Seventh Year Progress Report for NASA Cooperative Agreement NNX12AD05A

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

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Period of Performance: 3/1/18 to 2/28/19

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. Accordingly, we present the following progress report for the seventh year of this Cooperative Agreement.

The primary task of ARC-CREST is to work cooperatively with NASA Ames Research Center's Earth Science Division and related groups to achieve NASA's strategic Earth Science objectives. These objectives include: (1) the conduct of research into fundamental questions related to the atmosphere, the oceans, the biosphere, and Earth's land masses; (2) the use of informational and computational sciences to visualize, analyze, and interpret Earth Science data; (3) the application of technology necessary for Earth Science research; and (4) the provision of outreach and education to the general public regarding Earth Science. In the seventh 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, study tropospheric ozone production, coastal ocean biology, space weather, solar physics, plant physiology, 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. Our scientists also continued to adapt NASA unmanned aerial vehicles (UAVs) for use in fighting forest fires.

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.

ARC-CREST Partners

Bay Area Environmental Research Institute
California State University at Monterey Bay
NASA Ames Research Center – Earth Sciences Division

ARC-CREST Staff

BAERI

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CSUMB

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NASA

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Gore, Warren
Guild, Liane
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Iraci, Laura
Jensen, Eric
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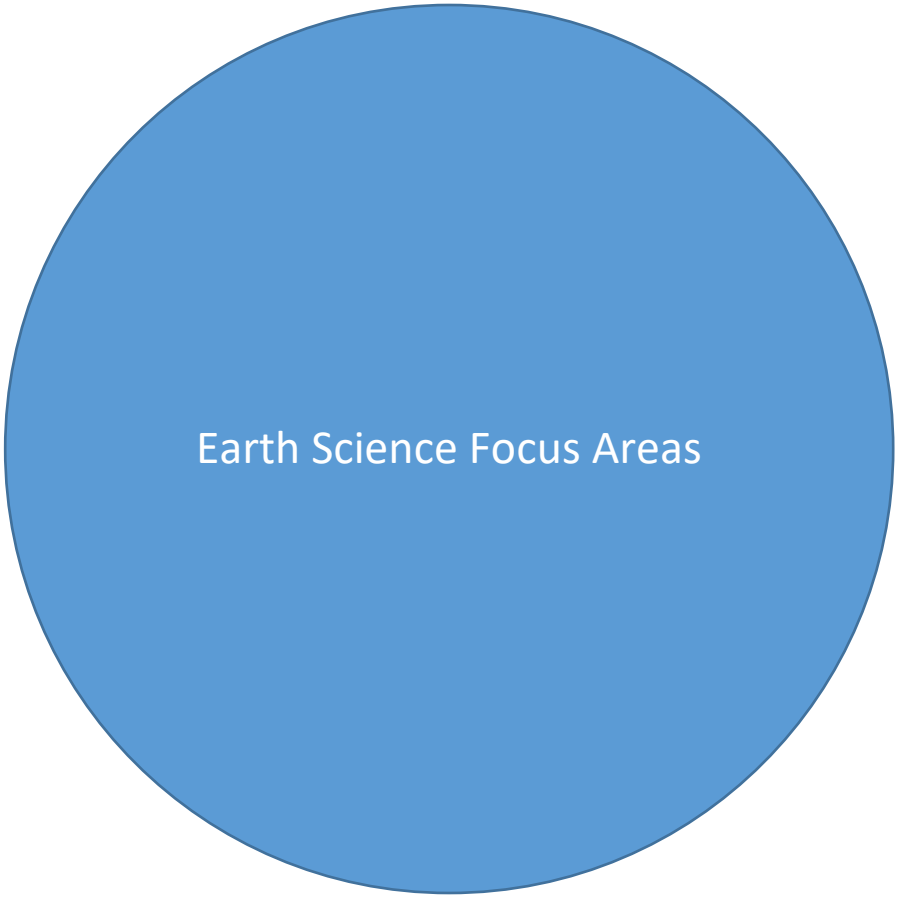
Mansour, Nagi
Murakami, David
Nemani, Rama
Payne, Vivienne
Pfister, Leonhard
Potter, Chris
Rios, Joey
Redemann, Jens
Scargle, Jeff
Scofield, Christine
Spackman, Ryan
Vasques, Marilyn
Worden, John


Earth Science Focus Areas

Aerosol Modeling

Project Participants

NASA: Mian Chin
BAERI: Qian Tan

Project Description

Aerosols are small particles suspended in the air. They can affect the air quality and climate in many ways. The vertical distribution of aerosols and their precursors can largely affect their lifetime and the magnitude of their impacts. The team studies this vertical distribution of aerosols and their precursors using both a global aerosol transport model and measurements from airborne and space-borne instruments. Multi-model comparison shows very large differences among simulated distribution of aerosols in the upper troposphere and lower stratosphere. This can lead to uncertainty in estimated source attribution and their climate impacts.

Accomplishments

- Compared simulated sulfate aerosols and SO_2 by 16 aerosol transport models from the Aerosols Modeling Inter-Comparison project (AEROCOM);
- Compared vertical distribution of aerosols from two space-borne LIDARs and tracked their transport; and
- Worked on a project to study the impact of soil moisture measured by a new satellite on the dust emission in Africa.

Publications and Presentations

Lau W. K. M., K-M Kim, J. Shi, T. Matsui, M. Chin, Q. Tan, C. Peters-Lidard, W. K. Tao, Impacts of aerosol–monsoon interaction on rainfall and circulation over Northern India and the Himalaya Foothills, *Climate Dynamics*, doi:10.1007/s00382-016-3430-y, 1-16, 2016.

Tan Q., M. Chin, V. Aquila, G. Chen, M. Hoepfner, the vertical profile of SO_2 seen by aircraft, satellite and models, Kaufman Symposium, June, 2016, NASA GSFC, Greenbelt, MD (poster)

Tan Q., M. Chin, V. Aquila, G. Chen, Evaluation of modeled vertical distribution of SO_2 and sulfate, AeroCom Workshop, Sept 2016, Beijing, China. (poster)

Tan Q., M. Chin, V. Aquila, G. Chen, Evaluation of modeled vertical distribution of atmospheric SO2 and sulfate, AGU Fall Meeting, Dec 2016, San Francisco, CA.

Aerosol Remote Sensing

Project Participants

NASA: Matthew Johnson, Sharon Burton, Jens Redemann
BAERI: Meloë Kacenelenbogen,Yohei Shinozuka, Qian Tan

Project Description

To improve the predictions of aerosol composition in chemical transport models (CTMs) and global climate models (GCMs), the team has developed a flexible aerosol classification algorithm (called Specified Clustering and Mahalanobis Classification, SCMC) that assigns an aerosol type to multi-parameter retrievals by spaceborne, airborne or ground based passive remote sensing instruments [Russell et al., 2014]. To date, the best product the team could infer from passive satellite observations is qualitative aerosol types (e.g., urban industrial, dark and white biomass burning smoke, see Table 1) from A-Train's Polarization and Directionality of Earth's Reflectances (POLDER) optical retrievals [Hasekamp et al., 2011].

These aerosol types are useful to provide spatial context to support other observations of aerosols and clouds, or to evaluate other aerosol type classifications. However, they need to be translated into
satellite-derived total column mass concentrations per chemical species to be consistent with model output, and hence, are effectively correct models. To this end, the team has translated aerosol type identifications into an averaged distribution of different chemical components (e.g., organic,
sulfate, black carbon, mineral, sea salt) by an extensive dataset of aerosol chemical and physical properties taken onboard the aircraft during the 2013 Studies of Emissions and Atmospheric Composition, Clouds and Climate Coupling by Regional Surveys ($SEAC_4RS$) mission over the United States as a training dataset. These averaged distributions, paired with assumed mass extinction efficiencies and auxiliary measurements were used to estimate aerosol mass speciation at the height of the airplane.

Accomplishments

- Finalized global satellite-derived monthly, seasonal, and annual maps of aerosol types using optical retrievals of particle size and spectral light absorption from spaceborne satellite sensor POLDER on board the PARASOL platform;
- Inferred airborne aerosol types from three airborne optical instruments: the NASA Langley Aerosol Research Group Experiment (LARGE), the Differential Aerosol Sizing and Hygroscopicity Spectrometer Probe (DASH-SP) and the Polarized Imaging Nephelometer (PINeph) during the $SEAC_4RS$ experiment;
- Compared the aerosol types to number fraction measurements of different chemical components (e.g., sulfate, organic, nitrate, biomass burning, soot, mineral, sea salt) from various chemical instruments on the same aircraft: the Particle Analysis by Laser Mass

Spectrometry (PALMS), the High - Resolution Time - of - Flight Aerosol Mass Spectrometer (AMS), the Single-Particle Soot Photometers (HD-SP2) and the Soluble Acidic Gases and Aerosol (SAGA); and

- Estimated total and speciated mass concentrations from airborne optical measurements using (i) derived averaged normalized distribution of speciated mass measurements, (ii) measured airborne Relative Humidity, (iii) measured aerosol extinction coefficient and, (iv) assumed mass extinction coefficients. The presence of multiple optical and chemical instruments on-board the same aircraft during SEAC$_4$RS makes it possible to compare these estimates to coincident mass measurements. The team found good agreement (R_2 ~0.8) between measured and estimated ambient mass concentrations in the case of aerosol type UrbInd$_1$, for example. However, estimated values seem to generally underestimate measured ones.

Publications and Presentations

Dawson, K. W., Meskhidze, N., Burton, S. P., Johnson, M. S., Kacenelenbogen, M. S., Hostetler, C. A. & Hu, Y. (2017). Creating Aerosol Types from CHemistry (CATCH): a new algorithm to extend the link between remote sensing and models. Journal of Geophysical Research: Atmospheres, 122. https://doi.org/10.1002/2017JD026913

Kacenelenbogen M. et al, Bridging the Gap Between Optically-Inferred Aerosol Types and Chemical Mass Speciation, in preparation

Kacenelenbogen et al., 2019, "Inferring Airborne Total-Column Aerosol Mass Speciation from Optical Measurements: A Step Towards Satellite-Inferred Chemical Composition", Oral, 99th American Meteorological Society (AMS) meeting, 21st Conference on Atmospheric Chemistry, Phoenix, AZ, Jan 2019

Kacenelenbogen et al., 2018, "Are Satellite-Derived Aerosol Types Useful for Evaluating Global Chemistry Transport Models?", Oral, 97th American Meteorological Society (AMS) meeting, Conference on Atmospheric Chemistry, Austin, TX, 01/09/2018

Panels or Committees

- Regular reviewer (Kacenelenbogen) for articles submitted to peer-reviewed journals such as the Atmospheric Chemistry Physics (ACP), the Atmospheric Measurement Techniques (AMT), and the Journal of Geophysical Research (JGR); and
- Conference co-convener (Kacenelenbogen) for "Multi-sensor, Model, and Measurement Synergy: Aerosol Sources and Their Environmental Effects" session at the American Geophysical Union (AGU), Washington, DC, 10-14 Dec 2018.

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

- Submitted the results from the team's analysis to *Applied Optics* for publication and the paper was accepted in November 2018.

Publications and Presentations

Knobelspiesse, K, Q. Tan, C. Bruegge, B. Cairns, J. Chowdhary,
B. Van Diedenhoven, D. Diner, R. Ferrare, G. Van Harten, et al., 2018 Intercomparison of airborne multi-angle polarimeter observations from the Polarimeter Definition Experiment (PODEX), Applied Optics (accepted)

Agriculture, Health, and Marine Applied Sciences

Project Participants

NASA: Rama Nemani, Jennifer Dungan
CSUMB: Forrest Melton, Lee Johnson, Kirk Post, Alberto Guzman, Carolyn Rosevelt, Isabel Zaragoza, Michael Hang, Dan Muratore, Rachel Spellenberg,

Project Description

CSUMB personnel have a long history of participation and support of NASA research and applied science missions to apply satellite data to evaluate environmental conditions and ecological processes that affect agriculture, public health and vector-borne disease, and coral reefs and other marine ecosystems. Under this task, CSUMB conducts research and applied science activities in these areas in collaboration with the 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, ecological and weather models, agricultural models, and epidemiologic, vector, and pathogen models to advance the ability of U.S. and international institutions to understand and manage these processes. Activities under this task include analysis of satellite data, management of airborne and field campaigns to collect data, and development of models and decision support systems.

The primary objectives of this task are to:
1) Apply satellite data, airborne data, and surface sensor networks to model and map agricultural productivity and crop water demand;

2) Apply satellite data, climate models, and ecological models to map habitat for disease vectors and model vector-borne disease transmission risk; and

3) Apply satellite multispectral and airborne hyperspectral data coupled with field measurements of biological data, to contribute to research on ecosystem health, ecological structure, and benthic habitat biodiversity of coral reefs and associated biotopes (seagrass).

Accomplishments

- Published 2 peer reviewed journal articles, one conference proceedings paper, one technical report for the California State Water Resources Control Board (SWRCB), and three additional articles currently in preparation. Presented more than 12 scientific and technical talks/posters at science conferences and technical meetings.
- Mentored four CSUMB School of Natural Science (SNS) students and one Carnegie Mellon University student who worked with the Satellite Irrigation Management Support (SIMS) and Fallowed Area Mapping projects in 2018 (Josue Duque, Kali Prescott, Elizabeth Patron, Will Carrera, Conor Doherty). Additional research internships will be offered in 2019;
- Organized the kickoff meeting in May 2018 for the OpenET project at DRI with 20 scientists and technical experts and more than 65 partners and stakeholders. 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, EDF, Google, the Desert Research Institute, USDA, USGS, and multiple university research teams. F. Melton is one of the technical leads for the project and organized and led a team of >20 leading experts on remote sensing of ET and initiated work on the effort. The OpenET project has received more than $3.5 million in funding for the OpenET project from the S.D. Bechtel, Jr. Foundation and the Walton Family Fund;

- Continued work on the WesternET project, a NASA Research Opportunities in Space and Earth Sciences (ROSES) supported project on evapotranspiration (ET) mapping in the western U.S. in collaboration with DRI. Project Co-PI 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 conduct two training sessions for water resource managers from eight western states in October 2017 and June 2018 at DRI;
- Developed training materials for CA DWR to facilitate final transition of capabilities for satellite mapping of land fallowing in California. Adapted algorithms to support expansion of the Fallowed Area Mapping capabilities to Washington State and Nevada in partnership with the Washington State Depart of Agriculture and the Nevada State Engineer's Office;
- Continued field trials and research to quantify the value of SIMS and ET-based irrigation scheduling. Deployed and maintained instrumentation on one commercial farm in partnership with growers in the Salinas Valley. Collaborated with partner growers on data analysis and currently preparing manuscripts for publication. Results to date 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, onions and fresh market tomatoes to quantify the benefits of ET-based irrigation scheduling; and
- Collaborated with UC Davis and CA DWR on an intercomparison study of evapotranspiration models for the CA Delta. Final report published by UC Davis and delivered to the CA Delta Watermasters Office. Full results also being prepared for publication in a peer-reviewed journal.

Publications and Presentations

Zhang, J., Campana, P.E., Yao, T., Zhang, Y., Lundblad, A., Melton, F. and Yan, J., 2018. The water-food-energy nexus optimization approach to combat agricultural drought: a case study in the United States. Applied Energy, 227, pp.449-464.

Kustas, W.P., Anderson, M.C., Alfieri, J.G., Knipper, K., Melton, F., Post, K. (27 authors total) 2018. The grape remote sensing atmospheric profile and evapotranspiration eXperiment (GRAPEX). Bulletin of the American Meteorological Society, (2018).

Melton M., Johnson, L., Guzman, A., et al., 2018. The Satellite Irrigation Management Support (SIMS) System: Applications of satellite data to support improvements in irrigation management in California: Applications of Satellite Data to Support Improvements in Irrigation Management in California. ASA California Plant & Soil Conference, 6-7 Feb., Fresno. (invited)

Medellín-Azuara, J., et al., (F. Melton, L. Johnson, and A. Guzman among 25 co-authors), 2018. Estimation of Crop Evapotranspiration in the Sacramento-San Joaquin Delta. https://watershed.ucdavis.edu/project/delta-et

PRESENTATIONS

Melton, F., Johnson, L., Guzman, A., Dexter, J., Zaragosa, I., Rosevelt, C., Michaelis, A., Cahn, M., Temesgen, B., Trezza, R., Frame, K., Eching, S., Huntington, J., Morton, C., Grimm, R., and Hall, M., 2017. Applications of Satellite Data to Support Improvements in Irrigation and Groundwater Management in California. American Geophysical Union Fall Meeting, New Orleans, CA, December 11-15, 2017.

Zaragosa, I., Dexter, J., Post, K., Spellenberg, R., Haffa, A., Kortman, S., Cahn, M., and Melton, F., 2017. Utilizing on-farm best management practices: Managing Nitrate Leaching Using Evapotranspiration Based Irrigation Methods. American Geophysical Union Fall Meeting, New Orleans, CA, December 11-15, 2017.

Zhang, J., Campana, P., Yao, T., Melton, F., and Yan, J., 2017. Using a water-food-energy nexus approach for optimal irrigation management during drought events in Nebraska. American Geophysical Union Fall Meeting, New Orleans, CA, December 11-15, 2017.

Melton, F., Johnson, L., Guzman, A., Dexter, J., Zaragosa, I., Rosevelt, C., Michaelis, A., Cahn, M., Temesgen, B., Trezza, R., Eching, S., 2018. CIMIS and NASA's Satellite Irrigation Management Support System: Applications of satellite data to support improvements in irrigation management in California, WWAO Water Information Management Systems Workshop, Pasadena, CA, January 17-18, 2018.

Melton, F., Johnson, L., Guzman, A., Dexter, J., Zaragosa, I., Rosevelt, C., Michaelis, A., Cahn, M., Temesgen, B., Trezza, R., Eching, S., 2018. The NASA Satellite Irrigation Management Support (SIMS) System: Applications of satellite data to support improvements in irrigation management in California. Salinas Valley Ag Tech Summit, Salinas, CA, March 28, 2018.

Guzman, A., Zaragosa, I., Wang, T., Johnson, L., Cahn, M., 2018. Integration of SIMS and Crop Manage: Advancing sustainable practices for management of agricultural water supplies. NASA Water Resources Team Meeting, Boulder, CO, June 26-29, 2018.

Melton, F., Rosevelt, C., Guzman, A., Zaragosa, I., Wang, T., Johnson, L., Huntington, J., Morton, C., 2018. Satellite Mapping of Agricultural Land Fallowing for Drought Impact Assessment and Decision Support. NASA Water Resources Team Meeting, Boulder, CO, June 26-29, 2018.

