A Rotational View of the Atmoshere

Chapter 4

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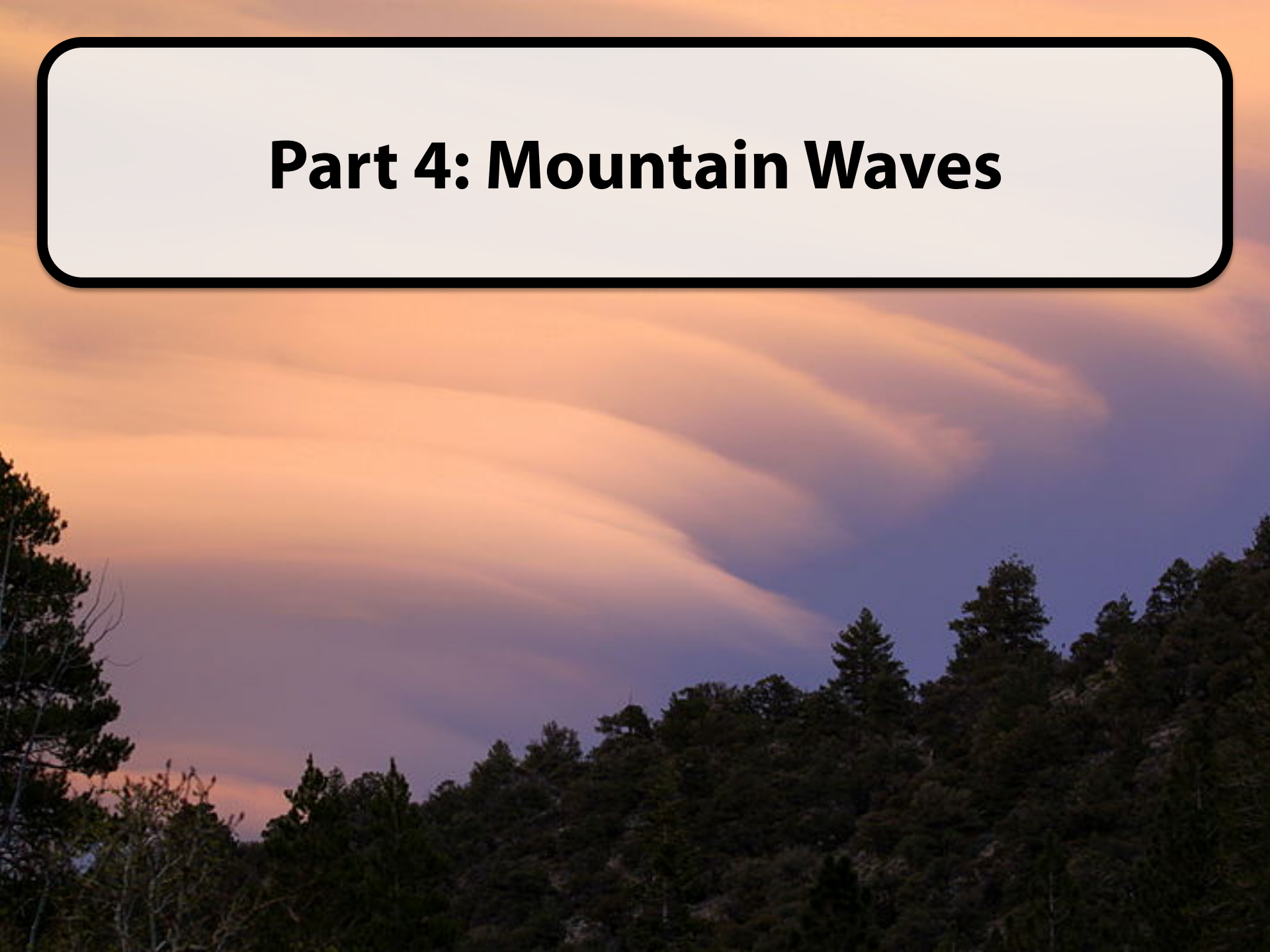
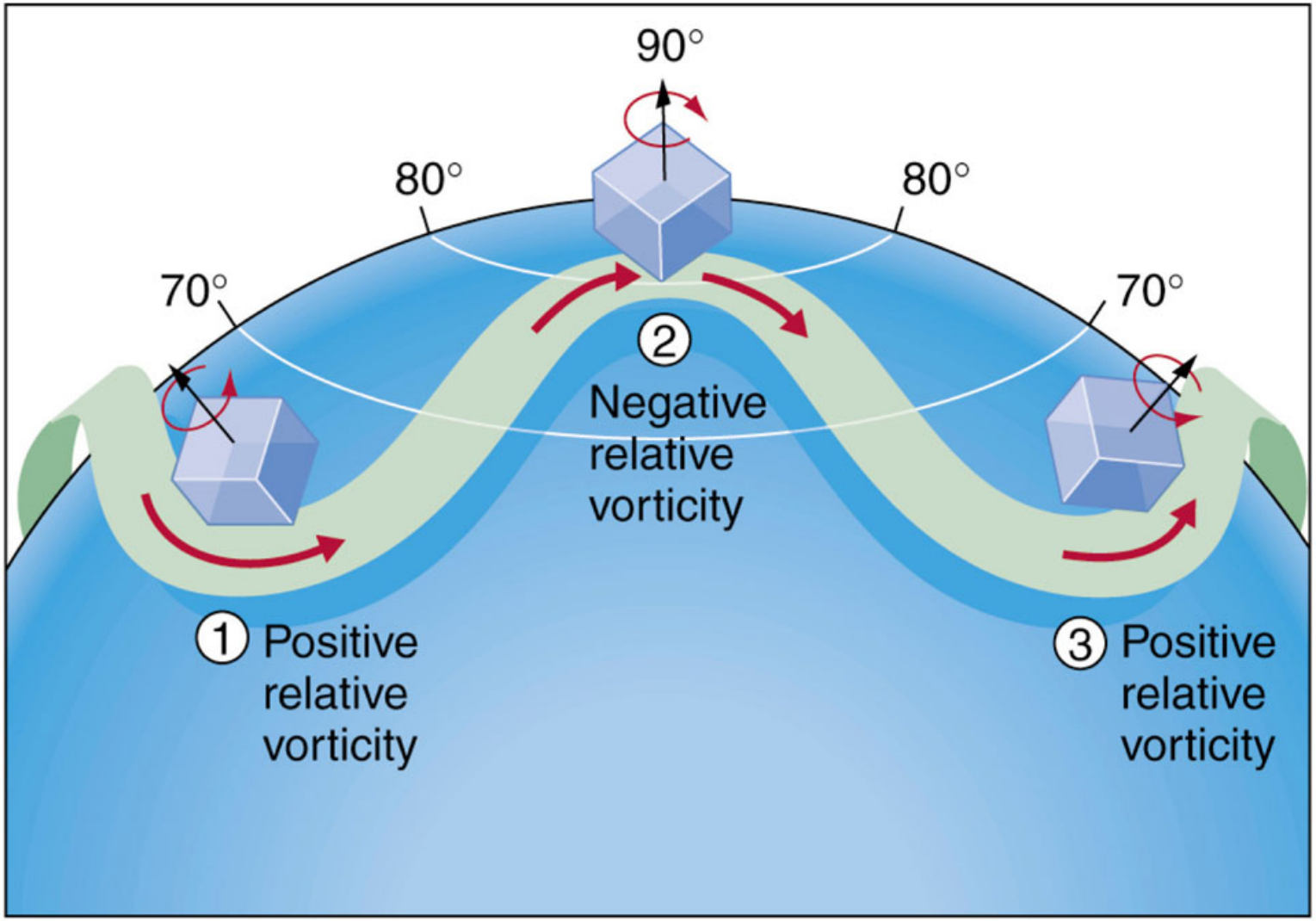
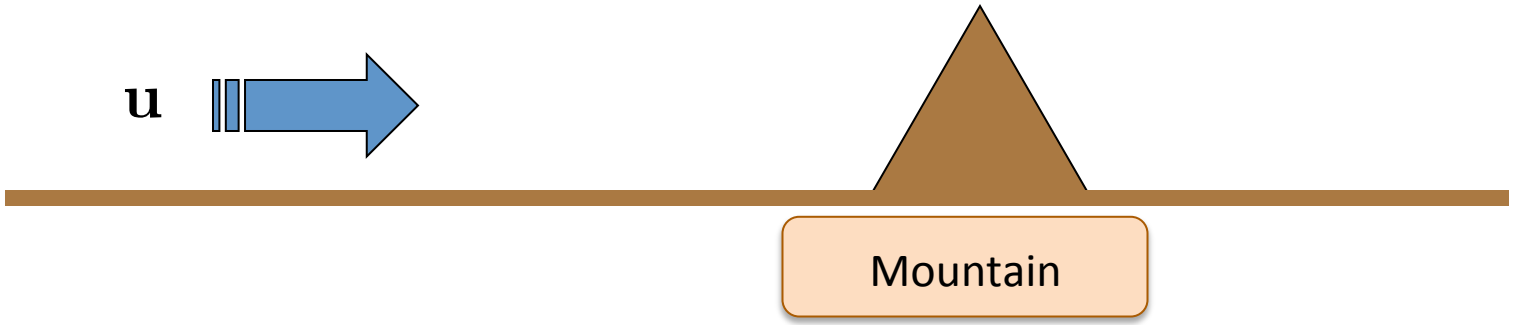
Part 4: Mountain Waves



Question: What might cause this wave-like flow?



Flow Over a Mountain



Potential Vorticity

In a Barotropic Fluid

For a barotropic, incompressible and homogeneous fluid:

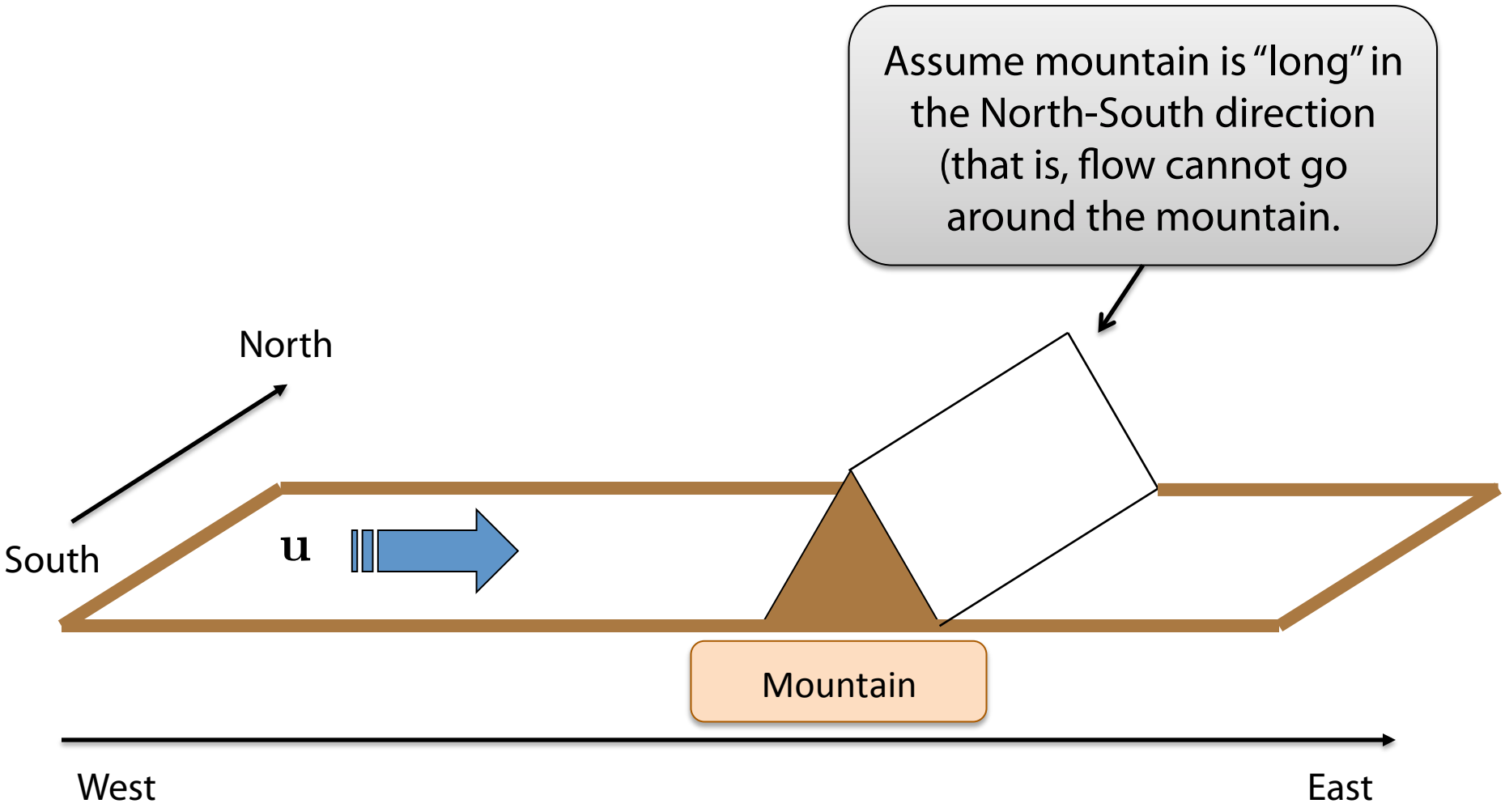
$$\frac{D_h}{Dt}\left[\frac{\zeta_g + f}{h}\right] = 0$$

