

Dynamical Ice Sheet Disintegration

The most unfortunate decision to date, made by the climate change leadership community, was that the IPCC Fourth Assessment report did not acknowledge the extraordinary risk of dynamical ice sheet changes. They inserted numerous caveats in their report to make sure that it was understood that dynamical ice sheet changes were possible. But they did not make any estimate of their strength, amount, speed, or any mention of the huge risks that lay before society given the known past frequency of these types of phenomena.

In-fact, their judgment had an even greater flaw. They assumed that ice sheet changes would continue at rates representative of the period from 1993 to 2003 even though it is widely accepted knowledge that ice sheet discharge and melting since the turn of the century has greatly increased. These increases in the speed and quantity of discharge are generally 2 to 3 times greater range, but sometimes even as high as ten times greater than a decade ago.

What leading scientist around the world now fear, is that sea-level rise could be greater by several times, by ten times and even by up to fifty times greater than is being predicted.

Why is IPCC not Warning the World? Science is by nature conservative. Scientists must be conservative or they lose their jobs. It could take just one error to lose credibility. Consider space shuttle scientists for instance. When they make errors, entire crews could die, and billions of dollars are at stake.

When a scientist is uncertain about his answer, he or she cannot answer the question because of a lack of or conflicting information, so an exception or caveat is included along with the answer, or maybe the question is not answered at all and only the caveats remains. In academia, where the rule is “publish or perish” if the scientist is wrong, he or she does not get published. Without a steady stream of published papers, the scientist will lose (or never attain) credibility, tenure, funding, etc. Without these things, the scientist is nothing; he has no job; she has no way to feed her family.

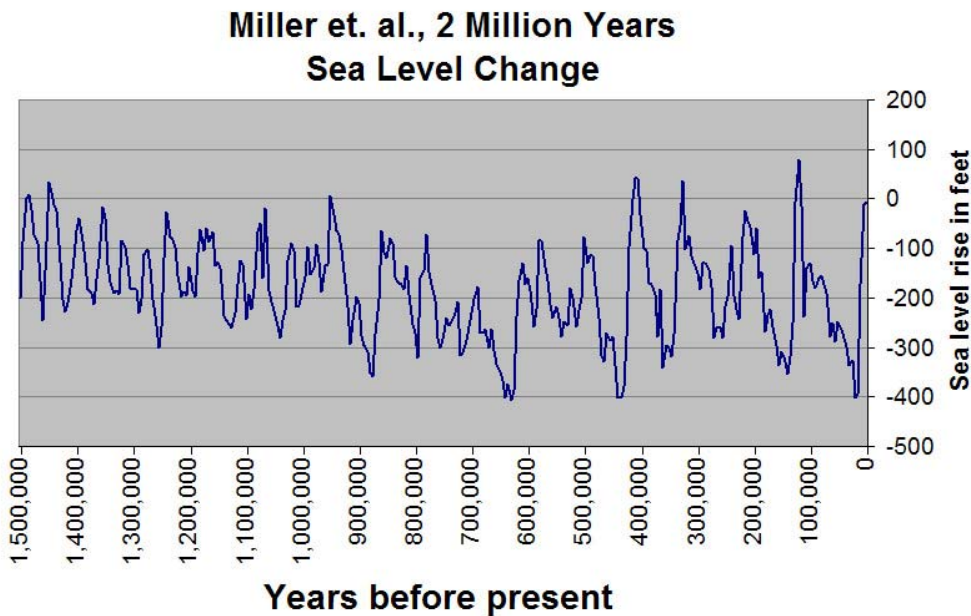
To attain such a high level of certainty in their work, scientists adhere to their work with religious fervor. Adherence to routine and the rigorous understanding of principles are paramount. The fundamentals are sacrosanct. New concepts are slow to be embraced because they are foreign to existing understanding. New ideas haven't put in there time in the halls. Precociousness is not abundant. Aggressive leaps in thought are nearly non-existent. It takes decades for concepts to become established. Things like tectonic theory, microbial theory and atomic theory took decades to become accepted. Ice age theory took eighty years to become well accepted in academia. Large leaps in knowledge are not made easily.

