: An overview Presented at the International Symposium on Fungi/Microbes Under Stress, May 18-26, San José de Los Campos, Brazil.

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 a several NASA Centers. ASP also provides payload integration services and mission assistance including flight planning, data management, and communications. To ensure that the right capabilities are available and will be available for future science activities, Advanced Planning maintains an out-year schedule of mission plans and the assets and services required. Information is gathered from NASA Earth Science program and from the science community through workshops, conferences, and ongoing interactions.

Accomplishments

- Updated the Airborne Science Program (ASP) 5-year plan, monthly, for ASP management;
- Prepared for ASP management a monthly map of all ESD airborne missions;
- Began preparation of an updated ASP Requirements Report by meeting with scientists at NASA Centers and collecting survey results;
- Contributed to an update of the Airborne Science Program strategic plan;

ASP 2019 publications

- Prepared the ASP 2018 Annual Report and two semiannual newsletters;
- Participated in various science team meetings related to NASA Earth Science missions to gather airborne requirements data; and
- Updated characteristics of Hale Altitude Long Endurance UAVs suitable for NASA Earth science

Presentations

Fladeland, M., S. Schoenung, V. Chirayath, and J. Podolske. 2019. Supporting NASA Science with High-Altitude Long-Endurance Aircraft, ESA Living Planet Symposium, May 13-17, Milan, Italy.

Fladeland, M., S. Schoenung, and R. Albertson. 2019. NASA Activities with UAS for Long Duration Global Monitoring" 38th ISRSE Conference, Oct. 6-11, Baltimore, MD

Schoenung, S., M. Fladeland, and B. Tagg. 2019. NASA Airborne Science Contributions to Continuous Earth Monitoring, 38th ISRSE Conference, Oct. 6-11, Baltimore, MD.

Autonomous Scheduling of Earth-orbiting Satellite Constellations

Project Participants

NASA: David Murakami
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.

Then there's another theme that 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.

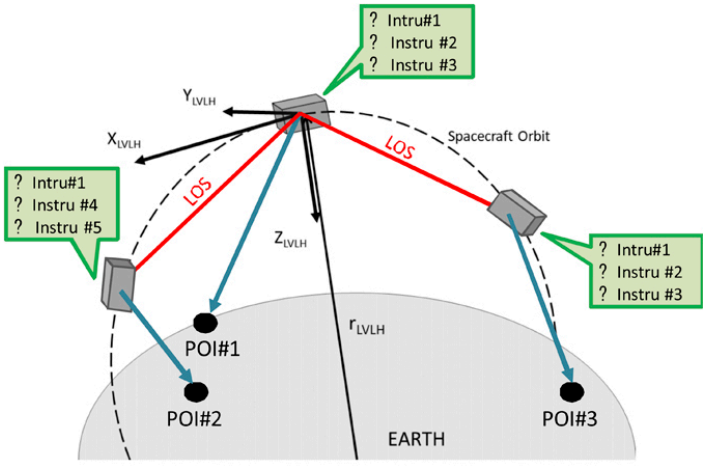
Cabrera, J., S. Nag, and D. Murakami. 2019. An Initial Analysis of Automating Conjunction Assessment and Collision Avoidance Planning in Space Traffic Management, 29th AAS/AIAA Space Flight Mechanics Meeting, Jan. 13-17, Ka'anapali, HI.

Awards

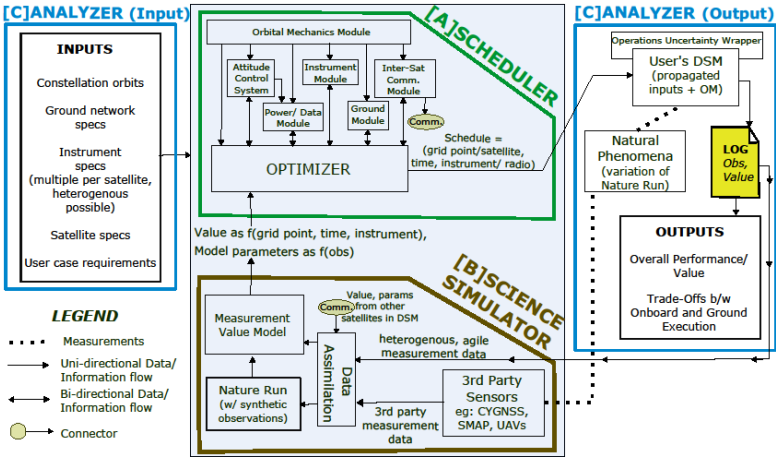
SA Advanced Information Systems Technology Grant as Principal Investigator, for "D-SHIELD: Distributed Spacecraft with Heuristic Intelligence to Enable Logistical Decisions", in 2019-21.

Panels and 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



Cartoon of a 3-sat DSM, with different instrument sets, using, D-SHIELD to make coordinated decisions of pointing and instrument usage.



Information flow chart of the D-SHIELD Technology (Scheduler-Science Simulator) and Assessment plan (using Analyzer, which also serves as the User interface).

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.

Earth Science Project Office (ESPO)

Project Participants

NASA: Marilyn Vasques
BAERI: Erin Justice, Quincy Allison, Sommer Nicholas, Brad Bulger, Ayuta Padhi, Brent Williams, Andrew Thompson, Tony Chua, Katie Stern, Alex Stanfill, Susan McFadden, Caitlin Murphy.

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.

FIREX Team Group Photo on the tarmac with DC-8.

BAERI employee, Alex Stanfill, setting up CAMPEX network.

Accomplishments

- In 2019, the NASA-ARC-based ESPO team supported the following research campaigns under the ARC-CREST agreement:
  - ✦ CAMP2Ex (Cloud, Aerosol and Monsoon Processes Philippines Experiment) responded to the need to deconvolute the fields of tropical meteorology and aerosol science at the meso-b to cloud level. The campaign was successfully completed in October 2019, with science flights on the NASA P-3 predominantly occurring from August-September. Operations were based out of Clark airport in the Philippines.
  - ✦ FIREX-AQ (Fire Influence on Regional to Global Environments and Air Quality) investigated wildfires in the Northwest US and prescribed fires in Southeast US, utilizing the DC-8. Deployments were successfully completed out of Boise, ID and Salina, KS from July-September, 2019.

- EXPORTS (EXport Processes in the Ocean from RemoTe Sensing) is a five-year ocean biology project. The first very successful deployment took place August and September of 2018. Data submission and planning for the 2020 deployment continues.
- ESPO is managing the following Earth Venture Suborbital-3(EVS-3) Missions. Each of the missions are in various states of the planning and approval process, with deployments starting early 2020 through 2023.

CAMPEX Team group photo with P-3 on tarmac of Clark Airport, Philippines.

- 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-V, a Twin Otter, a research vessel, as well as ocean surface drifters, wave gliders and floats. The first deployment is scheduled for April 2020.
- IMPACTS (Investigation of Microphysics and Precipitation for Atlantic Coast-Threatening Snowstorms) is a multi-NASA 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 US.
- 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.

Instruments Data Metric Evaluator for Tradespace Analysis Tool for Constellations (TAT-C)

Project Participants

BAERI: Vinay Ravindra, Sreeja Nag

Project Description

Tradespace Analysis Tool for Constellations (TAT-C) is an simulation toolkit which will allow scientists to explore satellite constellation mission architectures, that minimize cost and maximize performance for pre-defined science goals, and will be aided by knowledge databases and machine learning. A primary functionality to be provided by this toolkit is the ability to simulate instruments operating during the mission and provide expected observation data metrics to the user. This coupled with running of multiple simulations over a search-space of possible instruments which can be used by the mission, allows the user to build a tradespace infobase to study the dependencies of the Distributed Satellite Mission (DSM) performance on different instrument parameters.

