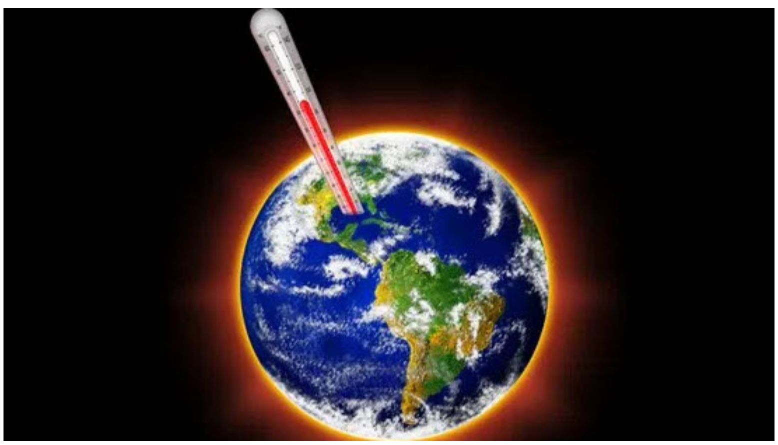
The Holgate result was confirmed by another 2008 paper authored by Jevrejeva et al, which found the fastest sea level rise during the past 300 years was observed between 1920 – 1950 with maximum of 2.5 mm/yr.

In other words: global sea level rise has *decelerated* since the 1950s.

http://notrickszone.com/2018/02/...

It is becoming more and more apparent that sea levels rise and fall without any obvious connection to CO2 concentrations.



NASA Confirms Falling Sea Levels For Two Years Amidst Media Blackout

"Sea level has been rising for the last ten thousand years, since the last Ice Age*…the question is whether sea level rise is accelerating owing to human caused emissions.* ***It doesn't look like there is any great acceleration, so far, of sea level rise***

associated with human warming. *These predictions of alarming sea level rise depend on massive melting of the big continental glaciers — Greenland and Antarctica.* ***The Antarctic ice sheet is actually growing****. Greenland shows large multi-decadal variability. ….* ***There is no evidence so far that humans are increasing sea level rise in any kind of a worrying way."*** *— Dr. Judith Curry,* **video interview** published 9 August 2017

Gravity has enormous influence on the oceans by controlling the tides around the world. It is the force of gravity from the moon and sun control the amazing tides. Dr. Khan's new paper also finds gravity in a different way not climate change is responsible for sea level rise and fall just like the tides coming in and out.

CLIMATE CHANGE SCIENCE
https://rclutz.wordpress.com/2018/03/26/co2-rise-≠-sea-level-rise/

The Chill of Solar Minimum

SEPTEMBER 27, 2018 / DR.TONY PHILLIPS

Sept. 27, 2018: The sun is entering one of the deepest Solar Minima of the Space Age. Sunspots have been absent for most of 2018, and the sun's ultraviolet output has sharply dropped. New research shows that Earth's upper atmosphere is responding.

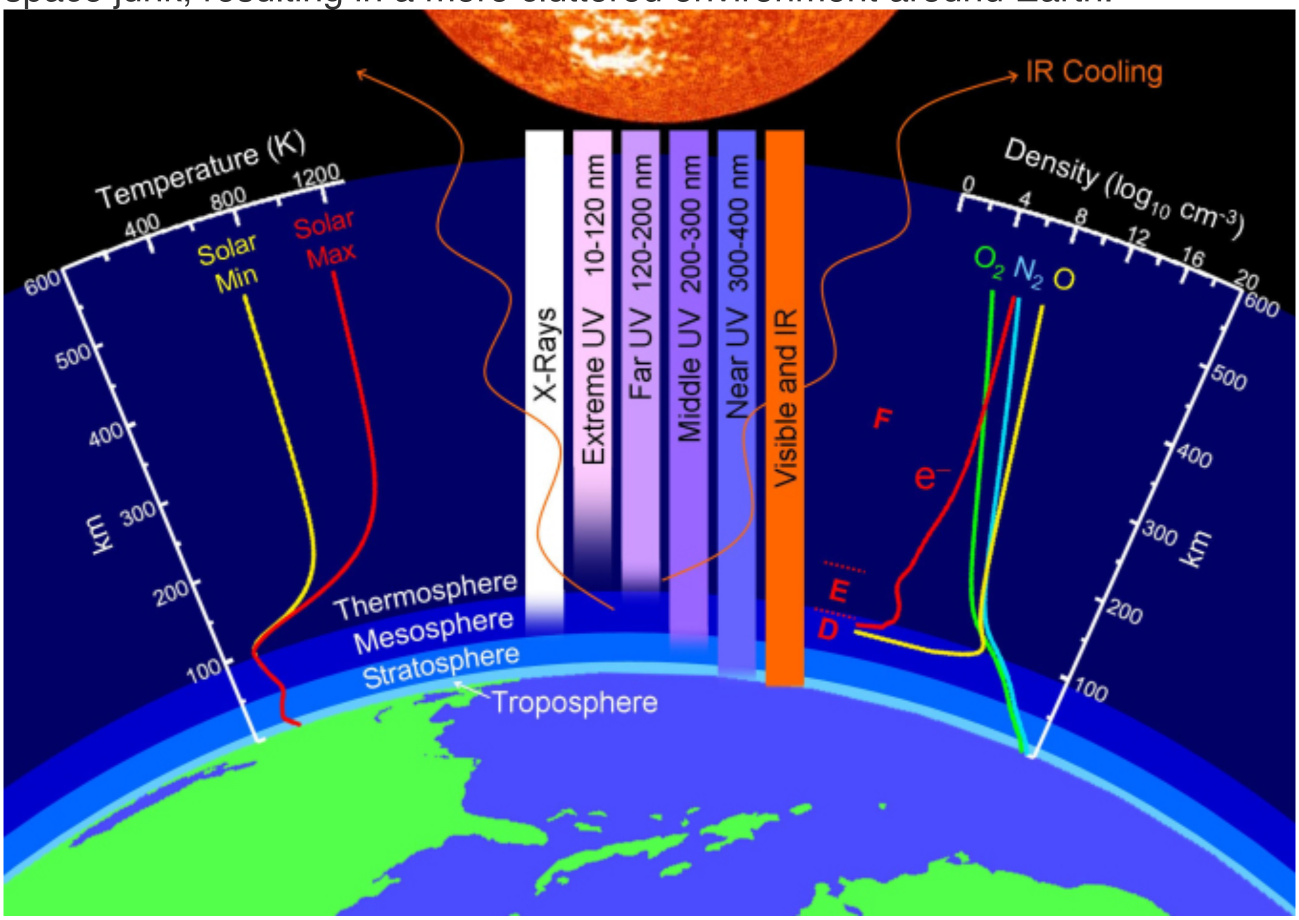
"We see a cooling trend," says Martin Mlynczak of NASA's Langley Research Center. "High above Earth's surface, near the edge of space, our atmosphere is losing heat energy. If current trends continue, it could soon set a Space Age record for cold."

Above: The TIMED satellite monitoring the temperature of the upper atmosphere

These results come from the SABER instrument onboard NASA's TIMED satellite. SABER monitors infrared emissions from carbon dioxide (CO2) and nitric oxide (NO), two substances that play a key role in the energy balance of air 100 to 300 kilometers above our planet's surface. By measuring the infrared glow of these molecules, SABER can assess the thermal state of gas at the very top of the atmosphere–a layer researchers call "the thermosphere."

"The thermosphere always cools off during Solar Minimum. It's one of the most important ways the solar cycle affects our planet," explains Mlynczak, who is the associate principal investigator for SABER.

When the thermosphere cools, it shrinks, literally decreasing the radius of Earth's atmosphere. This shrinkage decreases aerodynamic drag on satellites in low-Earth orbit, extending their lifetimes. That's the good news. The bad news is, it also delays the natural decay of space junk, resulting in a more cluttered environment around Earth.

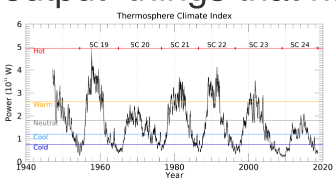


Above: Layers of the atmosphere. Credit: NASA

To help keep track of what's happening in the thermosphere, Mlynczak and colleagues recently introduced the "Thermosphere Climate Index" (TCI)–a number expressed in Watts that tells how much heat NO molecules are dumping into space. During Solar Maximum, TCI is high ("Hot"); during Solar Minimum, it is low ("Cold").

“Right now, it is very low indeed,” says Mlynczak. “SABER is currently measuring 33 billion Watts of infrared power from NO. That’s 10 times smaller than we see during more active phases of the solar cycle.”

Although SABER has been in orbit for only 17 years, Mlynczak and colleagues recently calculated TCI going all the way back to the 1940s. “SABER taught us to do this by revealing how TCI depends on other variables such as geomagnetic activity and the sun’s UV output–things that have been measured for decades,” he explains.



Above: An historical record of the Thermosphere Climate Index. Mlynczak and colleagues recently published a paper on the TCI showing that the state of the thermosphere can be discussed using a set of five plain language terms: Cold, Cool, Neutral, Warm, and Hot.

As 2018 comes to an end, the Thermosphere Climate Index is on the verge of setting a Space Age record for Cold. “We’re not there quite yet,” says Mlynczak, “but it could happen in a matter of months.”

“We are especially pleased that SABER is gathering information so important for tracking the effect of the Sun on our atmosphere,” says James Russell, SABER’s Principal Investigator at Hampton University. “A more than 16-year record of long-term changes in the thermal condition of the atmosphere more than 70 miles above the surface is something we did not expect for an instrument designed to last only 3-years in-orbit.”

Soon, the Thermosphere Climate Index will be added to Spaceweather.com as a regular data feed, so our readers can monitor the state of the upper atmosphere just as researchers do. Stay tuned for updates.

References:

Martin G. Mlynczak, Linda A. Hunt, James M. Russell, B. Thomas Marshall, Thermosphere climate indexes: Percentile ranges and adjectival descriptors, *Journal of Atmospheric and Solar-Terrestrial Physics*, https://doi.org/10.1016/j.jastp.2018.04.004

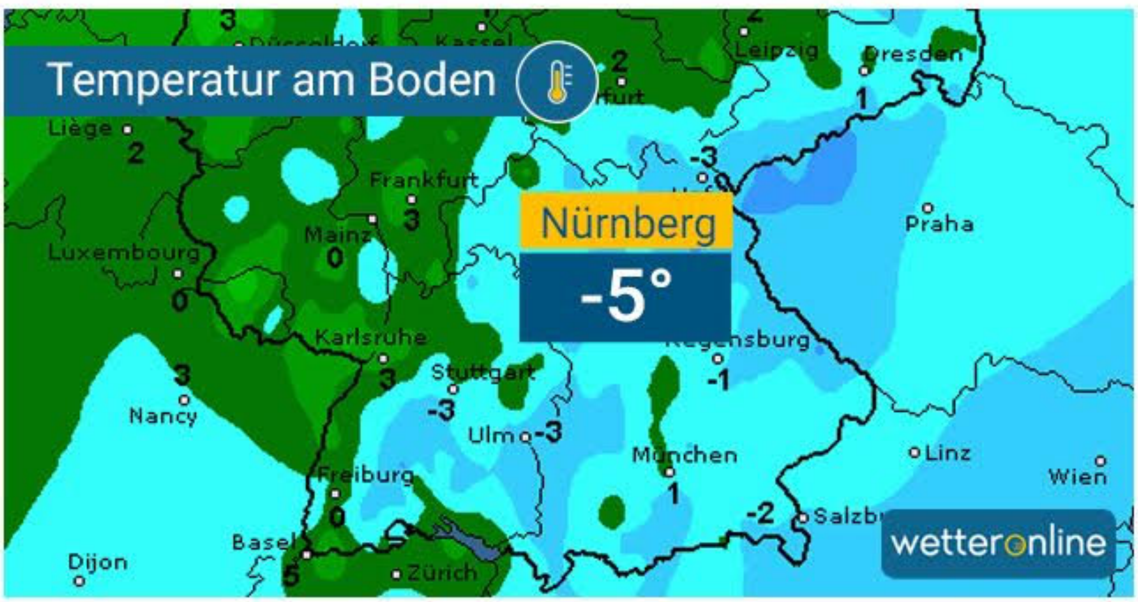
Mlynczak, M. G., L. A. Hunt, B. T. Marshall, J. M. RussellIIII, C. J. Mertens, R. E. Thompson, and L. L. Gordley (2015), A combined

solar and geomagnetic index for thermospheric climate. *Geophys. Res. Lett.*, 42, 3677–3682. doi: 10.1002/2015GL064038.
Mlynczak, M. G., L. A. Hunt, J. M. Russell III, B. T. Marshall, C. J. Mertens, and R. E. Thompson (2016), The global infrared energy budget of the thermosphere from 1947 to 2016 and implications for solar variability, *Geophys. Res. Lett.*, 43, 11,934–11,940, doi: 10.1002/2016GL070965

https://spaceweatherarchive.com/2018/09/27/the-chill-of-solar-minimum/

26. September 2018

Kälteste Septembernacht seit Messbeginn



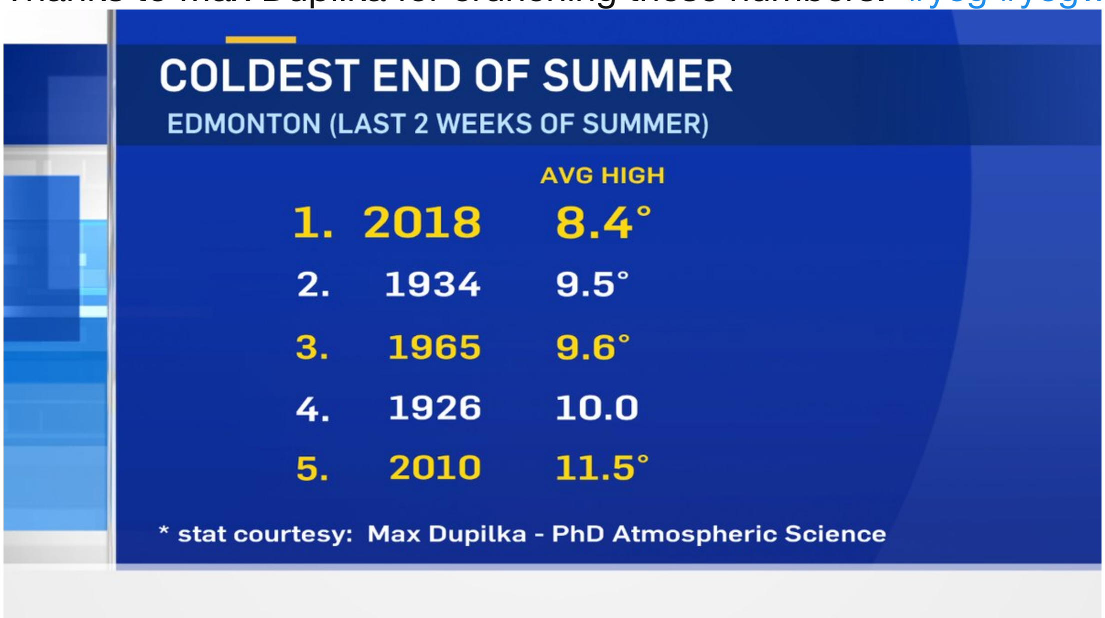
Mit verbreitetem Bodenfrost hat der Herbst unmissverständlich klargemacht, dass seine Zeit angebrochen ist. Südlich einer Linie von Köln bis Berlin hat sich am Morgen vielerorts Reif am Boden gebildet. Besonders in Tal- und Muldenlagen zeigt das Thermometer aber auch in zwei Meter Höhe negative Werte an. Nur im Norden und auf den Bergen ist es milder.

Germany – Coldest September morning since weather records began!

September 26, 2018 by Robert

It's a record! this has been the COLDEST last 2 weeks of Summer on record in Edmonton. (and those records date back to the 1880s).

Thanks to Max Dupilka for crunching these numbers. #yeg #yegwx



Falling seas globally are documented by NASA for the past few years and there has never been more than an minute annual rise of a couple of mm - the size of a dime laying flat. If the seas are now falling or not rising enough to see for the past 100 years and glaciers are expanding and temperatures falling where is the danger for a 'mass migration?'

Bewildered Scientists…A Global Warming Crisis Fails

To Appear: Sea Level Rise Grinds To A Crawl

By P Gosselin on 2. February 2018

Over the past months a spate of scientific papers published show sea level rise has not accelerated like many climate warming scientists warned earlier. The reality is that the rise is far slower than expected, read here and here.

Alarmist bedwetting by scientists over sea level rise proving to have been needless. Photo: PIK climate scientist Stefan Rahmstorf. Source: Potsdam Institute for Climate Impact Research, Rahmstorf FTP folder.

Scary scenarios abound

The latest findings glaringly contradict alarmist claims of accelerating sea level rise. For example the National Oceanic and Atmospheric Administration (NOAA) here wrote sea levels would "likely rise for many centuries at rates higher than that of the current century", due to global warming.

In 2013 The Potsdam Institute for Climate Impact Research (PIK) wrote here sea-level rise in this century would likely be 70-120 centimeters by 2100″ (i.e. 7 – 12 mm annually) and that 90 experts in a survey "anticipated a median sea-level rise of 200-300 centimeters by the year 2300" (i.e. on average circa 7 to 10 mm every year).

It's important to note that the above scary figures given above are mostly based on computer simulations, where parameters are simply assumed by the scientists.

Evidence in fact points to deceleration

Using these modelled estimates, the globe should now be seeing a rapid acceleration in sea level rise. Yet no evidence of this can be found so far. In fact the real measured data show the opposite is happening: a deceleration in sea level rise is taking place.

Instead of the 7 – 12 mm annual sea level rise the PIK projected in 2013, a recent study appearing in the Geophysical Research Letters in April 2017 corrected the satellite measured sea level rise downwards from 3.3 mm annually to just 3.0 mm over the past 24 years – or less than half what PIK models projected.

Only 1.5 mm/year

Worse, satellite data measuring sea level have turned out to be far more complex and uncertain than one would wish, and evidence is piling up and showing that satellite data likely have been overstating sea level rise. For example when measuring sea level rise along coastlines (where people actually live)using tide gauges, the rise has even been far slower. Renowned Swedish sea level expert Axel Mörner published a paper in 2017 showing an observed sea level rise rate of only 1.5 – 2.0 mm/year.

Second half of the 20th century slower than in the first half

In another newly published paper by Frederiske et al. 2018 just this year, oceanographers estimate that global sea levels rose at a rate of only 1.42 mm per year between 1958 and 2014. That figure closely coincides with the results of Dr. Simon Holgate from 2007. According to the Holgate study: "The rate of sea level change was found to be larger in the early part of last century (2.03 ± 0.35 mm/yr 1904–1953), in comparison with the latter part (1.45 ± 0.34 mm/yr 1954–2003)."

The Holgate result was confirmed by another 2008 paper authored by [Jevrejeva et al](), which found the fastest sea level rise during the past 300 years was observed between 1920 – 1950 with maximum of 2.5 mm/yr.

In other words: global sea level rise has *decelerated* since the 1950s.

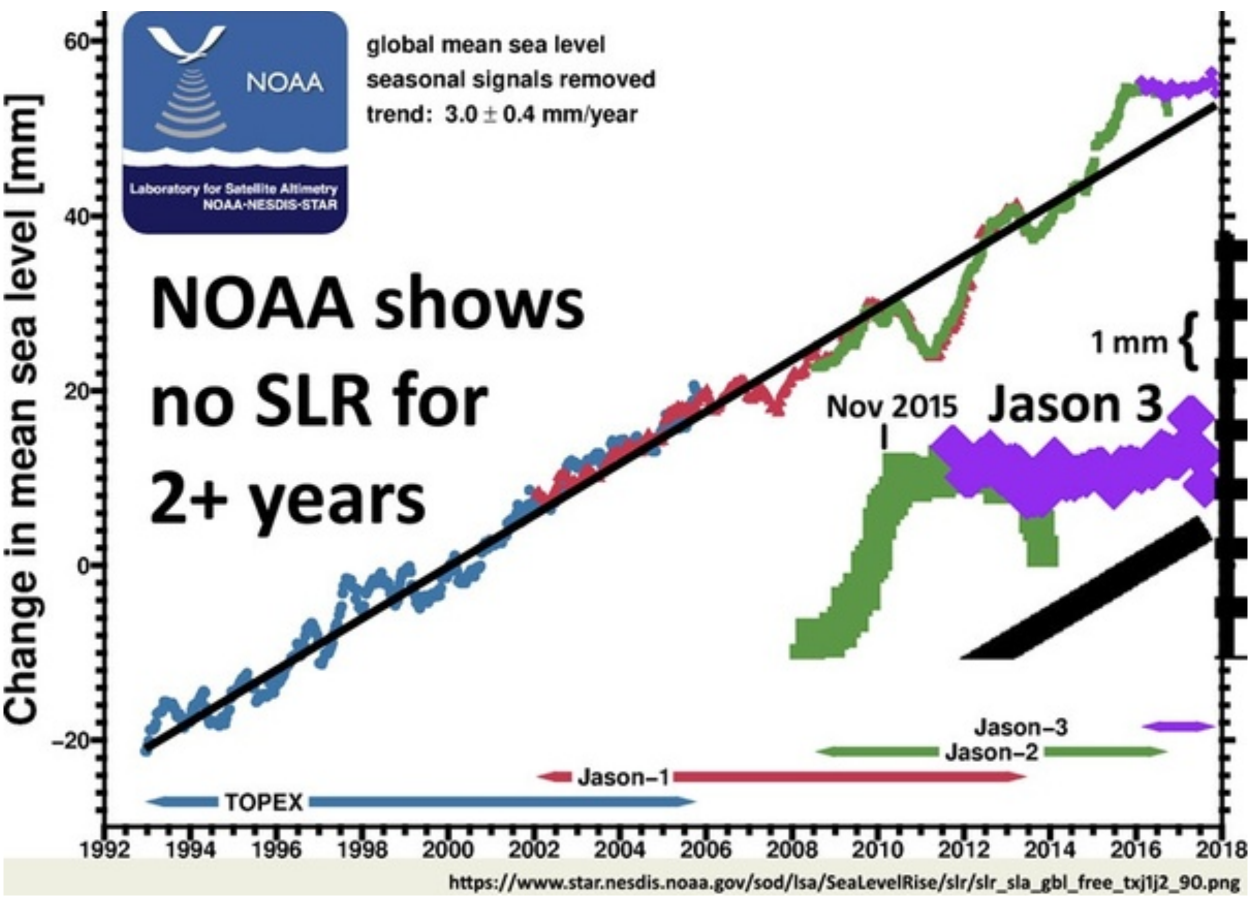
At less than 2 mm annually, sea level is rising at only one sixth of the 12 mm per year rate p

http://notrickszone.com/2018/02/... rejected by the PIK in 2013.

12. Sea level predictions

1981 James Hansen, NASA scientist, predicted a global warming of "almost unprecedented magnitude" in the next century that might even be sufficient to melt and dislodge the ice cover of West Antarctica, eventually leading to a worldwide rise of 15 to 20 feet in the sea level. See here.

Reality check: Since 1993 (24 years) we have totaled 72 mm (3 inches) of sea level rise instead of the 4 feet that corresponds to one-fourth of a century. The alarming prediction is more than 94% wrong, so far. See here.



A NASA study, published in the Journal of Glaciology in 2015, claims that Antarctic ice mass is increasing. See here. Antarctic sea ice reached a record extent in 2014, see here.

11. Glacier predictions

2007 IPCC AR4 says there is a very high likelihood that Himalayan glaciers will disappear by the year 2035 and perhaps sooner if the Earth keeps warming at the current rate. See here.

IPCC officials recanted the prediction in 2010 after it was revealed the source was not peer-reviewed. Previously they had criticized the Indian scientist that questioned the prediction and ignored an IPCC author than in 2006 warned the prediction was wrong. See here.

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Ice

Oct. 31, 2015

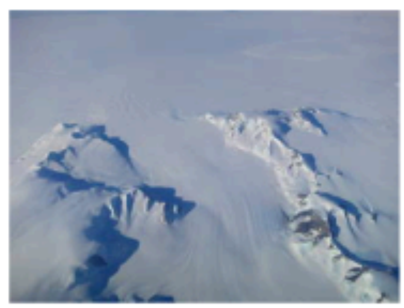
NASA Study: Mass Gains of Antarctic Ice Sheet Greater than Losses

A new NASA study says that an increase in Antarctic snow accumulation that began 10,000 years ago is currently adding enough ice to the continent to outweigh the increased losses from its thinning glaciers.

The research challenges the conclusions of other studies, including the Intergovernmental Panel on Climate Change's (IPCC) 2013 report, which says that Antarctica is overall losing land ice.

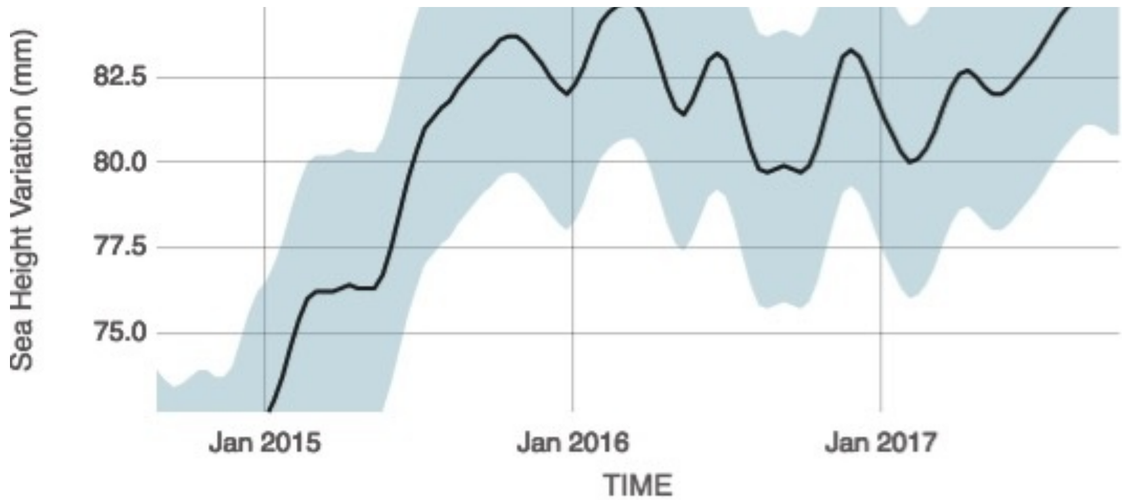
According to the new analysis of satellite data, the Antarctic ice sheet showed a net gain of 112 billion tons of ice a year from 1992 to 2001. That net gain slowed to 82 billion tons of ice per year between 2003 and 2008.

"We're essentially in agreement with other studies that show an increase in ice discharge in the Antarctic Peninsula and the Thwaites and Pine Island region of West Antarctica," said Jay Zwally, a glaciologist with NASA Goddard Space Flight Center in Greenbelt, Maryland, and lead author of the study, which was published on Oct. 30 in the *Journal of Glaciology*. "Our main disagreement is for East Antarctica and the interior of West Antarctica – there, we see an ice gain that exceeds the losses in the other areas." Zwally added that his team "measured small height changes over large areas, as well as the large changes observed over smaller areas."



A new NASA study says that Antarctica is overall accumulating ice. Still, areas of the continent, like the Antarctic Peninsula photographed above, have increased their mass loss in the last decades.
Credits: NASA's Operation IceBridge

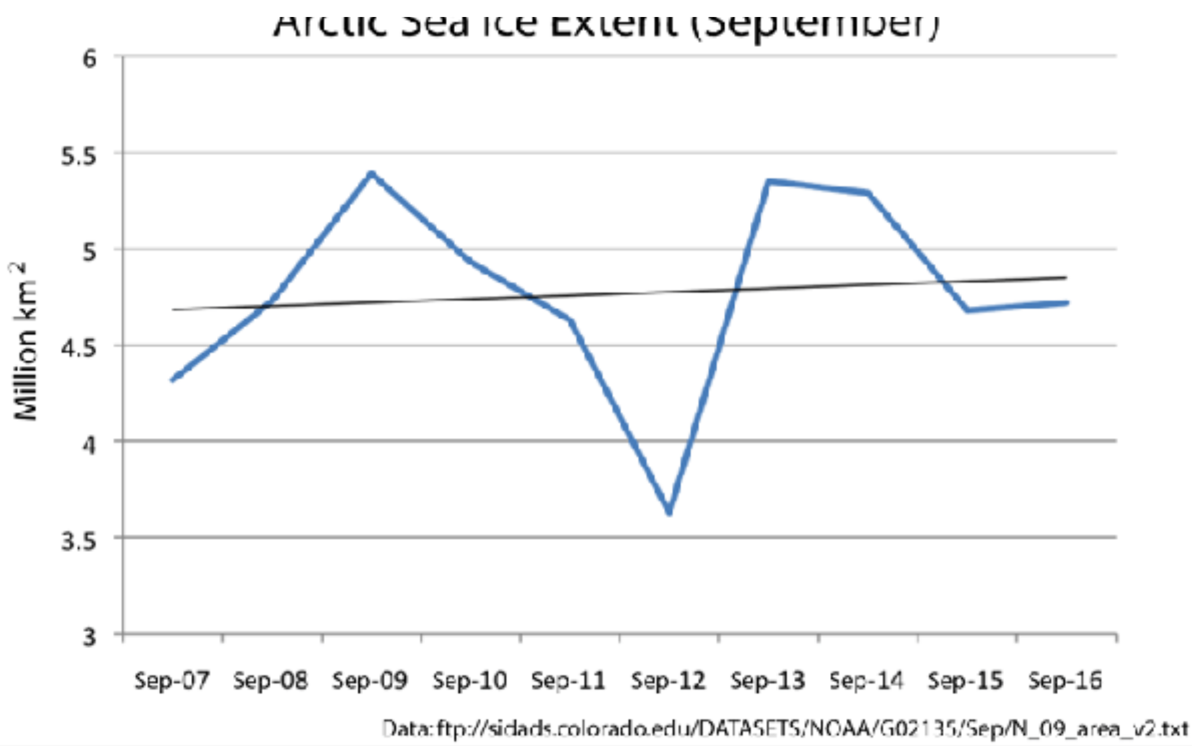
12. Sea level predictions



Source: climate.nasa.gov

If you don't trust the graphs review for yourself the visual photos proving no rising seas over past 100 years based on pictures of Sydney harbour Australia.

Reality check: No decrease in September Arctic sea ice extent has been observed since 2007, see here and here.



13. Sinking nations predictions

1989 Noel Brown, director of the New York office of the U.N. Environment Program (UNEP) says entire nations could be wiped off the face of the Earth by rising sea levels if the global warming trend is not reversed by the year 2000. As global warming melts polar icecaps, ocean levels will rise by up to three feet, enough to cover the Maldives and other flat island nations. See here.

Reality check: Tide gauges referenced by GPS at 12 locations in the South Pacific reported variable trends between -1 to +3 mm/year for the 1992-2010 period. See here.

The Diego Garcia atoll in the Indian ocean experienced a land area decrease of only 0.92% between 1963 and 2013. See here.

The Funafuti atoll has experienced a 7.3% net island area increase between 1897 and 2013. See here.

RESEARCH ARTICLE|JUNE 01, 2015

Coral islands defy sea-level rise over the past century: Records from a central Pacific atoll

P.S. Kench D. Thompson M.R. Ford H. Ogawa R.F. McLean

Geology (2015) 43 (6): 515-518.

https://doi.org/10.1130/G36555.1

Abstract

The geological stability and existence of low-lying atoll nations is threatened by sea-level rise and climate change. Funafuti Atoll, in the tropical Pacific Ocean, has experienced some of the highest rates of sea-level rise (~5.1 ± 0.7 mm/yr), totaling ~0.30 ± 0.04 m over the past 60 yr. We analyzed six time slices of shoreline position over the past 118 yr at 29 islands of Funafuti Atoll to determine their physical response to recent sea-level rise. Despite the magnitude of this rise, no islands have been lost, the majority have enlarged, and there has been a 7.3% increase in net island area over the past century (A.D. 1897–2013). There is no evidence of heightened erosion over the past half-century as sea-level rise accelerated. Reef islands in Funafuti continually adjust their size, shape, and position in response to variations in boundary conditions, including storms, sediment supply, as well as sea level. Results suggest a more optimistic prognosis for the habitability of atoll nations and demonstrate the importance of resolving recent rates and styles of island change to inform adaptation strategies.

Tuvalu is rising not sinking no migration here!

Société de Calcul Mathématique, SA

A recent White Paper by a major French Society of Mathematics demolishes the ridiculous scaremongering by alarmists about sea rising and severe weather.

Part 1: The facts

Chapter 1: The crusade is absurd

There is not a single fact, figure or observation that leads us to conclude that the world‘s climate is in any way ‚disturbed‘. It is variable, as it has always been, but rather less so now than during certain periods or geological eras. Modern methods are far from being able to accurately measure the planet‘s global temperature even today, so measurements made 50 or 100 years ago are even less reliable.

Concentrations of CO2 vary, as they always have done; the figures that are being released are biased and dishonest. Rising sea levels are a normal phenomenon linked to upthrust buoyancy; they are nothing to do with so-called global warming. As for extreme weather events – they are no more frequent now than they have been in the past. We ourselves have processed the raw data on hurricanes.

We are being told that ‚a temperature increase of more than 20C by comparison with the beginning of the industrial age would have dramatic consequences, and absolutely has to be prevented‘. When they hear this, people worry: hasn‘t there already been an increase of 1.90C? Actually, no: the figures for the period 1995-2015 show an upward trend of about 10C every hundred years! Of course, these figures, which contradict public policies, are never brought to public attention.

“Groundbreaking New Paper Finds Global Warming, Ice Melt ‘Not Related To Sea Level Rise’”

By Kenneth Richard on 26. March 2018

1 – 2 Meters Of Sea Level Rise By 2100 A ‘Highly Erroneous’ Claim

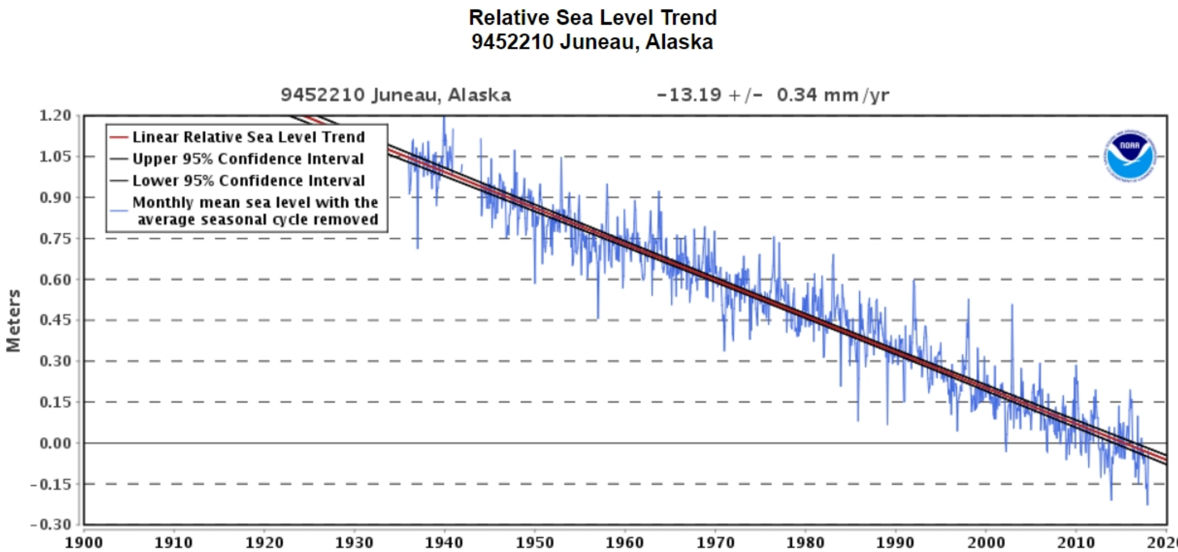
Geophysicist and tectonics expert **Dr. Aftab Khan** has unearthed a massive fault in the current understanding of (1) rapid sea level rise and its fundamental relation to (2) global-scale warming/polar ice melt.

Succinctly, Dr. Khan concludes *the two have little to nothing to do with one another*.

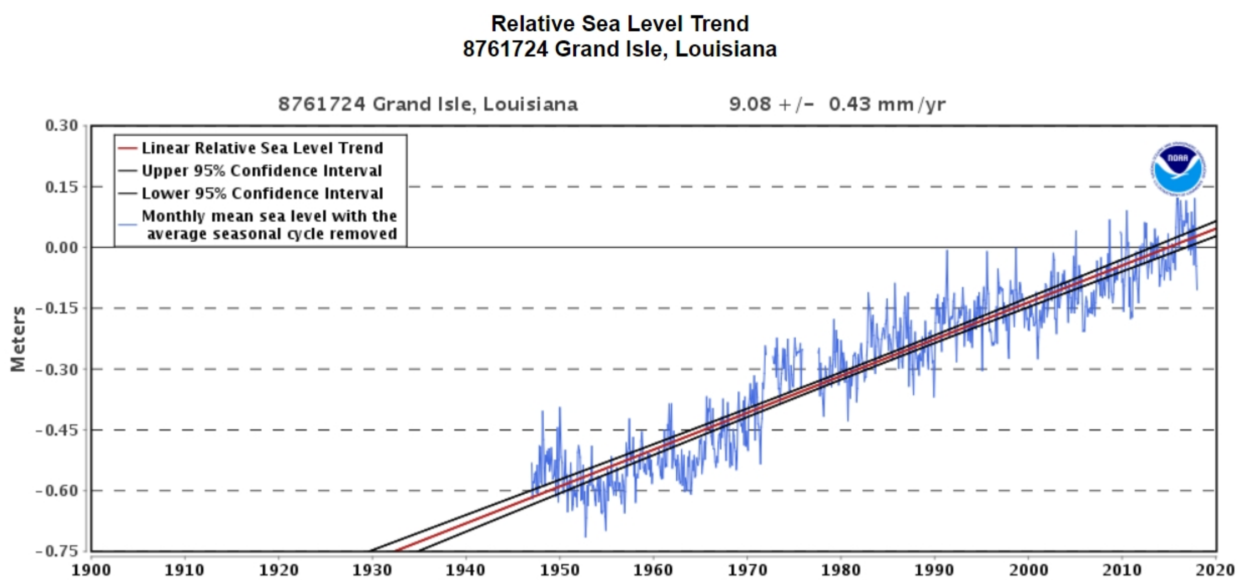
That’s because land height changes — subsidence (sinking) or uplift (rising) — connected to the Earth’s gravitational attraction and shifting plates assume the dominant role in determining sea level rise and fall. The extent to which thermal expansion from Rising Ocean heat contributes to sea level rise is, as Dr. Khan indicates, “definitely a conjecture”.

