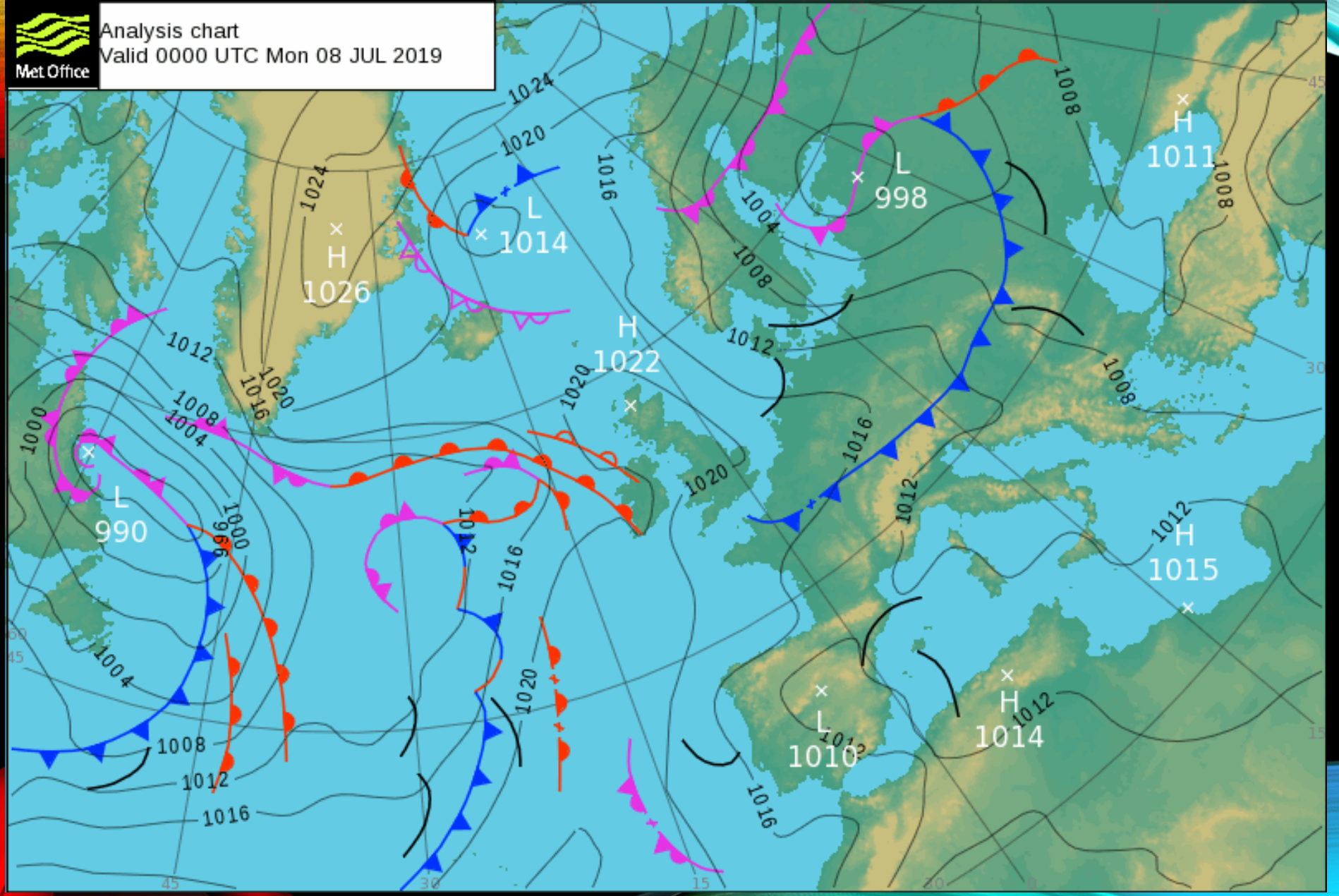
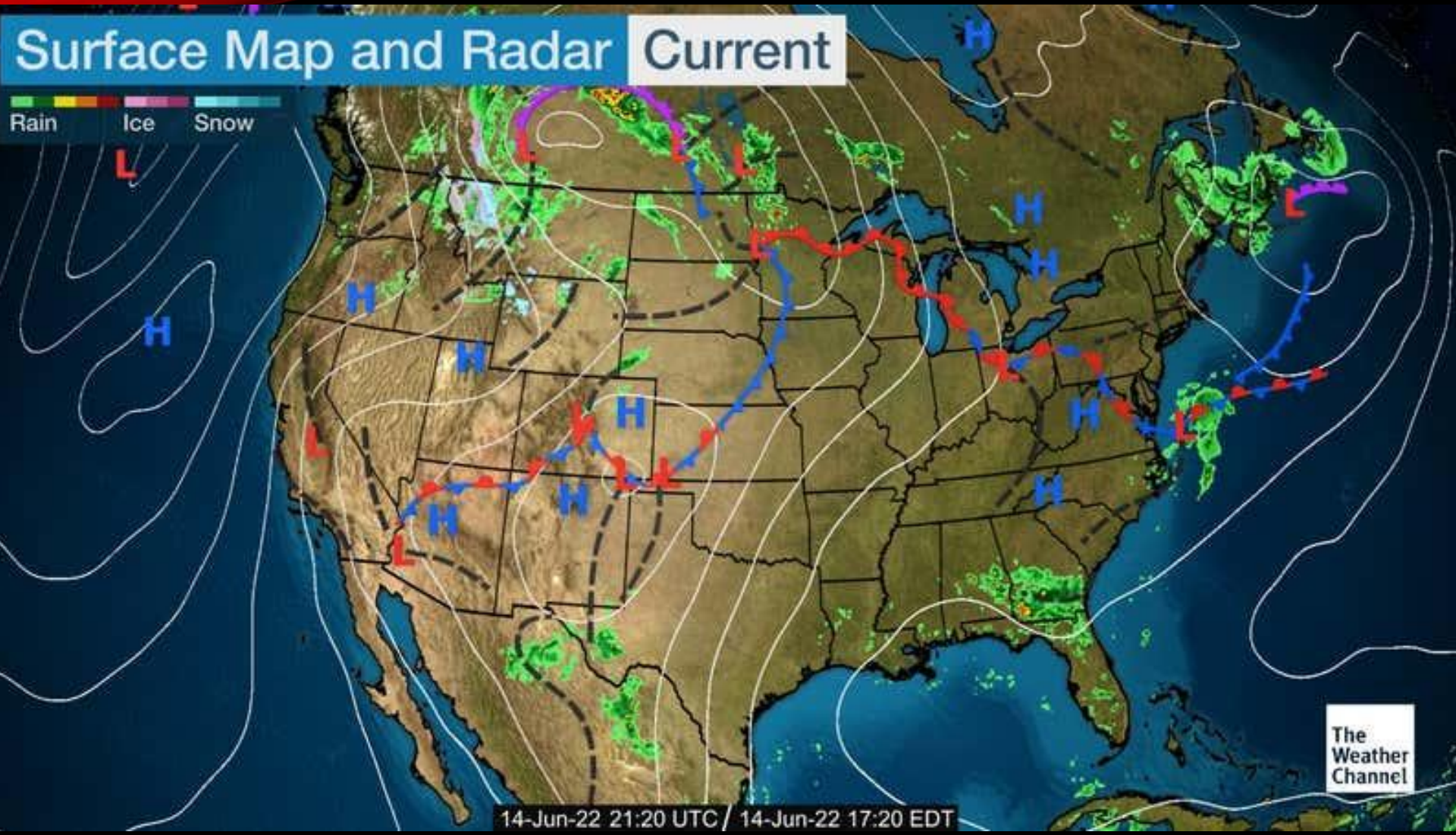
Understanding weather and the weather forecast

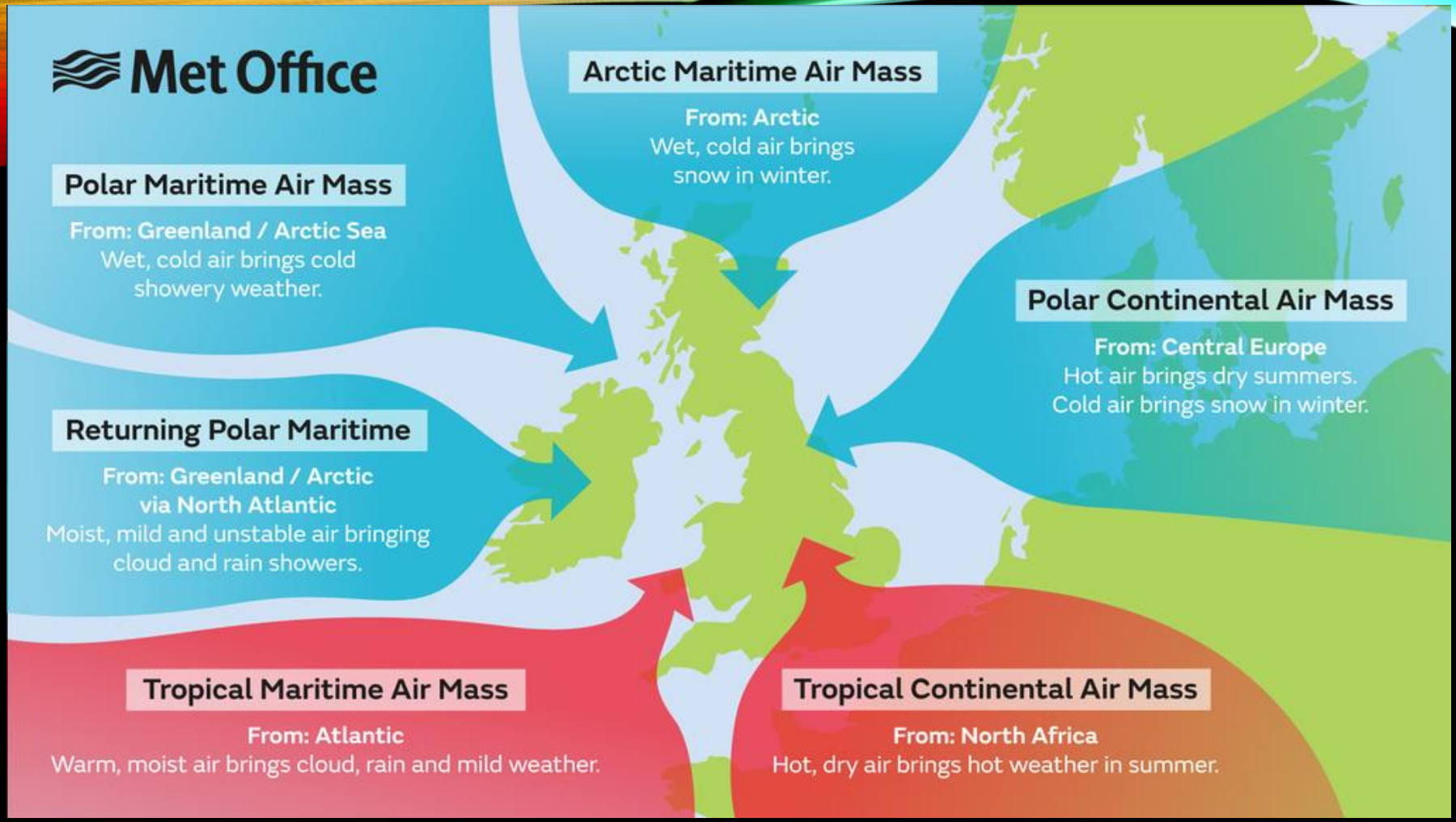
Week 16 More on Fronts, Troughs and Lows

