Response to Reviewer 1

This study examines the impact of local and remote wind forcing on interannual sea surface height (SSH) variability in the south Indian Ocean, based on numerical experiments with an ocean general circulation model (OGCM). Many past studies worked on this issue using a 1.5-layer, reduced gravity long Rossby wave model that possibly suffers adopted approximations. The current study uses an OGCM and has an advantage over past studies. It is potentially worth publication, but I have a question about the setting of numerical experiments. This and other comments are listed below. I recommend major revision.

We would like to thank the reviewer for the constructive and helpful remarks. We have tried addressing them all and we hope that the revised version of the manuscript has been improved. Below we detail the changes we have made to the manuscript, addressing point by point all the issues raised in the review. The comments from the reviewer are shown in bold, while our responses are interspersed between the comments in non-bold text. Changes made to the manuscript are finally listed in italic, whereby page and line numbers indicated in our responses correspond to the new version of the manuscript.

Major comment

1) In the ITF-off experiment, the Indonesian archipelago is blocked by land. This eliminates propagation of oceanic waves from the Pacific to the Indian Ocean, but possibly allows wave propagation from the equatorial Indian Ocean to the west Australian coast along the eastern boundary. This route is unrealistic, because waves in the equatorial Indian Ocean intrude into the Indonesian Seas (Durland and Qiu 2003; Syamsudin and Kaneko 2004) and leak out of the basin (Wijffels and Meyers 2004) if the topography is realistic (i.e., there is an opening in the Indonesian archipelago). ENSO excites zonal wind variability in the equatorial Indian Ocean via changes in the Walker circulation (e.g., Xie et al. 2002), which excites equatorial waves (e.g., Chambers et al. 1999; Feng and Meyers 2003). These waves might propagate to the west Australian coast in the ITF-off experiment. Thus, I wonder if ENSO impacts SSH variability along the west Australian coast through zonal wind variability in the equatorial Indian Ocean in the ITF-off experiment, which is an artificial process owing to the experimental setting and does not happen in observations. Please check this possibility and add discussions to the manuscript.

We thank the reviewer for bringing this important and likely issue to our attention. As the reviewer reasonably noted, the closure of the Indonesian throughflow in the ITF-off experiment could have generated an artificial waveguide allowing long waves originating in the equatorial Indian Ocean to propagate all the way to the west Australian coast. In the revised version of the manuscript, we used the daily SSH output to investigate the wave propagation in both the ITF-on and the ITF-off experiments. We established that in both experiments there is a discontinuity in the propagation of coastal trapped waves along the Maritime continent and the northwest-west Australia coasts. Specifically, the waves originating in the equatorial region apparently dissipate in the internal Indonesian seas before reaching the southern coast of Timor island. Coastal trapped waves are also found along the northwest and west Australia coast, but no relation between these waves and the waves along the Maritime continent was found. We have added some discussion about this analysis along with a figure to the revised version of the manuscript.

l. 250-276; p. 8-9: "ENSO excites zonal wind variability in the equatorial Indian Ocean via changes in the Walker circulation (e.g., Xie et al. 2002), which generates equatorial Kelvin waves (e.g., Chambers et al. 1999; Feng and Meyers 2003). These waves can eventually get trapped along the Indonesian coast and partly propagate southward. The coastal trapped waves intrude into the Indonesian seas through passages between the islands (Molcard et al., 1996; Durland and Qiu 2003; Syamsudin and Kaneko, 2004; Pujiana et al., 2013; Pujiana and McPhaden, 2020) and then penetrate the Western Pacific (Wijffels and Meyers 2004; Yuan et al., 2018) without significantly affecting the dynamics along the Australian coast. In the ITF-off experiment, an artificial wall was placed to close the Indonesian passages and the Torres Strait. Theoretically, such a wall may permit waves originated in the eastern equatorial Indian Ocean to follow the artificial coastline, pass through the Indonesian Archipelago, and reach the western coast of Australia. If this is the case, then closing the ITF would generate spurious variability in the ESIO.

