
Synoptic Meteorology 1
Lecture 9
Sahraei
Physics Department
Razi University
http://www.razi.ac.ir/sahraei

Air Masses

An air mass is an extremely large body of air whose properties of temperature and moisture content (humidity) are similar in any horizontal direction at any given latitude. (Very similar to a balloon)

Airmasses cover large regions of the earth, typically several hundred thousand square kilometers.

Airmasses can be as deep as the depth of the troposphere or as shallow as 1 to 2 km.

Part of weather forecasting is a matter of determining air mass characteristics, predicting how and why they change, and in what direction the system will move.

Airmasses form when air remains over a relatively flat region of the earth with homogeneous surface characteristics for an extended period of time.

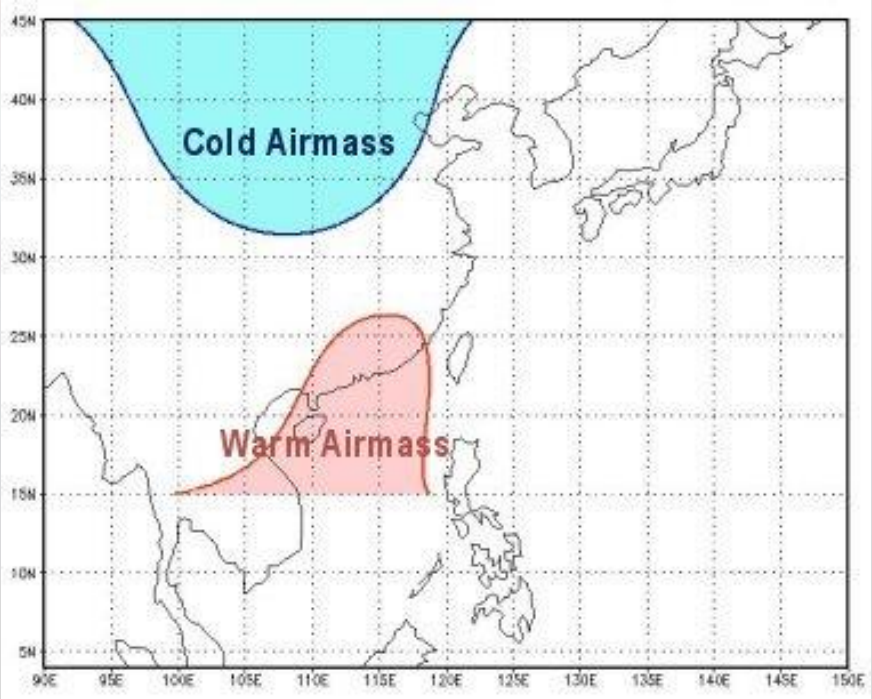
Canadian and Siberian plains, cool oceanic regions such as the North Atlantic and Pacific, deserts, such as the Sahara, and tropical oceanic regions including the equatorial Atlantic and Pacific, and smaller water bodies such as the Caribbean Sea and the Gulf of Mexico.

Air Masses

Air mass can be divided into cold air mass and warm air mass.

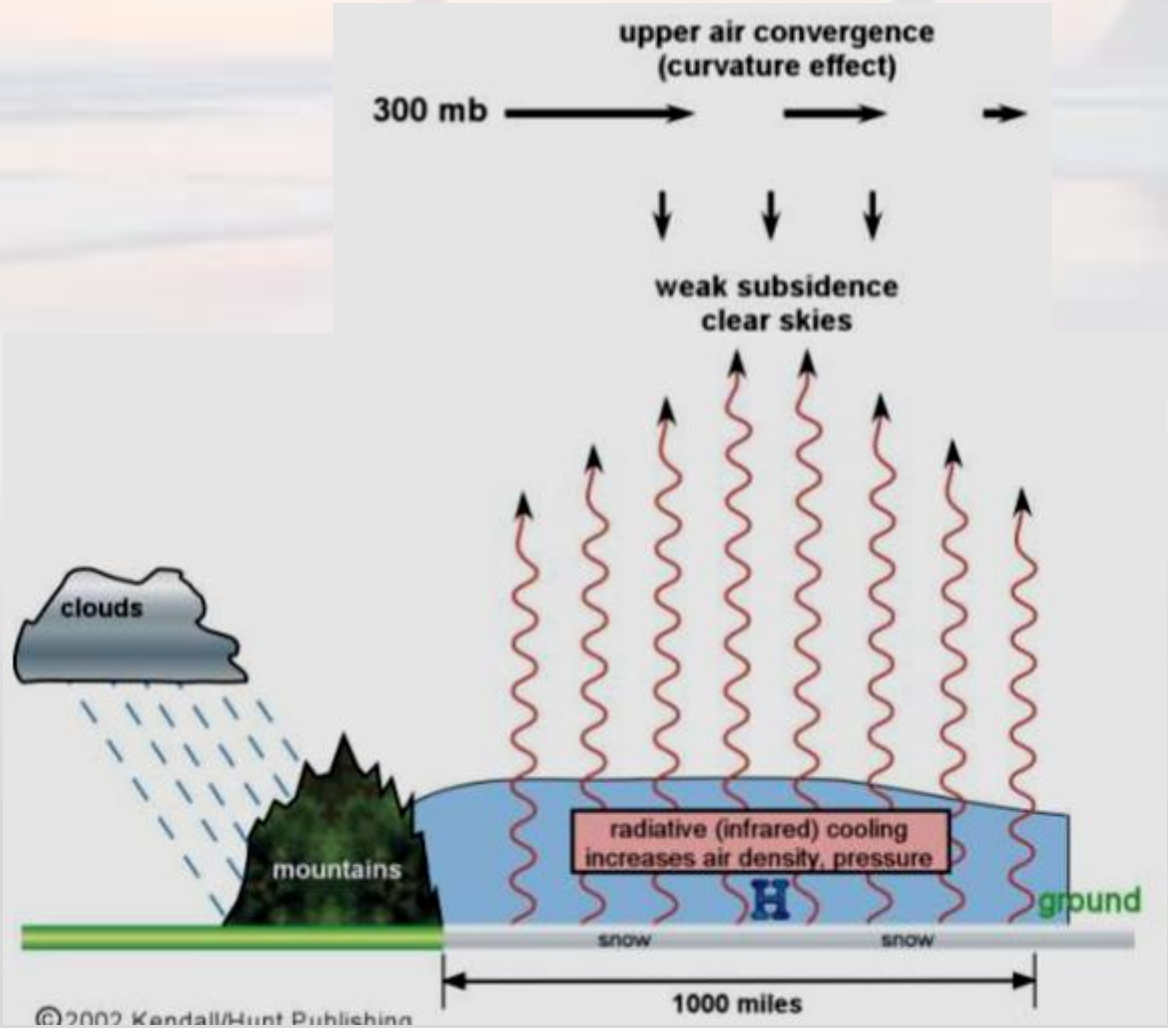
It changes in properties as it moves to different regions.

This is due to the changes of physical properties of the surface and the vertical movement etc.

