Outline for 11 October (Thursday)

- Questions about Comparative Planetology
  (20 minutes)
- The Living Earth (Chapter 9 of text)
  (55 minutes)

Why are craters circular …

- … if asteroids can strike the surface at angles?
- http://deepimpact.jpl.nasa.gov/science/cratering.html

Take 10 minutes

Review Questions For Topics Covered in Lecture and Reading

1. Do all the planets orbit the Sun in the same direction? Are all of the orbits circular?
2. What are the characteristics of a terrestrial planet?
3. What are the characteristics of a Jovian planet?
4. In what ways does Pluto not fit the usual classification of either terrestrial or Jovian planets?
5. What is meant by the average density of a planet? What does the average density of a planet tell us?
6. In what ways are the largest satellites similar to the terrestrial planets? In what ways are they different?
7. The absorption lines in the spectrum of a planet or satellite do not necessarily indicate the composition of the planet or satellite's atmosphere. Why not.
8. Why are hydrogen and helium abundant in the atmospheres of the Jovian planets but present in only small amounts in the Earth's atmosphere?
9. What is an asteroid? What is a comet? In what ways are these minor members of the solar system like or unlike the planets?

Review Questions For Topics Covered in Lecture and Reading

10. What are the asteroid belt and the Kuiper belt? Where are they located? How do the objects found in these two regions compare?
11. What is the one piece of evidence that impact craters are actually caused by impacts?
12. What is the relationship between the extent to which a planet or satellite is cratered and the amount of geologic activity on that planet or satellite?
13. How do we know that the surface of Venus is older than the Earth's surface but younger than the Moon's surface?
14. Why do smaller worlds retain less of their internal heat?
15. How does the size of a terrestrial planet influence the amount of catering on the planets surface?
16. How is the magnetic field of a planet different from that of a bar magnet? Why is a large planet more likely to have a magnetic field than a small planet?

Review Questions For Topics Covered in Lecture and Reading

1. Do all the planets orbit the Sun in the same direction? Yes, CCW. Are all of the orbits circular? No, but almost (elliptical).
2. What are the characteristics of a terrestrial planet? Small, dense, rocky, warmer, fewer satellites, no rings.
3. What are the characteristics of a Jovian planet? Large, not dense, gas and liquid, colder, many satellites and rings.
4. In what ways does Pluto not fit the usual classification of either terrestrial or Jovian planets? Distance is similar to Jovian planets. Composition similar to Earth-like planets.
5. What is meant by the average density of a planet? What does the average density of a planet tell us? Mass divided by volume. Density can help tell us about what the planet is made from.
6. In what ways are the largest satellites similar to the terrestrial planets? In what ways are they different? Similar size, solid surface, but lower density.
7. The absorption lines in the spectrum of a planet or satellite do not necessarily indicate the composition of the planet or satellite's atmosphere. Why not. Contains pieces of the solar spectrum and effects from Earth's atmosphere.
8. Why are hydrogen and helium abundant in the atmospheres of the Jovian planets but present in only small amounts in the Earth's atmosphere? Temperature and gravity. Hydrogen and Helium can escape from Earth, but from Jupiter it cannot because Earth has higher temperature and lower gravitational pull. Jupiter has lower temperature and higher gravitational pull.
9. What is an asteroid? What is a comet? In what ways are these minor members of the solar system like or unlike the planets? Asteroid is rocky, comet is icy. Both orbit Sun, as do planets. Smaller and more of them than planets.

