The background of the slide is a vibrant space scene. On the left, a large, dark planet with a textured surface is partially visible. In the center, a bright blue star or nebula glows, with a smaller, blue-tinted planet orbiting it. The right side of the image is filled with a dense field of blue and white stars, creating a sense of depth and cosmic wonder. Two white rounded rectangular boxes with black borders are overlaid on the image, containing text.

Applications of the Basic Equations Chapter 3

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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

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

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

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

Vertical Motion

Recall the equation for ω :

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

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

$w = 0$ 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

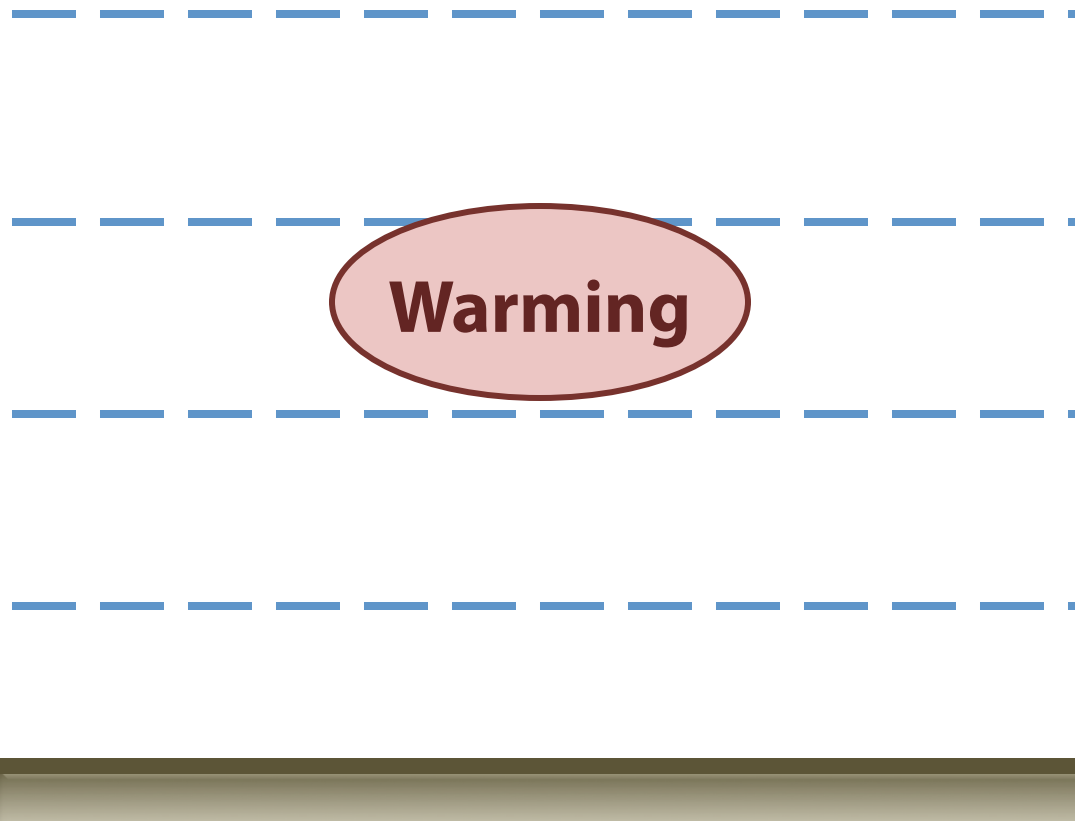