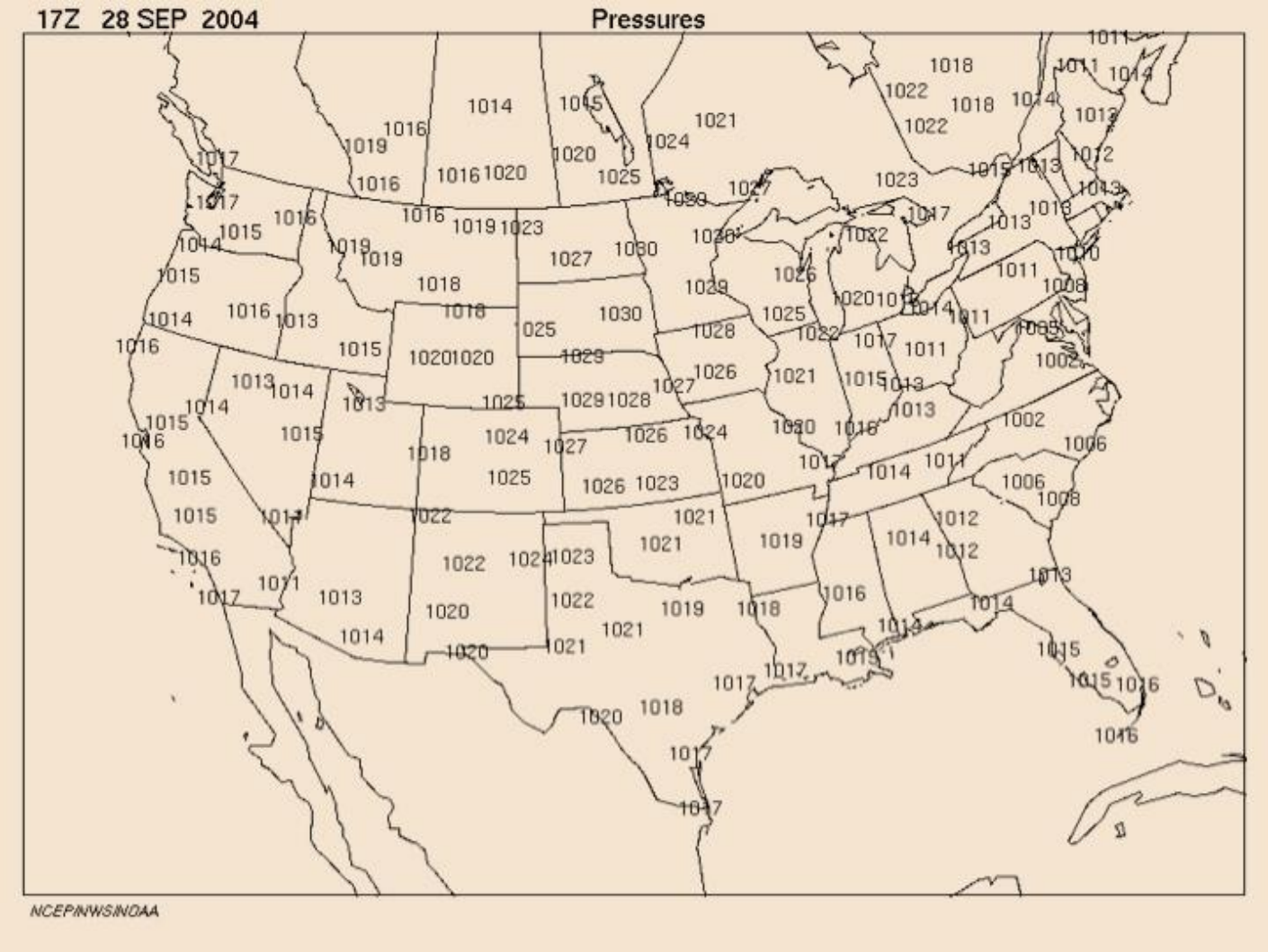


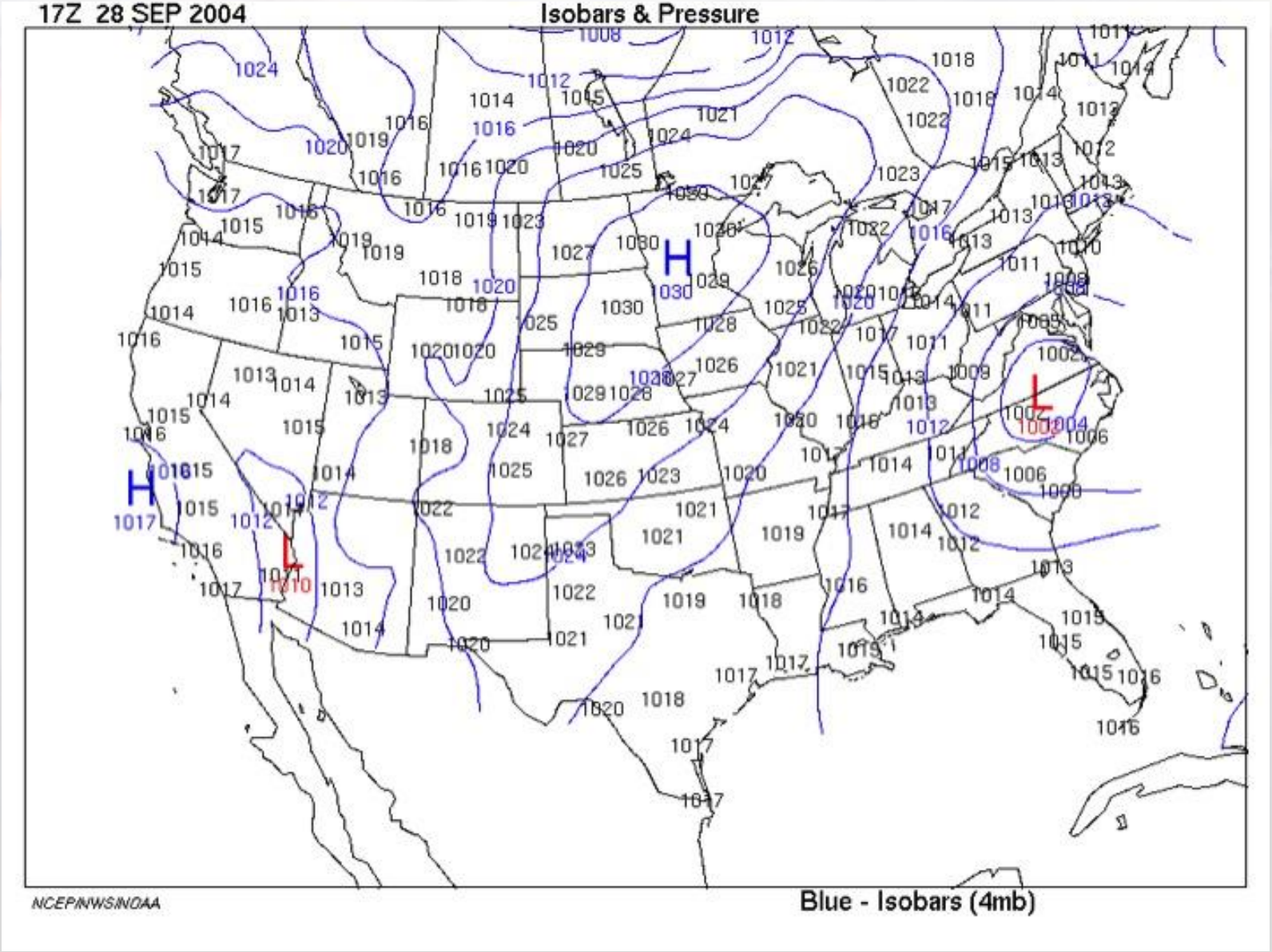
Key features of an airmass on weather maps

The centers of cold airmasses are associated with high pressure on surface weather maps. High pressure develops in response to cooling.

