Review for Exam 4

GEOL 1147: Introduction To Meteorology Lab

Exam 4

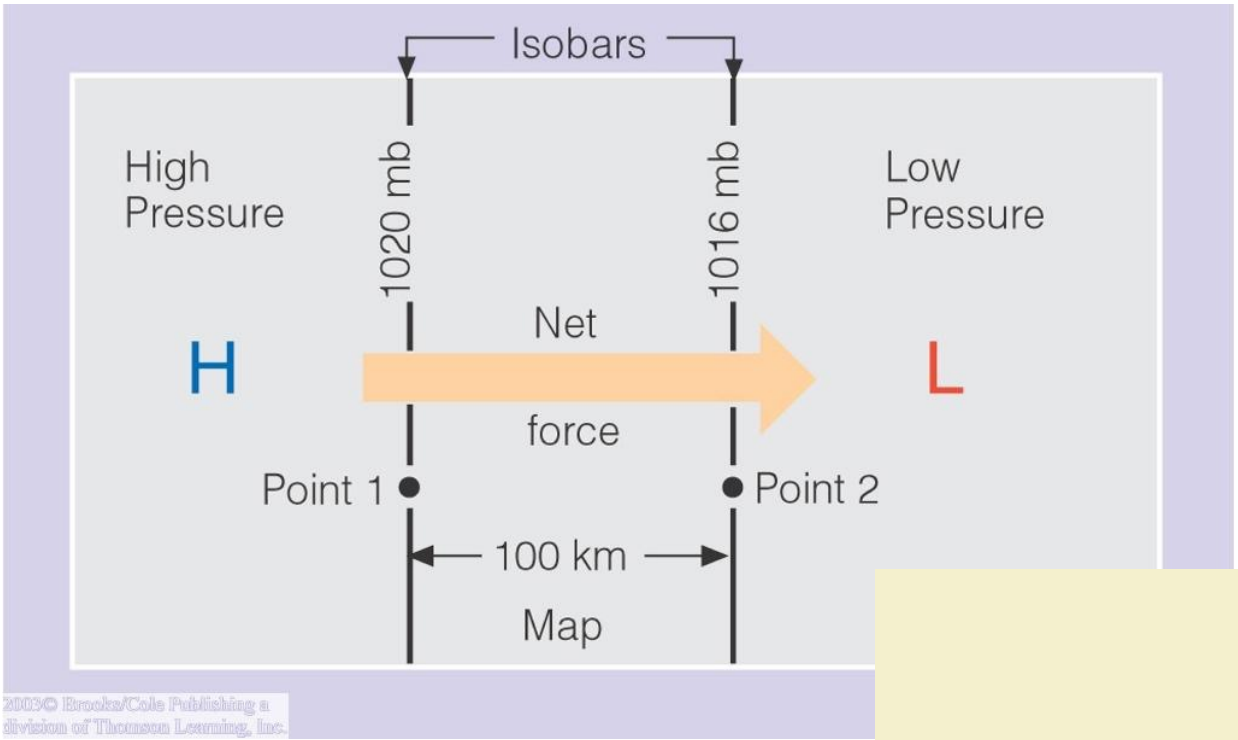
Cover: Labs 8-9

Close-book Exam

You can bring a calculator with you.

Exam counts 22.5% of the total grade.

