CONSTRUCTING CLIMATE RESILIENT COMMUNITIES, LANDSCAPES, AND COASTS IN CALIFORNIA AND NEVADA

CNAP

California-Nevada Climate Applications Program

A NOAA RISA team

PERFORMANCE PERIOD: JUNE 1, 2018—MAY 31, 2019

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WHAT IS CNAP?

MISSION
To improve resilience in California and Nevada by providing decision makers usable climate information through integrating cutting edge physical and social science.

CNAP, California Nevada Applications Program, has a long history of providing cutting edge climate science to stakeholders in the region. The program began with an emphasis on California issues in 1999 as the California Applications Program (CAP). In 2011, the team expanded its geographic scope to include Nevada and became CNAP. CNAP's core priority sectors include understanding effects of climate variation on water resources, natural resources and coastal resources (see below), along with other linked systems including societal components.
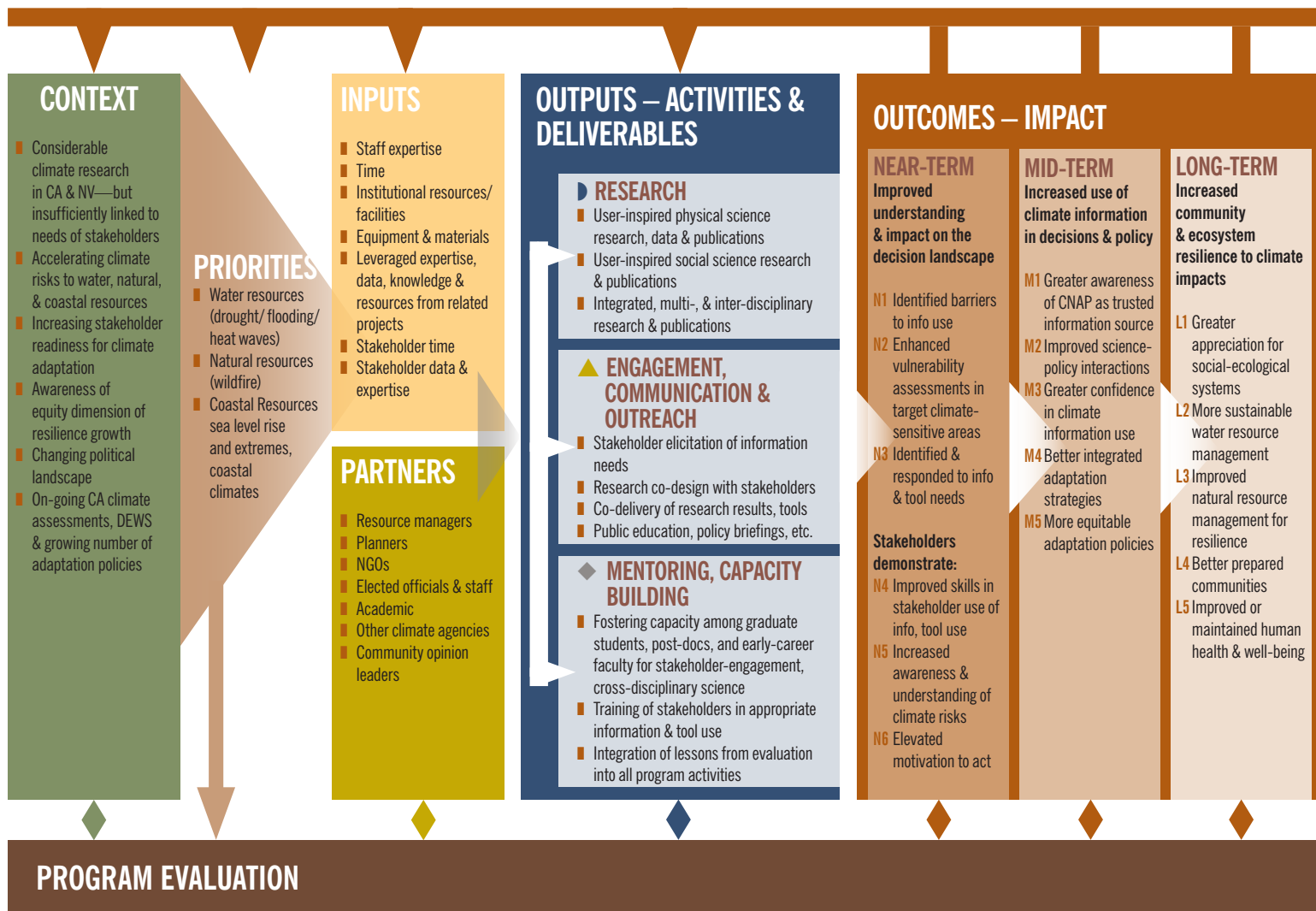
Since 2005, CNAP has worked closely with the California Energy Commission (CEC) and other State Agencies in taking a leading role in the first three California Climate Change Vulnerability and Adaptation Assessments, and has recently completed the Fourth California Climate Change Assessment. CNAP has also collaborated with California Department of Water Resources (DWR) in providing data, observations and interpretation to better anticipate how climate and associated weather events affect water resources and water hazards in the State. CNAP, working with California agencies including DWR, CEC and the California Ocean Protection Council, has contributed to a better understanding of climate impacts on the California coast, including the occurrence of coastal storms and two iterations of Sea Level Rise Guidance to State Agencies. Another focus of CNAP is working with fire agencies in California, Nevada and across the western U.S. to investigate effects of climate and weather on wildfire, with important contributions in understanding the strong influence of climate fluctuations upon the regionally varying wildfire patterns, differences in climatic influences across different types of landscape and vegetation, and changes over recent decades towards a more active wildfire regime, with projections of possible enhanced wildfire threat in future decades.

Additionally, CNAP has put new focus on the institutional knowledge in the wildfire community, working with fire fighters to better understand how climate information has and could play into planning and decision making. With increased emphasis on Nevada climate issues, CNAP has worked with Great Basin tribes to understand barriers to climate data and helped develop a resilience plan with Washoe County. Over this past year, CNAP has worked with National Weather Service Offices and Predictive Services on understanding the how Red Flag Warnings are used throughout the region. On a local scale CNAP has also worked with Watersheds Coalition of Ventura County on a project that provided climate projection information to support Integrated Regional Water Management.

Since the inception of the California Nevada Drought Early Warning System (CA/NV DEWS) CNAP has partnered closely with the National Integrated Drought Information System (NIDIS) to coordinate communication and to research topics surrounding drought and water resources.

