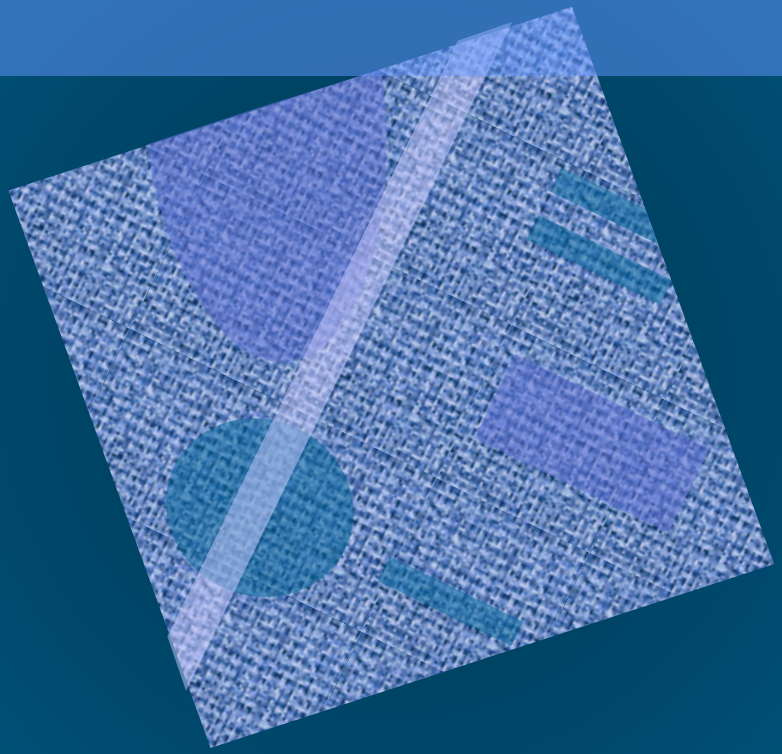
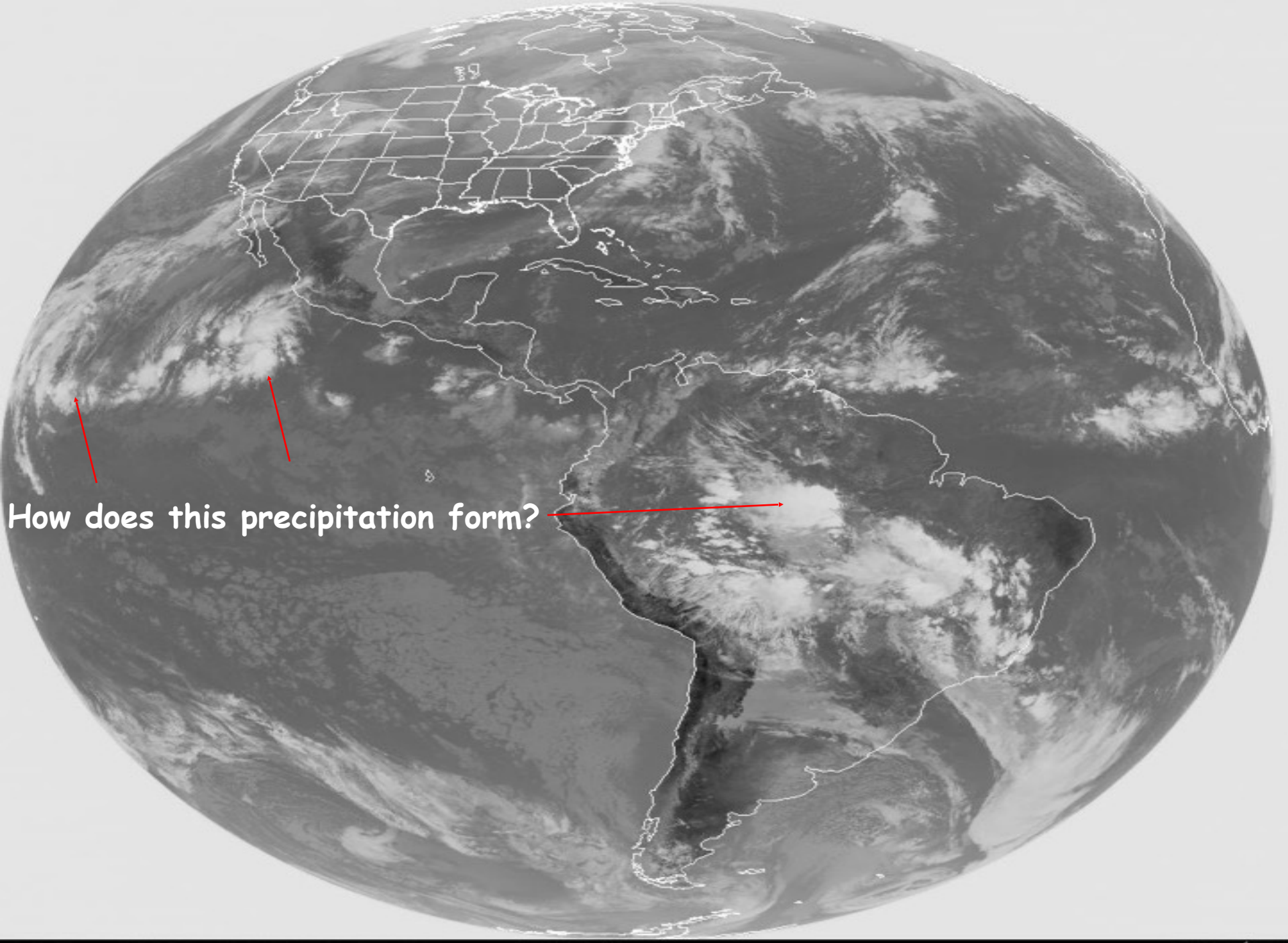
Air masses and fronts



Textbook, Chapter 9

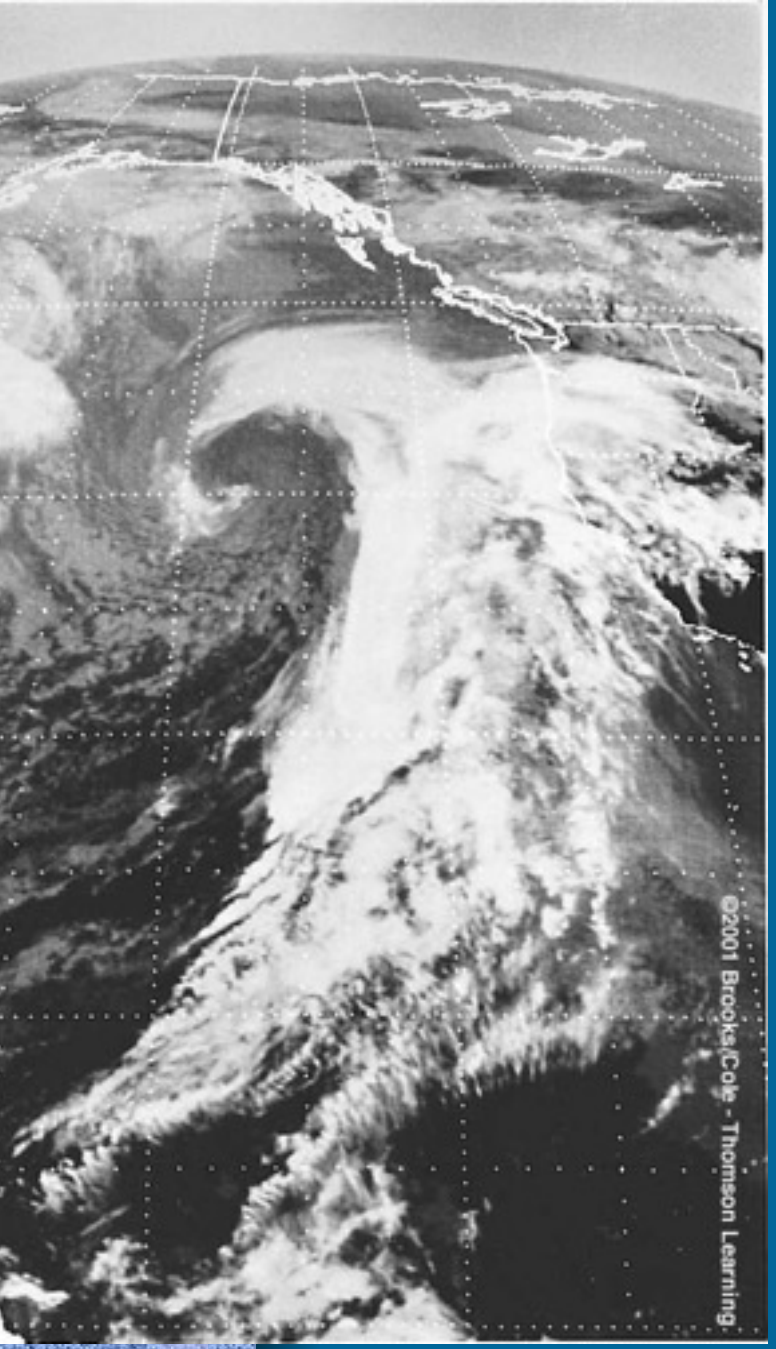
Discussion

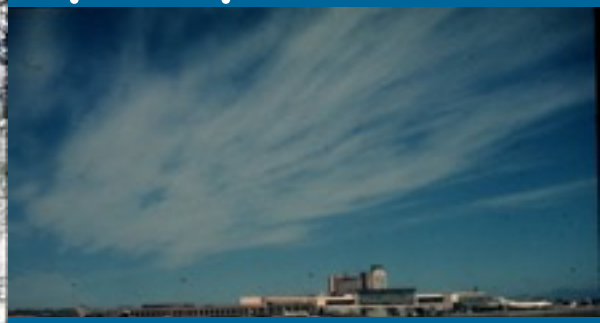
How do precipitation systems form?

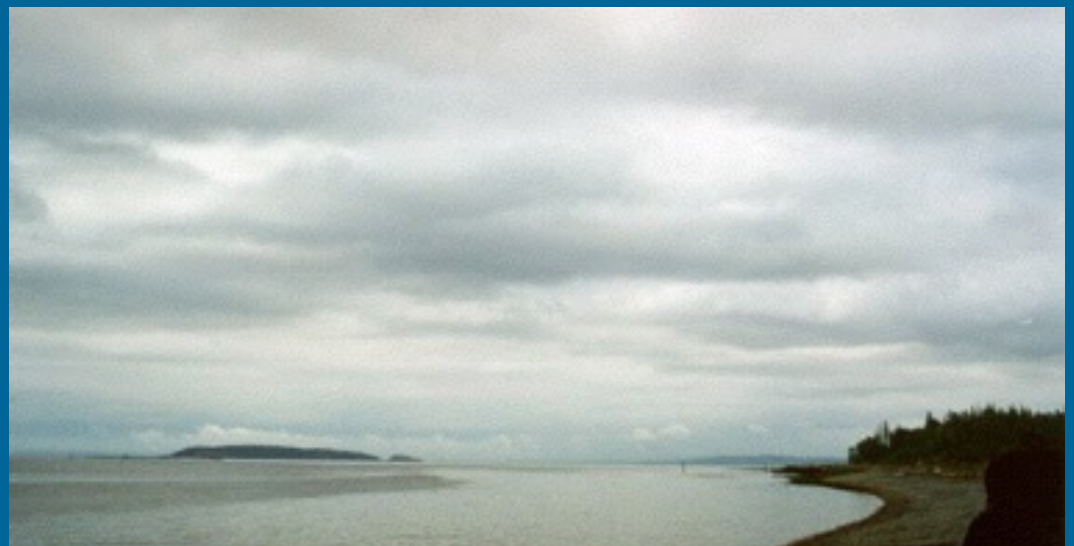

How does this precipitation form?
14 Nov 2000 17:45:14Z 10.70 um GOES-8
CIRA/NO

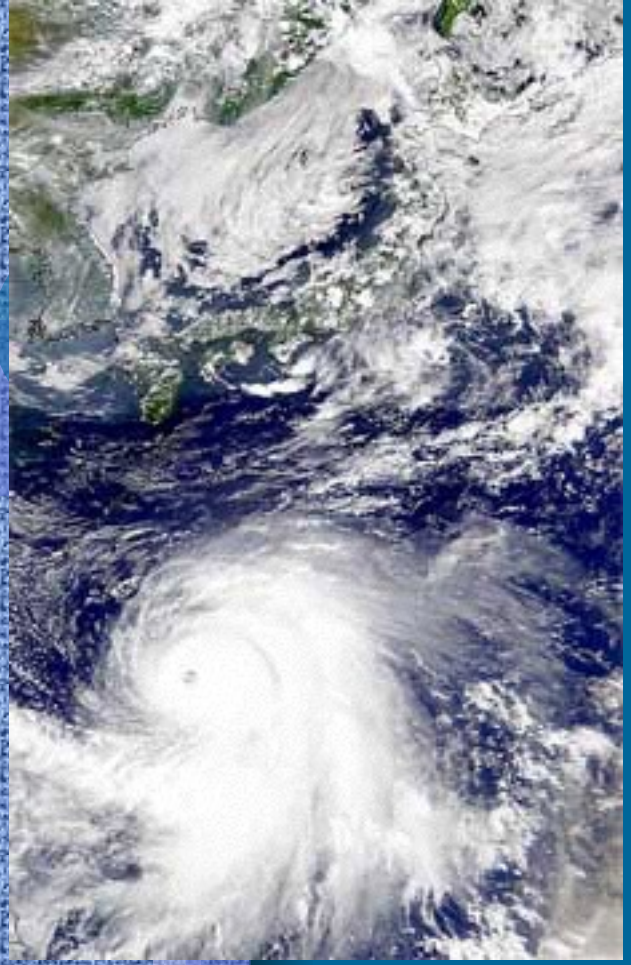
How does this precipitation form?

How does this precip form?





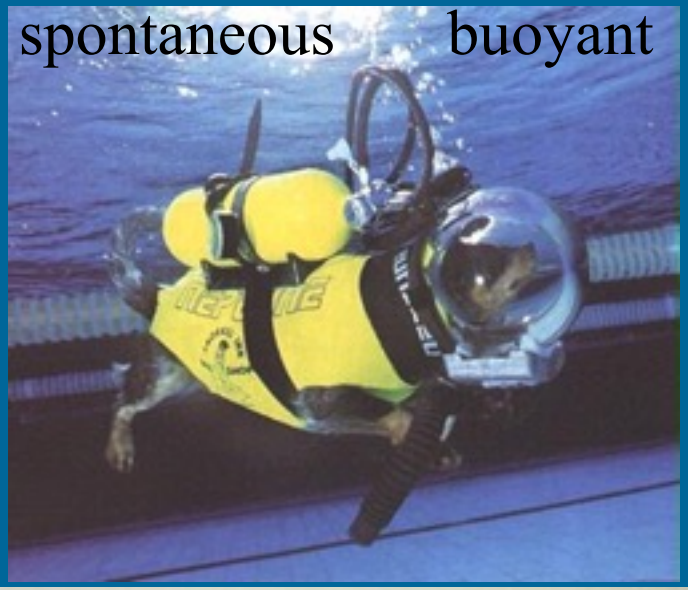




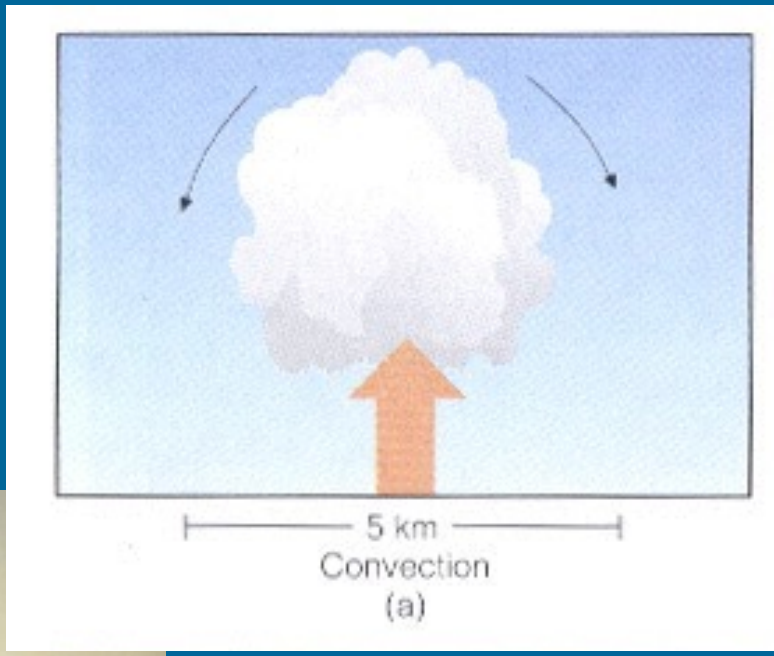
How does this storm form?

