Estimating Sediment Input to Chesapeake Bay from Tidal Shoreline Erosion

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Modeling Workgroup
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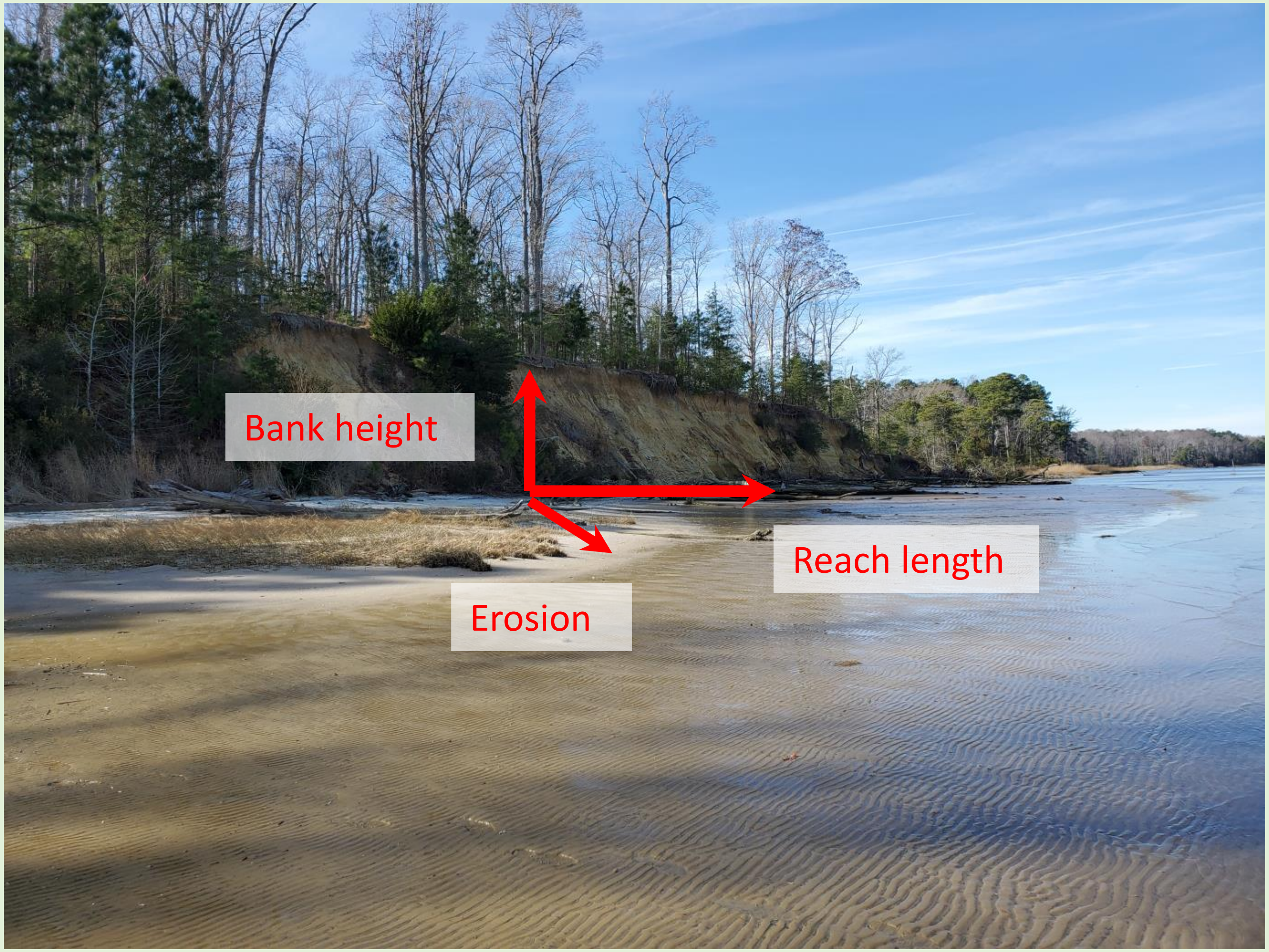
James River, VA

Local sediment input from bank erosion



bluffs along James River

Calculate volume of sediment:
shoreline erosion (m/yr) * bank height (m) * reach length (m) = m3/yr

Convert volume to mass using bulk density:
sediment volume (m3/yr) * bulk density (kg/m3) = sediment load (kg/yr)

Bulk density is very important but problematic. There are never enough measurements!

