We thank Dr. Fabien Desbiolles for his constructive comments. We overall agree with the points raised, which have been considered in revising the manuscript. In the following, our responses to the reviewers are shown in *blue italics*.

The reviewer's comments encouraged us to introduce the concept of potential upwelling to clarify our methodology. Please see lines 108-118 "We mainly analyze the variability of atmospheric quantities and associated impacts on upwelling across the BUS. We introduce the concept of potential upwelling to distinguish the quantities used in our analysis from those describing realistic, highly complex vertical transport processes in the ocean. In this sense, potential curl-driven upwelling is the upwelling that would take place within an unbounded ocean with only wind-driven surface currents under the absence of other drivers of upwelling, baroclinicity, bottom topography, coastlines, geostrophic flow, inertial or planetary waves. Potential coastal upwelling characterizes an upwelling process driven solely by the alongshore wind and is related only to the cross-shore divergence of the wind-driven cross-shore directed flow. We derive the potential upwelling quantities from analytical theories of ocean dynamics, the steady state Ekman theory, and a theory of coastal upwelling given by Fennel (1999). This keeps the focus on well-defined quantities, even if they do not reflect realistic upwelling that may be modified by other processes like alongshore wind variability, coastally trapped waves, frontal dynamics, etc." and lines 465-468 "We introduced the concept of potential upwelling which indicates upwelling processes driven solely by the vertical flux of atmospheric horizontal momentum into the ocean. This approach helps to focus on well-defined quantities, even though they do not reflect a comprehensive picture of processes that can considerably modify the upwelling (i.e., alongshore wind variability, coastally trapped waves, frontal dynamics, etc.)".

Reviewer #2 (Dr. Fabien Desbiolles)

The paper discusses the relationship between long-term trends in the position and strength of the South Atlantic Anticyclone (SAA) and upwelling dynamics. The author uses ERA5 reanalyses and focuses on different aspects of the upwelling system, namely the windstress-driven and the curl-driven upwelling. Overall, the paper is well presented and well written. In particular, the methodology is clear and seems promising to disentangle different aspects of the complex and multiscale nature of an Eastern Bounduary Upwelling System (EBUS), i.e. from large-scale wind forcing to local-scale modifications of the wind by orography and/or SST/wind interactions.

In particular, the authors show that a robust change in the position and strength of the SAA together affects both curl-driven and wind-driven upwelling, with a pronounced increase in the curl-driven mechanism. However, this robust change cannot be attributed to Bakun's theory because it is difficult to attribute the SAA change to climate mode variability or to the difference in warming between the land and ocean. Strong spatial heterogeneity of a weak long-term trend in ERA5 is shown, making any strong conclusion difficult. However, the limitations of the study and the use of ERA5 are well presented in the last sections of the paper. The paper could be suitable for publication after discussion of the following aspects:

(1) ERA5 is a medium-resolution reanalysis with a relatively short time span. It remains difficult to relate anthropogenic global warming to the long-term trends present in the data set. Also, with an analysis period of 40 years, it is complicated to disentangle the anthropogenic signal from climate mode and decadal variability. I remain convinced that a lot can be done and said with ERA5, which remains a very useful dataset, albeit limited. For example, one can ask whether there is a signal in ERA5 for differential warming over land and ocean. If so, can this signal explain the long-term trend in SSA strength and position? How are climate modes represented in the ERA5 dataset, and what are the consequences for SAA position and strength? The paper gives some hints, but would benefit from a clearer and more thorough discussion of these two aspects. Please note that this comment does not necessarily require important new diagnostics.

