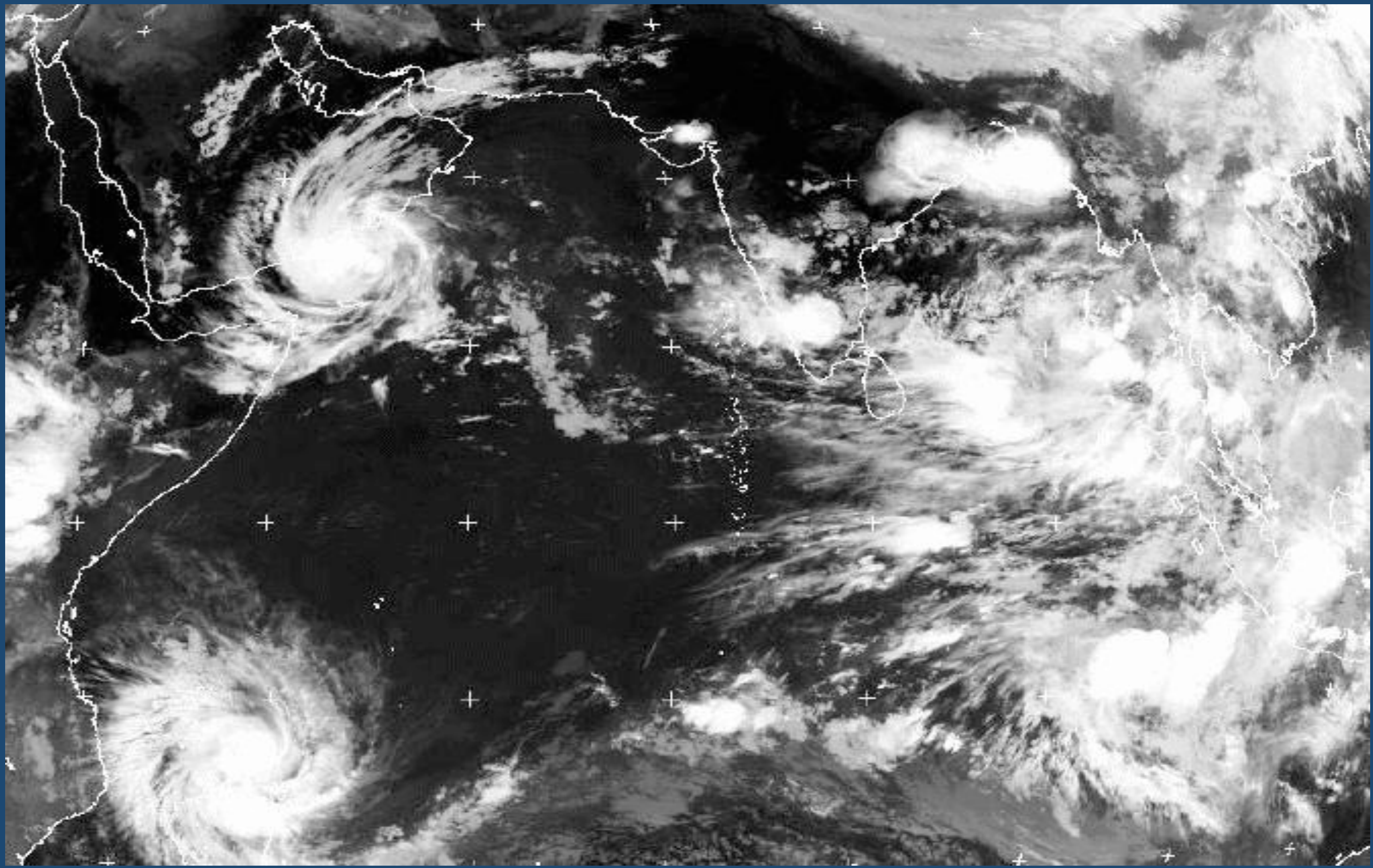
MJO Theme

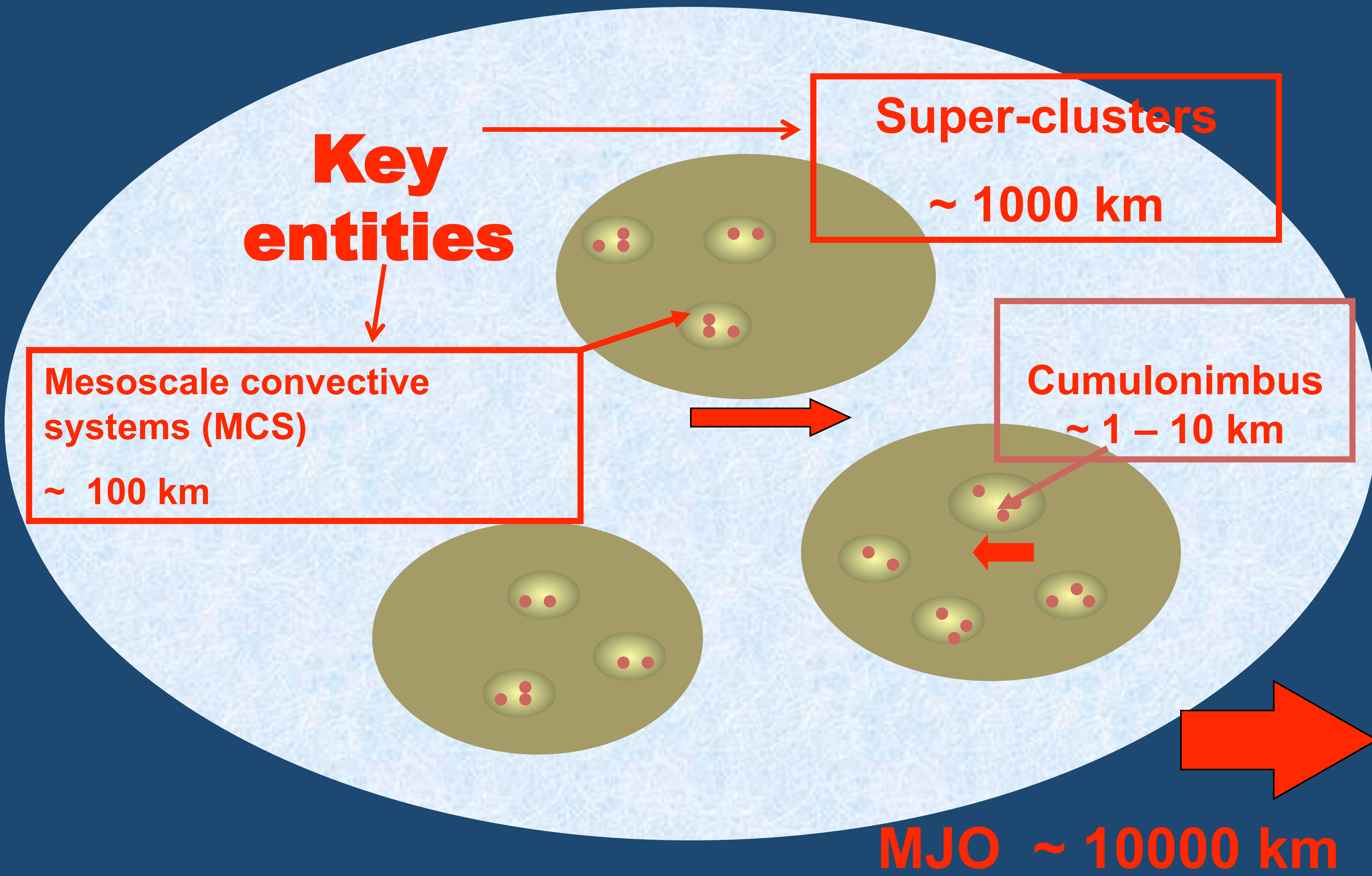


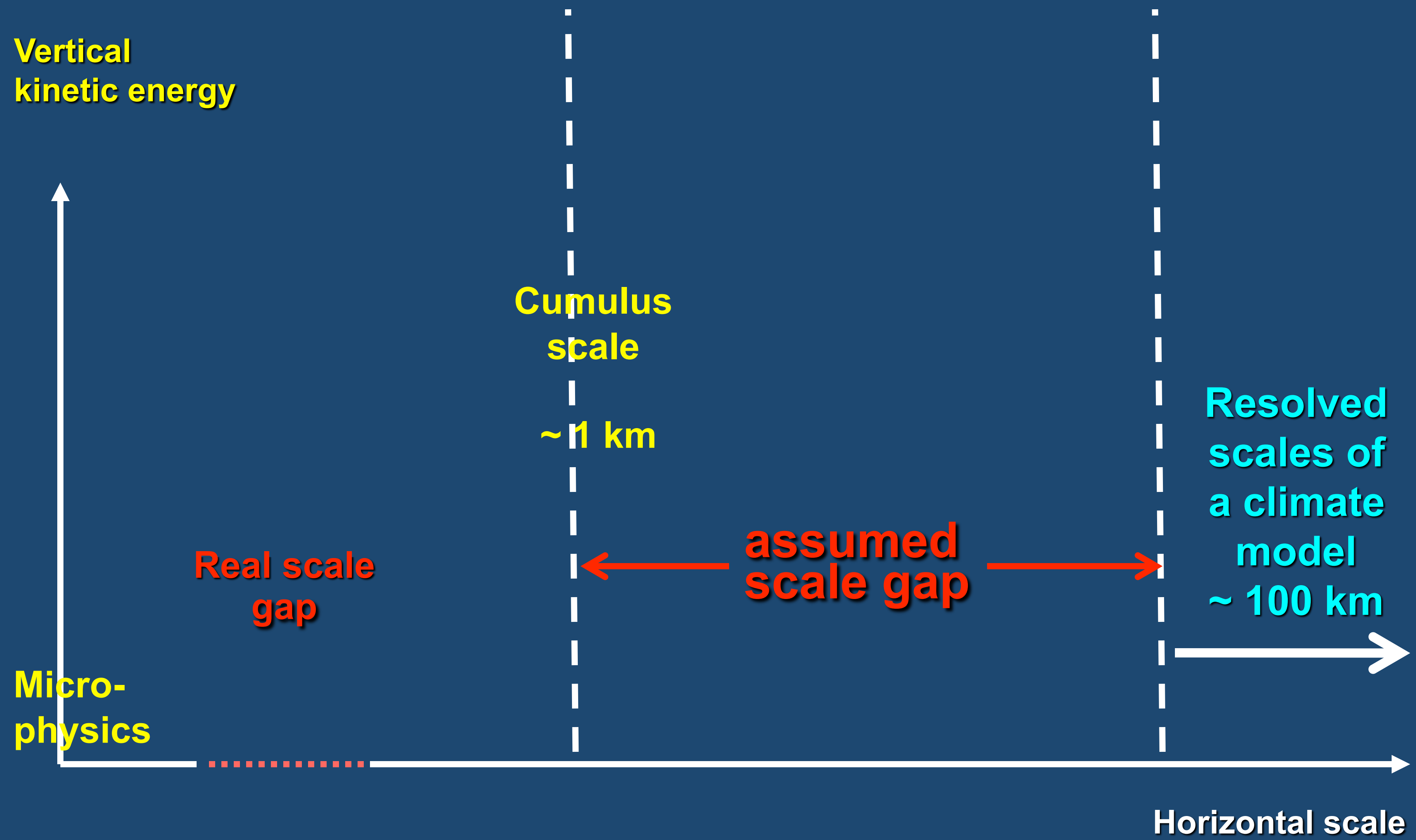
