NATS 101
Section 13: Lecture 21

Air Masses

Air Mass: **A relatively large body of air (1000s of sq. mi) with similar temperature and moisture characteristics.**

Air Mass Source Regions

<u>Typically have the following characteristics</u>:

Generally flat and spatially expansive

Of a uniform composition

Calm conditions, so air resides in the region for a relatively long time (several days or longer)

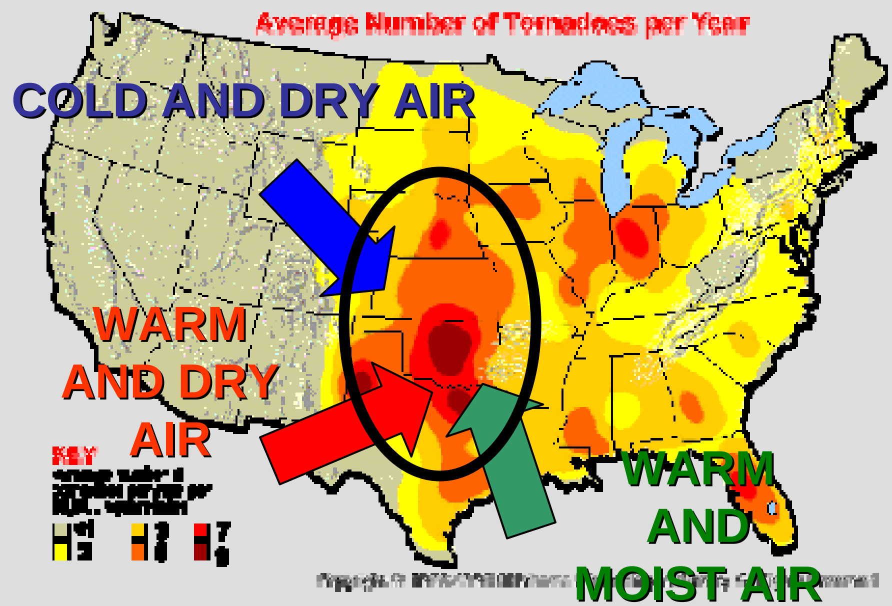
<u>Good places for air mass generation</u>:

Interior of the continents under areas of high pressure

- **Subtropical deserts in summer**
- **Polar regions like Canada and Siberia (especially in winter)**

Over the oceans

When air masses "clash" in mid-latitudes, exciting weather can happen…



Supercell thunderstorms that spawn tornadoes are most prevalent in "tornado alley" in the central U.S.

Three different airmasses clash here.

Air Mass Classification System

First Lowercase Letter:

Indicates whether air originates over an ocean or continent

m = Maritime
c = Continental

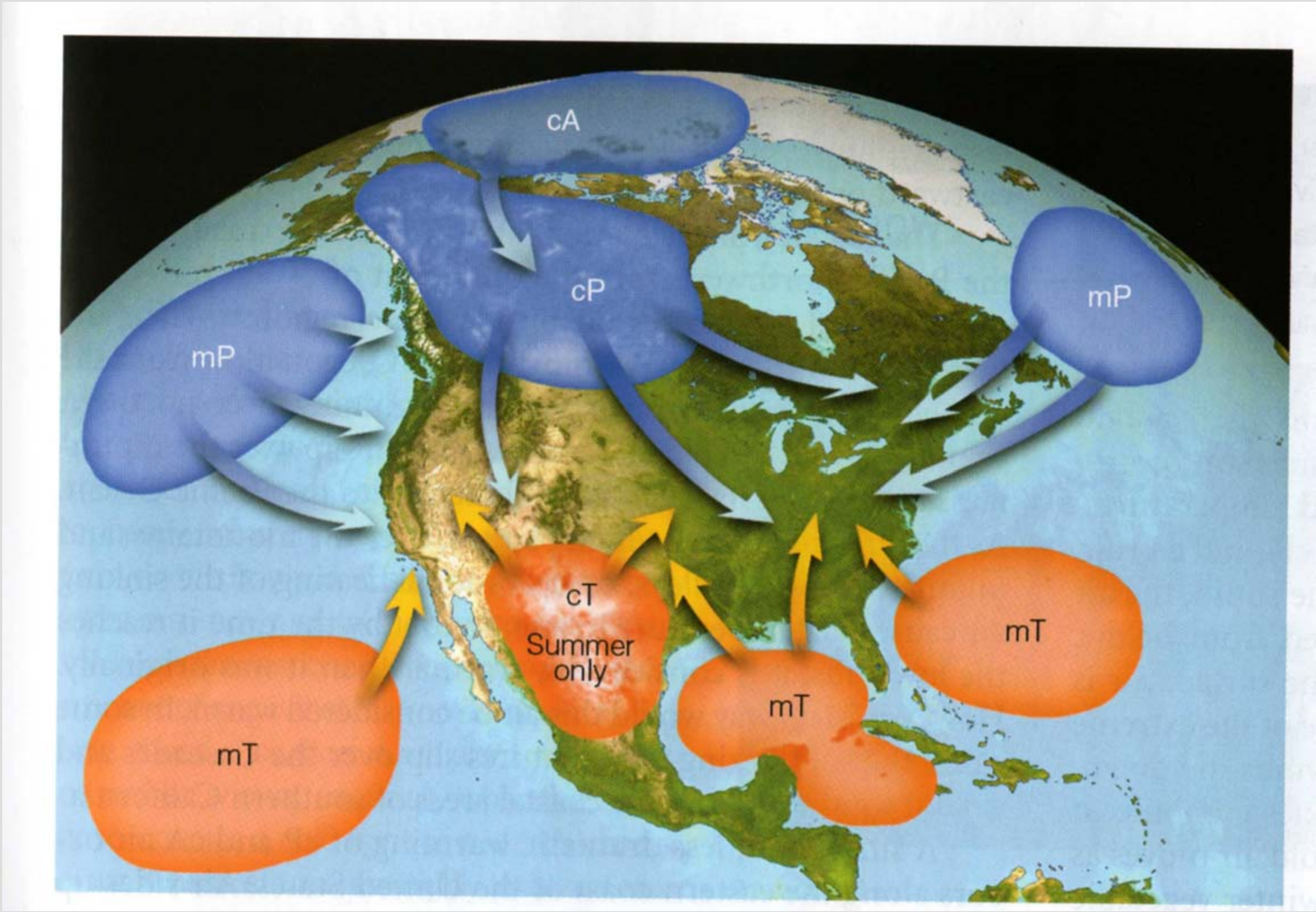
Second Uppercase Letter

Indicates whether air originates over tropical or polar latitudes.

T = Tropics
P = Poles

From combining these four, all the air masses can be described.

Air masses that affect North America



Write out in words what each air mass notation means.

Continental polar (cP) air masses in the Northern Hemisphere originate in the northernmost parts of North America and Asia over vast snow covered plains

EXCEPT for Antarctica, these are the coldest spots on Earth.

Continental polar (cP) air mass source regions in N. Hemisphere

SIBERIA

NORTHERN CANADA

Why does it get so cold in Northern Canada and Siberia?

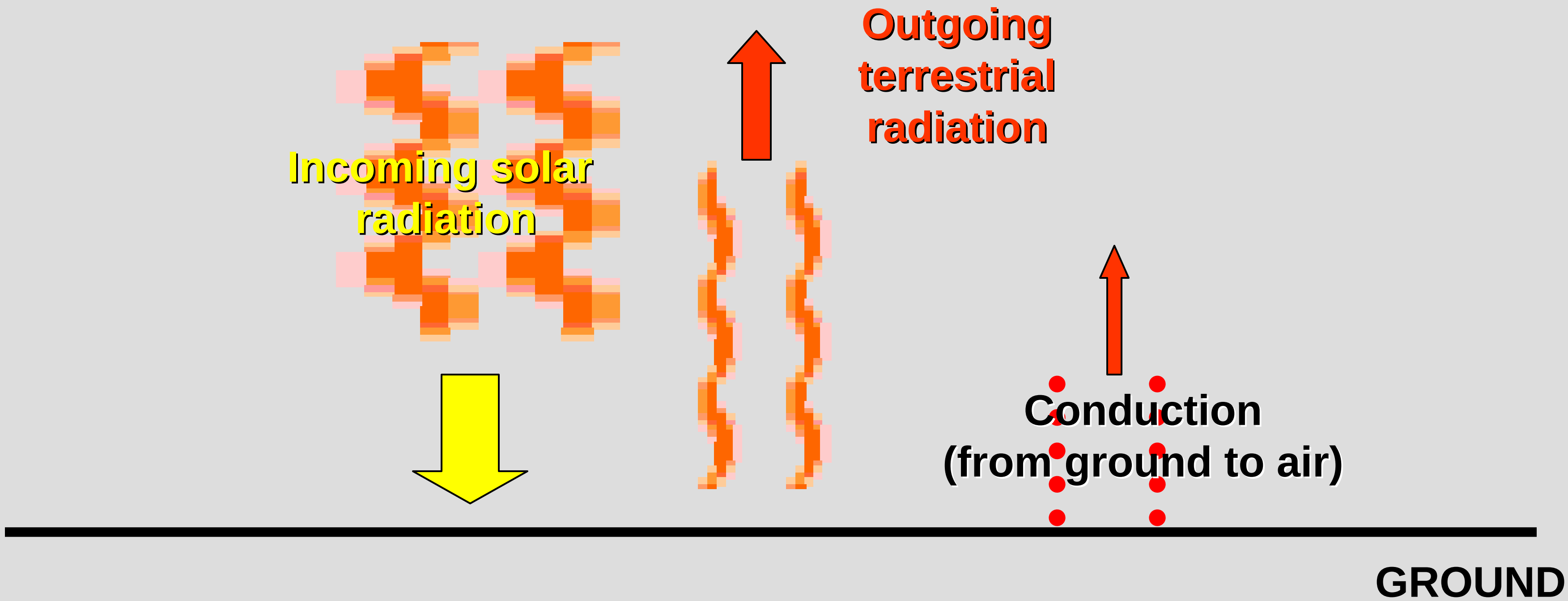
Three factors:

Vast snow covered surfaces: Why is this important?

Small amount of solar radiation

They are land masses—and land has a __________ specific heat.

