Sea Level Rise: Tidal Station Data Examined

Rick Bradford, August 2025

Contents

1. Purpose and Context

I present an analysis of sea level data across the globe. I have not examined satellite data, preferring to concentrate on ground-based tidal station data. There is something in the order of a thousand such tidal stations, so it is obviously not possible to analyse all their data in a few days. I have examined data from 81 stations.

This is an (extensive) update of my 2020 analysis. The principal changes are the inclusion of five additional years' data and additional analyses focused on changes of rise rate, comparing before 1960 with the present (2025). The previous analysis focused on datasets with the longest records so as to permit confirmation that much of the currently observed rate of sea level rise was also occurring before 1960 (available data confirms this back to the mid-19th century). In this revision I also include data fits which take their earliest data from 1960, or thereafter, so as to be able to compare rise rates during the “modern phase” of global warming with those before, where available.

Prediction of future sea level rises is problematic but is attempted here on a reasonable basis of extrapolation, believed to be bounding. The sea level rise rates and predicted rises are all relative, i.e., including the effects of land movements.

2. What Does the Data Mean?

Global Versus Local Sea Level Rise, Land Movements and Errors

Is there such a thing as a uniform global sea level rise? Yes, but only as an average effect, not something locally observable. But even if sea level rise was uniform across the globe, it is not what tidal stations measure. Tidal stations can only measure sea level with respect to the local land. Hence, an apparent sea level rise might be just that, or it could be the land locally sinking. In practice, all these data will be a combination of both. However, it is the relative change that is significant as regards flooding potential, so the relative rise data are just what is required from that perspective.

Land movements can arise due to, (i) tectonic effects, (ii) isostatic rebound (the effects of glacier melting causing weight redistributions), (iii) local subsidence, e.g., arising from ground water extraction, mining, etc. As far as the UK as a whole is concerned, (ii) is a substantial issue. Isostatic rebound is causing Scotland to rise whilst southern England is sinking. Hence, (relative) sea level rise will tend to be greater in the south of Britain compared with the north. This can be seen in the data, for example the more rapid rise rates at Newlyn and Sheerness contrasted with the slower rise rates at Wick.

But this effect is not consistent in the data. For example, the data for Portsmouth indicate a low rise rate whilst Aberdeen apparently has a high rise rate. Such observations may merely indicate the errors in these data. But, more likely, these cases arise from local land movement issues, or from true (absolute) sea level differences between locations due to local currents, wind conditions, etc.

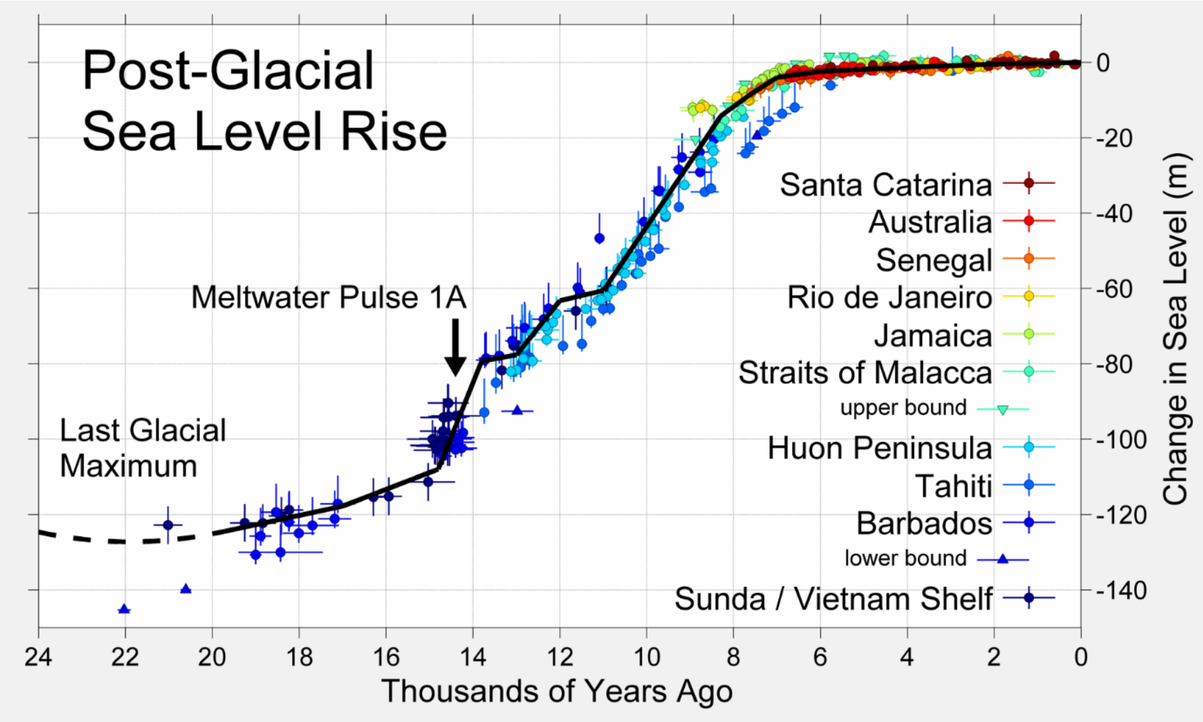
Consequently, the mean and standard deviations of sea level rises across different locations, as will be derived below, must be regarded as the combined effects of error but also genuine variations from place to place for several reasons.

3. Global Average Sea Level is Rising

This section summarises the standard picture of sea level changes over very long time periods. I shall not examine it closely as I shall concentrate on the period since about 1850 when routine tidal records began. Nevertheless, the longer timescale provides crucial background as it puts current sea level rises in context.

On average over the globe, mean sea level has been rising for about 20,000 years, since the end of the last glacial episode, like this…

Figure 1: Sea level rise over the last 20,000 years, from Refs.[1-3]



Note that the scale of this graph is in ***metres***. Over the last 20,000 years, global mean sea level (GMSL) has risen by about 125 metres (over 400 feet, or getting on for twice the height of the Avon Gorge). This is bound to have had dramatic effects on land geography. One of them was making Britain an island when the North Sea drowned Doggerland which had previously connected Britain to continental Europe.

On the scale of Figure 1 recent sea level rise (i.e., that occurring over the last century) is imperceptible. Current GMSL rise rates are around 3.5 $\pm$2 mm per year so even three centuries at that rate would see a rise of "only" the order of a metre, which would not be noticeable on the scale of Figures 1 or 2. This is what I mean by "putting in context".

The last 20,000 years is not unique – far from it. The sea level has been going up and down by the order of 125 metres repeatedly over the last million years or so (Figure 2), and probably for far longer. Even over the last thousand years the sea level has gone up and down, albeit by only about 10 cm until the last 130 years over which time there has been a rise of about 21 cm (Figure 3). It is this latter period on which I shall focus here.

Figure 2: Sea level over the last 800,000 years (from Ref.[4]), scale: metres

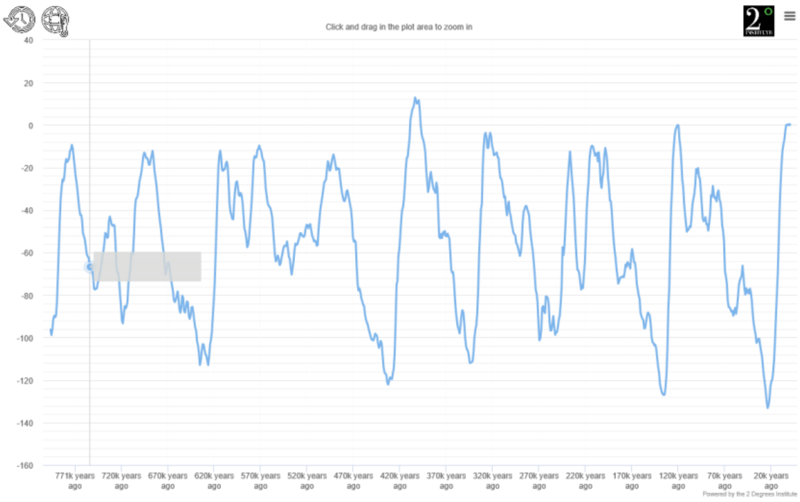
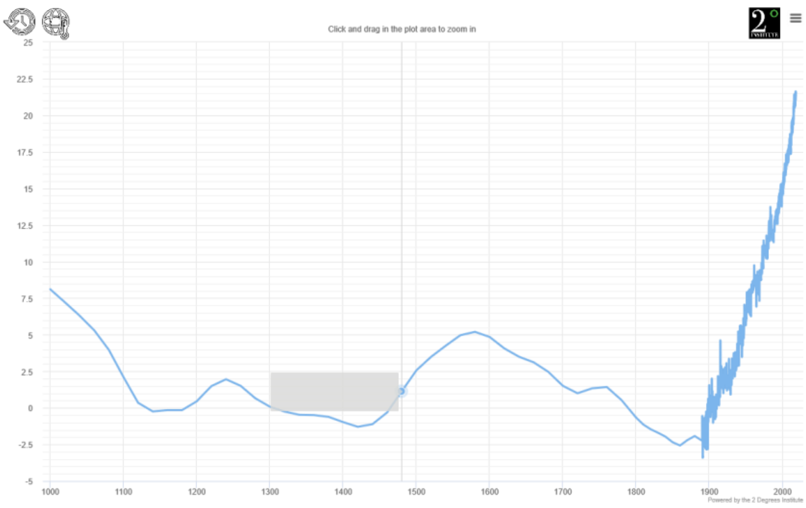


Figure 3: Sea level over the last 1,000 years (from Ref.[4]), scale: centimetres



4. IPCC Projections

The International Panel on Climate Change presents worrying projections of future sea level rises. The predictions published in the 2014 IPCC report, Ref.[9a], are shown in Figure 4. These predictions range between about 270mm (lower bound) to ~1 metre over this century. The four modelled scenarios (referred to as RCPs) used by IPCC are defined as follows,

"*The RCPs include a stringent mitigation scenario (RCP2.6), two intermediate scenarios (RCP4.5 and RCP6.0) and one scenario with very high GHG emissions (RCP8.5). Scenarios without additional efforts to constrain emissions ('baseline scenarios') lead to pathways ranging between RCP6.0 and RCP8.5 (Figure SPM.5a). RCP2.6 is representative of a scenario that aims to keep global warming likely below 2°C above pre-industrial temperatures.*"

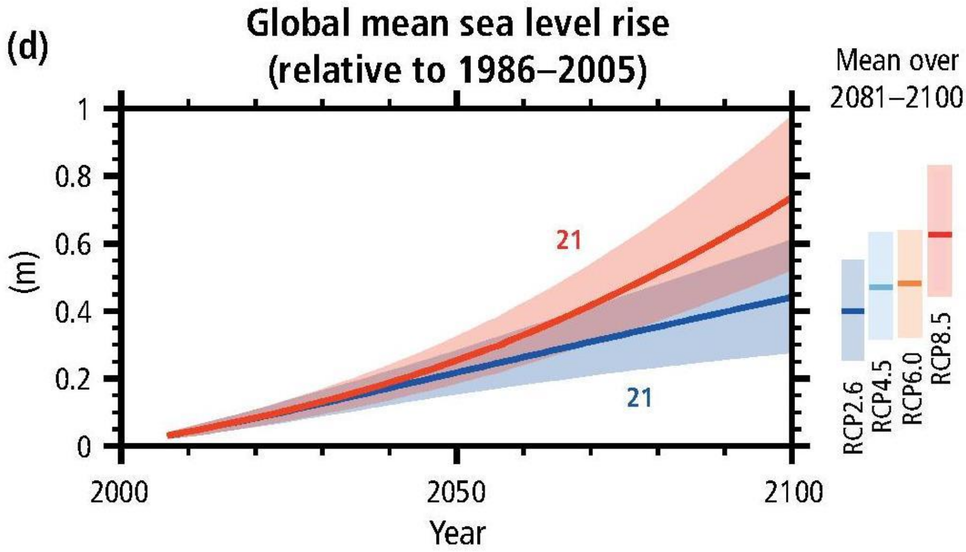
So IPCC refer to the higher, red-shaded, models in Figure 4 as "baseline scenarios", which range up to 1 metre. In the 2014 report, IPCC state,

"*For sea level, based on current understanding (from observations, physical understanding and modelling), only the collapse of marine-based sectors of the Antarctic ice sheet, if* *initiated, could cause global mean sea level to rise substantially above the likely range during the 21st century*."

By "likely range" here, IPCC mean the range shown in Figure 4. In other words predictions even greater 1 metre would require hypothesising some Antarctic ice melt. The 2023 IPCC synthesis report , Ref.[9b], includes a curve in the equivalent of Figure 4 which includes some Antarctic melt, and also raises the lower bound prediction.

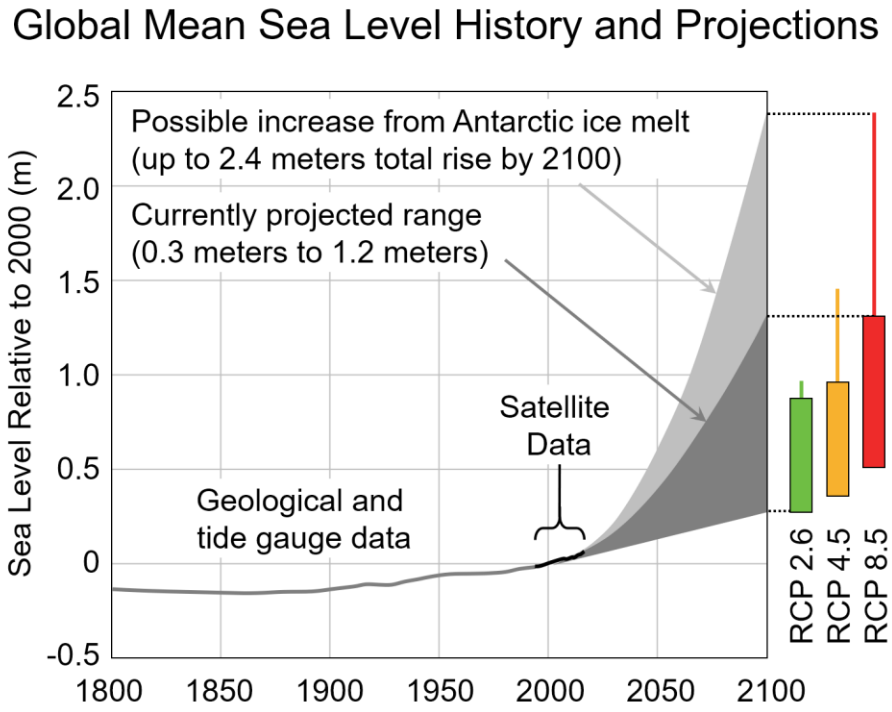
By 2017, work coming out of NOAA (the US National Oceanic and Atmospheric Administration) was already pushing predictions upwards, including the hypothesis of Antarctic ice melt contributing to the sea rise, as shown in Figure 5 from Ref.[10]. On this basis the prediction is up to 2.4 metres. But even without Antarctic melt, this NOAA report pushes the upper bound IPCC RCP8.5 scenario to 1.2 metres.

Figure 4: GMSL Rise Predictions from IPCC 2014, Ref.[9a]



Note added August 2025: The 2023 IPCC Synthesis Report, Ref.[9b], in its Summary for Policymakers, includes an updated version of the above graphic in which (i) an even higher curve has been added, and, (ii) the lowest extent of the blue region (i.e., the lower bound) has been pushed up from 0.28 m to 0.45 (see page 17). Thus, even their lower bound now looks too high to be compatible with the current global average rise rate (3.8mm/yr, see Tables 2 and 4) if this persisted over the rest of the century.

Figure 5: GMSL Rise Predictions from NOAA, Ref.[10]



4. Independent Data Analysis

4.1 Data Source and Selection

Data have been taken from the Permanent Service for Mean Sea Level (PSMSL), a service within the Global Sea Level Observing System (GLOSS), which is a programme coordinated by the Intergovernmental Oceanographic Commission. Specifically I have used an interactive world map provided by PSMSL which shows all tidal stations with relevant data (either current or historic). I estimate there are about 1,000 such stations.

It is not feasible to attempt, in a few days, a true global average over 1,000 or so land stations such as done by Church & White, Ref.[5]. I am content to examine a reasonable subset of stations. In 2020 I was most interested in stations with records starting at the earliest dates, preferably in the 1800s. The reason is the crucial importance of the sea level rise rate prior to the "modern phase" of global warming, roughly before 1960. I have retained these stations because the same data can also be pressed into service to analyse data from 1960 onwards. Usefully, the stations marked on the interactive map are colour coded according to the time-span of the data available, as follows.

- White = over 100 years: I used all these;
- Yellow = over 75 years: I used a random sample of these from around the world;
- Orange = over 50 years: I used some of these when a region would otherwise be unrepresented (Africa is very poorly served);
- Brown (>30 yrs) and Black (<30 yrs): I did not use these.

For this review I have also looked at a larger number of UK stations. In all this amounts to 47 stations for which I have carried out analyses, plus a further 34 stations whose datasets look anomalous compared to the other 47 (indicating no trend, or a downward trend, or being irregular in behaviour). Graphs of sea level for these anomalous 34 stations are given in Appendix C. Basing the quantitative analysis on the other 47 stations alone is probably quite conservative as regards the implied global average.

4.2 Analyses

Table 1

Table 1 records the results of quadratic regression applied to the whole timeseries for those stations with datasets which start significantly before 1960. Some of these start in the 1800s. Thus, regression fits to sea level are $y = at^2 + bt + c$ where y is in mm and t is in years. The instantaneous rate of rise is thus $2at + b$ (mm/year) and the acceleration in the rate of rise is 2a (mm/year^2).

A fitted acceleration which is statistically significant implies that the ***relative*** rate of sea level rise has increased over the time period of the dataset. Statistical significance was defined as a regression p value of 0.05 or less. 46% of the stations analysed showed such a statistically significant acceleration.

Table 1 also states what the fitted curves give for the rate of rise in 2025.

The graphs of sea level versus year corresponding to Table 1 are given in Figures A.1 (28 stations)

Table 2

Table 2 records the results of quadratic and linear regressions of data starting in 1960, or thereafter, and for all 47 stations analysed in this review. Note that the stations chosen were selected based on having data up to 2023 or 2024, i.e., as up to date as possible.

The Table also states what the fitted curves give for the rate of rise in 2025.

The Table records whether the fitted acceleration from the quadratic regressions were statistically significant. This was the case for 36% of stations.

For the 64% of stations where acceleration since 1960 was found not to be significant, a linear regression was also carried out to provide the preferred rate of rise.

Whilst it cannot be claimed that these 47 stations will provide an accurate global average, they will provide a reasonable estimate. The mean fitted rise rate in 2025 was 3.8 mm/year with a standard deviation of 2.22 mm/year. The mean rate of 3.8 mm/year is consistent with the lower bound of the range of predictions by the IPCC (Figures 4 and 5). However, 3.8 mm/year is not a lower bound but a best estimate.

The graphs of sea level versus year corresponding to Table 2 are given in Figures A.2 (47 stations)

Table 3

Where the quadratic fits of Table 2 (to data starting no earlier than 1960) indicated a statistically significant acceleration, cubic fits were also carried out, $y = jt^3 + at^2 + bt + c$ so that the rate of increase of the acceleration is $6j$ ("jerk"), and the acceleration and rise rate at any given year are $6jt + 2a$ and $3jt^2 + 2at + b$ respectively.

The statistical significance of the cubic (jerk) term was found from the regression. In all but five cases it was not significant and these fits can be ignored. The five exceptions all displayed features, when plotted graphically, that appear physically improbable – almost certainly due to "overfitting" (see the graphs for Key West, Pensacola, Bluff, Cebu and Portland in Figures A.2). Hence Table 3 can be ignored other than what it implies, namely that an increasing acceleration looks very unlikely.

Table 4

This Table compares the average rise rate prior to 1960 to the fitted rise rate in 2025 obtained from the fits to data from 1960 onwards. The ratio of these two quantities indicates the least proportion of the current rise rate which is not due to "modern phase" global warming, i.e., that since 1960. There is a wide variation in these ratios (in some cases the rise rate has apparently reduced). Taking seriously only ratios less than one, this implies that, as a global average, 56% of the current (2025) rate of rise of sea level is not due to global warming since 1960 (hence not caused by greenhouse gas emissions). However, at some locations – notably several in the UK – this does not apply, and only a smaller proportion of the observed (relative) rise rate can be attributed to pre-1960 effects.

4.3 Whence Cometh the Acceleration?

Tables 1 and 2 show that, whilst most locations do not display statistically significant accelerations in (relative) rise rate, many locations do (36% since 1960). The absence of acceleration at most locations is sufficient to imply that the local accelerations do not arise from a global effect and hence are less likely to be related to the absolute sea level rise than to localised land movements of some sort.

A crude mechanistic argument also arrives at this conclusion. The heat flow from atmosphere to ocean will depend upon the difference $T_{atmos} - T_{sea}$, where T_{atmos} is some characteristic atmosphere temperature, near sea level, and T_{sea} is some effective near-surface sea temperature. If T_{atmos} increases at a steady rate then the same steady rate of increase of T_{sea} provides a self-consistent solution as $T_{atmos} - T_{sea}$ is then constant so that the heat flow rate into the sea is constant, consistent with a constant rate of increase in sea temperature.

In contrast, isostatic rebound (and hence land movement) could have an accelerating component, namely that part of it which is driven by currently ongoing glacier melting. The heat flow from atmosphere to glacier will depend upon the difference $T_{atmos} - T_{ice}$, where T_{ice} is the temperature of the melting ice surface, which (unlike T_{sea}) is a constant. A steadily increasing T_{atmos} therefore implies a steadily increasing rate of heat flow into the glacier, and hence an increasing rate of melt, i.e., an acceleration of the isostatic rebound. However, for most locations the dominant cause of isostatic rebound is the ancient melting of the glaciers which were far more extensive 10,000 to 20,000 years ago (the Earth's crust taking thousands of years to readjust to a new equilibrium). There are exceptions, however. For example, isostatic rebound at Svalbard is dominated by current melting.

Moreover, the estimated land tilt across Britain due to isostatic rebound is roughly 100mm upwards in northern Scotland and 100mm sinking in East Anglia. While substantial, this is smaller than what is implied by the relative sea level rise at, say, Newlyn and Sheerness, which (as we will see) would suggest land drops of more than double this magnitude. This is consistent with Ref.[14] which suggests that local land movements can exceed those due to isostatic rebound alone by around 1mm/year. On the other hand, other southerly locations such as Dover and Portsmouth have relative sea level rises which are less than predicted based on the global average rate (3.8 mm/year).

I conclude that the observed accelerations in relative sea level rise are mostly a result of local factors not global factors, and hence not due to absolute sea level rise nor due to tectonic or isostatic rebound effects on gross land movements. Instead, accelerations appear to be due to very localised land movements, or perhaps local sea currents or winds. In this context the rather obvious fact is that all sea level data are relative specifically to ***coastal*** land. Such land is commonly subject to coastal erosion (especially parts of southern England, e.g., the Norfolk and Suffolk coasts). Consequently, one component of the ostensible rise in sea level will be land movements due to coastal erosion.

In summary, the accelerations in the relative rise data are likely to be due to land movements not absolute sea level rise. Land movements occur due to global tectonic effects, regional isostatic rebound, and local coastal erosion, and local subsidence due to mining, ground water extraction and sediment compactification. Accelerations, where real, are most likely due to one or more of the local mechanisms.

