The Dark Side
What if the Climate Pessimists Are Right?

A couple of people have asked me to summarize the present state of climate change knowledge with an eye to the most pessimistic views on the not-so-distant future. Here goes…

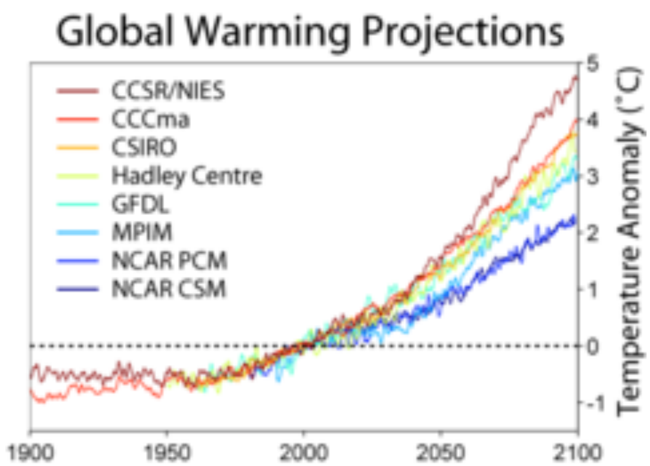
Consider this timeline:

Late 2007	The Intergovernmental Panel on Climate Change (IPCC)announces that the planet will see a 1° Celsius temperature increase due to climate change by 2100.
Late 2008	The Hadley Centre for Meteorological Research predicts a 2°C increase by 2100.
Mid-2009	The UN Environment Programme predicts a 3.5°C increase by 2100. Such an increase would remove habitat for human beings on this planet, as nearly all the plankton in the oceans would be destroyed, and associated temperature swings would kill off many land plants. Humans have never lived on a planet at 3.5°C above baseline.
October 2009	The Hadley Centre for Meteorological Research releases an updated prediction, suggesting a 4C temperature increase by 2060.
November 2009	The Global Carbon Project, which monitors the global carbon cycle, and the Copenhagen Diagnosis, a climate science report, predict 6°C and 7°C temperature increases, respectively, by 2100.
December 2010	The UN Environment Programme predicts up to a 5°C increase by 2050.
2012	The conservative International Energy Agency's World Energy Outlook report for that year states that we are on track to reach a 2°C increase by 2017.
November 2013	The International Energy Agency predicts a 3.5°C increase by 2035.

Notice what is happening to the predictions. In general, predicted temperatures are increasing and the time required for those temperature increases is decreasing.