Definition: The **barotropic potential vorticity** of a fluid column is defined as

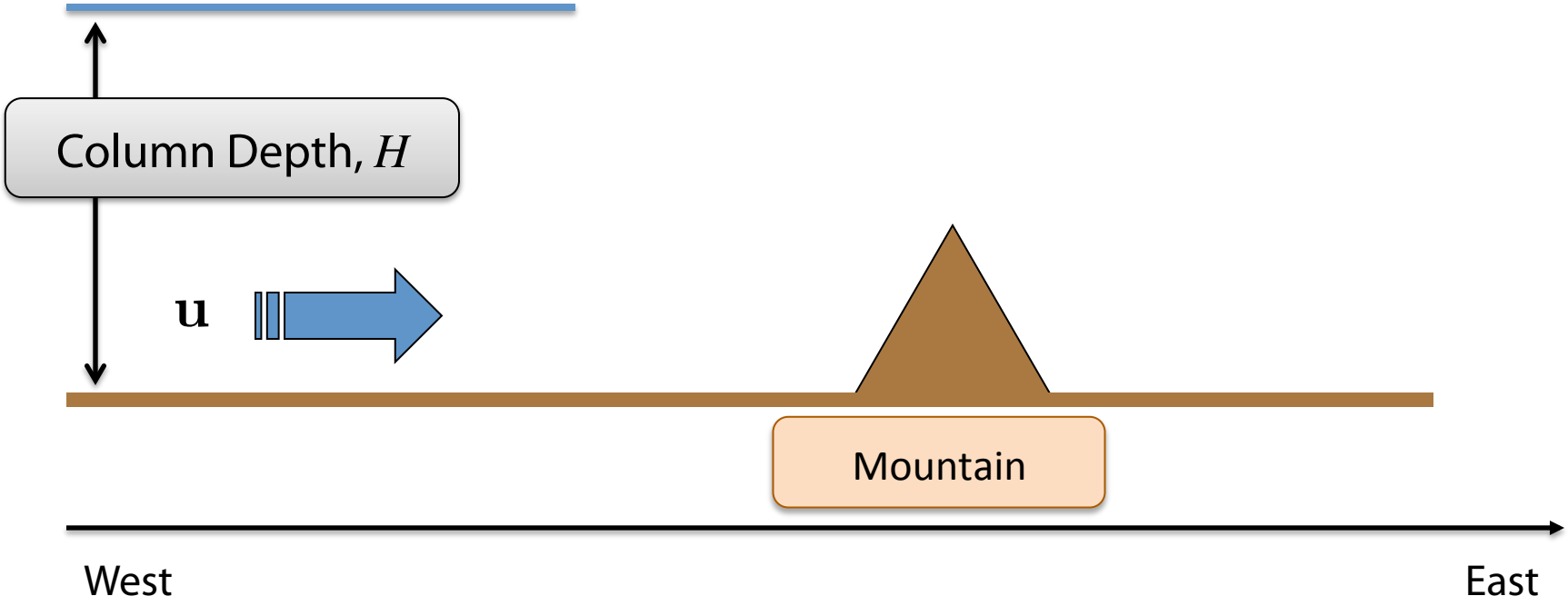
$$PV = \frac{\zeta_g + f}{h}$$

Question: What can barotropic PV tell us about flow over a mountain?

Flow Over a Mountain



Flow Over a Mountain



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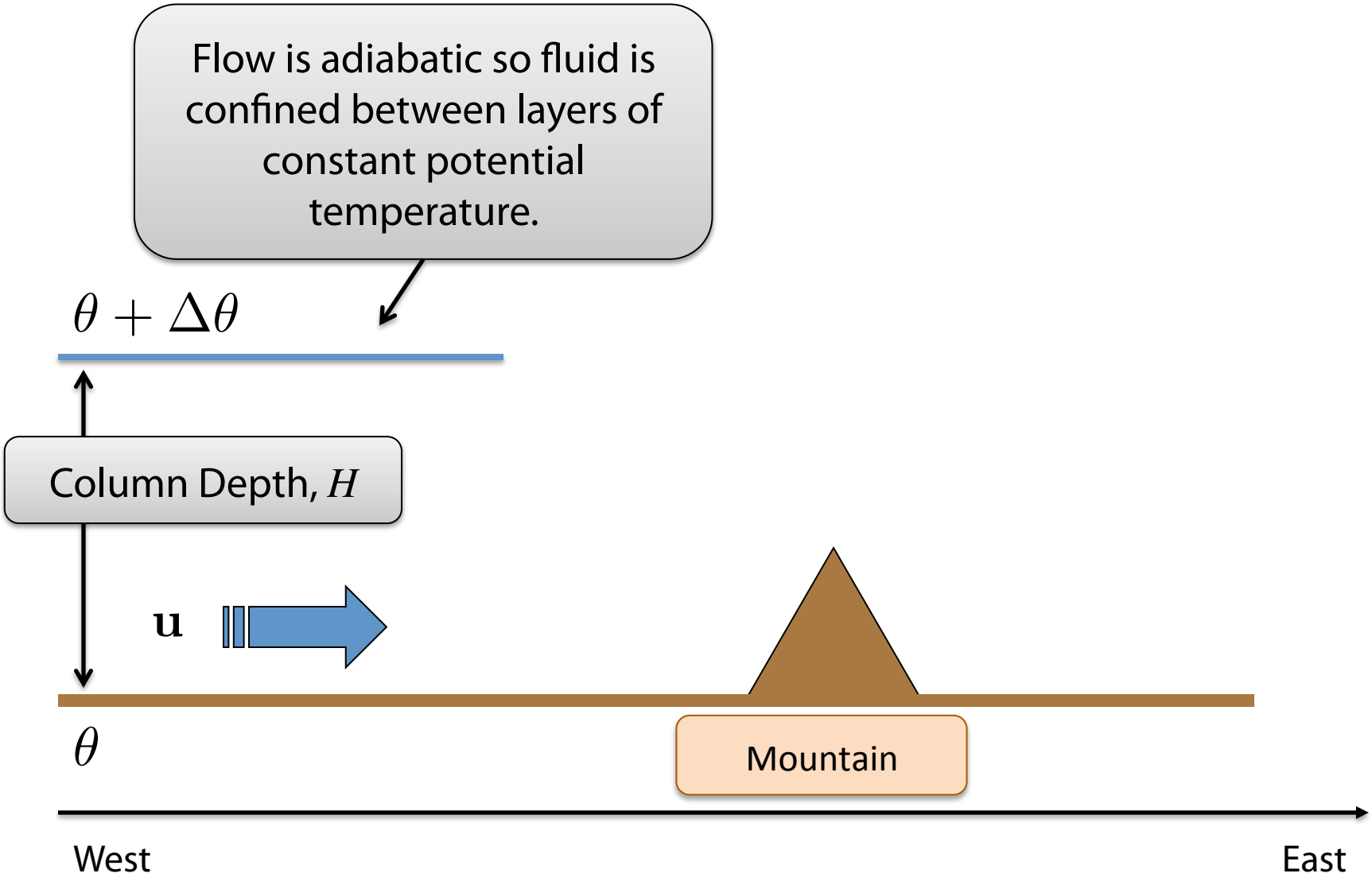
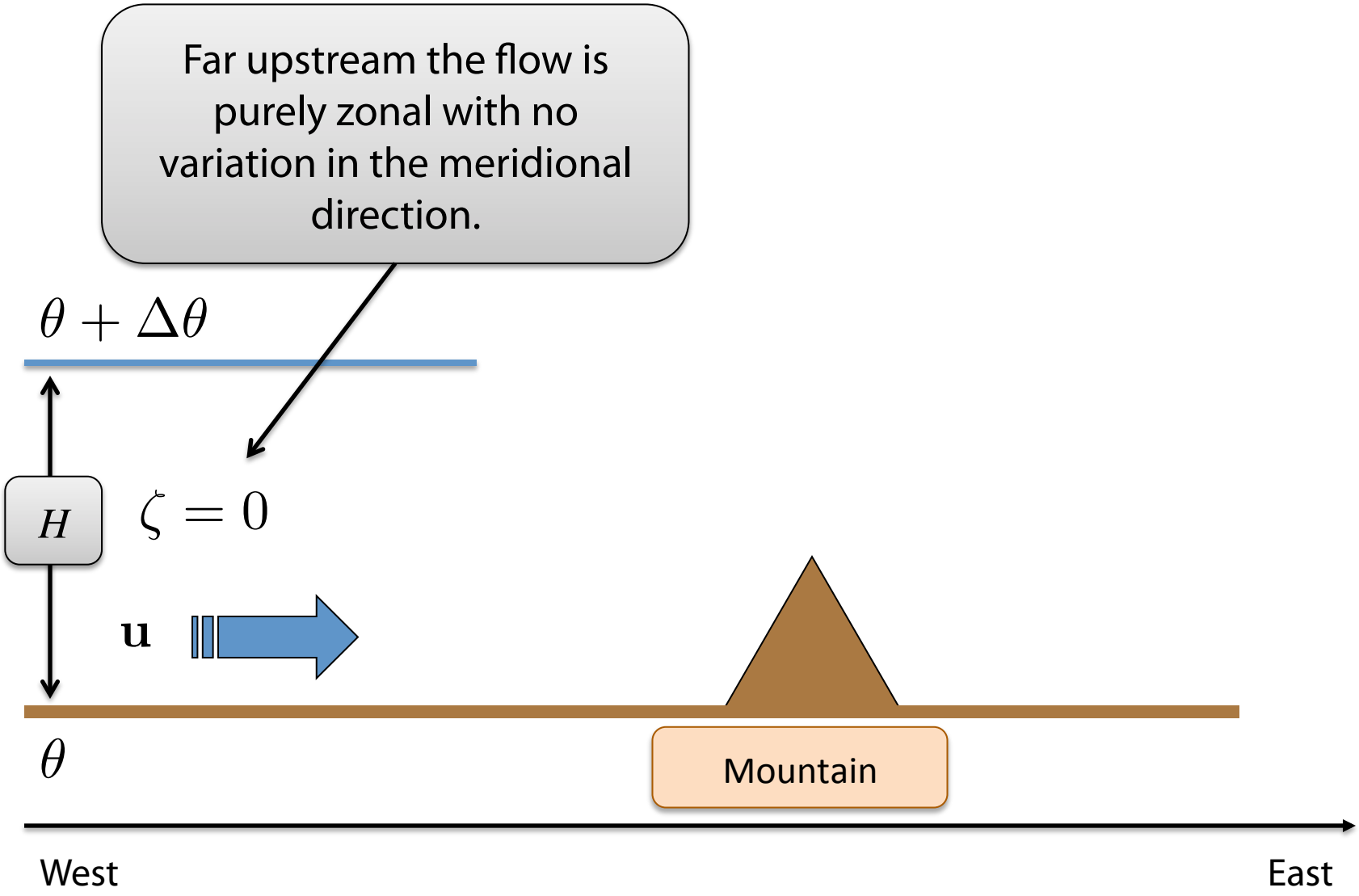
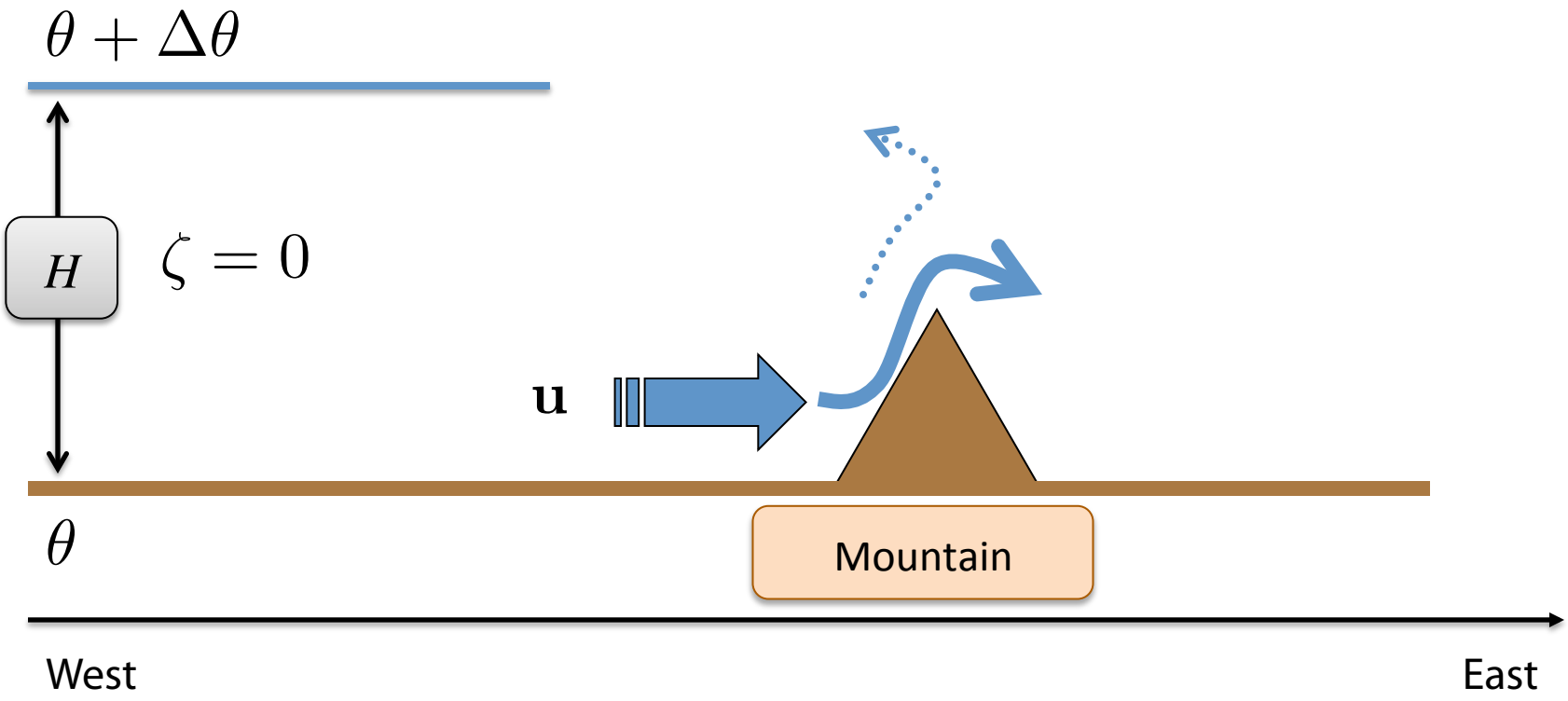


