

8
CONF-8907191--1

UCRL-101735
PREPRINT

**Climate Caucus Report:
Opportunities for Bridging the Gaps from Effects to Impacts**

Michael C. MacCracken

Proceedings, Workshop on Global Climate Change
and its Effects on California
DOE, University of California
Davis, California
July 10-12, 1989

April 1990



Lawrence
Livermore
National
Laboratory

This is a preprint of a paper intended for publication in a journal or proceedings. Since changes may be made before publication, this preprint is made available with the understanding that it will not be cited or reproduced without the permission of the author.

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

Climate Caucus Report:***Opportunities for Bridging the Gaps from Effects to Impacts***

Continuing emissions of infrared-absorbing (greenhouse) gases are changing atmospheric composition and pose the potential for significant global climatic change. Model projections indicate that global average temperatures could rise more rapidly and persistently than experienced during historical times, with the increase reaching as much as a few degrees Celsius by the latter half of the next century. In addition, the rates of global evaporation and precipitation are projected to increase by about 10%, although not uniformly over the globe. Warming ocean waters and melting mountain and polar glaciers are projected to accelerate the rate of sea level rise over the next century to several times the observed rate of change of about 10 to 15 cm/century over the past 100 years.

The ability of climate models to simulate a range of test cases, including the cycling of the climate over time scales from seasons to glacial/ interglacial intervals, gives some confidence that the models are properly estimating the sign and order of magnitude of the global average response (i.e., a warming of a few degrees for a CO₂ doubling). However, limitations in model resolution, treatment of the ocean, and representation of important physical and chemical processes introduce uncertainties in the results, particularly concerning the rate of climatic change and the seasonal and regional patterns of the response. As a consequence of these limitations, it is only possible to provide *plausible estimates* of future climatic conditions (often called *climate scenarios*) appropriate for use in investigating sensitivities and vulnerabilities of ecological, agricultural, hydrological, and societal systems to climatic change. It is not now possible, however, to provide detailed *predictions* of future climatic conditions.

Because California is among the most topographically, climatologically, economically, and socially diverse regions in the world, very large uncertainties are introduced when generating estimates of the climatic changes that might occur within the state; nonetheless, it

is instructive to construct scenarios to be able to identify and consider potential impacts of climatic change on California. Knox (1989) drew upon comparisons of warm and cold decades and upon interpolation of equilibrium climate model results to develop climate scenarios for the periods 2000-2010 and 2030-2070 (see Table 1 in Knox). It should be emphasized that these estimates, while plausible, are not predictions; they have been developed solely to provide a common basis for an initial evaluation of the sign and order of magnitude of potential impacts. Thus, although there may be uncertainties and disagreements about these projections and although they are not intended to be predictions, the values suggested can be used for estimating the general character of impacts, even though that different scientists might reasonably select different scenarios for consideration.

Role of the Climate Caucus

Climate Caucus participation in this workshop served several purposes. Of most importance was as a resource to help interpret and extend the climate scenario components for use in impact studies. A second role was to become better informed about potential interactions with the ecological, water, agricultural, and human systems represented by the panels so that more complete scenarios can be generated in the future. The third purpose was to develop plans and recommendations for extending collaborative efforts between climate researchers and those studying impacts of climate change on California.

An important consequence of the participation of members of the Climate Caucus in the workshop panels was recognition of the very important and persistent difficulties in evaluating impacts caused by the gaps between the information the climate researchers can provide and the needs of those studying impacts. One gap concerns the very different spatial scales of the methods (models) used by the two groups. Climate models represent the topographic complexity of California with only a few highly-smoothed grid points, while impacts researchers treat the spatially-complex climate, which has monthly average

temperatures that vary dramatically over distances of tens of kilometers due to orographic features (e.g., the Sierras to Death Valley).

A second gap arises due to the different temporal scales of the information. Climate models typically provide seasonal average changes, whereas impacts are often determined by changes in the limits of the diurnal temperature range or in the frequency of extreme, infrequent, or aperiodic events (e.g., winter storms, tropical storms, etc.). A third gap concerns the relatively simplified treatments of important processes such as hydrology in the global climate models in comparison to the complex interplay of factors known to be important in controlling observed fluxes and conditions.

Although the limited set of climatic conditions suggested by the climate scenario given in Knox did allow workshop participants to identify potential vulnerabilities and sensitivities, it is clear that substantial efforts must be made to bridge the spatial, temporal, and information gaps in ways that in the future will permit more detailed analyses and assessments.