Mitch Moncrieff & Marat Khairoutdinov

Activities

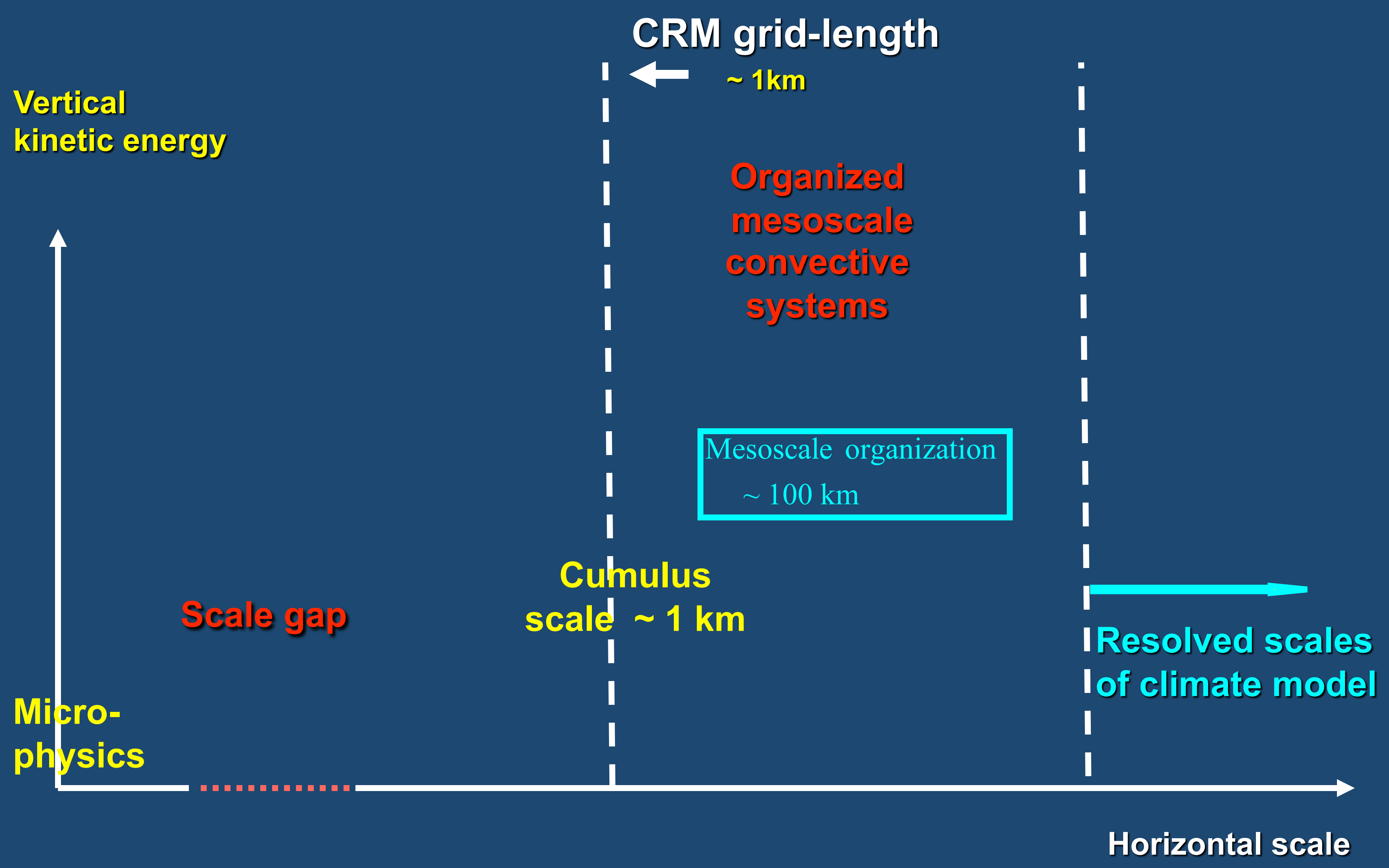
- Representation of MJO in CMMAP MMF via 2D CRM
- Observational evaluation (satellite and field data)

MJO paradigm: an envelope of interacting, finite-amplitude, multi-scale, propagating, organized convective systems