Flow Over a Mountain



Flow Over a Mountain

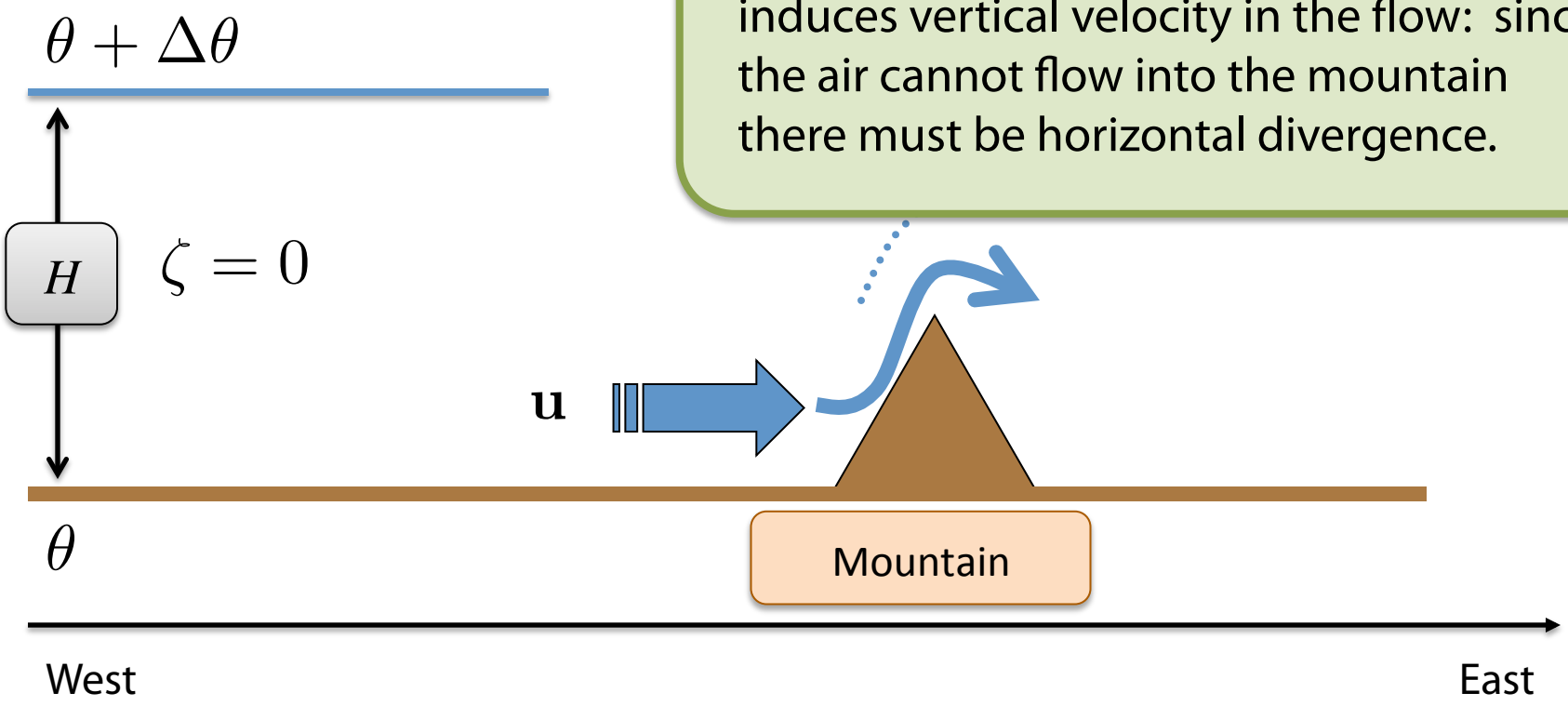
Question: What happens when the wind reaches the mountain?



Flow Over a Mountain

Question: What happens when the wind reaches the mountain?

Answer: Air must be lifted. The mountain induces vertical velocity in the flow: since the air cannot flow into the mountain there must be horizontal divergence.



