I want to thank Anonymous Referee #1 for their comments. They are greatly appreciated and will help improve the manuscript.

Comment 1:

> “The manuscript is well written, but the novelty of this study is unclear. In the abstract, there are only two sentences about the results of the present study (L6-10). As the authors cited in the manuscript, there are many studies that examined coastal sea level variability associated with the Kuroshio and the Gulf Stream variability. Also, recent review paper (Woodworth et al. 2019) compared coastal sea level variability between the Kuroshio and the Gulf Stream regions. What are the new findings in the present study? Please more clarify this point.”

Response:

In the Pacific, the coastal sea level upstream of the Kuroshio has been shown to co-variate with, on the one hand, the location of the Kuroshio as it approaches the Izu-Ogasawara Ridge (Kuroda et al., 2010), and on the other hand, with the atmospheric regime shifts in central North Pacific (Senjyu et al., 1999). These different results have been nicely tied up together by Sasaki et al. (2014) and Yasuda and Sakurai (2006), who have argued that Rossby wave, breaking as coastally trapped wave at arrival at the western margin, bring the central Pacific signal to the coast of Japan, while modifying the latitude of the Kuroshio. Our results compliment these findings, as we show using altimetry and subsurface temperature that the main mode of sea-level variability reflects change in the Kuroshio Extension location. However, findings of Sasaki et al. (2014) were limited to 1993 – 2011, and those of Yasuda and Sakurai (2006) to the model world, whereas our results hold for 1968 – 2019 and are solely based on observations.

In the Atlantic, to the contrary—and to the best of my knowledge—no study (including the recent work of Woodworth et al. 2019) had previously associated the location of the Gulf Stream Extension with the upstream sea level. That the agreement between the upstream sea level and the meridional shifts of the extension holds in both ocean separately is a new result, and our main finding. This finding is new and of great importance for the community interested in the sea-level variability of the North Atlantic western margin, and to those interested in the Gulf Stream North Wall, while in the same time it brings further evidence to the community working on the Japanese costal sea level and/or on the Kuroshio Extension.

We understand from the comment of Anonymous Referee #1 that the novelty of the study is not straightforwardly shown in the manuscript. We have identified places where the manuscript could be modified (abstract, introduction, conclusion) to present more accurately than at present what has been summarised in the two above paragraphs. An improved version of the manuscript will be presented in the final response.

Comment 2:

> “As the authors pointed out in section 3.2.1, the sea surface velocity changes associated with the first EOF mode in the upstream region of the separation point is different between the North Atlantic and North Atlantic (L341-349). The Kuroshio was shifted on-shoreward, but the Gulf Stream was shifted off-shoreward in the positive phase of the first EOF mode (Fig. 5), although the corresponding costal sea level anomalies are positive. However, the detailed difference has not been discussed in the manuscript. It is interesting to compare the sea level change in the across-shore direction between the two regions.”

Response:

Indeed, the upstream patterns of sea surface velocity are different in each basin. If significant, this discrepancy could be due to different interactions in each basin between the upstream jet and the bathymetry. It suggests that some more involved mechanisms than a pure Kelvin wave are at work. Across-jet analysis of the sea surface height (SSH) variability is feasible for the region southeast of Japan, because, there, the lateral shifts of the jet are large (Figure 5.a of the manuscript). Figure 1 below shows such analysis, where the 138.875°E was used. Agreement between the leading principal component of the tide-gauge obtained sea-level anomaly and the meridional shifts of the Kuroshio at 138.875°E is visible. Overall this analysis produces the same results than the sea surface velocity (SSV) analysis presented in the manuscript, and no different conclusion can be made.