Uplift And Subsidence Occurring Today

Along the coast of Juneau, Alaska, for example, the land surface has been rapidly rising due to gravitational uplift for many decades. Consequently, relative sea levels are plummeting in this region at a rate of over -13 mm/yr (-5 inches per decade) according to **NOAA**.



The opposite is occurring along the U.S. Gulf coast ( ), where the land area is sinking and thus sea levels are rising at a rate of over +9 mm/yr.



Sea Level Rise Trends Not Determinative Of Shoreline Changes

Many other scientists have also concluded that "**sea level rise is not the primary factor controlling the shoreline changes**" in regions where sea level rise is quite high. Even at rates exceeding 5 mm/yr, sea levels aren't rising fast enough to overcome the much more pronounced changes in coastal *expansion* due to accretion and uplift.

Testut et al., 2016

"We show that Grande Glorieuse Island has increased in area by 7.5 ha between 1989 and 2003, predominantly as a result of shoreline accretion **[growth]:** accretion occurred over 47% of shoreline length, whereas 26% was stable and 28% was eroded. **Topographic transects and field observations show that the accretion is due to sediment transfer from the reef outer slopes to the reef flat and then to the beach. This accretion occurred in a context of sea level rise:** sea level has risen by about 6 cm in the last twenty years **and the island height is probably stable or very slowly subsiding.** This island expansion during a period of rising sea level demonstrates that sea level rise is not the primary factor controlling the shoreline changes**. This paper highlights the key role of** non-climate factors **in changes in island area, especially sediment availability and transport."**

"The geological stability and existence of low-lying atoll nations is threatened by sea-level rise and climate change. Funafuti Atoll, in the tropical Pacific Ocean, has experienced some of the highest rates of sea-level rise (~5.1 ± 0.7 mm/yr), totaling ~0.30 ± 0.04 m over the past 60 yr**. We analyzed six time slices of shoreline position over the past 118 yr at 29 islands of Funafuti Atoll to determine their physical response to recent sea-level rise.** Despite the magnitude of this rise, no islands have been lost, the majority have enlarged, and there has been a 7.3% increase in net island area over the past century (A.D. 1897–2013)**."**

This is not just a local phenomenon, either. Instead of shrinking coasts and submerged shorelines due to global sea level rise and polar ice melt, scientists have found that **the land area above sea level has been *growing* across the world since the 1980s** ( ) . . . during the same period of time that anthropogenic CO2 emissions were rising.

"We expected that the coast would start to retreat due to sea level rise, but the most surprising thing is that the coasts are growing all over the world**," said Dr Baart. "We're were able to create more land than sea level rise was taking."**

Modern Sea Level Change Rates Almost Undetectable Relative To Past

Since 1958, sea levels have only been rising at a rate of between **1.3 and 1.5 millimeters per year**, a rate of about 5 to 6 inches per century ( ).

Meltwater from the Greenland and Antarctica ice sheets *combined* has contributed just **0.59 of an inch** to global sea levels during this period ( ).

Between 16,500 years ago and 8,200 years ago, by comparison, the *average* rate of global sea level rise was **1.2 *meters* per century (12 mm/yr)**, which is more than **800% faster than the rate achieved since 1958**. Included in that rate average is the "meltwater pulse" epoch around 14,500 years ago, when sea levels rose at rates of **4 meters per century (40 mm/yr)**.

"Rates and patterns of global sea level rise (SLR) following the last glacial maximum (LGM) are known from radiometric ages on coral reefs from Barbados, Tahiti, New Guinea, and the Indian Ocean, as well as sediment records from the Sunda Shelf and elsewhere. … Lambeck et al. (2014) estimate mean global rates during the main deglaciation phase of 16.5 to 8.2 kiloannum (ka) **[16,500 to 8,200 years ago] at 12 mm yr−1** [+1.2 meters per century] **with more rapid SLR [sea level rise] rates (~ 40 mm yr−1)** [+4 meters per century] **during meltwater pulse 1A ~ 14.5–14.0 ka [14,500 to 14,000 years ago]."**

Donoghue (2011) provides a visualization of the insignificance of modern changes relative to the past.

"For much of the period since the last glacial maximum (LGM), 20,000 years ago, the region has seen rates of sea level rise far in excess of those experienced during the period represented by long-term tide gauges. The regional tide gauge record reveals that sea level has been rising at about 2 mm/year for the past century, while the average rate of rise since the LGM has been 6 mm/year, with some periods of abrupt rise exceeding 40 mm/year **[4 meters per century]."**
"Sea level has at times risen at rates more than 20 times that of today, more than 40 mm/year**.** At such rates, the regional shorelines would have retreated by as much as 40 m/year, or more than 75 cm/week**."**

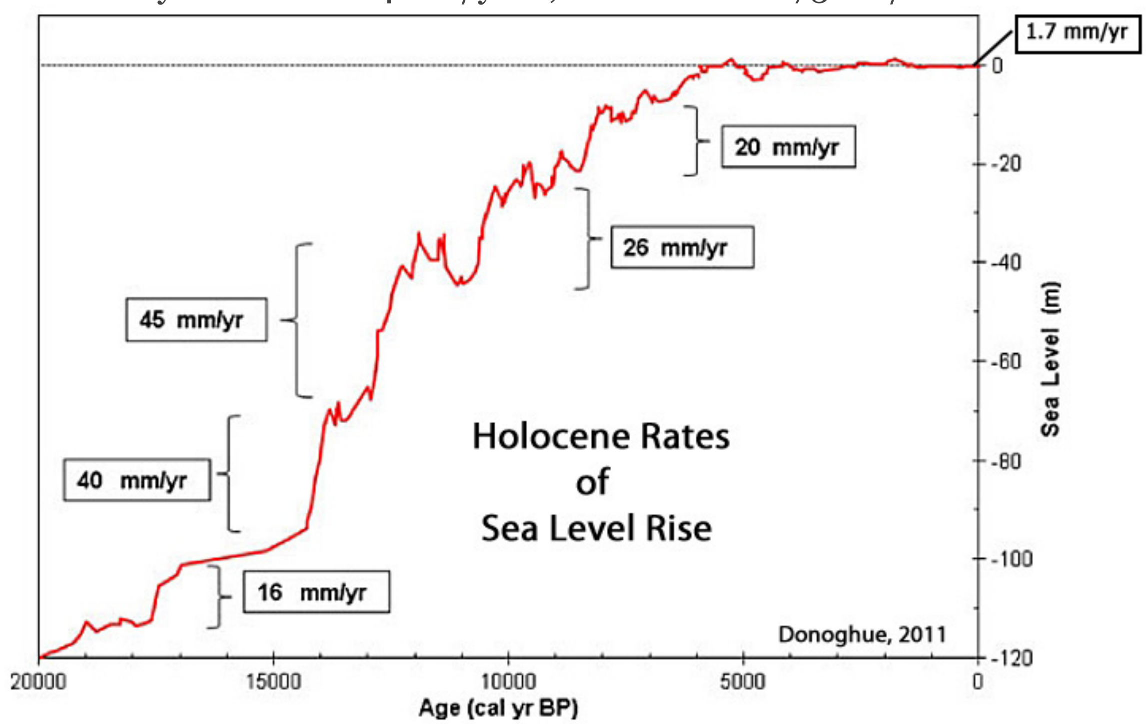


Fig. 3 Sea level history for the northern Gulf of Mexico since the last glacial maximum, based on approximately 300 radiocarbon-dated paleoshoreline indicators. Samples were taken from the coast and shelf of Florida, Louisiana, Texas, and Mexico. Several periods of rapid sea level rise are indicated. Figure adapted from Balsillie and Donoghue (2004)

Scientists affirm that an anthropogenic fingerprint in sea level rise trends are currently still "too small to be observable".

"[B]y making use of 21 CMIP5 coupled climate models, we study the contribution of external forcing to the Pacific Ocean regional sea level variability over 1993–2013, and show that according to climate models, externally forced and thereby the anthropogenic sea level fingerprint on regional sea level trends in the tropical Pacific is still too small to be observable by satellite altimetry**."**

"Furthermore, regressed CMIP5 MME-based sea level spatial trend pattern in the tropical Pacific over the altimetry period do not display any positive sea level trend values that are comparable to the altimetry based sea level signal after having removed the contribution of the decadal natural climate mode. This suggests that the residual positive trend pattern observed in the western tropical Pacific is not externally forced and thereby not anthropogenic in origin**."**

New Paper: Meter-Scale Sea Level Rise* Only *Related To Large-Scale Geologic Events

In a new paper published in the journal Geoscience Frontiers, Dr. Khan concludes that "**both regional and local sea-level rise and fall in meter-scale is related to the geologic events only and not related to global warming and/or polar ice melt**."

Obviously this leaves no room for global warming and polar ice melt to contribute to the alarming sea level rise predicted to materialize by the end of the century. Modeled predictions of 1 to 2 meters of sea level rise by 2100 are deemed "highly erroneous."

Hence, suggestions of an anthropogenic influence on sea level change — the scariest aspect of climate modeling predictions — may be significantly undermined by scientific observation.

Why would sea-level rise for global
warming and polar ice-melt?

Summary

•”**Geophysical shape of the earth is the fundamental component of the global sea level distribution.** Global warming and ice-melt, although a reality, would not contribute to sea-level rise. Gravitational attraction of the earth plays a dominant role against sea level rise.”

•”**As a result of low gravity attraction in the region of equatorial bulge and high gravity attraction in the region of polar flattening, melt-water would not move from polar region to equatorial region. Further,** melt-water of the floating ice-sheets will reoccupy same volume of the displaced water by floating ice-sheets causing no sea-level rise**. Arctic Ocean in the north is surrounded by the land mass thus can restrict the movement of the floating ice, while Antarctic in the south is surrounded by open ocean thus floating ice can freely move to the north. Melting of huge volume of floating sea-ice around Antarctica not only can reoccupy volume of the displaced water but also can cool ocean-water in the region of equatorial bulge thus can prevent thermal expansion of the ocean water.”**

•”Melting of land ice in both the polar region can substantially reduce load on the crust allowing crust to rebound elastically for isostatic balancing through uplift causing sea level to drop relatively**. Palaeo-sea level rise and fall in macro-scale are related to marine transgression and regression in addition to other geologic events like converging and diverging plate tectonics, orogenic uplift of the collision margin, basin subsidence of the extensional crust, volcanic activities in the oceanic region, prograding delta buildup, ocean floor height change and sub-marine mass avalanche.”**

•”Claim and prediction of 3 mm/yr rise of sea-level due to global warming and polar ice-melt is definitely a conjecture.”

•”Prediction of 4–6.6 ft sea level rise in the next 91 years between 2009 and 2100 is highly erroneous.”

Thermal Expansion* Claimed *Or* Opined *To Be Dominant Contributor To Sea Level Rise

•"**It is also** claimed **that ocean thermal expansion and glacier melting have been the dominant contributors to 20th century global mean sea level rise. It is further** opined**that global warming is the main contributor to the rise in global sea level since the Industrial Revolution (Church and White, 2006).**"

•"**According to Cazenave and Llovel (2010) rising of air temperature can warm and expand ocean waters wherein thermal expansion was the main driver of global sea level rise for 75 to 100 years after the start of the Industrial Revolution.** However, the share of thermal expansion in global sea level rise has declined in recent decades **as the shrinking of land ice has accelerated (Lombard et al 2005). Lombard et al. (2006) opined that recent investigations based on new ocean temperature data sets indicate that** thermal expansion only explains part (about 0.4 mm/yr) of the 1.8 mm/yr observed sea level rise of the past few decades**. However, observation** claim of 1.8 mm/yr sea level rise is also limited in scope and accuracy**.**"

Are Thermal Expansion–>Sea Level Change Models Accurate?

•"**Lombard et al. (2006) opined that recent investigations based on new ocean temperature data sets indicate that** thermal expansion only explains part (about 0.4 mm/yr) of the 1.8 mm/yr observed sea level rise of the past few decades**. However, observation claim of 1.8 mm/yr sea level rise is also limited in scope and accuracy.**"

•"**According to Domingues et al. (2008)** sea level rose about 0.8 mm/yr for the period 1993–2003**. On the other hand, the climate threat investigation using a combination of atmosphere–ocean modeling, information from paleoclimate data, and observations of ongoing climate change revealed that** modeling is an imperfect representation of the climate system**, paleo-data consist mainly of proxy climate information usually with substantial ambiguities, and** modern observations are limited in scope and accuracy **(Hansen et al., 2016).**"

•”**According to Zhang (2007)** thermal expansion in the lower latitude is unlikely **because of the reduced salt rejection and upper-ocean density and the enhanced thermohaline stratification tend to suppress convective overturning, leading to a decrease in the upward ocean heat transport and the ocean heat flux available to melt sea ice. The ice melting from ocean heat flux decreases faster than the ice growth does in the weakly stratified Southern Ocean, leading to an increase in the net ice production and hence an increase in ice mass.”**

Sea Level Changes Linked To Large-Scale Geological Events

•”There are good number of publications about the post glacial isostatic rebound of the polar region**. Works of Fleming et al. (1998) and Milne et al. (2005) are based on the vertical geologic motions associated with the post-glacial continental and isostatic rebound. Johansson et al. (2002) conducted research on a project BIFROST (Baseline Inferences for Fennoscandian Rebound Observations, Sea-level, and Tectonics) that combines networks of continuously operating GPS receivers in Sweden and Finland to measure ongoing crustal deformation due to glacial isostatic adjustment (GIA). They have found the maximum observed uplift rate 10 mm/yr for Fennoscandian region analyzing data between August 1993 and May 2000. Sella et al. (2007) and Lidberg et al. (2010) suggested that** postglacial rebound continues today **albeit very slowly wherein** the land beneath the former ice sheets around Hudson Bay and central Scandinavia, is still rising by over a centimeter a year**, while those regions which had bulged upwards around the ice sheet are subsiding such as the Baltic states and much of the eastern seaboard of North America.”**

•”**Snay et al. (2016) have found** large residual vertical velocities **[land uplift],** some with values exceeding 30 mm/yr, in southeastern Alaska**. The uplift occurring here is due to present-day melting of glaciers and ice fields formed during the Little Ice Age glacial advance that occurred between 1550 A.D. and 1850 A.D.”**

•”**Alaska is undergoing crustal deformation of uplift and subsidence each year within elastic-plastic phase associated with ice melt and ice cover formation.** When ice melts, load from the crust is reduced and it is uplifted and when ice cover builds-up, load onto the crust is increased and it is subsided**. Hence, pattern of the sea level curve of Alaska is oscillatory. Secondly, for each uplift and subsidence there remains a residual value between uplift and subsidence which is positive, hence, the corresponding sea level curve is negative.”**

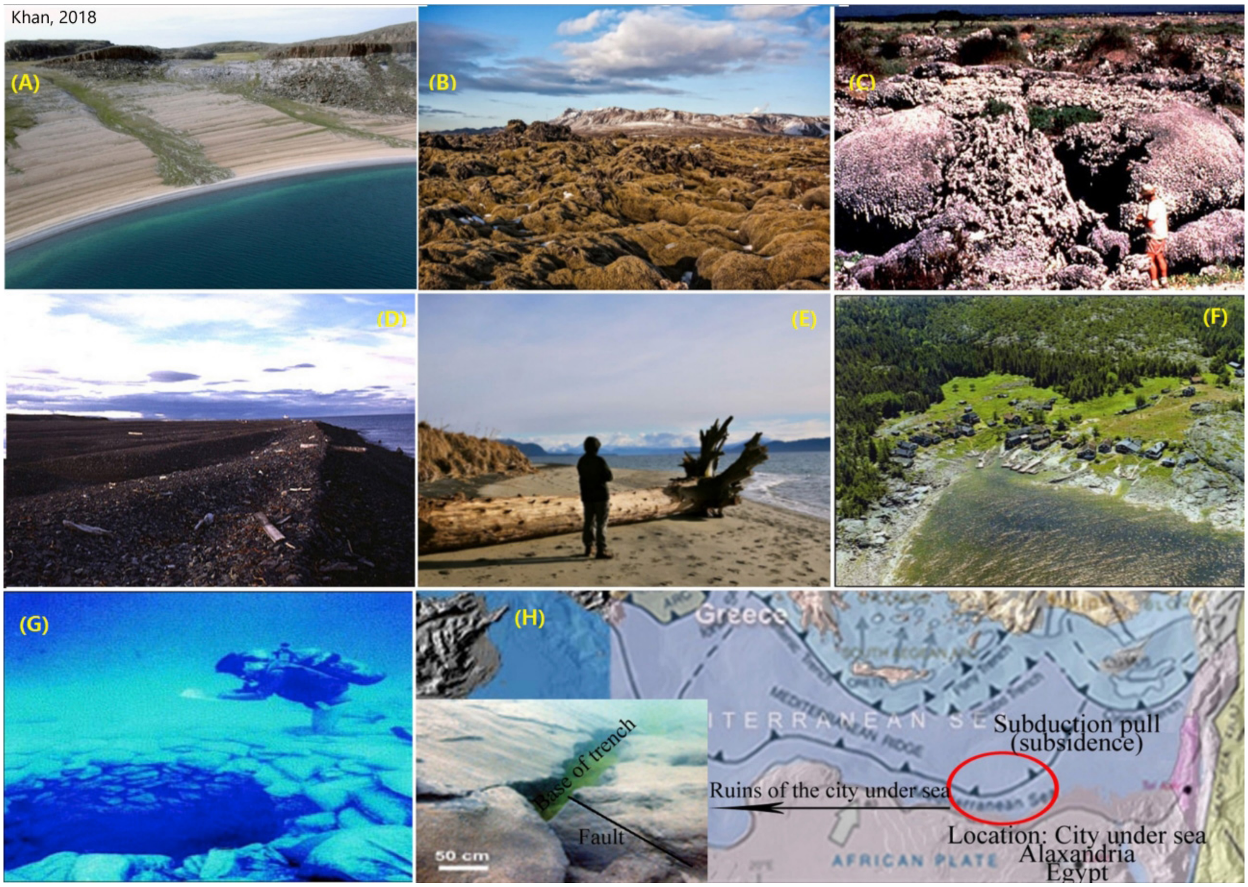
•”**When the land area shrinks globally, this corresponds to a global rise in sea level. From the curve** it is certain that sea level has changed in geologic time scale due to geologic events**.”**

•”Because global cycles of sea level changes are the records of geotectonic, glacial, and other large-scale processes, they reflect major events of Phanerozoic (Mesozoic to Present) history**. These events are related mostly to the large-scale orogenic (mountain building) movement such as trans-Himalayan orogeny, sedimentary basins formation such as Bengal Basin and Gulf Coast Basins. The Phanerozoic history of North America from the Late Triassic or Early Jurassic, corresponds to the Pangea breakup phase, during which North America drifted westwards. The eastern continental margin became the modern extensional Atlantic margin basins, while the western margin underwent tectonism and accretionary prism formation leading to the assembly of the Cordilleran orogen. Similar extensional basins and sedimentary accretionary prism leading to orogens developed along the eastern margin of the Atlantic Ocean in Africa and Europe, and in some region of Asia.** These mega events of the earth led to major sea-level rise and fall in terms of hundreds of meters as oceans suffered regional transgressions and regressions**.** Hence, when a region undergoes major subsidence can cause relative sea level (RSL) rise to the tune of tens of meters**. Examples of mid-Holocene (about 8000 years ago) subsidence forming Ganges depression, Jamuna depression and Meghna depression in the Bengal Basin causing major marine transgression to signify sea level rise in terms of 10 s of meters (Khan et al., 2000).”**

Visual Evidence Of Uplift/Subsidence Determining Sea Level Rise/Fall

•**"Geological processes are responsible of two types of major movements of the crustal block viz., uplift and subsidence. Hence,** the relation of sea level and crustal motion is attributed to sea level drops when there is an uplift while it rises when there is subsidence**."**

•**"Examples of uplift and subsidence of the crustal segments are given in the Fig. 13A–H. Layered beach at Bathurst Inlet, Nunavut is an example of post-glacial rebound after the last Ice Age. Isostatic rebound is still underway here (Fig. 13A). Some of the most dramatic uplift is found in Iceland. Much of modern Finland is former seabed or archipelago that shows sea level immediately after the last ice age (Fig. 13B). Massive coral (Pavona clavus) exposed in 1954 by tectonic uplift in the Galapagos Islands, Ecuador (Fig. 13C). Beach ridges on the coast of Novaya Zemlya in arctic Russia. Such ridges are formed by pushing of sea ice as a result of Holocene glacio-isostatic rebound (Fig. 13D). A beach in Juneau, Alaska where sea level is not rising, but dropping precipitously due to a phenomenon known as glacial isostatic adjustment GIA (Fig. 13E). Boat-houses in Scandinavia now considerably farther away from the water's edge where they were built demonstrates land uplift (Fig. 13F). An 8000-year old-well off the coast of Israel now submerged is a land mark of crustal subsidence (Fig. 13G). The "City beneath the Sea"; Port Alexandria on the Nile delta fits with the drowned well off the coast of Israe (Fig. 13G), both subsided due to subduction-pull of the downgoing African crustal slab as it enters the Hellenic trench (Fig. 13H). Venice is vanishing because of tectonics (subduction rollback of Adriatic slab) wherein down-going crustal segment causing subsidence of Venice, rather than sea level rise associated with global warming and/or polar ice melt."**


Khan, 2018
(A)
(B)
(C)
(D)
(E)
(F)
(G)
(H)
Greece
Subduction pull
(subsidence)
Ruins of the city under sea
Base of trench
Fault
50 cm
Location: City under sea
Alaxandria
Egypt
AFRICAN PLATE

Meter-Scale Sea Level Changes* Only *Related To Geologic Events, Not Global Warming

•"**Transgression commences when continental block undergoes subsidence with respect to continental shelf and abyssal plain, while regression occurs when this process is reverse i.e., when continental block is uplifted with respect to continental shelf and abyssal plain. Prograding delta system in low lying areas and other geologic events may cause local/relative sea-level fall as new sedimentary deposition advances as accretion pushing sea further down the coast** irrespective of global warming and polar ice-melt**.**"

•"**Hence, both regional and local** sea-level rise and fall in meter-scale is related to the geologic events only and not related to global warming and/or polar ice melt**.**"

•"**Information on relative sea-level rise over the past ~8000 years obtained from a variety of geological indicators exhibit vertical land movement at tide-gauges resulting from glacial isostatic adjustment (GIA) theory. Although if it is generally thought that paleo sea level change of 10s to 100s m or future prediction of sea level rise more than 1 m in 100 years are due to the continuous process of the Earth, it is rather an abrupt or sudden geological process of fault rupture to result in crustal uplift and subsidence causing a visible sea level change. So** a visible measure of the sea level change is possible only after sudden fault rupture displacement between continent and ocean/sea**. Although a continuous deformation process prior to the uplift and subsidence could progress, a visible deformation of the crust would occur only due to sudden rupture (fault) of the crust.**"

•"In conclusion, global warming, both polar and terrestrial ice melts, and climate change might be a reality but all these phenomena are not related to sea level rise and fall**.**"

http://notrickszone.com/2018/03/26/groundbreaking-new-paper-finds-global-warming-ice-melt-not-related-to-sea-level-rise/#sthash.BtLHwayP.dpbs

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Research Paper

Why would sea-level rise for global warming and polar ice-melt?

Aftab Alam Khan

•In conclusion, global warming, both polar and terrestrial ice melts, and climate change might be a reality but all these phenomena are not related to sea level rise and fall.

•Geophysical shape of the earth is the fundamental component of the global sea level distribution. Global warming and ice-melt, although a reality, would not contribute to sea-level rise. Gravitational attraction of the earth plays a dominant role against sea level rise.

•Claim and prediction of 3 mm/yr rise of sea-level due to global warming and polar ice-melt is definitely a conjecture.

•Prediction of 4–6.6 ft [1-2 meters] sea level rise in the next 91 years between 2009 and 2100 is highly erroneous.

Highlights

- Global warming and polar ice-melt not contribute to sea level rise.
- Melting of huge volume of floating sea-ice around polar region cool ocean-water preventing thermal expansion.
- Polar ice melting re-occupy same volume of the displaced water causing no sea level rise.
- Gravitational attraction of the earth plays a dominant role against sea level rise.

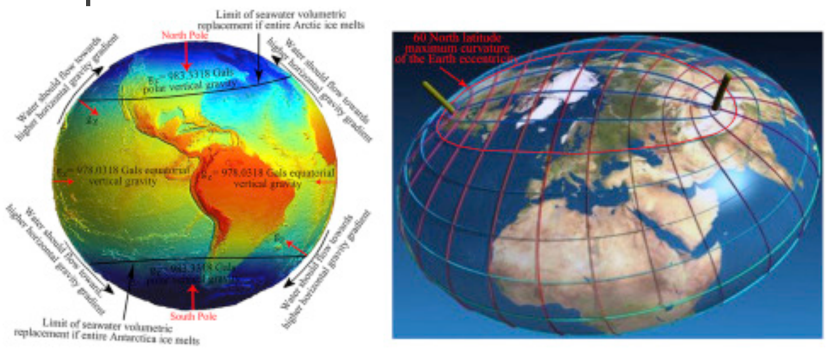
- Melting of land ice in the polar region allow crust to rebound elastically for isostatic balancing through uplift should cause sea level to drop relatively.

Abstract

Two major causes of global sea level rise such as thermal expansion of the oceans and the loss of land-based ice for increased melting have been claimed by some researchers and recognized by the IPCC. However, other climate threat investigators revealed that atmosphere–ocean modeling is an imperfect representation, paleo-data consist of proxy climate information with ambiguities, and modern observations are limited in scope and accuracy. It is revealed that global warming and polar ice-melt although a reality would not contribute to any sea level rise. Floating-ice of the polar region on melting would reoccupy same displaced volume by floating ice-sheets. Land-ice cover in the polar region on melting can reduce load from the crust to activate elastic rebound that would raise land for its isostatic equilibrium. Such characteristics would not contribute to sea level rise. Equatorial bulge, polar flattening, elevation difference of the spheroidal surface between equator and pole with lower in the pole, strong gravity attraction of the polar region and week gravity attraction of the equatorial region, all these phenomena would play dominant role in preventing sea level rise. Palaeo-sea level rise and fall in macro-scale (10–100 m or so) were related to marine transgression and regression in addition to other geologic events like converging and diverging plate tectonics, orogenic uplift of the collision margin, basin subsidence of the extensional crust, volcanic activities in the oceanic region, prograding delta buildup, ocean floor height change and sub-marine mass avalanche. This study also reveals that geophysical shape, gravity attraction and the centrifugal force of spinning and rotation of the earth would continue

acting against sea level rise.

Graphical abstract



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Keywords

Global warmingPolar ice-meltEquatorial bulgePolar flatteningGeologic eventsSea level rise

1. Introduction

Physical science-base of climate change has been extensively elaborated in the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2013). Sea Level Change in the Fifth Assessment Report includes detail explanation of the changes in the global mean sea level, regional sea level, sea level extremes, and waves (Church et al., 2013). Anthropogenic greenhouse gas emissions are causing sea-level rise (SLR) (Church and White, 2006; Jevrejeva et al., 2009). It is also claimed that ocean thermal expansion and glacier melting have been the dominant contributors to 20th century global mean sea level rise. It is further opined that global warming is the main contributor to the rise in global sea level since the Industrial Revolution (Church and White, 2006). According to Cazenave and Llovel (2010) rising of air temperature can warm and expand ocean waters wherein thermal expansion was the main driver of global sea level rise for 75 to 100 years after the start of the Industrial Revolution. However, the share of thermal expansion in global sea level rise has declined in recent decades as the shrinking of land ice has accelerated (Lombard et al 2005). Lombard et al. (2006)

opined that recent investigations based on new ocean temperature data sets indicate that thermal expansion only explains part (about 0.4 mm/yr) of the 1.8 mm/yr observed sea level rise of the past few decades. However, observation claim of 1.8 mm/yr sea level rise is also limited in scope and accuracy.

NOAA (http://oceanservice.noaa.gov/facts/sealevel.html) suggested that since 1992 the rate of sea-level rise has increased to 1.2 inches per decade which is a significantly larger rate than at any other time over the last 2000 years. Under the IPCC Special Report on Emission Scenarios (SRES) A1B scenario by the mid-2090s, for instance, global sea level reaches 0.22 to 0.44 m above 1990 levels, and is rising at about 4 mm per year. Further at the Paris climate conference (COP21) in December 2015 it is declared that the current global average temperature is 0.85 °C higher than it was in the late 19th century. According to Church et al. (2013) regional sea level change projections suggested that in the 21st century and beyond, sea level change will have a strong regional pattern and significant deviations of local and regional sea level change from the global mean change. Church et al. (2008) showed that recent satellite-altimeter data and tide-gauge data have indicated that sea levels are now rising at over 3 mm/yr. According to Domingues et al. (2008) sea level rose about 0.8 mm/yr for the period 1993–2003. On the other hand, the climate threat investigation using a combination of atmosphere–ocean modeling, information from paleoclimate data, and observations of ongoing climate change revealed that modeling is an imperfect representation of the climate system, paleo-data consist mainly of proxy climate information usually with substantial ambiguities, and modern observations are limited in scope and accuracy (Hansen et al., 2016).

2. Sea level measurement issues

Mean Sea Level (MSL) is defined as the zero elevation for a local area. The zero surface referenced by elevation is called a vertical datum. Since sea surface conforms to the earth's gravitational field, MSL has also slight hills and valleys that are similar to the land surface but much smoother. The MSL surface is in a state of gravitational equilibrium. It can be regarded as extending under the continents and is a close approximation of geoid. By definition geoid describes the irregular shape of the earth and is the true zero surface for measuring elevations. Because geoid surface cannot directly be observed, heights above or below the geoid surface can't be directly measured and are inferred by making gravity measurements and modeling the surface mathematically. Previously, there was no way to accurately measure geoid so it was roughly approximated by MSL. Although for practical purposes geoid and MSL surfaces are assumed to be essentially the same, but in reality geoid differs from MSL by several meters. Geoid moves above MSL where mass is excess and moves below MSL where mass is deficient. Distribution of mass in the crust in terms of 'excess' and 'deficient' can cause volume expansion and contraction for relative sea-level change. Height of the ocean surface at any given location, or sea level, is measured either with respect to the surface of the solid Earth i.e., relative sea level (RSL) or a eustatic sea level (ESL) (Fig. 1A). Relative sea level (RSL) change can differ significantly from global mean sea level (GMSL) because of spatial variability in changes of the sea surface and ocean floor height. RSL change over the ocean surface area gives the change in ocean water volume, which is directly related to the sea level change. Sea level changes can be driven either by variations in the masses or volume of the oceans, or by changes of the land with respect to the sea surface. In the first case, a sea level change is defined 'eustatic'; otherwise, it is defined 'relative' (Rovere et al., 2016). According to Kemp et al. (2015) land uplift or subsidence can result in, respectively, a fall or rise in sea level that cannot be considered eustatic as the volume or mass of water does not change. Any sea level change that is observed with respect to a land-based reference frame is defined a relative sea level (RSL) change. Eustatic Sea Level (ESL) changes also occur when the volume of the ocean basins changes due to tectonic seafloor spreading or sedimentation.

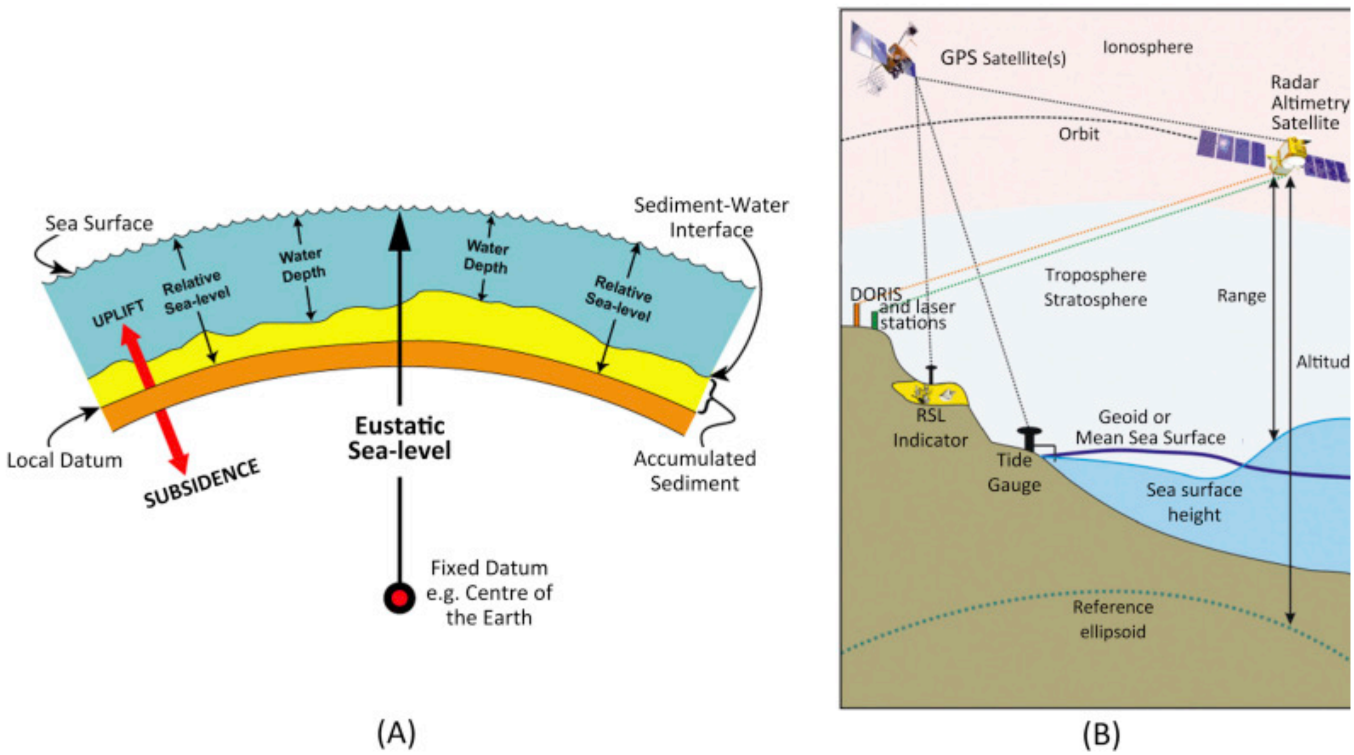

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Figure 1. (A) Definition of sea level i.e., eustatic sea level and relative sea level (B) Different types of sea level observation techniques: satellite altimetry (based on NASA educational material), tide gauge and paleo sea level indicators (see text for details). Modern tide gauges are associated with a GPS station that records land movements.

Changes in sea level can be observed at very different time scales and with different techniques (Fig. 1B). Regardless of the technique used, no observation allows to record purely eustatic sea level changes. At multi-decadal time scales, sea level reconstructions are based on satellite altimetry/gravimetry and landbased tide gauges (Cabanes et al., 2001). At longer time scales (few hundreds, thousands to millions of years), the measurement of sea level changes relies on a wide range of sea level indicators (Shennan and Horton, 2002; Vacchi et al., 2016; Rovere et al., 2016a). One of the most common methods to observe sea level changes at multi-decadal time scales is tide gauges. Modern tide gauges are associated with a GPS station that records land movements (Fig. 1B). However, tide gauges have three main disadvantages: (i) they are unevenly distributed around the world (Julia Pfeffer and Allemand, 2015); (ii) the sea level signal they record is often characterized by missing data (Hay et al., 2015); and (iii) accounting for ocean dynamic changes and land movements might prove difficult in the absence of independent datasets (Rovere et al., 2016). Since 1992, tide gauge data are complemented by satellite altimetry datasets (Cazenave et al., 2002). The altitude of the satellite is established with respect to an ellipsoid, which is an arbitrary and fixed surface that approximates the shape of the Earth. The difference between the altitude of the satellite and the range is defined as the sea surface height (SSH) (Fig. 1B). Subtracting from the measured SSH a reference mean sea surface (e.g. the geoid), one can obtain a 'SSH anomaly'. The global average of all SSH anomalies can be plotted over time to define the global mean sea level change, which can be considered as the eustatic, globally averaged sea level change. The shape of the geoid is crucial for deriving accurate measurements of seasonal sea level variations (Chambers, 2006). According to Rovere et al. (2016) measurements of paleo eustatic sea level (ESL) changes bear considerable uncertainty. Further, sea level changes on Earth cannot be treated as a rigid container although eustasy is defined in view of Earth as a rigid container. In reality, internal and external processes of the earth such as tectonics, dynamic topography, sediment compaction and melting ice all trigger variations of the container and these ultimately affect any sea level observation. An estimated, observed, and possible future amounts of global sea level rise from 1800 to 2100, relative to the year 2000 has been proposed by Melillo et al. (2014) based on the works of Church and White (2011), Kemp et al. (2011) and Parris et al. (2012) (Fig. 2). The main concern of the predicted future global sea level rise shown in Melillo et al. (2014) is the forecast beyond 2012 up to 2100. Although sea level rise is shown by 0.89 ft in 209 years (between 1800 and 2009) at the rate of 0.0043 ft/yr, the prediction of 4–6 ft at the rate of 0.044 ft/yr and 0.066 ft/yr respectively in 91 years between 2009 and 2100) is highly questionable. An abrupt jump in the sea level rise after 2009 is definitely a conjecture.