Some older studies in MD collected bulk densities in the coastal bays. Noe et al. (2022) collected multiple samples in Chesapeake Bay watershed.

Unsure if there are any recent studies quantifying bulk density values for tidal river banks in the Bay, especially over large areas, or if there have ever been any studies on the spatial variability in bulk densities. (Please contact me if you have info.)

Methodologies for collecting some of the components have changed over time, and work well for large study areas.

For shoreline erosion using satellite imagery instead of shore-normal transects from aerial imagery (eg DSAS). Can also use lidar data to generate a shoreline, but results are very noisy.

For bank heights using topographic lidar or drones.

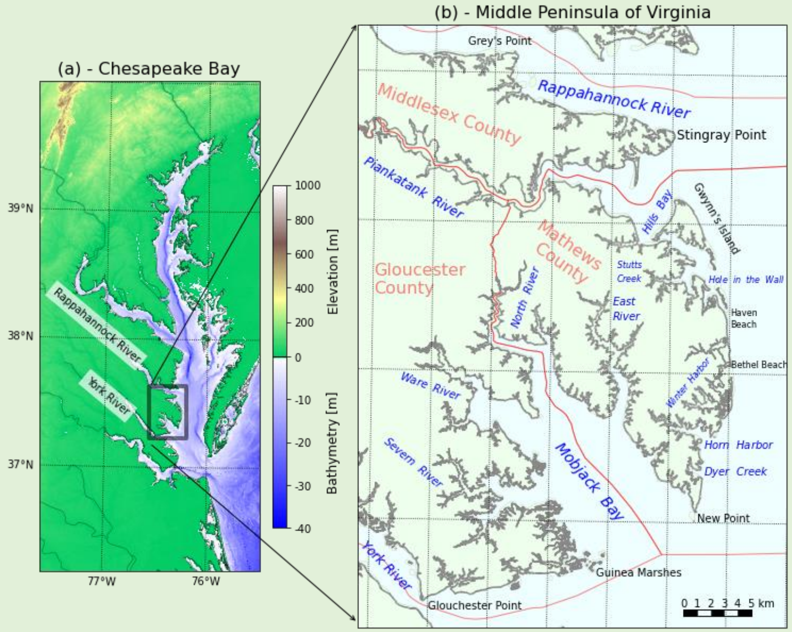
Machine learning and AI are also new entries.