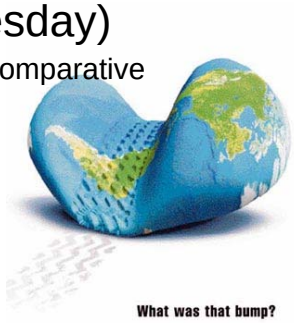
Review Questions For Topics Covered in Lecture and Reading

10. What are the asteroid belt and the Kuiper belt? Where are they located? How do the objects found in these two regions compare? Asteroid belt between Mars and Jupiter. Kuiper belt is near orbit of Neptune and contains comets.
11. What is the one piece of evidence that impact craters are actually caused by impacts? Meteorite compounds at location of crater. Circular craters.
12. What is the relationship between the extent to which a planet or satellite is cratered and the amount of geologic activity on that planet or satellite? Geologic activity fills in craters.
13. How do we know that the surface of Venus is older than the Earth's surface but younger than the Moon's surface? Venus has small craters. Bigger ones have been erased by geologic activity. Smaller, older worlds have less geologic activity.
14. Why do smaller worlds retain less of their internal heat? Surface area to volume ratio is higher. More surface area means more radiation.
15. How does the size of a terrestrial planet influence the amount of catering on the planets surface? Smaller and older means less geologic activity. Smaller radiates heat faster and so geologic activity continues for a shorter amount of time.
16. How is the magnetic field of a planet different from that of a bar magnet? Why is a large planet more likely to have a magnetic field than a small planet? Earth's field is made by bulk motion of fluid in core. Bar magnet's field

Outline for 11 October (Tuesday)

- Questions about Comparative Planetology
- The Living Earth

(Chapter 9 of text)



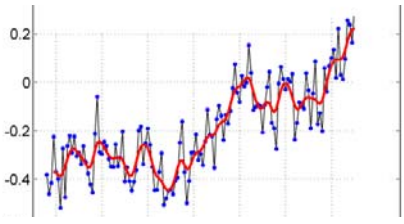
Key Words

- albedo
- atmospheric pressure
- aurora (*plural* aurorae)
- biosphere
- global warming
- greenhouse effect
- greenhouse gas
- solar wind
- plasma
- magnetosphere
- northern and southern lights
- outgassing
- ozone
- ozone layer
- Van Allen Radiation belts

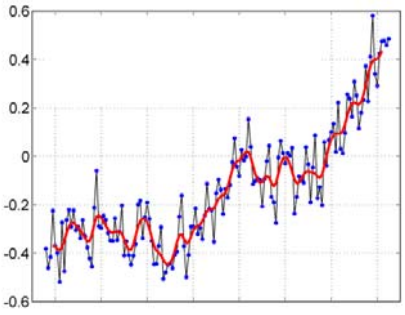
Guiding Questions

1. What is the greenhouse effect? How does it affect the average temperature of the Earth?
2. How does our planet's magnetic field protect life on Earth?
3. Why is Earth the only planet with an oxygen-rich atmosphere?
4. What are global warming and the "ozone hole"? Why should they concern us?

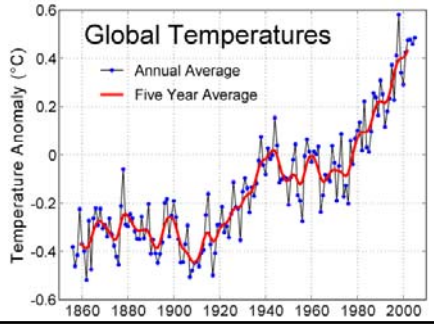
A highly debated plot What happens next?



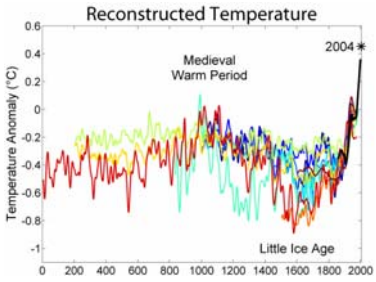
Now predict what will happen



Do we need to worry?