CALIFORNIA NEVADA CLIMATE APPLICATIONS PROGRAM MODEL

CONTEXT

- Considerable climate research in CA & NV—but insufficiently linked to needs of stakeholders
- Accelerating climate risks to water, natural, & coastal resources
- Increasing stakeholder readiness for climate adaptation
- Awareness of equity dimension of resilience growth
- Changing political landscape
- On-going CA climate assessments, DEWS & growing number of adaptation policies

PRIORITIES

- Water resources (drought/ flooding/ heat waves)
- Natural resources (wildfire)
- Coastal Resources sea level rise and extremes, coastal climates

INPUTS

- Staff expertise
- Time
- Institutional resources/ facilities
- Equipment & materials
- Leveraged expertise, data, knowledge & resources from related projects
- Stakeholder time
- Stakeholder data & expertise

PARTNERS

- Resource managers
- Planners
- NGOs
- Elected officials & staff
- Academic
- Other climate agencies
- Community opinion leaders

OUTPUTS – ACTIVITIES & DELIVERABLES

▶ RESEARCH

- User-inspired physical science research, data & publications
- User-inspired social science research & publications
- Integrated, multi-, & inter-disciplinary research & publications

▲ ENGAGEMENT, COMMUNICATION & OUTREACH

- Stakeholder elicitation of information needs
- Research co-design with stakeholders
- Co-delivery of research results, tools
- Public education, policy briefings, etc.

◆ MENTORING, CAPACITY BUILDING

- Fostering capacity among graduate students, post-docs, and early-career faculty for stakeholder-engagement, cross-disciplinary science
- Training of stakeholders in appropriate information & tool use
- Integration of lessons from evaluation into all program activities

OUTCOMES – IMPACT

NEAR-TERM
Improved understanding & impact on the decision landscape

- N1 Identified barriers to info use
- N2 Enhanced vulnerability assessments in target climate-sensitive areas
- N3 Identified & responded to info & tool needs

Stakeholders demonstrate:

- N4 Improved skills in stakeholder use of info, tool use
- N5 Increased awareness & understanding of climate risks
- N6 Elevated motivation to act

MID-TERM
Increased use of climate information in decisions & policy

- M1 Greater awareness of CNAP as trusted information source
- M2 Improved science-policy interactions
- M3 Greater confidence in climate information use
- M4 Better integrated adaptation strategies
- M5 More equitable adaptation policies

LONG-TERM
Increased community & ecosystem resilience to climate impacts

- L1 Greater appreciation for social-ecological systems
- L2 More sustainable water resource management
- L3 Improved natural resource management for resilience
- L4 Better prepared communities
- L5 Improved or maintained human health & well-being

PROGRAM EVALUATION

CNAP program model highlights the outcomes, or the type of products it produces including scientific journal articles, reports, stakeholder workshops, and mentoring early career scientists. The program model also describes the short-term, near-term and long-term goals for the program.

CNAP TEAM ROLES/RESPONSIBILITIES

DRI

- Tamara Wall
- Tim Brown
- Justin Huntington
- Nina Oakley*
- Kristin VanderMolen*
- Dan McEvoy*
- Alex Horganic*

- Provide leadership to the social science team and guide collaborative interdisciplinary efforts (CA/NV)
- Primary support for social science research in Nevada and California
- Focus on Nevada stakeholder climate information needs
- Provide support and expertise to California-based team members
- Train postdocs and early-career faculty
- Support evaluation design and implementation
- Co-manage media and social media outreach and engagement

SCRIPPS

- Dan Cayan
- Julie Kalansky*
- David Pierce
- Alexander Gershunov
- Jordan Goodrich*

- Provide leadership to the physical science team (CA/NV)
- Lead role in physical science research
- Focus on California stakeholder climate information needs
- Provide support and expertise to Nevada-based team members
- Train postdocs and early-career faculty
- Overall program management
- Co-manage media and social media outreach and engagement

ADDITIONAL SUPPORT

- Susanne Moser, Moser Research & Consulting
  - —Social science research in California
  - —Support evaluation design and implementation
- LeRoy Westerling, UC Merced
  - —Research on wildfire and climate impacts in the Sierra Nevada
- Shraddhanand Shukla* UC Santa Barbara
  - —Drought monitoring and forecasting
- Mike Dettinger, USGS
  - —Hydrology and extreme events
- Dennis Lettenmaier, UCLA
  - —Hydroclimatology
- Duane Waliser, JPL
  - —Atmospheric sciences

*Early Career CNAP Scientists, postdoctoral fellows, or graduate students.

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PROUDEST ACCOMPLISHMENT THIS PAST YEAR:
FIRE WARNINGS AND WATCHES

CNAP researchers, T. Wall and T. Brown, are working with multiple NOAA partners and stakeholders on reviewing and revising Red Flag Warnings (RFW). Overall, there is a concern amongst NWS and fire agency personnel that the Red Flag Warning is not an effective messaging medium. As a result, CNAP, NWS Fire Weather, the National Integrated Drought Information System (NIDIS) and the National Wildfire Coordinating Group Fire Environment Committee, began a collaborative project in 2018 to begin an assessment of this forecast product with the aim of developing an improved product that meet the NWS, the fire management community, and public warning needs.

The first step of this assessment was a review of 40 annual operating plans for NWS Weather Forecast Offices, and coding all red flag criteria. In all, 524 unique RFW criteria were identified. At a workshop in Boise, ID in September 2018, several paths forward to refine and standardized RFW criteria were determined. The need to be in alignment with the NWS Hazard Simplification program was also recognized. In support of an analysis of the RWF criteria, the project team applied for and received funding from the NOAA CSTAR program to do the following:

- **Quantitative (percentile) analyses of fire weather-danger-behavior indices to determine the best consistent set of inputs needed for established breakpoint criteria for fire weather watch/warning decisions;**
- **Determine breakpoint criteria (e.g., categories ranging from 0-5) linked to fire management and public notifications and actions necessary for safety.**

Future work includes identifying potential messaging for communicating forecast confidence and uncertainty of probabilistic hazard information to fire management building off current fuel indices research and developing a prototype decision matrix with NWS, fire management, and emergency services with these inputs.
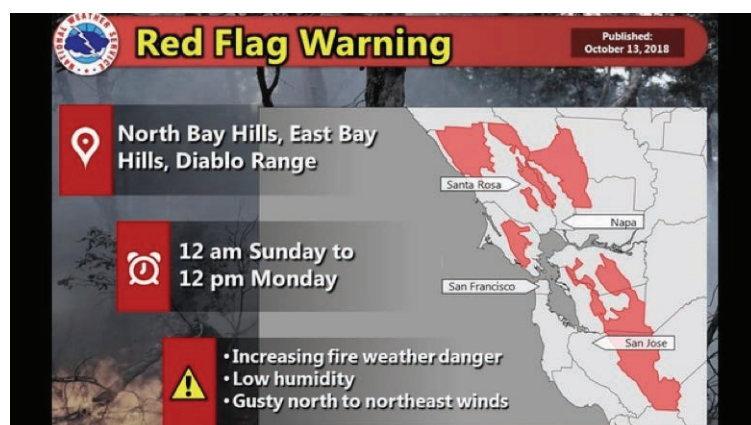
The work with the Red Flag Warnings and Watches program has been a truly cross-agency project, and within NOAA as well, involving two line offices (OAR and NWS) and multiple programs/ projects within those line offices, particularly in the NWS (CSTAR, Fire Weather, Hazard Simplification). We are very happy that the competitive RFP we submitted to the CSTAR program was selected for funding, as it allowed us to leverage our CNAP/NIDIS funding to support a graduate student and move forward with the development of standardized red flag criteria—we believe this also shows good alignment of resources across NOAA line offices in support of an important public product that needs this support. While very important for California and Nevada, this project has obvious impacts nationally as well, demonstrating the value of leveraging resources across programs to meet local, state, regional, and national needs.

