Lecture 18. Local and regional pollution issues: plumes of pollution.

Objectives:
1. Large-scale temperature inversions.
2. Plumes of pollution.

Readings: Turco: p.128-135; Brimblecombe: p.130-138

1. Large-scale temperature inversions.

Temperature profile is one of the most fundamental meteorological parameters used in interpreting the behavior of the atmosphere.

- Measurements of temperature versus altitude are referred to as soundings.

NOTE: recall temperature inversion defined in Lecture 4.

Temperature inversions are typically very extensive, covering entire cities or regions.

Major types of temperature inversions:

1. Marine inversion.
2. Regional subsidence inversion.
3. High-pressure inversion.
4. Radiation inversion.

Marine inversion forms when a layer of warm air from land overlying a cold marine air.

Figure 18.1 Formation of marine inversions.

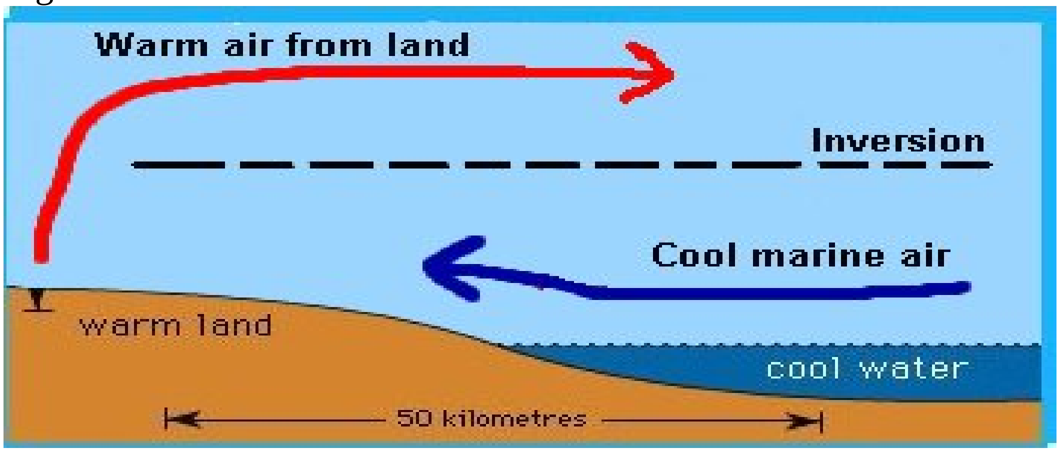
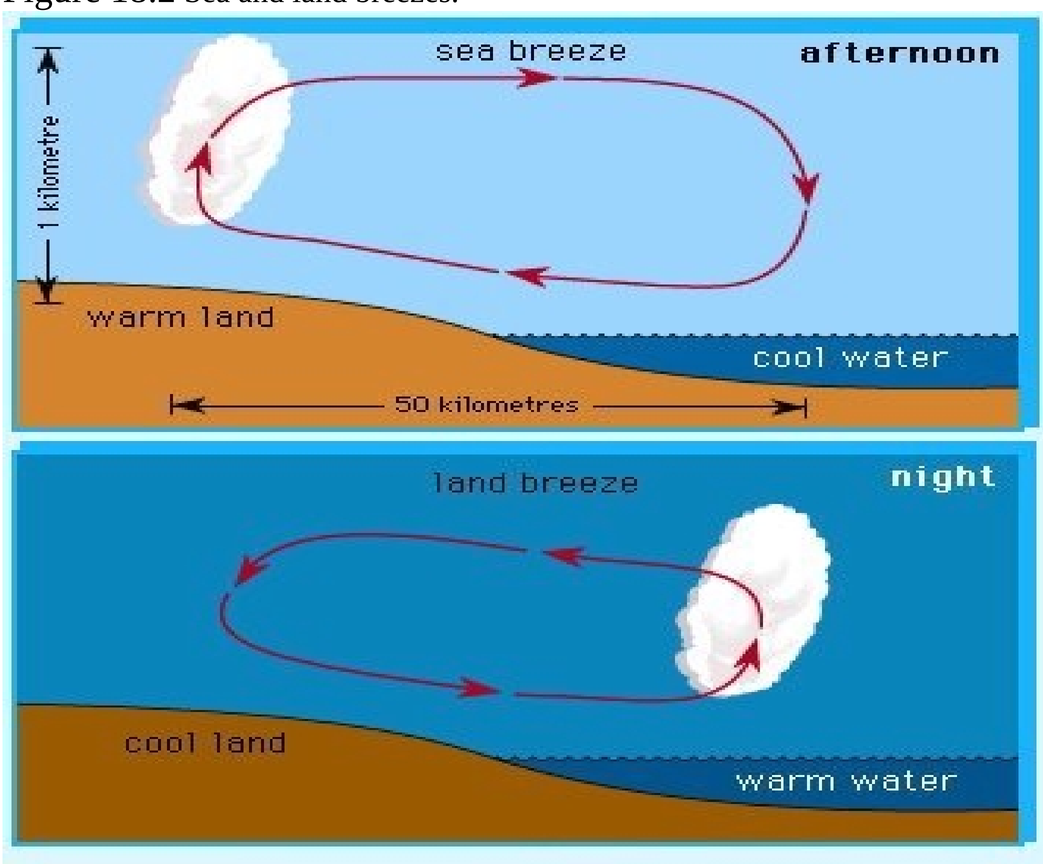
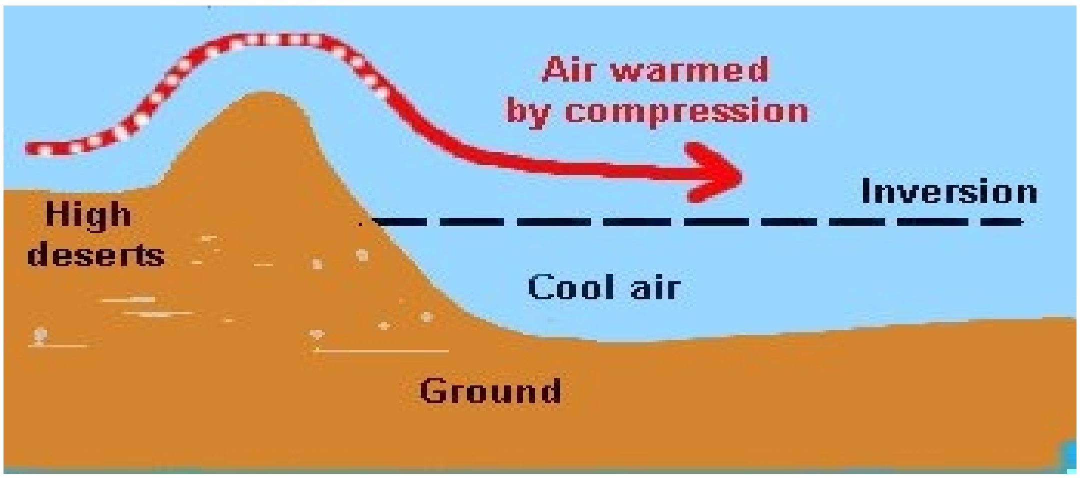