Accomplishments

- Worked on the AIST 2017-19 supported project titled 'Tradespace Analysis Tool for Constellations (TAT-C)'; and
- Developed an instrument module to evaluate data-metrics of potential observations made by the DSM to enable a wider and more sophisticated DSM performance evaluation. Passive optical imagers with different scanning techniques, synthetic aperture radars were the instruments modeled within this module. It was made in as a lightweight Python package with an easy to use interface. The documentation is included within the package and could be built to a user-friendly HTML format. The developed software is complete and is currently undergoing the software release process to make it available as an open-source package.

Publications

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, 6 (6): 1-13. 10.1109/JSTARS.2019.2952531

Presentations

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.

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 micro-physical 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

- Calibrated and re-processed DC-8 MMS data from the High Ice Water Content (HIWC-II) experiment.
- Developed a mitigation strategy to improve vertical winds by recovering attack angle data corrupted by ice (or super-cooled water) ingestion during cloud penetrations.
- Verified periods of compromised data by comparing flow angle spectra before, during, and after cloud encounters.
- Employed statistical relationships between sensors to remove icing artifacts from pressure data measured by flow angle probes.
- Evaluated the impact of electrical noise on analog data streams.
- Substituted CMIGIT variables where LN-100 INU navigation parameters were unreliable.
- Developed statistical relationships to correct total pressure measurements by removing aerodynamic shadowing effects impacting horizontal winds, caused by relocation of the fuselage pitot probe to a 6 O'clock position on the aircraft fuselage.
- Verified the impact of correction algorithms on related meteorological variables, as well as on the whole dataset.
- Compared revised with preliminary data. Submitted final 1 Hz and 20Hz data files to project archive.
- Provided remote data analysis and processing support during the Fire Influence on Regional to Global Environments Experiment – Air Quality (FIREX-AQ). Evaluated performance of MMS sensors and components during the field campaign, using both time series and spectral analysis methods.
- Recommended flight conditions needed for (and performed initial analysis of) in-flight maneuvers.

- Calibrated and began re-processing DC-8 MMS data from FIREX-AQ and the 2019 Student Airborne Research Program (SARP). Compared MMS temperature data from all 27 flights to determine dates and times of errant fast temperature measurements.
- Developed a statistical algorithm to use backup temperature data to estimate the missing fast temperatures to within +/- 0.1K.
- Optimized attack angle adjustments due to aerodynamic up- and down-wash to minimize vertical wind errors.
- Substituted CMIGIT ground velocities where LN-100 INU navigation parameters were unreliable.
- Compared revised with preliminary data and resolved differences.
- Monitored and quality-controlled Alpha Jet MMS data, including dedicated flight maneuvers from all Alpha Jet Atmospheric eXperiment (AJAX) flights.
- Processed MMS pressure, temperature and wind data from research flights as needed by project participants.
- Reviewed and improved manuscripts written by scientists utilizing MMS data from either DC-8 or Alpha Jet platforms, prior to submission and former peer review.
- Provided context and interpretation of MMS measurements to primary authors, clarifying wording and logical presentation as needed.

Publications

Ryoo, J.-M., L.T. Iraci, T. Tanaka, J.E. Marrero, E.L. Yates, I. Fung, A.M. Michalak, J. Tadi'c, W. Gore, T.P. Bui, J.M. Dean-Day, and C.S. Chang. 2019. Quantification of CO2 and CH4 emissions over Sacramento, California, based on divergence theorem using aircraft measurements, Atmospheric Measurement Techniques, 12,2019, doi: 10.5194/amt-12-2949-2019

Awards

2019 NASA Honor Awards, Group Achievement Award for AToM (Atmospheric Tomography Mission) science mission.

NSRC Mission Operations

Project Participants

NASA: Matt Fladeland
NSRC: Melissa Yang Martin, Adam Webster, Kelly Edmond, David Van Gilst, Eric Stith, Sebastian Rainer, Steven Schill, Ryan Bennett, Pat Finch

Project Description

The National Suborbital Research Center (NSRC) is a partner in the ARC-CREST cooperative agreement with NASA Ames Research Center. NSRC is responsible for two tasks for the Airborne Science Program:

- Task 1: Science Mission Operations and
- Task 2: Communications and Training.

In support of Task 1, NSRC provides the 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, in addition to flight data archiving and distribution.

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.

Accomplishments

In 2019, NSRC supported nine major aircraft campaigns and a continuum of engineering, data system and satcom updates and improvements. The nine major aircraft campaigns were as follows:

ND-MAX (An ASP fully reimbursable field campaign based in Germany)
NASA's ongoing research into what happens with engine performance, emissions and contrail formation when you use different types of fuels in jets. The international collaboration will use the German Aerospace Center (DLR)'s Advanced Technology Research Aircraft (ATRA) A320 aircraft burning alternative biofuels, while the DC-8 trailed a safe distance behind, sampling and analyzing gases and particles within the ATRA's wake.

OIB Spring (has been occurring yearly since 2010)
Using a fleet of research aircraft, NASA's Operation IceBridge images Earth's polar ice to better understand connections between polar regions and the global climate system. IceBridge studies annual changes in thickness of sea ice, glaciers and ice sheets. ICEBridge bridges the gap between the ICESat missions.

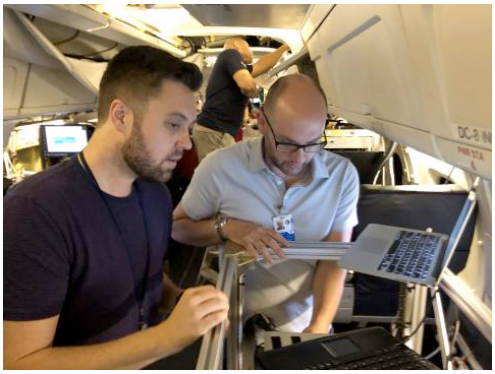
NAAMES 4
This was the final installation of the 5-year study, as part of the EV-S projects. The North Atlantic Aerosols and Marine Ecosystems Study (NAAMES) is a five-year investigation to resolve key processes controlling ocean system function, their influences on atmospheric aerosols, and clouds and their implications for climate.

ACT America 4
This was the fourth out of five campaigns, as part of the EV-S projects. Atmospheric Carbon and Transport – America, will conduct five airborne campaigns across three regions in the eastern United States to study the transport and fluxes of atmospheric carbon dioxide and methane.

AToM 4 This was the final installation of the 5 year study, as part of the EV-S projects.

Atmospheric Carbon and Transport – America, conducted five airborne campaigns across three regions in the eastern United States to study the transport and fluxes of atmospheric carbon dioxide and methane.

HIWC II - An ASP fully reimbursable field campaign.
The goal for this NASA-led research campaign, which also involved the FAA, The Boeing Company, and other industry partners, was to record both instrumented weather and standard radar data as the plane flew in known HIWC conditions, and then see if by comparing the data a potential HIWC radar signature could be identified.



Steve Schill (left), Aircraft IT) and Joe Kattich (right) of the SP2 instrument team onboard the DC-8 during FIREX-AQ mission.

ORACLES 3. This was the final installation of the 5-year study, as part of the EV-S projects.
ORACLES (ObseRvations of Aerosols above CLouds and their intEractionS) is a five-year investigation with three Intensive Observation Periods (IOP) designed to study key processes that determine the climate impacts of African BB aerosols.