pressure
surfaces



Earth's surface

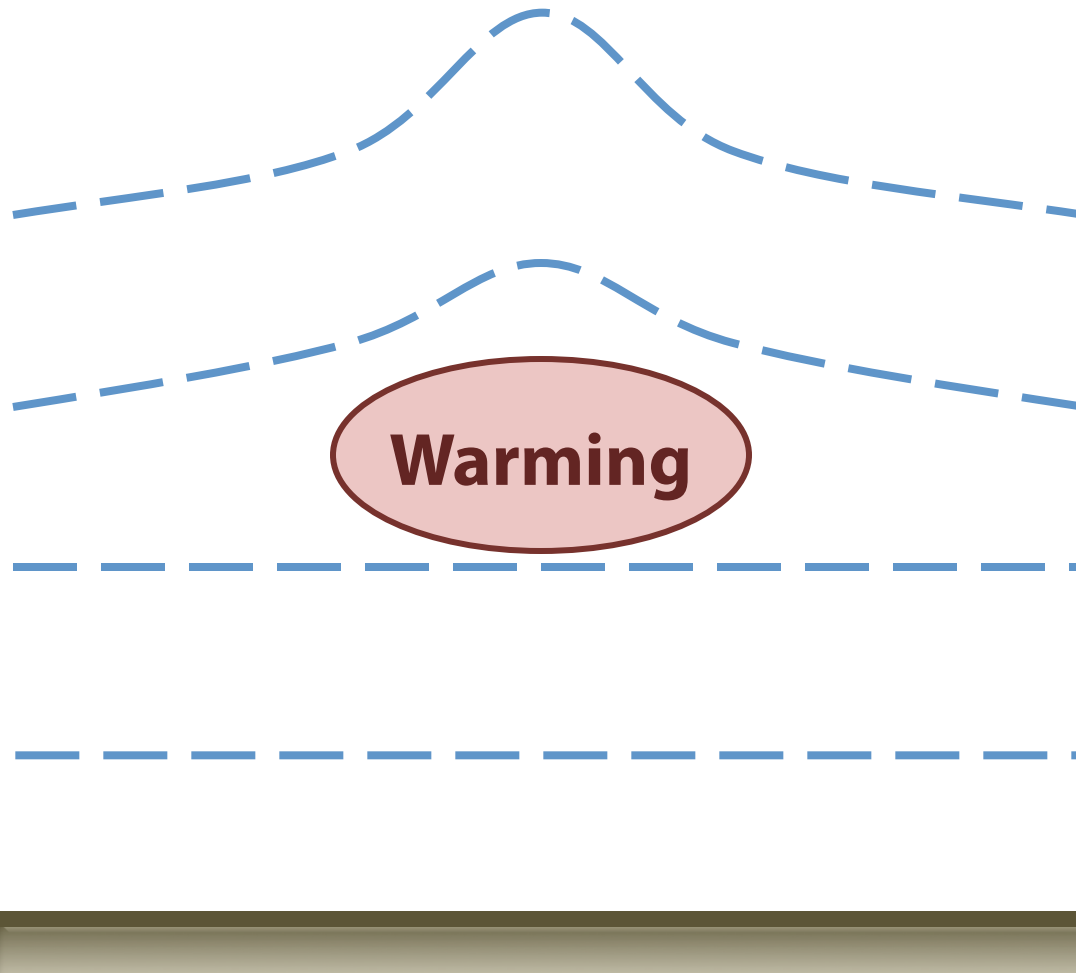
Development of a Surface Low



pressure
surfaces

Earth's surface

Development of a Surface Low

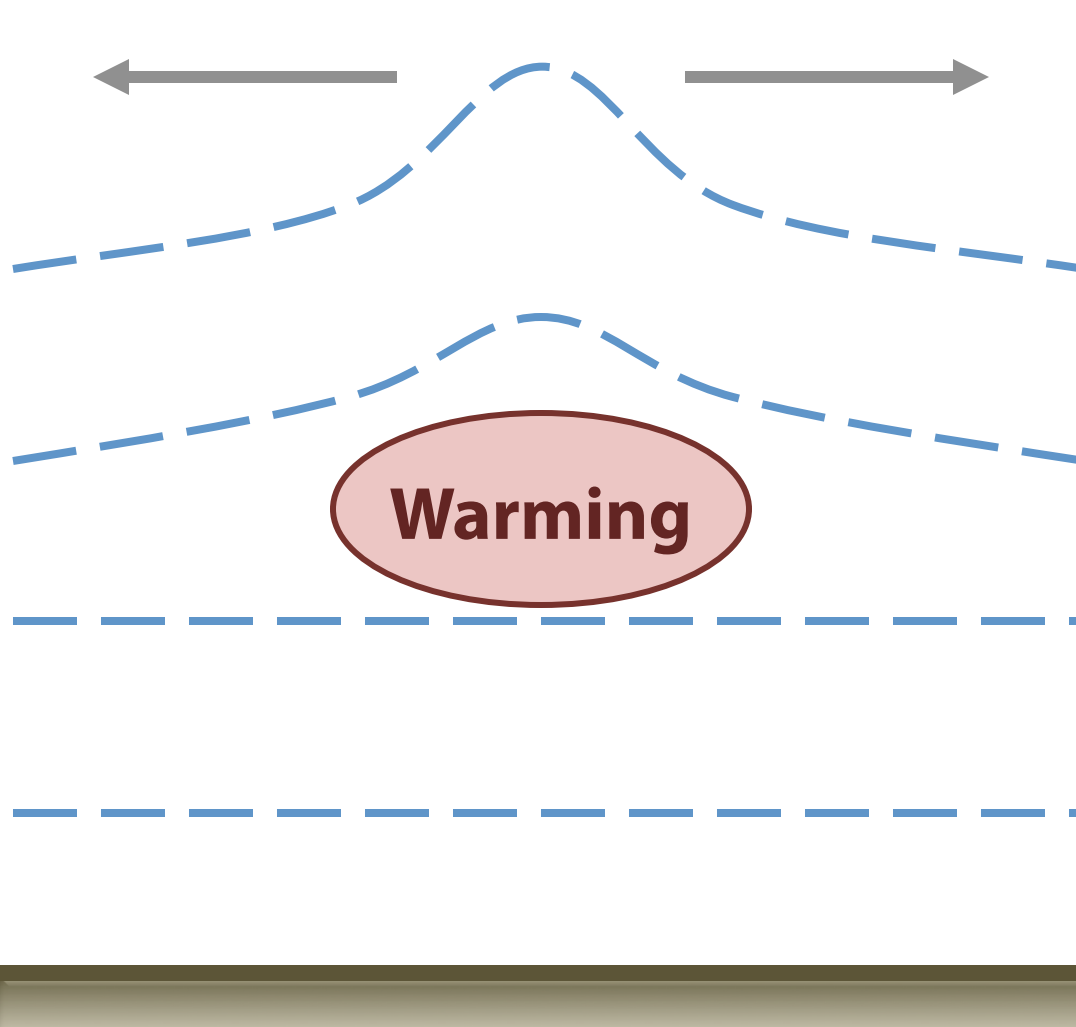


pressure
surfaces

warming
increases
thickness

Earth's surface

Development of a Surface Low

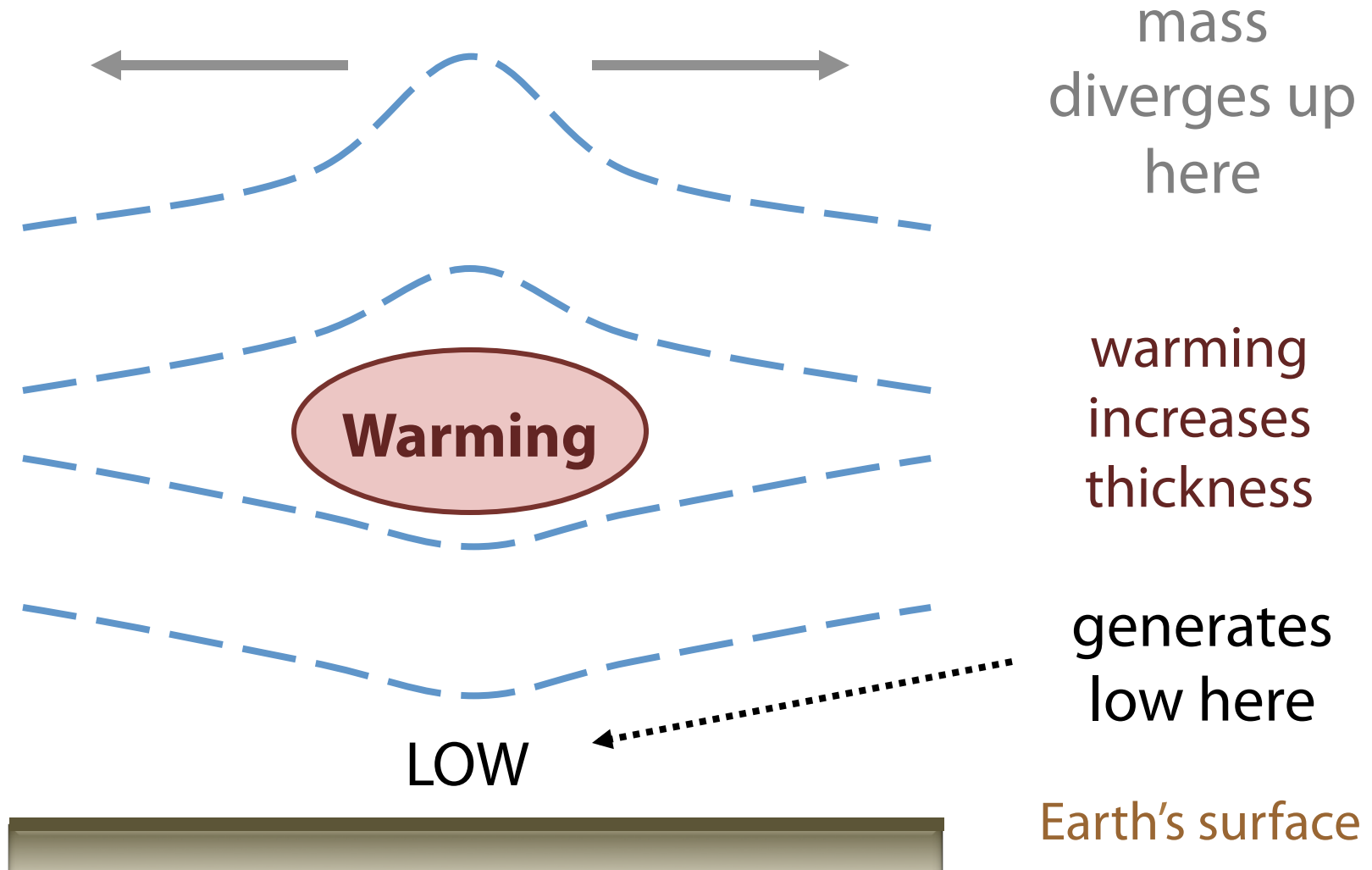


