Fundamentals of synoptic meteorology

Lecture 5

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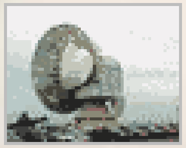
Remote Sensing

Remote sensing is the science and art of acquiring information about an object, area or phenomena without actually being in contact with it.

The sensor is usually mounted on moving platforms such as balloons, aircraft and satellites

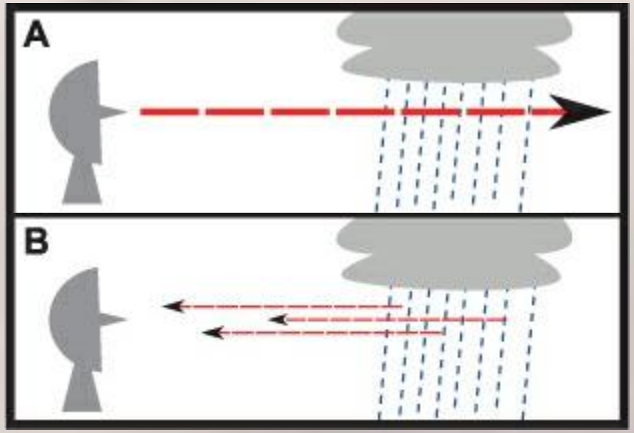
Measurement of environmental conditions by processing signals that are either emitted by an object or reflected back to a signal source

Radar **Satellites**



The basic principle of a radar retrieval.

A pulse of microwave radiation is transmitted from the radar (A).



A small fraction of this is reflected from raindrops, and this signal is received at the radar (B).

Radar = RAdio Detection And Ranging

Lidar = LIght Detection And Ranging

The signals are sent out as short pulses which may be reflected by objects in their path, in part reflecting back to the radar.
When these pulses intercept precipitation, part of the energy is scattered back to the radar.

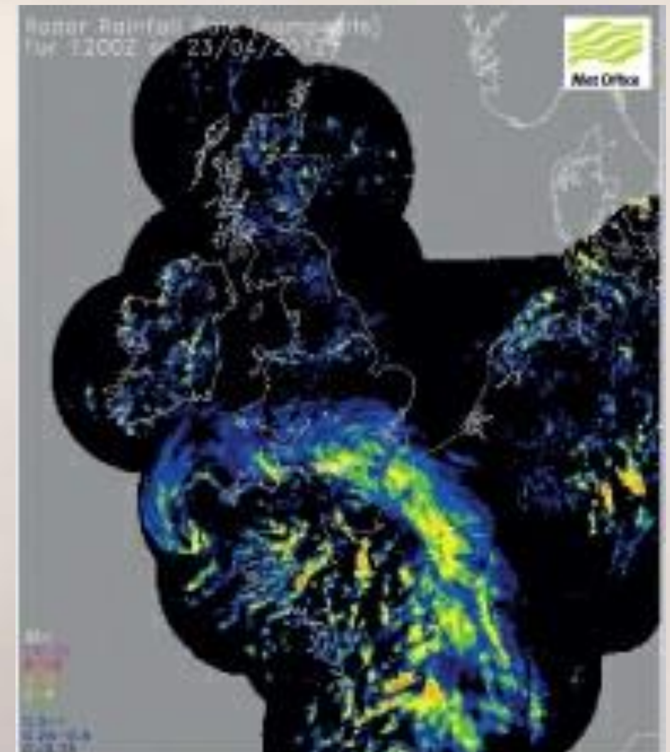
This concept is similar to hearing an echo. For example, when you shout into a well, the sound waves of your shout reflect off the water and back up to you.

In that same way, the pulse reflects off precipitation and sends a signal back to the radar. From this information the radar is able to tell where the precipitation is occurring and how much precipitation exists

The distance and intensity of the rainfall can be inferred from the strength and timing of the return signal.

Operational radars are housed within a dome

A radar image showing rainfall from a lowpressure system extending over southern England and northern France on 23 April 2012.



Radars send out electromagnetic waves similar to wireless computer networks and mobile phones.

Components Of The Radar

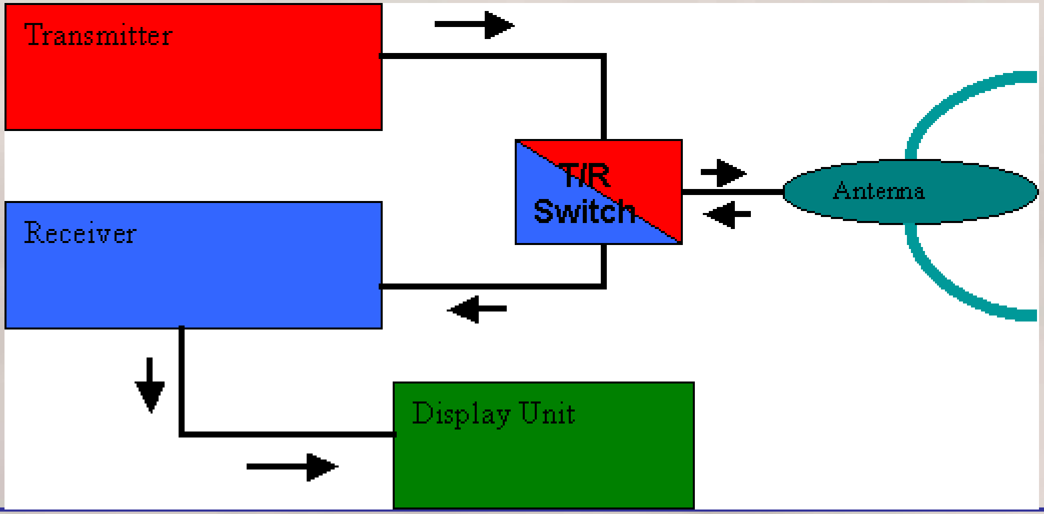
Radars in their basic form have four main components:

1) A transmitter, which creates the energy pulse.

2) A transmit/receive switch that tells the antenna when to transmit and when to receive the pulses.

3) An antenna to send these pulses out into the atmosphere and receive the reflected pulse back.

4) A receiver, which detects, amplifies and transforms the received signals into video format.



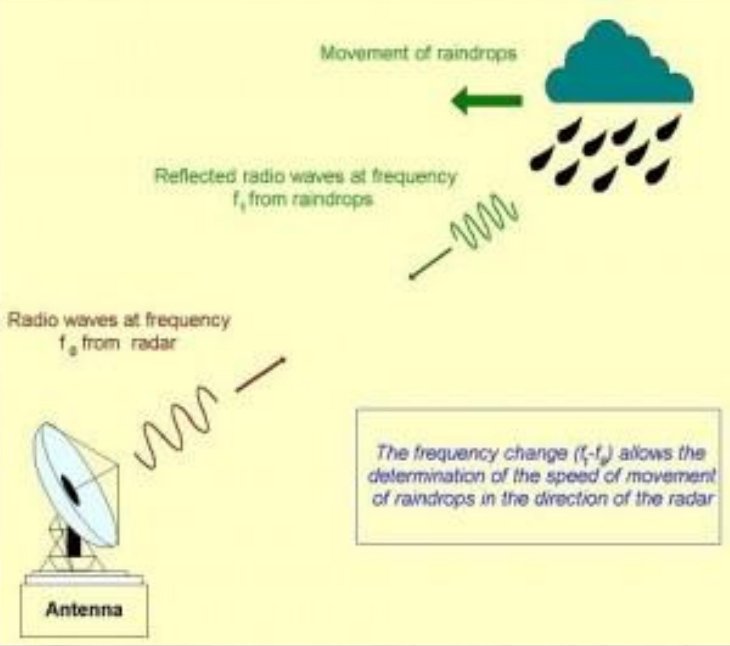
The received signals are displayed on a display system

