Propagating precipitation systems over the US continent

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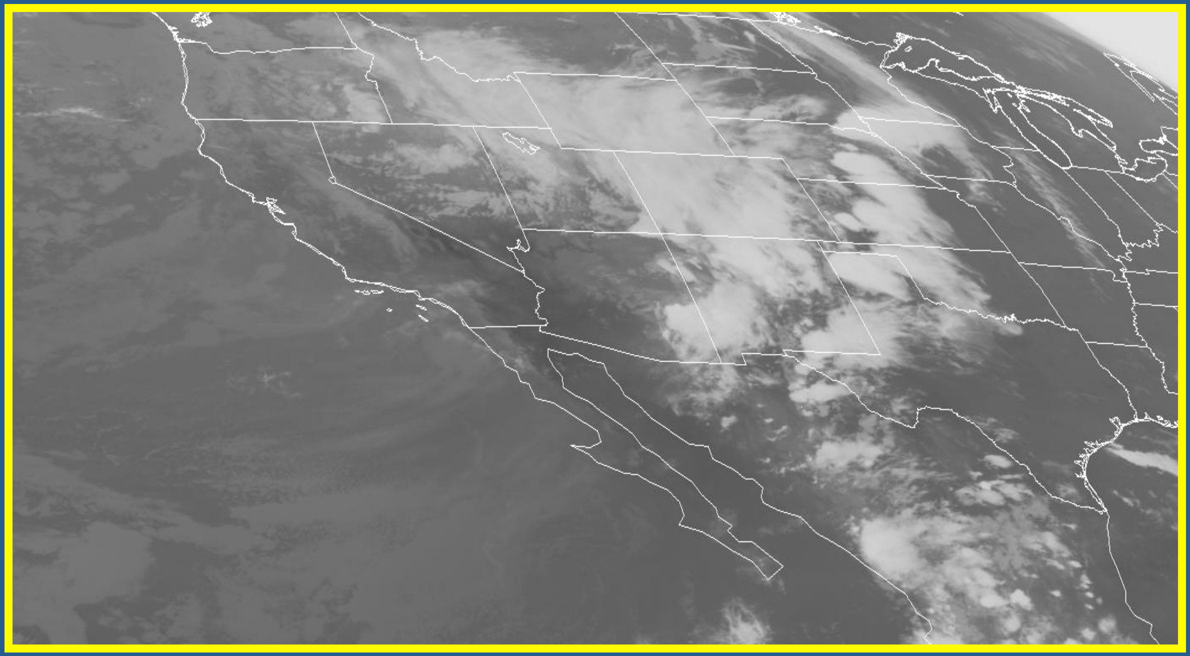


KT Breakout, CMMAP
Workshop, Fort Collins, Aug 3-5 , 2010

IPCC AR4: *Changes in precipitation* estimated from climate models for World's most populated regions have low confidence (< 66% of models agree on the sign of the change, white), especially in summer

