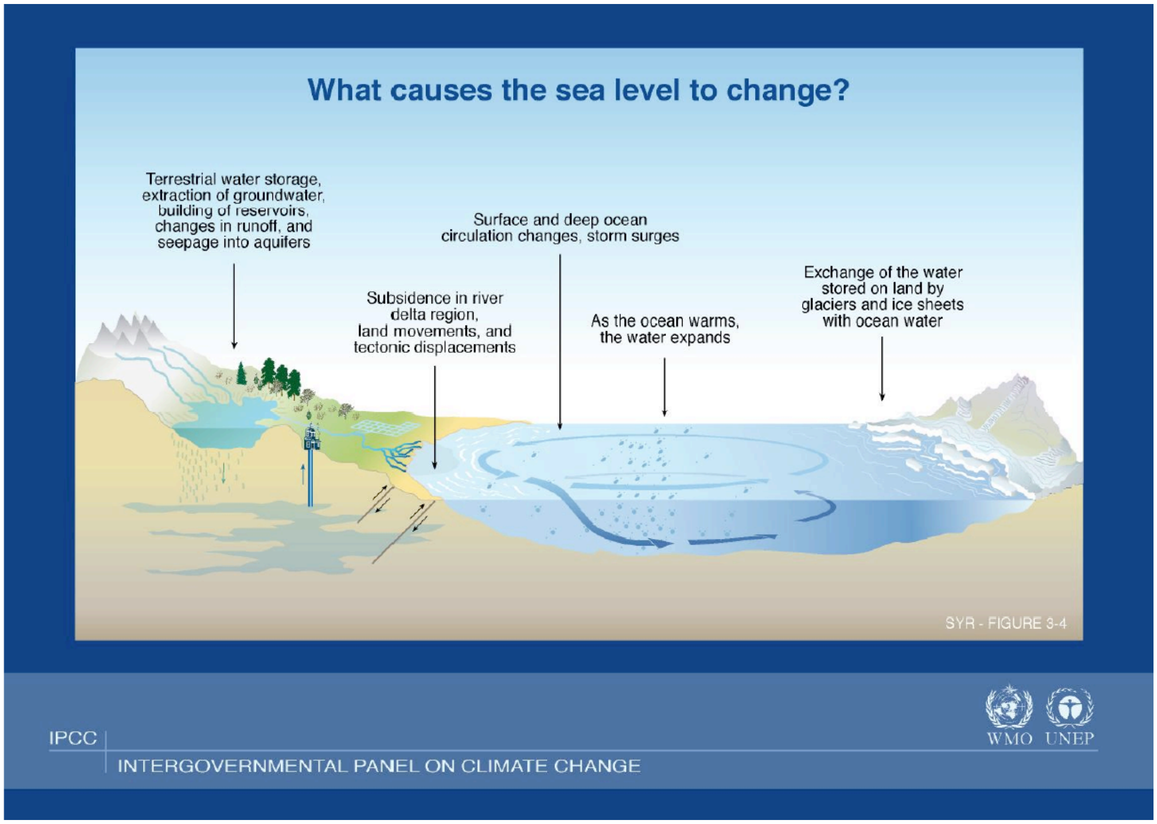
Summary of an online lecture by Dr. Eric Rignot, Jet Propulsion Laboratory, CalTech, Pasadena, California, November 2008. Weather, Sea Level Change, and Climate Change, COSEE-West Online Workshop, http://www.coexploration.org.

The factors that cause sea level to change are complex as the following diagram illustrates:



The average global sea level is currently rising and is 100 meters higher than it was 140,000 years ago. Sea level is not, however, rising uniformly throughout the world and in some places, such as the Alaska coast, sea levels are stable or dropping. This variation is because sea level is dependent not only on eustatic contributions from the thermal expansion of sea water as air temperatures warm and the addition of glacial meltwater, both of which are guided by climate, but also on isostatic contributions from the rebound of land that has been depressed by the weight of glacial ice, sedimentation, or land subsidence as a result of plate tectonics or other processes.