Daytime Energy Budget in Arctic: No snow

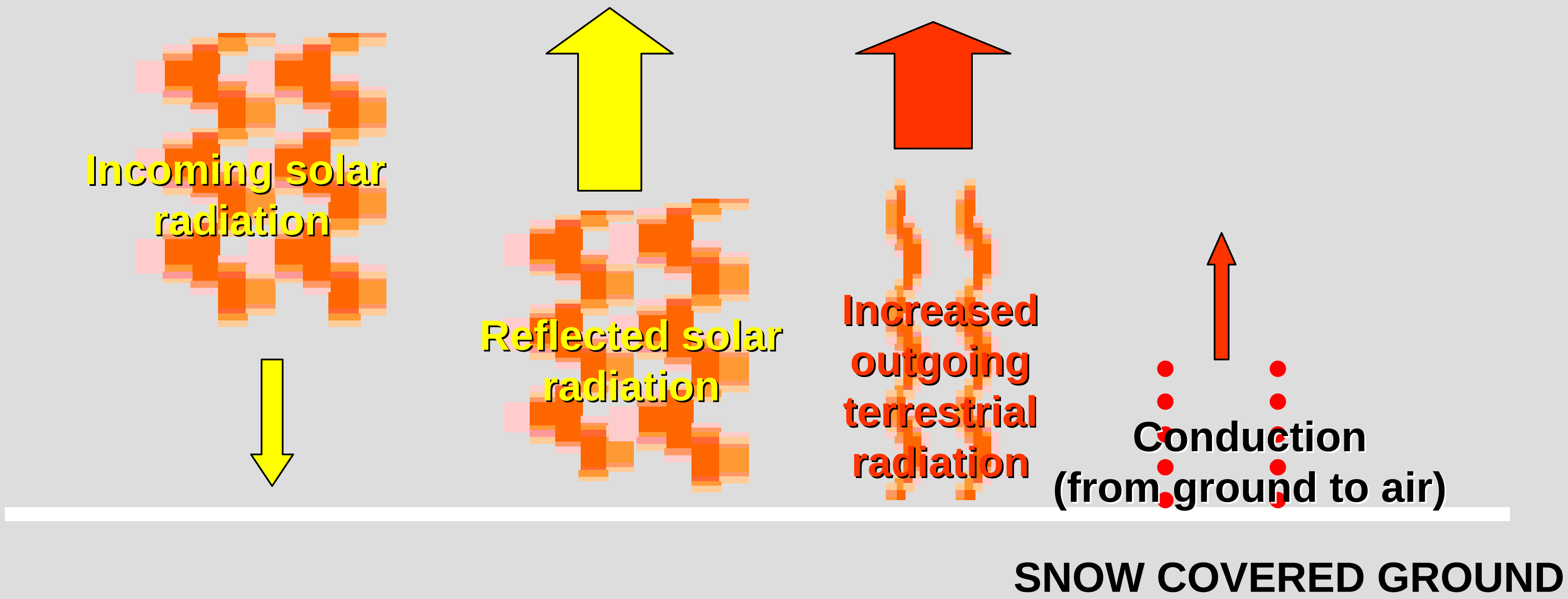


Why is there no convection here?

Solar radiation is absorbed at the surface.

Outgoing terrestrial radiation and conduction.

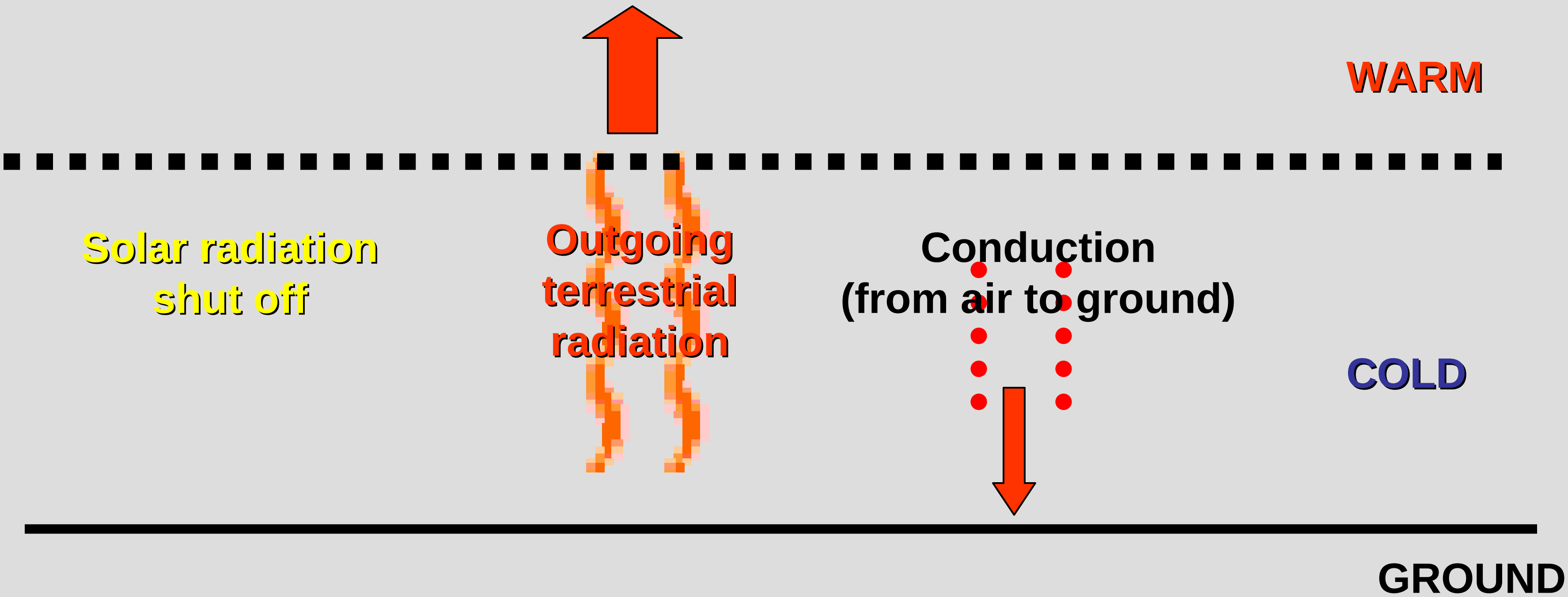
Daytime Energy Budget in Arctic with snow = Cooler surface



Why is about 70-90% of the solar radiation reflected?

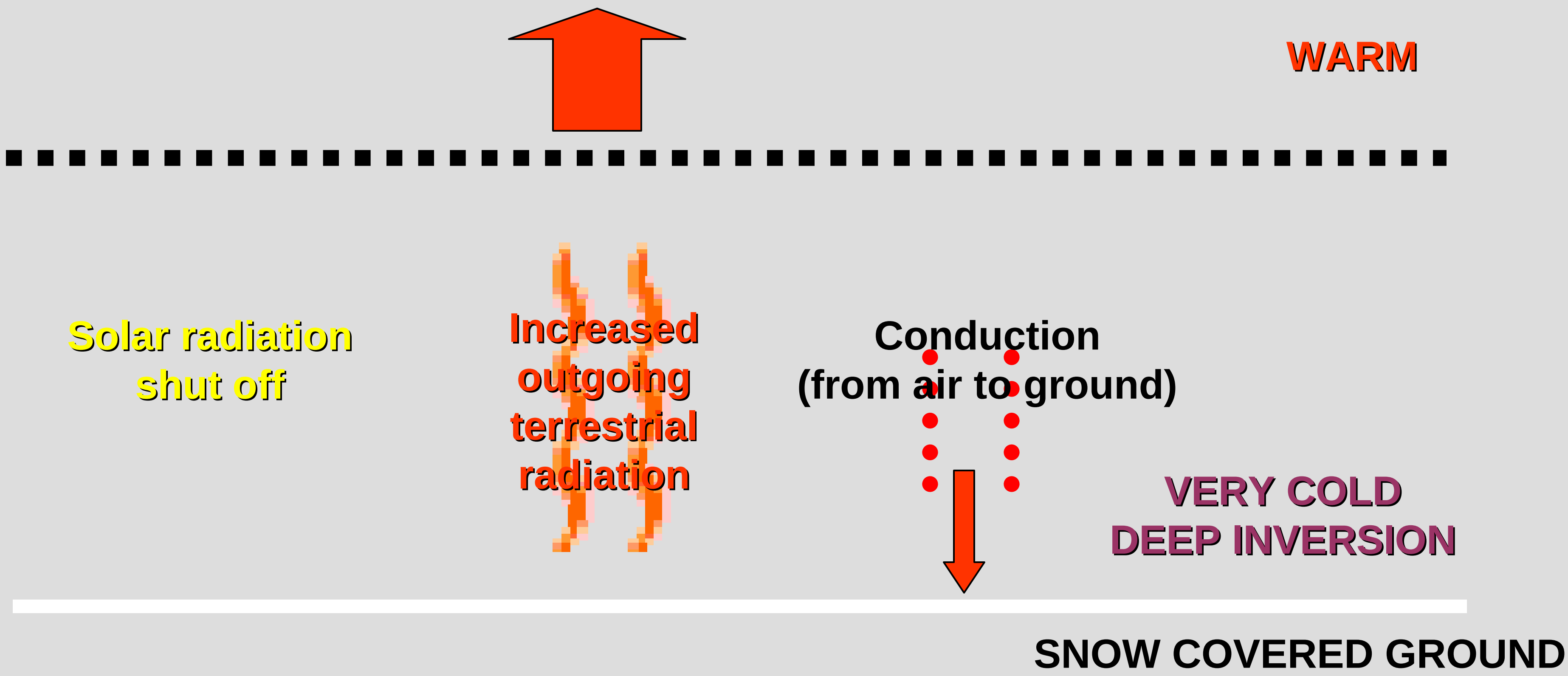
Why is the outgoing terrestrial radiation increased?

Nighttime Energy Budget in Arctic: No snow



Radiational cooling creates a temperature inversion.

Nighttime Energy Budget in Arctic: with snow = cooler temperatures

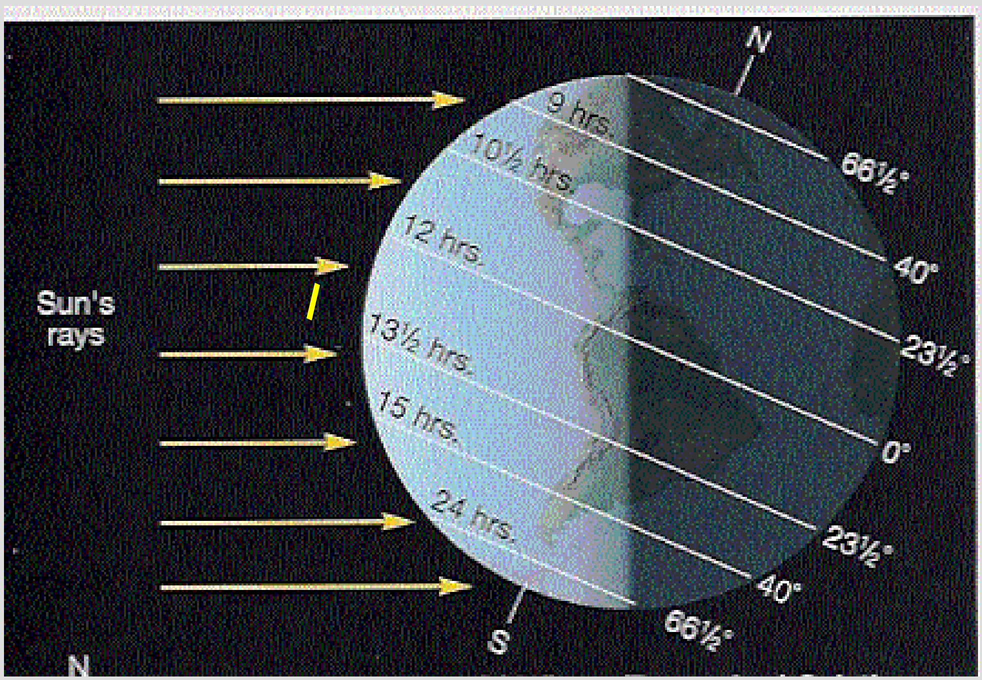


Increased radiational cooling creates a very deep temperature inversion.

Is the solar radiation strong enough to break this inversion?

