Climate change, coastal cloud cover, and vegetation: will California's current distribution of native plant species soon be a foggy memory?

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The distributions of many native Californian plant species are limited to California's coastal fogbelt, which extends from the Pacific Ocean to roughly 20 mi. inland. Fossil records and pollen buried in lake-bed and ocean-floor sediments long ago indicate that many of these species, such as coast Redwood, Douglas fir, and Bishop pine have been more widespread to the south during times when climate was cooler and wetter than it is now. This means that distributions of many coastal plant species are elastic and that their southernmost populations are probably more drought stressed than those to the north. It has long been speculated that the persistent fog and overcast typical of coastal Californian summers reduces otherwise fatal drought stress for many of these southern populations by providing moisture and shade.

However, airport cloud records document changing cloud behavior at several sites along coastal California since the 1940s. Fog events have decreased at several sites and there has been a documented rise in spring and summer cloud-base height in Santa Barbara. The reason for this change is unclear, as cloud response to global climate is still poorly understood. My preliminary analysis, however, indicates connections between Santa Barbara fog frequency and large-scale patterns of atmospheric pressure and sea surface temperature. It seems possible then that populations of native, fog and stratus-dependent coastal plant species may find their future survival at the mercy of changes in global climate. The proposed research will address three general questions: (1) Where and how much have cloud height, timing, and frequency changed since modern meteorological records began? (2) Why are they changing? (3) What and where are the plant communities that will be impacted by these changes? My ultimate goal is to show Californian's how global climate phenomena have affected local atmospheric behavior and how local atmospheric changes will likely have large impacts on what can grow where.

To answer the first question, I will perform a detailed analysis of cloud-height data from multiple coastal airfields to determine specifically how cloud behavior has changed in recent decades. I recently determined coastal cloud cover to be linked to large-scale climate systems. I will identify the components of the of the large-scale climate system such as atmospheric pressure, sea surface temperature, and temperature inversions that affect cloud cover at each airport analyzed using global and national datasets. To determine where and which plant communities are most sensitive to cloud frequency, I will conduct a variety of ecological studies, each of which I have begun. For the first, I will collect and analyze tree-ring widths and chemical properties to determine whether there is a northern or southern boundary where fog deposition and cloud shading become negligible to tree growth. My previous tree-ring studies of pines on the northern Channel Islands show incredible sensitivity to year-to-year variations in summer fog and cloud cover. Second, I will evaluate drought stress (through carbon-13 analysis) of Manzanita individuals growing along the steep, coastal cloud gradients. The third study will employ cloud-frequency maps of California's coastline that I have generated using satellite imagery to determine how well spatial gradients in cloud-cover regularity can explain spatial gradients in the density of many native Californian plant populations.