SENSITIVITY OF SIMULATED CONVECTIVELY COUPLED KELVIN WAVES TO PHYSICS SCHEMES AND RESOLUTION WITH AN IDEALIZED TROPICAL CHANNEL

Joaquín E. Blanco [1], David S. Nolan [1] and Stefan N. Tulich [2]

1 - Rosenstiel School of Marine and Atmospheric Science, University of Miami, Miami, FL

2 - NOAA Earth System Research Laboratory, CIRES/University of Colorado, Boulder, CO

1. MOTIVATION AND BACKGROUND: THE CCKWs

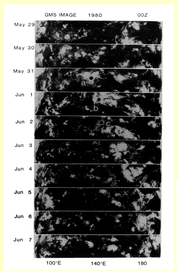
Why are CCKWs important?

- They contribute significantly to the variability of the ITCZ and might also influence its structure
- As with the ITCZ, model representation varies with different physics schemes, in particular cumulus and boundary layer.

Properties of CCKW

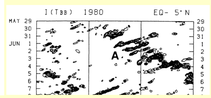
- L~2000-4000km (region of enhanced convection)
- T~30-45 days (to move around the globe)
- Cx ~ 8-15º/day ~ 10-20m/s

The observed CCKW began to be studied in the 1980s, referred as "SUPERCLUSTERS" or "SUPER CLOUD CLUSTERS" (SCC) propagating eastward at the equator

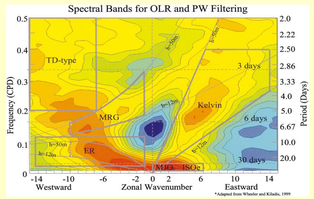


Nakazawa, 1988, JMSJ
Hayashi and Nakazawa, 1989, JMSJ
Takayabu and Murakami, 1991, JMSJ
Takayabu, 1994, MWR

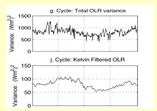
Within the SCC individual cloud clusters move westward



More recently, studies apply a filtering in the k-ω space to isolate CCKWs



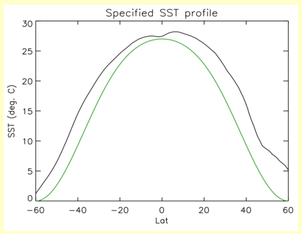
Wheeler and Kiladis, 1999, JAS
Straub and Kiladis, 2002, JAS
Straub and Kiladis, 2003, JAS
Roundy and Frank, 2004, JAS
Roundy, 2008, JAS

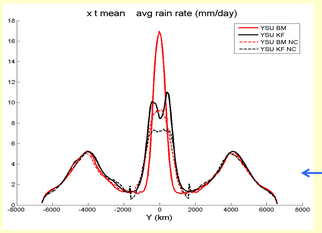


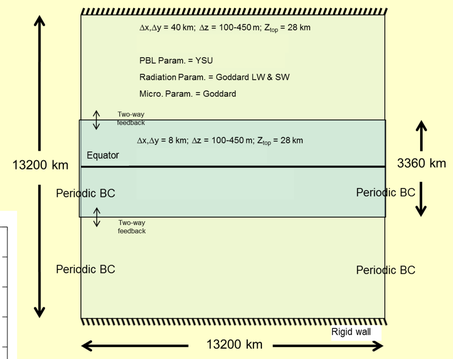
2. WRF IDEALIZED SIMULATIONS: MODEL SETUP AND SCHEMES

The model configuration:

- equatorial β-channel
- no topography, ocean only
- 64 vertical levels
- spin-up time ~ 1 year
- "observed" SST profile (aquaplanet intercomparison project: *Neale and Hoskins, 2000*)







Simulations are performed with either:

1) convection parameterized everywhere
2) convection treated explicitly in the tropics through grid nesting