Response: *We computed the linear trend in the ERA5 surface air temperature over 1979-2021, and the result has been displayed in Figure S11. As can be viewed in this figure, the rate of warming* *over land is more significant than that in the adjacent ocean. We discussed that in the main text, lines 348-351 "In general, the rate of warming over land is larger than the adjacent ocean across the BUS in 1979-2021 (Fig. S11). This feature is more pronounced in the BUS northernmost sector (i.e., Cape Frio and Kunene upwelling cells), where the rate of warming over land exceeds 0.05 °C/year. Thus, one may expect an enhanced SLP gradient between the land and the adjacent ocean".*

In addition, we have now addressed the ability of ERA5 reanalysis to represent the impacts of dominants of climate modes (Atlantic Niño, ENSO, SAM) on the SAA. Please see lines 134-140 "The connection of the SAA variability with the onset and development of Atlantic Niño events and associated SST changes over the Angola Benguela front (15°S-17°S) is well represented in the ERA5 data (Prigent et al., 2020). The poleward (equatorward) displacement of the SAA during austral summer when the tropical Pacific features La Niña (El Niño) events is well represented in the ERA5 data sets (Rouault & Tomety, 2022). In addition, the spatial structure of the SAM and meridional wind anomalies over the southern hemisphere during different SAM phases are well reproduced in the ERA5 data sets (Marshall et al., 2022)".

We also discuss this point in lines 486-493 "Despite a slight upward SLP trend in the subtropical South Atlantic during 1979-2021, the ratio between changes associated with the long-term SLP trend (i.e., Δ) and the standard deviation of the long-term trend subtracted yearly mean SLP is small across the entire domain. Further, potential upwelling quantities, including Wcoast and Wcurl, in several upwelling cells remained steady and exhibited neither a significant long-term trend nor prominent changes in the characteristics of the variability (i.e., period, amplitude, and extremes). Overall, our results neither demonstrate nor rule out the potential impacts of anthropogenic global warming on the atmospheric drivers of upwelling in the BUS. A possible explanation is that a much longer time is likely required to detect the robust global warming signals in the wind-driven upwelling across the BUS".

(2) Several mechanisms are responsible for curl-driven cross-shore upwelling.

(i) Offshore, winds blowing along a permanent or semi-permanent front adjust through the so-called downward momentum mixing mechanism, with a decrease (increase) of the surface wind over the cold (warm) flank of the front (see e.g. Chelton et al., 2004). Even with the relatively low resolution of the dataset, this mechanism is important in the dynamics of the ERA5 surface winds, especially in the EBUS where near-neutral conditions prevail. (ii) Near the coast, the coastal wind dynamics are mainly driven by the differential stress between the ocean and the continent and the role of the coastal orography. This mechanism usually implies a dropoff zone (as mentioned in the paper) and possibly a cape effect. Both points mentioned here are driven by important structures in the curl that favor upwelling and are hidden in the Wcurl calculated in the paper. The paper would benefit from a fuller discussion of these aspects. The orography-induced wind drop is undoubtedly not well characterized in ERA5 due to poor resolution (coastal points also suffer from the so-called Gibbs phenomena). The coastal orography varies from the southern seasonal upwelling to the more permanent northern counterpart; inducing a different permanent wind curl signal at the coast.

Response: *Thanks for this constructive comment and for introducing this study. We read the suggested paper and cited it in the new version of our manuscript. We have now discussed the uncertainty in the ERA5 data set and briefly discussed the suggested mechanism by the reviewer. Please find our response to this comment in lines 144-154 "There is another source of data uncertainty over coastal areas with frequent upwelling events. The offshore transport of upwelled cold water often forms SST fronts near the coast (de Szoeke and Richman 1984), altering the local structure of the wind stress curl. On the cold side of the front, the near-surface air column is stabilized, decelerating the local wind speed. At the same time, the air column is destabilized over the warm side, and the wind intensifies (Chelton et al., 2004). In this way, small-scale SST fronts drive local convergence and divergence of the surface wind, which is proportional to the size of the crosswind SST gradient. This aspect of small-scale (i.e., sub-mesoscale) ocean-atmosphere interaction is not adequately represented in ERA5 reanalysis because the model's resolution is too coarse. Further, orographic features near the coast (i.e., mountain passes, coastline geometry, and capes), which are not well resolved in the model used in ERA5 reanalysis, can diverge or converge the winds locally and alter the structure of wind stress curl (Chelton et al., 2004)".*

We also mentioned these point in line 472-475 "Since it provides an accurate estimate of W_{total}, this approach is promising and suitable for the ERA5 data, even though the spatial resolution of *this data is too coarse (i.e., 0.25°×0.25°) to resolve the small-scale processes driven by coastal SST fronts, orographic features near the coast, which can alter the structure of surface winds and amplify or reduce the coastal wind drop-off.".*

And lines 496-499 "Indeed, one cannot attribute the entire wind field variability over the BUS solely to the SAA and the regional cross-shore surface air temperature gradient. Localized drivers of the surface winds (e.g., sub-mesoscale SST fronts, orographic effects, eddies, and land-sea breezes), which the operational model used in ERA5 reanalysis does not resolve, may significantly alter the surface wind field".