Melton, F., Johnson, L., Guzman, A., Dexter, J., Zaragosa, I., Rosevelt, C., Michaelis, A., Cahn, M., Temesgen, B., Trezza, R., Eching, S., 2018. Applications of satellite data to support improvements in irrigation management in CA. NASA Water Resources Team Meeting, Boulder, CO, June 26-29, 2018.

Melton F. , Haffa A. , Cahn M. , Cassel-Sharma F., Dexter J., Duque J., Garcia, A., Goorahoo D. , Hang M. , Johnson L. , Kortman S. , Mele A. , Patron E., Prescott K. , Stanfield E. , Wang T. , Zaragosa, I., 2018. Quantifying the Benefits of On-farm Best Management Practices: Managing nitrate leaching using evapotranspiration-based irrigation scheduling, Agricultural Research Institute Conference, Sept. 12, 2018.

Melton, F., Johnson, L., Guzman, A., Dexter, J., Zaragosa, I., Rosevelt, C., Michaelis, A., Cahn, M., Temesgen, B., Trezza, R., Frame, K., Eching, S., Huntington, J., Morton, C., Grimm, R., and Hall, M., 2018. 2015-2016 Delta Consumptive Use Analysis – Remote Sensing Approaches. Bay Delta Science Conference, Sacramento, CA, Sept. 12-14, 2018.

Johnson, L., Irriquest Calculator for Irrigation Sustainability Metrics, invited presentation to Monterey County Resource Conservation District, Salinas, CA, October 2018.

Johnson, L. co-organized UCCE Field Day for celery growers in Salinas, CA and presented on results of field trials and integration of data from SIMS in CropManage, Salinas, CA, October 2018.

Panels or Committees

Forrest Melton participated on multiple ROSES peer review panels for the Applied Sciences Program.

Lee Johnson participated on a review panel for NASA-ROSES under the Applied Sciences Program.

Lee Johnson was Member of Scientific Committee for the 2018 Institute of Electrical and Electronics Engineers (IEEE) International Geoscience and Remote Sensing Symposium.

Western Federal Agency Support Team (WESTFAST, F. Melton)

California Department of Water Resources Open Water Information Architecture Technical Committee (F. Melton)

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

Western Water Applications Stakeholder Engagement Working Group (F. Melton)

Alpha Jet Atmospheric Experiment (AJAX)

Project Participants

NASA: Warren Gore, Laura Iraci
BAERI: Emma Yates, Caroline Parworth, Ju-Mee Ryoo, Josette Marrero

Project Description

AJAX is a public-private partnership between the aircraft owner (H211, LLC) and NASA Ames Research Center. The aircraft is based at and operated from Moffett Field, CA under a Space Act Agreement. It is a tactical strike fighter developed by Dassault-Breguet and Dornier. Carrying a crew of two, it has a ceiling of 51,000 ft, speed of 150 - 500 knots, and a range of approximately 1,200 miles (2.5-hours flight duration). Scientific instruments are housed in externally mounted wing pods. Current scientific payload consists of an ozone monitor, a greenhouse gas (carbon dioxide and methane) sensor, a meteorological measurement system (MMS), and a formaldehyde measuring instrument. In addition, plans are underway to install a nitrogen dioxide (NO_2) monitor.

In the past seven years, AJAX has flown over 200 science flights and participated in numerous field campaigns. The AJAX team researches many topics including 1) Satellite and remote sensing validation (OCO-2, GOSAT, TCCON), 2) investigating the transport of ozone from the free troposphere to the surface, impacting air quality, 3) identifying inaccuracies (under-estimations) in methane emission inventories for the State of California and 4) studying emissions from recent California wildfires.

Accomplishments

- Over 20 AJAX flights were performed in the first half of the year;
- The aircraft was grounded in the summer due to technical issues;
- A new aircraft has been sourced to provide flights so the team can continue to meet its (funded) obligations to perform satellite validations; and
- Specifications/technical details are being provided to find a complete replacement aircraft.

Publications and Presentations

K.R.Baker, M.C.Woody, L.Valin, J.Szykman, E.L.Yates, L.T.Iraci, H.D.Choi, A.J.Soja, S.N.Koplitz, L.Zhou, Pedro Campuzano-Jost, Jose L.Jimenez, J.W.Hair, Photochemical model evaluation of 2013 California wild fire air quality impacts using surface, aircraft, and satellite data, Science of the Total Environment, 637, 1137-1149.

Ira Leifer, Christopher Melton, Marc L. Fischer, Matthew Fladeland, Jason Frash, Warren Gore, Laura T. Iraci, Josette E. Marrero, Ju-mee Ryoo, Tomoaki Tanaka, and Emma L. Yates, Atmospheric characterization through fused mobile airborne and surface in situ surveys: methane emissions quantification from a producing oil field, Atmospheric Measurement Techniques, 11 (3).

A.O.Langford, R.J.AlvarezII, J.Brioude, S.Evan, L.T.Iraci, G.Kirgis, S.Kuang, T.Leblance, M.J.Newchurch, R.B.Pierce, C.J.Senff, E.L.Yates, Coordinated profiling of stratospheric intrusions and transported pollution by the Tropospheric Ozone Lidar Network (TOLNet) and NASA Alpha Jet experiment (AJAX): Observations and comparison to HYSPLIT, RAQMS, and FLEXPART, Atmospheric Environment, 174, 1-14.

Conference Presentation:

Emma Yates, Outcomes of 7 years of airborne trace gas measurements over California and Nevada: The Alpha Jet Atmospheric eXperiment (AJAX), Oral presentation, AGU, Washingon DC, Dec 2018

Bioengineering

Project Participants

NASA: Diana Gentry
BAERI: Ali-Imran Tayeb

Project Description

The Automated Adaptive Directed Evolution Chamber (AADEC) is a self-contained automated bacteria growth chamber intended to study the evolution of organisms under certain conditions. It consists of a growth chamber with various sensors and actuators that can be controlled and activated remotely. The sensors are intended to monitor the cell health in the chamber with readings such as cell density, pH, Red-Ox potential, and electrical conductivity. The actuators such as pumps, agitators, heaters and lights maintain the environment and provide stressors for the organisms. In the current iteration, UV light is being used to douse the cells and see how they survive. Experimentation is done in a black box environment where the organisms are not directly tampered with or examined on a DNA level. The team only checks the outcomes of the team's inputs to the system to see if the bacteria behave as expected.

Accomplishments

- Analyze previously designed circuits for validity and understanding;
- Design and Organization of state machine and control algorithms for system operation;
- Re-write control architecture in C to simplify operation, moving away from microcontrollers to full Linux system; and
    - Create digital electrical schematics of existing architecture and create PCB fabrication drawings for manufacture.

Publications and Presentations

Govinda Raj C, Bake A, Tayeb A, Ludman C, Joshi P, Wang J, Gentry DM. Enabling Experimental Evolution: Multi-parameter Sensor System Integration into a Culture/Stressor Bio-fluidics System. Abstract #467264, American Geophysical Union 2018 Fall Meeting, Washington D.C., December 2018.

Govinda Raj C, Bake A, Tayeb A, Wang J, Gentry DM, .Sensor Selection and Implementation for an Autonomous Experimental Evolution Bio-fluidics System. Abstract #110, 34th Annual Meeting of the American Society for Gravitational and Space Research, Maryland., October 2018.

Carbon Monitoring Systems (CMS)

Project Participants

NASA: Ramakrishna Nemani
BAERI: Sangram Ganguly, Subodh Kalia, Shuang Li, Thomas Vandal

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: Project: NASA CMS (Saatchi) Annual GHG Inventory and MRV System for the US Forestlands

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

Accomplishments

- Created and delivered the yearly 30-m Landsat-based forest/non-forest maps since 2010. 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 studies at AGU;
- Published a number of peer reviewed articles; and
- Led (Dr. Ganguly) the NASA CMS working group on Algorithm inter-comparison and uncertainty assessment and will present updates on the upcoming NASA CMS science team meeting.

Publications and Presentations

Basu, S., et al. 2018 (S. Ganguly, one of 7 co-authors), Deep neural networks for texture classification—A theoretical analysis, *Neural Networks*, 97, 173-182.

Kumar, U., et al. 2017 (S. Ganguly, one of 14 co-authors), Exploring Subpixel Learning Algorithms for Estimating Global Land Cover Fractions from Satellite Data Using High Performance Computing, Remote Sensing, DOI:10.3390/rs9111105.

Vandal, T., et al. 2018 (S. Ganguly, one of 6 co-authors), Generating High Resolution Climate Change Projections through Single Image Super-Resolution: An Abridged Version, IJCAI, 5389-5393.

Vandal, T., et al. 2018 (S. Ganguly, one of 6 co-authors), Quantifying Uncertainty in Discrete-Continuous and Skewed Data with Bayesian Deep Learning, 24rd ACM SIGKDD Conference on Knowledge Discovery and Data Mining, arXiv:1802.04742.

Vandal, T., et al. 2017 (S. Ganguly, one of 6 co-authors), DeepSD: Generating High Resolution Climate Change Projections through Single Image Super-Resolution. 23rd ACM SIGKDD Conference on Knowledge Discovery and Data Mining, 1663-1672.

Ferraz, A., et al. 2018 (S. Ganguly, one of 19 co-authors), Carbon storage potential in degraded forests of Kalimantan, Indonesia, Environmental Research Letters, 13(9), 095001.

PRESENTATIONS
Kalia, S., et al. 2018 (S. Ganguly, one of 7 co-authors), GEONEX: CloudCNN 2.0 - A Deep Neural Network for Real-time Cloud Type Classification and Segmentation from Geostationary Data, AGU 2018.

Mr Prabhat, et al. 2018 (S. Ganguly, one of 16 co-authors), ED53E-0758: ClimateNet: bringing the power of Deep Learning to the climate community via open datasets and architectures, AGU 2018.

Gorooh, V. A., et al. 2018 (S. Ganguly, one of 12 co-authors), GEONEX: Application of Deep Neural Networks and CloudSat Data in Cloud Type Classification of GOES-16 Multispectral Images for Improving PERSIANN-CCS, AGU 2018.

Ganguly, S., et al. 2018, NEX-AI: A Cloud and HPC Agnostic Framework for Scaling Deep Learning and Machine Learning Applications for Earth Science, AGU 2018.

Collier, E., et al. 2018 (S. Ganguly, one of 10 co-authors), GEONEX: Progressive Conditional Generative Adversarial Training Using Transfer learning, AGU 2018.

Madanguit, G. E., et al. 2018, NEX-AI: Deployment of Machine Learning Pipelines using Google Cloud ML Engine and AWS SageMaker, AGU 2018.

Panels or Committees

Dr. Ganguly is science committee member of the NASA Frontiers Development Lab (FDL)

Dr. Ganguly was in the program committee of the Eighth Workshop on Data Mining in Earth System Science (DMESS 2018) held in Singapore.

Dr. Ganguly is a co-author for the publication “Data-driven solutions” in support of the UNA-UK Climate 2020 Action Plan.

Dr. Ganguly was in the organizing committee of the 2018 Big Data Driven Agriculture. Advances, challenges and Opportunities held in Arlington, VA.

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

Project Participants

NASA-JPL: Vivienne Payne
BAERI: Susan Kulawik

Project Description

The Cross-track Infrared Sounder (CrIS), provides soundings of the atmosphere with 1305 spectral channels, over 3 wavelength ranges: Long Range Infrared (LWIR) (9.14 - 15.38um); Mid-Wave Infrared (MWIR) (5.71 - 8.26um); and Short Wave Infrared (SWIR) (3.92 - 4.64 um). The CrIS instrument, a Fourier transform spectrometer, has an 8 cm clear aperture and utilizes plane mirror interferometer technology. CrIS scans a 2200km swath width (+/- 50 degrees), with 30 Earth-scene views. Each field consists of 9 fields of view, arrayed as 3x3 array of 14km diameter spots (nadir spatial resolution). Each scan (with an 8-second repeat interval) includes views of the internal calibration target (warm calibration point), and a deep space view (cold calibration point). The overall instrument data rate is <1.5Mbps. Only photovoltaic detectors are used in the CrIS instrument. The detectors are cooled to approximately 81K using a 4-stage passive cooler with no moving parts. They have a low-risk heritage design of over 50 space units.

This project examines new constraints on the impacts of fires on air quality and the nitrogen cycle from CrIS observations of peroxyacetyl nitrate (PAN). PAN plays a critical role in long-range pollution transport, atmospheric chemistry, and in the redistribution of nitrogen in the troposphere. The team is developing a new PAN product for the CrIS instrument.

Accomplishments

- Set up CrIS PAN retrievals and evaluated the degrees of freedom and initial results of CrIS PAN versus the ATom aircraft observations of PAN. We will be showing initial results at the Aura meeting in January, 2019.

Distributed Spacecraft Autonomy (DSA)

Project Participants

NASA: Diana M. Acosta, Julia M. Badger, Anupa R. Bajwa, Daniel Cellucci, Terry Fong, Jeremy D. Frank, David R. Hunt
BAERI: Sreeja Nag

Project Description

Autonomy is an immature, yet important technology for multi-spacecraft missions. Autonomous decision making will be needed for multi-spacecraft missions due to latency, bandwidth constraints, and mission complexity. Additionally, autonomy can significantly increase the effectiveness of multi-spacecraft missions by operating them as a collective rather than individually. To address the needs of future missions, the Distributed Spacecraft Autonomy project (DSA) has the following goals:

1) Advance command and control methodologies for controlling a swarm of assets as a single entity.
2) Develop, mature, and demonstrate autonomous coordination between multiple assets in the swarm.
3) Develop, mature, and demonstrate approaches for adaptive reconfiguration and distributed decision-making across a swarm of assets.

The DSA project plans to achieve the following objectives as it proceeds through its orbital and ground-based autonomy experiments:
1) Develop a suite of tools which enables an operator to command a swarm and receive data from a swarm.
2) Develop a model of swarm behavior in the presence of anomalies or failures.
3) Perform a ground demonstration with simulated and hardware-in-the-loop elements to validate the DSA autonomy architecture for controlling swarms of up to 100 assets.
4) In conjunction with the Starling/Shiver (Flight Opportunity/AFRL) project, demonstrate the capability to communicate with all nodes in a smwarm topology for single-entity command, control, and status through telemetry.
5) Demonstrate the ability to autonomously achieve goals and plan/re-plan for both nominal and off-nominal conditions as required. The planned on-orbit mission goal is the mapping of the electron density of the ionosphere using radio tomography.

Accomplishments

- Successful submission of the flight mission project plan to NASA Game Changing Development (GCD) for the following concept of operations:
    - Starling swarm comprised of four identical spacecraft flying in Low Earth Orbit (LEO) at 550 km altitude, in-train formation within 100km of one another. Opportunity for a flight demonstration that allows satisfaction of a subset of Level One requirements for the Distributed Satellite Autonomy project.

- Successful definition of Level 1 and 2 requirements, in conjunction with the NASA ARC Starling team, for the following experiment:
    - The intent of the DSA experiment is to provide real-time data from a natural source from which the satellite formation can allocate resources related to data measurement. The phenomenon being measured is the Total Electron Content in the Plasmasphere, and the instrument that will be used to perform this experiment is a dual-band Novatel GPS receiver. This receiver measures the amount of delay accrued by the radio signals that are broadcast by the GPS Satellites, and calculates the plasma density from this delay.

Earth System Data Records

Project Participants

NASA: Matt Fladeland
BAERI: Susan Kulawik

Project Description

The Earth Science Data Records (ESDR) project supports the NASA Earth Science Data Systems Program. The Program's mission is to both manage and expand the many Earth science data records obtained from NASA satellites, airborne platforms, ground stations, and other sources. Management of these datasets includes archiving, algorithm development, calibration and validation, processing, quality control, and continued support to the user community. One component of the ESDR Program, the ESDR Uncertainty Analysis, seeks to extend and enhance Earth system data records used by NASA communities, including climate data records, through rigorous estimation of errors. Projects under the Earth System Data Records Uncertainty Analysis umbrella increase the scientific value of the measurements by identifying and validating systematic uncertainties in input data and physical models, and improving error estimations.

Dr. Kulawik is working on developing and validating long-term records of atmospheric trace gases, including CO_2. They are using multiple remote sensing derived data products as well as airborne and ground-based data to create long-term, consistent data records of atmospheric CO_2 and other trace constituents. This data can be used for mitigation of natural hazards, K-12 science education, and other societal benefits.

Accomplishments

- Completion of the work published in Kulawik, et al. (2016), by applying the same analysis to the OCO-2 v8 and v9 data. The results have been presented at conferences and are being written up.

Publications and Presentations

Susan S. Kulawik, "Characterization of OCO-2 biases and errors for flux estimates", 14th International Workshop on Greenhouse Gas Measurements from Space. Toronto, Canada, Toronto, ON, May 8-10, 2018

Susan S. Kulawik, "Characterization of OCO-2 and ACOS-GOSAT systematic error", OCO-2 Science Team Meeting, NCAR Mesa Lab, Boulder, CO, October 23-25, 2018.

5STAR/Eng-Sci

Project Participants

NASA: Stephen Dunagan, Roy Johnson, Jens Redemann
BAERI: Kristina Pistone, Sam LeBlanc, Michal Segal-Rosenhaimer, Meloe Kacenelenbogen, Lauren Fahey, Jordan Liss, Conrad Esch, Scott Venancio, and Ali-Imram Tayeb
PNNL: Connor Flynn
CSUMB: Bob Dahlgren

Project Description

The ARC Sun-photometer/Satellite group supports a variety of instruments with a specific focus on airborne sun photometers that provide measurements of tropospheric aerosols (i.e. low-level atmospheric particles, such as from smoke, dust, or pollution) and trace gases. The ARC SunSat team is funded to maintain existing instruments (2STAR, 3STAR, 4STAR) and develop the next generation instrument (5STAR). 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 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. A wide dynamic range tracking camera will provide a high precision solar position tracking signal as well as an image of sky conditions around the solar axis.

