The MJO and global warming: A CCSM-4 study

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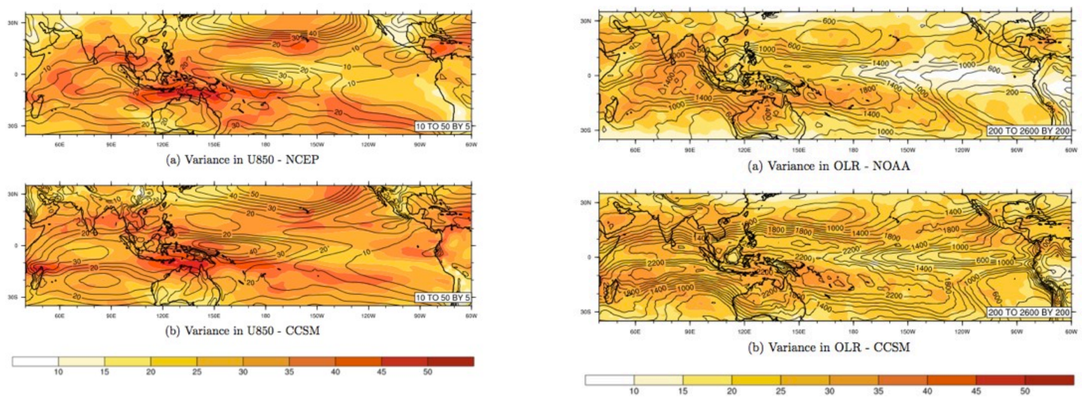
Motivation

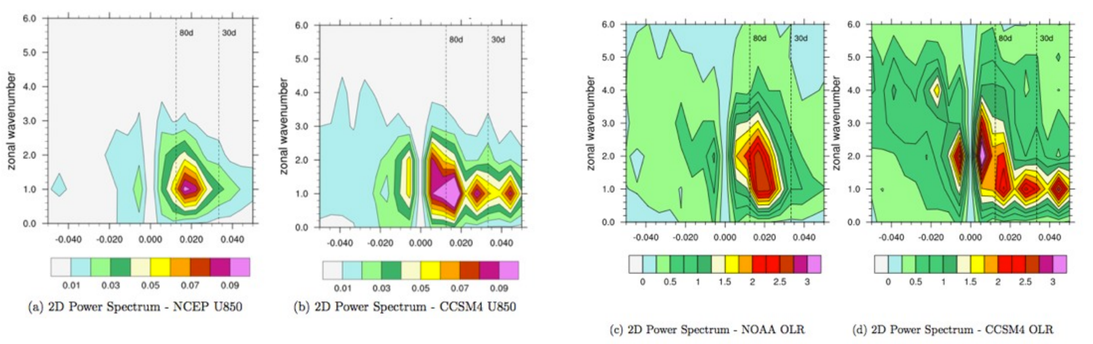
- To diagnose MJOs in CCSM4
- To understand the behavior of MJOs concomitantly with different climate phenomena

