Lecture 15. Extratropical Cyclones

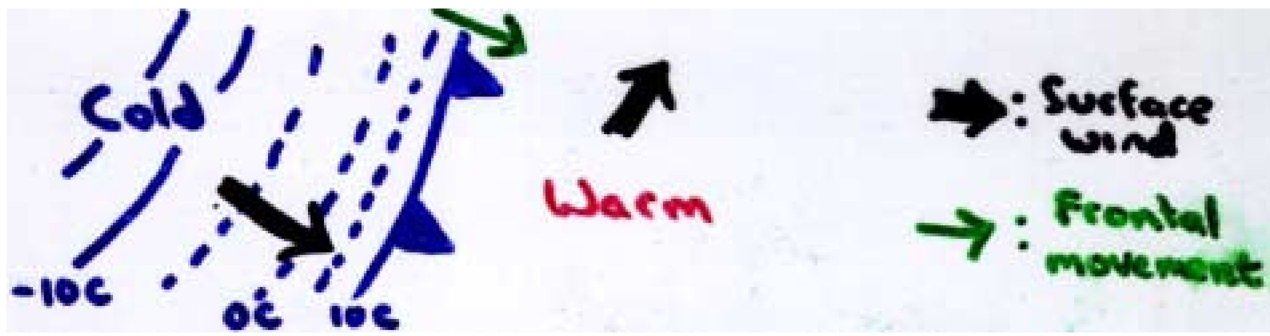
- In mid-latitudes, much of our weather is associated with a particular kind of storm, the **extratropical cyclone**
  Cyclone: circulation around low pressure center
    Some midwesterners call tornadoes cyclones
    Tropical cyclone = hurricane
- Extratropical cyclones derive their energy from horizontal temperature contrasts.
- They typically form on a boundary between a warm and a cold air mass associated with an upper tropospheric jet stream
- Their circulations affect the entire troposphere over a region 1000 km or more across.
- Extratropical cyclones tend to develop with a particular lifecycle .
- The low pressure center moves roughly with the speed of the 500 mb wind above it.
- An extratropical cyclone tends to focus the temperature contrasts into 'frontal zones' of particularly rapid horizontal temperature change.

The Norwegian Cyclone Model

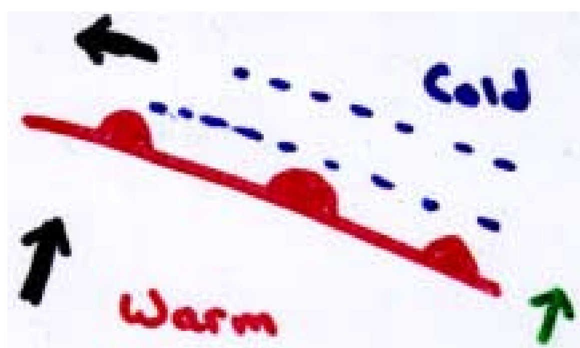
In 1922, well before routine upper air observations began, Bjerknes and Solberg in Bergen, Norway, codified experience from analyzing surface weather maps over Europe into the *Norwegian Cyclone Model*, a conceptual picture of the evolution of an ET cyclone and associated frontal zones at ground

They noted that the strongest temperature gradients usually occur at the warm edge of the frontal zone, which they called the front. They classified fronts into four types, each with its own symbol:

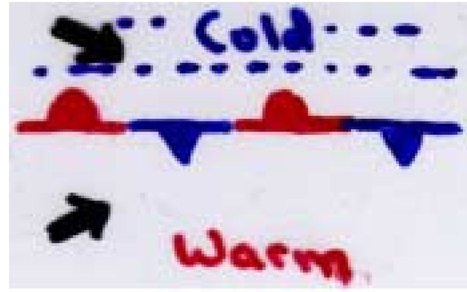
Cold front - Cold air advancing into warm air



Warm front - Warm air advancing into cold air



Stationary front - Neither airmass advances



Occluded front - Looks like a cold front which has caught up to a warm frontal zone.

