

# Overview of The Earth System

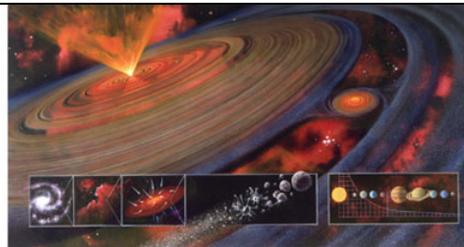
ATS 150  
Lecture 2

## The Earth System

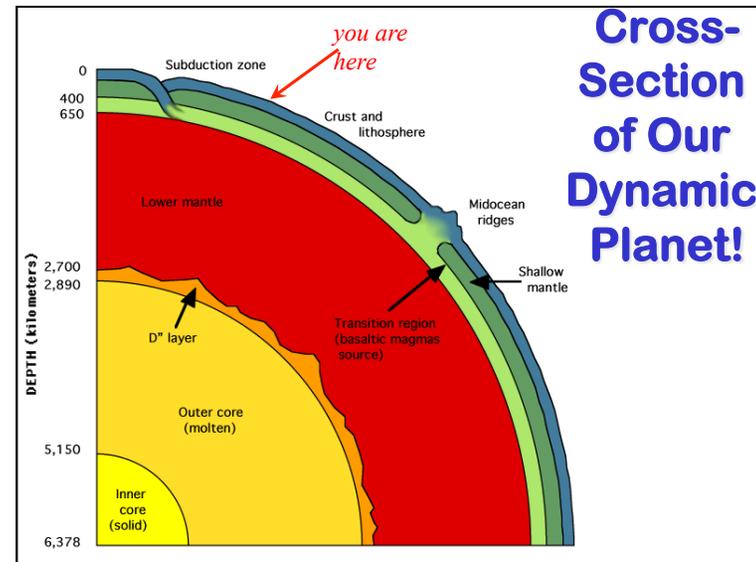
The Earth's climate results from the interaction of many properties and processes

- Solar radiation and orbital geometry
- The size, gravitational force, and rotation rate of the planet
- The composition, structure, and internal dynamics of the planet
- The geography of continents, glaciers, mountain ranges, and oceans
- Ocean properties and circulation
- Atmospheric constituents, their chemical interactions, circulation, and the hydrologic cycle
- The living ecosystems that inhabit the planet, and the biogeochemical transformations they conduct

## Origins

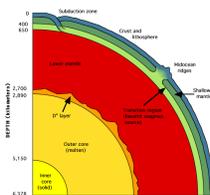
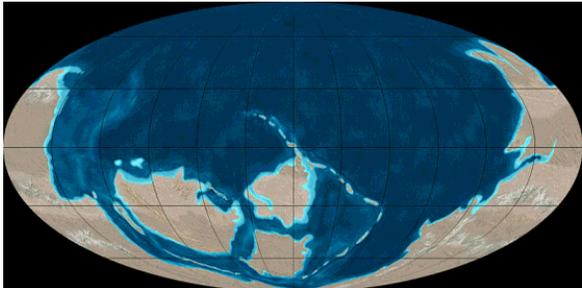


- Earth formed by gravitational accretion ~ 4.7 billion years ago
- Solar "constant" was ~ 30% less than today
- Impact heating kept surface hot and sterile
- Giant collision separated the Moon and helped differentiate chemical layers

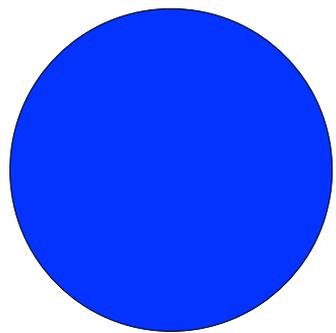


## Plate Tectonics and Climate

- Continental plates are lighter (buoyant) and rise in collisions, whereas oceanic plates subduct
- Rearrangement of ocean basins dramatically changes poleward heat transport**

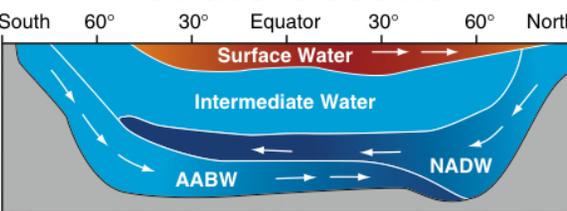
## Energy Reservoirs



- The oceans are about 4000 m deep
- The top 10 m equal the mass of the atmosphere
- The top 3 m equal the heat capacity of the atmosphere!