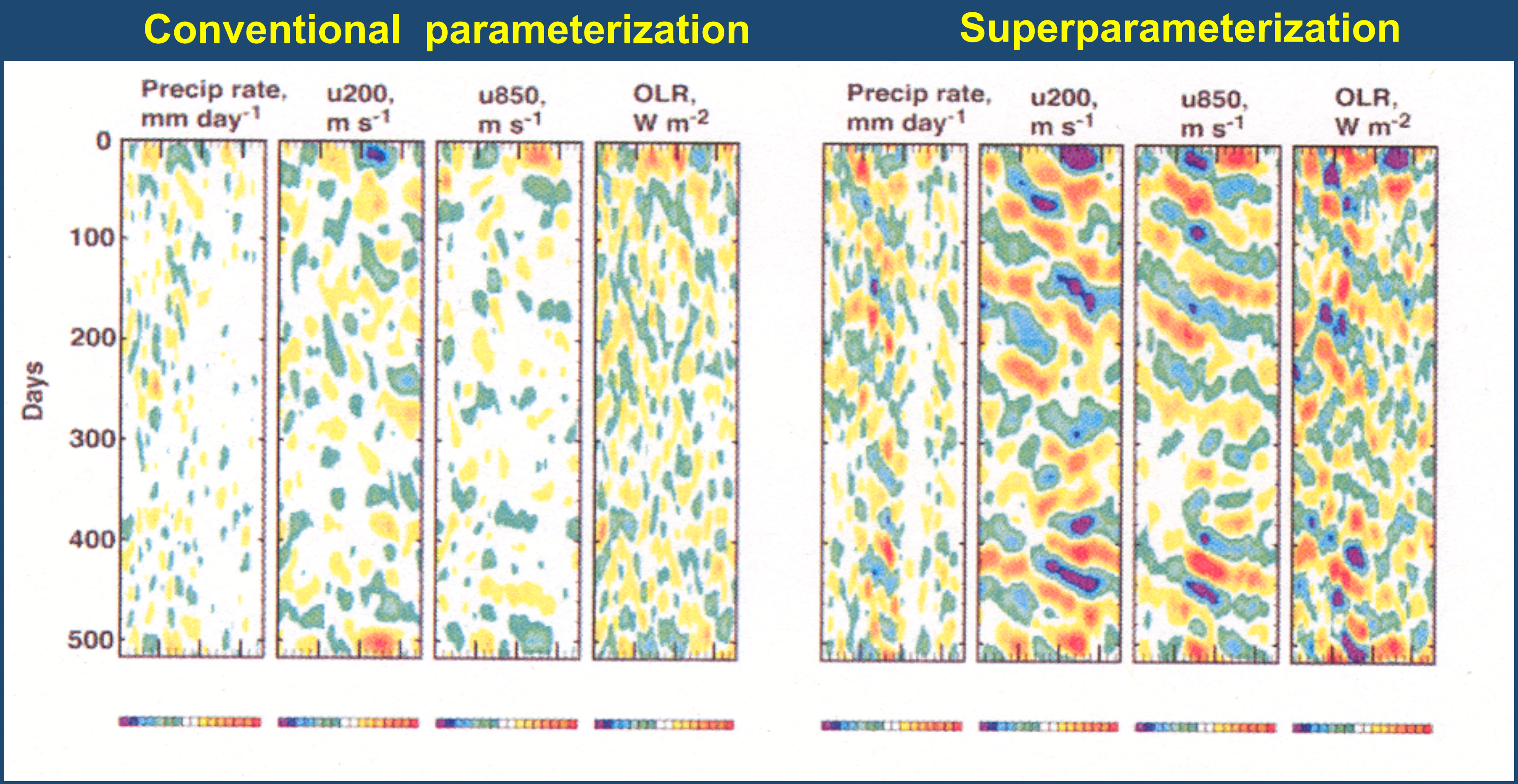


Contemporary Parameterization



Superparameterization

MJO in the Community Atmospheric Model



Khairoutkinov & Randall (2004)

Why do MJOs occur in MMFs?

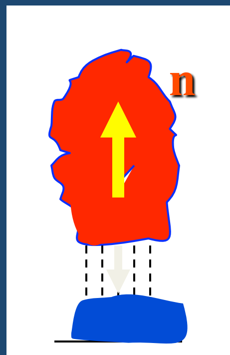
- CRMs embedded in climate models simulate propagating MCS-like convective systems -- CRM strongpoint

i) cold pools/density currents trigger new cumulonimbus: scale ~ 10 km

ii) cumulonimbus families generate MCS : scale ~ 100 km

iii) families of MCS (superclusters) interacting with convectively-generated tropical waves

Stages of upscale evolution



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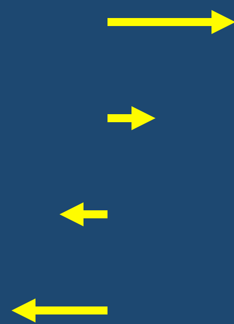

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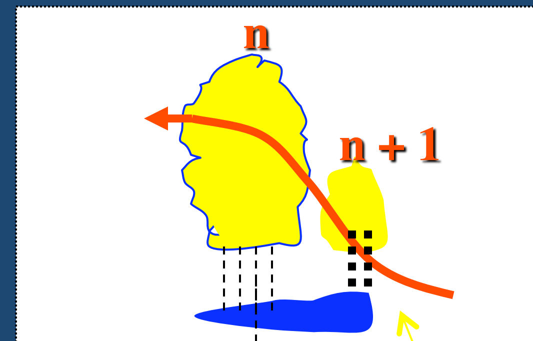
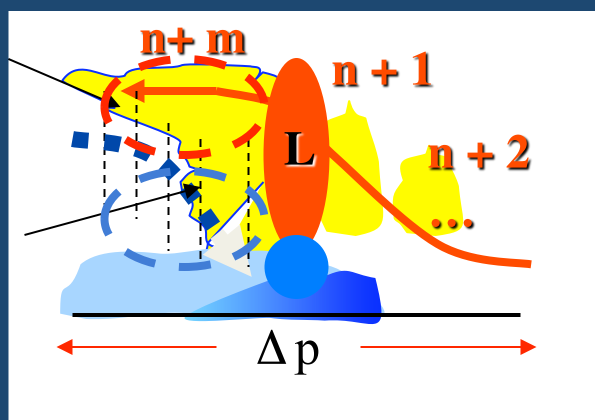


