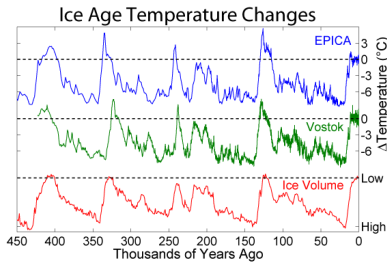




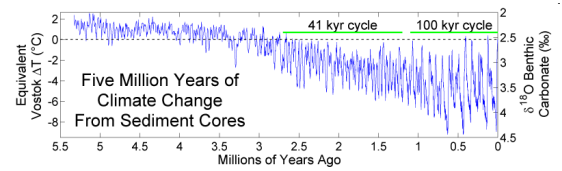
Climate has a cyclicity with a 100,000 year period.

- Ice cores from Antarctica and Greenland
- Verified by ocean sediment cores
- Controlled by subtle variations in the Earth's orbit (Milankovitch cycles)



<http://globalwarmingart.com/>

The ice age cycles started up about 2.5 million years ago. About 1 million years ago they changed periodicity from 41,000 years to 100,000.

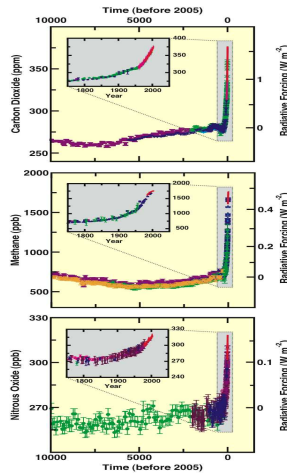


<http://globalwarmingart.com/>

Human and Natural Drivers of Climate Change

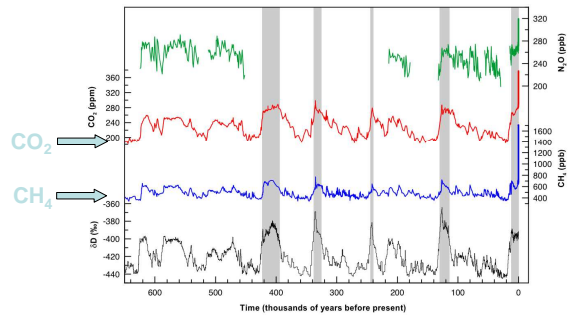
CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O Concentrations  
- far exceed pre-industrial values  
- increased markedly since 1750 due to human activities

Relatively little variation before the industrial era



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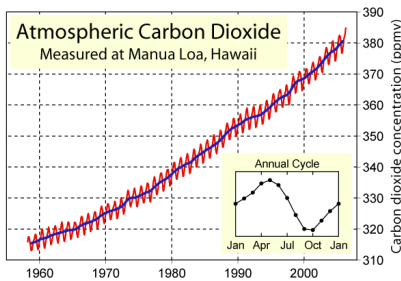
Glacial-Interglacial Ice Core Data



The atmospheric concentration of CO<sub>2</sub> and CH<sub>4</sub> in 2005 exceeds by far the natural range of the last 650,000 years

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CO<sub>2</sub> measured at Mauna Loa, Hawaii has been increasing rapidly since the Industrial Revolution.

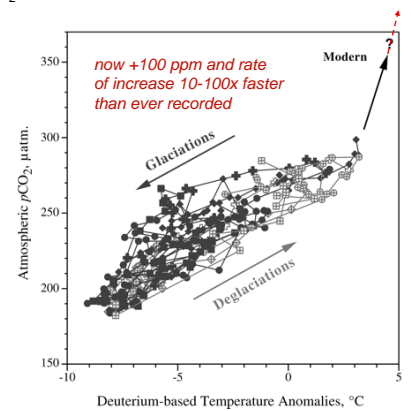


<http://globalwarmingart.com/>

Link between CO<sub>2</sub> and climate

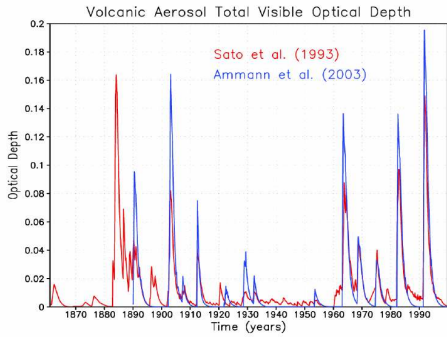
Although high-resolution analysis of ice cores suggests that there are periods in Earth's history when temperature can change relatively sharply without a discernible change in CO<sub>2</sub>, the converse does not appear to be true

Figure: A correlation between atmospheric partial pressure of CO<sub>2</sub> (pCO<sub>2</sub>) and isotopic (D) temperature anomalies as recorded in the Vostok ice core. The figure shows that climate variations in the past 420,000 years operated within a relatively constrained domain.