4.4 Professional Analyses of Sea Level Rise

From an extensive analysis of global data from both tidal stations and satellites, and after adjustment for isostatic rebound, Church & White (2011), Ref.[5], concluded,

"*...the estimated rate of rise is 3.2 ± 0.4 mm per year from the satellite data and 2.8 ± 0.8 mm per year from the in-situ data. The global average sea-level rise from 1880 to 2009 is about 210 mm. The linear trend from 1900 to 2009 is 1.7 ± 0.2 mm per year and since 1961 is 1.9 ±*

0.4 mm per year. There is considerable variability in the rate of rise during the twentieth century but there has been a statistically significant acceleration since 1880 and 1900 of 0.009 ± 0.003 mm year^{-2} and 0.009 ± 0.004 mm year^{-2}, respectively."

A more recent analysis focussed specifically on Britain is that due to Hogarth et al (2020), Ref.[15], who conclude,

"*We find a mean rate of sea level rise of 2.39 ± 0.27 mm yr^{-1}, and an acceleration of 0.058 ± 0.030 mm yr^{-2} between Jan. 1958 and Dec. 2018*."

My understanding of this paper is that the above mean sea level rise results relate to analysis of the data after correction for isostatic rebound (and other datum offset factors).

In as far as land movements will cancel out when averaged across the globe, the above estimates of acceleration from Refs.[5,15], i.e., 0.009 and 0.058 mm/yr^2, may be compared with that from Table 2, i.e., 0.0315 mm/yr^2, but with a very large standard deviation of 0.0896 mm/yr consistent with most stations showing no significant acceleration.

However, mean rates are not directly comparable because Table 2 gives rates at 2025 whereas Ref.[5] gives the average rate between 1961 and 2009, whilst Ref.[15] gives the rate between 1958 and 2018. Using their quoted accelerations, these imply rates at 2025 of 2.12 mm/yr (Ref.[5]) and 4.13 mm/yr (Ref.[15]). These compare with the mean rate between 1960 and 2024 from Table 2 of 3.8 mm/yr.

4.5 Basis of Future Prediction of Relative Sea Level Rise

Prediction is necessarily very uncertain.

Here the predictions are based on simple extrapolation.

The most problematical issue is the treatment of acceleration.

I have argued in Appendix D that any ongoing acceleration in the global or isostatic rebound mechanisms is unlikely, and this adds to the argument of section 4.3 which suggests that acceleration is predominantly associated with local land movements.

In respect of, say, flooding risk, local factors will be dominant and these will vary markedly over small distances. Consequently, the local factors implicit in the relative sea rise data from tidal stations are not indicative of flooding risk at inland locations. The best way of proceeding would therefore be to,

i. Subtract from the tidal station data the part due to local land movement, and,
ii. Predict future sea level rise based on extrapolation assuming the current rate after such subtraction persists unchanged (noting that acceleration is expected to be minimal after removing the local effects), and,
iii. For local predictions add to the above prediction the increase in land lowering due to the local factors that require sources beyond those considered here.

Here only (i) and (ii) would be done as (iii) requires entirely separate, and highly localised, considerations. Note that the result of (i) and (ii) still includes the global or regional effects of tectonics and isostatic rebound. Only the more localised factors have been removed.

However, we cannot carry out that procedure because (i) is unknown. We therefore proceed based on (ii) alone, i.e., assuming the current rise rate without subtraction persists. This will over-estimate the future relative sea level rise provided that it is understood that local effects have not been fully accounted for. This will provide an over-estimate because the current rise rate has been found including all effects and the net acceleration to 2025. Consequently, the predictions continue to include allowance for local effects but based on no further acceleration in these after 2025 (which may not be justified).

On this basis, Table 5 gives the resulting predictions for the rise in sea level at the UK locations from 2025 to 2050, 2075 and 2100. The average rise across the UK locations in the next 25 years is 90mm (standard deviation 53mm), and 2 or 3 times this over 50 or 75 years.

However, the rise at some locations, especially southerly locations, is predicted to be substantially larger, notably at Newlyn, Sheerness and Lowestoft.

The extreme is to assume that accelerations, as measured between 1960 and 2025, persist unchanged over the next 75 years. This would then be a full allowance for local effects. Table 6 gives the resulting bounding predictions of the sea level rise after 2025 based on assuming the fitted acceleration persists to the end of the century.

5. Conclusions

[1] Globally, 81 tidal stations' data on sea levels have been considered and 47 analysed.

[2] Tidal station data does not measure absolute sea level rise but the sea level rise with respect to the local land as datum. This will be called "relative sea level rise." Vertical land movements can be as greater as, or greater than, the absolute sea level rise.

[3] Relative rise is appropriate in assessing flooding risk but will be strongly dependent on local conditions of land subsidence.

[4] A large proportion of stations' data display behaviour which is anomalous in some way, often showing no trend or a clear trend towards lower (relative) sea level. Appendix C includes the sea level graphs for 34 cases of this sort. The exclusion of these from the analysis will bias upwards the average rise rates calculated.

[5] More than half the current (2025) rate of (relative) sea level rise also occurred prior to 1960, and as far back as the mid-19th century (at least), and hence cannot be attributed to the "modern phase" of global warming (that since 1960 and generally attributed to greenhouse gas emissions). Less than half the current rate of rise could be due to greenhouse gas emissions.

[6] Regression fits to the (relative) sea level rise data have been carried out assuming linear or quadratic variation with time. Quadratic fits were used to predict current and future rise rates only if the acceleration was found to be statistically significant.

[7] Statistically significant acceleration in the rate of rise of sea level since 1960 was seen only in one-third of the tidal stations' data examined.

[8] It has been argued that, where significant acceleration is found, it is likely to be due mostly to local land subsidence effects.

[9] Cubic fits were carried out when accelerations were significant but the cubic terms (rate of increase of acceleration) were mostly not statistically significant or resulted in graphical behaviours regarded as improbable (likely due to over-fitting). Consequently, increasing accelerations are deemed unlikely.

[10] Across the 47 tidal stations whose data was analysed, the regression fits provided an average rate of rise of (relative) sea level of 3.8 mm/year with a standard deviation of 2.22 mm/year. The latter uncertainty will be mostly attributable to the variability in local effects from location to location.

[11] The mean rate of 3.8 mm/year is consistent with the lower bound of the range of predictions by the IPCC in 2014 (Figure 4). However, in the present analysis 3.8 mm/yr is not a lower bound but a best estimate. In 2023 the IPCC (Ref.[9b]) raised the lower bound to be rather greater than my best estimate.

[12] This average rate of rise of 3.8 mm/year may be indicative of the absolute sea level rate of rise if land movement effects can be assumed to cancel out over the averaging process (i.e., as much rising and lowering of land levels).

[13] Using their quoted rates and accelerations, Refs.[5,15] respectively imply absolute sea level rise rates at 2025 of 2.12 mm/yr and 4.13 mm/yr, compared with my 3.8 mm/year.

[14] The average relative rise in sea level across Britain from 2025 to 2100 was estimated to be 269mm, with a standard deviation of 159mm indicative of very large local variations due mainly to land movements. For British locations with no currently significant acceleration, this average rise will be bounding (Table 5).

[15] For some British locations there is a statistically significant acceleration. For these the estimates of relative sea level rise after 2025 in Table 5 may not be bounding. Those of Table 6 will be bounding. The largest of these approaches the upper bound of the IPCC predictions (Figure 4) but is substantially lower than more recent upper bounds (e.g., Figure 5). It is important to appreciate that such large ***relative*** sea level rises are due mostly to the land dropping not to the sea rising, and as such will apply only to a few specific locations, not across the globe – or even across Britain - as IPCC may suggest.

6. References

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[8] https://research.csiro.au/slrwavescoast/sea-level/

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(b) IPCC Climate Change Synthesis Report 2014, IPCC_AR6_SYR_FullVolume.pdf

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[15] P. Hogarth, C.W. Hughes, S.D.P. Williams and C. Wilson (2020). Improved and extended tide gauge records for the British Isles leading to more consistent estimates of sea level rise and acceleration since 1958. Progress in Oceanography, Volume 184, May 2020, 102333. https://doi.org/10.1016/j.pocean.2020.102333.

Table 1: Quadratic fits over longest available timebase where the earliest date is before 1960, $y = at^2 + bt + c$. The "statistical significance" refers to the acceleration, not the rate of rise. These datasets often start around or before 1900.

Station	Acceleration Statistically Significant?	Acceleration (mm/year^2)	Fitted Rate of Rise 2025 (mm/year)
Newlyn, UK	Yes	0.0223	3.30
North Shields, UK	No	0.0003	1.96
Sheerness, UK	Yes	0.0173	3.44
Holyhead	No	0.0206	3.28
Aberdeen	Yes	0.0330	2.75
Oostende	Yes	0.0571	4.58
Seattle, USA	No	0.0104	2.75
Prince Rupert, Gulf of Alaska	No	0.0043	1.33
Den Helder, Netherlands	Yes	0.0071	2.13
Esbjerg, Denmark	No	0.0106	2.01
Korsor, Denmark	No	0.0083	1.40
Warnemunde, Germany	Yes	0.0078	1.97
Tuapse, Black Sea	No	0.0035	2.51
Poti, Black Sea	Yes	0.0211	8.35
La Jolla, California	No	-0.0026	1.85
Key West, Gulf of Mexico	Yes	0.0266	4.11
Pensacola, Gulf of Mexico	Yes	0.0372	4.65
Atlantic City, USA	Yes	0.0180	5.26
Charlotte, Canada	Yes	0.0163	4.16
Wellington (NZ)	Yes	0.0447	4.54
Visak, Bay of Bengal	Yes	0.0469	3.57
Hoek Van Holland	No	0.0009	2.50
Cuxhaven, Germany	No	-0.0012	2.03
Hilo, Hawaii	No	-0.0134	2.54
Portland, Maine, USA	No	0.0033	2.16
Boston, USA	No	0.0044	3.15
St.John, Canada	No	0.0018	2.35
Montevideo, Uruguay	No	0.0161	1.90
Mean	***46% Yes***	***0.0151***	***3.09***
Standard Deviation	***54% No***	***0.0166***	***1.48***

Table 2: Quadratic and Linear fits to data from 1960 or later, $y = at^2 + bt + c$ or $y = bt + c$. The "statistical significance" refers to the acceleration, not the rate of rise. If not significant the linear fit to the data provides the preferred current rate of rise and is listed in brackets.

Station	Acceleration Statistically Significant?	Acceleration (mm/year^2)	Fitted Rate of Rise 2025 (mm/year)
Newlyn, UK	Yes	0.1200	6.58
North Shields, UK	Yes	0.0790	4.59
Lowestoft, UK	Yes	0.0812	5.80
Sheerness, UK	Yes	0.1371	7.30
Dover, UK	No	0.0013	2.42 (2.37 linear)
Immingham	No	-0.0774	-2.36 (0.68 linear)
Portsmouth	No	0.0210	2.80 (2.09 linear)
Devonport	No	0.0422	3.97 (2.56 linear)
Holyhead	No	0.0376	3.43 (2.04 linear)
Heysham	No	0.0598	5.03 (3.07 linear)
Aberdeen	Yes	0.0752	4.37
Wick	No	0.0361	2.71 (1.57 linear)
Calais	Yes	0.1933	7.47
Dunkerque	No	0.0361	3.00 (1.77 linear)
Oostende	Yes	0.0699	4.95
Zeebrugge	No	0.0174	3.53 (2.97 linear)
Dieppe	No	-0.0388	3.29 (4.62 linear)
Seattle, USA	No	0.0220	2.89 (2.16 linear)
Prince Rupert, Gulf of Alaska	No	-0.0457	-0.51 (1.01 linear)
Den Helder, Netherlands	No	0.0468	3.67 (2.11 linear)
Esbjerg, Denmark	No	0.0488	3.90 (2.12 linear)
Korsor, Denmark	No	-0.0004	1.21 (1.23 linear)
Warnemunde, Germany	No	0.0285	2.84 (1.88 linear)
Tuapse, Black Sea	No	-0.0234	1.74 (2.54 linear)
Poti, Black Sea	No	-0.0086	8.20 (8.51 linear)
La Jolla, California	No	-0.0464	0.55 (2.08 linear)
Key West, Gulf of Mexico	Yes	0.0894	6.41
Pensacola, Gulf of Mexico	Yes	0.1392	8.17
Atlantic City, USA	No	0.0474	6.30 (4.72 linear)
Charlotte, Canada	Yes	0.0752	6.11
Wellington (NZ)	Yes	0.0502	4.72
Bluff (NZ)	Yes	0.0622	4.63
Adelaide. Australia	No	0.0246	2.97 (2.02 linear)
Cebu, Philippines	Yes	0.1836	8.90
Visak, Bay of Bengal	No	0.0484	3.77 (2.17 linear)
Bunbury, Australia	No	0.0548	3.72 (1.87 linear)
Hoek Van Holland	No	-0.0126	2.55 (2.97 linear)
Cuxhaven, Germany	No	0.0758	4.97 (2.43 linear)
Reykjavic, Iceland	No	-0.0094	2.07 (2.39 linear)
Kotelnyi, Russia (Laptev Sea)	No	-0.0644	1.67 (4.21 linear)
Hilo, Hawaii	No	0.0158	3.39 (2.86 linear)

Portland, Maine, USA	Yes	0.0668	4.16
Boston, USA	Yes	0.1044	6.65
St.John, Canada	No	0.0338	3.27 (2.13 linear)
Phrachula, Thailand	Yes	-0.4300	1.85
Argentine Islands, Antarctica	No	-0.0112	0.75 (1.16 linear)
Montevideo, Uruguay	No	0.0217	2.04 (1.32 linear)
Mean	***34% Yes***	***0.0315***	***3.80****
Standard Deviation	***66% No***	***0.0896***	***2.22****

**using the linear fit when acceleration is not significant*

Table 3: Cubic fits to data from 1960 or later, $y = jt^3 + at^2 + bt + c$, only listed if the quadratic fit (Table A.2) has significant acceleration. The "statistical significance" in this Table refers to the jerk ($6j$, the rate of change of acceleration), not to the rate of rise or the acceleration. If the jerk is not significant then the quadratic fit (Table 2) is preferred to this cubic fit. In all cases where the jerk was significant the fits are rejected on judgmental grounds (see Figures A.2).

Station	Jerk Statistically Significant?	Jerk (mm/year^3)	Acceleration (mm/year^2)	Fitted Rate of Rise 2024 (mm/year)
Newlyn, UK	No	0.00335	0.2317	8.09
North Shields, UK	No	0.00009	0.0822	4.63
Lowestoft, UK	No	-0.00405	-0.0613	3.73
Sheerness, UK	No	-0.0088	-0.1352	3.76
Aberdeen	No	-0.0077	-0.1972	0.26
Calais	No	0.00255	0.2672	8.29
Oostende	No	0.00404	0.2033	6.72
Key West, Gulf of Mexico	Yes	0.0129	0.5219	12.39
Pensacola, Gulf of Mexico	Yes	0.0159	0.6654	8.17
Charlotte, Canada	No	0.0070	0.3052	9.09
Wellington (NZ)	No	-0.0039	-0.0771	3.04
Bluff (NZ)	Yes	0.0165	0.6131	11.84
Cebu, Philippines	Yes	0.0167	0.7343	16.14
Portland, Maine, USA	Yes	0.0126	0.4825	9.69
Boston, USA	No	0.0007	0.1268	6.95

Table 4: Comparison of average rise rate before 1960 to the fitted rise rate at 2025

Station	Average rise rate before 1960, mm/yr	Fitted rise rate at 2025 mm/yr	Ratio (before 1960 / 2025)
Newlyn, UK	2.12	6.58	0.32
North Shields, UK	2.03	4.59	0.44
Sheerness, UK	1.05	7.3	0.14
Holyhead, UK	0	2.04	0.00
Aberdeen, UK	1.23	4.37	0.28
Oostende	0.49	4.95	0.10
Seattle, USA	1.69	2.16	0.78
Prince Rupert, Alaska	0.47	1.01	0.47
Den Helder, Netherlands	1.34	2.11	0.64
Esbjerg, Denmark	1.11	2.12	0.52
Korsor, Denmark	0.71	1.23	0.58
Warnemunde, Germany	1.08	1.88	0.57
Tuapse, Black Sea	2.23	2.54	0.88
Poti, Black Sea	6.39	2.08	3.07
La Jolla, California	2.11	0.55	3.84
Key West, Gulf of Mexico	2.62	6.41	0.41
Pensacola, Gulf of Mexico	3.49	8.17	0.43
Atlantic City, USA	3.83	4.72	0.81
Charlotte, Canada	3.22	6.11	0.53
Wellington (NZ)	2.51	4.72	0.53
Visak, Bay of Bengal	1.89	2.17	0.87
Hoek Van Holland	2.42	2.97	0.81
Cuxhaven, Germany	2.32	2.43	0.95
Hilo, Hawaii	3.55	2.86	1.24
Portland, Maine, USA	2.29	4.16	0.55
Boston, USA	4.36	6.65	0.66
St.John, Canada	2.41	2.13	1.13
Phrachula, Thailand	2.72	1.85	1.47
Montevideo, Uruguay	0.65	1.32	0.49
Mean	***2.15***	***3.52***	***0.81****
Standard Deviation	***1.35***	***2.11***	***0.81****

**the mean and standard deviation of the ratios including only those ratios less than 1 are 0.56 and 0.23 respectively. Hence, as a global average, about 56% of the ongoing rate of sea level rise seen in 2025 is not caused by global warming since 1960 (i.e., that often attributed to greenhouse gas emissions).*

Table 5: <u>Relative</u> Sea Level Rise Predicted from 2025 to Given Year for the 12 UK Stations (based on the fitted rise rate at 2025 persisting), mm. These predictions include global land movement effects due to tectonics and isostatic rebound, and also account for local land movements at the indicated locations. Local effects are only partly included in the other locations, bounding predictions for which are given in Table 6.

Station	2050	2075	2100
Newlyn, UK@	165	329	494
North Shields, UK@	115	229	344
Lowestoft, UK@	145	290	435
Sheerness, UK@	182	365	547
Dover, UK*	59	119	178
Immingham, UK*	17	34	51
Portsmouth, UK*	52	105	157
Devonport, UK*	64	128	192
Holyhead, UK*	51	102	153
Heysham, UK*	77	154	230
Aberdeen, UK@	109	219	328
Wick, UK*	39	79	118
Mean	*90*	*179*	*269*
Standard Deviation	*53*	*106*	*159*

**This Table is bounding, including all mechanisms.*

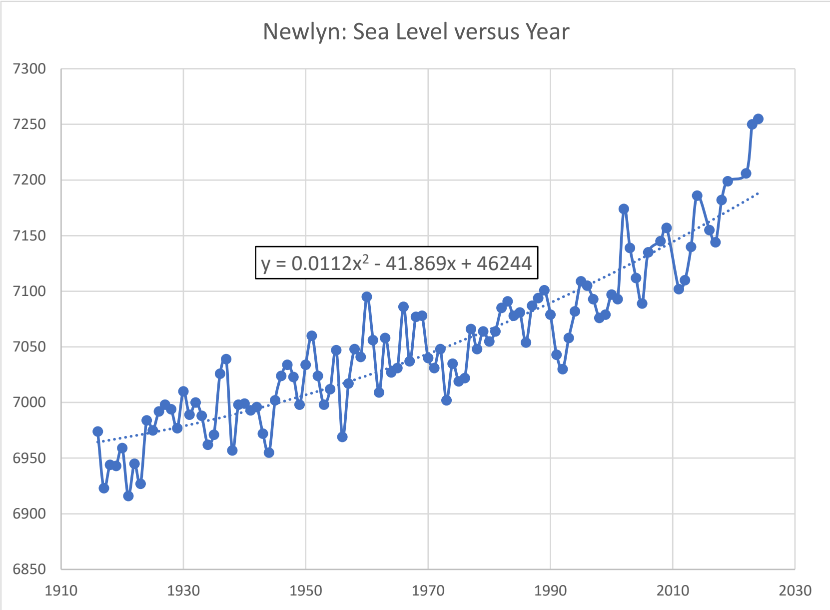
@*Only partly accounts for local land movements (that part which does not accelerate after 2025). For bounding predictions including all mechanisms see Table 6.*

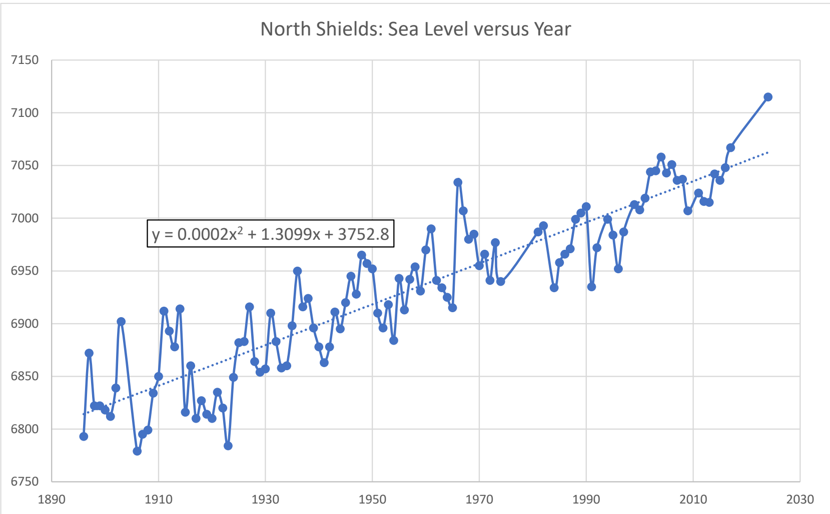
Table 6: <u>Relative</u> Sea Level Rise Predicted from 2025 to Given Year based on the fitted acceleration in rise rate persisting (for the 5 UK stations where there is a statistically significant acceleration), mm. There are 7 UK stations with no statistically significant acceleration which are predicted to have rises of between 51 and 230 mm by 2100. The relative sea level rises at the five locations below will be bounded by the values given below, including all mechanisms and acceleration. However, these predictions may have little relevance to locations just a small way inland of the tidal stations in question.