Figure 18.2 Sea and land breezes.



Regional subsidence inversion forms when air flows over an obstacle such as a mountain range of blows from a high plateau and descends into a lower basin overlying a colder air at the surface.

Figure 18.3 Formation of regional subsidence inversions.

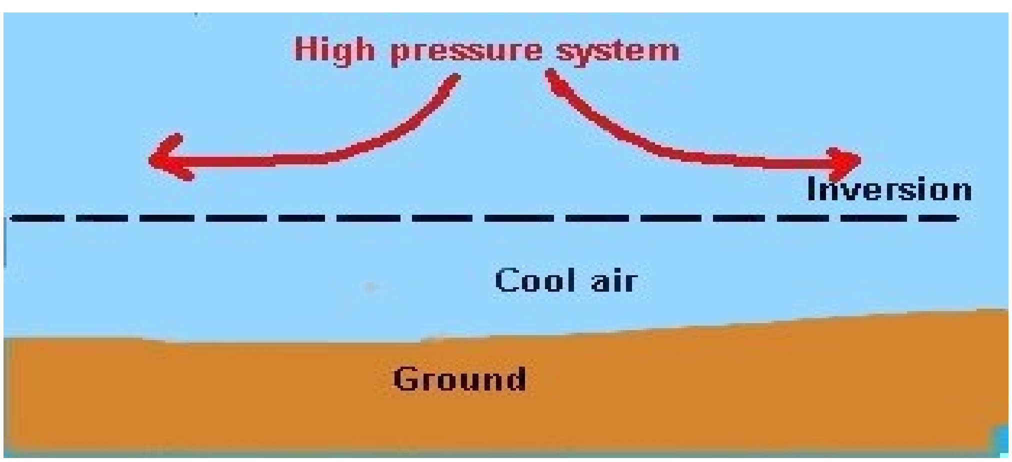


Examples: Santa Ana winds blown through Los Angeles;

Chinook winds blown in Eastern Rocky Mountains.

High-pressure inversion forms when a stationary warm high-pressure system settles over a region.

Figure 18.4 Formation of high-pressure inversions.

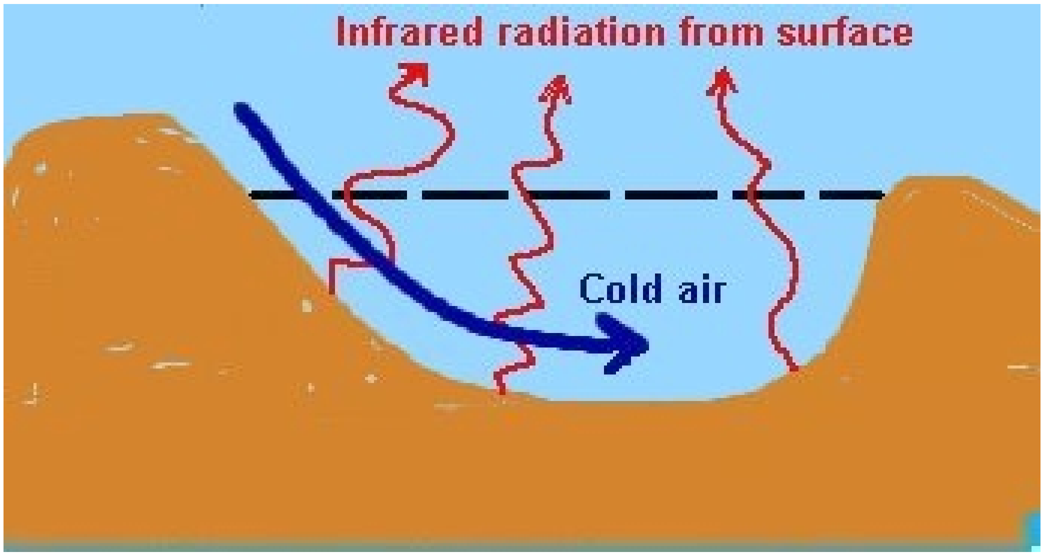


Radiative inversion forms when heat is rapidly lost from the surface by thermal radiation.

NOTE: recall Lecture 5 on radiation:

thermal radiation = infrared radiation = longwave radiation

Figure 18.5 Formation of radiation inversions.



- Radiation inversions are most likely to form on clear nights with low winds. Clear skies are necessary for the surface radiation to escape; overlying clouds or fog absorb thermal radiation and radiate back to the surface.

2. Plumes of pollution.

Plume of pollution is formed whenever pollutants emitted from a source into the atmosphere continuously over a period of time.

