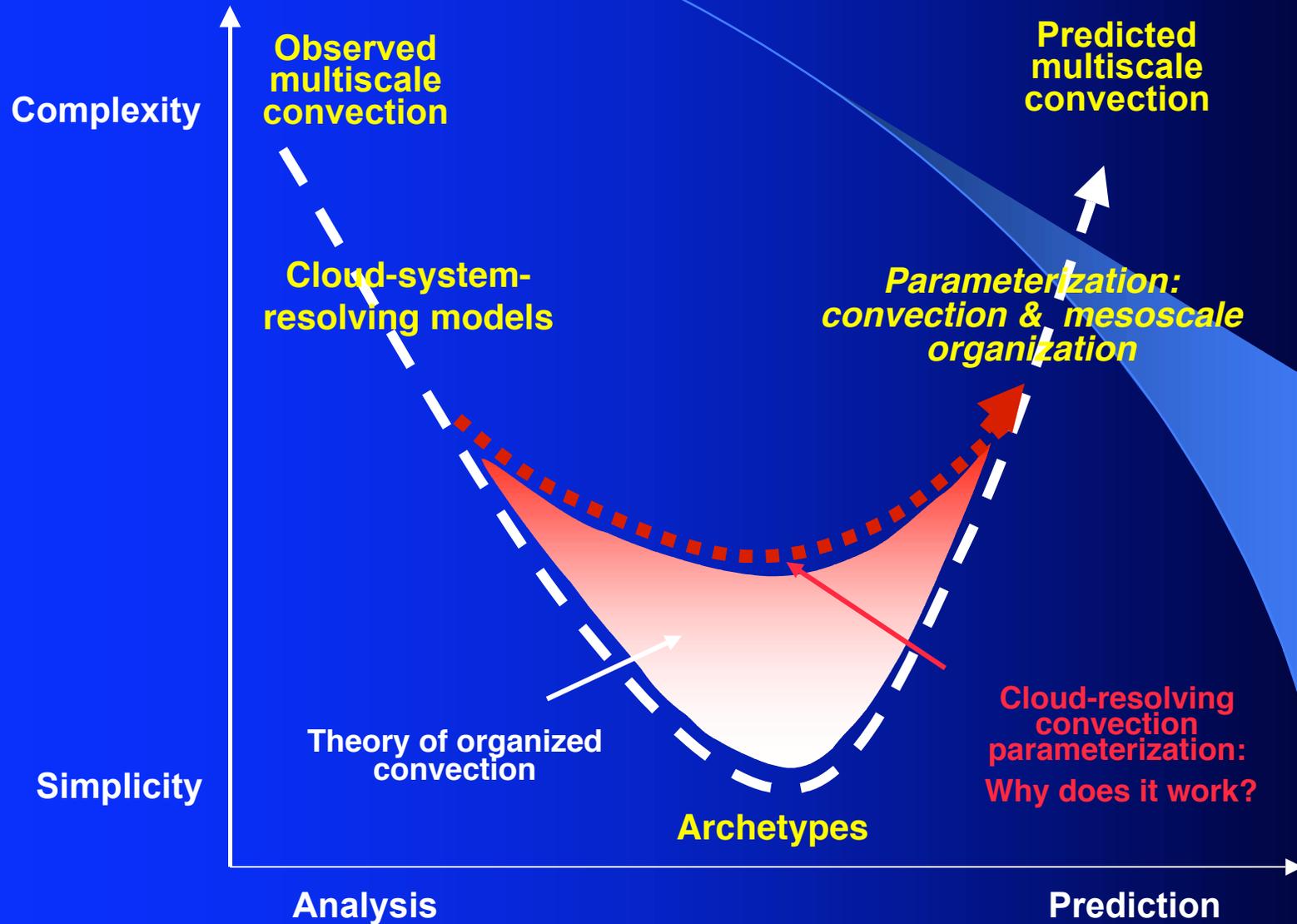


Analytic Representation of the Multiscale Organization of Tropical Convection

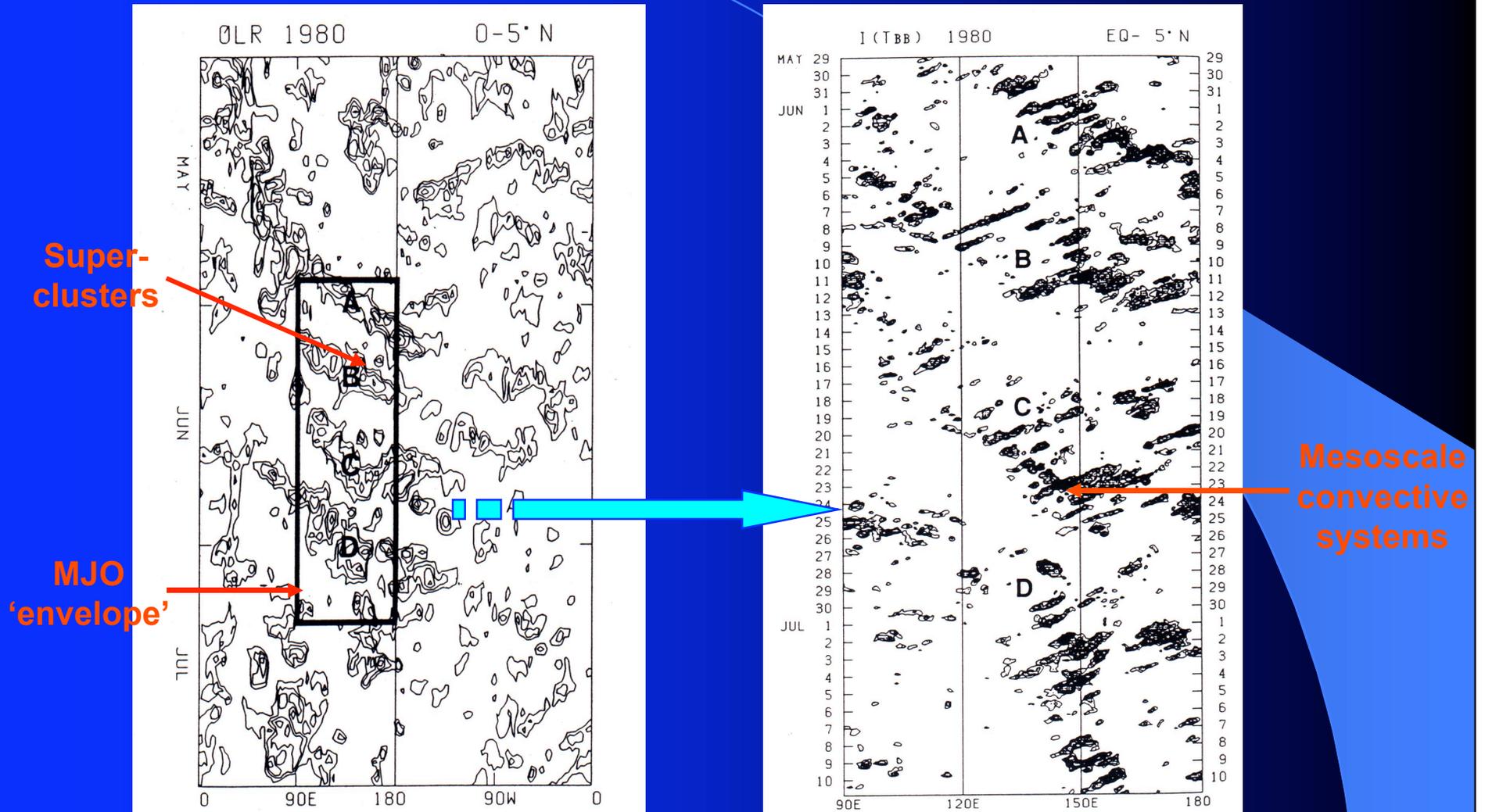
Mitchell Moncrieff
Cloud Systems Group,
NCAR

*Workshop on the Future of Cloud Parameterization,
Princeville, HI , 7-9 May 2003*