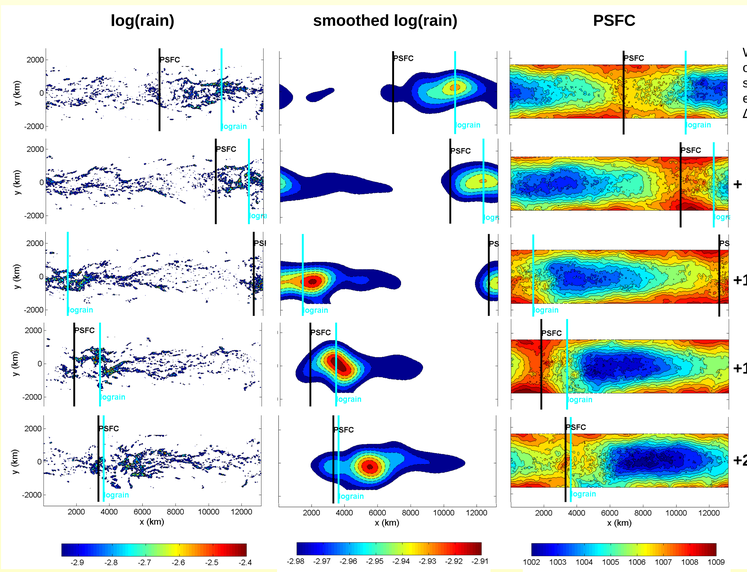
A) Betts-Miller-Janjic (BM) cumulus scheme [based on moist convective adjustment]
B) Kain-Fritsch (KF) cumulus scheme [based on entraining/detraining plume]

4 experiments: BM BM-NC KF KF-NC

"MODEL CLIMATOLOGY"
BM: sharp ITCZ on the equator
KF: weaker, double-peak ITCZ
NC cases: weaker ITCZ

3. METHODOLOGY: TRACKING THE CCKWs

An algorithm is implemented to track the axis associated with the CCKW: tests with different parameters and variables were performed. Chosen variable is surface pressure, PSFC. Below, an example for the BM-NC case.

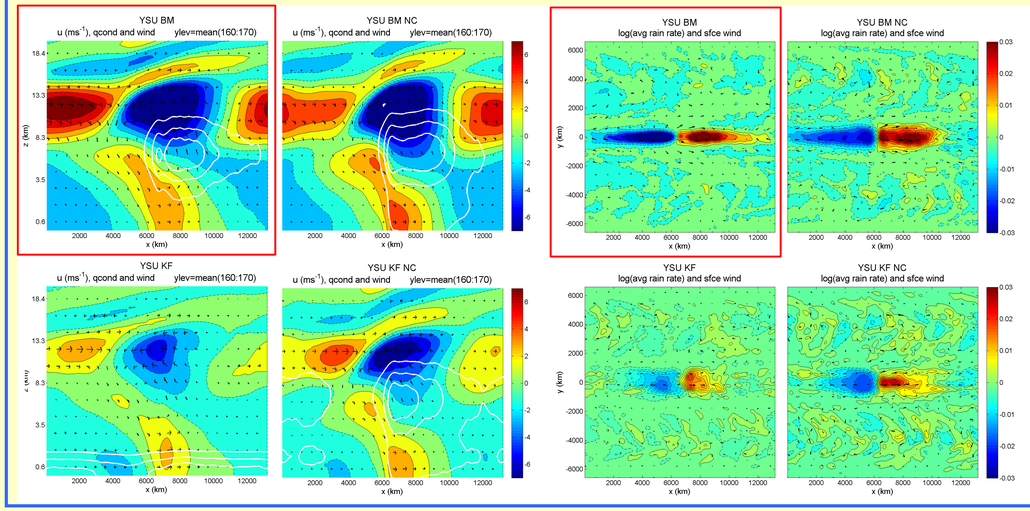


4. RESULTS: COMPOSITES

With reference to the maximum PSFC (tracker of the CCKW), all 2D and 3D variables are shifted in the E-W direction and averaged in time. Axis of the composited CCKW is relocated to the center of the domain. The zonal mean of the composite (time and zonal mean of raw variable) is subtracted to obtain the perturbation composite. Horizontal fields at different levels and vertical slices at the equator are shown.

