Author Comments 1 on "Spatial and temporal variability of solar penetration depths in the Bay of Bengal and its impact on SST during the summer monsoon"

We would like to thank Reviewer 1 who provided constructive comments and interesting questions that have improved the revised manuscript. Reviewer 1's comments have been reproduced in black with the authors response in blue and excerpts from the revised manuscript in italics. The revised and renumbered figures are included at the end of the document.

Response to Reviewer 1

Specific comments and technical corrections

1. Paragraph 105: the scale depth, h_2, is not previously defined as h_2 in the introduction.
   Thank you for spotting this. We have now introduced the scale depth (h_2) in the preceding paragraph.

   Line 107: *"...allowing us to determine the downward penetration of solar radiation, as represented by the length scale associated with the absorption of blue light, which is represented by the parameter h_2."*

2. Paragraph 145: can it be assumed that the shipboard CTD fluorescence sensor was itself calibrated to in situ bottle samples?
   The shipboard CTD fluorescence sensor was not calibrated to in situ bottle samples, and so is not mentioned in the methodology.

3. Paragraph 220: are these uncertainties of the scale depth linearly related? And are they quoted later in the text?
   The individual source uncertainties that produce the overall uncertainty in h_2 are not linearly related. They are shown as error bars on Figs. 3 to 9 but are not quoted in the text. We have now added the uncertainties of h_2 throughout the text in Section 3. We have better explained the method of h_2 uncertainty.

   Line 228: *"We combine the maximum and minimum values of each source of uncertainty to calculate the upper and lower uncertainty bounds of each derived value of h_2."*

4. Paragraph 230: when averages are quoted it is nice to see standard deviations as well.
   The Reviewer is correct in suggesting that standard deviations should be supplied with average values. These have now been added throughout Section 3.1.

5. Paragraph 235: might be nice to be reminded from what values the ML is freshening and warming to, e.g. "....freshens from 34 to 33.3 g kg^{-1}".
   Thank you for your suggestion, we have reminded the reader what values the ML has freshened and warmed from and included standard deviations from the previous comment.

   Line 244: *"Within the SMC, the mixed layer warms from 28.0 to 29.0 ± 0.2 °C and freshens from 34.0 to 33.3 ± 0.1 g kg^{-1} (Fig. 3a and 3b)."*

6. Paragraph 245: "the variability of h2 is large" (add standard deviation?; Fig 4a).
   The standard deviation has now been added to give greater clarity.

Line 252: *"The temporal variability of h_2 in the SMC is large with a standard deviation of 4 m (Fig. 4a)."*

7. Paragraph 260: looking at figures 6a and 6b, it appears that the ML only deepens around the 26th July – perhaps mark on the figure the time the period you refer to. Might also be useful to the reader to mark out the barrier layer definition in the caption or on the figure again.
We have highlighted the section of the Figure we refer to in the text using solid black lines. This is now referenced in the text. The definition of the barrier layer is repeated for the reader in Figure 6 caption. Please see revised Figure and caption at the end of the document.

Line 268: "…as barrier layer thickness increases to 40 m (*area between two solid black lines*; Fig. 6a and 6b)."

8. Paragraph 260: "similar to the sub-daily variability of h2 observed from the glider in the SMC." Quote the values or reference figure 3 here.
We have reminded the reader what the variation in h_2 is for the glider.

Line 270: *"Average values of h_2 are around 16 ± 1 m, varying between 10 to 20 m, smaller than the 15 to 31 m sub-daily variability of h_2 observed from the glider in the SMC."*

9. Paragraph 265: Could abbreviate mixed layer depth to MLD here and elsewhere in the text.
We have now defined the acronym on first encounter (line 41) and thereafter abbreviated instances of mixed layer depth to MLD throughout the manuscript.

10. Paragraph 270:

10.1. The transition from describing the conditions observed by float 629 to that observed by the glider presumably is a bit confusing here. Suggest beginning the following sentence with "in contrast" or "conversely".
We agree with Reviewer 1 and have now improved the readability of this paragraph.

Line 272: *"Conversely, observations on the western side of the basin from float 629, between 8 and 11° N, show average h_2 values of 20 m compared with the average h_2 values of 16 m in the SMC from SG579 (Fig. 5a)."*

10.2 "As a result h2 is reduced" – does this imply h2 getting deeper or shallower. Suggest rephrasing for clarity.
h_2 is defined as a length scale, so it increases and decreases, not deepens or shoals.

