EARTH·WIND·SEA·AND SKY

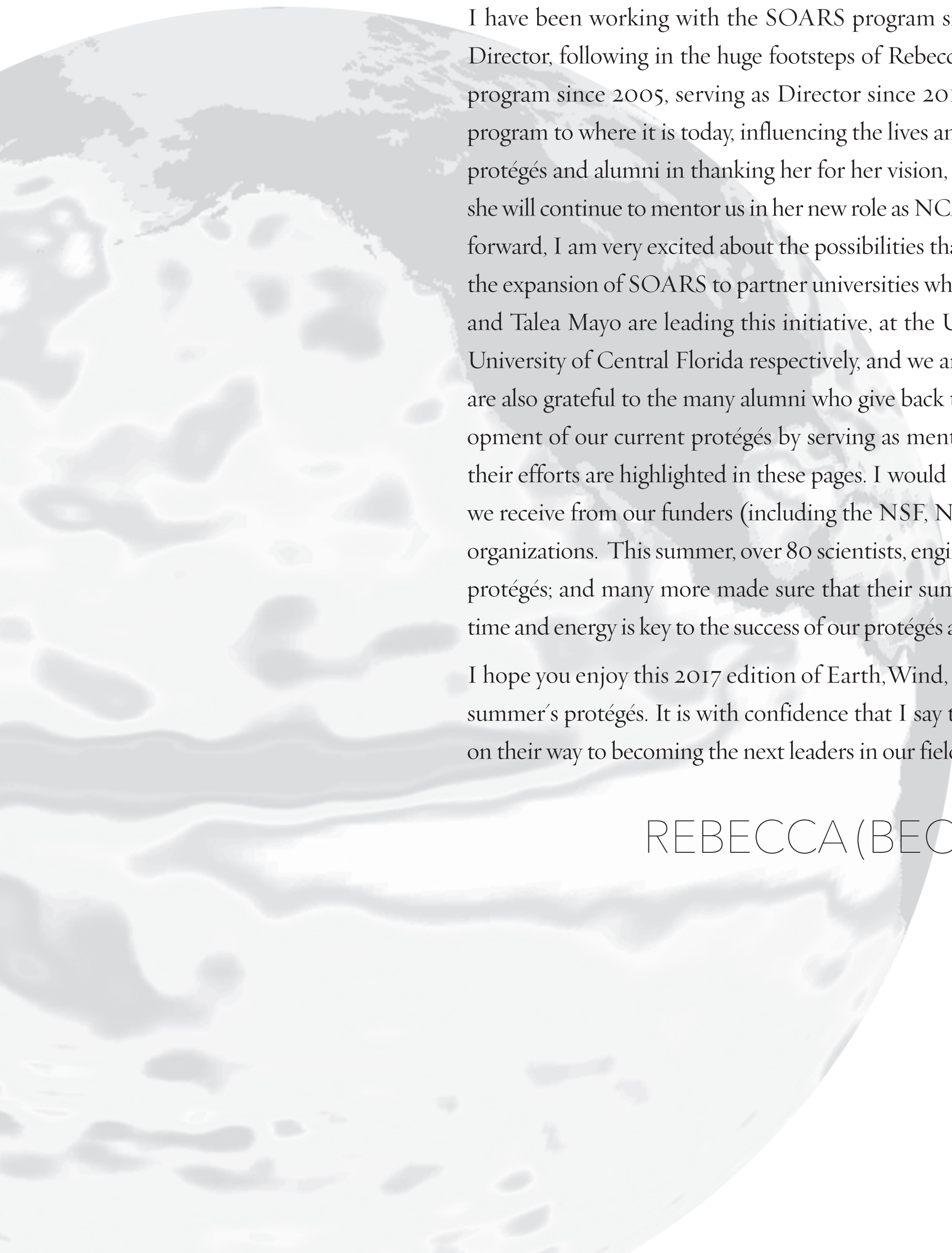
SOARS PROTÉGÉ ABSTRACTS
2017

RESEARCH MENTORING COMMUNITY

Protégé Ebone Smith works with mentors Xiao-Wei Quan and Leslie Hartten to understand rainfall on Kiritimati Island

As we move through a challenging hurricane season, and see increasing reports of climate impacts and new record extreme weather events, the Significant Opportunities in Atmospheric Research and Science (SOARS) program´s mission of increasing the diversity of our field has never been more relevant. The atmospheric and climate sciences include some of the biggest challenges we face as a nation and a planet, and embracing the full talent, voice and experience of our population offers our best chance to solve these critical problems. The vision of the SOARS founders was to create a program where students from traditionally underrepresented groups were holistically supported in advancing their research careers so that they could become the next leaders in our field. Twenty-one years on, their vision is reaching fruition as our alumni step into positions of leadership across government, academia and industry. The combination of strong community, genuine research experience and comprehensive mentoring that makes up the backbone of the SOARS program remains as relevant today as it was then, and we are proud to continue to support their vision of a better future.

EARTH · WIND · SEA · AND SKY



I have been working with the SOARS program since 2011, and in March stepped into the role of Director, following in the huge footsteps of Rebecca Haacker. Rebecca has worked with the SOARS program since 2005, serving as Director since 2011, and in this time has supported and grown the program to where it is today, influencing the lives and careers of so many. I join with all of the SOARS protégés and alumni in thanking her for her vision, dedication and commitment, and am grateful that she will continue to mentor us in her new role as NCAR´s Director of Education and Outreach. Looking forward, I am very excited about the possibilities that have opened up through our alumni, particularly the expansion of SOARS to partner universities where they are now faculty. Professors Deanna Hence and Talea Mayo are leading this initiative, at the University of Illinois Urbana-Champaign and the University of Central Florida respectively, and we are eager to see where this partnership will lead. We are also grateful to the many alumni who give back to SOARS, contributing to the professional development of our current protégés by serving as mentors, panelists, speakers and role-models. Some of their efforts are highlighted in these pages. I would also like to acknowledge the excellent support that we receive from our funders (including the NSF, NOAA, CU, WHOI and UCAR/NCAR) and our organizations. This summer, over 80 scientists, engineers and staff served as mentors and advisors to 24 protégés; and many more made sure that their summers were productive. This huge commitment of time and energy is key to the success of our protégés and our program, and we couldn´t do it without you.

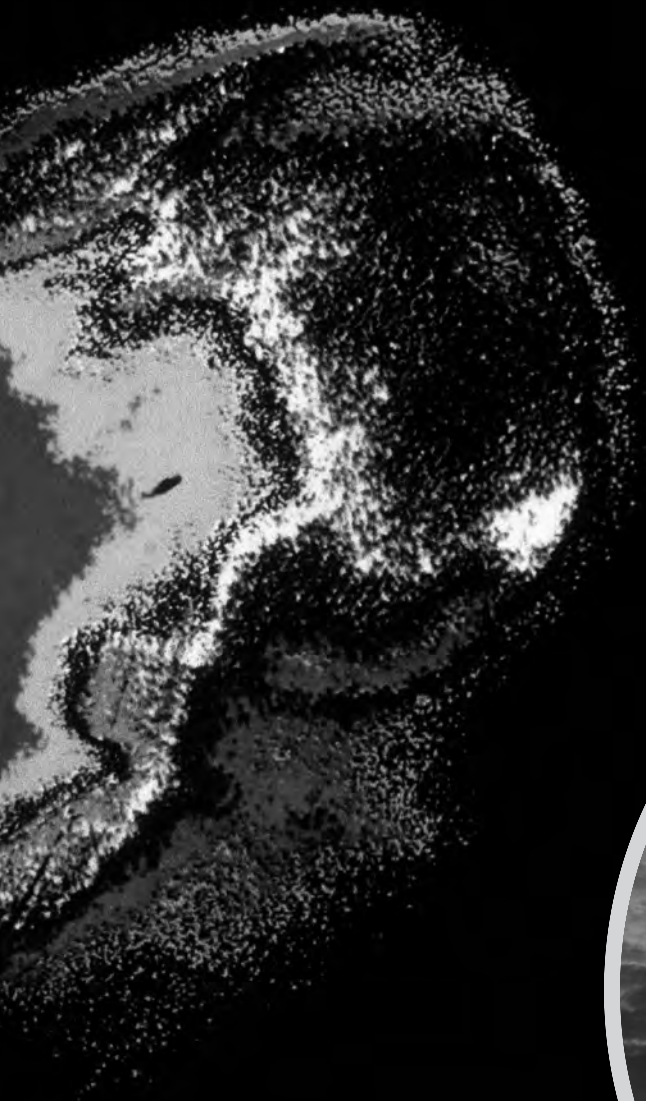
I hope you enjoy this 2017 edition of Earth, Wind, Sea, and Sky, which showcases the research of this summer´s protégés. It is with confidence that I say that these students are inspiring, talented, and well on their way to becoming the next leaders in our field. Thank you for your support.

REBECCA (BEC) BATCHELOR SOARS Director

UCAR/NCAR

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 home of the SOARS program. 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 over 100 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. Institutional support and the mentoring of their scientists, engineers and staff have been a key to the success of the program.

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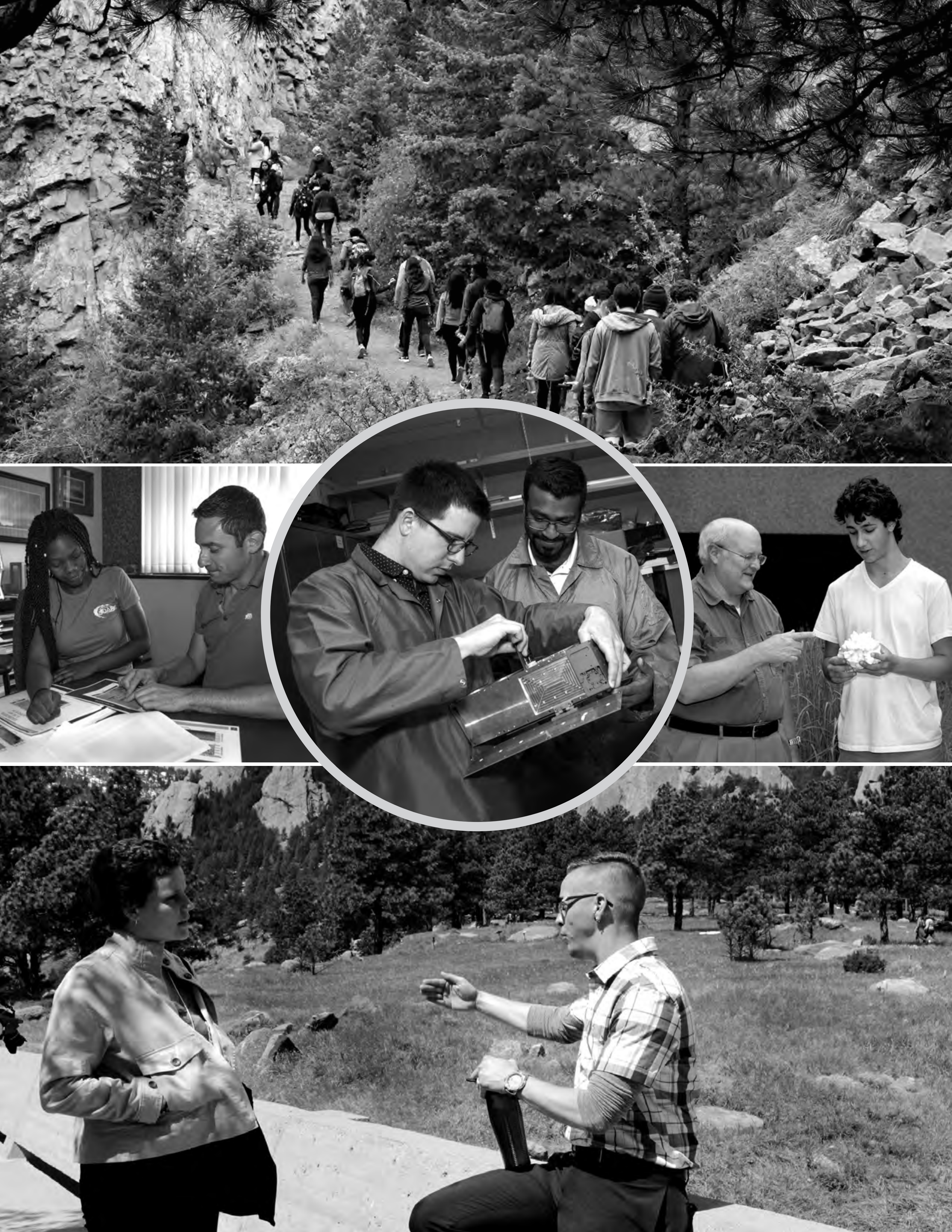
Protégé Jordan Benjamin (left) with mentors Alvaro de la Cámara (center) and Marta Abalos (right), both NCAR postdoctoral fellows.



Significant Opportunities in Atmospheric Research and Science

SOARS is an undergraduate-to-graduate bridge program 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 the National Center for Atmospheric Research (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 summer program includes a weekly communication workshop, data and computing workshops, 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.

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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 on to 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.

