Intraseasonal Variability and the Onset of Monsoon Rainfall

Kenneth R. Sperber

Program for Climate Model Diagnosis and Intercomparison
Lawrence Livermore National Laboratory, USA
(E-mail: sperber1@llnl.gov)

Goal: Multiscale analysis to evaluate the relationship between monsoon onset and intraseasonal variability

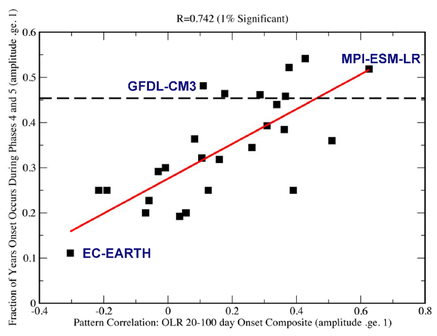
- Observations: The composite onset of Australian summer monsoon over Darwin is associated with the eastward propagation of the MJO (Hendon and Liebmann, 1990, *JAS*, 47, 2227-2240)
- CMIP5: Monsoon Onset (Sperber and Annamalai, 2014)
  - Pentad precipitation (Northern Australia and All-India Rainfall)
  - Onset defined for fractional accumulation of 0.2
- CMIP5: Evaluate the intraseasonal state at monsoon onset
  - Austral summer: MJO strong OLR patterns from Sperber (2003)
  - Boreal summer: CsEOF OLR patterns of Annamalai and Sperber (2005)

Data: Rainfall and OLR

- Pentad Averages: precipitation and 20-100 day bandpass filtered OLR analyzed
  - Observations (1979-2004)
    - GPCP and AVHRR OLR
  - CMIP5 (27 models: historical runs, 1961-1999)
    - ACCESS1.0, ACCESS1.3, BCC-CSM-1, BCC-CSM-1-m, BNU-ESM, CanESM2, CMCC-CESM, CMCC-CM, CMCC-CMS, CNRM-CM5, CSIRO-Mk3.6.0, EC-EARTH, FGOALS-g2, GFDL-CM3, GFDL-ESM2G, GFDL-ESM2M, INM CM4, IPSL-CM5A-LR, IPSL-CM5A-MR, IPSL-CM5B-LR, MIROC-ESM, MIROC-ESM-CHEM, MIROC5, MPI-ESM-LR, MPI-ESM-MR, MRI-CGCM3, and NorESM1-M

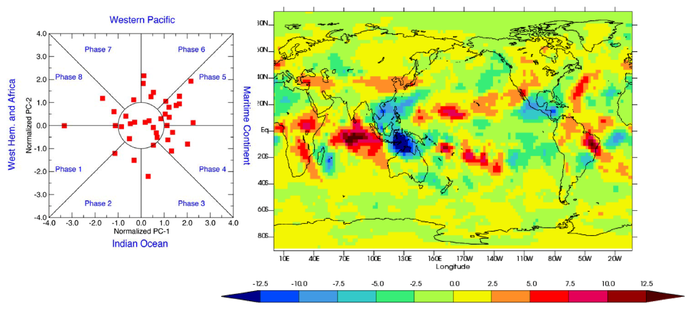
Skill: Composite filtered OLR at onset vs. fraction of years that PC's are in Phases 4-5 at onset

- In observations the MJO is active 45% of the time during Australian monsoon onset
- The pattern correlation is calculated over 45°E-120°W, 20°S-20°N



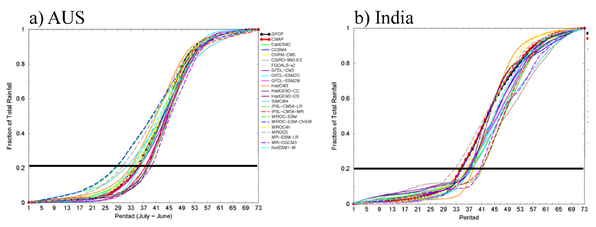
MPI-ESM-LR: MJO Phase 4-5 composite (years with amplitude ≥ 1) for Australian monsoon onset

