Applications of the Basic Equations

Chapter 3

Paul A. Ullrich

paullrich@ucdavis.edu

Part 5: A Developing Surface Low

Vertical Motion

Continuity Equation

$$\left(\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}\right)_p+\frac{\partial \omega}{\partial p}=0$$

Integrate both sides

$$\int_{\omega(p=p')}^{\omega(p=0)} d\omega = -\int_{p=p'}^{p=0}\left(\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}\right)_p dp$$

$$\omega(p') = -\int_0^{p'}\left(\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}\right)_p dp$$

This equation formally links vertical pressure velocity and horizontal divergence on pressure surfaces.

Vertical Motion

Recall the equation for ω:

$$\omega = \frac{\partial p}{\partial t} + \left(u_a \frac{\partial p}{\partial x} + v_a \frac{\partial p}{\partial y} \right) - wg\rho$$

Local change in pressure:

$$\frac{\partial p}{\partial t} \approx \frac{U \Delta P}{L} \approx 10^{-2} \text{ Pa s}^{-1}$$

Pressure advection by ageostrophic wind:

$$\mathbf{u}_a \cdot \nabla_h p \approx 0.1 \times \frac{U \Delta P}{L} \approx 10^{-3} \text{ Pa s}^{-1}$$

Vertical velocity term:

$$wg\rho \approx W g\rho \approx 10^{-1} \text{ Pa s}^{-1}$$

$w = 0$ at the surface

Vertical Motion

At the surface we instead have $\omega \approx \frac{\partial p}{\partial t}$

$$\omega(p') = -\int_0^{p'} \left(\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} \right)_p dp$$

