Climatic Change (2008) 87 (Suppl 1):S7–S20
DOI 10.1007/s10584-007-9359-8

Linking climate change science with policy in California

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Received: 5 December 2006 / Accepted: 5 October 2007 / Published online: 22 December 2007

Abstract Over the last few years, California has passed some of the strongest climate policies in the USA. These new policies have been motivated in part by increasing concerns over the risk of climate-related impacts and facilitated by the state's existing framework of energy and air quality policies. This paper presents an overview of the evolution of this increased awareness of climate change issues by policy makers brought about by the strong link between climate science and policy in the state. The State Legislature initiated this link in 1988 with the mandate to prepare an assessment of the potential consequences of climate change to California. Further interactions between science and policy has more recently resulted, in summer of 2006, in the passage of Assembly Bill 32, a law that limits future greenhouse gas emissions in California. This paper discusses the important role played by a series of state and regional climate assessments beginning in 1988 and, in particular, the lessons learned from a recently completed study known as the Scenarios Project.

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1 Introduction

The California Climate Change Scenarios assessment (the "Scenarios Project") was initiated to explore possible climate change impacts in the state to help inform important state climate policy decisions such as: (1) how much climate change is acceptable? and (2) what actions are needed to enhance our ability to cope with future change? California policy makers have long recognized the critical role science can play in the policy process by characterizing the risks and alternatives for managing climate change. In this paper we describe how the Scenarios Project, along with a series of other climate assessments, has helped to establish California as one of the most significant climate policy actors in the USA.

Across the globe, science has been crucial for raising awareness of climate change and building support for climate policy. At the international level the Intergovernmental Panel on Climate Change (IPCC) assessments have helped move international policy with the signing of the UN Framework Convention on Climate Change and the Kyoto Protocol. At the national level the US Climate Change Science Program was similarly developed to inform policy and management decisions around climate issues.

Over the last decade a number of scientific assessments have been undertaken to build awareness and inform regional climate policy decisions within the USA. For example, the Climate Impacts Group (CIG) at the University of Washington, established as part of the NOAA Regional Integrated Sciences and Assessments (RISA) Program, has prepared a series of reports on the recent and possible future climate changes in the Pacific Northwest and their impacts on sensitive systems including water resources, fisheries and forests.[1] CIG, along with partners from King County, Washington and Local Governments for Sustainability, have also prepared a guide book providing information for local governments on how to adapt to climate change[2]. In Colorado, The Rocky Mountain Climate Organization has prepared reports on how climate disruption threatens[3] the West's snow and water.[4] Many of these regional assessments have been the outgrowth of formal or informal regional climate research networks.

In California, the state has established the California Climate Change Center[5] as a regional interdisciplinary research program to help inform relevant climate science. The papers presented in this special issue were produced as part of a California Climate Change Center assessment, the Scenarios Project, in response to the Governor's Executive Order of June 2005. The research for the Scenarios Project was carried out by over 70 scientists from within and outside of the California Climate Change Center, many of whom were also connected to other formal or informal research networks focused on regional climate-related issues. The findings from this assessment were included in a high-profile state report to the Governor and Legislature outlining a strategy for climate action.[6]

As regional and national efforts to manage climate variability and change expand, climate research programs such as the California Climate Change Center and the National Oceanic Atmospheric Administration's RISA programs are likely to become increasingly important. We believe these regional decision-support efforts could benefit by sharing

[1] http://www.cses.washington.edu/cig/pnwc/cc.shtml

[2] http://www.metrokc.gov/exec/speeches/20060522stateofthecounty.aspx

[3] http://www.rockymountainclimate.org/index.htm

[4] http://www.rockymountainclimate.org/index.htm

[5] http://www.climatechange.ca.gov/research/index.html

[6] http://www.climatechange.ca.gov/climate_action_team/reports/index.html

experiences among programs. As a result, we have written this paper to document experiences from the California assessment activities.

This paper is divided in three sections. First, we present a brief history of how climate change research in California has interacted with the policy arena and in particular, highlight those events that led up to the Scenarios Project. Next, we point to the characteristics of the Scenarios Project that made it a challenging assessment to carry out and describe facets that contributed to its successful completion. Finally, we conclude with some lessons learned from this climate assessment experience.