Examining the impact of climate change on the stratosphere-troposphere exchange

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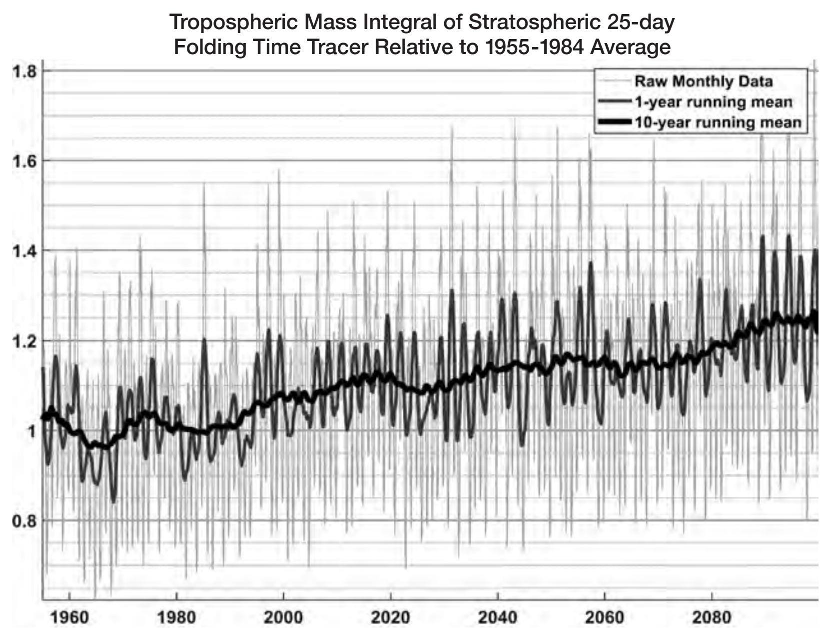
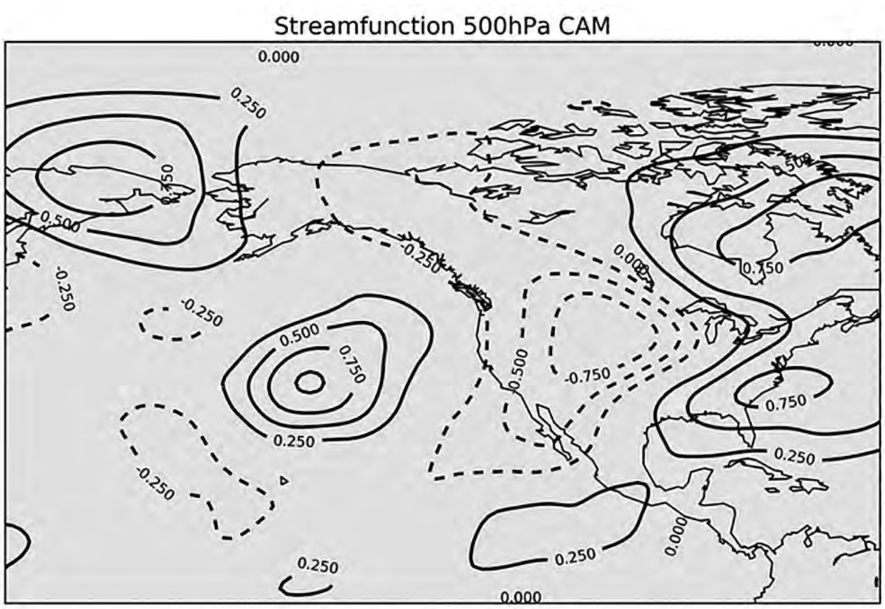
While climate change is predicted to strengthen the stratospheric Brewer-Dobson circulation, the impacts on stratosphere-troposphere exchange (STE) remain uncertain. Understanding the increase in the Brewer-Dobson driven STE contributes to better understanding of the radiative and dynamical balance of the stratosphere and to quantifying future pollution and other hazards from chemical species such as ozone. We sought to quantify these changes in the Whole Atmosphere Community Climate Model (WACCM) REF-C2 ensemble, a full Chemistry Climate Model with simulation of chemical and dynamical processes up to the lower thermosphere. We used monthly output from fully-coupled runs spanning the time period from 1955-2099 under a RCP 6.0 IPCC scenario. We utilized an inert tracer, fixed in concentration above 80 hPa and with an e-folding time of 25 days, to quantify transport while excluding chemical effects. This study focused on the Upper Troposphere/Lower Troposphere (UTLS) region and identified increases in transport across the tropopause, especially in the subtropics. Relative to a 1955-1984 baseline, upper tropospheric annual-mean tracer concentrations increase by as much as 25% by the end of the century, and lower troposphere concentrations by 5-10%, with northern polar regions approaching 15-20%. The max seasonal increases (primarily in boreal autumn/winter) approach 40% in the upper troposphere, 15-20% in the lower troposphere, and 20-30% in the northern polar regions. The tropospheric tracer burden increases by approximately 1.7% per decade, following a significant linear trend. We showed that the greatest concentration increases are primarily controlled by vertical transport through the subtropical tropopause layer, and that these transport-driven increases are also realized by modeled tracers that do include chemical effects such as ozone. Thus, climate change effects a significant strengthening impact on the STE in this model, potentially suggesting meaningful impacts for humans and the climate system.



Tropospheric mass integral of an inert transport tracer relative to a baseline 30-yr mean from 1955-1984. The tracer is fixed in concentration above 80 hPa and has an e-folding time of 25 days.

Analysis of daily timescale surface temperature variability in the Community Atmosphere Model

Extreme temperature events take thousands of lives every year and are a threat to agriculture and the biosphere. Therefore, it is essential that climate models be able to accurately reproduce the statistics of these extreme events and provide accurate predictions for how the probability of extreme events is expected to change in the future. This study analyzed the accuracy of the Community Atmosphere Model 5 (CAM5) in modeling the distribution of extreme temperature events through statistical analysis and comparisons with the MERRA-2 reanalysis. In regions where CAM was deficient in its representation of daily temperature variability, the dynamical processes that underlie the variability in these regions were contrasted and compared between CAM5 and MERRA-2 in order to understand the reason for these deficiencies. In particular, it was found that the variance of daily timescale surface temperatures in the winter season (December/January/February) over northwest North America in CAM were considerably higher than in MERRA-2. This large variance seems to be due, in large part, to strong circulation anomalies in the model. This leads to a stronger temperature gradient from north to south in the region of interest, which results in increased advection of cold air from the north into the northwestern part of North America.



The average deseasonalized eddy stream function for a composite of extreme cold days between 1980 and 2005, at 500hPa, in northwestern North America for the Community Atmosphere Model 5.

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Forecast verification of the 2017 Lake Oroville flooding using the National Water Model

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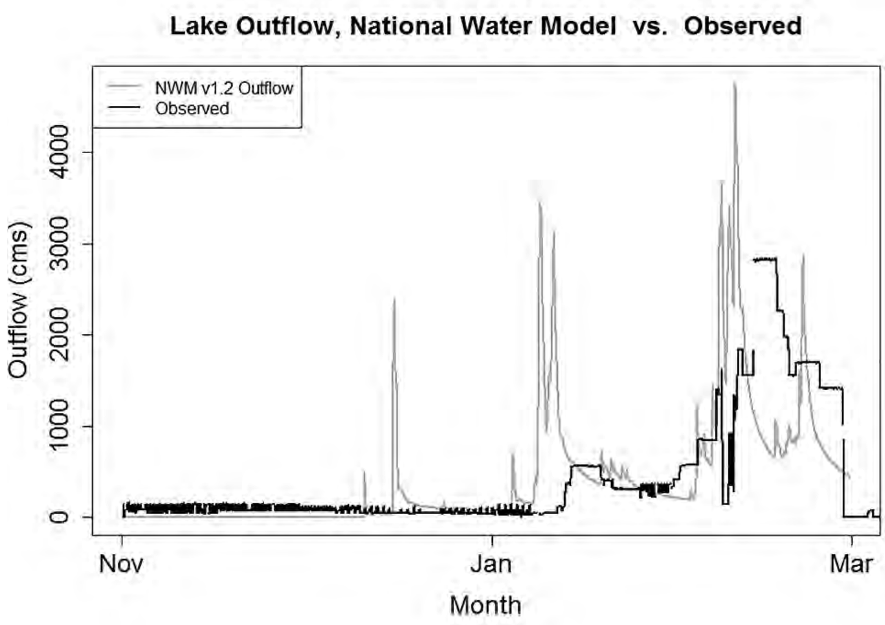
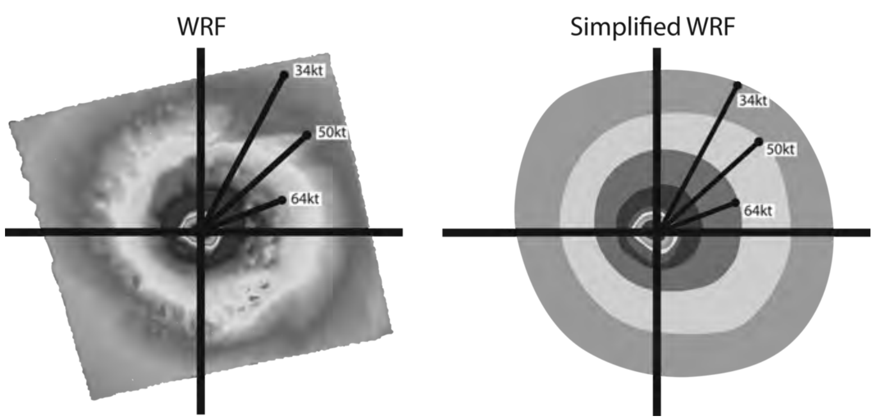
Northern California experienced multiple heavy precipitation events in early 2017, filling the Lake Oroville reservoir to near maximum storage. Officials became increasingly concerned over the emergency spillway potentially failing due to erosion, which would send large volumes of water downstream, effectively flooding the nearby communities. The National Water Model (NWM) forecasts streamflow nationwide and went operational in late 2016, presenting a unique opportunity to compare modeled to observed streamflow for this event. This research involved comparing subsequent versions (1.1 and 1.2) of the model to assess if either accurately captured the flooding experienced at Lake Oroville. Multiple types of data such as inflow, outflow, and reservoir elevation pertaining to Lake Oroville from the California Data Exchange Center (CDEC) and discharge data from the Thermalito Afterbay (THA) gage were assessed against NWM outputs for version 1.1 and 1.2. Statistics were computed to test simulated versus CDEC and THA observed flow and showed relatively good agreement between the model and the observations for lake inflows. Data analysis indicated that NWM was able to forecast similar inflow peaks and peak timing to observed measurements, although outflows and lake levels were not well represented by the model. This research highlighted opportunities for the improved representation of reservoirs in NWM, which would increase the accuracy of flood forecasts in the many communities affected by reservoir management.



Forecasted outflow from version 1.2 of the National Water Model compared to the observed outflow from the California Data Exchange Center. The black line represents the observed lake discharges, and the gray line indicates modeled lake outflow.

A comparison of ADCIRC storm surge predictions given different forcing inputs

In September of 2008, Hurricane Ike swept across the Gulf of Mexico and hit the coast of Galveston, Texas causing high storm surges that led to billions of dollars in damage and killed hundreds of people. Predicting storm surges is difficult, due to limits in computational ability and forecasting errors, which hinders emergency evacuations and preparation. Simulations of Hurricane Ike were used to better understand the usefulness of different methods of constructing and imposing the storm in the surge model environment in an attempt to explore the resulting surge and to increase predictive abilities. The ADvanced CIRCulation (ADCIRC) model was forced with two different representations of the storm, both originating from forecast data generated with the Weather Research and Forecasting model (WRF). The comparison was made between the storm surge simulations forced with the full WRF wind and pressure fields, and a simplified storm approximation constructed from the WRF data, partly developed in this work. The simplified approach used for forcing, developed here, was obtained by measuring the nautical distance from the center of the hurricane, at 6 hour intervals, for the maximum extent of the 34-, 50-, 64-knot, and strongest winds. Differences were found among the resulting storm surges, most noticeably in the points of inundation near where the storm made landfall. Given further investigation, the simplified storm model may produce results more consistent with WRF, but currently the complicated WRF model is a better tool for determining where evacuation and emergency preparation efforts should be focused.



To create the simplified WRF model, the maximum extent of the 34-, 50-, 64-knot, and strongest winds were measured manually from the center of the storm. This figure illustrates the process of measurement for one quadrant of the storm.