Sea level rises of 16 feet per century have been recorded in abrupt climate changes in paleo-history. Scientists are confident that sea level has behaved this way in the past, and understand that these events are controlled by ice sheet collapse. However, massive discharge of ice from ice sheets is not easily understood from the geologic record. Considering that sea level has only changed a couple of feet in the last couple of centuries, since Earth's society has become dependent on a stable sea level, implications of these massive sea level changes reoccurring are quite disturbing.

Over the last century sea level has changed by no more than 1 to 2 mm per year, which is more than one half inch but less than 1 inch per decade.

Dynamical Ice Sheet Changes: What a great phrase. It carries the persona of superheroes from the 1960s. But the implications are far from fictional. The information presented below spans nearly 20 years of the latest research into sea level changes because of global glaciation. Early research was relatively crude with relatively large uncertainties. Two decades of intensive research however have significantly reduced the uncertainties associated with this research. Today this information is extremely valuable in relationship to possible future sea level changes on a planet that is warming more rapidly than it was during any of period in the past, including the periods of abrupt, rapid and catastrophic sea level change described by the following research:

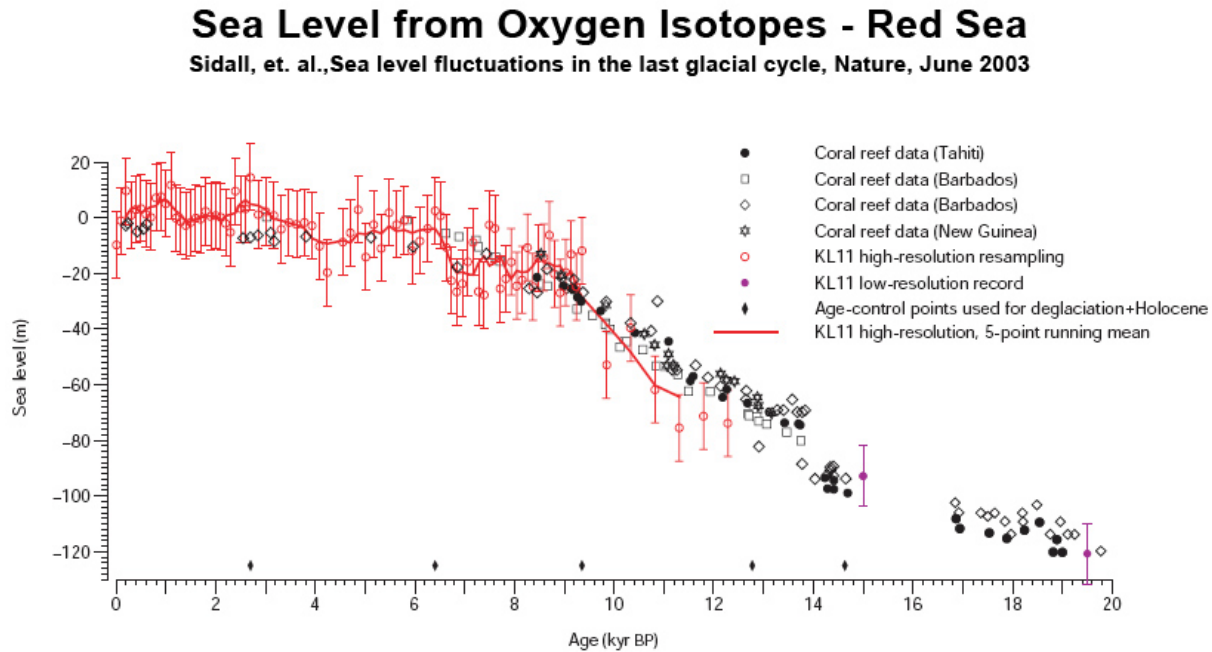
Tow Million Years of Sea Level Change: Miller, et. al., in Science this February published a paper on sea level elevation for the last 1.5 million years. They found repeated changes of sea level of up to 400 feet in 10,000 years. That's four feet per century, three times what the IPCC projects. There is one big exception though. The resolution of Miller's study is 5,000 years.