Winter solstice
Northern Hemisphere

Summer solstice
Southern Hemisphere



Date of winter solstice: December 21

The amount of incoming solar radiation associated with the seasons is also a big factor in creating very cold air masses

<u>Arctic in winter</u>:

Very little daylight—if any at all

Large solar zenith angle

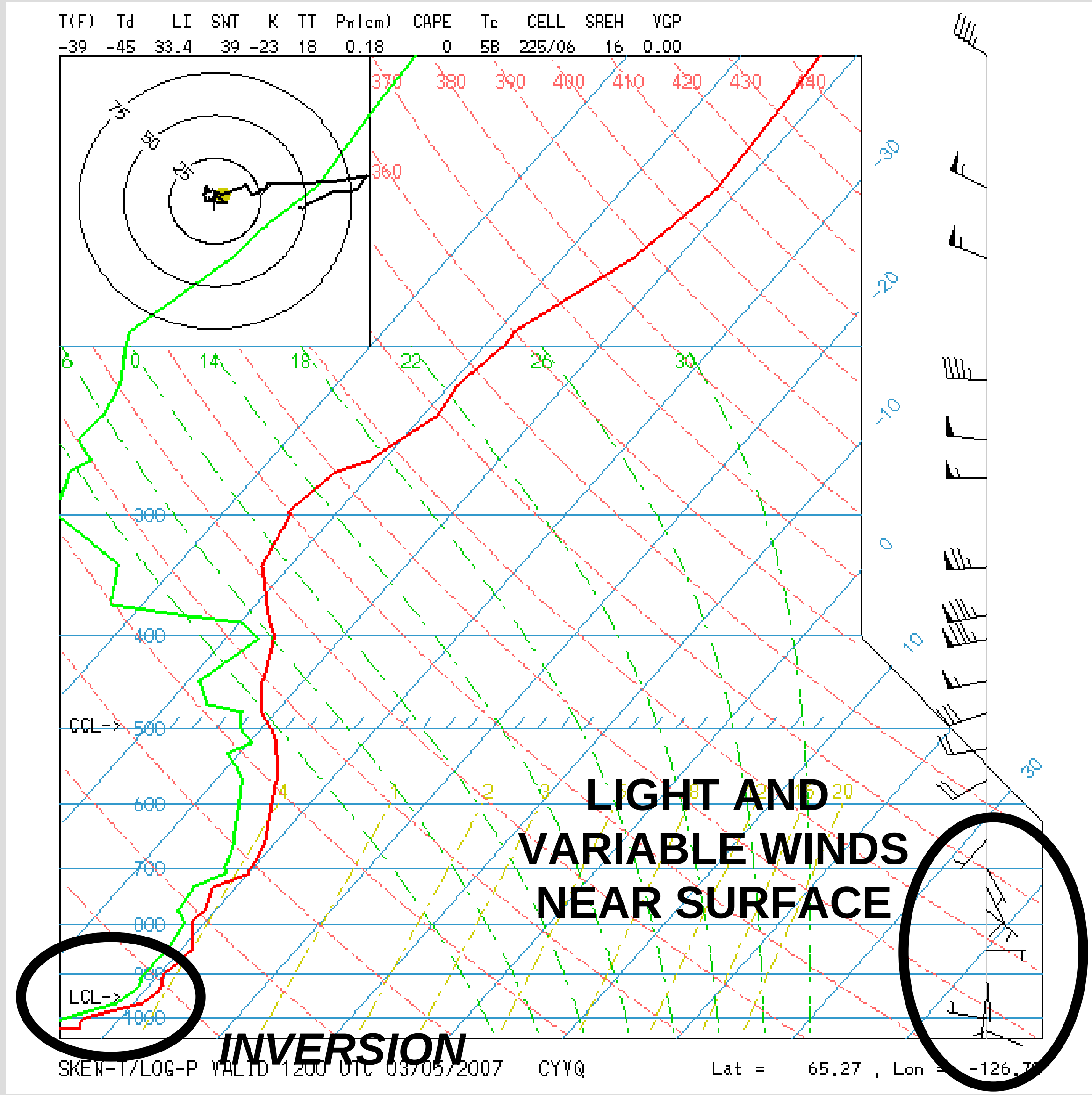
What is the result?

