**ATMOSPHERIC SCIENCES**

# Reconstructing Past Global Change in Western North America

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A major effort is under way to reconstruct past changes in climate in western North America to help predict physical and biologic responses to climate. Reconstructions and modeling methods can maximize the scientific return of this effort. Paleoclimate transects are one strategy for organizing climate-related research.

by Roger Y. Anderson, University of New Mexico, Albuquerque; and Robert B. Dunbar, Rice University, Houston, Texas.

A longitudinal paleoclimate transect can be used to observe the past behavior of the Earth system and its linkages at several locations simultaneously. Reconstructing **paleoclimate records** from different areas, at annual- to century-scale resolution, allows one to observe phase relationships in dynamic components in the climate system as change over past decades to millennia. For example, comparing **El Niño Southern Oscillation**/rainfall patterns in the Pacific Northwest with patterns in the southwestern United States can help identify interdecadal modes and changes in the El Niño Southern Oscillation system.

"Past Global Changes (PAGES), a core project of the International Geosphere-Biosphere Program, is using several paleoclimate transects to study past climate. Eventually, these transects will constitute a global network of paleoclimatological sites. PEP-I is comprised of North and South America, PEP-II covers Australia and Asia, and PEP-III includes Africa and Europe.

To develop the concept, atmospheric scientists, hydrologists, biologists, paleoclimatologists, and model developers skilled in reconstructing and interpreting records of climate variability are examining the information potential of a single segment of the Americas transect. This transect extends from "Pole-Equator-Pole" (PEP) along the American continents (Figure 1) and includes marine and terrestrial aspects.

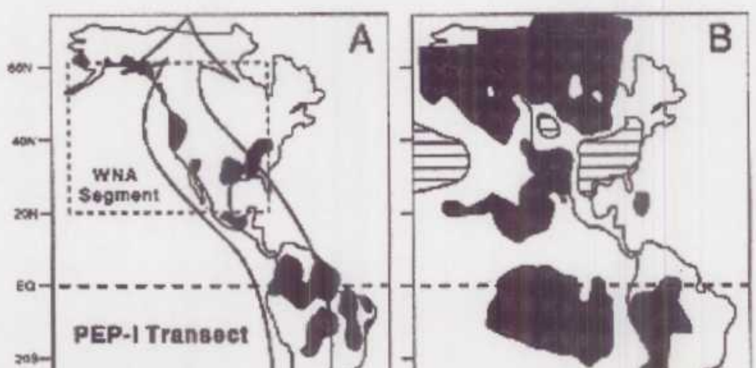
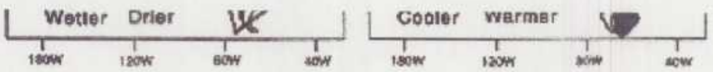



**Fig. 1.** *Western hemisphere showing PEP-I paleoclimate transect (arrow), approximate extent of the Western North America (WNA) segment, and climate anomalies since 1977. A) Anomalies in precipitation December through February, along the Americas transect. B) Anomalies in sea-surface temperature and air temperature over land, December through February. Geographic patterns of coexisting anomalies allow for comparison of instrumental records with climate changes recorded in natural archives such as tree rings, corals, and lake sediments, and also link changes in the fossil record to components of the climate system.*




Since 1977, anomalous warm, cold, wet, or dry conditions have persisted in different parts of the Americas transect and adjacent ocean areas (Figure 2). Changes in the climate of western North America have been strongly influenced by the Pacific Ocean, as reflected in instrumental indices of climate and circulation such as the Southern Oscillation Index and the Pacific North American Index. Such indices provide a means for relating longer and stronger climate changes and responses in paleoclimate records to the modern climate system. Reconstructing climate at sites along the PEP-I transect will provide data for interpreting system behavior for the time interval older than the instrumental record of ~100 years.