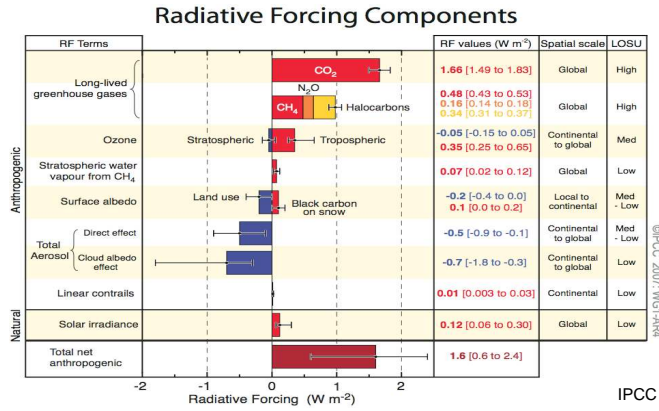
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## Volcanic aerosols



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## Present-day global-average radiative forcing estimates and ranges

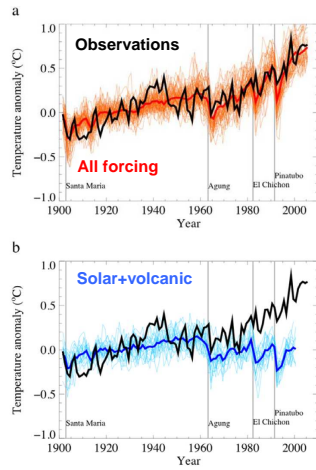


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## Attribution

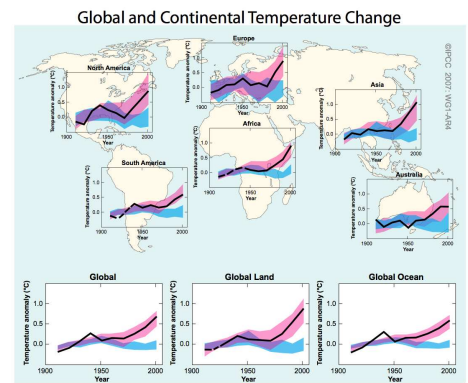
- Are observed changes consistent with
- expected responses to forcings
  - inconsistent with alternative explanations



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## Understanding and Attributing Climate Change

Continental warming *likely* shows a significant anthropogenic contribution over the past 50 years



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## The IPCC released its 1st summary report Feb 2, 2007. <http://www.ipcc.ch/SPM2feb07.pdf>

Phenomenon* and direction of trend	Likelihood that trend occurred in late 20th century (typically post 1950)	Likelihood of a human contribution to observed trend <sup>b</sup>	Likelihood of future trends based on projections for 21st century using SRES scenarios
Warmer and fewer cold days and nights over most land areas	Very likely <sup>d</sup>	Likely <sup>a</sup>	Virtually certain <sup>a</sup>
Warmer and more frequent hot days and nights over most land areas	Very likely <sup>d</sup>	Likely (nights) <sup>a</sup>	Virtually certain <sup>a</sup>
Warm spells / heat waves. Frequency increases over most land areas	Likely	More likely than not <sup>f</sup>	
Heavy precipitation events. Frequency (or proportion of total rainfall from heavy falls) increases over most areas	Likely	More likely than not <sup>f</sup>	V. Likely
Area affected by droughts increases	Likely in many regions since 1970s	More likely than not	Likely
Intense tropical cyclone activity increases	Likely in some regions since 1970	More likely than not <sup>f</sup>	Likely
Increased incidence of extreme high sea level (excludes tsunamis) <sup>g</sup>	Likely	More likely than not <sup>f,h</sup>	Likely

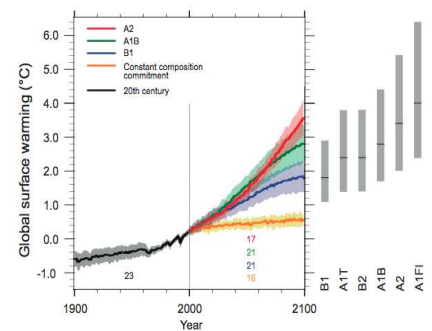
Definitions: Virtually certain means greater than 99% confidence, very likely means 90-99%, likely means 66-90%, more likely than not is 50-66% confidence.

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## Projections of Future Changes in Climate

Best estimate for low scenario (B1) is 1.8°C (*likely* range is 1.1°C to 2.9°C), and for high scenario (A1FI) is 4.0°C (*likely* range is 2.4°C to 6.4°C).

