

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

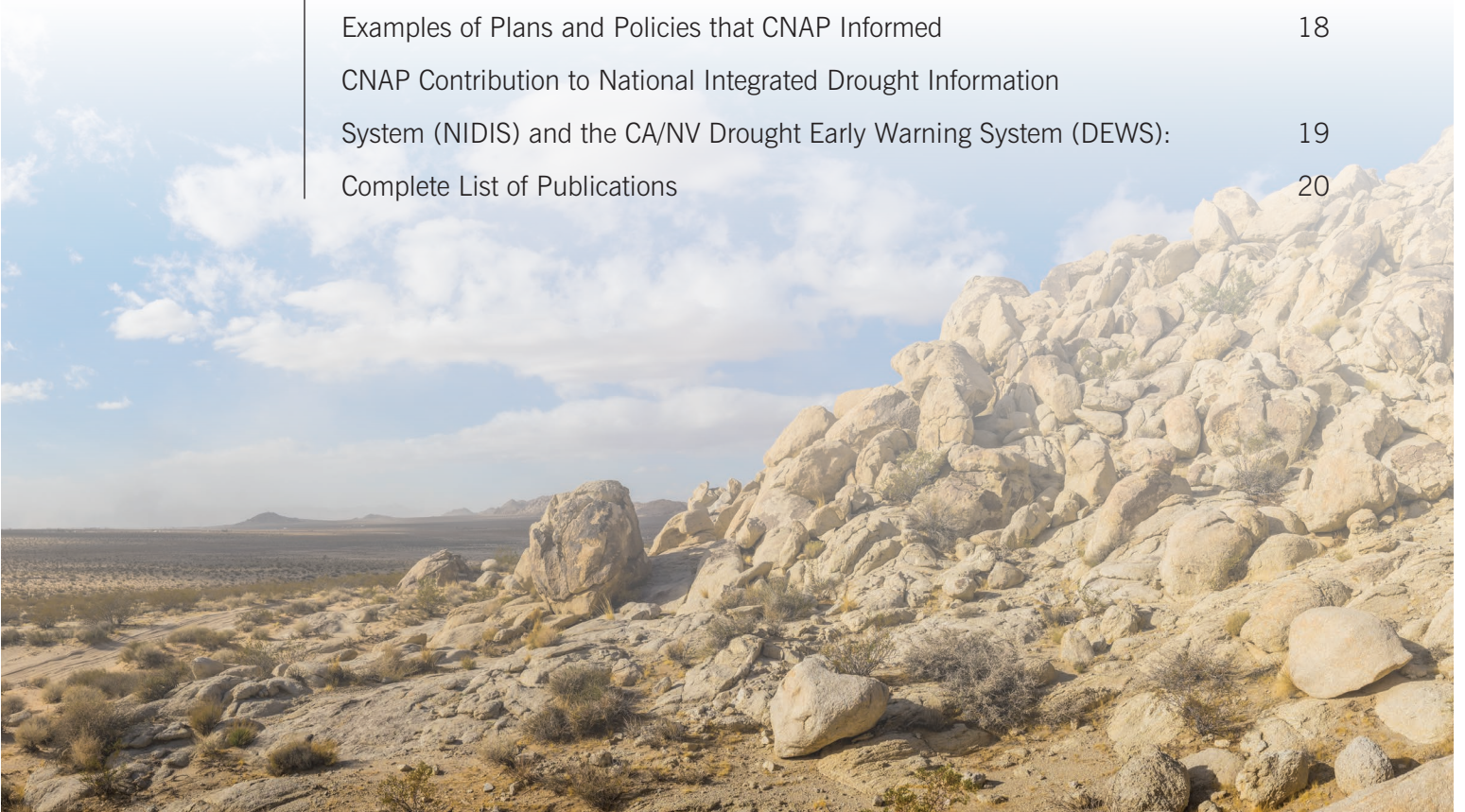


California-Nevada Climate Applications Program  
A NOAA RISA team

**PERFORMANCE PERIOD**  
**SEPTEMBER 1, 2017—MAY 31, 2018**

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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 (Figure 1), 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 is currently completing 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. More recently CNAP is working with Southern Nevada Water Authority to better understand how climate variation drives changes in water demand in their Clark County service territory. CNAP is also working with the Bureau of Land Management (BLM), and local National Weather Service offices on climate related projects, and CNAP researchers recently teamed with the Science Climate Alliance – South Coast to develop a comprehensive study of the vulnerability of San Diego County ecosystems to climate influences.

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.

We want to note that, within this report, some of work and results discussed have been accomplished using funding from a prior CNAP award through a no-cost extension (NCE). We will note this throughout the report when applicable.