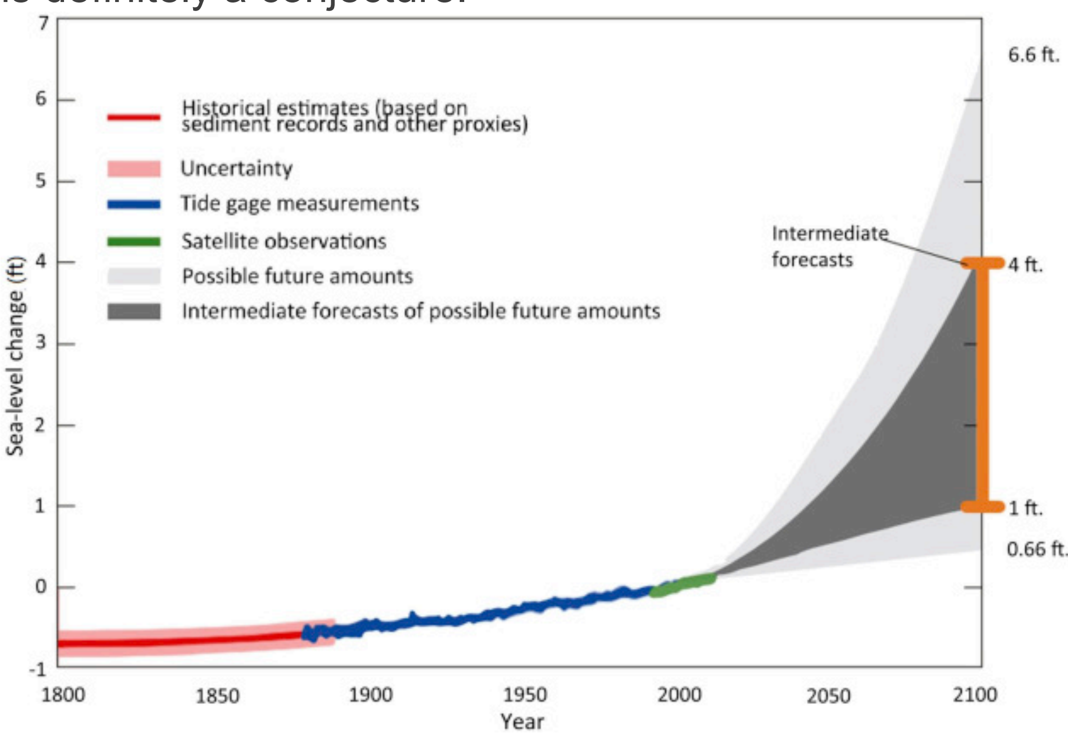

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Figure 2. Estimated, observed, and predicted global sea level rise from 1800 to 2100. Estimates from proxy data are shown in red between 1800 and 1890, pink band shows uncertainty. Tide gauge data is shown in blue for 1880–2009. Satellite observations are shown in green from 1993 to 2012. The future scenarios range from 0.66 ft to 6.6 ft in 2100 (Redrawn from Melillo et al., 2014).

3. Material and methods

This study is based on the geophysical aspects of the earth wherein shape of the earth is the fundamental component of global sea level distribution. The physical surface of the earth adjusted to the mathematical surface of the earth is spheroidal. This spheroidal surface always coincides with the global mean sea level (Fig. 3). Having relationship between the shape of the earth and the global sea level, gravitational attraction of the earth plays a dominant role against sea level rise. Gravity is a force that causes earth to form the shape of a sphere by pulling the mass of the earth close to the center of gravity i.e., each mass-particle is attracted perpendicular towards the center of gravity of the earth (Fig. 4A). The sphere-like shape of the earth is distorted by (i) greater gravity attraction of the polar region causing polar flattening and lesser gravity attraction of the equatorial region causing equatorial bulging, and (ii) the centrifugal force of its rotation. This force causes the mass of the earth to move away from the center of gravity, which is located at the equator. Ocean-fluid surface takes a outward normal vector due to centrifugal force which is maximum at the equator and zero at the poles (Fig. 4B). Mathematical surface, an imaginary surface coinciding with the mean sea level of the Earth is a spheroidal surface due to its spin, and it is the centrifugal force due to the Earth's spin caused polar flattening and equatorial bulge. The polar flattening ratio (eccentricity) of 1/298 implied that sea level at the equator is about 21 km further from the center of the Earth than it is at the poles. Water would find its hydrostatic level which is curvilinear, and this level is influenced by the gravity as well as centrifugal force. Centrifugal force acts as much on the oceans as it does on the solid Earth, which is maximum at the equator and minimum at the pole (Fig. 4B). Any addition of water to the oceans is supposed to flow uphill towards equator from the poles causing sea level rise everywhere, but it does not. Hence, although ocean water at the equator makes a level difference of 21 km higher than at the poles, it is the centrifugal force maximum at the equator and zero at the poles would prevent ocean water-column from moving down-hill toward poles effectively restricting sea level rise at the higher latitudes. On the otherhand high gravity attraction and zero centrifugal force at the poles and low gravity attraction and maximum centrifugal force at the equator effectively balance sea-level and restrict sea-level rise. While, equatorial ocean-fluid surface always attains relatively higher altitude than that of polar ocean-fluid surface, ocean water column from polar region would not move towards equatorial region.

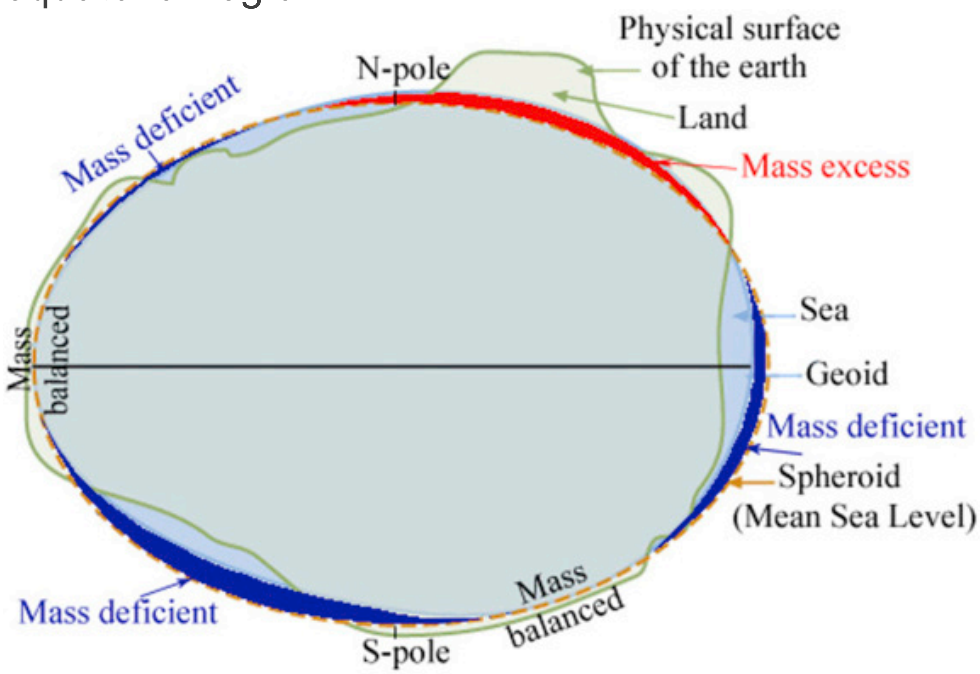

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Figure 3. Physical surface (light green undulating line) of the earth adjusted to spheroidal surface (yellow broken line) by removing mass from continent above mean sea level and filling same mass in ocean below mean sea level. Geoid surface (light blue solid line), on the other hand, depends on the internal mass distribution i.e., geoid moves below spheroid where mass is deficient and it moves above spheroid where mass is excess. Where geoid surface and spheroidal surface coincides is accounted for mass balanced. By definition geoid describes the irregular shape of the earth and is the true zero surface for measuring elevations. Because geoid surface cannot be directly observed, heights above or

below the geoid surface can't be directly measured and are inferred by making gravity measurements and modeling the surface mathematically. MSL surfaces are assumed to be essentially the same, at some spots the geoid can actually differ from MSL by several meters.

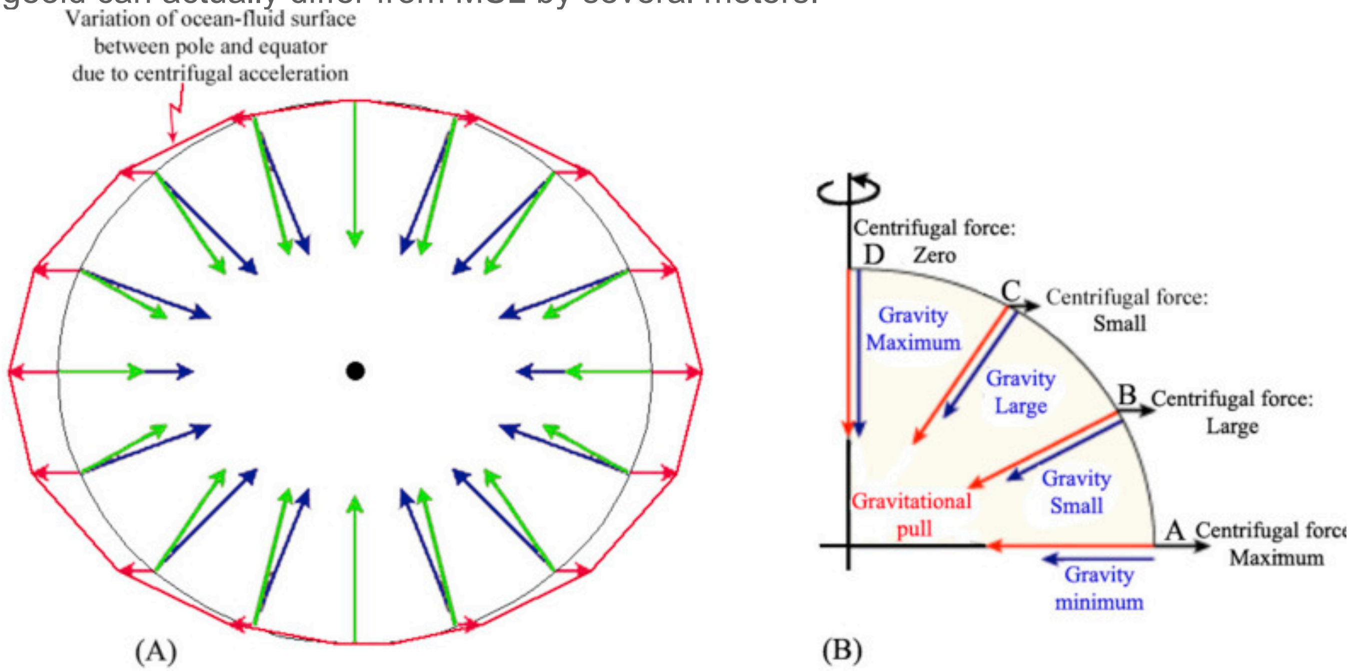

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Figure 4. The shape of a sphere by pulling the mass of the earth close to the center of gravity. Blue arrows point from Earth's surface toward its center. Their lengths represent local gravitational field strength. Gravity is strongest at the poles because they are closest to the center of mass. This difference is enhanced by the increasing density toward the center. Red arrows show the direction and magnitude of the centrifugal effect. On the equator, it is large and straight up. Near the poles, it is small and nearly horizontal. Vector addition of the blue and red arrows gives the net result of gravity plus centrifugal effect. This is shown by the green arrows. Rotation of the earth produces more centrifugal force at the equator, less as latitude increases, and zero at pole.

Shape of the earth, on the otherhand, established as a result of geodetic measurements and more recently by satellite tracking, is practically spheroidal, bulging at the equator and flattened at the poles, such that the difference between equatorial ‘a’ and polar ‘b’ radii, divided by the former ‘a’, is 1/298 (Fig. 5). This ratio is known as the polar flattening. Theoretically it is possible to calculate the shape by assuming the earth to be a fluid mass, rotating about its polar axis and having a density which increases with depth (≈3 g/cm3 at surface to about 12 g/cm3 at the center). The surface of this theoretical shape is an equipotential of the gravity field plus the centripetal acceleration. Centripetal acceleration is the rate of change of tangential velocity. The direction of the centripetal acceleration is always inwards along the radius vector of the circular motion. The magnitude of the centripetal acceleration is related to the tangential speed and angular velocity. In general, a particle moving in a circle experiences both angular acceleration and centripetal acceleration.

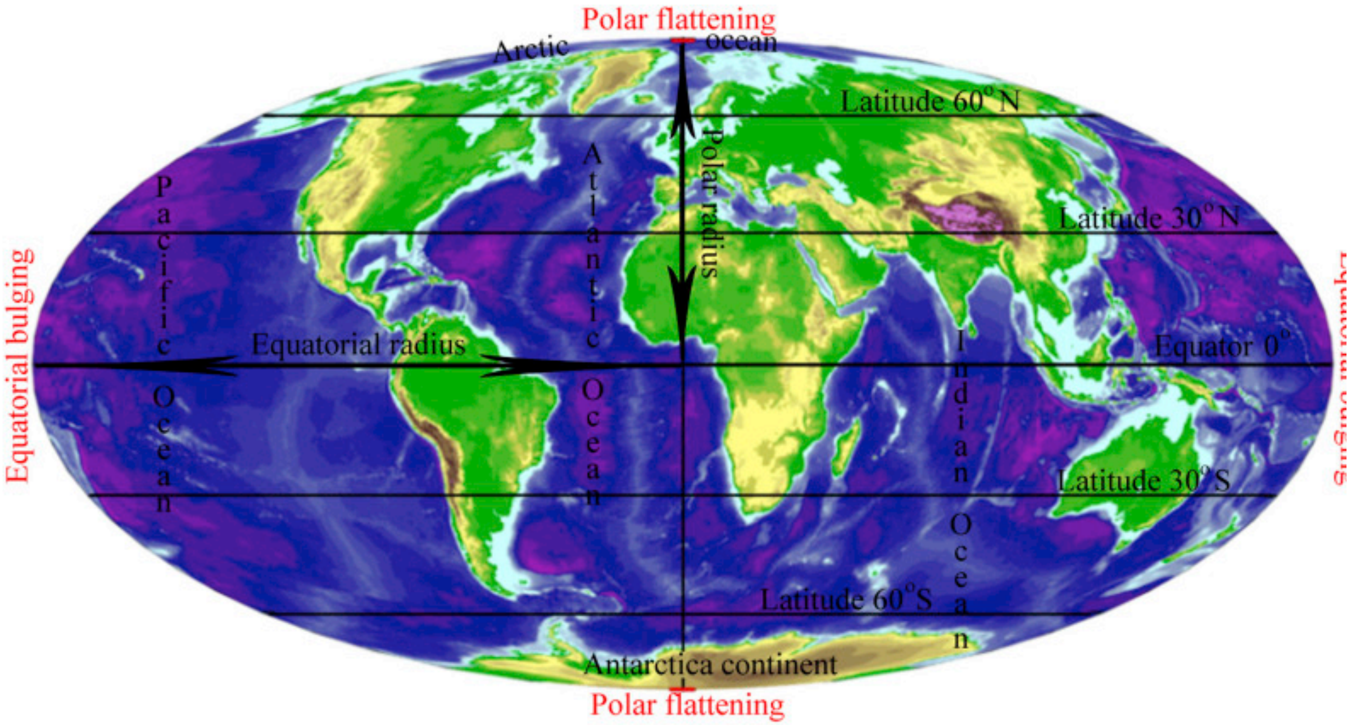

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Figure 5. Spheroidal earth due to equatorial bulging and polar flattening exhibits altitude difference. North pole and South pole region exhibit relatively lower altitude than equatorial region which exhibits higher altitude. Water should not move from lower altitude to higher altitude level.

Equatorial radius ‘a’ is the distance from the Earth's center to the equator and equals 6378.1 km. While polar radius ‘b’ is the distance from the Earth's center to the North and South poles, and equals 6356.8 km. Difference of about 21 km between equator and poles is accounted for equatorial bulge

and polar flattening wherein the equatorial region poses higher elevation than the polar region. The circumference of the Earth along the equator (equatorial circumference) is 40,075 km and along longitude (polar circumference) is 40,008 km. This difference of 67 km also larger at the equator than at the pole which poses an upward gradient 1 in 149.28 (equivalent 0.602°) towards equator. Hence, an upward curvature towards equator and downward curvature towards pole always remain. Inflection point of this curvature coincides with the spheroidal surface at around 60° latitude. This makes higher surface level at the equatorial bulge and lower surface level at the polar flattening. Fluid-column of the oceans would not flow normally from lower level to higher level.
Surface of the earth is defined as the mathematical surface in terms of gravity values at all points. This mathematical surface is known as the reference spheroid. It is related to the mean sea-level (MSL), a surface with excess land masses removed and ocean deeps filled. Thus it is an equipotential surface, that is, the force of gravity (g_z) is everywhere normal to this surface, or the plumb line is vertical at all points directed to the center of the earth (Fig. 6A). A good overall fit to the observed relation between gravity and latitude, based on measurements made in all parts of the earth, is obtained by using the formula (Eq. (1)) adopted by the International Association of Geodesy in 1967 (Telford et al., 1976). The formula expresses ‘g’ value at any point on the latitude as:
(1)
$$g = g_o 1 +$$

$$\alpha \sin^{2}\phi + \beta \sin^{2} 2\phi$$

where go = equatorial gravity = 978.0318 Gal, ϕ = latitude, and the constants α and β are equal to 0.005324 and −0.0000058 respectively. The value of gravity obtained from this relation is the one that would be observed at sea level that has smoothed spheroidal shape giving the best fit to its actual shape. From the above formula, total gravity at the equator is found to be 978.0318 Gal and at the poles is 983.3318 Gal. Hence, both north and south poles have 5.3 Gal (5300 mGal) more gravity attraction than at the equator. Minimum gravity at the equatorial region coincides well with the equatorial bulge (volumetric expansion causing lower density and lower gravity attraction) while maximum gravity of the polar region coincides well with the polar flattening (volumetric contraction causing higher density and higher gravity attraction). Further, horizontal gravity gradient (a component of force of gravity, g_z) is also significantly less towards equatorial region that would prevent sea water from moving towards equator (Fig. 6A). Fig. 6B exhibits maximum curvature of the spheroidal surface coincides with 60°N latitude.

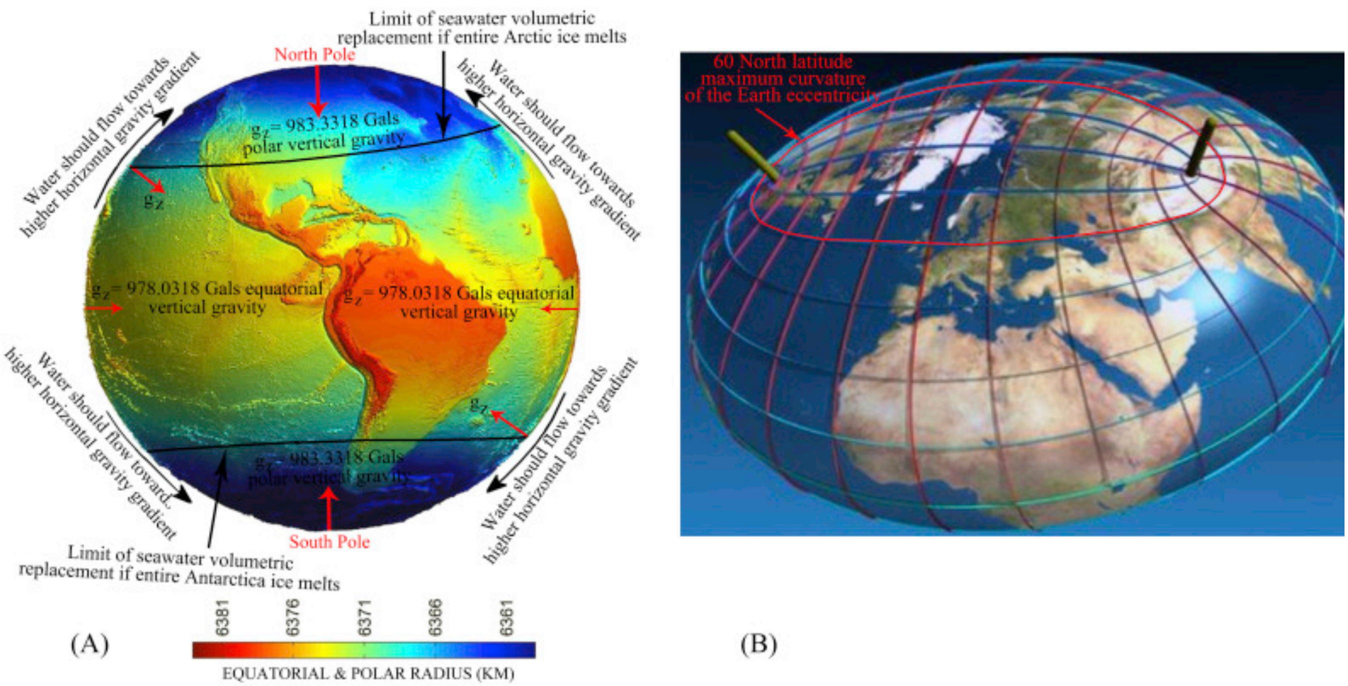

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Figure 6. (A) Surface of the earth is defined in terms of gravity values at all surface points known as the reference spheroid. It is related to the mean sea-level (MSL) surface with excess land masses removed and ocean deeps filled. Thus it is an equipotential surface, that is, the force of gravity (g_z) (red arrows) is everywhere normal to this surface, or the plumb line is vertical at all points directed to the center of the earth having maximum at the poles and minimum at the equator. Two components work against sea level rise i.e., greater gravity attraction of the polar region and the equatorial bulge (B) Maximum curvature of the spheroidal surface of the Earth coincides with 60^{o}N latitude. Floating ice from Antarctica surrounded by open ocean can freely move to the north likely to be limited maximum upto 60^{o}S latitude where spheroidal surface has the maximum curvature.

4. Results and discussion

Because of the Earth's rotation around its own axis, gravitational acceleration is less at the equator than at the poles. The difference of 0.0178 m/s^2 in gravitational acceleration between the pole and the equator is predominantly due to the fact that objects located at the equator are about 21 km further away from the center of mass of the earth than at the poles, which corresponds to a smaller gravitational acceleration. A mass of fluid under the rotation assumes a form such that its external form is an equipotential of its own attraction and the potential of the centripetal acceleration. Above analogy reveals that even if entire polar-ice melts due to the global warming, the melt-water will not flow towards equatorial region where surface has an upward gradient and gravity attraction is also significantly low in comparison to the polar region. However, conditions at both the poles are different. Arctic Ocean in the north is surrounded by the land mass thus can restrict the movement of the floating ice, while, Antarctic in the south is surrounded by open ocean thus floating ice can freely move to the north. But this movement is likely to be limited maximum upto 60°S latitude where spheroidal surface has the maximum curvature (Fig. 6B). As usual, water can not flow from higher gravity attraction to lower gravity attraction rather it is other way around wherein higher gravity attraction of the poles would attract water from moving towards equatorial region and water column would be static at every 'g_z' direction. Further, greater horizontal gravity gradient toward poles would also help melt-water to remain attracted toward polar region (Fig. 6A). Although a maximum curvature of the Earth's spheroidal surface should occur around 45°N and 45°S latitudes, it is actually 60°N and 60°S where maximum curvature of the surface between polar flattening and equatorial bulge would occur. The International Gravity Formula adopted by the International Association of Geodesy in 1967 (Telford et al., 1976) was used to prepare a map expressing the height of geoid as measured from spheroidal surface (Dobrin, 1976) (Fig. 7). A geoid surface thus prepared exhibits bulges and hollows of the order of hundreds of kilometers in diameter and upto hundred meter in elevation occurring in the zone mostly between 60°N and 60°S latitudes. Marked changes in the contour pattern of the geoid height in the zone between 60°N and 60°S suggests maximum curvature along 60°N and 60°S. Hence any change of the global sea level due to the predicted ice melt would not extend beyond 60°N and 60°S. However the reality is that no sea-level rise actually would occur due to ice melt as a result of same volumetric replacement between melt-water and floating ice. Now, question arises where and how melt-water would be accommodated when polar-ice melts. Simple analogy opines that floating ice-sheets occupying volume of the displaced water will reoccupy most of its volume on melting causing no sea level rise. Status of ice in the two polar region is clearly demonstrated in Fig. 8. Fig. 8A and B are taken from the internet https://www.nasa.gov/ wherein an article entitled "Opposite Behaviors? Arctic Sea Ice Shrinks, Antarctic Grows" posted by Maria-José Viñas of NASA's Earth Science News Team has shown two opposite records concerning ice in the Arctic and Antarctica for September 2012. While Arctic Ocean clearly exhibits significant melting, ice cover around Antarctica expanded as of 2013 (Bintanja et al., 2013). According to NASA's Goddard Space Flight Center Greenbelt, there has been an overall increase in the polar-ice cover in the oceans around Antarctica (Fig. 8 B), which is the opposite of what is happening in the Arctic Ocean (Fig. 8 A). An article entitled "Third dimension: new tools for sea ice thickness" posted on May 6, 2015 provides information on ice thickness prepared by the Center for Polar Observation and Modeling, UCL London (Lindsay and Schweiger, 2015) (http://nsidc.org/arcticseaicenews/2015/05/new-tools-for-sea-ice-thickness). It shows average thickness of sea-ice about 3 m in the Arctic Ocean from March 29, 2015 to April 25, 2015. Monthly April ice extent for 1979 to 2015 shows a decline of 2.4% per decade relative to the 1981 to 2010 average. The ice extent curve between 1979 and 2015 shows a decline of about 1,208,000 km^2 in its areal extent (Fig. 9A). But, overall ice extent decreased to about 862,000 km^2. Lindsay and Schweiger (2015) provide a longer-term view of ice thickness, compiling a variety of subsurface, aircraft, and satellite observations. They found that ice thickness over the central Arctic Ocean has declined from an average of 3.59 m (11.78 ft) to only 1.25 m (4.10 ft), a reduction of 65% over the period 1975 to 2012. Map shows sea ice thickness in meters in the Arctic Ocean from March 29, 2015 to April 25, 2015 (Fig. 9B). Total volume of ice-melt water of more than 2,500,000 km^3 has been added to ocean water over an area more than 14,500,000 km^2 of the central Arctic Ocean (Fig. 9B blue shaded area). By now this additional water should have caused sea level rise more than 178 mm which is much greater than what has been projected and predicted. However there is no record of such sea level rise.

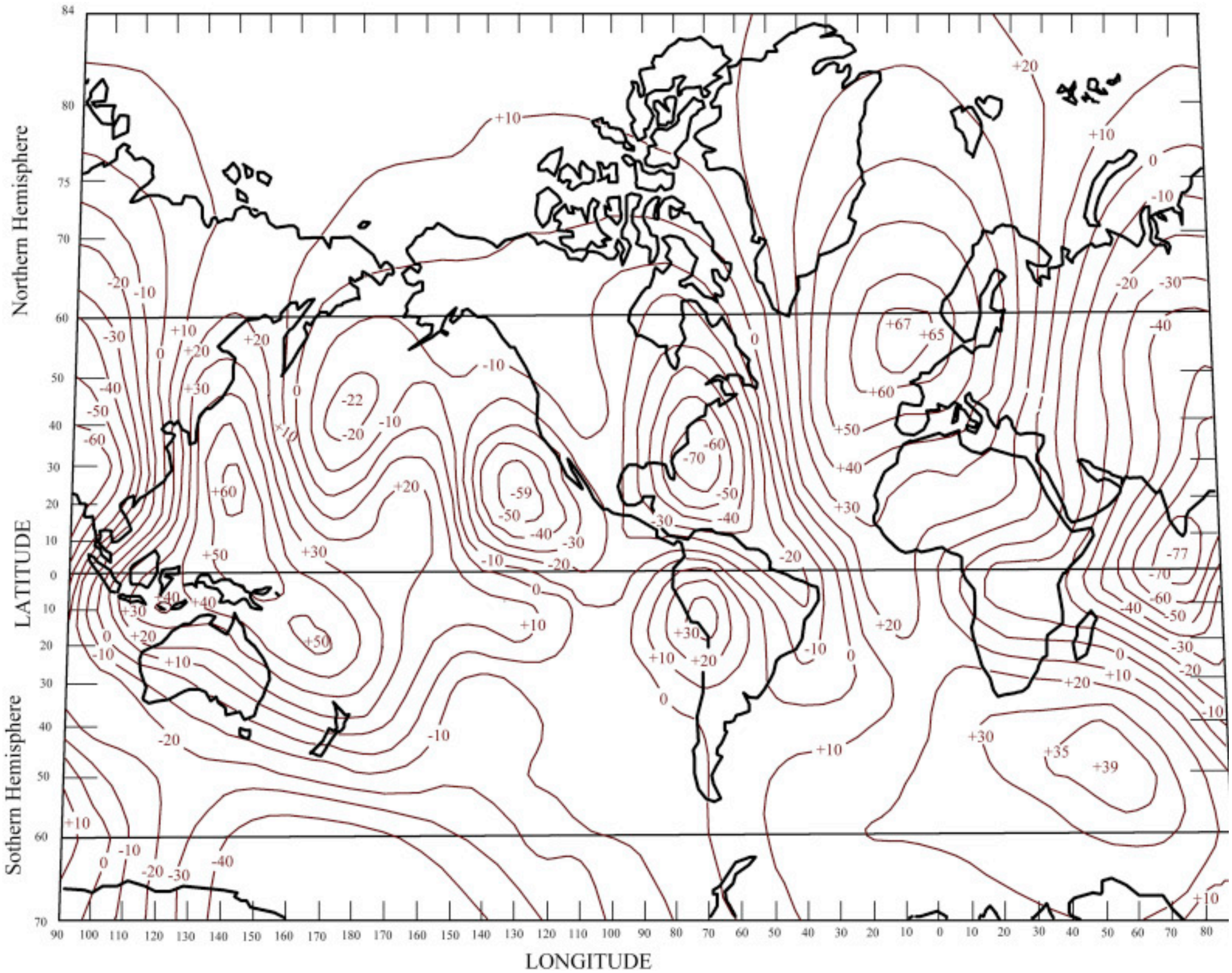

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Figure 7. Map shows height of geoid (contour lines with values) measured from spheroidal surface. Geoid surface exhibits bulges (positive values) and hollows (negative values) occurring within the zone mostly between 60oN and 60oS latitudes (source: Dobrin, 1976).

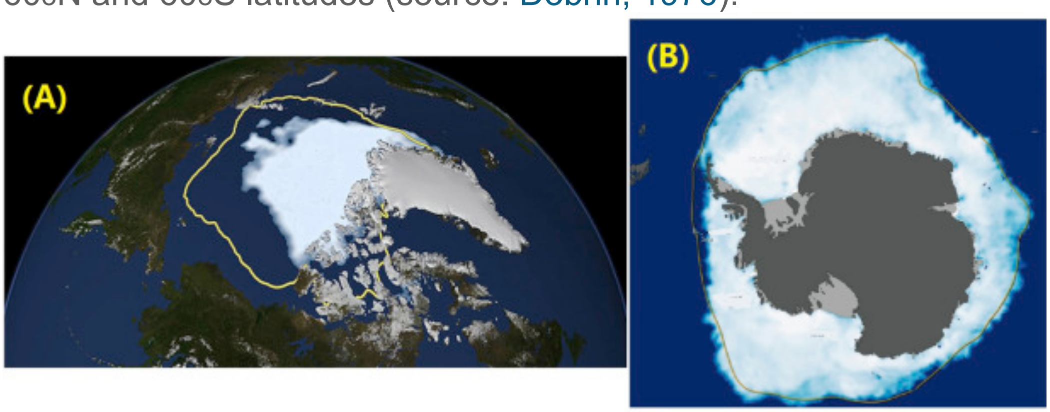

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Figure 8. Status of ice cover in the two polar region (A) Arctic Sea ice cap experienced an all-time summertime low in September 2012 that has melted since 1979 marked by yellow line (Source: https://www.nasa.gov from news article “Opposite Behaviors? Arctic Sea Ice Shrinks, Antarctic Grows” by Maria-José Viñas, NASA's Earth Science News Team (B) Antarctic sea ice reached a record winter maximum extent in September 2012 marked beyond yellow line (Source: NASA/Goddard Space Flight Center Scientific Visualization Studio and NASA Earth Observatory).

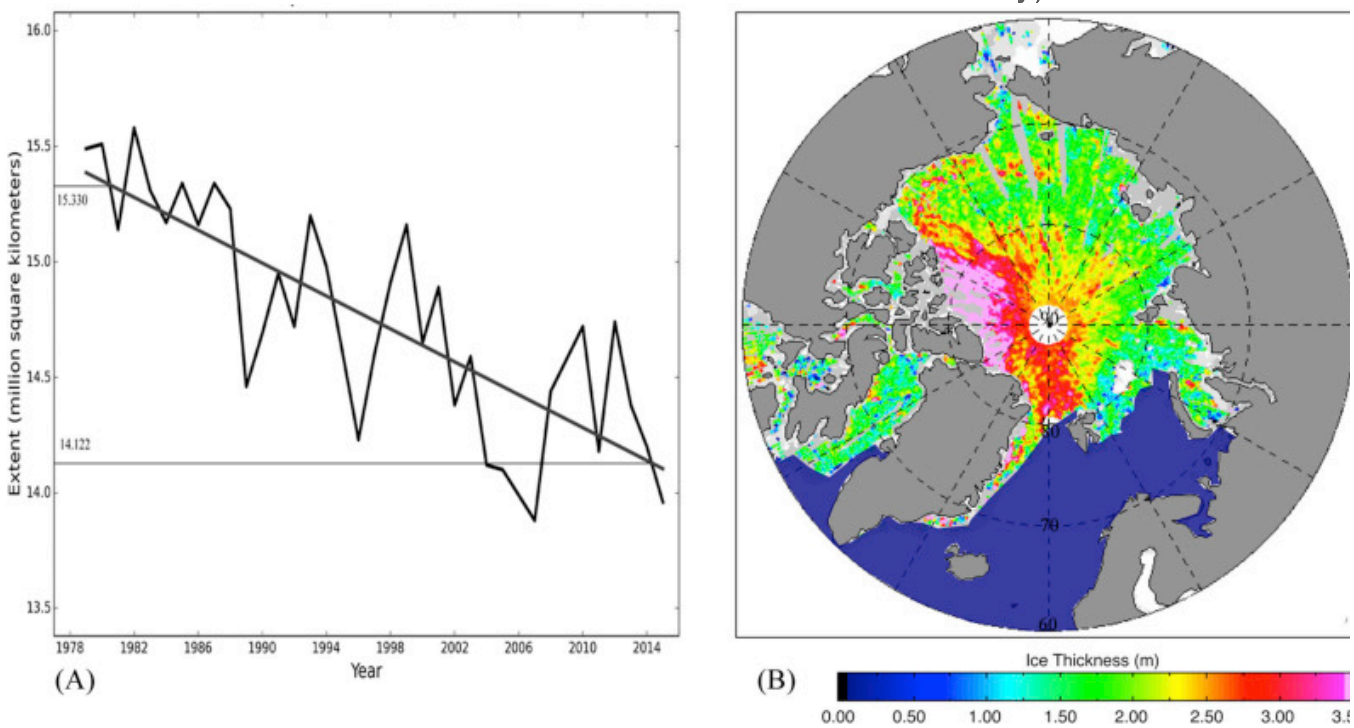

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Figure 9. (A) Monthly April ice extent for 1979 to 2015 shows a decline of 2.4% per decade relative to the 1981 to 2010 average. The ice extent curve between 1979 and 2015 shows a decline of about 1.208 million square kilometer (B) Sea-ice thickness in meters in the Arctic Ocean from March 29, 2015 to April 25, 2015. Blue shaded area represent Artic Sea (Source: Center for Polar Observation and Modelling, University College London posted at http://nsidc.org/arcticseaicenews/2015/05/.

Zhang (2007) showed mean model-simulated ice thickness and satellite-observed ice extent in the Antarctic Ocean between 1979 and 2004. Interestingly, September 2012 witnessed two opposite records concerning sea-ice in the polar region. Two weeks after the Arctic Sea ice-cap experienced an all-time summer time low for the satellite era, Antarctic sea-ice reached a record winter maximum extent.

But sea-ice in the Arctic has melted at a much faster rate than it has expanded in the Southern Ocean (Maria-José Viñas of NASA's Earth Science News Team). An average Arctic sea-ice extent for April 2015 was about 14,000,000 km^2 (Fig. 9A). An average of 3 m thickness of the floating ice, maximum areal extent of Arctic floating-ice is about 14,500,000 km^2 that can occupy volume equivalent to 435,000 km^3. Areal extent of the floating ice is reduced to 7,000,000 km^2 equivalent to 17,500 km^3 volumetric space at the end of summer-melt season. Hence, out of total 39,000 km^3 of floating ice in the Arctic Ocean, about 312,000 km^3 ice-melt would occupy same volume of the displaced water by the submerged ice-sheets and no-sea-level rise would occur. Fig. 10 envisages that melts of submerged ice-sheets would reoccupy the same volume occupied by the submerged ice-sheets. On the other hand, Arctic sea-ice has already reduced its volume due to melting from 33,000 km^3 in 1979 to 16,000 km^3 in 2016 without showing any sea level rise. Although Arctic sea-ice has reduced its volume, Antarctic has gained (Zhang and Rothrock, 2003) (http://psc.apl.uw.edu). In contrast to the melting of the Arctic sea-ice, sea-ice around Antarctica was expanding as of 2013 (Bintanja et al., 2013). NASA study shows an increase in Antarctic snow accumulation that began 10,000 years ago is currently adding enough ice to the continent to outweigh the increased losses from its thinning glaciers. According to analysis of the satellite data, Antarctic ice-sheet showed a net gain of 112 billion tons of ice a year from 1992 to 2001. That net gain slowed to 82 billion tons of ice per year between 2003 and 2008. An article “Arctic vs. Antarctic” posted by the National Snow & Ice Data Center posted (https://nsidc.org/cryosphere/seaice/) indicated “*because Antarctica is a land mass surrounded by an ocean, the open ocean allows the forming sea-ice to move more freely, resulting in higher drift speeds. Also,* *because there is no land boundary to the north, the sea-ice is free to float northward into warmer waters where it eventually melts. As a result, almost all of the sea ice that forms during the Antarctic winter melts during the summer. During the winter, up to 18,000,000 km^{2}of ocean is covered by sea-ice, but by the end of summer, only about 3,000,000 km^{2}of sea-ice remain. Antarctic ice is typically of 1–2 m thick*". From the above statement it is clearly understood that about 23,000 km^3 sea-ice of Antarctica can freely float northward into the warmer water where it eventually melts every year without showing any sea level rise in the lower latitudes. Further, melting of such a huge volume of floating sea-ice of Antarctica not only can reoccupy volume of the displaced water but also can cool ocean-water in the lower latitudes of the southern oceans thus can prevent sea level rise due to thermal expansion of the ocean water. According to Zhang (2007) thermal expansion in the lower latitude is unlikely because of the reduced salt rejection and upper-ocean density and the enhanced thermohaline stratification tend to suppress convective overturning, leading to a decrease in the upward ocean heat transport and the ocean heat flux available to melt sea ice. The ice melting from ocean heat flux decreases faster than the ice growth does in the weakly stratified Southern Ocean, leading to an increase in the net ice production and hence an increase in ice mass.

