Southern Ocean Origin of Multidecadal Variability in the North Brazil Current

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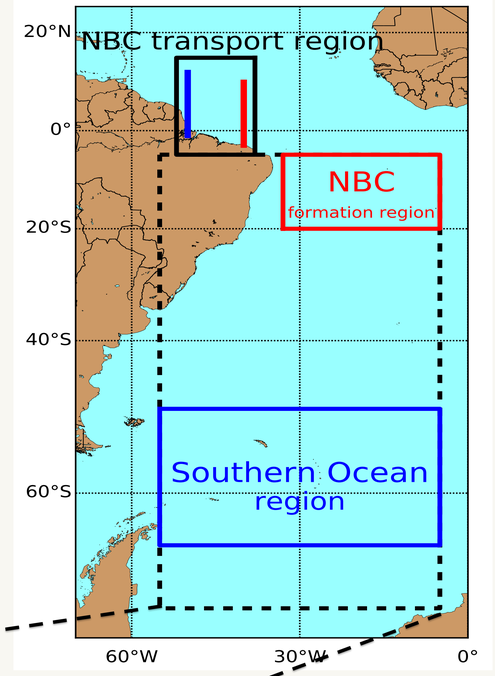
1. Introduction

- 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.

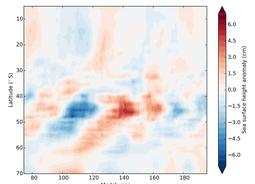


4. Summary and Conclusions

- 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



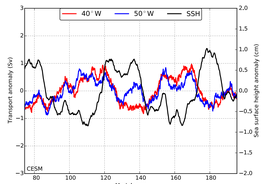


Figure 6:

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.

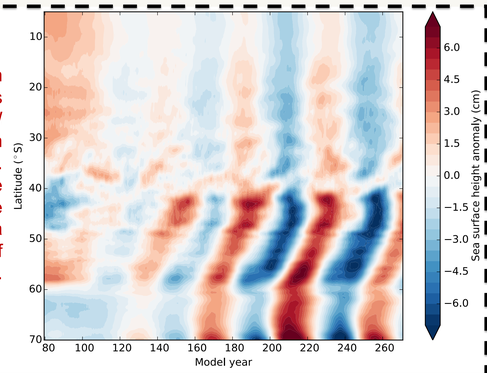


Figure 2:

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.

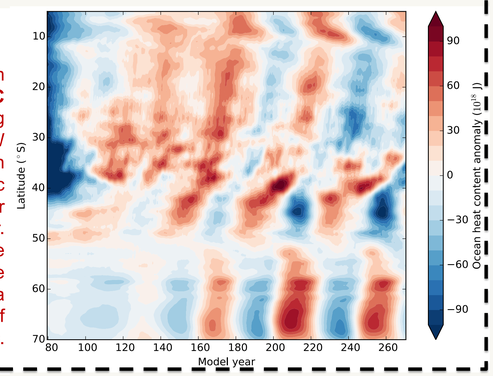


Figure 3:

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.

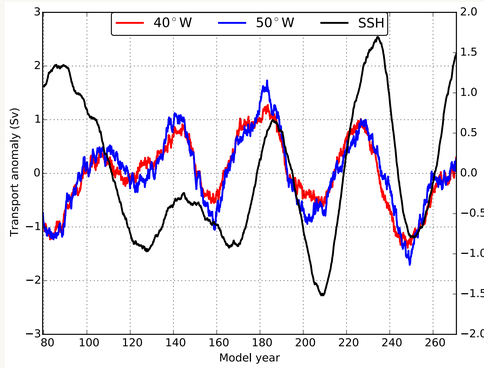
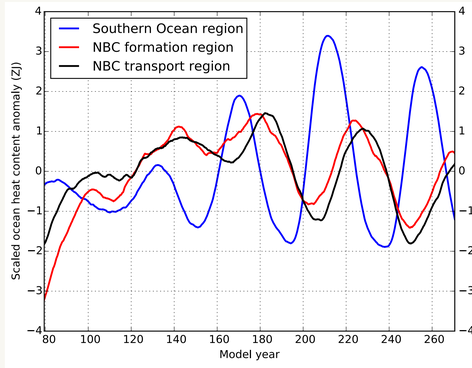


Figure 4:

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.

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