Exam 1 Review

- Four types of questions:
  - 1. Multiple choice (40 points, 20 questions)
  - 2. Matching (fill in the blank with words given): 30 points for 15 answers
  - 3. Identification (very short definition or explanation): 15 points, 5 questions
  - 4. Short answer: 15 points + 10 extra credit points, 5 questions (choose 3 to answer)

- 1. Weather: state of the atmosphere at a given time and place. It is constantly changing.

- 2. Climate: “average” weather conditions, but the average doesn’t stay steady. I.e. Ice ages, El Niño, etc.

Climate is what you expect, but weather is what you actually get.

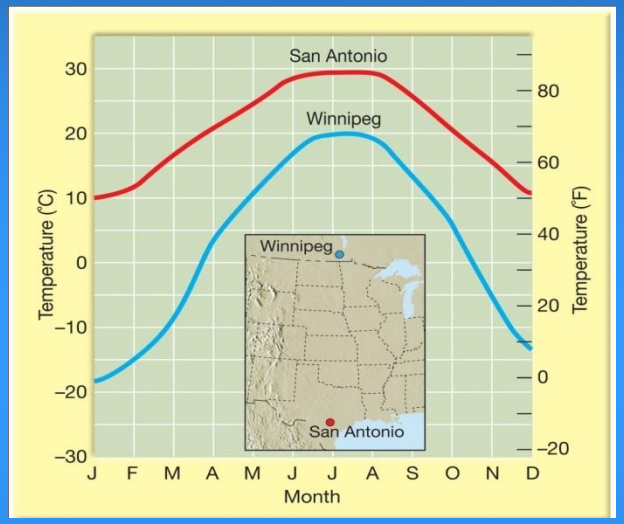
3. Four “Spheres” in the climate system: Geosphere, Atmosphere, Hydrosphere, Biosphere

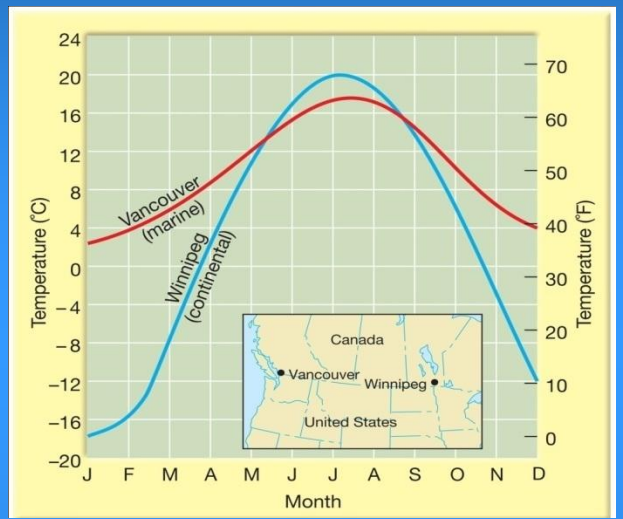
4. Climate Controls

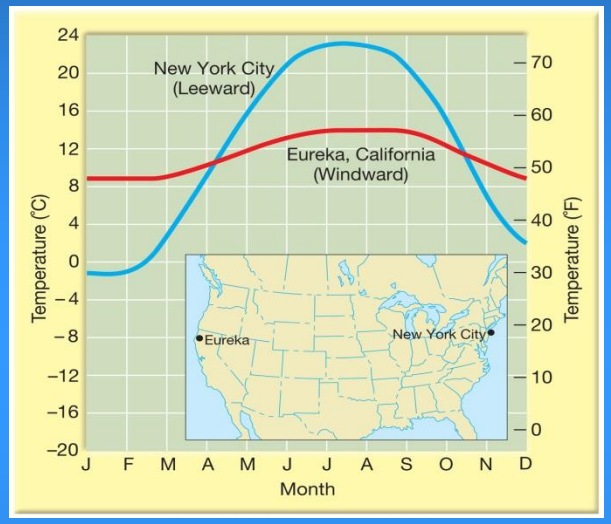
Latitude, Land and Water

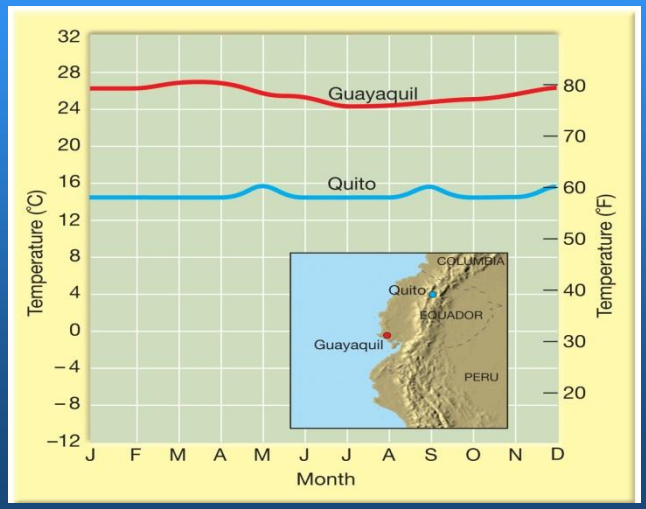
Geographic Position, Mountains and Highlands

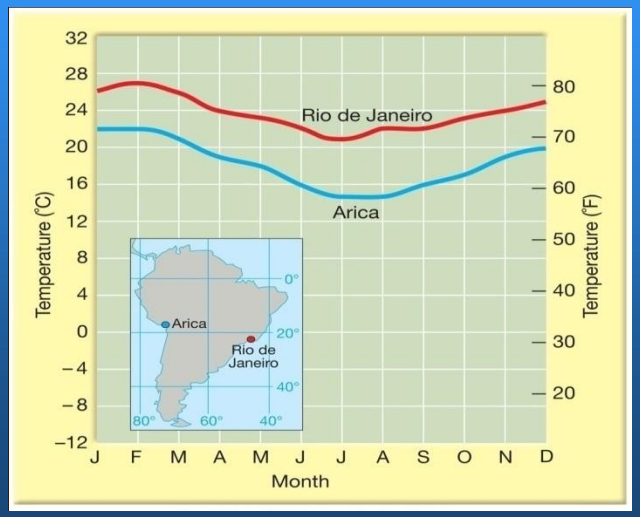
Ocean Currents, Pressure and Wind Systems











5. Composition of atmosphere

Nitrogen (N_2), Oxygen (O_2), Argon (Ar), Carbon dioxide (CO_2),
Minute trace gases: water vapor (H_2O),Methane (CH_4), Ozone (O_3), Nitrous Oxide (N_2O)

6. Vertical structure of atmosphere

Troposphere: the lowest layer of the atmosphere

- Averaged Surface temperature is 288.16K, or 15C.
- Decreases 6.5C per km up to ~11 km
- Nearly all weather happens in this layer

