RESEARCH MENTORING COMMUNITY

Earth, Wind, Sea, and Sky

2014 SOARS, NEON, AND PRECIP ABSTRACTS

SOARS protégé Ma´Ko´Quah Jones preparing samples for phytolith analysis using centrifuging and wet chemical methods at the LacCore laboratories at the University of Minnesota - Minneapolis.

We are very pleased to share with you the 2014 edition of Earth, Wind, Sea, and Sky, showcasing the summer research of students from our three internship programs, Significant Opportunities in Atmospheric Research and Science (SOARS), the Undergraduate Internship Program at the National Ecological Observatory Network (NEON) and the Pre-College Internship Program (PRECIP) at the National Center for Atmospheric Research (NCAR).

These internship programs are designed to broaden participation in the science, technology, engineering and math (STEM) fields. Our country faces a chronic discrepancy between the demographic makeup of the STEM workforce and the country as a whole. We need a scientific workforce representative of the U.S. population, especially including members of groups who are already and will be disproportionally impacted by current and future environmental change. Our internships engage students in real-world projects at world-class science facilities, pair them with scientists and engineers who are at the cutting edge of their fields, and build community to support these future STEM professionals. We encourage students from groups that are historically under-represented to enter the ecological, atmospheric and related sciences, and help prepare them to succeed in graduate school and the professional workplace, often with advanced degrees.

Earth, Wind, Sea, and Sky

We are very proud of our interns and the projects they managed to complete this summer. Their success would not be possible without the support and dedication of a number of people and organizations. The biggest thank you goes to our funders, our many partnering laboratories, and of course to our mentors. Thank you for your careful guidance of the interns, and for modeling what an exciting science or engineering career looks like! Without you these programs would not be possible.

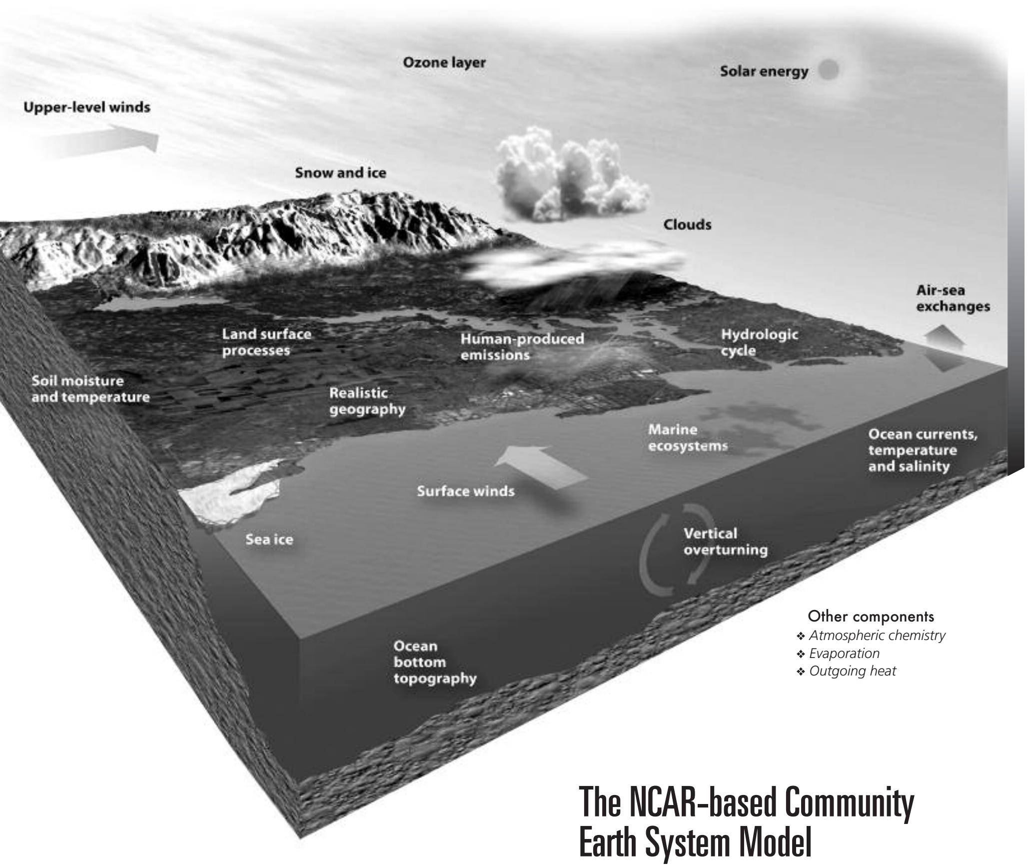
We hope that you will enjoy this volume of abstracts. Please join us in congratulating our 2014 SOARS, NEON and PRECIP interns!

LIZ GOEHRING Undergraduate Internship Program Director, NEON

REBECCA HAACKER-SANTOS SOARS Director, UCAR Center for Science Education

SCOTT LANDOLT PRECIP Director, NCAR

UCAR/NCAR



The NCAR-based Community Earth System Model

is one of the world's most sophisticated models of global climate. Created by scientists at NCAR, the Department of Energy, and collaborators, this powerful model simulates the many processes in our climate system, ranging from clouds and atmospheric chemicals to ice to marine ecosystems.

The University Corporation for Atmospheric Research (UCAR) serves as a national hub for research, education, and advanced technology development for the atmospheric and related Earth sciences. On behalf of the National Science Foundation (NSF) and the university community, UCAR manages the National Center for Atmospheric Research (NCAR) and the UCAR Community Programs (UCP), the organizational homes of the PRECIP and SOARS programs. UCAR's mission is to support, enhance and extend the capabilities of the university community, nationally and internationally; understand the behavior of the atmosphere and related systems and the global environment; and foster the transfer of knowledge and technology for the betterment of life on Earth. There are currently 103 member institutions that offer education and research programs in the atmospheric or related sciences, including virtually all of the major research universities of North America.

NCAR is a federally funded research and development center, conducting a wide range of weather, climate, and solar science and related applications research. At the heart of this work is improving predictions about our atmosphere—how it behaves from moment to moment, day to day, and decade to decade, and the risks and opportunities associated with these changes. Each year, hundreds of people from universities, labs, and the weather enterprise collaborate with NCAR staff, and rely on NCAR resources, in order to carry out vital research and applications.

NCAR and UCAR have been supporting the SOARS Program since its inception in 1996, and the PRECIP Program since 2010. Institutional support and the mentoring of their scientists, engineers and staff have been a key to the success of these programs.

NEON

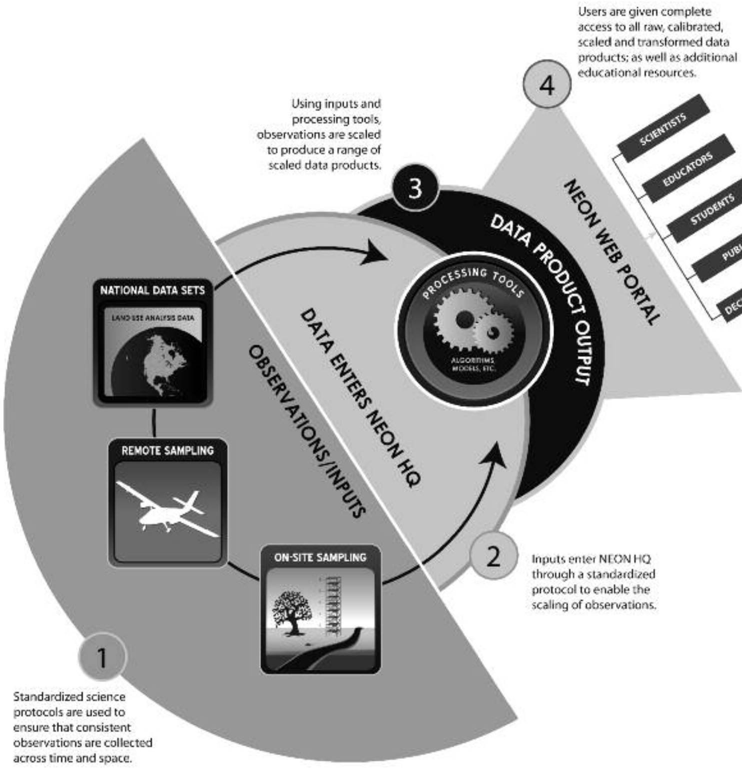
The National Ecological Observatory Network (NEON) provides open, continental-scale data that characterize and quantify complex, rapidly changing ecological processes. Sponsored by the National Science Foundation, NEON will collect and process data from terrestrial, aquatic and stream experiment field sites located across the continental US, Puerto Rico and Hawaii over a 30-year timeframe. The Observatory's comprehensive design supports greater understanding of ecological change and enables forecasting of future ecological conditions.

NEON sites are strategically located across the US within 20 ecoclimatic domains that represent regions of distinct landforms, vegetation, climate and ecosystem dynamics. Integrated biological, physical and chemical measurements are collected at each field site using a combination of field-based observations, as well as *in situ* and remote sensor methods. NEON data characterize plants, animals, soil, nutrients, freshwater and the atmosphere, and may be combined with external datasets to support the study of continental-scale ecological change. NEON assures high-quality, comparable data through standardized and quality-controlled data collection and processing methods.

Construction of NEON began in 2012 with full operation planned for 2017. When operational, all NEON data and associated design, data collection and processing documentation will be available to download and use through the NEON Data Portal.

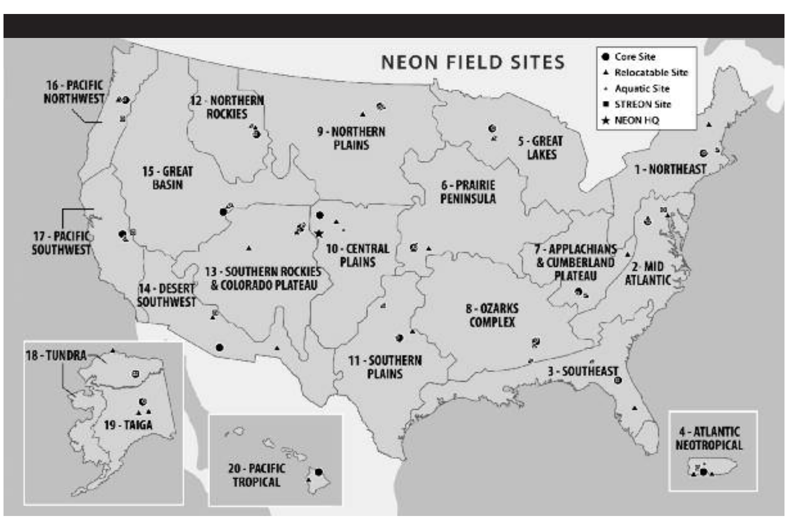
Education

Education and public engagement are important to NEON's mission. Education programs are intended to facilitate increased awareness and understanding of ecological change. Two of NEON's educational goals are 1) to help educate the next generation of scientists and engineers; and 2) to enhance diversity of ecological research and education communities. NEON's Undergraduate Internship Program is designed specifically to address these goals.



NEON's Open-Access Approach

NEON's open-access approach to data and information products will enable scientists, educators, planners, decision makers and the public to map, understand and predict the effects of human activities on ecology and effectively address critical ecological questions and issues.



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SOARS®

Significant Opportunities in Atmospheric Research and Science

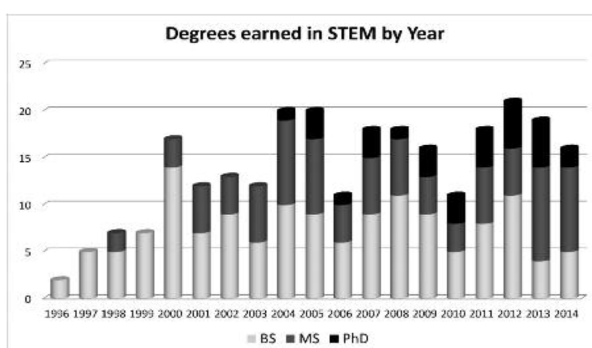
SOARS is an undergraduate-to-graduate bridge program hosted at NCAR and designed to broaden participation in the atmospheric and related sciences. SOARS complements our partnering academic institutions' efforts in preparing students for careers in academia, research and industry by combining a summer internship with year-round mentoring, conference travel and career support. During the summer, SOARS protégés work at NCAR, partnering laboratories and universities to gain experience with what a career in atmospheric sciences could look like for them. In addition to this authentic research experience, guided by scientific mentors, the program includes a weekly communication workshop, seminars about graduate school and career choices, and end-of-summer poster and oral presentations by the students. Topics of research span the broad field of climate and weather, including computing and engineering in support of the atmospheric sciences. After the summer, protégés stay engaged through webinars, one-on-one career counseling, and conference travel.

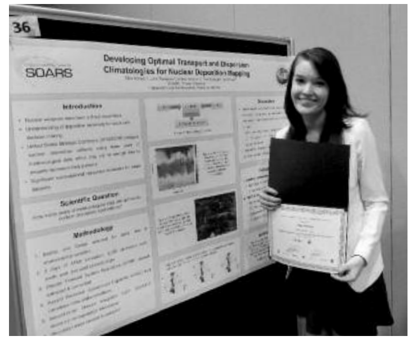
Protégés are able to participate in SOARS for up to four years, gaining additional independence in subsequent years to select, focus, and direct their research. By the time SOARS protégés move onto graduate school, they are well prepared to succeed in independent research. Many use SOARS as an opportunity to expand their research through contacts and facilities available at a national laboratory, and it is common for students and their advisors to collaborate and publish with mentors beyond their SOARS research experiences. In addition, SOARS provides publishing and grant-writing support to their protégés and alumni, helping them stay connected with the wider community.

SOARS is proud of their alumni, the vast majority of whom go on to excel in graduate school and move on to careers in atmospheric science or related STEM fields. They remain connected to the SOARS community, committed to the SOARS mission of increasing diversity in the sciences, and play an important role in increasing the strength and diverseness of the STEM workforce.

Degrees Earned in STEM by Year

Degrees earned in science, technology, engineering or mathematics (**STEM**) by SOARS protégés and alumni, as of September 1, 2014.





Protégés are pictured left to right:
Front Row Arianna Varulo-Clarke, Candace Hvizdak, Alicia Camacho, Sarah Al-Momar, Gabriela De La Cruz Tello, Meghan Applegate Mitchell, Eliza Nobles, Zoraida Pérez Delgado
Back Row Steven Naegele, Jonathan Martinez, Brandt Scott, Eugene Cody, Erin Dougherty, Anthony Torres, Carlos Martinez, Jenine McKoy, Ryan Adams

Understanding the 2013 Boulder flood: Assessing extreme precipitation events and future climates in the Community Earth System Model (CESM)

The Boulder flood of September 2013 resulted in significant structural damage, inundated communities, and accelerated land erosion in central and northern Colorado. This exceptional event led to approximately 11,000 people being evacuated in the area as more than 17 inches of rain fell in parts of Boulder County, Colorado in seven days. This storm resulted from persistent southerly flow and high precipitable water values, which were responsible for the record-breaking precipitation. This study assessed the factors associated with extreme precipitation events in both observations and climate model simulations. Satellite-based observed precipitation from the Tropical Rainfall Measuring Mission (TRMM), and ERA-Interim Reanalysis of precipitable water and low-level winds were used in this study.