let's revisit the lifting mechanisms …

Five Mechanisms



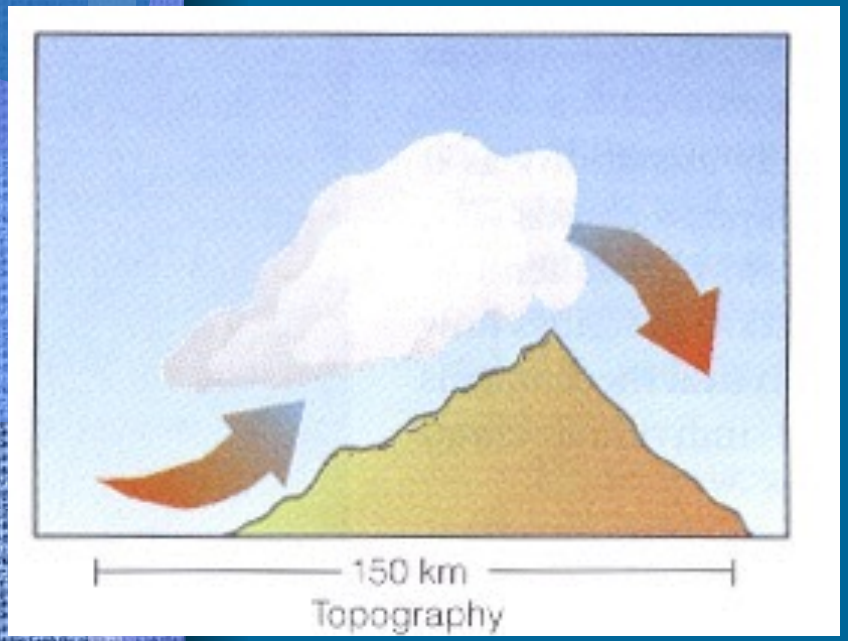
1. Convective ascent



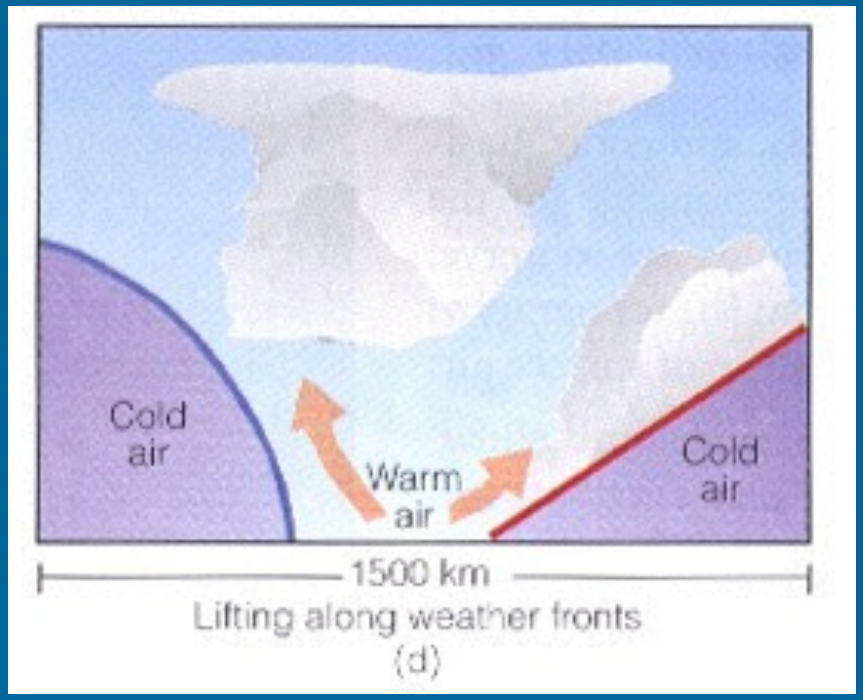
Cumulus clouds …

The 4 other mechanisms are forced ascent …

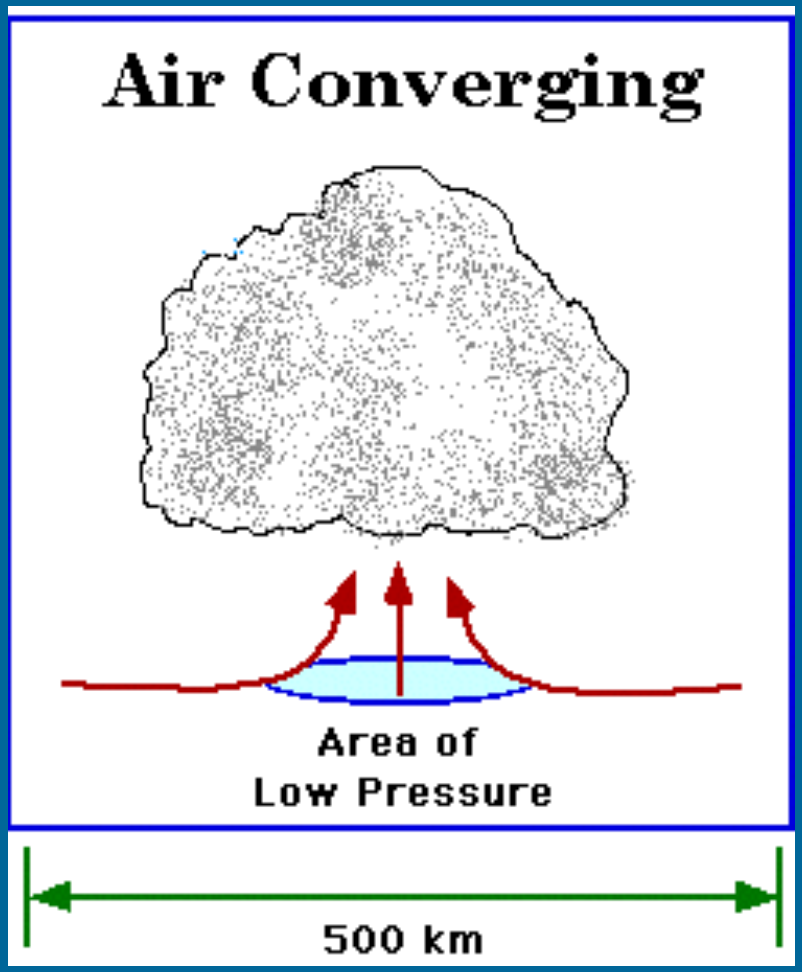
(a) over a mountain



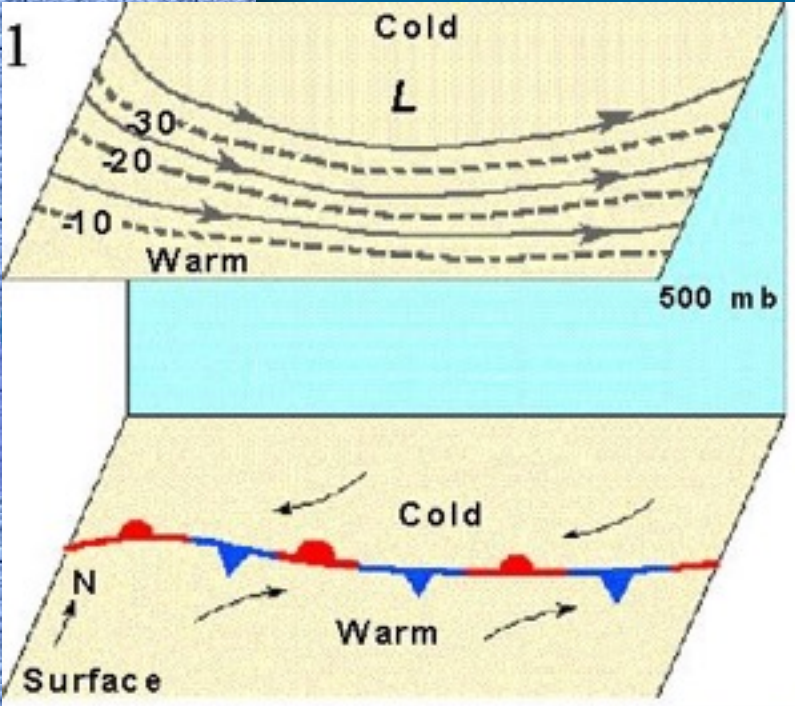
(b) or a front



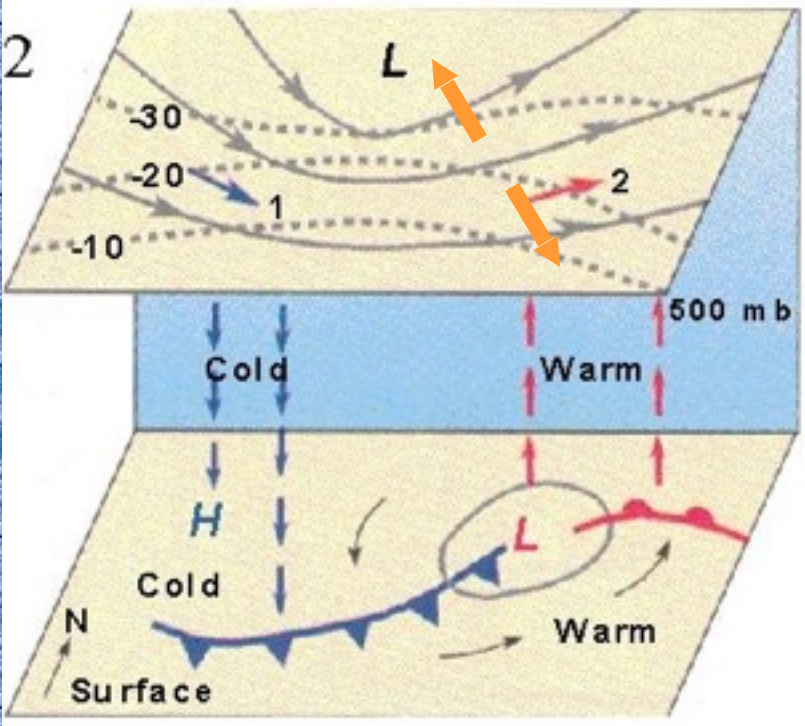
(c) Convergence into surface low

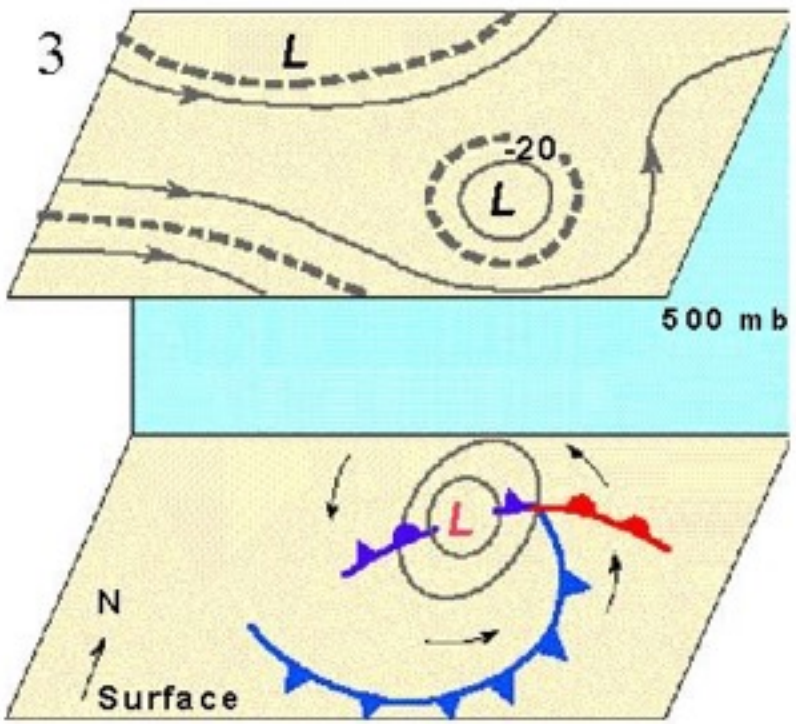


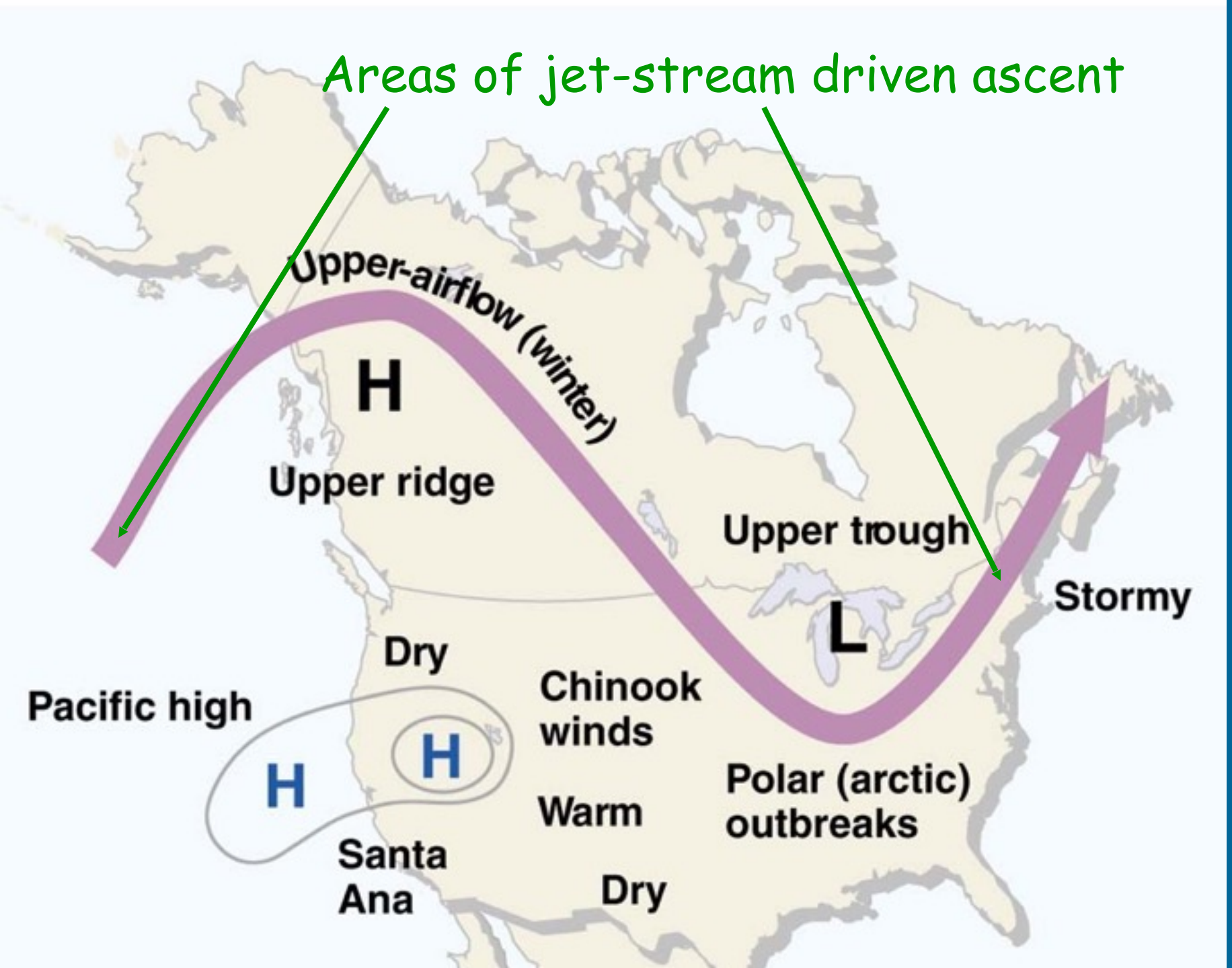
(d) Uplift forced by jet stream



Upper-level divergence






Areas of jet-stream driven ascent
Upper-airflow (winter)
H
Upper ridge
Upper trough
L
Stormy
Dry
Pacific high
Chinook winds
H
H
Polar (arctic) outbreaks
Warm
Santa Ana
Dry

Cloud & precipitation formation mechanisms

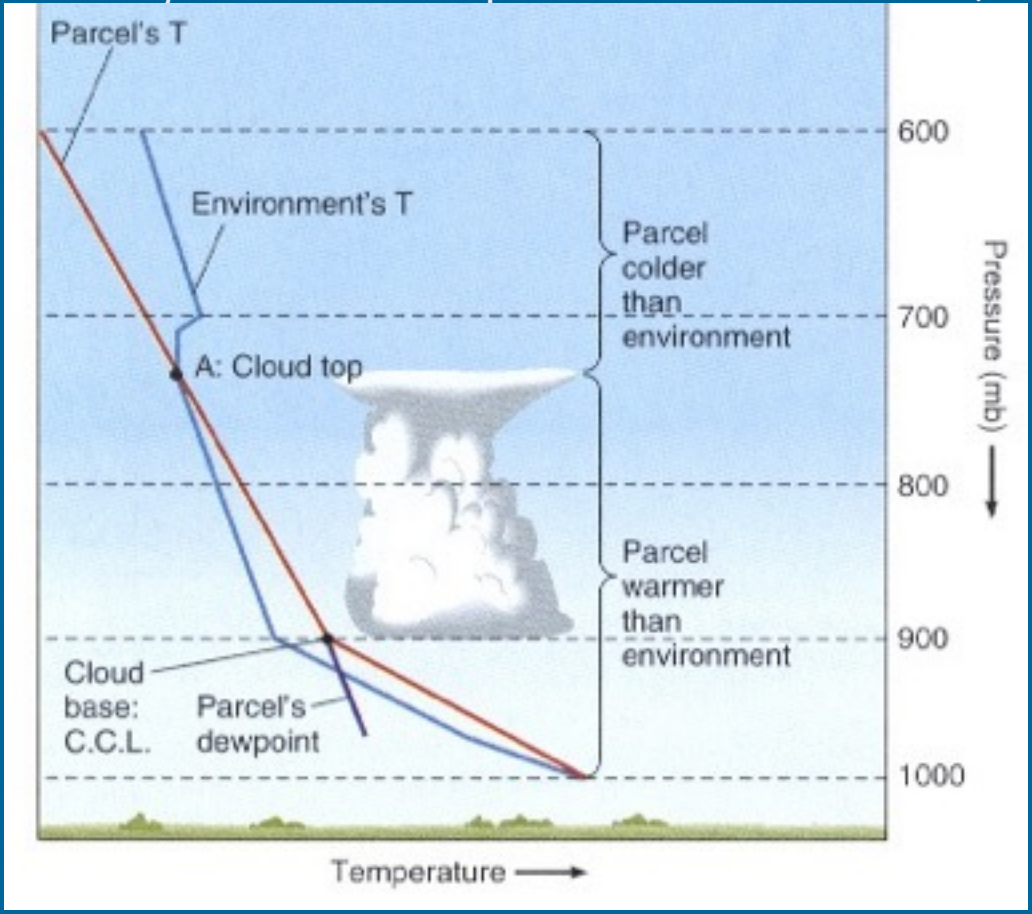
- Buoyant ascent [bubble ascent]
- Forced ascent [layer ascent]
  a) Orographic
  b) Frontal
  c) Low-level convergence (friction)
  d) Upper-level divergence (jet stream)

- Many clouds are the result of several simultaneous processes.

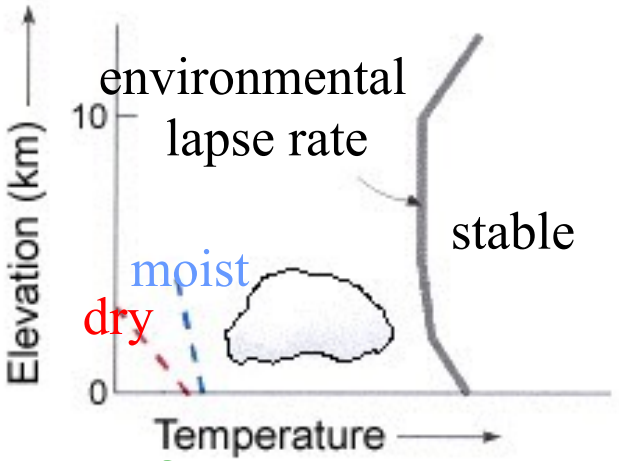

1. Buoyant ascent

1. Buoyant ascent

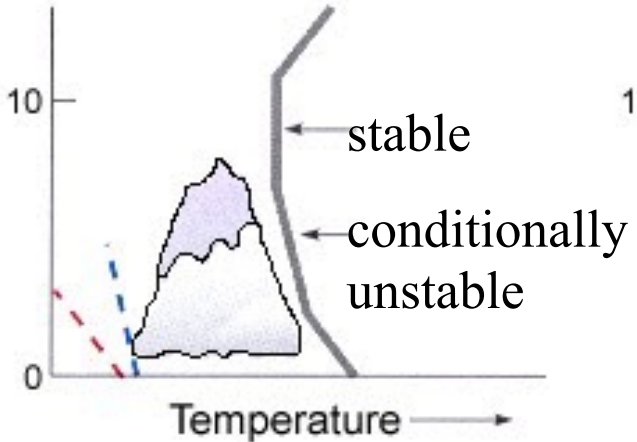
- We've talked about stability and parcel ascent (Chapter 4, Lab 7).
- Remember that in a conditionally unstable atmosphere, a cloud will continue to rise as long as its core temperature exceeds that of the surroundings



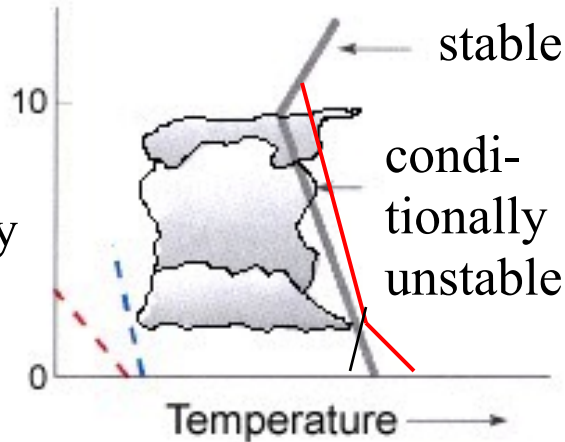
cumulus growth



Cumulus humilis



Cumulus congestus



Cumulonimbus

Lifting up a mountain may cause destabilization, …which is why Cu clouds first form there

Cloud & precipitation formation mechanisms

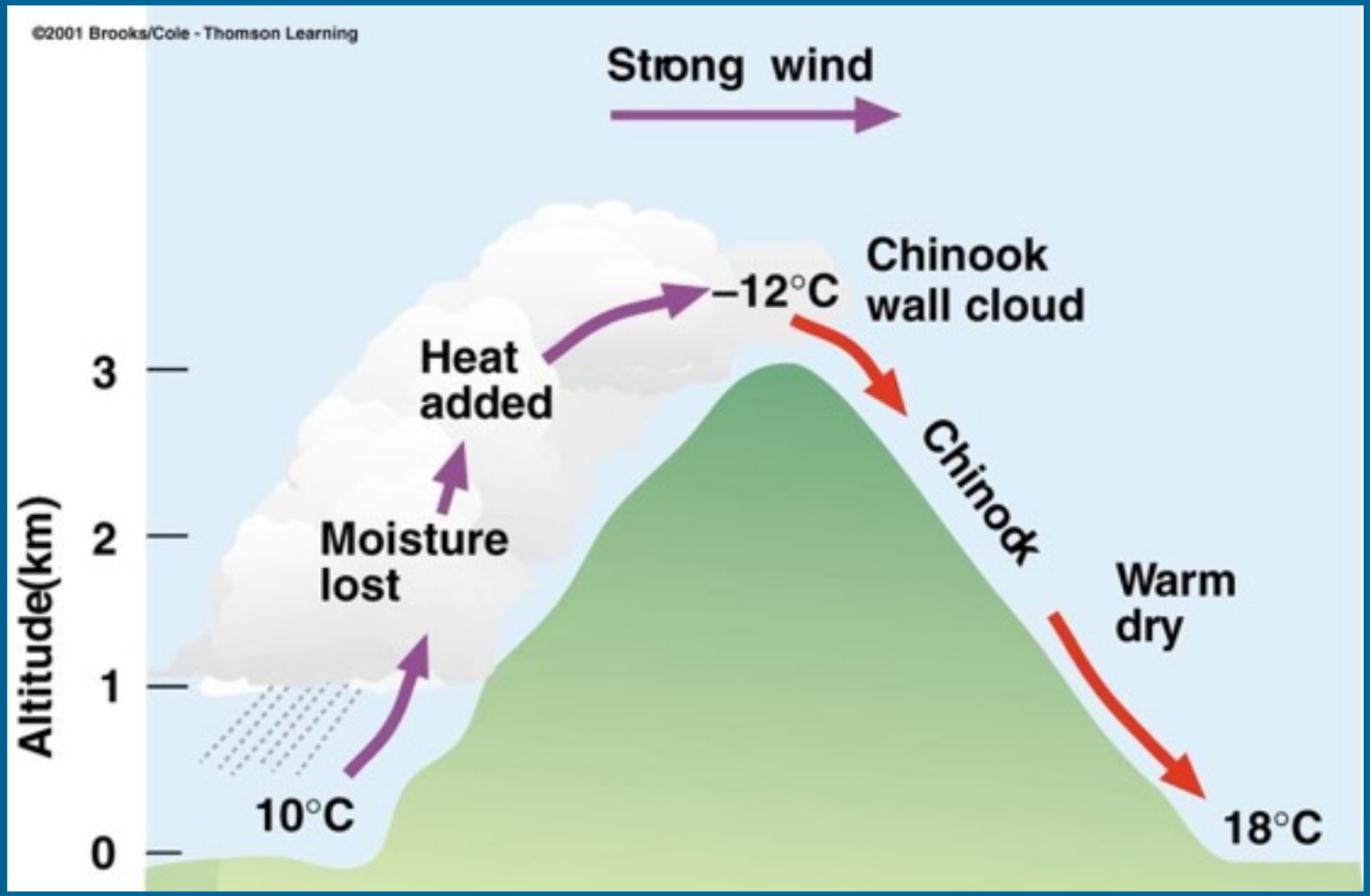
- Buoyant ascent [bubble ascent]
- Forced ascent [layer ascent]
  a) Orographic
  b) Frontal
  c) Low-level convergence (friction)
  d) Upper-level divergence (jet stream)

- Many clouds are the result of several simultaneous processes.