# California Nevada Climate Applications Program Model

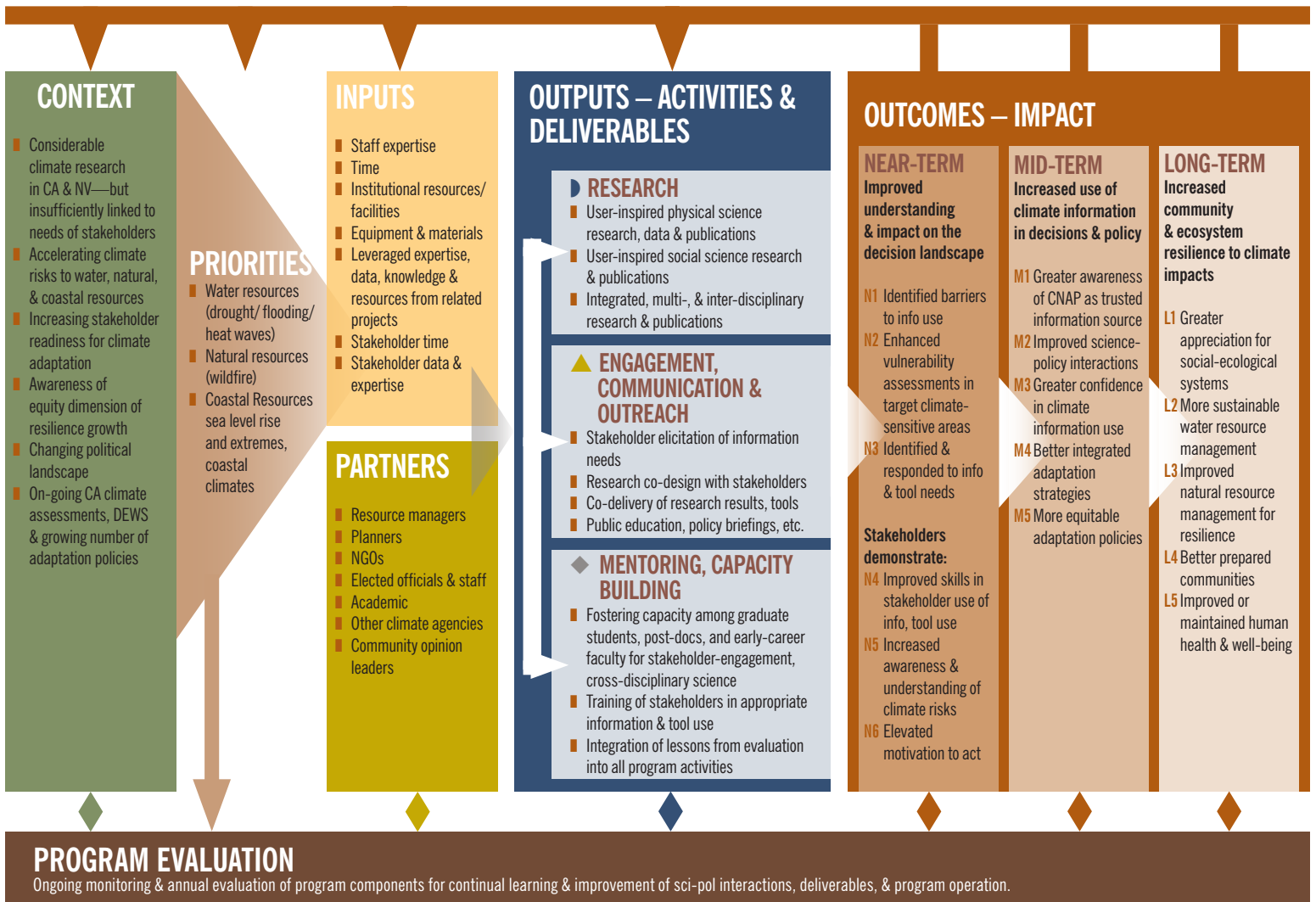


Figure 1. CNAP program model highlights the outcomes, or what the type of products it produces including scientific journal articles, reports, stakeholder workshops, and mentoring early career scientists. The program model also describes the short-term, near-term and long-term goals for the program.

# 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
- Amanda Sheffield\*
- 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
- Shradhdhanand 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.

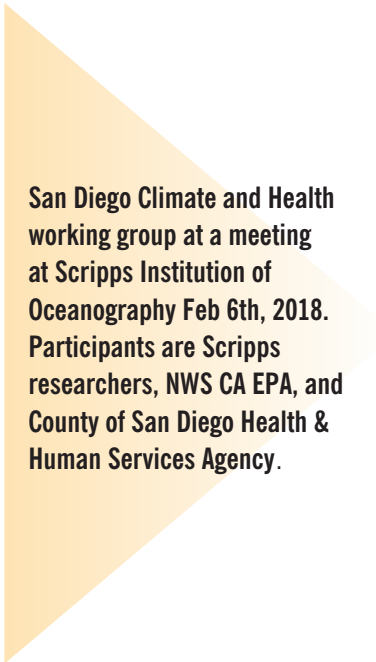


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## NEW PARTNERSHIPS

**CA 4th Climate Change Assessment Regional Reports (Kalansky, Cayan, Dettinger, Westerling):** As part of the CA Fourth Assessment, the State decided to incorporate regional reports to examine climate vulnerabilities and adaptation that are occurring on a more local scale. CNAP researchers took a leading role in developing three (San Diego – Kalansky & Cayan; Sierra – Dettinger; San Joaquin Valley – Westerling) of the nine regional reports. The reports required working intricately with other regional scientists and a diverse group of stakeholders to ensure the reports captured information about climate impacts and adaptation for multiple sectors including but not limited to water, energy, transportation, land-use, agriculture, ecosystems and health. These reports are currently under review and will be highlighted at the California Adaptation Forum in August 2018. Similar to the above mentioned ecosystem report, the regional reports leverage funding from CA Energy Commission (CEC) for the climate, sea level rise and wildfire risk projections, these reports were not funded by the CEC and we relied on RISA funding to complete the reports.

**Santa Ana Winds, Wildfire, and Health (Gershunov):** In an effort by CNAP researcher A. Gershunov, we have developed a greater partnership with San Diego County, Health and Human Services Department. The department is quite interested and engaged in using the climate projections and research into public health planning, particularly as it relates to heat waves. Recent research has identified different temperature thresholds for impacts to public health in different locations and demographics in San Diego which in large part is dictated by access to air conditioning (Guirguis et al., 2018). The San Diego Department of Public Health is interested in how to apply this information to more effectively communicate warnings and messaging surrounding heat waves to mitigate impacts from these extreme events. The San Diego National Weather Service is a key partner in these collaborations, and colleagues in the NWS office have been at all the meetings. We are in the very early phases of discussing how climate may impact disease burdens. Barriers remain in that we still need to find the expertise to model disease burdens.