In addition to rapid temperature changes, the following are often associated with fronts:

- Shift in wind direction
- A pressure ‘trough’ - lower pressure along the front than to either side

Depending on geographical location, the following may also be observed

- Change in moisture content of air
- Characteristic patterns of clouds and precipitation

Surface Weather Map for a Typical Extratropical Cyclone

(EOM Appendix C)

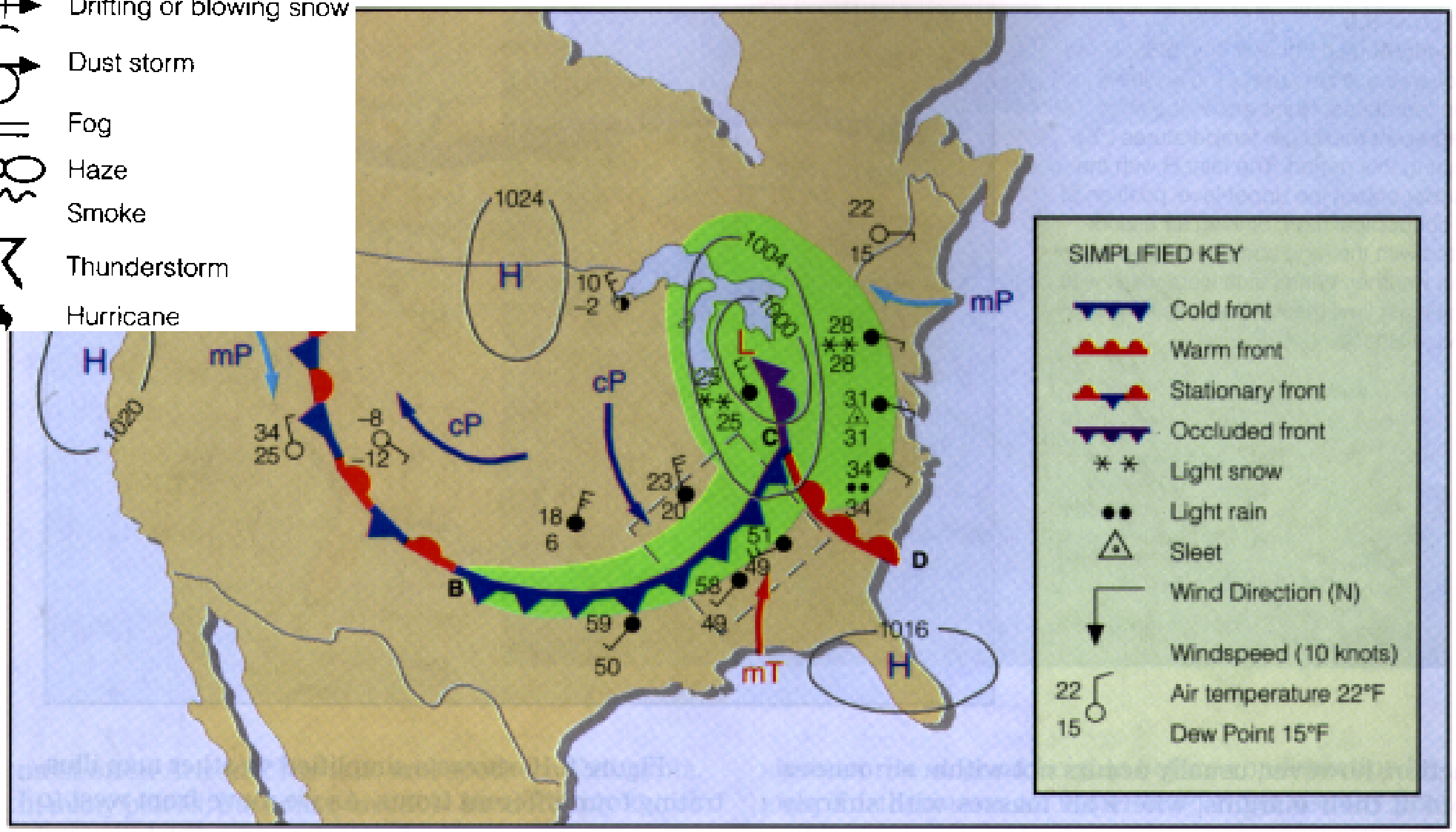
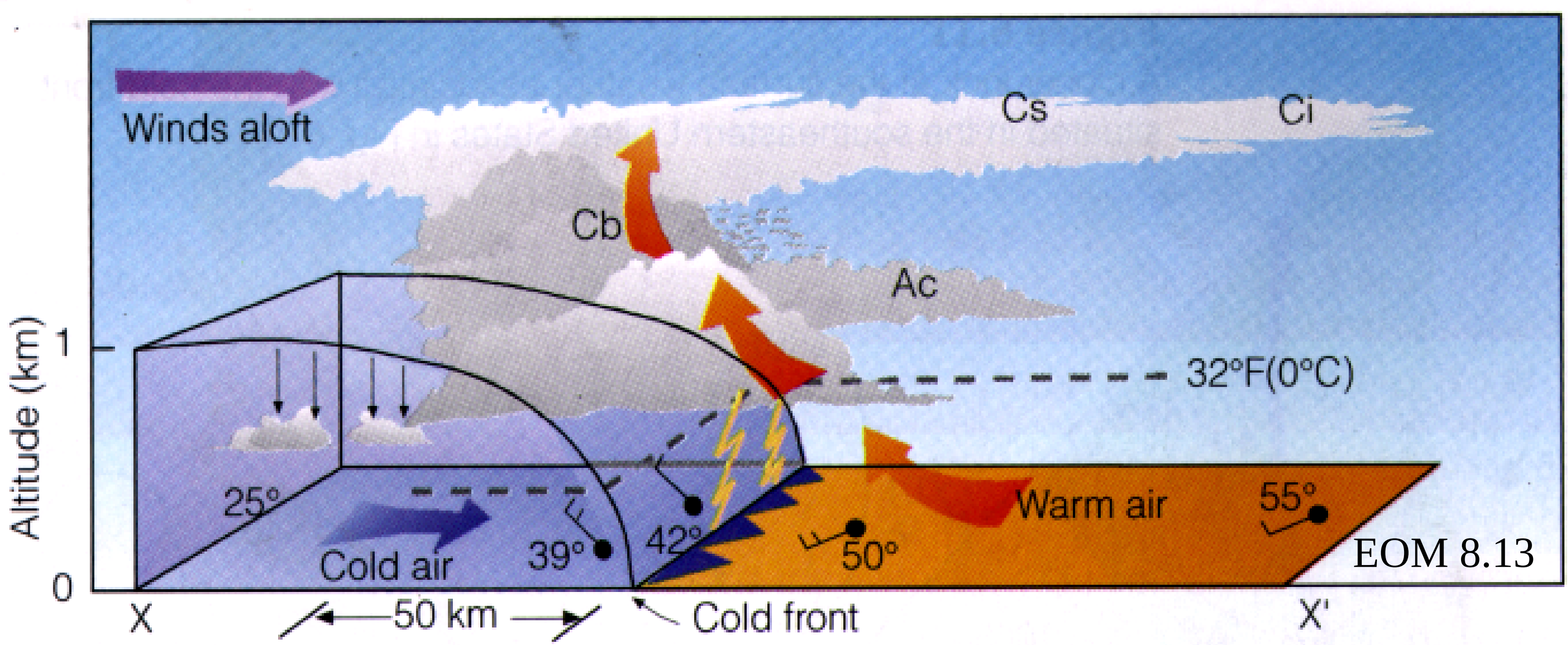