Recommendations for Bridging the Gaps from Climate Change to Impact Assessments

Through interactions between Climate Caucus members and the various panels, a number of opportunities were identified that could serve to significantly enhance the quality and completeness of impact assessments.

- 1. Analysis of GCM Simulations.** General circulation models (GCMs) simulate the global climate by attempting to represent the hour by hour evolution of the atmosphere in a manner statistically similar to the evolving weather. Although the spatial resolution of available GCMs is relatively coarse (i.e., grid points are a few hundred kilometers apart), the model simulations can more easily and more completely be sampled than can the real atmosphere. The potential availability of such a rich set of model results led to significant interest in greatly intensified analysis of the model output in

order to develop information that can be compared to the present observational record as a prelude to provision of the data for more detailed and refined impact analyses. Examples of climatic measures of potential interest, assuming model simulations are reasonable, include:

- a. Storm speeds, tracks, and frequencies;
- b. Intervals between rain events;
- c. Relative and absolute humidity and dew point;
- d. Soil temperatures, daily range, and frost free period;
- e. Cloud cover and solar radiation;
- f. Variances, extremes, and duration of unusual conditions.

To accomplish these intensified analyses, it was recommended that GCM results for the California region and with daily resolution be made generally accessible on a computer and that suitable data analysis routines be developed, documented, and made available for processing the information. An important caution is that modelers have not yet compared many of these fields to observations for present (control) conditions; therefore, those processing the model output for impact analyses are urged to do so in order to develop estimates of the degree of confidence to place in the results. Shortcomings identified in comparisons with data can also provide guidance for model improvements.

2. Finer Spatial Resolution. Given the topographic complexity of California, it is essential to develop means for moving from the relatively coarse resolution of GCMs to the finer resolution on which potential impacts need to be evaluated. As an example of the mismatch, estimating changes in river runoff requires resolution on typical watershed scales (of order 10 to 20 kilometers) rather than on GCM scales. A number of approaches have the potential, as yet largely untested, for bridging this spatial gap.

- a. Finer grid GCMs, either for the entire global domain or, with more difficulty, for sub-areas, will soon be able to provide results for some types of problems with a resolution of about 75 to 150 km rather than 250 to 500 km.

- b. Deriving boundary conditions for mesoscale models having horizontal grid resolutions of 10 to 20 km using results from coarse grid GCMs can provide greater spatial detail, although representing the finer scales in a non-interactive way may somewhat limit or bias the resulting estimates.
- c. Transfer of meteorological information from the relatively coarse grids of global weather forecast models to local regions is currently accomplished using empirically-derived statistical relationships. The potential exists to apply this approach to estimate local climatic change. This may be particularly effective if the relationships rely on the relatively more robust climatic measures generated by the GCMs, (e.g., geopotential height and large-scale circulation) than on surface temperatures at individual gridpoints.

With this variety of potential approaches and the intense need for the finer scale information, accelerated research efforts are clearly warranted.

3. Mesoscale Meteorological Assessments. A number of meteorological conditions were identified that have not and cannot be investigated using global models. For these unusual and, in some cases, uniquely California situations, mesoscale models or other special approaches need to be used. Examples of such conditions include:

- a. Reduced snow cover and less intense cooling in the mountains may alter formation rates and patterns of wintertime drainage flows (i.e., cold air formed in the mountains flowing downslope) that promote fog formation in the Central Valley.
- b. Warming of the land more (or less) than the ocean may intensify (or moderate) the air-sea contrast that drives the sea breeze, thereby changing diurnal patterns of local climates, altering energy demand, wind energy potential and perhaps even the relative climatic appeal of different areas.

c. Flooding of large areas of the Sacramento-San Joaquin River delta, while not substantially affecting water availability for evaporation because of the current intensive irrigation of agricultural fields, could significantly affect surface heat capacity, and thereby average temperature, evaporation rate, and other climatic factors. (Such changes may also reduce hydrocarbon emissions and alter ozone formation potential.)

4. Coastal Ocean Temperatures. To a large extent, the California coastal climate (and thereby the sea breeze and other climatic features that reach inland) is controlled by the temperature of the coastal Pacific Ocean, which in turn is determined by the intensity of upwelling of cold water forced by the California current. This intensity of upwelling is largely dependent on the speed and pattern of winds along the Pacific coast, which are in turn dependent on the general circulation of the global atmosphere, although tropical ocean variations (e.g., El Niño) can also have dramatic effects on coastal ocean temperatures. General circulation models do not as yet satisfactorily treat such oceanic features. Models of the California current are, however, being developed and the potential for perturbations to coastal ocean temperatures could be tested by studying the effects of changes in atmospheric circulation determined by the GCMs.