**San Diego Climate and Health working group at a meeting at Scripps Institution of Oceanography Feb 6th, 2018. Participants are Scripps researchers, NWS CA EPA, and County of San Diego Health & Human Services Agency.**

**Red Flag (NIDIS, Wall and Brown):** A Red Flag Warning (RFW) is a term that has been used since the 1960s by National Weather Service (NWS) fire weather forecasters to alert forecast users to an ongoing or imminent critical fire weather pattern. The NWS, the principal partner of this project, desires to explore potential changes to the RFW to improve its value to fire management and the public. Wall and Brown attended the National Cohesive Wildland Fire Management Strategy Meeting, March 27–29, 2018, Reno NV to present on the Red Flag Project and gather feedback from attendees scheduled for March 29th, 10:15-11:15 (session title: Are Red Flag warnings a resource tool or safety product?) The goal of this interactive session was to begin the conversation with fire management on revising the Red Flag Warning system and (where appropriate) begin connecting NDAWN to the National Cohesive Strategy. To continue the discussion, Wall and Brown, attended the Fire Continuum Conference in Missoula, Montana May 21-24th, 2018 to present on NDAWN and included the Red Flag project to continue gathering input from key stakeholders. Below is summarized some of the key points that came out of the workshops.



**KEY POINTS:**

- Fuels are an important issue for RF products—whose responsibility?
- Scale—timing of weather (timescale) and severity scale.
- Standardization—is this necessary? Possible? What are good criteria? What criteria s/b used?
- Public vs. Fire Management needs—don't drop FM needs in favor of meeting public perceptions.
- Possible Changes: get rid of watch, reduce issuance to critical fire conditions only, messaging issue.

**Spring Green-up (McEvoy, VanderMolen, Shukla, Oakley):** The Spring Green-Up Project is to examine the weather pattern characteristics that lead to a spring time greening in the Great Basin and impacts ranching in the region. Through the project we are working with new stakeholders including Patti Novak, the NRCS state rangeland management specialist, to understand needs related to grazing permitting and drought management. The intention is to understand what type of products could be useful and should be developed for stakeholders from this project. We are also planning to work with Sarah Peterson who is the BLM state lead for soil, water, air, and riparian programs.

**As part of the NIDIS CA/NV DEWS (McEvoy):** Attended or remotely assisted with seven workshops that we provided to NV BLM rangeland staff. The workshops focused on how to use remote sensing and drought indices for range management and part of each workshop included hands-on training about how to use Climate Engine, an online climate data and visualize tool. The Nevada BLM offices covered included Carson City, Reno, Elko, Winnemucca, Battle Mountain, Ely, and Caliente.

**Sea Level Rise Uncertainty (Kalansky and Cayan):** Still in its infancy, we are working with partners in San Diego to develop graphics and informational brochures to communicate the uncertainty surrounding sea level rise but also the importance of planning for it now, as some adaptations will take decades to plan. As part of this effort Kalansky has been attending the Sea Level Rise Working Group meetings that include all coastal cities in San Diego as well as the Port, Navy, the local county planning agency (SANDAG) and the California Coastal Commission. She discussed the new sea level rise projections that were developed for the CA 4th Climate Change Assessment and the uncertainty surrounding these projections. At these meetings, CNAP has heard from the California Coastal Commission and the cities that easily digestible information on this complex topic is important as communities to move forward with vulnerability assessments and adaptation plans. We are in the early phases of putting something together with collaborators that are part of the SLR working group.



**San Diego Sea Level Rise Working Group.**  
With the support of RISA funding Kalansky has been able to participate and attend the SLR working group meetings.

**California’s Climate-Safe Infrastructure Working Group (Moser and Cayan):** Moser is co-facilitating and Cayan is part of the Climate Safe-Infrastructure working group. Established by AB 2800 (Quirk, Statutes of 2015-16), the working group unites experts from multiple scientific and state infrastructure disciplines to bolster the inclusion of climate impacts in state design processes. Through its deliberations, the working group will investigate current informational and institutional barriers to integrating projected climate change impacts into state infrastructure design and critical information that engineers, responsible for infrastructure design and construction, need to address climate change impacts. Currently Moser’s time is being funded by the State of California, but this is a new partnership that may lead to new user inspired research or applications of research.



## NEW CLIMATE SERVICES

**San Diego County Ecosystems: Ecological impacts of climate change on a biodiversity hotspot** (Cayan, Kalansky, Gershunov, Pierce): Several CNAP researchers worked closely with ecologists to develop a comprehensive report on climate impacts on ecosystems in San Diego. This project was done under the umbrella of the Science Climate Alliance, a boundary organization that CNAP works closely with. The report has been accepted as part of the California Fourth Climate Assessment. Once the report was submitted for review, the Science Climate Alliance developed a condensed “Reader Digest” version that has been distributed to over 500 land managers, city and county planners and officials. This also included a climate summit, which was in part sponsored by the Southwest Climate Science and Adaption Center, which had over 200 attendees (see pictures below). In addition, information from this report has already been presented to California Department of Fish and Wildlife, SERCAL (California Society for Ecological Restoration) Conference, and San Diego Integrated Regional Water Management group. The project was a highly leveraged project as there was no funding for it, so each researcher brought their own funding to complete the project. RISA funding supported Cayan’s and Kalansky’s time to write the report. The report further leveraged funding from California Energy Commission in that report incorporated downscaled climate projections that were made as part of California Fourth Climate Assessment (CA Fourth Assessment). More information and the Reader’s Digest version can be found at [www.climate-science-alliance.org/sdc-ecosystems-assessment](http://www.climate-science-alliance.org/sdc-ecosystems-assessment).



