First 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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Period of Performance: 3/1/12 to 2/28/13

Date: December 31, 2012

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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 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 first 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") have made great strides toward achieving 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 the Hurricane and Severe Storm Sentinel (HS3) mission, the Deep Convective Clouds and Chemistry Experiment (DC3), the Airborne Tropical Tropopause Experiment (ATTREX), the Southeast Asia Composition, Cloud, Climate Coupling Regional Study ($SEAC^4RS$), Operation IceBridge, the High Resolution Assessment of Carbon Dynamics in Seagrass and Coral Reef Biomes (SEAGRASS), and the Indianapolis Flux Experiment (INFLUX).

Third, the ARC-CREST partners have provided support to critical Earth Science Division activities at Ames including the Applied Sciences Program's Water Resources Program; 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 SARP, CSUMB's educational program, and DEVELOP, ARC-CREST participants have worked with the Ames Research Center to provide a extensive educational and public outreach opportunities related to Earth Science

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

Earth Science Research

In this past year, ARC-CREST 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. ARC-CREST personnel in the Ecological Forecasting (EF) Group at NASA Ames are working to integrate advances in these areas to advance development of the NASA Terrestrial Observation and Prediction System (TOPS) ecological forecasting modeling framework (Nemani et al., 2009). In addition, under the NASA Earth Exchange (NEX) project (Nemani et al., 2011), CSUMB, BAER and Ames Earth Science Division (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 objectives of this task are to support further development of TOPS / NEX, to build and incorporate new technologies, and to extend TOPS / NEX capabilities for fundamental and applied science.

Activities conducted under this task are focused on improving in all components of the TOPS architecture, integrating new component carbon and biogeochemical cycle models, and incorporating observations from future NASA satellite and airborne missions. In addition, we collaborate closely with Ames scientists to apply TOPS and NEX to assess long-term and emerging trends in ecosystem conditions, conduct simulations of climate and land use change impacts on terrestrial and aquatic ecosystems, map patterns in biodiversity, and collaborate with the broader NASA Earth Science community to conduct analyses to support the National Climate Assessment. We also apply TOPS and NEX to support applied science activities, such as development of indicators of climate change impacts for Landscape Conservation Cooperatives (LCCs) and NASA Centers, development of information products to support land managers, agricultural producers, and water managers throughout the United States, and to support monitoring and modeling of natural disasters and emerging public health threats.

Project Participants

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

BAER: Senior Scientists: Sangram Ganguly, PhD, Gong Zhang, PhD

Accomplishments

- Supported more than 27 NASA funded projects and activities, as Primary Investigators, Co-Investigators, or Collaborators;
- Published 5 peer reviewed journal articles, plus 5 articles currently in review;

- Presented more than 25 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 develop the project plan for NEX, and secured core funding for the NEX project;
- Completed formal requirements and use case studies for NEX together with NASA Advanced Supercomputer Division (NAS);
- Completed initial multi-year project plan that integrates all the key components of the NEX system implementation scheduled in three-phase system;
- Completed formal requirements review of the NEX system;
- Completed initial system architecture of the NEX system with NAS;
- Coordinated migration of NEX web portal from NASA code TI to NAS;
- Created a new database system for Landsat, MODIS, and TRMM datasets;
- Designed and implemented a scalable database system that provides query capabilities for both distributed file locations, but also for specific anomalies in the data. A prototype has been developed using MySQL and MongoDB;
- Prototyped new Landsat processing pipeline system using VisTrails software package;
- Continued to work with NASA's code TI to develop new scalable algorithms for both on-line and off-line anomaly detection in large Earth Science datasets;
- 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 research results at the NASA Land Cover and Land Use Change meeting and the NASA Carbon Cycle & Ecosystems meeting. Currently completing analysis using the NASA Earth Exchange. Presented initial results for gross primary productivity, evapotranspiration, and watershed outflow to the National Park Service;
- 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. Currently working with the NASA Goddard NCCS climate DAAC to transfer a copy of the dataset for distribution to the public;
- Contributed to the technical working groups and technical reports for the 2013 National Climate Assessment (NCA);
- 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;
- In partnership with the NOAA National Marine Fisheries Service, applied a coupled river temperature modeling and forecasting framework driven by data from the TOPS-WRF forecasting system for the SF Bay Delta. Transitioned operation of the

system to NOAA NMFS to ensure a sustained capacity for river temperature forecasting in the Sacramento Basin by NOAA NMFS. Currently conducting 1km modeling of the SF Bay Delta;

- Continued to produce data, data summaries, and key indicators of ecosystem condition for ecosystems along the Appalachian Trail. Provided updated datasets and indicators to the University of Rhode Island, NPS, and USGS. Continued production of data to be used as the basis for ecological vulnerability and risk assessments for the Great Northern and Appalachian Landscape Conservation Cooperatives;
- Collaborated with researchers at NASA JPL to develop a simple model to estimate aboveground biomass for forests in California from the Landsat LAI and GLAS LIDAR data;
- Conducted model simulations to establish vulnerability of NASA Ames Research Center infrastructure and ecosystems of surrounding watersheds to projected changes in sea level, temperature, and precipitation;
- Developed methods to automate the extraction of sub-pixels fractions of impervious and vegetated surfaces from Landsat satellite data for North America. The results were presented at the 2012 NASA Land Cover and Land Use Change Spring Meeting; and
- Completed a first generation Leaf Area Index (LAI) dataset from Landsat Data for the forested areas of conterminous United States for the nominal growing season 2005. This first-of-its-kind data set will be used to produce high resolution forest biomass data for the United States.

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.
- Danner, E., Melton, F., Pike, A., Hashimoto, H., Michaelis, A., Caldwell, J., Rajagopalan, B., Nemani, R., Dewitt, L., and S. Lindley. 2012. River Temperature Forecasting: a Coupled-Modeling Framework for Management of River Habitat. IEEE J. of Selected Topics in Applied Earth Observations and Remote Sensing, Vol. 5, No. 6, Dec. 2012.
- Ganguly, S., Nemani, R., Zhang, G., Hashimoto, H., Milesi, C., Michaelis, A., Wang, W., Votava, P., Samanta, A., Melton, F., Dungan, J., Vermote, E., Gao, F., Knyazikhin, Y., and R. Myneni. 2012. Generating Global Leaf Area Index from Landsat: Algorithm Prototyping and Implementation. Remote Sensing of Environment, 122:185-202, http://dx.doi.org/10.1016/j.rse.2011.10.032.

- Weng, E., Y. Luo, W. Wang, H. Wang, D.J. Hayes, and et al., 2012. Ecosystem carbon storage capacity as affected by disturbance regimes: a general theoretical model. Journal of Geophysical Research, 117, doi:10.1029/2012JG002040.
- Hashimoto, H., Wang, W., Milesi, C., White, M., Ganguly, S. Gamo, M., Hirata, R., Myneni, R., Nemani, R., 2012. Exploring simple algorithms for estimating gross primary production in forested areas from satellite data. Remote Sensing, 2012; 4(1):303-326.
- Grimm, N., Chapin, S., Bierwagen, B., Gonzalez, P., Groffman, P., Luo, Y., Melton, F., Pairis, A., Raymond, P., Schimel, J., Williamson, C., Bernstein, M. 2013. Impacts of Climate Change on Ecosystem Structure and Functioning. Frontiers in Ecology, in review.
- Wang, W., Ciais, P., Nemani, R.R., Canadell, J.G., Piao, S., Sitch, S., White, M.A., Hashimoto, H., Milesi, C., Myneni, R.B. 2012. “Variations in Atmospheric CO_2 Growth Rates Controlled by Tropical Temperature", Nature Geoscience, in review.
- Zhang, G., S. Ganguly, M. White, R. Nemani, J. Dash, P. Atkinson, J. Chockalingam, F. Melton, C. Milesi, S. Hiatt, R. Myneni. 2012. Evaluation of the MODIS Phenology Product with Ground Measurements and Inter-comparison with Existing Phenology

Selected Presentations

- Melton, F, C Lund, L Johnson, A Michaelis, L Pierce, A Guzman, S Hiatt, A Purdy, C Rosevelt, W Brandt, P Votava, R Nemani. 2012. An Operational Framework for Estimation of Agricultural Evapotranspiration with the Terrestrial Observation and Prediction System. AGU Chapman Conference.
- Palmer, C., Osborne, H., Krone-Davis, P., Melton, F., Hobbins, M. 2012. National Weather Service – Forecast Reference Evapotranspiration (FRET), American Meteorological Society Meeting, 2012.
- Melton, F. et al. NASA Earth Exchange. GEOSS Water Working Group, invited talk. San Francisco, CA, Nov 30, 2012.