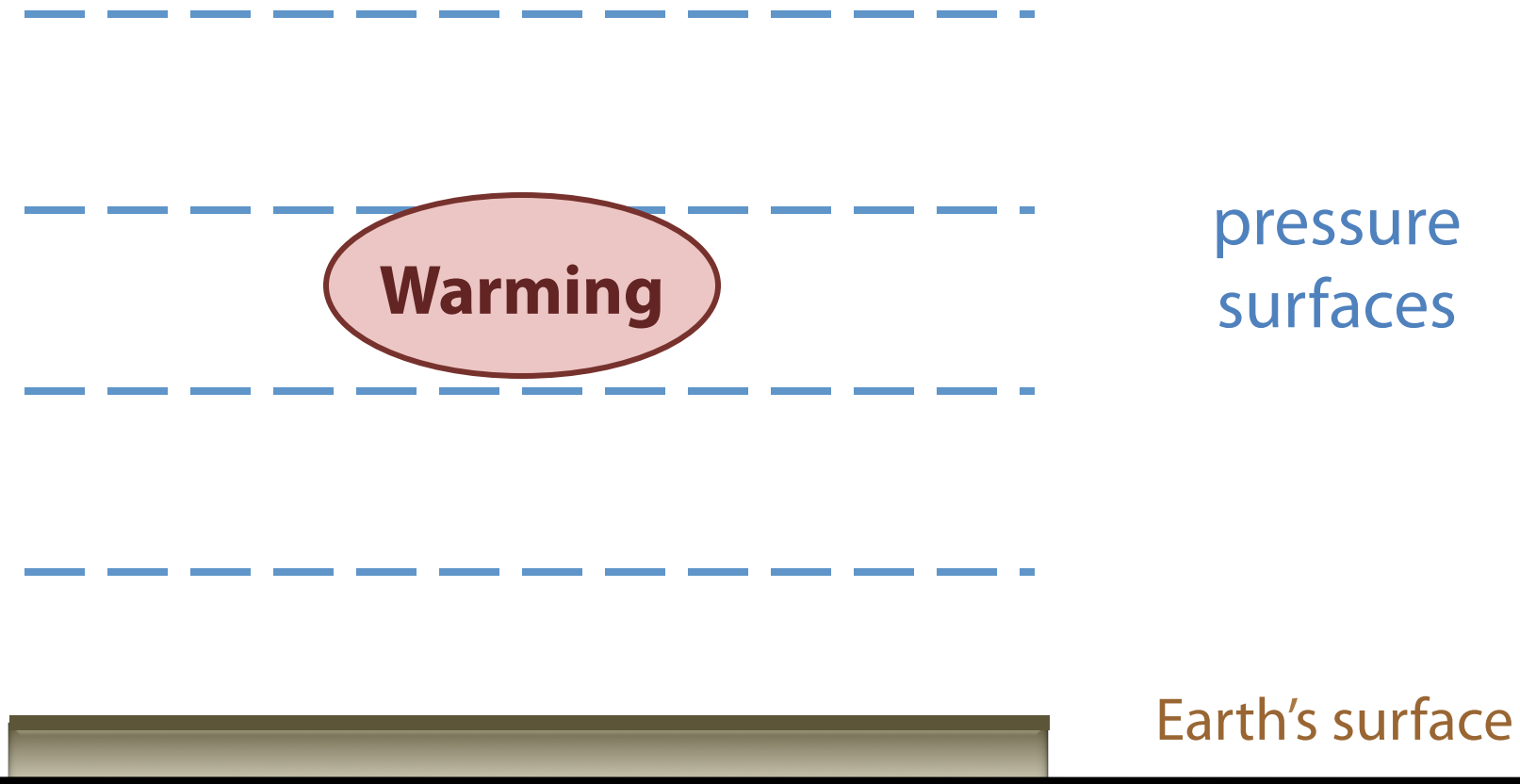
p_s denotes surface pressure

$$\omega(p_s) \approx -\int_0^{p_s} \left(\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} \right)_p dp$$

