Global Coastal Sea Level Change on Decadal and Century Timescales

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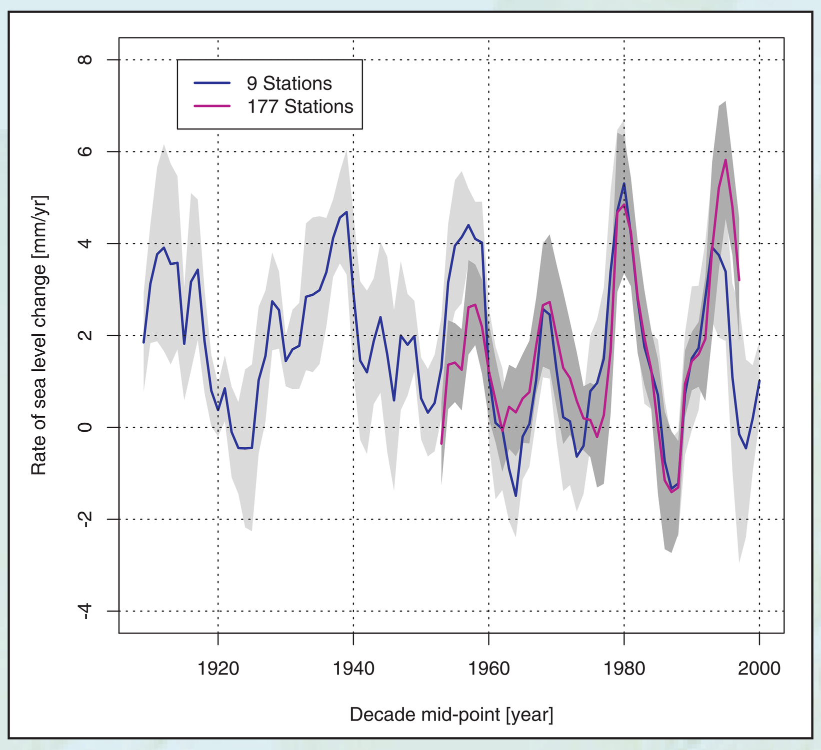
