



The Case for Anthropogenic Warming, II

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 University of Minnesota
 Mathematics of Climate Seminar
 September 18, 2018




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Anthropogenic Warming

Is the globe warming?
 What determines the Earth's temperature?
 What is the role of human activity?
 How big is the problem?


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Anthropogenic Warming

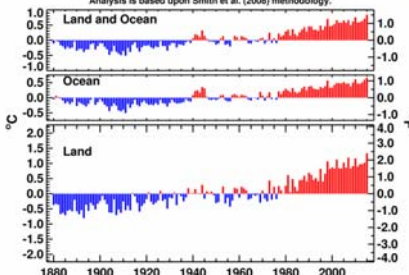
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Anthropogenic Warming

Jan-Jul Global Surface Mean Temp Anomalies
 NCEP/NESDIS/NOAA
 Analysis is based upon Smith et al. (2008) methodology.

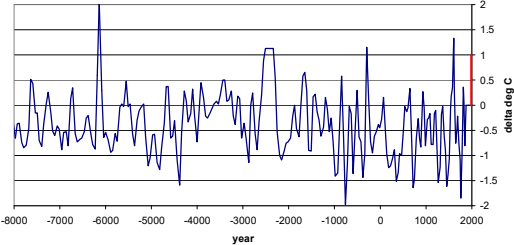


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Antarctic Temperature Data



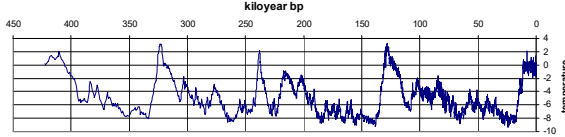
Petit, et al, *Nature* 399 (June 3 1999), pp.429-436

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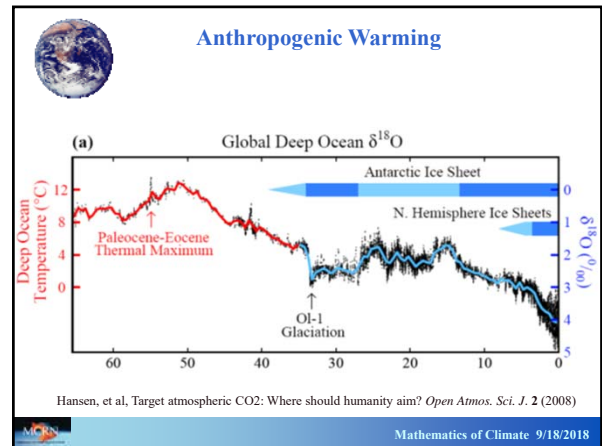
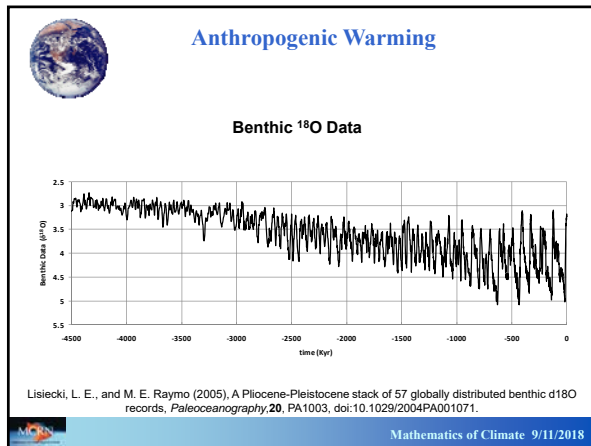
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Anthropogenic Warming

Why isn't the Earth a Snowball?
The Greenhouse Effect!