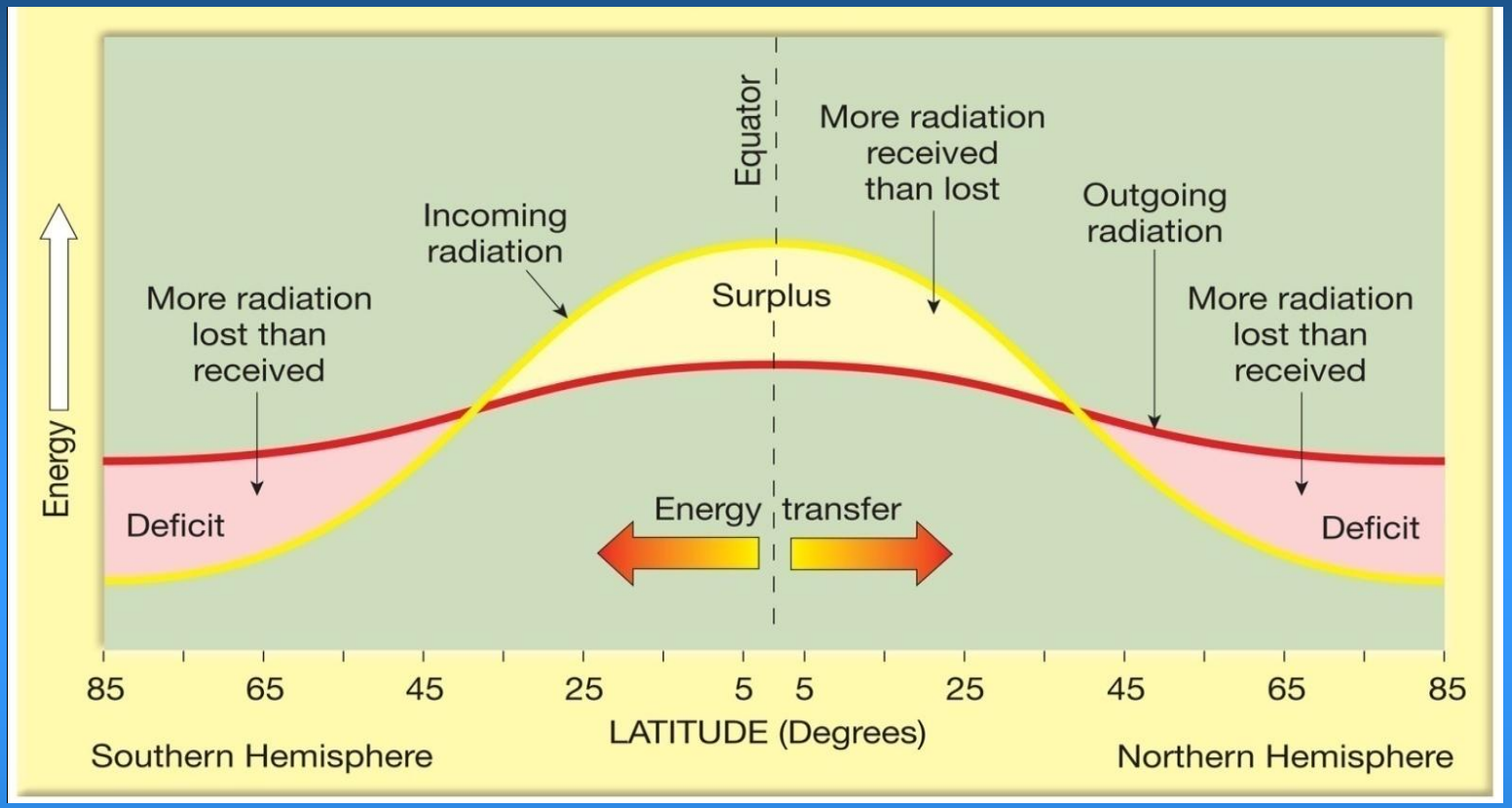
Tropopause: the top of the troposphere

Stratosphere: the layer between ~11km and ~50 km

Stratopause: the top of the stratosphere

- Temperature increases in this layer.
- O_3 is distributed in this layer

7. Annual radiation budget

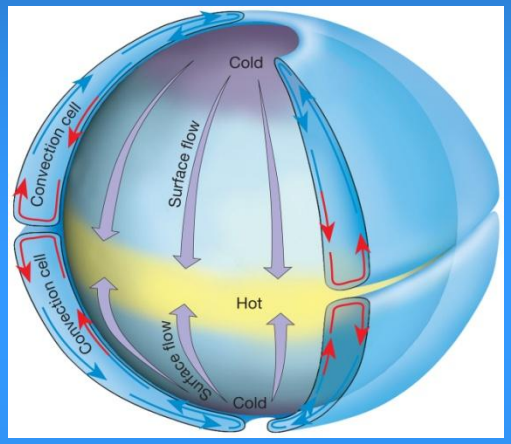


8. Transport by atmospheric motion and ocean currents

Atmospheric motion and ocean currents transport energy from tropics to high latitude and equalize the global temperature

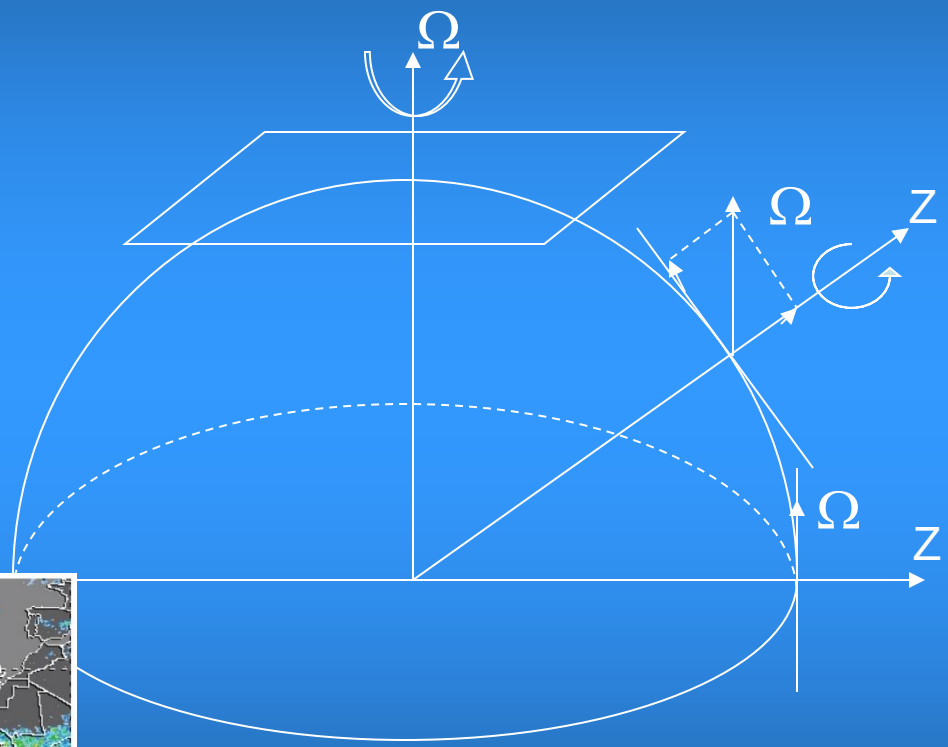
9. Global circulation

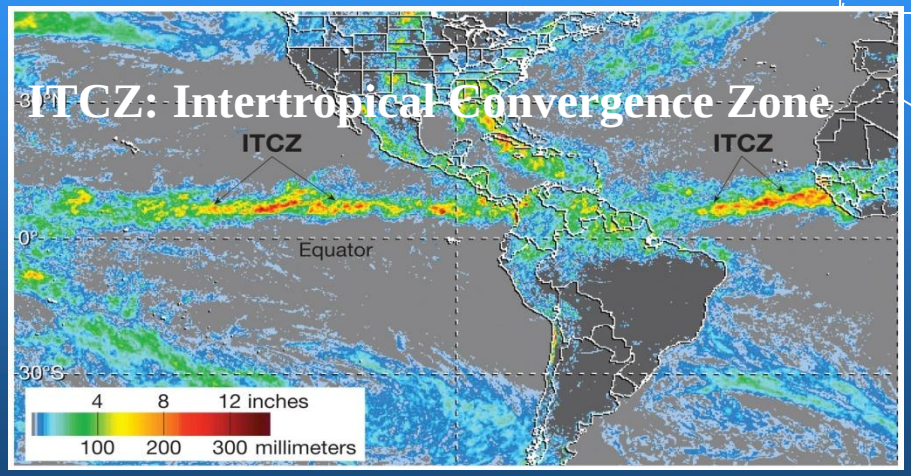
Thermally driven circulation (direct circulation)

