Ocean Sci. Discuss., 10, C458–C463, 2013
www.ocean-sci-discuss.net/10/C458/2013/

Ocean Science
Discussions
Open Access

Interactive comment on "One plausible reason for the change in ENSO characteristics in the 2000s" *by* V. N. Stepanov

Anonymous Referee #2

Received and published: 5 September 2013

Overview:

In previous manuscripts the author hypothesizes and presented evidence for a link between the wind stress at mid-to-high latitudes of the Southern Hemisphere (SH) that influence subsequent fluctuations in ENSO. More specifically the fluctuations in the winds, mainly associated with short term variability of the southern annual mode (SAM), drive changes in the Antarctica Circumpolar Current (ACC) and drive changes in the mass flux. The mass flux causes pressure perturbations via its column integrated effect (barotropic component) including interaction with the bottom topography. Papers by Ivchenko et al. (2004, 2006) indicate that the barotropic anomalies in the ocean can propagate rapidly as westward Rossby waves and then equatorward propagating Kelvin waves along the Australian coast (although the latter are not mention in this

Full Screen / Esc
Printer-friendly Version
Interactive Discussion
Discussion Paper

paper) that reach the equator within a few weeks where they influence the warm water volume in the western Pacific. Finally these anomalies spread east via baroclinic Kelvin waves where they can influence ENSO.

With this hypothesis in mind the author examines the sea level pressure variability (presumably the winds that drive the ocean will vary with the geostrophic relationship and surface friction) over the globe with some focus on the Southern Hemisphere SLP and its relationship to SST & SLP conditions in the tropical Pacific. For the period 1985-2011 there is a fairly strong correspondence between meridional mass fluctuations across 40°S in July-September and SST anomalies in the subsequent winter in the Nino 4 region. Based on changes in the correlations between Nino SST/Southern Oscillation and indices of SLP variability in the Southern Hemisphere for the periods 1989-1999 and 2000-2008 (or 2000-2011) the author concludes that the SLP variability in the latter period was more efficient at driving ENSO variability than in the 1990s.

Review:

Over the last decade or so many studies have proposed mechanisms by which processes in other parts of the globe can influence ENSO variability. The hypothesis discussed here is novel and interesting: can fast oceanographic processes (e.g. barotropic waves) driven by (stochastic) atmospheric variability influence ENSO? Furthermore can the Southern Hemisphere SLP variability result in decadal variability in ENSO.

To address the first question the author mainly references previous work he has done (Stepanov 2009a&b, Oceanology) or studies by Ivchenko et al (2004, 2006). Little additional hard evidence is presented here for the number of complex processes needed to accomplish this connection other than correlations of SLP measures and ENSO over a fairly short record ~20 years, which is subsequently divided into two ten year periods.

1) While the description of the processes connecting the Southern Hemisphere to the tropics is lengthy but with many ambiguities:

OSD

10, C458–C463, 2013

a) The author uses large-scale measures in difference in SLP between latitude bands but then appears to argue for the importance of SLP variability right at the Drake passage. Changes in the flow of the ACC at the Drake passage is supposedly a key measure of the pressure forcing but itself appears to have little relationship to the ENSO variability (see Fig. 4).

b) Are the critical pressure anomalies due to the wind driven flow against the west coast of South America. If so how do they reach the equator? The author just indicates that it is similar to the mechanism described by Ivchenko and due to barotropic Rossby waves. What are the path(s) for the waves and wave energy to reach the equator? Do the Rossby waves mainly propagate westward in the open ocean and then travel equatorward as coastally trapped Kelvin waves along the Australian coast (as suggested by studies by Ivchenko et al. of salinity forced anomalies near Antarctica)? How does the barotropic signal influence the baroclinic structure on the equator? Based on Fig. 5 (presented in a previous study) are the equatorial anomalies at depth (50-200 m), which appear to be less than 0.3 °C, of sufficient amplitude to influence ENSO? Temperature anomalies at depth associated with ENSO are often an order of magnitude larger than this.

c) Given that the connection between the SH SLP and ENSO is very novel (and far from most conventional thinking), can it be better supported? For example can the location of the pressure anomalies be tied to the wind forcing (wind stress curl and or wind-drive flow impinging on topography) in both location and time and then the resulting ocean anomalies tracked toward the equator using sea surface height data from satellites or output from ocean reanalyses? The following studies have used SSH from satellites to investigate barotropic Rossby waves.

Andres, M., Y.-O. Kwon, and J. Yang (2011), Observations of the Kuroshio's barotropic and baroclinic responses to basin-wide wind forcing, J. Geophys. Res., 116, C04011, doi:10.1029/2010JC006863.

OSD
10, C458–C463, 2013

Farrar, J. Thomas, 2011: Barotropic Rossby Waves Radiating from Tropical Instability Waves in the Pacific Ocean. *J. Phys. Oceanogr.*, **41**, 1160–1181.

