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Sea Level Rise: It's not a myth!

There was a time when I thought everything stayed the same and did not change. This was a naïve belief I had when I was a child, but when I was exposed to the news about Hurricane Andrew and Iniki back in 1992, that was when I discovered the power of nature, and how easy things could change in a given instant. I would never have thought waves could come onto the shore so far inland and destroy so many homes. I had become afraid of water for a great while, but I soon grew a respect for the power of water because I actually understood it better. This was what got me interested in the science of Meteorology.

One of the most pressing issues our culture has dealt with in the past decade is the big topic on global climate change, and whether or not it exists. I have spent several years studying about global climate change and hearing many lectures about it in school, and what I have observed was there is a general consensus among the scientific community that indeed climate change is not only occurring, but it is Anthropogenic. In other words scientists believe climate change has been driven by humans. The problem I have seen was everyone is not aware of the effects climate change would have on all of us and often confuse climate change with global warming. There has been a great campaign by corporations to mislead the public that their business practices and goods are not causing adverse effects to the environment, which this is not an unheard of tactic. It is hard to check facts and claims with so many mixed messages. There are a couple sources of sea level rise, and many impacts sea level rise will have on the world.

The first cause of sea level rise is ice sheets are melting. The National Oceanic and Atmospheric Administration or NOAA has shown there is a correlation of increasing carbon dioxide, decreasing ice mass, and the increase of our sea level. Ahrens (2009) says, there has been an interesting though startling revelation that the amount of carbon dioxide has not only grown worse, but it has also gone askew from the natural rhythm. The reason why carbon dioxide is so much of a concern is it has the property to let visible light to pass through but absorb outgoing infrared radiation (Timberlake, 2009). Activities that are driving the anthropogenic source of CO_2 are fossil fuel burning, cutting down forests, and agriculture. We can compare our current ratio of Carbon-12 to Carbon-13 isotopes in the present atmosphere with ice core samples taken from air bubbles deep in the Antarctic ice sheet. These bubbles contain air from an atmosphere thousands of years ago.

What is an isotope? It is the mass of an element, which you can deduce how many neutrons it has. The more neutrons the heavier the element is, and the 3 forms of Carbon that occur naturally are Carbon-12, 13, and 14. We do not measure the ratio of Carbon-14 because it is radioactive, which this means the mass is too unstable, and it gives off particles essentially turning it into another element. Carbon-12 is the preferred isotope for photosynthesis. With this we can show the CO_2 rise in the atmosphere since the industrial revolution is anthropogenic as currently our atmosphere is enriched in Carbon-12 compared to any of the older samples in the Ice cores which go back as far as 100,000 years

ago. Carbon-12 is coming from all that Fossil Fuel that has been buried in the ground for millions of years.

