

# Atmospheres of the Moon, Mercury, and Mars

11/13/2009

# Opening Discussion

- [http://www.youtube.com/watch?v=X7\\_XanCMAQY](http://www.youtube.com/watch?v=X7_XanCMAQY)
- Have you seen anything interesting in the news?
- What did we talk about last class?
- <http://www.newscientist.com/article/dn18135-will-pr>
- <http://dotearth.blogs.nytimes.com/2009/11/12/warm>
- Survey results : Yes – 27, No – 20, Unsure – 7, Other – 7
- Fallacy of “it was like that in the past and natural cycles.”

# Cool Image

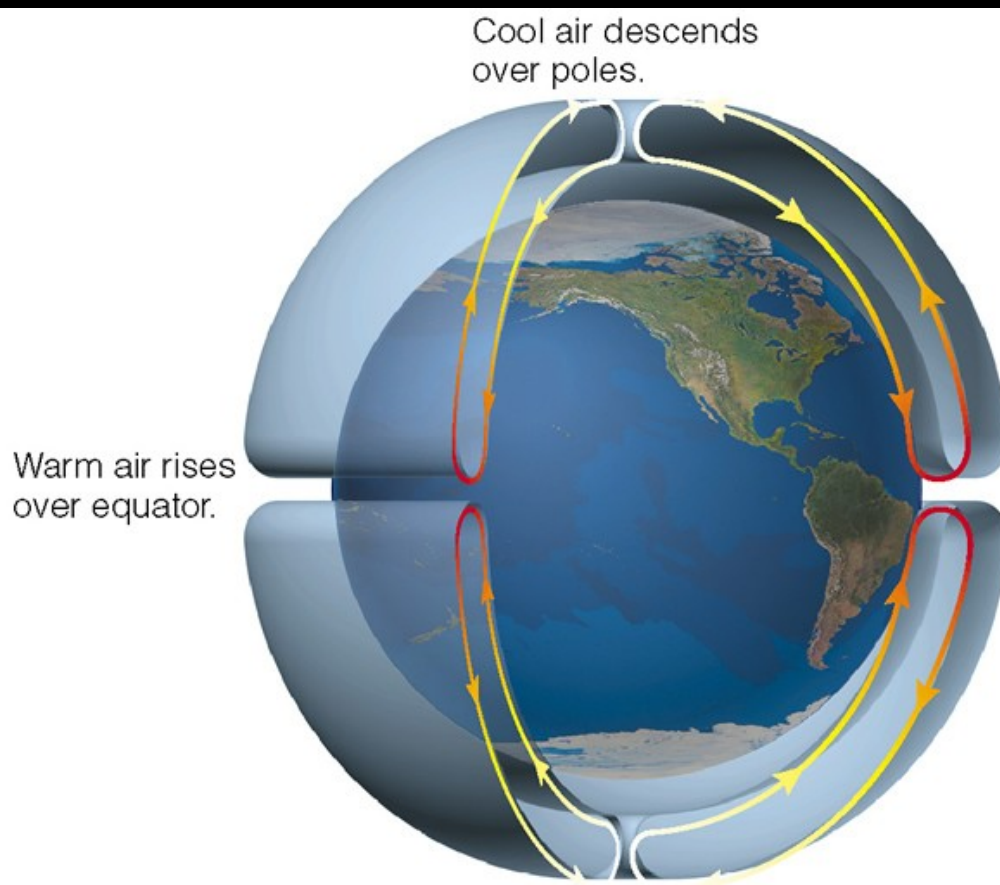
<http://www.nasa.gov/topics/universe/features/milky>

# Weather and Climate

- Weather is what you experience day-to-day in the atmosphere. It is local physically and temporally.
- Climate is a long term average of the weather.