Hierarchical approach

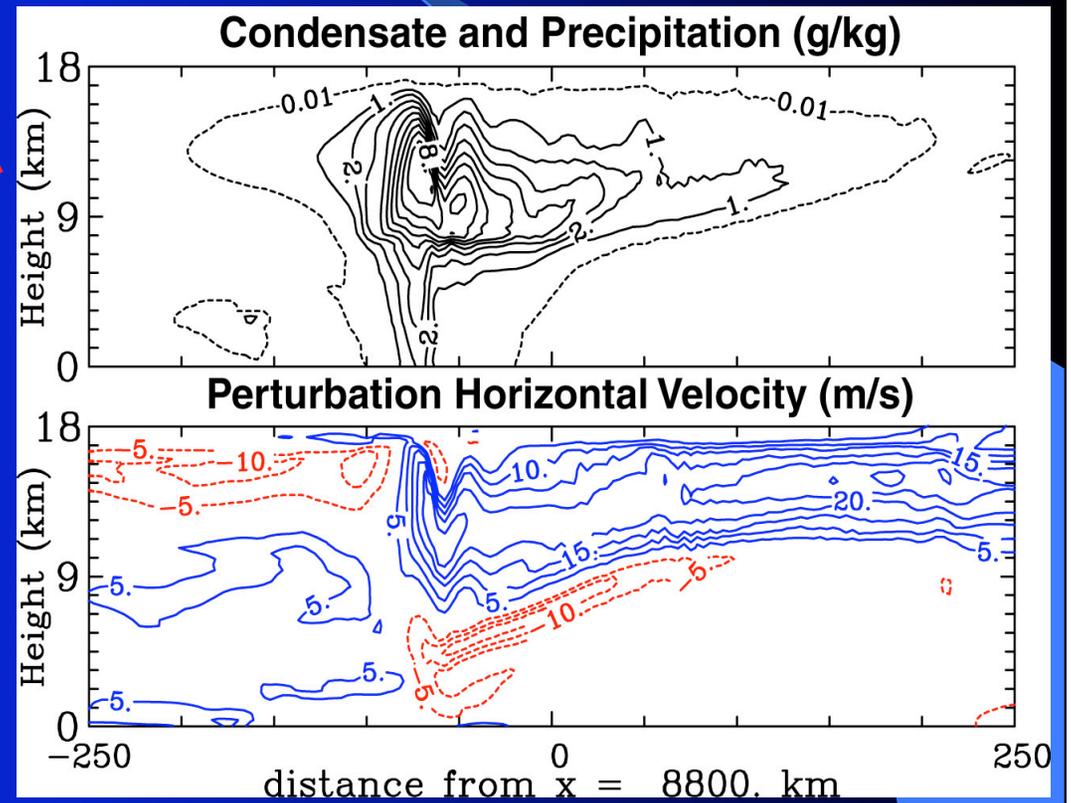
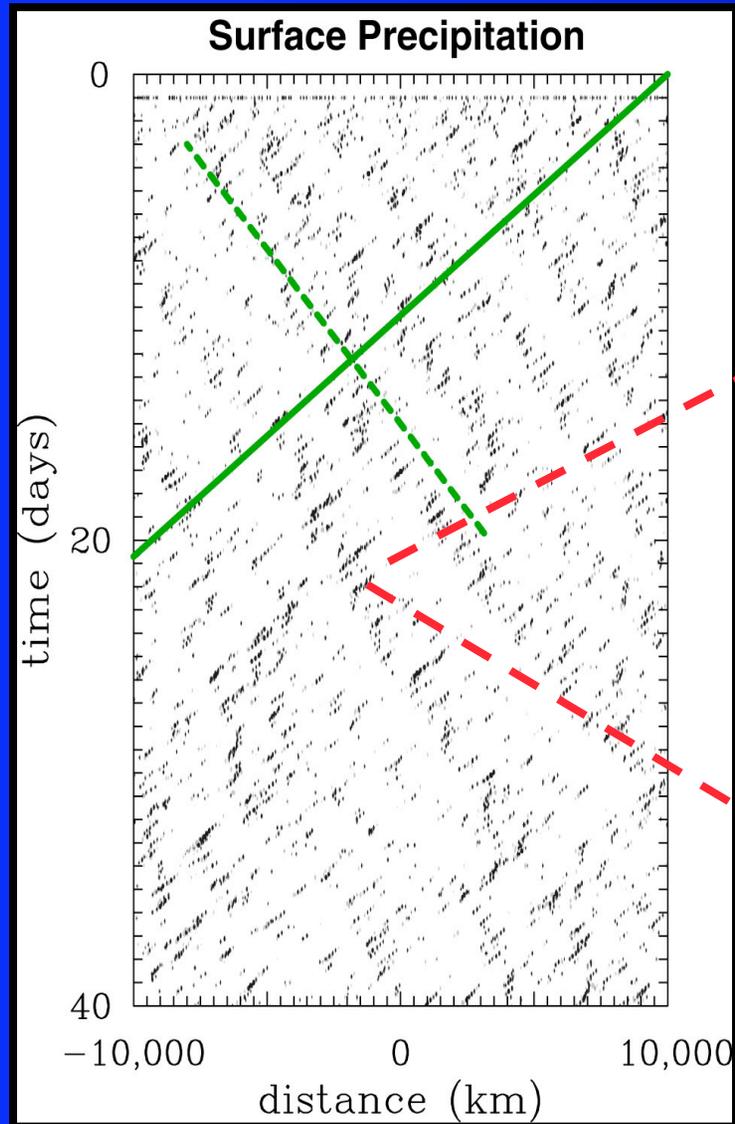


Multiscale hierarchy (reality)



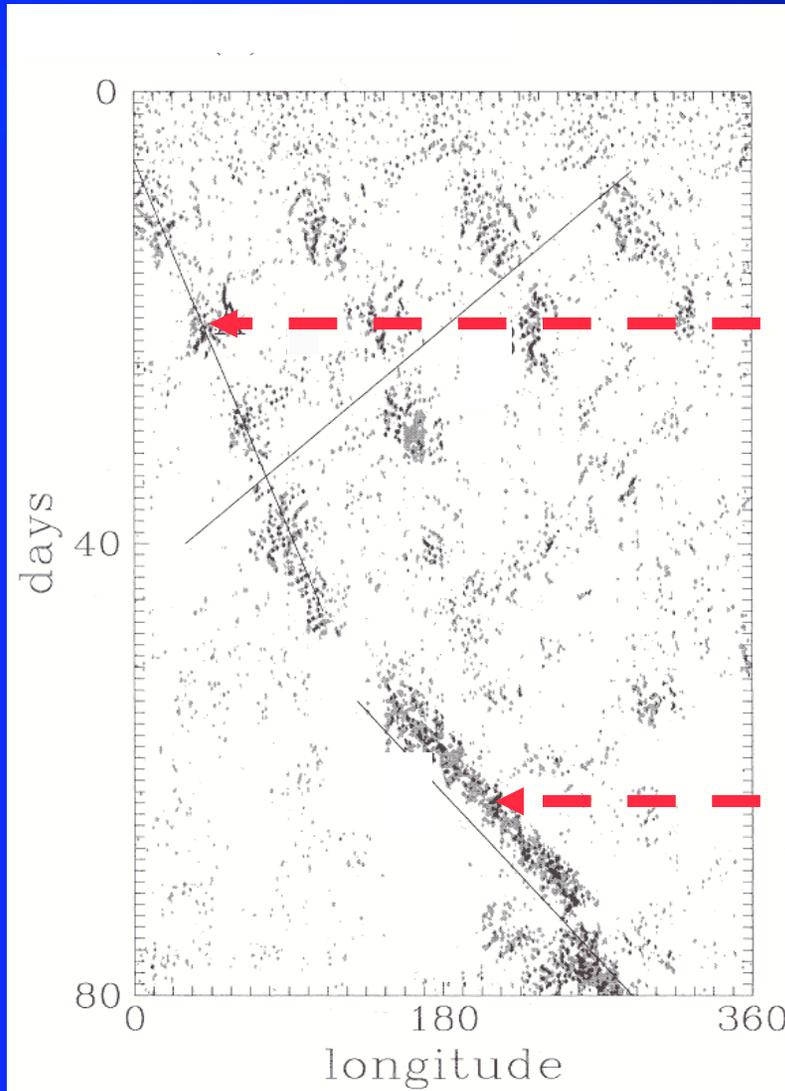
Nakazawa (1988)