For the upstream Atlantic situation, an across-jet SSH analysis does not produce satisfactory results and is hence not shown. Comparatively to southeast Japan, where the change of path of the Kuroshio produces large SSV change (Figure 5.a of the manuscript), SSV changes across the Florida Current are small and have small zonal extent (see Figure 5.b of the manuscript), which largely complicates an across-jet analysis. Nonetheless, that the Florida Current shifts off-shoreward in the positive phase of the first EOF mode is not impossible. A similar situation is seen in the Pacific, southeast of Kyūshū (Figure 5.a of the manuscript). Indeed, when the Kuroshio shifts off-shoreward at 138.875°E, it moves in-shoreward southeast of Kyūshū (See Figure 2 below). The upstream situation in the Atlantic hence doesn't necessarily conflicts with the patterns seen in the Pacific. In any case, and most importantly, conclusions drawn from SSH analysis, as those obtained with SSV analysis, are only valid from 1993 onwards due to the altimetry data availability. Contrarily to the region of the Gulf Stream and Kuroshio extensions, we cannot validate altimetry obtained results for the upstream Gulf Stream and Kuroshio with subsurface temperature indices extending further back in time. Hence, this topic was not developed furthermore in the manuscript.

We understand from the comment of Anonymous Referee #1 that a more developed discussion on the behaviour of the upstream jet would be beneficial to the paper. While I agree with Anonymous Referee #1, I must also admit that what we can bring to the discussion is limited, because the altimetry results for the upstream situation cannot be cross-validated with subsurface temperature (at least, not with the data we have produced). A detailed investigation of the difference between the two upstream situation (Pacific and Atlantic) and of the involved mechanisms is beyond the scope of this work. Nonetheless, any changes to the manuscript will be presented in the final response. Any advices on this very interesting subject are welcome.

Again, I want to thank Anonymous Referee #1 for their comments.

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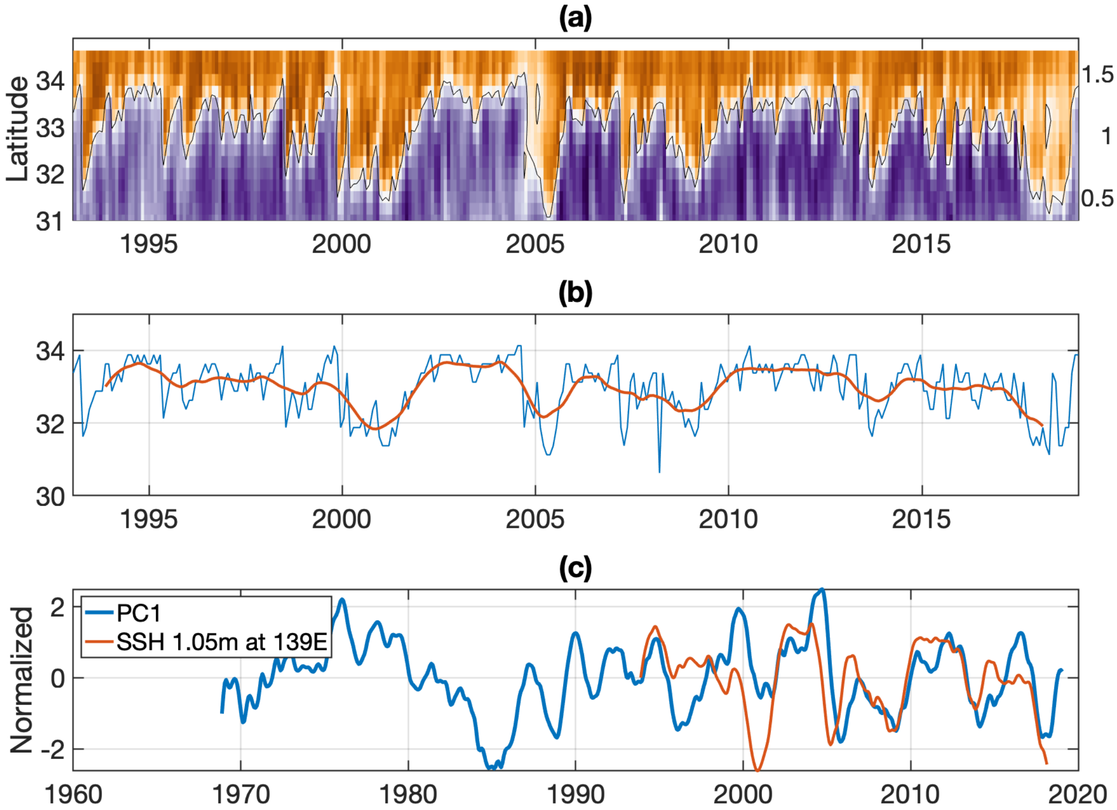

