

Our Ocean Backyard — *Santa Cruz Sentinel* columns by Gary Griggs, Director, Institute of Marine Sciences, UC Santa Cruz.

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Climate, Carbon Dioxide and Sea Level

My last column focused on the astronomical factors that have influenced global climate and sea-level fluctuations over the Earth's 4.5 billion year history, essentially the changing distance between the Earth and the Sun over tens of thousands of years, which determines how much heat we receive.

I stopped short of any discussion of human impacts on climate and sea level, which left a number of people wondering. Trying to explain any topic as complicated as climate change or sea-level rise is difficult to do in a single 600-word column. Some topics require more words and more than one column, so more of that story follows.

When the last ice age ended 20,000 years ago, about 10 million cubic miles of seawater had been transferred from the oceans to the continents where it took the form of ice sheets and glaciers. Removing all of that water lowered the level of the oceans about 400 feet. Had you been around then you could have walked from San Francisco out to the Farallons, or jogged 10 miles west from Lighthouse Point in Santa Cruz and still been on dry land.

The climate then shifted again as those astronomical cycles collectively brought us a little closer to the Sun and the planet started to warm again. Ice sheets melted and glaciers retreated, with all of that water flowing back into the ocean. Between 18,000 and 8,000 years ago, sea level rose nearly 400 feet, or at an average rate of about a half an inch per year.

Evidence suggests that this wasn't a smooth continuous rise but occurred in pulses, where sea level rose at closer to an inch a year for hundreds of years, then slowed for a while. We now believe that these pulses or periods of more rapid rise were due to the collapse of ice sheets and surging of large glaciers in Antarctica. The probability of this happening today or in the near future is being studied by glaciologists in Antarctica today and there are good reasons to believe that the likelihood of this occurring is increasing as the ocean continues to warm and rise.

About 8000 years ago, after the level of the oceans had risen about 400 feet, the rate of sea-level rise declined as global warming slowed. From 8000 years ago to about 1850, sea level rose very slowly, perhaps 0.05 inches or less than 1mm per year, almost imperceptible.

In the latter half of the 1800s, coal began to replace charcoal as fuel for the expanding industrial revolution. The amount of coal burned began to increase exponentially, and as coal was burned, carbon dioxide was released into the atmosphere. With the development of the internal combustion engine and then the automobile, the use of petroleum products as fuels for an expanding fleet of motor vehicles (cars, trucks, busses, trains, airplanes and ships) led to a rapid expansion of the use of the products of oil refining. The combustion of these hydrocarbons released increasing amounts of carbon dioxide.

Svante Arrhenius, a Swedish chemist who won the Nobel Prize, determined in 1896 that increased levels of carbon dioxide in the atmosphere could alter the Earth's temperature through the greenhouse effect. Interestingly, there is a natural greenhouse effect from naturally occurring carbon dioxide, methane, nitrous oxide and ozone, which produces an average global temperature of 60 degrees F, making the Earth habitable for humans; without this, the average temperature on Earth would be 0 degrees F, and life would be quite different.

Antarctic ice cores 11,500 feet deep have now been recovered and extend back 800,000 years. The ice contains the record of atmospheric carbon dioxide for this entire period. For 800,000 years the carbon dioxide content of the atmosphere varied between 175 and 300 ppm (parts per million). Over the past 150 years the atmospheric concentration has risen to 405 ppm, higher than any time in the past 800,000 years, primarily from the burning of coal, oil and natural gas. And its still increasing. This story is not finished.