OIB Antarctica (occurring yearly since 2009)
Using a fleet of research aircraft, NASA's Operation IceBridge images Earth's polar ice to better understand connections between polar regions and the global climate system. IceBridge studies annual changes in thickness of sea ice, glaciers and ice sheets. ICEBridge bridges the gap between the ICESat missions.

<u>Aircraft Specific Engineering Accomplishments</u>

- DC-8 Specific Engineering and Data and Satcom System Accomplishments: Implemented an ADS-B based system for tracking of nearby aircraft by the DC-8 Housekeeping data system. This system utilizes a Raspberry Pi and RealTek Software Defined Radio chipset along with the open source Stratux ADS-B software, resulting an extremely cost-effective way of ingesting low-latency position and velocity data from nearby aircraft. System currently mounts via suction cup to a cockpit window; options for permanent antenna placement which would increase system range to 150+nm are being investigated; Began initial testing of integrating the FlightAware XML API with ADS-B system, allowing the retrieval of additional traffic information (Aircraft types, destination and flightplan) to supplement the data available via ADS-B; Continued work to permanently integrate ADS-B and Foreflight with the housekeeping data system;
    - ✦ Investigated antenna and RF Splitter options for 360 degree coverage.
    - ✦ Discussed potential applications during the HIWC campaign.
    - ✦ Designed a system for generating second-by-second real-time prediction of aircraft exhaust plume advection. By plotting these plume predictions on the DC-8 aircraft map. This system allowed ND-MAX to quickly and repeatedly locate the exhaust plumes of the D-ATRA and other commercial aircraft even in non-contrailing conditions. Science and flight crew have been very pleased;
    - ✦ Began investigating possibilities for using the Stratux software to tightly integrate the pilot's iPads/ Foreflight Electronic Flight Bag (EFB) software with the NSRC data system software. DC-8 flight crew and NAAMES mission science have expressed significant interest in this capability;
    - ✦ Developed template and details for stress reports for minor instrument and hardware installations on the DC-8;
    - ✦ Designed and made drawing for DC-8 forward cargo compartment ventilation tube end cap that splits cooling tube into three separate tubes;

Adam Webster (left) and Dave Van Gilst in the engineering lab during FIREX-AQ.

- ✦ Provided design input, pictures of DC-8 hardware and aircraft structure, and participated in telecons to discuss integrating Hight Altitude Lidar Observatory (HALO) instrument on DC-8 in the future. In particular, discussions were regarding how to best fit the instrument to the DC-8 nadir ports;
- ✦ Participated through the Mechanical Engineering (ME) team in DC-8 discussions and created methods for moving forward regarding new restrictions on certain rack loading limits;
- ✦ Started, through the data systems team, a comprehensive revamp of our onboard video recording and distribution capability, partially in response to our new 4K cameras. Improvements that will be addressed are:
  - ★ Rework of Motion JPEG (MJPEG) distribution to support authentication and improved reliability;
  - ★ Adding support of H.264 / WebRTC video distribution;
  - ★ Improved recording software, supporting clipping of stationary/non-flight video;
  - ★ Redundant recording to removable media; and
  - ★ Simpler transmission of low-rate imagery to the ground.
- ✦ Continued updates to onboard real-time mapping capabilities;
- ✦ Continued updates to onboard systems in anticipation of new IT Security requirements; and
- ✦ Continued work with Multi-path Transmission Control Protocal (MPTCP) on Iridium-only missions.

- ER-2 Specific Engineering and Data and Satcom System Accomplishments
  - ✦ Provided backup data systems support; and
  - ✦ Participated in ER-2 tracking camera requirements gathering; began work on satcom segment and pilot display components.
- P-3 Specific Engineering and Data and Satcom System Accomplishments
  - ✦ Cleaned and reintegrated P-3 data system in new rack.
  - ✦ Worked on design of permanent P-3 data system installation on the P-3B:
  - ✦ Met with Wallops Flight Facility (WFF) personnel to discuss a path forward for finally getting some portion of the data system permanently installed on the P-3. With miniaturization that has occurred over the years, we are now able to move away from a rack-based setup, which will allow us to cut weight and install in the existing P-3 infrastructure
  - ✦ Gathered initial requirements and created tentative schedule for mechanical engineering support needed for permanent installation of data system on the P-3.
  - ✦ Continued to investigate paths for improving the housekeeping water vapor measurement; and
  - ✦ Provided, through the ME team a quick turnaround structural analysis of fasteners on the B-200 seat pair installation on the P-3, in time for the final ORACLES deployment. Discussed using that analysis as a basis for a fuller analysis to be completed later.
- C-130 Specific Engineering and Data and Satcom System Accomplishments
  - ✦ C-130 436

★ Provided information for modifications required for new Buck hygrometer installation

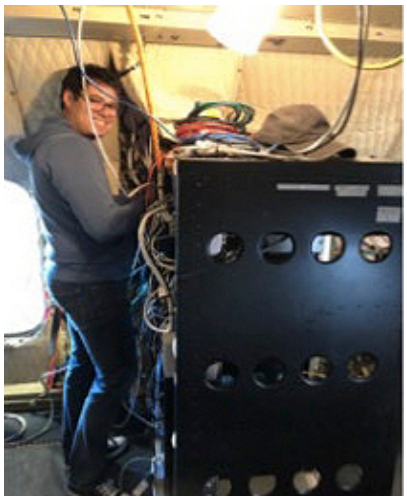
C-130 439

★ Created a drawing for the Aventech Research, Inc. (ARIM) 200 probe mount to be modified, and had the shop perform the modification before being sent to WFF (for use on the C-130 (N439NA) for NAAMES 2018);
★ Created model and drawing for blankoff plates to be used to cover holes left behind when Total Air Temperature (TAT) and hygrometer hardware is removed from aircraft. Parts were sent out for fabrication;
★ Created model and drawing for temperature element sensor replica plug to be inserted into TAT inlet when data is not required. Parts were sent out for fabrication; and
★ Collected drawings for antennas on C-130 (N439NA) that need blankoff plates when the antennas are removed from the aircraft

- Global Hawk Specific Engineering
  - ★ Dedicated approximately 12 hours to the maintenance of Global Hawk IT Security infrastructure in September. This number is expected to come down as systems are brought up to date with other ASP IT systems.
- AFRC B200 Specific Engineering
  - ★ Helped assess the feasibility of integrating the Scanning L-band Active/Passive (SLAP) instrument onto the Armstrong Flight Research Center (AFRC) B200 (N801NA) in time for a summer deployment. Attended meetings regarding SLAP's mechanical drawings, structural analysis, and past integrations on the Langley B200 and UC-12
- G-V Specific Engineering and Dat and Satcom System Accomplishments
  - ★ Showed an engineer from Johnson Space Center (JSC) working on the new G-V the various window assemblies used on the DC-8, the DC-8 window frame structures, and the environmental lab for testing windows. Discussed how windows are built and tested for the DC-8.

