

ES10 Greenhouse Warming  
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1. Observations:
  - a. Climate has been warming in the past 200 years;
  - b. Atmospheric CO<sub>2</sub> and other greenhouse gases have been increasing since the preindustrial revolution 200 years ago;
  - c. atmospheric CO<sub>2</sub> increase is about half of emissions from fossil fuel combustion – land and oceans have absorbed the remainder.  
 $\Delta \text{CO}_2 = \text{sources} - \text{sinks}$ .
2. Theory: CO<sub>2</sub> is a greenhouse gas
3. Hypothesis: Warming is due to increasing CO<sub>2</sub> concentration
4. Counter-hypothesis: the warming can be part of natural oscillations in climate
5. Policy: United Nations Climate Convention 1992; Kyoto Protocol 1997: reduce CO<sub>2</sub> emissions 2008-2012 from 1990 levels. US: 7% reduction. Ambiguity – which emission? Gross emission (like fossil fuel burning, right hand side of equation) or net emission (left hand side of equation, like after the land and ocean uptake)?
6. Bush: “Kyoto Protocol is fatally flawed”.
7. May 2001: National Academy Report in response to questions from the White House: “Climate Change Science: An Analysis of Some Key Questions” – warming “observed over the last several decades are *likely mostly* due to human activities, but we cannot rule out that some significant part of these changes are also a reflection of natural variability. Human-induced warming and associated sea level rises are expected to continue through the 21<sup>st</sup> century.”
8. June 2001: Bush Rose Garden Speech: greenhouse warming is a serious problem.
9. Scientific challenge: what are the mechanisms that ecosystems and oceans absorb CO<sub>2</sub> from the atmosphere? How will these mechanisms change with climate?
10. Policy challenge: how to factor the environment into decisions about economy, unemployment, trade, ...

# Global Mean Surface Air Temperature

