West Coast of North America Sea Level Records

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1.1 Overview

The west coast of North America has three long records of relative sea level a century or more in length, and many others more than 50 years long. Table 1 lists the ones considered in this informal exposition, from south to north. There are others, but these will suffice to show some of the problems and characteristics of West Coast sea level records.

	Span	Years	Begin	lat, N	long, W
SAN DIEGO	97	94	1906	32.72	117.17
LA JOLLA	78	72	1925	32.87	117.25
LOS ANGELES	79	78	1924	33.72	118.27
SANTA MONICA	70	60	1933	34.02	118.50
PORT SAN LUIS	57	52	1946	35.17	120.75
ALAMEDA	63	61	1940	37.77	122.30
SAN FRANCISCO	148	149	1855	37.80	122.47
CRESCENT CITY	70	67	1933	41.75	124.20
ASTORIA	77	76	1926	46.22	123.77
SEATTLE	104	104	1899	47.60	122.33
NEAH BAY	68	65	1935	48.37	124.62
VICTORIA	93	86	1910	48.42	123.37
VANCOUVER	92	67	1911	49.28	123.12
SITKA	65	65	1938	57.05	135.33
JUNEAU	67	65	1936	58.30	134.42
SKAGWAY	58	43	1945	59.45	135.32
YAKUTAT	63	59	1940	59.55	139.73

Table 1. Representative selection of West Coast North America long record tide gauge sites. The Span column is the total number of years since the date in the Begin column to 2003. Several more years of data may be available now. The Years column shows the actual number of years for which annual mean data are available. Years << Span indicates gaps in the data may significantly affect results or indicate data problems.

Three long and much used records are from San Diego, San Francisco, and Seattle. It is interesting to compare them because they are widely spaced along a coastline well known to be affected by ENSO events (Chelton and Davis, 1982; Papadopoulos and Tsimplis, 2006). Figure 1.1 shows these records. The series have been smoothed with a 3-year average filter, and no Glacial Isostatic Adjustment (GIA) correction is applied here or in any of the results below.

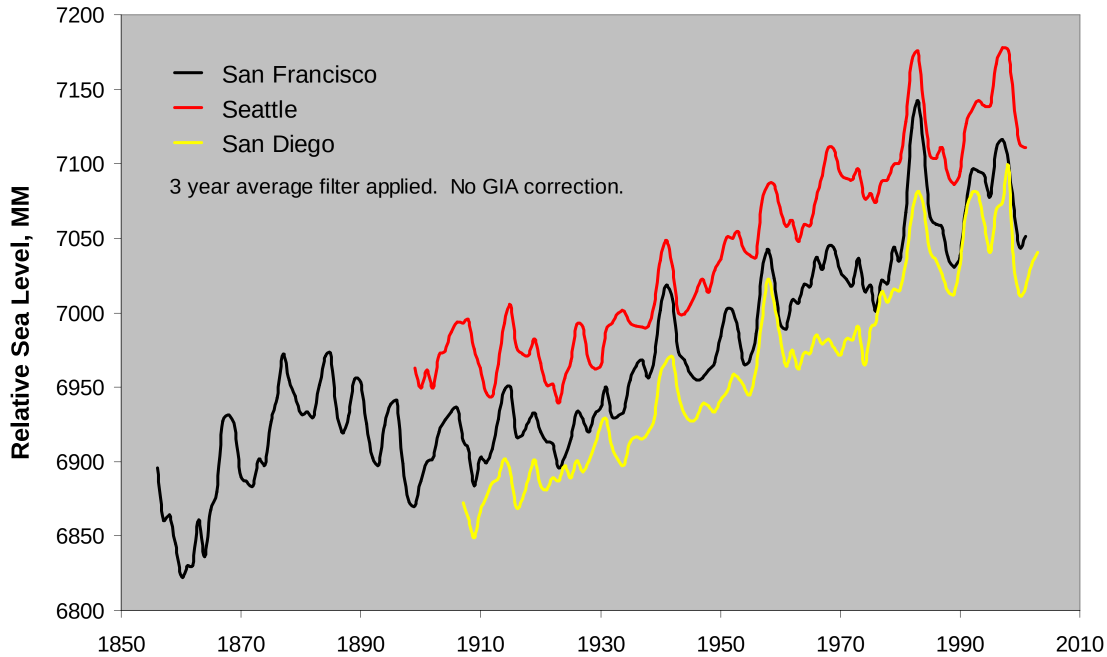

Figure 1.1 Relative sea level from the longest tide gauge records on the west coast of North America.

