Statement of Recent Career Achievements
Kristen Guirguis 7/2018-7/2020

My broad research interests lie in the area of climate variability, climate change and societal impacts. My goal as a scientist is to provide useful information through research that has applications for hazard mitigation and resource planning. I began my professional career at UCSD/SIO as a postdoctoral scholar in 2009 studying extended range predictability of cold snaps for energy applications. In 2010, I was awarded the Postdocs Applying Climate Expertise (PACE) fellowship, which provided me the opportunity to collaborate with epidemiologist in studying heat waves and human health impacts in California. Through this work on heat waves and health, I have contributed to State and Regional Climate Change Assessments on topics including heat extremes, ecosystem impacts, and human health, and I have co-produced science with State and local stakeholders including the California Environmental Protection Agency, National Weather Service, and San Diego Health and Human Services Agency.

Since becoming a Project Scientist at SIO in 2013, I have continued my work on extreme weather, climate change, and impacts. I have been involved in research projects studying heat waves, air pollution and health, climate change and extreme heat in the Southwest US, precipitation regime change in future climate, the effect of off-season heat waves on snowmelt in the Sierra Nevada mountains, and predictability of atmospheric rivers on subseasonal-to-seasonal (S2S) timescales. My research collaborations and affiliations include the Weather and Climate Impacts Analytics group (WECLIMA, weclima.ucsd.edu), the Center for Western Weather and Water Extremes (CW3E, cw3e.ucsd.edu), and the Southwest Climate Adaptation Science Center (SWCASC, swcasc.arizona.edu).

During the most recent reporting period (2018-2020), my research efforts have focused on (i) atmospheric rivers and extreme precipitation in western North America, and (ii) the effects of ambient temperatures and heat waves on human health in California. I have published six journal articles (two first-authored) and contributed to several research grants. Below is a detailed description of my recent career accomplishments focusing on noteworthy contributions to research, professional activity, and public service.

I. Research

A. Atmospheric Rivers and Extreme Precipitation

During this recent reporting period, most of my research has focused on atmospheric rivers (ARs) and their drivers and impacts in collaboration with CW3E. ARs are characterized as narrow corridors of strong atmospheric moisture transport that can bring heavy precipitation and flooding to the coast of western North America. They are responsible for about half of coastal California's annual precipitation and most of the floods. As such, there is a great need for an improved understanding of their drivers and impacts, and ultimately improved predictions on S2S timescales needed for water resource management. My work in this reporting period contributed to an improved understanding of synoptic drivers of atmospheric rivers with the goal of improving predictability, and investigated future changes in West Coast precipitation due to climate change.

In **Guirguis et al. (2018)**, we used a 70-year catalog of landfalling AR activity to study the relationship between atmospheric circulation patterns and AR landfalls at different latitudes along the North American west coast. We identified 15 modes of atmospheric variability over the North Pacific using empirical orthogonal function (EOF) analysis and showed that a small subset of these patterns were responsible for most AR landfalls. Specifically, the four most influential patterns were identified as a pressure anomaly in the Gulf of Alaska, a pressure anomaly off of California's shore, a Canadian-Pacific dipole pattern, and a Baja-Pacific dipole pattern. In this study, we demonstrated how these modes interact to direct moisture plumes to different locations along the coast. Additionally, we found a strong relationship between the seasonal persistence of these modes and AR landfall variability. This study has served as a springboard for further studies on the topic of S2S predictability of ARs. I designed the study, conducted all of the data analysis using an AR detection catalog previously produced by our group, and wrote the manuscript with ongoing advice and feedback from co-authors.