(a) Orographic clouds

Altocumulus lenticularis, Greenland

The Foehn or Chinook effect

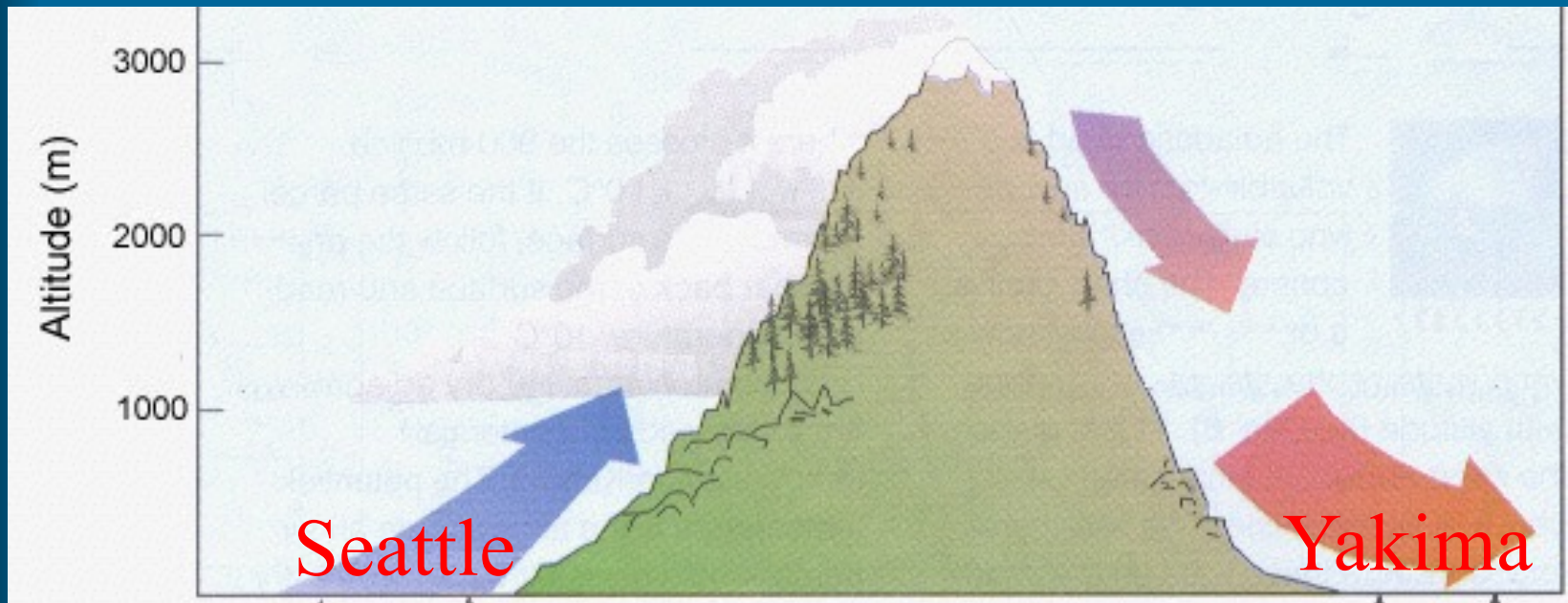


Quantifying the Foehn effect
(web link)

Chinook wall cloud

Pop quiz: when a good westerly wind blows and heavy snowfall occurs over the Cascades, then in Yakima on the east side it will be ……. than in Seattle on the west side.

A: sunnier but cooler
B: sunnier, warmer, drier, and windier
C: sunnier, cooler, more damp, and calmer
D: cloudier, cooler, more damp, and windier.

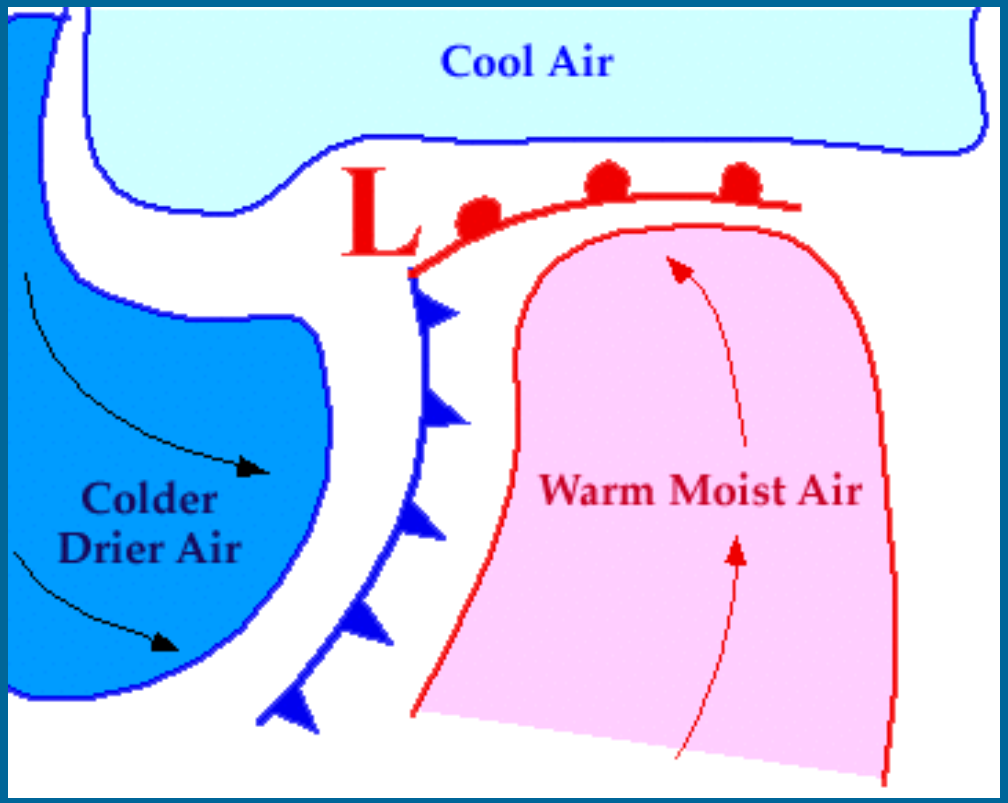


Cloud & precipitation formation mechanisms

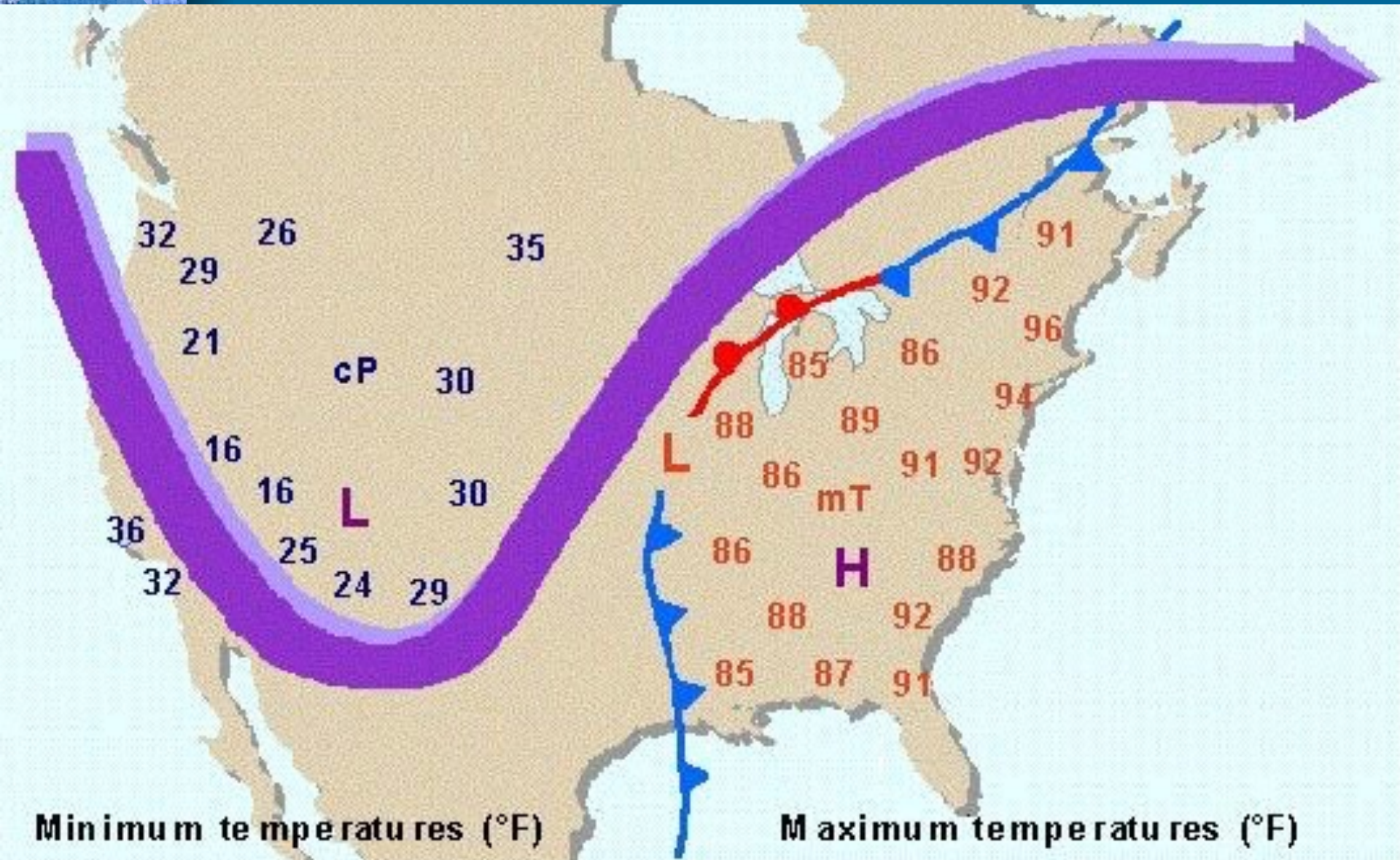
- Buoyant ascent [bubble ascent]
- Forced ascent [layer ascent]
  a) Orographic
  b) Frontal
  c) Low-level convergence (friction)
  d) Upper-level divergence (jet stream)

(b) Uplift along fronts

A front is a sudden transition between airmasses



Fronts separate airmasses



Types of airmasses

	continental	maritime
polar	• cP	• mP
tropical	• cT	• mT

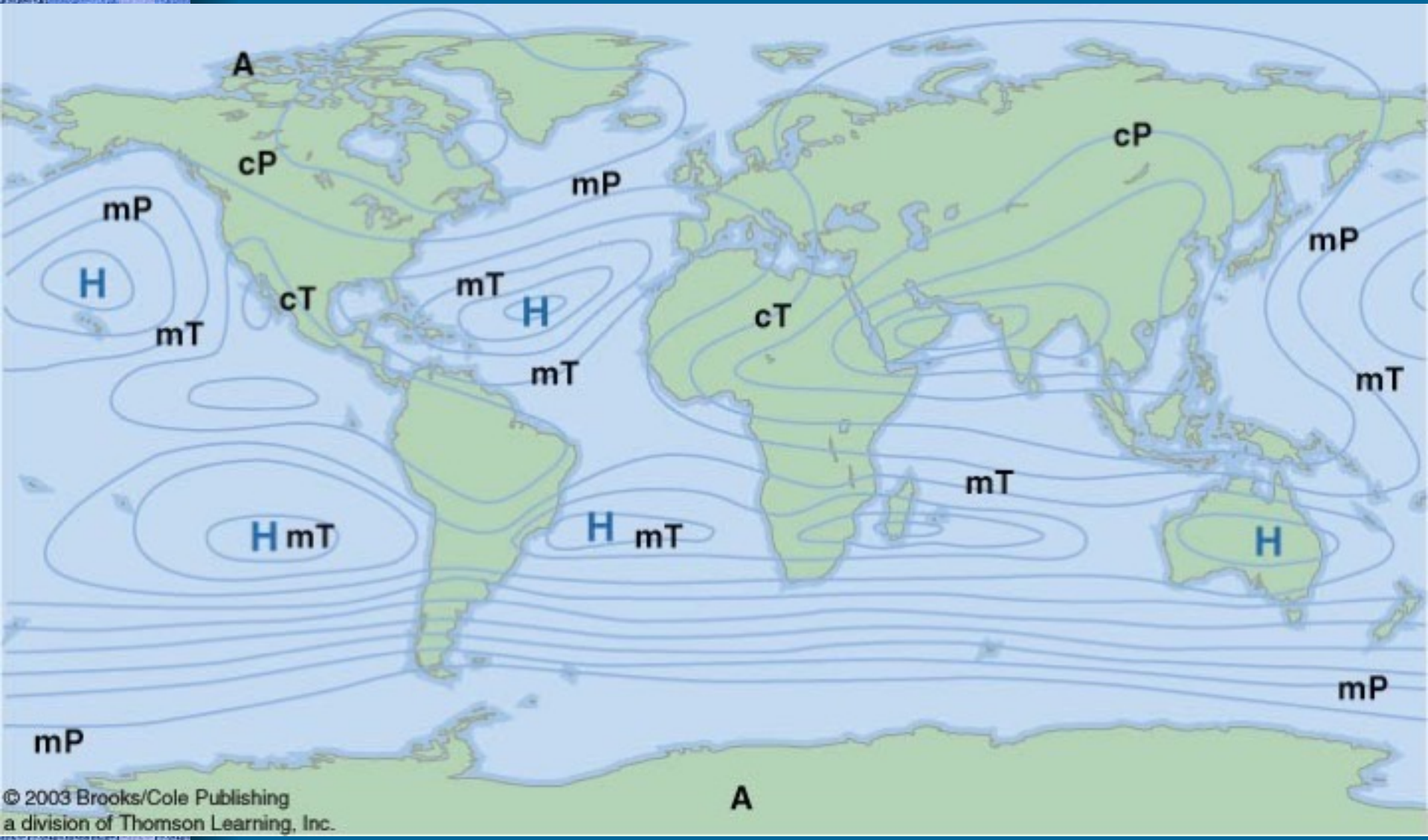

A
cP
mP
mP
H
cT
mT
mT
H
mT
cP
cT
mP
mT
mT
H mT
H mT
H
mP
mP
A
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Fig. 9.3

