

MEETINGS

Discussing the Future of U. S. Western Mountains, Climate Change, and Ecosystems

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Mountain regions are uniquely sensitive to changes in climate, and are especially vulnerable to climate effects acting on many biotic systems and the physical settings. Because mountain regions serve as sources of needed natural resources (e.g., water, forests) and as foundations for desired human activities (e.g., tourism, places to live), changes in mountain systems cascade into issues of regional and national concern. Mountains also comprise highly sensitive systems that may act as “canaries in the coal mine” to provide early signals of significant climate-driven changes in many of our valued resources.

Why the Focus on the Western United States?

The Mountain Climate Science Symposium, held last May, arose from the recognition by a cross section of physical scientists working on western United States mountain climate and ecosystems that there is need for more and improved observations, better integration, and greater attention at all levels of society to potential vulnerability of western society to climate variability and change. An ad hoc committee was formed to promote greater understanding of the physical processes affecting western mountains and to promote better communication of scientific findings to decision makers. The group's goal is to establish a Consortium for Integrating Climate Research in Western Mountains (CIRMOUNT), and the symposium was organized to facilitate that goal.

Mountain ecosystems of the western United States are complex, and include cold desert biomes, such as those found in Nevada, alpine biomes found in the upper tree-line zone, and tundra ecosystems occurring above timberline. The alpine ecosystem within the cordilleran region that extends into Central America is the only one that exists in all different climatic zones from the equator to the polar region. This environment is among the most sensitive to climatic changes occurring on a global scale, and comprises glaciers, snow, permafrost, frozen ground (landscape-scale frozen ground structures important for water archiving), liquid water, and the uppermost limits of vegetation and other complex life forms. The stratified, elevationally controlled vegetation belts found on mountain slopes represent an analogue to the different latitudinally controlled climatic zones, but these condensed vertical gradients are known to support unique hot spots of biodiversity and provide vital corridors for endemic mountain species. High relief, steep gradients,

and isolated “island effect” of high summit zones make mountain ecosystems vulnerable to slight changes of temperatures and to extreme precipitation events.

The mountain regions of the western United States may be especially vulnerable to changes in climate and to the ensuing changes in snowpack, streamflow, ecosystem functioning, and a host of other impacts on a variety of human and nonhuman systems. The current sustained and severe drought in the western United States has highlighted the region's sensitivity to climate and other environmental changes. Recent decades have shown a tendency for declines in spring snowpack and earlier runoff in many watersheds within the western mountain zones. The role of mountains in providing life-sustaining water to downstream ecosystems and communities means that climatic and other environmental changes in the mountains of the West will have a large impact, not only on the regional society, but also on the nation as a whole.

Specific Goals of the Symposium

The specific objectives of the symposium were to respond to the following situation in western North American mountain regions:

(1) While a significant amount of scientific research and information regarding climate variability, climate change, and climate-related impacts on western landscapes and ecosystems has been accumulating, sorely needed integration and application of findings and results has not been fully developed.

(2) Although lowland sites are well-represented by weather monitoring stations, mountain areas are vastly under-observed.

(3) Escalating demands on western North American mountain resources increasingly stress natural systems and enhance human vulnerability to ongoing and future climate and environmental changes.

(4) Scientific knowledge about climate change, as well as the need to monitor changes in climate and their impact on mountain ecosystems, have been virtually ignored in mountain land-use planning and natural-resource policy.

The symposium reviewed current knowledge of mountain climate (including hydrology) variability and change in the context of the ecosystem functions, with a view to anticipating challenges to western mountain ecosystems and resources. Participants considered potentially important factors that are affecting western mountains, and may affect them in the future, based on a variety of observational studies and model simulations.

With regard to future changes in climate and their impact on western mountains, the

participants underscored that the following areas need particular attention:

- Climate system monitoring. It was agreed that climate system monitoring—including the biosphere, hydrosphere, and cryosphere components—was at the top of the priority list for sustainable management of western resources, in light of predicted future climate conditions under an enhanced greenhouse effect.