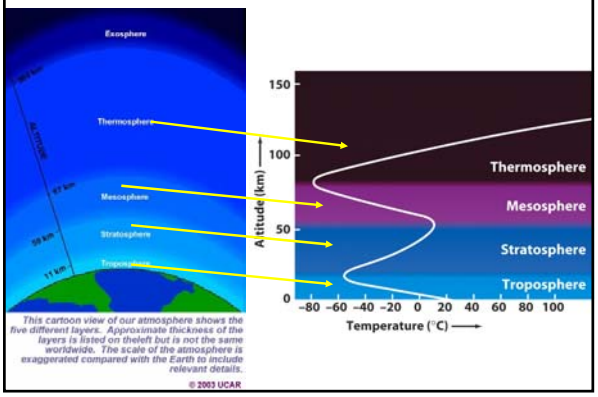
At what point should we worry?



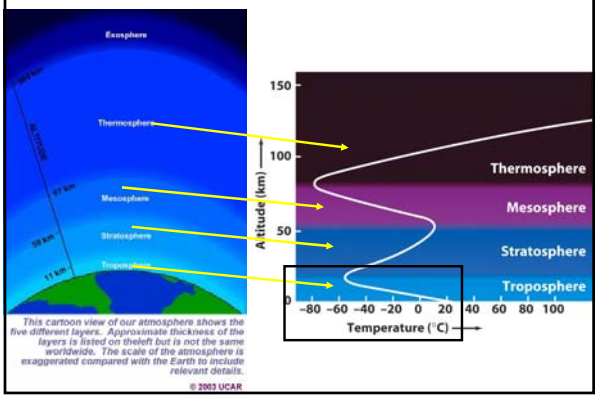
Protective Shields

- Atmosphere
- Magnetic field

Atmosphere



Atmosphere



Atmosphere

On Predictions

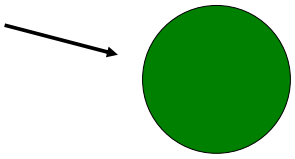
- If we know how atmospheric chemistry affects climate, why not engineer a solution?

Energy Balance

- Three modes of energy transfer
  - Convective – Bulk movement of mass
  - Conductive – jiggling material but no bulk movement of mass
  - Radiative – why you feel colder when it is colder outside in a room that is always 70 degrees

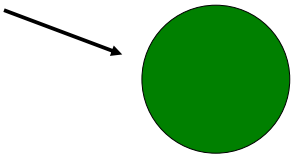
Energy Balance

- Simple model: Sun inputs energy to big ball, Earth. What happens to temperature?



Energy Balance

- Simple model: Sun inputs energy. What happens to temperature? Increases.

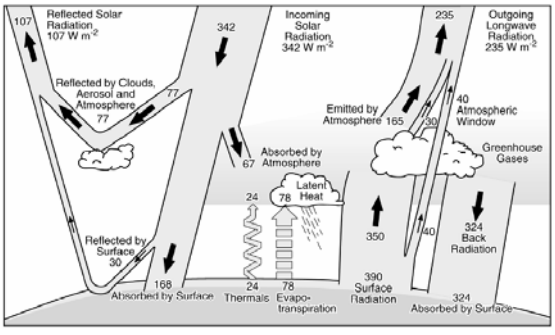


To keep temperature constant, we need a way of getting rid of it once we are at an acceptable temperature

Energy Balance

- Can't convect energy to space
- Can't conduct energy to space
- Need to radiate. And as something is heated up, it radiates more (remember blackbody curves?)

Energy Balance – the full picture

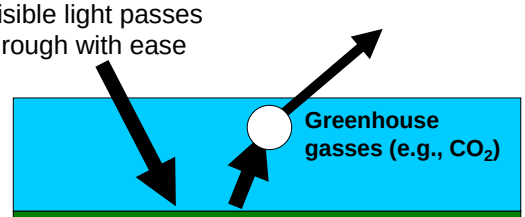


The Greenhouse effect

- Two usages:
  - An effect that occurs on a planet with an Earth-like atmosphere
  - An enhancement of the above effect due to human activity

The Greenhouse effect

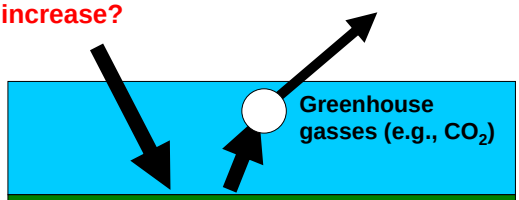
Visible light passes through with ease



Greenhouse gasses absorb energy that would have been otherwise sent back to space. Thus temperature will increase (global warming).