Upper Air Sounding

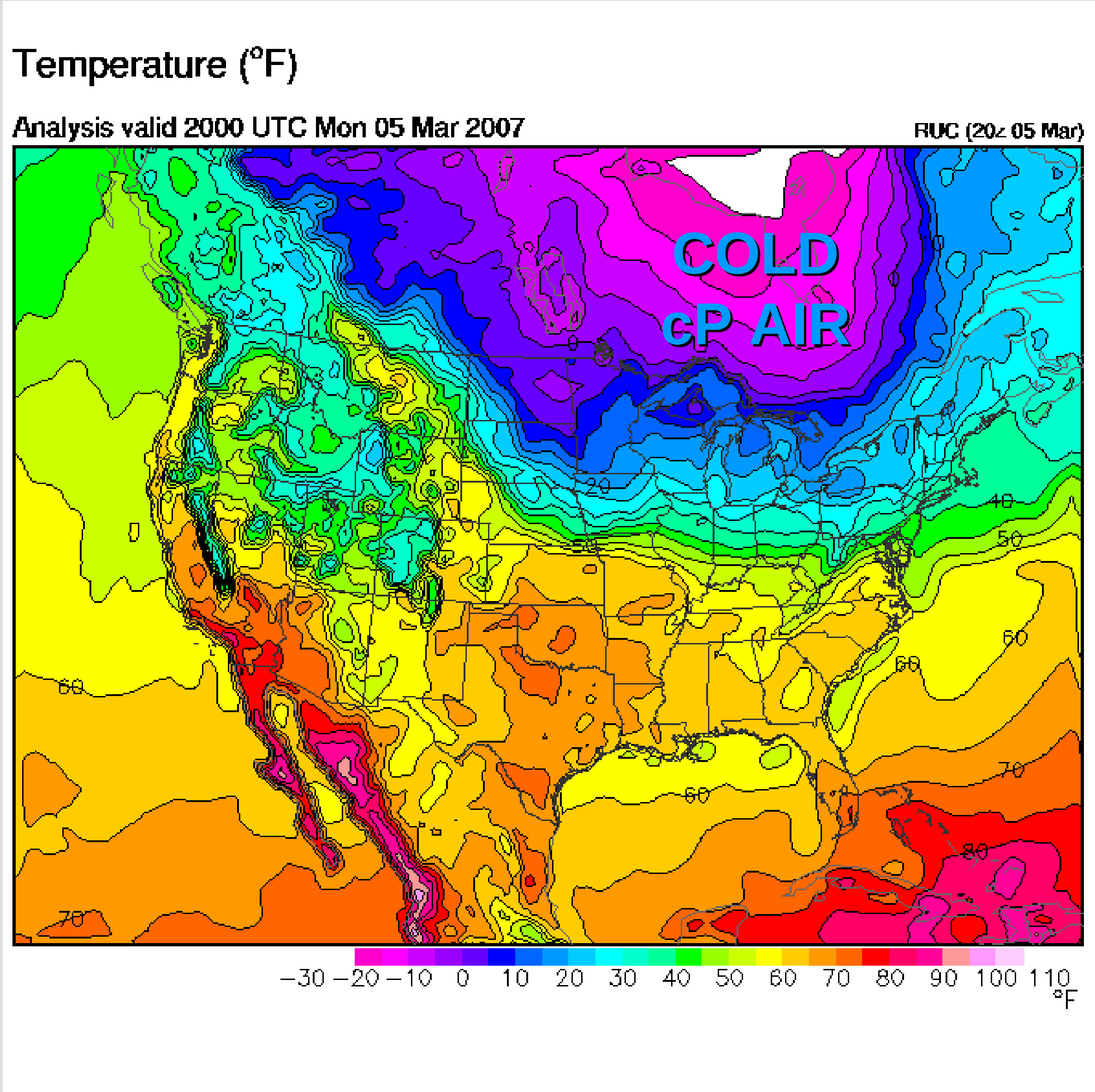
Northwest Territories, Canada

March 5, 2007

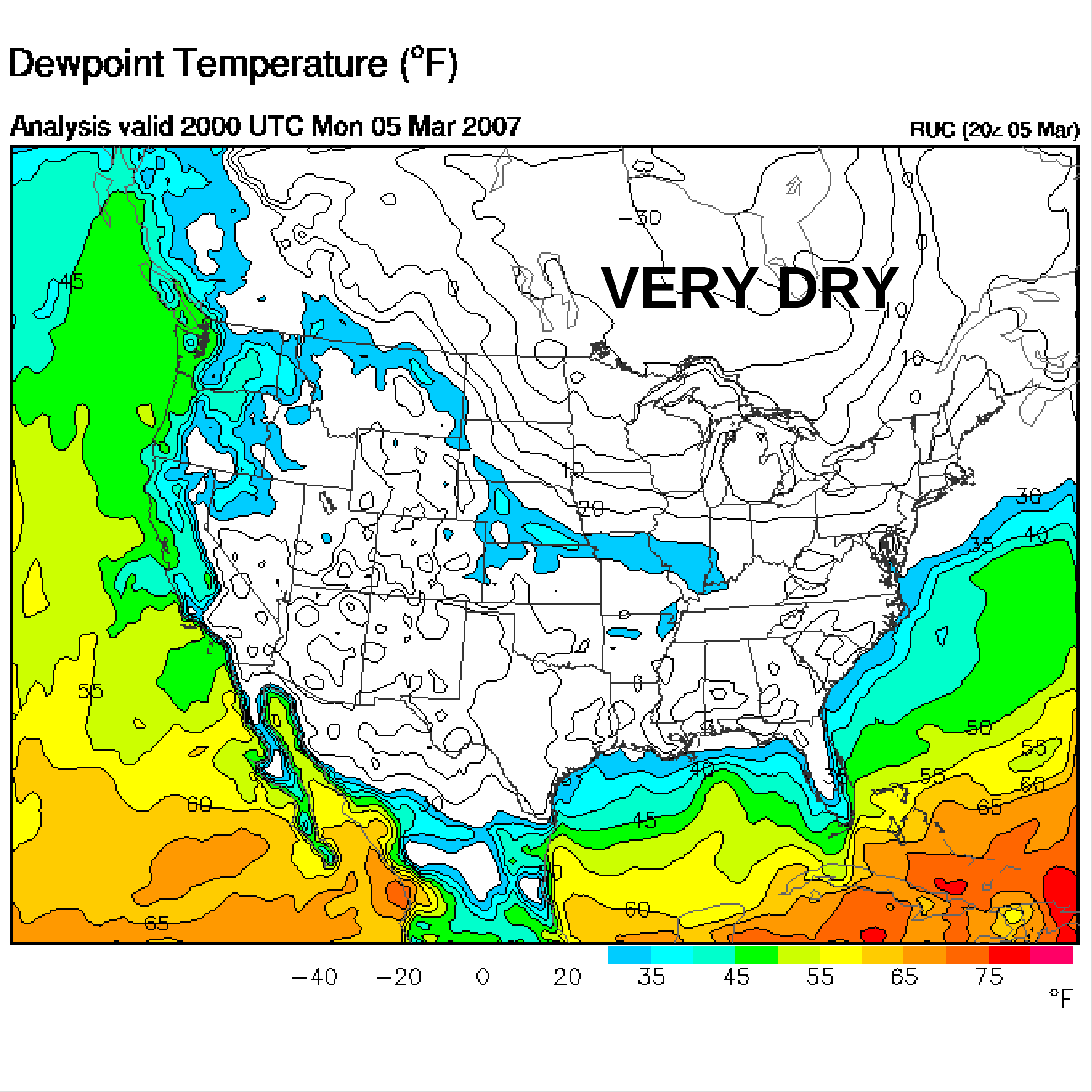
Surface Temp. below -30 °C



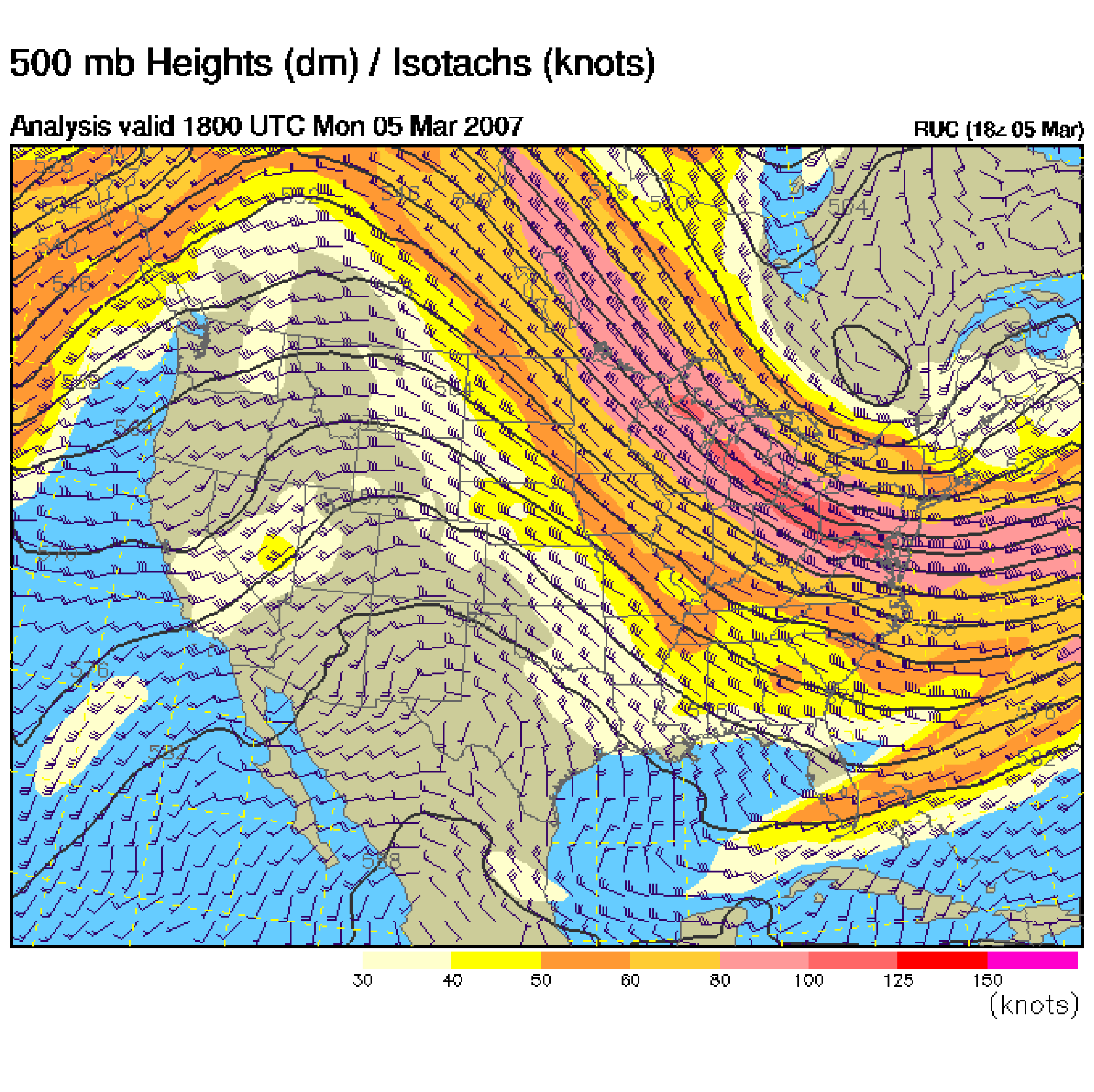
March 5, 2007 Surface Temperature Analysis



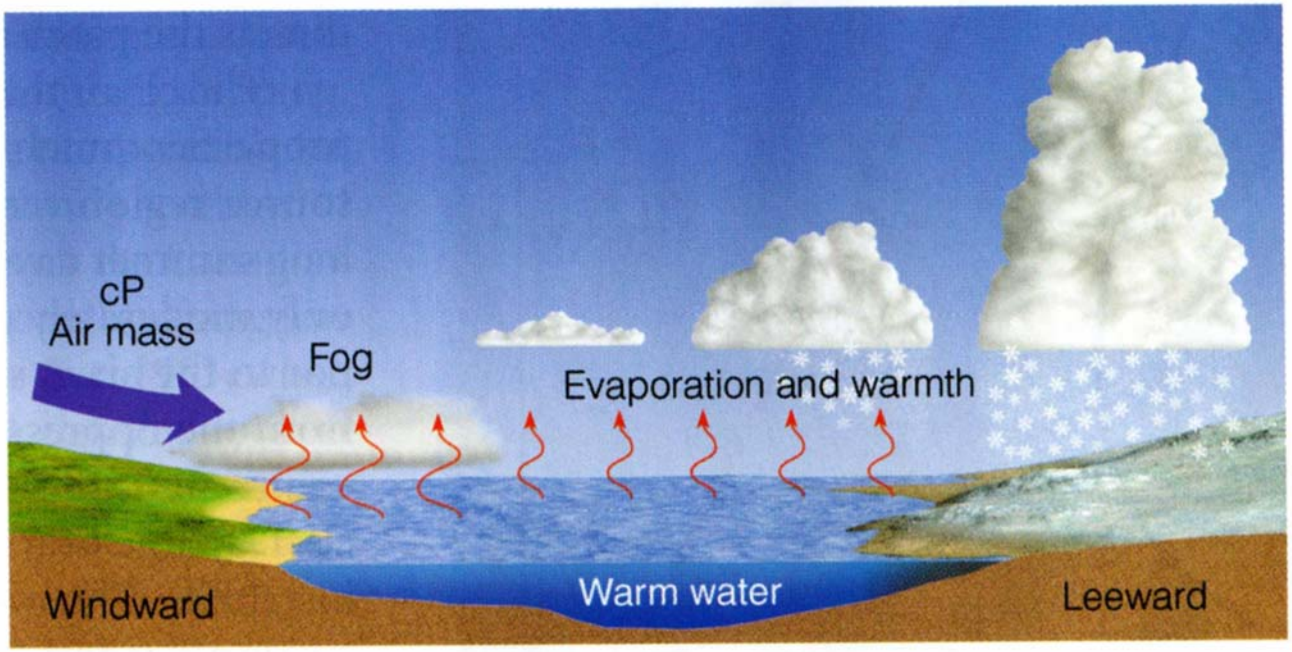
March 5, 2007 Dew point analysis



March 5, 2007
500-mb Winds



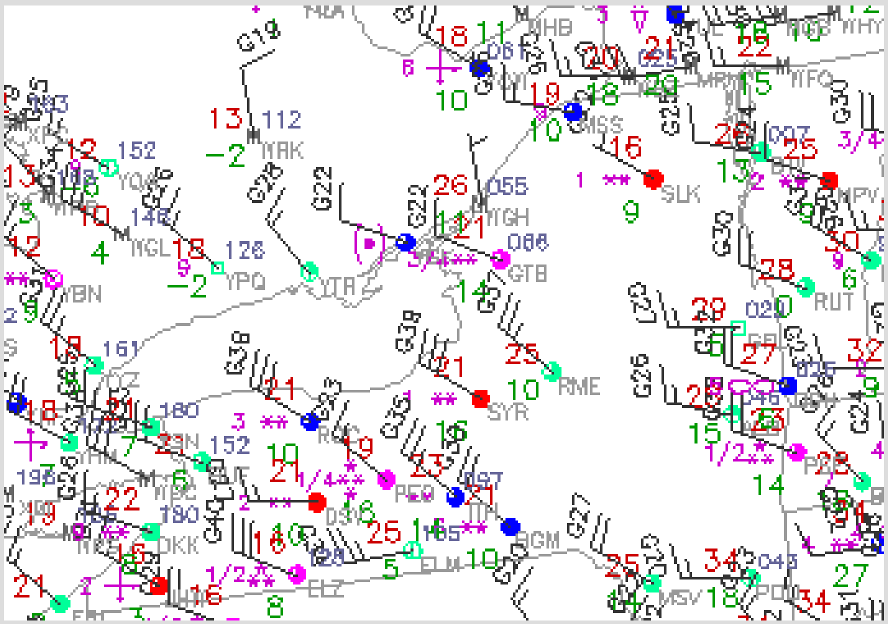
Lake Effect Snow

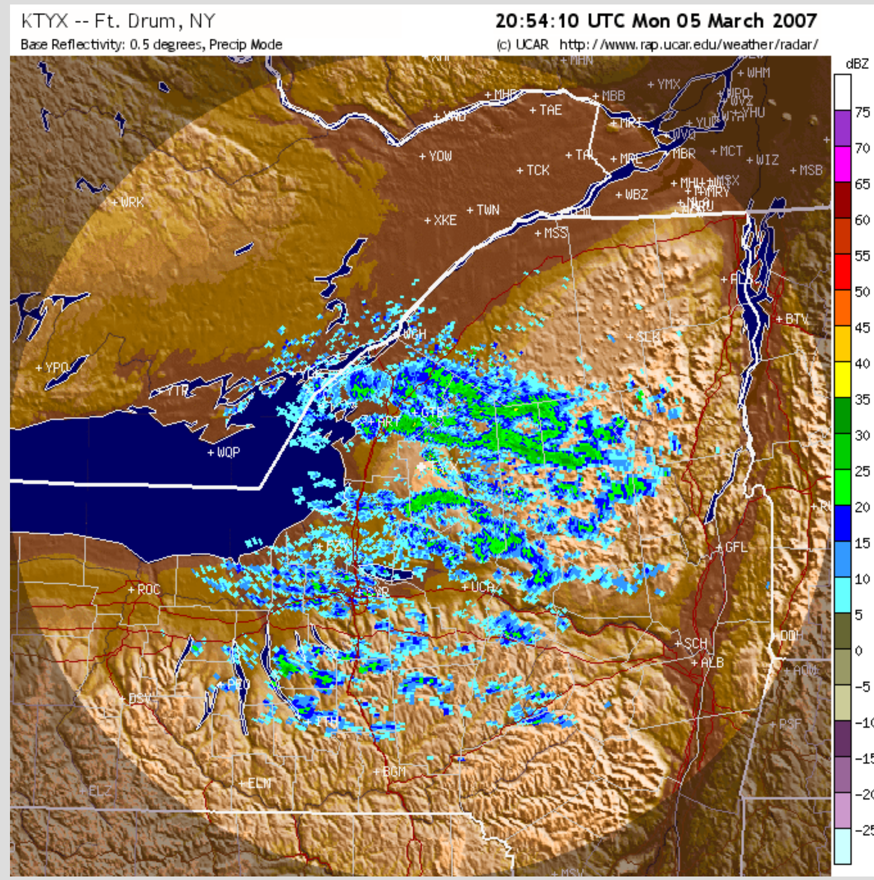


• FIGURE 1

The formation of lake-effect snows. Cold, dry air crossing the lake gains moisture and warmth from the water. The more buoyant air now rises, forming clouds that deposit large quantities of snow on the lake's leeward shores.