<u>AGU 2012 Presentations</u>

- H21H-1272. Forrest S. Melton; Christopher Lund; Lee Johnson; Andrew Michaelis; Lars Pierce; Alberto Guzman; Sam Hiatt; Adam J. Purdy; Carolyn Rosevelt; William T. Brandt; Petr Votava; Ramakrishna r. Nemani, Satellite Mapping of Agricultural Water Requirements in California with the Terrestrial Observation and Prediction System,
- H24E-03. Ramakrishna R. Nemani et al., NASA Earth Exchange (NEX): Earth Science Collaborative For Global Change Science
- B41C-0293. Kazuhito Ichii; Masayuki Kondo; Weile Wang; Hirofumi Hashimoto; Ramakrishna R. Nemani, Sequential Optimization Of A Terrestrial Biosphere Model Constrained By Multiple Satellite Based Products

- B41E-0333. Arindam Samanta; Sangram Ganguly; Eric F. Vermote; Ramakrishna R. Nemani; Ranga Myneni, Why is Remote Sensing of Amazon Forest Greenness so Challenging?
- B43D-0432. Hirofumi Hashimoto; Weile Wang; Cristina Milesi; Jun Xiong; Sangram Ganguly; Zaichun Zhu; Ramakrishna R. Nemani, Structural Uncertainty In Model-Simulated Trends Of Global Gross Primary Production
- B43D-0433. Sangram Ganguly; Gong Zhang; Ramakrishna R. Nemani; Michael A. White; Cristina Milesi; Weile Wang; Sassan S. Saatchi; Yifan Yu; Ranga Myneni, A simple Parametric Estimation of Live Forest Aboveground Biomass in California Using Satellite Derived Metrics of Canopy Height and Leaf Area Index
- B53F-0744. Cristina Milesi; Weile Wang; Jun Xiong; Forrest S. Melton; Hirofumi Hashimoto; Laura T. Iraci; Max Loewenstein, Use Of The Terrestrial Observation And Prediction System (TOPS) For Developing Climate Adaptation Strategies: Projecting Changes In Tree Biomass And Its Storm Water Regulation Potential For NASA Field Centers.
- A11B-0053. Jun Xiong; Weile Wang; Hirofumi Hashimoto; Gong Zhang; Sangram Ganguly; Ramakrishna R. Nemani, Assessing of Subpixel Land Surface Temperature from Multi-Windows Correlation of Vegetation Index-Radiometric Temperature
- IN43C-1531. Petr Votava; Andrew Michaelis; Ramakrishna R. Nemani, Connecting Provenance with Semantic Descriptions in the NASA Earth Exchange (NEX)
- B51B-0494. Weile Wang; Philippe Ciais; Ramakrishna R. Nemani; Josep Canadell; Shilong Piao; Stephen Sitch; Michael A. White; Hirofumi Hashimoto; Cristina Milesi; Ranga Myneni, Climatic Responses of Tropical Ecosystems Control Variations in Atmospheric CO2 Growth Rates
- IN52A-05. David P. Roy; Indrani Kommareddy; Valeriy Kovalskyy; Petr Votava; Ramakrishna R. Nemani; Junchang Ju, Prototyping Global Web Enabled Landsat Data Production, Distribution and Visualization

Sustainability Science

Project Description

Remote sensing and ecosystem models integrated with climate data allow the monitoring of natural and managed ecosystems for the detection of changes caused by both natural events and human activities. Integrated earth system models increase the capability to simulate, understand, and predict ecosystem changes and their interactions with other natural processes and human activities as well as consequent impacts.

Under the Sustainability research task, we are engaged in using remote sensing data ecohydrological models to monitor land use changes caused by urbanization, assessing vulnerabilities to global food security by mapping global croplands and evaluating hazards and impacts of climate changes to the natural and built environment of NASA field centers.

Current work under this task on urbanization has focused primarily on mapping subpixel vegetation fractions of North American ecosystems at the Landsat satellite scale (spatial resolution 30m). In particular, the impact of urban expansion was evaluated on changes in vegetation within urban environments and in the peri-urban areas from the year 1990 to present by developing a robust spectral unmixing approach that has the potential to be applied to Landsat data globally.

Changes in climate can impact operations at the 12 NASA field centers distributed across the United States. At NASA Ames Research Center, projected changes in climate are expected to challenge operations and expose infrastructure and employees to an increased frequency of hazards. Located at the southern end of the San Francisco Bay estuary, NASA ARC will have to accommodate continuing sea level rise and the related vulnerability of its infrastructure and of the protected animal species living within the boundaries of the Center. Other vulnerabilities of Center operations arise from the potential of increased storm intensity and its impact on storm water drainage. Increases in average and extreme temperatures are likely to increase Center consumption and cost of water and power. Work under this task has concentrated on coupling downscaled climate model projections on changes in biomass and storm water regulation and fresh water availability for the watersheds in which the California NASA Centers (NASA Ames, NASA JPL, and NASA Dryden) are located.

Project Participants

CSUMB: *Senior Scientist*: Cristina Milesi

Accomplishments

- Published 1 paper plus 2 papers currently under review;
- Cristina Milesi was part of the team that received the 2012 NASA Group Achievement Award to the NASA/Ames CASI (Climate Adaptation Science Investigator) Team in recognition for work on identifying vulnerabilities to climate change impacts at NASA Ames Research Center;
- Continued conducting model simulations to establish the vulnerability of the NASA Ames Research Center infrastructure and of ecosystems of surrounding watersheds to projected changes in sea level, temperature, and precipitation. Collaborated with colleagues at NASA GISS to extend the simulations at NASA Ames Research Center to other NASA Field Centers;
- Assembled a global database of spectral data to capture the global variability of reflectances for vegetation and substrates to calibrate a robust model for spectral unmixing of Landsat data;
- Created a first dataset of sub-pixel vegetation fractions from Landsat data for the nominal year 2005 for the state of California and analyzed changes since the year 1990 around major metropolitan areas; and
- Collaborated with colleagues at UC Irvine in analyzing the health effects of urban vegetation on pregnancy outcomes for 80,000 births in Southern California.

Publications

- Rosenzweig, C., R. Horton, D. Bader, M. Brown, R. DeYoung, M. Fellows, L. Friedl, K. Gotwals, W. Graham, C. Hall, S. Higuchi, C. Hudson, G. Jedlovec, J. Kaye, M. Lowenstein, T. Mace, C. Milesi, W. Patzert, P. Stackhouse, and K. Toufectis. 2012. Enhancing Climate Resilience at NASA Centers: The Climate Adaptation Science Investigator (CASI) Workgroup for Science and Stewardship. BAMS. Submitted.
- Laurent, O., Wu, J., Li, L. and Milesi, C. 2012. Green spaces and pregnancy outcomes in Southern California. Journal of Epidemiology & Community Health. Submitted.
- Thenkabail, P.S., Knox, J.W., Ozdogan, M., Gumma, M.K., Congalton, R. G., Wu, Z., Milesi, C., Finkral, A., Marshall, M., Mariotto, M., You, S., Giri, C., Nagler, P. 2012. Assessing Future Risks to Agricultural Productivity, Water Resources and Food Security: How Can Remote Sensing Help? Photogrammetric Engineering & Remote Sensing. 78: 773-782.

Selected Presentations

- Milesi, C. Climate Change and Extreme Weather Events: Economic Implications – 2012 Plenary Panel on Perspectives on Global Trade and Climate Volatility. Pricing the risk of climate change, Sustainable Silicon Valley presented the Water, Energy and Smart Technology (WEST) Summit, Santa Clara University, Santa Clara, CA, May 24, 2012. Invited.

Terrestrial Ecosystem and Carbon Simulation Modeling

Project Description

The main focus of the Carbon modeling team is the study of trace gas fluxes (CO_2, CH_4, N_2O and NO) and plant production at global and regional scales. This work is mainly done using the NASA-CASA (NASA-Carnegie-Ames-Stanford Approach) model, or the scaled-down version of the model called CASA Express. The NASA-CASA model is one of a few satellite coupled global models that simulates controls over terrestrial production processes, interactions of trace gas flux components through nutrient substrate availability, soil moisture availability, temperature stress, soil texture, and microbial activity. This model is a highly aggregated representation of major ecosystem carbon and nitrogen pools and associated transformation variables. NASA-CASA's modeling of biogeochemical cycles of carbon and nutrients provides a unique understanding of biosphere-atmosphere interactions. The NASA-CASA model is used for predicting ecosystem responses to global climate warming and changes resulting from land use patterns, understanding influences on terrestrial net primary productivity, quantifying carbon pools, and estimating trace gas fluxes (CO_2, CH_4, N_2O and NO) at global and regional scales. The NASA-CASA model has been used to generate maps of annual net primary production (NPP) and aboveground biomass carbon stocks or pools in forests over various regions of the world. An advantage of NASA-CASA results over most

other available map products for forest carbon accounting is that NASA-CASA can cover an entire country at a relatively high resolution. The NASA-CASA model is currently being used for a number of ongoing research projects. The Carbon modeling team is always developing new ways to incorporate the latest NASA satellite data products into the NASA-CASA model.

Project Participants

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

Accomplishments

Migratory Species (waterfowl) Response to Changing Climate and Climate Impacts

- Worked in conjunction with the Yellowstone Ecological Research Center (YERC) to apply the CASA Express model to selected wetland ecosystems in North America for the purpose of investigating migratory waterfowl species response to climate change and climate impacts;
- Developed, in conjunction with the YERC staff, a new version of CASA Express to address specifically these wetland regions; and
- Developed, in conjunction with the YERC staff, new analysis techniques to produce CASA model products at higher spatial and temporal scales than previously produced.

Drought Monitoring

- Worked in conjunction with Arizona State University;
- Applied the CASA Express model to both Brazil and Mexico at 1km resolution. The purpose of this project was to develop detailed (i.e., high spatial resolution) drought impact metrics that characterize current cropland, rangeland, and forest productivity to help inform resource managers about changing water availability, soil moisture conditions, and vegetation productivity. The soil moisture and vegetation production data for this part of the project have been delivered to ASU & the Planetary Skin Institute to be integrated into their Drought Monitoring System platform;
- Developed a separate platform for the Southern Plains states to deliver drought indicator data in support of local recovery and planning activities called DART. The data for the DART platform was produced and compiled by Dr. Shuang Li.
    - The CASA model was applied with NASA's MODIS data to assess the change in plant production across the drought affected regions of Texas, Oklahoma, and New Mexico from 2010 to 2011. Substantial declines in plant production and associated losses of forage and fiber products predominated the region in 2011. The largest decline in annual production rates on a unit area (e.g., acre) basis was estimated for pastures and croplands cover types. CASA estimated production losses in these areas typically ranged from 1.2 to 2 tons per acre of dry matter in 2011 over approximately 5.7 million acres of pastures and croplands. Additionally, the largest decline in annual production in any single cover class on a

regional basis was estimated for shrubland vegetation types, due mainly to the extensive area coverage of this ecosystem in the Southern Plains states.