Figure 8.10
A simplified weather map showing surface pressure systems, air masses, and fronts. (Green-shaded area represents precipitation.)

EOM 8.11

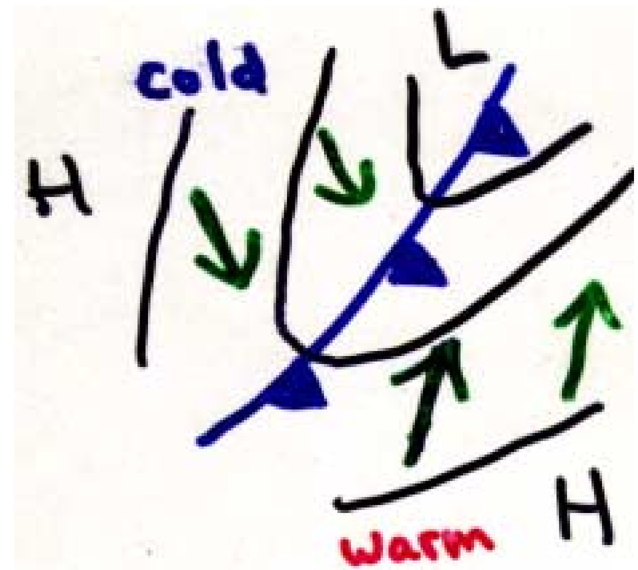
About Cold Fronts



EOM 8.13

Cold fronts are the leading edge of a wedge of cold air which deepens by about 1 km in the first 50 km behind the front.

