Intraseasonal Variability in the South American monsoon in the SP-CAM

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Background

Seasonal and extreme precipitation totals in subtropical South America depend on variations on the time scale of 10 to 90 days. Two important features in particular are the low level jet (LLJ) east of the Andes, and the South Atlantic convergence zone (SACZ).

Low level jet The wind patterns in the LLJ have been shown to fall into two regimes: westerly and easterly. The regime affects rainfall and convection to the southeast of the LLJ maximum, and can also affect rainfall above the Altiplano and northern South America. Variations have been shown to exist on 10-70, 10-30, and 30-70 day scales (Jones & Carvalho, 2002).

South Atlantic Convergence Zone – Fluctuations in outgoing longwave radiation (OLR) of less than 90 days have maximum variance in the SACZ and over central South America during DJF. On the 2-30 day time scale, variations are associated with a Rossby wave train visible at 200 mb.

Madden-Julian Oscillation - On the 30-60 day time scale, there is a link between the SACZ and the MJO. Certain phases of the MJO also look similar to the easterly and westerly wind regimes of the LLJ.

Models & Data

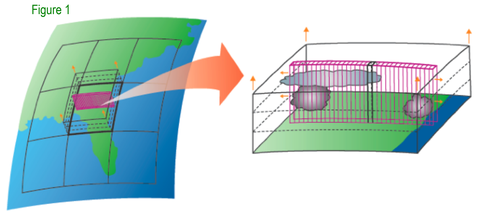
Model results and observations were interpolated onto a 2.5x2.5 degree grid for comparison's sake.

- **CAM:** The Community Atmosphere Model (CAM) is the latest in a series of global atmosphere models developed at NCAR for the weather and climate research communities. Version 3.0 was run with prescribed SSTs (AMIP) from Sept. 1, 1985-Sept. 1, 2004.
- **SPCAM-P:** The "superparameterized" version of the CAM contains a row of cloud-resolving models in each GCM grid cell (Figure 1). The CRMs replaces the conventional parameterizations of moist physics, convection, turbulence, and the boundary layer (Khairoutdinov et al., 2008). It was run for the same time period as the CAM with prescribed SSTs.
- **SPCAM-S**: A version of the SPCAM with a slab ocean model was run from Sept. 1, 1999 - Sept. 1, 2004. In this simulation, tropical SSTs are permitted to deviate slightly from their prescribed values in the presence of anomalous surface fluxes, thus allowing the ocean to respond to the atmosphere.

TRMM 3B42 merged satellite precipitation product - .25 degree data interpolated to 2.5 degrees, from 1998-2004. (http://rain.atmos.colostate.edu/CRDC/datasets/TRMM_3B42.html)

NCEP Reanalysis version 2 data provided by the NOAA/OAR/ESRL PSD, Boulder, Colorado, USA, from their Web site at http://www.esrl.noaa.gov/psd/.

Figure 1



Intraseasonal Variations in Convection

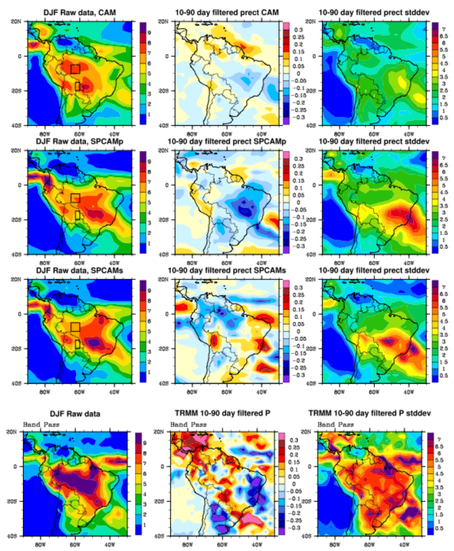


Figure 2 shows the DJF average precipitation rate (left column), 10-90 day filtered anomalies of precipitation (middle), and the standard deviation of these anomalies (right column). TRMM observations from 98-04 are on the bottom row.

- Variability is much improved in the superparameterized models.
- Main regions of precipitation variability on these time scales are northeastern Amazon basin, South Atlantic Convergence Zone (SACZ), and region influenced by the South American low level jet (LLJ).

The Low Level Jet

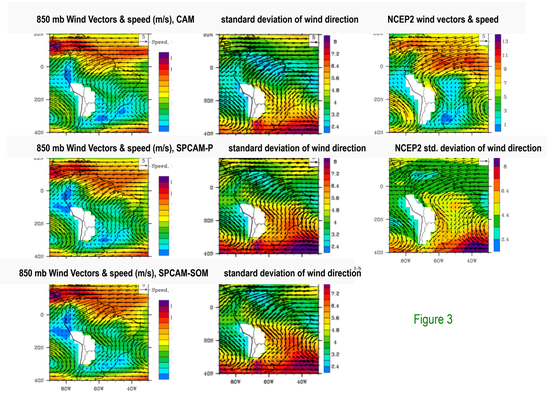


Figure 3

Model resolution is on the order of 200 km, leading to poor resolution of the Andes. Despite this, many features of the LLJ show up:

- Wind speed maximum located on northeastern edge of Andes.
- Strong variability in wind direction during summer months.
- Identify LLJ focus region for subsequent plots as 15S, 62.5W for the models, and 20S, 60W for NCEP.