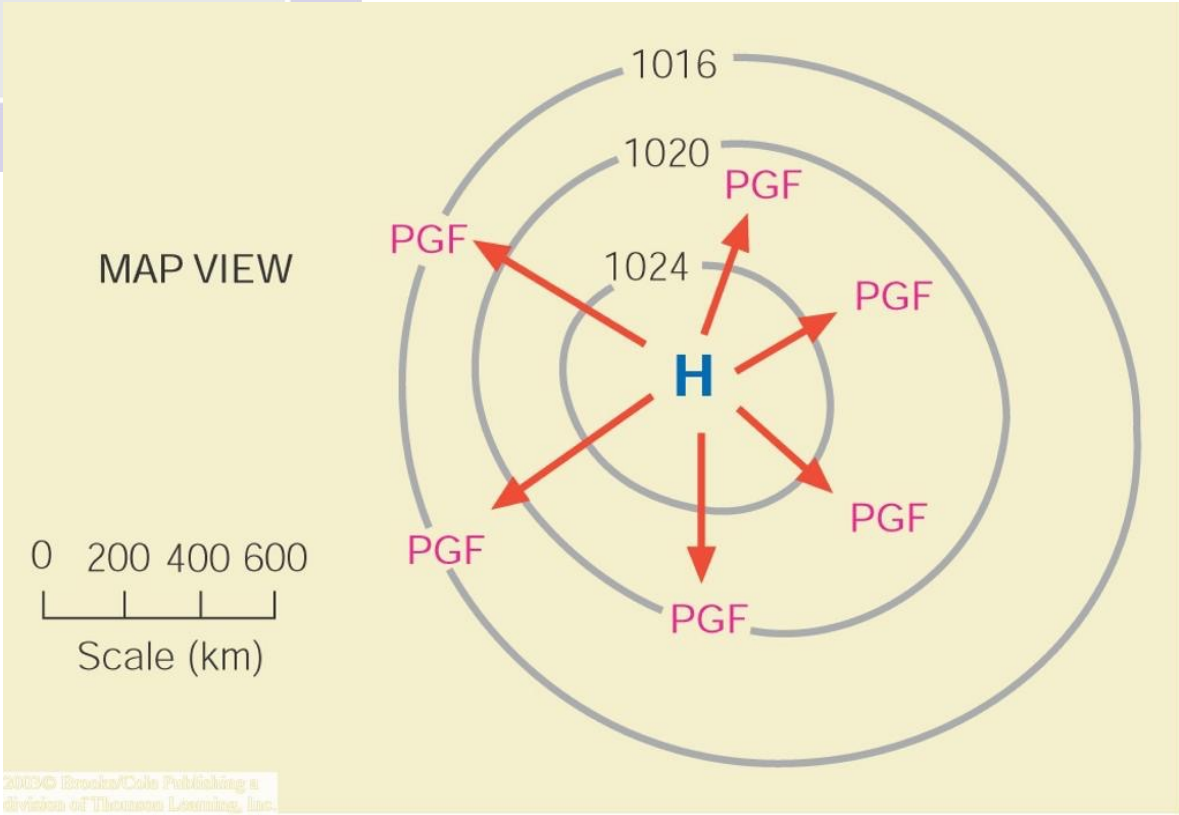
How to calculate pressure gradient force?



Pressure gradient force equals changes in pressure per changes in distance

$$PGF = (1/\rho) \cdot (\Delta P / d)$$

e.g., PGF = 1/(1kg/m^3)(1020 mb-1016 mb) / 100 km = 4 × 10^{-3} N/kg



What determine the magnitude of Coriolis force ?

