Second Year Progress Report for NASA Cooperative Agreement NNX12AD05A

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

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Introduction

The primary task of the Ames Research Center Cooperative for Research in Earth Science and Technology (ARC-CREST) is to work cooperatively with NASA Ames Research Center's Earth Science Division (AESD) 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 this second year of the ARC-CREST cooperative agreement, the coop's participants, Bay Area Environmental Research Institute (BAER), California State University Monterey Bay (CSUMB), and the University of North Dakota (UND) continued to achieve each of these objectives.

First, members of the ARC-CREST scientific team, working closely with the Ames Earth Science Division, have explored Ecological Forecasting, Carbon Modeling, and Environmental Applications and Management, specifically focusing on three Earth Science objectives: 1) quantifying, understanding, and predicting changes in Earth's ecosystems and biogeochemical cycles, including the global carbon cycle, land cover, and biodiversity; 2) designing innovative systems and software to exploit an advanced computing architecture to facilitate improvement of Earth system modeling and data assimilation; and 3) promoting innovation in the use of NASA Earth Science.

Second, ARC-CREST participants have also worked closely with NASA on many scientific field missions including Deriving Information on Surface Conditions from Column and Vertically Resolved Observations Relevant to Air Quality (DISCOVER AQ), Hurricane and Severe Storm Sentinel (HS3), the Airborne Tropical Tropopause Experiment (ATTREX), the Southeast Asia Composition, Cloud, Climate Coupling Regional Study (SEAC^{4}RS), Operation IceBridge (OIB), Active Sensing of CO_2 Emissions over Nights, Days, and Seasons (ASCENDS), and the Indianapolis Flux Experiment (INFLUX).

Third, the ARC-CREST partners have provided support to critical Earth Science Division activities at Ames including the Earth Science Project Office; the Applied Sciences Program's Water Resources Program; the Airborne Science Program including payload integration engineering, data display and networking, facility instrumentation for NASA's fleet of research aircraft; and support for the Meteorological Measurement System.

Finally, through the Student Airvorne Research Program (SARP), CSUMB's educational program, and the Digital Earth Virtual Environment and Learning Outreach Project (DEVELOP), ARC-CREST participants have worked with the Ames Research Center to provide extensive educational and public outreach opportunities related to Earth Science

Below, this report discusses the progress made in the second year of the coop to implement these objectives.

Earth Science Research

In this past year, ARC-CREST personnel participated in the following Earth Science research projects and missions.

Ecological Forecasting

Project Description

Ecological forecasting predicts the effects of changes in the physical, chemical, and biological environments on ecosystem state and activity. The ability of models to describe and to predict ecosystem behavior has advanced dramatically over the last two decades, driven by major improvements in process-level understanding, climate mapping, computing technology, and the availability of a wide range of satellite and ground-based sensors. In the past year, CSUMB and BAER personnel in the Ecological Forecasting (EF) Group at NASA Ames have worked to integrate advances in these areas to develop the NASA Terrestrial Observation and Prediction System (TOPS) ecological forecasting modeling framework. In addition, under the NASA Earth Exchange (NEX) project, CSUMB, BAER and AESD scientists and software engineers have implemented the TOPS framework on high-end computer resources in the NASA Advanced Supercomputing (NAS) facility to develop a collaborative supercomputing environment for global change research. The primary objective of this task is to continue to support further development of TOPS/NEX, build and incorporate new technologies, and extend TOPS/NEX capabilities for fundamental and applied science.

Project Participants

NASA: Rama Nemani

CSUMB: *Senior Scientists*: Forrest Melton, Petr Votava, *Scientists*: Alberto Guzman, Hirofumi Hashimoto, Sam Hiatt, Andrew Michaelis, Weile Wang

BAER: Senior Scientists: Sangram Ganguly, Gong Zhang

Accomplishments

- Supported more than 23 NASA funded projects and activities, as Primary Investigators, Co-Investigators, or Collaborators;
- Published 18 peer reviewed journal articles; additional articles currently in review;
- Presented more than 12 scientific and technical talks/posters at science conferences and technical meetings. Many of these publications and presentations are available at http://ecocast.arc.nasa.gov/pubs/pbs.php;
- Worked with AESD, NAS, and NASA HQ to continue to develop the project plan for NEX, and secured core funding for the NEX project;
- Completed the following for the NASA Earth Exchange project:
  - Established user working group and held two initial UWG meetings;
  - Completed two rounds of user data query requirements gathering;
  - Developed a new data provenance system that captures user activities so that users can replay it and;

    - Coordinated migration of NEX web portal from NASA code TI to NAS by the NAS web development team.
- Participated in testing and development of the new web portal and also developed content moderation component for the portal;
- Contributed to NASA-Amazon agreement and establishment of OpenNEX, which will facilitate broad engagement of climate research community;
- Created initial interface between Pleiades computer nodes and NEX database infrastructure;
- Implemented ticketing user support system for NEX and integrated it with NAS user support services;
- Supported 158 active NEX science platform users (up from 40 in FY12), and 420 registered members for the NEX portal (up from 340);
- Continued analysis of combined impacts of climate and land use change for the United States, in collaboration with Woods Hole Research Center and Colorado State University at Boulder. Presented initial results for gross primary productivity, evapotranspiration, and watershed outflow to the National Park Service. Publication in preparation;
- In collaboration with the Climate Analytics Group, utilized NEX to complete the first ever downscaled, bias corrected, 800m CMIP5 climate scenarios for the United States. Worked with NASA NCCS on metadata and distribution of NEX-developed NEX-DCP30 dataset to the general public. Also transferred dataset to Amazon Web Services to increase access to dataset by the climate change science community;
- Contributed to the technical working groups and technical reports for the 2013 National Climate Assessment (NCA). Co-authored a paper summarizing the results for the technical working group report for the Ecosystem chapter in the NCA (Grimm et al., 2013). Prepared downscaled climate scenarios and conducted modeling analysis of combined impacts of climate and land use change in support of NCA. Performed watershed-based assessments of sensitivity of gross primary production and runoff to projected changes in climate as described by ensembles of CMIP5 downscaled projections under RCP (regional concentration pathways) scenarios 4.5 and 6.0;
- Collaborated with researchers at Boston University to develop a physical algorithm in creating long-term Leaf Area Index (LAI) and Fraction of Photosynthetically Active Radiation (FPAR) products from the Advanced Very High Resolution Spectroradiometer (AVHRR) sensor
- Collaborated with researchers at University of Maryland, College Park to develop a physical algorithm for large-scale retrieval of LAI and Vertical Foliage Profile from the Spaceborne Waveform Lidar (GLAS/ICESat);
- Created a standalone software package to calculate global MODIS 250-m vegetation anomalies utilizing the High Performance Computing Infrastructure at NASA's Advanced Supercomputing Division to execute parallel implementation of the algorithm. The algorithm is based on the framework as described in Liang et al.,

2011 and Samanta et al., 2011. A similar study using this module analyzed vegetation response to extreme climate events on the Mongolian Plateau from 2000 to 2010 (John et al., 2013);

- Developed a validation framework to compare land surface phenology products from MODIS and MERIS to ground based observations;
- Collaborated with researchers at University of Maryland, Dept. of Public Health to conduct a national scale assessment of the impact of climate change on asthma morbidity;
- Collaborated with researchers at NASA JPL as part of the NASA Carbon Monitoring System (CMS) project to estimate aboveground biomass at the national scale with associated pixel-level uncertainties. As part of this project, we are also creating a carbon pool map of the continental United States;
- Collaborated with researchers at Boston University to estimate total aboveground biomass in forest stands using the Allometric Scaling and Resource Limitations Model (Shi et al., 2013 and Choi et al., 2013);
- Collaborated with researchers across various institutions to study plant growth in Arctic ecosystems due to amplified surface warming (Xu et al., 2013); and
- As part of the NASA NPP funded project (Extending TOPS to Suomi-NPP Applications), created a framework to test the continuity of Land Surface Reflectance and Derived Vegetation Index products from MODIS to NPP VIIRS.

Publications

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- Monahan, W.B., T. Cook, **F. Melton**, J. Connor, B. Bobowski. (2014), Forecasting species' responses to climate change at management-relevant scales: Limber Pine in Rocky Mountain National Park. Plos One, doi: PONE-D-13-29000R1 10.1371/journal.pone.0083163, *in press*;
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- Pike, A., E. Danner, D. Boughton**, F. Melton, R. Nemani,** B. Rajagopalan, S. Lindley (2012), River Temperature Prediction: An Updated Stochastic Dynamics Approach, *Water Resour. Res., 49, doi:10.1002/wrcr.20389*;
- Zhao, J., Y. Wang, **H. Hashimoto, F. Melton, S. Hiatt,** H. Zhang, **R. Nemani**, (2012), The Variation of Land Surface Phenology from 1982 to 2006 along the Appalachian Trail, IEEE JSTARS, *in review*;
- Jia Zhang, **Petr Votava**, Tsengdar J. Lee, Shrikant Adhikarla, Isaraporn Kulkumjon (Cherry), Matthew Schlau, Divya Natesan, **Ramakrishna Nemani**, (2013) "A Technique of Analyzing Trust Relationships to Facilitate Scientific Service Discovery

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- **Ganguly, S.,** Green Leaf Area and Fraction of Photosynthetically Active Radiation Absorbed by Vegetation (2013, in press), *Biophysical Applications of Satellite Remote Sensing (Book Chapter)*, Springer-Verlag Berlin Heidelberg, Series 10182;
- Zhu, Z., Bi, Jian, Pan, Y., **Ganguly, S.,** Anav, A., Xu, L., Samanta, A., Piao, S., **Nemani, R. R.**, and Myneni, R. B. (2013), Global Data Sets of Vegetation LAI3g and FPAR3g derived from GIMMS NDVI3g for the period 1981 to 2011, *Remote Sensing (MDPI),* 5(2), 927-948;
- Tang, H., Dubayah, R., Brolly, M., **Ganguly, S., Zhang, G.** and Zhao, F. (2013a), Large scale retrieval of Leaf Area Index and Vertical Foliage Profile from the spaceborne waveform Lidar (GLAS, ICESat), submitted to *Remote Sensing of* Environment;
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- Shi, Y., Choi, S., Ni, X., **Ganguly, S.,** et al., (2013), Allometric Scaling and Resource Limitations Model of Tree Heights: Part 1. Model Optimization and Testing Over Continental United States, *Remote Sensing* (MDPI), 5(1), 284-306;
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Cao, J. C. Stroeve (2013), Temperature and vegetation seasonality diminishment over northern lands, *Nature* (Climate Change), 3, 581-586.

Selected Presentations

- **Votava, P., Nemani, R., Basu, S., Ganguly, S., Michaelis, A.** (2013), Zooming In with the NASA Earth Exchange (NEX), Supercomputing 2013, Denver, CO, November 18-22, 2013;
- **Ganguly, S., Melton, F., Dungan, J**. and **Nemani, R. R**. (2013), Extending the Terrestrial Observation and Prediction System (TOPS) to Suomi-NPP Applications, S-NPP Science Team Meeting (oral presentation), January 24, 2013;
- **Ganguly, S., Melton, F., Nemani, R. R, Dungan, J.**, Miura, T. and Devadiga, S. (2013), Extending the Terrestrial Observation and Prediction System (TOPS) to Suomi-NPP Applications, NASA Terrestrial Ecology Meeting (poster), April 30, 2013;
- **Ganguly, S.**, Basu, S., Mukhopadhyay, S., **Michaelis, A., Votava, P. and Nemani, R. R.** (2013), Deriving Continuous Fields of Tree Cover at 1-m over the Continental United States From the National Agriculture Imagery Program (NAIP) Imagery to Reduce Uncertainties in Forest Carbon Stock Estimation, American Geophysical Union (Oral Presentation under the Big Data in Geosciences Session).