**San Diego Climate Summit  
March 6, 2018**

**Partnering with NIDIS, establishment of the NIDIS Drought and Wildfire Nexus (NDAWN) (Wall and Brown):** NDAWN is beginning to expand the network of drought and wildland fire interests through developing information communication pathways and assessing drought-fire relationships via existing and needed research; and understanding decision context for drought information usage. This activity is currently focused on the western U.S. but will expand nationally over time. The Evaporative Drought Demand Index (EDDI) is a specific tool that is beginning to be utilized in the wildland fire community.

# EVALUATION PLAN

Over the next five years (one year past the end of the current award), CNAP plans on utilizing several evaluation approaches, including summative, formative and developmental. Over the next two years, we will focus primarily on using a developmental evaluation approach, which emphasizes providing insights to emerging and on-going projects or efforts. Details are provided below. Using the logic model developed for this award period, we will use the near-term outcomes (N1-6) to guide development of survey and interview materials.

## RETROSPECTIVE: SUMMATIVE EVALUATION

**A. Great Basin Climate Forums (GBCF):** The GBCF were started in 2013. As a part of the forums, we have always asked participants to fill out pre/post questionnaires, regarding their current climate-related concerns, the effectiveness of the forums, and the value of the information provided. Currently, the forums are held twice a year. However, recently participant numbers have been flat or declining. This may be due to the cessation of multi-year drought in the region or may reflect an overall declining interest in the format. As such, evaluating the overall impact and value of the Great Basin Climate Forum series provides an opportunity to potentially revise the format to better meet stakeholder needs/interests or move these resources to other projects/efforts. Basic statistical analysis and review of the pre/post forum questionnaires will be supplemented with 1) a survey sent to all participants on the current email lists and 2) a set of in-depth interviews with key stakeholders/participants in past forums. (Given the longevity of the forums, we will also use LM outcomes from the mid-term level to guide evaluation materials and begin to set up for assessing at long-term outcomes).

**B. California 4th Climate Assessment, Regional Reports:** Several CNAP PIs have been involved in producing two of the 4th CA Climate Assessment Regional reports. PIs Kalansky and Cayan have led the development of the San Diego Report and PI Dettinger has led the effort for producing the Sierras Regional report. Both approaches have been individualistic and characteristic of their respective regions, providing an opportunity to compare the utilization of climate information across these regions. Both reports will be released in the summer of 2018. We plan to take a mixed-method approach (a combination of media searches, in-depth interviews, short surveys, and short narrative methods) to identify how information is used from the reports. This work will build on current efforts by PI VanderMolen and Wall (along with researchers at U. of Arizona) to better understand and develop a topology of climate information use.

## CNAP INTERNAL COLLABORATIONS/MENTORING: FORMATIVE EVALUATION

One of the focus areas of the current CNAP award is mentoring early career faculty and graduate students. Additionally, as CNAP has moved into a team that has a strong presence in both California and Nevada in the previous award period, understanding how the team collaborates across their geographic locations and how to enhance collaboration and partnerships with stakeholders has implications for both CNAP and the RISA Network, as other teams potentially build in numbers and new teams may enter the network. Because of the sensitivity of these issues, Dr. Susi Moser, a researcher with experience in evaluating several RISA teams, will lead this effort, rather than PI Wall or VanderMolen. Initial evaluation efforts in this area will focus on early career faculty and CNAP PIs in understanding what they perceive as effective mentoring, what effective mentoring actions look like, to what level mentoring is useful/needed, and the value of mentoring. Initial efforts in team collaboration will focus on mapping current collaborations, areas (geographic or sector/topical) that would benefit from increased collaboration, and current satisfaction/concerns regarding collaboration.

### CNAP EXTERNAL COLLABORATION (FORMATIVE)

The RISA program is interested in promoting cross-RISA collaboration. In this portion of our evaluation efforts, we want to establish a baseline of what cross-RISA collaboration is already occurring and what potential areas for cross-RISA collaboration there might be in the future. Dr. Susi Moser will lead this effort. She has completed a similar effort under the leadership of the MARISA (Mid-Atlantic), engaging the GLISA and CCRUN. She will apply a similar mixed-methods approach (survey and interviews) and engage the Western U.S. RISAs (WWA, CNAP, PNW) and other close climate service centers across the region (e.g., climate science centers). The expected insights gained will inform future CNAP collaborative foci.

### PROJECT-BASED EVALUATION OF IMPACT: SUMMATIVE AND DEVELOPMENTAL

Over the next year, there are three projects that we plan to evaluate, or begin setting up an evaluation protocol. These include:

**A. Red Flag** (large multi-stakeholder project, many users). This project has been initially selected to include in an economic evaluation of the value of the information produced and/or the economic impact of the research. We selected this project because it 1) is starting, and therefore a set of metrics can be identified and implemented early in the project; 2) involves several NOAA line offices, including NWS and OAR; 3) is within the NWS warning and watches product line; and 4) has a clear set of end-users and stakeholders, as well as being used with regularity in extreme climate and weather-related events throughout the wildfire season. We hope to develop these metrics in collaboration with the RISA PM office and NIST economist(s).

**B. Data and Technology application in Southern Nevada** (specific stakeholder driven project). This was an initial effort during the last year to develop stakeholder relations in southern Nevada. The research team included members from both SIO and DRI, also providing an opportunity to look at collaboration across team members, as well as assessing the use of products developed for a specific stakeholder/decision maker, allowing a more detailed assessment of how the information was/is being used.

**C. West Wide Drought Tracker (WWDT)** (specific climate tool). This is a sister tool to the California Climate Tracker (CCT), which has recently been upgraded and redeveloped to include more interactive and robust tools. We have heard from both PIs and stakeholders on the value of the WWDT. Over the next six months, we plan to redevelop the WWDT similar to the CCT. Building off of work started by VanderMolen and Wall on the evaluation and assessment of climate information tools, we plan to assess the utilization of the WWDT by CNAP stakeholders. Given the plethora of climate tools available, refining our basic protocol for evaluating climate tools would be valuable for both CNAP, the RISA network, and other CPO programs such as SARP and NIDIS.