<u>Overall ASP Development Work</u>

- Met (the data system team) with Langley personnel to define new requirements for metadata submission to improve long-term data archiving;
- Evaluated failures of Edgetech Dew Point instruments, investigation of alternatives;
- Updated engineering documentation for DC-8 housekeeping rack;
- Worked 4K Camera Install for DC-8;
- Investigated alternative options for in field data archiving technologies;
- Continued work to increase ASP-Archive available disk space;
- Started an update of the NSRC provided API for accessing real-time instrument and housekeeping data, implementing shared-memory caching for performance improvements and moving off of the now-deprecated Pyramids web development framework. This work will continue for the next couple months, and will enable



Sebastian Rainer works on instrument integration oon the P-3 in preparation for IMPACTS mission, commencing 2020.

further upgrades to other data system software, as well as significant performance improvements to numerous other services that rely on this Application Programming Interface (API);

- Investigated optimal toolset for web-based plotting of data for integration with the onboard data system.
- Worked to build an API and toolsets for real-time import of ASP data into common data analysis packages in common use by our client base, such as IGOR, Matlab, Python and R.
- Continued work to improve remote management of autonomous OIB Camera/Tracking/X-Chat system, with a specific focus on remotely managing the electronic focus on the cameras so as to reduce load on personnel in the field;
- Implemented a very cost-effective sub-metre GPS based on the Novatel OEMv2 board and RTKLib software. Initially implemented to support the ND-MAX Campaign, this capability is intended to become a permanent facility instrument;
- Began design of a low-cost, permanent system for integrating Long Term Evolution (LTE) internet with the onboard network to support ground operations as a potential replacement for the portable "Mifi" units that currently get used. Intent is to try and provide a permanent system with known capabilities and a real antenna to reduce the current firedrill associated with acquiring and operating these units in the field;
- Assembled updated permanent fly away kits for DC-8 and P-3.
- Made several improvements to video handling tools to support 4K cameras, improving recording and onboard distribution; and
- Continued decommissioning of C130 N429NA; parts are still coming off and being returned to NSRC.

IT Infrastructure Management Activities

- Applied patches associated with the Spectre / Meltdown vulnerabilities;
- Provided consulting to staff managing NSRC configured servers in the GHOC to patch various outstanding vulnerabilities;
- Visited (Steven Schill) Ames to assist Finch with moving systems to a new rack and cleaning up existing wiring;
- Worked (Eric Stith) with Finch to address crashes in the existing ASP Modem server infrastructure;
- Worked to identify an upgrade path for the current servers that are nearing the end of useful life;
- Worked with ConnectTech to record LN-251 data through their bluestorm cards, removing the need for a separate USB RS-422 adapter and allowing us to upgrade systems to newer linux kernels;
- Began investigating options for replacing MotionJPEG with WebRTC and H.264 in onboard video systems to improve frame-rate and reduce bandwidth.
- Setup a new ground-based Internet Relay Chat (IRC) Server for NASA Activities, and linked it to the NCAR IRC Server. This change is intended to reduce the risk of downtime caused by IT changes made outside of our change control process.
- Completed upgrade of ASP-Archive with an additional disk storage, allowing for a potential of up to 36 TB of archive space; We are currently limited to 16 TB by the OS installed, and will need to complete that work in the next couple of months.
- Investigated potential replacements for modem servers. There are a number of potential routes forward here, some of which might allow us to eliminate our own modem infrastructure entirely. It will probably be a couple months before we can bring this to a conclusion.

Ground infrastructure at Ames

- We identified some nominal paths forward for a number of things, in particular:
- Asp-interface-1/2/archive replacement. Significant consolidation is possible here while improving redundancy;
- Some aspects of a planned aircraft test / simulation environment; and
- A path forward for full encryption / access control for Inmarsat Broadband Global Area Network (BGAN) traffic

IT Security

- Worked extensively to bring our laptops and server infrastructure into compliance with the new NASA SINS / UD policies. This has included both an extensive amount of systems administration work and NSRC staff completing required System for Administration, Training, and Educational Resources for NASA (SATERN) trainings in accordance with new IT security plan;
- Upgraded work laptops, and traveled to NASA Ames for completion of domain attaching computers to the network and setting up required software;
- Met (Van Gilst) with NASA Ames research center personnel who will be involved in the writing of a new IT Security plan.

Education and Outreach Activities

Applied Remote Sensing Training (ARSET)

Project Participants

BAERI: Cindy Schmidt, 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, starting with the fundamentals of remote sensing, to finding and downloading NASA data, and then on to processing and analyzing data within a geospatial software for decision-making. All of our materials are freely available in both English and Spanish on the ARSET website: https://arset.gsfc.nasa.gov/

Accomplishments

- Trainings Conducted:
  - *Remote Sensing for Conservation and Biodiversity* (Jan 2019): The United Nations Millennium Ecosystem Assessment states: “ecosystems are critical to human well-being - to our health, our prosperity, our security, and to our social and cultural identity.” Conservation and biodiversity management play important roles in maintaining healthy ecosystems. Earth observations can help with these efforts. This online webinar series introduced participants to the use of satellite data for conservation and biodiversity applications. The series highlighted specific projects that have successfully used satellite data. Examples included: monitoring chimpanzee habitat loss, decreasing whale mortality, detecting penguins, monitoring wildfires, and biodiversity observation networks.
  - *Investigating Time Series of Satellite Imagery* (April 2019): Evaluation of satellite imagery for an area over time can be used to identify trends and changes. This type of time series analysis can be used to assess forest disturbance, land cover changes, vegetation health, and agriculture monitoring and expansion. NASA Earth observations can provide long-term records from Landsat, and frequent imagery from sensors including MODIS. This training focused on two tools, AppEEARS from the LPDAAC and LandTrendr via Google Earth Engine (GEE). AppEEARS enables users to integrate point or polygon ground-based data with satellite imagery. The GEE implementation of LandTrendr enables users to analyze land cover dynamics, including short-term disturbances and long-term trends. Both sessions featured a lecture, followed by time for hands-on exercises and questions.
  - *Remote Sensing for Monitoring Land Degradation and Sustainable Cities SDGs* (July 2019): The Sustainable Development Goals (SDGs) are an urgent call for action by countries to preserve our oceans and forests, reduce inequality, and spur economic growth. The land management SDGs call for consistent tracking of land cover metrics. These metrics include productivity, land cover, soil carbon, urban expansion, and more. This webinar series highlighted a tool that uses NASA Earth Observations to track land degradation and urban development that meet the appropriate SDG targets. In this training, attendees learned to use a freely-available QGIS plugin, Trends.Earth, created by Conservation International (CI). The training included guest speakers from the United Nations Convention to Combat Desertification (UNCCD) and UN Habitat. Trends.Earth allows users to plot time series of key land change indicators. Attendees learned to produce maps and figures to support monitoring and reporting on land degradation, improvement, and urbanization for SDG indicators 15.3.1 and 11.3.1. Each part of the webinar series featured a presentation, hands-on exercise, and time for the speaker to answer live questions.

- *Remote Sensing for Freshwater Habitats* (September 2019): Freshwater habitats play an important role in ecological function and biodiversity. Remote sensing of these ecosystems is primarily tied to observations of the drivers of biodiversity and ecosystem health. Remote sensing can be used to understand things like land use and land cover change in a watershed, habitat connectivity along a water body, water body location and extent, and water quality parameters. This webinar series guided participants through using NASA Earth observations for habitat monitoring, specifically for freshwater fish and other species. The training also provided a conceptual overview, as well as the tools and techniques for applying landscape environmental variables to genetic and habitat diversity in species.
- *New Sensor Highlight*: ECOSTRESS (November 2019): This webinar focused on a NASA instrument that was launched and installed on the International Space Station in Summer 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. The primary science and applications mission of ECOSTRESS is to address three critical questions around vegetation health and agriculture: (1) How is the terrestrial biosphere responding to changes in water availability? (2) How do changes in diurnal vegetation water stress impact the global carbon cycle? (3) Can agricultural vulnerability be reduced through advanced monitoring of agricultural water consumptive use and improved drought estimation.