Multiscale hierarchy (resolved)



Grabowski and Moncrieff (2001)

Multiscale hierarchy (CRCP)



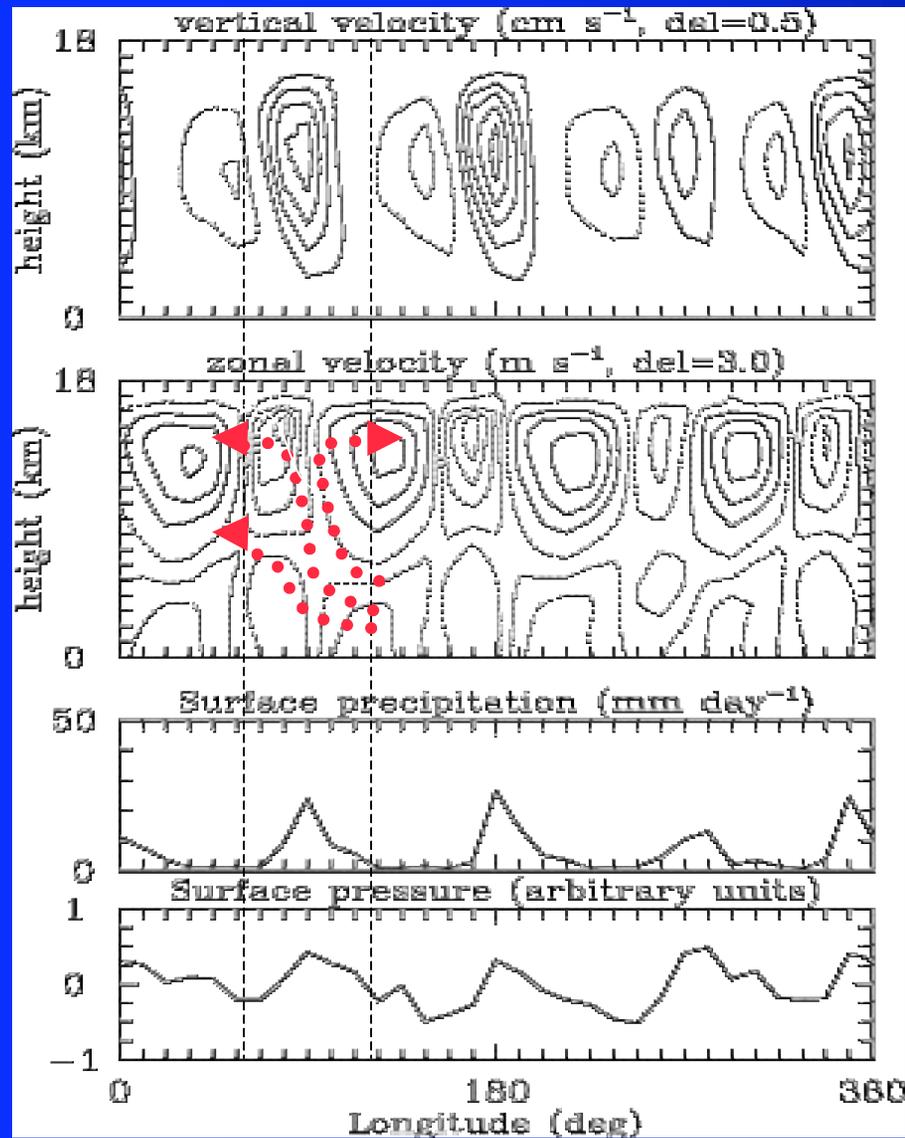
Convectively-coupled system
($c = 3.5$ m/s)

MJO-like system
($c = 8$ m/s)

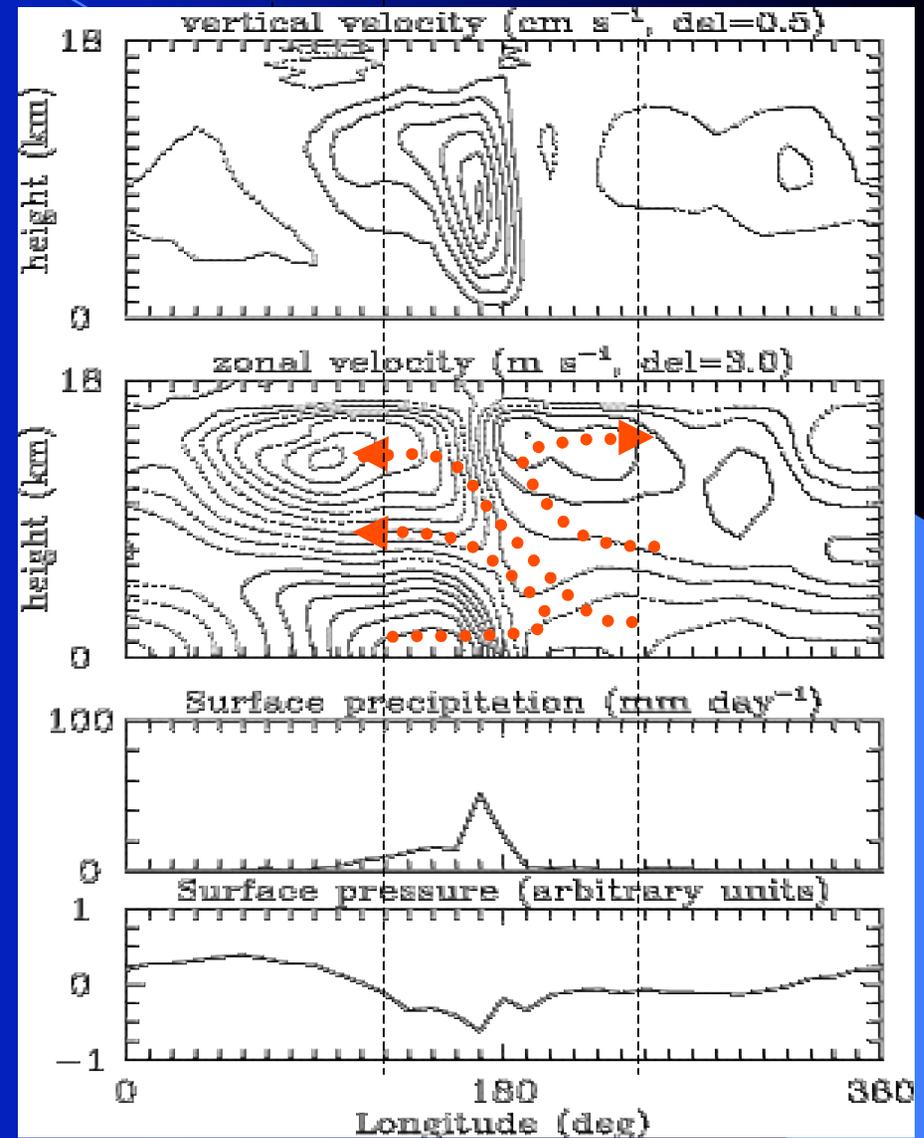
Grabowski (2001)

