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GARP0206

Test 2

1. Radiative Forcing

Radiative forcing is a concept that is described by the process of sunlight being reflected back into space while the rest travels down and is absorbed into the Earth. Net forcing is determined by the balance between the amount of radiation being absorbed and the amount leaving the atmosphere. Positive radiative forcing occurs when the amount of radiation being absorbed into the Earth was greater than the amount of energy escaping the atmosphere. Negative radiative forcing occurs when the amount of radiation being absorbed into the Earth is less than the amount of energy that leaves the atmosphere. It is measured in watts per meter in the troposphere, lower level of the atmosphere.

Thinking simply, one might assume that to find the value of radiative forcing, you would simply take away the amount of energy leaving from the radiation coming in and use the resulting number. But radiative forcing is not so simple. There are many anthropogenic factors that go into determining the value of radiative forcing. Some of these factors include greenhouse gases, ozone, surface albedo, and aerosols. Aerosols from volcanic activity, clouds, and fossil fuels burning out. Aerosols in the air in the form of clouds and the troposphere create a shield, reflecting radiation away from the Earth, creating a cooling effect. It's anthropogenic factors such as this which influence the warming and cooling of the Earth beyond radiation. This is why you can't only factor in the Sun when creating a value for radiative forcing. In figure 1 below you can see how many other factors go into radiative forcing, and how small (in comparison) the Sun's effect is.