Terry Hart



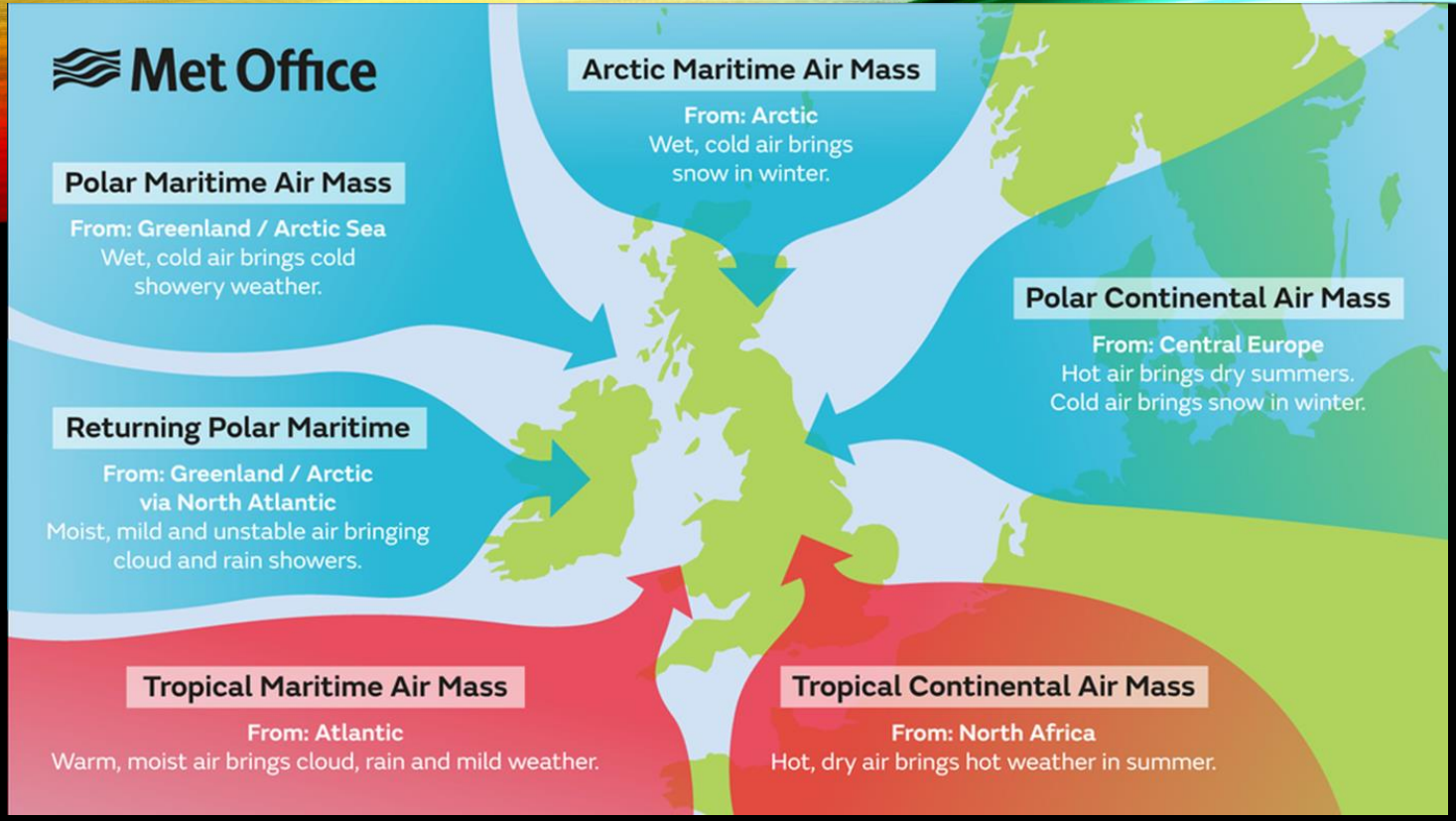
Northern Hemisphere – Fronts are very complex and systems tend to stay around longer


Surface Map and Radar
Current
Rain
Ice
Snow
The Weather Channel
14-Jun-22 21:20 UTC / 14-Jun-22 17:20 EDT



The Bergen School introduced the idea of **air mass** - a large volume of air in the atmosphere that is *mostly* uniform in temperature and moisture, with character determined by its origin.

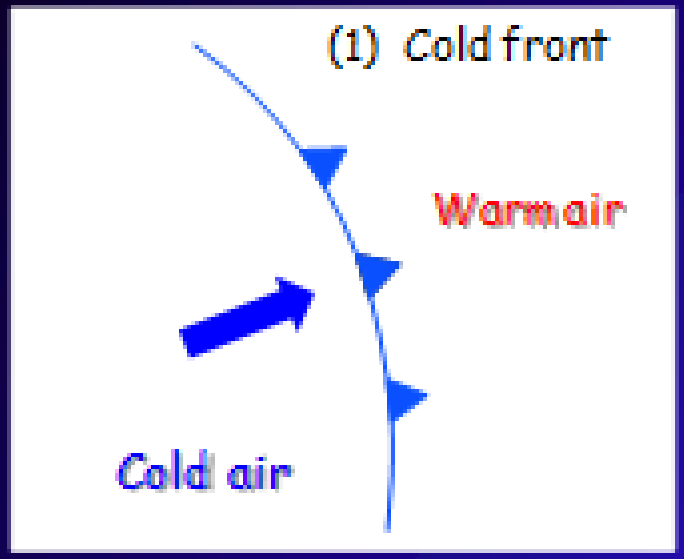
https://www.youtube.com/watch?v=kvk-hBFnBTI

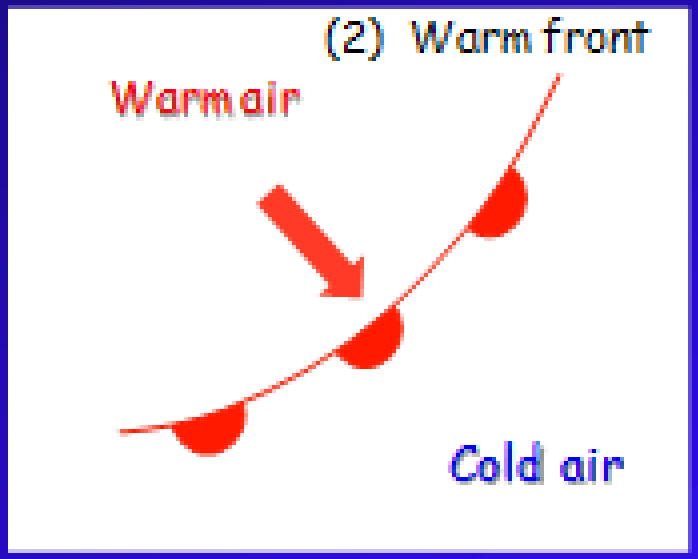


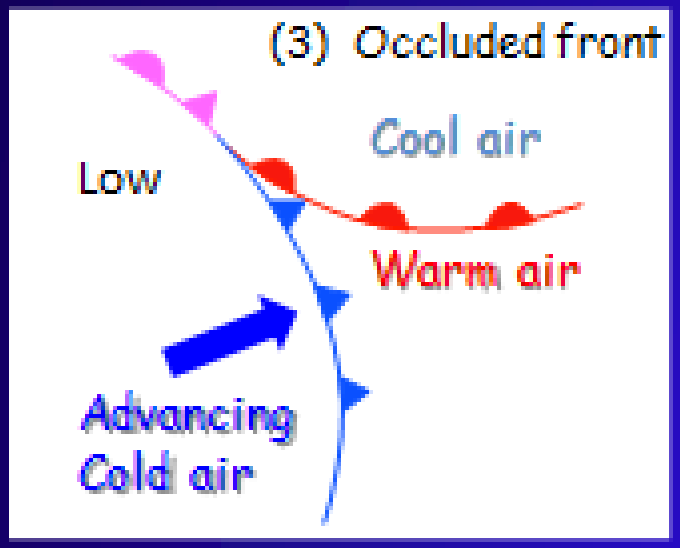
The Bergen School introduced the idea of **air mass** - a large volume of air in the atmosphere that is *mostly* uniform in temperature and moisture, with character determined by its origin.

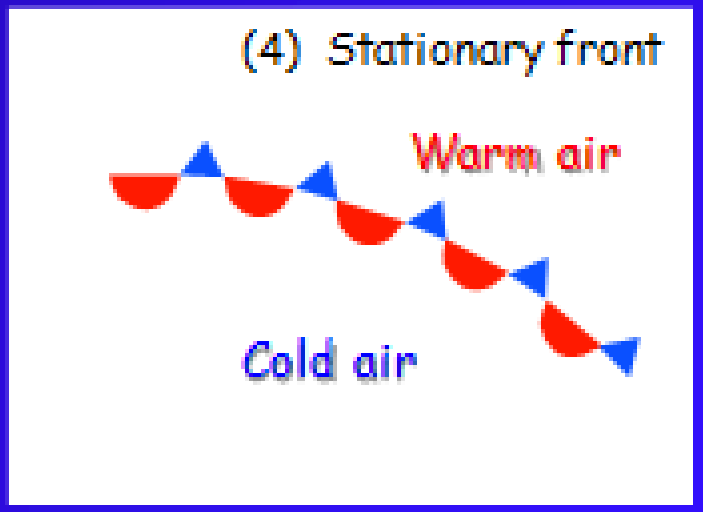
Based on their experience in Europe they realised that much of the rain occurred at the boundaries between air masses. Given that they were developing their ideas during the First World War, the concept of a **front** arose.

