ESS 7
Lecture 24
June 2, 2010
Other “Space Weather” Phenomena
Atmospheric Weather and Space Weather

• The amount of energy hitting the Earth from the Sun drives weather and climate.
• Variations in sunlight come the rotation of the Earth and annual variation in hemispheric tilt away and toward the Sun.
• The Earth’s climate changes over thousands and millions of years.
• The Earth’s climate cycle is between periods of global cooling and Ice Ages to warmer periods.
• The last Ice Age was 2-3 million years ago- Quaternary.
• The present era (Holocene) is characterized by mild temperatures and with them agriculture and civilization.
Changes in Climate

- Changes related to the changes in the Earth’s orbit (eccentricity and inclination) – 10’s to 100’s of thousands of years.

- Plate tectonics – creating and destroying mountains, oceans etc.

- Life – photosynthesis and the release of oxygen.

- Global warming – rapid increase over short period since Industrial Revolution.
During the Maunder minimum of the sunspot cycle (<1700) no sunspots and no aurora were reported. This period was also called the “Little Ice Age”
Solar Effects on Weather

- Solar luminosity changes very little (0.1%) between solar minimum and maximum.
- Global models indicate that such small changes can’t effect weather appreciably.
- Solar UV and X-rays can change by 6-8% (peak at solar maximum).
- High-energy EM radiation absorbed in the upper atmosphere influences the chemical reaction.
- The thermosphere’s temperature increases by a factor of two (1000K to 2000K) over the solar cycle – coupling unknown.
Space Weather and Clouds

- Clouds effect climate because they block sunlight and have greenhouse properties.
- Clouds are formed by water vapor condensing on small particles called aerosols.
- From below aerosols come from dust, sea spray and volcanoes.
- Our cars and factor smokestacks (after some chemistry) form aerosols.
- Cosmic rays form aerosols.
Cosmic Rays can Interact with the Atmosphere in a Number of ways to form Aerosols
Solar Activity Regulates Cosmic Ray Fluxes

- The flux of cosmic rays that hit the Earth depends on the IMF. Cosmic rays are minimum at solar maximum.
- A decrease in the amount of cosmic rays reaching the Earth leads to a decrease in cloud cover and more sunlight reaching the surface.
- During the Maunder Minimum solar activity was low and more cosmic rays could hit the atmosphere.
- This would increase the amount of cloud cover and decrease the amount of sunlight hitting the surface.
- The warm period called the Medieval Climate Optimum was a period of intense solar activity.
Medival Climatic Optimum

• The warm period between 900-1250 was a period of warm temperature in the North Atlantic.

• Crops were being grown here – they named this fertile land Greenland
Asteroid and Comet Impacts

- Early in Earth’s history a large asteroid (Mars size) hit the Earth forming the Moon.
- Earth has been hit by comets and asteroids continuously with the peak about 4.5 to 3.8 billion years ago (Hadean –hell)
- Most asteroids are now in the asteroid belt but a few still cross Earth’s orbit.
- 65 million years ago an asteroid impact killed the dinosaurs.
- On a given day 100 tons of extraterrestrial dust hits the Earth.
- Those with 1 and 2km size can cause global effects.
Meteor Crater in Arizona

- 1200m wide, 170m depth was made by 50m meteor.
- One of these hits the Earth every few thousand years.
Tunguska

- Occurred in 1908 in Siberia
- Thought to be an air burst of a meteoroid or comet fragment above the Earth’s surface.

Photo from Kulik’s 1927 expedition
In 2000 Comet Shoemaker-Levy 9 Crashed into Jupiter
Frequency of Collisions Versus Energy
Impact Consequences

• Sea impacts (the most common) can place large amounts of water into the stratosphere and create giant tsunamis.

• Over land dust would be ejected into the stratosphere and there would be widespread fires. The dust could cause global cooling.

• NASA has a program to identify all comets and asteroids that cross Earth’s orbit and have a probability of hitting the Earth.
Nearby Supernova

• There are two types of supernovas –
  – Type I occurs when a white dwarf in a binary system accretes material from its companion and the built up material heats and leads to an explosion.
  – Type II occurs when a massive star exhausts its supply of fuel, thermonuclear reactions end and it collapses under its own gravitational force. This leads to a massive explosion.

• Energy from a supernova is in the form of gamma rays and energetic particles.

• If a supernova went off with 50-100 LY of the Earth there would be a significant energy input into our atmosphere.

• The photochemistry of the atmosphere would change and the ozone layer would be destroyed.
Supernova Effects at Earth

• The UV radiation could be as large as 10,000 times normal. This could affect the biosphere.

• There are maybe 14,000 stars within 100LY. In our galaxy a star goes supernova about once a century although the last was in 1680.

• In 1987 a star went supernova in the Large Magellanic Cloud (one of our companion galaxies).

• Time between supernovae near the Earth is 100 million years.
Supernova
The Sun will Become a Red Giant

- In about 4 BY from now the sun will leave the main sequence and make life (if it is still around) miserable.