- All of this data plus other available water administrative data for these regions were put together in a user friendly spatial database freely accessible on the internet.

National Climate Assessment

- Worked for the past year under the federally funded National Climate Assessment project;
- Addressed 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 unsustained forest production and large annual sources of CO_2 fluxes;
- In response to the NASA National Climate Assessment, applied the CASA model to predict changes in forest NPP;
- Worked to quantify annual carbon sink or source fluxes from all forested lands in the continental US;
- Predicted pools of wood and soil biomass carbon based on the best available stand age and disturbance survey data sets; and
- 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. Final results are pending.

CASA-HYDRA Modeling

- To support the ASU drought monitoring project mentioned above, applied HYDRA (Hydrological Routing Algorithm) model to the Sonora River in Mexico and the Capibaribe River in Brazil;
- Applied the CASA-HYDRA to the continental U.S. at 1km resolution;
- Completed a study at 250m resolution of the Merced River headwaters and a paper describing this study is currently in review at the Journal of the American Water Resources Association. The results of this study were also presented at the 2012 Yosemite Hydroclimate Workshop;
- Analyzed the sub-basins of the Merced River basin to determine which bio-physical characteristics in the Sierra differed to the largest degree in extreme low-flow and high-flow years. Average elevation and snowpack accumulation were found to be the most important explanatory variables to understand sub-basin contributions to monthly discharge rates;
- Integrated the impacts of irrigation and impoundments into the HYDRA model as well as measures of water quality, such as dissolved oxygen and water temperature; and
- Integrated a flood detection algorithm and ran the model at a daily time step. These improvements are included in the goals of an internship project that we

have organized in conjunction with NASA's DEVELOP program. The internship project, which will occur from January 28, 2013 to August 9, 2013, will entail applying the CASA-HYDRA model in Yosemite National Park at 90m resolution. The goal of the project will be to make improvements to data inputs and to model parameters and algorithms, with the ultimate objective of creating a modeling tool that can be used by Yosemite park staff.

Fog Detection on the Pacific Coast

- Used remotely sensed data to detect fog events along the Pacific Coast, specifically in redwood forests around Big Sur, in order to determine the frequency and distribution of fog events. The results are being used to improve estimates of how much precipitation fog can contribute to the landscape, identify recent historical trends in fog occurrence, and determine how changes in fog patterns could affect coastal redwood ecology; and
- Used the MODIS Brightness Temperature Difference fog product (BTD) to map the absence of nighttime fog deposition with some reliability.
    - BTD predicted the presence of deposition at one of the three study sites. These results are, in part, due to the fact that quantities of fog collected differed greatly between field sites.
    - Collected airport weather records and additional fog deposition to improve validation. The results of this research are currently being published in Atmospheric and Climate Sciences and were presented at the annual AGU meeting by Cyrus Hiatt.

North America Post Forest Fire Analysis

- Worked on post forest fire analysis across North America; and
- The goal of this study was to determine whether climate has affected vegetation regrowth over the past decade (2000 to 2010) in post-fire forest ecosystems of the United States and Canada. Our methodology detected trends in the monthly MODerate resolution Imaging Spectroradiometer (MODIS) Enhanced Vegetation Index (EVI) timeseries within forest areas that burned between 1984 and 1999.

Climate Change Impacts on Tundra Pilot Project

- Worked on pilot research of climate change impact on tundra regions across Alaska;
- Processed and analyzed Alaska Fire Perimeters data since 1940, monthly PRISM climate data, monthly MODIS EVI data, and the Alaska Wetlands Map from Satellite L-band Synthetic Aperture Radar to examine the correlation between climate measurements and tundra degradation during past decades; and
- Used climate moisture index (CMI) and growing degree day (GDD) to investigate the change of tundra across Alaska. The results show that the ecosystem of post-fire tundra is vulnerable and the degradation of tundra is related closely with temperature change. A manuscript is currently being prepared by Dr. Shuang Li to report on this work.

Web Server Updates & Development

- Completed work on updating our old external web server which serves all of our geospatial products to the general public on the internet; and
- Replaced the old server, installed all new geospatial software and developed all new Flex-based application environments in order to better serve the CASA modeling data products to those who want to use them for research or general reference.

In addition to the above mentioned projects, the Carbon modeling team is continually working to improve the NASA-CASA model. Some recent improvements have included: techniques for the geographical removal and redistribution of litter to improve flux estimates to more accurately simulate harvesting of plant biomass and also boosting plant production in croplands to better capture agricultural fluxes.

Publications

- Li, S. and C. S. Potter, 2012, Vegetation Regrowth Trends In Post Forest Fire Ecosystems Across North America From 2000 to 2010, Natural Science, 4(10): 755-770. doi:10.4236/ns.2012.410100
- Potter, C., S. Li, and C. Hiatt, 2012, Declining Vegetation Growth Rates In The Eastern United States From 2000 to 2010, Natural Resources, doi:10.4236/nr.2012, Online Publication Update (in press).
- Li, S., C. Potter, and C. Hiatt, 2012, Monitoring of Net Primary Production in California Rangelands Using Landsat and MODIS Satellite Remote Sensing, Natural Resources, 3(2), 56-65.
- Shupe, J., and C. Potter, 2012, Modeling Discharge Rates for the Merced River in Yosemite National Park, Journal of the American Water Resources Association, (in review).
- Hiatt, C., D. Fernandez, and C. Potter, 2012, Measurements of Fog Water Deposition on the California Central Coast, Atmospheric and Climate Sciences, (in press).
- Li, S., C. Potter, C. Hiatt, and J. Shupe, 2012, Fusion Of Hyperspectral And L-Band SAR Data To Estimate Fractional Vegetation Cover In A Coastal California Scrub Community, Journal of Geophysics & Remote Sensing, 1:104.doi:10.4172/jgrs.1000104.
- Potter, C., S. Klooster, V. Genovese, C. Hiatt, S. Boriah, V. Kumar, V. Mithal, and A. Garg, 2012, Terrestrial Ecosystem Carbon Fluxes Predicted From MODIS Satellite Data And Large-Scale Disturbance Modeling, International Journal Of Geosciences, doi:10.4236/ijg.2012.
- Potter, C., S. Klooster, and V. Genovese, 2012, Net Primary Production Of Terrestrial Ecosystems From 2000 to 2009, Climatic Change, doi:10.1007/s10584-012-0460-2.
- Karpatne, A., X. Chen, Y. Chamber, V. Mithal, M. Lau, K. Steinhaeuser, S. Boriah, M. Steinbach, and V. Kumar, C. Potter, and S. Klooster, 2012, New Algorithms For

Detecting Forest Fires On A Global Scale From MODIS Time Series Analysis, Online Publication Update (in review).

- Potter, C., S. Li, S. Huang, and R. Crabtree, 2012, Analysis Of Sapling Density Regeneration In Yellowstone National Park With Hyperspectral Remote Sensing Data, Remote Sensing of Environment, 121: 61-68.
- Fairweather, S., C. Potter, R. Crabtree, and S. Li, 2012, A Comparison Of Multispectral ASTER And Hyperspectral AVIRIS Multiple Endmember Spectral Mixture Analysis For Sagebrush And Herbaceous Cover In Yellowstone, Photogrammetric Engineering & Remote Sensing, 78, (in press).
- Li, S., and C. S. Potter, 2012, Patterns Of Aboveground Biomass Regeneration In Post-Fire Coastal Scrub Communities, GIScience & Remote Sensing, 49, 182.201.

Disaster, Wildfire and Environmental Monitoring & Management

Project Description

The objectives of the Disaster, Wildfire and Environmental Monitoring and Management task are:

1. To explore, develop, and integrate remote sensing and data modeling and visualization to improve strategies and foster improved understanding of the role of wildfires in climate change;

2. To develop remote sensing payloads for use on manned and unmanned aerial systems (UAS) and the analysis 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.

Both science objectives are achieved through collaboration with commercial entities, federal and state agencies to improve utilization of NASA-derived data and models acquired from both airborne manned and unmanned platforms and satellite sensors (both current and planned in the Decadal Survey), such as MODIS, NPOESS VIIRS and GOESS. Additional focus includes the development of manned and UAS platform-acquired, near-real-time image modeling, data communications and telemetry systems, and development of GIS and visualization frameworks to share model data. The UAS development activities are necessary to improve data acquisition in environments where manned platforms are less efficient to operate. The UAS element objectives are to develop improved capabilities for end-to-end processes and technologies to be more rapidly developed into operational utility.

