THE IMPRINT OF GLACIAL ISOSTATIC ADJUSTMENT ON U.S. WEST COAST RIVERS

Over an ice age, the loading and unloading of continental ice sheets causes solid Earth deformation, resulting in hundreds of meters of sea-level variation across the globe. This process of glacial-isostatic adjustment (GIA) produces patterns of geographically variable sea-level change that are particularly pronounced in regions close to past ice sheets, including on the U.S. west coast[1,2]. To date, the evolution of U.S. west coast rivers in response to spatially variable sea level has not be explored despite the fact that GIA produces uplift and subsidence that outpace tectonic uplift rates by over an order of magnitude. Remarkably, rates of coastal tectonic uplift on the west coast of the U.S. are largely spatially uniform[3,4]. Hence, uplift rates induced by GIA, which, in addition to eclipsing tectonic uplift rates, vary in sign from northern Washington to southern California (Figure 1), may represent the dominant control on the recent evolution of rivers.

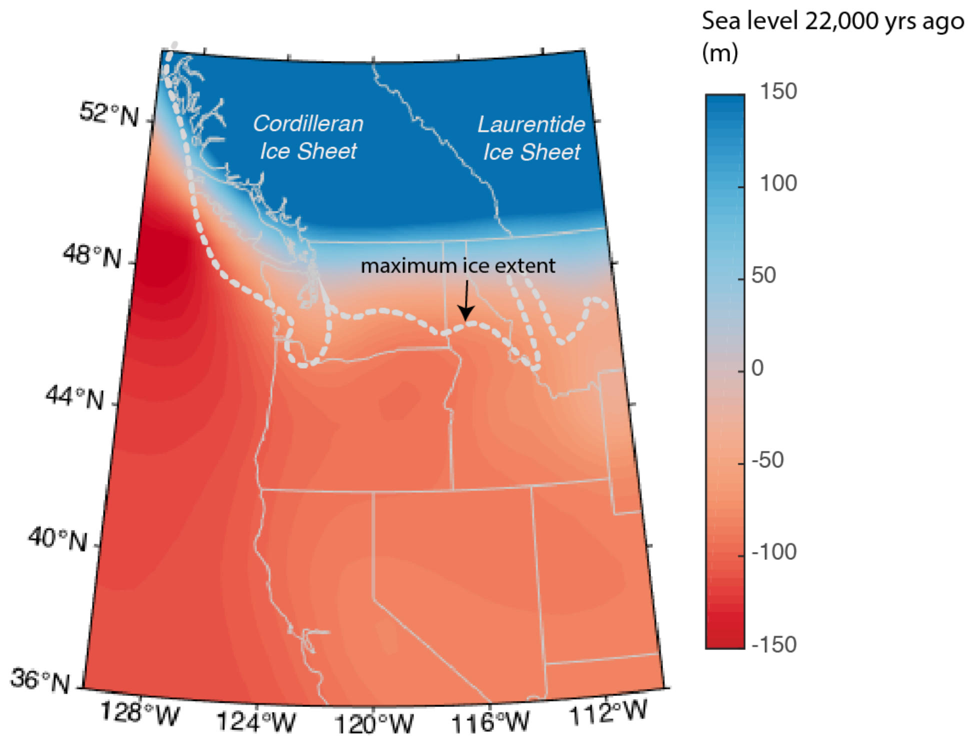

Figure 1 | Change in sea level 22,000 yrs ago relative to today. Red regions have experienced a sea-level rise (subsidence) from 22,000 yrs ago to today, whereas blue regions have experienced a sea-level fall (uplift).