<u>AGU 2013 Presentations</u>

- H21H-1272. IN11B-1523. A Near Real-time Decision Support System Improving Forest Management in the Tropics, Karyn Tabor; John Musinsky; Juan Carlos Ledezma; Andriambolantsoa Rasolohery; Eddy Mendoza; Howard Kistler; Marc Steininger; Douglas C. Morton; Forrest S. Melton; John Manwell; Kellee Koenig;
- IN52A-08. Ganguly, S,S Basu, S Mukhopadhyay, A Michaelis, C Milesi, P Votava, R Nemani, Presentation, Deriving Continuous Fields of Tree Cover at 1-m over the Continental United States From the National Agriculture Imagery Program (NAIP) Imagery to Reduce Uncertainties in Forest Carbon Stock Estimation;
- H41Q-05. Melton, F, C Lund, L Johnson, A Guzman, K Post, S Hiatt, C Rosevelt, S Keefauver, G. Miller, A Michaelis, P Votava, R Nemani, Presentation, Satellite Mapping of Agricultural Water Requirements in California;
- GC53A-1028. Mills, WB, PD Bromirski, RN Coats, M Costa-Cabral, J Fong, M Loewenstein, C Milesi, N Miller, N Murphy, S Roy, Poster, Quantifying Climate Change Hydrologic Risk at NASA Ames Research Center;
- IN23B-1435. P Votava; A Michaelis; R. Nemani, Poster, Knowledge Acquisition and Management for the NASA Earth Exchange (NEX);
- B11E-0400. W Wang, RR Nemani, KM Schaefer, CR Schwalm, DN Huntzinger, G Zhang, J Xiong, CO_2 Fertilization: What Models Can Talk to Observations;
- B43C-0530. Zhang, G, S Ganguly, S Saatchi, S Hagen, N Harris, Y Yu, RR Nemani, Detecting Forest Disturbance Events from MODIS and Landsat Time Series for the Conterminous United States;
- H43G-1539. Hashimoto, H; RR Nemani, Satellite measurements of changes in water storage and their impact on vegetation dynamics; and

- Dungan, J. et al., NASA Booth talk, NASA Earth Exchange: Collaborative supercomputing for global change research

Terrestrial Ecosystem and Carbon Simulation Modeling

Project Description

The ARC-CREST Carbon research group studies terrestrial carbon fluxes to predict ecosystem responses to global climate warming and changes resulting from land use patterns and to understand influences on terrestrial net primary productivity and quantify carbon pools by applying the NASA-CASA Ecosystem model to global and to regional scale studies using satellite data inputs of environmental variables.

The BLM Desert Soil Mapping Project supports the Desert Renewable Energy Conservation Plan (DRECP) in land cover base mapping. This project will deliver new soil maps and show the dynamics of sand dune movements, along with riparian zones, wetlands, desert pavements, playas, alluvial fans, riparian channels, washes, seeps, springs, and pools, and biological soil crusts. The project focuses on data processing of largely unmapped areas most likely to be used for energy developments, such as within the Renewable Energy Study Areas (RESA). The study site includes eastern Riverside County, California, from Hayfield Dry Lake area east to the Colorado River where proposed Renewable Energy Development areas, other areas for potential energy development, and Desert Conservation Lands are under consideration as part of the DRECP. The Carbon research team collaborates with GIS specialists and scientists at the BLM to characterize soil properties and other Earth features in the DRECP areas.

SilvaCarbon, named after the Latin word for forest, is the United States Government contribution to the GEO Forest Carbon Tracking task, a component of the Global Earth Observation System of Systems (GEOSS), which provides data and information about a variety of Earth observations to users around the world. In conjunction with SilvaCarbon, the U. S. Agency for International Development supports a Forest Carbon, Markets and Communities (FCMC) program whose core mission is to build technical capacity by developing tools and training that support USAID and SilvaCarbon contributions to the international architecture for Reducing Emissions from Deforestation and Forest Degradation (REDD+). At the mission level, FCMC contributes to REDD+ readiness by enabling countries to access “pay-for-performance" finance and by identifying sustainable development options that represent "no-regrets" investments in climate change mitigation and adaption. User guides are posted (in English and Spanish) on the Carbon team website accompanied by methods for using the CASA-CQUEST model’s annual change in forest carbon to conservatively define the upper limit for the amount of harvested wood products that can be removed and still avoid degradation (net loss) of the total wood carbon stock over that same time period. One of the first products the Carbon team developed for this project is for Borneo, Indonesia.

The Carbon modeling team has also been working for the past 2 years under the federally funded National Climate Assessment project. This assessment is addressing the overarching question of which variables are most closely associated with high sustained forest

production and sinks for CO_2 over the past decade, and which variables are most closely associated with unsustainable forest production and large annual sources of CO_2 fluxes. In response to the NASA National Climate Assessment, the CASA model is being applied to predict changes in forest NPP. Annual carbon sink or source fluxes from all forested lands in the continental US are being quantified.

Project Participants

NASA: Chris Potter

CSUMB: *Senior Scientist*: Steven Klooster; *Scientists*: Vanessa Brooks Genovese, Cyrus Hiatt, Shuang Li, John Shupe

Accomplishments

BLM Desert Soil Mapping Project

- Evaluated state-of-the-art remote sensing applications, and identified four crucial ecosystem variables as baselines (i.e. Biological Soil Crusts, Migration of Desert Sand Dune, Desert Pavements, and Potential Water Source);
- Conducted fieldwork campaign in April 2013 to support the task;
- Completed a report evaluating the remote sensing approach for sand dune movements. This report has been submitted to USGS and BLM;
- Completed the first maps of Biological Soil Crusts, Sand Dune movements and Possible Water Source by using L-band Radar data; and
- Participated in three meetings with BLM specialists reporting project developments. and also reported research findings to staff from Lawrence Berkeley National Lab and Argonne National Lab.

Silva Carbon

- Evaluated degradation of the forests in Vietnam, Indonesia, Peru, and Gabon using Landsat 8 imagery inputs to the CASA model;
- Processed Landsat ETM+ images for 2012 and 2013 for to the study site and generated region-wide estimates of forest net primary production (NPP) at 30 meters spatial resolution; and
- Worked closely with the Nature Conservancy's Climate Change technical team on a scientific survey of Berau's forests to identify areas most at risk and to develop a baseline for measuring degradation in the inventory of stored forest carbon. Results are pending.

National Climate Assessment

- Predicted pools of wood and soil biomass carbon based on the best available stand age and disturbance survey data sets;
- Performed statistical analysis of recent patterns in forest production across each U.S. forest region, with reference to both environmental variables (elevation, slope, aspect, soils, etc.) and human management (protected areas, logging practices, wildfire/suppression, etc.); and
- Continued to update the results of this analysis with the recent years' satellite data;
- Run the model with several different scenarios representing a "normal" scenario and a "removal" scenario where the forests are harvested and removed and the by-products are spatially redistributed.

CASA-HYDRA Modeling & Drought Monitoring Project

- Finished applying the HYDRA (Hydrological Routing Algorithm) model this year to the Sonora River in Mexico and the Capibaribe River in Brazil;
- Transferred the evapotranspiration products from the model to the drought monitoring project lead at ASU for evaluation and assimilation into their database;
- Conducted more work applying CASA-HYDRA to the continental U.S. at 1km resolution;
- Completed a paper detailing a study conducted last year at 250m resolution of the Merced River headwaters. The results were published in the Journal of the American Water Resources Association this year;
- Organized the 2013 Yosemite Hydroclimate Workshop, but the workshop was cancelled at the last minute because of the government shutdown;
- Continued to integrate the impacts of irrigation and impoundments into the HYDRA model as well as measures of water quality, such as dissolved oxygen and water temperature. Additional improvements to the model, including integrating a flood detection algorithm and having the model run at a daily time step, were attempted in conjunction with an internship project through NASA's DEVELOP program; and
- Attempted, during the internship project, which occurred from January 28, 2013 to August 9, 2013, to apply the CASA-HYDRA model in Yosemite National Park at 90m resolution, but the project remained unfinished at the conclusion of the internship term.

Fog Detection on the Pacific Coast

- Continued to work during the year to monitor the frequency and distribution of fog events along the Pacific Coast, specifically in Redwood forests around Big Sur, using remotely sensed data; and
- Collected airport weather records and additional fog deposition sites to improve validation;

Computer Server Updates & Development

- Completed work on upgrading its modeling computers with additional memory and storage to serve expanding data storage and processing needs.

In addition to the above mentioned projects, the Carbon modeling team is continually working to improve the NASA-CASA model algorithms to allow the model to more accurately represent environmental processes in specific regions of interest.

Publications

- Potter, C., S. Klooster, and V. Genovese, (2013), Alaska ecosystem carbon fluxes estimated from 3 MODIS satellite data inputs from 2000 to 2010, *Carbon Balance and Management*, 8:12.
- Potter, C., S. Klooster, V. Genovese, and C. Hiatt, (2013), Forest production predicted from satellite image analysis for the Southeast Asia region, *Carbon Balance and Management*, 8, 9.

- Potter, C., S. Li, S. Klooster, V. Genovese, (2013), Changes in the terrestrial carbon cycle of China during the 2010 drought, *Journal of Earth Science Climate Change*, 4: 141. doi:10.4172/2157-7617.1000141.
- Potter, C., S. Li, and R. Crabtree, (2013), Changes in Alaskan tundra ecosystems estimated from MODIS greenness trends, 2000 to 2010, *Journal of Geophysics & Remote Sensing*, 2: 107, doi:10.4172/2169-0049.1000107.
- Shupe, J., and C. Potter, (2013), Modeling Discharge Rates for the Merced River in Yosemite National Park, *Journal of the American Water Resources Association*, 1-10.DOI:10.1111/jawr.12124.

Disaster, Wildfire and Environmental Monitoring & Management

Project Description

The objectives of this task are:

(1) To explore, develop and integrate remote sensing and data modeling/visualization to improve strategies and foster improved understanding of the role of wildfires in climate change and to support NASA Applied Sciences efforts facilitate improved fire application uses of remote sensing data; and

(2) The development of remote sensing payloads for use on manned and unmanned aerial systems (UAS) and the analysis/utility of data acquired by these systems for environmental monitoring and management. This includes payload engineering and integration, data system development (including data acquisition, processing, analysis, and archiving) and validation. Support the partnership and applied uses of small UAS for scaled studies in remote sensing assessments.

Project Participants

NASA: Jim Brass

CSUMB: *Senior Scientist*: Vince Ambrosia; *Scientist*: Robert Dahlgren

Accomplishments

- Assisted the NASA HQ Applied Science Program (ASP) Associate Program Manager for Wildfires, by providing evaluations of 17 wildfire application projects. This work included budget evaluation, metrics tracking, scheduling, performance review, and reporting;
- Modified the existing Non-Reimbursable Space Act Agreement (SAA) with USFS-RSAC to partner in technology and information sharing in support of wildfire imaging capabilities, and the transfer operations, training support and calibration support of the AMS – Wildfire sensor;
- Developed new processing capabilities for the USFS AMS scanner to be adopted during operational missions on the USFS-NIFC aircraft platform;
- Organized and led two meetings (May 2013 (NASA-Ames Research Park) and November 2013 (Boise, ID)) of the Tactical Fire Remote Sensing Advisory Committee (TFRSAC). The meetings included participation from various fire management agencies and focused on facilitating improved observational capabilities for wildfire occurrences;

- Transferred the AMS instrument to the USFS and integrated the instrument on a IUSFS platform and supported USFS airborne missions, all to assist USFS adapt the AMS in the USFS operational sensor inventory;
- Developed project budget documentation for USFS support of team personnel involved in SW/HW modifications to AMS sensor;
- Provided instruction at CalFire and USFS training classes on the use of the AMS data and the CDE. This outreach helped the community improve their adaptation on data sets provided during wildfire events by our team;
- Served on planning committees for national and international conferences including ISRSE (2015 Planning);
- Led reviews of NASA SBIR instrument development projects (Xiomas, Inc. TMAS, WAI, and StareWAI);
- Developed working agreements (contracts, SAAs, etc.) with other partners and Cooperative agreements at NASA-ARC. These include CalFire, BAERI, RedCastle Resources, Inc. as well as Technical University of Catalunya (Spain, E. Pastor);
- Supported the Interagency Arctic Research Policy Committee (IARPC) on the Wildfire Implementation Team, as the NASA science representative;
- Provided project documentation and support materials to NASA Headquarters for Program Management presentations to HQ staff, Congress, and OSTP;
- Supported Visiting Scientist / Faculty colleagues /Visitors at Ames, including:
    - Hannes Bauser, University of Heidelberg, Germany (and UC-Davis)
    - Karen Joyce, PhD., Charles Darwin University, Darwin, AU
    - Enric Pastor, PhD., Technical University of Catalonia (UPC), Castelldefels, Spain, and
    - Jorge Pantoja and Pedro Meneses, Universidad San Francisco de Quito, Ecuador
- Supported Center efforts to further engage the BYU Center for Unmanned Aerial Systems, and provided briefings and entertained partnership efforts in research, applications, and student program development;
- Chaired Committee on Tactical Fire Remote Sensing Advisory Committee, 2013, NASA-USFS Cooperative project on fire remote sensing; and
- Served on review panels for National Science Foundation, Indo-US Science and Technology Forum, International Journal of Remote Sensing, Remote Sensing of Environment Journal, IGARSS-TGRS, Journal of Field Robotics, Geocarto International Journal, AIAA Journal of Aircraft, IEEE IGARSS, NASA SBIR Proposal, and USDA SBIR Proposal.

