

## CNAP Annual Report, 2011-2012

**1. Award Title:** California Nevada Climate Applications Program (CNAP)

**2. Performance Period:** May 1, 2011 - April 30, 2012

**3. Team Members:** Dan Cayan, Mike Dettinger, Kelly Redmond, Anne Steinemann, Tim Brown, Sasha Gershunov, Randy Hanson Sam Iacobellis, Francisco Munoz-Arriola, Jennifer Paolini, David Pierce, Mary Tyree, Tamara Wall, Anthony Westerling

**4. What are your new areas of focus or partnerships that have begun this past year?**

- San Diego Gas & Electric, the USFS GACC at Riverside, CA and the NWS at Oxnard, CA to develop a Wildfire Alert Classification System for emergency professionals, media professionals, and the general public.
- Pacific Fog Group to better understand the formation of fog along California's coastline and to communicate findings to interested stakeholders such as habitat management and conservation organizations.
- UC Los Angeles and UC Santa Barbara to use information derived from our GOES database to improve climate models and to estimate fog occurrence at various sites on the Channel Islands.
- Multi-scenario MODFLOW-FMP-VIC simulations for Central Valley to understand the uncertainties associated to the scenarios and the climate models' outputs.
- Soil Moisture-Evapotranspiration Links in the Mountainous Areas of California to investigate the role of soil moisture regulating ET in the Sierras at the sub-basin scale.
- DOI-funded Southwest Climate Science Center.
- Predictability of weather regimes and extremes in collaboration with EarthRisk, a company in San Diego. This has a northern hemispheric focus, but funds are leveraged to support our heat wave work.
- Marine layer dynamics and Santa Ana Winds, both in collaboration with San Diego Gas and Electric (SDG&E).
- Climate scenarios and other precipitation runoff models in the analysis, reanalysis of Central Valley with updated, upgraded, and refined integrated hydrologic model of Central Valley (CVHM), with application to Pajaro Valley.

- Coupled Wildfire-Ecosystem-Carbon cycle modeling to describe how climate change and vegetation management will affect fire regimes, forest extent and structure, and carbon cycling in western US forests.
- National Predictive Services with weekly products for monthly to seasonal fire forecasting, using output from the NCEP Climate Forecast System.
- New wildfire classification system for public and media, with Victoria, Australia Department of Sustainability and Environment
- California NIDIS Pilot, and four California Pilot Activities (Southern California, Russian River, Central Valley, Klamath), to develop drought early warning information in partnership with local, regional, state, and federal agencies, industries, tribes, water users, and other stakeholders.
- Southern California NIDIS Pilot to explore and develop drought early warning information relevant to urban areas, working with local, regional, state, and federal agencies, industries, tribes, water agencies, and other stakeholders.

**5. Please provide a list of 1 - 5 research findings (e.g. dust-on-snow reduces Colorado River runoff by 5%)**

- Catalina Eddy formation significantly impacts Southern California marine stratus. Marine stratus cloud cover strongly related to inversion strength and base height.
- Cold extremes of the Northern Hemisphere winters 2009-10 and 2010-11 explained by the negative phase of the North Atlantic Oscillation. Warm extremes only consistent with the global warming trend.
- Humid nighttime-accentuated heat waves are projected to increase in magnitude relative to dry daytime-accentuated heat waves. Coastal heat waves are projected to increase in magnitude even relative to the non-stationary median warming.
- Frequency of extreme fire seasons in Northern California forests is projected to increase by at least an order of magnitude by end of century under business as usual. Emissions from California wildfires may increase up to 100% over the coming century.
- Changes in California precipitation are projected to be small (slightly dry in the south, slightly wet in the north), but those small changes hide much larger changes in the seasonal patterns of storm frequency and intensity. Streamflow reductions of ~30% – 40% from major rivers flowing from Sierras to Central Valley in later decades of 21st Century under A2 scenario.

**6. \*\*Please provide a summary of 1 - 5 ACCOMPLISHMENTS from your research activities and stakeholder collaborations. In your summary, please include PIs, partners including stakeholders, abstract, findings, leveraged funding sources. Where possible, please include a relevant high-resolution graphic or figure.\*\***

### **6.1 Theme: Information and Tools for Adaptation**

#### *California Coastal Marine Clouds*

- PIs/partners: Sam Iacobellus, Dan Cayan, Sasha Gershunov and Rachel Schwartz (SIO Grad Student).
- Abstract, findings: This work examines cloudiness along the California coastline using 16 years (1996-2011) of high resolution GOES satellite retrievals. Our results have shown that both the strength of the inversion as well as the height of the inversion base are important factors controlling marine stratus cloudiness. The amount of marine stratus cloudiness is determined mainly by the inversion strength, while over land the inversion base height is the dominant factor. The amount and duration of cloudiness over both water and land impacts many sectors including energy management, fisheries, agriculture and health
- Leveraged funding sources: CEC.
- Stakeholder Interactions: We are working with San Diego Gas & Electric (SDG&E) to help provide a better understanding of solar energy power generation potential with regards to marine stratus cloudiness. Lead times of only a few hours may be quite useful to SDG&E to help prevent spikes in the power grid. We are also participating in a working group focusing on Pacific Coastal Fog. The group consists of scientists from several disciplines as well as many conservation groups studying the formation of coastal fog in California, its transport, and integration into the hydrologic cycle. (see Figures 1 and 2)

#### *Interdependence between Climate and the Conjunctive use of Groundwater and Surface Water in California's Central Valley*

- PIs/partners: Michael Dettinger, SIO-UCSD; Daniel Cayan, SIO-UCSD; Randall Hanson, USGS
- Abstract, findings: The U.S. Geological Survey's recently developed Central Valley Hydrologic Model (CVHM) was used to route both the regulated and non-regulated streamflow to the Central Valley and simulate the resulting hydrologic system. The simulated recharge and groundwater pumping rates under four sets of conditions (dry unregulated, wet unregulated, dry regulated, and wet regulated) showed that the southern basins are more sensitive to water regulation than the northern basins.

#### *Climate Variability and Change in the San Diego County Water Resources*

- PIs and partners: Daniel Cayan, SIO-UCSD; Michael Dettinger, SIO-UCSD; Tim Bombardier, San Diego County Water Authority; Emily Young, The San Diego Foundation
- Abstract, findings: We collaborate with the San Diego County Water Authority with the overall goal to explore the effect of climate variability, and possible effect of climate change on local water supply and demand in the county. Our approach is to link a series of models that refine large-scale hydroclimatological data to water management variables.
- Stakeholder interactions: Close interactions with SDCWA.
- Graphics: (see Figure 3)

### *Heat Wave Characterization, Diagnostics and Projections with Impacts on Public Health*

- PIs and partners, including stakeholders: Alexander Gershunov, Helene Margolis (UCD Medical School), Paul English (California Dept of Public Health), Rupa Basu (CalEPA/Office of Environmental Health Hazard Assessment), Alex Tardy (National Weather Service, San Diego), Kristen Guirguis.
- Abstract, findings: Current and projected heat waves were examined over California and its sub-regions in observations and downscaled global climate model (GCM) simulations. California heat wave activity falls into two distinct types: (1) typically dry daytime heat waves and (2) humid nighttime-accentuated events (Type I and Type II, respectively). Both types are associated with advected heat due to a synoptic surface pressure pattern that includes a high over the Great Plains and a low over the coastal Pacific Ocean. Of the three GCMs considered, one was found to simulate California heat waves for the correct synoptic reasons. This GCM projects Type II heat waves to intensify more with climate change than the historically characteristic Type I events, although both types are projected to increase. This trend is already clearly observed and projected over all sub-regions of California.
- Leveraged funding sources: NIH ARRA grant “Projected Heat Wave Magnitudes and Public Health Impacts,” Dr. Margolis, UCD, PI.
- Stakeholder interactions: Extensive interactions with epidemiologists (Drs. Margolis, English, and Basu) and initial interaction with NWS meteorologists that issue heat warnings (e.g. Alex Tardy). Some initial interaction with San Diego Gas and Electric (SDG&E) on aspects of heat outlooks and forecasting.
- Graphics: See Figures 4 and 5 from Gershunov and Guirguis (in prep)

### *Role of Observations*

- PIs and partners: NOAA CNAP, NOAA WRCC, California DWR
- Abstract, findings: As part of a significant ongoing contribution toward the goals of CNAP, WRCC personnel routinely produce a variety of products describing recent and current climate anomalies, and their long-term temporal context. CNAP relies on this interest as an entry point for many economic sectors to engage on climate topics. One thesis that CNAP is exploring is that the availability of various types of climate indicators and tracking tools has an influence on public perceptions of climate, climate variability, and climate trends. One example is whether projections of future climate made in the past 10-20 years or longer.