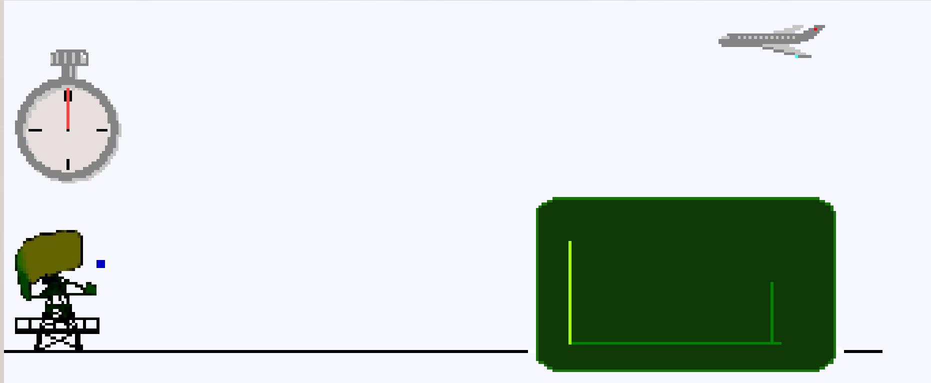
Radar output generally comes in two forms:
- reflectivity
- velocity

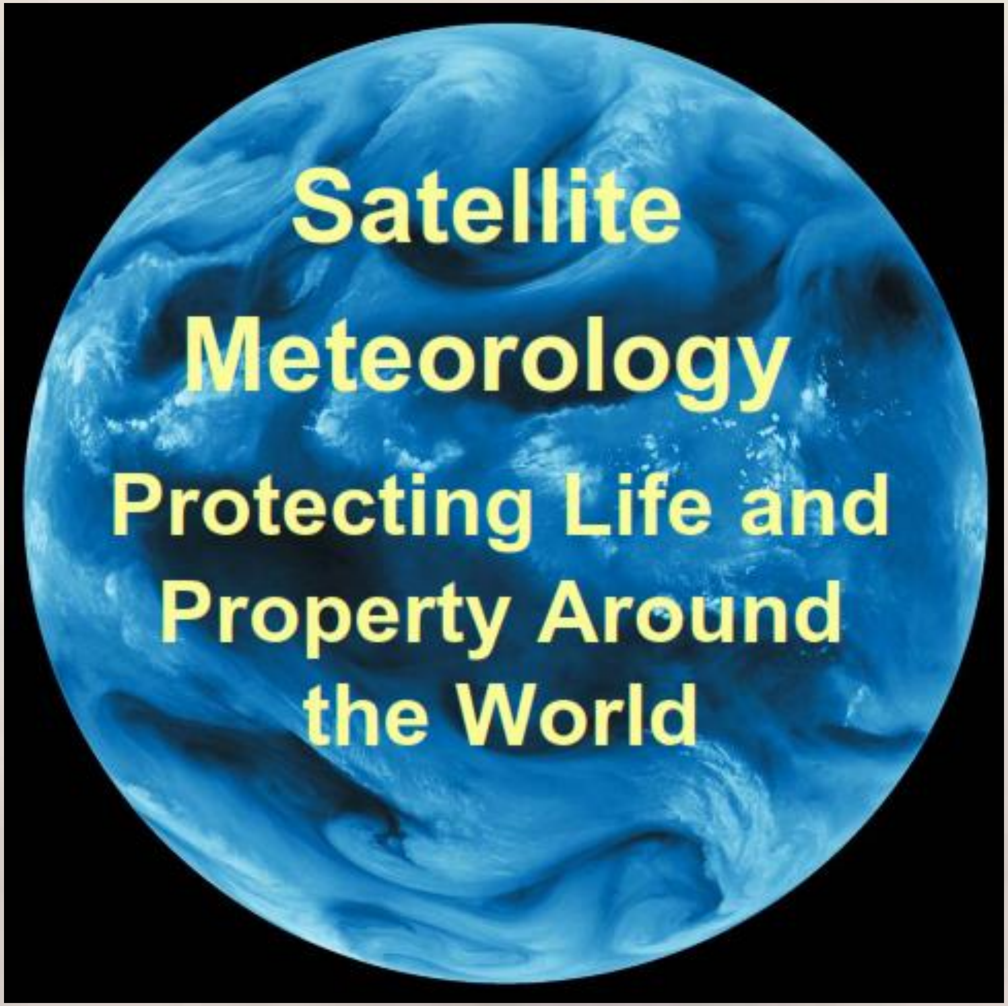
Reflectivity is a measure of how much precipitation exists in a particular area.

Velocity is a measure of the speed and direction of the precipitation toward or away from the radar.

Most radars can measure reflectivity but you need a Doppler radar to measure velocity.


Movement of raindrops
Reflected radio waves at frequency f_1 from raindrops
Radio waves at frequency f_0 from radar
The frequency change (f_1-f_0) allows the determination of the speed of movement of raindrops in the direction of the radar
Antenna



