2500 scientists say we've caused global warming.

I'd like a second opinion.
5. Describe one piece of information you thought was interesting in this report.
Solutions Proposal – Due 10/3

• ~250 word (half page) paragraph proposal supported by scientific evidence. i.e. Provide a strong argument that your solution addresses a global change problem.

• Statements in your proposal based on the literature should be cited.

• Literature review of 4 peer reviewed papers related to the global change topic.
Everything you ever wanted to know about climate change science

www.realclimate.org
Global Carbon Cycle

Reservoir sizes in GtC:
- Atmosphere: 597 + 165
- Vegetation, Soil & Detritus: 2300 + 101 - 140
- Fossil Fuels: 3700 - 244
- Surface Ocean: 900 + 18
- Intermediate & Deep Ocean: 37100 + 100
- Marine Biota: 3
- Surface Sediment: 150

Fluxes and Rates in GtC yr⁻¹:
- Weathering: 0.2
- Respiration: 119.6
- GPP: 120
- Land sink: 2.6
- Land Use Change: 1.6
- Weathering: 0.2
- Respiration: 0.8
- Rivers: 70.6
- Surface Ocean: 70
- Fossil Fuels: 22.2
- Marine Biota: 20
- Intermediate & Deep Ocean: 6.4

Weathering: 0.2
Respiration: 119.6
GPP: 120
Land sink: 2.6
Land Use Change: 1.6
Weathering: 0.2
Respiration: 0.8
Anthropogenic Greenhouse Gas Emissions

- CO$_2$ fossil fuel use: 56.6%
- CO$_2$ (deforestation, decay of biomass, etc): 17.3%
- CO$_2$ (other): 2.8%
- CH$_4$: 14.3%
- N$_2$O: 7.9%
- F-gases: 1.1%
Annual Greenhouse Gas Emissions by Sector

- Industrial processes: 16.8%
- Power stations: 21.3%
- Waste disposal and treatment: 3.4%
- Land use and biomass burning: 10.0%
- Residential, commercial, and other sources: 10.3%
- Fossil fuel retrieval, processing, and distribution: 11.3%
- Agricultural byproducts: 12.5%
- Transportation fuels: 14.0%
- Other: 20.6%

- Carbon Dioxide: 29.5% (72% of total)
- Methane: 40.0% (18% of total)
- Nitrous Oxide: 62.0% (9% of total)
Atmospheric CO\textsubscript{2} at Mauna Loa Observatory

1974-2007 NOAA/ESRL

CONCENTRATION (parts per million)

YEAR

Line of evidence #1: Physics

“if the quantity of carbonic acid increases in geometric progression, the augmentation of the temperature will increase nearly in arithmetic progression”

- Svante Arrhenius, 1896
Line of evidence #1: Physics
Line of evidence #1: Physics

More scatter of radiation

Solar radiation coming in (primarily as light)

Earth radiation going out (primarily as heat)
Line of evidence #2: Paleoclimate

Atmospheric CO₂ at Mauna Loa Observatory

1974-2007 NOAA/ESRL

CONCENTRATION (parts per million)

YEAR
Where do these data come from?
European Project for Ice Coring in Antarctica

Paleoclimate to 650,000 years
Paleoclimate to 5 million years

Five Million Years of Climate Change From Sediment Cores

41 kyr cycle

100 kyr cycle
Paleoclimate to 65 million years

65 Million Years of Climate Change

Millions of Years Ago

Polar Ocean Equivalent $\Delta T\ (^\circ C)$

- PETM
- Eocene Optimum

Antarctic Glaciation
Antarctic Thawing
Antarctic Reglaciation
Rapid Glacial Cycles

Benthic $\delta^{18}O$ (per mil)
Paleoclimate to 65 million years

Paleocene-Eocene Thermal Maximum

- Global temperature rise of 6°C over 20,000 years
- Mass extinction of benthic forams (*protozoa – single celled organisms*) and terrestrial mammals
- Carbonate dissolved in oceans (ocean acidification)
Line of evidence #3: Observations

Atmospheric CO$_2$ at Mauna Loa Observatory

1974-2007 NOAA/ESRL
Line of evidence #3: Observations

Global average observed warming is 0.85 °C (1.5 °F) since 1880.
Temperature rise continues


No need to consult your local weather, I made a detailed map for you:
Line of evidence #3: Observations
Line of evidence #3: Observations

Red/orange: Satellite records
Line of evidence #3: Observations

Muir & Riggs Glaciers (Alaska)

Olympic National Park - Lillian Glacier
Line of Evidence #4: Models
Logic connecting emissions to projected climate changes

The most uncertainty in climate projections comes from how much we will continue to emit
## Modeling groups in IPCC AR4

<table>
<thead>
<tr>
<th>Originating Group(s)</th>
<th>Country</th>
<th>CMIP3 I.D.</th>
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<tbody>
<tr>
<td>Beijing Climate Center</td>
<td>China</td>
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<td>Bjerknes Centre for Climate Research</td>
<td>Norway</td>
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<td>ECH0-G</td>
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<td>UKMO-HadGEM1</td>
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</table>
Summary of lines of evidence

1. Increasing atmospheric CO$_2$, N$_2$O and CH$_4$ cause surface warming by absorbing and re-radiating heat from the earth’s surface

2. Current magnitudes and rates of greenhouse gas accumulation are unprecedented in paleo-climate history

3. We have observed increasing temperatures and temperature-associated processes (sea ice melt, glacier melt, sea level rise)

4. Models cannot account for temperature trends unless they include human influence
Go through remaining questions from Smoke, Mirrors & Hot Air

1. This report was written by a journalist and reads differently from a science paper. Do you find the arguments more or less credible?

2. ExxonMobil created ‘manufactured uncertainty’ relatively cheaply ($16 million). Why do you think scientists have done a comparatively poor job convincing the public about anthropogenic climate change?

3. Describe the marketing idea behind the term ‘sound science’.

4. Describe what the report refers to as the ‘echo chamber’ used for information laundering.