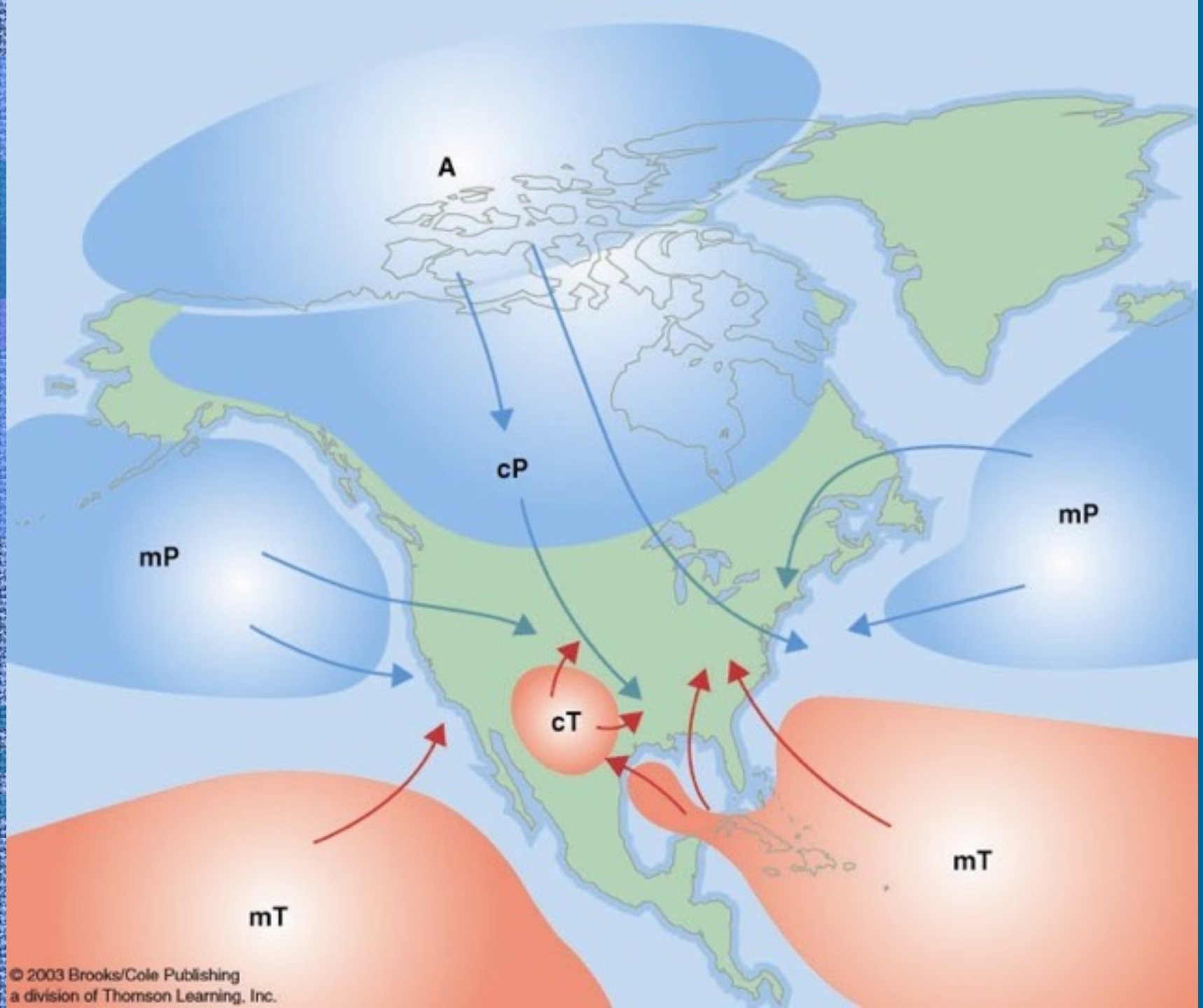
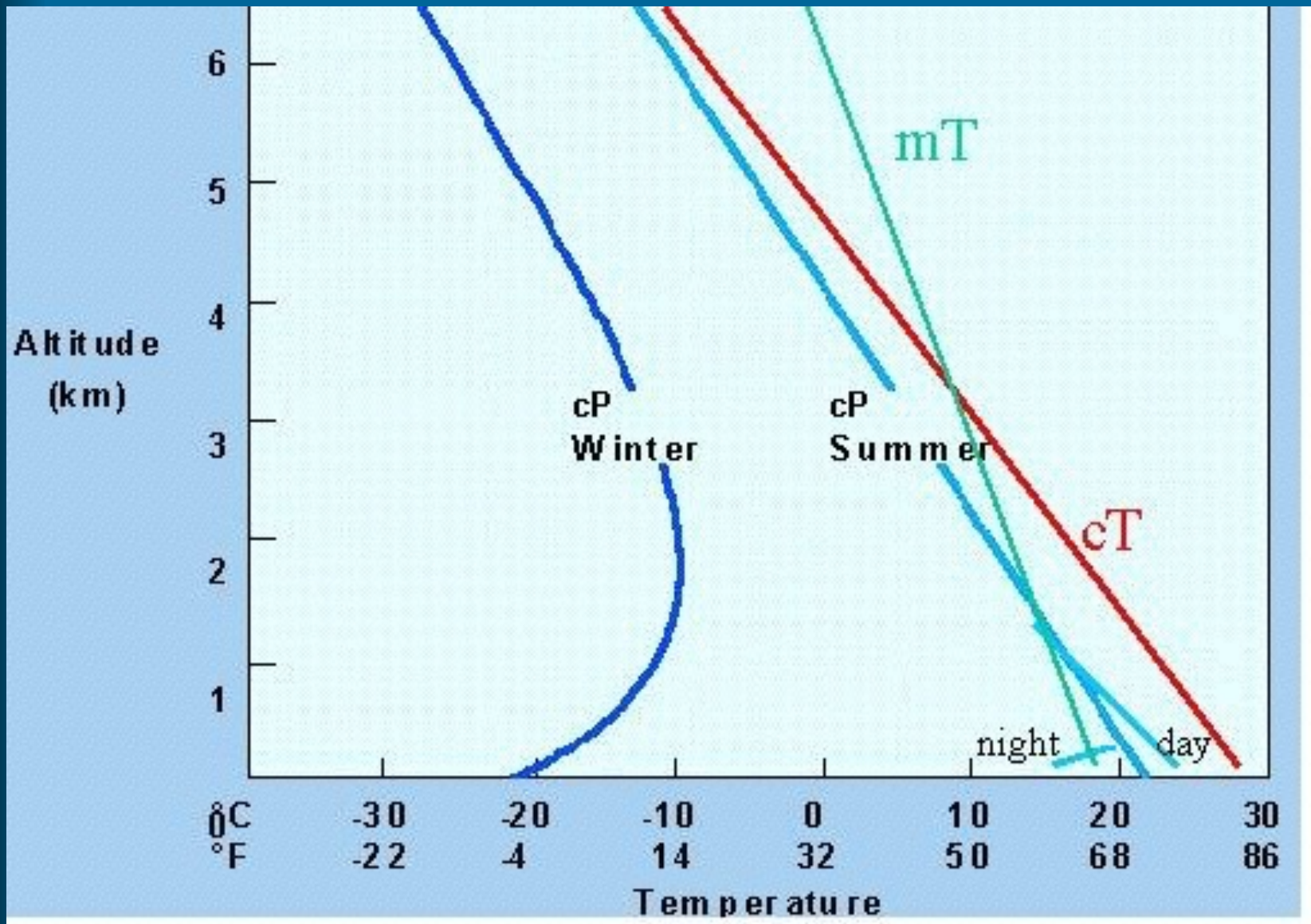
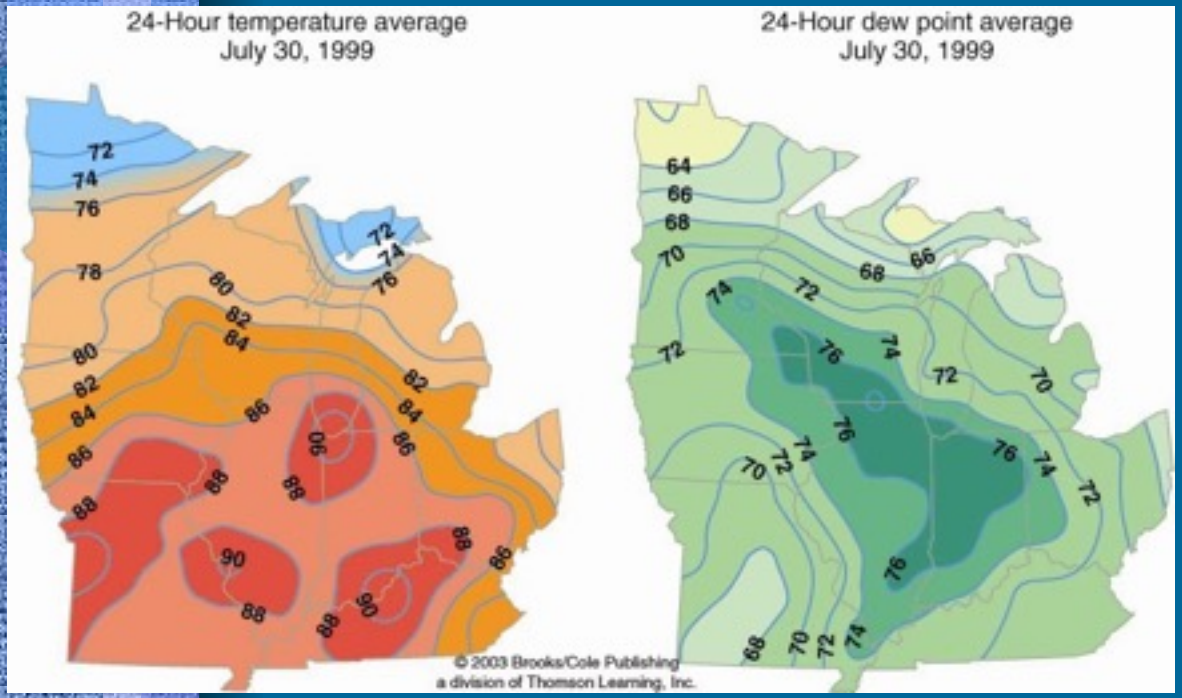


Fig. 9.4

Air masses have distinct lapse rates, and therefore also distinct cloud and precipitation characteristics



Pop quiz: what airmass is this ?



cP

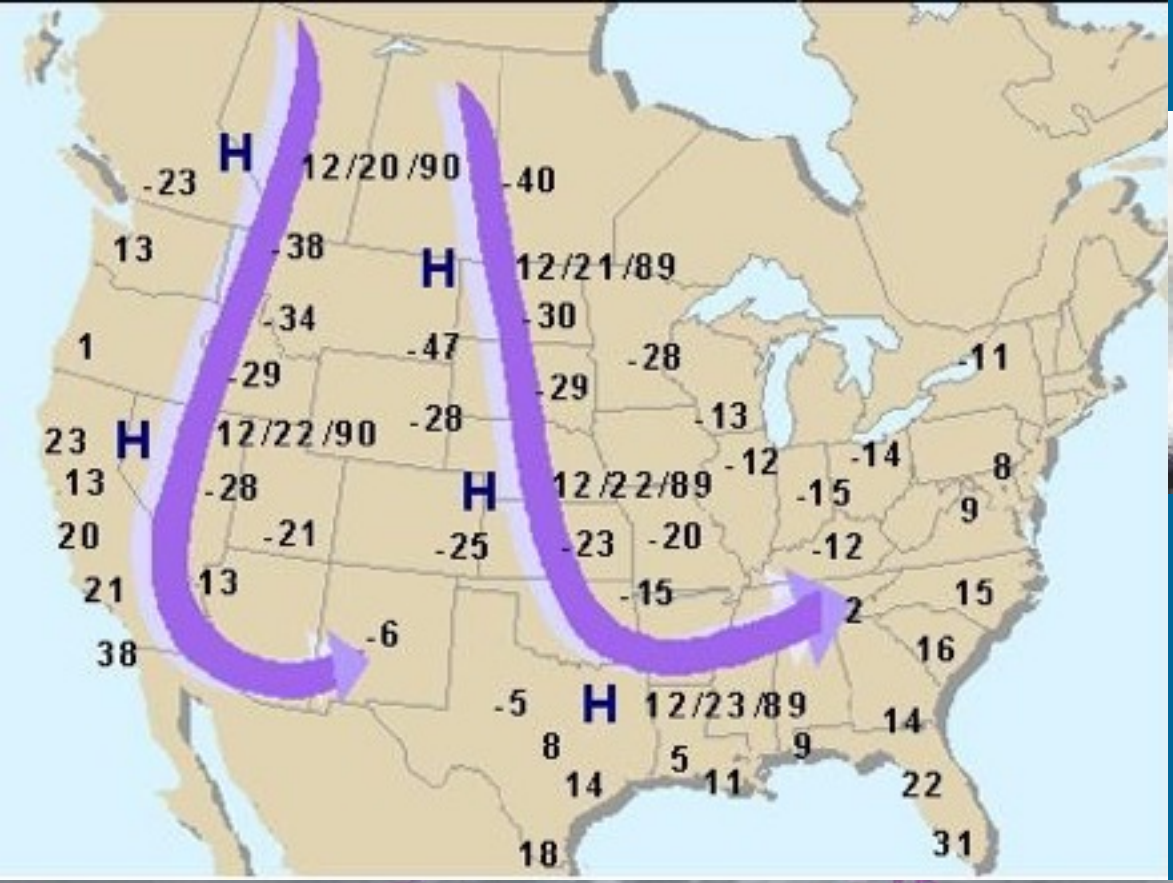
cT

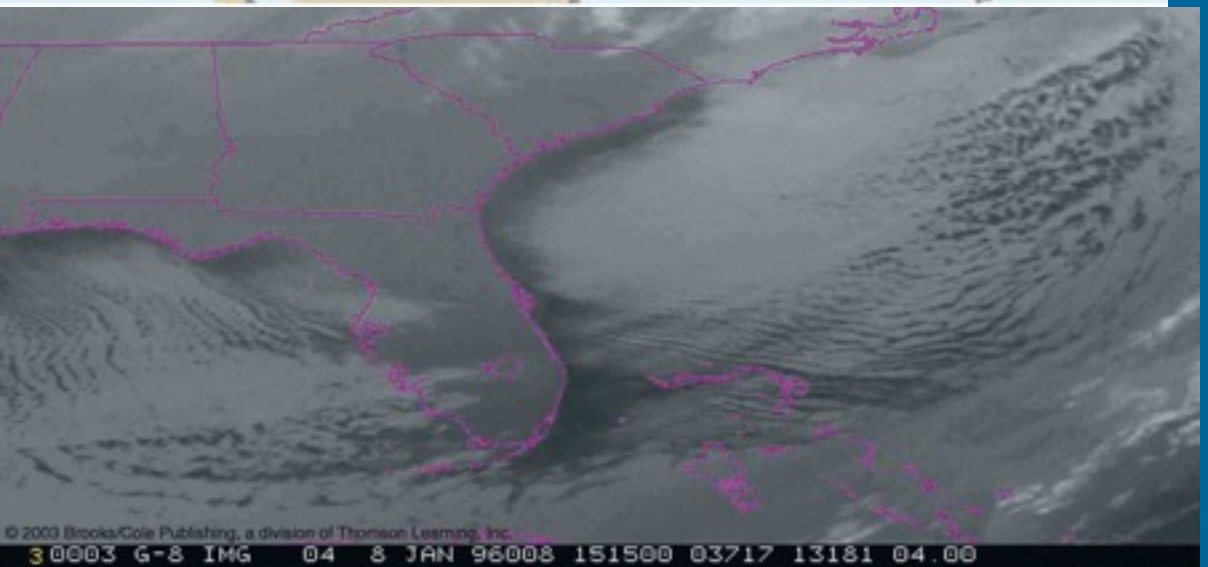
mP

mT

Pop quiz: what airmass is this ?

cP
cT
mP
mT



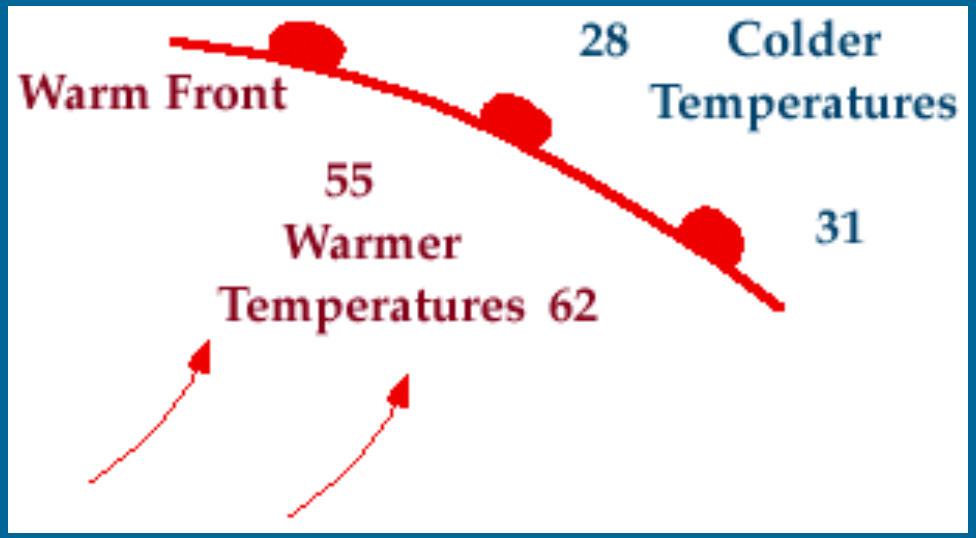


Pop quiz: what airmass is this ?

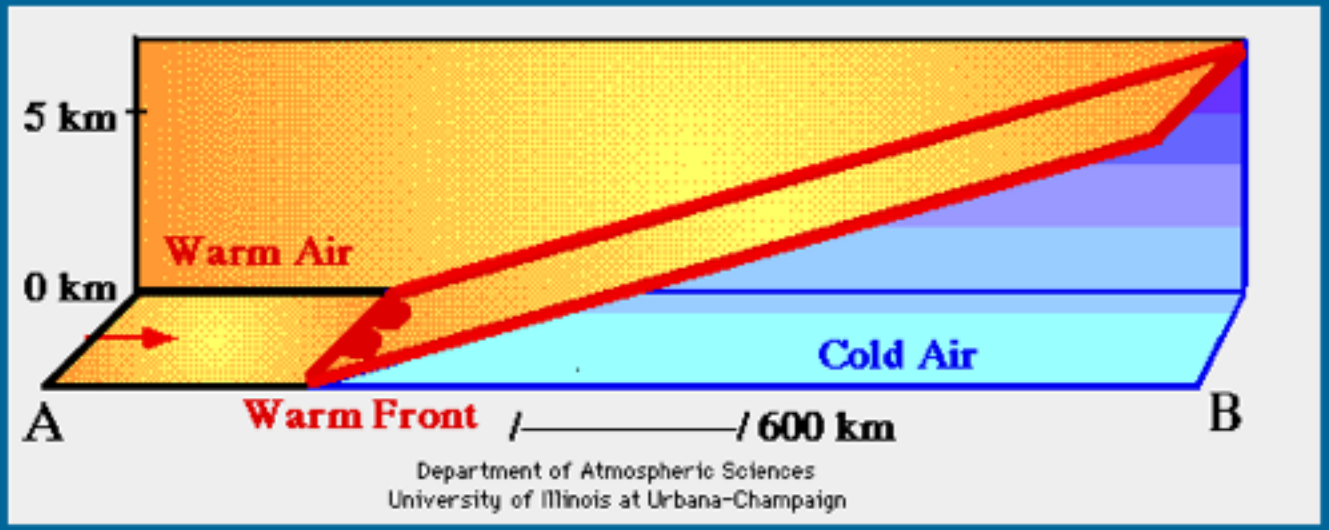
cP
cT
mP
mT

Hint: this happens in winter

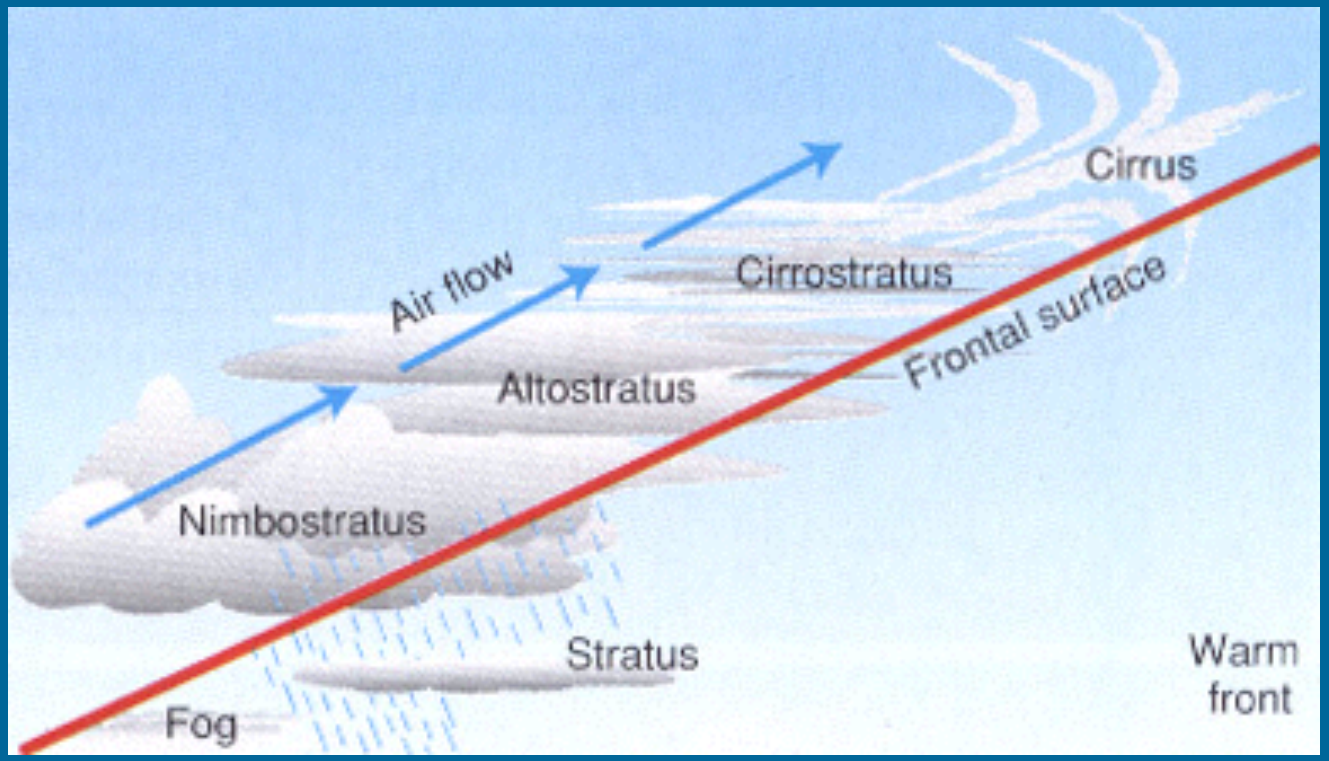
Warm fronts



The cold air recedes …



Warm front clouds



Where is the cold air??