NEW PARTNERSHIPS AND FOCUS AREAS

VENTURA COUNTY CLIMATE REPORT (OAKLEY)

CNAP researcher N. Oakley developed a new partnership with the Watersheds Coalition of Ventura County and its member agencies (wholesale water agencies, groundwater sustainability agencies), Ventura County Watershed Protection District, agricultural organizations within Ventura County (Resource Conservation District, Farm Bureau, Cooperative Extension), and environmental organizations (The Nature Conservancy, Ojai Valley Land Conservancy). The partnership was developed based on a project that provided climate projection information to support Integrated Regional Water Management (IRWM) plans in California. IRWM planning process is required as part of California's Sustainable Groundwater Management Act. The final report for this project can be found at https://wrcc.dri.edu/Climate/reports.php. This new partnership and effort allowed Oakley to develop new relationships and build rapport with various entities in Ventura County while getting to know the climate-related issues of this area in-depth. We identified needs of the region that we can focus on in future work.

NIST BUSINESS DISRUPTION SURVEY (WALL, VANDERMOLEN AND CORRINGHAM)

A new partnership with National Institute of Standards and Technology (NIST) economists has led to a project that examines primary and secondary wildfire smoke impacts on small businesses in the central sierra region of California and Nevada. The business disruption survey data collection will in September 2019.

DROUGHT TRACKING AND DEWS INDICATORS (DETTINGER)

Two new areas of focus—to complement existing indices from previous years—are (1) new evapotranspiration (ET_o) odds of reaching water-year normal maps (sometimes overlain onto existing precipitation odds of reaching water-year normal, and (2) new Upper Colorado River Basin snowpack-plus-reservoirs water storage updates to complement existing Sierra snowpack-plus-reservoirs updates. In the two cases, these extensions of previous Drought Early Warning System (DEWS) indicators add breadth to complement the information provided by those previous indicators by (1) adding a second "front" on the drought monitoring effort and (2) by extending the water-storage monitoring to the other major water source for California, especially for southern California, the Upper Colorado River Basin. We will work with NIDIS to determine the best way to automate these drought trackers.

Researchers met with small groups of stakeholders to discuss climate change concerns in greater depth at a Ventura climate change meeting.

EVAPORATIVE DEMAND IN FUTURE CLIMATES (MCEVOY, PIERCE, KALANSKY AND CAYAN)

This new focus area explores possible future changes in evaporative demand determined from downscaled global climate model projections, from several GCMs under two emission scenarios. This project combines two separate CNAP efforts, which have a common interest in understanding future evaporative demand in California and Nevada. The first effort is a collaboration with Southern Nevada Water Authority, which has determined that Evaporative Drought Demand Index (EDDI), developed by D. McEvoy and collaborators, correlates well with water use in their service area. This is of interest because evaporative demand quite strongly affects water demand. The second effort is a comparison of evaporative demand determined using EDDI with that determined by the VIC hydrological model, whose validity is a concern because VIC may incorrectly represent crops. In comparing their respective versions of evaporative demand, this project will also help to understand possible future levels and variability of evaporative demand, which will support water resource planning by the Southern Nevada Water Authority and by multiple agencies and stakeholders in California.

SIGNIFICANT OUTPUTS BEING USED BY STAKEHOLDERS

- San Diego Health and Human Services Agency is using climate and health research results from CNAP researchers to inform a Health Adaptation plan for San Diego County.
- U. S. Navy ecosystems managers are using data and analyses of weather and climate (marine layer clouds, precipitation, temperature, etc.) from CNAP researchers to understand the impacts on the San Clemente Island ecosystem.
- Watersheds Coalition of Ventura County is using the report "Projected Changes in Ventura County Climate" and presentations/communications with CNAP researchers to support the development of their Integrated Regional Water Management Plan, a plan which is mandated by the State of California.
- Sounthern Nevada Water Authority is using the climate projections from the CNAP report to screen projects that might be climate sensitive and determine if a more detailed climate change risk assessment should be undertaken.
- Predictive Services North Ops is using EDDI maps as guidance in interagency severity funding requests and as part of their fire potential outlooks.
- City and county agencies and other decision makers in San Diego County are using numerous results from the San Diego Regional Climate Change Assessment, including atmospheric climate, water resources and coastal sea level rise, in adaptation planning for climate changes in the region.

For information about research findings and papers please see the complete list at the end of the report.

OUTREACH AND ENGAGEMENT ACTIVITIES

GREAT BASIN CLIMATE FORUM (VANDERMOLEN, WALL)

In December 2018, CNAP researchers Wall and VanderMolen co-organized the Great Basin Climate Forum in Reno. There were about 50 natural resource managers in attendance from federal, state, and tribal agencies throughout the Great Basin. Presentations/discussion covered topics of snow drought, wildfire management and effects under a changing climate, and health impacts of wildfire smoke. Attendees also received an inside look at the U.S. Drought Monitor—its development and intended uses—and the climate tools and resources available through the USDA Climate Hubs.

Stakeholders working in groups at the Great Basin Climate Forum.

SIERRA NEVADA REGIONAL REPORT (DETTINGER)

With the Sierra Business Council, CNAP co-hosted the Sierra Nevada Regional report meeting in South Lake Tahoe in early December 2018. The meeting had 70 attendees from all over the Sierra Region. CNAP researcher, M. Dettinger, led the report and presented on the findings along with other authors of the report. The attendees discussed the most pressing climate issues for the region and on-going or potential adaptation strategies.

SAN DIEGO REGIONAL REPORT (KALANSKY, CAYAN)

Working with the Climate Science Alliance, CNAP participated in the meeting on the Regional Report in March 2019. The meeting had a sell-out attendance. Kalansky and Cayan presented on the major finding of the report and then authors and regional stakeholders participated in panels to discuss climate adaptation efforts in their sectors. The afternoon focused on sea level rise and brought together many of the scientists that contributed to the coasts section in the regional report. More pictures and the presentations can be seen here (https://www.climatesciencealliance.org/2019-climate-summit). CNAP also supported the translation of the executive summary of the report into Spanish to make it accessible to a broader audience.