Project Participants

CSUMB: *Senior Scientist*: Vince Ambrosia; *Scientists*: Pat Finch, Brad Lobitz, Kenneth Weinstock

Accomplishments

- Team-developed software for quick visualization of geo- and terrain-rectified data of post-fire products in addition to the standard active fire hot-spot detection software;

- Developed new real-time derived post-fire assessment products from the AMS spectral data to support recovery and remediation teams;
- Organized and led two meetings (May 2012 and November 2012) of the Tactical Fire Remote Sensing Advisory Committee, which garnered participation from various fire management agencies to facilitate improved observational capabilities for wildfire occurrences;
- Developed new collaborations with the fire science communities at other NASA centers and with NOAA science team members (from UMd) for WRAP Project science element integration;
- Successfully transitioned a number of demonstrated capabilities to the disaster management community for operational employment. These included the contracting, management and operation of small UAS platforms for wildfire observations, the transfer of Over-The-Horizon (OTH) sensor telemetry systems, and the operational employment of the Collaborative Decision Environment (CDE) at the National Interagency Fire Center - National Incident Command Center (NIFC-NICC), and the USFS Remote Sensing Applications Center;
- Taught at CalFire and USFS training classes on the use of the wildfire intelligence 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 a number of national and international conferences including ISRSE (2015 Planning), ASPRS, & IGARSS;
- Led TFRSAC Spring (March) 2012 Meeting in Sacramento, CA in conjunction with ASPRS Conference and Fall (November) 2012 TFRSAC Meeting in Boise, ID;
- Research and engineering team focused on the integration and development of payload instruments and telemetry equipment transfer of capabilities to the USFS Cessna Citation Bravo (Tail No. 144Z) manned aircraft. Team members (image and data scientists) focused on the development of rapid, autonomous, improved image analysis and geo-rectification software for real-time disaster imagery sharing. Also developed documentation for the software operations and “cleaned-up” software operations for real-time image generation;
- Developed new autonomous on-board processes for deriving disaster-related real-time critical data including refined hot-spot detection algorithm-derived data and post-fire Normalized Burn Ration derived data products;
- Further improved both their Normalized Burn Ratio (NBR) algorithm and the BAER imagery for improved product delivery to fire managers and post-fire teams. Additional development of a Fire Radiative Power (FRP) algorithm to assess same derivation from the MODIS and future VIIRS orbital sensor assets;
- Established a series of collaborative agreements with other state and federal agencies and private companies to facilitate technology transfer of WRAP project-developed technologies and information. Those agreements include Space Act Agreements between NASA and the US Forest Service and CalFire;

- Maintained synergistic collaborations with various science entities at Ames to develop criteria for UAS operations, including the Collaborative Decision Environment, swarming technologies, and showcasing the WRAP project as a leading driver in the development of mission-specific UAS operations;
- Worked with NASA Center management to facilitate new project developments and collaborations by briefing various dignitaries and sister agency personnel who visit ARC, including IBAMA DHS, EPA, Department of Agriculture – ARS, NASA HQ, CALFIRE, CA-OES, CA. Governor's Office (members of California Biodiversity Council), and universities;
- Provided project documentation and support materials to NASA Headquarters for Program Management presentations to HQ staff, Congress, and OSTP;
- Supported NASA HQ as a Proposal Reviewer on ROSES proposal calls;
- Supported UC-Davis researchers (H. Bauser and S. Ustin) in developing a UAS Airborne Flight Safety Review Board (AFSRB) / Flight Readiness Review Board (FRRB) documentation in preparation for land surface imaging experiments from a sUAS at Fort Hunter Liggett, CA; and
- Supported Center efforts to engage the BYU Center for Unmanned Aerial Systems, and provide briefings and entertain partnership efforts in research, applications and student program development.

Publications

A. Published Book Chapters:

- Hinkley, E.A., V.G. Ambrosia, S. Wegener, 2012. "Unmanned Aircraft Systems in Environmental Monitoring Applications." In Society of American Engineers International, In editing, 2012
- Ambrosia, V. G. and T. Zajkowski, 2012. 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, 2012, In Final Editing.

B. Peer-Reviewed Journal Articles:

- Watts, Adam C., V.G. Ambrosia, and E.A. Hinkley. 2012. "Unmanned Aircraft Systems in Remote Sensing and Scientific Research: Classification and Considerations of Use." Remote Sensing. Vol. 4, no. 6: 1671-1692.
- Peterson, D., J. Wang, C. Ichoku, E. Hyer, V. Ambrosia, 2012. A Sub-Pixel-Based Calculation of Fire Radiative Power from MODIS Observations: 1. Algorithm Development and Initial Assessment. Remote Sensing of Environment, Manuscript no: RSE-D-11-00954R2, Accepted, 2012.

C. Presentations / Unpublished Papers / Articles:

- Ambrosia, V.G., 2012. UAS Remote Sensing Platforms for Emergency Response and Management. Northern California Region – American Society of Photogrammetry and Remote Sensing (ASPRS) Summer 2012 Technical Session: Remote Sensing of Fire and Ecosystem Impacts, McClellan Park, Sacramento, CA., 8 August 2012, Invited Speaker.

  Peterson, D., J. Wang, C. Ichoku, E. Hyer, V. Ambrosia, 2012. A Sub-Pixel-Based Calculation of Fire Radiative Power from MODIS Observations: Retrieval, Validation

and Sensitivity Analysis. Remote Sensing of Environment, 92nd Annual American Meteorological Society (AMS) Meeting, New Orleans, LA., 24 January 2012, Abstract and *Poster.*

- *Ambrosia, V.G.,* S. Wegener, T. Zajkowski, J.A. Brass, 2012. *Sensor Innovations for Data Delivery from UAS Platforms: The NASA Ikhana Experience.* Proceedings of 2012 American Society of Photogrammetry and Remote Sensing (ASPRS) Annual Conference, CD Proceedings, Sacramento, CA, March 2012, pp. 1-4. and Sensitivity Analysis. Remote Sensing of Environment, 92nd Annual American Meteorological Society (AMS) Meeting, New Orleans, LA., 24 January 2012, Abstract and Poster.
- Ambrosia, V.G., S. Wegener, T. Zajkowski, J.A. Brass, 2012. Sensor Innovations for Data Delivery from UAS Platforms: The NASA Ikhana Experience. Proceedings of 2012 American Society of Photogrammetry and Remote Sensing (ASPRS) Annual Conference, CD Proceedings, Sacramento, CA, March 2012, pp. 1-4.

Agriculture, Health, and Marine

Project Description

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

The primary objectives of this task are to:

1) Apply satellite data, airborne data, and surface sensor networks to model and map agricultural productivity and crop water demand;

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

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

Project Participants

CSUMB: *Senior Scientists*: Lee Johnson, Forrest Melton, Petr Votava; *Scientists*: Pam Krone-Davis, Alberto Guzman, Sam Hiatt, Shuang Li, Chris Lund, Andrew Michaelis, Carolyn Rosevelt

Accomplishments

The primary activities conducted under this task in 2012 focused on objective 1 above, as per currently funding activities under ARC-CREST. The major accomplishments were:

- Five CSUMB DSEP students worked with the SIMS project in 2012 (A.J. Purdy, William Brandt, Kirk Post, Pam Krone-Davis, and Evan Delay). Purdy and Brandt graduated and entered Ph.D. programs at UCSB and UC Irvine. Pam Krone-Davis graduated and is working as a research assistant for the SIMS project. Kirk Post is now a second year. M.S. candidate and continuing to work with the project. Additional research internships will be offered in 2013;
- Published 3 peer reviewed journal articles, and initiated work on 2 additional articles currently in preparation. Presented more than 10 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
- The Satellite Irrigation Management Support (SIMS) project received significant press coverage, including:
    - The Western Farm Press in August, 2012, (http://westernfarmpress.com/miscellaneous/science-helping-farmers-manage-weather-extremes?page=1)
    - NPR California Report, in July 2012 (broadcast statewide) http://blogs.kqed.org/climatewatch/2012/07/17/satellites-helping-save-water-on-california-farms/)
    - The Western Grower & Shipper newsletter;
- Completed 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 2012 and presented work on SIMS to growers and grower associations across California;
- Deployed instrumentation on 10 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 commercial growers, USDA ARS, and UCCE, conducted trials to quantify total applied irrigation and yields using different irrigation management approaches and tools. Demonstrated potential for achieving ~30% reduction in total applied water without reduction in yields, and up to 50% reduction in nitrate losses, using SIMS approach and/or UCCE CropManage tool;
- 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 reports, and delivered data to partners at USGS and USDA;
- In collaboration with the NOAA NWS, completed analysis of comparison between NOAA FRET data products and CIMIS reference evapotranspiration data and presented comparisons at the 2012 Fall AGU Conference;

- Developed algorithms to map fallowed acreage in California from Landsat and MODIS data. Work on these algorithms is ongoing and progressing rapidly;
- Presented the data of NASA - NOAA Coral DSS Project on hyperwall at NASA Advanced Supercomputing Division;
- Coordinated with NOAA coral reef watch group, Institute for Marine Remote Sensing (IMaRS) of University of South Florida (USF), and hyperwall group of NASA Ames;
- Designed the display strategy and wrote codes by using Interactive Data Language (IDL); and
- Attended the project meeting at Washington DC and reported the latest advancement working with hyperwall.

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.
- Johnson, L. and T. Trout, 2012. Satellite NDVI assisted monitoring of vegetable crop evapotranspiration in California's San Joaquin Valley. Rem. Sens. 4:439-455, doi:10.3390/rs4020439.
- Johnson, L., R. Nemani, J. Hornbuckle, W. Bastiaanssen, B. Thoreson, B. Tisseyre, and L. Pierce, 2012. Remote sensing for vineyard research and production. Chapter 12 in The Geography of Wine: Regions, Terroir, and Techniques (P. Dougherty, Ed.), Springer Science, the Netherlands (ISBN: 978-94-007-0463-3).

Selected Presentations

- Melton, F, C Lund, L Johnson, A Michaelis, L Pierce, A Guzman, S Hiatt, A Purdy, C Rosevelt, W Brandt, P Votava, R Nemani. 2012. An Operational Framework for Estimation of Agricultural Evapotranspiration with the Terrestrial Observation and Prediction System. AGU Chapman Conference. February, 2012.
- Melton, F., et al., NASA Satellite Irrigation Management Support. 2012. Presented to at the San Benito Water Conservation District Grower Training event. February 9, 2012.
- Melton, F., et al. 2012. Managing Irrigation from Space: NASA Satellite Irrigation Management Support Project. Invited presentation to the Western Growers Association, May 2, 2012.
- Melton, F., et al., 2012. Satellite Irrigation Management Support with the Terrestrial Observation and Prediction System. NASA ASP Water Resources Workshop, Moffett Field, CA. Sept, 2012.
- Verdin, J., et al. 2012. Fallowed Area Mapping with Satellite Data. NASA ASP Water Resources Workshop, Moffett Field, CA. Sept, 2012.

