Low-level wind, moisture, and precipitation relationships near the South Pacific Convergence Zone in CMIP5 Models

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Introduction

The South Pacific Convergence Zone (SPCZ) is a broad region of rainfall in the Southwestern Pacific Ocean particularly intense during austral summer (December-February, DJF) as shown in **Figure 1**. While SPCZ interactions with the El Niño/Southern Oscillation (ENSO) and the Madden-Jullian Oscillation (MJO) have been the subject of previous studies, high frequency interactions (i.e. daily to weekly timescale) are poorly understood. Lintner and Neelin [2008] (hereafter LN08) show that perturbations to low-level inflow east of the SPCZ are associated with changes in the transport of dry air toward the SPCZ as well as "shifts" in the edge of convection. We aim to determine whether current generation models are capable of capturing relationships analogous to those found in LN08 and, if so, to explore the cause-effect relationship between dynamics (dry processes) and thermodynamics (moist processes) in the region.

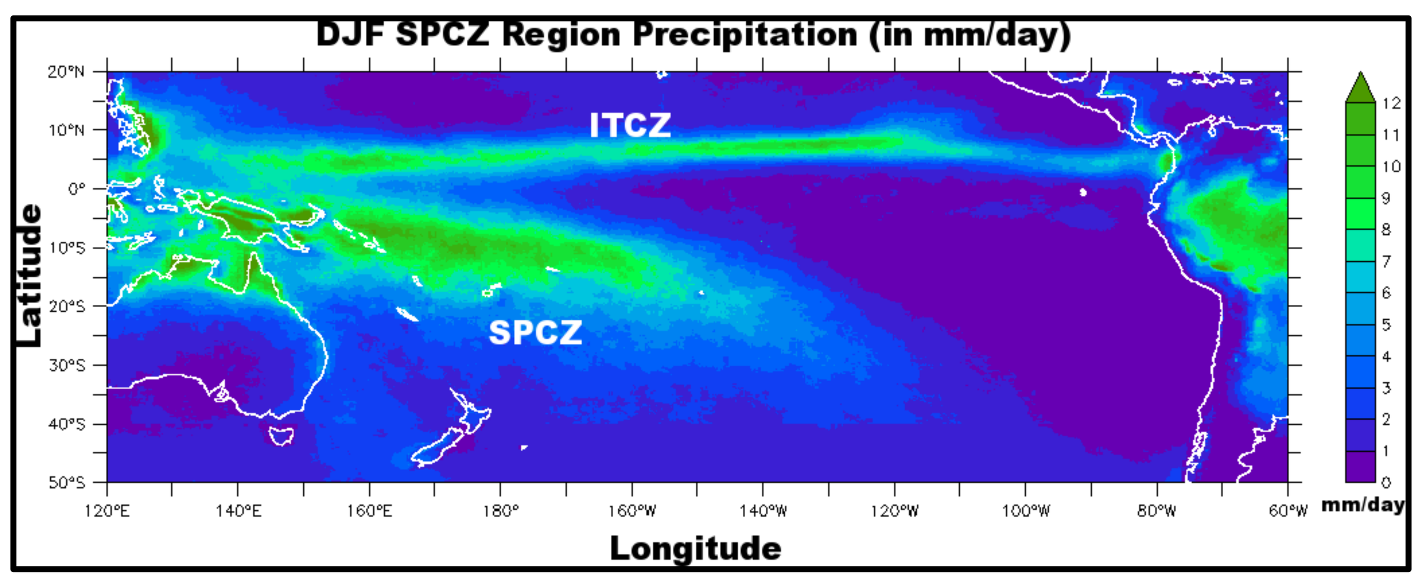

Figure 1. Climatological position of precipitation (in mm/day) across the South Pacific during austral summer (DJF) using data from the Tropical Rainfall Measurement Mission (TRMM, January 1998-June 2011).

Methodology & Data

Output at daily resolution is available from 26 models in the World Climate Research Programme (WCRP) Coupled Model Intercomparison Project phase 5 (CMIP5) historical experiment, which uses observed forcings from 1850 through 2005 (Taylor et al. 2012). For each model, the first available ensemble member was chosen and regridded to a common 2.5° x 2.5° grid. Data from each January spanning 1960 through 1999 was extracted and, for each day, the mean zonal wind at 850 hPa (mean u_{850}) was calculated within the region 140-120°W and 20-10°S. These values were then normalized by subtracting the mean u_{850} during the entire month in order to remove any biases due to low frequency phenomena, such as El Niño-Southern Oscillation (ENSO). The positive and negative composites of zonal and meridional wind, specific humidity, and precipitation were then calculated by averaging all days for which the composite index was beyond a threshold relative to the index standard deviation, σ. The positive composite includes all days exceeding +1σ; for the negative composite, all days less than -1σ. Composite difference plots were then generated by subtracting the negative composite from the positive composite. Leadtime plots were similarly generated but using only those days for which the absolute value of the composite index is greater than the day before and day after (i.e. maximum/minimum values).

