When projecting coastal resilience, sediment compaction is key

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River deltas like this one in the Lower Cook Inlet of Alaska's Kachemak Bay grow as sediments are deposited, although this deposition also compacts layers below the surface. Credit: Alaska ShoreZone Program NOAA/National Marine Fisheries Service (NMFS)/Alaska Fisheries Science Center (AKFSC), courtesy of Mandy Lindeberg, NOAA/NMFS/AKFSC, CC BY 2.0

Coastlines are among Earth's most dynamic environments. Tidal action, river sediment deposition, erosion, decomposition of organic matter, and more combine to create constantly evolving landscapes.

These processes tend to produce loose agglomerations of sedimentary material containing a relatively large fraction of empty space between particles. And all this void space means that as new material accumulates at the surface, underlying layers typically compress, a process known as autocompaction. Past studies of changing coastal environs have tended to underestimate the importance of sediment compaction, however, because they have relied on field sampling of surface-level soils or on simplifications in numerical models.

Overlooking sediment compaction may be particularly problematic in studying and projecting marshland resilience to sea level rise. As climate change drives increases in ocean volume, marshes will need to accumulate new material at rates sufficient to keep up with the rising water, or they will be inundated. But those sedimentation rates may be underestimated if compaction is not taken into account.

In a paper recently published in the *Journal of Geophysical Research: Earth Surface*, Xotta et al. addressed this problem by developing a new computer model, called NATSUB3D, to study landform evolution comprehensively. Building on the earlier NATSUB2D model, they took a Lagrangian approach, constructing a 3D finite element simulation that combines a 3D groundwater flow model with a 1D geomechanical simulation.

The team applied the model to three scenarios in which sedimentation compaction is common: the growth of a tidal marsh, the filling of an oxbow lake, and the evolution of a delta lobe. The scenarios spanned several orders of magnitude in spatial scale.

In each case, the researchers observed that compaction played a significant role in the evolution of the landform. The magnitude of autocompaction varied significantly depending on sediment and substrate composition, as well as with the time-varying rate of deposition. The spatial variability of deposition and compaction in the scenarios highlights the necessity of a 3D approach.

The study's results indicate that sediment compaction should not be neglected when projecting shoreline resilience to sea level rise, the researchers say. Indeed, many of the most sensitive ecosystems, such as salt marshes, are among the most susceptible to compression.

More information: R. Xotta et al, Modeling the Role of Compaction in the Three-Dimensional Evolution of Depositional Environments, *Journal of Geophysical Research: Earth Surface* (2022). DOI: 10.1029/2022JF006590

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