CCSM4 Diagnostics

Spatial and temporal intraseasonal variability



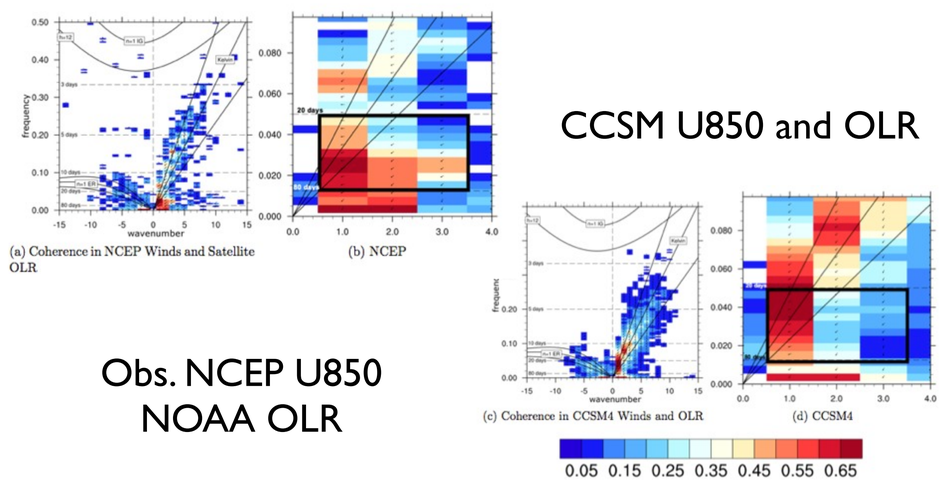
- CCSM4 has 26 levels in the vertical, 0.9x1.25^o horizontal atmosphere and land resolution, 1^o ocean and sea ice resolution
- The structure of the ISV pattern in CCSM4 consistent with MJO characteristics (minima in zonal wind variance along the equator in both the Indian and Pacific Oceans and a max variance over the Maritime Continent.
- Dominant peak at 60 days is somewhat stronger and more broadbanded in CCSM4 than obs.



- Overall, CCSM4 contains significant eastward propagating energy in the same frequency range for wavenumbers in the MJO band during the winter season, but the signals have more energy than observations.
- Peak in the spectral power of CCSM4 OLR is at higher frequencies than the intraseasonal band. This is consistent with findings discussed in later sections that the dynamical convective coupling in CCSM4 is weaker than that in nature.

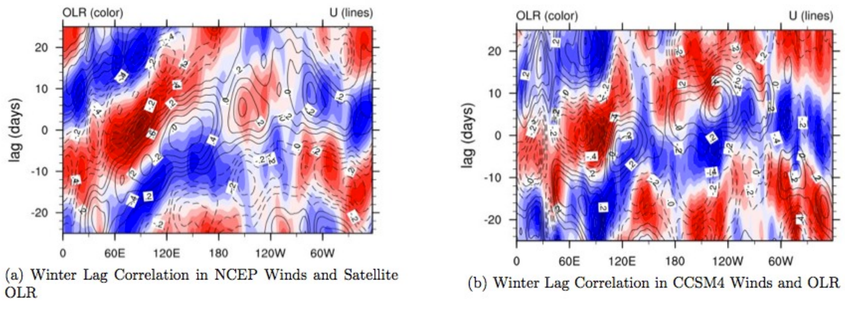
MJO Diagnostics

Coupling between dynamics and convection



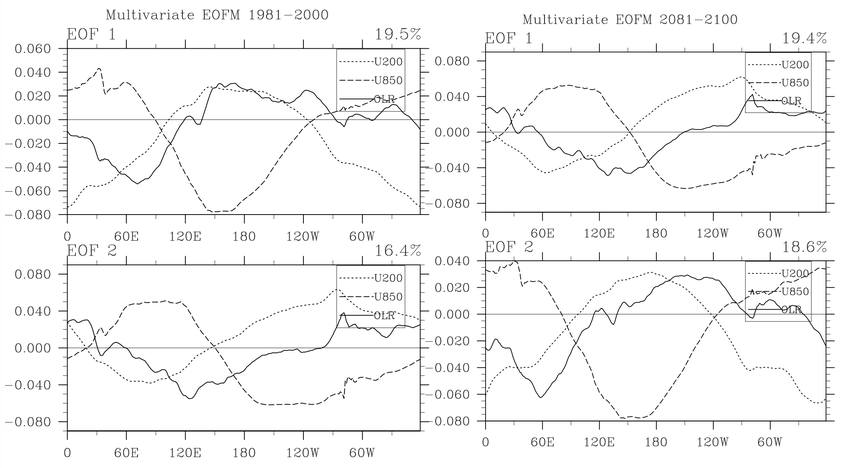
- CCSM4 exhibits strong coherence in this low-wavenumber band, with lags similar to obs.
- The model's spread of coherency into higher frequencies at wavenumber 1 suggests that more linear Kelvin wave activity, with a convective signature, is present in CCSM4 than in observations (Roundy 2008).
- Faster phase speed of MJO in CCSM4 is also evident in the lag correlation between the convection and the dynamic winds for observations and model.