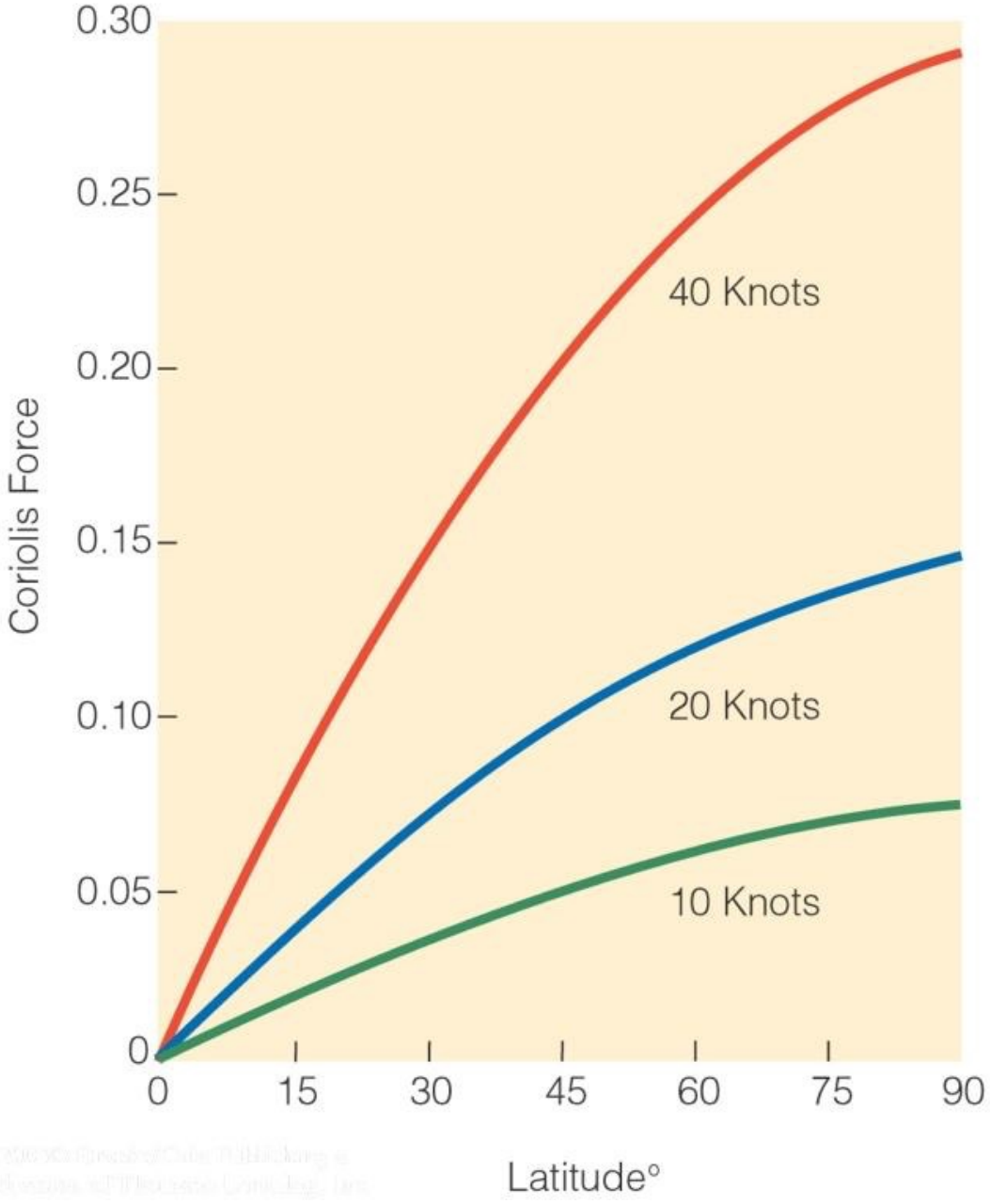
Coriolis force = $f \cdot V$

V is wind speed

f is the *Coriolis parameter*

$f = 2 \times$ earth's rotational rate $\times$ sin of latitude

Earth's ratation rate ($7.3 \cdot 10^{-5}$ radian/s)



Coriolis Force (*CF*)

- **Apparent force due to the rotation of the earth**

- **Magnitude depends on latitude and the speed of the air parcel**

  The higher the latitude, the larger the Coriolis force

  Zero at the equator, and maximum at the poles

  The faster air moves, the larger the Coriolis force

- **Causes the parcel to deflect**

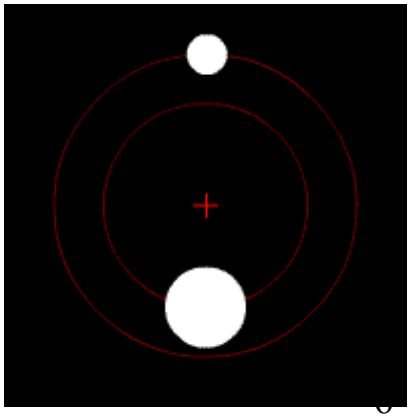
  to the right of its intended path in the northern hemisphere

  to the left of its intended path in the southern hemisphere.

Only influence wind direction, no effect on wind speed !

Centrifugal Force

- Magnitude CENTF = mV^2/R
  - m is the mass
  - R the radius of curvature of the curved path
  - V is the speed of the air parcel
- Direction
  - Pointing away from the center of the curve
  - **The faster the speed and the tighter the curve of the path traveled (i.e., the smaller R), the larger the centrifugal force.**



