Driving mechanisms of sea-level variability in the U.S. mid-Atlantic during the last millennium

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Last millennium relative sea-level (RSL) changes along the U.S. Atlantic coast are spatially variable. Glacial isostatic adjustment (GIA) has been a significant driving factor in RSL rise during the last millennium, producing maximum rates of vertical land motion in the mid-Atlantic region due to its proximity to the margin of the former Laurentide Ice Sheet. However, there is uncertainty surrounding the influence of other regional and local processes on RSL changes such as ocean and atmosphere circulation dynamics; gravitational, rotational, and deformational signals associated with ice mass and distribution changes; sediment compaction; and tidal range change.

Here, we examined the high spatial density of high-resolution RSL records along a ~200 km stretch of coastline from New York City to southern New Jersey to distinguish between local, regional, and global scale drivers. We produced a new high-resolution (decimeter vertical, decadal temporal) RSL record of the last millennium in northern New Jersey and integrated it into an updated global database of instrumental and proxy sea-level records of the Common Era. We used a spatiotemporal empirical hierarchical model to estimate past RSL and rates of RSL change and their associated uncertainties in the context of broader regional changes by decomposing the records into global, regional linear, regional non-linear, and local components.

We found that RSL in northern New Jersey continuously rose over the last 1000 years at a rate of 1.2 ± 0.2 mm/yr (2σ) from 1000 to 1700 CE before increasing to 1.3 ± 0.7 mm/yr from 1700-1800 CE to 1.8 ± 0.6 mm/yr from 1800-1900 CE to 3.0 ± 0.6 mm/yr from 1900-2000 CE. Most of the RSL rise during the past 1000 years is attributed to regional-scale linear processes that we interpret primarily as GIA. The linear component of the RSL records exhibits a north to south gradient, with a greater contribution of RSL rise in southern New Jersey and a smaller contribution in New York
City. The regional-scale non-linear contribution from the records have a magnitude <10 cm and are nearly identical because they fall within the same regional scale determined by the spatiotemporal model. The rate of the regional non-linear component fluctuated between -0.1 and 0.1 mm/yr until the late 19th century when it increased to a rate of 0.6 ± 0.1 mm/yr in the late 20th century. These trends are likely explained by a combination of physical processes, including the evolving mass of the Greenland Ice Sheet, steric effects, or ocean mass changes from atmospheric circulation and ocean currents. The local-scale contribution is <10 cm at all sites, but varies in magnitudes and rates of change, which may be due to sediment compaction or tidal range change.