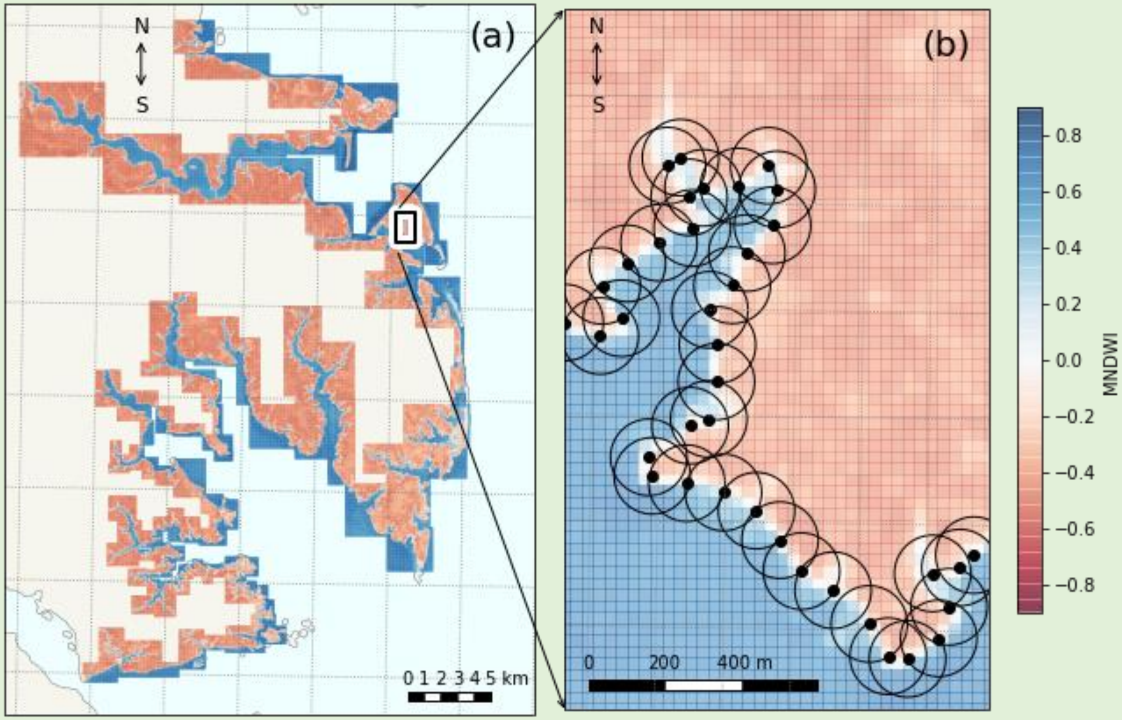
Today, briefly looking at my recent work, on two very different scales:

- Estimating shoreline erosion rates with satellite imagery
- Monitoring bluff erosion and measuring bank heights using drone structure-from-motion, and ground-based lidar with USGS colleagues

Nezlin, Nickolay P., Julie D. Herman, Jonathan Hodge, Stephen Sagar, Robbi Bishop-Taylor, Guangming Zheng, Paul M. DiGiacomo. 2023. Assessment of changes of complex shoreline from medium-resolution satellite imagery. Estuaries and Coasts, in review. nikolay.nezlin@noaa.gov

- Erosion rates from satellite imagery were compared to those calculated using historical aerial images.
- Used Landsat and Sentinel-2 imagery (30m pixels) to assess tidal shoreline changes, including both straight and complex shorelines.
- Study area was Middle Peninsula, Virginia (lower Chesapeake Bay)