Publications

Prados, A., A. Carleton-Hug, P. Gupta, A. Mehta, B. Blevins, C. Schmidt, A. McCullum, D. Barbato, E. Hook, E. Podest, M. Follette-Cook, S. Hudson-Odi, and T. Kinsey. 2019. Impact of the ARSET Program on Use of Remote Sensing Data, Internantional Journal of Geo-Information, 8 (6): 261. https://doi.org/10.3390/ijgi8060261

Presentations

ARSET Program @ the NASA Hyperwall, ASPRS Annual Meeting, Oct. 6-11, Baltimore, MD. [Authors unknown]

California State University at Monterey Bay (CSUMB) Educational Program

Project Participants

CSUMB: Susan Alexander, Kenneth Weinstock
CSUMB Students: Sahana Bojorquez, Will Carrara, Josue Duque, Patrick Lopez, Nicole Lykfers, Arev Markarian, Israel Mandujano Olivera
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, or 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; and
- Communicate results of our scientific activities through community outreach events, conferences, publications, and other venues.

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, Conor Doherty, and Will Carrera conducted research and assisted with field activities under the mentorship of ARC CREST Senior Scientists Forrest Melton and Lee Johnson and ARC CREST Research Scientist Tian Xin Wang.
  - 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 Arev Markovian was a member of the American Somoa Water Resources Team through her DEVELOP internship at NASA ARC under the supervision of Dr. Juan Torres-Perez and Farnaz Bayat.
- Education Support Products and Benefits:
  - Provided hardware/software support and mentoring for 10+ students participating in the DEVELOP Summer 2019 session and year-round support for permanent DEVELOP staff and project teams during the spring and fall sessions. Installed three new Dell Precision T3620 systems. Upgraded 10 older DEVELOP computer systems from Windows 7 to Windows 10 as Windows 7 support ends on January 14, 2020;
  - Provided mentoring and IT support to 8 summer interns associated with the NASA/San Jose State University Center for Applied Atmospheric Research and Education program (CAARE) which is co-located in N-242 with the DEVELOP intern program;
  - Provided year-round large-format poster graphics output support for scientific meetings with large effort prior to the AGU Fall Meeting for both the Earth Science and Space Science Divisions;
  - Major focus on replacing obsolete Coop computer systems to meet new NASA configuration and security requirements. Update all Windows desktop systems to current NASA support level of Windows 10 version 1809 and Macintosh systems to OS version 10.14.6 ;
  - Began transitioning IT support from ARC-CREST to an on-site contract supporting the Earth Science and Space Science divisions as ARC-CREST Education staff member (Weinstock) will be retiring at the end of CY2019;

Presentations

Will Carrara (right) presented his student research to staff and members of the California State Legislature at the California State University (CSU) Agricultural Research Institute (ARI) Legislative Briefing on October 24, 2019 in Sacramento, CA. Will's research focuses on multi-sensor satellite data fusion for irrigation management applications. Will's research has been part of a project led by CSUMB, and support by CSU ARI, that is focused on quantifying the benefits of data-driven approaches for management of irrigation and fertilizer. Will anticipates graduating with a B.S. degree in computer science in December, 2019 and plans to continue his research as a software engineer at NASA Ames Research Center, working under the Cooperative Agreement between CSUMB and NASA Ames Research Center.

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 creates capacity for young professional from diverse academic backgrounds (undergraduate, graduates and recent graduates) on the use of remote sensing and GIS to assess environmental problems.

Accomplishments

The Ames projects during the past year have included a wide range of themes such as water availability and lithium mining in Chile, water quality and coral reefs in American Samoa and West Maui, land use and land cover changes in Hawaii, and coal mining in Wyoming, among others.

Presentations

The projects conducted during each term (Spring, Summer and Fall) were presented to the Ames Earth Sciences Division community. Additionally, the DEVELOP National Program Office conducts a one-day closeout in NASA Headquarters in August and representatives from Ames DEVELOP presented the project outcomes to the broader NASA community. Several presentations were also conducted in national meetings.

Panels or Committees

NASA SpaceApps competition judge

Awards

Several Certificates of Appreciation for mentoring DEVELOP projects. These Certificates are given by the DEVELOP National Program Office at the end of each term.

SARP

NASA: [Jack Kaye, Bruce Tagg]
BAERI: Emily Schaller

Project Description

The Student Airborne Research Program (SARP) is an eight-week summer program for rising senior undergraduate students to acquire hands-on research experience in all aspects of a scientific campaign using one or more NASA Airborne Science Program flying science laboratories.

The eleventh annual SARP took place June 16-August 9 at the NASA Armstrong Flight Research Center and the University of California, Irvine. SARP provides a unique opportunity for rising senior undergraduate students majoring in science, mathematics or engineering fields to participate in a NASA Airborne Science research campaign. SARP's goal is to stimulate interest in NASA's Earth Science research and aid in the recruitment and training of the next generation of scientists and engineers, many of whom had their first hands-on research experience during this program.

2019 SARP students and DC-8

The 28 SARP 2019 participants came from 28 different colleges and universities in 20 different states. They were competitively selected based on their outstanding academic performance, future career plans, and interest in Earth system science. The students flew onboard the NASA DC-8 where they sampled and measured atmospheric gases to study pollution and air quality. The DC-8 flew over dairies, oil fields and wineries in the San Joaquin Valley and the Los Angeles basin, as well as the Salton Sea at altitudes as low as 1,000 feet in order to collect air samples and measure atmospheric gases.

During the SARP flights, the DC-8 was preparing for the FIREX-AQ campaign, which is studying the impacts of U.S. wild res and agricultural res on air quality and climate. The DC-8 carried the full scientific payload for FIREX-AQ for the SARP flights, providing a multi-benefit opportunity for the science team to test their instruments, collect data over a variety of sources and topography, and to mentor students at the same time.

Students also used data from a remote-sensing instrument (AVIRIS- NG) on a King Air B-200, owned and operated by Dynamic Aviation, to study drought, re burn scars and post-fire mud flows in Southern California, along with ocean biology along the California coast. In addition to airborne data collection, students took measurements at field sites near Santa Barbara, Fresno and the Salton Sea.

The final six weeks of the program took place at the University of California Irvine where students analyzed and interpreted data collected aboard the aircraft and in the eld. From this data analysis, each student developed a re- search project based on his or her individual area of interest. In addition to the new data collected during the program, students had the opportunity to use data gathered by SARP participants in previous years, as well as data from other NASA aircraft and satellite missions. Four students submitted conference abstracts to present the results of their SARP research at a future American Geophysical Union Fall Meeting.

SARP Program Manager, Emily Schaller, receiving two NASA Ames Honor Awards: (left) Group Achievement for SARP, and (right) Exceptional Public Service Medal, Nov. 7, 2019. Presenting the awards were Mr. Clayton Turner, Deputy Director for NASA Langley Research Cemter and (right) Dr. Eugene Tu, NASA Ames Center Director.

Publications and Presentations

Publications

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Presentations

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Johnson, L. 2019. Co-organizer for UCCE Field Day for about 40 cauliflower growers in Salinas, CA and presenter on results of field trials and integration of data from SIMS in CropManage, Salinas, CA.

Johnson, L., M. Cahn, and S. Benzen. 2018. Evapotranspiration-based irrigation scheduling in cool season vegetables. AGU Fall Meeting, Dec. 10-14, Washington (#H43G-2535)

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Kulawik, S. 2019. Intensive Scans over Dallas, GeoCarb breakout meeting, U.S. Climate and Variability and Predictability, Oct. 1-3, Boulder, CO.