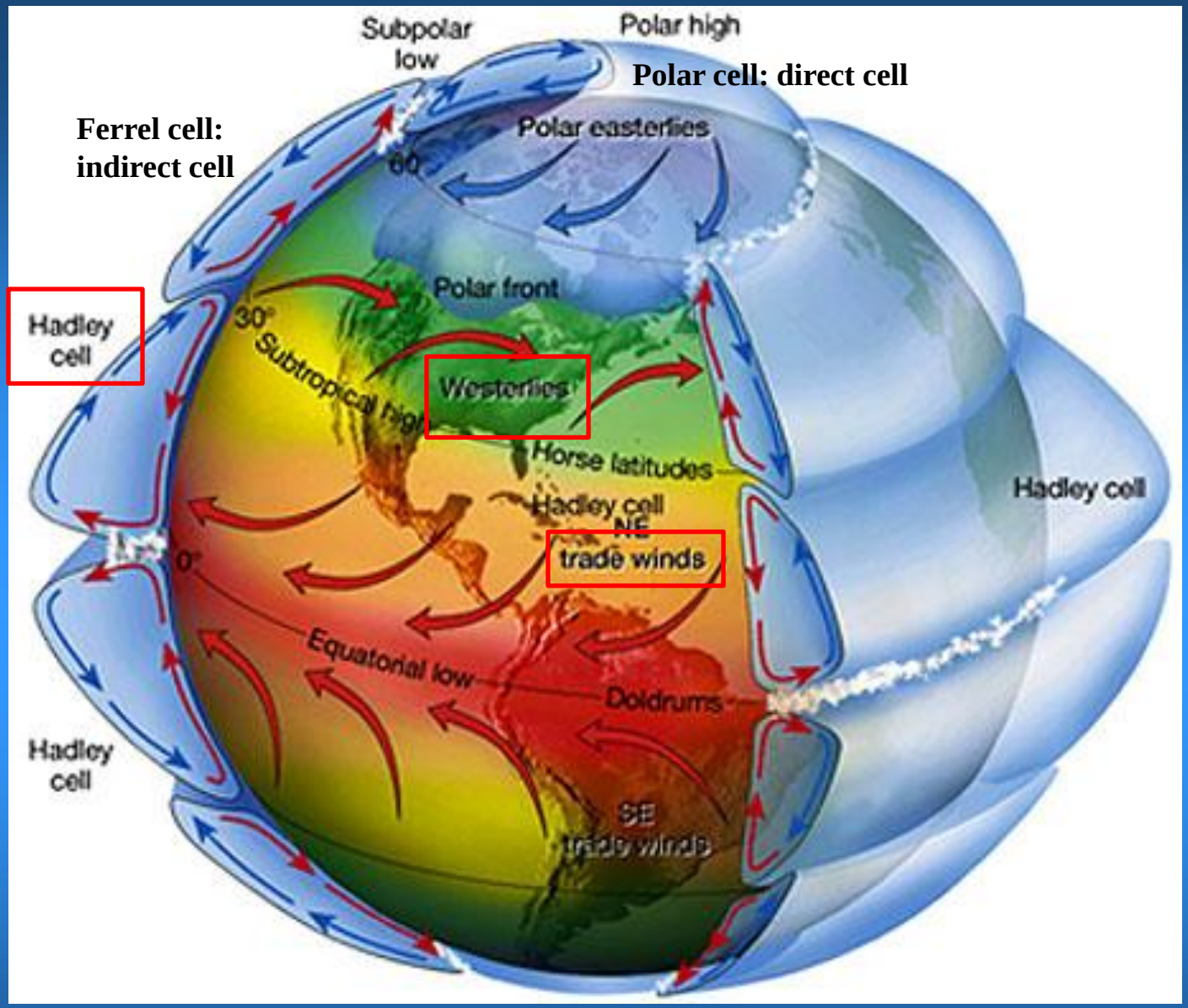


Corisolis effect:

