Updated 04-13-24 at end

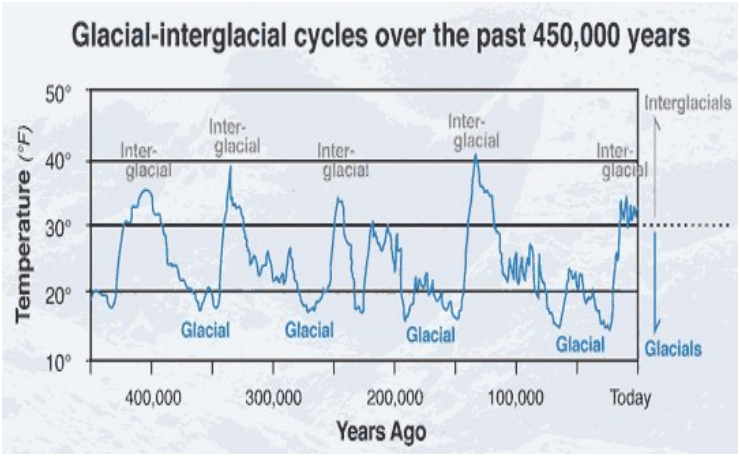
CliSciPol

Climate Science and Policy for Nonscientists

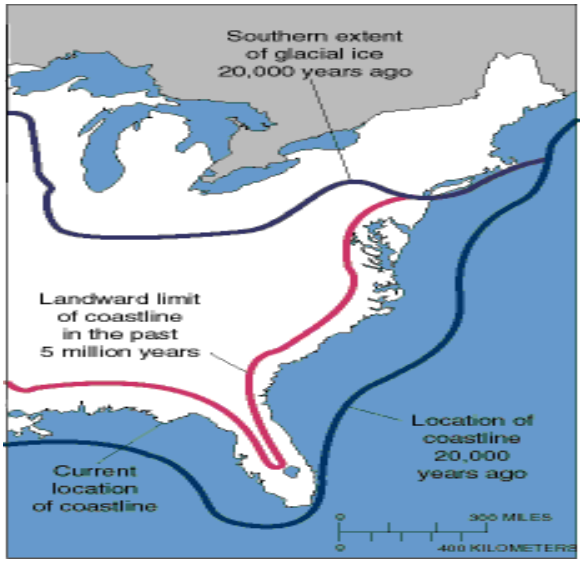
One picture is worth a thousand words.

SEA LEVEL RISE - PAST AND TO 2100

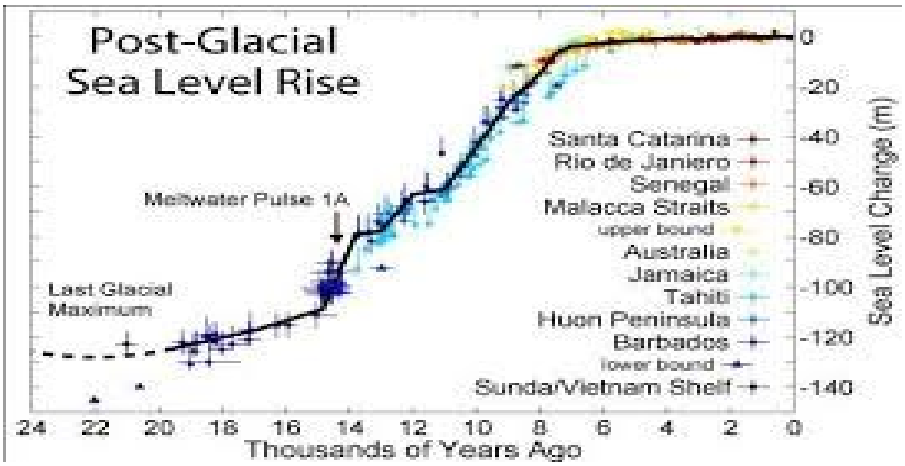
Sea level rise and fall is caused primarily by global warming and cooling. For about the last million years the earth has been going through 100,000 year cycles of glaciation with temperature swings of as much as 20 F or 10 C (with a high level of uncertainty). The IPCC agrees that the last interglacial, the Eemian, about 125,000 years ago was warmer than today. [AR6 WGI p. 6 (2021)]. Sea levels then were about 16-33 feet higher than today. Much of Florida was under water. Scandinavia was an island.



The most recent glacial maximum occurred about 20,000 years ago. The Laurentide Glacier covered most all of Canada and significant parts of the Northern US. All of New England was under a glacier nearly a mile thick.