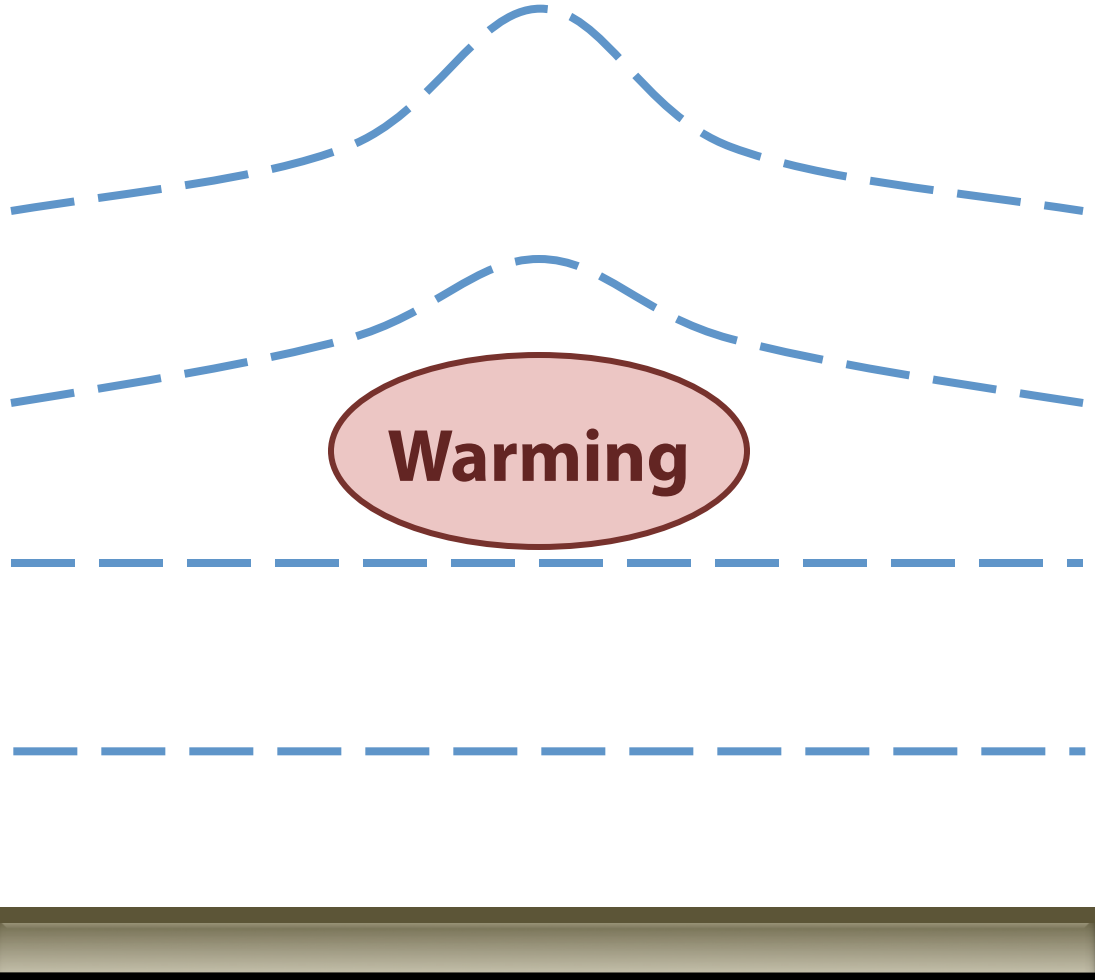
Convergence of mass into the column above will increase the surface pressure. Divergence of mass will decrease the surface pressure.

