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Scientific Commentary

How short can short-term human-induced climate oscillations be?

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In an article not exempt from controversy, Ruddiman (2003) suggested that pre-industrial anthropogenic activities could have been important enough to stop a glaciation event. New ice sheets should have begun to grow several millennia ago but did not, possibly because human-induced global warming began far earlier than previously thought, that is, well before the industrial era (Ruddiman, 2005). If Ruddiman's ideas are correct for the pre-industrial world, what could be the impact of modern society on the global balance of CO_2 and therefore on global temperatures?

We currently face a public debate that at least in part has become bitter and somewhat ideological. On one side stand those who mildly or strongly oppose the mere notion of man-induced climate change. On the other, there is a strong faction that in its extreme side freely speaks in terms of a near-future 'doomsday'. In the middle stands a community that would really want to see a sound discussion and actual proofs going beyond climate modelling. In this respect, as indicated by Murphy et al. (2004), "*…planners are typically faced with a wide range of predicted changes from different models of unknown relative quality, owing to large but unquantified uncertainties in the modelling process*." Most if not all of the weight in the debate has been placed upon the rapid build-up of CO_2 atmospheric levels. However, we all know well that nature has a complexity that in many cases goes beyond our full understanding. For example, apart from greenhouse gases (such as CO_2), there is an intimate interplay between oceans and climate (e.g., Sutton and Allen, 1997; Rahmstorf, 2002; Gagosian, 2008; among others). In fact, ocean circulation is an active and highly nonlinear factor in global climate, and there is increasing evidence relating ocean circulation and abrupt climate shifts (Rahmstorf, 2002). The El Niño-Southern Oscillation (ENSO) shifts the seasonal temperature and precipitation patterns (seasonal climate oscillations) in many different regions of the world, even in those that are distant from the equatorial Pacific Ocean (IRI, 2007). In this respect, the ENSO is associated with anomalously warm sea surface temperatures that periodically interact with the air in the central Pacific Ocean (The National Academies, 2008). More connections between climate and oceans are provided by the work of Lund et al. (2006), who suggested that diminished oceanic heat transported by the Gulf Stream could have contributed to the Little Ice Age cooling in the North Atlantic. Equivalent conclusions were reached by Sicre et al. (2008) who related the influence of ocean currents and sea temperatures in the northern Atlantic to remarkable climate oscillations such as those of the Medieval Warm Period and the Little Ice Age. To geologists climate change is not the exception but the norm. There is not a 'standard climate' to start with, so change would be the least one could expect, either in the short- or long-term. This is not a geologic vision expressed in terms of millions or billions of years, but also applies to short periods of time (e.g., the Medieval Warm Period shortly followed by the Little Ice Age, all in a few centuries). Additionally, although global temperatures were very low on average during the last ice age, they had periodic and notorious oscillations until they slowly but steadily started to rise some 17,000 years BP as shown from data gathered from the Vostok ice core (Antarctica; Petit et al., 1999; Oyarzun et al., 2005). Thus, climate is not a steady state as it varies on a range of time-scales.

However, having said that climate change can happen in short periods of time, how short can a short period of time be? Moreover, can man indeed affect climate in the very short-term? Abrupt climate change has been recently defined as "*…a large-scale change in the climate system that takes place over a few decades or less, persists (or is anticipated to persist) for at least a few decades, and causes substantial disruptions in human and natural systems…*" (Clark et al., 2008). We have explored the concept of 'abruptness', to test the idea of 'very short-term' climate oscillations, more in the range of years than decades or centuries, and not necessarily persistent in time. In order to achieve this we checked a particular time segment of our recent history. Advocates of man-induced global warming will say that it has been fast industrialization during the 19th–20th Centuries and associated massive burning of fossil fuels that has induced the rapid

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