Probability distribution functions (PDFs) were calculated for daily values of observational and reanalysis variables: precipitation, precipitable water, and low-level winds. Each of the PDFs was compared with equivalent variables in the CESM simulations and analyzed over three regions of different areal extent occupying the eastern Rocky Mountains. The PDF calculations were found to be sensitive to the choice of the spatial region with fewer high precipitable water events in the northern domain and a greater number of high precipitable water events in the more southerly domain. The similarities between observational and present-day CESM PDFs enabled us to study changes to PDF distributions in future climate simulations. They predict a significant increase in precipitable water over the Boulder flood region. Given the importance of high precipitable water in the 2013 Boulder flood precipitation event, the potential for more frequent and stronger flooding events is significant.

Ryan Adams

1st-year Protégé
Senior
California University of Pennsylvania
Earth Science – Meteorology

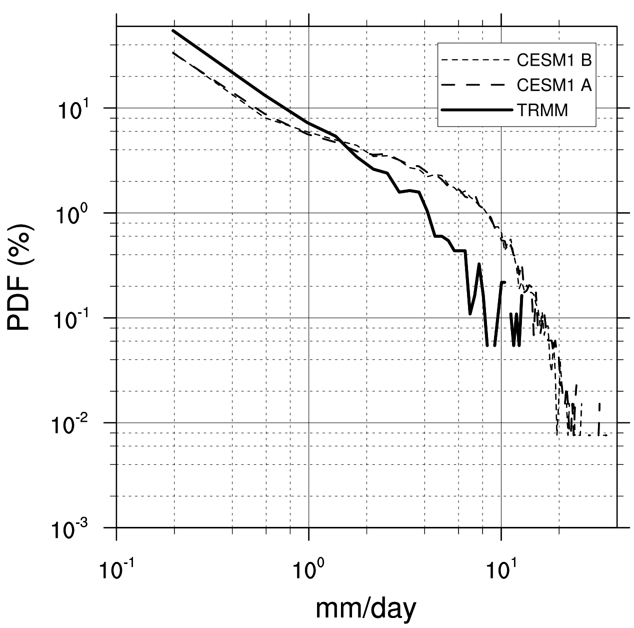
MENTORS

RESEARCH
Richard Neale, NCAR

WRITING & COMMUNICATION
B.J. Smith, NCAR

COACH
Becca Hatheway, UCP

PEER
Brandt Scott, SOARS



Probability distribution functions (PDFs) for July–November precipitation, representing the daily precipitation accumulation magnitudes (mm/day) with their respective percentages of occurrence across the Colorado Front Range region. The TRMM PDF is computed from 1998 to 2009 and the CESM PDF's are computed from 1920-2005.

Examining in-cloud convective turbulence in relation to total lightning and the 3D wind field of severe thunderstorms

Sarah A. Al-Momar

3rd-year Protégé
Graduate Student
Plymouth State University
Applied Meteorology

MENTORS

RESEARCH
Wiebke Deierling and
John K. Williams, NCAR

WRITING & COMMUNICATION
Amy Stevermer, UCP

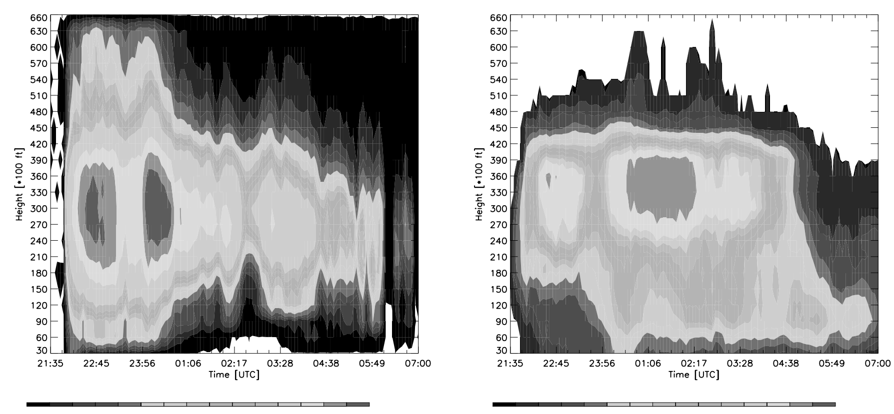
GRADUATE ADVISOR
Eric Hoffman, Plymouth State University

PEER
Eliza Nobles, SOARS

SOARS

Convectively induced turbulence (CIT) is commonly listed as a cause or factor in weather-related commercial aviation accidents. In-cloud CIT is generated in part by shears between convective updrafts and downdrafts. Total lightning is also dependent on a robust updraft and the resulting storm electrification. The relationship between total lightning and turbulence could prove useful in operational aviation settings with the use of future measurements from the geostationary lightning mapper (GLM) onboard the GOES-R satellite. Providing nearly hemispheric coverage of total lightning, the GLM could help identify CIT in otherwise data-sparse locations.

For a severe thunderstorm case on 7 June 2012, in-cloud eddy dissipation rate estimates from the NCAR Turbulence Detection Algorithm were compared with cloud electrification data from the Colorado Lightning Mapping Array and radar products from the Denver, Colorado WSR-88D (KFTG). These comparisons showed that high very high frequency (VHF) source densities emitted by lightning occurred near and downstream of the storm's convective core. Severe turbulence was also shown to occur near this area, extending near the melting level of the storm and spreading upward and outward. Additionally, increases in VHF sources and turbulence volumes occurred within a few minutes of each other. More research on the spatial and temporal relationships between total lightning and thunderstorm kinematics (i.e. updrafts and downdrafts) are needed to solidify these results. A dual-Doppler analysis using KFTG and CSU-CHILL radars and/or a Variational Doppler Radar Assimilation System (VDRAS) analysis will aid in this research by providing the storm's 3D wind field.



Time-height plots for Lightning Mapping Array (LMA) very high frequency (VHF) sources (left) and NCAR/NEXRAD Turbulence Detection Algorithm (NTDA) moderate or greater turbulence (right) for a severe thunderstorm in Colorado on 7 June 2012. Moderate or greater turbulence is defined as an eddy dissipation rate ≥ 0.22 $m^{2/3}$ s^{-1}. For each time and altitude, the plots show the number of times a VHF source or moderate or greater turbulence grid point occurs in the storm volume, normalized by dividing by the size of the storm's domain.

Skill of the WRF model's wind speed, direction, and shear forecasts for an Iowa wind farm

Wind energy is a leading alternative energy source, however changes in power output in a wind farm can occur due to changes in wind direction and wake-turbine interactions. Forecasting wind direction changes can help forecast fluctuations in wind farm power output. Wind direction, speed, and shear observations from two meteorological towers at an Iowa wind farm were compared to the Weather Research and Forecasting (WRF) model to determine the WRF model's skill in forecasting for this farm. Two 6-hour cases were selected when the two towers agreed and the farm was producing substantial power, with wind speeds above 6 m s^{-1} and under 20 m s^{-1}. Forecasted wind direction, speed, and shear from a 48-h WRF model run were compared with observations from the towers to assess model skill for these cases. Yaw angle data from 5 turbines were additionally compared to 80-m hub height observations to analyze the wind directions of the turbines. Yaw angle analysis suggested surface level convergence, though further research is needed to test this. The mean wind speed and direction biases were 1.01 m s^{-1} and 9 degrees for Case 1 and the 0.53 m s^{-1} and 17 degrees for Case 2, when averaged over all heights. Since these biases were relatively small, the model proved skillful in forecasting wind speed and direction , however biases in the wind shear were found to be larger. Further cases studies are needed to better quantify these results.

Meghan Applegate Mitchell

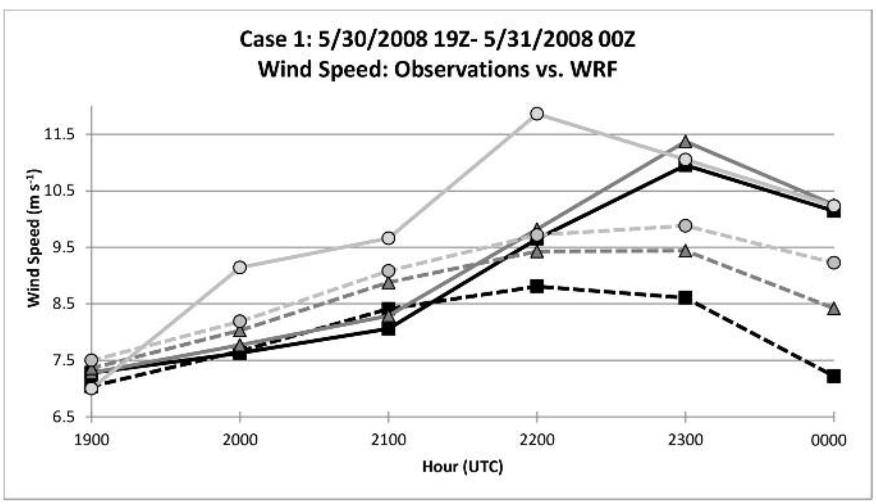
2nd-year Protégé
Senior
Iowa State University
Meteorology

MENTORS

RESEARCH
Eugene Takle and Renee Walton, ISU

WRITING & COMMUNICATION
Rebecca Batchelor, SOARS

PEER
Zoraida Perez-Delgado, SOARS



Wind speeds observed (solid lines) over the 6 hr period of Case 1 for each height of interest, 40 m (squares), 80 m (triangles), and 120 m (circles) with the WRF forecasted wind speeds (dashed lines) for each of the heights over the same period.

Alicia C. Camacho

1st-year Protégé
Senior
Valparaiso University
Meteorology & Mathematics

MENTORS

RESEARCH
Daven Henze, Kateryna Lapina,
Yanko Davila, CU

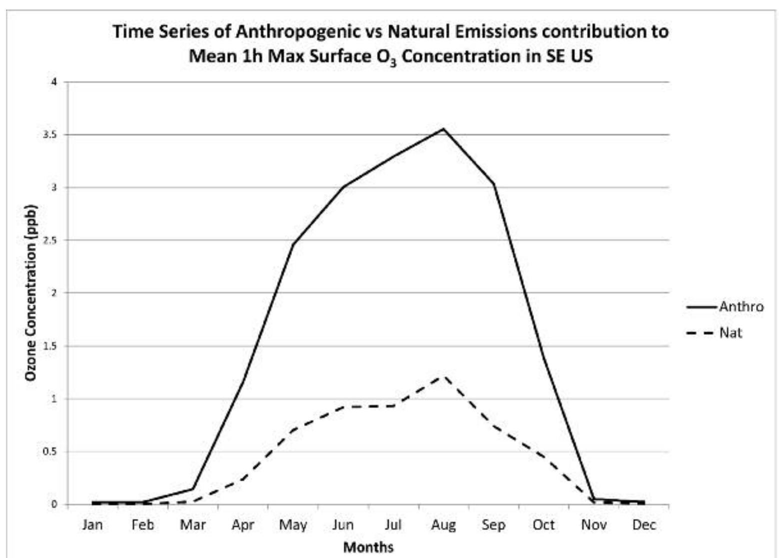
WRITING & COMMUNICATION
Vu Nguyen, CU

COACH
Adrianna Hackett, CU

PEER
Arianna Varuolo-Clarke, SOARS

Identifying long-range sources of ozone utilizing an adjoint method

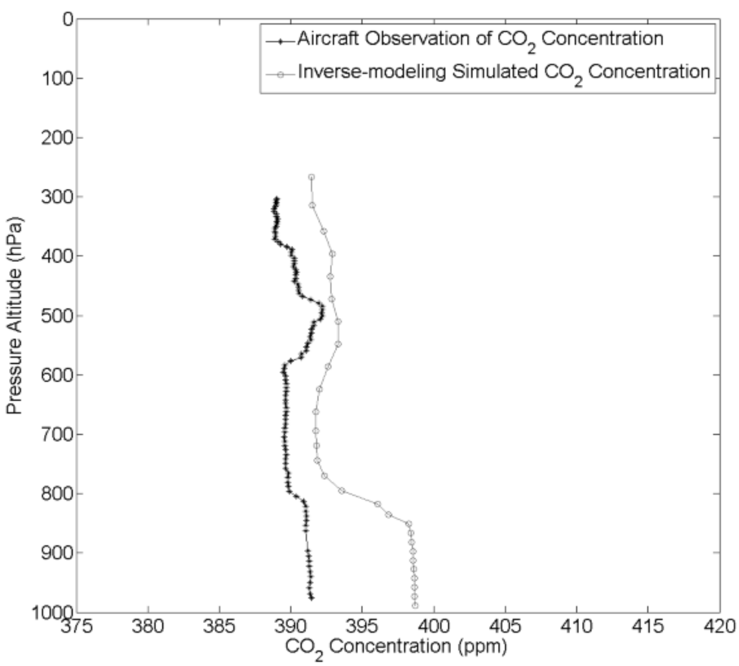
It has been observed that local ozone concentrations can be impacted by both local emissions and by emissions that were transported from distant source regions. Thus, changes in ozone concentration in a particular region can only be understood by analyzing the precursor emission sources, such as nitrogen oxides (NOx), carbon monoxide (CO), and volatile organic compounds (VOC), over multiple regions. In this study, the primary sources of ozone concentration in seven receptor regions within North America were quantitatively described by employing the GEOS-Chem model and its adjoint. The model results across all regions show that the mean contribution of natural emissions to ozone concentration is 57% less than the contribution of anthropogenic emissions. It is also observed that local emissions have a larger contribution (at least 60%) to ozone concentrations than long-range transport in all observed regions except for eastern Canada. Further results show that peak ozone concentration and transport between regions in the model mostly occur during the spring and summer months. The exception to this trend is seen in Mexico, which has its largest ozone concentration and intake of transported emissions during Northern Hemisphere winter. Overall, this study concludes that ozone concentration and transport depend on a number of factors including emission type, season and geographical location.



Anthropogenic (solid) vs natural (dashed) emissions from seven regions in North and Central America's contribution to the 6 month mean daily 1 hour maximum surface ozone concentration in the Southeast United States in 2010.

Three-dimensional variation of atmospheric CO_2: A comparison of aircraft measurements with inverse model simulations

Accumulation of CO_2 impacts climate resulting in an increase of global temperatures. It is vital to know the underlying processes driving the uptake of CO_2 emissions by the biosphere and oceans to infer the rate at which CO_2 concentrations will increase in the atmosphere. In this paper, we compare vertical profiles of carbon dioxide concentrations from aircraft measurements to simulated CO_2 concentrations from an atmospheric inverse model simulation. The inverse model simulations are based on assimilation of atmospheric CO_2 observations from: (a) the Greenhouse gases Observing SATellite (GOSAT) instrument, (b) the NOAA/ESRL surface flask network, and (c) the Total Carbon Column Observing Network. Since the inverse model simulations generate CO_2 fluxes at ~1 degree, these are then fed into an atmospheric transport model to simulate the atmospheric CO_2 concentrations. The independent set of aircraft measurements are obtained from a suite of NOAA/ESRL instruments and the HIAPER pole-to-pole flight campaigns (HIPPO-3 and HIPPO-5 field phases). Both qualitative and quantitative analyses are used to evaluate the quality of the simulated CO_2 concentrations from the inverse modeling approach. Results show: (a) a greater difference between the aircraft and the inverse modeling simulated CO_2 concentrations over land regions relative to over ocean basins, and (b) the inverse simulations under-estimate in the winter and over-estimate in the summer. Both of these differences can be attributed to the greater variability and heterogeneity in the CO_2 signal near the land surface, which does not get simulated well by the inverse modeling approach. Future work will examine possible ways to improve the inverse model simulations in order to obtain better agreement with the aircraft data.