2 Brief history

Climate change has been on the minds of policy makers in California for at least 18 years. In 1988 State Senator Byron Sher spearheaded the adoption of the state Assembly Bill 4420 (AB 4420) which called the California Energy Commission (CEC) to lead the preparation of the first assessment of the potential impacts of climate change on California and of the options for reducing greenhouse gas (GHG) emissions in the state. The 1988 law led to two high profile climate reports – "The Impacts of Global Warming on California" (CEC 1989) and "Climate Change Potential Impacts and Policy Recommendations" (CEC 1991). These reports helped to generate public discussion around climate change in the state; however, it was over a decade before the state implemented its first policies taking real action to address climate change (Fig. 1). This lack of political action for over a decade can likely be attributed to at least two reasons: (1) absence of a unified "voice" from the scientific community in California conveying their concerns about potential impacts directly to decision makers;[7] and (2) absence of leadership in Sacramento in the Governor's Office on climate change issues.[8] In this section, we highlight California's most significant climate policies and describe the central role of regional climate science research efforts for building support for climate action in the state.

2.1 California climate policies

Over the last 6 years California has passed some of the strongest climate policies in the USA. These new policies have been motivated in part by increasing concern over the risks of climate-related impacts and facilitated by the state's existing framework of energy and air quality policies.

California took its first steps to regulate GHG emissions in 2000 by passing Senate Bill 1771, which specified the creation of the non-profit organization, the California Climate Action Registry (CA Registry). The CA Registry allows state organizations to register their emissions and track voluntary emissions reduction measures. Senate Bill 1771 was a mild Legislative response to a report issued in 1998 by the California Energy Commission updating the statewide inventory of greenhouse gas emissions (CEC 1998a), describing the strategies that could be implemented to reduce emissions (CEC 1998b), and suggesting that companies reducing emissions should be protected against future potential mandatory

[7] The Union of Concerned Scientists (UCS) played a major role in fostering this collating of scientists as discussed in other parts of this paper.

[8] Governor Schwarzenegger took office in November 2003 replacing Governor Gray Davis who had mostly pursued an extremely cautious and middle-of-the-road approach to environmental policy. Prior to Davis, Governor Wilson had opposed initiatives on climate change (Hanemann 2007).

