

**Math 1901**  
**Freshman Seminar**  
**Mathematical Climate Models**

Fall 2024  
**1:00 - 2:15 Mondays and Wednesdays**  
**Vincent Hall 213**

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course website  
<https://www-users.cse.umn.edu/~mcgehee/Course/Math1901/>

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**Math 1901**

We have analyzed the Mauna Loa CO<sub>2</sub> data and the Berkeley Earth temperature data and have shown that they are correlated.

CO<sub>2</sub> and Temperature

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temperature anomaly vs. atmospheric CO<sub>2</sub>

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**Math 1901**

*Why do we think that the increasing atmospheric CO<sub>2</sub> is the cause of the increasing temperature?*

*Why do we think that human activity is causing the increasing atmospheric CO<sub>2</sub>?*

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**Math 1901**

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**The Greenhouse Effect**

Greenhouse gases (CO<sub>2</sub>, H<sub>2</sub>O, CH<sub>4</sub>) are transparent to visible light, but opaque to infrared light. The energy from the sun passes through the atmosphere and heats the surface. The surface radiates energy at a lower temperature (infrared), which is absorbed by the atmosphere.

**Svante Arrhenius**, "On the Influence of Carbonic Acid in the Air upon the Temperature of the Ground," *Philosophical Magazine and Journal of Science (Fifth Series)* **41**, pp. 237-276, 1896.

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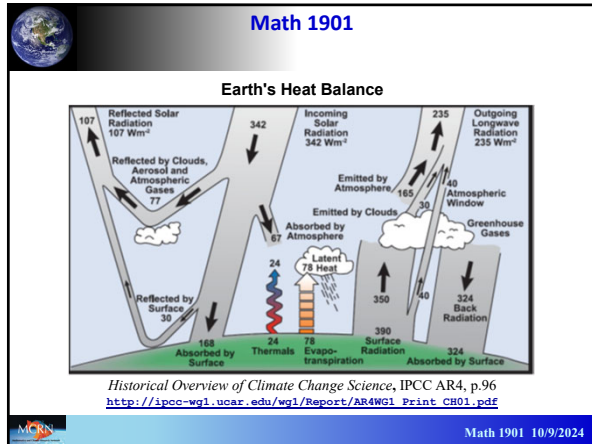
**The Greenhouse Effect**

GREENHOUSE EFFECT  
 A prerequisite for life on earth, the greenhouse effect occurs when infrared radiation (heat) is retained within the atmosphere.

1 Most solar energy reaching the earth is absorbed at the surface.  
 2 The warmed surface emits infrared radiation.  
 3 Like a blanket, atmospheric greenhouse gases absorb and re-radiate the heat in all directions, including back to the earth.  
 4 Human activity has increased the amount of greenhouse gas in the atmosphere and thus the amount of heat returned to the surface. In consequence, global temperatures have risen.

Gary Stix, *Scientific American* September 2006, pp.46-49

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**Math 1901**

*Why do we think that the increasing atmospheric CO<sub>2</sub> is the cause of the increasing temperature?*

**The Greenhouse Effect**

That's a nice theory, but I'm not convinced that it explains anything about the climate.  
 Hasn't the climate always changed?  
 Wasn't it changing when there were no humans?

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**Arguments from Climate Skeptics**

*Earth's climate has changed many times in the past.  
 Why do we think humans are responsible now?*

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*Humans haven't been around very long in geologic time.  
 They couldn't have been the cause of climate changes in the distant past.*

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*Humans didn't cause the climate changes on Mars.*

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**Earth's climate has changed many times in the past.**

Paleoclimate

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**Earth's climate has changed many times in the past.**

Paleoclimate

*Paleoclimatology* is the scientific study of climates predating the invention of meteorological instruments, when no direct measurement data were available. As instrumental records only span a tiny part of Earth's history, the reconstruction of ancient climate is important to understand natural variation and the evolution of the current climate.

<https://en.wikipedia.org/wiki/Paleoclimatology>

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**Paleoclimate**

**Earth's climate has changed many times in the past.**

regional glaciation global glaciation oxygen level

4.0 3.0 2.0 1.0 0 100% 10% 1% 0.1%  $\log pO_2$

Hadean Archean Proterozoic Phan.

Solar System Origin

Late Heavy Bombardment

bacteria & archaea algae animals, fungi, plants

Time (billions of years before present)

<http://www.snowballearth.org/when.html>

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**Snowball Earth**

Humans didn't cause the Earth to become a snowball. Complex life did not exist then.

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<https://en.wikipedia.org/wiki/Phanerozoic>

**Life timeline**

This box view -lak-est-  
Quaternary era age\*  
Earliest apes / humans

Modern Birds (Dinosaurs)  
Dinosaurs  
Hominoids (Monkeys)  
Kangaroo era age\*  
Earliest mammals  
Fossil record  
Phanerozoic eon  
Cambrian explosion  
Earliest life  
Cryogenian era age\*  
Earliest animals  
Earliest plants

Multicellular life  
Earliest fungi  
Earliest multicellular life

Eukaryotes  
Sexual reproduction

Photosynthesis  
Fungus glaucosa\*

Single-celled life  
Earliest oxygen  
LHB meteorites  
Earliest fossils

Water  
LUCA  
Earliest water  
Earliest formed

(million years ago) \*for Ages

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**Four Geologic Eons**

Phanerozoic

Proterozoic

Archean

Hadean

<https://en.wikipedia.org/wiki/Phanerozoic>

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