### *Great Basin Climate Variability*

- PIs and partners: NOAA CNAP, NOAA WRCC, Great Basin Landscape Conservation Cooperative (GBLCC), Nevada EPSCoR
- Abstract, findings: Climate and its variations have significant effects throughout the Great Basin. Beginning this year CNAP has begun a more concerted effort to systematically probe the effects of climate, and the needs for climate information within the region. Kelly Redmond has been working with several colleagues at WRCC and at DRI to produce a report on climate issues affecting the Great Basin, expected in summer 2012, as part of a project with Southern Nevada Water Authority. CNAP and WRCC joined the Great Basin Landscape Conservation Cooperative in hosting the “First Annual” Great Basin Climate Forum at DRI on April 12, 2012. This meeting was a great success, with attendance by about 60 in person, and another 20 or so by webinar.
- Leveraged funding sources: NOAA CNAP, NOAA WRCC, GBLCC

### *California Central Valley ground water modeling and diagnostics*

- PIs and partners: Hanson, R.T., Flint, L.E., Flint, A.L., Dettinger, M.D., Faunt, C.C., Cayan, D., and Wolfgang Schmid (Stakeholders USGS, NOAA, USBR, California DWR)
- Abstract, findings: The objective of this study is to develop a modeling system that links global climate models with regional hydrologic models, using the California Central Valley as a case study. The new method is a supply and demand modeling framework that can be used to simulate and analyze potential climate change and conjunctive use. Application of this method demonstrates the potential transition from predominantly surface water to groundwater supply for agriculture with secondary effects that may limit this transition of conjunctive use.
- Leveraged funding sources: U.S.G.S. Global Climate Change Program, ASCE Workshop and Talk (Morocco), India Workshop
- Stakeholder interactions: Interest by CADWR Delta Modeling group to use our climate scenarios or data as input to their model.

### *Climate Change, Vulnerability, and Adaptation Assessments*

Dan Cayan has contributed to assessments of climate change in California and in the Southwestern U.S., focusing on physical aspects of regional climate change and sea level rise. Since 2006 the scientific community in California, in cooperation with resource managers, has been conducting periodic statewide studies about the potential impacts of climate change on natural and managed systems. Cayan helped organize and is contributing to an ongoing Vulnerability and Adaptation Assessment, California-wide as well as in the San Francisco Bay region. He also served as one of the editors of a Special Issue of Climatic Change which describe results from the California Climate Change Scenarios Assessment, concluded in 2009. As with the 2006 studies that influenced the passage of California's landmark Global Warming Solutions Act (AB32), these papers have informed policy formulation at the state level, helping bring climate adaptation as a complementary measure to mitigation. Coastal sea level variability and change is connected to water resources and ecosystems in California in several ways, one of which is because much of the state's water supply is extracted from the inland reaches of the San Francisco Bay/Delta estuary. Cayan also participated in the NRC Panel investigating sea level rise along the West Coast of the U.S. and was a member of the National Climate Assessment sea level rise team. An effort to assess climate change over the Southwest U.S. will be a contribution to the U.S. National Climate Change Assessment and to a stand-alone guide that will be provided by the RISAs in the region as well as by the newly formed Southwest CSC. Cayan is lead author on the chapter describing possible changes in mean climate and attendant impacts in the Southwest during the 21<sup>st</sup> Century. These are not predictions—rather they are scenarios using the set of IPCC AR4 SRES A2 and SRES B1 greenhouse gas emissions scenarios that was selected as the core of the U.S. National Climate Assessment.

## 6.2 Theme: Decision Support for Environmental Resource Management

### *Eastern, Southern and Southwest Areas Seasonal Wildfire Outlook*

- PIs and partners: Tim Brown, National Interagency Fire Center, CLIMAS
- Abstract, findings: Co-organized and participated in workshop with National Interagency Fire Center and CLIMAS. This workshop held annually brings together national, regional and state climate scientists, fire managers, and fuel and fire specialists to formally produce regional and national seasonal fire potential assessments and outlooks. This information is utilized for both national and regional planning. Report can be found at <http://www.predictiveservices.nifc.gov/outlooks/outlooks.htm>

### *California NIDIS Pilot*

- PIs and partners: Anne Steinemann, NIDIS Program Office, and more than 50 other stakeholders and groups (including water utilities, NGOs, government agencies, tribes, universities, water users)
- Abstract, findings: The California NIDIS Pilot will explore and demonstrate a variety of early warning and drought risk reduction strategies, in partnership with both the providers of drought information and the users of drought information, including resources agencies, industries, institutions, and other major stakeholders. The California NIDIS Pilot includes four Pilot Activities in Southern California, Russian River, Central Valley, and the Klamath.
- Leveraged funding sources: NOAA/NIDIS
- Stakeholder interactions: Extensive and regular interactions with diverse stakeholders including federal, state, regional, and local agencies; industries; water users, and others.

### *Southern California NIDIS Pilot Activity*

- PIs and partners: Anne Steinemann, Dan Cayan, Mike Dettinger, and more than 25 other stakeholders and groups (e.g., regional water agencies, local water utilities, government agencies, tribes, universities, water users)
- Abstract, findings: The Southern California NIDIS Pilot Activity explores drought issues in a major urban area where water supplies are primarily imported and water demands are heavily residential. Expected products include stakeholder-based applications of drought early warning information, a statewide drought resources portal, and drought monitoring products that capture the complexities of California droughts, and that can be transferred to other areas of the country.
- Leveraged funding sources: NOAA/NIDIS
- Stakeholder interactions: Extensive and regular interactions with diverse stakeholders including federal, state, regional, and local agencies; industries; and researchers.

### *Drought Planning in the Western U.S.*

- PIs and partners: Steinemann, with Redmond, National Drought Mitigation Center, Western Governors' Association, Western RISAs (CNAP, WWA, CLIMAS, CIG, ACCAP, PacificRisa), state drought managers in the 19 Western states, and NIDIS Program Office.

Abstract, findings: Steinemann conducted an in-depth study of drought planning in the Western U.S., which included an analysis of each state's drought plan and interviews with state drought managers in each of the 19 Western Governors Association states. Identified and detailed the needs for improved drought early warning information, including more effective and relevant drought indicators and triggers, and the importance of information provided by the RISAs and NIDIS for reducing drought damages.

- Leveraged funding sources: NOAA CNAP, NOAA WRCC, WGA, and others
- Stakeholder interactions: Western Governors' Association, 19 Western states, Western RISAs, NIDIS Program Office

#### *National Fuels Management Seasonal Forecast Guidance*

- PIs and partners: Tim Brown
- Abstract, findings: The MC1 dynamic vegetation model run by Jim Lenihan (US Forest Service/Oregon State University) is used to produce seasonal forecasts of Standardized Precipitation Index, wildfire rate of spread and fire line intensity among other outputs. These three outputs have been examined in association with managed fires (prescribed fire and fire use) to determine thresholds from each of these forecast elements. Monthly forecast maps out to six months are produced operational that whether or not a particular threshold is exceeded. The forecast maps are made available at <http://cefa.dri.edu/mc1>. This is an ongoing operational product.
- Leveraged funding source: DOI Fuels Management Committee.

#### *Wildfire Pocket Cards*

- PIs and partners: Tim Brown and Tamara Wall
- Abstract, findings: The Fire Danger PocketCard provides a format for interpreting and communicating key index values provided by the National Fire Danger Rating System. The objective is to lead to greater awareness of fire danger and subsequently increased firefighter safety. This project assesses operational use and acceptability of the cards through several questions that will be conducted via an interview process with firefighters. The Southwest and Northern California Geographic Areas are being used as the study regions.
- Leveraged funding sources: USFS RD&A program.