Selected Presentations

- Ichoku, C., L. Ellison, W. Schroeder, M. Dickinson, V. Ambrosia, 2013. “The role of satellites in characterizing fire behavior.” 4th Fire Behavior and Fuels Conference (At the Crossroads: Looking Toward the Future in a Changing Environment), St. Petersburg, Russia, 1-4 July 2013;

- Ambrosia, V.G., 2013. Enhancing our Nation's Wildfire Management Capabilities Through Application of NASA Science and technology. AIAA – Second Annual California Aerospace Week, Sacramento, CA, 12 March 2013, Invited Panel Speaker;
- Ambrosia, V.G., 2013. UAV Remote Sensing Platforms for Emergency Response and Management. OSPR / Chevron Oil Spill Response Technology Workshop, San Ramon, CA, 28 February 2013, Invited Speaker;
- Ambrosia, V.G., 2013. UAV Remote Sensing Platforms for Emergency Response and Management. 52nd Annual Fresno State Geomatics Engineering Conference, Clovis, CA, 25 January 2013, Invited Speaker;
- USGS Innovation Center for earth Sciences Workshop, Menlo Park, CA, February 2013;
- AIAA, Civilian Applications of UAVs – A California Perspective, Thousand Oaks, CA, March 2013;
- Tulane University, Guest lecture, Disaster Assessment, New Orleans, LA (remote presentation), April 2013;
- Rayburn House Congressional Lunch & Learn on NASA / Wildfires, Washington DC, May 2013;
- OSTP Workshop on Science and Technology Challenges in Fighting Wildfires, NASA ARC Research Park, September 2013;
- Chapman University / JPL Workshop on Wildfire Remote Sensing, November, 2013;
- San Francisco State University, San Francisco, CA, November 2013; and
- AeroVironment, Inc., Simi Valley, CA, November 2013.

Publications

A. Published Book Chapters:

- Hinkley, E.A., V.G. Ambrosia, S. Wegener (2013), "Unmanned Aircraft Systems in Environmental Monitoring Applications," *Society of American Engineers International*, *in editing*;
- Ambrosia, V. G. and T. Zajkowski (2013), Selection of Appropriate Class UAS / Sensors to Support Fire Monitoring, Real-Life Experiences In the U.S. Ed: K. Valavanis, Unmanned Aerial Systems Handbook, P. X-XX, 2013, In Final Editing.

B. Peer-Reviewed Journal Articles:

- Schroeder, W., E. Ellicott, C. Ichoku, M. Dickinson, R. Ottmar, C. Clements, D. Hall, V. Ambrosia, R. Kremens (2014), Integrated Active Fire Retrievals and Biomass Burning Emissions Using Complementary Near-Coincident Ground, Airborne and Spaceborne Sensor Data, *Remote Sensing of Environment*, Vol. 140, pp. 719–730.

Agriculture, Health, and Marine

Project Description

CSUMB personnel have long supported NASA research and applied science missions to apply satellite data to improve our understanding of environmental conditions and ecological processes that affect agriculture, public health and vector borne disease, and coral reefs and other marine ecosystems. Key NASA projects, which CSUMB has supported in these areas, include TOPS-SIMS, CHAART, COAST, VSIM, VINTAGE, CRUSH, and Pathfinder-Kauai.

Project Participants

NASA: Ed Sheffner

CSUMB: *Senior Scientists*: Forrest Melton, Lee Johnson; *Scientists*: Pam Krone-Davis, Alberto Guzman, David Hamblin, Sam Hiatt, Shane Keefauver, Chris Lund, Andrew Michaelis, Gwen Miller, Sam Phillips, Kirk Post, Carolyn Rosevelt

Accomplishments

- Worked with the Satellite Irrigation Management Support (SIMS) project using four CSUMB Dept. of Environmental Science, Technology and Policy (DESTP) students (David Hamblin, Gwen Miller, Sam Phillips, Kirk Post). Post graduated and is now a research scientist with the project. Additional research internships will be offered in 2014. The SIMS project was highlighted in the NASA Applied Sciences Program 2012 Annual Report, and received additional press coverage in the Western Grower and Shipper magazine. The project team also received numerous invitations to present to the agriculture and water management communities.
- Briefed Rep. Garamendi on the SIMS project in collaboration with NASA ESD management and USGS on Dec. 17, 2013 in Davis, CA;
- Completed two ASP Water Resources Stage I feasibility projects;
- Continued development of a fully functional prototype of the SIMS data processing system on the NASA Earth Exchange (NEX), including prototype web and mobile interfaces (http://ecocast.arc.nasa.gov/sims);
- Operated interface in 2013, and presented work on SIMS to growers and grower associations across California;
- Implemented a prototype mobile interface, and integrated data from Landsat 8 into the SIMS architecture;
- Deployed and maintained instrumentation on 12 commercial farms in partnership with growers in the Salinas Valley and Central Valley;
- Collaborated with partner growers and CSU Fresno on data analysis. Currently preparing manuscripts for publication.
- In collaboration with Salinas Valley commercial growers, USDA ARS, and UC Cooperative Extension, Dole/Fresh Express, and Tanimura and Antle, conducted trials in lettuce and broccoli to quantify total applied irrigation and yields using different irrigation management approaches and tools. Demonstrated potential for achieving ~20-30% reduction in total applied water without reduction in yields, with

large reductions in nitrate losses, using SIMS approach and/or UCCE CropManage tool. Manuscripts in preparation;

- In collaboration with NOAA, USGS, and USDA, planned and conducted field surveys to map fallowed acreage in the California Central Valley as part of a validation experiment for satellite estimates. Prepared datasets and report, and delivered data to partners at USGS and USDA. Demonstrated ability to map fallowed agricultural lands in the Central Valley using a decision tree algorithm that met DWR requirements for timeliness and accuracy. Presented research results at AGU Fall Meeting and to Director of The National Integrated Drought Information System NIDIS; and
- In collaboration with the NOAA National Weather Service (NWS), completed analysis of comparison between NOAA Forecast Reference Crop Evapotranspiration (FRET) data products and California Irrigation Management Information System (CIMIS) reference evapotranspiration data, and presented results at the 2013 Fall AGU Conference.

Publications

- Melton, F., Johnson, L., Lund, C., Pierce, L., Michaelis, A, Guzman, A., Trout, T., Temesgen, B., Frame, K., Sheffner, E., and Nemani, R. (2012.), Satellite Mapping of Crop Condition and Evapotranspiration for Irrigation Management Support with the Terrestrial Observation and Prediction Systems. IEEE J-STARS, special issue on Interoperability Architectures and Arrangements for Multi-Disciplinary Earth Observation Systems. IEEE J. of Selected Topics in *Applied Earth Observations and Remote Sensing*, Vol. 5, No. 6, Dec. 2012;
- Milesi, C., C. Small, L. Johnson, and T. Trout, (2013), Comparison of a Landsat standardized spectral mixture model and vegetation indices with ground measurements of crop canopy cover, *Rem. Sens. Environ., in review* (submitted Oct 2013); and
- Wu, Z., P. Thenkabail, R. Mueller, A. Zakzeski, F. Melton, L. Johnson, C. Rosevelt, J. Dwyer, J. Jones, and J. Verdin, (2013), Seasonal cropland mapping using the Automated Cropland Classification Algorithm (ACCA), *J. Applied Rem. Sens. (in revision Sep 2013)*.

Selected Presentations

- Melton, F., et al., (2013), Mapping Crop Water Requirements and Fallowed Area with Satellite Observations and CIMIS Data, CA DWR Drought Preparedness Workshop, Center for Irrigation Technology, Fresno, CA, Dec 18, 2012;
- Melton, F., et al., (2013), Managing Irrigation from Space: Mapping Crop Water Requirements with Satellite Observations and CIMIS Data, California Irrigation Institute, Sacramento, CA, Feb 4, 2013 (invited);
- Melton, F., et al., (2013) Using Satellite Data to Support Improvements in On-Farm Water Management and Reduce Nitrate Losses, CSUMB Agricultural Outreach Event, Monterey, CA, Oct 10, 2013;

- Melton, F., L. Johnson, C. Lund, A. Guzman, S. Hiatt, A. Michaelis, P. Votava, C. Rosevelt, K. Post, P. Krone-Davis, and R. Nemani, 2013. Satellite Mapping of Agricultural Water Requirements in California, ASPRS Annual Conference, 24-28 March, Baltimore;
- Melton, F., et al., 2013. Using Satellite Data to Support Improvements in Irrigation Management, California League of Food Processors, Davis, CA, Nov. 7, 2013 (invited);
- Melton, F., et al., 2013, Mapping a Thirsty State: Applications of Remote Sensing and GIS for Water Resources Management, CSU Stanislaus GIS Day, Turlock, CA, Nov. 20, 2013 (invited keynote);
- Johnson, L., M. Cahn, F. Martin, F. Melton, C. Lund, B. Farrara, and S. Benzen, 2013. New tools for ET estimation and irrigation management in specialty crops. Paper #131595001, Proceedings ASABE Annual Int'l Mtg. (ASABE Technical Library), 21-24 July, Kansas City;
- Lund, C., K. Post, A. Purdy, D. Adhikari, A. Guzman, L. Pierce, S. Hiatt, I. Harlen, L. Johnson, and F. Melton. 2013. Monitoring crop evapotranspiration: sensor network applications in California's Central Valley. ASA/SSSA/CSSA, 4-6 Nov., Tampa;
- Anderson, R., D. Wang, C. Lund, F. Melton, L. Johnson, J. Prueger, L. McKee, J. Alfieri, and W. Kustas, 2013. Assessing Evapotranspiration, Basal Crop Coefficient, and Irrigation Efficiency in Production Peach Orchard in California's San Joaquin Valley, Geologic Society of America, 2013 Cordilleran Section Meeting, 20-22 May, Fresno; and
- Johnson, L., et al., 2013. ET-based irrigation scheduling of cool season vegetables, Irrigation and Nutrient Management Meeting, UC Cooperative Extension, 26-Feb, Salinas;

<u>AGU 2013 Presentations</u>

- H41Q-05. Melton, F, C Lund, L Johnson, A Guzman, K Post, S Hiatt, C Rosevelt, S Keefauver, G. Miller, A Michaelis, P Votava, R Nemani, Presentation, Satellite Mapping of Agricultural Water Requirements in California;
- H43G-1565. Comparison of Satellite-based Basal and Adjusted Evapotranspiration for Several California Crops, Lee Johnson; Christopher Lund; Forrest S. Melton;
- H43G-1558. Application of Satellite Data for Early Season Assessment of Fallowed Agricultural Lands for Drought Impact Reporting, Carolyn Rosevelt; Forrest S. Melton; Lee Johnson; James P. Verdin; Prasad S. Thenkabail; rick mueller; Audra Zakzeski; Jeanine Jones;
- H21A-1012. National Weather Service Forecast Reference Evapotranspiration, Holly D. Osborne; Cynthia K. Palmer; Pamela Krone-Davis; Forrest S. Melton; Mike Hobbins; and
- H41Q-08. Tracking Fallow Land in California Using USDA's Cropland Data Layer Audra Zakzeski; rick mueller; Carolyn Rosevelt; Forrest S. Melton; Lee Johnson; James P. Verdin; Prassad Thenkabail; Jeanine Jones.

Space Synthetic Biology and Astrobiology

Project Description

ARC-CREST personnel have extensive experience in biological systems exposed to space conditions. Valuable research is occurring in gravitational biology, synthetic biology, proteomics, and biotechnology. One of the projects the group is taking on is the Synthetic Drug Synthesis System prototyping project. The study brings together past work in synthetic biology using using E. coli transformed to produce melanin and to work with the Rotating Disc Analytical System (RDAS) to develop a prototype automated system for the production of melanin. The project seeks to create an automated purification in a system capable of working in micro-gravity.

