

# Earth, Wind, Sea, and Sky

RESEARCH | MENTORING | COMMUNITY

CELEBRATING 26 YEARS OF SOARS:  
STRENGTHENING RESILIENCE AND ADVOCACY  
IN THIS COMMUNITY OF PRACTICE

SOARS PROTÉGÉ ABSTRACTS 2022



Significant Opportunities in Atmospheric Research and Science

University Corporation for Atmospheric Research

[www.soars.ucar.edu](http://www.soars.ucar.edu)

Since 1996, SOARS continues to provide authentic research experiences with expert scientists and engineers for historically marginalized communities in the atmospheric and related sciences. As an undergraduate-to-graduate bridge program, SOARS is designed to broaden participation in the geosciences. By supporting students from diverse backgrounds and experiences, SOARS guides participants to enter and succeed in graduate school; contribute to research, and become leaders in the geoscience community. SOARS complements academic institutions' mission in preparing students for career pathways in academia, research, and industry by combining summer research experiences with year-round mentoring, conference travel, and supportive community.

We are thrilled to share this 2022 edition of **Earth, Wind, Sea and Sky**; showcasing the summer research of the Protégés from the Significant Opportunities in Atmospheric Research and Science (SOARS) Program! SOARS began in 1996, and remains true to its mission of increasing the diversity of the atmospheric and related sciences, by engaging students from historically marginalized communities in STEM, in genuine research. The Protégés' ability to do excellent work in such a short period of time, and in a hybrid environment, is a credit to their hard work and dedication; and to the exceptional training, care, and guidance of their mentors. We are ever so grateful for the mentors' commitment to the Program.

The hallmark of the SOARS mentoring structure, which includes up to five (5) types of mentors and a supportive learning community; continues to be the heart of the program and remains relevant. The Geoscience community continues to evolve and our scientific challenges change. As such, SOARS continues to adapt and grow, meeting the new needs of the field. Now in its seventh year, the SOARS computation and scientific data workshop (CDW) recognizes the movement of geoscience literature toward sharing data and code; preparing Protégés with tools to flourish in an open-access environment. This year's CDW complemented the scientific communication and writing workshop (SCW) with weekly sessions. We recognize new careers in the atmospheric sciences are emerging that make use of weather and climate products; and there is a need for scientists to translate these products for fields as diverse as agriculture, emergency management, insurance policy, and space weather, to name a few. Our professional development series exposes our Protégés to the many opportunities available to them, and prepares them to succeed not only in graduate school, but in multiple careers pathways as well.

**KADIDIA THIERO**  
SOARS PI/Program Lead  
UCAR Center  
for Science  
Education

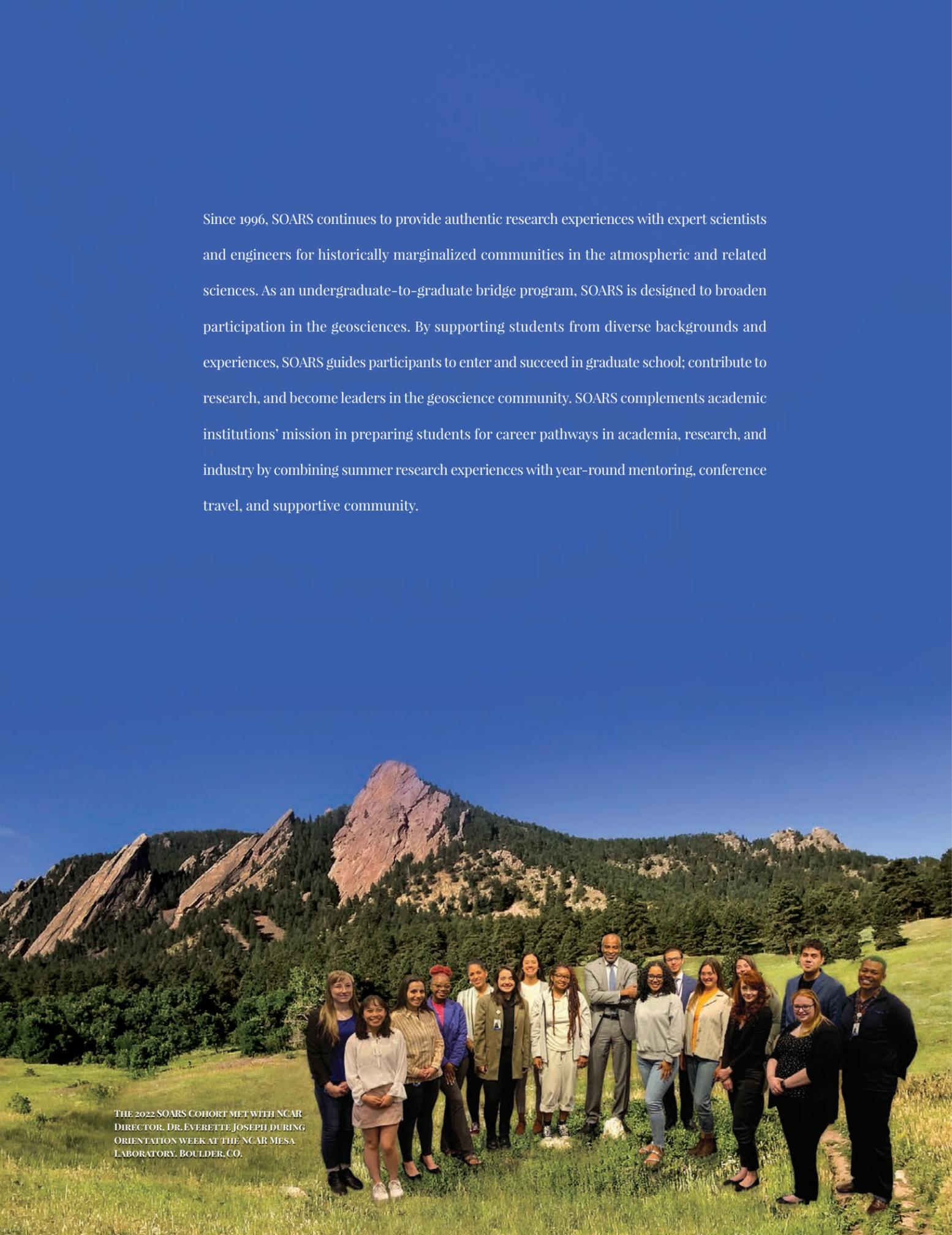


## 2022 Earth, Wind, Sea, and Sky

Because of the 26+ years' legacy and success of SOARS, we are able to tap into the strengths of our Alumni. Our Alumni also serve as mentors, panelists, graduate-school selection advisors, and on the SOARS Steering committee. Beyond SOARS, our Alumni are filling leadership roles in our national membership societies, federal, state, and local government, industries, and in higher education institutions. Their perspective and leadership, along with that of our mentors, sponsors, and partners, help SOARS advance and remain a leader and valued partner in the geoscience community.

As the geosciences continue to evolve, and our planet and climate face rapid change; the need for diverse voices has never been greater, particularly those who can connect science, leadership, and community. SOARS has an ongoing role and responsibility in helping develop these voices. The network of Protégés, Alumni, Mentors—current and former, staff, and partners continues to grow; and their voices and leadership are making vital contributions to the science and safety of our planet. We are grateful for your ongoing support, and we are extremely proud to be part of this amazing community!

We hope you enjoy this publication of **Earth, Wind, Sea, and Sky**. Please join us in congratulating the 2022 Cohort of Protégés!



THE 2022 SOARS COHORT MET WITH NCAR DIRECTOR, DR. EVERETTE JOSEPH DURING ORIENTATION WEEK AT THE NCAR MESA LABORATORY, BOULDER, CO.

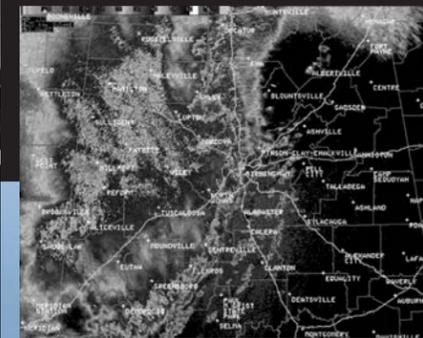
The UNIVERSITY CORPORATION OF ATMOSPHERIC RESEARCH (UCAR) is a nonprofit consortium of more than 120 North American colleges and universities focused on research and training in the Earth system sciences. UCAR is the experienced manager of the NATIONAL CENTER FOR ATMOSPHERIC RESEARCH (NCAR) on behalf of the National Science Foundation. Founded in 1960 to fulfill this role, UCAR is the trusted administrator of the financial, human resources, facilities, and information technology functions that are essential to NCAR's success. Since UCAR's inception, collaborations between university researchers and our own scientists and engineers have helped push the boundaries of the Earth system sciences.

Activities in the UCAR COMMUNITY PROGRAMS (UCP) include everything from training weather forecasters, firefighters, and emergency managers (COMET), to supporting a constellation of atmosphere-observing satellites (COMET and JCSDA). The Unidata program develops internship programs and educational resources, provides real-time data and software analysis tools, and manages projects and staffing for scientific programs across the country and around the world. UCP provides a suite of innovative resources, tools, and services to researchers, educators, and practitioners in the Earth system science community.

NCAR provides the atmospheric and related Earth system science community with state-of-the-art resources, including supercomputers, research aircraft, sophisticated computer models, and extensive data sets. 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.

