ENS803 – Climate Change Impact and Adaptation in the Pacific

Review Questions Solutions

Essays – You are to choose 3 topics from the list given below, and write 3 essays. Each essay should be about ¾ -page to 1 page ~500 words. Your essay should include explanations of the terms we use in climate science, which we have been discussing in class.

Essay Topics:

1. 'Albedo positive feedback' – Describe the mechanism whereby the high albedo of snow would produce the phenomenon known as the 'albedo positive feedback.

Points you should include in your essay:

1. Definition of 'albedo', = Amount of solar radiation reflected by a surface.

Show your understanding of 'albedo' by using examples of snow and ice with albedo of 1 (highest) and a perfectly black surface having an albedo of 0 (lowest). Anything in between has albedo from 0% to 100%. Today Earth has an average albedo of just over 30% i.e. Earth reflects 30% of solar radiation back to space. Typi

2. Then describe with diagram the phenomenon known as the 'albedo positive feedback'. Firstly explain what 'positive feedback' is = it is a process whereby the initial change (e.g. cooling or warming of the climate) is reinforced or amplified.

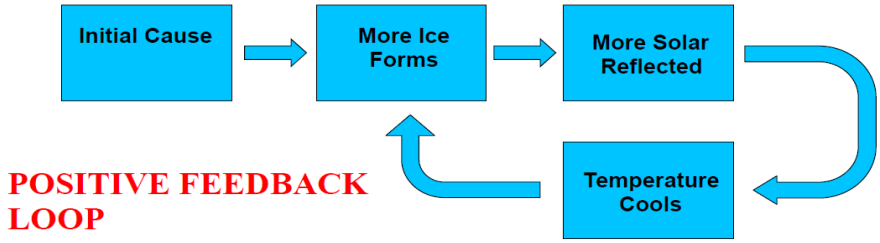
3. Therefore 'Albedo positive feedback' is the process whereby a chain of events occurs as follows (refer diagram):

ALBEDO = Amount of solar radiation reflected by surface

Typical Albedos

Ocean	**~5-10%**
Global Avg	**~30-35%**
Snow/Ice	**~80-90%**

ICE-ALBEDO FEEDBACK:



Explanation: *If the climate cools (initial change), snow forms and covers more of the land while sea-ice covers more of the oceans. Snow has a higher albedo than bare ground (land) and ice has a higher albedo than the ocean. Due to the higher albedos of the snow on land and sea-ice in the oceans, the effect of the initial cooling will be more cooling (amplification of the initial cooling) as the amount of sunlight reflected back to space is now increased. This is what* ***'positive albedo effect'*** *means, shown by the loop in the diagram above.*

(Try applying this principle to the reverse situation, i.e. if the initial change is a warming effect – describe the positive feedback effect in that situation) Page 62, Q. 3.2.1 – ' Sustainability' text.

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2. Mars is colder than the Earth. Venus, on the other hand is much hotter with average surface temperatures of around 450^{o}C. Venus is closer to the Sun than the earth, and so receives about twice as much solar radiation. Venus's atmosphere is also different than the Earth's, as it is much thicker and mainly consists of carbon dioxide.

Using the terms **insolation** and **greenhouse gases**, can you suggest reasons why Venus is so hot?

Points you should include in your essay:

1. The closer a planet is to the sun, - the greater the ***insolation.*** *Earth is closer to the sun than Mars, thus Mars is colder than Earth. Venus on the other hand is closer to the sun than Earth, so Venus is hotter than Earth.*

2. Define 'insolation' = the measure of the amount of solar radiation falling on a surface. Insolation is one of the main factors affecting the climate of the earth

3. a) Comparing Earth and Venus, Venus is hotter, being closer to the sun, so insolation on Venus is twice as much as on Earth.

b) The thickness and composition of the atmosphere determines how much of the reflected infrared radiation (the wavelength of solar radiation that is reflected from earth surface back to space) is actually reflected back to earth – the thicker the atmosphere, the greater the amount of infrared radiation reflected back to earth (see diagram on page 59 'Sustainability' text)

Venus has a thicker atmosphere than Earth – so on Venus, a greater amount of infrared radiation will be reflected back to Venus, making it so much hotter.

Secondly, because the thick atmosphere on Venus consists mainly of carbon dioxide which is a greenhouse gas, this CO_2 absorbs the outgoing infrared radiation that the planet emits back to space, keeping the planet Venus so much hotter (the greenhouse effect). See Fig. 3.27 , page 84 'Sustainability' text.