To verify this possibility, we carried out a cross-correlation analysis of the daily low-pass filtered (with a cutoff period of 1 year) SLA output at a number of locations along Indonesian and Australian coastlines in both the ITF-on and the ITF-off experiment (Figure 3). Apparent signal propagation is observed between Points 1 and 4, but not traceable in the Timor Passage (Point 5) and further east, indicating that the incoming Indian Ocean Kelvin wave energy transmits southeastward along the southern coasts of Sumatra, Java and Nusa Tenggara, with part of the energy making its way into Makassar Strait. Most coastal trapped wave energy appears to leak and dissipate in the internal Indonesian seas. Both experiments exhibit similar cross-correlation functions with maximum values at the same time lags for Points 1-4 (Figure 3 b,c). It takes about 10 days for the signal to propagate from the equator to Point 4 (the distance of approximately 2500 km), which yields the wave phase speed of about 3 m s^{-1}. Further east at Points 5-7, the cross-correlations do not suggest a continued wave propagation (Figure 3b,c). The propagation of coastal trapped waves is also observed along the northwestern and western Australian coast (Figure 3a). The lagged correlations are observed between Points 8 and 12, and the high-frequency SLA variability at these points is uncorrelated with the high-frequency SLA variability in the Torres Strait at Point 7 (Figure 3d,e). In both experiments, it takes about 7 days for a coastal trapped wave to propagate approximately 5000 km from Point 8 to Point 12, which yields the phase speed of about 5 m s^{-1}. Overall, coastal trapped waves appear to propagate and dissipate similarly in both the ITF-on and the ITF-off experiments, meaning that the artificial wall created in the ITF-off experiment is unlikely to generate spurious variability in the ESIO."

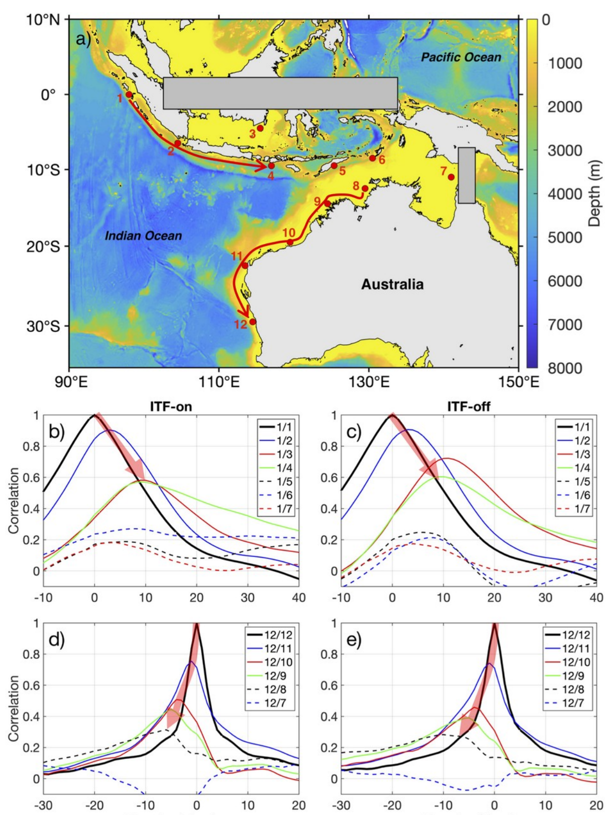

Figure 3: (a) Bottom topography in the ESIO and the locations (1 to 12) used for cross-correlation analysis. Cross-correlation functions between the daily SLA in (b,d) the ITF-on and (c,e) the ITF-off simulations. The locations 1 and 12 are used as reference points to detect waves propagating along the Maritime continent from 1 to 7 (b, c) and along the west

Australian coast from 7 to 12 (d, e). The red shaded arrows connect the peaks of cross-correlation functions associated with coastal trapped waves.

2) As is stated in the manuscript, winds along the Australian coast explain only 11 or 15% of local SSH variability (Line 311-313 and 446-448). This low ratio can be visually confirmed by the discrepancy between solid and dashed lines in Figs. 6c and 6d. The authors do not discuss what explains the remaining variability. I suggest more analysis should be carried out to specify the cause of SSH variability along the west coast of Australia in the ITF-off experiment. As is mentioned in the previous comment, there can be an unrealistic process in the ITF-off experiment.

We are thankful for this remark, to address this point we have added some discussion about the physical processes potentially causing the remaining variability.

l. 365-367; p.12: "The remaining variability can be explained by instabilities of the LC generating mesoscale eddies in the area and coastal trapped waves originating along the northwest coast of Australia (e.g., Zheng et al., 2018)."

A detailed quantification linking these different forcings with the observed variability would go, however, beyond the scope of the paper. As noted in our response to the previous comment, the possibility of an unrealistic wave propagation from the equatorial region towards the west Australia coast in the ITF-off experiment can be rejected (l. 250-276; p. 8-9).

