

The Science Behind Global Climate Change

Professor Tom Bitterwolf
 Department of Chemistry
 bitterte@uidaho.edu

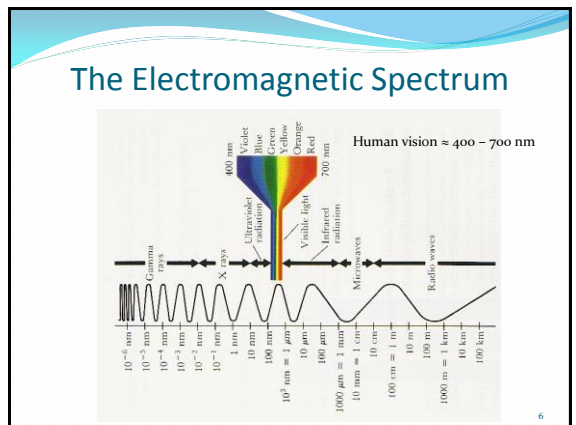
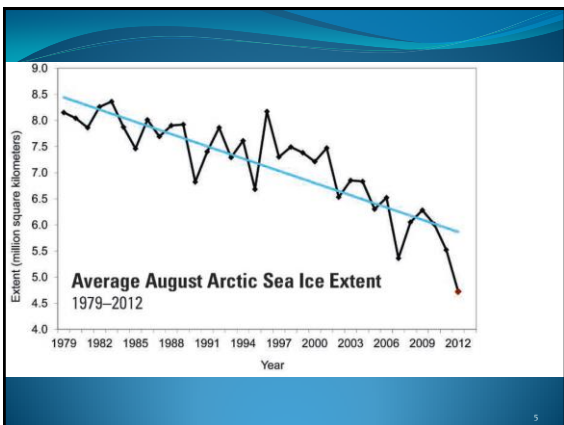
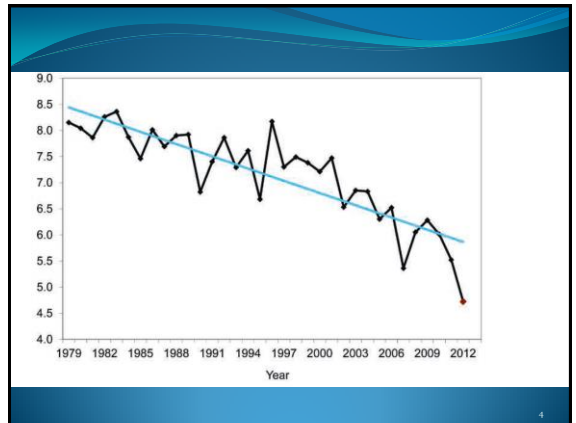
Presentation to CSS 235, Society & Natural Resources