1) caused by earth's rotation
2) Depends on latitude



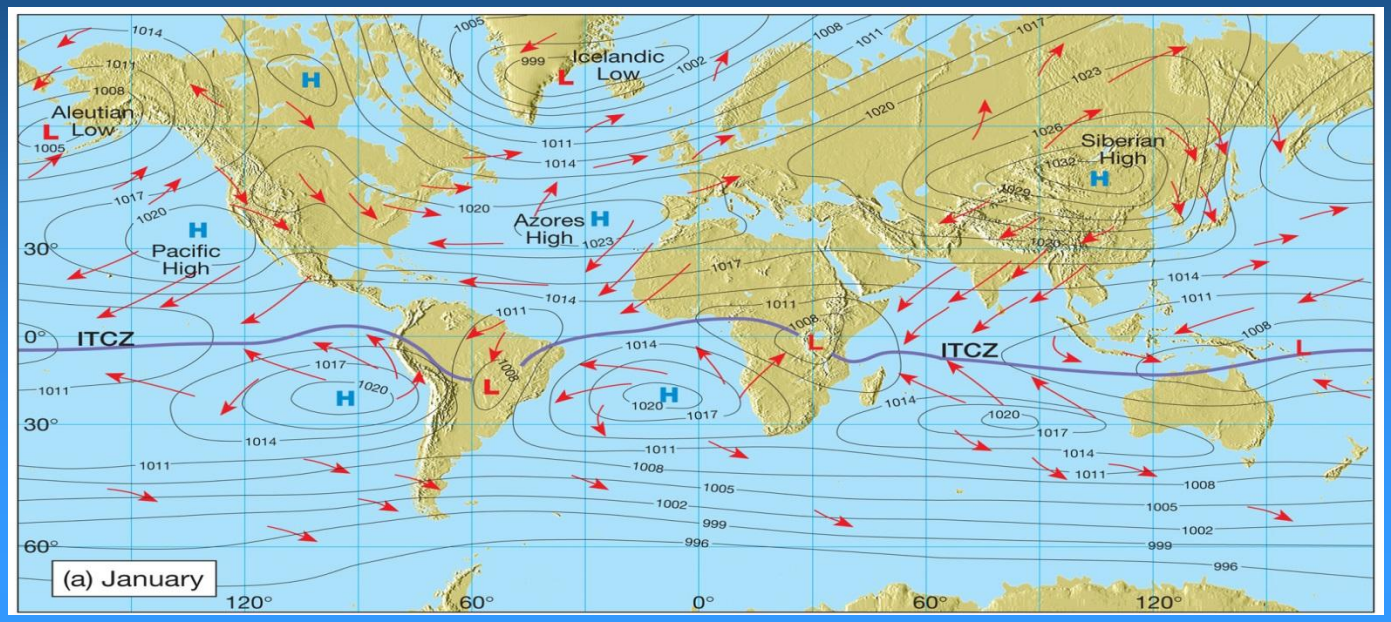


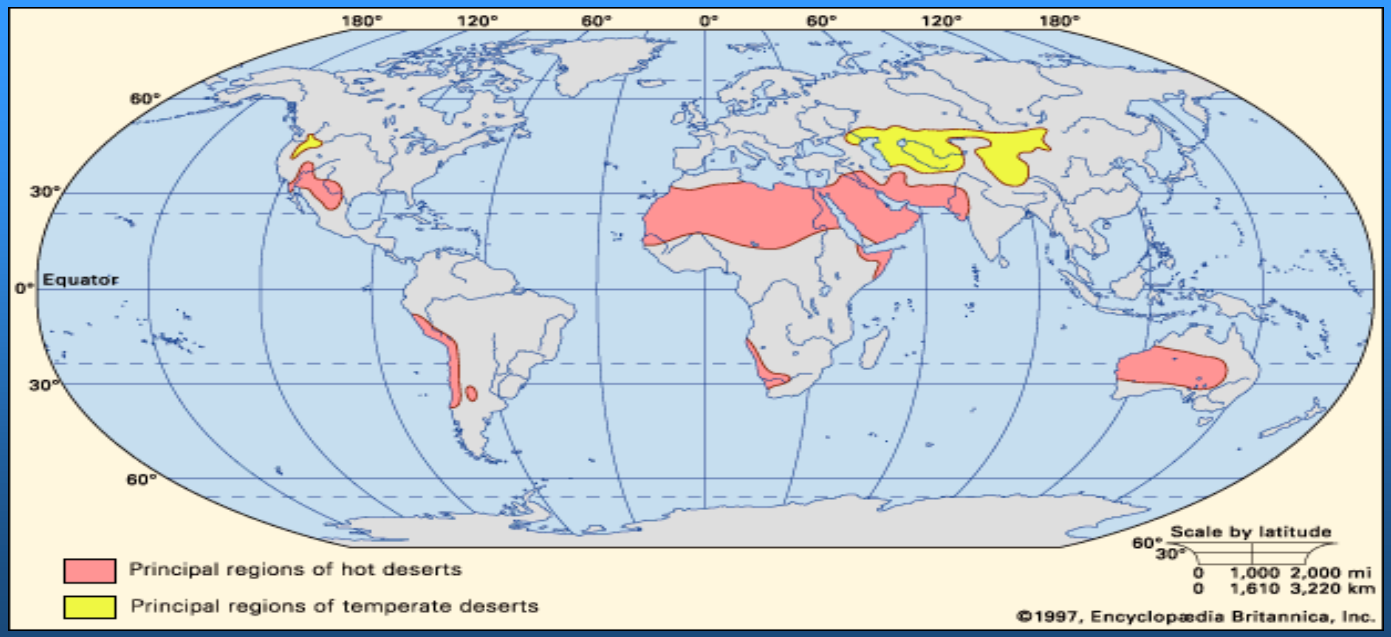


Three cell model: Why not a single giant cell?

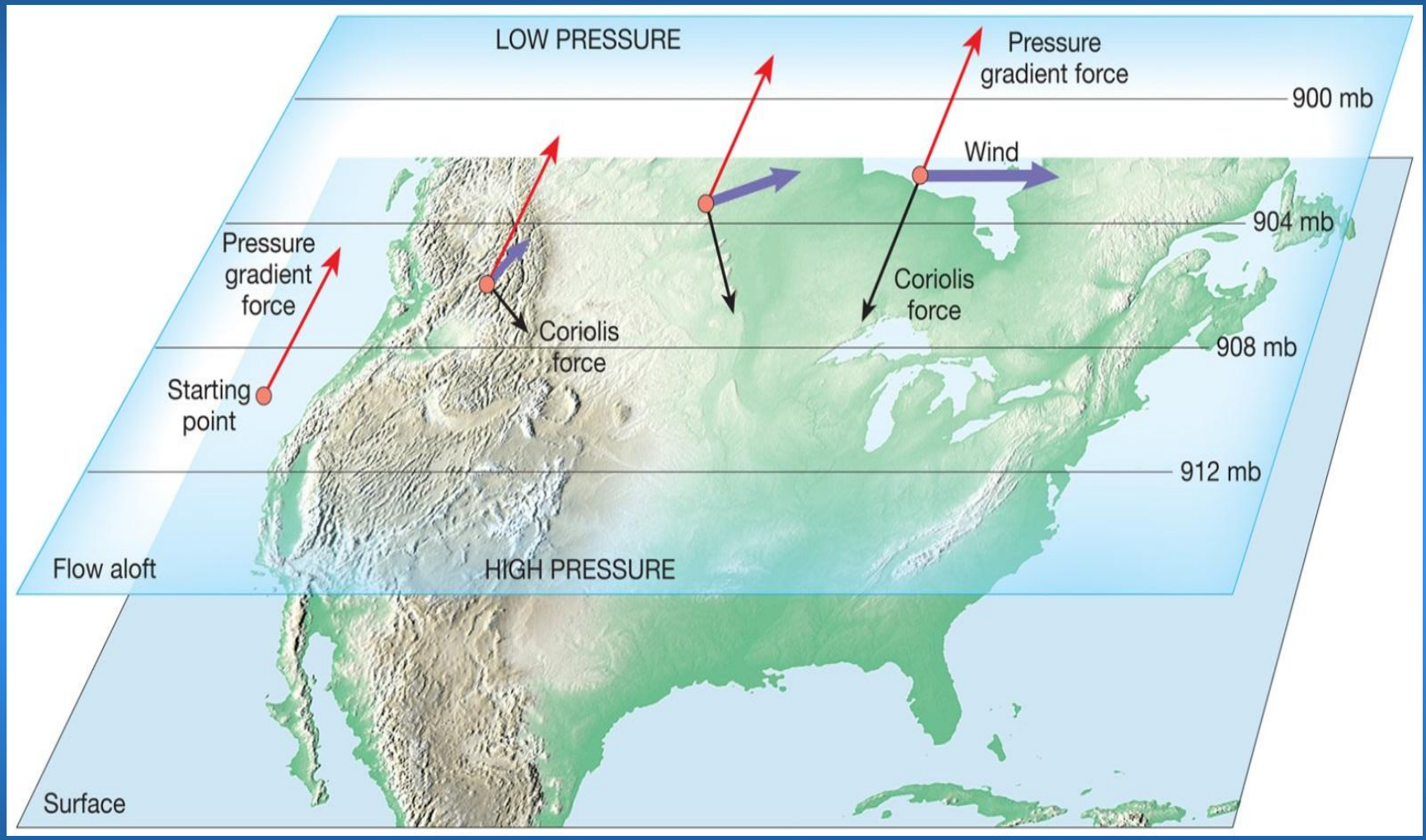
Definitions: Hadley cell, trade-wind, mid-latitude westerly