At a given location, a cold frontal passage is usually associated with



- Wind shift, usually from SE-SW to W-NW, and pressure minimum.
- Falling temperatures
- Heavy rain or thunderstorms, followed by a few hours of showers

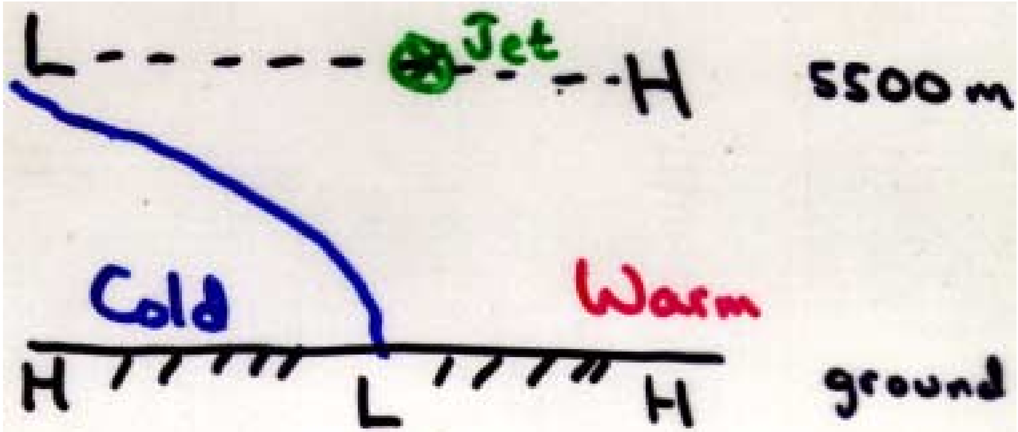
Winds driven by pressure variations maintain front by blowing warm air from S ahead of front, cold air from NW behind front.

While cold fronts are very distinctive in the Midwest or Eastern US, they are often less distinctive in Seattle since:

- Our location behind the Olympics masks the wind shifts that are occuring over the ocean.
- The surface air often is only slightly cooler behind the front since it has been warmed by the ocean.

We see a transition from rain to showers, wind shifting from SE-S to SW, drop in mountain snow line.

Why is pressure minimum at front?



Pressure aloft (at 5500 m) is lowest over the cold air.
In the cold (dense) air, pressure increases faster as we descend than in the warm air, so surface pressure is higher under the cold wedge than at front

About Warm Fronts

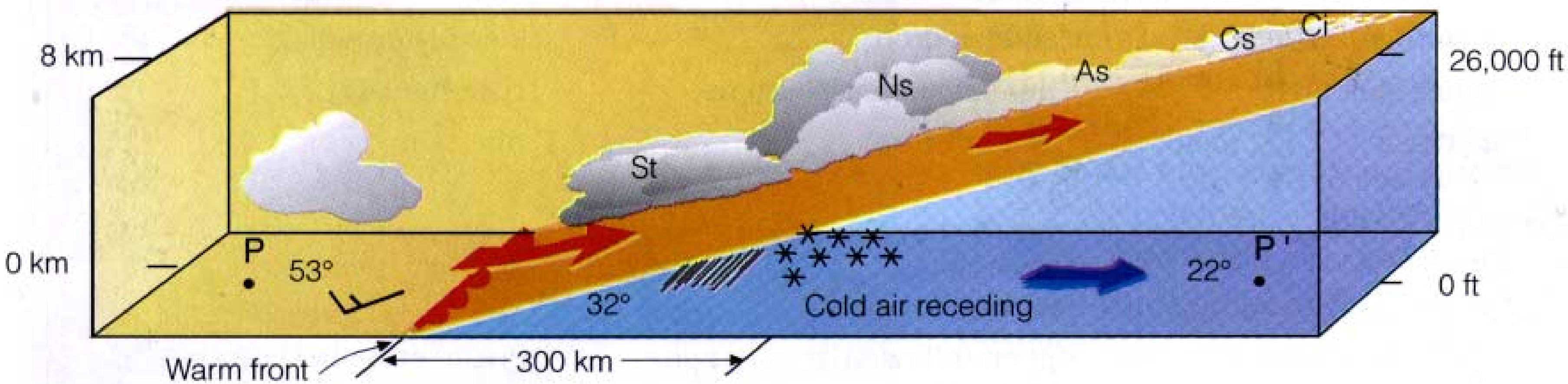


Figure 8.15 (EOM)
Vertical view of clouds, precipitation, and winds across the warm front in Fig. 8.14 along the line *P–P'*.