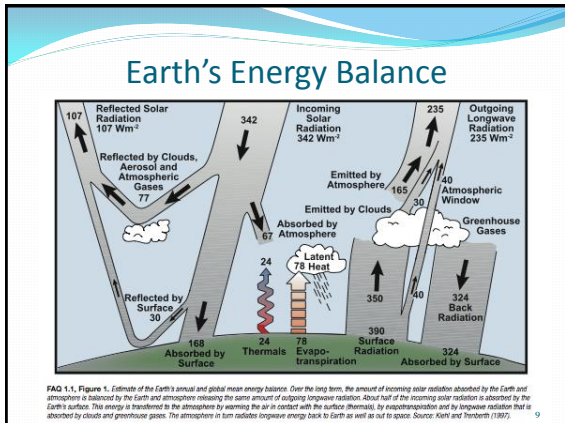
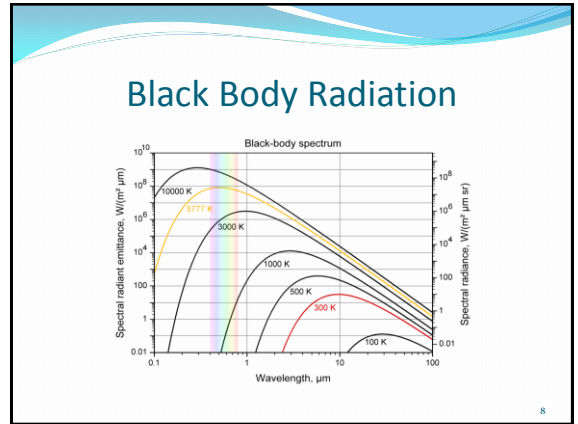
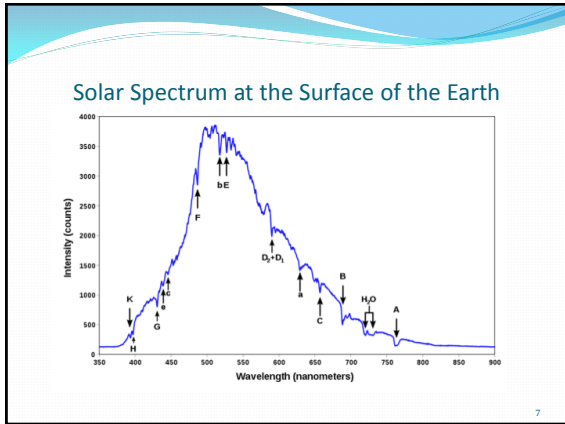
Everyone is entitled to his own opinion, but not to his own facts

Attributed to
 Sen. Daniel Patrick Moynihan

"...the debate on the authenticity of global warming and the role played by human activity is largely nonexistent among those who understand the nuances and scientific basis of long-term climate processes".

P. T. Doran and M. K. Zimmerman, EOS 90, 2009, 22





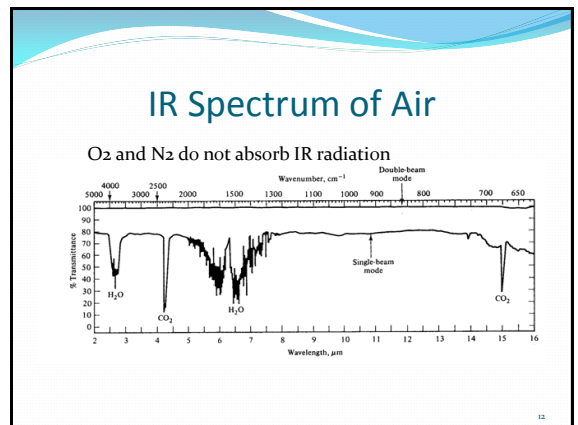
What do Greenhouse Gases do?

- These gases absorb light in the infrared part of the spectrum.
- N_2 and O_2 make up the vast majority of the atmosphere and these gases are transparent to infrared light.
- Without greenhouse gases the Earth's temperature would be 0°F (-18°C) as opposed to its actual temperature of 57°F (14°C).

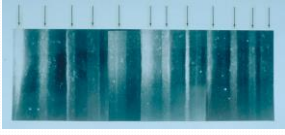
What are the Greenhouse Gases?

Greenhouse Gas	% Contribution on a Clear Day
Water	60
CO_2	26
Ozone	8
Methane and Nitrous Oxide	6

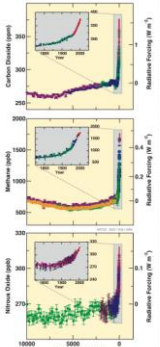
Kiehl, Bull. Am. Meteorological Soc., 78, 1997, 197



Atmospheric Gas Record from Vostok Ice Cores

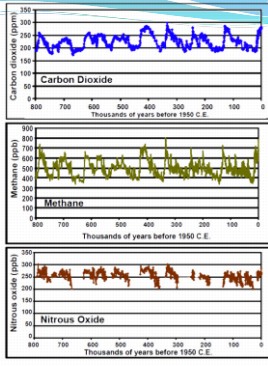


IPCC, 2007: Summary for Policymakers. In: *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA



