

Interactive comment on “Marine climate change over the eastern Agulhas Bank of South Africa” by Mark R. Jury

Anonymous Referee #2

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I recommend against publication of this paper in the present form. The author want to solve too many questions at once which lead to serious shortcut. The narrative is interesting although the style is too telegraphic, but hypothesis are not substantiated properly and there are serious problem in the papers, the data used and the figure presented by the author do not substantiate the hypothesis and sometimes contradict his own narrative. There are a lot of problem when one look deeper in each of the issues, each of the figures or when one study the bibliography of the various topics or regional feature in details, many having been omitted. Many important papers are not cited or cited for the wrong reason or not cited for the main results. The overarching problem is that the author is trying to solve too many complex problems using web sites only which limit his ability to in depth analysis and. He is using a great number of

C1

satellite data, model or reanalysis which are not validated for trends especially as such a small regional scale. To do a proper job would need far more figures and a complete state of the art bibliography as well as calculation not permitted by web site. I will now go to four or five major issues raised by the paper and I suggest 3 possible papers with more in depth study and analysis and up to date bibliography especially that the authors conclude by giving a future scenario for the relatively small region he study and this has serious social economical consequence id one would follow Jury scenario for the future.

The first issues is that the warming in the Agulhas Current and coastal cooling in the Port Elizabeth Port Alfred region as well as the possible causes, namely the intensification of the Agulhas Current has been already presented by Rouault et al. (2009) paper but Rouault (2010) a follow up paper is cited by Jury. To validate Rouault et al (2009, 2010) and Jury hypothesis would be a valuable contribution, but one would need to go a bit further. However, the main concern is that Rouault et al. (2009) and therefore Jury paper hypothesis had been seriously challenged and contradicted by many authors. Biastoch et al 2009 who made the cover page of Nature with his story made the hypothesis that the current is slowing down since the 80's , not accelerating. Beal et al. in another Nature paper has claimed that the Current is widening and not intensifying. It would be interesting to follow on Beal approach using Beal, a long time series of the transport of the Agulhas Current to look at Jury hypothesis and validate the model he is using. Model are notoriously bad when it comes to reproduces the basic annual cycle of the Agulhas Current (Hutchinson et al, 2018) never mind Interannual variability, decadal variability or trend. Most of those studies use the Agulhas transport and not the speed. That can be calculated with model and observation and Jury should also calculate the transport of his model. Other papers have put together that the warming is due to stronger Westerly to the South (Durgadoo et al; Loveday et al). Anyway, it could be that the cooling inshore is due to the intensification of the upwelling dynamic created by the Agulhas Currents as stated by the authors and Rouault et al (2010) but there are a lots of problem in Jury paper regarding the increased upwelling due to in-

C2

crease wind. A major problem in the paper is that the dynamic upwelling created by the Agulhas Current is not found in Algoa Bay as Jury claim but in the Port Alfred upwelling further East and the dynamic is much more complex that described here, hence a paper more focused on that issue with the proper dynamic is needed. . Another problem is that is more the meandering of the Current that its speed that is creating this sporadic upwelling which would give credence to Beal hypothesis of a more meandering and turbulent Agulhas Current.

Rouault, M., Penven, P. and Pohl, B., 2009. Warming in the Agulhas Current system since the 1980's. *Geophysical Research Letters*, 36(12).

Biastoch, A., Böning, C.W., Schwarzkopf, F.U. and Lutjeharms, J.R.E., 2009. Increase in Agulhas leakage due to poleward shift of Southern Hemisphere westerlies. *Nature*, 462(7272), pp.495-498.

Beal, Lisa M., and Shane Elipot. "Broadening not strengthening of the Agulhas Current since the early 1990s." *Nature* 540, no. 7634 (2016): 570-573.

Durgadoo, J.V., Loveday, B.R., Reason, C.J., Penven, P. and Biastoch, A., 2013. Agulhas leakage predominantly responds to the Southern Hemisphere westerlies. *Journal of Physical Oceanography*, 43(10), pp.2113-2131.

K Hutchinson, LM Beal, P Penven, I Anson, J Hermes 2018 Seasonal Phasing of Agulhas Current Transport Tied to a Baroclinic Adjustment of Near-Field Winds *Journal of Geophysical Research: Oceans* 123 (10), 7067-7083

Concerning the wind driven coastal upwelling and potential cooling is the second serious issues. That region is not a typical upwelling region such as the South Benguela to the West or other Eastern boundary currents. In fact the plot shown by the author (Figure A1 and A2) show that the easterly component upwelling favourable is very weak and very seasonal and the wind is not upwelling favourable all year long. Its seasonal trend does not correspond to the seasonal trend in SST shown at the coast by Jury.

C3

Moreover, the annual cycle of SST shown by Jury show warmer water in early summer when the easterly upwelling favourable is stronger and stronger trend when the (weak) upwelling season is over. This does not seem to indicate upwelling as a major driver of SST there or this indicate a serious problem in the data. The SST used is using interpolation to replace missing data and could be the source of the problem. Another problem is the SST used is an operational problem that has not been reanalysed and the methods used to produce the SST have changed leading to potential problem in trend detection. The data is using AVHRR data, a product that does not see through clouds too. In any case the trend in SST shown by Jury or Rouault (2009, 2010) is stronger in austral fall when the wind is weak or westerly and not upwelling favourable. This contradiction can be found in the Figure presented by Jury. This still leave the possible intensification of the Agulhas Current as a driver of the coastal SST, but the warming of the Agulhas Current warming is all year long and the costal trend is seasonal.

