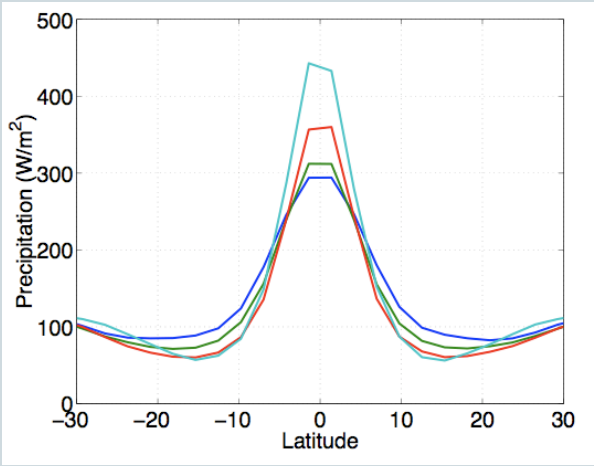
Next: Moisture Effects on Mean Circulation

- Non-rotating Walker cell derivation
  - "Weak temperature gradient" aside
  - Precipitation change with global warming aside
- Application to Hadley cell derivation
- Testing in simplified moist GCM

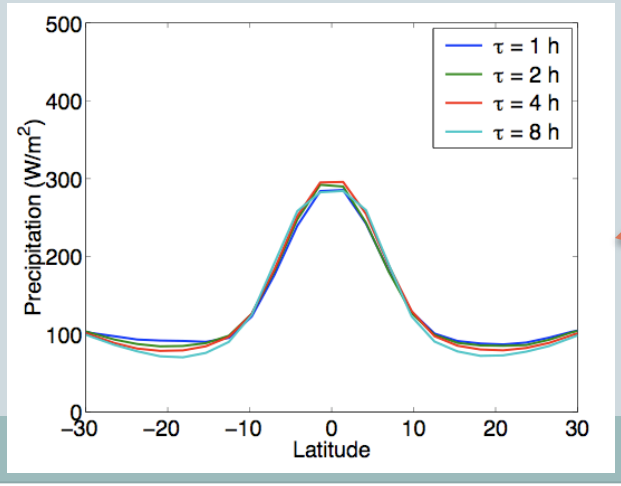
Hadley Circulation in Moist GCM

- Hadley circulation is sensitive to some conv. scheme parameter changes:

Tropical precipitation distribution with identical forcing, moisture content, etc.



- Not sensitive to others:



