Geography & Climate

All species have limits to their distributions…

To examine species ranges,
it helps to understand the physical template and climate

This is fundamental to biogeography

Goals and learning objectives

1) Understand how thermal energy is distributed over the Earth's surface, and how this influences major biomes

2) Be familiar with the major ocean gyres and understand how these major winds and currents determine where we see deserts

3) Understand how major topographic landscape features, such as mountains, can influence regional climate patterns

All biogeographic patterns are ultimately influenced by the geographic template

Environmental conditions vary in a highly non-random manner across geographic gradients (e.g., latitude, elevation, depth, proximity to major landforms – mountains, coastlines)

Most biogeographic patterns are derived from this very regular spatial variation in environmental conditions

All biogeographic patterns are ultimately influenced by the geographic template

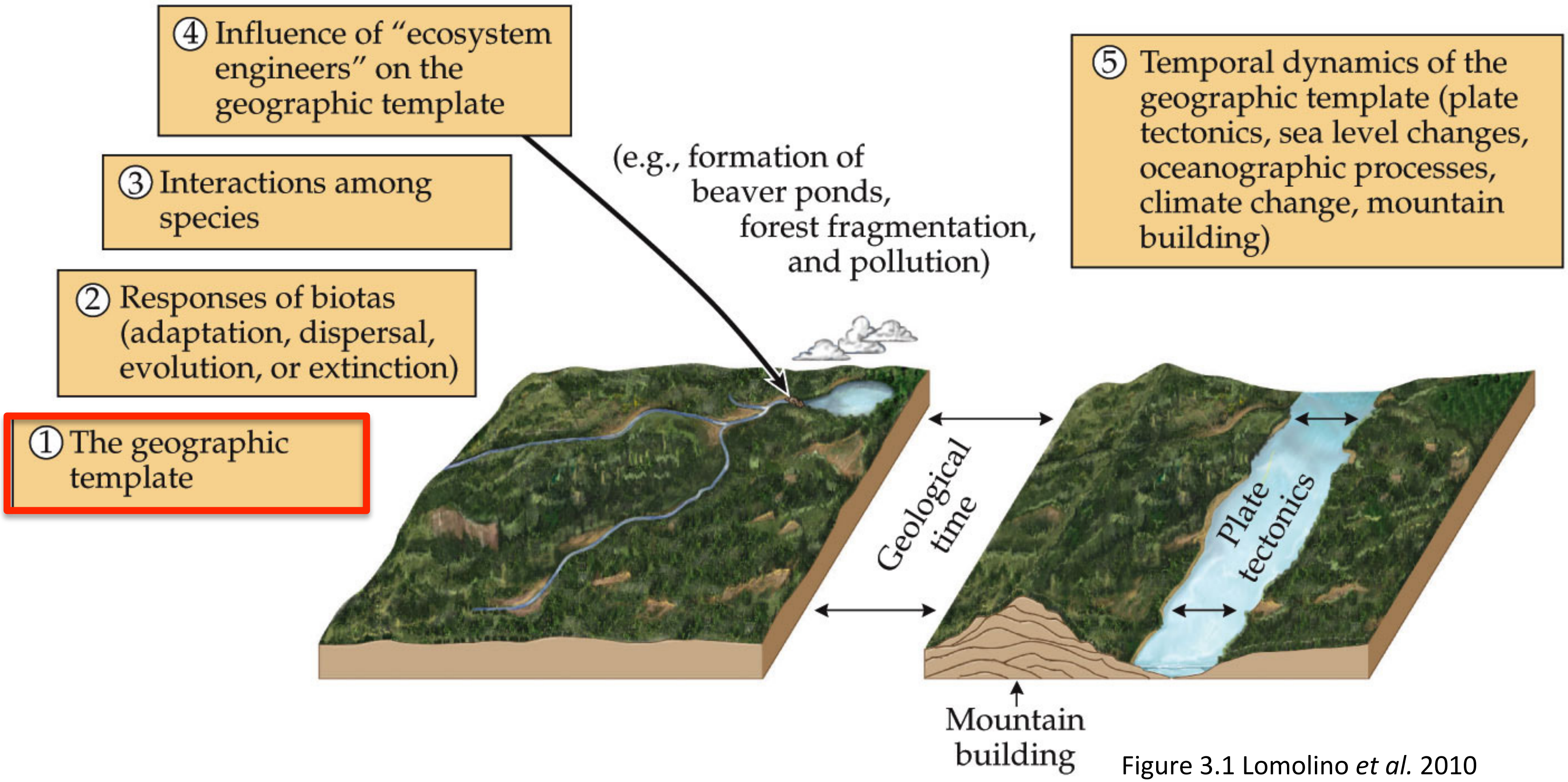


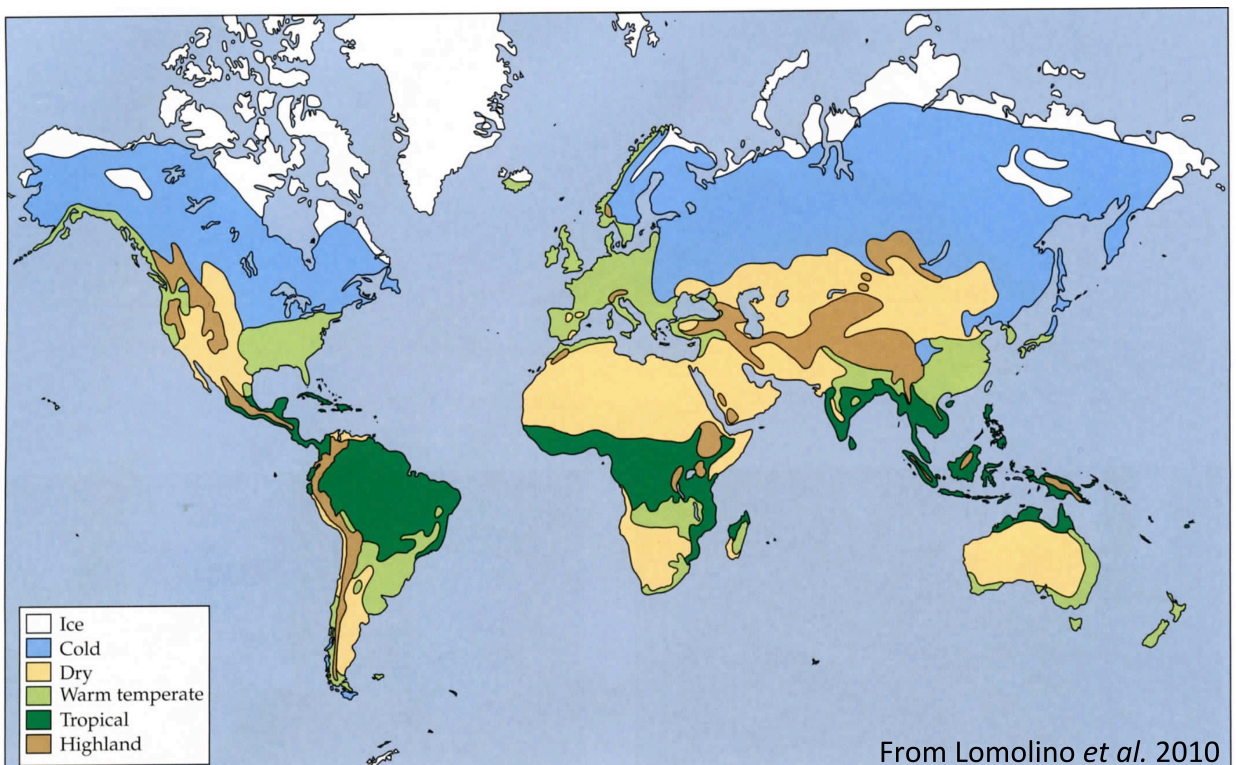
Figure 3.1 Lomolino *et al.* 2010

(5) Sometimes called TECO events – plate Tectonics, Eustatic changes in sea level, Climate change, Orogeny (mountain building)

Climate reflects temperature and precipitation

Climate and tectonic change are the most important large-scale factors influencing species general distributions

Here we'll look at how temperature and precipitation vary across geographic and regional scales



From Lomolino *et al.* 2010

Temperature and thermal energy

Spherical shape of earth causes latitudinal gradient in thermal radiation

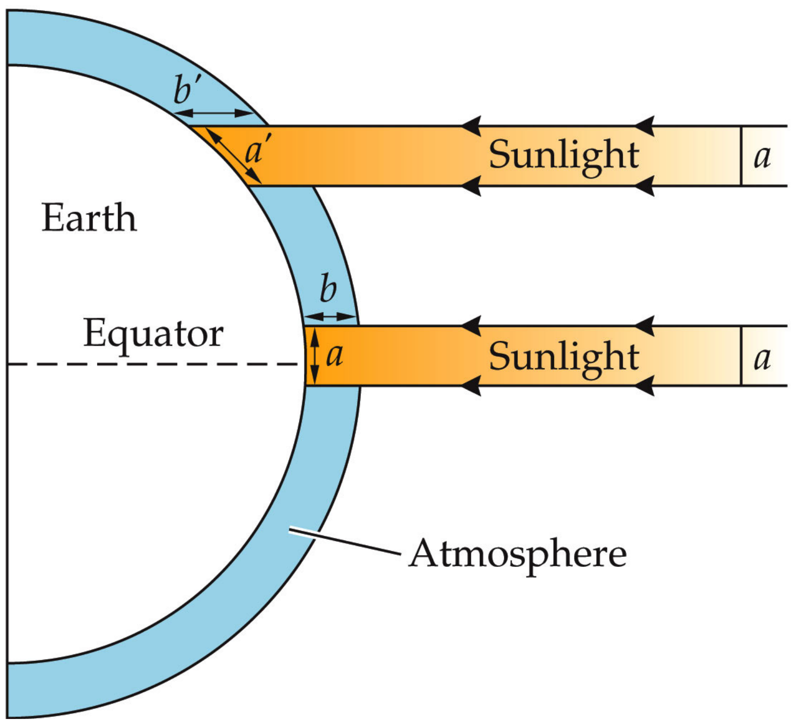


Figure 3.2 Lomolino *et al.* 2010

Angle of incoming radiant energy affects amount of heat absorbed

Most intense heating occurs where incoming sunlight is perpendicular to Earth's surface:

1) The greatest amount of energy is delivered to the smallest surface area (a < a')

2) Solar radiation passes through less atmosphere; the distance traveled through the air is minimized (b < b')

Temperature and thermal energy

The angle of inclination of the earth's axis causes seasonality

Solar radiation falls perpendicularly on different parts of the Earth at different times of year

