Statement of Career Achievements
Kristen Guirguis
2018-2022

My research focuses on understanding and predicting different types of extreme weather impacting California and the western US. I am interested in the roles of natural variability and anthropogenic climate change, as well as impacts of extreme weather on society. In this capacity, I have investigated atmospheric rivers (ARs) making landfall along the coast of western North America, Santa Ana winds (SAWs) in Southern California, and heat waves over California and the western US. During this reporting period, I have developed a new research track focused on atmospheric weather patterns observed over the North Pacific Ocean and along the West Coast, which I have linked to a variety of weather impacts including ARs, extreme precipitation, historic California floods, SAWs, heat waves, and wildfires. This work has led to the development of a new method of predicting extreme weather in California, which I am currently developing in collaboration with the Center for Western Weather and Water Extremes (CW3E). I am also continuing with my work on environmental health impacts through regular collaboration with epidemiologists, with the goal of helping to enhance decision-making capacity and improve outcomes for future extreme weather events, which are expected to become more frequent due to climate change.

Since my promotion to Associate Project Scientist in July 2018, I have contributed to ten research articles including three that I led, published two new datasets, and designed and implemented a subseasonal-to-seasonal (S2S) forecast product for predicting extreme weather impacts over California. My work over this period includes interdisciplinary collaborations with federal, state, and local decision-making agencies who work at the intersection of environmental science and health and society. My research is described below (Section 1), along with my funding support (Section 2), descriptions of recent professional activity and university and public service (Section 3), commitment to diversity (Section 4), and future research goals (Section 5).

1. Recent and Ongoing Research

Below I describe my research, which I have categorized into three topics. Section 1.1 describes a new research track focused on atmospheric weather regimes impacting California with applications for S2S predictability, and which represents most of my effort over the past four years. Section 1.2 describes research focused on precipitation regime change and Santa Ana winds, two studies that were led by Dr. Alexander Gershunov, to which I contributed. Section 1.3 describes research that I contributed to on the impacts of environmental hazards on human health and society, which were led by epidemiologists and other close collaborators. My personal contribution to the publications from this reporting period is provided in Section 1.4.

1.1 A Weather Regime Approach to Predicting Impactful Winter Weather in California

The bulk of my work during this reporting period has been focused on understanding relationships between synoptic-scale atmospheric circulation and weather impacts over California and Western North America. This effort began with a focus to improve predictability of landfalling ARs on extended range to S2S timescales (on the order of 10-30 days) in collaboration with CW3E. Recently, this work has evolved to include other types of extreme weather such as Santa Ana winds and heat waves, which has implications for California wildfire hazard. This work has resulted in three research papers, two new datasets, and a skillful forecast product that was run experimentally

in real-time last winter. This work represents a new research direction with many possible applications.

Guirguis et al. (2018) was the first in a series or research papers focused on classifying atmospheric circulation patterns important for West Coast weather. In this paper, we used Empirical Orthogonal Function (EOF) analysis applied to 500 mb geopotential height (Z500) anomaly fields to identify dominant modes of variability over the North Pacific Ocean and along the West Coast. We then investigated relationships between each of these modes and landfalling ARs. An important result of this work was the finding that most AR landfalls along the coast are driven by only four modes of atmospheric variability, which has implications for predictability. We named these four modes according to their geographic centers of action as: the Baja-Pacific (BP), Alaskan-Pacific (AP), Canadian-Pacific (CP) mode, and Offshore-California (OC) modes.