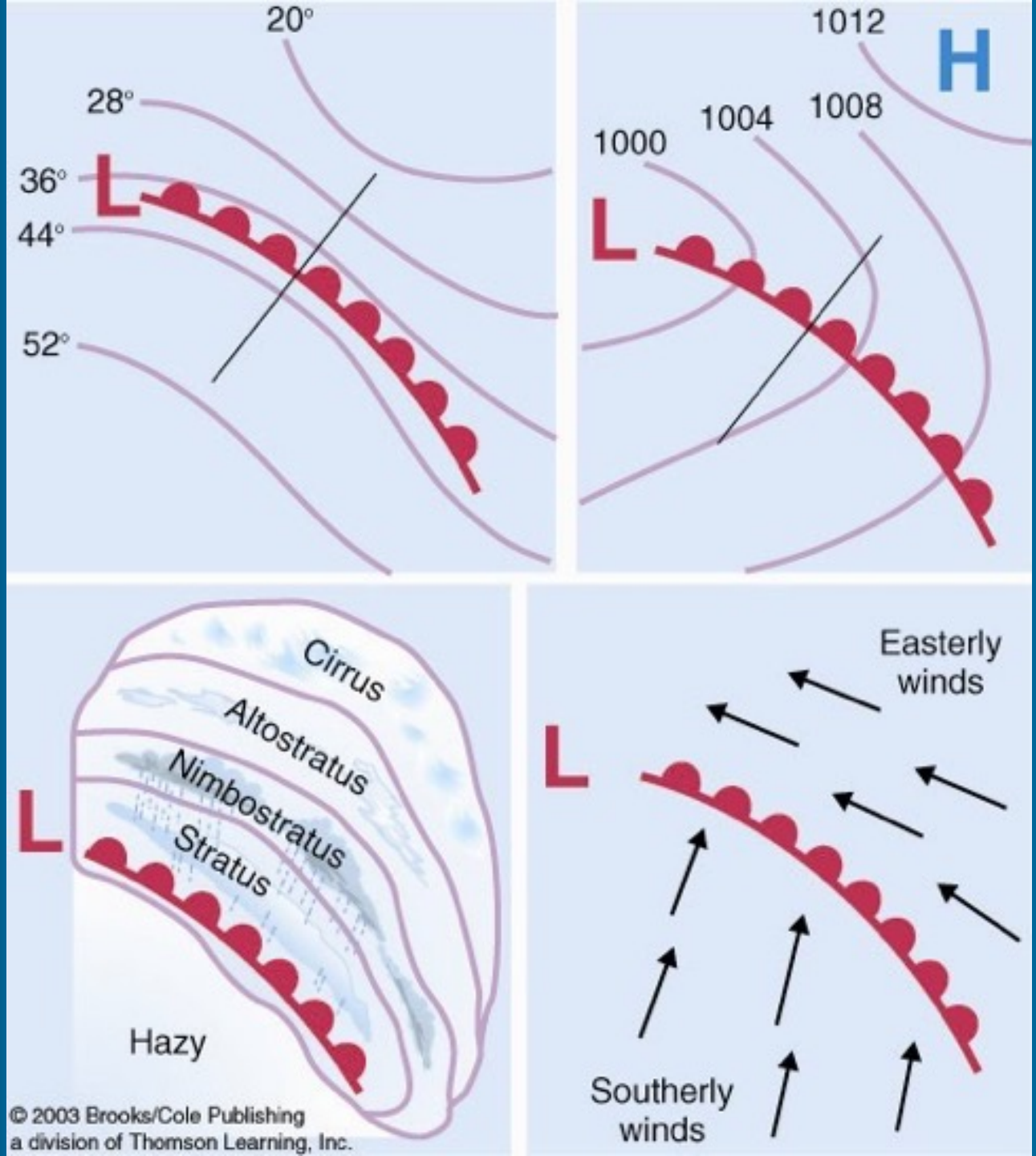
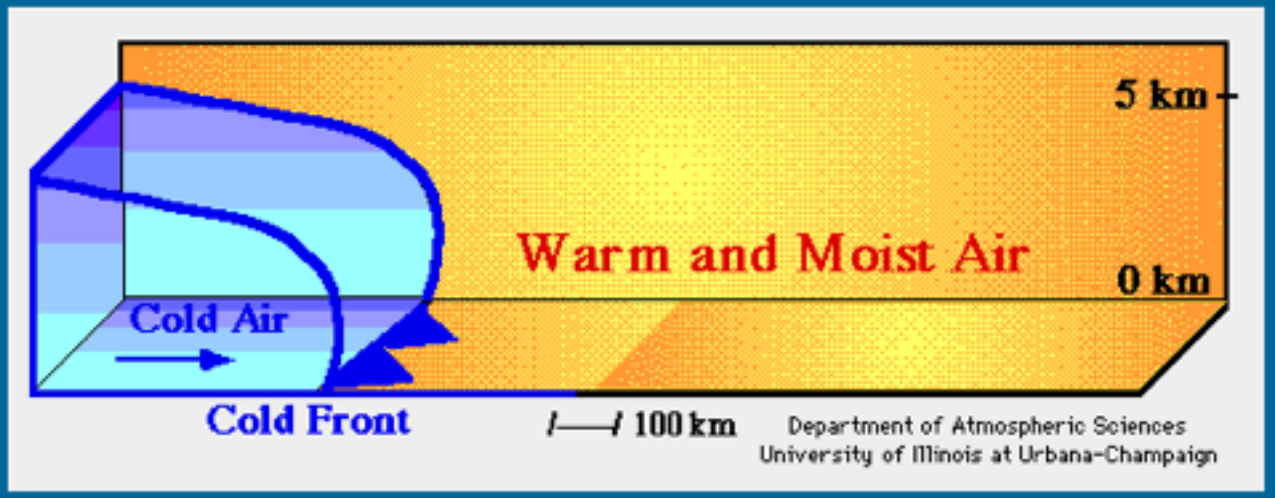
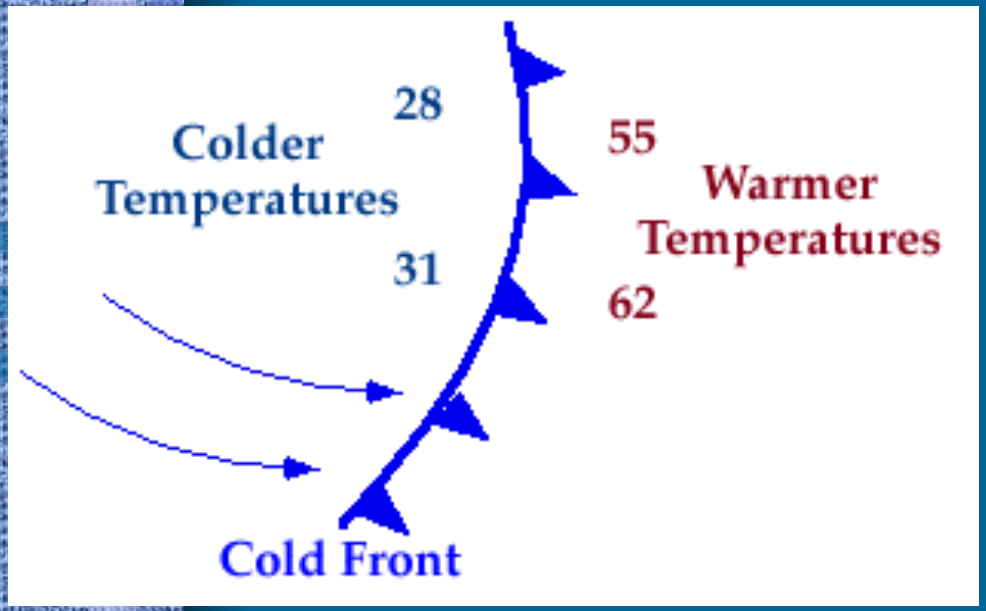
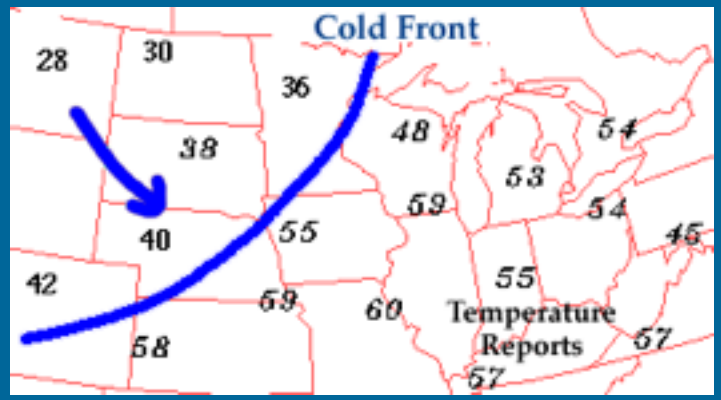


Fig. 9.16

Cold fronts

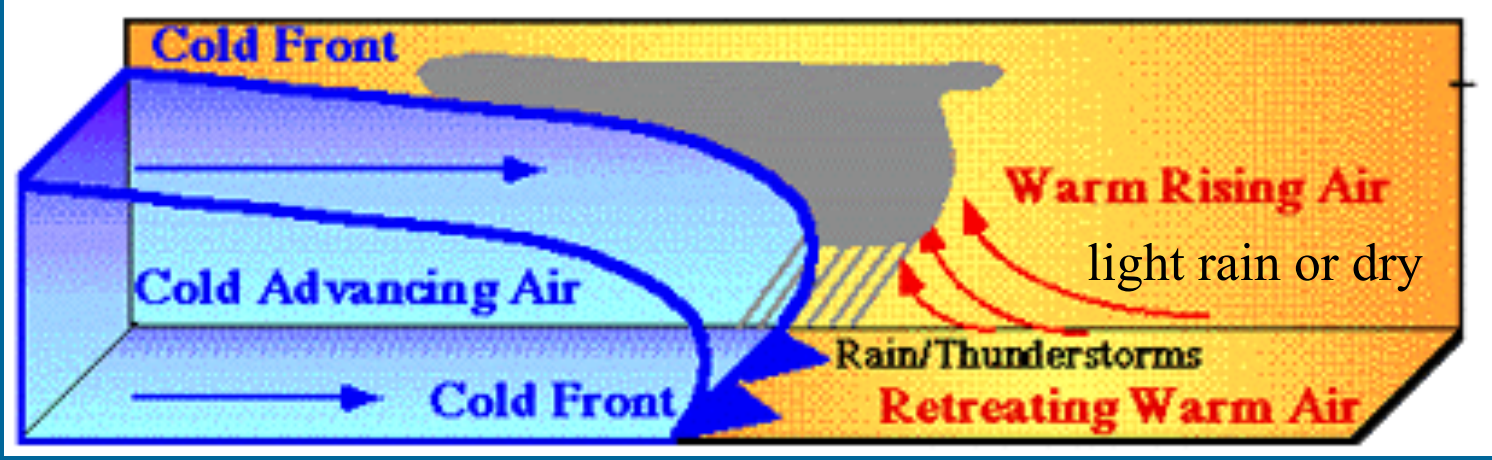

5 km
Warm and Moist Air
0 km
Cold Air
Cold Front
100 km
Department of Atmospheric Sciences
University of Illinois at Urbana-Champaign


28
Colder
Temperatures
31
55
Warmer
Temperatures
62
Cold Front

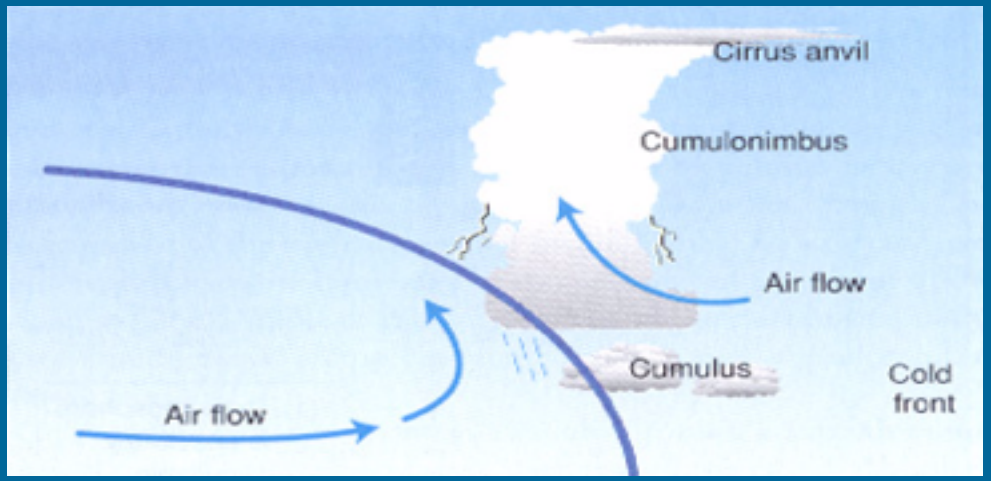

Cold Front
28
30
36
38
48
54
53
59
54
40
55
46
42
55
59
60
Temperature
Reports
57
58
57

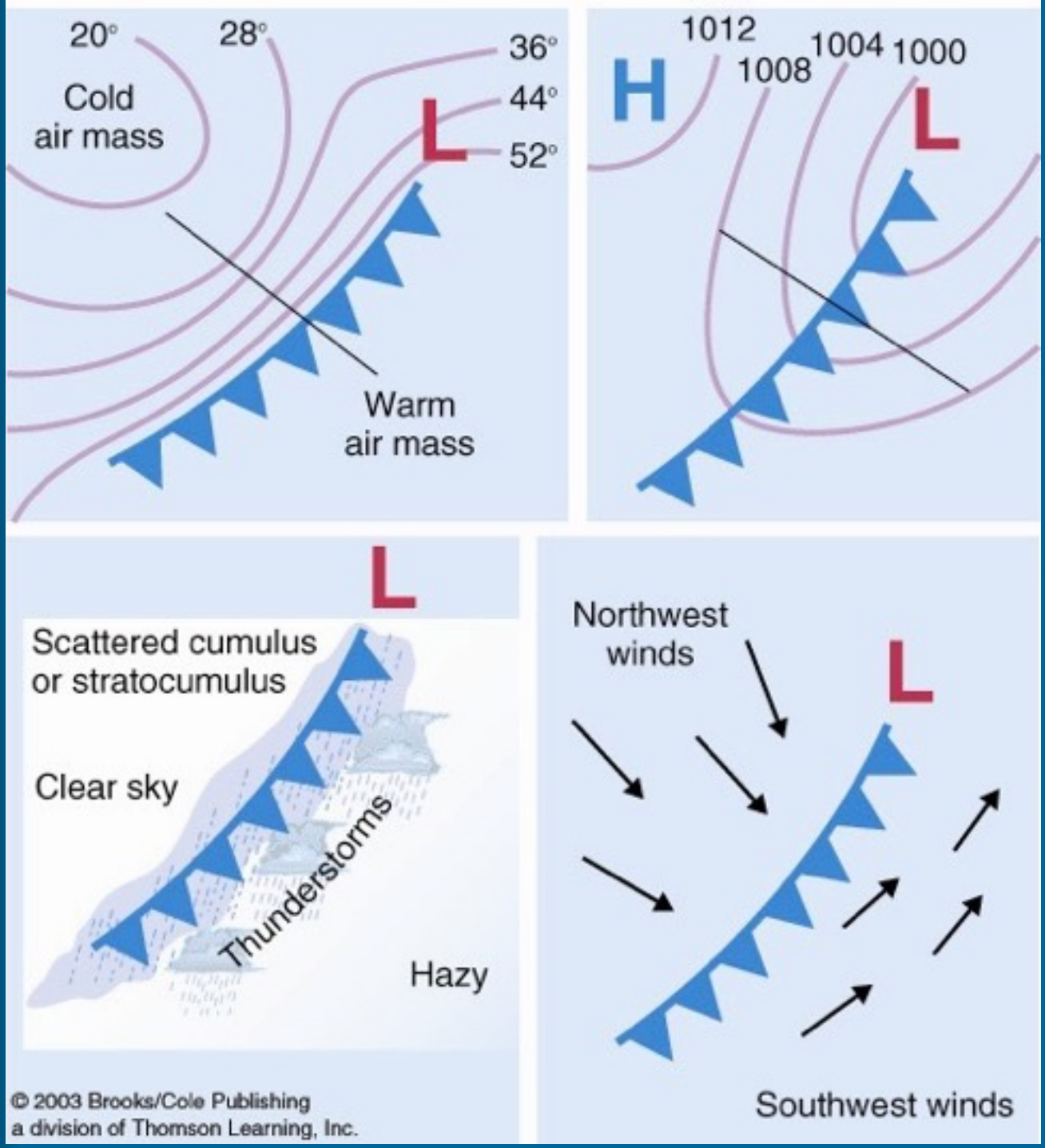
Cold front clouds

(1) stable air ahead of cold front



(2) unstable air ahead of cold front




20°
28°
36°
44°
52°
Cold
air mass
L
Warm
air mass
1012
1008
1004
1000
H
L
L
Scattered cumulus
or stratocumulus
Clear sky
Thunderstorms
Hazy
© 2003 Brooks/Cole Publishing
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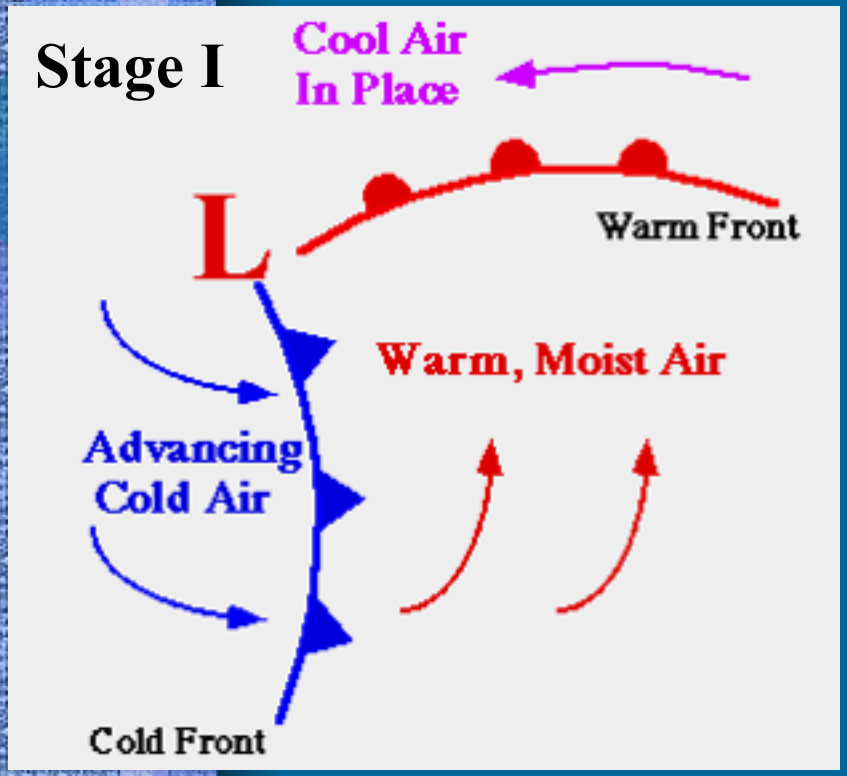
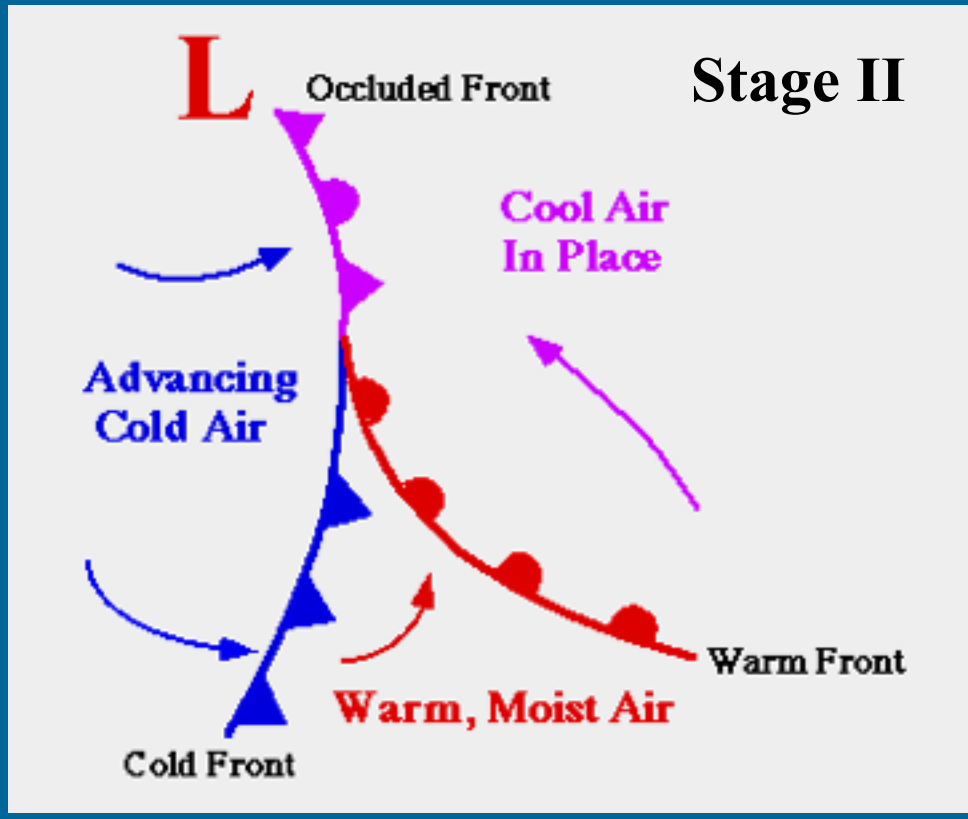
Northwest
winds
L
Southwest winds

