Recent Developments in Climate Change Detection and Attribution Research

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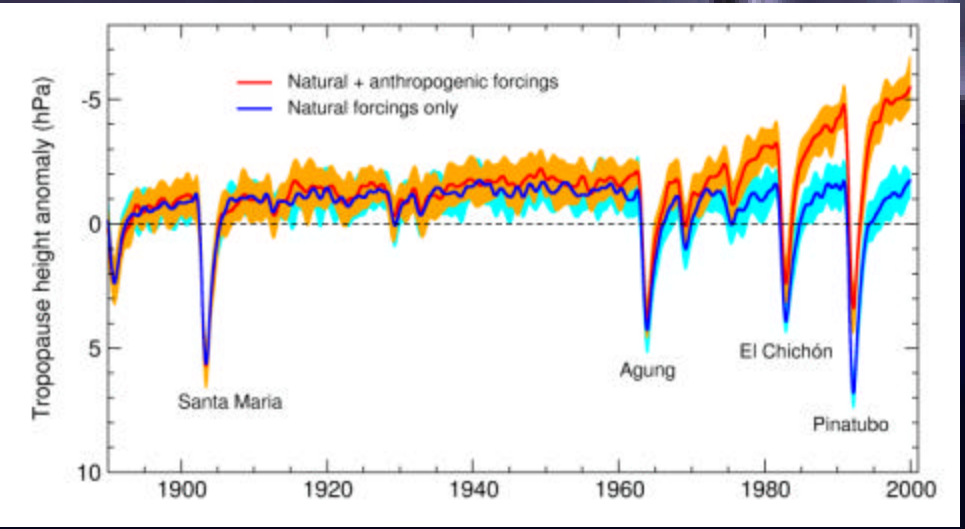
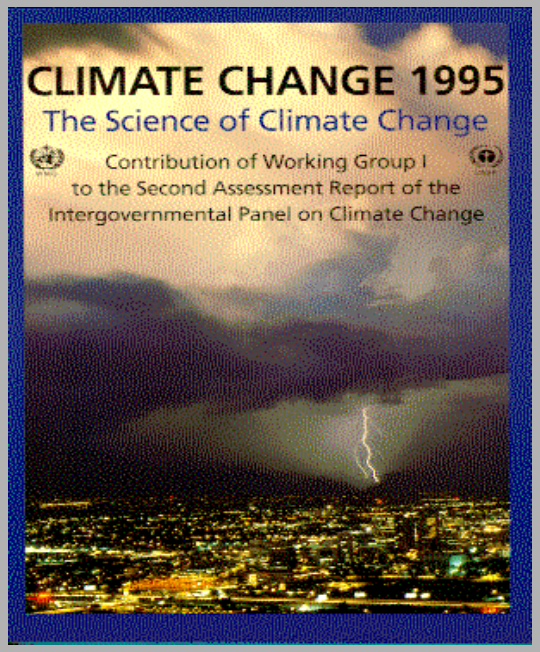
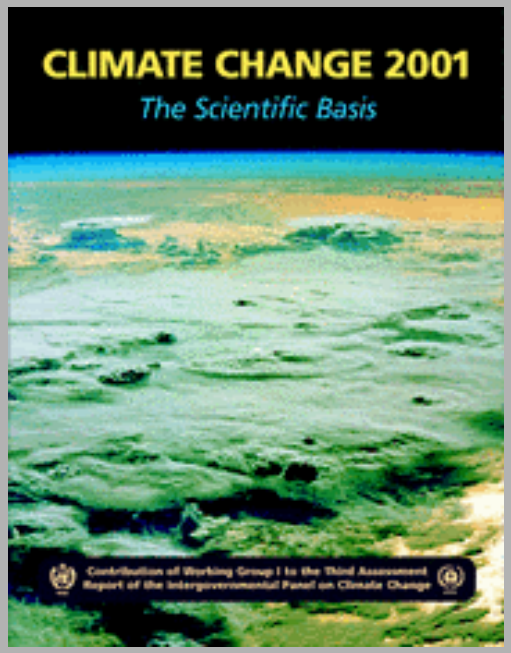
California Air Resources Board
Los Angeles, CA, September 23th, 2004



Key findings of the Intergovernmental Panel on Climate Change: Humans are affecting Earth's climate





"The balance of evidence suggests a discernible human influence on global climate"

"There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities"

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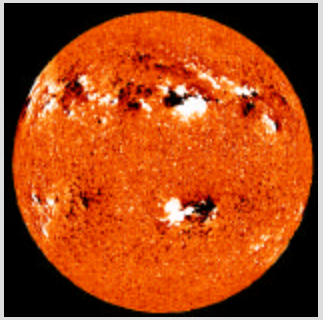
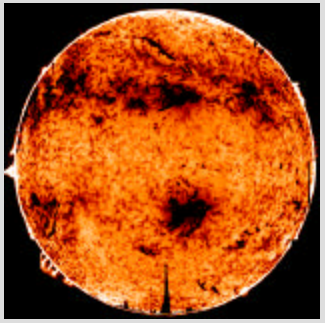
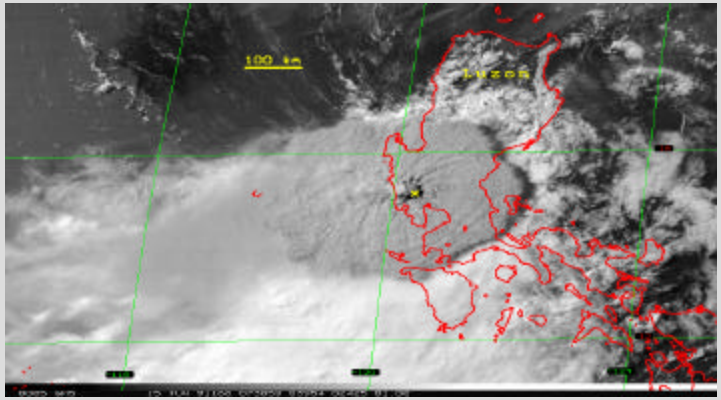
Climate Change 101: Natural mechanisms influence climate