Changing convective relaxation time by a factor of 8

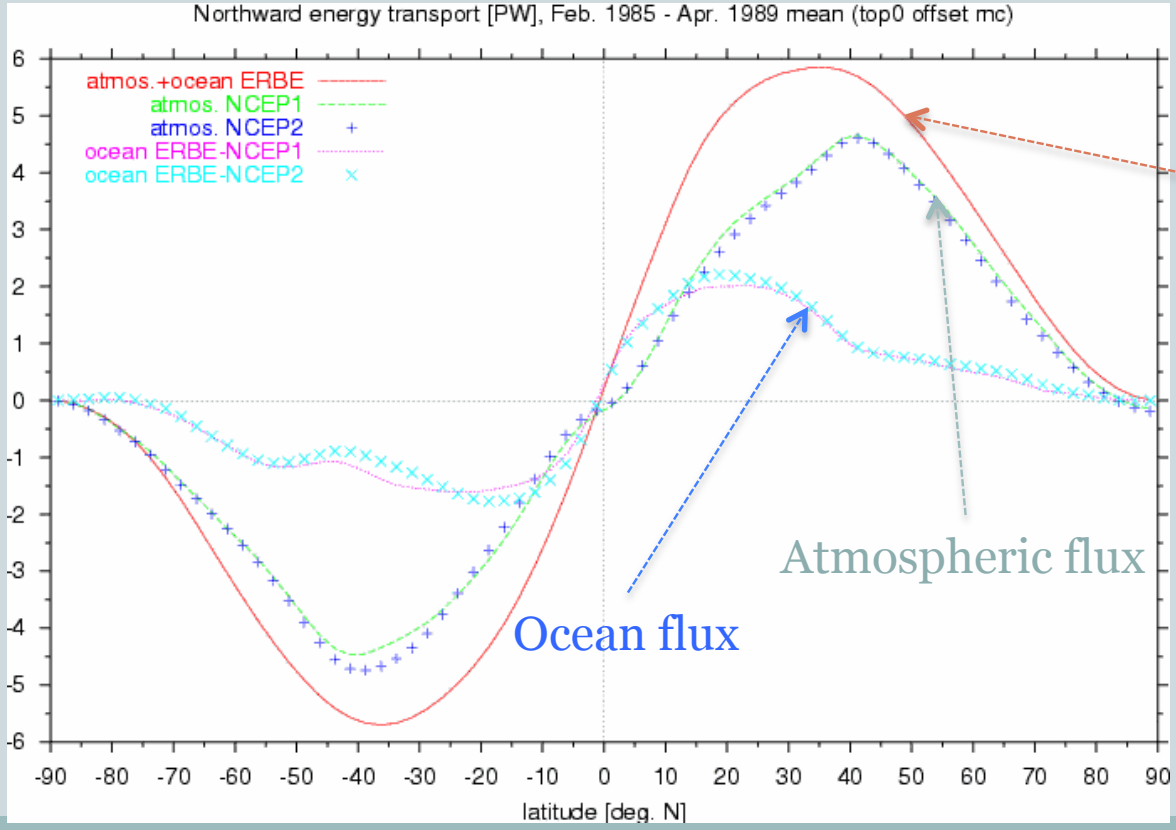
See Frierson (2007a) for more detail

Effect of Gross Moist Stability

- Parameters that don't change GMS don't affect Hadley cell
- GMS can change cell strength though
  - Different than Satoh b/c dry region is never completely dry (precipitation in subtropics changes)

Tropical Energy Fluxes

- Oceanic flux is actually larger than atmospheric flux in the deep tropics!



Total (atmosphere plus ocean) flux

Atmospheric transport dominates in extratropics

Atmospheric flux

Ocean flux

Latitude

Tropical Oceanic Fluxes

- What determines oceanic flux larger?
- Relation to Hadley circulation flux?
- Held (2001) derivations:
  - Ekman transports
  - Oceanic upwelling mass flux
  - Oceanic and atmospheric energy fluxes

Tropical upwelling

- Tropical upwelling forces thermocline up, drives SSTs down

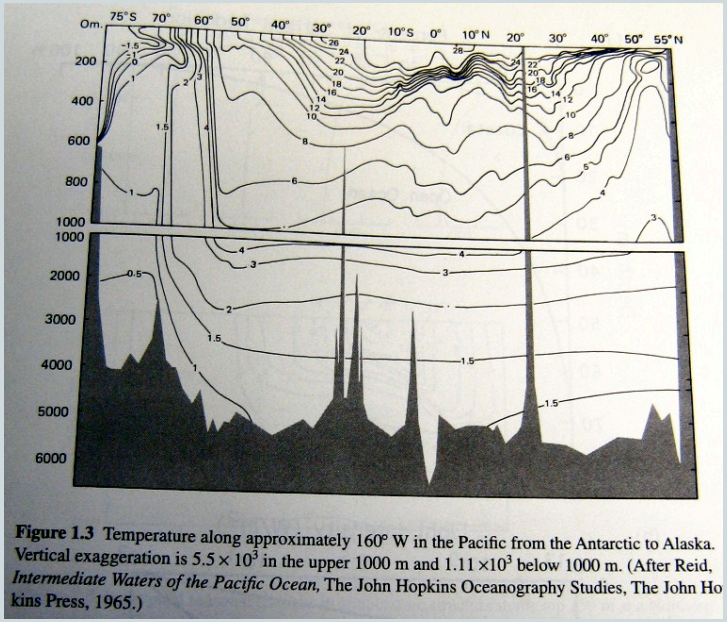


Figure 1.3 Temperature along approximately 160° W in the Pacific from the Antarctic to Alaska. Vertical exaggeration is 5.5×10^3 in the upper 1000 m and 1.11×10^3 below 1000 m. (After Reid, *Intermediate Waters of the Pacific Ocean*, The John Hopkins Oceanography Studies, The John Ho kins Press, 1965.)