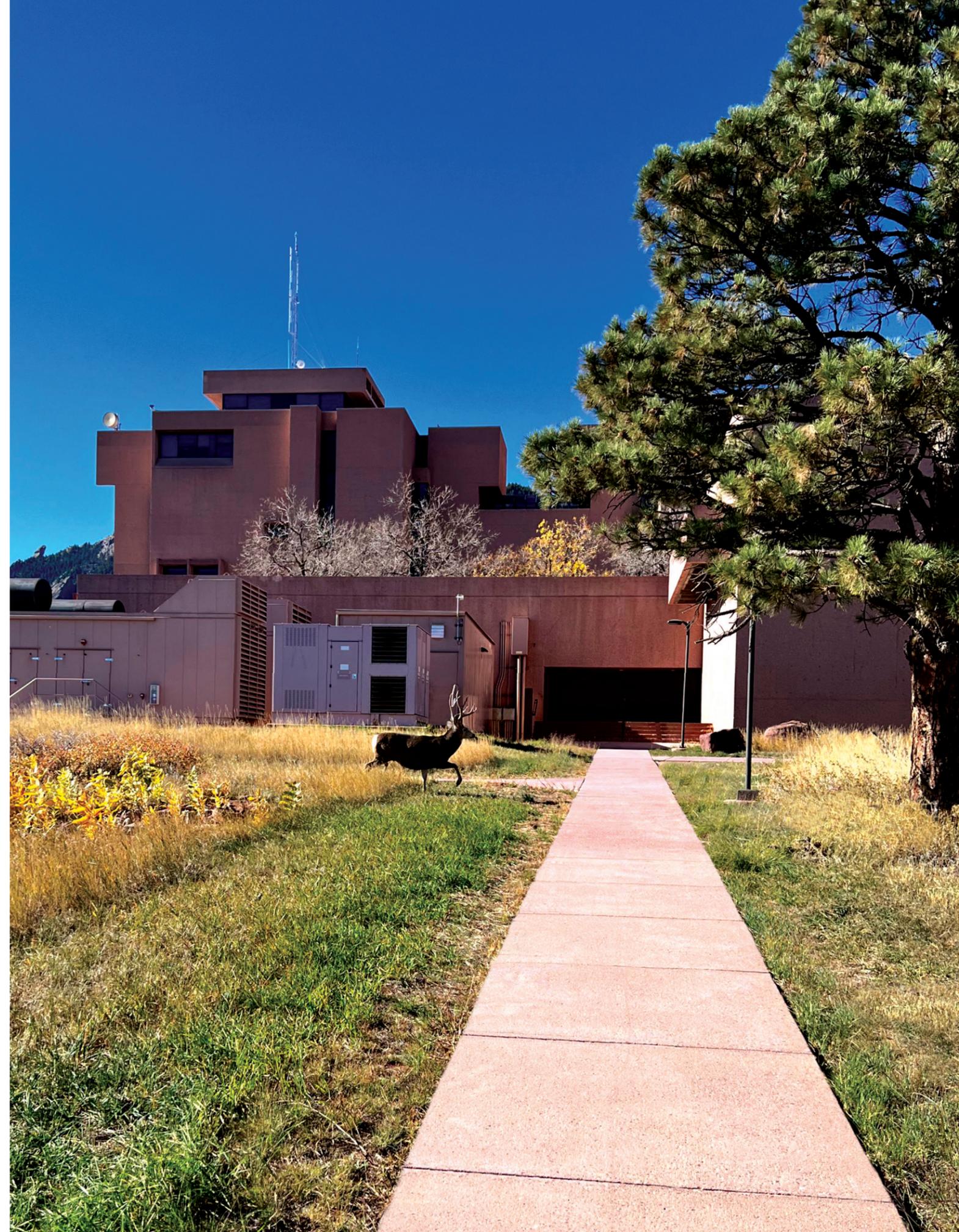
NCAR and UCAR have been supporting the SOARS Program since its inception in 1996. Institutional support and the mentoring of their scientists, engineers and staff have been the key to the success of SOARS. We are grateful for the support of NCAR|UCAR leadership and our growing number of mentors who make SOARS possible.

# NCAR | UCAR



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During this summer, SOARS Protégés conducted research at the National Center for Atmospheric Research (NCAR), the University Corporation for Atmospheric Research (UCAR), the National Oceanic and Atmospheric Administration (NOAA), the University of Colorado at Boulder, and the Cooperative Institute for Research in Environmental Sciences, for the first-ever hybrid experience. Protégés began the summer in a virtual environment for the first two weeks; and then spent the remaining nine weeks in Boulder, CO.

During the past 26 years, research projects were also conducted with partnering laboratories, and universities to gain experience in the geosciences field. Topics of research span the disciplines of climate and weather, computing, and engineering in support of atmospheric sciences, oceanography, and solar physics. Incoming Protégés are supported in their research by up to five (5) types of mentors, including research/scientific, writing, computing, peer, and community coach. In addition to this authentic research experience, which culminates in end-of-summer poster and oral presentations by the Protégés; the summer program incorporates a comprehensive, professional development series, relevant to STEM research, academia, as well as various career pathways. After the summer, Protégés remain engaged through webinars, one-on-one career counseling, and participation at professional, national conferences.

Protégés may participate in SOARS up to four (4) years, gaining additional independence in subsequent years to select, focus, and direct their research. By the time SOARS Protégés enter 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 national laboratories. It is also common for Protégés and their advisors to collaborate and publish with mentors beyond their SOARS research experiences; examples include graduate and doctoral theses. In addition, SOARS provides publishing and field campaign support to our Protégés and Alumni, encouraging connections with the wider community.

SOARS is proud of our Alumni, the vast majority of whom excel in graduate school; and move on to careers in atmospheric science and/or related STEM fields. Many are now faculty, and we are excited to partner with Alumni to spread the SOARS mission. Various partnerships include the pilot SOARS Satellite programs at Emory University, and at the University of Illinois-Urbana Champaign (UIUC). SOARS Alumni serve as the leads and Co-PIs at Emory and UIUC. An amazing addition to the existing partners is the Columbia University-led NSF Science and Technology Center (STC): Learning the Earth with Artificial Intelligence and Physics (LEAP). SOARS is the only educational partnership that is a part of LEAP; and SOARS returning Protégés will have the opportunity to participate in summer research, and present their research to their Cohort at the end of the summer. Also, share the SOARS program's best practices with LEAP Fellows and postdocs based at NCAR for summer visitations. Connect LEAP Fellows and postdocs with interested SOARS Protégés for mentoring via monthly telecons, which would support the Protégés' acquisition of data science literacy and research skills before the summer internships.

Wherever their careers take them, our SOARS Alumni 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 capacity and diversity of the national STEM workforce.

SOARS PROTÉGÉS AND STAFF AFTER THE ANNUAL RESEARCH COLLOQUIUM.  
UCAR FOOTHILLS LABORATORY, BOULDER, CO



## Using Measurements of PM<sub>2.5</sub> to Assess the Applicability of Low-Cost Sensor Networks for Understanding the Impact of Wildfire Smoke



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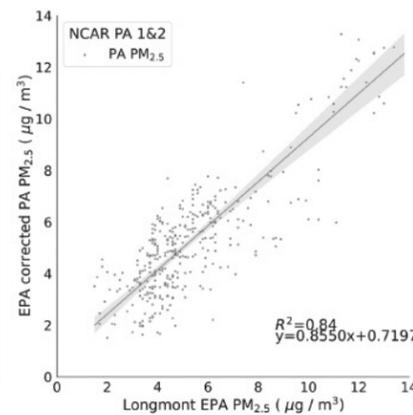
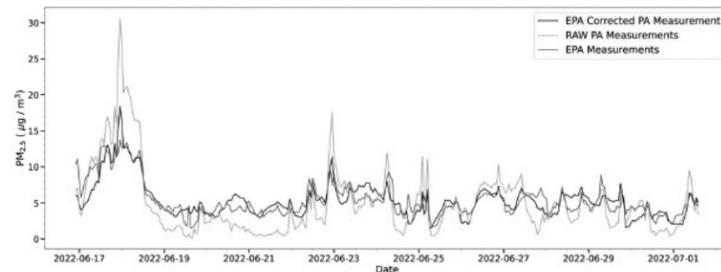
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Wildland fires emit large quantities of gases and particulate matter that can be transported downwind, impacting the air quality of communities in the path of the smoke. In 2020, as wildfires spread through the Front Range of Colorado, particulate matter smaller than 2.5  $\mu\text{m}$  (PM<sub>2.5</sub>) in the smoke impacted not only the health, but the visibility of those in its path. The Environmental Protection Agency (EPA) manages a sparse network of well-calibrated, research grade PM<sub>2.5</sub> measurement instrumentation and has also made recommendations to correct PurpleAir (PA) PM<sub>2.5</sub> measurements to better agree with the EPA observations. Previous research has shown that PA monitors have been shown to overestimate PM<sub>2.5</sub> in wildfire smoke. Using the PA network of low cost sensors (LCS) positioned within a 4.5 km radius of EPA-managed research-grade sensors, we explore the ability of the LCS network to quantify wildfire PM<sub>2.5</sub>. We use data impacted by the 2020 East Troublesome and Cameron Peak Fires in Colorado and assess the EPA-recommended PA correction for wildfire smoke. For PA sensors with sufficient data, the EPA correction brought the hourly averaged PA PM<sub>2.5</sub> data much closer to the official EPA PM<sub>2.5</sub> observations. These results suggest that PA monitors can be reliably used with the EPA correction applied to understand air quality in regions impacted by wildfire smoke, enabling the community-level LCS measurements to increase the spatial resolution of atmospheric measurements available for public health and welfare assessments.

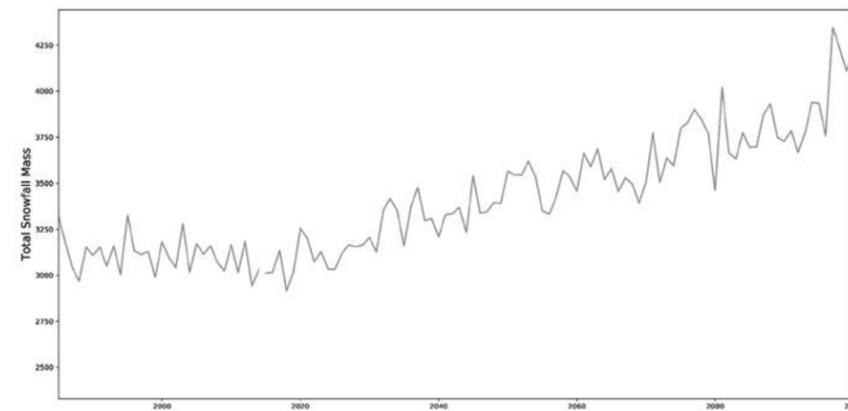


Top: Time series of PM<sub>2.5</sub> observations from the Longmont EPA instrument (green), the raw data from the collocated NCAR PA1& PA2 monitors (orange), and the EPA corrected data for the NCAR PA1& PA2 monitors (black) during a 2-week time period in June 2022.

