New study documents the natural relationship between CO2 concentrations and sea level

January 2 2013

By comparing reconstructions of atmospheric CO2 concentrations and sea level over the past 40 million years, researchers based at the National Oceanography Centre, Southampton have found that greenhouse gas concentrations similar to the present (almost 400 parts per million) were systematically associated with sea levels at least nine metres above current levels.

The study determined the 'natural equilibrium' sea level for CO2 concentrations ranging between ice-age values of 180 parts per million and ice-free values of more than 1,000 parts per million.

It takes many centuries for such an equilibrium to be reached, therefore whilst the study does not predict any sea level value for the coming century, it does illustrate what sea level might be expected if climate were stabilized at a certain CO2 level for several centuries.

Lead author Dr Gavin Foster, from Ocean and Earth Science at the University of Southampton which is based at the centre, said, "A specific case of interest is one in which CO2 levels are kept at 400 to 450 parts per million, because that is the requirement for the often mentioned target of a maximum of two degrees global warming."

The researchers compiled more than two thousand pairs of CO2 and sea level data points, spanning critical periods within the last 40 million

years. Some of these had climates warmer than present, some similar, and some colder. They also included periods during which global temperatures were increasing, as well as periods during which temperatures were decreasing.

"This way, we cover a wide variety of climate states, which puts us in the best position to detect systematic relationships and to have the potential for looking at future climate developments," said co-author Professor Eelco Rohling, also from Ocean and Earth Science at the University of Southampton.

The researchers found that the natural relationship displays a strong rise in sea level for CO2 increase from 180 to 400 parts per million, peaking at CO2 levels close to present-day values, with sea level at 24 +7/-15 metres above the present, at 68 per cent confidence limits.

"This strong relationship reflects the climatic sensitivity of the great ice sheets of the ice ages," said Dr Foster. "It continues above the present level because of the apparently similar sensitivity of the Greenland and West Antarctic ice sheets, plus possibly some coastal parts of East Antarctica."

According to the study, sea level stays more or less constant for CO2 changes between 400 and 650 parts per million and it is only for CO2 levels above 650 parts per million that the researchers again saw a strong sea level response for a given CO2 change.

"This trend reflects the behaviour of the large East Antarctic ice sheet in response to climate changes at these very high CO2 levels. An ice-free planet, with sea level 65 metres above the present, occurred in the past when CO2 levels were around 1200 parts per million."

Professor Rohling said, "Sea level rises to these high values will take

many centuries, or even millennia, but the implications from the geological record are clear – for a future climate with maximum warming of about two degrees Centigrade, that is with CO2 stabilized at 400 to 450 parts per million, sea level is set to steadily rise for many centuries, towards its natural equilibrium position at around 24 +7/-15 metres, at 68 per cent confidence. In Intergovernmental Panel on Climate Change terms, this is a likely rise of at least nine metres above the present. Previous research indicates that such rises above present sea level may occur at rates of roughly one metre per century."

Based on these results, which document how the Earth system has operated in the past, future stabilization of CO2 at 400-450 parts per million is unlikely to be sufficient to avoid a significant steady long-term sea level rise.

More information: The study is published this week online ahead of print in *Proceedings of the National Academy of Sciences* (*PNAS* manuscript # 2012-16073R).

Provided by National Oceanography Centre, Southampton