March 5, 2007
Surface and Radar Obs.: Upstate NY



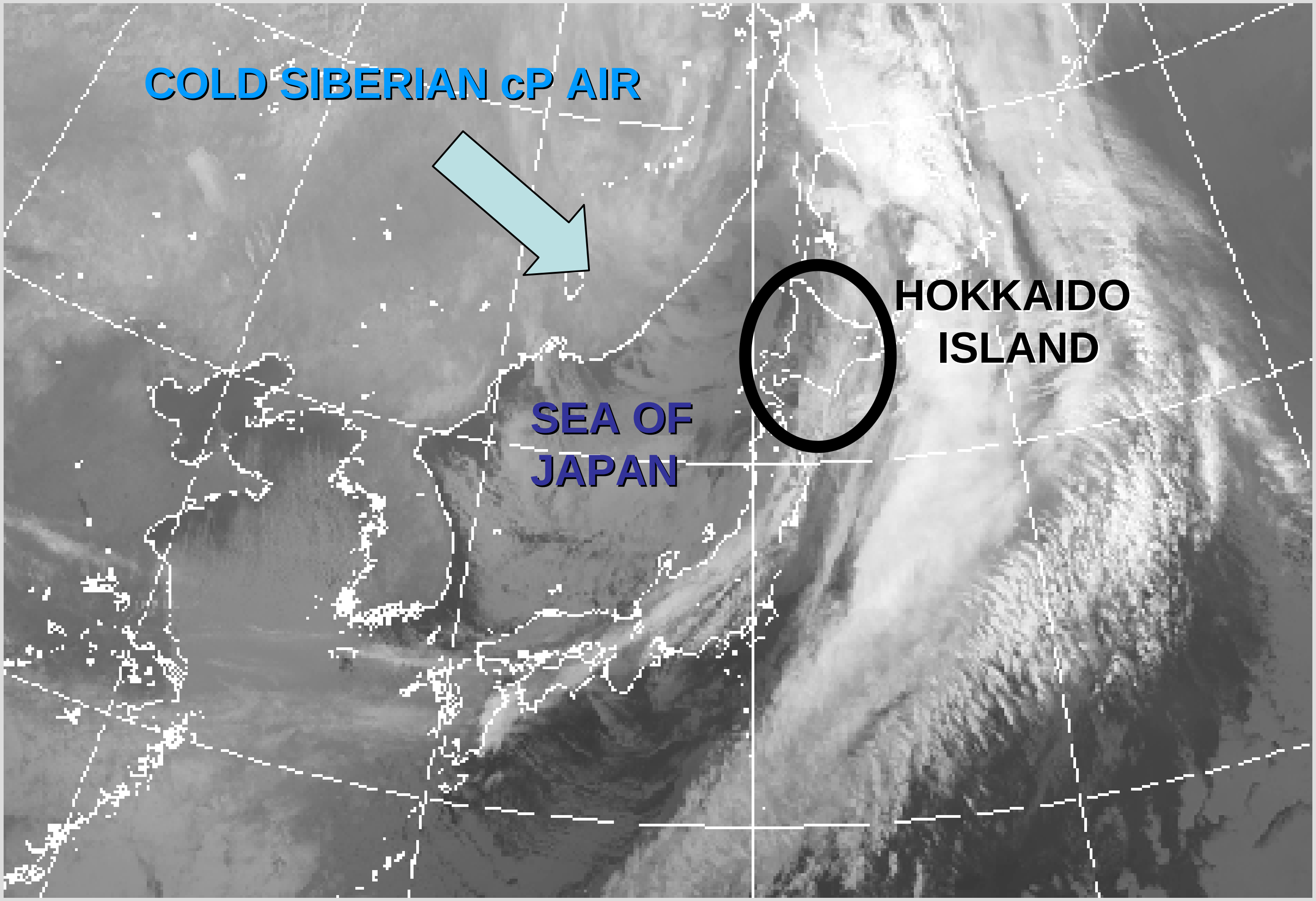


A very similar phenomenon to our lake effect happens in northwest Japan.

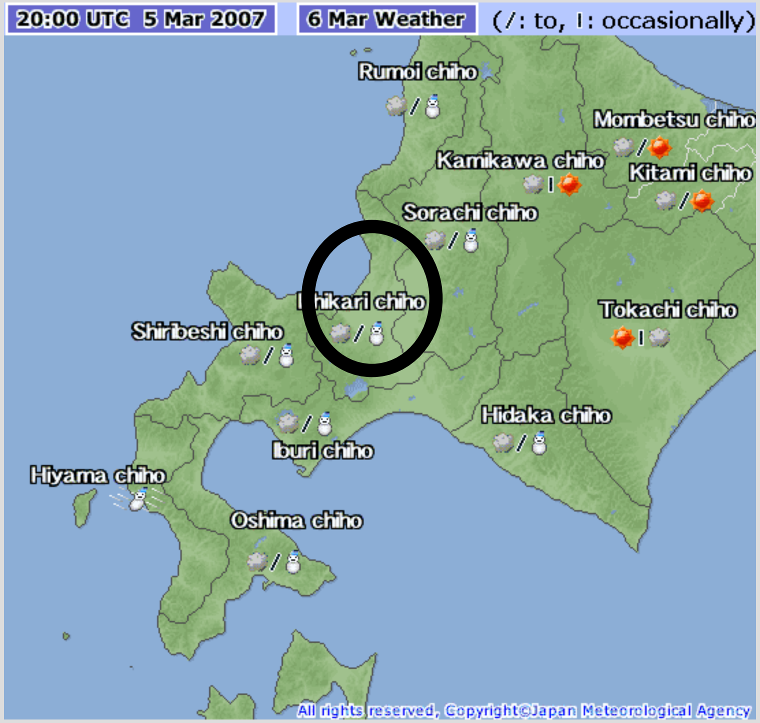
However, *more* snow occurs there because:

1. **Air mass is colder (from Siberia)**
2. **Air goes over the Sea of Japan—not a lake**
3. **Steeper terrain in Japan**

Japanese Satellite Image
March 5, 2007

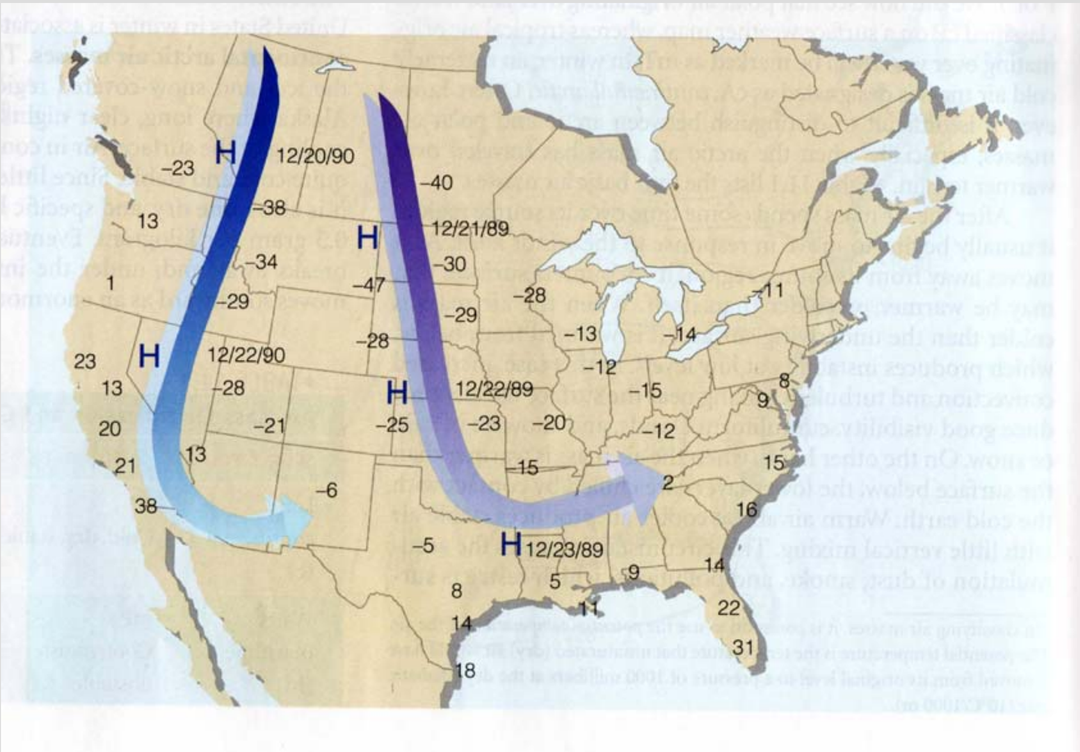


SAPPORO, JAPAN



AVG. ANNUAL SNOWFALL IN SAPPORO, JAPAN = 16 FEET

Arctic Outbreaks in U.S.
Flow directs cP air from Canada or Siberia



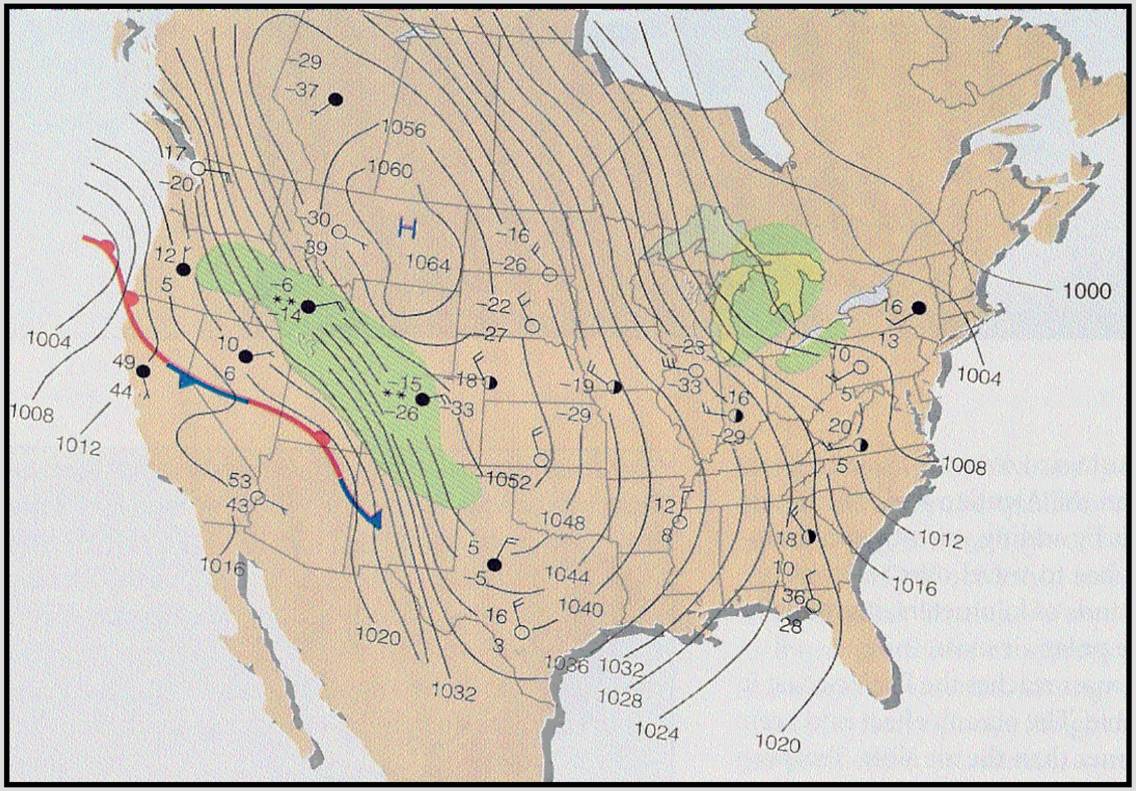
Airflow and temperatures during severe December arctic outbreaks

East of the Rockies favored because no topographic barriers to stop cold arctic air.

In the most severe outbreaks, below freezing temperatures can reach the Gulf of Mexico.

The number of Arctic outbreaks in a given winter has to do with the strength of the Arctic Oscillation.

