Posted on 22 Nov 2022 — The copyright holder is the author/funder. All rights reserved. No reuse without permission. — https://doi.org/10.1002/essoar.b1c27ad7aadf2e74.69090f2b89e624456d.1 — This a preprint and has not been peer reviewed. Data may be preliminary.

Southern Ocean Origin of Multidecadal Variability in the North Brazil Current

René van Westen[1] and Henk Dijkstra[1]

[1]Affiliation not available

November 22, 2022

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.

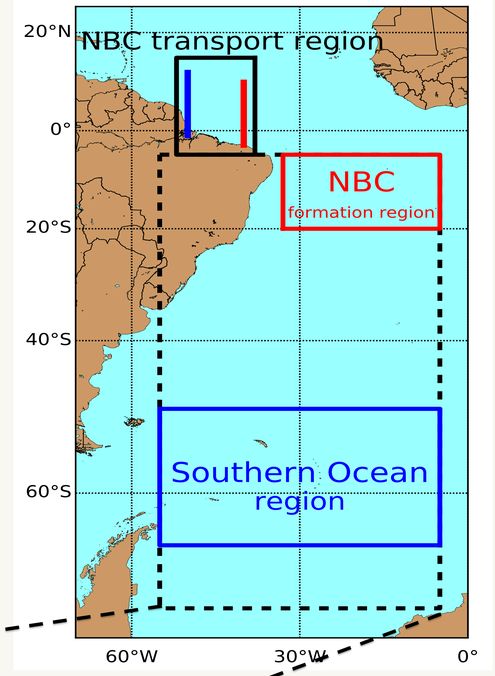
Southern Ocean Origin of Multidecadal Variability in the North Brazil Current

René M. van Westen[1] and Henk A. Dijkstra[1]

IMAU Institute for Marine and Atmospheric research Utrecht

1. Introduction

- Observations show multidecadal variability in the North Brazil Current (**NBC**).
  - Peak-to-peak variations of 7 sverdrups, *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.
- Is the **NBC** influenced by the Southern Ocean?
  - High-resolution version (0.1° × 0.1°) of the Parallel Ocean Program (**POP**).
  - Yearly repeated seasonal forcing.
  - Control simulation of 200 years, monthly resolution.

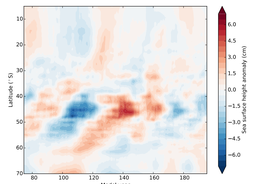


4. Summary and Conclusions

- 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).

Figure 5:

Similar to Fig. 1, CESM results



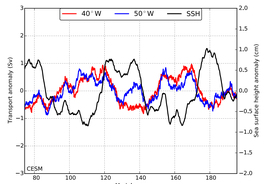


Figure 6:

Similar to Fig. 3, CESM results

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**.

Scan for animations!

Figure 1:

Hovmöller diagram of **SSH** anomalies along 5°W – 55°W (dashed region) in the South Atlantic. The **SSH** time series are smoothed by a running mean of 10 years.

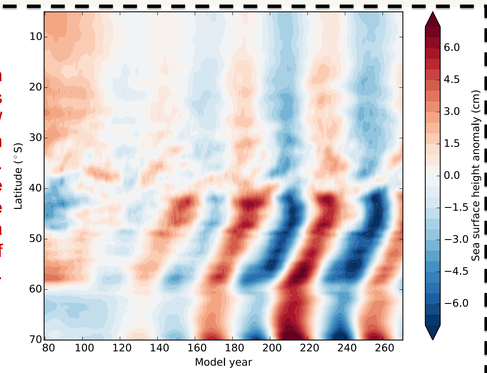


Figure 2:

Hovmöller diagram of subsurface **OHC** anomalies along 5°W – 55°W (dashed region) in the South Atlantic averaged over 300 – 700 meter. The **OHC** time series are smoothed by a running mean of 10 years.

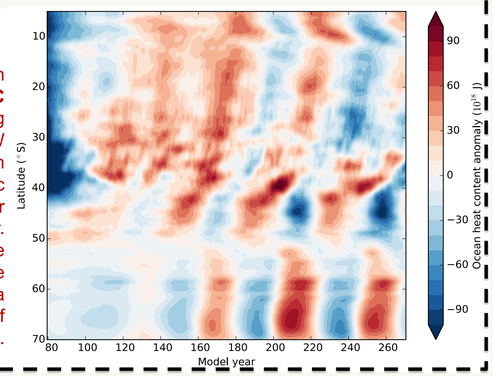


Figure 3:

Time series of the average **SSH** anomaly of the **NBC** transport region (black region) and the westward **NBC** transport anomalies. The time series are linearly detrended and smoothed by a running mean of 10 years.

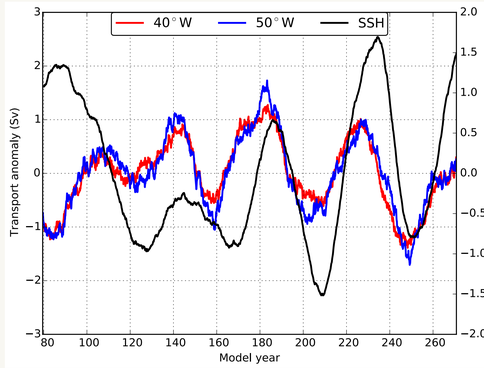
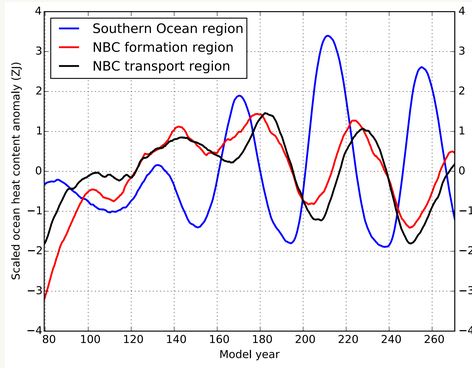


Figure 4:

Time series of the **OHC** anomaly averaged over 300 – 700 meter for three regions. The time series are smoothed by a running mean of 10 years.



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**.

References:

1. **Zhang et al. (2011)**, Multidecadal Variability of the North Brazil Current and its connection to the Atlantic Meridional Overturning Circulation. *Journal of Geophysical Research*, **116**.
2. **Le Bars et al. (2016)**, A Southern Ocean Mode of Multidecadal Variability. *Geophysical Research Letters*, **43**, 2102–2110.
3. **van Westen and Dijkstra (2017)**, Southern Ocean Origin of Multidecadal Variability in the North Brazil Current. *Geophysical Research Letters*, **40 (20)**, 10540 – 10548.

Utrecht University

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