Introduction to Global Climate Change

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Background

- Mean surface temperatures are rising.
- Atmospheric CO$_2$ and CH$_4$ levels are rising.
- There are natural fluctuations in solar flux.
  - Sunspots
  - Variations in Earth's orbit.
- Ocean currents redistribute thermal energy.
- Global energy budget and radiative forcing by gases and aerosols.
Global Annual Mean Surface Air Temperature Change


Atmospheric CO₂

Atmospheric CO₂ at Mauna Loa Observatory

Atmospheric Methane


Sunspots and Solar Variability

The Maunder Minimum

Very few sunspots were observed 1645 – 1715. This corresponded to a period of global cooling called the “Little Ice Age”. Source: The Sunspot Cycle, http://solarscience.msfc.nasa.gov/SunspotCycle.shtml.

Orbital Variations: Milankovitch Cycles

Period of 23,000 years

Period of 100,000 years


Orbital Variations: Milankovitch Cycles

Period of 41,000 years

**Thermohaline Circulation System**


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**2013 Global Energy Budget**

Conclusions

- The global climate system is complex.
- Ocean currents appear to have several steady states. Transitions between the states can occur over just a few years.
- Atmospheric and oceans models must be coupled.
- We are going to focus on simple global temperature models to better understand the effects of changes in radiative forcing on mean surface temperature.