# Circulation Cells

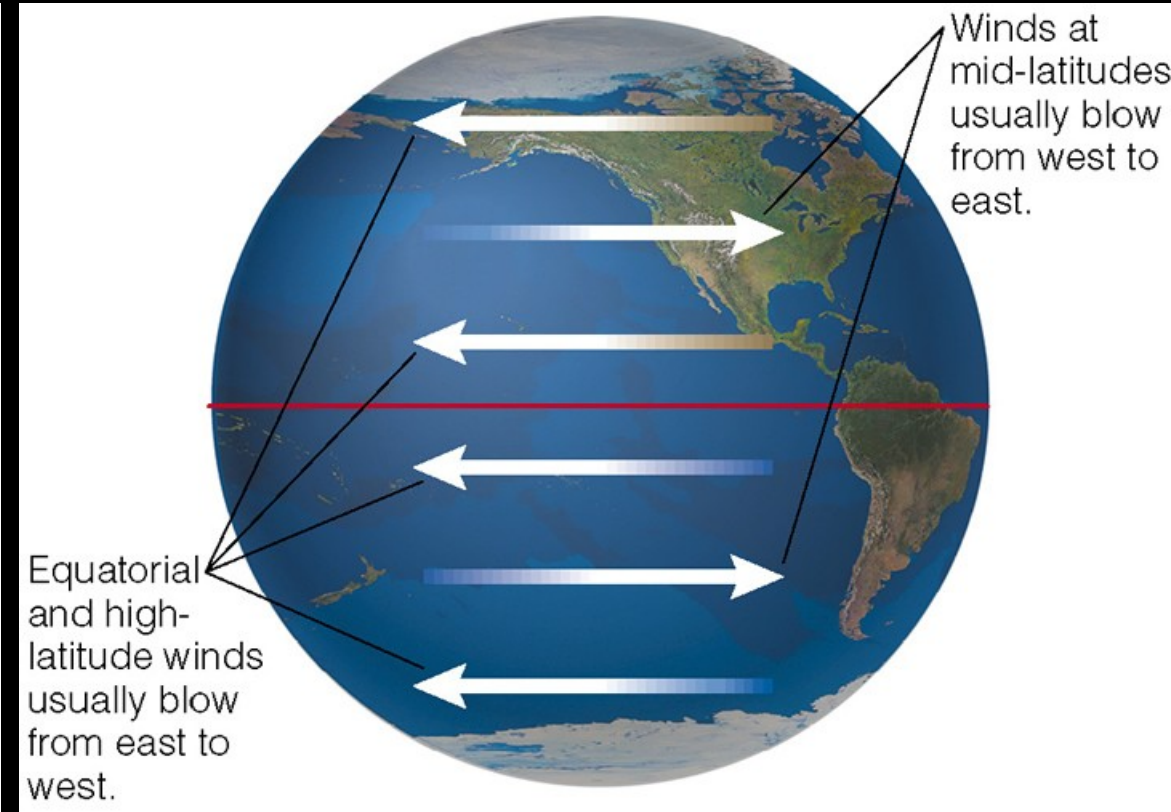
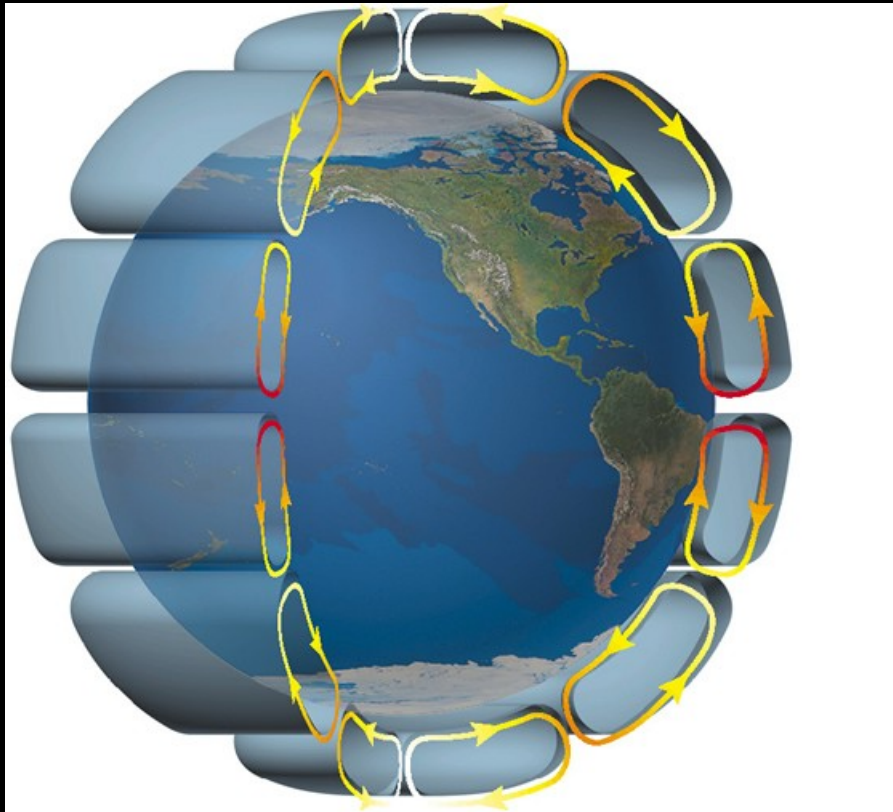
- Air will naturally move to transport heat around a planet. In a convective like manner hot air rises and cold air sinks, but you also have hotter equatorial air swapping with colder polar air.
- If nothing stopped it, the cells would look like this and the planet would be a fairly uniform temperature. That is true on Venus. The thin Martian atmosphere leaves the poles much colder than the equator.