The Greenhouse effect

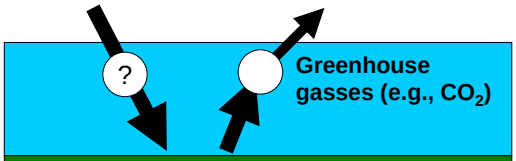
- **Why won't temperature continue to increase?**



Greenhouse gasses absorb energy that would have been otherwise sent back to space. Thus temperature will increase.

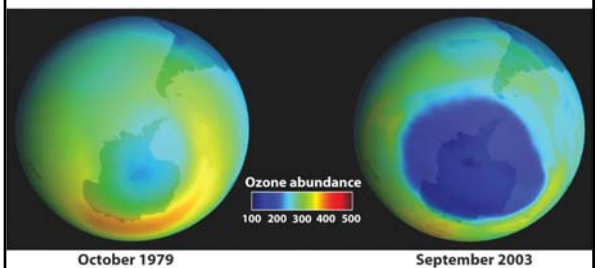
The Greenhouse effect

- **Why doesn't radiation get absorbed by greenhouse gasses on the way down?**

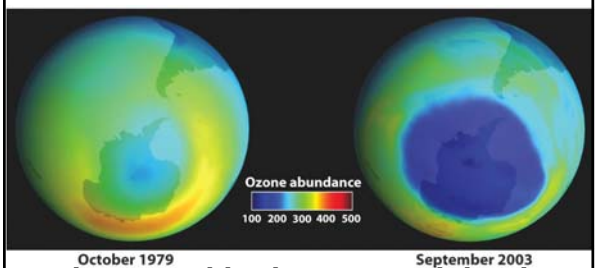


Greenhouse gasses absorb energy that would have been otherwise sent back to space. Thus temperature will increase.

How is Global Warming Related to the Ozone Hole?

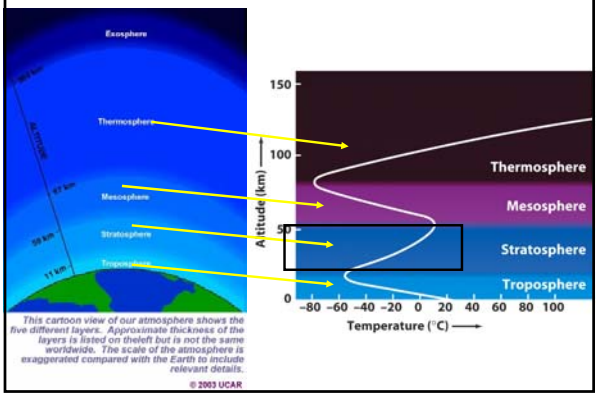


How is Global Warming Related to the Ozone Hole?



Both caused by human activity, but, you can have one without the other

Ozone in Earth's Atmosphere



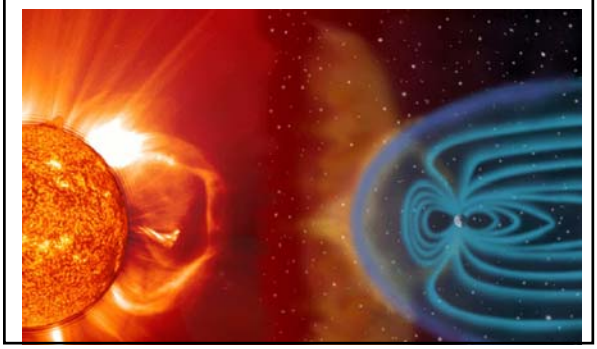
Group Questions

- Make an argument to justify the statement: "The temperature trend is due to chance."
- Make an argument to justify the statement: "The temperature trend is not due to chance".
- Name three pieces of information that would help justify/refute each of the statements.
  - Due to chance
    1.
    2.
    3.
  - Not due to chance
    1.
    2.
    3.