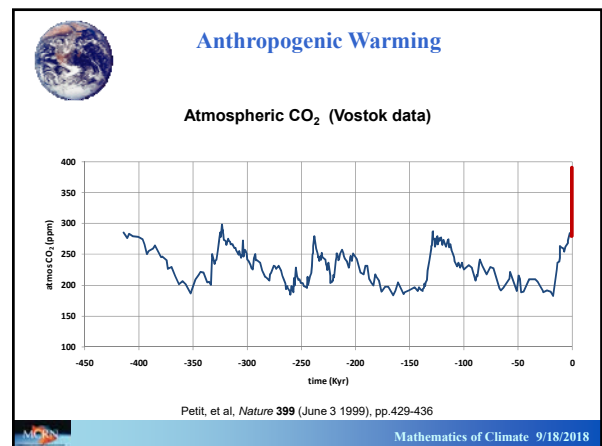
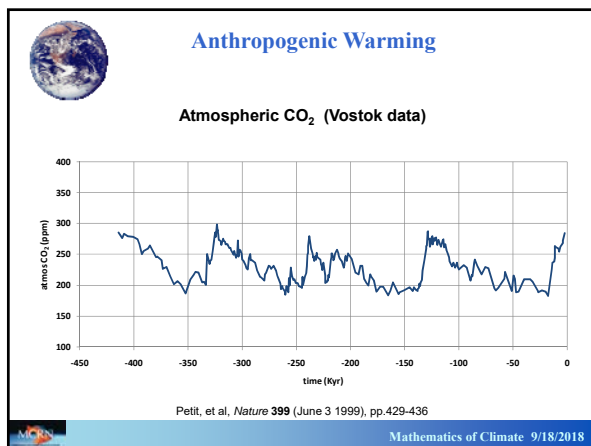
Joseph Fourier, *Mémoires de l'Académie des Sciences de l'Institut de France*, t. vii. 1827.

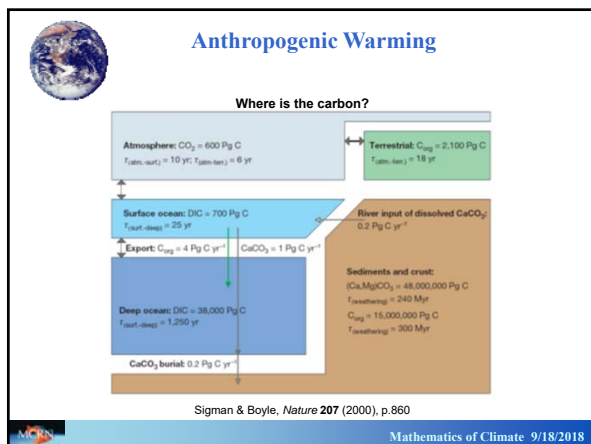
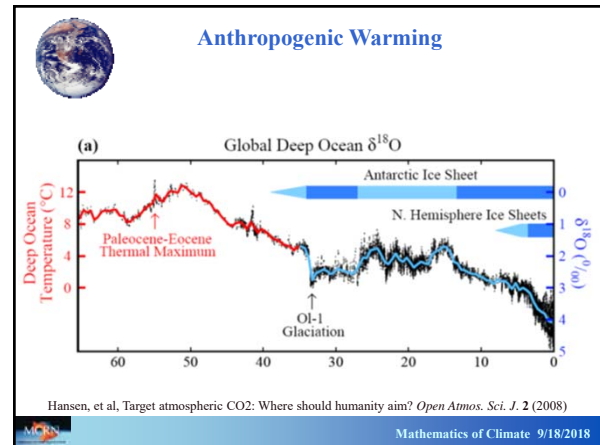
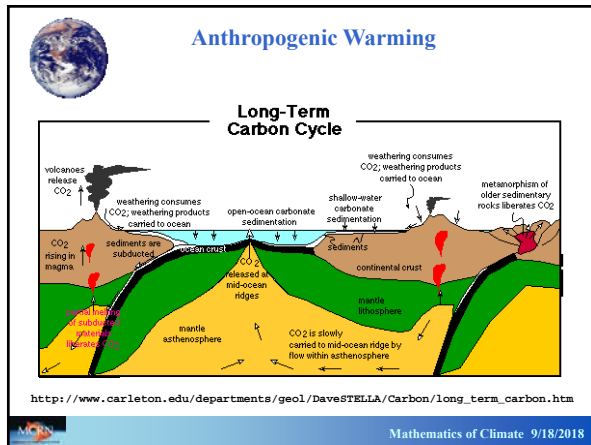
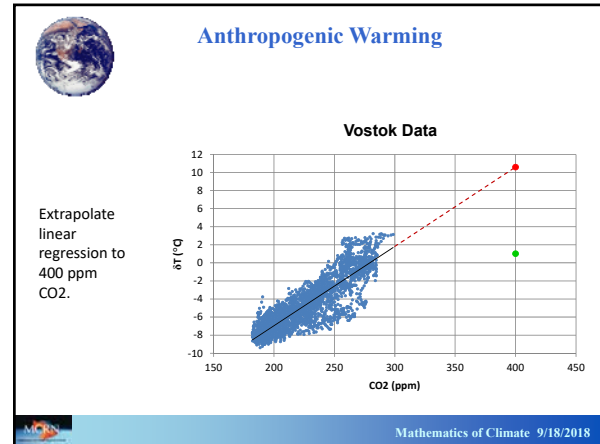
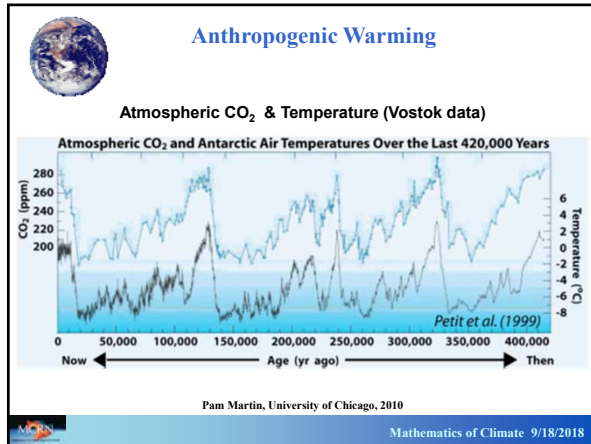