- Melton F., et al.. 2012. Satellite Irrigation Management Support with the Terrestrial Observation and Prediction System. Remote Sensing of Western Water workshop, San Diego, CA, Sept. 28, 2012.
- Melton F., et al.. 2012. Satellite Irrigation Management Support with the Terrestrial Observation and Prediction System. Invited presentation to the U.S. Bureau of Reclamation, Oct 9, 2012.
- Palmer, C., Osborne, H., Krone-Davis, P., Melton, F., Hobbins, M. 2012. National Weather Service – Forecast Reference Evapotranspiration (FRET), American Meteorological Society Meeting, 2012.
- Melton, F. et al. NASA Earth Exchange. GEOSS Water Working Group, invited talk. San Francisco, CA, Nov 30, 2012.

AGU 2012 Presentations

- H21H-1272. Forrest S. Melton; Christopher Lund; Lee Johnson; Andrew Michaelis; Lars Pierce; Alberto Guzman; Sam Hiatt; Adam J. Purdy; Carolyn Rosevelt; William T. Brandt; Petr Votava; Ramakrishna R. Nemani, Satellite Mapping of Agricultural Water Requirements in California with the Terrestrial Observation and Prediction System
- B22A-03. Lee Johnson; Michael Cahn; Frank Martin; Christopher Lund; Forrest S. Melton, Irrigation Trials for ET Estimation and Water Management in California Specialty Crops
- H33B-1310. Pamela Krone-Davis; Forrest S. Melton; Holly D. Snell; Cynthia Palmer; Carolyn Rosevelt, Comparison of NOAA Experimental Forecasted Reference Evapotranspiration and Observed CIMIS Reference Evapotranspiration

Space Synthetic Biology and Astrobiology

Project Description

ARC-CREST personnel have extensive experience in biological systems exposed to space conditions. Valuable research in gravitational biology, synthetic biology, proteomics, and biotechnology cannot be accomplished using existing micro-fluidic technologies without significant improvements in our ability to manage gases in these systems. We are developing a system that addresses these limitations. This research enables a wide range foundational research in Space Synthetic Biology, Fundamental Space Biology, and Astrobiology, ultimately generating the knowledge required to engineer a potentially broad range of space biotechnology applications employing synthetic organisms and microbial bioreactors for in situ resource utilization and biological life support systems.

In order to grow microbes in a closed micro-well, metabolic by-product gases need to be removed. If they are not removed, they build up and affect growth rates and cellular function. A gas removal system is required that is capable of removing carbon dioxide, nitric oxide, hydrogen sulfide, and organic compounds such as alcohols, ethane, and other organic metabolic byproducts. To accomplish this, a combination of gas selective adsorbents can be used. These adsorbent beds will be placed in the micro-well and in adjacent wells that are

connected by micro-fluidic gas channels. Gas delivery is required to provide oxygen and nitrogen. Oxygen is consumed by aerobic microbes and nitrogen is lost in small amounts from leaks through diffusion and pressure compensation venting. Delivery of oxygen and nitrogen will be accomplished through the use of adsorption beds integrated into the micro array. Oxygen and N_2 partial pressures will be controlled by heating the adsorbents to drive off the adsorbed gases. Temperature control of the liberated gas will be accomplished through a torturous path micro-fluidic delivery channel that provides enough contact time to cool the gas to ambient levels. Micro-pumps integrated into the micro-well will be used for gas circulation. Gas circulation will insure that the micro atmosphere is well mixed in the micro-array and that no dead spots exist within the well. The circulation system will also be used for circulating gases though the adsorption beds.

Valves are required to direct gases from different chambers or into different micro-fluidic pathways. Bladder type valves engaged by thermal wax or pressure actuators will be used in our system. Valves will not be required to maintain significant pressure differences, but will be used to control diffusive flow. The micro-well will be sealed to isolate the internal micro atmosphere from the external ambient atmosphere. The entire micro array will be sealed and will be sterilized by thermal (e.g., autoclaving) or chemical (e.g., ethylene oxide) means. Microfluidic channels will be used to provide gas flow channels and to re-circulate gases through adsorption beds. Nano-fluidic channels will be etched into the adhesive used to affix the glass cover sheet to the micro well and the micro-well itself.

Micro-well plates are widely used with automated optical readers and florescent microscopes. The objective of this proposal is to make a sealed micro-atmospheric micro-well that can interface with existing readers and microscopes. As a result the proposed system will be designed to provide optical characteristics that interface with analytical technologies. The optical interface will be accomplished by integrating a glass cover slip to the top of the micro well. This cover slip will be positioned to provide a proper depth of field to the top surface of the growth medium to insure optical analyses (e.g., microscopy) can be applied.

The system will have a septum port on the bottom of the well through which microbial samples, genetic material, and molecular probes can be added directly to the sample. This port will be self-sealing and will be designed for use of a syringe or an automated injection system. The micro-array can also be heated slightly if necessary. All sensors actuators and electrical components will be integrated and controlled by a Lab-ViewTM control and data acquisition system. Because developing a complete system is beyond the scope of a CIF project, we only proposed to demonstrate the feasibility of two key aspects of the system. They are the demonstration of the capability to measure gases at a nano scale at the bottom of a microwell and a study of the benefits of growing a microbial culture in a sealed microwell with a controlled micro-atmosphere.

Project Participants

BAER: Rocco Mancinelli, PhD

Accomplishments

- Completed a two month preliminary design study of a micro-atmospheric system; and

- Conducted an engineering assessment of a microwell-plate microfluidic system, surveyed potential sensor systems, and potential adsorbents. This concept is for the development of a micro-fluidic/well-plate system that is sealed with a transparent cover slip and has the capability to mix, measure, and control the composition and concentrations of gases in the micro-atmosphere that exist within each microwell. The system will use a new class of nanosensors to measure gas concentrations above a growth media, gas phase adsorbents as gas reservoirs and partial pressure control actuators, and micro pumps and valves to circulate gases and insure good mixing. The technology will provide a method to asses and control atmospheric variation and nano-scale mixing in biological or non biological payloads. All of the subject gas molecules identified in this work have been evaluated for detection using nano-tube sensors. In addition, testing of these sensors by NASA has resulted in the development of array constructs that are of the size required for sensing within a microwell.

Partnerships and Collaborations

NASA Centers – ARC Code SCB (Micro-well plate development and integrated system testing) and Code TS (nanotube sensors); KSC (voltometry)

Academia – University of Puerto Rico (PI and sensor development and testing, in collaboration with Code TS)

Plant Physiology

Project Description

ARC-CREST personnel supported the ongoing work using remote sensing, ecosystem modeling, and biological performance assessment of the response of invasive species to the environment. The work relates to understanding the potential for spread of invasive species and the impact on aquatic, riparian, wetland, and range land ecosystems. This task involves collection of data relevant to phenological and ecophysiological development of invasive and natural species found in subject ecosystems. Effort requires both field data collection and controlled laboratory studies to provide model inputs regarding species response to environment and management practices and the resulting ecosystem impact.

Project Participants

BAER: Greg Schlick and Dave Wilson

Accomplishments

- Finalized field data collection parameters for Tamarix phenological changes with USDA and NASA investigators;
- Coordinated and executed Tamarix data collection with USDA collaborators' field site operations;
- Assembled Tamarix phenologic data report;
- Assisted in designing studies to determine environmental effects (light, temperature and water) on triggering phenologic changes in Tamarix (to include spectral reflectance data collection);

- Designed and executed modifications to laboratory growing systems to accommodate Tamarix;
- Participated in validation of remote sensing and model outputs in target ecosystems;
- Supported field and laboratory, soil, and plant CO_2 flux studies; and
- Maintained laboratory growing systems.

Space Weather

Project description

Space weather affects 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

BAER: Jean Paul Rabanal

Accomplishments

This project was initiated in the fall of 2012 and is currently in the beginning phases.

Field Missions

Hurricane and Severe Storm Sentinel (HS3)

Project Description

Close to 100 million Americans live within 50 miles of a coastline, thus exposing them 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;
- 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 will require 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 the HS3 scientists will use are 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-Altitutde Imaging Wind and Rain Airborne Profiler (HIWRAP), the multi-frequency Hurricane Imaging Radiometer (HIRAD), and the High Altitude MMIC Sounding Radiometer HAMSR).

Project Participants

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

BAER: Erin Czech, Susan McFadden, Dan Chirica, Erin Justice, Michaela Herman, Quincy Allison, Marshal Chaidez and Sue Tolley

Accomplishments

Activity Undertaken through the National Suborbital Education and Research Center

- Conducted pre-mission testing of data and satcom systems at the Dryden Flight Research Facility and the Wallops Flight Facility;
- Developed a system for providing HDVis data to MTS, a system for sending quick-look products to MTS in real time, and configured low-rate real-time data feeds to MTS;
- Provided hardware specifications for the payload trailer server infrastructure;
- Trained ASF personnel in the configuration of payload trailer server infrastructure;
- Provided support for NSERC developed software in GHOC and remoter trailer infrastructure, and 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 from August 8, 2012 to October 8, 2012; and
- Prepared a “lessons learned” document and provided new procedures and checklists for the HS3 meeting.