Accomplishments

- Worked to develop a block diagram for all electronics components;
- Completed draft layout and schematics for TEC controllers board;
- Reviewed concept for integrating sphere input to spectrometer;

- Checked out USB operations through slipring and ribbon cable clockspring;
- Evaluated AvaSpec-Mini2048CL-OEM for intensity on sunlight and skylight; and
- Measured backlash in Varvel SRS02810G3P1587;

4STAR and Satellite Data Analysis

Part One - Combined CALIOP and A-Train observations to study direct aerosol radiative forcing and its attribution; NASA ROSES 2012 A.23 CloudSat and CALIPSO Science Team (CCST) Recompete

Project Participants

NASA: J. Redemann
BAERI: Meloe Kacenelenbogen, Yohei Shinozuka, Sam LeBlanc, Qin Zhang

Project Description

The CloudSat/Cloud Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO) project combines A-Train satellite observations (i.e. Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP) aerosol backscatter, Moderate Resolution Imaging Spectroradiometer (MODIS) spectral aerosol optical depth, and Ozone Measuring Instrument (OMI) absorption aerosol optical depth retrievals) for the purpose of estimating full spectral sets of aerosol radiative properties, and ultimately for calculating the 3-D distribution of Direct Aerosol Radiative Effects (DARE).

Part 1: We compare the spatio-temporal distribution of the MODIS-OMI-CALIOP (MOC) retrievals and MOC-based calculations of seasonal clear-sky Direct Aerosol Radiative Effects (DARE) to values derived from models that participated in the phase II AeroCom model intercomparison initiative. We assess the effects of temporal and spatial sampling of the MOC retrievals on the global clear-sky DARE representation.

Part 2: Significant efforts are required to estimate the Direct Radiative Effects of aerosols above clouds (DAREcloudy). We have used a combination of passive and active A-Train satellite sensors and derive mainly positive global and regional DAREcloudy values (e.g., global seasonal values between 0.13 and 0.26 W m-2). Despite differences in methods and sensors, the DAREcloudy values in this study are generally higher than previously reported. We discuss the primary reasons for these higher estimates

Accomplishments

- Part 1: We have produced global seasonal clear-sky aerosol radiative forcing results based on multi-satellite sensor aerosol retrievals; those results were then compared to values derived from a subset of models that participated in the latest AeroCom initiative; we have used

model results of higher temporal and spatial resolution to assess the effects of spatially and temporally sparse satellite observations to our global Direct Aerosol Radiative Effect calculations. A paper is in preparation.;

- Part 2: We have developed an alternate retrieval of aerosol above opaque water clouds using the CALIOP/ CALIPSO Depolarization Ratio Technique over the globe; we have computed global Aerosol Optical Depth, Extinction-to-backscatter (lidar) ratio and Direct Aerosol Radiative Effects above opaque water clouds from 2008 to 2012. A paper has been submitted to *Atmospheric Chemistry and Physics Discussions* (ACPD).

Publications

Kacenelenbogen, M. et al., Estimations of Global Shortwave Direct Aerosol Radiative Effects Above Opaque Water Clouds Using a Combination of A-Train Satellite Sensors, *Atmos. Chem. Phys. Discuss*., https://doi.org/10.5194/acp-2018-1090, 2018.

Redemann J. et al., Use of A-Train Aerosol Observations to Constrain Direct Aerosol Radiative Effects (DARE) and Comparisons with AeroCom Phase II DARE results. (In preparation).

Presentations

Kacenelenbogen et al., A-Train Satellite Sensors to Constrain Global Direct Aerosol Radiative Effects in Clear-Skies and Above Clouds (A-Train to Constrain Models), Telluride Scientific Research Council, TSRC, Telluride, CO, 07/30-08/03 2018

Kacenelenbogen et al., "Global Satellite-Derived Aerosol Optical Properties and Constraining Direct Aerosol Radiative Effects (DARE)", Poster, CloudSat/ CALIPSO Annual Science Review, Boulder, CO, 04/23/2018

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: J. Redemann
BAERI: Cecilia Chang, Sam LeBlanc, Yohei Shinozuka, Qin Zhang, Michal Segal-Rosenheimer, Jordan Liss, Lauren Fahey

Project Description

The goal of this project is to improve, upgrade, analyze data from and operate the newly developed airborne Spectrometer for Sky-Scanning, Sun-Tracking Atmospheric Research (4STAR) instrument and its successor, 4STAR-B. The 4STAR concept combines airborne sun tracking capabilities of the Ames Airborne Tracking Sun Photometer (AATS-14) with AErosol

RObotic NETwork (AERONET)-like sky scanning capability and adds state-of-the-art fiber coupled grating spectrometry to yield hyperspectral measurements of direct solar irradiance and angularly resolved sky radiance. It provides improved measurements of H_2O, O_3, clouds and aerosols in the stratosphere and troposphere, while enabling measurements of additional gases such as NO_2. 4STAR-B aims to achieve higher stability through the implementation of a clockspring and a few other technological upgrades.

Accomplishments

- We have completed working on improving instrument reliability and accuracy through the AITT project. Test measurements at Mauna Loa Observatory and Ames were successfully conducted. The results, evaluated with coincident measurements with AATS-14, demonstrate improved calibration stability. We contributed to the AITT final report led by Steve Dunagan at NASA Ames.

Publications

Redemann J., C. Flynn, K. Pistone, et al., Aerosol optical properties retrieved from airborne sky radiance measurements in SEAC4RS – a proof-of-concept study. (In preparation).

Part Three - NAAMES (North Atlantic Aerosols and Marine Ecosystems Study) Project Participants

NASA: J. Redemann
BAERI: Kristina Pistone, Cecilia Chang, Yohei Shinozuka, Sam LeBlanc, Qin Zhang

Project Description

The NAAMES campaign consists of 4 deployments. The first occurred in Fall of 2015, the second in April 2016, and the third in August-September 2017. We participated with the 4STAR instrument in the first phase, AATS-14 in the second, and the 4STAR-B in the third, all through installation, operation on the test, transit and science flights, and de-integration. The plan for the fourth NAAMES deployment was March-April 2018, with Shinozuka and Pistone operating the instrument in the field, but due to multiple mechanical failures of the C-130 aircraft, the deployment was scrubbed after the outbound transit flight. The Aerosol Optical Depth (AOD) flight data of 4STAR-B has been delivered to the NAAMES-3 archive.

Accomplishments

- Data have been acquired during the third phase (September 2017). Data from Phase 1-3 (2015-2017) have been screened, quality-controlled and submitted. The plan for the fourth NAAMES deployment was March-April 2018, with Shinozuka and Pistone operating the instrument in the field, but due to multiple mechanical failures of the C-130 aircraft, the deployment was scrubbed after the outbound transit flight. However, the AOD flight data of

4STAR-B has been screened, quality-controlled, and delivered to the NAAMES-3 archive. This is the first finalized archival of airborne data from 4STAR-B.

Presentations

Pistone, K., S. LeBlanc, R. Johnson, Y. Shinozuka, J. Redemann, NAAMES Science Team Meeting 2018 "Airborne measurements of aerosol optical depth in NAAMES."

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

BAERI: Michal Segal-Rosenheimer (PI), Meloe Kacenelenbogen, Sam LeBlanc, Kristina Pistone,

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 and around), source characterization (urban outflow, power plants), and the effect of long-range transport that interacts with the local pollution. 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, O_3 and NO_2 amounts under various conditions.

Accomplishments

- During the past year, a collaborative paper on NO_2 measurements during KORUS-AQ with Pandora, and 4STAR data was published at Atmospheric Measurement Techniques (AMT); and
- Michal Segal-Rozenhaimer presented her work on a manuscript *in prep.* at the Asian Oceania Geosciences Society (AOGS) conference (June, 2018, Honolulu, HI).

Publications

Herman J., Elena Spinei, Alan Fried, Jhoon Kim, Jae Kim, Woogyung Kim, Alexander Cede, Nader Abuhassan, and **Michal Segal-Rozenhaimer** , (2018), NO2 and HCHO measurements in Korea from 2012 to 2016 from Pandora Spectrometer Instruments compared with OMI retrievals and with aircraft measurements during the KORUS-AQ campaign, Atm. Meas. Tech., Atmos. Meas. Tech., 11, 4583–4603, 2018 https://doi.org/10.5194/amt-11-4583-2018, https://www.atmos-meas-tech.net/11/4583/2018/amt-11-4583-2018.pdf

Presentations

Segal-Rozenhaimer, Michal, Daniel L. Goldberg, Meloë Kacenelenbogen, Samuel LeBlanc, Connor Flynn, Jens Redemann, Jay Herman, Alexander Cede, Nader Abuhassan, Lok N. Lamsal, (2018), Assessing how aerosols effect OMI NO2 retrievals during KORUS-AQ , AOGS (Asia Oceana Geoscience Society), 03-08 Jun 2018, Honolulu, Hawaii.

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

BAERI: Sam LeBlanc (PI), Kristina Pistone,

Project Description

The NRC-COSR experiment was a joint venture with the Canadian National Research Council, BAERI, and NASA Ames Research Center. The 4STAR instrument was lent to NRC by NASA Ames Research Center, and the scientific and technical expertise were provided by BAERI. The experiment consisted of flying a Canadian Research Aircraft with 4STAR integrated on board, in the Canadian oil sand region, quantifying the emissions from various oil sand processing plants.

Accomplishments

- We have successfully integrated 4STAR onto the NRC Convair-580 and supported from afar, the deployment of the Convair during the Canadian Oil Sand Region experiment. We have also successfully started a new partnership with the Canadian National Research Council.

Publications

Herman J., Elena Spinei, Alan Fried, Jhoon Kim, Jae Kim, Woogyung Kim, Alexander Cede, Nader Abuhassan, and **Michal Segal-Rozenhaimer** , (2018), NO2 and HCHO measurements in Korea from 2012 to 2016 from Pandora Spectrometer Instruments compared with OMI retrievals and with aircraft measurements during the KORUS-AQ campaign, *Atm. Meas. Tech., Atmos. Meas. Tech*., 11, 4583–4603, 2018 https://doi.org/10.5194/amt-11-4583-2018, https://www.atmos-meas-tech.net/11/4583/2018/amt-11-4583-2018.pdf

Presentations

Segal-Rozenhaimer, Michal, Daniel L. Goldberg, Meloë Kacenelenbogen, Samuel LeBlanc, Connor Flynn, Jens Redemann, Jay Herman, Alexander Cede, Nader Abuhassan, Lok N. Lamsal, (2018), Assessing how aerosols effect OMI NO2 retrievals during KORUS-AQ , AOGS (Asia Oceana Geoscience Society), 03-08 Jun 2018, Honolulu, Hawaii.

Participation on Panels or Committees (Overall)

Michal Segal Rozenhaimer: ROSES-2018 DSCOVR Science Team panel reviewer
Meloë Kacenelenbogen: ROSES-2016 Atmospheric Composition: AURA science and atmospheric composition modeling and analysis program panel reviewer
Meloë Kacenelenbogen: Co-convener for "Multi-sensor, Model, and Measurement Synergy: Aerosol Sources and Their Environmental Effects" session at the American Geophysical Union (AGU), Washington, DC, 10-14 Dec 2018
Samuel LeBlanc: Co-convener and chair for "Cloud-aerosol-radiation-climate interactions in the southeast Atlantic" session at the American Geophysical Union (AGU), Washington, DC, 10-14 Dec 2018.
Samuel LeBlanc: Co-chair for "New Approaches to Radiation Measurements" session at the 15th Conference on Atmospheric Radiation (AMS-Rad), Vancouver, BC, 8-13 July, 2018.

GEONEX

(30-m Global Food Security Support Analysis Data)

Project Participants

BAERI: Jun Xiong
CSUMB: Jia Zhang, Weile Wang, Yunfeng Jiang

Project Description

GEONEX is a collaborative effort for generating land surface products from the new generation of geostationary satellite sensors such as Geostationary Operational Environmental Satellite (GOES)16/ABI.

In collaboration with the NASA Earth Exchange (NEX), GEONEX serves as a platform for scientific partnership, knowledge sharing and research for the Earth science community.

Accomplishments

- Integrated the ABI_Fire code into the GEONEX near-real-time pipeline, which can produce ABI Fire products over the continental United States (CONUS) region once GOES16 data was pushed on the AWS buckets, the latency for CONUS area is within 5-7 mins. ABI Wildfire product was identified as GO16_ABI15 in GEONEX product list;
- Established a workflow with NASA/Global Imagery Browse Services (GIBS) team to provide the detected fire mask, the active fires in vector format and the background imagery for GIBS to visualize the products;

- Tracked the 'Camp Fire' in California starting from Nov 7 by triggering the GEONEX pipeline in a trial mode at every 5 min;
- Carried out a comparison between the output of NOAA fire code and GEONEX version with certain time points (e.g. Aug 16, 2018, Oct 1, 2018) with expected results. Furthermore, we will do inter-comparison between NOAA code, GEONEX version, MODIS/VIIRS products, and local records during a longer period (mid-July to August 2018, November 2018) to get a comprehensive idea about the performance of GOES16 fire products.

JOURNAL ARTICLE:

Teluguntla, P., Thenkabail, P., Oliphant, A., Xiong, J., Gumma, M.K., Congalton, R.G., Yadav, K. and Huete, A., 2018. A 30-m landsat-derived cropland extent product of Australia and China using random forest machine learning algorithm on Google Earth Engine cloud computing platform. ISPRS Journal of Photogrammetry and Remote Sensing, 144, pp.325-340.

Gumma, M.K., Thenkabail, P.S., Deevi, K.C., Mohammed, I.A., Teluguntla, P., Oliphant, A., Xiong, J., Aye, T. and Whitbread, A.M., 2018. Mapping cropland fallow areas in myanmar to scale up sustainable intensification of pulse crops in the farming system. GIScience & Remote Sensing, pp.1-24.

CONFERENCE PRESENTATION:

Xiong, J, Weile Wang, Shuang Li, Sangram Ganguly, Andrew Michaelis, Satya Kalluri, Tsengdar J Lee, Ramakrishna R Nemani. 2018. GEONEX: Enhancing Real-time Active Fire Detections from GOES-16/ABI data using Machine Learning. Dec 2018, DC, AGU 2018

NASA Earth Exchange (NEX)

Project Participants

NASA: Rama Nemani, Jennifer Dungan, Ved Chirayath, Piyush Mehrotra
BAERI: Sangram Ganguly, Alan Li, Shuang Li, Jun Xiong, Thomas Vandal, Wen Yip
CSUMB: Alberto Guzman, Hirofumi Hashimoto, Forrest Melton, Andrew Michaelis (resigned in 2018), Weile Wang

Project Description

Over the past five years, the Ecological Forecasting task has increasingly focused on development of the NASA Earth Exchange (NEX) project (Nemani et al., 2011).

Under this task, ARC-CREST scientists and software engineers collaborate with scientists and engineers in the NASA Ames Earth Science Division and the NASA Advanced Supercomputing

(NAS) Division to develop and support the NEX collaborative supercomputing/cloud computing environment for large-scale Earth Science research.

Since its inception in 2009, the NEX project has evolved from having a sole focus on ecological forecasting to providing access to large Earth science datasets, supercomputing and cloud computing capabilities, and the development of an online collaborative research environment. The primary objective of the NEX project is to accelerate scientific discovery using data from NASA's satellite missions and climate models, and to facilitate scientific collaboration in a way that was not previously possible. NEX maintains a large set of satellite observations and climate model data for use by NASA-supported researchers who are tackling science questions that involve data and computing intensive analyses at regional to global scales. NEX provides the Earth science research community with a virtual collaborative, where scientists can process large data sets, run model codes, and share the results and knowledge. As the data products and models available within NEX and the community utilizing NEX grow, the support needed to maintain this unique collaborative environment also grows.

ARC-CREST researchers collaborate closely with scientists in NASA Ames Earth Science Division, as well as the broader NASA Earth 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 also supports applied science activities, such as the development of indicators of climate change impacts for Landscape Conservation Cooperatives and NASA Centers, and development of information products to support land managers, agricultural producers, and water managers throughout the U.S. NEX also supports monitoring and modeling of natural disasters and emerging public health threats. In addition, NEX supports production of global long-term data records for NASA's Making ing Earth System Data Records for Use in Research Environment (MEaSURE)'s program, as well as large-scale visualizations for data from NASA's Earth Observing System Data and Information System (EOSDIS).

The OpenNEX initiative, a collaboration between NASA and Amazon Web Services, develops cloud-hosted data, tools and solutions for working with satellite and climate data (e.g. virtual labs). Development of these tools and maintenance and administration of the OpenNEX platform are also are performed by ARC-CREST researchers. Additional information about NEX can be found at: https://nex.nasa.gov/nex/

Accomplishments

- Published 6 peer review publications in 2017-2018, with additional publications in preparation.

(Open)NEX Development:

- Developing a set of tools for management and discovery of science data and workflow components both internal and external to NEX;
- Implementing National Climate Assessment (NCA) modules and containers on NEXhub;

- Updating the NEX-Global Daily Downscaled Projections (GDDP) downscaled climate dataset with key new variables (wind, solar radiation, and humidity) in support of the NCA community;
- Create NEX-Generalized Dissimilarity Models (GDM) climate baseline dataset for future climate downscaling projects;
- Producing 10 new lectures and labs on OpenNEX YouTube Channel; and
- Present NEX at science meetings and workshops to engage the stakeholder community.

GEONEX:

- Prepared Top of Atmosphere (TOA) Reflectance Product (Version 1): Advanced Hirawami Instrument (AHI) (2016/07-2017/12) and Advance Baseline Imager (ABI) (2018/01 - 2018/09);
- Containerized the GEONEX TOA code and tested it on the Amazon Web Service (AWS) realtime processing pipeline;
- Compared of AHI TOA with corresponding MODIS products with the ray-matching method;
- Atmospheric Optical Thickness Surface Reflectances (SR) Product (Version 1): AHI (2016/07-2017/12);
- Built and maintained NASA Multi-Angle Implementation of Atmospheric Correction (MAIAC) software package for atmospheric correction and the production of Aerosol Optical Thickness (AOT) and SR data;
- Produced daily SR composite and Normalized Difference Vegetation Index ‘
- Produced Leaf Area Index (LAI) and Fraction of Absorbed Photosynthetically Active Radiation (FPAR): collaborating with Boston University team on algorithm development
- Phenology Product: collaborating with South Dakota State Unversity team on product development
- Gross/Net Primary Production (GPP/NPP) products: collaborating with University of Montana team on GPP/NPP product development
- Near-Real Time Fire products: collaborating with NOAA team on adapting NOAA WF-ABBA algorithm on NEX;
- Building a processing pipeline on AWS to generate the near-realtime ABI fire products;
- Surface Incoming Solar Radiation Product: collaborating with JAXA scientists on generating the surface incident solar radiation products;
- Building the GEONEX website (https://www.geonex.org) for community engagement; and
- Organizing a special issue on Remote Sensing on land monitoring with the new generation of geostationary sensors.