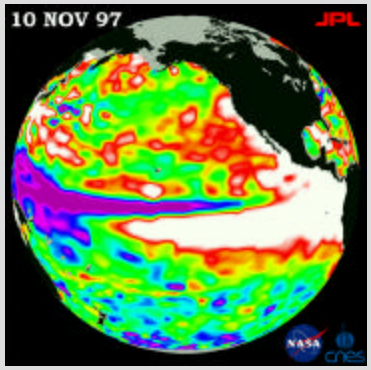
Natural mechanisms

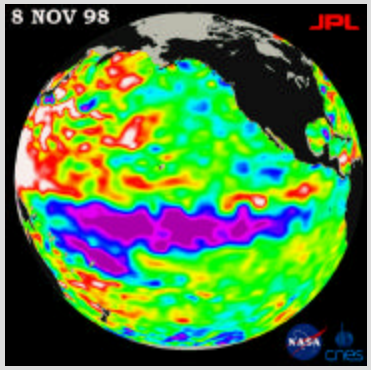
- Changes in the Sun
- Changes in the amount of volcanic dust in the atmosphere
- Internal variability of the coupled atmosphere-ocean system











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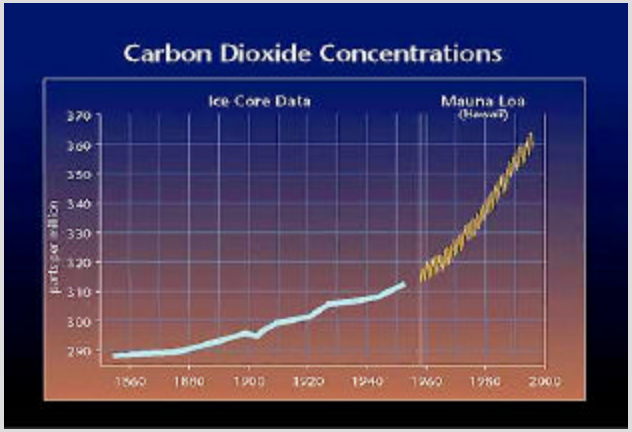
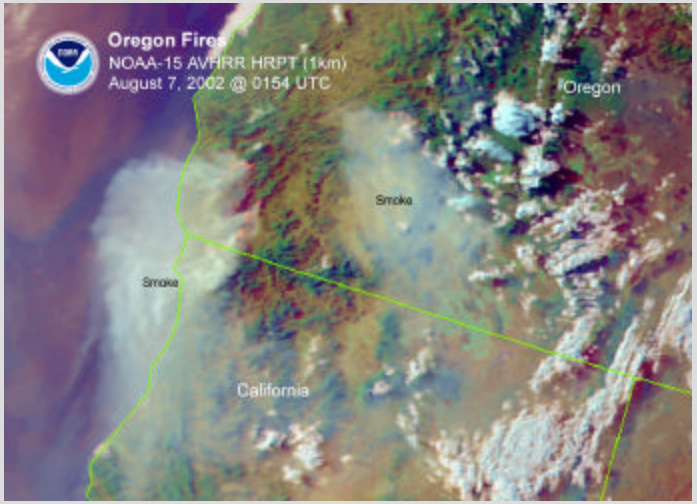
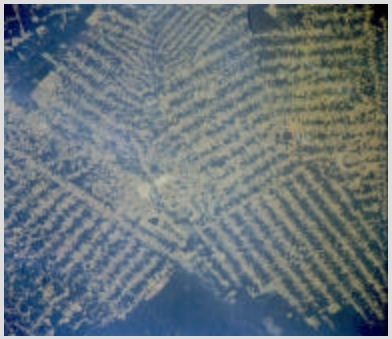
Climate Change 101: Human factors also influence climate

