Effect of climate change on the ocean currents system along the Brazilian coast, focusing on Brazil Current

Anderson Soares (andersonsoares@poli.ufrj.br) ; Djalma Falcão; Raquel Toste; Luiz Paulo de Freitas Assad; Luiz Landau

Federal University of Rio de Janeiro, RJ, Brazil.

Introduction

Oceans currents plays an important role in heat transfer and consequently climate regulation. The **Brazil Current** (BC) is a significant southward flow in the South Atlantic Ocean that affects significantly the regional and global climate. However, the effects of climate change on the dynamics of BC remain poorly understood.

This works aims to understand how **climate changes** based on the Brazilian Earth System Model (**BESM**) projections can affect the BC **dynamics**, its meandering and the consequent formation of eddies.

Methods

BESM projections were downscaled to an eddy-resolving nested grid using the Regional Ocean Modelling System (**ROMS**). Specifically, the BESM-OA2.5 (BESM Ocean Atmosphere version 2.5) experiments (Capistrano *et al.*, 2018), following CMIP5 (Coupled Model Intercomparison Project) were used, with the **historical** experiment selected to represent current climate and **RCP4.5** (Representative Concentration Pathway) to represent future climate change.

The last 30 years of both experiments were evaluated to choose a representative year of each experiment to be simulated in ROMS. The numerical grid used in the two-nested model had a horizontal resolution of 1/5° and 1/15°, named G1 and G2S (Figure 1) respectively, and 40 vertical levels. The anomaly of surface currents (RCP - historical) was assessed to examine the variation of surface current intensity. Additionally, the strength of the meanders and vortices was measured using the Okubo-Weiss parameter, which becomes more negative as it indicates higher vorticity. In order to evaluate the change in the number of eddies over time, an eddy detection algorithm was also applied.

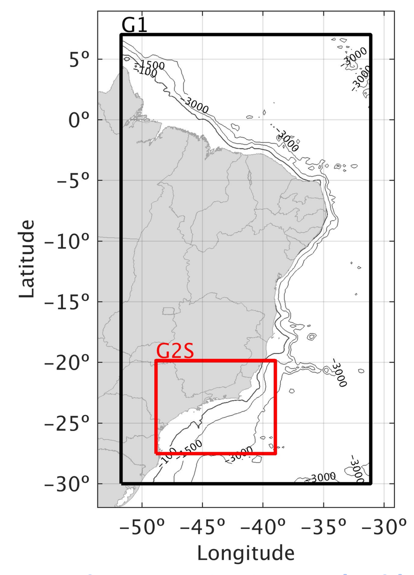

Figure 1: ROMS nested grid system.

Results

As depicted in Figure 2, our analysis of surface velocity anomalies has revealed a notable **weakening** of the BC, both in the annual mean and in seasonal analyses. Besides that, the Okubo-Weiss average indicates a significant weakening of **meanders** and **eddies** across much of the region, with positive anomalies occurring precisely where there is higher rotation (Figure 3). These findings suggest a potential link between the changes in ocean currents and the dynamics of rotating eddies in the study area, which could have important implications for understanding the regional and global oceanic circulation patterns. However, despite the weakening of rotation, the number of vortices counted in the simulations remains similar (Figure 4).