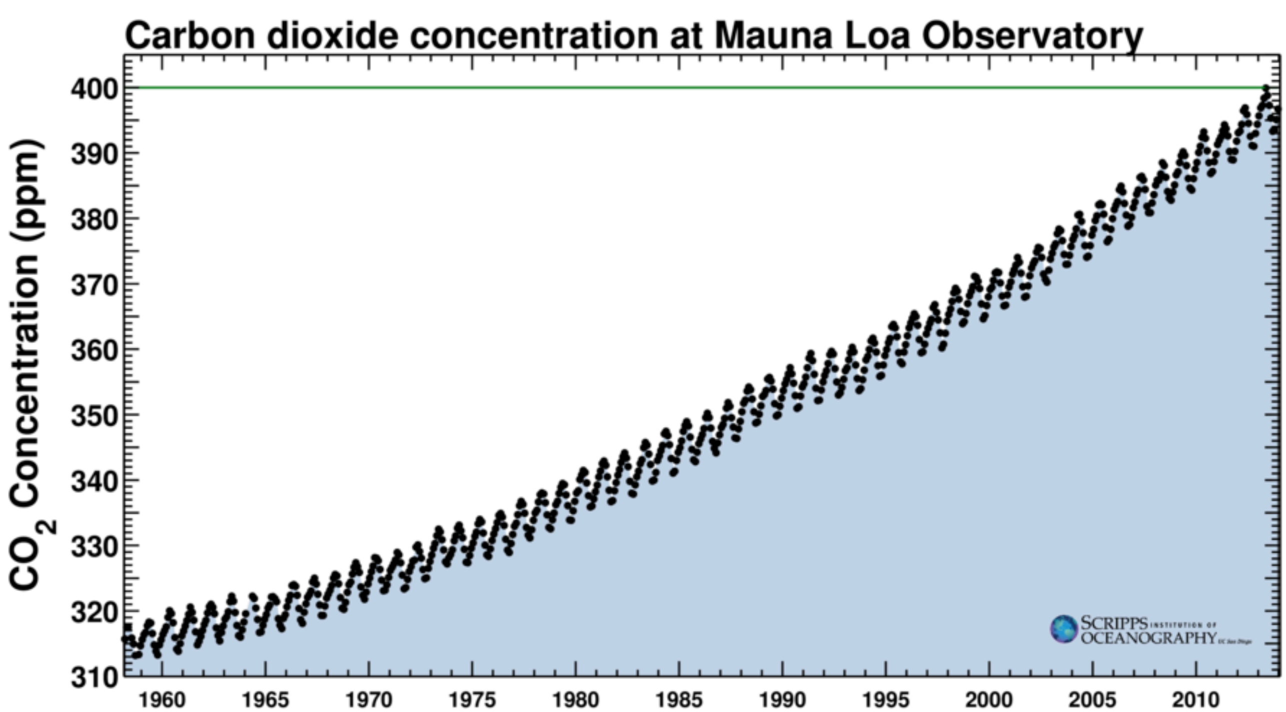
These predictions are based on computerized climate models. Some people resist believing the models saying that they must be prone to error. Nobody in the climate community believes that there is no possibility of error. However, that does not mean that they have no confidence in the models. Let me give you one example as to why. Project Zooniverse is an example of a Citizens Science Project. Google it and you can get an idea of what they are up to. One of their projects, in which I participatedby the way, is called Old Weather. In that project, the hundreds and hundreds of logs from British warships, compiled prior to World War I and containing daily weather observations, were transcribed by citizen volunteers over the web and compiled into computer files. Contemporary climate models had the direction of their "time arrow" switched so that what the models saw as the future was really our past. The models were run and the results were compared to the actual records. The results were that the models were highly accurate.

Another example is "convergence." Given that there are two dozen or so powerful weather models in existence, if built-in error was substantial we would then expect a substantial divergence in model prediction. There are differences in the climate predictions certainly, but those differences are relatively small. Given that there is an enormous interest in climate prediction accuracy, we may expect dramatic improvements in the model's "resolving power" as the sophistication of the models and the power of the underlying technology improves. Since the model's predictions have been converging over recent decades, I believe that it is incumbent on deniers to explain why and how that predictive convergence will disappear. The global average temperature projections, from eight of the more muscular models in use, is shown below.



You can see that all of these models are in essential agreement, differing by only 3°C by 2100 CE.

There is data from direct, instrumentation-based, measurements contributing to climate change pessimism. The "Keeling Curve below shows a graph of the complete lifetime record of the Scripps Oceanographic Institute's CO_2 observatory on Mauna Loa going back to the 1950's.



Note that last year, the CO_2 concentration reached 400 parts per million for the first time.

Some people ask about the “waviness” of the graph on a year-to-year basis. Consider that the earth’s axis is tilted so that the intensity and amount of sunlight reaching the northern and southern hemispheres varies over the year. Further consider that the northern hemisphere has more land area than does the southern. As spring and summer approach in the northern hemisphere and leaf-out commences in earnest, the level of photosynthesis rises sharply and the uptake of CO_2 spikes. CO_2 gets used up and the atmospheric concentration goes down, As fall and winter approach, CO_2 uptake falls off and the atmospheric concentration goes up.