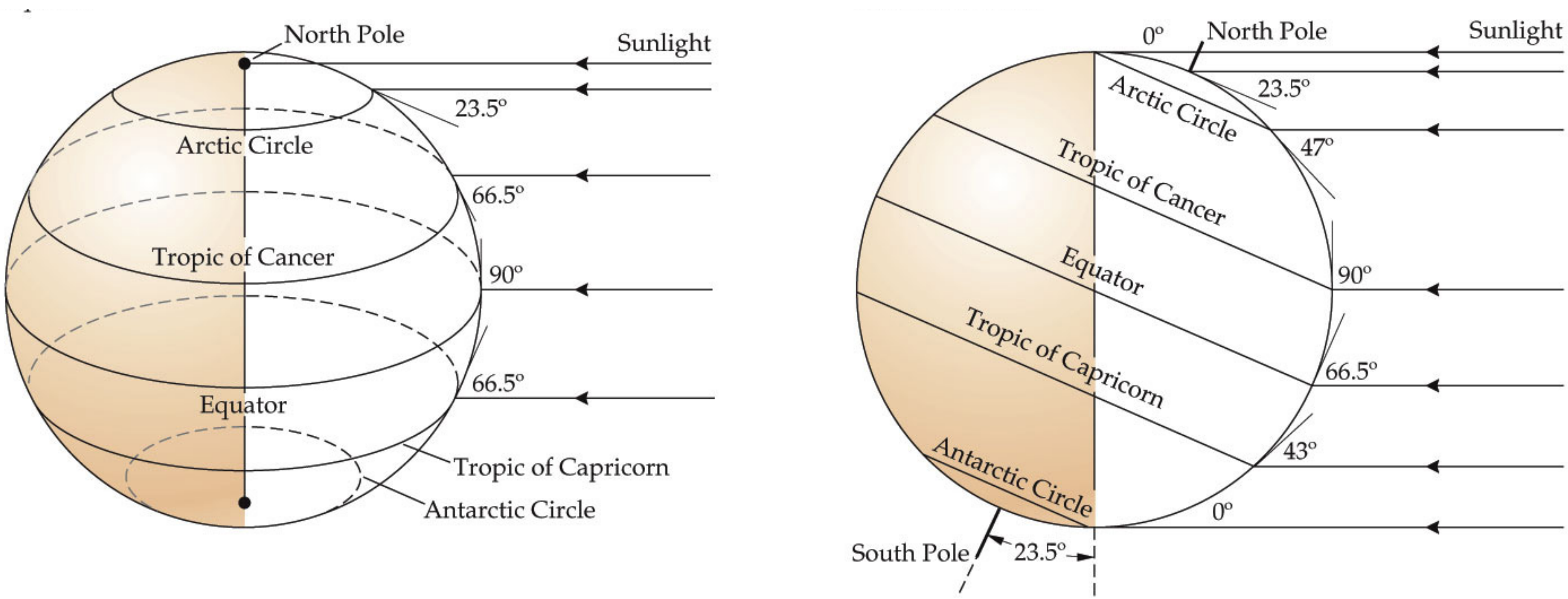
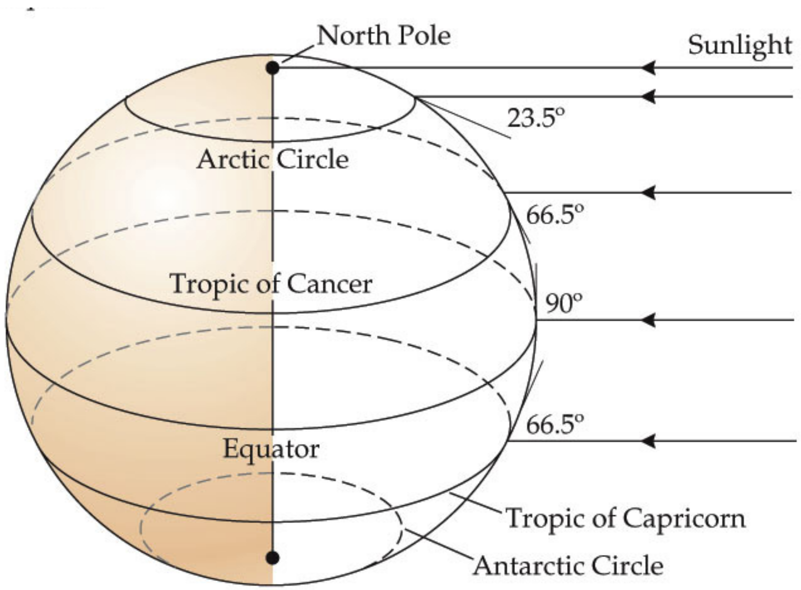


Figure 3.3 Lomolino *et al.* 2010

Temperature and thermal energy

The angle of inclination of the earth's axis causes seasonality

What is the angle and how does this relate to the Tropic of Cancer and Capricorn?



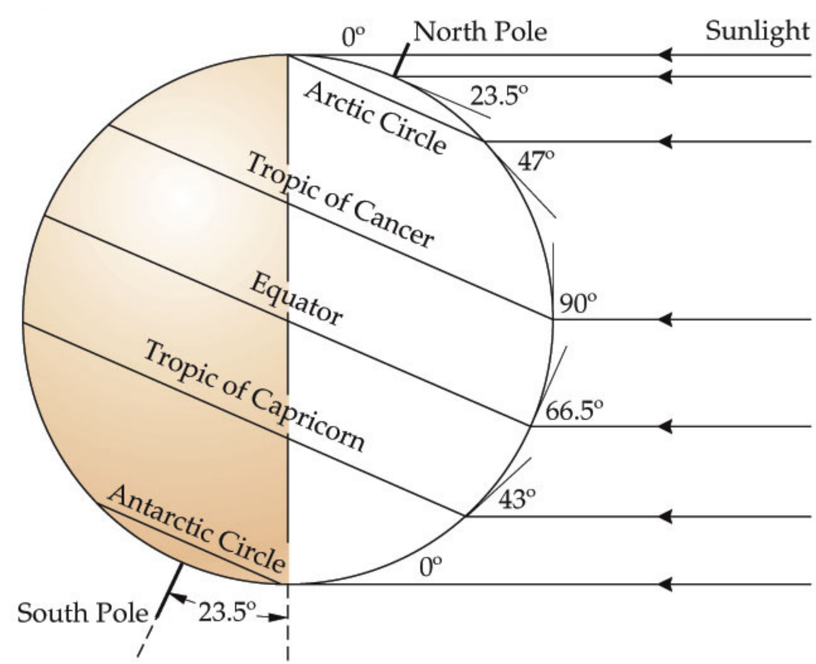


Figure 3.3 Lomolino *et al.* 2010

Looking at the figure on the right, what day of the year is it?

Cooling effects of elevation

We examined latitudinal variation in temperature and seasonality ...what about altitude?

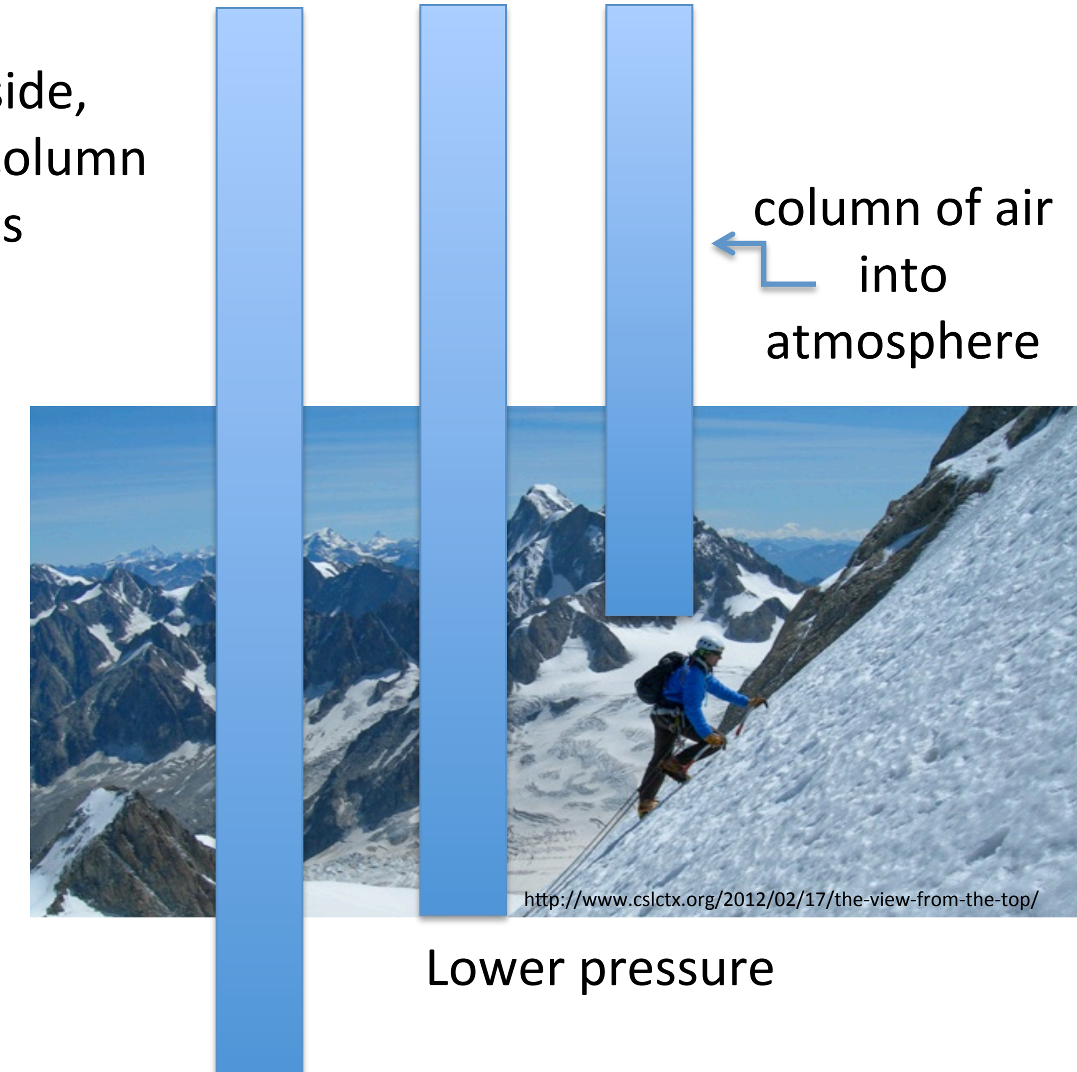
Why does Mount Kilamanjaro, near the equator in East Africa, have permanent ice at the top?

This has to do with thermal properties of air...