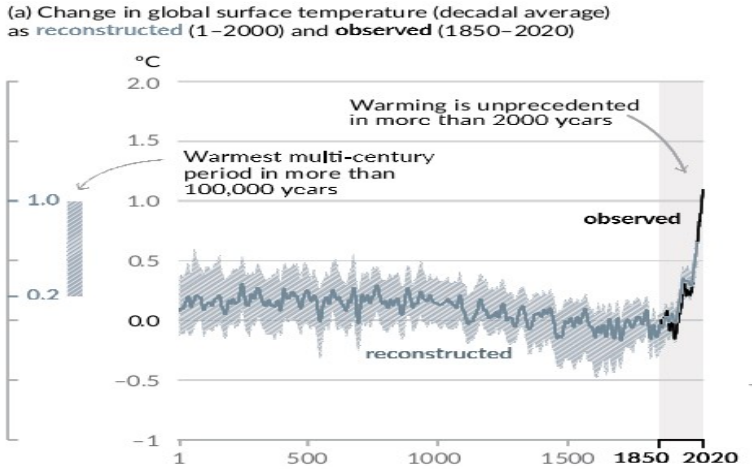


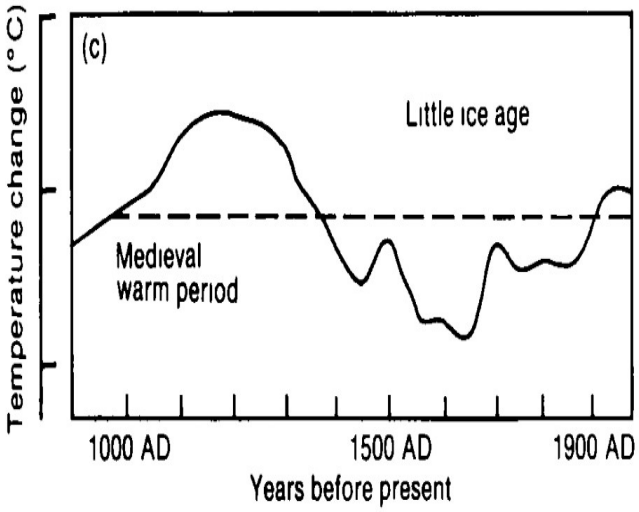
Seal levels were nearly 400 feet lower than today, so the US coastline extended far seaward of it present position (the black line). The red line shows how far inland the coast extended at its maximum advance in the past 5 million years.



From about 20,000 years ago to about 8,000 years ago world temperatures dramatically rose, causing sea levels to rise over 120 meters or nearly 400 feet. Since then sea levels have been relatively stable as compared to this dramatic period.

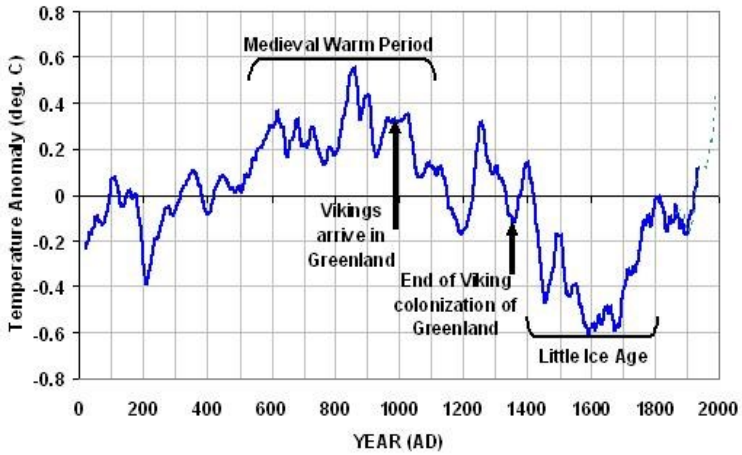
There is a major dispute as to world temperatures during the Medieval Period, 900-1200. The graph at right shows the IPCC position [AR6 WGI p.6], which is that world temperatures were basically flat (with a slight decline) from about 2,000 years ago up to the 1700s.

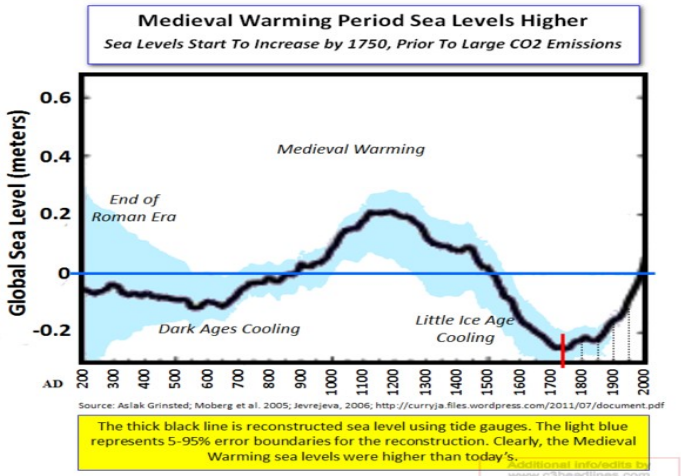




By contrast this is the graph of world temperatures since 900 that appeared in the IPCC's First Assessment Report of 1990 at p. 202. This graph acknowledges that the Medieval Warm Period was significantly warmer than today, and that the Little Ice Age was significantly colder.

