Climate Change is Now

by L. D. Swift, PhD

Our climate is changing at an increasingly rapid rate. We have already exceeded the worst case scenario predicted in 2007 by the Intergovernmental Panel on Climate Change (IPCC) and are on our way to irreversible consequences.

Let's look at where we are today from a geologic perspective. Ice core data from Antarctica track variations in temperature, CO_2, and methane (CH_4). Over the past 800,000 years, the variations of these three parameters tend to correlate (Figure 1). The maxima during the past 800,000 years were, for CO_2 ~300 ppmv, and for methane ~800 ppbv. Both CO_2 and methane are Greenhouse Gases (GHG) and cause heat to be "trapped" and temperatures to rise. Correlating with the maximum values of CO_2 and methane, temperature was ~4°C above the zero point ("zero" is taken as temperature in the year 1950). Note that homo sapiens have only been around for about the past 300,000 to 400,000 years (Figure 1). Therefore in all of human evolution, we have never seen temperatures greater than 4°C above 1950 levels.

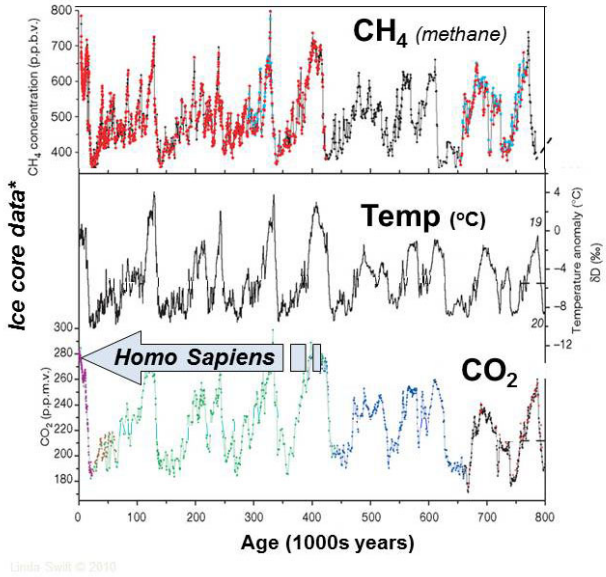

Figure 1 Values of methane (CH_4), Temperature (°C), and CO_2 over the past 800,000 years as measured or extrapolated from ice core. Note that the three parameters correlate. At maxima where CO_2 was ~300 ppmv and methane was ~800 ppbv, temperatures were ~4°C higher than 1950 temperatures. Data and figures from Loulergue et al (p. 383) and Luthi et al (p. 379), Nature, 15 May 2008.

Now let's look at where we are today. As seen in Figure 2, we have exceeded values of CO_2 and methane (CH_4) by significant amounts over any value seen in the last 800,000 years. At these very high values of greenhouse gases we would expect to see significant temperature increases. Models, done by the IPCC (Feb. 2007 report), show increases of 4-5°C by the end of this century in the continents of the northern hemisphere. We've started down the road. Actual measured data show an increase of 1-2°C from 1970 to 2004 in much of North America, Northern Africa and Asia (IPCC, Apr 6, 2007 report) which is acceleration from that shown by the models.

