Homework (Week 11)

1. Tectonic Motions (4 pts)

a. In what ways can tectonic movement alter the global climate? (2)

Ans: Tectonic motion, can change the arrangement of the continents across the Earth's surface which can directly lead to large changes in the climate through different mechanisms.
For example,

1. The location of continents determines whether ice sheets form.
2. The location of the continents determines the ocean circulation.
3. The movement of the continents can also indirectly affect the climate by regulating atmospheric carbon dioxide.

b. Is tectonic motion responsible for this most recent global warming? Why? (2)

Ans : No, Because Tectonic motion happen over 10's of millions years. Continental movements cannot change the climate over decades or centuries.

For example,

1. Antarctic Peninsula separated from the southern tip of South America 30 million years ago, thereby opening the Drake Passage.
2. The Indian subcontinent collided with the Asian continent, forming the Himalayas and the adjacent Tibetan Plateau 40 million years ago.

2. Solar Output (5 pts)

a. How many years is the period of solar output variation? (1)

Ans: 11-year cycle

b. Why does Earth's climate not respond much to solar output variations? (2)

Ans: Because of the enormous thermal inertia of the oceans, the climate does not respond much to these 11-year variations. For example, if we put a water pot on the stove and turn off and on on every second. If you measured the temperature of the water, you will see the temperature of the water would be constant, this is why the climate does not respond to 11-year solar variations.

c. Why is the sun not responsible for this most recent global warming? (2)

Ans : To support this argument "Sun is responsible for recent global warming" required a long-term increase in solar constant over past few decades but there is no evidence for that. Also, increase in solar output would warm the whole atmosphere but this is not happening rather, the measurement of weather balloon and satellite showed stratosphere has cooled over past few decades. From this evidence, we can say the sun is not caused by recent global warming.

3. Earth's Orbit Changes (10 pts)

a. What is the name of the cycles of Earth's orbital variations called? (1)

Ans: Milankovitch cycles

b. List and explain in detail three main ways that Earth's orbital path varies over time. Include a description of the average time period and how it might affect Earth's climate and or seasons? (9)

Ans: "Earth's orbit is ellipse whose eccentricity which is the ratio of the length of the ellipse to the width – varies with time". Over the course of 100,000 years or so, the orbit cycles between an orbit that is slightly more eccentric and one that is slightly less so. As the orbit becomes more eccentric, the distance from the sun to earth increased which caused the decrease in solar energy on earth. But for earth's orbit, the eccentricity change caused solar constant to vary by approximately 0.5 W/m2 which can lead to climate change.

The timing of closest approach to the Earth to Sun (perihelion) is another aspect of varies in Earth's orbit. Today Earth is closest to the sun during January and it's winter in the northern hemisphere.

Over the next 23,000 years, the date of closest approach will cycle through the entire year. In roughly 11,500 years, the Earth will be closest during July, and in 23,000 years it will again be January.

The tilt of the Earth is another important cause of varies in the orbital path which is known as obliquity. Today, the Earth's spin axis is tilted 23.5 ◦ from vertical. However, the Earth's tilt will complete a cycle through a range of tilt angles from 22.3 ◦ to 24.5 ◦ over the next 41,000 years.

The changing in the date of closest approach to the Sun and earth tilt does not change the distance from Sun to Earth therefore, it does not change solar constant. But it changes how sunlight would distribute over the earth. For example, During the tilt sunlight would hit more to polar but less on tropics which can change the climate.

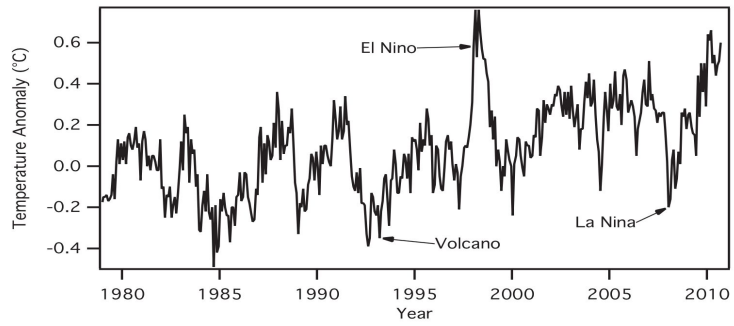
The paleoclimate shows that there's is perfect agreement between ice ages cycle and variation in Earth's orbit. The high latitude summer temperature determines the growth of big ice sheet because it determines whether snow from fall will survive in summer or not. As we know Orbital variation decides of sunlight distribution, therefore, it plays key role to control this temperature.