Cooling effects of elevation

As a climber goes up a mountainside, the length (and pressure) of the column of air above the climber decreases

With reduced pressure, air undergoes **adiabatic cooling,** a process where gases lose heat energy as molecules move farther apart (and have fewer collisions)



Winds and Currents

Coriolis Effect: the tendency for moving objects (e.g., wind and currents) to veer clockwise (to the right) in the NH and counterclockwise (to the left) in the SH. We see this effect generally between 0° and 30° North and South latitude

https://www.youtube.com/watch?v=dt_XJp77-mk

The coriolis effect also influences the rotation of large storm systems like hurricanes, explained well in this video:
https://www.youtube.com/watch?v=i2mec3vgeaI

Winds and Currents

Differential heating with latitude drives the major atmospheric air circulation, resulting in global wind patterns

1) Equator is heated most intensively. Air at the equator expands as it is heated, becomes less dense than surrounding air and rises

2) Rising air reduces atmospheric pressure over the equator and surface air north and south of equator flows into area of reduced pressure

3) Rising heated air undergoes adiabatic cooling, is pushed away from the equator, and descends at ~30 degrees N and S latitude

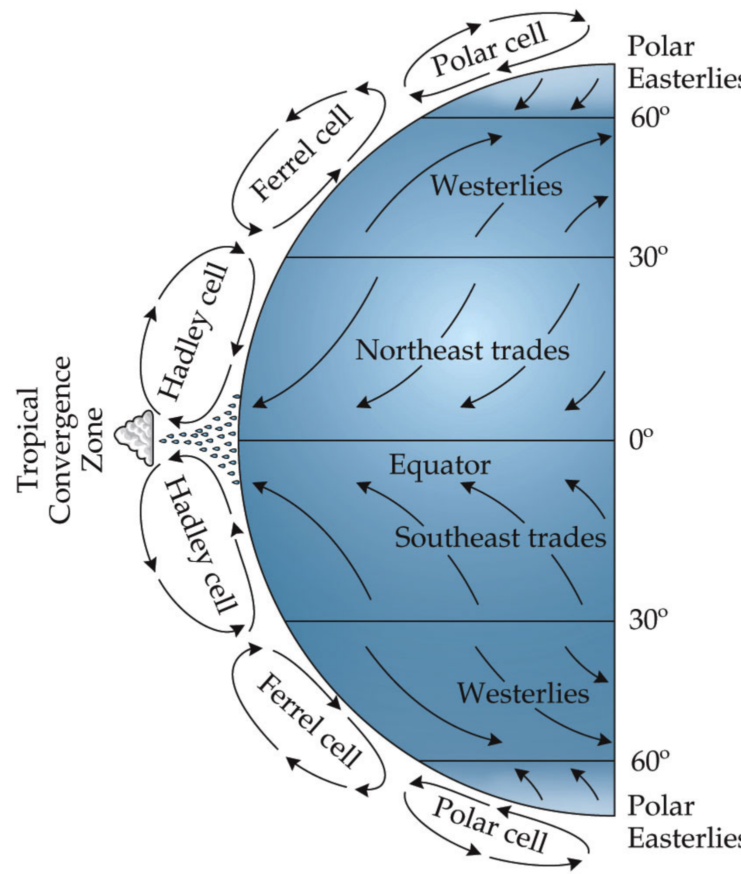


Figure 3.4 Lomolino *et al.* 2010

Winds and Currents

Differential heating with latitude drives the major atmospheric air circulation, resulting in global wind patterns

4) Circulating air masses produce surface winds blowing toward the equator between 0 and 30 degrees and toward the poles between 30 and 60 degrees

5) Surface winds do not blow due N or S because of the rotation of the Earth

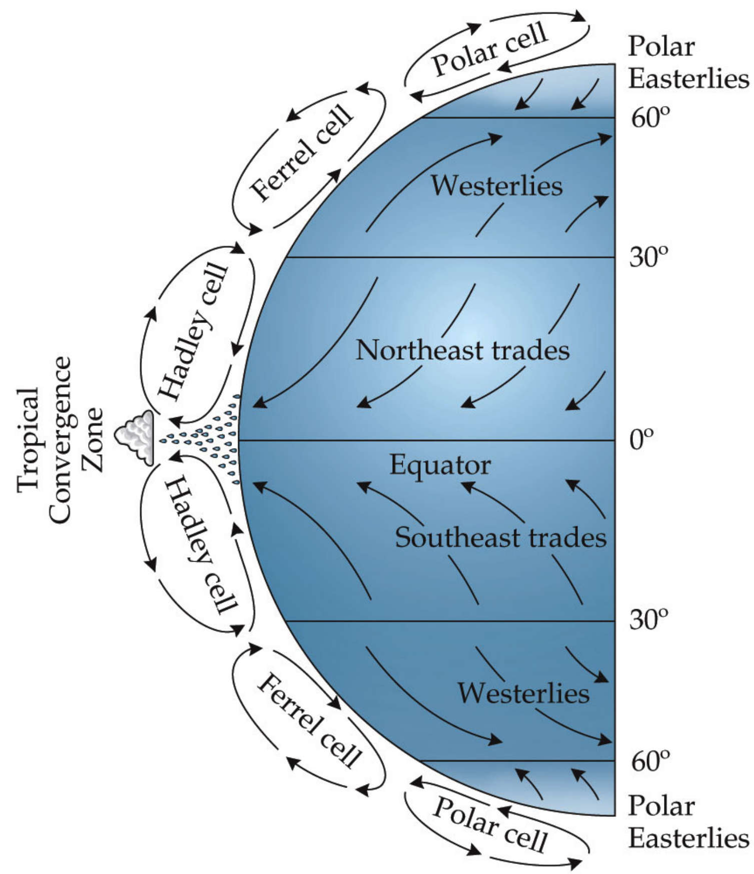


Figure 3.4 Lomolino *et al.* 2010

Winds and Currents

Differential heating with latitude drives the major atmospheric air circulation, resulting in global wind patterns

6) Every point on Earth's surface makes one rotation every 24 hours.

7) Points at higher latitudes travel a shorter distance with every rotation, moving at a slower rate than points at the equator

8) This induces the **Coriolis effect**, where surface winds are deflected toward the right in the NH and to the left in the SH

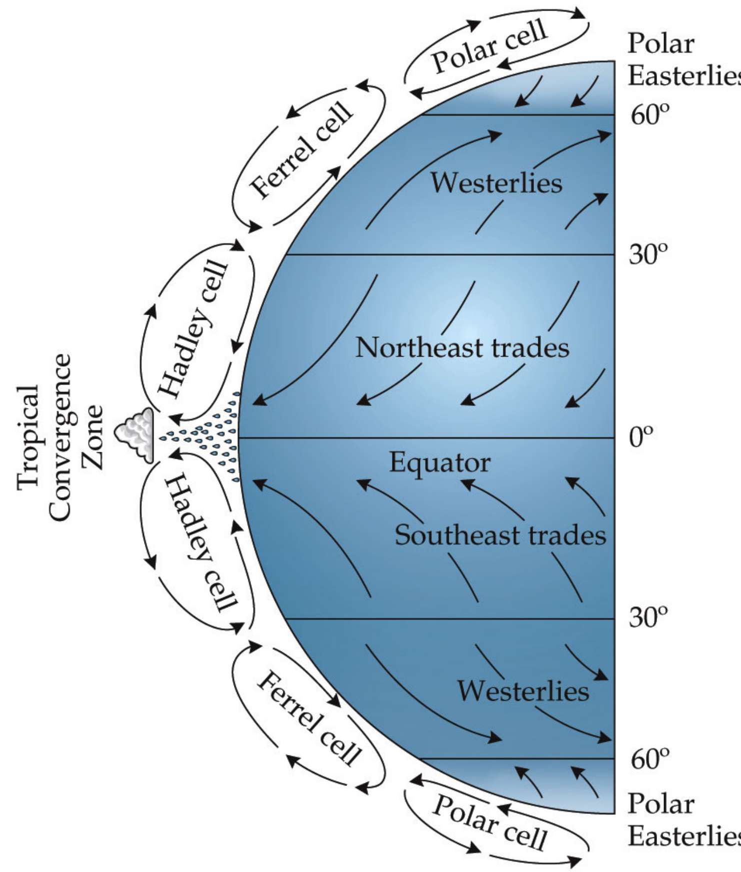


Figure 3.4 Lomolino *et al.* 2010

Winds and Currents

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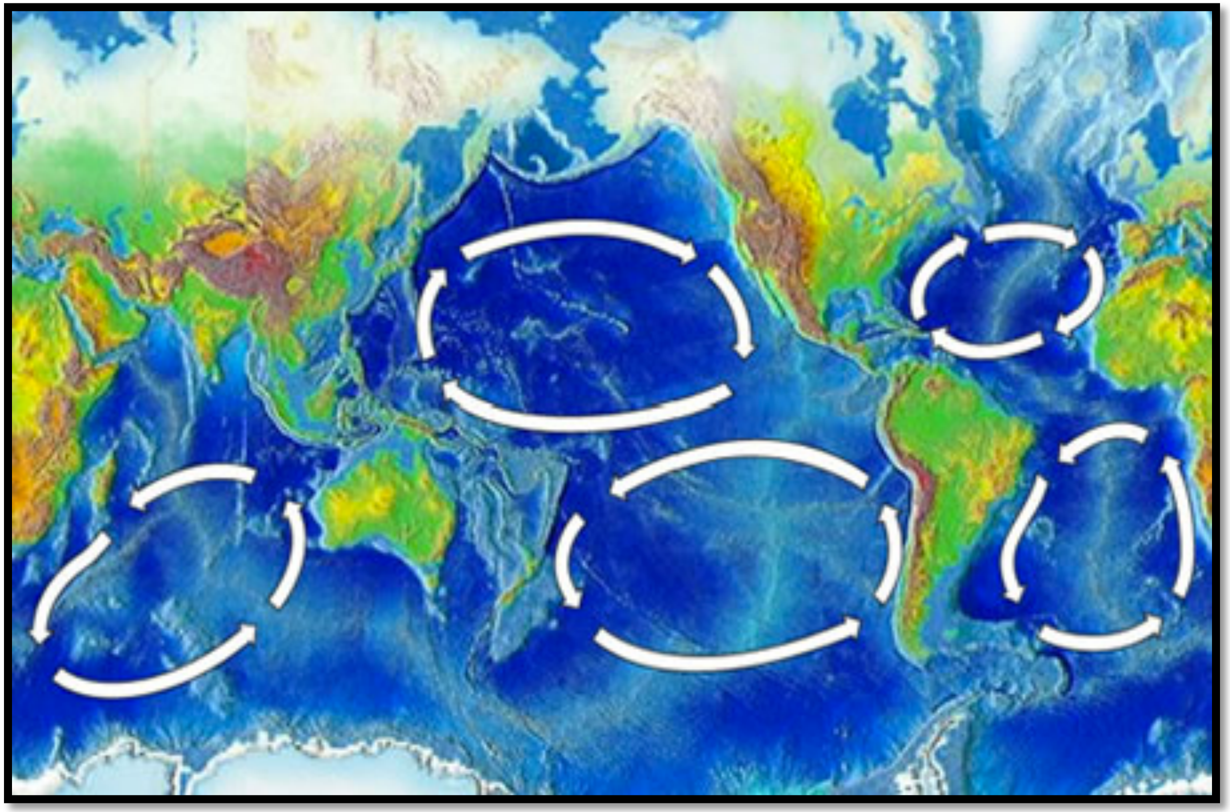
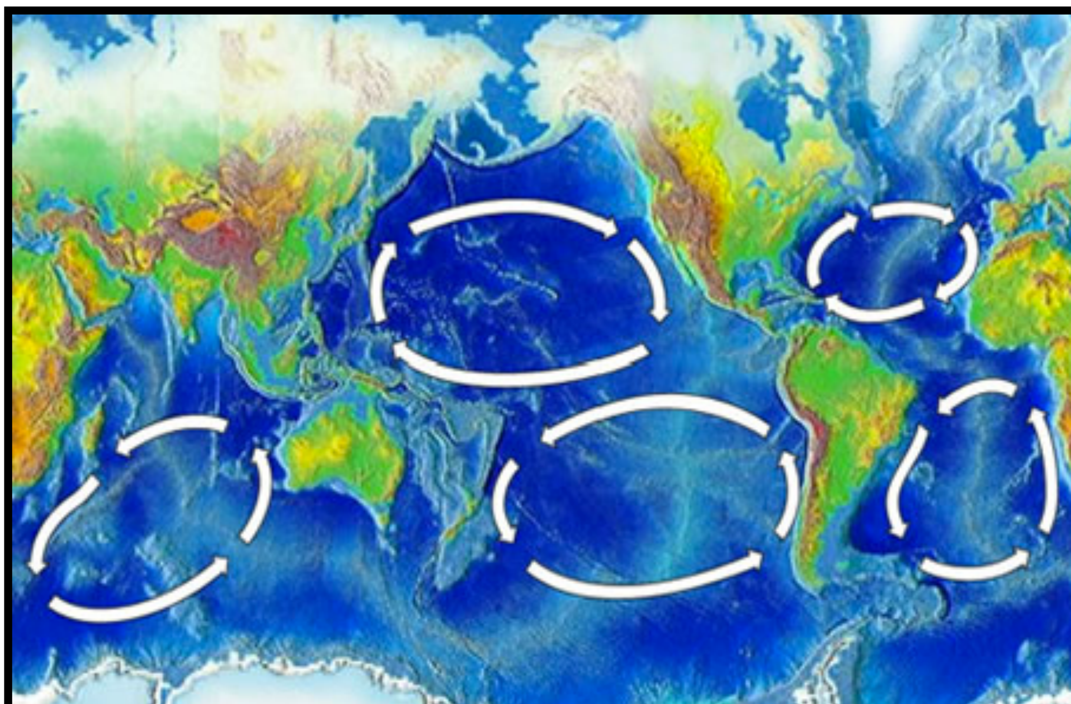