*The state of the oceans determines the climate on time scales of thousands to millions of years!*

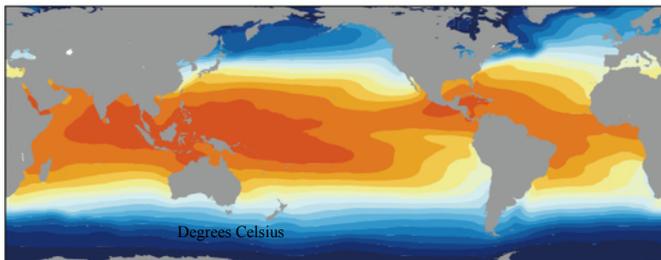
## Vertical Structure of the Oceans



- Increased nutrients & dissolved CO<sub>2</sub>
- Warm, low nutrients, & oxygenated

- Warm buoyant "raft" floats at surface
- Cold deep water is only "formed" at high latitudes
- Very stable, hard to mix, takes ~ 1000 years!
- Icy cold, inky black, most of the ocean doesn't know we're here yet!

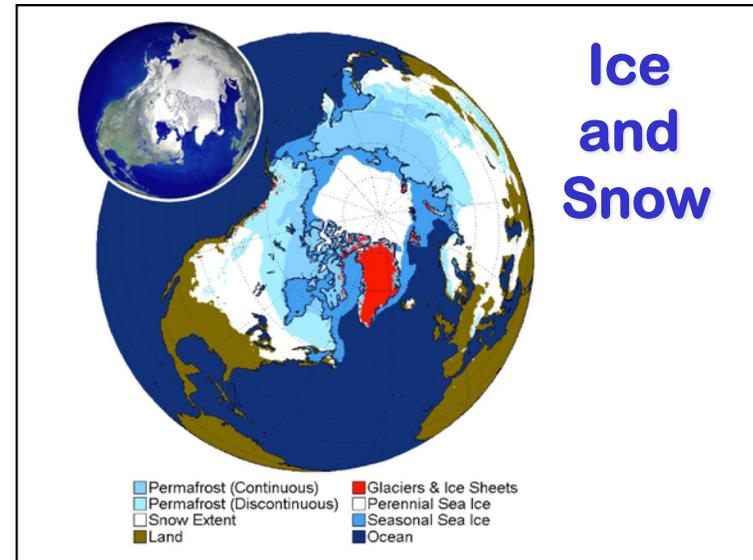
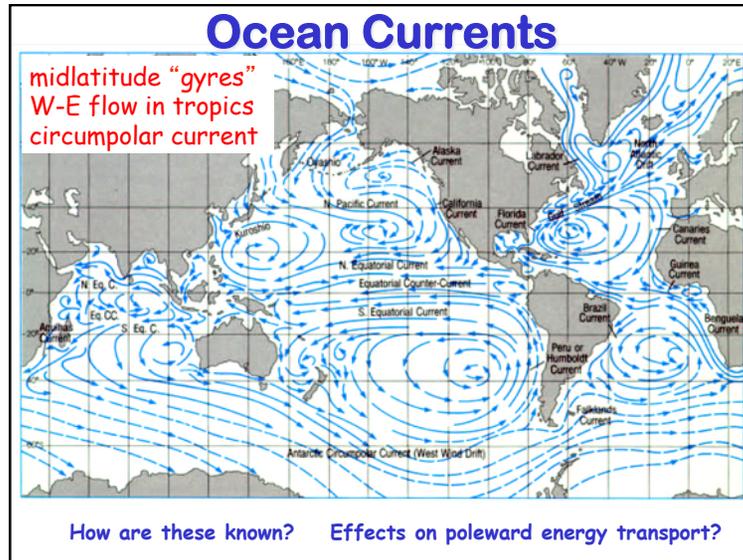
## Sea-Surface Temperatures