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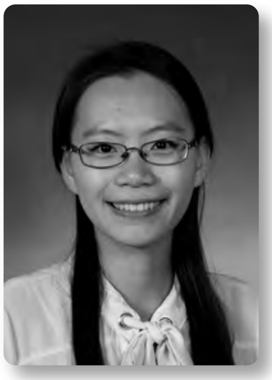
Impact of terrain resolution on precipitation formation in a simulated orographic cloud



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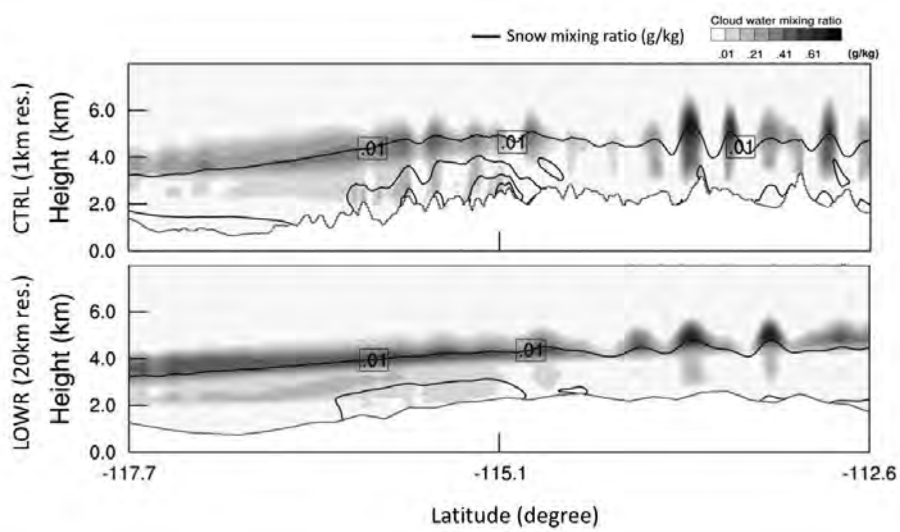
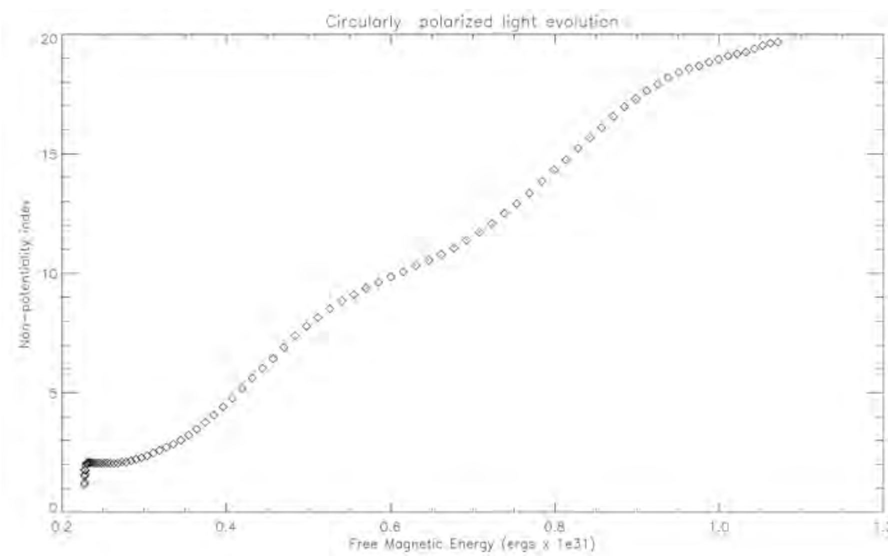
Orographic precipitation is the primary water resource in the western United States. Snowmelt from orographic precipitation in the mountains of Idaho powers over a dozen hydroelectric power plants and irrigates over 2 million acres of land. Although advances have been made in understanding orographic precipitation formation and associated cloud microphysics, investigations on the relationship between precipitation and complex terrain on a fine grid scale are still limited. This research aims to better understand the impact of terrain height on orographic clouds and their subsequent precipitation formation using a high-resolution simulation (0.9 km grid spacing) of the Weather Research and Forecasting (WRF) model. This modeling study is based on a case from the Seeded and Natural Orographic Wintertime clouds: the Idaho Experiment (SNOWIE) field campaign that occurred on 31 January 2017. In this case, a shallow cloud formed with an abundance of supercooled liquid water and strong westerly winds, which were over 33 $m \cdot s^{-1}$ at around 4875 m. Modifications were made to the resolution of the WRF topography to explore the role of terrain on the formation of natural orographic precipitation in this case. The results show precipitation was generally less in the lower topography resolution (LOWR, about 20 km) case while more precipitation and clouds over mountains were present in the default topography resolution (about 1km) case. Notably, a broad layered cloud with higher supercooled liquid water content upwind of mountains was present in the LOWR case.



West-east vertical cross section of cloud mass mixing ratio ($g \cdot kg^{-1}$) in filled contours and snow mass mixing ratio ($g \cdot kg^{-1}$) in line contours at 2315 UTC 31 January 2017. Both panels have 0.9 km grid spacing. The upper panel has terrain resolution of 1 km while the lower panel has terrain resolution of 20 km.

New coronal magnetic field energy diagnostic to enhance space weather predictions

Solar driven space weather events pose a threat to space-bound and terrestrial technology that our society relies on daily. These events are driven by instability in the solar atmosphere, often related to the non-potentiality of the coronal magnetic field, which is linked to higher energy storage in the magnetic field. Energy is stored in the magnetic field through plasma dynamics of the lower boundaries of the solar atmosphere, twisting and stressing the magnetic field as it emerges into the corona. Coronal mass ejection prediction (CME) diagnostics to date have focused on key features of the lower magnetic boundary and loops in solar active regions. In this study, we developed a novel approach of predicting CMEs by examining the connection between instability in the upper solar atmosphere, the non-potentiality of the coronal magnetic field, and polarimetric observations of the coronal magnetic field. We used simulated polarimetric observations in the infrared 10747 iron (Fe) spectral line to analyze topological features of the coronal magnetic field. These observations consisted of linearly and circularly polarized light intensities. We examined the key topological features of non-potentiality found in the observations, and the sensitivity of telescopes like NCAR's Coronal Multi-channel Polarimeter (CoMP) to these features. We developed a new CoMP diagnostic of non-potentiality from polarimetric observations that correlates with free magnetic energy.



Non-potentiality index of circularly polarized light (Stokes V/I) evolving as the magnetic energy changes in the coronal magnetic field. Pseudo-observation (diamonds) are from a simulated flux rope emerging to the corona, which leads to a solar eruption (CME).

Marcel F. Corchado Albelo

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Protégés are pictured left to right: **Front Row** Jamin Rader, Arianna Varuolo-Clarke, Gabriela Negrete Garcia, Shaowen (Amy) Chen, Kimberly Brothers, Jaylond Harvey, Rosa Vargas-Martes, Briah Davis, Ebone Smith
Middle Row Keon Gibson, William Evonosky, Nkosi Muse, Brittany Welch, Colette Brown
Back Row Ryder Fox, Jeremiah Piersante, Shay Gilpin, Pedro Brea, Tony Hurt, Keenan Eure, Jordan Benjamin, Marcel Corchado Albelo

PHOTO BY CARLYE CALVIN


Atmospheric Science
3915A Laporte Avenue
SOARS Colloquium
2017
UCAR

Visualizing in Python: Analyzing GOES 16 data sets in the cloud

BRIAH' DAVIS

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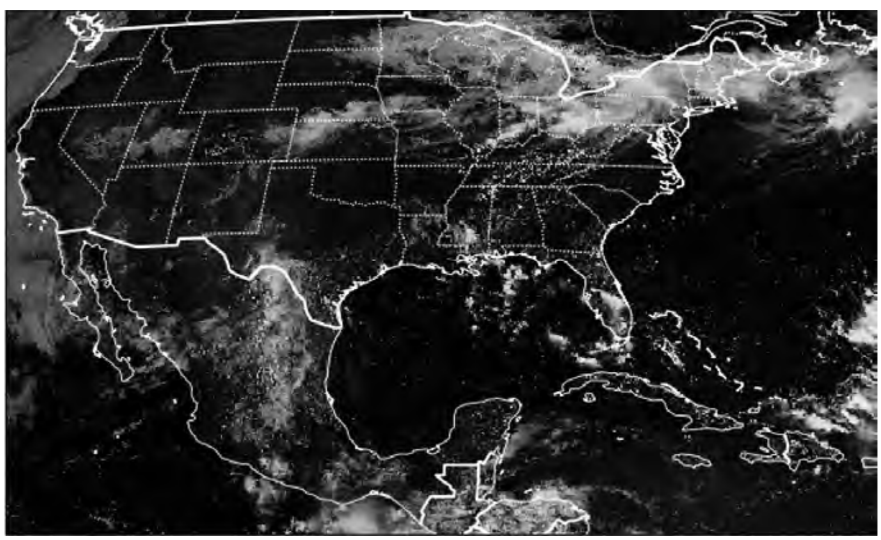
Brittany Welch

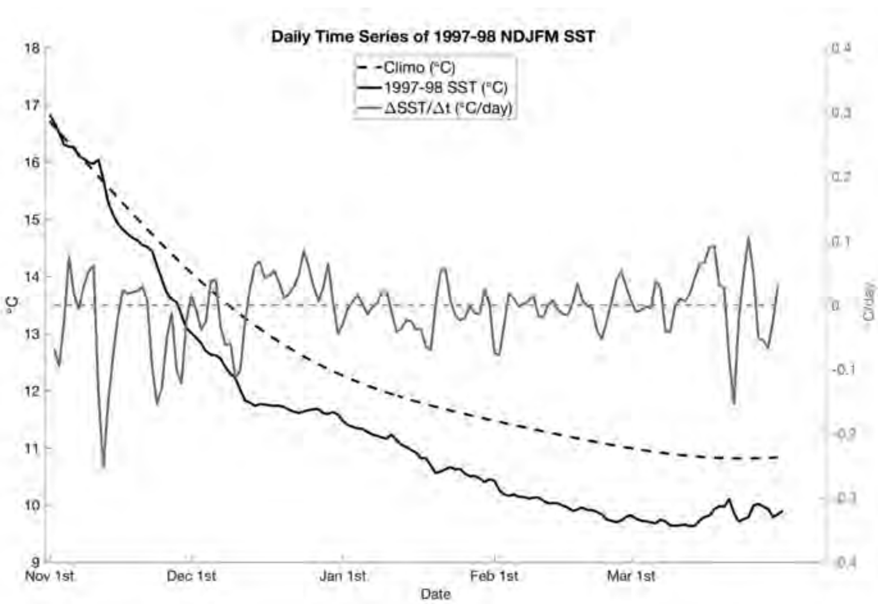
While the geostationary operational environmental satellite known as GOES 16 is still in its experimental phase, it is clear it will provide the scientific community with a unique opportunity to observe never before seen phenomena. With improved spectral information, spatial resolution, and coverage speed over the current GOES satellite (GOES 13), GOES 16 is better able to resolve more meteorological features and thus improve the way forecasts are made and potentially enhance the quality of research results. Boasting 6 different sensors in areas relating to the earth, the sun, and space, GOES 16 produces roughly a terabyte of data a day. This proves difficult to analyze because of the inability to efficiently move such immense amounts of data. Generating the analysis where the data sets are located and transferring the resulting visualizations consumes less financial and computing resources than moving the data alone. Thus, utilizing data-proximate analysis by creating visualizations within the cloud environment the data is stored in significantly reduces the cost and network traffic associated with analyzing the large volume of data produced daily by the satellite. Archiving this process within a Jupyter notebook lends the convenience of neighboring the code alongside its analysis, and will allow the notebook to serve as a reference on data-proximate analysis and conducting meteorological analysis on large data sets. Once generated the Jupyter notebook also functions as a resource, with several blocks of code that can be adapted to the needs of various studies and research projects within the meteorological community.



GOES-16 experimental data visualized using datasets taken from the Advanced Baseline Imager (ABI) instrument on the satellite. The image shows the top of the atmosphere outgoing radiance per unit wavelength taken over the Continental United States in the visible "Red" band (Channel 2) at July 13, 2017 16:02:19.8Z.

The influence of ENSO on the North Pacific Ocean through daily weather changes

During El Niño-Southern Oscillation (ENSO) events, enhanced convection in the equatorial Pacific creates a wave pattern over the Pacific-North America (PNA) region. The associated changes in winds, temperatures, and moisture foster atmospheric forcing on the North Pacific Ocean, which induce sea surface temperature (SST) anomalies, especially during winter. This atmospheric connection between two ocean basins, termed the "atmospheric bridge," has been well documented on seasonal and monthly time scales, so this research investigated the North Pacific Ocean's response to the atmospheric bridge on daily time scales during two strong ENSO winters. November through March of 1997-98 and 2015-16 were analyzed using daily Climate Forecast System Reanalysis (CFSR) anomaly data for sea level pressure, SSTs, surface wind, latent and sensible heat flux, sea level pressure, and 500 mb geopotential height. The daily SST tendency was calculated throughout both seasons, since forcings affect the SST tendency directly. Using a threshold of one standard deviation below the average daily SST tendency over both seasons, composites of the above variables were analyzed for days meeting this criterion. SST tendency had a particularly high dependency on latent heat flux. The days included in the composites accounted for 125 % of the cooling that occurred over the 1997-98 season, whereas 70% of the cooling over the 2015-16 season occurred during days included in the composite, highlighting differences between ENSO events.



Time series of the 1997-98 season's daily SSTs over the box (solid black line) overlaid with climatological averages (dashed black line) and SST anomaly tendencies (solid gray line), with a reference line (dashed gray line) at 0°C/day.