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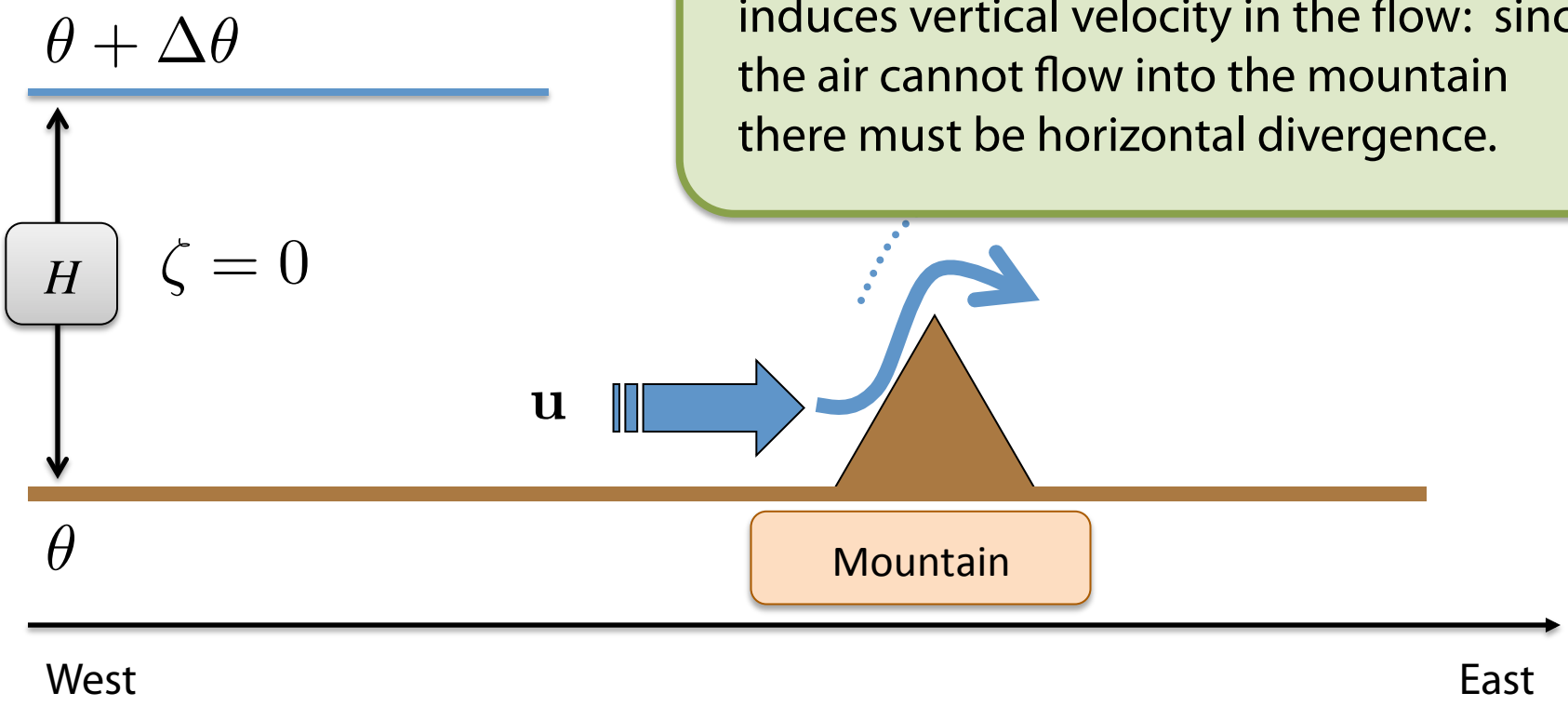
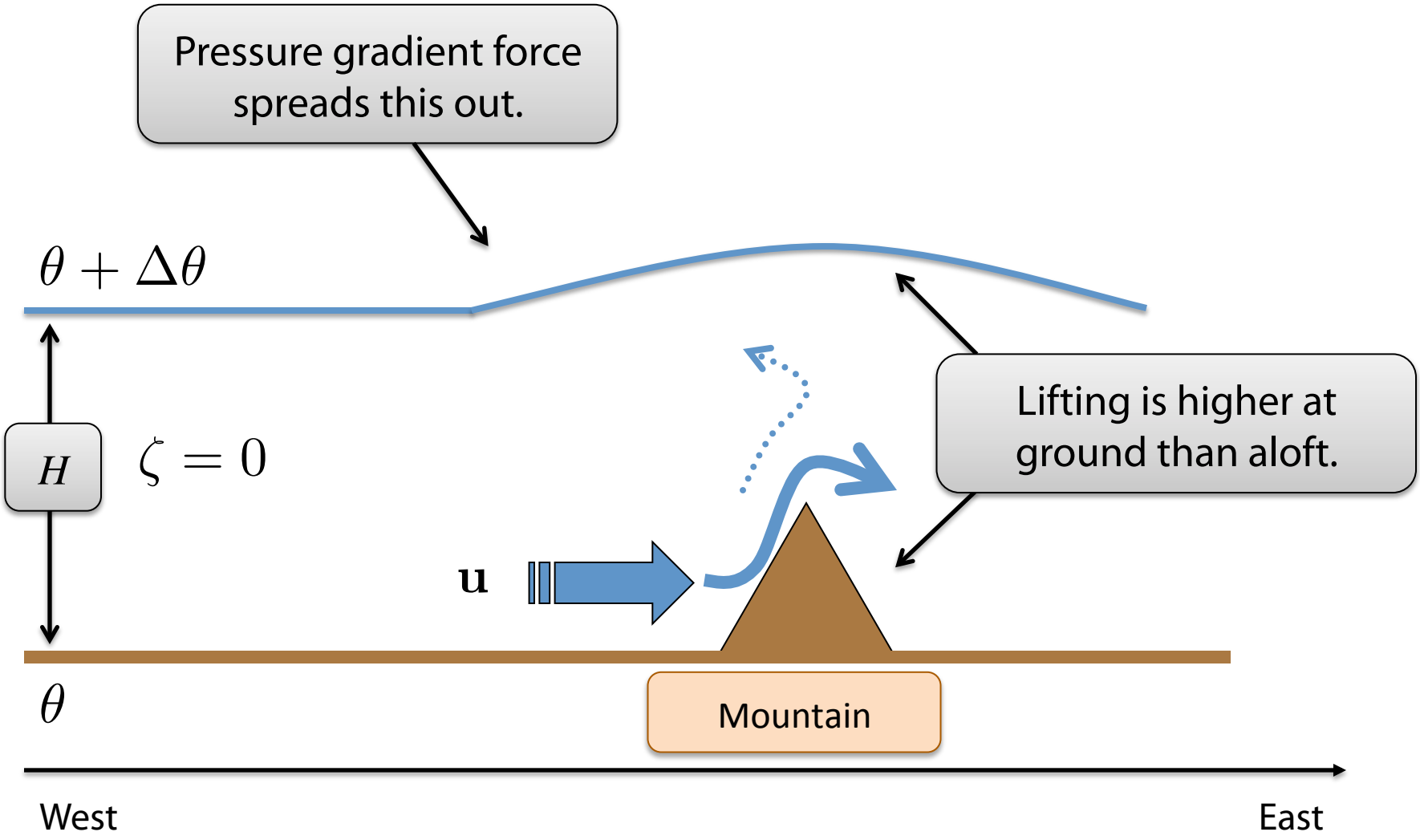


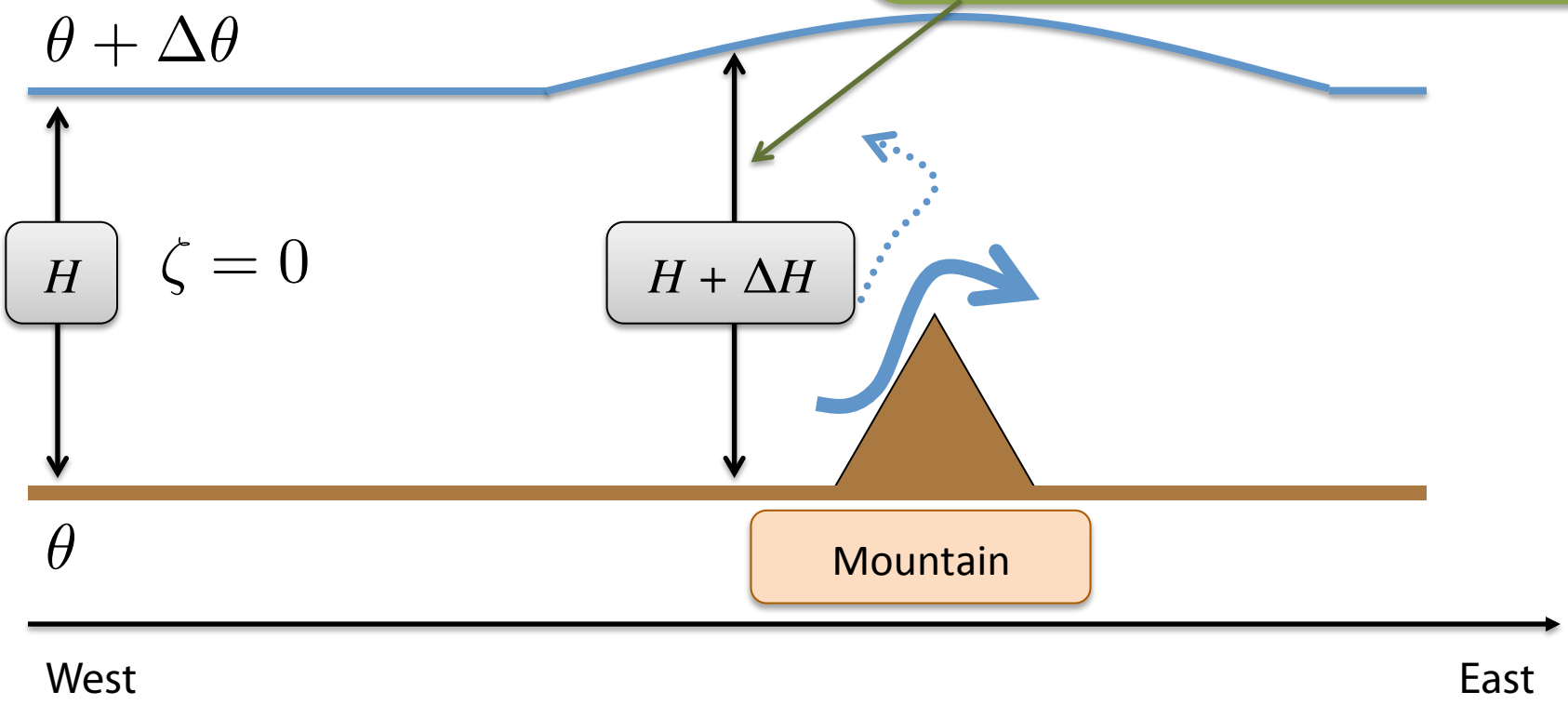
Flow Over a Mountain



Flow Over a Mountain

$$\frac{D_h}{Dt}\left[\frac{\zeta_g + f}{h}\right] = 0$$

Observe: By conservation of PV, ζ must increase here

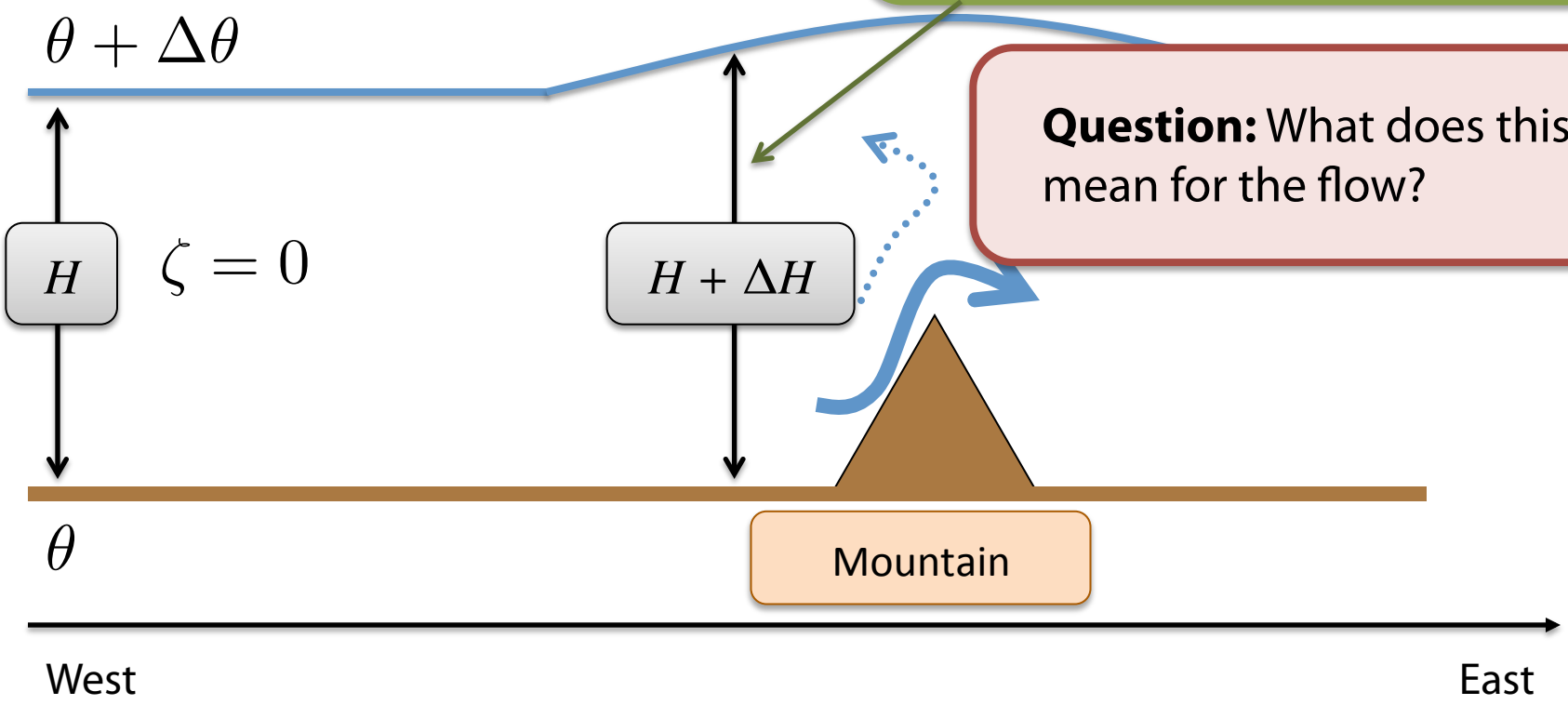


Flow Over a Mountain

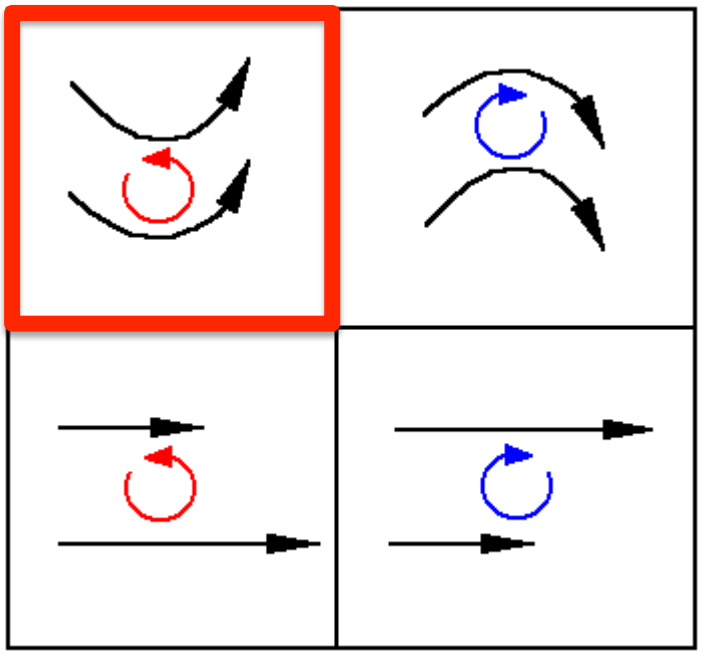
$$\frac{D_h}{Dt}\left[\frac{\zeta_g + f}{h}\right] = 0$$

Observe: By conservation of PV, ζ must increase here

Question: What does this mean for the flow?