Correlated with organized convective activity over continents

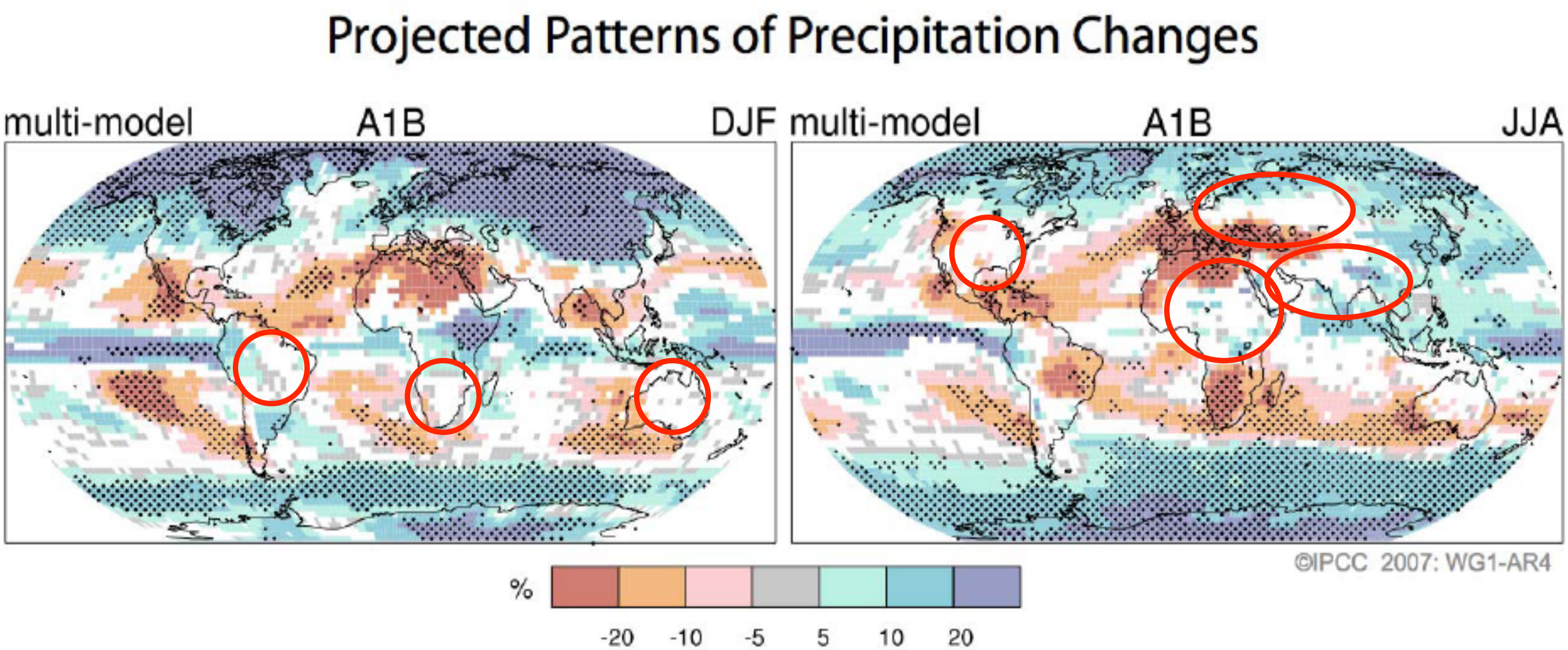
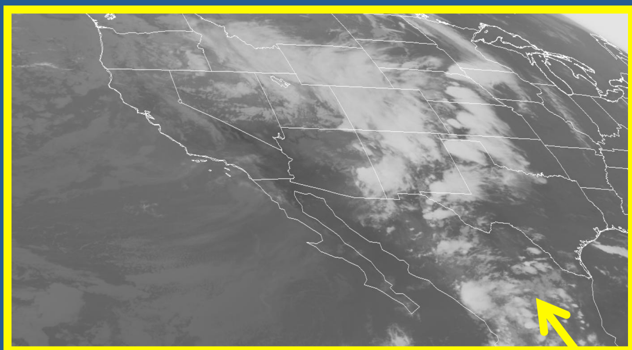
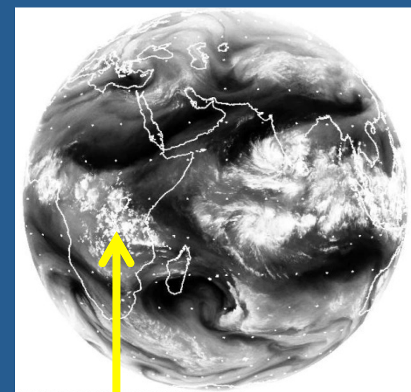
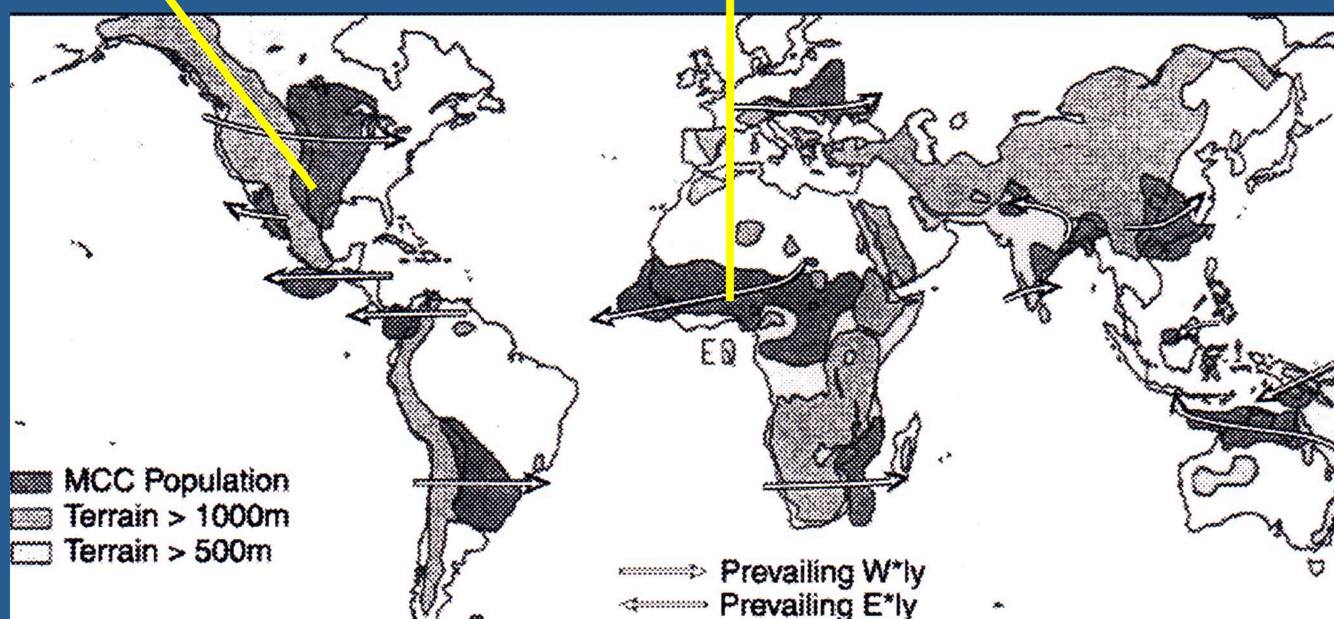


FIGURE SPM-7. Relative changes in precipitation (in percent) for the period 2090–2099, relative to 1980–1999. Values are multi-model averages based on the SRES A1B scenario for December to February (left) and June to August (right). White areas are where less than 66% of the models agree in the sign of the change and stippled areas are where more than 90% of the models agree in the sign of the change. {Figure 10.9}