Developed by the author from supporting material for Miller et. al, The Phanerozoic record of sea level change, Science, February 2008

Miller and his colleagues determined sea level for the last 2 million years in 5,000 year increments. They could see no more detail than this in their data. What their data does show is that sea level is nowhere near a stable thing and that it changes often and radically.

20,000 Years under the Red Sea: Sidall, et. al., analyzed sediments in the Red Sea in 2003 and found that sea level had changed up to 115 feet at a rate of about 10 inches per decade or 8 feet per century. This is four times greater than the IPCC projections. Sidall's graph also shows the exceptional stability of sea level for the last 6,000 or 7,000 years as compared with the rest of the records.



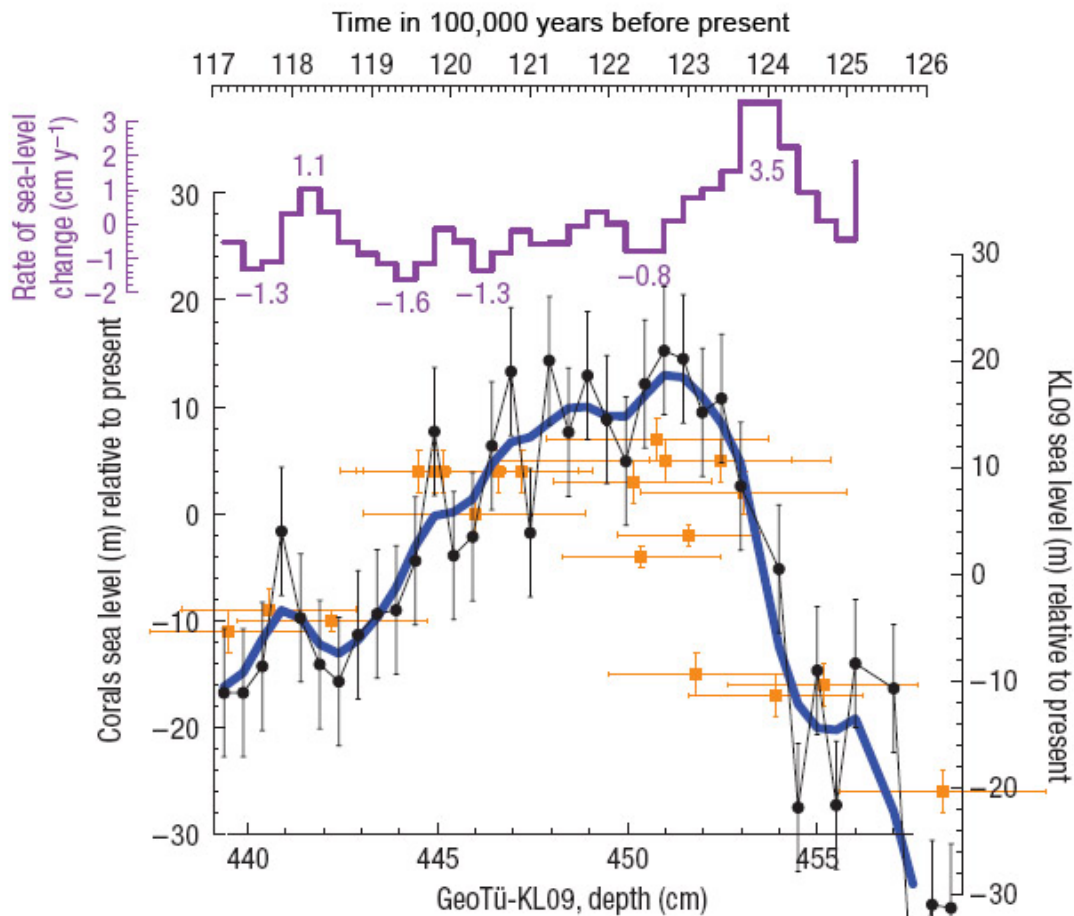
This graph from Sidall also shows relatively well the low sea level rate change of the last several thousand years.

