Math 5421

An Introduction to Mathematical Climate Models

Spring 2025
1:25 – 3:20 Tuesdays and Thursdays
Blegen Hall 155

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course website
https://www-users.cse.umn.edu/~mcgehee/Course/Math5421/

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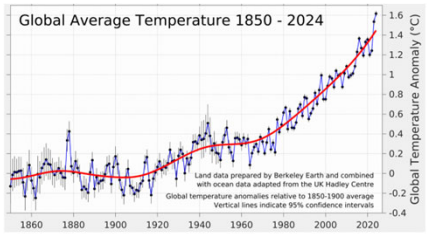
Global Mean Temperature

Is the climate changing?



It seems to be getting hotter.

Why?

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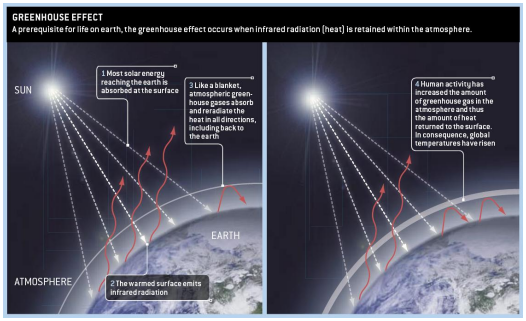
Greenhouse Effect



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

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Greenhouse Effect

The Greenhouse Effect

Greenhouse gases (CO_2, H_2O, CH_4) 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.

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Greenhouse Effect

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Who discovered the greenhouse effect?

1. A meteorologist
2. A physicist
3. A chemist
4. A mathematician
5. Al Gore

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Greenhouse Effect

The Greenhouse Effect

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Who discovered the greenhouse effect?

A mathematician!

Joseph Fourier (1827), Mémoire sur les Températures du Globe Terrestre et des Espaces Planétaires, *Mémoires de l'Académie Royale des Sciences*, t. vii., p. 569.

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Greenhouse Effect

The Greenhouse Effect!

Joseph Fourier, *Mémoires de l'Académie des Sciences de l'Institut de France*, t. vii. 1827.

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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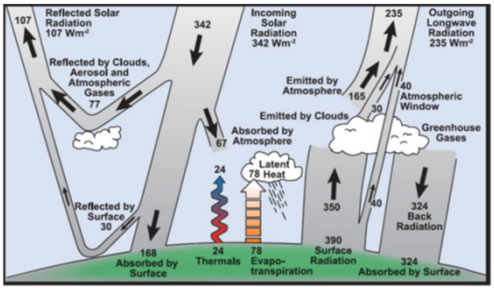
Greenhouse Effect



Historical Overview of Climate Change Science, IPCC AR4, p.96
http://ipcc-wg1.ucar.edu/wg1/Report/AR4WG1_Print_CH01.pdf

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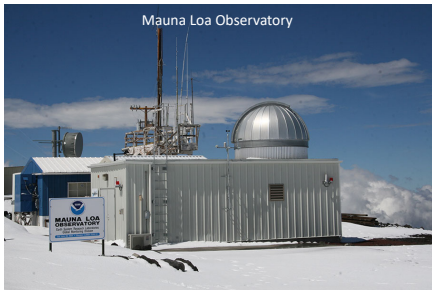
Math 5421
Atmospheric CO2

Can we measure greenhouse gasses?



https://research.noaa.gov/Portals/0/EasyDNNnews/1502/2000600p587EDNmain10061mlo_sign_miller.jpg

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Atmospheric CO2

Can we measure greenhouse gasses?

https://keelingcurve.ucsd.edu/

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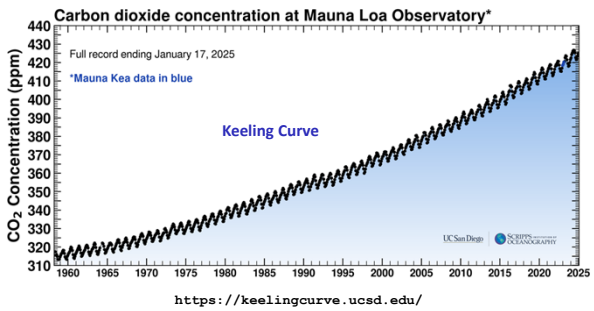
Atmospheric CO2

Can we measure greenhouse gasses?



