Dear Reviewer #2,

Thank you for the careful reading of our work and constructive feedback, which has contributed to improving our manuscript.

Following the major requests, see below the point-by-point responses and changes we have applied accordingly. Note that the lines indicated below will always refer to the submitted version since, following the rules of this ‘interactive comments section’ we cannot provide here the revised version as a supplement.

1.- A major error is the calculation for wind stress shown in equation (1). The zonal and meridional wind stress should be calculated respectively for both wind speed and wind vector. However, the authors applied the wind speed as the total wind speed. This is definitely resulting in significant over estimation of wind stress.

We have performed several tests to address this concern and reviewed the methodology we applied. In order to be clear, we have included Equations 1-3 in the revised version. These equations are used to compute the wind stress, and its components, as widely employed in the literature (see references below). Furthermore, for a better approach, we incorporate a drag coefficient that depends on the magnitude of the wind speed. This was not the case in the former version of the manuscript. However, the same spatial patterns stand out within the same order of magnitude as shown in the previously submitted version. We find no significant over estimations of the wind stress following either of the two procedures.

Lines 174-179 in the original manuscript read:

“We calculate the wind stress (τ) and its components following Equation 1:

$$\tau_x = \rho\, C_D U_{10} u\,; \quad \tau_y = \rho\, C_D U_{10} v\ , \qquad (1)$$

where τ_x and τ_y are the zonal and meridional wind stress components, respectively; ρ is the air density (1.225 kg m^{-3}); C_D is the drag coefficient ($1.25x10^{-3}$; Kara *et al.*, 2007); $U_{10} = \sqrt{u^2 + v^2}$ is the wind speed at 10 m above the surface; u and v are the eastward and northward velocity components; and, x and y are the eastward and northward spatial coordinates, respectively."

These lines in the revised manuscript read:

"We calculate the wind stress (τ), and wind stress zonal (τ_x) and meridional (τ_y) components, following Equations 1-3 (Patel, 2023):

$$\tau = \rho \cdot U_{10}^2 \cdot C_D \,, \qquad (1)$$
$$\tau_x = \rho \cdot U_{10} \cdot u \cdot C_D \,, \qquad (2)$$

$$\tau_y = \rho \cdot U_{10} \cdot v \cdot C_D \,, \qquad (3)$$

where ρ is the air density (1.2 kg m^{-3}); $U_{10} = \sqrt{u^2 + v^2}$ is the wind speed at 10 m above the surface (u and v are the eastward and northward velocity components, respectively); x and y are the eastward and northward spatial coordinates; and, C_D is the drag coefficient, which is a function of wind speed, U_{10}. The equations used for wind stress computation are based on Gill (1982) formula and a non-linear C_D based on Large and Pond (1981), modified for low wind speeds (Trenberth *et al.*, 1990). We note that the mean C_D we obtained for our climatological maps in the BS is $1.4x10^{-3} \pm 0.16x10^{-3}$, analogous to the values reported by Kara et al. (2007) over the SO."

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2.- The major feature in Figure 1(b) is less helpful and can be combined into Figure 1(a). While the mean SST or chl-a (contour) can be shown instead for readers to understand the major patterns in the study region.

We appreciate your feedback regarding Figure 1(b). However, we think it may not be optimal to combine it into Figure 1(a) as it could potentially overload the figure, especially considering the new addition of the three observational data transects which derive from the requests and suggestions of Reviewer #1. Nevertheless, to address this concern, we have included the major patterns also in Figure 1(b).

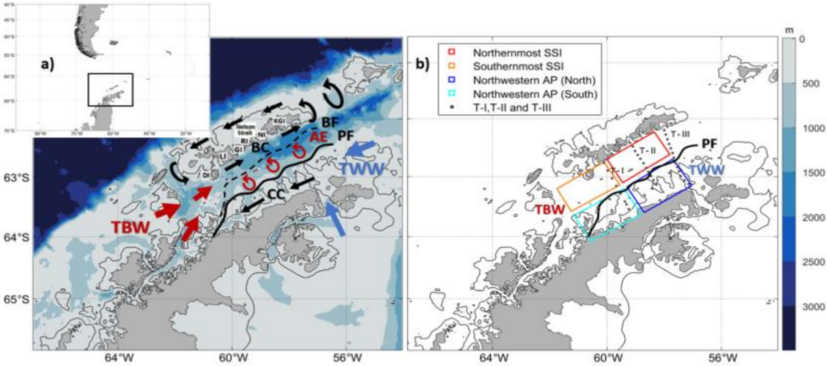

Figure 1. (a) Sketch of the circulation in the Bransfield Strait. Acronyms for South Shetland Islands (SSI) include DI (Deception Island), LI (Livingston Island), GI (Greenwich Island), RI (Robert Island), NI (Nelson Island) and KGI (King George Island). Acronyms for major oceanographic features are as follows: AE (Anticyclonic Eddy), BC (Bransfield Current), BF (Bransfield Front), CC (Antarctic Coastal Current), PF (Peninsula Front), TBW (Transitional Bellingshausen Water), TWW (Transitional Weddell Water); (b) Map showing cruise transects and boxes selected for dedicated analysis. The transects are from two different oceanographic cruises and include T-I and T-III from CIEMAR (December 1999) and T-II from COUPLING (January 2010). Additionally, four boxes are defined between the SSI and the Antarctic Peninsula (AP): Northernmost SSI (red), Southernmost SSI (orange), Northwestern AP - North (dark blue) and Northwestern AP - South (light blue). The 200 m isobath is highlighted with a black contour in both panels.