Development of a Surface Low

Development of a Surface Low



Development of a Surface Low

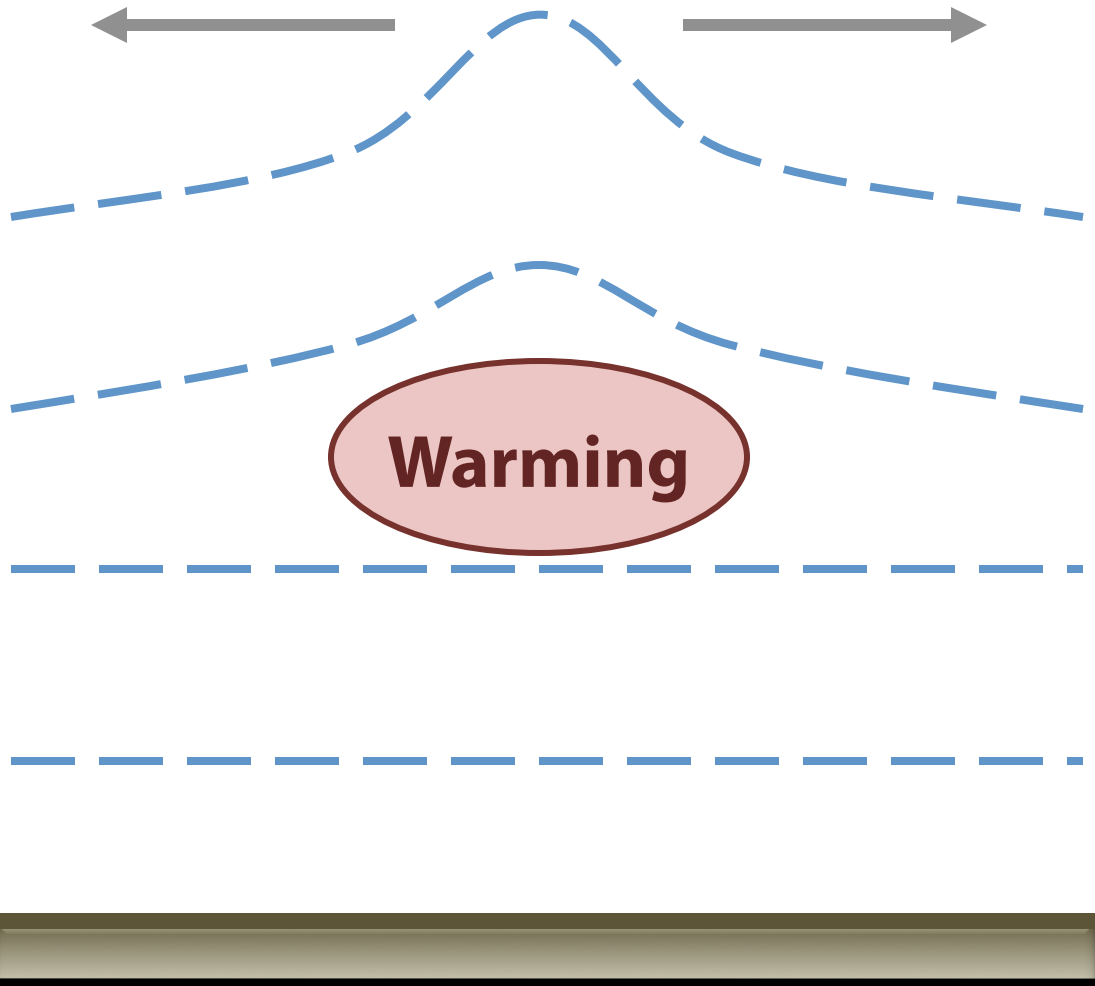


pressure surfaces

warming increases thickness

Earth's surface