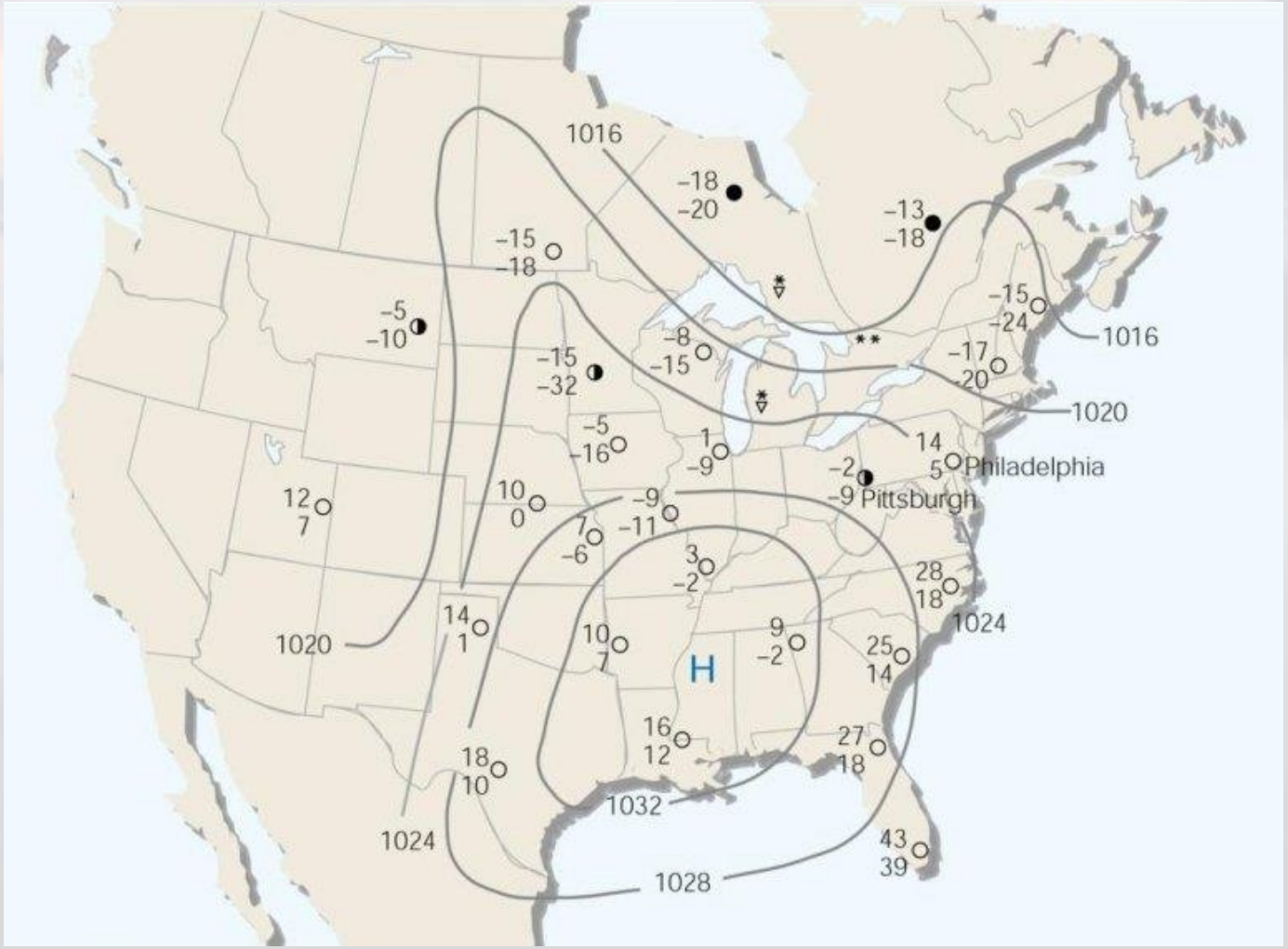


In winter, high-pressure centers form and are the dominant feature over the northern parts of the continents of Asia and North America.




17Z 28 SEP 2004
Isobars & Pressure
NCEP/NWS/NOAA
Blue - Isobars (4mb)

Here, a large, extremely cold water air mass is dominating the weather over much of the United States.



At almost all cities, the air is cold and dry.

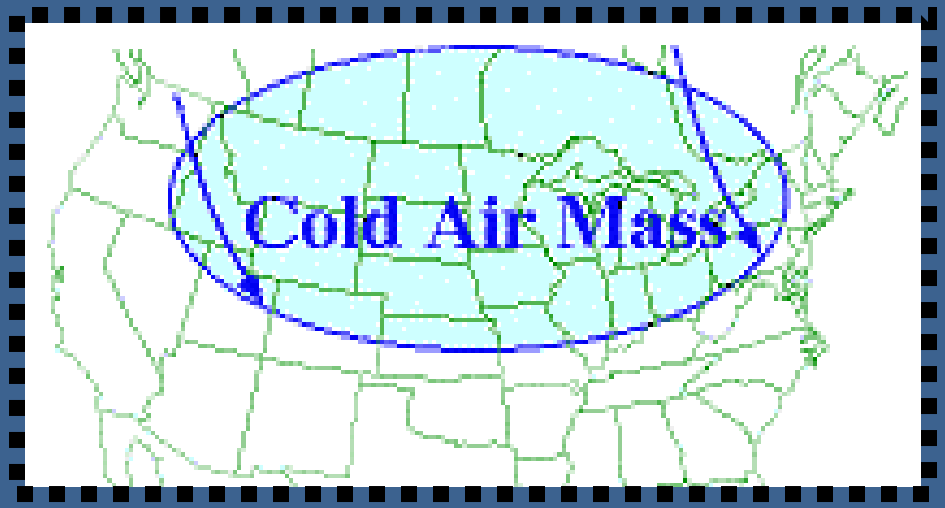
Upper number is air temperature (°F); bottom number is dew point (°F).

Air Mass

A huge "bubble" of air that shares the same temperature and pressure.
(can be big enough to cover several states!)

Air Masses are huge clumps of air that move around the Earth, bringing changes in weather.

Air masses are like the surface they form over



The air mass shown above formed over land in northern Canada

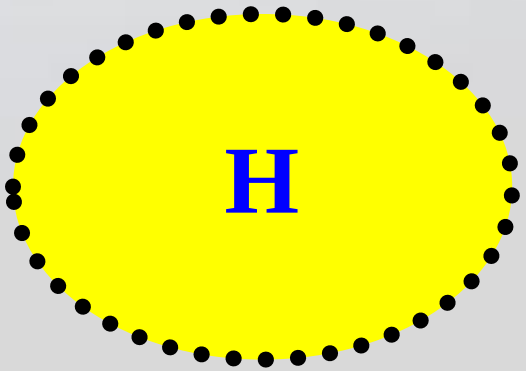
Therefore the air mass will be…

cold and dry

A polar air mass brings cold air

Cold Air Mass – this is an air mass made up of cool temperatures and high pressure.

Usually does not hold much moisture
Forms over cold water or land.



The pink air mass formed over the ocean near the equator

The air mass will be…

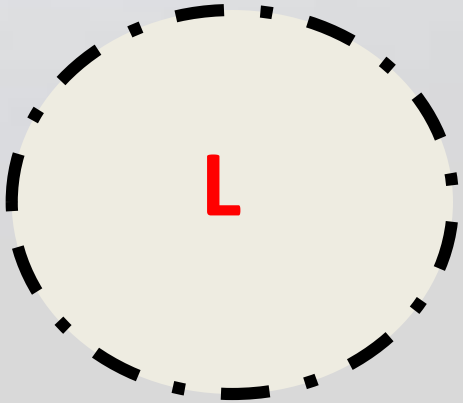
warm and moist

Warm Air Mass – this is an air mass made up of warm air that has a low pressure

Usually holds a lot of moisture

Forms over hot land or water

A tropical air mass brings warm air



AIR MASS CLASSIFICATION

Bergeron classification – 1920s

Consists of 2 letters ***ab***

Source region (a) Thermal property (b)

Air mass properties gradually change as it travels

Acquire characteristics of invading regions

Thermal properties

Stability

Whether it is heated or cooled from below

Nomenclature only applies to recent history of air mass

AIR MASS CLASSIFICATION

SOURCE REGIONS

Maritime (m) – formed over the oceans or large bodies of water

Continental (c) – formed over large land

m or c indicate influence of surface on air mass characteristics (water and land)

THERMAL TYPES

Tropical (T) – from low latitudes	Hot or warm
Polar (P) – from mid-high latitudes	Cold or cool
Arctic (A) – from high latitudes (> 65°N)	Very cold