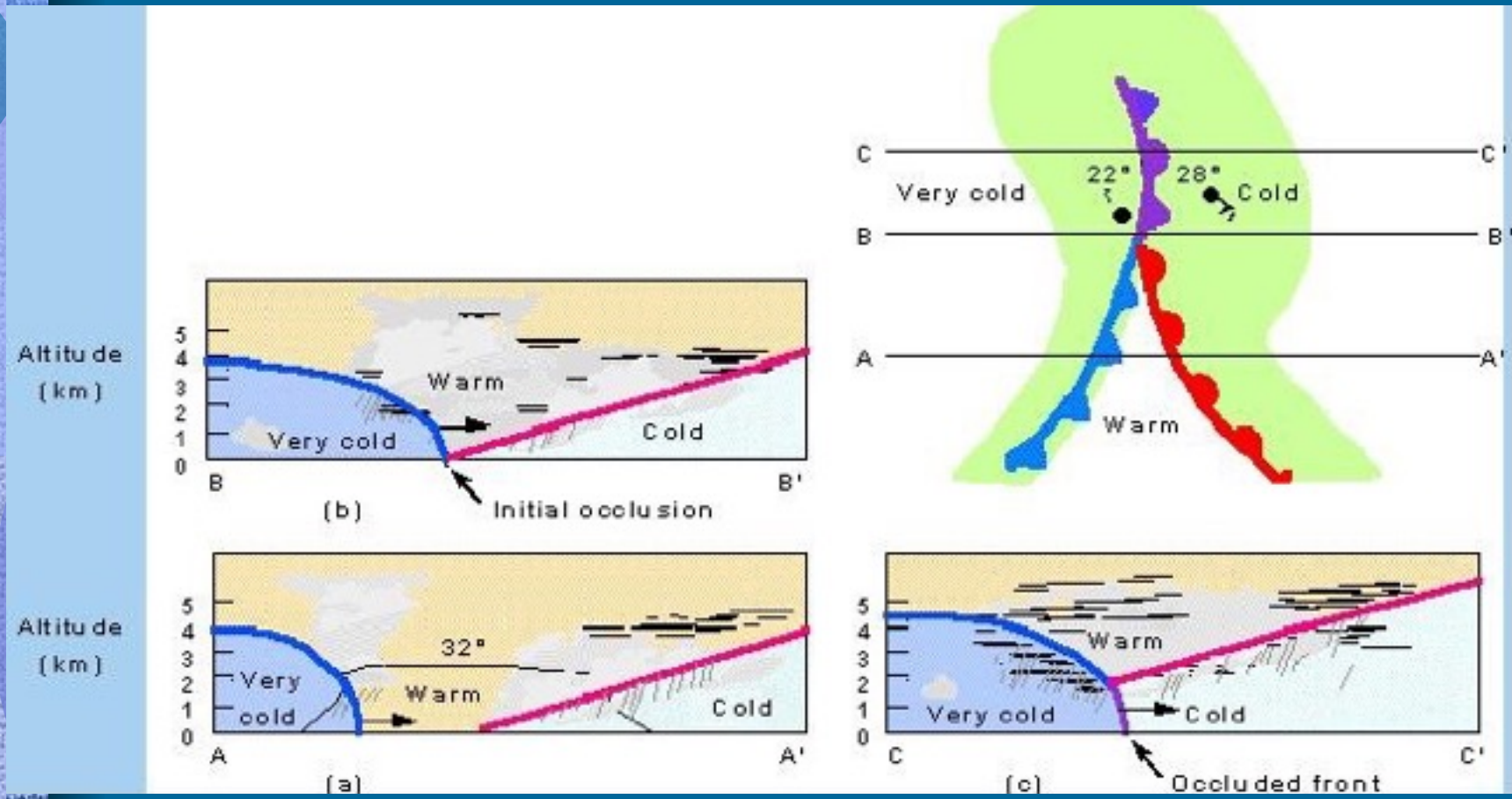
Fig. 9.14

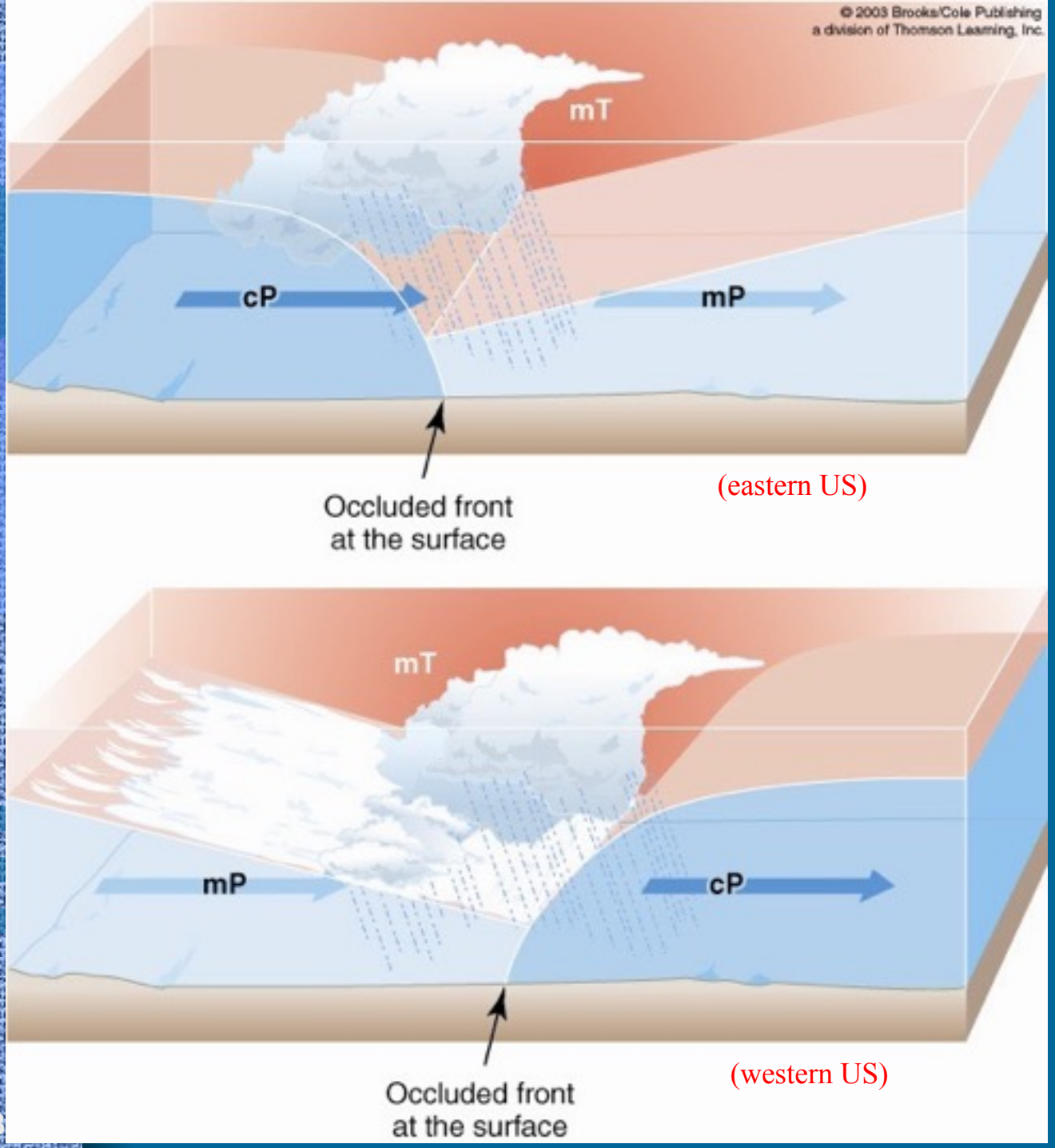
Occluded fronts





Cross section through an occluded front





Cold occlusion

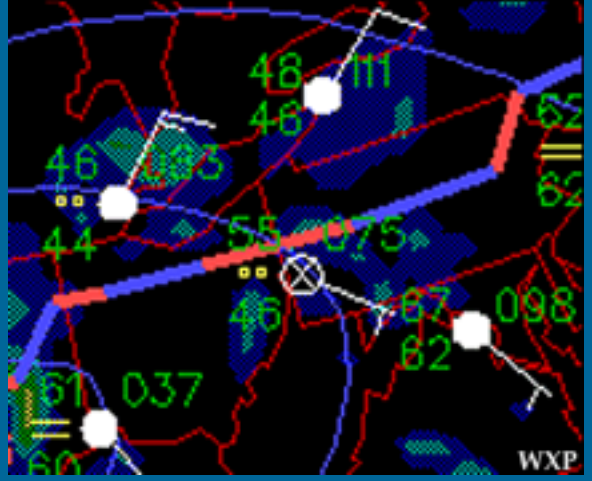
(eastern US)

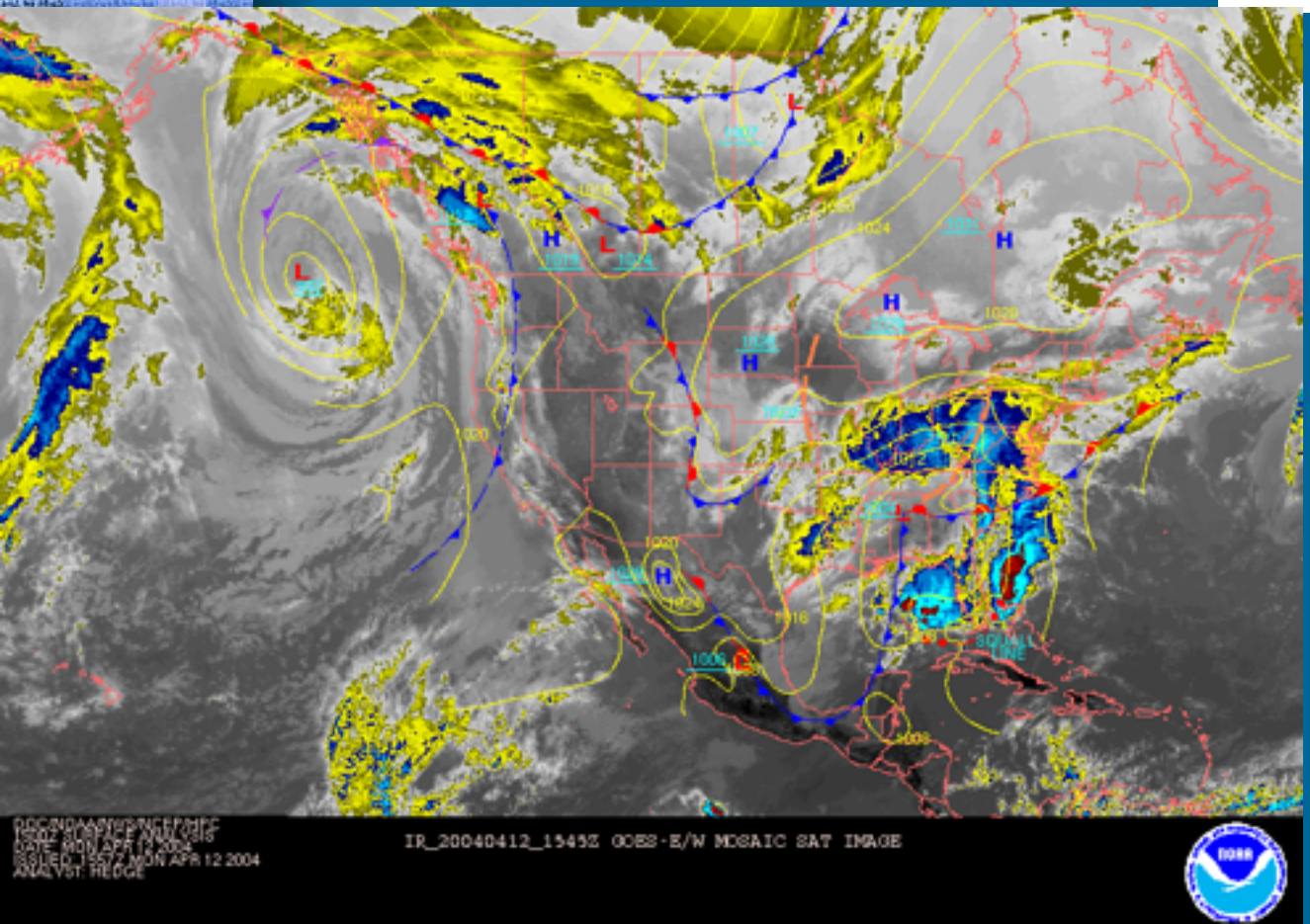
Warm occlusion

(western US)

Fig. 9.18

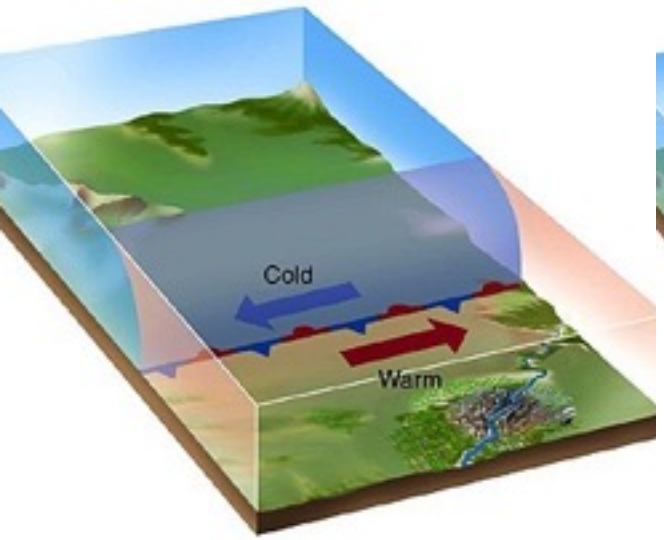
Stationary fronts

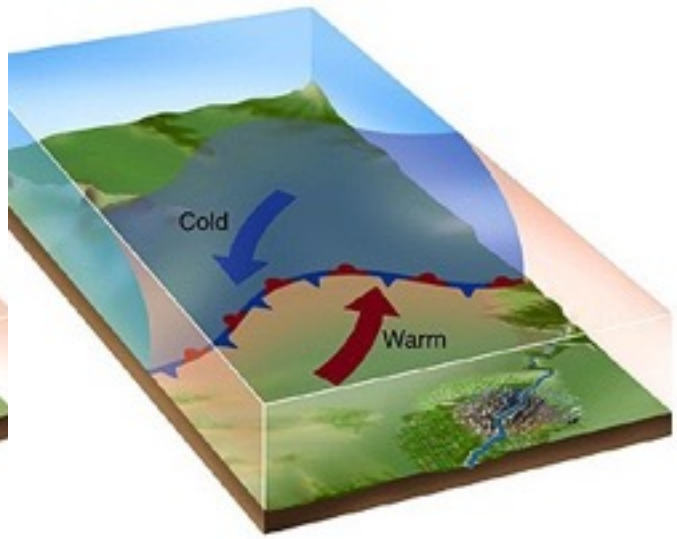


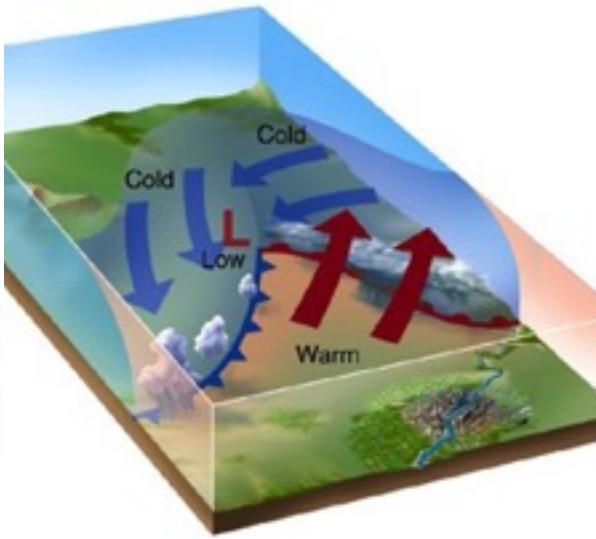


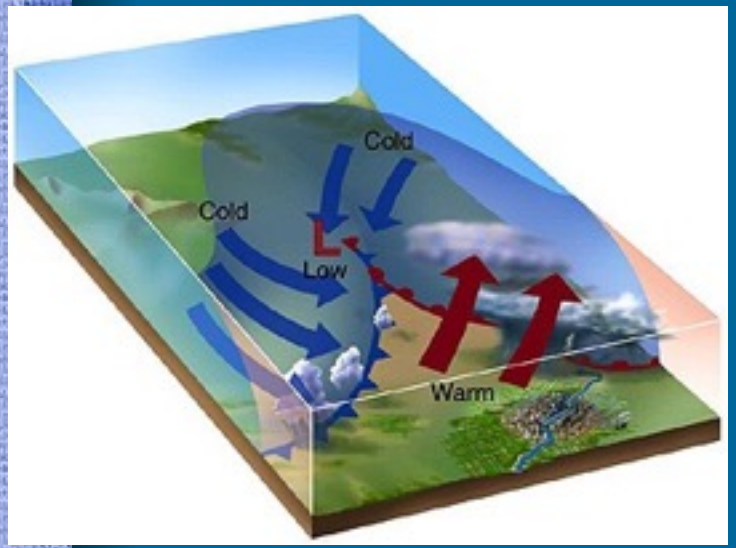
Current analysis

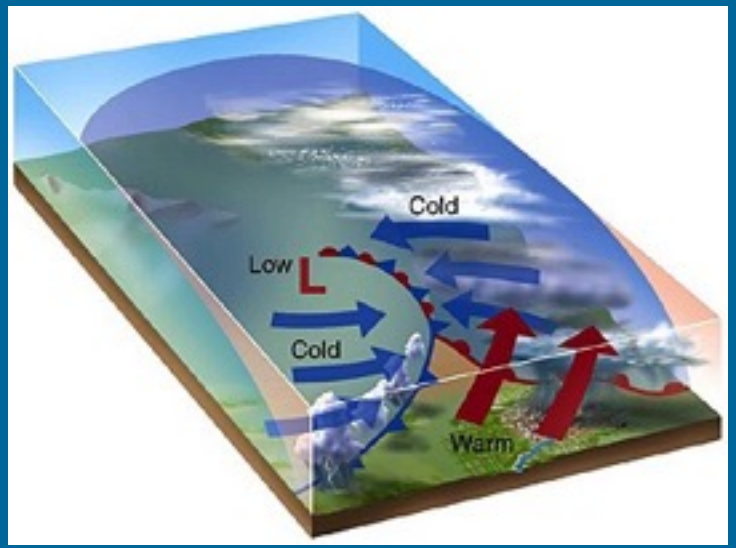
3D view of fronts during the evolution of a frontal disturbance