I propose to model the influence of glacial isostatic adjustment on U.S. west coast rivers. Over the last ice-age, northern Washington subsided under the weight of continental ice sheets, causing sea level to be higher by > 100 m at 22,000 yrs ago (Figure 1). In contrast, regions in the vicinity of the ice sheet load, including Oregon and California, were uplifted by > 100 m (Figure 1). Changes in topography, such as tectonic uplift or sea-level change force rivers to respond dynamically[5,6]. Sea-level fall triggers erosion, whereas sea-level rise floods the coast, producing estuaries and wide floodplains[7–9]. These processes exert a basic control on river topography, ecology, and thus early human settlement[10]. Nevertheless, coastal landscape evolution in the western U.S. has not yet been linked to GIA. Through my Ph.D I gained expertise in modeling both GIA and landscape evolution. My interdisciplinary approach, the first to quantitatively measure the influence of ice-age surface deformation on river dynamics, uniquely positions me to investigate this question.

Aim 1: Improve ice history constraints

Understanding the erosional response of rivers to spatially variable sea level requires an accurate history of the growth and decay of ice loads. During my Ph.D I developed a new ice model for the glaciation of the eastern Laurentide Ice Sheet and the deglaciation of the Cordilleran and Western Laurentide Ice Sheet[11,12]. Using a refined history of ice cover will produce accurate shoreline predictions along the U.S. west coast over the ice age, which is crucial to modeling a river's response to elevation changes.

Aim 2: Quantify river response

River mouths contain evidence of past sea-level change[6]. Estuaries develop where sea-level rise has occurred[13]. Further, the bottom of the flooded river valley at these locations should reflect the elevation of the river mouth during the time corresponding to the lowest sea-level[14]. As sea level falls, rivers erode into bedrock[9].

I hypothesize that rivers from north to south should record a pattern of spatially variable sea-level change along the U.S. west coast through the depth of flooded valley bottoms, and the presence or size of estuaries in regions that experienced sea-level rise. Using the shorelines predicted in *Aim 1*, I will model the location and elevation of river mouths during the lowest point of sea level. Next I will compare these modeled river mouth locations to observations of estuaries[15], and buried valley bottoms in river channel profiles, using seismic reflection data[16], drill cores[17], and valley morphology[18]. The proposed research quantifies the response of rivers to spatially variable sea level, a subject that has been unexplored in previous studies, although it is fundamental to the ecology, archaeology, and topography of the western U.S.

GENDER & RACE IN GEOSCIENCE

Seeking to better understand and address the persistent underrepresentation of women and minorities in the geosciences drove me to pursue research in feminist science studies, through a Ph.D. concentration in Women, Gender, and Sexuality Studies. In this stream of my research, I use quantitative and qualitative methods to document and analyze how social conventions and cultural practices affect the retention of women and underrepresented minorities in geosciences.

In one study, I investigated the representation of women as first authors, and found a large first-authorship gender gap. I used webscraping-techniques to compile the names of first authors for the last five years (n = 32408) in 13 leading geoscience journals. I classified the likely gender associated with the name using a database across 89 languages. I found that female-name first authors represent less than 25% of total first authors in the majority of journals analyzed (10/13), a result I presented at the AGU Fall Meeting 2018 and that is currently under review at *PLOS ONE*.

Broadly, I am interested in understanding the origins of dominant cultural norms in geoscience that continue to impact women and minority geoscientists. I am interested in how practices in 19th century American geology continue to shape cultural norms and training of geoscientists today. For example, in an article published by *Scientific American*, I researched the 1869 Powell Expedition to the Grand Canyon, a formative event in American geology and demonstrated how this expedition participated in scientific racism [19].

Future work will focus on cultures around harassment in modern geoscience fieldwork. Specifically, by analyzing the use of sexual metaphors in geology I will identify how "field speech" mirrors cultures of masculinity embedded in the discipline, connecting to 19th century geologic literature to unroot the origins of such sexualized language[20]. Another future project, "Landscapes of Difference", aims to explore the role of scientific racism in shaping geology as a discipline, exposing foundational American geologists' involvement in studies of racial typology, which fueled the eugenics movement. At UCSC I am eager to continue this research, which will benefit from connection with Feminist Studies and the History of Consciousness departments with strong traditions in feminist science studies, and the Science and Justice Research Center.

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