HIPPO-3: March 31, 2010 – Hawaii to American Samoa. CO_2 concentrations (ppm) versus pressure altitude (hPa) for the HIPPO-3 flight path over the West Pacific. The pressure altitude was divided into 4 altitude bins, and the root mean square error (RMSE) calculated for each bin:
(a) 1000 – 0 hPa: RMSE = 4.92 ppm (n = 26);
(b) 1000 – 800 hPa: RMSE = 6.97 ppm (n = 11);
(c) 800 – 500 hPa: RMSE = 2.46 ppm (n = 10);
(d) <500 hPa: RMSE = 2.64 ppm (n = 5).

Eugene D. Cody

1st-year Protégé
Senior
Haskell Indian Nations University
American Indian Studies

MENTORS

RESEARCH
Abhishek Chatterjee, NCAR

WRITING & COMMUNICATION
Nan Rosenbloom, NCAR

COACH
Jeff Weber, UCP

PEER
Jonathan Martinez, SOARS

Links between oxygen minimum zones and the Hadley circulation

The purpose of this research is to find links between the projected changes in oceanic oxygen minimum zones (OMZs) and the Hadley Circulation (HC). OMZs are regions of very low oxygen concentrations. Recent research suggests that the HC circulation is composed of three regional cells instead of the two globe-encircling cells previously thought to be the case. These three cells are co-located with OMZs along the eastern edges of ocean basins. The HC and OMZs are expected to expand in concert with global warming, which will have many consequences. The National Center for Atmospheric Research (NCAR) Community Earth System Model 1.0 (CESM), Representative Concentration Pathways 8.5 experiment with a resolution of 0.9 by 1.25 degrees was used for this analysis. It was run via the Coupled Model Intercomparison Project phase 5 (CMIP5), and the data was retrieved from the Woods Hole Oceanographic Institution (WHOI) community storage server. Analysis was performed using the NCAR Command Language (NCL). Meridional winds and oceanic oxygen concentrations were the primarily analyzed variables. Meridional winds overlaid with oxygen concentration confirm that surface Hadleywise flow and OMZs are linked. Latitudinal ocean oxygen slices place the OMZs in the eastern edges of ocean basins. Area-averaged time series spanning historical through RCP 8.5 confirm that future changes in OMZs and the HC may be connected. Further research could lead to improved understanding of the forces that drive changes in both, which could help anticipate and mitigate the consequences discussed previously.

Gabriela De La Cruz Tello

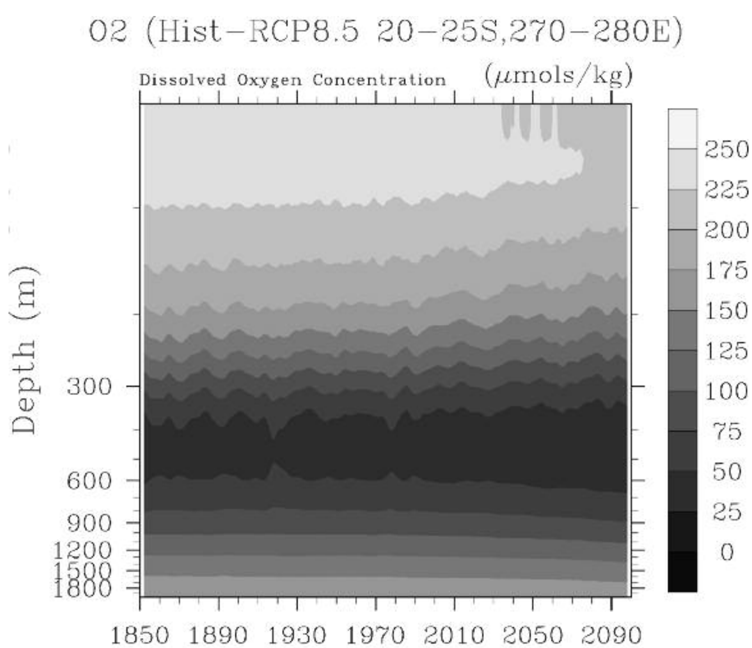
2nd-year Protégé
Senior
San Jose State University
Meteorology and Climate Science

MENTORS

RESEARCH
Caroline Ummenhofer and
Kris Karnauskas, WHOI

PEER
Manuel Hernandez, WHOI

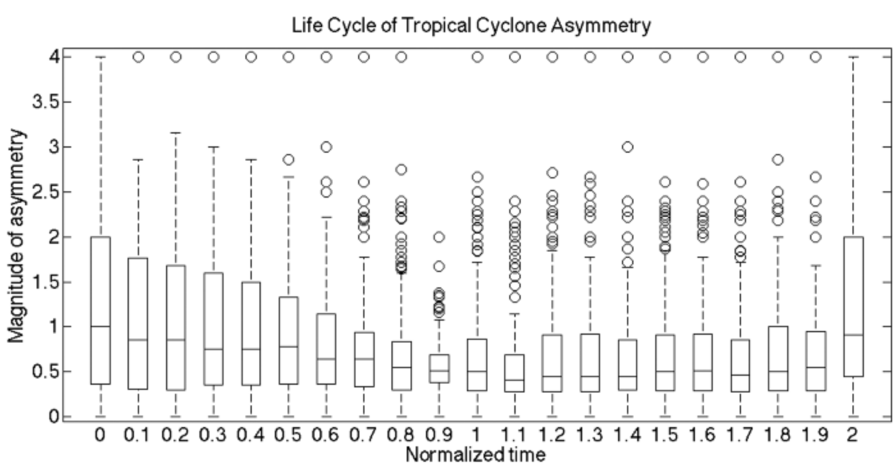
SOARS



Area-averaged oxygen concentrations varying from 1850 to 2100, for the historical and Representative Concentration Pathways (RCP) 8.5 experiments, just off the west coast of South America. Darker colors show lower oxygen concentrations. Expansion and shoaling of the lower oxygen concentrations is visible through time.

Observations of wind asymmetries in Atlantic tropical cyclones

Most major cities are located on coastlines, vulnerable to the direct impacts of tropical cyclones. Therefore, it is critical to understand and improve prediction of these storms in order to make communities more resilient. Though hurricane warning systems have improved in recent years, these warnings are still insufficient, as they fail to account for an indication of tropical cyclone wind asymmetry, or the radial extent of maximum winds in different locations within the cyclone. This study explored the wind asymmetry (defined by magnitude and orientation) among 337 Atlantic tropical cyclones from 1988–2012, utilizing the National Hurricane Center's (NHC) Extended Best Track Dataset (EBT) and Statistical Hurricane Intensity Prediction Scheme (SHIPS). Asymmetry was defined as the magnitude of the largest difference in the radius of gale-force wind across opposing quadrants, normalized by the average of the four wind radii. The asymmetry orientation pointed along the axis of maximum asymmetry toward the quadrant with the greater gale radius. Relationships between wind asymmetry and various storm characteristics such as geographical location, storm life cycle, intensity, size, storm motion, and vertical wind shear were examined. The magnitude of asymmetry increased in higher latitudes and along coastlines, particularly in smaller storms. Asymmetry was higher at the beginning of a storm's life, possibly owing to a less well-organized structure, and higher near the end of a storm's life, coinciding with an increase in vertical wind shear and translation speed. Results from this study may allow for improved tropical cyclone forecasts and warnings to help protect seaside communities.



The life cycle of tropical cyclone asymmetry, starting at the beginning of a storm's life (normalized time=0), to the end of a storm's life (normalized time=2), with the storm's maximum intensity located in the middle of the life cycle (normalized time=1). The magnitude of asymmetry is the maximum difference in the radial extent of gale-force winds between any two diagonal quadrants when the storm is split up into four quadrants and is a normalized value to accounts for storm size. Circles outside of the box-and-whisker plot denote outliers during each stage.

Erin Dougherty

1st-year Protégé
Senior
University of Virginia
Environmental Science

MENTORS

RESEARCH
Chris Davis, NCAR

WRITING & COMMUNICATION
Kate Young, NCAR

COACH
Teresa Eastburn, UCP

PEER
Anthony Torres, SOARS

Using GLOBE student cloud type and contrail data to complement satellite observations

Candace Hvizdak

1st-year Protégé
Senior
University of Texas at El Paso
Environmental Science-Hydroscience

MENTORS

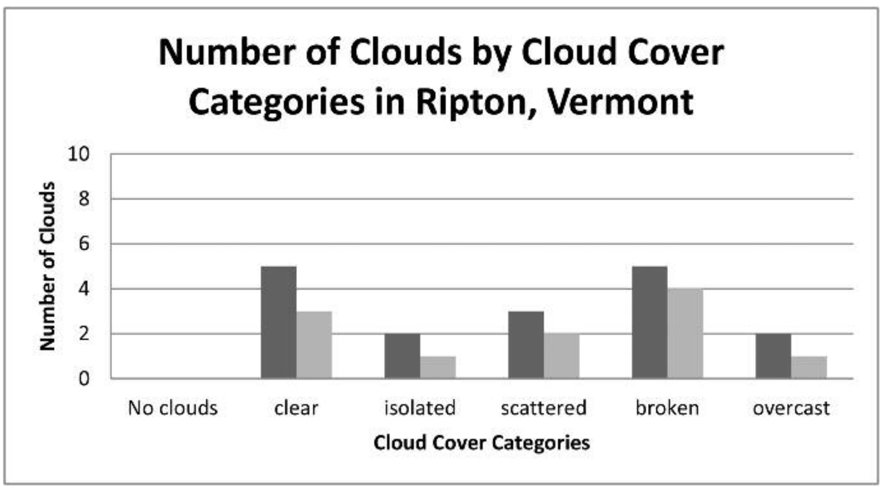
RESEARCH
Julie Malmberg, Travis Andersen,
Gary Randolph, Kristin Wegner, UCP

WRITING & COMMUNICATION
David Ahijevych, NCAR

COACH
Christopher Williams, NCAR

PEER
Steven Naegele and
Carlos Martinez, SOARS

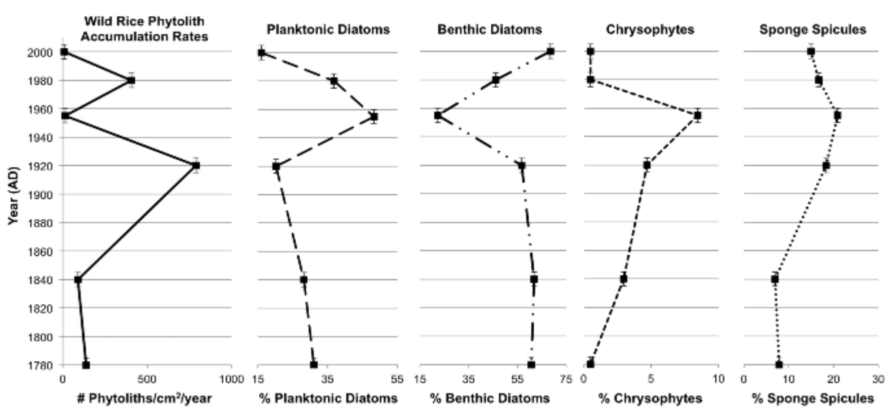
The GLOBE Program is a community program of students, teachers, and scientists who collect and analyze Earth Science data to help sustain, understand and improve the earth. In one of the GLOBE projects, students from around the world record and submit cloud type and contrail data online. The purpose of this study was to compare the student data with cloud data obtained from weather satellites, specifically the cloud type and contrails recorded by the students, and visible imagery from the GOES-13 and Meteosat 7 satellites. Visible satellite images only show tops of cloud cover and nothing underneath. However, there are many layers to cloud cover. GLOBE student cloud observation data for Ripton, Vermont and Mantasoa, Madagascar were downloaded and compared with satellite observations obtained through NOAA's CLASS system and the EUMETSAT data center to determine whether there could be more cloud layers than previously thought. The agreement between the student and satellite observations in this study was very good, however two of the twenty images studied revealed that due to cloud layering, some lower clouds were present but hidden from satellite view. The results suggest that GLOBE student cloud type observations and contrail data could provide supplemental information to visible satellite observations.



Ripton, Vermont, cloud observations reported by GLOBE students (dark grey) showed that of the ten direct comparisons, multiple types of clouds were observed in clear, broken and scattered skies, while the observations from satellites (light grey) showed fewer clouds.

A tribal story written in silica: Using phytoliths to research the effects of mining on past wild rice (*Zizania palustris*) abundance in Sandy Lake, MN

Wild rice (*Zizania palustris, manoomin*) is an emergent aquatic plant that grows annually in the northern Great Lakes region of North America. This region is also rich in iron ore deposits and correspondingly has an extensive history of mining activities. Wild rice no longer grows in some areas where it was previously abundant. Sandy Lake, located in St. Louis County on federally protected lands that are ceded territory of the Fond du Lac Band of Lake Superior Chippewa in Minnesota and downstream of the nearby U.S. Steel Minntac mine, was selected as a test site. This lake has a history of ricing activities by the Ojibwe (Chippewa) People, for whom manoomin has cultural importance. Lake cores were taken on June 17, 2014 by LacCore and FDLRM staff and samples were obtained. This project used phytolith analysis to answer the question of past wild rice presence and abundance in Sandy Lake. Phytoliths are microscopic opal silica deposits produced in some plants. Zizania palustris produces phytolith morphotypes that are unequivocally diagnostic of this species in this region. Microscopic slides were prepared and analyzed for wild rice phytoliths. Concentration values ranged from 25 to 4379 phytoliths per cm^3/year, and wild rice accumulation figures ranged from 7 to 789 phytoliths/cm^2/year, the maximum values of which occurred in the 1920s and generally declined to the current lowest levels observed. Mining has likely impacted wild rice populations by causing increased sulfate levels and possibly contributing to higher lake levels.



Wild rice phytolith influx compared to other siliceous microfossils. Wild rice phytolith influx is a proxy for wild rice abundance. The ratio of planktonic to benthic diatoms is a proxy for relative lake level depth. Chrysophytes prefer oligotrophic waters and freshwater sponges thrive in slightly alkaline waters.

