[JGR Oceans]

Supporting Information for

Modulation of western South Atlantic marine heatwaves by meridional ocean heat transport

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Introduction

The **Text S1** of this Supplementary Material describes the concept of the Bayes' Theorem and the methodology used to calculate probabilities of MHWs and CSs occurrences conditional to the western South Atlantic SLA reconstructed by the CEOF1 mode. **Figure S1** shows the four clusters calculated for MHW and CSs, with the first column shown the clusters analyzed in this work. **Figure S2** shows the result of the posterior conditional probabilities described in Text S1, and **Table S1** shows the values of the individual probabilities used to calculate the posterior probabilities. **Figure S3** shows the seasonal cycle of the mixed layer heat budget (in W/m^2) and the mixed layer depth (in meters) averaged in the western subtropical South Atlantic (46°W-35°W/33°S-27°S). The mixed Layer heat budget is calculated using the monthly ORAS5 reanalysis. **Figure S4** shows the full cycle of the main westward propagating SSH mode in the subtropical South Atlantic and associated geostrophic velocity anomalies calculated from the SSH patterns. **Figure S5** shows the composites of SST, SLA, wind/SLP and MLD during two MHW events (2002, 2014) and two CS events (1999, 2008).

Text S1. Conditional Probability

The probability of an event occurring based on prior knowledge of the conditions that might be relevant to the event is described by the Bayes' theorem. The Bayes' theorem is expressed in the following formula:

$$P(A \vee B) = \frac{P(B \vee A) . P(A)}{P(B)}$$

Where P(A|B) is the posterior probability that event A occurs given that event B has occurred, P(B|A) is the likelihood that both events A and B occur, and P(A) and P(B) are the observed independent probabilities of the events A and B occurring, respectively.

In our particular case, we assume that the variables A and B are binary, in which A represents the MHW (A+) and CS (A-) events, and B represents the CEOF+ (B+) and CEOF- (B-) events. The occurrences of these events are treated as mutually exclusive, thus P(B) can be defined as the sum of all factors affecting B:

$$P(B) = P ¿.$$

Therefore, P(B) can be regarded as a normalization factor for the posterior probabilities. Thus, in agreement with the main mechanism examined here, we are interested in analyzing if the alternative hypothesis [P(MHW,CEOF+), P(CS,CEOF-)], in which the CEOF and temperature extremes are in phase, is significantly higher than the null hypothesis of an out-of-phase relationship [P(MHW,CEOF-), P(CS,CEOF+)], and in this case we can reject the null hypothesis.

The events are analyzed over 9681 days, from which MHW events occurred during 651 days and CS events occurred during 635 days. The CEOF+ events occurred during 4922 days, from which 533 MHW events and 118 CS events occurred, and CEOF- events occurred during 4759 days, from which 517 CS and 118 MHW events occurred. The individual probabilities are given in **Table 1**.

Text S2. Seasonal mixed layer heat budget in the box of **Figure 6**. In **Figure S3b**, the temperature advection (ADV) across the boundaries of a box is calculated according to this equation:

$$ADV = \frac{\oint_S (V.\hat{n})(T_h - T_m)\, h\, dS}{Volume}$$

Where T_h is the averaged mixed layer temperature, T_m is the temperature averaged over the mixed layer volume inside the closed domain *S*, *h* is the mixed layer depth, and $V.\hat{n}$ is the velocity vector across each wall of the box.