Down branch of the Hadley Cell and world's desert distribution



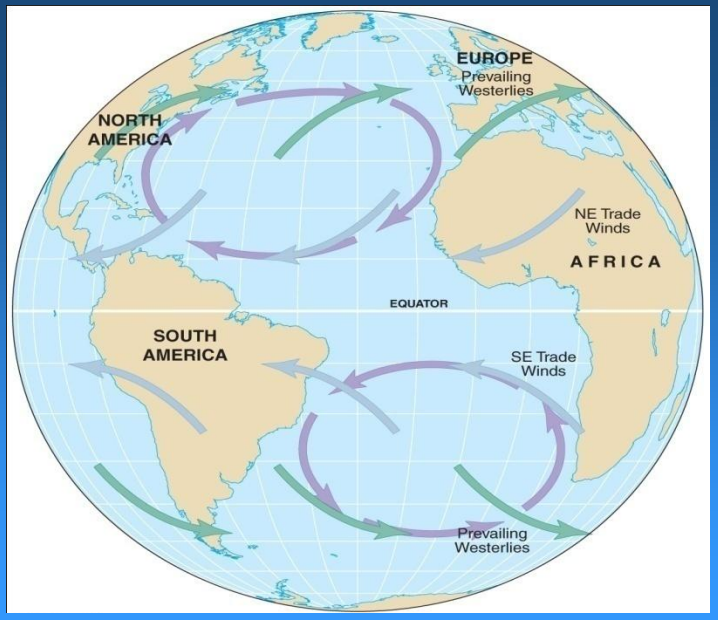


10. Geostrophic Balance

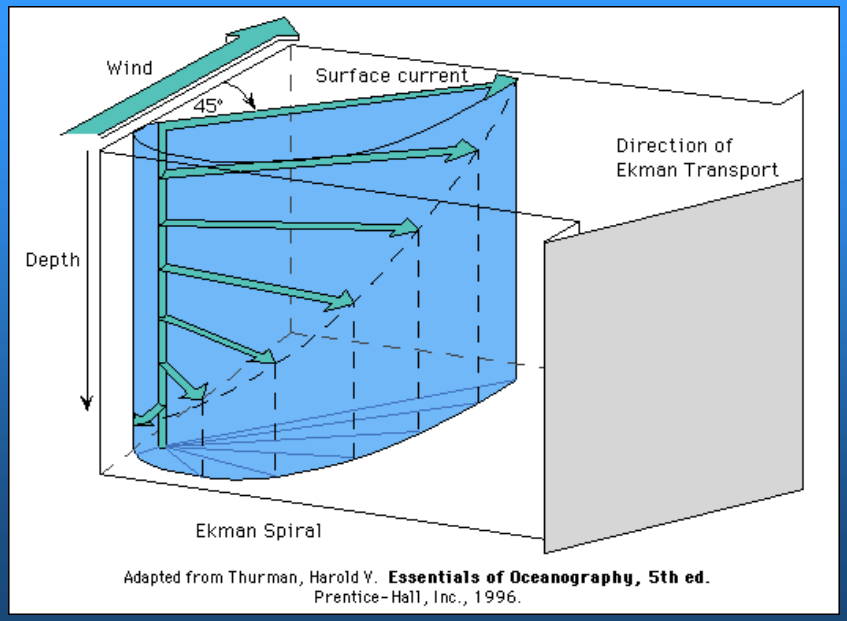


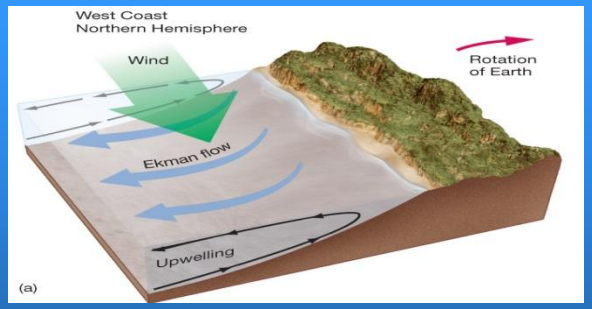
Balance between pressure gradient force and Coriolis force

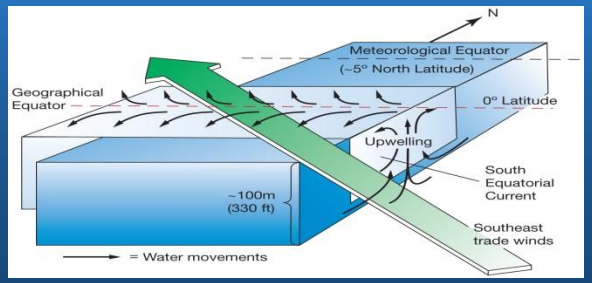
11. Wind driven Surface Current



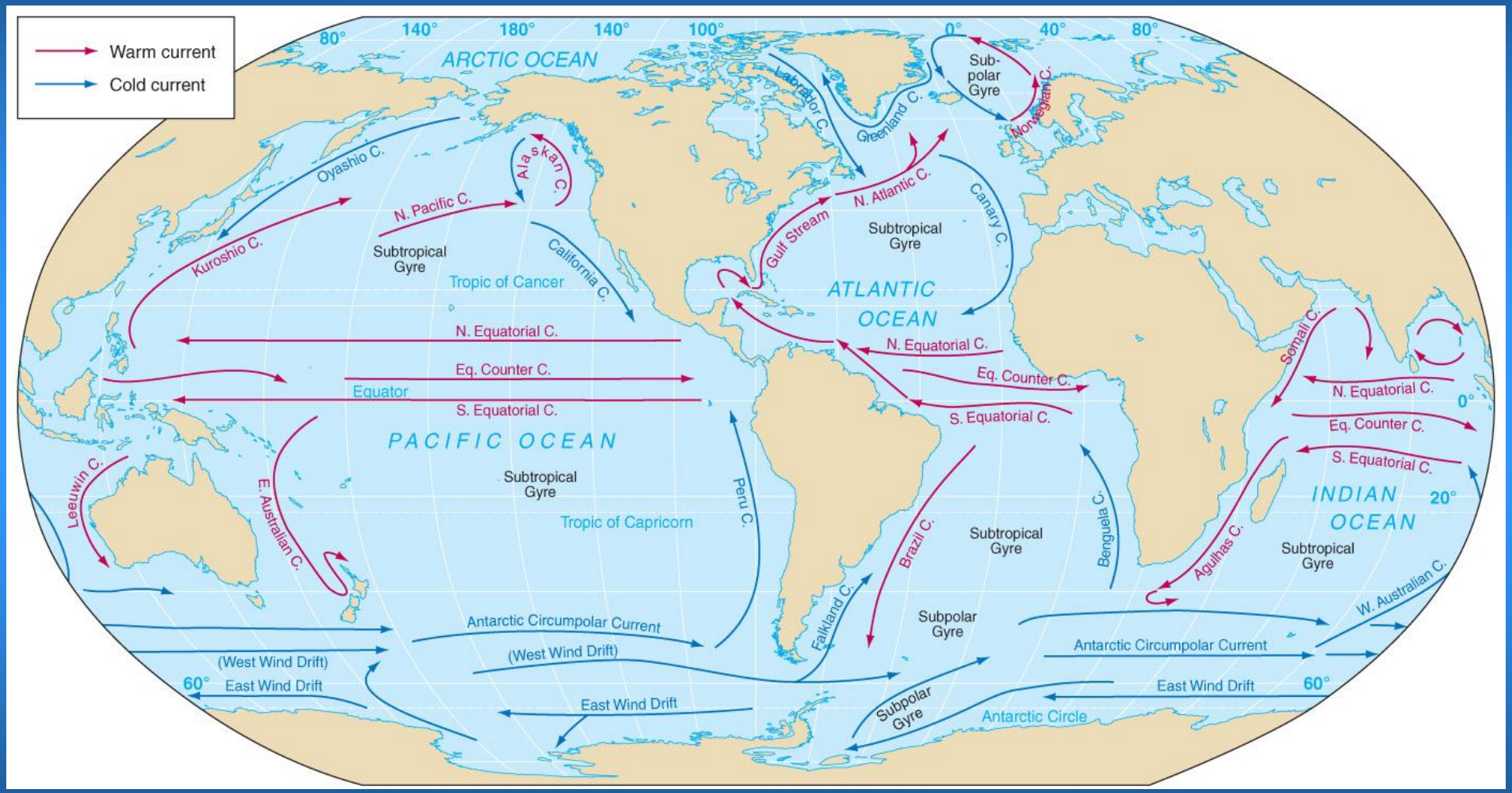
12. Ekman effect and coastal upwelling and equatorial upwelling





