Air-sea interaction in the impact of the MJO on South American climate

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Summary – Air-sea interaction is important to set up the strength of the rainfall response in eastern South America during the MJO. Changes in atmospheric circulation during Phase 23 induce net surface heat flux anomalies that generate a positive SST anomaly off Brazil in Phase 45. This SSTa strengthens the winds possibly through a less stable PBL, inducing stronger convergence/divergence to the south/north of the SACZ, leading to larger rainfall anomalies. (Barreiro et al 2018, accepted Int. J. Climatology)

Background

The Madden-Julian Oscillation (MJO) is known to impact South American climate through atmospheric teleconnections (e.g. Jones et al 2004, Alvarez et al 2016). The South Atlantic Convergence Zone (SACZ), a band of enhanced convection that extends from the Amazon basin toward the South Atlantic during December-February is strongly influenced by the MJO. .

Observed data and methodology

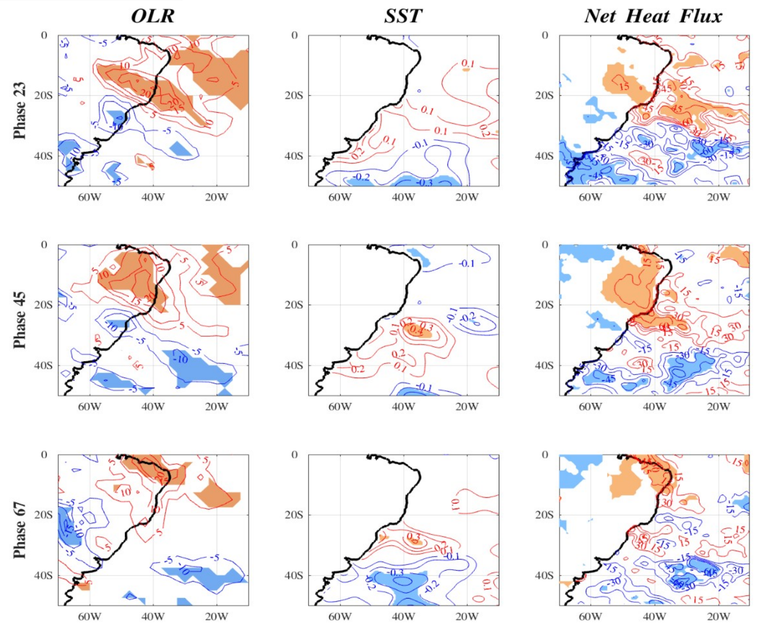
- NOAA Interpolated OLR dataset (Liebmann and Smith 1996), and ERA Interim Reanalysis (Dee et al 2011).
- Analysis is performed for 9 DJF seasons, each spanning 90 days. Daily annual cycle and interannual variability are removed.
  - Use RMM indices for MJO. To increases robustness we consider together phases 2&3 (Phase 23), phases 4&5 (Phase 45) and phases 6&7 (Phase 67).

Model simulations

- We use the regional coupled model RegCM-ES (Sitz et al 2017). It is composed by the RegCM atmospheric model defined over [145W-60E,55S-20N] and of the MITgcm ocean model defined over [70W-30E,54S-10N].
- 2 simulations from January 1988 to December 1997: (1) fully coupled model RegCM-ES & (2) SST-forced RegCM.

Observations - Evolution of OLR, sea surface temperature anomalies and net surface heat fluxes during phases of the MJO.

During phase 23 and phase 45 there is a weakening and southward shift of the SACZ which, though changes in the net surface fluxes, induce an SST warming during phase 45 and phase 67. Is there a role for the SSTa?