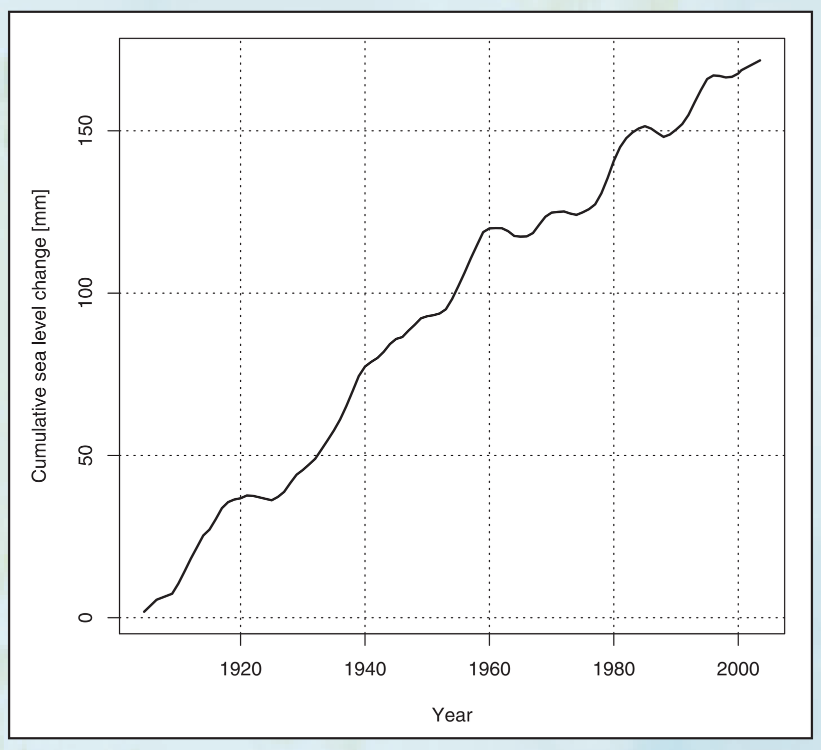
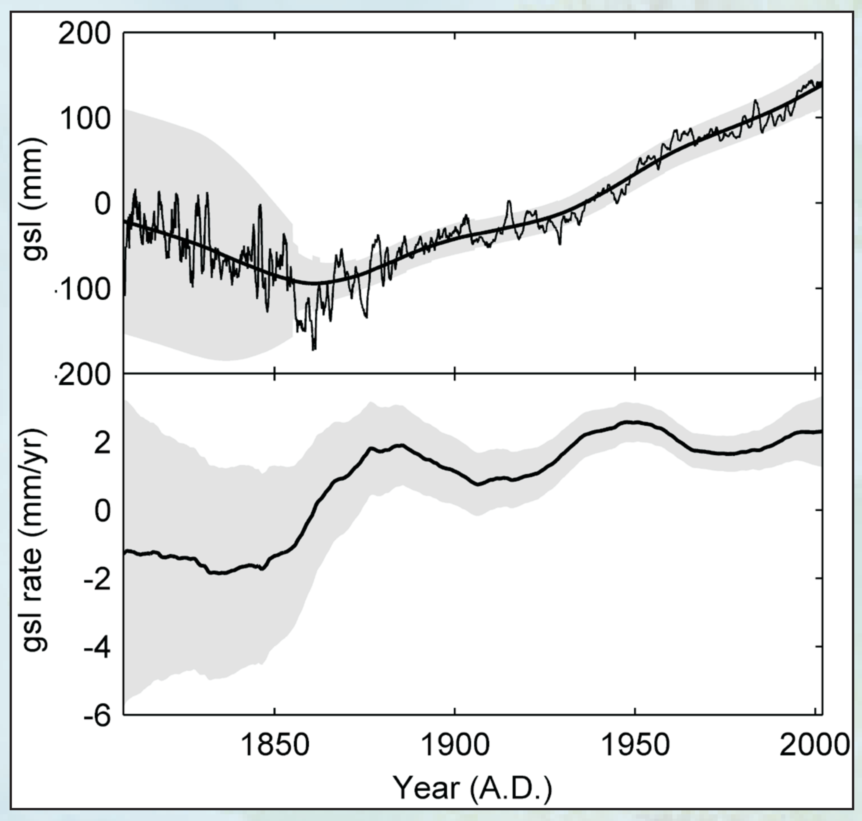
Decadal rates of global sea level change