- How are the vertically stacked ecosystems changing? Boundaries between the various biophysical systems in mountains may experience changes due to global climate change (e.g., snow line, tree line, upper limit of plant life, etc.). Observations to date indicate changing snowmelt timing signals, pine beetles moving north and infecting large and new areas, massive forest dieback, and increasing size and intensity of fires in western forests. Greater efforts are needed to monitor and study the effects of environmental changes in these areas. There is a need to improve our understanding of the relationship between ecosystem structure and function through process studies.

- Linking ecosystem and human processes. Climate variability and change, including the presence of trends and changes in climate regimes, lead to variability and changes in water resources, the carbon cycle, forest health, and biodiversity. These systems provide multiple services that may be vulnerable to critical thresholds and rapid changes.

- Insufficient integration of disciplinary research. There is a need to develop tools for integrated assessments (projections) of global change impacts in mountain regions. Among such tools are the development of quantitative models, and some initial efforts have been made toward this end. More is needed.

- Enhance the delivery of information (communication) of important scientific findings relevant to western mountains to decision makers. There is a need to base the information on the best available science provided by multiple disciplines, for better communication with nonscientists, and to evaluate credible future scenarios to help managers mitigate impacts of climate change.

Participants concluded by proposing a research initiative aimed at improving our understanding and ability to predict future climate and ecosystem changes in the West. In particular, they agreed that strategies were needed to encourage the close collaboration among researchers from many disciplines, such as climate system sciences, ecology, and related disciplines regarding temperature and precipitation changes arising from both natural variability and greenhouse warming. Answering these questions will be critical in assessing their impact on the hydrology of the West, and how those changes may be linked to ecosystem goods and services.

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Montana State University's Big Sky Institute for Science and Natural History.

A publication titled *Mapping New Terrain: Climate Change and America's West*, to be edited by the conveners, is in preparation. This publication will present a synthesis of some of the major climate and climate-related issues facing the mountainous western United States, identifying critical problems and providing suggestions for addressing such concerns.

The Mountain Climate Science Symposium was held 24–27 May 2004 at the North Tahoe Conference Center in Kings Beach, California.

—HENRY F. DIAZ, Climate Diagnostics Center, NOAA, Boulder, Colo.; and CONSTANCE I. MILLAR, Pacific Southwest Research Station, USDA Forest Service, Albany, Calif.

GEOPHYSICISTS

William Malcolm Sackett (1930–2003)

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William Malcolm Sackett, retired distinguished research professor at the Department of Marine Sciences, University of South Florida, died 30 November 2003, from acute leukemia. He was 73. Bill was admired as an outstanding geochemist and dearly loved as a colleague and friend.

Born on 14 November 1930, in St. Louis, Bill was active in sports in his high school years. He lettered in cross-country and helped his high school track team win the Missouri State Track Crown in 1946. Bill chose, however, to follow a scientific life, a rewarding choice, but one that carried more risk than one might imagine.

He paid for his B.A. in chemistry at Washington University in St. Louis by working 4 years at Mallinckrodt Chemical Works on uranium processing. Decades before there were safety regulations requiring personal protective equipment, Bill and many others worked directly with such materials without special gear. Whether the leukemia that was discovered only one week before his death or the multiple sclerosis that was diagnosed in 1983 were related to that early exposure, to a lifetime of exposure to other hazardous chemicals, or simply to "fate" is unknown. In spite of the disease, however, Bill had a positive attitude. He considered the MS, which eventually forced him into a wheel chair, as an inconvenience.