Svante Arrhenius, "On the Influence of Carbonic Acid in the Air upon the Temperature of the Ground," *Philosophical Magazine and Journal of Science (Fifth Series)* 41, pp. 237-276, 1896.



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Silicate Weathering

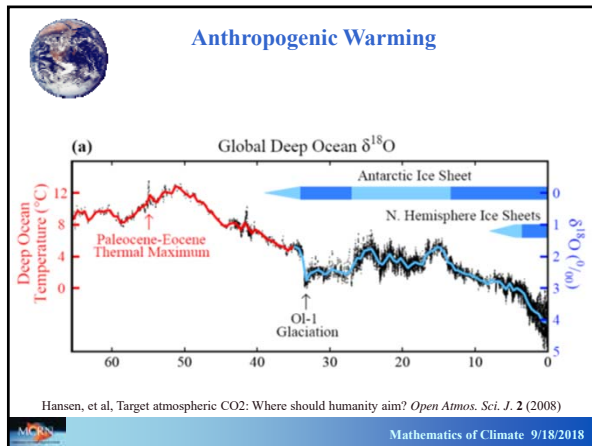
Rainwater containing dissolved CO₂ falling on silicate rocks replaces a silicon atom with a carbon atom, ultimately producing calcium carbonate (limestone) and silicon dioxide (quartz). For example, calcium silicate (Wollastonite):

$$CaSiO_3 + CO_2 \rightarrow CaCO_3 + SiO_2$$

Under volcanic conditions, the carbon atom is replaced by a silicon atom, completing the long term carbon cycle.