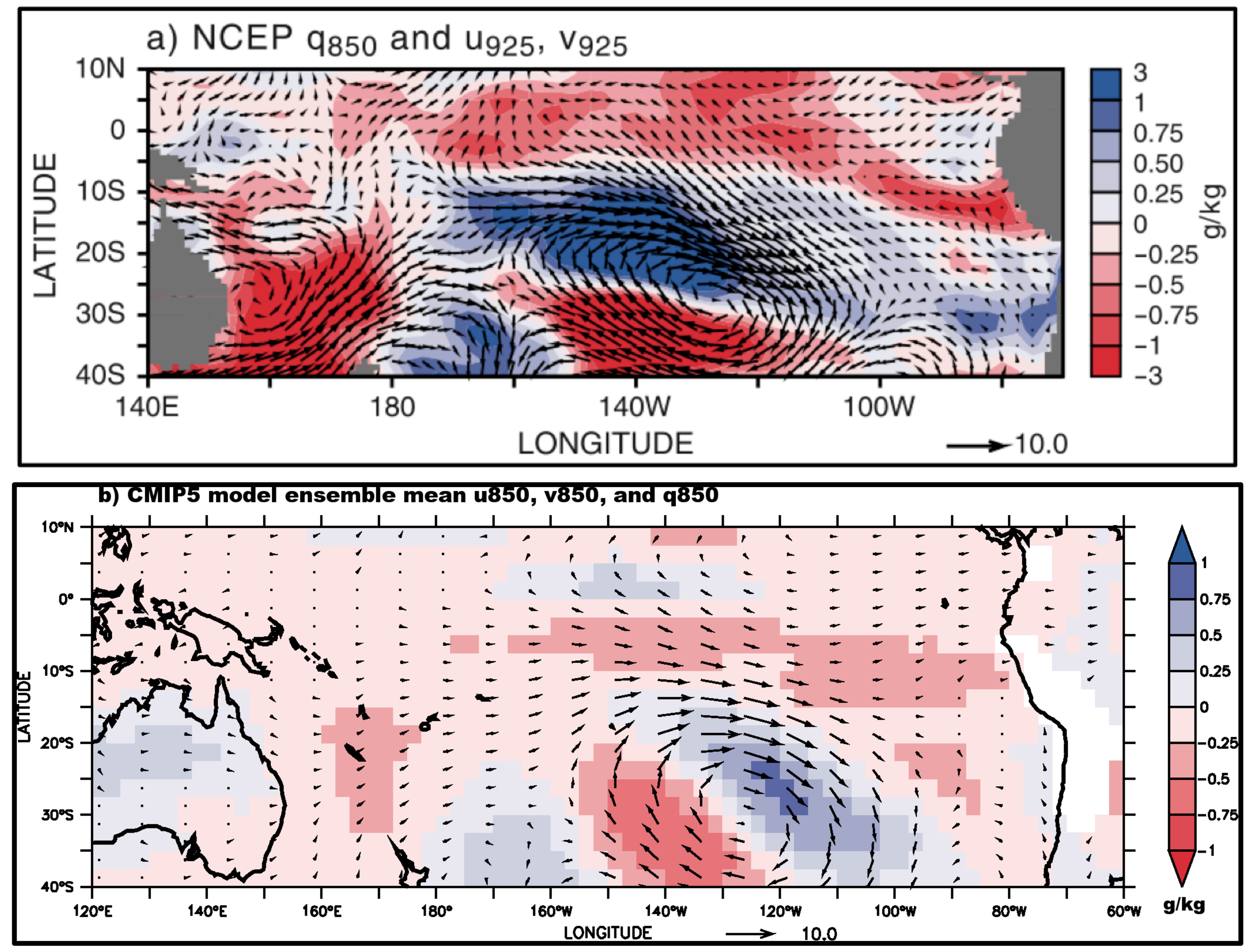

Figure 2. Composite difference winds (in m/s) and specific humidity (in g/kg) using data from a) NCEP Reanalysis I (from LN08) and b) the CMIP5 model ensemble mean.

Results & Discussion

Figure 2 shows the similarity in the structure of the wind and moisture anomalies between data from the National Center for Environmental Prediction (NCEP) Reanalysis I and the CMIP5 model ensemble mean (MEM), though a clockwise rotation of the moisture anomaly in the MEM is evident. **Figure 3** shows the results of the leadtime analysis. At day -3 (**3a**) and even before (not shown), a positive moisture signature along 20°S is evident, independent of any strong wind anomalies. As this moisture anomaly strengthens through days -2 and -1 (**3b-3c**), the wind signature gradually appears. Beyond day 0 (**3d-3f)**, the anomaly decays and is completely missing by day 3. The evolution of the wind and moisture anomalies as seen in the MEM suggests that the wind signature is a response to anomalous convection triggered by an outside influence, contrary to our previous understanding of the interactions.