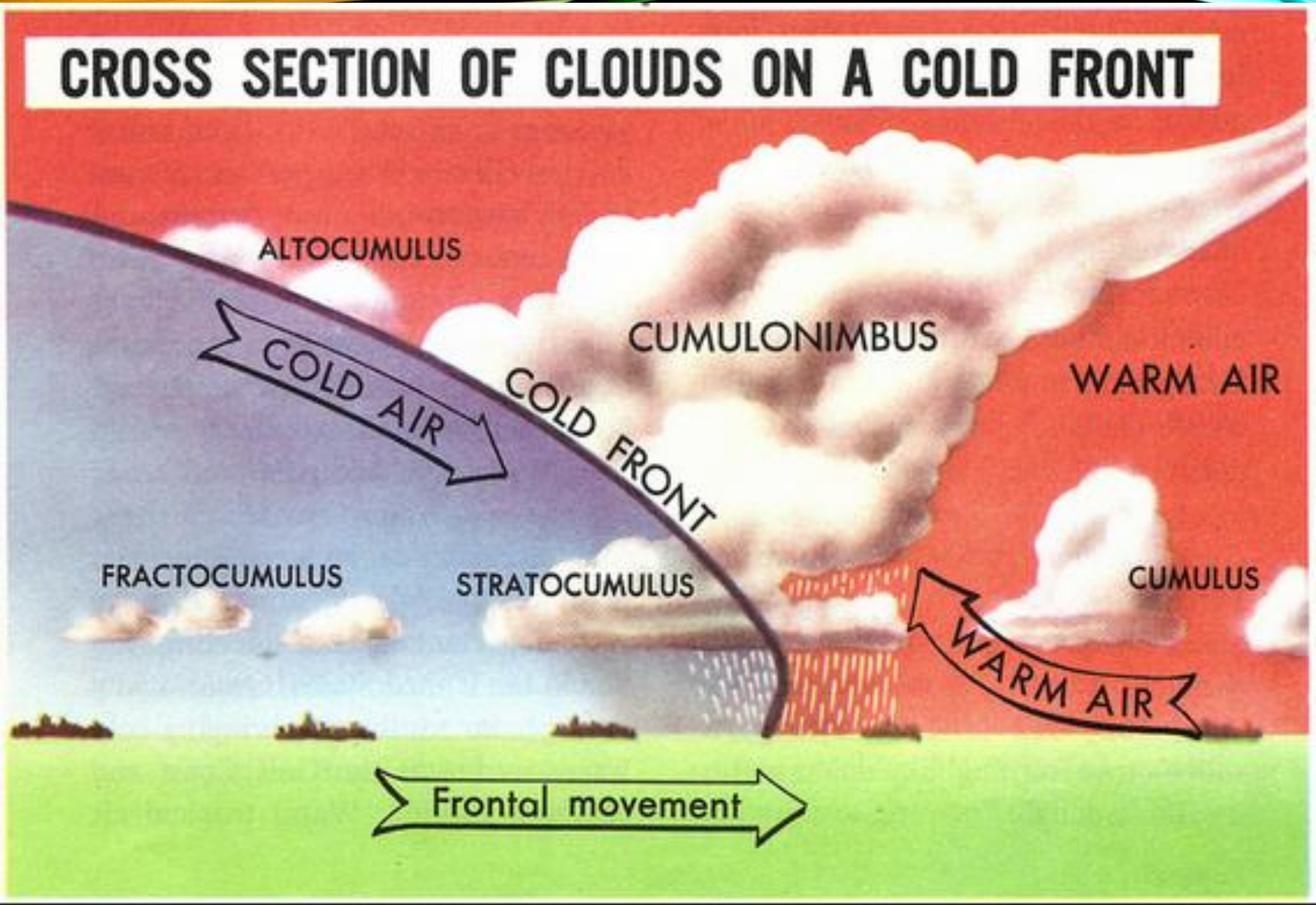
Fronts


(1) Cold front
Warm air
Cold air

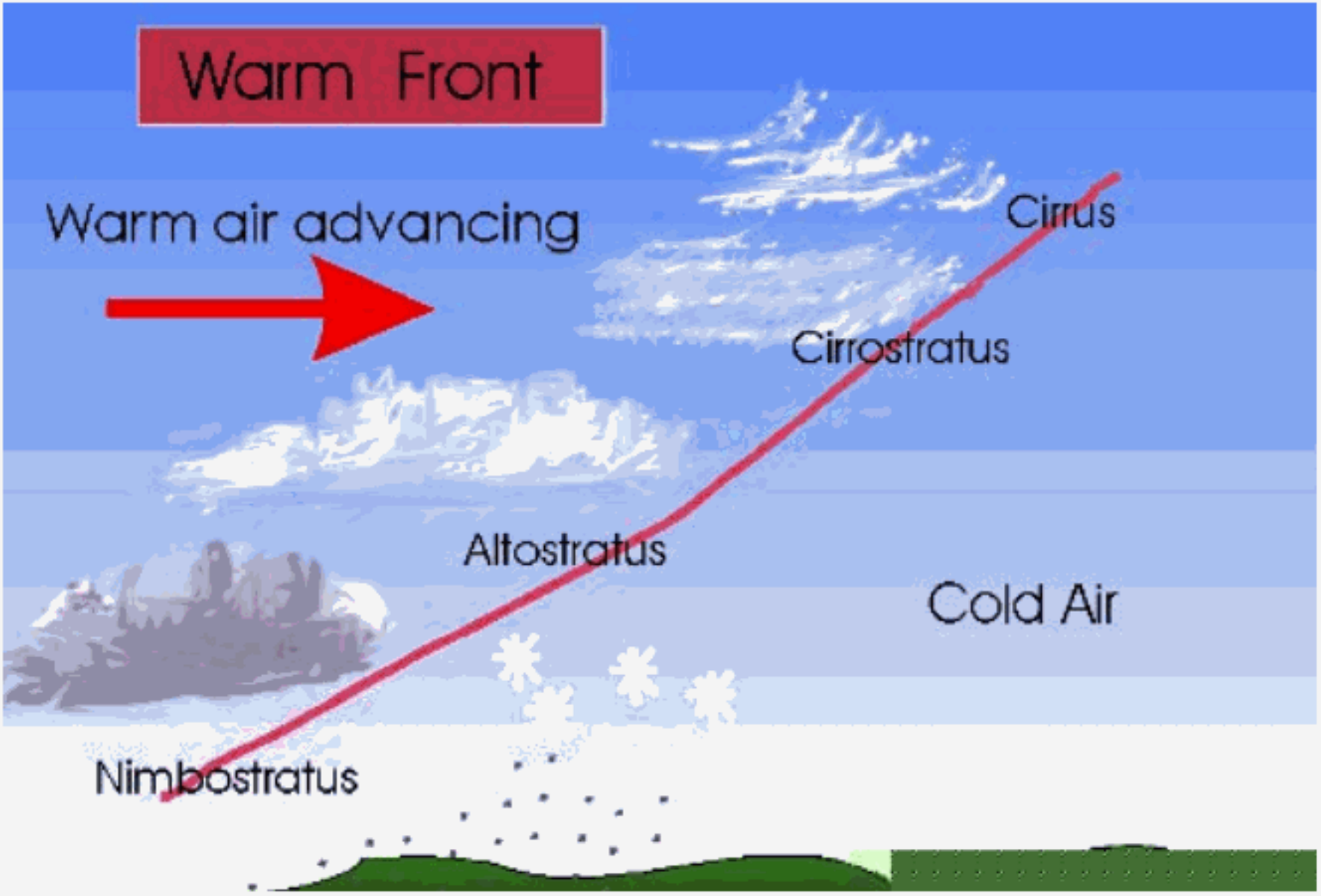

(2) Warm front
Warm air
Cold air


(3) Occluded front
Cool air
Low
Warm air
Advancing
Cold air

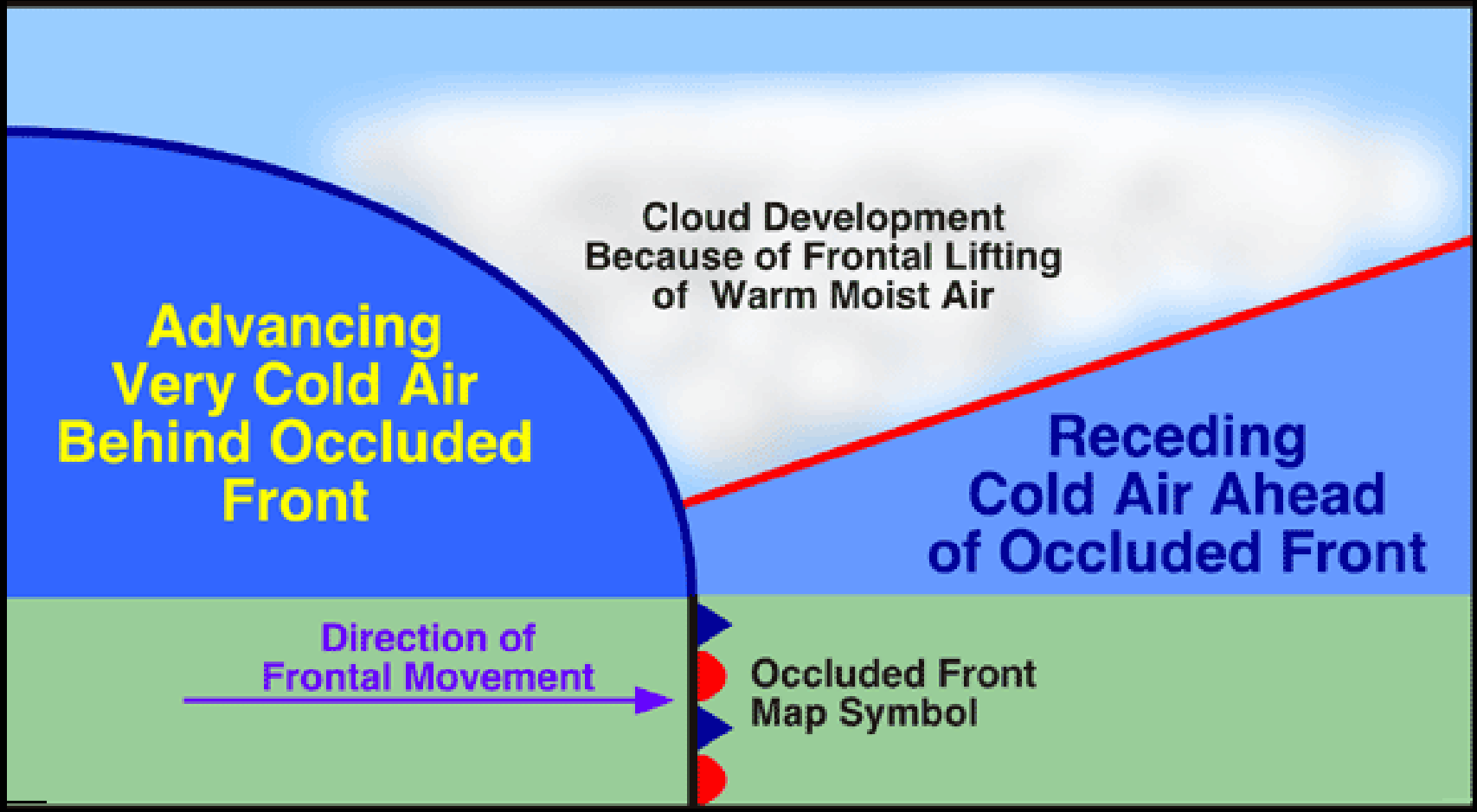

(4) Stationary front
Warm air
Cold air


CROSS SECTION OF CLOUDS ON A COLD FRONT
ALTOCUMULUS
COLD AIR
COLD FRONT
CUMULONIMBUS
WARM AIR
FRACTOCUMULUS
STRATOCUMULUS
CUMULUS
WARM AIR
Frontal movement

Warm front


Warm Front
Warm air advancing
Cirrus
Cirrostratus
Altostratus
Cold Air
Nimbostratus

Occluded front



Cold fronts and warm fronts video:

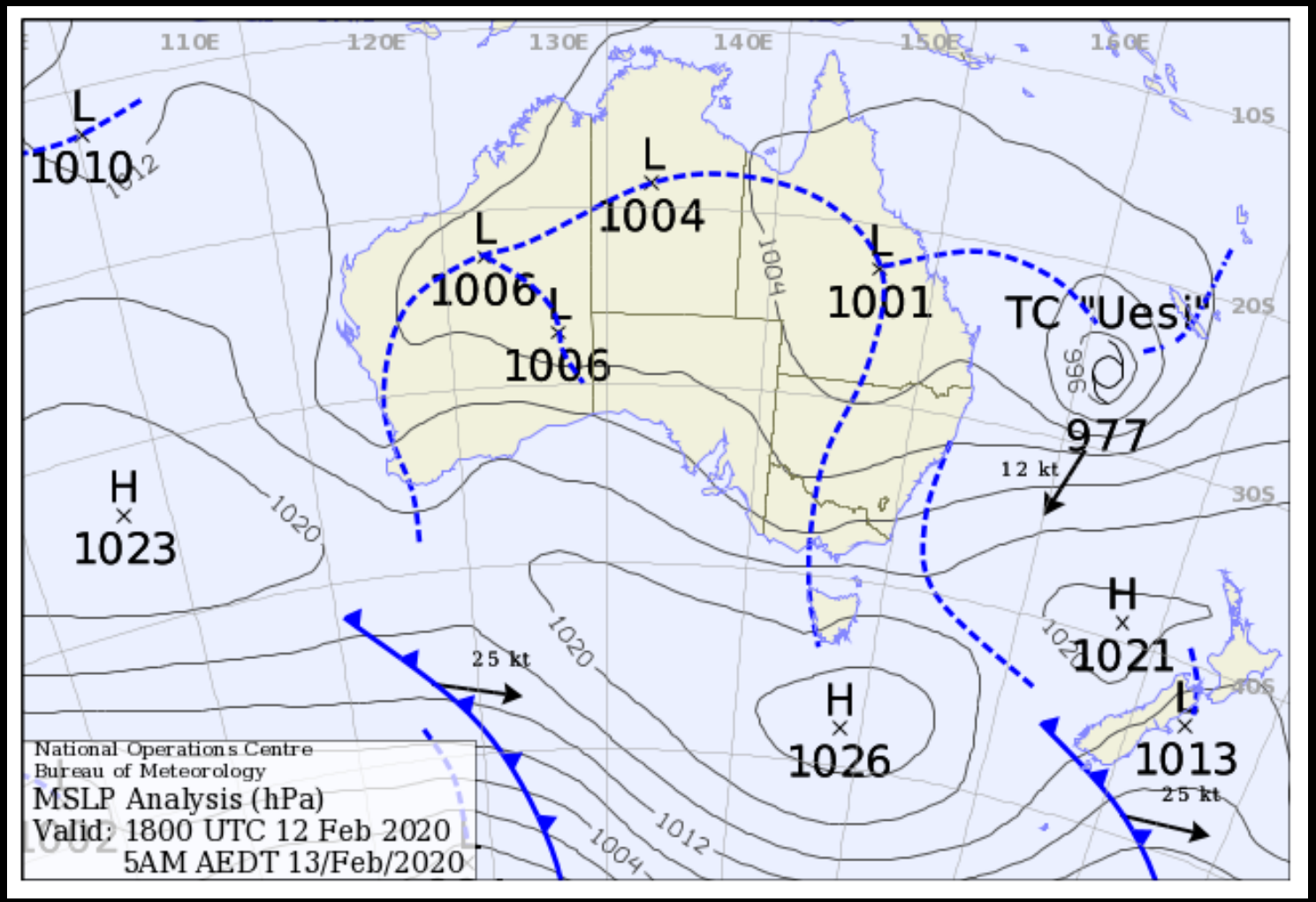
Front as a “wedge”
https://www.youtube.com/watch?v=huKYKykjcm0&t=30s

(Met Office https://www.youtube.com/watch?v=G7Ewqm0YHUI)

BoM https://www.youtube.com/watch?v=OFeN5nMqT7M

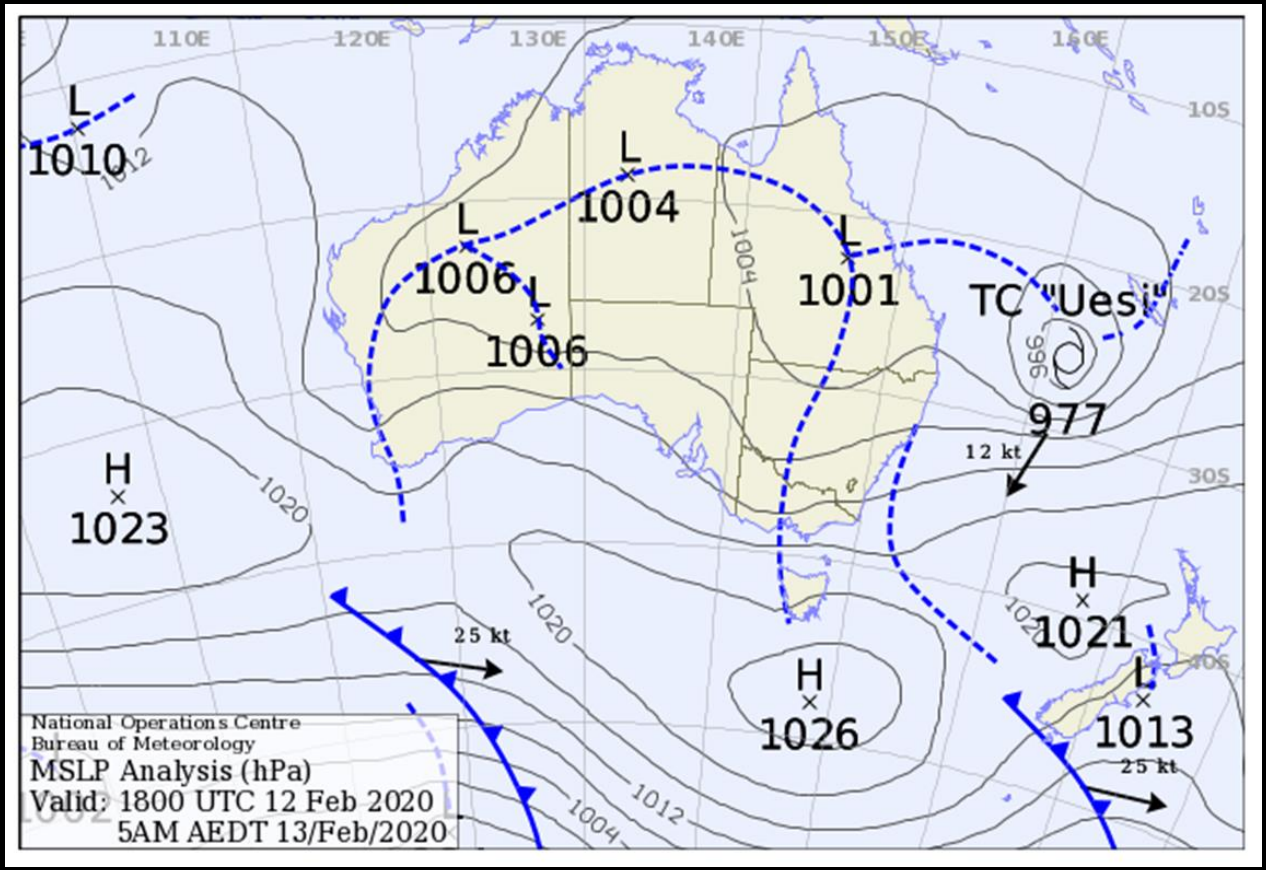
https://www.abc.net.au/news/2019-07-12/what-is-a-cold-front/11303562

