ECC3640 Economics of Climate Change

Exam Study Guide

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Topic 1: The Science and Climate Scepticism

1.1 Introduction to Climate Change

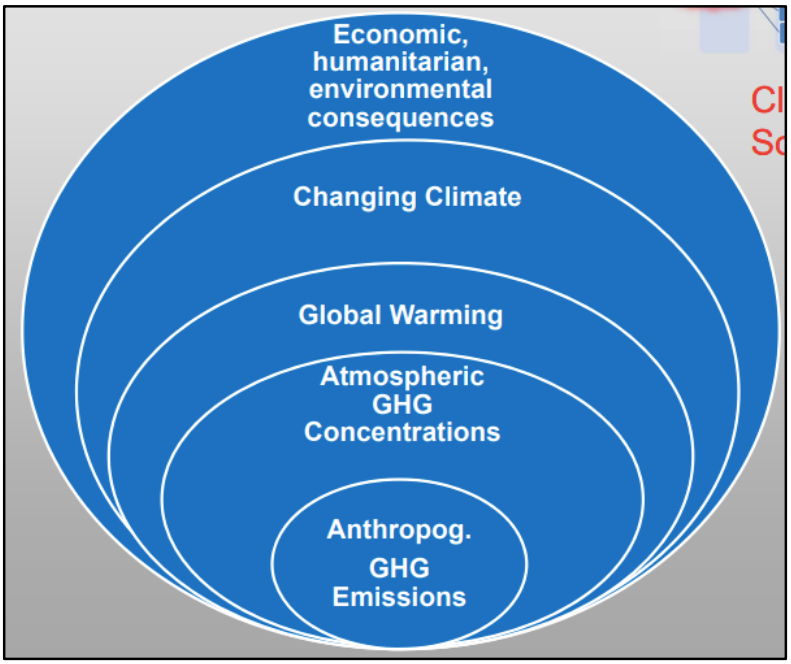
How does Climate Change happen?

- The atmosphere is the most vulnerable part of the Earth's system because it is so thin
- We are capable of changing its composition
- Greenhouse Effect
    1. Solar radiation in the form of light waves passes through the atmosphere
    2. Most of this radiation is absorbed by the Earth and warms it
    3. Some absorbed radiation is re-radiated back into space in the form of infrared waves (IR)
    4. Some of this outgoing IR is trapped in the Earth's atmosphere and warms it
- Enhanced Greenhouse Effect
    - Atmosphere layer is being thickened by global pollution, thereby causing more outgoing IR to be trapped

What is the primary issue?

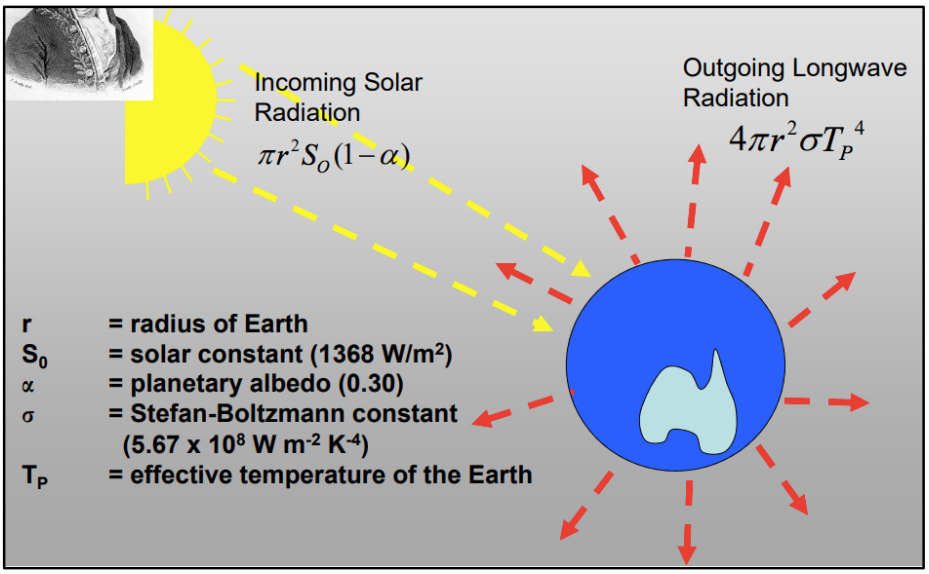
- Excessive CO2 concentration
- We expect continuous rise in the future