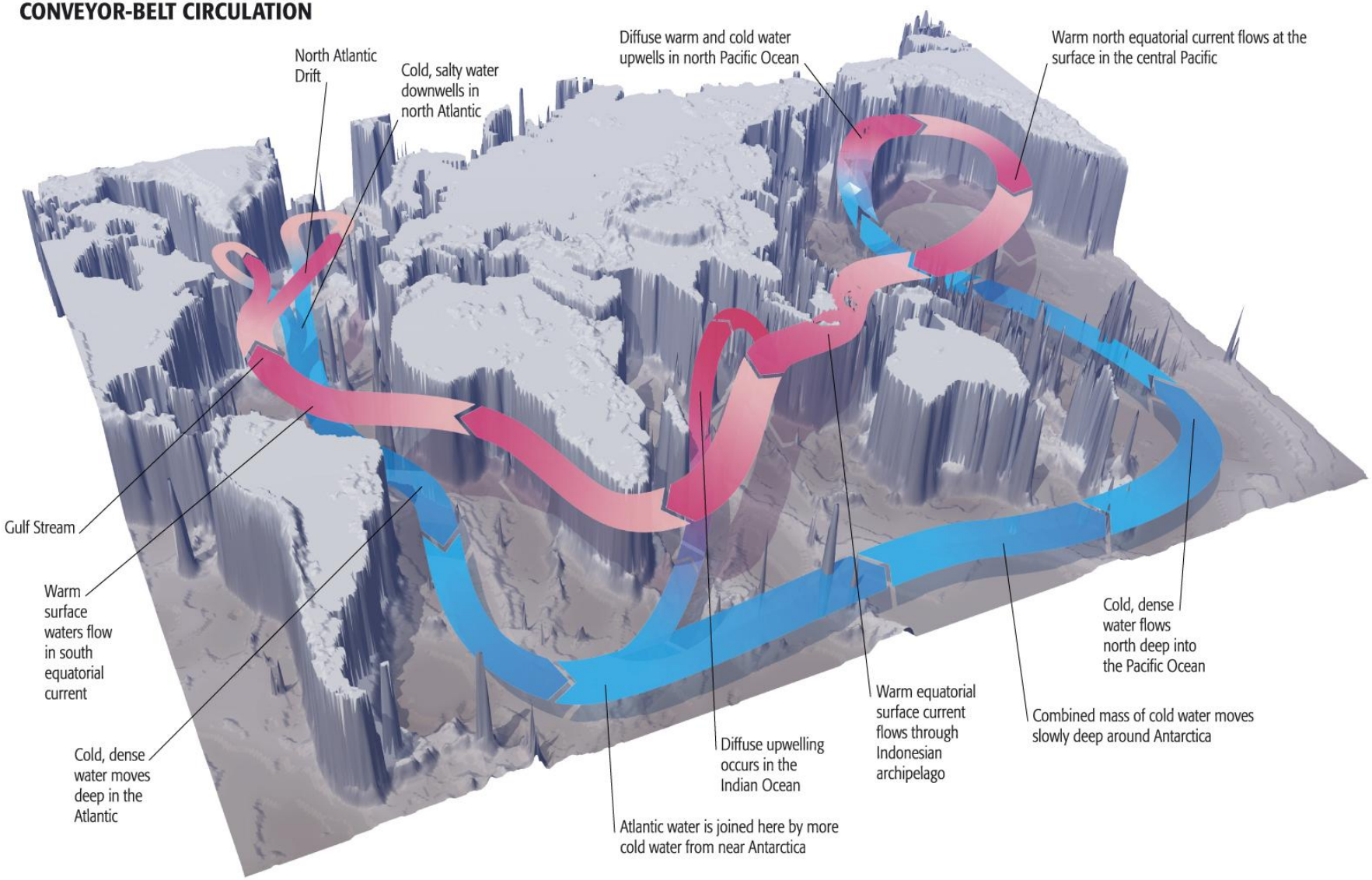


Ocean surface currents



Eastern boundary currents are cold because they carry water from high-latitude;
Western boundary currents are warm because they carry water from equatorial regions.

13. Deep ocean density driven circulation



14. Proxy data – indirect evidence using natural recorders of climate variability
   - Sea floor sediments
   - Oxygen isotope analysis
   - Coral deposits
   - Glacial ice rings
   - Tree rings
   - Fossil Pollen
   - Historical documents

