Horizontal Pressure Gradients and Circulation

- *Vertical* pressure differences (gradients) in the vertical are nearly balanced by gravity
  - Hence, vertical motions are weak
- *Horizontal* pressure gradients are weak but not balanced by gravity
  - Hence, horizontal pressure gradients drive winds
    - Air is forced (accelerated) from high towards low pressure
  - The larger the pressure difference, the stronger the acceleration
  - E.g., sea breeze, wind gust, etc.

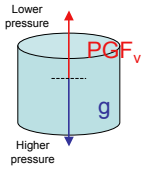
Force Balance

Vertical

$$\frac{1}{\rho}\frac{\Delta P}{\Delta z} = -g$$

Acceleration due to *vertical* pressure differences (gradients)

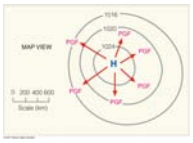
Acceleration due to gravity



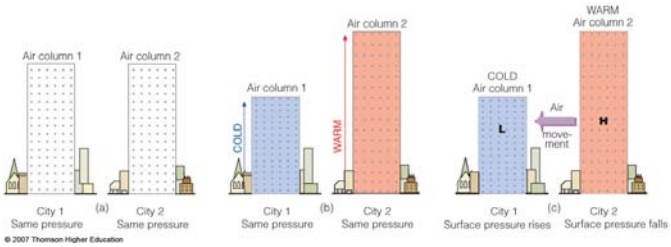
Horizontal

$$\frac{1}{\rho}\frac{\Delta P}{\Delta x} = ?$$

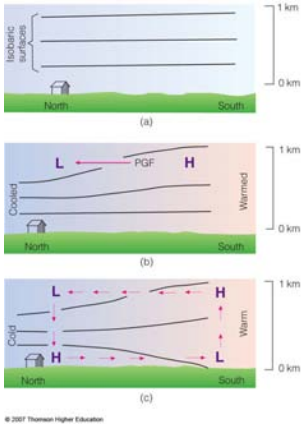
Acceleration due to *horizontal* pressure differences (gradients)



Sea Breeze driven by horizontal pressure gradients

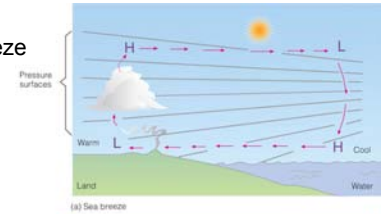


Sea Breeze driven by horizontal pressure gradients



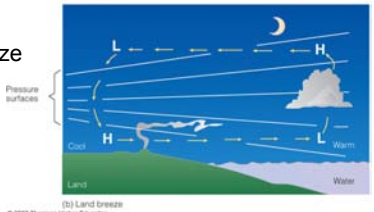
Sea Breeze driven by horizontal pressure gradients

Sea Breeze



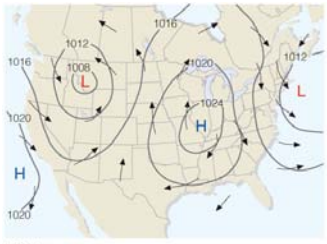
(a) Sea breeze

Land Breeze

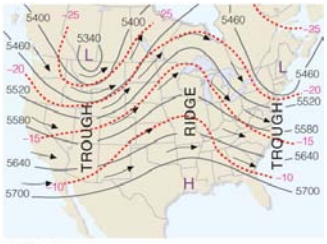


(b) Land breeze

Horizontal Forces & Circulation



(a) Surface map



(b) 500-millibar map

- If the *horizontal* pressure gradients last long enough (longer than several hours) or the air displacement is large enough (1000 of km)
  - The rotation of the earth greatly affects the motion (Coriolis Force)
  - The *horizontal* pressure gradients are balanced by Coriolis Force
    - The wind blows along a line of *constant* pressure and is said to be in geostrophic balance
  - E.g., hurricanes, mid-latitude cyclones, jet stream