#### *Coping with Drought*

- PIs and partners: Kelly Redmond, Mike Hayes, NOAA CNAP, NOAA WRCC, NOAA NWS WFO (Eureka and Medford, perhaps Sacramento), NOAA Fisheries, NOAA NIDIS, US Drought Monitor, Cal DWR, USDI (BuRec, USGS, NW-CSC, SW-CSC), tribes, Oregon Climate Office, potentially numerous others
- Abstract, findings: Redmond is working with the NIDIS Program Office to help insure that different NIDIS-related activities are coordinated, and that they are tied to ongoing quasi-operational activities as much as possible. Within California this entails working with the four different activities now being coordinated by Steinemann, and taking a lead.
- Leveraged funding sources: NOAA CNAP, NOAA WRCC, California Department of Water Resources, California Energy
- Stakeholder interactions: 1) begin developing stakeholder relationships and networks in Nevada and the Great Basin, as CNAP begins to expand their presence in this region, 2) identify and assess stakeholder needs related to climate science and how CNAP may be able

to either provide information from past research or develop new research to meet these needs and 3) develop research projects that contribute to understanding how the efficacy of information transfer between CNAP scientists and stakeholders can be improved.

#### *Gridded Wildfire Seasonal Outlook*

- PIs and partners: Anthony Westerling, Alisa Keyser, Haiganoush Preisler, Jeanne Milostan, Dan Cayan. We have provided a small amount of funding to Dennis Lettenmaier's group for support of this project as well. Partners: National Interagency Fire Center, National Wildfire Coordinating Group, California South Ops (Riverside)
- Abstract, findings: We are working to extend seasonal forecasts spatially (to eventually cover the western US), temporally (to provide retrospective forecasts to 1918) and in scope, include more variables (fire frequency, area, severity, emissions, cost). We are also refining our models to provide lightning and wind scenarios. This will allow fire managers to anticipate how observed climate can interact with meteorological-scale influences that cannot be predicted at seasonal lead times, but whose historical distribution is somewhat well-understood.
- Leveraged funding sources: NOAA, USDA.

#### *Climate Change Impacts: Wildfire Scenarios (Burned Area and Emissions)*

- PIs and partners: Westerling, Hurteau (NAU/Penn State), Wiedenmyer (NCAR), Turner (Wisconsin-Madison), Romme (Colorado State), Smithwick (Penn State), Ryan (USFS), Bryant (RAND)
- Abstract, findings: Westerling developed scenarios for wildfire under climate change for California and for the Northern Rockies. Scenarios for Nevada, the central/southern Rockies and the Southwest are under development. Westerling, Hurteau and Wiedenmyer are using these wildfire scenarios to develop air pollution and carbon emissions scenarios for use with stakeholder outreach activities. California wildfire scenario development leveraged support from the California Energy Commission; Northern Rockies scenario development leveraged support from the Joint Fire Sciences program and the Forest Service. Nevada, central/southern Rockies, and the Southwest scenarios are solely supported via CNAP.
- We plan to develop emissions scenarios for the Northern Rockies and Greater Yellowstone region this summer.
- Leveraged funding sources: California Energy Commission, US Forest Service.

#### *Climate Change Impacts: Wildfire Scenarios (Residential Property Risk)*

- PIs and partners: Westerling (UC Merced), Bryant (RAND), Pierce (SIO)
- Abstract, findings: Westerling and Bryant have developed ~30,000 scenarios for residential property risks, incorporating global emissions scenarios, climate model sensitivities, population growth scenarios and models, growth footprints, definitions of wildland/urban interface, fire management resources and structure vulnerability to loss from fire. These scenarios allow us to assess the impacts of various policy-relevant factors on potential vulnerabilities to climate change. A PIER/CCCC white paper is in press.

#### *West Coast Closed Lows*

- PIs and partners: NOAA CNAP and NOAA WRCC



- Abstract, findings: CNAP has maintained a focus on physical processes affecting hydroclimatic characteristics of the Sierra Nevada /Cascades and the Coast Range as these pertain to water supplies and their effect on the economies of California and the western Great Basin and Nevada. These efforts have included the role of atmospheric rivers, the effects of the different phases of ENSO, orographic enhancement, and other physical factors. Efforts have been initiated to better understand the trajectories of storm systems affecting the West Coast and California.
- Leveraged funding sources: NOAA CNAP and NOAA WRCC

#### *Climate extremes*

- PIs and partners: NOAA CNAP, CLIMAS, WWA, CIRC, NOAA WRCC, California Department of Water Resources, Western States Water Council, Western Governors Association
- Abstract, findings: In collaboration with the California Department of Water Resources, and motivated by wider interest in the western states, CNAP has co-sponsored a set of meetings on climate extremes starting in 2011 to determine whether changes in precipitation extremes have occurred, are expected to occur, and could be sufficiently well observed by present or planned observational systems. This topic was addressed at meetings in March, May, July and December.

#### *National Climate Assessment*

- PIs and partners: numerous
- Abstract, findings: Investigators from CNAP played an active role in participation and guidance of portions of the National Climate Assessment, and in particular those efforts relevant to the Southwestern United States. This included participation in a June 2011 meeting sponsored by the RISA program at CIRES in Boulder on the Upper Colorado River, intended to evaluate our current ability to perform such climate assessments. CNAP was significantly involved in an “authors meeting” also held in Boulder in early August to develop and guide the production of a formal document intended to serve as input to the National Climate Assessment.

#### *The Climate Services Ecosystem*

- PIs and partners: NOAA RISA projects, NOAA RCCs, USDI Climate Science Centers, Landscape Conservation Cooperatives, American Association of State Climatologists
- Abstract, findings: In recent years a number of structures have been established that are capable of informing, contributing to, and operationally providing climate services on national and especially on regional scales. To this end, CNAP personnel have taken a leadership role in helping to formulate encapsulated and abbreviated, yet accurate, descriptions of these various interlocking roles. The notion of an ecosystem of climate services has arisen, and the efficacy of this analogy is under exploration in a variety of influential meetings and sessions. Early indications are that this is likely to be a viable and useful approach. Especially in an era of constrained resources, this seems like a particularly needed effort that fits well with the social science dimensions of the RISA program, and in effect consists of the RISA projects examining the climate services environment in which they are embedded.
- Leveraged funding sources: NOAA WRCC, NOAA CNAP

**7. List of completed publications, white papers, or reports (with internet links if possible) from the past year. These can be either non-peer reviewed or peer-reviewed. For peer-review publications, please list either published or in press, but *not* “in review”. Please \* the ones where any of the information has been communicated to decision makers and stakeholders (please identify to whom the information has been communicated).**

Gershunov, A, Z. Johnston, H.G. Margolis and K. Guirguis, 2011: The California Heat Wave 2006 with Impacts on Statewide Medical Emergency: A space-time analysis. *Geography Research Forum*, 31, 6-31.\*

Guirguis, K., A. Gershunov, R. Schwartz and S. Bennett, 2011: Recent warm and cold daily winter temperature extremes in the Northern Hemisphere, *Geophysical Research Letters*, 38, L17701, doi:10.1029/2011GL048762. \*\*

Macias D., M.R. Landry; A. Gershunov; A.J. Miller; P.J.S. Franks, 2012: Climatic Control of Upwelling Variability along the Western North-American Coast. *PLoS ONE*, 7, 1-13. \*\*\*

\* communicated to public health decision makers at the California Dept of Public Health (CDPH, Dr. Paul English) and CalEPA/Office of Environmental Health Hazard Assessment (OEHHA, Dr. Rupa Basu)

\*\* communicated to stakeholders in the energy sector: EarthRisk, Chesapeake Energy, etc. This article also raised media interest, it was a subject of an SIO news release and multiple interviews were given to journalists.

Cox, D., et al., 2010, ARkStorm--California's other big one: ARkStorm Summit handout, 4 p., [http://tenaya.ucsd.edu/~dettinge/ARkStorm\\_summary.pdf](http://tenaya.ucsd.edu/~dettinge/ARkStorm_summary.pdf)

\*Hanson, R.T., Flint, A.L., Flint, L.E., Faunt, C. C., Schmid, Wolfgang, Dettinger, M.D. Leake, S.A., and Cayan, D.R., 2010, Integrated simulation of consumptive use and land subsidence in the Central Valley, California, for the past and for a future subject to urbanization and climate change: Proceedings of the Eight International Symposium on Land Subsidence (EISOLS), Queretaro, Mexico, October, 2010, pp. 467-471

\*Information Memorandum for the Secretary of Interior (03/10/2011), From R.T. Hanson through Marcia McNutt, Director, U.S. Geological Survey, SUBJECT: Conjunctive Use in Response to Potential Climate Changes in the Central Valley, California, 2p.