Another Look at the Red Sea: Rohling and colleagues have taken Red Sea sediment analysis one step further. Their data shows an accuracy of 12 meters which is nearly three times greater than typical data for sea level analysis from previous studies. This increased confidence will give decision makers greater ability to make better decisions based on future sea level rise.

Rohling and his colleagues also found, that their study shows changes in sea level elevation of up to 3.5 centimeters per year. This is about 14 inches per decade, or 11.5 feet per century. This rate is about 10 times what the IPCC estimates as the rate of sea level change for the next century.

Sea Level from Oxygen Isotopes - Red Sea

Rohling, et. al., High rates of sea level rise during the last interglacial, *Nature*, January, 2008



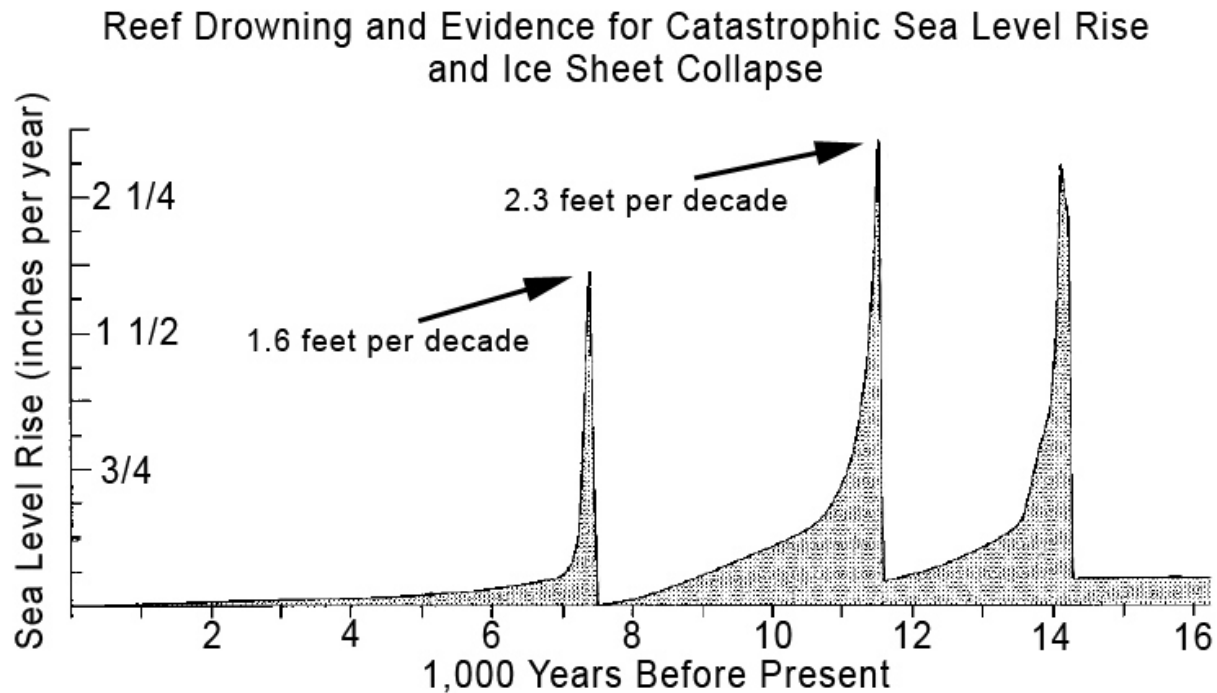
The black line with solid circles is the data from sediment core KL09. Orange squares are coral data. The long term average trend is the thick blue line. Error bars are shown. Note the rate of sea level change depiction in purple at the top of the graph. Rate of sea level change (cm y^{-1}) is cm per year. 3.5 cm per year is 14 inches per decade or 11.5 feet per century.