1: Cumulonimbus

2: Cumulonimbus family

Stratiform ascent

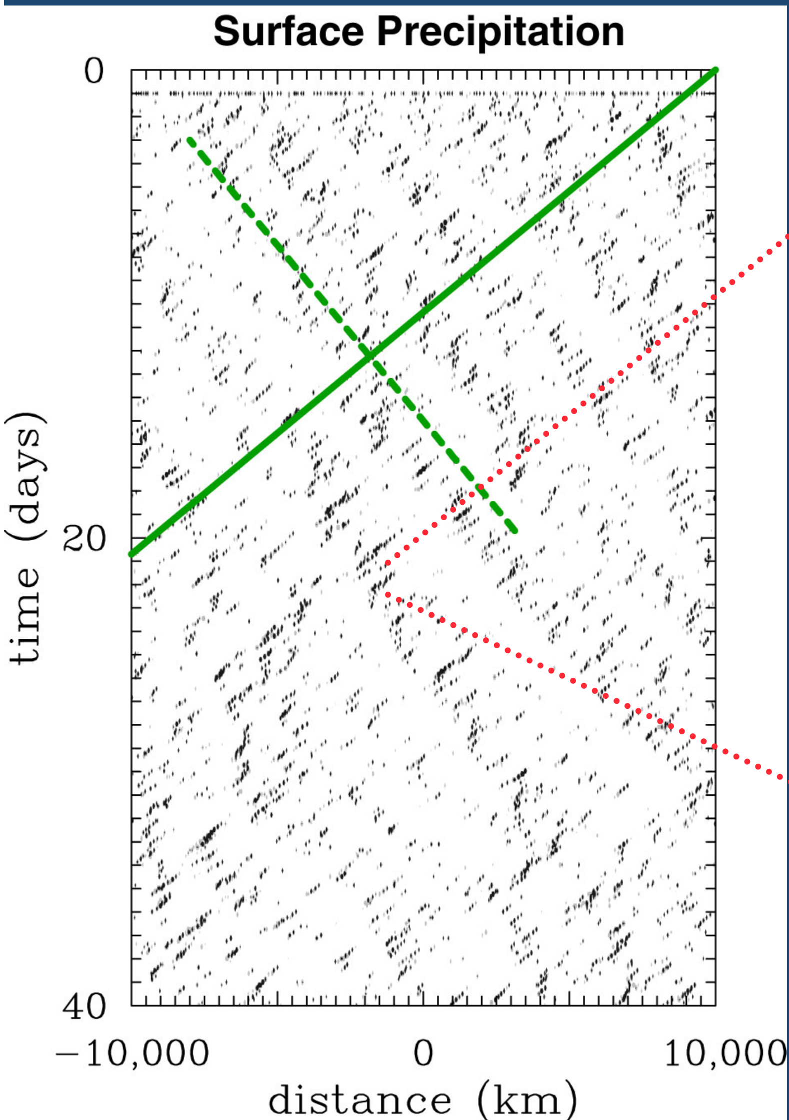
Mesoscale downdraft

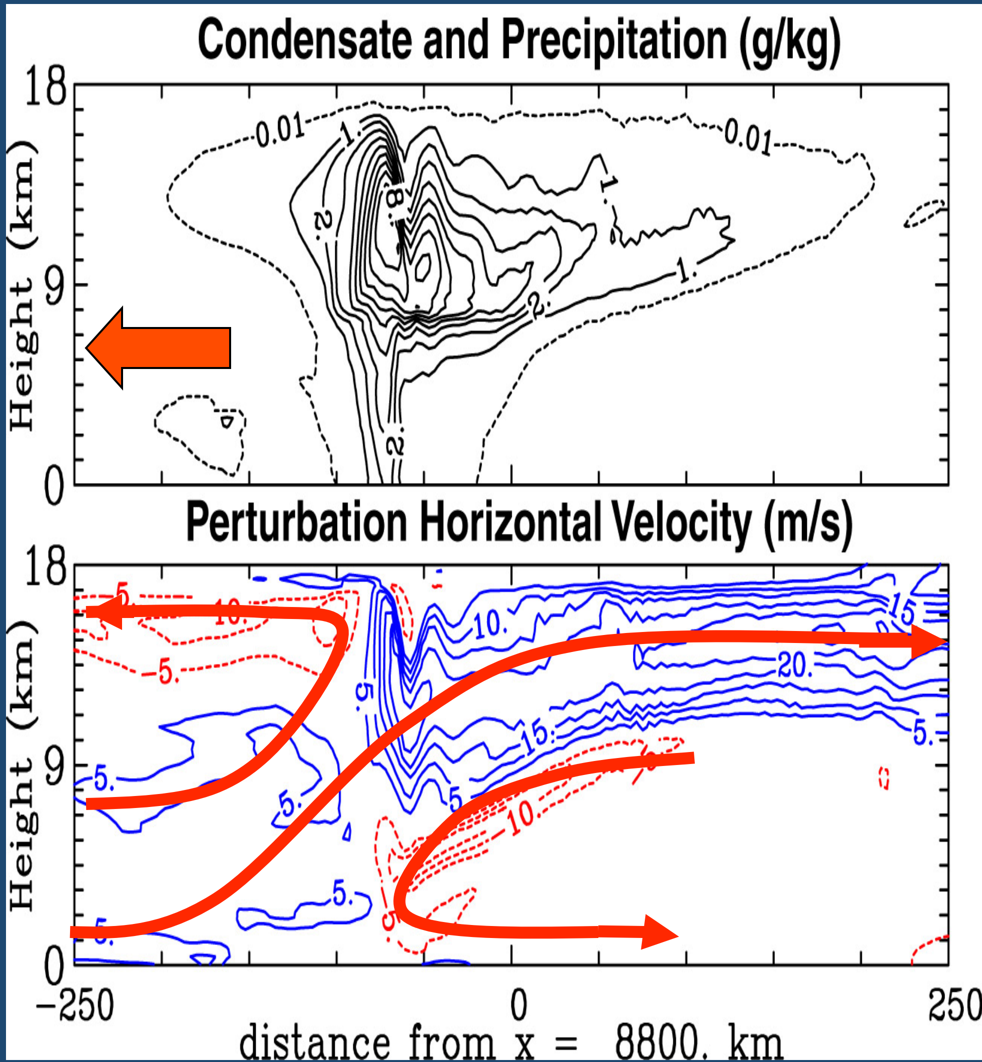


3: Mesoscale convective system

Cold-pool boundary-layer convergence triggers families of cumulonimbus

Tilted westward-traveling MCSs embedded in eastward-traveling waves, starting from a uniform motinless state