### PROGRAMMATIC TRACKING OF IMPACT

Although it is early in the current award period, in an effort to begin gathering evaluation data in an on-going manner, we plan to develop a short on-line form that PIs can enter information on a monthly basis. This will be partially based on the reporting needs for RISA by the numbers, but also contribute information on where more detailed or nuanced evaluation efforts maybe helpful. As we look toward meeting our initial and mid-term desired outcomes, these will guide additional questions in the on-line form, and in-depth interviews of stakeholders, CNAP researchers, and graduate students.

# BUILDING EXPERTISE OF DECISION MAKERS TO PREPARE AND ADAPT

**Southern Nevada Water Authority (Kalansky, Sheffield, Cayan, Pierce):** Leveraging funding provided by Southern Nevada Water Authority and with the continuation of NIDIS from 2016–2017, we completed a report that examined the historical climate variability, evaluated the most representative models and provided climate projections for Clark County. We are engaging with Southern Nevada Water Authority to determine the most useful next steps for this project and what it will look like for Southern Nevada Water Authority, however, we have been able to provide information on climate projections, atmospheric rivers and feedback on climate related research that has been used and circulated within the agency for planning.

**Post-Fire Debris Flows (Oakley):** CNAP researcher Oakley supported California Geological Survey (CGS) in monitoring weather conditions related to post-fire debris flows over the course of winter 2017–18. She provided CGS with improved awareness of what types of storm systems are likely to generate post-fire debris flows so they can better plan for potential field visits. Oakley also engaged with NWS offices related to post-fire debris flow hazard and assessment. For example, she presented on post-fire debris flow hazards during FIRESCOPE meeting which featured NWS and fire personnel from CA, NV, and elsewhere in the Southwest. She also visited NWS Monterey to present to forecasters on post-fire debris flow hazards and learn about their challenges following the North Bay fires of October 2017. Additionally, Oakley has supported NWS Reno in visiting and monitoring the Farad burn area, where a debris flow impacted I-80 in August 2017. Currently, Oakley is working with NWS Los Angeles to write a paper assessing the meteorology of the Montecito debris flow on January 2018. Overall, this support has helped NWS personnel improved situational awareness of post-fire debris flow hazards, and Oakley has been able to connect them to the geology community who can provide the support that she is unable to give. This is also reported on in CNAP's report on its no cost extension of the previous award.

## PROUDEST ACCOMPLISHMENT THIS REPORTING PERIOD

The CNAP team has put in substantial effort for the California Fourth Climate Change Assessment. This was a leveraged project, in that Cayan, Kalansky, Pierce and Westerling were funded by California Energy Commission to develop scenarios for the assessment and much of CNAP contributions applied these scenarios. The RISA funding supported the applications of the scenarios to discuss climate impacts and adaptation approaches at the regional level. This includes the ecosystem and climate report for San Diego as well as the regional reports (more details on these efforts are noted above). The release of the San Diego County Ecosystems report facilitated regional discussions around the topics that are continuing to this day and are being incorporated into planning at the regional level (please see examples below). The Regional Reports serve as a great experiment in how regional climate impact and adaptation reports can be used. The various CNAP authors dedicated significant time and effort to ensure that the reports will be informative for adaptation planning at multiple planning levels and for multiple sectors. Although the reports ultimately had the same goal, the approach and the information included in each were different and serve very different communities. An evaluation of a couple of the reports will serve the climate service community well in identifying best practices in providing climate information guided toward local adaptation.

## HIGHLIGHTED PUBLICATIONS

For a complete list of publications, please see end of report.

**Southern Nevada Water Authority Report:** This December, CNAP researchers Kalansky, Sheffield, Pierce and Cayan completed a report for Southern Nevada Water Authority that was co-produced with the agency. Working collaboratively with SNWA, we examined the temporal and spatial variability of maximum temperature ( $T_{max}$ ), minimum temperature ( $T_{min}$ ) and total precipitation (P), determined the climate models that best represent Clark County climate, and examine future projections. Results consistent throughout the county show that  $T_{min}$  trends are stronger than  $T_{max}$ , and there is no significant trend in precipitation. The model selection followed the methodology of Cayan et al. (2015) and compares the model historical runs against observations. The methodology relies on previous work by Gleckler et al. (2008) and Rupp et al. (2013) that evaluate models on a larger spatial scale. The evaluation metrics selected, number of wet days in summer and winter and  $T_{max}$  variability within a month impact water demand in the region. The third metric was atmospheric patterns of extremes. The six models selected from the evaluation process included ACCESS-1.0, CCSM4, CMCC-CMS, CNRM-CM5, HadGEM2-ES, and MPI-ESM-LR. Evaluation of  $T_{max}$ ,  $T_{min}$  and precipitation projections suggest that fall season may have the largest change in temperature of all seasons and spring may become dryer. The wide range of projections for precipitation indicates the uncertainty with projected changes in precipitation in the region. The projections are beginning to be incorporated into long range planning through conversation about how to incorporate projections for infrastructure and conservation planning.

**San Diego County Ecosystems:** Ecological impacts of climate change on a biodiversity hotspot: San Diego County is a particularly unique part of Southern California, considering the region's complex topography, highly variable precipitation, and other climatic factors, which play important roles in determining the resident biological palette in this biodiversity hotspot. Although home to a major metropolitan area, San Diego County still hosts expanses of native and preserved habitats where management and conservation action could be greatly enhanced through science-based assessments and planning for climate change and increased climate variability. Some of this work is already underway, but a recent assessment of the impacts of climate change on San Diego's ecosystems, led by a unique collaboration of local ecologists and climatologists, can further guide action in the region. This assessment presents the state of the science on the projected climatic changes in temperature, precipitation regime, fire weather, and coastal low clouds and fog and the likely effects of these climatic shifts on the region's diverse ecosystems, habitats, plants, and animals. This effort is a model of how science-based assessments can serve as a baseline for guiding future research, management, and planning efforts, highlighting knowledge gaps to be filled, and providing opportunities for supporting resilience through adaptation. To be released in Aug 2018 as part of the CA 4th Climate Change Assessment.