A warm front is the trailing edge of a retreating shallow wedge of cold air, increasing in depth by 1 km for each 100-150 km ahead of the front.

As frontal zone passes surface observer sees

- High cloud, thickening and lowering, with E wind and lowering pressure
- Steady precipitation developing, possibly starting as snow, then changing to freezing rain or rain.
- Front, marked by a shift to warmer SW wind and often some clearing.

- ET cyclones usually develop warm fronts but often don’t produce distinct warm fronts.

- In Seattle wintertime warm frontal passages can be pronounced if an arctic airmass entrenched E of the Cascades has spilled cold air over the mountains into Puget Sound.
- Warm fronts can also produce copious rainfall in WA as moist marine subtropical air rises over colder continental air trapped E of the Cascades

Occluded Fronts

Occluded fronts often result when warm fronts overtake slower moving cold fronts near the low center.

EOM 8.16, 8.17

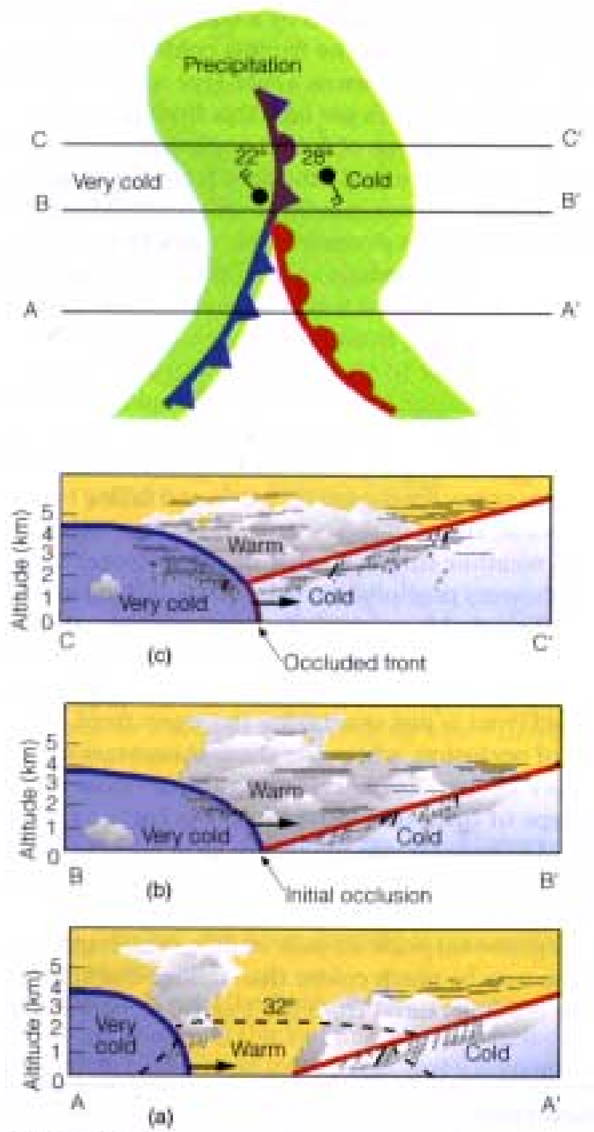


Figure 8.16
The formation of a cold-occluded front. The faster-moving cold front (a) catches up to the slower-moving warm front (b) and forces it to rise off the ground (c).