MA'KO'QUAH JONES

2nd-year Protégé
Graduate Student
Vermont Law School
Environmental Law and Policy

MENTORS

RESEARCH
Ida Clarke, BHSU
Chad L.Yost, U of A
Christa Drake, U of M
Jammi Ladwig, U of M
Amy Myrbo, U of M
Thomas Howes, FDLRM

North Atlantic atmospheric blocking and Atlantic Multidecadal Oscillation: Analysis through climate models, reanalysis, and datasets

Carlos Martinez

1st-year Protégé
Junior
Texas A&M University
Meteorology

MENTORS

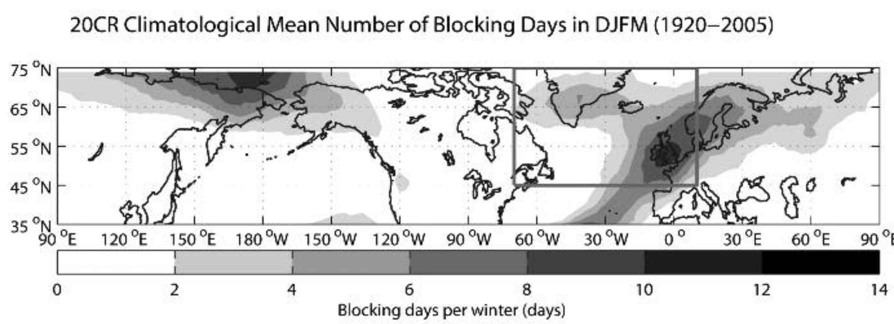
RESEARCH
Hyodae Seo and Young-Oh Kwon, WHOI, Justin Small, NCAR

WRITING & COMMUNICATION
Melissa Bukovsky, NCAR

COACH
Eileen Carpenter, UCP

PEER
Candace Hvizdak and Steven Naegele, SOARS

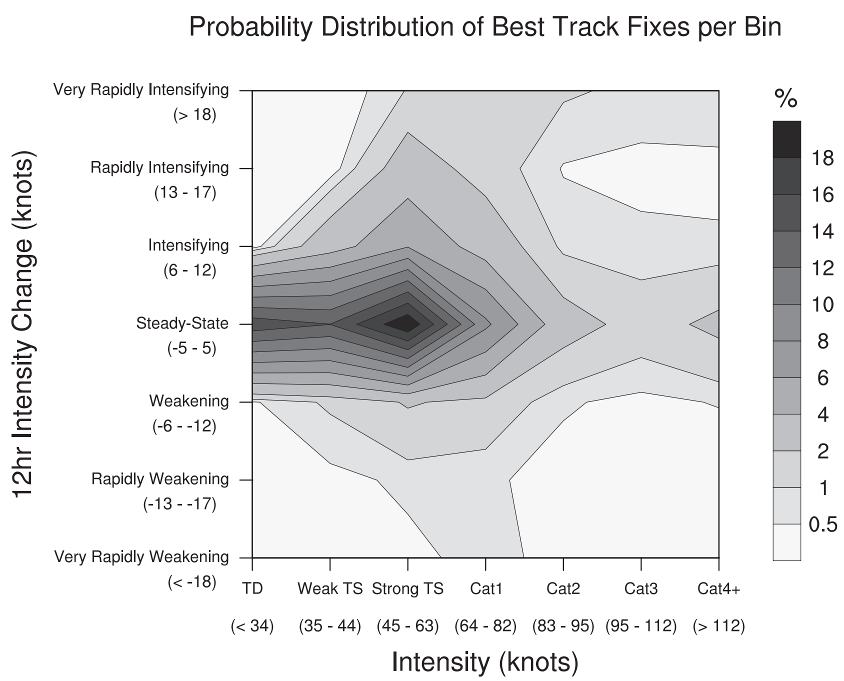
Atmospheric blocking is an unusual weather phenomenon that is often associated with severe weather events such as heat waves, cold spells, and droughts. Improved understanding of the long-term variability of atmospheric blocking thus has important societal implication, as its mechanisms are not well understood. This project investigates the variability of atmospheric blocking in the North Atlantic and its relationship with multi-decadal oceanic variability represented by the Atlantic Multidecadal Oscillation (AMO) using observation data and the Community Earth System Model (CESM). The mean number of blocking days in the North Atlantic is examined in the 20th Century Reanalysis (20CR) and the 30 member CESM Large Ensemble (CESM1LE) simulations. The AMO index is examined in the Hadley Centre Sea Ice and Sea Surface Temperature data set version one (HADISST) and the CESM1LE. In the observations, the two primary maxima of atmospheric blocking occurrence are found over the Greenland and the British Isles. CESM1LE underestimates the mean number of blocking days in these two locations, but the time-scale of variability in each region is comparable to that in the observations. CESM1LE also shows a reasonable AMO with similar amplitude and periodicity to the observations. In the observations, preliminary results show some correlation between the blocking in the North Atlantic and the AMO on decadal time-scales when the AMO leads the blocking by 4 to 8 years. This suggests that atmospheric blocking and the associated extreme weather variability in the North Atlantic might be modulated by the multi-decadal oceanic variability associated with the AMO.



This figure shows the number of blocking days captured by the 20th Century Reanalysis (20CR). The box indicates the North Atlantic Sector, and the greyscale bar displays the average number of blocking days.

Examining the link between tropical cyclone radial structure and intensification using the FLIGHT+ aircraft flight level dataset

Radial structure differences between groups of tropical cyclones (TCs) with similar intensities and intensity changes are examined using flight level data recorded between 2000 and 2013. Data were collected from the National Oceanic and Atmospheric Administration (NOAA) WP-3D aircraft and the United States Air Force (USAF) 53rd Weather Reconnaissance fleet of WC-130 aircraft. Tropical cyclone intensity and intensity change were determined using the National Hurricane Center's Best Track (BT) dataset for TCs in the Atlantic basin. Data from radial legs flown through the center of the TCs were then categorized based on the intensity and previous 12 h intensity change determined from the BT dataset. Radial legs were sorted into bins based on seven different intensity and intensity change thresholds. The radial wind data were then normalized by the radius of maximum winds (RMW) and maximum storm-relative wind speed for each leg, providing a non-dimensional analysis that facilitated comparisons with the radial structure of ideal vortex profiles. Composites of the radial legs were also created for each bin. This non-dimensional analysis revealed the wind structure of the majority of radial legs decaying rapidly outside the RMW up to a normalized radius of two, and then a shallow decay of wind speeds thereafter. Analyses of the radial wind structure in fully dimensional coordinates revealed a tighter RMW for radial legs flown at the 700 hectopascal (hPa) level compared to those flown at the 850 hPa level and a steeper decay of winds outside the RMW for radial legs flown at the 700 hPa level.



Probability distribution function of the number of Best Track fixes in the Atlantic Basin, 2000–2013, binned by their intensity and previous 12 h intensity change.

Jonathan Martinez

2nd-year Protégé
Graduate Student
University of Hawaii
Atmospheric Sciences

MENTORS

RESEARCH
Jonathan Vigh, NCAR,
Michael M. Bell, UH

WRITING & COMMUNICATION
Joseph Wakefield, NOAA/ESRL

Innovating the future: Engineering sustainable cooking technologies in Northern Ghana for improved air quality

Jenine N. McKoy

2nd-year Protégé
Junior
University of Michigan
Environmental Engineering

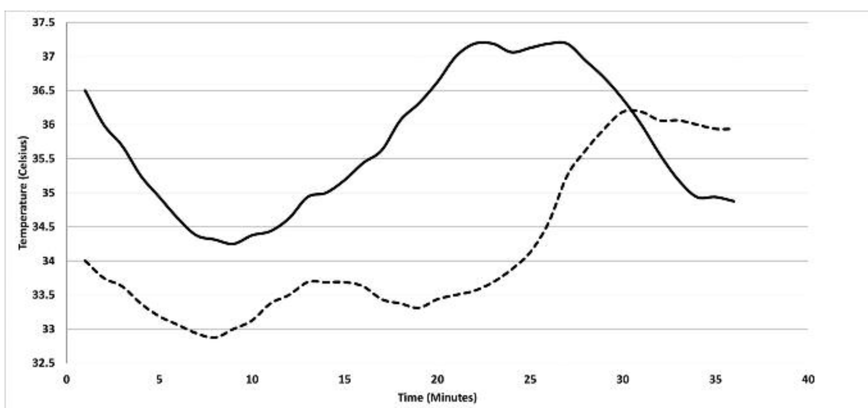
MENTORS

RESEARCH
Michael Hannigan, CU,
Christine Wiedinmyer, NCAR

WRITING & COMMUNICATION
Anne Smith, NCAR

SOARS

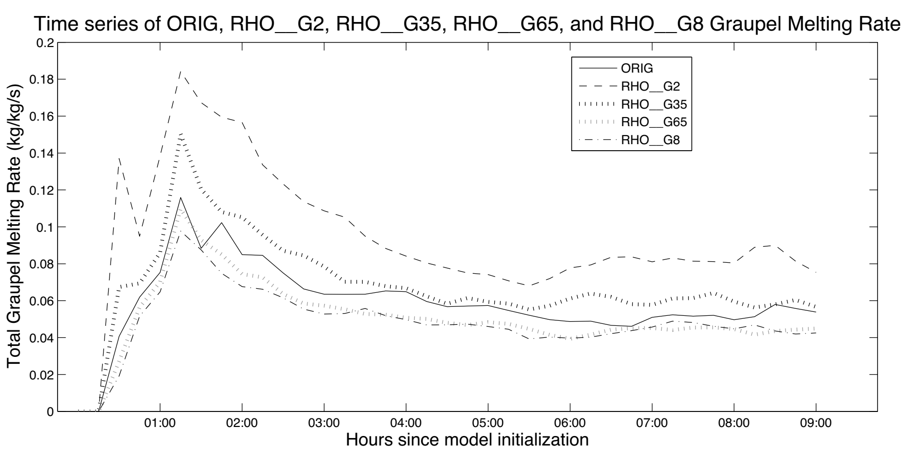
Over half of the world's population in developing nations heats their homes and cooks using open fire or cookstoves fueled by solid biofuels. The emissions generated from the burning of biofuels have the potential to have a significant impact on human health, air quality, and the regional and global climate. To investigate this, the REACCTING Project (Research of the Emission, Air Quality, Climate and Cooking Technologies in Northern Ghana) includes the implementation of a stove intervention among 200 households in Northern Ghana and an evaluation of the environmental and health impacts. The evaluation of the success of the stove intervention and the development of an emissions inventory, key goals of the project, are highly dependent on stove usage. Stove usage is measured qualitatively through self-reporting household surveys and quantitatively with stove use monitors (SUMs). In this study, we simulated realistic cooking experiences during which we measured stove temperatures with SUMs and the fuel used. In the simulated cooking experiences, we conducted multiple control cooking tests (CCTs) using three stoves used in the intervention that are currently deployed in Ghana; the traditional three stone, a Ghanaian-made Gyapa stove, and the Philips gasifier stove. The CCTs gave quantitative measures of the relationship between the different stoves, including factors such as temperature variability, changes in cooking times, and heat efficiencies. We found that the placement of the SUMs on each stove is significant and creates artificially high temperature variability profiles of the stove. We found that additional technology should be adopted in future in order to produce more accurate temperature profiles. The conclusions drawn regarding cooking practices, ultimately lead to understanding how cooking practices affect emissions from the cookstoves used in the study.



SUMs Data from CCT on June 26, 2014. The temperature profile shows two different temperature variability profiles that were taken during a cooking experience on the Ghanaian-made Gyapa stove. The bold profile is representative of the temperature variability of the SUMs that was placed in the sun. The dotted profile is representative of the temperature variability of the SUM that was placed in the shaded area on the stove.

Sensitivity of a simulated squall line to the microphysical representation of graupel

In order to accurately simulate storms and their precipitation within atmospheric models, we need to ensure that atmospheric processes are well parameterized. In the case of the Thompson microphysics parameterization, the vapor, rain, snow, cloud ice and graupel/hail hydrometeor categories have their particle densities set to a constant value. This is a good assumption for particles where the density doesn't vary much, like rain or ice, but it is not very realistic for the graupel/hail category since the density of graupel and hail is known to vary greatly between and within storms. This study assessed the sensitivity of an idealized simulated squall line to the prescription of graupel density using the Weather Research and Forecasting (WRF) model. The range of graupel density was varied from 200 kg m^{-3} to 800 kg m^{-3}, representing particles more characteristic of graupel than to those of hail, respectively. As the density of graupel particles was decreased from being hail-like to graupel-like, simulations showed a faster squall line with less graupel and more ice. There was a notable increase in the graupel melting rate, which resulted in more latent cooling and therefore a more intense cold pool in the lower density cases. This led to the faster storm propagation speed, indicating a sensitivity of this simulated storm to the prescription of graupel density. These results provide motivation to use graupel density as a predicted variable when modeling storm formation characteristics such as precipitation, cold pool formation, and subsequent storm evolution.



Melting rate of graupel for the original case where the density of graupel is set to 500 kg m^{-3} (ORIG, displayed as the solid line) and four experimental cases where the density of graupel was changed to 200 kg m^{-3} (RHO_G2, the dashed line), 350 kg m^{-3} (RHO_G35, the darker dotted line), 650 kg m^{-3} (RHO_G65, the lighter dotted line), and 800 kg m^{-3} (RHO_G8, the dashed-dotted line).

Steven M. Naegele

1st-year Protégé
Senior
University of Illinois at Urbana-Champaign
Atmospheric Sciences

MENTORS

RESEARCH
Sarah Tessendorf, Greg Thompson, Trude Eidhammer, NCAR

WRITING & COMMUNICATION
Rachel McCreary, NCAR

COACH
Bob Wiley, UCAR

COMPUTING
Sherrie Fredrick, NCAR

PEER
Carlos Martinez

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SOARS

Developing optimal transport and dispersion climatologies for nuclear deposition mapping

Eliza Nobles

1st-year Protégé
Sophomore
Drexel University
Environmental Engineering

MENTORS

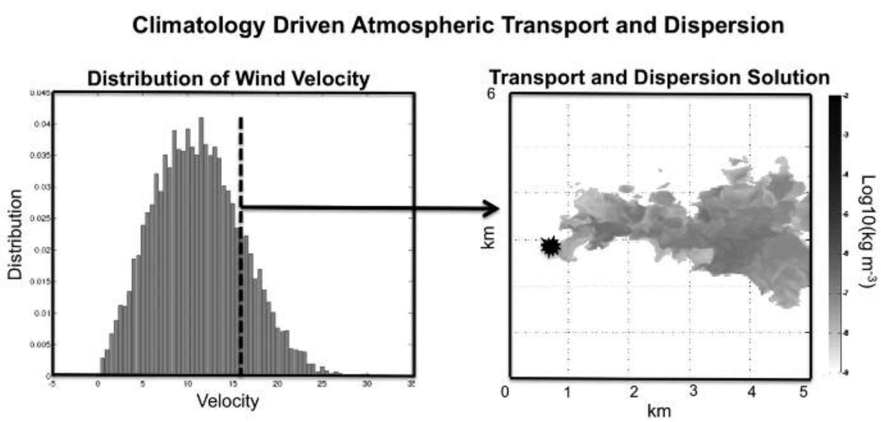
RESEARCH
Luna Rodriguez,
Andrew J. Annunzio, and
Paul E. Bieringer, NCAR

WRITING & COMMUNICATION
Dan Marsh, NCAR

COACH
Ian C. Colón Pagán,
Georgia's Department of
Natural Resources

PEER
Sarah Al-Momar

An understanding of the probable movement of nuclear material through the atmosphere is of interest to the United States government, and is also crucial for the well-being of society in the scenario that a nuclear attack or accident occurs. The United States Strategic Command (STRATCOM) is responsible for the management of and response to nuclear weapon use. To analyze likely deposition patterns of nuclear material following a nuclear attack, STRATCOM conducts analyses that utilize past meteorological events from climate datasets to investigate the medium range atmospheric transport and dispersion (AT&D) of airborne materials. A limiting factor of these analyses is the computational and data storage burden; significant computational resources are necessary to compute thousands of transport and dispersion simulations using a climate dataset, and the climate datasets and transport and dispersion solutions require significant data storage capabilities. This study examined simulated nuclear strikes using the Hazard Prediction and Assessment Capability and Second-order Closure Integrated PUFF (SCIPUFF) tools. The goal was to ameliorate computational and data storage costs by identifying the smallest meteorological record length required to sufficiently capture the full distribution of AT&D solutions. While a final conclusion has not yet been reached, programs were created to initialize and run SCIPUFF with various dataset lengths to generate AT&D solutions. The most efficient data subset length for nuclear deposition mapping will hence be the outcome of future work.

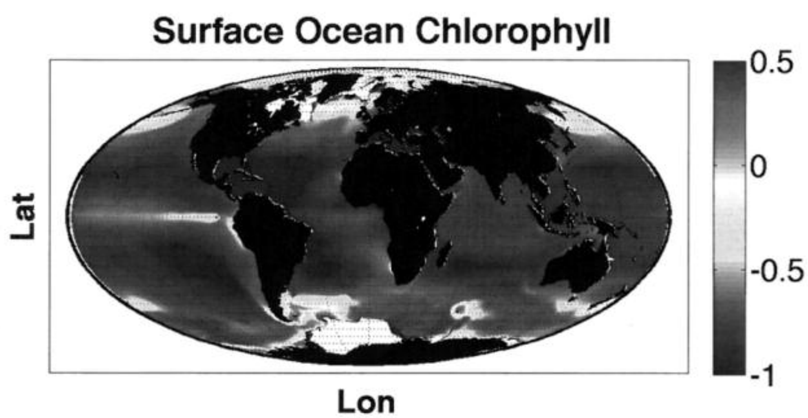


A typical distribution of radioactive material (right) produced from the SCIPUFF transport and dispersion model using one sample from a wind climatology (left).