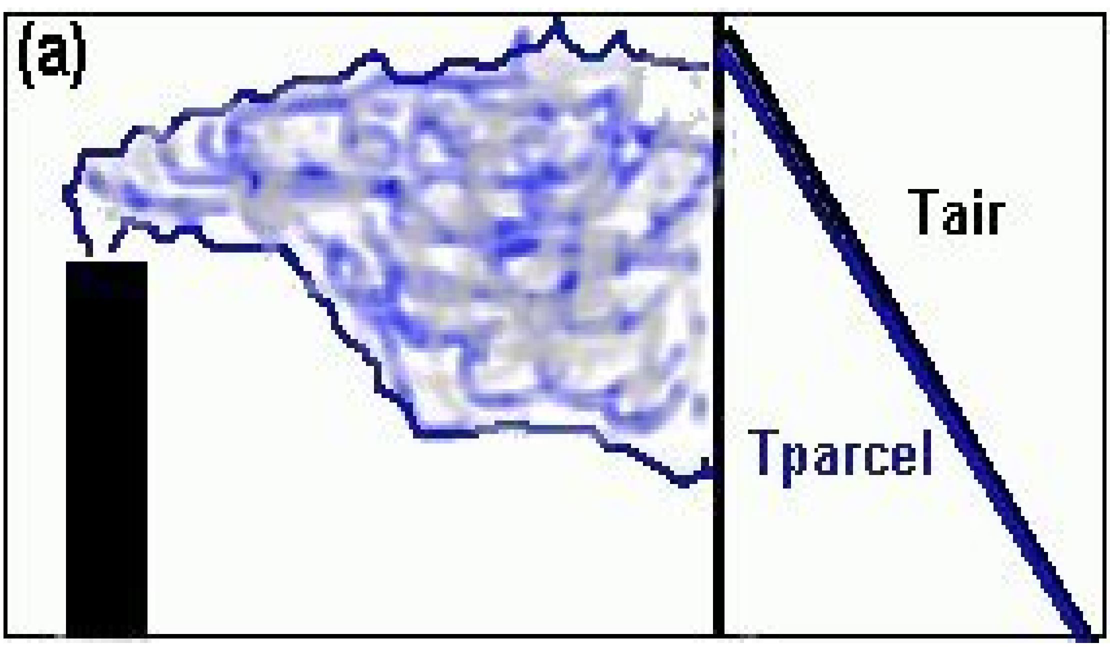
Major factors that influence the dispersion of smokestack plumes:

1. Local atmospheric stability (determines the rate of vertical mixing and dilution of the plume).
2. Winds (control the distance that the pollution can travel and the areas that will be affected).

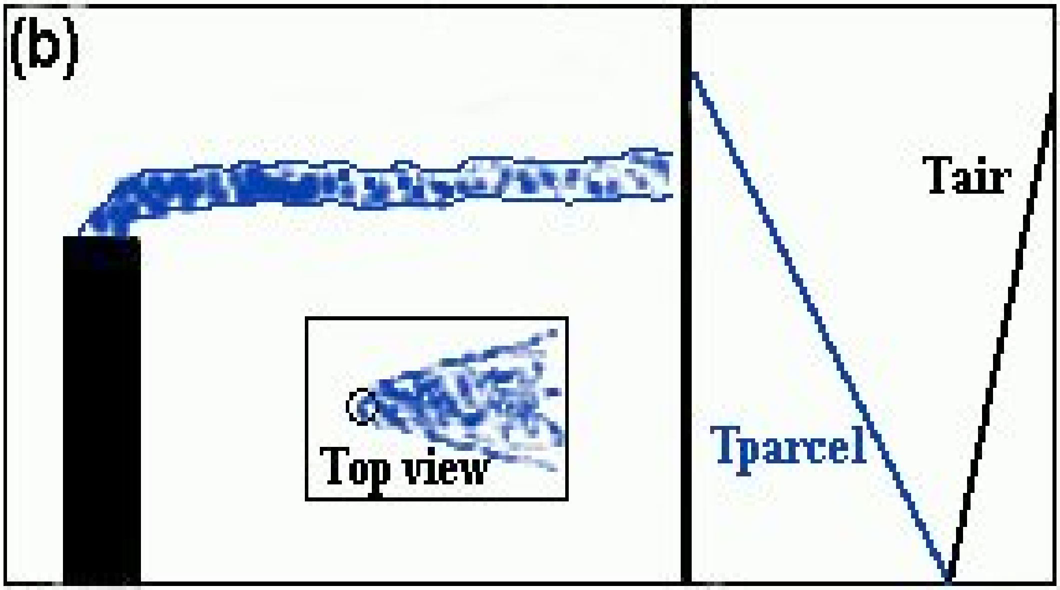
- Turbulence and convection control the local mixing of a plume, while advection by winds controls transport.

Figure 18.6 Behavior of smokestack plumes.