This weather map shows lines of equal Mean Sea Level Pressure (MSLP). Marked on it are fronts and also dotted lines indicating a line of relatively low pressure (called a **trough**)



A **trough** is the general term for an area of (relatively) low pressure (like a valley in a terrain map)

Because air is likely to be rising in these areas that is where rain and thunderstorms tend to form. So the analyst will often mark these with a dashed line to emphasise their significance.



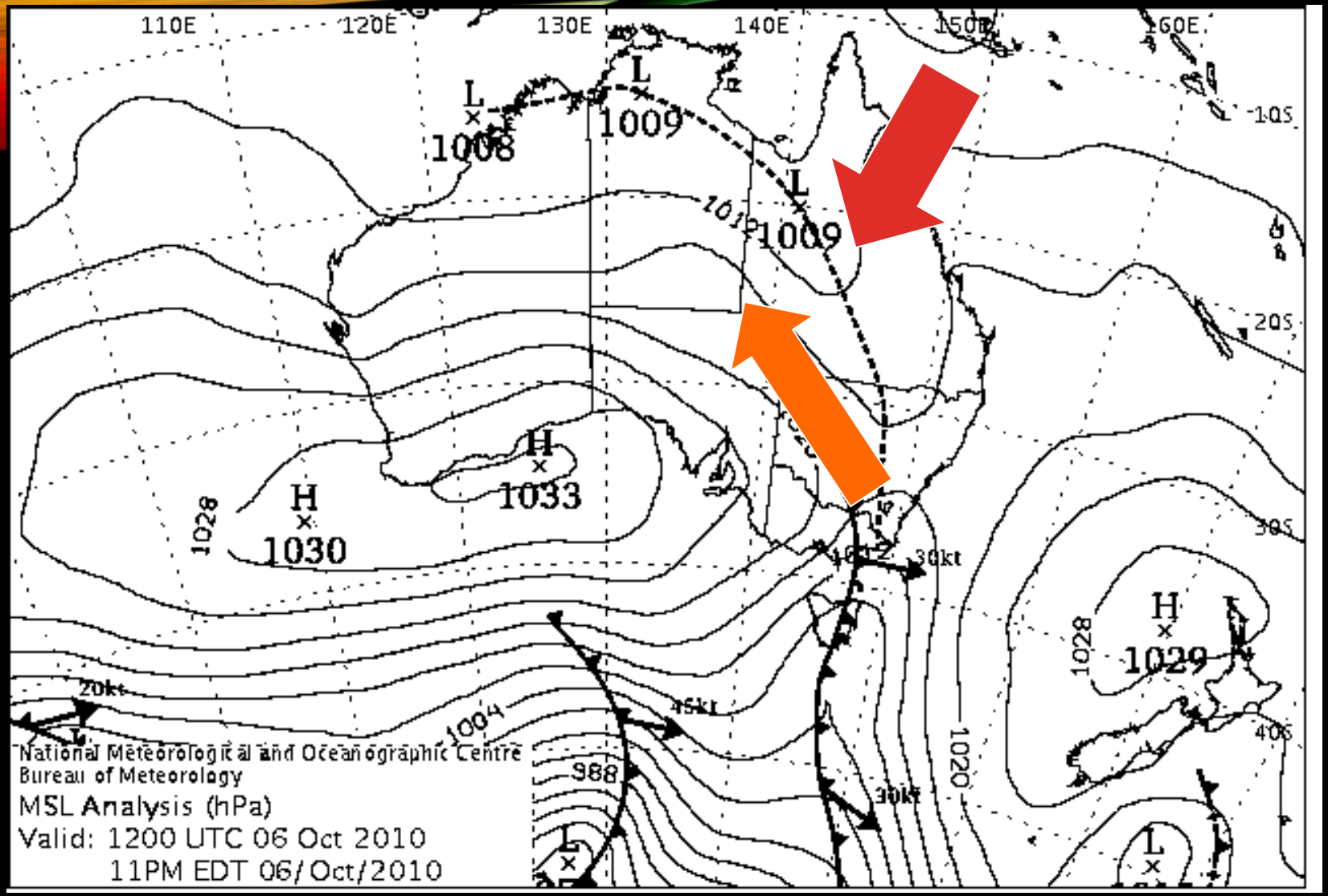
In low latitudes (tropical areas):

It is more difficult to develop a deep low as the Coriolis force is weaker. Air can move from areas of high pressure to lower pressure without being deflected so quickly by the effects of the earth's rotation.

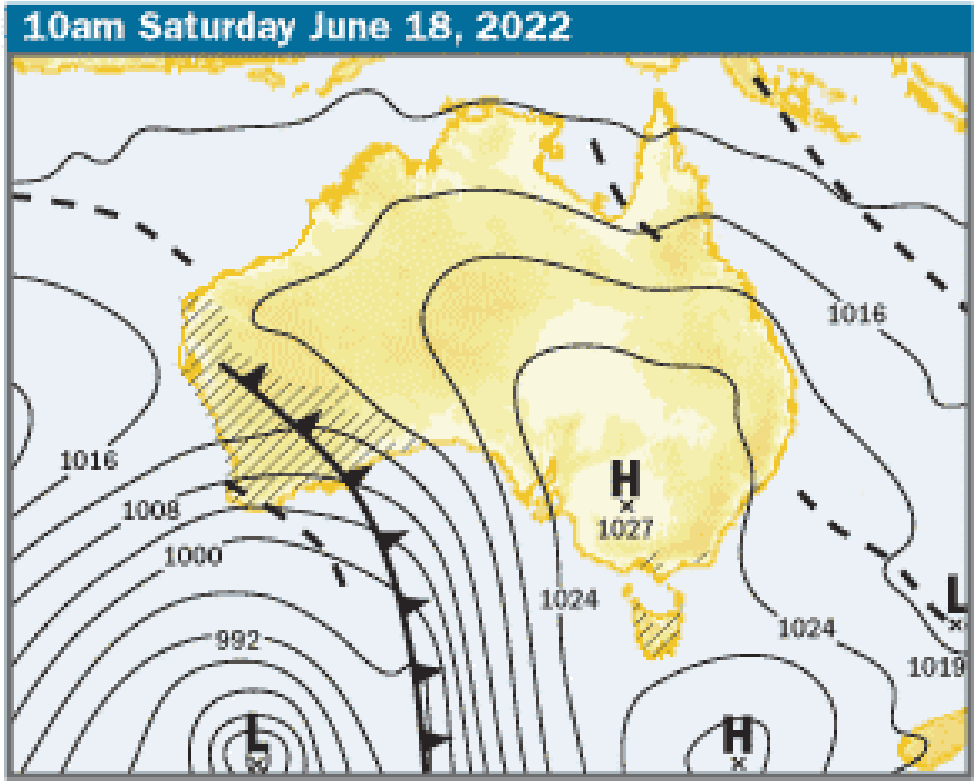
(E*xception – tropical cyclones where the intense rainfall leads to a strong feedback cycle)*

Because temperature is more uniform there may not be a strong temperature contrast on either side of the trough. There may be a contrast in the humidity (moisture content)

So, at low latitudes, troughs are common but lows with circular isobars are rarer.



Even though the trough over Queensland is not very deep, the wind direction is quite different on either side of the trough line. There may be significant differences in the “air mass” – but probably in moisture content rather than temperature.



Bureau Home > Australia > Weather Maps > Interactive Weather and Wave Forecast Maps

Interactive Weather and Wave Forecast Maps

Map Viewer Help | Glossary | Recent Weather Maps | Feedback

Map Selection

These forecast maps are produced from computer models and are used by forecasters to develop the official forecast maps on MetEye.

Show: Surface Winds
Level: Surface
Timezone: Australian Eastern (South)

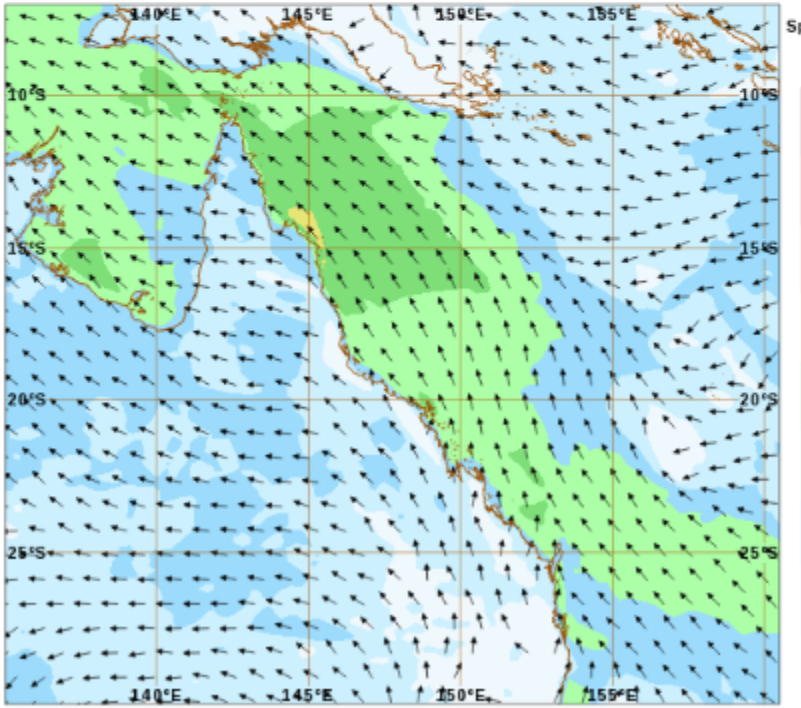
Animate

THURSDAY | FRIDAY | SATURDAY | SUNDAY | MON

04 07 10 13 16 19 22 01 04 07 10 13 16 19 22 01 04 07 10 13 16 19 22 01 04 10 16 22 04 10