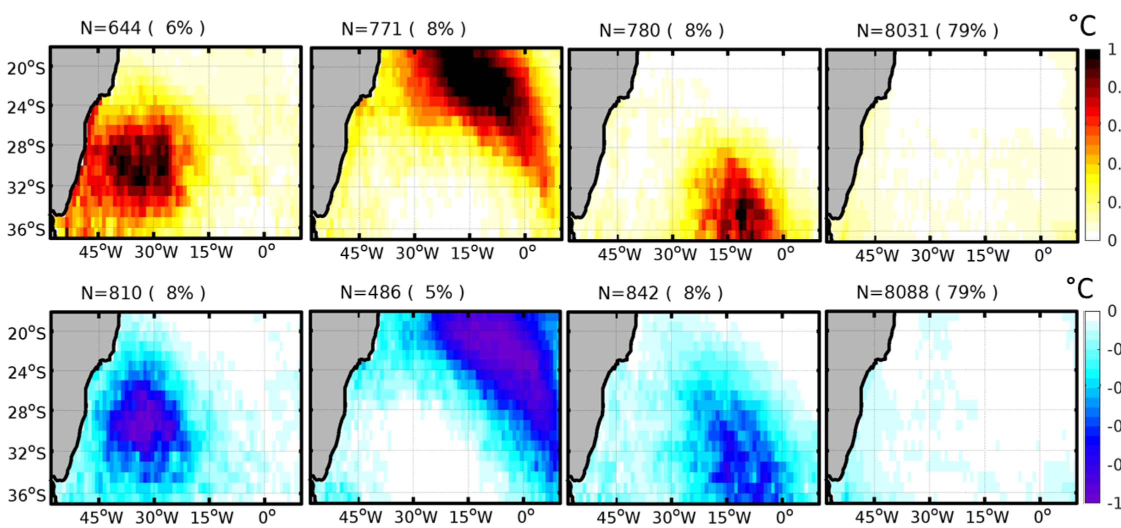

Figure S1. Averaged SSTA for the defined four cluster modes for MHWs (top) and CSs (bottom). The number of days and percentage of total days in the analyzed period are shown on top of each panel. The left column shows the clusters selected for the western South Atlantic.

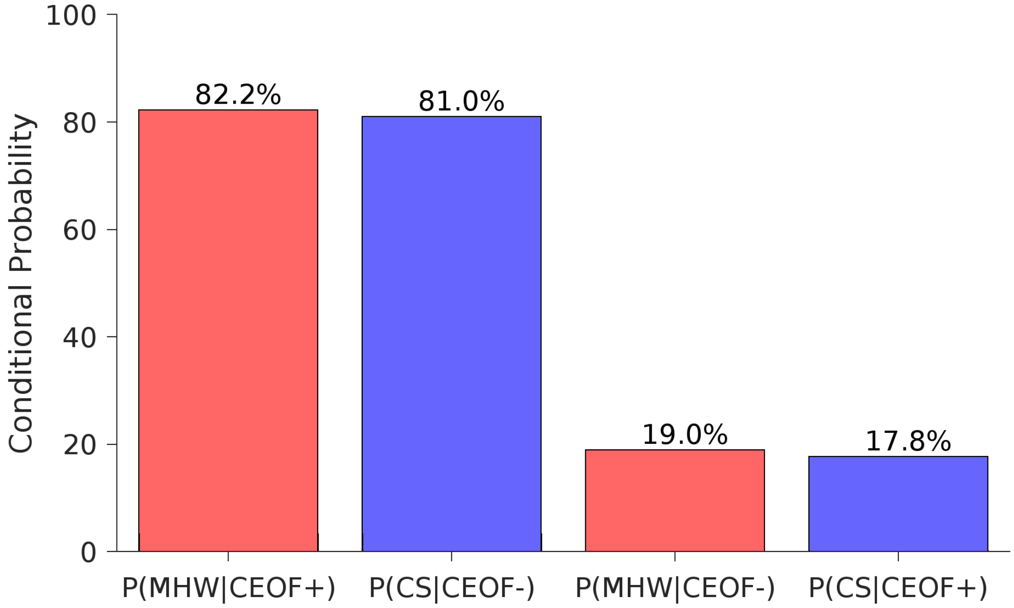

Figure S2. Conditional probabilities (%) of MHW and CS events given a particular phase of the SLA reconstructed in the western South Atlantic (box of Figure **6c**) using the CEOF1 mode. Conditional probabilities are calculated using the Bayes' theorem (see **Text S1**), and values are shown in **Table S1**.