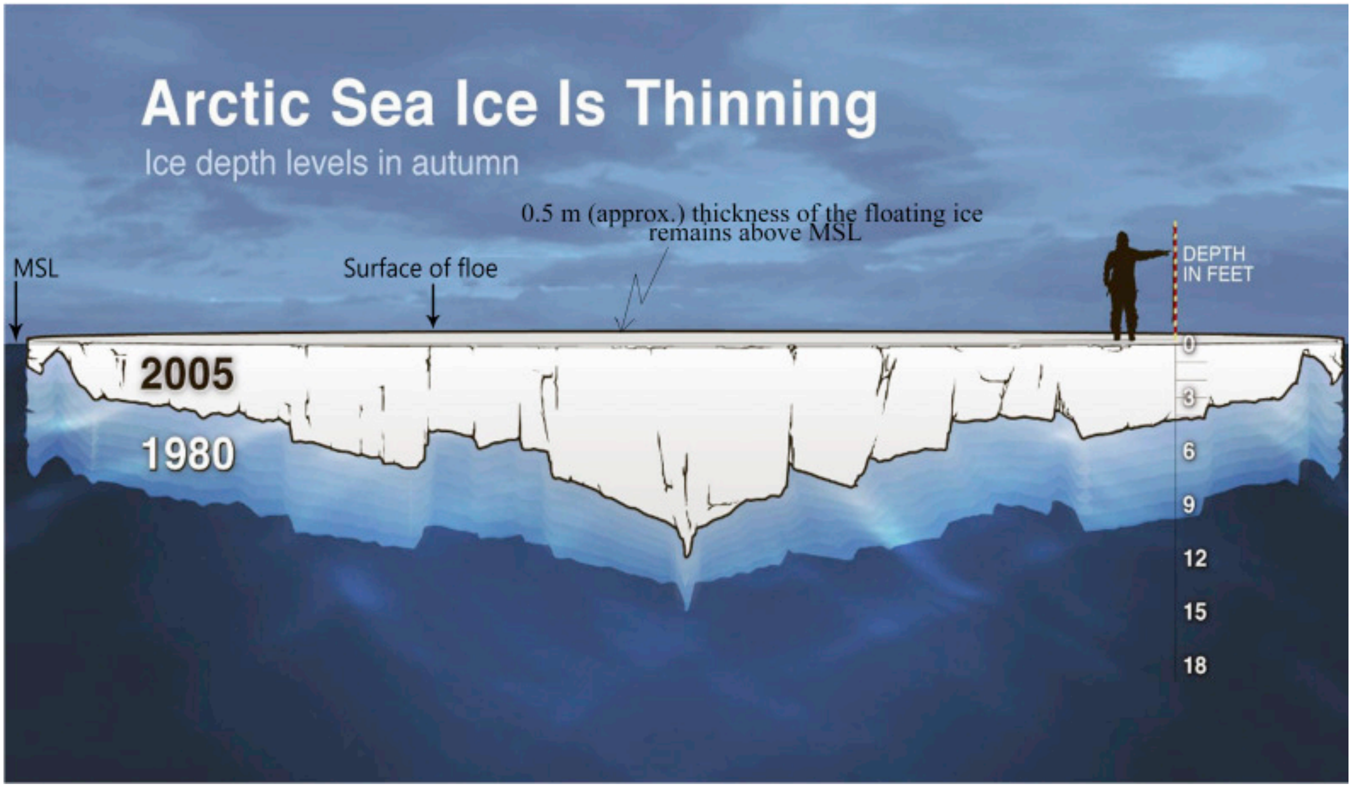

Figure 10. Profile shown here depict roughly what fraction of sea ice fell within different thickness ranges for the years shown, within the area of the Arctic Ocean where the Navy has declassified its soundings. Data provided by NASA scientist Ron Kwok, based on his research cited in the references: Kwok, Ron and Rothrock, A., 2009. Decline in Arctic sea ice thickness from submarine and ICESat records: 1958–2008. Geophysical Research Letters 36, L15501. http://www.climatecentral.org/gallery/graphics/arctic_sea_ice_thinning_fall.

Both the polar region exhibit reduction in ice-load in the crust due to melting and removal of ice-cover from the continental blocks every year. Reduction of such weight in the continent thus can cause isostasy to come into play and land start to uplift due to elastic rebound to maintain its isostatic equilibrium which is load-dependent and would prevent sea level rise. Fig. 11 exhibits vertical motion of the crust in the two polar region applying glacial isostatic adjustment (GIA) theory prepared by Erik Ivins, 2010 of NASA's Jet Propulsion Laboratory in Pasadena, California USA alongwith his article entitled “Rate of lithospheric uplift due to Postglacial

Rebound”, posted in the website https://en.wikipedia.org/wiki/Post-glacial_rebound. The map showing vertical motion of the crust is based on the work by Paulson et a.l (2007) (Fig. 11).

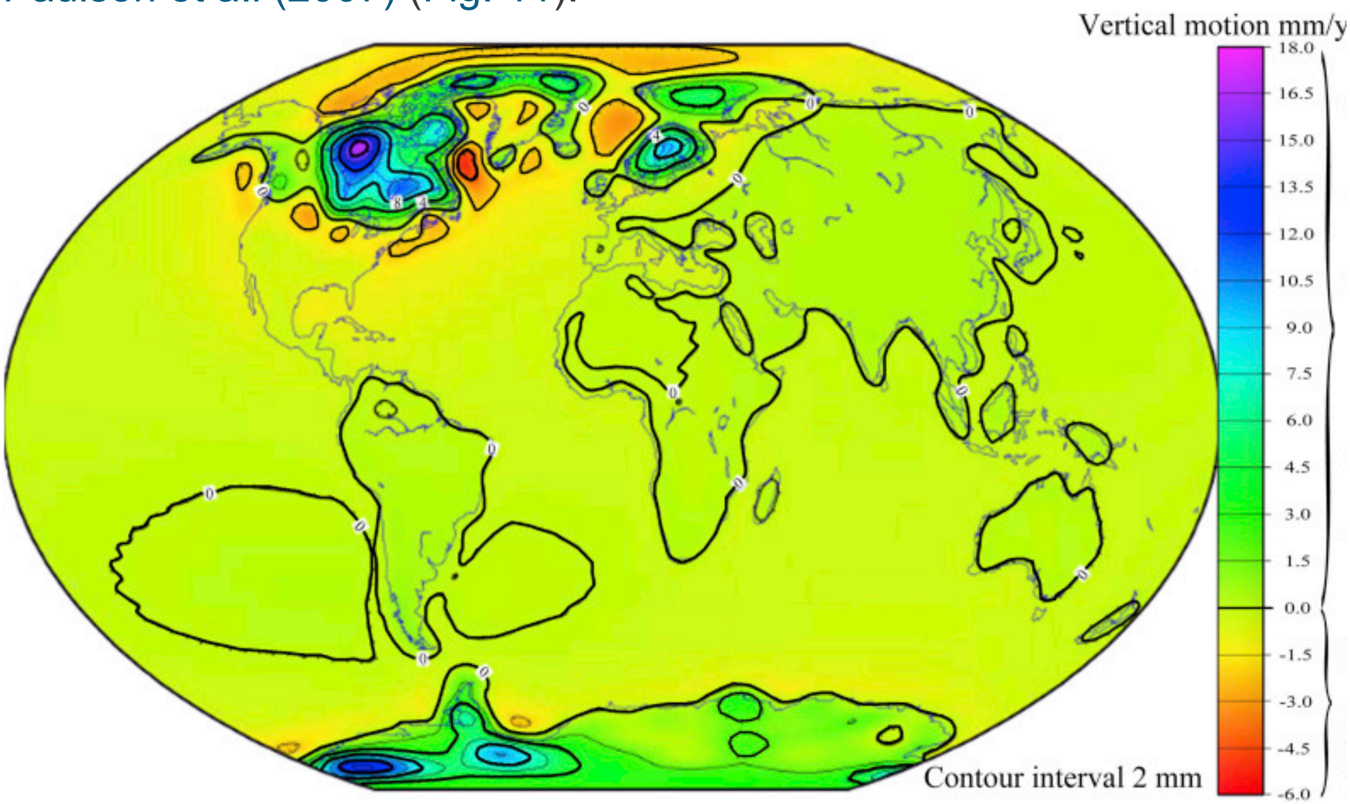

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Figure 11. Global vertical crustal motion with respect to elastic rebound for isostatic balancing of the crust (taken from https://commons.wikimedia.org/wiki/File:PGR_Paulson2007_Rate_of_Lithospheric_Uplift_due_to_PGR.png. Both Arctic and Antarctic polar region exhibit significant vertical motion in terms of uplift and subsidence. Uplift term is much greater than subsidence represented by color code. Because of greater uplift than subsidence, residual uplift value remains. Polar region are not effected by sea level rise. Both Arctic and Antarctic polar region are isostatically unbalanced while all the lower latitude areas are isostatically balanced (source: Erik Ivins, 2010 of NASA's Jet Propulsion Laboratory in Pasadena, California USA alongwith his article entitled “Rate of lithospheric uplift due to Postglacial Rebound”, posted in the website https://en.wikipedia.org/wiki/Post-glacial_rebound.

Both the polar region exhibit noticeable uplift and subsidence of the crust for attaining its isostatic equilibrium. In the north polar region, crust is characterized by the maximum

18 mm/yr uplift surrounded by the region of maximum 6 mm/yr subsidence. Difference of 12 mm/yr is attributed for the uplift that should result in the sea-level drop. While, in the south polar region, Antarctica shows maximum uplift 12 mm/yr and maximum subsidence 2 mm/yr with a difference of 10 mm/yr attributed to uplift that would also result in the sea-level drop. There are good number of publications about the post glacial isostatic rebound of the polar region. Works of Fleming et al. (1998) and Milne et al. (2005) are based on the vertical geologic motions associated with the post-glacial continental and isostatic rebound. Johansson et al. (2002) conducted research on a project BIFROST (Baseline Inferences for Fennoscandian Rebound Observations, Sea-level, and Tectonics) that combines networks of continuously operating GPS receivers in Sweden and Finland to measure ongoing crustal deformation due to glacial isostatic adjustment (GIA). They have found the maximum observed uplift rate 10 mm/yr for Fennoscandian region analyzing data between August 1993 and May 2000. Sella et al. (2007) and Lidberg et al. (2010) suggested that postglacial rebound continues today albeit very slowly wherein the land beneath the former ice sheets around Hudson Bay and central Scandinavia, is still rising by over a centimetre a year, while those regions which had bulged upwards around the ice sheet are subsiding such as the Baltic states and much of the eastern seaboard of North America. Snay et al. (2016) have found large residual vertical velocities, some with values exceeding 30 mm/yr, in southeastern Alaska. The uplift occurring here is due to present-day melting of glaciers and ice fields formed during the Little Ice Age glacial advance that occurred between 1550 A.D. and 1850 A.D.

Global paleo sea-level fluctuation curves of Vail and Hallam also show downward trend (a drop) in 542 Ma time span (Fig. 12). The Vail curve representing past global sea-levels is based on the study of unconformities in the geological record representing times of marine regression. The Vail curve is based on proprietary data of the Exxon-Mobil corporation which the general public is not allowed to see. The Hallam curve was constructed on the basis of calculating the area of the continents covered by the sea over the course of time by seeing where marine sediments were and were not deposited at various times, allowing to sketch out a series of shorelines for the various continents over time. When the land area shrinks globally, this corresponds to a global rise in sea level. From the curve it is certain that sea level has changed in geologic time scale due to geologic events. Hence, polar ice-melting would not contribute to sea-level rise rather sea-level would drop around the Arctic region as long as isostatic rebound will continue. Claim and prediction of 3 mm/yr rise of sea-level due to global warming and polar ice-melt is definitely a conjecture. Prediction of 4–6.6 ft sea level rise in the next 91 years between 2009 and 2100 is highly erroneous.

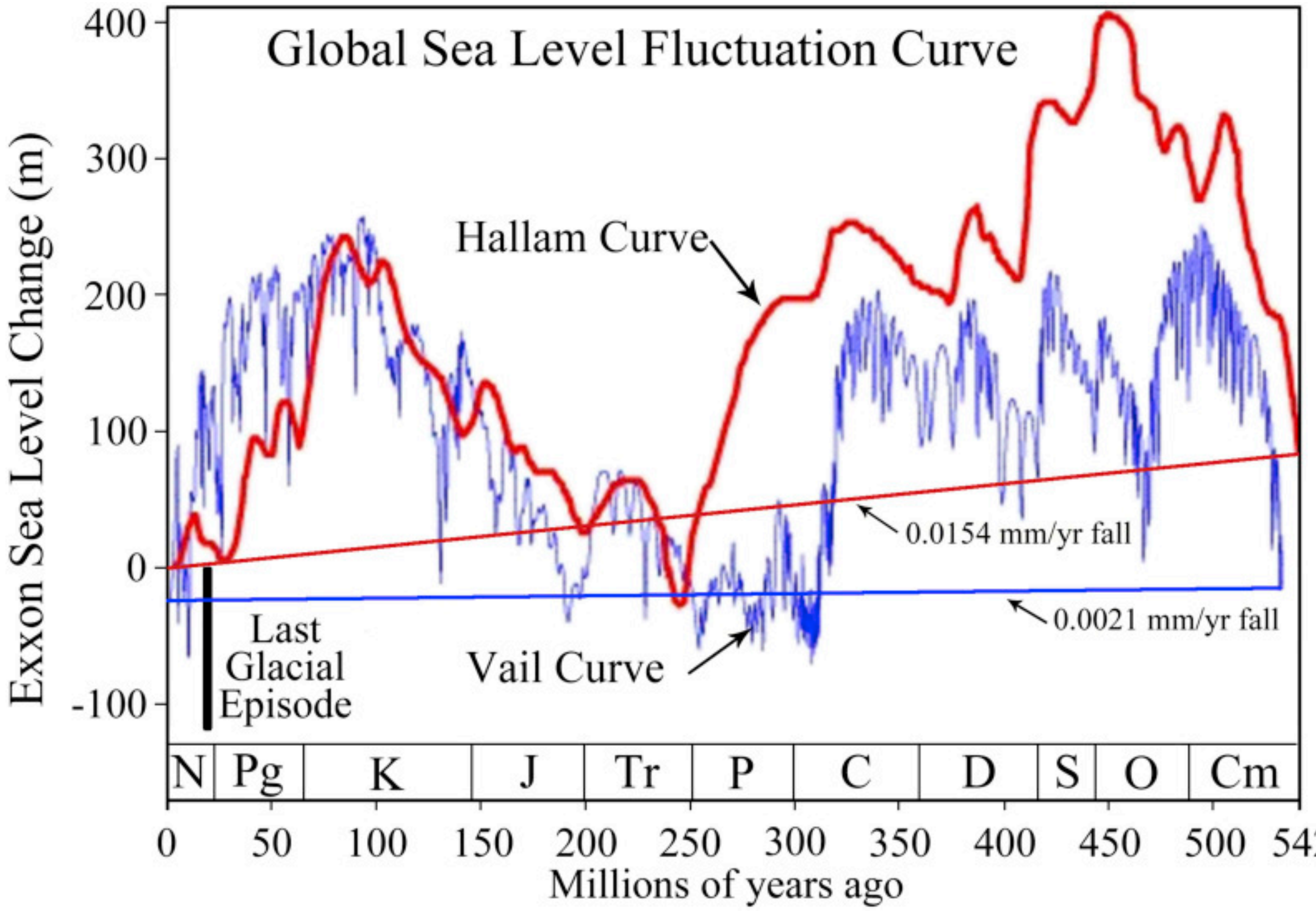

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Figure 12. Vail and Hallam curves of global paleo sea level fluctuations from the last 542 million years (Copied and redrawn from https://en.wikipedia.org/wiki/Sea-level_curve).

5. Geology versus sea-level

There are numerous geological processes that can change ocean floor height nonetheless tectonism, volcanism, visco-elastic deformation, trench-slope deposits and sub-marine fan deposits are the most important. Inter-regional unconformities are related to cycles of global highstands and lowstands of sea level, as are the facies and general patterns of distribution of many depositional sequences (Vail et al., 1977). A variety of processes drive height changes of the ocean surface and ocean floor, resulting in distinct spatial patterns of sea level change at local to regional scales. Palaeo-sea level changes have been identified from the geological records wherein data from the Late Triassic (~227 Ma) to the present time are reasonably well documented but the amplitudes of the eustatic changes of sea level (Eustatic change is when the sea level changes due to an alteration in the volume of water in the oceans or, alternatively, a change in the shape of an ocean basin and hence a change in the amount of water the sea can hold. Eustatic change is always a global effect) are only approximations (Vail et al., 1977). Because global cycles of sea level changes are the records of geotectonic, glacial, and other large-scale processes, they reflect major events of Phanerozoic (Mesozoic to Present) history. These events are related mostly to the large-scale orogenic (mountain building) movement such as trans-Himalayan orogeny, sedimentary basins formation such as Bengal Basin and Gulf Coast Basins. The Phanerozoic history of North America from the Late Triassic or Early Jurassic, corresponds to the Pangea breakup phase, during which North America drifted westwards. The eastern continental margin became the modern extensional Atlantic margin basins, while the western margin underwent tectonism and accretionary prism formation leading to the assembly of the Cordilleran orogen. Similar extensional basins and sedimentary accretionary prism leading to orogens developed along the eastern margin of the Atlantic Ocean in Africa and Europe, and in some region of Asia. These mega events of the earth led to major sea-level rise and fall in terms of hundreds of meters as oceans suffered regional transgressions and regressions. Hence, when a region undergoes major subsidence can cause relative sea level (RSL) rise to the tune of tens of meters. Examples of mid-Holocene (about 8000 years ago) subsidence forming Ganges depression, Jamuna depression and Meghna depression in the Bengal Basin causing major marine transgression to signify sea level rise in terms of 10 s of meters (Khan et al., 2000).

Geological processes are responsible of two types of major movements of the crustal block viz., uplift and subsidence. Hence, the relation of sea level and crustal motion is attributed to sea level drops when there is an uplift while it rises when there is subsidence. Examples of uplift and subsidence of the crustal segments are given in the Fig. 13A–H. Layered beach at Bathurst Inlet, Nunavut is an example of post-glacial rebound after the last Ice Age. Isostatic rebound is still underway here (Fig. 13A). Some of the most dramatic uplift is found in Iceland. Much of modern Finland is former seabed or archipelago that shows sea level immediately after the last ice age (Fig. 13B). Massive coral (Pavona clavus) exposed in 1954 by tectonic uplift in the Galapagos Islands, Ecuador (Fig. 13C). Beach ridges on the coast of Novaya Zemlya in arctic Russia. Such ridges are formed by pushing of sea ice as a result of Holocene glacio-isostatic rebound (Fig. 13D). A beach in Juneau, Alaska where sea level is not rising, but dropping precipitously due to a phenomenon known as glacial isostatic adjustment GIA (Fig. 13E). Boat-houses in Scandinavia now considerably farther away from the water's edge where they were built demonstrates land uplift (Fig. 13F). An 8000-year old-well off the coast of Israel now submerged is a land mark of crustal subsidence (Fig. 13G). The “City beneath the Sea”; Port Alexandria on the Nile delta fits with the drowned well off the coast of Israe (Fig. 13G), both subsided due to subduction-pull of the downgoing African crustal slab as it enters the Hellenic trench (Fig. 13H). Venice is vanishing because of tectonics (subduction rollback of Adriatic slab) wherein down-going crustal segment causing subsidence of Venice, rather than sea level rise associated with global warming and/or polar ice melt.

Figure 13. (A) Layered beach at Bathurst Inlet, Nunavut signifying post-glacial isostatic rebound (B) Some of the most dramatic uplift is found in Iceland. Evidence of isostatic rebound (C) Massive coral (Pavona clavus) exposed in 1954 by tectonic uplift in the Galapagos Islands, Ecuador (D) Beach ridges on the coast of Novaya Zemlya in arctic Russia, an example of Holocene glacio-isostatic rebound (E) A beach in Juneau, Alaska where sea level is not rising, but dropping due to glacial isostatic adjustment (F) Boat-houses in Scandinavia now considerably farther away from the water's edge where they were built demonstrates land uplift (G) An 8000-year old-well off the coast of Israel now submerged, which is a land mark of crustal subsidence (H) The "City beneath the Sea"; Port Alexandria on the Nile delta and the drowned well off the coast of Israe (panel (G), both subsided due to subduction-pull of the downgoing African crustal slab as it enters trench.

Transgression commences when continental block undergoes subsidence with respect to continental shelf and abyssal plain, while regression occurs when this process is reverse i.e., when continental block is uplifted with respect to continental shelf and abyssal plain. Prograding delta system in low lying areas and other geologic events may cause local/relative sea-level fall as new sedimentary deposition advances as accretion pushing sea further down the coast irrespective of global warming and polar ice-melt. Hence, both regional and local sea-level rise and fall in meter-scale is related to the geologic events only and not related to global warming and/or polar ice melt. Information on relative sea-level rise over the past ~8000 years obtained from a variety of geological indicators exhibit vertical land movement at tide-gauges resulting from glacial isostatic adjustment (GIA) theory. Although if it is generally thought that paleo sea level change of 10 s to 100 s m or future prediction of sea level rise more than 1 m in 100 years are due to the continuous process of the Earth, it is rather an abrupt or sudden geological process of fault rupture to result in crustal uplift and subsidence causing a visible sea level change. So a visible measure of the sea level change is possible only after sudden fault rupture displacement between continent and ocean/sea. Although a continuous deformation process prior to the uplift and subsidence could progress, a visible deformation of the crust would occur only due to sudden rupture (fault) of the crust.

Sea level curve of 9452210 Juneau, Alaska with mean sea level trend prepared by the National Oceanic and Atmospheric Administration (NOAA) show a monthly mean sea level without the regular seasonal fluctuations due to coastal ocean temperatures, salinities, winds, atmospheric pressures, and ocean currents (Fig. 14A). The mean sea level trend is −13.14 mm/yr with a 95% confidence interval of ±0.35 mm/yr based on monthly mean sea level data from 1936 to 2016 which is equivalent to a change of −4.31 ft in 100 years. The plotted values are relative to the most recent Mean Sea Level datum established by NOAA's Center for

Operational Oceanographic Products and Services (CO-OPS). A negative sea level trend implied that Alaska is being uplifted continuously and corresponding sea level is dropping. However, permanent uplift and corresponding sea level drop of Alaska will occur through ultimate fault rupture between land and sea. Until that time it will continue to show the pattern of sea level as of Fig. 14A. This pattern of the sea level curve can raise two pertinent questions, one, the reason for oscillatory nature of the curve, and two, the continuous downward trend of the curve. As already explained, crustal uplift and subsidence is not a continuous geologic process rather an abrupt or sudden process although a continuous deformation process prior to the uplift and subsidence would progress. However, simple stress-strain diagram of deformation (Fig. 14B) can explain this process. The stress-strain diagram states that dynamic Earth is continuously in the strain build-up phase due to on-going stress. Strain increases in response to applied increased stress through distinct elastic-plastic phases. In the elastic phase a deformed object would return to its original shape if an applied stress is withdrawn, while, in the plastic phase a deformed matter would partially return to its original shape if an applied stress is withdrawn. It is interpreted that Alaska is undergoing crustal deformation of uplift and subsidence each year within elastic-plastic phase associated with ice melt and ice cover formation. When ice melts, load from the crust is reduced and it is uplifted and when ice cover builds-up, load onto the crust is increased and it is subsided. Hence, pattern of the sea level curve of Alaska is oscillatory. Secondly, for each uplift and subsidence there remains a residual value between uplift and subsidence which is positive, hence, the corresponding sea level curve is negative. In conclusion; global warming, both polar and terrestrial ice melts, and climate change might be a reality but all these phenomena are not related to sea level rise and fall. However, any geo-environmental hazards like inundation, submergence, flooding, land erosion and coastal contamination and pollution in the low lying and coastal areas, as claimed due to sea level rise, now should be directed to other pertinent reasons. An increase in the coastal hazards like cyclone, storm surge, tidal bore would cause flooding, water logging and salinity encroachment in the low lying and coastal areas. Increased rainfall and deterioration of sediments carrying capacity of the terrestrial rivers is also a cause of flooding in the land interior.

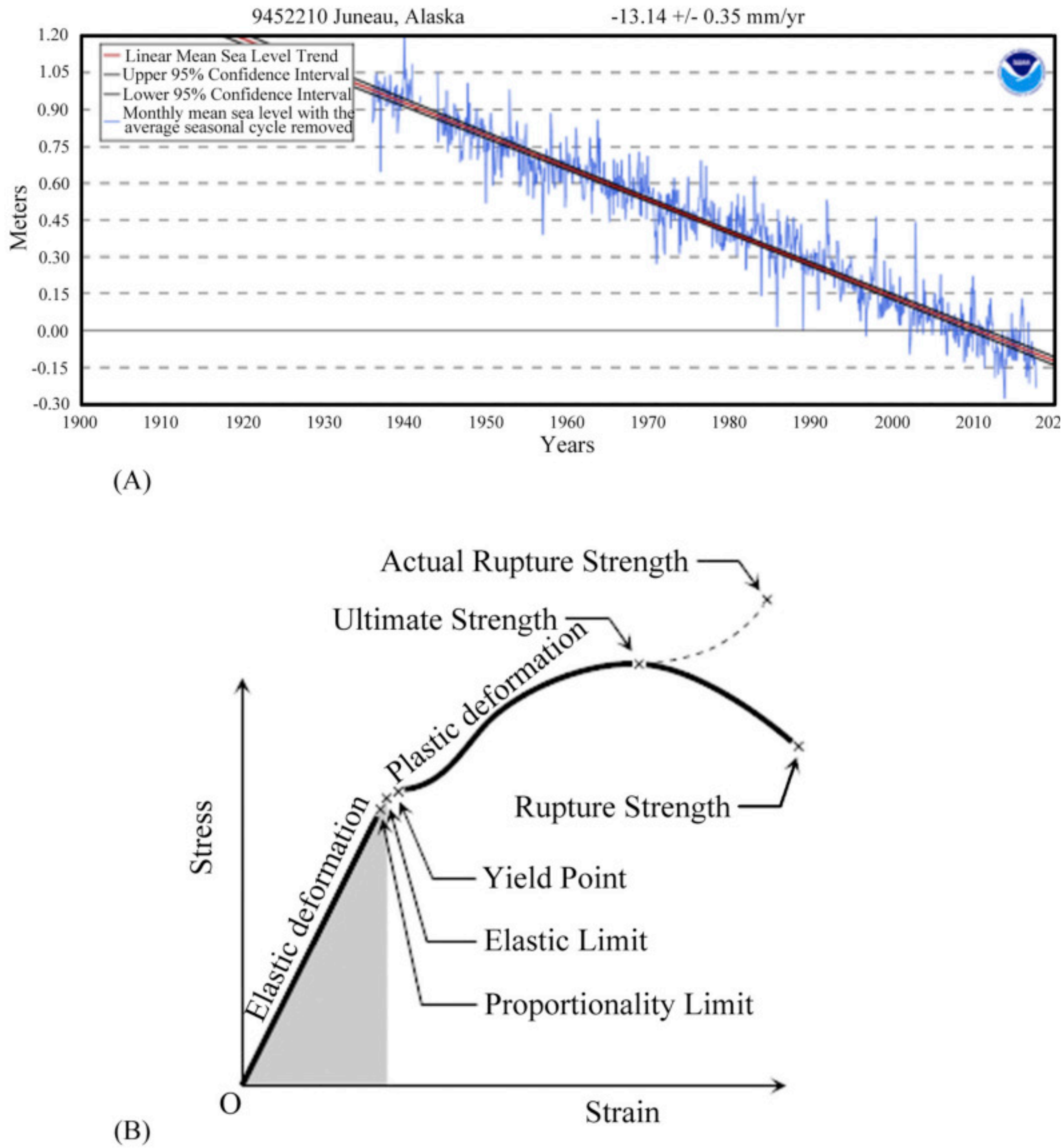

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Figure 14. (A) Sea level curve of 9452210 Juneau, Alaska with mean sea level trend prepared by the National Oceanic and Atmospheric Administration (NOAA) show a monthly mean sea level (B) Stress-strain diagram signify continuous deformation in the elastic-plastic phase and permanent deformation by an abrupt fault rupture for uplift and subsidence.

6. Conclusion

Geophysical shape of the earth is the fundamental component of the global sea level distribution. Global warming and ice-melt, although a reality, would not contribute to sea-level rise. Gravitational attraction of the earth plays a dominant role against sea level rise. As a result of low gravity attraction in the region of equatorial bulge and high gravity attraction in the region of polar flattening, melt-water would not move from polar region to equatorial region. Further, melt-water of the floating ice-sheets will reoccupy same volume of the displaced water by floating ice-sheets causing no sea-level rise. Arctic Ocean in the north is surrounded by the land mass thus can restrict the movement of the floating ice, while, Antarctic in the south is surrounded by open ocean thus floating ice can freely move to the north. Melting of huge volume of floating sea-ice around Antarctica not only can reoccupy volume of the displaced water but also can cool ocean-water in the region of equatorial bulge thus can prevent thermal expansion of the ocean water. Melting of land ice in both the polar region can substantially reduce load on the crust allowing crust to rebound elastically for isostatic balancing through uplift causing sea level to drop relatively. Palaeo-sea level rise and fall in macro-scale are related to marine transgression and regression in addition to other geologic events like converging and diverging plate tectonics, orogenic uplift of the collision margin, basin subsidence of the extensional crust, volcanic activities in the oceanic region, prograding delta buildup, ocean floor height change and sub-marine mass avalanche.

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Peer-review under responsibility of China University of Geosciences (Beijing).

James Grant Matkin · 1 Day Ago

This new science research resonates with our common sense as we see many coasts where the evidence of dramatic sea levels falling is obvious. We visited Crete last year and saw a well preserved harbour from Roman times that is now 200 metres in land. We were told the land rose not that the sea fell. It is widely accepted that contrary to alarmism the Pacific Islands are rising, not declining, therefore there is no fear of islanders forced evacuation. Recent news headlines – Alaska News –

Southern Alaskan sea levels defy worldwide trends with sea levels falling 4.31 feet over last 100 years. See the detailed TIDES AND CURRENTS MAPPING Juneau, Alaska – " mean sea level trend is -13.14 millimeters/year with a 95% confidence interval of +/- 0.35 mm/yr based on monthly mean sea level data from1936 to 2016 which is equivalent to a change of -4.31 feet in 100 year." Experienced scientists find that the Alaska coast land is rising not that the seas are falling.

Most relevant is the debunking of the wildly exaggerated sea level fear mongering by alarmists like Al Gore predicting the end of major US coastal cities like New York City drowned by the sea. All this adds support to the science that global warming and polar ice melt have nothing to do with sea level rise or fall. Rather the "gravitational attraction of the earth plays a dominant role against sea level rise." Therefore, "the prediction of 4–6 ft at the rate of 0.044 ft/yr and 0.066 ft/yr respectively in 91 years between 2009 and 2100) is highly questionable. An abrupt jump in the sea level rise after 2009 is definitely a conjecture." YES.

https://rclutz.wordpress.com/2018/03/26/co2-rise-≠-sea-level-rise/

70+ Papers Show There Is Nothing Unusual About Today's Sea Level Rise And Rate

An alarmist's vision of the future if CO_2 levels continue to rise is an overwhelming sea level rise.

70+ Papers: Holocene Sea Levels 2 Meters Higher – Today's Sea Level Change Indistinguishable From Noise

1. Are Modern 'Anthropogenic' Sea Levels Rising At An Unprecedented Rate? No.

Despite the surge in CO_2 concentrations since 1900, the UN's Intergovernmental Panel on Climate Change (IPCC) has concluded that global sea levels only rose by an average of **1.7 mm/yr during the entire 1901-2010 period**, which is a rate of ***just 0.17 of a meter per century***.

During the **1958 to 2014** period, when **CO_2 emissions rose dramatically**, a recent analysis revealed that the rate of sea level rise slowed to between 1.3 mm/yr to 1.5 mm/yr, or ***just 0.14 of a meter per century***.

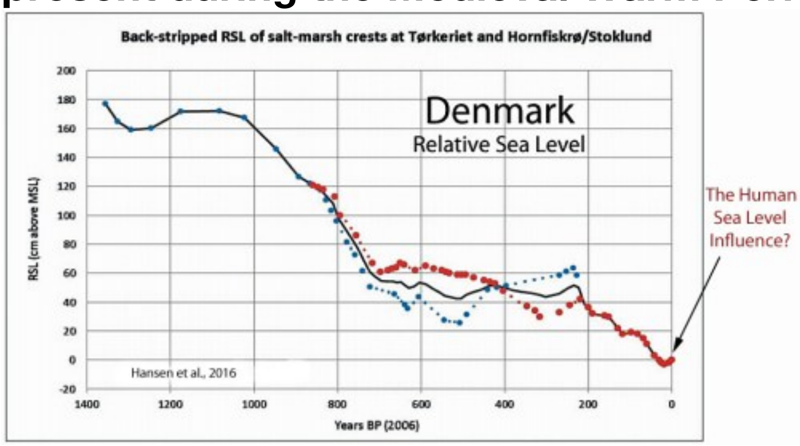
Frederiske et al.,2018 "Anthropogenic" Global Sea Level Rise Rate (1958-2014): **+0.14 of a meter per century**

"For the first time, it is shown that for most basins the reconstructed sea level trend and acceleration can be explained by the sum of contributors, as well as a large part of the decadal variability. **The global-mean sea level reconstruction** shows a trend of **1.5** ± 0.2 **mm yr**$^{-1}$ **over 1958–2014** (1σ), compared to **1.3** ± 0.1 **mm yr**$^{-1}$ for the sum of contributors."

2. ~15,000 – 11,000 Years Ago, Sea Levels Rose At Rates Of *+4 to +6 Meters Per Century*

In the past few thousand years, sea levels in some regions rose and fell at rates of + or – **0.5 to 1.1 meters per century**. Sea levels during the **Medieval Warm Period were+170 centimeters higher than today**.

Hansen et al., 2016 Denmark, **+1.7 meters higher than present during the Medieval Warm Period**



"Continuous record of Holocene sea-level changes … **(4900 years BP to present)**. … The curve reveals **eight centennial sea-level oscillations of 0.5-1.1 m superimposed on the general trend of the RSL** [relative sea level] **curve** [relative sea levels **~1.7 m higher than present** from 1400 to 1000 years ago]."

Cronin et al., 2017 Global Sea Level Rise Rate: **+4 meters per century** (14,500 to 14,000 years ago)

"**Rates and patterns of global sea level rise (SLR) following the last glacial maximum (LGM)** are known from radiometric ages on coral reefs from Barbados, Tahiti, New Guinea, and the Indian Ocean, as well as sediment records from the Sunda Shelf and elsewhere. … Lambeck et al. (2014) estimate **mean global rates during the main deglaciation phase of 16.5 to 8.2 kiloannum (ka)** [16,500 to 8,200 years ago] **at 12 mm yr−1** [+1.2 meters per century] with more rapid SLR [sea level rise] rates **(~ 40 mm yr−1)** [+4 meters per century] **during meltwater pulse 1A ~ 14.5–14.0 ka** [14,500 to 14,000 years ago]."

Abdul et al., 2017 Global Sea Level Rise Rate: **+4 meters per century**(11,450 to 11,100 years ago)
"We find that sea level tracked the climate oscillations remarkably well. Sea-level rise was fast in the early Allerød (25 mm yr-1), but decreased smoothly into the Younger Dryas (7 mm yr-1) when the rate plateaued to <4 mm yr-1here termed a sea-level "slow stand". No evidence was found indicating a jump in sea level at the beginning of the Younger Dryas as proposed by some researchers. Following the "slow-stand", **the rate of sea-level rise accelerated rapidly, producing the 14 ± 2 m sea-level jump known as MWP-1B; occurred between 11.45 and 11.1 kyr BP with peak sea-level rise reaching 40 mm yr-1** [+4 meters per century]."

Ivanovic et al., 2017 Northern Hemisphere Sea Level Rise Rate: **+3.5 to +6.5 meters per century** (~14,500 years ago)
"During the Last Glacial Maximum 26–19 thousand years ago (ka), a vast ice sheet stretched over North America [Clark et al., 2009]. In subsequent millennia, as the climate warmed and this ice sheet decayed, large volumes of meltwater flooded to the oceans [Tarasov and Peltier, 2006; Wickert, 2016]. **This period, known as the "last deglaciation," included episodes of abrupt climate change, such as the Bølling warming** [~14.7–14.5 ka], **when Northern Hemisphere temperatures increased by 4–5°C in just a few decades** [Lea et al., 2003; Buizert et al.,

2014], **coinciding with a 12–22 m sea level rise in less than 340 years** [3.5 to 6.5 meters per century] (Meltwater Pulse 1a (MWP1a)) [Deschamps et al., 2012].”

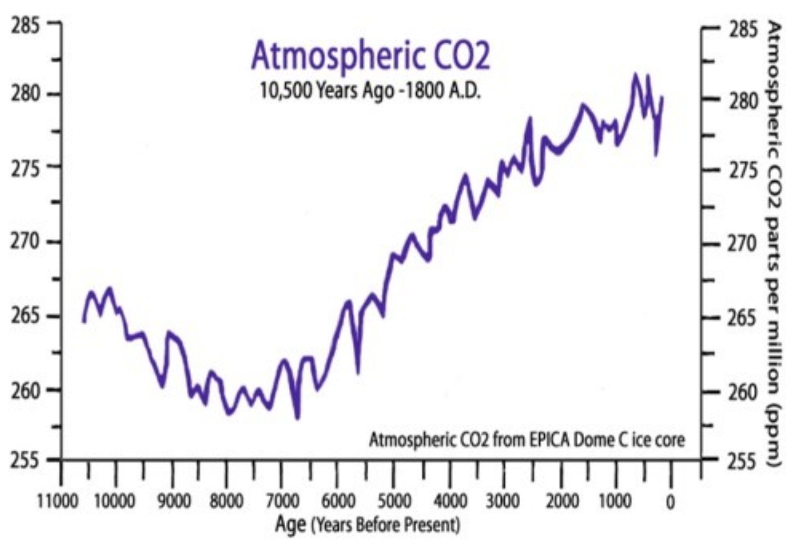
Zecchin et al., 2015 Regional Sea Level Rise Rate: **+6 meters per century**(14,500-11,500 years ago)

“[M]elt-water pulses have punctuated the **post-glacial relative sea-level rise with rates up to 60 mm/yr.** [6 meters per century] **for a few centuries.**”

3. Over 70 Papers Affirm Sea Levels Were 2+ Meters Higher Than Now A Few Thousand Years Ago When CO2 Levels Were ‘Safe’

70+ Papers: Sea Levels 2+ m Higher 9,000-4,000 Years Ago While CO2 Levels Were ‘Safe’ (265 ppm) More Here

Before the advent of the industrial revolution in the late 18th to early 19th centuries, carbon dioxide (CO_2) concentrations hovered between 260 to 280 parts per million (ppm).



