Consistent Inconsistencies: a New Method for Assessing Time Corrections Needed for Analog Seismograms

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With seismic instruments and networks of today timed by GPS, synchronization of data is not typically a day-to-day concern. In the analog era, stations often had their own clocks, and precisely comparing timing of data from different stations was far more difficult. Today, new methods by which analog (paper) seismograms can be digitized have begun to allow application of modern seismological analyses to a wealth of historical data. This is a compelling prospect that would allow for investigations over previously unviable timescales. However, reconciling recording times across systems using different clocks and recording systems to account for time offsets and clock drift is critical to these types of studies

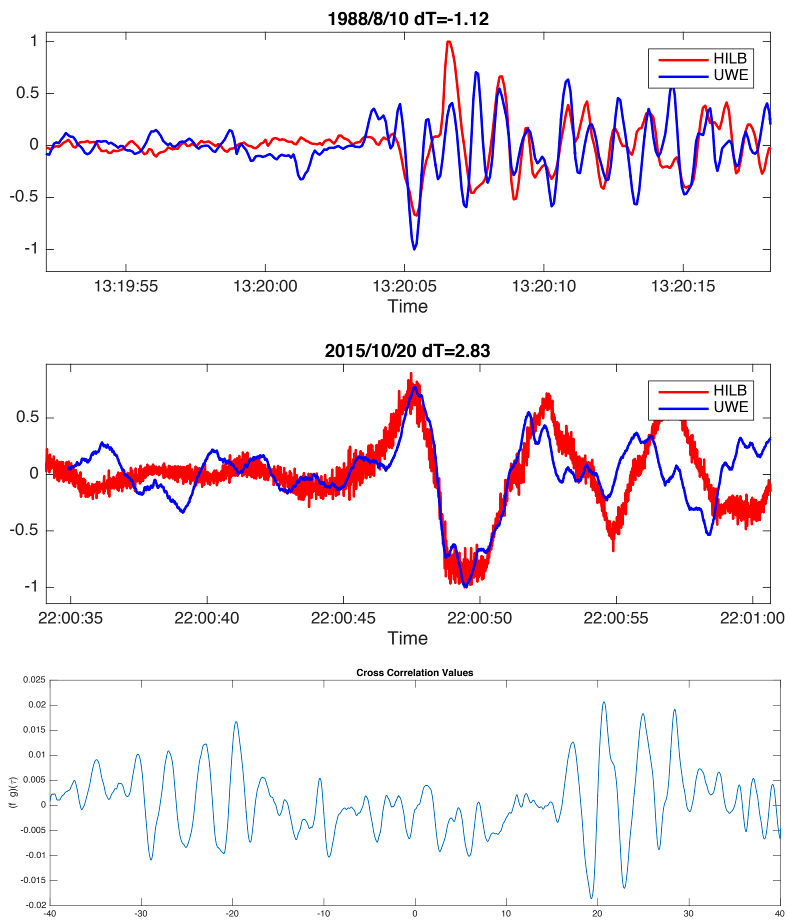

Figure 1: **Top:** Digitized analog arrivals with time adjusted to show offset between arrivals. **Middle:** The arrivals from the equivalent modern earthquake with time adjusted to show offset between arrivals (Note the different time offset). **Bottom:** The time-corrected noise correlation function for the analog data displayed at top (Note the symmetry about 0).

With this in mind, we examine timing inconsistencies across different analog recording systems, and introduce a methodology for synchronization of time between seismograms, based on a two-step procedure. First, teleseismic P-wave arrivals from a pair of earthquakes that have nearly identical distances from stations in Hawaii, locations, and depths, but occurring during the digital and analog eras are considered. The relative time corrections between a pair of contemporaneous stations can then be compared between the analog and digital data. The difference in time provides a rough estimate of the relative time correction. Second, taking advantage of the symmetry of ambient noise correlation function further refines this rough correction.

We apply this procedure to historical seismograms from the Hawaiian Volcano Observatory collection. The time offsets obtained from our analysis of a number of earthquake doublets are shown to be consistent within single pairs of helicorder on the same day. This implies that a time inconsistency is stable through at least one-record day. Our method should be extended to investigate time drifts across adjacent records and establish methods to provide time corrections for any recording, including those without teleseismic arrivals.