Guirguis K., R. Basu, W. K. Al-Delaimy, T. Benmarhnia, R.E.S. Clemesha, I. Corcos, J. Guzman-Morales, B. Hailey, I. Small, A. Tardy, D. Vashishtha, J.G. Zivin, and A. Gershunov (*in press*), Heat, disparities, and health outcomes in San Diego County's diverse climate zones, *GeoHealth*.

Climate variability and change are issues of growing public health importance. Numerous studies have documented the risks of extreme heat on human health in different locations around the world. Strategies to prevent heat-related morbidity and reduce disparities are possible, but require improved knowledge of health outcomes during hot days at a small-scale level as important within city variability in local weather conditions, socio-demographic composition and access to air conditioning (AC) may exist. We analyzed hospitalization data for three unique climate regions of San Diego County alongside temperature data spanning 14 years to quantify the health impact of ambient air temperature at varying exceedance threshold levels. Within San Diego, coastal residents were more sensitive to heat than inland residents. At the coast, we detected a health impact at lower temperatures compared to inland locations for multiple disease categories including heat illness, dehydration, acute renal failure, and respiratory disease. Within the milder coastal region, heat sensitivity was reduced through access to central AC, which is not prevalent due to generally mild weather. We detected a 14.6% increase (95%CI=4.5%, 24.6%) in hospitalizations during hot weather in comparison to colder days in coastal locations where AC is less common while no significant health impact was observed in areas with higher AC saturation. Disparities in AC ownership were associated with income, race/ethnicity, and home ownership. Given that heat waves are expected to increase with climate change, understanding the health impacts of heat and the role of acclimation is critical for improving health outcomes in the future.

Oakley, N. S., Lancaster, J. T., Hatchett, B. J., Stock, J., Ralph, F. M., Roj, S. C., Lukashov, S. (2018). A 22-year climatology of cool season hourly precipitation conducive to shallow landslides in California, *Earth Interactions*, Accepted.

We developed a quality controlled dataset of extreme precipitation for RAWS stations in California. The USGS has since used this to support some of their landslide modeling efforts. We observed that coastal locations with complex terrain are most likely to have precipitation conducive to shallow landslides, which is consistent with observations of landslide distribution. Precipitation over landslide thresholds was often linked to atmospheric rivers; this finding has prompted USGS researchers to pay more attention to these features and forecast tools that monitor them. Additionally, we found that the Sierra Nevada, most notably downstream of the San Francisco Bay Area terrain gap, experience frequent over-threshold events, though landslides are not frequently observed. This raises interesting research questions about whether triggering rainfall thresholds are extremely high, or if landslides are poorly monitored due to sparse population. Note: Included in the NCE report.

VanderMolen, K.A., Horangic, A. (2018). Implications of Regulatory Drought for Farmer Use of Climate Information in the Klamath Basin, *Weather, Climate, and Society*, 10, (2), 269-274, <https://doi.org/10.1175/WCAS-D-17-0078.1>

Despite the risk of climate variability to agriculture, farmer use of climate information in agricultural decision-making generally remains low. Research has suggested that where farmers already have robust “repertoires” of decision-making resources adapted to some degree of climate variability, such new information may simply factor less saliently. This study asks whether farmer use of climate information increases under the occurrence of more extreme climatic events for which those repertoires lack referent—in this case, severe hydrological and related regulatory drought in the Klamath Basin. Semi-structured interviews with key informants of Klamath Basin agriculture indicate a marked increase in farmer use of climate and climate-related information since the onset of drought in 2001. What information farmers utilize, however, depends on whether it retains its predictive and explanatory value under both types of drought. Findings highlight the need for consideration of coproduction approaches to the development of climate information if it is to serve farmers where the extremity of climate events produces changes not only in availability of but also in access to key agricultural resources. Note: Included in the NCE report.

## RESEARCH FINDINGS

**Not included in reports mentioned above.**

**Results from the Fire Stories** project indicate that climate/weather related events are likely factors when firefighter’s experience extreme or erratic fire behavior. Of these climate/weather related factors (RH, Temp, Precip, Wind), wind was most often indicated as a factor. This research has implications for supporting the improvement/enhancement of existing training to include a more robust weather/climate module. Increased understanding of these factors will likely help support situational awareness and safety in wildland firefighters across the United States.

**Central Valley Groundwater Pumping Estimates:** Working toward developing a near real time estimate of ground water pumping in California’s Central Valley, we used statistical relationships with meteorological variables and land-use type, to generate surface water diversion data for input to the Central Valley Hydrological Model. From this we can then estimate groundwater pumping and storage throughout the Central Valley. The results of this effort indicate very good skill in our ability to recreate 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.

**Future Changes in Santa Winds:** Using the downscaled wind projections developed for the Fourth Assessment, analysis by Pierce indicated a slight increase in the dry, how winds. This has significant implication for wildfires in the Southern California region because the most catastrophic fires in Southern California occur under Santa Ana Wind conditions. There is significant interest from many agencies on the topic which has become apparent during work with them during the San Diego regional report.

# OUTREACH AND ENGAGEMENT ACTIVITIES

**CNAP Drought Tracker:** CNAP members pooled their individual efforts and partnership with collaborators to develop a drought blog. This was in large part a response to the extremely dry season California and Nevada had in the beginning of the water year. Although not very interesting now, given that everything is dry during summer, the blog remains up on the website and can be found here. There were over 700 visits to the site primarily in March, as the site was made live in late February (<https://scripps.ucsd.edu/programs/cnap/drought-tracker>).