Within the last century, atmospheric CO_2 concentrations have risen dramatically. Just recently they eclipsed 400

ppm.
Scientists like Dr. James Hansen have concluded that pre-industrial CO_2 levels were climatically ideal. Though less optimal, **atmospheric CO_2 concentrations up to 350 ppm have been characterized as climatically "safe"**.
However, CO_2 concentrations *above* 350 ppm are thought to be dangerous to the Earth system. It is believed that such "high" concentrations could lead to rapid warming, glacier and ice sheet melt, and a harrowing **sea level rise of 10 feet within 50 years**.
To reach those catastrophic levels (10 feet within 50 years) predicted by proponents of sea level rise alarmism, the current "anthropogenic" change rate of +0.14 of a centimeter per year (since 1958) will need immediately explode into +6.1 centimeters per year.
The likelihood of this happening is remote, especially considering Greenland and Antarctica *combined* only contributed a grand total of 1.54 cm since 1958 (**Frederiske et al., 2018**).
It is becoming more and more apparent that sea levels rise and fall without any obvious connection to CO_2 concentrations.
And if an anthropogenic signal cannot be conspicuously connected to sea level rise (**as scientists have noted**), then the greatest perceived existential threat promulgated by advocates of dangerous man-made global warming will no longer be regarded as even worth considering.

https://climatechangedispatch.com/70-papers-show-there-is-nothing-unusual-about-todays-sea-level-rise-and-rate/#more-20138

We recently visited the ancient harbour at KOMMOS, CRETE providing port needs of Phaestus, Crete about 2000 BC. The port is no longer at the edge of the sea. There is a dramatic sea level fall SLF as photos show the old port is hundreds of meters away. Why? Locals claim there has been a rising uplift of the land. Deglaciation is an explanation for SLF in Alaska, Canada and Scandinavia, but not Crete.

The Role of Kommos in Phoenician Routes

9th July 2017

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Kommos

1. Introduction

'Any Phoenicians sailing to the western Mediterranean would have been foolish to avoid the Aegean' and especially the island of Crete [Fig. 1.1].[1] Even though trade between Crete and other Mediterranean regions had already been established before the tenth century BC, it was throughout this century that maritime traffic from Phoenicia to the west intensified due to the tribute demand from Assyria following its growth in the eighth century BC.[2] Cypro-Levantine objects started to appear in many places, such as Sardinia and Italy, north-west Africa and southern Spain, as well as the Aegean. Even though many Levantine exports are not of Phoenician origin, it is thought that they were likely carried by Phoenician sailors.[3] Cultural encounters, social interactions and negotiations between Phoenicians and locals from the areas mentioned took place in a so-called middle ground, where a phenomenon of glocalisation (the adoption of foreign practices in local communities) occurred, beliefs were transmitted and practices were shared and imitated.[4]

Strategic trading and stopping points started to develop across the Mediterranean, in which Near Eastern cultural and religious values were transferred due to trading contacts, for instance the port-town of Kition in Cyprus or Kommos and Knossos in Crete.[5] Phoenician contacts with Crete could have been an end in themselves, although they probably happened as they were going to the west.[6] The main east-west routes that the Phoenician merchants followed were through the Cyclades to Euboea and Attica, crossing the isthmus of Corinth, or through the south of Crete, where Phoenician installations were supplied.[7] Therefore, the site of Kommos appears to have played an important role in east-west Phoenician routes and this article will analyse whether Kommos was a Phoenician installation.

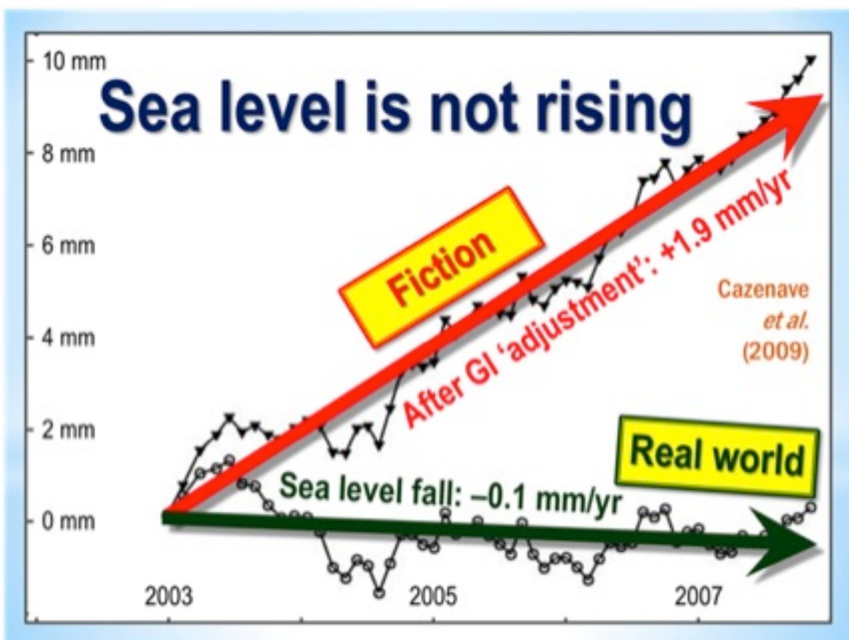
2. The site

Kommos [Fig. 2.1 and 2.2] is a port site in the south of Crete. According to the *Odyssey,* describing the place of Menelaos' shipwreck, Kommos is identified as the ancient harbour of Phaistos, even though other sources identify Phaistos with Matala.[8] Kommos is thought to have been, together with Kition (Cyprus), a Phoenician trading installation, as will be discussed later, and its temple should be compared to religious centres like those of Delos, Delphi and Olympia, places from which the Greeks absorbed oriental elements and beliefs, as confirmed by the archaeological record from the second to the first millennium BC.[9] The focus of this article however, will be on the finds from the first millennium BC. By the end of the eleventh century BC a rectangular construction identified as a small temple was built upon the ruins of Minoan civic structures. The building, called Temple A, was replaced by a larger one, Temple B [Fig. 2.3], during the ninth century BC, which was in turn replaced by another one, Temple C, towards the end of the fourth century BC.[10] Temple B, as explained below, has an oriental structure and it is associated with the Phoenician merchants who came to Kommos on their route to the west.[11] Near Eastern objects, including Phoenician pottery such as *amphorae* and drinking vessels, were found in this structure as well as in surrounding buildings.[12]

These observations have led to speculation about the nature of the Phoenician presence at Kommos.[13] Negbi argues that Phoenician traders were permanently living at the site, as they had a permanent religious building, whilst Aubet claims they lived there only semi-permanently in order to trade.[14] Kourou also mentions that craftsmen, as well as traders, were inhabiting the site.[15] The use of Temple B is also questioned by Aubet, who defends its economic role, whereas other scholars such as Papalardo support its religious function.[16]

Travel Brochure -

The archaeological site of Kommos is located 4km west of Phaestus, near Pitsidia and Matala. Kommos (or Komos) was a small Minoan town founded in 2000BC and served the port needs of Phaestus, with which it was linked by road. Kommos was probably destroyed by an earthquake in 1700BC, but survived up to the Hellenistic period.
The excavations in the period 1976-1996 by the archaeologists Joseph Shaw and Mary Koutroubaki unearthed several Minoan houses, public buildings, warehouses, well maintained facilities of olive presses, a large courtyard and the first known shipyards in Crete.



THE FACTS

1. **Sea levels are falling**

In the global warming crusade by the UN IPCC and Al Gore dramatic sea levels rise has been their primary fear mongering prediction.

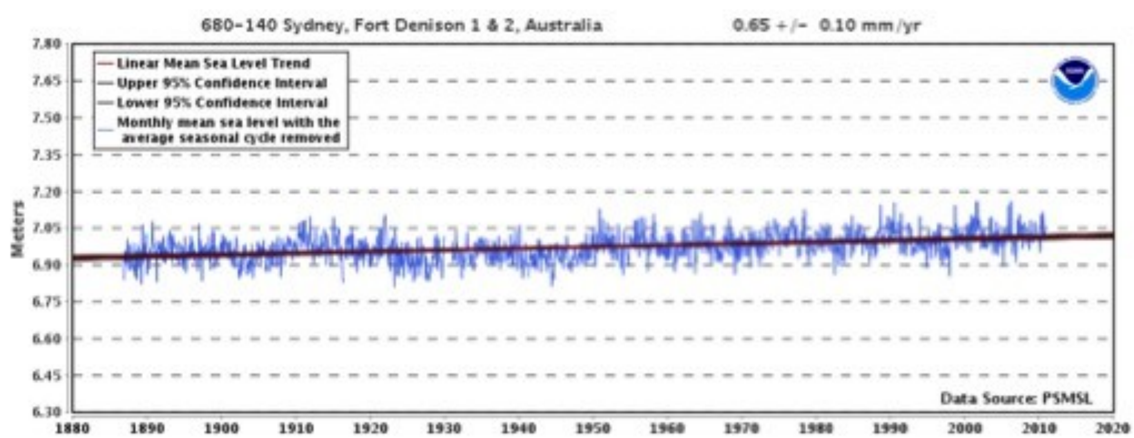
Ridiculous exaggerations have been blamed on fossil fuel Co2 emissions without any evidence.

'*For example, Gore in his Oscar-winning film An Inconvenient Truth went much further, talking of 20 feet, and showing computer graphics of cities such as Shanghai and San Francisco half under water,' Booker noted.*

Global sea level data is more fiction than fact because of the limited tide stations and natural variations at the regional level. Scientists deride the alarmist fearmongering on sea rise and admit over the past 130 years 7″ rise is imperceptible.

Sea-level rise is not accelerating, and has not accelerated since the 1920s.

There are about sixty good-quality, 100+ year records of sea-level around the world, and they all show the same thing: there has been no statistically significant acceleration (increase) in the rate of sea-level rise in the last 85 years or more. That means anthropogenic CO2 emissions do not measurably affect sea-level rise, and predictions of wildly accelerated sea-level rise are based on superstition, not science.

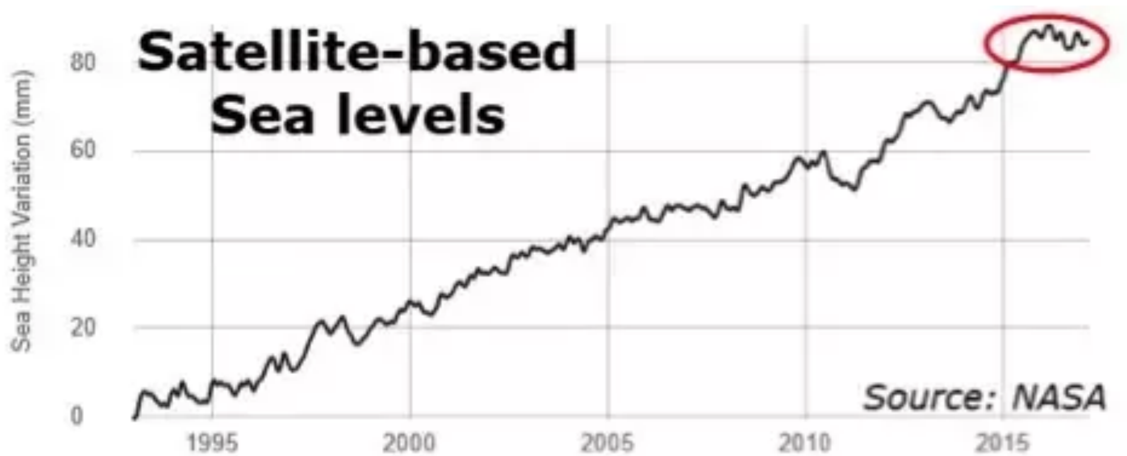


Here are two very high quality sea-level measurement records, one from the Pacific and one from the Atlantic:

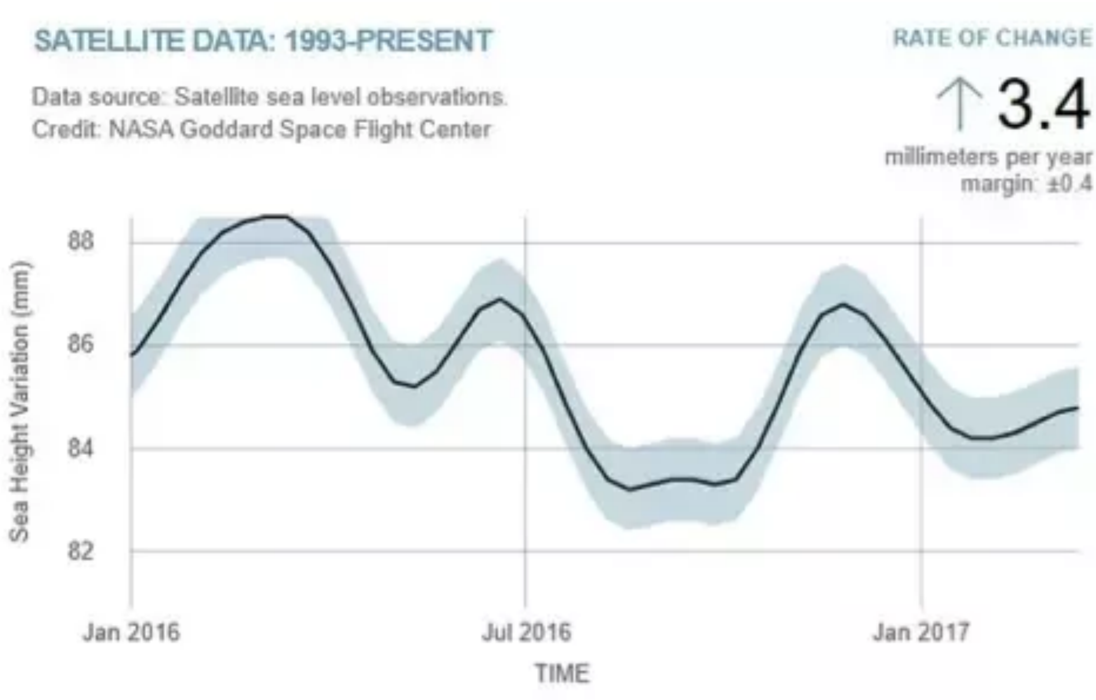
They show no activity that could be related to increase fossil fuel emissions.

A fortiori as lawyers would say is the fact that recently the global sea level data has gone negative to the point that NASA has been forced to explain falling sea levels -

On a NASA page intended to spread climate alarmism(https://climate.nasa.gov/vital-s...), NASA's own data reveal that **worldwide ocean levels have been falling for nearly two years**, dropping from a variation of roughly 87.5mm to below 85mm.

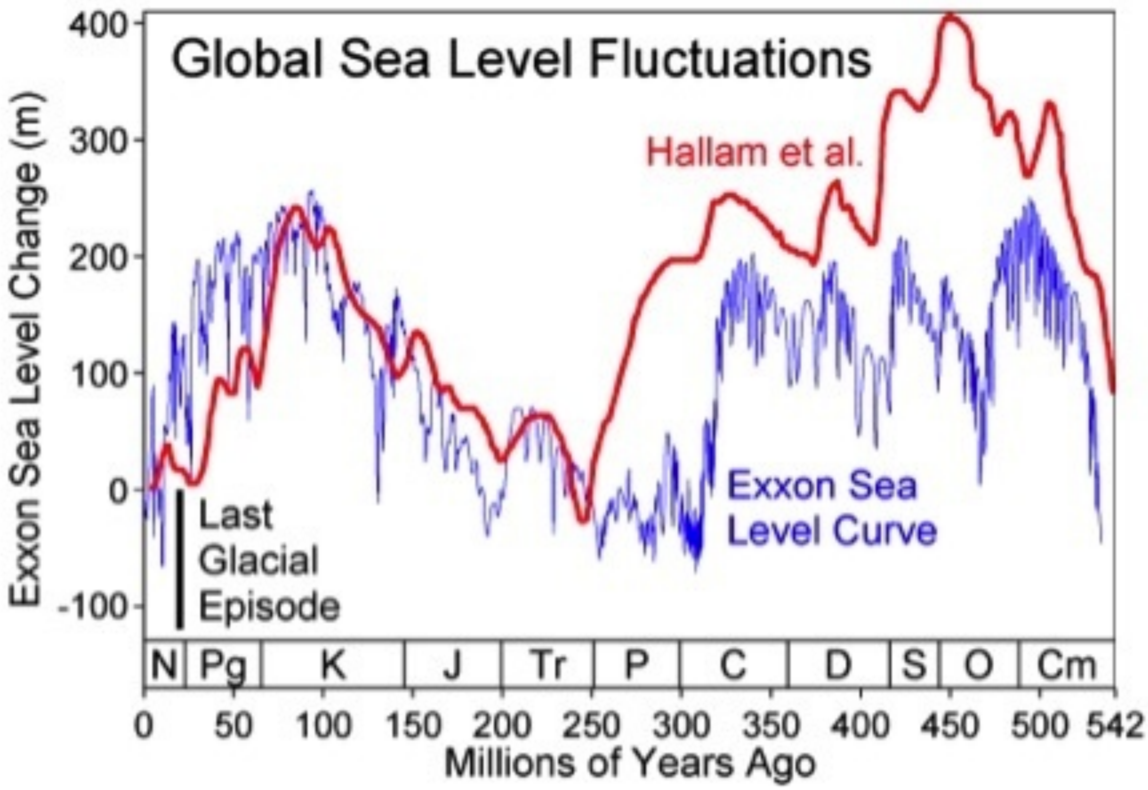


Here is the same data presented in a shorter timeline.



This is too short to say it is a trend but it certainly rebuts the fictional and wildly ridiculous claims of Al Gore et al.

It is relevant that sea levels today are the lowest in the history of our planet and yet they are very stable.


Global Sea Level Fluctuations
Hallam et al.
Exxon Sea Level Curve
Last Glacial Episode
Exxon Sea Level Change (m)
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300
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0
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Millions of Years Ago

Nils-Axel Mörner

via NoTricksZone By P Gosselin on

4. February 2018 (Climatism bolds & links added) :

SEA LEVELS 'ABSOLUTELY STABLE'

World Leading Authority: Sea Level "Absolutely Stable"… Poor Quality Data From "Office Perps"…IPCC "False"

German-speaking readers will surely want to save the text of *an interview conducted by the online Baseler Zeitung* (BAZ) of Switzerland with world leading sea level expert **Prof. Nils-Axel Mörner**.

Few scientists have scientifically *published* as much on sea level as Mörner has.

Yet because he rejects the alarmist scenarios touted by the media and alarmist IPCC scientists, **the Swedish professor has long been the target of vicious attack campaigns** aimed at discrediting him – yet to little effect.

Mörner, who headed of the Paleogeophysics & Geodynamics (P&G) Department at Stockholm University from 1991 to 2005, has studied sea level his entire career, visiting 59 countries in the process.

Sea level hijacked by an activist agenda

In the *interview* Mörner tells science journalist **Alex Reichmuth** that **climate and sea level science has been completely politicized and hijacked by an activist agenda and has become a "quasi religion".**

According to the BAZ, recently Mörner has been at the Fiji Islands on multiple occasions in order "to study coastal changes and sea level rise", and to take a first hand look at the "damage" that allegedly has occurred due to climate change over the past years.

IPCC is false

The Swedish professor tells the BAZ that he became a skeptic of alarmist climate science early on because **"the [UN] IPCC always depicted the facts on the subject falsely"** and **"grossly exaggerated the risks of sea level rise"** and that the IPCC **"excessively relied on shaky *computer models* instead of field research."**

He tells the BAZ: "I always want to know what the facts are. *That's why I went to the Fiji Islands*."

"Very poor quality data" from "office perps"

Mörner also dismisses claims by the Swiss **ProClim** climate science platform who recently announced that the *Fiji Islands are seeing a rapid sea level rise*. According to Mörner the data were taken from poor locations. "We looked over the data, and concluded that they are of very poor quality" and that the researchers who handled the data were "office perps" who were "not specialized in coastal dynamic processes and sea level changes".

"Many of them have no clue about the real conditions."

Sea level "absolutely stable"

Mörner tells the BAZ that *sea level at the Fiji islands was in fact higher than it is today between 1550 and 1700*. Coral reefs tell the story and "they don't lie," the Swedish professor said. He added he was not surprised by the data because "it is not the first time the IPCC has been wrong".

Over the past 200 years: "The sea level has not changed very much. Over the past 50 to 70 years it has been absolutely stable".

"Because they have a political agenda"

Not only is sea level rise due to climate change at the Fiji Islands exaggerated, but the same is true worldwide as a rule. When asked why are we seeing all the warnings from scientists, Mörner tells the BAZ: **"Because they have a political agenda."**

Mörner warns readers that the IPCC was set up from the get-go with the foregone conclusion man was warming the globe and changing the

climate: Mörner says: “And it is sticking to that like a dogma – no matter what the facts are.”

When asked if *sea level rise poses a problem for the islands*, Mörner answers with one simple word: “No.”

Strong evidence solar activity impacts sea level

The Swedish professor also tells the BAZ that the **rates of water rushing into the ocean due to glacier melt are exaggerated** and that **thermal expansion of the ocean is minimal**. Mörner adds:

“Sea level appears to depend foremost on solar cycle and little from melting ice.”

Junk surveys produce “nonsense”

When asked by the BAZ why he became skeptical, Mörner recalls the “great anger” from an IPCC representative when he spoke at a 1991 sea level conference in the USA. He was surprised by the reaction, alluding to the fact that it is normal to have different views in science. And **as the years followed, he became increasingly aware of the falsehoods made by the IPCC and the organization’s refusal to admit to them**.

On the subject of publishing research results:

“Publishers of scientific journals no longer accept papers that challenge the claims made by the IPCC, no matter the paper’s quality.”

In his decades long career, **Mörner has authored some 650 publications**, and he tells the BAZ that he has no plans to stop fighting. “No one can stop me.”

Near the end of the interview Mörner calls **the claim that 97% of all climate scientists believe global warming is man-made “nonsense”** and that the number comes from “unserious surveys”.

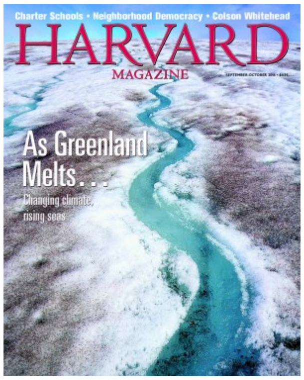
“In truth the majority of scientists reject the IPCC claims. Depending on the field, it’s between 50 and 80 percent.”

F. Cooling over the next decades

Mörner also sees little reason to reduce CO2 emissions, and calls **the belief in man-made climate change a religious movement driven by public funding.**

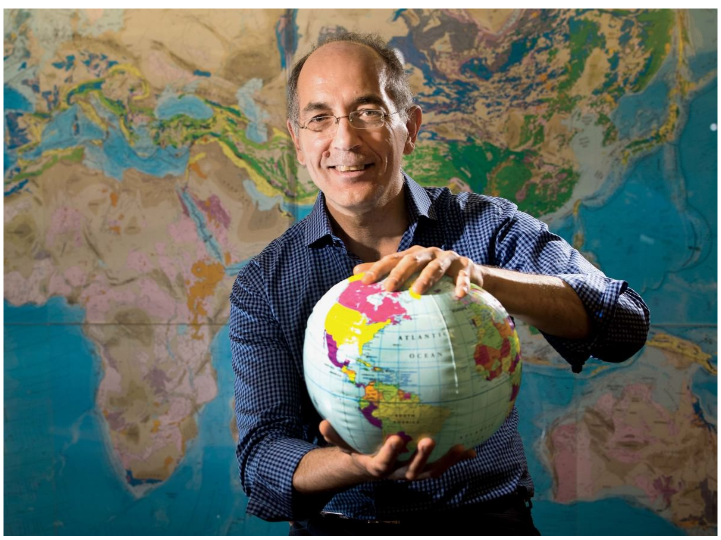
In conclusion Mörner tells the BAZ that he thinks solar activity will likely decrease and that cooling will ensue over the coming decades.

“Then it will become clear just how wrong the global warming warnings are.”



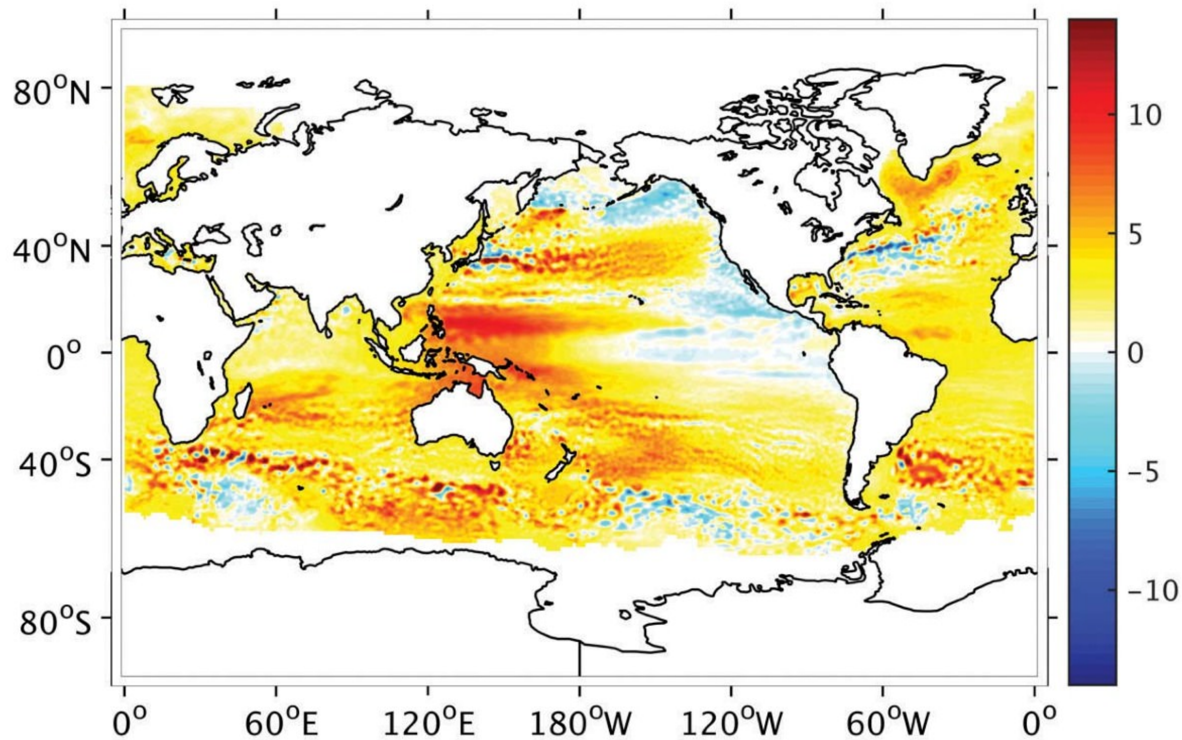
The Plastic Earth

Jerry Mitrovica connects the planet's dynamic history to climate change.
by JONATHAN SHAW
SEPTEMBER – OCTOBER 2016

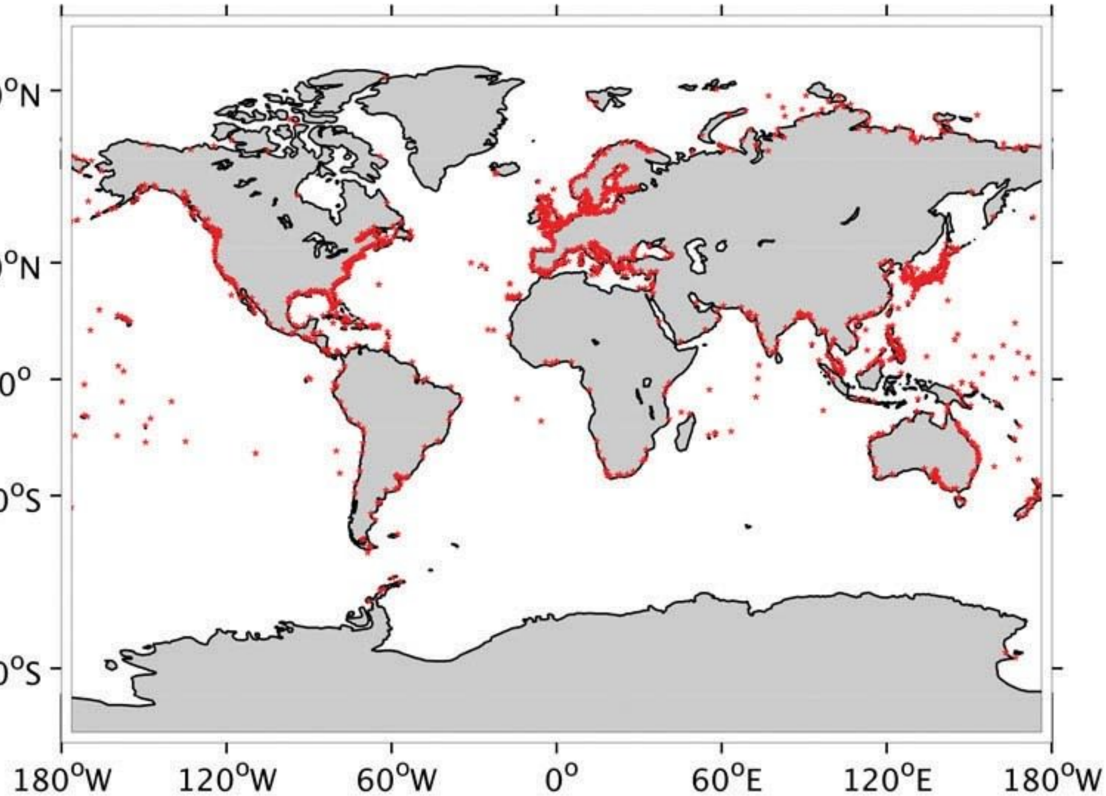


JERRY MITROVICA is a solid-earth geophysicist, but the description is inapt. He spends much of his time demonstrating that the earth is not firm at all—it moves. His lab in Cambridge, for example, oscillates up and down by nearly eight inches twice a day. Mitrovica is a pioneer of dynamic topography, the study of such vertical motions. For most people, these ebbs and flows are new ground. But for Mitrovica, who investigates changes large and small to the planet's shape, on timescales ranging from hours to eons, using evidence that ranges from the history embedded in coral to eclipse records, it's terra firma.

His research, of fundamental importance to earth scientists, also has a public resonance, because his discoveries about the planet's plasticity, and his explorations of its shape-changing past, bear directly on the problem of melting ice sheets and rising sea levels in an era of rapid climate change. Fame of the academic variety came early to Mitrovica and mushroomed about a decade ago, when he reminded people what happens to local sea levels in the vicinity of a melting ice sheet, like those covering Greenland and Antarctica. The effect was first described a hundred years ago, but "people had forgotten how big it was," he says. "It's *big*." If Greenland's ice sheet melted entirely, sea level would *fall* 20 to 50 meters at the adjacent coast. That's counterintuitive, but the ice sheets are so massive (Greenland's ice, one-tenth the size of the Antarctic ice sheets, weighs on the order of 3,000 trillion tons) that two immediate effects come into play. First, all that ice exerts gravitational pull on the surrounding ocean. When an ice sheet melts, that gravitational influence diminishes, and water moves away from the ice sheet, causing sea levels to drop as far as 2,000 kilometers away. (The drop is most pronounced close to the glacier, because gravity's effects dissipate with distance.) But because the sea level has fallen where the ice sheet melted, it rises everywhere else beyond that 2,000-kilometer boundary, and on distant shores this rise is far *greater* than the global average. The effect amplifies the rise in average global sea level attributable to the addition of the meltwater itself to the oceans. (Greenland alone contributed a trillion tons of melted ice from 2011 to 2014.) Second, the land beneath the now-vanished ice sheet slowly rebounds, rising as the weight of the mass above diminishes, a process that continues for thousands of years after the ice sheet is gone. Locally, this doubles the relative drop in sea level. But globally, the uplifting crust pushes water outward, further raising sea levels around the world.



Satellites have measured absolute annual changes in sea level from 1993 to 2010 (mm/yr), independent of shifts in the height of land.
Courtesy of Carling Hay



Click image to see larger version
A global network of tide gauges records changes in sea level relative to land, which also moves up and down.
Courtesy of Carling Hay

Intuition guides people to think of the ocean as a bathtub, says Mitrovica: add meltwater and sea level rises equally everywhere. He remembers the reaction at a lecture in the Netherlands when he explained that the sea rises most at the places *farthest* from the melting source. "You have less to worry about from the melting of Greenland," 3,000 kilometers away, "than from ice sheets in Antarctica," he explained to his Dutch audience. But even well-educated people trained to challenge intuitive judgments don't believe it, he says. That counterintuitive finding matters today because temperatures are rising faster toward the polar regions, where ice sheets still remain, but the effect on sea level will be felt most strongly far away, along the coasts where much of humanity has settled.

Data from global tide gauges stretching back a century have confirmed differences in the rate of sea-level rise from one place to another. Mitrovica's work not only explained why this is so, but showed how the signals from each melt source—the pattern of progressively higher rates of sea-level rise at locations farthest from an ice sheet—could be disentangled to infer how rapidly Greenland's ice sheets, or those in Antarctica, are melting. Among the places distant from both poles that will be hit hard are the east and west coasts of North America.

Probing the Paleoclimate

DESPITE the public interest in Mitrovica's work, his main focus is neither the present nor the future. He uses geophysics principally to study paleoclimate during, for example, the mid-Pliocene ice age of three million years ago, when "the earth was as warm as we are about to get in the next 100 years—and yet we don't really know how the polar ice sheets fared." Figuring out what happened to them, and by extension, to sea level, he explains, poses "questions that a solid-earth scientist can answer."

At the beginning of his career, Mitrovica never imagined that his research would become politicized.

Focusing on the distant past, he says, also affords him and his students a temporary refuge from politically charged scientific debates: "Sometimes we avoid modern climate questions just because there are thousands of people who study them, and it is nice to be able to take a little bit of time to just think through things. We have had the luxury of doing that more than we would have if we were 100 percent in modern climate research." The reaction to a 2015 paper on modern sea-level rise by his postdoctoral fellow Carling Hay underlines the point. "Carling demonstrated that the rise in global average sea level during the twentieth century proceeded at a slower rate than previously believed," Mitrovica says. Climate-change skeptics pounced, claiming, "'You see, it is not as bad as we thought.'"

"But this was in no way a good-news result," he continues. After taking into account contributions such as melting glaciers and ice sheets, and thermal expansion of the warming oceans, they concluded that global average sea level rose between 1 millimeter (mm) and 1.4 mm annually between 1901 and 1990, significantly less than previous estimates (1.6 mm to 1.9 mm per year). But they estimated that between 1993 and 2010, the average global sea level rose at about 3 mm per year, in agreement with other published estimates. Accordingly, they concluded, sea-level rise from the twentieth to the earliest part of the twenty-first centry is accelerating faster than previously believed, and faster than at any time in the past 5,000 years.

"You write a paper like this, and you think the message is clear, but people can misrepresent the message quite easily. It’s a lesson,” he says. Having been “caught up in that mud that comes from studying modern sea level,” he adds, resignedly, “These are important problems. We will always do them when we feel we have a contribution to make, but the pushback on these issues does make you a little bit weary.”

At the beginning of his career, Mitrovica never imagined that his research would become politicized. He completed his undergraduate and graduate studies at the University of Toronto, a center of plate-tectonics research. His first major paper was on the topography of the American West, where the interior of the continent was under water some 80 million years ago. Debate was raging over whether the land had sunk or the sea had risen. With guidance from a generous colleague, Christopher Beaumont at Dalhousie University, Mitrovica showed that the western half of the North American tectonic plate had tilted downward, causing the ocean to inundate the interior. At the time, he declares, “I can assure you, I wasn’t thinking of it as a sea-level problem. I was thinking of it as a plate-tectonics problem. It never dawned on me that I was entering into what is now called ‘long-term sea-level research.’”

How Earth Shapes Its Climate

MITROVICA CAME to Harvard from Toronto in 2009 for opportunities to expand his interdisciplinary research. “In Toronto, for example, we did no work on ice-sheet stability, and we didn’t look at the statistical analysis of climate signals.” Since arriving in Cambridge, he and his students have “branched out in ways I would not have predicted, and each of them has really made an important contribution.” At Harvard, he landed among people like professor of earth and planetary sciences Peter Huybers, with whom he and his students have collaborated on a number of important papers, and Adam Dziewonski, then Baird professor of science, who pioneered the use of seismic tomography—the measurement of waves propagating from earthquakes—to create images analogous to sonograms of the earth’s interior.

“Earth is not an onion with layers that vary with depth,” Mitrovica explains. “There are large-scale changes sideways.” Imagine for the first time having a tool that “tells you how things vary laterally.” Dziewonski’s revolutionary work revealed the existence of two “large and deep vertical structures” with defined edges, one beneath the continent of Africa and the other under the Pacific Ocean, and thus changed the way geophysicists modeled everything from plate tectonics to deformations in the planet’s shape.

“Earth is not an onion with layers that vary with depth,” Mitrovica explains.

“There are large-scale changes sideways.”