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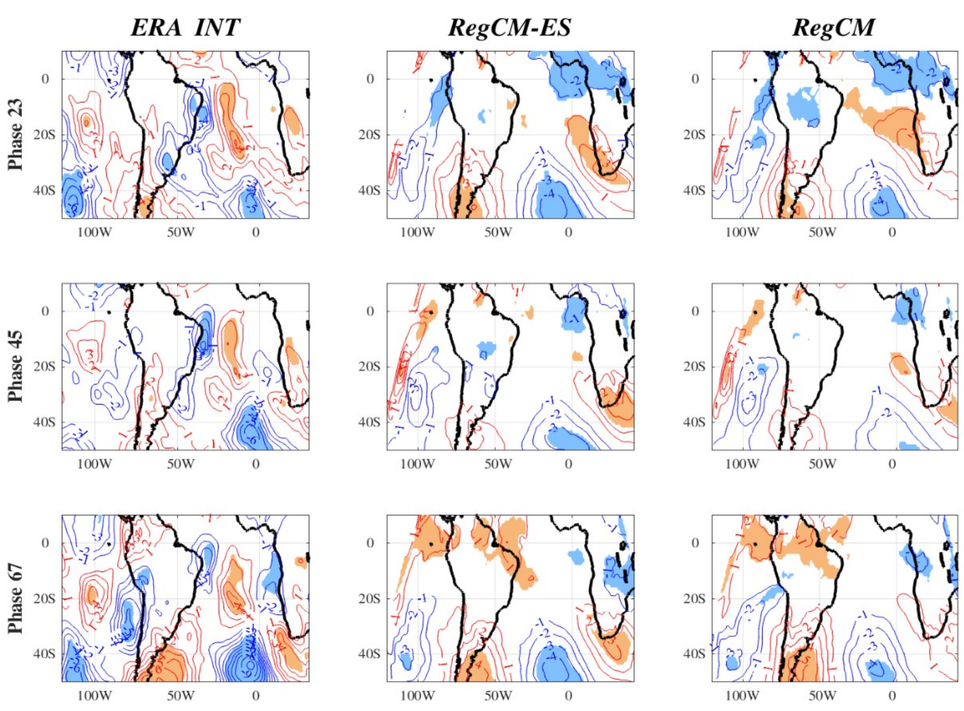
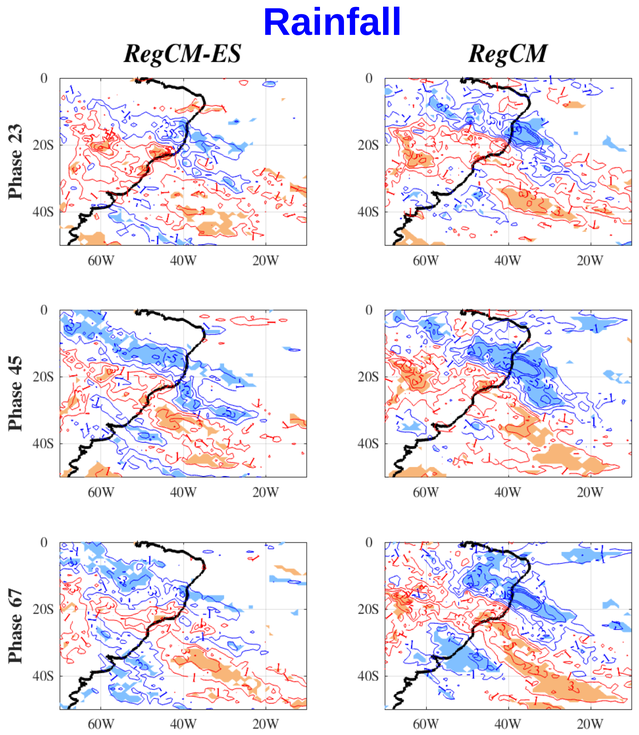


Model Results

- Both model configurations are able to capture the upper level teleconnection associated with the MJO.
- It consists in a barotropic cyclonc anomaly over South America between 30-60S, which favors a southward shift of the SACZ.
- The southward SACZ shift, seen in rainfall anomalies, is much stronger in the stand-alone AGCM experiment (RegCM) and tends to last longer.