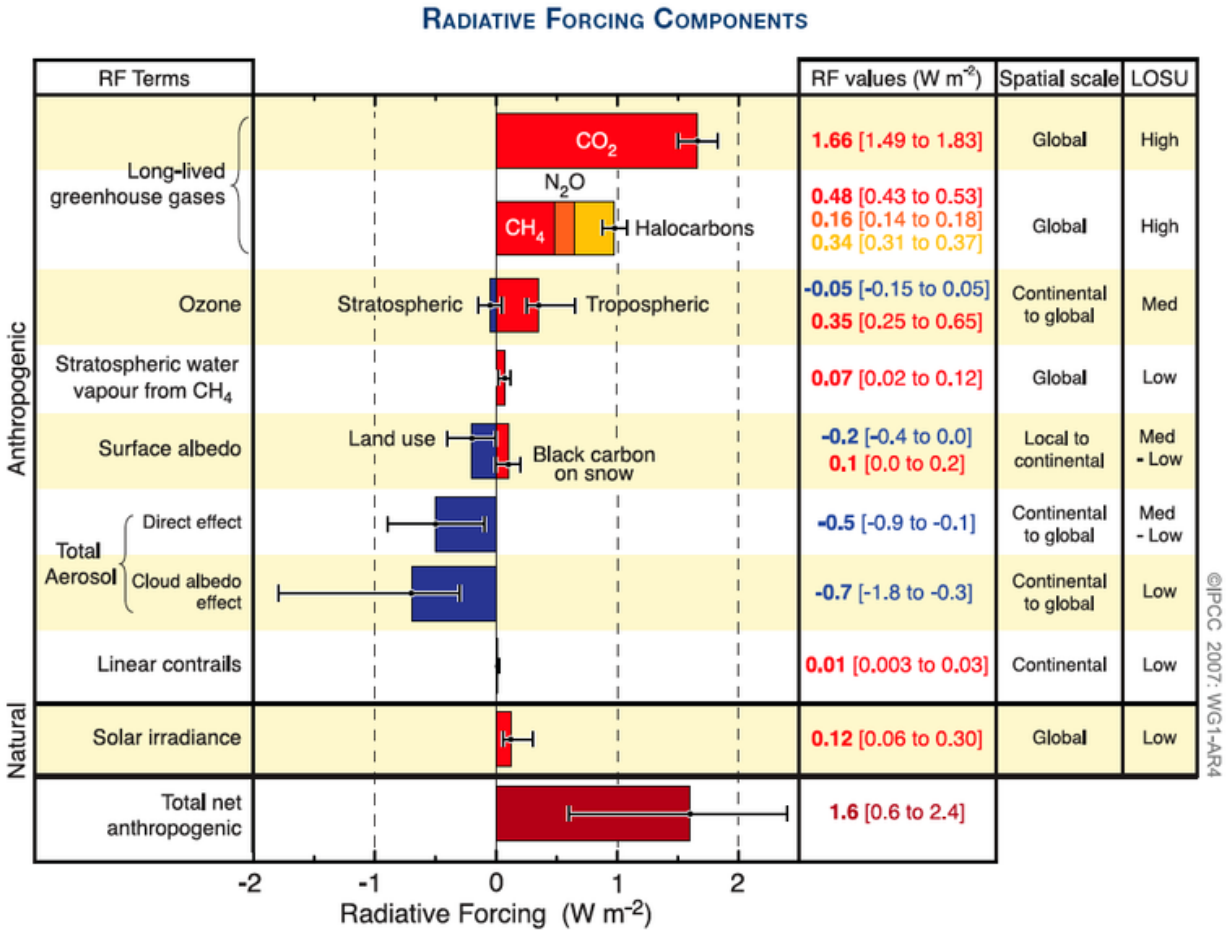


Figure 1: Factors of Radiative Forcing

Image Source: <http://ossfoundation.us>

In the figure about you can see illustrated in red, the positive forcing from solar irradiance and other anthropogenic factors. In blue you see the negative forcing from anthropogenic factors. As illustrated the aerosols create a negative forcing, but overall there is positive forcing. You can clearly see how more than just the Sun and natural cooling go into creating a value for radiative forcing.

Annotated Bibliography

Chandler, David L. "MIT News Office." *MIT News Office*. N.p., 10 Mar. 2010. Web. 01 Apr.

2014. <<http://newsoffice.mit.edu/2010/explained-radforce-0309>>.

This article explains the concept of radiative forcing. It gives a definition as well as discusses the way that it is measured and some of the discrepancies around those methods.

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<<http://grimstad.uia.no/puls/climatechange/nng01/07nng01.htm>>.

This reference discusses some of the factors that go into determining a value for radiative forcing. it describes the current number and balance of radiative forcing.

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<http://en.wikipedia.org/wiki/Radiative_forcing>.

This reference gives a definition for radiative forcing as well as discusses some of the factors, the IPCC, and gives data for past radiative forcing.

2. Carbon Cycle

The carbon cycle is the cycle or process that carbon undergoes through the Earth and atmosphere. It travels in the atmosphere in the form of carbon dioxide and methane. It exists in everything in the biosphere and oceans. In the slow carbon cycle, carbon moves through the lithosphere and ocean over hundreds of millions of years. The fast carbon cycle occurs in a measured “lifespan”. Carbon moves through plants on the Earth and the atmosphere. You can see in figure 2 how plants and plankton in the ocean absorb carbon, while natural decomposition and human influence emit carbon. Because the carbon cycle is constant there is always a reservoir of carbon in one component, flowing in or out, and there is balance. When there is some sort of shift in the amount of carbon flowing in or out of one component, the balance is thrown off, which can affect the Earth’s climate.

Millions of years ago the amount of carbon dioxide in our atmosphere dropped as new vegetation and plankton absorbed it. Recently the amount of carbon dioxide in the atmosphere is increasing with the introduction of humans and technology. Transportation, power plants, and deforestation or just a few of the ways that humans are shifting the flow of carbon through its cycle, changing the balance. While plants are continuing to work to take carbon out of the atmosphere, we are taking away some of those plants as well as adding carbon back into the atmosphere; the plants can’t keep up.

The biggest impact of the increased carbon concentration in the atmosphere, in the form of carbon dioxide, is the fact that increased carbon dioxide causes an increase in temperature. So with humans disrupting the carbon cycle by adding more carbon dioxide and taking away some of the ways that carbon is absorbed, humans are in effect causing an increase in temperature. You

can see in figure 3 how carbon dioxide and temperature correlate. When there is less carbon dioxide the temperature decreases, which the Earth experienced millions of years ago. When the concentration of carbon increases then the temperature increases, which is what the Earth is experiencing currently.