His presence in the office next door also influenced the work of one of Mitrovica’s current graduate students, Harriet Lau. Inspired by seismic tomography, Lau is attempting to develop a parallel technique, “tidal tomography,” using the daily rise and fall in land elevations, like the eight-inch flux observed in Cambridge, to see whether these movements can enhance understanding of the planet’s internal structure. Measured by GPS receivers on the earth’s surface, such “body tides,” which vary by geographic location, are caused by the same predictable forces that drive ocean tides (the gravitational pull of the sun and the moon). The goal of Lau’s ambitious work is to determine whether the two large structures Dziewonski imaged are buoyant, energetically upwelling features, or dense anchors on the slow creep of rock within the earth’s rocky mantle. Answering that question will shed light on the pace of the earth’s evolution since its birth 4.5 billion years ago, a key unresolved issue in understanding how the atmosphere, ocean, geology, and climate have changed over time.

“When most people think of climate, they think of the atmosphere and things like that,” Mitrovica says. “They don’t imagine that the solid earth plays any role in the evolution of the climate system.” In fact, “it plays a crucial role.”

For example, at the height of the last ice age, glaciers covered Canada, Scandinavia, and much of the northeastern United States. Twenty thousand years ago, the glaciers began melting; by 5,000 years ago, they were nearly gone. But how much ice was there at the glacial maximum? Scientists want to know because that will tell them something about ice-age climate and about how the ice sheets responded to cooling and warming.

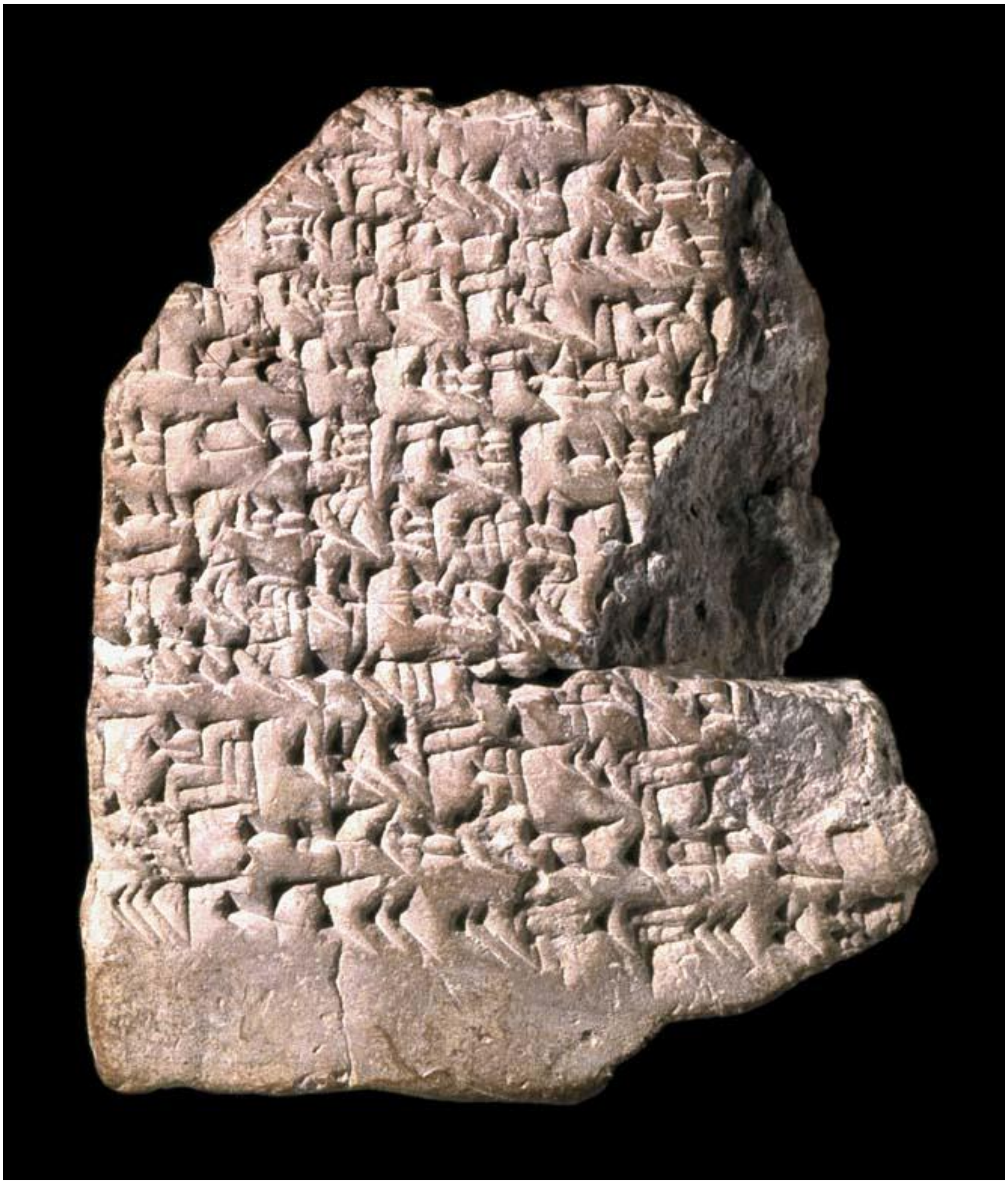
Coral reefs in Barbados, above, reveal changes in sea level relative to land. But did the sea fall, or did the land rise?
Photograph by Bill Thompson/WHOI

One way to estimate the size of those ice sheets, which locked up a *lot* of water, is by reconstructing what happened to sea level as they melted. Scientists often use Barbados as a gauge to calculate ancient sea level because the island lies far from the polar ice sheets' maximum extent. Cliffs of fossilized coral, which grows only underwater, ring the island and record how sea level has changed in the past 20,000 years. But "the problem with that is that Barbados is not a magical meter stick," Mitrovica explains. "It is influenced by a number of solid-earth processes." Some of these geophysical processes cause the island to sink, others to rise. "There is no way to model those processes accurately if you don't know something about the structure underneath Barbados. To get a measure of how much water entered the ocean as the glaciers melted, you have to know how the crust around Barbados" uplifted as a result of forces ranging from plate tectonics to deformations caused by the melting ice itself. Information gleaned from seismic or tidal tomography, he hopes, "will allow us to better constrain that internal structure and improve our estimates of ice volumes."

Several years ago, Mitrovica's graduate student Jacqueline Austermann used seismic imaging of the structure beneath Barbados, which included a portion of a tectonic plate that had descended beneath the crust, to do just that. She found that the existing consensus of a 120-meter rise in sea level was low by as much as 10 meters, or about 33 feet. In other words, an additional volume of water greater than that now stored in the Greenland ice sheet had been missed. (The Greenland ice sheet currently holds enough fresh water to raise average global sea level 20 feet, while the Antarctic ice sheets hold another 200 feet). The melting of that much ice would be sufficient to affect sea level significantly, to deform the earth's crust, and even to affect the axis of the planet's rotation.

"The better we understand the earth's internal structure, the more we can learn about paleoclimate," says Mitrovica. Lau's work, in other words, has an application well beyond describing the structure of the deep earth. "Imagine, she is using tides measured by GPS receivers around the world to improve estimates of ice mass 20,000 years ago," he says. "It is shocking in a way, but more and more scientists are making these connections, and I think that is a really positive development."

Last year, Mitrovica won the Geological Society of America's Day Medal, which recognizes "outstanding distinction in the application of physics and chemistry to the solution of geologic problems." The award was given in part for research that tackled a problem that had been unresolved for nearly 15 years: Munk's enigma. Walter Munk, a renowned professor emeritus at the Scripps Institution of Oceanography, argued that if all the land-based ice that has supposedly been melting for the last century really *has* been melting, the water that was released from polar regions should have flowed toward lower latitudes and the equator—and this redistribution of mass should have slowed the rotation of the earth (much as spinning skaters slow as they extend their arms). But modern satellite observations suggested that the earth's spin has not slowed as much as forecast. Although Munk wasn't questioning estimates of sea-level rise per se, his enigma posed a serious challenge to earth scientists involved in studies of global warming.



Eclipse records, like this Babylonian report written on a clay cuneiform tablet from January 30, 10 B.C.E., reveal that Earth's rotation has slowed through time.
Courtesy of The British Museum
The solution to the enigma required a reanalysis of a very different class of Earth rotation data. Specifically, ancient eclipse records extending back thousands of years from "Babylonian, Chinese, Arab, and Greek astronomers indicate that the earth's rotation has slowed about four hours" in two and a half millennia, Mitrovica explains. Geophysicists have long attributed this slowing to two effects. First, tides crashing on shorelines

apply a brake on Earth's rotation—an effect known as tidal dissipation. The second is a remnant effect of the last ice age. "The earth 20,000 years ago was covered by ice at the poles" and that mass "squished the solid earth down, so that the earth's shape was a little flattened. As those ice sheets melted—and continuing to the present day—the earth has gradually become more and more spherical," and therefore less flattened—and fattened—at the equator. "As it comes back," he says, linking the planet's evolving geometry to figure skaters drawing their arms in—"it's speeding up." These two effects neatly added up to the four hours of slowdown evident in the eclipse record.

But Mitrovica and his colleagues realized that a very important process had been left out of this analysis. Magnetic coupling between the earth's iron core and its rocky mantle has also been causing the rotation of the crust to slow. When Mitrovica's team included this braking effect, the numbers no longer worked. They realized that the ice-age model scientists had been using in their calculations had been inaccurate. The model had to be revised so that all three effects—tidal dissipation, ice-age shape changes, and magnetic coupling—added up to the four hours of slowing.

How does that connect to Munk's enigma, which asked why modern glacial meltwater had not measurably slowed the earth? The answer is a roundabout one. Modern satellite measurements allowed scientists to make an independent measurement of the earth's rotation. When the satellite data were corrected for ice-age effects using the new model that fit the eclipse records, a small, unexplained slowdown was revealed. This discrepancy, Mitrovica says, was precisely the signal one would expect from the melting of glaciers during the past century. Munk's enigma was solved—and another, albeit subtle, perturbation to the progressively warming Earth system was revealed. As Mitrovica explains, "Munk's enigma reinforces my view that significant progress in understanding the real, long-term effects of climate change—past, present, and future—will sometimes require that we look downwards to embrace the complex, dynamic evolution of the solid earth."

Jonathan Shaw '89 is managing editor of this magazine.

MY COMMENT RATED BEST

James Matkin •

Your article about the plasticity of the earth reinforces the flaw of single issue climate alarmists, who only focus on trace increases of C02 AGW (the staff of life for plants by photosynthesis) ignoring other relevant variables THAT CONTRADICT THIS SINGLE ISSUE. For example, recent "the Sea-Ice -Albedo Feedback research" shows a warming planet will have more cloud and snow reversing or at least arresting the warming trend.

Your casual treatment of Greenland melting is weak to say the least. First, failing to note some Greenland glaciers are expanding and not melting and "Despite fears that global warming is harming the Arctic region faster than the rest of the world, Greenland is defying climate scientists and currently growing at its fastest rate in four years."

"The Danish Meteorological Institute reports that Greenland's ice sheet has seen more growth so far this year than in the last four years. Greenland's growth in 2015 is also higher than the mean growth for 1990 to 2011."

See also Rebellious Greenland Glacier Keeps Growing - Length has increased almost 5 kilometers.

http://www.iceagenow.com/Rebel...

"These omissions are often ignored by others not wanting to confuse the public with inconvenient facts, but why did you feel necessary to badly misrepresent the Antarctic ice climate? This is most disheartening. You write - "Mitrovica's work not only explained why this is so, but showed how the signals from each melt source—the pattern of progressively higher rates of sea-level rise at locations farthest from an ice sheet—could be disentangled to infer how rapidly Greenland's ice sheets, or those in Antarctica, are melting. [NOT MELTING] Among the places distant from both poles that will be hit hard are the east and west coasts of North

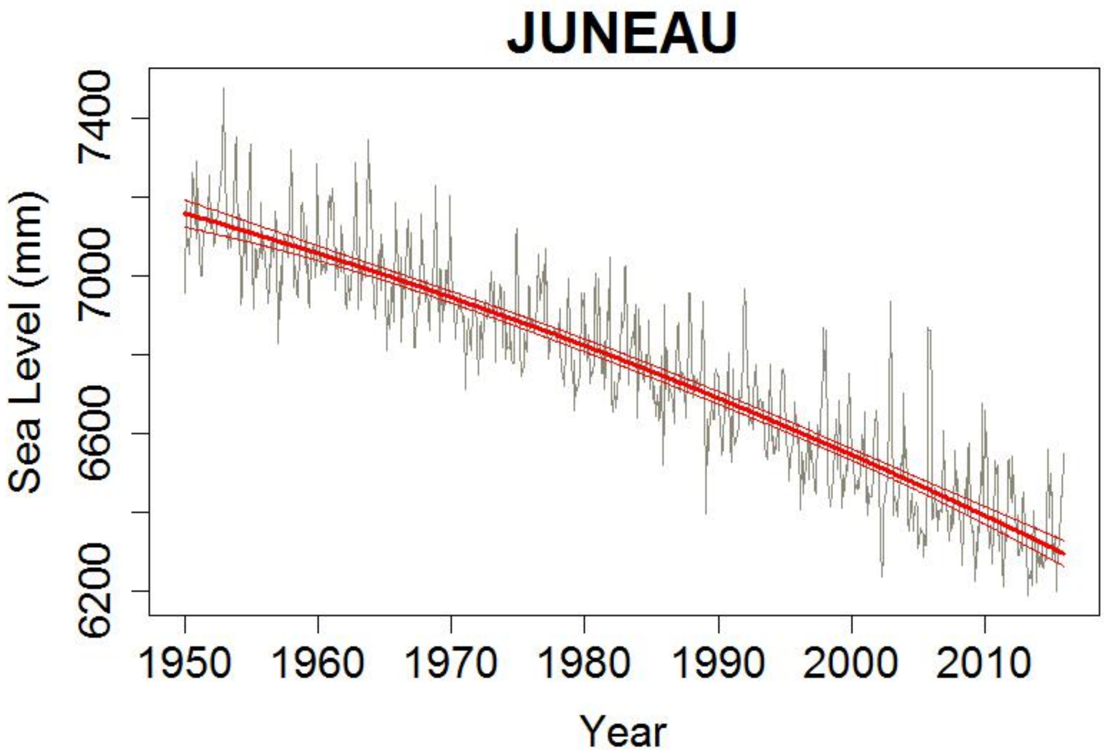
America.
Why do you slough off Antarctica as parallel to Greenland when the former is 10 times more ice and growing. You admit the size difference making your passing off worse. Antarctica ice is EXPANDING FOR PAST DECADES NOT MELTING. It is drawing billions of tons of ice into the sea helping arrest any annual sea rise beyond a fingernail? Many stories support this fact - here is the National Geographic - What Antarctica's Incredible "Growing" Icepack Really Means
A NASA study has climate scientists up in arms; here's what it means.
"Antarctica is actually gaining ice."
"Scientists concluded in the Journal of Glaciology that the loss of glacier mass in Antarctica's western region is being offset by thickening of glaciers on the continent's eastern interior, which has experienced increased snowfall. The result: A net gain of about 100 billion tons of ice per year, according to the report.
"That increase in ice translates to about a quarter of a millimeter per year less sea level rise than was previously predicted, says lead author Jay Zwally, chief cryospheric scientist at NASA's Goddard Space Flight Center in Maryland.
http://news.nationalgeographic...

Dramatic sea level decline is happening in Juneau Alaska, Canada, Scandinavia, Iceland and the Pacific Islands defying the conventional wisdom. Here are some media headlines.

Alaska News

Southern Alaskan sea levels defy worldwide trends

Absolute sea level in the Gulf of Alaska has been falling, contradicting a global trend, according to a new study that focused mainly on the "good news-bad news" situation in Chesapeake Bay on the United States' East Coast. But Alaska scientists have found a more complicated picture.



THE AUSTRALIAN

THE NATION

Sea level fall defies climate warnings

- GRAHAM LLOYD
- TheAustralian
-

  - THE La Nina weather pattern that caused widespread flooding across eastern Australia was also responsible for a dramatic turnaround in sea level rises.
  - Global average sea levels fell by 5mm last year, presenting an inconvenient fact in a climate change narrative that warns of severe long-term threats to coastal settlements.
  - The 5mm decline was almost twice the rate of the 3mm-a-year average increase recorded over the past 20 years and three times the 130-year average rise rate of 1.7mm a year.

- https://www.theaustralian.com.au/news/nation/sea-level-fall-defies-climate-warnings/news-story/41b3c99fc95a4b823e855a83f56e29be?sv=ea83e0b0703ac6fda66c1976fdf615f4

Why is relative sea-level falling in Hudson Bay?

21

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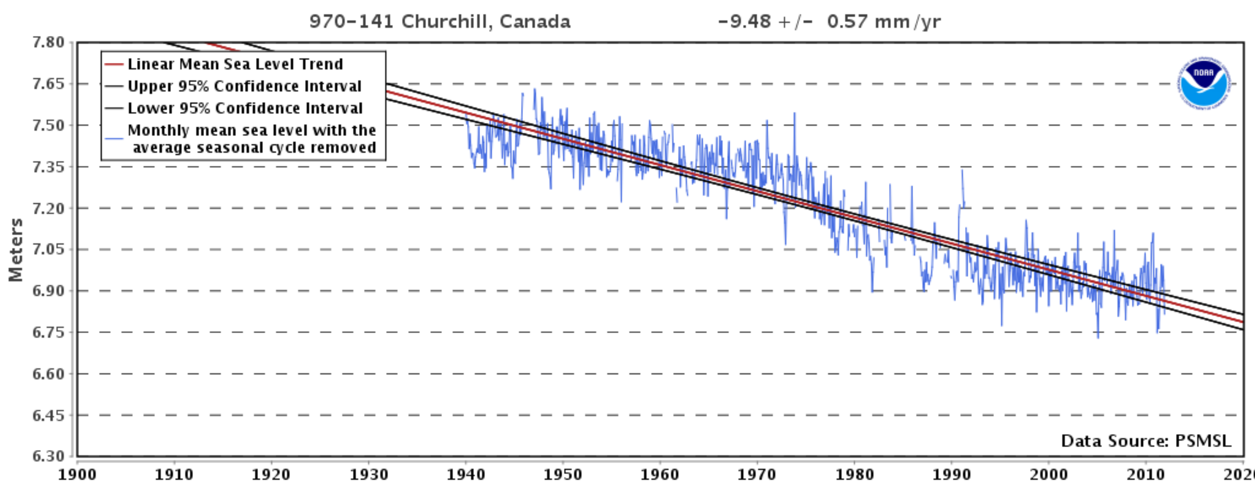
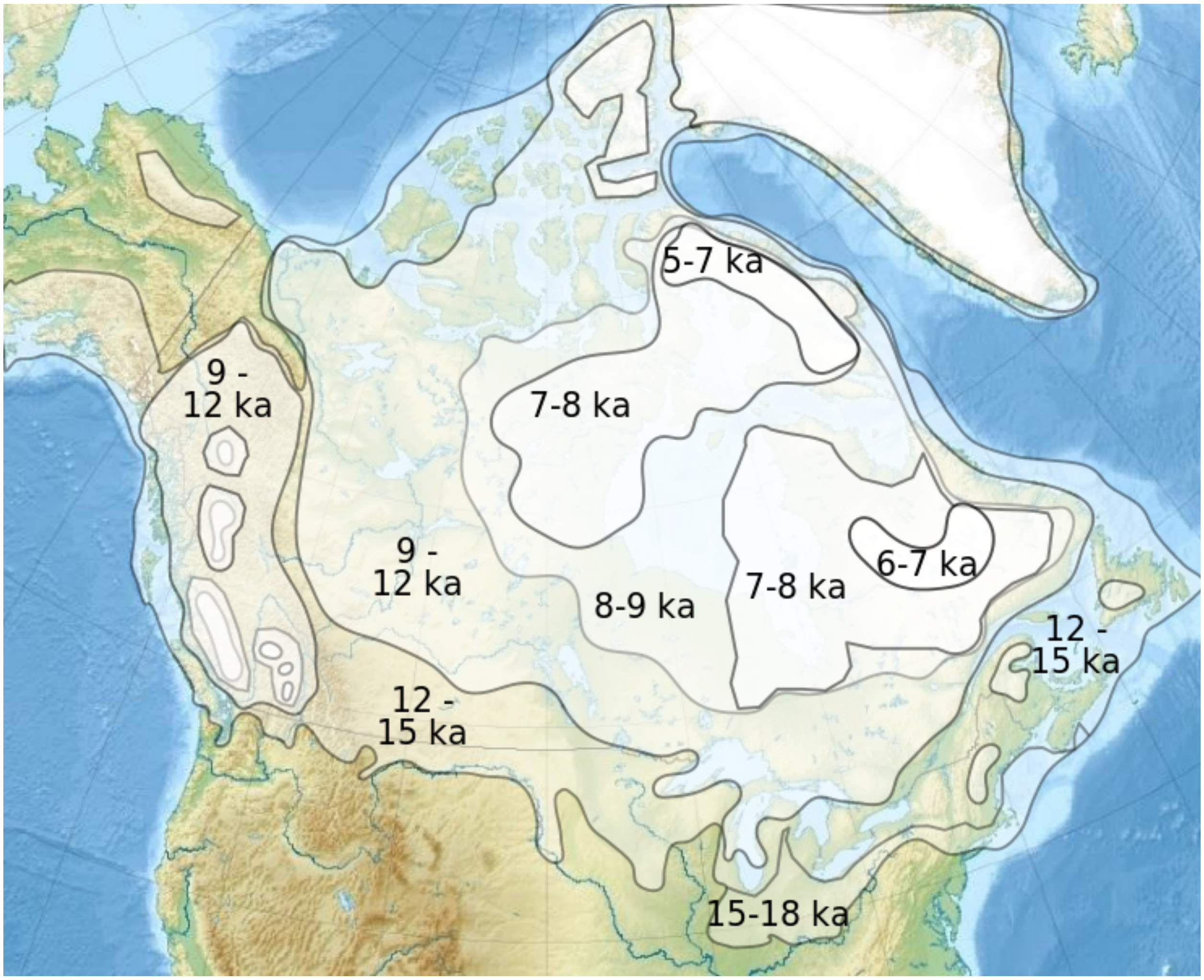
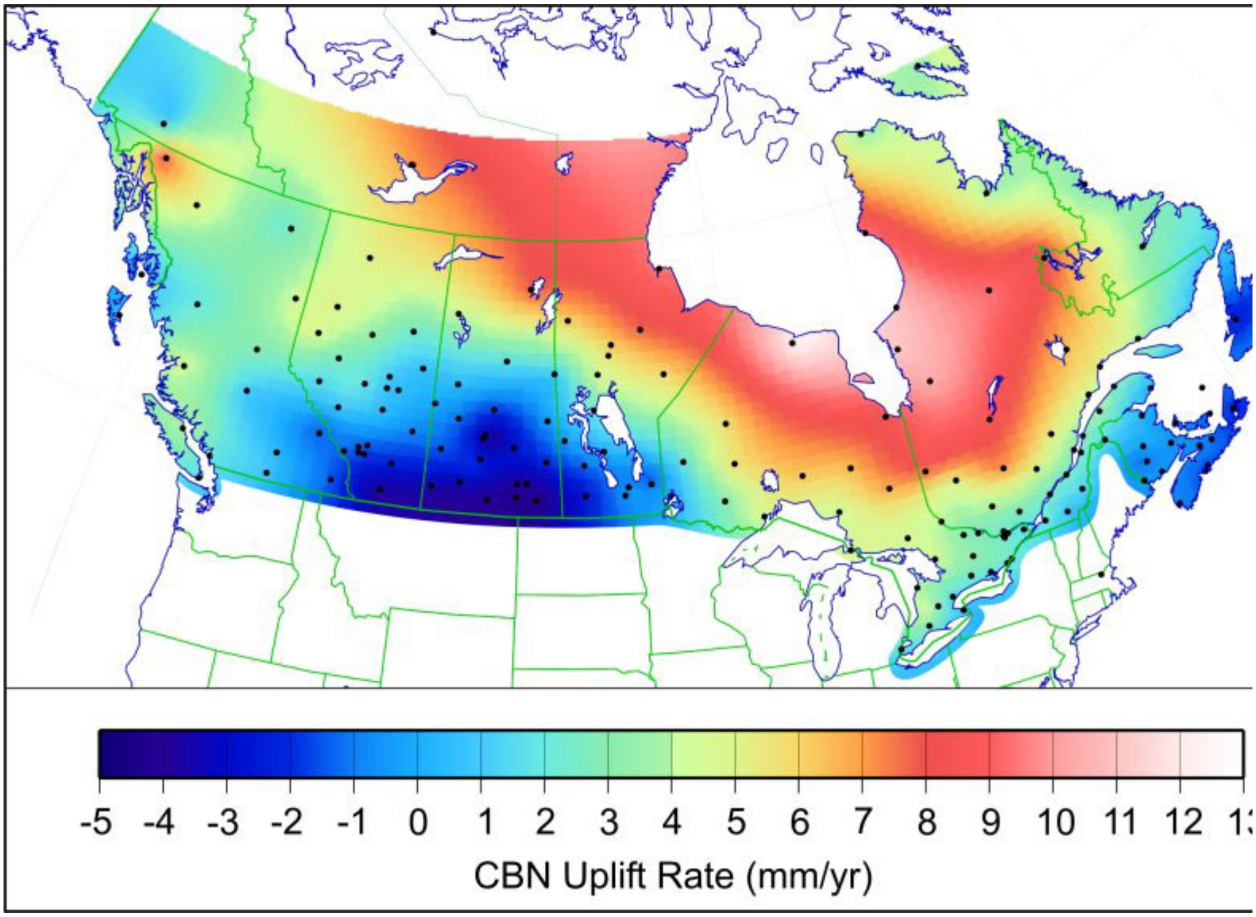


- Why is the sea level in Hudson Bay decreasing so much? Hudson Bay is pretty far up north, much closer to glaciers. Would it make sense for it to recede at this level with sources of fresh water relatively close by.
- **The area is experiencing post-glacial isostatic rebound.**
- Much of Canada was covered in an extensive ice sheet in the last glacial period (the 'Ice Age'), from about 110 ka until 12 ka. The ice in the Hudson Bay area was among the last to melt:



- A thick ice sheet depresses the crust (the lithosphere), making a small dent in the uppermost mantle (the asthenosphere) in the process. Well, not that small: p 375 in Gornitz (2009, *Encyclopedia of Paleoclimatology and Ancient Environments*) says it could be 800 m for a 3000 metre-thick ice sheet!
- Since the asthenosphere is highly viscous, it takes a long time time for the depression to 'bounce' back up. This map from Natural Resources Canada shows the current rate:



- Since *global* sea-level is currently rising at about 3 mm/a, a *local* uplift at this rate will break even. Anything more will result in relative sea-level fall, as we see in Hudson Bay (as well as in Scandinavia, the UK, Alaska, and elsewhere — this map is wonderful).

https://earthscience.stackexchange.com/questions/4728/why-is-relative-sea-level-falling-in-hudson-bay

CLIMATE CHANGE

Iceland Is Rising Out of the Water

Kelsey Campbell-Dollaghan
1/30/15 9:30amFiled to: GEOLOGY

Iceland is rising at the rate of as much as 1.4 inches per year. That's right — the land itself is moving upward.

Ice is heavy, so it's only logical that when it disappears, the material below it rises. But it's still tough to wrap your brain around the findings of three scientists who have shown that as Iceland's ice caps are melting, the land is rising — and fast.

Image: Aljo Hartgers on Flickr/CC.
This month, a study authored by a team from University of Arizona and University of Iceland shows exactly how dramatic the unexpected effects of climate change really are. The paper, Climate driven vertical acceleration of Icelandic crust measured by CGPS geodesy, analyzed data from GPS sensors all over Iceland to measure how much and how often those points of land moved (geodesy is the science of measuring the Earth's surface). The authors kept track of

just how far the sensors shifted over time—and found that those data points told a fascinating and awful story.

https://gizmodo.com/iceland-is-rising-out-of-the-water-1682673365

Glacial isostatic uplift of the European Alps

Jürgen Mey, Dirk Scherler, Andrew D. Wickert, David L. Egholm, Magdala Tesauro, Taylor F. Schildgen & Manfred R. Strecker

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Abstract

Following the last glacial maximum (LGM), the demise of continental ice sheets induced crustal rebound in tectonically stable regions of North America and Scandinavia that is still ongoing. Unlike the ice sheets, the Alpine ice cap developed in an orogen where the measured uplift is potentially attributed to tectonic shortening, lithospheric delamination and unloading due to deglaciation and erosion. Here we show that ~90% of the geodetically measured rock

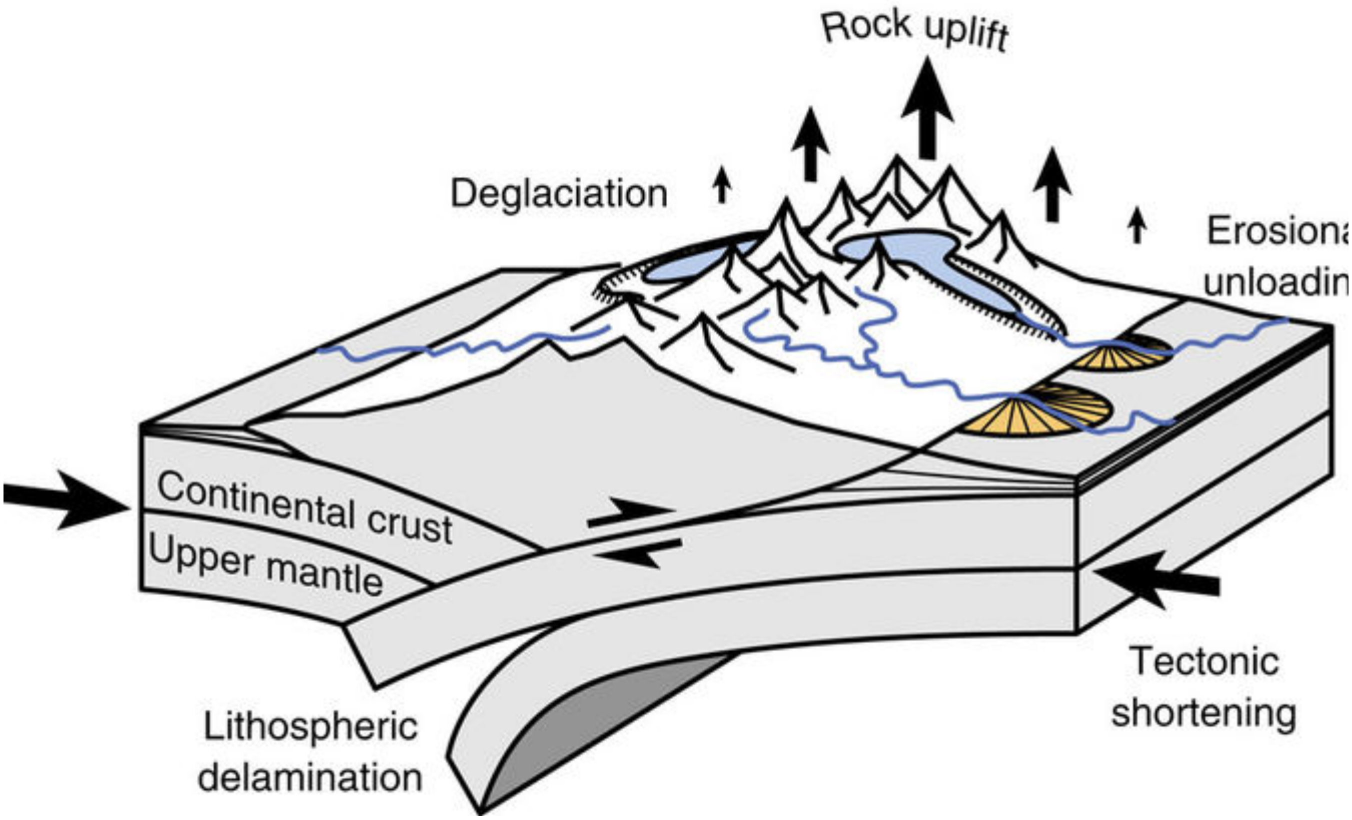
uplift in the Alps can be explained by the Earth's viscoelastic response to LGM deglaciation. We modelled rock uplift by reconstructing the Alpine ice cap, while accounting for postglacial erosion, sediment deposition and spatial variations in lithospheric rigidity. Clusters of excessive uplift in the Rhône Valley and in the Eastern Alps delineate regions potentially affected by mantle processes, crustal heterogeneity and active tectonics. Our study shows that even small LGM ice caps can dominate present-day rock uplift in tectonically active regions.

Introduction

Recent vertical movements of the Earth's crust are mostly due to tectonic deformation along plate boundaries, volcanism and changes in crustal loading from water, ice and sediments[1]. The decay of continental ice sheets caused uplift of the formerly glaciated regions and was the primary cause for the Holocene eustatic sea level rise, which is one of the main concerns of the impacts of global warming on coastal communities worldwide[2]. Changes in the ice load of tectonically active mountain ranges, such as the Alps, the Alaska Range or the Himalaya, although much smaller, nevertheless trigger an isostatic response. The induced surface uplift and/or subsidence is thought to have caused changes in fluvial networks[3], and the resulting stress changes in the Earth's crust can influence crustal deformation and seismicity[4] and might have triggered some of the largest intraplate earthquakes since last glacial maximum (LGM) deglaciation[5]. The key controls on how the Earth responds to changes in crustal loading are the viscosity of the upper mantle and the lithospheric effective elastic thickness (EET)—a geometric measure of the flexural rigidity of the lithosphere, which describes the resistance to bending under the application of vertical loads[1]. Most previous estimates of mantle viscosity come from old and tectonically stable continents, where the vertical motion can almost entirely be attributed to postglacial rebound[6]. In contrast, the complexity of the uplift signal in tectonically active orogens requires the relative contribution of different potential driving mechanisms to be disentangled.

For half a century, the cause for recent uplift of the European Alps has been debated. Possible drivers of uplift include postglacial rebound[7], erosional unloading[8], tectonic deformation[9], lithospheric slab dynamics[10] and combinations thereof (Fig. 1). Some of these processes, such as lithospheric delamination, manifest themselves on timescales of ∼106–107 years, whereas others, such as postglacial rebound, occur relatively rapidly (∼103 years). New approaches to modelling orogen-scale sediment storage[11], glaciation[12] and spatial variations in EET (ref. 13) provide new constraints for estimating the contribution of glacial isostatic adjustment (GIA) to present-day uplift rates in the European Alps.

Figure 1: Processes contributing to rock uplift in a contractional orogen.

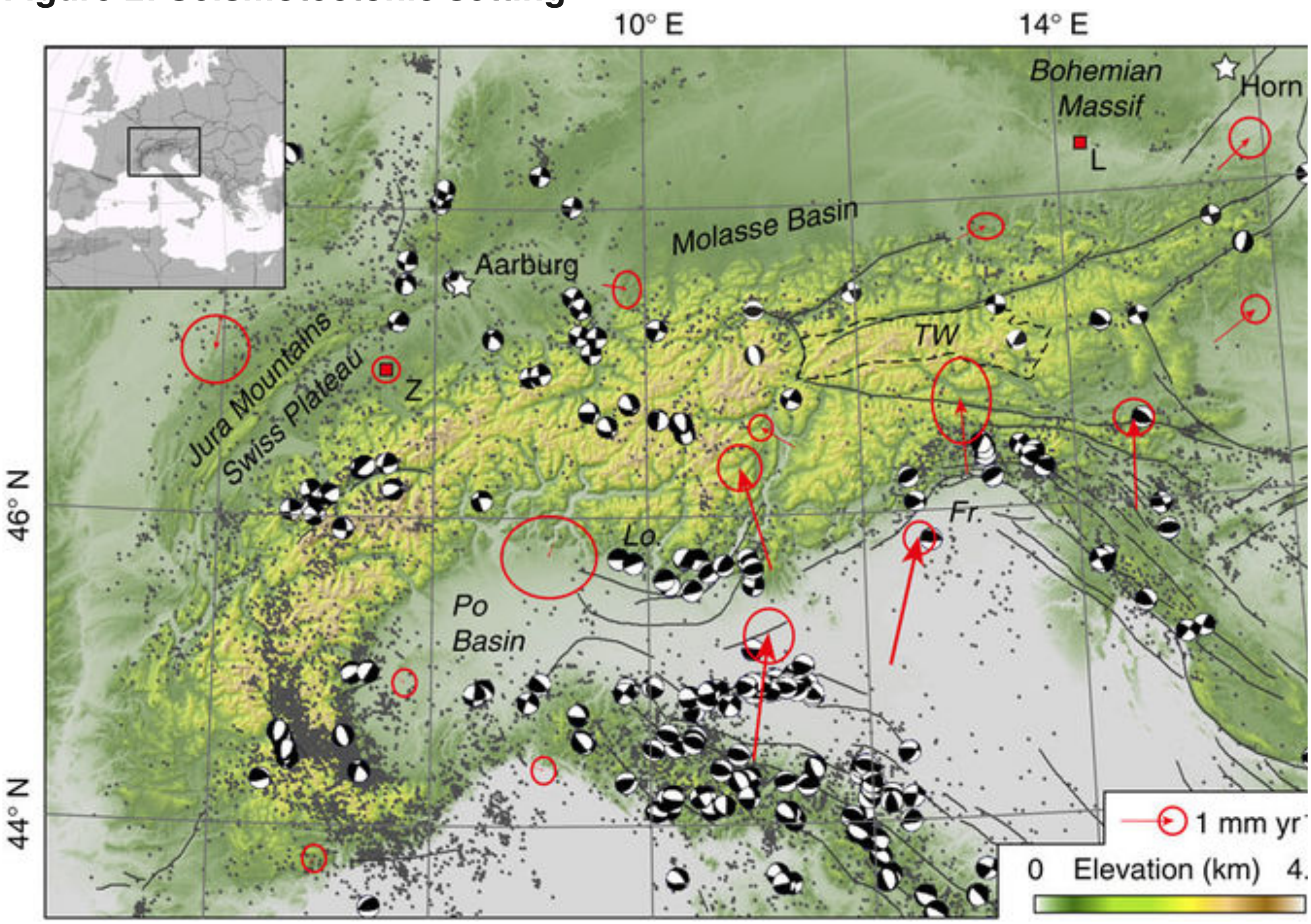


The individual components are interdependent and their relative contribution to rock uplift changes over time. Blue and orange polygons indicate glaciers and alluvial fans, respectively.