Winds and Currents

Surface winds initiate the major ocean currents

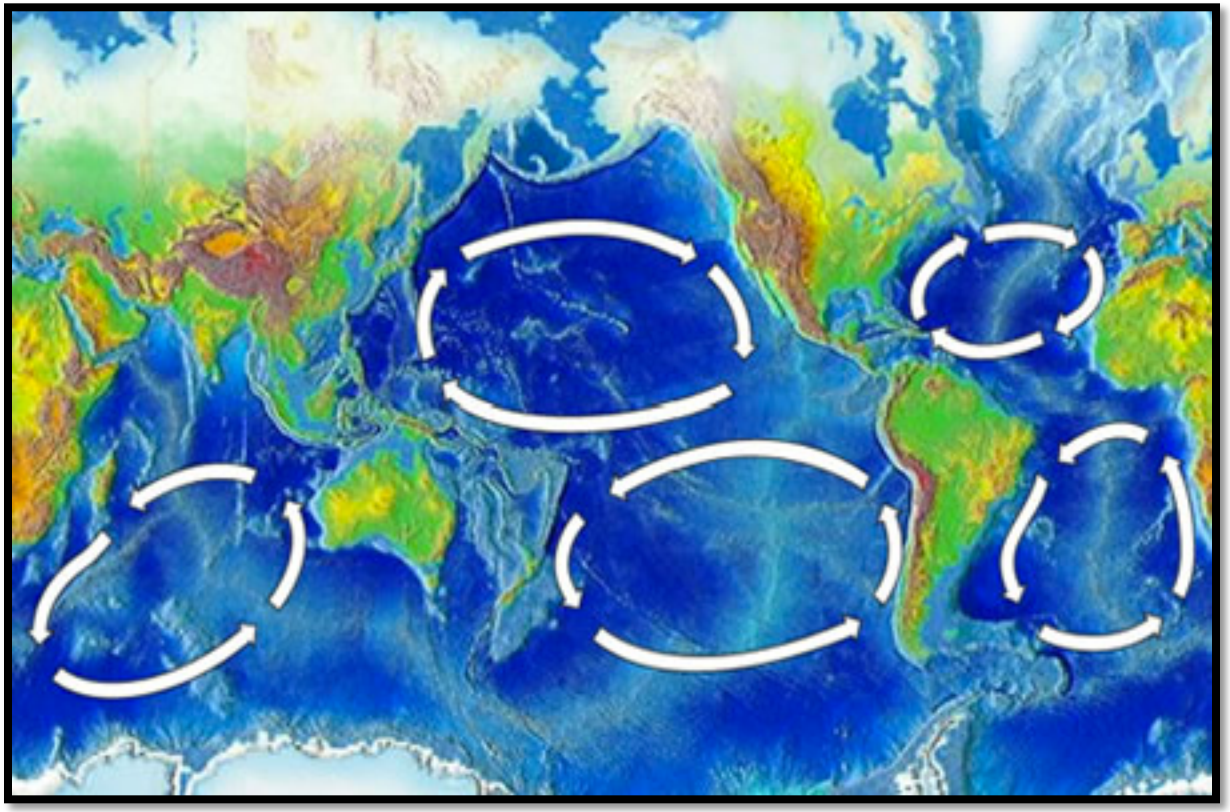
(1) Trade winds push ocean currents westward at the equator
(2) Westerlies produce eastward currents at high latitudes (N and S)

The net results are circular ocean currents, clockwise in the NH and counter-clockwise in the SH.



Winds and Currents

The five major ocean circling currents are called gyres:
N. Atlantic, S. Atlantic, N. Pacific, S. Pacific and Indian Ocean Gyres.



Winds and Currents

The temperature of currents and surface winds affects the climate on land

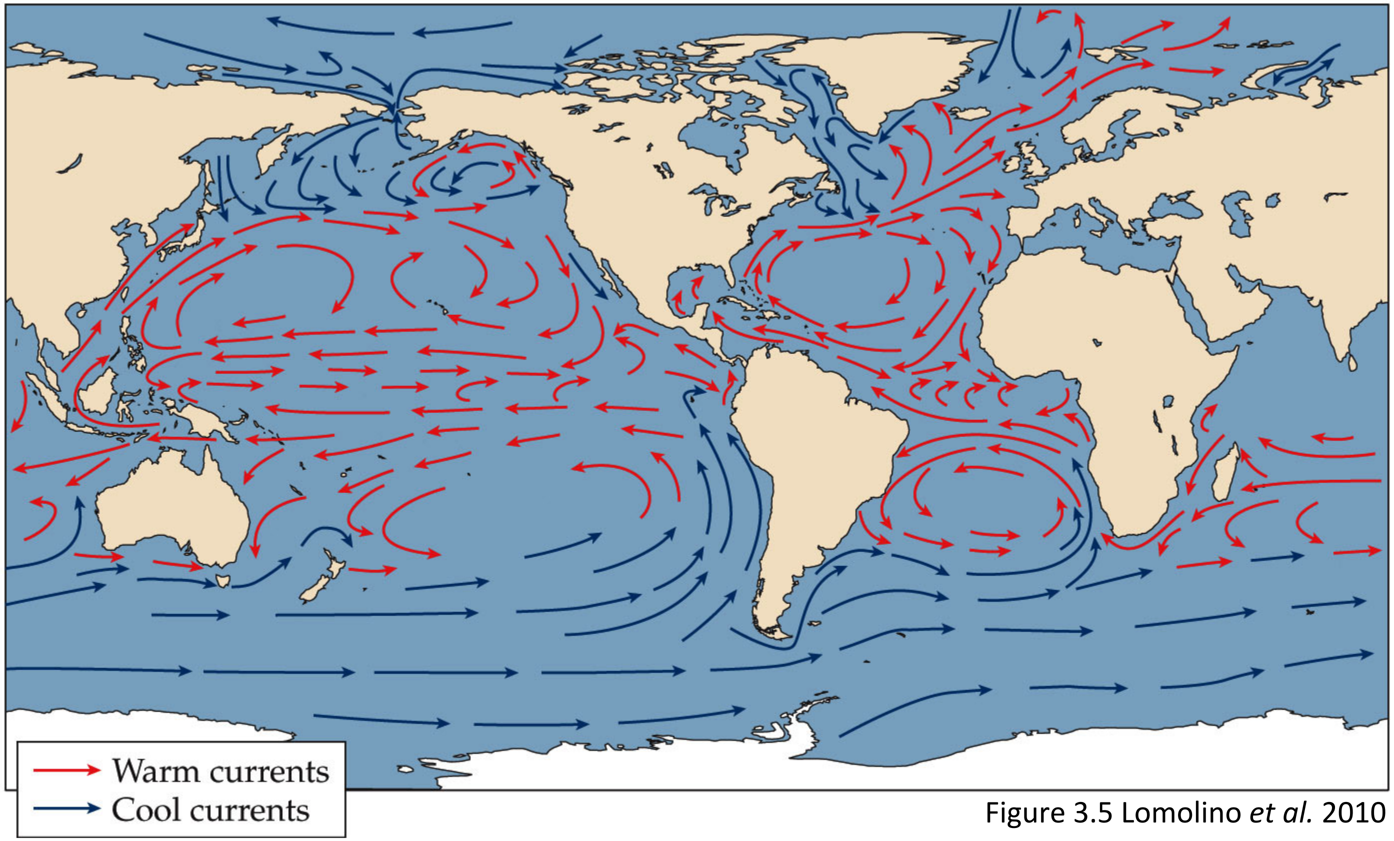


Figure 3.5 Lomolino *et al.* 2010

Geographic precipitation patterns

Global temperature, winds, and currents interact to influence precipitation

Part of this has to do with cloud formation and adiabatic cooling...

As air warms, it can absorb more water vapor evaporated from land and water

When air contains moisture and cools, there is a point at which the air is saturated with water vapor (dew point)

Further cooling results in condensation and cloud formation. When water and ice particles are too heavy to remain airborne, they fall as rain and snow.