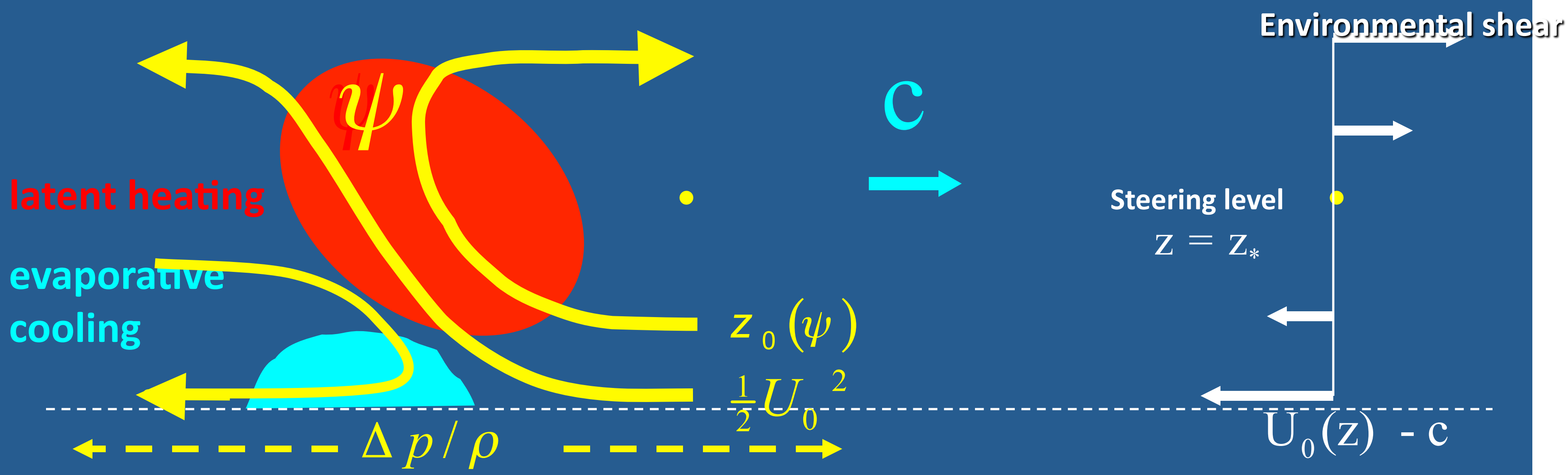
Orogenic MCS downstream of mountains







Slantwise layer overturning: A highly efficient regime of convective organization



Dimensionless quantities:

$$E = \Delta p / \tfrac{1}{2}\rho U_0^2 \qquad F_c = \sqrt{\mathrm{U}_0^2/\mathrm{CAPE}}$$

Governing equation:

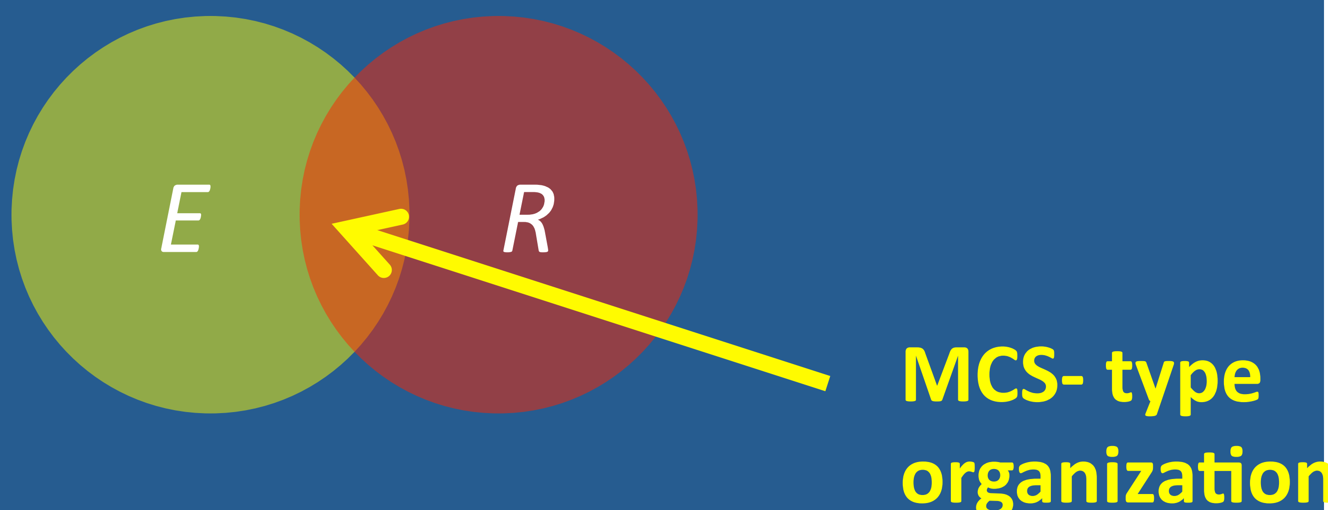
$$\nabla^2 \psi = G(\psi) + \int_{z_0}^{z} \left(\frac{\partial H}{\partial \psi} \right) dz$$

$G(\psi)$ environmental shear $\qquad H(\psi, \mathrm{z})$ Updraft / downdraft buoyancy

