We use a time series of terrestrial LiDAR (TLiDAR) scans with cm scale resolution as a tool to test fundamental hypotheses on sea cliff erosion, such as, is material preferentially removed from the top, middle, or base of the sea cliff during periods of increased frequency and magnitude of storm events? The time series of TLiDAR scans includes 3D data sets from several sites along the coastline of Santa Barbara (figure 1). Scans were taken at five different dates that encompass Pre-El Nino conditions, post-El Nino storms, and post El Nino conditions. The dates of the scans range from Nov 15’ through September 16’. During the winter months (Nov-March) local sea levels were raised by up to 20cm and the coastline experienced greater amounts of wave energy and storm surge. Six different sites along the Santa Barbara coastline were investigated to determine the influence of different shoreline attributes and wave dynamics. From the 3D point clouds, we detect fine-scale patterns and rates of change with the M3C2 differencing technique developed by Lague et al. (2013). The threshold level of detection (LOD95%) was determined to be 5 cm or less for all scan sites and dates.

It is often assumed that wave energy is correlated with erosion rate, and causes erosion at the base of the sea cliff, creating a wave cut notch in the cliff that destabilizes the rest of the slope. Wave erosion is thought to be focused on points where wave set up is larger, and as a result, is hypothesized to straighten the coast. Preliminary evaluation of the sea cliffs at Coal Oil Point Reserve, Isla Vista, and Lagoon Rd. at The University of California Santa Barbara, suggests that wave action alone does not erode the cliff base significantly. Instead, wave action primarily acts to remove the eroded particles at the base of the cliff, or in some cases, may impart enough kinetic energy in the particles to actively abrade and erode the cliff face. We find that the middle of the sea cliff lost the most material during these conditions, and that beach width (instead of shoreline angle) plays a large role in “protecting” the cliff from erosion.

For weaker shales at Coal Oil Point reserve, preliminary results show that even though it is the most exposed section, it experienced the lowest erosion rates (1-5cm/year), whereas, much higher rates of 5-50cm/yr were observed off Camino Del Sur in Isla Vista (figure 2). Intermediate rates of 5-20 cm/yr were observed at lagoon rd. All erosional events occurred as small (1-50 cm³) frequent rockfalls, except at Lagoon Rd., where three larger (1-10 m³) terrace failures occurred. We posit that the primary mechanisms for increased sea cliff erosion during this period is the result of 1. particles, mainly cobbles, that are thrown at the cliff from waves and 2. subaerial weathering. Once the beach is stripped, exposing the bedrock platform, storm waves that hit the cliff are reflected back while a new surge of water rushes in. The interaction of these masses results in an upward force or surge of water that is able to “throw” suspended cobbles at the cliff, causing abrasion and...
quarrying of loose fractured or weathered rocks in the middle of the cliff. The spatial pattern of erosion is explained by schmidt hammer measurements, which show that the rocks at the base of the cliff (return values of 20) are less weathered, have larger fracture spacing and density, and are therefore less prone to erosion than rocks toward the middle of the cliff (return values of 0). The decrease in rock strength and increased degree of weathering along the mid-section of the cliff is hypothesized to be attributed to increased cycles of wetting and drying, causing slaking and salt weathering of the shales, allowing them to slowly “crumble” over time.

Figure 1. Map of study sites for TLiDAR scans along the coast of Santa Barbara, Ca.
Figure 2. Erosion map of Camino del sur from Nov 15’ –Sept 16’.

References