Bottom: Correlation plot of the EPA corrected PM<sub>2.5</sub> data from the NCAR PA1& PA2 monitors and the Longmont EPA PM<sub>2.5</sub>.

## How will Antarctic Precipitation Change in a Warming Future Climate?

Due to increased human emissions of greenhouse gases, temperatures are increasing globally, including in the high-latitude Southern Hemisphere. The Antarctic Ice Sheet (AIS), the largest body of freshwater on Earth, is losing ice in response to global warming. It is expected that the AIS will continue to lose mass and contribute to rising sea levels throughout the remainder of the 21st century. AIS mass balance, and its contribution to sea levels, constitutes the difference between incoming mass at the ice sheet surface (snowfall), and the discharge of ice to the ice shelves and ocean (ice flow). As current and future AIS mass loss will be primarily driven by increased ice flow, it is unclear how much snowfall on the ice sheet will be required to keep the mass balanced. In this research, we analyze historical and future simulations of the Community Earth System Model version 2 (CESM2) produced by the National Center for Atmospheric Research (NCAR). We are comparing the future and historical AIS snowfall to better understand how AIS snowfall will change throughout the 21st century, and how much it could potentially offset enhanced AIS mass loss driven by increased ice flow. We found that throughout the future period, snowfall is projected to increase, especially around the coastal regions of the continent.



Time evolution (1985-2100) of area-integrated AIS snow accumulation (GT/yr).



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## Factors that Control Interannual Variability in Congo Basin Precipitation: A CESM Perspective



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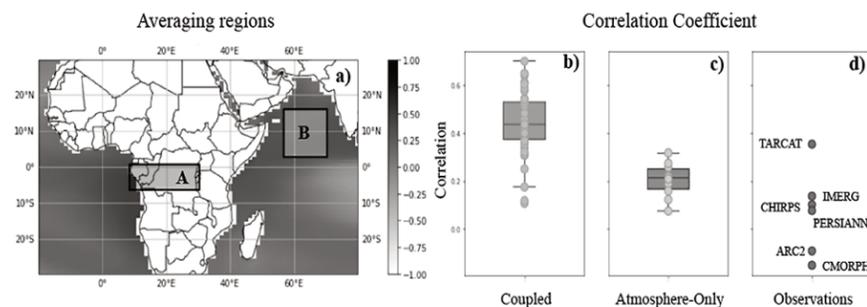
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The Congo Basin hosts the world's second-largest rainforest and river basin, and these features are dependent upon receiving ample precipitation. However, there are still many unknowns regarding the processes controlling precipitation over this region, including a limited understanding of how the precipitation over the Congo Basin responds to various modes of climate variability on an interannual time scale. This is partly because in-situ observations over the Congo Basin are limited, spatially and temporally, which limits the ability to study precipitation processes over this domain. One way to address this limitation is through a model analysis. In this study, we utilize the Community Earth System Model (CESM) Large Ensemble along with complementary prescribed sea surface temperature (SST) simulations to understand the processes controlling the precipitation over this region. First, we assess how well the CESM represents Congo Basin seasonal precipitation and its variance of precipitation through a direct comparison with six observational datasets. Our results suggest that both CESM simulations (coupled and atmosphere-only) overproduce precipitation in the rainy seasons and underproduce in the dry season, but generally capture the seasonal precipitation cycle. Second, we analyzed the relationship global SSTs have to regional precipitation with observations and CESM in the September, October, November season. With the CESM datasets, we discover there is a robust connection between precipitation and SSTs in various locations, but there is a large spread across the observations that do not all agree with CESM. Only one observation, TARCAT, agrees with the precipitation variability represented through CESM for both the Atlantic and Indian Ocean.

### Southern Congo Basin Precipitation and Northern Ocean Sea Surface Temperatures



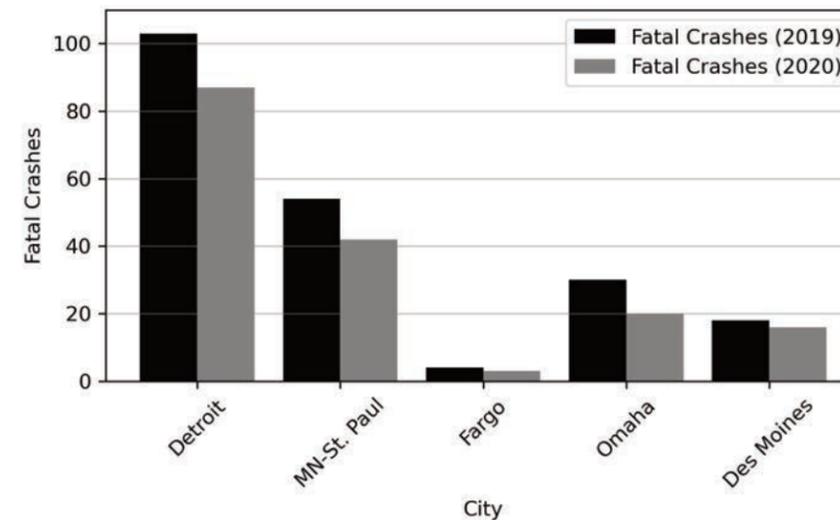
(a) Southern Congo Basin precipitation (A) and northern Indian Ocean sea surface temperatures (B) averaging regions (right).

Correlations of these regions are the (b) coupled simulation with 50 ensemble members (c) atmosphere-only with 10 ensemble members, and the (d) observations which show the range from all six observational datasets.

## How Motorist Exposure to Adverse Weather has Changed Through the COVID-19 Pandemic

Inclement weather conditions greatly impact traffic safety and the mobility of drivers on roads. In a typical year, one-fifth of all vehicle crashes in the United States are caused by some form of adverse weather, resulting in over 5,000 fatalities annually. During the COVID-19 pandemic, traffic volumes were greatly reduced. However, it is unclear how this reduction may have impacted motorist exposure to adverse road weather. This study examined how motorist exposure to adverse weather changed through the COVID-19 pandemic in 2020 relative to the pre-pandemic period from 2016 through 2019. Five United States metropolitan statistical areas (MSAs) were selected to assess this change in exposure. For each MSA, weather-related fatal vehicular crash data were obtained from the Fatality Analysis Reporting System (FARS) and precipitation data were obtained from the National Centers for Environmental Information (NCEI). We found that despite an increase in fatal crashes in 2020, a much lower percentage of these crashes were weather-related compared to previous years. Reduced traffic flow and shifted preference for remote work due to pandemic restrictions may explain why this percentage was reduced. However, it is important to note that more analysis is necessary as rain and snow accumulation was lower in 2020 compared to 2019. This reduction may have also influenced the percentage of fatal weather-related crashes. These findings can deliver possible reasons for why resource allocations (like plowing and road closures due to inclement weather) and roadway safety messaging may need to be modified to accommodate post-pandemic commuting patterns.

### Weather-Related Fatal Crashes



Weather-related crash distributions for the selected MSAs in 2019 and 2020.



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**2nd-year SOARS Protégé**  
Senior  
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## Predictability of Extreme Precipitation within Drought Conditions



**ERIN ELISE EVANS**

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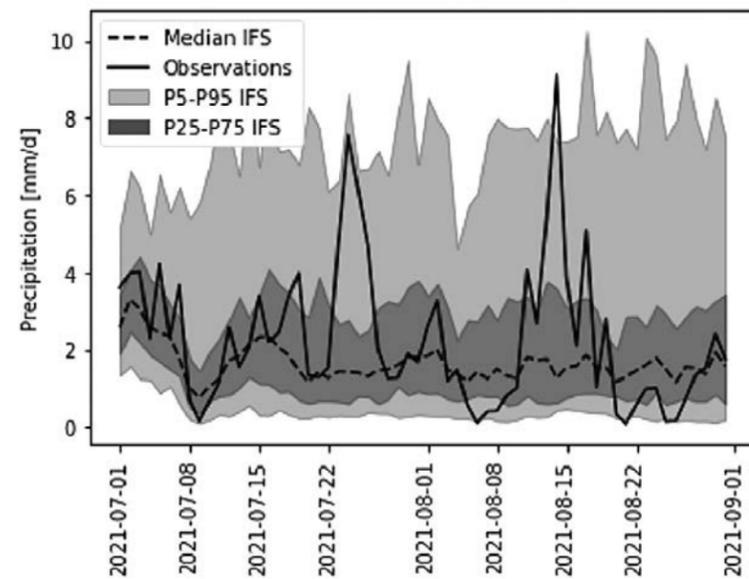
**MENTORS**

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 James M. Done, NCAR  
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 Lesley Smith, CIRES/NOAA



As extreme drought conditions become more common over the western United States, water managers in these regions are looking for skillful precipitation forecasts to more effectively manage this valuable resource. Research has suggested that medium range seasonal forecast models could potentially predict the onset of seasonal precipitation within these dry regions on a seasonal scale by forecasting the large-scale weather patterns instead of the actual precipitation. This research looks into the extent to which the seasonal models were able to predict observed, localized instances of extreme precipitation. One case study is a particular wet period during the monsoon season of 2021 in the US southwest, while the second case study is an extreme atmospheric river event that occurred in California in October 2021. Both regions are prone to severe drought, and finding credibility in seasonal forecast models to predict characteristics of specific precipitation events two weeks or further in advance could aid water managers. By comparing observed and forecast precipitation and large-scale weather patterns, neither case captured the timing or the magnitude of the events. In California, even the large-scale pattern was not predictable, suggesting that the event was associated with shorter timescale synoptic variability that is not predictable three weeks in advance. For the monsoon case, the forecast was able to produce extreme precipitation events, just not on the day observed. This suggests that for the monsoon region, potentially usable information on extreme precipitation can be produced by the forecasts.



Average precipitation over the defined region (Arizona & New Mexico) shown in observations (solid black line) as well as the ensemble forecast. The median of the ensemble averages is represented by the dotted black line. The darker grey shading represents the P25-P75, or middle 50% of the ensemble members, while the light grey shading represents P5-P95, which would include the more extreme of the ensemble members.