Non-natural mechanisms

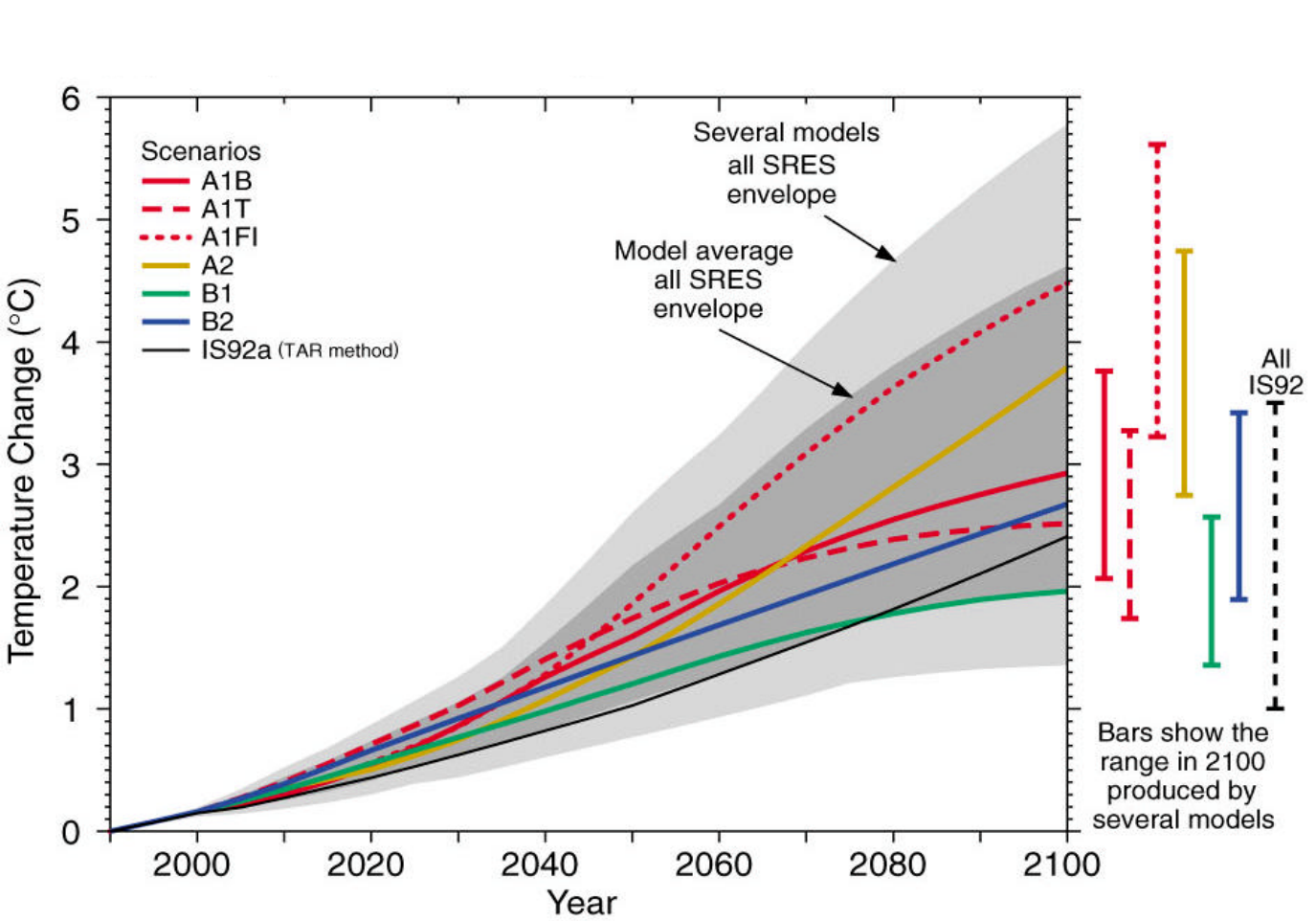
- Changes in atmospheric concentrations of greenhouse gases
- Changes in aerosol particles from burning fossil fuels and biomass
- Changes in the reflectivity (albedo) of the Earth's surface







Climate Change 101: There are large uncertainties in projections of future global-mean temperature changes



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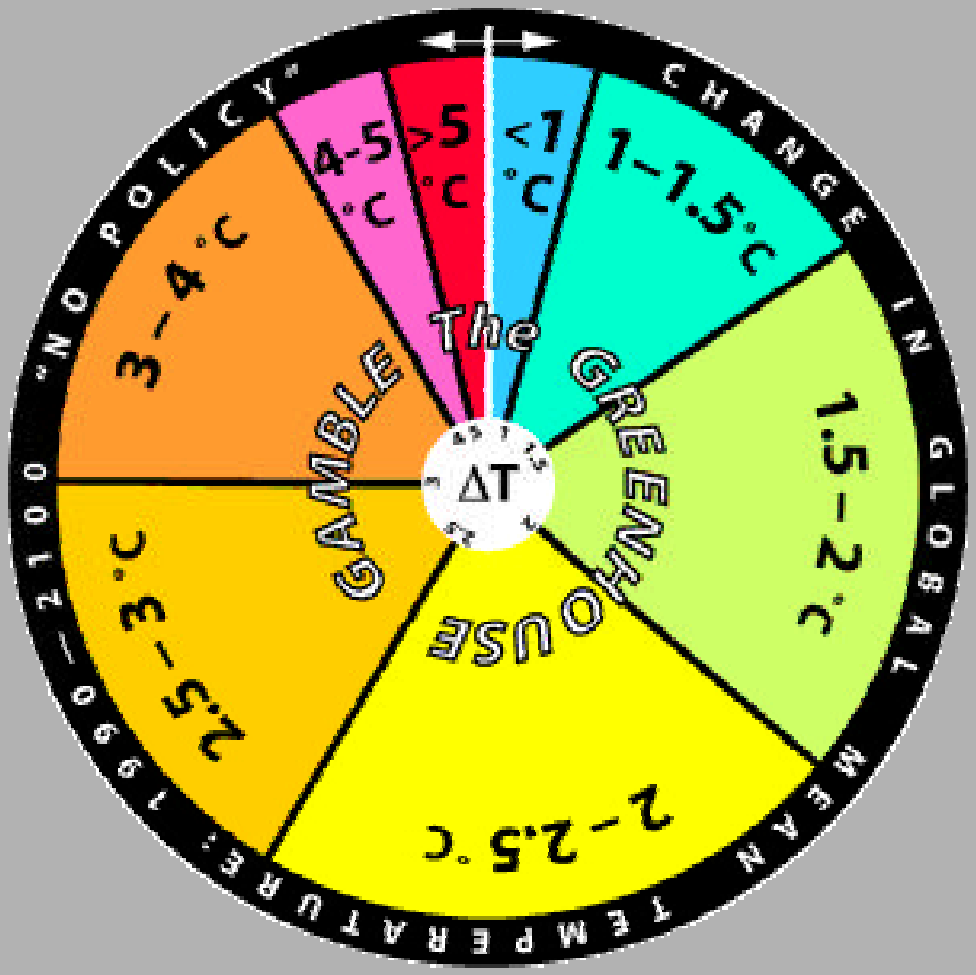
*** Source: IPCC Third Assessment Report, Summary for Policymakers**