https://keelingcurve.ucsd.edu/

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Atmospheric CO2

https://www-users.cse.umn.edu/~mcgehee/Course/Math5421/assignments/A02.html

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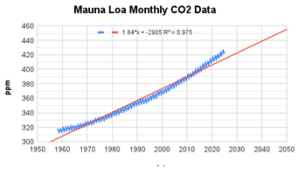
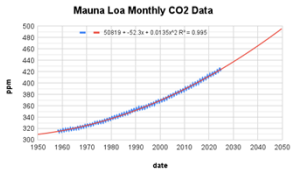
Math 5421
Atmospheric CO2

2030: 423 ppm
2050: 455 ppm



2030: 438 ppm
2050: 495 ppm



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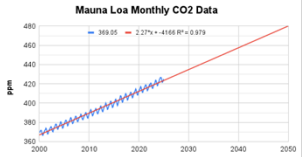
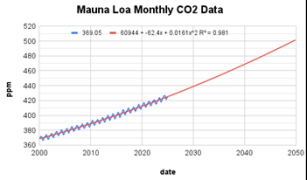
Atmospheric CO2

2030: 435 ppm
2050: 481 ppm



2030: 440 ppm
2050: 502 ppm



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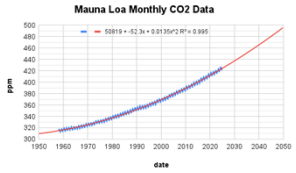
Math 5421
Atmospheric CO2

2030: 438 ppm
2050: 495 ppm



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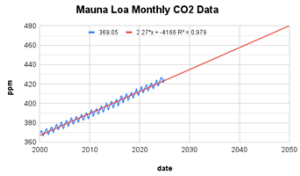

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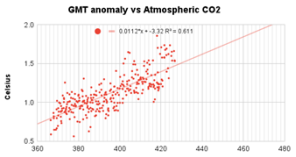
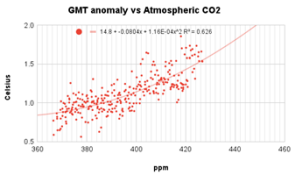
Greenhouse Effect

1.5: 425 ppm
2.0: 474 ppm



1.5: 424 ppm
2.0: 448 ppm



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Math 5421
Greenhouse Effect

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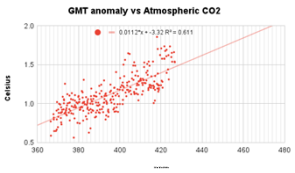
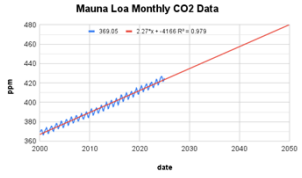


2025: 425 ppm: 1.5
2048: 474 ppm: 2.0



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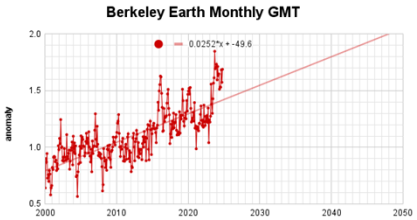
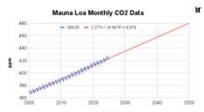
Greenhouse Effect

2028: 1.5
2048: 2.0



2025: 425 ppm: 1.5
2048: 474 ppm: 2.0



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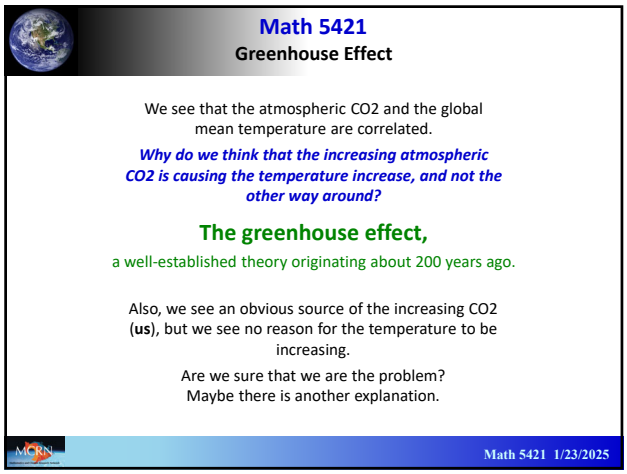
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Greenhouse Effect
We see that the atmospheric CO2 and the global mean temperature are correlated.
Why do we think that the increasing atmospheric CO2 is causing the temperature increase, and not the other way around?
The greenhouse effect,
a well-established theory originating about 200 years ago.
Also, we see an obvious source of the increasing CO2 (us), but we see no reason for the temperature to be increasing.
Are we sure that we are the problem? Maybe there is another explanation.
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