The wind/SST interaction is an important factor for the Ekman pumping in the BUS. Even though it is a coupled mechanism, some insight into the SST forcing used in ERA5 would be nice to discuss (possible cold biases; structures of the fronts, etc.). The paper, and with legitimate argument, examines only atmospheric variables, but the quality of the SST forcing seems crucial to discuss, especially with the role of the front in shaping the Ekman pumping.

Response: *We agree with the point raised by the reviewer. We briefly discuss the data used for the data assimilation in ERA5 and how the SST-wind interaction is represented in this reanalysis. We also briefly discuss the source of data uncertainty. Please see lines 126-133 "HadISST2 data set, which was developed by the UK Met Office Hadley Centre, is widely implemented in ERA5 reanalysis (Hirahara et al., 2016). HadISST2 is on a 0.25°×0.25° regular grid and is derived from in-situ observations and two infrared radiometers, including the Along Track Scanning Radiometer (ATSR) and the Advanced Very High-Resolution Radiometer (AVHRR) (Hirahara et al., 2016). From mid-2008 onward, OSTIA SST from the UK Met Office with a resolution of 0.05°×0.05° was also used in ERA5 reanalysis (Hirahara et al., 2016). OSTIA is based on various types of observation, including in-situ observation, geostationary satellites and microwave imagers. In the Agulhas region located on the southern border of the BUS, both OSTIA and HadISST successfully represent the sub-mesoscale eddies."*

We also discuss the potential impacts of SST fronts on the wind stress and the wind stress curl. please see lines 144-154 (please see previous comment).

(3) The morphology of the continental shelf is important when comparing WSD and WSCD upwelling. As Marchesiello and Estrade (2010), the competition between reducing coastal upwelling and increasing Ekman pumping can be assessed by comparing the length scales of coastal upwelling (Lu) and orographically induced wind drop-off (Ld). If the two length scales are equal, there is no effect on the total upwelling water in the cross-shore direction. The continental shelf of the area, especially around the upwelling cells mentioned, could be discussed and drawn on one of the maps.

Response: Thanks for informing us of the study by Marchesiello and Estrade (2010) entitled "Upwelling limitation by onshore geostrophic flow". The author of this paper used an analytical theory alongside the regional ocean model, which provide very interesting results. As the reviewer correctly pointed out, the size of Lu is in the order of several kilometers, which ERA5 data cannot capture. In addition, information on wind drop-off properties suffers from the same issue. We wanted to implement this comment to more precisely evaluate the length scale of coastal upwelling and wind drop-off. However, the spatial resolution of ERA5 data introduces a barrier to correctly estimating the factors mentioned above. We also found the discussion of the suggested study around the superposition of onshore geostrophic current and along-shore driven upwelling very interesting. We discuss the result of this study in line 215-221 *"Ocean dynamics is associated with many other flow elements, such as the formation of horizontal pressure gradients from upwelling, coastal jets, thermal fronts, sub-mesoscale instabilities, etc. (Fennel 1999; de Szoeke and Richman 1984; Abrahams et al., 2021). For example, the presence of geostrophic onshore directed current can remarkably alter the structure of coastal upwelling (Marchesiello and Estrade, 2010). When the surface and deep Ekman layers overlap over shallow continental shelves, the cross-shore width of coastal upwelling is proportional to the inverse of the bottom slope (Marchesiello and Estrade, 2010). The occurrence of wind drop-off over this zone can cause a large divergence in offshore transport which can significantly alter the structure of coastal upwelling".*