This graph presents one of a large number of reconstructions that disagree with the IPCC's present position, and that conclude that the Medieval Warm Period was significantly warmer than the present, and that the Little Ice Age was significantly colder. All of the reconstructions (including the IPCC's) are based on proxy data and so have a much greater margin of error than current measured temperatures.

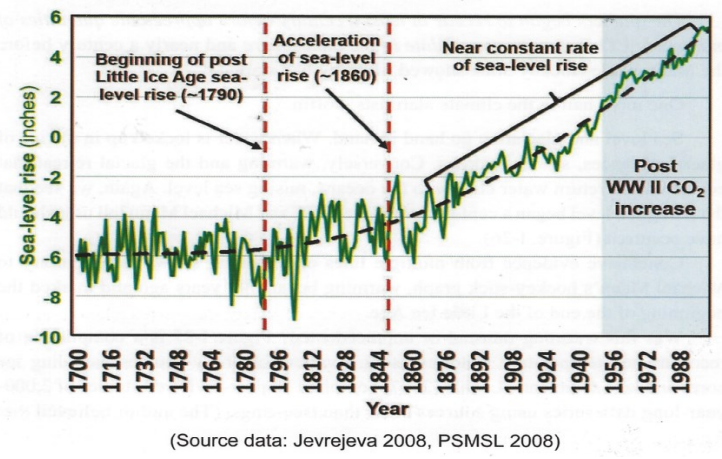




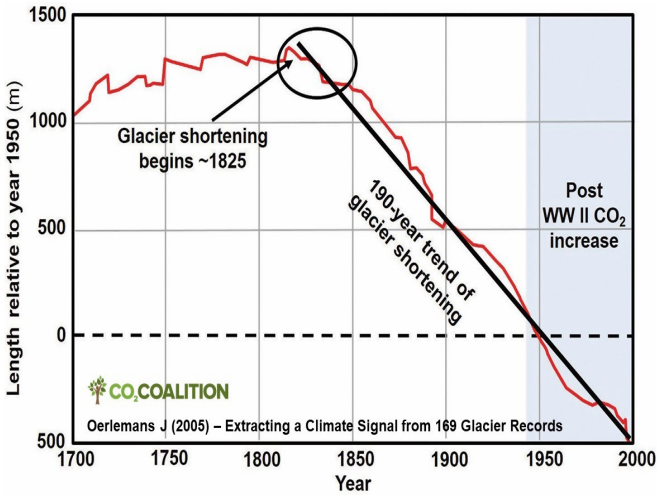
The research on sea levels supports those who disagree with the current IPCC position. It tends to show sea levels roughly 1-2 feet higher than today during the Medieval Warm Period (as a result of the significantly higher temperatures) and roughly 1-2 feet lower than today during the Little Ice Age.

In the mid-1700s it is generally agreed that the world started its modern warming period, and by the late 1700s sea levels started to rise. The rate of rise increased until the mid-1800s, and, since the mid-1800s, the rate of rise, as measured by tide gauges, has remained remarkably constant, despite the significant increase in atmospheric CO2 levels after the 1950s.