Frictional Force

- **Frictional drag of the ground slows wind down.**

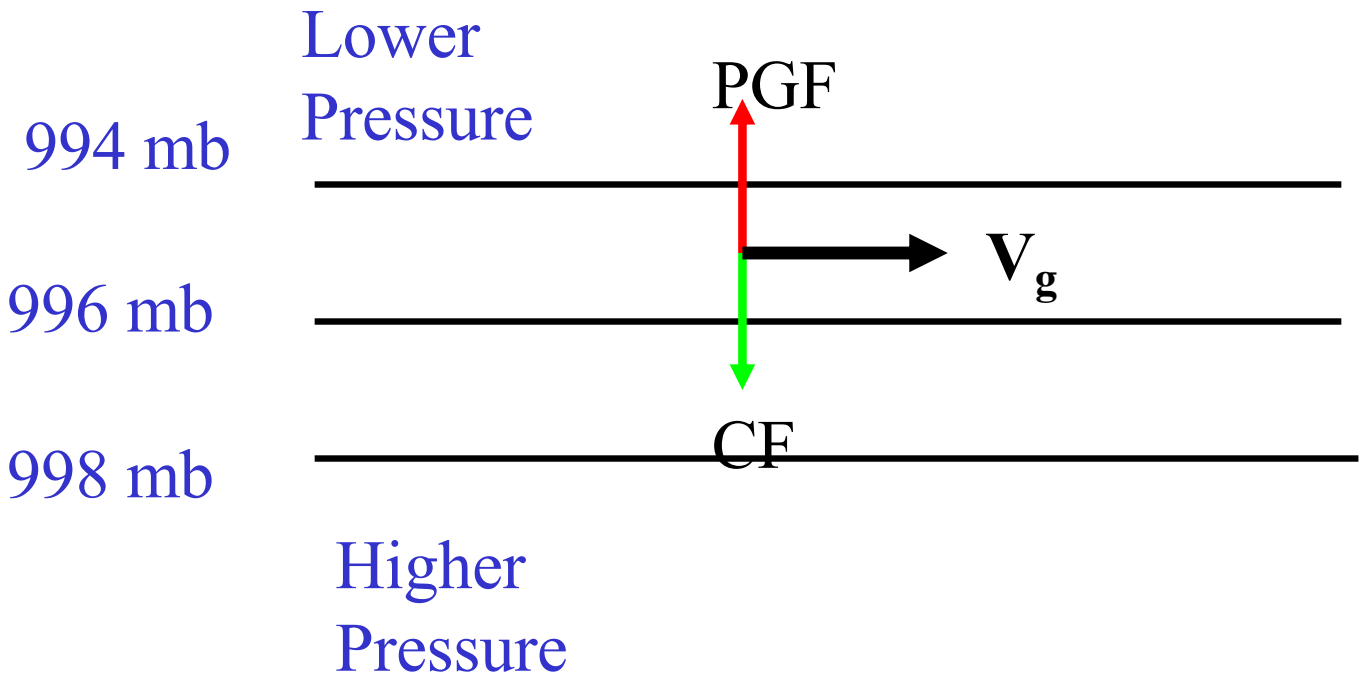
$$FF = -kV$$

  - **Magnitude**
    - **Depends upon the speed of the air parcel (V)**
    - **Depends upon the roughness of the earth's surface (k)**
  - **Direction**
    - **Always acts in the direction opposite to the movement of the air parcel (minus sign emphasizes this)**
  - **Important in the friction layer (planetary boundary layer)**
    - **~lowest 1000 m of the atmosphere**

Geostrophic Wind

When the pressure gradient force is balanced by the Coriolis force, the wind is called geostrophic wind.