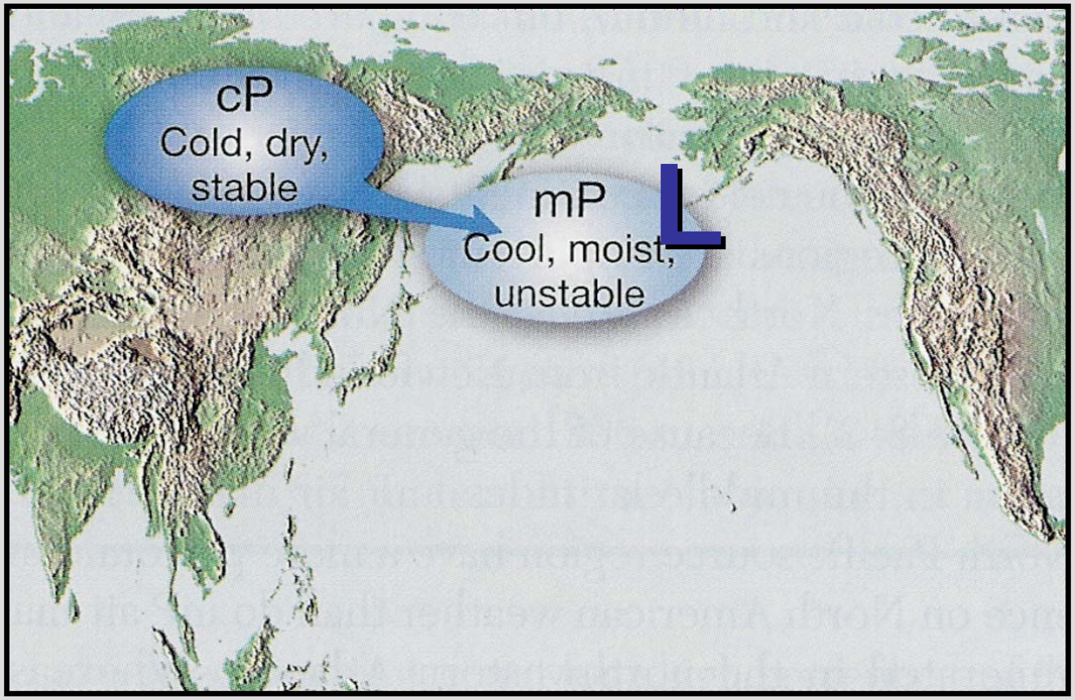
December 1983 Arctic Outbreak



The “core” of the cold air is located underneath the surface high.

Why can’

Maritime polar (mP) air mass

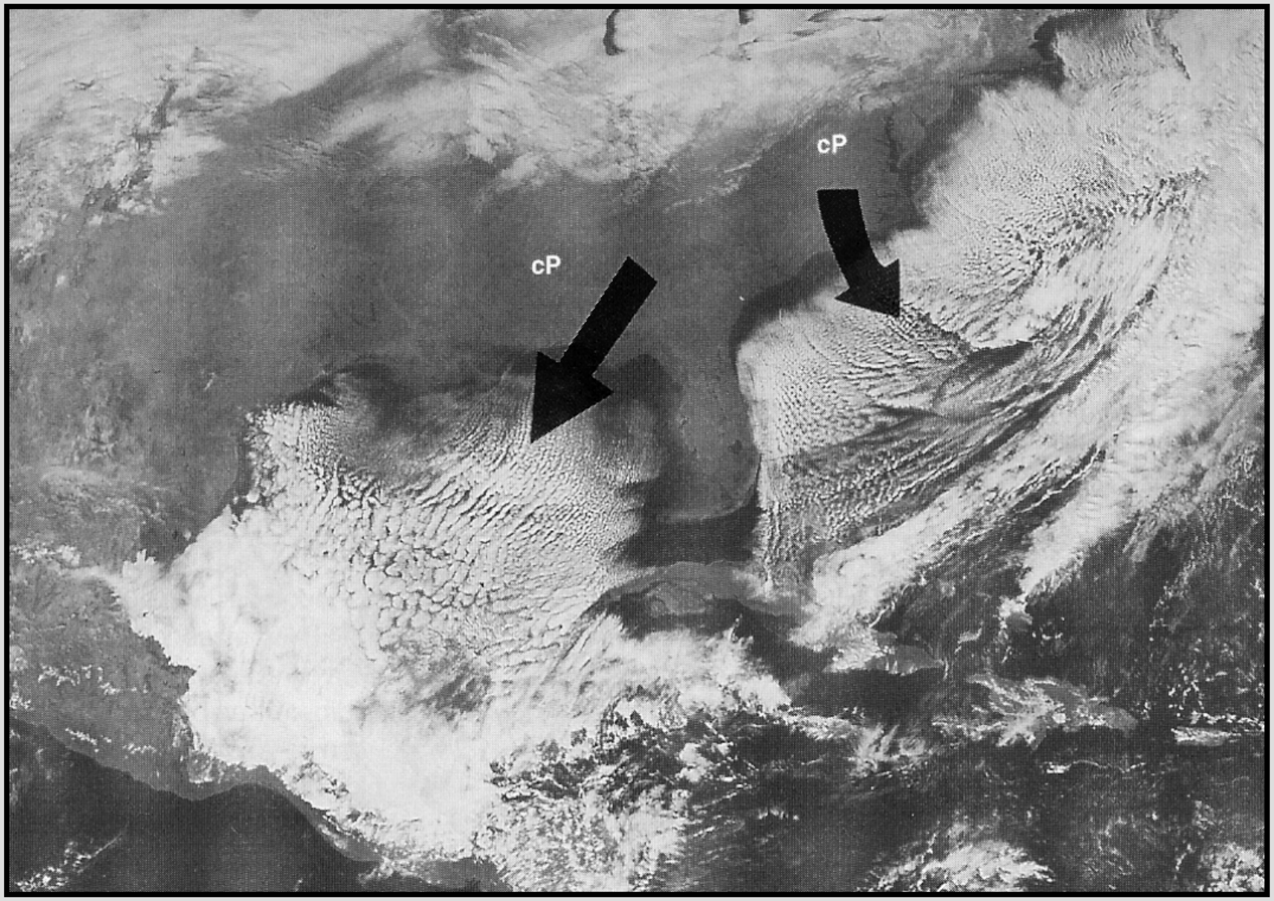


Lutgens and Tarbuck

Forms when continental polar air moves over the ocean. The ocean moistens the air and makes it conditionally unstable.

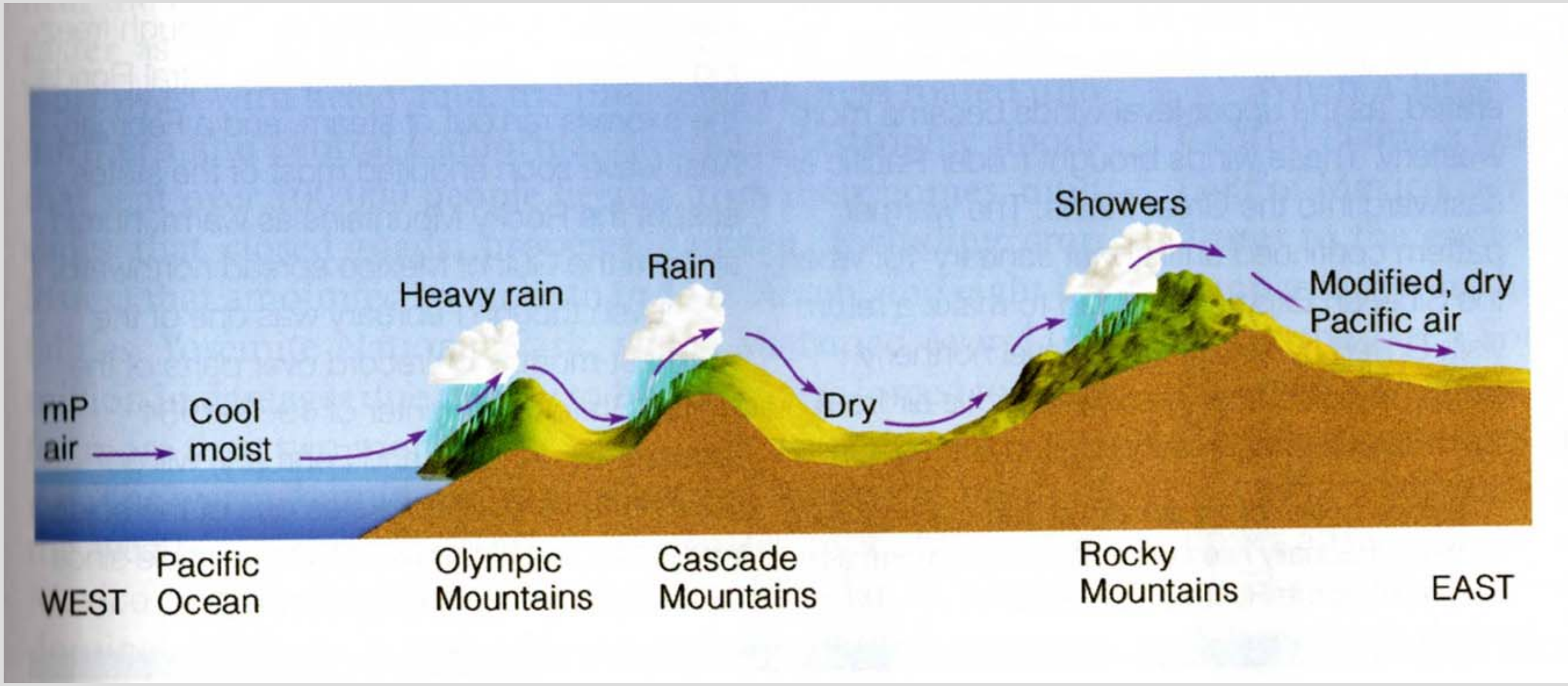
The type of air mass associated with semi-permanent low pressure areas in the Pacific and Atlantic during winter.

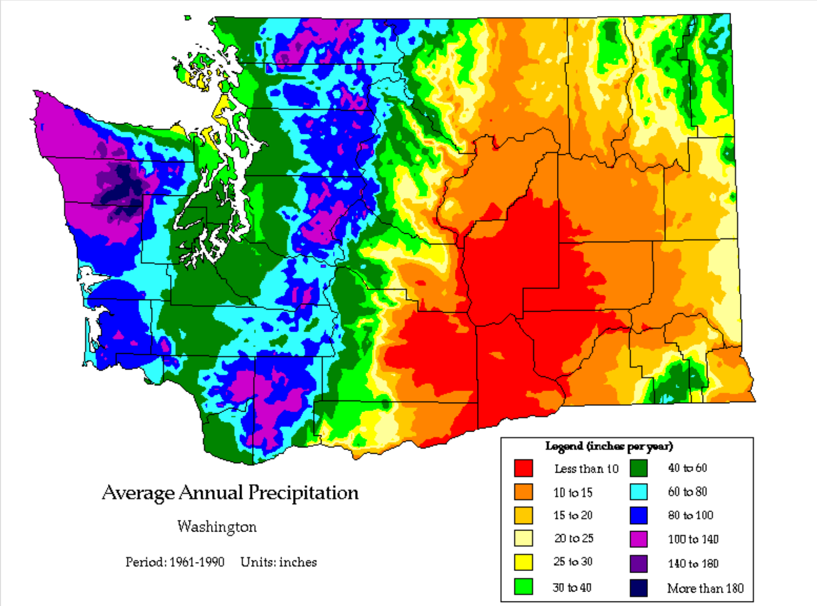
Cloud Streets: A sign of an cP air mass being modified to mP



Similar to Lake Effect snow process. Cold air passes over relatively warmer water, clouds form, atmosphere moistens and warms.