4. Internal Variability (10 pts)

a. What is the difference between forced climate variability and internal climate variability? (2)

Ans: Forced variability changes in an output of the Sun or Earth's orbital and in this process Earth's climate change to impose the change in planet energy. However, Earth climate also can change by internal natural forces. El Nino/ Southern Oscillation (ENSO) is the best example of internal climate variability.

b. What is El Niño ('El'-'neen'-'yo') Southern Oscillation (ENSO) and why is it an example of internal climate variability? Describe in detail the difference between El Niño and La Niña. (6) You may use the lecture or other external references and resources to answer this question.



El Nino/ Southern Oscillation (ENSO) is an event when the earth warms several tenths of degree Celsius and this event occurs every few years and also last year. ENSO events cause temporary changes but not long-term for example, Earth experienced warming during El Nino in 1998 as well cooling during La Nino in 2008. In fact, these all shorts term variation in temperature lead back to ENSO events. El Nino is an example of internal climate variability because it occurs due to internal natural forces for example ocean temperature coupling. The key difference between El Nino and La Nino is that they both are opposite which mean during the El Nino earth warms several tenths of a degree but cooled down during the La Nino. "When the Walker Circulation is weak or reverses, there is the very little upwelling of cold water, resulting in an El Niño with warmer than average ocean temperatures in the eastern equatorial Pacific Ocean. When the Walker Circulation is very strong, upwelling increases, resulting in a La Niña with cooler ocean temperatures there."

c. How might a very strong El Nino affect California weather patterns? (2)

Ans : The El Niño influence on California precipitation strengthens from early to late winter and is stronger in the south than the north. Eight of ten moderate-to-strong El Niños in the late winter put southern California become wettest and but on another hand northern California does not become driest. The effect of El Niño on California is increased rainfall with accompanying floods, landslides, and coastal erosion. The effects are variable across the state and are more

predictable in Southern California.

5. Greenhouse Gases (10 pts)

a. What is the PETM? (2)

Ans : Thermal Maximum or PETM, This event occurs due to the massive release of methane and carbon dioxide which increase the Earth's global average temperature from 5 to 9 degree C over the next few thousand years.

b. Why is it a good analog for this most current global warming? (2)

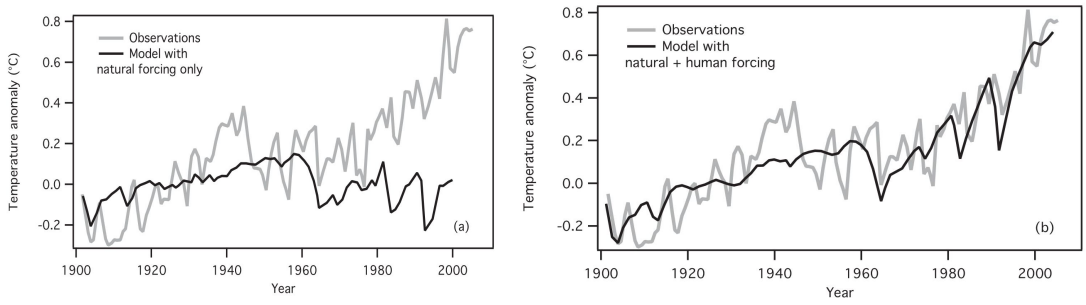
Ans: The amount of carbon released is less than the amount contained in all of the Earth's fossil fuels. Thus, the PETM is sometimes viewed as a good analog to what will happen if humans burn all of the fossil fuels over the next few centuries. Because the burning of fossil fuel can increase earth's temperature so quickly.

c. What is the key difference between the PETM and this most current warming? (2)

Ans: During PETM the amount of carbon release over several thousand years but in current carbon releasing in several hundred years due to human activity. So we can conclude that current warming is happening faster than PETM.

d. What is the last, very strong, argument that the chapter provides as a reason why anthropogenic greenhouse gases is responsible for the global warming after 1960? Explain the argument (2).

Ans:



In the case of the ice ages, we are not exactly sure what process releases carbon to the atmosphere as the climate warms. The two biggest sources of carbon for the atmosphere are the land biosphere and ocean. However, there is evidence which supports recent warming caused by an increase in greenhouse gases. The simulation completely fails to capture the rapid warming that began around 1960. This model captures the rapid warming since 1960 that the model with only natural forcing fails to simulate. This suggests that human greenhouse-gas emissions, volcanic, and solar effects have all contributed to global temperature changes of the past century, but that greenhouse- gas emissions are responsible for most of the rapid late-20th-century warming.