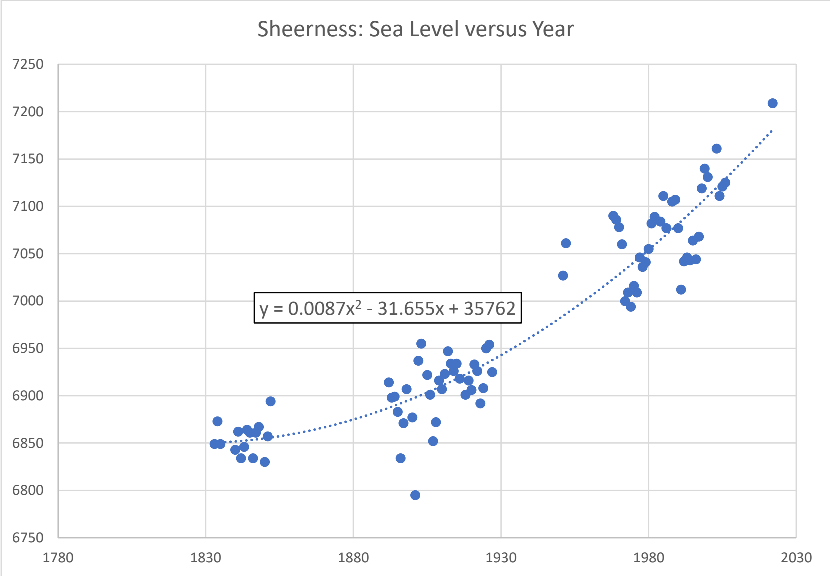
Station	2050	2075	2100
Newlyn, UK	202	479	831
North Shields, UK	139	328	566
Lowestoft, UK	170	391	663
Sheerness, UK	225	536	933
Aberdeen, UK	133	313	540

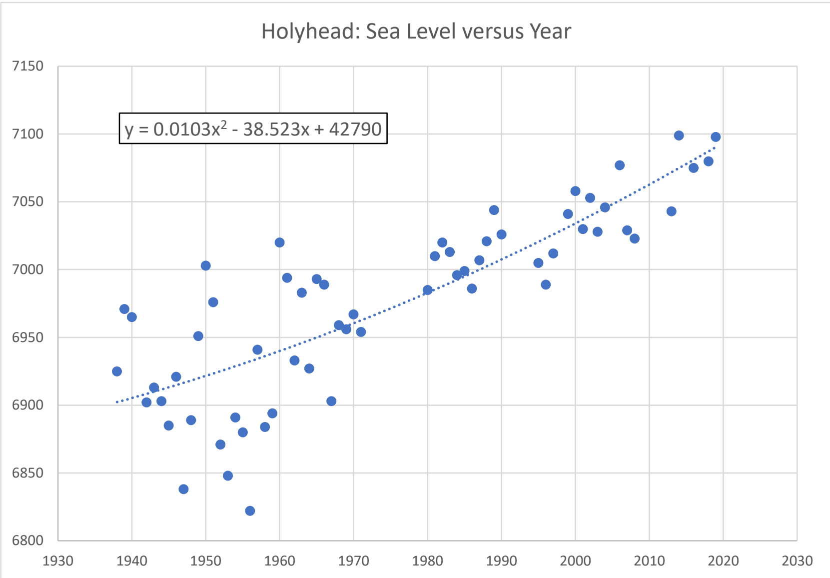
Appendix A: Graphs of Sea Level v Time

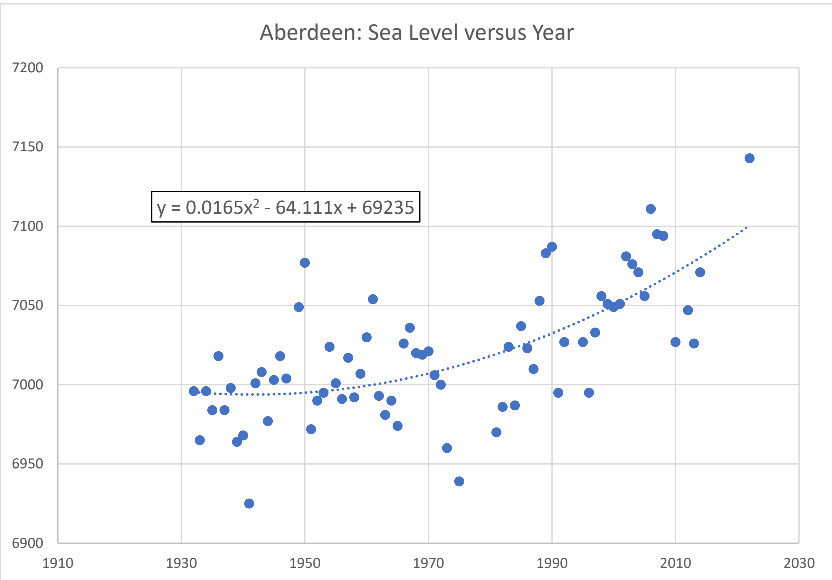
Figures A.1: Sea level data (mm) over the whole of the available timescales together with quadratic or linear fits (corresponding to Table 1).

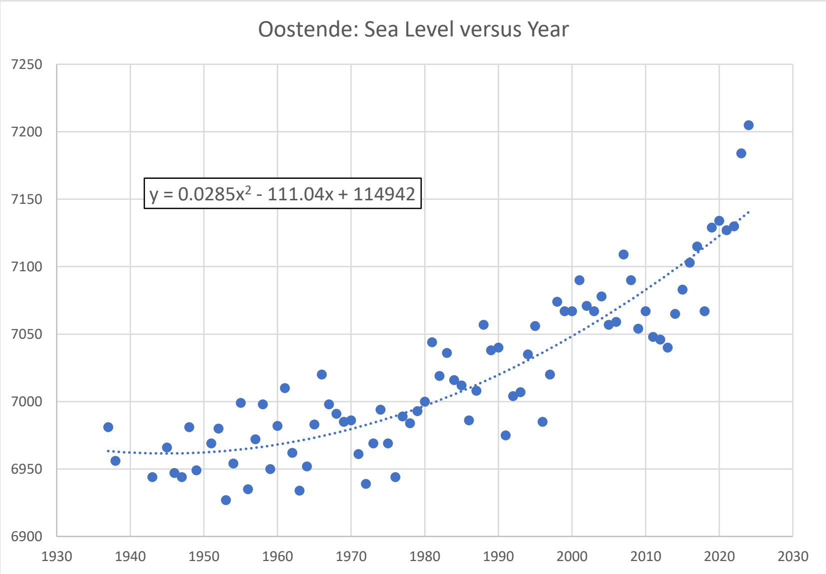




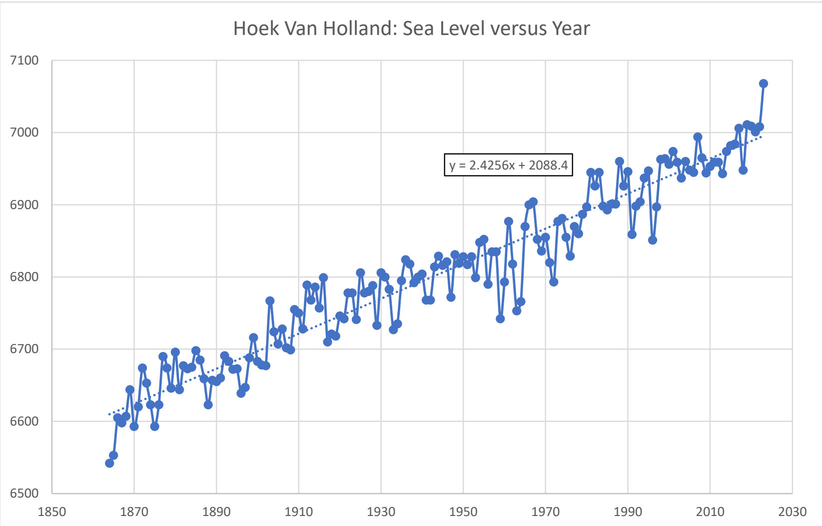

Sheerness: Sea Level versus Year
y = 0.0087x² - 31.655x + 35762
7250
7200
7150
7100
7050
7000
6950
6900
6850
6800
6750
1780
1830
1880
1930
1980
2030


Holyhead: Sea Level versus Year
y = 0.0103x² - 38.523x + 42790
7150
7100
7050
7000
6950
6900
6850
6800
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
2030

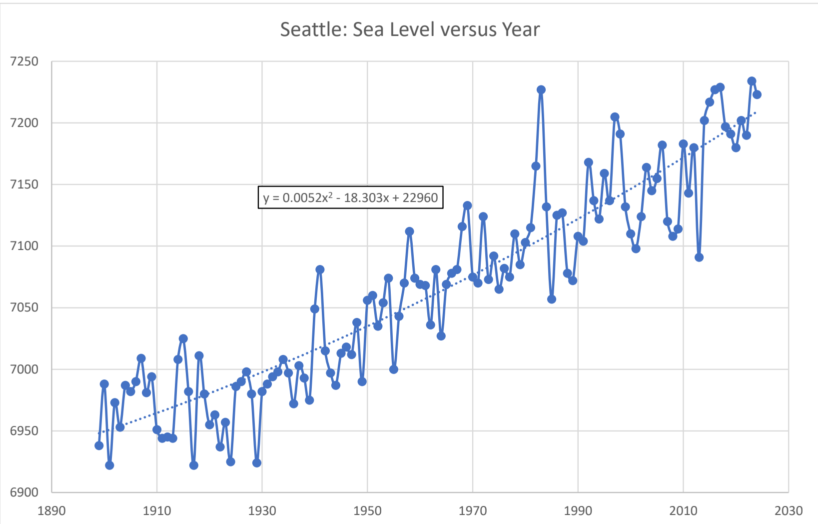

Aberdeen: Sea Level versus Year
y = 0.0165x² - 64.111x + 69235
7200
7150
7100
7050
7000
6950
6900
1910
1930
1950
1970
1990
2010
2030



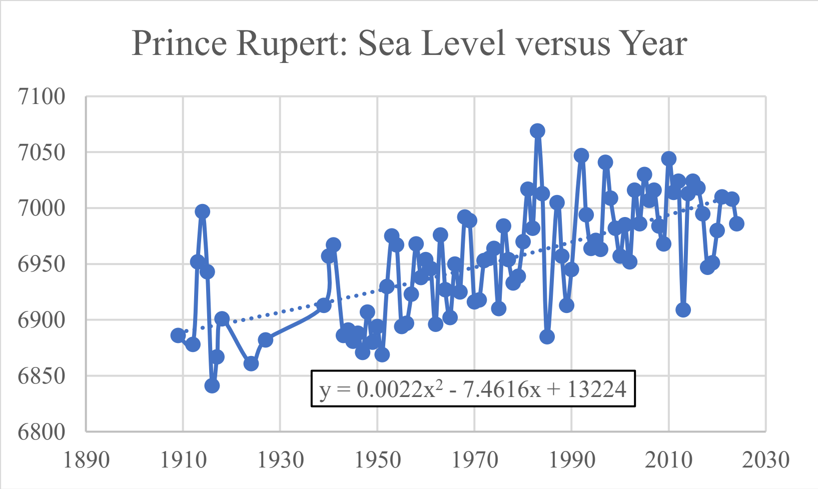
Oostende: Sea Level versus Year
y = 0.0285x² - 111.04x + 114942
7250
7200
7150
7100
7050
7000
6950
6900
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
2030

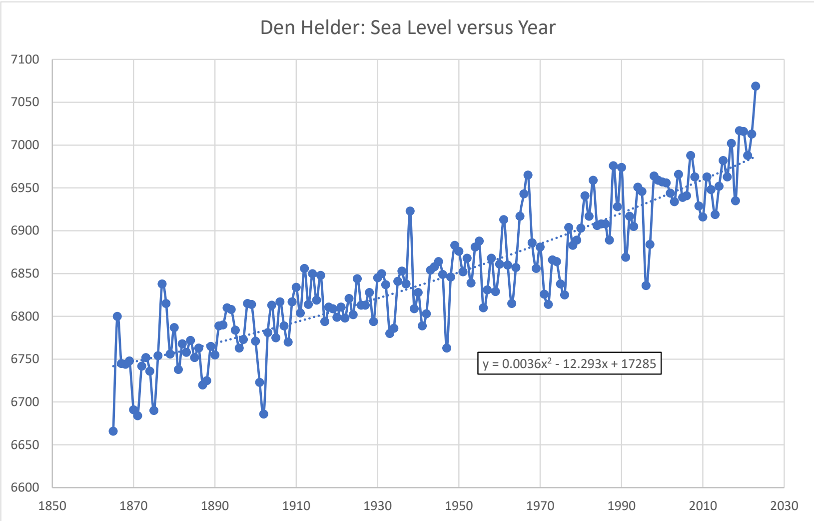


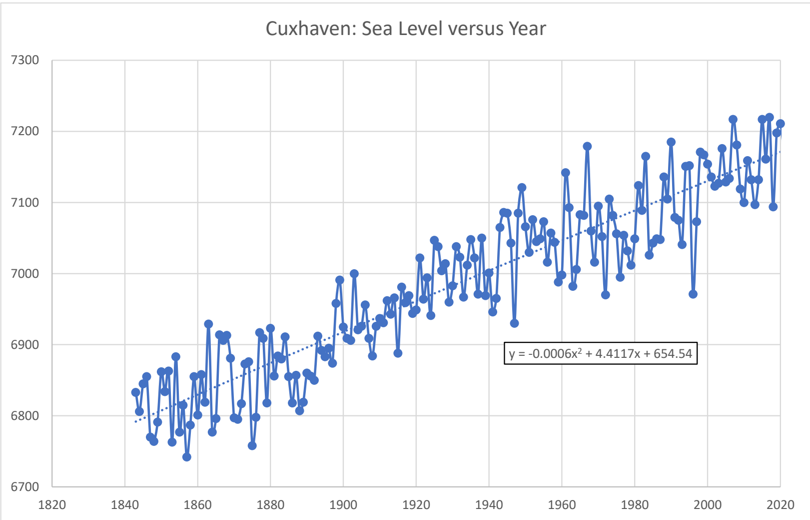
Hoek Van Holland: Sea Level versus Year
y = 2.4256x + 2088.4
7100
7000
6900
6800
6700
6600
6500
1850
1870
1890
1910
1930
1950
1970
1990
2010
2030

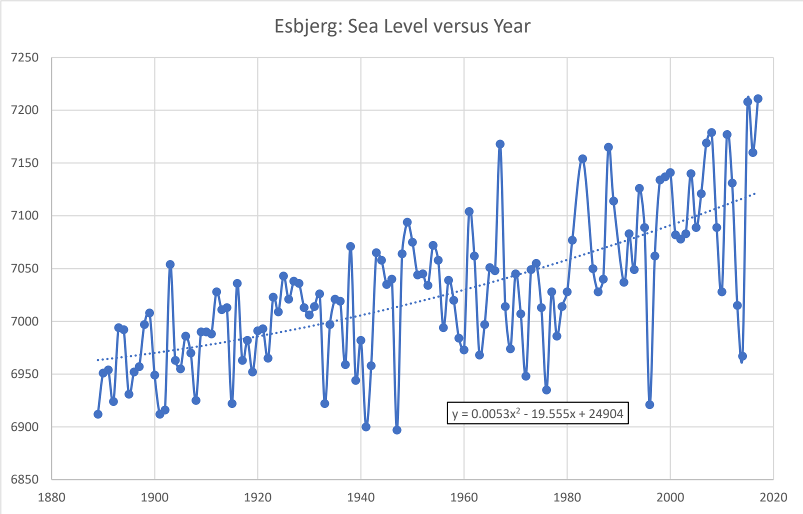


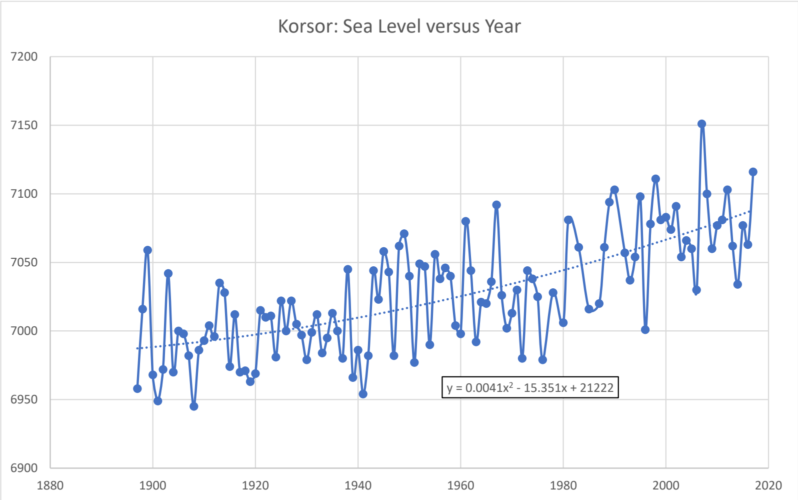
Seattle: Sea Level versus Year
y = 0.0052x² - 18.303x + 22960
7250
7200
7150
7100
7050
7000
6950
6900
1890
1910
1930
1950
1970
1990
2010
2030

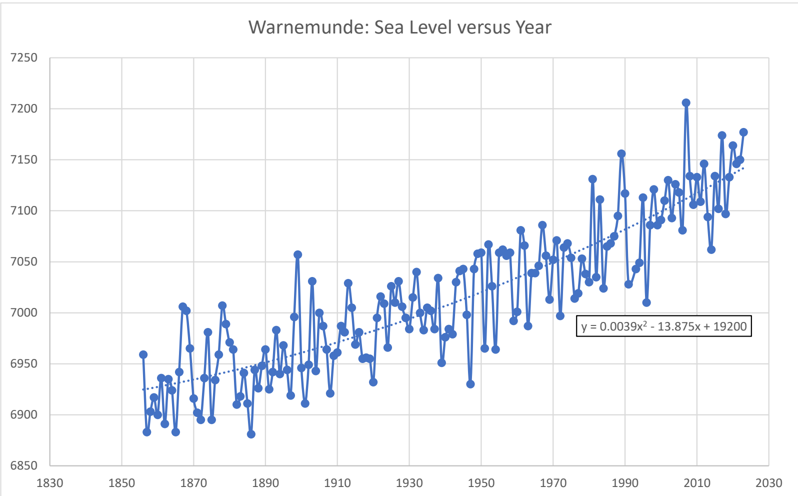

Prince Rupert: Sea Level versus Year
y = 0.0022x² - 7.4616x + 13224
7100
7050
7000
6950
6900
6850
6800
1890
1910
1930
1950
1970
1990
2010
2030

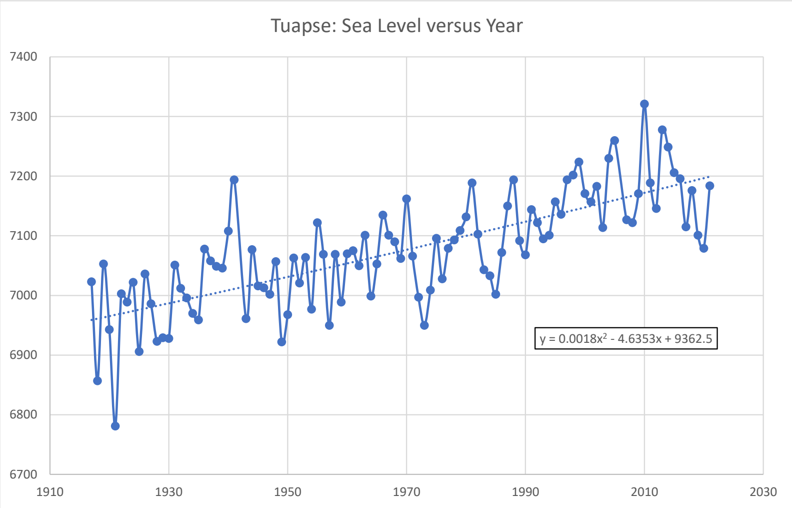

Den Helder: Sea Level versus Year
y = 0.0036x² - 12.293x + 17285
7100
7050
7000
6950
6900
6850
6800
6750
6700
6650
6600
1850
1870
1890
1910
1930
1950
1970
1990
2010
2030

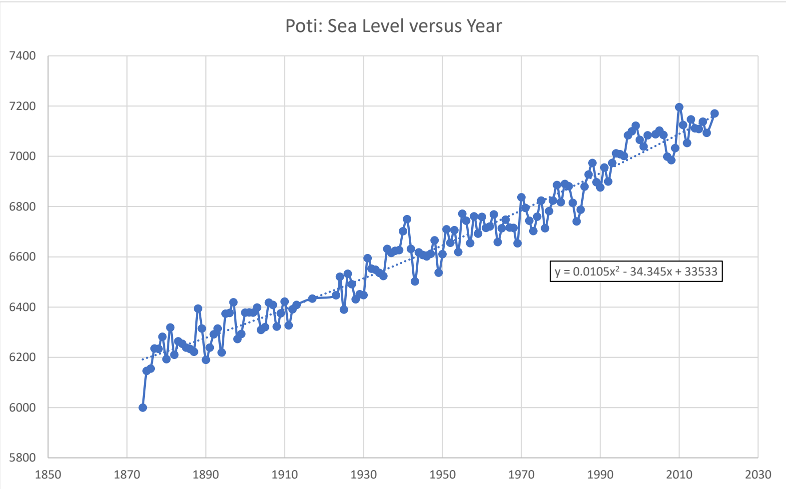

Cuxhaven: Sea Level versus Year
y = -0.0006x² + 4.4117x + 654.54
7300
7200
7100
7000
6900
6800
6700
1820
1840
1860
1880
1900
1920
1940
1960
1980
2000
2020

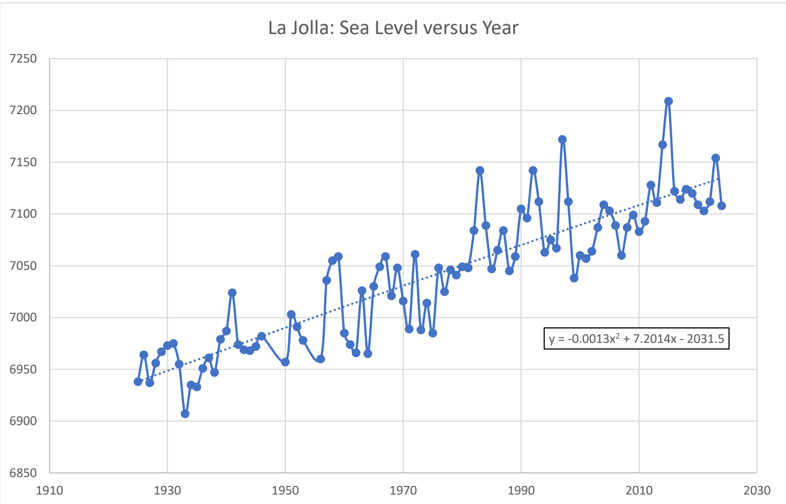

Esbjerg: Sea Level versus Year
y = 0.0053x² - 19.555x + 24904
7250
7200
7150
7100
7050
7000
6950
6900
6850
1880
1900
1920
1940
1960
1980
2000
2020

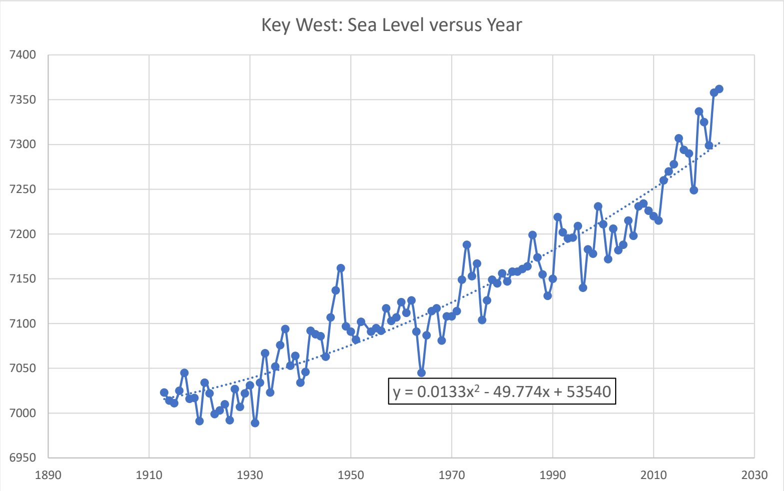

Korsor: Sea Level versus Year
y = 0.0041x² - 15.351x + 21222
7200
7150
7100
7050
7000
6950
6900
1880
1900
1920
1940
1960
1980
2000
2020