**San Diego Regional Report Workshop:** CNAP PI Kalansky and Cayan co-hosted a regional workshop to identify knowledge and coordination gaps as it relates to climate adaptation in San Diego. The workshop had over 40 people from a diversity of sectors, including city and county planners, San Diego Gas and Electric, USFS, San Diego Association of Governments, County Health officials and several climate researchers in the area. The results of the workshop were included in the regional report which will inform funding opportunities for adaptation in California and ideally, specific for San Diego.



Stakeholder meeting for the San Diego Regional Report on May 1st, 2018 organized by CNAP researchers Kalansky and Cayan. Participants included a wide array of local and federal agencies as well as climate researchers focused in San Diego.



**Agricultural Producers:** In the first year of the new award, CNAP has begun to successfully expand our engagement with the agricultural producer communities in both California and Nevada. While developing relationships in these communities will take time, working with these disadvantaged and/or vulnerable communities in our region, outside of the urban areas that have previously been CNAP's focus is important. CNAP needs to support the economic stability and resiliency from the climate extremes that the rural areas in the California-Nevada region are highly prone to experiencing, but do not necessarily have the same level of capacity to respond to as more urban areas. (Also included in NCE report)

**NIDIS Webinars and Meetings:** 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 2017: Julie Kalansky, Jordan Goodrich, and Dan Cayan
- November 2017: Dan McEvoy
- January 2018: Julie Kalansky, Shrad Shukla, Tim Brown

J. Kalansky also supported the regional NIDIS workshop in San Diego which focused on drought monitoring needs. This highlighted how San Diego could potentially be used as an example for other areas throughout Southern California.

**ClimateFeedback:** Leveraging RISA funding, CNAP researcher Westerling helps sustain and expand work with ClimateFeedback. This organization, that Westerling and colleagues founded at UC Merced, recruits climate scientists to review and provide science-based feedback on media reporting on climate change. We used these funds to support ClimateFeedback on reporting on climate impacts related to water, wildfire, drought, etc. in California, Nevada and the West, and to engage a group of RISA and other scientists in a dialog about the climate and other influences that led to the very significant 2017 wildfire season in California, with the largest fire in state history and the first wintertime megafire occurring in December. This dialog was curated, edited and published online (<https://climatefeedback.org/discussion-experts-california-wildfire-links-climate-change/>).

**NWS and CNAP host Wildfire Information Webinar:** Wall with NWS collaborators host a webinar to highlight the work to better understand and improve the flow of information between Incident Meteorologists and firefighters and the role that trusted relationships play in translating research findings to operational end users. This need for accurate and trusted information and the value of networks for information transfer and feedback was abundantly clear during the webinar on CNAP's research regarding spot weather forecasts, and hyper-local weather forecasts that fire managers use to make go/no-go decisions about prescribed burns and wildfires. In addition to the need for spot forecasts to be physically accurate, in-depth interviews conducted by Wall emphasized the importance of trusted relationships and mutual awareness of working conditions for incident meteorologists, who deliver spot forecasts, and fire managers, who make critical decisions based upon them. This webinar and was supported by additional funding from NIDIS, SARP and Joint Science Program. This is included in the NCE report.

## EXAMPLES OF PLANS AND POLICIES THAT CNAP INFORMED

**Port of San Diego:** Kalansky presented on sea level rise and scenarios at a San Diego Port to the Seal Level Rise Ad Hoc Group which was part of the Environmental Advisory Committee. The Advisory Committee makes recommendation to the Board. Based on the presentation, and other material the Ad Hoc group supported using projection from the Ocean Protection Council's SLR Guidance which was the 95th percentile in 2030, 2050 and 2100 as well as a 50th percentile change in 2100.

**Integrated Regional Water Management (IRWM) Presentation:** With the information from the presentation on climate projections to water supply (local and imported) by Pierce, and potential impacts on ecosystems reported in Climate Summit (San Diego County Ecosystems: Ecological impacts of climate change on a biodiversity hotspot report), the IRWM group is planning to update the matrix of vulnerabilities and potential actions. This updated matrix will then inform funding priorities for the region. The meeting ended with a discussion about a CNAP member potentially becoming part of the IRWM advisory committee.

**Update to Fire Behavior Training (Brown):** As a result of the lecture given in the Advanced Fire Behavior course, the drought section of the fire management course S390 *Introduction to Wildland Fire Behavior Calculations* will be updated to expand discussion on different drought indices, in particular SPEI and EDDI. Also, meteorology sections in the National Fire Behavior Reference Guide (a book for fire behavior and long-term analysts) will be updated in the sections covering critical fire weather patterns, climate variability and weather station siting. Note: Also included in the NCE report.



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

One of the largest projects under the NIDIS umbrella for CNAP funding is the drought and water supply monitoring for the region. This includes the on-going maintenance and improvement of the hydrologic monitoring that is being done by D. Lettenmaier ([http://www.hydro.ucla.edu/monitor\\_ca/index.html](http://www.hydro.ucla.edu/monitor_ca/index.html)), the snowpack plus reservoir monitoring by M. Dettinger, and regional storm total precipitation that is being monitored by D. Pierce. All of these components are included in the **Drought Tracker** and have become a staple in the NIDIS webinar climate updates.

The **Red Flag Warning Project** directly applies to identification of vulnerability and risk. A Red Flag Warning (RFW) is a term that has been used since the 1960s by National Weather Service (NWS) fire weather forecasters to alert forecast users to an ongoing or imminent critical fire weather pattern. The NWS, the principal partner of this project, desires to explore potential changes to the RFW to improve its value to fire management and the public. This project requires significant coordination between the fire agencies and NWS.