Activity Undertaken with the Earth Science Project Office

Working hand-in-hand with the Earth Science Project Office (ESPO), BAER employees, working through ARC-CREST, completed a number of tasks necessary to carry out the HS3 project. These tasks included project coordination and the provision of information technology services and logistical support.

Project Coordination

- Worked on site surveys and selection and set up pre- and post-mission meetings;
- Developed agreements with host organizations or local vendors for facilities, lodging, aircraft support, ground support equipment, security, janitorial services, and construction and maintenance at chosen facilities;
- Worked on facility set-up, including the provision of electrical power, air-conditioning and heat, the establishment of communication networks for voice and data, and the set-up of weather and imaging equipment, lab and office furniture, storage facilities, copiers and printers, and break rooms;
- Updated the badging database and produced and issued badges for access to facilities;
- Assisted with education and public outreach activities and media events;
- Produced mission graphics and maintained mission website content;
- Developed, maintained, and published participant contact lists and assisted with the production of orientation packages providing HS3 scientists with information regarding access, security, location, communications, scheduling, and local availability information;

- Posted all needed coordination information for HS3 missions including flight schedules, meeting and event information, and reports;
- Maintained communication continuity with all parties, obtained needed consumables, and handled local purchases and finances;
- Participated in the tear-down and close-out of mission facilities; and
- Resolved post-mission financial issues.

Logistical support

- Developed and implemented a shipping plan for mission equipment and instruments (including hazardous materials). The shipping plan also involved the transport of aircraft ground support equipment, tools, and spare parts, as well as program management equipment and education and public outreach supplies;
- Arranged for the safe storage of hazardous materials on-site. (This shipping task required interfacing with all of the shipping and transport agencies involved, both foreign and domestic); and
- Set up and dismantled HS3 field site facilities.

Information Technology Support

- Created, maintained, and updated the HS3 mission website and maintained posting and communication capabilities for the site;
- Created and maintained the mission database and science data archive and developed a network plan for field sites;
- Worked with local internet providers to ensure internet connections and adequate bandwidth for all deployment sites; and
- Set up printers, local area networks, wireless routers and other equipment for deployment sites and provided on-site, in-field IT support for HS3's scientists.

The Deep Convective Clouds and Chemistry Project (DC3)

Project Description

The Deep Convective Clouds and Chemistry Project (DC3) field campaign investigated the impact of deep, midlatitude continental convective clouds, including their dynamical, physical, and lightning processes, on upper tropospheric (UT) composition and chemistry. The DC3 project attempted to quantify and characterize the convective transport of fresh emissions and water to the upper troposphere within the first few hours of active convection, investigating storm dynamics and physics, lightning and its production of nitrogen oxides, cloud hydrometeor effects on wet deposition of species, surface emission variability, and chemistry in the anvil. The project also attempted to quantify the changes in chemistry and composition in the upper troposphere after active convection, focusing on 12-48 hours after convection and the seasonal transition of the chemical composition of the UT.

Project Participants

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

Accomplishments

National Suborbital Education and Research Center Activity

- Served on the NASA HQ instrument selection panel;
- Served as the interface between the DC-8 instrument teams and the National Science Foundation staff during the project's deployment in Salina, Kansas;
- Integrated eight instruments into the DC-8 for the DC3 missions. This integration included five new inlet installations, two new equipment rack designs, three new floor-mounted pump plates, new zenith and nadir community radiometer installations, and new zenith cloud radar horn installation.;
- Designed new wingtip pylon sleds to accommodate substantially more instrumentation;
- Added a wireless access point to the DC-8. Ultimately, this project included the largest number of instruments transmitting data from the DC-8 or a NASA mission; and
- Four NSERC staff deployed to Salina, Kansas for the DC3 field campaign, providing logistical and mission management support as well as over 99% satcom uptime during the science phases of flight.

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 **A**irborne **T**ropical **TR**opopause **EX**periment (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

BAER: Erin Czech, Susan McFadden, Dan Chirica, Erin Justice, Michaela Herman, Quincy Allison, and Marshal Chaidez

Accomplishments

An objective of the ARC-CREST coop this past year was to work with ESPO to move the ATTREX project forward. As with the HS3 project, this effort involved providing project coordination, logistical and information technology support.

Project Coordination

- Set up pre- and post-mission meetings;
- Developed and maintained a spreadsheet for tracking travel, providing reports for required specialty lodging (such as military housing or single POC);
- Produced and issued badges for the project;
- Produced mission graphics;
- Maintained the content for the mission's website;
- Assisted with education and public outreach activities;
- Developed, maintained, and published participant contact lists;
- Assisted with the production of orientation packages (involving issues related to access, security, location, communications, scheduling, and local availability;
- Posted all needed information regarding mission flight scheduling, meetings, events, and reports;
- Maintained communication continuity;
- Obtained consumables;
- Handled local purchases and finances;
- Worked to tear down and close-out mission facilities; and
- Resolved post-mission financial issues

Information Technology Support

- Created, maintained, and updated the mission website and maintained posting and communication capability for the sites;
- Created a database for the mission regarding participants, team and instrument requirements, and necessary identification; and
- Maintained a science data archive.

Logistical support

- Developed a shipping plan and obtained quotes for expenditures related to future deployment.

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). Participation by the GV will be through a collaboration in which the DC-8 will participate in the NSF-sponsored DC3 mission.

Project Participants

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

BAER: Erin Czech, Susan McFadden, Dan Chirica, Erin Justice, Michaela Herman, Quincy Allison, and Marshal Chaidez

Accomplishments

Activity Undertaken with the Earth Science Project Office

A major objective of the ARC-CREST coop with respect to SEAC^{4}RS was to support a study scheduled to take place in August and September of 2012 out of Thailand. However, this particular study was cancelled because regional authorities refused to provide the necessary approvals in the timeframe necessary to support the mission's planned deployment in the scientific observation window. Accomplishments included:

- Set up of pre-mission meetings;
- Produced mission graphics;
- Developed, maintained, and published participant contact lists;
- Created, maintained, and upgraded the mission website (including content);
- Creating a database for the mission regarding participants, team and instrument requirements, and necessary identification;
- Developed and activated a Shipping Plan for ESPO equipment, scientific instruments, equipment and tools, hazardous materials, aircraft ground support equipment, spares,

hazardous materials and other material related to program management and education and public outreach. Implementation of this plan involved interfacing with all shipping and transport agencies involved, both foreign and domestic, as well as packing all ESPO equipment for shipping, assist aircraft and other organizations with packing and documentation for shipment, loading and unloading shipping/transport vehicles/containers, and assisting military crews with aircraft loading when military transport was involved. All of this work was done despite the fact that the 2012 field deployment for SEAC^{4}RS was cancelled at the last possible minute because shipping of project materials was done in the expectation of that the 2012 study was going forward. Some goods even made it all the way to Asia and had to be returned.

Activity Undertaken through the National Suborbital Education and Research Center

- NSERC staff member serves on the SEAC^{4}RS Leadership team;
- Gathered information from the principal investigator regarding the logistical requirements for integration and data system requirements for the mission; and
- Designing integration components for the instruments that will be new to the DC-8 and is making changes to existing instruments.
- Note: Some of the same equipment developed and installed for the DC3 project will be used in the SEAC^{4}RS study.

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, and thus 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 over much smaller overall 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

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

BAER: Erin Czech, Susan McFadden, Dan Chirica, Erin Justice, and Michaela Herman, Quincy Allison, Marshal Chaidez and Sue Tolley

Accomplishments

Activity Undertaken through the National Suborbital Education and Research Center

- Provided integration engineering for the instruments used for this project;
- Designed and fabricated an interface for the new ATM mini instrument;
- Completed the OIB integration (including the new ATM-Sigma installation, some new equipment for KU, and modifications to the Snow/Ku-Band RF pressure bulkhead passthroughs);
- During the project's deployment to Punta Arenas, Chile, NSERC staff were on-site, operating data and satcom systems on all of the DC-8's flights;
- At the Punta Arenas airport, NSERC staff set up the Thecus server for video/data backup and to provide experimenter access to flight parameter data and video;
- Set up a spare Fujitsu tablet with Falconview 4.2 (upgrade from 3.3) for testing purposes and started work on a custom image transfer program. (The transfer of images from the DC-8 for OIB is complicated by the need to very, very carefully manage bandwidth); and
- Investigated the source of continued IRC Dropouts which occur in the absence of Iridium Dropouts.

Activity Undertaken with the Earth Science Project

A major of aim of work under the ARC-CREST coop this year has been to support Operatoin IceBridge, which has had two mission periods. Operation IceBridge studies in the Arctic were undertaken from March to May, while flights in the Antarctic went forward during October and November. Work under the coop included project coordination and information technology and logistical support in conjunction with ESPO as well as project implementation through NSERC.

Project Coordination

- Updated the database used for badging and facility access and issued badges;
- Developed and maintained a travel tracking spreadsheet;
- Provided reports used when specialty lodging (such as military housing) was required;
- Arranged transit and mission hotel lodging;
- Produced mission graphics;
- Developed and published participant contact lists;
- Posted all needed coordination information for the missions; and
- Resolved post-mission financial issues.