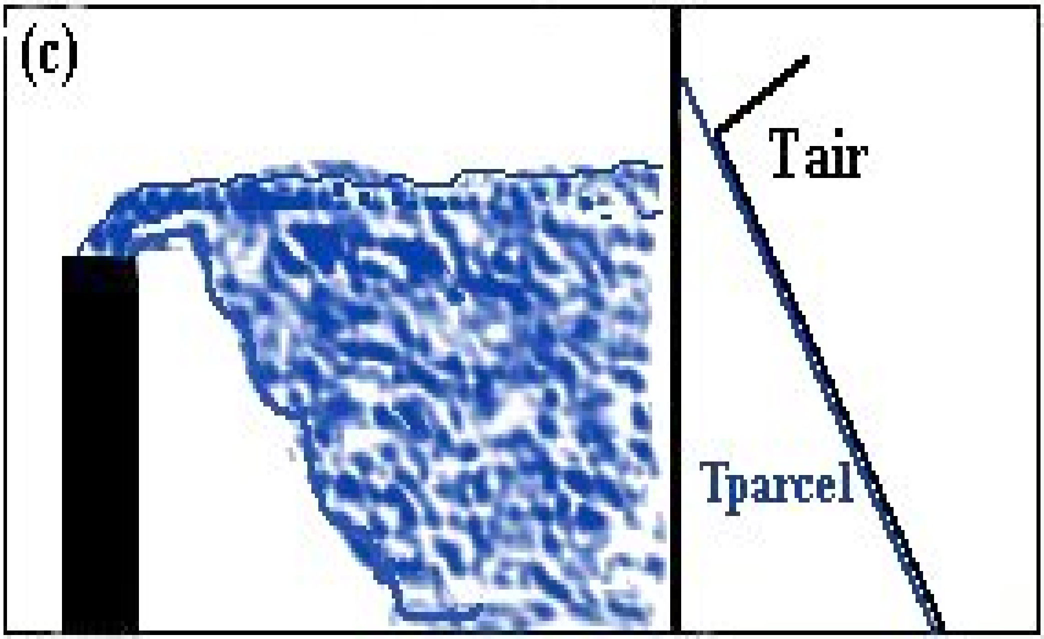
(a) When the atmosphere is neutrally stable, the plume cones, or spreads in all directions as it travels from the stack.



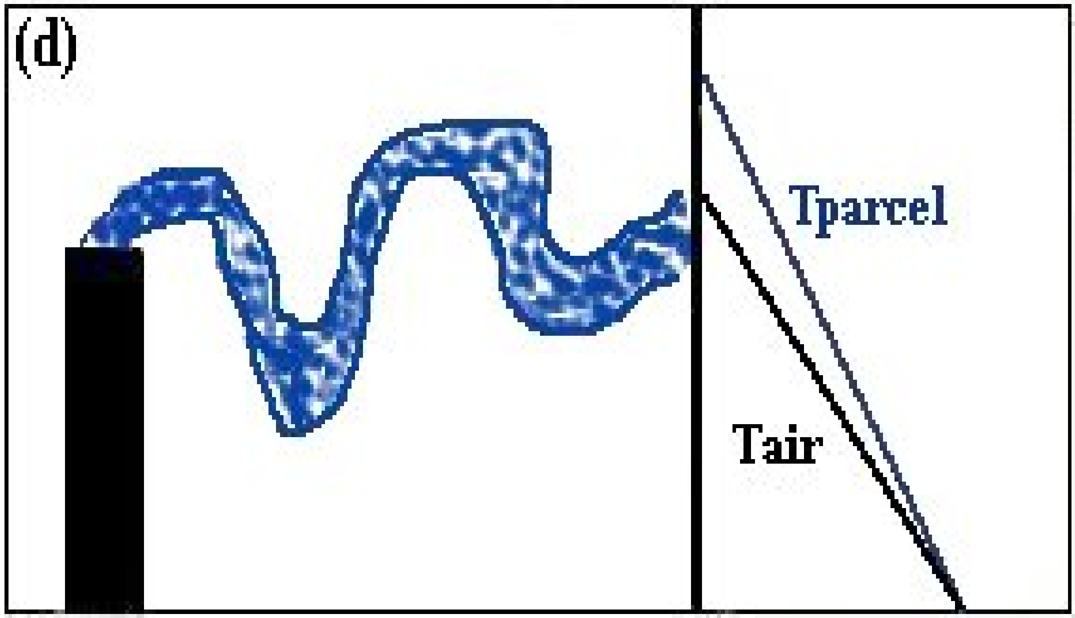
(b) If the atmosphere is stable, the plume cannot spread vertically but can disperse horizontally, producing a fan.