Project Participants

NASA: Michael Flynn
BAER: Rocco Mancinelli

Accomplishments

- Developed and successfully demonstrated a protocol for separating the melanin from the organism and growth medium manually using laboratory scale centrifugation; and
- Developed a protocol for purifying and concentrating the gene product in a prototype miniaturized system such as RDAS; and
- For Eu:CROPIS, worked to develop protocol for nitrogen species analysis.

Publications

- Cohen, M., Matossian, R. L., Mancinelli, R. L., and Flynn, M.T. (2013), *Water Walls Life Support Architecture*, AIAA #3517.

Tropospheric Emission Spectrometer (TES)

Project Description

ARC CREST personnel are supporting the data analysis and preparing scientific publications using the data from the Tropospheric Emission Spectrometer (TES). TES is an infrared spectrometer flying aboard the Aura satellite, currently in Earth orbit. Its high spectral resolution enables it to measure concentrations of ozone, carbon monoxide, water vapor, and methane at various altitudes in the atmosphere, which reveals important information about global warming and climate change, the water cycle, and air pollution.

As the Aura satellite is in a "sun-synchronous" orbit, the satellite is over each latitude at the same local "solar mean time" each day. For example, each time Aura crosses the equator, the local solar mean time is about 1:43 PM. This means that the sun is as close as possible to the same angle (given the constant changing of the sun's angle due to the tilt of Earth's axis) each time TES is over a given point on the ground. Sunlight plays a critical role in many of the chemical reactions that affect air quality, and keeping the sun at a nearly constant angle for each observation of the same location simplifies interpretation of the data. In principle, TES is capable of observing chemicals at any altitude, but in practice it specializes in the portion of

the atmosphere that extends from the ground up to the middle of the stratosphere, to an altitude of about 32 km. This includes the entire troposphere, the lowest part of the atmosphere, which stretches from the stratosphere to Earth's surface.

Project Participants

NASA: John Worden
BAER: Susan Kulawik

Accomplishments

- As Level 2 Algorithm lead, organized a bi-weekly teleconferences with TES team members and followed all and participated in many algorithm changes;
- Updated the prototype code with the latest v006 updates. This includes capability to analyze TES data for new minor species of HCOOH, CH_3OH, and OCS. The prototype code is how TES team members rapidly test algorithm updates for the next release and science investigations;
- Participated in TES papers and promoted use of TES data.
- Promoted use of TES data;
- Updated TES Lite products, and worked on the transition of this processing to Science Investigator-led Processing Systems (SIPS).

Publications

- L. Kuai, J. Worden, S. S. Kulawik, S. A. Montzka, and J. Liu (2013), Characterization of aura tropospheric emissions spectrometer carbonyl sulfide retrievals, *Atmos. Meas. Tech. Discuss.*, 6, 6975-7003.

Orbiting Carbon Observatory - 2 (OCO-2)

Project Description

ARC CREST personnel are supporting the development of the algorithms for analyzing the data from the Orbiting Carbon Observatory-2 (OCO-2) instrument. OCO-2 is based on the original OCO mission developed under the NASA Earth System Science Pathfinder Program Office and launched from Vandenberg Air Force Base on February 24, 2009. Before spacecraft separation on the OCO mission, a launch vehicle anomaly occurred that prevented the OCO spacecraft from reaching injection orbit, and the mission failed. OCO-2 is comprised of a single instrument that flies on a dedicated spacecraft. The instrument, consisting of three high resolution grating spectrometers, will acquire precise measurements of atmospheric CO_2. The Observatory will launch from the Vandenberg Air Force Base in California on a dedicated Delta II rocket in July 2014. The Observatory will acquire data in three different measurement modes. In Nadir Mode, the instrument views the ground directly below the spacecraft. In Glint Mode, the instrument tracks near the location where sunlight is directly reflected on the Earth's surface. Glint Mode enhances the instrument's ability to acquire highly accurate measurements, particularly over the ocean. In Target Mode, the instrument views a specified surface target continuously as the satellite passes overhead. Target Mode provides the capability to collect a large number of measurements over sites where ground based and airborne instruments also measure atmospheric CO_2. The OCO-2 Science Team will compare

Target Mode measurements with those acquired by ground-based and airborne instruments to validate OCO-2 mission data. The Observatory has a planned operational life of two years.

Project Participants

NASA: Ken Jucks
BAER: Susan Kulawik

Accomplishments

- Began testing synthetic retrievals for non-linear effects, errors, and predicted sensitivity; and
- Analyzed first cases for measurement error and predicted sensitivity (Averaging kernel). Some issues were found in ocean cases, and these require follow-up.

CO_2 Earth Science Data Record

Project Description

This project seeks to develop a rigorous error estimation methodology to unify atmospheric CO_2 data products from AIRS, SCanning Imaging Absorption spectroMeter for Atmospheric CHartographY **(**SCIAMACHY), Tropospheric Emission Spectrometer (TES), Greenhouse gases Observing Satellite (GOSAT), OCO-2 (after it is launched in 2014), and the CarbonTracker assimilation system. Errors will be characterized using vertical profiles and total column CO_2 measurements traceable to international reference standards for atmospheric CO_2. The methodology accounts for the unique measurement attributes of each satellite sensor via its averaging kernel (Rodgers and Connor, 2003) to yield consistent precision and bias estimates for all space-based CO_2 measurements. The methodology also assesses the impact of clouds, spatial and temporal averaging, and characterizes biases as a function of time and location. This work is essential for producing consistent, calibrated, long-term CO_2 data products across multiple satellite sensors and lays the groundwork for creating the first atmospheric CO_2 Earth Science Data Record (ESDR).

Project Participants

NASA: Martha Maiden
BAER: Susan Kulawik

Accomplishments

- Prepared and presented latest developments for the 2013 American Geophysical Union (AGU) meeting;
- Completed a paper describing the project, that is about to be submitted to the *Atmospheric Chemistry and Physics* journal. Co-authors are reviewing the paper;
- Organized bi-weekly conference calls with team members; and
- Worked with a program the team developed for comparing aircraft data with the HIPPO dataset.

Space Weather

Project description

Space weather affects the Earth's geophysical systems and our technological infrastructure: many power-grid disturbances, satellite anomalies, and positioning errors, for example, are attributable to the coupling of solar magnetic activity into the electrical, electronic, or electromagnetic components of modern everyday life. Impacts include catastrophic ones (including transformer short circuits and satellite outages), relatively mild fluctuations in the system (such as frequency shifts in power grids and communications interruptions), and gradual but persistent effects (oxidation on long metal systems such as oil pipelines that shorten life cycles). The combination of these effects has been estimated to cost the U.S. economy billions of dollars each year, with the potential of trillions of dollars for high-impact low-frequency extreme events. This study of evaluating the costs of external perturbations to a national or global economy, particularly those associated with electrical power grids or satellite systems will enable better estimates of the threats to society and of the value of the economic impacts, i.e., to map the hazard of space weather to a quantitative risk.

Project Participants

NASA: Jeff Scargle, John Marmie, Nagi Mansour
BAER: Jean Paul Rabanal, Bob Stein, Thomas Hartlep

Accomplishments

- Designed a unique survey for users of space weather information;
    - Jointly analyzed and interpreted the responses in order to assess the importance of space weather information for different sectors;
    - Approximately 40 percent of respondents expect serious to very serious impact from space weather events if no action is taken or in the absence of adequate space weather information; and
    - there is considerable uncertainty about how to act on the space-weather information that is provided;
- Improved speed of code by optimizing radiation transport module. Doubled speed on Blue Waters and increased it 50% on Pleiades;
- Extended 96 Mm wide magneto-convection domain from 20 to 30 Mm depth and began relaxing and developing convection in the bottom third. Needed to interface to interior models;
- Ran dynamo model in 96 Mm wide by 20 Mm deep domain. Investigating surface dynamo action. Magnetic energy is directly proportional to kinetic energy as a function of depth and has reached 1% of kinetic energy after one turnover time;
- Searched for available numerical libraries for efficient parallel computation of spherical harmonic transforms for a new code to be written that realistically simulates the convection in the whole solar interior;
- Downloaded, compiled and evaluated performance of such libraries on NASA's "Pleiades" supercomputer, estimated workloads of the new simulation code, generated scaling plots for up to 10,000 cores;

- Performed literature study on force-free and magnetic-hydrostatic modeling of the sun;
- Helped devise and formulate new procedure for generating force-free and magneto-hydrostatic models; and
- Implemented the new force-free formulation in a numerical code.

Field Missions

Hurricane and Severe Storm Sentinel (HS3)

Project Description

Tens of millions of Americans live along the Atlantic and Gulf coasts, exposing themselves to the destructive power of hurricanes. While hurricane track prediction has improved in recent decades, the quality of predictions regarding hurricane intensity have not kept pace. This deficiency is due to insufficient observations of hurricanes and their surrounding environment and a poor understanding of processes involved in storm intensity change.

For more than a decade, NASA has conducted field campaigns to research the genesis, intensity, change, and structure of tropical cyclones. The scientific focus on intensity is particularly timely in light of the current heightened Atlantic storm activity and the continuing challenges of forecasting rapid tropical cyclone intensity change. With an aim to better understand how tropical storms form and develop into major hurricanes, NASA is conducting the Hurricane and Severe Storm Sentinel (HS3) investigation, a study specifically targeted to enhance our understanding of the processes that underlie hurricane intensity change in the Atlantic Ocean basin.

Some of the overarching scientific issues HS3 scientists are exploring are the impact the large-scale environment has on intensity change, the role of internal storm processes in intensification, and the extent to which these processes are predictable. To get at these larger issues, the scientists have developed several hypotheses that the HS3 project will attempt to test:

- Research has suggested that the Saharan Air Layer has both positive and negative influences on hurricane formation and development. HS3 will test the hypothesis that once thunderstorm formation occurs, the Saharan Air Layer is not a major determinant of subsequent intensification;
- Generally, it appears that environmental wind shear leads to the weakening of storms, but sometimes it can be beneficial. HS3 will test the hypothesis that RI increases when upper-level westerlies are weak and when broad outflow is favored; and
- There has been some question whether the deep, strong convection towers are the building blocks of the vortex or just contributors to the total mass flux needed for development. HS3 scientists will test the hypothesis that these hot towers actively contribute to the genesis and RI of these storms through vortex tube stretching and the convergence of low-level angular momentum.

Addressing these science questions requires a sustained series of measurements over several years due to the limited sampling opportunities in any given hurricane season. Past NASA hurricane field campaigns have all faced the same limitation: a relatively small sample (3-4) of

storms forming during the campaigns under a variety of scenarios and undergoing widely varying evolutions. The small sample is not just a function of tropical storm activity in any given year, but also the distance of storms from the base of operations.

To address these difficulties, the HS3 program will last five years, and the main instruments will be two NASA Global Hawk (GH) unmanned aircraft systems (UAS). The scientists will send these aircraft in the region of developing Atlantic tropical storms or hurricanes. The Global Hawks are ideal platforms for investigating hurricanes because of their ability to carry heavy scientific payloads, to overfly deep thunderstorms, and to use their long flight duration to reach storms over much of the Atlantic or to take measurements in nearby storms for long periods (2-3 times as long as conventional aircraft). Indeed, the flight duration of these aircraft is 26 hours, enabling access to unrestricted air space and coverage of the entire Atlantic Ocean basin. The planes can be on-station up to 20 hours.

One of the Global Hawks will be equipped with instruments geared toward measurement of the surrounding environment and the second with instruments suited to study inner-core structure and processes. The environmental payload includes the Scanning High-resolution Interferometer Sounder (S-HIS), the Advanced Vertical Atmospheric Profiling System (AVAPS, or dropsondes), the Cloud Physics Lidar (CPL) and the Tropospheric Wind Lidar Technology Experiment (TWiLiTE), while the over-storm payload includes the conically scanning High-Altitude Imaging Wind and Rain Airborne Profiler (HIWRAP), the multi-frequency Hurricane Imaging Radiometer (HIRAD), and the High Altitude MMIC Sounding Radiometer HAMSR).

