Atmospheric Forces and winds
AOSC 200

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Class Web Site: http://www.atmos.umd.edu/~tcanty/aosc200

Topics for today:

Pressure
Forces
Types of winds

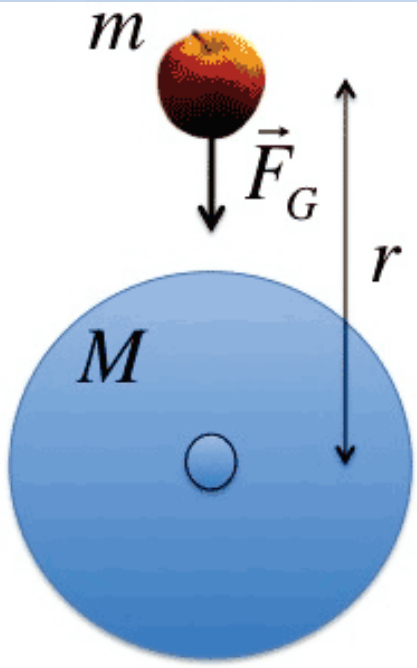
Lecture 16
Oct 22 2019

Understanding the Wind

To understand the wind we need to understand forces....

Isaac Newton started us off in the 17th Century

Gravity



$$F = ma$$

$$\frac{GMm}{r^2} = ma$$

Then, cancelling m on both sides:

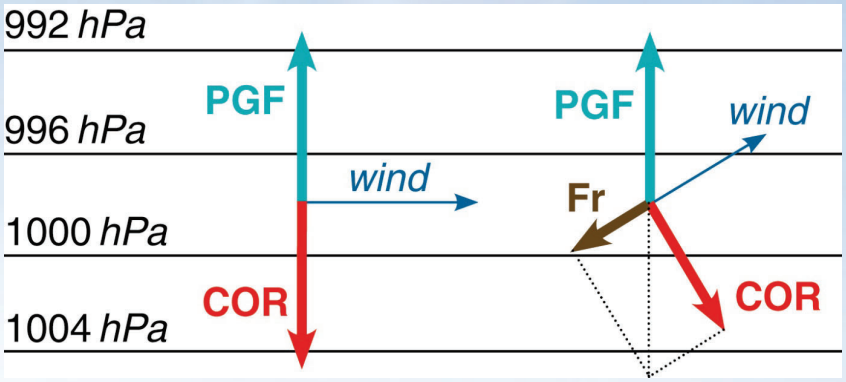
$$a = \frac{GM}{r^2} = g$$

g= -9.81 m/s²

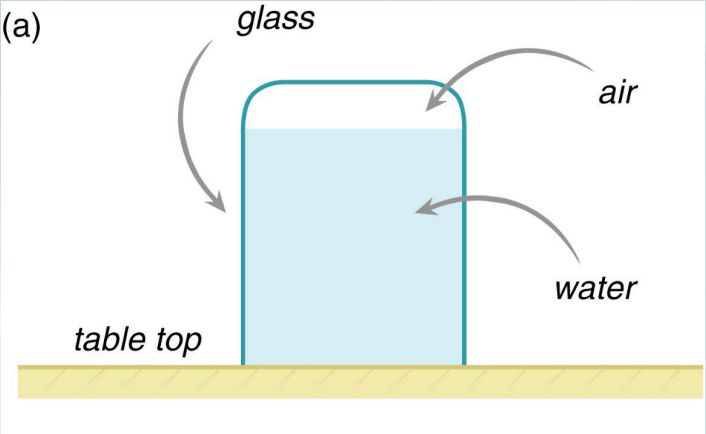
Combination of Forces

5 major forces control wind:

- Gravity
- Pressure Gradient
- Coriolis
- Centrifugal
- Friction



Pressure Gradient Force

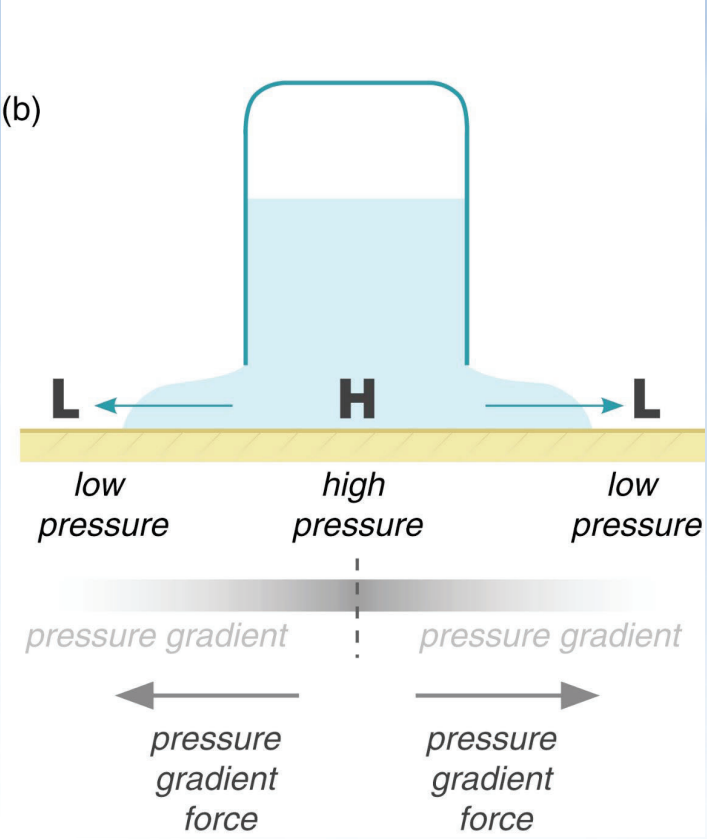


Pressure Gradient Force: due to differences in pressure over a distance

Always pushes from high pressure to low pressure

Fig 8.1 *Weather: A Concise Introduction*

Pressure Gradient Force



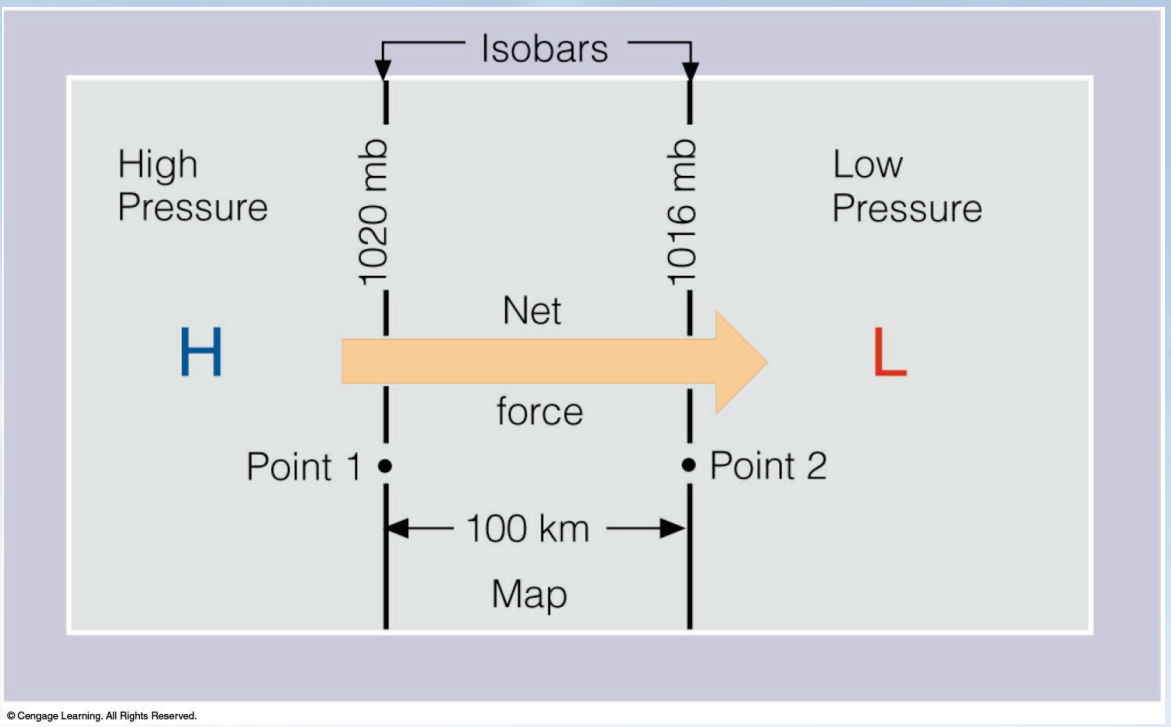
Pressure Gradient Force: due to differences in pressure over a distance

Always pushes from high pressure to low pressure

As the glass is lifted, gravity pulls the water down creating high pressure at the surface and forcing the water into the lower pressure surroundings.