- This model has a realistic MJO spatial structure for Australian monsoon onset



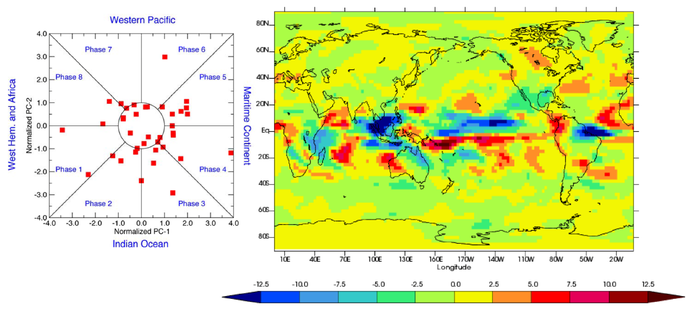
CMIP5 Climatological rainfall: Monsoon onset (Sperber and Annamalai, 2014)

- Onset occurs at a fractional accumulation of 0.2
- AUS: model onset equitably distributed about the observations
- India (and Gulf of Guinea, SAM): most models have delayed onset (not shown)
- Sahel and NAM: most models early annual cycle (not shown)



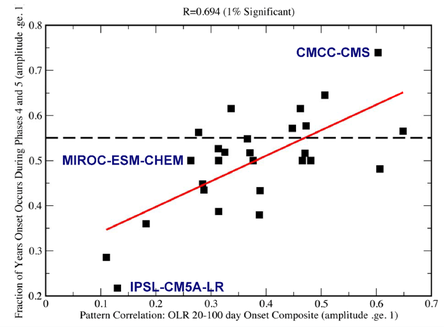
GFDL-CM3: MJO Phase 4-5 composite (years with amplitude ≥ 1) for Australian monsoon onset

- This MJO spatial structure at onset is less realistic than observed with extensive signals throughout the tropics



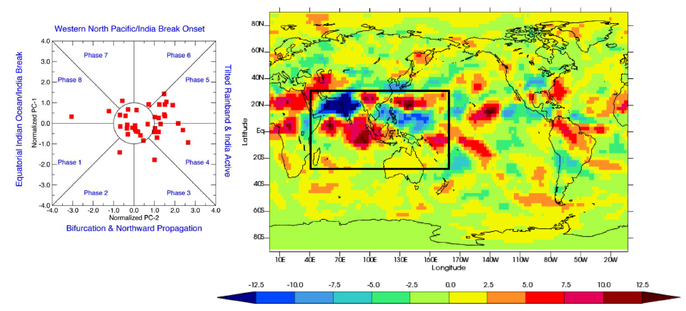
Skill: Composite filtered OLR at onset vs. fraction of years that PC's are in Phases 4-5 at onset

- In observations the BSISV is active 55% of the time during Asian monsoon onset
- The pattern correlation is calculated over 40°E-180°E, 30°S-30°N



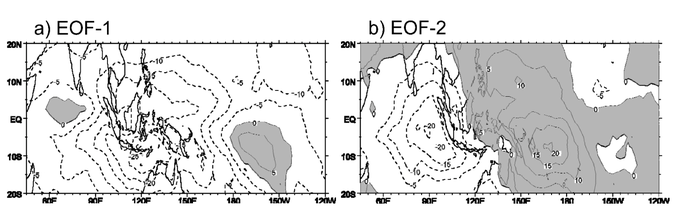
CMCC-CMS: BSISV Phase 4-5 composite (years with amplitude ≥ 1) for Indian monsoon onset

- The 20-100 day bandpass filtered OLR shows that onset of the Indian monsoon occurs during an active phase of the BSISV, with the tilted rainband more evident than in the observations



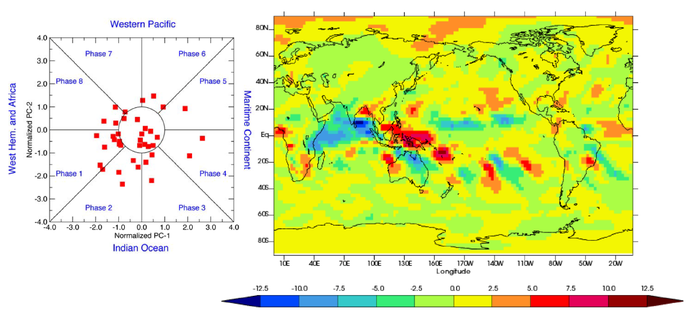
MJO AVHRR OLR EOF patterns; strong years (20-100 day filtered OLR; Wm^{-2})