$$CaCO_3 + SiO_2 \rightarrow CaSiO_3 + CO_2$$

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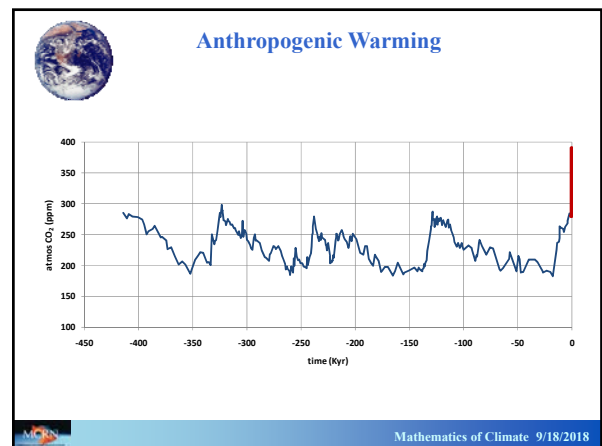
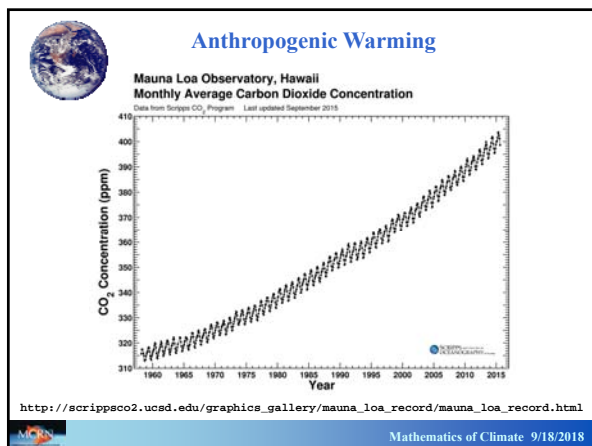
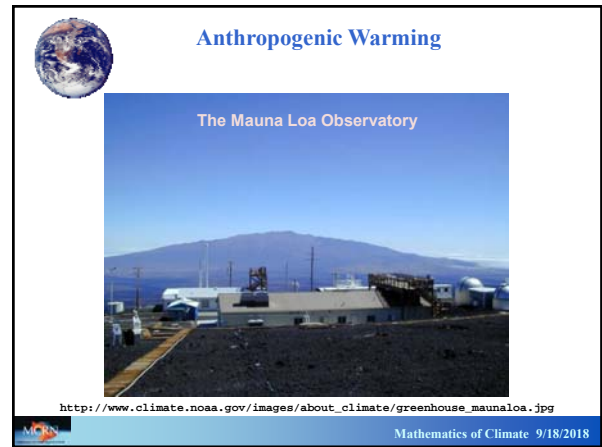
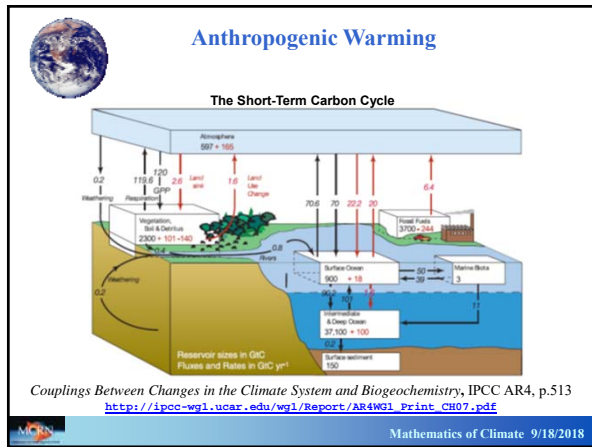
Anthropogenic Warming

Is the globe warming?
Yes, but, from a geologic perspective, not so much.


What determines the Earth's temperature?
Physics! Solar heating plus the carbon cycle.

What is the role of human activity?
 How big is the problem?

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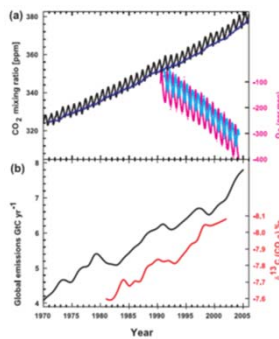


Anthropogenic Warming




Carbon isotope ratios and atmospheric oxygen depletion indicate that the increase in atmospheric CO₂ comes from burning fossil fuels.

Changes in Atmospheric Constituents and in Radiative Forcing, IPCC AR4, Chap. 2, p.138
http://ipcc-wg1.ucar.edu/wg1/Report/AR4WG1_Print_Ch02.pdf



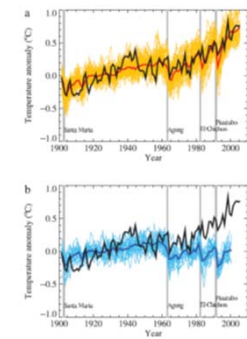
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Models with and without human activity.