A collection of photos from the San Diego Regional report meeting; San Diego Climate Summit. TOP LEFT: Opening slide of the summit; BOTTOM LEFT: Arial photo of the summit audience; TOP MIDDLE: Panel during the morning of the summit discussing climate impacts to infrastructure in San Diego; MIDDLE BOTTOM: Dan Cayan presenting on the climate impacts to the San Diego region; TOP RIGHT: Dan Cayan and Louise Bedsworth in a panel discussion about the importance of regional climate science to plan and build regional resilience; BOTTOM RIGHT: Science Climate Annual Awardees.

WATERSHED COALITION VENTURA COUNTY (OAKLEY)

In Ventura County, we held two workshops on the climate report developed for Ventura County as part of the Integrated Regional Water Management Plan. In October 2018, we met with a variety of the stakeholders to present general information about climate change in Ventura County and to discuss and collect their questions and specific data analysis requests. We also had extensive small group discussions with various stakeholders that served to help us as researchers understand their challenges and concerns as well as build rapport; these meetings were critical to the success of the project and have set us up for future partnership and success in working with these groups. In April 2019, preliminary results of analyses requested by stakeholders were presented and discussed. One benefit of these meetings was that it allowed an open discussion of climate change concerns among the varied stakeholder groups attending. Dialogue on concerns led to conversations on potential adaptation strategies.

NIDIS BI-MONTHLY WEBINAR SERIES

CNAP participates in and co-hosts with NIDIS a bi-monthly CA-NV DEWS *Drought & Climate Outlook* webinar series designed to provide stakeholders and other interested parties in the region with timely information on current drought status and impacts, as well as a preview of current and developing climatic events such as ENSO, stream forecasts, etc. The CNAP team works with A. Sheffield in brainstorming topics and speakers. Presentations:

- **July 2018: J. Kalansky – Southern Nevada Water Agency and Climate Information**
- **November 2018: J. Kalansky – Outlook and Update; Tools for the Winter (CNAP & CW3E)**
- **February 2018: J. Goodrich – Outlook**
- **May 2018: D. Cayan – Outlook and Update; D. McEvoy – EDDI and Fire Research**

INITIATIVES TO ADVANCE

A new partnership is with I See Change (https://www.iseechange.org), leveraging IRAP funding for a project in public health and heat. The larger IRAP project is looking at heat impacts at sub-daily levels in San Diego, Tijuana, Mexicali, and Calexico. This project is designed to look at in-home heat impacts, to complement the larger scale sub-daily impacts and understand how heat impacts are resolved across time and intensity, i.e., is the lack of night time cooling more impactful than high temperatures? Is duration more impactful than intensity? This will help identify possible vulnerable populations at a more granular scale, as well as understand how heat messaging can be targeted to those populations.

CNAP is developing a stronger partnership with County of San Diego Health & Human Services Agency. These partners are staying abreast of our Climate and Health research results and we are co-organizing an outreach event, a climate and health Convening for Winter/Spring 2020. The Convening will be designed to inform public health stakeholders of the latest research on weather and climate impacts on health in the region as well as to solicit their feedback on an eventual adaptation plan for San Diego County's health sector to weather extremes in a changing climate. This health-focused adaptation plan would be the first such plan in California and working with California Department of Public Health, the San Diego adaptation plan may serve as an example for other localities.

BUILDING EXPERTISE OF DECISION MAKERS TO PREPARE AND ADAPT

SEA LEVEL RISE AND PLANNING FOR UNCERTAINTY (KALANSKY)

CNAP, with the Tijuana National Estuarine Research Reserve, developed a handout using regionally specific sea level rise data that discusses adaptation approaches for now, the near term and the long term. This handout enhances planners' ability to communicate about the current scientific information related to sea level rise and adaptive management approaches to be prepared for extreme events now and in the future. Feedback on the initial product by sea level rise experts, local planners in coastal communities in San Diego and the Coastal Commission expressed how the handout could be used to communicate sea level rise science and planning. Gabe Buhr from California Coastal Commission said, "In general, I think the product is great, and will definitely help in the public information process." We are currently in the process of the larger roll-out and will have more information on utilization for the next year's report. The handout can be viewed at https://scripps.ucsd.edu/programs/cnap/sea-level-rise-adaptation-and-planning/ and is also shown on page 12.

Today's proactive choices prepare San Diego for rising seas.

To prepare for the rapid increase in the rate of sea level rise (see other side), our communities need to implement short-term strategies directly linked to long-term solutions. This **phased adaptation** can help communities make small, manageable, and affordable changes in the near-term that will cumulatively result in long-term improvements. Today's decisions should put us on the path to resilience before the high sea levels projected for mid-century irreversibly impact our beaches, our communities, our neighbors, and our homes.

Below is one example of a community adapting to sea level rise through a phased approach. Each community will have a different vision for the future. There is no one size fits all when it comes to adaptation.

Sea levels are rising now...
California has experienced several extreme sea level events in recent years. San Diego experienced its highest recorded sea level in November 2015.

Left: A flooded beach and access point in La Jolla resulted in loss of recreation.

Center: Marsh habitat in Mission Bay is almost entirely submerged during flooding.

Right: High water reaches Imperial Beach's Seacoast Avenue.
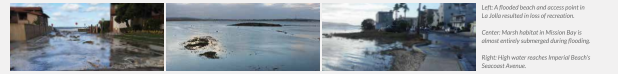
... and will rise even faster beyond 2050.
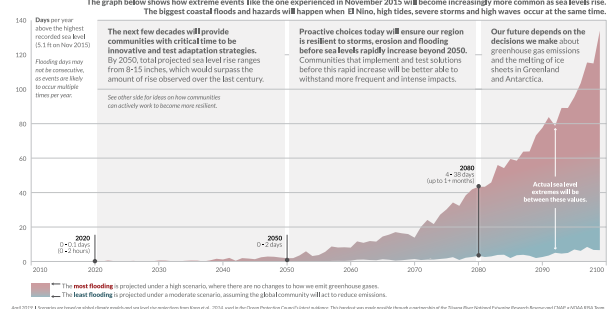
The two page handout that was developed to help with communication of how to plan for the uncertainty of sea level rise. The front panel illustrates a phase approach and provides examples. The back panel uses photos to show the impacts of extreme sea level and uses local San Diego data from the California 4th Climate Assessment to show the number of hours above the historical maximum sea level.

Use of EDDI in Understanding FIRE Risk (McEvoy): Leveraging a SARP project and working with stakeholders that CNAP has worked with for many year, CNAP researcher D. McEvoy is working with fire risk managers on ways to utilize EDDI. In particular, interactions with Predictive Services and EDDI for fire risk management has shown the strong need for direct interactions between scientists and stakeholders. Without the in-person presentations, webinars, and conversations between D. McEvoy and stakeholders there would not be enough knowledge and confidence in the stakeholders to use the EDDI products.