Reef Drowning: Evidence for Ice Sheet Collapse Drowned coral reefs from the eastern Caribbean region of the island of Barbados have shown clear evidence of major abrupt sea level changes during recent deglaciation that in the words of the authors:

“...(R)eefs from the Caribbean-Atlantic region document three catastrophic, metre-scale sea-level-rise events during the last deglaciation. These catastrophic rises were synchronous with (1) collapse of the Laurentide and Antarctic ice sheets, (2) dramatic reorganization of ocean-atmosphere circulation, and (3) releases of huge volumes of subglacial and proglacial meltwater. This correlation suggests that release of stored meltwater periodically destabilized ice sheets, causing them to collapse and send huge fleets of icebergs into the

Atlantic. Massive inputs of ice not only produced catastrophic sea-level rise, drowning reefs and destabilizing other ice sheets, but also rapidly reduced the elevation of the Laurentide ice sheet, flipping atmospheric circulation patterns and forcing warm equatorial waters into the frigid North Atlantic. Such dramatic evidence of catastrophic climate and sea-level change during deglaciation has potentially disastrous implications for the future, especially as the stability of remaining ice sheets—such as in West Antarctica—is in question. (emphasis added)

The authors Blanchon and Shaw studied the reef coral acropora, analyzing the way reef growth responds to changing sea level elevation. The acropora coral has a narrow limit of water depth within which it can grow and therefore is an ideal candidate for study.



Shaded area is abrupt sea level rise. Adapted from Blanchon and Shaw, Reef drowning during the last deglaciation: Evidence for catastrophic sea level rise and ice sheet collapse, *Geology*,

The elevation increases for the three events range from 21 to 44 feet. Duration of the rises are only inferred from the minimum rate of sea level rise possible based on coral growth rates overcoming the sea level rise. This amount is about 1.75 inches per year or 1.5 feet per decade. Thus the maximum event durations were between 140 to 290 years. But based on the discussion below, the period for the sea level rise was likely much, much shorter.

Blanchon and Shaw’s paper, was based on the following: The acropora coral grows in single species colonies at depths less than 16 feet. It becomes intermixed with another coral named palmata at depths between 16 and 32 feet. Below 32 feet only the palmate species grows, and below 48 feet deepwater corals grow. When sea level rises greater than 16 feet above the acropora coral, the palmate coral starts to grow mixed with the acropora like two different kinds of wildflowers growing together in a field. There is no longer a monoculture of one species. As sea level rises greater than 32 feet, the acropora disappears altogether.

Acropora grows at a rate of up to about a half inch per year, so sea level could conceivably rise fast enough that when the scientists cored down into the fossil coral beds, they would find no matrix of the two corals growing together where the sea level was between 16 and 32 feet deep. They determined that $\frac{3}{4}$ inches of sea level rise per year, would allow the accumulation of about 6 feet of mixed acropora / plamata coral that could easily be seen in their cores. The coral growth rate and sea level rise combination gave a minimum sea level rise of $1 \frac{3}{4}$ inches per year.