Development of a Surface Low

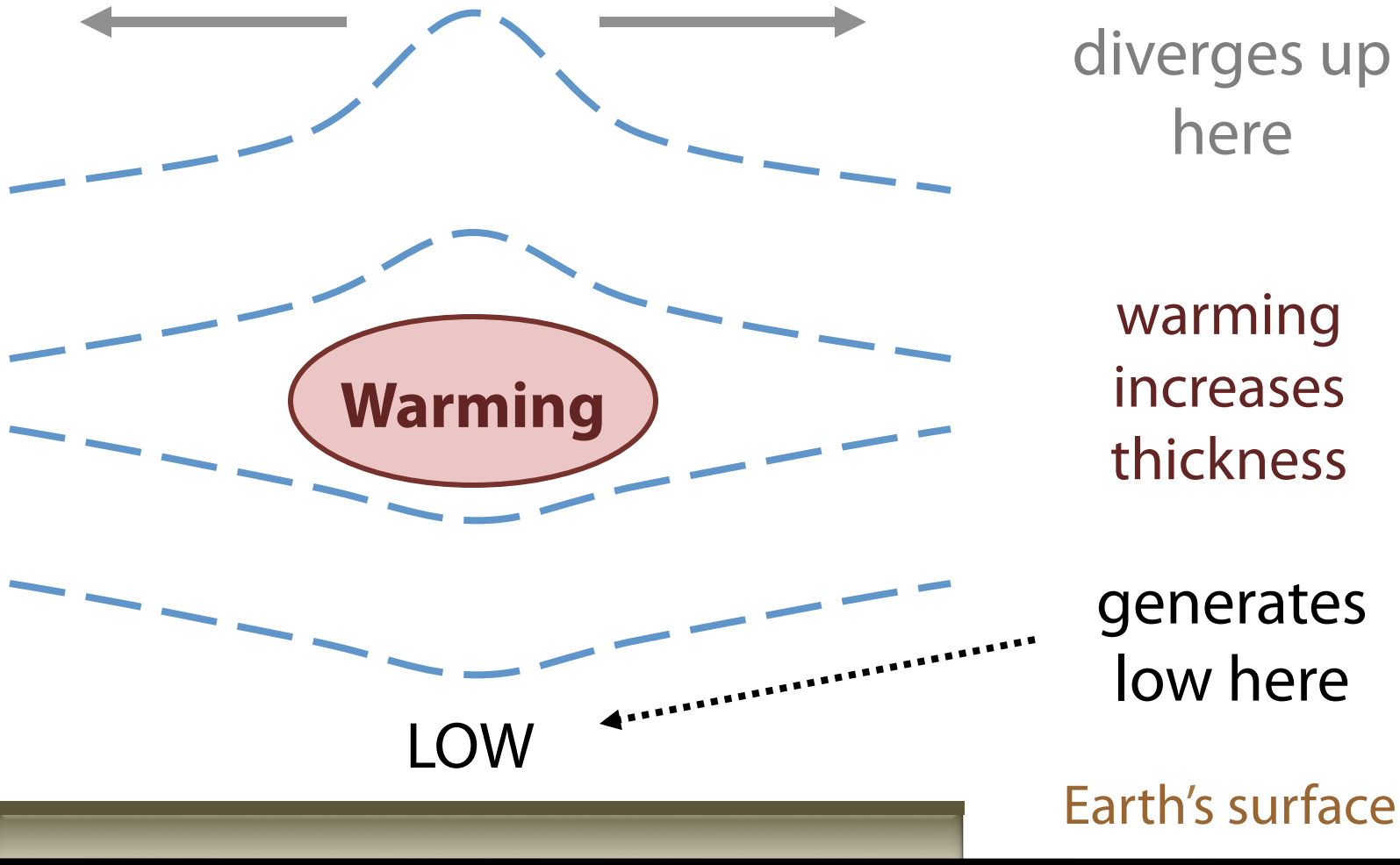


mass diverges up here

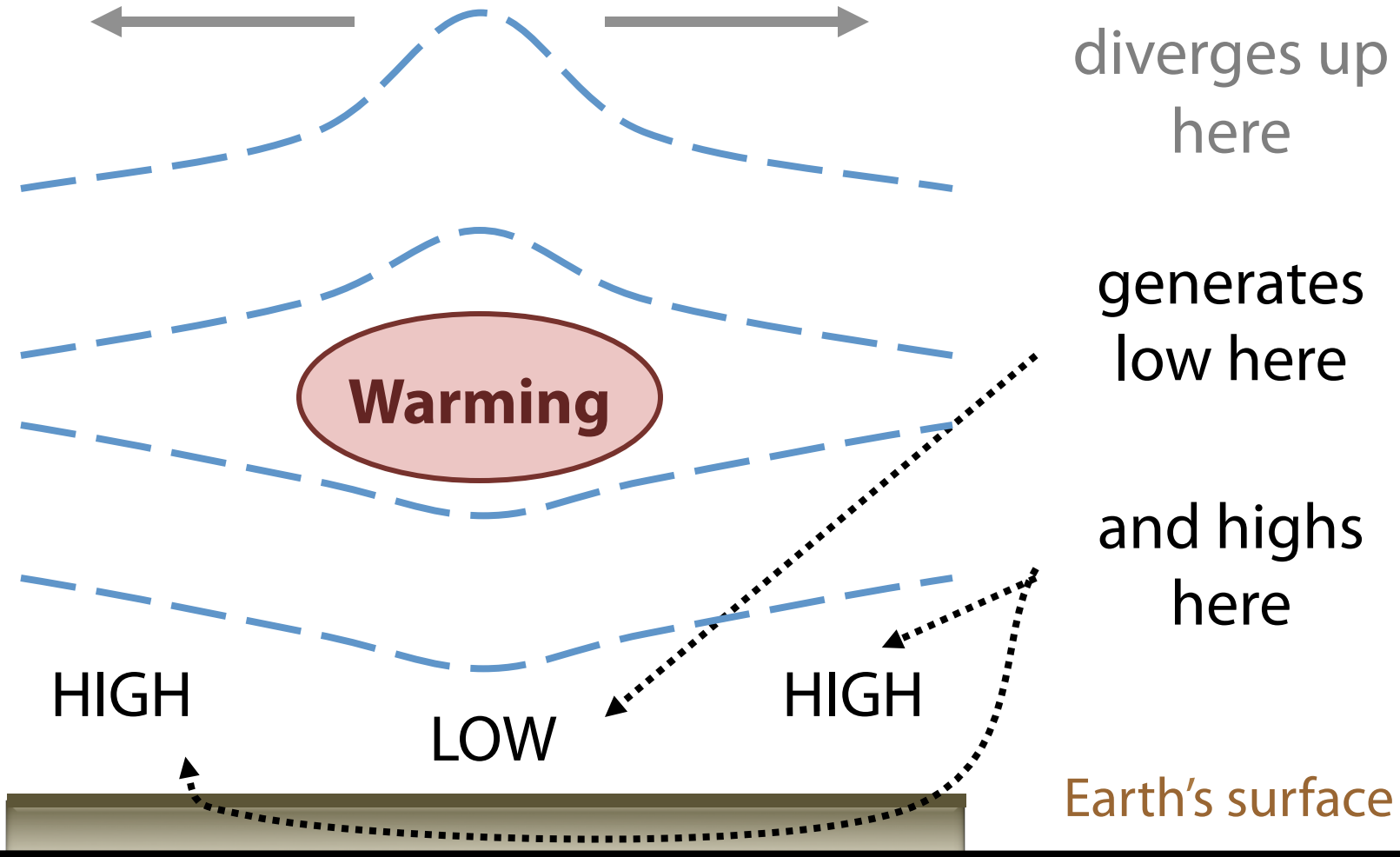
warming increases thickness

Earth's surface

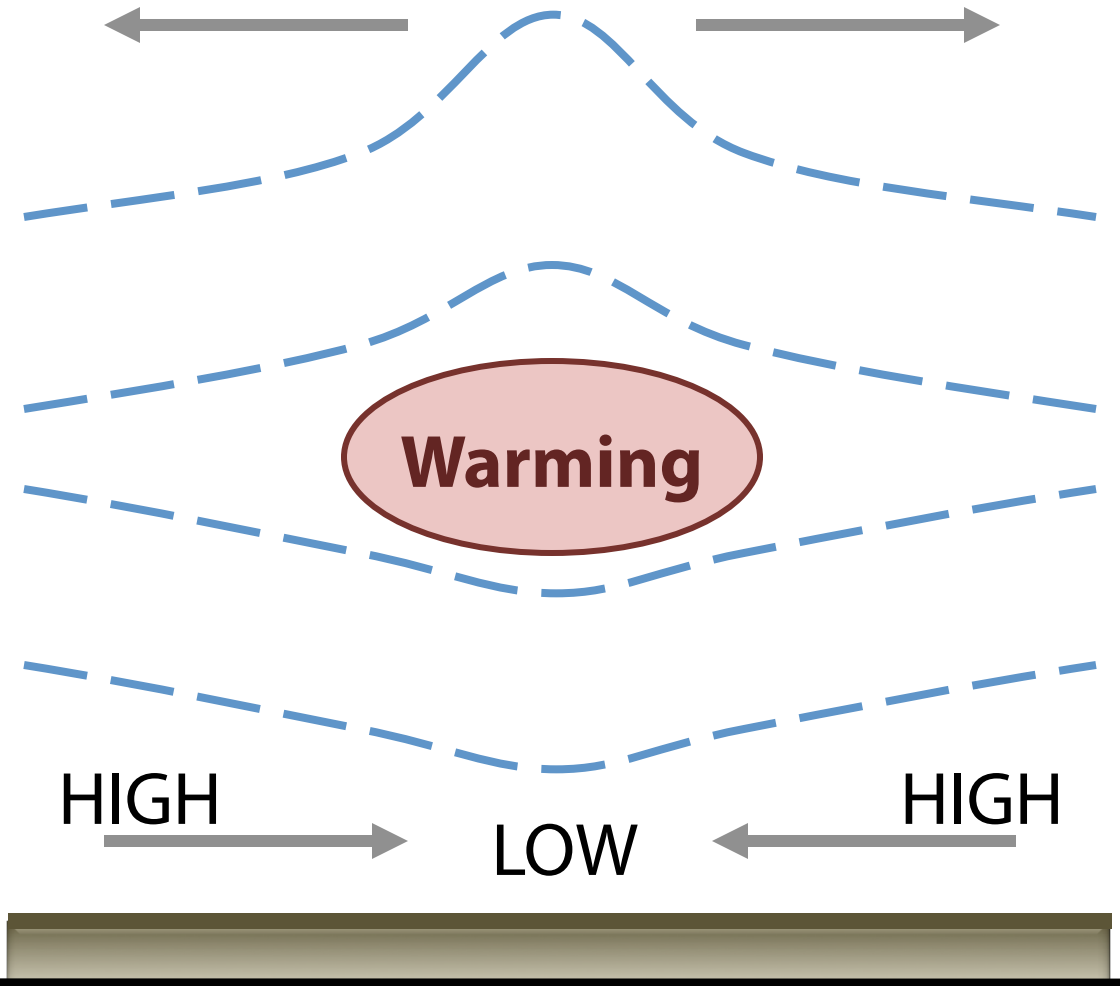
Development of a Surface Low



Development of a Surface Low



Development of a Surface Low



mass diverges up here

pressure gradient initiates convergence down here

Earth's surface