Stat dyn.

NUM MODELS!

(Calc-Gebra)
"DYNAMICS PROBLEMS"

THERMO

EQ SET!
N eqs, N unks.

PHYS LAWS

BOOKK

$$\frac{\partial}{\partial t}(\text{stuff}) = \underbrace{\text{transport of stuff}} + \text{Source} - \text{Sink}$$

"conv of"

$-\vec{\nabla}\cdot(\vec{\text{flux}}_{\text{of stuff}})$

2 ways to measure "stuff"

1. per unit volume of space: "flux convergence"
2. per unit mass of air : "advection"

$-\vec{V}\cdot\vec{\nabla}(\text{stuff})$

"advection of"

1. is nice for integrating.
   e.g. vanishes for whole earth!
   → climate $\xleftrightarrow[\text{cut}]{}$ weather

2. is good for intuition!

: q or q_v $\boxed{\text{specific}}$ humidity $\xrightarrow{\text{per unit mass of air}}$ units $\left(\frac{\text{kg water}}{\text{kg air}}\right)$

$q(x, y, z, t)$

flux of air mass was

$(\rho \vec{V})$ units: $\left(\frac{\text{kg}_{air}}{\text{m}^2\,\text{s}}\right)$

flux of humidity is:

$(q \rho \vec{V})$ $\left(\frac{\text{kg}_w}{\text{m}^2\,\text{s}}\right)$

flux of eastward (zonal) momentum: need specific momentum: $\frac{\left(\cancel{\text{kg}}\ \text{m/s}\ (\text{mom units})\right)}{\cancel{\text{kg}}}$

$(u \rho \vec{V})$

u

another interp of velocity as a "stuff"

flux of (thermal internal energy)

$((c_v T) \rho \vec{V})$

specific internal energy $\rightarrow (c_v T)$ units $\left(\frac{\text{J}}{\text{kg}}\right)$

specific enthalpy $(c_p T)$

From flux form to advection form:

We had already

$$(1) \quad q\left[\frac{\partial}{\partial t}(\rho) = -\underbrace{\vec{\nabla}\cdot}_{\text{con. of.}}(\overset{\text{mass flux}}{\rho V})\right]$$

For water density

$$\frac{\partial}{\partial t}(q_v\rho) = -\vec{\nabla}\cdot(q_v\rho\vec{V}) + (\overset{\text{evap.}}{e} - \overset{\text{cond.}}{c}) \leftarrow \text{(Vapor Source-Sink)}$$

$$= -\frac{\partial}{\partial x}(q\rho u) - \frac{\partial}{\partial y}(q(\rho v)) - \frac{\partial}{\partial z}(q(\rho w)) + (e-c)$$

$$\rho\frac{\partial q}{\partial t} + q\frac{\partial \rho}{\partial t} = -\rho u\frac{\partial q}{\partial x} - \rho v\frac{\partial q}{\partial y} - \rho w\frac{\partial q}{\partial z}$$

$$\underbrace{-q\left[\frac{\partial}{\partial x}(\rho u) + \frac{\partial}{\partial y}(\rho v) + \frac{\partial}{\partial z}(\rho w)\right]}_{-q[\nabla\cdot\rho\vec{v}]} + (e-c)$$

1. subtract $q\cdot(1)$ — zero!

2. divide by ρ

$$\boxed{\frac{\partial q}{\partial t} = -u\frac{\partial q}{\partial x} - v\frac{\partial q}{\partial y} - w\frac{\partial q}{\partial z} + (e-c) = \left[-\vec{V}\cdot\vec{\nabla}\right]q + (e-c)}$$

Advection form of transport, e-c is source term