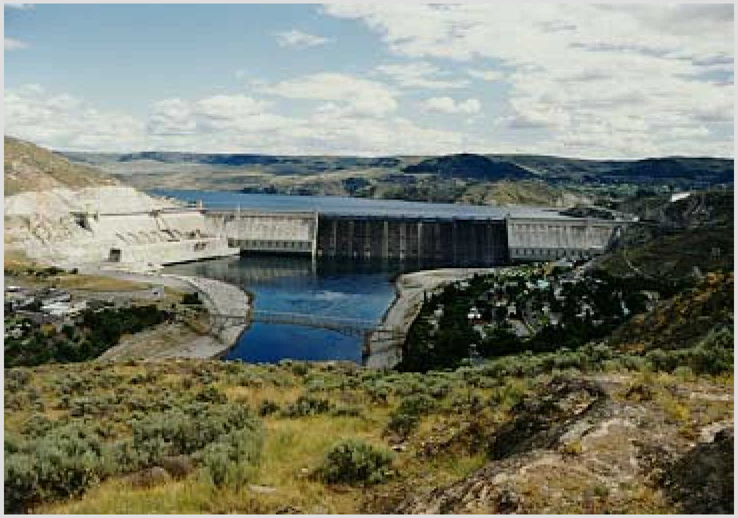
Continental modification of mP air mass



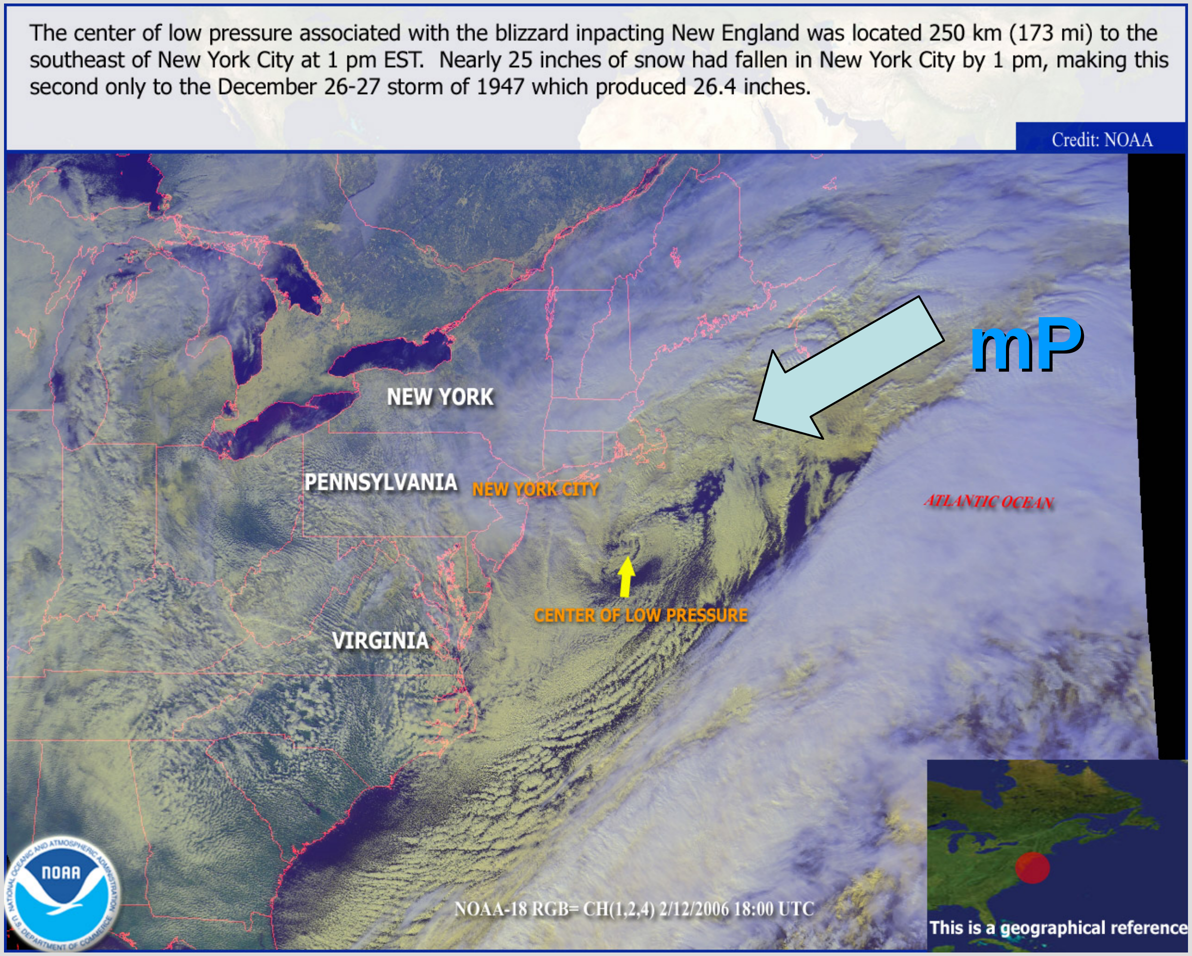


OLYMPIC NATIONAL PARK
WEST OF CASCADES

GRAND COULEE DAM
EAST OF CASCADES



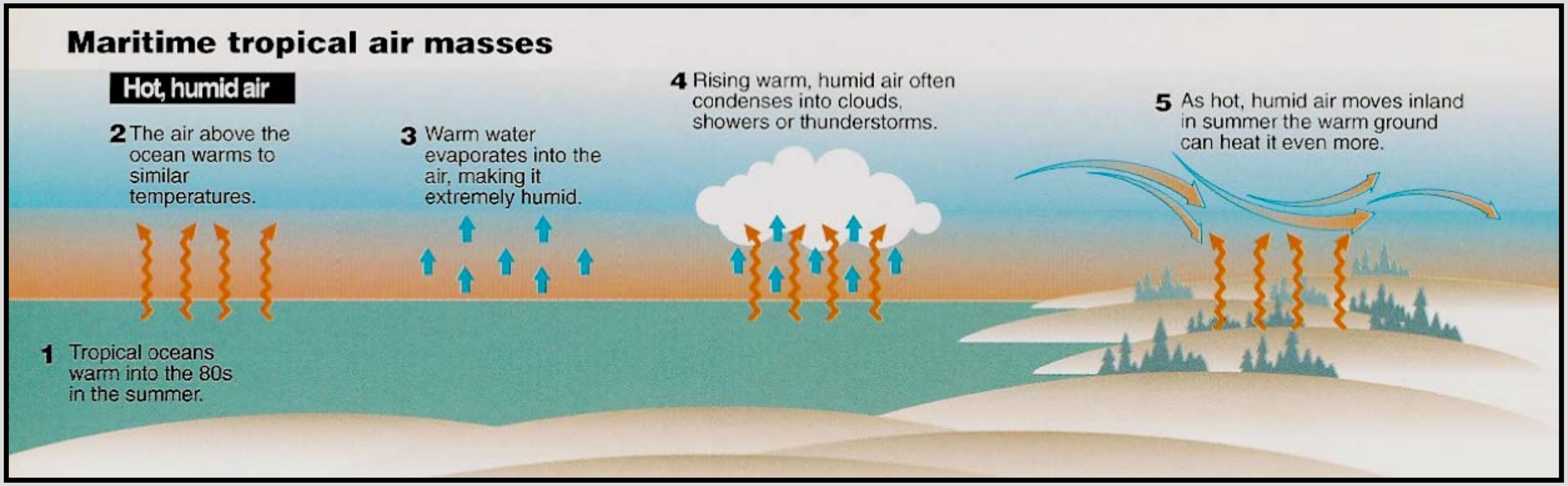
mP air masses and U.S. East Coast



NOAA imagery

A moisture source for east coast snowstorms

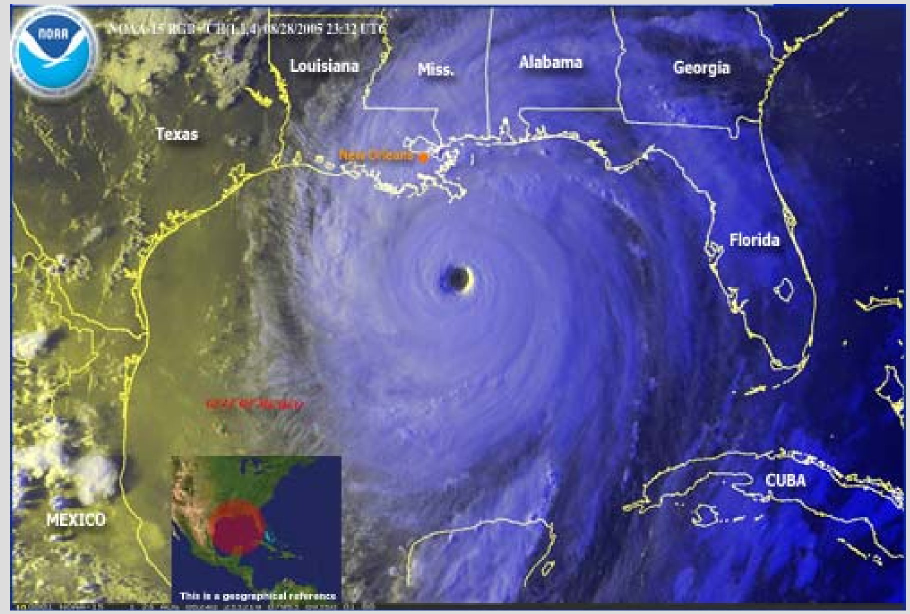
Maritime Tropical (mT) air masses



Williams, *The Weather Book*

These originate over warm tropical oceans.

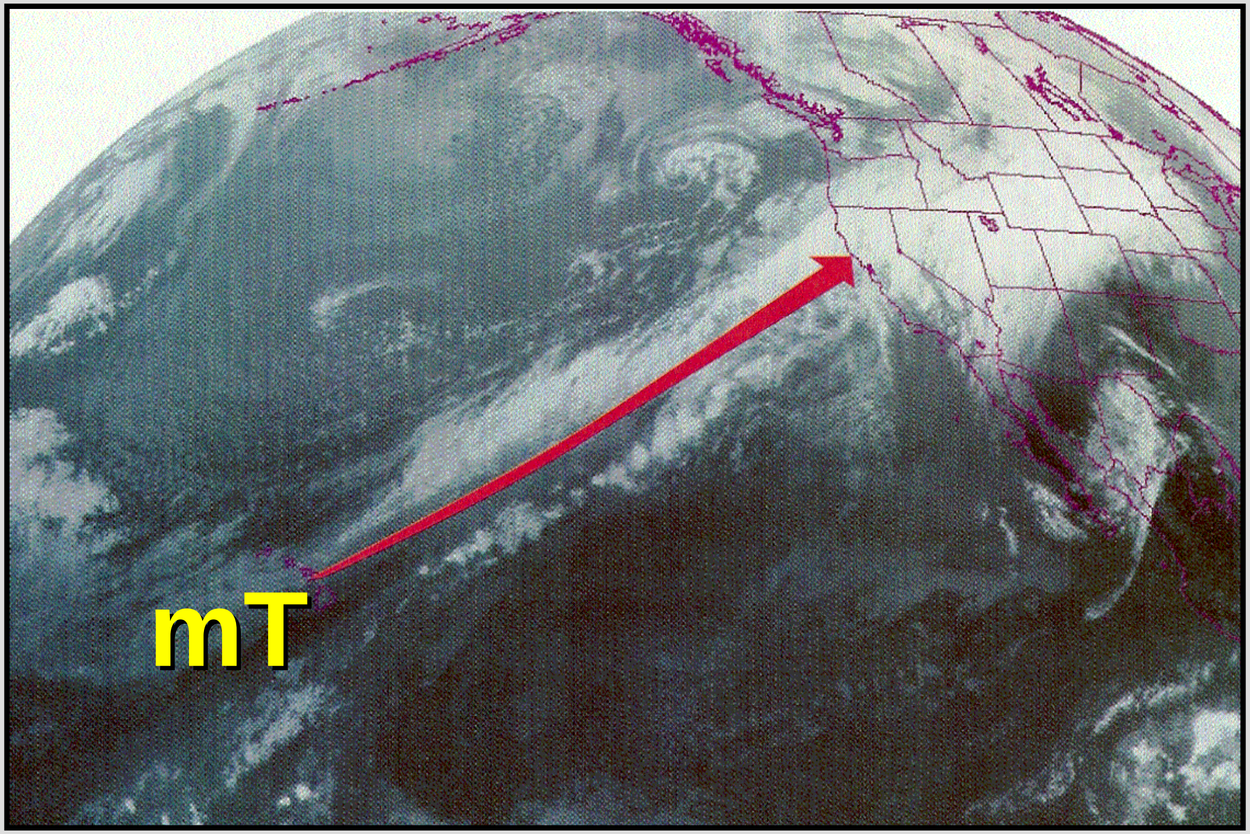
mT air mass weather over oceans



Moist humid air in a mT airmass has A LOT of potential energy. Why??