Fig 8.1 *Weather: A Concise Introduction*

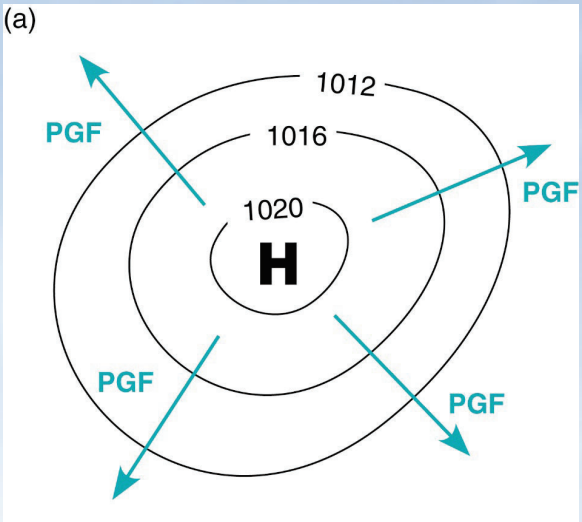
Pressure Gradient Force

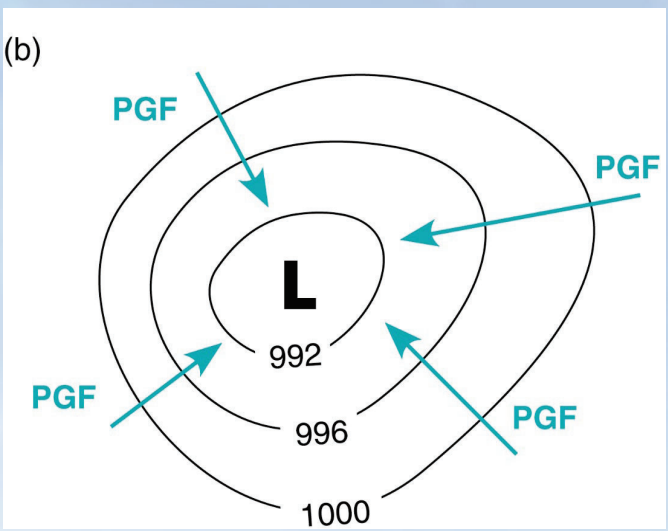


$$\text{PGF} = \frac{\text{Change in Pressure}}{\text{Distance}}$$

Fig 6.11: ***Essentials of Meteorology***

Pressure Gradient Force

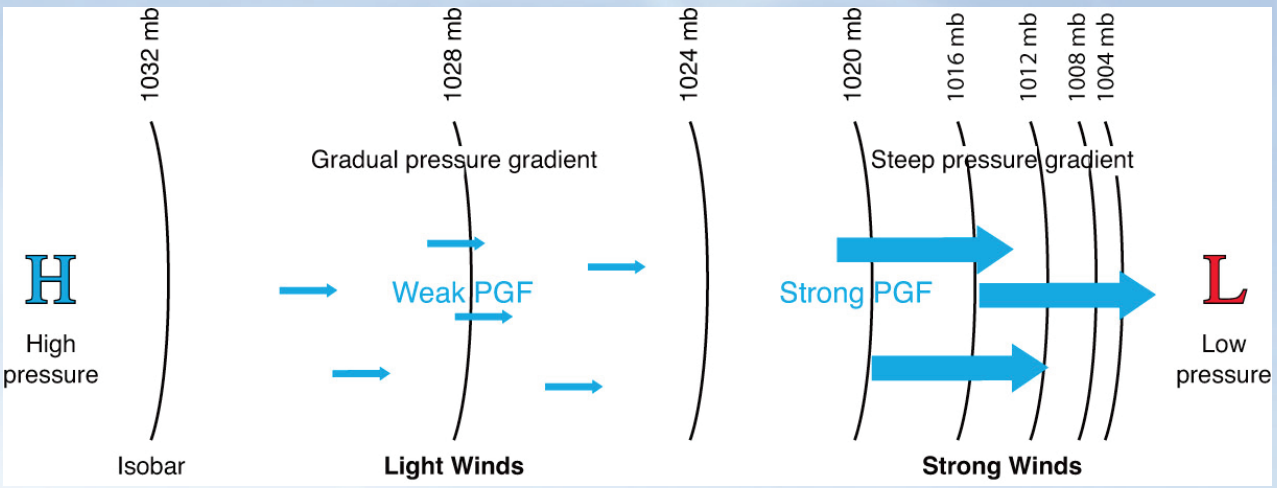




Air flows out of a high pressure system and diverges
Air flows into a low pressure system and converges

Fig 8.2 *Weather: A Concise Introduction*

Pressure Gradient Force



Lines of constant pressure are called *isobars*
The closer the isobars the stronger the PGF