The reported rate of change of global sea level depends upon the length of the window used to compute the rates and varies around a long term 20th century mean value (typically 1.7 mm/year).



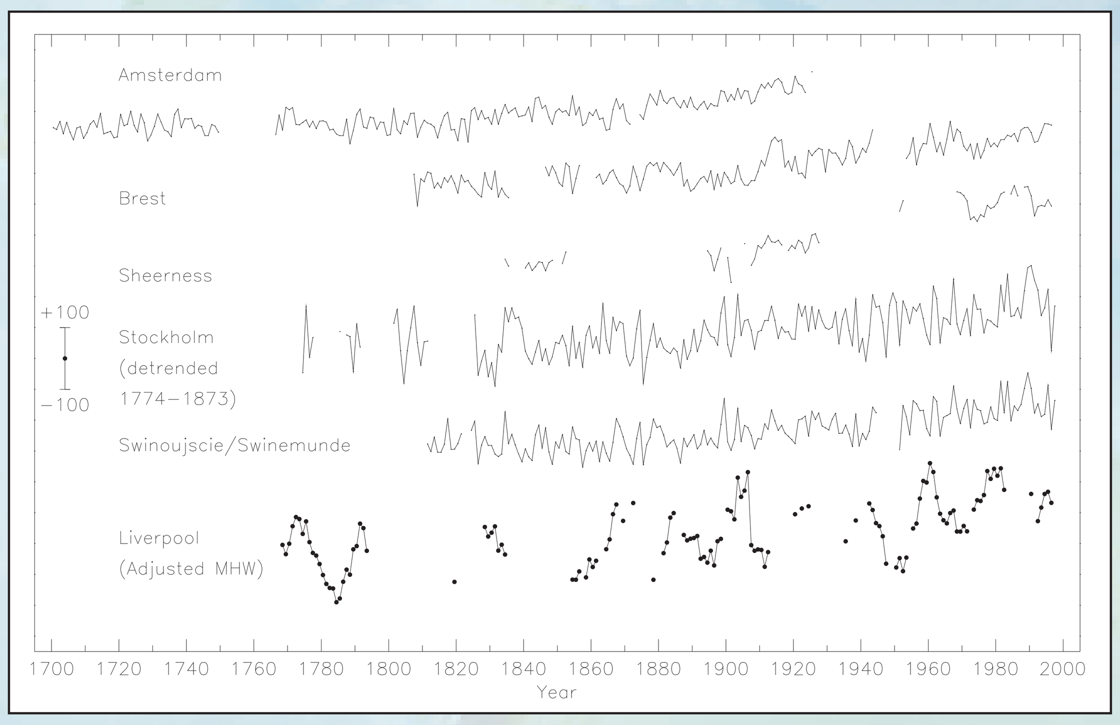
Left curve shows a comparison of decadal rates of 'global coastal' sea level change from 9 long records spanning almost a century (Holgate, GRL, 2007), and from 177 stations grouped into 13 regions for approximately a half century (Holgate and Woodworth, GRL, 2004). One can see similarities over their common period, which inspires confidence in the use of a small number of records (e.g. 9) for the longer period. Right curve shows that the integral of the decadal rates from Holgate (2007) can be used to make a global sea level curve.

Lower curve shows the non-linear trend in 'global coastal' sea level from over 1000 records grouped into 12 regions using a stacking technique and with an embedding period (low pass smoothing) of 30 years (Jevrejeva et al., JGR, 2006). Note the apparent acceleration at the end of the 19th century. Upper curve shows the corresponding sea level curve. Grey bands indicate uncertainty ranges.

During the 20th century, particularly large decadal rates were found in over half a dozen periods, most recently during the 1990s. The highest rates with the longer filter are found at the end of the 19th century, in the mid-20th century and in recent years.