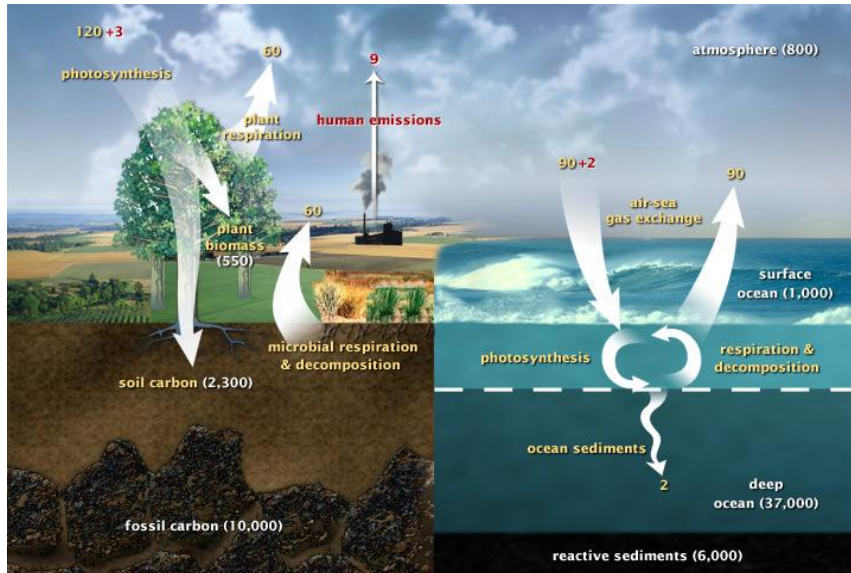


Figure 2: Fast Carbon Cycle
Image Source:

<http://upload.wikimedia.org>

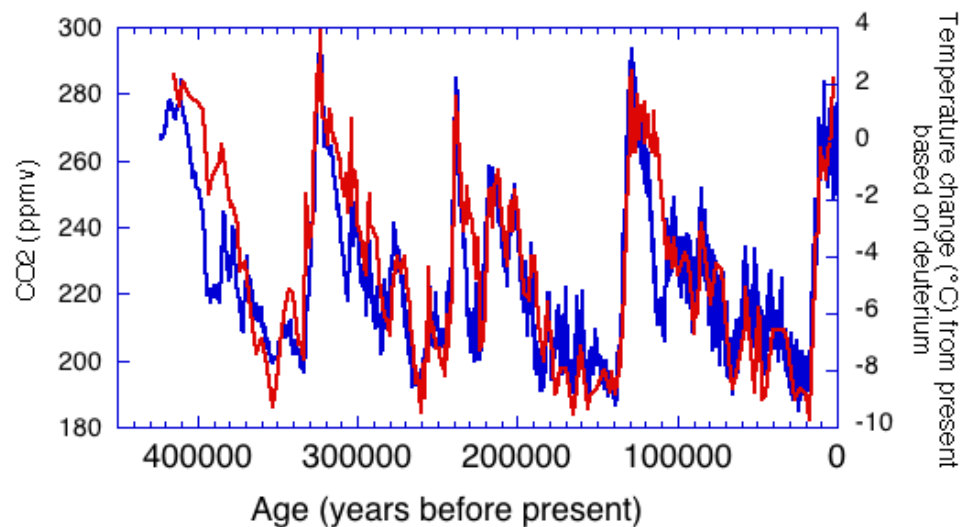
This image shows the different areas and components that influence the carbon cycle. you can see how there is a flow in and out of each, designated by arrows.

Figure 3: Carbon Dioxide and Temperature

Image Source:

<http://www.ncdc.noaa.gov>

This figure shows the correlation between temperature, shown in blue, and carbon dioxide, shown in red. You can see how they rise and fall together.



Annotated Bibliography

"The Carbon Cycle : Feature Articles." *The Carbon Cycle : Feature Articles*. N.p., n.d. Web. 01

Apr. 2014. <<http://earthobservatory.nasa.gov/Features/CarbonCycle/page5.php>>.

This source discusses the effects that a change in the carbon cycle can have on land, ocean, and the atmosphere.