Vertical structure

a) Convectively-coupled system

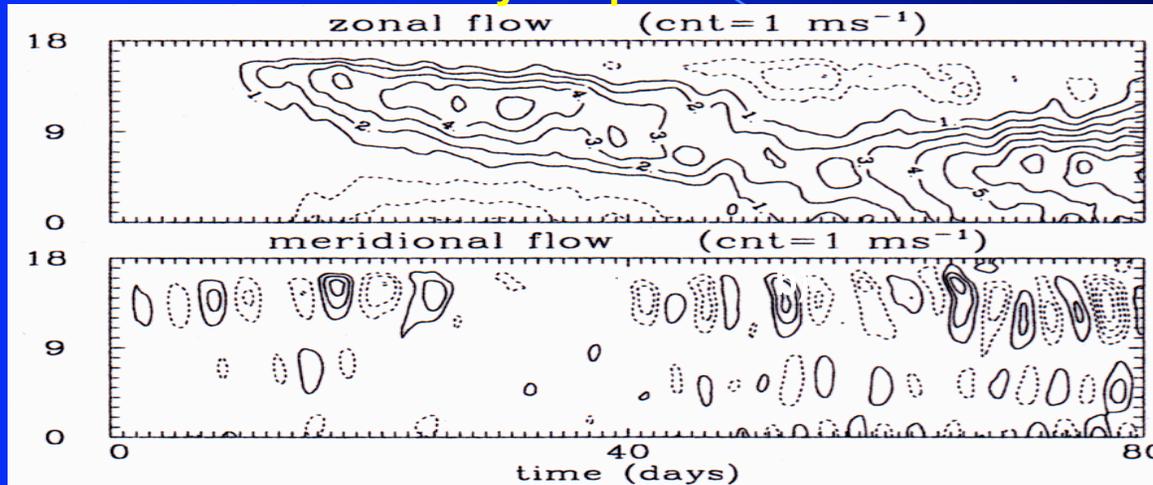


b) MJO-like system

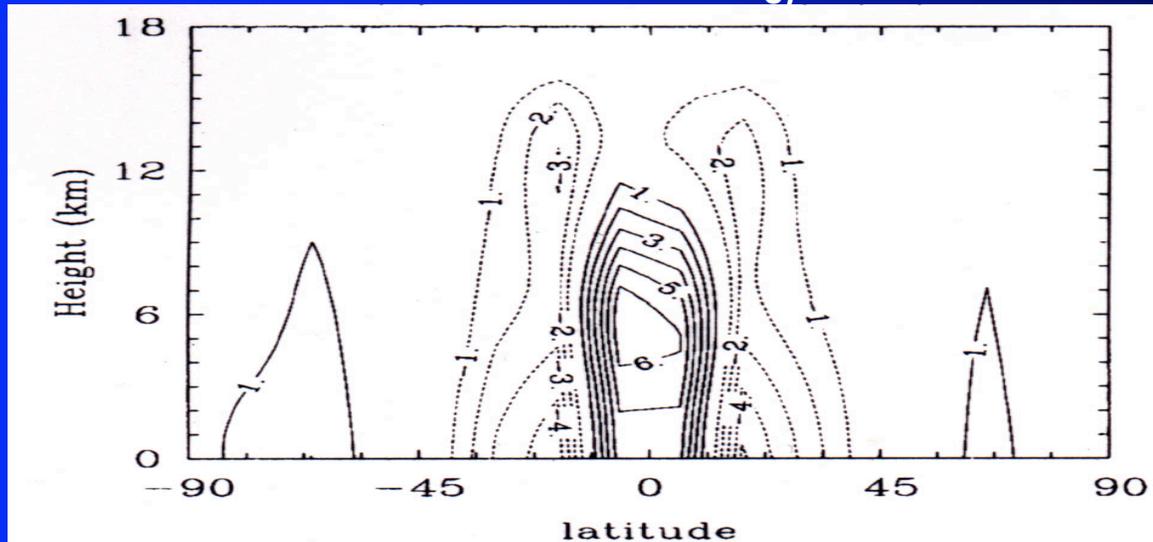


Equatorial super-rotation

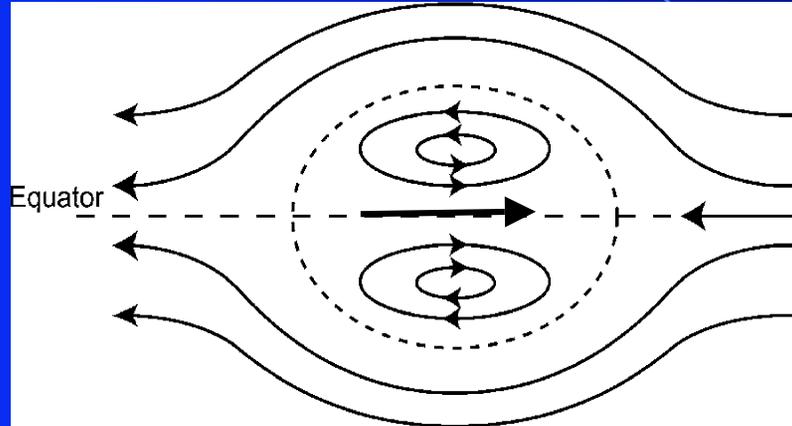
← Convectively-coupled → ← MJO-like →



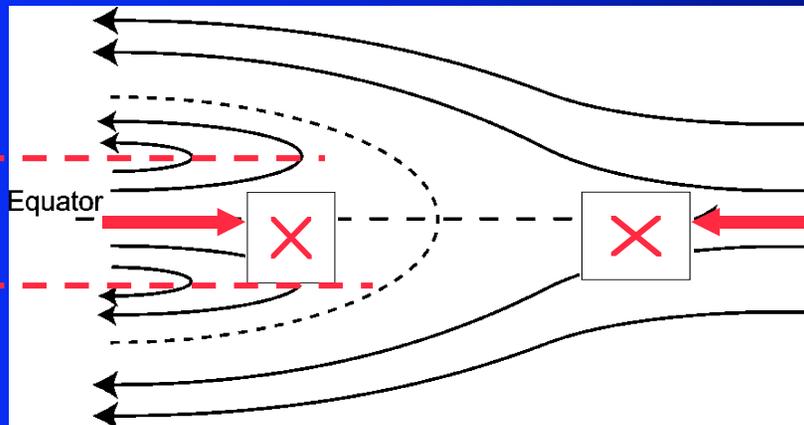
c)