Broadly consistent with span quoted for SRES in TAR, but not directly comparable



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## Annual Mean Surface Air Temperature Change, 1971–1990 to 2041–2060

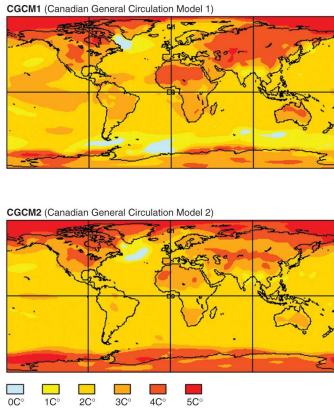


Figure 7.29

## Antarctic Ice

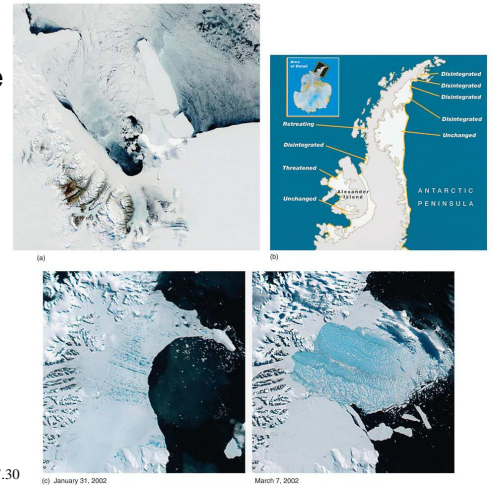
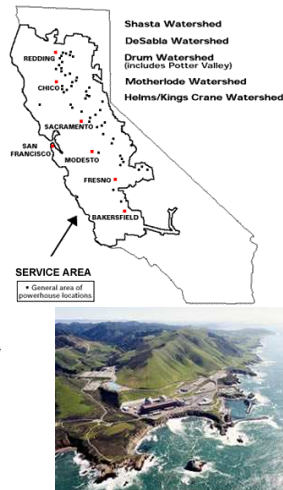


Figure 7.30

## We have the power

From PG&E.com. Upper right: hydroelectric plants, lower right: Diablo Canyon nuclear reactor



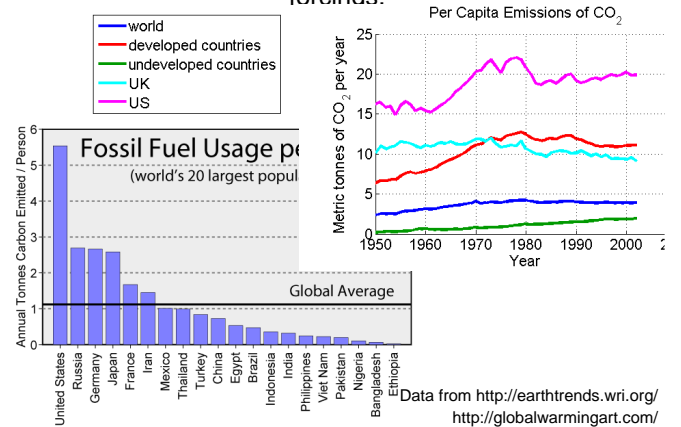
**PG&E's 2005 Retail Electricity Sales by Fuel Type**

- Natural Gas - 42%
- Nuclear - 24%
- Large Hydroelectric - 20%
- Total California Renewable - 12%
- Coal - 1%
- Other - 1%

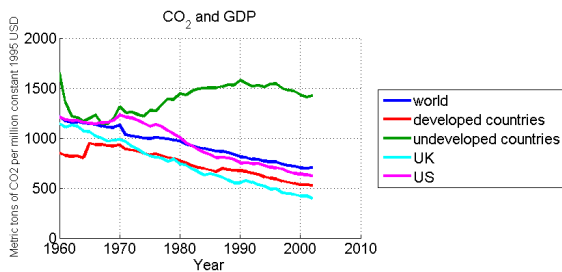
**2005 California-Eligible Renewable Representation\***

- Biomass - 38%
- California-Eligible Hydroelectric - 33%
- Geothermal - 19%
- Wind - 10%
- Solar - less than 1%

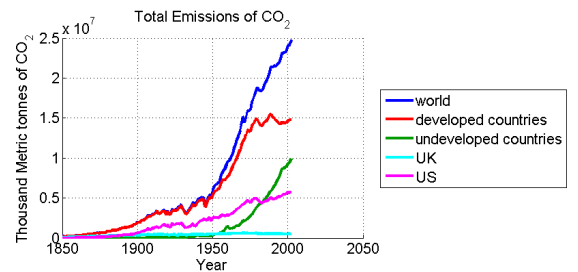
## CO<sub>2</sub> emissions are the largest of the anthropogenic forcings.



Data from <http://earthtrends.wri.org/>  
<http://globalwarmingart.com/>



Data from <http://earthtrends.wri.org/>



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