Vorticity

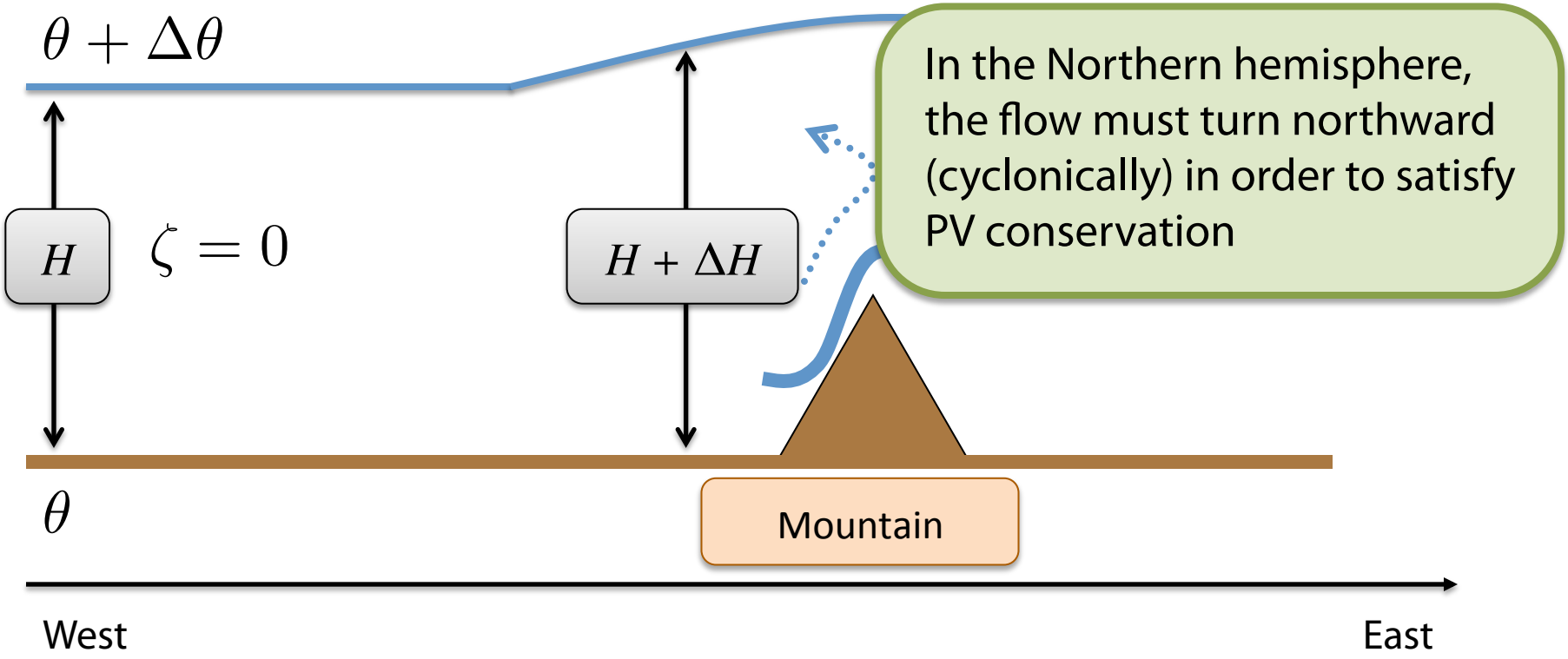


Shear vorticity requires meridional asymmetry

Flow Over a Mountain

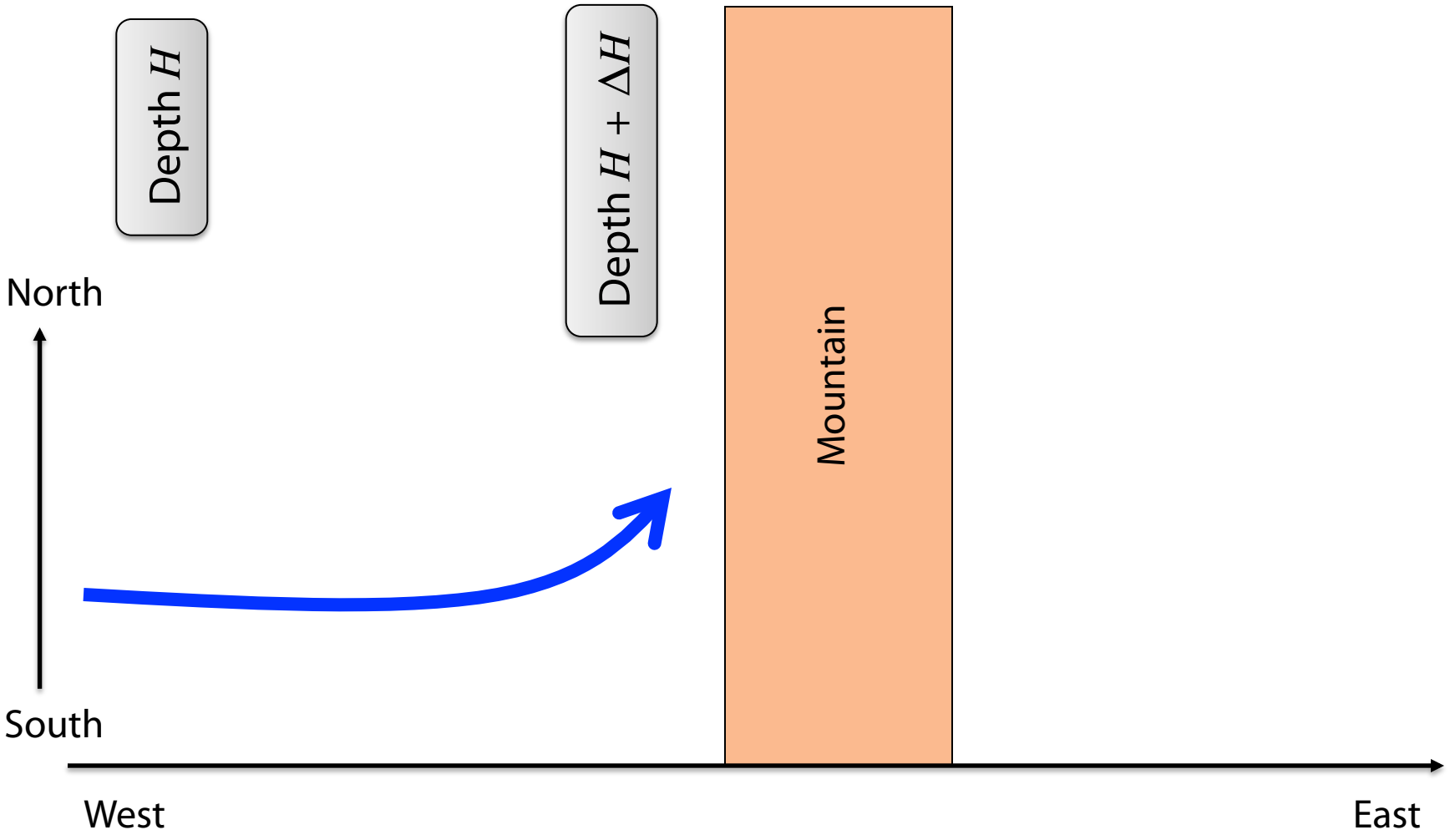
Question: What happens to air as it hits the mountain?

By conservation of PV, ζ must increase here.