- MJO EOF's used in observed and model studies
  - Sperber (2003, 2004), Sperber et al. (2005), Sperber and Kim (2012)
- Project model 20-100 day filtered OLR onto these observed patterns to obtain PC time series, that are used to construct the MJO life-cycle phase plots (PC-1 vs. PC-2)



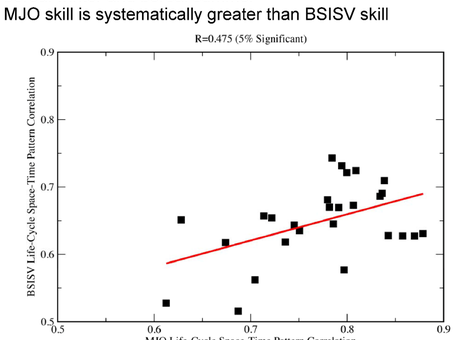
EC-EARTH: MJO Phase 4-5 composite (years with amplitude ≥ 1) for Australian monsoon onset

- This MJO spatial structure at onset is poorly represented



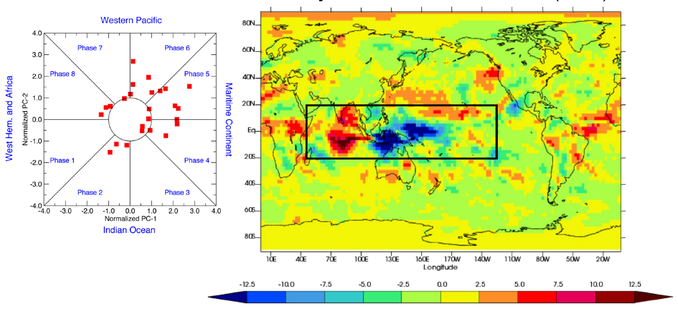
CMIP5: MJO Skill vs. BSISV Skill

- Best fit space-time pattern correlations relative to observed Days -15, -10, -5, 0, 5, 10, 15, 20
  - There is a statistically significant relationship between the ISO skill in boreal winter and boreal summer
  - MJO skill is systematically greater than BSISV skill



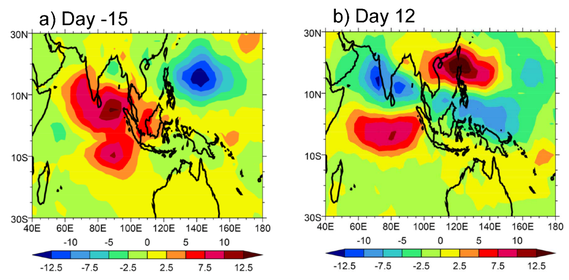
Australian monsoon onset: Observations

- MJO PC-1 vs. PC-2 for onset pentad for each year (1979-2004)
- Composite 20-100 day filtered OLR for the onset pentads in Phase 4-5 (amplitude ≥1)
- Australian monsoon tends to occur during an active phase of the MJO, consistent with the study of Hendon and Liebmann (1990)



Boreal Summer Intraseasonal Variability (BSISV) Quadrature patterns (filtered OLR Wm^{-2})

- These patterns correspond to Day -15 and Day 12 from the BSISV cyclostationary EOF analysis of Annamalai and Sperber (2005) and Sperber and Annamalai (2008)
- Project model 20-100 day filtered OLR onto these observed patterns to obtain PC time series, that are used to construct the BSISV life-cycle phase plots (PC-1 vs. PC-2)



Preliminary Findings

- In observations there is a clear link between monsoon onset and the phase of the ISO (MJO and BSISV) during both Austral summer and Boreal summer
  - The ISO impacts monsoon onset in 45% (55%) of the years during Austral (Boreal) summer
  - In Austral (Boreal) summer the majority (half) of models do not have as strong of a link between the ISO and onset
- The composite intraseasonal spatial pattern at monsoon onset is poorly represented by the majority of models
  - Variations other than the MJO and ISO are present in most models on intraseasonal time scales
- Overall, in CMIP5 the MJO space-time evolution is better represented than the BSISV space-time evolution

PCMDI
Program for Climate Model Diagnosis and Intercomparison
www-pcmdi.llnl.gov

This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344. The author is supported by the Regional and Global Climate Modeling Program of the United States Department of Energy's Office of Science. (LLNL-POST-732244)