Keenan C. Eure

1st-year Protégé
Senior
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INSPIRESat-1: Science expectations for an ionosphere exploring Cubesat

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3rd-year Protégé
Graduate Student
University of Colorado Boulder
Aerospace Engineering

MENTORS

RESEARCH
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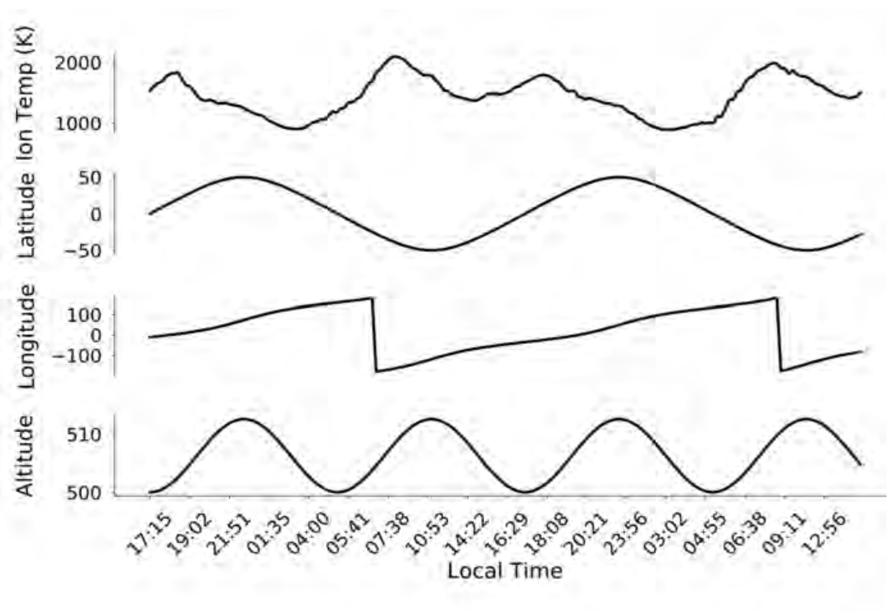
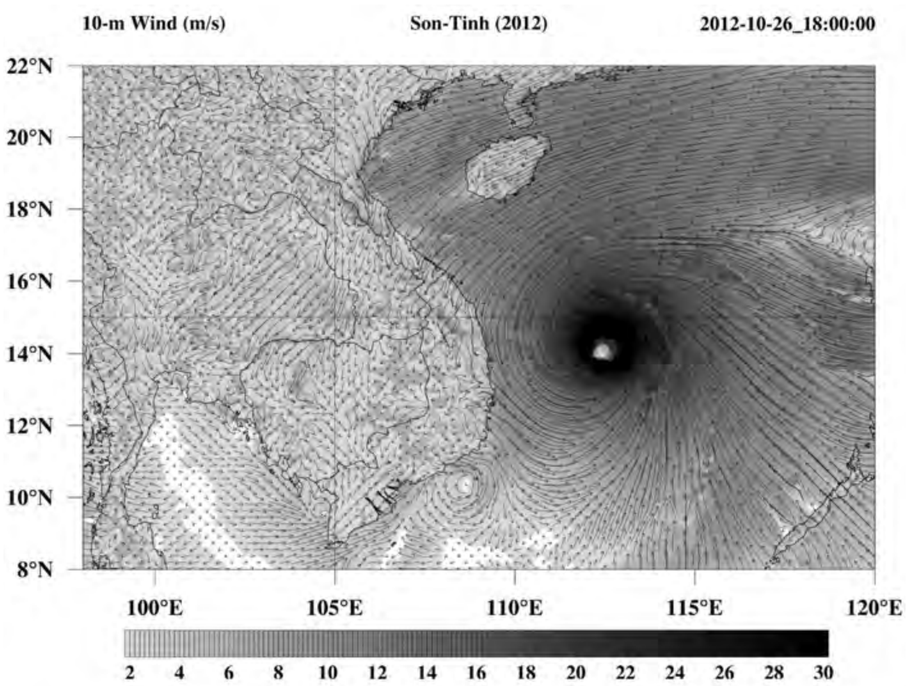
The International Satellite Program in Research and Education's first satellite (INSPIRESat-1) is a 3U ionosphere exploring cubesat carrying the compact ionosphere probe (CIP). The INSPIRESat-1 CIP will measure ion temperature, composition, drift velocity, and density as well as electron temperature in an expected orbit of 500 km and 50° inclination. The mission is slated for launch with the Indian Space Research Organization (ISRO) in 2019. The primary science objectives are to better understand the morphology of nighttime small-scale plasma irregularities and to investigate the latitudinal extent of the midnight temperature maximum (MTM). In this study, the capability of the INSPIRESat-1 to study the MTM was analyzed by sampling simulation results from the coupled Whole Atmosphere Model (one of the few models capable of producing the MTM) and Global Ionosphere Plasmasphere model at the expected orbit. The simulated satellite data were examined by plotting global data coverages and individual measurements through a few orbits to determine the extent to which the INSPIRESat-1 will be able to resolve the MTM or not.



Top to bottom: Ion temperature from a one-day WAM-GIP simulation sampled over the expected orbit, satellite latitude, longitude, and altitude all as functions of local time.

Evaluating tropical cyclones simulated by a global convection-permitting model

Global models traditionally have low resolutions (~15 km) that impede accurate tropical cyclone intensity forecasts. Recent breakthroughs in global convection-permitting numerical weather prediction models have led to cost-efficient, high-resolution forecasts at the global scale. While numerous studies have examined the predictive skill of tropical cyclones in coarse resolution global models, few have investigated their predictive skill at convection-permitting resolutions. For this study, a 20-day long simulation was produced with the Model for Prediction Across Scales (MPAS) using a globally uniform 4-km resolution mesh. The tropical cyclones simulated in eight tropical cyclone basins during this period were compared against observations. Specifically, the Geophysical Fluid Dynamics Laboratory Vortex Tracker was adapted to this high-resolution run to determine MPAS's forecast skill with regard to tropical cyclone track and intensity. It was found that MPAS tends to spin up more cyclones than observed (4 hits, 2 misses, and 18 false alarms). While reproducing the intensity of Typhoon Son-Tinh (2012), the model tends to over intensify the cyclones it captured in the Indian Ocean. These biases indicate that MPAS needs to be improved to provide accurate tropical cyclone forecasts at convection-permitting resolution.



MPAS simulation of Son-Tinh (2012) preceding maximum intensity. Son-Tin was well forecast by MPAS, including track, timing, and intensity. The storm's peak intensity was predicted hours earlier and at most its track varied by five degrees.

K. Ryder Fox

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There is something unique about field work. The opportunity to apply your skills and knowledge; the close quarters; the thrill of learning something new or experiencing an event in a whole new way. SOARS is excited to continue to support our protégés in getting "in the field."

SOARS IN THE FIELD

SNOWIE

Over three months this winter, aircraft and Doppler on Wheels (DOWs) sampled the skies above Idaho's Payette Mountains as part of Seeded and Natural Orographic Wintertime clouds: the Idaho Experiment (SNOWIE). To better understand the processes involved in wintertime orographic precipitation and whether cloud seeding has influence, a team of over 50 scientists sampled seeded and non-seeded storms using a variety of instrumentation.

SOARS alum **Sarah Tessendorf** (2001-2002) is one of SNOWIE's principal investigators. She was joined in the field for a week each by two of our protégés, **Shaowen (Amy) Chen**, now a graduate student at the University of Illinois at Urbana-Champaign, and New Mexico Tech undergraduate, **Ryder Fox** (as well as a large number of other students from participating institutions). Ryder provided base support for the operations team by monitoring real-time flights and atmospheric variables and was inspired by the team effort. *"I am impressed by the collaborations, forethought, research questions, and operational skill involved in the field campaign"*, says Ryder. During Shaowen's time in Idaho, she sampled the storm environment by launching weather balloons. The experience was phenomenal, she says, *"You don't learn everything in a classroom so it's really unique, but also challenging because you're not in a typical classroom setting!"*

Over the summer, Shaowen brought this real life experience back to the lab, working with Sarah and **Lulin Xue** in NCAR's Research Applications Laboratory to apply modeling techniques to better understand the observations made in the field. Her research, "Impact of terrain resolution on precipitation formation in a simulated orographic cloud" (page 07) focuses on a case study from SNOWIE.

We gratefully acknowledge the contribution of Sarah Lee (SOARS 2012-2014) to this story.

SOARS protégé and Jackson State University undergraduate **Keon Gibson** spent the summer working with NCAR's High Altitude Observatory researchers **Steve Tomczyk** and **Scott Sewell** to develop a telescope mount and observing system that would use two NASA-funded cameras to measure the solar corona in the ~ 2 minutes of totality during August's total solar eclipse (see abstract on page 17). SOARS was happy to support him to join his mentors in running the instrument from Wyoming during the event. Thankfully the weather cooperated, and his telescope mount and cameras all worked. He says the experience was "incredible," and a highlight was having the opportunity to talk with and hear the stories of the other scientists who were at the camp with him. Keon says that though he really enjoys meteorology, he was so thankful that he had taken the opportunity to get involved with this project, as he has discovered a new passion for space weather and astronomy. He encourages others to be willing to *"try out something new, as you never know where it will lead you."* He says *"I just threw myself out there and discovered a whole new field."* Keon is continuing to work with the HAO team as they process and publish the results of the observations. His photos (taken with his own camera, through a telescope) are profiled on the cover of this edition of EWSS, and were also shared on NASA's Eclipse Imagery page: https://svs.gsfc.nasa.gov/12704 and in *Science News*: https://www.sciencenews.org/article/wyoming-eclipse-physics-corona

Far left: Shaowen (Amy) Chen (right) and a fellow student prepare a balloon launch at the base of the Payette Mountains. PHOTO BY SHAOWEN (AMY) CHEN

Left: Sarah Tessendorf and Ryder Fox prepare a briefing for the SNOWIE operations team. PHOTO BY SARAH TESSENDORF

Above: Mentors Steve Tomczyk (left) and Scott Sewell (center) discuss the telescope with protégé Keon Gibson (right). PHOTO BY CARLYE CALVIN

Circle: Keon Gibson making measurements of the solar corona during the eclipse on August 21st. PHOTO BY PAUL BRYANS

Measuring solar coronal magnetism during the total solar eclipse of 2017

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WRITING & COMMUNICATION
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PEER
Marcel Corchado Albelo

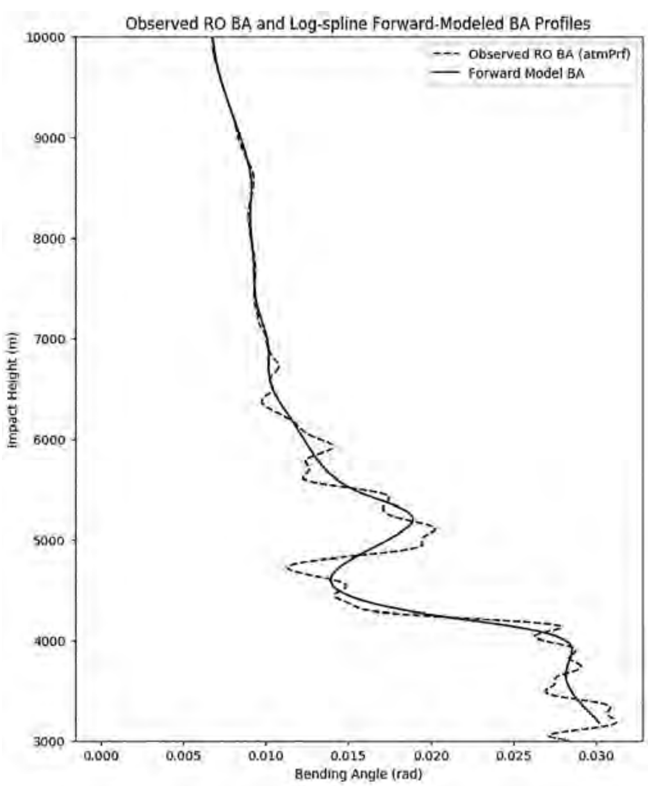
The total solar eclipse on August 21, 2017 provided a notable opportunity to measure the solar corona at specific emission wavelengths to gain information about coronal magnetic fields. Solar magnetic fields are intimately related to the generation of space weather and its effects on the earth, and the infrared imaging and polarization information collected on coronal emission lines here will enhance the scientific value of several other ongoing experiments, as well as benefit the astrophysics and upper atmosphere communities. Coronal measurements were collected during the 2 minute and 24 second totality period from Casper Mountain, WY. Computer-controlled telescopes automatically inserted four different narrow band pass filters to capture images in the visible range on a 4D PolCam, and in the infrared range on the FLIR 8501c camera. Each band pass filter selected a specific wavelength range that corresponded to a known coronal emission line possessing magnetic sensitivity. The 4D PolCam incorporated a novel grid of linear polarizers precisely aligned with the micron scale pixels. This allowed for direct measurement of the degree of linear polarization in a very small instrument with no external moving parts as is typically required. The FLIR offered short exposure times to freeze motion and output accurate thermal measurements. This allowed a new observation of the sun's corona using thermal infrared technology.

The sun's corona during the August 21st, 2017 total solar eclipse.

Calculation of radio occultation bending angles from models: Sensitivity to vertical interpolation and filtering methods

Radio occultation (RO) is a remote sensing method that provides vertical profiles of atmospheric properties. RO retrieves bending angles (BA) of radio wave trajectories traversing the atmosphere between two satellites. The BA profiles can be directly assimilated into numerical weather prediction (NWP) models with a demonstrated positive impact on NWP forecasts. Since BA are not variables analyzed and predicted by NWP models, a forward model must be used to compute BA from model variables (temperature, water vapor, and pressure) to compare with the observed BA in the data assimilation process. The forward model requires vertical differentiation of refractivity, which is specified on a relatively sparse vertical grid. Accurate differentiation requires interpolation of refractivity from the low-resolution model grid to a high-resolution computational grid. In contrast, the RO observed BA, which are observed on a relatively high-resolution grid, require filtering before comparison to the forward-modeled BA to reduce possible aliasing effects. Thus, interpolation and filtering are important steps in the data assimilation process.