Importance of flow separation



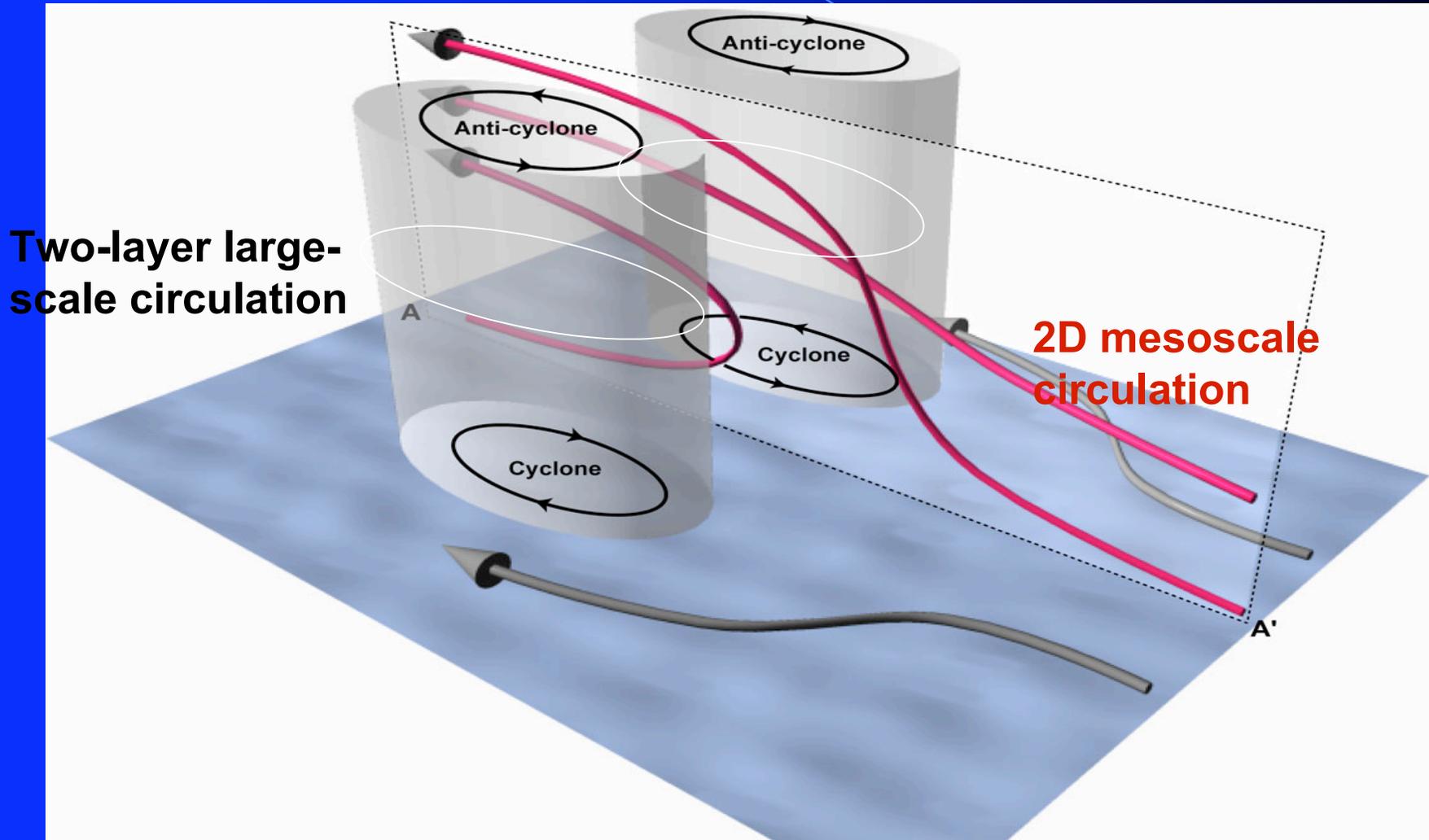
Convectively-coupled system



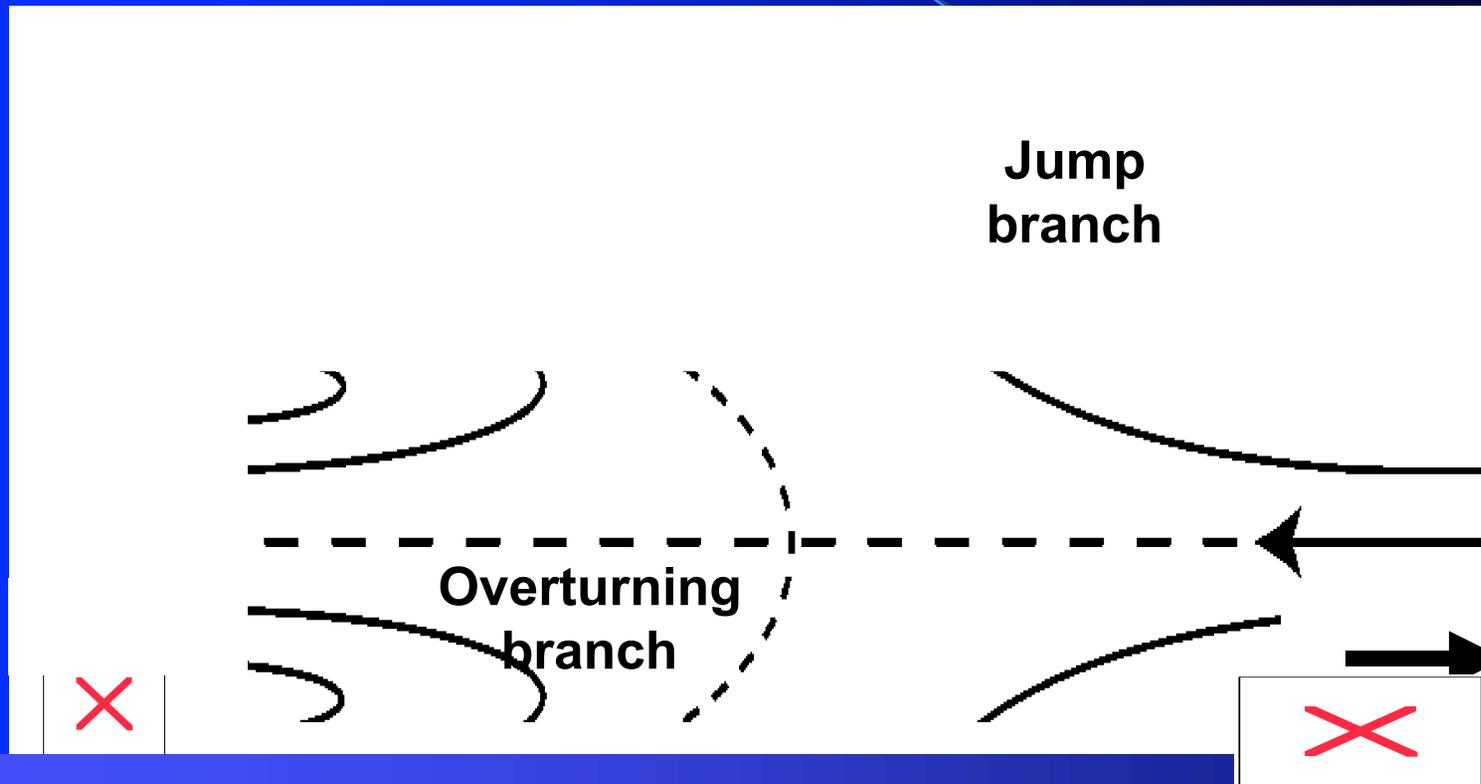
Super-rotation

MJO-like system

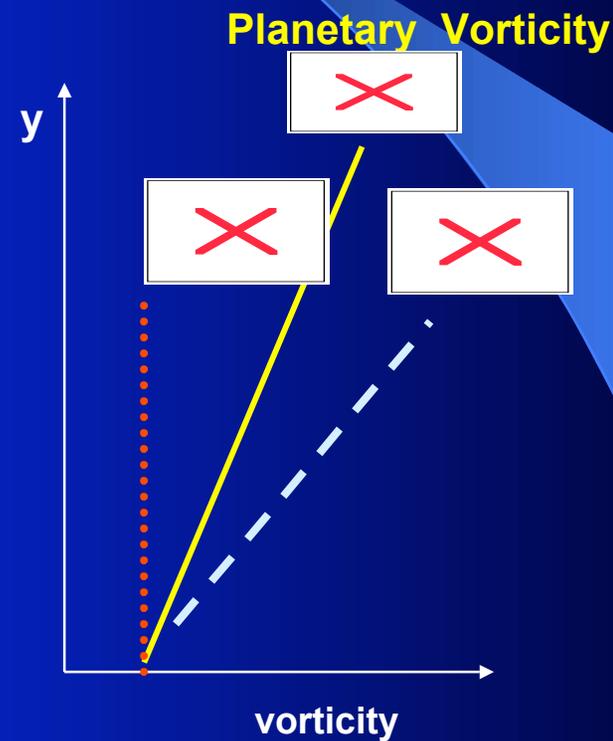
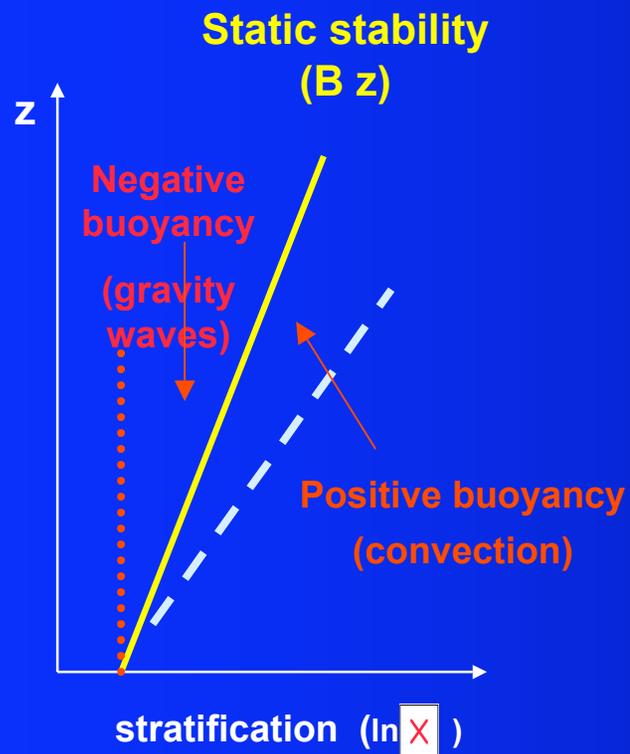
Approximation of 3D circulation



