Scanned UC Berkeley Seismograms to Investigate Ocean Wave Heights Since 1931

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Project Background

Heightened ocean wave activity resulting from global warming-associated climate change will greatly affect coastal communities, biosystems, and infrastructure. As sea level rise progresses, the impacts of wave activity will be aggravated, resulting in increased coastal erosion and flooding of low lying regions. These issues are particularly problematic along the California coast, where vulnerable sea cliffs will experience increasing wave impacts. Because of sea level rise, projections at the end of the 21st century indicate that even moderate waves will produce coastal impacts comparable to recent extreme winter wave events. Consequently, understanding potential changes in the magnitude of mean wave heights resulting from climate change are important. Near-coastal buoy observations indicate that wave heights have exhibited little or no increase since about 1980. Estimates of coastal wave activity along the California coast are poorly known further back in time. Seismogram records at UC Berkeley begin in 1930, and can be used to determine reliable records of historic mean winter wave heights.

Long-term coastal wave climate changes under global warming cannot be reliably assessed from relatively short duration buoy significant wave height (*Hs*) observations that began about 1980. Alternatively, microseisms at double the wave frequency (DFM) provide a proxy record of coastal wave activity. The project goal is to employ an empirical wave reconstruction methodology developed by *Bromirski et al*. (1999) to transform DFM from UC Berkeley seismic station seismograms to *Hs* along the California coast for winters beginning Nov. 1930 to Mar. 1931 through Mar. 1988.

Data Overview

Three seismometers were in sequential operation at the UC Berkeley seismic station from 1930 onward, yielding daily analog paper seismogram records. The seismograms from the Berkeley Seismological Laboratory (BSL) archives were electronically "scanned" at 400 dpi (dots/inch) using an IDEAL FSS8000 full length scanner and stored as "tif" files. Galitzin (GAL) seismometer records were scanned for the 1930-1962 period. The transition from GAL to the Sprengnether (SPR) seismometer began in 1962. SPR seismograms were scanned for the Nov. 1962 to Mar. 1988 period, except months of GAL during Jan.-Mar. and Dec. 1964. The current broadband digital STS-1 seismometer began continuous operation in 1992, and provides reference DFM spectral levels that GAL and SPR are normalized to.

Each scanned seismogram image consists of a series of quasi-parallel sequential 30-minute or 60-minute traces that generally cover about a day, with two partial traces at the beginning and

end of each image. Seismograms were digitized with the SeisDig digitizing package (*Bromirski and Chen*, 2003). In addition to high amplitude earthquake signals, the arrival of high amplitude storm waves at nearby shorelines (*Bromirski and Duennebier, 2002*) cause elevated DFM noise levels, both types of signals resulting in the common occurrence of adjacent trace intersections and overlaps that complicate digitization.

Storage problems over time have damaged some seismograms (particularly at edges), further complicating digitization of full seismograms. Degradation of the seismogram paper quality (especially for many pre-1950 seismograms), and the difficulty in perfectly aligning the 36 inch long seismograms in the scanner feed groove, commonly resulted in either slightly skewed or slightly curved trace images, typically exaggerated at the trace ends.

Digitizing the seismograms proved expensive, making it impractical to digitize the complete multi-decade scanned daily archive. Digitizing four 1 hour nominally equally-spaced data segments per day was sufficient sampling to well-characterize DFM variability and give good estimates of near-coastal wave height variability.

Data Inventory

There are subfolders for each year, each containing five months Nov.-Mar. (a few winters contain Oct. and/or Apr. scanned seismograms).

Each of the “month” folders should contain an excel file with start and end "date times" for each scan, with some comments.

Winter months not having scans: Nov. and Dec. 1932; Jan. and Mar. 1981; Nov. and Dec. 1988. Several months have missing day-long seismograms. Scans are not available for 1989 to 1991, except Sep. 1991 for calibration of SPR with initial STS-1 records.

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References

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