Continuing work on NASA ESTO Advanced Information Systems Technology (AIST) Project - Framework for Mining and Analysis of Petabyte-size Time-series on the NASA Earth Exchange (NEX)

Continuing work on two NASA ACCESS projects:

- (Open)NEX: Enabling Code-to-Data Migration between High-Performance Computing, Cloud and Beyond; and
- Object Store-Based Data Service for Earth System Science (collaboration with the HDF Group)

Collaborating on three NASA CMAC projects:

- NEX App Store (CMU);
- Climate Model Diagnostic Analyzer Services on NASA Earth Exchange Platform (JPL); and
- 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

Data management:

- Brought into NEX 300 terabytes of Landsat Collection 1 data for the Web-enabled Landsat Data (WELD) project; and
- Brought into NEX 150 terabytes of MODIS and Multi-Angle Implementation of Atmospheric Correct (MAIAC) data for GEONEX project

Publications and Presentations

JOURNAL ARTICLES:

Wang, W., R. Nemani, H. Hashimoto, S. Ganguly, D. Huang, and et al., 2018: An interplay between between Photons, Canopy Structure, and Recollision Probability: A Review of the Spectral Invariants Theory of 3D Canopy Radiative Transfer Processes. Remote Sensing, 10(11), https://doi.org/10.3390/rs10111805.

Li, S., S. Ganguly, J.L. Dungan, W. Wang, and R. Nemani, 2017: Sentinel-2 MSI Radiometric Characterization and Cross-Calibration with Landsat-8 OLI, Advances in Remote Sensing, 6, 147-159.

Li, S., W. Wang, S. Ganguly, R. Nemani, 2018: Radiometric Characteristics of the Landsat Collection 1 Dataset, Advances in Remote Sensing, 7, 203-217.

Fisher, et al. (W. Wang of 27 co-authors.), 2018: Missing pieces to modeling the Arctic-Boreal puzzle. Environmental Research Letters, 13, 020202.

Hashimoto, H., W. Wang, F. S. Melton, A. L. Moreno, S. Ganguly, A. R. Michaelis, and R. R. Nemani, High-resolution mapping of daily climate variables by aggregating multiple spatial datasets with the random forest algorithm over the conterminous US. International journal of Climatology, (in review-minor revision).

Hashimoto, H., R. R. Nemani, G. Bala, L. Cao,A.R. Michaelis, S. Ganguly, W. Wang, C. Milesi, R. Eastman, T. Lee, and R. Myneni, Constraints to vegetation growth reduced by region-specific changes in seasonal climate, Climate, (in review-minor revision).

CONFERENCE PRESENTATION:

Ganguly, S., S. Kalia, K. Duffy, E. D. Collier, G. E. Madanguit, G. Shreekant, S. Li, S. Mukhopadhyay, M. Prabhat, T. Vandal, A. T. Albert, H. Hashimoto, W. Wang, T. J. Lee, D.G. Choudhury, A. Michaelis, S. Saatchi, C. J. Tucker, and R. R. Nemani, NEX-AI: A cloud and HPC agnostic framework for scaling deep learning and machine learning applications for earth science. AGU 2018 Fall Meeting, Washington DC.

Hashimoto, H., W. Wang, J. Xiong, S. Li, S. Ganguly, H. Takenaka, A. Higuchi, T.J. Lee, and R. R. Nemani, 2018: GEONEX Real-time hourly 1-km weather data for the conterminous US for land surface modeling using GOES/ABI data. AGU 2018 Fall Meeting, Washington DC.

Li, S., W. Wang, J. Xiong, H. Hashimoto, S. Ganfuly, A Michaelis, T. J. Lee, and R. R. Nemani, 2018: GEONEX: Challenges in producing MODIS-like land products from a new generation of geostationary sensors. AGU 2018 Fall Meeting, Washington DC.

Nemani, R. R., T. J. Lee, A. Lyapustion, W. Wang, S. Ganguly, S. Li, H. Hashimoto, H. Takenaka, A Higuchi, J. Xiong, R. B. Myneni, and A. Michaelis, 2018: GEONEX: A NASA-NOAA collaboration for producing land surface products from geostationary sensor using cloud computing, AGU 2018 Fall Meeting, Washington DC.

Takenaka, H., T. Y. Nakajima, A. Higurashi, M. Hashimoto, A. Higuchi, K. T. Murata, M. Sekiguchi, H. Hashimoto, and R. R. Nemani, 2018: Development of active learning and NNN for satellite analysis, AGU 2018 Fall Meeting, Washington DC.

Panel or Committees

W. Wang, Guest Editor for MDPI Remote Sensing Journal, Special Issue on “Land Monitoring from A New Generation of Geostationary Satellites”.

F. Melton served on the Technical Working Group for the Climate Explorer for the National Climate Assessment chaired by NOAA and the U.S. Global Change Research Program.

F. Melton served on the Technical Advisory Committee for the Californa Open Water Information Architecture.

Ocean Biology

Project Participants

NASA: Jim Brass, Liane S.Guild
BAERI: Juan L. Torres-Pérez

Project Description

The project aims to understand the effects of humans on the health and resilience of reefs, particularly those in the Caribbean. Torres-Perez is the PI of the NASA-funded project entitled "Coral Bleaching Assessment through remote Sensing and Integrated Citizen Science (CoralBASICS)", currently under a Non-Cost Extension. The aim of the project is to integrate members of the local recreational diving community in Puerto Rico to assess the condition of local coral reefs coupled with a water quality assessment using remote sensing and simple field techniques.

> Torres-Perez is the PI of the Human Impacts to Coastal Ecosystems in Puerto Rico or HICE-PR (currently under a Non-Cost Extension). It aims at studying how anthropogenic impacts to watersheds in PR have caused detrimental effects on the shallow coastal reefs of the Island. Torres-Perez is also Co-PI of the NASA-funded "Neural Network for Global Coral Reef Assessment (NeMO-Net; Chirayath - PI). This project aims at developing accurate algorithms for the identification of coral reef organisms at different taxonomical levels using remotely-sensed data.

Accomplishments (All Bullets Related to Torres-Pérez

- Continued performing duties as Science PI of the HICE-PR project. Because this project is interdisciplinary, it takes a great effort to coordinate;
- Coordinated the big citizen science component for the CoralBASICS project. Torres-Pérez coordinated, prepared, and conducted a series of workshops aimed at training local dive instructors on the collection of scientifically-valuable underwater data to characterize the present condition of coral reefs in PR;
- Worked on the HICE-PR data analysis and expects to submit the results to the project PI for inclusion in the final report (June 2019);
- Involved in a field campaign in Monterey Bay related to the C-HARRIER project. Juan was in charge of collecting and analyzing field spectral information at Pinto Lake in Watsonville, California; and
- Continued participating in the NASA-funded project "The Neural Multi-modal Observation and Training Network for Global Coral Reef Assessment (NeMO-Net) (Ved Chirayath, PI). Juan will be in charge of coordinating field efforts for data collection and participate in the training of the neural network, particularly looking at areas with confusing benthic identification signatures (i.e. coral vs algae vs sponges, etc.). The team will have their first

field campaign in Puerto Rico in January 2019 and an additional campaign in Guam, late 2019.

Presentations

Torres-Pérez, J.L., L.S. Guild, and P. Bontempi. 2018. NASA-funded projects on coral reef science (Pacific Ocean). 40th U.S. Coral Reef Task Force. August 14-16. American Samoa.

Torres-Pérez, J.L., R. Viqueira, and W. Hernández. 2018. Benthic community structure characterization and assessment of turbidity impacts of the north (Manatí and Vega Baja) and south (Guánica) coasts, Puerto Rico: Benthic Assessment. 40th U.S. Coral Reef Task Force. August 14-16. American Samoa.

ORACLES

(ObseRvations of Aerosols above CLouds and their intEractionS)

Project Participants

NASA: Kirk Knoblespeisse, Jens Redemann
BAERI: Michal Segal-Rozenhaimer, Yohei Shinozuka, Qin Zhang, Sam LeBlanc, Kristina Pistone, Jordan Liss

Project Description

The ObseRvations of Aerosols above CLouds and their intEractionS (ORACLES) experiment is a five-year project defined as NASA's Earth Venture - Suborbital (EV-S) containing three intensive operating periods, which deploys during 2016, 2017, and 2018 focusing on the South East Atlantic based in Africa. ORACLES provides multi-year airborne observations over the complete vertical column of the key parameters that drive aerosol-cloud interactions, an area with some of the largest inter-model differences in aerosol forcing assessments on the planet. This September-October 2018, the team deployed to Sao Tomé operating 4STAR on board the NASA P3 helping to achieve 15 successful research flights, completing the last deployment of this experiment. The team also directly sampled aerosol from biomass burning in Africa overlying marine stratocumulus clouds in the Atlantic.

Accomplishments

- Finalized the methodology and sensitivity study and published a paper on Development of neural network retrievals of liquid cloud properties from multi-angle polarimetric observations;
- Finished a manuscript on ORACLES 2016-2017 cloud property summary results;

- Archived ORACLES 2016-2017 data;
- Processed lookup tables for Aerosols above clouds for ORACLES P-3 measurements;
- Improved real-time mapping of geostationary and sun synchronous satellite maps for flight planning purposes.
- Continued the developed and implementation of a flight planning software;
- During ORACLES 2018 (phase III of III), 4STAR has generated total AOD, columnar water vapor, O3 and NO_2 amounts, as well as sky scans for all ORACLES flights. These will be inverted to get optical properties of the BB aerosols and other aerosols encountered during the campaign;
- 4STAR has measured Zenith cloud radiance as well, and data was processed to retrieve cloud optical depth and cloud droplet effective radii, which is scheduled to be archived soon. Shinozuka managed the ORACLES data, 4STAR and others, in collaboration with ESPO;
- Data analysis: summaries of AOD above clouds and gas amounts above clouds have been generated; and
- Continued investigation of Aerosol above cloud impact from measurements.

Publications and Presentations

Segal Rosenheimer, M., Daniel Miller, Kirk Knobelsppiese, Jens Redemann, Brian Cairns, Mikhail Alexandrov, (2018), Development of neural network retrievals of liquid cloud properties from multi-angle polarimetric observations, Journal of Quantitative Spectroscopy & Radiative Transfer 220 (2018) 39 -51

Miller,D., Michal Segal Rozenhaimer, Kirk Knobelspiesse, Jens Redemann, Brian Cairns, Mikhail Alexandrov, Low Level Liquid Cloud properties during ORACLES derived from airborne polarimetric measurements using a Neural-Network based Algorithm, in preparation for AMT (manuscript)

LeBlanc, S., Jens Redemann, Connor Flynn, Meloë Kacenelenbogen, Kristina Pistone, Michal Segal-Rosenheimer, Yohei Shinozuka, Stephen Dunagan, Robert P. Dahlgren et al., Above Cloud Aerosol Optical Depth from airborne observations in the South-East Atlantic, in preparation for ACP

Pistone, K. et al., Intercomparison of biomass burning aerosol optical properties from in-situ and remote-sensing instruments in ORACLES-2016, in preparation

LeBlanc, S. (2018, November 5). samuelleblanc/fp: Moving Lines: NASA airborne researchflight planning tool release (Version v1.21). Zenodo. http://doi.org/10.5281/zenodo.1478126

PRESENTATIONS

Pistone, K. et al at AGU Fall Meeting 2018: Intercomparison of biomass burning aerosol properties from in-situ and remote-sensing instruments in ORACLES-2016.

Pistone, K. et al, talk at Stockholm University Department of Meteorology, October 2018: “Results from ORACLES-2016: observations of biomass burning aerosol over the southeast

Atlantic Ocean and the meteorological context."

Pistone, K. et al, talk at NASA Goddard Space Flight Center Climate & Radiation Laboratory Seminar Series, April 2018: "Results from ORACLES-2016: observed biomass burning aerosol properties over the southeast Atlantic Ocean and the relationship to meteorology."

Pistone, K. et al, at ORACLES STM 2018: Intercomparison of biomass burning aerosol properties from in-situ and remote-sensing instruments in ORACLES-2016

LeBlanc, S. E., J. Redemann, C. J. Flynn, M. Segal-Rosenhaimer, M. S. Kacenelenbogen, K. Pistone, Y. Shinozuka, K. S. Schmidt, and S. Cochrane: Cloud radiative effect changed due to shading from above cloud absorbing aerosol in the South East Atlantic, AMS 15th Atmospheric Radiation Conference, Vancouver, BC, Canada, 9-13 July 2018.

LeBlanc, S. Aerosol Optical Depth above clouds in the South East Atlantic, invited talk, NASA Goddard Space Flight Center, Ocean Ecology Laboratory, Greenbelt, MD, September 2018.

LeBlanc, S. et al.: 4STAR ORACLES overview for 2016 and 2017, ORACLES Science Team Meeting, NASA Ames Research Center, June 5-8, 2018.

Awards

Ames Contractor Council Excellence Award for ORACLES' BAER team.

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

Project Participants

NASA: Matt Fladeland
BAERI: Susan Kulawik
NOAA: Sourish Basu

Project Description

The goal of this project is to develop vertically resolved GOSAT and OCO-2 products. Solving the carbon cycle to 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) is a complex problem utilizing satellite observations, ground-based measurements, and transport modeling. Separation of satellite carbon dioxide measurements into lower and upper partial columns provides better constraint on model transport errors and uncertainties, and better information on whether variations in carbon dioxide result from nearby (lower partial column) versus transported (upper partial column) sources. Previous studies have shown that model transport error results in uncertainties in the carbon dioxide emissions and uptakes on continental scales and that vertically resolved observations can identify and constrain transport error.

Accomplishments

- Created an initial lower tropospheric OCO-2 product. The AJAX team collected one vertically-resolved ocean observation co-located to an OCO-2 overpass. The initial OCO-2 product has been compared to aircraft observations and presented at the OCO-2 Science Team meeting.

Publications and Presentations

Susan S. Kulawik, "CO_2 Profile Information from OCO-2", OCO-2 Science Team Meeting, NCAR Mesa Lab, Boulder, CO, October 23-25, 2018

Plant Physiology

Project Participants

NASA: Dave Bubenheim
BAERI: Dave Wilson, Greg Schlick

Project Description

ARC-CREST researchers on the Plant Physiology team are studying the ecophysiology of biological systems in both synthetic and natural environments. In natural environments, the team is investigating how plants respond to environmental toxicity, bioremediation, and adaptation to climate change, as well as how invasive plant species impact ecosystem functions. This investigation is especially important because the range of many plant species is expected to shift with changing climate and associated changes in resource availability. As the climate changes, different types of plants may be co-located that were not historically within the same ecosystem. This project is currently focused on the Yellowstar Thistle and Cheatgrass, invasive species to California.

The team uses a variety of techniques including: forward osmosis for determining toxicity thresholds; growth chambers, and experiments to induce phenology changes; soil water dynamic studies; and remote sensing techniques (e.g. hyper-spectral imaging to view accumulation of toxins). These techniques are also used to investigate carbon flux and plant physiology.

Finally, the Plant Physiology team is developing "Sustainable, Closed Ecology Systems" to provide life support for space travel and other planetary habitats. Using plants to produce food, oxygen, and water while removing CO_2 from the air and recovering nutrients from wastes is important to achieving sustainable, self-sufficient human settlements in space or on other planets.

Accomplishments

Mapping – Biomass Estimation - Our previously developed mapping of floating aquatic vegetation (FAV) area coverage is changing operational protocol for operational partner. The addition of biomass estimation further aides in operational protocol. When treated with the most

prominently used herbicides plant growth is affected but the plants remain, so area coverage is not an adequately responsive parameter to assess treatment effectiveness. On the other hand, biomass is effective as result of rapid growth response to herbicides.

- Validating biomass estimation in growth chambers for Water Hyacinth and Primrose (most abundant FAV species) through series of mapping, on water sample collection, canopy measurements, determination of sample total biomass and within plant mass distribution, and comparison with Satellite-derived biomass prediction on an individual pixel basis;
- Upper limit for standing biomass estimation in Hyacinth has been identified and understanding of how canopy development changes when reaching this high-density threshold changes and leads to decreased sensitivity of the mapping tool to further mass increases; and
- No high-density limits identified for Primrose thus far but validation efforts continue in Primrose, primarily in growth chamber growth studies focused around nutrient loads, water and air temperature variances and elevated CO_2 environments.

Mapping – FAV Species Distinction - Original Mapping tool developed utilizing Landsat imaging. Landsat derived product cannot provide distinction between Hyacinth and Primrose. In very short period Hyacinth has gone from widely dominate FAV species to current situation with Primrose invading and replacing Hyacinth in significant areas. Previously developed tool only designates FAV.

- Testing use of new ESA Satellite series (Sentinel) and the newly developed standard product by NASA using Sentinel to provide continuity with historic Landsat archives while capitalizing on improved spectral band number, range, and red-edge presence enabled by Sentinel.
- Training Sentinel derived tool outputs using specific field locations validated to be Hyacinth or Primrose; and
- Hyacinth and Primrose communities are grown in controlled environments in stand-alone and mixed-species communities and reflectance signatures collect and evaluated for use in developing Sentinel Landsat Continuity product processing for FAV distinction and mapping.

Biological Impacts in the Delta - Conducting focused set of Hyacinth and Primrose studies to define dynamic response to environmental factors - water quality, temperature, light. Gas exchange methods used to rapidly define these responses – photosynthesis and transpiration (evapotranspiration). These eco-physiological responses are used to parameterize environmental response models for Hyacinth and Primrose. These studies are focused in growth chamber research.

- Completing Hyacinth response to water quality gap filling with emphasis on short term response and low nutrient concentrations for nitrogen and phosphorous;
- Completing Primrose temperature (air and water) response growth and development;
- Completing Evapotranspiration definition for hyacinth; Primrose studies initiated; and
- FAV (Hyacinth and Primrose) base model to be populated with above data above.

Publications and Presentations

Dr, David Bubenheim, Greg Schlick, David Wilson, Vanessa Genovese, Christopher Potter. Using Remote Sensing Mapping and Growth Response to Environmental Variability to Aide Aquatic Invasive Plant Management. Western Aquatic Plant Management Society. March, 2018 Reno, NV.

Dr. David L. Bubenheim, Greg Schlick, David Wilson. Using Remote Sensing to Assess of Growth and Distribution for Floating Invasive Plants and Growth Response Times to Altered Environments. Bay Delta Science Conference, Sept. 2018

Dr, David L. Bubenheim, Vanessa Genovese, David Wilson, Greg Schlick. Using Remote Sensing to Assess Growth and Distribution for Floating Invasive Plants. DRAAWP Stakeholders Meeting. October, 2018 Stockton CA.