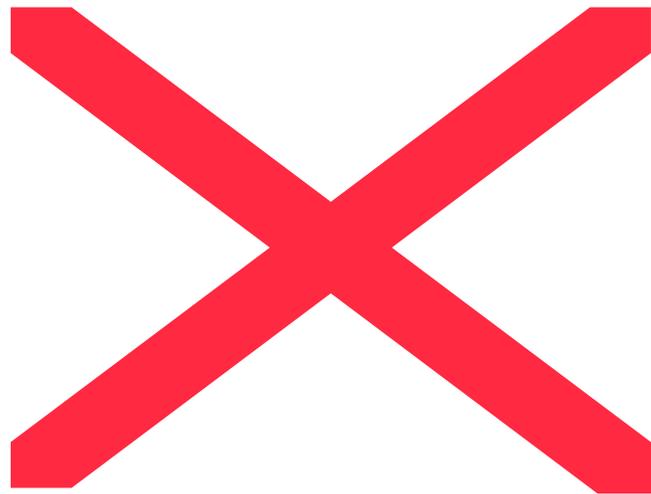
Idealization: large-scale & mesoscale



Equivalence of gravitational and equatorial beta-plane dynamics



Dimensionless quantities

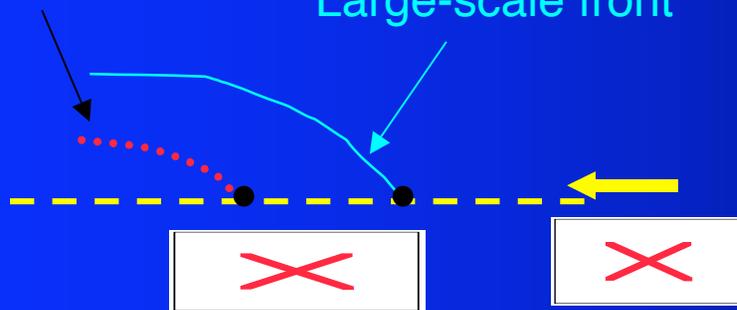


Retrogressive and stationary solutions

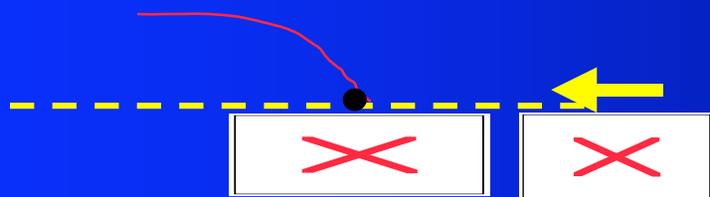
(a) Retrogressive

Mesoscale front

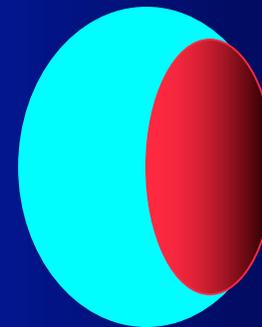
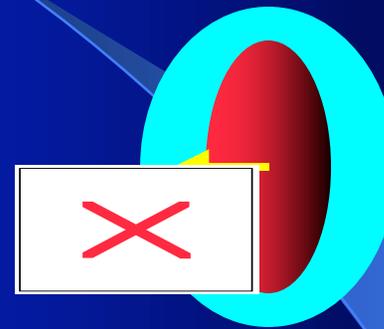
Large-scale front



(b) Stationary

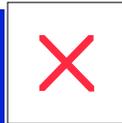
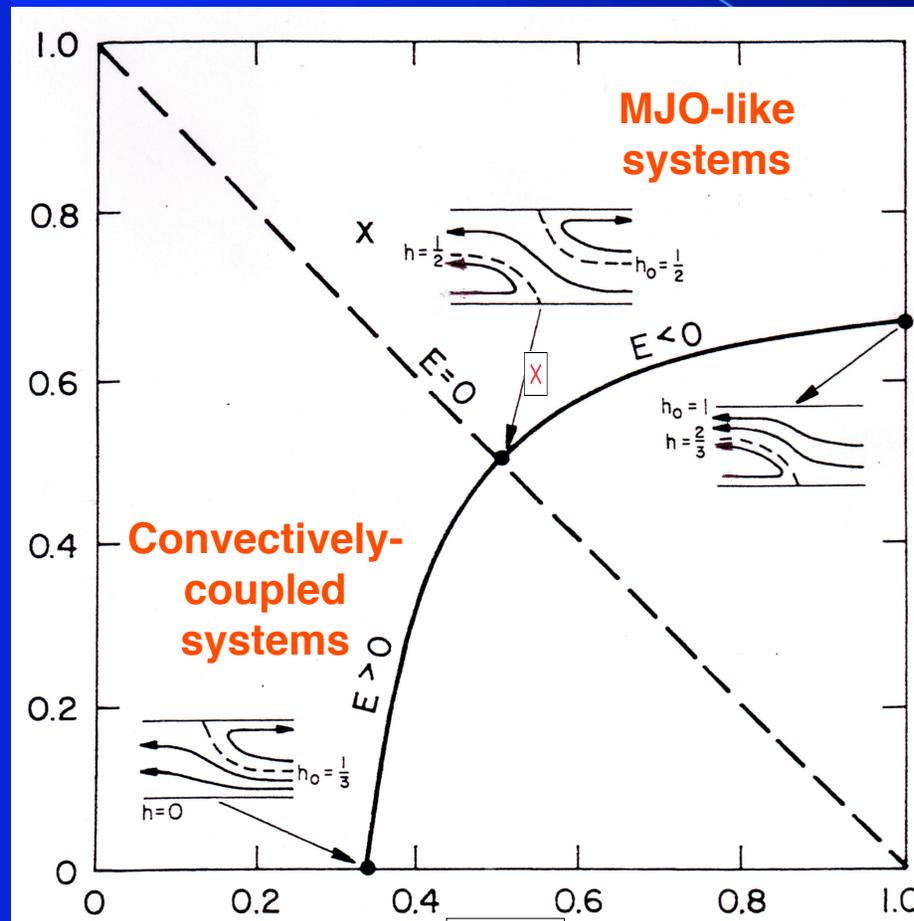