Guirguis, K, A. Gershunov, T. Shulgina, A. Subramanian, R.E.S. Clemesha, F.M. Ralph, 2018: Circulation drivers of Atmospheric Rivers along the North American West Coast. *GRL,* 45. *https://doi.org/10.1029/2018GL079249*

In **Guirguis et al. (2020)**, we expanded on the results of Guirguis et al. (2018) by quantifying the role of the four circulation regimes described above (which we call the NP4 modes) in driving AR activity and precipitation in California on daily and seasonal timescales. This 2020 study emphasized the importance of the interactions between the NP4 modes. In general, we found that when three or more modes align in the positive phase, this reinforces onshore flow over California and is associated with elevated AR activity, heavy precipitation, and historical flooding. Conversely, when multiple modes are jointly negative, this favors upstream atmospheric ridging and dry conditions for California. Using multiple linear regression, we developed statistical models to quantify the relationship between the NP4 modes and coastal vapor transport, and demonstrated that these synoptic patterns explain a substantial amount of the daily coastal vapor variability (~40% for Northern California). Seasonally, these regimes tend to favor one phase over another in a given water year and we found that dry (wet) years tend to occur when the negative (positive) phase dominates for multiple modes. We also developed seasonal statistical models to show that the NP4 modes explain a substantial amount of interannual precipitation variability in California (over 50% for some Northern California locations). We additionally investigated the role of El Niño Southern Oscillation (ENSO) in modulating the seasonal phase prevalence of the NP4 modes. We showed that while ENSO does play a role in stacking the deck towards wet or dry conditions in California via certain phase preferences of the NP4, there is still much variability within the season and the probability of extreme precipitation depends on the timing and frequency of synchronous interactions between the NP4 modes on daily timescales. The results of this study have applications for S2S predictability on a number of fronts including applications to dynamical model forecasts, statistical seasonal forecasts, and statistical-dynamical hybrid models, as well as climate change applications as discussed in Section 3 below. I motivated and designed this study, conducted all of the data analysis and wrote the manuscript with ongoing advice and feedback from co-authors.

Guirguis, K., A. Gershunov, M.J. DeFlorio, T. Shulgina, L. Delle Monache, A.C. Subramanian, T.W. Corringham, and F. M. Ralph, 2020: Four atmospheric circulation regimes over the North

Pacific and their relationship to California precipitation on daily to seasonal timescales. *GRL*. https://doi.org/10.1029/2020GL087609

In **Gershunov et al. (2019),** we examined the future of precipitation extremes in western North America using a suite of 16 climate models from Phase 5 of the Coupled Model Intercomparison Project (CMIP5). The study provided an examination of the models based on their ability to adequately reproduce AR landfall frequency and AR contribution to precipitation in the West, and then selected the most realistic five models to constrain the overall uncertainty. The results showed that while there is not strong agreement in the projected change to annual total precipitation, there is strong agreement that year-to-year variability in precipitation will increase. This is an important finding since California and the southwestern US already have a highly variable hydroclimate, which makes water resource planning a challenge. The finding that this variability will increase suggests even greater year-to-year swings in the amount of water available for the densely populated region. Importantly, the work showed that the future precipitation regime will be less frequent but more intense, meaning that most of the West's precipitation will come in the form of heavy precipitation with longer dry spells between. Interestingly, while the reduction in precipitation frequency is due to non-AR events, the increase in intensity is primarily due to AR landfalls. Thermodynamics are the clear cause of these changes in AR activity in a warming climate. Dynamical meteorological causes of these projected changes have not yet been determined. However, we expect that the methods developed in Guirguis et al. (2018 and 2020) could help to answer this question. For this project, I contributed to ongoing meetings to discuss the research results and analysis lead by Drs. Shulgina and Gershunov and offered feedback and suggestions along the way as well as contributing to the editing of the manuscript after the first draft was prepared by the lead author.