The major issue which the Keeling Curve illustrates however, is the rise from year-to-year in the overall concentration. The carbon in the CO_2 has been analyzed and compared to the carbon in the CO_2 from bubbles entrained in ice sheets, mainly in Antactica and Greenland. ^{14}C is an isotope of carbon produced by the bombardment of the nuclei of nitrogen atoms in the upper atmosphere by cosmic rays. It is unstable and decays into the much more common ^{12}C over thousands of years. As time passes, the rate of ^{14}C creation and decay reaches equilibrium and the relative amounts of each isotope in the atmosphere remains constant. When a plant or animal dies, it stops taking in ^{14}C and so the relative amount of ^{14}C in its remains begins to fall. Plant and animal remains were incorporated into fossil fuels millions of years ago. They now have virtually no ^{14}C remaining. If the CO_2 in the atmosphere were from what some people call “natural” sources, that is to say sources not tainted by carbon from fossil fuels, we would expect ^{14}C levels to approximate historical norms. However, since the onset of large-scale fossil fuel use, we have seen a fall off in the ^{14}C level in the atmosphere. Turning that around slightly, since the onset of fossil fuel use in 1850 or 1860 CE or so, we have seen an increase in ^{12}C levels. Volcanoes and lava flows are also sources of old carbon, but not in the amounts required to explain current observation. We are forced to conclude that the excess of old carbon is due to the burning of fossil fuels.

That increase in CO_2 has consequences, some potentially severe, some potentially catastrophic.

On December 3, 2013, a study by eighteen eminent scientists, including the former head of NASA’s Goddard Institute for Space Studies, James Hansen, showed that the long-held, internationally agreed-upon target to limit rises in global average temperatures to two degrees Celsius was in error and far above the 1C threshold that would need to be maintained in order to avoid the effects of catastrophic climate change.

A briefing provided to the failed UN Conference of the Parties in Copenhagen in 2009 provided this summary: “The long-term sea level that corresponds to current CO_2 concentration is about 23 meters above today’s levels, and the temperatures will be 6 degrees °C or more higher. These estimates are based on real long-term climate records, not on models.”

From Dar Jamail in The Nation, December 17, 2013:
“We as a species have never experienced 400 parts per million of carbon dioxide in the atmosphere,” Guy McPherson, professor emeritus of evolutionary biology, natural resources, and ecology at the University of Arizona and a climate change expert of twenty-five years, told me. “We’ve never been on a planet with no Arctic ice, and we will hit the average of 400 ppm…within the next couple of years. At that time, we’ll also see the loss of Arctic ice in the summers.… This planet has not experienced an ice-free Arctic for at least the last three million years.”

From the same article:

For the uninitiated, in the simplest terms, here's what an ice-free Arctic would mean when it comes to heating the planet: minus the reflective ice cover on Arctic waters, solar radiation would be absorbed, not reflected, by the Arctic Ocean. That would heat those waters, and hence the planet, further. This effect has the potential to change global weather patterns, vary the flow of winds, and even someday possibly alter the position of the jet stream. Polar jet streams are fast flowing rivers of wind positioned high in the earth's atmosphere that push cold and warm air masses around, playing a critical role in determining the weather of our planet.

And more…
Professor Peter Wadhams, a leading Arctic expert at Cambridge University, has been measuring Arctic ice for forty years, and his findings underscore McPherson's fears. "The fall-off in ice volume is so fast it is going to bring us to zero very quickly," Wadhams told a reporter. According to current data, he estimates "with 95% confidence" that the Arctic will have completely ice-free summers by 2018. (US Navy researchers have predicted an ice-free Arctic even earlier—by 2016.)

So, where is the Emergency? Why all the fuss? The emergency and fuss lies in the world of Feedbacks. It is this world of feedbacks that has the climate scientists running around with their hair on fire.

Let's look at a nice simple feedback loop in our atmosphere. Sunlight reaches the earth's surface. As it does so, it warms that surface. If the surface contains water, the evaporation rate increases. As the evaporation rate increases, the rate of cloud formation increases. As cloud formation increases, the amount of sunlight reaching the surface decreases, slowing the evaporation rate. This is a Negative Feedback Loop. Of course, it isn't all that simple. There is a Positive Feedback Loop also involved. Water vapor is a Greenhouse Gas, a gas which inhibits the passage of infra-red radiation. (the radiation from Infra Red lamps keep the fries warm at McDonald's.) When the water evaporates, the water vapor level rises trapping more heat near the surface, causing more evaporation and so on. You now just begin to get a hint at the underlying complexity of climate systems. There are a myriad of feedbacks, positive and negative, superimposed on long term cyclical changes in such things as the earth's orbit and axial tilt, solar output, changes in wind patterns and ocean circulation due to continental drift and so on, all modeled by an array of simultaneous differential equations. Tweek one item a little bit and an avalanche of calculation is required for the system to adjust.