Perhaps the satellite topography data is of sufficient temporal resolution (10 days) to examine some aspects of the propagating signal.

2) Most of the new results presented here assume that the SH wind forcing is the main mechanism for generating decadal differences in ENSO and then uses differences in correlations or in the variability of the Southern Hemisphere atmosphere to support his idea. However, there are several major issues with this approach:

a) Climate time series include multiple signals and randomly generated variability. Thus two time series will exhibit periods of stronger and weaker correlations by chance, especially when examining interannual variability over short periods. So differences in the correlations between a measure of ENSO and SH SLP variability between two ten-year periods is to be expected and no way confirm the former is differentially driving the latter. Once can perform significance tests to determine if the differences in correlations between periods are significant, e.g. see

Gershunov, A., N. Schneider, and T. Barnett, 2001: Low frequency modulation of ENSO-Indian Monsoon rainfall relationship: Signal or noise? *J. Climate*, **14**, 2486–2492.

However, the difference values reported here between two ten-year periods are not likely to be significant.

b) the paper switches between measures of ENSO and of SH SLP variability. Sometimes Nino 4 is used some times Nino 3.4. Sometimes the southern Annular mode is used, sometimes a difference in SLP between two points. Switching of indices, (to get more favorable results) takes a way credibility of the findings.

c) It is unclear why the correlation between the Southern Oscillation (tropical SLP) and NINO SST is an indication of changing influence of remote locations, including the SH on ENSO. The author assumed that even though there wasn't a large difference in the SH SLP variability between the 1990s and the 2000s but based on the variability in to the SO and NINO indices between these periods indicates that processes near Antarctica still impacted the tropical Pacific Ocean with the same efficacy. There appears to be a huge leap in logic here and an assumption that the only factor influencing ENSO variability is the mechanism proposed here.

d) The author finds that maximum correlation between the SLP variability during July-September (SH winter/spring) leads the ENSO variability (which peaks in December) by 4 months. While this could provide evidence for SH variability driving ENSO other factors could come into play. Key among these is the evolution of ENSO and the atmospheric teleconnections associated with tropical SST anomalies. While ENSO peaks in boreal winter (Nov-Jan) SST anomalies are already well established in the tropical Pacific by boreal summer (July). Multiple studies have shown that the Southern Hemisphere atmosphere responds to these tropical SST anomalies both in Austral winter (JJA) and the following austral summer (DJF). For example see:

Karoly, David J., 1989: Southern Hemisphere Circulation Features Associated with El Niño-Southern Oscillation Events. *J. Climate*, **2**, 1239–1252.

Qinghua Ding, Eric J. Steig, David S. Battisti, John M. Wallace. (2012) Influence of the Tropics on the Southern Annular Mode. *Journal of Climate* **25**:18, 6330-6348

Ryan L. Fogt, David H. Bromwich. (2006) Decadal Variability of the ENSO Teleconnection to the High-Latitude South Pacific Governed by Coupling with the Southern Annular Mode. *Journal of Climate* **19**:6, 979-997

Michelle L. L'Heureux, David W. J. Thompson. (2006) Observed Relationships between the El Niño–Southern Oscillation and the Extratropical Zonal-Mean Circulation. *Journal of Climate* **19**:2, 276-287

In addition ENSO influences both SAM and the dipole pattern in SST near the tip of

South America, the two leading patterns of variability in the Southern Hemisphere and the ones focused on here. Thus the correlation between SH SLP and ENSO may actually be dominated by the rapid atmospheric teleconnections that occur in response to topical Pacific SSTs in austral winter (JJA, and the subsequent increase in the ENSO signal through austral spring and into winter <DJF>due to process within the tropical Pacific) rather than by wind-driven ocean process in the SH causing the lag between SH SLP and tropical SSTs.

Other comments/suggestions:

1) Figures:

a) several of the figures, including figures 1, 2a&b, 3, are well known and don't really contribute to the main points of the paper.

b) Figures 4 and 5 have appeared in the literature before (the former has appeared twice) although in a difficult to obtain journal.

c) some of the figures are very small and difficult to see.

2) Some generalizations are made about ENSO that are over statements or not completely true. For example, on page 954 lines 15-30. It is argued that Nino 4 responds to the primary forcing while the Nino 3 variability lags and is amplified by its proximity to land. In terms of SST, ENSO events can evolve where NINO4 leads NINO3 but also the reverse occurs events occur where NINO3 SSTs lead Nino 4 (e.g. see the classic paper by Rasmusson and Carpenter 1982, Mon. Wea Rev.). The author states that NINO 3 SSTs are amplified by land sea interactions, but Nino 3 is still thousands of kilometers from South America and its probably more due to ocean process then the proximity to land that cause larger amplitude SST anomalies in NINO3.

Interactive comment on Ocean Sci. Discuss., 10, 951, 2013.