Fig 6-4 *Meteorology: Understanding the Atmosphere*

Understanding Pressure

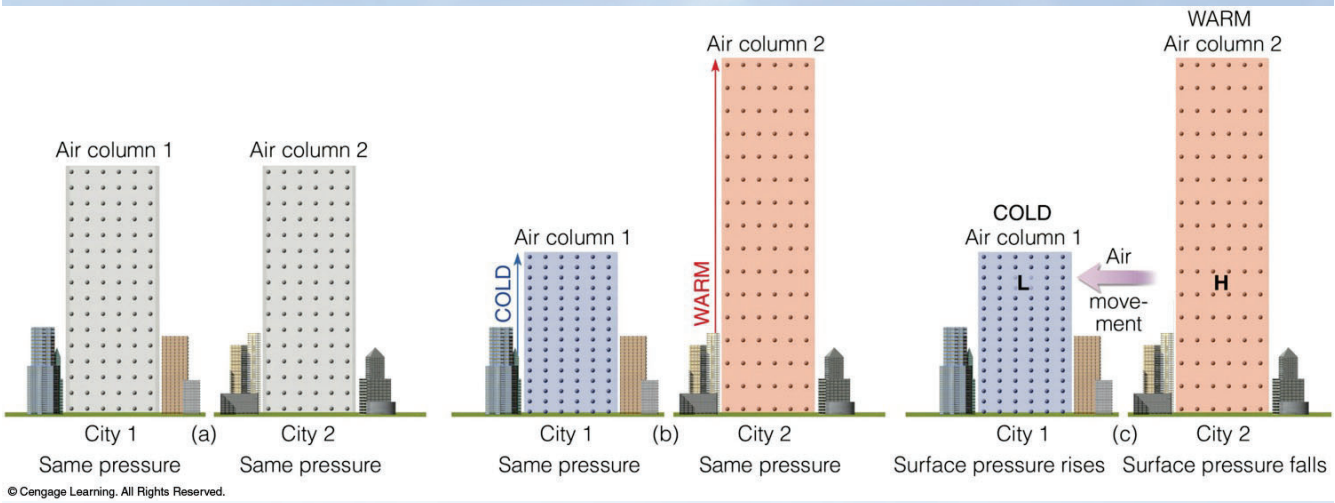


Fig 6.2: ***Essentials of Meteorology***

Understanding Pressure

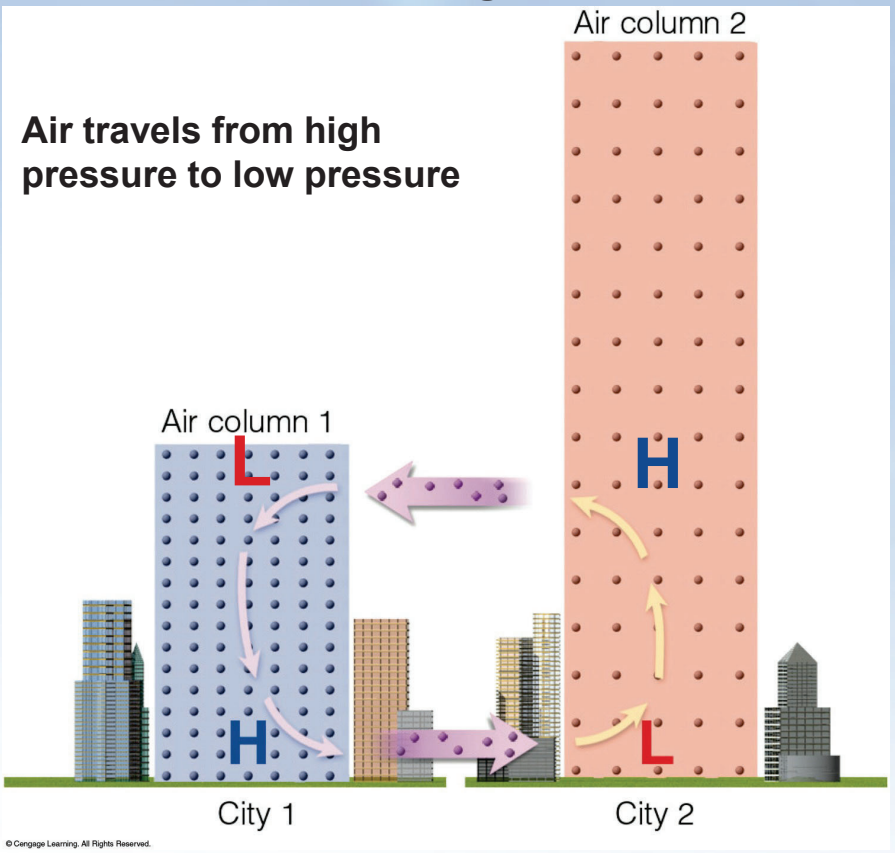


Fig 6.3: ***Essentials of Meteorology***

Sea Breeze

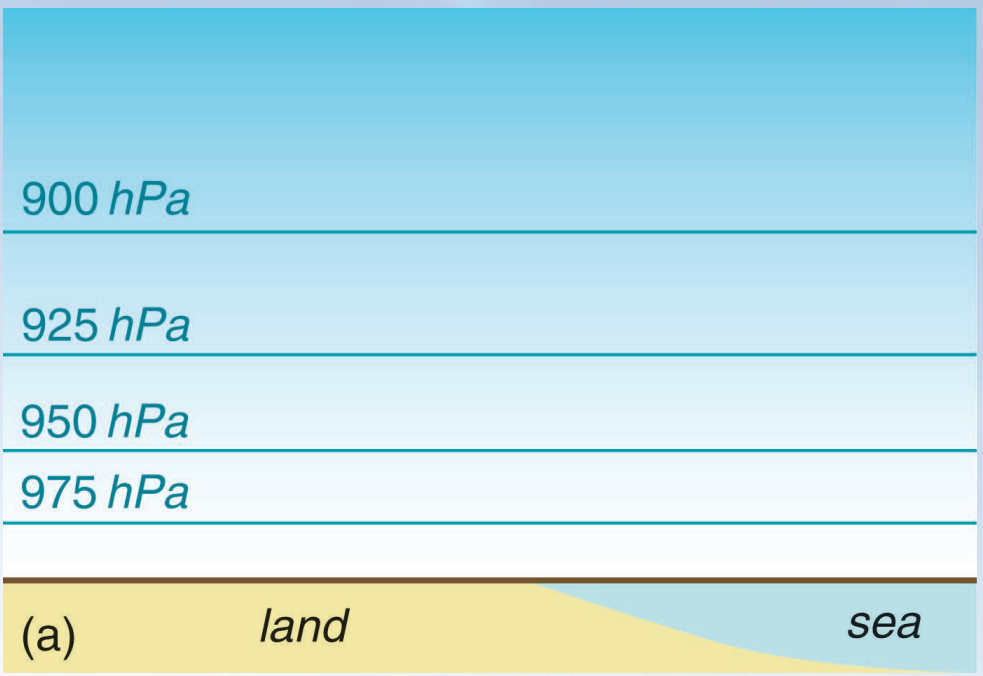


Fig 8.2 *Weather: A Concise Introduction*

Sea Breeze

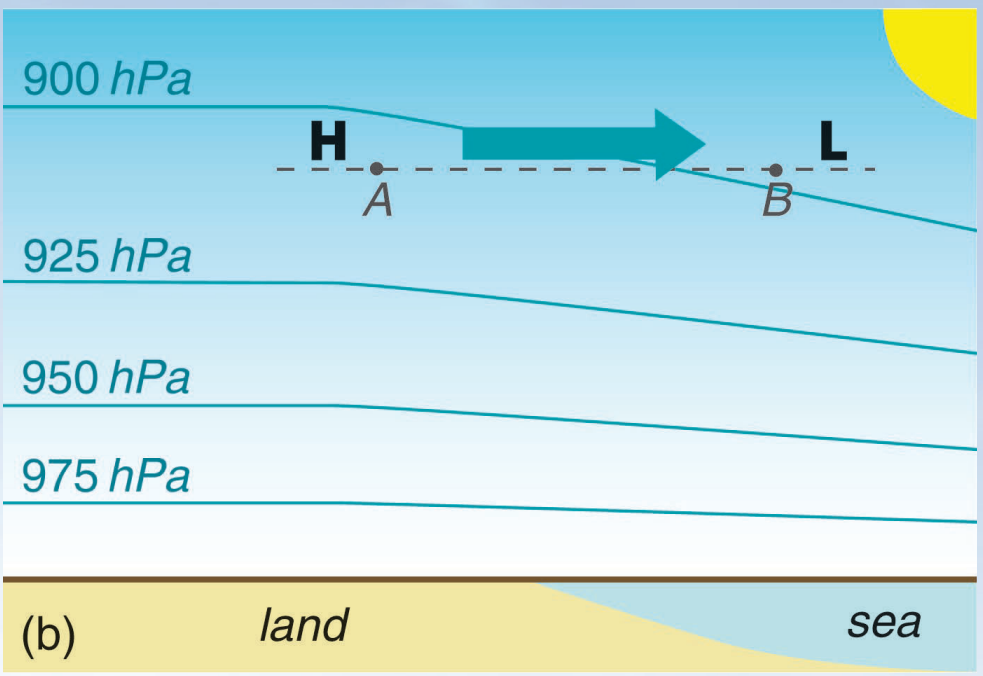


Fig 8.2 *Weather: A Concise Introduction*

Sea Breeze

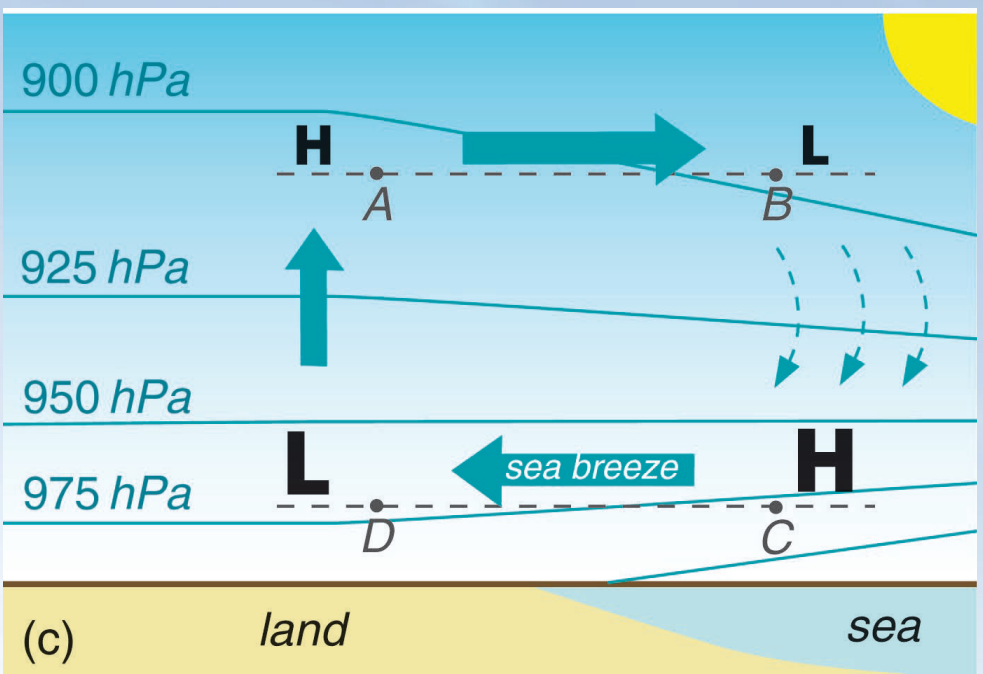