The Scientific Basis



1.2 History of Climate Science

Fourier (1824): Calculating the theoretical temperature of Earth



- To maintain the Earth's energy balance, Incoming Solar Radiation = Outgoing Longwave Radiation

$$\pi r^2 S_O(1-\alpha) = 4\pi r^2 \sigma T_P^4$$

- Solving for T should result in the temperature of the Earth
- Findings:
  - Fourier calculated the Earth should be about -18 degrees Celsius
  - Earth's actual temperature is around +15 degrees Celsius

Tyndall (1856)

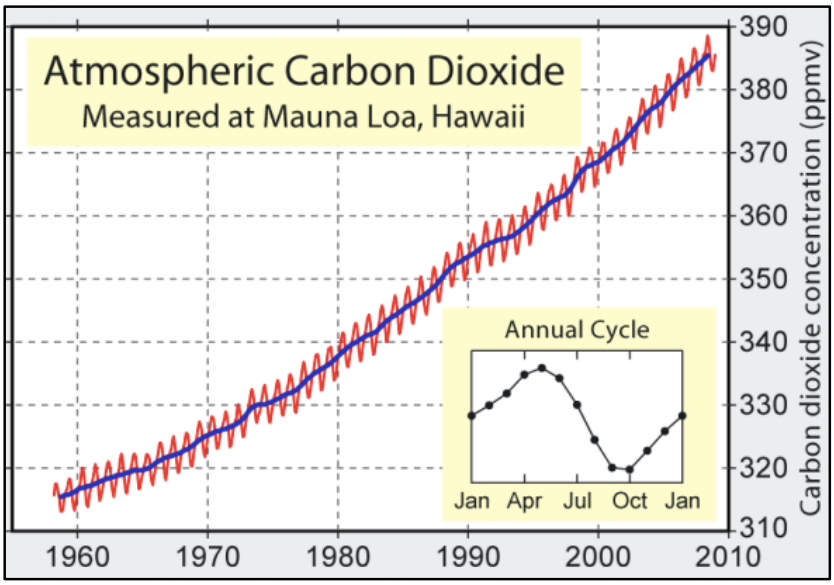
- Why is the sky blue?
- Found out the power of certain atmospheric heat-trapping gases

Arrhenius (1896)

- Calculated 2-4.5 degrees Celsius warming for doubling of CO2
- Called for more exploitation of fossil fuels

Keeling (1958) Curve

- Plots the change in Earth's carbon dioxide concentration over time



Charney (1979)

- Meteorologist
- Published *Carbon Dioxide and Climate: A Scientific Assessment*
- The consensus has been that increasing carbon dioxide will lead to a warmer Earth with a different distribution of climate regimes
- Doubling CO2 in models results in 1.5 to 4.5 degrees Celsius warming
- Positive feedbacks will increase the warming
- The Intergovernmental Panel on Climate Change (IPCC) supports this range of equilibrium climate sensitivity

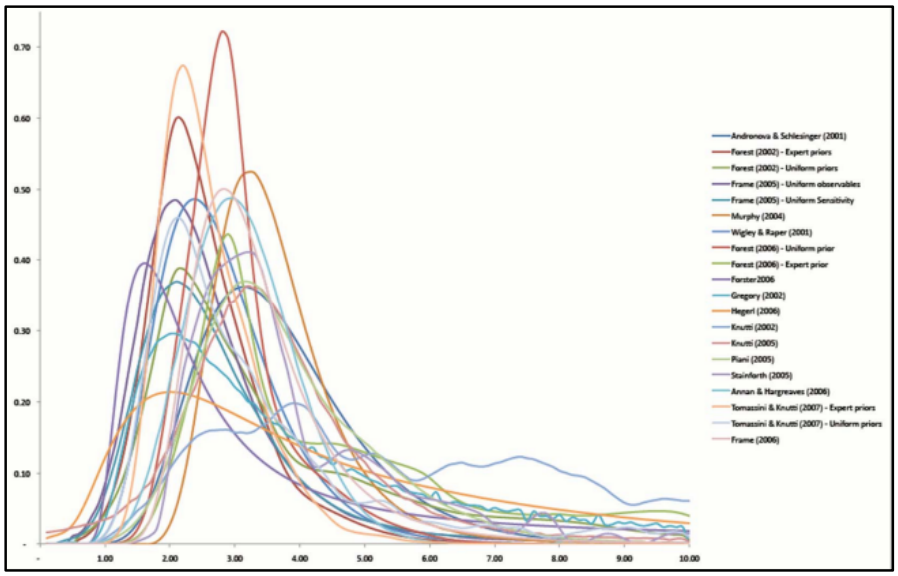
1.3 Equilibrium Climate Sensitivity

Definition

- The equilibrium global average surface warming following a doubling of CO2 concentration
- Measures the climate system's response to sustained radiative forcing