P and T suggest importance of latitude of source regions

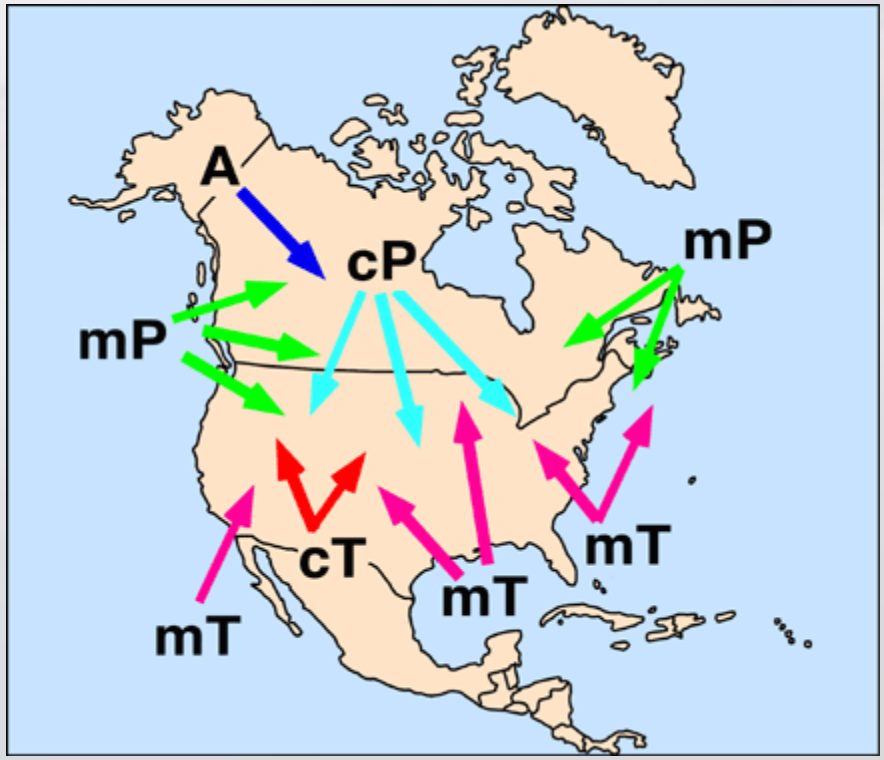
Types of Air Masses

Continental Polar, "cold and dry"
Originates closer to the Poles over land-locked regions.

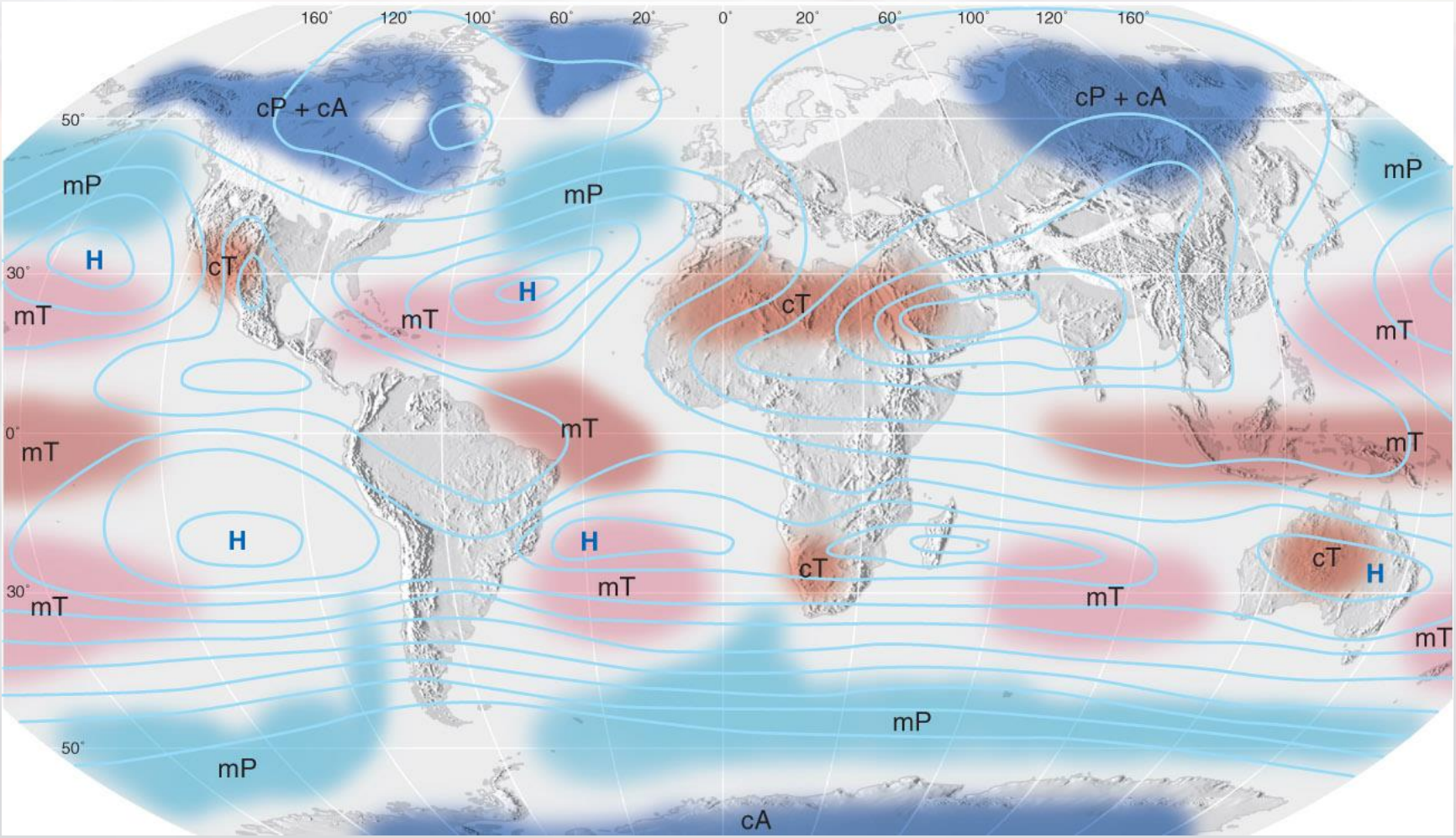
Continental Tropical, "warm and dry"
Originates closer to the Tropics over land-locked regions.

Maritime Polar, "cold and damp"
Originates closer to the Poles over water.

Maritime Tropical, "warm and humid"
Originates closer to the Tropics over water.