Vertical plane

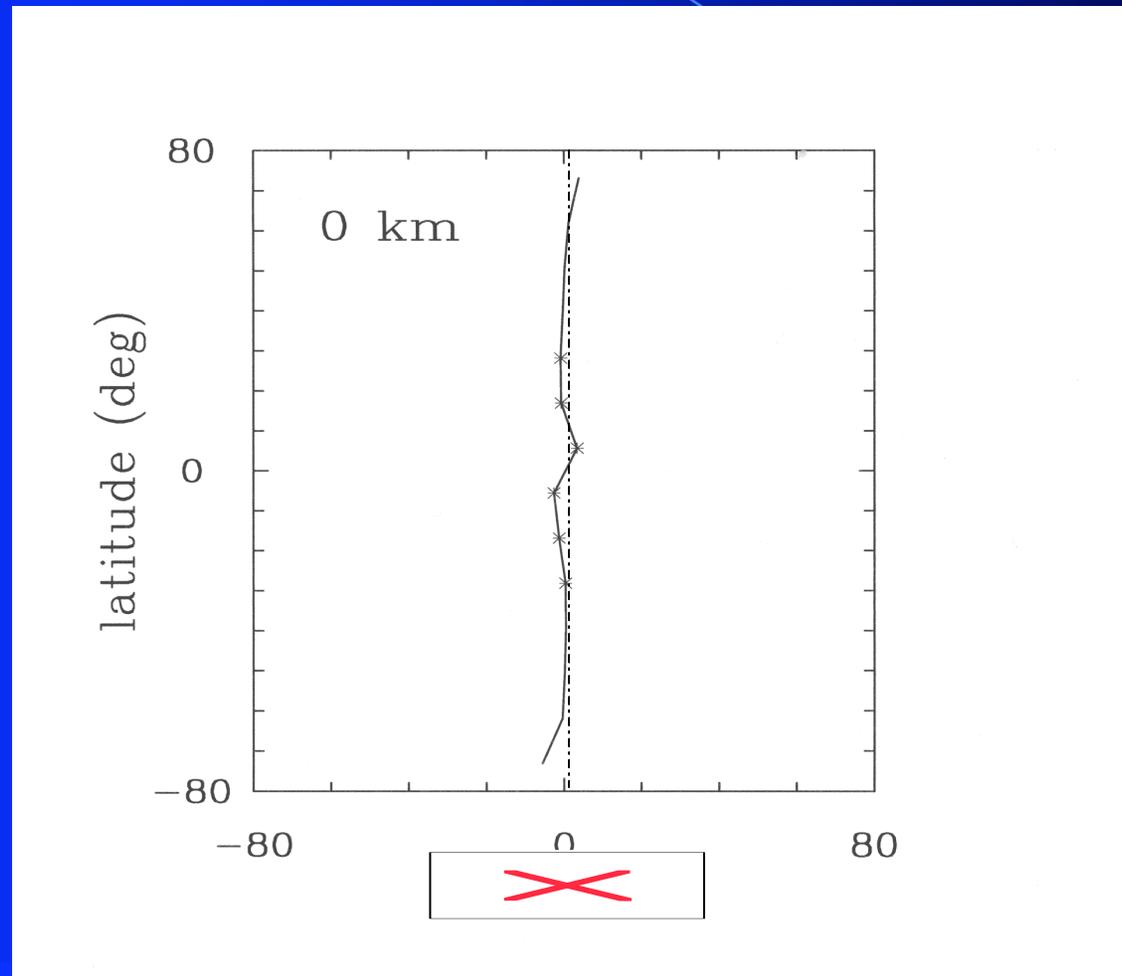


Horizontal plane

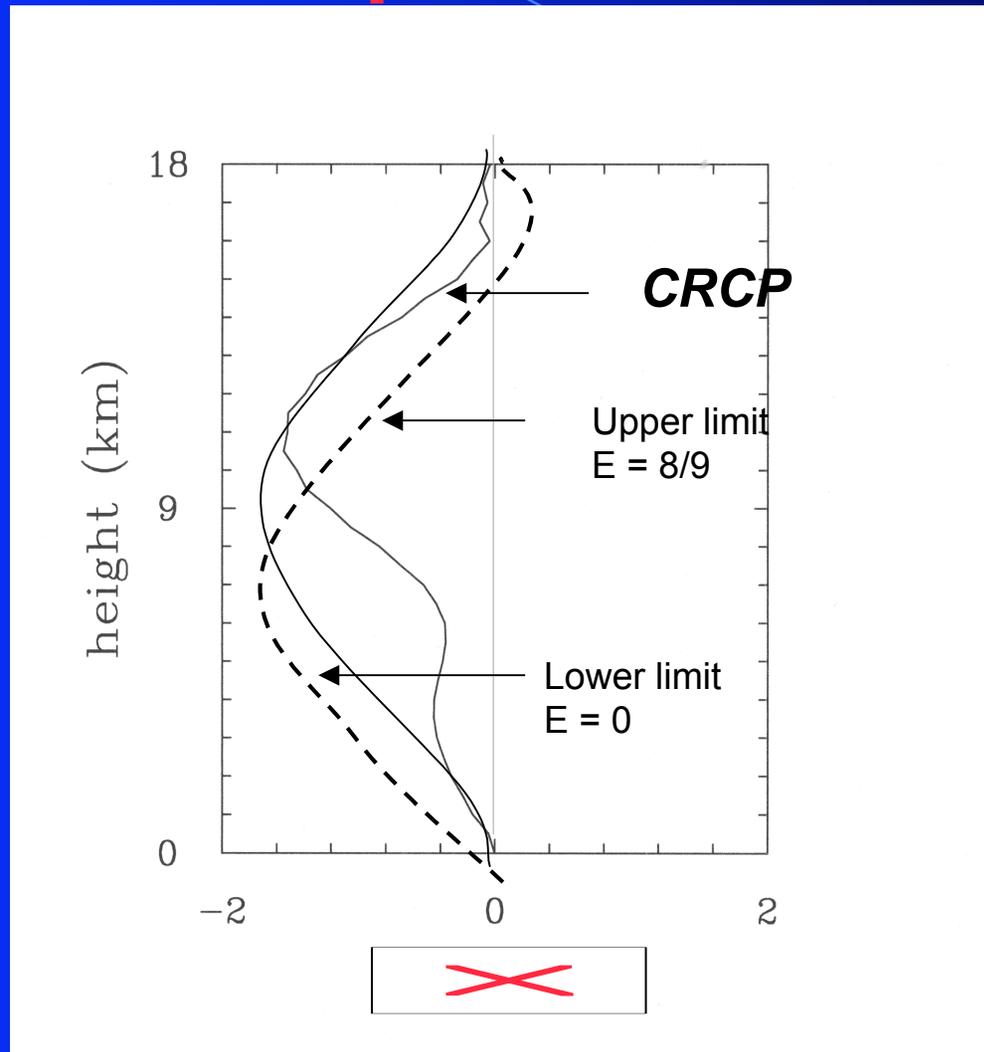
Archetypal organization



Convectively-coupled system: large-scale momentum transport

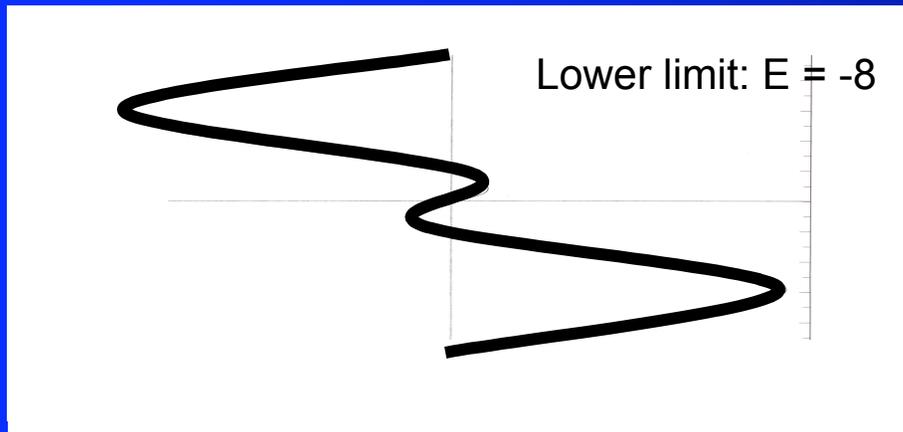
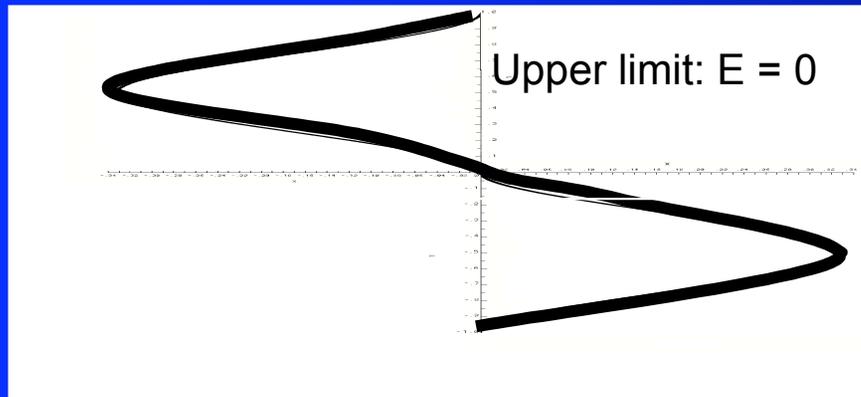