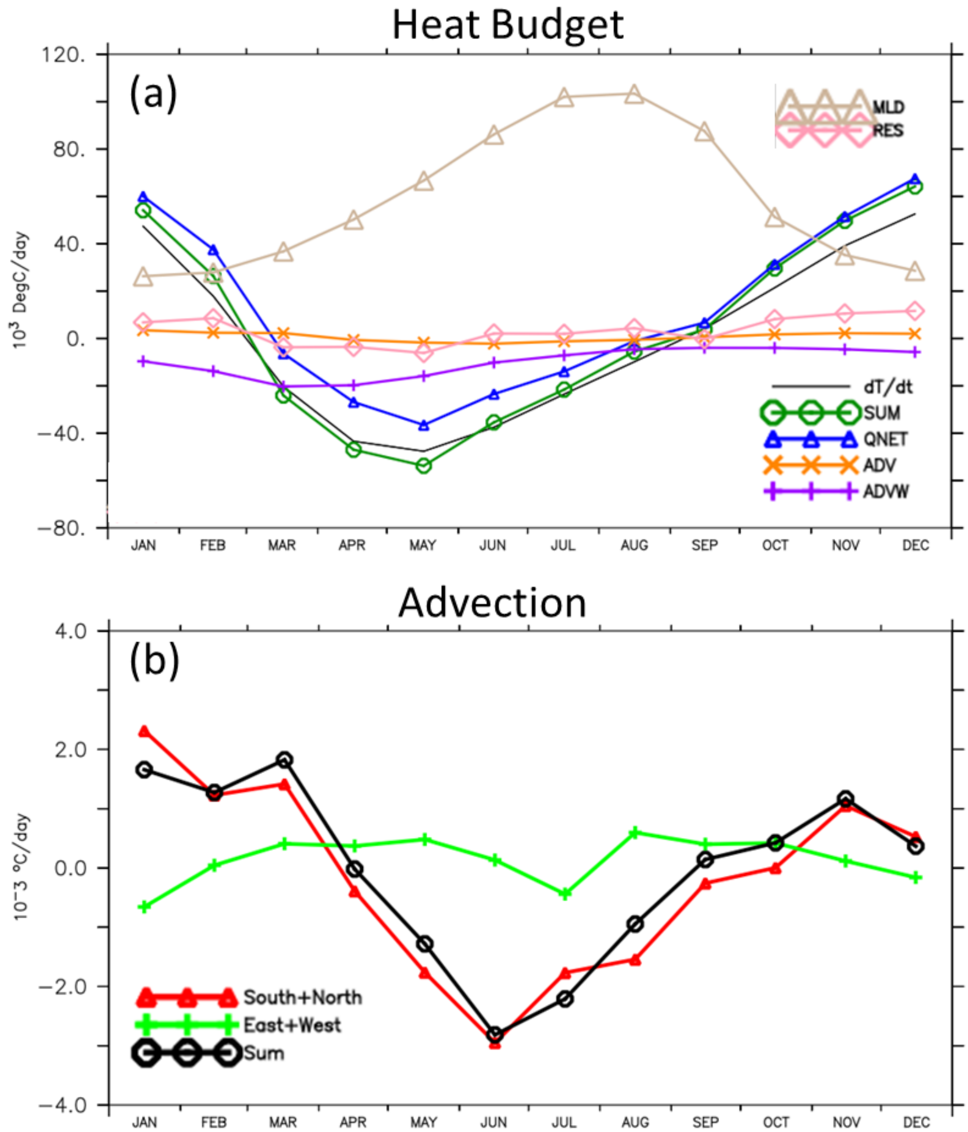

Figure S3. Seasonal cycle of the mixed layer heat budget terms in the box of **Figure 6c**. (a) Deepening of the MLD during fall (Feb-Jun) provides cooling to the mixed layer due to vertical entrainment. A rapid warming due to net heat heating occurs when the mixed layer is shallow during late spring and summer. (b) Seasonal cycle of the horizontal advection directional components into the box of **Figure 6c**.

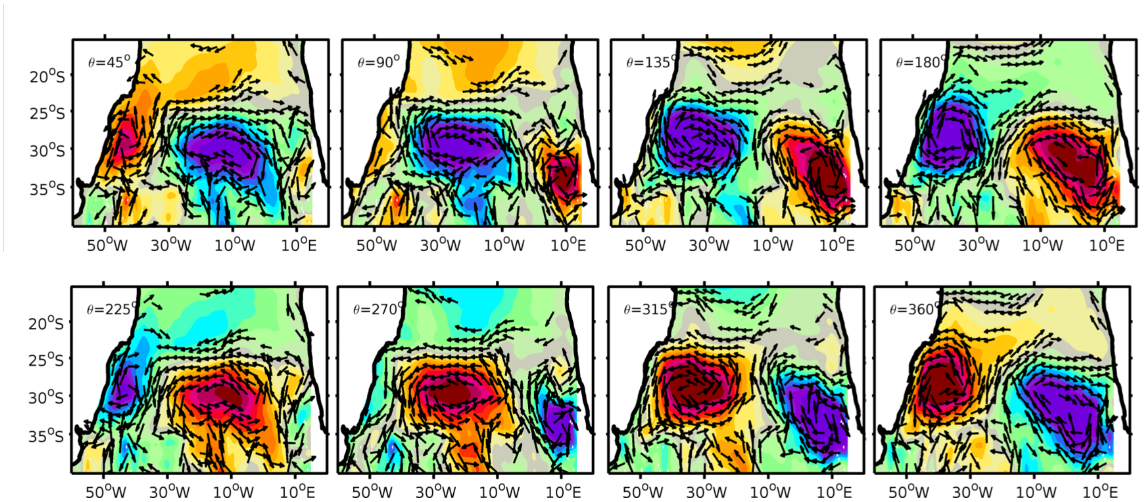

Figure S4. Full cycle (360° every 45°) of the East-west propagating SSH mode, filtered spatially using a 5° horizontal Gaussian filter, overlaid by the statistically significant calculated geostrophic velocities (black arrows).