Sentinel-2

Project Participants

NASA: Jennifer Dungan, Ramakrishna Nemani
BAERI: Sangram Ganguly
CSUMB: Shuang Li

Project Description

Sentinel-2 (S2) is a land monitoring constellation of two satellites that provides high resolution optical imagery by European Space Agency (ESA). Sentinel-2A is the first of two satellites was successfully launched in June 2015. Its MultiSpectral Instrument (MSI) capitalizes on the technology and the vast experience acquired with SPOT and Landsat over the past three decades. The S2 MSI samples 13 spectral bands: four bands at 10 meters, six bands at 20 meters and three bands at 60-meters spatial resolution.

NASA Earth Exchange (NEX) team has been working on radiometric cross-calibration of the S2 MSI and Landsat-8 OLI sensors based on the latest released sample S2 images from ESA. An S2 processing pipeline has also been developed to provide research ready S2 imagery to the remote sensing community. The algorithm used for S2 atmospheric correction is consistent with standard Landsat OLI product, which provides potential data harmonization between Landsat 8 and S2. NEX supercomputing facility will be used to process daily-acquired S2 images.

Accomplishments

- Published a peer reviewed article on the quality of Sentinel-2 data and its harmonization with Landsat 8;

- Presented analysis on harmonization between NEX and Landsat-Sentinel-2 data at the annual NASA Land Cover Land Use Science Team Meeting; and
- Set up the NEX supercomputing workflow for the UMD Sentinel-2 processing architecture that includes a number of modules from atmospheric correction to BRDF modeling to spectral calibration and validation. All Sentinel-2 and related Landsat input data and output data are available on NEX for researchers to use and validate results.

Terrestrial Ecosystem and Carbon Simulation Modeling

Project Participants

NASA: Chris Potter
CSUMB: Steven Klooster, Vanessa Brooks Genovese

Project Description

The ARC CREST terrestrial carbon research group utilizes the NASA-CASA (NASA-Carnegie-Ames-Stanford Approach) model, or the scaled-down version of the model called CASA Express, to model terrestrial trace gas fluxes (CO_2, CH_4, N_2O and NO) and plant production at global and regional scales using satellite data inputs. In addition, as of late, the terrestrial carbon research group has been asked by partners in other federal (USDA and BLM) and local agencies, such as the Department of Boating and Waterways (DBW) to map environmental parameters using satellite data for their environmental mitigation projects: specifically, the USDA-ARS California Delta Areawide Project for Integrated Resource Management, the USDA Coffee mapping project, and the BLM desert research project.

Accomplishments

- Continued working on the invasive weed mapping for the Delta project using Landsat 8 data for the USDA-ARS California Delta Areawide Project for Integrated Resource Management. In addition, a python tool was developed in ArcMap and transferred to the DBW for their use in ongoing mapping and FAV invasive species control measures;
- Completed work on mapping the coffee crops of Maui were using WV2 data for the USDA/NASA Coffee Mapping Project; and
- Continued to work on mapping desert pavements and analyzing the field data collected to determine the extent of the disturbance of these fragile landscapes for the BLM Desert Research Project. Multiple scripts were written to help process and analyze the field data.

Tropospheric Emission Spectrometer (TES)

Project Participants

NASA: John Worden
BAERI: Susan Kulawik

Project Description

The Tropospheric Emission Spectrometer (TES) is an infrared spectrometer flying aboard the Aura satellite, currently in Earth orbit. Its high spectral resolution enables it to measure concentrations of many chemical constituents in our atmosphere including: O_3, CO, H_2O (g), PAN, CH_2O_2, CH_3OH, CH_4 and other gases. Measurements made by TES advance our understanding of the atmosphere's chemistry, a knowledge that is prerequisite to addressing air pollution and climate change. TES focuses on the troposphere, the layer of atmosphere that stretches from the ground to approximately 32,000 ft. TES can distinguish concentrations of gases at different altitudes, a key factor in understanding their behavior and impact. It is the first orbiting instrument able to measure O_3 profiles, a very important chemical with regard to both global warming and air pollution.

ARC-CREST researchers and their partners at NASA-JPL are analyzing and interpreting TES data, making high quality TES data products available to the scientific community. Their work requires close coordination with the NASA Distributed Active Archive Center where these large datasets are hosted. Further, they work closely with the TES science team to expand the retrieval algorithms to capture additional atmospheric gas concentrations, to improve existing algorithms by reducing or better quantifying errors, and to conduct comparisons with other satellite or ground-based retrievals.

Accomplishments

- Updated the TES prototype for R15, including linear PAN retrievals, the addition of the new HCN species, and incorporated new, 100 times faster radiative transfer protocol, into the code.

Publications and Presentations

John R. Worden, Susan S. Kulawik, Dejian Fu, Vivienne H. Payne, Alan E. Lipton, Igor Polonsky, Yuguang He, Karen Cady-Pereira, Jean-Luc Moncet, Robert L. Herman, Frederick W. Irion, and Kevin W. Bowman. Characterization and Evaluation of AIRS-Based Estimates of the Deuterium Content of Water Vapor. Atmos. Meas. Tech. Discuss., https://doi.org/10.5194/amt-2018-372, 2018.

Dejian Fu, Susan S. Kulawik, Kazuyuki Miyazaki, Kevin W. Bowman, John R. Worden, Annmarie Eldering, Nathaniel J. Livesey, Joao Teixeira, Fredrick W. Irion, Robert L. Herman, Gregory B. Osterman, Xiong Liu, Pieternel F. Levelt, Anne M. Thompson, and Ming Luo. Retrievals of tropospheric ozone profiles from the synergism of AIRS and OMI: methodology

and validation. Atmos. Meas. Tech., 11, 5587-5605, https://doi.org/10.5194/amt-11-5587-2018, 2018.

U.S. Coral Reef Task Force (USCRTF)

Project Participants

NASA: Paula Bontempi, Jim Brass, Liane S. Guild
BAERI: Juan L. Torres-Pérez

Project Description

The focus of the research is in understanding the effects of humans activity/presence 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), Dr. Torres-Pérez participates in monthly coordination calls of the CRTF Steering Committee, Watershed Partnership Initiative, and the Climate Change Working Group. He also participates in the CRTF's two annual meetings (in DC and one of the US jurisdictions).

Accomplishments

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

Presentations

Torres-Pérez, J.L., L.S. Guild, and P. Bontempi. 2018. NASA-funded projects on coral reef science (Pacific Ocean). 40th US Coral Reef Task Force. August 14-16. American Samoa.

Torres-Pérez, J.L., R. Viqueira, and W. Hernández. 2018. Benthic community structure characterization and assessment of turbidity impacts of the north (Manatí and Vega Baja) and south (Guánica) coasts, Puerto Rico: Benthic Assessment. 40th US Coral Reef Task Force. August 14-16. American Samoa.

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.

Space Traffic Management (STM)

Project Participants

NASA: David Murakami
BAERI: Sreeja Nag, Nolan Johnson, Miles Lifson, Jannuel Cabrera

Project Description

Space is becoming increasingly congested as the number of on-orbit satellites and debris objects continues to grow. Space traffic management (STM) is critical for ensuring that the expanding orbital population operates safely and efficiently, avoiding collisions and radio-frequency interference while still facilitating widespread space operations. Recent events such as the Federal Communication Council (FCC) approval of SpaceX's ~12,000 satellite constellation, the signing of Space Policy Directive 3 (which moves Space Situational Awareness responsibilities away from the Department of Defense and to a civil agency), and the growth in rideshare and small launch vehicles illustrate the rapidly changing nature of this domain. We are working toward the concept of operations (ConOps) for a civilian STM research initiative, which has been developed from previous NASA work to enable safe operation of small unmanned aircraft systems. The STM ConOps proposes an architecture to enable efficient data sharing and coordination between participants to facilitate safe spaceflight operations. It is designed to utilize and promote the emerging field of commercial STM services, as a complement to existing government-provided STM services. The concept envisions a phased evolution that would gradually integrate additional capabilities, proposing a first phase architecture and tentative plans for a broader system. We are also working towards developing an STM research and prototyping platform.

Accomplishments

- Developed the STM architecture and concept of Operations, as published in the Digital Avionics Systems Conference (DASC) 2018 and SciTech 2019 papers;
- Defined Application Programming Interfaces, roles, functions within the architecture;
- Sketched the roadmap with Technology Capability Levels;
- Found an initial set of industry, academic, government partners;
- Developed a research lab with 4 workstations and a hyperwall (Visualization environment) at NASA Ames N243 R237; and
- Started Implementing a strawman STM prototype using the Urchin Tracking Model (UTM) Flask and Swaggerhub codebase, as well a prototype Conjunction Assessment service provider, as published in Spaceflight Mechanics 2019.

Conference Proceedings

S. Nag, D. Murakami, M. Lifson, P. Kopardekar "System Autonomy for Space Traffic Management", IEEE/AIAA Digital Avionics and Systems Conference, London, United Kingdom, September 2018

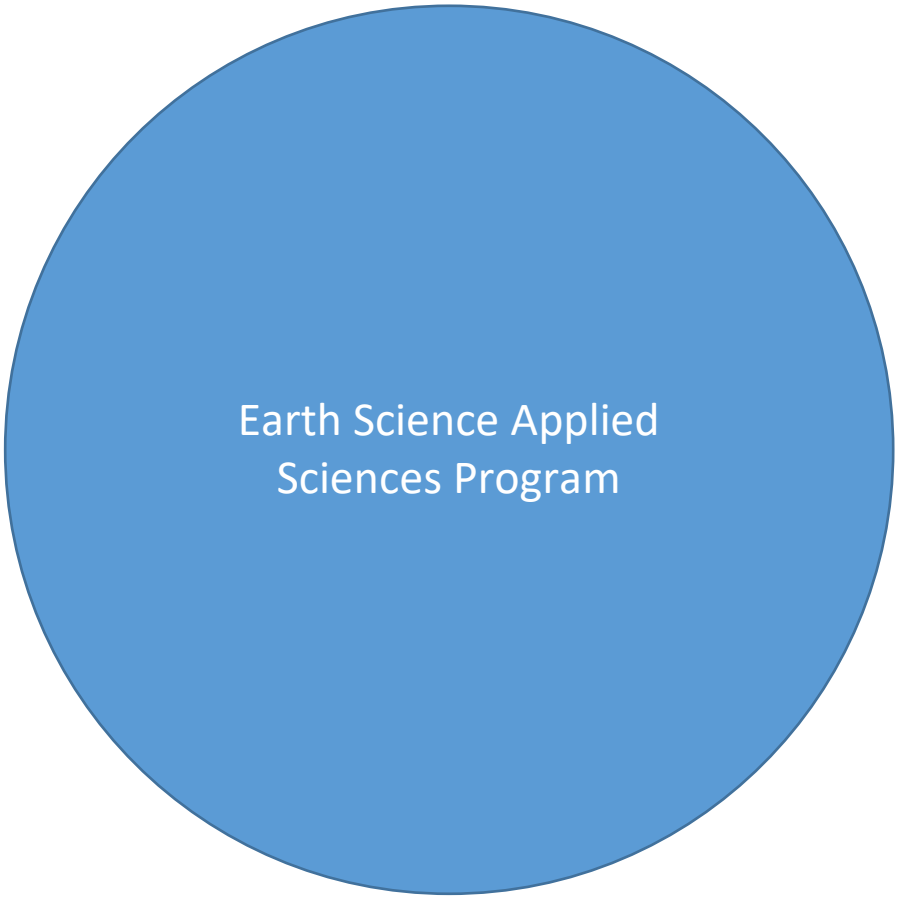
D. Murakami, S. Nag, M. Lifson, P. Kopardekar, "Civilian Space Traffic Management (STM) Concept of Operations", AIAA Science and Technology Forum and Exposition (AIAA SciTech), San Diego USA, January 2019

J. Cabrera, S. Nag, D. Murakami, "An Initial Analysis of Automating Conjunction Assessment and Collision Avoidance Planning in Space Traffic Management", AAS/AIAA Space Flight Mechanics Meeting, Hawaii USA, January 2019

J. Jung, C.R. Drew, S. Nag, E.O. Torres, A.K. Ishihara, M. Do, H.C. Modi, "Initial Approach to Collect Small Unmanned Aircraft System Off-nominal Operational Situations Data", AIAA Aviation, Atlanta Georgia, June 2018

INVITED CONFERENCE PRESENTATION:

S. Nag, D. Murakami, M. Lifson, J. Cabrera, P. Kopardekar, "A Concept for Civil Space Traffic Management", AIAA Small Satellite Conference, Logan, USA, August 2018


Earth Science Applied
Sciences Program

Disaster Management

Project Participants

NASA: Jim Brass
CSUMB: Vince Ambrosia, Robert Dahlgren, Lee Johnson

Project Description

The Disaster Management Task is composed of two principal elements: 1) Staffing to support the NASA Applied Science Program 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:

A. **Disaster Task Element 1**: Since 2013, Assistant Program Manager, Vince Ambrosia has supported a portfolio of funded project efforts within the ASP-Wildfire Program. That responsibility includes scientific oversight of the project goals and objectives, budgetary management of the funded efforts of disparate organizations and investigators, metrics monitoring for the projects, interactions with partner agencies involved in the projects and serving as a 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 and use of EO data to support wildfire science and applications by the community

B. **Airborne Systems** (UAS for Environmental and Disaster Monitoring and Science Support) (1) Research directed at lowering the cost of remote sensing using small unmanned aerial systems (sUAS), aka small drones, as stable low-altitude platforms to host payloads such as sensing instruments. What is unique about this research is the concept of modularity that allows UAS airframes that can be assembled Lego*-like and scaled such that they are holistically optimized to maximize performance for a given remote sensing mission. As a demonstration concept, components from surplus military sUAS are converted into modular aircraft capable of a variety of configurations, which are in development and scheduled for flight testing at the end of 2016. Some of the applications of these mass-customized aircraft will be volcanic plume observation, magnetometer surveys, wildlife census, marsh erosion, post-wildfire recovery, landslide hazard mapping, geological survey, inundation mapping, mudflat quality and quantity, and other data collection campaigns.

(2) Applied research and improvement of sensors and instruments for onboard manned and unmanned aircraft. This includes development and construction of specific instruments such as n-STAR, sun glint sensor, and polarimetric sensors. This work also includes the integration of payloads such as Micro Differential Optical Absorption Spectroscopy (DOAS) and MFAM that

often require significant effort for suspension system, aerodynamics, electromagnetic compatibility (EMC), and system engineering development.

(3) Electrical engineering of avionics and telemetry systems for commercial sUAS and larger military surplus unmanned aerial systems (UAS) at the NASA Ames Research Center. Subject matter expert in optical sensor physics, gyroscopes/accelerometers, lasers, and EMC testing.

(4) Education and outreach activities supporting several undergraduate and graduate interns at NASA Ames Research Center. Provide mentorship and focused sUAS projects for intern teams during the summer, and individuals throughout the school year, via a variety of programs.

*Lego is the trademark of the LEGO Group, Billund, Denmark.

Accomplishments

Disaster Element Task 1 (Ambrosia):

- Organized a series of meetings and workshops 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 a portfolio of 9 NASA ASP-funded Wildfire projects as they came to a conclusion in 2018, including metrics tracking, budget maintenance and reporting, investigator interface, partnership / co-agency development and maturation and review / evaluations of work accomplished by those 9 teams.
- 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.
- Sat on Technical and Scientific Panel of international remote sensing conferences, including the ISRSE 2019 meetings, the RSCy2018 and 2019 meetings.
- Served as Section Chair of the New Platforms and Sensors session of the 2nd IECRS, and for 3rd ICERS (2019);
- Represented NASA Wildfire Program by serving on Planning Committees for upcoming scientific symposia, International Symposium on Remote Sensing of the Environment (ISRSE)-2019;
- Sat on numerous journal peer-review panels; Provided scientific peer review of 7 manuscripts submitted to journals in 2018.
- Managed the NASA ROSES16 A.50-Group on Earth Observations (GEO)Work Programme; 3.3.7 Global Wildfire Information System (GWIS) solicitation, lead the panel review selection, and served as manager of the GWIS program projects (3) in the solicitation for 2018 through 2020;
- Reviewed two USDA Small Business Innovation Research (SBIR) submission for fire science support.

- Worked with NASA HQ Public Affairs on program descriptions and development of press releases and video of wildfire program project highlights.
- Scientific content manager of the NASA Applied Science Program - Wildfire website.
- Prepared NASA Applied Science Program - Wildland Fire 2018 Annual Program Report.
- Served on the External Advisory Board of project "EXCELSIOR" (ERATOSTHENES: Excellence Research Center for Earth Surveillance and Space-Based Monitoring Of the Environment), a project proposed under 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 advisory to their remote sensing applications program development.

Disaster Element Task 2 Dahlgren

- Icing Testing of UAS. Test direction of three UAS in the Icing Research Tunnel (IRT) at the NASA Glenn Research Center. This involved coordination with multiple Federal agencies (USCG, NOAA, DOE) and test article suppliers (Navmar, Griffon, Pemdas, CU) and the IRT facility;
- SIERRA-B. General electrical engineering support for the Sierra-B project, payload integration and medium-class UAVs. A schematic review has been performed on a large drawing set for the Sierra-B aircraft, and a number of issues were addressed. SIERRA-B received airworthiness certification in 2018;
- 5-STAR. This project is to evaluate opto-mechanical impairments in the 4STAR instrument and advise the science and engineering teams on photonics matters. Developed, inspected and redesigned the wiring for the sun photometer while keeping the previous wiring drawing standards and methods;
- Aerobiology. This project is to attempt to obtain samples of fog water to examine fogborne life such as bacteria, protozoa, and other microbial life forms;
- Space Act Agreement. Obtain Space Act Agreement between NASA Ames and Draper Lab to share data on the Open NEX platform at Ames;
- Moved UAS lab from Bldg. N211 room 262 to Bldg. N248 room 118; and
- Provided topic and guided student Henry Haig on his Sr. Capstone project at Bowdoin U.

Presentations

Ambrosia, V.G., A. J. Soja, L. Friedl, 2018. NASA Applied Science Efforts: Collaborations in Earth Observation Data, Information, Models and Tools Supporting Wildland Fire Management, The Fire Continuum Conference: Preparing for the Future of Wildland Fire, Missoula, MT, 22 May 2018.

Ambrosia, V. G. and L. Friedl, 2018. NASA's Global Perspective: Observations Programs and Future Missions. Sixth International Conference on Remote Sensing and Geoinformation of Environment, Paphos, Cyprus,26 March 2018.

Dahlgren, R.P. "UAS Ice Accretion Testing and Simulation at NASA," Alaska UAS Interest Group (Anchorage 2018).