10m winds — **ACCESS-G3**

Valid 00UTC Sat 18 Jun 2022 — **t+054**



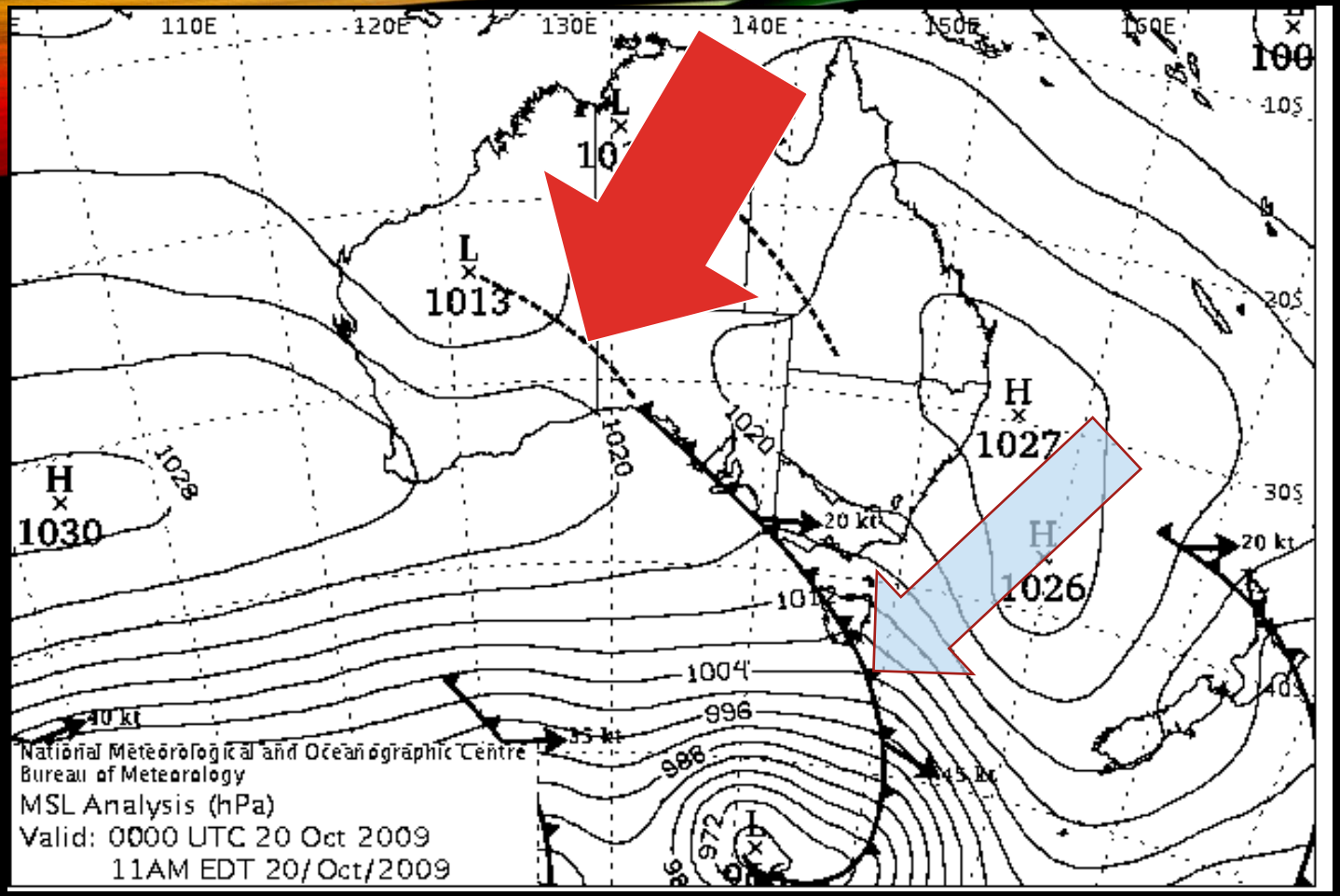
At higher latitudes (towards the poles), where the Coriolis force is stronger, a trough can deepen and eventually have **closed isobars**.

It is then called a **low** or a **cyclone**.

At higher latitudes there is often a strong change of temperature in the north-south direction. As the low develops it brings air of different temperatures (air masses) together.

As part of the dynamics of the cyclone a sharp line can form where different air masses are brought together. This line is called a **front**.

A front is a particular type of trough:
. Linked to a high latitude low
. Has a strong contrast of temperature.



The cold front is associated with a deep low to the south of Australia.

Further north, when the front gets too far removed from the parent low it is marked just as a trough. There was probably a continuous line of cloud on the satellite picture, although the northern part was probably less distinct.

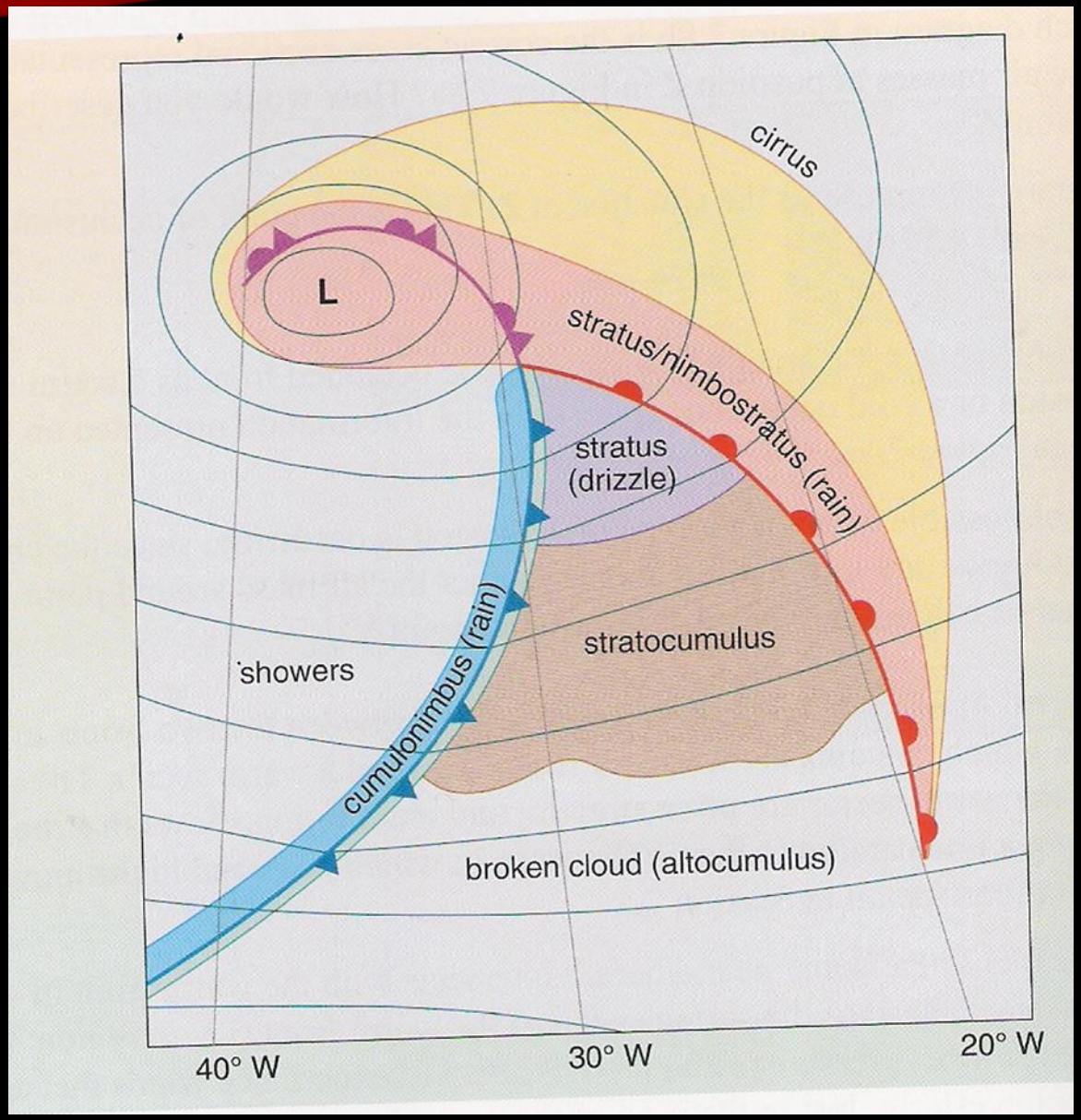
- The concept of the front introduced by the Bergen School was dominant for many years.

- However, the images of wedges of cold and warm air really only show a **two-dimensional** view.

- Even the Bergen School realised that the air flow is actually more complex and **three-dimensional**.

- Detailed classification of the various types of fronts is not so important these days. The focus is more on the details of the particular situation – just as Vilhelm Bjerknes had envisaged.

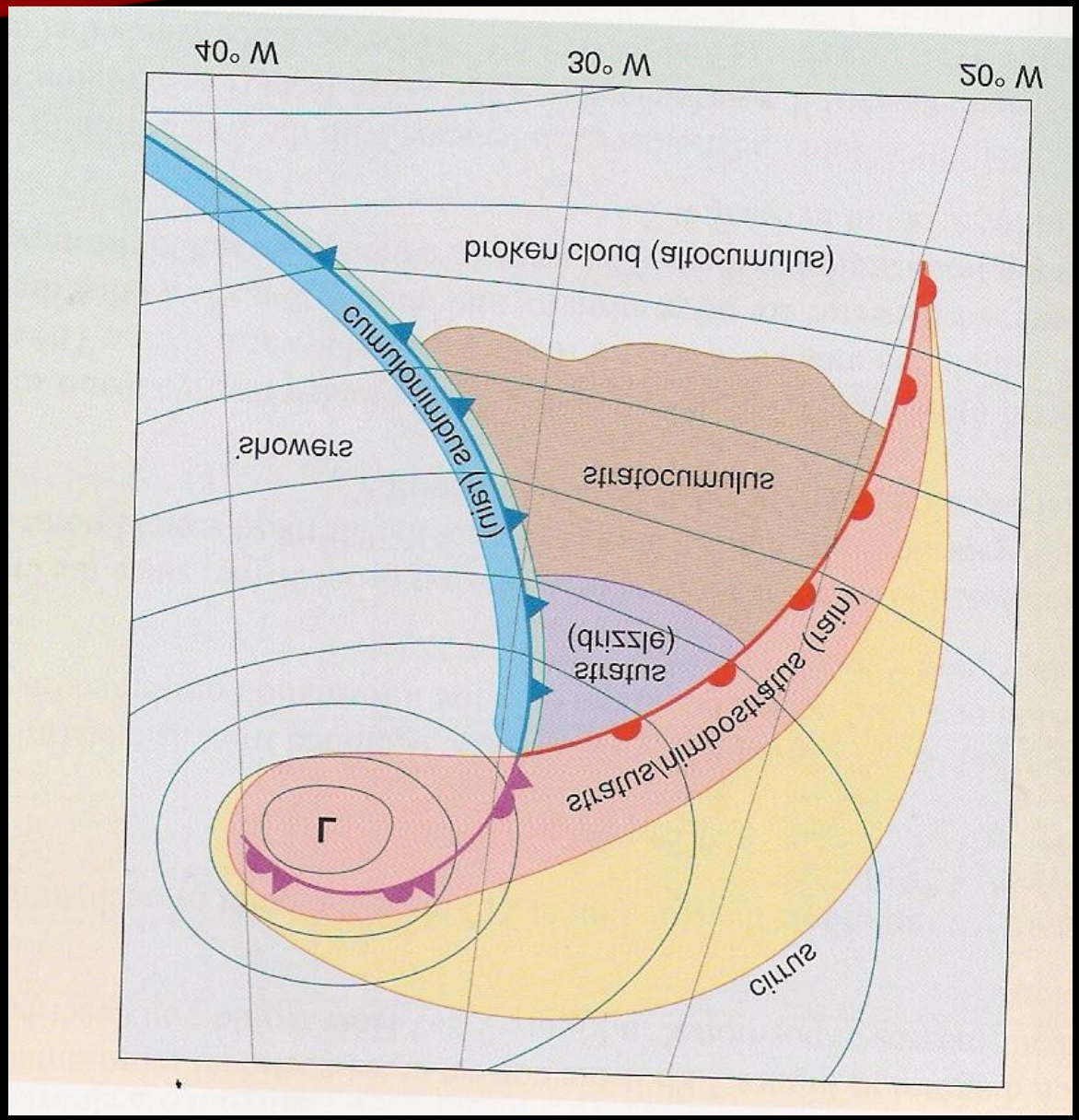
Formation of Fronts and is associated with the development of a low (cyclogenesis)



Typical cloud and rain pattern in a low and associated fronts

(Excuse the northern hemisphere example)

Formation of Fronts and is associated with the development of a low (cyclogenesis) - southern hemisphere



Typical cloud and rain pattern in a low and associated fronts

(Excuse the flipped text!)

Often in the Australian region the warm front is diffuse and we have cloud and rain in the warm sector ahead of the cold front

ON THE THERMAL STRUCTURE OF MATURE SOUTHERN OCEAN CYCLONES

J. W. Zillman and P. G. Price

Central Office, Bureau of Meteorology, Melbourne

(Manuscript received February 1972)

Australian Meteorological Magazine 1972

Much of the theory of fronts had been developed before satellite images became available.

With the lack of data over the Southern Ocean it was even more difficult to understand fronts in our region.

Studies with satellite images from the 1960s showed that fronts over the Southern Ocean did not quite fit the Norwegian theory.