mass
diverges up
here

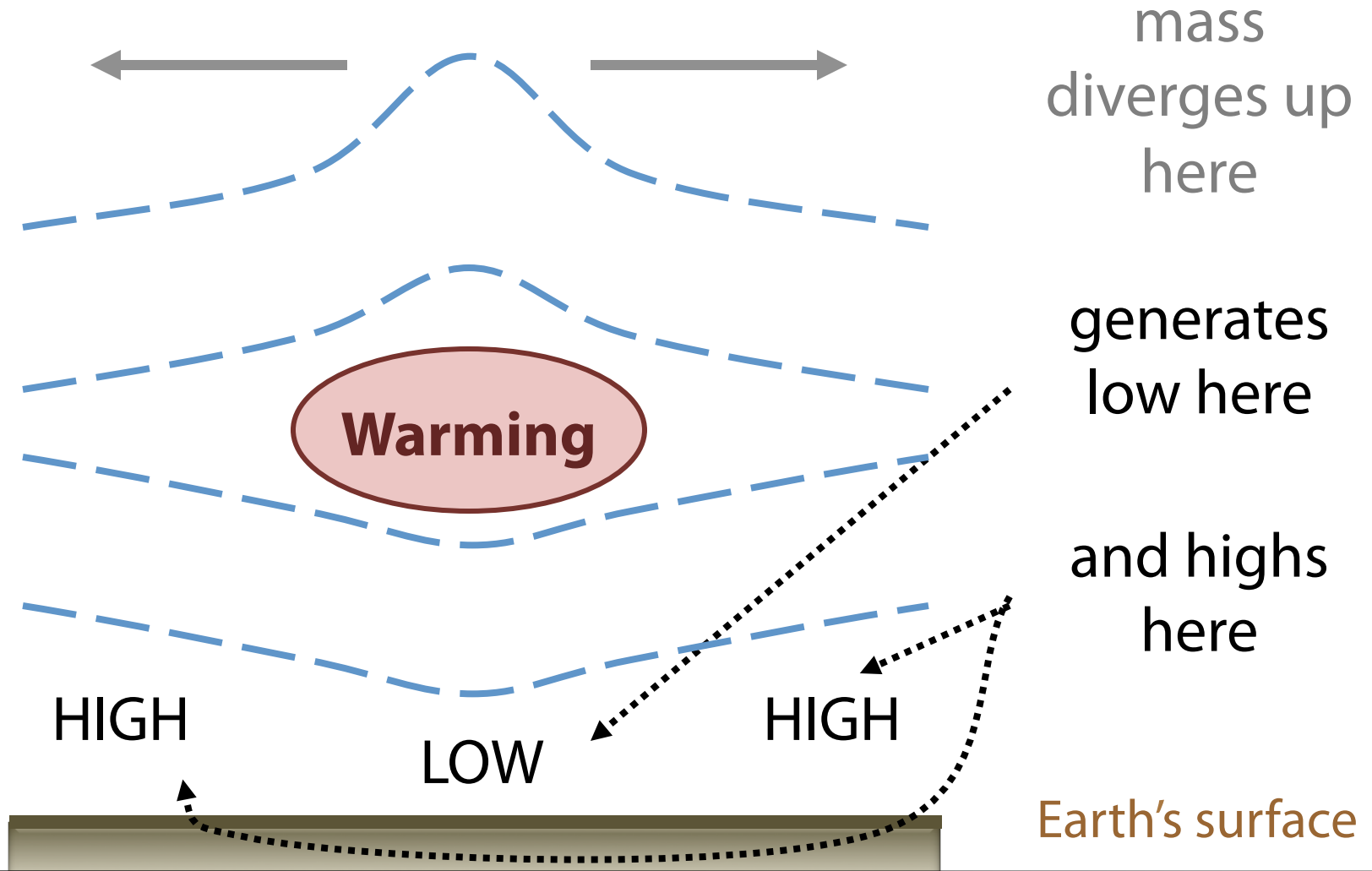
warming
increases
thickness

Earth's surface

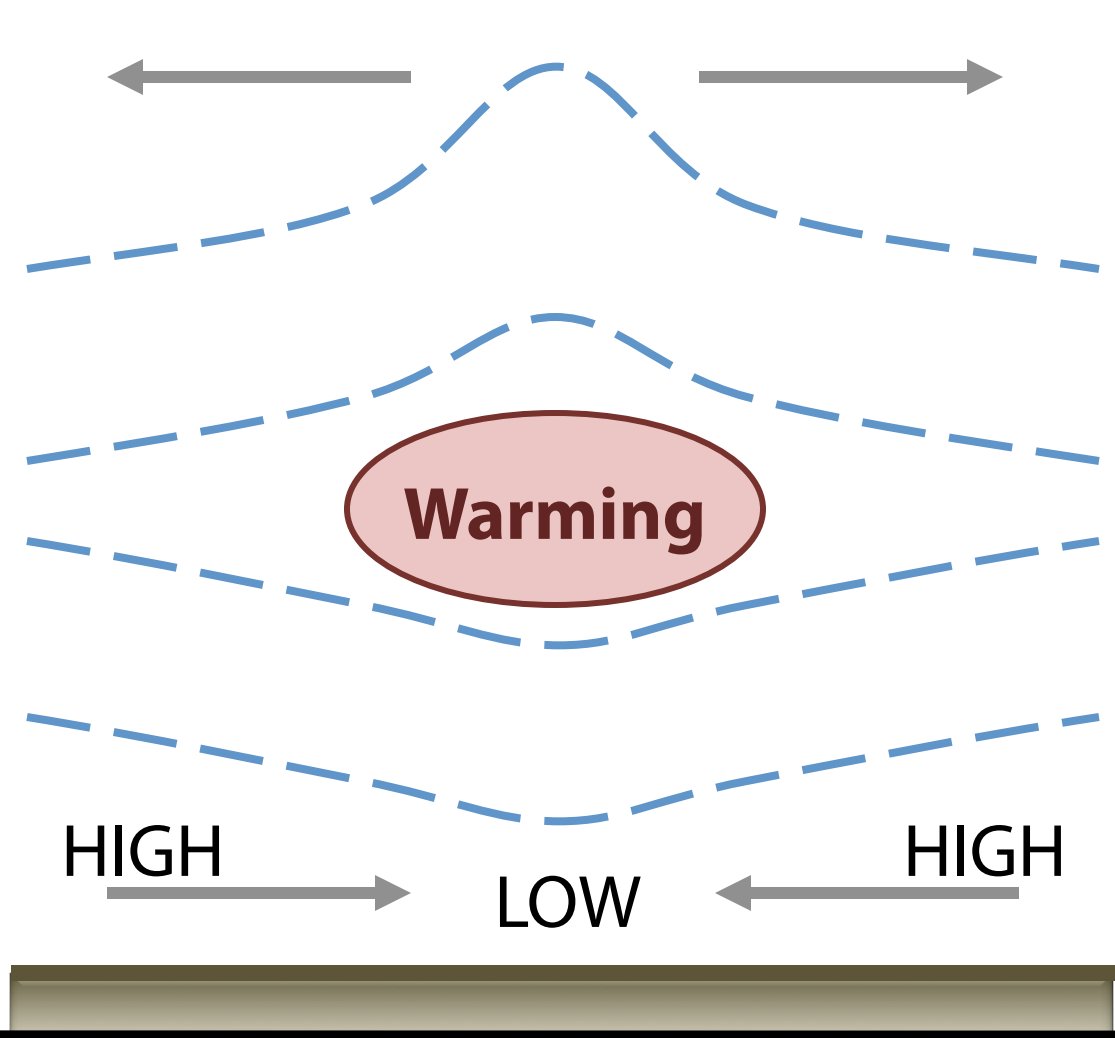
Development of a Surface Low



Development of a Surface Low



Development of a Surface Low



mass
diverges up
here

pressure
gradient
initiates
convergence
down here

Earth's surface