Project Participants

NASA: Marilyn Vasques

National Suborbital Education and Research Center (NSERC): Rick Shetter, Adam Webster, David Van Gilst, Eric Stith, Eric Buzay, and Karen Katrinak

BAER: Erin Czech, Dan Chirica, Erin Justice, Michaela Herman, Quincy Allison, and Steven Todorov

Accomplishments

Activity Undertaken through NSERC

- Performed pre-mission testing of data and satcom systems at Dryden Flight Research Facility and Wallops Flight Facility;
- Developed system for providing HDVis data to MTS;
- Developed system for sending quick-look products to MTS in real time;
- Configured low-rate real-time data feeds to MTS;
- Specified Hardware configuration for payload trailer server infrastructure;
- Trained ASF personnel in the configuration of payload trailer server infrastructure;
- Provided support for NSERC developed software in GHOC and remote trailer infrastructure;
- Assisted with integration of experimenter IT systems into the Global Hawk IT Infrastructure;
- Supported the Global Hawk Operations Centers in Wallops Flight Facility in Virginia and at Dryden Flight Research Center in California for the entire mission; and

- Developed lessons learned document and new procedures and checklists for HS3.

Activity Undertaken with the Earth Science Project Office (ESPO)

See the section discussing ESPO's work this past year below.

Airborne Tropical TRopopause EXperiment (ATTREX)

Project Description

Stratospheric water vapor has a large impact on the Earth's climate. Recent studies suggest that even small changes in stratospheric humidity may have climate impacts that are significant when compared to increases in greenhouse gas concentrations. In turn, climate change may lead to significant changes in stratospheric humidity and ozone concentration.

While the tropospheric water vapor climate feedback is well represented in global models, predictions of future changes in stratospheric humidity are highly uncertain because of gaps in our understanding of physical processes occurring in the Tropical Tropopause Layer ("TTL"), the boundary layer of the atmosphere located 8 to 11 miles above the earth between the troposphere and the stratosphere. The Tropical Tropopause Layer controls the composition of the stratosphere. Uncertainties in the chemical composition of the Tropical Tropopause Layer also limit our ability to predict future changes in stratospheric ozone.

The Airborne Tropical TRopopause EXperiment (ATTREX) will perform a series of measurements using the long-range NASA Global Hawk to study the tropical tropopause. This multi-year study will involve a consortium of scientists from NASA (including the Ames, Dryden and Langley research centers, Goddard Space Flight Center, and the Jet Propulsion Laboratory), the National Oceanic and Atmospheric Administration (NOAA), the National Center for Atmospheric Research (NCAR), three universities, and private industry. As part of this project, NASA has installed 11 instruments on Global Hawk No. 872. The instruments include a LIDAR, a spectrometer, a photometer, a chromatograph, a radiometer, hygrometers, and several atmospheric data sensors. These instruments will measure clouds and temperature above and below the aircraft as well as water vapor, cloud properties, meteorological conditions, radiation fields, and numerous trace gases.

Project Participants

NASA: Dave Jordan, Lenny Pfister, Eric Jensen

BAER: Patrick Hillyard, Erin Czech, Dan Chirica, Erin Justice, Michaela Herman, Quincy Allison, and Steven Todorov

Accomplishments

Meteorological Forecasting

- Website development and support;
- Meteorological data analysis and plotting;
- Server and data management; and
- Coordination of different data sources and accessibility of data.

Activity Undertaken with the Earth Science Project Office (ESPO)

See the section discussing ESPO's work this past year below.

Southeast Asia Composition, Cloud, Climate Coupling Regional Study (SEAC^{4}RS)

Project Description

The Southeast Asia Composition, Cloud, Climate Coupling Regional Study (SEAC^{4}RS) will address key questions regarding the influence of emissions from Asia on clouds, climate, and air quality as well as fundamental satellite observability of the system. Science observations will focus specifically on the role of Asian monsoon circulation and convective redistribution in governing upper atmospheric composition and chemistry. Satellite observations suggest a strong impact of the Asian Summer Monsoon on Tropopause Transition Layer composition and a direct relationship to surface sources including pollution, biogenic emissions, and biomass burning. Attention will also be given to the influence of biomass burning and pollution, their temporal evolution, and ultimately impacts on meteorological processes which in turn feed back into regional air quality. With respect to meteorological feedbacks, the opportunity to examine the impact of polluting aerosols on cloud properties and ultimately dynamics will be of particular interest.

To accomplish the goals of SEAC^{4}RS, multiple aircraft are required. The NASA DC-8 will provide observations from near the surface to 12 km, and the NASA ER-2 will provide high altitude observations reaching into the lower stratosphere as well as important remote sensing observations connecting satellites with observations from lower flying aircraft and surface sites. A critical third aircraft needed to sample convective outflow and slow ascent of air above the main convective outflow level (~12 km) has been identified as the NSF/NCAR GV (HIAPER).

Project Participants

NASA: Mike Craig

NSERC: Rick Shetter, Adam Webster, David Van Gilst, Eric Stith, Eric Buzay, and Karen Katrinak

BAER: Patrick Hillyard, Erin Czech, Dan Chirica, Erin Justice, Michaela Herman, Quincy Allison, and Steven Todorov

Accomplishments

Meteorological Forecasting

- Website development and support;
- Meteorological data analysis and plotting;
- Server and data management; and
- Coordination of different data sources and accessibility of data

Activity Undertaken with the Earth Science Project Office (ESPO)

See the section discussing ESPO's work this past year below.

Operation IceBridge

Project Description

Operation IceBridge is a program of airborne remote sensing measurements designed to fill the gap in measurements between NASA's Ice, Cloud and Land Elevation Satellite (ICESat) -- in orbit since 2003 -- and ICESat-2, planned for late 2015. ICESat stopped collecting science data in 2009. This mission will last six years and be the largest airborne survey of Earth's polar ice ever flown. It will yield an unprecedented three-dimensional view of Arctic and Antarctic ice sheets, ice shelves, and sea ice. These flights provide a yearly, multi-instrument look at the behavior of the rapidly changing features of the Greenland and Antarctic ice.

Operation IceBridge uses airborne instruments to map Arctic and Antarctic areas once a year. The first IceBridge flights were conducted in March/May 2009 over Greenland and in October/November 2009 over Antarctica. Other smaller airborne surveys around the world have been part of the IceBridge campaign.

Operation IceBridge will make two major contributions to cryospheric science. First, it will provide surface elevation data now that the ICESat-1 mission has ended, focusing on areas undergoing rapid change that are critical to characterizing select areas of sea ice and modeling the processes that determine the mass balance of the terrestrial ice sheets. Due to the time variable and non-linear changes that these areas undergo, repeated monitoring is required. Operation IceBridge also allows more detailed studies over these areas, though overall much smaller areas. Second, Operation IceBridge will support complementary measurements critical to ice models such as bed topography, grounding line position, and ice and snow thickness. These parameters cannot be measured by satellite, but can be measured from aircraft. They are the other great unknowns in understanding the ice in general and developing predictive models of sea level rise in response to climate change.

Project Participants

NASA: Kent Shiffer

NSERC: Rick Shetter, Adam Webster, David Van Gilst, Eric Stith, Eric Buzay, and Karen Katrinak

BAER: Erin Czech, Dan Chirica, Erin Justice, and Michaela Herman, Quincy Allison, Steven Todorov, and Sue Tolley

Accomplishments

Activity Undertaken through NSERC:

- Designed, implemented and installed a fully autonomous light-weight system on the P-3 for OIB Antarctica which provided recording of 2 HD cameras, chat services, and tracking of the aircraft for both the Greenland and Antarctic Missions.

Activity Undertaken with the Earth Science Project Office (ESPO)

See the section discussing ESPO's work this past year below.

Deriving Information on Surface Conditions from Column and Vertically Resolved Observations Relevant to Air Quality (DISCOVER AQ)

Project Description

Near-surface pollution is one of the most challenging problems for Earth observations from space. However, with an improved ability to monitor pollution from satellites from DISCOVER-AQ, scientists could make better air quality forecasts, more accurately determine the sources of pollutants in the air and more closely determine the fluctuations in emissions levels. In short, the more accurate data scientists have at hand, the better society is able to deal effectively with lingering pollution problems.

DISCOVER-AQ will make three major contributions to atmospheric science:

1. Relate column observations to surface conditions for aerosols and key trace gases O_3, NO_2, and CH_2O. Researchers will ask: How well do column and surface observations correlate?; What additional variables (e.g., boundary layer depth, humidity, surface type) appear to influence these correlations? On what spatial scale is information about these variables needed (e.g., 5 km, 10 km, 100 km) to interpret column measurements?

The mission hopes to improve understanding of the extent to which column observations (as observed from space) can be used to diagnose surface conditions.

2. Characterize differences in diurnal variation of surface and column observations for key trace gases and aerosols. Researchers will ask: How do column and surface observations differ in their diurnal variation? How do emissions, boundary layer mixing, synoptic transport, and chemistry interact to affect these differences? Do column and surface conditions tend to correlate better for certain times of day?

3. Examine horizontal scales of variability affecting satellites and model calculations. Researchers will ask: How do different meteorological and chemical conditions cause variation in the spatial scales for urban plumes?; What are typical gradients in key variables at scales finer than current satellite and model resolutions?; How do these fine-scale gradients influence model calculations and assimilation of satellite observations?

The mission hopes to improve interpretation of satellite observations in regions of steep gradients, improve representation of urban plumes in models, and demonstrate how to assimilate satellite data in models more effectively.

Project Participants

NASA: Matt Fladeland

NSERC: Rick Shetter, Adam Webster, David Van Gilst, Eric Stith, Eric Buzay, and Karen Katrinak

Accomplishments

Activity Undertaken through NSERC

- Communicated with PI Jim Crawford about data system requirements for Discover AQ California;

- Provided cryogens and gases for P-3 teams during the deployment in Palmdale;
- Provided P-3B engineering staff with information on wingtip probes in support of flying PMS canister type probes on the P-3 for DISCOVER AQ California;
- Staff member performed installation and testing of the NSERC data and satcom systems on the P-3; and
- Staff member operated the data and satcom systems on test flights, transits, and all science flights for the mission.

Activity Undertaken with the Earth Science Project Office (ESPO)

- See the section discussing ESPO's work this past year below.

Active Sensing of CO_2 Emissions over Nights, Days, and Seasons (ASCENDS)

Project Description

ASCENDS will improve models and predictions of long-term changes in the climate cycle through better understanding of the natural processes driving the variability of natural carbon sources and sinks and on the transport of carbon through the atmosphere. Ultimately, the project hopes to use laser-based remote sensing devices installed on satellites to carry out this mission. For now, testing of equipment is occurring on NASA's DC-8 aircraft.

Project Participants

NASA: Matt Fladeland

NSERC: Rick Shetter, Adam Webster, David Van Gilst, Eric Stith, Eric Buzay, and Karen Katrinak

BAER: Dan Chirica, Quincy Allison, and Marshal Chaidez

Accomplishments

Activity Undertaken through NSERC

- Designed and fabricated components for the integration of new instruments; and
- Operated the data and satcom systems on test flights, transits, and all science flights for the mission.

Activity Undertaken with the Earth Science Project Office (ESPO)

See the section discussing ESPO's work this past year below.

Indianapolis Flux Experiment (INFLUX)

Project description

The Indianapolis Flux Experiment (INFLUX) is a greenhouse gas quantification experiment in the city of Indianapolis. A Total Carbon Column Observing Network (TCCON) Fourier Transform Spectrometer (FTS), was installed by NASA Ames and ARC-CREST personnel in Indianapolis and acquired daily CO_2 measurements through the summer and fall of 2012. Laura Iraci, Jim Podolske, and Pat Hillyard managed the deployment of the instrument and monitored its status until the field portion of the INFLUX experiment concluded in December 2012. The TCCON instrument was returned to JPL and re-deployed to NASA

Dryden in the summer of 2013 to participate in future CO_2 observation missions and projects including OCO-2 data calibration/validation.

Project Participants

NASA: Laura Iraci, Jim Podolskie
BAER: Patrick Hillyard, PhD

Accomplishments

- Led the implementation and execution of data analysis for NASA Ames;
- Led publication of INFLUX TCCON data to International TCCON data archive;
- Led the implementation of TCCON computation hardware/software installation at NASA Ames;
- Performed data transfer and backups;
- Performed quality control/assurance on TCCON data;
- Studied changes in greenhouse gases around an urban center as a member of large multi-institutional INFLUX collaboration;
- Formed ideas, in partnership with collaborators, for a paper using measurements at INFLUX;
- Created outline, in partnership with collaborators, for a paper using measurements at INFLUX;
- Participated in teleconferences with collaborators for both the INFLUX and TCCON working groups;
- Assisted in data/computer aspects of transitions of TCCON instrument from Indianapolis to JPL;
- Assisted in data/computer aspects of transitions of TCCON instrument from JPL to Dryden;
- Managed on-board disk storage on the TCCON instrument;
- Analyzed data obtained from Dryden; and
- Performed qualitative comparisons of aircraft vertical profiles and TCCON data at Dryden.