# Coriolis Effect

- If a planet spins, then air moving from one latitude to another is also changing its radius of rotation. The air has to conserve angular momentum so it must slow down or speed up depending on whether it is moving toward or away from the equator.
- This is why large weather systems, where air moves in toward a low pressure region, spin in characteristic directions and those directions are the opposite for the north and south hemispheres.

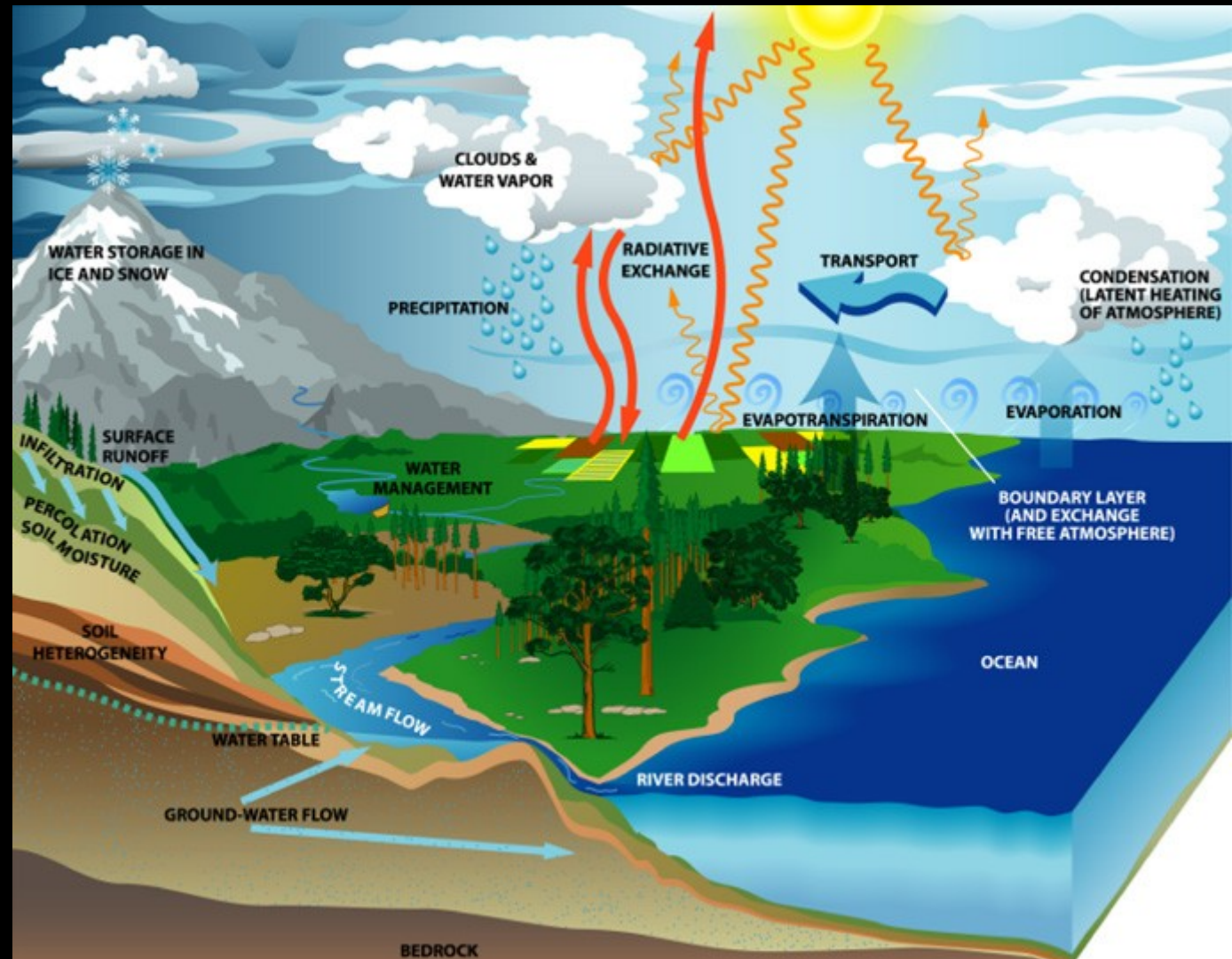
# Global Wind Patterns





# Clouds and Precipitation

- Can warm or cool.
- Form when minor components condense.
- Often form on convective currents.





# Climate Change

- There are four main factors that can lead to changes in climate.
  - Solar brightening – main sequence stars get brighter as they age. Our Sun is roughly 30% brighter now than it was 4 billion years ago.
  - Changes in axis tilt – biggest factor in natural, cyclic climate change.
  - Changes in planetary reflection – changes in fractional coverage for clouds, ice, aerosols, trees, pavement, etc.
  - Changes in greenhouse gas abundance – most important for long term change.

# Atmospheric Sources

Sources of gasses in the atmosphere.