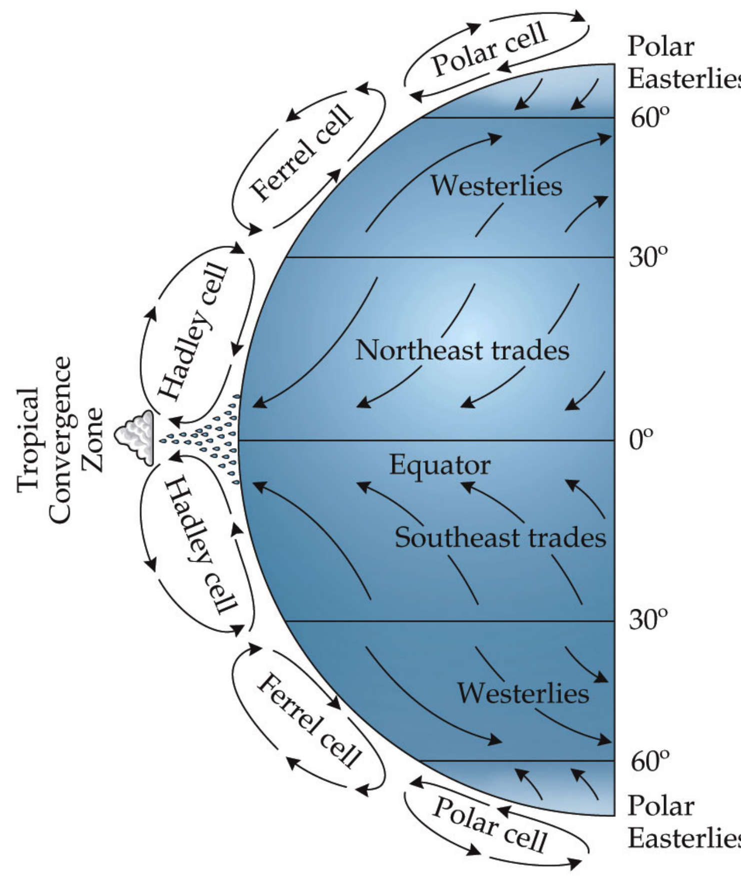


Figure 3.4 Lomolino *et al.* 2010

Geographic precipitation patterns

Horse Latitudes: warm, dry surface winds "dry-out" the land and create most of our great deserts near 30º N and S latitude
(e.g., Mojave, Sonoran, Sahara, Gobi, and Great Sandy deserts)

Tropical rains are heaviest when the sun is directly overhead and the rate of heating is most intense
(the spring and fall equinoxes)

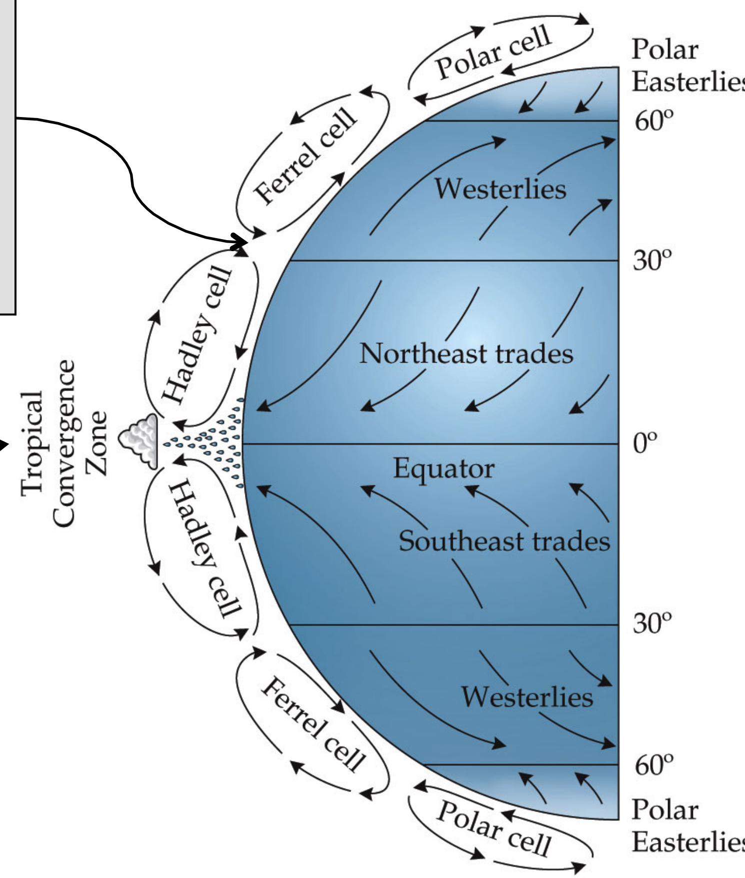


Figure 3.4 Lomolino *et al.* 2010

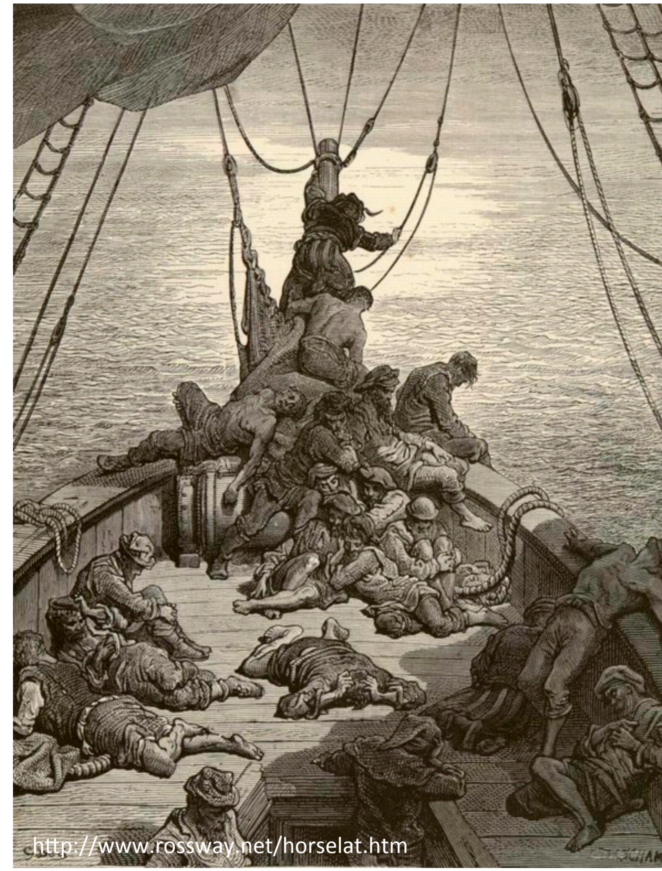
Horse Latitudes and adjacent zones

Two belts of dry climates encircle the globe

Over land, these belts are the world's deserts and Mediterranean climates (mild rainy winters and hot dry summers)

Over oceans, these belts have hot air and little wind

The term may come from when Spanish ships transported horses to the West Indies

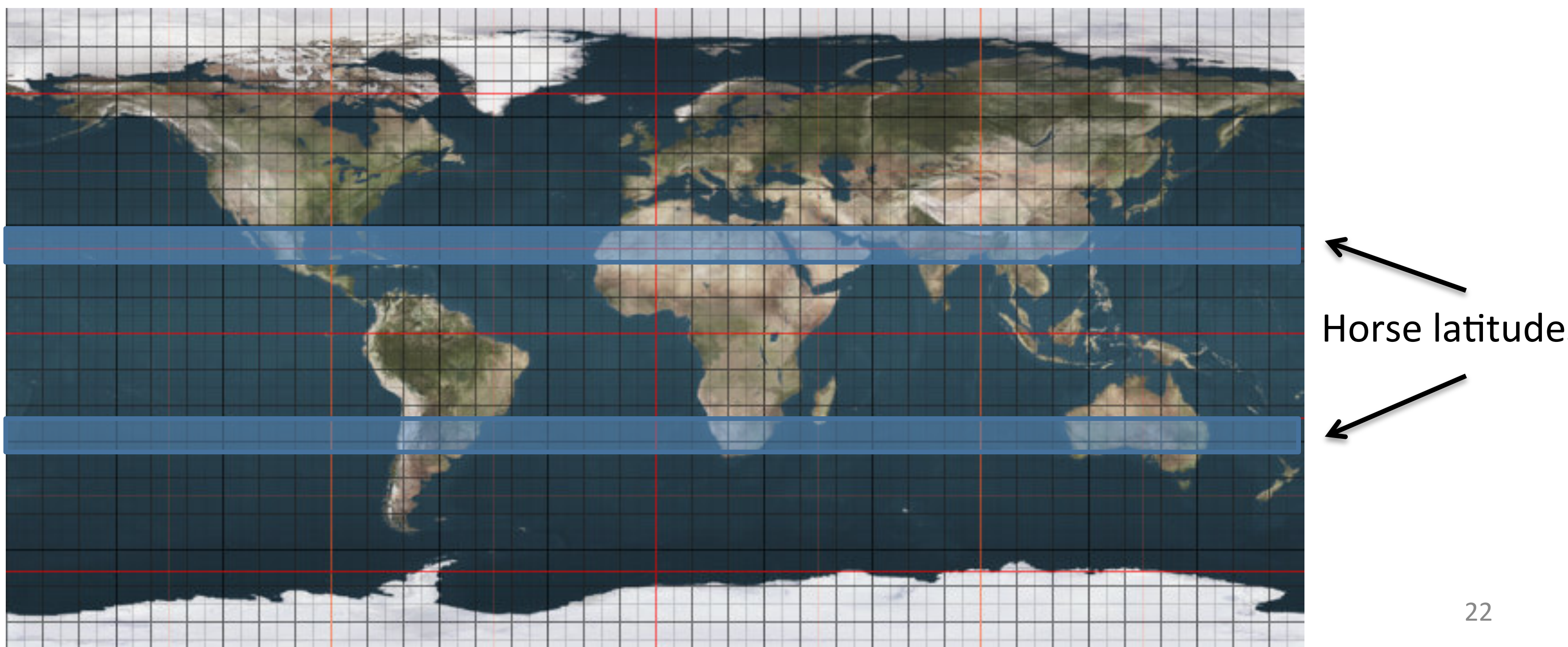


Ships would slow in mid-ocean in this latitude, prolonging the voyage... water shortages forced crews to throw their horses overboard

Horse Latitudes and adjacent zones

Deserts and Mediterranean climates are usually on the Western side of continents

Here, the land temperature is warmer than the cold ocean…
cool westerly winds off the ocean warm when they pass over land
Thus, they absorb lots of water and “dry the land” when they come onshore

