

**ESCI 241 – Meteorology  
Lesson 13 – Small Scale Circulation**

**Reading: Meteorology Today, Chapter 10**

**SCALES OF ATMOSPHERIC MOTION**

- **Atmospheric circulations are broken-down into different scales based on physical size and duration.**
  - ***Macroscale* – This is the largest scale, and includes two important sub-scales**
    - ***Planetary scale* – These circulations last for weeks or months, and extend in size from 5000 to 40,000 km.**
      - **Examples are the Asian monsoon, *El Nino*, and *La Nina*.**
    - ***Synoptic scale* – These circulations last from days to weeks, and range in size from 100 to 5000 km.**
      - **Examples are the high- and low-pressure systems we see on weather maps. Also, hurricanes are synoptic scale phenomena.**
  - ***Mesoscale* – These circulations last from minutes to hours, and range in size from 1 to 100 km.**
    - **Examples are thunderstorms, tornadoes, and land-sea breezes.**
  - ***Microscale* – These are the smallest circulations, lasting under a few minutes, and being less than 1 km in size.**
    - **Examples are wind gusts and dust devils.**
- **The scales are not independent. A synoptic scale circulation may have mesoscale circulations embedded in it. For example, a hurricane (synoptic scale) contains numerous thunderstorms (mesoscale).**

**SOME MESOSCALE CIRCULATIONS**

- **Many mesoscale circulations are the result of differential heating. The hypsometric equation tells us that if a layer is warmed, its thickness will increase. If the heating (or cooling) is not uniform in the horizontal, the change in thickness can result in a horizontal pressure gradient, which will drive the circulation.**

- ***Land-sea breezes*** – These occur because water and land are heated at different rates.
  - During the afternoon the land is hotter than the water. This causes the thickness over the land to increase, and results in a shallow circulation from the sea to the land in the low levels (called a *sea-breeze*), and from the land to the sea in the upper levels.
  - During the night the land becomes cooler than the water. This causes a decrease in thickness over the land, and results in a circulation that is the reverse of the sea-breeze (called a *land-breeze*). The land-sea breeze circulation occurs only near the coastline (within 100 km or so), and is very regular.
  - The contrast between the cool ocean air moving over the land and displacing the warm air often sets up a *sea-breeze front*. In humid locations (such as Florida) this often triggers afternoon thunderstorms.
  - The land-sea breeze circulation doesn't have to occur by the ocean. Large lakes can also have these circulations.
- ***Mountain and valley breezes*** – These breezes occur because of differential heating between mountain peaks and valley.
  - *Valley breeze* – During the day the air along the mountain slopes gets heated more than air at the same elevation over the valley. This generates upward flow over the mountains, and a breeze from the valley toward the mountains.
    - The valley breeze is often why thunderstorms develop over the mountains in the afternoon.
  - *Mountain breeze* – At night the air over the mountain slopes cools much more quickly than the air over the valley. This sets up a circulation with flow down the mountain slopes, and down the valley.
- ***Drainage flow*** – Cold air is denser than warm air, and so cold air tends to collect in low-lying areas such as hollows or river bottoms, and this flow can generate light winds over terrain with little relief.
  - Since the cold air collects in low lying regions, these regions are often the first to experience frost or radiation fog.

- ***Chinook* (or foehn) Winds**
  - These winds occur when air moves up over a mountain barrier and then down the leeward side. As the air descends it is adiabatically compressed and warmed. These relatively warm winds are also very dry.
  - They usually occur over the east slope of the Rocky mountains during the winter. Here they are called *chinook*, which is the American Indian word for *snoweater*.
  - A similar wind occurs in the Alps, where they are called *foehns*.
  - The *Santa Ana* winds in California are also of this type.
- ***Katabatic* (fall) winds**
  - Katabatic winds are formed when air over snow-covered, high terrain is cooled and becomes very cold. It then drains down slope (similar to the mountain breeze). However, this air is very cold and dense, and moves down slope very rapidly.
  - Even though it is adiabatically warmed, it still arrives in the valley at very cold temperatures and causes a cold, stiff wind.
  - The most famous of the katabatic winds is the *Mistral* of the French Alps, which blows downward into the Mediterranean Sea.
- ***Country breeze*** – Though the name sounds pleasant, the country breeze is actually a result of the urban heat island, which sets up a circulation from the surrounding countryside into the city.