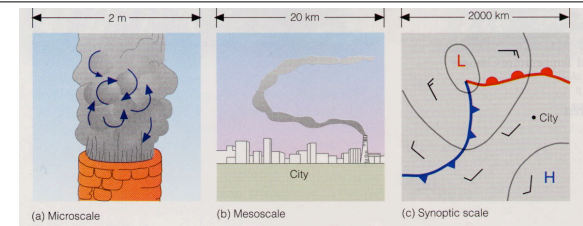




Scales of Motion

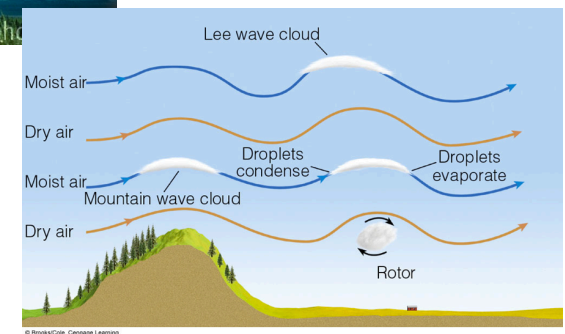


- **Microscale: meters**
 - Turbulent eddies
 - Formed by mechanical disturbance or convection
 - Lifetimes of minutes
- **Mesoscale: km's to 100's of km's**
 - Local winds and circulations
 - Land/sea breezes, mountain/valley winds, thunderstorms, tornadoes
 - Lifetimes of minutes to hours
- **Synoptic 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
- chinooks
- katabatic winds

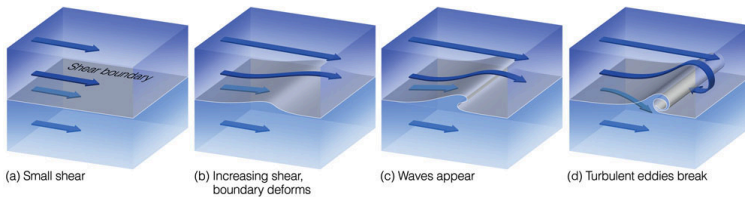
Mountain/Lee waves



shear instability (leads to clear air turbulence)



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(a) Small shear

(b) Increasing shear, boundary deforms

(c) Waves appear

(d) Turbulent eddies break

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Sea and Land Breezes

Sea and land breezes are:

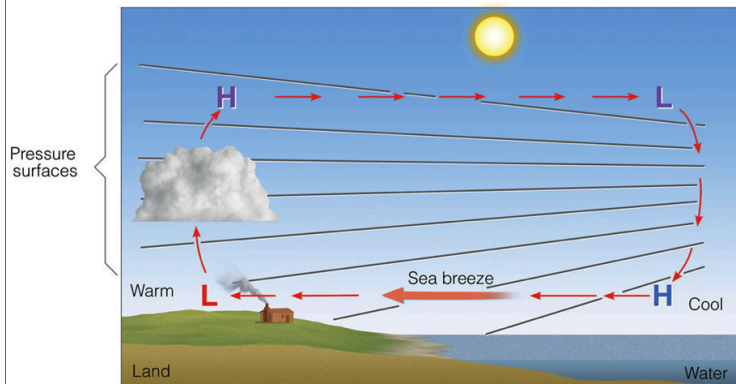
- Mesoscale coastal winds
- Thermal circulations driven by differential heating/cooling of adjacent land and water surfaces
- Most prevalent when/where solar heating is strong

Sea breezes:

- Cool coastal communities
- Bring more humid air
- Haze
- Fog
- Often produce summer thunderstorms inland from the coast

• Sea breeze development

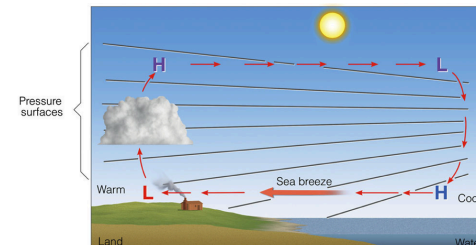
- Solar heating raises land temperature more than water. Air in contact with land warms and rises
- Cooler (denser) sea air moves in to replace rising air over land
- Air sinks over the water in response to surface air movement, producing return circulation (land-to-sea breeze) aloft



(a) Sea breeze

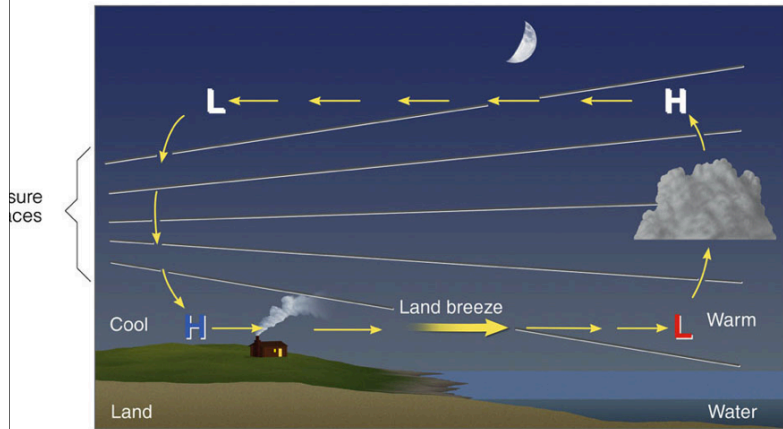
• We can also think of sea breeze formation in terms of pressure gradients

- Land is heated creating “bulging” pressure surfaces
- Heated column produces “H” aloft over land
- Air aloft flows outward from land to ocean
- Upper flow creates surface “H” over water
- Surface flow responds with flow toward land at low levels
- Large scale ascent over land destabilizes column - enhances cloud development - thunderstorms
 - descent over ocean stabilizes oceanic column



