

Momentum

Atmosphere conserves

- Energy (mechanical, heat, ...)
- Mass (of air, and other gases)
- Momentum (and angular momentum)

To describe motion, we can make use of:

- Newton's 2nd law ($\sum F = ma$)
- First Law of Thermodynamics
- We need to account for fact that earth is rotating, spherical and there is gravity

Some assumptions

- Atmosphere is thin so distance from center is about the same as the earth's radius.
- Gravity is constant
- Given these, also neglect horizontal component of rotation ensures momentum equations conserve momentum.
- *These are called the “traditional approximation”*

Primitive equations (basic building blocks)

- Momentum (horizontal)
- Hydrostatic (vertical)
- Continuity
- Thermodynamic
- (and equation of state: ideal gas)

$$\frac{du}{dt} = fv - \frac{1}{\rho} \frac{\partial p}{\partial x}$$

$$\frac{dv}{dt} = -fv - \frac{1}{\rho} \frac{\partial p}{\partial y}$$

$$\frac{\partial p}{\partial z} = -\rho g$$

$$\frac{1}{\rho} \frac{d\rho}{dt} = -\left(\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z} \right)$$

$$c_p \frac{dT}{dt} - \alpha \frac{dp}{dt} = J$$

$$p = \rho RT$$

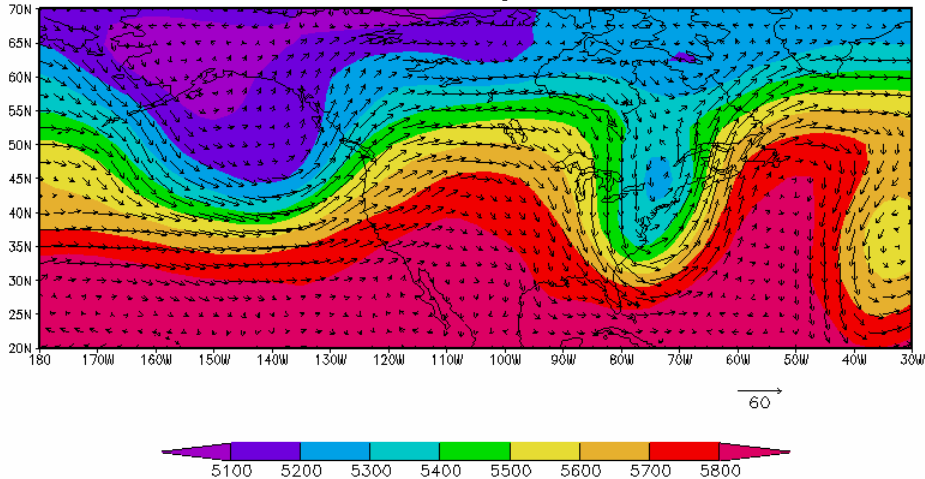
Boundary layers add an extra force for momentum equations, and contributes to J in thermodynamic equation

Otherwise, a closed set of PDEs

See Holton Ch2 for full derivation

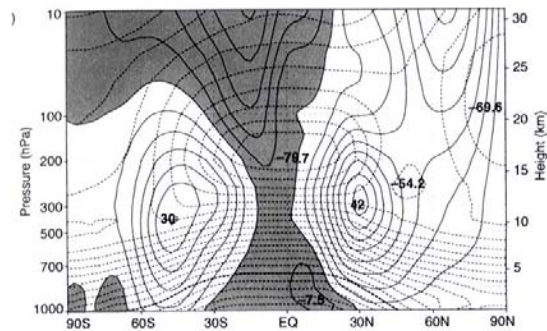
NCEP Reanalysis data

500 mb wind field and heights for 00Z15NOV1975



Christopher Godfrey's NCEP Reanalysis Page

<http://weather.ou.edu/~cgodfrey/reanalysis/>



Westerly wind and temperature

Temperature and wind field related
(thermal wind balance)

i.e., $\partial u / \partial p \sim \partial T / \partial y$

- Knowing temperature gradient, estimate jet.
- Knowing jet, estimate gradient.