\*Hanson, R.T., Flint, L.E., Flint, A.L., Dettinger, M.D., Faunt, C.C., Cayan, D., and Schmid, Wolfgang, 2012, A method for physically based model analysis of conjunctive use in response to potential climate changes: *Water Resources Research*, Vol. 48, 23p., doi:10.1029/2011WR010774

\*Bryant, B.P., A.L. Westerling: "Scenarios to Evaluate Long-term Wildfire Risk in California: new methods for considering links between changing demography, land use and climate" Public Interest Energy Research, California Energy Commission, Sacramento, CA. In Press. A copy can be provided on request.

\*(communicated to Governor's staff via workshops in San Diego and Bay Area. See also presentations list below. Also covered extensively in the media due to an article in the San Francisco Chronicle).

Westerling, A.L. | S.P. Harrison and P.J. Bartlein 2012: "Fire: Are we facing an increase in wildfires?" PAGES news, 20(1):24-25. [http://www.pages-igbp.org/download/docs/PAGES%20news%202012-1\(24-25\)\\_Fire.pdf](http://www.pages-igbp.org/download/docs/PAGES%20news%202012-1(24-25)_Fire.pdf)

\*Westerling, A.L., B.P. Bryant, H.K. Preisler, T.P. Holmes, H. Hidalgo, T. Das, and S. Shrestha 2011: "Climate Change and Growth Scenarios for California Wildfire" Climatic Change, 109(s1):445-463. [http://ulmo.ucmerced.edu/pdffiles/11CC\\_Westerlingetal.pdf](http://ulmo.ucmerced.edu/pdffiles/11CC_Westerlingetal.pdf)

\*(communicated to Governor's staff via workshops in San Diego and Bay Area. See also presentations list below. Also covered extensively in the media due to an article in the San Francisco Chronicle).

Westerling, A.L. 2011: "Brevia: Climate Change Could Rapidly Transform Greater Yellowstone Fire Regimes" Mountain Views: The Newsletter of the Consortium for Integrated Climate Research in Western Mountains (CIRMOUNT), 5(2):30-32. [http://gis.fs.fed.us/psw/cirmount/publications/pdf/Mtn\\_Views\\_nov\\_11.pdf#page=33](http://gis.fs.fed.us/psw/cirmount/publications/pdf/Mtn_Views_nov_11.pdf#page=33)

\*Westerling, A.L., M.G. Turner, E.H. Smithwick, W.H. Romme, M.G. Ryan 2011: "Continued warming could transform Greater Yellowstone fire regimes by mid-21st Century" Proceedings of the National Academy of Sciences, 108(32),13165-13170. <http://www.pnas.org/content/108/32/13165.abstract>

\* Presented to Park Service leadership group at Dept of Interior headquarters in Washington DC.

Fleishman, Belnap, Cobb, Enquist, Ford, MacDonald, Pellant, Schoennagel, Schmit, Schwartz, Van Drunick, Westerling: "Chapter 8: Natural Ecosystems" The Southwest Climate Assessment Technical Report, in review (peer review completed. public comment period still open).

\*Wall, T., G. Garfin, J. Galayda. (2012) Evaluating Our Capacity: A Discussion of Capability for Ongoing Climate Assessment in the Colorado River Basin. <http://www.climas.arizona.edu/publications/2375> \* By his request, sent to Tim Mackilin, NRCS, Western Governors Association Liaison

Mote, P.W., and K.T. Redmond, 2011. Western climate change. Chapter 1, 3-26, In *Ecological Consequences of Climate Change: Mechanisms, Conservation, and Management*, editors J.L. Belant and E. Beaver, Taylor and Francis Publishing, CRC Press, New York, NY. Published Oct 24, 2011. 336 pp.

Kunkel, K.E., T.R. Karl, H. Brooks, J. Kossin, J. Lawrimore, D. Arndt, L. Bosart, D. Changnon, S. Cutter, N. Doesken, K. Emmanuel, P. Ya. Groisman, R.W. Katz, T. Knutson, J.J. O'Brien, C.J. Paciorek, T. Peterson, K.T. Redmond, D. Robinson, J. Trapp, R. Vose, S. Weaver, M. Wehner, K. Wolter, and D. Wuebbles, 2011 (in revision). *Monitoring and Understanding Changes in Extreme Storm Statistics: State of Knowledge*. Bulletin of the American Meteorological Society, submitted Nov 16.

Steenburgh, W.J., K Redmond, K. Kunkel, N. Doesken, R. Billies, J. Horel, M.P. Hoerling, (in revision). *The Weather and Climate of the Southwest United States*. Chapter 4, *Southwest Climate Assessment*, submitted to National Climate Assessment, in review.

Redmond, K., G. McCurdy, G. Kelly, L. Edwards, and D. Simeral, 2011. *Development of SC-ACIS for California*. Final Report, GEI Subcontract 08-06-DRI, March 14, 2011, 17 pp.

Edwards, L.M., and K.T. Redmond, 2011. *Climate Assessment for the Sierra Nevada Network Parks*. National Park Service, Natural Resource Report NPS/2011/NRR-2011/482. 155 pp.

Kunkel, K.E., L.E. Stevens, S.E. Stevens, E. Janssen, and K.T. Redmond, 2011 (in revision). *Climate of the Northwest U.S.*, for National Climate Assessment, 41 pp.

Kunkel, K.E., L.E. Stevens, S.E. Stevens, E. Janssen, K.T. Redmond, 2011 (in revision). *Climate of the Southwest U.S.* Submitted to National Climate Assessment, August 2011. 63 pp.

Smithwick, E. A. H., A. L. Westerling, M. G. Turner, W. H. Romme, M. G. Ryan 2011: "Vulnerability of Landscape Carbon Fluxes to Future Climate and Fire in the Greater Yellowstone Ecosystem." In *Questioning Greater Yellowstone's Future: Climate, Land Use, and Invasive Species*. Yellowstone National Park, WY, and Laramie, WY: Yellowstone Center for Resources and University of Wyoming William D. Ruckelshaus Institute of Environment and Natural Resources.  
[http://ulmo.ucmerced.edu/pdffiles/11gyeproc\\_Smithwicketal.pdf](http://ulmo.ucmerced.edu/pdffiles/11gyeproc_Smithwicketal.pdf)

Preisler, H.K., A.L. Westerling, K. M. Gebert, F. Munoz-Arriola, T. Holmes 2011: "Spatially explicit forecasts of large wildland fire probability and suppression costs for California" *International Journal of Wildland Fire*, 20, 508-517.  
[http://ulmo.ucmerced.edu/pdffiles/10IJWF\\_Preisleretal.pdf](http://ulmo.ucmerced.edu/pdffiles/10IJWF_Preisleretal.pdf)

\*Cloern, J. E., Knowles, N., Cayan D. R., et al, 2011: Projected Evolution of California's San Francisco Bay-Delta-River System in a Century of Climate Change. PLoS One 6:e24465. \* presented to California Bay/Delta Conservancy January 18 Board meeting; communicated to numerous policy/decision makers, e.g. David L. Wegner, Senior Democratic Staff, Subcommittee on Water Resources and Environment, Committee on Transportation and Infrastructure; and to many media outlets.

\*Rodo, X. Burns, J., Cayan, D.R. et al., 2011: Association of Kawasaki disease with tropospheric wind patterns. Nature Scientific Reports. 2011; 1: 152. Published online 2011 November 10. doi: 10.1038/srep00152. Communicated to numerous media outlets and also featured as a News Feature "Blowing in the Wind" by Jane Fraser in *Nature*, 5 Apr 2012.

Das, T., Pierce, D., Cayan, D. R., Vano, J. and D. P. Lettenmaier, 2011: The importance of warm season warming to western U.S. streamflow changes. *Geophysical Research Letters*, 28, L23403, doi:10.1029/2011GL049660.

Zhao, Z, S.-H. Chen, M. J. Kleeman, M. Tyree and D. Cayan, 2011: The impact of climate change on air quality related meteorological conditions in California . Part I: Present time simulation analysis, *J. Climate.*, 24, 3344-3361.