Arctic, "very cold"
Originates in the very cold land-locked areas



Major air mass source regions of the world

A Air Masses

Formed over the frozen Arctic

Much colder than cP air masses

Confined to a shallow layer near the surface

Little precipitation

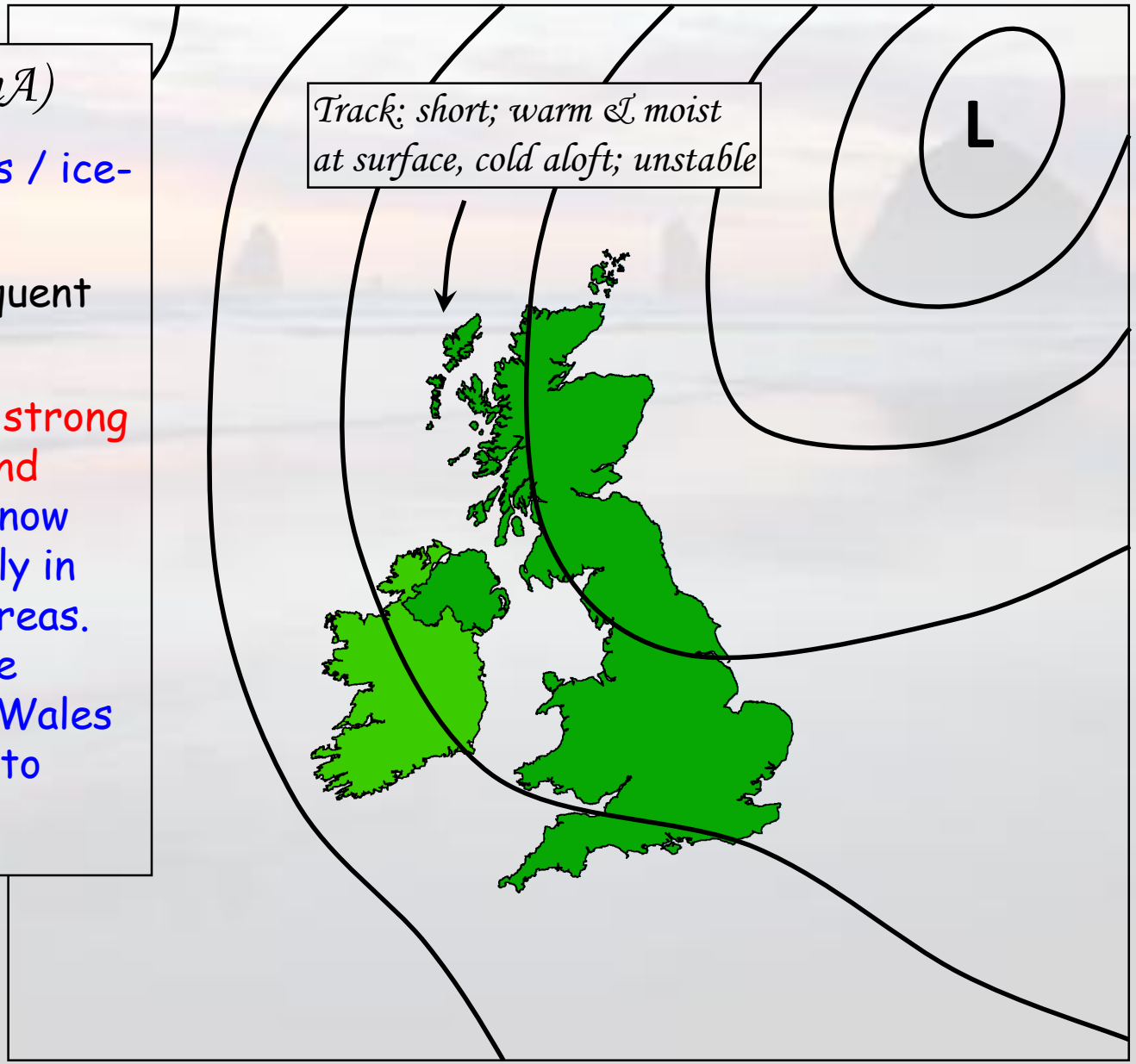
Cause record-breaking low temperatures

Arctic Maritime (mA)

Source: Arctic seas / ice-cap. Very cold.

Summer: Cold, frequent heavy showers.

Winter: Very cold; strong winds from north and northwest. Heavy snow showers, particularly in north and coastal areas. Cold & bright in lake district and South Wales in lee of mountains to north.



Continental Arctic (cA)

Frigid – record low temperatures

Dry - very low dew points

Dense - very high barometric pressure

Usually originate north of the Arctic Circle

Siberian Express

Usually once or twice a winter

very rarely form during the summer

because the sun warms the Arctic.

mP Air Masses

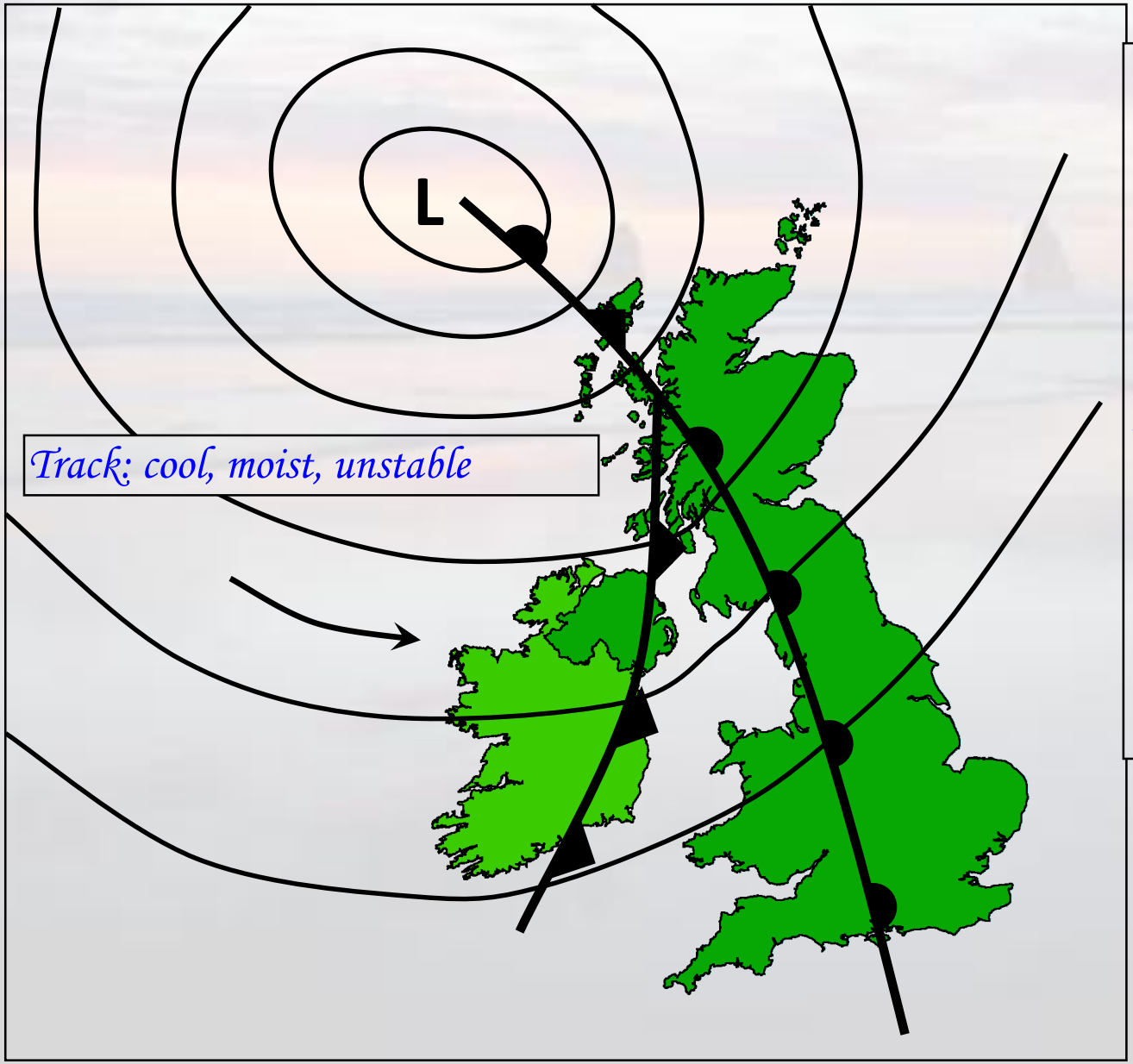
Form over the oceans at high latitudes

- During winter, can affect weather as far south as California

Weather with mP air masses is variable

- Cold mP air moving across a warm surface can become unstable and showery

If the surface is only slightly warmer, less unstable, and possibly fog and drizzle



Maritime Polar (mP)