10.3 "Sedimentary material also reduces the solar penetrative depths and increases solar absorption in the surface layers of the coastal region. As a result, h2 is reduced to the west of 83E (Fig.5b), associated with higher remotely sensed chlorophyll concentrations in this region (Fig. 5a)." – the second sentence here seems to be referring to increased nutrients from river runoff, not sedimentary material.
Thank you for pointing this out, we are sorry for the confusion. We have now clarified the last sentence.

Line 283: *"As float 629 approaches the East India continental shelf, h_2 is reduced to the west of 83°E (Fig. 5b), likely due to high chlorophyll concentrations and sedimentary material in this region as captured by satellite (Fig. 5a)."*

10.4 ..., associated with increased satellite chl-a concentrations. The previous sentence mentions sedimentation also being a factor in setting h2 depth. Suggest relooking at this paragraph for increased readability.

As mentioned in our response to 10.3 we have improved the readability of this paragraph.

10.5 Add anticyclonic eddy track to supplementary? (maybe not necessary?)
This is an interesting suggestion, but we argue that adding the track of the anticyclonic eddy to the supplementary section is not necessary and may distract the reader.

11. Paragraph 280: "Towards the end of September, the SMC influence at 89° E reduces and the current shifts to the western side of the basin (Fig. 1f), consistent with climatological observations (Webber et al., 2018)." Suggest changing to active voice: "...at 89E, the influence of the SMC *(on chl-a concentration?)* decreases and the current shifts to the western side ..."
We agree with the Reviewer's suggestion and have now changed the sentence.

    Line 288: *"Towards the end of September at 89° E, the influence of the SMC on chlorophyll concentration decreases as the SMC shifts to the western side of the basin away from float 630 (Fig. 1f), consistent with climatological observations (Webber et al., 2018)."*

12. Float 631 yields h2 values greater than 20 m – replace greater with deeper?
As in comment 10.2, h_2 is defined as a length scale, and so we respectfully disagree with the Reviewer's suggestion here.

13. Paragraph 290: "The chlorophyll concentration of the surface layer, where the majority of visible radiation is absorbed, is a key control on the amount of visible radiation absorbed and thus on the radiant heating rate of the surface layer." Suggest rewording.
Thank you for your suggestion. We have now reworded this sentence.

    Line 299: *"The majority of visible radiation is absorbed at the near surface, hence the chlorophyll concentration at the near surface strongly influences the amount of visible radiation absorbed, which strongly influences the radiant heating rate of the ocean surface."*

14. Paragraph 340: "all determined values..." Is this referring to all values of h2 derived from observations during that period?
Reviewer 1 is correct in that all determined values from the glider and floats were used to calculate the h_2 percentiles. We have clarified this in the text.

    Line 349: *"... all determined values of h_2 from the glider and floats respectively throughout July 2016."*

15. Paragraph 370: "from 26 m to 14 m leads to an increase in daily average SST of 0.35°C" suggest "...has the potential to increase daily average SST by 0.35C".
We have changed the wording of this specific statement to better reflect what happened in our experiment.

    Line 378: *"In the idealised KPP experiments, changing h_2 from 26 m to 14 m led to an increase in daily average SST by 0.35 ℃ within a month (black line; Fig. 10e)."*

16. "Decreasing h2 from 26 m to 17 m, 19 m and 21 m, leads to progressively smaller increases" – this order appears unintuitive. Should one not decrease form 26 m to 21, 19 17? Or perhaps I have misunderstood.
We agree with Reviewer 1 in that it would be more intuitive if the order is the other way round.

    Line 381: *"Decreasing h_2 from 26 m to 21 m, 19 m and 17 m, leads to progressively larger increases in daily average SST from 0.14°C, 0.18°C and 0.25°C by the end of July 2016, respectively (Fig. 10e)."*

17. Discussion: The authors demonstrate that chlorophyll-a concentration impacts the radiative absorption capacity of the surface ocean. While shallower scale depths induce larger changes in SSTs, it appears that the net impact of this warming is dependent on the depth of the mixed layer – which itself has multiple forcing mechanisms. Particularly, there is a large body of literature which discusses submesoscale variability which could be mentioned in the discussion on implications and assumptions. The assumption that the region is 1D forced should be discussed given the available literature on submesoscale 3D processes active in the BoB. It could also be interesting to suggest possible links between horizontal processes of SMS, shoaling of ML/added nutrients and the link the chl-a concentration and warmer waters. Suggested literature: Ramachandran et al., 2018; Jaeger and Mahadevan, 2018; Shroyer et al., 2020.
    We have added an additional paragraph to the discussion outlining the limitations to KPP.