In this study, we tested four interpolation schemes (linear, log-linear, log-spline, and log-cubic) from an arbitrary model grid to a high-resolution computational grid to investigate the sensitivity to vertical interpolation and filtering and determine an optimum method that can be applied to any model grid. The forward-modeled BA are compared to observed BA, which are low-pass filtered with a resolution consistent with the model grid. Preliminary tests indicate log-spline interpolation minimizes differences between the forward modeled and observed BA relative to other interpolation methods.



Observed RO BA profile (dashed) and computed BA using a forward model (solid) up to 10 km impact height. The observed RO BA contains high-frequencies models cannot resolve, whereas the forward-modeled BA are filtered to model resolution while preserving the low-frequency structure very similar to the observed BA profile.

Shay Gilpin

2nd-year Protégé
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WRITING & COMMUNICATION
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research | mentoring | community
SOARS®

Exploring the capabilities of the CHM 15k ceilometer to detect icing conditions within clouds

Jaylond Harvey

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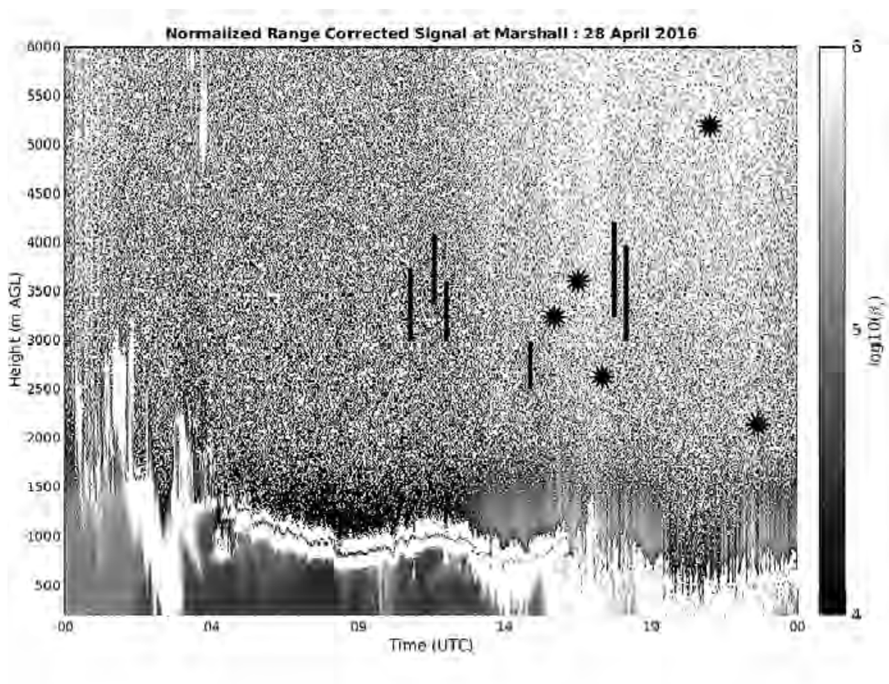
Aircraft icing is a known hazard in the aviation field that results from supercooled liquid water in clouds impacting aircraft surfaces. Detecting icing conditions is an important step in keeping aircraft out of harm's way. However, detecting icing conditions aloft can be difficult. In this study, data from a Lufft CHM15k ceilometer were analyzed to determine if the sensor could detect icing conditions aloft. A CNR1 solar radiation sensor was used to determine cloudy days and a GEONOR 600mm precipitation gauge was used to identify precipitation events on the cloudy days. Each case identified from these sensors was categorized into the days considered for the precipitating, non-precipitating and null case events for this study. PIREPs (pilot reports) are used to provide air traffic control and other pilots with a variety of information including encountered weather type, icing severity, altitude, and date/time of occurrence. The relevant information from PIREPs were compared against the ceilometer data to investigate whether the ceilometer identified any evidence of icing conditions aloft. The ceilometer data were plotted as a function of time and the raw signal return data was analyzed to determine if there was any information in the signal that might indicate icing conditions in the atmosphere. The time period analyzed was from 1 August 2015 to 12 June 2017. It is evident that the CHM 15k ceilometer has some potential skill in detecting icing conditions but more research is still needed.



Raw signal from a CHM 15k ceilometer with PIREP locations (*) and altitude ranges (vertical bars) overlain for a case study from 28 April 2016.

Examining diurnal variability across the equatorial Pacific basin associated with ENSO

TONY O. HURT, JR.

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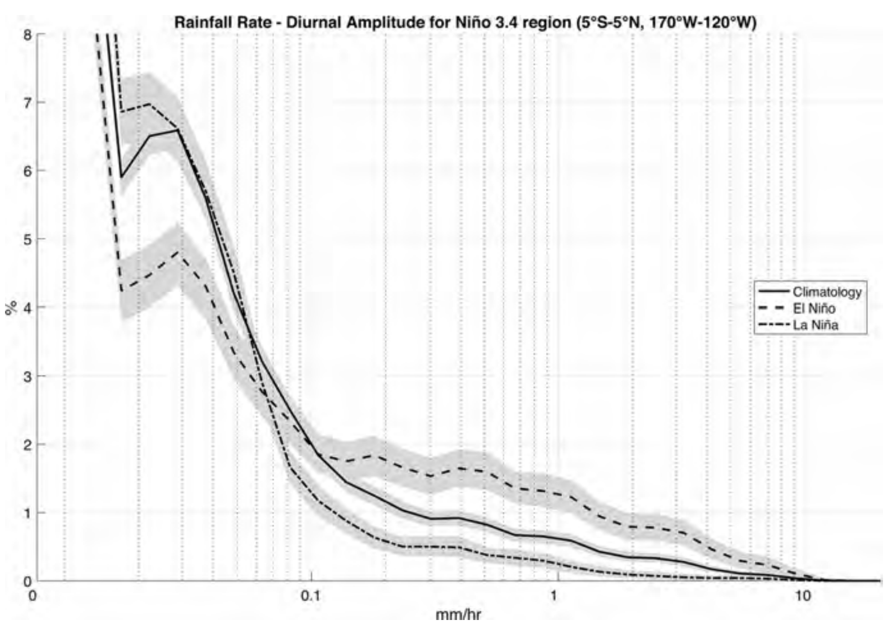
PEER
Keenan Eure
Ebone Smith

Many questions remain regarding driving mechanisms behind the diurnal cycle across ocean basins and factors that influence it. Advancements in weather and climate predictability are closely related to improved accuracy of diurnal cycle depiction in numerical models, and the proliferation of atmospheric observation tools such as satellites and buoys during recent decades has enabled increasingly detailed research. The Global Tropical Moored Buoy Array (GTMBA) is one such tool that presents a unique advantage in analysis of the relationship between diurnal cycle variability and large-scale climate variations such as El Niño – Southern Oscillation (ENSO), largely due to the temporal resolution of its collected data. This study examines diurnal variability of selected atmospheric variables, notably rainfall, across the equatorial Pacific basin during the December through February (DJF) seasonal period from 1998 through 2012. Daily mean, diurnal amplitude and phase were calculated for each variable using GTMBA data, along with probability distributions of amplitude and phase. Air and sea-surface temperature, relative humidity and surface winds were also examined to evaluate potential contributions to the diurnal variability of rainfall. Analysis indicated increased frequency of heavier rainfall during ENSO warm phase (El Niño) events as suggested by larger diurnal amplitude and greater variability in observed rainfall rates across the central Pacific basin, while diurnal phase exhibited a large degree of variability across the basin regardless of ENSO phase. Comparison of buoy rainfall measurements against microwave satellite rainfall measurements was also conducted, with similarities in characteristics of diurnal amplitude and phase observed in both.



Probability distribution (95% confidence interval shaded) of diurnal amplitude for DJF hourly rainfall rate data obtained via GTMBA within Niño 3.4 region from 1998 through 2012.

The SOARS Legacy:

Top: SOARS career panel with **Matthew Coleman** (2002-2004, now at Nephila Advisors, left), **Aaron Piña** (2010-2011, now at Aeris, right) and **Shanna Pitter** (2001-2002, now at the National Weather Service, on screen).

Left: **Dana Pauzauskie** (2008-2010) sharing her career path and introducing a talk on the wisdom of the Lakota Nation.

Left circle: **Deanna Hence** (2003-2004, now at the University of Illinois at Urbana-Champaign) discusses "Diversity in Academia" with protégés.

Right circle: **Marcus Walter** (2007-2009, now at WeatherNation) discusses communicating severe weather to the public, through a Google hangout, with SOARS protégés.

Bottom: 2017 SOARS protégés with **Dereka Carroll** (2010-2013, now at Jackson State University and a graduate student at UIUC, 7th from right) following her presentation "If it happened in…A pseudo-global warming assessment of tropical cyclone tornadoes" and discussion on incorporating societal impacts in your work.

PHOTOS BY REBECCA BATCHELOR

Alumni Giving Back

Evaluating high-resolution CESM hurricane climatology of the North Atlantic: Comparing model landfalls to observational landfalls

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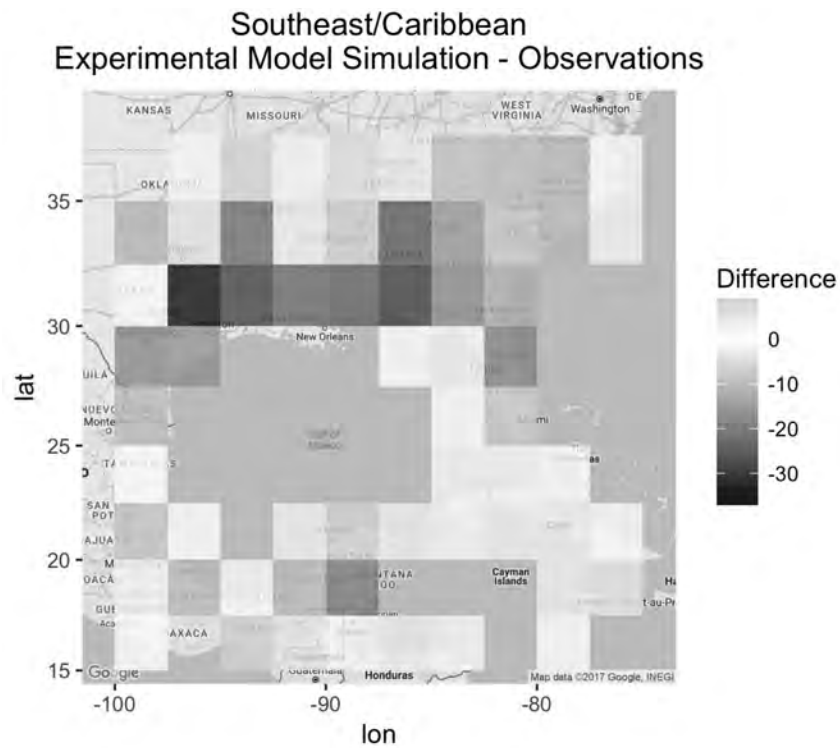
PEER
Pedro Brea

In areas where human civilization is most vulnerable, the impact of the massive storms known as tropical cyclones can be devastating and linger for generations. One way to mitigate the impact of tropical cyclones is by refining models that have the ability to predict their development and course. Using a high-resolution (28 km) version of the Community Earth System Model (CESM), the CESM's simulations of hurricane climatology can be evaluated utilizing sea surface temperature observations coupled with a free running atmospheric model. Between 1979 and 2012, a 34-year period, three model ensemble member outputs were compared to actual observations of tropical cyclones. This allowed for analysis of quantitative and qualitative differences between the National Hurricane Center's Hurricane Reanalysis Database (HURDAT) observation data and objectively tracked CESM tropical cyclones. Storm landfall and trajectory points were filtered by surface elevation to only include storms making landfall over land 50 meters above sea level in the final analysis. Storms were also filtered by intensity and time frame to see how the model simulates stronger storms and when the model performs best. Upon breaking the western North Atlantic Ocean into two regions, it was visible that along the coastline of the northeast United States the model did well or underpredicted tropical cyclone landfalls. In the southeast United States, as well as around the Gulf of Mexico and in the Caribbean, the model overpredicted tropical cyclone impacts. The differences between observations and model simulations were enhanced when looking only at storms that could be categorized as hurricanes in both regions.



The difference between CESM landfalls and observational landfalls along the Southeast United States, the Gulf of Mexico, and the Caribbean.

Southern Ocean acidification: Assessing vulnerability

Models project that with current CO_2 emission rates the Southern Ocean surface will be undersaturated with respect to aragonite and calcite by the end of the 21st century resulting in widespread impacts on biogeochemistry and the ocean ecosystem. However, accurate assessment of future acidification changes and impacts require a better understanding of present-day saturation state and depth of the saturation horizon in the Southern Ocean. We analyzed present-day carbonate chemistry and assessed the current vulnerability of the Southern Ocean with respect to ocean acidification using freely-available cruise data published in the Global Ocean Data Analysis Project Version 2 (GLODAPv2), along with an interpolated version of these data that gap fills when data have not been collected at a particular location or time. We found that the present-day saturation horizon for aragonite varies from 400-2000 m depth. The saturation horizon is shallowest around 60°S and deeper north and south of this latitude at 40°S and 70°S. We found very low data density at the depth of the saturation horizon, which may bias the interpolated product's estimate of the horizon depth in many locations. We further assessed whether predictions of the present-day horizon depth from Earth system models are consistent with these observations.