In **Guirguis et al. (2020a)**, we continued with this work, focusing on these four main drivers of AR landfalls (i.e., the BP, AP, CP, and OC modes), which are collectively named "North Pacific Modes", or "NP4 modes" to highlight their joint influence. We showed how on daily timescales the joint positive/negative phase combination of these modes can reinforce atmospheric ridges and troughs in certain locations over the North Pacific Ocean and along the West Coast, leading to wet or dry conditions over California. We linked these different phase combinations to California precipitation and damaging historical California floods. On seasonal timescales, these modes tend to persist preferentially in one phase or another, and this seasonal persistence is important in determining whether California experiences a wet or a dry winter. We demonstrated that the El Niño Southern Oscillation (ENSO) modulates the seasonal phase prevalence of some of these NP4 modes, but there is much variability even after accounting for ENSO. These results improved our understanding of why the strong El Niño event of 2016 was not nearly as wet for California as other strong El Niño winters (e.g., 1997/1998 and 1982/1983) and serve as motivation for future work on seasonal predictability of California precipitation. Along with this work, we published a new dataset of historical observed daily NP4 mode amplitudes that can be used for future research (**Guirguis et al. 2020b**).

In **Guirguis et al. (2022a),** we provided a deeper examination of the role of the NP4 modes in driving California winter weather. We showed that as the NP4 modes fluctuate on daily timescales throughout the season, their joint phase combinations result in distinct weather patterns that reoccur throughout the historical record. Using these phase relationships, we defined sixteen weather regimes that drive impactful weather in California. Through a rigorous analysis applied to multiple observational datasets, we catalogued the relationships between each weather pattern and AR landfalls, extreme precipitation, SAWs, heat waves, historic California floods, and Southern California wildfires. We additionally showed that the types of weather patterns associated with destructive California wildfires are increasing in frequency while the types of weather patterns associated with precipitation in Southern California and the Desert Southwest are decreasing in frequency. Importantly, the frequency of weather patterns linked to historic California floods are not diminishing. These findings support the results of earlier work described in Gershunov et al. 2020 and 2022 (see in Section 1.2 below) and highlight the increasing risk of compound extreme events during California winters. We additionally published a catalog of these historical observed weather patterns spanning more than 70 years for use in future research studies (**Guirguis et al. 2022b**).

The motivation for these studies was to better understand relationships between synoptic-scale atmospheric circulation and California weather, to develop new methods for predictability. I have used the findings from these three publications to develop a new methodology for predicting

various types of impactful weather events in California, including ARs, SAWs, and heat waves. This new S2S forecast product combines forecasts of mid-tropospheric atmospheric circulation (Z500) from dynamical weather forecast models together with a statistical model to predict the probability of certain weather impacts over California and the Western US. This statistical-dynamical hybrid product was recently run experimentally in real-time last winter. The model and skill assessment results were presented at the American Geophysical Union Fall Meeting (**Guirguis et al. 2021a**), and we aim to submit the final results for peer review later this year.

- **Guirguis, K**, A. Gershunov, T.M. Shulgina, A. Subramanian, R.E.S. Clemesha, F.M. Ralph. (2018). Circulation drivers of Atmospheric Rivers at the North American West Coast. *Geophysical Research Letters*, **45**,12,576-12,584. https://doi.org/10.1029/2018GL079249.

- **Guirguis, K**., A. Gershunov, M.J. DeFlorio, T. Shulgina, L. Delle Monache, A.C. Subramanian, T.W. Corringham, and F. M. Ralph. (2020a). Four atmospheric circulation regimes over the North Pacific and their relationship to California precipitation on daily to seasonal timescales. *Geophysical Research Letters*. **47**, https://doi.org/10.1029/2020GL087609

- **Guirguis, K**., A. Gershunov, B. Hatchett, T. Shulgina, M.J. DeFlorio, A.C. Subramanian, Janin Guzman-Morales, R. Aguilera, R. Clemesha, T.W. Corringham, L. Delle Monache, D. Reynolds, A. Tardy, I. Small, and F. M. Ralph (2022a). Winter Wet-Dry Weather Patterns Driving Atmospheric Rivers and Santa Ana Winds Provide Evidence for Increasing Wildfire Hazard in California. *Climate Dynamics*. https://doi.org/10.1007/s00382-022-06361-7