SOARS

Evolution of phytoplankton in a changing climate

Anthropogenic emissions of greenhouse gases have led to an increase in CO_2 and temperature in the atmosphere, as well as an increase in the sea surface temperature (SST). It has been suggested that a rise in SST leads to an increase in ocean stratification, surface nutrient limitation, and a possible decrease in the abundance of phytoplankton in the surface ocean. Here, we investigate long-term changes in surface phytoplankton, specifically diatoms, diazotrophs, and small plankton abundance using monthly output from a hindcast (1958–2007) simulation of the Community Earth System Model. We find that annual-mean modeled phytoplankton chlorophyll concentration is similar to that observed from satellites, and that small phytoplankton dominate the surface ocean chlorophyll field at most locations. Seasonal evolution of the phytoplankton shows small plankton and diatoms peak in the summer months, while diazotroph abundance peaks in the spring season. Linear trends in the abundance of the three groups reveals the response of each group to past climate change. Small plankton and diatoms exhibit similar trends: increasing concentration with time in the Arctic and Southern Ocean, but decreasing concentration with time in the subtropics, while diazotrophs show a decrease in concentration with time in the subtropical regions.



Annual-mean surface chlorophyll concentration from 1958 to 2007, as estimated by the Community Earth System Model.

Zoraida P. Pérez Delgado

1st-year Protégé
Senior
Universidad Metropolitana
Environmental Science

MENTORS

RESEARCH
Nicole Lovenduski, CU

WRITING & COMMUNICATION
McArthur Jones, CU

COACH
Robert Stillwell, CU

COMPUTER
Natalie Freeman, CU

PEER
Jenine N. McKoy and
Meghan Applegate Mitchell

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Utilizing portable air quality monitors to assess the patterns of ozone along the Northern Front Range

Brandt Scott

1st-year Protégé
Junior
Union College
Geology

MENTORS

RESEARCH
John Orlando and Julia Lee-Taylor, NCAR, Michael Hannigan, CU

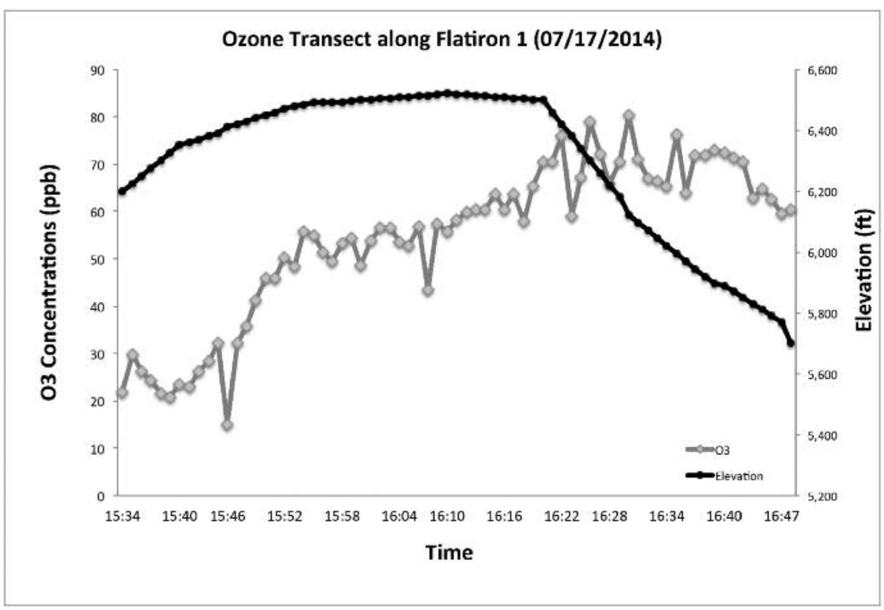
WRITING & COMMUNICATION
Carl Drews, NCAR

COMPUTING
Keith Maull, NCAR

COMMUNITY
Rebecca Hornbrook, NCAR

PEER
Ryan Adams, SOARS

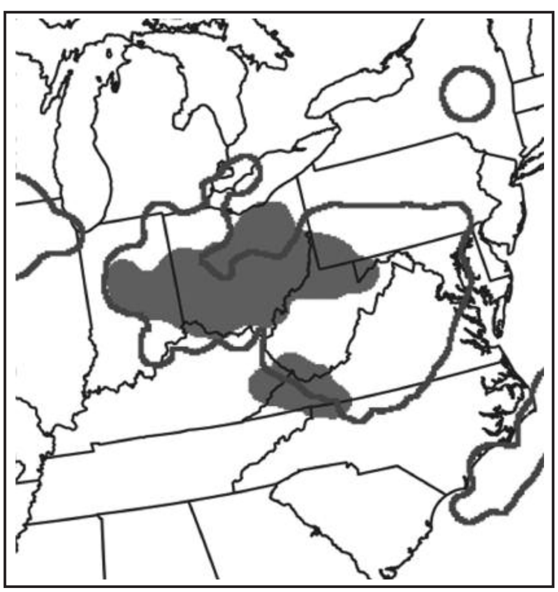
High levels of ozone in the troposphere are known to produce a myriad of harmful effects on human health. Due to a significant interest in the quality of air along the Front Range in Colorado, the Front Range Air Pollution and Photochemistry Éxperiment (FRAPPÉ) launched a field campaign utilizing both ground and airborne instruments to monitor air pollution during the summer of 2014. This study contributes to the FRAPPÉ campaign by using newly developed portable air quality monitors (Mpods) in conjunction with stationary ground instruments to monitor air quality. The Mpods were calibrated co-location style: they were placed near a regulatory monitor at the Continuous Air Monitoring Project (CAMP) site in Denver to record data. A calibration curve was then created using the data from the regulatory monitor as a standard. For this study, four Mpods were distributed to hikers and deployed twice a week over a period of four weeks. Deployment locations varied to cover a large extent of the Front Range. Ozone concentrations recorded by the Mpods exhibited strong correlations to the relative humidity and temperature recorded. It was concluded that this correlation was due to the way in which they were calibrated and had the potential to skew the ozone measurements recorded. Future studies can use this data to further explore the use of cost-effective personal air quality monitors.



Spatial ozone concentrations (gray line) and elevation (black line) recorded by Mpod 17 along the 1st Flatiron in Boulder, Colorado between 3:34pm–4:47pm on July 17th, 2014. Ozone concentrations exhibited a relative increase over time with a maximum value of 81ppb. Several of these values exceed the EPA standard for ozone.

Using the Mesoscale Model Evaluation Testbed to test physics options in the Weather Research & Forecasting model

The Mesoscale Model Evaluation Testbed (MMET) has been set up by the Developmental Testbed Center (DTC) to assist the research community in efficiently testing and evaluating newly developed model techniques aimed to more accurately predict the weather and to potentially be implemented into operations. For this project, datasets available through the MMET were utilized to test the forecast performance of several configurations of the Weather Research & Forecasting model (WRF v3.5.1) using the Advanced Research WRF dynamical core for different physical parameterization schemes and grid-spacing. A significant derecho event that occurred on 29 June 2012 over the U.S. Midwest and Mid-Atlantic states was chosen for this case study. Statistical analysis of each WRF configuration was conducted using the Model Evaluation Tools (MET) and results were plotted using R, a statistical package. Standard verification metrics were calculated for surface and upper-air temperature, dew point temperature, and wind speed, as well as precipitation. In addition, a more advanced spatial verification technique, known as the Method for Object-based Diagnostic Evaluation (MODE), was utilized to diagnose errors in forecast precipitation placement, coverage, and orientation. Results indicated that model performance was sensitive to grid-spacing and physics options. Adjusting the grid-spacing from 15- to 5-km while utilizing the same physics options allowed for strong convective development that otherwise did not occur. Substituting different microphysics and radiation options at the 5-km grid-spacing had significant effects on developing the storm and resulting storm structure, while changing the planetary boundary layer scheme positively impacted the storm placement. The synoptic environment depicted by the WRF configurations that were able to simulate strong convective development is consistent with research on derecho formation.



Example illustrating MODE objects created from WRF 3-h accumulated precipitation fields and the associated Stage II analysis fields for the 39 hour forecast from the 28 June 2012 12 UTC initialization. In this example, the configuration being evaluated is using the RRTMG long- and short-wave radiation schemes. A convolution threshold of 0.254 mm was used to define the objects; the shaded regions represent objects in the forecast field, and outlined areas represent objects in the observed field.

Anthony Torres

1st-year Protégé
Senior
University of Michigan
Earth Systems Science and Engineering

MENTORS

RESEARCH
Michelle Harrold, Cody Phillps, Jamie Wolff, NCAR

WRITING & COMMUNICATION
Wendy Abshire, UCP

COACH
Marcus Walter, WKYC-Cleveland

PEER
Erin Dougherty, SOARS

Effects of large volcanic eruptions on climate in the Community Earth System Model

Arianna Varuolo-Clarke

1st-year Protégé
Junior
Lyndon State College
Atmospheric Sciences

MENTORS

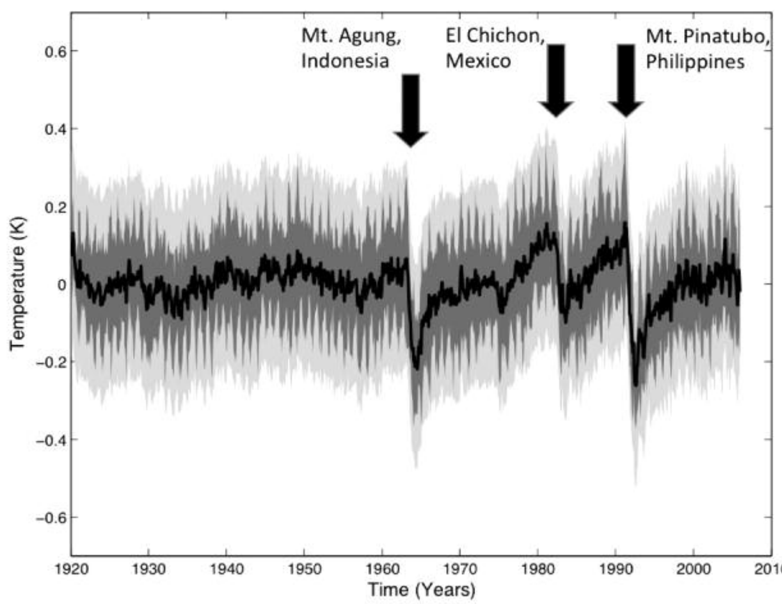
RESEARCH
Brian Medeiros, NCAR

WRITING & COMMUNICATION
Brian Bevirt, NCAR

COACH
Luna Rodriguez, NCAR

PEER
Alicia C. Camacho, SOARS

This research investigates the climate system's response to large volcanic eruptions in simulations of a global atmosphere model called the Community Earth System Model-Large Ensemble (CESM-LE). This is important for developing better predictions of how volcanic eruptions affect the atmosphere, oceans, cryosphere, and biosphere, and to help people and communities develop mitigations and adaptations to volcanic impacts. Using 29 CESM-LE global simulations with each ensemble member making unique predictions about how the weather and climate will change, the climate system's response to large volcanic eruptions can be better understood. This analysis involved examining three large 20th century eruptions, Mount Agung, El Chichón, and Mount Pinatubo and their effect on CESM-LE ensemble members. Anomalies and standard deviations were distinguished and calculated from the ensemble means of three climate variables: surface temperature, precipitation, and surface pressure. The analysis focused on surface temperature anomalies to look for two climate responses: Northern Hemisphere (NH) winter warming and changes in El Niño Southern Oscillation (ENSO) events. The first task was to determine whether the observed response of NH winter warming appears in the climate model. The second task involved assessing the likelihood of a volcanic eruption triggering an ENSO event in the CESM-LE. Initial model results indicate that volcanic eruptions were not found to trigger northern hemispheric winter warming or an increased probability of an ENSO event in the eastern Pacific Ocean.



Global surface temperature anomaly for the 29 member CESM-LE. The black line traces the ensemble mean temperature anomaly. The dark gray band shows the +/- 1σ envelope and the light gray band shows the full ensemble spread. The major volcanic eruptions are labeled.

NEON Internship Program

NEON's Internship Program is designed to help undergraduate students in science, engineering, and computing build successful work experiences and prepare for future STEM careers.

Intern projects span the breadth of NEON's endeavors - from programming algorithms that automate field sensor data and image analyses to testing protocols and analyzing complex data sets for signals of environmental change. A cornerstone of our program is mentoring. Each intern receives support from his/her own team of mentors who guides the work and provides insights on career options and career paths. NEON interns also receive training in scientific communications, a critical skill for STEM professionals, and are given multiple opportunities to practice sharing their work in a variety of formats including scientific or technical papers, posters and oral presentations. Our goal is for interns to leave NEON with completed projects they are proud to include on their resume along with workplace skills that position them as future leaders in their field.

Because NEON is committed to broadening participation in science and engineering fields, reflected in the mission of the internship program, we are particularly interested in working with students from historically under-represented groups in science and engineering. NEON uses best practices for recruitment and intern support, and provides career exploration seminars and advanced technology workshops. We also collaborate with SOARS on cross-program student activities such as leadership training and scientific poster sessions that strengthen all students' experiences.