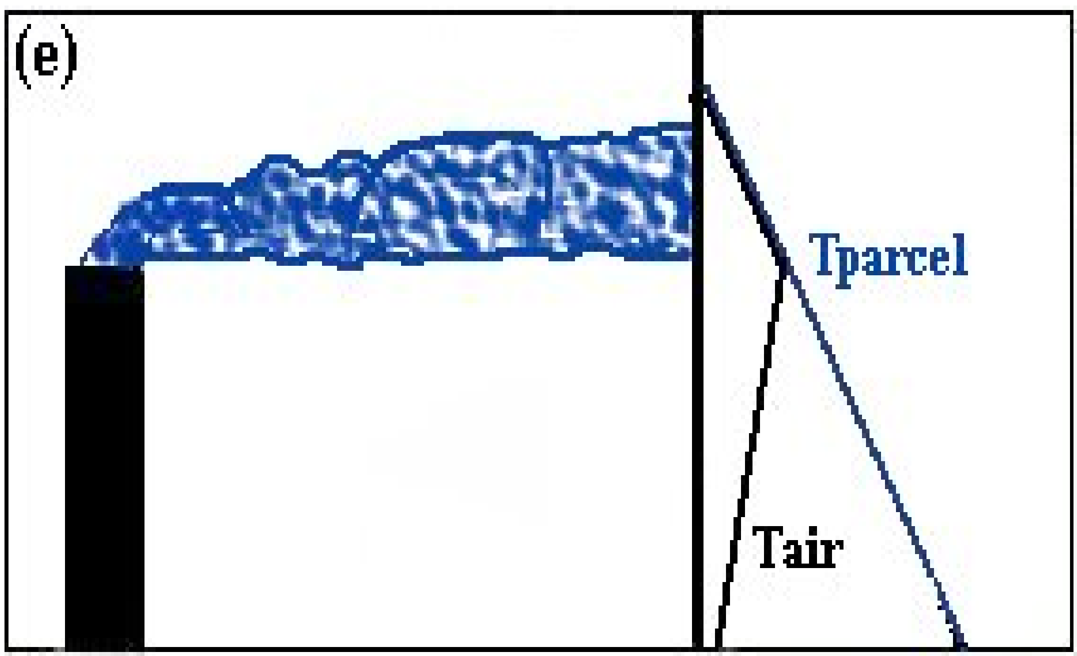
(c) Fumigation occurs when stack emissions are dispersed to the ground by the overturning of the atmosphere below an inversion layer.



(d) Looping occurs in an unstable atmosphere where upward and downward motions in large turbulent eddies are equally likely.



(e) The injection of stack emissions above a stable stratified layer results in a lofting of the emissions.



- The situations in Figure 18.6 (b) and (e) are the most favorable from the point of view of pollution at the ground level.
- The situations in Figure 18.6 (c) and (d) are the worst.

Several other factors that influence the dispersion of smokestack pollution:

- ♦ Height of the stack: Higher chimneys generally produce less local pollution!
- ♦ Temperature of the fumes: The warmer the emissions from the stack are, the longer they are likely to remain aloft.
- ♦ Exit velocity of fumes: Greater exit velocities from the stack have a similar, but smaller, effect.

Ground plume is a special case of plume that emitted at ground level.
Sources of ground plumes: automobiles, garbage dumps, agricultural pollutants, etc.

- The dispersal rate of a ground plume depends on the atmospheric stability and surface winds, like smokestack plumes.
- The most serious threat develops when a strong, low-altitude temperature inversion is present.

Predicting of formation, movement, and dispersion of air pollution is very complicated problem. To date, no one can do it with any precision.

NOTE: chemical transport models will be discussed in Lectures 29-30.