Conference Presentations:

- **Guirguis, K**., A. Gershunov, M.J. DeFlorio, B. Hatchett, T. Shulgina, and A.C. Subramanian. (2021a). Predicting Extreme Weather Events in California on Subseasonal-to-Seasonal (S2S) Timescales Using a Statistical-Dynamical Weather Regime Impacts Model, Oral Presentation, AGU Fall Meeting, December 17, 2021

Published Datasets:

- **Guirguis, K**., Gershunov, A., DeFlorio, M. J., Shulgina, T., Delle Monache, L., Subramanian, A. C., Corringham, T., and Ralph, F.M. (2020b). Data from: Four atmospheric circulation regimes over the North Pacific and their relationship to California precipitation on daily to seasonal timescales. *UC San Diego Library Digital Collections.* https://doi.org/10.6075/J0154FJJ

- **Guirguis, K**; Gershunov, A.; Hatchett, B.; Shulgina, T.; DeFlorio, M.J.; Subramanian, A.C.; Guzman-Morales, J.; Aguilera, R.; Clemesha, R.; Corringham, T.W.; Delle Monache, L.; Reynolds, D.; Tardy, A.; Small, I.; Ralph, F.M. (2022b). Historical Catalog of Winter Weather Regimes Impacting California, 1949-2017. UC San Diego Library Digital Collections. https://doi.org/10.6075/J089161B

1.2 Precipitation Regime Change and Santa Ana Winds

In addition to studying extreme weather and predictability using my weather regime approach, I also contributed to two studies on extreme weather led by Dr. Alexander Gershuov. In **Gershunov et al. (2019)**, we studied atmospheric river landfalls over the North American West Coast in observations and climate model projections to quantify future behavior of precipitation and the role of atmospheric rivers. The results provided a new understanding about precipitation regime change in California. While there is much uncertainty about projected changes to annual totals, there is strong agreement among models that the year-to-year variability in precipitation will increase, and that a larger contribution to these totals will come from atmospheric rivers. This means that California will receive a larger portion of its water resources from heavy precipitation, even as the frequency of dry days increases, leading to more volatility in California hydroclimate.

In **Gershunov et al. (2021)**, we studied different flavors of Santa Ana winds impacting Southern California. We identified hot and cold flavors of SAWs and highlighted important differences in their synoptic origins and impacts. While hot SAWs originate by high pressure forming over the Great Basin, cold SAWs occur from Rossby wave breaking over the northwestern coast. Hot SAWs were shown to be primarily responsible for historic wildfires with large burn areas partly because they are longer and have a drying effect on vegetation, but also because cold SAWs tend to be preceded by precipitation. These results were instrumental in motivating and informing the work of Guirguis et al. (2022a), which continued the classification of hot and cold SAWs and further quantified their distinctive impacts.

- Gershunov, A., T.M. Shulgina, R.E.S. Clemesha, **K. Guirguis**, D.W. Pierce, M.D. Dettinger, D.A. Lavers, D.R. Cayan, S.D. Polade, J. Kalansky and F.M. Ralph. (2019). Precipitation regime change in Western North America: The role of Atmospheric Rivers. *Nature Scientific Reports*, **9**:9944, DOI:10.1038/s41598-019-46169-w. https://rdcu.be/bJPK0.

- Gershunov, A., J. Guzman Morales, B. Hatchett, R. Aguilera, T. Shulgina, **K. Guirguis**, J. Abatzoglou, D. Cayan, D. Pierce, P. Williams, I. Small, R. Clemesha, L. Schwarz, T. Benmarhnia, A. Tardy (2021). Hot and cold flavors of southern California's Santa Ana winds: Their causes, trends, and links with wildfire. *Climate Dynamics*. https://doi.org/10.1007/s00382-021-05802-z.

