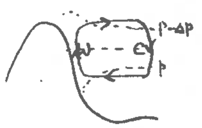
- large scale forcing : Synoptic scale vorticity ⇒ vertical motions on synoptic scale, enhancing mesoscale vertical motions.
  CAA ⇒ steepening of lapse rate ⇒ more instability.

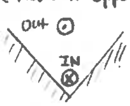
7. Describe/Distinguish between the following terms:
   anabatic/katabatic flows
   slope circulations
   valley circulations
   anti… flows

Sol)
- anabatic flow : relatively warm air rising up the side of a mountain during daytime :

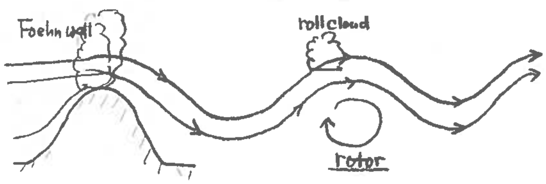


warmer air on mountain slope ; cooler air at some altitude over vally. ∇p from high to low pressure due to these ∇T

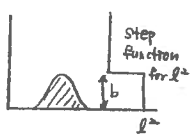
- katabatic flow : relatively cool air sinking along mountain slope during nighttime (opposite situation from anabatic flow)
- Slope circulation : occurs when air flows down the slope of a mountain.
- Valley circulation : daytime flow in the valley where flow goes toward higher elevations. (a larger scale)
- Anti flows : return flow on the top of slope or valley circulation. (flows in opposite direction)



8. Sketch a cross section through a mountain. Include streamlines that depict lee waves and a rotor. Also show clouds corresponding to a foehn wall and a roll cloud.
   List several factors that are conducive to lee wave formation

Sol)


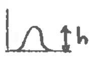
Factors conducive for lee waves
- Static stability near mountain top ; stable environment
- Strong horiz. flow
- Wind shear
- Scorer parameter : $\ell^2_{lower} - \ell^2_{upper} > \pi/4b^2$



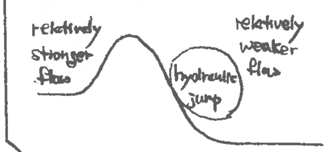
9. Describe a foehn , Describe a bora
   Several hypotheses for downslope flows have been advanced. Specifically. Briefly describe the "blocking" hypothesis.
   " " " "hydraulic jump" hypothesis

Sol)
foehn : dry, warm downslope wind
bora : dry, cool downslope wind } → compared to environment.

Blocking hypothesis : mountain acts as a block to horiz. flow
If $h > \pi/\ell$, then mountain can effectively act as a block to low level flow. ℓ : Scorer param. which contains static stability and winds



Hydraulic jump :



As relatively stronger flow goes over mountain, a strong adjustment is needed ⇒ a shock wave, or hydraulic jump occurs.

10. Prepare a sketch that looks down on the circulation to the lee of an isolated island. Describe the various features of your sketch and give any other useful information.

Sol) → look at Holton's book.

11. There are two major categories of ways by which gravity waves are formed.
    List these two categories, and give as many specific examples for each as you can
    What is the Richardson number? How is it a factor in diagnosing gravity waves?

Sol)
- Gravity waves which ride along a external forcing
  These are often due to convection, frontogenesis or cyclogenesis whereby the atmosphere is trying to get back into geostrophic balance after ageostrophic condition
- Shear instability gravity waves, which often dissipate fairly quickly.
  These may be due to vertical motions giving rise to pressure perturbations

$$R_i = \frac{\text{buoyancy}}{\text{shear}^2}$$

If $R_i < 0.5$, favorable for gravity waves.
Most favorable situation for gravity waves (to last longer):
stable layer where wind speed < phase speed of gravity wave
Above the stable layer ⇒
a less stable layer where $R_i < 0.25$
and wind speed ≥ phase speed.

12. Sketch a cross section through a gravity wave near the surface.
    Show surface winds that indicate convergence/divergence at the proper locations.
    Show areas of rising/sinking air at the proper locations

Sol) Skip.

13. Describe/Compare/Contrast the following terms :
    conditional instability, potential instability, convective instability
    Define CAPE and CIN in your own words. How do these relate to vertical motion

Sol)
- Conditional instability : occurs when a parcel's lapse rate is in between the dry + moist adiabatic lapse rate. An unsaturated parcel is stable, but if it can become saturated, it will be unstable. This is simply the parcel method. No layers are considered.
- Convective or potential instability : These essentially are the same. If θe decreases with height and we are saturated, then we are convectively or potentially unstable with respect to the saturated layer.
- CAPE : Convective available potential energy : positive buoyancy area on a sounding between the LFC and equilibrium Level (EL). units : J kg^{-1}
  $W = \sqrt{2 \cdot CAPE}$
- CIN : Convective inhibition : the cap or area of negative buoyancy in the lower layers of the atmosphere below the LFC. Once this cap is weakened, the CAPE may be realized.
  $W = \sqrt{2 \cdot CIN}$ (to reach the LFC)

Synoptic scale vertical motions will not weaken the cap sufficiently. Instead, synoptic scale vertical motions can lead to mesoscale vertical motions which may