Dahlgren, R.P. Cultivating Sustainable Internship Projects in UAS at the NASA Ames Research Center, Aerial Pathways Conference, (2018, Saratoga, CA).

Dahlgren, R.P. "Drones and UAS at NASA," ASSURE Summer Student Drone Academy, (2018, Davis, CA).

Vanderbilt, V.C., Daughtry, R. Dahlgren, "Leaf water status from lab estimates of Vis-NIR Reflectance and Transmittance," IGARSS, (2018, Dallas, TX).

Vanderbilt, V.C., C.S.T. Daughtry, R.P. Dahlgren, "Leaf Water Status Estimated from Visible-NIR Polarization Measurement," AGU Fall Meeting, accepted, (2018, Washington DC).

Wong, A., A. Navazo, J. Perez, R.P. Dahlgren, and D. Gentry, "An Improved UAV-Based Fog Collector for Local-Scale Aerobiological Sampling," AGU Fall Meeting, accepted, (2018, Washington DC).

Panels or Committees

Vince Ambrosia:
NASA Representative on the Group on Earth Observations (GEO), Global Wildfire Information System (GWIS) committee; GEO Work Plan 2011-2015 and 2016-2021.

NASA representative on the Technical Advisory Committee of the Fire and Smoke Model Evaluation Experiment (FASMEE). The multi-agency effort focuses on developing an integrated field measurement campaign to improve wildland fire and smoke models.

Technical Organizing Committee: 2019 International Symposium on Remote Sensing of Environment (ISRSE), Denver, CO;

USDA Small Business Innovative Research (SBIR) Program Science Review Panel member - 2018

NASA SBIR Review Panel Member - 2018

NASA Applied Science Program Disasters, ROSES-2018 Solicitation Panel Review Co-Chair, October 2018.

NASA Tactical Fire Remote Sensing Advisory Committee (TFRSAC); a USFS / NASA committee focused on technology development and EO in support of wildland fire management;

Section Chair: New Platforms and Sensors, in 2nd International Electronic Conference on Remote Sensing, March 22-April 5. 2018.

Guest Editor, Special Issue, Remote Sensing Journal, "New Trends in Forest Fire Research Incorporating Big Data and Climate Change Modeling", 2018.

Scientific Peer-Review Journal Reviewer for: International Journal of Wildland Fire, Journal of Field Robotics, Remote Sensing, Remote Sensing of Environment, Photogrammetric Engineering and Remote Sensing (PERS)

Robert Dahlgren:
Member, American Geophysical Union (AGU) Natural Hazards Section Committee.

Member, AGU Natural Hazards Graduate Research award Committee

Judge, AGU Outstanding Student Paper Award (OSPA) Program.

Member, Program Committee, Symposium on Optical Components and Materials, (SPIE Photonics West)

Member, USCS Baskin Alumni Advisory Council.

Awards

KEYNOTE ADDRESS: Ambrosia, V. G., 2018. "NASA's Global Perspective: Observations Programs and Future Missions". Sixth International Conference on Remote Sensing and Geoinformation of Environment, Paphos, Cyprus, 26 March 2018.

R. Dahlgren, part of SIERRA-B team that received an Ames Team Honor Award, November 2018.

Ecological Forecasting

Project Participants

NASA: Jim Brass
BAERI: Cindy Schmidt

Project Description

The Ecological Forecasting program is a sub-program within NASA's Applied Science Program whose larger goal is to advance innovative and practical uses of Earth observations and modelling in order to enhance stewardship of natural resources and decision making of public and private organizations. ARC-CREST staff are part of the program management team. In this capacity, they track the projects in the Ecological Forecasting portfolio, support strategic planning activities, help coordinate annual program review meetings, and participate in interagency activities and meetings as required by the Program Manager for Ecological Forecasting. ARC-CREST staff help manage the following projects:

1. Projecting Effects of Climate Change on River Habitats and Salmonid Fishes, PI: Gordon Luikart, University of Montana

2. Bayesian Data-Model Synthesis for Biological Conservation and Management in Antarctica, PI: Heather Lynch, Stony Brook University
3. Bringing Wildlife Management into Focus: Integrating Camera Traps, Remote Sensing and Citizen Science to Improve Population Modeling, PI: Phil Townsend, University of Wisconsin
4. Using NASA Resources to Better Inform Wildlife Conservation in the Anthropocene: Spatially Predicting Impacts of Anthropogenic Nightlight and Noise on Wildlife Habitat Integrity Across the Contiguous U.S., PI: Neil Carter, Boise State
5. Using Earth observations and ecosystem modeling to improve the sustainability of agribusiness and extractive industries in working landscapes; PI: Gretchen Daily, Stanford
6. Harnessing NASA satellite remote sensing in support of large-scale conservation management on BLM lands; PI: Greg Okin, UCLA
7. Informing UN-assisted National Biodiversity Strategy Action Plans with Earth observations: Application to forest integrity and connectivity; PI: Andy Hansen, Montana State
8. Integration of Earth observations for decision making on biodiversity management and conservation in Colombia: Consolidation of the Colombian Biodiversity Observation Network; PI: Victor Gutierrez-Velez, Temple University
9. Expanding Wallace biodiversity modeling software to support national biodiversity change indicator calculations for GEO BON assessment and reporting; PI: Mary Blair, American Museum of Natural History
10. Improving linkages between Earth observations and ecosystem service models with Essential Biodiversity Variables; PI: Gretchen Daily, Stanford

Accomplishments

- Attended Natural Capital symposium, March 21-23, Stanford University to meet with Mongolia project team;
- Helped organize and run Ecological Forecasting and Biodiversity PI team meeting, April 23-27, Washington DC;
- Participated in NASA Applications showcase - displayed Ecological Forecasting poster, July 31-Aug 2, Washington DC; and.
- Traveled to Mongolia for Mongolia project team meeting and field excursion to visit goat herders in the Gobi Desert, September 13-22.

Publications and Presentations

Schmidt, C. 2018. Monitoring Biodiversity from Space (Invited plenary), Digital Data in Biodiversity Research, Jun 4-5, Berkeley, CA

Leidner, A., Schmidt C., Satellites and citizens: Combining observational capabilities to inform conservation (organized session), North American Congress of Conservation Biology, July 22-27, Toronto, Canada

Kreibel, C., Schmidt C., New web-based tools for analyzing satellite Earth observations and ground collected data (workshop), North American Congress of Conservation Biology, July 22-27, Toronto, Canada

BOOK CHAPTER:

Brink, A. and Schmidt, C. 2018. Chapter 2: Introduction to remote sensing for conservation practitioners. In Satellite Remote Sensing for Conservation Action. Eds. Allison Leidner and Graeme Buchanan.

Panels or Committees

Proposal review panel for ROSES A.8: Supporting UN Sustainable Development Goals 14 and 15 in the Context of Climate Variability and Change, held in Washington D.C., August 20-24.

Indigenous Knowledge

Project Participants

NASA: Jim Brass
BAERI: Cindy Schmidt, Amber McCullum, Sherry Palacios

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 bases that include a deep understanding of local environments and adaptive processes passed down through generations. That knowledge, referred to as "indigenous knowledge" or "traditional ecological knowledge (TEK)" is typically passed down by oral tradition through generations, and holistic in having cultural and spiritual components. TEK 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 TEK can inform NASA Earth Science activities.

Accomplishments

- January 2-5 - conducted Introduction to Remote Sensing workshop with tribes in the Pacific Northwest, Northwest Indian College, Bellingham, WA;
- May 9-10 - Organized and conducted an Indigenous Peoples/NASA workshop to develop recommendations for interacting and engaging with indigenous communities and to understand how indigenous knowledge can be incorporated into NASA Earth science programs and activities. Held on the tribal lands of the Red Cliff Band of Lake Superior Chippewa, WI;
- June 11-16 - Traveled to Peru with the NASA-funded Earth Observations for Indigenous Peoples project (PI: Karyn Tabor, Conservation International), to participate in the Dedicated Grant Mechanism indigenous knowledge exchange, funded by the World Bank;

- July 9-11 - Participated in a panel on indigenous people and disaster resilience and vulnerability, Natural Hazards Workshop, Boulder, CO;
- Oct. 15-19 - Conducted Introduction to Remote Sensing training with the Sault tribe, Sault Ste. Marie, MI; and
- Oct 30-Nov. 1 - Conducted Advanced Remote Sensing training with tribes in the Pacific Northwest, Anacortes, WA.

Publications and Presentations

NASA's Indigenous Peoples Pilot Program, Society for Conservation GIS, Asilomar, July 2018

Informing NASA's Indigenous Peoples Capacity Building Pilot Through Collaborative Storytelling and Systems Mapping, AGU, December 2018

NASA Data for Decision Making: Drought Reporting and Geospatial Training, New Mexico Geographic Information Council Annual Meeting, ABQ, April 20

Using NASA Satellites to Monitor a Changing Earth, Conference for the Environment, Michigan City, IN, June 8

NASA Earth Observations in Service to Society, Vanderbilt Earth and Environmental Sciences Seminar Series, Nashville, TN, November 16

Water Resources Program

Project Participants

NASA: Jim Brass
CSUMB: Forrest Melton

Project Description

The primary objectives of this task are to:

1) Support the NASA Applied Sciences Program, Water Resources application area by serving as an Associate Program Manager for Water Resources, and a Deputy Program Manager for the Suomi NPP satellite mission.

2) 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.

3) Engage and support the NASA Applied Sciences stakeholder community.

Accomplishments

- Co-organized the annual NASA Applied Sciences Program (ASP) Water Resources PI Meeting held at the NOAA Center for Weather Prediction in College Park, MD. Co-authored the meeting report;
- Led the organization of a joint workshop with the World Bank on the topic of Remote Sensing of Evapotranspiration for Food and Water Security, held at the World Bank in Washington, DC. The meeting was attended by more than 150 scientists, water resource managers, World Bank staff, and stakeholders from around the world. Co-authored the meeting report and a whitepaper submitted to the NRC Decadal Survey request for information;
- Co-organized the Climate Change and Water Resources Working Group interagency workshop at the NOAA Fisheries Science Building in Seattle, WA, attended by 60 scientists and water resource managers;
- Maintained the ASP Water Resources website (https://c3.nasa.gov/water);
- Co-authored the 2018 ROSES Water Resources solicitation and jointly organized the review panel with the Program Manager for Water Resources;
- Tracked and coordinated 9 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 project managers and Associates at 6 ASP Program Reviews; and
- Served as the NASA Representative to Western States Federal Agency Support Team (WestFAST) and the Climate Change and Water Working Group, which are federal interagency coordinating organizations.

Publications and Presentations

Melton, F. Advances in Mapping Evapotranspiration with Satellite Data, 2017. National Academy of Sciences, Fifth Arab American Frontiers Symposium, Rabat, Morocco, November 3, 2017 (National Academy of Sciences invited lecture).

Melton, F., 2017. Advances in Remote Sensing for Sustainable Supply Chains. Water and Long-Term Value Conference, San Francisco, CA, Oct 24-25, 2017.

Melton, F., Huntington, J., Grimm, R., Hall, M., Erickson, T., 2018. OpenET, Western States Water Council Water Information Management Systems Workshop, Pasadena, CA, Jan 16-18, 2018.

Melton, F., Huntington, J., Grimm, R., Hall, M., 2018. User requirements for measuring evapotranspiration, OpenET Workshop, Reno, NV, May 17-18, 2018.

Melton, F., 2018. Remote Sensing of Evapotranspiration, Lecture at Stanford University, Stanford, CA, March 13, 2018.

Lee, C., Bolten, J., Melton, F., Brennan, B., and Doorn, B., 2018. Applied Sciences Program: Water Resources. AWWA Sustainable Water Management Conference, March 25-28, Seattle, WA.

Melton, F., Doorn, B., Bolten, B., Lee, C., Brennan, S. Remote Sensing of Water Resources. Airborne Snow Observatory Workshop, Mammoth, CA, Sept 11, 2018.

Melton, F., Doorn, B., Bolten, B., Lee, C., Brennan, S., Doorn, B., 2018. ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station (ECOSTRESS) and the NASA Western Water Application Office, Western States Water Council Fall Meeting, Couer d'Elene, ID, Oct 24-26, 2018.

Awards

Forrest Melton was invited to serve as the Program Scientist for the Western Water Applications Office and accepted this role effective in September 2018.

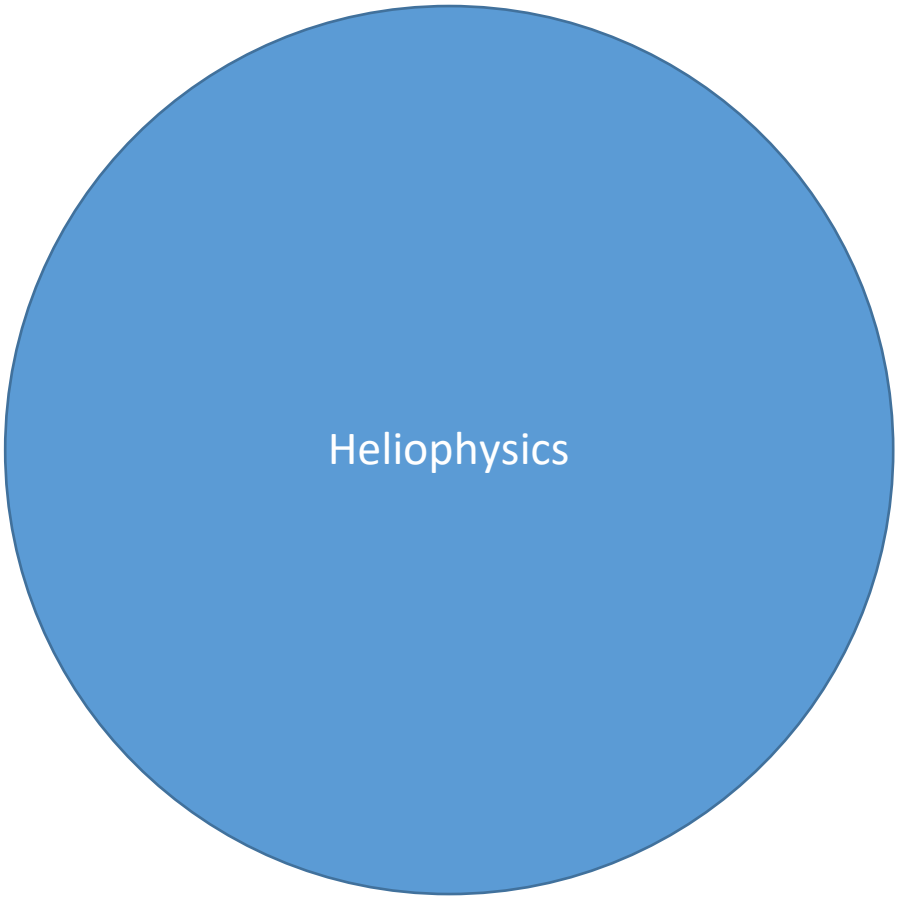
Panels or Committees

Forrest Melton participated on multiple ROSES peer review panels for the Applied Sciences Program.

Western Federal Agency Support Team (WESTFAST, F. Melton)

California Department of Water Resources Open Water Information Architecture Technical Committee (F. Melton)

Western Water Applications Stakeholder Engagement Working Group (F. Melton)


Heliophysics

Heliophysics Modeling and Simulation

Project Participants

NASA: Alan Wray
BAERI: Irina Kitiashvili, Viacheslav Sadykov

Project Description

In this project, we study Where and how solar magnetic fields are generated and how they affect the structure and dynamics of the solar surface and atmosphere. These questions 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" that operates near the surface. This dynamo produces ubiquitous, small-scale magnetic elements that contributes to the magnetic carpet in the photosphere and to the magnetic structure and dynamics of the solar atmosphere. Observations from the NASA space mission Interface Region Imaging Spectrograph (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 these dynamics. It appears that the primary drivers in the energetics and dynamics of the chromosphere and transition region are small-scale, previously unresolved, quiet-Sun magnetic fields.

In this study, the traditional force-free and potential models of the quiet-Sun magnetic carpet and chromospheric loops are replaced with radiative magnetohydrodynamic (MHD) models that describe the properties and dynamics of the photosphere and chromosphere more realistically. The realistic simulations are capable of reproducing various known magnetic features (loops, vortices, jets, oscillations). Also, these features 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.

Accomplishments

- Performed high-resolution MHD simulations of the quiet-Sun dynamics that cover the solar interior and atmosphere. The simulations revealed spontaneous formation of self-organized funnel-like structures that extend through the chromosphere and corona;
- Investigated effects of distributed magnetic fields and compact magnetic structures on properties of acoustic wave excitation on the Sun. Analysis of the depth distribution of acoustic events showed the strongest concentration of sources at the depth of 0.2 - 1Mm beneath the surface outside the magnetic structure, and 1-3 Mm or even deeper inside the structure;
- Performed initial calculations of synthetic spectral line profiles, for modeling and interpretation of observation from the IRIS mission, as well as observables of the

Atmospheric Imaging Assembly (AIA) instrument inboard of NASA's Solar Dynamics Observatory;

- Developed methodology for including Non-local Thermodynamical Equillibrium (NLTE) effects in the StellarBox simulations. The methodology had been tested for the 1D Fast Lagrangian Analysis of Continuaity (FALC) standard solar model; and
- Expanded capabilities of the StellarBox code. In particular, extension of the computational domain box into deeper layers of the convective zone and higher to atmosphere had been developed and tested. Implemented "open" bottom boundary conditions, including the capability to increase the horizontal size of the domain to obtain more realistic large-scale patterns.

Publications and Presentations

JOURNAL ARTICLE:
Kitiashvili, I.N., A.G. Kosovichev, N.N. Mansour, A.A. Wray, T.A. Sandstrom. 2018. Origin of deep acoustic sources associated with solar magnetic structures. Astrophysical Journal (submitted). arXiv:1810.06133, https://arxiv.org/abs/1810.06133

Sadykov, V.M., A.G. Kosovichev, I.N. Kitiashvili, A. Frolov. 2018. Statistical study of properties of the Soft X-ray emission during solar flares. Astrophysical Journal (submitted). arXiv:1810.05610, https://arxiv.org/abs/1810.05610

BOOK CHAPTER:
Kitiashvili, I.N. 2018. Advances in realistic MHD simulations of the Sun and stars. In Book: "Variability of the Sun and Sun-like stars: from asteroseismology to space weather". Eds. J.-P. Rozelot, E.S. Babaev, EDP Sciences Proceedings. 63-88.