Figure I-26: Greater than 200 years of sea-level rise

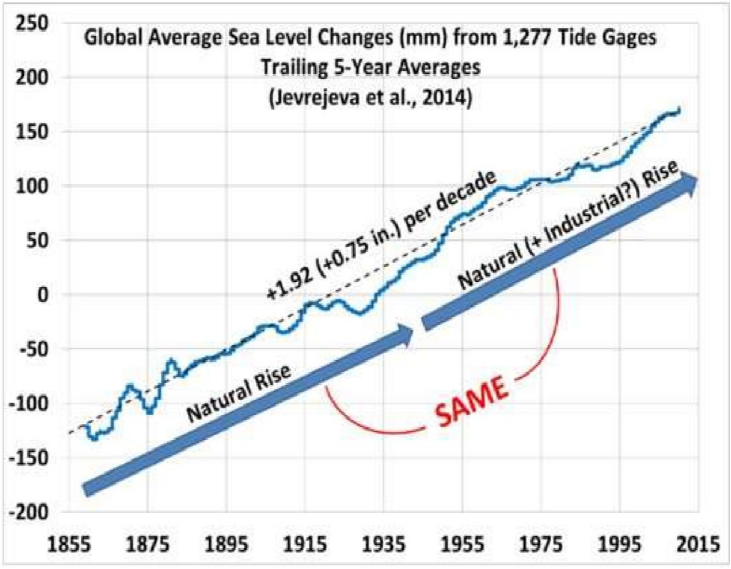


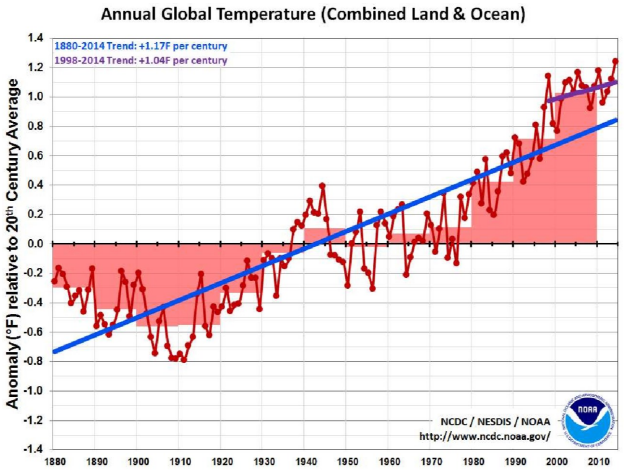
(Source data: Jevrejeva 2008, PSMSL 2008)



Non-polar glaciers started retreating (as measured in feet per year) in the 1820s. The rate of melting has remained roughly constant since that time, again despite the significant increase in atmospheric CO2 levels after the 1950s. The run-off from melting glaciers is one of the significant contributors to sea level rise. During the Little Ice Age, particularly in the 1600s, glaciers in the Alps advanced and crushed whole villages.

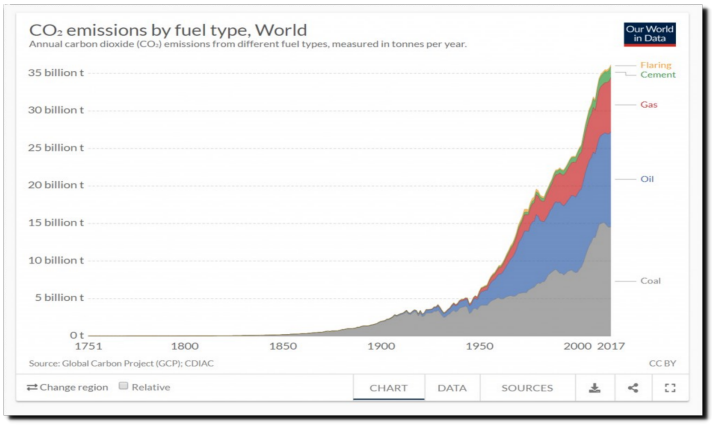
Scientists have good quantities of quality tide gauge data since the mid-1800s. Tide gauge data is available from over 2,000 ports. This study concluded that the rate of rise for the last 160-odd years has been relatively steady at 7.5 inches/century with no noticeable increase in the rate of rise following the 1950s, when human emissions of CO2 dramatically spiked upward.

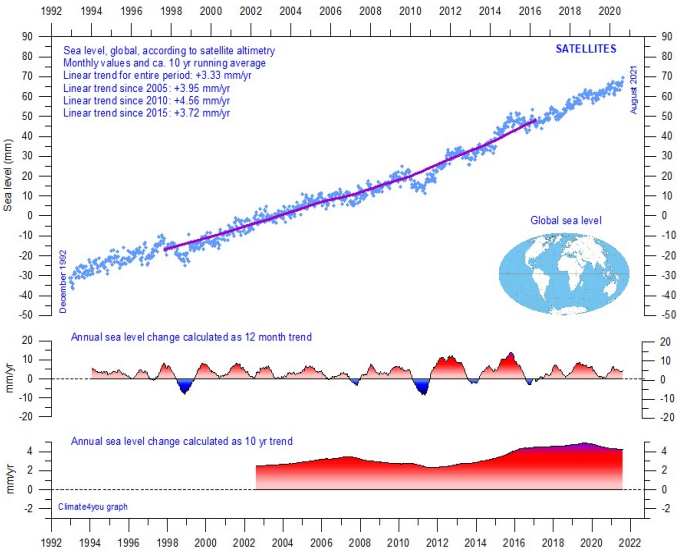




World temperatures have been rising at a relatively linear rate for the last 140 years or so. AR6 states that the temperature rise has been roughly 1.09 C since the preindustrial period [AR6 WGI p.5], which means a rate of warming less than 1 C per century. The linear rate of temperature rise correlates with the linear rate of sea level rise and the linear rate of non-polar glacial melting. If temperatures continue to rise at a linear rate, it is reasonable to expect that sea levels will continue to rise at about 7.5 inches per century.

CO2 emissions spiked in the 1950s and have been rising at a rapid and steady rate ever since. But there has no corresponding increase in the rate of temperature rise or in the rate of sea level rise or the rate of non-polar glacier melt.

