Global Warming Caused By Increased Absorbed Solar Radiation

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Simulated Global Warming Caused By Increased Absorbed Solar Radiation

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Outline

• Science Questions
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- Science Questions
- Background / Expectations
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• Evolution of Simulated Global Budgets
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• Evolution of Simulated Global Budgets
• Regional and Latitudinal Structure
Outline

- Science Questions
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- Evolution of Simulated Global Budgets
- Regional and Latitudinal Structure
- Processes?
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• Evolution of Simulated Global Budgets
• Regional and Latitudinal Structure
• Processes?
• Implications
Our Questions: What Drives Simulated Climate Change?
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Set 1: Immediate / Specific
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- What **processes** govern the energy budget?
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- What **processes** govern the energy budget?

Set 2: General
Our Questions: What Drives Simulated Climate Change?

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  What are its spectral and regional characteristics?
  What is its temporal evolution?

- What **processes** govern the energy budget?

Set 2: General

- Why has the inter-model spread of simulated climate sensitivity remained so large in successive model generations?
Our Questions: What Drives Simulated Climate Change?

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- What is the basic **character** of the planetary imbalance? What are its spectral and regional characteristics? What is its temporal evolution?

- What **processes** govern the energy budget?

Set 2: General

- Why has the inter-model spread of simulated climate sensitivity remained so large in successive model generations?

- Do meaningful observational proxies of sensitivity exist?
Our expected view of Climate Change
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SW

Moistening

LW

Warming

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Our expected view of Climate Change

Moistening

Warming

SW

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Other expectations

Warming
Other expectations

1) relative humidity is constant
Our expected view of Climate Change

Other expectations

1) relative humidity is constant

2) low clouds dominate cloud feedbacks and differentiate model sensitivity
Our expected view of Climate Change

Other expectations

1) relative humidity is constant

2) low clouds dominate cloud feedbacks and differentiate model sensitivity

3) greatest warming is at high latitudes
The CMIP3 Archive
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- 24 coupled simulations spanning the 20\textsuperscript{th} and 21\textsuperscript{st} centuries from 18 modeling centers
- SRES-A1b
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- This leaves us with 13 simulations.
The Planetary Imbalance

Net planetary imbalance increases through the 21st century
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- Clouds lessen the imbalance. (Mean State - Not feedback!)
The Planetary Imbalance

- Current imbalance is \( \sim 0.8 \text{ W m}^{-2} \)
- Late 21st century imbalance is \( \sim 1-2 \text{ W m}^{-2} \) and begins to decline
The Planetary Imbalance

- In current climate OLR’ heat the planet. Aerosols cool it.
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• In current climate OLR’ heat the planet. Aerosols cool it.
The Planetary Imbalance

- In current climate OLR' heat the planet. Aerosols cool it.
- Feedbacks in ASR drive the imbalance after 2100 and to equil.
What regions are processes are suggested?
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- OLR
- lapse rate feedback?
- water vapor feedback?
- cloud feedback?
What regions are processes are suggested?

OLR
- lapse rate feedback?
- water vapor feedback?
- cloud feedback?

ASR
- ice albedo feedback?
- cloud feedback?
- land snow feedback?
- aerosol forcing?
Regional Structure
Regional Structure

CMIP3 Ensemble Mean [Global = 0.15 \times 10^{24} \, \text{J}]

1998

NH ocean 0.1

SH ocean 0.7

NH land -0.2

SH land 0.1

\[ \int \Delta \text{RTMT}_{1900-1950} \]

-4 -3 -2 -1 0 1 2 3 4

-6.0 -4.0 -2.0 0.0 2.0 4.0 6.0

[10^{21} \, \text{J deg}^{-1}]
**Lat/Time Structure of the Imbalance**

- Planetary Imbalance $>0$, 50N-50S, ice-albedo feedback suggested to be weak
OLR anomalies > 0 except for deep tropics and southern oceans
ASR increases at all latitudes except 45-65S
Lat/Time Structure of Cloud %

- In regions of $R_T$ and ASR increase, cloud change is $< 0$
Loss of mid-level clouds is more intense and extensive than for other types.
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• Loss of mid-level clouds is more intense and extensive than for other types.
Relationship to Sensitivity

S vs ΔRSR 2090

r = -0.82

Δ RSR [W m⁻²]

2.0 2.5 3.0 3.5 4.0 4.5

S

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Relationship to Sensitivity

S vs $\Delta RSR$ per K at 2090

$\Delta RSR/K [W m^{-2} K^{-1}]$

$r = -0.78$

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Role of Model Resolution

Net Warming [W/m²]

1960 1980 2000 2020 2040 2060 2080 2100

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Role of Model Resolution

4 lowest resolution models
Role of Model Resolution

The diagram illustrates the role of model resolution in climate modeling over time. It shows a graph with Net Warming [YJ] on the y-axis and years from 1960 to 2100 on the x-axis. The graph compares 4 highest resolution models and 4 lowest resolution models, with distinct shading to differentiate their results. The models are shown to have varying responses to warming, with the highest resolution models capturing more detailed changes.
Conclusions: Set 1
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- Spectral contributions to the planetary imbalance evolve.
  - LW 20th and early 21st centuries
  - SW mid- to late-21st century and beyond
  - (LW is a net negative feedback)
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- Cloud loss largely drives the reduction in Albedo
Conclusions: Set 2

- Cloud loss sensitivity largely determines $S$

- Large implications for efforts to gauge sensitivity based on present-day variability. Models suggest that current warming is NOT driven or distinguished by the processes that primarily determine $S$. 