Logistical Support

- Set up facilities;

- Ensured the provision of electrical power, air-conditioning, heat, communication networks; voice/data and weather/imagery equipment, lab and office furniture, and copiers and printers;
- Obtained needed consumables;
- Handled local purchases and finances;
- Developed and implemented shipping plan for mission equipment, instruments (including hazardous materials). Implementing the shipping plan also involved the transport of aircraft ground support equipment, tools, and spare parts, as well as program management equipment and education and public outreach supplies. To accomplish this shipping activity, ARC-CREST had to interface with all of the shipping and transport agencies involved, both foreign and domestic; and
- Arranged for the safe storage of hazardous materials on-site

Information Technology Support

- Created, maintained, and updated the mission website and maintained posting and communication capability for the sites;
- Worked with local internet providers to ensure internet connection and adequate bandwidth for all deployment sites;
- Developed network plans for field sites, and provided a network set-up kit for local installation;
- Set up printers, local area networks, wireless routers, and other equipment at the deployment sites;
- Maintained a science data archive;
- Provided on-site, in-field IT support for field participants;
- Maintained security at the site; and
- Produced mission graphics

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

Project Description

Seagrass and coral reef ecosystems are considered vulnerable to the predicted sea level changes associated with global warming. Scientists predict that productivity will vary diurnally in response to photon flux and CO_2 availability and that this diurnal variation will be detectable using long-duration low-altitude Unmanned Aircraft Systems equipped with hyperspectral sensors. This study investigates the seasonality of any quantifiable diurnal variation through repeated UAS flights conducted at two study sites (in Florida and Tobago) at different times of the year. The proposed measurements in unrestricted airspace will serve to establish the hyperspectral metrics of seagrass and coral productivity leading to a better understanding remote areas of the world where in-water measurements are logistically difficult and limited in spatial coverage. By increasing our understanding of nearshore environments, the data collected through this mission will serve as a validation tool for the NASA Decadal Survey Mission.

Project Participants

NSERC: Rick Shetter, Adam Webster, David Van Gilst, Eric Stith, Eric Buzay
BAER: Dan Chirica, Quincy Allison, and Marshal Chaidez

Accomplishments

- Created, maintained, and upgraded website pop-up for the mission;
- Developed and completed a shipping plan for all equipment, scientific instruments, aircraft, aircraft ground support equipment, spares, hazardous materials and tools, program management equipment, and education and public outreach supplies to all field sites;
- Packed all ESPO equipment for shipping;
- Assisted Aircraft and other organizations with packing and documentation;
- Secured lodging; and
- Set up and dismantled field sites, including all furniture, equipment, and network installations.

Indianapolis Flux Experiment (INFLUX)

Project description

INFLUX (The Indianapolis Flux Experiment) is a greenhouse gas quantification experiment in the city of Indianapolis. A Total Carbon Column Observing Network (TCCON) Fourier Transform Spectrometer (FTS), set up by NASA Ames and ARC-CREST personnel in Indianapolis, is currently operating and taking daily CO_2 measurements Laura Iraci, Jim Podolske, and Pat Hillyard are managing the deployment of this instrument and monitoring its status remotely. The INFLUX experiment will conclude in December 2012. At that time the TCCON instrument will be returned to JPL prior to a more permanent installation in northern California.

Project Participants

BAER: Patrick Hillyard, PhD

Accomplishments

- Involved in planning and logistics for deploying a TCCON FTS to Indianapolis for participation in the INFLUX experiment, a large, multi-institutional, multi-national collaboration;
- Traveled to JPL for pack-up of the TCCON FTS instrument in collaboration with JPL and Caltech for deployment to the INFLUX project in Indianapolis;
- Learned the intensive data workup procedures for the FTS data in the TCCON framework in collaboration with JPL and Caltech;
- Applied analysis to TCCON data from INFLUX to obtain usable data produc;t
- Analyzed TCCON data;
- Attended AGU Conference; and
- Commenced preparing publication(s) in 2013 from the TCCON data obtained at Indianapolis as part of the INFLUX project

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NASA Support Activity

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

CSUMB: Forrest Melton.

Accomplishments

- Tracked status of more than a dozen funded projects;
- Communicated with project PIs on a monthly basis;
- Presented project overviews to Program Management meetings every 2 months;
- Worked with PIs to identify and resolve programmatic issues and ensure successful completion of projects;
- Planned, organized, and hosted the 2012 Water Resources PI meeting at NASA Ames Research Center in September, 2012. More than 50 PIs and project personnel, including CSUMB students attended, as well as water managers from California agencies;
- Facilitated participation by >20 remote participants;
- Worked with the California Water Foundation and the Environmental Defense Fund to plan and organize the Remote Sensing of Western Water workshop in San Diego on Sept 27-28, 2012. Attended by more than 100 NASA science PIs, and water managers from across the Western U.S.;
- Represented the program and numerous science meetings, workshops, and conferences;
- Presented three invited talks on behalf of the program; and
- Worked with NASA HQ to plan water resources program activities, including outreach and education activities in 2012 and 2013.

Selected Presentations

- Melton, F. 2012. Extreme Weather Events and Applications of Remote Sensing. Western States Water Council, July 31, 2012. Invited presentation.

- Melton, F., Mohr, K., Doorn, B. 2012. NASA ASP Water Resources Applications. Western States Remote Sensing of ET Workshop. Boise, ID, October 24-25. Invited presentation.
- Melton, F. et al., 2012. NASA Earth Exchange. GEOSS Water Working Group, invited talk. San Francisco, CA, Nov 30, 2012.

AGU 2012 Session Chairs

- H11N. H11N. Convener(s): Dongryeol Ryu (The University of Melbourne), Susan Steele-Dunne (Technische Universiteit Delft), Forrest Melton (CSU Monterey Bay) and Karen Mohr (NASA-GSFC), Remote Sensing Applications in Hydrology I
- H12E. H12E. Convener(s): Dongryeol Ryu (The University of Melbourne), Susan Steele-Dunne (Technische Universiteit Delft), Forrest Melton (CSU Monterey Bay) and Karen Mohr (NASA-GSFC), Remote Sensing Applications in Hydrology II
- H13M. H13M. Convener(s): Dongryeol Ryu (The University of Melbourne), Susan Steele-Dunne (Technische Universiteit Delft), Forrest Melton (CSU Monterey Bay) and Karen Mohr (NASA-GSFC), Remote Sensing Applications in Hydrology III
- H14E. H14E. Convener(s): Dongryeol Ryu (The University of Melbourne), Susan Steele-Dunne (Technische Universiteit Delft), Forrest Melton (CSU Monterey Bay) and Karen Mohr (NASA-GSFC), Remote Sensing Applications in Hydrology IV
- H21H. H21H. Convener(s): Dongryeol Ryu (The University of Melbourne), Susan Steele-Dunne (Technische Universiteit Delft), Forrest Melton (CSU Monterey Bay) and Karen Mohr (NASA-GSFC), Remote Sensing Applications in Hydrology V Posters

Airborne Science Program Planning

Project Description

ARC CREST personnel are providing input of the future needs of the NASA Airborne Science Program.

Project Participants

BAER: Susan Schoenung, Steve Wegener

Accomplishments

- Authored the Airborne Science Program (ASP) 2011 Annual Report;
- Participated in ASP planning meeting with NASA HQ Program Scientists and Executives;
- Developed 5-year plan update for ASP (semi-annual update / 2 times per year);
- Wrote quarterly progress briefing charts for three grants under “UAS Enabled Earth Science” (ROSESNNH10ZDA001N-UAS) – financial and technical progress
- Wrote the requirements update for Airborne Science program – preliminary briefing based on survey of five NASA science centers;

- Supported the requirements update for Airborne Science program support of NASA Earth Science satellite missions based on discussions with all upcoming satellite mission science teams;
- Produced ASP Strategic Plan briefing materials / maps;
- Contributed to the Report to Congress on Student Participation in ASP;
- Attended science team meetings for the following activities;:
- Participated in the Operation Ice Bridge / Program for Arctic Regional Climate Assessment (PARCA);
- Participated in the HyspIRI Symposium on Products;
- Participated in the 8th International Workshop on Greenhouse Gas Measurements from Space / OCO-2 meeting;
- Participated in the 3rd SMAP Cal/Val workshop; and
- Participated in the American Geophysical Union (AGU) Fall Meeting

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

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

Accomplishments

- Recruited and hired new Assistant Network Engineer to allow for support of data and satcom system for multiple simultaneous missions;
- Addition on new HD video cameras with wide angle lenses on the DC-8 and P-3.
- Addition of XM Radio real time weather display on the DC-8;
- Designed, implemented and installed a fully autonomous light-weight system on the P-3 for OIB Spring which provided recording of 2 HD cameras and tracking of the aircraft;
- Came up with a plan for 400 hertz power drops for the new Falcon UPSs. Need to do some load testing on the three different phases to determine which two we want to use;
- Uninterruptible Power Supply upgrades being tested for the DC-8;
- Provided training to the new GHOC staff for data and satcom services;
- Implementing new GB fiber optic network switches for the DC-8;
- Designed, fabricated and installed an adaptation of the P-3 bomb bay to accept a DC-8 Nadir 2/7 adapter assembly that will allow easy cross platform instrument installations;

- Started development of a new Drupal-based webpage to replace the current NSERC page;
- Investigated hosting options for the web page with Drupal software;
- Created a detailed 3D model of the DC-8 dropsonde tube installation;
- Completed the remaining ice detector installation design;
- Completed AIS VHF antenna installation design/drawings.
- Visited NASA Ames to speak with Doug McKinnon in regards to potential DC-8 documentation (in particular regarding wingtip pylons) that NSERC may not have;
- Completed purchase of hardware for 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;
- Began planning migration of data off of Delphi preliminary to storage upgrade;
- Investigated cloud based Archive backup options - Chose Amazon Glacier. This is the lowest total-cost option found, and is FISMA compliant.;
- Created automatic failover plan for asp-interface-* and asp-modems. Purchased hardware to support automatic failover of asp-modems;
- Extensive on-site meeting with Jay Ely from LaRC in regards to integrating their lightning measurement instrument on the DC-8;
- Provided some information on various venturi designs to LaRC personnel for installation on the Falcon for ACCESS;
- Staff member traveled to Colorado Springs for altitude chamber training so he can continue being a DC-8 mission manager;
- Came up with a test plan to environmentally test all of our new permanent installations, and it was approved by Ops Engineering;.
- Completed housekeeping power, network switch power, and network overhead box electrical drawings;
- Provided some design advice to the CoSMIR instrument team as they perform some instrument upgrades;
- 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;.
- Diagnosed and characterized issues with the ppp-based multichannel Iridium system relating to significant performance dropoffs at high load, which was affecting the MPCS and CPL systems;
- Traveled to Ames to:

    -Split out phone lines through patch panel, allowing for remote switchover between modem servers.