Dettinger, M.D., Ralph, F.M., Hughes, M., Das, T., Neiman, P., Cox, D., Estes, G., Reynolds, D., Hartman, R., Cayan, D., and Jones, L., 2011, Design and quantification of an extreme winter storm scenario for emergency preparedness and planning exercises in California: *Natural Hazards*, 27 p.

Dettinger, M.D., Ralph, F.M., Das, T., Neiman, P.J., and Cayan, D., 2011: Atmospheric rivers, floods, and the water resources of California. *Water*, 3 (Special Issue on Managing Water Resources and Development in a Changing Climate), 455-478, doi:10.3390/w3020445.

Das, T., M.D. Dettinger, D.R. Cayan and H.G. Hidalgo, 2011: Potential increase in floods in California's Sierra Nevada under future climate projections. *Climatic Change*, 24 pp, doi:10.1007/s10584-011-0298-z.

Franco, G., Cayan D.R., Moser, S., Hanemann, M. and M. Jones, 2011: Second California assessment: integrated climate change impacts assessment of natural and managed systems. Guest editorial. *Climatic Change*, (in press).

Hanson, R. T., A.L. Flint, L.E. Flint, M.D. Dettinger, C.C. Faunt, Dan Cayan, and Wolfgang Schmid, 2011: Conjunctive Use in Response to Potential Climate Changes in the Central Valley, California, *Water Resources Research*, (in press).

Cayan, D., G. Franco, S. Moser, M. Hanemann and M. Jones, editors: California Second Assessment: New climate change impact studies and implications for adaptation. Special Volume of *Climatic Change*, Springer, (in press).

Delgado, E., C. Leonard, J. Sullens, T. Brown, and G. Garfin, 2012: National Seasonal Assessment Workshop for the Eastern, Southern & Southwest Areas. January 2012, Workshop Report, 4 pp.

Pierce, D. California Climate Extremes Workshop Report. (A summary of the workshop held at SIO in December of last year.) [http://sio.ucsd.edu/extreme\\_climate/CA\\_climate\\_extremes\\_report\\_SIO\\_Dec2011.pdf](http://sio.ucsd.edu/extreme_climate/CA_climate_extremes_report_SIO_Dec2011.pdf)

Rosenberg, E.A., Wood, A.W., Steinemann, A.C. Statistical applications of physically based hydrologic models to seasonal streamflow forecasts. *Water Resources Research* 47, 2011.

Shukla, S., Steinemann, A.C., Lettenmaier, D.P. Drought Monitoring System for Washington State: Indicators and Applications. *Journal of Hydrometeorology* 12(1): 66-83, 2011.

**8. Please provide one specific example of how your team has linked this past year with a NOAA entity and/or NOAA regional partners (e.g. Regional Climate Service Directors, RCCs, Sea Grant extension, etc...) to exemplify regional climate services.**

We have interactions with several other components of NOAA, relating to NIDIS, and with NWS (National, Regional, WFOs and RFCs), NCDC, and the USRCRN program, for which we have done all of the regional survey work. The RCCs, along with the RCSDs, currently constitute the current NOAA regional climate services activity, and work from the same budget. We will be working even more closely with them under the next RCC contract, and in fact the RCSDs will in many ways act in service to the RCC program.

**9. Please explain how much of a priority NCA activities will be (and in what form the NCA activities will take) for your RISA team after June 1, 2012, compared to the rest of your RISA activities.**

NCA activities will continue to be a high priority. We are committed to following through on the Southwest Climate Change Assessment (part of the NCA); Redmond, Dettinger, Westerling (coordinating lead author, Natural Ecosystems chapter), Gershunov (lead author, Projected Extremes Chapter), Cayan (lead author, Projected Mean Climate Chapter) also, Dettinger is a member of the NCA Water Resources team, Cayan is a member of the NCA Sea Level team, and both are committed to following these reports through to completion.

10. Please fill out the attached table and indicate which team projects are RISA-led\* (RISA-led means RISA investigator is leading the effort and/or RISA funding is primary source) and which ones your team or a RISA PI contributes to (where RISA funding and/or RISA-funded investigator time contributes to the project but is not the main component of the project)\*\*.

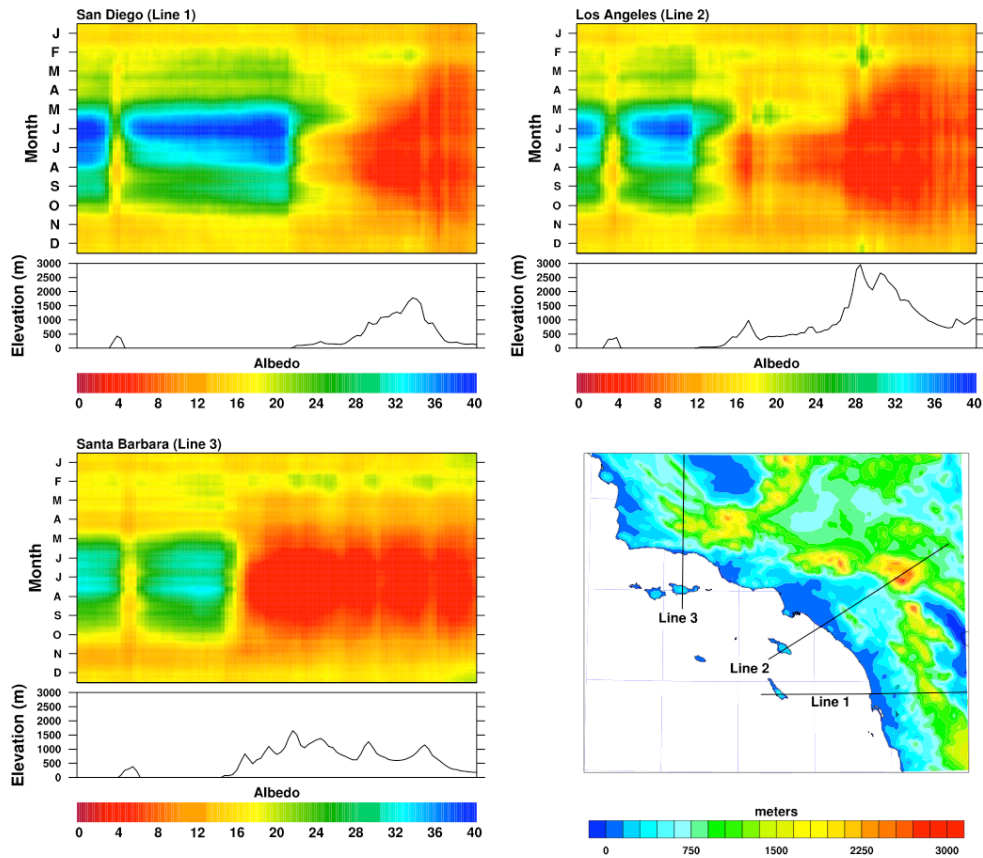
| PI                      | Project Title   | End Date                   | Deliverables/<br>Products  | Abstract/Description | Partners   | If this is a RISA-led project, please mark A*. If RISA is a contributor, please mark B**. | If B, please indicate who is the primary lead                   |
|-------------------------|---|----------------------------|--|----------------------|--|---|---|
| Tim Brown               | National Fuels Management Seasonal Forecast Guidance  | Continuing                 | Monthly forecast maps  | See #6 above         |  | A*  |   |
| Tim Brown               | Wildfire Pocket Cards   |                            |  | See #6 above         | Tamara Wall  | A*  |   |
| Tim Brown               | Eastern, Southern and Southwest Areas Seasonal Wildfire Outlook   |                            | Report can be found at <a href="http://www.predictiveservices.nifc.gov/outlooks/outlooks.htm">http://www.predictiveservices.nifc.gov/outlooks/outlooks.htm</a>   | See #6 above         | National Interagency Fire Center, CLIMAS   | A*  |   |
| Sam Iacobellus          | California Coastal Marine Clouds  | Continuing                 |  | See #6 above         | Dan Cayan, Sasha Gershunov and Rachel Schwartz (SIO Grad Student)  | A*  |   |
| Francisco Munoz-Arriola | Interdependence between Climate and the Conjunctive use of groundwater and surface water in California's Central Valley | Open                       | Papers (2):<br><br>Hydroclimatological and Water Regulation Influences on Conjunctive Use of Water in Central Valley, California<br><br>Extreme Events and the Hydrological Cycle in California's Central Valley | See #6 above         | Michael Dettinger, SIO-UCSD; Daniel Cayan, SIO-UCSD; Randall Hanson, USGS  | A*  |   |
| Francisco Munoz-Arriola | Climate Variability and Change in the San Diego County Water Resources  | Open                       | two papers   | See #6 above         | Daniel Cayan, SIO-UCSD; Michael Dettinger, SIO-UCSD; Tim Bombardier, San Diego County Water Authority; Emily Young, The San Diego Foundation | B**   | Blasker Foundation-led project co-founded by RISA-contributions |
| Alexander Gershunov     | Heat Wave Characterization, Diagnostics and   | June 2011 (effort ongoing) | Two research articles: Gershunov et al. (2011) and Gershunov and   | See #6 above         | Helene Margolis (UCD Medical School), Paul English (California Dept of Public Health), Rupa  | A*  |   |