Fig 8.2 *Weather: A Concise Introduction*

Land Breeze

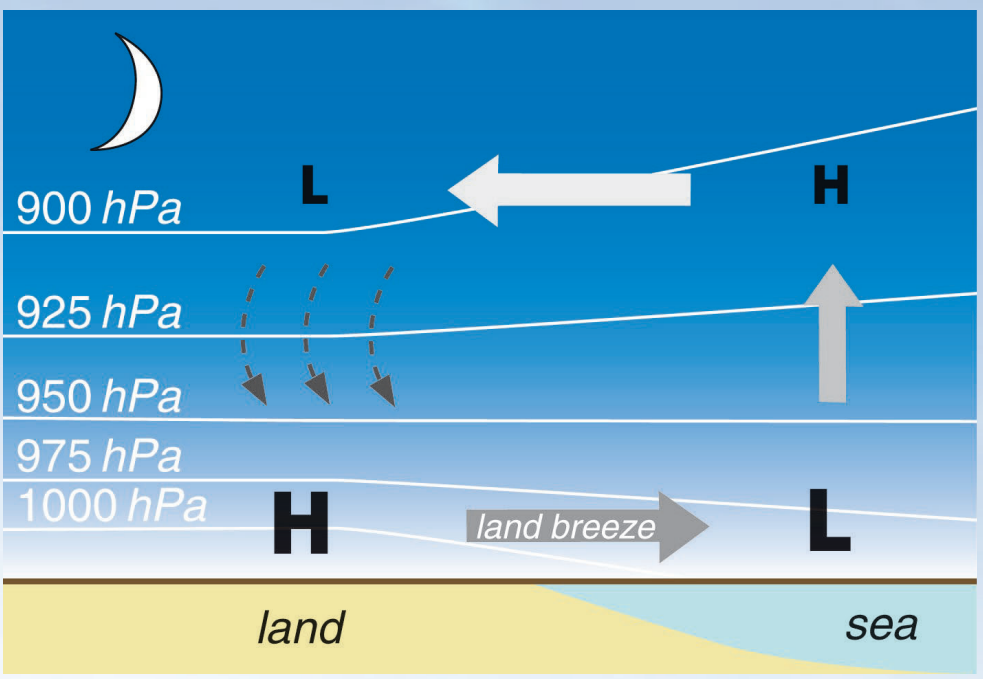
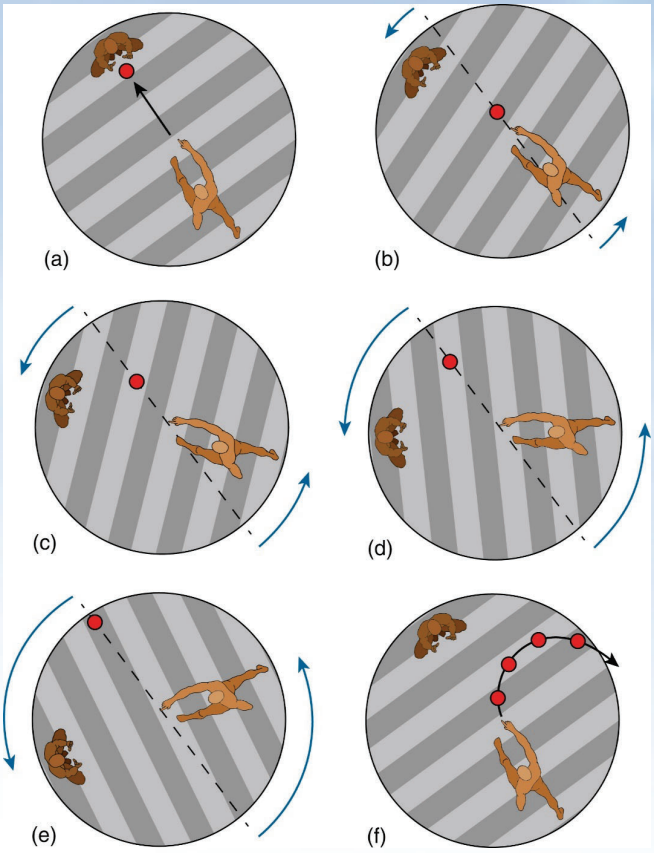


Fig 8.3 *Weather: A Concise Introduction*

Bay Breeze over Chesapeake Bay

Coriolis Force



The ball keeps moving in straight line once it leaves the hands of the person throwing it.

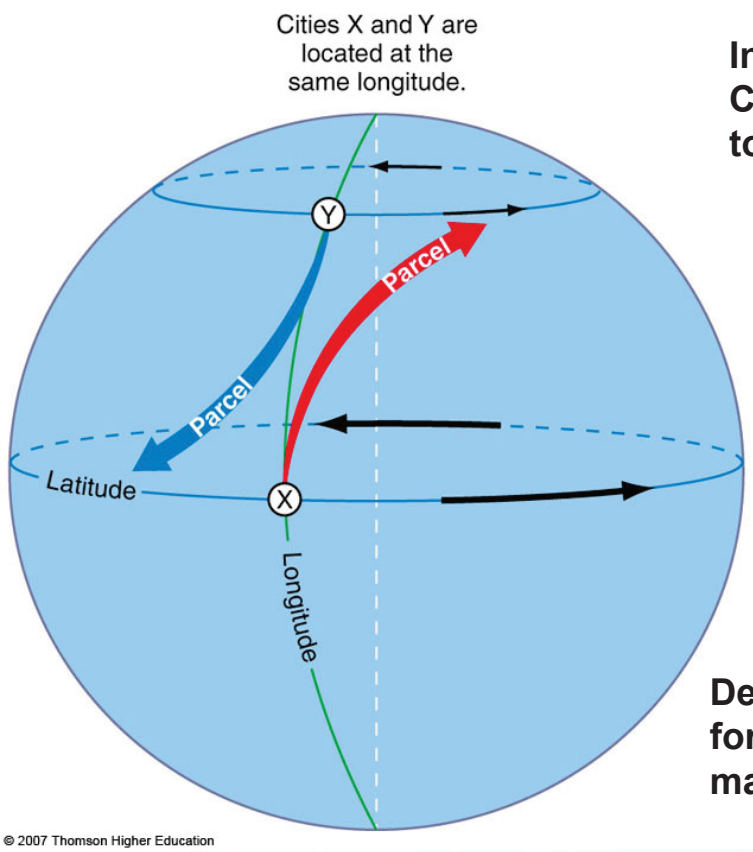
If the people on the platform don't know that it's spinning, it looks to them as if the ball is curving on it's own and there must be some force acting on it for that to happen.