Kulawik, S., V. Payne, E. V. Fischer, K.W. Bowman. 2019. Improved Aura-TES PAN retrievals for increased sensitivity to low PAN values, Aura meeting, Aug. 27-29, Pasadena, CA.

Li, S., W. Weile, H. Hirofumi, T. Vandal, Y. Jing, and R. Nemani. 2019. Surface Reflectance Product from Geostationary Satellite, AGU Fall Meeting, Dec. 9-13, San Francisco, CA.

LeBlanc, S., et al. 2019. Above cloud AOD changes between 2016, 2017, and 2018, ORACLES Science Team Meeting, May 14-15, Miami, FL.

LeBlanc, S., et al. 2019. Aerosol above cloud, optical depth, and direct radiative effect in the southeast Atlantic, Session A11N: Cloud-aerosol-radiation-climate interactions in the southeast Atlantic II Posters, AGU Fall Meeting, Dec. 9-13, San Francisco, CA.

LeBlanc S., et al. 2019. Airborne Observations Above Cloud Aerosol Optical Depth in the Southeast Atlantic during biomass burning seasons over 3 years. Session AS1.41: Aerosols, radiation and clouds over the southeast Atlantic, European Geophysical Union General Assembly, April 7-12, Vienna, Austria.

LeBlanc, S., et al. 2019. Quantifying Cloud Radiative Effects with Overlying Aerosol using Hyperspectral Transmitted Light, Hyperspectral Imaging and Sensing of the Environment, paper HW5C.3, June 25-27, San Jose, CA.

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Marley, A., A. McCullum, and C. McClellan. 2019. Snowpack and Drought Monitoring on the Navajo Nation Using NASA Earth Observations, AGU Fall Meeting, Dec. 9-13, San Francisco, CA.

Matthews, E., M. Johnson, V. Genovese, and C. C. Treat. 2019. Methane from high-latitude wetlands, lakes and reservoirs: Mutually-exclusive source data and emissions, AGU Fall Meeting, Dec. 9-13, San Francisco, CA.

McClellan, C., A. McCullum, and C. Schmidt. 2019. Navajo Storytelling and NASA Earth Science, AGU Fall Meeting, Dec. 9-13, San Francisco, CA.

McCullum, A., R. Green, and C. McClellan. 2019. Satellite-based Drought Reporting on the Navajo Nation, NASA Water Resources Annual Meeting, July 16-19, Portland, OR.

McCullum, A., C. McClellan, B. Daudert, and J. Huntington. 2019. Satellite-based Drought Reporting on the Navajo Nation, ASPRS Annual Meeting, Oct. 6-11, Baltimore, MD.

McCullum, A., C. McClellan, J. Huntington, and B. Daudert. 2019. A partner-driven water resource management tool on the Navajo Nation, AGU Fall Meeting, Dec. 9-13, San Francisco, CA.

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Melendy, L., S.C. Hagen, S. Saatchi, Y. Yu, G.M. Domke, B.F. Walters, R. Nemani, S. Ganguly, A. Bloom, S. Li, S. and Y. Yang. 2019. Net Carbon Change: Emissions and Attribution for US Forests in 2005-2016. AGU Fall Meeting, Dec. 9-13, San Francisco, CA.

Melton, F., et al., 2019. Remote sensing applications for vineyard management. National Grape Research Alliance Annual Meeting, Nov. 12, Sacramento, CA.

Melton et al., 2018. OpenET: Filling the biggest gap in water data for the Western U.S. AGU Fall Meeting, Dec. 10-14, Washington, D.C. (#H53B-07).

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Melton, F., A. Guzman, I. Zaragosa, T. Wang, L. Johnson, J. Huntington, and C. Morton. 2019. Satellite Mapping of Agricultural Land Fallowing for Drought Impact Assessment and Decision Support. NASA Water Resources Annual Meeting, July 17, 2019, Portland, OR.

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.

Murray, B., A. McCullum, and K. Sousa. 2019. Cross-Cultural Scientific Investigation: Connecting Indigenous Knowledge with Satellites, National Adaptation Forum, April 23-25, Madison WI.

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.

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., 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.

Nita, G.M., V.M.Sadykov, A.G. Kosovichev, and V. Oria. 2019. A Generalized Spectral Kurtosis Solar Image Variability Descriptor. AGU Fall meeting, Dec. 9-13, San Francisco, CA.

Park, T., S. Ganguly, S. Li, and R. Nemani. 2019. Tree cover delineation for CONUS from 1-m NAIP imagery, NASA CMS Science Team Meeting, Nov. 12-14, La Jolla, CA.

Park, T., R. B. Myneni, and Y. Knyazikhin. 2019. Disturbance, cultivation, and climate drive a widespread North American vegetation greening. AGU Fall Meeting, Dec. 9-13, San Francisco, CA.

Pistone, K., et al. 2019. Intercomparison of biomass burning aerosol properties from in-situ and remote-sensing instruments in ORACLES-2016. Talk: European Geophysical Union General Assembly, April 7-12, Vienna, Austria.

Pistone, K. 2019. When there are different types of smoke in the sky it changes how the sun light goes through the sky? (Talk: Up-Goer Five Science Communication Challenge session), AGU Fall Meeting, Dec. 9-13, San Francisco, CA.

Pistone, K. , I. Eisenman, and V. Ramanathan. 2019. Radiative impacts of Arctic sea ice melt. Talk: 32nd CERES Science Team Meeting, Oct. 29-31, Lawrence Berkeley National Laboratory, Berkeley, CA.

Pistone, K., I. Eisenman, and V. Ramanathan. 2019. Radiative impacts of Arctic sea ice melt: using observations to inform future climate effects. Talk: AGU Fall Meeting, Dec. 9-13, San Francisco, CA.

Pistone, K., et al. 2018. Aerosol optical properties from 4STAR sky scans, 2016-2018. Talk: ORACLES Science Team Meeting, May 14-15, Miami, FL.

Poulter, B., S. Serbin, and W. Wang. 2019. The SBG modeling working group report, SBG Community Workshop, June 12-14, Washington DC.

Sadykov, V. M. 2019. Multi-wavelength Investigation of Energy Release and Chromospheric Evaporation in Solar Flares. American Astronomical Society Meeting #234, id. 310.06. Bulletin of the American Astronomical Society, 51 (4).

Sadykov, V. 2019. Predicting Solar Flares Using Machine Learning: Advances and Challenges (SH34B-05). AGU Fall meeting, Dec. 9-13, San Francisco, CA.

Sadykov, V. M., I. Kitiashvili, and A.G. Kosovichev. 2019. Cluster analysis of spectroscopic line profiles in RMHD simulations and observations of the solar atmosphere. Solar Atmospheric and Interplanetary Environment (SHINE 2019), Aug. 5-9, Boulder, CO. https://shinecon.org/CurrentMeeting.php, id.11

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Sadykov, V., A. Kosovichev, I. Kitiashvili. 2019. Enhancement of Binary and Probabilistic SWPC NOAA Flare Forecast by Using Machine Learning Algorithms. Space Weather Workshop, April 1-5, Boulder, CO.

Sadykov, V.M., A.G. Kosovichev, and I.N. Kitiashvili. 2019. Cluster analysis of spectroscopic line profiles and EUV emission in RMHD simulations and observations of the solar atmosphere. Data Mining Lab workshop at Georgia State University, Oct. 1-2, Atlanta GA.