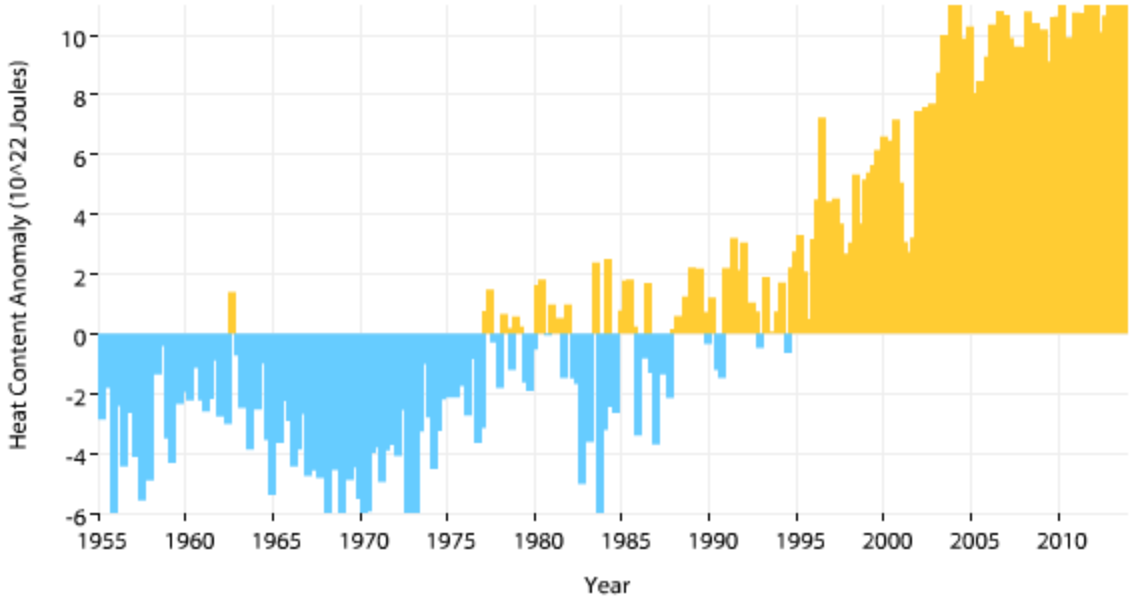
Weller (2008) and Ahrens both say the ice sheet on Greenland, which will contribute to a significant amount of sea level rise, which is enough to raise the sea level six meters or 20 feet. The melting of glaciers and ice sheets is also reducing the earth's albedo; consequently, this is a positive feedback because it increases the amount of visible light absorbed leading to more warming, and more ice melts. The increase in Carbon Dioxide has initiated a chain reaction, resulting in more ice being melted than anticipated. A common misconception is the sea ice and ice shelves melting makes sea level rise. The fact is the sea ice and ice shelves have already displaced the same amount of water that ice itself contained, but when you melt the sea ice and ice shelves, you will decrease the albedo regardless. In Lovgren's article in the National Geographic, he says the rate of Ice melt of the Greenlandic Ice is around 2,600 km^3 per year or 624 mi^3 per year. This would rise the sea level 70 centimeters every 100 years (2.7 feet) every 100 years and all of the ice would be gone in 1000 years. If the current trend continues; however, that rate is accelerating, meaning it would probably be ice free even sooner.

Weller and Ahrens both say Antarctica has the most ice than any other landmasses in the world, about 25,000,000 km^3 or 6,000,000 mi^3. They also say 98 percent of Antarctica is covered in ice, with a maximum depth of 13,000 feet. The amount of stored water is enough to raise the sea level 60 meters or 200 feet. According to Conway of NASA, the rate of Ice melt of the Antarctic Ice melt has been 100 km^3 per year or 24 mi^3 per year. That means at the current rate it would take 250,000 years for all the ice to thaw out on Antarctica. Although recent findings from NASA and German Aerospace Center have found that Antarctica may be melting faster than we thought (Conway, 2010). Luckily the Antarctic sea ice have been growing keeping the frozen continent from losing too much albedo, but climate scientists are not certain why Antarctic sea ice is growing or if this trend will continue. There are other glaciers that have been melting as well. In fact, Africa's tallest mountain, Mt. Kilimanjaro, has lost 82 percent of its ice in 90 years, and it is expected to be ice free in 2020 (Minarcek, 2003). Even the permafrost in Alaska has been melting, and it has been leaving the arctic tundra riddled with sinkholes.

The second cause of sea level rise is thermal expansion. Lovgren (2004) says, in the past 100 years about four to eight inches of the sea level rise so far has been attributed to thermal expansion. Since 70% of the world is covered in ocean, most of the energy being absorbed is going into the oceans thus warming them. 50% of the sea level rise has been observed so far has been attributed to thermal expansion (Climate Services, 2011).

In the graph above, you can see the amount of energy going into the oceans in 10 ZJ (Zetta Joules). This is the deviation from average between 1955 and 2006. In the past decade we have 100 ZJ more heat stored into the oceans than average. This is where most of the energy is going into, and that is a lot of Joules (Climate Services, 2011).

After the 2005 and 2012 hurricane seasons, our society began to see the global climate change process may be playing a role in more frequent major hurricanes, and the increased likelihood of direct hits, however it seems all of their attention has been shifted exclusively towards the storm aspect. What I have seen are many people of our society pay more attention to the short-term consequences and not the long term, or they will ignore it as they perceive it as not having an impact on them. What they do not realize is the sea level has also been rising, which there are fine examples of the effects; however there is not much coverage in the media.



