Tropical Biases Breakout

I. Errors/challenges

- A. Pacific climatology
  - a. Double ITCZ
  - b. Cold tongue extends too far west, too cold in E. Pacific
  - c. Precipitation deficit Indonesian area
  - d. E. Pacific S. of equator too warm
  - e. Annual cycle of SST along equator poorly simulated
- B. Atlantic climatology
  - a. E/W gradient of rainfall wrong, double ITCZ
  - b. Zonal slope of the equatorial thermocline is wrong sign
  - c. E. Atlantic too warm (mirrors Pacific)
- C. Tropical waves in atmosphere poorly simulated
- D. QBO missing
- E. Challenge: tropics are highly dynamically interconnected. A change in one region will affect other regions (aerosol climatology changes in Africa affect Atlantic).
- F. Initial spin down of precip in NWP
- G. Precipitation too strongly linked to SST
- H. Amazon, West African precipitation
- I. Errors in land surface scheme
- J. Diurnal cycle

II. Root causes

- A. Pacific
  - a. Double ITCZ
    - i. Present in atmospheric models (better than before)
    - ii. Mass convergence in SH is correct, but dry shallow circulation in nature. AGCM responds incorrectly
    - iii. Given the annual cycle of solar forcing, the ITCZ should move across the equator twice a year (as on land). The real question that needs to be answered is why the ITCZ in E. Pacific stays in the NH in SH summer.
  - b. Cold tongue too cold in E. Pacific
    - i. Equatorial meridional heat convergence by ocean TIW too low?
    - ii. Atmospheric resolution too low to resolve SST fine structure, giving too strong easterlies?
  - c. Indonesia region very complex, may require high resolution to model realistically
  - d. E. Pacific S. of equator too warm
    - i. Stratus amounts too low? But AMIP models with the most stratus cooling are not the best when coupled
    - ii. Upwelling region, wind stress errors could contribute
- B. Atlantic
  - c. Same problem as in Pacific argues against Andes causing Pacific error
- F. Spin up from imbalance between dynamics, physics and data. Initialization (e.g. to suppress inertial instability) may also be involved.

III. Broader implications

- A. Pacific – changes affect other regions
  - i. Changes in subtropical jet related to ENSO affect midlatitude planetary waves
  - ii. Midlatitude ENSO teleconnections on regional scales sensitive to tropical biases
  - iii. Midlatitude stationary waves
  - iiii. Incorrect SST climatology affects simulation of MJO/ISO
  - Iv. Poor mean state degrades ENSO simulation, mean state drift reduces ENSO predictability and degrades predictions
- B. Atlantic climate variability and connections to other regions poorly understood
- C. Waves poor: Degraded predictability
- D. QBO poor: Degraded climate predictability
- F. Reduced predictability in NWP
- G. Something missing in climate models
- H, I Systematic errors over land too large for realistic simulations from coupling vegetation models, carbon cycle models, downscaling
- J Disturbing lack of understanding

IV. Promising approaches

- Pacific
  - i. NWP initial errors (before dynamics can respond)
  - ii. HadGEM high resolution ocean (good TIW), atmosphere able to resolve SST fine structure.
  - iii. Momentum balance diagnosis of tropical atmosphere
  - iiii. Sensitivity to varying ocean color is large (GFDL warms equator, loses ENSO when low color regions in western subtropics outside 10° are set to be perfectly clear)
  - v. Suppressed convection parameterization experiments and getting the right answer for the wrong reasons helps to understand the roles of convection parameterization
  - vi. SST correction and sea breeze parameterization for land/ocean grid boxes.
  - vii. Flux correction may be telling us something useful
  - viii. Coupling resolving the diurnal cycle (at least of solar flux)

V. Coordinated experiments

- 1. Short runs to look at initial drift
  - a. AGCM only, prediction mode
  - b. Coupled prediction mode – spin up CGCM by relaxing surface winds to observed evolution for initial states
- 2. Aquaplanet with idealized SST forcing
- 3. Simple to do sensitivity experiments (ocean color)

VI. Observational data

- 1. Vertical heating profiles in atmosphere, observed and from model
  - a. TRMM, CloudSat
  - b. Vertical profiles of reflectivity, cloud top height
- 2. More accurate global mean precipitation (within .1 mm/day)
- 3. Better ocean surface heat flux and better transfer coefficients