|                 |   |  |  |              |   |       |  |
|-----------------|---|--|--|--------------|---|-------|--|
|                 | Projections with Impacts on Public Health   |  | Guirguis (2012, in preparation). Downscaled climate model data provided to our public health partners for epidemiological analyses.  |              | Basu (CalEPA/Office of Environmental Health Hazard Assessment), Alex Tardy (National Weather Service, San Diego), Kristen Guirguis                  |       |  |
| Randy Hanson    | California Central Valley ground water modeling and diagnostics Project   |  | Article in <i>Water Resources Research</i> (See #7 above)<br>Power Point presentations of all workshops distributed through USBR parallel project, CNAP web page and new Central Valley Web page | See #6 above | R.T., Flint, L.E., Flint, A.L., Dettinger, M.D., Faunt, C.C., Cayan, D., and Wolfgang Schmid (Stakeholders USGS, NOAA, USBR, California DWR         | A*    | .  |
| Tony Westerling | Gridded Wildfire Seasonal Outlook   | 2015   | forecast maps  | See #6 above | Alisa Keyser, Haiganoush Preisler, Jeanne Milostan, Dan Cayan.  | A*    |  |
| Tony Westerling | Climate Change Impacts: Wildfire Scenarios (Burned Area and Emissions)  |  | Manuscripts for California and Northern Rockies wildfire burned area scenarios have been published<br>See #7 above   | See #6 above | Hurteau (NAU/Penn State), Wiedenmyer (NCAR), Turner (Wisconsin-Madison), Romme (Colorado State), Smithwick (Penn State), Ryan (USFS), Bryant (RAND) | A*    |  |
| Tony Westerling | Climate Change Impacts: Wildfire Scenarios (Residential Property Risk)  |  | PIER/CCCC white paper is in press.<br>Ecosystems technical report for the Southwest also in press.   | See #6 above | Bryant (RAND), Pierce (SIO)   | A*    |  |
| Dan Cayan       | Climate change and sea level rise scenarios, California Assessment and Southwest contribution to National Climate | Partially ending summer 2012, but ongoing for California Climate | Chapter 6 of Southwest Climate Change Assessment. One section of the California Vulnerability and Adaptation Assessment. Cloern et al. (2012)  | See #6 above | With Mary Tyree, David Pierce, and others.  | B, A* | California Energy Commission, Department of Interior-- Southwest Climate |



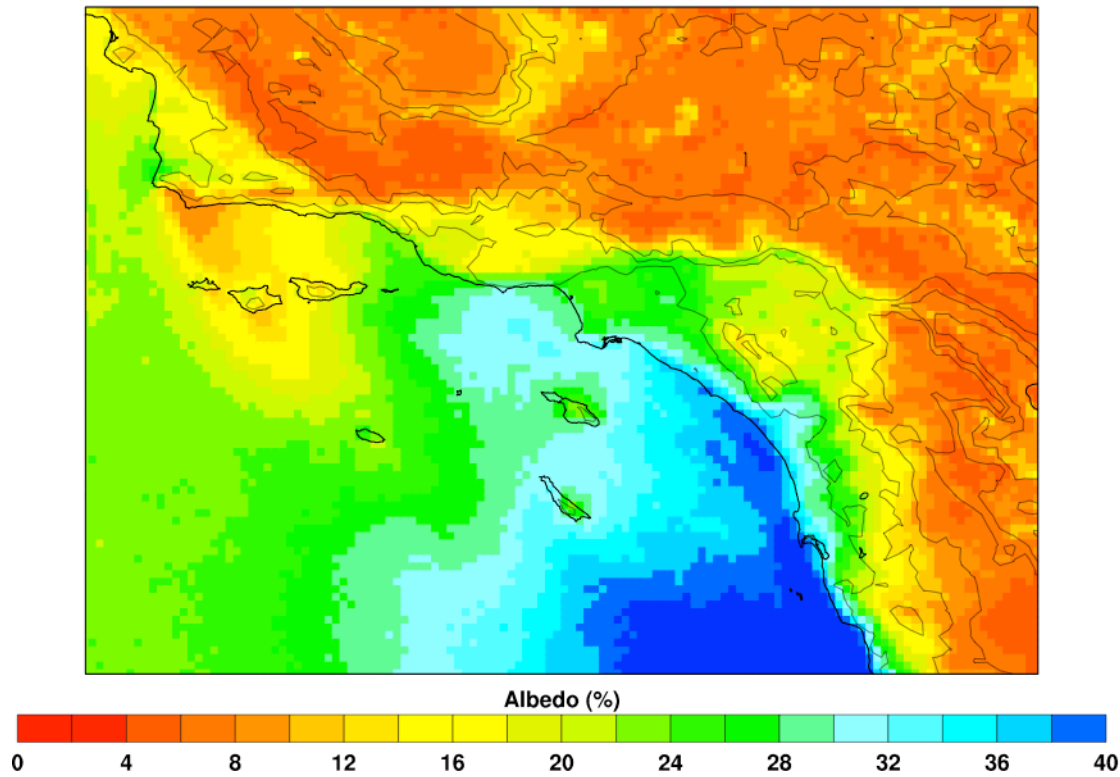
|                 | Assessment                             | Change Assessment |   |              |  |      | Science Center   |
|-----------------|--|-------------------|---|--------------|--|------|--|
| David Pierce    |  |                   | California Climate Extremes Workshop Report | See #6 above | With Dan Cayan, Guido Franco and several contributing participants,  | A,B* | California Energy Commission, USGS, California Department of Boating and Waterways |
| Anne Steinemann | California NIDIS Pilot                 | 2013              | drought early warning information           | See #6 above | NIDIS Program Office, and more than 50 other stakeholders and groups (including water utilities, NGOs, government agencies, tribes, universities, water users)   | A*   |  |
| Anne Steinemann | Southern California Pilot Activity     | 2016              | drought early warning information           | See #6 above | Dan Cayan, Mike Dettinger, and more than 25 other stakeholders and groups (e.g., regional water agencies, local water utilities, government agencies, tribes, universities, water users)   | A*   |  |
| Anne Steinemann | State Drought Planning in Western U.S. | 2011              | drought planning guidance; journal article  | See #6 above | National Drought Mitigation Center, Western Governors' Association, Western RISAs, state drought managers in the 19 Western states, NIDIS Program Office   | A*   |  |
| Tamara Wall     |  |                   | Wall, T., G. Garfin, J. Galayda. (2012)     | See #6 above |  | A*   |  |
| Kelly Redmond   | Coping with Drought                    |                   |   | See #6 above | Mike Hayes, NOAA CNAP, NOAA WRCC, NOAA NWS WFO (Eureka and Medford, perhaps Sacramento), NOAA Fisheries, NOAA NIDIS, US Drought Monitor, Cal DWR, USDI (BuRec, USGS, NW-CSC, SW-CSC), tribes, Oregon Climate Office, potentially numerous others | A*   |  |