## What Factors Influence the Cloud-driven Cooling and Heating of Earth?



**MARK IRBY-GILL**

**1st-year Protégé**  
 Sophomore  
 Red Rocks Community College  
 Geological Engineering

**MENTORS**

**RESEARCH**  
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**WRITING & COMMUNICATION**  
 Nora Loose, CU Boulder

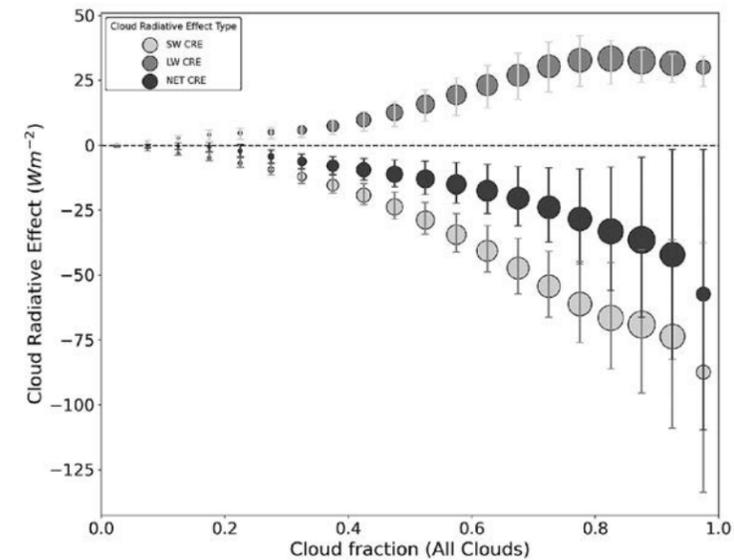
**COMPUTING/COACH**  
 Sheri Mickelson, NCAR

**PEER**  
 Ayman Elyoussoufi  
 University of Oklahoma



As the planet warms, it becomes more urgent to understand the mechanisms that drive the Earth's temperature. The Earth regulates its temperature by reflecting and emitting heat back into space. Clouds can cool the Earth by blocking the sun's heat or warm the earth by blocking heat from escaping to space. While clouds are known to impact the climate, there is still a need to understand historic and future cloud changes and how different cloud types and properties affect Earth's warming or cooling. Cloud types are determined by the thickness of the cloud and how high the cloud forms in the atmosphere. This study investigates how much each cloud type warms or cools Earth, here measured by the cloud radiative effect (CRE) of each cloud type. Using satellite datasets that report the incoming and outgoing heat energy by cloud type, the connection between CRE, cloud cover and cloud type, and how pollutants affect these relationships, is explored. While all clouds reflect sunlight and block heat energy, they do so in unequal amounts. Stratocumulus clouds have a large net cooling effect, cumulonimbus have a smaller net cooling effect, and cirrus clouds contribute a net warming effect. When the presence of pollutants is explored, the relative position of cloud versus aerosol must be considered to ensure that it is actual cloud-aerosol interaction being measured. To understand the net effect of cloud-driven climate change, future work must also consider the relative abundance of cloud types and pollutants.

**Cloud Radiative Effect for All Clouds**



Shortwave (bottom), longwave (top) and net (middle) CRE as a function of cloud fraction for all cloud types.

# SOARS 2022

## A Hybrid Approach for the Summer in Boulder, CO: Intentional Professional Development Complements Research Projects, Strengthening Resilience!

By Kadidia Thiero, SOARS PI/Program Lead

The SOARS® Program is excited to present the 26th Cohort of Protégés, as we pivoted to the first-ever hybrid summer. The program kicked off in May, virtually for two weeks; and the remainder of the program was completed in-residence in Boulder, CO. The summer housing accommodations resumed at the University of Colorado, Boulder's Bear Creek Apartments. The majority of NCAR|UCAR|UCP interns resided at the Bear Creek Apartments during the 2022 summer programs.

### THE PROTÉGÉS REPRESENTED 17 COLLEGES AND UNIVERSITIES IN THE UNITED STATES AND PUERTO RICO – FALL 2021

**Michelle Abdel-Massih**, University of Colorado, Boulder—First Year  
**Zaria Cast**, University of Tennessee, Martin—Returning, Second Year  
**Allysa Dallman**, University of Texas, Austin—Returning, Second Year  
**Ayman Elyoussoufi**, University of Oklahoma—Returning, Second Year  
**Erin Evans**, Ohio University—Returning, Second Year  
**Mark Irby-Gill**, Red Rocks Community College—First Year  
**Brittany Lazzaro**, Rowan College at Burlington County—First Year  
**William “Tony” Manriquez**, Iowa State University—First Year  
**Katurah McCants**, Metropolitan State University of Denver—Returning, Second Year  
**Miranda H. Miranda**, University of Texas, El Paso—Returning, Second Year  
**Mia Murray**, George Washington University—Returning, Fourth Year  
**Angelie Nieves-Jiménez**, University of Puerto Rico, Mayagüez—Returning, Fourth Year  
**Emily Nigro**, University of Chicago—First-Year  
**Rebecca Porter**, University of St. Mary—First-Year  
**Jannetta “Jae” Robinson**, University of Colorado, Boulder—First Year  
**Jocelyn Rodriguez**, University of California, Davis—First Year  
**Meghan Stell**, Arizona State University—Returning, Second Year  
**Jennifer Zaragoza**, Metropolitan State University of Denver—First Year

The majority of Protégés arrived in Boulder on May 28th, Memorial Day Holiday weekend! Boulder was abuzz with activity such as the Boulder Creek Festival, and the Bolder Boulder 10K. Orientation at Bear Creek provided the first opportunity to meet fellow Protégés, SOARS Alumni **Lumari Pardo** and **Armand Silva**, NCAR Scientist **Agbeli Ameko**, and AMS Director of Diversity, Equity, and Inclusion (DEI), **Katy Putsavage**. SOARS Team **Natalie Ponsford** and **Kadidia Thiero** set up the welcoming activities, and snacks for the orientation to Boulder.

On Tuesday, May 31st, the Protégés visited NCAR|UCAR for the first time as a Cohort. Headshots were taken, Protégés received their UCAR badges, and there was a SOARS Luncheon with UCP Director **Bill Kuo**, SciEd Director **John Ristvey**, and SOARS Alumni Engagement Liaison **Vanessa Vincente**. Also, Protégés toured the Earth Observing Laboratory (EOL) at the Foothills Lab; as well as the NCAR Mesa Lab, which included a meeting with the NCAR Director **Everette Joseph**; as a part of their welcoming activities.



The rest of the summer proved to be equally exciting with original research projects and relevant Professional Development. Protégés interacted with approximately 65 mentors, and with other NCAR|UCAR|UCP Interns. Field trips included one to NCAR's Research Aviation Facility, which has been recently renovated and houses the NSF aircraft. SOARS former Director **Bec Batchelor** hosted students from University of Puerto Rico, Humacao here in Boulder, and they had an opportunity to connect with the Protégés, and learn more about the Program.

### PROFESSIONAL DEVELOPMENT SERIES

#### ORIENTATION WEEK: VIRTUAL

The SOARS experience began on May 16th with an introduction to the SOARS Team, and various presentations and training. Included that first week were the UCAR Office of Diversity, Equity, and Inclusion overviews; presentations on safety ergonomics setups for home and in the office by UCAR's Health, Environment, and Safety Services; a presentation by the Office of the UCAR General Counsel on UCAR policies on ethics and harassment, and Cohort-building activities. Additionally, **Marissa Vara**, SOARS Undergraduate STEM Coordinator and I met with each Protégé to review their Individual Development Plans (IDPs). Protégés focused on goal setting, and short- and long-term objectives; these IDPs were revisited the last week of the Program, and Protégés may refer to them throughout the academic year. On Friday, May 20th the Protégés were introduced to the SOARS Instructors for the Scientific Communication and Writing Workshop (SCW)—**Noah Prior**; and the Computation and Data Science Workshop (CDW)—**Keith Maull, PhD**. Additionally, Protégés participated in a conversation about mental health resources with our licensed therapist, **Dr. Lori Kleinman**, who provided individual time and space during the summer, which was confidential and upon request.

#### WEEK TWO: “THE HISTORY OF SOARS”

One of the highlights, Friday, May 27th was the Professional Development, led by **Thomas “Tom” Windham, PhD**. Thomas is currently the Senior Advisor to the SOARS Program, and Inaugural Director of SOARS. The session focused on how SOARS came into existence as a national response to systemic racism in STEM; a successor to the UCAR Summer Employment Program (SEP); and an overview of the Program, in service of students and the earth system sciences community. The gathering was interactive, and included strategies and recommendations for self-care, and practices for coping. The Protégés received an overview of the various influences that shaped SOARS, and its evolution from 1996 to the current structure; as well as the importance of collaboration.

#### WEEK THREE: IN-PERSON CONNECTION

Tuesday, May 31st, the Protégés visited NCAR|UCAR for the first time as a Cohort. Headshots were taken, Protégés received their UCAR badges, and there was a SOARS Luncheon with UCP Director **Bill Kuo**, SciEd Director **John Ristvey**, and SOARS Alumni Engagement Liaison **Vanessa Vincente**. Also, Protégés toured the Earth Observing Laboratory (EOL) at FL, as well as the NCAR Mesa Lab, and met with the NCAR Director **Everette Joseph**; as a part of their welcoming activities.

One of the SOARS Protégés, **Angelie Nieves Jimenez**, had the opportunity to finally participate in a field campaign, the Prediction of Rainfall Extremes Campaign in the Pacific (PRECIP) in Taiwan. PRECIP had been delayed to the COVID-19 pandemic since 2020. Angelie conducted the research for her project in Taiwan, and returned to Boulder to present with her colleagues at the end of July.