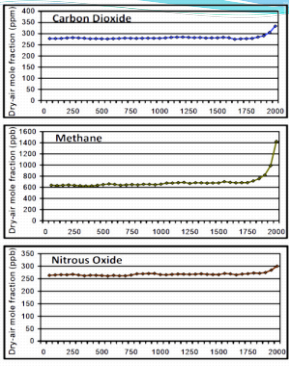
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800 kY Record



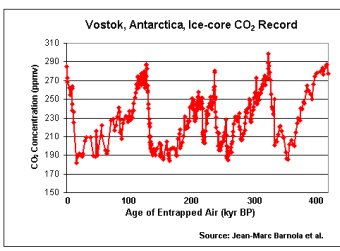
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2000 Y Record



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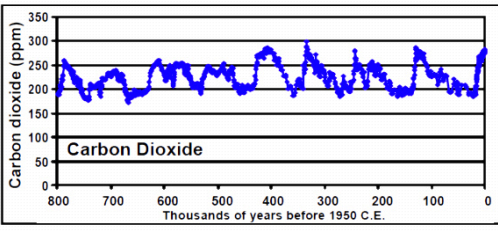
Current CO₂ ca. 390 ppm



Source: Jean-Marc Barnola et al.

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390 ppm exceeds any value for the last 800,000 years



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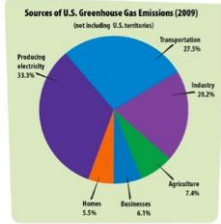
Natural Sources and Sinks of CO₂

- CO₂ is produced by all living things that utilize O₂ in their metabolisms
- CO₂ is released in volcanic events
- CO₂ is converted to plant materials by photosynthesis
- Soils absorb CO₂
- CO₂ is absorbed into the oceans –
 - CO₂ + H₂O → H₂CO₃ (carbonic acid)

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Anthropogenic Sources of CO₂

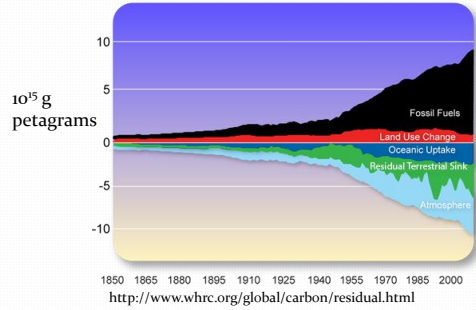
- Fossil fuel (coal, oil, gas) burning
- Iron and steel
- Cement manufacture



Source: EIA's Inventory of U.S. Greenhouse Gas Emissions and Sinks (2012).

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Global CO₂ Balance



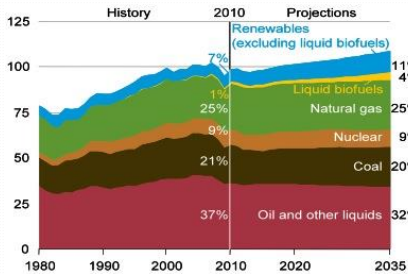
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How much CO₂ has been added since 1850?

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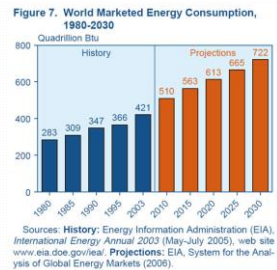
ca. 16 %

US Fossil Fuel Use Projections



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World Energy Use Projections

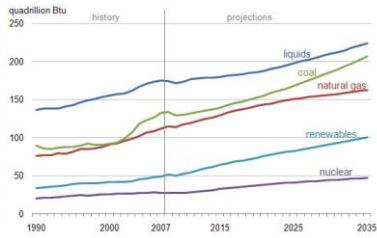


Sources: History: Energy Information Administration (EIA), International Energy Annual 2003 (May-July 2005), web site www.eia.doe.gov/iea/. Projections: EIA, System for the Analysis of Global Energy Markets (2006).

