Local Winds
Scales of Motion

- **Microscale:** meters
  - Turbulent eddies
    - Formed by mechanical disturbance or convection
    - Lifetimes of minutes

- **Mesoscale:** km’s to 100’s of km’s
  - Local winds and circulations
    - Land/sea breezes, mountain/valley winds, thunderstorms, tornadoes
    - Lifetimes of minutes to hours

- **Synoptic scale:** 100’s to 1000’s of km’s
  - Circulations around high and low pressure systems
    - Lifetimes of days to weeks

- **Global scale:** systems ranging over entire globe
in this section....

• mountain waves
• land/sea breeze
• monsoons
• mountain/valley winds
• chinookks
• katabatic winds
shear instability (leads to clear air turbulence)

Kelvin Helmholtz waves or “billows”

(a) Small shear
(b) Increasing shear, boundary deforms
(c) Waves appear
(d) Turbulent eddies break

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Sea and Land Breezes

(a) Isobaric surfaces

(b) Cooled vs. Warmed

(c) Cool vs. Warm
• Sea breeze development
  – Solar heating raises land temperature more than water. Air in contact with land warms and rises
  – Cooler (denser) sea air moves in to replace rising air over land
  – Air sinks over the water in response to surface air movement, producing return circulation (land-to-sea breeze) aloft

(a) Sea breeze
- Land breezes form at night due to stronger radiative cooling of the land surface leading to sinking and offshore flow of this cooler air mass with return flow aloft.

Land breezes between adjacent large islands converge to produce nocturnal rain over the ocean.
Sea breeze convection around Sri Lanka
The Maritime Continent

Hot bed for land and sea breeze triggered convection
The Monsoon

• Monsoon winds are
  – Seasonal
  – Common in eastern and southern Asia
  – Similar to huge land/sea breeze systems
• During winter strong cooling produces a shallow high pressure area over Siberia
  – Subsidence, clockwise circulation and flow out from the high provide fair weather for southern and eastern Asia

• During summer, air over the continent heats and rises, drawing moist air in from the oceans
  – Convergence and topography produce lifting and heavy rain formation

Cherrapunji received 30 feet of rain in July 1861!
Mountain/Valley winds

- Sunlight heats mountain slopes during the day. Slopes cool by emitting IR radiation at night.
- Air in contact with surface is heated/cooled in response.
- A difference in air density is produced between air next to the mountainside and air at the same altitude away from the mountain.
- Density difference produces upslope (day) or downslope (night) flow.
- Daily upslope/downslope wind cycle is strongest in clear summer weather when prevailing winds are light.
Consequences of Mountain/Valley winds

• Upslope flow during the day leads to formation of clouds and precipitation along mountain ranges
  – When is the best time for hiking and climbing?
• Upslope flow along the Front Range transports pollutants from the urban corridor into the high country
Chinook

Common along the Front Range here in Colorado during winter months
A literal translation of the “Chinook wind” is the Snow Eater

• Why?
  – The relative humidity during a windstorm is often less than 10%
  – The temperatures are often quite warm, often in the 50’s or 60’s in the middle of winter
  – Coupled with the strong wind, snow rapidly sublimates (or melts) and quickly disappears
Katabatic winds

- Refers to any downslope flow, but generally refers to:
- Cold temperatures on plateau lead to horizontal pressure gradient. Gradient initiates downward motion of cold, heavy air along edges of plateau.
Santa Anna winds

• Specific type of katabatic flow.
• Cold temperatures lead to relatively high pressure over interior of western US.
• Flow descends rapidly through mountain passes in southern California.
• Winds warm due to compression.
• Already dry air (desert air) drops to even lower relative humidity as temperatures rise due to compressional warming.
Santa Anna winds
Camp Fire (north); Hill Fire (south) on Nov. 9, 2018
Dust devil
Common in summertime over heated, dusty terrain

Haboob (dust storm)
Common in Arizona during “southwest” monsoon

Figure 9.36 A well-developed dust devil moves over a hot desert landscape on a clear summer day.