Obs. CCSM4

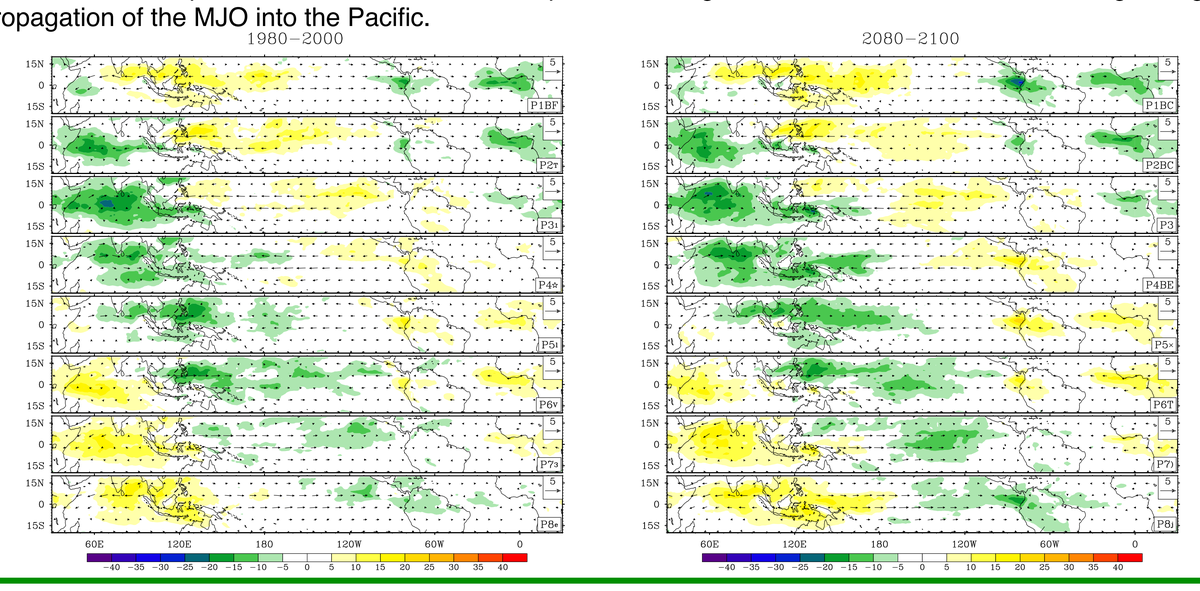


MJO and Global Warming: Composite changes

Combined EOFs of U and OLR. Composite maps

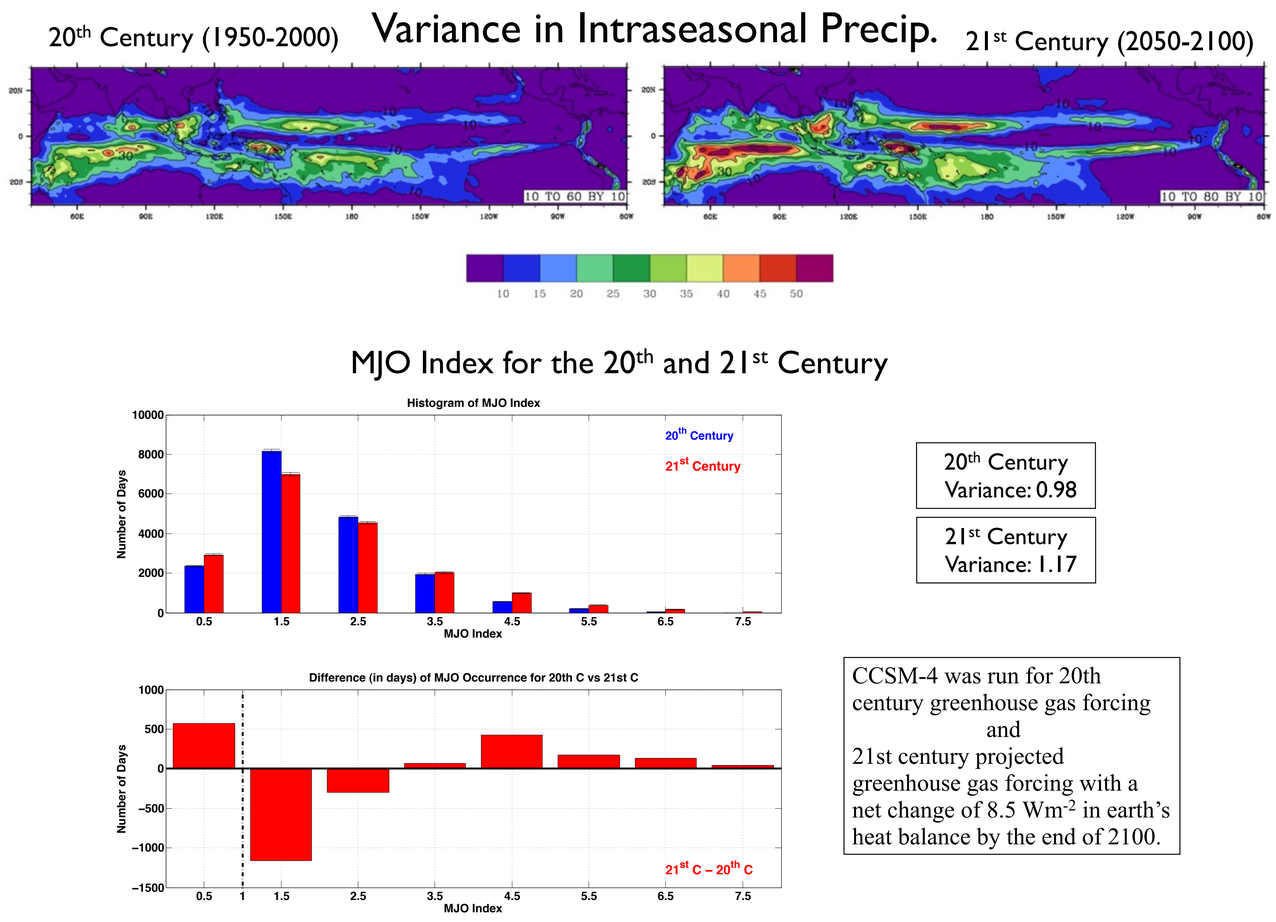


- Mode 2 from 21st C corresponds to Mode 1 of the 20th C.
- This pair of leading EOFs represents coherent eastward propagation of MJO.
- The lag correlation between PC-1 and PC-2 indicates that the dominant period is roughly 32 days in the 20th C run and 40 days in the 21st C run.
- The longitudinal location of the maxima, minima and zero crossings of all three variables correspond well between the two runs, except in the E. Pacific, the 21st C run shows greater amplitude.
- The composite is constructed by selecting full fields of U850, U200 and OLR during the time intervals when MJO is strongly excited.
- The convection in phase 7 and 8 in the 21st C ompositeis stronger than in the 20th C case indicating a longer propagation of the MJO into the Pacific.



MJO - Climate

Will global warming modify the activity of the Madden - Julian Oscillation?



- **Increased precipitation variance** in the 21st century in the **intraseasonal** time period
- **Model MJO** are **stronger** in the **21st century** simulation and the **tail of the distribution rises**!

Summary

CCSM4 produces **coherent, broadbanded** and **energetic patterns** in **eastward propagating intraseasonal zonal winds** and **OLR** consistent with MJO characteristics. Global warming (RCP 8.5 pathway) increases intraseasonal precipitation by >40% and the MJO is amplified with more persistent extreme events and it propagates farther into the Pacific ocean.

[1] **Subramanian, A. C., M. Jochum, A. J. Miller, R. B. Neale , Hyodae Seo, D. E. Waliser and R. Murtugudde, 2012: The MJO and Global warming: A CCSM-4 study. *Climate Dynamics, sub-judice***