Wray, A.A., K. Bensassiy, I.N. Kitiashvili, N.N. Mansour, A.G. Kosovichev. 2018. Realistic simulations of Stellar Radiative MHD. In Book: "Variability of the Sun and Sun-like stars: from asteroseismology to space weather". Eds. J.-P. Rozelot, E.S. Babaev, EDP Sciences Proceedings. 39-62.

PRESENTATIONS
Kitiashvili I.N., A.A. Wray, A.G. Kosovichev, N.N. Mansour. 2018. Dynamics of Self-Formed Funnel Structures in 3D Realistic Simulations of a Quiet-Sun Region. Triennial Earth-Sun Summit (TESS), 20-24 May 2018, Leesburg, Virginia.

Kitiashvili I.N., A.G. Kosovichev, A.A. Wray, N.N. Mansour. 2018. Effects of Distributed Magnetic Fields and Compact Magnetic Structures on the Properties of Acoustic Wave Excitation on the Sun. Triennial Earth-Sun Summit (TESS), 20-24 May 2018, Leesburg, Virginia.

Kitiashvili I.N., 2018. 3D Realistic Modeling of Spontaneous Plasma Eruptions in Quiet-Sun Conditions. International Space Science Institute meeting, Jul 2 – 6, 2018, Bern, Switzerland.

Sadykov V., A. Kosovichev, I. Kitiashvili. 2018. Using Machine-Learning Methods and Expert Prediction Probabilities to Forecast Solar Flares. Solar Heliospheric & Interplanetary Environment (SHINE) Workshop, July 30th-August 3rd, 2018, Cocoa Beach, FL

Kitiashvili, I., N. Collins, A.G. Kosovichev, N.N. Mansour, A.A. Wray 2017. Solar activity across the scales: from small-scale quiet-Sun dynamics to magnetic activity cycles. American Geophysical Union, Fall Meeting 2017, 10-14 December 2017, New Orleans, Louisiana. #SH13A-2466

Panels or Committees

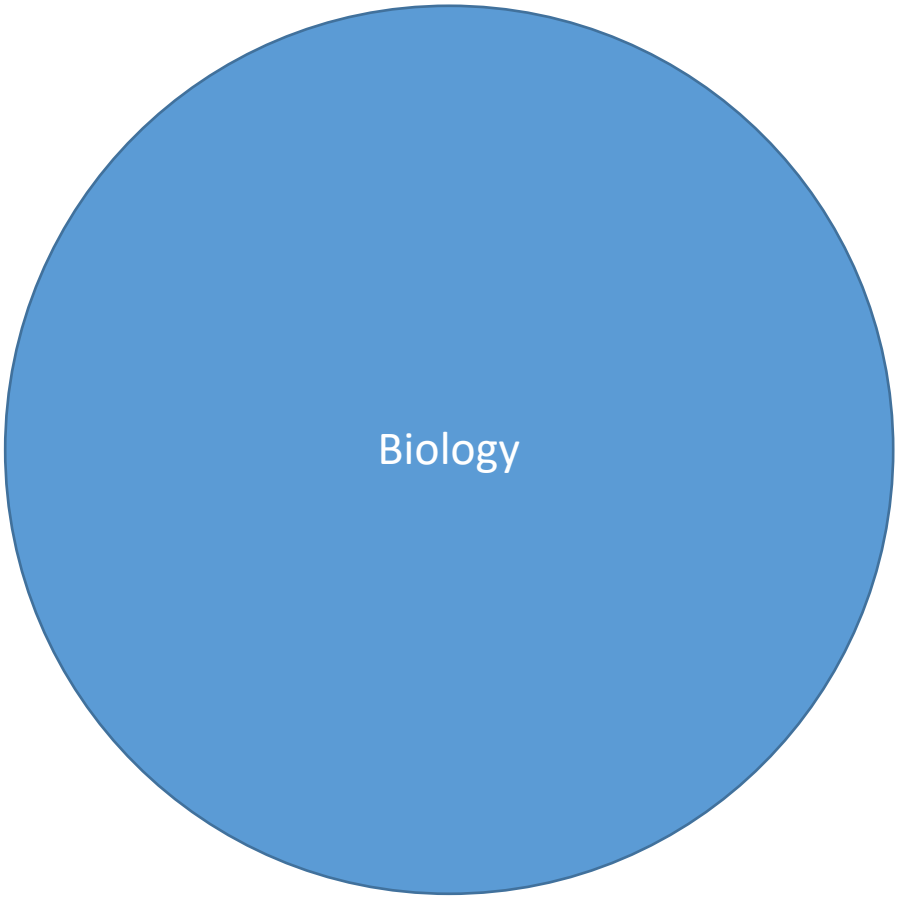
Kitiashvili, I:
Participation in proposal review panels:
Early Career Investigator Program in Heliophysics (NASA)
Astronomical sciences, Solar and Planetary Research Grants (NSF)

Steering committee:
EarthCube Project “Heliophysics Data, Modeling, and Analysis Tools”
Division E Sun and Heliosphere (International Astronomical Union)

Organization scientific session “Advancing Solar Activity Forecasts Through Observations, Data Assimilation and Machine Learning” at the SHINE meeting, July 30th - August 3rd, 2018, Cocoa Beach, FL

Awards

Selected to the Steering Committee Member of Division E Sun and Heliosphere (International Astronomical Union)


Biology

Space Synthetic Biology and Astrobiology

Project Participants

NASA: Michael Flynn
BAERI: Rocco Mancinelli

Project Description

We have extensive experience in biological systems exposed to space conditions. Valuable research in gravitational biology, synthetic biology, proteomics, and biotechnology cannot be accomplished using existing technologies without significant improvements in our ability to manage gases and fluids in these systems. We are developing systems that address these limitations. This research enables a wide range of foundational research in Space Synthetic Biology, Fundamental Space Biology, and Astrobiology, ultimately generating the knowledge required to engineer a potentially broad range of space biotechnology applications employing synthetic organisms and microbial bioreactors for in situ resource utilization and biological life support systems. To that end we focused on Euglena: Combined Regenerative Organic-food Production In Space (Eu:CROPIS), a flight experiment.

Eu:CROPIS. A significant part of using biological systems (synthetic or naturally occurring) in space is to understand the function of gravity in such systems from the gene level to the ecosystem level. A specific task to do this at the ecosystem level is Eu:CROPIS where we will elucidate the nitrogen cycle of an ecological system during spaceflight. This task will provide data allowing us to understand the ecology of closed bioreactor systems in space. The objective of the study is to determine the effect of different gravity levels on the nitrogen cycle leveraging experiments to be flown on the German Aerospace Center (DLR)'s aircraft.

Accomplishments

- The major work this year focused on developing a computer simulation model as well as testing the ground simulation facility. The following is what we accomplished regarding the computer simulation.
- Computer simulation of the filter column and the Eu:CROPIS-system.
- The simulation was performed with the GameMaker Software 8.1. (YoYo Games, Dundee, Scotland) that is commonly used to program computer games. Cell types as well as substances were programmed as objects with defined properties. The filter column as well as the subsequent compartments are programmed as 2D-objects (representing a section of a “real column”). Nutrients are “flushed” into the system at the top of the column, where they migrate through the column, through the algae/plant compartment and back to the column. On contact with organisms they were absorbed (“converted into biomass”), or converted other compounds (e.g. urea into CO_2 and 2 NH_3, NH_3 into NO_2-, NO_2- into NO_3-). The system enables performance of a “batch-run”, where an initial amount of nutrient is flushed into the system and subsequently degraded, “pulsed runs”, where preset amounts of substances are flushed into the system in regular time intervals and a combination of the two methods. In addition, substances can be added manually during an actual run. All instance

numbers are constantly recorded, displayed on the screen and stored in a file. Only the cycles of carbon and nitrogen are simulated other elements (phosphorous, potassium, trace elements) are neglected. Two different versions of the software were programmed: one for visualization of cell formation in the system (different horizons) and the other for detailed analysis of the degradation capacity of a column. The data are currently being evaluated.


Airborne Science and Mission Support

Airborne Science Advanced Planning

Project Participants

NASA: Matt Fladeland
BAERI: Susan Schoenung, Patrick Finch

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 ASP 5-year plan, monthly, for ASP management;
- Prepared a monthly map of all Earth Science Division (ESD) airborne missions for ASP management;
- Completed preliminary briefing: "Airborne Science Support for NASA Earth Science Satellite and International Space Station Missions";
- Prepared the ASP 2018 Annual Report and two semiannual newsletters; and
- Participated in various science team meetings related to NASA Earth Science missions to gather airborne requirements data.

Aircraft Remote Sensing

Project Participants

NASA: Joey Rios
BAERI: Sreeja Nag, Karishma Inamdar

Project Description

The Communications and Navigation (CN) Team of NASA's Unmanned Air Systems (UAS) manages a Traffic Management Project, also called UTM. UTM is a NASA effort, entirely in the public and open-source domain, to enable Civilian Low-Altitude Airspace and Unmanned Aircraft System Operations. These operations are very essential for high resolution airborne remote sensing. Alongside many committed government, industry and academic partners, NASA is leading the research, development and testing that is taking place in a series of activities called "Technology Capability Levels (TCL)," each increasing in complexity. Our role is to assist in research and development of TCL 2. We will identify commercially available technologies for UAS-to-UAS and UAS-to-ground communication, compare them to one another quantitatively, help the team procure select technologies for laboratory testing and assist in ground testing.

Accomplishments

- Assisted the CN team in their holistic goal of setting CN requirements for UTM operations such that ground operators can monitor the state of their UAS and can be operated in a safe environment for remote sensing operations.

Earth Science Project Office (ESPO)

Project Participants

NASA: Marilyn Vasques
BAERI: Dan Chirica, Erin Justice, Quincy Allison, Sommer Beddingfield, Elizabeth Juvera, Brent Williams, Brad Bulger, Ayuta Padhi

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 O_3 Expedition experiments. More recently, ESPO's NASA customers have included the Atmospheric Chemistry and Modeling Analysis Program, the Tropospheric Chemistry Program, the Radiation Sciences Program, Atmospheric Dynamics and Remote Sensing, the

Suborbital Science Program, and the EOS satellite validation program. Annually, the ESPO team manages the deployment of between six and ten major field missions and continues to provide support to the science team, airplane team, and the larger scientific community for previous years' missions. Finally, the ESPO team plays a critical role in planning for future missions, interfacing with NASA Headquarters, NASA and university scientists, crew members of airborne platforms, local support staff, and the larger scientific community. The unique work done by the ESPO team makes NASA Earth Science's core mission of collecting Earth Science data from airborne platforms with global coverage possible.

Accomplishments

In 2018, the NASA ARC-based ESPO team supported the following airborne missions under the ARC-CREST agreement:

- ATOM (Atmospheric Tomography Mission) is a five-year project using the NASA DC-8 to circumnavigate the globe four times throughout the project. ATom successfully completed all deployments and ESPO supported the project from the following locations: Palmdale, CA, Anchorage, AK, Kona, HI, Bangor, ME, Fiji, Ascension Island, Cape Verde, Azores, Chile, Greenland, and New Zealand.
- ORACLES (ObseRvations of Aerosols above CLouds and their intEractionS) is a five year project utilizing the NASA Wallops P-3 to measure aerosols, with an emphasis regarding smoke particles, and how they affect cloud composition and behavior. The campaign was successfully completed in 2018, with operations based out of the remote West African island of São Tomé.
- 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 this year. One global class research vessel, the R/V Roger Revelle, and one intermediate class research vessel, the R/V Sally Ride departed Seattle for a 35 day deployment with more than 60 scientist to the western Pacific Ocean. The second deployment is scheduled for spring of 2020 to the north mid-Atlantic Ocean.
- OIB (Operation IceBridge), a multi-year NASA mission, is the largest airborne survey of Earth's polar ice ever flown. There were 24 successful flights this year, matching the all-time record for an Antarctica OIB campaign, with flights being conducted out of Punta Arenas, Chile and Ushuaia, Argentina. ESPO has supported this project for more than 9 years and operated out of nearly a dozen locations.
- NAAMES (North Atlantic Aerosols and Marine Ecosystems Study) is a multi-year project utilizing the NASA C-130 and the R/V Atlantis. ESPO supported the final NAAMES deployment, which mobilized in San Juan, Puerto Rico, roughly six months after Hurricane Maria.

Meteorological Measurement Systems (MMS)

Project Participants

NASA: Thaopaul Bui
BAERI: Jon Dean-Day, Cecilia Chang

Project Description

The Meteorological Measurement System (MMS) provides in situ measurements of static pressure, static temperature, and 3D winds on several 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 that rely on our basic state measurements to compute reaction rates of atmospheric pollutants. Additionally, these measurements are useful to microphysical studies which focus on the formation and growth of ice crystals in cirrus clouds, and large scale transport studies which rely on our data to initialize back trajectories. The data are also useful for characterizing advection of pollutants in the planetary boundary layer and the structure and morphology of mesoscale waves that modulate the freeze-drying process of air rising through the tropical tropopause layer into the lower stratosphere.

The MMS is a fast-response (20Hz) 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. Also, it is 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

- Researched and developed the airborne scientific applications on DC-8 and Alpha Jet;
- Participated in the following missions: ATom-4 (Atmospheric Tomography Mission), AJAX (Alpha Jet Atmospheric eXperiment), SARP (Student Airborne Research Program) and High Ice Water Content (HIWC);
- Calibrated and re-processed DC-8 MMS data from the final two deployments of the Atmospheric Tomography project (ATom-3 and ATom-4) and the 2018 Student Airborne Research Program (SARP). Developed a filtering scheme that removed high frequency noise from total pressure measurements to provide accurate spectral response of both static temperature and wind data in turbulent environments. Substituted CMIGIT ground velocities where LN-100 INU navigation parameters were unreliable. Corrected short-term temperature artifacts using redundant sensors. Compared revised with preliminary data and resolved differences. Submitted final 1 Hz and 20Hz data files to project archive;
- Provided remote data analysis and processing support during the final deployment of the Atmospheric Tomography project (ATom-4) as well as the summertime High Ice Water

Content (HIWC-II) experiment. Continued performance evaluation of MMS sensors and components during both field campaigns, using both time series and spectral analysis methods. Evaluated static pressure correction model performance in light of new total pressure probe location. Developed corrections to recover pressure, temperature and wind data during icing periods;

- Monitored and quality-controlled Alpha Jet MMS data, including dedicated flight maneuvers from all Alpha Jet Atmospheric eXperiment (AJAX) flights. Updated calibration and data processing procedures to improve accuracy metrics and to mitigate wind errors, particularly from upwash effects driven by airspeed variations. 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 the DC-8 or Alpha Jet platforms, prior to submission and former peer review. Provided context and interpretation of MMS measurements to first authors, clarifying wording and logical presentation as needed;
- Completed the travel-time measurements of the new wave propagation simulations through 784 different flow perturbations and computed 3-dimensional sensitivity kernels for a range of travel distances using the 3D kernel code coded last year;
- Significantly improved the speed and memory efficiency of the kernel calculation code allowing for higher resolution kernels;
- Built an inversion code to derive the solar merdional flow profile. Inputs are the azimuthally averaged helioseismic wave travel times from solar observations and the new 3D numerical sensitivty kernels. Preliminary inversions have been performed using published solar measurements; and
- Prepared a poster for 2018 Solar Dynamics Observatory (SDO) Science Workshop and began work on a journal publication.

Publications and Presentations

Hartlep, T., and Zhao, Junwei 2018. A New Approach for Calculating Three- Dimensional Flow Sensitivity Kernels Using Global-Scale Wave-Field Simulations. 2018 SDO Science Workshop, Oct 29-Nov 2, Ghent, Belgium

Meteorological Support

Project Participants

NASA: Leonhard Pfister, Eric Jensen
BAERI: Rei Ueyama

Project Description

The NASA ARC-based Meteorological Support group provides meteorological and flight planning support for NASA airborne missions that mainly address upper tropospheric and lower stratospheric (UTLS) composition. A successful field campaign requires a good understanding of the climatological mean and variability of relevant atmospheric fields (to select the most

favorable time and location of the mission), an ability to quickly and comprehensively develop flight plans (to support effective data collection), a science team that is well informed of when and how meteorology can stymy aircraft operations (to facilitate smooth operation), and a detailed meteorological overview of the mission and knowledge of the origin and history of sampled air parcels (to maximize the scientific return from aircraft measurements).

Their work involves four tasks, which follow the time sequence of a typical field campaign from beginning to end: campaign conception and planning, detailed campaign preparation, in-field support, and post-campaign analysis. Campaign planning includes formulating the science questions about UTLS processes we seek to answer and deciding on times and places where a certain set of measurements can provide the answers. They advise the science team on the meteorological conditions relevant for a given science question, which are key to identifying where and when the best measurements can be made. They also develop conceptual flight plans that, along with the specific measurements, are needed to answer the science questions. The second phase, detailed preparation, involves assembling the meteorological and flight planning team, ensuring the availability of meteorological data (e.g., model forecast products, contextual satellite data), designing a meteorological website, and organizing forecasting and flight planning dry runs. For in-field support, they provide meteorological guidance to the science team in the field (usually in the form of daily weather briefings), provide the software infrastructure for systematic and efficient flight planning, and participate actively in flight planning discussions. During the post-campaign analysis phase, they provide the science team with the foundational meteorological information needed to interpret their data and trajectory-based analysis of convective influence which has been widely used by the science community to analyze the measurements of past field experiments.

Their analysis of past campaign data has primarily focused on understanding the role of convection in driving tropical UTLS composition.

Publications and Presentations

Rei Ueyama. Convective Influence on the humidity and clouds in the tropical tropopause layer during boreal summer. Journal of Geophysical Research: Atmospheres. 2018.

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, Emily Schaller, 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 2018, NSRC supported 9 major aircraft campaigns and a continuum of engineering, data system and satcom updates and improvements. The 9 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 4th out of 5 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.
- SARP 2018
  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.
- 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.
- 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 (has been 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.

Aircraft Specific Engineering Accomplishments

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.
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- 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 repeatably 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;
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- 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;
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- Developed template and details for stress reports for minor instrument and hardware installations on the DC-8;
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- Designed and made drawing for DC-8 forward cargo compartment ventilation tube end cap that splits cooling tube into three separate tubes;
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- 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;
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- 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;
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- 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.
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- Continued updates to onboard real-time mapping capabilities;
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- Continued updates to onboard systems in anticipation of new IT Security requirements; and
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- 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 Dat and Satcom System Accomplishments

C-130 436

- Completed design and drawings for new Buck hygrometer installation on Wallops C-130 (N436NA) for ACT-America Spring 2018; and

- 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

Overall ASP Development Work

- 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 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

- Worked with Pat Finch to apply 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 framerate 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

NASA: Jim Brass, Ana Prados
BAERI: Cindy Schmidt, Amber McCullum

Project Description

NASA's Applied Remote Sensing Training (ARSET) Program offers satellite remote sensing training that builds the skills to integrate NASA Earth Science data into an agency's decision-making activities. The project's goal is to increase the utility of NASA Earth Science data for applied resource management professionals, policy makers, and regulatory agencies.