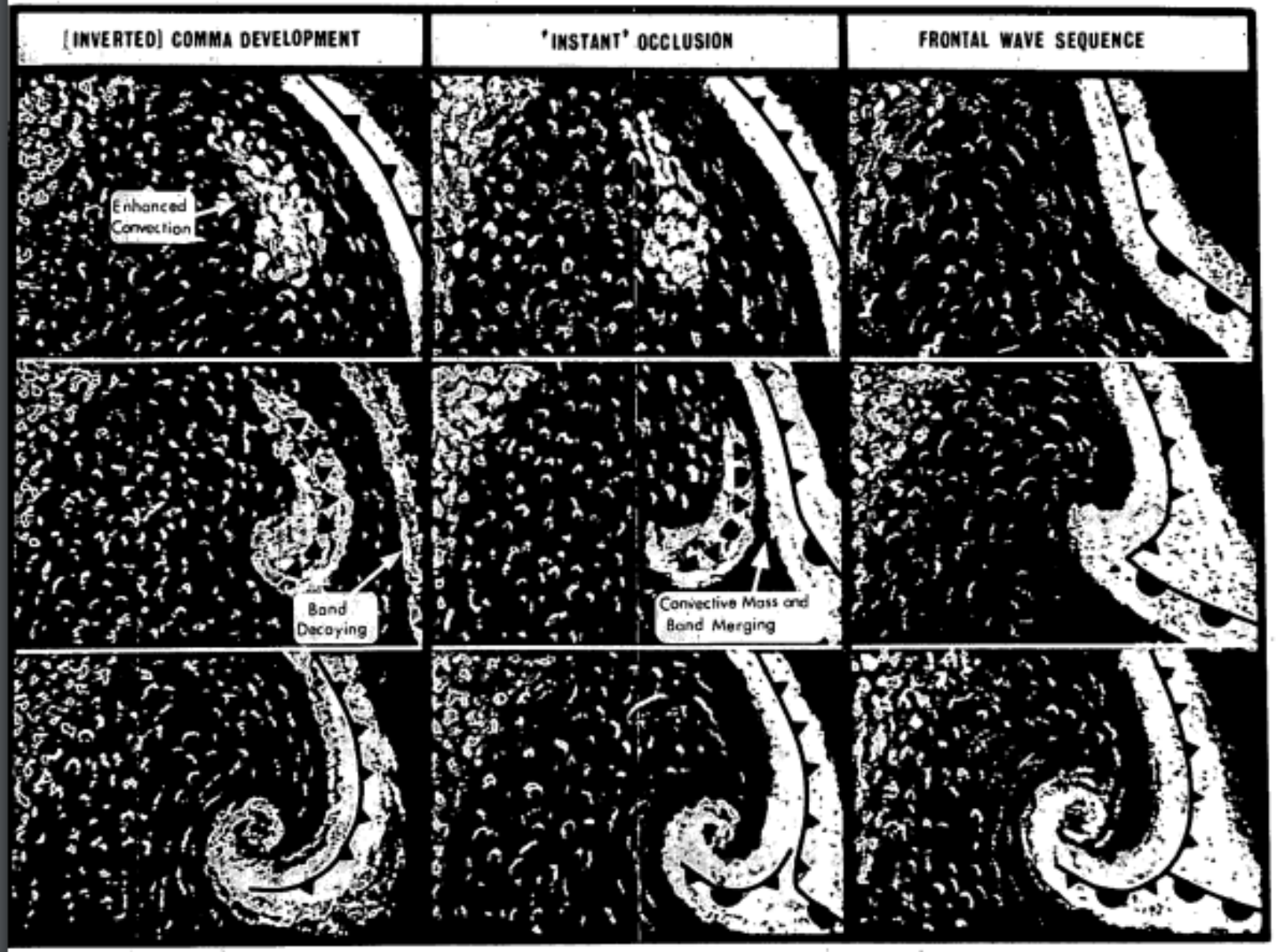


Fig 2 Schematic depiction of three basic sequences of vortex development evident in satellite photographs of the Southern Ocean. Frontal symbols indicate one scheme for representing the various evolution sequences with the equipment of conventional frontal analysis.

Fronts are tied up with the development of lows

Where there is some underlying contrast in temperature (usually north to south) fronts can be formed or at least re-activated by the development of a low (called **cyclogenesis**)

Cyclogenesis occurs in two main ways:

- Upper-level forcing (location of jet stream) over a region of temperature contrast
- From below by release of latent heat (e.g. tropical cyclones)

In some parts of the world lows develop in the lee of mountain ranges with suitable upper-level forcing.

Very rapid development of a low (explosive cyclogenesis) is sometimes called a **"weather bomb"**
https://youtu.be/lXgWTzHKn-w