"Carbon Cycle." *Wikipedia*. Wikimedia Foundation, 31 Mar. 2014. Web. 01 Apr. 2014.

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"Climate Science Info Zone." *Have Humans Changed the Carbon Cycle? - - Science Museum*.

N.p., n.d. Web. 01 Apr. 2014.

<<http://www.sciencemuseum.org.uk/ClimateChanging/ClimateScienceInfoZone/ExploringEarthscclimate/1point7.aspx>>.

This video briefly explains how the carbon cycle works and how it has changed with the introduction of human influence.

Riebeek, Holli. "The Carbon Cycle : Feature Articles." *The Carbon Cycle : Feature Articles*.

N.p., n.d. Web. 01 Apr. 2014. <<http://earthobservatory.nasa.gov/Features/CarbonCycle/>>.

This article discusses the carbon cycle and its two components, the slow and fast carbon cycles.

"Temperature Change and Carbon Dioxide Change." *NOAA Paleoclimatology Global Warming*.

N.p., n.d. Web. 01 Apr. 2014.

<<http://www.ncdc.noaa.gov/paleo/globalwarming/temperature-change.html>>.

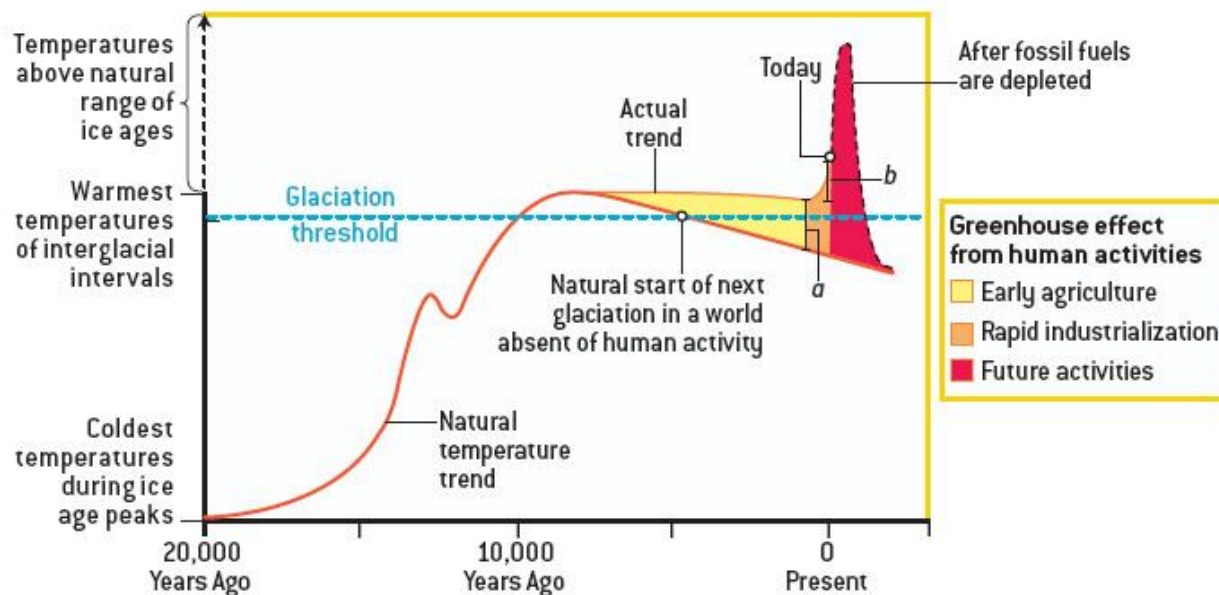
This source discusses the correlation between carbon dioxide and temperature.

3. Bill Ruddiman

Bill Ruddiman is marine biologist and professor at the University of Virginia who has been studying climate change for decades. Ruddiman hypothesized that human influence on climate change started before the industrial revolution, before cars and coal plants. In his article in the Scientific American he says, “New evidence suggests that concentrations of carbon dioxide started rising about 8,000 years ago, even though natural trends indicate they should have been dropping” (Ruddiman, 46). His evidence stems from observations of proxy records of carbon dioxide concentration, which indicate rising and falling that correlates with increases and decreases in human population (related to diseases and outbreaks). He discusses the impact of farming and early deforestation related to growing populations and the technology that was available at the time. He further supports his theory by claiming that following the current trend, the Earth should have experienced another ice age. Because of the increasing human activity due to deforestation, farming, and the eventual industrialization (but not starting then) humans causes a rise in carbon dioxide emissions, thus a rise in temperature.