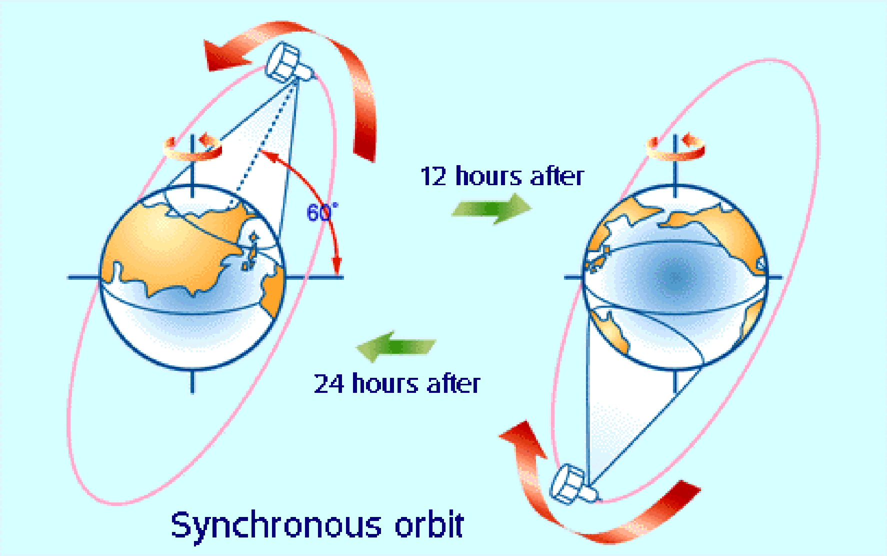

Satellite
Meteorology
Protecting Life and
Property Around
the World

SATELLITE ORBITS

LEO

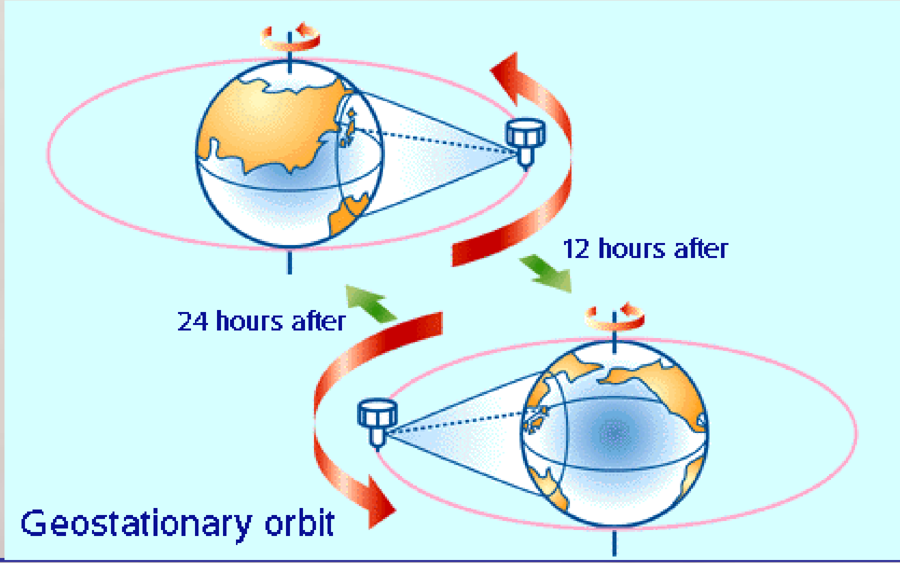
Observations from Space

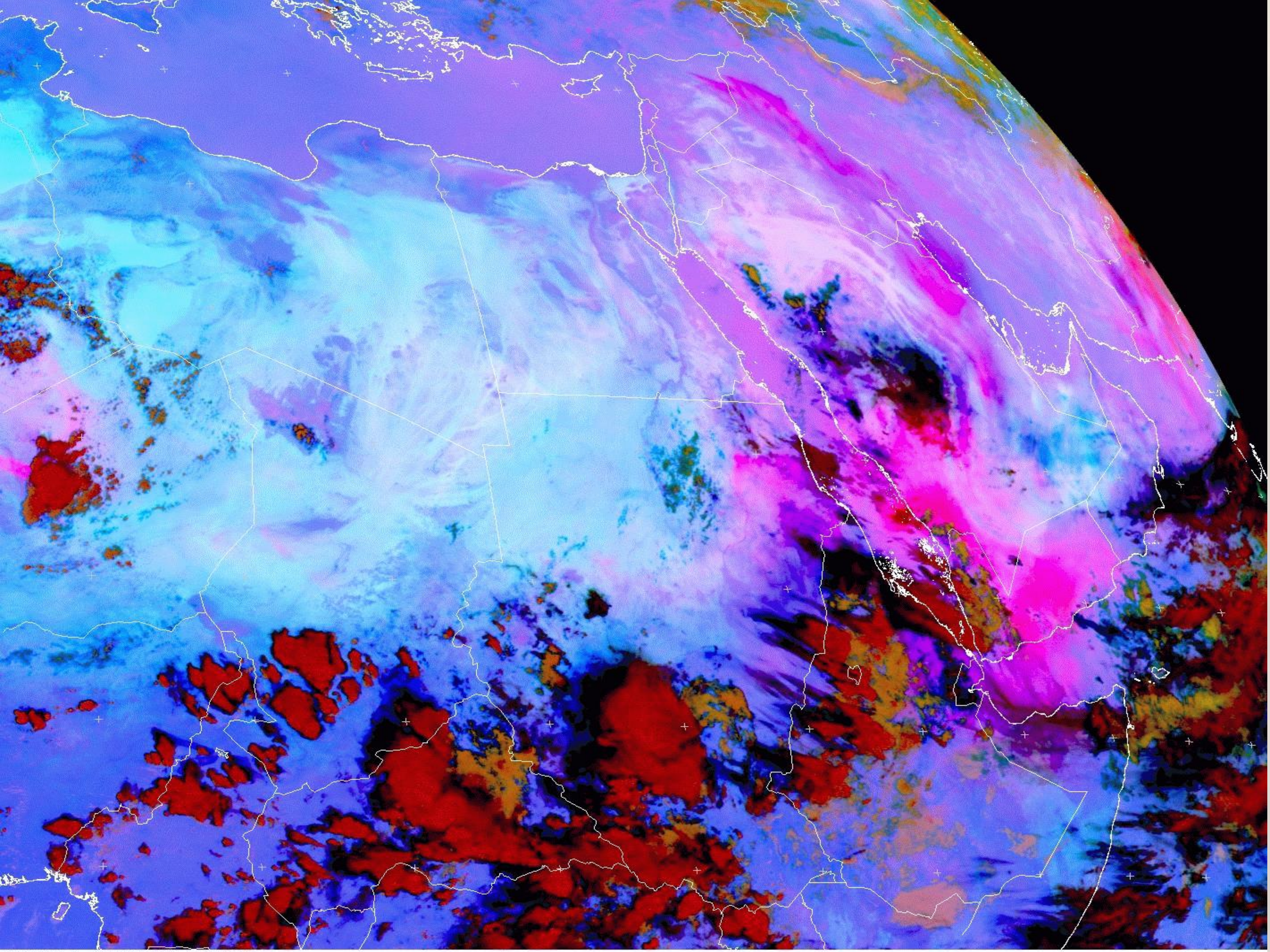
- Near polar orbiting
- 800 -900 km above the earth
- Has Sun-synchronous orbit
- Period of 101 minutes
- Excellent coverage at the poles
- Has relatively narrow field of view
- Has high resolution
- Passes vary with latitude
- Very suitable for vertical soundings



GEO

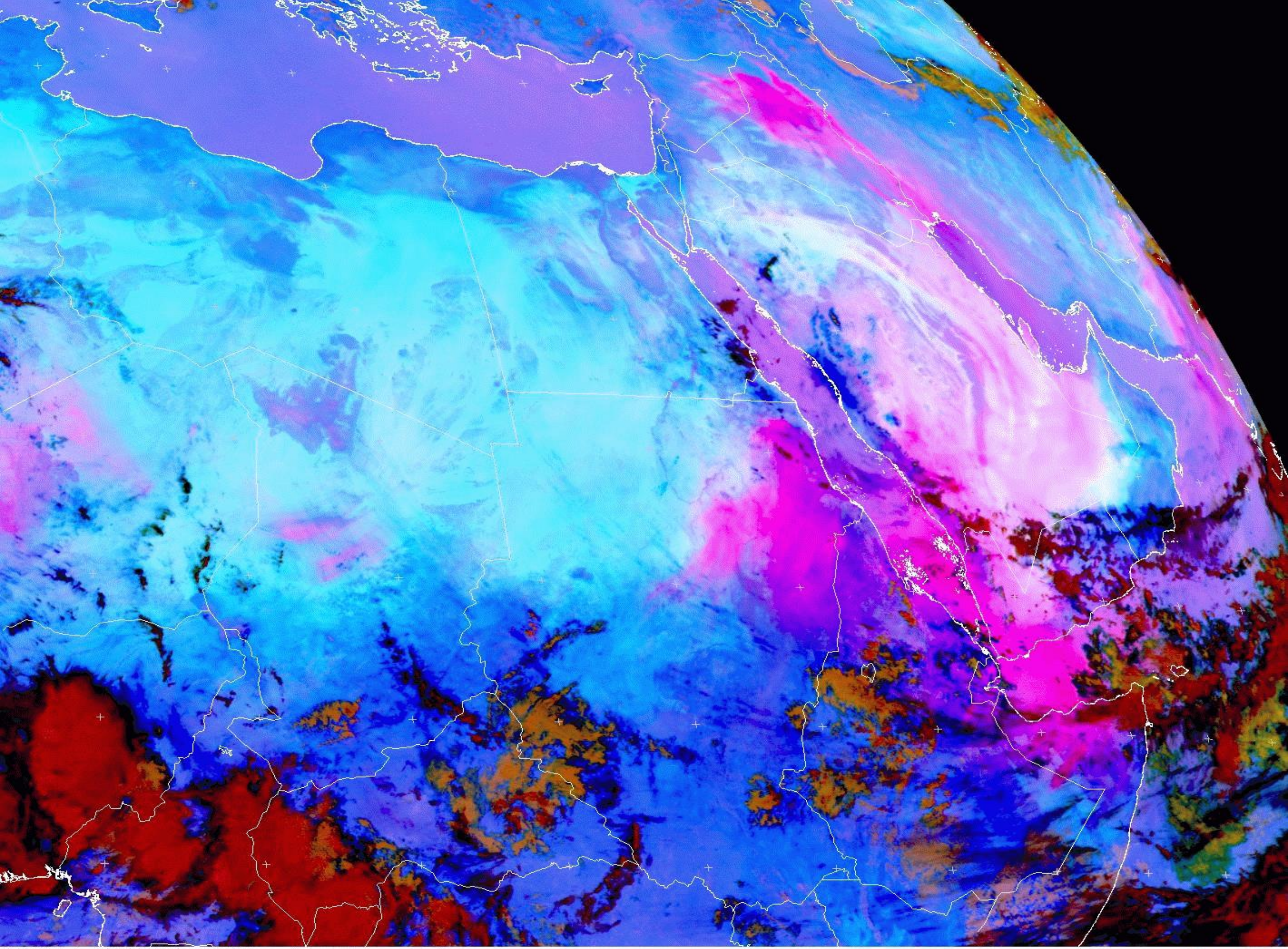
- Located along the equatorial plane.
- About 36000 km above the earth
- Has Geo-synchronous orbit
- Period of 1436 minutes
- Good coverage from remote areas
- Has wide field of view ~ 50 degrees
- Has low resolution
- Provides continuous data ~ 15-30 min.
- Not very suitable for vertical soundings