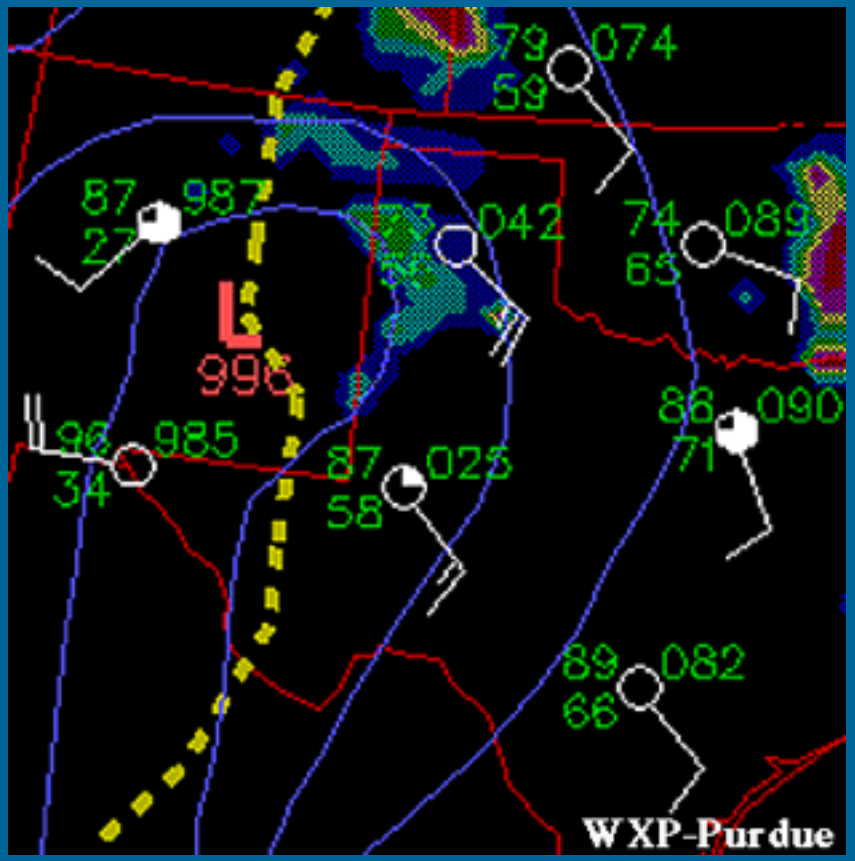


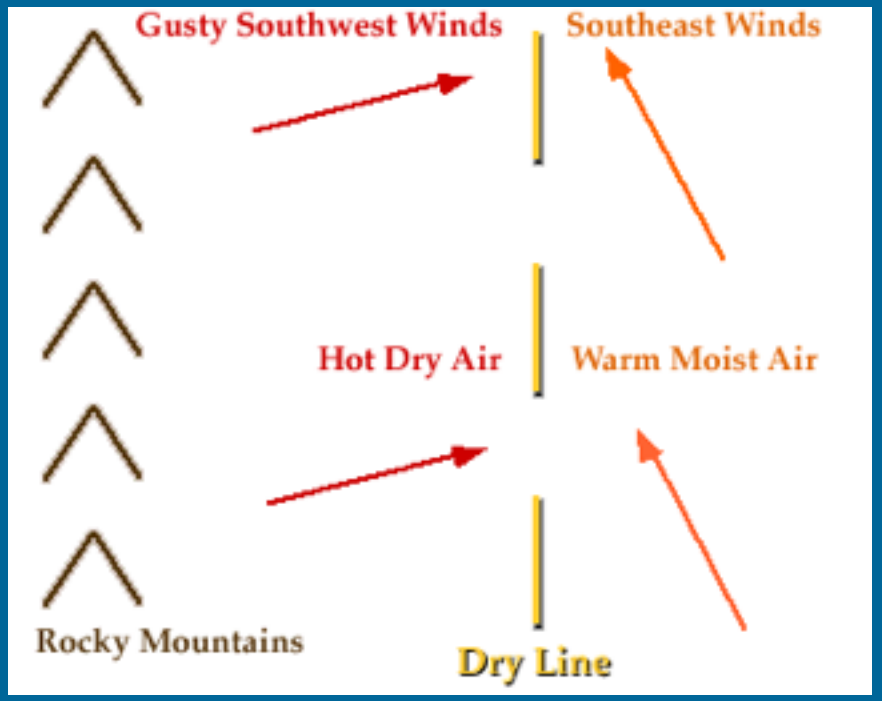






drylines





Thunderstorms, sometimes severe ones, can be triggered along the dryline.

Case study: winter storm of 10-13 Dec 2000

Cloud & precipitation formation mechanisms

- Buoyant ascent [bubble ascent]
- Forced ascent [layer ascent]
  a) Orographic
  b) Frontal
  c) Low-level convergence (friction)
  d) Upper-level divergence (jet stream)

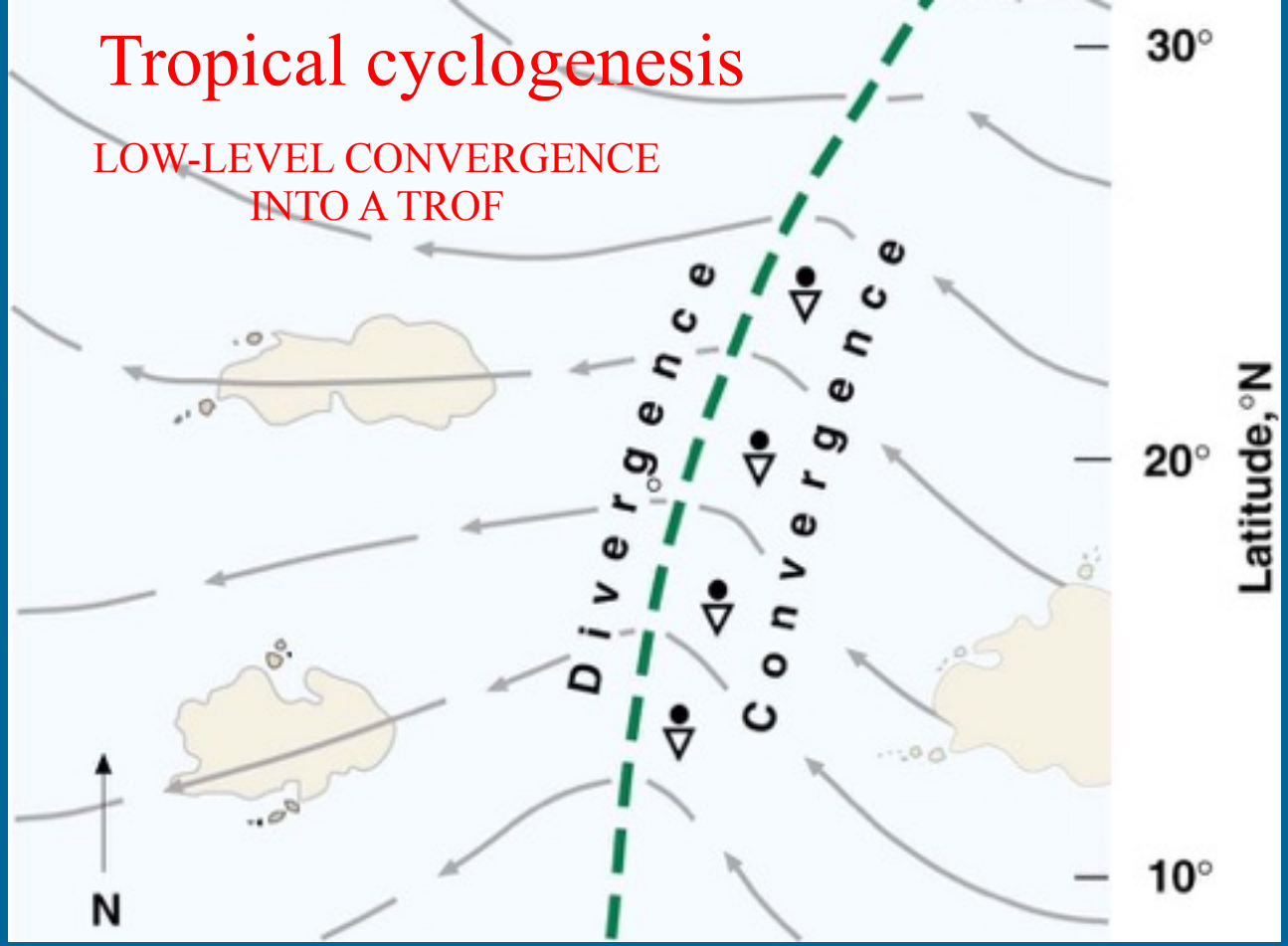
(c) Low-level convergence into lows or trofs

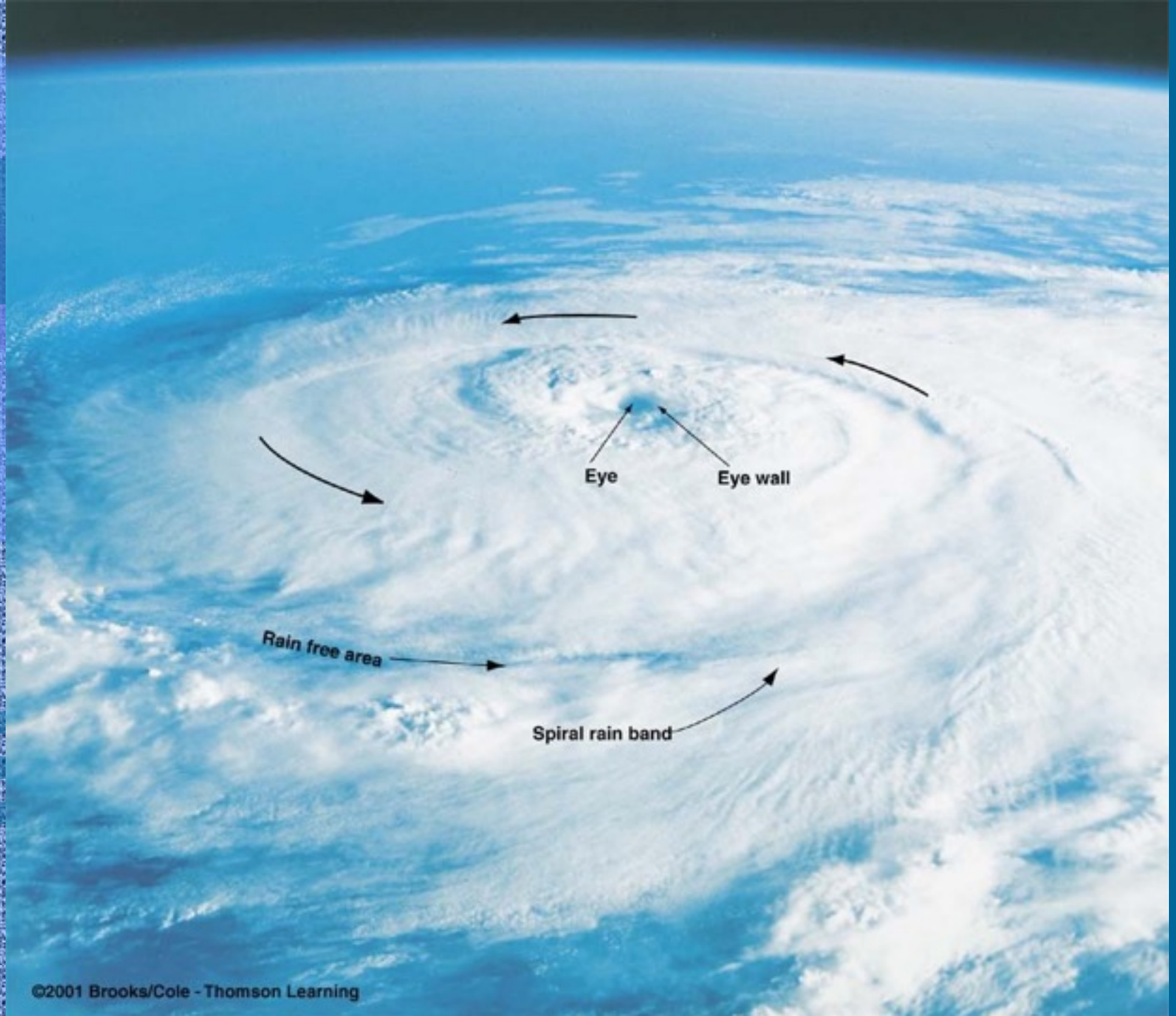
1) Tropical lows (hurricanes)
   extract their energy from latent heat release

2) Mid-latitude lows
   extract most of their energy from the jet stream

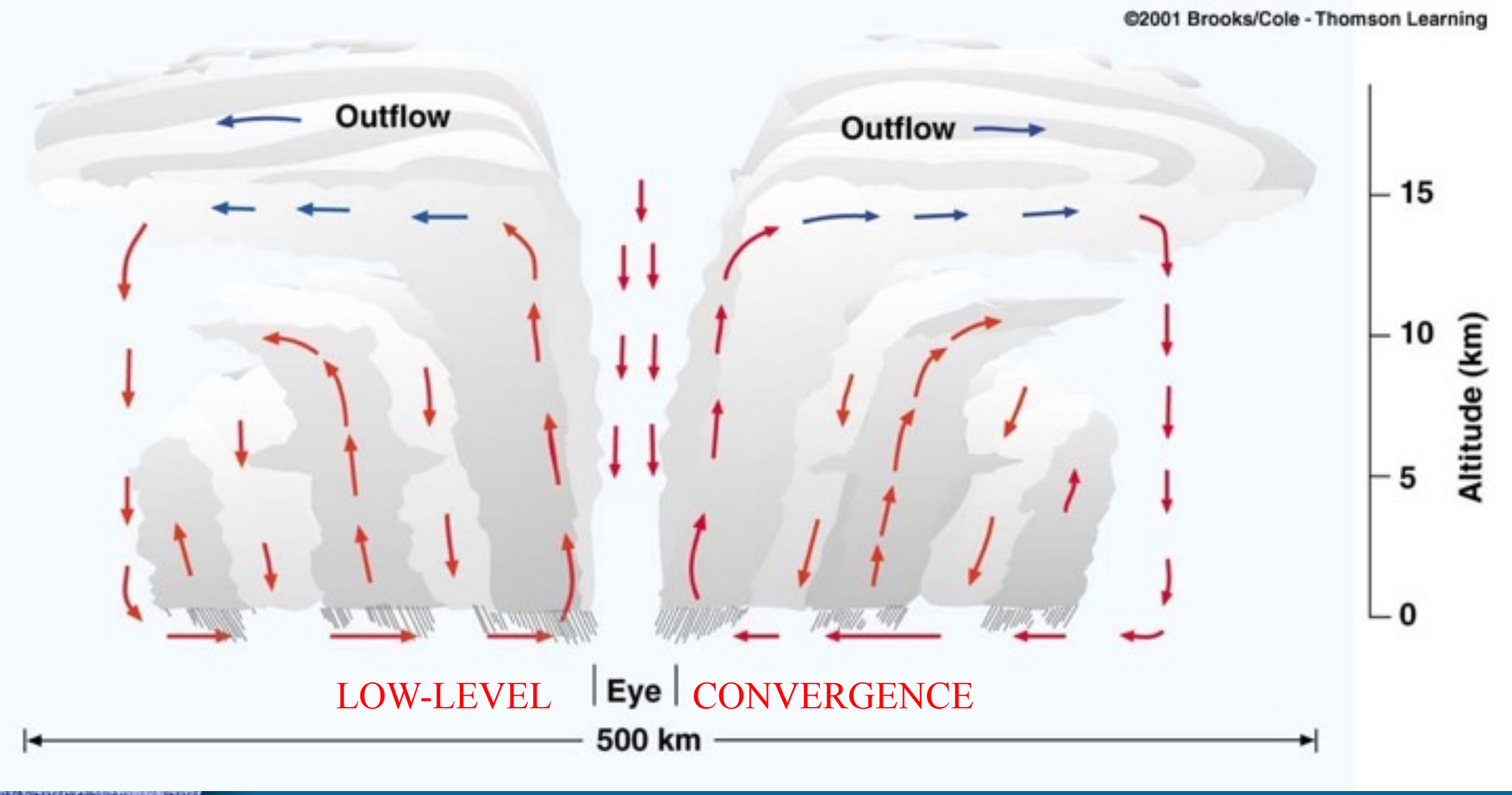
Tropical cyclogenesis

LOW-LEVEL CONVERGENCE
INTO A TROF

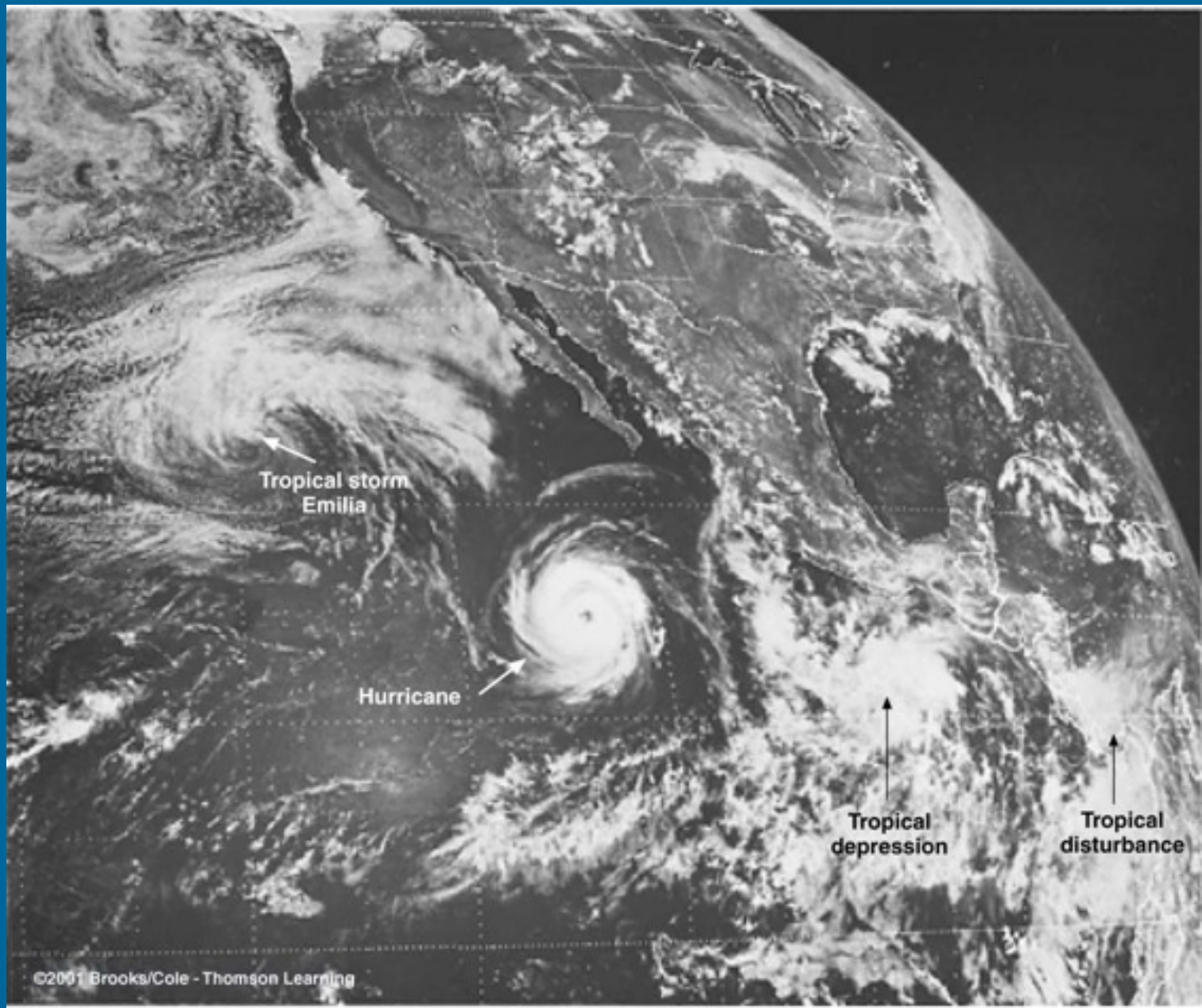



Eye
Eye wall
Rain free area
Spiral rain band
©2001 Brooks/Cole - Thomson Learning