The great “greenhouse gamble”…

<1°C	(4.1%; 1 in 24 odds)
1 to 1.5°C	(11.4%; 1 in 9 odds)
1.5 to 2°C	(20.6%; 1 in 5 odds)
2 to 2.5°C	(22.5%; 1 in 4 odds)
2.5 to 3°C	(16.8%; 1 in 6 odds)
3 to 4°C	(16.2%; 1 in 6 odds)
4 to 5°C	(4.6%; 1 in 22 odds)
>5°C	(3.8%; 1 in 26 odds)



Source: MIT Joint Program on the Science and Policy of Climate Change

We have made progress in resolving an important problem: The apparent lack of tropospheric warming

"…the theory that increasing concentrations of greenhouse gases like carbon dioxide will lead to further warming is at least an oversimplification. It is inconsistent with the fact that satellite measurements over 35 years show no significant warming in the lower atmosphere, which is an essential part of the global-warming theory".

James Schlesinger (former Secretary of Energy, Secretary of Defense, and Director of the CIA), "Cold Facts on Global Warming", L.A. Times, January 22, 2004

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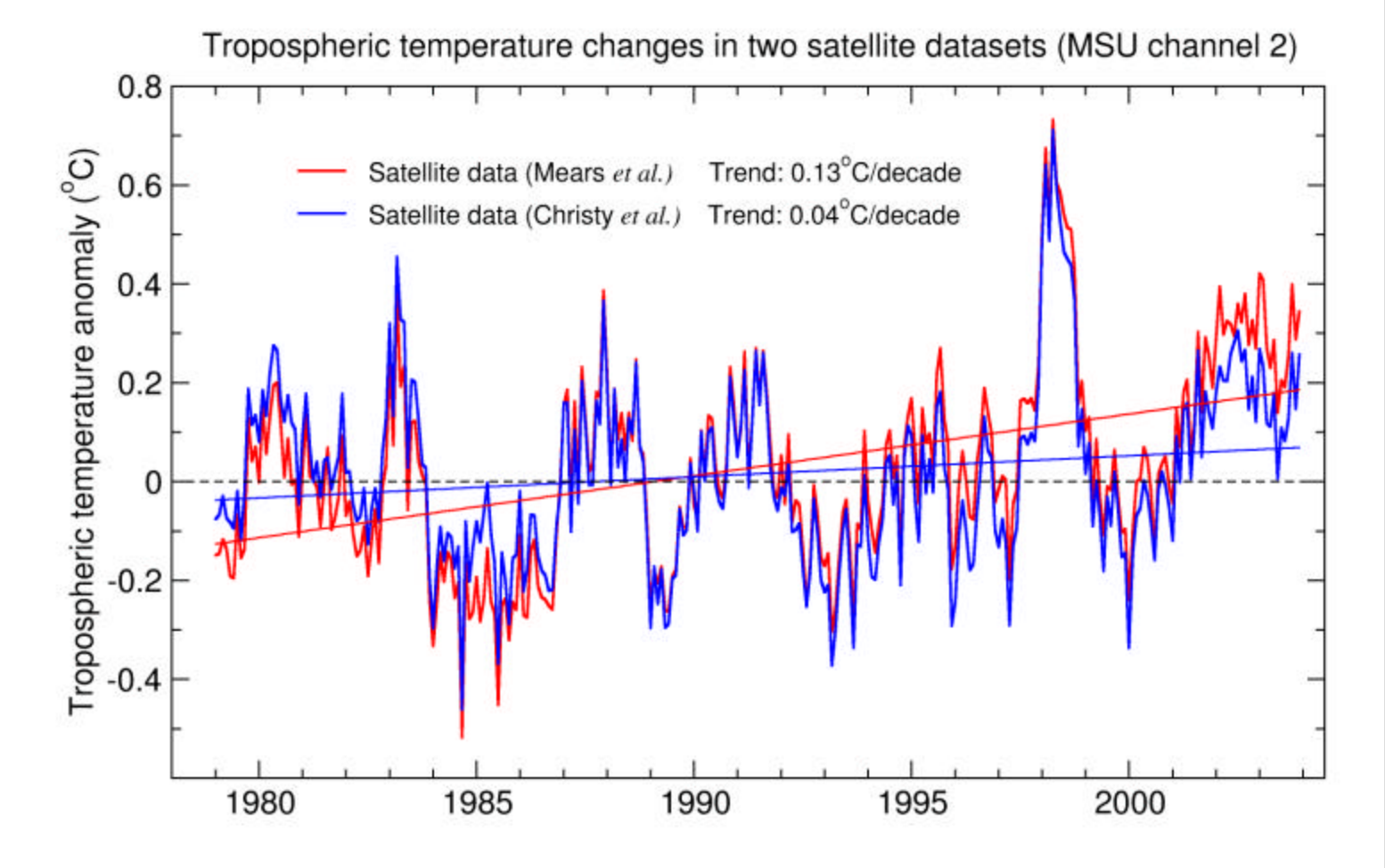
We now have multiple estimates of temperature change in the troposphere



