Feedback on Algoa marine climate change: Ocean Sci. Discuss., https://doi.org/10.5194/os-2020-44-RC1, 2020
Author replies in bold.

Reviewer#1
I- General view: The research, in general, touches on multiple important and interconnected aspects such as oceanic, atmospheric, hydrology, and vegetation which are less studied in unison within the Agulhas Current region. The research is based on a suite of reanalysis data sets and model projections. The manuscript sought to evaluate the oceanic and atmospheric trends, and their consecutive feedbacks subsequently establishing future projections. The manuscript also suggests a mechanistic explanation of the observed increasing rates. Overall, the research unpacks the existent changes, their forcings, and future scenarios. In my opinion, the subject is of interest. I do value the importance and challenges presented by this type of research for the region. This kind of research is worthy of publication in the Ocean Science (OS) journal. Besides the scientific value of this manuscript, I suggest the authors focus their efforts in addressing the following three (broad) aspects, as outlined below…

In the revised version, it is expected that the author should: (1) appropriately introduce the topic, (2) strengthen the interpretations supporting the results and the discussion part of the manuscript and, (3) add a few simple diagnostics to solidify the mechanisms related to the dynamic of upwelling, either by following some of the suggestions below or some other that they can find on their own.
Author did re-writing to extend the introduction and discussion, eg. (1) and (2) above. On (3) above, the author added further interpretations on wind- and current-induced upwelling.

II- Comments: - The reader expects to see three main points which are missing or less elaborated in the introduction:

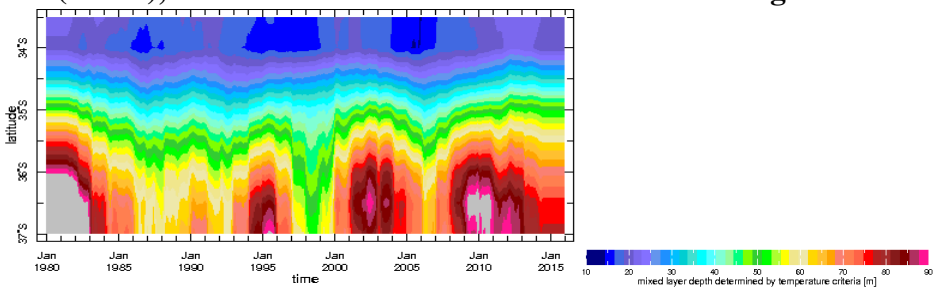
(1) The title for the paper implies that the focus of the paper is “Marine climate change”. The author has not specified what this means, especially in the context of the east Agulhas coast of South Africa. **Abstract says rate of change in the marine environment, this is repeated on line 49.**

(2) The introduction does not really introduce what the paper is about. Restructuring the literature review will improve the understanding of the study context. I [suggest] elaborating the mechanisms of coupled air-sea interaction in the literature, and more importantly state clearly connections such as wind-current-thermal feedback… in previous works, and how they can impact the ecosystem accordingly. **New paragraph was added on lines 40-48.**

(3) What do we know about the oceanic and atmospheric trends in the region, and their projections? I think that identifying these and stating the gap in the literature would elevate the importance of this work. **Covered by response to (2) above.**

- Line 172: “Changes in the Agulhas Current exhibit little vertical shear, consequently cyclonic vorticity-induced uplift is uniformly available but concentrated by the shelfslope (Lutjeharms 2006).” I would re-phrase such statement unless it was mechanically demonstrated… **OK, that was re-phrased with references to figure panels.**

- Line 192 - 195: “The hovmoller plot of SODA-3 zonal currents (Fig 4b) reveals a ‘pulsed’ intensification and coastward shift, contributing to near-shore uplift > 4 m/day (34.1-34.4◦S). Thus current- and wind-induced upwelling become additive.” Based on Figure 4a,b, the author claims to have found the evidence of the upwelling mechanism based on the observational approach. I do understand the challenge that it requires to unpack the dynamic of this upwelling. Therefore, I would suggest that the upward motion indicated in Figure 4b (contours) should be replicated into Figure 4a for highlighting the correspondence between temperature upwelling signature and the upward motion. Perhaps adding a supplementary subplot will solidify this finding. I would suggest a latitude-time plot (hovmuller) of the mixed layer depth (from Soda3) or the isopycnal slope just above the thermocline. This will inform about the dynamic of the subsurface in an upwelling event, due to the wind and/or current. The contour of the vertical motion should also be overlapped on this new subplot.
Author instead added new zonal wind stress and rainfall as Fig 4b and c, Fig 4a is surface temp, while Fig 4d shows uplift & westward currents. Author considered MLD (below), but felt that tau X and rainfall were more significant.