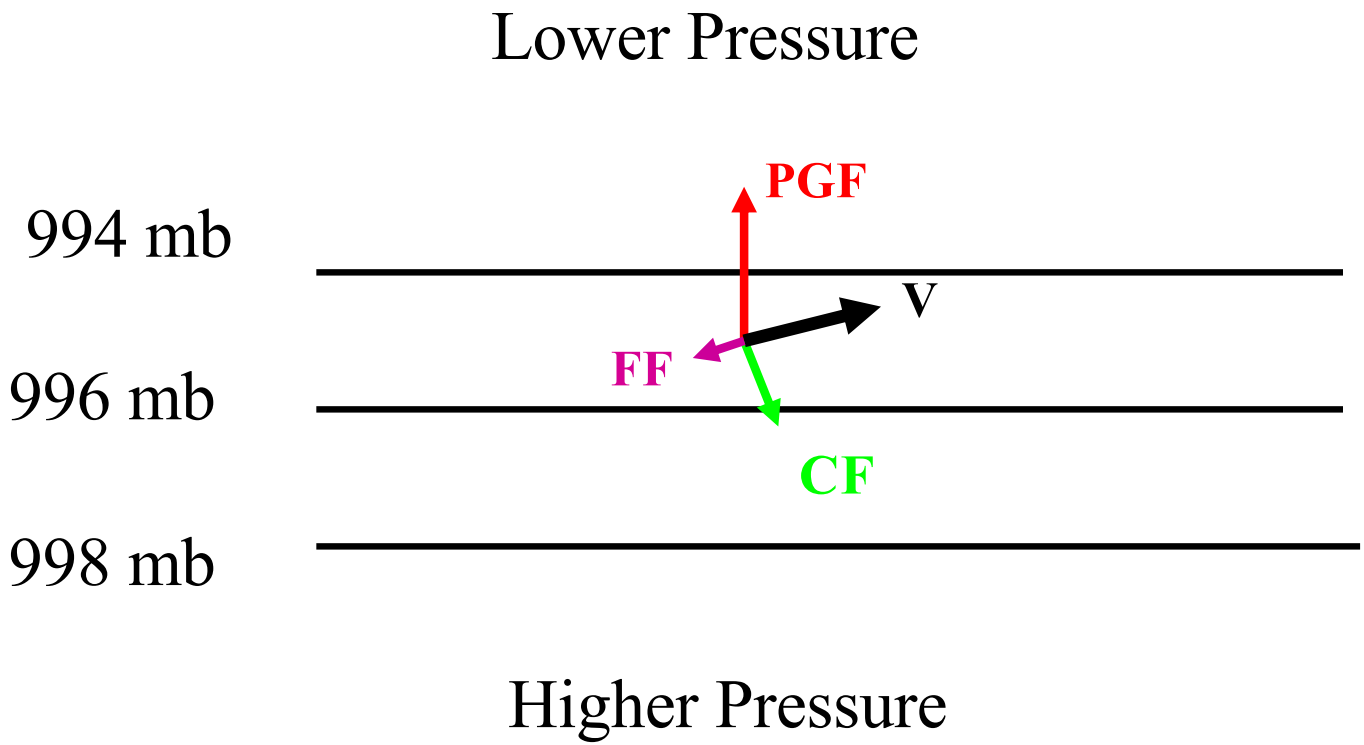
Geostrophic wind blows in a straight line parallel to isobars (constant pressure lines)



What happens when we add friction?

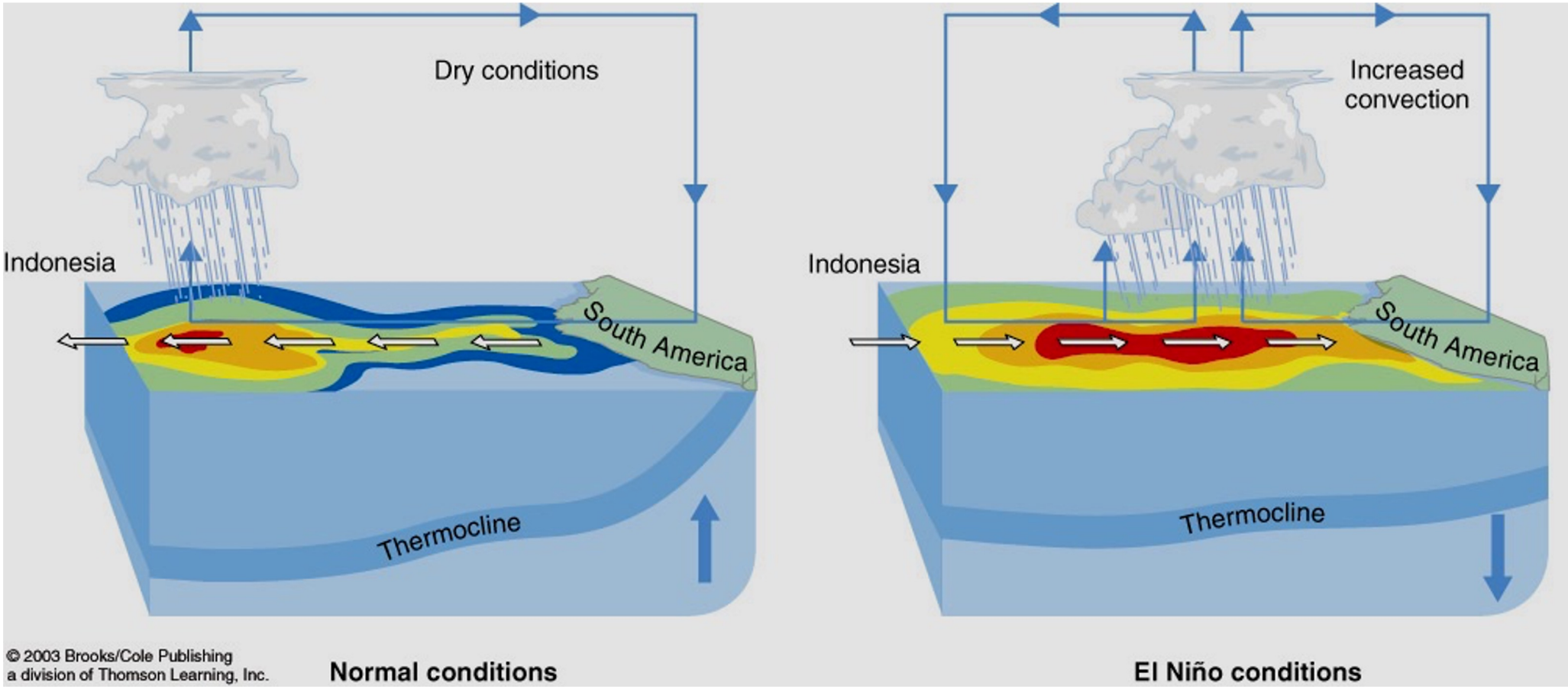
- **Friction can only slow wind speed, not change wind direction**
- **Therefore, in the northern hemisphere, if the wind speed is decreased by friction, the Coriolis force (CF=fV) will be decreased and will not quite balance the pressure gradient force**
  - **Force imbalance (PGF > CF) pushes wind in toward low pressure center and outward away from high pressure center**
  - **Angle at which wind crosses isobars depends on surface roughness**
    - **Average ~ 30 degrees**