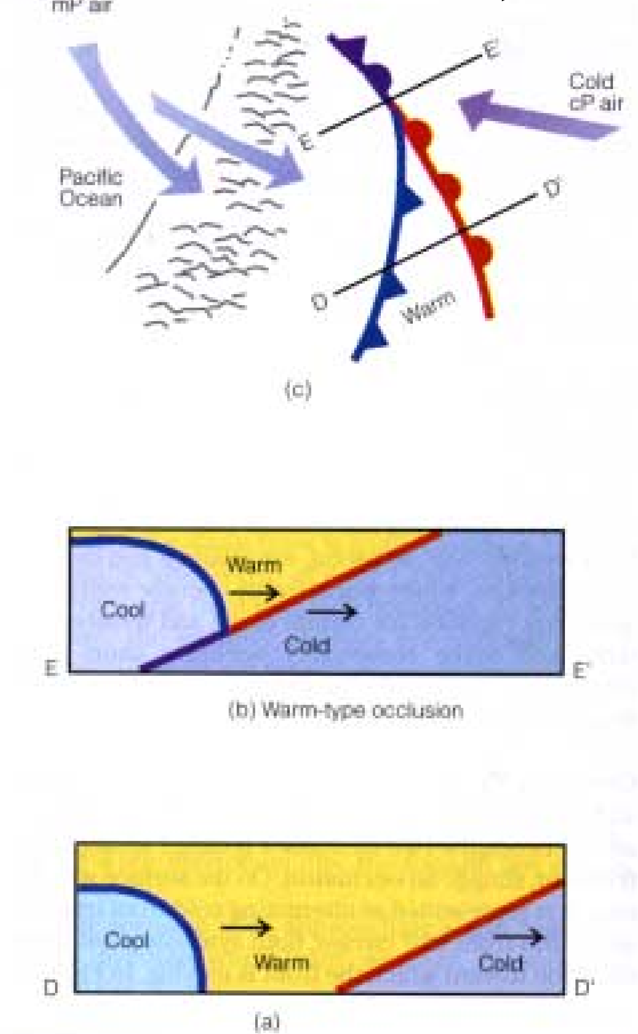
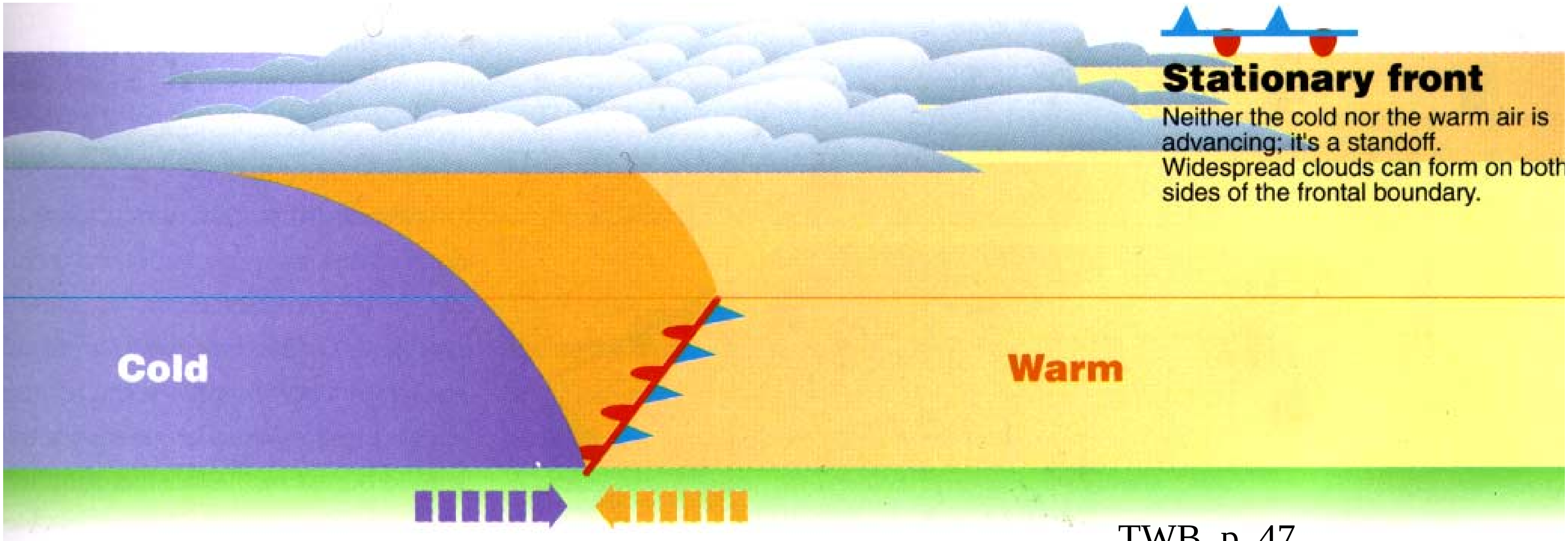


Figure 8.17
The formation of a warm-type occluded front. The faster-moving cold front in (a) overtakes the slower-moving warm front in (b). The lighter air behind the cold front rises up and over the denser air ahead of the warm front. Diagram (c) shows a surface map of the situation.

Stationary Fronts



TWB, p. 47

Airmass boundaries can stagnate

- after a cyclone has moved off (SE US)
- because they are trapped against mountains or high ground (E of Rockies or Cascades).

Weather and structure can vary widely.