|               |                                    |  |  |              |  |    |  |
|---------------|------------------------------------|--|--|--------------|--|----|--|
| Kelly Redmond | West Coast Closed Lows             |  |  | See #6 above | NOAA CNAP and NOAA WRCC  | A* |  |
| Kelly Redmond | Drought planning and vulnerability |  |  | See #6 above | Steinemann, NOAA CNAP and CIG, NOAA WRCC, NOAA NIDIS, NDMC, state water agencies, water managers, and climate offices, Western Governors Association | A* |  |
| Kelly Redmond | Climate extremes                   |  |  | See #6 above | NOAA CNAP, CLIMAS, WWA, CIRC, NOAA WRCC, California Department of Water Resources, Western States Water Council, Western Governors Association       | A* |  |
| Kelly Redmond | National Climate Assessment        |  | CNAP significantly involved in meeting held in Boulder in August to develop a formal document intended to serve as input to the National Climate Assessment.             | See #6 above | Multiple agencies and stakeholders   | A* |  |
| Kelly Redmond | Great Basin Climate Variability    |  | Developed and now teaching (Spring 2012) a 700-level Atmospheric Sciences graduate course at the University of Nevada on "Weather and Climate of the Intermountain West" | See #6 above | NOAA CNAP, NOAA WRCC, Great Basin Landscape Conservation Cooperative (GBLCC), Nevada EPSCoR  | A* |  |
| Kelly Redmond | Role of observations               |  |  | See #6 above | NOAA CNAP, NOAA WRCC, California DWR   | A* |  |
| Kelly Redmond | The Climate Services Ecosystem     |  |  | See #6 above | NOAA RISA projects, NOAA RCCs, USDI Climate Science Centers, Landscape Conservation Cooperatives, American Association of State Climatologists       | A* |  |

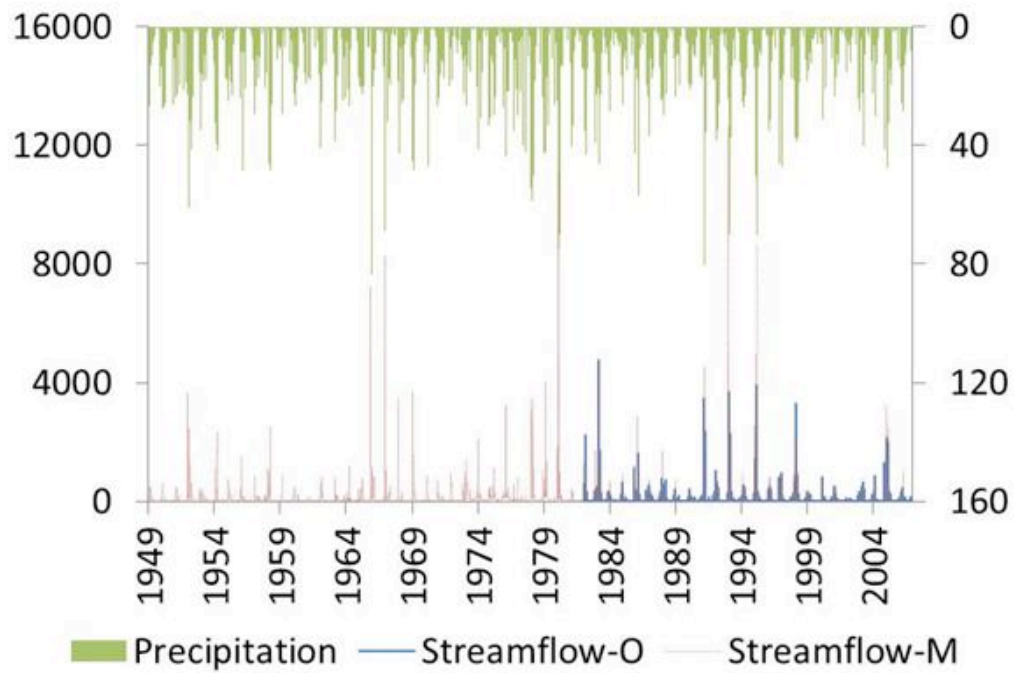


**Figure 1.** Seasonal cycle of 16Z (8am local) albedo along three cross-sectional lines for years 1996-2011. Hash marks on vertical axis represent midpoint of month. The inland extent of clouds (as represented by high albedo) is strongly limited by topography from May through September and is due to cloud top height being controlled by the inversion base height. Months with higher (lower) than normal inversion base heights would generally lead to marine stratus clouds covering a larger (smaller) amount of land area.

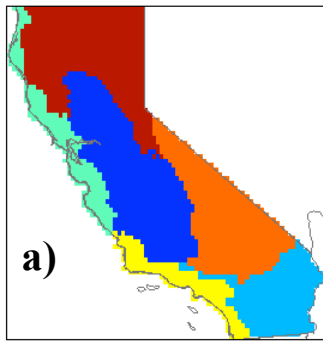
Mean 16Z Cloud Albedo During Catalina Eddy Days Apr-Oct 1996-2011



**Figure 2.** Mean cloud albedo at 16Z (8am local) on days when a Catalina Eddy was present during April-October 1996-2011. During these days significantly more clouds are present along the southern regions around San Diego. Also, clouds often extend a significant distance inland during these days due to increased inversion base heights. A relative minimum in coastal cloud albedo is noted near Point Conception and extending over some of the northern Channel Islands.



**Figure 3.** Streamflow Observed (O) and simulated by VIC-HRR models, corresponding to the San Diego River inflow to the urban boundary in mm/day, upwards bars scaled on the left y-axis. Precipitation in mm/day, downward bars, on the right y-axis.



Northern Forests  
 Mojave  
 Coastal South  
 Coastal North  
 Southern Deserts  
 Central Valley

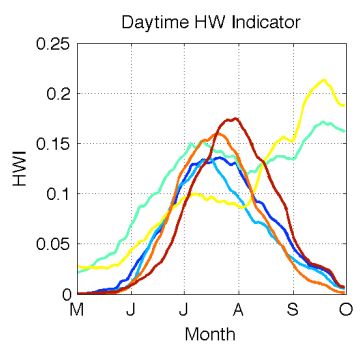
**a)**

Linear trends in Daytime &  
\*Nighttime heat waves (°C/decade)

|           | Obs       | CNRM-H    | CNRM-Pr     |
|-----------|-----------|-----------|-------------|
|           | (1.6)     | 3.8 (4.3) | 17.3 (24.1) |
|           | (2.5)     | 3.1 (3.4) | 19.6 (22.1) |
| <b>b)</b> | 0.6 (1.7) | 4.5 (3.6) | 21.4 (31.2) |
|           | (2.3)     | 3.7 (3.6) | 25.5 (28.7) |
|           | (1.4)     | 3.4 (4.0) | 15.5 (22.2) |
|           | (1.2)     | 3.7 (3.9) | 14.2 (24.1) |