Convectively-coupled system: mesoscale momentum transport

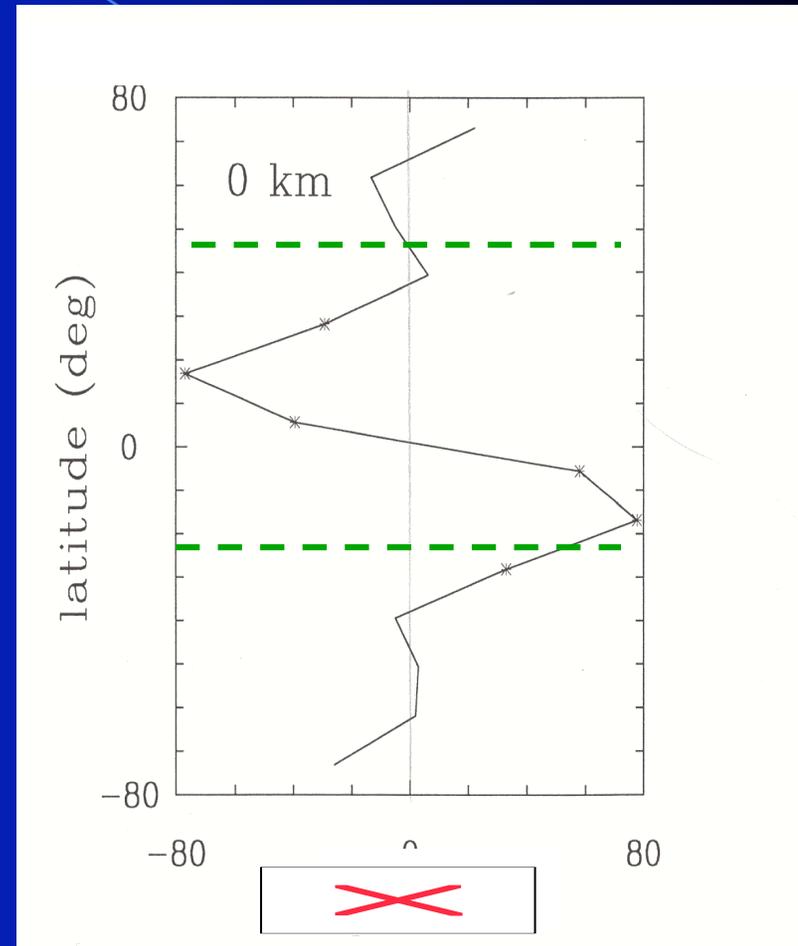


MJO-like system: large-scale momentum transport

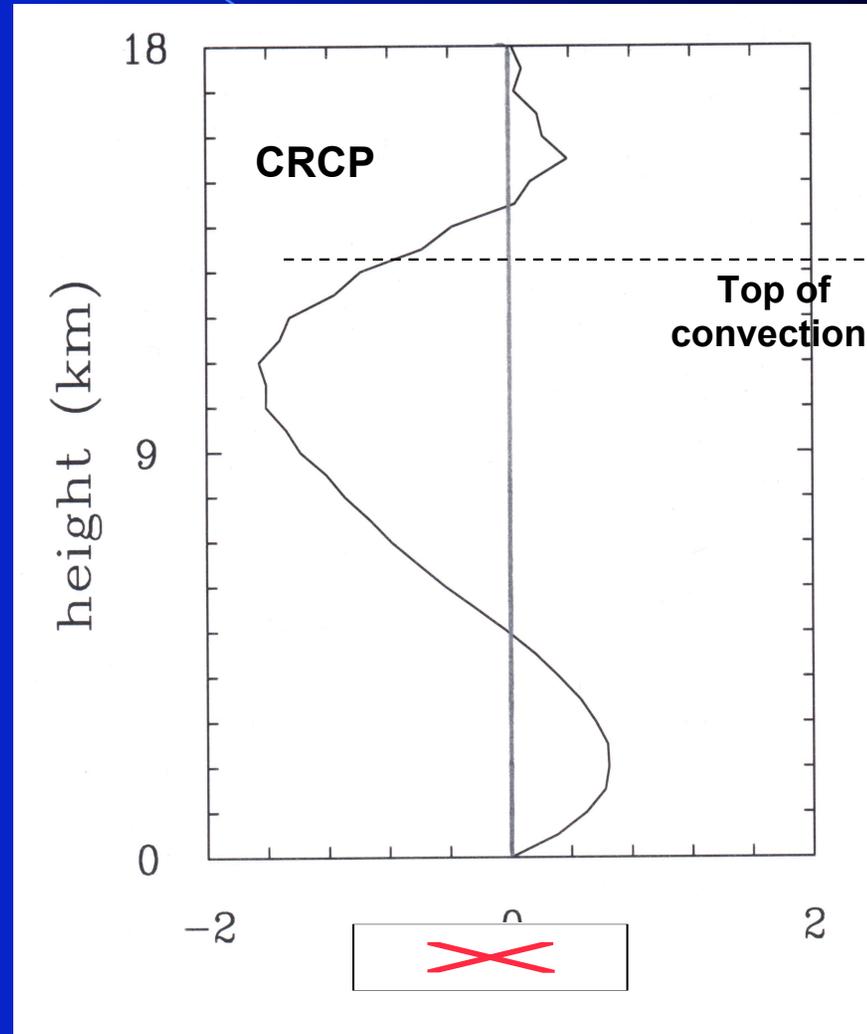
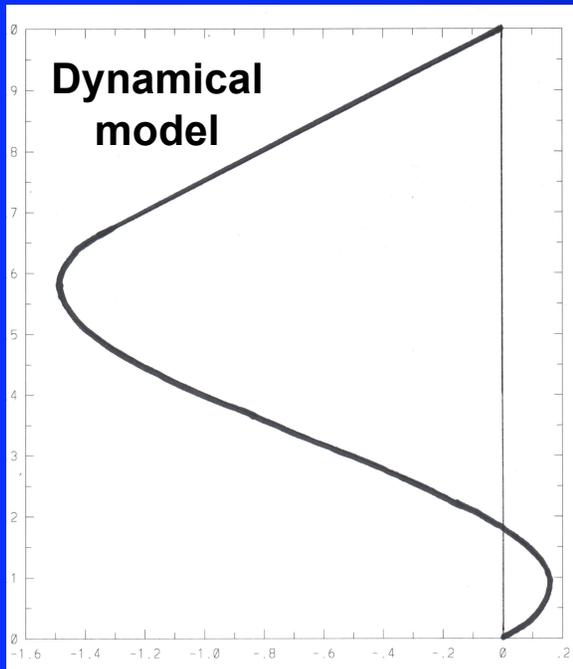
Archetypal model



CRCP

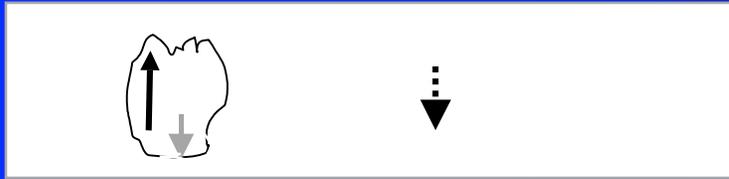


MJO-like system: mesoscale momentum transport



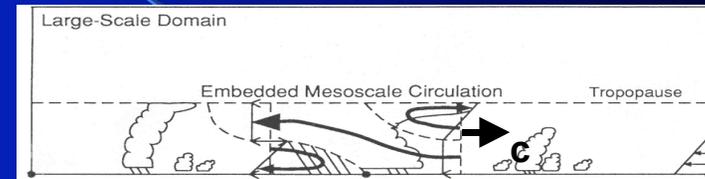
Ordinary vs. organized convection

Ordinary convection



Single grid volume

Organized convection



Perhaps many grid volumes

- Entraining plume
- Shear ignored
- No propagation/advection
- Closed (mass-balance within grid volume)
- Far-field effects minimal

- Organized flow
- Shear controls dynamics, transport
- Propagation/advection key aspects
- Open (interactive with environment)
- Far-field strongly affected

Ordinary and organized
convection are usually
concurrent

Conclusion

- Convection organized on mesoscales coupled analytically to equatorial dynamics has unusually strong 2D mesoscale characteristics: *first baroclinic mode in vertical and environmental shear are crucial.*
- Explains why CSRMs and super-parameterization in full climate models simulate MJO-like systems: they explicitly represent *mesoscale organization and attendant dynamical coupling.*
- *Mesoscale* momentum transport underscored here-- but organized flow has strong thermodynamic/radiative effects too.
- Formal demonstration that organized convection is *parameterizable*, at least in the MJO context; that CRCP can be reduced to a simple form.

Ongoing cloud system studies at NCAR

- **Tropical convection at large (e.g., W. Pacific warm pool, Indian Ocean, ITCZ).**
- **Summertime convection over US continent in weakly-forced conditions: diurnal cycle and propagation (advective) effects, orography (part of NCAR's Water-cycle Across Scales Initiative).**
- **Convection in the North American Monsoon system (NAME)**