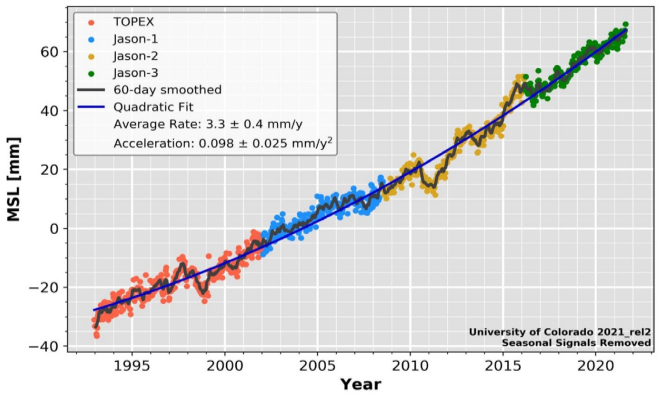


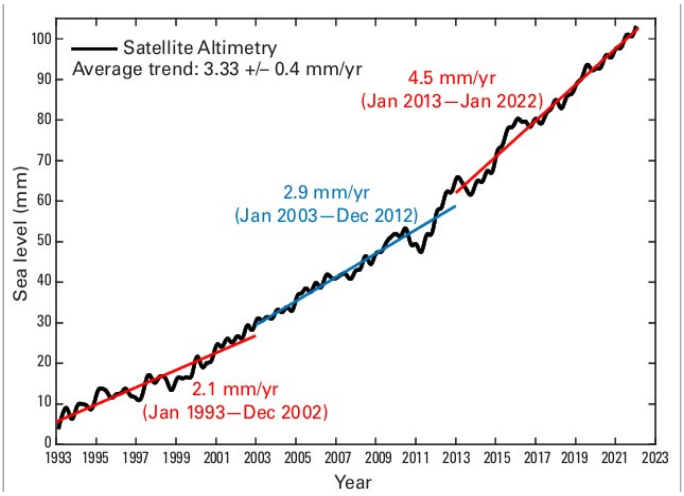


In December 1992 satellites started measuring sea levels. The satellite trend line for the 30 years through 2021 shows a rise at a linear rate of 3.33 mm/yr or 13.2 inches/century. If one looks at short time intervals, one finds that the rise for the period 2010-2021 was 4.56 mm/yr or 18.0 inches/century. The satellite numbers are so much larger than the tide gauge numbers (7.5 inches/century) that many scientists question the satellite data, and there is no consensus as yet about the reasons for the discrepancy.

4 different satellites have been used for measurements over different non-overlapping time periods, and there are a discontinuities in the data around 2010 and 2015 when the transition from the Jason 1 to the Jason 2 satellite occurred and then the transition from Jason 2 to Jason 3 in 2016. The Jason 2 measurements are clear outliers. The trend line for the Jason 3 satellite is 3.72 mm/yr = 14.7 inches/century significantly less than the 18.0 trend for 2010-2021.

SATELLITE DATA SLR = 3.3 mm/yr = 13.0"/cent.





The IPCC clearly uses the tide gauge data up to 2006 and then switches to the satellite data. But there is no discussion of why the IPCC considers the satellite data (which started in 1993) suddenly in 2006 became more reliable than the tide gauge data.

Figure 2. Global Sea-Level Rise, 1880–2013, from Tide-Gauge Data

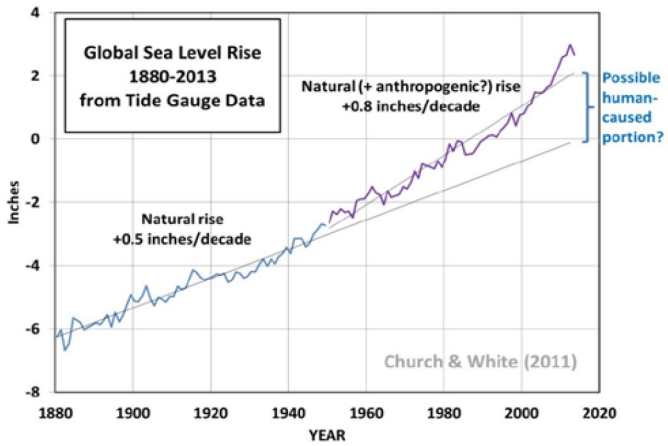


Figure 2. This figure shows sea-level rise dating back to 1880. Graph by Roy Spencer, Ph.D. For a more detailed analysis, see Spencer's article, which can be found in Note 4 in the References section below.

