EGU General Assembly 2023

UFRJ UNIVERSIDADE FEDERAL DO RIO DE JANEIRO

LAMCE COPPE.UFRJ.BR LABORATÓRIO DE MÉTODOS COMPUTACIONAIS EM ENGENHARIA

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Assessment of energy production potential from ocean currents along the Brazil coastline taking into account climate change

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Introduction

The increasing electricity demand, coupled with the global need to reduce greenhouse gases emissions, has made the use of renewable energies an attractive solution to this problem. The oceans offer good alternatives for diversification and expansion of the energy matrix, among the possibilities for energy production is that one comes from ocean currents.

Despite some studies in this field (e.g. Shadman *et al.*, 2019), few projects have already been implemented to extract energy from ocean currents around the globe, none of them focuses on the potential of harvesting energy considering future climate conditions . Therefore, this work aims to evaluate the harnessing energy from ocean currents along the Brazilian coast considering the present and future climate, using a dynamical downscaling experiment based on the projections from the Brazilian Earth System Model (BESM) in the scope of the Fifth phase of the Coupled Model Intercomparison Project (CMIP5). In addition to spatial and temporal variability, the synergy between ocean current as a source of electric power supply and others sources from the Brazilian electrical matrix will be discussed.

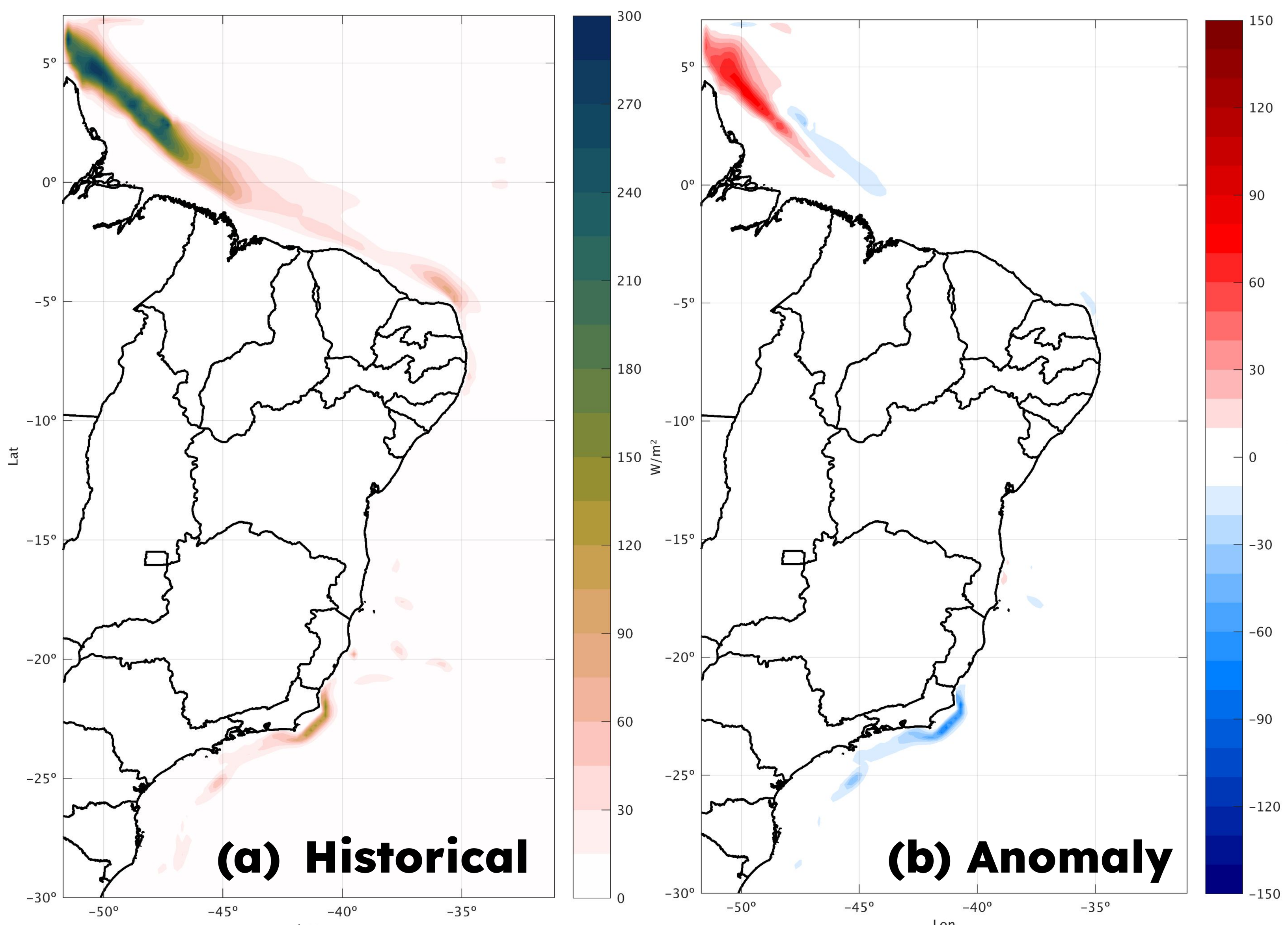

Fig. 2: Total ocean currents energy computed for the historical experiment, in Watts per square metre (a), and the projected anomalies (b).