On Friday, June 3rd, the Protégés and CISL's Summer Internships in Parallel Computational Science (SIParCS) Director and Intern participated in an engaging conversation about safety and security in Boulder, and at the various internship sites: NCAR|UCAR, NOAA, University of CO, Boulder, and the City of Boulder. The Chief of Police, Boulder Police Department (BPD), **Maris Herold** hosted the Protégés at the BPD Training Center, joining her on the panel were Chief of Police, CU Boulder, **Doreen Jokerst**; Deputy Police Chief, Department of Commerce (NOAA/NIST) **Julio Leon**; Director of UCAR Facilities, **Rob Reid**; BPD Chief Data Analyst **Daniel Reinhard**, and facilitated by SOARS PI/Program Lead **Kadidia Thiero**. The discussion centered on some of the safety protocols in place in the various buildings and campuses, and the challenges facing this college town: crimes of opportunity, homelessness, bike and car thefts, catalytic converter thefts, and strategies for safety and awareness. The conversation was sparked by events in Boulder and nationally that have been racially motivated, and targeted attacks. Protégés had the opportunity to ask questions, and learn more about their environment and surroundings. BPD Chief Herold would like to continue the conversation, and offered to meet at NCAR|UCAR for the next discussion.

**WEEK FOUR: STRESS AND TIME MANAGEMENT STRATEGIES FACILITATED BY LORI KLEINMAN, PHD**

As a part of the continuous feedback from Protégés, voicing the need for managing stressors, on Friday, June 11th, the Protégés participated in a closed, interactive session (no SOARS Staff) to discuss the following approaches to stress:

- I Introduction
- II What is stress?
- III Stress Hardiness
- IV Resilience
- V Prevention, Management, Restoration, Treatment
- VI Work-Life Style
- VII Questions and Discussion



2022

**WEEK FIVE: NCAR LIBRARIES OVERVIEW**

During the June 17th session, the Protégés learned about the resources that the NCAR Libraries offer, including a bookmarklet that bypasses the paywalls for most articles, journals, and other online materials; and the online resources with partner University of Colorado, Boulder. Additionally, the repository "Open Sky" was explained, and holds all digitized NCAR|UCAR associated research for public access, as well as the SOARS archives. The session was led by User Experience Librarian **Sara Byrd**, and Library Collections Technician **Krista Gawlowski**, and remotely by Metadata and Serials Librarian **Michael Flanagan**. The SOARS Newsletters have been reestablished, and will be updated in the SOARS collection as well.

**WEEK SIX: PRACTICE TALKS**

The SOARS 2022 Cohort presented their Practice Talks on Friday, June 24th, and were awesome! We really appreciated the time mentors invested by providing feedback and listening to their talks; both in advance and support on the day of the presentations. It was amazing to see the progress the Protégés have made in such a short time; and we remained excited to see how the work continued to evolve throughout the summer!

Afterwards, there was a joint Internship Programs Ice Cream Social; where summer interns and Protégés had the opportunity to meet each other, mentors, and network.



**WEEK 7: VISIT AND TOUR OF NCAR EOL RESEARCH AVIATION FACILITY (RAF)**

Protégés participated in a RAF presentation and were led on a tour by RAF Scientists **Cory Wolff**, **Pavel Romashkin**, and **Teresa Campos**. We spent two hours learning about the various instrumentation and projects that are connected to NCAR's mission. We also had some Protégés join virtually, with Marissa connected on Google Meet for students that were being cautious about health and safety. Overall, the visit was exciting, the renovation looked amazing, and the ability to walk into the plane, sit in the cockpit, and understand the instrumentation racks, and enhancements on the Gulf Stream V were remarkable.

**WEEK EIGHT: VISIT AND TOUR OF THE ATMOSPHERIC SCIENCES DEPARTMENT AT COLORADO STATE UNIVERSITY AND NSF GRFP OVERVIEW**

Faculty, Staff, and Graduate students from the Department of Atmospheric Sciences at CSU in Fort Collins discussed the graduate school process, in general; and the areas of research at CSU in particular. **Dr. Emily Fisher**, Associate Head, Atmospheric Sciences, spoke about connecting to Faculty, and the various areas of research. There was a graduate student panel, where students at various levels of their degree answered questions, and talked about their advisors, collaboration, and their cohorts. Among the graduate students on the panel was SOARS alumnus, Jamin Rader. And the students also met **Dr. Melissa Burt**, Assistant Professor and Assistant Dean for Diversity and Inclusion in the Department of Atmospheric Science and **Walter Scott, Jr.**, College of Engineering, and SOARS alumna.

During our Friday, July 15th morning Check-In, the Protégés had an opportunity to speak to UCAR NextGen Fellow **Akilah Alwan** about her experiences in geoscience education, DEIJ, and her NSF Graduate Research Fellowship Program (GRFP) Award and process. Our Undergraduate STEM Coordinator, **Marissa**, gave tips on applying for the competitive GRFP, and the various levels of funding and eligibility. The discussion was interactive, and Protégés had an opportunity to ask questions, and hear realistic feedback concerning when to apply, and how often to apply.

**WEEK NINE: SPECIAL EVENT THIS WEEK—NAVIGATING ACADEMIC SPACES AND FACULTY RELATIONSHIPS**

The final week of Professional Development Series provided the Protégés an opportunity to participate in a DEI-themed activity with undergraduate and graduate students from the Department of Atmospheric and Environmental Sciences at the University@Albany. The Professor and Filmmaker who produced "Can We Talk? Difficult Conversations with Underrepresented People of Color," **Kendall Moore, PhD** facilitated a panel with other Faculty, and how to navigate these academic spaces, often fraught with problematic issues, as well as the relationships between Faculty and Students.

The interactive session comprised of panelists, several of whom were in the movie, discussed their experiences in academia, and the students that they support currently at their respective institutions. The Faculty talking about their experiences were **Vernon Morris, PhD**, Arizona State University; **Aradhna Tripathi, PhD**, University of California, LA; and **Brian Tang, PhD**, University@Albany.

**FINAL WEEK: CLOSING ACTIVITIES AND REFLECTIONS**

The SOARS Program culminates the summer experience with submission of the deliverables: the SOARS Research Colloquium, oral presentations of the summer research projects; written abstracts and final papers, and a poster, which is presented at the Joint Summer Interns Poster Symposium. Protégés are using multiple ways to communicate their research, and gaining the necessary experience to present in various situations, such as national conferences and symposia.

The closing activities and reflections allow Protégés to revisit their experiences, as well as see themselves as a cohort, as well as collaborators in the field of earth system science. Protégés represent the next generation of scientists, and they are imbued with the sense of belonging, and understanding that they are contributors to real world solutions. ■



## Evaluating an Ensemble-Based Statistical Model in Predicting the Rapid Intensification of Tropical Cyclones



**BRITTANY LAZZARO**

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RESEARCH  
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Carlos Martinez\*, NCAR

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Jesse Nusbaumer, NCAR

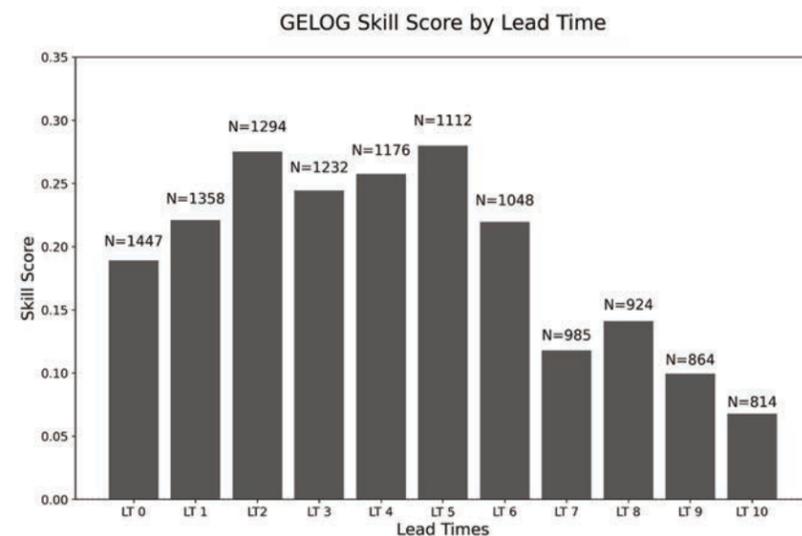
COMMUNITY COACH  
Meghan Myron-Karels, UCAR

COACH  
Zaria Cast,  
University of Tennessee, Martin

\*SOARS Alumni



Each year in the United States, tropical cyclones (TC) cause billions of dollars in damage and the loss of life. Given the undeniable impact, research into TC behavior, such as rapid intensification (RI), remains a high priority of the National Hurricane Center (NHC). Rapid intensification—defined here as a maximum wind speed increase (1-min 10-m sustained) of 30 kt or greater in a 24-hr period—is especially difficult for models to forecast. Here, a statistical prediction model, the Global Ensemble Forecast System (GEFS) Logistic Regression (GELOG) model, was evaluated to determine its ability to predict RI. GELOG utilizes logistic regression and a set of factors that can be indicative of RI to calculate the probability of RI occurrence for 24-hr periods throughout the life of a storm. The model can generate these probabilities with 0 to 60 hours of lead time, allowing greater visibility into future TC behavior and potential impact. Through skill assessment by comparing GELOG predictions to observational data, the model was assigned a skill score for each lead time. GELOG was found to be skillful at all lead times when compared to climatology, indicating that the model is capable of forecasting RI with some consistency. Additionally, comparison to several models currently in use at the NHC found GELOG to be the most skillful among them when predicting RI occurrence. GELOG, when used in tandem with existing models, could prove to be excellent guidance for forecasters when examining the potential for RI.



GELOG skill, sorted by lead time, where N equals the number of cases (predictions) included in the set analyzed for the given lead time.