These 3 series are remarkably consistent over their common time interval. However, the behavior of the San Francisco record in the 19th century compared to the 20th is very different. This figure shows that the 19th and 20th century trends of relative sea level (RSL) should not be expected to be the same.

1.2 San Diego and La Jolla, CA

These sites are about 20 km apart. Sites near each other ordinarily will have a close similarity in their variations of sea level at low frequencies.

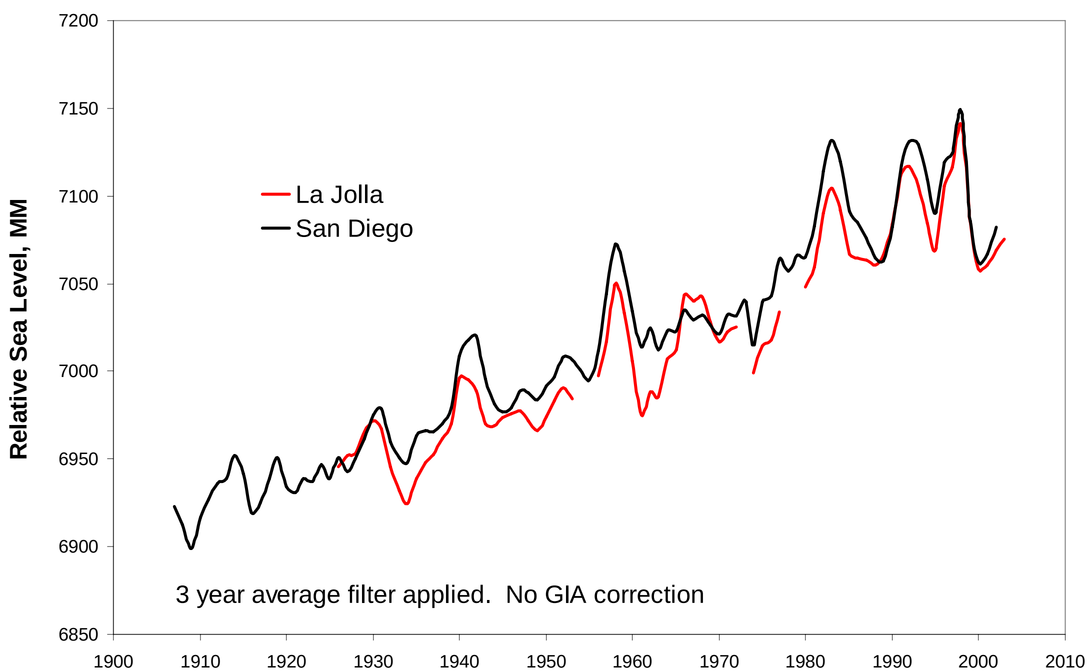

Figure 1.2. Relative sea level at San Diego and La Jolla, California. Both series have a trend of 2.13 mm/year.

Trends of sea level at both sites are identical at 2.13 mm per year. The San Diego record is longer, and does not have gaps. The agreement of the records provides confidence in the quality of their data.

1.3 San Diego and Los Angeles, CA.

The San Diego and Los Angeles sea level records also have very similar interannual variations (Figure 1.3, below), but different trends. The trend at Los Angeles is 1.32 mm per year less than at San Diego, suggesting more uplift at Los Angeles. Closer inspection of Figure 1.3 indicates that a simple difference of trend is all that distinguishes these sea level series from each other.