The first impact of sea level rise is more frequent flooding of estuaries and rivers influenced by tides. When there is a higher sea level the waterways will take a longer time to drain out, which this will mean rivers will back up more often and with a greater severity. This will be compounded with more frequent rains and storms due to warming temperature. You could see the water level rise above and below flood stage every tide cycle. In Venice, Italy the island is flood periodically by spring tides locally known as Acqua Alta, which they have already seen a progression in height of the tides. Sea level rise has been exacerbating the subsidence being experienced already thanks in part to the groundwater being pumped, which this lowers the pore pressure and compressing sediment layers (Ramsayer, 2012).

Figure 1

This picture was taken at Saint Mark's Square in Venice (12-1-2008) after a combination of Heavy rains and high winds pushed the water level 2 meters higher than usual flooding over 95 percent of the city. *Photograph by Andrea Pattero/AFP/Getty Images*

The Second impact of sea level rise is enhanced erosion, which in my hometown of Newport, Oregon, I have seen the increase in erosion first hand. Every time I walk to the beach, I go past some Million-dollar houses where they are perched on the edge of a 100 foot cliff overlooking ocean. The rocks were so unstable that I was able to flake off chucks of this rock with my bare hands. It is amazing to see the amount of things you see at the bottom of the cliff, a Satellite dish, irrigation pipes, sprinkler heads, a slide, fencing, railroad ties, etc. The ocean has actually been eating away at the cliff advancing towards the houses, but this is not an isolated incident.

According to Komar, the Nye beach area in Newport has seen the most drastic examples of erosion on the Oregon coast. One case happened to a place known as Jump-off Joe, one of Newport's well known natural landmarks back in the pre-world war I era. It was a 100 feet tall sea stack that was once joined to the mainland in 1868. It had a breath taking sea arch, and in a period of 100 years, the icon had become unrecognizable. Today, Jump-off Joe only exists as a group of lone rocks cast out in the sands. Another example was not very far from Jump-off Joe, there was a huge Landslide that took out a 3-block section of homes, about 20 in all, in just one winter (Komar). You can still see pipes, wires, and stairways even today protruding off the cliff. The landslides are still occurring now, and there is reason to suggest that more homes will be taken very soon as the oceans lap at the cliff face, not just in my neighborhood or Nye beach, but everywhere.

The third impact of sea level rise is human displacement. Most of the human population lives near the Oceans, Seas, or Estuaries. Large metropolitan areas like London, New York City, Tokyo, etc. will begin to see more direct effects from the rising sea levels, but with these population centers disappearing all of these people have to go somewhere (Vega-Leinert & Nicholls, 2008). Many island nations are already feeling the effects of a one-foot sea level rise. Some of these island nations are predicted to be wiped off the map in the next 20 to 40 years. One such case is happening to the island nation of Tuvalu in the South Pacific. Tuvalu has a population of 10,000 and a maximum elevation of 15 feet. Tuvalu is periodically flooded by a phenomenon known as the King Tide. This in itself is not a result of sea level rise, but it is caused by the moon and sun being in alignment, with their optimal gravitational pull on the ocean. In a documentary created by Booij, the tide is not like a regular column of water washing over the island, it is a more sinister bubbling seeping of salt water from the ground and collects everywhere. This leaves most of the land infertile due to the salt intrusion into the groundwater. Some scientists have seen the King tides become more frequent and less predictable, and they have noticed entire islands have lost all freshwater in the water tables (Booij, 2009).

Another island that is feeling the effects of rising sea levels is the nation of Maldives in the North Indian Ocean. Maldives has the lowest national maximum elevation of 7 feet, with a population almost 40 times larger than Tuvalu, about 400,000 people live on the island chain. In the 2004 Tsunami, the entire nation was flooded by the Tsunami, with the waves at 14 feet tall when it came on shore. Some of the islands were completely erased from the map as a result. Mohamed Nasheed, the president of Maldives, has mentioned to the British press he has looked into purchasing land from India, Sri Lanka, and Australia in anticipation of losing their land due to climate change (Shenk, 2011).