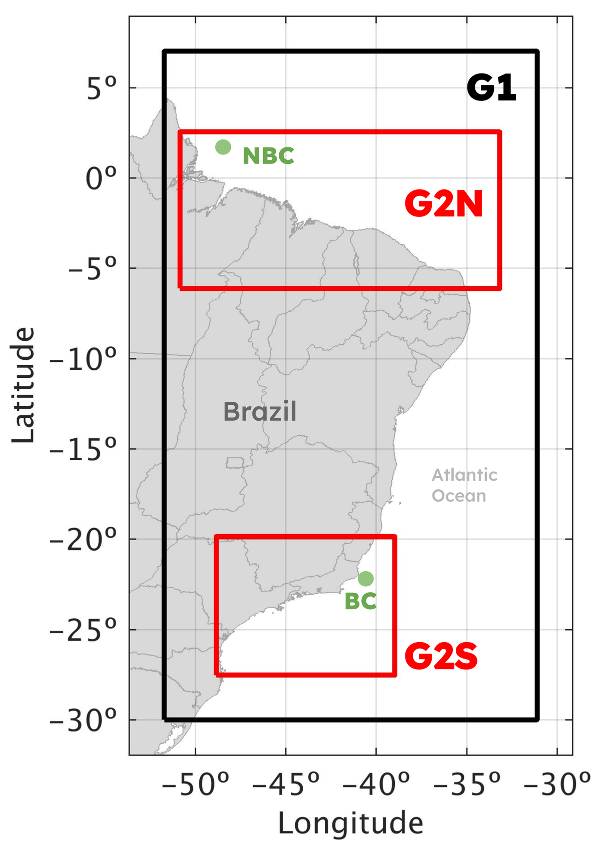

Fig. 1: Numerical grids used for the ROMS experiment (black and red rectangles) and the position where NBC and BC time series were extracted (green dots).

Methods

Due to low temporal and spatial resolution of CMIP5 models, the global projections were downscaled to focus in the Brazilian coast. The downscaling experiments were performed using the Regional Ocean Modeling System (ROMS, Shchepetkin and McWilliams, 2005) in a two-way nested model composed by a donor (G1) and two receiver grids, with 1/5° and 1/15° of horizontal resolution, respectively (Fig. 1). The highest resolution grids embrace the regions with the highest hydrokinetic potential on the southeastern (G2S) and northern (G2N) coasts, where the Brazil Current (BC) or North Brazil Current (NBC) predominates. BESM was the model chosen to be downscaled since it represents the land use over the Brazilian territory more accurately in comparison to other CMIP5 models (Capistrano *et al.*, 2018). In order to evaluate the effects of climate change on hydrokinetic production in the ocean, the simulation must represent the current and future climate conditions. Therefore, BESM results for the historical and RCP4.5 experiments were used, as initial and lateral boundary conditions and also as surface forcing to the ROMS experiments.

Two average years, in the sense that they not differ significantly from a 20y average, were simulated each representing the present and future scenarios. The results for horizontal components of velocity were then used to compute the kinetic energy in the ocean. The anomalies between these two scenarios were considered as due to climate change.

