Southern Ocean Origin of Multidecadal Variability in the North Brazil Current

René van Westen¹ and Henk Dijkstra¹

¹Affiliation not available

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Abstract

The North Brazil Current transport displays a pronounced multidecadal variability with about a 7 Sv peak-to-peak amplitude. Although it has been suggested that this variability is related to that of the Atlantic Meridional Overturning Circulation, its origin is still unknown. Here we present results of an analysis of model data from a long (200 years) simulation of a high-resolution (0.1 horizontally) version of the Parallel Ocean Program that indicates a connection between multidecadal variability in the Southern Ocean, due to the so-called Southern Ocean Mode, and multidecadal variability in the North Brazil Current. The interaction of the large-scale ocean circulation and eddies is crucial for the existence of the Southern Ocean Mode. We present the mechanisms of this teleconnection in detail, which involves the vertical displacement of isopycnals, generation of Rossby waves and meridional propagation of sea surface height and ocean heat content anomalies. In addition, we show that the same mechanism connecting Southern Ocean and North Brazil Current multidecadal variability is also found in a (200 years) simulation of a high-resolution global version of the Community Earth System Model, with the same horizontal ocean resolution of 0.1. The results provide a new mechanism for the multidecadal variability of the North Brazil Current.
1. Introduction

- Observations show multidecadal variability in the North Brazil Current (NBC).
  - Peak-to-peak variations of 7 svrdrupas, Zhang et al. (2011) 1.
- Variability in the NBC linked to the Atlantic Meridional Overturning Circulation (AMOC).
  - Buoyancy-induced changes in the Nordic Seas.
  - AMOC collapse in low-resolution ocean models leads to variations in the NBC.
- High-resolution ocean models show less coherency between NBC and AMOC.
  - Observations of NBC and AMOC are not directly compatible.
- The Southern Ocean Mode (SOM).
  - Intrinsic ocean mode in the Southern Ocean, Le Bars et al. (2016) 2.
  - Time scale of about 40 – 50 years.
  - Interaction between the general circulation and eddies.
- The Southern Ocean Region (SOM – NBC)
  - Variability submerges at 40°S, subsurface sea surface height (SSH) anomalies (Fig. 2).
  - Time series show a three regions. The formation region leads the variability is significant, period of 45 – 50 years.
  - Variability in the NBC has a Southern Ocean origin.
  - Similar variability is also found in a high-resolution coupled climate model.

2. Southern Ocean

- Sea surface height (SSH) anomalies in the Southern Ocean (Fig. 1).
  - Related to the SOM, 40 – 50 years.
  - Northward propagation of 70 km / yr.
  - Weakening at 40°S.
- Variability submerges at 40°S, subsurface ocean heat content (OHC) anomalies (Fig. 2).
  - Density differences at 40°S.
  - Baroclinic Rossby waves due to SOM.
  - Changes in phase speed, 200 km / yr.
  - Phase difference with overlying SSH.

3. North Brazil Current

- Southern Ocean variability reaches the NBC and influences SSH and NBC transport (Fig. 3).
  - SSH variability is significant, period of about 45 – 50 years.
  - NBC transport leads SSH by 5 years, phase difference is due to propagation of SSH and OHC anomalies in the South Atlantic (Fig. 1, 2).
- The subsurface OHC time series show a Southern Ocean origin in the NBC (Fig. 4).
  - The Southern Ocean region leads the NBC formation region by 13 years.
  - NBC formation region leads the NBC transport region by 1 – 4 years.
  - The OHC anomalies weaken while propagating northward.
- Variability of the Southern Ocean propagates further northwards and affects the AMOC.

4. Summary and Conclusions

- Multidecadal variability in sea surface height and westward transport in the NBC.
  - Period of about 45 – 50 years.
  - Variability in sea surface height is significant.
- Variability in the NBC has a Southern Ocean origin.
  - Variability in the Southern Ocean is induced by the SOM.
  - Variability in sea surface height related to the SOM propagates northwards to 40°S.
  - At 40°S, the variability submerges and reaches the NBC.
  - This teleconnection between SOM – NBC is established through Rossby waves.
- Similar variability is also found in a high-resolution coupled climate model.
  - Community Earth System Model (Ocean: 0.1° × 0.1°, Atmosphere: 0.5° × 0.5°).
  - Similar propagation mechanisms as in POP, more irregular variability (Fig. 5, 6).

References:

Contact information:
1. Institute for Marine and Atmospheric Research Utrecht, Department of Physics and Astronomy, Utrecht University, Princetonplein 5, 3584 CC Utrecht, The Netherlands.
E-mail: r.m.vanwesten@uu.nl