Conclusions & Future Work

Using a composite approach, we were able to show that the CMIP5 MEM is capable of capturing observed wind and moisture anomalies associated with perturbations to zonal wind in the Southeastern Pacific. In addition, the evolution of these features in the MEM suggests that the wind perturbations are a response to, instead of a cause of, anomalous convection. Moving forward, we will perform the same leadtime analysis on data from a more recent reanalysis product, the Climate Forecast System (CFS) reanalysis, in order to determine if the observations are consistent with the model results. Additionally, we plan to run model simulations with moisture anomalies as seen on day -3 to further explore these interactions, focusing on if the wind anomalies are reproducible.

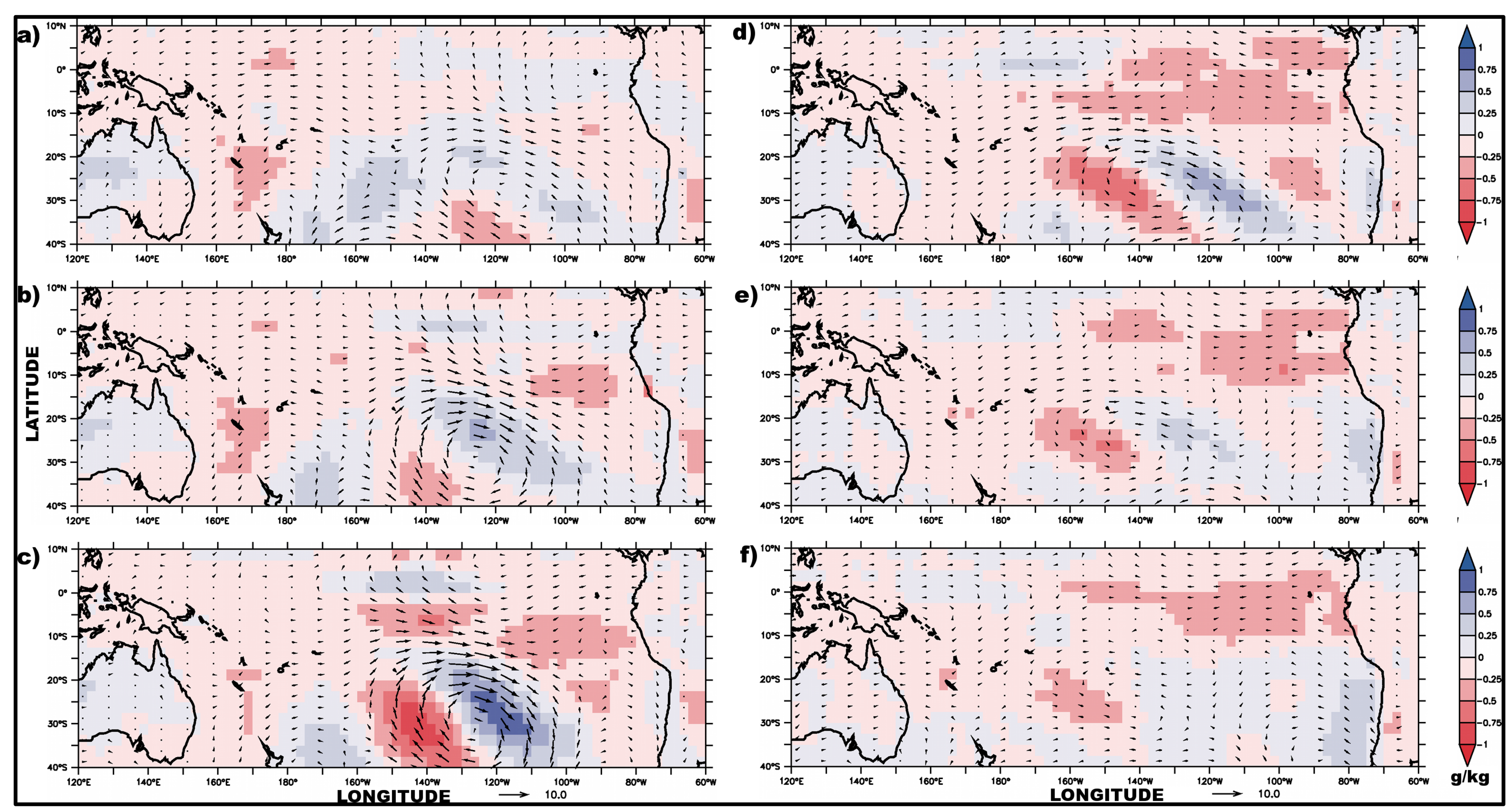

Figure 3. CMIP5 model ensemble mean leatime plots for a) -3 days, b) -2 days, c) -1 day, d) 1 day, e) 2 days, and f) 3 days, where day 0 is the difference between the mean of all maxima and the mean of minima (see **Methodology & Data**).

Acknowledgements

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References

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