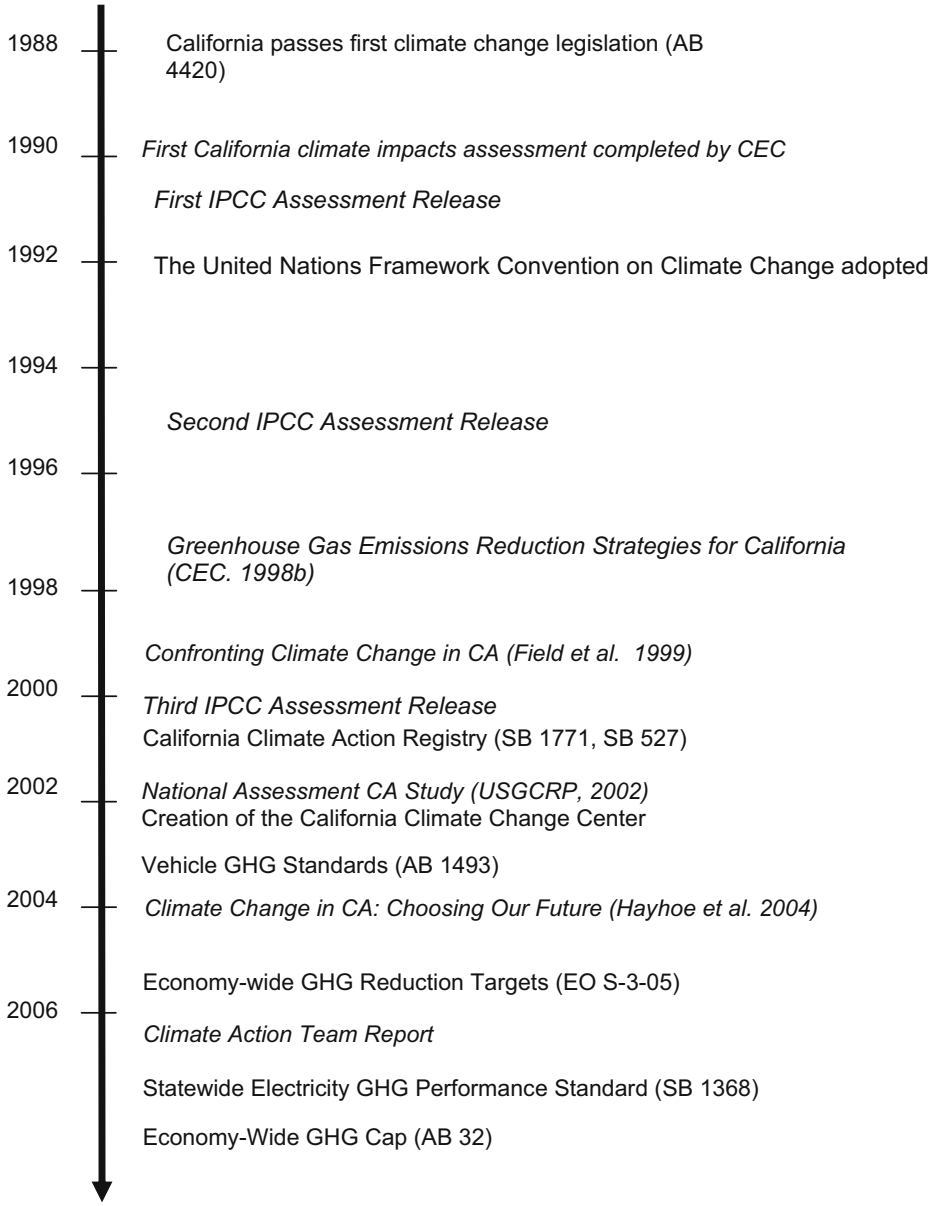

Fig. 1 Climate science and California climate policies. Analytical reports are listed in *italicized text*

requirements. This was followed in 2002 by the passage of Assembly Bill 1493 (Pavley), the precedent-setting law which required the Air Resources Board to develop regulations limiting the amount of greenhouse gases emitted from automobiles. Although automakers have filed suit to block the implementation of the vehicle GHG standards, arguing in part that these state pollution standards are pre-empted by federal fuel economy standards, many other states have moved forward to adopt California's standards. On April 2, 2007 the US Supreme court ruled that carbon dioxide is a pollutant and that the US Environmental

Protection agency has the authority to regulate this and other greenhouse gases. This rule will bolster the case that California is making regarding its authority to regulate greenhouse gas emissions from automobiles.

In June 2005, California once again demonstrated its leadership on climate issues when Governor Schwarzenegger signed an Executive Order (S-3-05) on June 1, 2005 establishing greenhouse gas emission targets for California. These targets are to bring emission levels in 2010 and 2020 to what the state emitted in the years 2000 and 1990, respectively, and to reduce emissions by 80% from the 1990 levels by 2050. The Executive Order also transferred the coordination of climate change activities in California from the CEC to the Secretary of the California Environmental Protection Agency (CalEPA), requiring the Secretary to prepare a report delineating how the state would be able to comply with the GHG emission targets. The CalEPA Secretary formed the Climate Action Team (CAT) with representatives from the California Resources Agency, Air Resources Board, the Energy Commission, and four other state agencies, to oversee the production of this report. The Executive Order also mandated the preparation of a biennial science report describing the impacts climate change would have on water supply, forestry, public health, agriculture, and the coastline, and discussing coping and adaptation strategies that the state should consider. This resulted in the "Scenarios Project" described in the next section of this paper.

In September 2006, the 2020 emissions reduction target set by the 2005 Executive Order was put into law with Assembly Bill 32. AB32 established mandatory reporting of GHG emissions from major sources in California and requires the Air Resources Board to develop regulations to cap GHG emissions to 1990 levels by 2020.

2.2 Climate science

Although advances in climate policy in California were relatively modest during the late 1980s and 1990s, a number of significant coordinated research efforts and research programs were initiated during this period that would lay the foundation for future climate action. In particular, a series of high profile assessments highlighted for California policy makers the severity of the risks posed by unabated climate change and helped raise public support for climate action. The growing support for climate action in California has been documented by a series of polls led by the Public Policy Institute of California (PPIC). In 2006 the PPIC poll indicated that 70% of likely voters favored actions to address global warming – this was up from 35% reported in a 2000 poll (PPIC 2000, 2006).

2.2.1 Government and academic institutions

In the late 1990s the National Oceanic Atmospheric Administration (NOAA), a federal agency whose mission includes predicting and understanding weather and climate, created the RISA research program to better understand information needs and provide research products for both short and long-term operation and planning purposes to regional and local resource managers. In California, under the NOAA RISA program, the California Applications Program (CAP) was established at the Scripps Institution of Oceanography, University of California San Diego. The CAP program has focused on climate variability and climate change impacts on water resources, wildfire, and human health and has been involved in climate impact studies and assessments produced in the state.[9] During this same

[9] http://meteora.ucsd.edu/cap/

period the US Department of Energy (DOE) funded the Accelerated Climate Prediction Initiative (ACPI) as a demonstration project, which on the US West Coast involved the Scripps Institution of Oceanography, the University of Washington at Seattle, Pacific Northwest National Laboratory (PNNL), and other research institutions. The main goal of this program was to increase capabilities to produce decade-to-century scale projections of climate at regional scales and to use these projections for climate impact and adaptation analyses. The results of this regional ACPI study were disseminated in a special issue in Climatic Change (Barnett and Pennell 2004). This study used one global climate model, the National Center for Atmospheric Research's (NCAR) Parallel Climate Model, and one global GHG emission scenario to investigate potential impacts of climate change on water resources and other water-related phenomena.

