BALANCE AND IMBALANCE BETWEEN UPWARD AND DOWNWARD TRANSPORTS

$$\frac{\partial q}{\partial t} + v \cdot \nabla_H q' + w\frac{\partial q'}{\partial z} + w\frac{\partial \overline{q}}{\partial z} = S$$

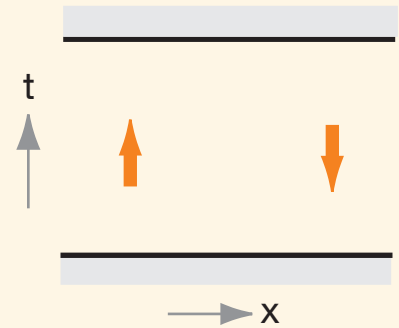
$$\frac{\partial \rho}{\partial t} + \nabla_H \cdot (\rho \mathbf{v}) + \frac{\partial}{\partial z}(\rho w) = 0$$

S : source/sink of q

$\overline{()}$: average in x

$()'$: $() - \overline{()}$

ρ : a function of z only



$$\frac{\partial}{\partial t}\frac{1}{2}\overline{\overline{\rho q'^2}} + \overline{\overline{\rho W q' \frac{\partial \overline{q}}{\partial z}}} = \overline{\overline{\rho q' S'}}$$

$\overline{\overline{()}}$: average in x, y and z

Assume $\frac{\partial}{\partial t}\frac{1}{2}\overline{\overline{\rho q'^2}} = 0$. Then

If $S' = 0$, $\overline{W'q'} = 0$ (no interaction with mean)

Balence between upward and downward transports

If $S' = -kq'$ (nudging to the mean), $\overline{\overline{\rho q' S'}} < 0$

bulk dissipation

Then $\overline{\overline{\rho W q' \frac{\partial \overline{q}}{\partial z}}} < 0$

downgradient transport dominating

Compuitational dissipation (and dispersion coupled with nonlinear cascade) produce artificial downgradient transport.