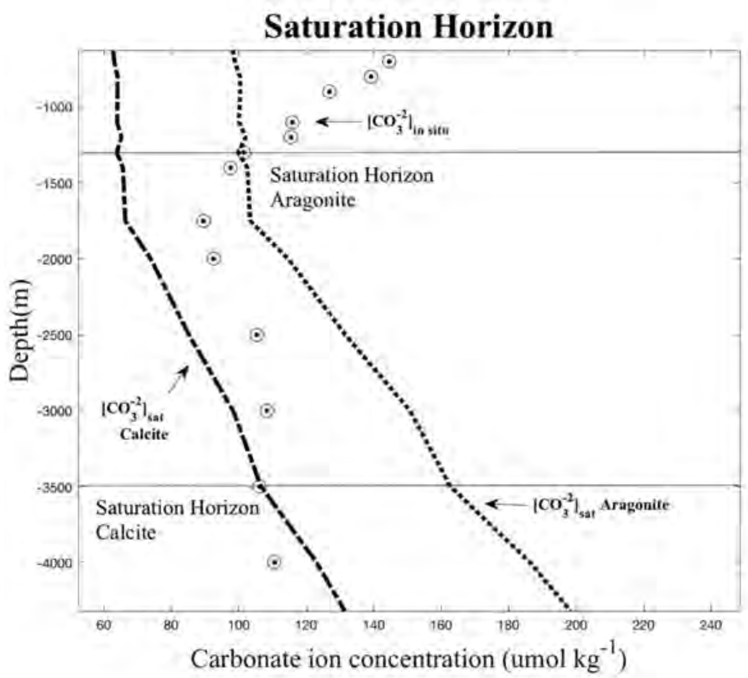


Illustration of the calcite and aragonite saturation horizon in the Southern Ocean using Cruise WOCE 1994. As pressure increases with depth, the solubility of calcite and aragonite increases as well ([CO32-]sat). The crossover between the in-situ carbonate ion concentration and the saturation concentration for calcite and aragonite determines the saturation horizon of the different mineral phases.

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Characteristics of hail events near the Sierras de Córdoba, Argentina

Argentina is a global hotspot for severe hailstorms, especially within the vicinity of the Andes Mountains and the Sierras de Córdoba. This hail activity results in substantial damage and economic loss in both urban areas and farms in the region. The RELAMPAGO (Remote sensing of Electrification, Lightning, And Mesoscale/microscale Processes with Adaptive Ground Observations) field campaign, which will take place during the austral summer of 2018, aims to deepen the understanding of the lifecycle of the region's convective storms through direct observations. To assist in locating equipment and personnel for the project, this study presents a hail climatology which addresses the diurnal, annual, and spatial patterns of the region's hail. Trends in hail size and the type of damage are also discussed. To create this climatology, 30 years of meteorological surface station data between 1 June 1987 and 31 May 2017 from 20 stations in the Mendoza, San Luis, and Córdoba provinces were supplemented with online newspaper and social media reports from 1 June 2013 to 31 May 2017. Both datasets show that hail peaked in the summer for Mendoza and San Luis, but in the spring for Córdoba, which was the province with the most hail reports. The combined effects of topography and population likely influenced the spatial distribution of hail reports. The two datasets disagree on the time of day hail most frequently occurred, however. This, in addition to the role of population density in hail reporting, highlights the potential for bias among the results.

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Geoscience and Spanish

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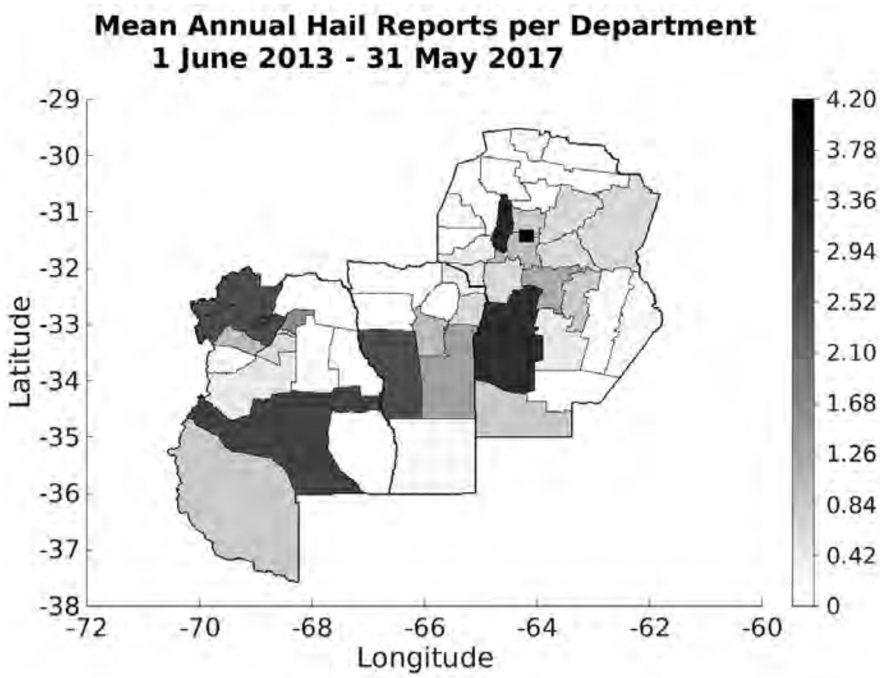
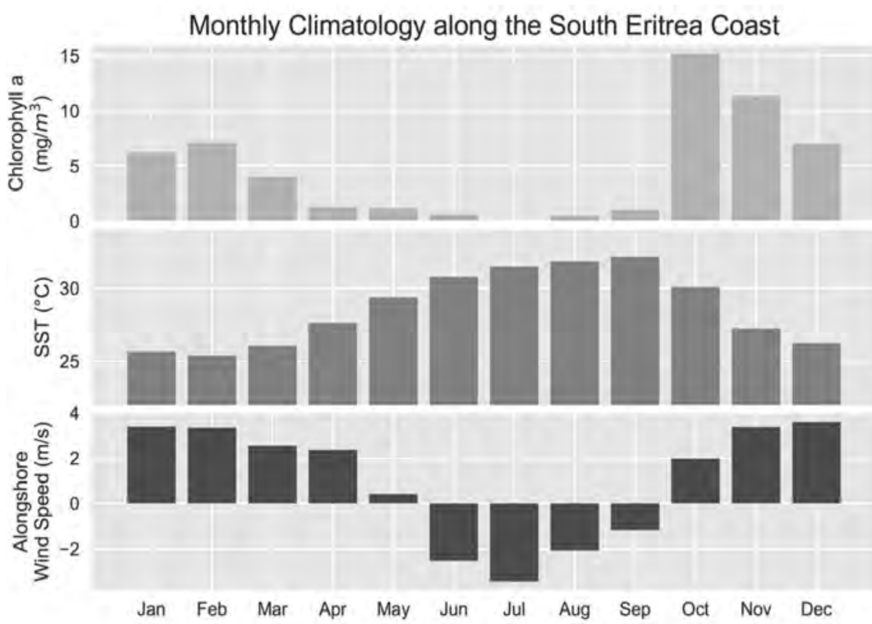
Amy Chen



Mean annual hail reports per department (i.e. county) between 1 June 2013 – 31 May 2017. The departments of the Mendoza, San Luis, and Córdoba provinces of Argentina are shaded based on the number of hail reports: darker shades indicate greater number of reports and vice versa. The most reports occurred in the most populated departments, which illustrates a limitation of human-based hail reporting.

Seasonal dynamics of productivity in the southern Red Sea using satellite measurements

Phytoplankton play a significant role in global biogeochemical cycles as they account for approximately 40 percent of annual carbon fixation, the conversion of inorganic carbon dioxide to organic compounds. Their ability to produce organic compounds provides food to marine organisms and, particularly in the case of the Red Sea, promotes biodiversity through its facilitation of coral growth. Satellite-derived concentrations of chlorophyll a, a pigment that is found in photoautotrophs, strongly correlate with the abundance of phytoplankton populations in ocean waters. This study used satellite-derived chlorophyll a concentrations from the Moderate Resolution Imaging Spectroradiometer (MODIS) instrument on board the NASA Aqua satellite, surface wind velocity data from NCEP-DOE Reanalysis 2 and sea surface temperature data from NOAA Optimal Interpolation (OI) v2 to explore the physical mechanisms driving seasonal variability of chlorophyll a in the southern Red Sea. The highest chlorophyll a concentrations in the region were seen along the southern Eritrea coast. These values maximized during the late fall and winter, caused by wind-driven coastal upwelling, and corresponded to nutrient advection from the Gulf of Aden as well as the aeolian transport and deposition of sediment from the Sahara. The aforementioned mechanisms begin to explain the seasonal cycle of primary production in the southern Red Sea, which has broader implications for understanding marine biogeochemical cycling in this region, and will be examined further in a future numerical modeling study.



Monthly climatologies of chlorophyll a concentration (mg/m3) (top), sea surface temperature (SST) (˚C) (middle) and alongshore wind speed (m/s) (bottom) along the south Eritrea coast over the period 2003–2016.

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For many years, SOARS directors have wondered what it would take to expand the program and reach more students, a request we often hear from supporters, students, and the atmospheric science community in general. SOARS is limited in the number of students it has been able to serve, due to funding and available research mentors for the summer internship component of the program. The idea of multiple locations for the program has been tested with partnering labs, such as WHOI or UNAVCO, or field placements with educational partners such as the South Louisiana Wetlands Discovery Center or partnering REUs. Yet to truly expand to multiple locations, we need leads who understand the program and can replicate and adapt its model to other institutions.

THE FUTURE IS HERE!

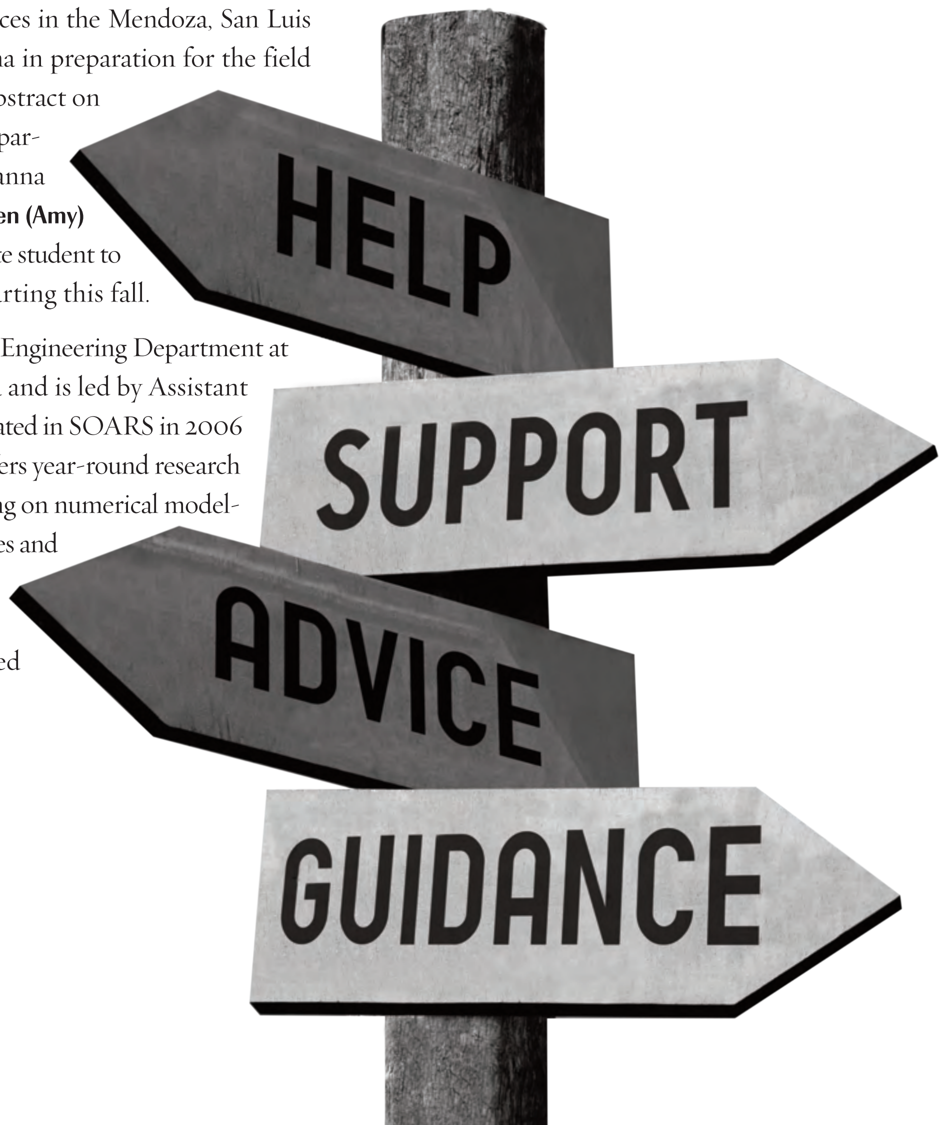
As we saw SOARS alumni advance in their careers and move into faculty positions at top universities across the country, an idea developed: A network of SOARS satellite programs, led by alumni with the support of their institutions, each satellite adapted to the needs and specific circumstances of the school.