Figure 1: Change in SSH in the across-jet direction at 138.875°E (South of Japan, just west of the Izu-Ogasawara Ridge). (a) Hovmöller diagram of change in SSH along the 138.875°E. The thin black line represents the 1.05-meter iso-SSH. (b) Variations in time of the 1.05-meter iso-SSH at 138.875°E (blue), and same quantity after 19-month filtering (red). (c) The filtered 1.05-meter iso-SSH at 138.875°E (red) next to the leading principal component of tide-gauge obtained sea-level anomaly (blue). The 138.875°E longitude is close enough to the ridge for the SSH variability to be only weakly affected by occurrence of the typical Large Meander—atypical meandering (straddling the ridge) is however apparent in 2000 – 2001, and explains the disagreement with the leading principal component of the sea-level anomaly then (Panel c).

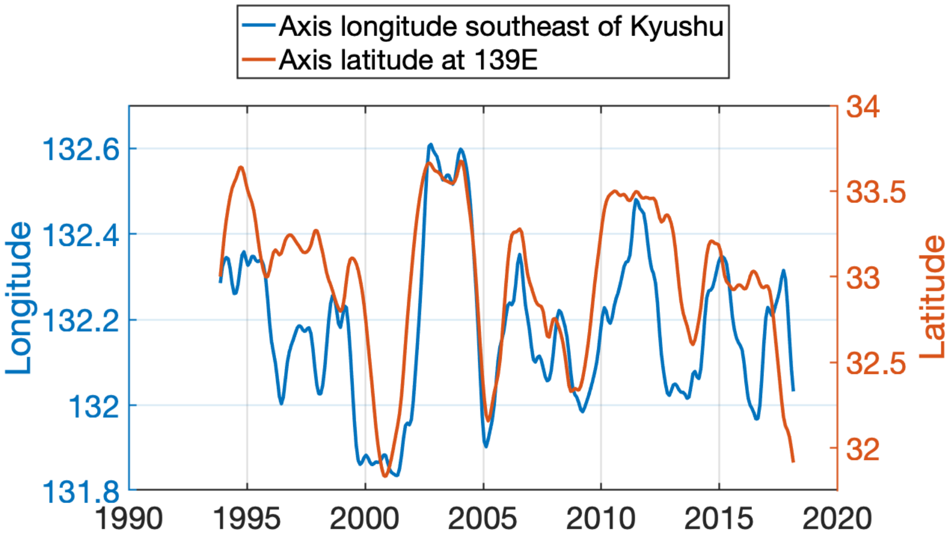

Figure 2: Path change of the axis of the Kuroshio at 138.875°E (red) and at 30.875°N, that is, southeast of Kyūshū (blue). The axis is defined as the 1.05-meter iso-SSH at 138.875°E, and as the 1.15-meter iso-SSH at 30.875°N.

References

Kuroda, H., Shimizu, M., & Setou, T. (2010). Interannual variability of subsurface temperature in summer induced by the Kuroshio over Bungo Channel, Tosa Bay, and Kii Channel, south of Japan. Continental Shelf Research, 30(2), 152-162.

Sasaki, Y. N., Minobe, S., & Miura, Y. (2014). Decadal sea-level variability along the coast of Japan in response to ocean circulation changes. Journal of Geophysical Research: Oceans, 119(1), 266-275.

Senjyu, T., Matsuyama, M., & Matsubara, N. (1999). Interannual and decadal sea-level variations along the Japanese coast. Journal of Oceanography, 55(5), 619-633.

Woodworth, P. L., Melet, A., Marcos, M., Ray, R. D., Wöppelmann, G., Sasaki, Y. N., ... & Merrifield, M. A. (2019). Forcing factors affecting sea level changes at the coast. Surveys in Geophysics, 40(6), 1351-1397.

Yasuda, T., & Sakurai, K. (2006). Interdecadal variability of the sea surface height around Japan. Geophysical research letters, 33(1).