Meanwhile at the national level, the US Global Change Research Program published the first national 2001 assessment report (USGCRP 2001), which has been praised for its inclusiveness and its high involvement of stakeholders (Morgan et al. 2005). As part of this work, several regional assessments reports were produced, including one dealing exclusively with California (USGCRP 2002). The California contribution to the National Assessment was widely disseminated and Dr. Robert Wilkinson, the Director of the California Climate Assessment, provided several presentations to high-level officials in the state and to other audiences at multiple meetings and forums.

At the same time the National Assessment was under preparation, California initiated its own state supported integrated climate research program. The California Energy Commission's Public Interest Energy Research (PIER) program started climate change research with an exploratory project with the Electric Power Research Institute (EPRI) involving scientists from California as well as outside California to investigate the potential impacts of climate change on water resources, forestry, agriculture, coastal properties, and ecosystems. This project culminated with a report in 2003 suggesting that human adaptation to climate change would be costly for California and that impacts on ecosystems would be severe, with little room for adaptation considering other stressors such as increased unabated urbanization. This study served as the foundation for future studies and some features of the study, e.g. the use of estimated future urban growth patterns still remain a unique feature of this study (Wilson et al. 2003).

Following this initial report, PIER commissioned roadmaps of research on different topics such as regional climate modeling, GHG inventory methods, water resources, and carbon sequestration. The roadmaps were designed to identify research gaps not adequately covered by existing research programs at the national or international levels but of high importance for California. Technical staff from different state agencies and researchers associated with universities and research institutions in California participated in the review process for these roadmaps. This effort culminated with an integrated 5-year research plan on climate change for California, released at the end of 2003 and aimed at addressing the following policy relevant questions:

- How is climate changing in California and what are plausible climate change scenarios for California?
- How would climate change (physical impacts) affect California's environment and economy?
- What are the merits of different mitigation and adaptation strategies?
- How would climate change affect energy supply and demand?
- How would climate change policies affect the economy?

The integrated plan extracted the critical areas of work that PIER could support with a funding level of about $6 million a year and that could substantially assist PIER in

addressing the above questions. To implement this plan, the PIER program created a virtual research center, the California Climate Change Center (Center), with core research at the University of California at Berkeley and at the Scripps Institution of Oceanography, University of California San Diego, as well as an equally important and substantial complementary set of diverse research activities at other research institutions. This research center is remarkable in being one of the first state-sponsored climate research programs in the USA. An important underpinning of the PIER program is that it uses on-going national and international research efforts as the foundation for its research program. PIER mostly funds applied research projects with a goal of informing policy formulation in the state.

This paper only reports on the activities of the Center that are related to the Scenarios Project. It is important to indicate, however, that the Center has and will continue to generate information on other climate change topics such as regional climate detection and attribution, regional climate projections, improved methods to estimate greenhouse gas emissions, and mitigation, impacts, and adaptation studies.[10] Research results generated by the Center have been used to prepare the official statewide inventory of GHG gases in the state (CEC 2002, 2005a) and to identify preliminary mitigation strategies in different policy forums (CEC 2005b; CAT 2006).

Among the many high impact products that were produced from the various coordinated research programs were those highlighting the potentially severe threats that climate change posed to California's water resources. This threat was first brought to the attention of the scientific community when the Chief Hydrologist of the California Department of Water Resources (DWR) released a study (Roos 1991) showing that the contribution to annual water-year runoff occurring in the spring and summer months has been on a declining trend since records began in the early 1900s. Peter Gleick and others had hypothesized that warming would result in an early melt of snow in the Sierra Nevada reducing the capacity of the snowpack to serve as a natural water reservoir in California (Gleick 1986, 1987). Then in 2002 CAP scientists produced an analysis that graphically showed how April 1st snow levels in the Sierra Nevada would be increasingly and substantially reduced as climate warms (Knowles and Cayan 2002). When this report was released the executive branch of state government had different players, most of them unaware or only partially aware of the work done on climate change in prior years including the early Energy Commission's report on the subject (CEC 1989). The CAP study, along with others reported by researchers associated with the University of Washington at Seattle, produced as part of the ACPI project raised the awareness of top water managers in California to the potential serious effects of a warming climate on water resources in the state. These managers decided that the 2005 version of the State Water Plan, which is a major water policy document in California prepared every 5 years, should include a discussion on climate change. Given the limitations of time and resources available from the time this decision was made to the public release of this plan, only very limited information on climate change was included in the plan. In its final form, the 2005 plan contained a literature review on climate change and water resources in the state and some side notes with relevant information taken from the 2003 PIER study (DWR 2006).