IPCC on ECS

- Likely to be in the range of 2-4.5 degrees Celsius
- Best estimate of about 3 degrees Celsius
- Very unlikely to be less than 1.5 degrees Celsius
- Values substantially higher than 4.5 degrees Celsius cannot be excluded



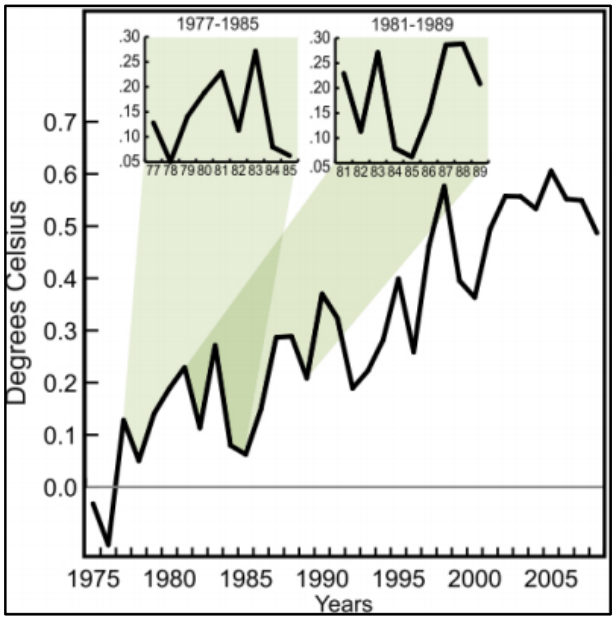
1.4 IPCC Report: Climate Change 2013

Major Findings

1. Warming in climate system is unequivocal
2. Human influence on climate system is clear
3. Continued greenhouse gas emission cause further climate change for centuries to come
4. Limiting climate change requires substantial and sustained reductions in greenhouse gases

Rising Surface Temperature

- Average surface temperature has increased 0.85 degrees Celsius since 1880
- Warming occurs on long timescales
  - it is easy to falsely cherry-pick shorter term trends



15 Indicators of a Warming World

Rising:

1. Temperature over land
2. Tree-line shifting
3. Species migration
4. Humidity
5. Temperature over oceans
6. Air temperature near surface
7. Sea Level
8. Ocean Heat Content
9. Sea Surface Temperature

Falling:

10. Glaciers
11. Snow Cover
12. Permafrost
13. Spring coming earlier
14. Ice sheets
15. Sea ice

Global Ocean Heat Content

- Rising trend
- Urban- heat island effect has no role in the oceans
- An urban area is significantly warmer than it's surrounding rural areas due to human activity

Albedo Effect (stronger than thought)

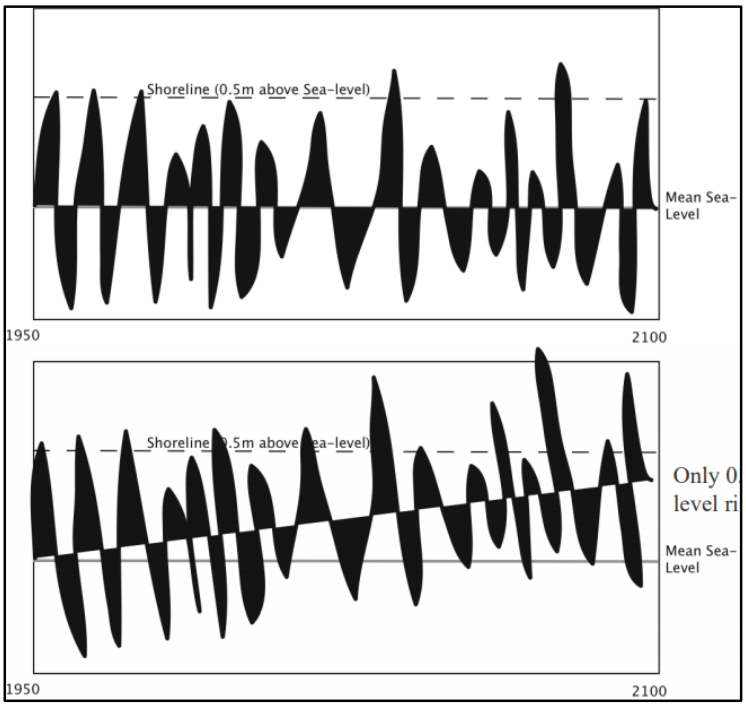
1. Increase in global temperature
2. Causes snow and ice to melt
3. Decreases the Earth's albedo (less energy is reflected)
4. More energy is absorbed
5. Further warming