Full size image

Mountain building in the European Alps is due to the convergence of Africa and Eurasia beginning in the Mesozoic with continental collision culminating in the Eo-Oligocene[14]. A late phase of outward tectonic growth in the Early Miocene created the Jura Mountains and thrusting of the Swiss Plateau[14] (Fig. 2). Further tectonic shortening was accompanied by eastward extrusion of the Eastern Alps and exhumation of metamorphic domes in the Central Alps[15]. The cessation of outward tectonic expansion of the Western and Central Alps during the Late Miocene might reflect an increase in the ratio of erosional to accretionary material flux and the onset of orogenic decay[16]. During the Pleistocene, the Alps were repeatedly glaciated with ice caps that covered almost the entire mountain belt and substantial parts of the northern foreland[17]. Locally, glaciation was presumably associated with a twofold increase in exhumation rates[18],[19] and topographic relief[20], which may be controlled by feedbacks between glacial erosion, crustal unloading, isostatic uplift and deep-seated processes.

Figure 2: Seismotectonic setting.



Seismicity (grey dots, NEIC, 1973–2008), focal plane solutions[63] and seismogenic faults (black solid lines, http://diss.rm.ingv.it/share-edsf/) superimposed over a DEM of the study area. Red arrows depict the horizontal velocity field of permanent GPS stations in a Europe-fixed reference frame[64]. Error ellipses show 1-sigma (67%) confidence level. Stars indicate locations of the reference points for the Swiss and Austrian precise levelling data, respectively. 'L' and 'Z' are the locations of the permanent GPS stations used to adjust the levelling data to the global reference frame IGb08. Fr., Friuli; Lo., Lombardy; TW, Tauern Window.

Full size image

Permanent global positioning system (GPS) stations indicate ongoing crustal convergence of 1–2 mm yr−1 across the Eastern Alps (Fig. 2) that is controlled by the counterclockwise rotation of the Adriatic plate[21]. The convergence is accommodated by thrusting in the Italian Friuli and Lombardy regions and by eastward extrusion along strike-slip faults[15,21]. In the Central and Western Alps, however, only minor or no crustal shortening can be detected[22] and earthquake focal plane solutions are dominated by extensional and strike-slip mechanisms (Fig. 2).

In this study, we re-evaluate the effect of GIA on the present-day rock uplift in the Alps while accounting for postglacial erosion, sediment deposition and variations in lithospheric strength. We show that most of the postglacially eroded material was trapped within the mountain belt and did not contribute to erosional unloading as previously suggested[8]. Instead our results demonstrate that the long-wavelength uplift signal is best explained by the Earth's viscoelastic response to ice unloading after the LGM. We conclude that present-day uplift rates in other tectonically active and glaciated mountain belts could also carry a component related to LGM deglaciation.

https://www.nature.com/articles/ncomms13382

Why Are Sea Levels Dropping In Places Closest To The

Melting Glaciers?

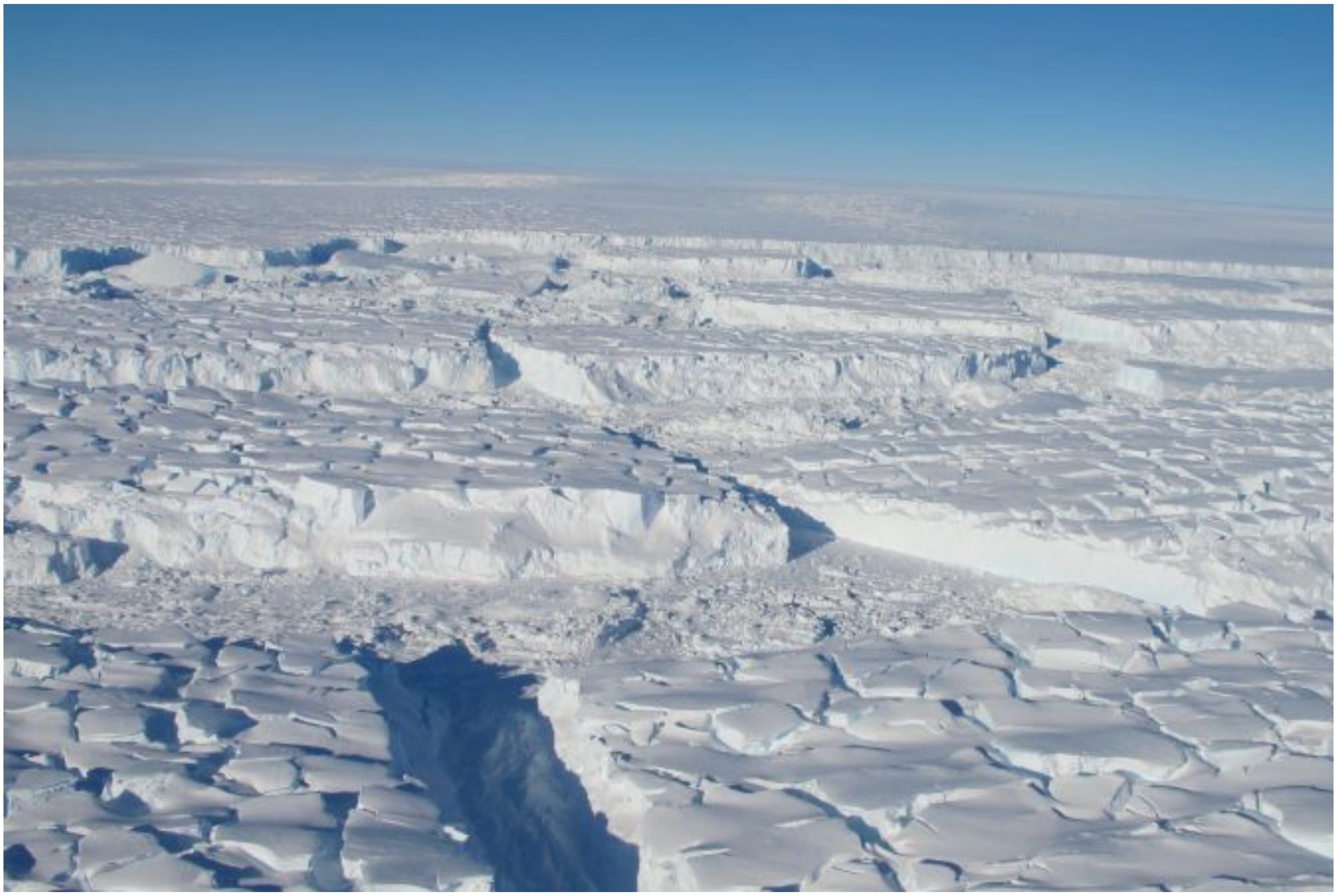
Mika McKinnon
2/09/15 2:10pmFiled to: EXPLAINER

Our dynamic planet has an apparent paradox: the more ice melts from landlocked glaciers, the lower the sea level gets in nearby areas. How does this happen? Through the physics of isostatic rebound, when the surface of the planet acts as an elastic sheet dimpling and rebounding under changing loads.

Perito Moreno Glacier in Argentina is one of the few terrestrial glaciers advancing in modern times. Image credit: Frank Kehren

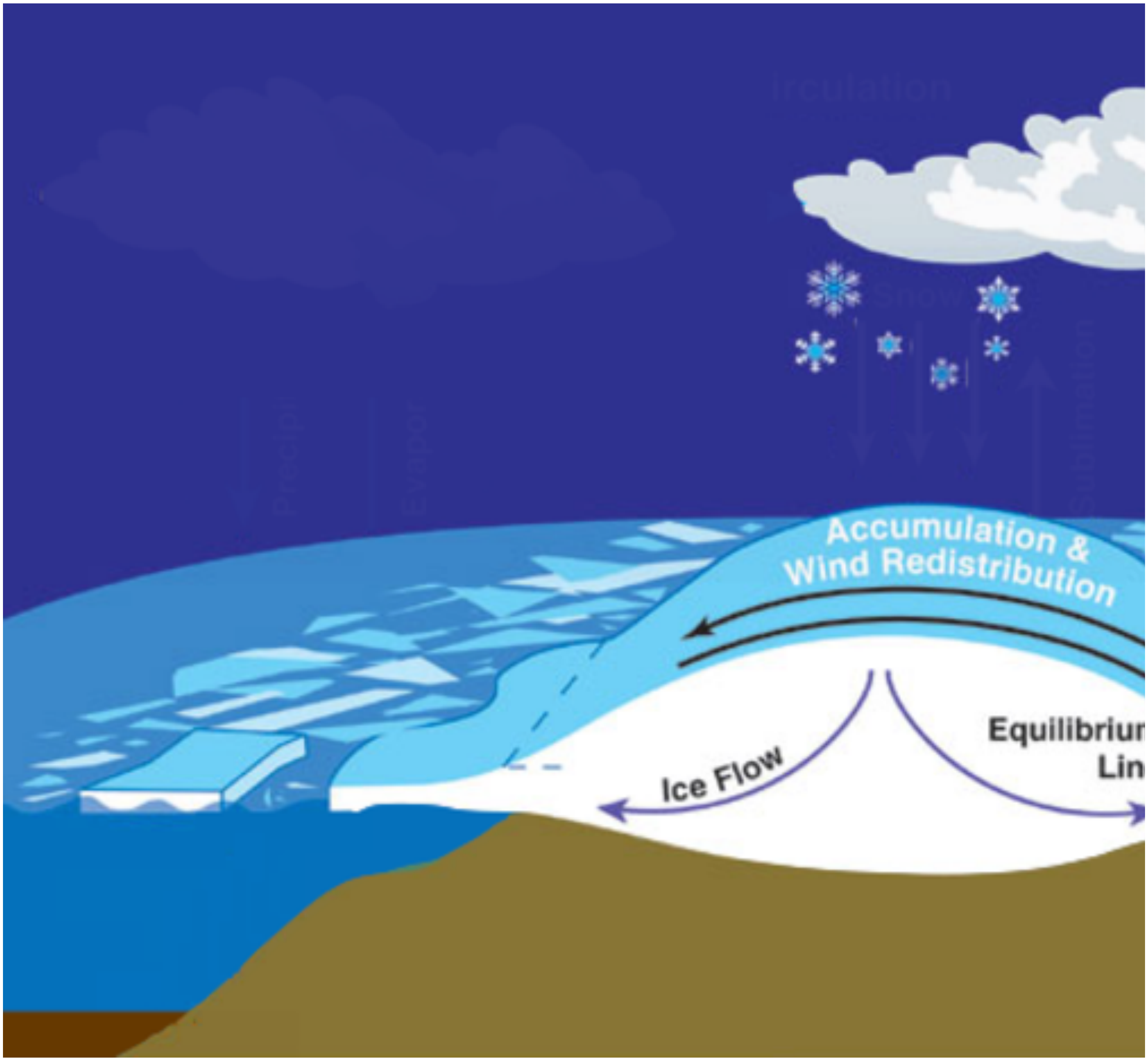
Rocks seem so very solid from our puny human perspective. Things are rock hard, rock solid, and are reliable as the rock itself. But from a geological perspective, rock is an elastic sheet that encompasses our planet in a thin, flexible membrane that responds to every disturbance.

Nowhere is this more evident than with isostatic rebound, a process of geological buoyancy by which the earth's crust, having sunk beneath the weight of glaciers from a preceding ice age, bounces up as ice sheets melt and the water runs back into the sea. While this melting ice is filling the oceans, the land can rebound so quickly that it rises even faster than the climbing sea level. The result is an apparent paradox: where continental glaciers are melting and exposing the land, the local sea levels are dropping.



The Thwaites ice shelf in Antartica as surveyed in October 2013 by Operation IceBridge. Image credit: James Yungel/NASA

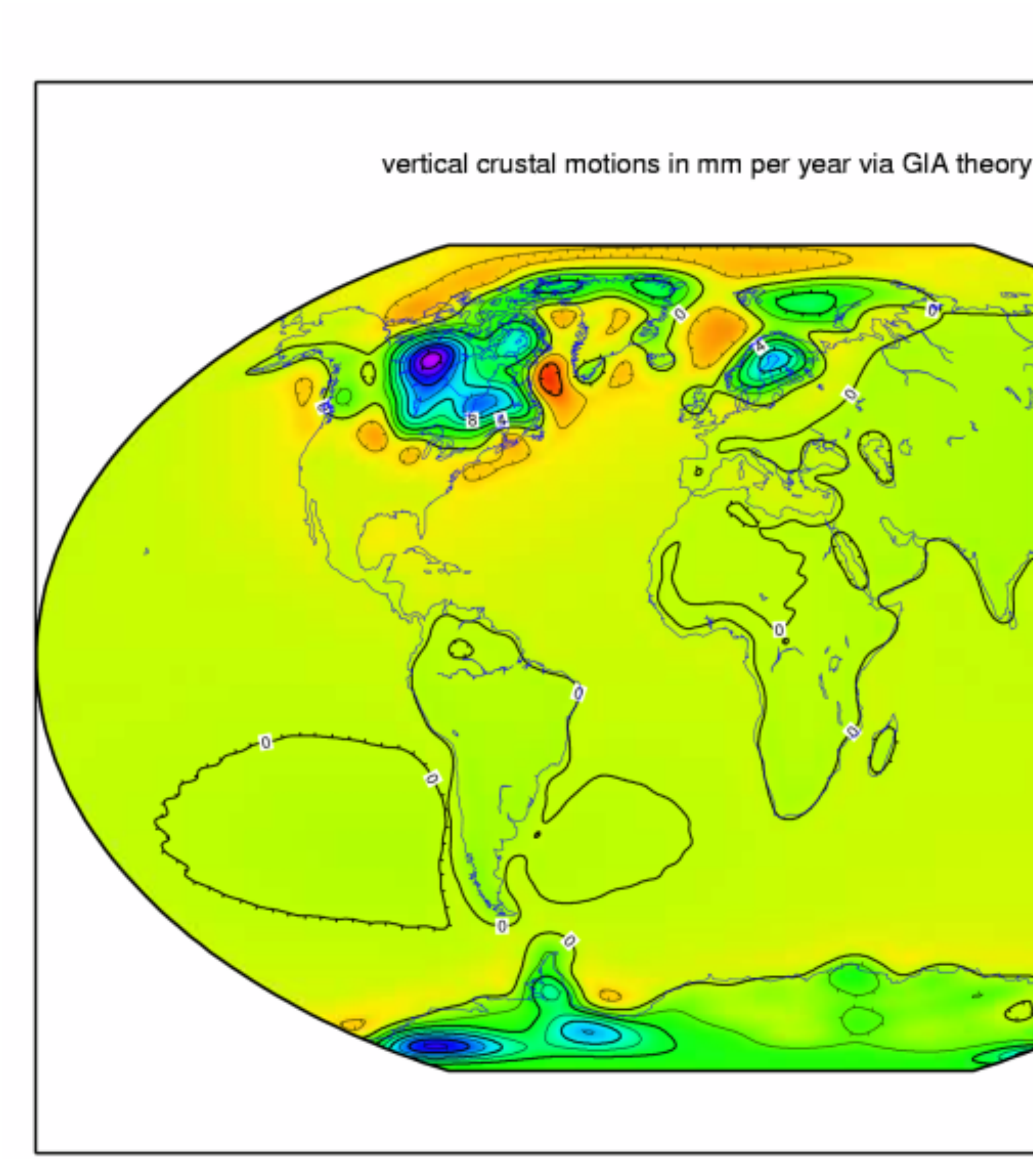
During each ice age, massive glaciers crawl across the land. These vast ice sheets contain an enormous quantity of water. And water is very, very heavy.



The crust and mantle deform under the weight of ice sheets. Image modified from NASA

During the last ice age 15,000 to 20,000 years ago, Canada and the United States were groaning under the weight of the Laurentide and Cordilleran ice sheets while Scandinavia struggled under the Fennoscandian ice sheet. The Earth's lithosphere, the rigid crust and uppermost mantle, buckled under the weight of up to 3 kilometers of ice. Like an iceberg floating in water with a vast root hidden under the waves, the crust sank into the mantle until hitting a buoyant balance between the weight of ice and rock over hot mantle. Kept under load for thousands of years, the lithosphere flowed and deformed to reach equilibrium under the new normal.

When the world shook off the ice age, the ice sheets melted quickly. The land was bare in a geologic heartbeat, lifting the weight far, far faster than it built up millennia before. The elastic crust rebounded nearly instantaneously, bouncing back like a balloon's surface freed from an aggressive squeeze. But the more viscous mantle was slower to reach equilibrium in the new isostatic regime, driving slow uplift as the mantle flowed under the dented land. The rebound is ongoing today, with the land recovering at centimetres per year. With the rebound rates akin to the speed at which fingernails grow, it will take another 10,000 years before the land recovers from the last ice age.



Global rebound rates as the world adjusts from the last ice age.
Image credit: A. Paulson/S. Zhong/J. Wahr

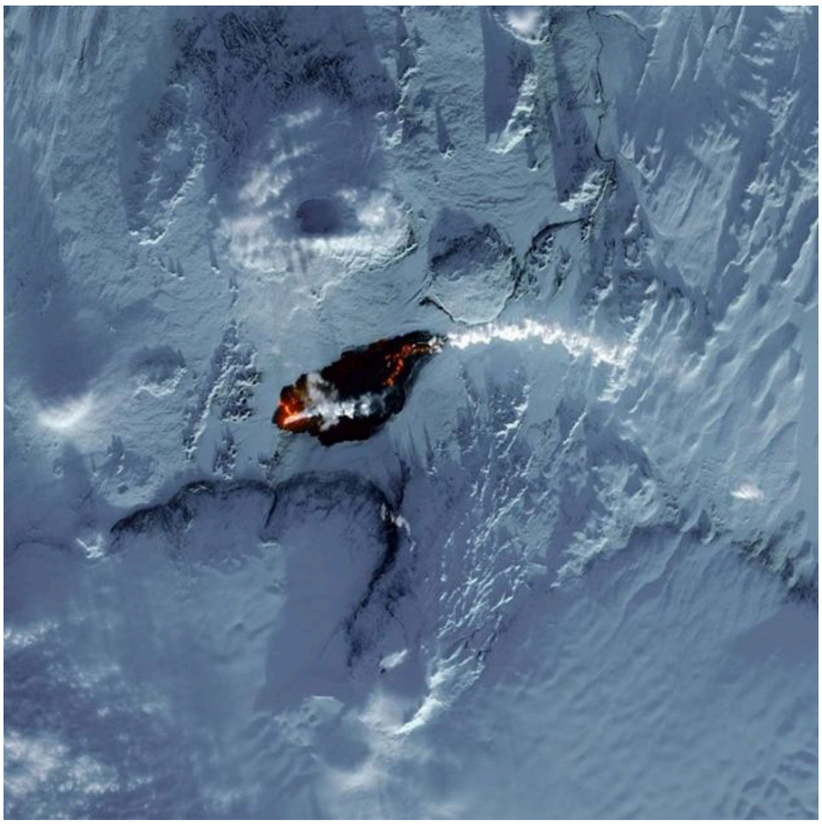
The same story is happening everywhere that was covered in ice: the lithosphere buckled under the massive weight of ice sheets, and has been slowly recovering in the millennia since they were exposed. From the Antarctic still shedding weight to Canada's Hudson Bay racing upwards at nearly 2 centimeters per year, the surface of our planet is literally reshaping beneath our feet. For people in the far north and south of our planet, every time they trim their nails they can reflect on how much higher their home has bounced since the last manicure.

As the lithosphere rebounds, it carries the entire landscape with it. Sea cliffs and rivers are stranded far above their formation location, and strandlines of past beaches are laid out in beautiful, delicate features tracing sea levels long gone. Even the tilt of the land changes: drainage patterns struggling to adjust to keep water flowing downhill.

A stranded river cuts a new waterfall as the land rebounds above the sea in Alaska. Image credit: Jim & Laura Massie

The arrival and release of weight impacts the stress of the entire region, potentially triggering earthquakes and volcanoes. Before fracking and injection wells made a mess of the continental interior, the biggest causes of intraplate earthquakes far from plate tectonic boundaries were attributed to the shifting stresses of isostatic rebound. These impacts can be far-reaching in both space and time: despite being ice-free, the infamous 1811 New Madrid earthquake in the American south may have been induced by intraplate stresses induced from the last ice age.

The same thing is happening for volcanoes. A key trigger of eruptions is changing in the subsurface pressure and stress adjustments in the magma chamber. As the lithosphere flexes and recovers, this redistribution can be enough to fuel a surge in volcanic activity. Right now, the released pressure in Iceland could be fuelling a surge in volcanism, magma chambers long kept confined expanding and pushing out into surface eruptions from the flight-disrupting Eyjafjallajökull to the ongoing slow, steady trickle of Bárðarbunga.

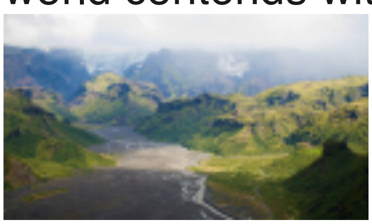


The Bárðarbunga eruption in Iceland is spilling across the country's terrestrial glaciers. Image credit: NASA

But most fascinatingly of all, isostatic rebound is the secret process behind how locations can have sea levels changing at odds with the rest of the planet. While we all know about global sea levels rising and falling, geologists also track local sea levels, the relative change in sea level at particular locations.

During an ice age, water once free to flood the oceans is tied up in continental ice sheets. This drops global sea levels, exposing seafloor as the new coastline. Yet the land with these new ice sheets is under load, dropping down relative to its former height. Relatively speaking, despite the global sea levels falling, the local sea level can actually rise.

Right now, we're distinctly not in an ice age. The land-bound glaciers are melting, and sea levels are rising from both the influx of released water and thermal expansion. And yet, for the places suddenly relieved of their frozen load, the land itself is rebounding higher above the waves, maybe even faster than the grasping clutch of the sea. Determining just how quickly each process is occurring is a jumbled mess of scrambling to monitor rapidly changing data to calibrate our models, but for now, parts of Iceland, Greenland, and Canada are climbing faster than their sea levels. From the perspective of beach-side homes, the relative sea level is staying stagnant or even dropping while the rest of the world contends with higher storm surges and floods.



Iceland Is Rising Out of the Water

Iceland is rising at the rate of as much as 1.4 inches per year. That's right — the land…

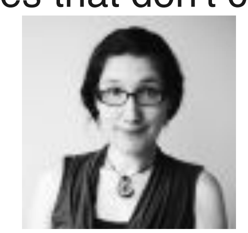
Read on **gizmodo. com**

Strandlines mark the relative sea level change from isostatic rebound in Bathurst Inlet, Nunavut. Image credit: Mike Beauregard

Isostatic rebound is just one example of how the surface of our planet is a dynamic, changeable place where the materials behave far differently in aggregate than we perceive them from our daily perspective.

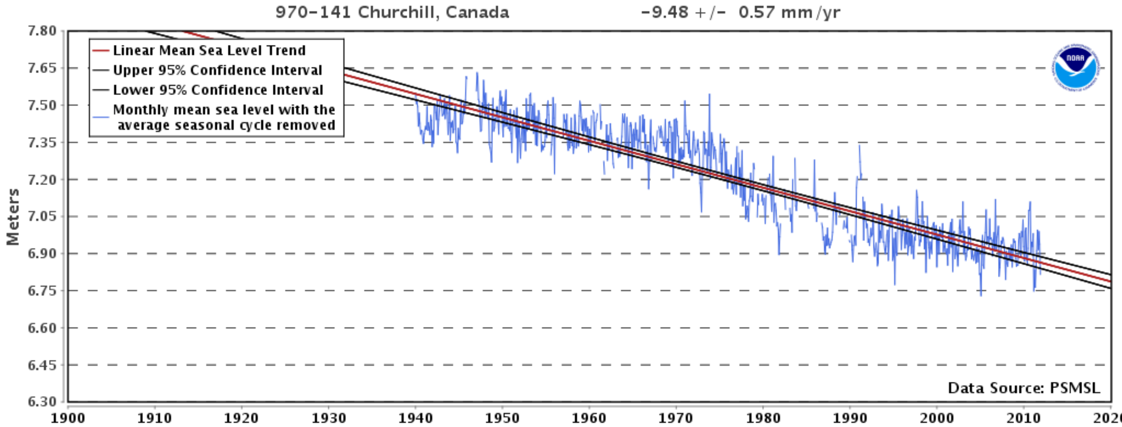
Discussion

old Shuck ate bob_d Mika McKinnon2/09/15 5:38pmPlus, the gravitational pull of those masses of ice is significant to sea levels as well - it causes the oceans to "mound up" around the coasts to a significant degree. (The ocean is *really* not flat.) So there are two mechanisms that cause the sea to recede where ice is disappearing. This also, of course, means that the sea level will rise that much more in places that don't currently have glaciers.2Reply



Mika McKinnonold Shuck ate bob_d2/09/15 6:29pmThis is like going down the rabbit hole — I swear we can always go into one more level of complexity!Your browser does not support HTML5 video tag.Click here to view original GIFThe planet isn't a sphere. It's a weird, lumpy geoid where the surface of gravimetric equipotential is bulging and distorted and freakish.

Then we have sea level, which bulged up by wind, tides, gravity, temperature, salinity, and so much more. Then we have the tectonic plates, with areas of uplift and rebound, and the land itself with subsidence, erosion, and deposition. When looking at sea surface topography maps, it's important to understand what exactly they're mapping. Is it the topography relative to the geoid, or to the simplified ellipsoid? Is it an absolute height away from the mean sea level, or an anomaly compared to another fixed point in time? How much of it is responding to the changing gravitational field influenced by geodynamics and tides, how much by temperature, and how much by wind? It's a totally delightful mess of complexity; you can keep reading about the challenges here.Your browser does not support HTML5 video tag.Click here to view original GIFOne of the things I love about science is that each of these facets is subject to dedicated research projects with people devoting their lives to monitoring and understanding exactly what is happening. But one of the challenges about trying to communicate this science is how thoroughly interrelated everything is: it is nearly impossible to talk about just one part without ended up hitting all the other tangents!This is part of what makes precise predictions of sea level rise so difficult. The global problem is complicated enough — how thermodynamics will change with an influx of cold water but hotter surface temperatures and subsequent thermal contraction and expansion, and a million other equally complex questions. But then adding in all the local exceptions from uplift, rebound, subsidence, erosion, exposure, human engineering, and all the other messy details of real life? Ugh. Near futility.



Comment

The evidence is overwhelming and compelling concerning the release of gravity as ice sheets decompose and lose mass. The piece is without a mention of the word "gravity" or anything else essential (Why Are Sea Levels Dropping In Places Closest To The Melting Glaciers?).

Explainer: how do you measure a sea's level, anyway?

May 19, 2015 5.54am EDT

Author

1.  Gary Griggs

Director, Institute of Marine Sciences and Distinguished Professor of Earth & Planetary Sciences, University of California, Santa Cruz

Disclosure statement

Gary Griggs does not work for, consult, own shares in or receive funding from any company or organisation that would benefit from this article, and has disclosed no relevant affiliations beyond their academic appointment.

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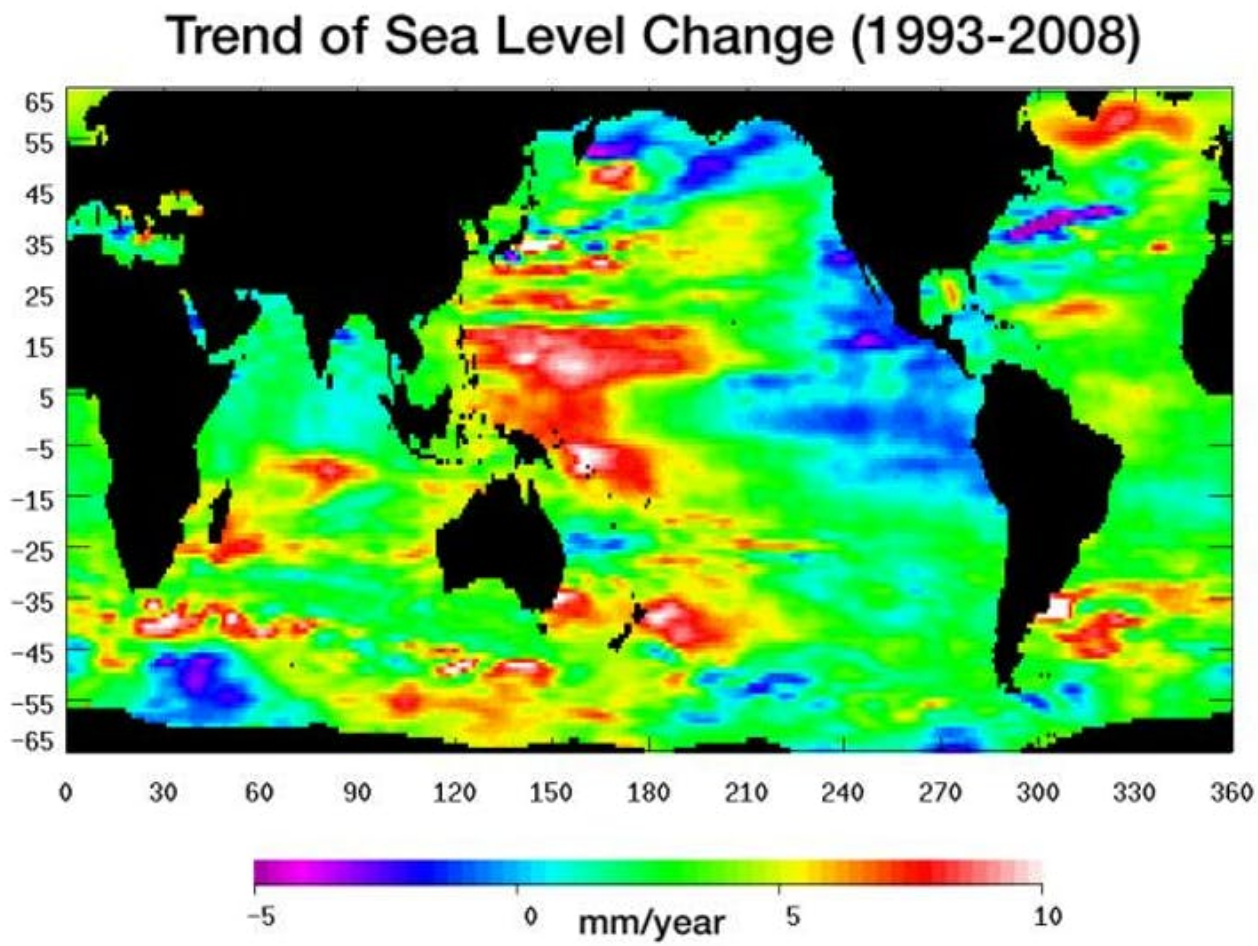
OK, but which sea's level? And how do you know what it is?

There are about 330 million cubic miles of water in the world oceans today, 97% of all the water on the planet. Early in our planet's 4.5 billion year history, water from the atmosphere and from the interior of the Earth gradually collected in the low areas on the planet's surface to form the ocean basins, accumulating salts along the way.



Sea level change between 1993 and 2008. NASA/JPL

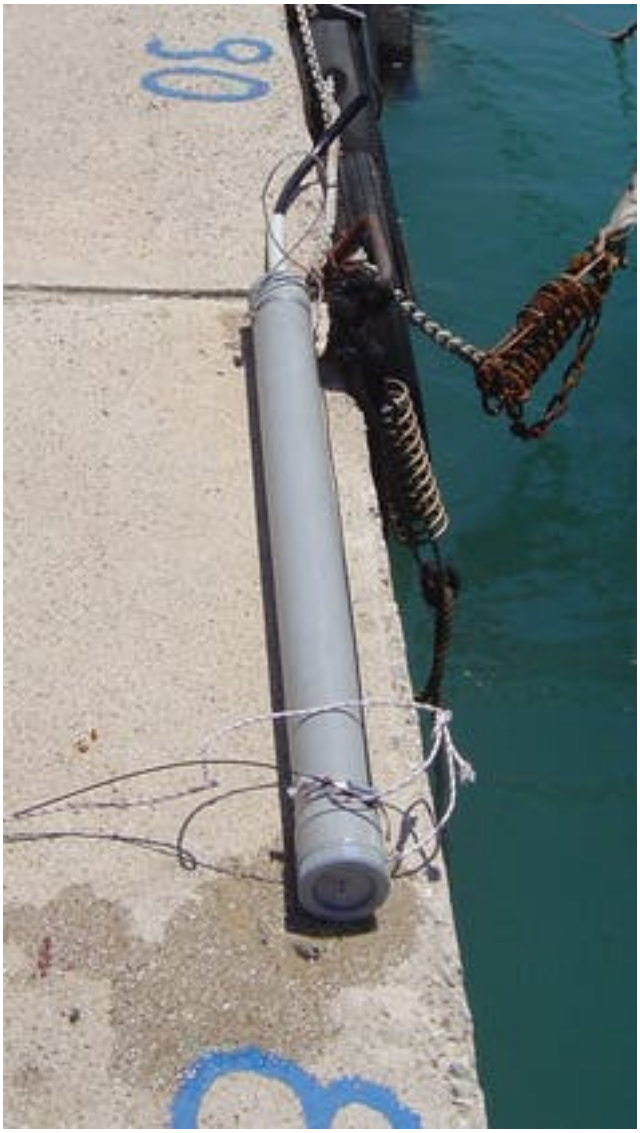
The level of the ocean around the Earth, and therefore the location of the shoreline, are directly related to the total amount of water in the oceans, and also closely tied to climate. As climate changes, so does sea level.

Throughout the history of the oceans, which goes back about 3.5 billion years, give or take a few million, climate has constantly changed and, in response, sea level has gone up and down. As seawater warms, it expands and sea level rises. As the Earth warms, ice sheets and glaciers melt and retreat, adding more water to the oceans, which raises sea level.

Installing a tide gauge in Alaska. NOAA Photo Library, CC BY

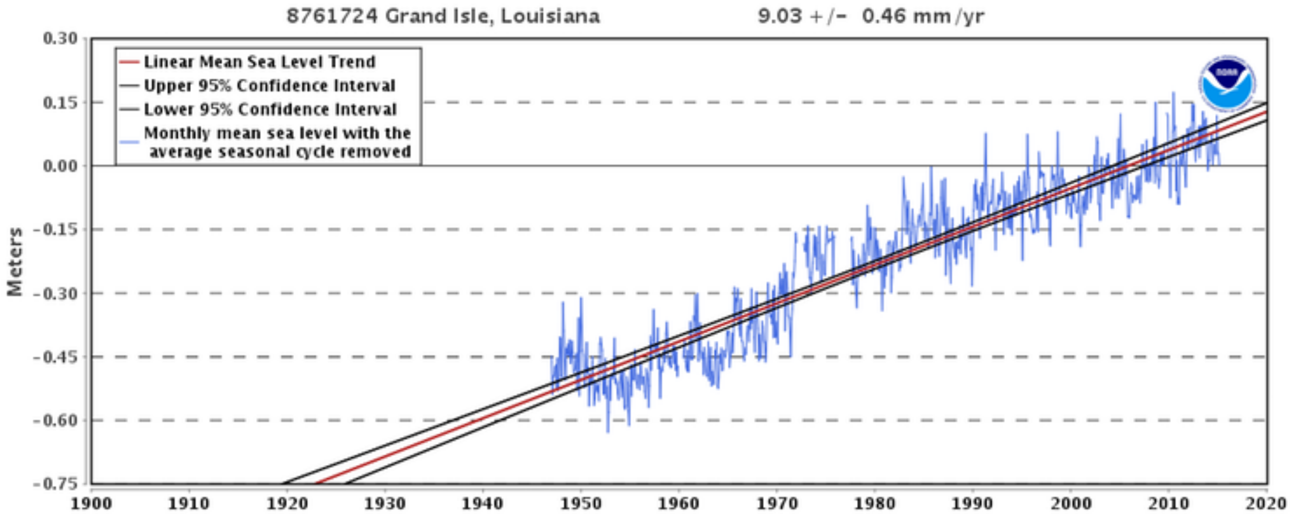
People have been keeping track of sea level, or the elevation of the oceans, for about 200 years. Until fairly recently, this was done with tide gauges, which are water-level recorders anchored to some structure along the coastline. It might be a wharf, a concrete breakwater or some other solid structure that is stable over long periods of time.

The oldest tide gauge in the world is on the coast of Poland and was installed in 1808. In the United States, there are two tide gauges that have been in operation since 1856, one in New York and one in San Francisco. There are many others as well, but most of them are much newer; many were set up over the past 50-75 years.



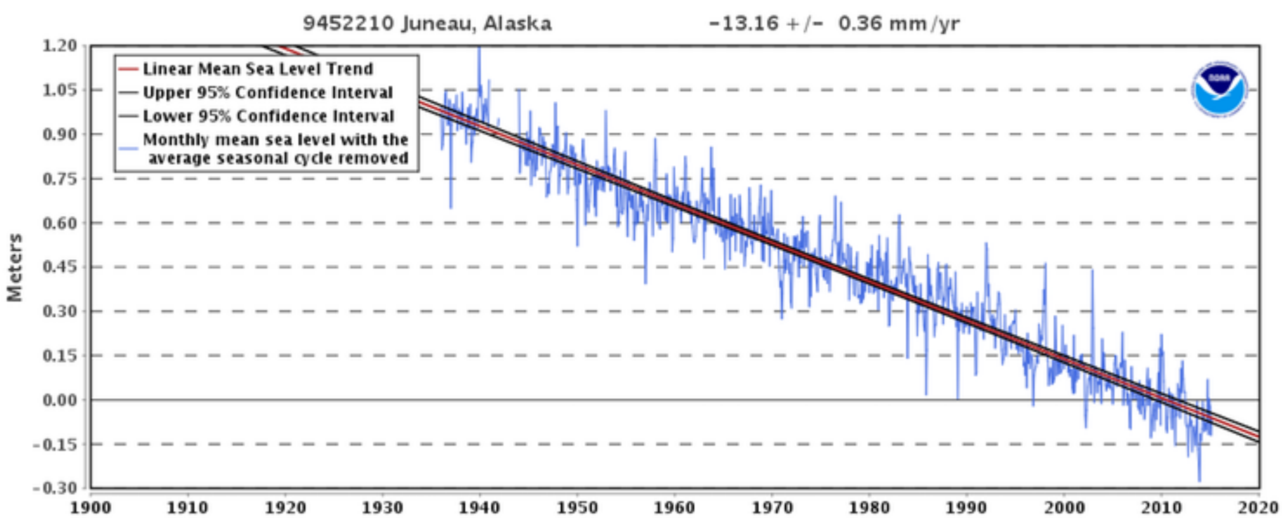
A tidal gauge, ready to be installed. David Monniaux, CC BY-SA
A tide gauge is essentially a large pipe inserted into the ocean, which has a float inside that moves up and down as the water level changes. As the tide rises and falls each day, these gauges record those changes in water level, day after day, year after year.