The emergence of information with increasing levels of detail about potential climate change impacts in the region helped create the momentum necessary for meaningful climate policy formulation in California. At the same time, the continuity and focus of the science effort to elucidate regional climate change phenomena was enabled by a somewhat informal, but tight knit collaboration among several climate scientists in the State and the

[10] http://www.climatechange.ca.gov/research/index.html

region. Support from several respective academic and government institutions and at least a modicum of funding for long standing climate problems was key in sustaining this involvement. The existence of forums such as the Pacific Climate (PACLIM) Workshop series, soon to hold its 23rd annual or semi-annual meeting, is one example of the cohesiveness of the science network.

2.2.2 Non-governmental organizations

An important part of the climate-science interface in California includes the non-governmental (NGO) community that has taken the lead in coordinating research reports and a couple of influential climate impact assessments. These assessments differed from many of the previous studies in that they focused, from their inception, on communicating the risks of climate change to the non-technical audience. For example, in 1999 the Union of Concerned Scientists (UCS) and The Ecological Society of America (ESA) initiated and coordinated an assessment that was led by Prof. Chris Field and other prominent California scientists on the potential impacts of climate change on ecosystems in California (Field et al. 1999). The final report was distributed widely to state agencies and has been referred to as the "green book" that helped to educate California policy makers about climate change (Boyd 2006).

This 1999 assessment drew much attention in the state government and helped to re-initiate discussions about climate change. The California Resources Agency coordinated these discussions but the effort did not result in concrete implementation of new climate change initiatives in part due to a lack of interest in the Governor's office. However, the report by Field and colleagues was likely influential in building support in the legislature for Assembly Bill 1493 (Pavley), the California vehicle GHG standard.

In 2004 UCS initiated a second California assessment that was again focused from its inception on both outreach and scientific credibility. The resulting study was conducted by 18 scientists, including the principal scientist associated with the California Climate Change Center. The results of the analysis were first published in a paper in 2004 in the Proceedings of the National Academy of Sciences (PNAS; Hayhoe et al. 2004). The major contribution of this paper was to show that future global greenhouse gas emission levels could play a substantial role in determining the severity of impacts in California. UCS worked with the science team to produce a summary of the PNAS paper for outreach to non-technical audiences. The public version of this report, titled *Choosing Our Future: Climate Change in California* was released in the weeks leading up to the public hearings around the rule makings for AB1493 to help provide support for climate action in the state. Following the release, a series of presentations were conducted by report authors with high-level officials at the different state agencies, policy makers, and the Governor's office.

This 2004 PNAS paper and the public version of this report ("Choosing our Future") received wide media attention and has had a major impact on climate policy in the state. Its findings were made part of the rulemaking record with testimony provided by some of the researchers during the public hearings that the Air Resources Board conducted for consideration of the, at that time, proposed regulations for AB 1493 (Pavley). It was also included as an appendix to the Western Governor's Association Recommendations.[11] Even outside California the PNAS study and the *Choosing our Future* outreach brochure drew attention in the policy world. Authors were asked to report on the analysis in the US Congress as well at international conferences on climate policy.

[11] http://www.climatechange.ca.gov/westcoast/documents/index.html

3 California climate scenarios project

The California Climate Scenarios Project was prepared in response to a 2005 state Executive Order's call for biennial science reports. The Secretary of CalEPA entrusted the leadership of the preparation of these science reports to the PIER program and the California Climate Change Center. However, CalEPA was also aware of the importance of communicating the assessment to non-technical audiences and therefore also recruited UCS to play a lead role in synthesizing the assessment findings.

The final science report, which became known as the "Scenarios Project," was prepared as a multi-institutional collaboration among CEC, other state agencies including the Air Resources Board, the Department of Water Resources, and the California Department of Forestry and Fire Protection, and UCS. The Climate Action Team adopted the findings of the scientific team and included the full set of reports prepared by the science team in the report that the CalEPA Secretary and the Climate Action Team submitted to the Governor and Legislature (CAT 2006).

The Scenarios Project was unique among the climate assessments that have been conducted in California. Several distinguishing factors include: (1) The Scenarios Project was built into a State mandated, comprehensive report that outlined a set of strategies for managing climate change through aggressive mitigation and adaptation approaches; (2) the Scenarios Report was initiated and completed in less than eight months; (3) the dissemination of its key findings to the scientific community (this issue), policy makers, and the public (California Climate Change Center 2006) was planned from the beginning; (4) the Scenarios assessment was broader than previous efforts, including the efforts of 70 physical science and social science experts from academic, government and other organizational units; and (5) connections between the scientists, and the technical staff at different state agencies were established or reinforced which will improve the quality of future long-term planning in California prepared by these agencies.