3.- The front is generally identified using the SST gradient and the frontal probability is usually applied for identifying the location of fronts. The identified frontal distribution from satellite observation can be compared with the cruise observation. The authors should elaborate more discussion related with front dynamics in current study.

We appreciate the reviewer bringing to the front the insightful work performed by Yu *et al*. (2019) in his/her/their comments; thanks to that we better understand the above suggestion.

We have carefully read the paper suggested by the reviewer and found the Frontal Probability tool of high interest to explore the front dynamics regarding the existence of a recurrent oceanic front; however, we think the use of this tool becomes meaningful when aiming to automate the process of identifying the front in interannual variability studies. In our case, the focus is on seasonal variability, particularly during the summer chlorophyll-a bloom. To achieve this, we generate a climatological map (i.e. a map with historical memory) of summer Sea Surface Temperature (SST) and a climatological map of summer chlorophyll-a concentration, where the adjustment of the thermal front and chlorophyll bloom boundaries is straightforward.

To reinforce this adjustment, two approaches may be considered: (1) confirming it using frontal probability, as in Yu *et al*. (2019); (2) exploring *in situ* oceanographic data over different years to ascertain the recurrent nature of this adjustment. In our case, we have chosen option 2, as we have data validating the physical-biological coupling along the front. Furthermore, we substantiate this adjustment with an extensive literature review (Table 1), shedding light on our hypothesis of frontal coupling in the BS using information reported by previous authors over several decades. The pieces of information were always there; we have just assembled them to form the narrative. While acknowledging that using frontal probability may strengthen our hypothesis, we believe it will be more beneficial in future studies of interannual variability using solely remotely-sensed observations through an automated algorithm, where such a tool (the frontal probability) could potentially play a central role.

In the current study, we believe that employing frontal variability would unnecessarily extend the paper, given its already substantial length.

Finally, we would like to draw the reviewer's attention to one additional paragraph that we have added to account for his/her/their suggestion of including more discussion about the front dynamics in the context of chl-a blooms. In the new manuscript, the revised version reads the following as a closure of Section 3, and after discussing Figure 10:

"Lastly, it is worthwhile noting that the alignment of the chl-a spatial distribution along an oceanic front is not a novel feature in the world's oceans, and has been already investigated in the literature (Moore and Abbott, 2002; Baird *et al*., 2008; Von Bodungen *et al*., 2008; Yu *et al*., 2019). Thus, the novelty of our work lies in demonstrating through *in situ* observations and remotely-sensed measurements that such a biophysical coupling has the potential to be used to monitor the chl-a blooms and phytoplankton assemblages occurring seasonally in BS. This aspect is particularly relevant because BS is a key region for the sustainability of marine Antarctic ecosystems, which is challenging to monitor due to the hazardous prevailing conditions in polar regions. In future studies, we expect the calculation of the frontal probability (Yu *et al*., 2019) of the Peninsula Front through a multi-year time-series of SST data may be beneficial to assess and co-locate interannually the alignment of the thermal front and the chl-a bloom domains using an automated algorithm for the Bransfield Strait study case."

4.- The same approach is actually applied by Yu et al. (2019, JMS) for underscoring the dependence between chl-a and other factors. Thus, the creativity is not relying on the intercorrelation among different parameters, unless the difference between current and former study is highlighted.

While we acknowledge that intercorrelation among chl-a and marine environmental factors is a well-known aspect in the literature since several decades ago (Martinez *et al*., 1990; Sasaoka *et al*., 2002; Schwarz *et al*., 2010; Yu *et al*., 2019; Moradi and Moradi, 2020), we would like to highlight that our study focuses on the unique context of the Bransfield Strait. Unlike Yu *et al*. (2019), who conducted their research in the South China Sea, our study is situated in a region where the different ocean dynamics prevent us from concluding beforehand that an analogous approach, applied elsewhere, will also apply here. This idea is especially relevant considering the particular environmental conditions of the Southern Ocean as a high-nutrient low-chlorophyll

(HNLC) domain. Unless research such as the one we presented here is performed, one cannot assume that the approach previously followed by Yu *et al.* (2019), and many others, can be applied in BS.