TESTIMONY FROM BRENT WACHTER, PREDICTIVE SERVICES DURING SUMMER 2018 EDDI TESTING

"I already have a case from an event that 'yielded' two 2000 plus acre fires. I used an EDDI (believe it was 1 week) graphic to brief Cal Fire officials about the potential for 'extra stressed' fuels that happened to be where the two 2000 plus acre fires occurred. From what I can tell...1 to 2 week graphics are best right now for some of the higher risk events. North CA is sitting at 4 to 5x the normal amount of fuel loading and fires are active during breezy situations regardless of humidity...even at 40 to 50% RH. Thus...hoping to use EDDI to help hone in on the more dangerous fuel conditions combined with stronger wind. I will probably also push to get this product placed in the NWCG Fire Behavior Fuel Reference Guide."

EXAMPLES OF PLANS AND POLICIES THAT CNAP INFORMED

CLIMATE CONDITIONS IN CLARK COUNTY (KALANSKY, SHEFFIELD, PIERCE, CAYAN)

The co-produced report, Climate Conditions in Clark County, NV, is being used within Southern Nevada Water Agency (SNWA) to screen projects that might be climate sensitive. The screening process is being incorporated in SNWA's project initiation procedure for capital projects. A fact sheet based on the Clark County report forms the basis of a climate conditions guide used to screen projects to see if a more detailed climate change risk assessment should be undertaken.

VENTURA COUNTY CLIMATE REPORT (OAKLEY)

Results from the Ventura County Climate report are being incorporated into the Ventura County 2040 General Plan as well as Ventura County's IRWM plan. Stakeholders commented that it is useful to have climate change information in one place, focused specifically on Ventura County and using their particular questions and thresholds of interest. Several stakeholders said they will use the report as a reference in future work, in both planning and grant applications.

EVALUATION PLAN

PROGRAMMATIC EVALUATIONS: CNAP INTERNAL COLLABORATIONS/MENTORING (MOSER)

In our current statement of work, CNAP has embraced an effort to more fully understand how mentoring activities happen in our network, their impact, and how we can both do better and be more effective in our mentoring practices. In particular, we desire to better understand what mentoring practices have the most positive impact, what practices are commonly used successfully, and what the barriers to successful mentoring are in CNAP. A geographically diverse team, we now encompass a range of disciplines (including physical science and social science researchers), a wide range of researchers at varying stages in their careers (students through senior researchers), and gender diversity. As a large team of affiliated researchers across five institutions in California and Nevada, CNAP presents a unique opportunity in the RISA network to test mentoring evaluation methods and instruments that can be potentially utilized across the network. This is relevant, as many RISA investigators have noted that training early-career scientists in co-production climate research is a key component in capacity building and climate adaptation efforts. CNAP collaborator S. Moser has developed a survey instrument and interview guide for both CNAP mentors and mentees, received IRB clearance, and began data collection in June 2019. We expect to have preliminary results ready for the Annual RISA meeting in September, 2019, and also for our scheduled CNAP programmatic review which will be completed by December 1, 2019.

RETROSPECTIVE EVALUATIONS

GREAT BASIN CLIMATE FORUMS (GBCF) (VANDERMOLEN & WALL)

Following the 2018 Great Basin Climate Forum (GBCF) in Reno, we sent a survey to all GBCF attendees to explore what they find most and least beneficial about the forum, and whether and how the structure and content of the forum might be modified to best meet their needs. Ten attendees responded to the survey. The majority noted the climate outlook (a 45-minute talk that opens the forum with an update on current and anticipated climate conditions) as most beneficial. Feedback on least beneficial aspects of the GBCF were more mixed but focused overall on the structure of talks, noting that these could be shorter in duration, more dynamic, and more applicable to decisionmaking. Relatedly, the majority noted that a more interactive forum—including, for example, practice with the tools/models presented and micro-polling during or between presentations to evaluate comprehension and stimulate discussion—would help to better meet their needs. Based on this feedback and our desire to try a different GBCF format after seven years, we have initiated conversation with The Global Learning and Exchange Network and will seek funding to contract their expertise in interactive workshop design to help in restructuring the forum.

The proposed restructuring includes a change from a biannual forum (Reno in fall; rotating location in spring) to a series of smaller, interactive meetings focused on a single climate-related theme at different locations within the Great Basin (e.g., Elko, NV; Bishop, CA; Klamath Falls, OR) throughout the year. Initially, we will select each year's theme from the priority climate-related concerns noted by GBCF attendees over the last seven years in pre- and post-forum feedback surveys. We recently performed an analysis of those concerns to identify any changes in priorities since the GBCF began. We found that climate impacts to water resources and ecosystems have remained of top concern over time, followed by climate impacts to wildfire and wildlife. We therefore plan to work through those priorities but will introduce others as needed to meet any changes in attendees' needs. The proposed restructuring also includes a change from an emphasis on information delivery and discussion to an emphasis on information exchange, with particular attention given to enhancing attendees' knowledge and understanding of available climate information resources as relevant to their work and needs expressed.

CALIFORNIA 4TH CLIMATE ASSESSMENT, REGIONAL REPORTS
(DETTINGER, KALANSKY, WALL)

Our evaluation of stakeholder perceptions of the 4th California Climate Assessment focused on participants at roll-out meetings for the Sierra Nevada and San Diego Regional Reports. We prepared a short survey that asked respondents to answer how they saw themselves primarily utilizing the report(s), as supporting general knowledge/awareness (conceptual use), in making a decision (instrumental use) or for planning purposes (conceptual and/or instrumental use). The figures below indicate most people are utilizing the report information to support general knowledge and for planning purposes, but a small percentage are planning on using the information to make decisions. Approximately one year after the meetings, we plan to contact the meeting participants with a follow up survey about their use of the regional reports, and approximately 5-6 participants from each geographic area for short interviews on use. One open response from the San Diego survey emphasized the gap between research and action, *"There still feels like a big gap between science and action. I would like to see more application of science to adaptation, like how the Resilient Futures project in Imperial Beach informed adaptation choices by the city. Where and how are communities trying to affect change? What are the challenges THEY need help with? I think this would also be helpful to scientists to hear what research gaps exist that communities need filled."*
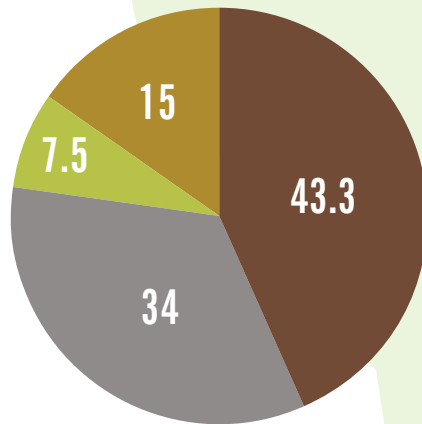
Sierra Nevada