This "apparent" force is called the Coriolis Force.

It's not real… we pretend it's a force to account for the rotation of the Earth.

Fig 8.5 *Weather: A Concise Introduction*

Coriolis Force

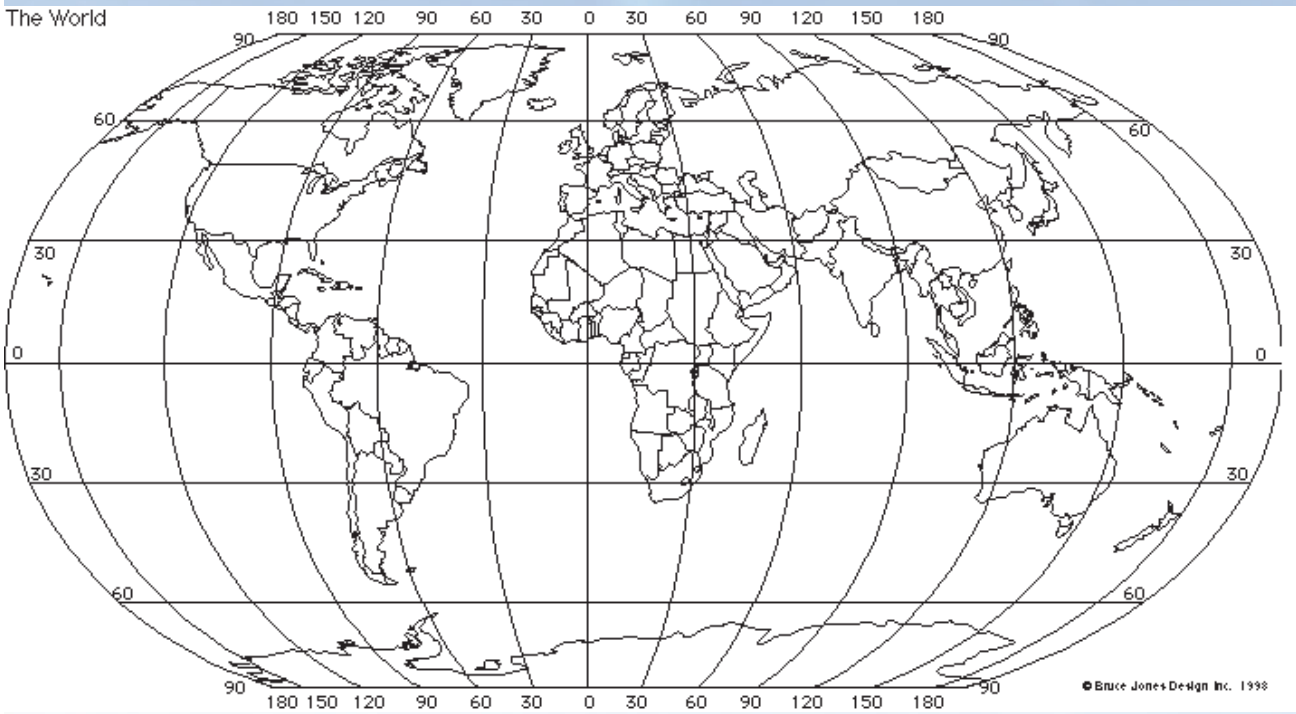


In the Northern Hemisphere, Coriolis forces always deflect to the *RIGHT*

City X has a greater distance to travel in the same amount of time

Depends on latitude. Coriolis forces are ZERO at the equator, maximum at the poles.

Latitude and Longitude



The equator is at 0° latitude
The poles are at 90° latitude

Coriolis Force

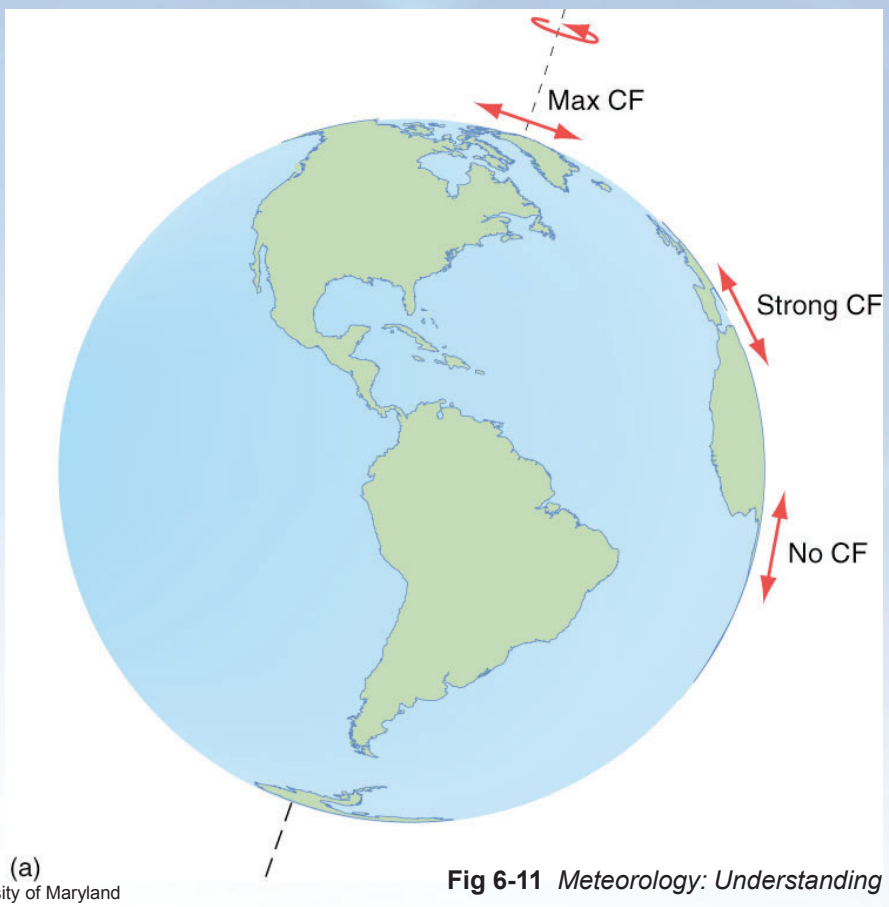
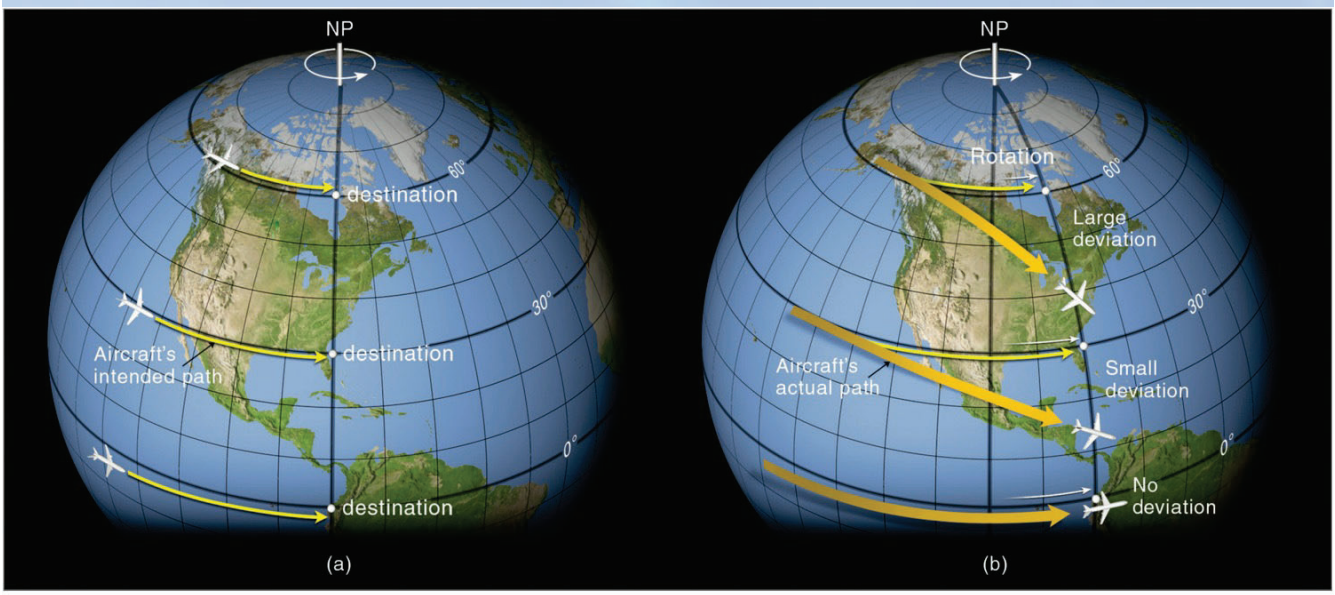