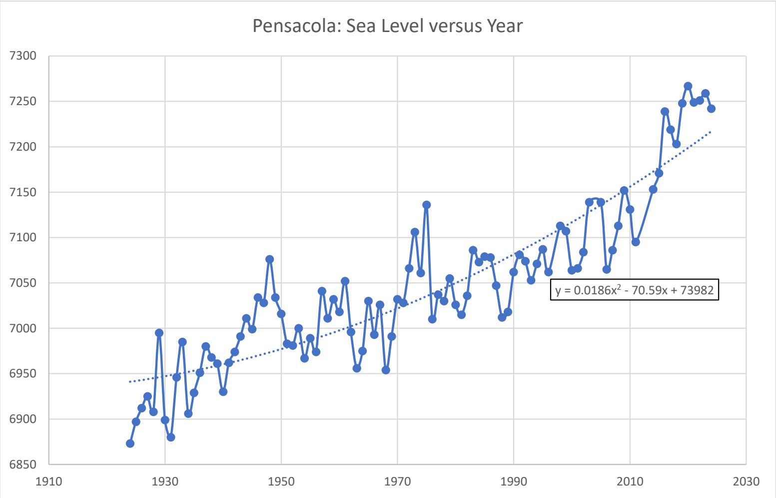

Warnemunde: Sea Level versus Year
y = 0.0039x² - 13.875x + 19200
7250
7200
7150
7100
7050
7000
6950
6900
6850
1830
1850
1870
1890
1910
1930
1950
1970
1990
2010
2030

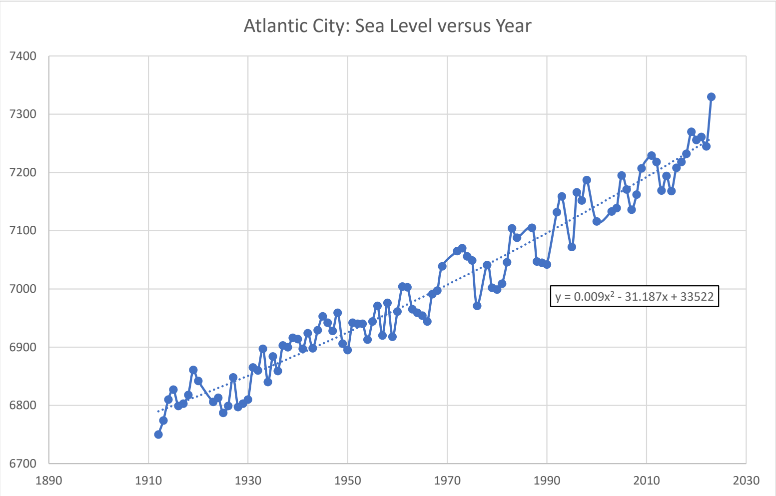

Tuapse: Sea Level versus Year
y = 0.0018x² - 4.6353x + 9362.5
7400
7300
7200
7100
7000
6900
6800
6700
1910
1930
1950
1970
1990
2010
2030

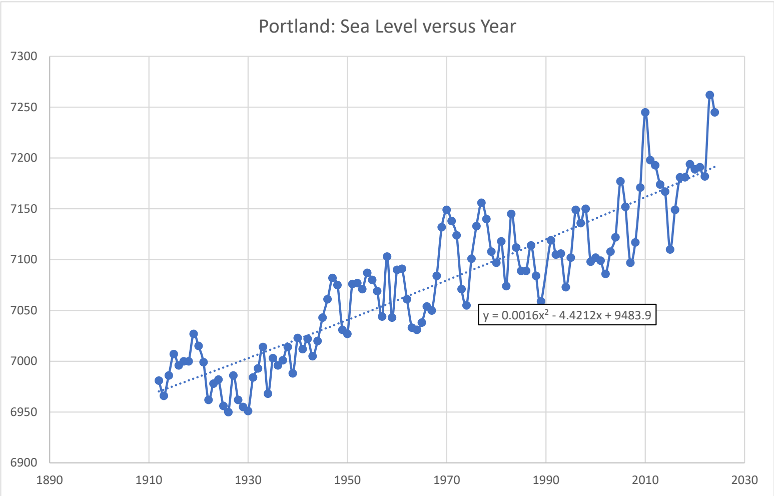

Poti: Sea Level versus Year
y = 0.0105x² - 34.345x + 33533
7400
7200
7000
6800
6600
6400
6200
6000
5800
1850
1870
1890
1910
1930
1950
1970
1990
2010
2030

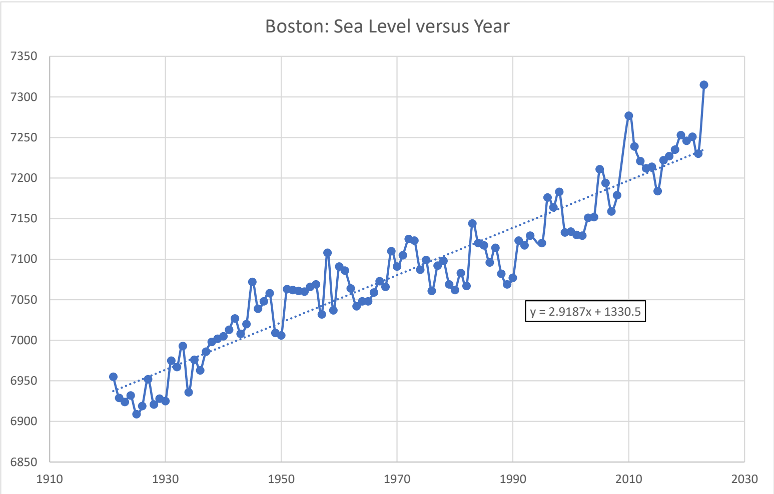

La Jolla: Sea Level versus Year
y = -0.0013x² + 7.2014x - 2031.5
7250
7200
7150
7100
7050
7000
6950
6900
6850
1910
1930
1950
1970
1990
2010
2030

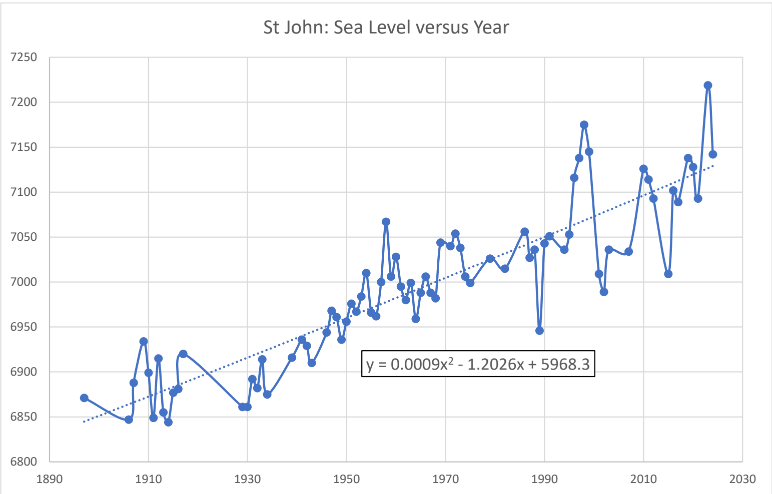

Key West: Sea Level versus Year
y = 0.0133x² - 49.774x + 53540
7400
7350
7300
7250
7200
7150
7100
7050
7000
6950
1890
1910
1930
1950
1970
1990
2010
2030

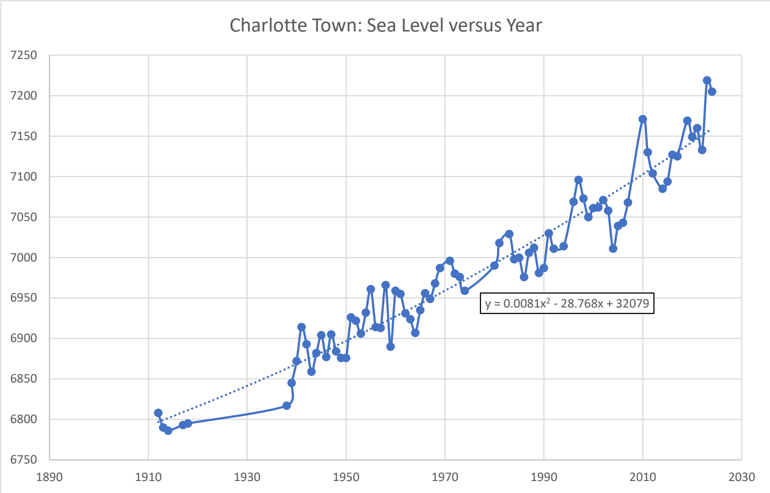

Pensacola: Sea Level versus Year
y = 0.0186x² - 70.59x + 73982
7300
7250
7200
7150
7100
7050
7000
6950
6900
6850
1910
1930
1950
1970
1990
2010
2030

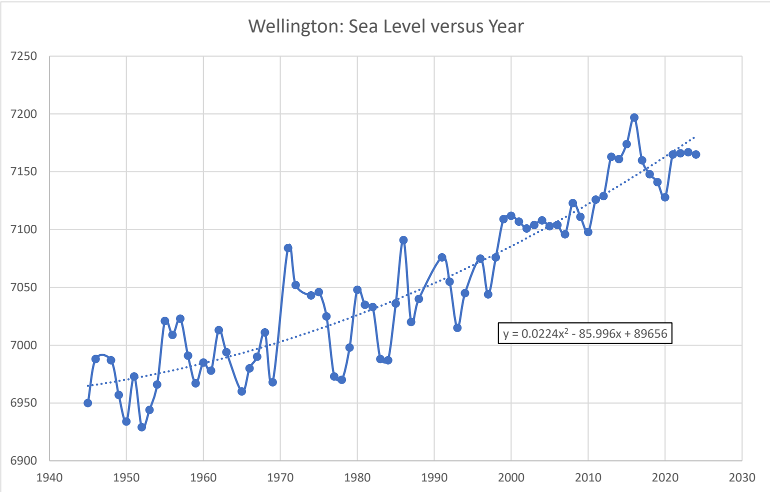

Atlantic City: Sea Level versus Year
y = 0.009x² - 31.187x + 33522
7400
7300
7200
7100
7000
6900
6800
6700
1890
1910
1930
1950
1970
1990
2010
2030

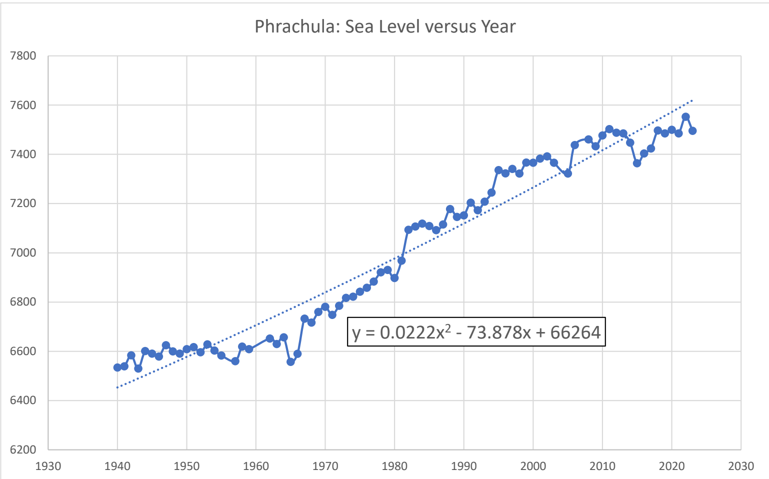

Portland: Sea Level versus Year
7300
7250
7200
7150
7100
7050
7000
6950
6900
1890
1910
1930
1950
1970
1990
2010
2030
y = 0.0016x² - 4.4212x + 9483.9

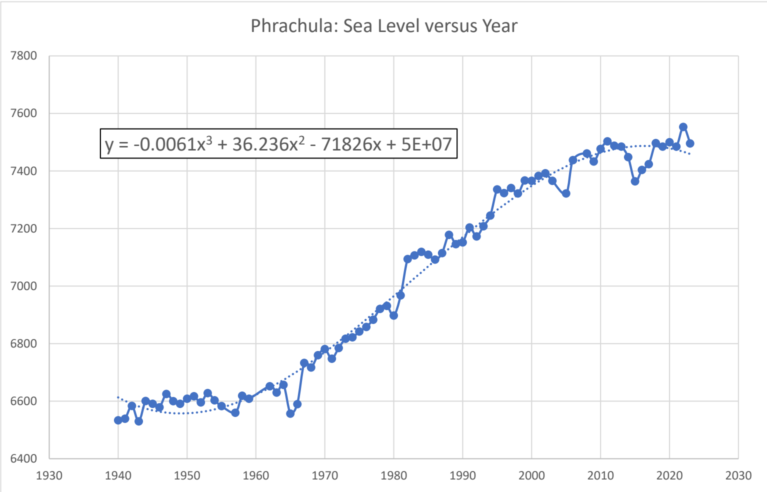

Boston: Sea Level versus Year
7350
7300
7250
7200
7150
7100
7050
7000
6950
6900
6850
1910
1930
1950
1970
1990
2010
2030
y = 2.9187x + 1330.5

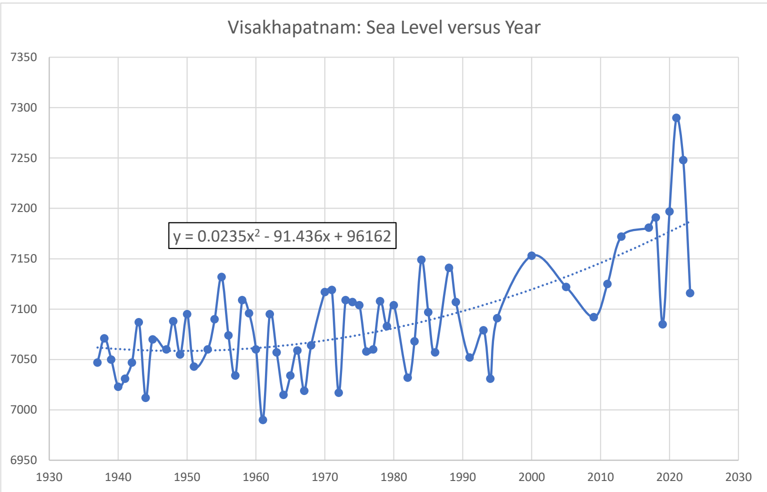

St John: Sea Level versus Year
7250
7200
7150
7100
7050
7000
6950
6900
6850
6800
1890
1910
1930
1950
1970
1990
2010
2030
y = 0.0009x² - 1.2026x + 5968.3

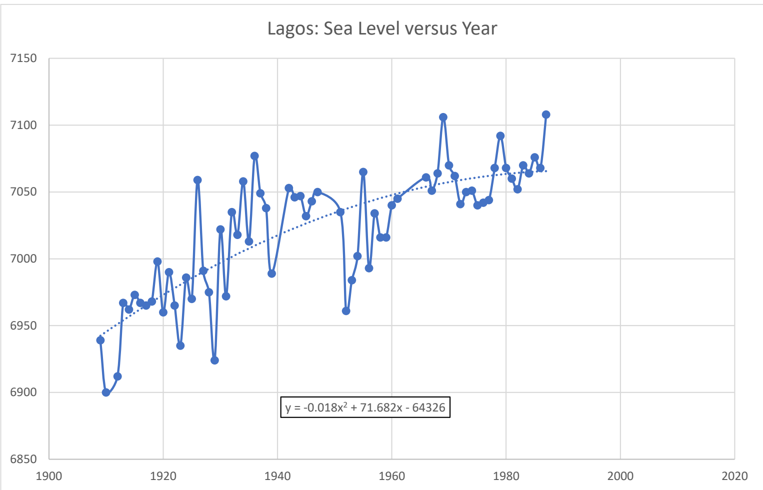

Charlotte Town: Sea Level versus Year
y = 0.0081x² - 28.768x + 32079
7250
7200
7150
7100
7050
7000
6950
6900
6850
6800
6750
1890
1910
1930
1950
1970
1990
2010
2030

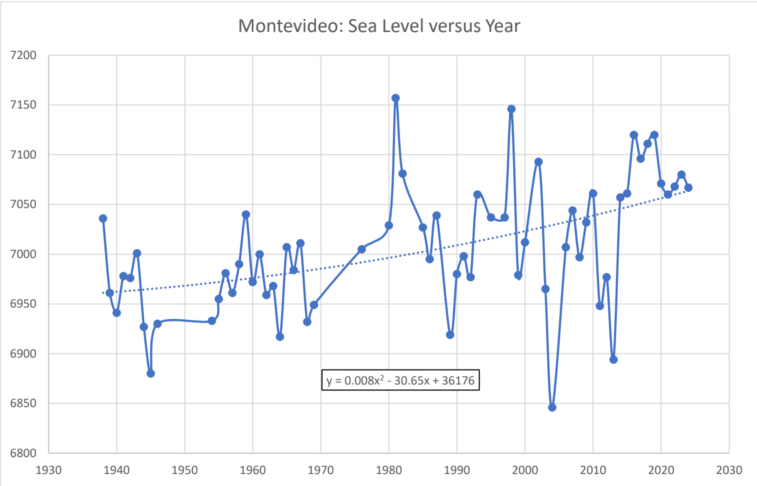

Wellington: Sea Level versus Year
y = 0.0224x² - 85.996x + 89656
7250
7200
7150
7100
7050
7000
6950
6900
1940
1950
1960
1970
1980
1990
2000
2010
2020
2030


Phrachula: Sea Level versus Year
y = 0.0222x² - 73.878x + 66264
7800
7600
7400
7200
7000
6800
6600
6400
6200
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
2030

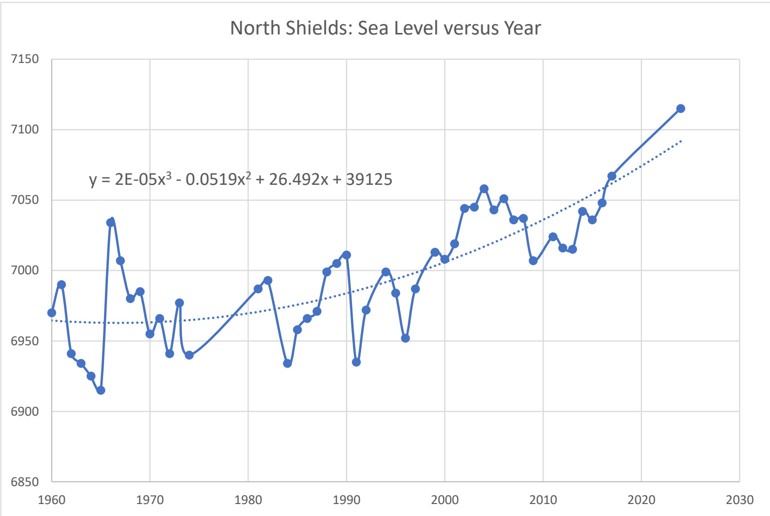

Phrachula: Sea Level versus Year
y = -0.0061x³ + 36.236x² - 71826x + 5E+07
7800
7600
7400
7200
7000
6800
6600
6400
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
2030

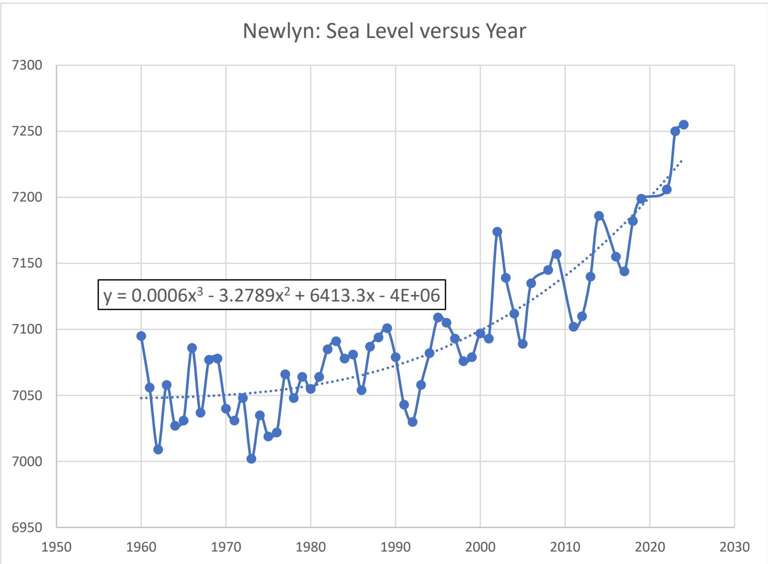

Visakhapatnam: Sea Level versus Year
y = 0.0235x² - 91.436x + 96162
7350
7300
7250
7200
7150
7100
7050
7000
6950
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
2030

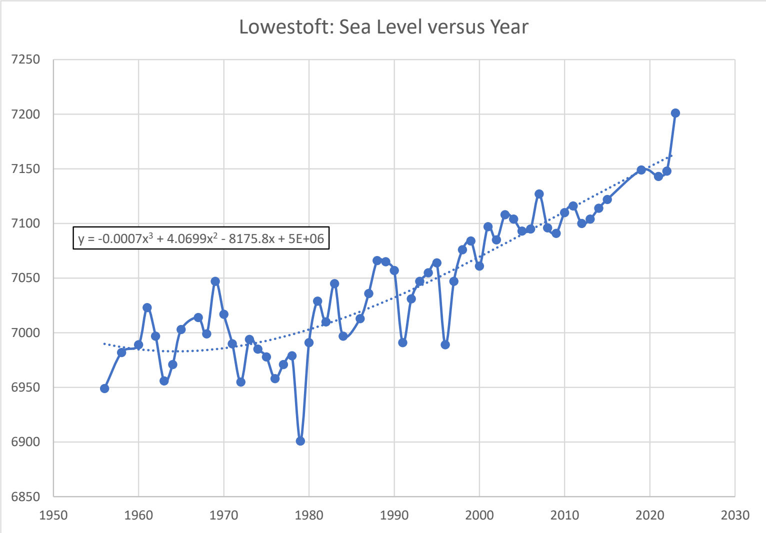

Lagos: Sea Level versus Year
y = -0.018x² + 71.682x - 64326
7150
7100
7050
7000
6950
6900
6850
1900
1920
1940
1960
1980
2000
2020

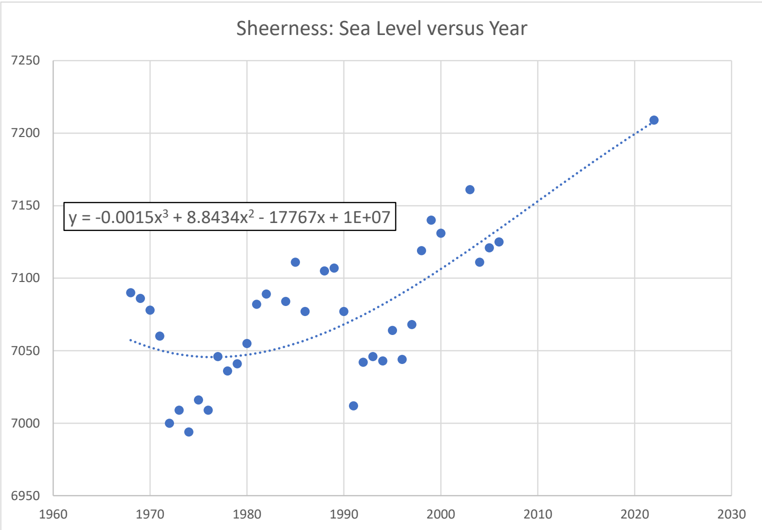


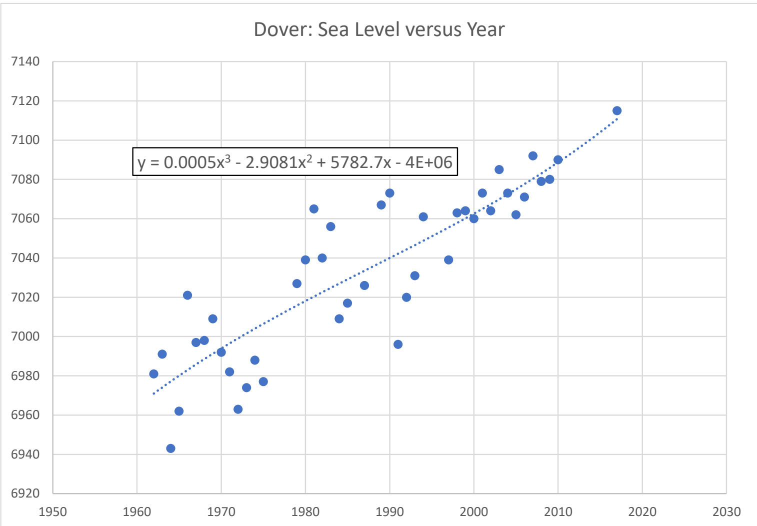
Figures A.2: Sea level data (mm) since 1960 or thereafter together with cubic, quadratic or linear fits (corresponding to Table 2).