PGF+CF+FF=0



The wind no longer blows parallel to the isobars, but is deflected toward lower pressure; this happens close to the ground where terrain and vegetation provide friction

El Nino

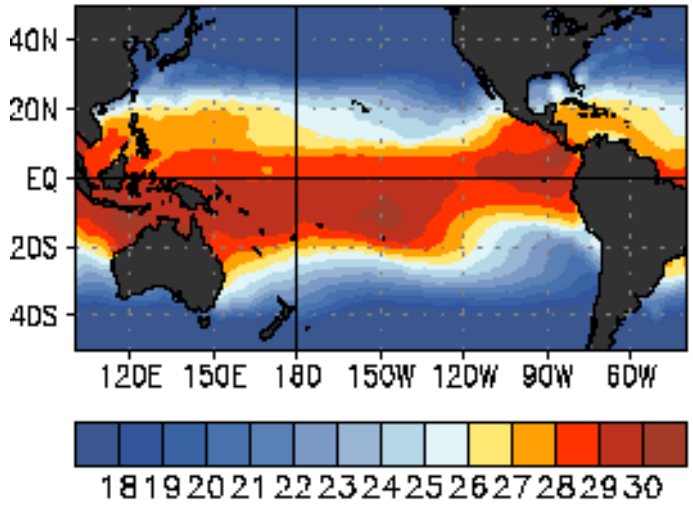


Normal conditions

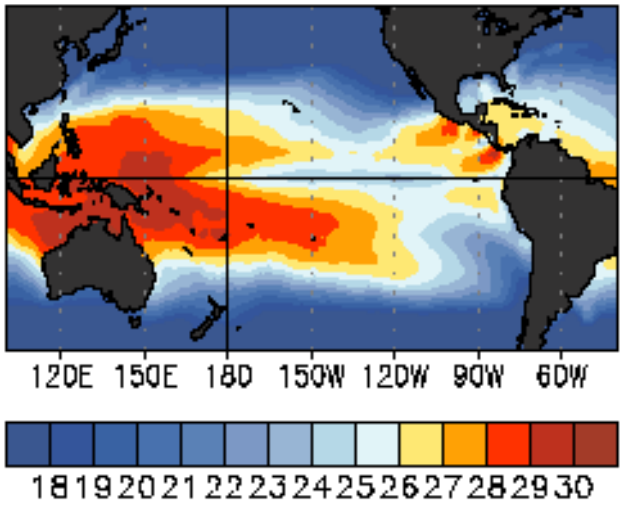
El Niño conditions

OCEAN TEMPERATURES (°C)

EL NIÑO
Jan-Mar 1998



LA NIÑA
Jan-Mar 1989



OCEAN TEMPERATURE DEPARTURES (°C)