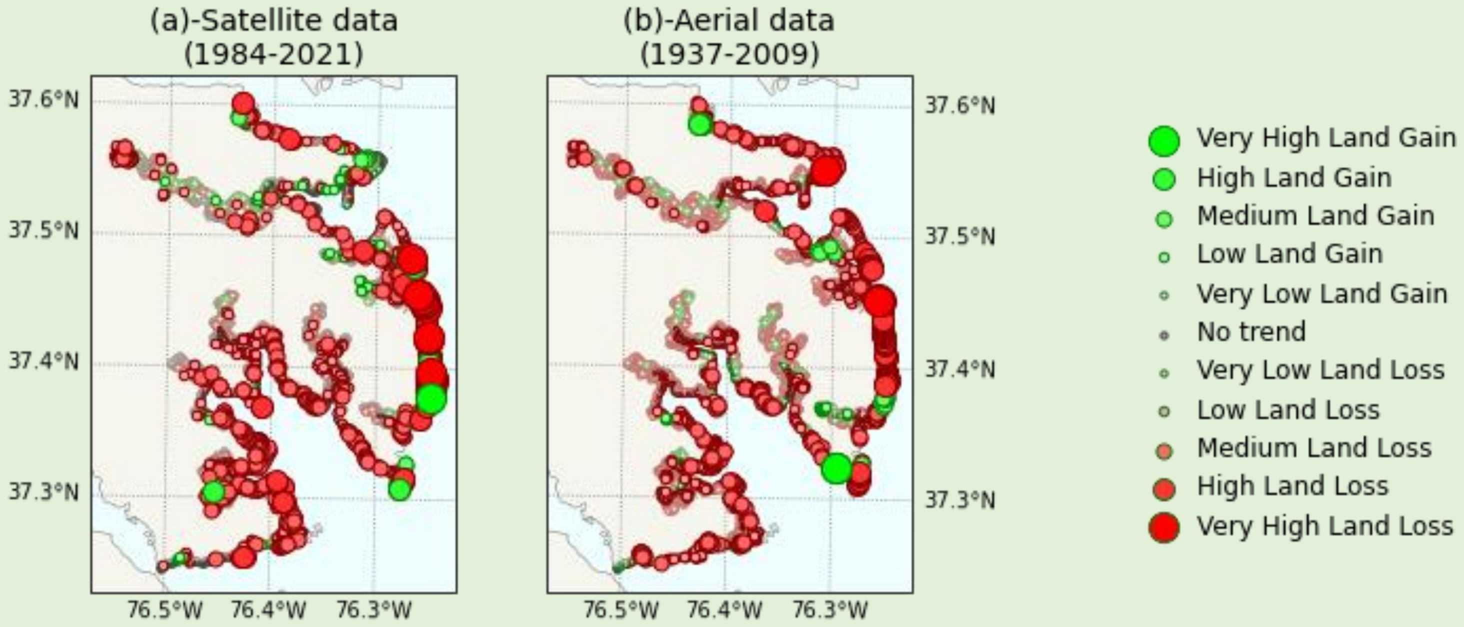


Pixels were classified as “land” or “water” using the Modified Normalized Difference Water Index (MNDWI) (Xu, 2006), also called Land Surface Water Index (LSWI) (Xiao et al., 2002; Bera & Maiti, 2019). Positive MNDWI values indicate water, negative values indicate a non-water or land surface and the maximum MNDWI gradient between them indicates shoreline.

The rates of change (land loss, no change, land gain) of the numbers of “land” pixels in the circles (pixels/yr) were transformed to linear measures of shoreline change (m/yr) comparable to the rates obtained in the studies based on cross-shore transects.

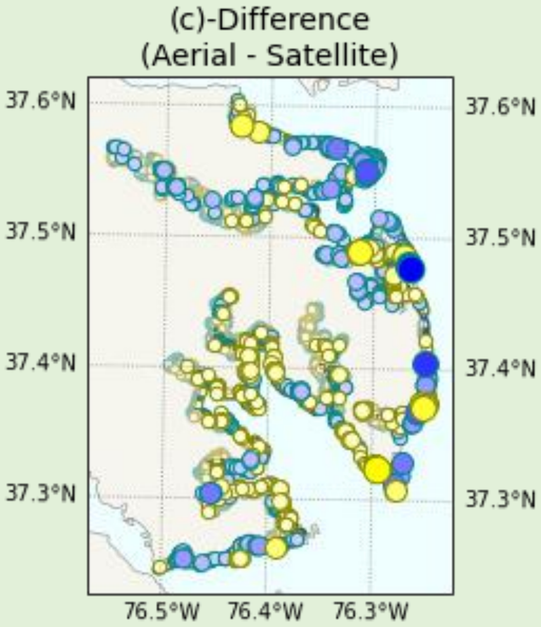
The range of shoreline change rates detected from satellite data (1984–2021) was comparable to the rates detected from aerial photography analysis (1937-2009) done by the Shoreline Studies Program at VIMS.

Spatio-temporal patterns of shoreline change were analyzed with Empirical Orthogonal Functions, showing differences between satellite and aerial assessments.



The colors and sizes indicate the contribution of that location to the temporal variations of the EOF mode

- The maps of the grades of shoreline evolution obtained by both methods were similar
- Maximum changes (mostly “land loss/erosion”) along exposed reaches of shoreline
- Few locations demonstrate evident disagreement probably resulting from the differences in the periods of assessment.



Darker blues more negative difference. Darker yellows more positive difference.

The comparison of shoreline change demonstrates reasonable agreement with traditional aerial assessments, considering differences in the analyzed time periods and the accuracy of land-water edge detection. The methodology is useful for large areas and complex shorelines.