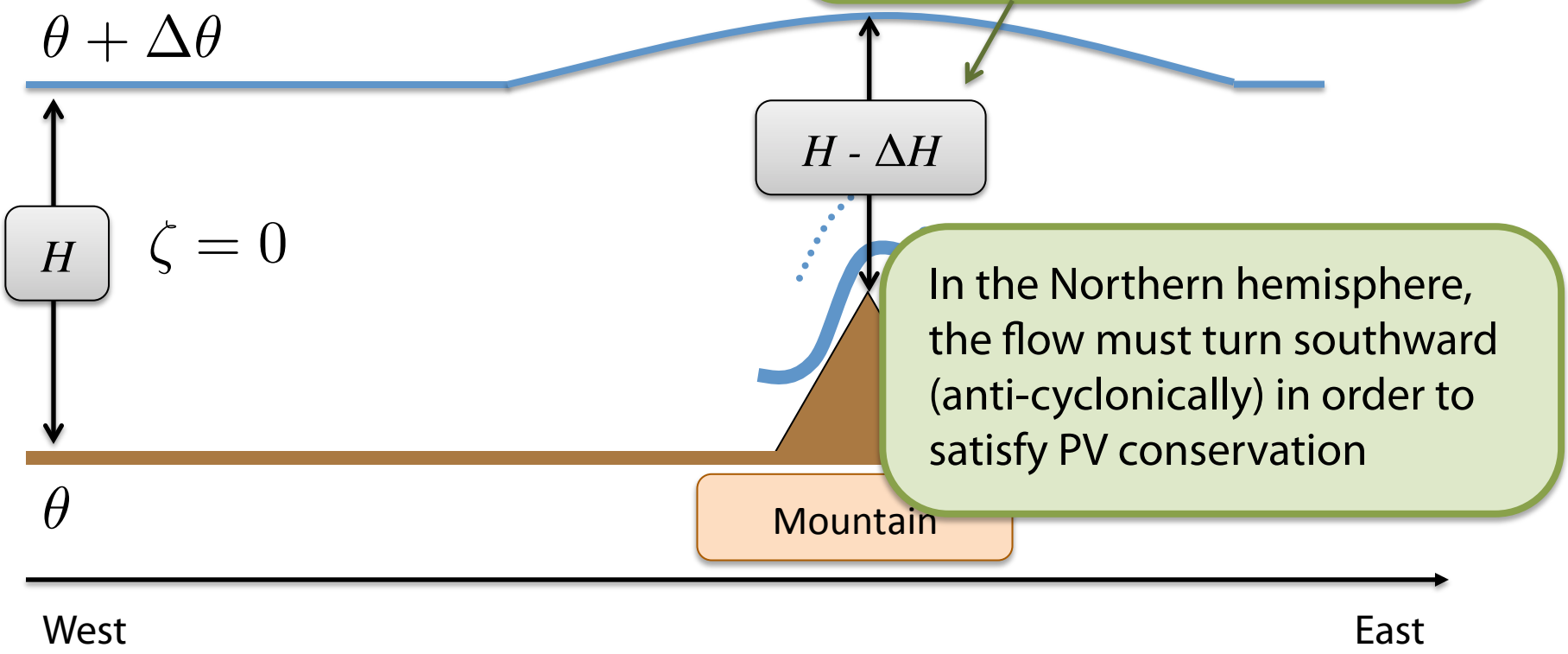
Flow Over a Mountain

Looking down from above

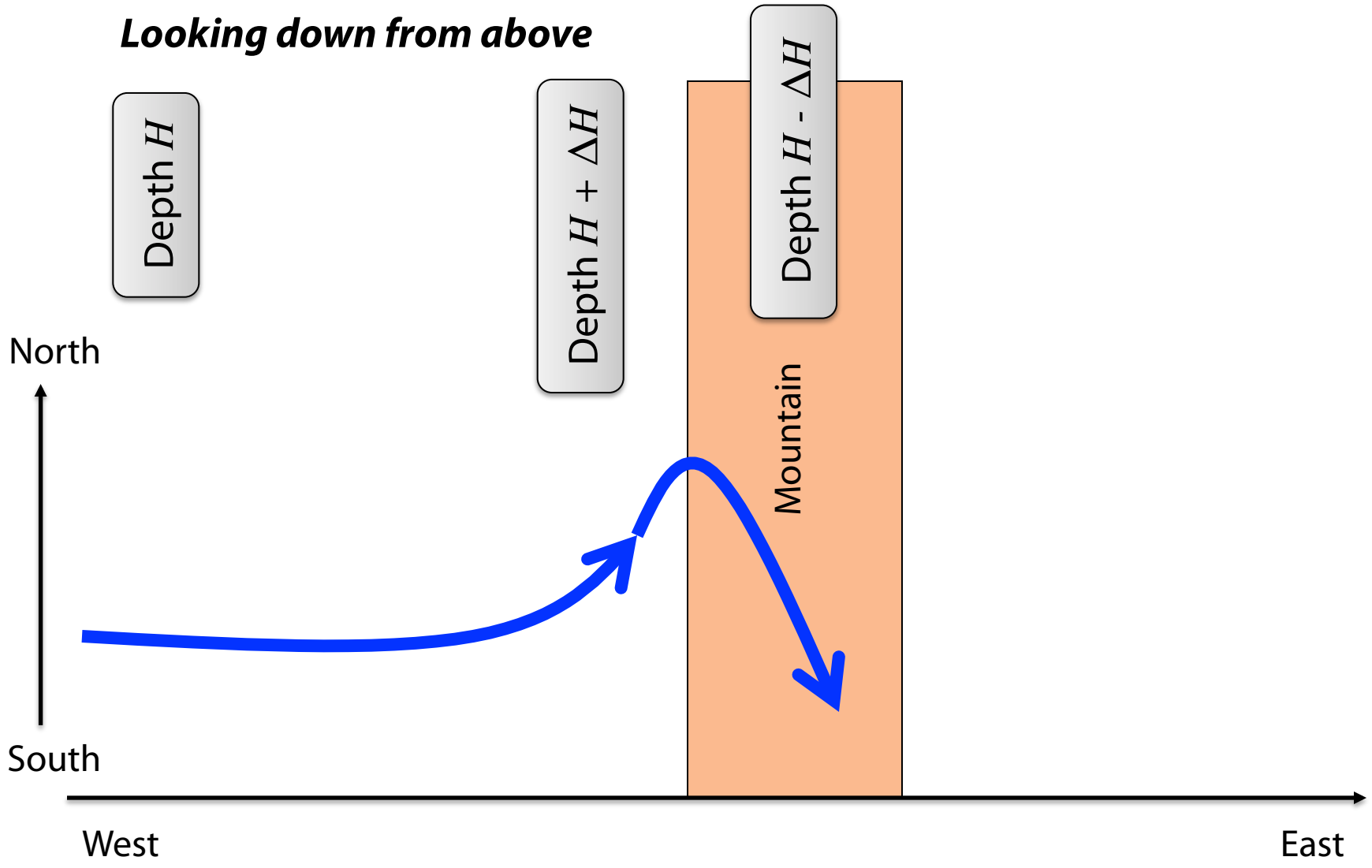


Flow Over a Mountain

$$\frac{D_h}{Dt}\left[\frac{\zeta_g + f}{h}\right] = 0$$



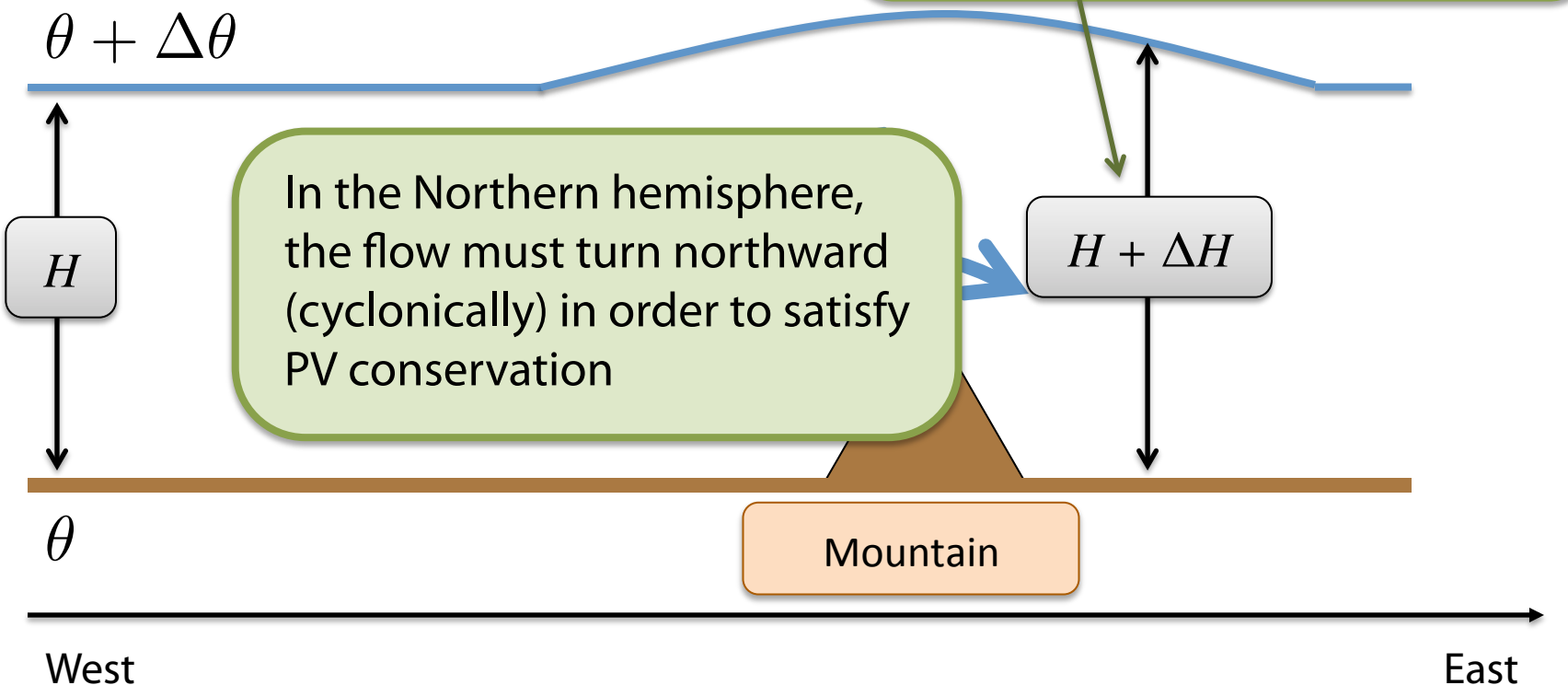
Flow Over a Mountain



Flow Over a Mountain

$$\frac{D_h}{Dt}\left[\frac{\zeta_g + f}{h}\right] = 0$$