    Line 458: *"KPP is a one deimensional model and neglects horizontal advection. Submesoscale frontal and eddy activity in the BoB create sharp horizontal and vertical gradients in temperature and salinity (Ramachandran et al., 2018; Jaeger and Mahadevan, 2018). Strong seasonal surface currents, such as the SMC, advect different water masses, forming fronts and eddies that are continually moving and changing around the BoB. This submesoscale dynamical variability is not replicated in the one dimensional KPP model. However, for the purposes of this paper, the simplicity inherent in not representing three dimensional dynamics means that the results of our chlorophyll sensitivity experiments are unambiguous."*

18. General: punctuate equations.
    Thank you for spotting this. We have now punctuated the equations.

    E.g. Line 485: "$\ln E_d(\lambda, z) = \ln E_d(\lambda, -0) - \sum_1^n K_d(\lambda, z)\, \Delta z$,"

19. Average chl-a in surface 0-30 m is repeated a number of times throughout the text. Suggest defining and abbreviating at the beginning.
    Thank you for your suggestion. We have now abbreviated 0-30 m chlorophyll concentration to *Chl-a*$_{30}$. This has been defined in Section 3.1.

    Line 240: *"... (henceforth referred to as Chl-a*$_{30}$*) ..."*

20. Figure 10: It is difficult to see differences between simulations in figure 10f. Suggest zoomed in inset.
    Thank you for your suggestion. We have provided a zoomed in inset of the MLD time series for the period of 24 to 30 July, which is labelled as Fig. 10g. We have referenced this new panel in the text.

21. A1d – would it be worth plotting a chl-a profile from the glider compared the float 629 which look to be close in space/time (looking at Figure 5?)
    As mentioned in our comment to Reviewer 2, the distance between the deployment location of float 629 and SG579 is approximately 56 km, which is large enough for noticeable changes in chlorophyll concentration. Hence, we have not added the chlorophyll concentration profiles in the same plot as it would not provide a useful comparison with fluorescence-derived chlorophyll concentration.

References

Jaeger, G. S. and Mahadevan, A.: Submesoscale-selective compensation of fronts in a salinity-stratified ocean, Science Advances, 4, 1701504, https://advances.sciencemag.org/lookup/doi/10.1126/sciadv.1701504, 2018.

Ramachandran, S., Tandon, A., Mackinnon, J., Lucas, A. J., Pinkel, R., Waterhouse, A. F., Nash, J., Shroyer, E., Mahadevan, A., Weller, R. A. and Farrar, J. T.: Submesoscale processes at shallow salinity fronts in the Bay of Bengal: Observations during the winter monsoon, J. Phys. Oceanogr., 48, 479–509, https://journals.ametsoc.org/view/journals/phoc/48/3/jpo-d-16-0283.1.xml, 2018.