3) In the current study, SSH variability in the ITF-off experiment is attributed to the effect of the atmospheric bridge. However, the authors do not describe how the atmospheric bridge causes wind variability near the west coast of Australia, but guessed its effect from results of the ITF-off experiment. I suggest that they should conduct additional analysis (such as a correlation analysis between an ENSO index and atmospheric pressure and winds near Australia) and discuss how ENSO impacts surface winds near Australia.

The relationship between ENSO and wind forcing in the SIO was described in Volkov et al. (2020). In the revised version of the manuscript, we also included a regression of wind forcing on ENSO in the eastern SIO.

l.350-354; p.11: "As follows from the regression of wind and Ekman pumping anomalies on MEI (Figure 7a), El Niño events (i.e., positive MEI) are associated with weaker trade winds in the SIO and easterly wind anomalies along the equator. This atmospheric circulation pattern favors a negative (into the ocean) Ekman pumping anomaly along the western Australian coast, resulting in upper-ocean warming. The opposite occurs during La Niña events (i.e., negative MEI)."

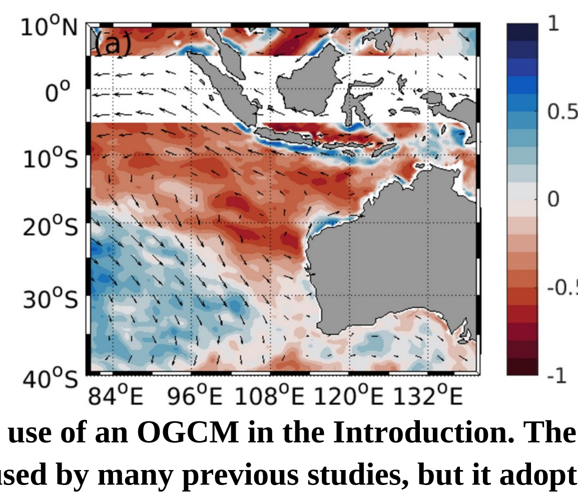

Figure 7a: Regression of Ekman pumping (color shading) and wind stress (arrows) on MEI, expressed in meters per month per 1 standard deviation change of the index. Negative (positive) Ekman pumping anomalies associated with the upper-ocean warming (cooling) are shown by red (blue) color.

4) It may be better to mention the advantage of the use of an OGCM in the Introduction. The 1.5-layer, reduced gravity, long wave model has been used by many previous studies, but it adopts many assumptions and arbitrary parameters. OGCMs cover a far wider range of dynamics in

comparison to the 1.5-layer model. The uniqueness of the current study will be further clarified by mentioning this.

We thank the reviewer for pointing this out. We have added a sentence highlighting the advantage of using a GCM in the Introduction.

l.114-119; p. 4: "*Previous studies of sea level variability in the SIO were mainly based on simple linear models (e.g., Zhuang et al., 2013; Jin et al., 2018; Menezes and Vianna, 2019; Volkov et al., 2020; Nagura and McPhaden, 2021). Although these models contain the essential dynamics capable of explaining the majority of the observed sea level variations, they adopt some assumptions and arbitrary parameters. Here, we aim to further investigate this topic using an ocean general circulation model that contains the full range of oceanic dynamical processes responsible for sea level variability.*"

Minor comments

5) I am not sure what "with a gap from October 2008 to August 2009" at Line 220 means. There is a gap in mooring observations between 2011 and 2013 in Fig. 2b (magenta line), but no gap in 2008 and 2009.

Thanks for catching that typo. You are right, we included the correct dates for the gap in the observations.

l. 238-239; p. 8: "Over the period of 2004-2017 with a gap from August 2011 to August 2013, the observed and simulated mean ITF transports are -12.5 Sv and -11.6 Sv (minus sign indicates southward transport), respectively."

6) I suggest that "remote forcing at mid-latitudes" at Line 259 should be replaced with "remote forcing", because remote forcing is not located at mid latitudes. ("Remote forcing" mainly refers to wind forcing in the tropical Pacific Ocean in this study, which is located at the near-equatorial regions in the Pacific Ocean.)

Fixed as suggested (l. 304; p.10).

7) I suggest that discussions presented at Line 409-417 should be moved to the Introduction. This paragraph summarizes results of past studies and does not mention results obtained in the current study.

Good point. We moved this paragraph to the Introduction (l. 51-59; p.2).