Understanding and Attributing Climate Change, IPCC AR4, Chap. 9, p.684
http://ipcc-wg1.ucar.edu/wg1/Report/AR4WG1_Print_Ch09.pdf



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Anthropogenic Warming



Is the globe warming?
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What determines the Earth's temperature?
Physics! Solar heating plus the carbon cycle.


What is the role of human activity?
We are adding CO₂ to the atmosphere.

How big is the problem?

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Anthropogenic Warming


The IPCC Fourth Assessment Report



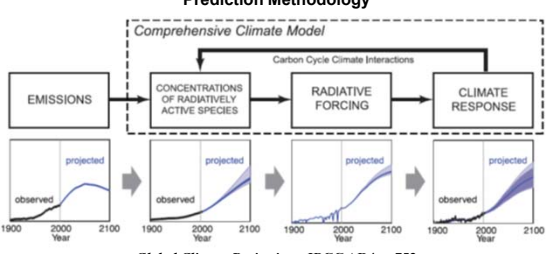
http://nobelprize.org/nobel_prizes/peace/laureates/2007/

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Prediction Methodology



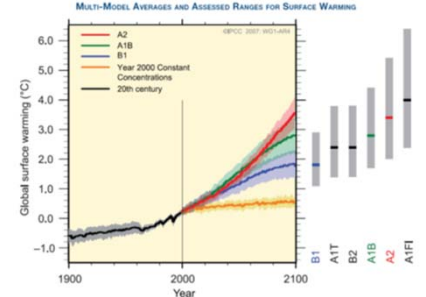
Global Climate Projections, IPCC AR4, p.753
http://ipcc-wg1.ucar.edu/wg1/Report/AR4WG1_Print_Ch10.pdf

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The IPCC Fourth Assessment Report