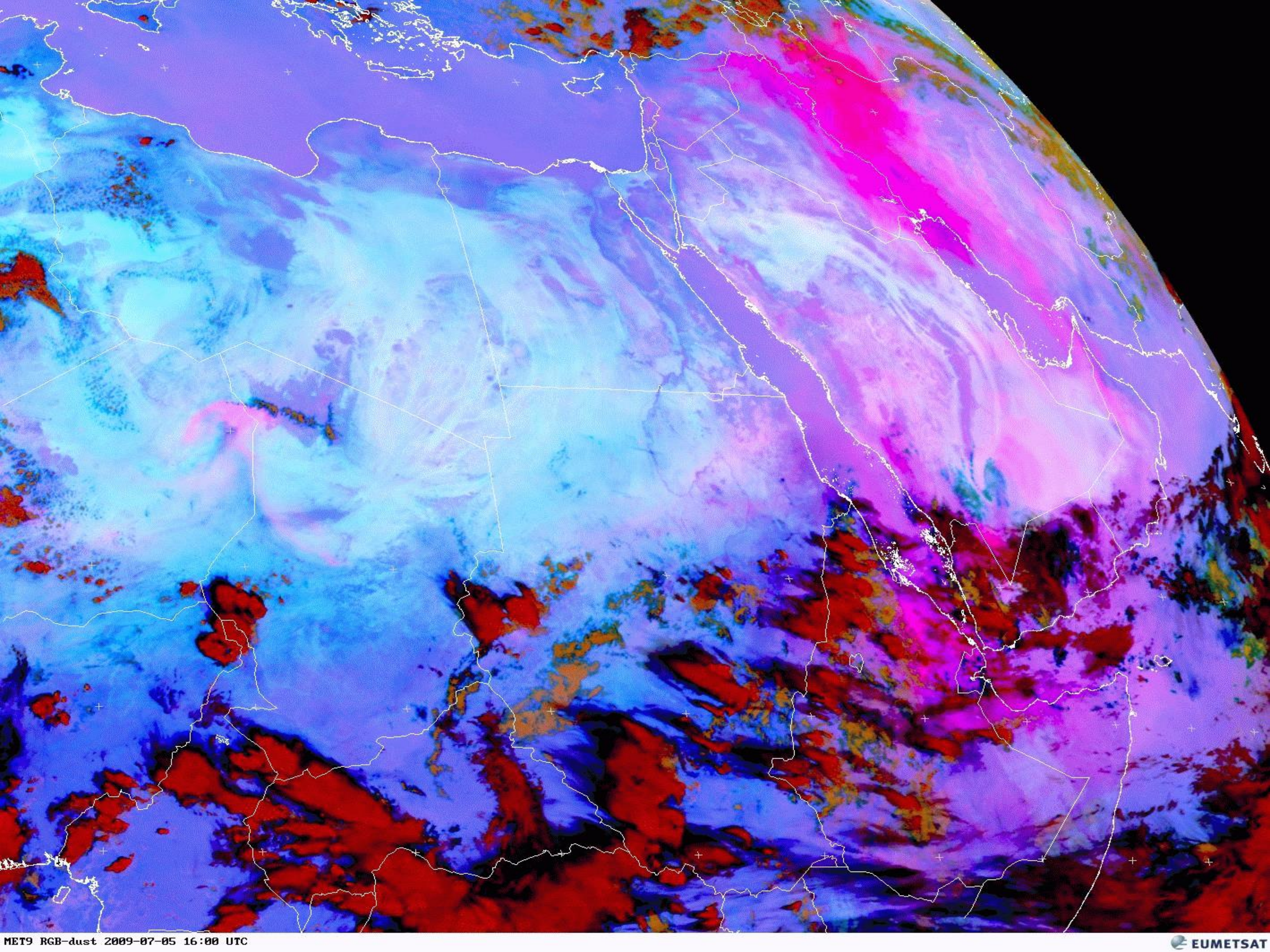
MET9 RGB-dust 2009-07-02 16:00 UTC

EUMETSAT



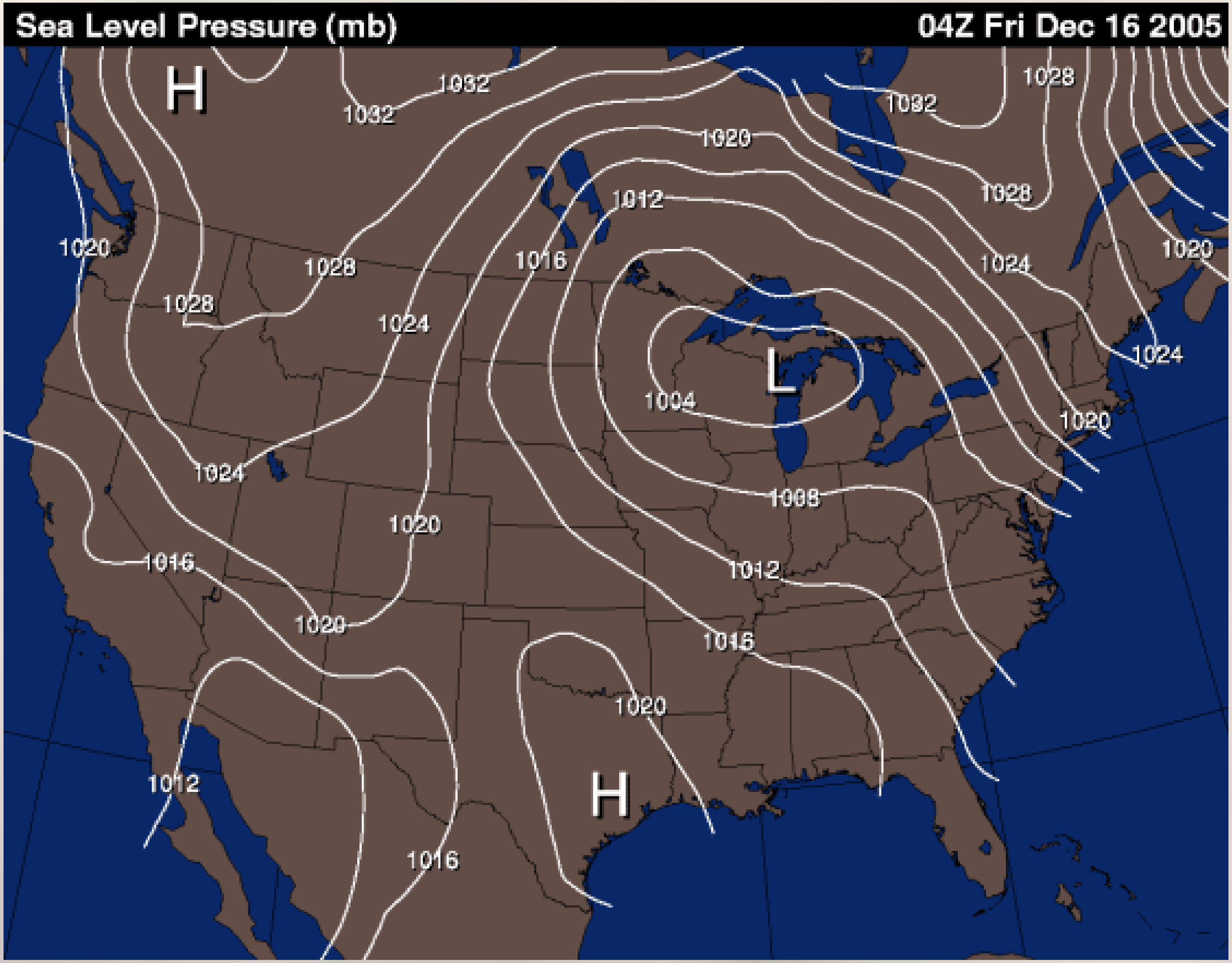
MET9 RGB-dust 2009-07-03 10:00 UTC

EUMETSAT


MET9 RGB-dust 2009-07-05 16:00 UTC
EUMETSAT

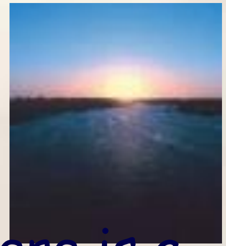
Maps

These **maps** refer to **meteorological** data



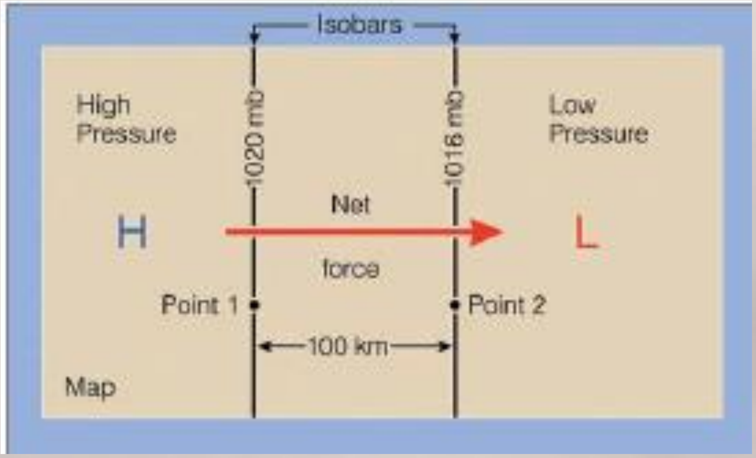
Supercomputers

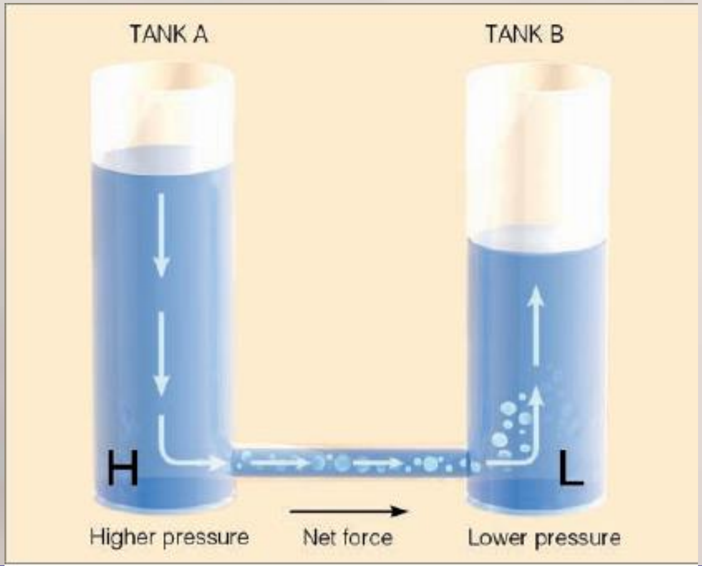
pressure gradient



Notice that when differences in horizontal air pressure exist there is a net force acting on the air.