The Marginal Ice Zone Observations and Processes Experiment (MIZOPEX)

Project description

MIZOPEX is an airborne project using the NASA Ames SIERRA UAV to obtain observations of the Arctic sea ice off of the north coast of Alaska. The project will directly address gaps in our understanding of marginal ice zones where the Arctic sea ice is changing most rapidly and experiencing ice loss that has no precedent in human history.

Project Participants

NASA: Matt Fladeland, Randy Berthold
BAER: Steven Wegener

Accomplishments

- Activities centered on the preparation for the July MIZOPEX UAS deployment to Prudhoe Bay;
- Maintained a detailed milestone schedule to guide project management;
- Identified long pole activities;
- Maintained list of aircraft operators and updated Notices to Airman of UAS activities in the Deadhorse area during deployment;
- Continued efforts to bring on the Herwitz Sentential radar;
- Developed preliminary SOW to contract with 70 North for RADAR testing;
- Developed preliminary cut at a logging plan;
- Explored the feasibility of utilizing the ASP Mission Tool Suite; and
- Continued contact with deployment site service providers in the effort to develop infrastructure and facilities in Deadhorse and Oliktok.

Alpha Jet Atmospheric eXperiment (AJAX)

Project description

The Alpha Jet Atmospheric eXperiment (AJAX) atmospheric measurement flights began in 2011, and AJAX is currently performing regular missions to measure ozone and greenhouse gases, such as carbon dioxide (CO_2) and methane (CH_4), over California and Nevada. NASA's flexible relationship with the aircraft provider allows Ames Research Center to collect data on a regular basis over multiple seasons – data that complement surface and tower-based observations collected elsewhere in the region. It also allows AJAX to provide validation data for satellite sensors over months and years to help assess sensor health and calibration. AJAX supports NASA's Orbiting Carbon Observatory (OCO-2) Science Team and is developing collaborations with the California Air Resources Board (CARB). The AJAX project provides hands-on training for Ames personnel in the areas of instrument development, systems engineering, science mission development, and project management.

Project Participants

NASA: Warren Gore, Laura Iraci, Max Loewenstein

BAER: Quincy Allison, Steven Todorov

Accomplishments

Activity Undertaken with the Earth Science Project Office (ESPO)

See the section discussing ESPO's work this past year below.

NASA Support Activity

Earth Science Project Office (ESPO)

Office Description

The Ames Earth Science Project Office 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 campaigns, especially airborne missions. ESPO has a long history of successful field campaigns, beginning in 1987 with the Stratosphere-Troposphere Exchange Project (STEP) and the Airborne Antarctic Ozone Expedition (AAOE) experiments. ESPO's primary customer has been NASA's Upper Atmosphere Research Program, but in recent years ESPO 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.

Project Participants

NASA: Mike Craig, Marilyn Vasques

BAER: Erin Czech, Dan Chirica, Erin Justice, Michaela Herman, Quincy Allison, Sue Tolley, and Steven Todorov

Accomplishments

Logistical and Support

- Setup and managed deployment sites, including usual setup tasks of arranging facilities, lodging, transport, and Customs;
- Made high-level arrangements for missions for foreign national participants;
- During missions, maintained, updated, and processed on a daily basis Flight Request data and interfaced with Aircraft Leads, PI's, and Program Managers;
- Stored and maintained equipment used for national and international deployments;
- Provided an extensive inventory of specialized equipment tailored to the scientific research mission and supported multiple missions in different locations;
- Provided procedures for packing and shipping to insure safe and timely arrival of equipment;
- Coordinated with NASA shipping and transportation, freight forwarders and common commercial carries from pickup to delivery; and
- Provided deployment set-up and on-site support throughout the duration of several missions, including ATTREX, HS3, Operation IceBridge (Arctic and Antarctic), SEAC^{4}RS, and AJAX. Some of the services provided included furniture set-up, office and network equipment installation, gasses and cryogen orders, and purchases and resupplying expendables
- Provided payload management services on Global Hawk missions.[1]

[1] Any operational information that needs to be communicated from the instrument operators or the Science Team in the Payload Operations Room to the mission manager or pilots in the

Review Activity

- Served on writing panel for Observance of Upper-Level Typhoon Flow Lifecycle Over the West Pacific (OUTFLOW), an EVS-2 proposal;
- Reviewed proposal for ObseRvations of Aerosols above CLouds and their intEractionS (ORACLES); and
- Wrote the Management section and the Master Equipment List for NASA Goddard led proposal called "Lifecycles of Precipitation and Cloud" (LifePaC)

Programming and IT Support

- Provided system administration services for all ESPO computers, servers and systems;
- Provided in-field IT support for website, system and network setup, and user support for all Field Missions;
- Redesigned and maintained Ames Earth Science Division website;
- Developed, maintained, and provided user support for SEAC^{4}RS, HS3, ATTREX and AJAX missions;
- Maintained and added features to the websites for ESPO, the ICEBridge mission, the ESPO Data Archive, ESPO Mission Database, the ESD Publications Database, the Airborne Science Program (ASP), and the Science Operations Flight Request System (SOFRS);
- Maintained archives of past mission websites;
- Provided network and hardware mission support ranging from setting up printers and wireless routers to working with ISP companies to ensure an internet connection for deployment sites;
- For the Mabel Mission in Thule Greenland, managed all tasks including Budget, Logistics, Theater Clearance, Internet access/setup, Rotator flight access (military contract flights limited to Thule Mission personnel, military access only housing in Thule).

Educational Program Support

- Gave three one-hour presentations and Q&A sessions regarding ATTREX at the Palmdale Aerospace Academy;
- Organized an all-day tour of the ATTREX facilities at NASA Dryden Flight Research Center for about 200 students where they were taken through the hangar and the Global Hawk Operations Center and were allowed to ask questions to pilots, scientists, etc.

Flight Operations Room goes through the Payload Manager. The purpose of this single line of communication is to reduce chatter. Because Global Hawk flights are 24 hours or longer, the Payload Manager role gets broken into 2-4 shifts depending on how many capable people are available.

Applied Sciences Program's Water Resources Program

Project Description

The primary objectives of this task are to:

1) Track a portfolio of NASA ASP funded projects, including project progress and funding status;

2) Enhance coordination among funded projects and enhance communication with project partners and stakeholders in the water resource management community; and

3) Plan and convene workshops, meetings, and workshop sessions to enhance visibility of Water Resources Program's projects and activities.

Project Participants

NASA: Ed Sheffner

CSUMB: Forrest Melton

Accomplishments

- Tracked status of more than a dozen ASP funded projects;
- Communicated with project PIs on a monthly basis;
- Presented project overviews to ASP at the Program Management meetings every 2 months;
- Worked with PIs to identify and resolve programmatic issues, and ensure successful completion of projects;
- Planned, organized, and co-hosted the 2013 ASP Water Resources PI meeting at the National Drought Mitigation Center in Lincoln, Nebraska, attended by more than 40 Water Resources PIs and project personnel. Also facilitated participation by >15 remote participants.
- Represented the program at numerous science meetings, workshops, and conferences;
- Presented three invited talks on behalf of the program;
- Led development and implementation of the ASP Water Resources website;
- Organized and led three oral sessions and one large poster session for the ASP Water Resources program at the 2013 Fall AGU Meeting, and assisted Christine Lee in organizing the NASA ASP Water Resources Town Hall meeting at AGU; and
- Worked with NASA HQ to plan ASP water resources program activities, including development of a ROSES solicitation, as well as outreach and education activities in 2013 and 2014.

Selected Presentations

- Melton, F., et al., (2013), Mapping a Thirsty State: Applications of Remote Sensing and GIS for Water Resources Management, CSU Stanislaus GIS Day, Turlock, CA, Nov. 20, 2013 (invited keynote);
- Melton, F., Doorn, B., Mohr., K. (2013), Water Resources Application Area, USAID Study Tour for Government of Morocco, Moffett Field, CA, April 12, 2013; and

- Melton, F. (2012, Fallowed Area Mapping for Drought Impact Reporting for Decision Making. Western States Water Council, San Diego, CA, Aug. 6, 2013. Invited presentation.

AGU 2013 Session Chairs

- H31N. H31N. Remote Sensing Applications for Water Resources Management I: Water Supply, Precipitation, and Snow Water Resource Monitoring Convener(s): Forrest Melton (CSU Monterey Bay), Michael Gunson (Jet Propulsion Lab), Bradley Doorn (NASA HQ) and Karen Mohr (NASA-GSFC);
- H32F. H32F. Remote Sensing Applications for Water Resources Management II: Groundwater Monitoring, Data Integration and Modeling Convener(s): Forrest Melton (CSU Monterey Bay), Karen Mohr (NASA-GSFC), Michael Gunson (Jet Propulsion Lab) and Bradley Doorn (NASA HQ);
- H42E. H42E. Remote Sensing Applications for Water Resources Management IV: Water Quality and Wetlands Convener(s): Forrest Melton (CSU Monterey Bay), Karen Mohr (NASA-GSFC), Michael Gunson (Jet Propulsion Lab) and Christine Lee (AAAS/NASA); and
- H43G. H43G. Remote Sensing Applications for Water Resources Management I Posters Convener(s): Forrest Melton (CSU Monterey Bay), Karen Mohr (NASA-GSFC) and Bradley Doorn (NASA HQ);

Airborne Science Program Planning

Project Description

The NASA Airborne Science Program develops and tests specialized instruments, integrates them into systems for use on airborne platforms (science payloads), operates these airborne platforms (manned and unmanned), conducts missions to test new measurement approaches, collects detailed in situ and remote-sensing observations that are needed to better document and test models of Earth system processes, and provides calibration/validation information for satellites. The Airborne Science Program's primary role is to support the observation and measurement needs of the NASA Earth Science community. Anticipating these needs requires analysis, advance planning, and outreach, typically through a liaison function to assure that airborne platforms are available and prepared to meet research requirements. In addition to platform capabilities, scientists look to the Airborne Science Program to provide or integrate sensors for in situ or remote sensing during flight. Various groups maintain sensors for the Program and need expert support to maintain communication with the science community regarding sensor payload requirements.

Project Participants

NASA: Matthew Fladeland

BAER: Susan Schoenung, Steve Wegener

Accomplishments

- Updated ASP requirements including a survey of Science Centers and briefing materials;
- Prepared and updated the 5-year flight plan;
- Participated in science meetings for upcoming satellite missions and field campaigns, collecting data on airborne requirements to support future missions;
- Worked on the ASP 2012 Annual Report;
- Prepared quarterly reports on "UAS-Enabled Science" projects;
- Participated in UAS-related teleconferences, webinars, and meetings to collect data specific to UAS developments for science; and
- Contributed to the ASP quarterly newsletter.

General Engineering and Data and Satcom System Activity

Project Description

NSERC supports science mission operations and aircraft deployments for Earth Science research campaigns conducted by the NASA Airborne Science Program. NSERC provides payload integration engineering, data display and networking, and facility instrumentation for NASA's fleet of research aircraft, including the DC-8 and P-3B airborne laboratories, the WB-57 high altitude platform, and the Global Hawk Uninhabited Aerial Vehicle, among others.