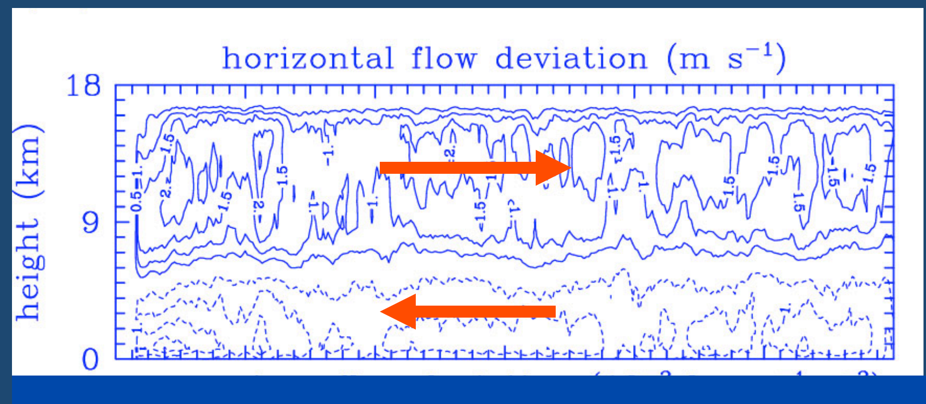


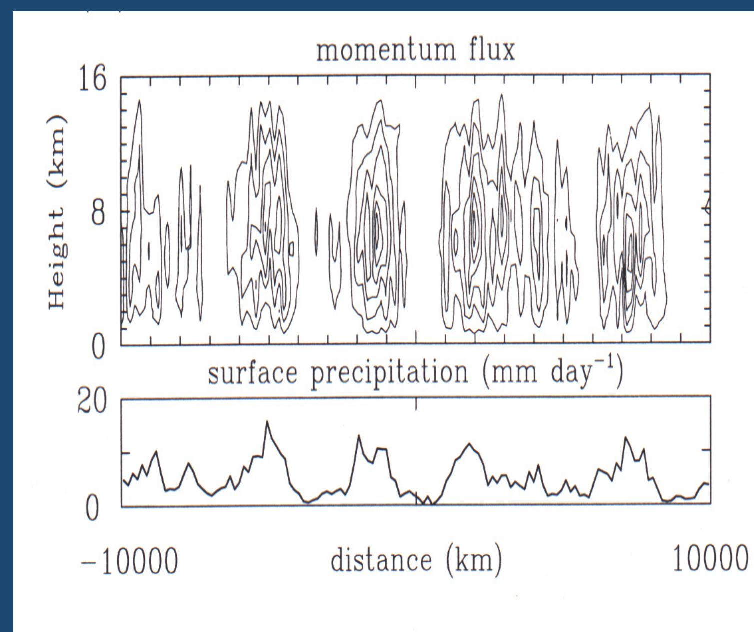


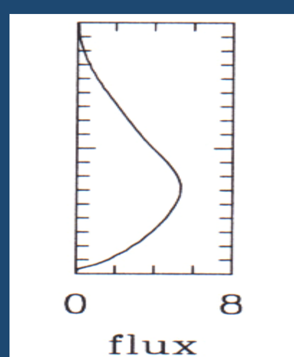
Grabowski and Moncrieff (2001)