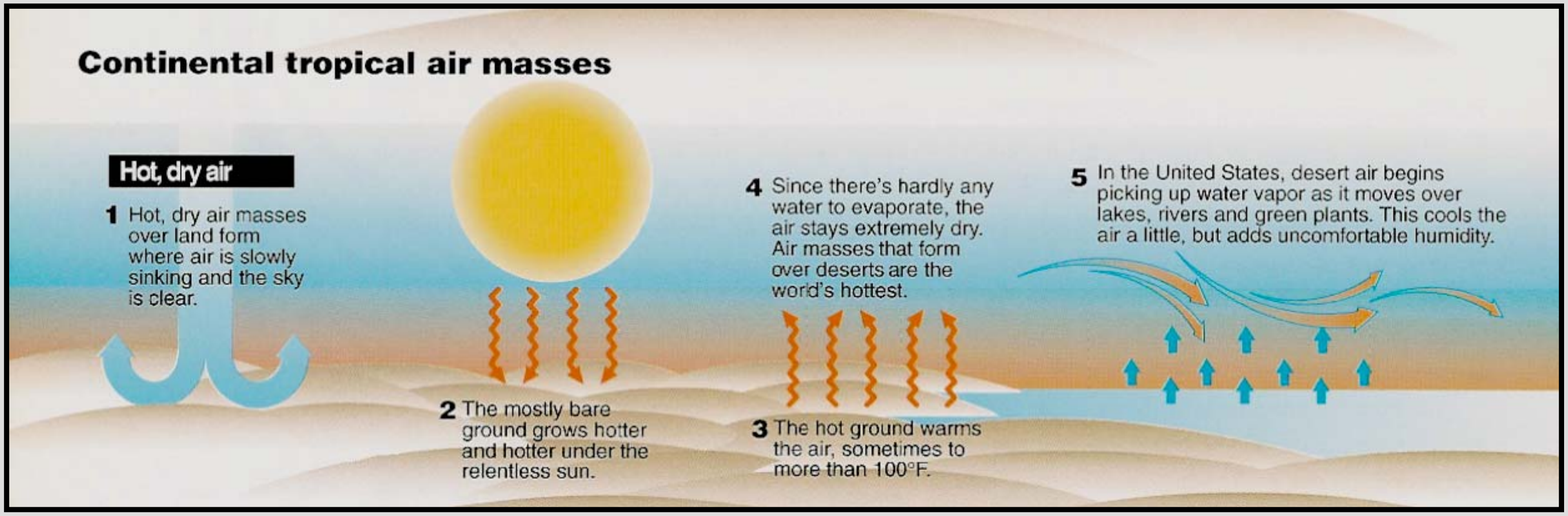
This energy can be released in thunderstorms—which sometimes organize into tropical cyclones.

The Pineapple Express
An example of an atmospheric river



If the jet stream picks up this moisture from the tropics, this can result in very heavy rains along the west coast in winter.

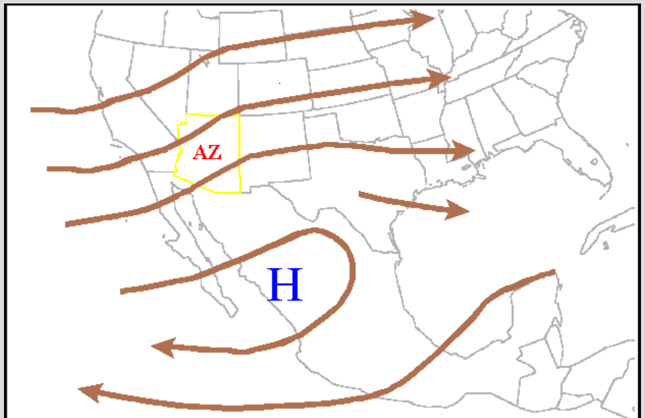
Continental tropical (cT) air mass



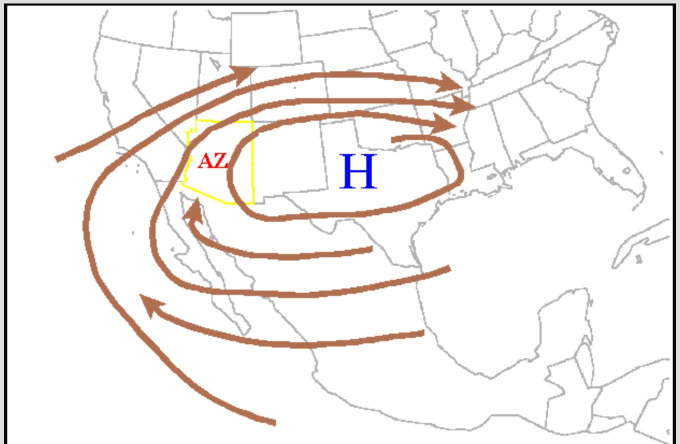
Williams, *The Weather Book*

Originate in the interior of continents in desert regions—like Arizona!

In the U.S., the "center" of cT air mass is defined by the position of the monsoon ridge—which sits right above the Mexican Plateau and Arizona during most of the summer.

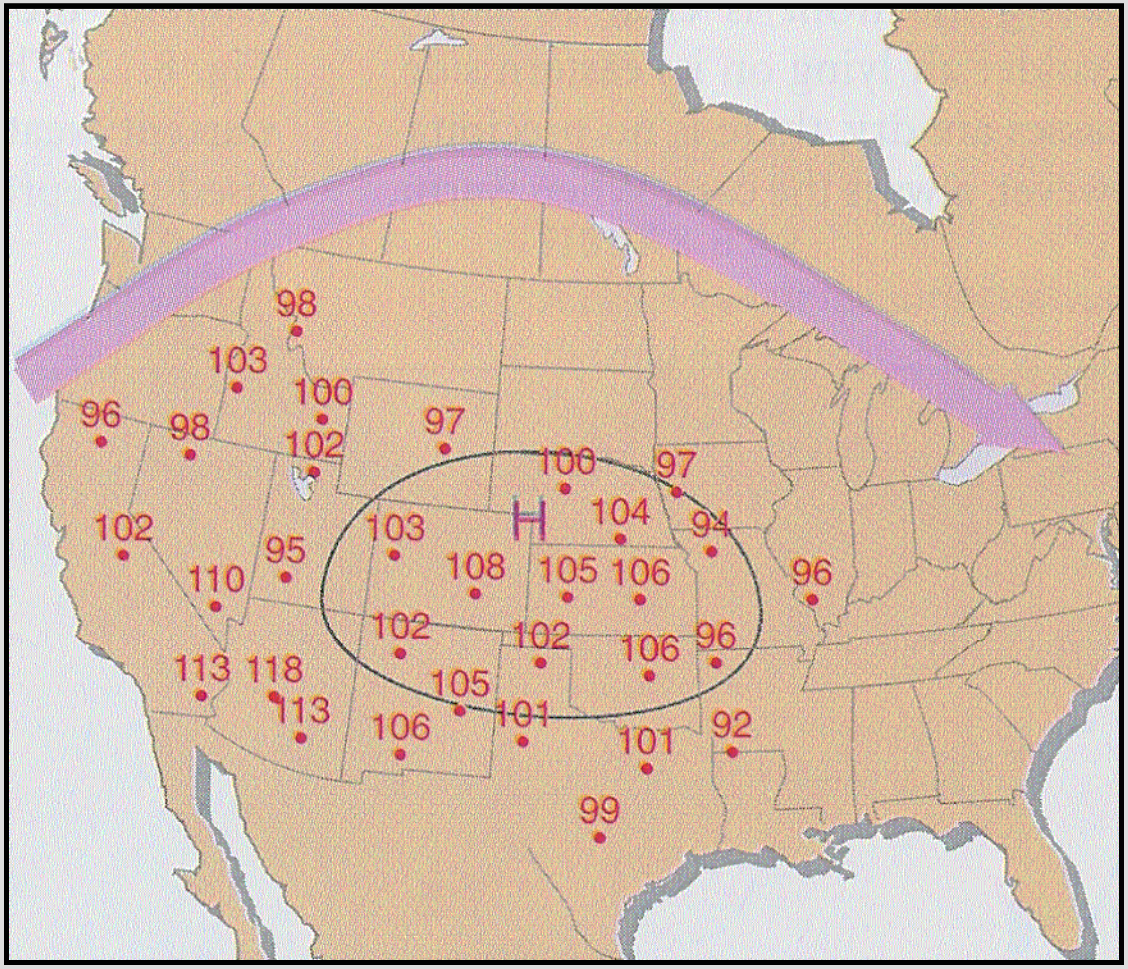


June Mean Flow at 18,000 Feet



July Mean Flow at 18,000 Feet

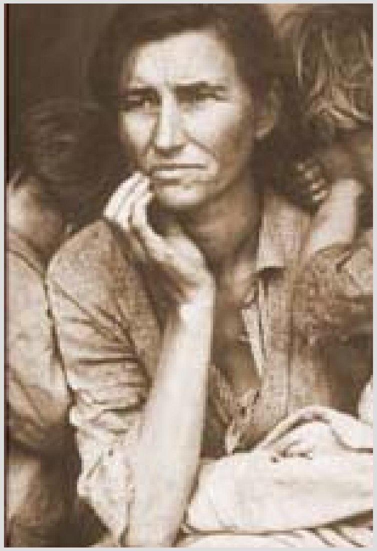
Monsoon ridge position for hottest days in Phoenix and Tucson: late June 1990



When a ridge like this persists for a long time in the central U.S., drought conditions are the result.

Such conditions are favored in La Niña years and a low phase of the Pacific Decadal Oscillation.

Great Plains Dust Bowl: Mid-1930s



Summary of Lecture 21

An air mass is a relatively large body of air with similar temperature and moisture characteristics. Their source regions are flat, uniform, and expansive. These include the interior of continents, in polar or desert regions, or over the oceans.

Air masses are classified by origin:

Maritime (m) vs. Continental (c)
Tropical (T) vs. Polar (P)

cP air originates over Canada and Siberia because these areas have large amounts of snow cover and a small amount of solar radiation. These cause arctic outbreaks, mainly in the eastern U.S., and lake effect snows.

mP air forms when cP air moves over the ocean and modifies. As such air masses pass over continents, the mountains can wring out their moisture.

mT air originates over tropical oceans and is very moist with lots of potential energy for thunderstorms.

cT air originates in hot and dry desert regions. In N. America, the center of cT air is defined by the position of the monsoon ridge.

Reading Assignment and Review Questions

Reading: Chapter 11, pp. 296-306 (8th ed.)
pp. 298-309 (9th ed.)

<u>Chapter 11 Questions</u>

Questions for Review: 1,2,3,4,7,8,10,11

Questions for Thought: 1,2,4

Problems and Exercises: 1