Project Participants

NASA: Don Sullivan

NSERC: Rick Shetter, Adam Webster, David Van Gilst, Eric Stith, Eric Buzay, and Karen Katrinak

Accomplishments

- Added new HD video cameras with higher resolution on the DC-8 and P-3;
- Upgraded Software to improve archiving of the data;
- Installed small form factor system with built in PoE capabilities;
- Worked to improve archival and distribution of video, including increasing the size of disk arrays, creating automated systems for providing recompressed, reduced sized videos, and improving the backup of archived video;
- Provided training to the new GHOC staff for data and satcom services;
- Completed a new NSERC webpage to replace the current NSERC page;
- Completed the remaining ice detector installation and integration into the data display system;
- Completed the Delphi server disk-capacity upgrade;
- Worked to improve automatic failover and remote management of ground infrastructure capabilities to allow ASP Personnel to better react to technical problems and required configuration changes while in the field. This includes:

        - Configuration of servers and storage for remote management through the Dell OMSA and DRAC integrated lights-out management systems.
        - Creation of remotely operable systems for failover between resources, including modem banks and database application servers.
        - Planning for fully-automated failover between redundant ground station systems.
        - Creation of software for improved monitoring of ground station systems.
        - Creation of documentation of software and hardware systems.
    - Environmentally tested all of the new permanent installations;
    - Completed housekeeping power, network switch power, and network overhead box electrical drawings. (Iridium system drawing is almost completed, so all that's left is a network drawing that includes fiber/ethernet connections, a drawing for REVEAL/NASDAT to patch panel, and updating the housekeeping circuit breakers and terminal blocks drawing);
    - Collected information on cloud microphysics measurement capabilities of the DC-8 in potential support of testing of the new Air Force Airborne Icing Tanker program;
    - Worked on a system for automatically reducing the size of our video so that we have a smaller version to distribute;
    - Worked on a system for testing the Iridium channels on the multichannel and the NASDAT systems;
    - Provided engineering and satcom guidance to a number of EVS-2 proposers;
    - Prepared for the DC-8 heavy maintenance check by removing all of the fiber network components and the entire housekeeping rack suite;
    - Designed a new wiring scheme for the DC-8 housekeeping rack;
    - Provided design services for the ISRnet mission on the B-200. This consisted of antenna installations and modeling of existing installations; and
    - Supported the Global Hawk Operations Center IT audit.

<u>Specific Engineering and Data and Satcom System Accomplishments</u>

- Assisted ASF staff in troubleshooting a problem on the ER-2s (809). Discovered what appear to be several wiring faults which prevented the network from actually being a redundant ring topology. Once the ring was closed, we started seeing a broadcast storm;
- Assisted in creating cabling to allow use of the Fluke network tester in the ringing out and testing of the ER-2 wiring;
- Investigated Fluke Network testing tools to find an appropriate tool for testing of aircraft ethernet wiring and enable more effective speed and wiring tests in the field; and
- ER-2 INMARSAT System Installation project:
    - Obtained detailed solid models of all the INMARSAT electrical system components in support of the ER-2 installation.
    - Completed compiling detailed installation design requirements from staff.

- Completed detailed installation design and analysis.
- Completed overseeing of the fabrication of necessary components.
- Completed installing and some testing on the platform.

Meteorological Measurement System (MMS)

Project Description

The Meteorological Measurement System (MMS) is a proven instrument to measure accurate, high resolution in situ airborne state measurements. Accurate measurements of these quantities require judicious choices of sensor locations, repeated laboratory calibrations, and proper corrections for compressibility, adiabatic heating and flow distortion.

Project Participants

NASA: Paul Bui

BAER: Jon Dean-Day, Cecilia Chang

Accomplishments

- Examined data from the Global Hawk LN-100G Inertial Navigation System (INS) to determine time delays via comparison with C-MIGITS III INS data, and developed a scheme to correct spikes in static pressure measurements;
- Prepared and presented a poster titled “An Inter-Comparison of the NASA DC-8 MMS with the NCAR G-V Met System and nearby Vaisala GPS Radiosondes” at the Deep Convective Clouds and Chemistry Experiment (DC3) Science Team Meeting, Boulder, CO, February 25-28, 2013;
- Calibrated, corrected, and re-processed MMS field data from phase II of the Airborne Tropical TRopopause Experiment (ATTREX-2013). Position accuracy was evaluated by comparing latitude and longitude from two INS units with data obtained from a RACAL GPS unit prior to its removal during the experiment. Navigation data from the Global Hawk LN-100G INS was filtered to minimize noise. Due to RACAL sampling errors, software was adapted to use the ship clock as the timekeeper for all flights. Pressure, temperature, and winds were analyzed to estimate MMS data precision;
- Prepared MMS processing code for the Alpha Jet Atmospheric Experiment (AJAX). Timing differences between the SDN500 and C-MIGITS III INS units were used to estimate absolute time delays of SDN500 variables using the Xbow tilt angle sensor. The effect of engine thrust on the yaw angle calibration was evaluated. Limits of key measurements (attack angle, roll, dynamic pressure) in sharp turns were determined, and strategies to correct out-of-limit data were evaluated with consideration to the precision of these parameters during normal flight. An initial calibration of MMS data was obtained from aircraft maneuvers flown on dedicated flights. Maneuvers were designed to evaluate engine thrust effects on the pod-mounted MMS air data system. Preliminary data from several key flights was distributed to the AJAX science team;
- Developed and updated MMS processing code for both ER-2 and DC-8 aircraft for

the Studies of Emissions and Atmospheric Composition, Clouds and Climate Coupling by Regional Surveys (SEAC4RS) experiment. DC-8 MMS instrument response was evaluated using spectral analysis methods, and updates to preliminary data were provided to correct for icing encounters. Comparisons were made between DC-8 MMS and AIMMS20 probe data across the flight envelope, including during MMS maneuvers, HCHO flux encounters, and profiling maneuvers in the vicinity of radiosondes. Spectral analysis of data from both instruments was utilized to determine flux sensing capabilities. An initial calibration of ER-2 pressure and temperature data was provided; strategies were developed for possible post-mission calibration of ER-2 winds;

- Analyzed MMS temperature profiles from ATTREX-2013 and prepared presentation graphics for the ATTREX Science Team Meeting in Boulder, CO;
- Contributed as a co-author to the paper "Dehydration in the tropical tropopause layer: A case study for model evaluation using aircraft observations" by R. Ueyama, L. Pfister, E.J. Jensen, G.S. Diskin, T.P. Bui, and J. Dean-Day. Tasks included reviewing drafts of the manuscript, and correcting an analysis of MMS temperature data used in comparison with ERA-Interim model temperature fields; and
- Attended the American Geophysical Union Fall Meeting, San Francisco, CA, December 9 - 13, 2013.

Capacity Building and Outreach Activity

The Student Airborne Research Program (SARP)

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 campaign using NASA's DC-8 or P-3 airborne science laboratories. The DC-8 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.

Project Participants

NASA: Jack Kaye
NSERC: Rick Shetter, Emily Schaller, Jane Peterson, and Karen Katrinak

Accomplishments

General Accomplishments

- Provided and added frequent content about missions to the Airborne Science Program web page, blog, and Twitter accounts;
- Ran a successful Student Airborne Research Program with 32 undergraduate students, 5 graduate student mentors and 6 faculty members;
- Submitted 2013 actual and 2014 estimated budget numbers for SARP and ASP K-12 Mission educational outreach to OEPM (Office of Education Performance Management) system;
- Completed “Best-of ASP” video;
- Staffed the NASA booth at the National Science Teachers Association Meeting in San Antonio to promote the Mission Tools Suite for Education (MTSE) to science teachers;
- Presented to teachers attending the Dryden and Wallops HS3/ATTREX summer teacher workshops on the Mission Tools Suite for Education;
- Gave eight in-school presentations about the Airborne Science Program that reached over 500 K-12 students;
- Staffed the NASA booth at the Fall AGU meeting in San Francisco to promote SARP and the Mission Tools Suite for Education; and
- Coordinated educational chats and flight following using the Mission Tools Suite for Education during DISCOVER-AQ California, ATTREX, IceBridge Arctic, HS3, DISCOVER-AQ Houston and IceBridge Antarctic missions that reached over 4800 K-12 students.

DISCOVER-AQ California P-3B Mission (January-February 2013)

- Coordinated and ran online educational chats with the Mission Tools Suite for Education website that reached 468 K-12 students;
- Prepared a report with data from all DAQ educational chats (numbers of students and teachers online during each flight) for submission to the OEPM (Office of Education Performance Management) system; and
- Helped staff and gave presentations about MTSE at the Airborne Science Media Day Educator Tour of the DFRC and the P-3B (Jan 25)

ATTREX Global Hawk Mission (February-March 2013)

- Coordinated and ran online educational chats with MTSE during Global Hawk flights that reached 581 K-12 students over the course of the mission;
- Prepared a report with data from all ATTREX educational chats (numbers of students and teachers online during each flight) for submission to the OEPM (Office of Education Performance Management) system; and
- Assisted with escorting/chaperoning students from two Bay Area high schools and a Palmdale middle school during two school visits to DFRC (Feb 2 & Feb 23).

Operation IceBridge P-3B Mission (March-May 2013)

- Prepared and sent a summary of the IceBridge mission to K-12 teachers and encouraged their participation in online chats;

- Coordinated and ran chats during nearly all P-3B flights over Greenland that reached 813 K-12 students and their teachers through the MTSE website; and
- Prepared a report with data from all OIB educational chats (numbers of students and teachers online during each flight) for submission to the OEPM (Office of Education Performance Management) system.

SARP 2013 DC-8 mission (June-August 2013)

- Managed of the 2013 Student Airborne Research Program including program design, faculty recruitment, participant recruitment, selection, and logistics;
- Completed selection of 32 students from 150 applications;
- Provided logistics for 32 students;
- Organized all science flights;
- Selected the top student presentations for participation at the AGU conference;
- Organized the conclusion of SARP 2013 with final student presentations on July 30th and 31st, the final graduation meeting on the evening of July 31st, collection of student evaluations and SARP laptops on August 1st, and checkout from the UCI housing, return of the students for their flights home to the John Wayne Airport, and return of SARP equipment and staff to the DFRC on August 2, 2013;
- Presented a poster about SARP in an AGU education session on undergraduate programs in the Earth system sciences;
- Prepared a poster on SARP for the NASA Earth Science EPO retreat (retreat canceled due to government shutdown);
- Distributed over 200 flyers about SARP at the NASA Airborne Science table at AGU;
- Assisted the 11 SARP 2013 students attending AGU with preparing their presentations;
- Organized SARP AGU reunion dinner during AGU (30 students from all 5 classes were in attendance); and
- Completed the SARP 2013 documentary/recruitment video.

HS3 Global Hawk Mission (August-September 2013)

- Coordinated and ran live educational chats with elementary, middle and high school students during HS3 AV-6 and AV-1 flights. Reached 1619 students (1054 unique participants as some classrooms logged in more than once);
- Prepared a report with data from all HS3 educational chats (numbers of students and teachers online during each flight) for submission to the OEPM (Office of Education Performance Management) system;
- Collected video footage for HS3 mission documentaries and educational videos (September 7-17, 2013);
- Submitted first HS3 Educational video regarding the SMD product review process -- DVD's of video distributed to teachers at summer teacher workshops at Wallops and Dryden;
- Completed second HS3 Educational video, which will be submitted to the January 2014 review cycle;

- Gave presentation about MTSE to teachers attending Wallops HS3 Education Day and assisted with staffing event; and
- Gave two in-person presentations to schools in Maryland about HS3 reaching over 150 students.

DISCOVER-AQ Houston P-3B Mission (September 2013)

- Helped coordinate and run (with Melissa Yang) online educational chats with the Mission Tools Suite for Education website that reached 606 K-12 students; and
- Prepared a report with data from all DAQ educational chats (numbers of students and teachers online during each flight) for submission to the OEPM (Office of Education Performance Management) system.

Operation IceBridge DC-8 Mission (November 2013)

- Prepared and sent a summary of the IceBridge mission science to K-12 teachers and encouraged their participation in online chats;
- Gave five in-person presentations at schools in California and Hawaii about OIB reaching 256 K-12 students;
- Coordinated and ran 24 classroom chats reaching 761 students (545 unique students – several classrooms logged in more than once) in 12 schools in 7 states (Hawaii, California, Arizona, Kansas, Illinois, Maryland and Virginia); and
- Submitted final data for all of the OIB educational chats (numbers of students and teachers online during each flight) for submission to the OEPM (Office of Education Performance Management) system.

SARP 2014 Planning/Recruiting

- Obtained HQ budget approval for an 8 week SARP 2014 with 32 students;
- Received commitments from SARP faculty and currently gathering information on their funding requirements for field trips, integration and analysis costs for inclusion into our budget;
- Posted SARP 2014 application on NSERC website;
- Published SARP 2014 announcement in the Student Opportunities section of EOS, the weekly publication of the American Geophysical Union, the SACNAS job register, the Pathways to Science Institute for Broadening Participation job register, and the Earth Science Women's Network; and
- Sent emails about SARP with the flyer to over 1000 US college and university STEM departments.