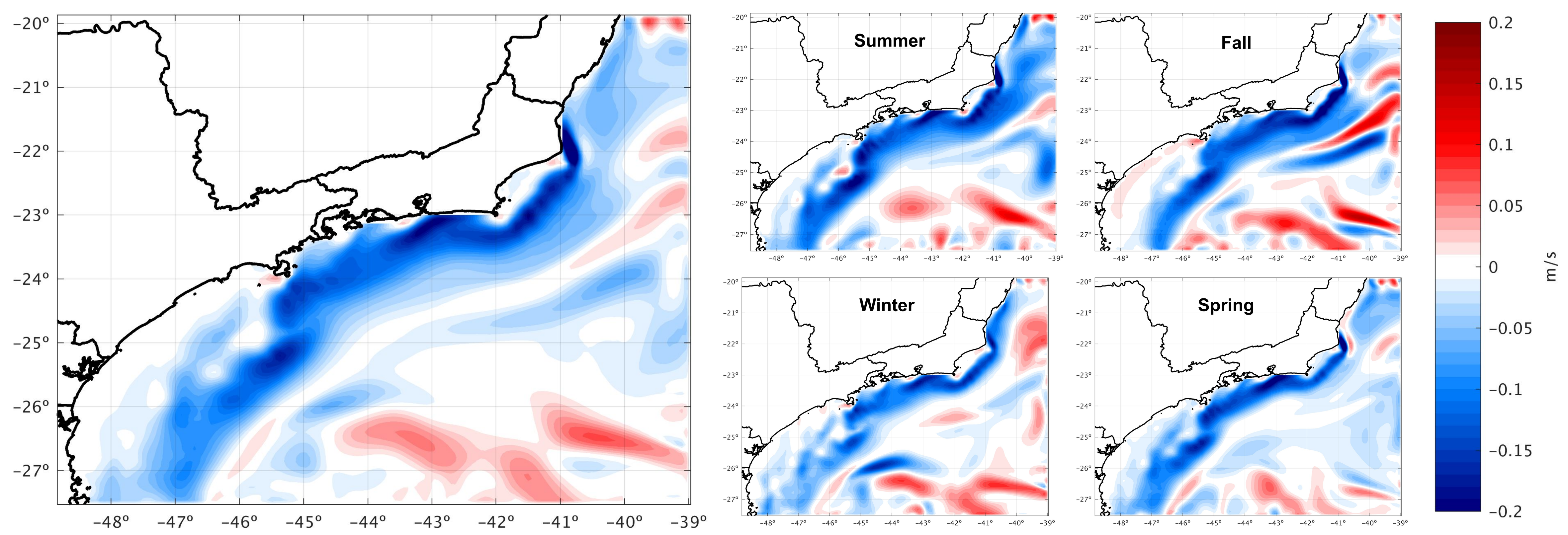

Figure 2: Surface velocity anomalies for both annual means (RCP-historical) on the left and seasonal means on the right, with reference to the southern hemisphere seasons. The surface velocity anomalies are color-coded to represent the strength of the current, with blue representing weaker currents and red denoting stronger currents.

It is important to note that BESM exhibits greater warming at high latitudes, whereas other global climate models show greater warming in the equatorial zone for climate change scenarios (Broggio *et al*., 2021; Ruela *et al., 2020*). In the long term, this decrease in the temperature gradient might be one of the mechanisms contributing to the predicted decrease in the intensity of the Brazil Current by BESM (Chiessi *et al*., 2014).