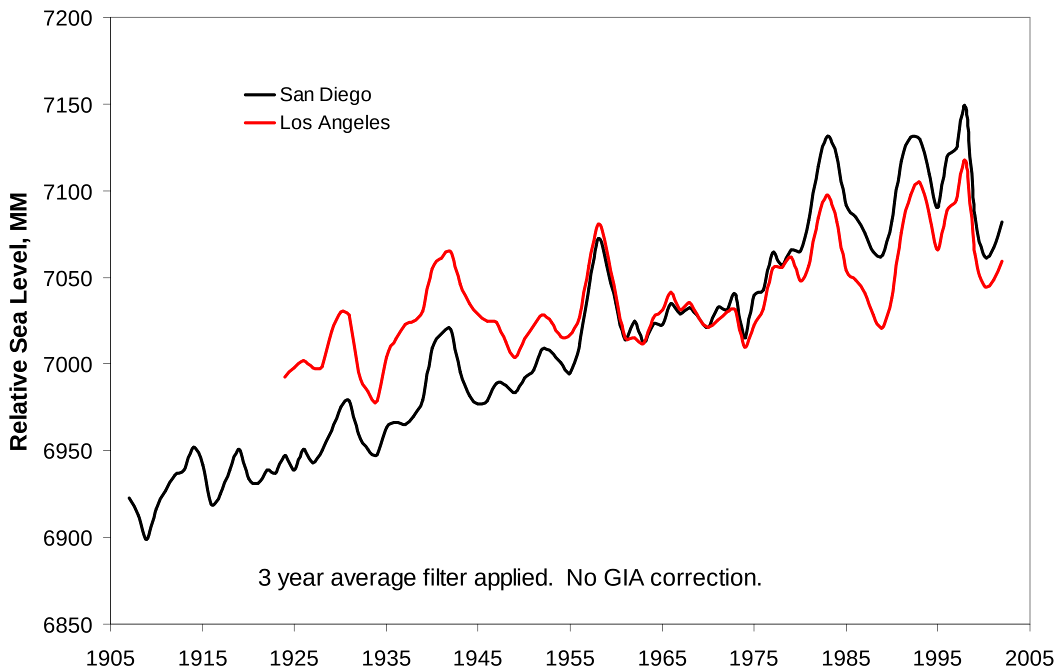

Figure 1.3. Relative sea level at San Diego and Los Angeles, CA. Except for the trend difference, these series closely resemble each other.

1.4. Los Angeles and Santa Monica, CA.

This comparison illustrates some issues raised elsewhere in the PSMSL web site about data gaps. Santa Monica has several large gaps and eccentric behavior in the neighborhood of the gaps. The 1983 value of relative sea level is missing at Santa Monica because the 1982/83 ENSO event destroyed the gauge in early 1983. Data from 1989 – 2001 agrees well with Los Angeles, but the data subsequent to reestablishment of the gauge (1984 – 1989) is very different from data taken at Los Angeles. A similar phenomenon can be seen at either side of the gap 1965 – 74. All tide gauge records should be examined carefully when gaps are present.