ARSET operates with a gradual learn approach, where they often conduct basic introductory webinars followed by more in-depth advanced webinars or in-person trainings. Their webinars consist of multi-week sessions about a specific topic and can be a combination of lectures, live demos of tool, and tutorials. Recordings of the live webinars are freely available. Most webinar materials are available in Spanish and English. Many courses need no previous experience with remote sensing, but there are prerequisites for advanced webinars. The ARSET program regularly partners with organizations to host two to four day in-person workshops with regionally specific curricula. Conducted in a computer lab, workshops provide a combination of lectures and hands-on activities and frequently feature guest speakers from NASA and other organizations. Attendees learn how to access, interpret and apply NASA data on local and global scales, with an emphasis on case studies.

ARSET conducts trainings in the focus areas of Health and Air Quality, Water Resources, Land Management, Wildfires, and Disasters. The ARSET team is located at multiple NASA centers and consists of scientists with backgrounds specific to the topic area they teach. The Ames team focuses on trainings in the Land Management and Wildfires areas. Since 2009, ARSET has had over 4,000 participants from more than 1,400 organizations and 130 countries. All ARSET materials are free and available for participants to access, use, and adapt.

Accomplishments

- January 30-Feb 1 - participated in ARSET retreat, Goddard Space Flight Center, MD;
- Feb 13 and 20 - Conducted advanced webinar on accuracy assessment;
- Mar 5-9 - Conducted in-person training on Ecological Forecasting at the North Central Climate Adaptation Center, Fort Collins, CO;
- May 29-31 - Participated in LP DAAC Working Group meeting, Madison, WI;
- July 12 and 19 - Conducted Advanced Wildfire webinar with Josh Picotte, USGS;
- September 28 and Oct. 5 - Conducted Advanced webinar on Change Detection; and
- Nov 14 - Conducted webinar on overview of ARSET for the Conservation Biology Institute and Society for Conservation GIS.

Publications and Presentations

Wildfire PI meeting, Boise, ID, March

Hyperwall presentations on the use of NASA data for Wildfire applications, International Union for Conservation of Nature and Natural Resources (IUCN) World Conservation Congress, Hawaii, September 2018

From Remote Sensing Dud to Stud: NASA's ARSET Program, AGU Annual Fall Meeting, NASA Booth Presentation, December 2016

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California State University at Monterey Bay (CSUMB) Educational Program

Project Participants

NASA: James Brass
CSUMB: Susan Alexander, Kenneth Weinstock, Josue Duque, Kali Prescott, Elizabeth Patron, Conor Doherty, Will Carrera

Project Description

The Division of Science and Environmental Policy at CSUMB offers a Bachelor of Science degree program in Environmental Science, Technology, and Policy (ESTP) and a Master of Science degree program in Applied Marine and Watershed Science (AMWS). 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 AMWS offers two degree options: Professional Science Masters (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 AMWS 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 applies 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 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

The California State University at Monterey Bay (CSUMB) Educational Program continues to facilitate research collaborations between AMWS graduate students, ESTP senior undergraduate students, Cooperative Agreement Research Scientists, and NASA PIs at Ames Research Center on the following projects:

- ESTP and Environmental Science (ENSCI) students Kali Prescott, Elizabeth Patron, Josue Duque, Conor Doherty, and Will Carrera conducted research and assisted with field activities under the mentorship of ARC CREST Senior Scientist Forrest Melton, ARC CREST Research Scientists Jason Dexter (no longer employed by UCorp),Tian Xin Wang, and CSUMB Associate Professor Dr. Arlene Haffa;
- ENSCI graduate student Katie Szelong participated in a summer internship program at NASA ARC under the supervision of Dr. Laura Iraci and Dr. Sherry Palacios as part of the Center for Applied Atmospheric Research and Education (CAARE) partnership between San Jose State University and the NASA Ames Research Center.

Education Support Products and Benefits:

- Provided hardware/software support and mentoring for 10+ students participating in the DEVELOP Summer 2018 session and year-round support for permanent DEVELOP staff and project teams during the spring and fall sessions. Installed four new Dell Precision T3620 systems. DEVELOP support activities are expected to continue in 2019 at the same level;
- Provided mentoring and IT support to summer interns associated with the NASA/San Jose State University CAARE which is expected to continue in 2019. Since a reduction in the staffing of the 2018 Summer DEVELOP project teams resulted in two open rooms, a decision was made to co-locate the CAARE interns in building N242 with the DEVELOP interns which resulted in significant interaction between the interns;
- 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;
- Replaced obsolete Coop computer systems (approximately 7) in the NEX project to meet new NASA configuration and security requirements. Replace or update laptop systems

utilized for telework including new VPN client software and mandatory access via NASA smartcard usage;

Presentations below include CSUMB students, recent graduates, and tenure-track faculty, and are also listed under CSUMB ARC CREST Task 4: Agriculture, Health, and Marine Applied Science.

Publications and Presentations

Duque, Josue. 2018. California State University research briefing to legislative staff at the state capitol. Sacramento, CA June 28, 2018; ne3https://csumb.edu/naturalsciences/csumb-biology-student-josue-duque-testifies-importance-research-csu-system

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Zaragosa, I., Dexter, J., Post, K., Spellenberg, R., Haffa, A., Kortman, S., Cahn, M., and Melton, F., 2017. Utilizing on-farm best management practices: Managing Nitrate Leaching Using Evapotranspiration Based Irrigation Methods. American Geophysical Union Fall Meeting, New Orleans, CA, December 11-15, 2017.

Zhang, J., Campana, P., Yao, T., Melton, F., and Yan, J., 2017. Using a water-food-energy nexus approach for optimal irrigation management during drought events in Nebraska. American Geophysical Union Fall Meeting, New Orleans, CA, December 11-15, 2017.

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Panels or Committees

Dr. Bob Dahlgren (CSUMB ARC CREST Senior Scientist) was an invited speaker on the Science Professionals Career Panel at CSUMB on November 5, 2018.

DEVELOP

Project Participants

NASA: James Brass
BAERI: Juan L. Torres-Pérez

Project Description

The Applied Sciences' Digital Earth Virtual Environment and Learning Outreach Project (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. As such, the Ames projects during the past year have comprehended a wide range of themes such as such as the effects of Hurricanes Irma and Maria on the water quality of the US Virgin Islands coastlines, the impact of the green algae Cladophora on Lake Michigan, urban heat island effect in Richmond (CA) and changes in air quality in California.

Accomplishments

- Juan L. Torres-Pérez - began working with DEVELOP as the Center Mentor in 2014. Since then he has mentored multiple teams of participants in about 29 different projects;

- Provided advice on the use of different imagery available for analysis, methodologies, results, and comments/edits on the deliverables of each project (technical paper, posters presentations, oral presentations, lightning talks, Earthzine/YouTube videos, etc.);

- Participated each week in staff meetings and seminars. Also, during the interim periods between terms we conducted multiple interviews with the applicants. In total, each year he reviews about 150 different applications for all three terms;

- Recruited six participants on each of the Fall and Spring terms and 8-12 for the Summer term to work on two-three different projects during each term. The team submits about 7-8 different project proposals per year to the National Program Office for their approval. This year, as in 2017, one of the projects (US Virgin Islands) was unique. This was a joint DEVELOP/NASA Established Program to Stimulate Competitive Research (EPSCoR) project that allowed for a student from the University of the Virgin Islands to be at Ames

directly collaborating with the other participants. One student ended doing his own project aimed at producing a land use land cover changes analysis of St Croix for the period of 1985-present.

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.

Student Airborne Research Program (SARP)

Project Participants

NASA: Jack Kaye
NSRC: Melissa Yang Martin, Emily Schaller

Project Description

The Student Airborne Research Program (SARP) is an eight-week summer program for junior and senior undergraduate and early graduate students to acquire hands-on research experience in all aspects of a scientific mission using NASA's DC-8 or P-3 airborne science laboratories. The DC-8, ER-2 and P-3 are major NASA resources for studying Earth system processes, calibration/validation of space-borne observations, and prototyping instruments for possible satellite missions. Participants assist in the operation of instruments onboard the aircraft to sample atmospheric chemicals and to image land and water surfaces in multiple spectral bands. Along with airborne data collection, students participate in taking measurements at field sites. The program culminates with formal presentations of research results and conclusions. Students participating in the program have a strong academic background in disciplines relevant to the Earth system including the physical, chemical or biological sciences or engineering. Many have experience with image processing and GIS systems.

Accomplishments

Each of the twenty-eight SARP participants delivered a 12-minute conference-style presentation on the results of his/her individual research project and wrote an American Geophysical Union style abstract. Presentations took place at UC Irvine and were attended by all of the SARP students and mentors, NSRC staff, faculty members from UC Santa Cruz, UC Santa Barbara, University of Virginia, and UC Irvine as well as guests, Ryan Spackman (NASA Ames), Gao Chen (NASA Langley), and Michael Thomson (NASA Armstrong).

Final Student Projects

<u>Vegetation Remote Sensing Group</u>

Faculty Advisor: Dr. Dar Roberts, UC Santa Barbara
Mentor: Alana Ayasse

1) Fire Risk Assessment on the Wildland Urban Interface (WUI) of Goleta, California pre-Holiday Fire (2018) using Imaging Spectrometer Data
2) Mapping Impervious Surface Fraction of the Santa Barbara Front Range
3) Mapping the Fire Front of the Thomas Fire Using MODIS, Landsat, and AVIRIS Active Fire Data
4) Detecting Hotspots Ahead of Wildfires and their Correlation to Wind and Fuel Types
5) A Partial Recovery Analysis of the Thomas Fire Scar
6) Determining Biomass for Wildfires Using Hyperspectral Imaging
7) Remote Sensing Analysis of the Montecito Debris Flows

Tropospheric Chemistry Group
Faculty Advisor: Dr. Sally Pusede, University of Virginia
Mentor: Laura Barry

1) Observing Boundary Layer Heights over Mountainous Terrain Using Aircraft Vertical Profiles
2) Calculating Surface Energy Budgets Utilizing the Airborne Eddy Covariance Method
3) Using Enhancement Ratios for Source Apportionment of Greenhouse Gas Emissions near Bakersfield,
4) N_2O Emissions as a Function of Animal Agriculture Density in the California San Joaquin Valley
5) Observational Constraints on Atmospheric Chemical Production of Formaldehyde over Bakersfield, CA
6) Investigating the Health Impacts of Changes in Ozone in Central and Southern California
7) Reducing ozone air pollution through an urban forestry project in Bakersfield, California

Oceans Remote Sensing Group
Faculty Advisor: Dr. Raphe Kudela, UC Santa Cruz
Mentor: Henry Housekeeper

1) Historical Declines of Northern California Bull Kelp Canopy Following El Niño Southern Oscillation Events
2) Remote Sensing of Ocean Microplastics in the Near-Infrared (NIR): A Feasibility Study
3) The Spatial Distribution of Dinoflagellates in Retention Zones of the California Coastline
4) Evaluating phytoplankton size class shifts in Monterey Bay using remote sensing and in-water imaging platforms
5) Tracking the Montecito Mudslide Plume and Response via Remote Sensing in the Santa Barbara Channel
6) From Fire to Flora: Effects of Ash from the Thomas Fire on the Biology of the Santa Barbara Channel in December 2017
7) Environmental Analysis of Proposed Changes to the Los Angeles/ Long Beach Traffic Separation Scheme

Whole Air Sampling Group

Faculty Advisor: Dr. Donald Blake, UC Irvine
Mentor: Chris Woods

1) Hydroxyl-Radical Removal: Los Angeles and Oildale
2) Dimethyl Sulfide Chemistry at the Salton Sea, California
3) Impact of Dimethyl Sulfide Emitted from the Salton Sea on Regional Air Quality
4) Tracing Sources of Light Alkyl Nitrates Observed at High Altitudes during SARP 2018
5) Estimating Long Range Transport Times of Air Masses Using Hydrocarbon Concentrations
6) Can Airborne Whole Air Sampling be used as a Compliance Tool for Air Quality Regulations?
7) Potential Sources of Increased Halon-1301 in the Southern Central Valley of California


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Presentations

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Basu, S., et al. 2018 (S. Ganguly, one of 7 co-authors), Deep neural networks for texture classification—A theoretical analysis, Neural Networks, 97, 173-182.

Cabrera, J., S. Nag, D. Murakami, "An Initial Analysis of Automating Conjunction Assessment and Collision Avoidance Planning in Space Traffic Management", AAS/AIAA Space Flight Mechanics Meeting, Hawaii USA, January 2019

Collier, E., et al. 2018 (S. Ganguly, one of 10 co-authors), GEONEX: Progressive Conditional Generative Adversarial Training Using Transfer learning, AGU 2018.

Dahlgren, R.P. "UAS Ice Accretion Testing and Simulation at NASA," Alaska UAS Interest Group (Anchorage 2018).

Dahlgren, R.P. Cultivating Sustainable Internship Projects in UAS at the NASA Ames Research Center, Aerial Pathways Conference, (2018, Saratoga, CA).

Dahlgren, R.P. "Drones and UAS at NASA," ASSURE Summer Student Drone Academy, (2018, Davis, CA).

Dawson, K. W., Meskhidze, N., Burton, S. P., Johnson, M. S., Kacenelenbogen, M. S., Hostetler, C. A. & Hu, Y. (2017). Creating Aerosol Types from CHemistry (CATCH): a new algorithm to extend the link between remote sensing and models. Journal of Geophysical Research: Atmospheres, 122. https://doi.org/10.1002/2017JD026913

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Duque, Josue. 2018. California State University research briefing to legislative staff at the state capitol. Sacramento, CA June 28, 2018; https://csumb.edu/naturalsciences/csumb-biology-student-josue-duque-testifies-importance-research-csu-system

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Ganguly, S., et al. 2018, NEX-AI: A Cloud and HPC Agnostic Framework for Scaling Deep Learning and Machine Learning Applications for Earth Science, AGU 2018.

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Gumma, M.K., Thenkabail, P.S., Deevi, K.C., Mohammed, I.A., Teluguntla, P., Oliphant, A., Xiong, J., Aye, T. and Whitbread, A.M., 2018. Mapping cropland fallow areas in myanmar to scale up sustainable intensification of pulse crops in the farming system. GIScience & Remote Sensing, pp.1-24.

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Hartlep, Thomas, and Zhao, Junwei 2018. A New Approach for Calculating Three- Dimensional Flow Sensitivity Kernels Using Global-Scale Wave-Field Simulations. 2018 SDO Science Workshop, Oct 29-Nov 2, Ghent, Belgium

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Johnson, L. co-organized UCCE Field Day for celery growers in Salinas, CA and presented on results of field trials and integration of data from SIMS in CropManage, Salinas, CA, October 2018.

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Lee, C., Bolten, J., Melton, F., Brennan, B., and Doorn, B., 2018. Applied Sciences Program: Water Resources. AWWA Sustainable Water Management Conference, March 25-28, Seattle, WA.

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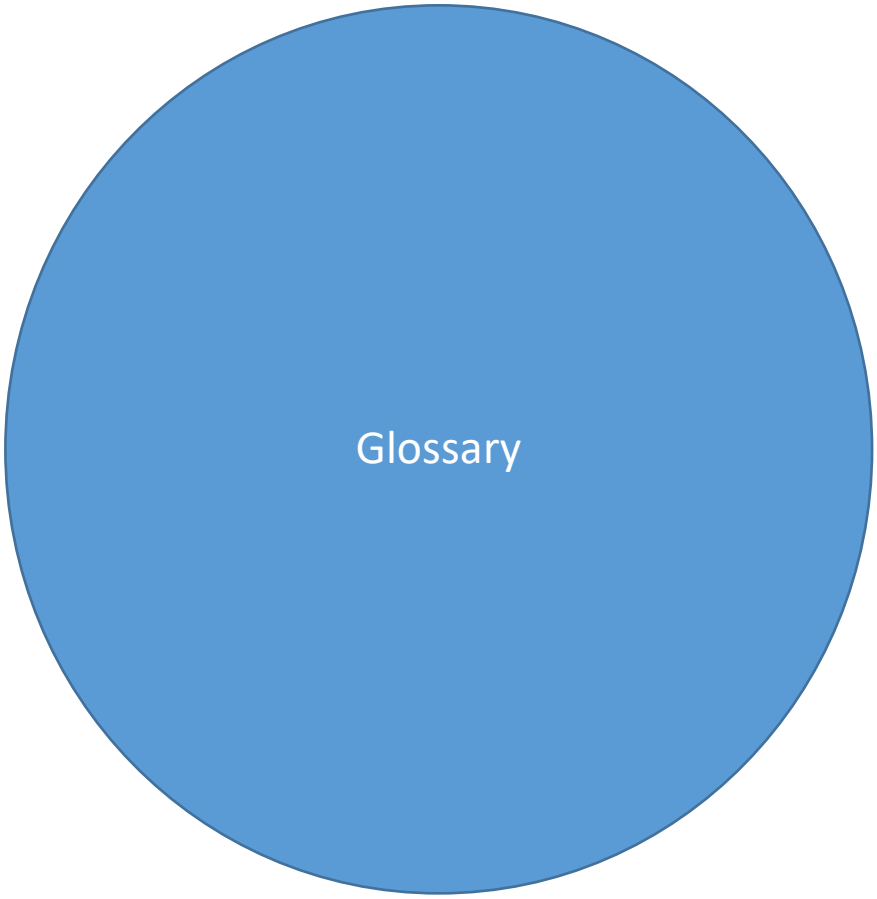
Glossary

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

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

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

COMEX - CO_2 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 – ERATOSTHENES: 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

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

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

PSM – Professional Science Masters

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

RF – Radio Frequency

ROSES – Research Opportunities in Earth and Space Science

S2 - Sentinel-2

SARP - Student Airborne Research Program

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

SBIR – Small Business Innovation Research

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

SHOUT - Sending Hazards with Operational Unmanned Technology

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

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

UCSC - University of California, Santa Cruz

UNA-UK – United Nations United Kingdom

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

WIT - Wildfire Implementation Team

WUI – Wildland Urban Interface

WWAO – Western Water Applications Office

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