Results

The energy from ocean currents was evaluated using the results for G1 grid. From the total energy computed in the historical experiment, it is clearly observed the regions dominated by ocean currents (Fig. 2a), with the highest values associated with the NBC. According to the projections, a decrease in BC potential energy is expected, while for the NBC, this potential would increase (Fig. 2b). Since the speed of these currents is modulated by the seasons, the potential energy is also expected to vary along the year. During the Austral Winter, when the NBC flow is stronger, the highest anomalies are projected along the NBC main core. For the other seasons, this increase is observed mainly west of 45°W, and during the Spring a overall weakening is expected in the whole area. For the BC, there is a consistent decrease in the available energy throughout the year (Fig. 3).

The correlation analysis between the normalized series of electricity production showed a strong complementarity between the available energy for NBC and the hydroelectric power plants in the Northern region (-0.91), and for BC with the current production of wind energy in the South (-0.84). It is also worth highlighting the strong complementarity between the energy series of the BC and NBC points (-0.99).

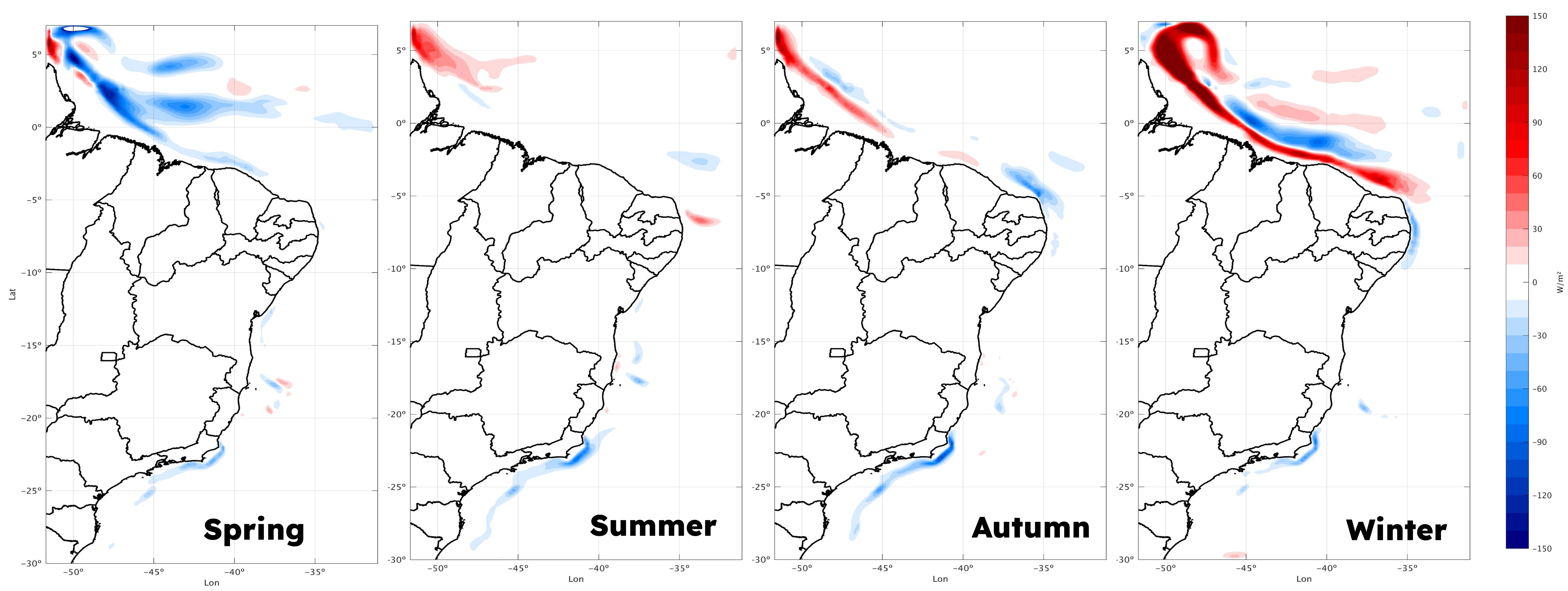

Fig. 2: Anomalies for the Austral seasonal ocean currents energy, in Watts per square metre.

Final remarks

According to these preliminary results, the NBC has potential to have energy explored and it would increase even under climate change conditions. On the other hand, the BC region, would be less energetic than under present climate conditions. It is important to notice that these patterns reflect the general behaviour projected by BESM and further studies would be necessary to include other models and climate change scenarios. Despite that, the present work shows the possibility of exploring ocean currents as complementary to other sources of energy now used in the Brazilian energy matrix.

References

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