This force, called the pressure gradient force *(PGF)*, is directed from higher toward lower pressure at right angles to the isobars.
The magnitude of the force is directly related to the pressure gradient.
Steep pressure gradients correspond to strong pressure gradient forces and vice versa.

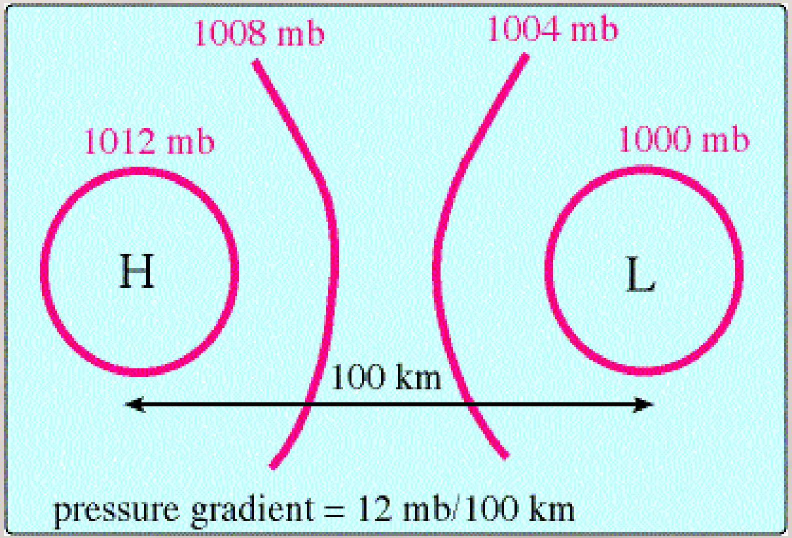




The Pressure Gradient Force

The pressure gradient can be defined as a change in pressure over a given distance, i.e.,:

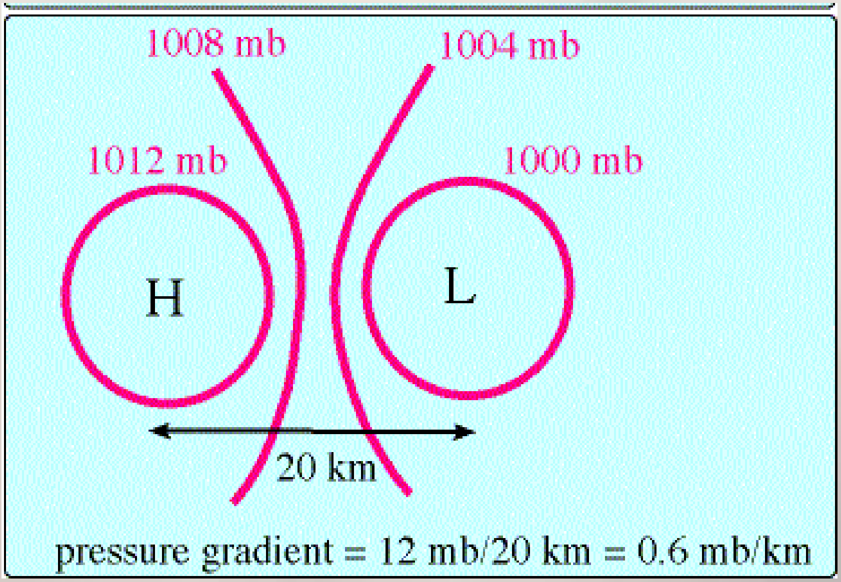
$$\textbf{Pressure gradient} = \frac{\Delta P}{distance} = \frac{P_{high} - P_{low}}{distance}$$