Sea Level

- Since 1900 global-average sea level has risen ~3mm/year

Averages are not the problem

- Rising averages cause peaks to be more extreme



Cause of Climate Change

- 2 models:
  1. Natural Forcing only
  2. Natural and Anthropogenic Forcing (more accurately reflects data)
- Observed temperature changes…consistent with
- ARE: expected response to greenhouse gas emissions
- ARE NOT: alternative explanations like solar variations

Significance of 1-5 degrees Celsius warming

- Severe!
- The last ice age (18000 years ago) was caused by an average temperature drop of only 4-6 degrees Celsius
- Manhattan back then was under 1km of ice and sea-level was 120m lower than today

Ocean Acidification

- Increase of 30% since pre-industrial time
- Caused by uptake of CO_2 from the atmosphere
- Causes pH level of the ocean to fall → Higher acidity
- Forms a layer of acid on surface
- Long-term threat to coral reefs and other species

Effect of Global Financial Crisis on Emissions

- Reduces economic activity
- Higher energy intensive
- Overall, a net increase in emissions

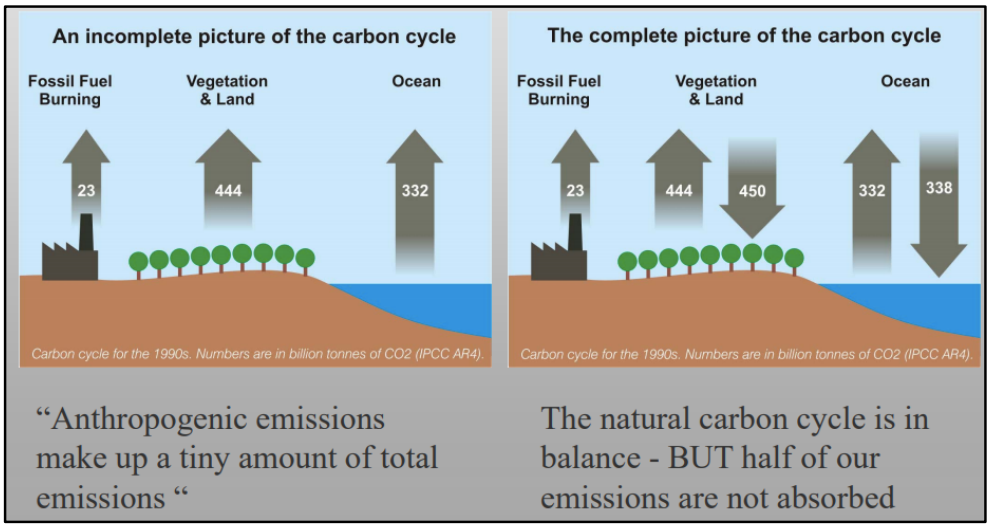
The Future of Climate Change

- Depends on:
  1. Economics
  2. Technology
  3. Policy

1.5 Climate Scepticism

Sceptical Science vs. Climate Scepticism

- Sceptical Science considers all the facts before coming to a conclusion
- Climate Scepticism does the opposite; looks at small pieces of the puzzle, while neglecting the full picture
  - left side of image highlights climate scepticism's way of thinking



1.6 Common Myths about Climate Change

Climate Myth	What the Science says
1. Climate's changed before	Climate reacts to whatever forces it to change at the time; humans are not eh dominant forcing
2. It's the sun	In the last 35 years of global warming, sun and climate have been going in opposite directions
3. It's not bad	Negative impacts of global climate on agriculture, health and environment far outweigh any positives
4. There is no consensus	97% of climate experts agree humans are causing global warming
5. It's cooling	The last decade 2000-209 was the hottest on record
6. Models are unreliable	Models successfully reproduce temperatures since 1900 globally, by land, in the air and ocean

7. Temp record is unreliable	The warming trend is the same in rural and urban areas, measured by thermometers and satellites
8. Animals and plants can adapt	Global warming will cause mass extinctions of species that cannot adapt on short time scales
9. It hasn't warmed since 1998	The years 2005, 2010, 2014, 2015, 2016 all broke the record for being the hottest year on record
10. Antarctica is gaining ice	Satellites measure Antarctica losing land ice at an accelerating rate