Fig 6-11 *Meteorology: Understanding the Atmosphere*

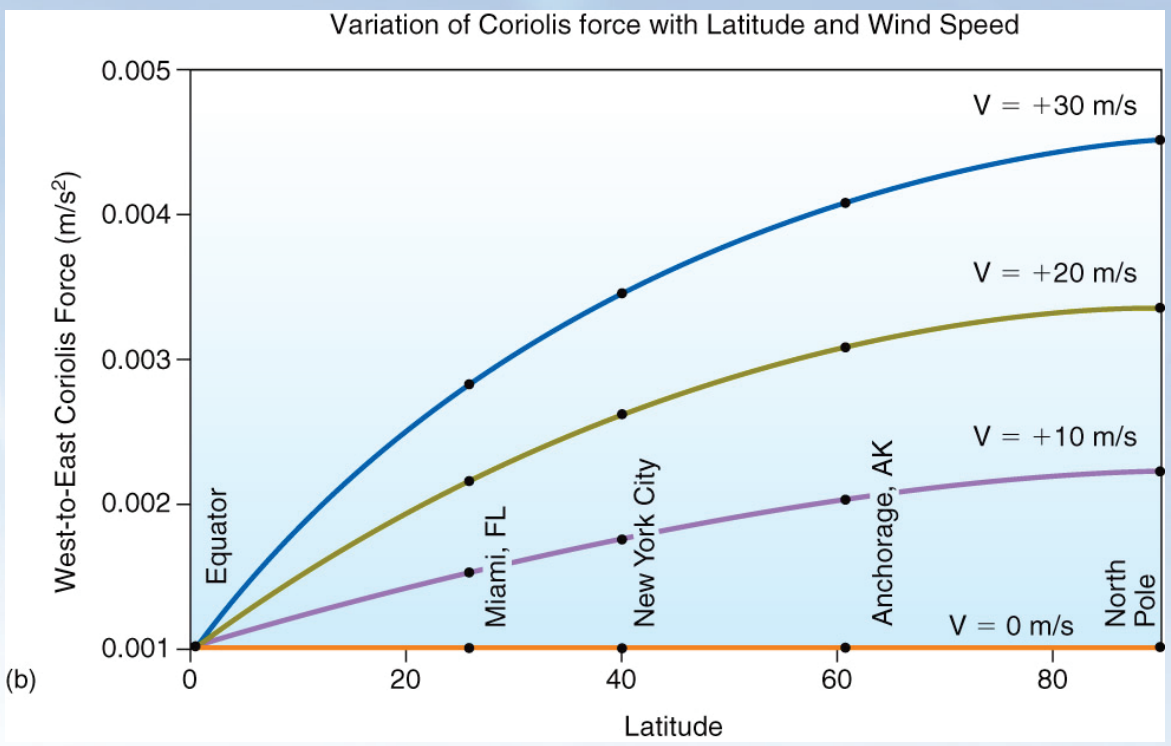
Coriolis Force



The closer to the pole, the stronger the Coriolis force
Also depends on how fast the object is moving

Fig 6-15 *Meteorology: Understanding the Atmosphere*

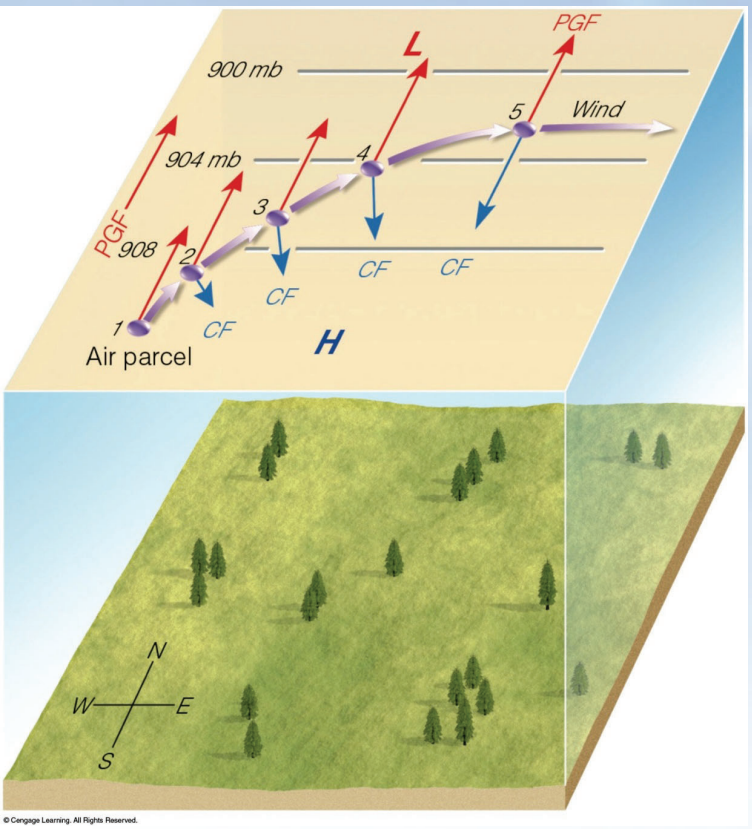
Coriolis Force



$$CF = \pm f\,V$$ f **is proportional to sin(latitude)**

Fig 6-11 *Meteorology: Understanding the Atmosphere*

Combining pressure gradient and coriolis forces



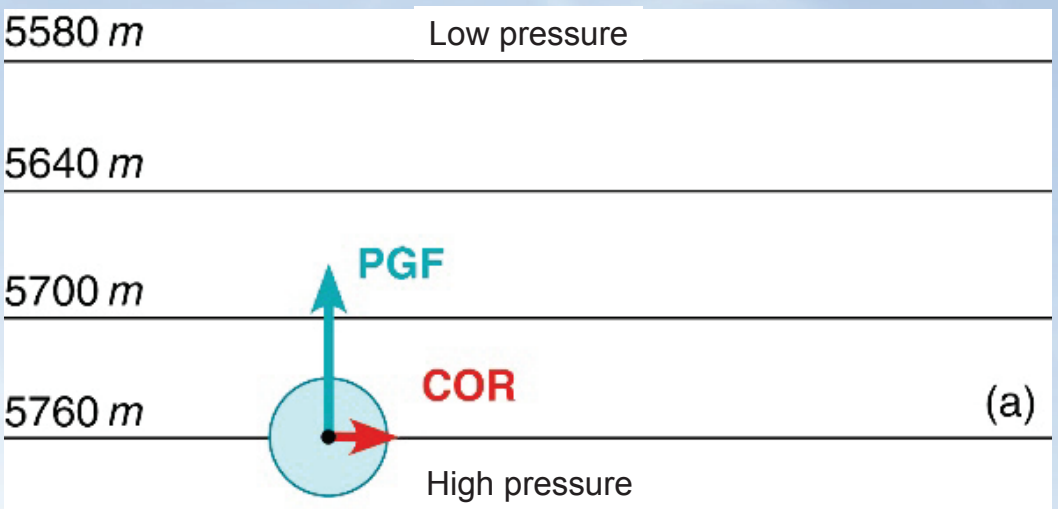
Wind is forced from high pressure to low pressure (PGF)