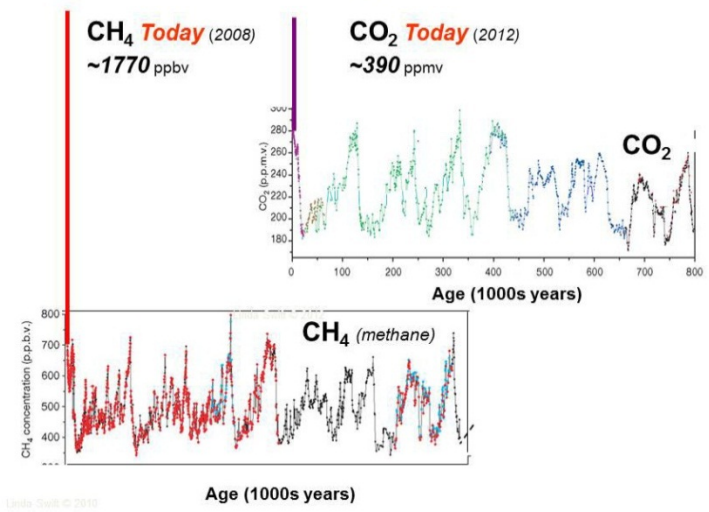

Figure 2 Current values of CO_2 and methane (CH_4) are significantly higher than anything seen over the past 800,000 years. Ice core data and figures from Loulergue et al (p. 383) and Luthi et al (p. 379), Nature, 15 May 2008. CO_2 values of today from http://co2now.org/. CH_4 values today from IPCC, 2007 reports, www.ipcc.ch/

Temperature has not risen more primarily because, in addition to heating our atmosphere via greenhouse gases, we are also cooling through direct shading from particulates (smog) and because clouds nucleate around those same particles and further shade the planet (cf. IPPC, 2007 reports). But whereas the warming effects of greenhouse gases stay with us for ~100 to 200 years, the cooling effects can disappear in a matter of weeks. That means that if we reduce particulate "pollution", we will nearly immediately see an increase in temperature.

Other indicators are also well beyond what some authors label "safe" limits. As seen in the table below, in addition to CO_2 and methane, nitrogen is increasing (nitrous oxide – N_2O – is another greenhouse gas). And, as a likely result of the changing climate, biodiversity is decreasing fairly drastically. During pre-industrial times, the number of species which went extinct per million species existing was from 0.1 to 1.0 per year. Today we are seeing 100 species go extinct out of each million species currently existing – every year! That is 1000% over the "safe" limit.

	Pre-Industrial	"Safe" boundary	Current	Percent above "safe" boundary
CO_2 concentration (ppmv)	280	350[1]	394[2]	13%
Methane concentration[3] (ppbv)	800(max)	~800	1770	220%
Nitrogen cycle[1] MM tons/yr	0	39	133	340%
Biodiversity[4] extinct/MM/yr	0.1-1.0	10	100	1000%

[1]Foley, 2010, Scientific American
[2]http://co2now.org
[3]Swift, 2010, http://www.msubillings.edu/urban/video/index.htm
[4]Rockstrom et al., 2009, Nature

Do Scientists Agree?

Nearly all scientists and major institutions agree that climate change is happening and it is primarily due to human causes (fossil fuel burning is the largest contributor). A 2009 study of earth scientists showed that 96-97% of publishing climate scientists agree that climate change is occurring and due to human causes (Doran and Kendall-Zimmerman, 2009, EOS v. 90 no. 3, pp. 22-23). The Intergovernmental Panel on Climate Change (IPCC) itself, which was convened by the UN specifically

for the purpose, determined that climate change is a major threat. All major institutions also agree:

for example, NASA, NOAA, USGS, National Academy of Sciences, and universities and institutions worldwide. So yes, the vast majority of scientists agree.

Interconnected

The science of climate change is complex, to say the very least. It is not particularly overstated to say that all of life, with the intricate interdependencies among the plants and animals of our living planet, is affected by climate and the resulting weather. Like the proverbial butterfly causing major storms, what at first blush appear to be small changes in temperature can in fact cause large results that reverberate in weather systems, biosystems, and even affect geologic systems. Just a couple of simple examples: Moose populations in the northern U.S. are declining, partly because of increased loads of ticks, which flourish in the warmer weather, and other related stresses. Increased CO_2 dissolved in the oceans raises acidity which, together with increasing water temperatures, affects ocean life, such as coral, and the basis of the entire food chain – phytoplankton. Farmers are coping with changes of weather patterns with rain and warmth coming at different times affecting patterns of planting and harvest. The many complex interdependencies make predicting results and timing of changes very difficult to predict. The scientific community is working actively on refining our predictions, but research takes time. And never count humans out. We are a very resourceful and intelligent species. And, albeit slowly at first, we are rising to this enormous challenge.

For excellent information on the key elements of climate change see the Woods Hole and American Museum of Natural History sites.