Observe: By conservation of PV, ζ must again increase here



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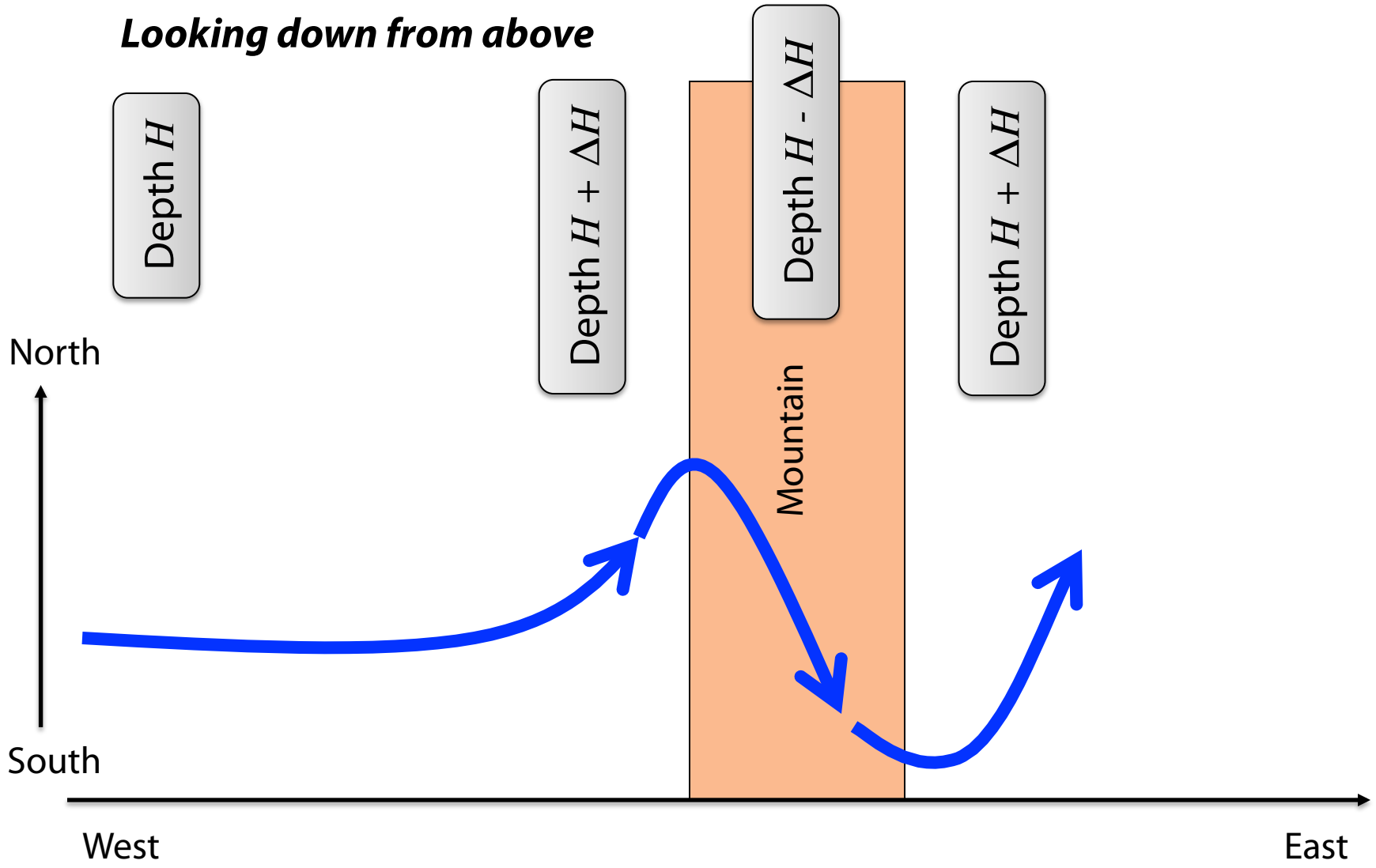
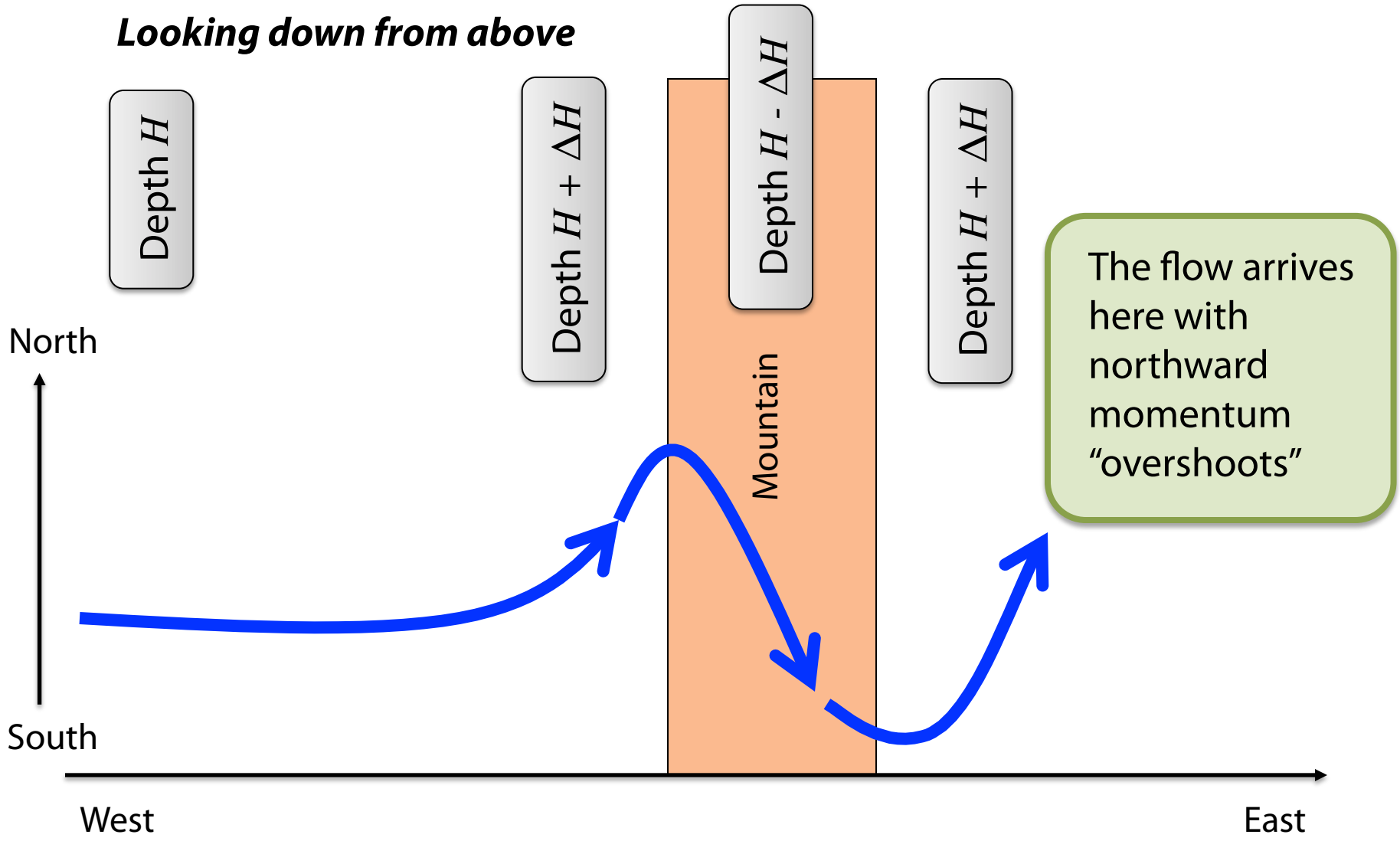
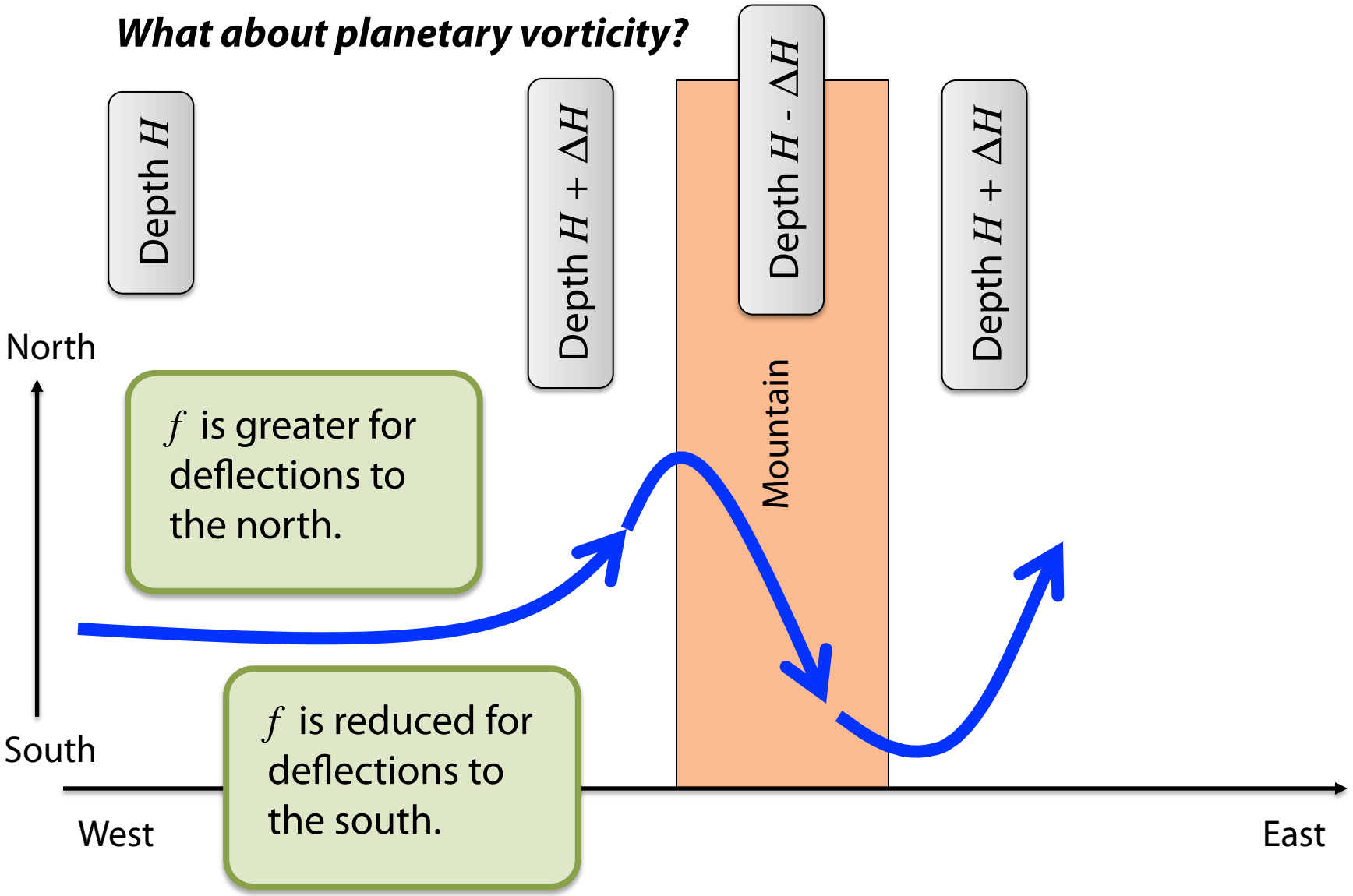


Flow Over a Mountain



Flow Over a Mountain

What about planetary vorticity?