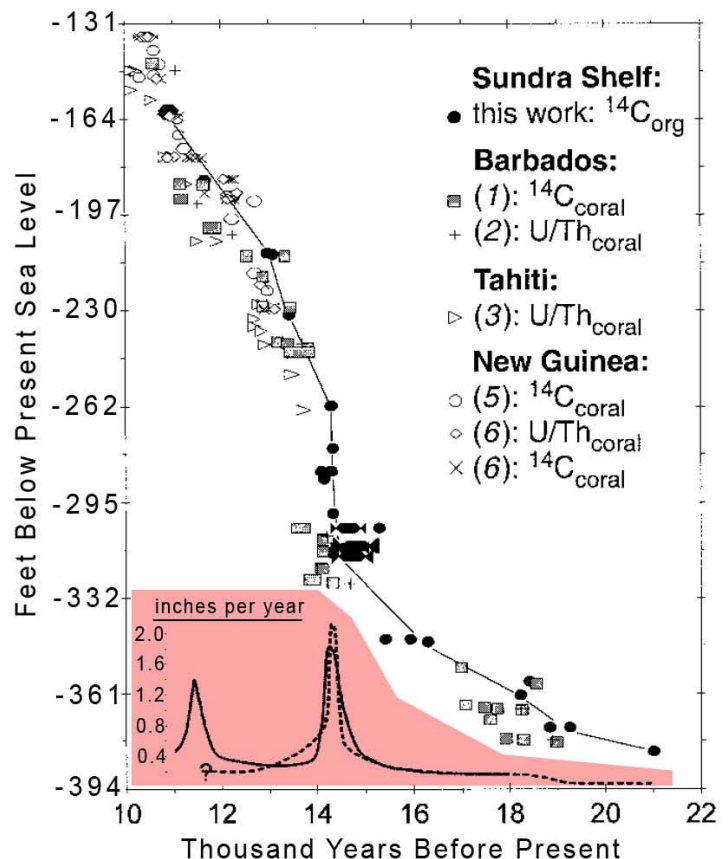
But many of the coral cores showed no identifiable matrix between the fossilized acropora and palmate implying that sea level rose rapidly enough that there was not enough time for the two species to intermix and form an easily identifiable layer in the core. With the coral growing up to a half inch per year, in a decade there would be 5 inches of coral growth, which would likely be visible. The authors have this to say about the extreme rate of sea level rise during these periods:

“Such drowning events must have been truly catastrophic, involving—to our knowledge—the fastest rates of (glacier-caused) sea-level rise yet reported.”

The Sunda Shelf, Vietnam

Hanebuth and colleagues analyzed the radiocarbon dates of organic material (mangrove roots and organic debris) from a submerged flat plain off the coast of Vietnam. Their research, published in 2003 is likely the most accurate on abrupt sea level rise to date. They found that in a 300 year period during the height of the last deglaciation, sea level rose 52.5 feet in 300 years. This is 17.5 feet per century or $1 \frac{3}{4}$ feet per decade – on average. Their calculated statistical range for the rate of sea level change during this period was 10 to 52 feet per century with a caveat that the high calculation of 52 feet per century is unrealistic for reasons related to sediment accumulation rates. Given this information though, we can assume that for shorter periods than a century, the rate of sea level change could have approached the upper limit for short periods of years to decades.

The Sunda Shelf: 53 Feet of Sea Level Rise in 300 Years



Sunda Shelf: this work Reference: Hanebuth, et. al., Rapid Flooding of the Sunda shelf: A late glacial sea level record, Science, May, 2000. ^{14}C is carbon 14 dating, U/TH is Uranium/Thorium dating - similar to ^{14}C , The pink shaded inset graph shows the yearly sea level rise rate.

Heinrich Events: Not to be confused with the Heimlich maneuver, Heinrich events are geologic scale episodes of iceberg armadas. There are many means by which tens of thousands or perhaps tens of millions of icebergs could be released into the oceans, most of which are related to dynamical ice sheet changes. How do we know of these vast iceberg armadas? Heinrich events.

These events, first described in the North Atlantic by a fellows named Bond and Heinrich, result in enormous continuous layers of ocean sediment that contain rocks, gravel and boulders that could not conceivably been washed in to where they are deposited. Heinrich event layers average 6 to 8 inches thick, but in the far north Atlantic and Labrador Sea are several feet thick. The iceberg armadas came from the great North American Ice sheet and their sediments can be found as far as the central Atlantic and near the coasts of Europe. These Heinrich sediments, sand, gravel, rocks and boulders, were carried in and on icebergs, possibly millions of them, and as the icebergs melted, the sediments fell to the ocean floor a little bit at a time. In other areas these sediments are called “ice rafted debris”.

One little peak into Earth’s paleo-climate is all it takes to understand that the old planet is a great big place that has secrets that most of us would never even dream of.

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