## Utilizing Machine Learning with Convection-Allowing Models to Predict Severe Weather



**WILLIAM ANTHONY MANRIQUEZ**

**1st-year SOARS Protégé**  
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Biological Systems Engineering  
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### MENTORS

RESEARCH  
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WRITING & COMMUNICATION  
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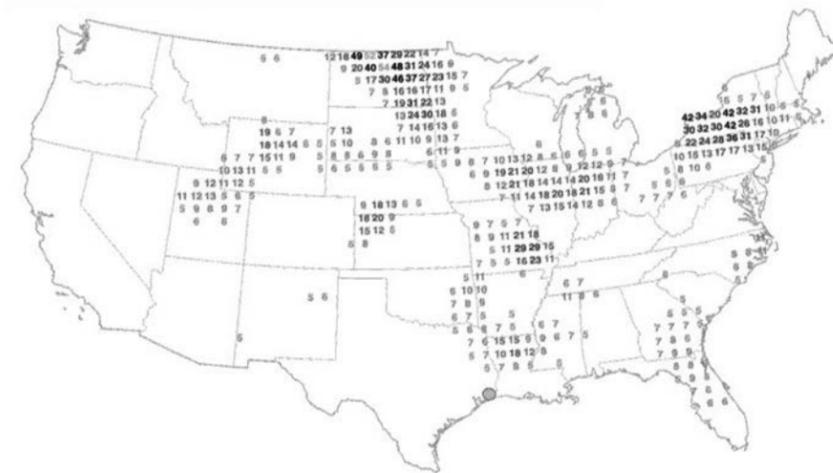
COACH  
Jeff Weber, UCAR

PEER  
Meghan Stell,  
Arizona State University



Machine learning (ML) has been introduced into many disciplines, including severe weather prediction. Recent research has shown that using a trained feed-forward neural network (NN) to produce probabilistic convective hazard predictions significantly improved forecast reliability and resolution compared to simple severe storm surrogates like updraft helicity. This study aimed to augment the current NN forecast model with convective mode information. Convective mode information is considered useful as a possible predictor of severe weather. The convective mode was derived from a separate ML model that classified storms as supercellular or quasi-linear based on pictures of simulated radar reflectivity. Approximately 700 forecasts from 2010-2019 were trained into our ML algorithm. The NN model included input from over 150 variables from the Weather Research and Forecasting (WRF) model. These inputs formed two hidden layers with 16 neurons producing an output layer with six probabilities between zero and one. The outputs were used to forecast the probability of severe weather hazards within a 40-km radius for 24 hours. After adding convective mode information to the ML algorithm, preliminary results indicate no statistically significant improvements with the model compared to its performance without convective mode information. Future work may focus on weather hazards, such as wind and hail.

**00 UTC HRRR Neural Network Convective Hazard Forecast**  
Max Day 1 (12Z-12Z) probability of any severe hazard within 40 km



Probability of any severe weather hazard within a 40-km radius for a 24-hour period for each numbered area as computed by the ML probability algorithm with input from the High-Resolution Rapid Refresh (HRRR) model.

## Determining the Horizontal Extent of Liquid Cloud Layers Using GOES-R and Ceilometer Data



**KATURAH MCCANTS**

**2nd-year SOARS Protégé**  
 Graduated BS – 2021  
 Metropolitan State University  
 of Denver  
 Meteorology

### MENTORS

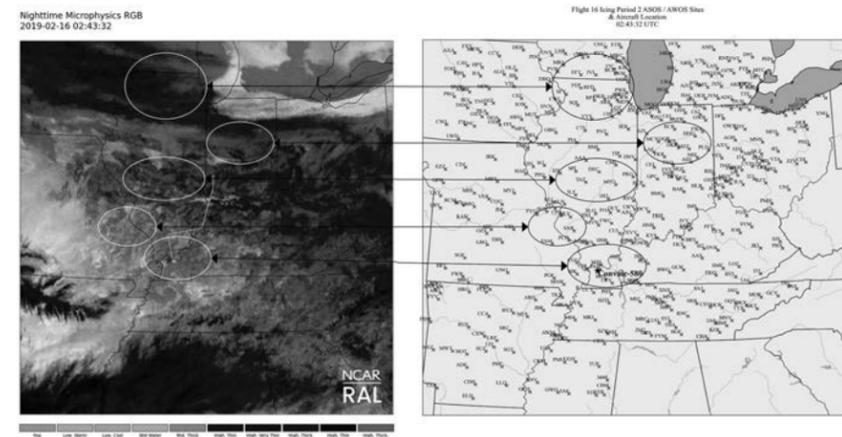
**RESEARCH**  
 Scott Landolt, NCAR  
 Darcy Jacobson, NCAR

**WRITING & COMMUNICATION**  
 Roberta Spivak, NCAR



Inflight aircraft icing is a well-known hazard for the aviation industry, resulting in multiple aviation accidents each year. Although many products have been developed to assist pilots in determining the current and forecasted locations of icing conditions, mitigation of these hazards is challenging due to the highly variable environments in which they occur. Geostationary satellite products have been useful in detecting icing conditions in single-layer cloud environments, but struggle when multiple cloud decks are present because the satellites are generally only able to observe the optical properties of the highest cloud deck. Examination of the low-level liquid cloud layers is critical because pilots generally encounter the most dangerous icing conditions in these layers.

The Geostationary Operational Environmental Satellite (GOES) R series has provided several products which provide invaluable information for detecting icing conditions in-cloud. Employing surface-based observations of cloud base heights gathered from the Automated Surface Observing System (ASOS) and Automated Weather Observing System (AWOS) network in combination with the GOES Daytime Cloud Phase and Nighttime Microphysics Red-Green-Blue (RGB) products, the objective of this project is to evaluate the ability of these RGB products in determining the areal coverage of low-level liquid cloud layers in multi-layered cloud environments. Preliminary results are promising, particularly for the GOES Nighttime Microphysics product, regarding its ability to extrapolate the spatial extent of cloud layers in multi-layered cloud environments.



GOES-R Nighttime Microphysics RGB satellite image (left), ASOS / AWOS stations in flight domain (right) for analyzed Flight 16 icing period. Regions examined highlighted in circles.

## Can We Detect the Influence of Surface Anthropogenic Pollution on Regional Tropospheric Ozone Variability?



**MIRANDA H. MIRANDA**

**2nd-year SOARS Protégé**  
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### MENTORS

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Anthropogenic pollution can travel long distances through the troposphere, impacting the air quality downwind of emission sources. In this study, carbon monoxide (CO) and non-regional tropospheric ozone (O<sub>3</sub>)—tracers of anthropogenic emissions—are used to quantify the influence of transported anthropogenic pollution. O<sub>3</sub> and CO data were obtained from two offshore NOAA aircraft sampling sites located in the northeast United States downwind of the Northeast megalopolis from 2006-2020. Ozone from NOAA's Tropospheric Ozone Aircraft Network and CO from NOAA's Global Greenhouse Gas Reference Network's Aircraft Program are studied in three broad layers: boundary layer (0-3 km amsl), free troposphere (3-6 km amsl) and upper troposphere (6-9 km amsl). The air being sampled by the aircraft was characterized using backward trajectories calculated using the NOAA Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPPLIT) model. Results from HYSPLIT were used to identify the source regions from which these air samples originated. The O<sub>3</sub>-CO relationship is discussed for each air sample source region. The influences of transported pollution as identified in the O<sub>3</sub>-CO relationship are discussed as are the potential identification of stratospheric intrusion, the downward transport of stratospheric ozone into the lower troposphere. Results for the O<sub>3</sub>-CO relationship at both sites showed a positive correlation during the summer and a negative correlation during the winter, a relationship possibly driven by nitrogen oxides and volatile organic compounds. The HYSPLIT trajectories showed eastward influences on the air mass in one of the sites and north-central U.S.A and Southern Canada (Great Lakes area) influences on the air mass in the second site.

### NHA HYSPLIT 72hr Backward Trajectory for Spring (M-A-M/06-16)



HYSPLIT 72-hour backward trajectory for the NOAA/ESRL/GML O<sub>3</sub> measurements taken in Portsmouth, New Hampshire (NHA) divided into lower, middle and upper troposphere showing major transport from the North Atlantic, mid-western United States and, to a lesser degree from the Pacific Ocean, off the coast of California and Baja California, Mexico.

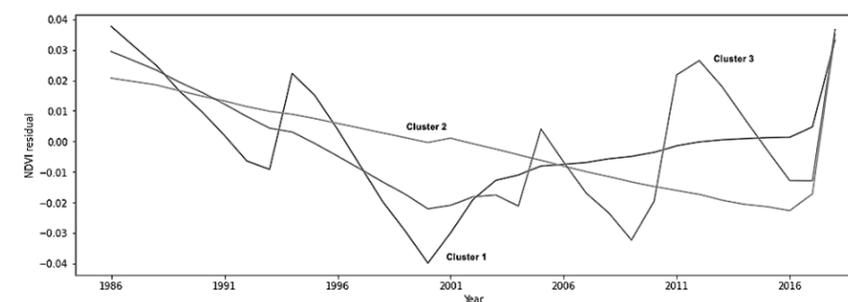


## Using Time Series Segmentation to Generate a Novel Land Cover Classification for Xilinhot, Inner Mongolia

Current modeling of land use and land cover of rangelands is limited by shortcomings in the ontological and methodological approaches to classification. For example, current classification schemes often limit rangeland cover types into one of a small number of categories, typically grassland, shrubland, or barren, and change is only measured when a pixel shifts to a new class. These coarse categories can mask the complex dynamics happening within a given land cover type, such as greening or browning that might occur prior to a state shift. A more nuanced classification of grasslands that represents the dynamics occurring within a class would contribute meaningfully to policy and management. In this study, we assess a novel method for classifying land cover change, focussed on Xilinhot, a provincial city in central Inner Mongolia, located in one of the largest remaining arid grassland regions of the world. The region has faced rapid development and land use conversion in recent decades and grassland condition is declining in many areas, but the mechanisms of these changes are difficult to assess with traditional change detection approaches.

In this study we apply the LandTrendr (LT) segmentation algorithm to a time series of Landsat-derived imagery of vegetation condition to capture changes in 30+ years of cover in Xilinhot. After accounting for effects of climate, we then classify the resulting segmented data within an unsupervised k-means clustering scheme. We identified three unique classes in the data; these classes represent unique pixel trajectories resulting from past changes in management and land use. These data on the influence of past intervention on pixel-level responses can be used to help build predictive models to better understand the potential impact of future policy and management changes.

**Time Series of Fitted Residual Greenness Clusters Identified in the Reclassified Combined Bands Data Set**



K-means time series trajectory of the fitted NDVI residuals for the final combined bands data set.



