

ATMS211 CLIMATE CHANGE – Final Exam Review (I have not included material from Week 1- Week 5. See Mid-term Review for this material).

Note: The following is intended to be a broad summary of material covered in class from Week 6 to the end of the quarter. The list is NOT exhaustive – please review your class notes and textbook to get a comprehensive overview of material.

Week 6: Evolution of the Earth's Climate and Atmosphere

Readings: Chapter 10 (p. 193-197), Chapter 11 (p. 207-220), Chapter 12 (p. 230-244) and "Snowball Earth" article.

Terms and concepts you are expected to know

Age and origin of the Earth and Oceans

Carbon Cycle

Carbonate-silicate cycle (inorganic carbon cycle)

- Weathering
- Long-term negative feedback
- Effect on atmosphere
- Timescale

Major reservoirs of carbon

Short term organic cycle (photosynthesis/respiration)

Snowball Earth

Evidence for glaciations

Isotopes

Oxygen isotopes as evidence for temperature changes

Rise in O₂

Evidence for an oxic transition eg. Decline in Banded Iron Formations (BIFs), presence of 'Redbeds',

Types of questions to expect

- 1 Describe the long-term negative feedback in the Carbonate-Silicate cycle (See p. 168 for answer).
- 2 Explain how grouping of the continents at tropical latitudes (see Fig 12-10) may have helped the initiation of a 'Snowball Earth' episode (See p. 241 for answer).
- 3 What evidence is there for increasing O₂ concentrations in the atmosphere that occurred approximately 2 billion years ago? (See p. 214-217 and Lecture #22)

Week 7: Ice Ages: The Effects of Volcanoes and Solar Variability

Readings: Chapter 12 (p. 245-249), Chapter 14 (all) and Chapter 15 (p. 292, p. 296-315)

Terms and concepts you are expected to know

Natural variability

Signal

Noise

Volcanoes

- Duration of volcanic perturbation (2-3 years)
- Negative forcing due to aerosols (sulfate aerosols, scatter solar radiation, increase Earth's albedo, cooling effect)

Solar Variability

Orbital Parameters

- Eccentricity
- Obliquity
- Precession of the spin axis and precession of the perihelion

Period of each cycle

Sunspot Cycle (11 year cycle)

El Nino: 2-10 year timescale

- What is El Nino?
- Climate impacts of El Nino

Past climate variability using using proxy data

eg. tree rings, ice cores, ocean sediments

Types of questions to expect

- 1 Match each question with the corresponding orbital parameter
 - i) Is the Earth's orbit nearly circular or highly elliptical? a) Precession
 - ii) Is there a small or large difference between summer and winter? b) Eccentricity
 - iii) Does NH summer occur when the Earth is at perihelion or aphelion c) axial tilt (obliquity)

Answer: i) b), ii) c), iii) a)

- 2 Explain why the timescale of the climate perturbation from a single volcanic eruption is 1-2 years. (See p. 300)

Weeks 8: Global Warming Science

Readings: Chapter 16 (all – except p. 335-336); IPCC Summary for Policymakers

Terms and concepts you are expected to know

Human-Perturbed Carbon Cycle

- Residence Time (years) $\frac{\text{Reservoir size at any time}}{\text{Inflow/Outflow rate}}$
- Removal Mechanisms and timescales (Lecture # 32)
- Human inputs of carbon and where they go (Lecture #32)

Forests – not a sink but a reservoir of C (Lecture #30)

Projections of future climate change: Global Climate Models (GCMs)

Sources of uncertainty

- Climate Sensitivity
 $\Delta T = \lambda \Delta F$
- Climate forcing by anthropogenic aerosols

Types of questions to expect

- 1 Name and give the chemical formula for the three major greenhouse gases that are being emitted to the atmosphere by human activities.
(Answer: Carbon dioxide CO_2 , Methane CH_4 , Nitrous Oxide N_2O – Note that human activities do not directly perturb the concentration of water vapor)
- 2 Greenhouse gases affect the longwave energy budget. What anthropogenic perturbation to the atmosphere is thought to have caused a change in the shortwave energy budget?
(Answer: Anthropogenic aerosols predominantly affect short wave radiation by scattering incoming solar radiation increasing the Earth's albedo, resulting in a cooling effect).

Weeks 9 & 10: Global Warming: Debate & Impacts

Readings: David King article, John Houghton book Chapter 8.

Terms and concepts you are expected to know

Effects of global warming:

Marine Environment:	Sea level rise, increase in acidity of oceans, coral bleaching
Terrestrial Environment	Trees, plants, animals, extinction rates (increased by flooding, droughts)
Regional effects of climate eg.	Northern hemisphere latitudinal effect Mid-latitude seasonal change

Type of question to expect

- 1 What are the two causes of sea level rise?
(Answer: Thermal expansion and melting of continental ice-sheets)