Schmidt, C. 2019. Earth observations for global biodiversity monitoring ,The GEO Biodiversity Observation Network, PECORA Conference, Baltimore, MD, Oct. 6-11, Baltimore, MD.

Schmidt, C., et al. 2019. Panel Discusion: The Role of GIS in Land Acknowledgement. Earth Observations for Conservation, 22nd Annual Society for Conservation GIS Conference, July 15-17, Pacific Grove, CA.

Schmidt, C., and A. McCullum. 2019. Connecting NASA's Capacity Building Program to Indigenous Communities, SACNAS Annual Meeting, Oct. 21-Nov.2, Honolulu, HI.

Schmidt, C., and A. McCullum. 2019. Web-based Climate Adaptation Planning Tools, NASA's Tribes and Resilience Resources, Tribal Leaders Summit, Sept. 3-5, Bismarck, ND.

Schoenung, S., M. Fladeland, and B. Tagg. 2019. NASA Airborne Science Contributions to Continuous Earth Monitoring, 38th ISRSE Conference, Oct. 6-11, Baltimore, MD.

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

Vandal, T., K.Duffy, and R. Nemani. 2019. Deep Learning and Uncertainty Quantification For Climate Resilience. INFORMS Annual Meeting. Oct. 20-23, Seattle, WA.

Vandal, T., S. Li, W. Wang, and R. Nemani. 2019. Transfer Learning to Generate True Color Images from GOES-16, AGU Fall Meeting, Dec. 9-13, San Francisco, CA.

Vandal, T. and R. Nemani. 2019. Estimating Optical Flows in Satellite Imagery, Space Lidar Winds Working Group Meeting, National Institute for Aerospace, Mar. 21-23, Hampton, VA.

Vandal, T., R. Nemani, W. Wang, and S. Li. 2019. Transfer Learning to Generate True Color Images from GOES-16. AGU Fall Meeting, Dec. 9-13, San Francisco, CA.

Vandal, T., R. Nemani and S. Ganguly. 2019. Enhancing Climate Data with Deep Learning, First Workshop on Leveraging AI in the Exploitation of Satellite Earth Observations and Numerical Weather Prediction, April 23-25, NOAA Center for Weather and Climate Prediction, College Park, MD.

Vanderbilt, V., C. Daughtry, and R. Dahlgren. 2019. Polarization to Estimate Leaf Surface Reflectance, SPIE Conference (Proc. SPIE. 11132), Polarization Science and Remote Sensing IX, Sept. 6, San Diego, CA.

Vargas, R., S. Li, and R. Nemani. 2019. Validation of tree cover maps across Mexico. AGU Fall Meeting, Dec. 9-13, San Francisco, CA.

Wang, T., F.S. Melton, F. Cassel-Sharma, D. Goorahoo, T. Thao, and A. Garcia. 2018. Intercomparison of Evapotranspiration Measurement Methods for Vegetable Crops in California (Abstracts). AGU Fall Meeting, Dec. 10-14, Washington, D.C.

Wang, W., R. Nemani, J. Xiong, S. Li, S. Ganguly, A. Lyapustin, Y. Wang, P. Meyer, S. Kalluri, and G. Stark. (2019). Near real-time fire detection on OpenNEX with Geostationary data, LANCE UWG Meeting. April 17, Boulder, CO.

Weile, W., S. Li, H. Hirofumi, T. Hideaki, J. Dungan, K. Satya, and R Nemani. 2019. Generating Accurate and Consistent Top-of-Atmosphere Reflectance Products from the New Generation Geostationary Satellite Sensors, AGU Fall Meeting, Dec. 9-13, San Francisco, CA.

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Xu, B., L. Jing, T. Park, O. Liu, Y. Zeng, G. Yin, K. Yan, C. Chen, J. Zhao, W. Fan, and Y. Knyazikhin. 2019. Improving leaf area index retrieval over heterogeneous surface mixed with water. AGU Fall Meeting, Dec. 9-13, San Francisco, CA.

Yates, E.L., et al. 2019. Investigating the Processes Affecting Surface Air-Quality in California's Sierra Nevada Mountain Range, AGU Fall Meeting, Dec. 9-13, San Francisco, CA.

Yates, E.L., et al. 2019. The Alpha Jet Atmospheric EXperiment (AJAX): Past, Present, and Future Airborne Measurements, May 21-22, Boulder, CO.

Yu, Y., S. Saatchi, G.M. Domke, B.F. Walters, S. Li, R. Nemani, S. Hagen, L. Melendy, and R.E. McRoberts. 2019. Monitoring Changes in Aboveground Biomass Across U.S. Forestlands Using Satellite Observations and Forest Inventory Data. AGU Fall Meeting, Dec. 9-13, San Francisco, CA.

Zaragosa, I., F.S. Melton, A. Guzman, M. Hang, C. Rosevelt, B. Temesgen, J.L. Huntington, T. Wang, J. Brito, and P. Beale. 2018. Applications of Satellite Data to Assess Agricultural Production and Quantify Fallowed Agricultural Acreage during Drought Events in Washington and Nevada (Abstracts). AGU Fall Meeting, Dec. 10-14, Washington, D.C.

Zhao, J., and T. Hartlep. 2019. Deriving Three-Dimensional Sensitivity Kernels for Large-Scale Solar Interior Flows Using Wavefield Simulations, American Astronomical Society Meeting #234, June 9-13, St. Louis, MO.