All of these factors contributed to making this a high profile assessment with the potential of influencing climate policy in the state. According to Eileen Tutt, Assistant Secretary for Climate Change Activities, California Environmental Protection Agency, "The findings of the report contributed greatly to our understanding of the effects of climate change emissions in California. These findings were the basis of the scientific evidence reflected in the March 2006 Climate Action Team report and in AB 32, the California Global Warming Solutions Act of 2006" (CEC 2007). However, several aspects added to the challenges of completing a successful product. Below we highlight some of the challenges of the Scenarios Project and some of the key factors that we attribute to the success of the assessment.

3.1 Challenges in preparing the scenarios project:

3.1.1 The conflicting pace of politics and science

The Executive Order called for the final science "scenarios" report by the end of January 2006 providing only six months for the preparation of this report. In practice, additional time was made available to the research team because the final report was released in March 2006. A substantial amount of time was consumed in non-research activities such as assembling the team and developing the scope of work. A logistic challenge was the process of putting in place many necessary contracts to fund different research groups. Given the tight timeline, work started immediately after the research team was assembled.

CalEPA, with some of the agencies under its purview, and the PIER program funded the study. The contracts were in place in September, well after the work was underway.

Due to the extremely tight deadline some of the Scenarios assessments relied on work that had already been started under funding by PIER or that which other researchers had produced or were close to completing.

3.1.2 Mixed expectations

What California policy makers wanted was sometimes beyond the bounds of what the science team could deliver. CalEPA requested an assessment of physical impacts and, importantly, the translation of these impacts to economic outcomes and discussions about adaptation strategies. However, given the lack of a comprehensive body of work on this subject, the lack of necessary data sets, and the extremely short time table, the economic analyses were only able to partially achieve these goals.

3.1.3 The challenge of eliciting stakeholder involvement

Given the extremely short schedule for the Scenarios Project, only very minor stakeholder involvement was possible. As part of the CAT activities, three public workshops were organized first to discuss the scope of the analyses and then to report draft and final results. Relatively little public input was received, which might be attributed to the following factors: (1) the stakeholders may have been more interested in the strategies that the CAT was developing to control GHG emissions from state sources; (2) very little time was available to digest the results presented; (3) the strong track record of the research team may have created a perception of high credibility and acceptance; (4) perceived high uncertainty of the results; (5) perception that significant impacts are far in the future; and (6) perceived lack of impacts that would affect the stakeholders directly. Ideally, as the awareness of decision makers is raised concerning the potential severity of climate change impacts, the dialogue between them and the scientific community will increase.

3.2 Factors that contributed to the success of the Scenarios Project

3.2.1 Scientific credibility

The research was based upon "mainstream" climate model simulations delivered to the IPCC climate assessment, and was carried out by active scientists from major research institutions within and outside the state. All the papers were submitted to a peer-review process and their major findings were summarized in an overview paper (Cayan et al. 2006). The Office of the President of the University of California was in charge of the peer-review process with at least two, and usually three reviewers per paper.

3.2.2 Presentation and communication

The authors of this paper, with assistance from the different researchers involved in this study, also prepared a brochure summarizing the major findings of the study in simple language (California Climate Change Center 2006). The target audience for this brochure was policy makers in state government and the private sector, and the public in general.

3.2.3 Project management

The Scenarios Project was managed by a committee established by the Climate Action Team. The committee was composed of representatives from PIER, the Air Resources Board, UCS, DWR, the California Department of Forestry and Fire Protection, the California Department of Food and Agriculture, the California Department of Finance, and the California Department of Transportation. This committee met four or five times during the execution of the project to discuss general progress and links to other components of the Climate Action Team report. Additionally, the science team formed a "gang of five" (the authors of this paper) who coordinated efforts and kept the individual study efforts in contact and on schedule in delivering results.

3.2.4 Scientific network

A large, strongly-to-weakly collaborative network of climate science researchers within and outside of California, provided the technical expertise, models and databases to complete an extensive analysis in an extremely short interval. The importance of local scientists, however, cannot be overemphasized. Because they were local, they were able to participate in multiple meetings with representatives from CalEPA and the CAT Team during the design phase of the study and to communicate the scientific findings to decision makers and the public in general at multiple forums. Their availability and accessibility to local news networks also resulted in "tailored" reporting in local news outlets about the implications of climate change to their communities.

4 Lessons learned

There are several lessons learned from the effort that culminated with the release of the Scenarios Report. These lessons become more illuminating, however, if they are internalized in the context of the larger climate change science-policy efforts that have been taking place in the state in the last 15 years. They include the following.

4.1 Timing matters

The high impact of the 2004 PNAS study/Choosing our Future report on California policy was likely, in part, because it was released at a point in time when the general public and key policy makers were prepared for enacting regulations for AB 1493 and the Governor's Executive Order S-3-05. Similarly, findings from the Scenarios Project were released in time to have an impact on deliberations associated with AB-32.