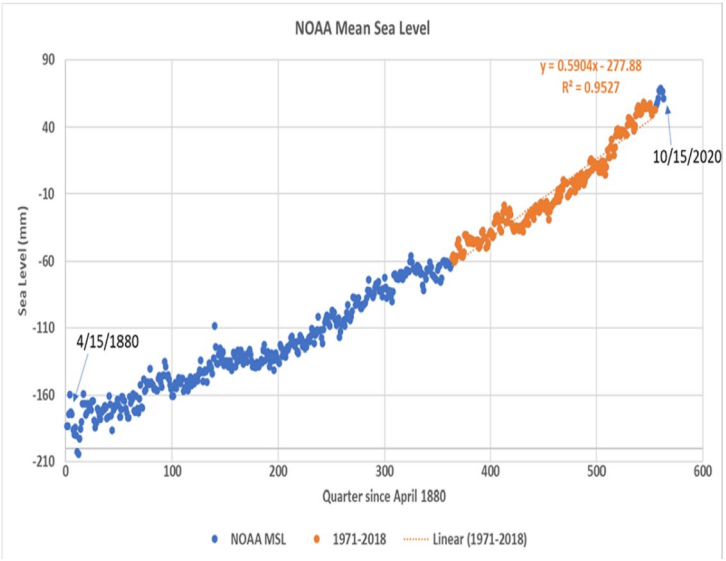
The US government (NOAA) dataset does show an increase in the rate of rise starting in 1971 (the orange dots). The rate of rise calculated for the orange dots is 0.5904 mm per quarter or 9.3" per century.

And a recent reanalysis finds an acceleration in the rate of rise to 17.8" per century for the period 2013-January 2022.

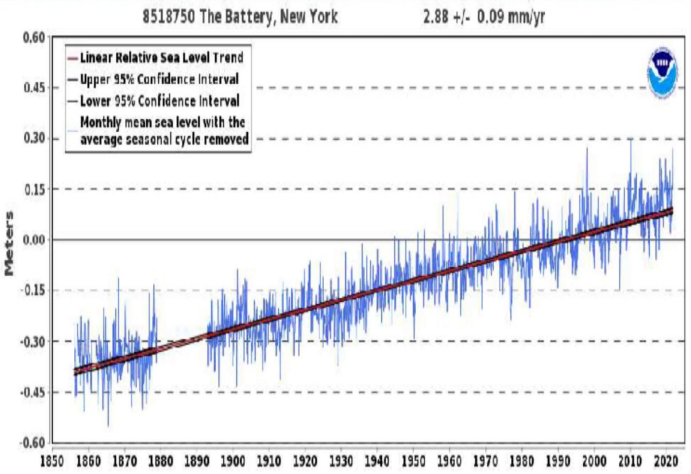
IPCC FINDINGS ON SEA LEVEL RISE [AR6 WGI p.5 (2021)]

Time Period	Rate of Rise Inches per Century
1901-1971	5.1
1971-2006	7.5
2006-2018	14.6

There are many ways that the voluminous tide gauge data can be re-analyzed. This analysis shows the rate of rise as 5.0" per century up to around 1950 and 8.0" per century thereafter. This graph supports the argument that the rapid increase in CO2 emissions in the 1950s may have caused the rate to rise. But the IPCC finding above was that the rate of rise did not increase until 1971. The IPCC concluded that human activity was "the main driver of these increases since at least 1971." [AR6 WGI p.5]



New York 2.88 mm/yr = 11.4"/cent
Sinking = 1.35 mm/yr = 5.3"/cent. Ocean rise = 11.4 – 5.3 = 6.1"/cent



But the tide gauge data around the world does not show any change in the rate of sea level rise. This data from New York City is typical. The measured rate of *relative* rise (which is what tide gauges measure) is 11.4" per century. New York is subsiding (sinking) at the rate of 5.3" per century, so the *absolute* rise if 6.1" per century..

Scientists disagree as to the rate of sea level rise over the last century. The IPCC in AR6 does not acknowledge the dispute nor does it explain its reasons for its conclusions.

The media routinely publishes articles claiming that low-lying island nations (typically coral atolls) are threatened by inundation. Tuvalu is the most often mentioned such nation. But a recent study found that Tuvalu is actually growing. Shore line accretion occurs slightly faster than the sea levels rise.

University of Aukland (2018)

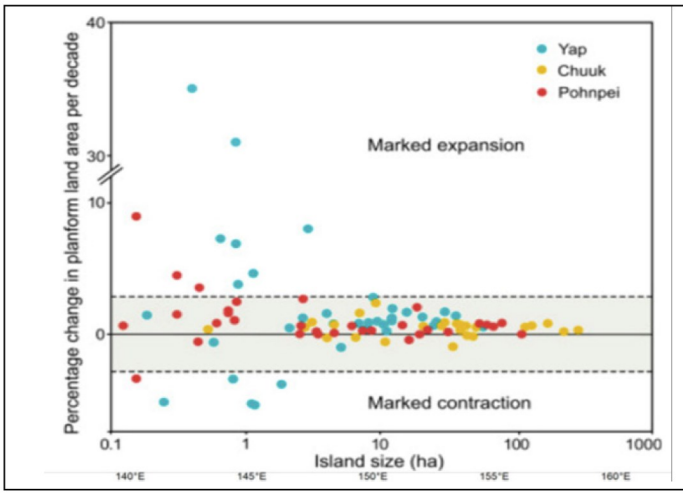
Studied the shorelines of Tuvalu's 101 islands over 40 years.

