

Bridging geophysics, paleoclimate, and landscape studies, this interdisciplinary thesis examines critical moments during the last ice age, employing geophysical simulations of glacial isostatic adjustment and non-traditional geologic sea-level records to revise models of both ice growth and decay, with implications for global climate. In particular, by simulating river responses to solid Earth deformation over the ice age, I demonstrate that past landscapes constitute a unique and novel constraint on former ice sheets. This thesis focuses on North American ice sheets, considering both the build-up of ice sheets leading to the Last Glacial Maximum (26,000 years ago), and the subsequent disintegration phase, characterized by rapid global sea-level rise.

First, I revisit two topics of considerable debate: the timing of both the expansion of the ice-free corridor between the two North American ice sheets and the flooding of the Bering Strait. I use observations of the Bering Strait flooding as sea-level indicators to fingerprint a significant source of ice melt from an expanding ice-free corridor during the interval 13,000-11,500 years ago. Ice melting of this region induces a regional sea-level fall, explaining the observed two-phased flooding history of the Bering Strait. Further, this melt introduces a large freshwater flux into the Arctic, reducing the vigor of the Atlantic Meridional Overturning Circulation, and providing a trigger for the Younger Dryas cold episode (13,000-11,700 years ago).

Next, I turn to the time period of glacial build-up preceding the Last Glacial Maximum (60,000 to 26,000 years ago). I use sea-level markers in the Bohai Sea, China dated to 50,000-35,000 years ago to derive an estimate of peak globally averaged sea level, and find that global ice volumes may have increased three-fold in the 15,000 years leading into the Last Glacial Maximum. Moreover, to partition global ice volumes during the glacial build-up phase into contributions from regional ice sheets, I analyze sea-level markers dated to 50,000-35,000 years ago at North Carolina and Virginia to infer the growth history of the North American ice sheet in eastern Canada. I conclude that this ice sheet experienced a phase of very rapid growth in the 15,000 years leading into the Last Glacial Maximum.

A fast growing North American ice sheet initiated uplift along the U.S. east coast as the solid Earth adjusted to an expanding ice load at rates of 10 mm/yr, matching or exceeding rapid tectonic uplift rates. I force a landscape evolution model with predictions of glacial isostatic adjustment, to show that a late and rapid glaciation of the Laurentide Ice Sheet is consistent with producing the eastward diversion of the Hudson River at 30,000 years ago observed in the geologic record. Moreover these simulations provide a mechanism that explains abrupt changes in river dynamics observed across the U.S. mid-Atlantic in the Delaware, Susquehanna, and Potomac rivers.