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

B. **Heat waves and Human Health Impacts**

Heat waves are the most dangerous weather event in the US in terms of human health, causing more deaths annually than any other type of extreme weather. However, negative health outcomes can be prevented with effective intervention and emergency response strategies. During this reporting period, I have been involved in three studies focused on California heat waves and health outcomes. Each of these studies represents an interdisciplinary collaboration with epidemiologists and stakeholders from decision-making agencies

In **Malig et al. (2019)**, we examined the relationship between warm ambient temperatures and human health outcomes in California using hospitalization data over 1999-2009. This study focused on renal disease and hepatobiliary disease (which involves the liver and gall bladder). Previous studies have found links between elevated ambient temperatures and other disease categories such as cardiovascular disease or respiratory disease, but the effects on the hepatobiliary

and renal systems were not well known. The study found a significant positive relationship between higher temperatures and both hepatobiliary and renal disease. Additionally, multiple renal system illnesses were shown to be affected including urinary stones, urinary tract infections, chronic kidney disease, and septicemia. These results have important implications for climate change as they suggest that warming temperatures will likely increase the risk of these types of illness. Further, the increased risk was shown to prevail even after removing extreme temperature events, suggesting that warmer background conditions, even on non-extreme days, can contribute to health risk. This study was a collaboration with epidemiologists at the Office of Health Hazard Assessment (OEHHA) at the California Environmental Protection Agency (CalEPA). For this study, I processed and provided weather and climate data, participated in ongoing discussions during the research process and provided suggestions and feedback regarding the analysis, and contributed to the writing/editing of the manuscript after the first draft was prepared by the lead author.

Malig BJ, Wu XM, Guirguis K, Gershunov A, Basu R. Associations between ambient temperature and hepatobiliary and renal hospitalizations in California, 1999 to 2009. Environ Res. 2019 10; 177:108566. PMID: 31323396.

In **McElroy et al. (2020)**, we examined heat-related health impacts in different climate zones within San Diego County. This work looked at the relative and attributable health burden associated with heat waves, where the definition of a heat wave varied. Currently, there is no universal definition of a heat wave, and this study demonstrated how different definitions can have important implications for identifying and mitigating risk to local populations. In this study, we examined different percentile thresholds for defining heat, and included definitions that were taken locally by climate zone and over the entire county. The findings showed that county-wide definitions failed to capture the full impact of heat in the cooler coastal climate zones, which highlighted the importance of local heat thresholds. Additionally, the results showed that the highest temperature thresholds, which captured the most extreme but rarer hot days, accounted for the greatest increase in the relative risk for the population. However, lower threshold definitions, which are less hot but more common, were important for capturing the overall attributable risk to the population. These results are important for emergency management, heat warnings, and long-term planning for climate change. This study was a collaboration with epidemiologists at the San Diego Health and Human Services Agency. For this study I contributed to the data curation, participated in ongoing discussions during the research process, and contributed to the writing/editing of the manuscript after the first draft was prepared by the lead author.

McElroy S, Schwarz L, Green H, Corcos I, Guirguis K, Gershunov A, Benmarhnia T. 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.

In Schwartz et al. (2020), we examined the relationship between fall, winter, and spring heat waves and health outcomes in California. Most previous studies looking at heat and health have focused on the warm season. However, in California where Santa Ana winds (SAWs) can bring elevated ambient temperatures to coastal regions it is important to understand and quantify the health burden of these cool-season heat events. The study first demonstrated the importance of

Santa Ana winds in driving off-season heat waves. For example, SAWs were shown to be associated with about 90% of all winter (DJF) heat waves in Southern California. Then, using hospital discharge data alongside different heat wave definitions, we detected significant health impacts for several disease categories including ischemic stroke, dehydration, and acute renal failure. The impactful off-season heat waves identified in the study were cooler than the temperatures reached in summer, but they were impactful to health nonetheless. These findings have important implications for emergency preparedness since most heat interventions do not consider the effects of cool-season heat waves on vulnerable populations. This study was a collaboration with epidemiologists at the Office of Health Hazard Assessment (OEHHA) at the California Environmental Protection Agency (CalEPA). For this study, I participated in ongoing discussions during the research process, and contributed to the writing/editing of the manuscript after the first draft was prepared by the lead author.