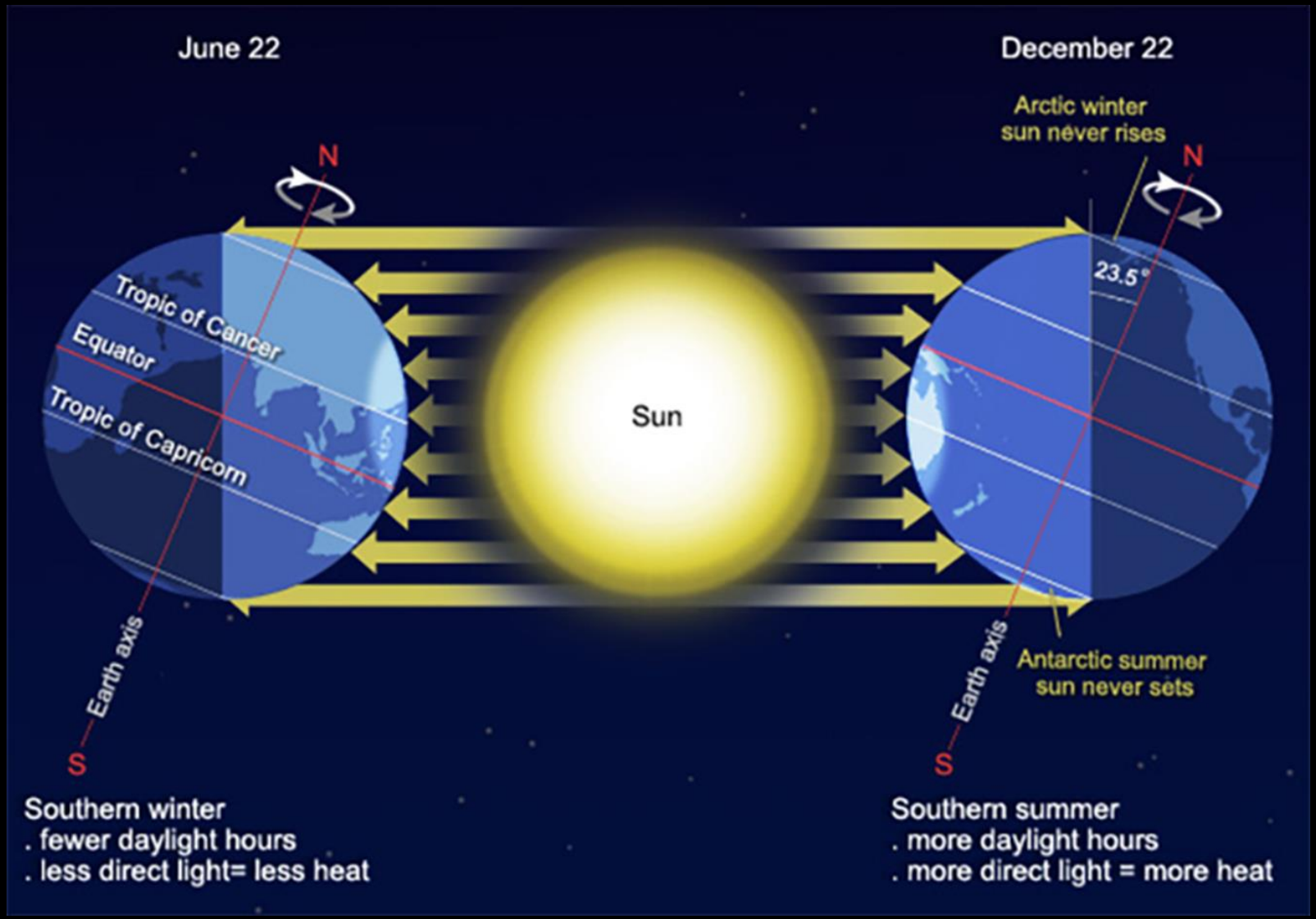
Fronts and the development of lows

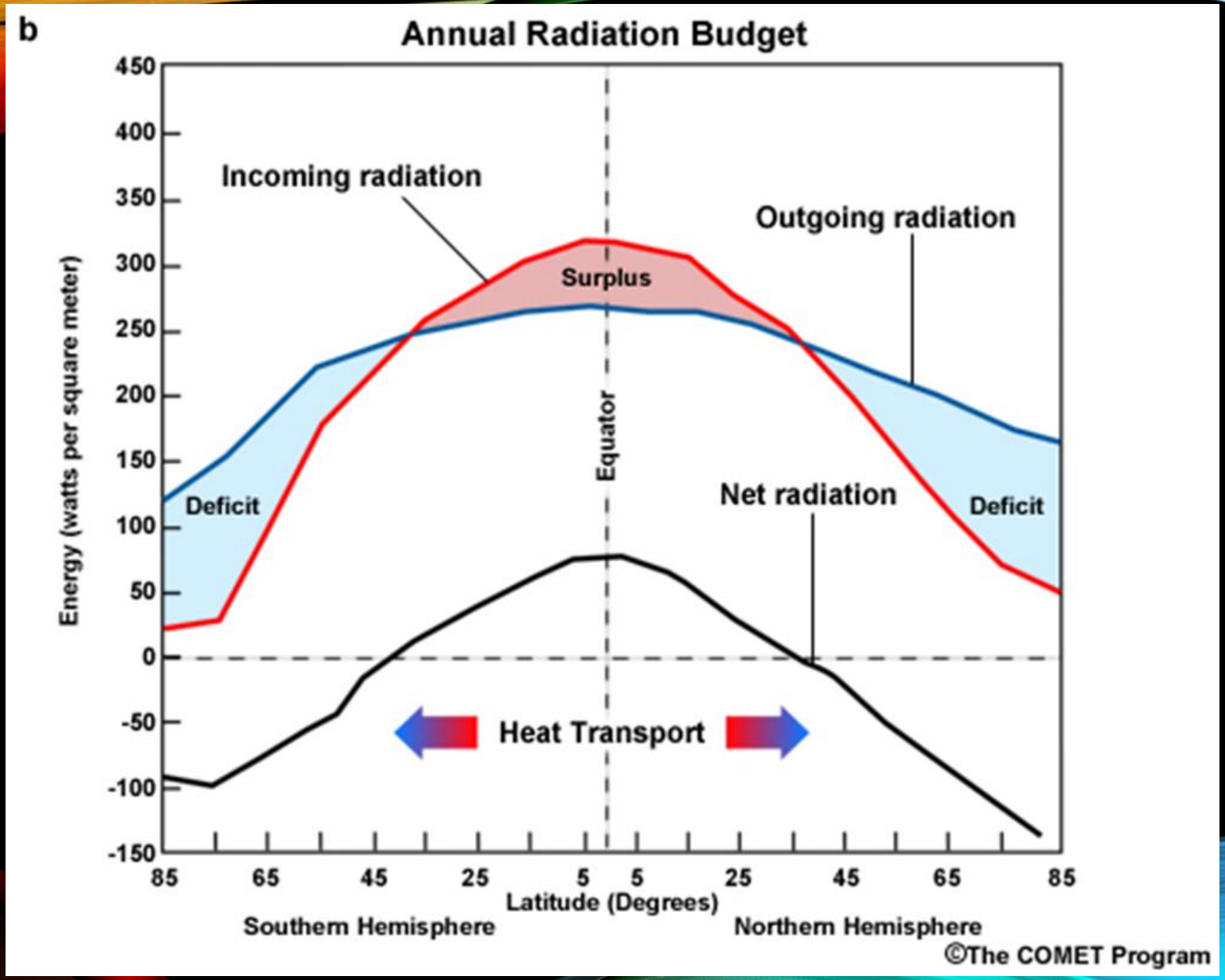
Role of Jet Streams

https://youtu.be/Lg91eowtfbw

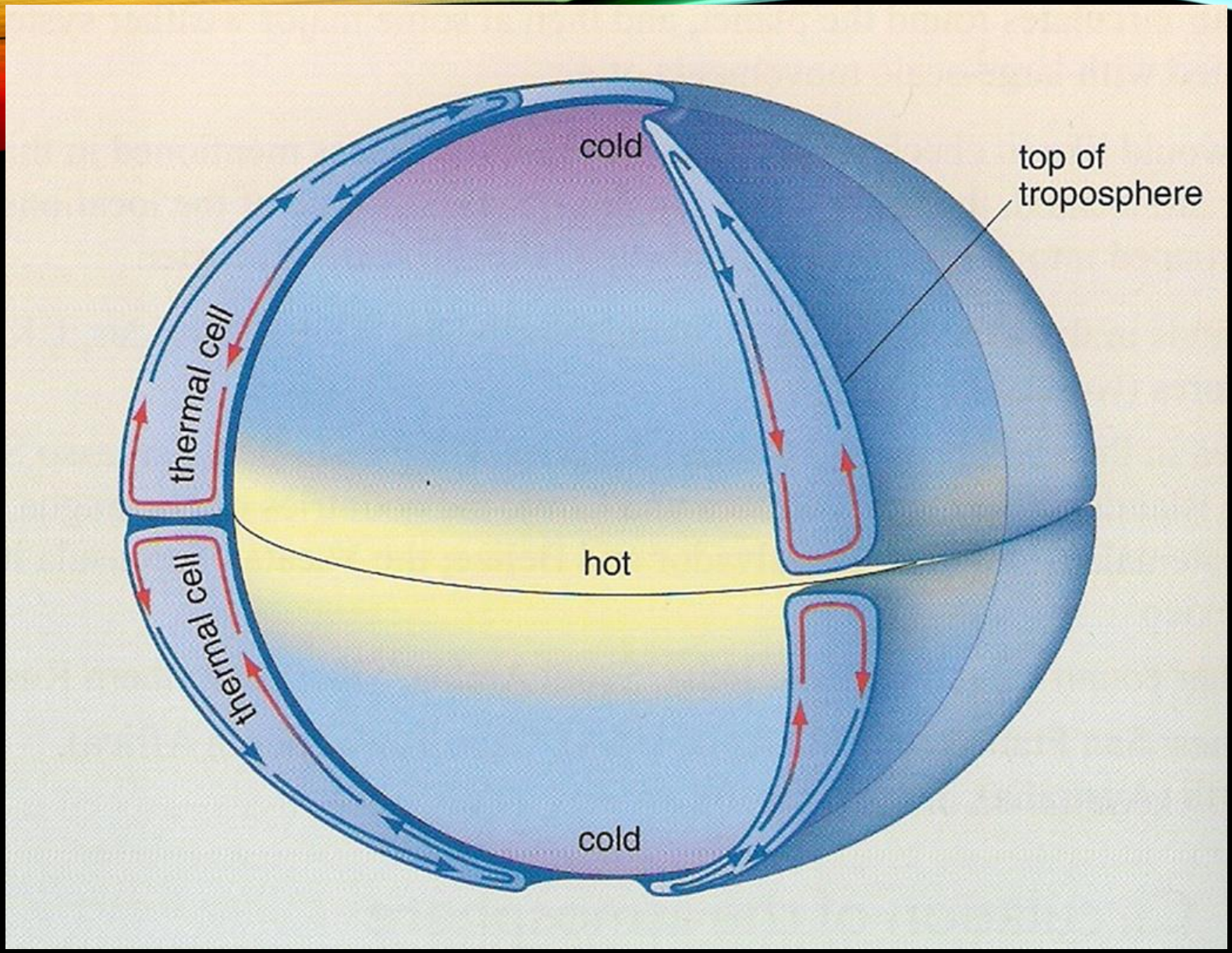
Why are there fronts?

What role do they play in the general circulation of the atmosphere?

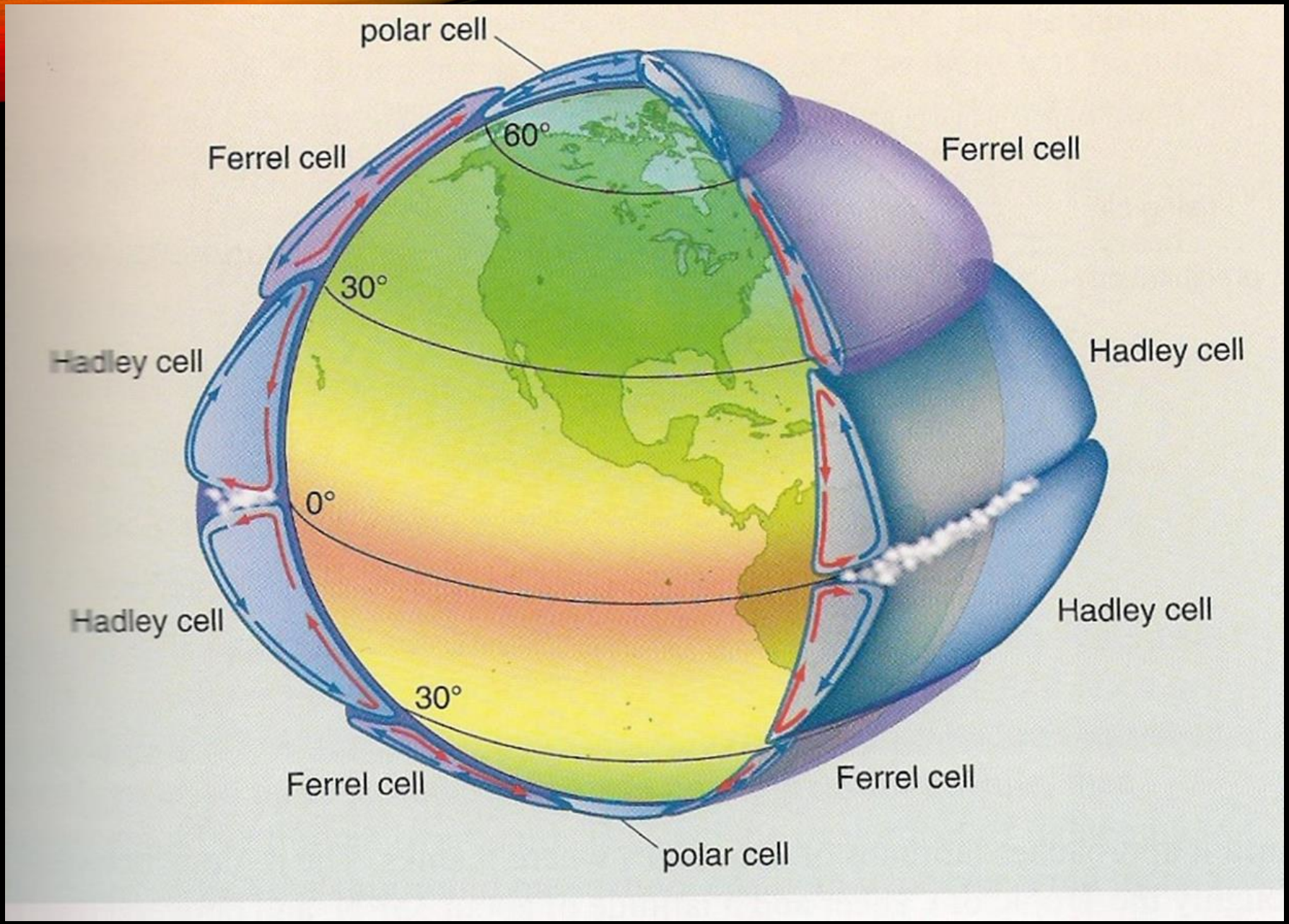




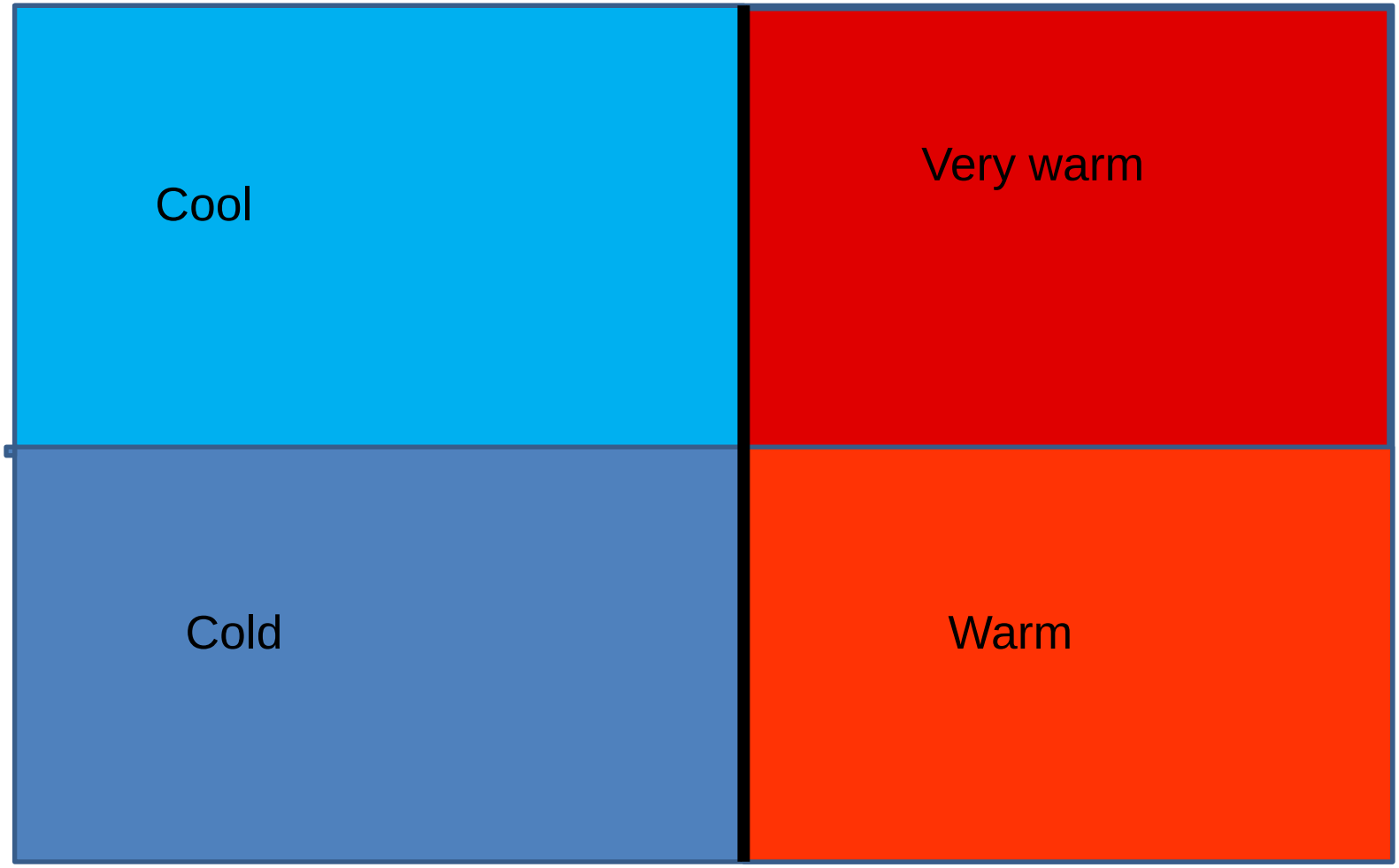
How is heat transported from the tropics to higher latitudes?



The early concept of the Hadley Cell


polar cell
60°
Ferrel cell
Ferrel cell
30°
Hadley cell
Hadley cell
0°
Hadley cell
Hadley cell
30°
Ferrel cell
Ferrel cell
polar cell

Imagine boxes of warm and colder liquid separated by a barrier.
What happens if the barrier is removed?



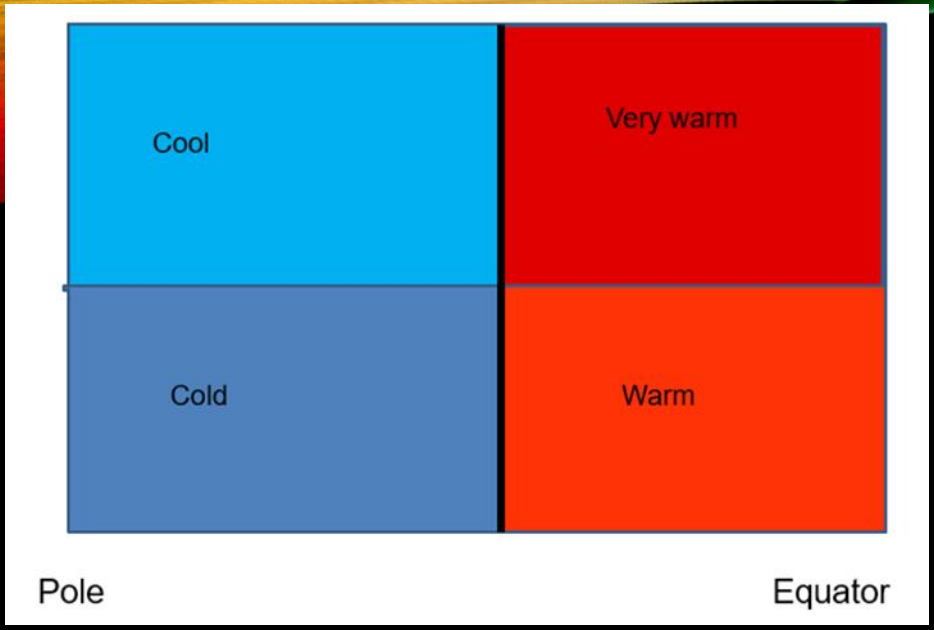
Pole

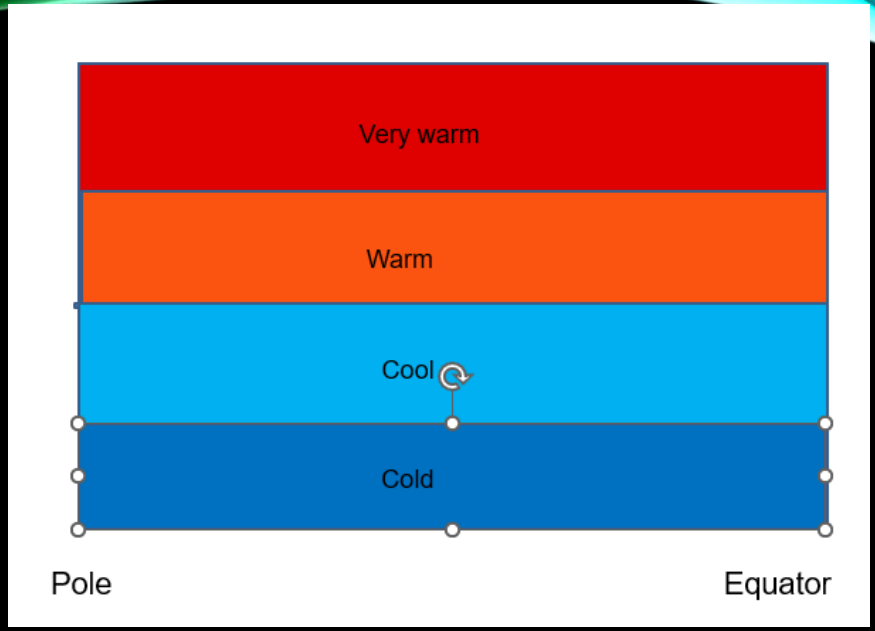
Equator

The air is now stable – the less dense air is at the top and the coldest at the bottom

Pole

Equator





In the end, the air is stable – the less dense air is at the top and the coldest (densest) at the bottom.

