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AN ORGANIZED SIGNAL IN SNOWMELT RUNOFF OVER THE WESTERN UNITED STATES[1]

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ABSTRACT: Daily-to-weekly discharge during the snowmelt season is highly correlated among river basins in the upper elevations of the central and southern Sierra Nevada (Carson, Walker, Tuolumne, Merced, San Joaquin, Kings, and Kern Rivers). In many cases, the upper Sierra Nevada watershed operates in a single mode (with varying catchment amplitudes). In some years, with appropriate lags, this mode extends to distant mountains. A reason for this coherence is the broad scale nature of synoptic features in atmospheric circulation, which provide anomalous insolation and temperature forcings that span a large region, sometimes the entire western U.S. These correlations may fall off dramatically, however, in dry years when the snowpack is spatially patchy.

(KEY TERMS: hydroclimatology; surface water hydrology; water management; snow hydrology.)

INTRODUCTION

Climate, the major source of variability in our nation's water resources, poses major challenges for water-resource and ecosystem management programs. In the western United States, a realistic assessment of water availability must accommodate linkages between climate, water, and energy along river corridors extending from mountain ranges to the coastal ocean. No segment within each corridor is independent of the others. That is, impacts and responses to climate variability and change in one segment cannot be assessed separately from others. Further, in the west, nearly half or more of the fresh water discharge is snowmelt (Serreze *et al.*, 1999). The snowmelt/discharge process is complex (Hartman *et al.*, 1999) and needs to be studied at all scales.

In general, large-scale regional studies of climate-river basin connections have focused mostly on monthly to interannual to decadal time scales (Cayan, 1996), while atmospheric/hydrologic processes at shorter time scales are generally studied at the catchment scale (c.f., Hardy *et al.*, 1998). The problem of connecting atmospheric conditions to river discharge on a regional scale is simplified by focusing on a major mode of variability. In this study we investigate variations in air temperature as a large-scale control on runoff fluctuations during the critical spring snowmelt season. Solar insolation, the important driving variable behind snowmelt discharge (Leavesley *et al.*, 1983), and which covaries with air temperature, is not considered because radiometer records are not sufficient to form a high elevation network.

In this paper we describe an observationally based study that examines a simplified snowmelt/discharge cycle, highly correlated daily-weekly fluctuations in snowmelt discharge among river basins in the upper Sierra Nevada and their strong correlation with air temperature, and the possible extension of such correlations to distant mountains. We conclude with a discussion of the implications of our study that are relevant to the management of water resources. Our study area includes ten stream-flow gaging stations (Figure 1) with primary focus on the Merced River at Happy Isles, Yosemite National Park, California.