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3. Explain how deforestation can lead to both a warming effect and a cooling effect for global temperatures?

Points you should include in your essay:

1. Deforestation – explain or define what it is and why man has over historical time, carried out large scale deforestation. To meet food demands and lifestyle changes, man has cleared forests and replaced them with intensive agricultural lands and cities. The net effect of human existence on Earth is to 'brighten the surface' and subsequently increase the global albedo. In addition large scale deforestation in South America and Africa have increased the Earth's albedo! THIS SHOULD HAVE RESULTED IN A COOLING EFFECT ON THE GOBAL CLIMATE.

2. Warming effect? Forests are carbon sinks, i.e. through the process of photosynthesis where green plants capture the carbon dioxide in the atmosphere and convert it to glucose (thus they are termed the 'producers' and the starting point in any food chain), forests help to keep the earth cool by removing the greenhouse gas CO_2 from the atmosphere. When forests are cleared (deforestation), the carbon sinks are removed, leading to elevated CO_2 concentrations in the atmosphere, and with increased atmospheric CO_2, the global climate is expected to get warmer THIS IS HOW DEFORASTATION CAN LEAD TO A WARMING EFFECT.

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4. Oxygen makes up over 20% of the Earth's atmosphere, while carbon dioxide makes up less than 0.04%. Oxygen is largely transparent to both visible and infrared light. Explain why carbon dioxide is a much more important greenhouse gas in the Earth's atmosphere than oxygen, even though there is much more oxygen than carbon dioxide.

Points you should include in your essay:

A gas is termed 'greenhouse gas' because of its ability to trap solar radiation in the atmosphere and thus provide a 'warm blanket effect' (like a greenhouse) over the earth. There are 4 main greenhouse gases in the Earth's atmosphere – i) water vapor; ii) carbon dioxide; iii) methane and iv) ozone. Oxygen is NOT a greenhouse gas because it is transparent (cannot trap or absorb) to both incoming visible light, and the emitted infrared light, even though it is present in a higher concentration compared to the GHG CO_2. (See Fig. 3.27 , page 84 'Sustainability' text.)

Light travels in wavelengths – incoming light/solar radiation are in the UV and Visible wavelengths. The Earth absorbs this energy and re-radiates it largely in the ***infrared (sometimes referred to as infrared light, heat or thermal radiation) wavelengths. It is this infrared light that gets absorbed by gases like CO_2*** *, creating a warming or greenhouse effect. Oxygen cannot absorb the infrared light, and is therefore not a GHG. (Read pg 58, 'Sustainability' text)*

5. The 'Milankovitch Cycles, the volcanic eruptions do affect the climate of the earth. Explain how these two factors affect the climate.

Points you should include in your essay:

1. Milankovitch Cycles refer to the 3 different cycles which describe how the Earth orbits around the sun. The Earth's orbit is not fixed – it changes regularly over time. These changes in Earth's orbit alter the pattern of insolation, which in turn climate swings between hot and cold during the Quaternary period (the period , some 2.6 million years ago).

There are 3 principle ways in which Earth's orbit varies:

1. ***Eccentricity or Orbital shape**, meaning the Earth's orbit is not perfectly circular, but instead it follows an eclipse. This means that the Earth is sometimes closer, and sometimes further away from the Sun. This changes the amount of insolation by a few percent.*
2. ***Axial Tilt or Obliquity**: This means that the Earth spins at an angle around the Sun. This angle known as 'axial tilt' is 23.5 degrees at this point in time. This change causes the different seasons for the northern and southern hemisphere. The larger the tilt, the greater the difference in temperature between summer and winter for the two hemispheres*
3. ***Axial Precession**: The axis of rotation for the Earth (straight line from North to South Pole) also change direction over a 20,000 year cycle, between pointing towards the star Polaris (as of now) or towards the star Vegas. This impacts the Earth's climate as it determines when the seasons occur. E.g. Now with the North Pole pointing towards Polaris, the Northern hemisphere summer is in July, while it is winter for the Southern Hemisphere. This situation would change when the North Pole points towards the star Vegas, in 20,000 years!*

2. *Volcanic eruptions:*

Warming effect: Volcanic activity warms the earth by adding carbon dioxide to the atmosphere, which is a GHG.

Cooling effect: At the same time, volcanic activity can cool the Earth when ash and sulphur is injected into the atmosphere. These substances raise the albedo of the atmosphere, reflecting much of the sunlight back into space, resulting in less sunlight reaching the surface of the Earth