Ruddiman has been challenged with claims that the type of carbon dioxide found in the ice cores is not the kind of carbon dioxide that would be emitted by burning trees (Fischman). Having read both Ruddiman’s evidence and theory as well as read some criticisms I am still unsure who’s side I am on. I have to say I am partially swayed towards Ruddiman’s theory though, in part because of the evidence of the Earth’s warming against a cooling trend. In looking at figure 4, below, you can see how temperatures plateaued instead of cooled and then, as we know, rapidly increased when industrialization began. Even though it is not really a warming trend, it does go against the supposed cooling trend. At the same time, who’s to say that

we would have experienced that trend without humans? Although the Earth was in a trend of glacial and interglacial periods, that was not the case for the entire lifespan of the Earth. The Earth experiences natural changes over thousands and millions of years. How do we know that we aren't at the beginning of a new natural trend as well as seeing drastic influence from



humans?

Figure 4: Temperature of Earth before and after the introduction of Humans

Image Source: <http://www.nature.com>

This figure shows where the suspected cooling trend, based on the trend of glacial and interglacial periods prior, should have began and what the actual temperature of the Earth was. It also shows the jump in temperature when most theorize humans began having an influence on global warming: the industrialization period.

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Mason, Betsy. "The Hot Hand of History." *Nature*. Nature Publishing Group, 12 Feb. 2004. Web.

Ruddiman, William F. "How Did Humans First Alter Global Climate?" *Scientific American*.

Scientific American Inc, Mar. 2005.

4. Dear Climate Geek

“What’s the issue here - the global warming we are seeing today is normal - the Earth goes through these natural warming and cooling cycles all the time. For example, it was much warmer all over the world 1,000 years ago - so warm in-fact that the Vikings settled Greenland! Therefore, there is nothing for us to worry about and nothing we can do anyways, so we can continue to do as we please.”

Actually, looking at climate data over the past, there is something to be concerned about! While you may think that because it was warm in the past, so this warming is natural, that’s not exactly true. Evidence from proxy data has show us that there is more carbon dioxide in the atmosphere, especially starting after the world began industrializing. Although there are many other factors such as the Sun and the Earth’s orbital position, scientists can only attribute warming and cooling to those factors up to a certain point before they need to take into account human activity (NASA). We know that humans have had a huge impact because of the correlation we’ve seen between the output of carbon dioxide on our part, and the rise in temperature. You can see in figure 5 below that while temperature was at a high point 1,000 years ago before slightly cooling, we’ve now passed that temperature and it is continuing to increase rapidly.

Even if this rise in temperature was higher 1,000 year ago than it is today, that doesn’t matter. There have many many times in history when the temperature was much greater. As shown in figure 6, the Earth has gone through far warmer and far colder times before today. This is important to know, because climate scientists can use this information and other information about the Earth along with climate models to try and determine where the Earth is headed (in a climate sense). It does not mean, though, that this warming is “okay”. The Earth is warming quite rapidly, and as previously determined, unnaturally. The state of the Earth was very different

throughout all these different periods, and with the natural change, had time to appropriately adapt and change. With our rapid increase in temperature climate is changing, weather patterns are increasing in severity, and flora and fauna may not have time to adapt.