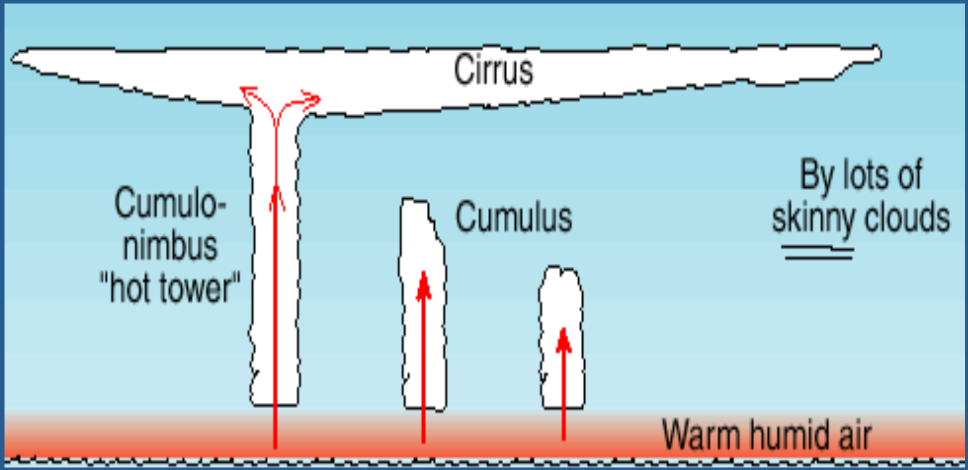
3 forms of energy -- convective available potential energy (CAPE); kinetic energy of shear flow, work done by the pressure gradient -- define 2 key dimensionless quantities:

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

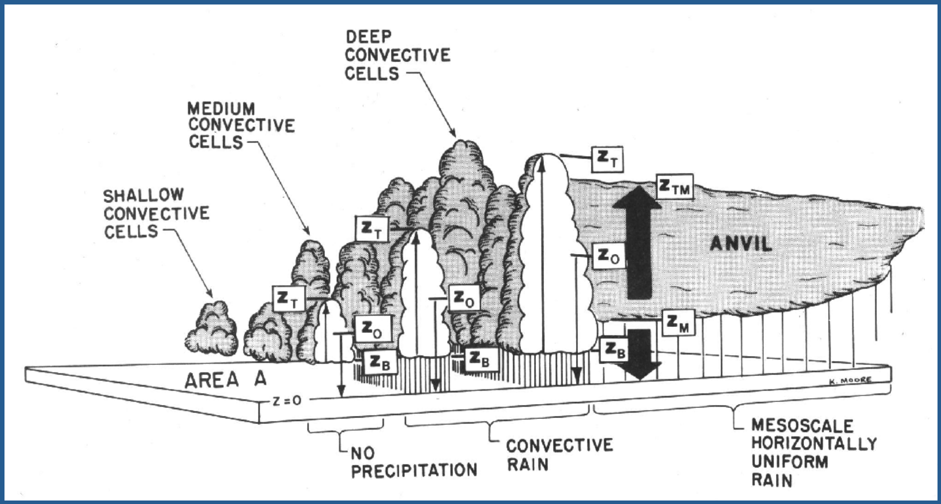
$$R = \frac{CAPE}{\frac{1}{2}(U_0 - c)^2}$$