Another island that is feeling the effects of rising sea levels is the island of Tokelau in the South Pacific. Tokelau is a commonwealth of New Zealand with a maximum elevation of 15 feet. Tokelau is highly susceptible to Cyclones, being so close to a tropical cyclone belt. Grinsted says with a rise in sea level will exaggerate the storm surge from Tropical cyclones or any other kind of storm, and it will also make storm surge occur 1000 times more often in vulnerable areas. After the 2004-05 Cyclone season Tokelau was bombarded by four systems ranging from categories 4 to 5, which one ended up being one

of the most intense Cyclone in the southern Hemisphere. Even being hundreds of miles away from these intense systems, they were still experiencing extensive damage (Grinsted, 2009).

Tokelau had lost a lot of land ever since then, and there are other Islands that will share the same fate as Tokelau, Maldives, and Tuvalu. The population centers of Bermuda, the Bahamas, Cuba, and Hawaii will be affected. St. George's, Nassau, Havana, and Honolulu will all be swamped with water if the sea level were to rise 6 meters (23 feet). This would just be the average tide, and there would be fluctuations with the tides, which some places could see a range of 55 feet with the addition of storm surge.

Islands alone are not the only places that will disappear. In fact, many low-lying areas of dry land will cease to be dry and habitable. There are some areas that are not only low lying, but they are also flat and featureless. Florida and Louisiana will be some of the places to face the greatest reduction in land mass if the sea levels rise. In the west coast of the United States, it is common to travel 50 miles from the coast to inland and see a 500 feet increase in elevation. In Newport, you would not even have to travel a mile to see a 100-foot increase in elevation. On the east coast, you travel 50 miles from the coast then inland, and you would only see a 150 feet elevation increase (NASA).

Florida's maximum elevation is 345 feet, but most of the state is at or near sea level. In a simulation provided by Flood maps (NASA), a 7 meters (23 feet) sea level increase could result in Lake Okeechobee reuniting with the Gulf of Mexico, forming a bay 40 to 70 miles wide over what is now the Everglades. Miami would most likely become swamped along with every city along the east coast (Lovgren, 2004). No city will be spared on the Gulf Coast. Cities like Galveston, Houston, Gulfport, Mobile, and Tampa will all be underwater.

New Orleans is most likely the first casualty of rising sea levels. On August 29, 2005, New Orleans was flooded from a couple levies failing due to Hurricane Katrina's storm surge, at the time it was the most costly natural disaster prior to the 2011 Sendai Tsunami. The reason why New Orleans flooded was the fact the city was many feet below sea level. In the case the sea levels rise, New Orleans would more likely see an increase of floods. According to flood maps, it would only take a 3 meter (9 feet) rise in sea level before New Orleans would become permanently flooded (Lovgren, 2004).

A fourth impact of sea level rise is the increase in pollution. When I started reading some of the concerns scientists had about sea level rise, I came across a point I had not even considered. What Oberrecht has brought up is all of the Landfills, Water treatment plants, industrial plants, etc. in low laying areas will be overtaken by the oceans (Oberrecht). Once the landfills and other hazardous waste get introduced into the currents, it will put more species at risk and even us at risk. The animals we eat from the sea would be contaminated with copious amounts of toxins and pathogens. This would most likely occur in a series of catastrophic events, such as Hurricanes, Tsunamis, Floods, etc. The 2011 Sendai Tsunami resulted in a failure in the cooling systems at the Fukushima Nuclear power plant. Fukushima experienced three complete meltdowns and one partial meltdown. It contaminated a local area of the ocean with radioactive Iodine and Cesium; there have been traces of the radioactive isotopes measured in tuna being caught off the west coast of the US. It is unnerving to think this scenario can happen again elsewhere, which there are vulnerable infrastructure on the shores of various population centers that can contaminate our food supply.

Even though we are influencing this great change in our global climate, we still have the power to lessen or even reverse the change we are causing our planet to undergo. We are an intelligent species of animals capable of creating weapons of mass destruction and even travelling to the moon. If we can

do this with our technology, then I believe we are fully capable of creating new technology that will replace the primitive technologies that spew out the copious amounts of carbon dioxide that started this chain reaction. The only thing we have to do is treat the cause of global climate change, but all we need is motivation and to acknowledge that it is even happening to do so if not then future generations will have a bigger mess to clean up.

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