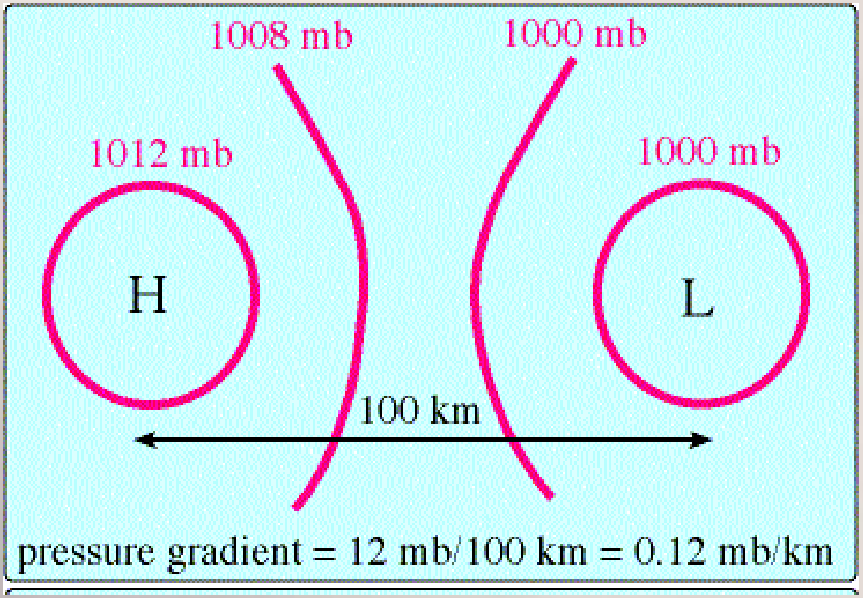


Isobar spacing and the magnitude of the pressure gradient

if the isobars are close together, the pressure gradient is large

if the isobars are far apart, the pressure gradient is small



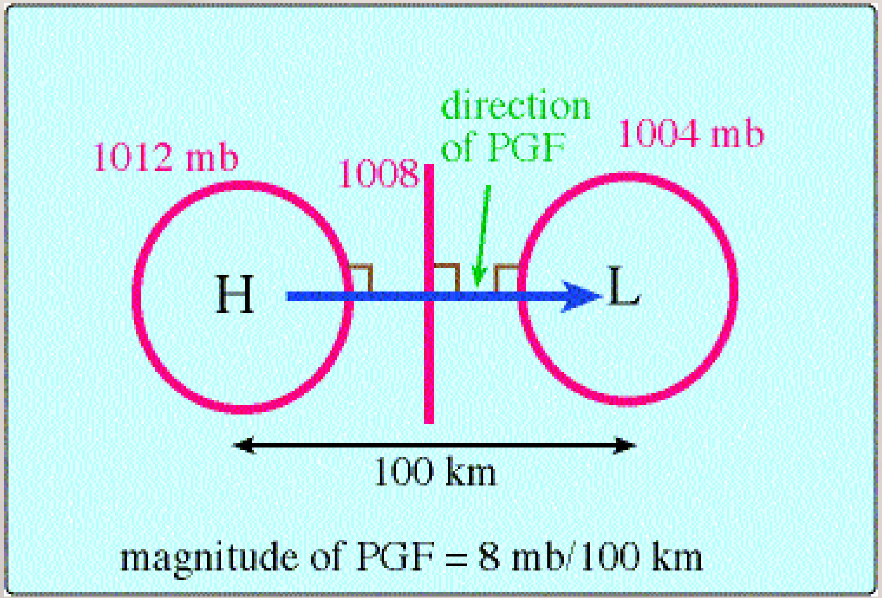


The Pressure Gradient Force (PGF)

The pressure gradient force, like any other force, has a *magnitude* and a *direction*:

Direction - the pressure gradient force direction is ALWAYS directed from high to low pressure and is ALWAYS perpendicular to the isobars

Magnitude - is determined by computing the pressure gradient



Surface pressure

Discontinuities in the pressure field do not exist in the atmosphere

- Isobars are smooth lines roughly parallel to one another
- Regions of light wind should have large spacing between isobars, and regions of strong wind should have small spacing

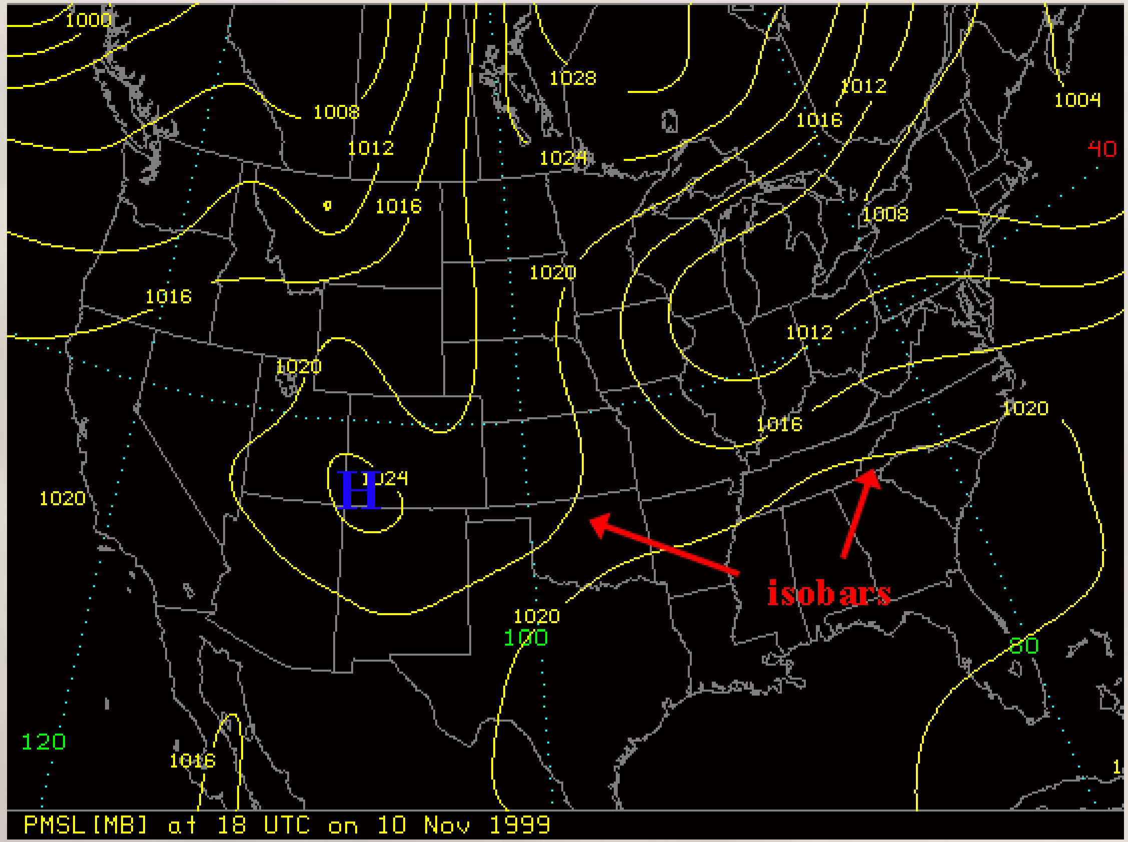
Contour the "4s" (1000 mb, 1004 mb, 996 mb, etc.)

And thus contour every 4 mb

Remember the station model: if pressure is listed as "002", that usually means 1000.2 mb. Pressure of "994" means 999.4 mb.