This idea is now developing. We plan to establish at least three satellite programs at universities over the next five years to reach more students and help create supportive communities on university campuses. **Deanna Hence**, who participated in SOARS in 2004 and 2005, is building the satellite program at the Department for Atmospheric Sciences at the University of Illinois at Urbana-Champaign, with a summer research internship that can be based in Illinois or divided between Illinois and NCAR. Her protégés will receive additional support during the year, including guidance on giving presentations, collaborating on research projects, and writing resumes. This summer, **Jeremiah Piersante**, an atmospheric sciences major at Hobart and William Smith Colleges, took advantage of this opportunity. He worked with both Deanna at UIUC and with NCAR scientists **Sarah Tessendorf** (SOARS alum, 2001-2002) and **Roy Rasmussen** in Boulder to research hail occurrences in the Mendoza, San Luis and Córdoba regions of Argentina in preparation for the field campaign RELAMPAGO (see abstract on page 25). With luck, Jeremiah will participate in the campaign with Deanna next year. SOARS protégé **Shaowen (Amy) Chen** was also recruited as a graduate student to work with Deanna at UIUC, starting this fall.

The second satellite is in the Civil Engineering Department at the University of Central Florida and is led by Assistant Professor **Talea Mayo**, who participated in SOARS in 2006 and 2008. In her satellite, Talea offers year-round research opportunities in her group, focusing on numerical modeling of coastal inundation due to tides and hurricane storm surges. Talea's students will have an opportunity to transition to the Boulder-based SOARS program next summer.

Several more locations for satellites are also being explored. The programs will not only consist of research internships, but additional support for students and mentors. Satellites can draw from the SOARS cohort to recruit talented graduate students to their schools. We hope that the strong SOARS culture of mentoring will take hold on more campuses around the country and make it easier for talented students from all backgrounds to contribute to our field.

We are very excited to see SOARS grow and to pass its future to the generation of leaders we first envisioned 21 years ago.



SOARS protégé Jeremiah Piersante and Deanna Hence.
PHOTO BY JEFFREY THAYER

Observing and analyzing variations in daily precipitation: The influence of El Niño-Southern Oscillation on Kiritimati Island

Ebone D. Smith

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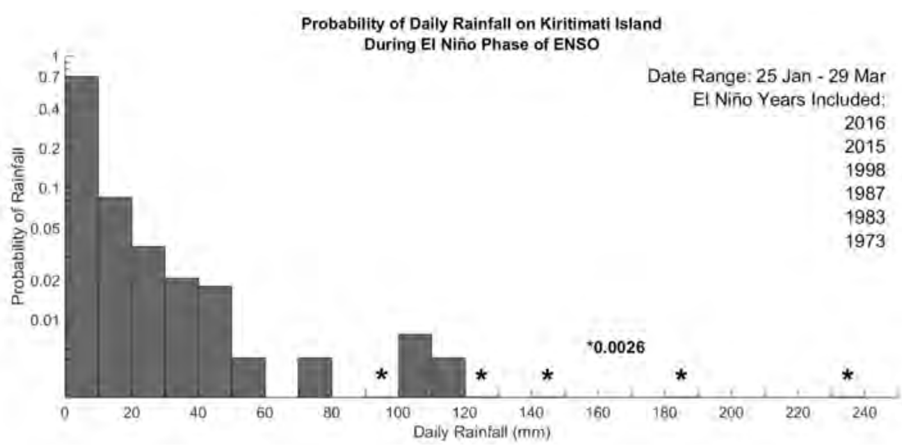
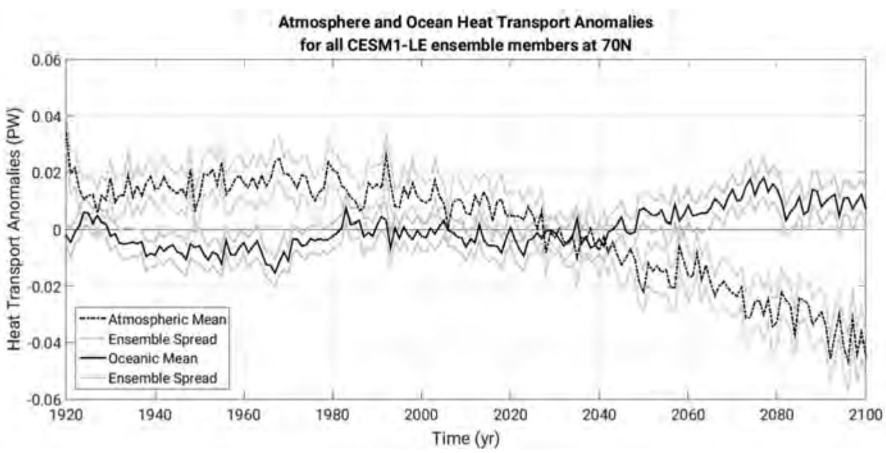
The El Niño-Southern Oscillation (ENSO) is an ocean-atmosphere interaction which changes the sea surface temperatures (SST) in the central equatorial Pacific and influences weather across the globe. Recently, the National Oceanic and Atmospheric Administration and partners conducted a field campaign, the El Niño Rapid Response (ENRR), to better understand ENSO. One component involved surface observations at Kiritimati Island (2 °N, 157.4 °W) during the robust El Niño in 2016, from 25 January through 29 March 2016. The large amount (938 mm) of rain during the deployment spawned the questions: 1) how was daily rainfall distributed on the island and 2) how did ENSO influence that distribution. Data from three weather sites on Kiritimati Island were examined: ENRR site (CXENRR), another automated weather station (Decca_AWS), and the official Kiribati Meteorological Service station (PLCH). Decca_AWS data was short-term, 22 May 2015 through 26 July 2016, and PLCH data was long-term, 1971-1990, 1996-2003, and 2015-2016. Time series from each dataset provided an outlook of daily precipitation characteristics. Histograms were plotted with data from PLCH from 25 January through 29 March for years that consistently diagnosed the three consecutive months as one phase of ENSO (neutral, El Niño, or La Niña). During the El Niño phase, the range of daily rainfall amounts increased as did the likelihood of rain in most rain-rate categories compared to the neutral phase. The La Niña phase showed higher probabilities of very little rainfall, narrower ranges of rainfall amounts, and reduced probability of high daily rainfalls.



Probabilities for daily rainfall events at PLCH during El Niño (25 January through 29 March) in 10-mm bins. The El Niño years are those for which PLCH data were available and with January through March diagnosed as having El Niño conditions by the Oceanic Niño Index.

The role of ocean and atmospheric heat transport in the Arctic amplification

Observational data and climate model projections have suggested that the Arctic is warming around two times faster than the rest of the globe, which has been referred to as the Arctic Amplification (AA). While local feedbacks are often suggested as the primary driver of AA by previous studies, the role of meridional heat transport by ocean and atmosphere is less clear. The study used the Community Earth System Model version 1 Large Ensemble simulation (CESM1-LE), a single, fully coupled climate model with 40 ensemble members, to understand the role that meridional oceanic and atmospheric heat transport play in AA. Each ensemble member spans two periods: the historical period from 1920 to 2005 using the Coupled Model Intercomparison Project Phase 5 (CMIP5) historical forcing and the future period from 2006 to 2100 using the CMIP5 Representative Concentration Pathways 8.5 (RCP8.5) scenario. The CESM1-LE projects an AA of 2.5-2.8 times faster than the global average. The spread of AA from the CESM1-LE, which is attributed to the internal variability, is ~2-3 times smaller than that of the CMIP5 ensemble, which may include the inter-model differences. CESM1-LE projects a significant decrease in the total and dry atmospheric heat transport into the Arctic, and an increase in the moist component. In addition, the ocean heat transport increases, primarily due to the Pacific Ocean transport. The analyses showed which energy transport elements are dominant in driving Arctic amplification; this in turn gave a better understanding of how remote effects will affect the future Arctic climate.



Ensemble mean atmospheric and oceanic heat transport anomalies into the Arctic at 70°N for the studied period 1920-2100 (darker lines) with 95% confidence interval (lighter lines). The decrease in the mean atmospheric heat transport anomaly (dashed line) is statistically significantly different from zero at a 95% level after the year 2050. Correspondingly, the increase in the mean oceanic heat transport anomaly (solid line) is significantly different from zero after the year 2050.

Rosa M. Vargas-Martes

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University of Puerto Rico at Mayagüez
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MENTORS

RESEARCH
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COMPUTING
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Investigating the dynamics of the North American monsoon in climate model simulations

ARIANNA VARUOLO-CLARKE

4th-year Protégé
Graduate Student
Stony Brook University
Atmospheric Science

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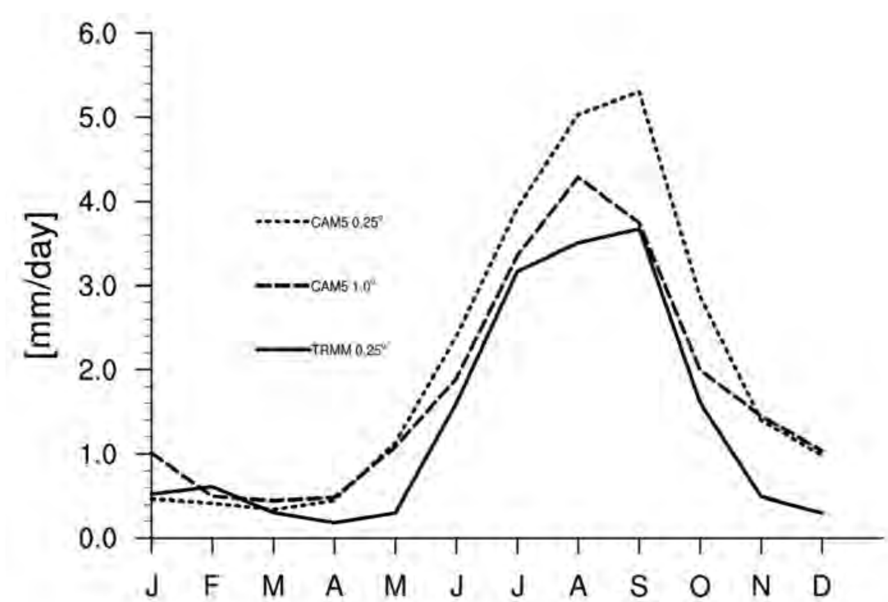
Jamin Rader

This project examined the influence of topography on the dynamics of the North American Monsoon (NAM), including the genesis, peak, and demise of the monsoon. The monsoon season (July, August, and September) in the southwestern United States and northwestern Mexico is characterized by an increase in rainfall that accounts for 40 to 80% of the total annual rainfall. We used a simple "monsoon index" and showed that simulations with the Community Atmosphere model capture the essential nature of the NAM. Comparing standard low-resolution (1° latitude x 1° longitude) and high-resolution (0.25° latitude x 0.25° longitude) simulations, we showed that the high-resolution produces a stronger NAM than the low-resolution model or observations. The physics and dynamics are the same between the high and low-resolution simulations, so the difference between them is due to differences in resolved circulation, which is partly driven by more realistic topography in the high-resolution configuration. To evaluate the models' representations of the NAM and to understand the origin of differences between the simulations, we analyzed the moist static energy budget in the monsoon region. Our preliminary results indicate that the simulated NAM is driven by locally-generated convection, with advection processes being secondary; this is consistent with the NAM being a result of the thermal contrast between the hot, summertime continent and cool ocean. A better understanding of the dynamics of the monsoon and the impact topography has on these dynamics will allow for a more accurate representation of the monsoon in projections of future climate.

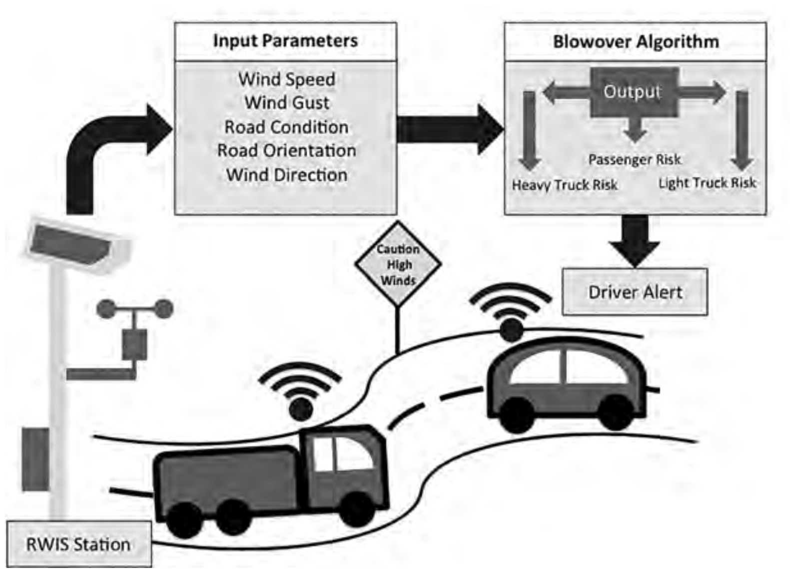


Monthly precipitation climatology averaged over the core NAM region (112° – 102°W, 18° – 33°N). Observations (solid line) are from the Tropical Rainfall Measuring Mission satellite products for the period of 1998 – 2005. The low and high-resolution simulations (large dashed and small dashed lines respectively) cover the period 1979 – 2006.

