The paleo-upwelling record from a northern California shell midden: the sensitivity of climate to solar forcing

Renee K. Takesue

Traditionally it is thought that long-term variations in earth's climate are caused by orbitally–induced changes in solar radiation and the amplifications that result (e.g. Hays *et al,* 1976; Hansen *et al.* 1997]. However, large and abrupt fluctuations of climatological parameters in polar ice and marine sedimentary records suggest that other processes, such as changes in ocean circulation or ocean-atmosphere interactions, may also have a significant influence on climate [Raynaud *et al.,* 1993; Broecker, 1997]. One way to assess the sensitivity of climate to solar forcing is to determine how climate varied in the past with changing insolation. Conditions since the beginning of the Holocene (10 ka) are appropriate for this kind of test, since northern hemisphere mid-latitude summer insolation has been declining from a maximum that was 8% greater than today 11,000 years ago (Crowley and North, 1991] while other boundary conditions such as ice volume and atmospheric greenhouse gas concentrations were similar to pre-industrial values [Kutzbach *et al.,* 1998). An 8% increase in solar radiation is expected to have a significant effect on climate, considering that general circulation models with full feedbacks predict the surface of the earth must warm by at least 2°C in order to balance a 2% increase in solar insolation [e.g. Hansen *et al,* 1997 and references therein].