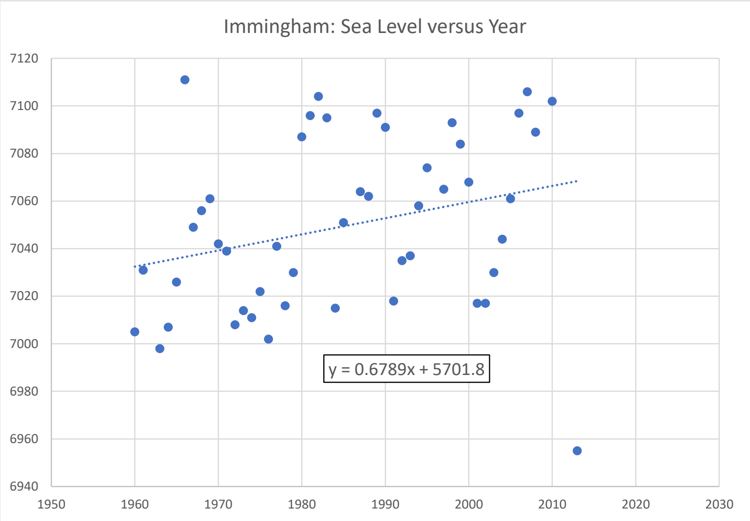




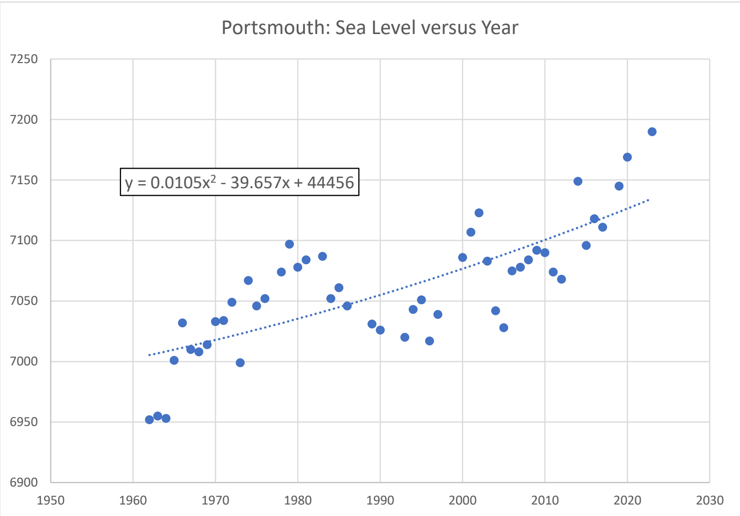

Lowestoft: Sea Level versus Year
y = -0.0007x³ + 4.0699x² - 8175.8x + 5E+06
7250
7200
7150
7100
7050
7000
6950
6900
6850
1950 1960 1970 1980 1990 2000 2010 2020 2030


Sheerness: Sea Level versus Year
y = -0.0015x³ + 8.8434x² - 17767x + 1E+07
7250
7200
7150
7100
7050
7000
6950
1960 1970 1980 1990 2000 2010 2020 2030

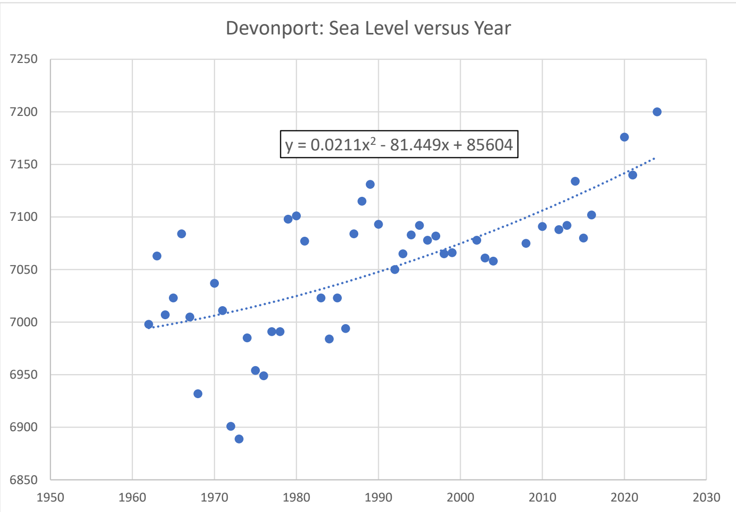

Dover: Sea Level versus Year
y = 0.0005x³ - 2.9081x² + 5782.7x - 4E+06
7140
7120
7100
7080
7060
7040
7020
7000
6980
6960
6940
6920
1950 1960 1970 1980 1990 2000 2010 2020 2030



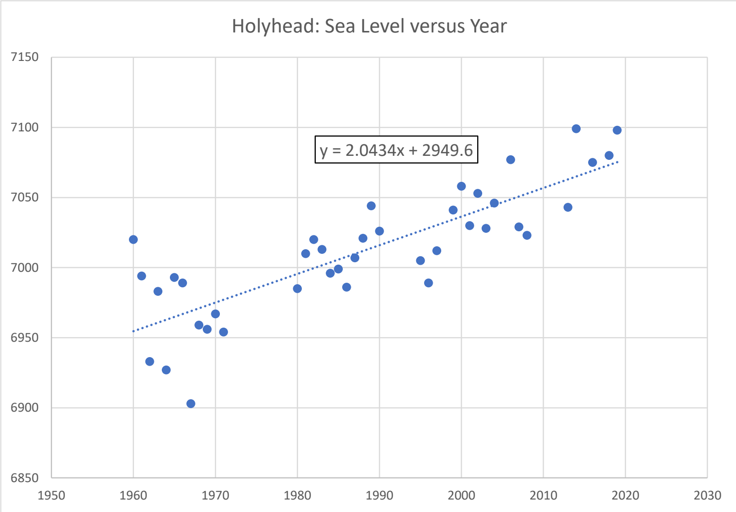
Immingham: Sea Level versus Year
7120
7100
7080
7060
7040
7020
7000
6980
6960
6940
1950
1960
1970
1980
1990
2000
2010
2020
2030
y = 0.6789x + 5701.8

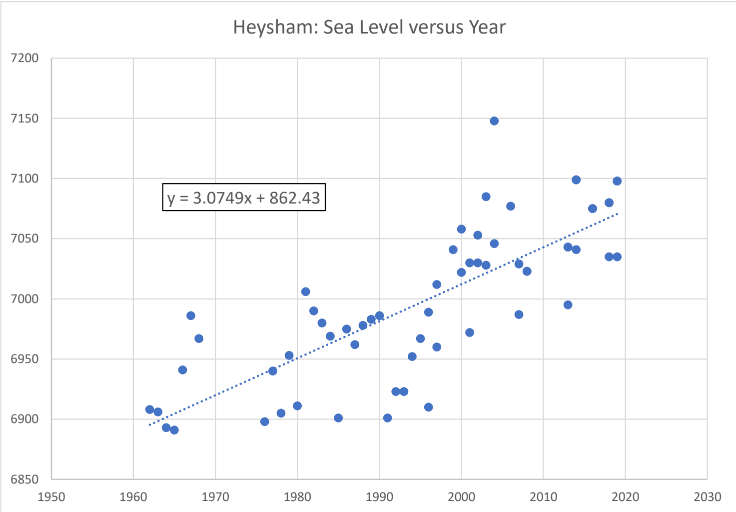


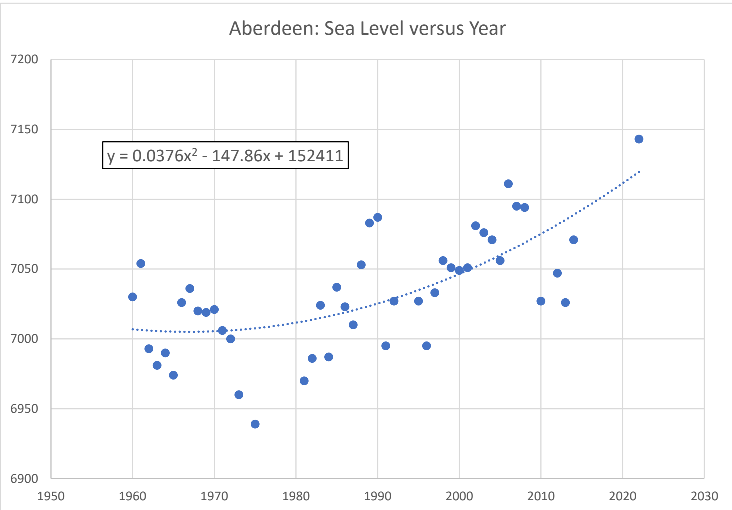
Portsmouth: Sea Level versus Year
7250
7200
7150
7100
7050
7000
6950
6900
1950
1960
1970
1980
1990
2000
2010
2020
2030
y = 0.0105x² - 39.657x + 44456

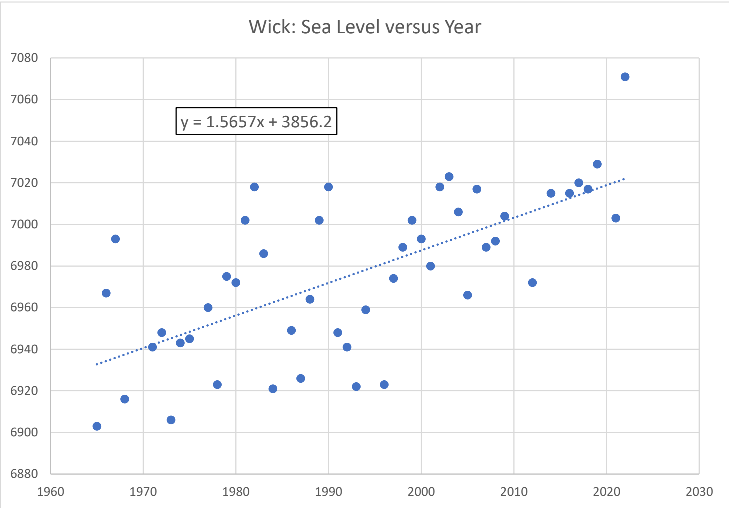


Devonport: Sea Level versus Year
7250
7200
7150
7100
7050
7000
6950
6900
6850
1950
1960
1970
1980
1990
2000
2010
2020
2030
y = 0.0211x² - 81.449x + 85604

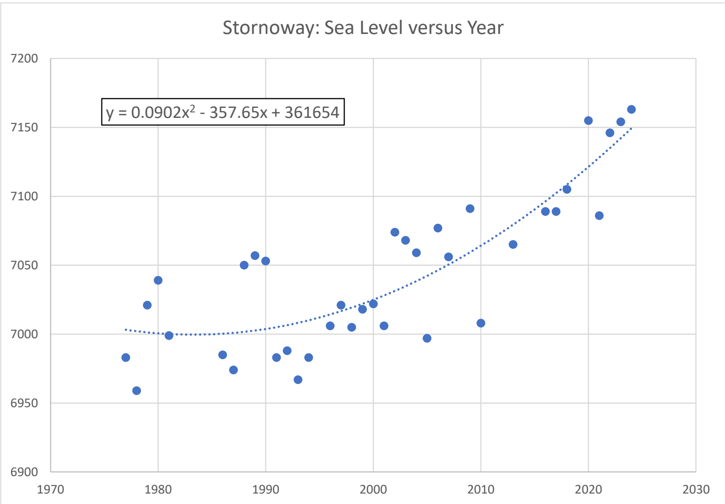

Holyhead: Sea Level versus Year
y = 2.0434x + 2949.6
7150
7100
7050
7000
6950
6900
6850
1950
1960
1970
1980
1990
2000
2010
2020
2030


Heysham: Sea Level versus Year
y = 3.0749x + 862.43
7200
7150
7100
7050
7000
6950
6900
6850
1950
1960
1970
1980
1990
2000
2010
2020
2030

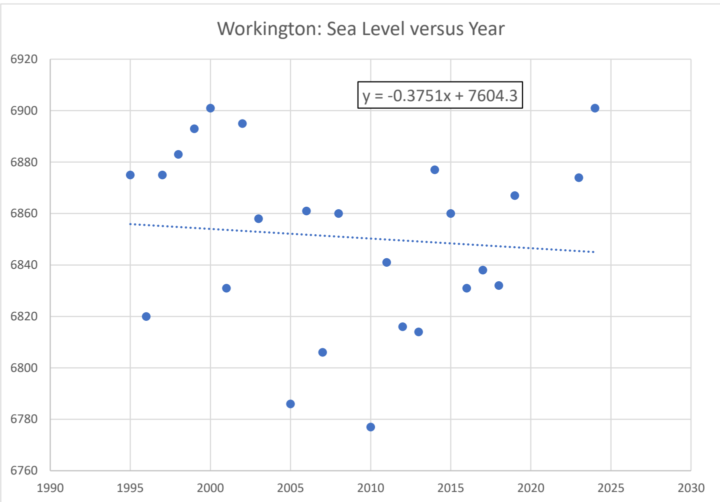

Aberdeen: Sea Level versus Year
y = 0.0376x² - 147.86x + 152411
7200
7150
7100
7050
7000
6950
6900
1950
1960
1970
1980
1990
2000
2010
2020
2030



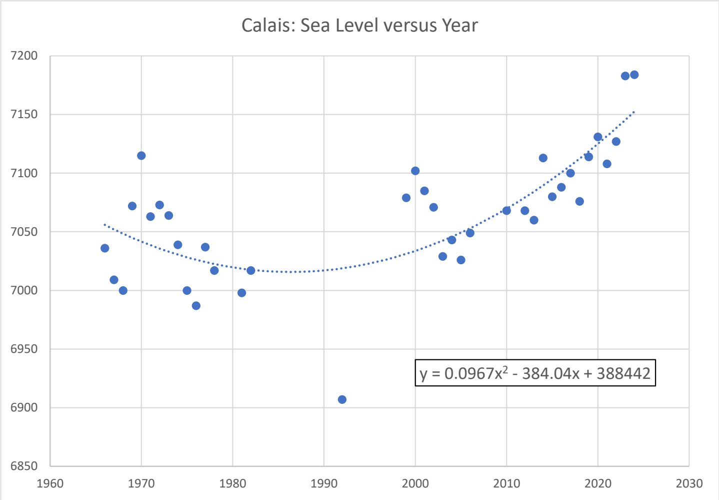
Wick: Sea Level versus Year
y = 1.5657x + 3856.2
7080
7060
7040
7020
7000
6980
6960
6940
6920
6900
6880
1960
1970
1980
1990
2000
2010
2020
2030

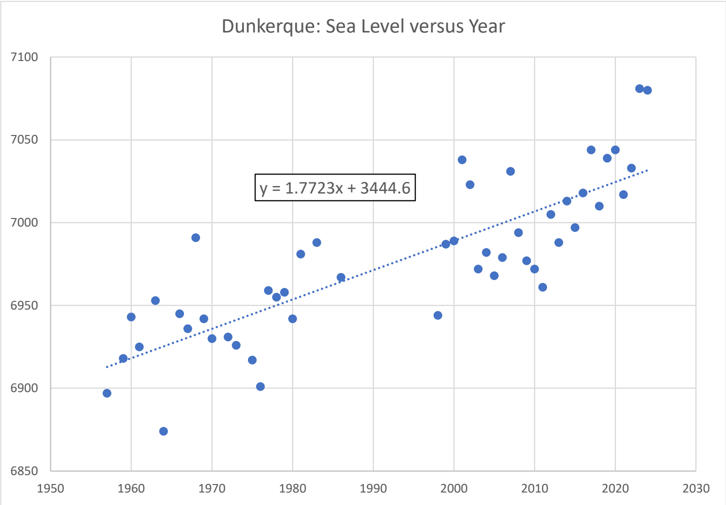


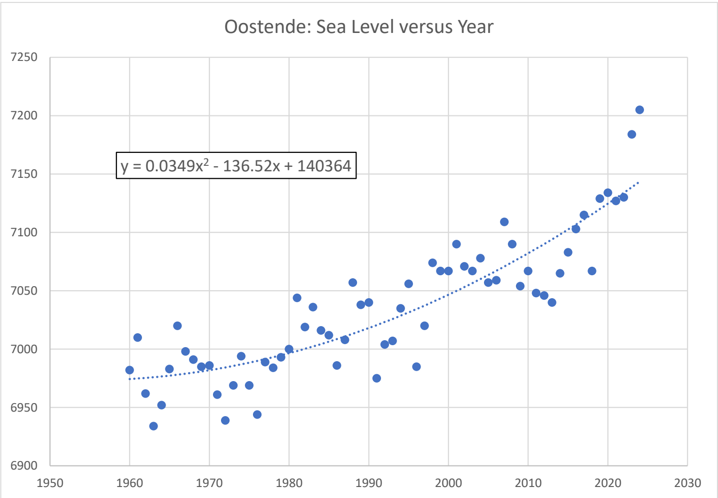
Stornoway: Sea Level versus Year
y = 0.0902x² - 357.65x + 361654
7200
7150
7100
7050
7000
6950
6900
1970
1980
1990
2000
2010
2020
2030

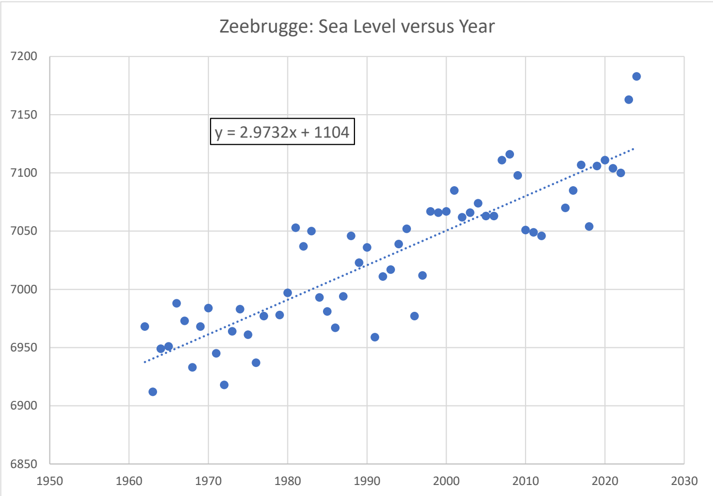


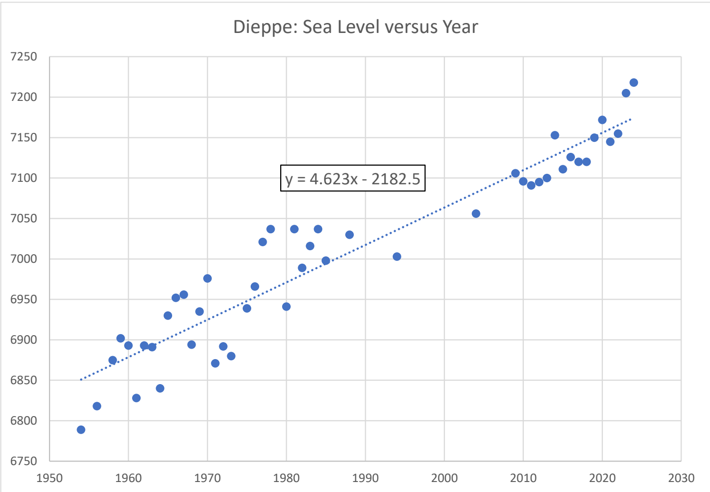
Workington: Sea Level versus Year
y = -0.3751x + 7604.3
6920
6900
6880
6860
6840
6820
6800
6780
6760
1990
1995
2000
2005
2010
2015
2020
2025
2030

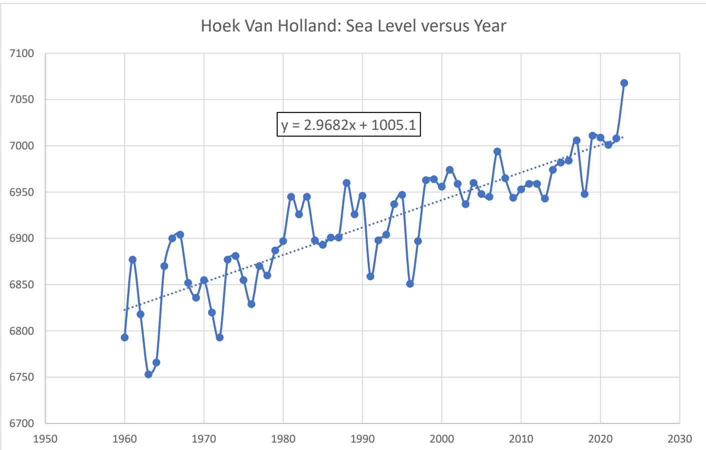

Calais: Sea Level versus Year
y = 0.0967x² - 384.04x + 388442
7200
7150
7100
7050
7000
6950
6900
6850
1960
1970
1980
1990
2000
2010
2020
2030

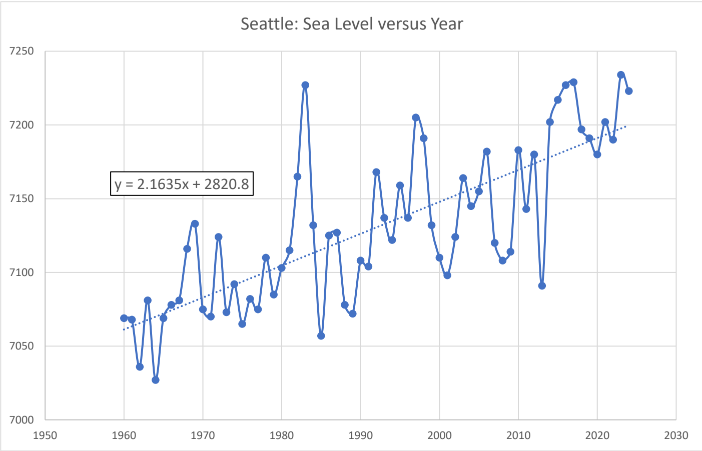

Dunkerque: Sea Level versus Year
y = 1.7723x + 3444.6
7100
7050
7000
6950
6900
6850
1950
1960
1970
1980
1990
2000
2010
2020
2030


Oostende: Sea Level versus Year
y = 0.0349x² - 136.52x + 140364
7250
7200
7150
7100
7050
7000
6950
6900
1950
1960
1970
1980
1990
2000
2010
2020
2030