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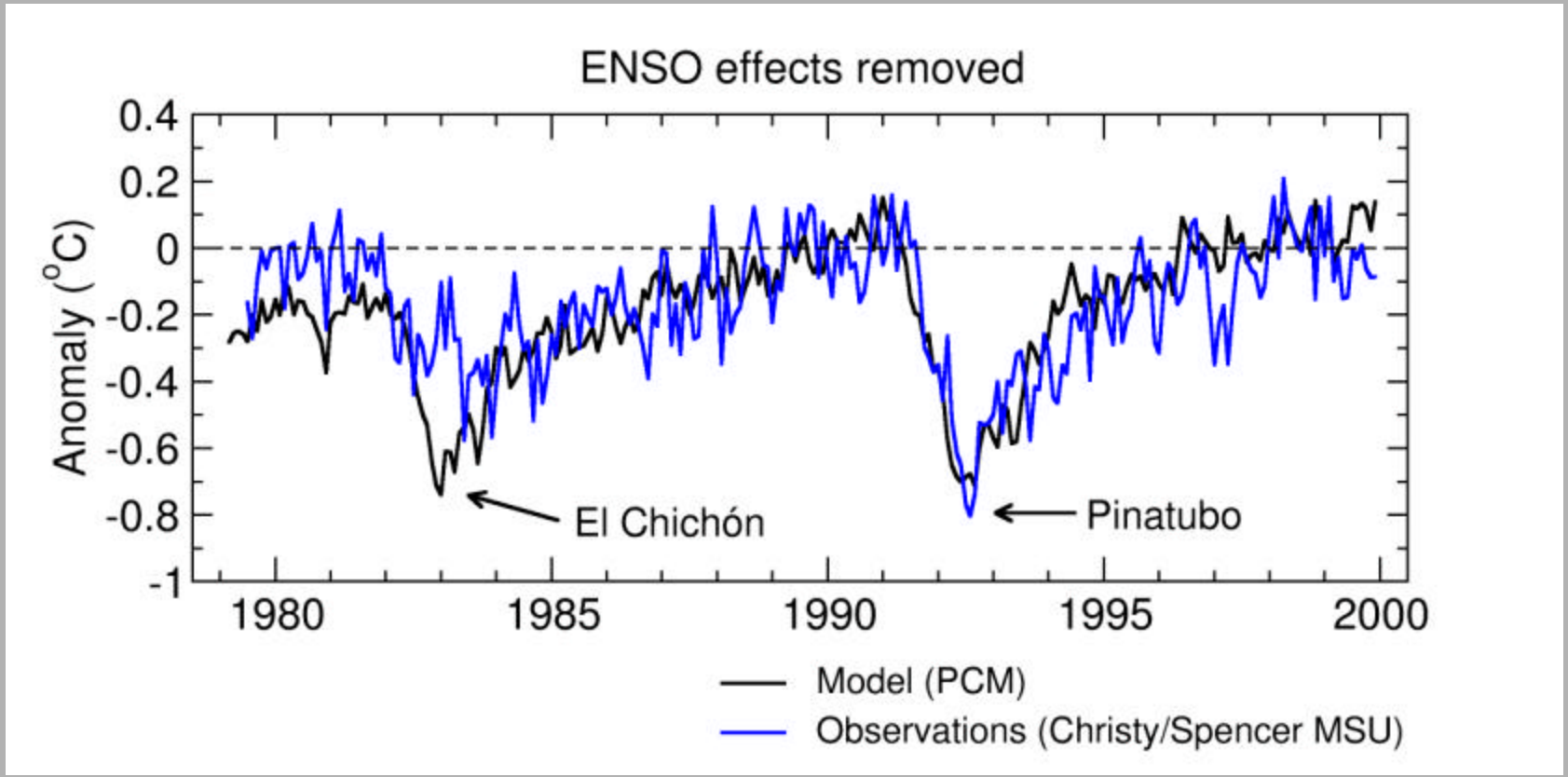
Testing climate models: Simulation of the tropospheric temperature changes after major volcanic eruptions



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We are making progress in defining the characteristic "fingerprints" of different climate forcings