37.8% Improved understanding on climate change
43.2% Use the information to develop a plan
13.5% Use the information to make a decision
5.4% Other

San Diego

43.3% Improved understanding on climate change
34% Use the information to develop a plan
7.5% Use the information to make a decision
15% Other
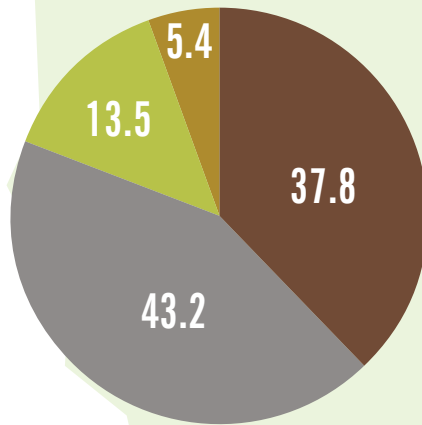
Legend:
- Improved understanding on climate change
- Use the information to develop a plan
- Use the information to make a decision
- Other

Results of a survey responses from the roll-out meetings of the Sierra Nevada and San Diego Regional Reports.

PROJECT-BASED EVALUATION

Over the last year, there have been two projects that, based on internal evaluation, CNAP has decided either to no longer pursue or to change the outcomes. The obstacles and pivots are discussed below.

SPRING GREEN-UP: The spring green-up project was designed to determine what atmospheric conditions are related to spring green-up and the feasibility of predicting these conditions, with the goal of informing and improving decision-making related to the Bureau of Land Management's (BLM) grazing permit process. The project team has discovered several challenges in completing the project through meeting with stakeholders, and in beginning the research and thus has modified the intended outcomes of the project. A primary hurdle is that grazing permits are issued in February, though green-up typically happens in May and June. This 3–4 month lead-time is currently well beyond the limits of useful seasonal precipitation predictions, creating a mismatch between useful information and the decision-making timeline. In addition, the BLM's permitting process is complex and considers other factors in addition to climate and weather. Additionally, challenges resulted from the spatial scales of information that are useful as well as distinguishing the type of vegetation that is creating the green-up. Given the obstacles of the project becoming useful for the stakeholder, CNAP has decided to place the effort into updating the Great Basin Dashboard with relevant information that stakeholders thought would be useful. This will be completed through the summer and fall of 2019.

CLIMATE INFORMATION UTILIZATION BY UNDERSERVED FARMERS: The objective of the proposed project with California underserved farmers was to develop understanding of their current and potential use of climate information given sociocultural, economic, and other barriers related to their underserved status. To achieve that objective, we partnered with the nonprofit organization, California FarmLink, in Santa Cruz, CA, to recruit underserved farmers in Santa Cruz and Monterey counties for semi-structured interviews on climate information use/non-use. We sought FarmLink as a partner given the organization's ties to underserved farmers in those counties through its mission to assist them in land acquisition, financing, and conservation. Under that partnership, FarmLink would provide assistance in recruitment of research participants and CNAP would share research results with FarmLink, including recommendations for increasing access to relevant climate information to interested farmers. FarmLink's outreach consisted of bilingual (English and Spanish) calls for participation by way of its monthly newsletter, and flyers distributed by its staff at a California farming conference. No participants were successfully recruited through these methods, so the project did not move forward. We acknowledge that a more active recruitment strategy, for example, consisting of direct phone calls, may have produced a different result but we deferred to FarmLink's preferred methods of engagement.

CNAP CONTRIBUTIONS TO NATIONAL INTEGRATED DROUGHT INFORMATION SYSTEM (NIDIS) AND THE CA/NV DROUGHT EARLY WARNING SYSTEM (DEWS)

NEW DROUGHT TRACKING PRODUCTS (DETTINGER)

The year-old and new snow and reservoir tracking products provide new perspectives on the combined stores of water in the river basins that provide most of California's water in real time, rather than expressing that overall storage in two separate bins (snowpack vs reservoirs). This is an extremely simple approach, so simple that the major agencies historically assume that everyone will manage to keep track of it in their heads. But it really does help to be able to know whether the snowpack (to date) has been adequate to fill reservoirs, or whether unusually full reservoirs are sufficient to compensate for developing snow droughts, as the year proceeds. Similarly, the odds-of-normal graphics provide direct reporting on aspects of drought development and termination that current reports "leave to the user's imaginations" (or internal calculations): (1) The ever-evolving tradeoffs between how much precipitation has fallen to date vs the declining amount of time left in the wet season/water year to make up any developing shortfalls or surpluses, and (2) the understudied/underreported effects that time-varying ET_0 has on how effectively the widely-reported precipitation deficits or surpluses develop (or not) into drought beginnings or terminations. Both of these ways of anticipating droughts are specifically designed to be more responsive to the next generation of climate-changed drought conditions that are currently projected, by (1) better incorporating/anticipating the potential roles of enhanced extreme storms in drought-afflicted settings and (2) by incorporating temperature contributions to drought more clearly and explicitly.
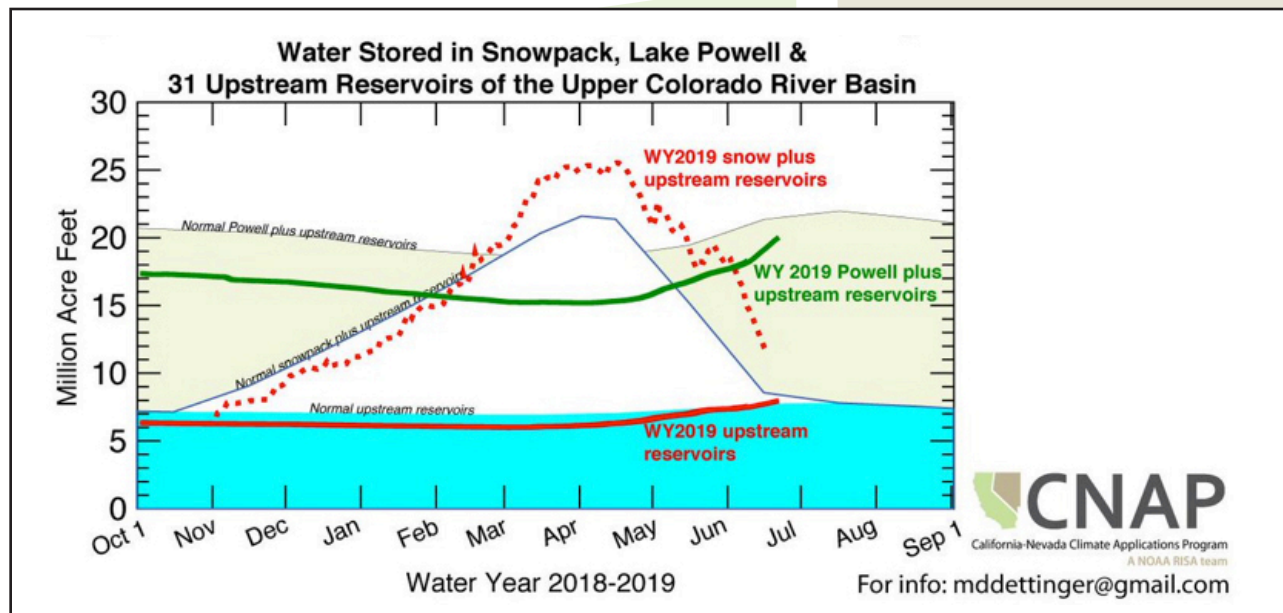
The new Colorado River Basin snow pack and reservoir storage tracking tool developed this past year.