**MIA MURRAY**

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**ANGELIE NIEVES JIMÉNEZ**

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**WRITING & COMMUNICATION**  
 Patricia DeRepentigny, NCAR

\*SOARS Alumni



## A Comparison of the Diurnal Cycle of Precipitation in Taiwan and Puerto Rico

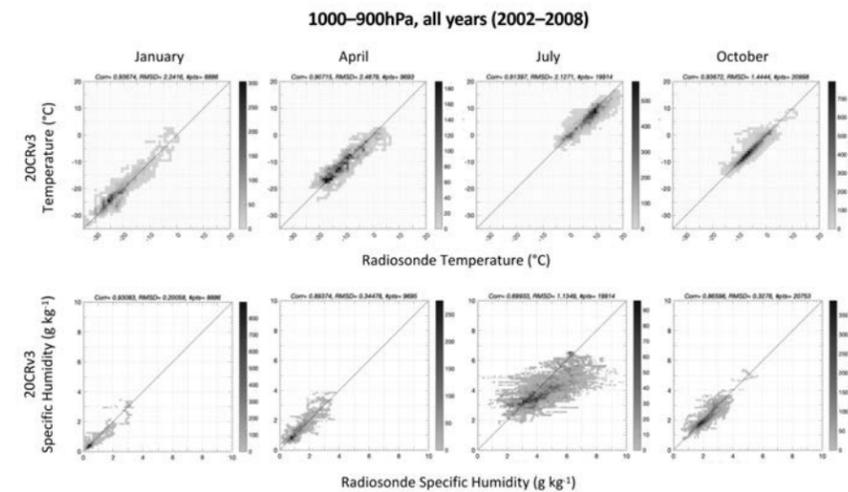
Puerto Rico and Taiwan are mountainous islands that experience heavy precipitation events that can cause significant societal disruptions. Field campaigns such as NASA's Convective Processes Experiment – Aerosols & Winds (NASA CPEX-AW) and the Prediction of Rainfall Extremes Campaign in the Pacific (PRECIP) in 2022 aimed to study convective storms and heavy precipitation events. In this study, we participated in and obtained radiosonde data from these projects to analyze and compare the islands' diurnal cycles of precipitation. Soundings before, during, and after the events were considered for wind profile comparison. We observed that both Puerto Rico and Taiwan's weather regimes are affected by their central mountain ranges and the environmental wind flow on each island. In future comparisons, the analysis will focus on characterizing more atmospheric variables, such as temperature and available moisture, that generated similar heavy rainfall events.



Taiwan's Central Weather Bureau (CWB) Automatic Radiosonde Launcher. Radiosondes launched at 00 UTC, 06 UTC, 12 UTC, and 18 UTC for the PRECIP field campaign. Source: Angelie Nieves Jiménez at Hsinchu, Taiwan (PRECIP 2022)

## Validating the Twentieth Century Reanalysis Version 3 (20CRv3) with North Slope of Alaska Radiosonde Observations

The NOAA-CIRES-DOE Twentieth Century Reanalysis Version 3 (20CRv3) is a historical weather reanalysis that reconstructs global atmospheric conditions from 1836–2015 using surface pressure observations. 20CRv3's performance in the Arctic, a region of great importance to global climate due to rapid warming and sea ice decline as well as important feedback mechanisms, has not been explored thoroughly. Since 2002, the U.S. Department of Energy's Atmospheric Radiation Measurement (ARM) Program has been collecting radiosonde observations at Utqiagvik, Alaska, on Alaska's North Slope. These observations provide a unique opportunity to evaluate the ability of 20CRv3 to reconstruct atmospheric conditions in the Arctic. Statistical methods were used to investigate how well 20CRv3 estimates match temperature and specific humidity profiles observed by radiosondes from 2002–2008. Full temporal and spatial dataset correlations are high, though 20CRv3 underestimates temperature between -52 and -45 °C and overestimates specific humidity at small values (<1 g/kg). When aggregated by month, 20CRv3 temperature has good correlation with the radiosondes and 20CRv3 specific humidity has moderate correlation; both variables have poor correlations in the upper atmosphere. Specific humidity correlations are lower when there is more moisture in the atmosphere, possibly owing to difficulties with modeling and observing this variable. Evaluated by year, 20CRv3 temperature is better correlated than specific humidity, and the atmospheric layer closest to the surface has better temperature correlations than the tropopause layer. These results are an exploratory first look at 20CRv3's performance in the Arctic and begin to provide confidence in its utility for the region.



Two-dimensional histograms of temperature (top row) and specific humidity (bottom row) between 1,000 and 900 hPa during winter (January), summer (July), and the transition seasons between them (April and October). The radiosonde values from ARM's North Slope of Alaska (NSA) site at Utqiagvik are plotted on the x-axes, while time- and space-matched 20CRv3 values are plotted on the y-axes.



**EMILY R. NIGRO**

**1st-year SOARS Protégé**  
 Junior  
 University of Chicago  
 Environmental Science

**MENTORS**

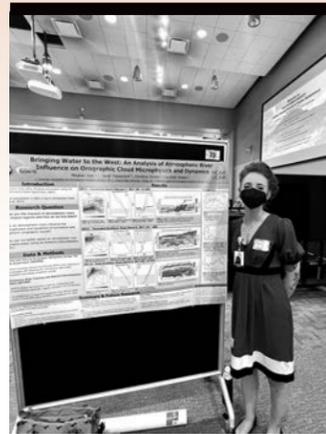
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**WRITING & COMMUNICATION**  
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**COACH**  
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**PEER**  
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 University of Maryland,  
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## Assessing the Need to Improve Road Safety and Mobility During Severe Convective Weather Events: A Wyoming Case Study



REBECCA PORTER

1st-year SOARS Protégé

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The University of Saint Mary  
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WRITING & COMMUNICATION  
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COACH  
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PEER  
Miranda H. Miranda  
University of Texas, El Paso



Wyoming is a key state in the transportation of goods and services across the country, as it has a major highway—Interstate 80—running through the southern portion of the state. Due to its importance in the transportation industry, monitoring and forecasting potentially adverse weather is critical in keeping I-80 open and traffic flowing as smoothly as possible. Any shutdown of this highway can cost \$1 million to the private trucking industry. The focus of this study is to understand the relationship between severe convective weather (SCW) and traffic safety and mobility in Wyoming using the Wyoming Department of Transportation's (WYDOT) crash database from 2010–2017 to inform future decisions regarding road weather safety measures. Here we focus on summertime SCW conditions, which are under-studied in the road weather community. Using the crash database information on road and weather conditions, this study aims to understand which conditions pose the most risk to transportation, which vehicles are at highest risk due to the effects of SCW, and whether these incidents predominantly involve single or multiple vehicles, among other information. Preliminary results suggest that a combination of wet roads and rainy weather poses the highest risk to travelers throughout Wyoming. Interstates are most affected by these incidents; in addition, the distribution of incidents depends on topography. These results will inform algorithm improvements in Pikalert®, a system employed by WYDOT to improve road safety and mobility during adverse road weather.

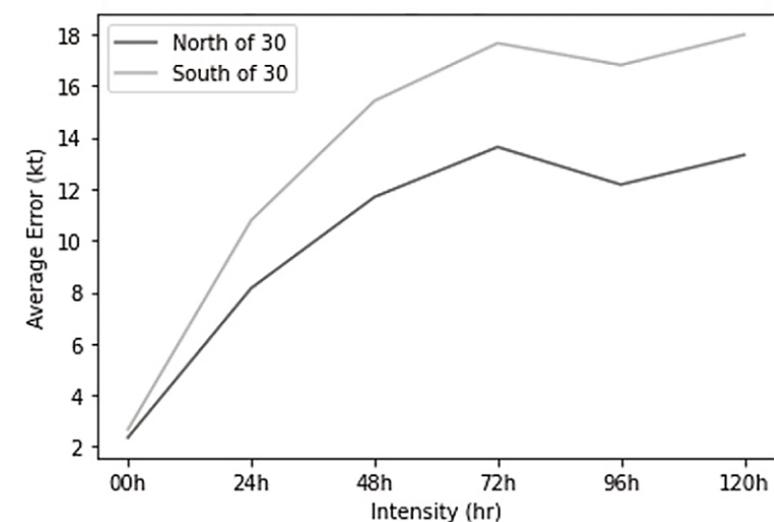
		Number of crashes per weather and road condition								
		Weather Condition								
Road Condition		Unknown	Clear	Rain	Fog	Blowing Dust/ Sand/Dirt	Severe wind only	Sleet/Hail/ Freezing rain	Cloudy/ Overcast	Severe T-storm/ Tornado
		Unknown	<b>60</b>	9	1	0	0	0	0	0
	Dry	17	0	13	15	7	<b>75</b>	0	0	2
	Wet	0	0	<b>1015</b>	27	1	21	<b>58</b>	<b>179</b>	5
	Ponding/ Flow	0	3	<b>79</b>	1	0	1	14	18	0
	Ice/Frost	0	18	6	5	0	0	12	7	0
	Slush	0	0	8	0	0	0	23	2	0
	Other	0	12	0	0	0	1	3	0	0

WYDOT database 2010-17. Number of crashes for each combination of road and weather condition. Conditions with over 50 crashes are shaded and bolded. There is overlap in some outputs, such as with how many incidents occurred under each weather or road type. If a specific incident has three weather types associated with it, that crash will be counted three different times, one in each of those categories.

## Observing Tropical Cyclone Forecast Error Variability in the North Atlantic Basin

Tropical cyclones cause billions of dollars in annual damage and have the highest mortality rate out of all weather catastrophes. The National Hurricane Center (NHC) issues forecasts every six hours to inform and warn the public about these disasters. After a hurricane season, the observations of that season go into a post analysis (Best Track) for documentation. The original forecasts are compared to the Best Track to get the forecast error, which is archived into the NHC Official Forecast Verification Dataset. Little research has been done on the characteristics of forecast error trends relating to spatial and specific temporal variation throughout the seasons (i.e., months, days, and hours). This study compares the intensity and track forecast average error variations temporally by decade, year, month, and day of month. Furthermore, intensity and track forecast average errors are calculated within specific regions in the Atlantic Ocean, such as areas within the tropic and subtropic mid latitudes. Comparing both track and intensity average error across time, average error decreases by decade and year, agreeing with other studies. This is mainly due to technological advances over time. Comparing average error within shorter time groups of months, days, and hours shows no significant relationship. Interestingly, comparing the average error filtering by north and south of 30N showed a significant relationship, track error being greater north of 30N and intensity error being greater south of 30N. In conclusion, the track and intensity forecast errors are not dependent on the studied aspects of time besides group by decade. There is significant spatial variability in both track and intensity errors with respect to latitude.