Solar

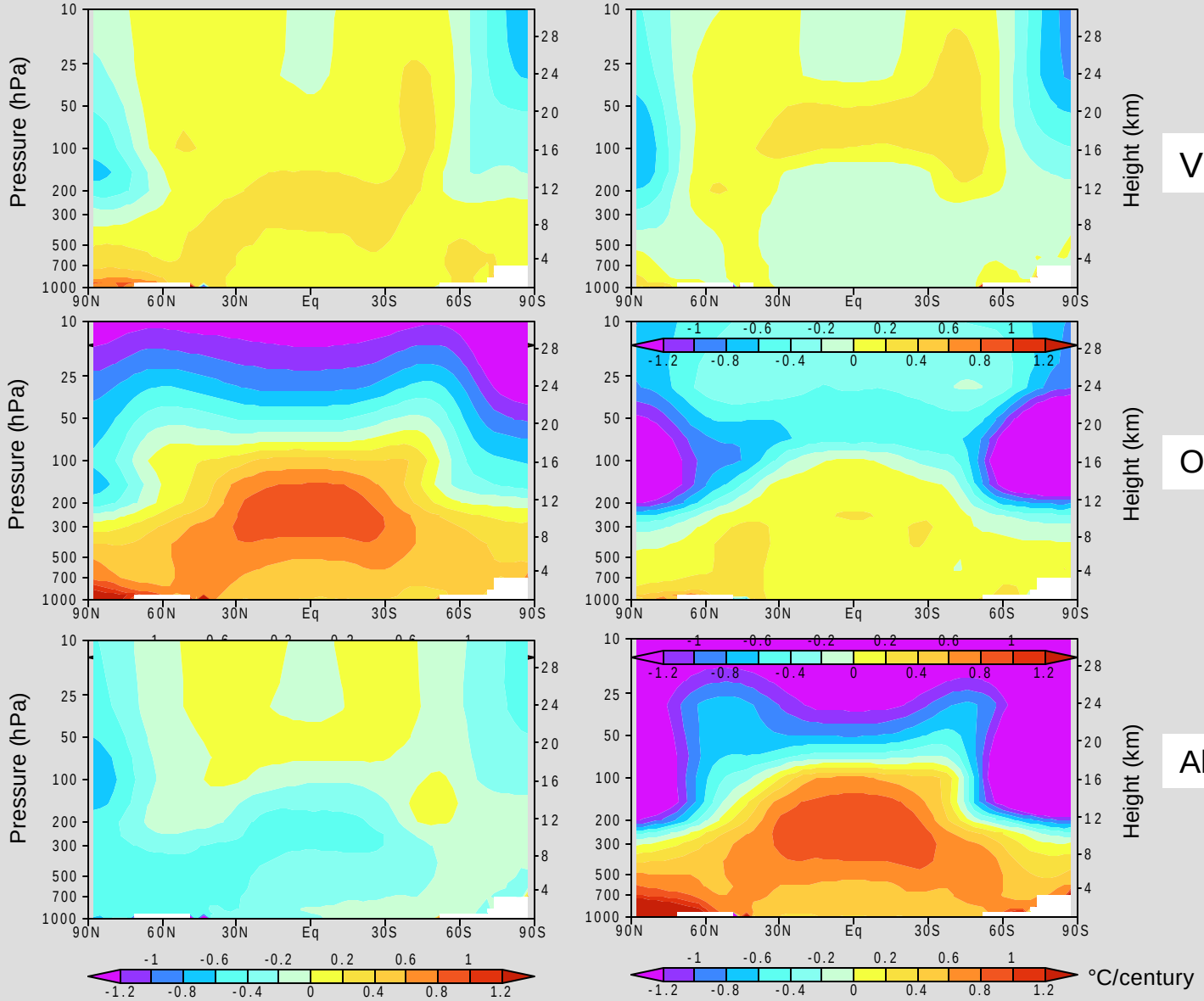
Volcanoes

Well-mixed GHGs

Ozone

Sulfate aerosols

All forcings



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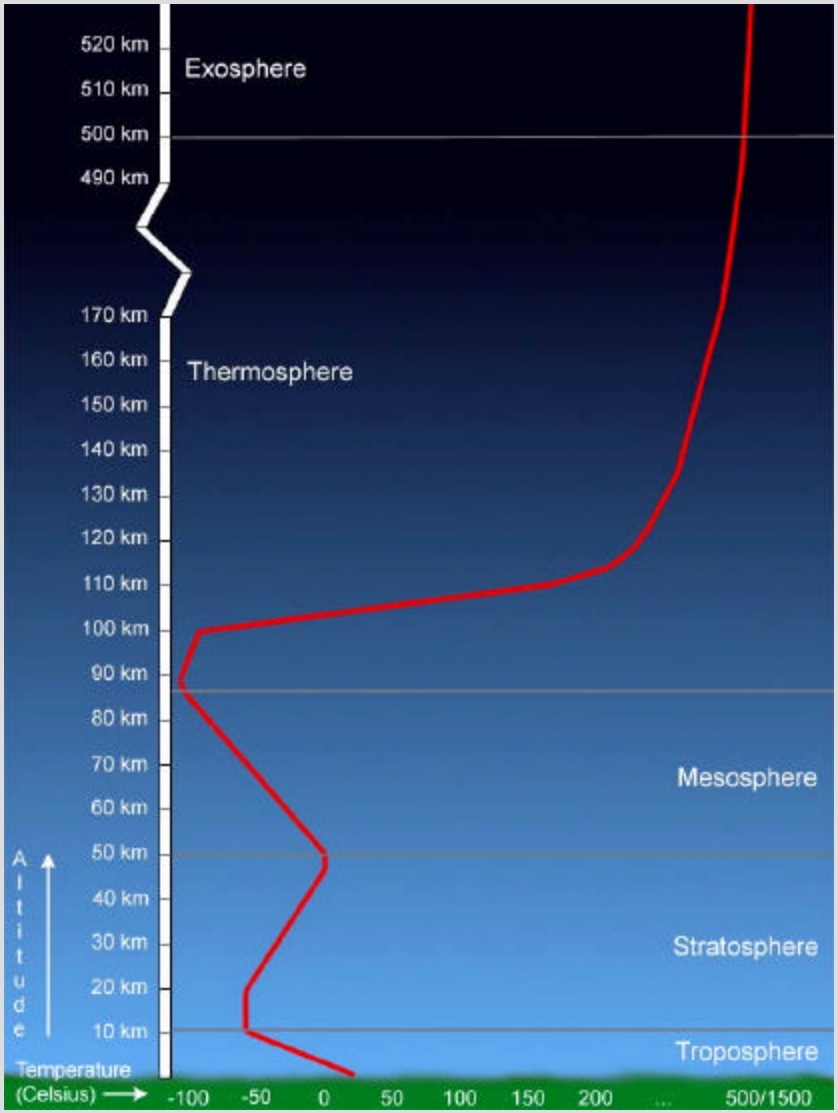
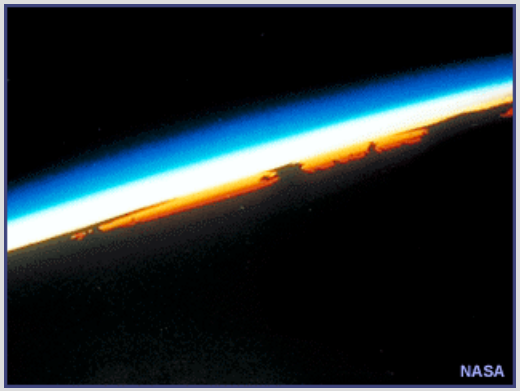