1.3 Impacts of Environmental Hazards on Health and Society

While the bulk of my work during this reporting period has focused on extreme weather and its predictability, I also contributed to research projects investigating the effects of environmental hazards on human health and society. These include studies focused on heat waves, air quality, hurricanes, wildfire smoke, and extreme cold winter weather.

I contributed to three publications on the effects of heat exposure on human health in California (Malig et al. 2019, McElroy et al. 2020, and Schwartz et al. 2020). In **Malig et al. (2019)**, we investigated the effects of ambient heat exposure on health outcomes in California, specifically focused on renal and hepatobiliary hospitalizations (diseases of the kidneys, liver, and urinary tract). Previous work had shown deleterious effects of heat using other disease categories, such as cardiovascular and respiratory disease, but comparatively little work has been focused on the renal and hepatobiliary systems. The results showed that higher temperatures during May-October resulted in increased hospitalizations for these types of disease categories, which has important implications for emergency planning and outreach efforts.

In **McElroy et al. (2020)**, we investigated subregional health outcomes associated with different temperature thresholds to better understand the role of climatological acclimation to heat when designing early warning systems. Using three different subregions of San Diego County (coastal, inland, and desert), we found important differences in the level of heat exposure leading to hospitalization in the three regions. This is due to different levels of climatological acclimation and access to air conditioning (coastal populations are less likely to have AC and are physiologically not as well adapted to hot temperatures, which are experienced less frequently at the coast). These results highlighted the importance of sub-county level criteria for early warnings.

In **Schwartz et al. (2020)**, we investigated the effects of heat waves on human health outcomes, specifically during the fall, winter, and spring. Previous work on heat waves and health has largely focused on the summer months. The results found significant increases in hospitalizations from heat waves that occurred during the winter and shoulder seasons, which has important implications for early warning systems and emergency response actions (such as cooling centers), which should be engaged all year. The findings also showed that Santa Ana winds were primarily responsible for the health-impactful heat events that occurred in fall and winter.

I also contributed to a study focusing on air quality, specifically on the effects of PM2.5 on respiratory health. In **Mehta et al. (2021)**, we investigated racial disparities in respiratory illness attributed to elevated levels of PM2.5 using hospitalization data for San Diego County during May-October. The results showed differences in the number of excess respiratory hospitalizations during elevated levels of PM2.5 for different racial/ethnic groups, which has implications for designing effective intervention strategies to improve respiratory health among vulnerable populations.

Finally, in another study focused on environmental hazards and impacts to society, we shifted our focus to look at human mobility data to quantify the effectiveness of stay-at-home advisories in the face of extreme weather events. In **Hatchett et al. (2021)**, we used county-level cellular data from Facebook's Humanitarian Data Exchange Movement range maps to measure local responses to hurricanes along the Atlantic Coast, wildfires in the Pacific Northwest, and the extreme deep freeze in Texas during 2020-2021. For all of these events, significant changes in human behavior were detected by reductions in mobility. This novel methodology highlights the utility of this type of data for human behavior studies.

- Malig, B.J., X.M. Wu, **K. Guirguis**, A. Gershunov, R. Basu. Associations between ambient temperature and hepatobiliary and renal hospitalizations in California, 1999 to 2009. (2019). *Environ. Res.* **10**; 177:108566. PMID: 31323396. https://doi.org/10.1016/j.envres.2019.108566

- McElroy, S., L. Schwarz, H. Green, I. Corcos, **K. Guirguis**, A. Gershunov, T. Benmarhnia. (2020). Defining heat waves and extreme heat events using sub-regional meteorological data to maximize benefits of early warning systems to population health. *Sci. Total Environ*. 2020 Mar 06; **721**:137678. PMID:32197289. https://doi.org/10.1016/j.scitotenv.2020.137678

- Schwartz, L. B.J. Malig, J. Guzman Morales, **K. Guirguis**, A. Gershunov, R. Basu and T. Benmarhnia (2020). The health burden fall, winter and spring extreme heat events in Southern California and contribution of Santa Ana Winds. *Environmental Research Letters*, **15** 054017. https://doi.org/10.1097/01.EE9.0000609948.36226.22

- Mehta, S., D. Vashistha, L. Schwarz, I. Corcos, A. Gershunov, **K. Guirguis**, R. Basu, T. Benmarhnia (2021). Racial/ethnic disparities in the association between fine particles and respiratory hospital admissions in San Diego County, CA. *Environmental Science and Health*. Part A, https://doi.org/10.1080/10934529.2021.1887686.