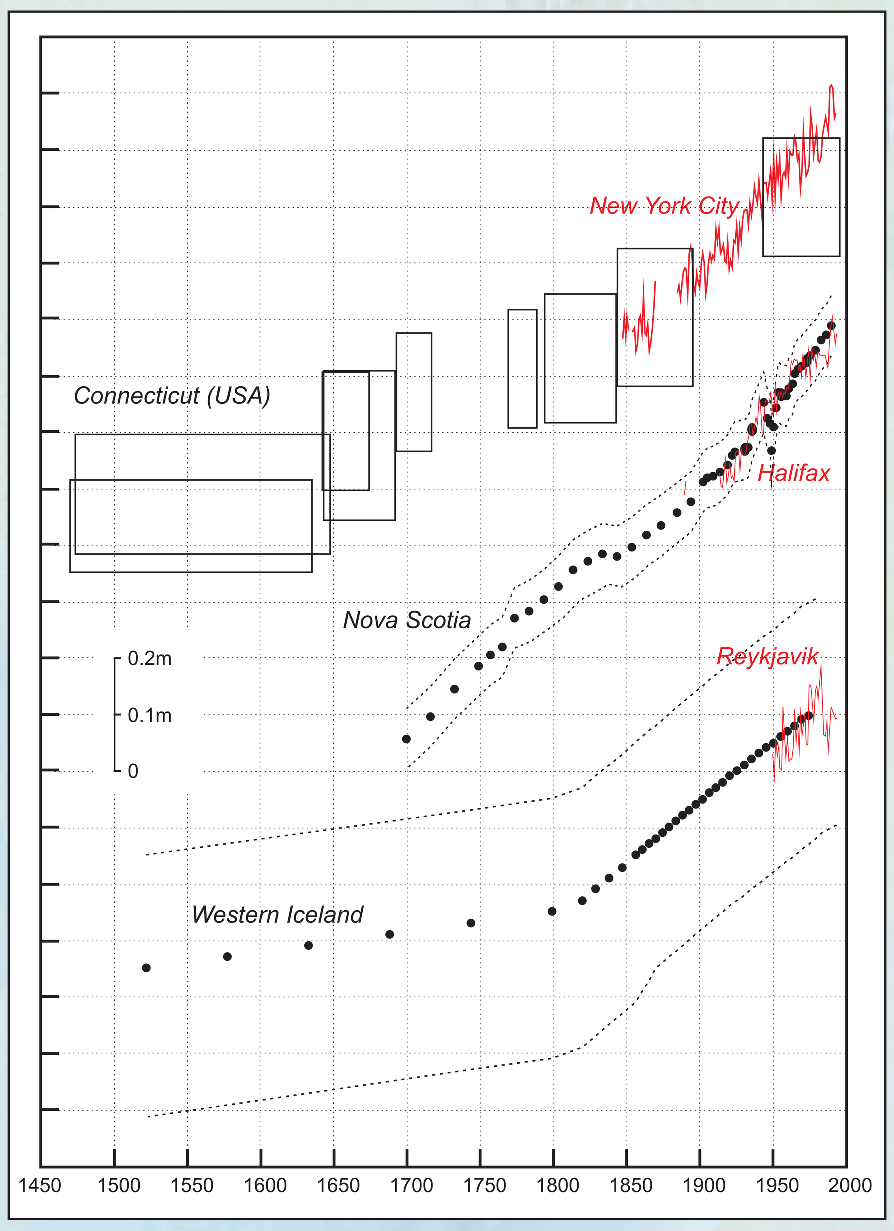
The tide gauge rates for the 1990s found from each tide gauge analysis are consistent with those observed from TOPEX/POSEIDON altimetry (approximately 3mm/year). The tide gauge data suggest that (in the absence of 'enhanced global warming') the T/P/J rates could eventually turn down again. Let's wait and see!

Longer term accelerations

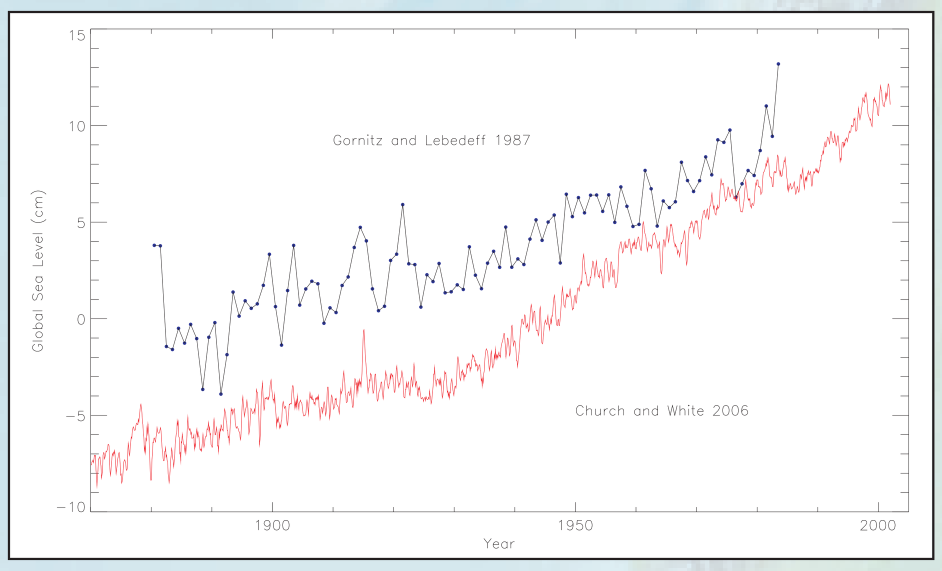


There is evidence from individual long tide gauge records from northern Europe for long-term accelerations between the 19th and 20th centuries (quadratic coefficient of order 0.4 mm/year/century) (from Woodworth, GRL, 1999).