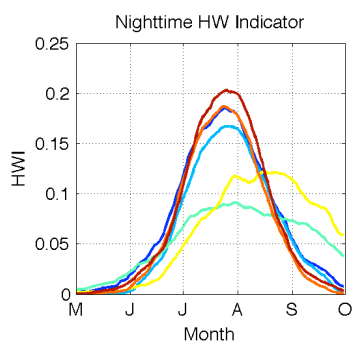
\*Nighttime trends are in parentheses

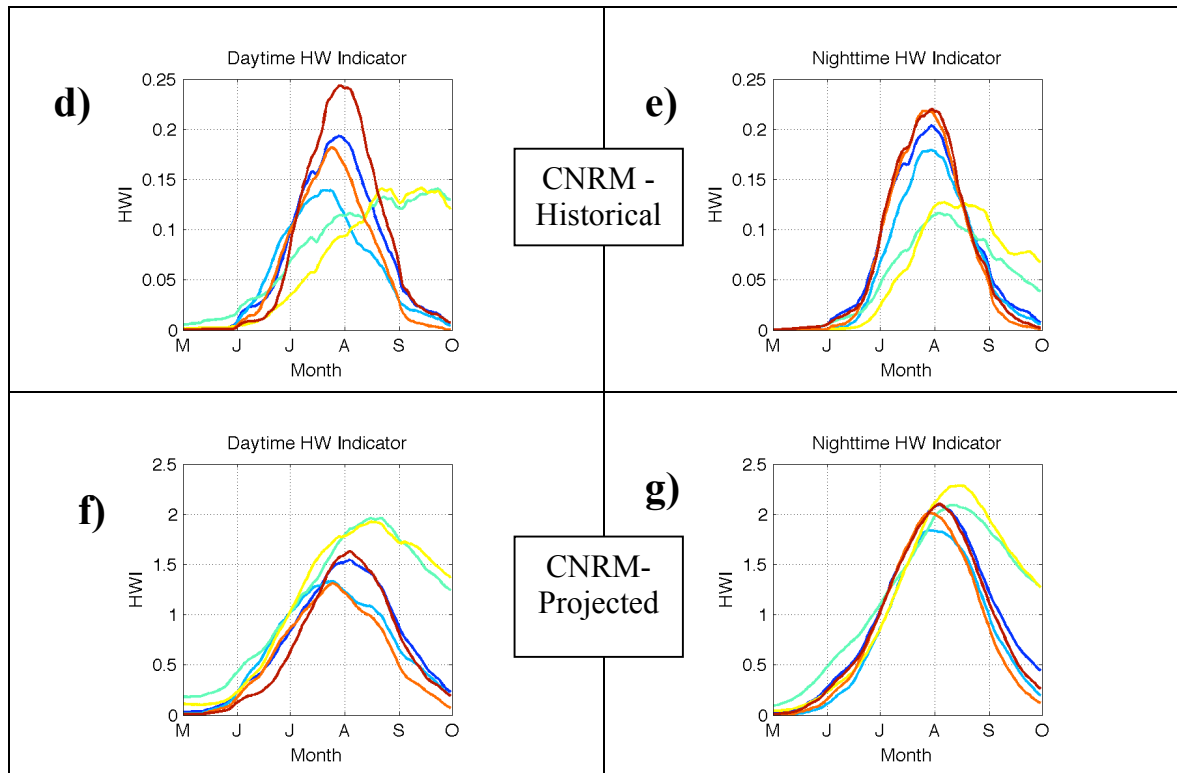
**b)**



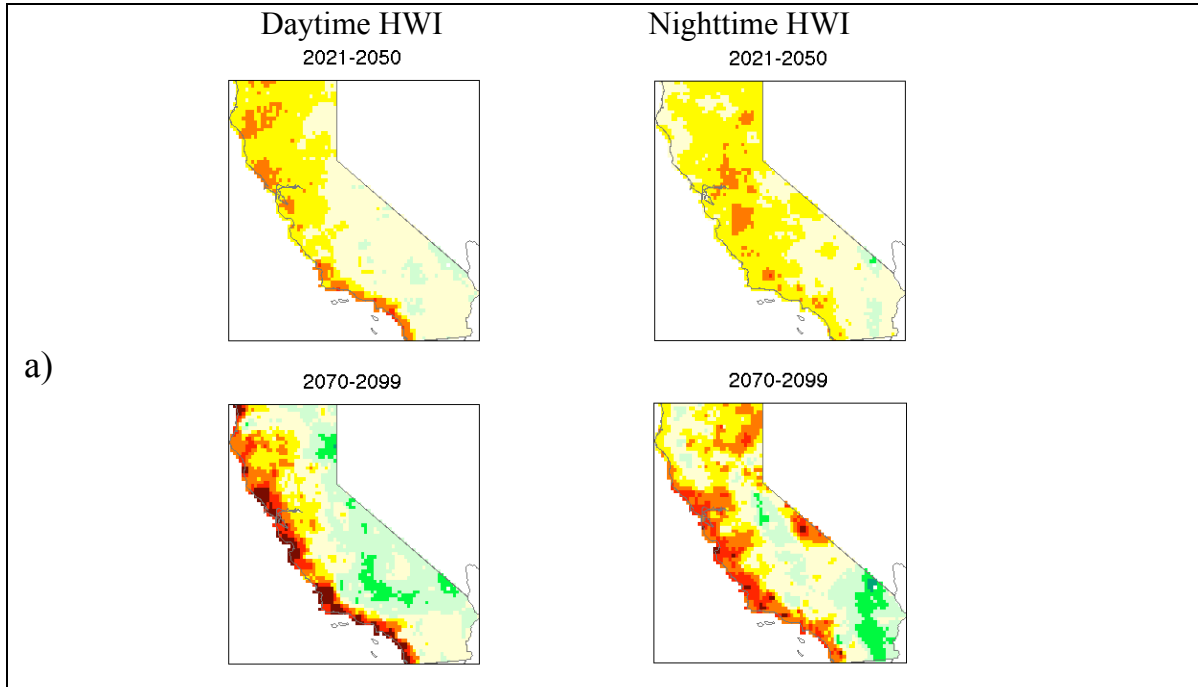
Observed

**c)**

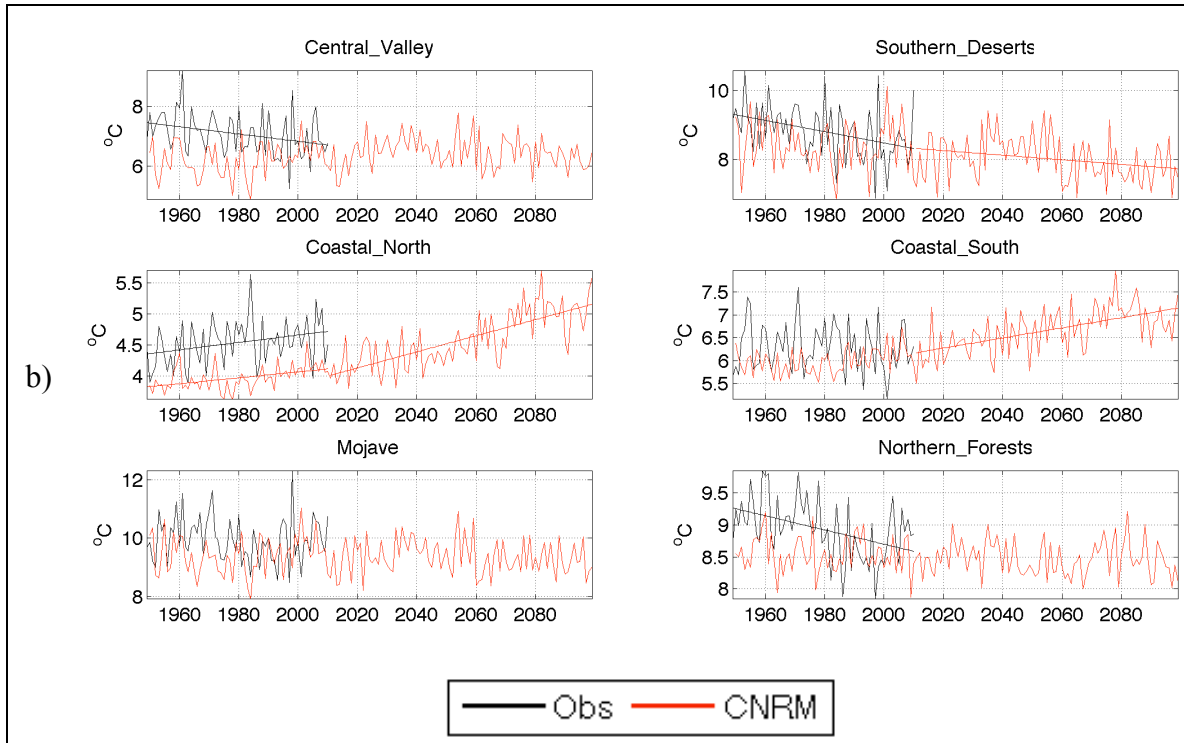




**Figure 4.** Regional expression of CA heat waves: (a) CA climate regions based on heat wave variability; (b) Table of daytime and nighttime HWI trends ( $^{\circ}\text{C}/\text{decade}$ ) for observations (Obs), CNRM historical (CNRM-H), and CNRM projected (CNRM-Pr). The table is color-coded by region and only trends significant at the 95% level are shown. (b-g) Climatology of heat waves showing the seasonality of the daytime (left) and nighttime (right) HWI according to observations (b,c), model-historical (d,e) and model-projected (f,g).







**Figure 5.** The RHWI index: (a) calculated at each grid cell from CNRM maximum (left) and minimum (right) temperatures and shown as a the difference between the mean RHWI for a given climate period (2021-2050 or 2070-2099) and the mean RHWI over the historical period (1971-2000); (b) calculated from regionally aggregated minimum temperatures according to observations (black) and CNRM simulations (red). Solid lines show linear trends significant at the 95<sup>th</sup> confidence level calculated separately for the periods 1950-2010 and 2011-2100.