ESCI 344 – Tropical Meteorology
Lesson 13 – Monsoons

References: *Tropical Climatology*, McGregor and Nieuwolt
"The Elementary Monsoon," Webster, in *Monsoons*, Fein (Ed.)
"Monsoon Overview," Slingo, in *Encyclopedia of Atmospheric Science*
"Monsoon Dynamical Theory," Webster and Fusillo, in *Encyclopedia of Atmospheric Science*

Reading: *An Introduction to the Meteorology and Climate of the Tropics*, Chapter 8
"Monsoon Overview," Slingo

GENERAL

- **Monsoon comes from "mausim," which is Arabic for season.**
- **There are a number of different definitions.**
- **Ramage's definition**
  - **Prevailing wind directions shifts by at least 120° between January and July.**
  - **Prevailing wind direction persists at least 40% of the time in January and July.**
  - **Mean wind speed exceeds 3 m/s in either January or July.**
  - **Fewer than one cyclone-anticyclone alternation every 2 years in either January or July.**
- **According to Ramage's definition, only Asia, Australia, and Africa have distinct monsoons.**
- **A more relaxed definition commonly used:**
  - **Wind must reverse in direction between summer and winter.**
  - **Summer season must be very wet, and winter season very dry.**
- **Using this definition, North America also experiences a monsoon (in the Southwest U. S. and Northern Mexico.)**
- **Using the relaxed definition, over ½ of the tropics and ¼ of entire globe experience monsoon-type climates.**
- **Three main driving mechanisms for the monsoon:**
  - **Differential heating of land and ocean**
  - **Moist processes**

- **Rotation of the Earth**

DIFFERENTIAL HEATING OF LAND AND OCEAN

- **The specific heat of water is much larger than that of dry soil.**
- **Effective heat capacity difference is even larger, because mass of ocean is much larger.**
  - **Only the upper most few centimeters of land are heated, due to slow molecular transfer of heat vertically.**
  - **In oceans, heat is effectively mixed downward tens of meters via turbulent mixing.**
- **The difference in heat capacities, rather than specific heats themselves, is most important.**
- **Moist soil has higher specific heat than dry soil.**
  - **Saturated soil behaves more like "ocean" than land.**
- **Differential heating sets up a horizontal pressure gradient (similar to land/sea breeze only on much larger scale.)**

ROLE OF MOIST PROCESSES

- **Differential heating is not enough to explain the strength and extent of monsoon circulations.**
- **Moisture acts as "stored energy" through latent heat release.**
- **Evaporation occurs over the oceans, and then moisture is transported over the land, where it is released through condensation.**
  - **This essentially "focuses" the effects of the solar heating collected over the ocean onto the land areas.**
  - **This process is often referred to as the "solar collector."**
- **Latent heating results in a more intense monsoon flow, and also a vertically deeper monsoon flow.**
  - **A moist monsoon has a depth on the order of the troposphere.**
  - **A dry monsoon is much shallower, extending only to the mid-troposphere.**
- **Moisture also changes the character of the heating of the land.**

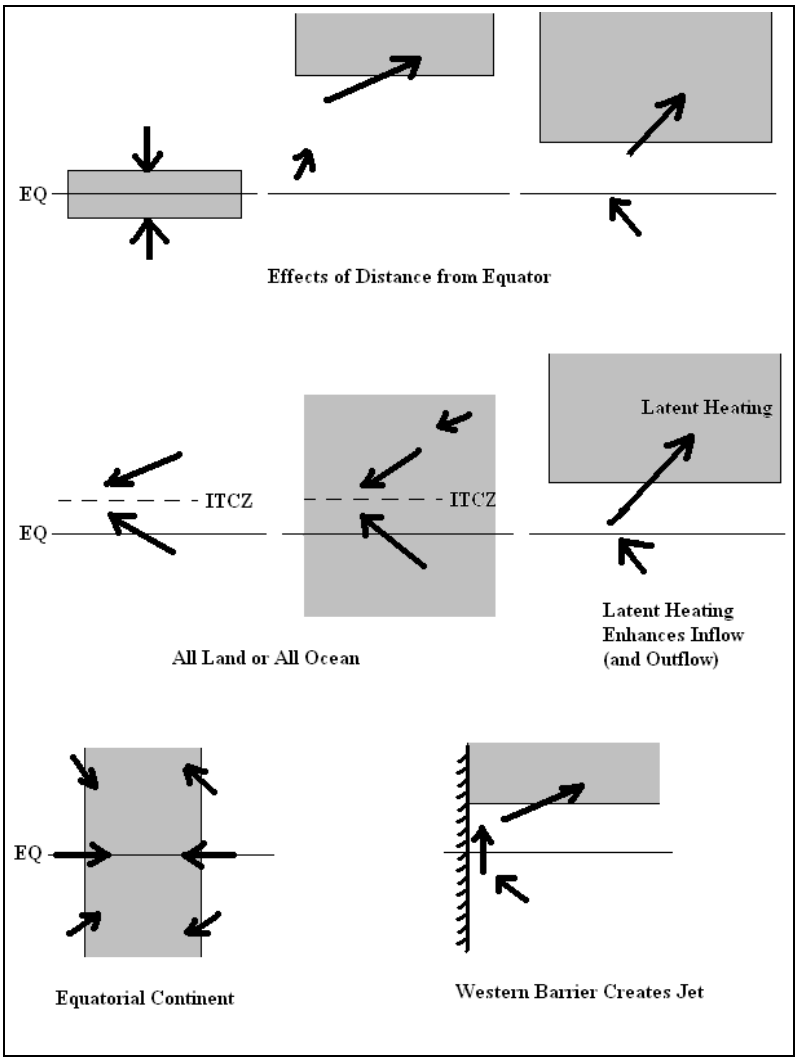
- **Moist land acts more like ocean.**
- **If land is dry, rising motion will occur closer to the coast, since the land will be very warm.**
- **As land becomes wet from precipitation, the rising motion will move inland over drier land.**
- **Precipitation will progress inland, allowing coastal area to dry out. Cycle will then repeat itself.**
- **This is one factor in monsoon variability and monsoon "breaks."**

ROTATIONAL AND FRICTIONAL EFFECTS

- **The Coriolis effect causes the air to "swirl" into the monsoon rather then flow directly in. It results in**
  - **cyclonic inflow at the surface**
  - **anticyclonic outflow aloft**
- **The longitudinal extent of the low-level, versus upper-level circulations are influenced by friction.**
  - **There is more cross-isobaric flow at the surface than aloft, so surface circulation has less of a longitudinal extent than does the upper-level outflow.**

LAND/OCEAN GEOMETRY

- **Latitude and orientation of land masses effect monsoon circulation, as shown in figure below, in which grey areas are land.**
- **Areas on or near Equator do not experience much rotation.**
- **Uniform surface (either all land or all water) result more in trade-wind trough ITCZ, and not monsoon (e.g., Central Pacific Ocean).**
- **Western boundary results in atmospheric jet (e.g., East African Low-level Jet).**



After "Physics of Monsoons: The Current View," J.L. Young, in *Monsoons* (Fein, ed)