CUSMB Educational Program

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

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

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

Project Participants

NASA: James Brass

CSUMB: Professor Susan Alexander; *Scientist*: Kenneth Weinstock

Accomplishments

We have formalized research collaborations between CWSP graduate students, ESTP senior undergraduate students, Cooperative Agreement Research Scientists, and NASA PIs at Ames Research Center on the following projects:

- CWSP student Sean Castorani is conducting his graduate Thesis research in conjunction with Lee Johnson and others.
- CWSP students (or recent graduates) Ty Brandt, David Hamblin, Shane Keefauver, Pam Krone-Davis, Gwen Miller, Sam Phillips, Kirk Post, AJ Purdy, Carolyn Rosevelt, Erin Stanfield, and Aimee Teaby are conducting research under the mentorship of Mr. Forrest Melton.
- CWSP student Aimee Teaby participated in the NASA DEVELOP student internship program at Ames Research Center in Summer 2013 under the guidance of John Shupe.
- CSUMB Faculty member Dr. Dan Fernandez collaborated with NASA PI Dr. Chris Potter and ARC CREST scientist Cyrus Hiatt on local fog research.

We have advertised student research opportunities at NASA Ames Research Center related to the Cooperative Agreement and will continue to promote student involvement in the Cooperative Agreement.

Support Products and Benefits

- Supported activities for 3 major UAV campaigns including data telemetry and archiving. Logistical support for field deployment emergencies including computer resources and spare parts.
- Supported iGEM (International Genetically Engineered Machine) team from NASA Ames/Brown University that placed in top 16 of the regional championships.
- Provided hardware/software support and mentoring for 20+ students participating in the DEVELOP Summer 2013 session.
- Planned/coordinated upgrade and installation of 16 additional modem lines to support increased requirements for aircraft asset tracking and telemetry for the NASA Airborne Sciences Program.
- Upgraded DEVELOP and Code SGE branch systems to ArcGIS to version 10.1.

DEVELOP/ARSET

Project Description

The DEVELOP National Program is a capacity building internship sponsored by NASA's Applied Sciences Program that provides young professionals and interns the opportunity to learn about NASA Earth Science and the practical applications of Earth observations. As part of the DEVELOP program, NASA Applied Remote SEnsing Training (ARSET) air quality project hopes to increase the utility of NASA Earth science and model data for policy makers, regulatory agencies, and other applied science professionals in the area of air quality applications. The two main activities of this project are to provide in-person and on-line courses, workshops and other capacity building activities throughout the year and to disseminate via this web page course materials and other information to enable training in applied air quality and remote sensing.

Project courses are a combination of lectures and computer hands-on activities that teach professionals how to access, interpret, and apply NASA aerosol and trace gas data at regional and global scales with an emphasis on case studies. Course topics include (1) Case

Studies in air quality analysis tailored to end-user needs, such as urban air pollution, dust, and fires; (2) Satellite aerosol and trace gas products, their application and relationship to in-situ monitor data; (3) Long Range Transport of atmospheric aerosols (or particulate matter) and trace gases; and (4) Satellite and regional air quality model comparisons.

Skills taught include:

- Search, access, and download of NASA data products and imagery
- Appropriate use and interpretation of satellite imagery.
- Visualization and analysis of NASA imagery using NASA, EPA, and NOAA webtools and other resources such as Google Earth, Panoply, RSIG, HDFLook, and MISRView.

Project Participants

NASA: James Brass
BAER: Cindy Schmidt

Accomplishments

- Reviewed over 120 student applications and hired 20 students for the summer 2013 term;
- Mentored students on three different projects:
    - Bird conservation through assessment of oak habitats in the Klamath Basin
    - Impacts of snow water equivalent on wildfire in the Sierra Nevada
    - Coupling the NASA –CASA ecosystem model with a hydrologic routing algorithm for improved water management decision-making;
- Organized the presentation of the student projects to the Ames science community in August;
- Attended a NASA Applied Sciences Capacity Building planning workshop for ARSET and DEVELOP in November;
- Attended AGU in December, where DEVELOP students presented 3 student posters, 1 Ignite presentation, and one NASA booth presentation;

Summer Short Course on Climate Modeling

Project Description

Bringing students to Ames both physically and virtually, leveraging the developments with the NASA Earth Exchange, Ames Virtual Institutes and access to the NASA Advanced Supercomputing facility, we are providing students a hands-on learning experience. Students have access to NASA space-based and other Earth observations, local to global Earth system models, and workflow management tools. We are expanding the pool of Earth science students with knowledge of and experience with Earth system / climate modeling.

Project Participants

NASA: Dr. Rama Nemani, Dr. Jennifer Dungan
BAER: Petr Votava, Andy Michaelis, Weile Wang, Sangram Ganguly

Accomplishments

- Recorded Ames colloquia lectures by Dr. James Hansen and Dr. Waleed Abdalati for use with the summer short course; and
- Developed the virtual collaboration and computing tools for remote student access;
- Conducted the training program during summer 2013, managing the student projects and recording all of the presentations and lectures;

Glossary

4STAR – Spectrometers for Sky-Scanning, Sun-Tracking Atmospheric Research

AAI – Ames Aerosol Instrument

AESD – Ames Earth Science Division

AGU – American Geophysical Union

AIRS – Atmospheric Infrared Sounder

AIS – Automatic Identification System

AMS – Autonomous Modular Scanner

ARC – Ames Research Center

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

ARCTAS – Arctic Research of the Composition of the Troposphere from Aircraft and Satellites

ARP – Annual Research Plan

ASF – Airborne Sensor Facility

ASP – Airborne Science Program

ASPRS – American Society of Photogrammetry and Remote Sensing

ASTER – Advanced Spaceborne Thermal Emission and Reflection Radiometer

ATTREX – Airborne Tropical Tropopause Experiment

AATS – Ames Airborne Tracking Sunphotometer

AVAPS – Advanced Vertical Atmospheric Profiling System

AVHRR – Advanced Very High Resolution Spectroradiometer

BAER – The Bay Area Environmental Research Institute

BGAN – Broadband Global Area Network

CAN – Cooperative Agreement Notice

CASA – Carnegie-Ames-Stanford Approach

CERES – California Environmental Resources Evaluation System

CH_4 – Methane

CHAART – Center for Health Applications of Aerospace Related Technologies

CIMIS – California Irrigation Management Information System

CO – Carbon Monoxide

COAST – Coastal and Ocean Airborne Science Testbed

COMPASS – Common Operations and Management Portal for Airborne Science Systems

CRUSH – Canopy Remote-sensing for Uniformly Segmented Harvest

CSIRO – Commonwealth Scientific and Industrial Research Organisation

CSC – Climate Science Center

CSGC – California Space Grant Consortium

CSTARS – The Center for Spatial Technologies and Remote Sensing

CSUMB – California State University Monterey Bay

CWSP – Coastal and Watershed Science and Policy

DC3 – Deep Convective Clouds and Chemistry Experiment

DFRC – Dryden Flight Research Center (NASA)

DRECP – Desert Renewable Energy Conservation Plan

DEVELOP – Digital Earth Virtual Environment and Learning Outreach Project

DISCOVER-AQ – Deriving Information on Surface conditions from Column and Vertically Resolved Observations Relevant to Air Quality

DPM – Deptartment of Payment Management

Dropsondes – Advanced Vertical Atmospheric Profiling System

DSEP – Division of Science and Environmental Policy

EARSeL – European Association of Remote Sensing Laboratories

EF – Ecological Forecasting

eMAS - Enhanced MODIS Airborne Simulator

EOS – Earth Observing System

EOS-PSO – EOS Project Science Office

ER-2 – Earth Resources 2 (Single-engine, high-altitude aircraft)

ESDR – Earth Science Data Record

ESTP – Environmental Science, Technology, and Policy

FFSIG – Forest Fire Special Interest Group

FPAR – Fraction of Photosynthetically Active Radiation

FTS – Fourier Transform Spectrometer

GH – Global Hawk

GIS – Geographic Information System

GHOC – Global Hawk Operations Center

GOSAT – Greenhouse gases Observing SATellite

GSFC – Goddard Space Flight Center

HAMSR – High Altitude MMIC Sounding Radiometer

HIAPER – High-performance Instrumented Airborne Platform for Environmental Research

HIRAD – Hurricane Imaging Radiometer

HIWRAP – High-Altitude Imaging Wind and Rain Airborne Profiler

HS3 – Hurricane and Severe Storm Sentinel

HYDRA – Hydrological Routing Algorithm

IARPC – Interagency Arctic Research Policy Committee

ICCAGRA – Interagency Coordinating Committee for Airborne Geoscience Research and Applications

ICESat – Ice, Cloud and Land Elevation Satellite

IGARRS – International Geoscience and Remote Sensing Symposium

INFLUX – Indianapolis Flux Experiment

INMARSAT – International Maritime Satellite Organization

INPE – Instituto Nacional de Pesquisas Espaciais

INTEX – Intercontinental Chemical Transport ExperimenT

ISE – Information System for the Environment

ISPRS – International Society for Photogrammetry and Remote Sensing

ISRSE – International Symposium on Remote Sensing of Environment

IT – Information Technology

IWGADTS – Interagency Working Group for Airborne Data and Telecommunications Systems

LAI – Leaf Area Index (LAI)

LMSAL – Lockheed Martin Solar & Astrophysics Laboratory

LSAMP – Louis Stokes Alliance for Minority Participation program

MASMODIS – Airborne Simulator

MASTER – MODIS/ASTER (airborne simulator)

MERIS – Medium Resolution Imaging Spectrometer (on Envisat satellite)

MILAGRO – Megacity Initiative: Local and Global Research Observations

MMS – Meteorological Measurement System

MODIS – Moderate Resolution Imaging Spectroradiometer

MWIR – Mid-wavelength infrared

N_2O – Nitrous Oxide

NAS – NASA Advanced Supercomputing

NASDAT – NASA Airborne Science Data and Telemetry

NCAR – National Center for Atmospheric Research

NEX – NASA Earth Exchange

NIDIS – The National Integrated Drought Information System

NIST – National Institute of Standards and Technology

NOAA – National Oceanic and Atmospheric Administration

NOAA FRET – Forecast Reference Crop Evapotranspiration

NPP – Net Primary Production

NSERC – National Suborbital Education and Research Center

NSF – National Science Foundation

NSSC – NASA Shared Services Center

NWS – National Weather Service

OCO-2 – Orbiting Carbon Observatory

OIB – Operation IceBridge

PANAK – PAN/Aldehyde/Ketone (instrument)

RDAS – Rotating Disk Analytical System

RESA – Renewable Energy Study Areas

RSAC – Remote Sensing Applications Center

SAFARI 2000 – Southern African Regional Science Initiative

SARP – Student Airborne Research Program

SCIAMACHY – Scanning Imaging Absorption Spectrometer for Atmospheric CHartographY

SEAC^{4}RS – Southeast Asia Composition, Cloud, Climate Coupling Regional Study

SEAGRASS – High Resolution Assessment of Carbon Dynamics in Seagrass and Coral Reef Biomes

S-HIS or SHIS – Scanning High-resolution Interferometer Sounder

SIERRA – Sensor Integrated Environmental Remote Research Aircraft

SIMS – Satellite Irrigation Management Support

SIPS – Science Investigator-led Processing Systems

STEM – Science, Technology, Engineering, or Mathematics

sUAS – small Unmanned Aerial Systems

SWIR – Short Wavelength Infrared

TARFOX – Tropospheric Aerosol Radiative Forcing Observational eXperiment

TCCON – Total Carbon Column Observing Network

TES – Tropospheric Emission Spectrometer

TOPs – Terrestrial Observation and Prediction System

TOPS-SIMS – Terrestrial Observation and Prediction System-Satellite Irrigation Management Support

TPI – Task Principal Investigator

TTL – Tropical Tropopause Layer

TWiLiTE – Tropospheric Wind Lidar Technology Experiment

UAS – Unmanned Aerial Systems

UAV – Uninhabited Aerial Vehicles

UCD – University of California at Davis

UND – University of North Dakota

UROC – Undergraduate Research Opportunities Center

USFS – United States Forest Service

USGS – United States Geological Survey

VINTAGE – Viticultural Integration of NASA Technologies for Assessment of the Grapevine Environment

VSIM – Vineyard Soil Irrigation Model

WRAP – Wildfire Research and Applications Partnership