Source: *North Canada & Greenland. Very cold.*

Summer: *Heavy showers, thunderstorms over high ground.*

Winter: *Heavy showers in north-west; clear skies in east at night giving frost. Dry in lee of mountains.*

cP Air Masses

Formed over interior high-latitude regions of a continent

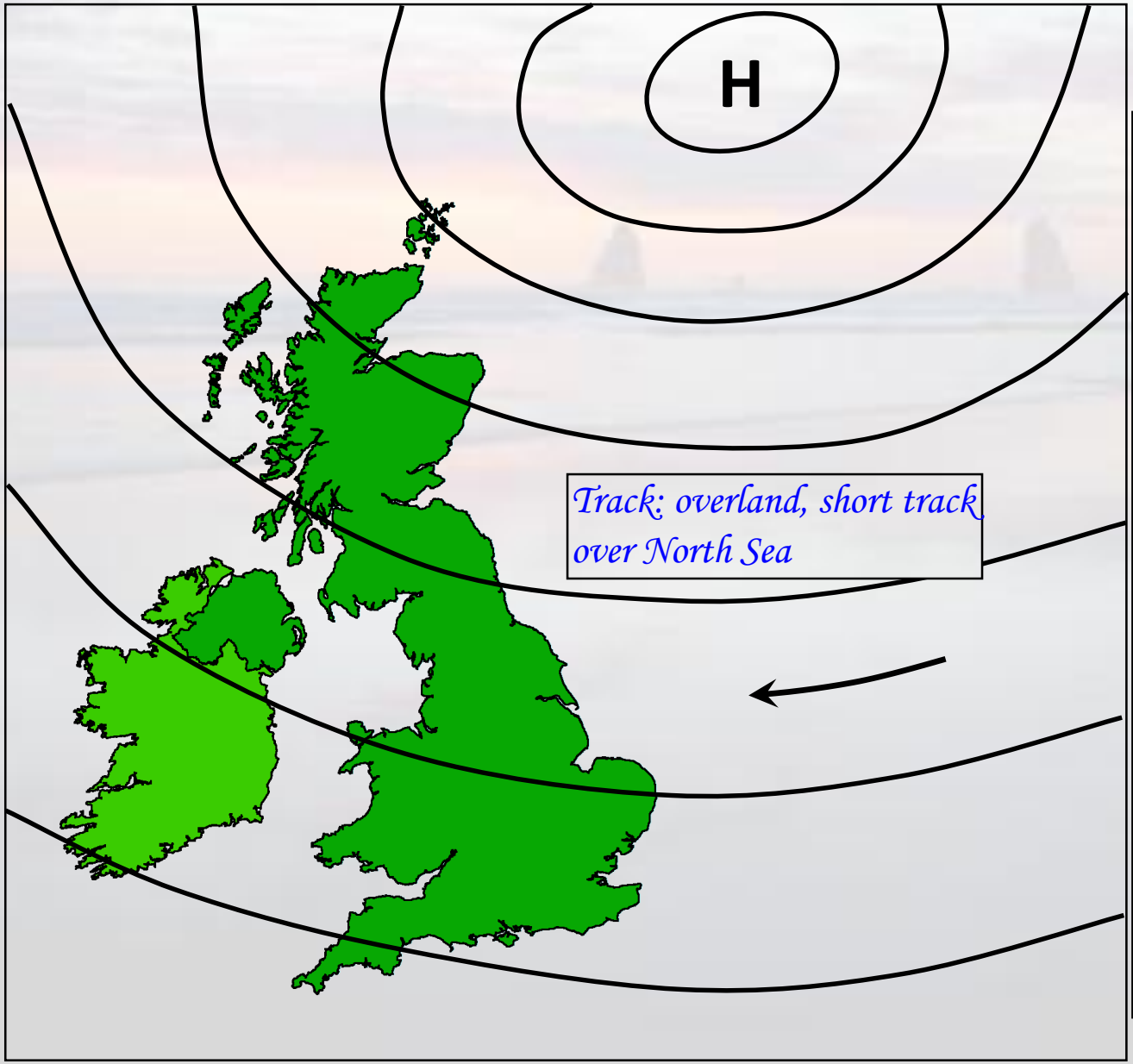
- For example, Alaska and Canada

In winter are very cold and dry

- Require long, clear nights to form
- Stable, surface inversions are often observed
- Cloud-free and frigid

In summer have more moderate temperatures

- Cool dry clear weather
- Daytime heating may produce puffy cumulus clouds



Continental Polar (cP)

Source: Siberia, very cold in winter, hot and dry in summer.

Summer: Warm & dry, cloud free, except perhaps at east coast where cool & showery.

Winter: Snow near east coast; occasional snow showers in west. Very cold & strong easterly winds

cT Air Masses

Hot and dry

Formed over tropical and subtropical deserts and plateaus

- Southwest U.S. and northern Mexico in summer
- Influences Central U.S. in summer

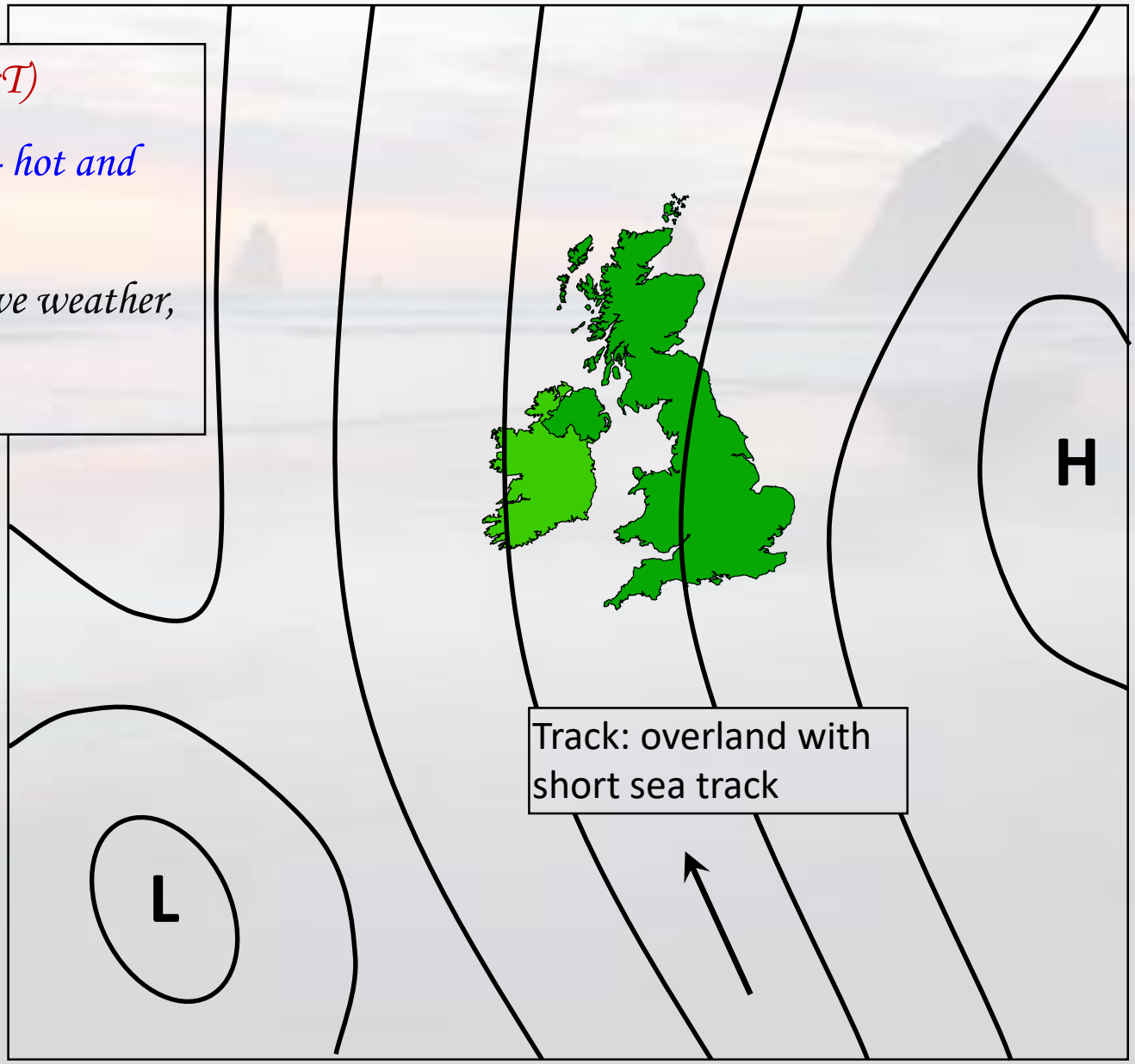
Unstable, but dryness limits cloud formation

- Can create a capping inversion

Continental Tropical (cT)

Source: North Africa – hot and dry.