Wind is pulled to the right (CF)

When the isobars are straight and the two forces balance, it is called the

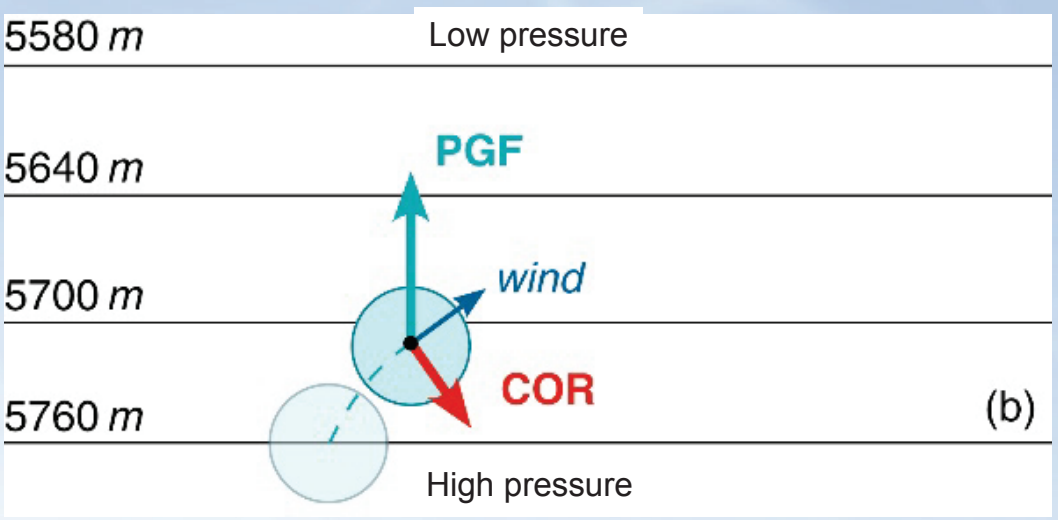
Geostrophic Wind

Fig 6.16: ***Essentials of Meteorology***



Remember: we can switch between pressure contours and height contours

Fig 8.6 *Weather: A Concise Introduction*



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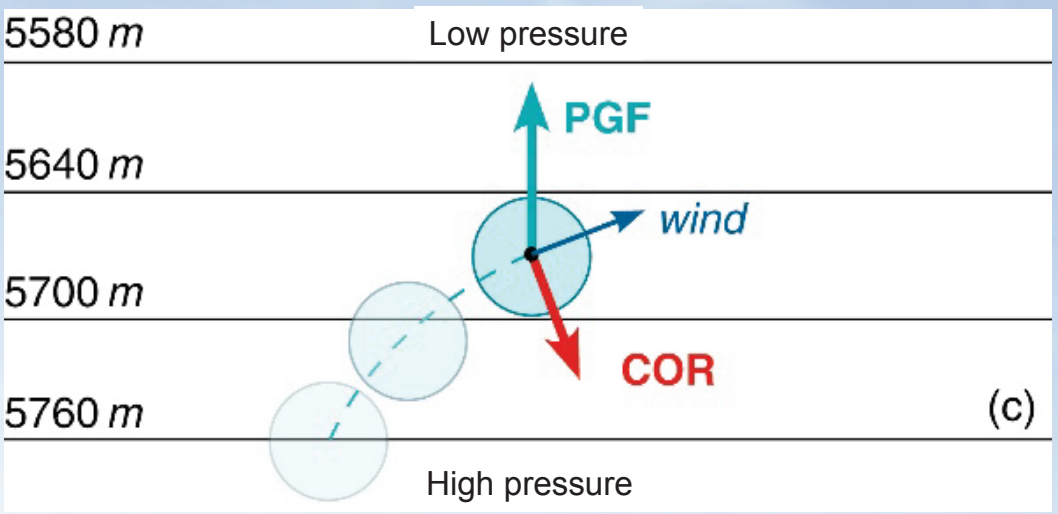

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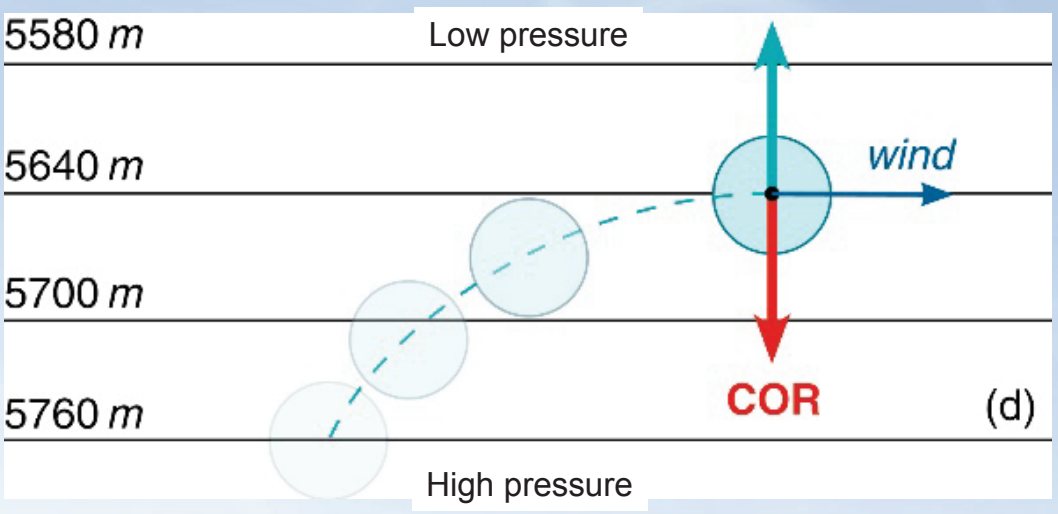
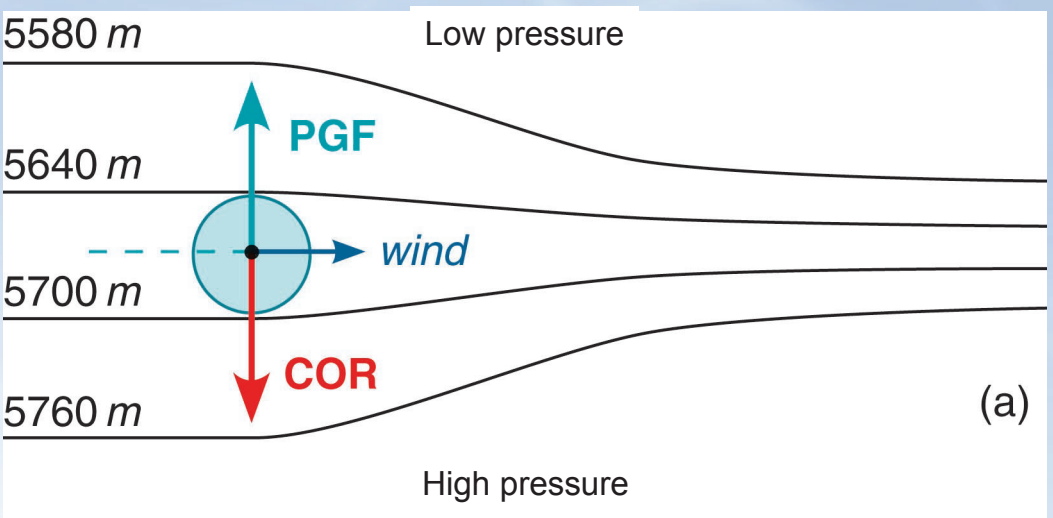