The truck blowover algorithm for the Pikalert® System

Over 5000 road weather fatalities occur yearly and road weather delays can cost trucking companies over 2.2 billion dollars. These impacts are strongly felt along Interstate 80 (I-80) in Wyoming, where extreme weather occurs year-round at elevations between 6,000 and 8,600 feet. Strong winds are one of these extreme forms of weather, preferentially affecting freight traffic due to their high profiles. With previous support from the Federal Highway Administration, the National Center for Atmospheric Research developed the Pikalert System, which is used in the Wyoming Department of Transportation Connected Vehicle Pilot (WYDOT CV Pilot). Pikalert uses various algorithms to combine vehicle and weather data and generate warnings for users, however it lacked a wind algorithm.

A blowover algorithm was developed using a fuzzy logic methodology with the purpose of being integrated into Pikalert. Three case study groups of increasing size were used to assess the algorithm, and based on the results the weights and functions within the algorithm were changed to provide an appropriate interest value for three vehicle classes. By integrating the algorithm into Pikalert, commercial trucks and vehicles receiving the warning will also have the information they need to take preventative action and avoid a crash. The warning will result in fewer road closures along I-80, as risk is targeted to specific vehicles rather than system-wide, and decreased economic losses. The algorithm and the Pikalert System application will be available to the community as part of the open source code developed for the WYDOT CV Pilot.



A visual interpretation of the process that the algorithm goes through to determine the risk level for various vehicle types. Weather and vehicle info flows into the algorithm as inputs then outputs a risk level. This risk level determines if a driver is alerted or not.

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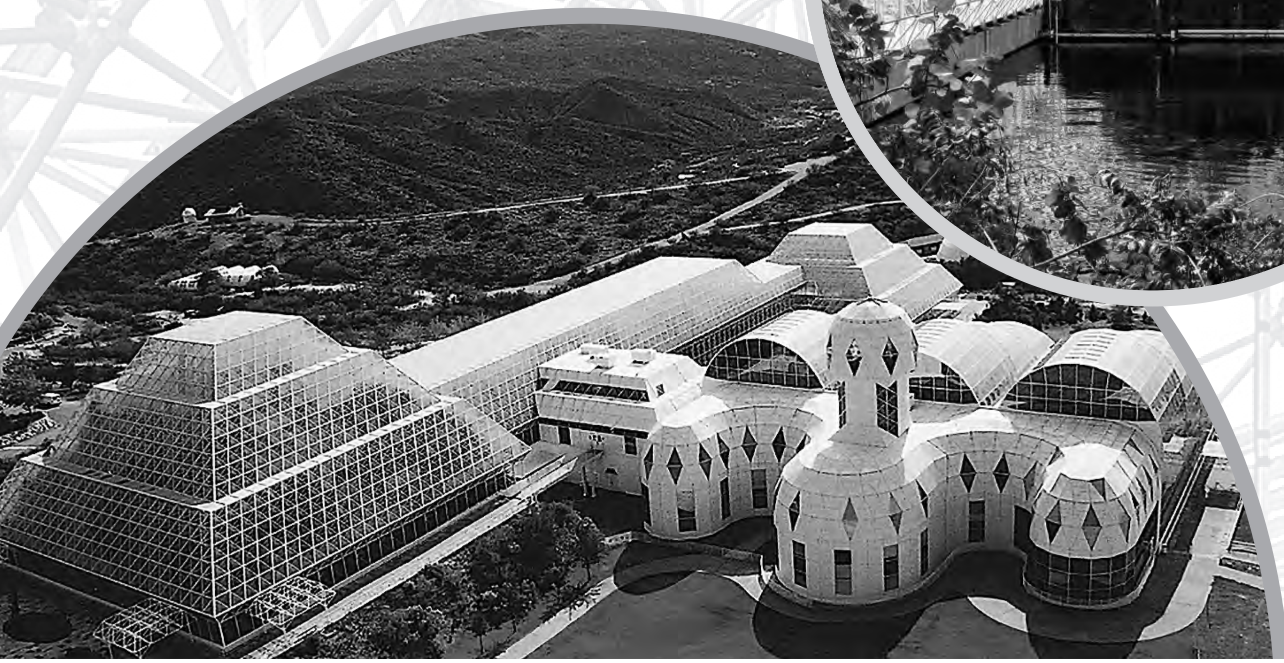

Bringing Indigenous and Western Knowledge Together:

The SOARS program is part of a project entitled "**Integrating Indigenous and Western Knowledge to Transform Learning and Discovery in the Geosciences**" that aims to bring indigenous knowledge together with western science. It is funded by the National Science Foundation and is one of several INCLUDES grants that have been awarded to promote diversity in the geosciences. As part of this project, a new partnership with the University of Arizona's Biosphere 2 REU program was created to offer research opportunities to indigenous students. Two students, **Maggie Ng** and **Mychal Thompson**, were named as the inaugural recipients of the SOARS/Biosphere 2 Fellowship for Indigenous Geoscience Students. This summer, Maggie and Mychal participated in the Biosphere 2 REU program where they conducted earth system science research with University of Arizona mentors (as will be described in the coming pages). They were also supported in spending three days at NCAR with the SOARS program (along with Biosphere 2 REU PI, **Kevin Bonine**). During this time they

A Partnership with Biosphere 2

were engaged with the INCLUDES project and met a number of NCAR scientists to discuss potential summer research projects for 2018. They also had the opportunity to connect with the SOARS cohort, attending a seminar on societally relevant research led by SOARS alum **Dereka Carroll**, a public lecture on storms, and sharing the research opportunities offered by the unique Biosphere 2 program with the SOARS group. We were glad to have them as part of our annual field trip to Rocky Mountain National Park, where we learned about climate change impacts on the park and participated in leadership and reflection activities.

This new joint fellowship offers the participants the chance to benefit from two well-established programs. In addition to their REU experience at Biosphere 2, they will have year-round support with SOARS, including presenting their research at a conference, last-dollar tuition scholarships, and writing and career support, and will be able to participate in the SOARS cohort in 2018. For our institutions, this project, including the engagement of these talented young scientists, brings a new perspective to the work that we are doing and opens new possibilities for collaboration, both institutionally and with indigenous collaborators. We are excited to continue to build bridges from SOARS that offer opportunities to underrepresented students and bring diverse perspectives and knowledge to the atmospheric sciences.

Facing page:
Top circle: Inside Biosphere 2
Large circle: Biosphere 2 from the outside, and participants in the 2017 Biosphere 2 REU.

FACILITY PHOTOS BY BIOSPHERE 2 AND PARTICIPANTS PHOTO BY MYCHAL THOMPSON

This page:
Protégé Maggie Ng growing seedlings for her research.

PHOTOS BY MAGGIE NG

Tree mortality due to heat waves: A multispectral approach for non-destructively detecting tree seedling stress during a heat waves experiment

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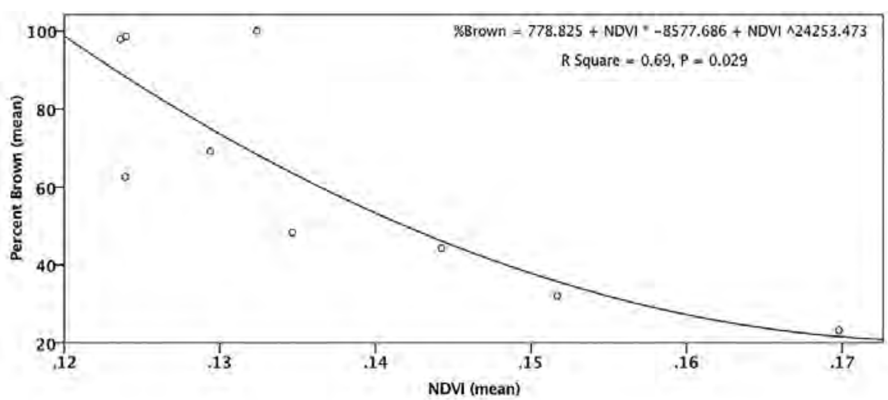
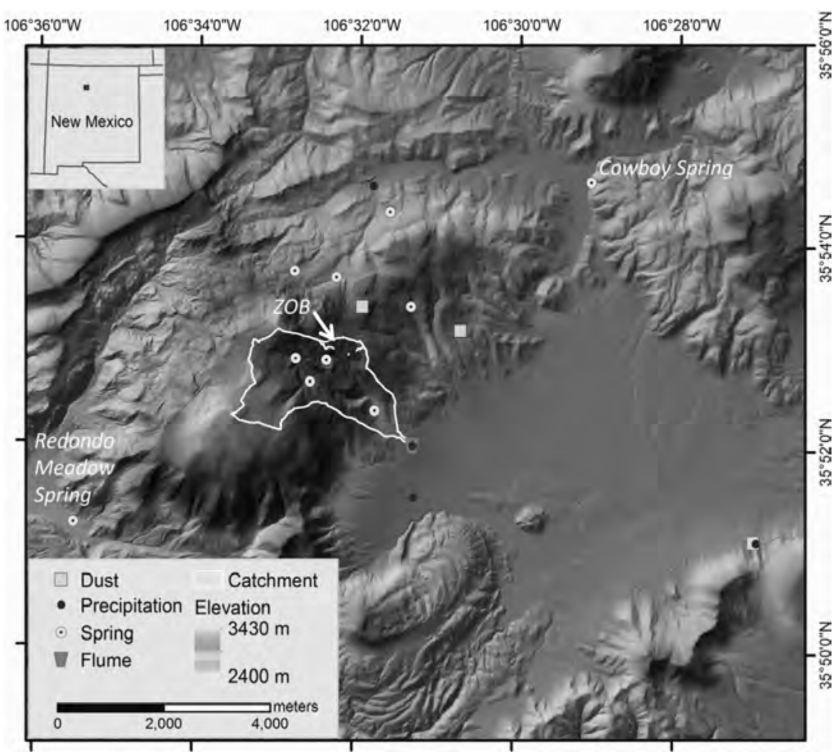
Large-scale tree die-off events in response to drought and warming are a global phenomenon of increasing concern in association with climate change. Recent research suggests that heat waves may be a trigger of mortality for mature trees during hotter droughts. Consequently, experiments are needed to examine if tree species mortality is exacerbated by heat waves. We are developing an experiment to study the relationship between tree mortality and heat waves for seedlings of piñon pine (Pinus edulis), a species which has experienced recent widespread die-off and has been a focus of hotter-drought-related mortality. To conduct this experiment, a non-destructive method is needed to determine the degree of tree stress in a group of seedlings as a function of time. Our objective is to develop such an approach using multi-spectral data. We obtained estimates of the Normalized Difference Vegetation Index (NDVI) for tree seedlings in various stages of stress and browning using a multispectral camera. We documented a significant relationship between NDVI and observed percent brown. This correlation then enabled us to develop a relationship between percent brown and estimated plant water potential. Our results indicate that NDVI can yield accurate data on both the transition from greening to browning that accompanies mortality and provide an estimate of plant water stress, thereby enabling a non-destructive measurement of plant condition for use in future heat wave experiments.



Normalized Difference Vegetation Index and % brown

Dissolved Organic Matter (DOM) composition changes during spring snow melt in the Jemez River Basin Critical Zone Observatory

Dynamics of DOM in stream waters are important indicators of internal processes in the Critical Zone (CZ) such as: decomposition and mobilization of soil organic matter, hydrologic flow paths, potential for metal mobilization and nutrient redistribution. It is postulated that the molecular composition and character of DOM changes with the advance of spring snowmelt. Water samples were collected from two flumes located at the outlets of the La Jara Creek and from a Mixed Conifer zero order basin through the spring snowmelt from March 1 to May 15, 2017. The DOM concentration increased with stream discharge. Quantification of molecular change was conducted using Fourier transform infrared spectroscopy, which showed the variation in carboxyl abundance correlated with dissolved organic carbon concentration, indicating that this component is relatively a constant fraction of the organic carbon exported through the stream during spring snowmelt. In contrast, amide vibrations were shown to decrease with the advance of spring snowmelt. Aliphatic components decreased from the beginning to the middle of sampling period, then showed an increase toward the end of snowmelt. O-Alkyl peak varied without a clear trend during the spring snowmelt. These changes in O-Alkyl and aliphatic compounds may be related to microbial derived compounds and indicate changes in microbial activity during the spring snowmelt. These results will be combined with concentration discharge analysis and data from fluorescence and UV-vis spectroscopy for evaluation and modeling of CZ processes dominated by spring snowmelt.



Location of the study catchments, Northern New Mexico. The La Jara (LJ) catchment with the Mixed Conifer (MC) zero order basin is outlined in the upper part of the area.

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On the cover: The total solar eclipse, as observed from Casper Mountain, Wyoming, on August 21, 2017 by SOARS protégé Keon Gibson. Photos by Keon Gibson.

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Key to Mentors' Affiliations

CIRA	Cooperative Institute for Research in the Atmosphere
CIRES	Cooperative Institute for Research in Environmental Sciences
COSMIC	Constellation Observing System for Meteorology, Ionosphere and Climate
CU	University of Colorado at Boulder
NCAR	National Center for Atmospheric Research
NOAA	National Oceanic and Atmospheric Administration
PSU	Pennsylvania State University
SOARS	Significant Opportunities in Atmospheric Research and Science
UA	University of Arizona
UCAR	University Corporation for Atmospheric Research
UCP	UCAR Community Programs
UIUC	University of Illinois at Urbana-Champaign
UM	University of Michigan
WHOI	Woods Hole Oceanographic Institution

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