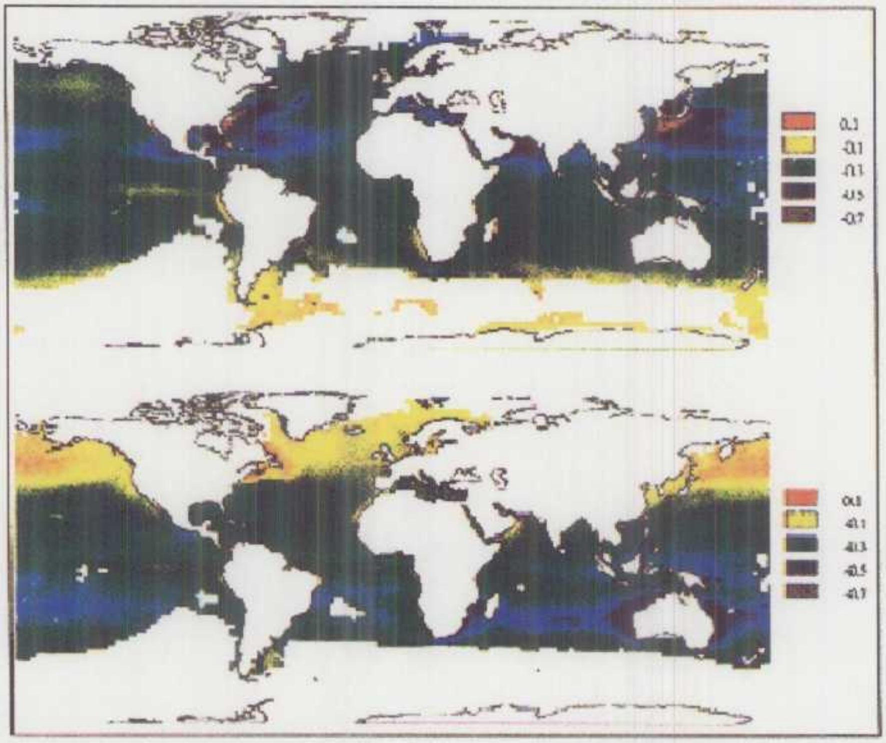


**Fig. 2**

Western North America is a favorable region for interpreting past climate records in terms of modern indices of climate change because a single climate "pacemaker"—the Pacific Ocean— influences much of the region. Although the PEP-I transect runs from pole to pole through the Americas (see Figure 2), climates along the transect are influenced by airstreams moving generally eastward from the Pacific, and in some regions by airstreams moving westward from the Atlantic. The PEP-I transect is not seen as a narrow strip. Rather, it is visualized as a wide band across the continents that has both a north-south and east-west direction. The east-west dimension allows one to compare changes over land with changes within the ocean, and thereby determine which area changed first (phase relationships). East-west comparisons also allow one to trace the effects of changes in the ocean, such as El Niño events, into the interior of continents.

Changes in climate on land are recognized in the geologic record through the use of a climate

**"proxy"** — for example, changes in lake level or changes in vegetation as recorded by fossil pollen grains. Changes in the abundance of marine organisms and their geochemistry serve as proxies for changes in ocean climate. Multiple biologic, sedimentologic, geochemical, and isotopic proxies are used to measure past changes in climatic variables such as temperature and precipitation. Proxies of climate change, when used in combination with models that simulate changes in the ocean, atmosphere, and inland lakes, provide a means for reconstructing and interpreting climate changes that took place before instrumental records were kept.

The precise timing of changes in climate, over land and in the oceans, must also be known to understand how the climate system works on the time scale of decades to centuries. Dating methods and chronological tools presently available are adequate for a coordinated effort to study past changes, and new tools on the horizon hold promise for achieving decade- to century-scale correlations of climate records from lacustrine, marine, and other environments.

## Responses to Climate Change

Past responses to climate change can also be used to estimate the effects of future changes in climate on physical and biological systems in western North America. Although the objective of understanding and reconstructing climate provides a unifying framework for regional investigation, a coordinated effort to understand and forecast the effects of climate change must also be incorporated into the design of future research.

Many of the same measurements and proxies used to reconstruct climate, such as species abundance and isotopic variations, are the main source of information about responses to climate change. Keystone species and certain keystone processes, such as fire, which are strongly linked to climate, can be used to track the response of ecosystems.

Obtaining regional information about climate and response systems, and applying it to problems of land use, conservation, etc., will cut across many scientific disciplines. New styles of collaboration must evolve from within a diverse scientific community, and flexible science management will be needed for a successful effort. Importantly, a new generation of **dynamic response models** must be developed to apply an improved understanding of climate variability to societal issues and problems.

Source: *Eos*, Vol. 76, May 30, 1995, p. 22.

## GLOSSARY

**El Niño-Southern Oscillation**

A change in the condition of the tropical atmosphere and ocean that occurs somewhat regularly, generally every 3-4 years. An El Niño "climate event" usually begins with a weakening of the trade winds and changes in atmospheric pressure over the sub-tropical Pacific Ocean, followed by a warming of the eastern tropical Pacific. The cycle or oscillation is completed by a return to stronger trade winds and a cooler ocean. The phenomenon is sometimes referred to ENSO, a contraction of El Niño-Southern Oscillation.

**Paleoclimate Record**

A record of past climatic or environmental change that has been reconstructed from geologic or other evidence. Examples include tree rings, changes in annual growth bands in corals, and changes in the composition of sediments that have accumulated in the bottoms of lakes.

**Proxy**

A substitute for the real thing. In paleoclimate studies, for example, changes in the thickness of tree rings indirectly measure the effects of changes in temperature or precipitation on tree growth (ring width). Other paleoclimate proxies include annual banding in corals, changes in the rate of sediment accumulation in lakes, etc.

**Dynamic Response Model**

Mathematic (computer) models that simulate the response of a system (for example, vegetation) over an interval of time after a change takes place in an initial condition (for example, precipitation).

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