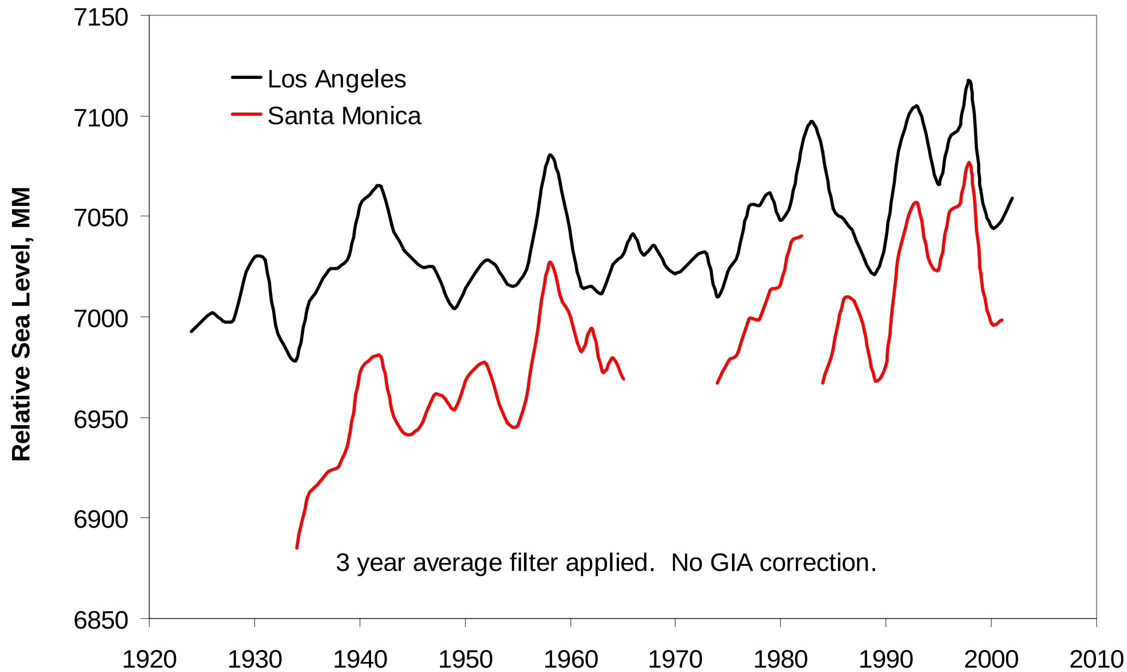

Figure 1.4. Santa Monica and Los Angeles relative sea level. Important differences occur at the edges of gaps.

1.5 Seattle – Puget Sound area

There are four long records in the Seattle – Puget Sound area. These are Seattle, Neah Bay, Astoria, and Friday Harbor. Figure 1.5 shows these records smoothed by a 3 year average filter.

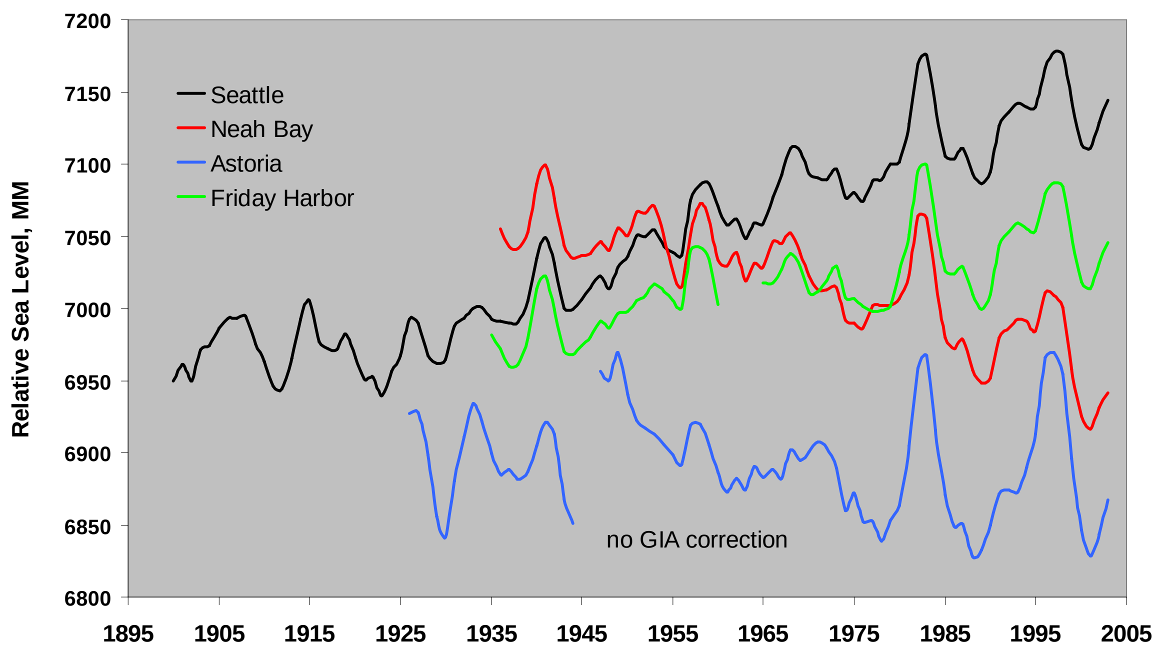

Figure 1.5. 20th century relative sea level in the Seattle – Puget Sound region.

The behavior here is very disparate, although the records show good agreement of the early1940s, 1982/83, and 1996/97 ENSO events. But their trends are markedly different, and these records have been used by geodesists to study vertical crustal movements in the region. But care is needed in that application or any other. Note that Astoria (blue) has a gap with the not uncommon suspicious signal for some years after the gap. The Friday Harbor record (green) appears to parallel the Seattle record until its gap is reached, then displays a much lower trend than Seattle thereafter. Further analysis of these records containing gaps is needed before they are used for scientific investigation.