5. Improvements to Model Physics. To represent the global climate, given available computational resources, a number of processes important to estimating the potential for climatic change in California have been highly simplified. Crucial examples include hydrology, orographic effects, and ocean currents, although it is also important that parameterization of the full range of model processes be improved to comparable levels of comprehensiveness. Application of present global model results to regions via the variety of techniques described in earlier recommendations is likely to identify further

important deficiencies in the models, helping set priorities for what model improvements need to be made. While an active national and international effort is underway, in which UC scientists are playing a role, much more could be done to accelerate this effort and to focus attention on improvement of the processes crucial for better representing changes in regions as complex as California.

- 6. Analysis of California Climate Data.** Although the observational record of past variations in California climate is of relatively short duration relative to the timescale of the projected changes, there have been climatic fluctuations that are probably larger than the projected changes in the ocean. For example, the range of past winter precipitation changes has been much larger than the $\pm 20\%$ that some models suggest may result from the changing atmospheric composition. There is also significant potential for learning from the observational data base how to better bridge from large to small scales. Despite the richness of past variations in the California climate, the State has supported only a comparatively modest climatology program (currently at a level of half-time support within the Department of Water Resources). Other states, for example Illinois and Colorado, have much stronger state climatology programs. Although the Federal government is initiating a western regional climate data center at the Desert Research Institute in Reno, a much stronger effort by California to assemble, analyze, utilize, and learn from its past climate could provide important benefits for both current economic purposes and for projecting and assessing the impacts of future climatic conditions. Such an activity could be undertaken by UC in collaboration with State agencies.

Computers, Data, Collaboration and Resources

Although California is complex topographically and climatically, the UC system and other intellectual capabilities exist for addressing the very important and challenging ques-

tions posed by global climatic change. These capabilities are, however, not being adequately supported or utilized.

To promote the research and collaborative efforts that could significantly advance the scientific understanding necessary for formulating and implementing effective policies, a mechanism, resources, and an impetus must be provided.

- a. Although significant public support is provided to the University, scientific research, especially the inter- and multi-disciplinary research needed on this issue, require the long-term commitment of additional financial resources.
- b. The availability of observational data sets, model results, and significant super-computer time could well serve as both the impetus for generating interest and the glue for cross-disciplinary research. Supercomputers are needed for both California-specific research and to further promote the participation of California scientists in advancing understanding at the national and international levels.
- c. The University of California is exploring collaborative mechanisms that augment the initiatives and research centers of the individual campuses. Such mechanisms are needed to allow continuing exploration of the issue as a means of formulating researchable questions and to build bridges across disciplines.

Summary

The workshop provided an important opportunity for those studying climate research to meet with those evaluating potential impacts as a bridge to formulating and developing effective policy responses. Participants identified an extensive range of capabilities at the U.C. campuses and laboratories, spanning experience in biogeochemical cycling, atmospheric and oceanic modeling, data and model analysis and intercomparison, monitoring and observation capabilities, and hydrology and surface processes. These diverse capabilities together create a significant strength in study of our physical and chemical environment.

Climate Caucus members identified a number of important initiatives that could extend understanding of potential changes in California. More detailed analysis of existing model simulations, model improvements including nesting of mesoscale models, and more extensive analyses of available data sets could provide important insights into potential changes in hydrology and in the intensity of the California current. Increased computer resources could provide both an incentive and the glue to enhance collaboration between physical and biological studies.

A strong commitment to pursue these opportunities could assure significantly more definitive assessments of the potential impacts of climate change on California and provide a firmer basis for policy consideration.

Acknowledgement: This report benefited greatly from many discussions at the workshop among both members of the Climate Caucus and with scientists and panelists with very different scientific interests. Support for preparation of the report was provided by the Department of Energy Atmospheric and Climate Research Division to the Lawrence Livermore National Laboratory under contract W-7405-Eng-48.

Members of the Climate Caucus

Tim Barnett, Scripps Institution of Oceanography

Sumner Barr, Los Alamos National Laboratory

W. Lawrence Gates, Lawrence Livermore National Laboratory

Carlos R. Mechoso, University of California Los Angeles

Michael C. MacCracken, Lawrence Livermore National Laboratory, Chair

Karl E. Taylor, Lawrence Livermore National Laboratory

Bryan Weare, University of California Davis