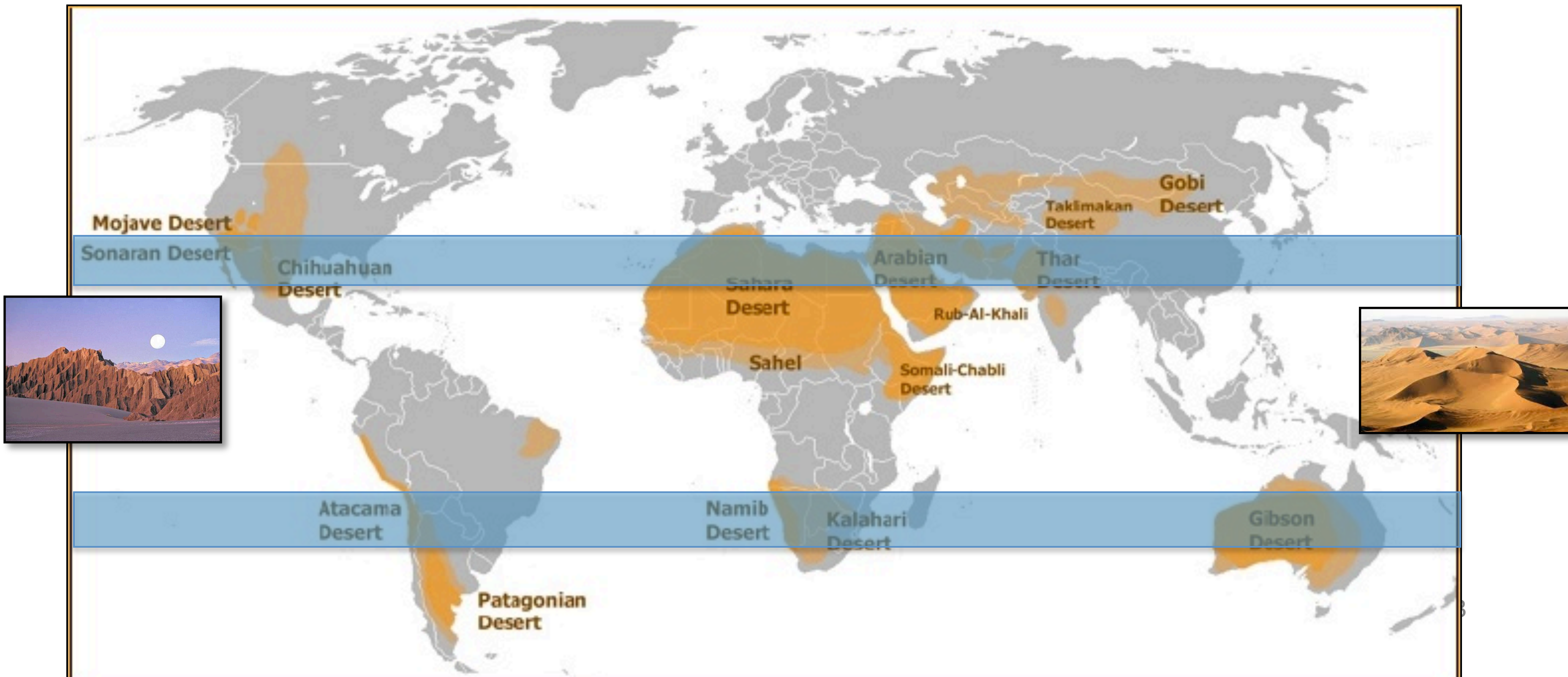


Horse Latitudes and adjacent zones

The world's driest deserts occur where westerlies bring cold currents and surface winds. In winter, there is little rainfall and summers are hot and dry

Atacama Desert: 1 mm/year

Namib Desert: 2-20 mm/year



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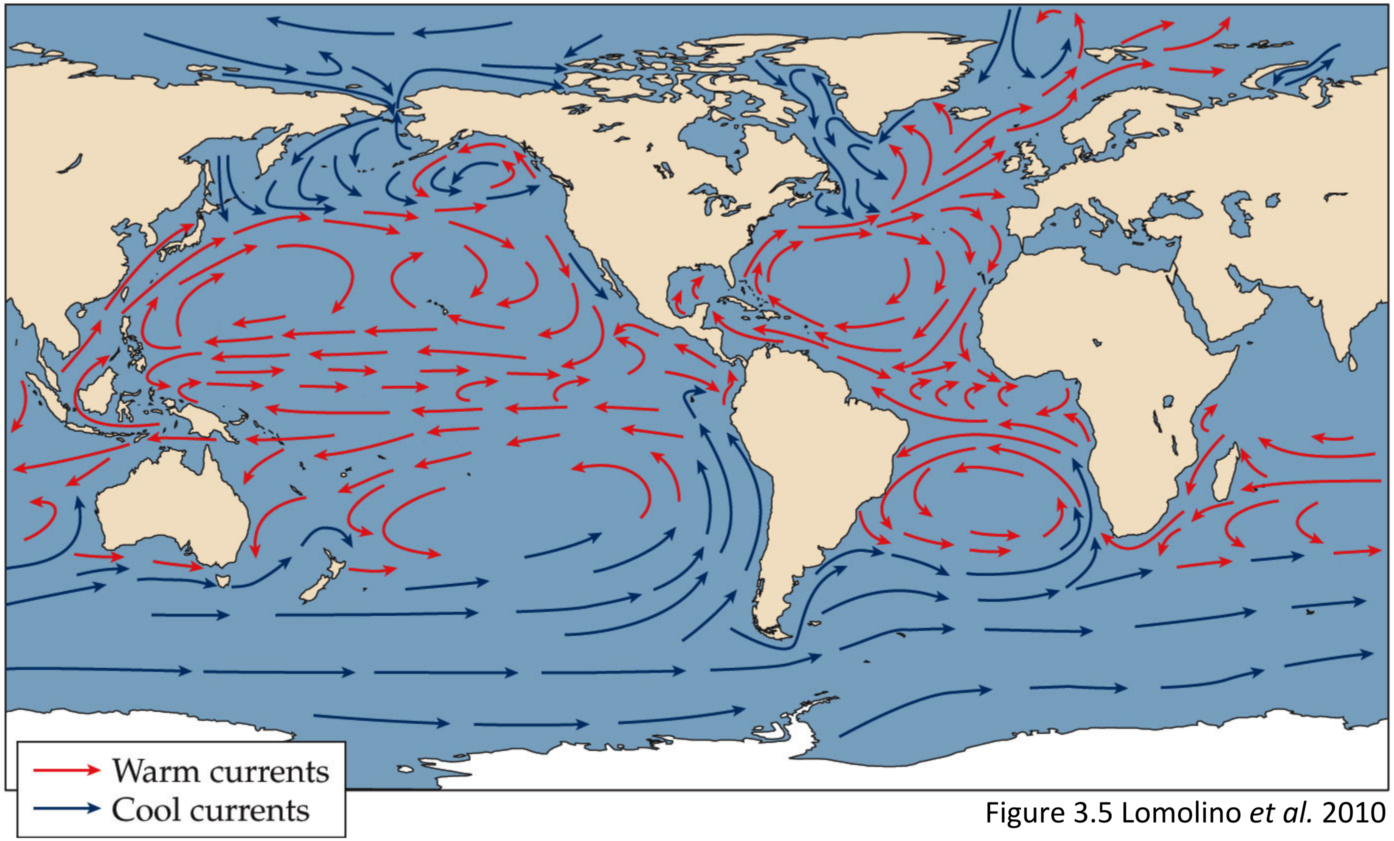


Figure 3.5 Lomolino *et al.* 2010

Regional precipitation

Mountains, in particular, have complex effects on regional precipitation

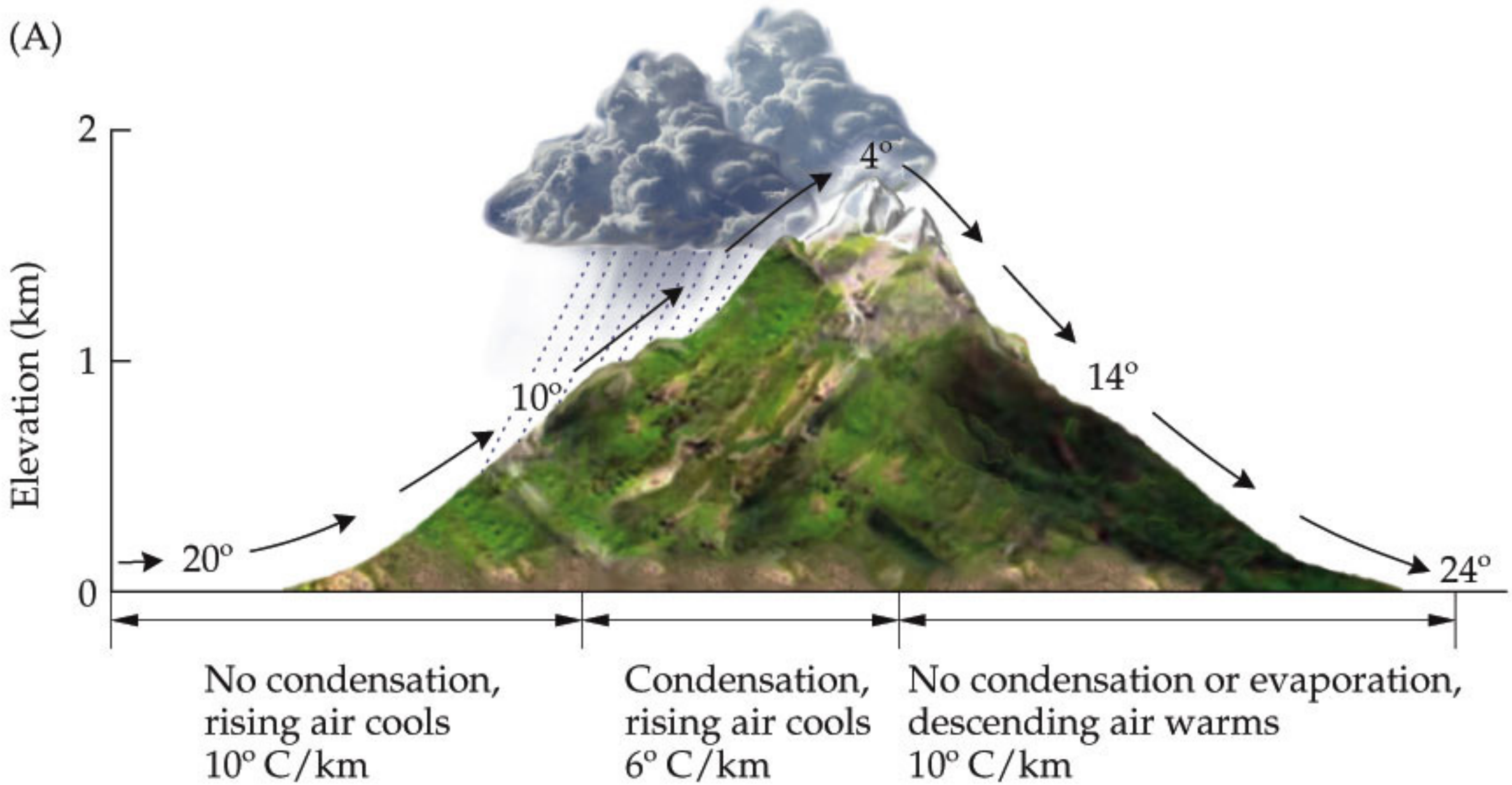


Figure 3.7 Lomolino *et al.* 2010

Regional precipitation

The **adiabatic lapse rate** is how quickly air cools as it rises. This rate varies for several reasons, but generally differs with and without condensation.