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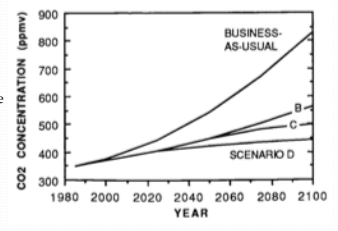
World Energy Use by Fuel

Figure 2. World marketed energy use by fuel type

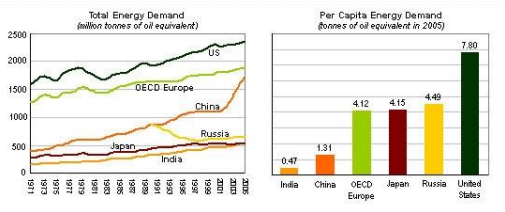


Which Scenario Are We Following?

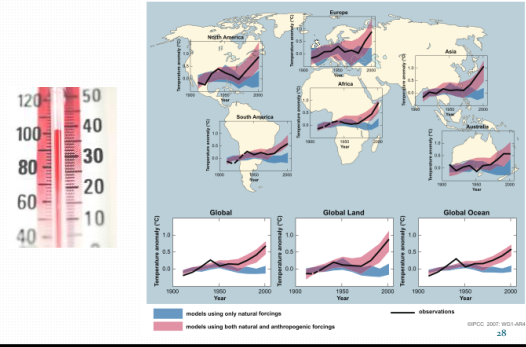
- In Scenario B
- The energy supply mix shifts towards lower carbon fuels, notably natural gas
- Large efficiency increases are achieved
- Carbon dioxide controls are stringent
- Deforestation is reversed
- The Montreal Protocol implemented with full participation



Per Capita Demand

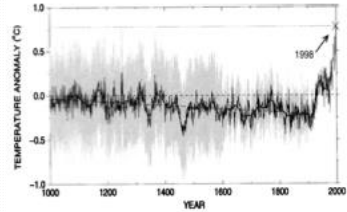


Global Temperature Change



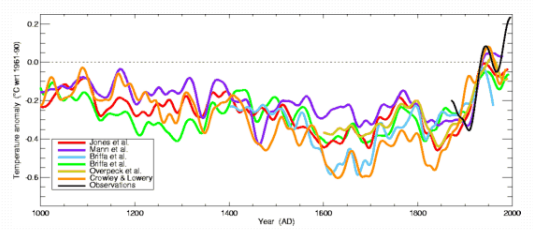
Millennial Temperature Record

- The original "hockey stick"



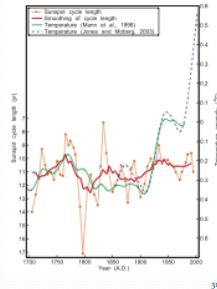
Mann, Geophysical Res. Lett. 26, 1999, 759

Millennial Temperature Record



What about the Sun?

- The sun is certainly a contributor to the Earth's temperature but solar variation is unable to account for the current rise



Milankovitch Cycle Variations

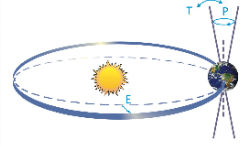
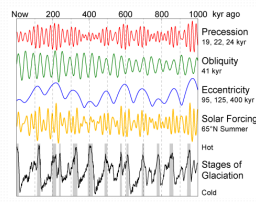
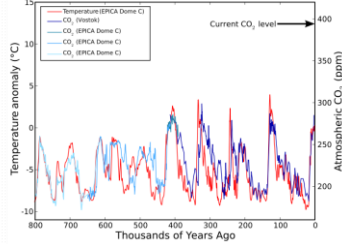


FIG 6.1, Figure 1. Schematic of the Earth's orbital changes (Milankovitch cycles) that drive the ice-age cycles. "P" denotes changes in the tilt or obliquity of the Earth's axis, "O" denotes changes in the eccentricity of the orbit due to variations in the major axis of the ellipse, and "E" denotes precession, that is, changes in the direction of the axis tilt at a given point of the orbit. Source: Rahmstorf and Schweitzer (2006).