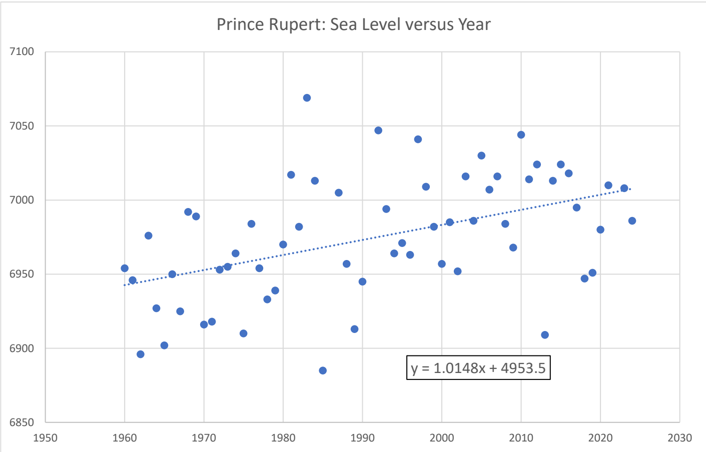

Zeebrugge: Sea Level versus Year
y = 2.9732x + 1104
7200
7150
7100
7050
7000
6950
6900
6850
1950 1960 1970 1980 1990 2000 2010 2020 2030


Dieppe: Sea Level versus Year
y = 4.623x - 2182.5
7250
7200
7150
7100
7050
7000
6950
6900
6850
6800
6750
1950 1960 1970 1980 1990 2000 2010 2020 2030

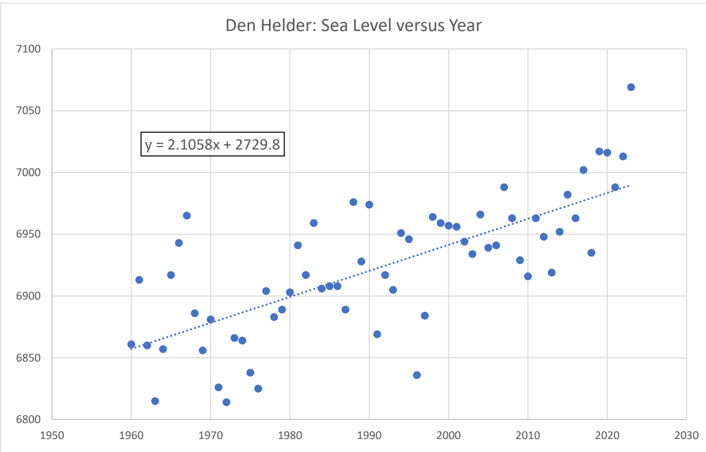

Hoek Van Holland: Sea Level versus Year
y = 2.9682x + 1005.1
7100
7050
7000
6950
6900
6850
6800
6750
6700
1950 1960 1970 1980 1990 2000 2010 2020 2030



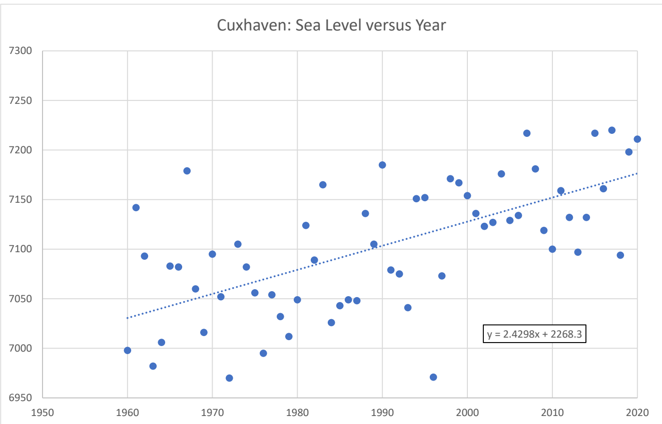
Seattle: Sea Level versus Year
y = 2.1635x + 2820.8
7250
7200
7150
7100
7050
7000
1950
1960
1970
1980
1990
2000
2010
2020
2030



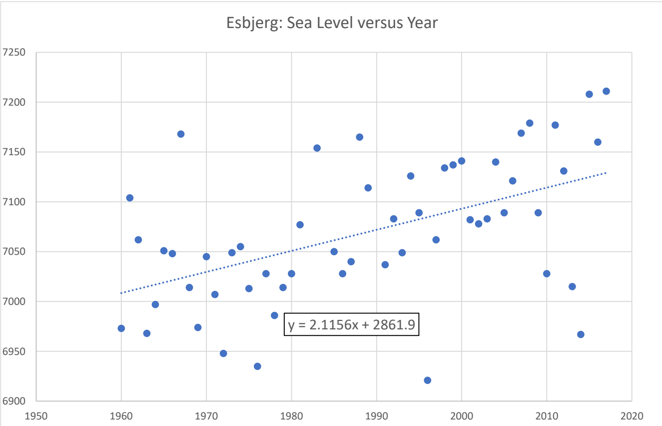
Prince Rupert: Sea Level versus Year
y = 1.0148x + 4953.5
7100
7050
7000
6950
6900
6850
1950
1960
1970
1980
1990
2000
2010
2020
2030

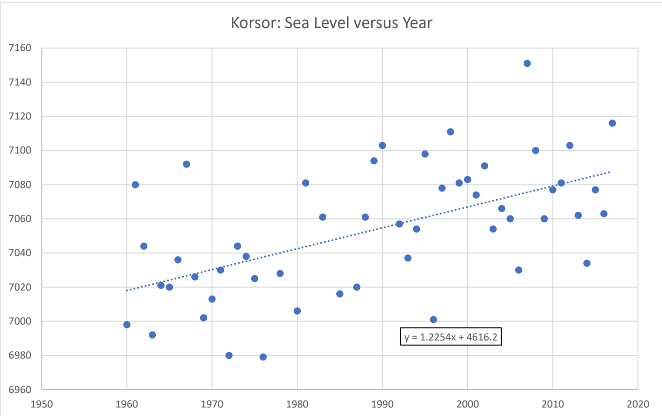


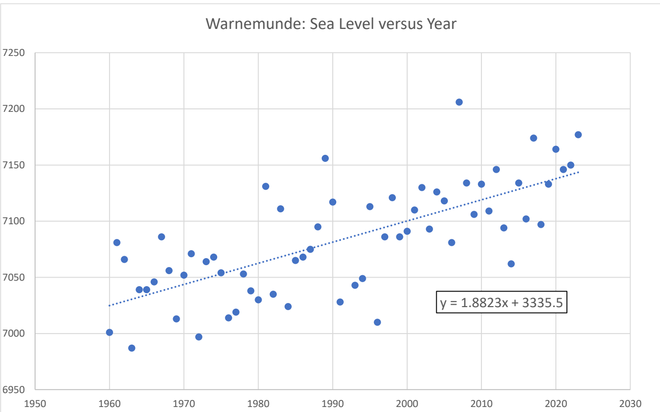
Den Helder: Sea Level versus Year
y = 2.1058x + 2729.8
7100
7050
7000
6950
6900
6850
6800
1950
1960
1970
1980
1990
2000
2010
2020
2030

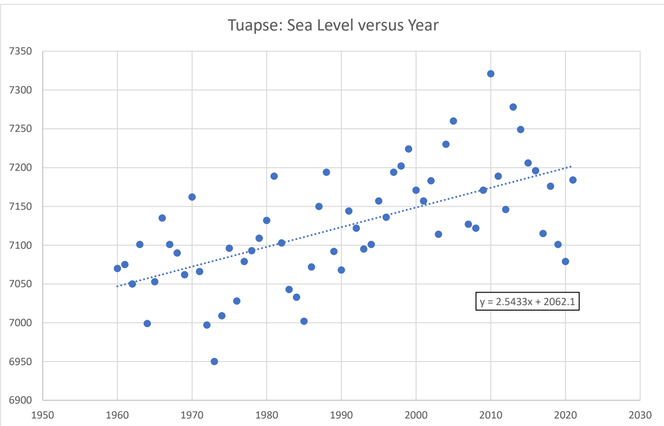


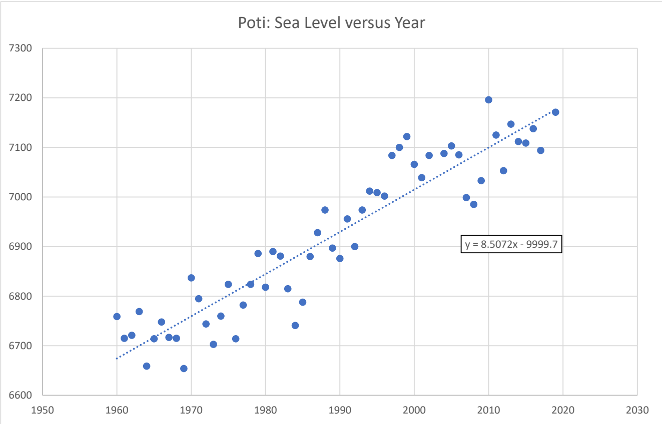
Cuxhaven: Sea Level versus Year
y = 2.4298x + 2268.3
7300
7250
7200
7150
7100
7050
7000
6950
1950
1960
1970
1980
1990
2000
2010
2020


Esbjerg: Sea Level versus Year
y = 2.1156x + 2861.9
7250
7200
7150
7100
7050
7000
6950
6900
1950
1960
1970
1980
1990
2000
2010
2020

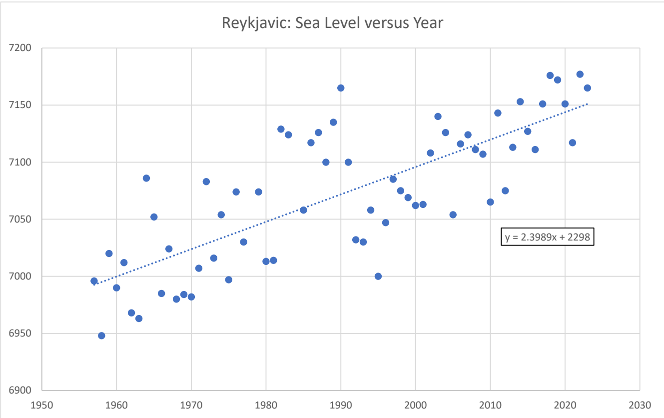

Korsor: Sea Level versus Year
y = 1.2254x + 4616.2
7160
7140
7120
7100
7080
7060
7040
7020
7000
6980
6960
1950
1960
1970
1980
1990
2000
2010
2020


Warnemunde: Sea Level versus Year
y = 1.8823x + 3335.5
7250
7200
7150
7100
7050
7000
6950
1950
1960
1970
1980
1990
2000
2010
2020
2030

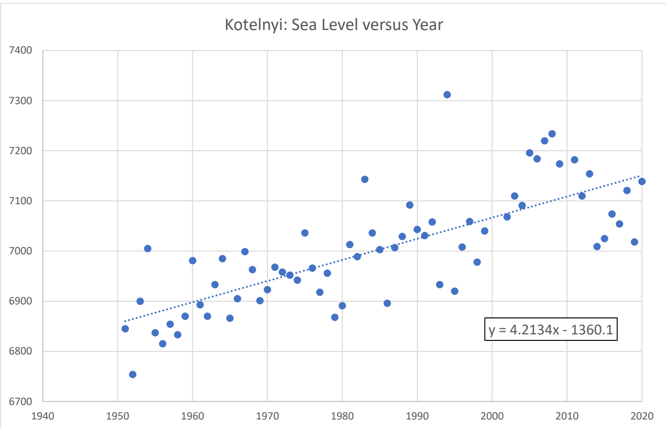

Tuapse: Sea Level versus Year
y = 2.5433x + 2062.1
7350
7300
7250
7200
7150
7100
7050
7000
6950
6900
1950
1960
1970
1980
1990
2000
2010
2020
2030



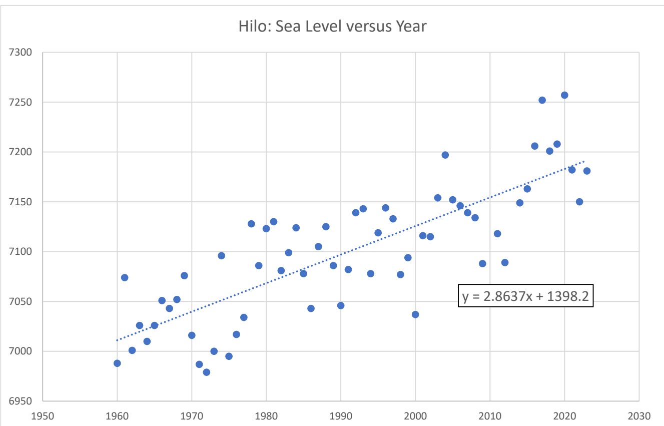
Poti: Sea Level versus Year
y = 8.5072x - 9999.7



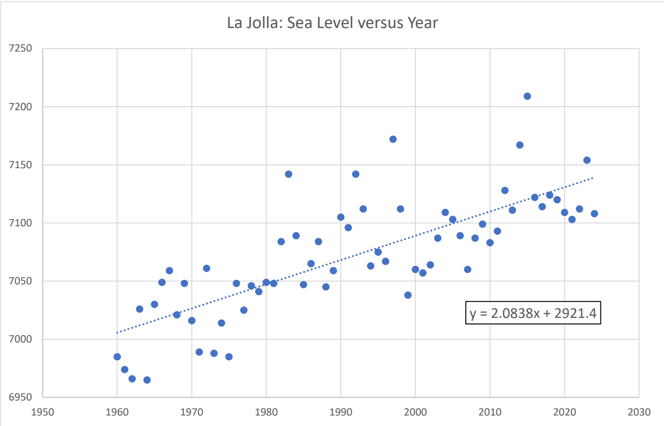
Reykjavic: Sea Level versus Year
y = 2.3989x + 2298

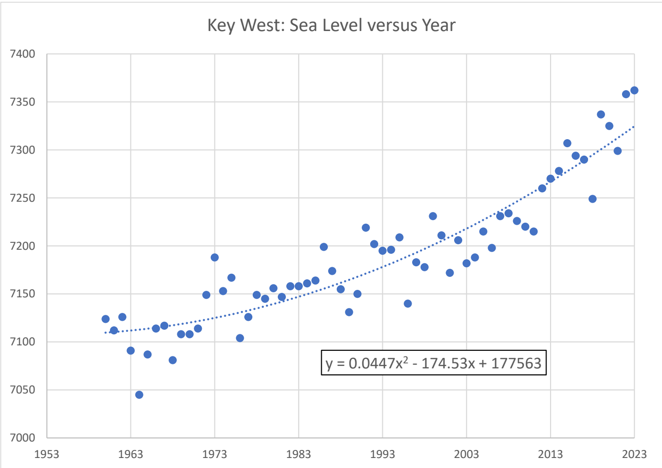


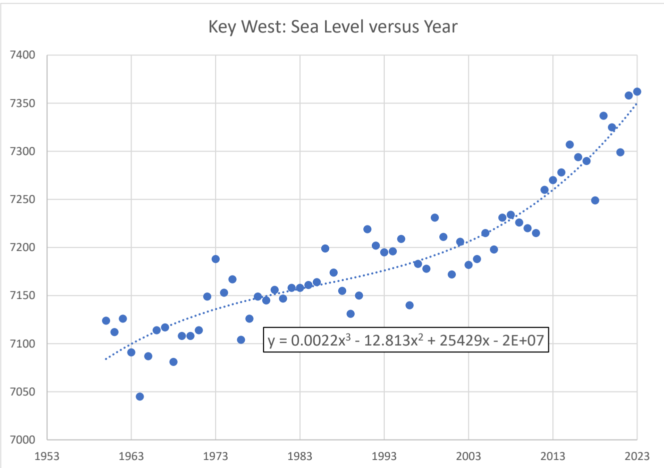
Kotelnyi: Sea Level versus Year
y = 4.2134x - 1360.1

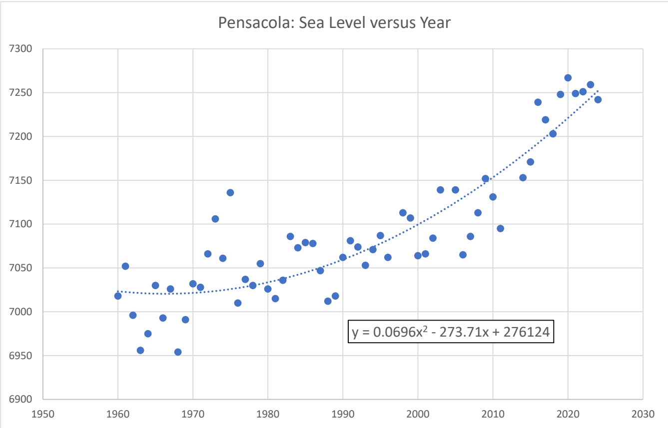


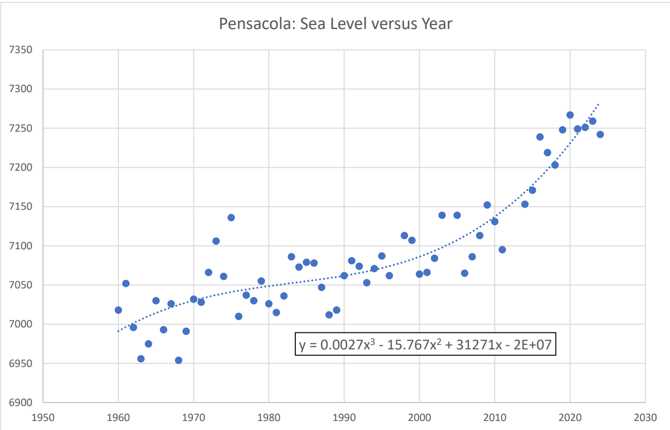
Hilo: Sea Level versus Year
y = 2.8637x + 1398.2

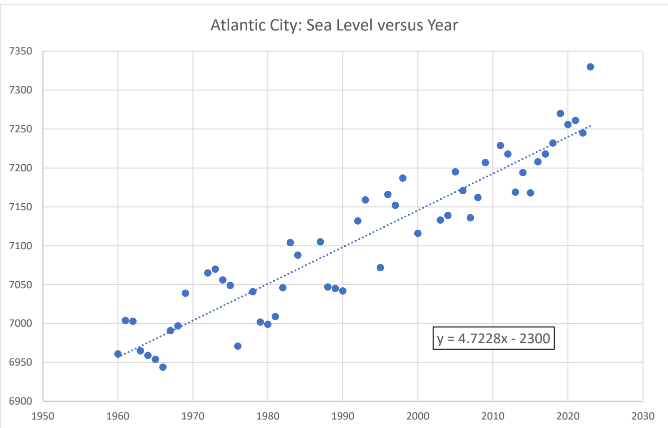

La Jolla: Sea Level versus Year
y = 2.0838x + 2921.4
7250
7200
7150
7100
7050
7000
6950
1950
1960
1970
1980
1990
2000
2010
2020
2030

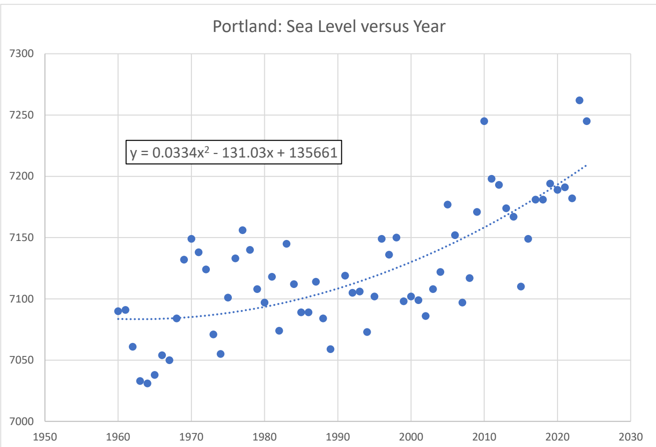

Key West: Sea Level versus Year
y = 0.0447x² - 174.53x + 177563
7400
7350
7300
7250
7200
7150
7100
7050
7000
1953
1963
1973
1983
1993
2003
2013
2023

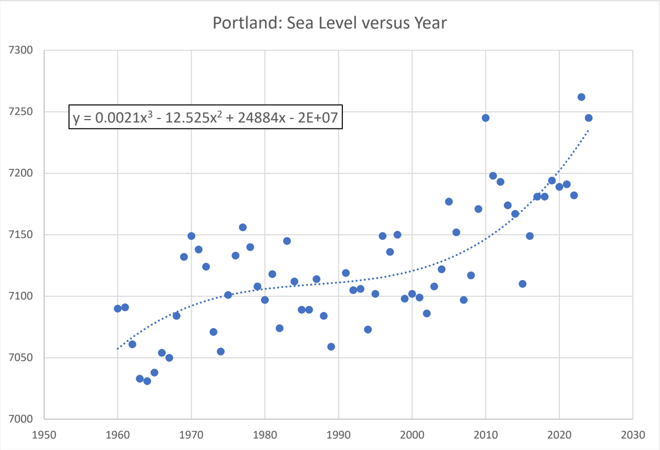

Key West: Sea Level versus Year
y = 0.0022x³ - 12.813x² + 25429x - 2E+07
7400
7350
7300
7250
7200
7150
7100
7050
7000
1953
1963
1973
1983
1993
2003
2013
2023

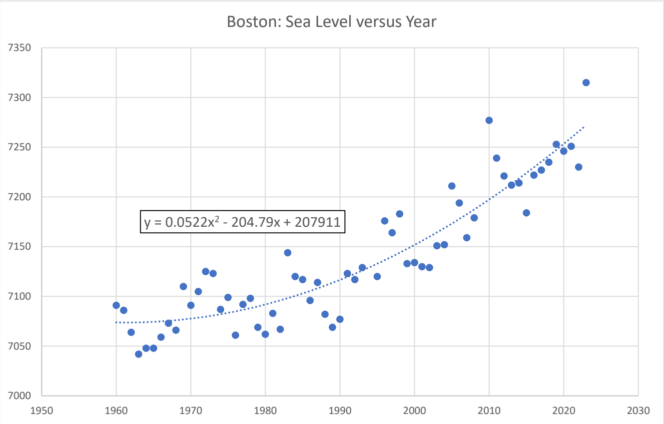

Pensacola: Sea Level versus Year
y = 0.0696x² - 273.71x + 276124
7300
7250
7200
7150
7100
7050
7000
6950
6900
1950
1960
1970
1980
1990
2000
2010
2020
2030

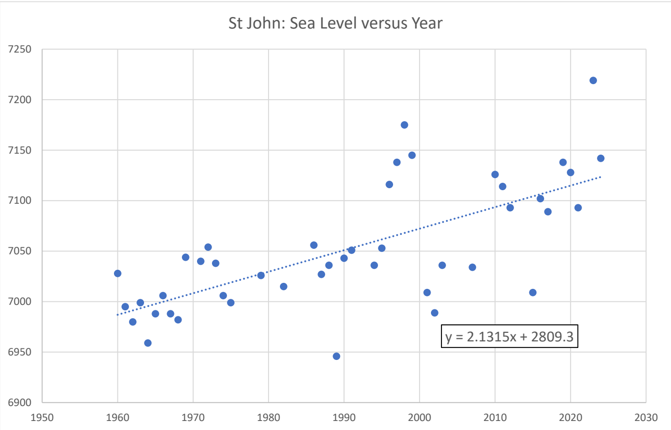

Pensacola: Sea Level versus Year
y = 0.0027x³ - 15.767x² + 31271x - 2E+07
7350
7300
7250
7200
7150
7100
7050
7000
6950
6900
1950
1960
1970
1980
1990
2000
2010
2020
2030