1.6. San Francisco Bay Area.

There is in addition to San Francisco a long record at Alameda, California. Figure 1.6 displays these sea level series during their common time interval. The San Francisco gauge is near the entrance to San Francisco Bay, and the Alameda gauge is 7 km to the east on the eastern shore of the Bay. Both gauges are east of the San Andreas Fault, but Alameda is situated virtually on the Hayward fault. The records agree well in their interannual fluctuations, but have trends about 1.1 mm apart.

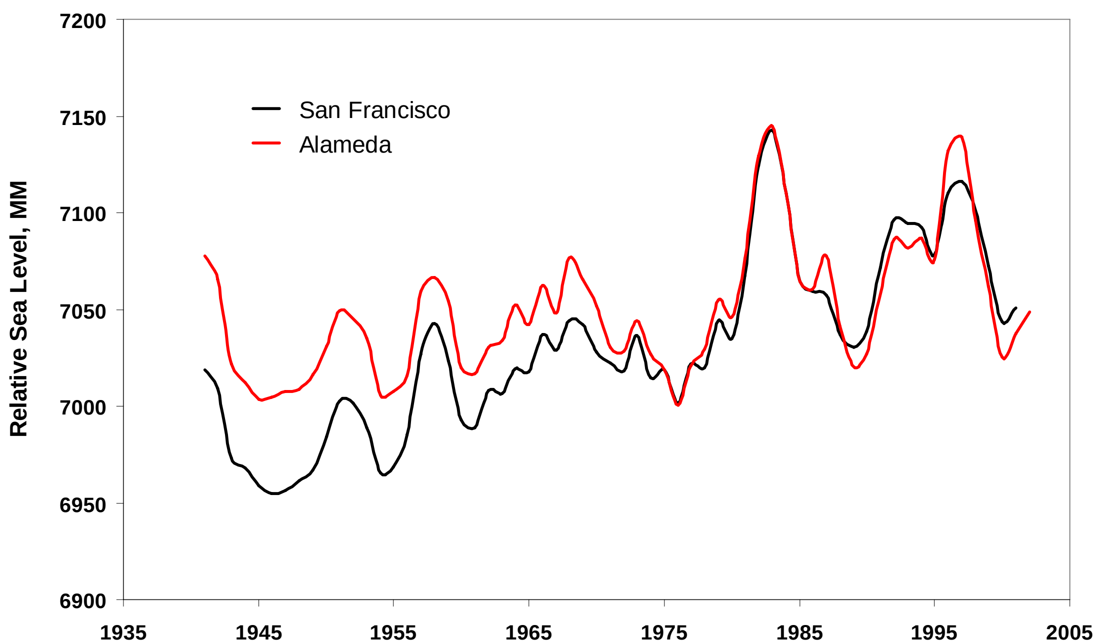

Figure 1.6. San Francisco and Alameda tide gauge records over their common time interval. The interannual variations agree well, but the trends are different by about 1.1 mm per year.

1.6.1. San Francisco and Crescent City

Crescent City is North of San Francisco. Its relative sea level measurements are highly coherent with those of San Francisco at interannual periods, but the overall trend has the opposite sign due to plate tectonic effects. Like Neah Bay, Astoria, and Friday Harbor, Crescent City is better suited to monitoring vertical crustal movements than sea level.