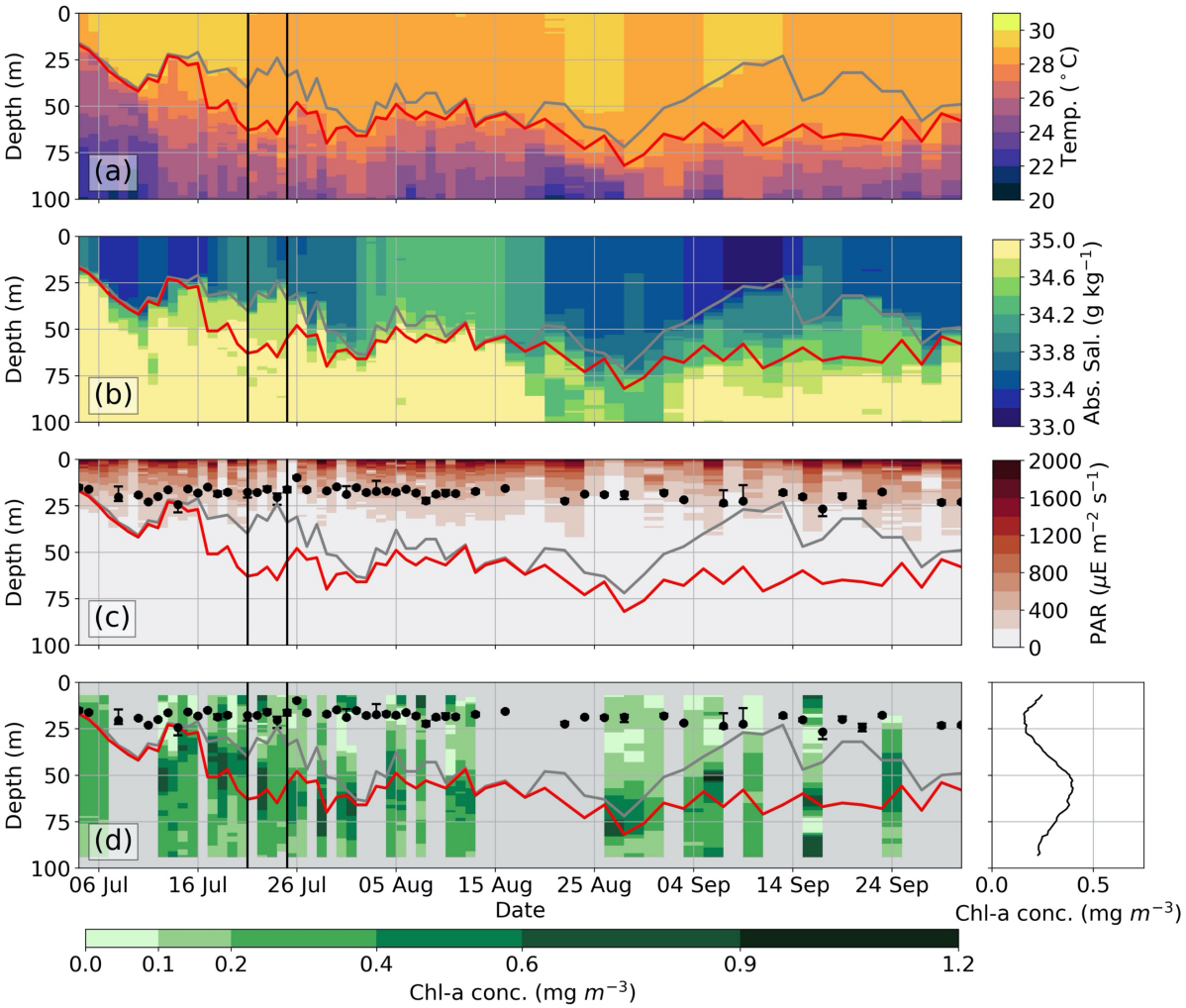

Figure 6: Time series of observations measured by float 631, linearly interpolated to 1 m depth intervals: (a) temperature [°C], (b) absolute salinity [g kg^{-1}], (c) PAR [µE m^{-2} s^{-1}], (d) chlorophyll concentration and vertical profile of the average chlorophyll concentration [mg m-3]. Grey sections in the chlorophyll time series represent removed $E_d(490)$ profiles that displayed excessive noise. The black dots are scale depth values, h_2 [m]. The region between the MLD (grey line) and isothermal layer depth (red line) is the barrier layer.