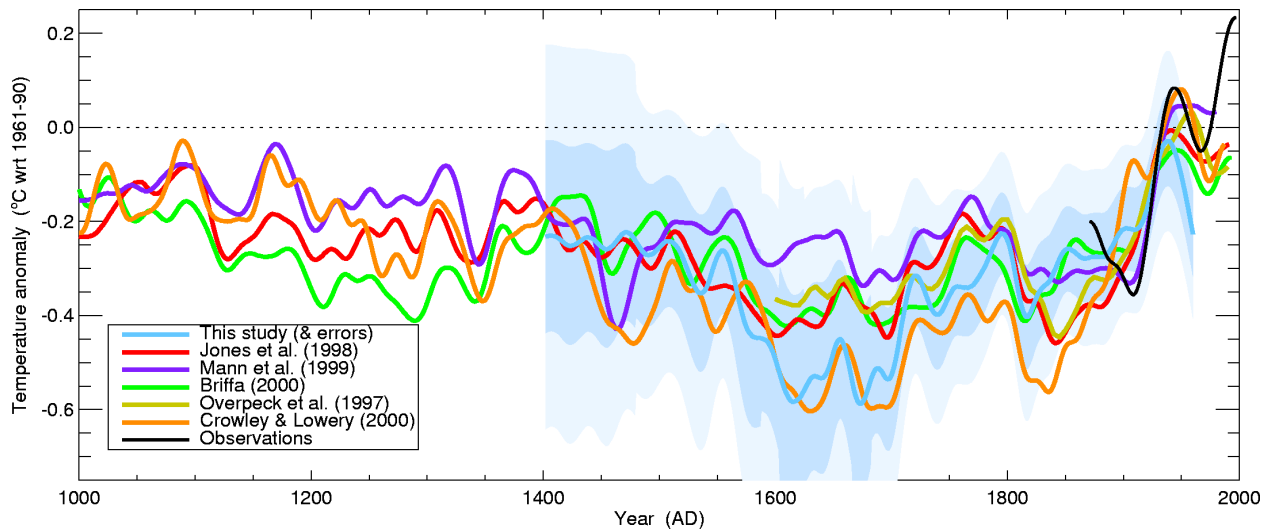


Figure 5: Temperature over the past 1,000 years.

Image Source: <http://www.ncdc.noaa.gov>

This figure shows the Earth's temperature over the past 1,000 years. The different lines show the data from different proxies, and the black from observed temperature. Although the lines do not match perfectly, they follow similar patterns and you can clearly see a slight drop and then a rapid increase.

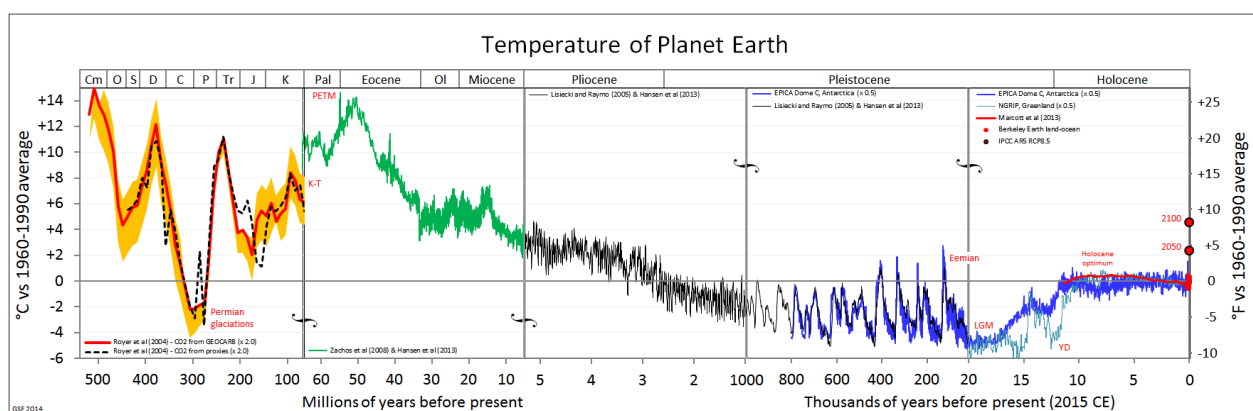


Figure 6: Temperature of the Earth 500 million years ago to present

Image Source: <http://upload.wikimedia.org>

This figure shows the Earth's temperature as far back as proxies and data has been collected. You can see that the data presents itself in very different trends, including our rapid spike in temperature over the last (approximate) 100 years.

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