These instruments were first set up to provide accurate information on water depths so ships could enter and leave ports safely. As time went on, however, it became clear that sea level recorded on these instruments was rising globally.



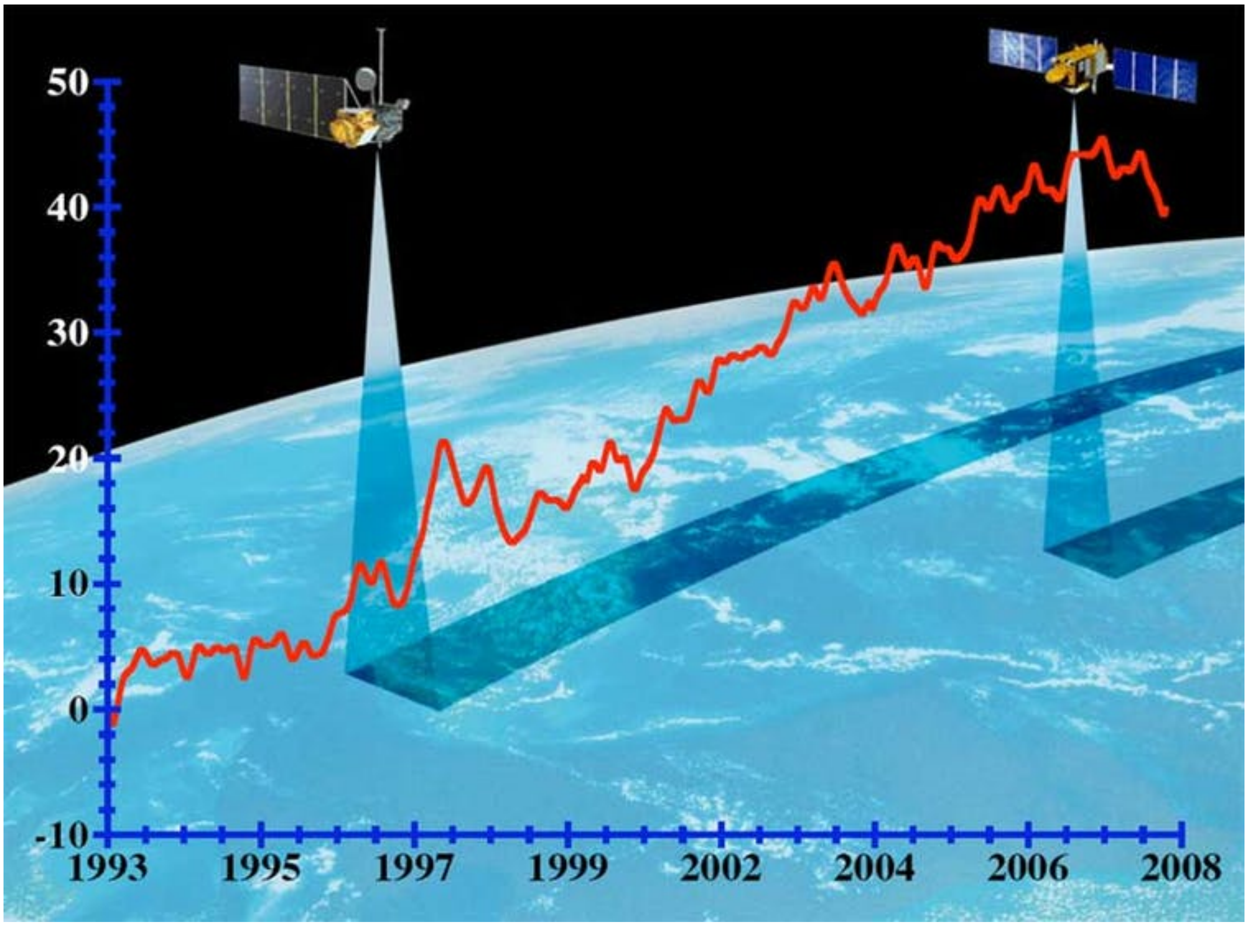
NOAA tide gauge data for Grand Isle, Louisiana (near New Orleans), where sea level is rising relative to the land at 9.03 mm/yr (36 inches/century) due to subsidence of the Mississippi delta area. NOAA

Each of these official tide gauges keeps track of sea level at a particular coastal location. Many coastal areas are not stable, however. Some are sinking (such as New Orleans or Venice), and some are rising (Alaska and Scandinavia, for example). Each tide gauge keeps track of how sea level is changing relative to the land on which it is anchored.



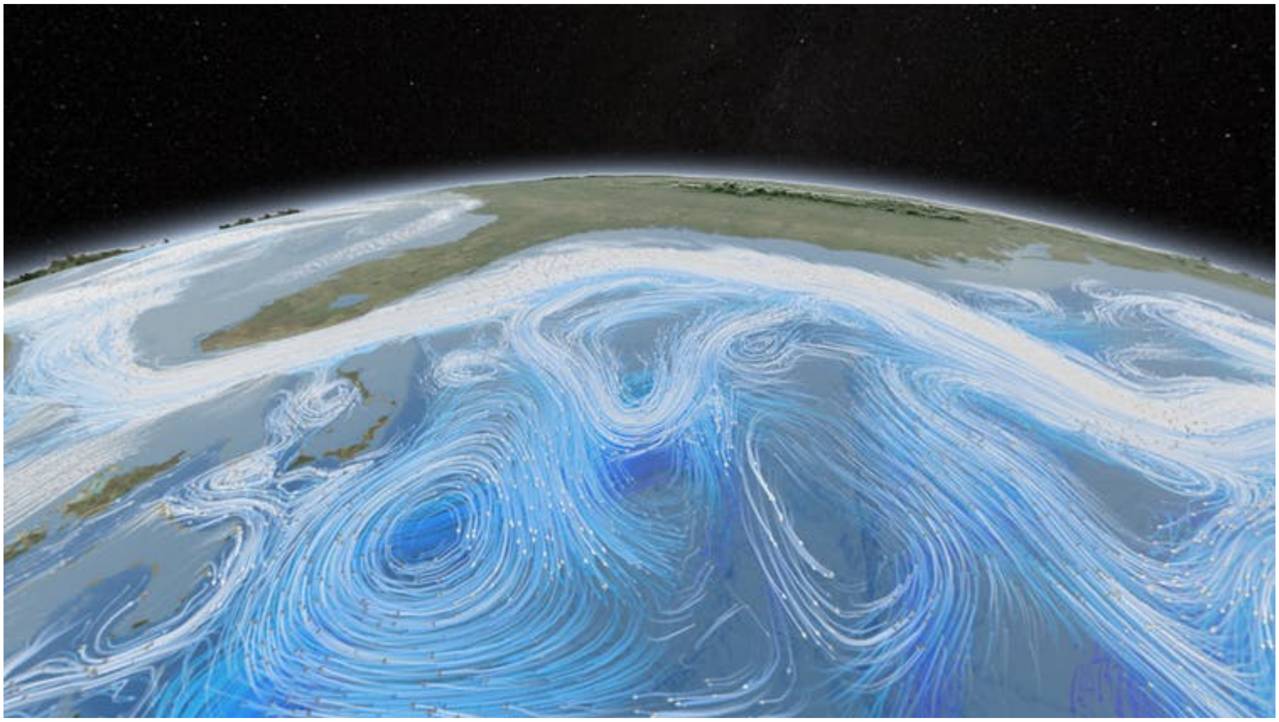
NOAA tide gage record for Juneau, Alaska, where local sea level is dropping relative to the land at 13.16 mm/year (4.3 feet/century) due to uplift of the coastline. NOAA

Even though sea level rose around the world at a rate of about 1.7 millimeters per year over the last century (nearly seven inches per century), because some gauges are on coasts that are rising and some on coasts that are sinking, these local sea-level rise rates will vary. In parts of Alaska, the land is rising faster than sea level, so the tide gauge actually records a drop in sea level relative to the land.



Global mean sea level as measured by satellite. University of Colorado/NASA

These geographic variations were resolved in 1993 when two satellites were launched that use radar to measure the level of the ocean very precisely from space. This high-tech approach eliminates the problems of land motion on Earth and has given us a new global sea-level rise rate over the past 22 years of 3.2 millimeters per year, the equivalent of 12 inches per century.


Wind and currents can affect a sea's level. NASA Goddard Space Flight Center, CC BY

Elevations on land, contour lines on maps and depths on nautical charts are based on the long-term average of sea level. This is complicated by the fact that sea level around the world at any instant is not the same, due to local variations resulting from differences in water temperatures, currents, atmospheric pressure and wind.

In order to bring some order to all of these geographical variations, and to provide a constant point of reference, a datum or base level was established based on averaging out the elevation of sea level from many tide gauges over an extended period of time. This datum is now called the North American Vertical Datum (or NAVD) and is the elevation (close to mean sea level) on which all map elevations are based. So if a wharf, highway or building is "20 feet above sea level," it is 20 feet above this official North American Vertical Datum.

COMMENT

Steve Case

logged in via Facebook

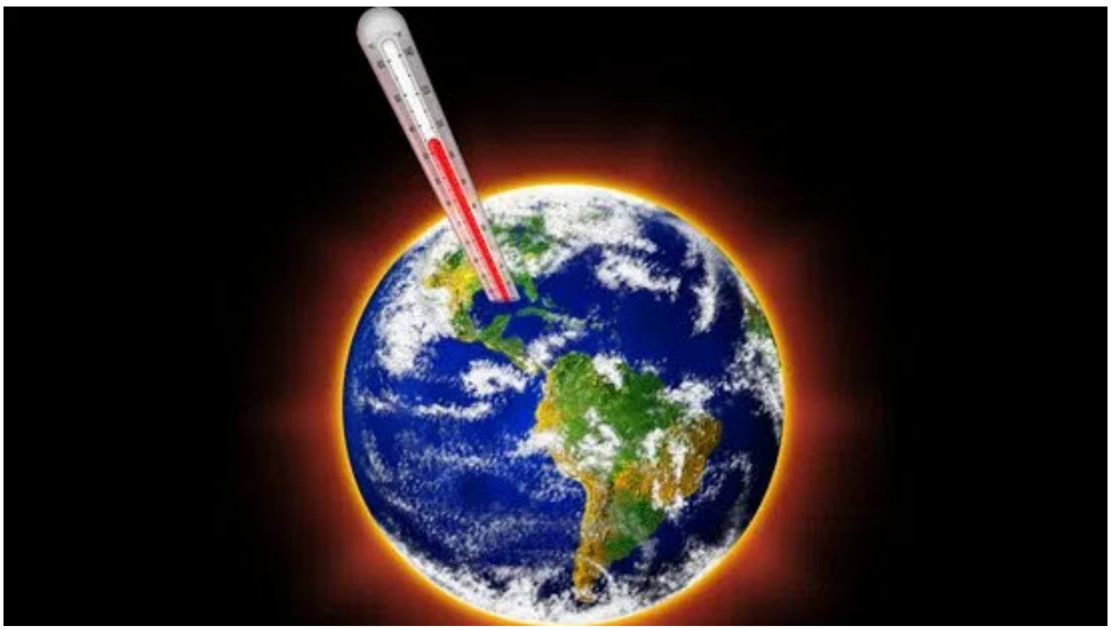
What Gary Griggs doesn't tell you is that "an acceleration of sea level rise not been observed during the altimeter era." If you Google that you will eventually find a presentation from R.S. Nerem of Colorado University's Sea Level Research Group that discusses that very fact. His presentation is a few years old now, but it remains true that the satellite record does not show an increase in the rate of sea level rise.

And what Dr. R. Steve Nerem doesn't tell you is that the rate of Sea level rise reported by his Sea Level Research Group looks like it has been systematically adjusted upwards over the last ten years. The time series from 1993 to 2004 (version_2004_rel1.2) was 2.6 mm/yr. Now that same 1992 - 2004 series (version_2015_rel2) says by 2004 the rate was 3.5 mm/yr. An upwards correction of 0.9 mm/yr.

Bottom line is that warming temps, and the rise and fall of coasts aren't the only issues that complicate measurements of sea level. Omission of facts and re-writes of historical data play an important role that everyone ought to be aware of.

NASA Confirms Falling Sea Levels For Two Years Amidst Media Blackout

by Tyler Durden
Thu, 07/27/2017 - 16:25



@SteveSGoddard
FollowingFollowing @SteveSGoddard

The Arctic is not melting. Greenland is not melting. Antarctica is not melting, The planet is not heating up. Severe weather is not increasing. Sea level rise is not accelerating. It is time to stop the global warming lies, and bring an end to the largest scam in history.

SEA-LEVEL RISE SANITY

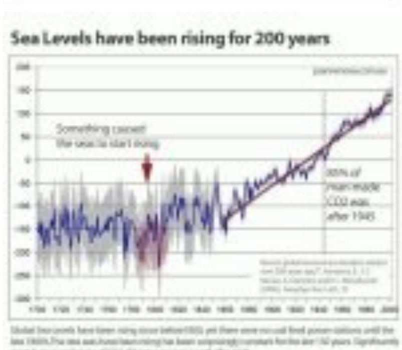
Dr Judith Curry …

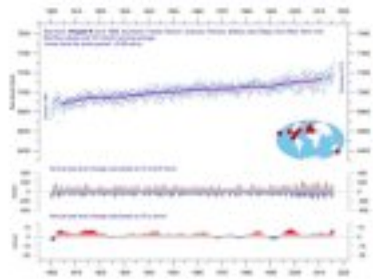
*“**Sea level has been rising for the last ten thousand years, since the last Ice Age**…the question is whether sea level rise is accelerating owing to human caused emissions. **It doesn’t look like there is any great acceleration, so far, of sea level rise associated with human warming.** These predictions of alarming sea level rise depend on massive melting of the big continental glaciers — Greenland and Antarctica. **The Antarctic ice sheet is actually growing**. Greenland shows large multi-decadal variability. …. **There is no evidence so far that humans are increasing sea level rise in any kind of a worrying way.”** — Dr. Judith Curry,* **video interview** published 9 August 2017

*“Observed sea level rise over the last century has averaged about 8 inches, although **local values may be substantially more or less based on local vertical land motion, land use, regional ocean circulations and tidal variations.**“*

(Climatism bolds)

Sea level rise acceleration (or not): Projections for the 21st century | Climate Etc.

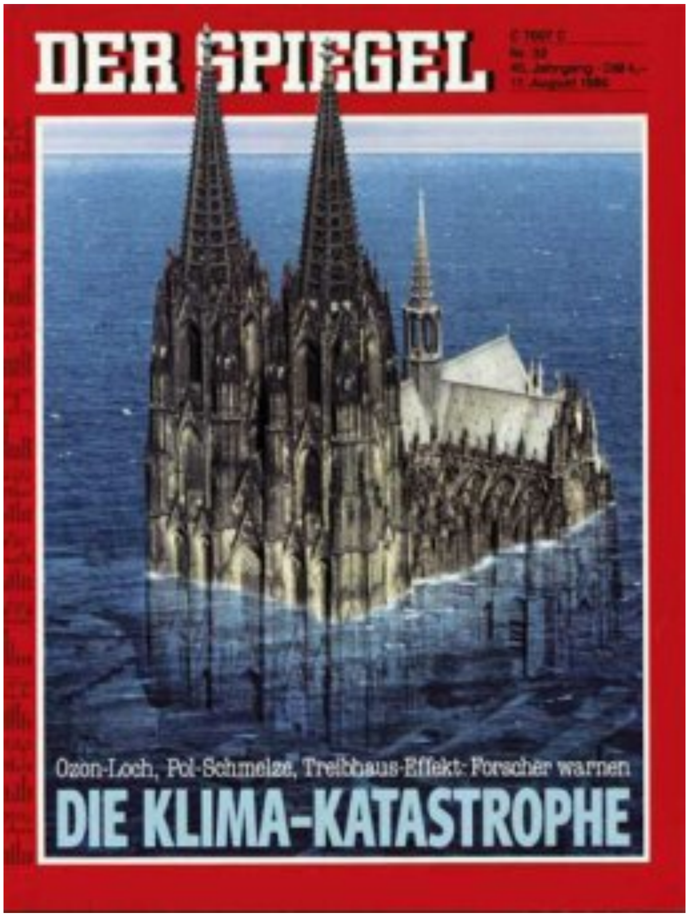




THE most basic of real-world observations – comparative photographs – provide a pretty accurate and interesting glimpse of sea-level rise change (or no change) over a century or so. Although not an exact ‘science’, these photos indicate that the horror scenarios depicted by climate alarmists are simply not happening in observed reality. Coastal inundation may happen in hundreds or thousands of years from now, if we choose not to adapt, but considering that there has been no acceleration in SLR over the past 200 years, or since around 1790, then the chance of entire cities being inundated by 2100 is pure fantasy.

PICTORIAL Guide To Sea-Level Rise Alarmism And Observed Reality

Posted: April 3, 2018 | **Author:** Jamie Spry | **Filed under:** AlarmismDEPICTIONS of catastrophic sea-level rise have become a useful propaganda tool for useful idiots in the *Climate Crisis Industry* who invent the most absurd future sea-level rise scenarios and recreate them in photoshopped horror stories that aim to shock you into belief…


DER SPIEGEL
Ozon-Loch, Pol-Schmelze, Treibhaus-Effekt: Forscher warnen
DIE KLIMA-KATASTROPHE

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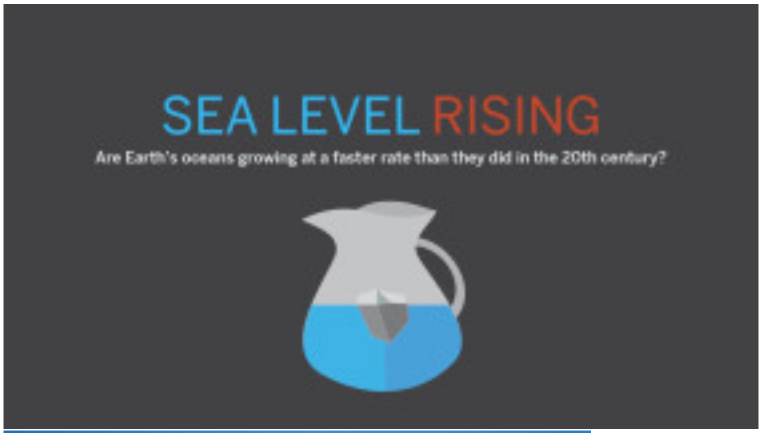
SEA THE REGION'S FUTURE

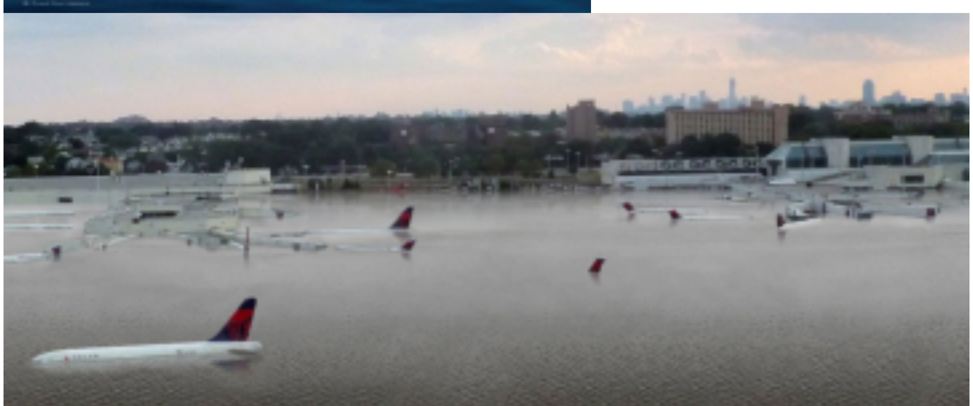
MAPPING SUGGESTS RISING OCEAN LEVELS COULD THREATEN MACKAY HOMES

STORY PAGE 5


NATIONAL GEOGRAPHIC
HOW THEY ARE CHANGING OUR COASTLINES
RISING SEAS


SEA LEVEL RISING
Are Earth's oceans growing at a faster rate than they did in the 20th century?


GOODBYE, MIAMI

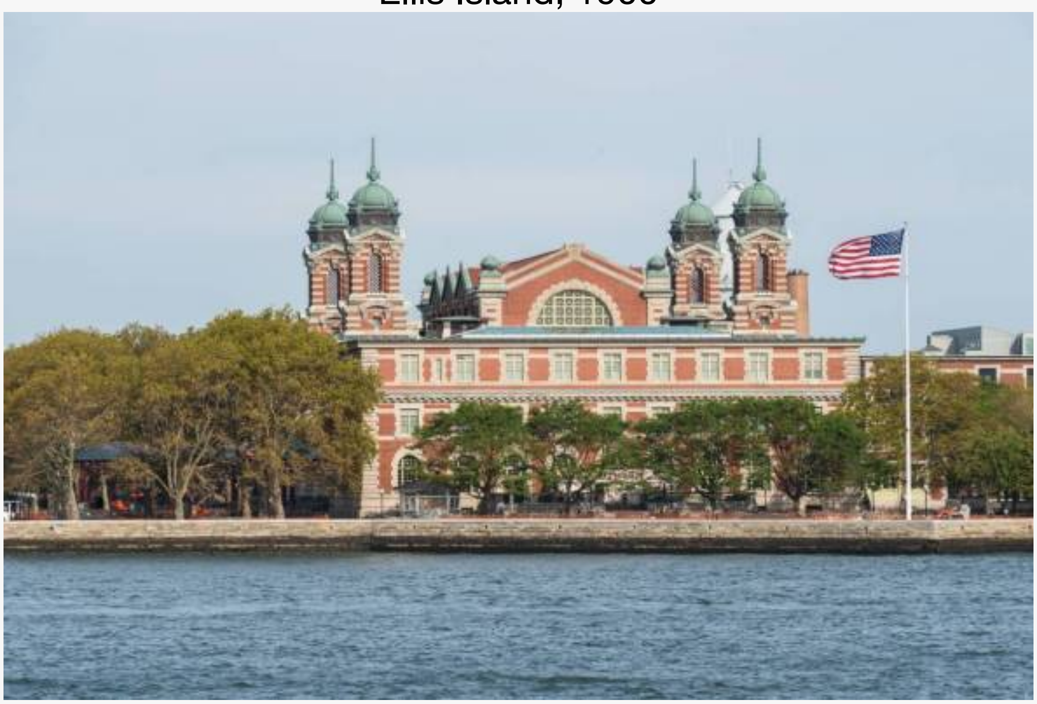



RISING SEAS
Frontiers of Climate Science

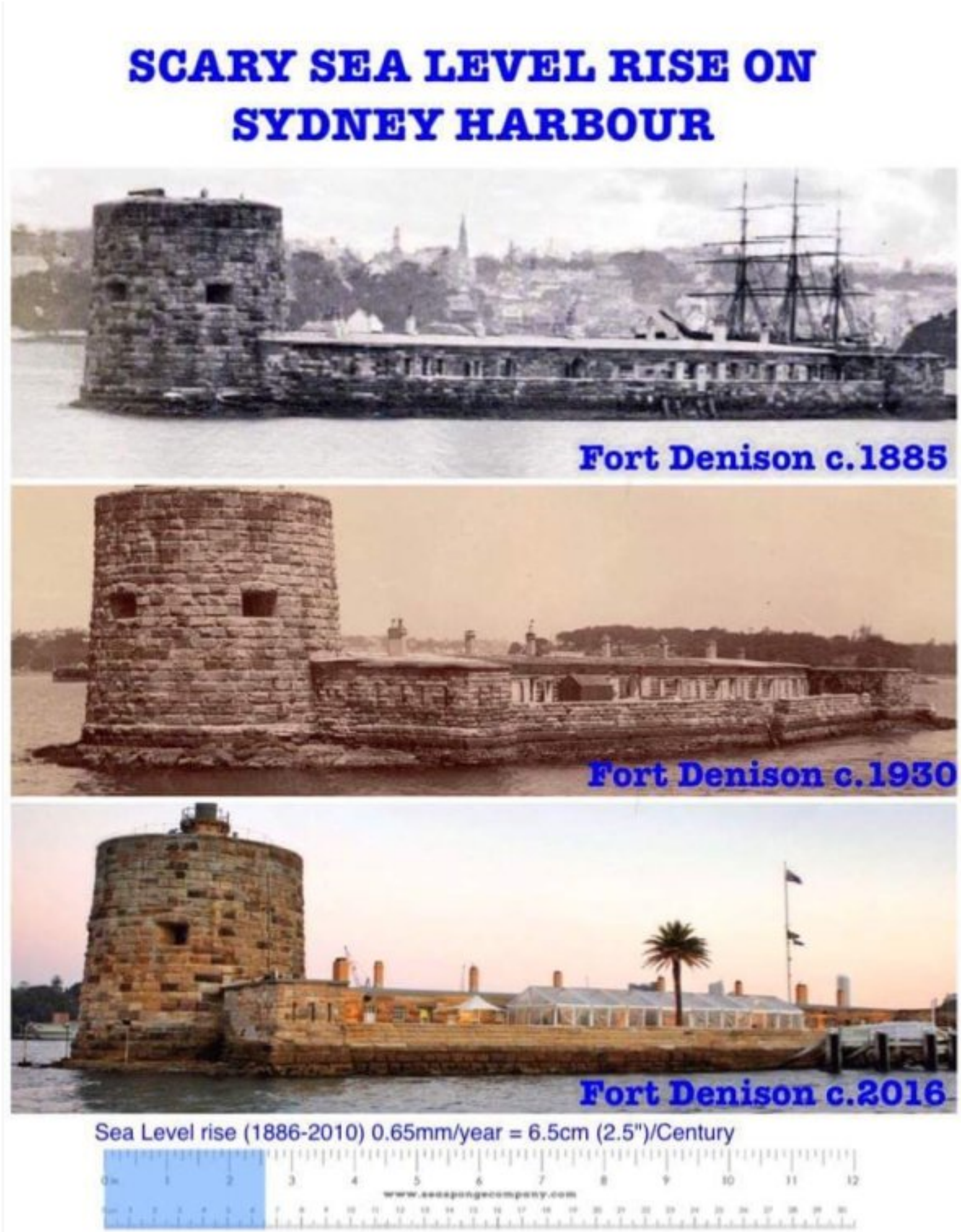

SEA LEVEL RISE

THE only place where such catastrophic scenarios exist are in the warped minds of alarmist hysterics who occupy the climate controlled offices of NASA, NOAA, BoM, National Geographic and the New York Times et al. Not even worst case scenario UN IPCC RCP8.5 climate models project such doom.


Ellis Island, 1900


Ellis Island, 2017

Florida beaches haven't changed in 58 years.



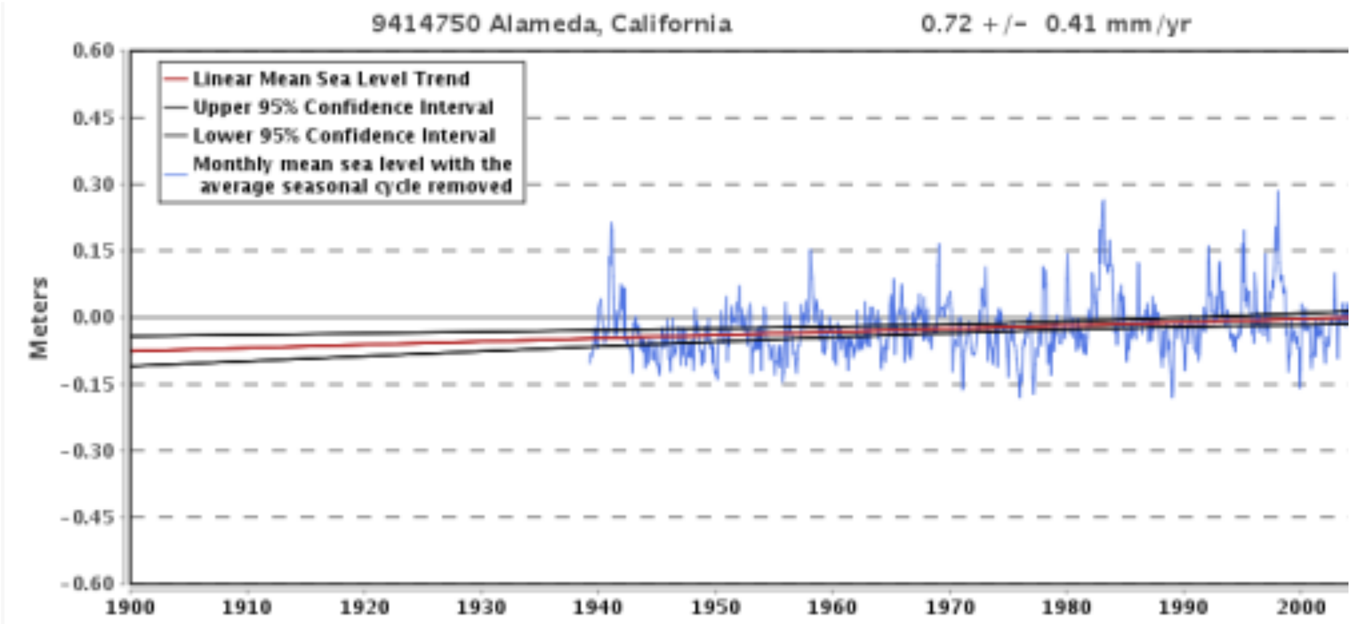
Fort Denison, Sydney

Key West 1968

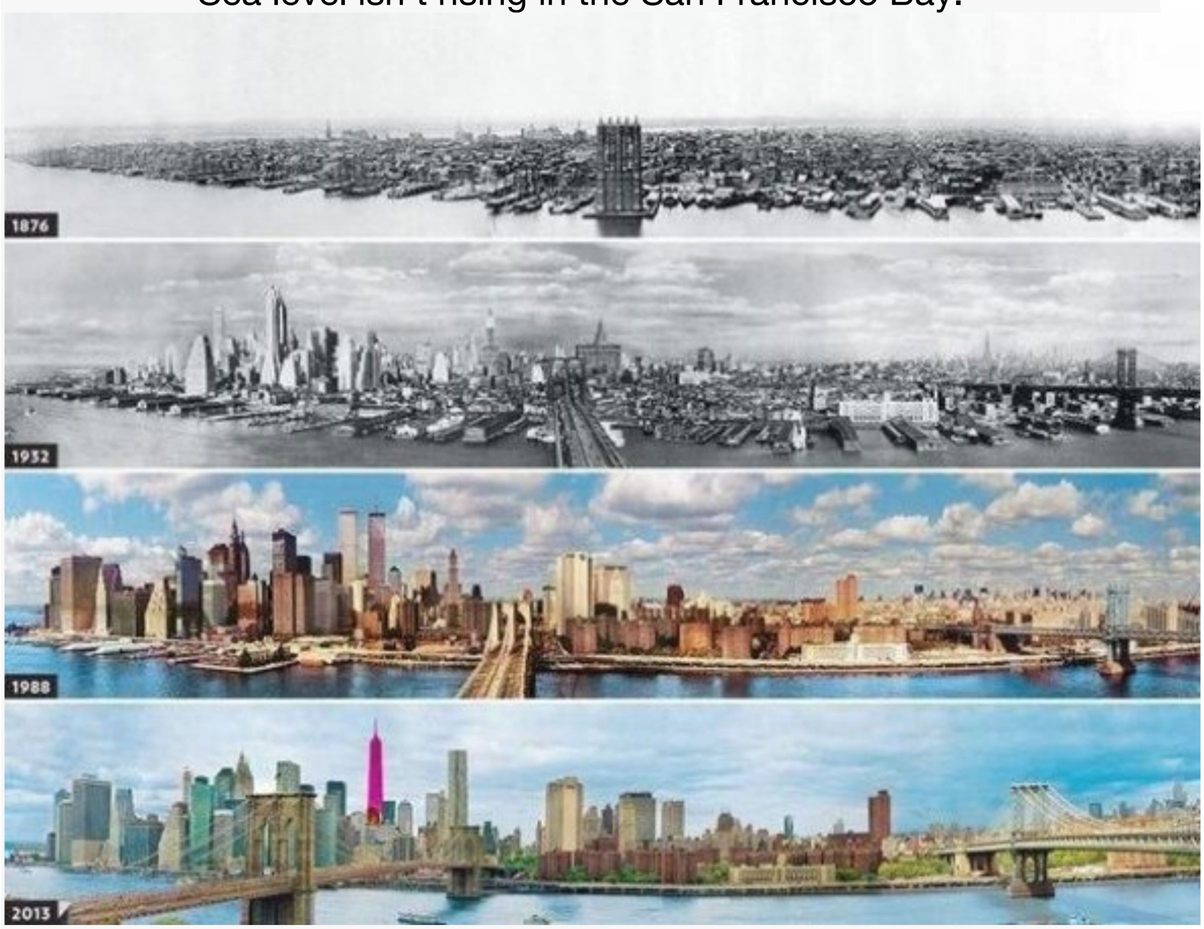
Key West 2013

High tide sea level at La Jolla, CA is about the same as it was in 1871.

At low tide, La Jolla beach looks like this. California beaches haven't changed in 145 years.

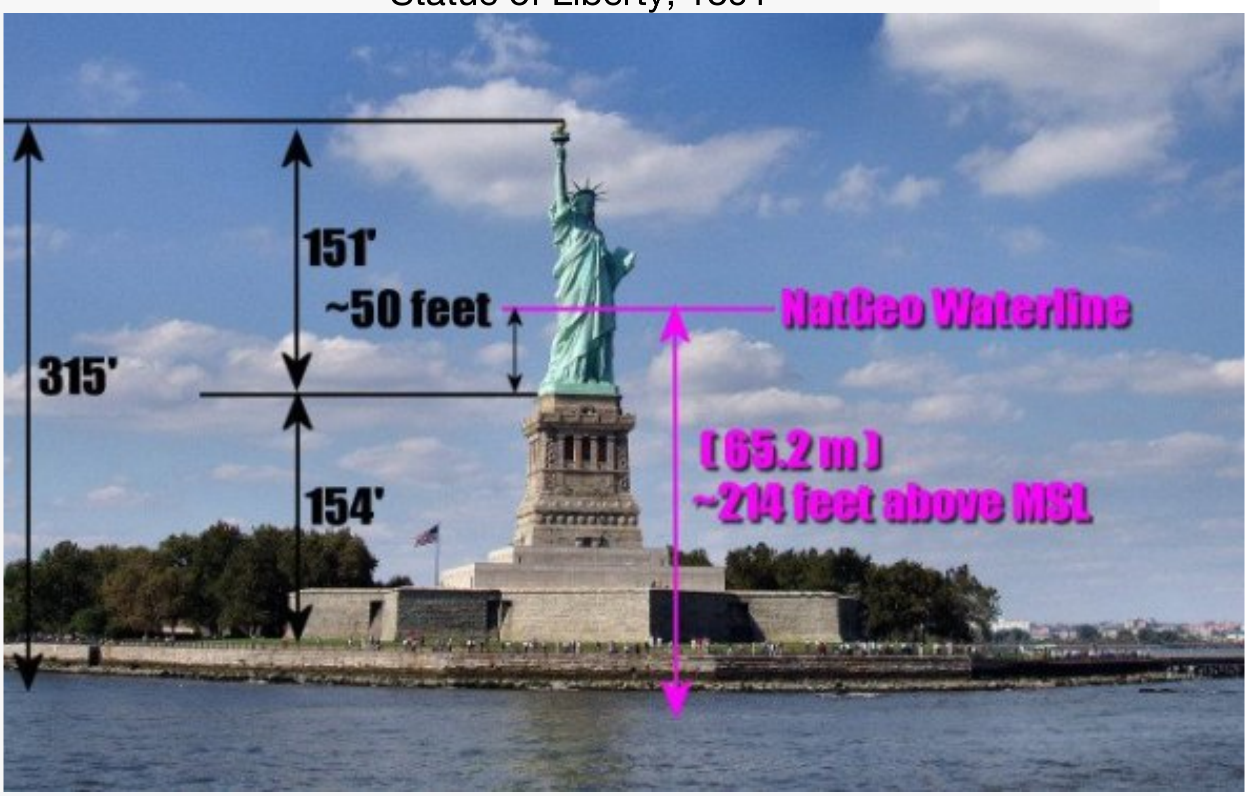


Sea level isn't rising in the San Francisco Bay.



NYC time series

Statue of Liberty, 1891



Statue of Liberty, 2017

GOOD OBSERVATION : How many years does it take the sea to wear away a cliff like this? 10,000 years? Less? More? Why is the sea level lower now? (tide range 2.7m max at Krabi) Remembering all sea is the same level. So, is the sea lower everywhere? **@JoKiwi55** (Krabi, Thailand)

Sea-level change (up or down) differs from place to place, depending on; local vertical land motion, land use, regional ocean circulations and tidal variations. 'Absolute SLR' and 'Vertical SLR' vary from region to region based on the geology of the area. See here for a good explanation of different types of SLR: ***NOAA — Straight Talk on Sea Level Rise | Watts Up With That?***
H/t **@JoKiwi55 @Keith_Mundy @_RaulRevere @rln_nelson @can_climate_guy @SteveSGoddard @Quantummist**

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IN CONCLUSION and A Message to Alarmist 'Scientists', Politicians and the Fake News Media:

IT'S easy to use photoshop and tweak a computer model to give you the desired outcome that your political agenda and paymaster requires. However, sea-level rise based on actual data and real-world observations bear no semblance to the alarmist tripe pumped out of activist laptops, whatsoever.

WHAT is bandied around the mainstream media and by activist groups is nothing more than rabid propaganda. And, those guilty of brazen sea-level rise fraud and fear mongering should get a life or read some of that "**science**" that they always bang-on about. CLIMATE alarmists and gullible, virtue-signalling politicians should be wary of insulting peoples' intelligence over and over again. More and more are seeing through the repetition of alarmist lies, coordinated exaggeration of weather events, **dud-predictions** and **manipulation of data**.

YOU are all doing a major disservice to 'science' and the 'scientific method'. We too have access to the internet and can evaluate a graph, see a photo and even read this quote, that is IMO central to the climate mafia's game-plan of mass climate-crisis indoctrination…

"IF you tell a lie big enough and keep repeating it, people will eventually come to believe it." –*Joseph Goebbells***

https://climatism.wordpress.com/2018/04/03/pictorial-guide-to-sea-level-rise-alarmism-and-observed-reality/