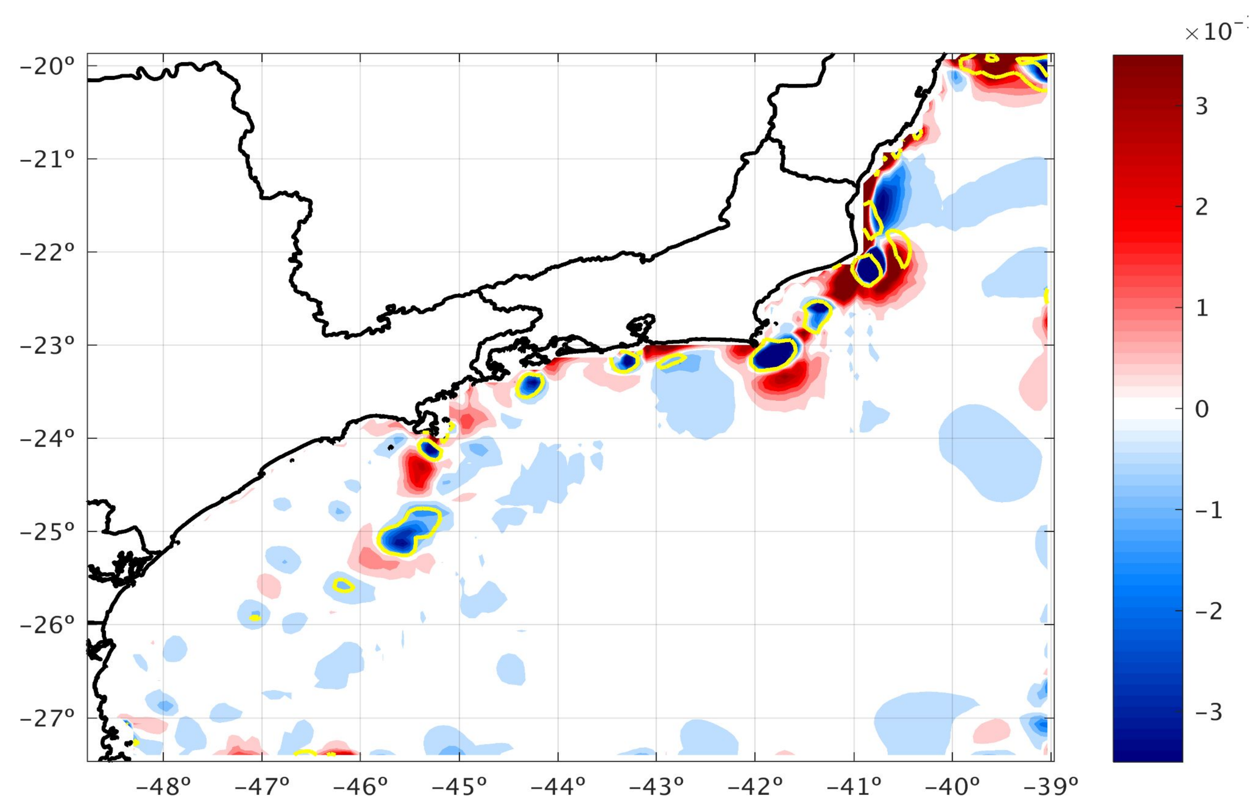

Figure 3: Mean Okubo-Weiss (1/s) for the historical simulation, with a contour line in yellow denoting positive anomalies (RCP4.5-historical)

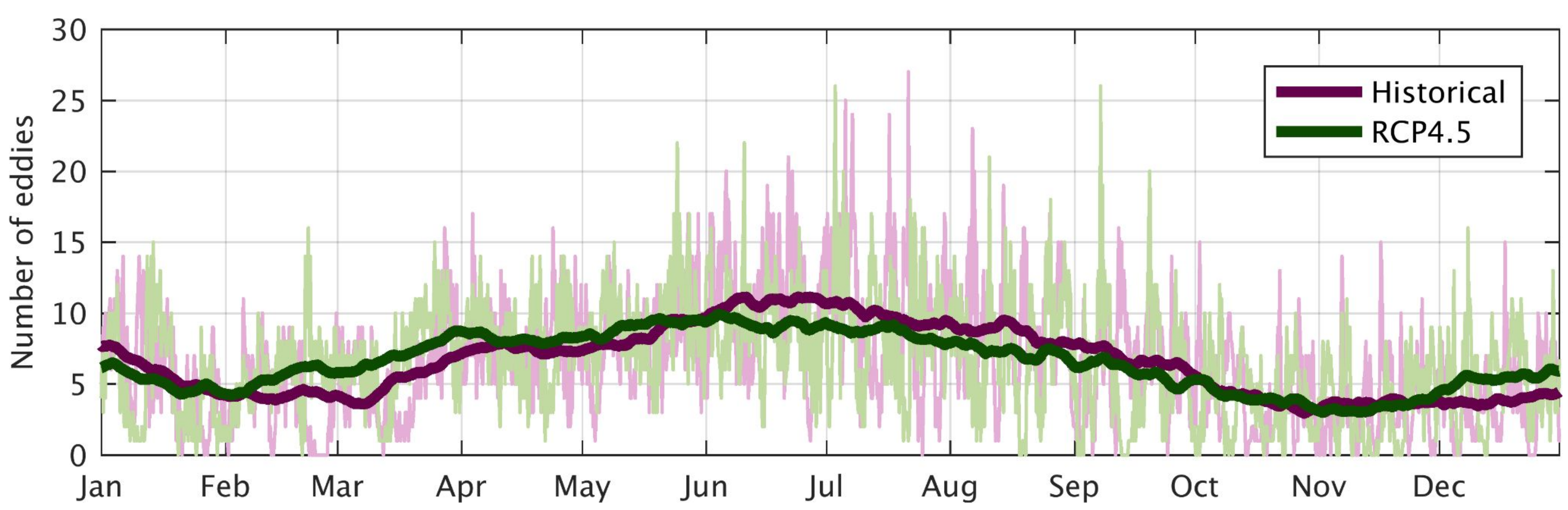

Figure 4: Representation of the temporal evolution of the number of eddies found in the simulations. The thin lines represent the results obtained every 3 hours, while the thick lines correspond to a 15-day moving average

References

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Conclusion

Investigating the impact of climate change on the BC dynamics is crucial for understanding the ocean's role in regulating the Earth's climate. This study will contribute to the scientific community's efforts to address the challenges of climate change and inform policymakers and stakeholders about the potential consequences of a changing climate on the South Atlantic region and beyond. However, while our study based on BESM results shows that the BC is weakening, other global models point to this current becoming stronger (Toste *et. al., 2018*). In order to reconcile these conflicting results and gain a fuller understanding of the underlying mechanisms causing these changes, more research is required.