Let's go back to the Arctic. Ice reflects about 90% of the sunlight it receives. Open water absorbs about 90% of the sunlight it receives. As the arctic ice retreats, the amount of open water increases, As the amount of open water increases, the amount of sunlight absorbed by the water sharply increases and the arctic ocean water warms. As the water warms, mostly nearer the surface, the seafloor near the edges of the ocean are bathed in warmer water. This is where the drama begins in earnest.

Water vapor is an important Green House Gas (GHG). However, there are others including CO_2, methane, nitrous oxides, chloroflorocarbons and some others. CO_2 is a big culprit in the climate change predictions. It is a moderately powerful GHG and a single molecule of CO_2 in the atmosphere has a calculated lifespan of about 100 years before it is removed by the carbon cycle. Methane, CH_4, is a much more powerful GHG but has a much shorter lifespan before becoming CO_2 and water vapor. Methane can be called a real climate "hothead."

Vast amounts of methane are locked up in the permafrost regions of Canada, northern Europe and Siberia. The permafrost extends outward from the shorelines under the arctic ocean. You probably can already sense the concern. As the water and atmosphere warm, even just a little bit, permafrost and the methane therein, also warms. As the permafrost warms, methane is released, warming the atmosphere a little bit more. More ice melts, more permafrost softens, more methane is released. You get the picture. So, how fast is it happening?

Also From Dar Jamail in The Nation:
In the last two centuries, the amount of methane in the atmosphere has increased from 0.7 parts per million to 1.7 parts per million. The introduction of methane in such quantities into the atmosphere may, some climate scientists fear, make increases in the global temperature of four to six degrees Celsius inevitable. The ability of the human psyche to take in and grasp such information is being tested. And while that is happening, yet more data continues to pour in—and the news is not good.

"The Arctic is warming faster than anywhere else on the planet," climate scientist James Hansen has said. "There are potential irreversible effects of melting the Arctic sea ice. If it begins to allow the Arctic Ocean to warm up, and warm the ocean floor, then we'll begin to release methane hydrates. And if we let that happen, that is a potential tipping point that we don't want to happen. If we burn all the fossil fuels then we certainly will cause the methane hydrates, eventually, to come out and cause several degrees more warming, and it's not clear that civilization could survive that extreme climate change."

Yet, long before humanity has burned all fossil fuel reserves on the planet, massive amounts of methane will be released. While the human body is potentially capable of handling a six-to-nine-degree Celsius rise in the planetary temperature, the crops and habitat we use for food production are not. As McPherson put it, "If we see a 3.5° to 4°C baseline increase, I see no way to have habitat. We are at 0.85°C above baseline and we've already triggered all these self-reinforcing feedback loops."

He adds: "All the evidence points to a locked-in 3.5° to 5°C global temperature rise above the 1850 'norm' by mid-century, possibly much sooner. This guarantees a positive feedback, already underway, leading to 4.5° to 6°C or more degrees above 'norm' and that is a level lethal to life. This is partly due to the fact that humans have to eat and plants can't adapt fast enough to make that possible for the 7-to-9 billion of us—so we'll die."

If you think McPherson's comment about lack of adaptability goes over the edge, consider that the rate of evolution trails the rate of climate change by a factor of 10,000, according to a paper in the August 2013 issue of *Ecology Letters*. Furthermore, David Wasdel, director of the Apollo-Gaia Project and an expert on multiple feedback dynamics, says, "We are experiencing change 200 to 300 times faster than any of the previous major extinction events."

I cannot remember where I saw this analysis but I am going to share it anyway. The grid below allows a framework for discussing our position on climate change. The vertical scale on the left shows action versus inaction while the horizontal scale along the top shows that climate change is either true or false. The entries in the grid show the consequences of decisions in each case. Which consequence is the most dire? Is No Action a reasonable position?

	Climate Change is	
And we take…	True	False
No Action	Catastrophe. Sea-level rise, depression, famine, wars, disease, possible extinction	Things are Pretty good!
Action	Slowing economic growth, probably a depression	Slowing economic growth, probably a depression