Organized convection redistributes horizontal momentum

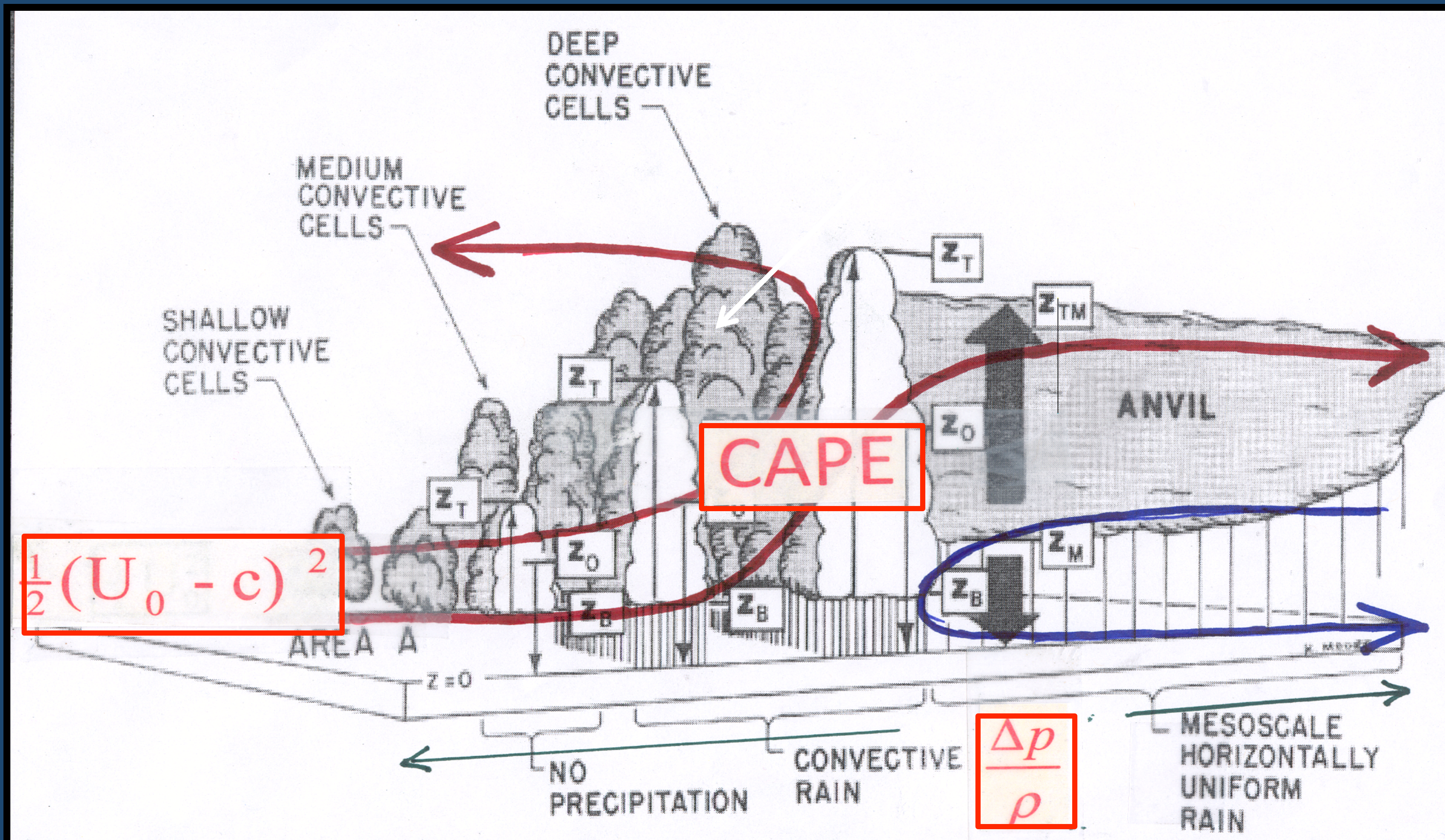
Vertically tilted airflow in MCS redistribute horizontal momentum (convective momentum transport) resulting in positive dynamical feedback via shear generation







Energetics of MCS-type organization



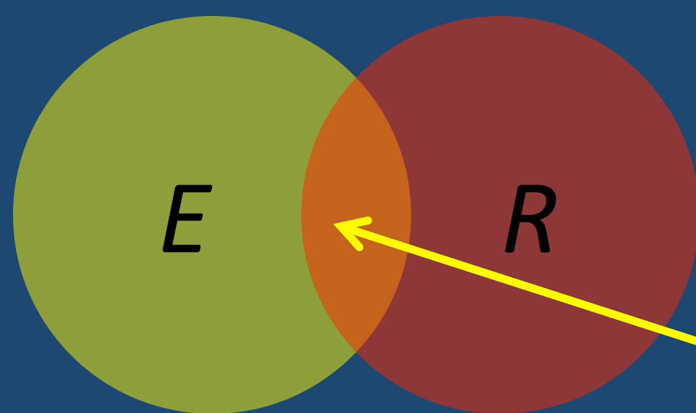
3 energy forms: i) potential; ii) kinetic; iii) work done by convectively-generated pressure gradient

2 scaled quantities:

$$E = \frac{\Delta p}{\rho \frac{1}{2}(U_0 - c)^2}$$

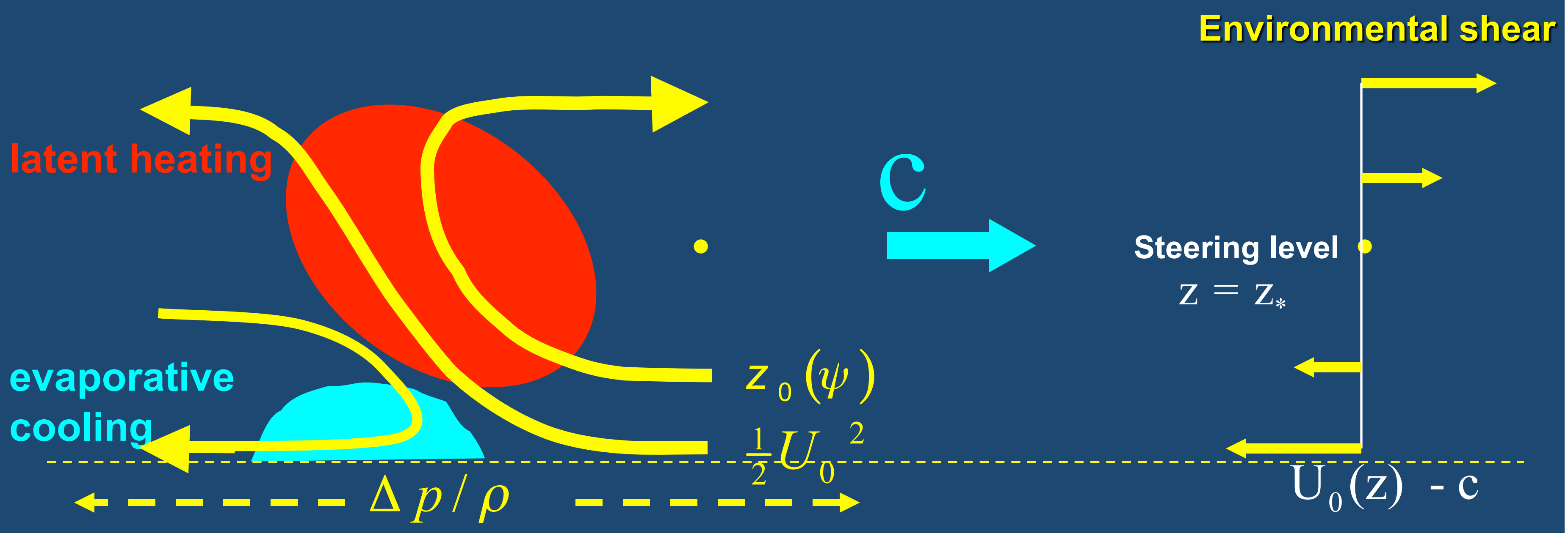
$$R = \frac{CAPE}{\frac{1}{2}(U_0 - c)^2}$$

