Quantifying variability in subsidence patterns related to seasonal surface loads across coastal Louisiana

Coastal Louisiana is subject to ongoing subsidence from a range of sources, including variations in sedimentation and erosion rates, sediment compaction, changes in hydrologic load, deep tectonic processes, and isostatic adjustment. Net subsidence is measured precisely at discreet locations, either with campaign leveling surveys at discreet points in time or with continuous high rate GPS stations. However, this subsidence is not uniform across the region, but instead varies spatially due to the heterogeneous nature of the individual processes contributing to net elevation. In addition, this subsidence is not uniform in time, but varies seasonally with rates that are comparable to or sometimes exceed the decadal trend of subsidence. This spatiotemporal non-uniformity makes it difficult to interpret decadal trends in subsidence from point measurements that sample different locations across coastal Louisiana at different times of year. A description of the complete spatiotemporal pattern of modern subsidence is key to the ability to extrapolate short-term field measurements to decadal predications of coastal change.

The goal of this research is to quantify and identify the sources of variability in geodetically observed subsidence patterns over annual to decadal timescales. The results will be of both practical importance, providing key contextualizing information to individual campaign elevation measurements made throughout the region, and of scientific importance, inferring subsurface properties and quantifying the physical mechanisms responsible for short term (annual to decadal) subsidence. To this end, we propose the following research activities:

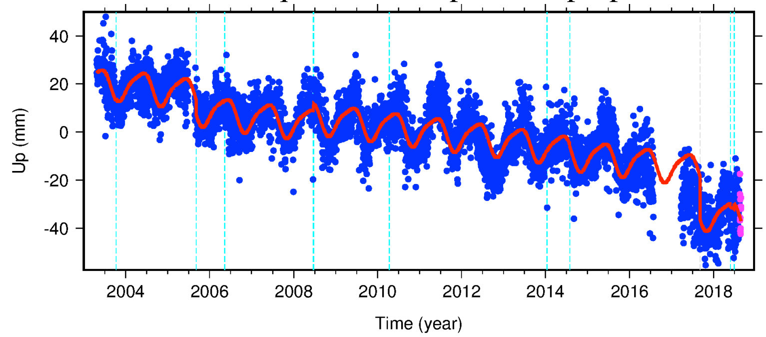
Task 1: *compile and synthesize observations of seasonal vertical elevation change* (uplift and subsidence) across southern Louisiana. Data from Continuously Operating GPS Reference Stations (CORS) will be processed for daily positions (east, north, and vertical locations). These time series will be analyzed to identify both the multi-year trend in position and the amplitude and phase (timing) of the seasonal signal.

Task 2: *compile and synthesize observations of seasonal surface mass variations* across southern Louisiana, particularly water load. Data from the Coastwide Reference Monitoring System (CRMS), the USGS and Army Corps of Engineers networks of stream gauges, and observations of varying ocean load from the GRACE satellite missions will be analyzed to identify the amplitude and timing of seasonal surface water inundation.

Task 3: *correlate patterns of seasonal vertical elevation change with patterns of surface mass variation* to identify the dominant loads responsible for seasonal subsidence, as a function of space and time. This will involve intensive spatio-temporal analysis of a variety of geophysical datasets, and will make up the bulk of student research activities. Preliminary results of this type of analysis are shown in Figure 1.

Task 4: *model the relationship between surface load and elevation change* by adapting existing subsidence modeling software to an appropriate rheological structure for coastal Louisiana, representing Holocene and Pleistocene sediment layers as elastic and viscoelastic medium. Model parameters will be tuned in order to provide the best fit between the seasonal load and the observed seasonal elevation change.

The proposed research activities will provide a student with key training in data analysis and critical thinking skills, as well as disciplinary knowledge in coastal geology, geophysicsl, crustal deformation, and numerical modeling. All the data described above is freely available to the public, and the relevant computational resources are available at LSU. No additional resources are required to complete the proposed research



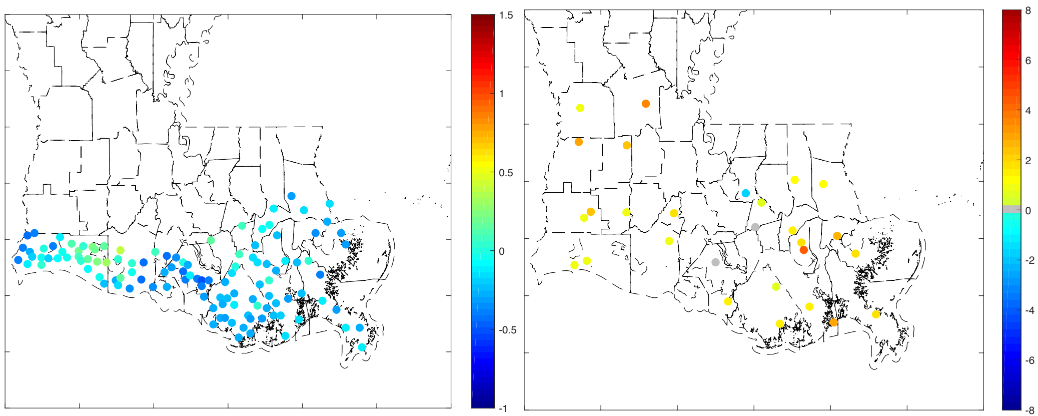


Figure 1. (a) a typical vertical elevation change record from a CORS station in southern Louisiana. The seasonal component of subsidence and uplift represents substantial variation superposed on the background trend of long-term subsidence. Example summary data from January 2017 showing (b) low relative water levels at CRMS stations correspond to (c) high relative elevations at CORS stations.

RELEVANCE OF FINDINGS TO LOUISIANA COASTAL MASTER PLAN

The proposed data analysis and modeling tasks will quantitatively evaluate the spatio-temporal patterns of vertical elevation change throughout coastal Louisiana over seasonal timescales. A quantitative description of spatio-temporal subsidence will help contextualize the observations of short-term field measurements and increase confidence in the decadal predictions of coastal change derived from the extrapolation of short-term measurements at benchmarks not occupied by a CORS station. Beyond this, an understanding of the interplay between variations in hydrologic and sediment loading and net subsidence rates will enhance the ability of coastal and deltaic morphodynamic simulations to efficiently incorporate spatio-temporal subsidence as an active feedback mechanism in models of coastal evolution. These results will help to reduce uncertainty in the geologic dynamics of subsidence, which is essential for effective implementation of projects outlined in the Louisiana Coastal Master Plan. As such, this research directly supports state efforts to sustain coastal ecosystems, safeguard coastal populations, and protect vital economic and cultural resources.