Summer only: Heatwave weather, hazy with occasional thunderstorm.



mT Air Masses

Associated with sultry summer weather over the eastern U.S.

Form over the Gulf of Mexico, subtropical western Atlantic Ocean and the Caribbean Sea

A moisture source for precipitation for the midwestern U.S.

When stable, can be oppressively humid and cause heat waves

Pacific mT air masses generate the Arizona Monsoon

Source Regions

AIR MASS PROPERTIES OVER NORTH AMERICA

WINTERTIME cP

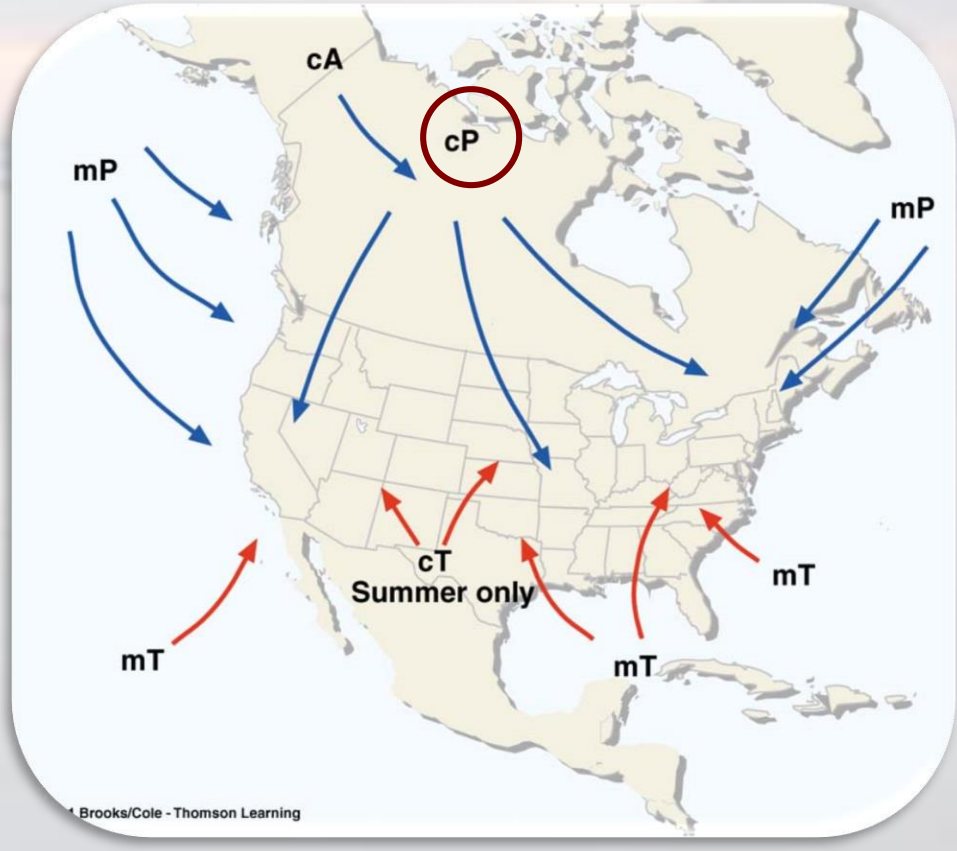
Source – Central Canada and Siberia

Frozen surface – ice and snow

Intense radiation cooling, lack of insolation heating

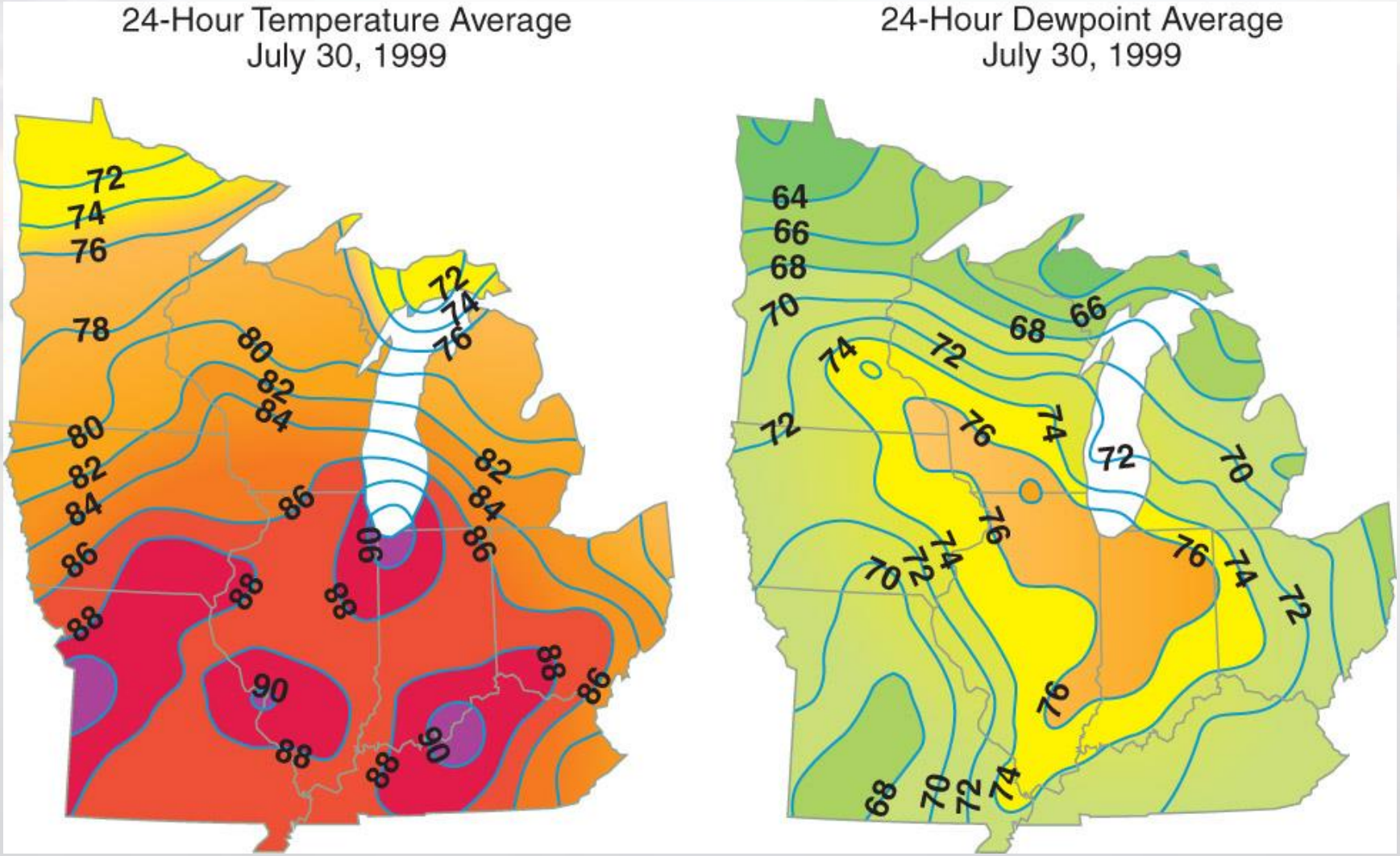
Extremely cold, stable, and dry

Clouds are non-existent



Temperature and Moisture Characteristics of Air Masses

Air Mass	Winter Characteristics	Summer Characteristics
Continental polar (cP)	Very cold and dry	Cool and dry
Maritime polar (mP)	Cool and humid	Mild and humid
Continental tropical (cT)	Cool and dry	Very hot and dry
Maritime tropical (mT)	Warm and humid	Warm and humid
Continental arctic (cA)	Bitter-cold and dry	—



Graphics of Wisconsin heat wave

Analyzing Air Masses

An air mass is most easily identified by comparing it to other air masses.