- Hatchett BJ, Benmarhnia T, **Guirguis K**, VanderMolen K, Gershunov A, Kerwin H, Khlystov A, Lambrecht KM, Samburova V. (2021). Mobility data to aid assessment of human responses to extreme environmental conditions. Lancet Planet Health. 2021 Oct;5(10):e665-e667, (21) 00261-8. PMID: 34627467. https://doi.org/10.1016/S2542-5196(21)00261-8

1.4 My personal Contribution to These Studies

For **Guirguis et al. (2018, 2020a, and 2022a)**, I was responsible for the study design and conceptualization, data curation, data analysis, visualization, and writing the original manuscript. For **Malig et al. (2019) and McElroy et al. (2020)** I contributed to research discussions and provided data curation and writing in the form of review and editing after the first draft was prepared by the lead author. For **Schwartz et al. (2020), Gershunov et al. (2020), Gershunov et al. (2022)**, I contributed to research discussions and contributed to writing in the form of review and editing after the first draft was prepared by the lead author. For **Hatchett et al. (2021)**, I advised on content and figures and contributed to writing in the form of review and editing after the first draft was prepared by the lead author. For **Mehta et al. (2021)** I contributed writing in the form of review and editing after the first draft was prepared by the lead author.

2. Funding Support

My funding for this reporting period has come from four grants on which I am a Co-Investigator. These projects are:

- "Interplay of marine layer clouds and heat waves along the California coast: Impacts on human health", National Oceanic and Atmospheric Administration, 2015-2019.
- "Drought and Public Health in a Warming California", University of California Multi-campus Research Programs and Initiatives, 2017-2023.
- "Health outcomes and health disparities from tropospheric ozone", California Environmental Protection Agency, 2018-2021.
- "Seasonal to Sub-seasonal predictability of Heat Waves over the Western US: Impacts on Snowpack", US Bureau of Reclamation, 2019-2021.

I am additionally supported by the University of Arizona's Southwest Climate Adaptation Science Center via the US Department of the Interior, and by CW3E through the Atmospheric River Program via the California Department of Water Resources.

3. Professional Service and Outreach

I aim to be active in the community by meeting and collaborating with decision-makers or community groups in San Diego County who have common goals and interests on subjects of extreme weather, climate change, and human health and society. However, the covid-19 pandemic and social distancing has limited these types of in-person interactions during the last two years. Before the pandemic, in April of 2019, I met with meteorologists at the National Weather Service (NWS) to discuss common research interests and potential future collaborations, and these collaborations are ongoing. In May of 2019, I met with the director of San Diego Office of Emergency Services to discuss research on heat waves and health. In October of 2019, I attended

the *California Conference of Directors of Environmental Managers* in Lake Tahoe, CA to discuss why climate change is a public health issue (it is often not perceived as such by environmental managers). Also in October of 2019, I attended the *Live Well Advance, Uniting for Impact* conference in San Diego, CA where I joined an exhibitor booth with the National Weather Service to distribute literature on heat waves. Recently, in June 2022, I had the fun opportunity to meet with visiting 5th graders to discuss SIO research as part of the Earthlab Community Partnership between UCSD and Groundwork San Diego during a field trip and balloon launch off Scripps Pier. I look forward to contributing to more of these types of events in the future.

