

HOMEWORK – THE GREENHOUSE EFFECT AND CLIMATE CHANGE

Due Friday, December 10, before 5pm to your TA's mailbox

Suppose that three asteroids (call them A, B, and C) are in orbit around the Sun, about 1 AU away.

Remember that the thermal radiation from something that is thousands of degrees (like the Sun) is largely visible light, but the thermal radiation from something that is hundreds of degrees (like Earth) is long-wavelength infrared.

Recall also that in Lab 9 you found that the temperature of a planet is set by the balance of thermal radiation from the Sun (sunlight) falling on its surface, and thermal radiation from its surface escaping into space.

- Asteroid A is just a bare rock in orbit around the Sun.
- Asteroid B is surrounded by a bubble of glass. Glass allows visible light to pass through, but partially blocks infrared light.
- Asteroid C is surrounded instead by a cloud of dust. Dust partially blocks visible light, but allows infrared light to pass through.

1. Rank these rocks in order of temperature. Which one would be coolest? Which one would be warmest? Which one would be in the middle?

2. Volcanic eruptions generate large amounts of ash and sulfur dioxide droplets, which behave similarly to dust. After the large volcano at Krakatoa erupted in 1883, temperatures fell worldwide by half a degree.

Explain briefly why this happened, and how a volcanic eruption can have a temporary cooling effect on Earth's climate.

3. How does the "pre-industrial" temperature of Earth compare to the things Earth's climate has done in the last million years during the cycle of ice ages?
4. How has Earth's average temperature changed since the beginning of the Industrial Revolution (around 1850)?
5. What range of climate outcomes (average temperature changes) are possible during the next century, depending on the choices we make regarding CO₂ emissions?
6. Compare the speed of human-caused climate change during the Industrial Revolution to the speed of climate changes that have happened during the last Ice Age. For a dramatic (and funny) illustration of this, see <https://xkcd.com/1732/>.