The Controls on Climate

- How much energy reaches Earth?
- Energy output of the Sun
- Relationships between Earth and Sun

How is the heat on Earth redistributed?
- Movement of energy from the equator to the poles
- Loss of energy from Earth

The Earth’s surface changes over time...

Global Climate Change: The Natural Controlling Factors
CC 3.32, Lectures 9 and 10

The Earth’s surface changes over time...

- How much land is at the poles?
- Land at the poles allows glaciers to form
- Glaciers reflect light and so reduce the amount of solar energy heating Earth
How well can water circulate around the globe?

- Ocean currents redistribute heat from the equator to the poles.
- If circulation is poor, then temperature will be more extreme.

The Earth’s orbit changes over time...

...which affects how much solar energy reaches Earth.

Earth surface variations may explain million-year-scale climate fluctuations.

Milankovitch Cycles

- Milutin Milankovitch was a Serbian mathematician who specialized in astronomy and geophysics.
- Milankovitch dedicated his career to developing a mathematical theory of climate based on the seasonal and latitudinal variations of solar radiation received by the Earth.
The shape of Earth’s orbit varies from circular to slightly elliptical over 100,000 years. Changes the distance of Earth to the Sun.

Changes the distance of Earth to the Sun.

The tilt of Earth’s axis varies from a minimum of 21.5 degrees to a maximum of 24.5 degrees over 41,000 years. The greater the tilt angle, the more extreme is the difference between seasons.

As it spins, Earth wobbles with a period of 23,000 years. Can result in greater seasonal extremes.

Eccentricity, precession, and tilt variations combine to affect total solar radiation that reaches Earth.
Orbital variations may explain millenium-scale climate fluctuations.

Energy output of the Sun changes over time...

- Photo-mosaic of the Sun
- X-ray output
- Every 120 days over 4 years

Both Earth and Sun have magnetic fields.

- The polarity of Earth’s magnetic field reverses on the order of hundreds of thousands of years.
The polarity of the Sun’s magnetic field reverses every 11 years.

Complex Magnetic Field on the Sun:
- The surface of the sun spins faster at the equator than at the poles.
- Magnetic lines of force are twisted and distorted.

Sunspots:
- As the magnetic lines become more distorted they emerge from the surface.
- These emergence points are relatively dark, and are called sunspots.
- The Sun is brightest when there are more sunspots.

Number of sunspots change over time.
Maunder Minimum

Solar output may explain decade/century climate fluctuations