Schwartz L. B.J. Malig, J. Guzman Morales, K. Guirguis, A. Gershunov, R. Basu and T. Benmarhnia, 2020: The health burden of fall, winter and spring heat waves in Southern California and contribution of Santa Ana Winds. *Environmental Research Letters,* 15 054017

II. Professional Activity & Outreach

I have contributed to a number of outreach activities aimed to **enhance collaborations with local and regional stakeholders** in the environmental health sector. In this capacity I have:

- Presented an invited talk on "Weather extremes, climate change, and health impacts in California" at the **California Conference of Directors of Environmental Health Managers** in Lake Tahoe, CA (Oct 2, 2019). This conference was a gathering for directors of local environmental health agencies from all over California. My role was to present on the importance of climate change as a public health issue. Currently climate change is not treated as a public health issue by many health departments, so my aim was to show exiting research on climate and health in order to contribute to the conversation.
- Attended the "**Live Well Advance, Uniting for Impact**" conference in San Diego, CA and participated in a joint exhibitor booth (distributing information on heat waves) alongside the San Diego County Health and Human Services Agency and the San Diego office of the National Weather Service. This conference was a gathering of local stakeholders working in different sectors joining together based on common interests to improve the quality of life of San Diegans (Oct 28, 2019)
- Met with the director of **San Diego County Office of Emergency Services** to discuss our research on heat, health, and climate change (May 23, 2019).

Additionally, I continue to **collaborate and publish with interdisciplinary groups and stakeholders** on the topic of environmental health (Malig et al. 2009, Schwartz et al. 2020, and McElroy et al. 2020).

I am a regular **reviewer for many 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, and Journal of Climate, PLOS One, and Science of the Total Environment.

During this reporting period, I am/have been a **Co-Investigator** on four grants, and I am/have been a collaborator on others. The grants on which I was a Co-I during this reporting period are:

- Interplay of marine layer clouds and heat waves along the California coast: Impacts on human health (National Oceanic and Atmospheric Administration, NOAA, 2015-2019)
- Drought and Public Health in a Warming California (University of California Multicampus Research Programs and Initiatives, 2017-2020)
- Health outcomes and health disparities from tropospheric ozone (California Environmental Protection Agency, 2018-2021)
- Seasonal-to-Subseasonal predictability of heat waves over the Western US: Impacts on snowpack (US Bureau of Reclamation (2019-2021)

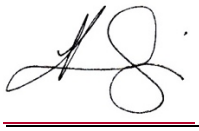
I am a researcher and collaborator with the **Southwest Climate Adaptation Science Center** (SWCASC, https://www.swcsc.arizona.edu), whose goal is to provide useful scientific information and tools for natural resource management.

I am a researcher and collaborator with the **Center for Western Weather and Water Extremes (CW3E)** where I actively contribute to the S2S predictability efforts of the group.

I am a collaborator with **UCSD's School of Medicine** via interdisciplinary research efforts with Dr. Tarik Benmarhnia on environmental health topics.

III. Future Research Goals

My research in the near term will continue to focus on topics of extreme weather, climate variability and impacts. Through my work on currently-funded research projects and proposals in progress, I expect my focus will be on S2S predictability of extreme weather. This includes research directed at improved predictability of atmospheric rivers and extreme precipitation in collaboration with CW3E, for which I am currently contributing the development of new S2S products for use in water resource management decisions. I am beginning to merge dynamical forecasts with statistical techniques to extend the lead-time and enhance the skill of weather forecasts. I am also interested in the predictability and impacts of heat waves both from the perspective of human health impacts, and also from a water resource perspective by studying the impacts of spring and early summer heat waves on snowmelt in the Sierra Nevada Mountains. I am interested in applying my weather regime methodology from Guirguis et al. (2018 and 2020) to climate model projections to study links between daily weather variability and climate change. I plan to continue working at the interface between climate, weather, and health via interdisciplinary collaborations with Dr. Tarik Benmarhnia, as well as partners at decision-making agencies including OEHHA, San Diego Health and Human Services Agency, and the National Weather Service on research with common interests. My overall goal is to work on collaborative science that helps improve decision-making capabilities and emergency preparedness through improved understanding and better predictions of extreme weather events.



7/31/2020

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Date