SOIL MOISTURE MONITORING (LETTENMAIER)

D. Lettenmaier has added the Noah with multiparameterization (Noah-MP) model (Niu et al., 2011; Yang et al., 2011) to the UCLA Drought Monitoring System for CA and NV. The system provides a near real-time with soil moisture and other hydrologic conditions expressed as percentiles relative to the climatological period 1920–2010. This allows for comparison between models. In addition D. Lettenmaier has also assembled observed soil moisture from various sources across CA and NV, which is express as percentiles for the upper 50 cm of the soil column in near real-time (http://www.hydro.ucla.edu/SurfaceWaterGroup/forecast/monitor_ca/soilmoisture.html). The availability of soil moisture data was determined by a station screening that was performed based on the following criteria: 1) at least 5-years of observation record, 2) not irrigation-affected, and 3) soil moisture time series passed a bivariate test between station precipitation and soil moisture (stated otherwise, low soil moisture corresponds to dry conditions over the last few months, and vice versa). For the stations that passed the screening, the web site shows near real-time daily analyses of observed soil moisture percentiles for 44 stations operated by the Natural Resources Conservation Service (NRCS)-Soil Climate Analysis Network (SCAN), the U.S. Climate Reference Network (USCRN) and the Western Regional Climate Center (WRCC). The approach used here and method developed to calculate percentiles may be applicable or utilized as part of the national soil moisture network.

DROUGHT STARTS AND STOPS (MCINNIS, PIERCE, KALANSKY, CAYAN)

This project examines both the physical science and the social science of when droughts in California and Nevada were declared and when the droughts ended. The project integrates both social and physical science by discussing the research collectively on project calls. Results show that physical indicators vary across officially declared droughts, but snowpack and runoff are consistently important. Examination of the climatic variables established that there is not a standard physical threshold for when a dry season comes to be officially seen by actors across California as a drought and thus that there is space for social and political arguments from a variety of groups to layer meaning onto the dry physical indicators of drought. Current sociology graduate student H. Mcinnis, is examining the discourse in media around droughts to understand how salient political issues influence the relative dryness (ex: court orders to reduce pumping in the Delta in order to protect endangered species greatly increase the impact of a dry year on various water users), and also alter the way in which dry seasons are framed and discussed as droughts. Results from this analysis will demonstrate the ways that a natural phenomenon can be shaped by society and politics in meaningful ways that go beyond the information provided by physical indicators.

UPDATED GROUNDWATER ESTIMATES IN THE CENTRAL VALLEY
(GOODRICH, CAYAN, PIERCE)

California's Central Valley (CV) is one of the most productive agricultural regions in the world, enabled by the conjunctive use of both surface-water and groundwater. The Central Valley hydrologic estimates will support both improvements in monitoring and impact assessment. Working toward developing a near real time estimate of ground water levels, pumping and land subsidence in California's Central Valley, statistical relationships with meteorological variables and land-use type were identified to generate surface water diversion data for input to the Central Valley Hydrological Model (CVHM). CVHM provides groundwater levels, pumping and land subsidence throughout the Central Valley. Our initial CVHM run using estimated surface water diversions yields good skill in recreating historical pumping, accounting for 80–90% of the variance in the original modeled pumping using reported surface water inputs. This provides an important estimate to a critical component of the water budget in California. It also provides a first order estimate of the response of groundwater to both wet and dry conditions. Results to date depict a dichotomy of regimes wherein diversions in the more arid southern basins are governed by year-to-year natural hydrologic variability, while those in the wetter northern basins more closely reflect land-use patterns and low frequency hydrologic patterns. The near-real time model estimates will provide a more rapid update of drought impacts on ground water pumping, subsidence and how wet years may provide recovery of drought. This methodology provides first order estimate but fills a major gap in understanding the water supply and water cycle in California. We investigated variations in the CV's managed surface-water diversions relative to climate variability.

DATA SHARING NOTE: All the data that we have used for the product this year have come from publically available data. CNAP has not produced any proprietary data this past year.

PUBLICATIONS WITH HIGHLIGHTS

Aguilera, R., A. Gershunov, and T. Benmarhnia, 2019, Atmospheric rivers impact California's coastal water quality via extreme precipitation. *Science of the Total Environment*, 671, 488–494, doi.org/10.1016/j.scitotenv.2019.03.318.

Bedsworth, L., D. R. Cayan, G. Franco, L. Fisher, S.A Ziaja (California Governor's Office of Planning and Research, Scripps Institution of Oceanography, California Energy Commission, California Public Utilities Commission), 2018, Statewide Summary Report, *California's Fourth Climate Change Assessment*, Publication number: SUM-CCCA4-2018-013. http://www.climateassessment.ca.gov/state/docs/20180827-StatewideSummary.pdf

Climate-Safe Infrastructure Working Group (CSIWG), 2018, Paying it forward: The Path Toward Climate-Safe Infrastructure in California. Executive Summary of a Report of the Climate-Safe Infrastructure Working Group to the California State Legislature and the Strategic Growth Council. Sacramento, CA, CNRA, Publication number: CNRA-CCA4-CSI-001. http://resources.ca.gov/climate/climate-safe-infrastructure-working-group/

Corringham, T.W. and D.R. Cayan, 2019, The Effect of El Niño on Flood Damages in the Western United States. *Weather Climate and Society*, 11, 489–504, doi.org/10.1175/WCAS-D-18-0071.1.