EARLY VIEW OF OCEANIC TROPICAL CLOUD EXSEMBLE

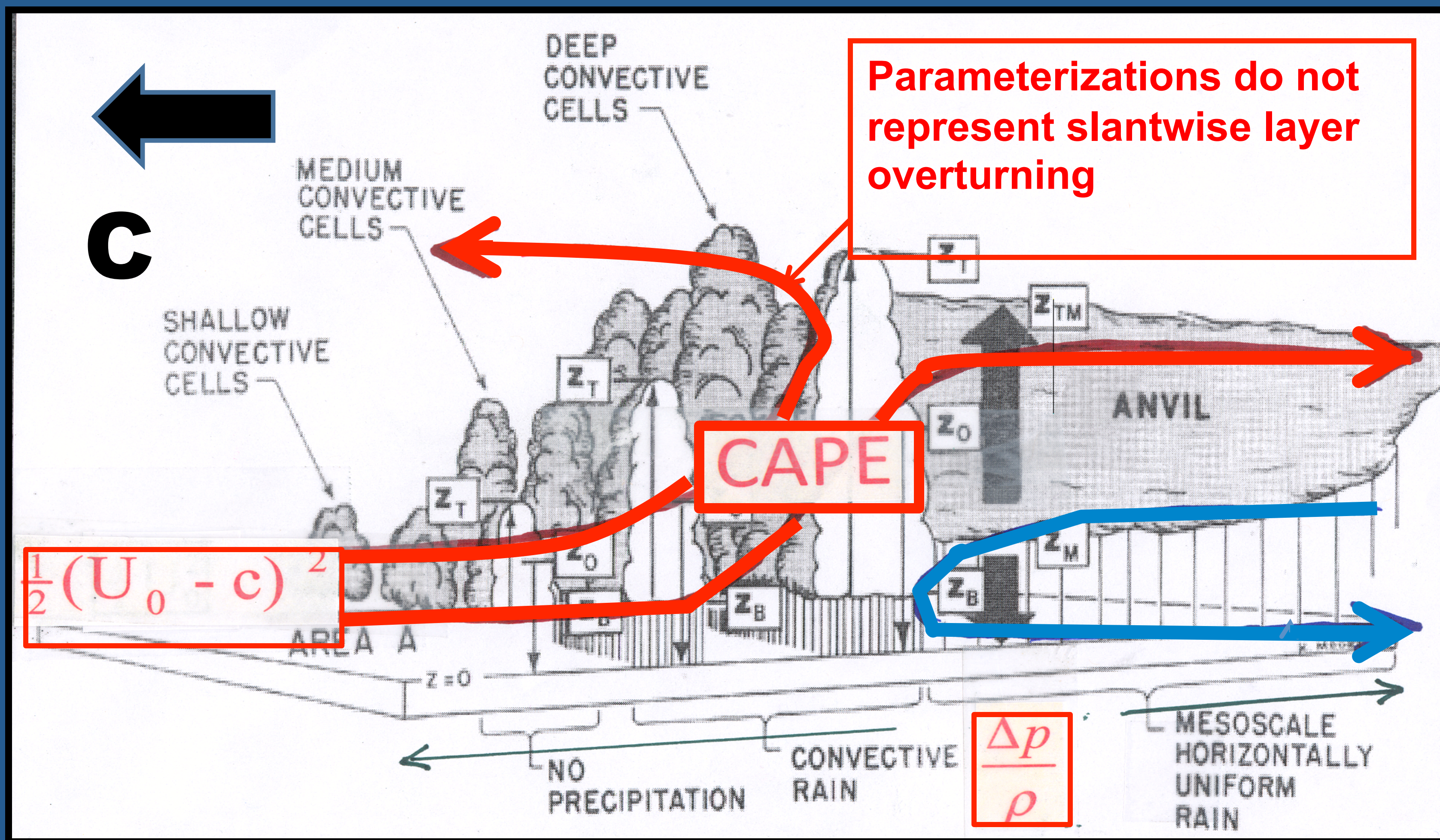


Arakawa & Schubert (1974)



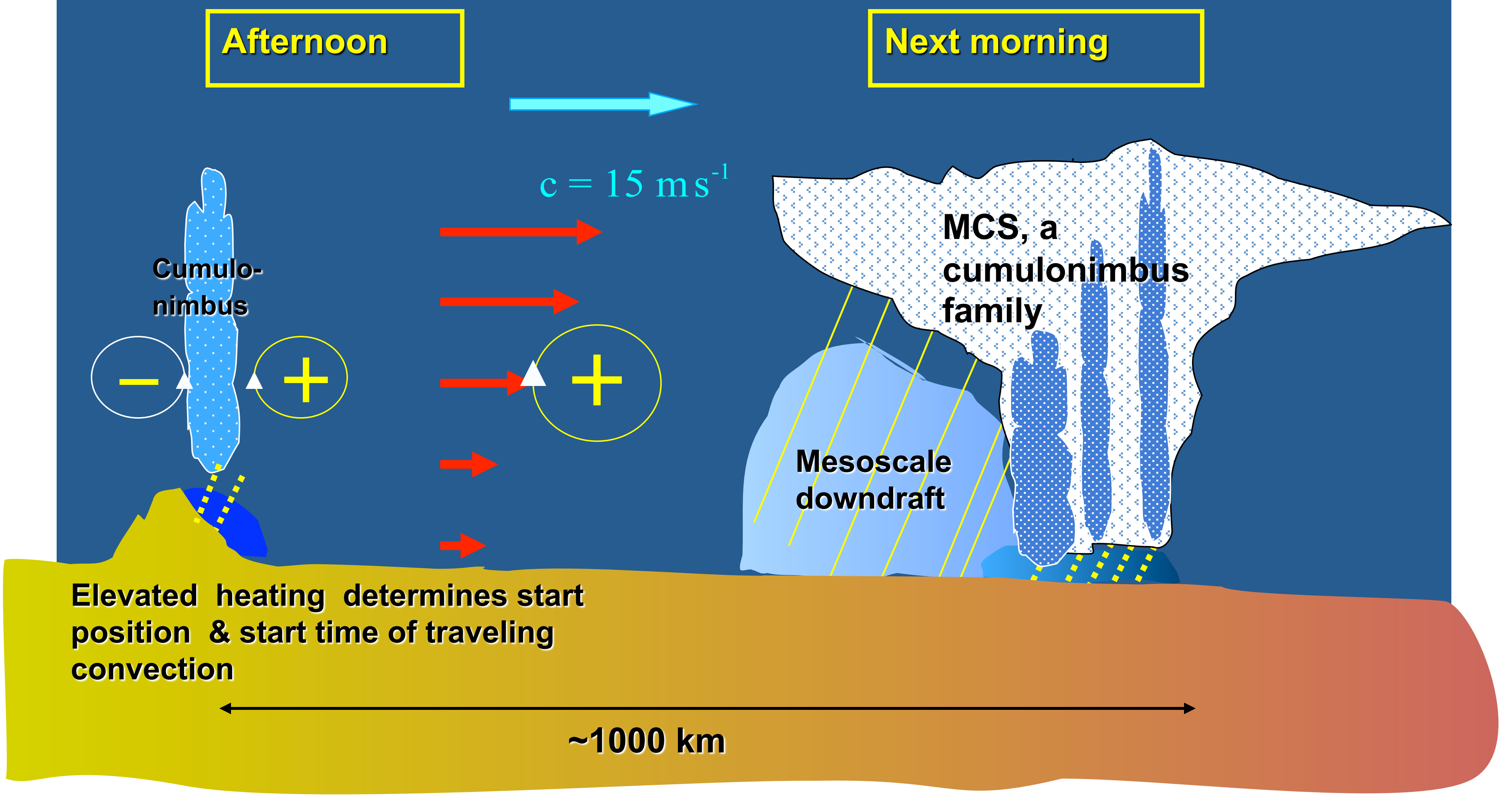
PROPAGATING MCS: 3-D cloud structures (shallow vs. deep, convective vs. stratiform, warm vs. cold downdrafts, and associated mesoscale circulation patterns (Houze 1984)

