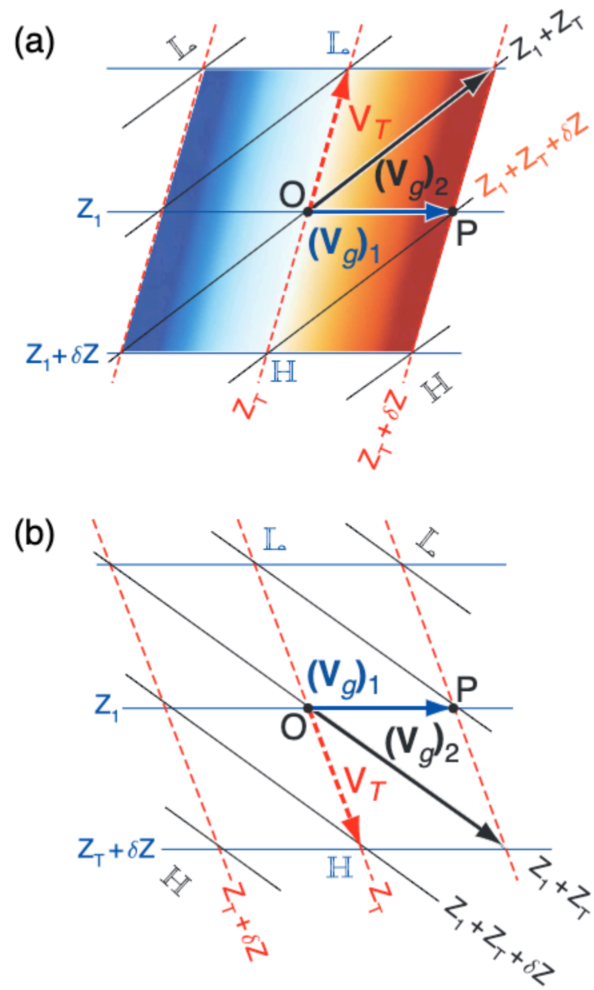

Fig. 7.14 Relationships among isotherms, geopotential height contours, and geostrophic wind in layers with (a) cold and (b) warm advection. Solid blue lines denote the geopotential height contours at the bottom of the layer and solid black lines denote the geopotential height contours at the top of the layer. Red lines represent the isotherms or thickness contours within the layer.

get rid of Φ

b. (5 points) **What is the final relative circulation** around the loop?

$$\frac{d\vec{V}}{dt} = f(\vec{V} \times \hat{k}) - \nabla\Phi$$

two approaches! → derivatives (construct a ? equation)

→ integrals around any closed loop

$$\boxed{\oint \frac{d\vec{V}}{dt} dl = \oint f(\vec{V} \times \hat{k}) dl} + \cancel{\oint \nabla\Phi \, dl} \to 0$$

$$\oint (\nabla\psi) dl = 0$$

c. (5 points) **What tangential wind speed** does this imply? **Clockwise or counter-clockwise**?

could work with this for circular loop changing its area or radius.

rate of change of vorticity can be written in the form

$$\frac{\partial}{\partial t}(f + \zeta) = -\mathbf{V} \cdot \nabla(f + \zeta) - (f + \zeta)(\nabla \cdot \mathbf{V}) \quad (7.21a)$$

or, in Lagrangian form,

$$\frac{d}{dt}(f + \zeta) = -(f + \zeta)(\nabla \cdot \mathbf{V}) \qquad (7.21b)$$

$$\frac{dA}{dt} = \delta x \delta y \frac{\partial u}{\partial x} + \delta x \delta y \frac{\partial v}{\partial y}$$

Dividing both sides by $\delta x \delta y$ yields

$$\frac{1}{A} \frac{dA}{dt} = \frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} \tag{7.2}$$

where the right-hand side may be recognized as the Cartesian form of the divergence in Table 7.1. Hence, *divergence is the logarithmic rate of expansion of the area enclosed by a marked set of parcels moving with the flow*. Negative divergence is referred to as *convergence*.

○ becomes

(circular loop of air)

write equation for tangential velocity V_t

$$\frac{dV_{tan}}{dt} = -fV_r$$

Integrate in a loop: circular radius r

$$\oint \frac{dV_{tan}}{dt} dl = -\oint f V_r \, dl$$

$$\int \boxed{\frac{dV_{tan}}{dt} \cdot (2\pi r) = f V_r (2\pi r)} \; \cancel{\oint f} \, dt$$

(dr/dt)

$\Rightarrow$ integration by parts