Degrees Celsius

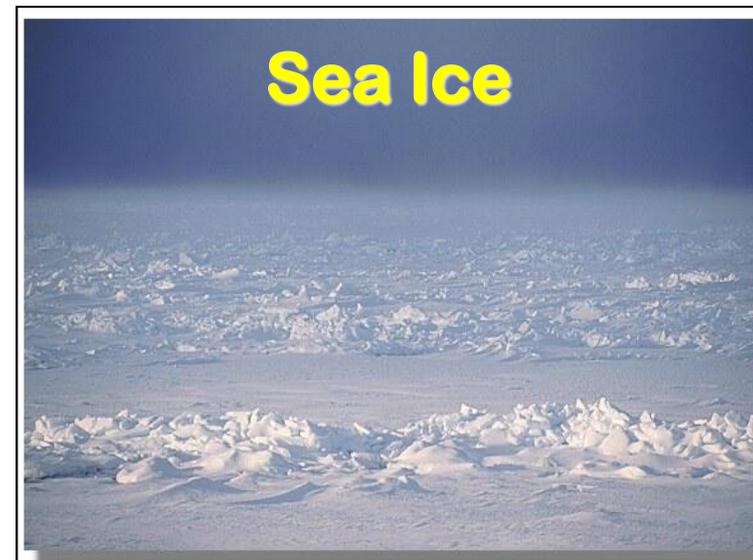
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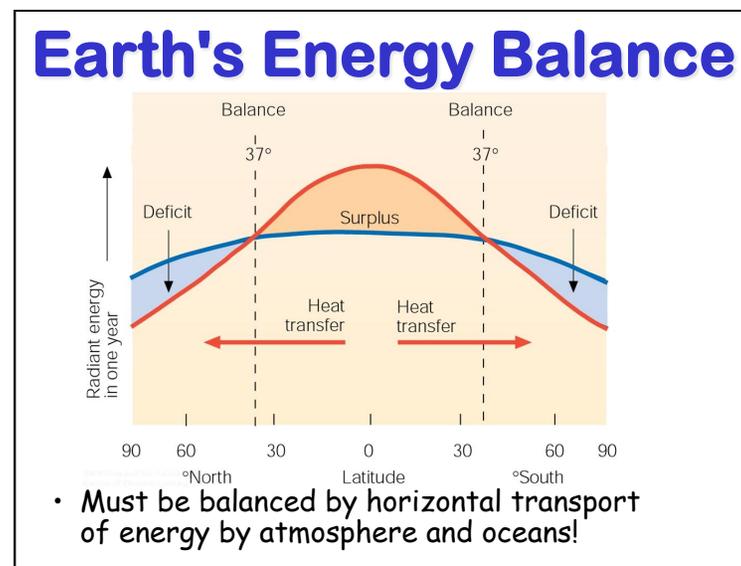
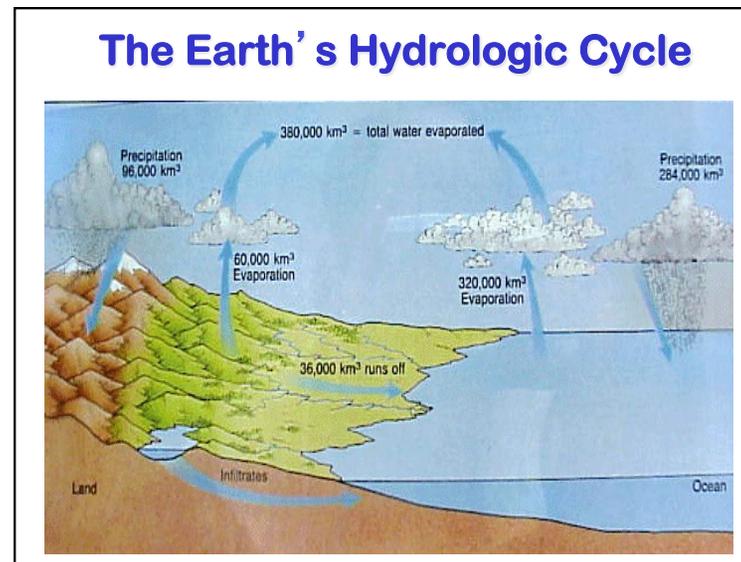
- W. Pacific "Warm Pool"
- Effects of Western vs Eastern boundary currents!