- In the context of global warming, the flux of western boundary current are already expected to increase and wind stress curl enhancing gyres are also expected to intensify.

Line 252: ”... revealed intensified coastal upwelling ...” implicating the Line 17-18 and Line 286. This is a great result and a big statement that should be emphasized. The upwelling is such indicator of enhancement of these external forcings in the region (wind and current). While this statement holds qualitatively by eye in Figure 2, it would be desirable to have more supporting results. I would expect “time series” (with linear trend) to illustrate quantitatively parameters indicating uwelling such as temperature (gradient of temperature), density (from SODA), perhaps stratification. Plus, time series of wind stress in your specified box and the volume transport of the Agulhas Current. I think that this kind of diagnostic will add more conviction for this great result. **Fig 3a shows the wind trend that is from easterly and curving around the convex coastline. Fig 6c shows that trends forward easterly winds are most evident in the future projection, whereas the past observed zonal wind trend is weak. These notes were added in the Discussion.**

- Line 280-290: Please help the reader to clearly understand the covariance of the listed parameters in a short paragraph like a summary. **The words 'contribute to' was changed to 'correspond with' on line 285. In line 290, sentence was added to say the co-varying features are a local response to the poleward shift of the subtropical ridge.**

- Line 290 - 295: the discussion about the projection deserves a full independent paragraph, and should be elaborated. **Author does not want to focus too much on the projections, because of weak trends in past observations.**

III- Minor points: - Please compute the trend per decade or per century. For climate dynamic and ocean scale point of view, trend per year sounds odd for me and less realistic (degC / 100 yr or century). **Author prefers to use per year.**

- Kindly specify where did you get these sets of data, perhaps you can insert them into your table 1. **Author has listed all data sources in the acknowledgements, as mentioned in table 1 caption.**

- Lines 47 and 48, the author writes "Understanding trends in climate can inform resource management decisions and aid socio-economic uptake of. . ." Can the author expand on what kind of resource management decisions and socio-economic uptake they are referring to here. **Author is not an expert there, so changed to say that past work offers guidance…**

- Line 159: "warming > 0.05 C/yr" (inferior or superior). This is a bit confusing for the reader. It should be fully written down and for the whole manuscript. **> symbol surely means 'more than'**
- Line 220: Do you mean: "Namibia"? **this word is used in line 262 correctly.**

- Line 262, the author writes "trends in coastal SST were analyzed around the world". Please provide references.
This was done in-house by the author… the sentence was re-written.

IV- Figures: - Please make the effort to describe properly figures in their captions.
- Figure 1f; Figure 2c,f; Figure 3a; Figure 5c,d: Arrows units (length) are not clear. I suggest overlapping arrows on top of maps with their colorbars for clarity**. Captions were improved. Vector scales were inset (over land).**

V- Acknowledgement: - It's very important to acknowledge the data sources used in this research. **Those are specified.**

Reviewer#2

Author has used some of the criticism and deleted the 'diatribe'.

…the author is trying to solve too many complex problems…

The scope of research was narrowed, and over-stated interpretations were removed: line 19 of abstract.

…warming offshore and cooling inshore (near Port Elizabeth) linked with intensification of the Agulhas Current, was presented by Rouault et al. (2009). However this hypothesis has been challenged by many authors: (Biastoch et al 2009, Beal ? transport and meandering of the Agulhas Current, Hutchinson et al 2018, Durgadoo et al, Loveday et al)… whether the cooling inshore is locally wind-driven or upstream current-induced can not be concluded.

Yes, it is said that both processes are involved: lines 17-18, 190-191, 258-259.

…the annual cycle of SST …is using (NOAA oi) interpolation to replace cloudy days and could be the source of the problem. … the SODA-3 and NOAA SST trend at the coast will be slave to the wind… The reanalysis are not reliable for trend analysis as shown by Nkwinkwa N, et al. 'Latent Heat Flux in the Agulhas Current' Remote Sensing…

Author uses the best available products, based on data assimilation and past ability to predict the climate of southern Africa. The author is confident that reported trends are robust, and avoids products with poor validation.