TC Intensity Error Averaged by Latitude (1990-2019)



Average intensity error over time of tropical cyclones in the Atlantic by latitude in degrees (North of 30 degrees and South of 30 degrees).



JANNETTA "JAE" ROBINSON

1st-year SOARS Protégé

Junior  
University of Colorado, Boulder  
Ecology and Evolutionary Biology

### MENTORS

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Falko Judt, NCAR

WRITING & COMMUNICATION  
Richard Neale, NCAR

COACH  
Julie Malmberg, UCAR

PEER  
Mia Murray  
George Washington University



## Comparing the Efficacy of Calculated and Measured Forest Canopy Temperature for Estimating Stomatal Conductance



**JOCELYN RODRIGUEZ**

**1st-year SOARS Protégé**  
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University of California, Davis  
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Management

### MENTORS

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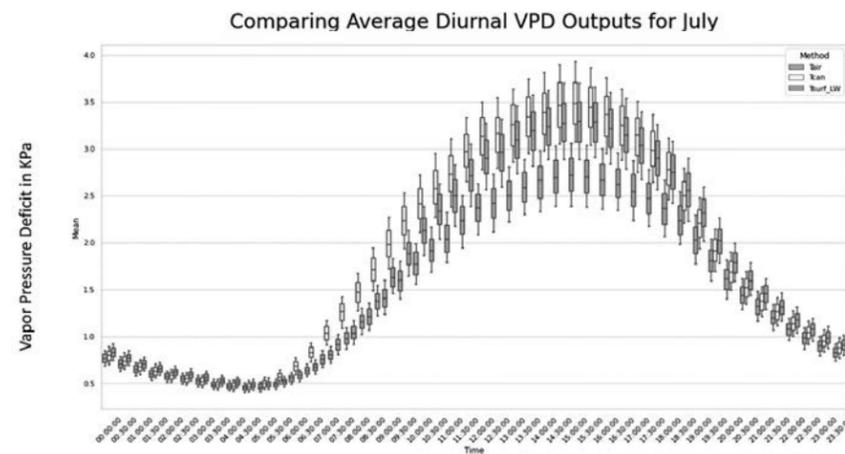
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Accurate stomatal conductance calculations enable more accurate evapotranspiration estimations. Past models use the inverted Penman-Monteith equation and atmospheric conditions to estimate stomatal conductance, but the lack of widely available canopy temperature data requires that the canopy temperature be approximated by air temperature. The sensitivity of the air-canopy approximation to small errors in temperature input may translate to exponentially larger errors in the output. The availability of canopy temperature data from flux towers creates an opportunity to compare model outputs of stomatal conductance when using different approximations of canopy temperature. To explore how different surface temperature approximations affect model output, we used data collected over seven months from a flux tower in Wind River, Oregon. We used this to run comparisons between model outputs given the following: (1) surface temperature equivalent to air temperature, (2) surface temperature calculated from net radiation, and (3) surface temperature interpolated from high frequency images. We plotted the difference in vapor pressure deficit across eight months and found there was a difference in vapor pressure deficit output during warmer conditions, but not during colder conditions. Understanding how the different temperature inputs translate to differences in the vapor pressure deficit output will allow us to trace how the magnitude of the differences translates across further calculations of stomatal conductance.



When looking at the month of July, we see that there is a difference in model output for vapor pressure deficits between groups at the 95th and 5th percentiles. Specifically, we see that the estimated output is greater when we run the model using the interpolated canopy temperature and estimation from net radiation than when using temperature of the canopy approximated as being equal to the air temperature above.

## Bringing Water to the West: An Analysis of Atmosphere River Influence on Orographic Cloud Microphysics and Dynamics



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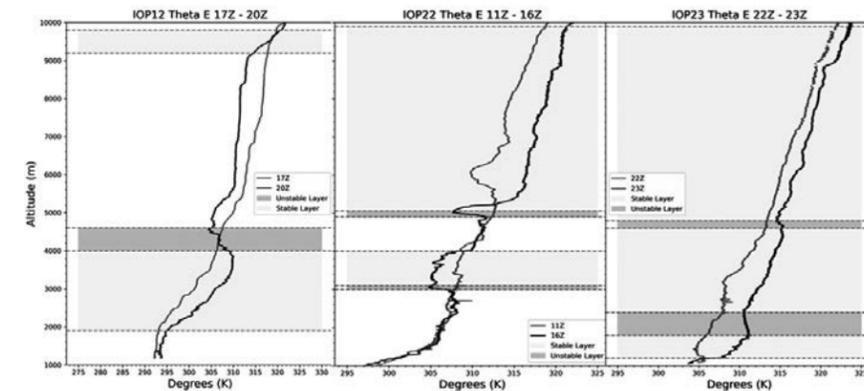
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Atmospheric Rivers (ARs) are important sources of moisture and influence precipitation in the inland US. This study focuses on inland-penetrating AR impacts on microphysics and dynamics of orographic clouds. During the Seeded and Natural Orographic Wintertime Clouds: the Idaho Experiment (SNOWIE) field campaign, multiple ARs reached Idaho, providing an opportunity to study the impacts of inland-penetrating ARs. Data from the Atmospheric River Tracking Method Intercomparison Project (ARTMIP) identified ARs over Idaho. AR impact was analyzed for three SNOWIE Intensive Observation Periods (IOPs): IOP12, a convective case, and IOPs 22 and 23, stratiform cases. Observations from SNOWIE were used to analyze the thermodynamics and microphysics in these IOPs. Analysis of IOP12 indicated enhanced moisture between 3,000-4,000 m as the AR impacted the region, increasing instability above 4,000 m. This instability led to elevated convection and mixed-phase conditions and snow in the convective clouds, in contrast to adjacent shallow orographic cloud tops that were mostly liquid with supercooled drizzle. This contrast provided evidence that convection enhanced ice-based precipitation formation. Analysis of IOP 22 indicated enhanced moisture between 5,600-8,700 m with a dry layer between 4,900-5,100 m leading to a decoupled stratiform cloud. During IOP23, enhanced moisture from 1,100-10,000 m led to a deep stratiform cloud. Mixed-phase conditions in IOP22 evolved into glaciated conditions with rimmed dendrites during IOP23. This study illustrates the influence of moisture from inland-penetrating ARs on orographic cloud thermodynamics, microphysics, and the resulting precipitation processes.



Atmospheric stability response to atmospheric river influence in IOP12 (left), IOP22 (middle) and IOP23 (right). In IOP12 the AR influence was observed between 2,000-4,000 m, resulting in increased instability above 4,000 m (dark grey shading) and enhanced convection. In IOP22 the AR brought upper-level moisture above 5,600 m. A dry layer between 4,900-5,100 m resulted in a decoupled stratiform cloud with stable conditions aloft (light grey shading). In IOP23 deep moisture from the AR was observed from 1,100-10,000 m, resulting in a deep stratiform cloud with overall stable conditions through the column of the atmosphere with a few shallow layers of instability.

## An Evaluation of an Aircraft Icing Product Using In-Situ Observations



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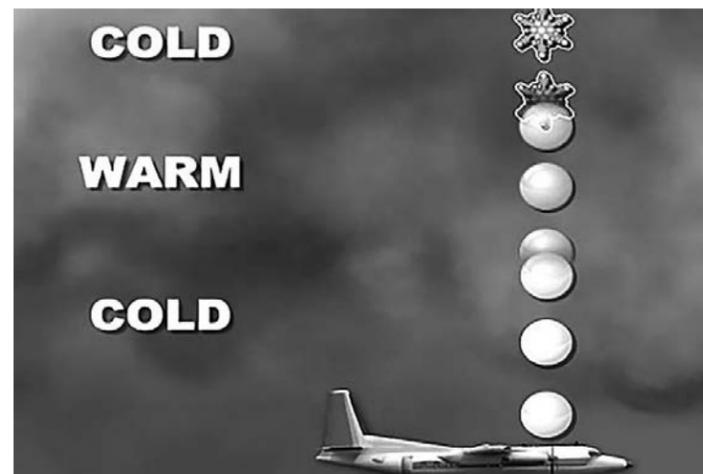
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The smooth surface and body of an aircraft is designed to allow airflow to glide over it with minimal effort and turbulence. If the plane's surface is modified while in flight, the results can cause the airplane to react to airflow in a very different manner that may lead to loss of control over the aircraft. Supercooled liquid water is an atmospheric hazard capable of rapidly changing the shape of an aircraft in flight and can be found in droplet form and in various types of clouds at freezing and subfreezing temperatures. Aircrafts fly through clouds containing supercooled liquid drops regularly and undergo ice buildup from this atmospheric hazard that has, in some severe instances, caused loss of aircraft control which ended in fatalities.

The purpose of this research is to evaluate and validate a new weather algorithm, the Terminal Area Icing Weather Information for NextGen (TAIWIN), through visual comparisons against verified icing environment data recorded during the In-Cloud Icing and Large-Drop Experiment (ICICLE) flight campaign. Four ICICLE case studies were chosen for comparison against TAIWIN algorithm results of icing or no icing present in a particular environment. In all four cases, TAIWIN correctly diagnosed the environmental conditions. Once put into practice, TAIWIN will assist air traffic control in guiding aircrafts away from potentially dangerous environments which can end in flight fatalities.



Supercooled liquid drops pose a significant hazard to aircrafts. The image represents the common atmospheric process that creates these hazards. Water droplets start as ice in the upper cold layer, melt in the warm layer, then remain liquid even as their temperature drops to below freezing in the lower cold layer, thereby becoming supercooled liquid drops.





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<b>CIRES</b>	Cooperative Institute for Research in Environmental Sciences	<b>NOAA</b>	National Oceanic and Atmospheric Administration
<b>COSMIC</b>	Constellation Observing System for Meteorology, Ionosphere, and Climate	<b>NSCP</b>	NOAA Science Collaboration Program
<b>COMET</b>	Cooperative Program for Operational Meteorology, Education and Training	<b>NSF</b>	National Science Foundation
<b>CPAESS</b>	Cooperative Programs for the Advancement of Earth System Science	<b>SOARS</b>	Significant Opportunities in Atmospheric Research and Science
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