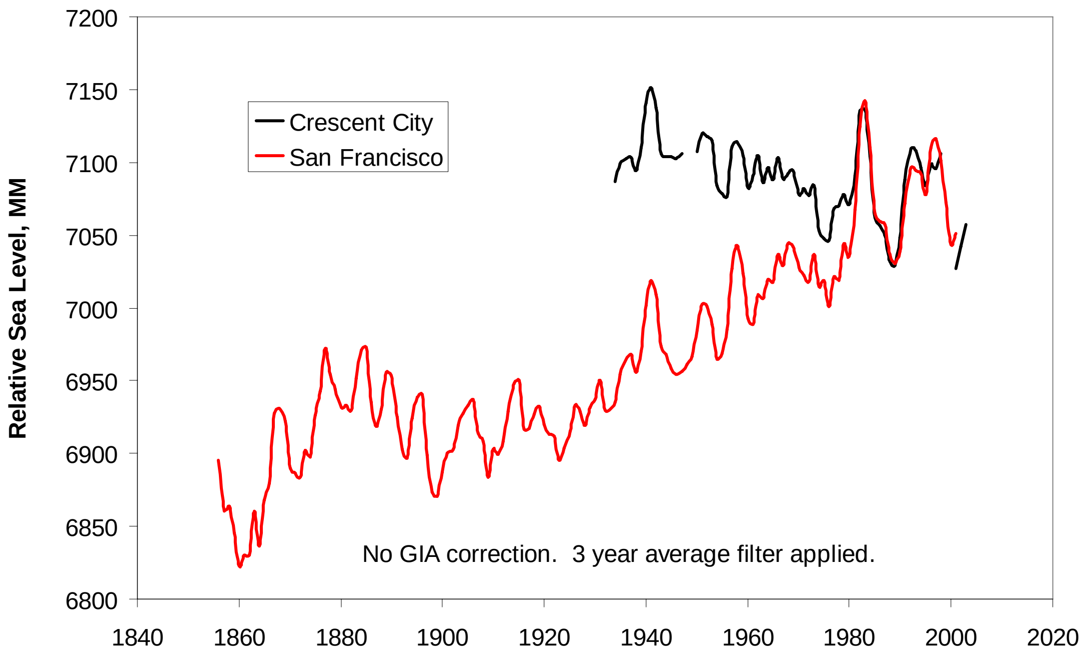

Figure 1.6.1. Relative sea level at San Francisco and Crescent City, CA. Interannual variations are in agreement, but the trends have the opposite signs.

1.7. Victoria, Vancouver, and Seattle sea level records.

Figure 1.7 displays Victoria, Vancouver, and Seattle sea level recorded during the 20th century. We find typical behavior here; agreement of interannual variations, differing trends, and suspicious data associated with gaps.

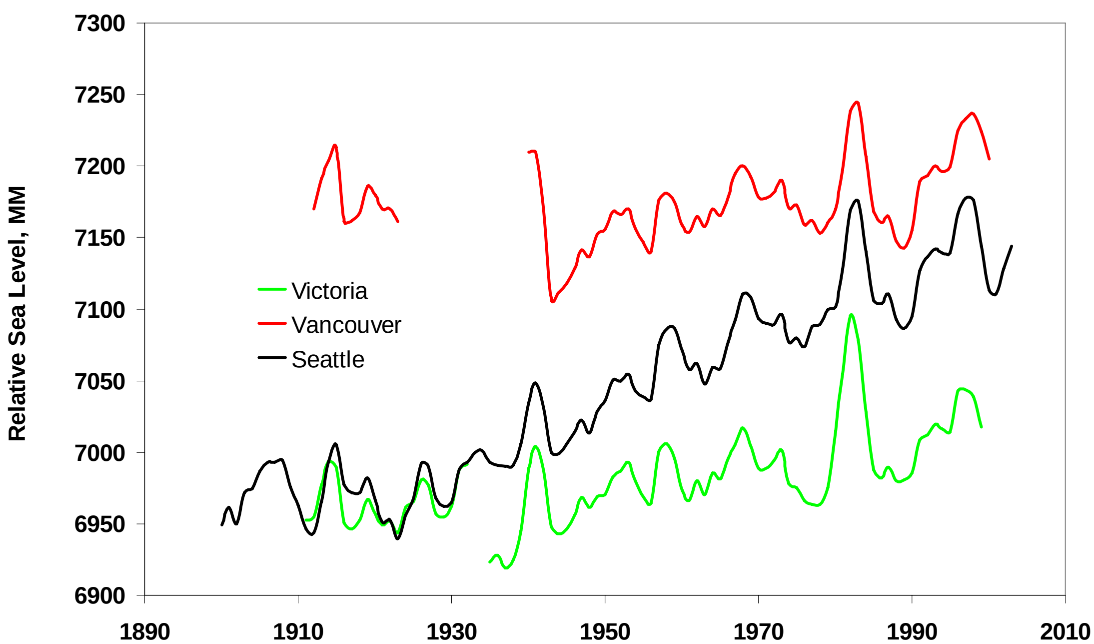

Figure 1.7. Sea level records in the NW of the USA and Canada. Agreement of interannual variations is excellent, but trends and low frequency variation are significantly different.