LLJ vertical profile

The models show a weak LLJ along the eastern flank of the Andes, but the strength is underestimated in all cases. The CAM and SPCAM-S capture two maxima in wind speed at low levels, similar to what is observed.

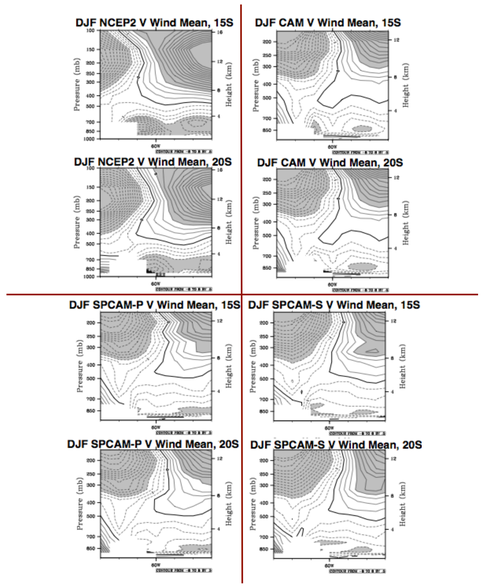
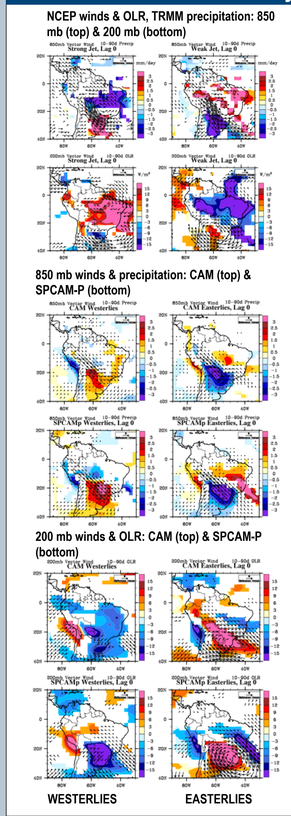


Figure 4: Meridional wind along 15S and 20S (from 80W to 40W) during DJF. Negative contour lines (northerly winds) are dashed. Wind speeds above 2 m/s or below -2 m/s are shaded. The Andes are whited-out.

Variability in the LLJ



Characteristics of "easterly" and "westerly" wind regimes are better resolved in the SPCAM compared to the CAM.

- During westerly wind events, SPCAM-P better captures the precipitation to the south, and the inhibited convection east of the jet.
- In the NCEP and the SPCAM-P, there is an upper-level anticyclone above the region of enhanced convection.
- The dipole pattern of convection during easterly events is also present in the SPCAM-P.

Figure 5. Composites of strong (westerly) and weak (easterly) wind events, following convention in Jones and Carvalho, 2002. Strong (weak) jets are defined as days with anomalous wind direction from 270-360 (90-180), and wind speed greater than 1 standard deviation of its mean.. Data is based on DJF time series pulled out from the 10-90 day filtered anomalies. Only anomalies significant above 90% are shown.

Variability in the SACZ

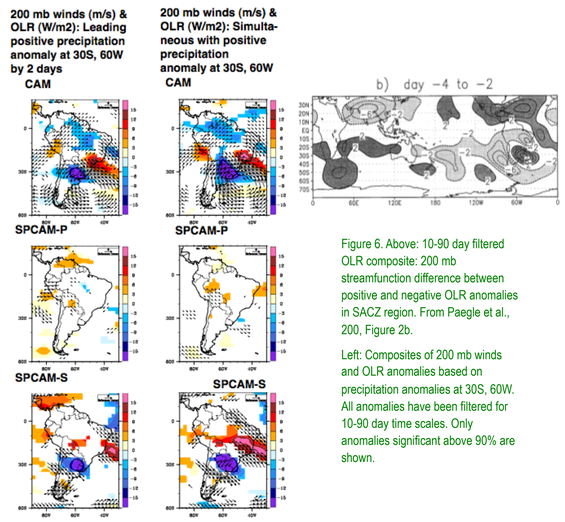


Figure 6. Above: 10-90 day filtered OLR composite: 200 mb streamfunction difference between positive and negative OLR anomalies in SACZ region. From Paegle et al., 200, Figure 2b.

Left: Composites of 200 mb winds and OLR anomalies based on precipitation anomalies at 30S, 60W. All anomalies have been filtered for 10-90 day time scales. Only anomalies significant above 90% are shown.

- Strong precipitation down-wind of the LLJ results in a dipole pattern of convection between 30S/60W and the SACZ.
- Wave train pattern to the west is best represented in the CAM and SPCAM-S.
- It's likely that the improved MJO in the SPCAM-S has improved this pattern compared to the SPCAM-P. This is a possible area of future research.

Conclusions

- **Replacing cloud parameterizations with a curtain of cloud-resolving models, assumed to be representative of convection in each grid cell, results in improved representations of convection associated with intraseasonal time scales in South America.**
- **The low level jet is not ideally represented, partially due to course resolution on the GCM scale, but variability in the jet still affects convection in expected ways.**
- **The superparameterizations improves many characteristics of easterly and westerly wind regimes.**
- **Dipole patterns in convection in the SACZ exist in both the standard CAM and the SPCAM-S (slab ocean model). However, the strength of variability is much stronger in the SPCAM-S.**
- **Both the SPCAM with prescribed SSTs & with the slab ocean model can be useful tools for further investigation of the intraseasonal variability in convection during the South American monsoon season.**

References & Acknowledgements

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