NEON is proud of its newest cohort of interns, and of their significant contributions towards building our national ecological observatory from the ground up.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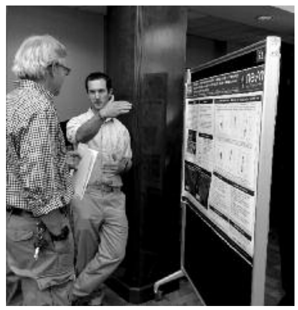


Interns are pictured left to right:
Inside truck: Ariel Kaluzhny, Rose Petersky, Victor Leos
On truck: Caleb Shaw, Kevin Sacca, Madeleine Ball, Stephanie Cortés

Photo courtesy of ©Abraham Karam

A comparative analysis of Landsat, AVIRIS, and NIS normalized difference vegetation indices in Domain 17, the Pacific Southwest

MADELEINE A.Z. BALL

Senior
Tufts University
Environmental Studies and
Earth and Ocean Sciences

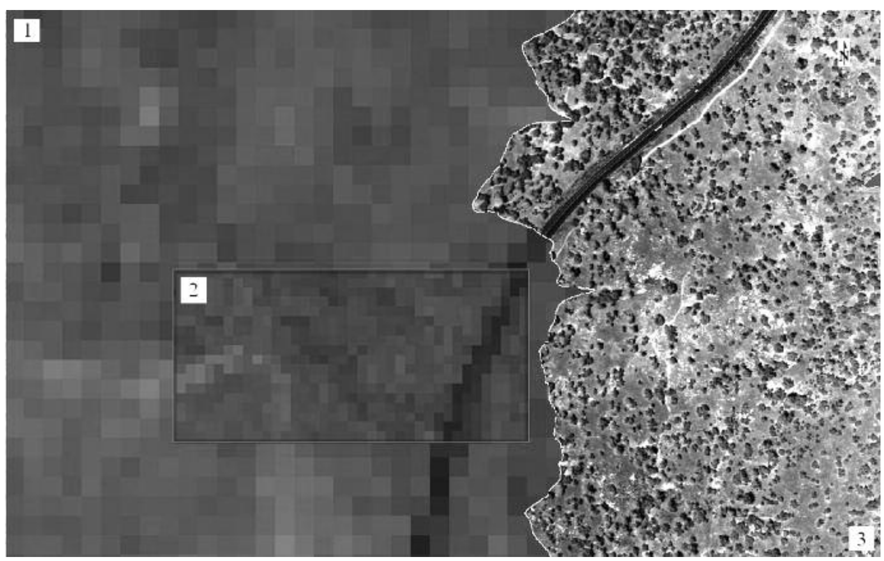
MENTORS

RESEARCH
Nathan Leisso, Shelley Petroy

WRITING & COMMUNICATION
Leah Wasser

COMMUNITY
Kat Bevington

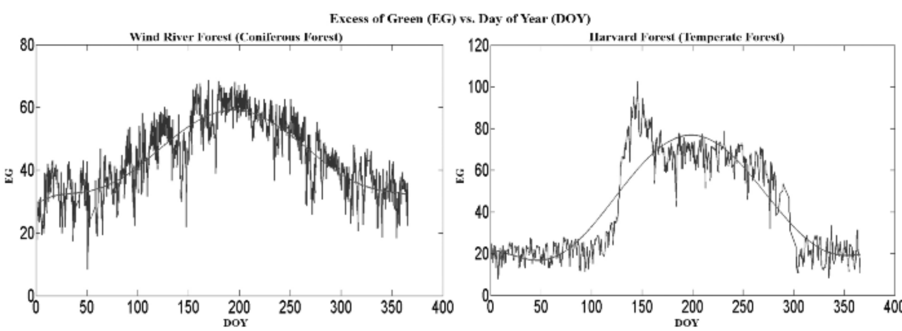
The National Ecological Observatory Network (NEON) is constructing an Airborne Observation Platform (AOP) to provide high resolution LiDAR, aerial, and hyperspectral data for NEON sites across the United States. This platform includes the NEON imaging spectrometer (NIS) that provides >420 bands of high resolution data across a spectral range of 380 nm to 2,510 nm. AOP will provide normalized difference vegetation indices (NDVIs) that use data in the red and near infrared portions of the electromagnetic spectrum to estimate vegetation density and health. Deriving NDVIs using NIS is challenging given the large volume of bands. Further, to allow scaling to larger regions, NIS products must be comparable to lower resolution products from other sensors such as Landsat and AVIRIS (Airborne Visible / Infrared Imaging Spectrometer). The goals of this study were to (1) determine NDVI sensitivity to NIS spectral band selection and (2) compare NIS NDVIs to Landsat and AVIRIS. Using 2013 NIS data collected from the San Joaquin Experimental Range near Fresno, CA, results indicated that NIS NDVIs are sensitive to band selection. Low wavelengths both in the red and near infrared show the greatest contrast between high and low values and should be used for visualization of vegetation. If comparing NIS NDVIs with Landsat or AVIRIS, it is best to spectrally and spatially resample before analysis. As NEON transitions to operations in 2017, it is important to understand optimal methods of creating data products so the scientific community has access to data that best meets its needs.



Differences in spatial resolution between 1) Landsat (30 m resolution), 2) AVIRIS (20m resolution), and 3) the NEON Imaging Spectrometer (1 m resolution) in the San Joaquin Experimental Range. Note the road, cars, and individual trees are distinguishable in NEON Imaging Spectrometer.

Interpreting canopy phenology using an automatic image analysis algorithm to process Phenocam images

The National Ecological Observatory Network (NEON) plans to provide data on climate change impacts. Data will be collected from sites in different ecosystems across the nation and this requires high quality and standardized methods to gather reliable data. Plant phenology is highly sensitive to climate change and can give information about its impacts. Also, changes in the plant cycle affect the time when plants act as a source or sink of carbon dioxide (CO_2). Stardot cameras are standardized and cost effective, and can be used to study plant phenology. An automated algorithm was prototyped to analyze plant phenology on images from the Phenocam Network. Six phenology metrics were used to summarize green and red color values in a selected area of the image. The area was divided into a grid and statistical analysis was applied to the phenometric values per zone in the grid. The results were plotted versus the day of the year (DOY). A curve fit was applied to calculate the representative function of the plot and by calculating the corresponding derivatives set to zero, the algorithm calculated the DOYs when the phenometrics were maximum, minimum or inflection points. The derivative results were related to green-up or brown-down in the plant phenology cycle. This algorithm was applied to 5 different ecosystems to find the different timing in the plant phenology cycles. This analysis, applied over the thirty years of NEON's data gathering, will give information on the changes in plant phenology.



Plots with a 6-degree polynomial fit of two ecosystems. A clear increase in the excess of green (EG) phenology metric during spring and summer is seen, even though both ecosystems have different vegetation, demonstrating that the algorithm can be standardized and automated for different ecosystems.

Stephanie Cortés

Senior
Universidad de los Andes
Bogotá, Colombia
Environmental Engineering and
Industrial Engineering

MENTORS

RESEARCH
Michael SanClements,
Sarah Elmendorf

WRITING & COMMUNICATION
Michael SanClements,
Sarah Elmendorf

COMMUNITY
Laura Sutton Aeling

Implementation, visualization, and output analysis of time series algorithms for NEON tower sensors

ARIEL KALUZHNY

Junior
Wesleyan University
Computer Science and Economics

MENTORS

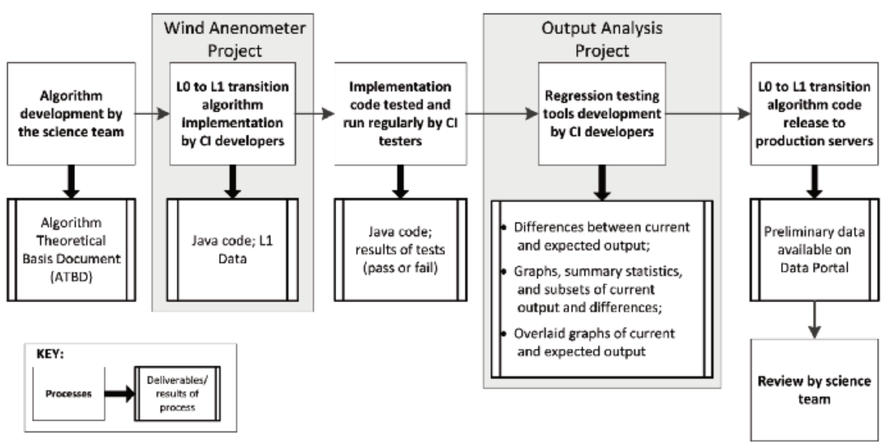
PROJECT
François Pradeau, Jim Arnow

WRITING & COMMUNICATION
Liz Goehring

COMMUNITY
Dee Dahanayake

The National Ecological Observatory Network (NEON) has a distribution of instrument towers across 20 eco-climatic domains in the United States, each equipped with variety of sensors to study long term, ecological change. These sensors collect atmospheric data, referred to as Level 0 (raw data), on a continuous basis, but the data are not readily comprehensible. NEON's Cyber Infrastructure Data Processing and Monitoring System (DPMS) transforms Level 0 data to higher level data products that will be made available to scientists, educators, and the public through NEON's Data Portal. The DPMS team implements algorithms provided by NEON scientists while assuring quality and accuracy in the data. This project involved (1) early stages of implementation of the 2D Sonic Wind Anemometer transition algorithms, and (2) creation of regression tests comparing outputs of algorithmic transitions before and after a code change for various atmospheric measurements. These regression tests are necessary to monitor outcomes after any code changes, ensuring consistency and accuracy of Level 1 data. The regression tests generate graphs of the data, summary statistics, and graphical displays of the differences between expected and current data. The regression tests were run on seven existing Level 0 to Level 1 data transitions and will be run on more as they become available. Both the regression test code and the algorithm implementations are essential to NEON's preparation to become fully operational in 2017.

Processes to transition raw data to preliminary data



Overall process and deliverables (tangible products) involved in the transition from a science Algorithmic Theoretical Basis Document (ATBD) to preliminary data in the NEON Data Portal. Project components are highlighted by shaded outer boxes.

Exploring vascular plant and carabid beetle diversity across three different ecoclimatic domains using NEON provisional data

The measurement of biodiversity to interpret population and ecosystem dynamics and structure is increasingly used in ecosystem research. The National Ecological Observatory Network (NEON) is a nationwide, 30-year project aimed at collecting data on long-term ecological change. This study explored two data sets obtained from NEON's 2013 provisional data, carabid beetle richness and vascular plant composition across multiple plots occurring in five sites that represent three eco-climatic domains. There were no statistically significant correlations between inverse Simpson diversity for beetles and plants at the plot, site, or domain level. This may be a result of marked overlap between beetle composition and vegetation type among some domains. An analysis of variance, however, indicated that there were significant differences in plant diversity between vegetation types at some of the domains. Further studies are needed to explore the influence that this may have on localized beetle community composition and diversity. This work demonstrates the potential capability of NEON-collected data to identify patterns that may be useful for informing management strategies that support biodiversity in a wide variety of ecosystems.

Victor Baldemar Leos

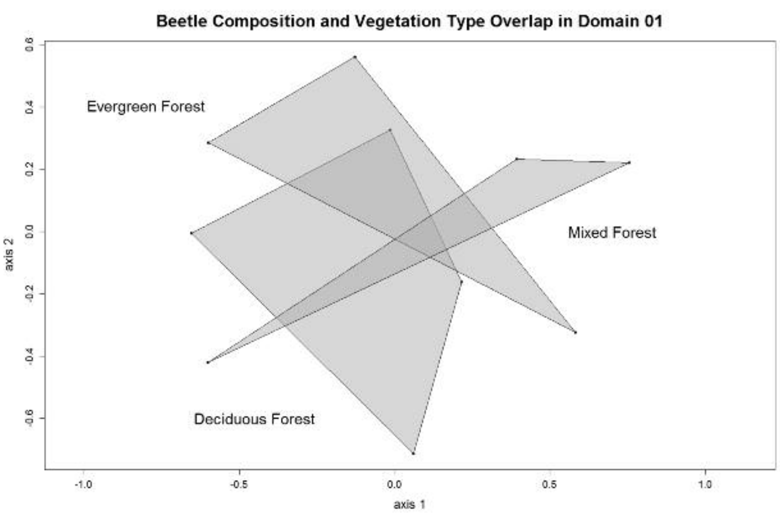
Junior
Bowdoin College
Environmental Studies
and Biology

MENTORS

RESEARCH
David Hoekman, Katie Jones,
Natalie Robinson

WRITING & COMMUNICATION
Katie Jones, Natalie Robinson

COMMUNITY
Maxwell Mathews



An ordination of 2013 carabid beetle community composition data for Domain 01 on two axes. Points on the graph represent plots within the domain and are placed using Bray-Curtis dissimilarities. Polygons represent different vegetation type groupings, and the area of the polygon represents the strength of beetle species similarities between plots; a smaller polygon representing greater similarity between plots. The overlapping of polygons suggests that some beetle species can be found in multiple vegetation types.

Determining the optimal spatial resolution of measurements for mapping stream geomorphology using land surveying

Rose Petersky

Senior
SUNY-ESF
Environmental Science

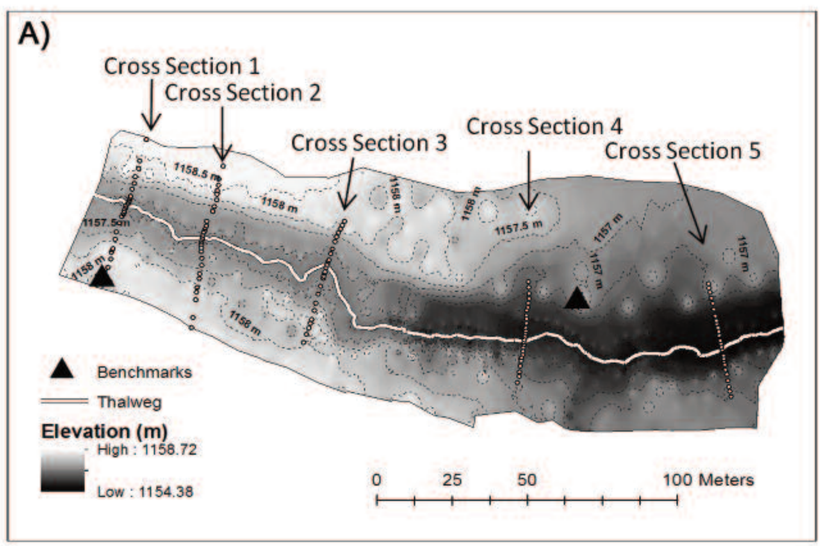
MENTORS

RESEARCH
Ryan Utz, Michael Fitzgerald

WRITING & COMMUNICATION
Ryan Utz

COMMUNITY
Dustin Whittemore

Digital elevation models (DEMs) are commonly used to illustrate and model geospatial information related to riparian channels. However, determining the exact elevation of every location in a stream reach is logistically impossible. DEMs therefore use interpolation to approximate elevation values. Surveying is time-consuming and therefore, minimizing the number of surveyed locations while accurately capturing the topographic features is important. High-resolution stream cross-section surveys were compared against an interpolated surface generated from field survey data obtained following NEON's initial draft Protocol for Stream Geomorphology. Points were collected using NEON's current protocol in a reach of the Arikaree River, a shortgrass prairie stream in Colorado, for geomorphological features and five cross sections. An inverse distance weighted (IDW) interpolation was performed with 100 random selections of 50, 60, 70, 80, and 90 percent of the points and the cross section measurements excluded. For each sample density, the root mean squared error (RMSE) values of the cross sections were found by comparing the measured elevation values to the interpolated values. The RMSE values were then compared with the cross section of origin and the sample density as predictor variables. Sample density did not have a statistically significant effect on accuracy. Therefore, theoretically, fewer points can be collected without negatively impacting the accuracy of the map. Accuracy may be impacted by other factors, such as where data is being collected, more than sample density. Future surveys should focus on the quality of sampling, and should reduce the amount of area without measured data.



Geomorphological map of the Arikaree river site with Cross Sections #1-5, benchmarks and thalweg included. Contours and elevation gradient created using an inverse distance weighted (IDW) interpolation with 100 percent of the data collected.

Determining snow depth using an automated image processing algorithm

The National Ecological Observatory Network (NEON) collects standardized ecological data from 106 sites distributed throughout the continental United States. Because snow is a common form of precipitation in the U.S., it needs to be measured accurately, which is challenging to do. The amount of snowfall in an ecosystem is important due to the insulating effects of snow cover, snow's effects on surface energy balance, and the amount of water it adds to the environment. Snow water equivalent (SWE) is the product of snow depth and snow density, and represents the amount of water entering the soil if the snowpack melts. NEON's towers are equipped with static phenology cameras for automatically collecting understory images remotely, but these same images can also be used to determine snow depth through robust image processing techniques. The challenge is collecting consistently accurate measurements on a continental scale. Instead of manually reading the lines on a staff gauge in an image, pixel data can be automatically analyzed. A line profile collects the intensities of pixels that fall on a designated line, and from their relative intensities, designated pixels can be classified as snow. The depth of snow on a staff gauge in pixel units translates to a depth in meters, and the depth is recorded with the time and location, allowing for long time series data. After testing this algorithm with simulated datasets, the accuracy of the measurements was within approximately 1cm, meeting the project's requirements. This data will be freely available via NEON's web portal.