## Volcanic outgassing

On Earth this releases water, carbon-dioxide, nitrogen, and sulfur-bearing gases.

## Evaporation/sublimation

From bodies of liquid or frozen surfaces.

## Surface ejection

By micrometeorites and high energy particles.

Only works on worlds without significant atmospheres.

## Impact deposition

# Atmospheric Loss

- Ways to lose atmospheric gas.
  - Chemical reactions with the surface.
  - Condensation
  - Impact cratering
  - Thermal escape
  - Sputtering
  - Hydrodynamic escape
- <http://www.cs.trinity.edu/~mlewis/PIAtm/>

# Thermal Escape

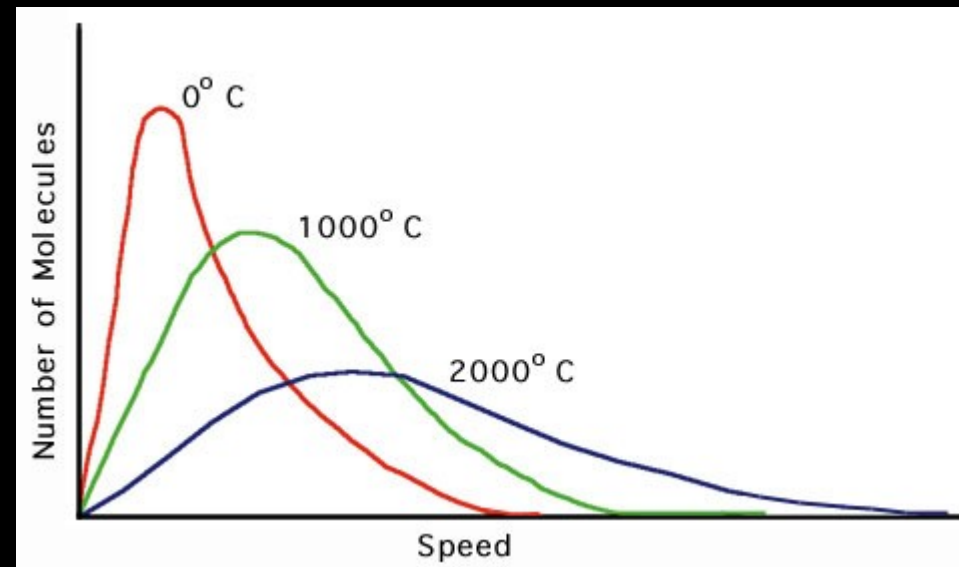
- Gas at a given temperature has particles moving at many different speeds.
- These speeds are distributed in a Maxwell-Boltzmann distribution.

$$v_{thermal} = \sqrt{\frac{2kT}{m}}$$

$T = \text{temperature [Kelvin]}$

$k = 1.38 \times 10^{-23} \text{ [J/Kelvin]}$

$m = \text{particleMass [kg]}$



# Mercury and the Moon

- Currently have nothing but an exosphere.
- Inevitably had outgassing early on.
  - Lost that due to thermal escape.
  - Mercury has hot day side.
  - Moon is cooler, but smaller.
- Might have ice in polar craters.
  - It seems this is likely on the Moon.
  - MESSENGER will give us more information for Mercury when it goes into orbit.