The behavior of the relative sea level record at Vancouver immediately after the gap is rather similar to that seen in Figure 1.5 for Astoria. These data should be considered unreliable, as should be the data prior to the gap. The Victoria record has its own issues associated with its gap. There are also more subtle features in both of these records. Both appear to "level off" after about 1960. Since this behavior is not shared by the nearby Seattle record, it must be investigated further.

1.8. Alaska Tide Gauge Records.

Gauge records in Alaska are well known to reveal large vertical crustal motions. Figure 1.7 presents the sea level records for Yakutat, Juneau, Skagway, and Sitka. There are significant gaps in several of the records, and more subtle differences as well. Note that the Yakutat and Skagway series show a significant (-0.6, -0.3 mm/yr^2) negative acceleration overall, not seen in the other series. The cause for this is unknown, but surely interesting.

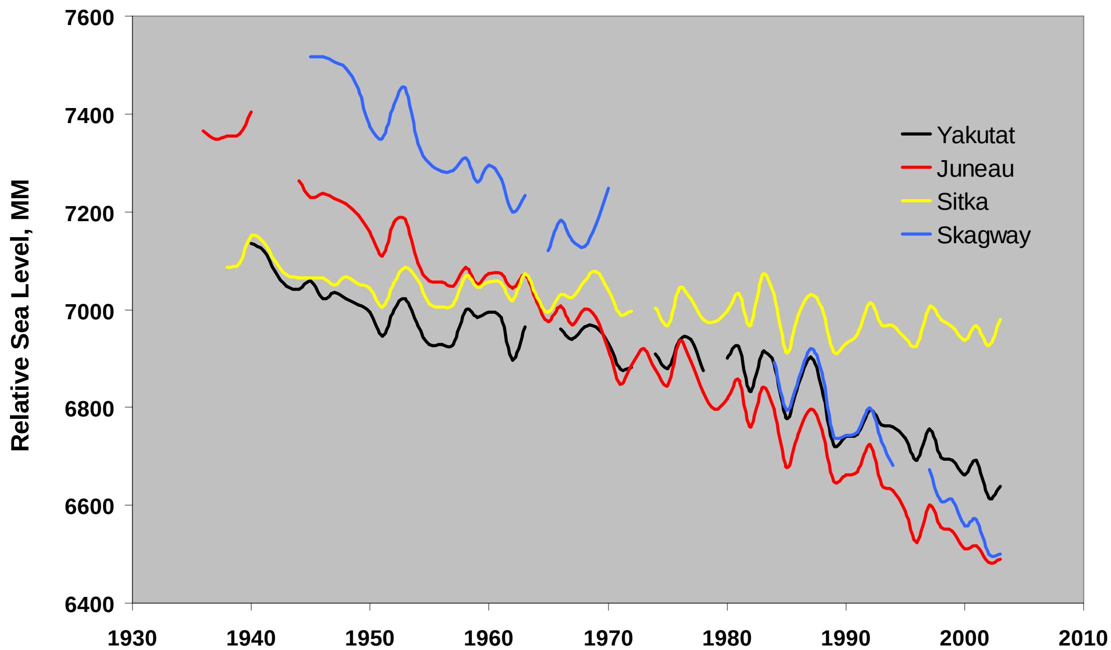

Figure 1.8. Relative Sea Levels in Alaska.

It is obvious from these examples that sea level records made by tide gauges contain a lot of information in addition to a contribution from global sea level rise. By intercomparing records from nearby gauges ("buddy checks") and paying close attention to geophysical and oceanographic/meteorological effects, these records can ultimately offer a unique view of important aspects of climate change in the 19th and 20th centuries, and beyond (Miller and Douglas, 2006; Miller and Douglas, 2007)

References:

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Papadopoulos, A., and Tsimplis, M.N., 2006. Coherent coastal sea level variability at interdecadal and interannual scales from tide gauges. *Journal of Coastal Research*, 22(3), 625–639.

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