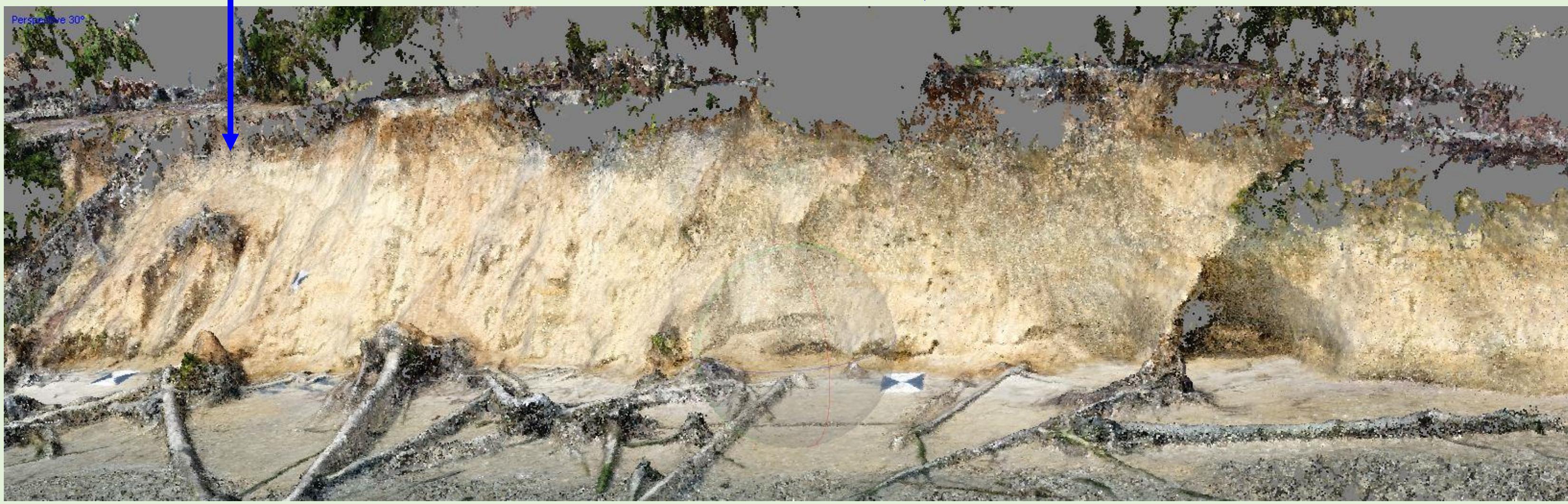
York River point clouds from Drone data

Draft data

2018

Bank erosive feature

Footholes cut in bank



2020

Bank erosive feature infilled

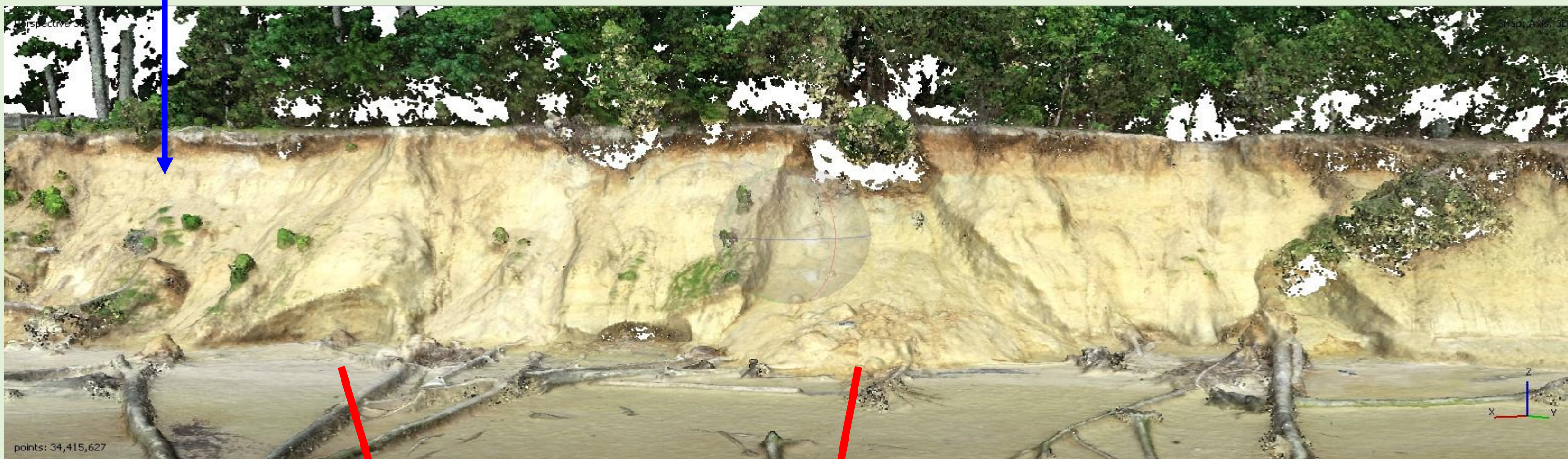
Slump and loss of some holes in bank

