Oregon State Bar
Sustainable Future Section

Photo: J. Michael Mattingly

Ice Age Lessons for Future Climate Change

By Andreas Schmittner

Geologists have known for more than a hundred years that Earth's climate fluctuated dramatically in the past. Because Earth's orbit around the sun changes slowly, the Earth got colder and warmer, glaciers came and went, and sea level rose and fell (by 300 feet and more). We have also learned that the amount of carbon dioxide (CO_2) in the atmosphere rose and fell in concert with climate, glaciers and sea level. Paleoceanographers and paleoclimatologists have reconstructed past changes in sea and air temperatures in innovative ways. For example, sea surface temperatures can be reconstructed by examining fossil shells from microscopic organisms in sea floor sediments. Some species of plankton (called foraminifera), each of which builds different calcium carbonate shells that can be distinguished by their shapes, live in warmer waters, and other species live in colder waters. Finding cold -water species in deeper layers of a sediment core, dating from an earlier time, at a location where currently only warm-water species live implies that temperatures in the past in that area were colder. In addition to examining the shapes of plankton shells, we can also use over land pollen from lake sediments to reconstruct air temperatures changes.

Using these and other methods, researchers have constructed a rich database of temperature change over the past decades. In preparing the recently published report "Climate Sensitivity Estimated from Temperature Reconstructions of the Last Glacial Maximum", our goal was to use this data together with climate models to better understand the relationship between climate and CO_2. This relationship, referred to as equilibrium climate sensitivity and usually expressed as the global average surface air warming due to a doubling of CO_2 from pre-industrial levels (ECS2xC), is currently uncertain.

Several recently published papers have suggested a small but significant possibility of very high values of climate sensitivity (greater than 15°F). Such high values imply enormous impacts, such as sea level rise, droughts and others, that would be difficult to avoid. On the other hand, climate skeptics claim that the climate sensitivity must be very small (less than 2°F), implying that we don't need to worry about climate change.

We have particularly good information about the height of the last ice age (the last glacial maximum, or LGM, approximately 20,000 years ago). From moraines and other geological evidence, we know the extent of the large ice sheets that covered North America and northern Europe at that time. We also know that, in many regions, different plants would grow and the air was dryer and dustier than now. Sea level was 360 feet lower than today, and ice cores show that CO_2 levels were one-third lower than before the industrial revolution. In preparing this report, we assembled existing, spatially extensive compilations of ocean and land temperatures into a single dataset and compared it with a suite of climate models. The different climate

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models were constructed to have different climate sensitivities ranging from near zero to ECS2xC = 18°F. Simulations of the LGM have been performed with each model, including the effects of lower CO_2, other greenhouse gases, dust, and the presence of large ice sheets over North America and northern Europe. Models with very high climate sensitivities (greater than 11°F) result in a completely snow- and ice-covered Earth. This demonstrates that these models are overly sensitive and therefore unrealistic. Climate models with small climate sensitivities, on the other hand, show almost no cooling during the last ice age in contrast to the reconstructions. We find that climate sensitivities of between 1.8°F and 5.4°F are consistent with the reconstructions. Our best estimate of climate sensitivities is slightly lower than that from the most recent assessment report from the Intergovernmental Panel on Climate Change (IPCC).

Our study, however, comes with a number of caveats. We used only one particular climate model. The model we used is simpler than those used by the IPCC and the varying results may be a result of the different models used. The model versions used in our study did not incorporate uncertainty from the effects of cloud changes on absorbed sunlight at the surface. Therefore, it is likely that the spread of viable climate sensitivity values in our study is overly narrow.

The paleoclimate data from the LGM teaches an important lesson: Even though climate was much different in many regions (e.g., sea level, ice sheets, dust, vegetation), ocean surface temperatures cooled by only 3.4°F. This suggests that small changes in global average temperature, which is dominated by the ocean, are associated with dramatic changes in certain regions, in particular over land at mid- to high latitudes. We estimate that the global average cooling of surface air temperatures during the LGM was only 5.4°F. These results help to put into perspective future climate changes, which have been projected to be between 3.6°F and 7.2°F in the next century, depending on how much carbon humans will emit.

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To view the entire report visit: http://mgg.coas.oregonstate.edu/~andreas/pdf/S/schmittner11sci_man.pdf