Flow Over a Mountain

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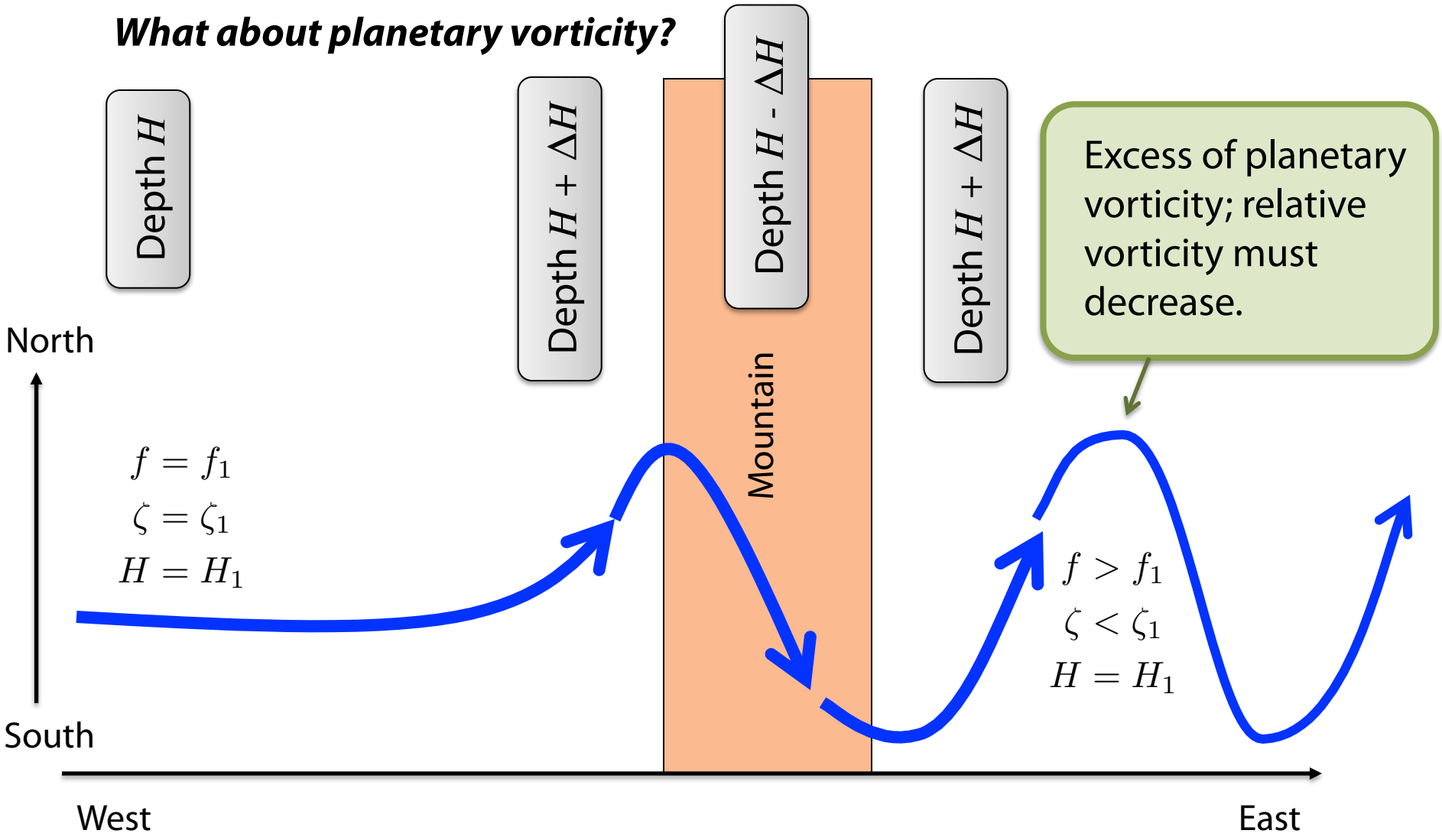
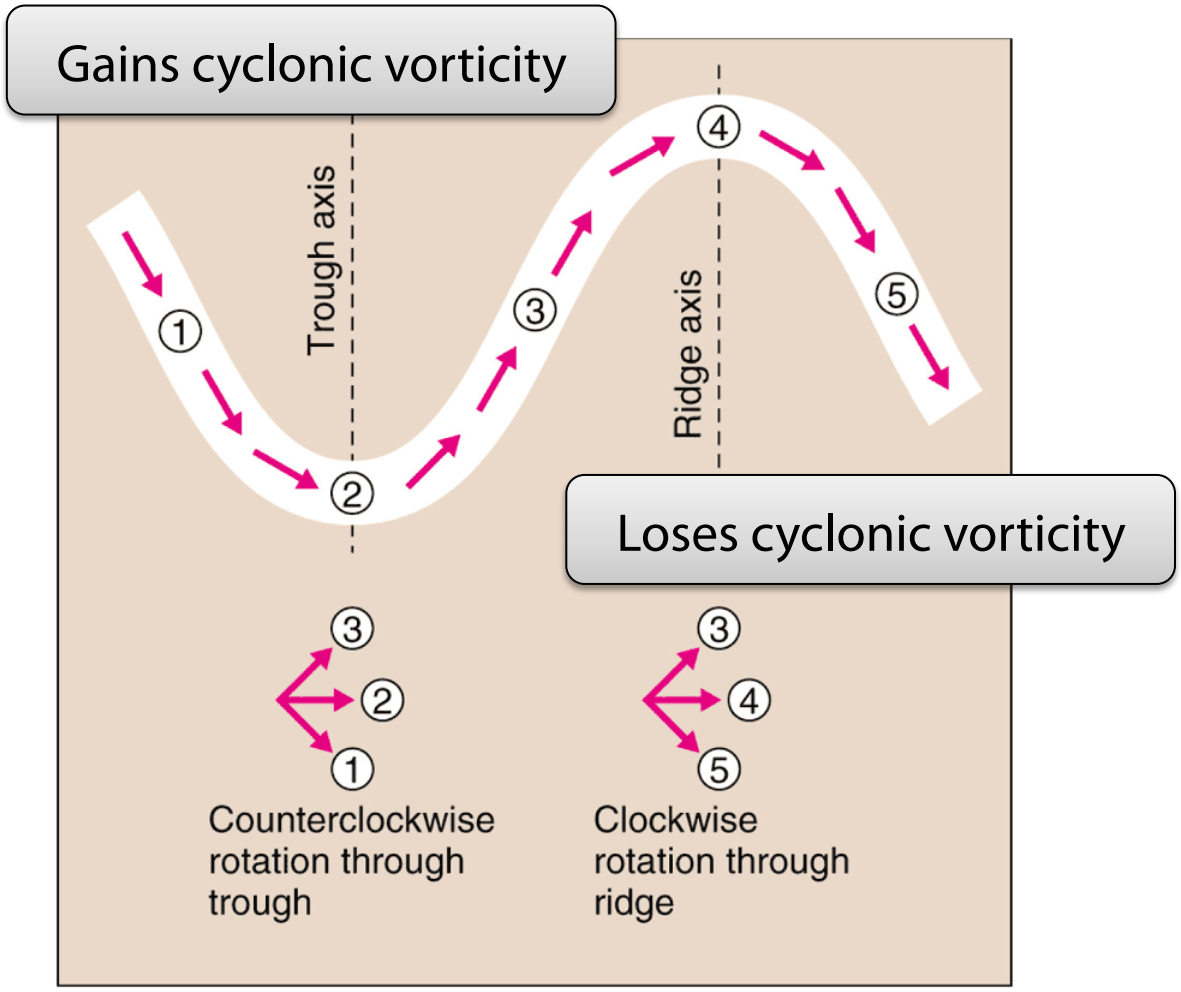
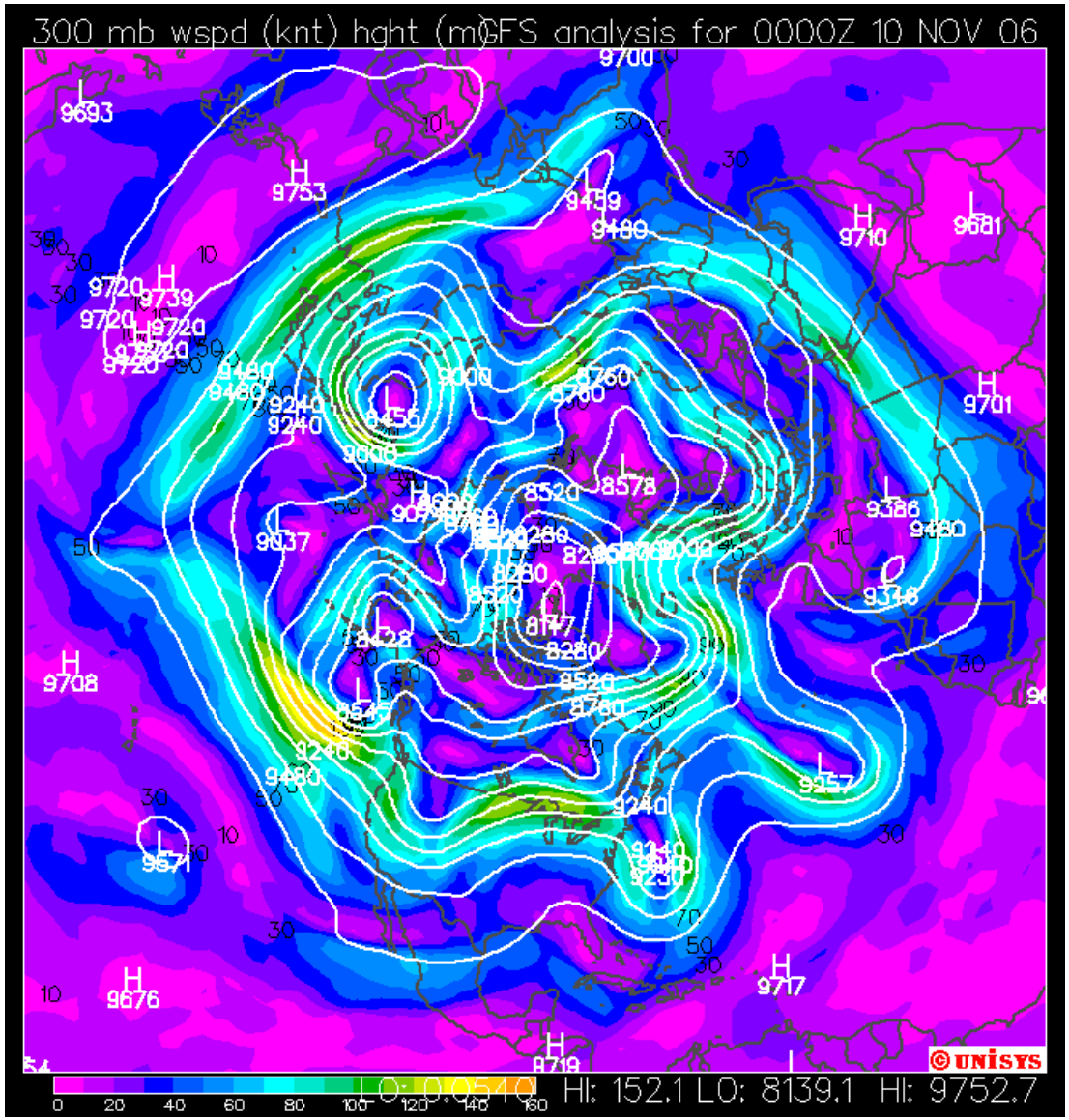


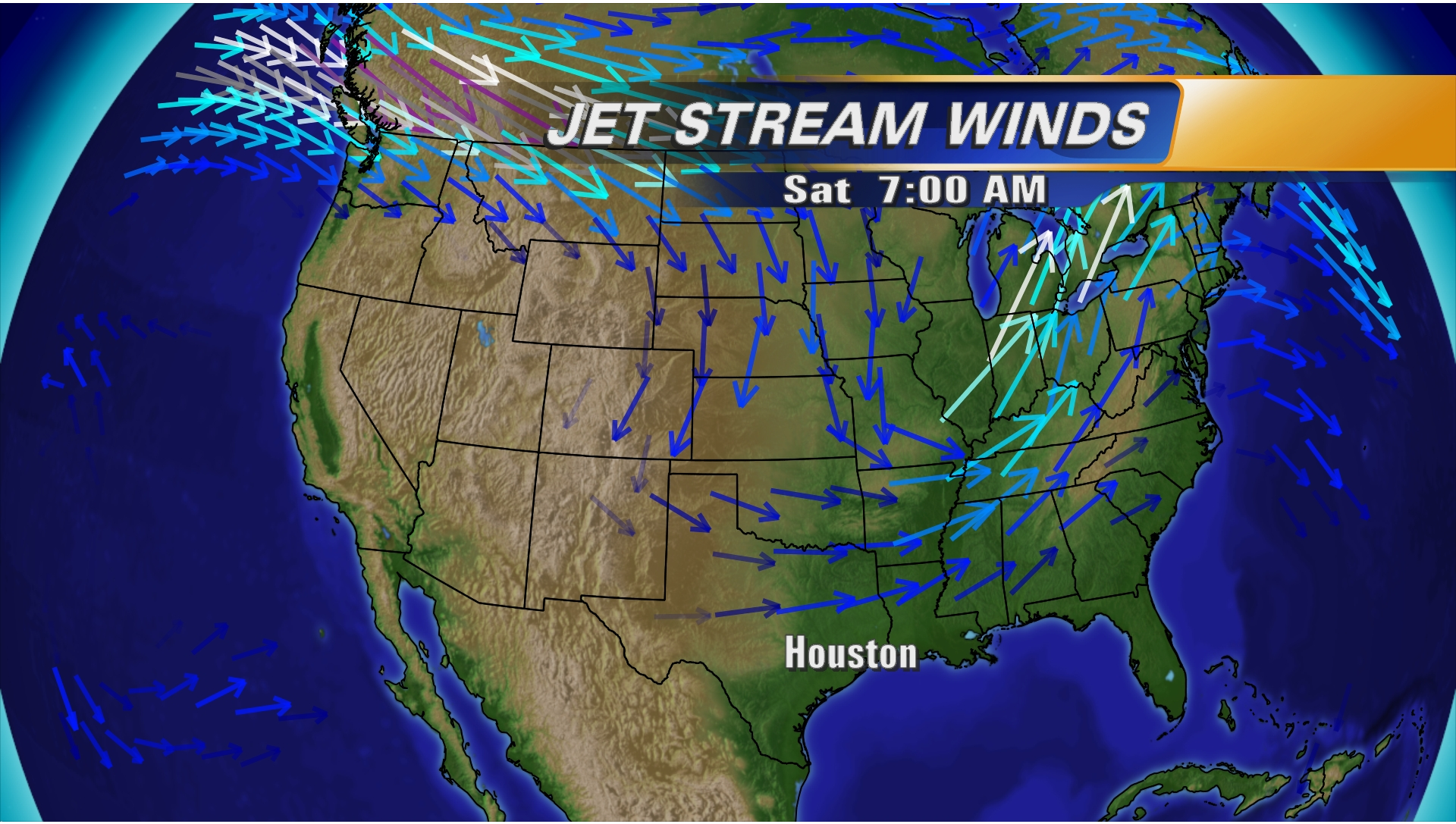
Atmospheric Waves



Atmospheric Waves



"Alberta Clipper"



Flow Over a Mountain

Question: What if the flow is from the East?