Protective Shields

- Atmosphere
- Magnetic field

The Solar Wind



The Solar Wind

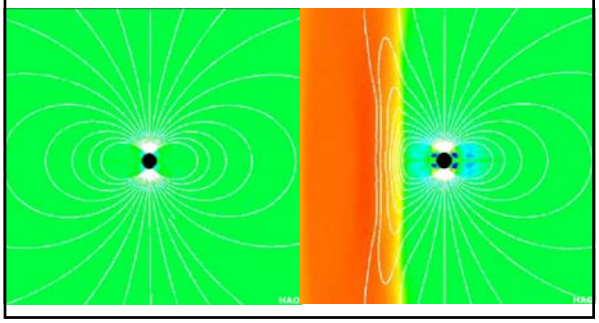
- A plasma is created by ionizing atoms
- Besides sending out photons, the sun is the source of the solar wind – a plasma traveling at ~ 400 km/s
- When the plasma gets near Earth, the charged particles are influenced by Earth's (internal) magnetic field.
- The path a particle takes is complicated – ions and electrons tend to rotate around magnetic field lines
  - www.spaceweathercenter.org/our_protective_shield/01/minigolf.html

The Magnetosphere

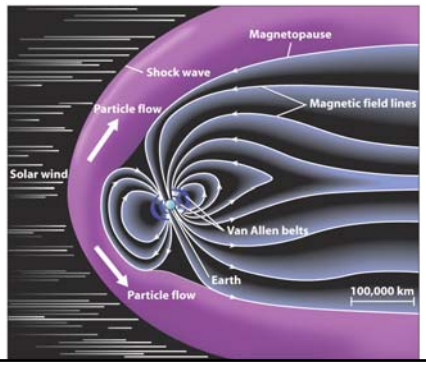
- The solar wind distorts Earth's dipole magnetic field to form the magnetosphere

Formation of the Magnetosphere

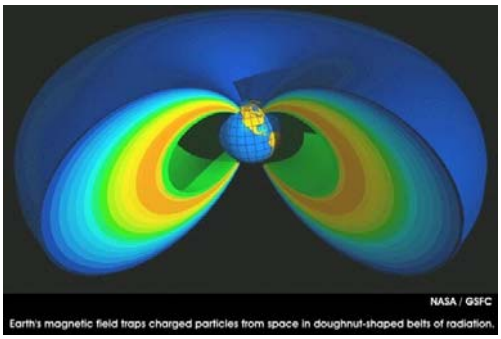
- http://meted.ucar.edu/hao/aurora/squish.htm



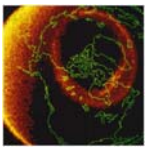
The Magnetosphere

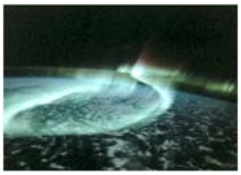


Van Allen Radiation Belts



Aurora





Some charged particles from the solar wind are trapped in two huge, doughnut-shaped rings called the Van Allen belts

Review Questions

- If the Earth did not have a magnetic field, do you think aurorae would be more common or less common than they are today?
- Carbon dioxide and ozone each make up only a fraction of a percent of our atmosphere. Why, then, should we be concerned about small increases or decreases in the atmospheric abundance of these gasses?
- What are three justifications for global warming?
- What are three rebuttals for global warming?

Review Questions

- What is the greenhouse effect?
- What is the solar wind?