All islands have changed in size, and the dominant mode has been expansion.

The total land area of the country has increased by 2.9%.

Miami Beach, Then and Now

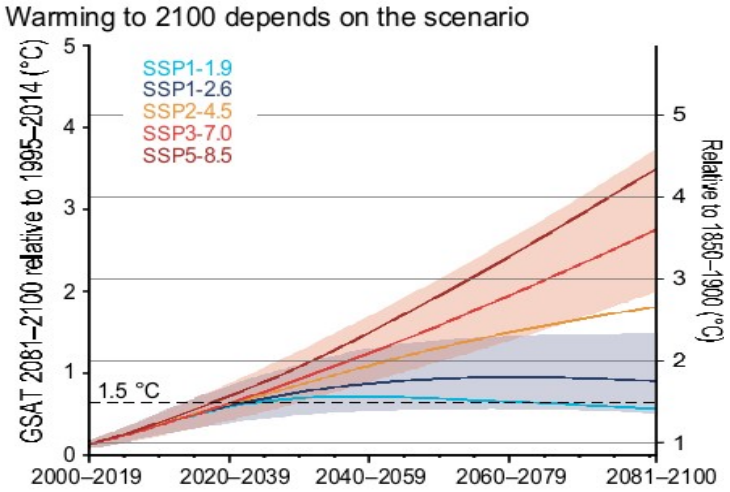
Similarly Miami Beach has, if anything, grown over the period 1925-2017. A recent study of the size of world beaches (Luikendijk 2018) concluded that 24% were shrinking, 48% were stable, and 28% were growing. A recently-published massive survey paper (see below) concluded that 73% of the 709 islands studied were stable in area, 15.5% increased in area, and only 11.4% decreased in area. This study was cited by the IPCC with agreement that "over the past three to five decades, shoreline changes were dominated by stability on reef islands." [AR6 WGI p.2055 (2021)].

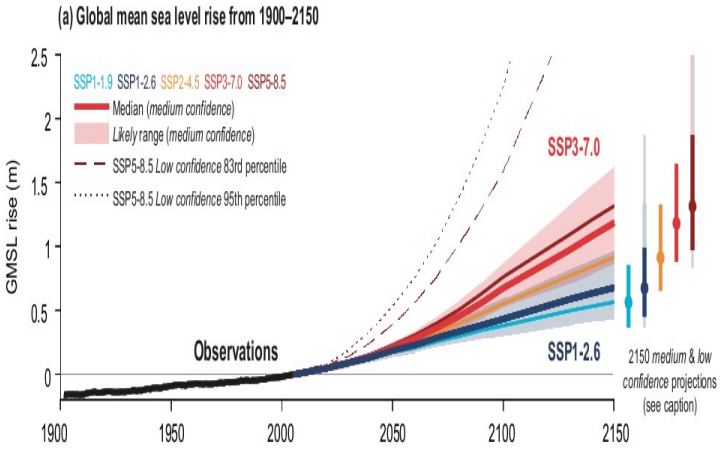


A 2019 global-scale analysis of 709 islands in the Pacific and Indian Oceans revealed 89% were either stable or growing in size, and that no island larger than 10 ha (and only 1.2% of islands larger than 5 ha) had decreased in size since the 1980s (Duvat, 2019).

A new analysis of post-2000 trends also indicates global-scale stable to expanding shorelines for hundreds of Pacific and Indian Ocean islands, with over half of the net growth (39 km² of 62 km²) occurring from 2013 to 2017.

The IPCC also makes predictions of future temperatures and sea level rise. None of the models used have been verified, but, putting aside this issue, every model run starts with a set of assumptions that determine the outcome. The IPCC uses 5 standard sets of assumptions, as shown. The 1.5 assumptions result in about 1.5 C warming. The 8.5 assumptions result in nearly 4.5 C warming. The amount of warming determines the amount of sea level rise.





This graph [AR6 WGI p. 78] shows the sea level rises calculated based on the 5 different sets of assumptions. The IPCC itself does not comment on "the feasibility or likelihood" of the 5 individual scenarios." [AR6 WGI p. 52 (2021)]. The world is probably (but subject to much debate) on a development path that puts it somewhere between SSP1-2.6 and SSP2-4.5.