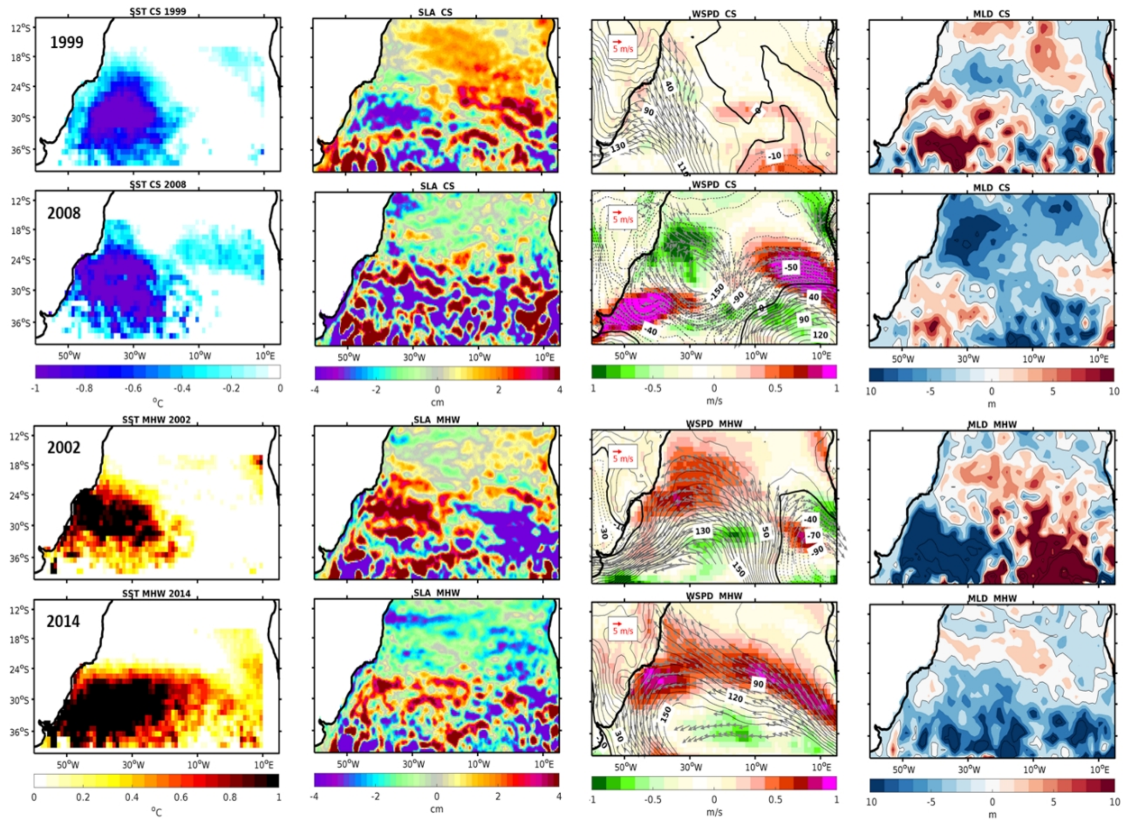

Figure S5. Left to right: Composites of anomalies of SST, SLA, Wind speed (shades)/Wind direction (arrows)/SLP (contours), and Mixed layer depth for selected CS (1999, 2008) and MHW (2002, 2014) events.

Table S1. Individual probabilities used in the Bayes' theorem estimation of conditional probabilities.

Probabilities	**%**
P(MHW)	6.7
P(CS)	6.6
P(CEOF+)	50.8
P(COEF-)	49.2
P(COEF+ | MHW)	5,5
P(COEF+ | CS)	1.2
P(COEF- | MHW)	1.2
P(COEF- | CS)	5.3
P(MHW |COEF+)	82.2
P(CS |COEF+)	17.8
P(MHW |COEF-)	19.0
P(CS | COEF-)	81.0
P(MHW|CEOF)	**81.6**
P(CS|CEOF)	**18.4**