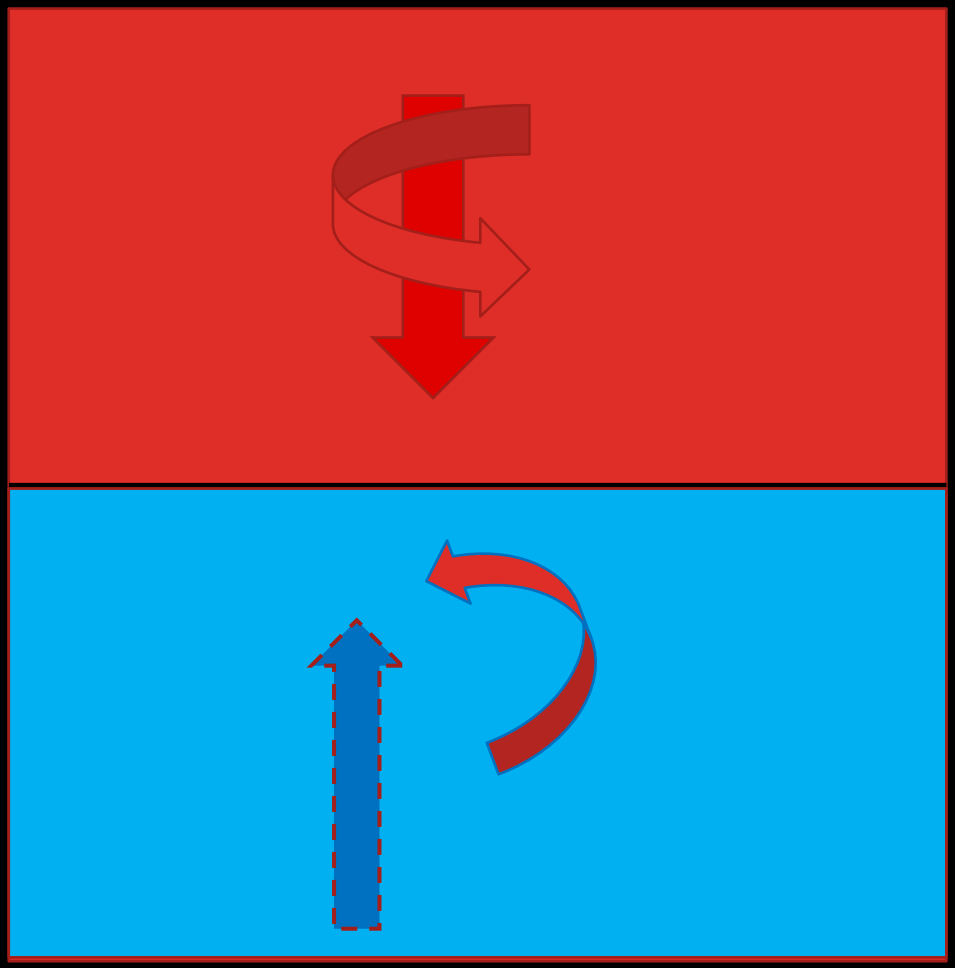
Also

- Some of the cold air has moved downwards and toward the Equator
- Some of the warm air has moved upwards and toward the Pole

When the barrier is removed the fluids **move –** so some of the **potential energy** in the partitioned fluid gets translated into motion (**kinetic energy**).

Looking from the top, there is an important complication on our rotating earth – the Coriolis Effect.

Equator



Pole

As the warm air moves south it is deflected to the east

As the cold air moves north it is deflected to the west

So we end up with a clockwise circulation, a low.

Lows form in middle latitudes because the temperature contrasts make the atmosphere unstable.

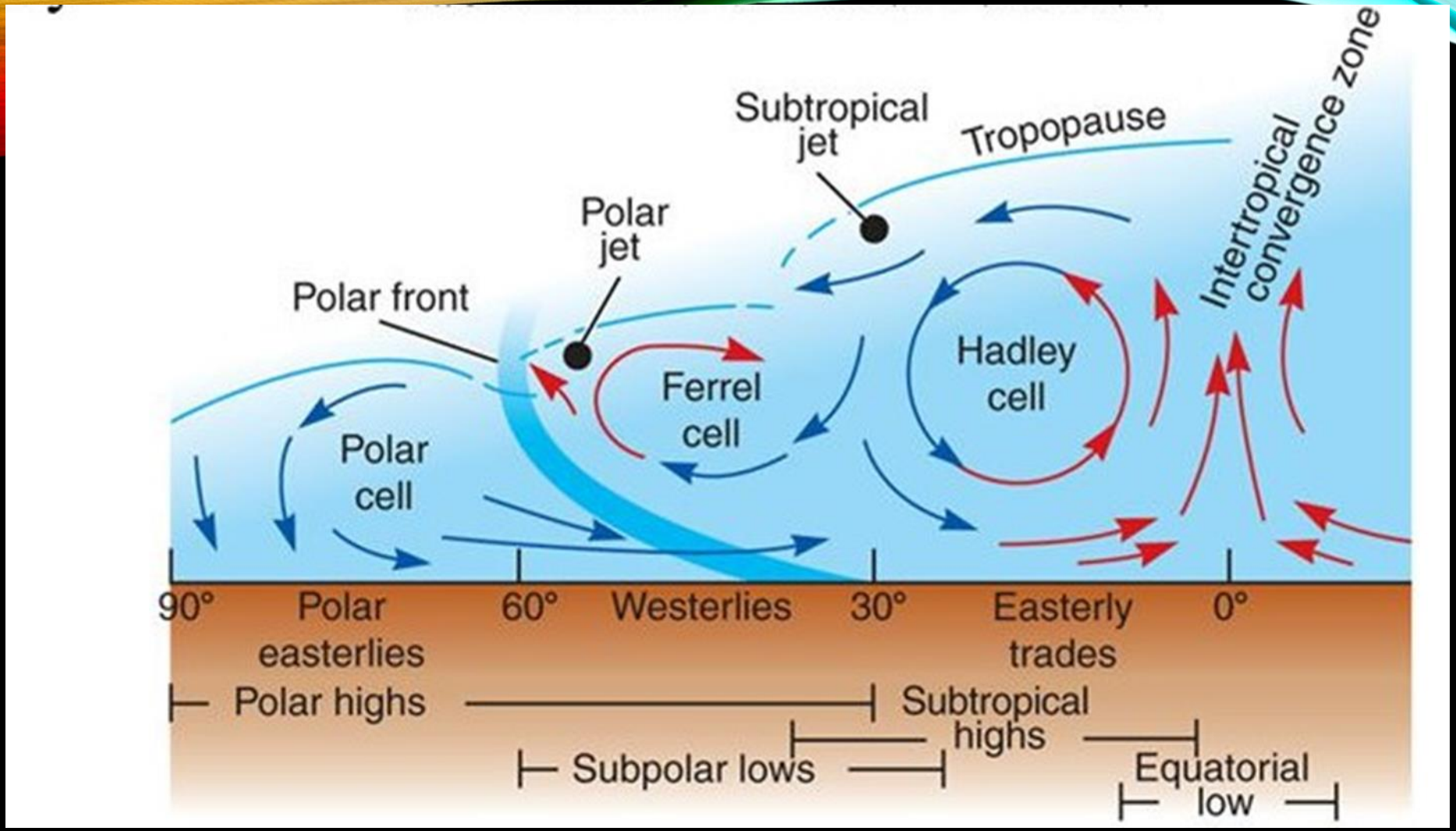
Low pressure systems develop as a result of the atmosphere trying to remove that instability, complicated by the earth's rotation.

The potential energy is converted into the winds (kinetic energy) in the lows

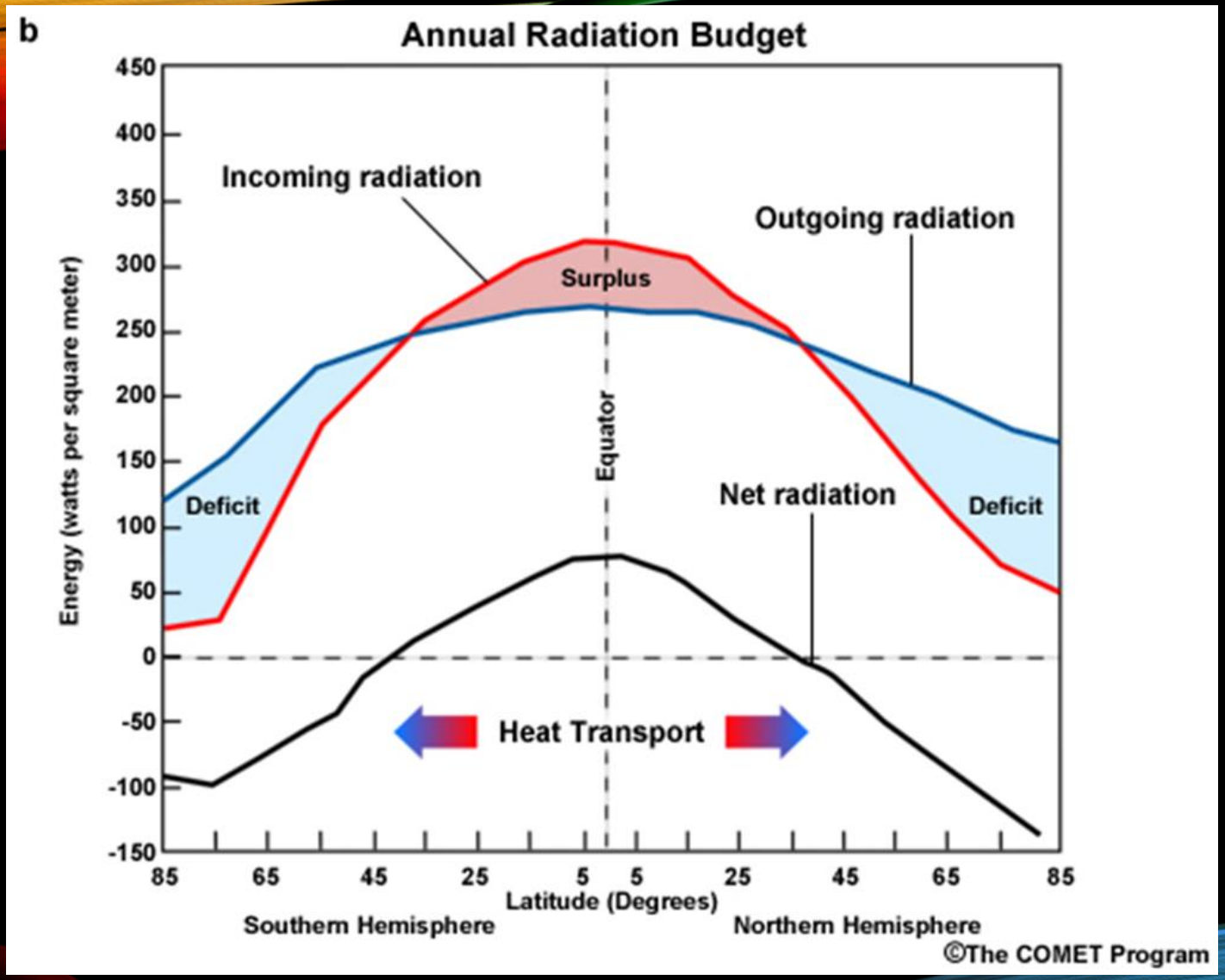
As a result, warm air is moved from the tropics to higher latitudes and colder air is moved toward the tropics.

Along the lines where the warmer and colder air are brought together, fronts can be formed.

So these lows play a major role in balancing out the energy imbalance between the tropics and the poles.



In the general circulation of the atmosphere, the “Ferrel Cell” is really the nett effect of the highs and lows in middle latitudes.



Lows and fronts are important! They play a big role in carrying heat from tropical to polar areas.