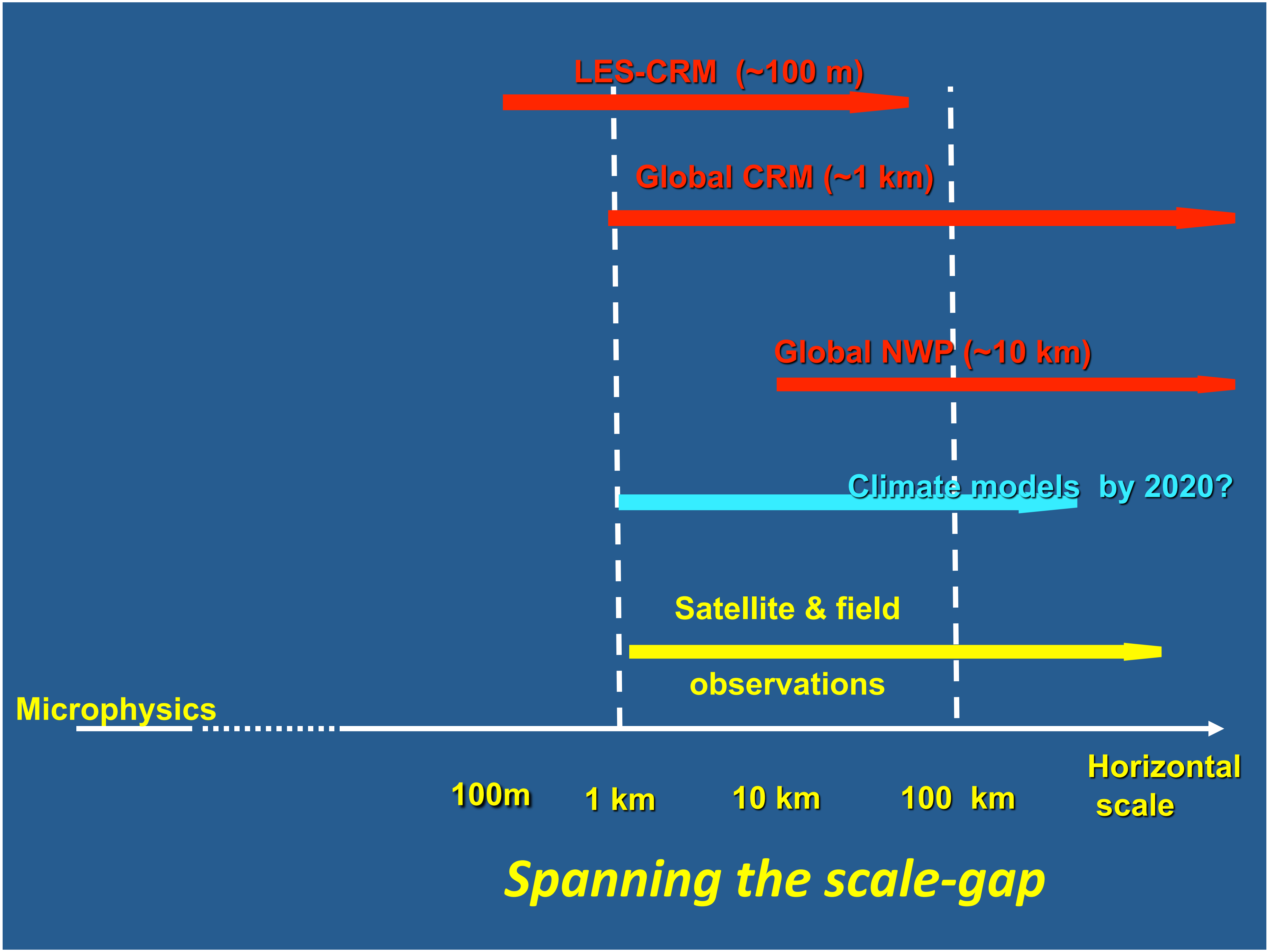
Anatomy of MCS-type organization



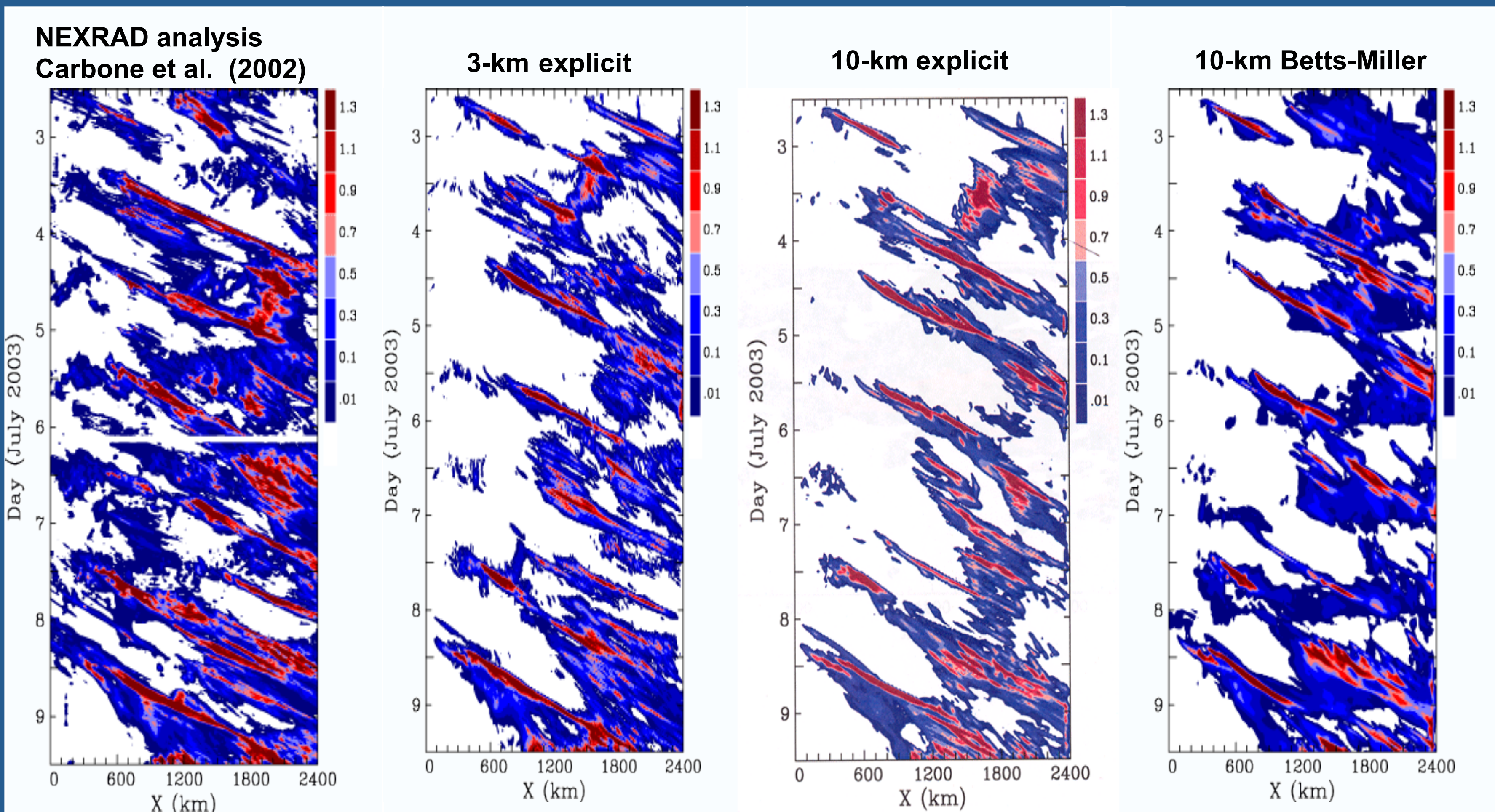
CAPE = Convective Available Potential Energy