The parcel starts moving from high to low pressure. As it speeds up, the Coriolis force increases but always pulls to the right.
Eventually the PGF is balanced by Coriolis and we reach:

Geostrophic Balance

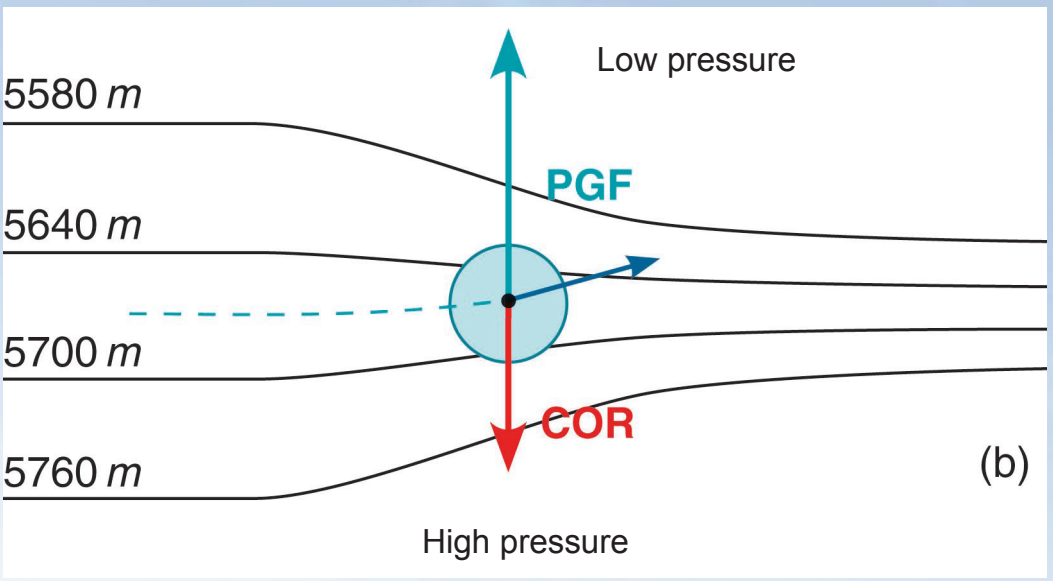
Remember: we can switch between pressure contours and height contours

Fig 8.6 *Weather: A Concise Introduction*



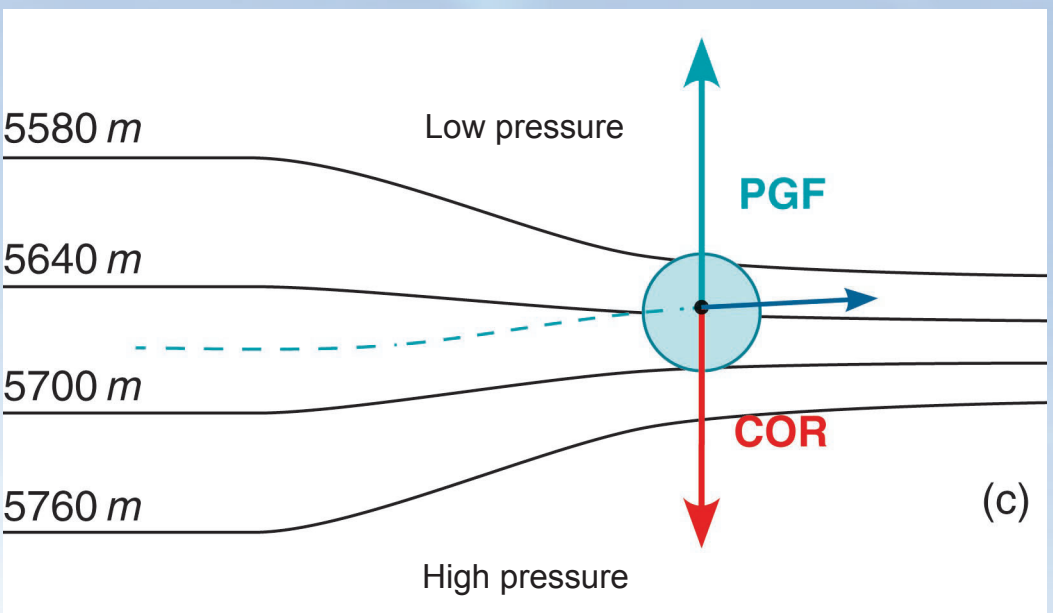
Remember: we can switch between pressure contours and height contours

Fig 8.7 *Weather: A Concise Introduction*



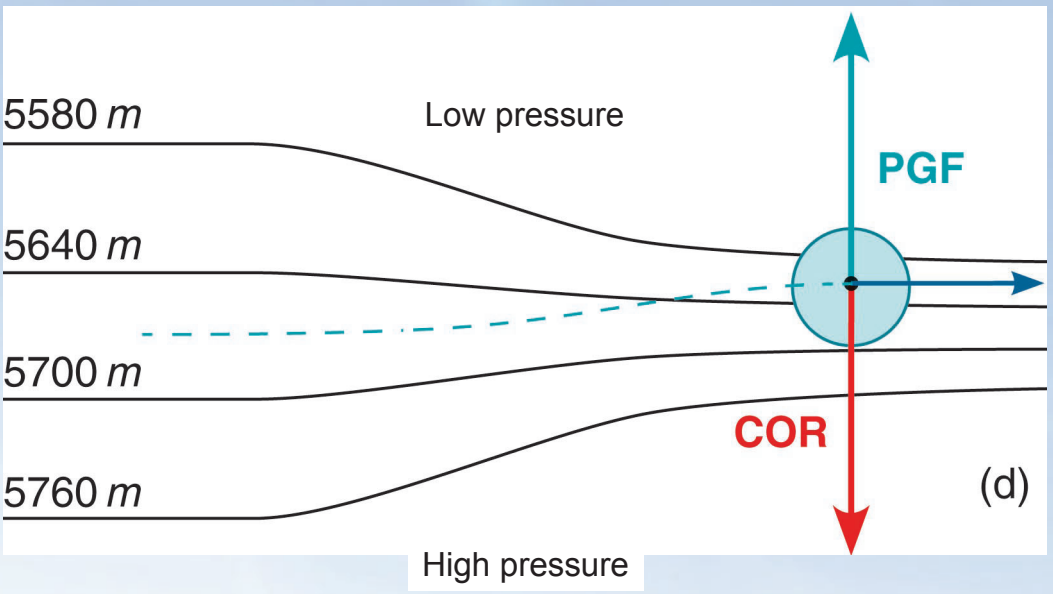
Remember: we can switch between pressure contours and height contours

Fig 8.7 *Weather: A Concise Introduction*



Remember: we can switch between pressure contours and height contours

Fig 8.7 *Weather: A Concise Introduction*



As the isobars (or height contours) get closer together: the PGF increases and so does the speed. The Coriolis force increases with speed and we reach a new equilibrium

Remember: we can switch between pressure contours and height contours

Fig 8.7 *Weather: A Concise Introduction*