Rainfall



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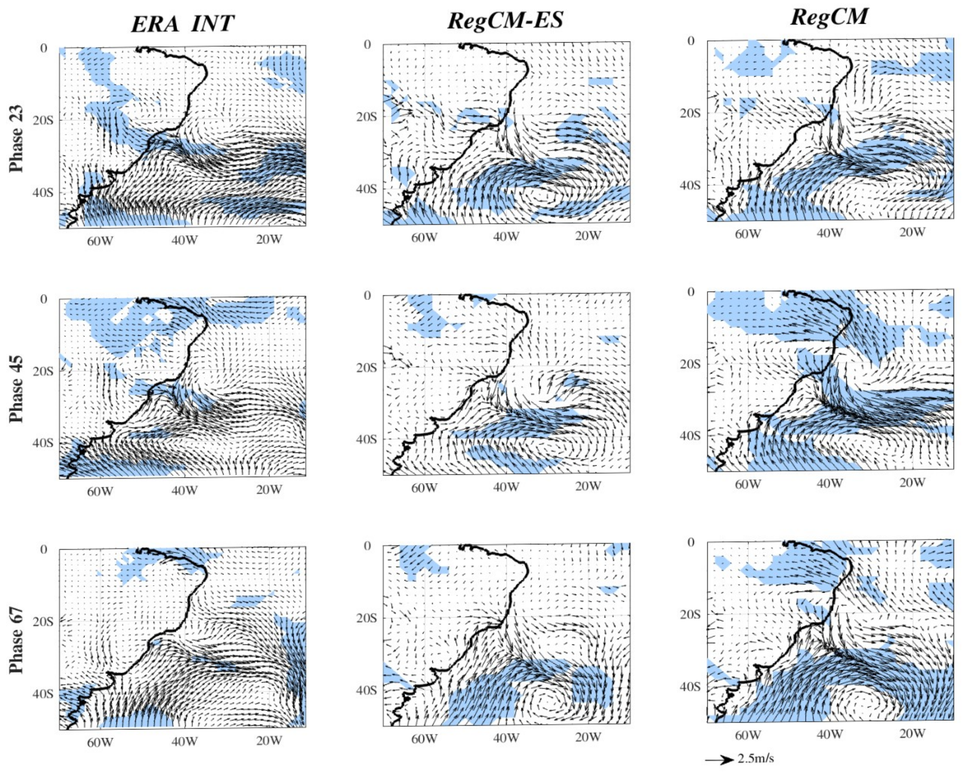
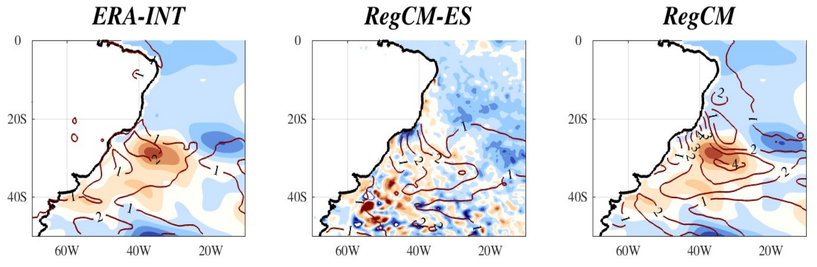


- Observations show a surface anticyclonic circulation anomaly off Brazil during Phases 23 and 45.
- The coupled model (RegCM-ES) is able to represent the anticyclonic circulation only during Phase45 and is weaker than in Obs.
- The stand-alone RegCM represents a stronger anticyclonic circulation, particularly in Phase 45, which increases convergence/divergence to the north/south of the SACZ, in agreement with rainfall anomalies.

SST & Wind speed



- The intensity of the surface wind anomalies are correct in RegCM-ES but are displaced compared to observations. In RegCM the wind intensity maintains the spatial structure as RegCM-ES but intensifies over the warm anomaly.
- The wind intensification over warm waters may be due to increased downward flux of horizontal momentum resulting from a more unstable boundary layer (Chelton and Xie 2010, Sitz et al 2017).
- In RegCM-ES the SST anomaly is very weak due to a cold bias that does not allow the ocean to stratify as expected during summer. Thus, surface winds do not intensify and anticyclonic anomaly is weak.