Measuring Pressure at the surface
the surface pressure chart

Surface pressure chart – isobars (lines of constant pressure) are plotted every 4 mb

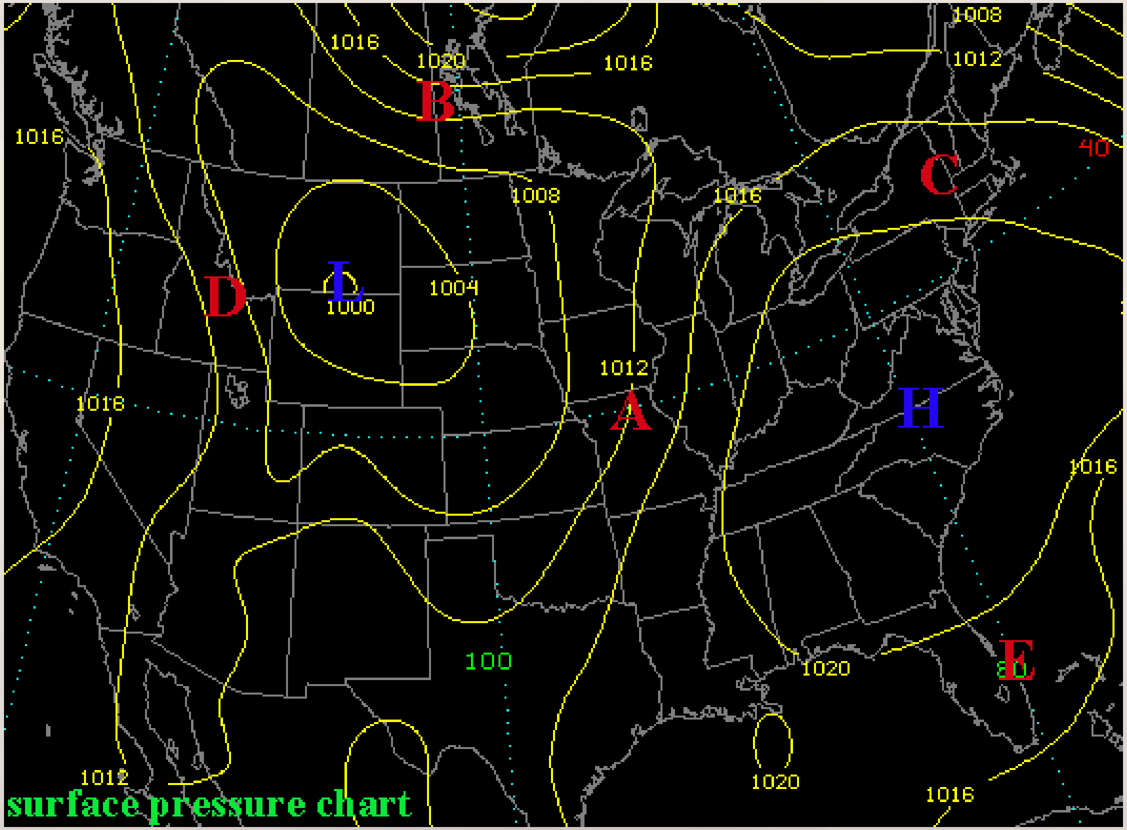


Maps of surface Pressure are very important:

give positions of highs and lows

can give information about the direction and strength of the surface winds

The Pressure Gradient Force - example

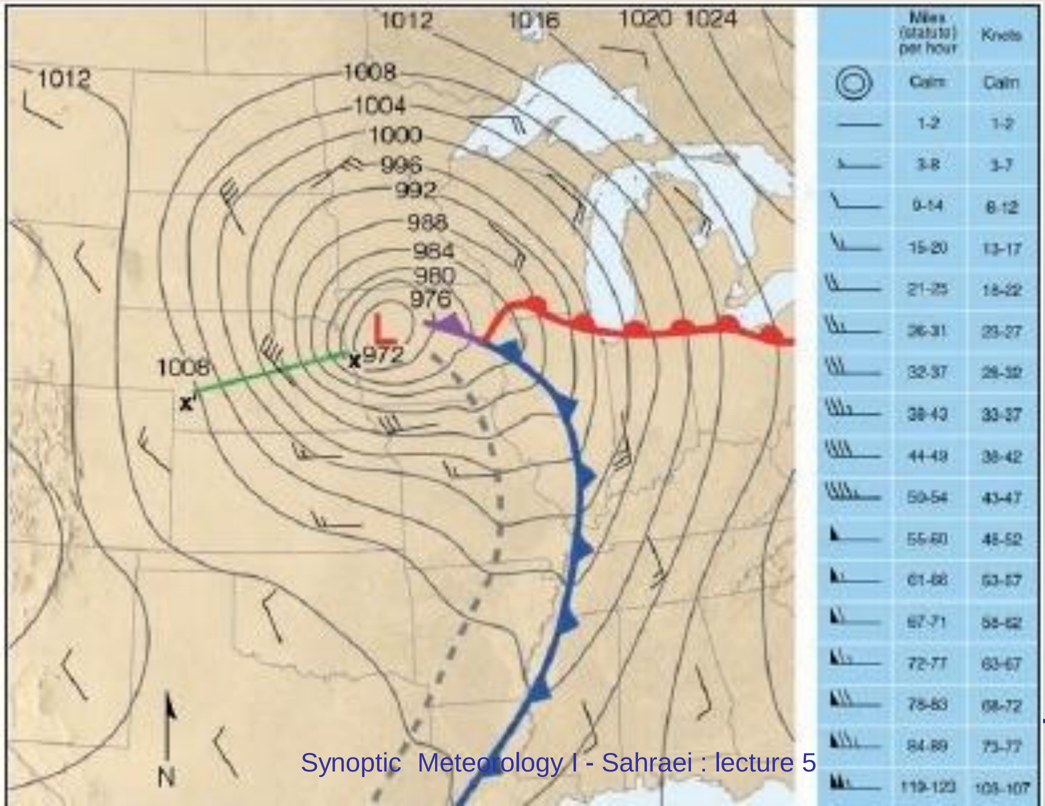


Q: What is the direction of the PGF at points A,B,C,D,E ?

Q: At which location is the PGF largest? Location B

Q: At which location is the PGF weakest? Location E

The pressure gradient force is the force that causes the wind to blow. Because of this effect, closely spaced isobars on a weather map indicate steep pressure gradients, strong forces, and high winds.
On the other hand, widely spaced isobars indicate gentle pressure gradients, weak forces, and light winds.
An example of a steep pressure gradient and strong winds is given in Fig. Notice that the tightly packed isobars along the green line are producing a steep pressure gradient of 32 mb per 500 km and strong surface winds of 40 knots.



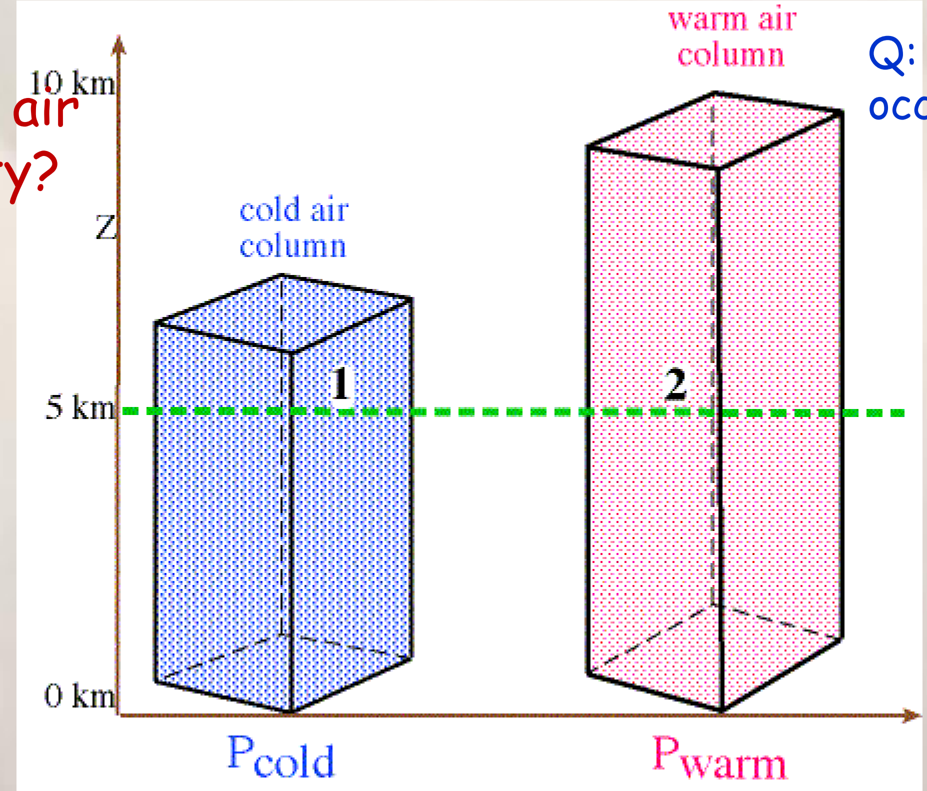
Q: which will be larger, the surface pressure for the cold air column or the surface pressure for the warm air column?