…Dieppois et al, 2016, 2019 has shown that CMIP5 coupled model do not represent… the EC20C reanalyses is also questionable … decadal variability exists (eg. Pohl et al 2019).

Yes, it is said that long-term and multi-decadal trends may be additive: line 213.

…there is little chance that the desiccation is linked to a change in the moisture flux… the author shows that the offshore Agulhas SST and associated latent heat flux have increased. This should bring more moisture to the coast when the wind is onshore…

Author shows that the wind is more offshore and upwelling favourable in Fig 3a, so this criticism seems unsupported. New rainfall hovmoller (Fig 4c) displays a sharp boundary between dry inshore / wet offshore climates.

Although much of reviewer#2 criticism seems unwarranted, there are some good points, so the author added the relevant references, and narrowed the scope of research questions: lines 50-54.

Author re-wrote the hydrology–salinity connection: lines 215+.

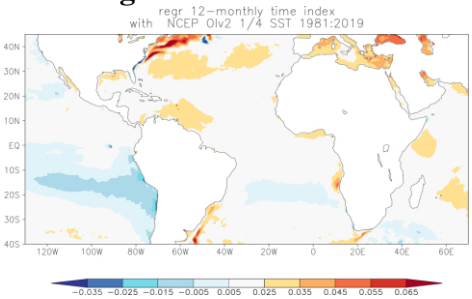
Throughout the text, statements that said 'the Agulhas Current is accelerating' were modified to say 'locally' eg. on the shelf-edge between 21-28E as shown in Fig 2c. On line 272 – 'Our analysis does not claim the whole Agulhas Current is strengthening, only along the shelf-edge of the eastern Agulhas Bank.'

Reviewer#3

General comments: The topic is of interest, and the authors do a good job considering

many data sources, and doing their best to integrate these pieces together. However, the paper could be introduced better, and some revisions are necessary particularly addressing the possible strengthening of the Agulhas Current.
My major points of revision on the paper regard three issues:
1) There is not very much information on how well these reanalyses simulate the region, particularly the velocity field. Does SODA-3 really simulate the real ocean well enough that we can trust a trend of -0.006 m s-1 y-1? I am doubtful, with the information given, but maybe you can convince the reader otherwise. **See note below**
2) You discuss at various points a strengthening or acceleration of the Agulhas Current. **The author will upload a powerpoint in supplementary data, which was used for training of oceanography staff in Port Elizabeth in Aug 2019 on coupled global data assimilation. That makes clear most data inflow is near the surface and models interpolate in space and extrapolate in depth. In that file and in two companion papers which have published recently, some attributes of ocean reanalysis are compared with insitu observations. It seems arbitrary to take a small portion of data going into the reanalysis as verification, when vast amounts of satellite data are used together with smart ocean models which are coupled with the atmosphere and land.** However, you only compute averages and show figures for the near surface (example: Fig 4c shows top 50 m). A stronger velocity in the upper 50 m does not necessarily imply the Agulhas Current as a whole has strengthen. There could be compensating changes at depth. Please compute trends in Sv yr-1, and state along with your trends in upper ocean m s-1 yr-1 so that the reader can assess whether you are truly seeing a strengthening current. 2) The observational paper which assesses a possible trend in the Agulhas Current volume transport finds no strengthening since 1993, and instead a broadening of the current (Beal & Elipot, 2016). While you do briefly mention this at line 270-273, there is no comparison to your results. Why do you suspect your results are different? **The author does not analyze the total volume transport, but the upper layer that is better observed.** Is it due to deficiencies in SODA3? Or due to the specific end years in Beal & Elipot, 2016, or some other methodological difference? If you compute a trend in Sv/yr, over the full depth of the Agulhas Current, over the same time period as Beal & Elipot, what do you get? I also think it would be useful to cite and discuss this paper earlier, possibly either in the introduction or in the paragraph starting at line 166. Specific comments: Introduction: A stronger introduction that addresses why the reader should care would be helpful. i.e., fishing industry, weather impacts, climate feedbacks, etc. due to any changes in the region. Line 39: The Agulhas Current meanders a mean of 1.6 times per year, add citation to Elipot & Beal (2015) Line 80: Citation or figure to show this? Line 82: Please give some description of what "transient EOF" is and how this varies from a general EOF **That was re-written to say it is the EOF evolution at lags -2 to +2 days**. Line 94-96: It would be helpful if you illustrated these regions on one of your maps, perhaps in Figure 1. Line 112: illustrating the regions on a map would help **A figure is now cited.**
Line 160: Please state value from Rouault (2010) **both the + offshore and – inshore SST trends are similar to the earlier findings, it depends on location and would be cumbersome to paraphrase.**
Line 164-165: Do you think this is real? Or are you saying it is an artifact of SODA3