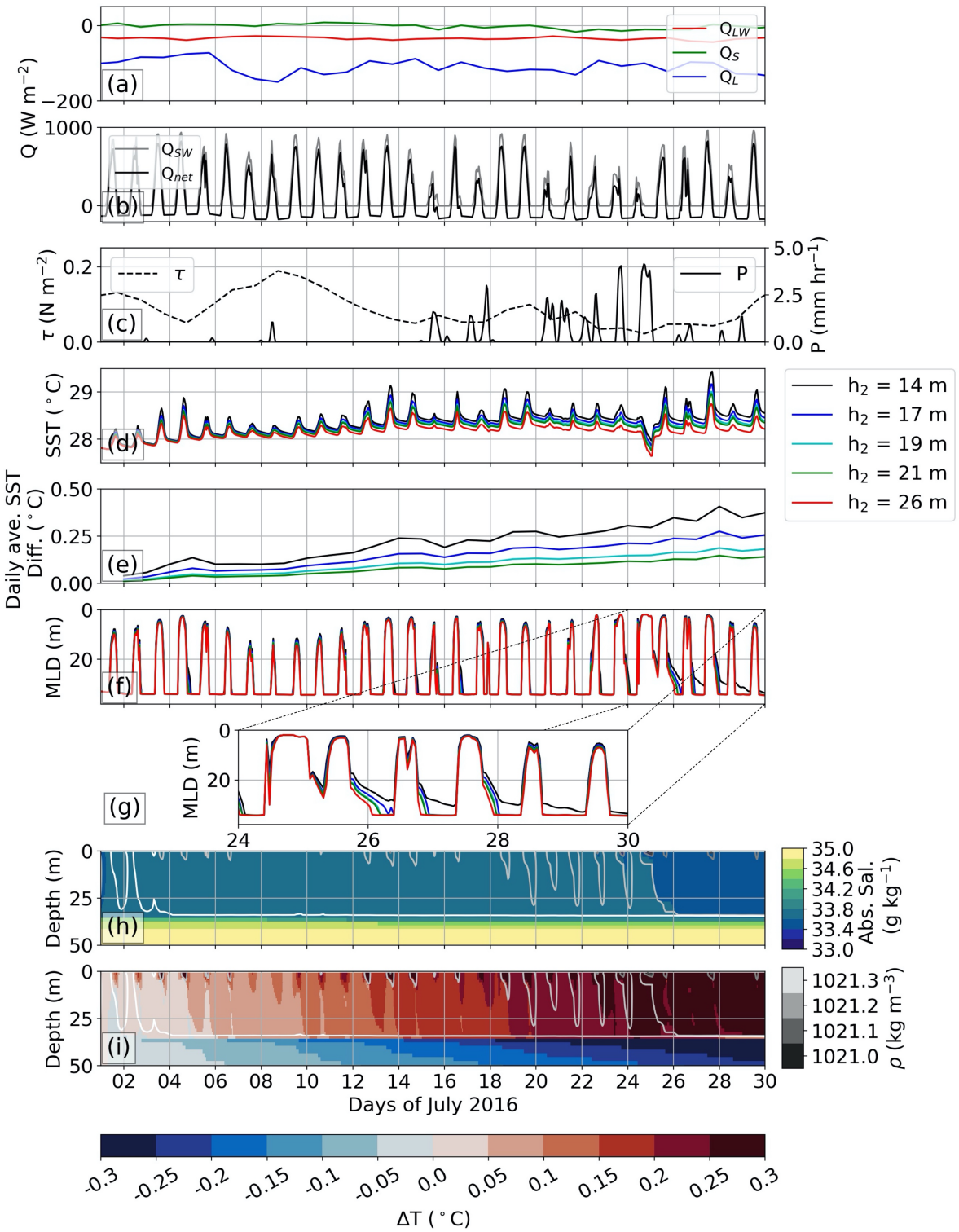

Figure 10: (a) Hourly surface longwave (red line), sensible (green line) and latent (blue line) heat fluxes [W m^{-2}] for July 2016; (b) Hourly surface shortwave (grey line) and net (black line) heat fluxes [W m^{-2}]; (c) Wind stress magnitude (dashed black line) [N m^{-2}] and precipitation rate (solid black line) [mm day^{-1}]; (d) Time series of model SST when h_2 is 14 m (black line), 17 m (blue line), 19 m (cyan line), 21 m (green line) and 26 m (red line); (e) Time series of daily average SST difference where SST$_{14m}$ minus SST$_{26m}$ (black line), SST$_{17m}$ minus SST$_{26m}$ (blue line), SST$_{19m}$ minus SST$_{26m}$ (cyan line) and SST$_{21m}$ minus SST$_{26m}$ (green line); (f) Time series of model mixed layer depth when h_2 is 14 m (black line), 17 m (blue line), 19 m (cyan line), 21 m (green line) and 26 m (red line); (g) Time series of model mixed layer depth between 24 and 30 July; (h) Depth-time section of salinity [g kg^{-1}] and density (contours) [kg m^{-3}] from the h_2 = 26 m simulation; (i) Depth-time section of temperature difference (T$_{14m}$ – T$_{26m}$) [°C] and density (contours) [kg m^{-3}] from the h_2 = 26 m simulation.