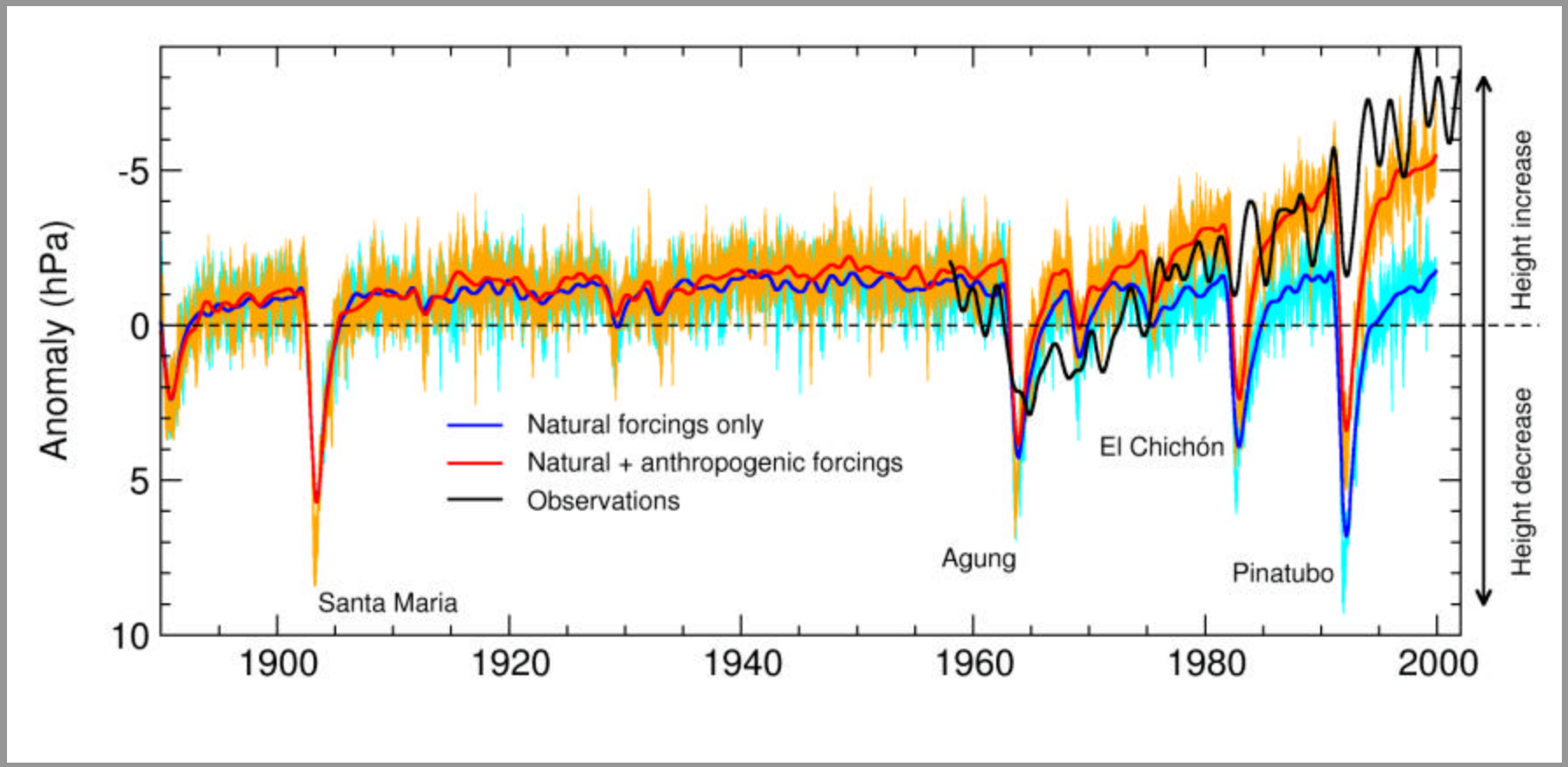
We are identifying new “fingerprints” of human effects on climate





In a climate model, human-caused changes in tropopause height are large relative to natural effects