Since 1991 there have been several attempts to convey to the Legislature and the Governor the importance of climate change to California (Hanemann 2007). Some of these attempts have been briefly mentioned in this paper. Climate change had always had its champions in the Legislature but the major stumbling block had been the Governor's Office. An unexpected opportunity occurred with the election of Governor Schwarzenegger who has been willing to hear what "his" scientists have to say about climate change and had been convinced of the high vulnerability of his state to climate change and, therefore, the need for urgent action.

4.2 Credibility must be attained within and outside the scientific community

Credibility must begin with scientific peer-review. Beyond this, it is important to engage local scientific and community leaders.

4.3 Findings must be accessible

Assessment findings must be presented in a manner that is accessible to non-technical audiences. This includes condensed, "user friendly" summaries and simple graphics and images that communicate key messages. Essential to the accessibility of scientific results is framing them in a manner that presents climate impacts together with solutions. The impacts reported in the Scenarios Project highlighted those impacts that could be avoided through climate action.

4.4 Scientific networks can provide a foundation

Research activities funded at the national and international levels on climate change are extremely important, but are not designed to address regionally specific issues. At the same time, the California-specific studies being funded by PIER and others cannot take place in the absence of national and international research efforts. Thus, a coordinated linkage between national and international climate change studies and regional climate research efforts is critical in order to provide decision makers with better information. Experience here suggests that these networks can be formal or informal, but are more likely to be effective if they are sustained over a period of several years.

In addition, as discussed above, the dissemination of relevant scientific findings to multiple audiences with different interests required the presence of California based scientists with in-depth understanding of the local conditions. The extensive scientific infrastructure in California allowed for this to happen. In situations when local scientific resources are not adequate, it might be necessary to create regional partnerships involving multiple states.

4.5 Institutional memory must be maintained

Changes in administration in state government, in this case in Sacramento in both the legislature and in the Governor's office, can result in a complete overhaul of top-level officials in the different state agencies. This can result in very little or no memory of past activities on climate change. Because of this turnover, and because climate science is not static but is still evolving, it is imperative that there is a process to periodically review and update key science findings for agency and administrative officials and their staff. Furthermore, having an ongoing linkage with government staff is crucial, since in many cases they are responsible for advising elected officials and other high level managers. Government staffers having an extended involvement in the climate change science and policy arena are extremely valuable. This involvement is, in our experience, the only way to attain a working familiarity and sense of the growing volume of knowledge and literature, an extensive community of science and policy experts, and a complex set of entangled climate impacts. Thus, close coordination between researchers and technical staff at the different state agencies has multiple benefits, which include building a repository for long institutional memory and enhancing the expertise at these agencies.

4.6 Outreach is essential

Outreach efforts are essential to disseminate science information to decision makers and also to provide crucial feedback to researchers on climate impact applications. However, in order to maintain scientific credibility, extreme care should be taken to "speak" with a clear non-advocacy voice.

Funding and research management programs such as PIER are, by necessity, constrained in its outreach activities given the fact that they are part of the state government. Outreach activities such as the ones organized by UCS in the state legislature and the Governor's office would have been impossible to undertake by a state-sponsored program. PIER has attempted to broadcast the results of PIER-sponsored research and other relevant research projects via its annual research conferences. These conferences have been very successful in engaging and linking the technical and scientific communities but only modestly successful in linking them to state government. They cannot replace direct meetings with Legislature and the Governor's office.

5 Conclusions

Concerted interest in climate change at different levels of the California state government started nearly two decades ago and recognition in Sacramento has grown since then to make it a key long-term issue. A number of political factors have helped to enable state policy makers to take climate action. In particular, federal inaction on environmental issues has allowed California to build on its legacy of successful energy and air quality policies to develop a climate-specific policy agenda that has drawn national and international support. A body of global and regional scientific studies have motivated and reinforced this process. Regional climate change assessments have clarified global climate research findings, and together these have helped to convince state decision-makers of the reality of climate change and the need for state action.

Other jurisdictions may lack public and/or governmental support to adopt similar policy actions and legislation as California on climate change. This does not diminish the need for climate assessments and the dissemination of scientific findings to the public and decision makers. These studies and education efforts will likely be needed when conditions are ripe for acceptance.

A long path of scientific investigations has been established and will surely continue. From the California experience, a crucial element, not traditionally a part of the science process, is the exchange of ideas and information among and between scientists and decision makers. This exchange has proven to be instrumental in instigating and informing policies that aim to better prepare California for the serious challenges posed by a changing climate. The Scenarios Project has taken some steps in that direction, but there needs to be a continuing, integrated assessment of climate change and its impacts in California. To this end, under the leadership of PIER and CalEPA, the State is already preparing the 2008 Scenarios Report.