Undercut bank

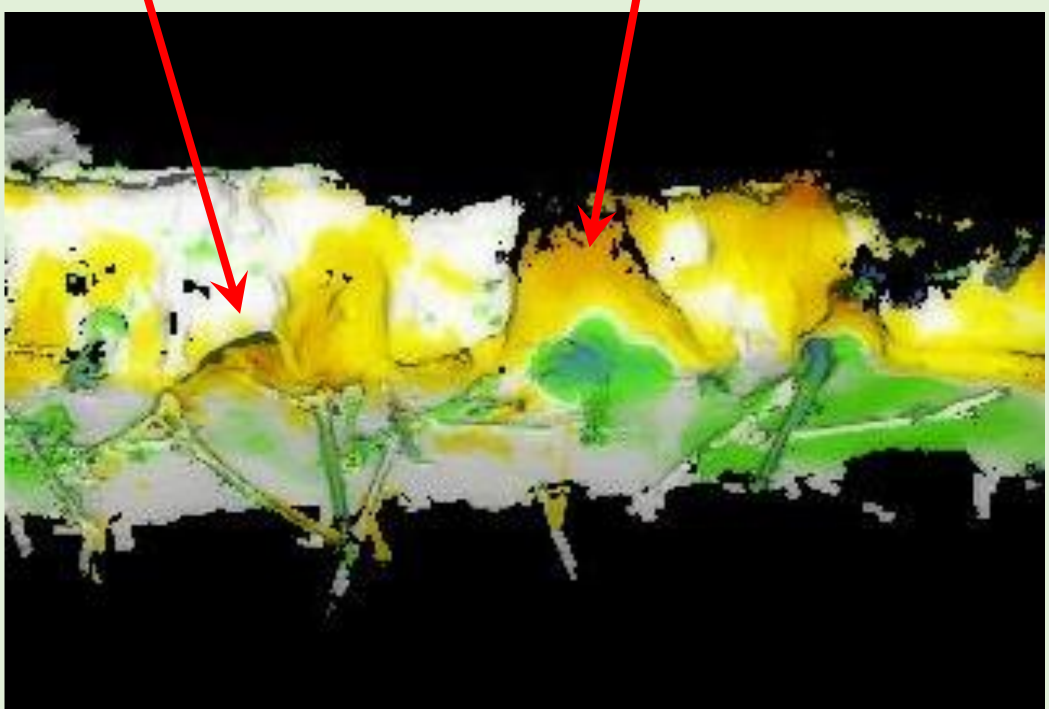
2020

Bank erosive feature infilled

Slump and loss of some holes in bank



Change detection—2018 to 2020



Changes in banks can be quantified. Green is accumulation; yellow is erosion.