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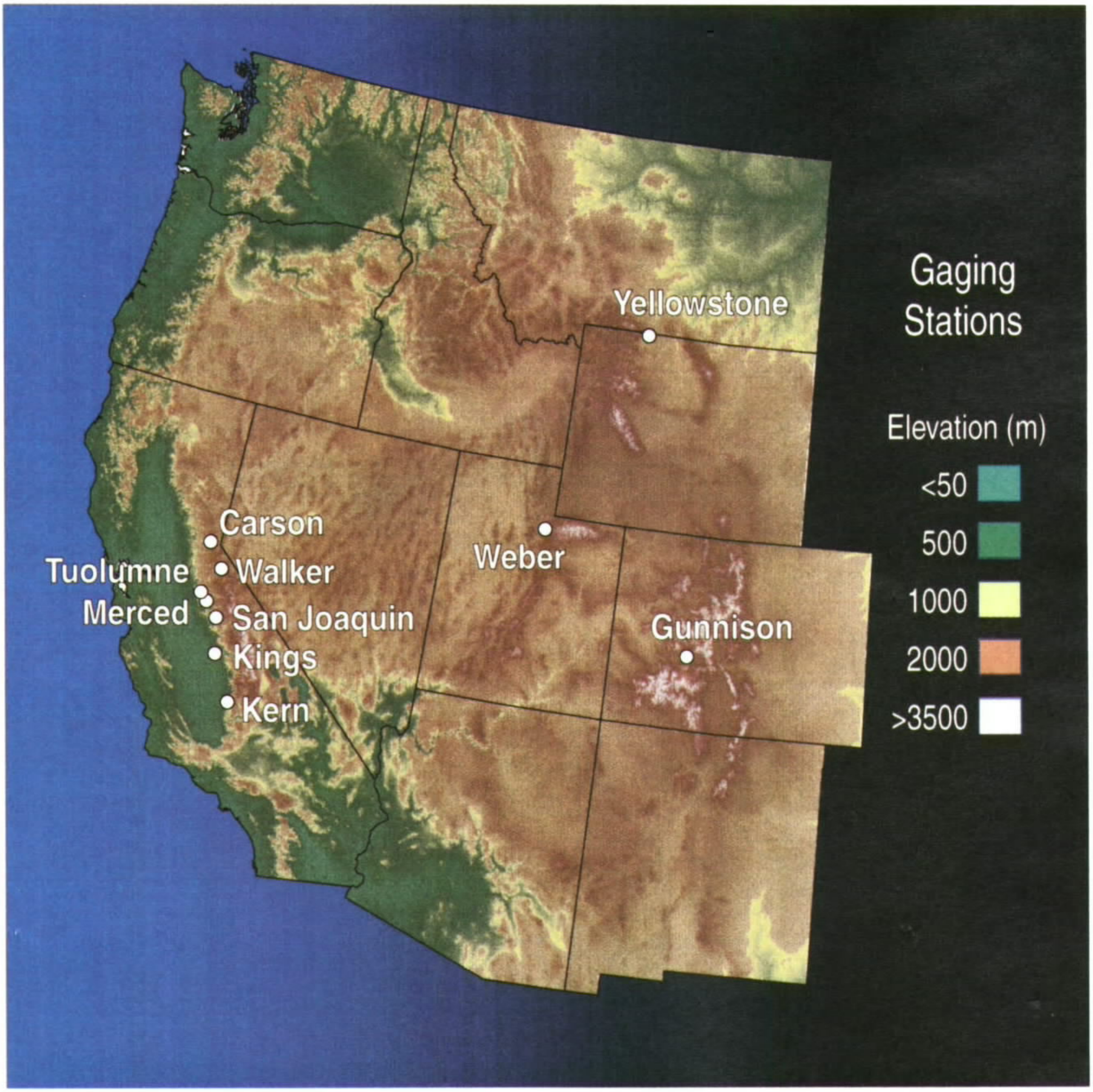
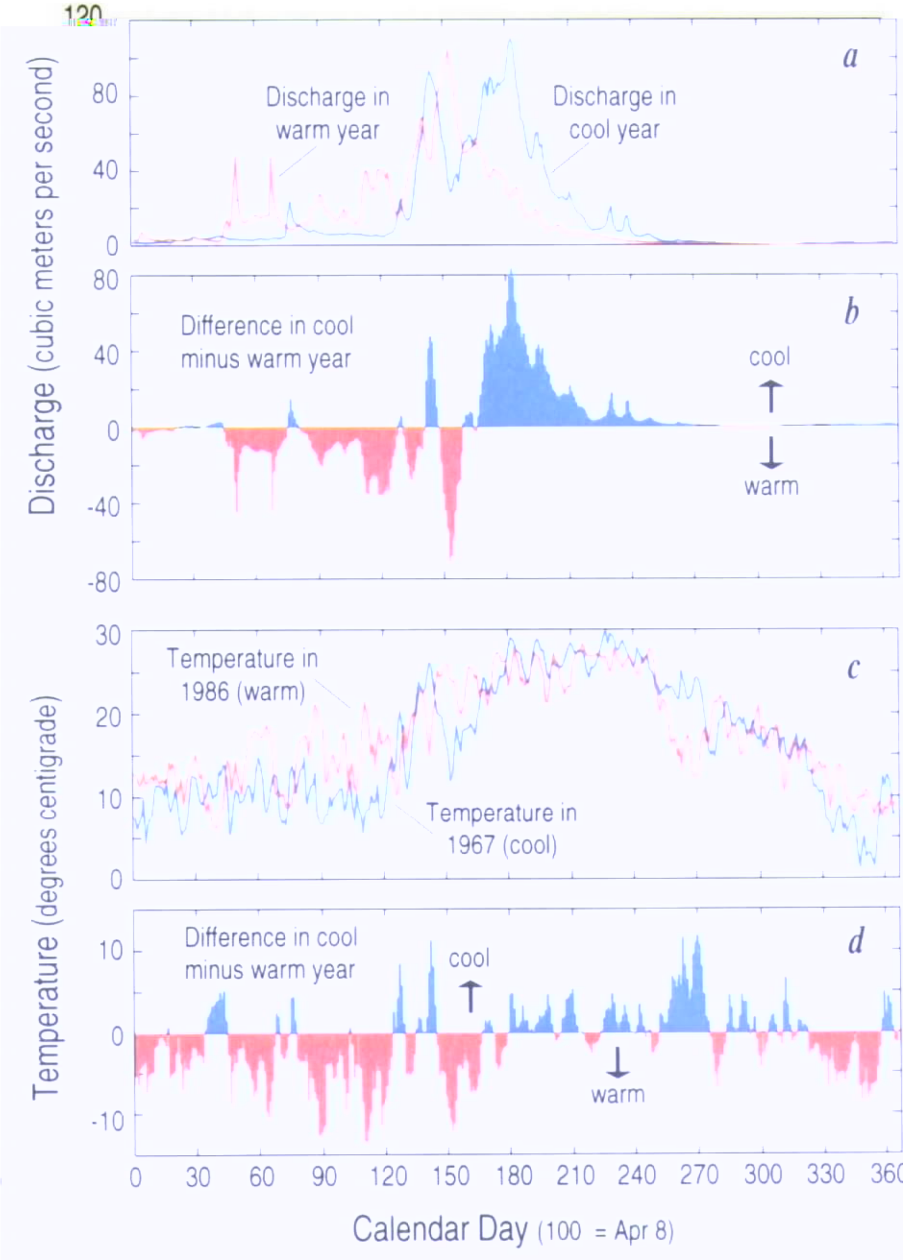

Gaging Stations
Yellowstone
Carson
Tuolumne
Walker
Merced
San Joaquin
Kings
Kern
Weber
Gunnison
Elevation (m)
<50
500
1000
2000
>3500


120
a
Discharge in warm year
Discharge in cool year
80
40
0
b
Difference in cool minus warm year
cool
warm
80
40
0
-40
-80
Discharge (cubic meters per second)
c
Temperature in 1986 (warm)
Temperature in 1967 (cool)
30
20
10
0
d
Difference in cool minus warm year
cool
warm
10
0
-10
Temperature (degrees centigrade)
0
30
60
90
120
150
180
210
240
270
300
330
36
Calendar Day (100 = Apr 8)