Sea levels dropped during the ice ages when large amounts of water were locked up in continental ice sheets and glaciers. Between the last glacial maximum 12,000 years ago and the present, sea level has been rising 6 mm per year. But this increase was not uniform. During some periods, sea level rise was very slow and in others, it was very, very, very fast.

In the last 8,000 years, sea level has been rising only very slowly because most of the large ice sheets—the ones in Canada and Europe—are gone already. Ice sheets still remain in Greenland and Antarctica, which complicates the overall picture with respect to global warming and sea level rise. The significance of rates of mountain glacial melt in Alaska is an area of active research in the larger context of the rate of melt of the ice sheets and the glaciers that drain them, and the rate of melt of ice shelves that are acting as dams to glacial flows into the ocean.

Sea level is not expected to rise as a result of melting sea ice for the reason illustrated by one of the activities in Investigation 2. Sea ice, icebergs that calve from the face of tidewater glaciers, and ice shelves that are extensions of glaciers are freshwater, not salt water, so they are all floating.

One of the other major impacts of a warming climate could be that the amount of freshwater that reaches the ocean from glacial melt would lower ocean salinities and shut off the global “conveyor belt” of currents (an application of the concepts that are the subject of the 7th grade Alaska Seas and Rivers unit).

Greenland and Antarctic Ice sheets and Glaciers
Greenland and Antarctica have both ice sheets and glaciers that contain 9% and 91% respectively of the freshwater currently locked up as ice. Glaciers drain the ice sheets and sometimes flow rapidly in ice streams of faster-moving ice in the midst of slower moving ice. The rate of ice stream and glacier flow can be accelerated by warming climate at lower elevations.

If the Greenland ice sheet were to melt completely, global sea level would rise 7 meters. The melt of the Antarctic ice sheet would cause it to rise 60 meters. But these dire statistics are not predicted by any model of climate change. In fact, the models that assume sustained and accelerating global warming predict that rainfall will increase in the tropics and result in more snow at the high elevation of the ice sheets.

Measurements of the mass of the Antarctic ice sheet show the same overall trends—the interior is getting thicker while the overall mass of glaciers on the continent is thinning. The glaciers in eastern Antarctica are getting thicker because they are stopped from moving and being exposed to the warmer ocean temperatures by large ice shelves. The ice shelves remain stable because the climate is not warming in this area. In sharp contrast, the Larsen Ice Shelf and Antarctic Peninsula in western Antarctica are experiencing climate warming that is six times larger than the global average. A major collapse of the Larsen Ice Shelf occurred recently. As it melted from the top, water percolated through crevasses and pushed its way through the shelf as it refroze, creating more weaknesses in the ice shelf. Scientists suspect that the collapse was accelerated by melting from the “top-down,” compounded by melting from the “bottom-up” as ocean temperatures got warmer.

Measurements of the Greenland ice sheet show that the interior of the ice sheet is more or less stable with a little thickening, but not much. On the other hand, there is a lot of thinning going on all around the coast and this thinning is concentrated into glaciers. The ice sheet is losing mass because it’s melting fast, but it’s also losing mass because the glaciers are moving faster. One glacier, Kaagerdlugssuaq, is moving three times faster now than it did ten years ago. A second glacier, Jakobshavn Isbrae, one of the largest glaciers in Greenland, has doubled its speed during that time period. The Jakobshavn glacier drains, on its own, 10% of Greenland. It was thickening in the early 1990s, and it started to thin. In 2002, its ice shelf broke away and the glacier doubled its speed. This was already the fastest glacier in the world, and now it is flowing twice as fast as it used to. It is losing 18 cubic kilometers of ice per year.

According to Dr. Rignot, the predictions by the Intergovernmental Climate Change Panel represent a consensus of scientists; but because there are insufficient data on the contribution of coastal glacier melt, the models may be missing a significant input of freshwater.