Draft data

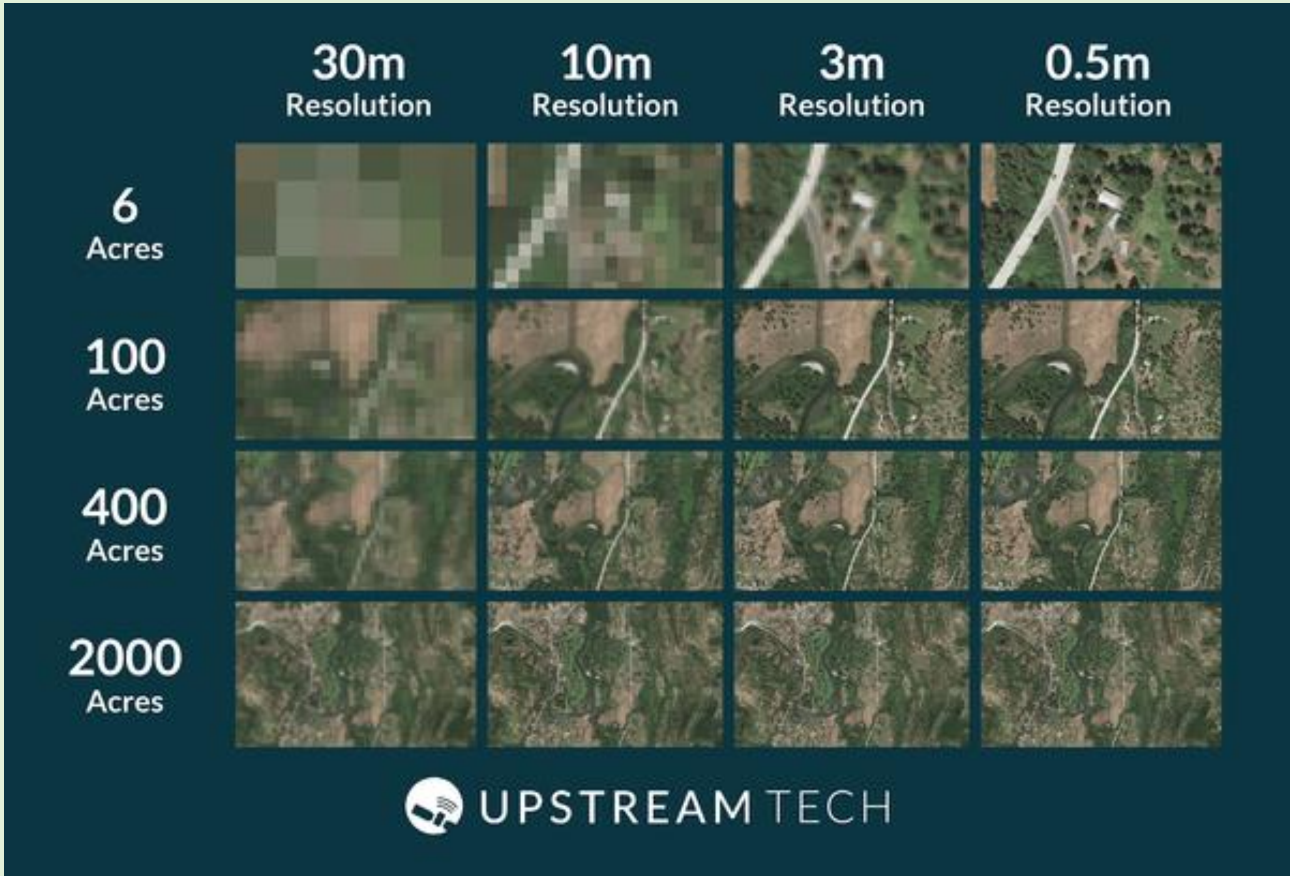
Next steps (and potential topics for presentation at Oct meeting)

- CCRM (Karinna Nunez and colleagues) will be investigating delineation of shorelines, and perhaps marshes, using newly obtained 3m satellite imagery for the next generation of Tidal Shoreline Inventories.

- Possibly using modified technique from Nezlin et al. to estimate shoreline erosion using the higher resolution satellite imagery.

- Machine learning application

Lv, Zhonghui, Karinna Nunez, Ethan Brewer, Dan Runfola. 2023. pyShore: A deep learning toolkit for shoreline structure mapping with high-resolution orthographic imagery and convolutional neural networks. Computers and Geosciences. 171. https://doi.org/10.1016/j.cageo.2022.105296



Questions?

Alternate method of sediment input