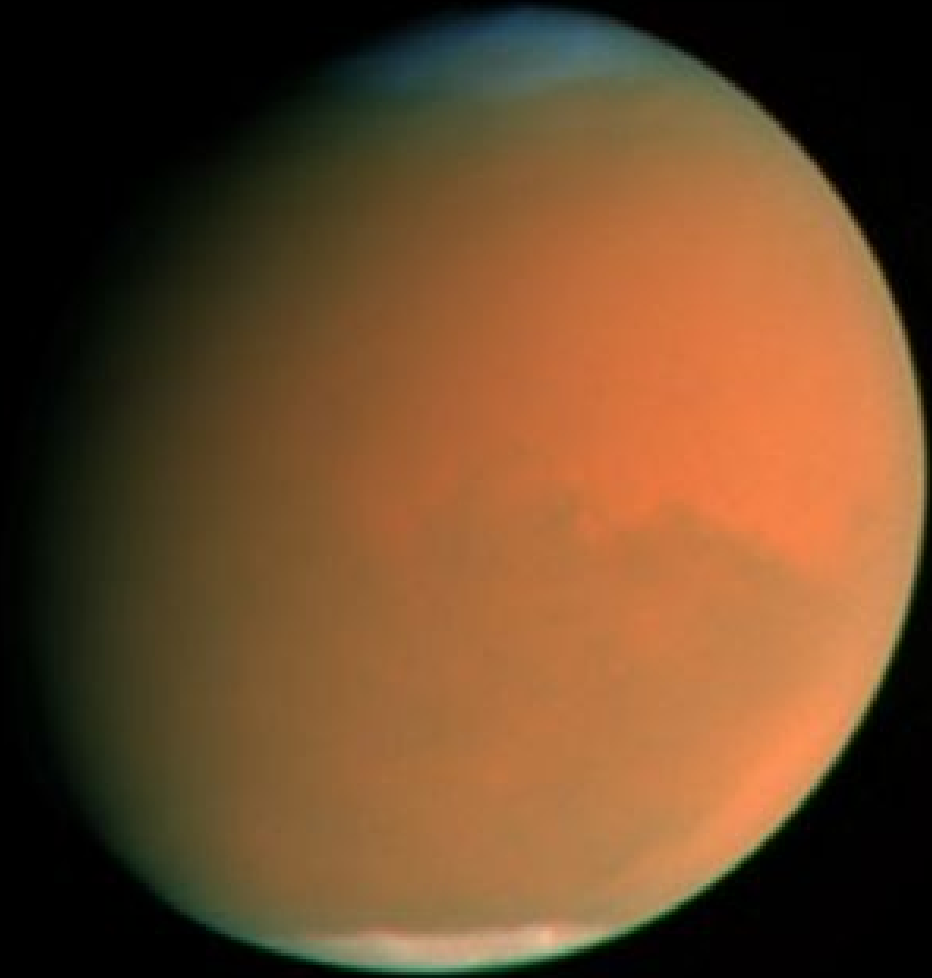
# Mars Today

- Mostly CO<sub>2</sub> atmosphere.
- Pressure less than 1% of Earth's.
- Average temperature of -50°C or -58°F.
- No oxygen implies no ozone layer.
- Has Earth-like seasons because of tilt of axis.
  - Last twice as long.
  - Orbit is more elliptical so southern summer and winters more extreme.
  - Air moves from summer pole to winter pole.

# Duststorms



June 26, 2001



September 4, 2001



# Dust Devils

- <http://www.youtube.com/watch?v=bKk6VkF9Tv4&M>



# Why Did Mars Change?

- It is likely that Mars had a much thicker atmosphere in the distant past that allowed liquid water.
- Current explanation for loss happens when the core cools and Mars loses its magnetic field. The solar wind can then strip away atmosphere.
- Small size makes this easier and also leads to thermal loss.
- Lack of ozone leads to photodissociation of water. Hydrogen is lost.

# Minute Essay

- If there were manned missions to Mars in your lifetime, would you want to go there?
- Astronomy labs (PHYS 1103). Don't just talk about it, see it! Counts for Using the Scientific Method.