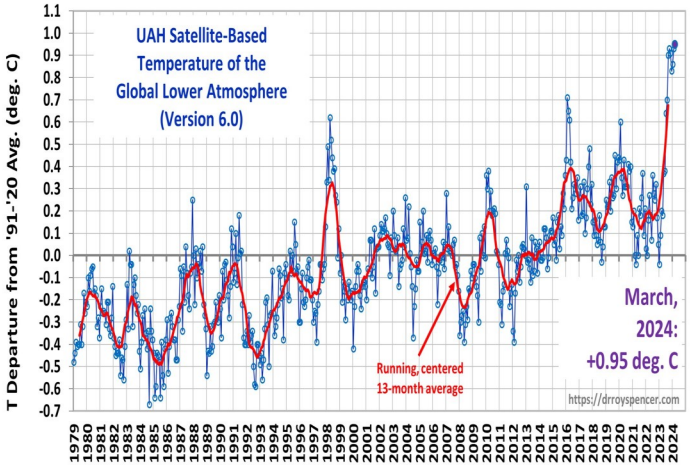
Based on the 2.6 and 4.5 scenarios, the IPCC projects a sea level rise of only 17" to 22" from the baseline of 1995-2005 to the year 2100. [AR6 WGI p. 1302 (2021)]. These numbers are much higher than the numbers being actually measured by the tide gauges around the world, but much lower than what is commonly reported in the media.

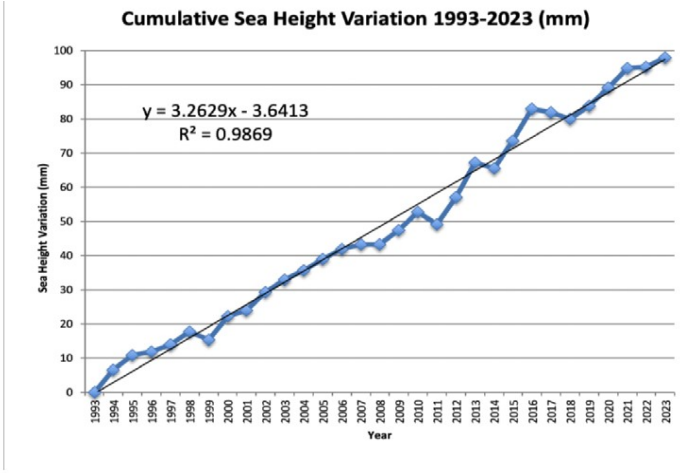
CONCLUSION

Scientists disagree about the amount of sea level rise over the last century. The range of the rate of rise appear to be between about 7" and 14" per century. This is enough to cause problems for certain low-lying coastal cities, particularly those that are subsiding (sinking) like Charleston . Low-lying ocean atolls are not in jeopardy, but these low-lying islands are in serious danger from storms and tidal waves. The reasonably likely sea level rise over the rest of the century (assuming the models are accurate) is only about 17-22," whereas the tide gauge trend line predicts only about 6-7." Sea level rise is a serious issue that warrants concern, but, to the extent that problems exist, they are slow developing, which gives coastal communities ample time to address the problems. Sea level rise is not a crisis.

UPDATE 04-14-24

In May 2023 world temperatures started to rise dramatically, reaching a high point in October. At year end 2023 had become the hottest year in the post-industrial era., and as of the end of March 2024, temperatures remained near the high point.





NASA SEA LEVEL DATA WITH LINEAR FIT

The satellite data for the year 2023 is now available and shows no increase in the rate of sea rise for 2023. The trend line is for a rise of 3.2629 mm/yr or 12.9 inches/century. The tide gauge data continues to show a rise of around half that amount, and scientists still have not been able to explain why the two methods of measurement give such different results.

To confuse the picture still more, a major new study of over 13,000 islands over a period of 30 years from 1990 to 2020 has found that about 88% of the islands had stable coasts. There was neither erosion nor accretion. About 7.5% of the islands lost coastal land area, while 6% of the islands gained land area. In total for the over 13,000 islands there was a slight gain in land area over the 30 year period. Where islands did suffer coastal erosion, the study concluded that sea level rise was not a primary or predominant causal factor.

Works Cited

Intergovernmental Panel on Climate Change Assessment Report 4, Working Group II, Impacts, Adaptation and Vulnerability (2007) (AR4 WGII)

Intergovernmental Panel on Climate Change Assessment Report 5, Working Group I, The Physical Science Basis (2013) (AR 5 WGI)

Intergovernmental Panel on Climate Change Assessment Report 6, Working Group I, The Physical Science Basis (2021) (AR6 WGI)

Intergovernmental Panel on Climate Change Assessment Report 6, Working Group II, Impacts, Adaptation and Vulnerability (2022) (AR6 WGII)

Footnotes

1. AR6 WGI p.6.
2. AR6 WGI p.5
3. Ar6 WGII p.2055
4. Ar6 WGII p. 2055
5. AR6 WGI p. 5
6. AR6 WGI p.77
7. AR5 WGI p. 290
8. Ar6 WGII p. 61
9. AR6 WGI p.89
10. AR6 WGI p. 21
11. AR6 WGII p.1467
12. AR4 WGII p.484
13. AR6 WGII p.588
14. AR6 WGI p.1800
15. AR6 WGII p.1513
16. AR6 WGI p.9