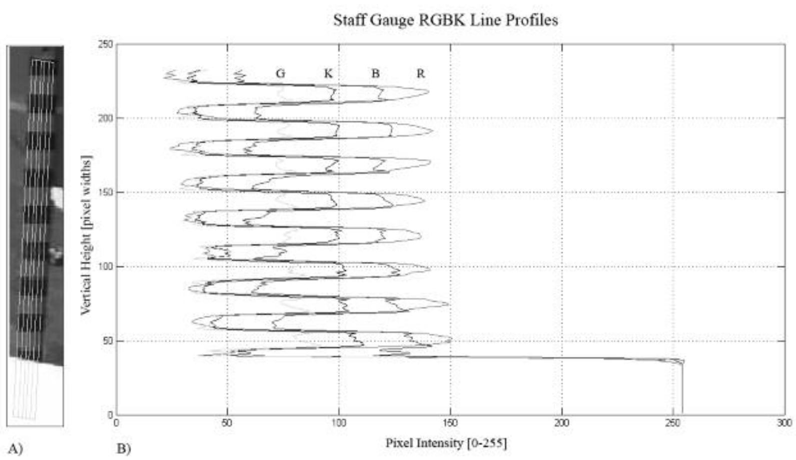


Image A shows a cropped region of interest of a staff gauge with the lines to be profiled. Graph B shows the line profiles of the staff gauge in the red (R), green (G), blue (B), and greyscale composite (K) channels. Note the regular oscillations of pixel intensity in the region of the staff gauge not covered by snow.

Kevin Sacca

Junior
Rochester Institute of Technology
Imaging Science

MENTORS

RESEARCH
Michael SanClements,
Sarah Elmendorf

WRITING & COMMUNICATION
Michael SanClements,
Sarah Elmendorf

COMMUNITY
Matt Ventimiglia

Comparison of common lilac (*Syringa vulgaris*) phenology timing between historical data and current Project BudBurst citizen science data: Challenges and lessons learned.

CALEB SHAW

STAR Teacher Researcher
University of New Hampshire, 2012

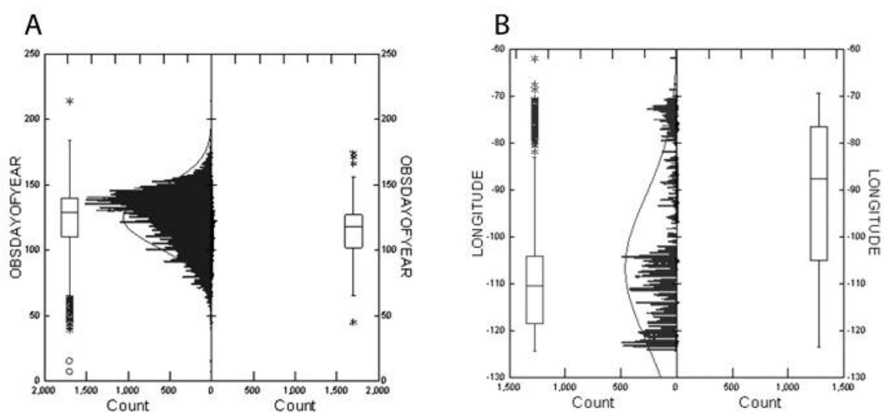
MENTORS

RESEARCH
Sarah Newman, Sandra Henderson, Tom Stohlgren (CSU)

WRITING & COMMUNICATION
Sarah Newman, Liz Goehring

EDUCATION
Liz Goehring

Observing the timing of plant phenology provides a way to monitor and predict effects of ecological change on plants. This study compared historical phenology data for common lilac dating from 1956–2003 with recent lilac phenology data collected by Project BudBurst citizen scientists from 2007–2013. Due to the lack of accessible growing degree day data, it was not possible to directly examine climate effects on phenology timing. Instead, we compared geographic distribution patterns between historical and Project BudBurst data to explore what factors might contribute to the timing of phenophase dates between data sets. T-tests were performed on latitude, longitude, and day of year of observation for the first flower and first leaf between the two data sets. Differences between latitudes of observation sites were not significant for first flower and first leaf ($p = 0.789$, $p = 0.489$, respectively) but there was a difference between longitudes for both variables ($p<0.001$). Mean observation dates for Project BudBurst data were 9.5 days earlier for first flower ($p = 0.0001$) and 2.3 days earlier for first leaf ($p = 0.063$) but the longitudinal difference of observation sites between data sets and the small sample size of the Project BudBurst data set make these findings inconclusive. Because of the differences of longitude, we suggest future analyses of data by geographic regions. Additional Project BudBurst observations in the western U.S. would allow better comparisons in that region and encouraging observations near historic sites would take advantage of a long, rich data set.



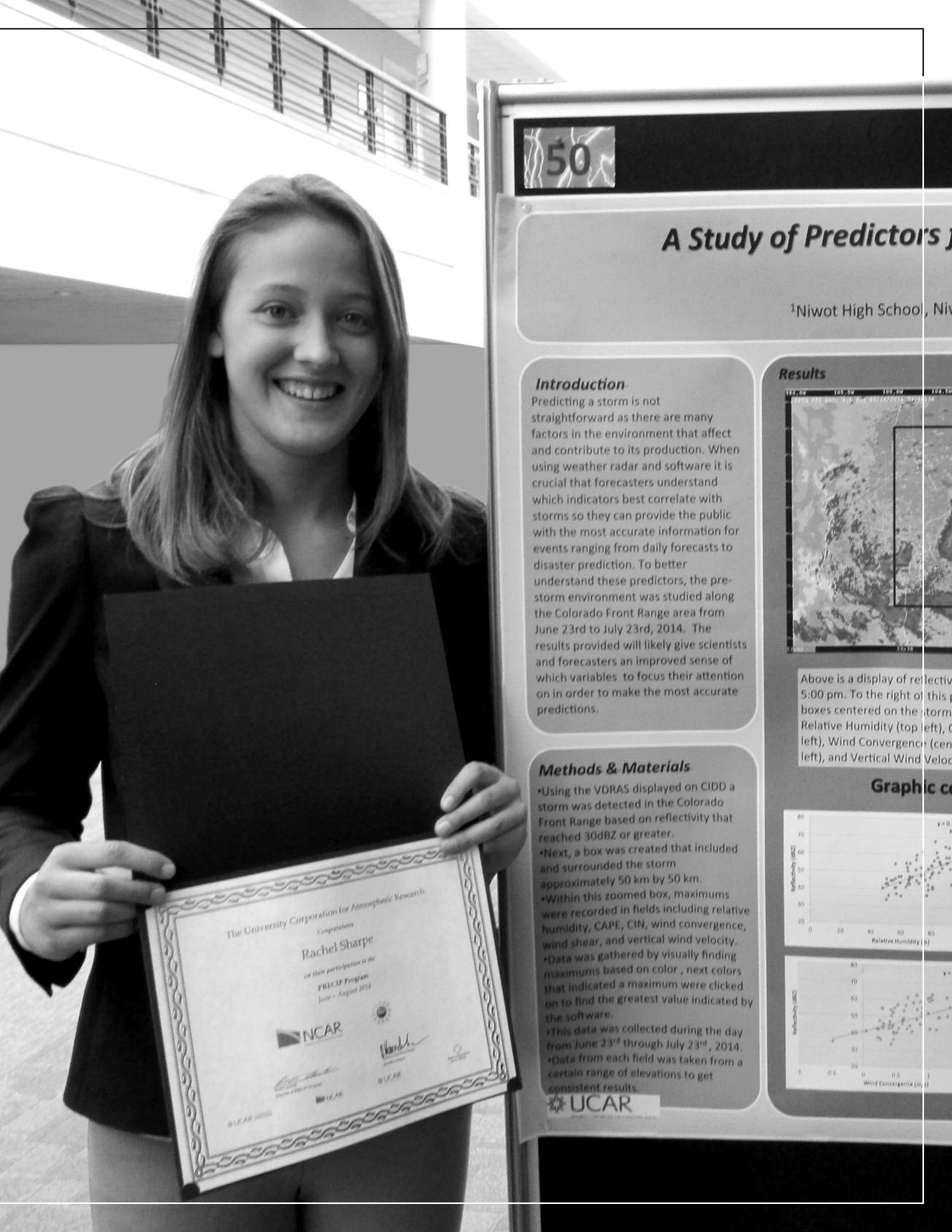
Two-Sample T-tests for first flower:
A) observation day of year
(historical: $M = 124.2$, SD = 22.3, Project BudBurst: $M = 114.7$, SD = 20.2), $t = 6.8$, $p = 0.0001$,
B) longitude
(historical: $M = -106.6$, SD = 15.3, Project BudBurst: $M = -90.5$, SD = 16.2), $t = -14.53$, $p = 0.0001$.
The left sides of the figures are historical data and the right sides are Project BudBurst data.

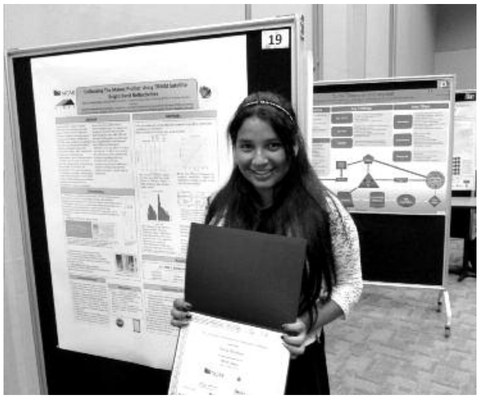
PRECIP NCAR

NATIONAL CENTER FOR ATMOSPHERIC RESEARCH

PRE-College Internship Program at NCAR

The NCAR/RAL PRECIP program, now in its fifth year, is designed to provide high school students with an opportunity to gain experience with real-world scientific research and engineering projects and to engage them in STEM-related fields. Eight Puerto Rican students attended the program through a partnership with the Ana Méndez University System's Pre-college summer research internship program. Five others from four local Colorado high schools were funded by RAL. For eight weeks, all 13 students worked closely with engineers and scientists on projects ranging from testing snow gauges and validating tipping bucket rain gauges, to comparing aircraft icing monitoring techniques. Students participated in a PRECIP Writing Workshop to help them develop scientific writing and poster development skills, including writing a scientific abstract and analyzing their data. They presented posters on their research at the conclusion of the summer program at a formal poster session open to all NCAR scientists, engineers, and other internships. The PRECIP program is proud of this year's students and our past students, almost all of whom have gone on to pursue college degrees in STEM-related fields.


50
A Study of Predictors
[1]Niwot High School
Introduction
Predicting a storm is not straightforward as there are many factors in the environment that affect and contribute to its production. When using weather radar and software it is crucial that forecasters understand which indicators best correlate with storms so they can provide the public with the most accurate information for events ranging from daily forecasts to disaster prediction. To better understand these predictors, the pre-storm environment was studied along the Colorado Front Range area from June 23rd to July 23rd, 2014. The results provided will likely give scientists and forecasters an improved sense of which variables to focus their attention on in order to make the most accurate predictions.
Methods & Materials
•Using the VDRAS displayed on CIDD a storm was detected in the Colorado Front Range based on reflectivity that reached 30dBZ or greater.
•Next, a box was created that included and surrounded the storm approximately 50 km by 50 km.
•Within this zoomed box, maximums were recorded in fields including relative humidity, CAPE, CIN, wind convergence, wind shear, and vertical wind velocity.
•Data was gathered by visually finding maximums based on color , next colors that indicated a maximum were clicked on to find the greatest value indicated by the software.
•This data was collected during the day from June 23rd through July 23rd, 2014.
•Data from each field was taken from a certain range of elevations to get consistent results.
UCAR
Results
Relative Humidity (%)
Wind Convergence (m/s)
The University Corporation for Atmospheric Research
Rachel Sharpe
NCAR
UCAR



Clockwise from top left:
Derek Champlin, Gian Carlo Di Cristina, Valerie Rodríguez Castro, Lucas Szewczyk, Forrest Eppler (not PRECIP), Justin Martyr, Ilya Fedorchuk, Paola Esteban Pérez, Luana Parades Sanchez, Lauren Sharpe, Rachel Sharpe, and Ricardo Rodríguez García (not pictured: José Cruz Ayala, Andrea Vásquez).

Derek C. Champlin

Senior,
Josefina Leon Zayas High School

MENTORS

RESEARCH
Scott Landolt, NCAR

The efficiency of the heating system technique in the NCAR snow precipitation gauge (GEONOR)

Accurate snowfall measurements are very difficult measurements to make, primarily due to variables such as wind velocity and temperature. The objective of this investigation is to determine whether the GEONOR heating system is impacting the snowfall measurements of the gauge, which is used in various precipitation networks around the world. During some snowfall events, snow will stick to the inner sides of the gauge, which can lead to snow capping and affect measurement accuracy. A series of 18 tests, nine with the heater on and nine with the heater off, was conducted to determine the effects of the heating on the gauge performance. The tests were made in a cold room laboratory using different air temperatures and snowfall rates in an artificial snowmaking machine. Additionally, this investigation focused on determining if there were actual heatplumes that could affect the precipitation measurements. The hardware used include thermocouples to measure heatplumes that may emerge from the GEONOR, a data logger to store the data from the thermocouples, and a solid state relay that provides the power to the GEONOR heater. The data collected confirm that the heating system prevents snow build-up in the orifice, even when the temperature was -25 °C. It was also observed that the colder the ambient temperature, the more snow accumulates on the gauge shoulders, regardless of heating being applied. When analyzing the thermocouple data to determine if heatplumes could be detected above the gauge opening, no significant heatplumes were observed above the gauge.

José C. Cruz Ayala

Senior
Josefina Leon Zayas High School

MENTORS

RESEARCH
John Mickey, NCAR

Accuracy of precipitation measurements using tipping bucket rain gauges

When dealing with precipitation gauges, there is a lot of variability in the measurements. In the case of tipping bucket rain gauges, some of this variability can be related to the different models of gauges. This research looked at the differences between two types of tipping bucket rain gauges. To get a clear view of the difference between them, 15 tipping bucket gauges were placed in NCAR's Sandlot, a local test site in Boulder, Colorado, to collect data during five days in July of 2014. These consisted of two models; six with a capacity of 7 ml and nine with a capacity of 8.5 ml. Tripods and bases were optimized for these precipitation gauges, giving them better stability. During the five-day period, the 7 ml tipping bucket collected an average of 19 ml of rain per bucket and the 8.5 ml tipping bucket collected an average of 19.4 ml of rain per bucket. Analysis of the data showed that the different styles of tipping buckets provide consistent measurements and had a really strong correlation between them. Scientists can therefore be confident in using these two styles of tipping bucket rain gauges in future research.

Variability in the measurement of two models of tipping bucket rain gauges

There are many ways to measure precipitation, each with its own strengths and weaknesses. The variability between these methods can lead to false measurements that produce unreliable data. The essence of this project is to compare two models of tipping bucket rain gauges, using a Parsivel as an unbiased way of comparing their data. The difference between the two models is in the capacity of precipitation that they hold; one style holds 7 mL before tipping and the other 8.5 mL. Six 7 mL and nine 8.5 mL buckets were deployed at NCAR in Boulder, Colorado. Although the parsivel malfunctioned, our readings indicate that, compared to one another, we see a very strong correlation with an r^2 value of 0.997. Additionally, both models recorded tips at nearly identical times over a seven day period during July 2014, which indicates the instruments are precise.