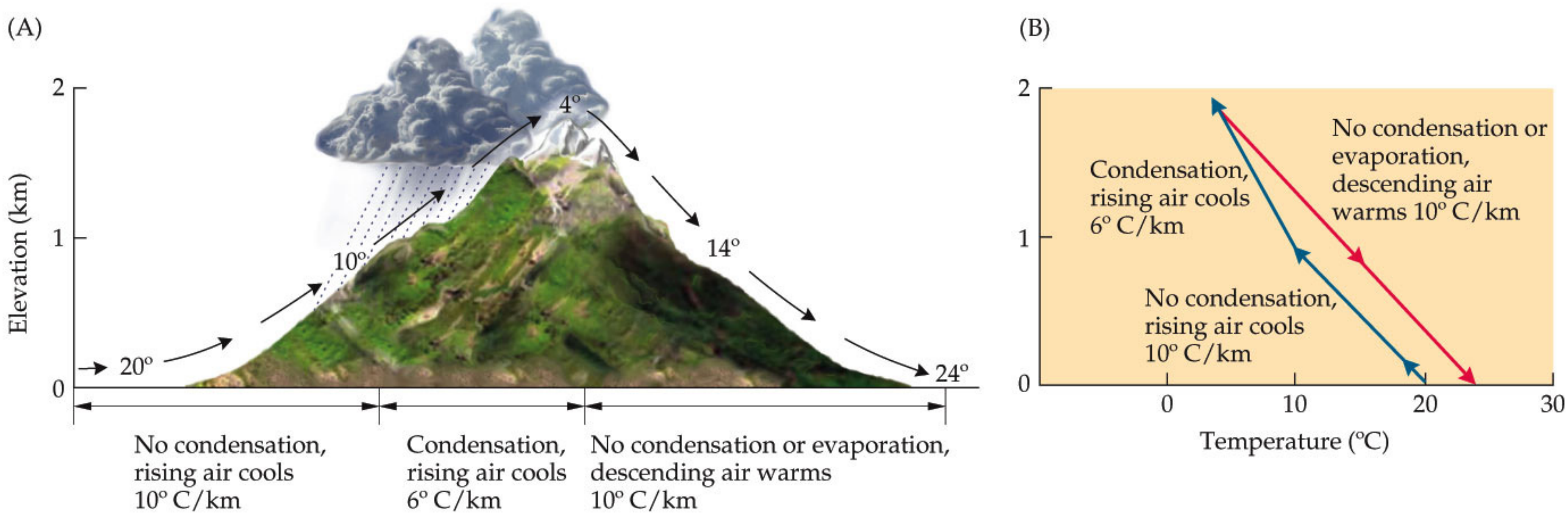


Figure 3.7 Lomolino *et al.* 2010

Regional precipitation

Air cools and loses moisture as it moves up the mountain slope
As it passes over the crest and descends, it warms at a higher rate
This creates a rainshadow effect on the leeward side of mountains

In Puerto Rico, the leeward side of the island receives lots of rain, but the southwest experiences an intense rain shadow effect

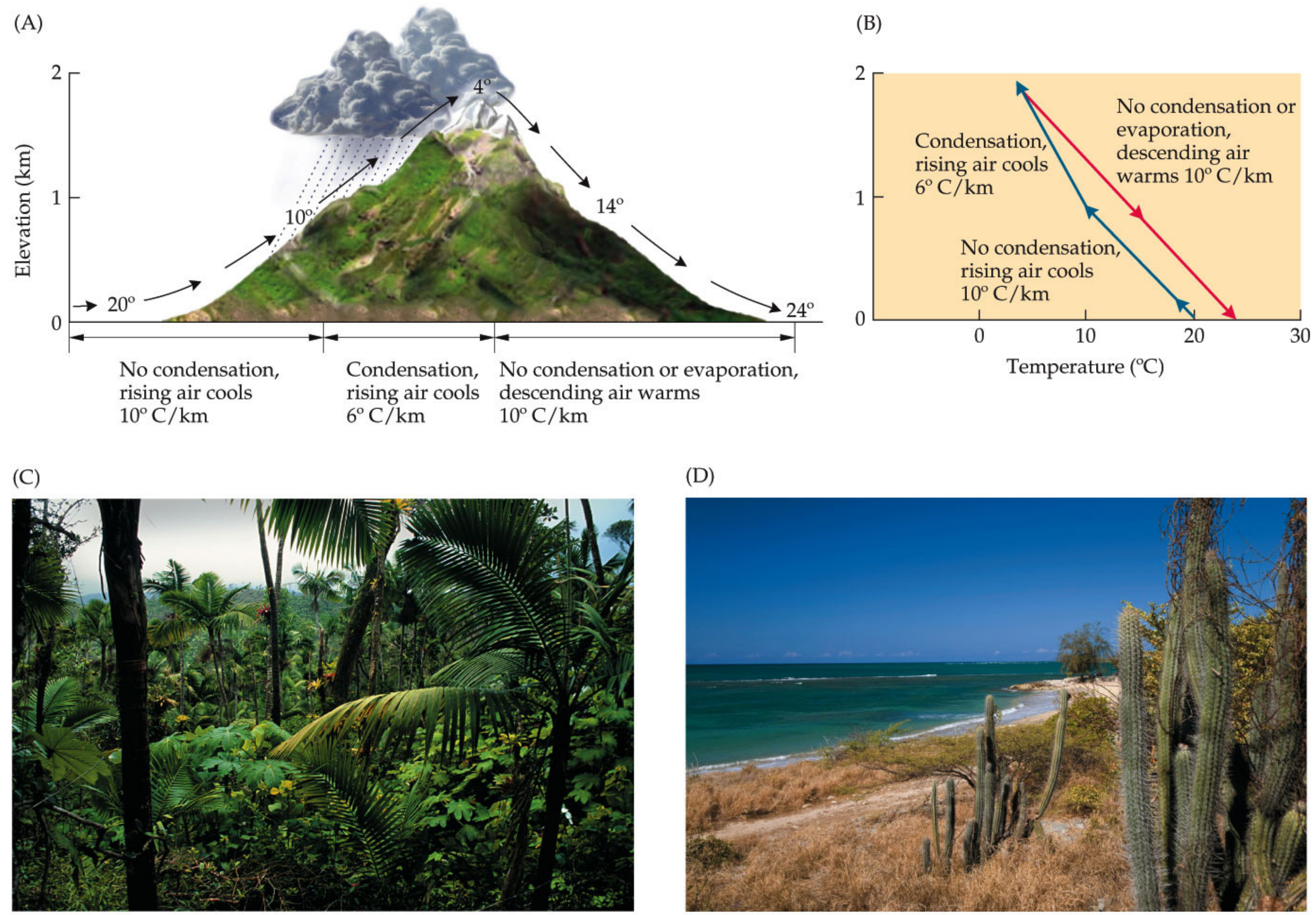


Figure 3.7 Lomolino *et al.* 2010

Not all mountain ranges are the same…

Mountains differ in temperature and precipitation regimes for many reasons: latitude, height and age, to name a few

As a comparison…consider these two ranges…

Whistler, Pacific Range, British Columbia, Canada

Great Smoky Mountains, Appalachian Range, Tennessee-North Carolina, USA

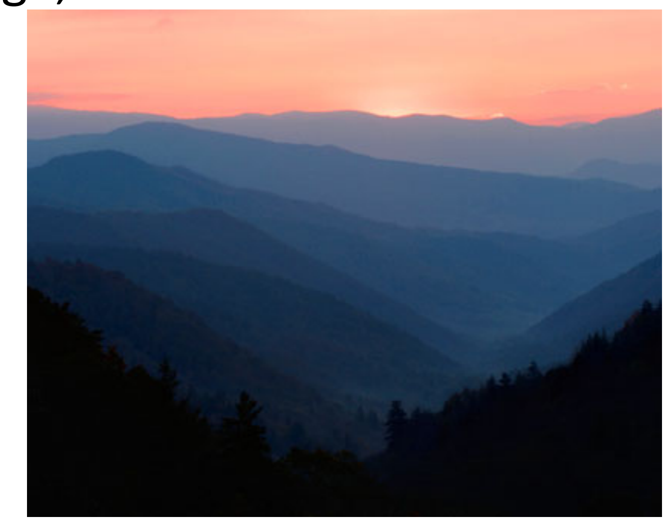
Not all mountain ranges are the same…

Consider how the height and position of mountains, combined with weather patterns, affect regional climate

Whistler, Pacific Range, British Columbia, Canada

Latitude: 51 degrees N
Highest peak: 4019 m (13186 ft)
Age: 60 million years

Great Smoky Mountains, Appalachian Range, Tennessee-North Carolina, USA



Latitude: 40 degrees N
Highest peak: 2037 m (6684 ft)
Age: 480 million years

Whistler vs. Great Smoky Mountains

Whistler, Pacific Range,
British Columbia, Canada

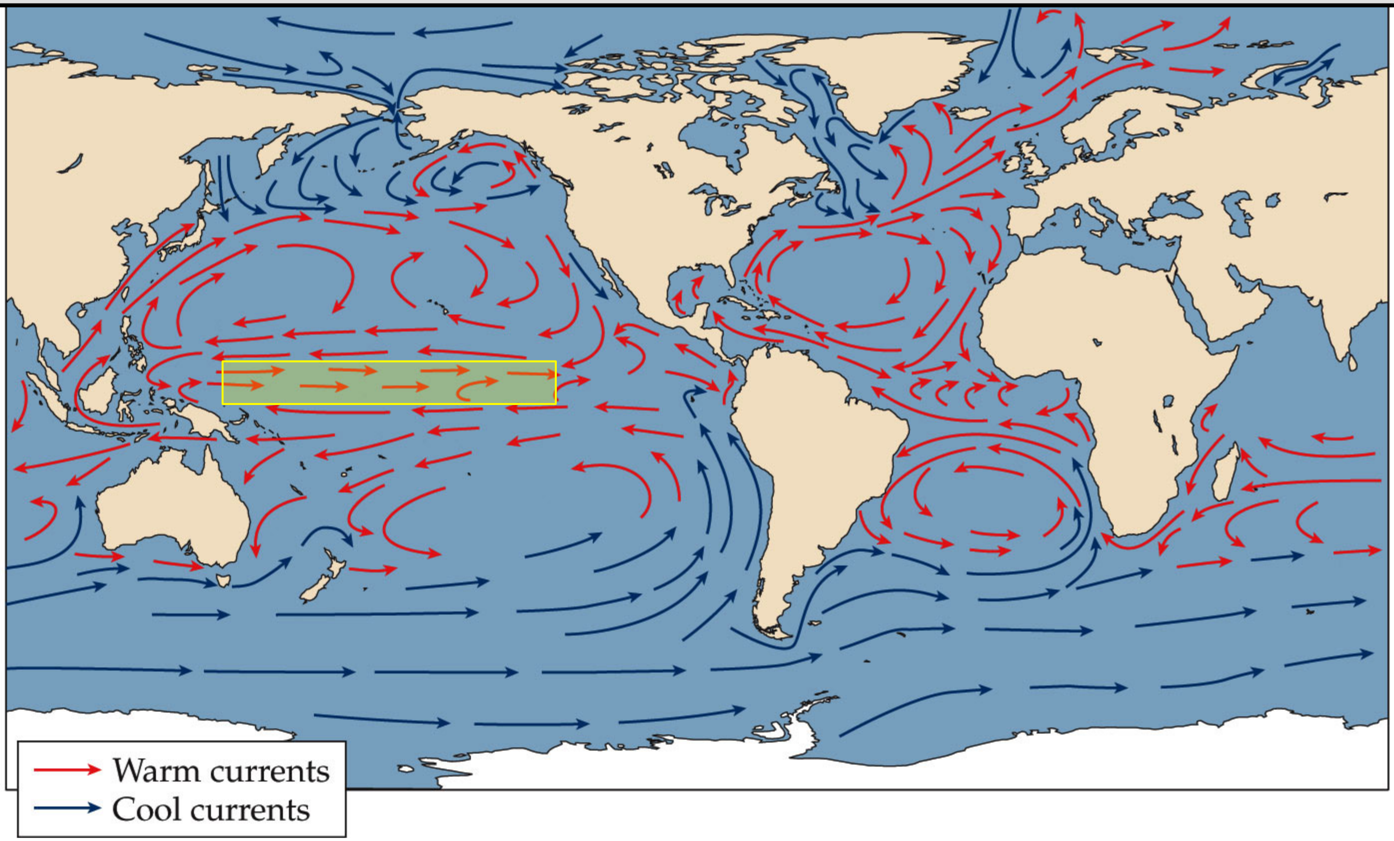
Great Smoky Mountains, Appalachian
Range, Tennessee-North Carolina, USA