Propagating convection downstream of moutains



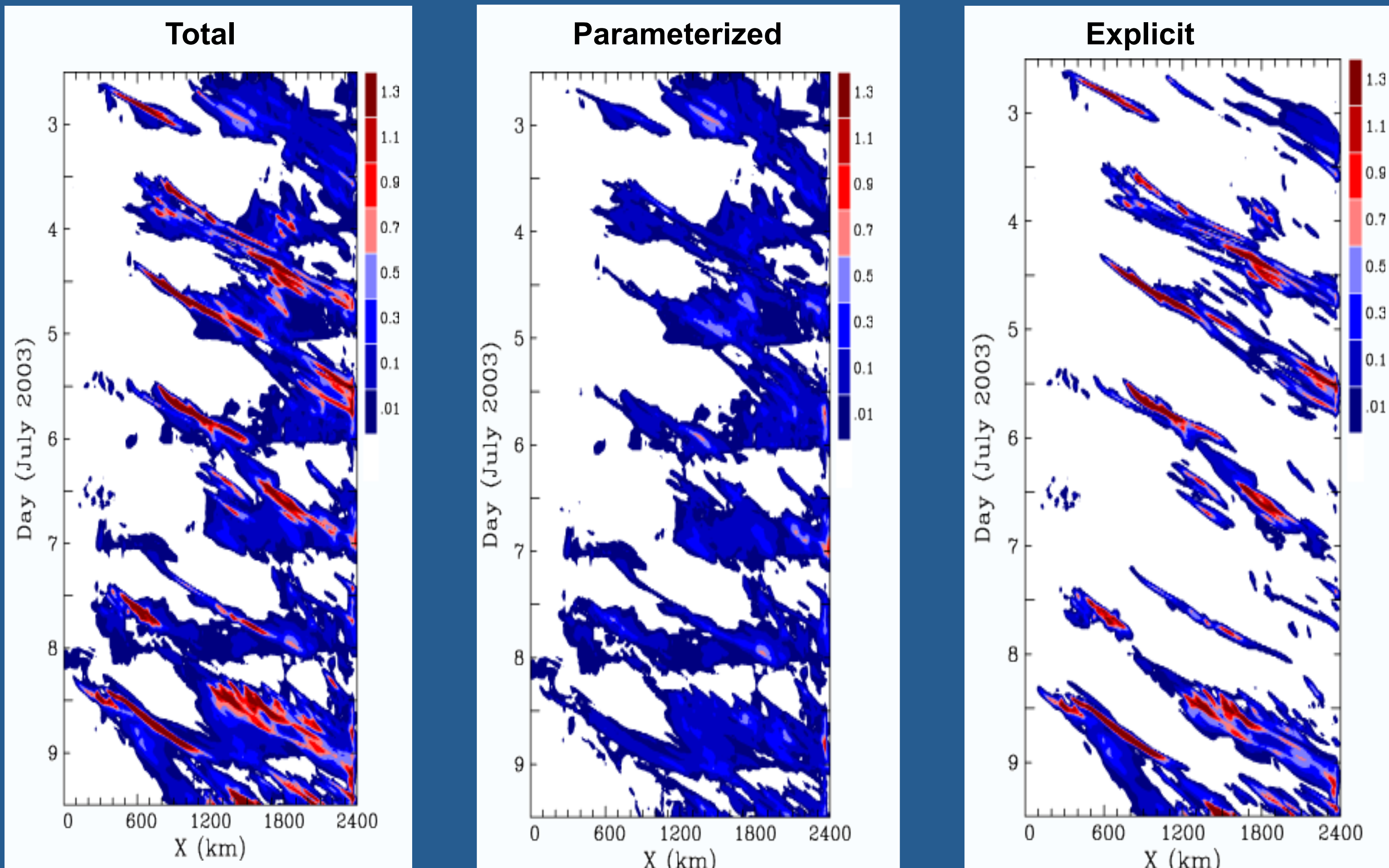

LES-CRM (~100 m)
Global CRM (~1 km)
Global NWP (~10 km)
Climate models by 2020?
Satellite & field
observations
Microphysics
100m
1 km
10 km
100 km
Horizontal scale
Spanning the scale-gap

Meridionally averaged rain-rate

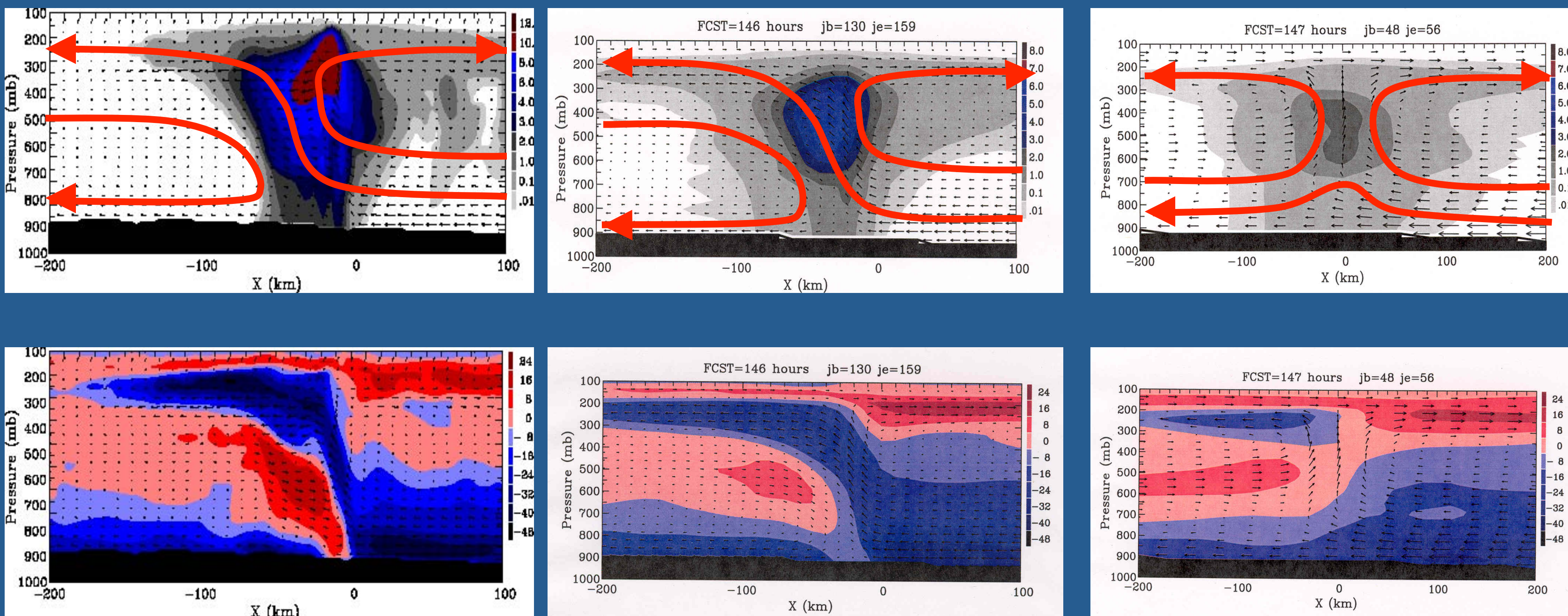


Moncrieff and Liu (2006)

‘Grid-scale’ circulations capture propagating precipitation



Resolution dependence



Δ = 3 km   Δ = 10 km   Δ = 30 km

3-km & 10-km grid – realistic

30-km grid – unrealistic

Over to Mike Pritchard…