I also serve regularly as a **reviewer for scientific journals** including Journal of Hydrometeorology, International Journal of Climatology, Geophysical Research Letters, Climate Dynamics, Urban Climate, International Journal of Environmental Research and Public Health, Atmospheric Science Letters, Environmental Research, Environment International, Journal of Geophysical Research, Journal of Climate, PLOS One, and Science of the Total Environment.

I am involved in **interdisciplinary research** with decision-makers at the Federal, State, and local levels (National Weather Service, California Environmental Protection Agency, and the San Diego Health and Human Services Agency, respectively), as well as with the UCSD School of Medicine. The results of these research collaborations from this reporting period are described in Malig et al. (2019), Schwartz et al. (2020), McElroy et al. (2020), Mehta et al. (2021), Gershunov et al. (2021), and Guirguis et al. (2022).

I served as a mentor for **CW3E's Summer Internship Program** during the summer of 2021. In this capacity I advised a visiting undergraduate student Martin Liu from UC Davis on his summer research project on the topic of "Avalanche Fatalities during Atmospheric Rivers in the Western US". This year (2022) I served as an **applicant reviewer** for the CW3E Summer Internship Program.

4. Commitment to Diversity

I believe strongly that we should strive to live in a society where there is equality in education, personal and professional opportunity, justice, and quality of life regardless of race/ethnicity, sexual orientation, gender, or gender identity. My chosen field (geoscience) is unfortunately considered among the least diverse fields, even in comparison with other physical sciences. Diversity has many practical benefits to any given institution and field by bringing novel and unique ideas, perspectives, and approaches that are cultivated as a result of our upbringing, education, and life experience. I have been encouraged by the many opportunities available at UCSD and SIO to learn about racism and antiracism and to participate in discussions and take part in committees designed to address inequality and work towards making our institution a more inclusive place to work and study.

I am currently participating in the Unlearning Racism in Geoscience (URGE) working group at SIO, which began in Spring 2021. URGE is an NSF-supported curriculum that has engaged universities nation-wide to address the lack of diversity in the geosciences. The goal of the SIO URGE group is to assess existing polices and resources at SIO and develop new strategies to improve diversity and retention of groups that have been historically underrepresented in geoscience fields. My role is to help develop a "resource map", which aims to curate and disseminate existing resources available at UCSD to students, staff, and faculty in a way that improves accessibility, especially for underrepresented groups.

I am also the co-chair of the committee on Equity, Diversity, and Inclusion at CW3E (Called the "EDI Task Force", December 2021-present). Our goal is to develop and implement

strategies for improving diversity and retention at the Center. This involves working to assess and developing guidance and strategies for various diversity challenges (e.g., attracting and retaining diverse candidates, creating a welcoming and inclusive environment, and engaging youth in geoscience education). I have appreciated these opportunities to be involved in collaborative efforts with my fellow SIO colleagues to work towards positive change, and I hope to continue with these efforts.

5. Future Research Goals

My future research goals are to contribute to the growing body of work designed to better understand the roles of natural variability and climate change on extreme weather events and their impacts on society. Ultimately, with the goal of improving predictability on multiple timescales to achieve better outcomes during future extreme weather events, and to provide knowledge for better adaptation strategies that are urgently needed to address climate change. The weather regime methodology I have developed has applications for S2S predictability as well as climate change and adaptation studies. This methodology could help to answer questions about the role of natural variability for real-time events, which could add a valuable element to climate change detection and attribution analyses. I am interested in expanding the methodology to predict summer heat waves and would like to extend my Santa Ana winds forecast tool to include Diablo winds to the North, to enhance predictability of wildfire hazard in California. There are also applications of this methodology to seasonal predictability, which I am in the early stages of exploring. I also aim to continue with my collaborative and interdisciplinary work with experts across fields to study societal impacts of extreme weather, including effects on human health and socio-economic disparities in extreme weather impacts and climate change vulnerabilities.

July 1, 2022

Kristen Guirguis Date