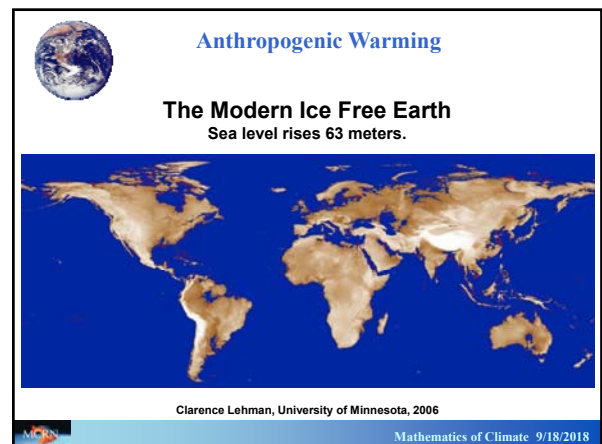
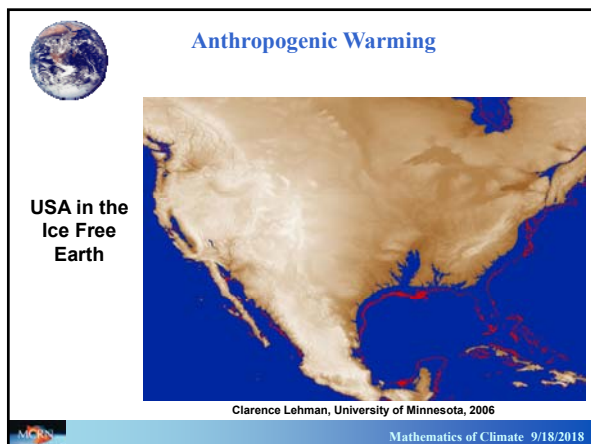
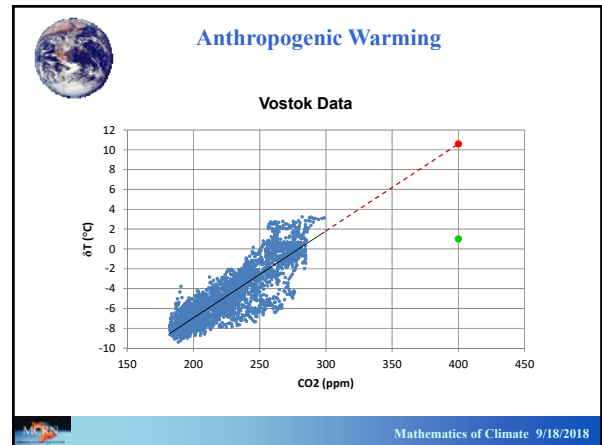
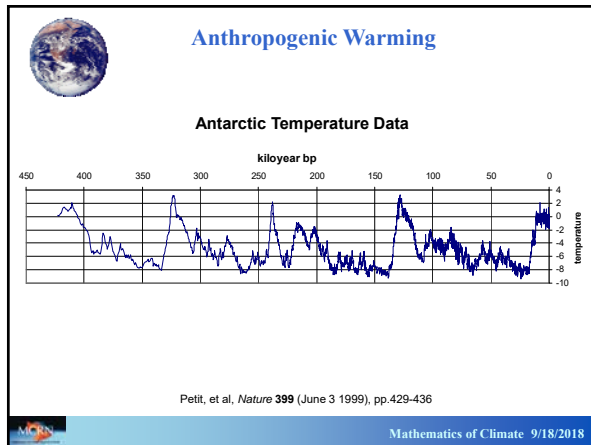
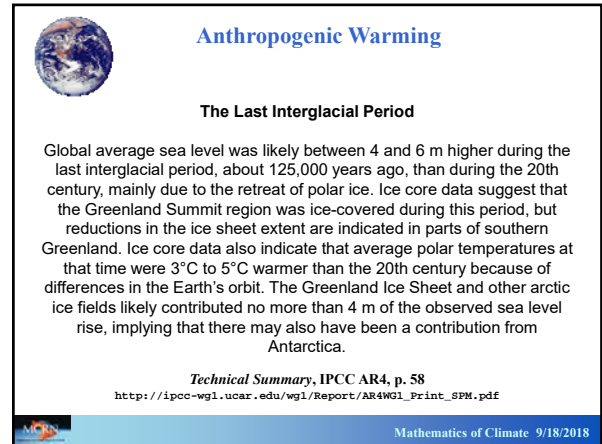
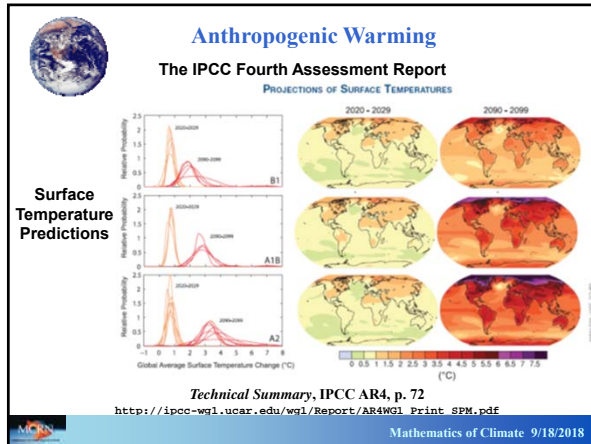
MULTI-MODEL AVERAGES AND ASSESSED RANGES FOR SURFACE WARMING




Global Mean Temperature Predictions

Summary for Policy Makers, IPCC AR4, p. 14
http://ipcc-wg1.ucar.edu/wg1/Report/AR4WG1_Print_SPM.pdf

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Anthropogenic Warming


Summary

Is the globe warming?
Yes, but, from a geologic perspective, not so much.


What determines the Earth's temperature?
Physics! Solar heating plus the carbon cycle.

What is the role of human activity?
We are adding CO₂ to the atmosphere.

How big is the problem?
Not big. Yet. ...



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Anthropogenic Warming


What can mathematicians do?

Models
Minimal complexity, aka "conceptual", "simple", "toy"
Intermediate complexity
Maximal complexity, aka "GCM"

Data
Parameter estimation (statistics)
Data assimilation

Quantification
Uncertainty
Resilience

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