USGS

WATER RESOURCES RESEARCH GRANT PROPOSAL

Title: Impact of Climatic Variations on Flood Magnitude and Frequencyin Three Hydroclimatic Regions of theWesternU.S.

Duration: September 1, 1997 - August 31, 1999

Federal funds requested: $133,055

Non-Federal funds pledged: $ 287,056

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Congressional Districts: Washington 04; Nevada 02

Statement of Problem:

Hydroclimatic variability over a wide range of spatial and temporal scales is directly linked to attendant variations in the magnitude and frequency of severe regional flooding events in the western U.S. Understanding this linkage is critical for i mproving flood-frequency forecasting and water resources management in this region. The spatial and temporal distributions of large floods in the western U.S, are largely controlled by persistent, anomalous patterns in hemispheric to global-scale atmosphe ric and oceanic circulation that directly influence flood-generating storm systems. Variability in flood frequency over short and long time scales thus provides an insight into variability in related larger-scale climatic phenomena over the same time scal es. Geologic evidence of paleofloods from the last several centuries to millennia reveal patterns in the magnitude and frequency of large floods that are not apparent from the relatively short stream-gage records in the western U.S. For example, paleofloo d studies in the Southwest have demonstrated that the frequency of extreme floods has varied significantly through time in direct response to climatic changes over the last 5000 years (Ely et al. 1993). This connection between floods and decadal- to cente nnial-scale climatic variations in the past has tremendous implications for probability assessments of the magnitude and frequency of future floods, especially in relation to scenarios of future global climate change.

We propose to use paleoflood analyses to compare the influence of decadal- to millennial-scale climatic variability on the magnitude and frequency of large floods on rivers in three distinct hydroclimatic regions of the western U.S' the Southwest, Nort hwest, and western Great Basin. This will be the first study to construct regional paleoflood chronologies for rivers in the Northwest and Great Basin, and this aspect of the project alone will greatly increase the accuracy of flood-frequency forecasting in these areas. In addition, our comparison of paleoflood chronologies from three areas of the western U.S. will allow us to go one step further and determine whether there are consistent, predictable, long-term similarities or differences in the occurren ce of large floods among these distinct hydroclimatic regions. Precipitation, streamflow and floods in the Northwest and Southwest tend to exhibit the opposite response to interannual variations in major large-scale atmospheric circulation patterns such a s El Nino/Southern Oscillation (ENSO), such that years of high precipitation and severe floods in the Northwest are often years of drought in the Southwest and vice versa (Redmond and Koch, 1991).

Floods in the Western Great Basin are transitional between these two end members, often coinciding with flooding in the Northwest, such as in the winters of 1964-1965 and 1996-1997, but sometimes responding independently as in the winter of 1950-1951 o r in a manner similar to the Southwest as in the winter of 1937-1938. This study will investigate whether the regional differences in the timing and controls on floods in the short-term records hold true for the response of large floods in the three regio ns to longer-term climatic variations.

Nature, Scope and Objectives

INTRODUCTION

In recent years, it has become apparent that human society is potentially capable of affecting global climate to a degree that may well exceed climatic conditions experienced within the historical period of observation (Houghton, 1996). Changes in the temporal and spatial distribution of water may be the single most important consequence of such climate change in the decades ahead. To predict with confidence the behavior of the hydrologic system under a scenario of altered climatic conditions we must u nderstand more fully the hydrologic responses to different environmental conditions. The rare, catastrophic events that characterize the upper extremes of the hydrological system are the least understood and the most difficult to study through traditional methods of direct observation (Baker,1987). Paleohydrologic data that reflect the occurrence of actual extreme floods in the past provide the only means to capture the natural range of variability exhibited by this most critical aspect of the hydrologic system.

Past research has shown that in certain regions, including the southwestern U.S., large floods tend to cluster in time in response to variations in climate at time scales of 100s to 1000s of years (Knox, 1983,1993; Enzel, 1992; Ely et al., 1993, 1996). Our proposed study will be the first to compare the temporal variations in the occurrence of large floods in more than one region of the western U.S. The observed relationships between floods or streamflow in different hydroclimatic regions of the wester n U.S. on an annual scale (Cayan and Peterson, 1989; Cayan and Webb, 1992; Redmond and Koch, 1991) do not necessarily predict the relationship between floods in different hydroclimatic regions over time scales that encompass variations in mean climatic co nditions. Analogies with the modem record suggest that past periods of frequent large floods in the Southwest could coincide with a decrease in severe floods in the Northwest and Great Basin. On the other hand, periods of high climatic variability lasting 1 Os to 100s of years could lead to an overall increase in floods in separate regions that have a very different precipitation response to annual forcing mechanisms. Understanding of these basic questions is integral to a comprehensive long-range strateg y for water-resource management across the western U.S. We have chosen preliminary study sites in three distinct hydroclimatic regions of the western U.S (Fig, 1). High-magnitude flooding on large rivers in each region often results from similar anomalous large-scale atmospheric. circulation patterns. All or part of each region is also characterized by physiographic conditions that are demonstrably conducive to the accumulation and long-term preservation of paleofiood deposits along major rivers. Taken to gether, these two points ensure that long records of high-magnitude flooding in each region from identifiable processes can be compiled. We will use research documenting the relationship between paleofloods and climate change in the southwestern U.S. over the last 5000 years (Ely, 1992; Ely et al., 1993) as a springboard for this regional comparison. In recent years, several paleoflood studies of individual rivers in the western U.S have been performed for various engineering, geomorphic, and archaeologic purposes. The synthesis of these records in conjunction with a few carefully chosen sites on additional rivers makes a comparative study of this magnitude feasible for the first time in the western U.S.