Gian Carlo Di Cristina

Senior
Centro de Desarrollo Integral

MENTORS

RESEARCH
John Mickey, NCAR

Calibrating the Manus profiler using TRMM satellite bright band reflectivities

A wind profiler is a type of weather observing instrument that uses radio waves to detect the wind speed and direction at different elevations above the ground. The Manus profiler was a 915-MHz radar, sensitive to precipitation and clear air, that operated on Manus Island in northeastern Papua New Guinea from 1992 to 2001. However this radar was not calibrated, and meteorologists need a calibration factor in order to use the radar to get more accurate measurements of the structure and strength of turbulence and precipitation in the lower atmosphere. To calibrate the profiler, average bright-band reflectivity at 2°S from the TRMM (Tropical Rainfall Measurement Mission) satellite is compared with the uncalibrated maximum reflectivities measured by the profiler when it observed bright bands. The analysis and comparison from the Manus profiler data through the years 1992–1994 will provide the information required to get the calibration factor. The calibration differs from Rodríguez Castro's calibration, which was based on surface rain data, by 7.16 dBZ (a factor of 5.2). Comparing resulting profiler rain estimates with surface rain measurements will test the profiler calibration and after the calibration constant is verified, data from this profiler may be used in a wider range of applications.

Paola S. Esteban Pérez

Senior
Colegio San José

MENTORS

RESEARCH
Leslie M. Hartten and
Paul E. Johnston,
CIRES/NOAA ESRL

Ilya Fedorchuk

Junior
Fairview High School

MENTORS

RESEARCH
Scott Landolt, NCAR

Comparing calibrated radar precipitation estimates based on measurements from ground instruments

The Weather System to Deicing Decision Making (WSDDM) operated by the National Center for Atmospheric Research (NCAR) receives data from the Front Range radar and surface precipitation gauges to derive an estimate of rainfall rates that are then applied to the entire radar scan. The purpose of this research is to determine the accuracy of the rainfall estimations by examining estimated rainfall rates from WSDDM and comparing them to four different surface precipitation gauge field sites in the Front Range area. There are two locations at Denver International Airport, one at Front Range Airport, and one at Greeley. The data sets analyzed were from the September 9th through September 12th, 2013 flood event. This time period was used due to the occurrence of heavy rainfall giving more data instances for the radar and precipitation gauges. The rates from the precipitation gauges show a weak positive correlation with the WSDDM system, indicating that the radar-derived estimates were not good for this particular case.

Justin Martyr

Senior
Longmont High School

MENTORS

RESEARCH
Scott Landolt, NCAR

Investigating the relative accuracy of weather instrumentation through comparisons with calibrated sensors at the NCAR Marshall Field Site

The relative accuracy of weather instruments and sensors is a common concern among meteorologists because of the impact on weather forecasting. This study investigates the accuracy of a selection of active weather instruments, which measure temperature, humidity, wind speed, and wind direction. The instruments chosen for the investigation have been deployed for one year at the National Center for Atmospheric Research (NCAR) Marshall Field Site and have not been removed for recalibration to prevent interruptions to infield measurements. A second set of instruments utilized in the infield comparison were first calibrated in a lab then set up on a weather tower at Marshall Field Site for comparison to the existing instruments. Weather conditions were observed by both sets of instruments for the period between July 21 and July 25, 2014. These data were plotted to observe how well the data from the tower instruments correlated with data from the field instruments. The results reveal that the infield temperature/humidity sensor needs to be recalibrated as the calibrated sensor showed different measurements than the infield sensor. Wind speed and wind direction on the tower and in the field were very similar to one another indicating those sensors don't require calibration.

Comparing optical-based sensors with precipitation gauges for measuring snowfall and rainfall intensity

Luana M. Paredes Sanchez

Junior
Colegio Colombo Británico

MENTORS

RESEARCH
Scott Landolt, NCAR

New weather sensors with the ability to automatically identify present weather types have been introduced recently, and scientists are beginning to use these weather sensors and precipitation monitors to compare data and make weather forecasts. However, these devices have never been calibrated against standard precipitation gauges to assess their accuracy. This research will analyze precipitation data that has been collected over the past year by three different present weather sensors at the NCAR Marshall Field Site in Broomfield, CO: the Thies OP Laser Monitor, the Campbell PWS100, and the Vaisala PWD22. These three optical sensors are capable of measuring precipitation rate and intensity. Data from these sensors were compared to data from a co-located GEONOR precipitation gauge at the Marshall site. The three laser sensors can differentiate between rain and snow, which allowed for data to be analyzed for both types of precipitation. Results indicate that data from the GEONOR precipitation gauge for rainfall intensity are most poorly correlated with the Vaisala PWD22 laser monitor data. The Thies OP Laser Monitor data was the most highly correlated with the precipitation gauge data. Snowfall intensity measurements from all three laser-based sensors correlated poorly with the data from the GEONOR. This indicates that there is some success in these instruments measuring rainfall, but very little success in measuring snowfall. Therefore, anyone using these sensors should be aware that there are significant discrepancies between the precipitation gauge and the optical sensors.

Calibrating the Manus Island wind profiler by comparing profiler and surface rain measurements

Valerie M. Rodríguez Castro

Freshman
University of Puerto Rico
at Mayagüez

MENTORS

RESEARCH
Leslie M. Hartten and
Paul E. Johnston,
CIRES/NOAA ESRL

Wind profilers are radars used to gather wind information using gradients of the index of refraction in the air. These radars are not usually calibrated because the relative reflectivity is sufficient to get the wind information. This creates a problem if these data are used in other types of research that require absolute values, such as studies of atmospheric turbulence. This study used relative reflectivity from the 915-MHz wind profiler located on Manus Island, Papua New Guinea, along with surface rain measurements to find the profiler calibration constant. A six-hour period of stratiform rain, identified by the presence of a bright band in reflectivity, was selected for analysis. The profiler reflectivity was converted to accumulated rain; a Z-R relationship appropriate for stratiform rain was used to establish the relationship between the radar reflectivity and the rain rate. The profiler radar constant was changed iteratively, based on comparisons of the estimated profiler rain accumulation and the rain gauge amount, to obtain the calibration constant for the radar. A calibration constant was identified for the wind profiler. It differs by a factor of 5.2 (7.16 dB) from the calibration obtained in a parallel study by Esteban using satellite bright-band reflectivity. After the calibration is verified, data from this profiler can be used in a wider range of applications.

Ricardo J. Rodríguez García

Senior
Escuela Secundaria de la
Universidad de Puerto Rico

MENTORS

RESEARCH
Daniel Adriaansen, NCAR

Improving the current icing potential algorithm through improved reports of METAR precipitation type

Icing is a phenomenon that can affect aircraft performance. It occurs when liquid water in subfreezing temperatures (Supercooled Liquid Water, SLW) quickly freezes upon contact with the aircraft's surface and restricts its maneuverability. In order to aid pilots in better detecting and avoiding areas of potential icing ahead of time, the National Center for Atmospheric Research's (NCAR) Aviation Applications Program (AAP) developed the Current Icing Potential (CIP) algorithm. This algorithm utilizes infrared satellite data, aviation routine weather reports (METARs) and other datasets to create a three dimensional product that diagnoses the icing probability during flight. However, sometimes the CIP algorithm calculates a high icing probability in areas where snow, a less significant threat than freezing rain or other Supercooled Large Drop (SLD) precipitation types, was occurring. This has been traced to an error in the METARs, which sometimes incorrectly report snow as rain in subfreezing temperatures. This research seeks to identify trends in the METARs to create a set of rules that will allow the algorithm to differentiate between correct and incorrect reports. It is anticipated that there will be a correlation between the reported wind speed and/or wind gusts and incorrectly reported precipitation type due to an accelerated hydrometeor fall speed under high wind conditions. The new rules will allow the CIP algorithm to predict icing hazards more accurately, thus allowing for more informed flight plans and efficient flying.

Lauren Sharpe

Senior
Niwot High School

MENTORS

RESEARCH
Rita Roberts, NCAR

Identifying surface and elevated nocturnal thunderstorms in the Southern Great Plains

Warm season thunderstorms and precipitation in the Southern Great Plains of the U.S. often occur after sunset and tend to develop into mesoscale convective systems that track across large regions of the country. Wilson and Roberts (2006) found that approximately fifty percent of these nighttime storms are initiated by cold air outflows known as gust fronts that are produced from downdrafts and outflows of nearby thunderstorms. The cause of the other nocturnal storms are not well understood, but are believed to be generated by elevated forcing. This research is being done in preparation for the Plains Elevated Convection at Night (PECAN) field campaign that will be conducted in 2015 in the Southern Great Plains region. Data collected from a network of radars in the same domain as the PECAN region during the two-week period of June 2 through June 12, 2014, were analyzed in order to identify where nighttime thunderstorms formed and moved. For the period of study, we identified the percentage of storm systems that originated in each state and those that tracked into other states. In addition, the presence of initiators such as bores and gust fronts were documented to determine which storms were surface-based. The objective of this research is to document the percentage of storms that were elevated versus near the surface based; on the presence of bores and gust fronts. This information will assist in examining only the elevated storms to understand what caused them to form and if their locations have been predicted.

A study of predictors of convective initiation across Colorado's Front Range

Rachel Sharpe

Senior
Niwot High School

MENTORS

RESEARCH
Jenny Sun, NCAR

Predicting a storm is not straightforward as there are many factors in the environment that affect and contribute to its production. When using weather radar and software, it is crucial that forecasters understand which indicators best correlate with storms. To better understand these predictors, the pre-storm environment was studied along the Colorado Front Range area from June 23rd to July 23rd, 2014. Data from the Variational Doppler Radar Analysis System (VDRAS) were collected between 2:00 and 7:00 pm on those days when radar reflectivity reached 30dBZ or above, indicating a storm. The VDRAS data were viewed by the software CIDD (Configurable Interactive Data Display) which allowed us to find the storms and record maximum values of relative humidity, CAPE (convective available potential energy), CIN (Convective Inhibition), wind convergence, wind shear, and vertical wind velocity in and surrounding the storm (within a square box of 50km approximately). These data were then used to determine which parameters best indicated a storm. Statistically significant correlations were found between reflectivity and relative humidity, CIN, wind convergence and vertical wind velocity, but no significant correlation with CAPE or wind shear. One reason for the lack of correlation with CAPE or wind shear may be that these two parameters represent the larger scale environment and thus the 50km box is too small to find statistically meaningful correlations. These results will give scientists and forecasters an improved sense of which variables to focus their attention on in order to make the most accurate predictions.

Improving the snowfall distribution pattern inside the NCAR snow machine

Lucas Szewczyk

Junior
Fairview High School

MENTORS

RESEARCH
Scott Landolt, NCAR

Aircraft deicing is critical for winter airport operations and currently there is no reliable way of testing deicing fluids year-round to establish failure times. One approach is to create an indoor artificial snow making system that accurately simulates winter conditions. The Research Applications Laboratory's (RAL) Aviation Applications Program (AAP) has been developing such a system. Many challenges exist related to artificial snowmaking, including creating a consistent distribution pattern of snow over test areas. As part of an effort to improve the indoor simulations, testing has been done on several prototype snow distribution devices. The current prototype utilizes a rectangular acrylic funnel with a hydrophobic coating to help prevent snow buildup to better control the distribution of the snow. Preliminary tests showed that the acrylic shroud was not sufficient by itself; therefore, fans were added to the top of the acrylic funnel to agitate the air within the system to better distribute the snow. Subsequent tests utilizing the fans have shown promising results. While smaller fans proved insufficient, larger fans were able to make a more adequate distribution of the snow. Accurately simulating winter conditions and allowing year-round testing of deicing fluid failure times will prove invaluable in validating the effectiveness of new deicing fluids and will improve aircraft safety in winter conditions.

Comparison of automated and human accuracy at data collection: When does freezing drizzle really occur?

Freezing drizzle is a known hazard for aircraft, which can lead to significant engine damage if not properly detected. Currently, contract weather observers identify freezing drizzle using only visual observations and it is unclear how accurate they are when collecting that data. The Automated Surface Observing Systems (ASOS) have B. F. Goodrich Ice Detectors that identify freezing rain, but NCAR scientists have developed an algorithm to identify freezing drizzle using the same sensor. This investigation evaluates data that was collected visually and compares it to the data that was detected by automated sensors, in order to assess the accuracy of the manual measurements. The data chosen was from the years 2000 to 2009 for the Denver (CO), Des Moines (IA), Akron (OH) and Juneau (AK) ASOS locations using the Goodrich Ice Detectors. The median annual hours of freezing drizzle were calculated for each site and the results were compared against the results found in Cortinas et al., 2004. Cortinas et al. (2004) also plotted occurrences of freezing drizzle as a function of time of day. This study duplicated that technique, which required converting local time of the observation to Normalized Solar Time (NST). The results show that the automated measurements identified many more hours of freezing drizzle at each station than what the manual observations showed. In addition, the peak occurrence of freezing drizzle during the day was similar between the manual and the automated measurements.

Andrea Vázquez

Freshman
Universidad Metropolitana

MENTORS

RESEARCH
Scott Landolt, NCAR

Key to Mentors' Affiliations

BHSU	Black Hills State University
CIRES	Cooperative Institute for Research in Environmental Sciences
CSU	Colorado State University
CU	University of Colorado at Boulder
ESRL	Earth System Research Laboratory
FDLRM	Fond du Lac Band of Lake Superior Chippewa Resource Management Division
ISU	Iowa State University
NCAR	National Center for Atmospheric Research
NCED	National Center for Earth-surface Dynamics
NEON	National Ecological Observatory Network
NOAA	National Oceanic and Atmospheric Administration
SOARS	Significant Opportunities in Atmospheric Research and Sciences
STAR	STEM Teachers and Researchers
UCAR	University Corporation for Atmospheric Research
UCP	UCAR Community Programs
U of A	University of Arizona
U of M	University of Minnesota
UH	University of Hawaii
WHOI	Woods Hole Oceanographic Institution

NEON Intern Madeleine Ball is measuring tarp reflectance for use in airborne spectrometer calibration.

NEON Undergraduate Internship Program

National Science Foundation
The STEM Teacher and Researcher Program (STAR)

SOARS

National Science Foundation,
Directorate for Geosciences, Atmospheric Sciences

National Oceanographic and Atmospheric Administration

National Center for Atmospheric Research

Center for Multi-scale Modeling of Atmospheric Processes
at Colorado State University

University of Colorado at Boulder

University Corporation for Atmospheric Research

Woods Hole Oceanographic Institute

Iowa State University

National Center for Earth-surfce Dynamics

PRECIP

National Center for Atmospheric Research

National Science Foundation

Sistema Universitario Ana G. Méndez

University Corporation for Atmospheric Research

The material is based upon work supported by the National Science Foundation under Grants No. ATM-0618847 (SOARS), and Grant No. EF-1029808 (NEON).

This publication has been printed on recycled-content paper by an environmentally-friendly printer.

STAFF

NEON: Liz Goehring, Kellie Bush

SOARS: Laura Allen, Rebecca Batchelor, Rebecca Haacker-Santos

PRECIP: Scott Landolt, Valerie Sloan, Laura Allen

Authors: NEON, SOARS and PRECIP students and staff

Editors: NEON, SOARS and PRECIP mentors and staff

Photography: UCAR, NCAR, NEON, and Abraham Karam

Design: Eugene Malowany, Malowany Associates

Printing: B&B Printers

SOARS is part of the UCAR Center for Science Education and a registered trademark of the University Corporation for Atmospheric Research.

Earth, Wind, Sea, and Sky is a joint publication of UCAR and NEON.

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On the cover: The cover photo was taken off the Pacific Coast of Mexico during the North American Monsoon Experiment by NCAR scientists which studies the large-scale dynamics of the atmosphere and oceans.

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Woods Hole Oceanographic Institution 1930
Iowa State University

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Undergraduate Internship Program

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