CNAP postdoc Tom Corringham and coauthor Daniel Cayan have published a paper that quantifies insured flood losses across the western United States from 1978 to 2017, presenting an analysis of National Flood Insurance Program (NFIP) claims and losses over this period. The NFIP data reveal that 1% of extreme events, covering wide spatial areas, caused over 66% of total insured losses. Connections between extreme events and El Niño–Southern Oscillation (ENSO) that have been documented in past research are borne out in the insurance data. In coastal Southern California and across the Southwest, El Niño conditions have had a strong effect in producing more frequent and higher magnitudes of insured losses, while La Niña conditions significantly reduced both the frequency and magnitude of losses. In the Pacific Northwest, the opposite pattern appears, although the effect is weaker and less spatially coherent. The persistent evolution of ENSO offers the possibility for property owners, policy makers, and emergency planners and responders that unusually high or low flood damages could be predicted in advance of the primary

winter storm period along the West Coast. Within the 40-year NFIP history, the study finds that the multivariate ENSO index would have provided an 8-month look-ahead for heightened damages in Southern California

Dettinger, M., H. Alpert, J. Battles, J. Kusel, H. Safford, D. Fougeres, C. Knight, L. Miller, S. Sawyer (United States Geological Survey), 2018, *Sierra Nevada Summary Report*, California's Fourth Climate Change Assessment. Publication number: SUM-CCCA4-2018-004. http://www.climateassessment.ca.gov/regions/docs/20180827-SierraNevada.pdf

The Sierra Nevada Regional Report and the San Diego Regional Report synthesized the climate impacts at smaller spatial scale than had been done previously for many areas in California which enables decision makers to use the results for more localized planning and decision making. The reports also discuss the impacts on multiple sectors including water, energy, and natural resources. These reports included many authors beyond academia to support the utilization of the information throughout both the regions. Recent feedback is the information is being integrated into larger planning efforts.

Dias, D. F., D. R. Cayan, A. Gershunov (Scripps Institution of Oceanography, University of California, San Diego), 2018, Statistical prediction of minimum and maximum air temperature in California and western North America, *California's Fourth Climate Change Assessment,* California Energy Commission. Publication Number: CCCA4-CEC-2018-011. http://www.climateassessment.ca.gov/techreports/docs/20180827-Projections_CCCA4-CEC-2018-011.pdf

Franco, G., D. R. Cayan, David W. Pierce, A. L. Westerling, J. H. Thorne (California Energy Commission), 2018, Cumulative Global CO2 Emissions and their Climate Impacts from Local through Regional Scales, *California's Fourth Climate Change Assessment*, Publication number: CCCA4-EXT-2018-007. http://www.climateassessment.ca.gov/techreports/docs/20180827-Projections_CCCA4-EXT-2018-007.pdf

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. N*ature Scientific Reports*, in press.

CNAP researcher S. Gershunov led a research effort into the role of atmospheric rivers in precipitation regime change that we have previously identified in climate projections. The results mechanistically explain the intensification of precipitation extremes robustly projected for California in CMIP5 GCMs as largely being a result of atmospheric rivers. This work put a puzzle together to explain the nuances of precipitation regime change projected for this and other Mediterranean climate regions around the globe. Knowing the mechanisms of change provides more nuanced value-added knowledge of the impacts on water resource and flood risk management.

Guirguis, K, A. Gershunov, T. Shulgina, A. Subramanian, R.E.S. Clemesha, and F.M. Ralph, 2018, Circulation drivers of Atmospheric Rivers along the North American West Coast, *Geophysical Research Letters*.

Guzman Morales, J. and A. Gershunov, 2019, Climate change suppresses Santa Ana Winds of Southern California and sharpens their seasonality, *Geophysical Research Letters*, doi: 10.1029/2018GL080261.

Kalansky, J.F., D. R. Cayan, K. Barba, L. Walsh, K. Brouwer, D. Boudreau (University of California, San Diego), 2018, San Diego Summary Report, *California's Fourth Climate Change Assessment*, **Publication number: SUM-CCCA4-2018-009. http://www.climateassessment. ca.gov/regions/docs/20180928-SanDiego.pdf**

Please see description from the Sierra Nevada Regional Report

Lamjiri, M. A, M.D. Dettinger, F. M. Ralph, N. S. Oakley and J.J.Rutz, 2018, Hourly Analyses of the Large Storms and Atmospheric Rivers that Provide Most of California's Precipitation in Only 10 to 100 Hours per Year, *San Francisco Estuary and Watershed Science*, 16(4).

McEvoy, D.J., M. Hobbins, T. J. Brown, K. VanderMolen, T. Wall, J. L. Huntington, and M. Svoboda, 2019, Establishing Relationships between Drought Indices and Wildfire Danger Outputs: A Test Case for the California-Nevada Drought Early Warning System. *Climate*, 7(4), 52. https://doi.org/10.3390/cli7040052

Oakley, N. S., F. Cannon, R. Munroe, J. T. Lancaster, D. Gomberg, and F. M. Ralph, 2018, Brief Communication: Meteorological and climatological conditions associated with the 9 January 2018 post-fire debris flows in Montecito and Carpinteria California, USA, *Natural Hazards Earth System Science*, doi.org/10.5194/nhess-2018-179.

Oakley, N. S., F. Cannon, E. Boldt, J. Dumas, F. M. Ralph, 2018, Origins and variability of extreme precipitation in the Santa Ynez River Basin of Southern California, *Journal of Hydrology: Regional Studies*, 19, 164-176, doi: 10.1016/j.ejrh.2018.09.001.

Oakley, N.S., B.J. Hatchett, D. McEvoy, and L. Rodriguez, 2019, Projected Changes in Ventura County Climate. Western Regional Climate Center, Desert Research Institute, Reno, Nevada. https://wrcc.dri.edu/Climate/reports.php

Roche, J., R. Rice, X. Meng, D. Cayan, M. Dettinger, D. Alden, S. Patel, M. Mason, M. Conklin, and R. Bales, 2019, Climate, snow, and soil moisture data set for the Tuolumne and Merced River watersheds, California, USA, *Earth System Science Data*, 11, 101-110, doi. org/10.5194/essd-11-101-2019.

Ullrich, P.A., Z. Xu, A. M. Rhoades, M. D. Dettinger, J. F. Mount, A. D. Jones, and P. Vahmani, 2018, California's drought of the future—A midcentury recreation of the exceptional conditions of 2012–2017, *Earth Future* 20 p., doi.org/10.1029/2018ef001007.

VanderMolen, K., T.U. Wall, and B. Daudert, 2019, A Call for the Evaluation of Web-Based Climate Data and Analysis Tools. *Bulletin of American Meteorology Society*, 100, 257–268, doi.org/10.1175/BAMS-D-18-0006.1.

Vano, J., M. Dettinger, R. Cifelli, D. Curtis, A. Dufour, R. Olsen, and A. Wilson,2018, Hydroclimatic extremes as challenges for the water-management community—Lessons from Lake Oroville and Hurricane Harvey, *Bulletin of the American Meteorological Society*; Special Supplement, Explaining Extreme Events of 2017, 99, S1-S6, doi:10.1175/BAMS-D-18-0219.1.

Wall, T., G. Garfin, J. Brugger, H. Hartmann, and T. Brown, 2018, Final Report: Scenario Planning in the Great Basin Region: Considering Climate Change Impacts and Management Strategies for the Future.

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A NOAA RISA team