Similar evidence comes from salt marsh records from the NE America and Iceland, examples shown here are from Connecticut, Nova Scotia and western Iceland (e.g. Gehrels et al., QSR, 2005). We believe that there is great potential in using the salt marsh technique at many other locations around the world. The black points are the salt marsh data while red values are from nearby tide gauges.



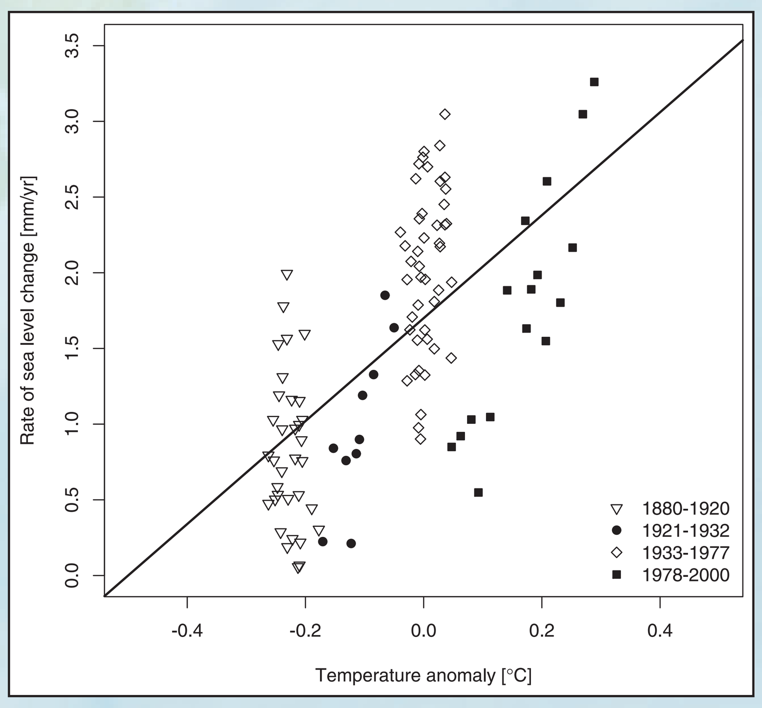
Dicussion Point 1: Long term acceleration in the 20th century



Some sea level reconstructions (e.g. Gornitz and Lebedeff, SEPM, 1987 and Church and White, GRL, 2006) appear to show an acceleration throughout the 20th century and something of a 'two stick' character with an inflexion point around 1935. Why is that? Is it, for example, an artifact of using combinations of short records from around the world? Analysis of individual long records, primarily from Europe and North America, show little evidence for acceleration in the 20th century itself, and many records even suggest a deceleration (cf. Woodworth, Int J Clim, 1990; Douglas, JGR, 1992). More work is required to resolve this issue.

Discussion Point 2: Are rates of global sea level change related simply to global air temperature (cf. Rahmstorf, Science, 2007)?

In an interesting discussion, Rahmstorf proposed a linear relationship between rate of sea level change and global average air temperature. The regression coefficient obtained from his analysis was used to replicate the observed 20th century sea level curve (Church and White) and to make sea level change predictions for the 21st century which exceed those obtained from the AOGCM modelling in the IPCC TAR (and even more than those in the IPCC 4AR).



The figure (left) relates rate of sea level change to temperature. It is the same as shown by Rahmstorf but indicates the sub-populations of sea level rate vs. temperature which occur in the data set. It can be seen that, within any one temporal subset of the data, there is no convincing linear relationship. Moreover, if the data were forced to be parameterized by linear fits, then different fits would be required for each subset.

In the black curve (right) we reproduce the Rahmstorf sea level hindcast based on the linear parameterization of sea level rate vs. temperature for the full data set. It appears to provide a satisfactory description of the observed sea level data, but how much confidence does that necessarily provide in a forecast for the 21st century? The figure shows that if one uses linear parameterizations for each half of the data set, then the simple description has no predictive power for the other half. Consequently, what confidence can there be in predictions for the 21st century based on such simple parameterizations?