(a) Sea breeze

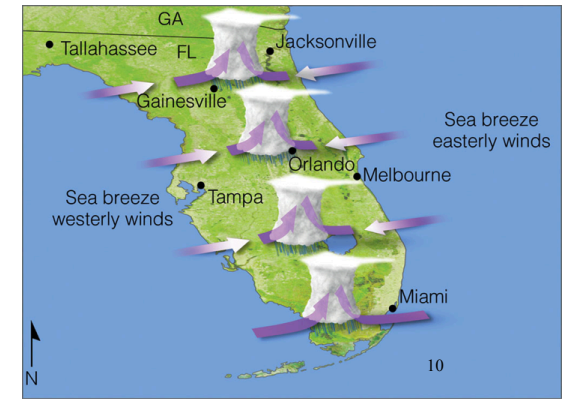
- Land breezes form at night due to stronger radiative cooling of the land surface leading to sinking and offshore flow of this cooler air mass with return flow aloft



(b) Land breeze

Cole, Cengage Learning

- Converging Gulf of Mexico and Atlantic sea breezes produce uplift and thunderstorm development in Florida



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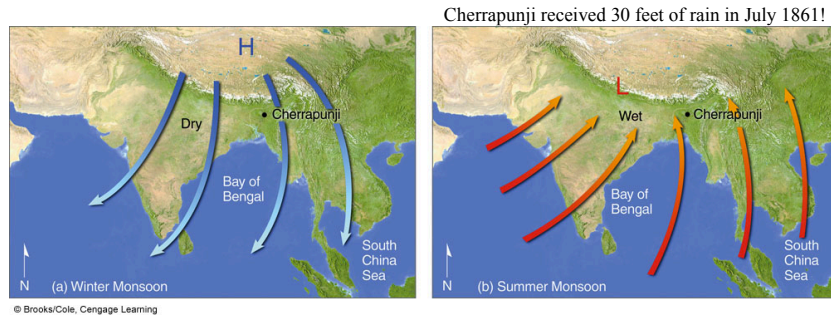
The Monsoon

- Monsoon winds are
 - Seasonal
 - Common in eastern and southern Asia
 - Similar to huge land/sea breeze systems



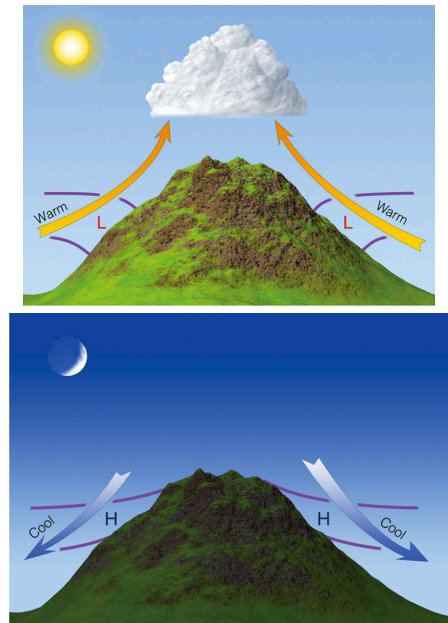
learning

- 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



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

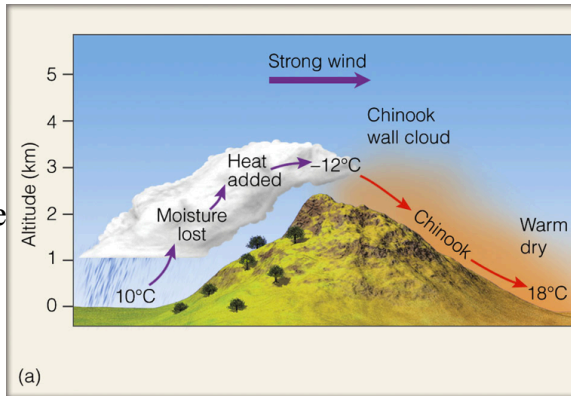
- Upslope flow during the day leads to formation of clouds and precipitation along mountain ranges
 - When is the best time for hiking and climbing?
- Upslope flow along the Front Range transports pollutants from the urban corridor into the high country



Chinook Down-slope Winds Meteorological Setting

- Very stable atmosphere on the upwind slope
 - Often a temperature inversion
- Strong winds aloft
- High pressure over the mountains; relatively low over the plains.

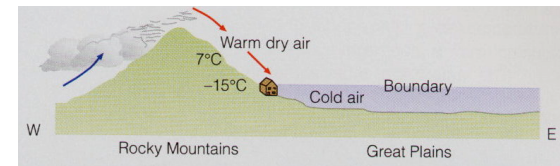
- Main source of heating is compression during downslope flow
- Latent heat release from condensation during upwind ascent also contributes to heating



Would we experience a Chinook wind if the upwind atmosphere was unstable?

Other Chinook Features

- Chinook wall cloud often visible along Rocky Mountain ridge line
- Cold air may pool near surface with warm Chinook flow above



Downslope Windstorm along the Eastern Sierra Nevada and Owens Valley, CA



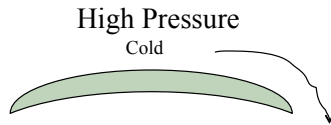
Photo by Robert Symons

A literal translation of the “Chinook wind” is the Snow Eater

- Why?
 - The relative humidity during a Chinook 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 and 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 US southwest.
- Flow descends rapidly through mountain passes in southern California.
- Winds warm due to compression.
- Already dry air (desert air) drops to even lower rH as temperatures rise.



Another Interesting Wind System

- Dust devils
 - Surface heating produces convection
 - Wind blowing past object twists rising air
 - Air rushes into rising column lifting dirt and debris
 - Tornados/hurricanes to be discussed later...