Santer *et al*., *Science*, 2003

Glacier retreat: Another fingerprint of human-induced climate change

1903

1928

2003

2004

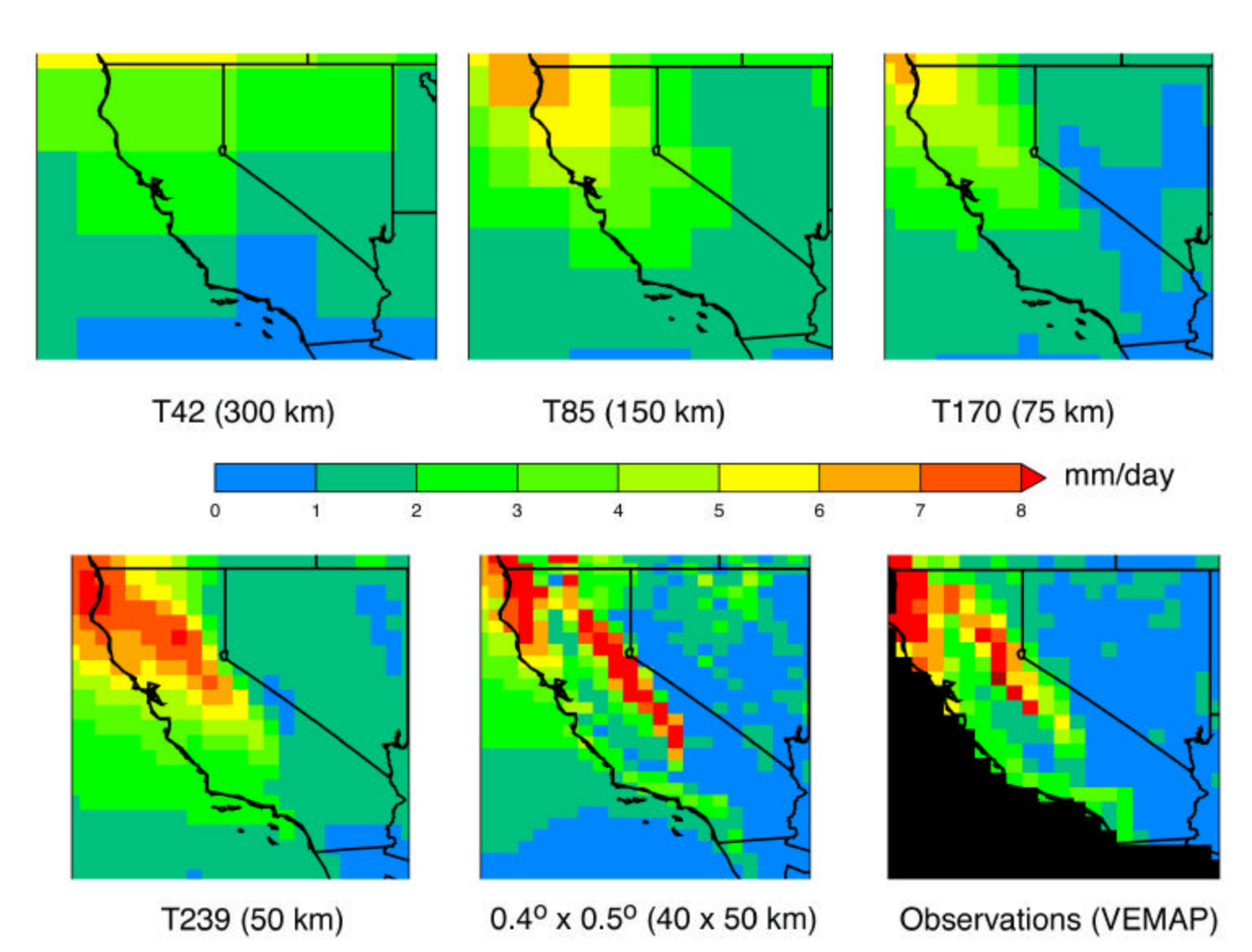
Lyell Glacier, Yosemite National Park

Upsala Glacier, Argentina

G.K. Gilbert and Hassan Basagic

Archivo Museo Salesiano and Greenpeace

Climate model resolution is improving, leading to improved regional simulations



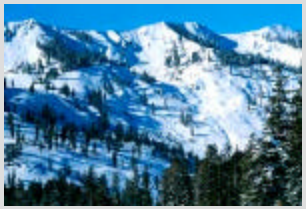
Duffy *et al.*

Why should we focus on regional climate?

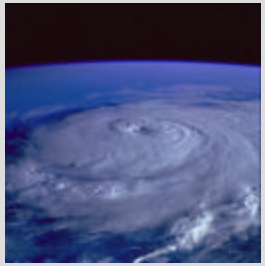
- **Because humans and natural ecosystems experience regional, not global, climate;**
- **Because improvements in climate models make meaningful regional projections possible**
- **Regional climate changes will determine societal impacts and drive climate-related policy decisions**

Water availability

Recreation



Extreme events



Air quality

Human health

Agriculture

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Conclusions

- **Human activities have changed the chemical composition of the atmosphere**
- **We have identified human-caused climate change in a number of different aspects of the climate system**
  - The climate system is telling us an internally–consistent story
- **We need to improve our ability to predict the regional-scale climate changes that are "in the pipeline", and their societal impacts**
  - It is these regional-scale changes that we will "feel" most strongly

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