Q: which column of air has a larger density?

dP = g p Z

cold air, *p* increases, Z must decrease

warm air, *p* decreases, Z must increase



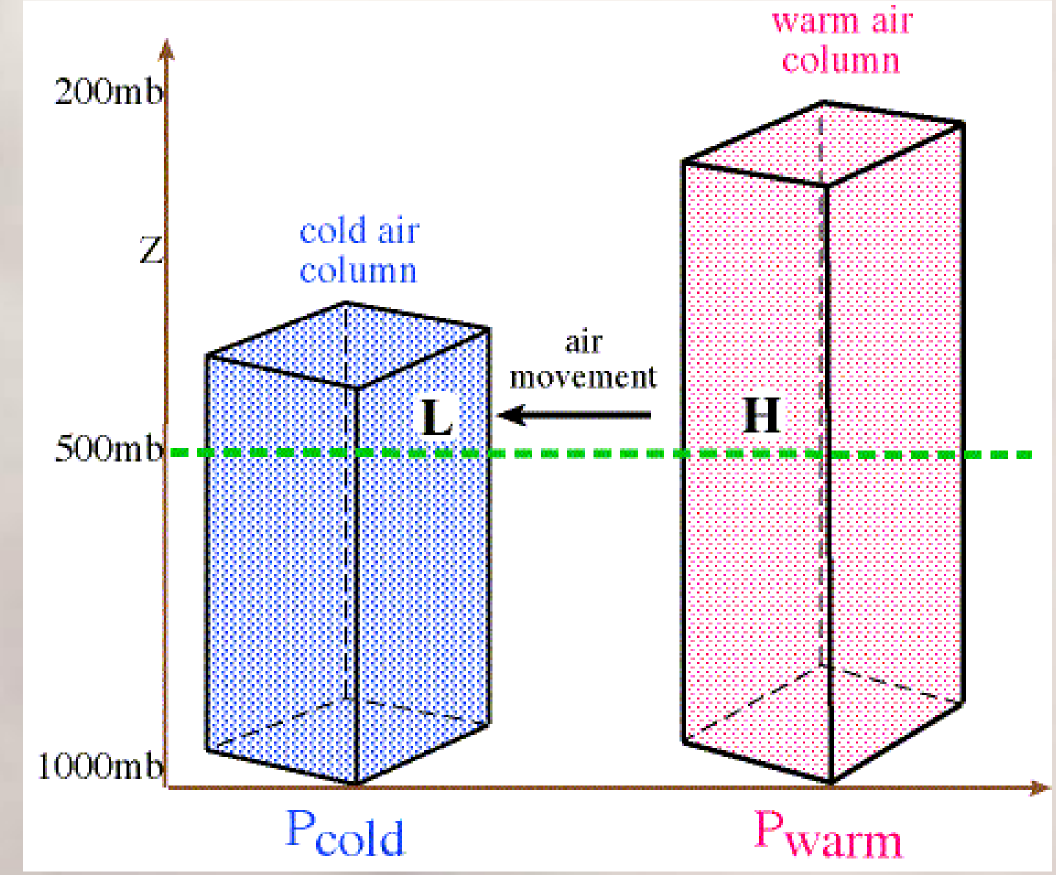
Q: which column of air occupies a larger volume?

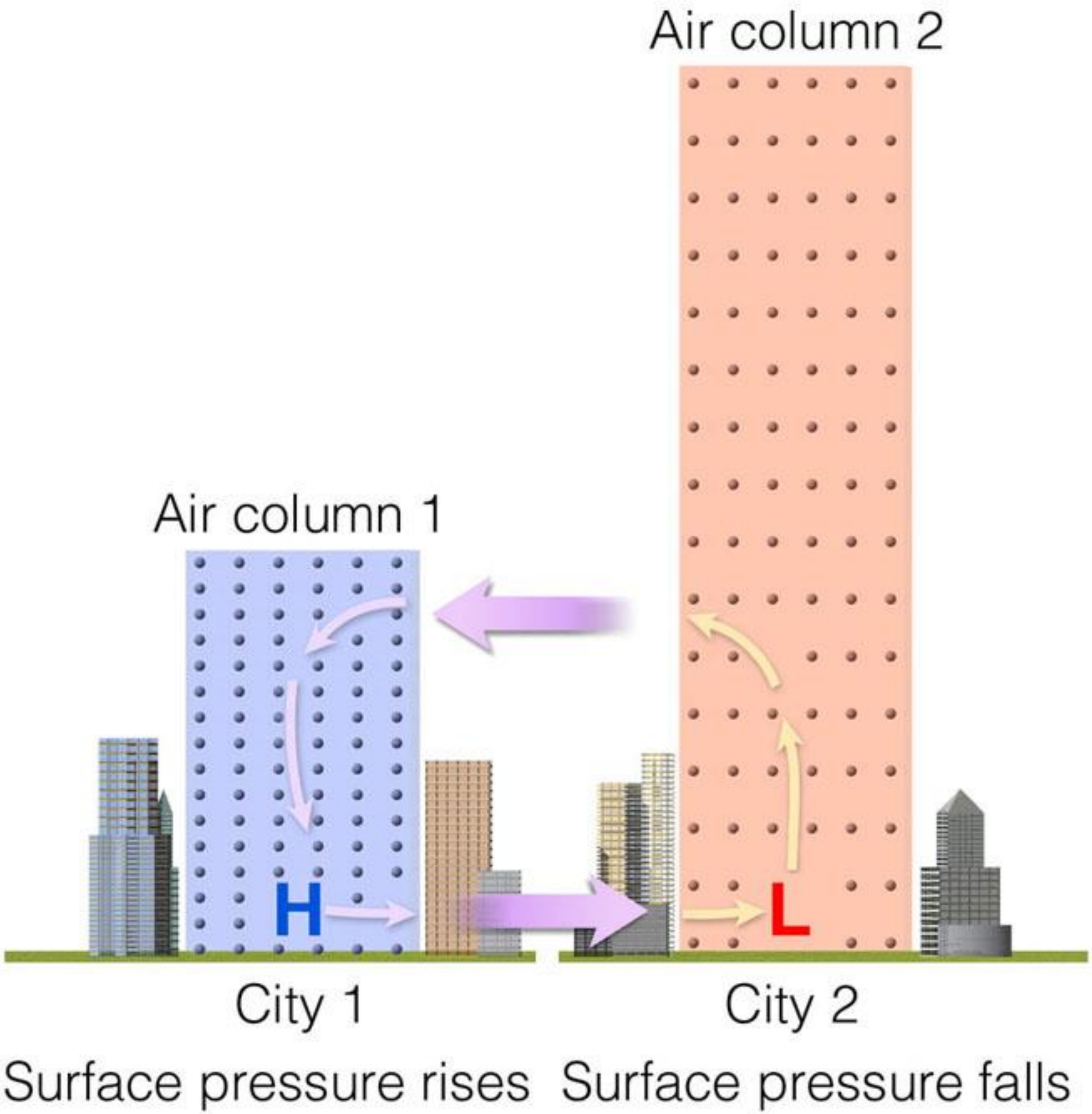
Q: At which location (1 or 2) will the pressure be higher?

A: At location 2, since there is more air molecule over location 2 than location 1.

Q: what will happen at 500 mb?

A: Air will move from the warm column to the colder column at 500 mb due to the pressure gradient force.




Air column 2
Air column 1
H
L
City 1
City 2
Surface pressure rises
Surface pressure falls