Temperature and CO₂

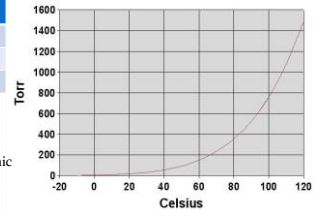
Temperature and CO₂ Records



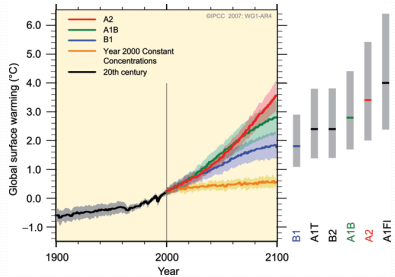
What about Water?

Temp (oC)	Pressure (MM Hg)
30	31.5
32	36
35	42

Water vapor is dependent upon atmospheric and oceanic temperatures
As T ↑; water vapor ↑
This is a positive feedback



Temperature Projections



Climate Change and the US

- <http://downloads.globalchange.gov/usimpacts/pdfs/climate-impacts-report.pdf>



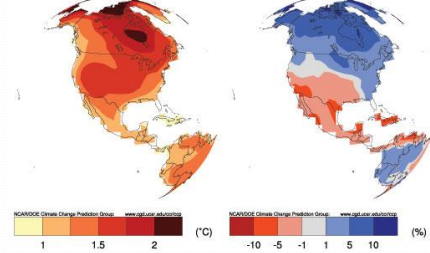
What does it mean for me?

- Total yearly precipitation in the NW will remain about constant but summer will be drier and winter wetter.
- Warmer temperatures will mean lower snowpack in the Cascades with somewhat less of an impact in the Northern Rockies.
- Models predict a temp rise of 0.1 – 0.6 °C per decade or about 3 times the 20th century rate.

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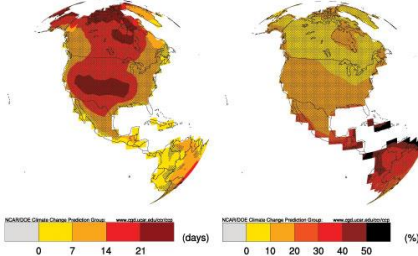
Projected Changes

IPCC A1B Sfc Air Temperature 2030-1990 IPCC A1B Precipitation 2030-1990



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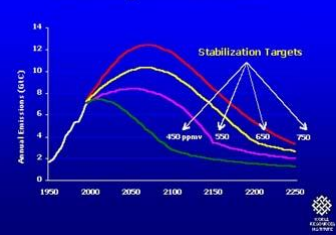
IPCC A1B Heat Waves 2030-1990 IPCC A1B Warm Nights 2030-1990



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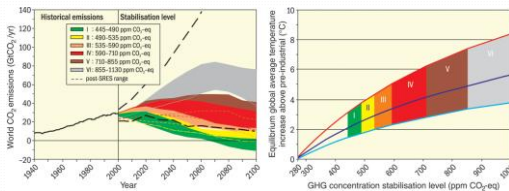
Stabilization Scenarios

Greenhouse gas emission scenarios



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What this means to temperature



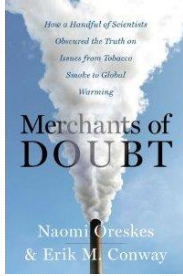
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Biological Impact

- It's the Rate, Stupid!
- Environmental change typically takes place over periods of thousands of years giving plants and animals time to either move habitats or to adapt to the new conditions.
- Compressing those temperature changes into the space of 150 years will have a dramatic impact on species survival.

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Why is there so much confusion?



- Heartland Institute document release shows efforts at deliberate misinformation of the public.
<http://www.desmogblog.com/heartland-institute-exposed-internal-documents-unmask-heart-climate-denial-machine>

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Where to go to learn more

- <http://climate.nasa.gov/>
- <http://epa.gov/climatechange/index.html>
- <http://www.noaa.gov/climate.html>
- <http://dels.nas.edu/Report/America-Climate-Choices/12781>
- http://www.usda.gov/oce/climate_change/
- <http://www.ipcc.ch/>
- <http://www.aip.org/history/climate/co2.htm>
- <http://www.realclimate.org/>
- <http://www.skepticalscience.com>

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National Academy of Sciences



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The Bottom Line

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