15. Natural Causes of Climate Change

   - Change in Solar energy and activities

   - Variations in Earth's Orbit

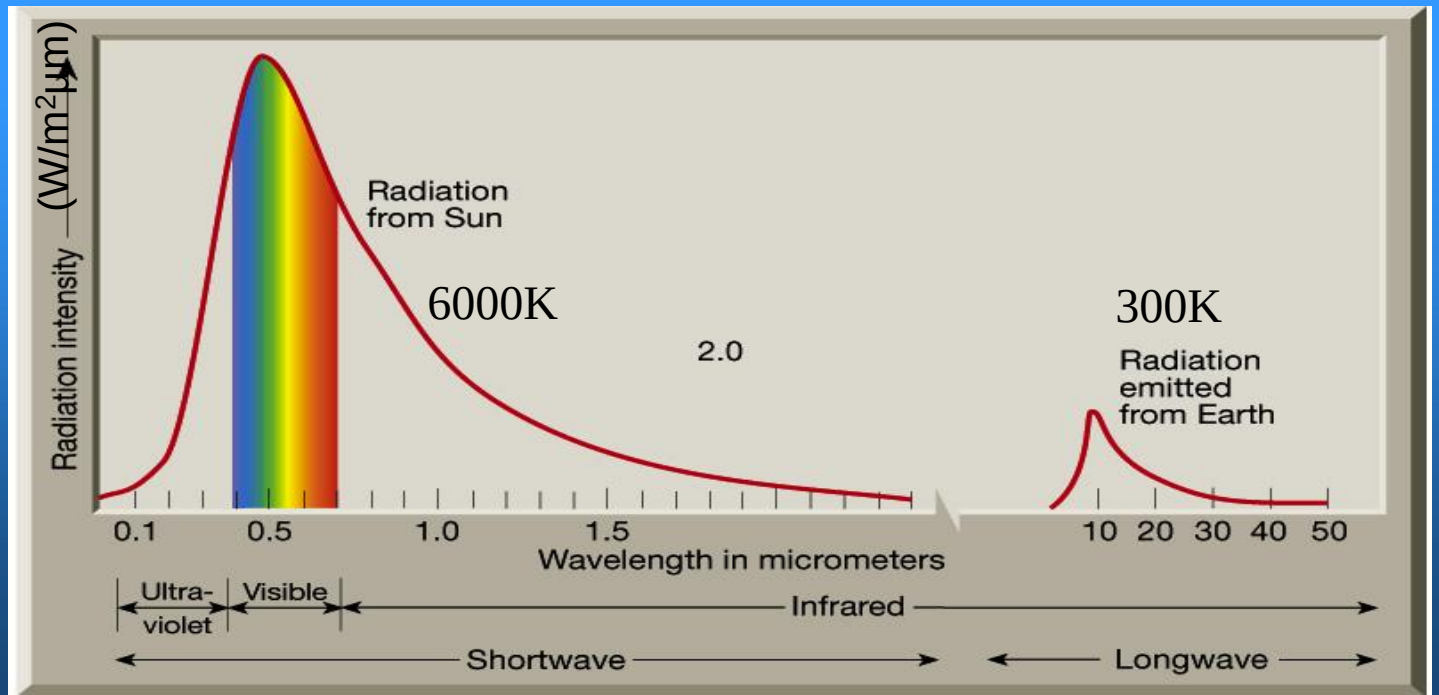
   - Continental drift

   - Volcanic Eruptions

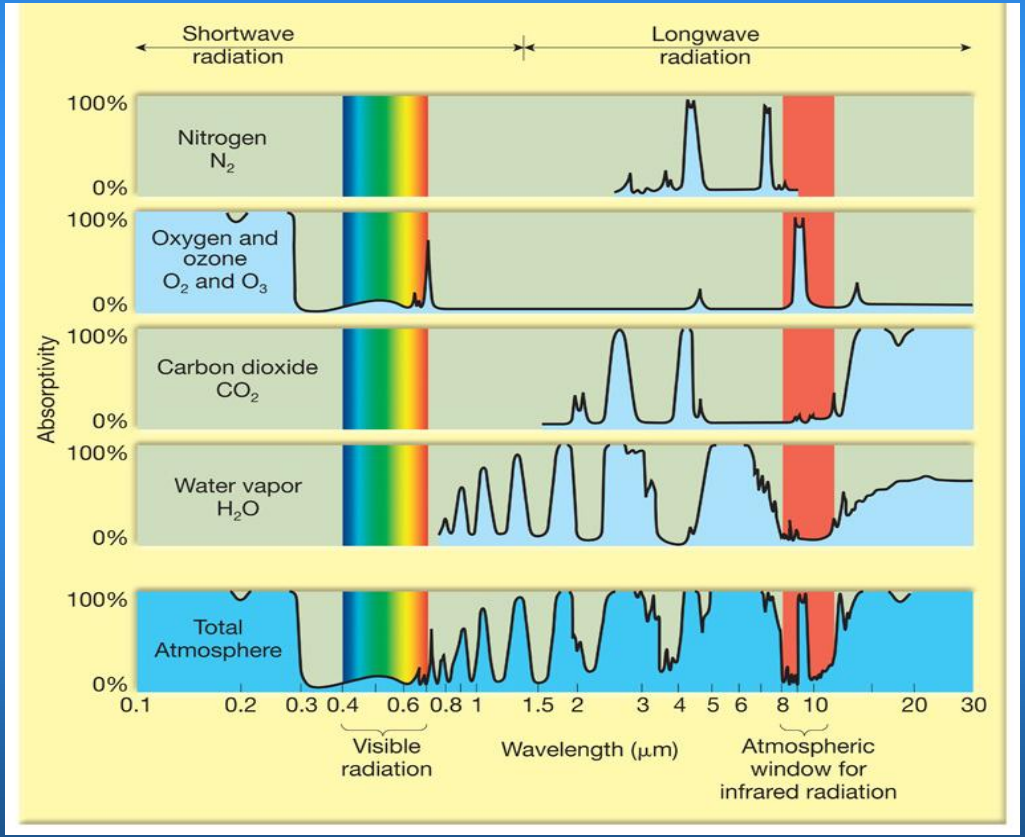
16. Human impacts on climate

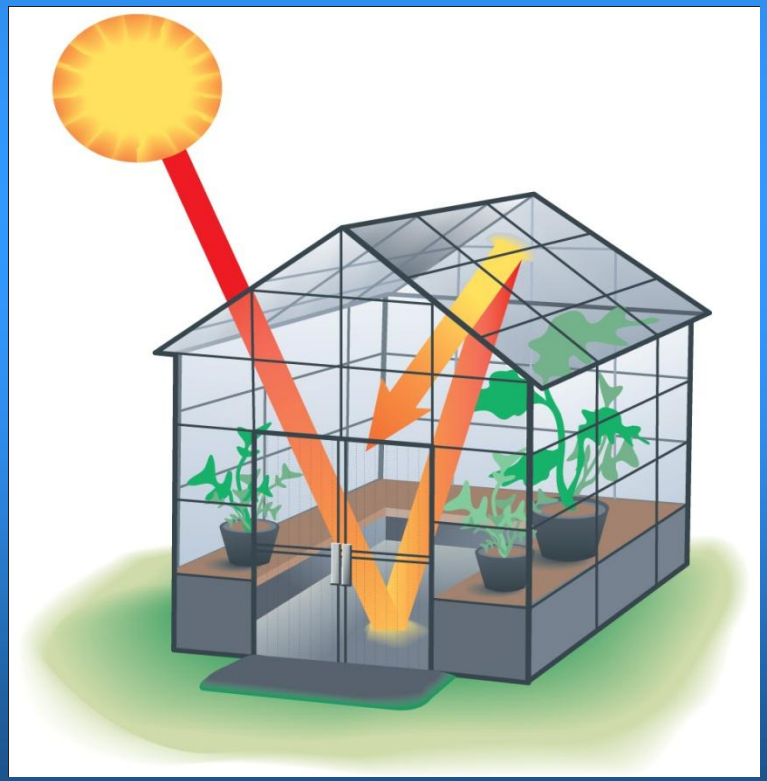
- Green house gas production
- Land use
- Deforestation
- Pollutants
- “bad” compounds for the atmosphere…

17. Radiation



18. Greenhouse effect: shortwave solar radiation is nearly transparent to the atmosphere, but longwave terrestrial radiation is trapped by greenhouse gases, causing the increase of surface temperature.