Bill remained at Washington U. to pursue graduate work in geochemistry. Under the direction of Herbert Potratz, he received his Ph.D. in 1958, with a dissertation entitled "Ionium-uranium ratios in marine deposited calcium carbonate and related materials." Bill's dissertation work on U series disequilibrium was essential in establishing the Th-230/U-234 and Pa-231/U-235 dating methods, and produced some of the first Th-230/U-234 dates of Pleistocene corals. During a postdoc with Ed Goldberg at Scripps Institution of Oceanography, he made the first reliable measurements of Th-230 and Pa-231 in coastal seawater and developed the Pa-231/U-235 dating method. During his 2 years as an assistant professor at Columbia University's Lamont-Doherty Geological Observatory, he continued the development of these dating methods.



An unappreciated paper Bill presented at a University of Rhode Island conference in 1964 took a new approach to determining sedimentation rates. In this paper, Bill measured the integrated Th-230 excess as a function of depth in deep-sea cores, and calculated sedimentation rates based on the fraction of the entire inventory present in different segments. This technique has now been widely applied to Pb-210 sedimentation rates, and is known as the constant rate of supply, or CRS, model. Another finding during Bill's early work was the unexpected differences in Th-230/Pa-231 activity ratios in deep-sea core tops. Most of the cores he measured had a much higher ratio than expected. This has been explained by differences in scavenging rates for Th and Pa, and these ratios are now used to reconstruct past scavenging patterns and paleoproductivity.

Bill spent the summer of 1955 as an intern at Los Alamos, where he undoubtedly learned much. However, the most important thing he brought back from that experience was a romance with Ann Hughey, who became his wife, lifelong friend, and mother of his beloved daughters, Susan and Karen.

It was during Bill's early years as an assistant professor at Lamont-Doherty (1962–1964) that he mentored his first student, Willard S. (Billy) Moore, whose M.S. thesis was on uranium and thorium in seawater.

"He was constantly looking for new ways to make measurements and interpret data. I think a lot of my success derives from these early

lessons. Certainly my love of research was established during those 2 brief years when so much happened," Moore recalled.

Over the next three decades, Bill continued his geochemical research at the University of Tulsa, Texas A&M University, and the University of South Florida, where he focused on the use of stable isotopes to study the diagenesis of hydrocarbons. In the late 1960s, he published groundbreaking work on carbon isotope fractionation as a result of thermocatalytic generation of methane from model compounds, petroleum, source rocks, and coals. The approach used by Bill and co-authors, which resulted in a series of publications over the next 30 years, has been to study the isotopic fractionations associated with molecular structure, temperature, and catalysis. A practical application of these pyrolysis experiments was the development of the pyrolysis-carbon isotope method for determining kerogen maturity. Studies on the destruction of methane and carbon isotope exchange between methane and amorphous carbon and carbon dioxide have been applied to determining the source of methane in hydrothermal fluids. The studies performed by Sackett and co-authors on the effects of high-temperature cracking of hydrocarbons on isotope fractionation proved very useful in understanding petroleum generation, including the rate and nature of the products.

Many of Bill's students benefited from his interest in isotope geochemistry. Their theses ranged from pioneering studies of carbon-isotope fractionation during thermal cracking to an analysis of manganese nodules. Bill's pioneering research resulted in more than 25 publications over the next 35 years on the application of carbon isotopes to understanding the carbon cycle in the atmosphere, marine and fresh water, and sediments.

The Sacketts moved from Tulsa to College Station, Texas, in 1968, where Bill became an associate professor of oceanography at Texas A&M University. He stayed at TAMU for 11 years, during which he became a full professor. His mentorship helped produce 10 M.S. and 15 Ph.D. degrees. Subjects of those theses included isotopic fractionation, biogeochemistry, pyrolysis, Antarctic sediments, brines, marine pollution, and the chemistry of marine-suspended particulate matter.

Bill was not afraid to take action to right a wrong. In 1973, while on a "hydrocarbon sniffer" cruise on the R/V *Aliminos*, Bill created quite a stir when he reported the tanker ship *Texaco Montana* for cleaning its tanks and leaving a distinctive oil slick while it was anchored over a reef in the northwestern Caribbean Sea.