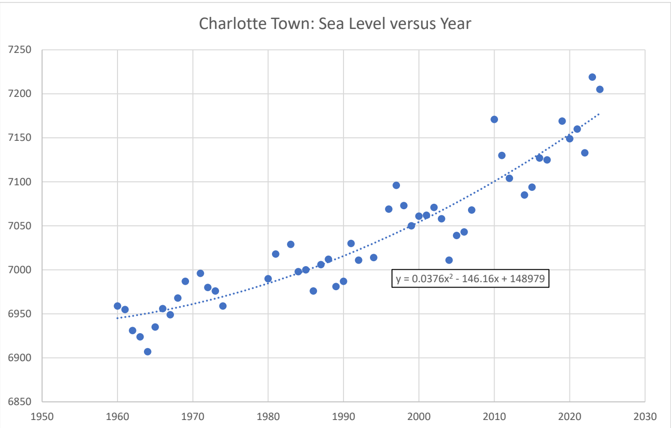

Atlantic City: Sea Level versus Year
y = 4.7228x - 2300
7350
7300
7250
7200
7150
7100
7050
7000
6950
6900
1950
1960
1970
1980
1990
2000
2010
2020
2030

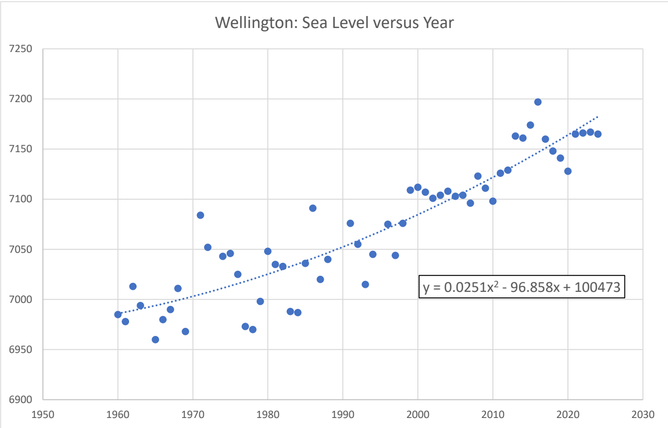

Portland: Sea Level versus Year
y = 0.0334x² - 131.03x + 135661
7300
7250
7200
7150
7100
7050
7000
1950
1960
1970
1980
1990
2000
2010
2020
2030

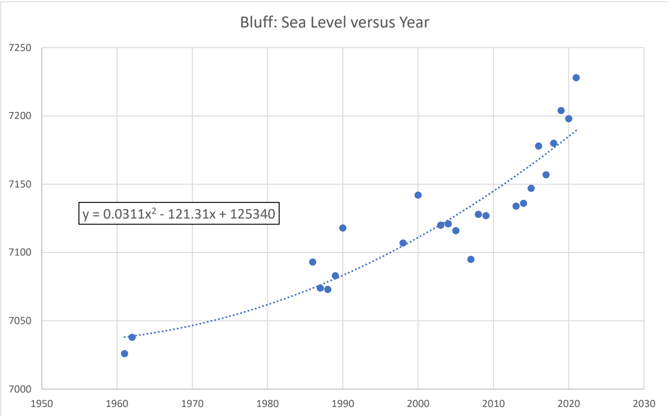

Portland: Sea Level versus Year
y = 0.0021x³ - 12.525x² + 24884x - 2E+07
7300
7250
7200
7150
7100
7050
7000
1950
1960
1970
1980
1990
2000
2010
2020
2030

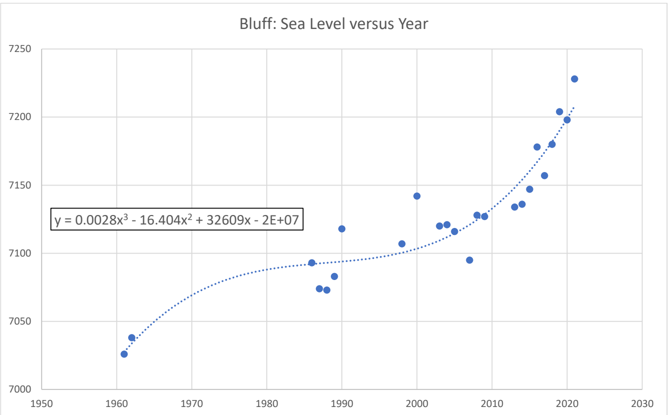

Boston: Sea Level versus Year
y = 0.0522x² - 204.79x + 207911
7350
7300
7250
7200
7150
7100
7050
7000
1950
1960
1970
1980
1990
2000
2010
2020
2030

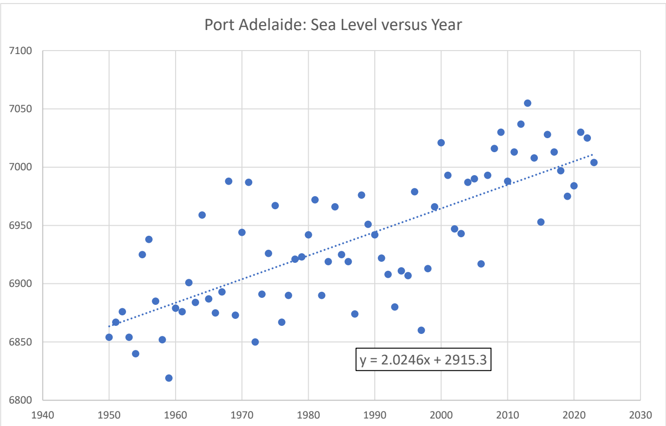

St John: Sea Level versus Year
y = 2.1315x + 2809.3
7250
7200
7150
7100
7050
7000
6950
6900
1950
1960
1970
1980
1990
2000
2010
2020
2030

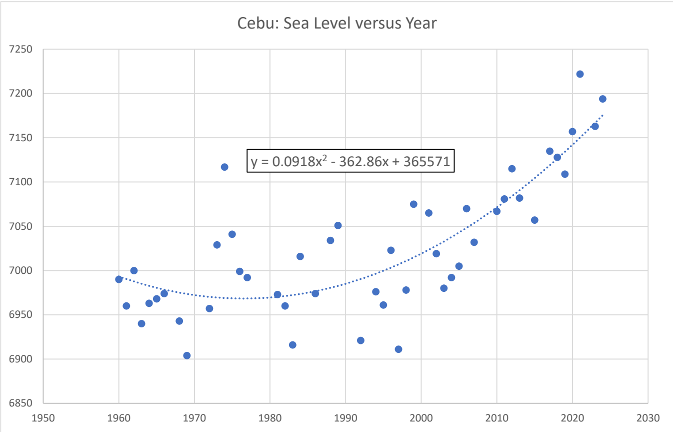

Charlotte Town: Sea Level versus Year
y = 0.0376x² - 146.16x + 148979
7250
7200
7150
7100
7050
7000
6950
6900
6850
1950
1960
1970
1980
1990
2000
2010
2020
2030

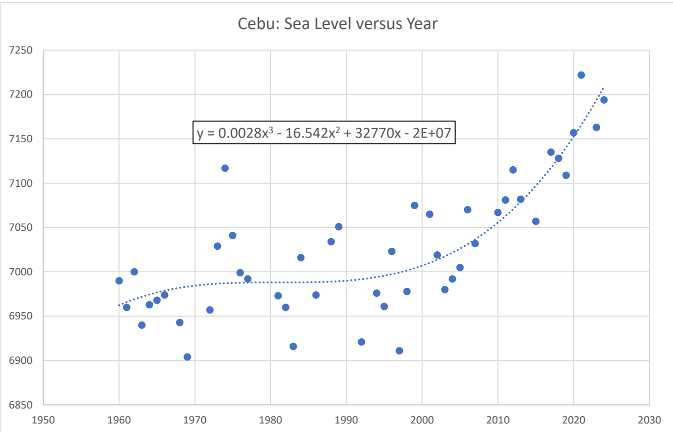

Wellington: Sea Level versus Year
y = 0.0251x² - 96.858x + 100473

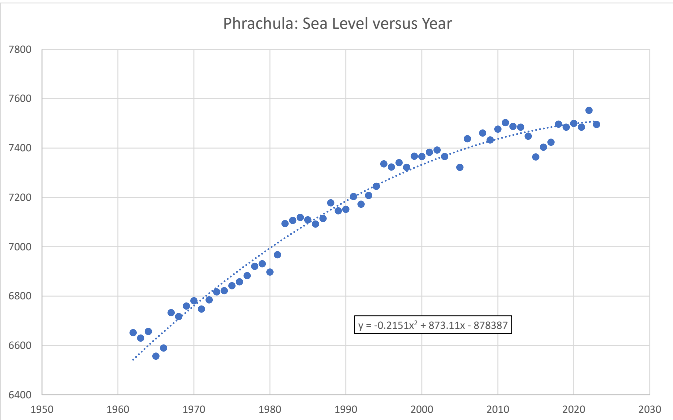

Bluff: Sea Level versus Year
y = 0.0311x² - 121.31x + 125340

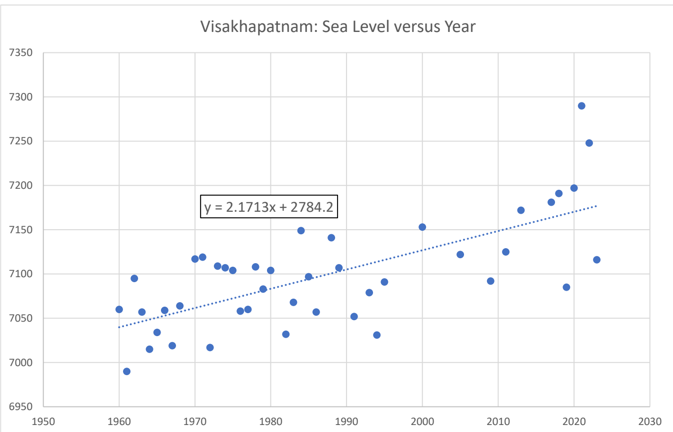

Bluff: Sea Level versus Year
y = 0.0028x³ - 16.404x² + 32609x - 2E+07

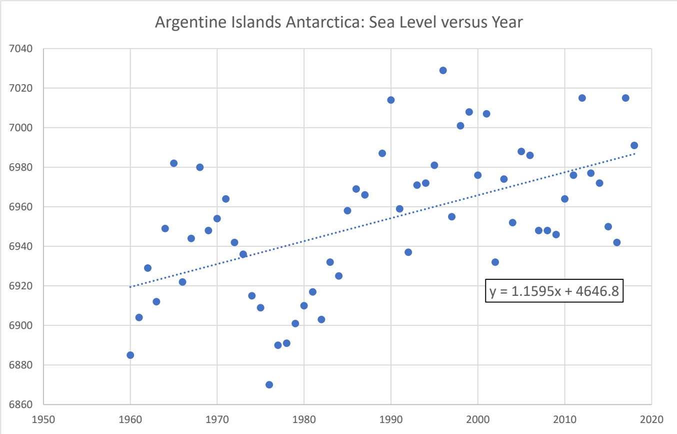

Port Adelaide: Sea Level versus Year
y = 2.0246x + 2915.3

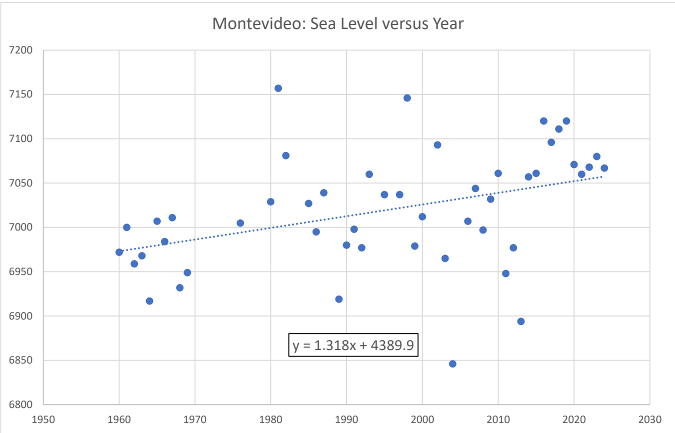

Cebu: Sea Level versus Year
y = 0.0918x² - 362.86x + 365571
7250
7200
7150
7100
7050
7000
6950
6900
6850
1950 1960 1970 1980 1990 2000 2010 2020 2030

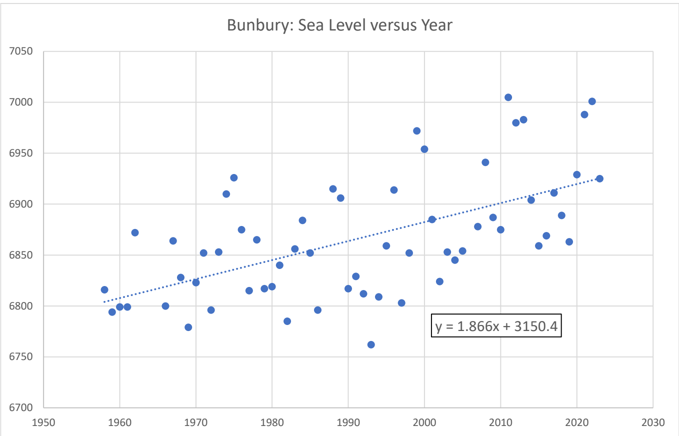

Cebu: Sea Level versus Year
y = 0.0028x³ - 16.542x² + 32770x - 2E+07
7250
7200
7150
7100
7050
7000
6950
6900
6850
1950 1960 1970 1980 1990 2000 2010 2020 2030


Phrachula: Sea Level versus Year
y = -0.2151x² + 873.11x - 878387
7800
7600
7400
7200
7000
6800
6600
6400
1950 1960 1970 1980 1990 2000 2010 2020 2030


Visakhapatnam: Sea Level versus Year
y = 2.1713x + 2784.2
7350
7300
7250
7200
7150
7100
7050
7000
6950
1950 1960 1970 1980 1990 2000 2010 2020 2030


Argentine Islands Antarctica: Sea Level versus Year
7040
7020
7000
6980
6960
6940
6920
6900
6880
6860
1950
1960
1970
1980
1990
2000
2010
2020
y = 1.1595x + 4646.8


Montevideo: Sea Level versus Year
7200
7150
7100
7050
7000
6950
6900
6850
6800
1950
1960
1970
1980
1990
2000
2010
2020
2030
y = 1.318x + 4389.9


Bunbury: Sea Level versus Year
7050
7000
6950
6900
6850
6800
6750
6700
1950
1960
1970
1980
1990
2000
2010
2020
2030
y = 1.866x + 3150.4

Appendix B: The Analysis of Church & White, 2011 (Ref.[5])

This analysis included data only to 2009, and so is not directly comparable to my analysis. It is particularly of interest because it corrects for isostatic rebound and hence gives a better picture of absolute, rather than relative, sea level rise. Church & White's result in the form of GMSL versus year is shown in Figure 4 (and Figure 5 after certain corrections). Note that their data starts in year 1860.

From Church & White's Abstract,

"*We estimate the rise in global average sea level from satellite altimeter data for 1993–2009 and from coastal and island sea-level measurements from 1880 to 2009. For 1993–2009 and after correcting for glacial isostatic adjustment, the estimated rate of rise is 3.2 ± 0.4 mm per year from the satellite data and 2.8 ± 0.8 mm per year from the in-situ data. The global average sea-level rise from 1880 to 2009 is about 210 mm. The linear trend from 1900 to 2009 is 1.7 ± 0.2 mm per year and since 1961 is 1.9 ± 0.4 mm per year. There is considerable variability in the rate of rise during the twentieth century but there has been a statistically significant acceleration since 1880 and 1900 of 0.009 ± 0.003 mm year*$^{-2}$ *and 0.009 ± 0.004 mm year*$^{-2}$*, respectively*."

Figure B.1: GMSL since 1860 from Church & White, Ref.[5]

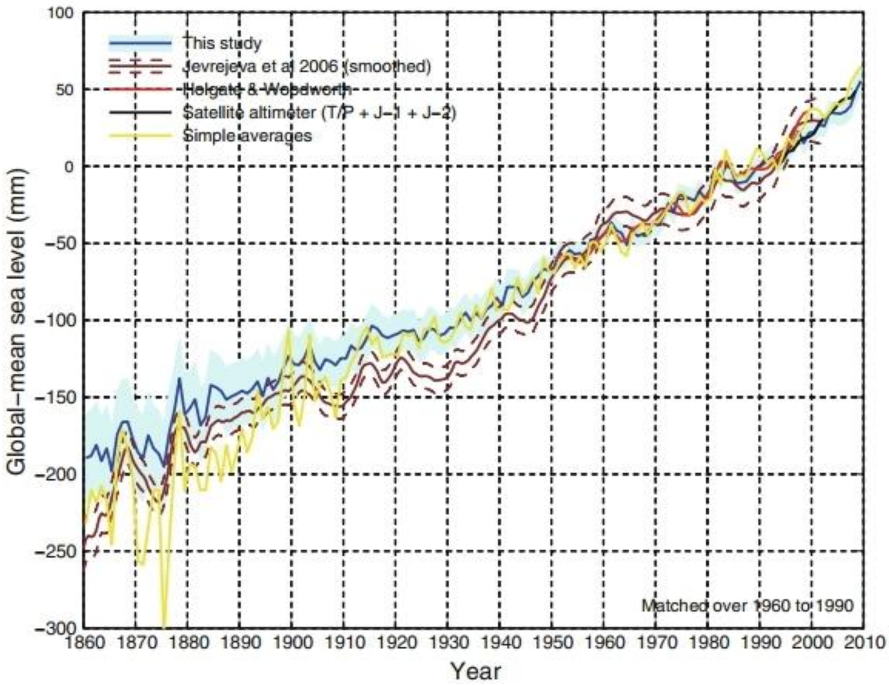
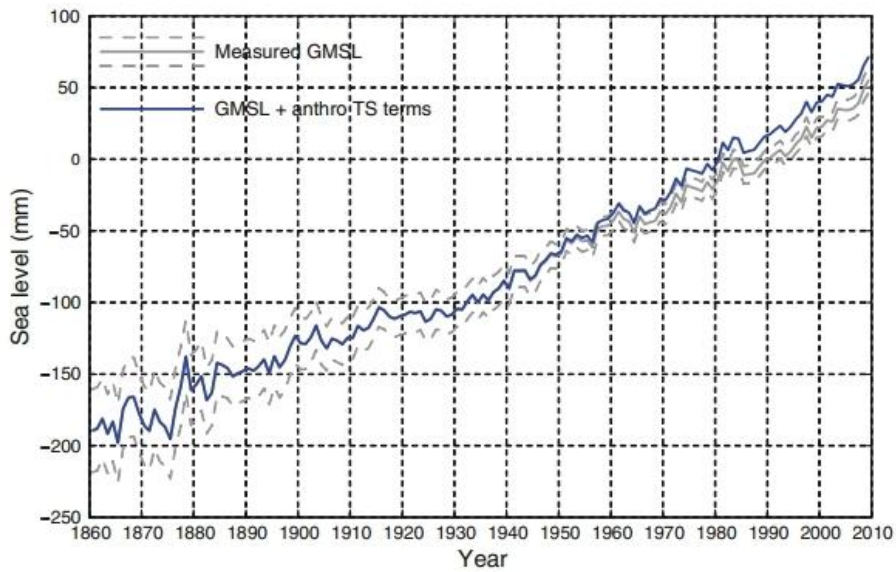
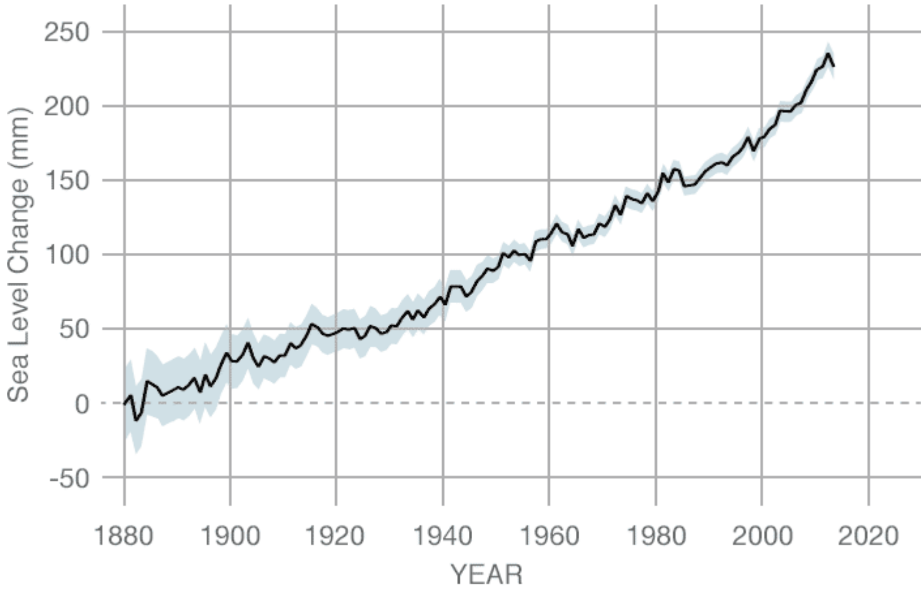


Figure B.2: GMSL since 1860 from Church & White, Ref.[5], after corrections



For comparison, Figure 6 shows the GMSL versus year, from 1880, from a NASA site, Ref.[6]. The starting datum is arbitrary, and apart from that the graphs of Figures 4,5 are broadly similar to Figure 6 although the latter exhibits slightly greater acceleration (upward curvature). The significance of this is discussed below.

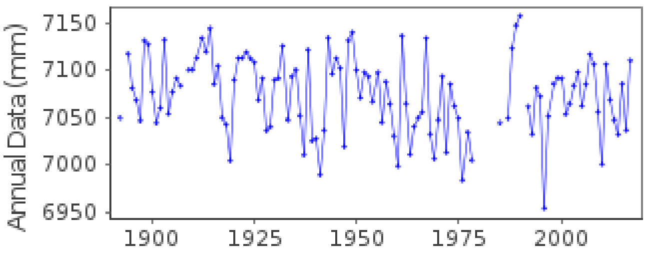
Figure B.3: GMSL over the last ~140 years (from Ref.[6]).



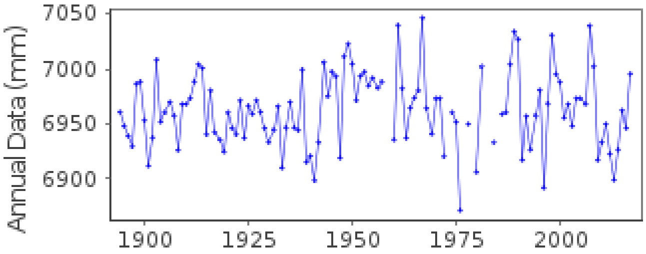
Appendix C: 34 tidal stations illustrating qualitatively different behaviour from the "standard picture" exemplified by Figures A.1,2

(These Figures not updated since 2020).