that may not exist in the real ocean? **Yes it is one of the few features that the author does not have full confidence.**
Line 191: Elipot & Beal (2018) is another useful point of comparison
Line 196: Need to make it clear you are only looking at velocity trends of upper 50 m. This is not necessarily equivalent to an acceleration of the full depth Agulhas Current. **Yes that is now said, acceleration is confined in depth and in breadth (eg. localized and not necessarily up- and down-stream)**
Line 214: Not sure what you mean by "Long-term trend and multi-decadal trends are acknowledged to be additive here". Perhaps you need to explain in more detail **That statement was re-written.**
Line 219: State value, even if it is not different from zero considering the error
Line 258-261: I am not sure what these two sentences mean. What is the technology which is reaching consensus? **Reanalysis is reaching consensus based on a shared data assimilation system – as now stated.**
Line 262: Please show this global analysis in a figure. **Author believes this will be distracting, this SST trend maps is shown below. The coastal upwelling regions are small in global context.**



Line 272-273: You may want to cite two recent papers presenting data from the ASCA array: McMonigal et al. (2020) JPO, doi: 10.1175/JPO-D-20-0018.1, Gunn et al. (2020) accepted to JPO, no doi yet.
Line 292-295: It is not clear to me how fisheries would benefit from these changes, besides the increased upwelling. But I am not sure what a faster Agulhas Current, drier weather, or increased easterly winds would do to marine productivity. Please describe and/or cite papers. **A companion paper is cited therein. Jury, M.R., 2019, Environmental controls on marine productivity near Cape St Francis, South Africa, Ocean Science, 15, 1579–1592. ocean-sci.net/15/1579/2019/ However, it is noted that increased chlorophyll content relates to fresh intrusions, hence not a drier climate, so that was re-written.**
Line 302: I strongly suggest that you do more comparison of the reanalysis and observational trends within this paper. It does not need to be extensive, but compare your trends to those from previous observational papers and explain why they agree (or why they disagree). **Intercomparisons were added as appendix Figs A1, A2, and have been done in parallel research, that is referenced: Jury, M.R. and Goschen, W., 2020, Inter-relationships between physical ocean-atmosphere variables over the shelf south of South Africa from reanalysis products, Cont. Shelf Research, 202, doi.org/10.1016/j.csr.2020.104135.**
Figure 2: Why are panels d,e,f only shown to 200 m depth? Is there no trend below

that? **Most observations and ocean influence on climate is from the surface layer, and satellite altimetry is extrapolated with depth. Fig 2e shows that trends over the shelf are relatively uniform with depth.**
Figure 3: very unclear that panel c is actually 5 panels.Maybe relabel so it is clear what c refers to **OK, that was revised.**
Figure 4: Please include a trend in in Sv yr-1, integrated over full depth, as well as in m s-1 yr-1 in upper 50 m. Otherwise, it is conceivable that your "accelerating" Agulhas is simply more surface intensified, but not actually strengthening. **The paper was re-written to indicate that strengthening is localized, and that trends are partially related to inshore upwelling (cf. Fig 2d).**
Figure A1: What are the solid and dashed lines? **That was re-analyzed.**
Citations: Elipot, S., & Beal, L. M. (2015). Characteristics, Energetics, and Origins of Agulhas Current Meanders and Their Limited Influence on Ring Shedding. Journal of Physical Oceanography, 45(9), 2294–2314. **OK, that reference was added.**
Elipot, S., & Beal, L. M. (2018). Observed Agulhas Current sensitivity to interannual and long-term trend atmospheric forcings. Journal of Climate, JCLI-D-17-0597.1.

Technical corrections: Line 97: "reduction to" should be "reduction of". Also unsure what "(Dec-Feb) interval" means. **No, the correct meaning is 'to', but the term 'interval' was misleading and fixed.**
Line 148: "accelerating 1900-2010" should be "accelerating over 1900-2010" **OK.**
Line 282: "SST : : : IS warming" **OK.**
Figure 4c caption: Do you mean meridional current? The Agulhas Current is (mostly) oriented southwards **No, in the study area the Agulhas Current is mostly westward.**