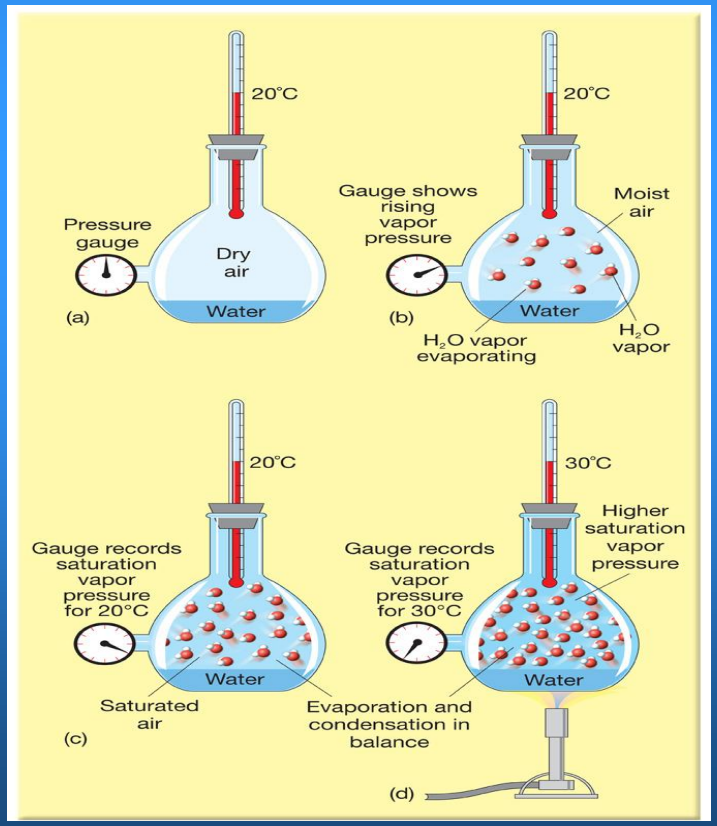




19. Atmospheric window

20. Water vapor, phase change, relationship among water vapor, saturation, and temperature

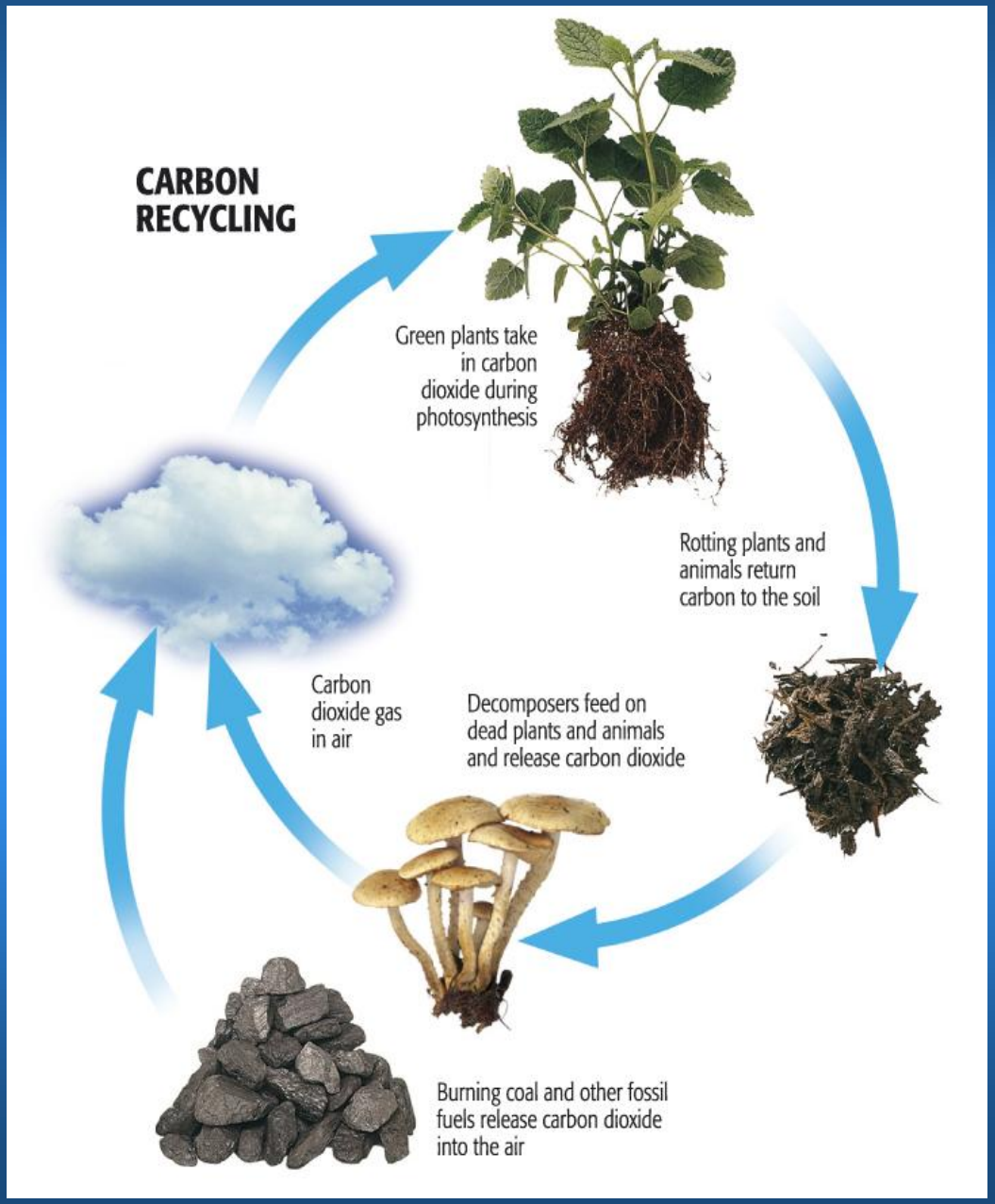
Three phase: water vapor, liquid water, and ice.
Latent heat: the heat transfer during water phase change.
Temperature keeps constant during the phase change.



The higher temperature, the more water vapor can be held in the atmosphere.

The more water vapor in the atmosphere, the stronger greenhouse effects, leading to the further increase of temperature.

21. Carbon Cycle



The lifetime of CO_2 in the atmosphere is about a decade. But this uptake and release Is balanced. It just recycle it. Ocean can dissolve some CO_2 as a removal mechanism. But it is a very slow process (hundreds or thousands of years).

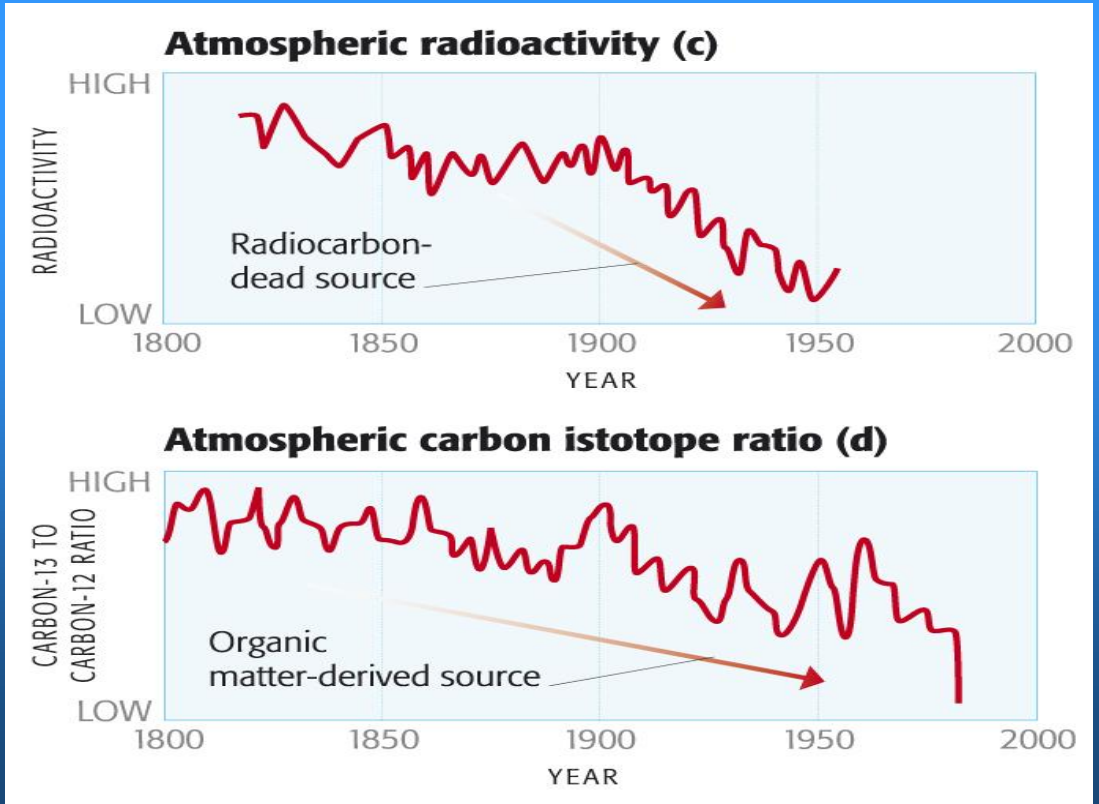
But excessive use of fossil fuels break the balance.

22. The recent dramatic increase of greenhouse gases is unlikely caused by natural processes

Scientific evidence

1. Ratio of C-14/C-12 is dropping.

2. Ratio of C-13/C-12 is dropping.



23. Trace gases, other important greenhouse gases

1. Methane 2. Nitrous Oxide 3. Chlorofluorocarbons (CFCs)

Why trace gases are so important to climate with such a small amount?

1. Highly un-reactive (long lifetime cycle) trace gases have strong absorption lines in the atmospheric window.

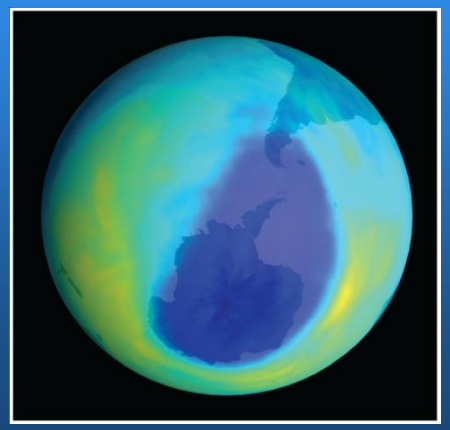
2. Destructing ozone layer.

24. Ozone layer and climate, ozone hole

Depletion of Ozone by Cl

The Ozone Hole

Chlorine species become very active on the surface of polar stratospheric clouds.



25. Observed global warming