-All power supplies plugged into power (several redundant supplies were not powered).Got all DRAC cards online.

Specific Engineering and Data and Satcom System Accomplishments

- 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"
- ER-2 INMARSAT System Installation project:
  - Obtained detailed solid models of all the INMARSAT electrical system components in support of the ER-2 installation.
  - Started compiling detailed installation design requirements from staff.
  - Began detailed installation design and analysis.

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

BAER: Jon Dean-Day, Cecilia Chang

Accomplishments

- Prepared and presented “Estimating synoptic scale cooling rates in cirrus clouds from WB-57 Meteorological Measurement System data during MACPEX” at the MACPEX/SPartICus Science Team Meeting, Salt Lake City, UT, January 18-20, 2012;
- Calibrated, corrected, and re-processed MMS field data from the Airborne Tropical TRopopause Experiment (ATTREX-2011). New filtering techniques were developed to combine 20 Hz data from the MMS CMIGIT with 1 Hz values sampled from the Global Hawk Litton 100-G inertial navigation system. In the re-processed data, numerous substitutions were made to recover data lost as the result of GPS reception problems experienced by the CMIGIT unit during science flights;
- Provided a detailed review of a manuscript submitted to the Journal of Atmospheric and Oceanic Technology (JTECH);

- Prepared processing software for, and provided calibration of MMS field data collected by the DC-8 during the Deep Convection Clouds and Chemistry Experiment (DC3);
- Prepared and presented “MMS Observations of the Eastern Pacific TTL during “ATTREX-2011” at the ATTREX Science Team Meeting, Boulder, CO, June 11-12, 2012;
- Calibrated, corrected, and re-processed MMS field data from DC3. Signatures of electrical noise in air flow probe data were studied to determine root cause and to develop mitigation procedures using proper filtering technique. Icing encounters were identified and data were corrected using redundant measurements. Final MMS data was compared with meteorological measurements collected aboard the NCAR Gulfstream-V aircraft during coordinated formation legs flown at multiple altitudes;
- Attended the American Geophysical Union Fall Meeting, San Francisco, CA, December 3 – 7, 2012;
- Supported the set up for SEAC4RS/DC3 mission for MMS;
- Traveled to Palmdale, CA to participate SEAC4RS/DC3 mission integration;
- Traveled to Salina, Kansas to participate DC3 mission for MMS;
- Supported the ATTREX mission for MMS; and
- Traveled to Dryden to participate ATTREX mission integration.

Education 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

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

Accomplishments

General Accomplishments

- Provided and added content about missions to the Airborne Science Program web page, blog, and Twitter accounts;
- Submitted our 2012 actual and 2013 estimated budget numbers for SARP to OEPM (Office of Education Performance Management) system;
- Staffed the NASA booth at SACNAS to recruit for SARP 2013. Obtained the email addresses of 80 interested undergraduates at the meeting. Distributed over 200 SARP fliers. Explained to students and faculty why SARP would be a great experience for them;
- Wrote and published nine posts on the Airborne Science and SARP blogs on varying topics throughout the year;
- Contributed two blog posts, video content and a profile on an ASP pilot to the NASA Earth Science Week (ESW) website and promoted ESW activities on the ASP website and Twitter;
- Staffed the NASA booth at the Fall AGU meeting in San Francisco to promote SARP 2013 to faculty and students in attendance; and
- Staffed the NASA booth at the Antelope Valley Career Fair to promote careers in the Earth Sciences at NASA to high school students

SARP 2012 P3-B mission (June-August 2012)

- Management of the 2012 Student Airborne Research Program including program design, faculty recruitment, participant recruitment, selection and logistics;
- Completed selection of 32 students from 200 applications;
- Provided logistics for 32 students;
- Organization of all science flights;
- Selection of the top student presentations for participation at the AGU conference;
- Staff organized the conclusion of SARP 2012 with final student presentations on August 7th and 8th, the final graduation meeting on the evening of August 8th, collection of student evaluations and SARP laptops on August 9th, and checkout from the UCI housing, return of the students for their flights, and return of SARP equipment and staff to the DAOF on August 10th;
- Completed an analysis of SARP 2012 students' performance in SARP vs application parameters. Re-reviewed their applications to attempt to correlate performance (as rated (on a scale of 1-8 with any parameter on their applications (eg. GPA, major, school, etc);
- Scheduled a one hour block at the NASA booth at AGU for SARP student presentations;
- Presented a poster on SARP in an AGU education session on undergraduate programs in the Earth system sciences;
- Presented a poster on SARP at the NASA Earth Science EPO retreat;
- Ordered SARP 2013 fliers for distribution at the NASA Airborne Science table at AGU;

- Assisted the 8 SARP 2012 students attending AGU with questions about their presentations and posters this week;
- Organized SARP AGU reunion dinner on Thursday evening; and
- Completed the SARP 2012 documentary video.

HS3 Global Hawk Mission (August – October 2012)

- Ran live educational chats with middle and high school students during HS3 AV-6 flights. Ran a total of 19 chats reaching 440 students;
- Submitted final data for all of the 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 (September 14-24, 2012);
- General public documentary completed and submitted for the NASA booth at the AGU meeting;
- Educational video in development for use in classrooms - Video to be submitted to the SMD product review process January 2013;
- Earth Science Week 2012 Career Spotlight Video completed October 1 on HS3 Forecaster Janel Thomas. Video can be found on the following NASA websites: http://climate.nasa.gov/eswSite/eswVideos/ http://svs.gsfc.nasa.gov/vis/a010000/a011000/a011099/; and
- Additional "SARP Spotlight" videos completed featuring past participants of the Student Airborne Research Program – Nicole Grossberg (SARP 2010), Jennifer DeHart (SARP 2009).

Operation Icebridge DC-8 mission (October-November 2012)

- Prepared and sent a summary of the IceBridge mission science to K-12 teachers;
- Deploymed to Punta Arenas on October 19-30 to run live educational chats live from the DC-8 during flights to Antarctica; and
- Ran a total of 49 classroom chats reaching 728 students in nine states in the US. and three cities in Chile.

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

Senior Faculty: 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) Randy Holloway, AJ Purdy, Rogelio Arenas, You-Young Lee, Carolyn Rosevelt, Pam Krone-Davis, Ty Brandt, and Kirk Post are conducting research under the mentorship of Mr. Forrest Melton.

- CWSP alumni William “Ty” Brandt participated in the NASA DEVELOP student internship program at Ames Research Center in Summer / Fall 2011. He was a DEVELOP graduate student intern for Spring 2012.
- CSUMB Faculty member Dr. Dan Fernandez is collaborating 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

- Completed conversion of existing electronics laboratory in building N242 into new student computer laboratory for the DEVELOP group including coordination of network and phone upgrades and installation of five new Windows7 computer systems.
- Upgraded DEVELOP computer software to ERDAS IMAGINE 2011 and ArcGIS 10.0 SP4.
- Provided hardware/software support and mentoring for 25 students participating in the DEVELOP Summer 2012 session.
- Completed transfer/installation of all Code SGE user and server systems from N242 to N245 including coordination of required network infrastructure upgrades.
- Coordinated move/installation of servers and modem lines in N245/015 to support NASA Airborne Sciences aircraft asset tracking system, with minimal downtime.

DEVELOP

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.

Project Participants

BAER: Cindy Schmidt

Accomplishments

- Reviewed over 160 student applications and hired 21 students for the summer 2012 term. Students ranged from high school to graduate level. Students arrived in June and worked in teams of five on four different projects:
  1. Evaluating the Impact of Climate Change on the Whitebark Pine along the Pacific Crest Trail;
  2. SAR-based Estimation of Glacial Extent and Velocity Fields on Isanotski Volcano, Aleutian Islands, Alaska;
  3. Downscaling GRACE Data in the Central Valley Aquifer; and

4. A Geospatial Analysis of a Harmful Algal Bloom Along the Central California Coast.

- Accompanied five students to NASA Headquarters in Washington D.C. to present their work to NASA program managers. Charles Bolden, the NASA Administrator, attended the event. All of the students gave a final presentation to the science community at NASA Ames on August 9, 2012, led by Schmidt;
- Accompanied three students to Sacramento to present summer research findings to the Department of Water Resources (DWR). This presentation was attended by over 100 people and broadcast to other DWR employees throughout the state;
- Attended the American Geophysical Union (AGU) conference where all the DEVELOP student teams were presenting posters;
- Attended a meeting in Klamath Falls, Oregon to discuss a project to bring Klamath Basin Tribal youth to NASA Ames. This project is a collaboration between seven federal agencies: US Fish and Wildlife, USGS, US Forest Service, Bureau of Land Management, Bureau of Reclamation, Bureau of Indian Affairs, and the National Park Service with the hope that NASA will be the eighth collaborating agency. This would enable tribal youth from the Klamath Basin to participate on projects that involve both ground data collection, and geospatial data from NASA. The current plan is to have at least five tribal youth come to Ames for 2 weeks during summer 2013;
- Conducted a remote lecture on Evapotranspiration to a group of water resource managers at the University of Kentucky; and
- Conducted a 1 hour webinar on Evapotranspiration to an international audience including the World Bank and several people from African countries.