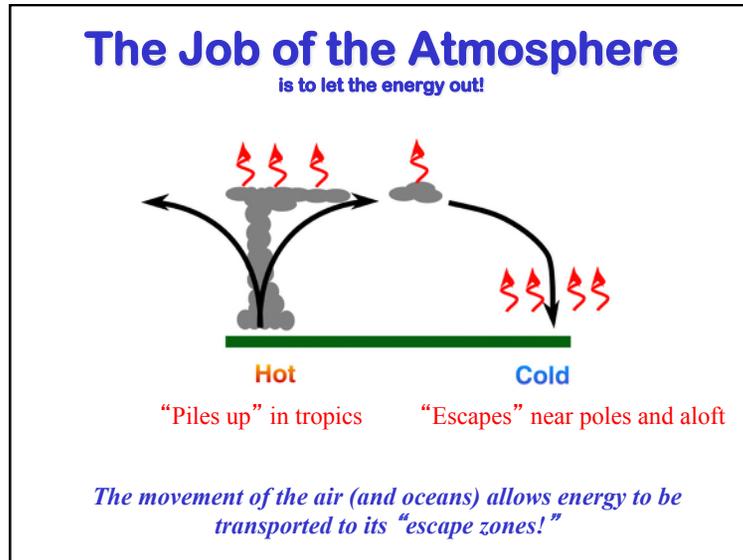


### Land and Sea Ice

- Greenland is covered with ice to depths of several kilometers
- Permanent ice cover further north overlies an isolated ocean basin

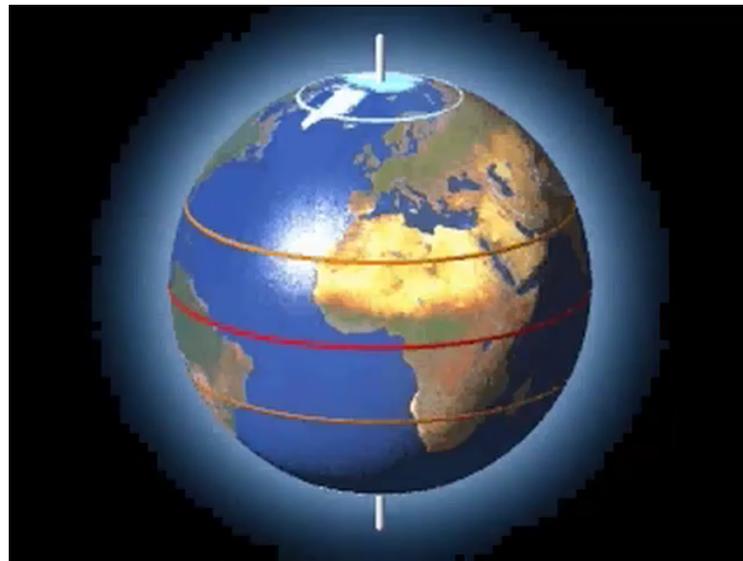






### If the Earth Didn't Spin ...

- Warm air rises (tropics)
- Cold air sinks (poles)
- Energy transported from equator toward poles



### Jet Streams

- 2 Jet Streams
  - Midlatitude Jet gives us storms
  - Subtropical Jet weaker, higher up

## Atmospheric Circulation in a nutshell

- Hot air rises (rains a lot) in the **tropics**
- Air cools and sinks in the **subtropics** (deserts)
- Poleward-flow is deflected by the Coriolis force into westerly jet streams in the **temperate zone**
- Jet streams are unstable to small perturbations, leading to huge eddies (**storms and fronts**) that finish the job