Another related issue is that the model trend at the coast will be slave to the wind trend so will not prove that it has happened. Reanalysis are also model based and have serious biased in the region. Reanalysis are not reliable for trend analysis as they ingest new product at different time leading to spurious trends. Many papers are talking about this issue especially valid at the regional scale. Jury claim that ERA Interim is a good product but Imbol Nkwinka et al have shown that it is the worst product in the region even at the seasonal climatological scale as far as surface wind and latent heat flux is concerned. So how can product who have issues at the climatological scale can be trusted for trend. Moreover, the so-called validation paper cited by Jury are not done in the region there are some serious different between latent heat flux product. A proper study would follow on Imbol Nkwinkwa et al approach of using all available reanalyses and satellite product in the region to study, validate or compare at interannual, decadal and trend of surface wind and latent heat flux in the region in the region. If the model trend has a spurious easterly trend then the model will have a spurious cool anomaly at the coast, but it would not mean the trend is real. In fact

C4

figure A1 show that the wind reanalysis is quite different from observation by a factor of two. Figure A2 show that most of the year the wind is not upwelling favourable and that water is warmer in Summer than in winter, following the annual cycle of radiation rather than being cooled by the easterly wind. This seriously questions the paper findings. It is a very complex issue. Contrary also to what the author write in the paper the ERA interim wind is the less reliable surface wind along the coast of South Africa by and seriously underestimate the mean annual cycle of wind speed. Note that the Agulhas Current is not forced by local wind so the local increase in wind speed cannot be responsible for the change in current but could generate more upwelling. This should be investigated and debated a depth. This would show that the dataset used were not handpicked to justify the narrative but that all venue were explored given the uncertainty in using ocean model and reanalysis or coupled model at the regional scale

Imbol Nkwinkwa N, A S, M, and J A. Johannessen. "Latent Heat Flux in the Agulhas Current." *Remote Sensing* 11, no. 13 (2019): 1576.

Up to date bibliography needs to be done as most recent relevant work on the problem of coupled model in the region. Dieppois et al, 2016, 2019 has shown that CMIP5 coupled model do not represent winter rainfall at all and do not represent the impact of ENSO on the region and the region was the all Southern Africa a domain 100 time larger than Jury domain study. Validity of 20 century reanalyses is also questionable and probably only model driven in the South Hemisphere. Moreover the Agulhas Current is not represented in CMIP5 coupled model. So all results concerning coupled model, global arming scenario and trend are very questionable in view of the large literature showing the problem of coupled model to represent regional climate properly, even ENSO. Dieppois et al, 2016, 2019 has also shown that decadal variability does exist in the region with a 10 to 12-year cycle and another 20 25 cycle linked to the Pacific and that those cycle not represented in Coupled model. In fact it could well be that the trends presented by the author is linked to the decadal variability of climate and not

C5

linked to global warming. IT seems that the trend in the Agulhas Current is weakest that it was 10 years ago which means that the trends is reversing. One would need to look at annual and seasonal mean and find out if the trend is really linear as it is more or less for global warming temperature or if it is just part of natural decadal variability As for the coupled model due to their low resolution and their problem to represent interannual variability, the effect of ENSO or decadal variability of Southern Africa climate, they cannot be used here. Unless they are validated. Paper exists showing those problems (work done by Dieppois et al, 2015, 2019, Pohl et al 2019). All in all it is very important to find out if the trend is linked to global warming trend and could carry on in the future or it is just part of natural variability. This is another paper by itself.

Another concern is that El Nino leads to weaker upwelling in the region and drought while La Nina leads to colder coastal water and more rainfall inland. This is the opposite effect as the effect proposed at the decadal scale or trends scale by Jury. This leads to a very serious concern. Why does the reduction in SST in Algoa Bay leads to the desiccation of the inland region, coastal water is not warm enough to lead to convection with potential advection of rainfall inland? However since the wind trend shown is easterly and not Southerly there is little chance that the desiccation is linked to a change in the moisture flux due to a cooled Algoa Bay. A stronger wind will lead to more evaporation too. Also the figure of satellite estimate of vegetation temperature change is not convincing as many areas have not changes and some remote region seems to be drier. Once again the dataset is using different instruments and maybe unreliable for trend analysis and it was not reanalysed for that matter. This product should be validated interannually first. A proper demonstration would involve looking the transport of moisture inland but also the generation of rainfall in more details. 100 of rainfall station are available in the region, why not used them. River data is not reliable and human abstraction can lead to decrease in the flow of those sporadic and small rivers. The Kruger paper cited regarding trend in rainfall do not show any trend in rainfall. The trend in wind speed is easterly not northerly so how does it work. What are the mechanism linking relatively cold water to rainfall inland? Where are not in a

C6

monsoon region and only when water is $> 15^{\circ}\text{C}$ that we find an effect of sea surface temperature on rainfall. It is not even clear why the coastal ocean and Algoa bay is a driver of rainfall in the region, a region where rainfall is brought about by large scale rainfall system such as huge cyclonic system such cold front, cut off low, tropical temperate trough or inland low pressure system that create mainly a offshore and not an onshore flow. Again more need to be done to proof that hypothesis. Moreover the increase in latent heat flux on the nearby Agulhas Current should largely compensate for the small loss in latent heat flux at the coast. Latent heat flux in Western Boundary current is 3 to 5-time higher than surrounding water and Jury is presenting a very strong trend in latent heat flux nearby. If Jury hypothesis is correct, this should be presented in another paper.. Correlation is not causality. Also, the author shows that the Agulhas Temperature and associated latent heat flux have substantially increase. This should bring more moisture to the coast when the wind is onshore, and this could compensate largely for the inshore cooling. This is not investigated or discussed at all in the paper. This probably the weakest point of the paper and I recommend the author to make a third paper in the issue as it could be independent of the rest.

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