Acknowledgements We would like to thank all the participants in the Scenarios Project and especially to Eileen Tutt from the California Environmental Protection Agency. We thank two anonymous reviewers for their extremely valuable comments; however, we remain responsible for the content of this paper and for any errors or omissions that may have escaped our attention. This paper reflects the views of the authors and does not necessarily reflect the views of the California Energy Commission or the state of California. Dan Cayan was partially supported by NOAA through their RISA program element.

References

Barnett TP, Pennell W (eds) (2004) Impact of global warming on Western US water supplies. Clim. Change 62 (Spec. Vol.)

Boyd J (2006) California Energy Commissioner. Statement at the Climate Change Science Meeting, Sacramento, September 13, 2006. http://www.climatechange.ca.gov/events/2006_conference/presentations/index.html

CAT (2006) Climate Action Team Report to Governor Schwarzenegger and the Legislature. March. http://www.climatechange.ca.gov/climate_action_team/reports/index.html

Cayan D, Luers A, Hanemann M, Franco G, Croes B (2006) Scenarios of climate change in California: an overview. FINAL report from California Energy Commission, Public Interest Energy Research (PIER) Program, California Climate Change Center, Publication no. CEC-500-2005-186-SF, posted February 27, 2006. http://www.climatechange.ca.gov/biennial_reports/2006report/index.html

California Climate Change Center (2006) Our changing climate. Assessing the risks to California. A summary report from the California Climate Change Center. CEC-500-2006-077

California Energy Commission (CEC) (1989). The impacts of global warming in California. (P500-89-004)

California Energy Commission (CEC) (1991) Global climate change: potential impacts and policy recommendations"

CEC (1998a) Historical and forecasted greenhouse gas emissions inventories for California. January. P500-98-001V3

CEC (1998b) Greenhouse gas emissions reduction strategies for California. January. P500-98-001V1

CEC (2002) Inventory of California greenhouse gas emissions and sinks: 1990–1999. November. Publication #600-02-001F

CEC (2005a) Inventory of California greenhouse gas emissions and sinks: 1990 to 2002 update. June. CEC-600-2005-025

CEC (2005b) Integrated energy policy report. November. CEC-100-2005-007CMF

CEC (2007) In the public interest developing affordable, clean, and smart energy for the 21st century California. (CEC-500-2007-020-SD). March. Page 72

DWR (2006) California Water Plan. Update 2005. Department of Water Resources

Field C et al (1999) Confronting climate change in California ecological impacts on the *Golden State*. The Union of Concerned Scientists and The Ecological Society of America

Gleick PH (1986) Methods for evaluating the regional hydrologic impacts of global climatic changes. J Hydrol 88:97–116

Gleick PH (1987) Regional hydrologic consequences of increases in atmospheric carbon dioxide and other trace gases. Clim Change 10(2):137–161

Hanemann WM (2007) How California came to pass AB32, the Global Warming Solutions Act of 2006. ARE Working Paper. University of California Berkeley

Hayhoe K, Cayan D et al (2004) Emissions pathways, climate change, and impacts on California. Proc Natl Acad Sci U S A 101(34):12422–12427

Knowles N, Cayan DR (2002) Potential effects of global warming on the Sacramento/San Joaquin watershed and the San Francisco estuary. Geophys Res Lett 29(18):1891

Morgan MG, Cantor R, Clark WC, Fisher A, Jacoby HD, Janetos AC, Kinzig AP, Melillo J, Street RB, Wilbanks TJ (2005) Learning from the U.S. National Assessment of Climate Change Impacts. Environ Sci Technol Policy Anal 39(23):9023–9032

PPIC (2000) Statewide survey: special survey on the environment. Public Policy Institute of California. June 2000

PPIC (2006) Statewide survey: special survey on the environment. Public Policy Institute of California. July 2006

Roos M (1991) A trend of decreasing snowmelt runoff in northern California. Proc. 59th Western Snow Conf., Juneau, AK, 29–36

USGCRP (2001) Climate change impacts on the United States. The potential consequences of climate variability and change. A report of the National Assessment Synthesis Team. US Global Change Research Program. http://www.usgcrp.gov/usgcrp/nacc/allreports.htm

USGCRP (2002) The potential consequences of climate variability and change for California. The California Regional Assessment. http://www.usgcrp.gov/usgcrp/nacc/california.htm

Wilson T, Williams L, Smith J, Mendelsohn R (2003) Global climate change and California: Potential implications for ecosystems, eealth, and the economy. Publication Number: 500-03-058CF. http://www.energy.ca.gov/pier/final_project_reports/500-03-058cf.html