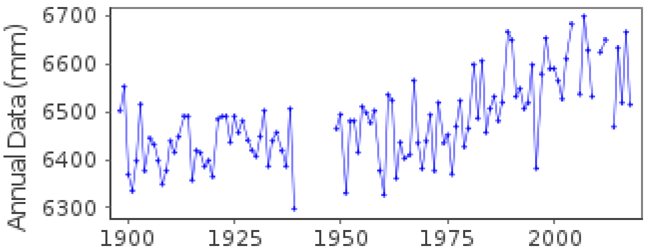
(a) Hirtshals (Denmark) – no trend



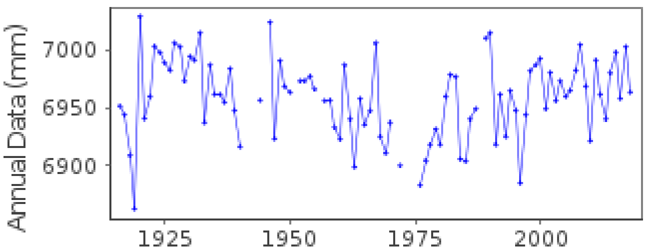
(b) Frederikshavn (Denmark) – no trend



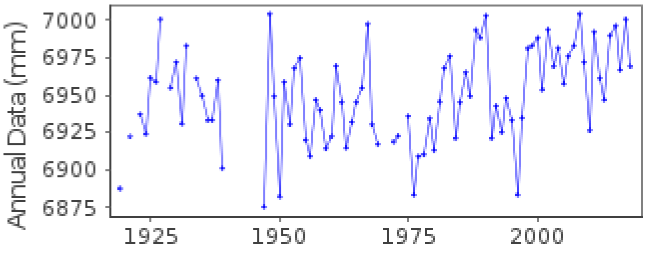
(c) Klaipeda (Lithuania)- irregular



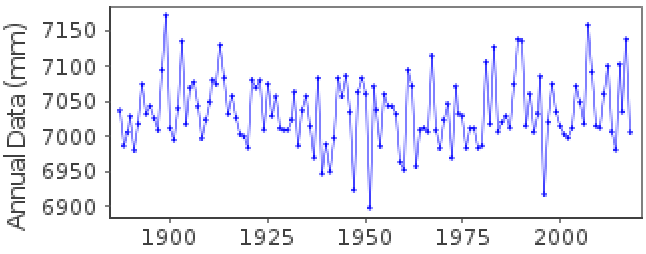
(d) Bergen (Norway) – no increase



(e) Stavanger (Norway) - little change

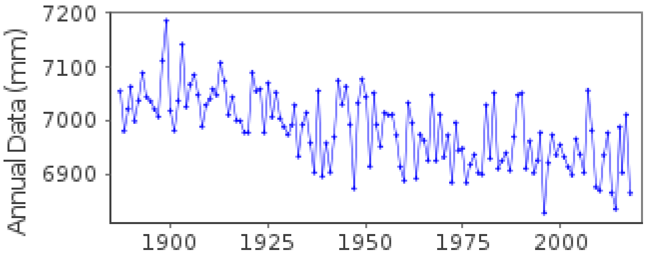


(f) Kungsholmsfort (Sweden) – no trend

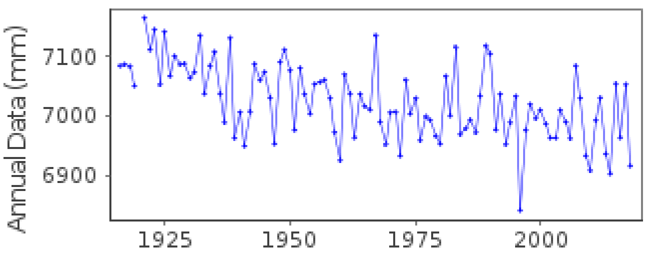


The next six are all on the Baltic and indicate a consistent downward trend. The Baltic is dropping.

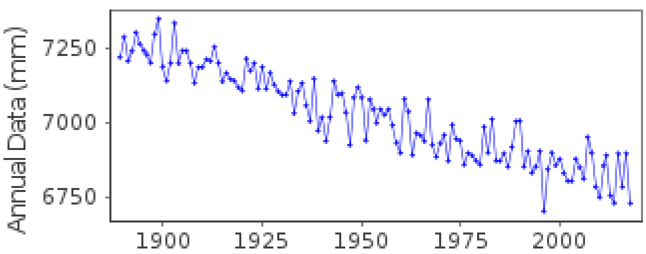
(g) Orlands Norra Udde (Sweden) – Baltic – Trends downwards



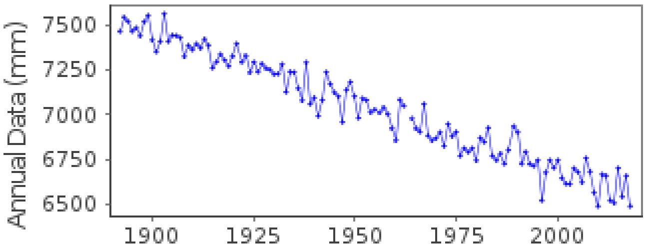
(h) Visby (Sweden) – Island in Baltic, opposite Orlands Norra Udde – also trends down



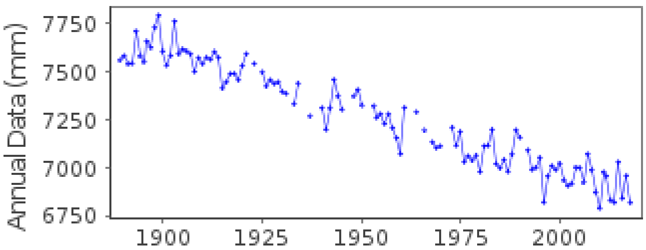
(i) Stockholm (Sweden) – also trends down



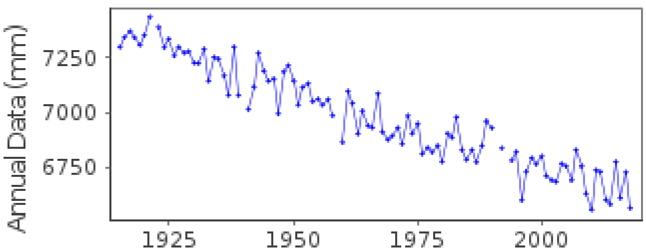
(j) Ratan (Sweden) – northern end of Baltic – also trends down



(k) Oulu / Uleaborg (Finland, Baltic) – again trends down – clearly real

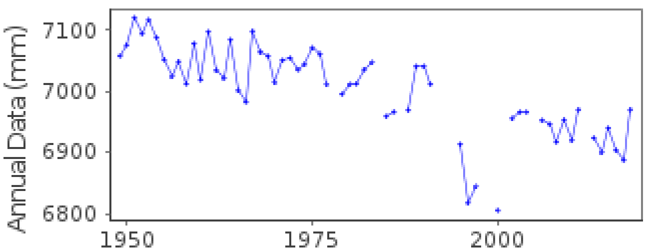


(l) Pietarsaari / Jakobstad (Finland) – and again

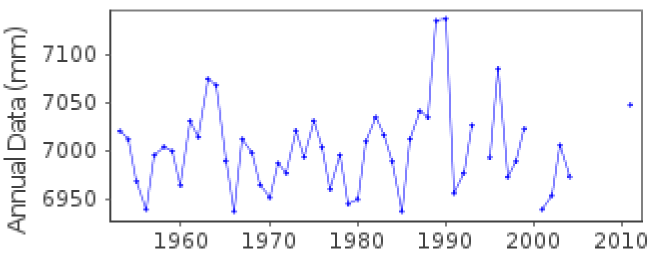


The next 8 are in cold northern seas and most indicate downward trends or no trend…

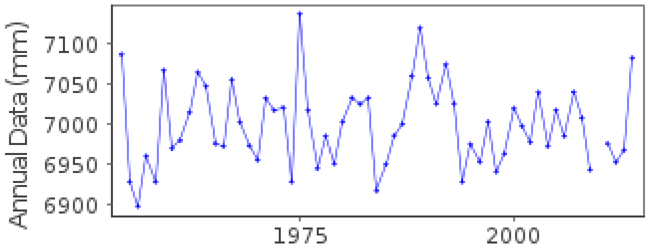
(m) Barentsburg (Svalbard) – Greenland Sea - trend downwards



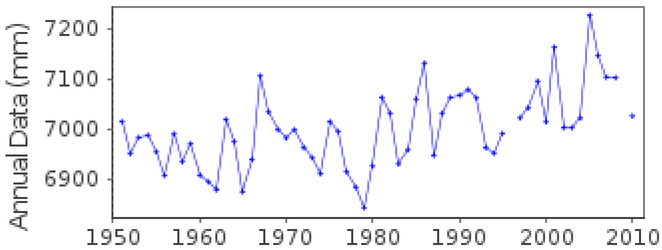
(n) Vise Ostrov (Island North of Russia in Kara Sea) – no trend



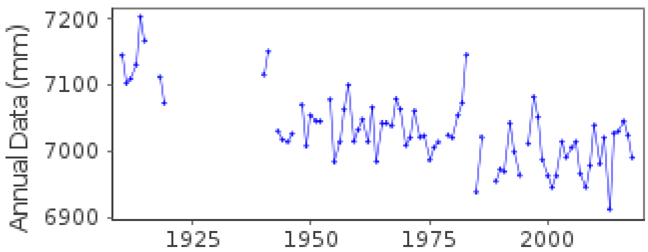
(o) Izvestia Tsik Ostrov (Russian Fed) Island in Kara Sea – no trend



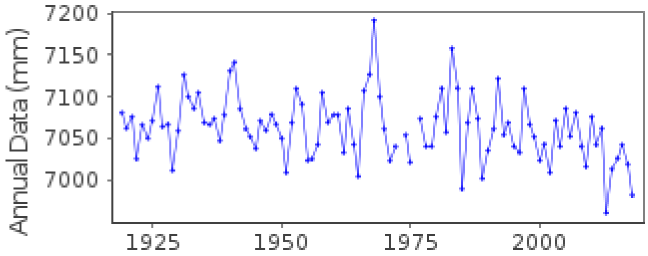
(p) Dunai Ostrov (Russian Fed) , Laptev Sea coast



(q) Tofino (north of Vancouver) – downward trend

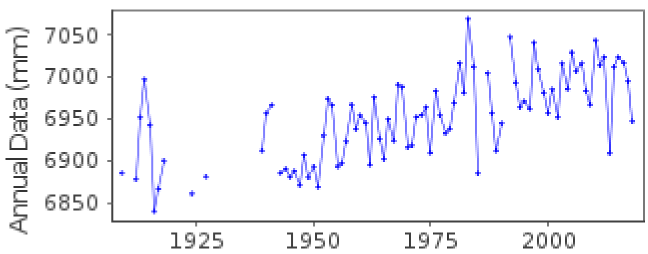


(r) Ketchikan (Gulf of Alaska) – downward trend

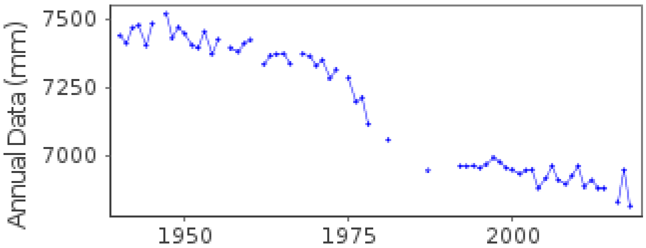


Ketchikan goes down, whilst nearby Prince Rupert goes up…

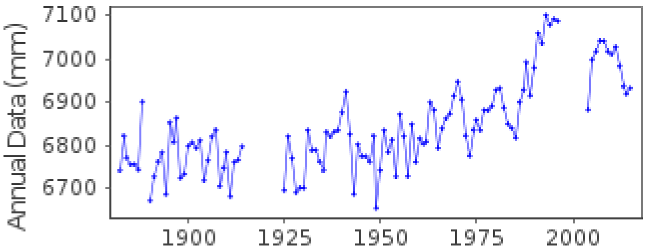
(s) Prince Rupert (Gulf of Alaska)



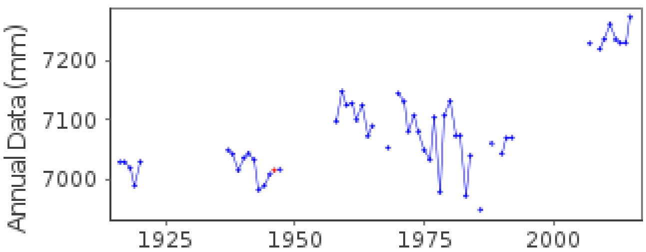
(t) Churchill (Canada) Hudson Bay – downward trend



(u) Batumi (Georgia) – Black Sea – Does not show such a clear trend as Poti, despite being close by

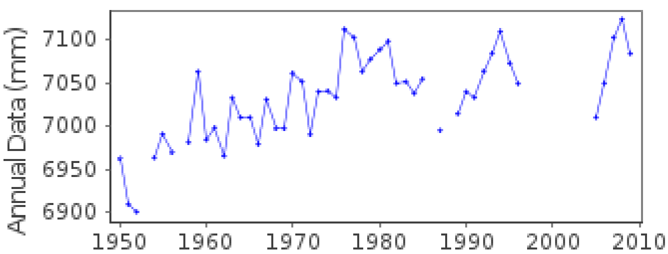


(v) Karachi – upward trend, but too intermittent to fit

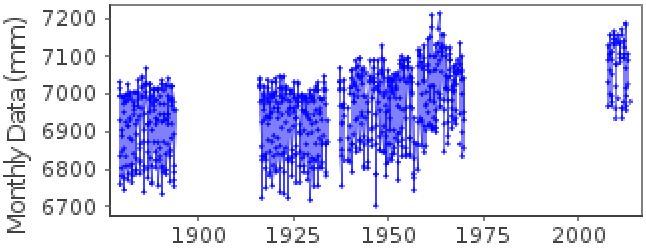


The credibility of the most recent Karachi data is challenged by the data a little further south down the Arabian Sea at Kandala…

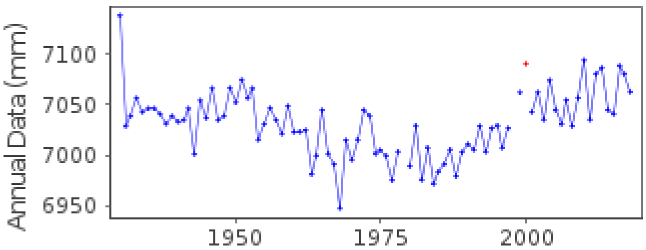
(w) Kandala – trend flat recently



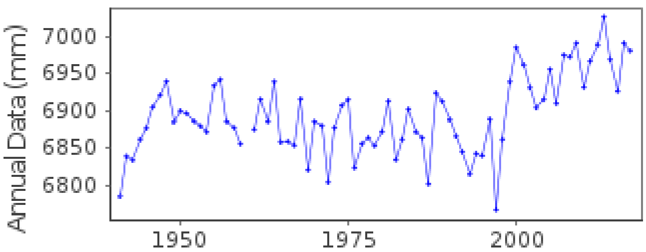
(x) Aden (monthly data) Arabian Sea near mouth of Red Sea – irregular



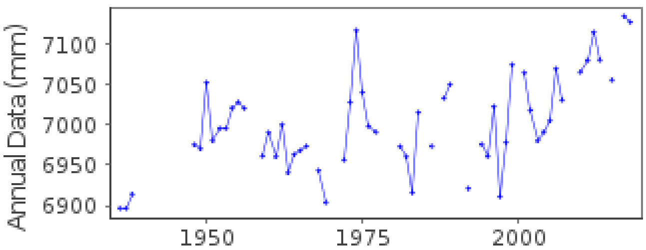
(y) Wajima (Japan) – no clear trend



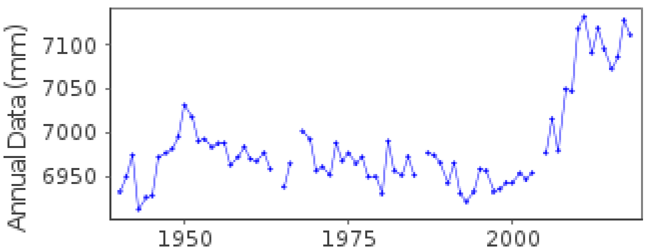
(z) Port Pirie (Australia, south coast)



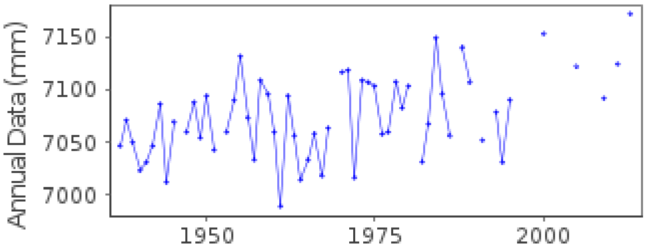
(ab) Cebu (Philippines)



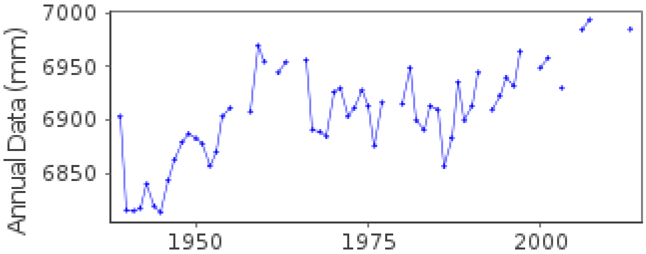
(bb) Kolak (Thailand)



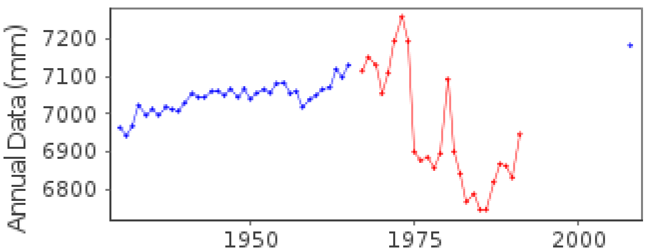
(cb) Visakhapatnam (India, Bay of Bengal)



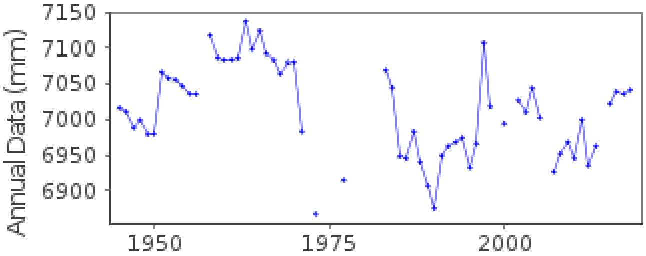
(db) Cochin (Willingdon Island) South India



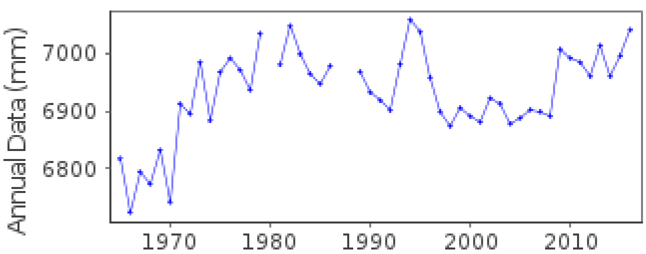
(eb) Takoradi, Ghana



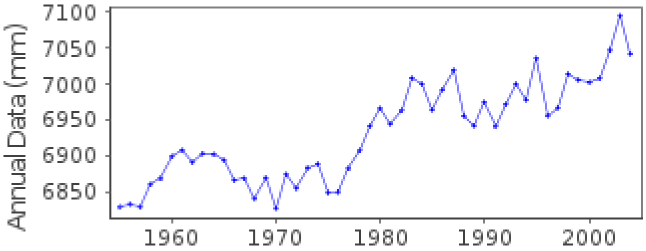
(fb) Valparaiso (Chile)



(gb) Ilha Fiscal (Brazil)



(hb) Cananeia (Brazil)



Appendix D: Will Accelerations Persist Beyond 2025?

Figures 6-9 from Refs.9b and 13 indicate that the greatest acceleration in greenhouse gas (GHG) emission rates occurred mid-twentieth century. Assuming GHG contributes to sea level rise, this suggests that any acceleration in the rate of rise since 1960 is related to that historic acceleration in GHG emission rate.

The future projected rate of emissions, even assuming no reductions beyond currently implemented policies, will rise from the present 55 GT/yr only to 60 GT/yr. In Figures 7 and 9 this lies between the red and yellow curves and hence suggests that the resulting CO2 concentration would increase roughly linearly. Even assuming that CO2 is responsible for the ongoing rate of sea level rise, a linear increase in CO2 concentration would not be consistent with an accelerating increase in global average temperature nor therefore with an accelerating rate of rise of sea level.

In short, it appears unlikely, where accelerations in sea level rise rate have been identified, that these accelerations will persist into the future. A more reasonable basis for projection is to assume the rise rate at 2025 will persist for the rest of the century, where this 2025 rise rate is estimated based on the quadratic fits, where significant, i.e., including acceleration to 2025 but not beyond.

Figure D.1

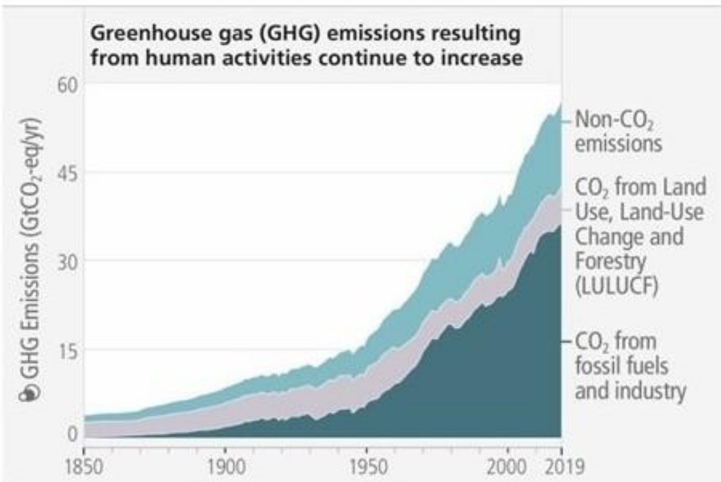


Figure D.2

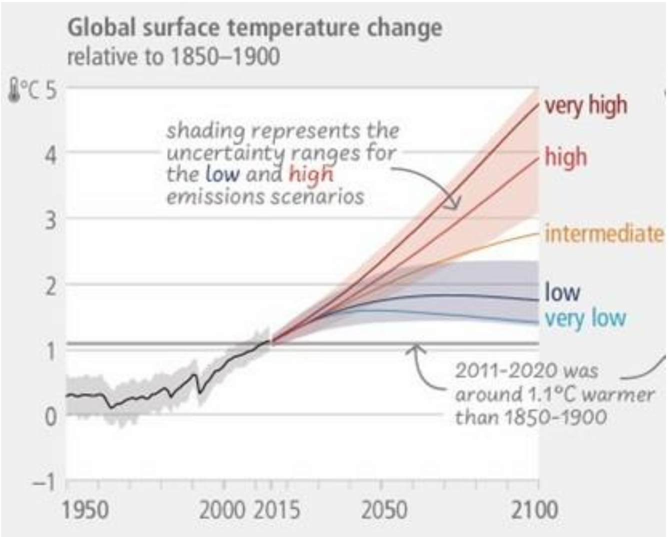


Figure D.3

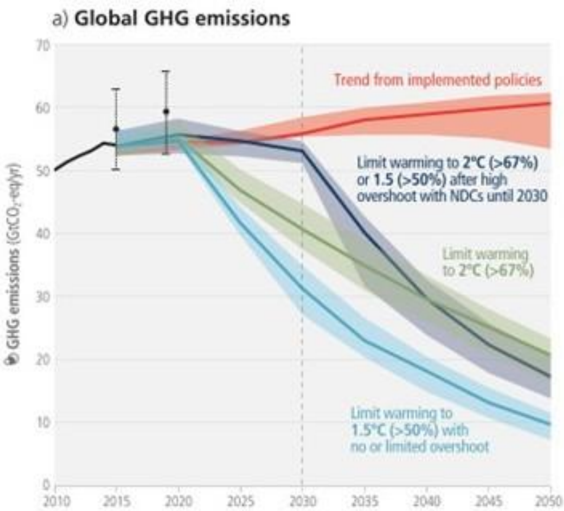


Figure D.4