Cross section thru a tropical cyclone



Check out some hurricane animations



Tropical cyclones have different names in different oceans

There spin is always cyclonic,
i.e. ccw in the north and cw in the south

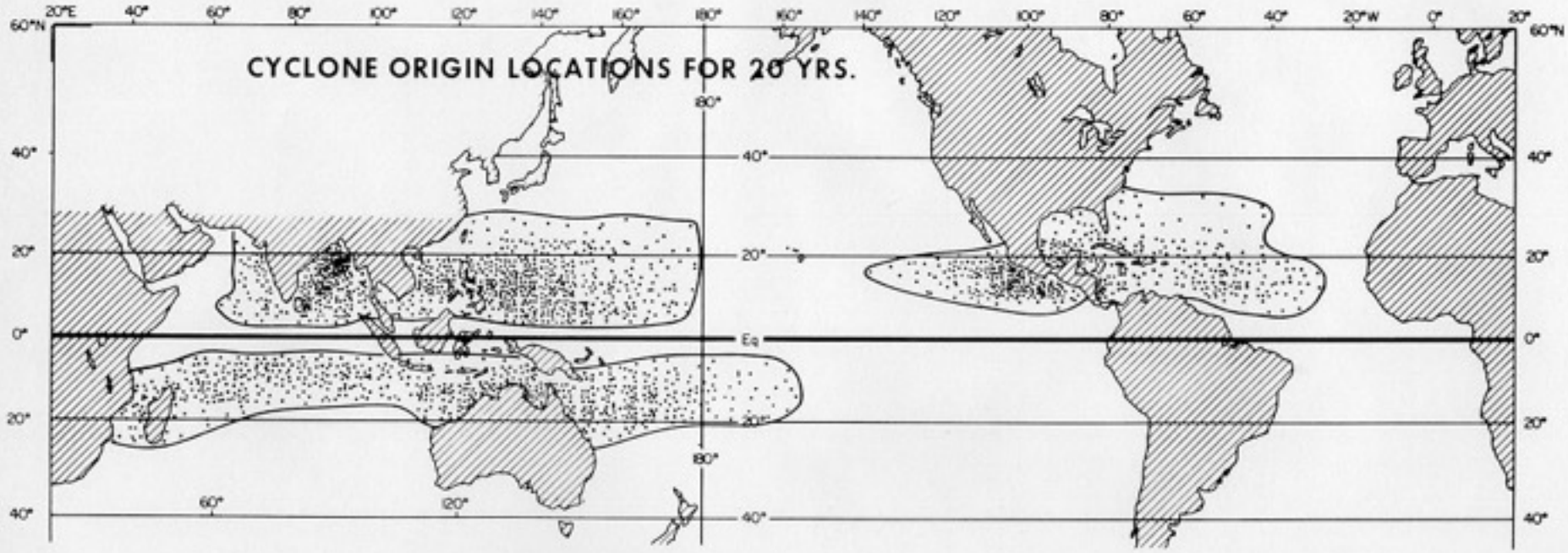
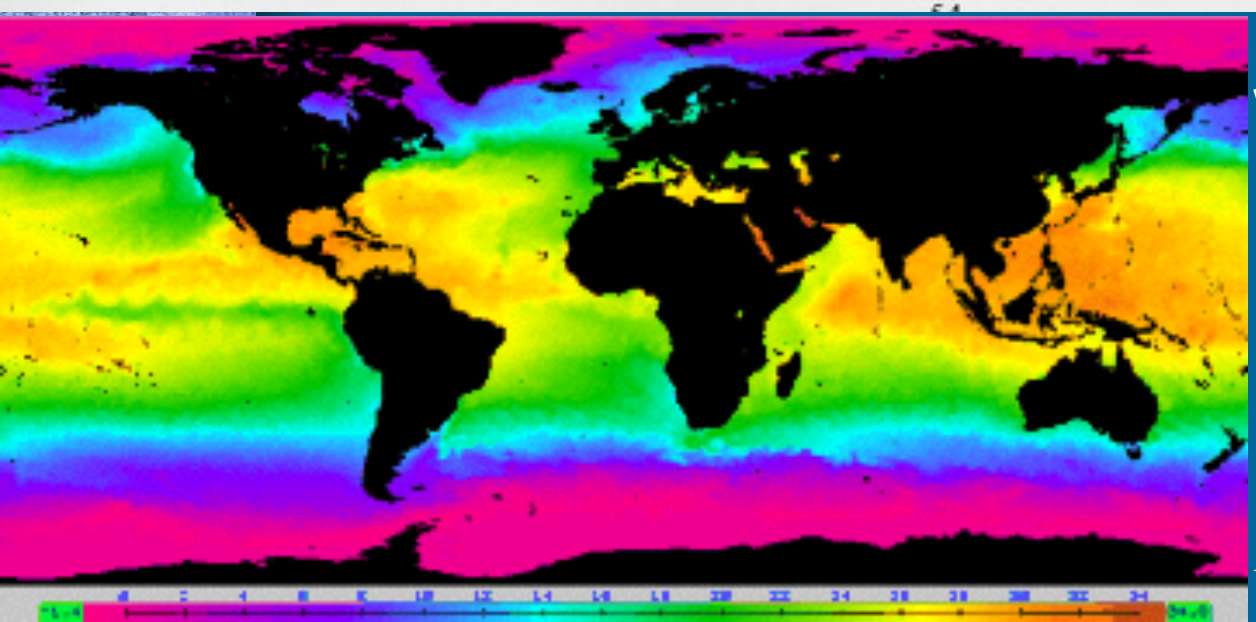


Fig. 3.1 Points of initial detection of pre-hurricane tropical disturbances (Gray, 1975).



August SST

Where do hurricanes form?

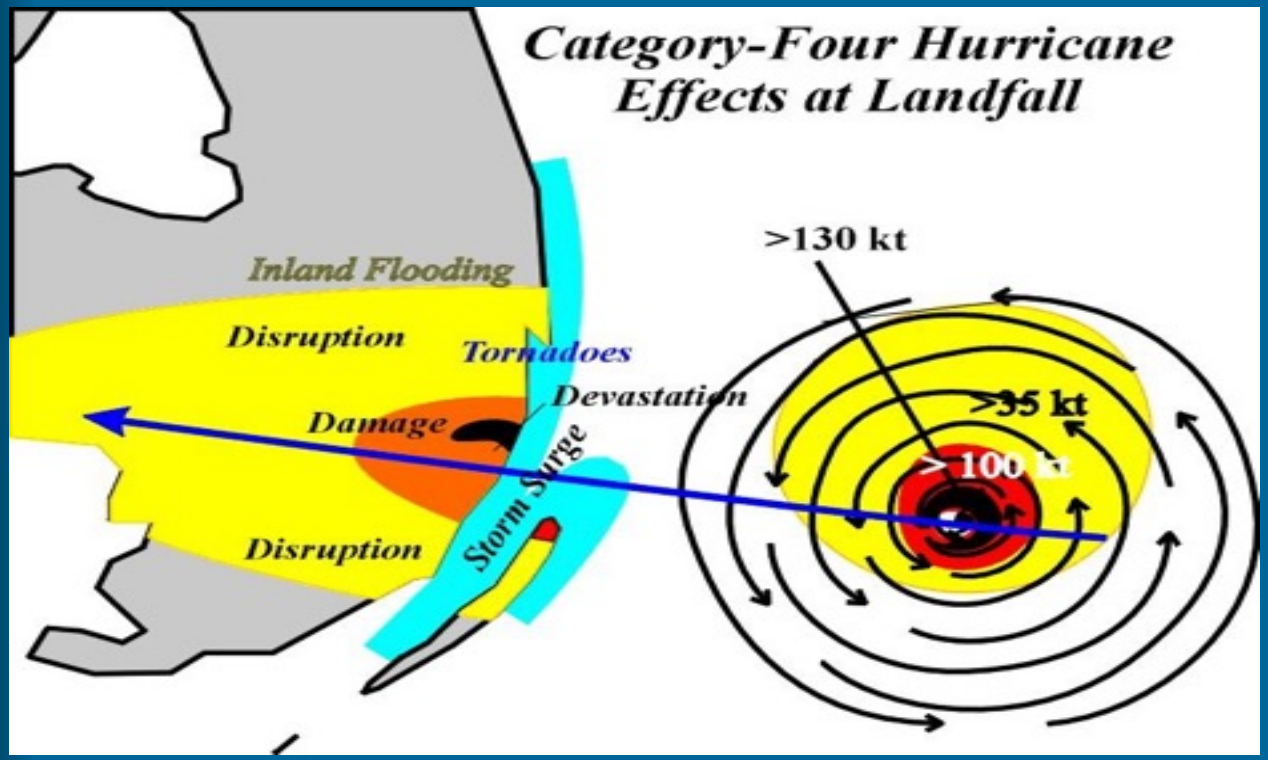
- Away from the equator
- Where the SST is at least 80°F

Hurricane Effects:

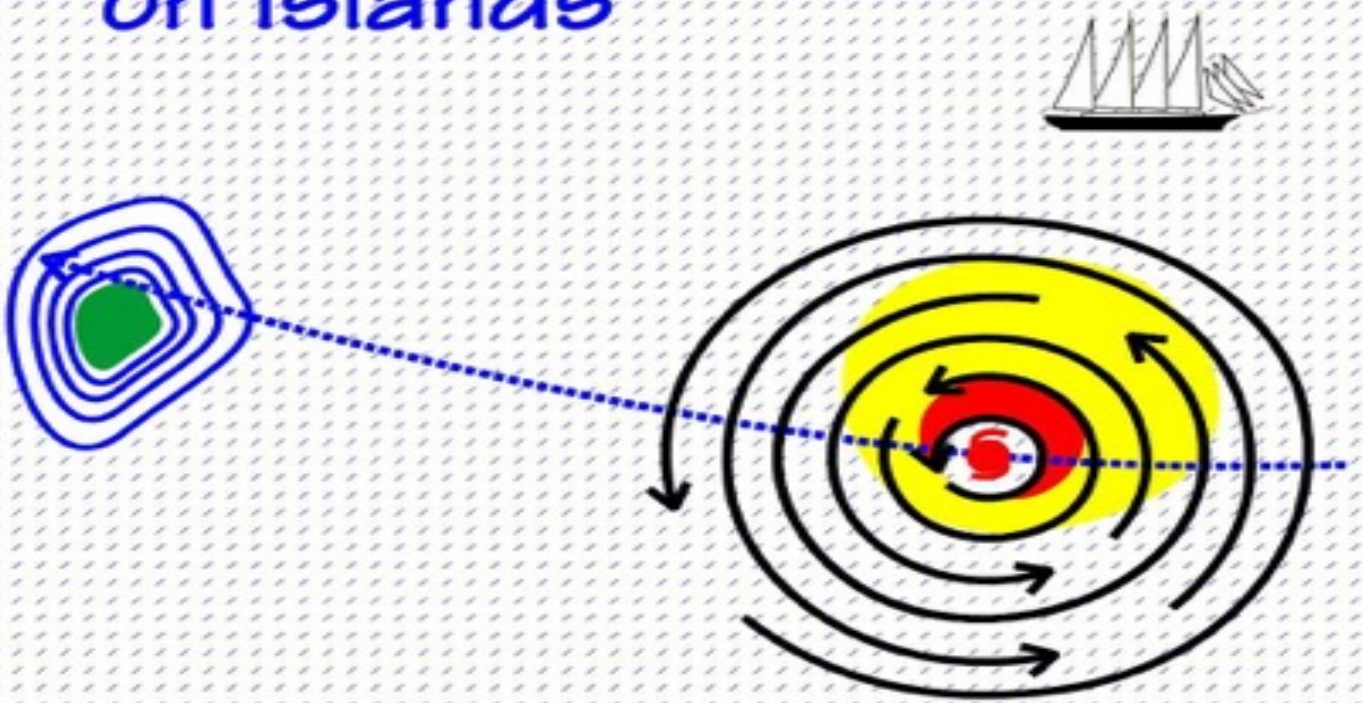
Wind: causes most damage, but limited mortality.

Storm surge: a historical killer, now mitigated by evacuation.

Rain and Inland Flooding: take more lives than wind, but do less damage.

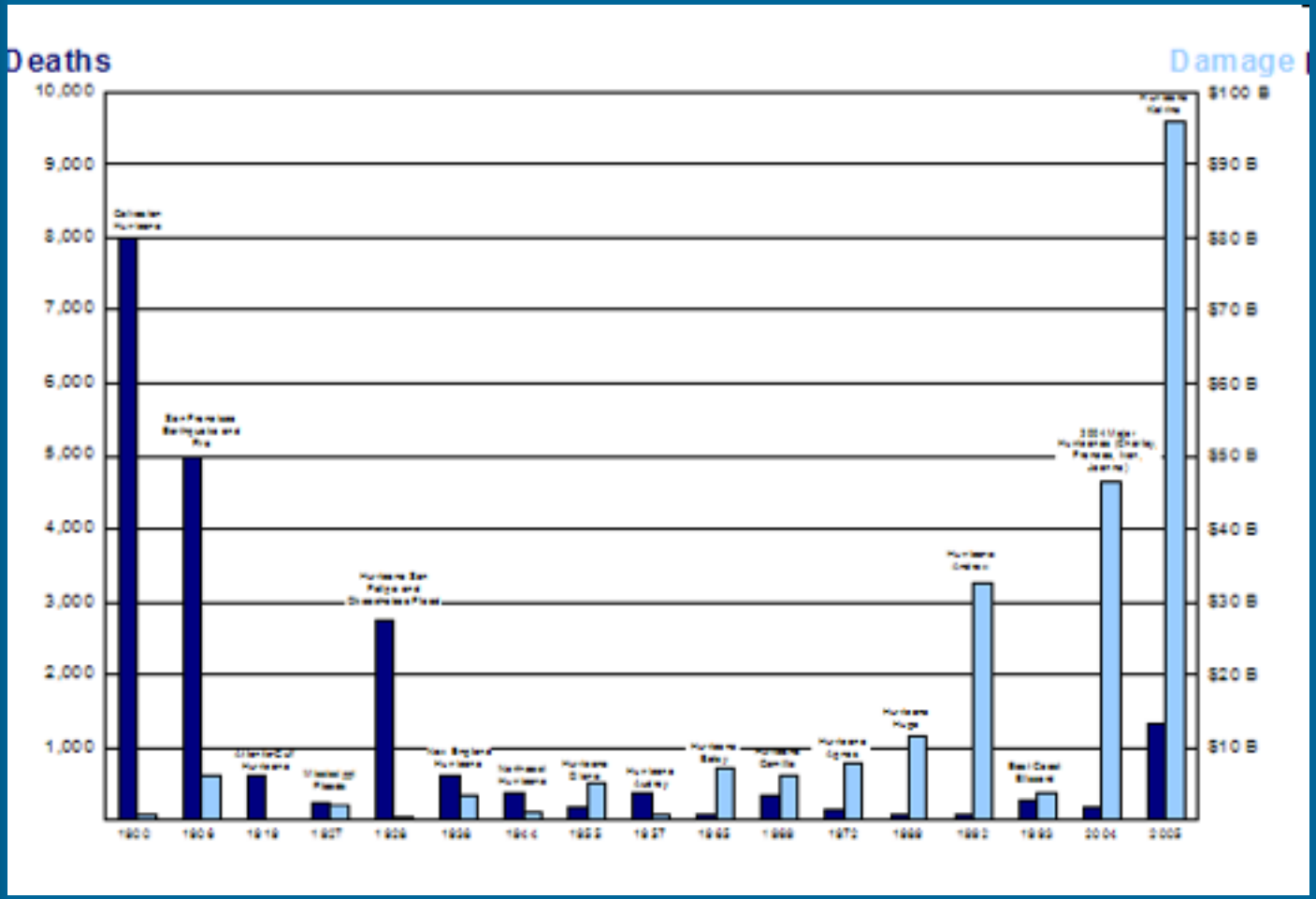


Hurricane Impacts on Islands



- Early closure of airfields
- Lack of protected anchorages
- Wave & swell battering
- Heavy rain on windward slopes
- Full force of the storm
- High winds on elevated terrain
- *ISOLATION*

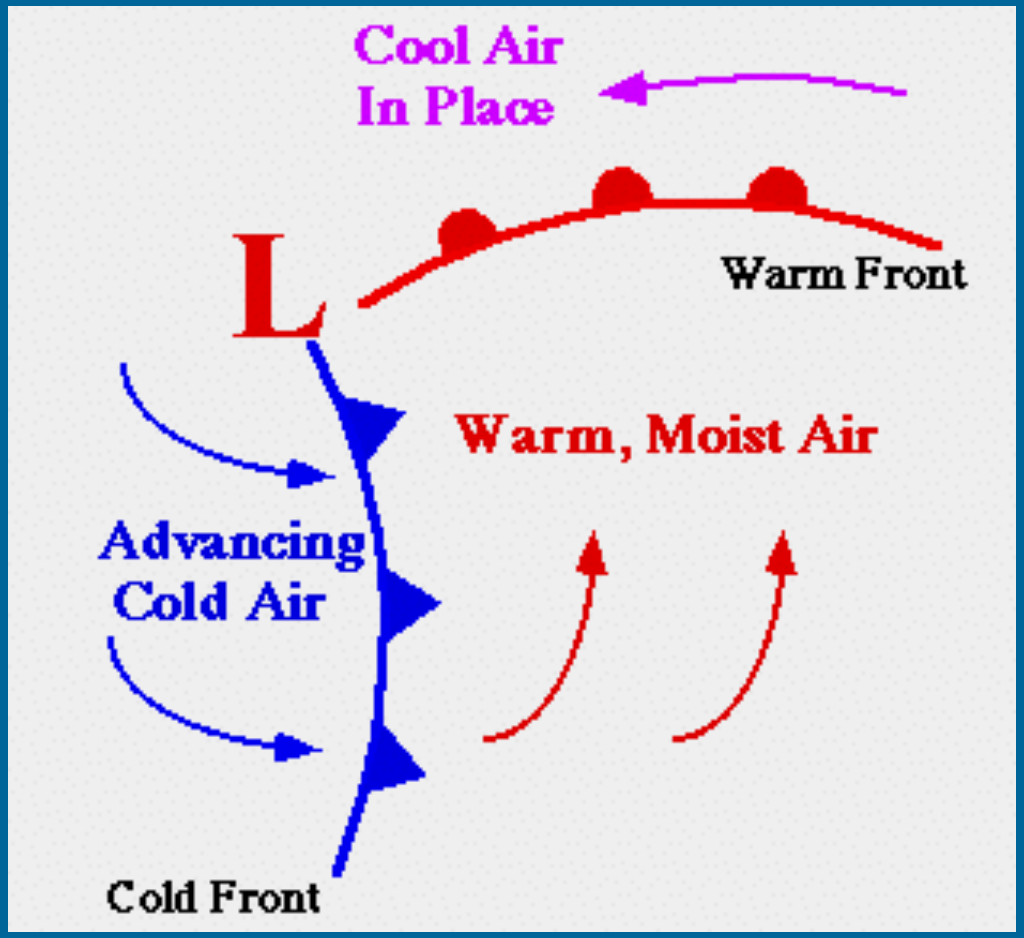
Hurricane mortality and damage, United States 1900-2008



Hurricanes are covered in the textbook in Chapter 8

Lows, and convergence, uplift, clouds, and precipitation, also occur at higher latitudes.

What energizes them?



Answer: the jet stream !!

- Buoyant ascent [bubble ascent]
- Forced ascent [layer ascent]
  a) Orographic
  b) Frontal
  c) Low-level convergence (friction)
  d) Upper-level divergence (jet stream)

THIS WILL BE COVERED IN CHAPTER 10

End of Chapter 9