

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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What determines the Earth's surface temperature?

Conservation of Energy
 Heat is a form of energy.
 Temperature measures heat.

temperature change ~ energy in - energy out

short wave energy from the Sun
long wave energy from the Earth

heat imbalance

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What determines the Earth's surface temperature?

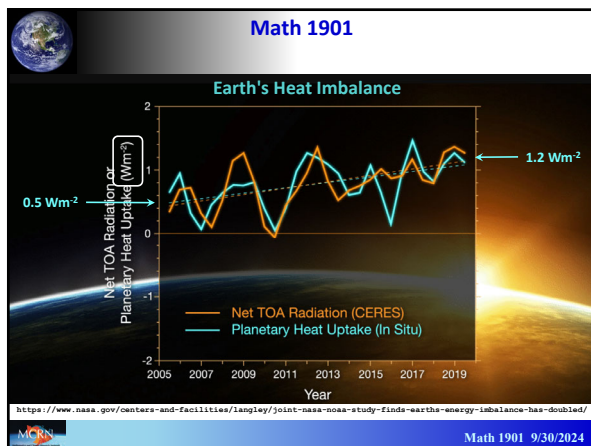
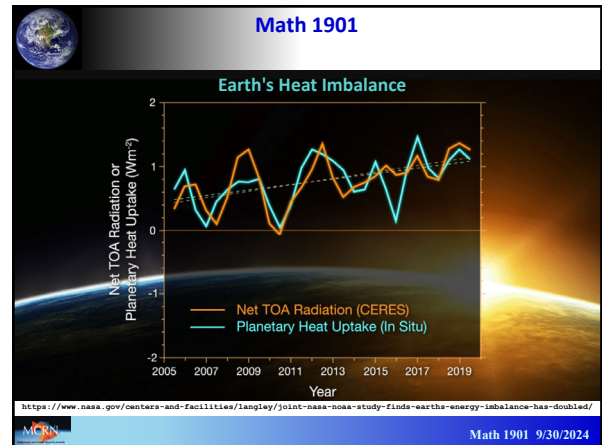
Conservation of Energy
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short wave energy from the Sun
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Can we measure heat imbalance?

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2020 Heat Imbalance

1 Wm⁻²

Surface area of Earth:
 500,000,000 km² = 5 × 10¹⁴ m²

Insolation over Earth's surface:
 5 × 10¹⁴ W = **500,000 GW**

How much is that?

GW = gigawatt
 = one billion watts
 = 10⁹ watts

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2020 Heat Imbalance

1 Wm^{-2}


Surface area of Earth:
 $500,000,000 \text{ km}^2 = 5 \times 10^{14} \text{ m}^2$

Insolation over Earth's surface:
 $5 \times 10^{14} \text{ W} = 500,000 \text{ GW}$

How much is that?

Earth's heat imbalance:
500,000 nuclear power plants

Prairie Island Nuclear Power Plant capacity: **1 GW**



https://en.wikipedia.org/wiki/Prairie_Island_Nuclear_Power_Plant

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2020 Yearly Heat Imbalance


Insolation over Earth's surface:
 $5 \times 10^{14} \text{ W} = 5 \times 10^{14} \text{ Joules/second}$

seconds in a year:
 30 million = 3×10^7

Yearly Heat Imbalance
 $15 \times 10^{21} \text{ Joules} = 15 \text{ zJ (zettajoules)}$

Biologically Stored Energy

total coal reserves: 10^{15} kg
 energy content: $3 \times 10^7 \text{ J/kg}$
 total energy in coal reserves: $3 \times 10^{22} \text{ J}$
 = **30 zJ**



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Where is the extra heat going?

Mostly into the ocean.

How do we know?

Argo

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Ocean Heat Content



part of the integrated global observation strategy



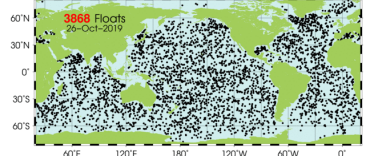
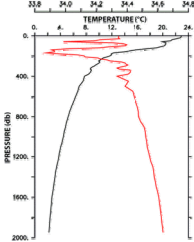

<http://www.argo.ucsd.edu/>

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Argo

part of the integrated global observation strategy

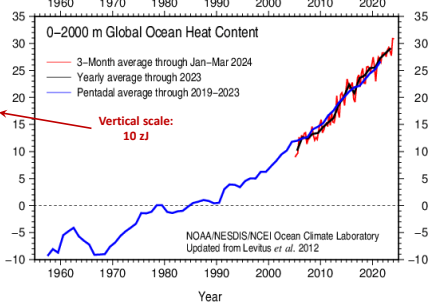



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0-2000 m Global Ocean Heat Content



Vertical scale: **10 zJ**

NOAANESDIS/NCEI Ocean Climate Laboratory
 Updated from Levitus et al. 2012

<https://www.ncei.noaa.gov/access/global-ocean-heat-content/>

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