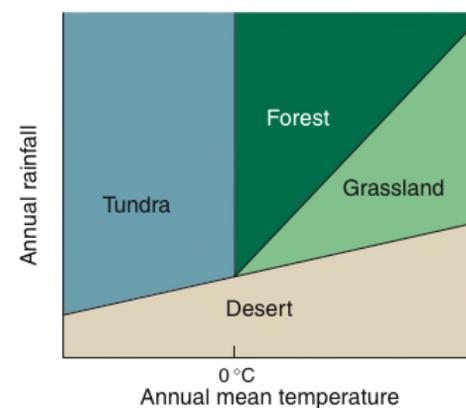
## Climates of the World

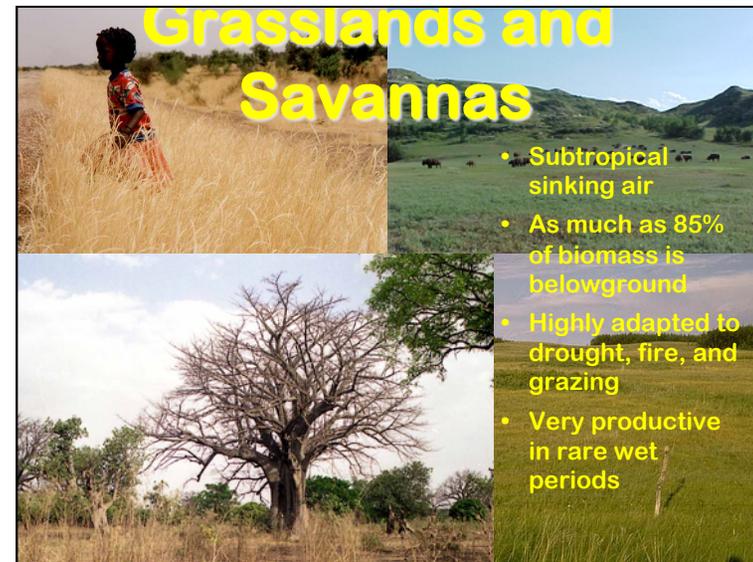
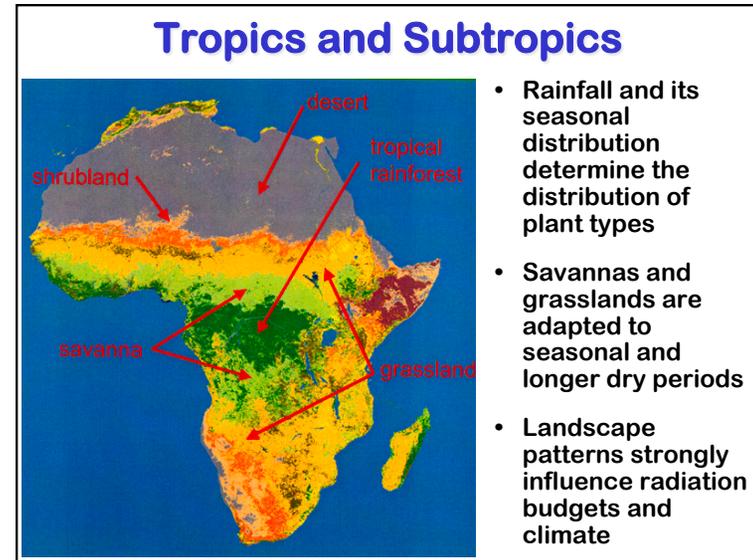
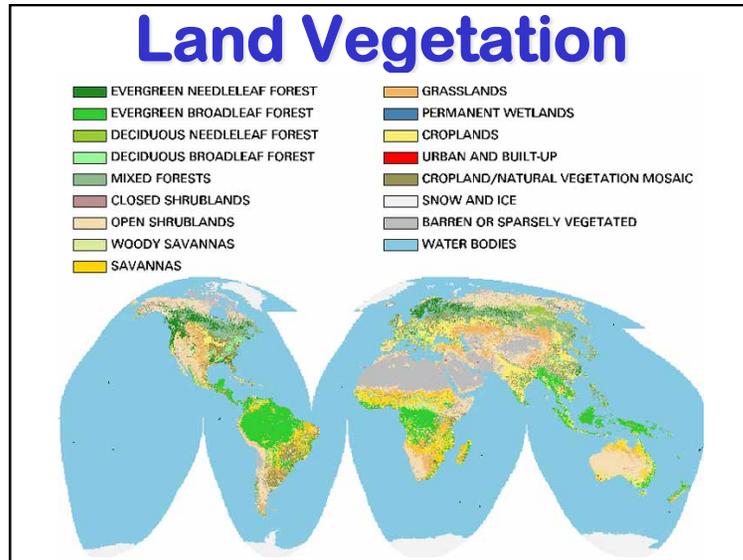
- **Deep Tropics:** hot and wet, with little seasonal variation
- **Seasonal tropics:** hot, with “summer” rain and “winter” dry (monsoon)
- **Subtropics:** dry and sunny, deserts and savannas, often with a well-defined rainy season (summer *or* winter)
- **Midlatitude temperate zone:** warm summers, cold winters, moisture varies by location but often comes in episodes throughout the year
- **Polar regions:** very cold, generally very dry, dark all winter!