The **Central Valley Groundwater Pumping Project** estimates in support both improvements in monitoring and impact assessment. As mentioned above this work is to estimate groundwater pumping using climate variables and surface water flows to reduce the time to see how drought impacts ground water pumping, subsidence and how wet years impact recovery of drought. This methodology provides first order estimate but fills a major gap in understanding the water supply and water cycle in California.

**Data Sharing Note:** All the data that we have used for the product this year have come from publicly available data. CNAP has not produced any proprietary data this past year.

# COMPLETE LIST OF PUBLICATIONS

- Clemesha, R.E., A.Gershunov, S.F. Iacobellis and D.R. Cayan, 2017, Daily Variability of California Coastal Low Cloudiness: A Balancing Act between Stability and Subsidence. *Geophysical Research Letters*, 44, doi:10.1002/2017GL073075.
- Crockett, J.L., Westerling, A.L., 2018. Greater temperature and precipitation extremes intensify Western US droughts, wildfire severity, and Sierra Nevada tree mortality. *Journal of Climate*31(1):341-354. doi:10.1175/JCLI-D-17-0254.
- Guirguis, K., A. Gershunov, D.R. Cayan and D. Pierce, 2017, Heat wave probability in the changing climate of the Southwest US. *Climate Dynamics* doi:10.1007/s00382-017-3850-3.
- Guirguis K., R. Basu, W. K. Al-Delaimy, T. Benmarhnia, R.E.S. Clemesha, I. Corcos, J. Guzman-Morales, B. Hailey, I. Small, A. Tardy, D. Vashishtha, J.G. Zivin, and A. Gershunov (*in press*), Heat, disparities, and health outcomes in San Diego County's diverse climate zones, *GeoHealth*.
- Hatchett, B.J., and D.J. McEvoy, 2018: Exploring the Origins of Snow Drought in the Northern Sierra Nevada, *Earth Interactions*, 22 (2), 1-13.
- Jennings, M.K., D. Cayan, J. Kalansky, A.D. Pairis, D.M. Lawson, A.D. Syphard, U. Abeysekera, R.E.S. Clemesha, A. Gershunov, K. Guirguis, J.M. Randall, E.D. Stein, and S. Vanderplank. San Diego State University. 2018. San Diego County Ecosystems: Ecological Impacts Of Climate Change On A Biodiversity Hotspot. California's Fourth Climate Change Assessment, California Energy Commission. Publication number: EXT-CCC4A-2018-XXX, in press.
- Keyser, A.R., and A.L. Westerling, 2017, Climate drives inter-annual variability in probability of high severity fire occurrence in the western United States. *Environmental Research Letters*.
- Moser, Susanne C., Ekstrom, J.A., Kim, J., Heitsch, S. (2018). *Adaptation Finance Challenges: Characteristic Patterns Facing California Local Governments and Ways to Overcome Them*. California's Fourth Climate Change Assessment, California Natural Resources Agency. Publication number: CNRA-CCC4A-2018-XXX, in press.
- Moser, Susanne C., Finzi Hart, J.A., Newton Mann, A.G., Sadrpour, N., and Grifman, P.M. (2018). Growing Effort, *Growing Challenge: Findings from the 2016 CA Coastal Adaptation Needs Assessment Survey*. California's Fourth Climate Change Assessment, California Natural Resources Agency. Publication number: EXT-CCC4A-2018-XXX, in press.
- Moser, S.C. and J.F. Hart (2018). *The Adaptation Blindspot: Teleconnected and Cascading Impacts of Climate Change in the Electrical Grid and Lifelines of Los Angeles*. California's Fourth Climate Change Assessment, California Energy Commission. Publication number: CEC-XXX-2018-XXX, in revision.
- Oakley, N. S., Lancaster, J. T., Hatchett, B. J., Stock, J., Ralph, F. M., Roj, S. C., Lukashov, S. (2018). A 22-year climatology of cool season hourly precipitation conducive to shallow landslides in California, *Earth Interactions*, Accepted.
- Pierce, D. W., Kalansky, J. F. and D. R. Cayan, (Scripps Institution of Oceanography). 2018. *Climate, Drought, and Sea Level Rise Scenarios for the Fourth California Climate Assessment*. California's Fourth Climate Change Assessment, California Energy Commission. Publication number: CEC-XXX-2018-XXX.
- Polade, S.D., A. Gershunov, D.R. Cayan, M.D. Dettinger and D.W. Pierce, 2017, Precipitation in a warming world: Assessing projected hydro-climate of California and other Mediterranean climate regions. *Nature Scientific Reports*, doi:10.1038/s41598-017-11285-y.
- VanderMolen, K.A., Horangic, A. (2018). Implications of Regulatory Drought for Farmer Use of Climate Information in the Klamath Basin, *Weather, Climate, and Society*, 10, (2), 269-274, <https://doi.org/10.1175/WCAS-D-17-0078.1>
- Velez, A. K., Diaz, J. M., Wall, T. U., 2017: Public information seeking, place-based risk messaging and wildfire preparedness in southern California, *Int. J. Wildland Fire*, 26 (6), 469-477, doi: 10.1071/WF16219
- Wall, T. U., McNie, E., Garfin, G. M., 2017: Use-inspired science: making science usable by and useful to decision makers, *Front. Ecol. Environ.*, 15 (10), 551-559, doi: 10.1002/fee.1735
- Wall, T. U., Brown, T. J., Nauslar, N. J., 2017: Fire Stories - Understanding Wildland Firefighters' Perceptions of Unpredictable and Extreme Fire Behavior. Final Report for U.S. Forest Service Research, Development and Applications Program, Submitted, 28 pp., December 2017.
- Wall, T.U., Haveland, A., Horganic, A. M., 2017: Understanding Barriers to Climate Resiliency Planning the Southwest. Final Report. Submitted 2017.