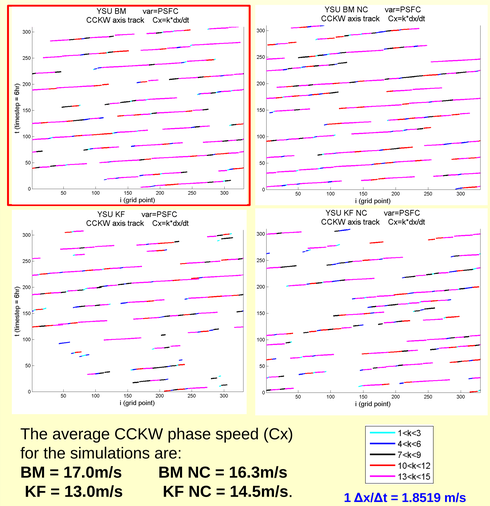
BM simulation

For u(z) and precipitation, the comparison among the 4 simulations is shown



4. RESULTS: PROPAGATION SPEEDS

The axis of the CCKW propagates with varying speed along the tropical channel



The average CCKW phase speed (Cx) for the simulations are:

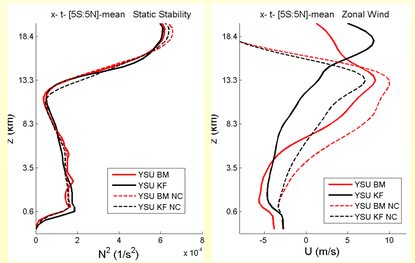
BM = 17.0m/s BM NC = 16.3m/s
KF = 13.0m/s KF NC = 14.5m/s.

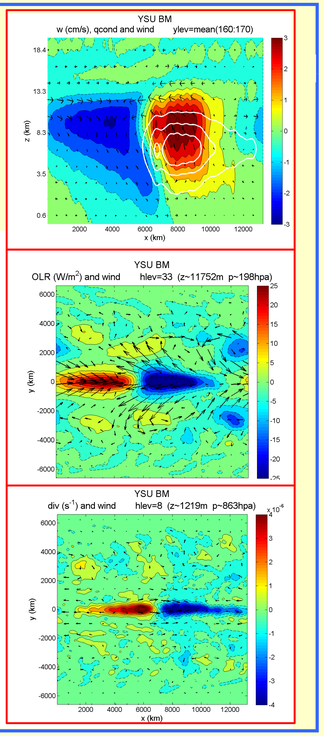
1<k<3
4<k<6
7<k<9
10<k<12
13<k<15

1 Δx/Δt = 1.8519 m/s

What causes different values of Cx?

- Static stability? NO
- Background zonal flow? Possibly





5. SUMMARY

- Algorithm for tracking CCKWs finds propagation speeds ~ 13-17 m/s
- The dynamic fields associated to the CCKW are in agreement with previous studies:
  - At low levels: westerlies, convergence ahead and divergence behind.
  - At high levels: easterlies, divergence ahead and convergence behind, with well-defined anticyclonic cells in both hemispheres
  - Vertical cross section at the equator: deep structures, westward phase tilt with height (mse,div), boomerang-like shape for u
- KF simulations have slower wave propagation and weaker signal in the perturbation composites
- Significant differences in the tropics between BM NC and KF NC because of the influence of extratropics

6. FUTURE WORK

- Understanding the different wave speeds and structures particularly with and without cumulus parameterization
- More WRF experiments
  - Replace prescribed SSTs with mixed layer ocean model
- Filtering in the frequency-wavenumber space

Acknowledgements
This research was supported by the National Science Foundation grant AGS-1146701

Corresponding author
Joaquin Blanco, jblanco@rsmas.miami.edu