Air masses can be modified with time, most notably by days of sunshine or lack thereof.

Fronts are the dividing line between air masses so understanding air masses, means understanding where fronts are located.

Air Mass Modification

Properties of air masses change as they move and exchange energy and moisture with the underlying surface, called air mass modification

Temperature, moisture, stability

Mechanisms that modify an air mass

Energy (heating) and moisture exchanges with the surface Mechanical lifting

Air Mass Modification Processes

Thermodynamic

Surface heating/cooling

- Change of temperature of surface, or advection over different surface

Addition of moisture

- Surface evaporation
- Evaporation of precipitation falling from higher level

Loss of moisture

- Condensation, precipitation

Radiative heating/cooling

- slow compared to surface heat exchange (up to 2 weeks)

Dynamic

Turbulent mixing

- Increases uniformity of air mass. Very efficient close to surface.

Large-scale lifting/descent

- Causes adiabatic changes of temperature
- May result in formation or evaporation of clouds

Examples of Air Mass Modification

When a cold cP air mass moves over a warm body of water

- Rapid exchange of energy and moisture
- Rapid evaporation may cause steam fog

When a cold cP air mass stalls over the warm Gulf of Mexico

- Rapid modification
- Large-scale weather pattern draws air north again
- Called a return flow event
- Responsible for severe weather along Gulf Coast

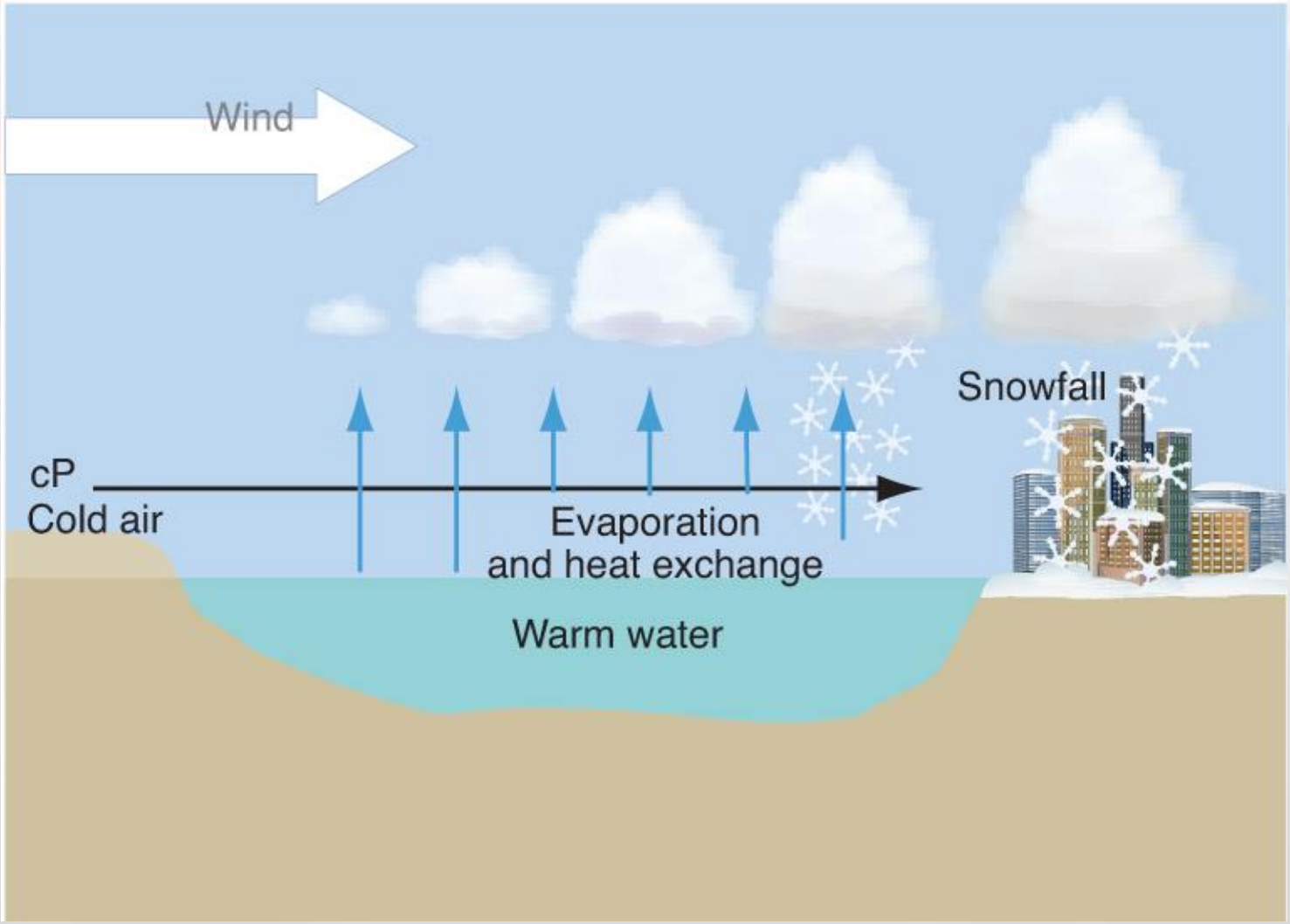
Stability of Air Masses

Warm air overlying cold air is stable

Polar air masses are generally stable

When the lower troposphere is warmed the air mass gets less stable

Tropical air masses are generally less stable than polar air masses



Lake-effect snow

Air Mass:

a large volume of air that has remained over a surface for a long enough period of time to be modified by the surface

- relatively uniform horizontal temperature and moisture content
- relatively homogeneous temperature lapse rate above the influence of the surface layer

Temperature of an air mass is classified by the general characteristics of its “source region”

A = Arctic (or AA for Antarctic)
P = Polar
T = Tropical

In addition, air masses are also defined by their moisture characteristics:

m = maritime (ocean) surfaces

c = continental (land) surfaces

The combination of temperature and moisture gives us five basic air mass types:

Continental Arctic (cA)

- extremely cold, formed over poles
- very dry due to extreme cold
- usually originate north of the Arctic Circle (in winter, 24 hours of dark allow extreme cooling)
- break southward across Canada and USA during winter
- rarely seen at lower latitudes during summer since summer warms region; polar front and jet stream found at higher latitudes

Continental Polar (cP)

- very cold, having developed over sub-polar regions (not as cold as Arctic air masses)
- very dry, due to cold and developing over land
- form further south in the subpolar Canadian North and Alaska
- common across continent during winter

- do form in summer, but mostly only in Canada and northern USA
- typically bring clear and pleasant weather during the summer

Maritime Polar (mP)

❖very cool and moist

❖ typically bring cloudy, damp weather

❖ form over northern Pacific and northern Atlantic Oceans

❖ can form at any time of year

Maritime Tropical (mT)

- very warm – develop in tropical and sub-tropical latitudes
- very humid
- originate over warm waters of southern Atlantic Ocean, and Gulf of Mexico
- can form year around, but are most common in summer

- responsible for hot, humid days of summer across much of the eastern half of North America

Continental Tropical (cP)

- very warm; develop in lower sub-tropical latitudes
- very dry because of formation over land
- form over the desert southwest and northern Mexico during summer
- bring heat to the US Plains states and Mississippi Valley during summer
- as air mass moves eastward, moisture is evaporated into it, making it more mT
- these air masses rarely form in winter