Also, because we are conscious that many previous papers address biophysical coupling in the ocean combining remotely-sensed chl-a and SST data, we do not claim at any moment the creativity of this research relies on the intercorrelation among different parameters; differently, we *simply* state that (lines 112-113) “We hypothesize that this biophysical coupling is strongly conditioned by the spatio-temporal variability of the Peninsula Front, as has been already argued.”

We focus on a very specific feature which applies to the BS case, the alignment of the surface chl-a blooms in BS along the Peninsula Front. This is also addressed in lines 10-12 (Abstract); and, in more detailed in lines 700-705 (Conclusions), where we account for the following:

“In this study, we address the hypothesis that the spring-to-summertime biophysical coupling controlling the chl-a bloom in the BS could be monitored through combination of remotely-sensed observations of chl-a and SST, which strongly conditions the spatio-temporal variability of the phytoplankton assemblage across the Peninsula Front. Our approach is based on the characterisation of climatological fields, following the motivation from novel and historical synoptic *in situ* observations (discussed in Section 3.1) which reveal that the Peninsula Front may be used as a guideline to contour two distinctive niches for phytoplankton assemblage in the BS, both horizontally and vertically.”

We agree that it is essential to always emphasize the differences between a present study and previous works; however, we disagree that we have claimed creativity on the intercorrelation among different parameters. Nevertheless, in order to make this point clearer, we have added in the revised version the following lines as a closure of section 3, Results and Discussion:

"Lastly, it is worthwhile noting that the alignment of the chl-a spatial distribution along an oceanic front is not a novel feature in the world's oceans, and has been already investigated in the literature (Moore and Abbott, 2002; Baird *et al.*, 2008; Von Bodungen *et al.*, 2008; Yu *et al.*, 2019). Thus, the novelty of our work lies in demonstrating through *in situ* observations and remotely-sensed measurements that such a biophysical coupling has the potential to be used to monitor the chl-a blooms and phytoplankton assemblages occurring seasonally in BS. This aspect is particularly relevant because BS is a key region for the sustainability of marine Antarctic ecosystems, which is challenging to monitor due to the hazardous prevailing conditions in polar regions. In future studies, we expect the calculation of the frontal probability (Yu *et al.*, 2019) of the Peninsula Front through a multi-year time-series of SST data may be beneficial to assess and co-locate interannually the alignment of the thermal front and the chl-a bloom domains using an automated algorithm for the Bransfield Strait study case."

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5.- Many careless in the writing, such as forgetting to upper case the unit of chlorophyll, the reference (Sangrà et al. (2017)), chl-a and SST among others should be used after defining the abbreviation. The authors should double check the text throughout the manuscript.

We appreciate the reviewer’s feedback on these issues and have carefully re-read the manuscript making corrections wherever it was needed.

6.- The governing dynamics should be discussed with observational evident, though only two cruises were available. Additional satellite observations or literature result can be applied as supplementary proof for the underlying dynamics.

We acknowledge the reviewer’s suggestion. The Bransfield Current System hydrography and dynamics have been extensively addressed and described in a handful of relatively recent papers (Sangrà *et al.*, 2011, Sangrà *et al.*, 2017, Veny *et al.*, 2022), some of them co-authored by the co-authors of this manuscript. Please note where we discuss the main features concerning our research in the Introduction (lines 33-60), Results and Discussion (lines 228-241; 252-260; 335-347; 384-387; 671-692), and Conclusions sections (lines 710-725).

We agree it is key to bear in mind the governing dynamical features of the Bransfield Current System; however, we consider we do so in the above-mentioned lines. If the reviewer is still missing some other particular assessment, or mention, in the text we would appreciate a more concrete guidance on his/her/their request.

Lastly, we would like to recall that the aim of the present manuscript is to link the well-known governing physics of the Bransfield Current System with the spatial distribution of the surface chl-a blooms and phytoplankton assemblages developing in the study region. To this aim we use observational, *in situ* measurements and satellite data for two available cruises and discuss profoundly these results against existing literature using the same tools (cruise data and satellite observations) to, eventually, propose a novel approach to monitor the surface chl-a blooms in BS through the combination of remotely-sensed SST and chl-a. This enables the separation of two chl-a blooms regimes in accordance to two distinct environmental scenarios (the TBW and TWW pools). To support this novel approach, besides the study of the two cruises presented in this work, we discuss results from a variety of previous studies in lines 204-214; 276-285; 301-315; 339-347; 359-366;

396-399; 419-431; and 531-554. We think the studies mentioned in these lines cover the satellite observations and literature review the reviewer is asking for. Furthermore, an extensive and carefully detailed summary-table reviewing the existing literature supporting the novel approach we propose is presented in Table 1, and discussed in lines 580-643. May the reviewer be referring to some other type of literature or data proof for the underlying dynamics, we will be happy to hear about it and include it.