These mountains have different effects on regional precipitation and climate (older mountains tend to be smaller with smaller rainshadow effects)

Climate variation

Seasonal and long-term variation in precipitation are tied to changes in solar radiation and current strength

El Nino Southern Oscillation (ENSO): period of weather change that occurs every 2-7 years due to strengthening of the equatorial countercurrent (cause still under study).
Increased rain (often 10x) in arid coastal regions of SA with reduced coastal upwelling



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Strong warm current pushes moisture laden air up the coasts of N and S America

Results in heavy precipitation in winter when the land is colder than offshore waters

The only time it rains in the extremely arid coastal deserts of South America

Atacama Desert

Climate variation

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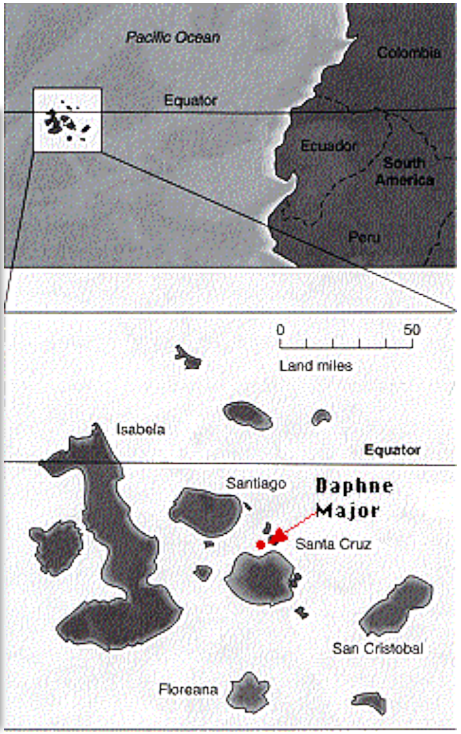
Brings more rain
(good for land dwellers)

Warm current reduces upwelling and food
(bad for marine life)

Galapagos Islands



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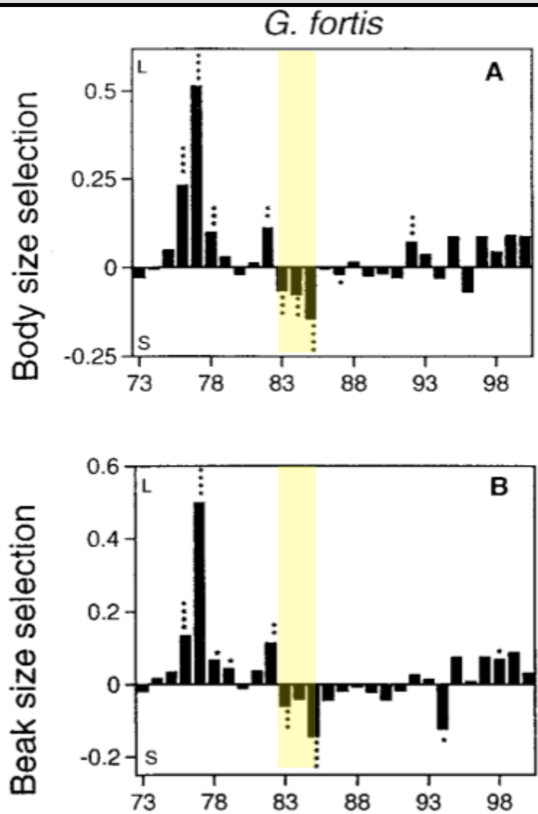


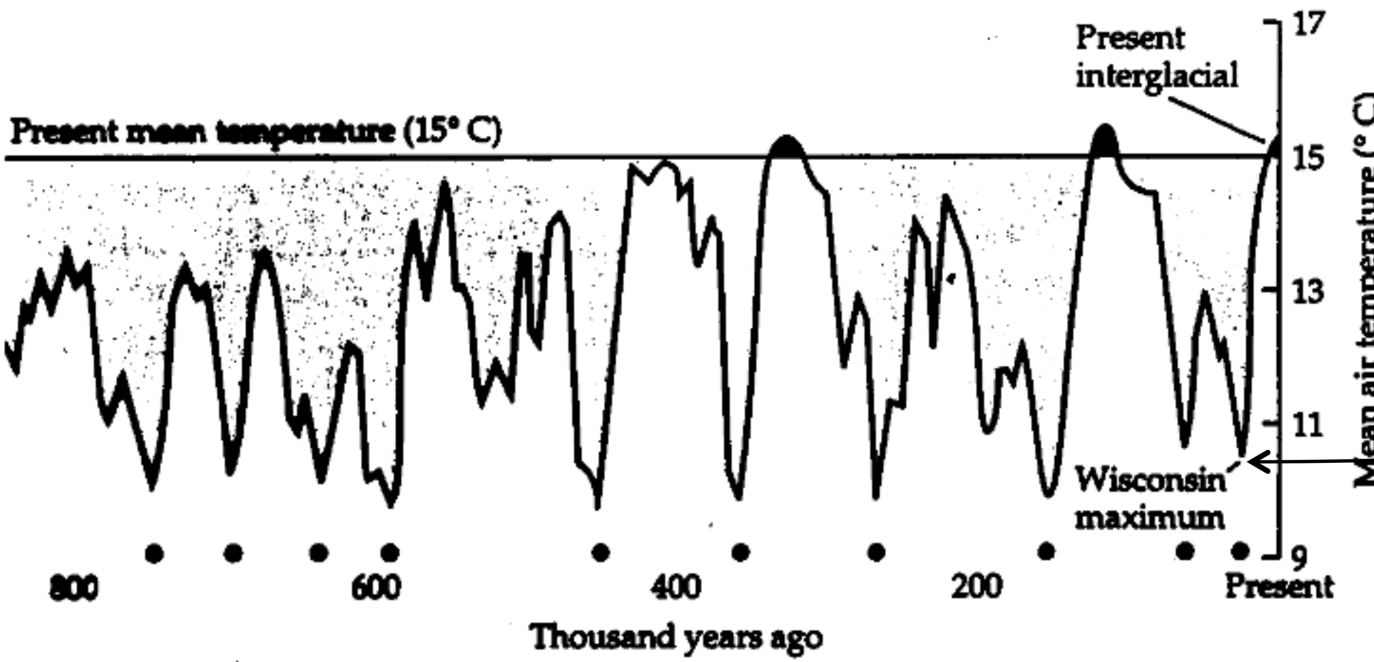
The especially strong El Nino in 1983 increased food availability on the islands, which alleviated selection on beak and body size in two finch species

(From Grant and Grant 2002)

Climate change

Global climate has changed frequently.

Climate has clearly changed with cycles of glaciation (more on this later)

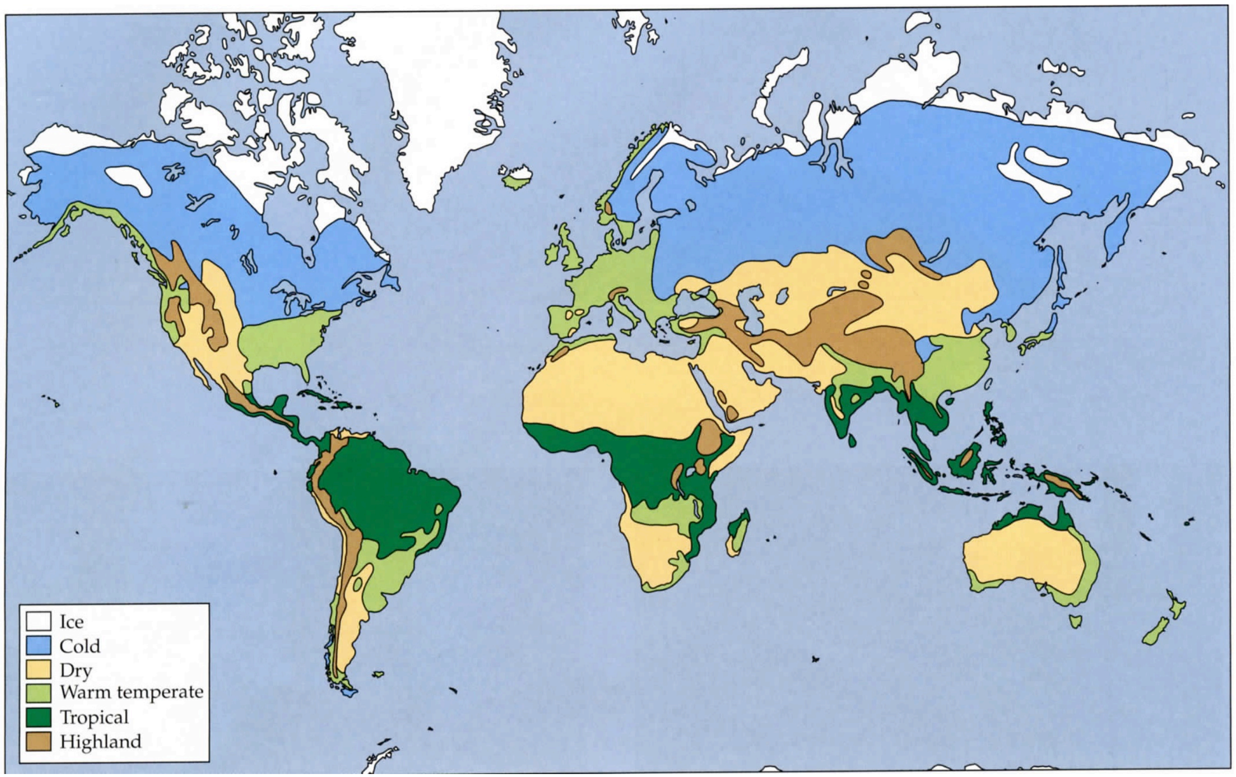


Change since last glacial max has not exceeded about 1 °C per 1000 yrs.

(From Gates 1993)

Climate reflects temperature and precipitation

This map should be more familiar now, with an understanding of latitudinal variation in temperature and why we see deserts and rainforests where we do…



(From Lomolino *et al.* 2010)

Climate and Climate Change

References for this section:

Gates, D.M. 1993. *Climate Change and its Biological Consequences*. Sunderland, MA: Sinauer Assoc.

Grant, P.R., and B.R. Grant. 2002. Unpredictable evolution in a 30-year study of Darwin's finches. *Science* 296: 707-711.

Lomolino, M.V., B.R. Riddle, R.J. Whittaker, & J.A. Brown. 2010. *Biogeography* (4th ed., Chapter 2). Sinauer Associates, Inc., Sunderland, Mass.

The Coriolis effect and the direction toilets drain in Northern & Southern Hemispheres:

https://www.youtube.com/watch?v=rdGtcZSFRLk

Your paper outline…

- Outline for the paper will be due ~ March 1st (after break)
- Your paper will be on a selected animal group of your choice (e.g., 3-5 species within a genus)
- The paper will explore the distributions and phylogenetic relationships of the group, to give a comprehensive picture of their biogeographic history