## Weather vs Climate

- **Weather:**  
the state of the atmosphere at a place and time as regards heat, cloudiness, dryness, sunshine, wind, rain, etc.
- **Climate:**  
the weather conditions prevailing in an area in general or over a long period of time

## Climate and Vegetation



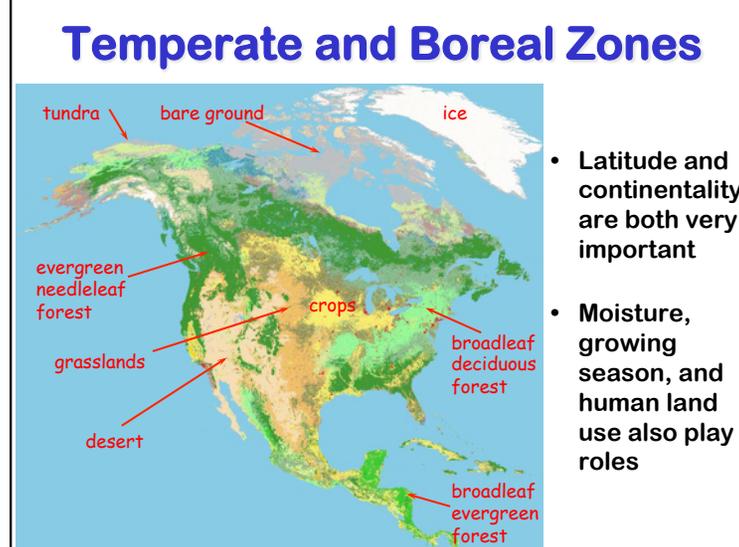


## Deserts



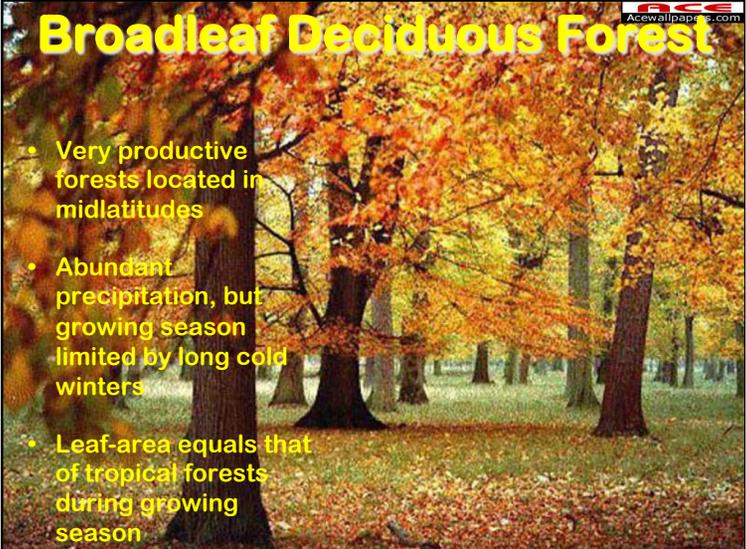
- Little or no rainfall
- Little or no vegetation
- Very bright (high albedo)
- Negative energy balance
- Sinking air

## Temperate and Boreal Zones



- Latitude and continentality are both very important
- Moisture, growing season, and human land use also play roles

## Broadleaf Deciduous Forest



- Very productive forests located in midlatitudes
- Abundant precipitation, but growing season limited by long cold winters
- Leaf-area equals that of tropical forests during growing season

## Boreal Forest



Mostly evergreen, needleleaf trees with little understory

Short growing season, susceptible to drought and fire

Low evaporative demand, so surface may be wet (bogs and fens)

Very low albedo

## Tundra



- High latitudes: cold dry climates, but very little evaporative demand, so surface may be very wet
- Underlain by permafrost in many places
- Low-growing, non-woody plants
- Very short growing season
- Supports migratory mammals