Hydraulic dynamics are key



MCS- type organization : at intersection of *E-R* space

MCS-type organization

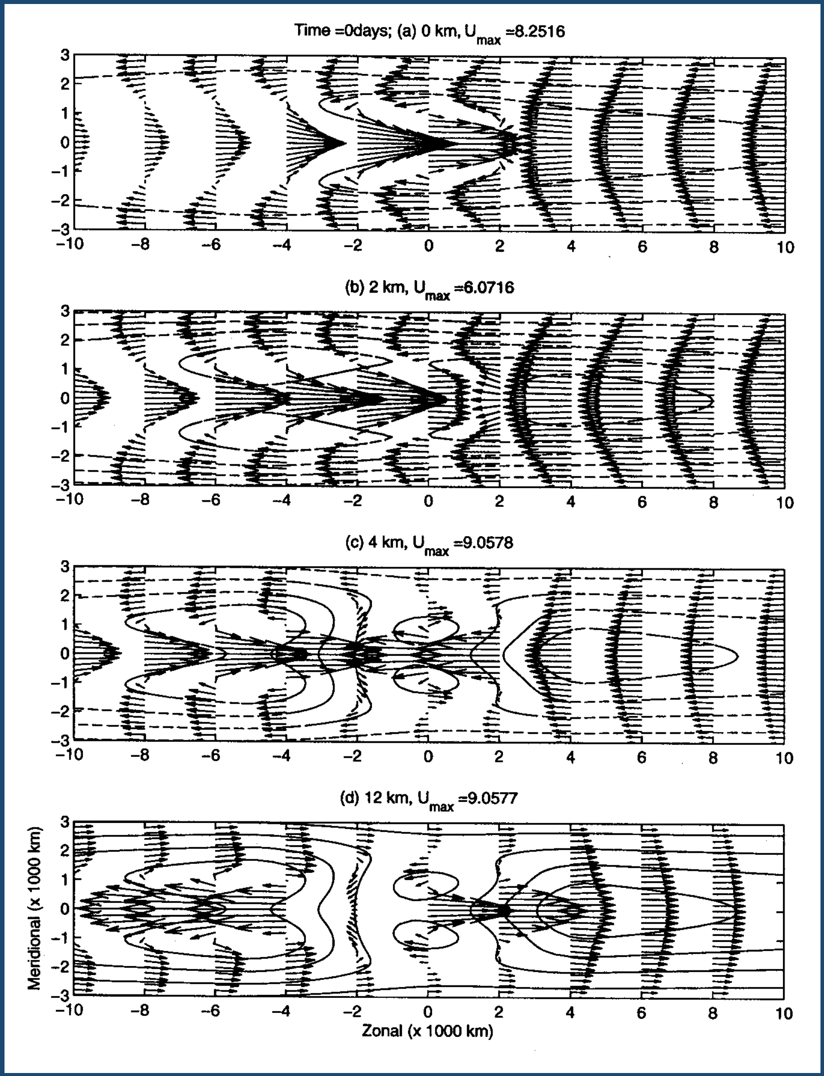


$$\nabla^2 \psi = G(\psi) + \int_{z_0}^{z} \left(\frac{\partial F}{\partial \psi} \right) dz$$

Rearward-tilted 2-D morphology: i) efficient transporter water, energy, mass and momentum ; ii) preferred regime of organization in CRMs and super-parameterized models

Do tilted MCS-like systems (i.e., mesoscale-to-synoptic scale heat and momentum transport) help MJOs?

Upscale effects of MCS-like heat & momentum transport on MJO



$$\bar{U}_t - y\bar{V} + \bar{P}_X = F^U - d_m\bar{U}$$

$$y\bar{U} + \bar{P}_y = 0$$

$$\bar{\theta}_t + \bar{W} = F^\theta - d_\theta + \bar{S}_\theta$$

$$\bar{P}_z = \bar{\theta}$$

$$\bar{U}_X + \bar{V}_y + \bar{W}_z = 0$$

$$F^U = -\overline{(v'u')}_y - \overline{(w'u')}_z$$

$$F^\theta = -\overline{(v'\theta')}_y - \overline{(w'\theta')}_z$$

Biello, Majda and Moncrieff (2007)

Some discussion items

- 2-D SP: generates MCS-type organization
- Do overly extensive MCS-like systems contribute to over-active MJO precipitation , etc.
- More attention to quantifying role of convective momentum transport (theoretical-dynamical insight suggests it's relevant)
- 3-D SP: computational domains too small to properly represent convective organization , but should improve explicit representation of cumulonimbus convection
- Representation of moist turbulence and PBL in CRMs, that CRMs do not resolve
- Parameterize MCS : needed for long climate integrations