Glossary

AATS - Ames Airborne Tracking Sun-photometer

ABI – Advanced Baseline Imager

ACCA - Automated Cropland Classification Algorithms

ACPD – Atmospheric Chemistry and Physics Discussions

ADS-B – Automatic Dependent Surveillance Broadcast

AEROCOM - Aerosols Modeling Inter-Comparison project

AERONET - AErosol RObotic NETwork

AESD - Ames Earth Science Division

AFRC - Armstrong Flight Research Center

AGB - Aboveground Biomass

AGU - American Geophysical Union

AHI – Advanced Himawari Imager

AI – Artificial Intelligence

AIA – Atmospheric Imaging Assembly

AIRS - Atmospheric Infrared Sounder

AIST - Advanced Information Systems Technology

AITT - Airborne Instrument Technology Transition

AJAX - Alpha Jet Atmospheric eXperiment

AMT – Atmospheric Measurement Techniques

AMWS – Applied Marine and Watershed Science

AOD – Aerosol Optical Depth

AOGS – Asia Oceania Geosciences Society

AOT – Aerosol Optical Thickness

ARMAS - Automated Radiation Measurements for Aerospace Safety

API – Application Programing Interface

ARC – Ames Research Center

ARISE - Arctic Radiation-IceBridge Sea and Ice Experiment

ARP - Annual Research Plan

ARSET Applied Remote Sensing Training

ASA – American Society of Agronomy

ASHS – American Society for Horticultural Science

ASP - Applied Sciences Program

ASRL - Allometric Scaling and Resource Limitations Model

ATom - Atmospheric Tomography Mission

ATRA – Advanced Technology Research Aircraft

AVIRIS - Airborne Visible/Infrared Imaging Spectrometer

AWS – Amazon Web Services

AWWS – American Water Works Association

BAER or BAERI – The Bay Area Environmental Research Institute

BB – Biomass Burning

BC - Black Carbon

BGAN – Broadband Global Area Network

BIA - Bureau of Indian Affairs

BLM – Bureau of Land Management

BRDF - Bidirectional reflectance distribution function

CAARE – Center for Applied Atmospheric Research and Education

CABOTS - California Baseline Ozone Transport Study

CALIOP - Cloud-Aerosol Lidar with Orthogonal Polarization

CALIPSO - Cloud Aersol Lidar and Infrared Pathfinder Satellite Observations

CalWater - California Water Service

CCN - Cloud Condensation Nuclei

CCST – CALIPSO Science Team

CDWR - California Department of Water Resources

CMIP5 - Coupled Model Intercomparison Project Phase 5

CMIS – Compact Micro-Imaging Spectrometer

CMS - Carbon Monitoring Systems

CN - Communications and Navigation

CoE - Centre of Excellence

COMEX - CO2 and Methane Experiment

CONUS – Continental United States

COSR – Canadian Oil Sands Region

CrIS – Cross-track Infrared Sounder

CRTF – Coral Reef Task Force

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

DAAC – Distributed Active Archive Center

DASC – Digital Avionics Systems Conference

D-ATRA – DLR Airbus A320-232

DARE - Direct Aerosol Radiative Effects

DASH-SP Differential Aerosol Sizing and Hygroscopicity Spectrometer Probe

DBW – Department of Boating and Motorways

DEVELOP - Digital Earth Virtual Environment and Learning Outreach Project

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

DOE – Department of Energy

DOAS - Differential Optical Absorption Spectroscopy

DRAAWP – Delta Region Area-wide Aquatic Weed Project

DSA – Distributed Spacecraft Autonomy

EAE - Extinction Angstrom Exponent

ECOSTRESS – ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station

EFB – Electronic Flight Bag

EMC – Electromagnetic Compatibility

ENSCI – Environmental Science (CSUMB)

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

ESPO - Earth Science Project Office

ESTO – Earth Science Technology Office

ESTEP – Environmental Science, Technology and Policy

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

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

FAA - Federal Aviation Administration

FALC – Fast Lagrangian Analysis of Continuity

FASMEE - Fire and Smoke Model Evaluation Experiment

FAV – Floating Aquatic Vegetation

FCC – Federal Communications Comissions

FDL – Frontiers Development Lab

FOV - Field-of-view

FPAR – Fraction of Absorbed Photosynthetically Active Radiation

FTS - Fourier Transform Spectrometer

GCMs - Global Climate Models

GEDI – Global Ecosystem Dynamics Investigation

GEO – Global Environment Outlook

GDDP – Global Daily Downscaled Projections

CDFA – California Department of Food and Agriculture

GDM – Generalized Dissimilarity Models

GEO-CAPE - GEOstationary Coastal and Air Pollution Events Mission

GHG – Greenhouse Gas(es)

GHOC – Global Hawk Operations Center

GIBS - Global Imagery Browse Services

GIS – Geographic Information System

GLAS - Geoscience Laser Altimeter System

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

GWIS - Global Wildfire Information System

HALO – High Latitude Lidar Observatory

HCN – Hydrogen cyanide

HEALPix – Hierarchical Equal Areal isoLatitude Pixelization

HIWC – High Ice Water Content

H-Q2O - High-Quality Optical Observations

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

HMI - Helioseismic and Magnetic Imager

HyspIRI - Hyperspectral Infrared Imager

IARPC - Interagency Arctic Research Policy Committee

ICES - Innovation Center for Earth Science

ICESat - Ice, Clouds, and Land Elevation Satellite

IECRS – Indian Environment Consulting and Research Services

IEEE – Institute of Electrical and Electronics Engineers

IGARRS - International Geoscience and Remote Sensing Symposium

ISRSE – International Symposium on Remote Sensing of the Environment

IOP – Intensive Observation Period

IRC – Internet Relay Chat

IRIS – Interface Region Imaging Spectrograph

IRT – Icing Research Tunnel

InVEST - In-Space Validation of Earth Science Technologies

IUCN - International Union for Conservation of Nature and Natural Resources

JAXA – Japan Aerospace Exploration Agency

JPEG – Joint Photographics Expert Group

JPL – Jet Propulsion Laboratory

JSC – Johnson Space Center

KORUS-AQ Korea U.S.-Air Quality

LAI – Leaf Area Index

LARGE - Langley Aerosol Research Group Experiment

LEO – Low Earth Orbit

LIDAR - Light Detection and Ranging

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

METRIC – Mapping EvapoTranspiration at high Resolution with Internalized Calibration

MFAM - Micro Fabricated Atomic Magnetometer

MHD – Magnetohydrodynamic

MJPEG – Motion JPEG

MMS - Meteorological Measurement System

MOC – MODIS OMI CALLIOP

MODIS – Moderate Resolution Imaging Spectroradiometer

MPTCP – Multi-Path Transmission Control Protocal

MSI - MultiSpectral Instrument

MTS - Mission Tools Software

MWIR – Mid-Wave Infrared

NAAMES - North Atlantic Aerosols and Marine Ecosystems Study

NAIP - National Agriculture Imagery Program

NAS – NASA Ames Supercomputing

NASA-CASA NASA-Carnegie-Ames-Stanford Approach

NASDAT NASA - Airborne Science Data And Telemetry System

NCEAS - National Center for Ecological Analysis and Synthesis

NDVI - Normalized Difference Vegetation Index

NCA – National Climate Assessment

NEX - NASA Earth Exchange

NIR – Near Infrared

NLTE – Non Local Thermodynamical Equilibrium

NASA ACCES – Advancing Collaborative Connections for Earth System Science

NOAA - National Oceanic and Atmospheric Administration

NRC - National Research Council

NSERC - National Suborbital Education and Research Center

NSTC - National Science & Technology Council

OCO-2 - Orbiting Carbon Observatory 2

OIB - Operation Ice Bridge

OLI – Operational Land Imager

OMI - Ozone Measuring Instrument

ORACLES - ObseRvations of Aerosols Above CLouds and their IntEractionS

ORNL – Oak Ridge National Laboratory

OSTP - Office of Science & Technology Policy

PALMS - Particle Analysis by Laser Mass Spectrometry

PAN – Peroxyocetyl nitrate

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

PSM – Professional Science Masters

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

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

ROSES – Research Opportunities in Earth and Space Science

SACNAS – Society for Advancing Chicanos/Native Americans in Science

SARP - Student Airborne Research Program

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

SBG – Surface Biology and Geography

SBIR – Small Business Innovation Research

SCBGP – Specialty Crop Block Grant Program

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

SGMA – Sustainable Ground water Management Act

SHOUT - Sending Hazards with Operational Unmanned Technology

SHINE - Solar Atmospheric and Interplanetary Environment

SIMS – Satellite Irrigation Management Support

SLAP – Scanning L-band Active/Passive

SMT - Spectral Matching Techniques

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

SSA - Single Scattering Albedo

SSEBop – (operational) Simplified Surface Energy Balance

STEM - Science, Technology, Engineering, or 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

TOA – Top of Atmosphere

TOAR - Total Ozone Assessment Report

TOPS – Terrestrial Observation and Prediction Systems

UAS – Unmanned Air Systems

UAV – Unmanned Aerial Vehicle

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

UNFCCC - UN Framework Convention on Climate Change

USCG – U.S. Coast Guard

USDA – U.S. Department of Agriculture

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

UTLS - Upper Tropospheric and Lower Stratospheric

UTM – Urchin Tracking Module

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

VIIRS – Visible Infrared Imaging Radiometer Suite

VPN – Virtual Private Network

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

WSNC – Western States Water Council

WIT - Wildfire Implementation Team

WUI – Wildland Urban Interface

WWAO – Western Water Applications Office

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