Re: Address comments from reviewer #1

Dear reviewer,

Thank you for your comments and suggestions to strengthen the manuscript. Please kindly find the authors' responses as follows:

Abstract
Line 25 – This sentence does not read well. Please consider rephrasing into "Study of the temporal TSS variation provides …." (i.e., add 'of the' and a final 's' in the verb).

Response: Thank you for your correction. Agreed with the changes made.

Line 30 - This sentence does not read well. "study on the" should be "study of the"

Response: Noted with thanks on the correction made.

Line 34 – "The results"

Response: Noted with thanks. Correction has been made.

Keywords
Comment: I find it interesting that 'Open Data Cube' is listed as a keyword but it does not appear at least once in the Abstract.

Response: Noted with thanks on this remark. The Open Data Cube has been introduced in the Abstract, and the change is found in Line 17.

Introduction
Line 92, is there a reason why the Authors are focussing on US satellites only, and why is there only one example mentioned as a (worse) alternative to MODIS? How about the ESA Sentinel-2 MSI and Sentinel-3 OLCI sensors, for example? They may be European, but they are used for global applications.

Response: Thank you for pointing out this discussion. Agreed that the comparison and discussion on the ESA Sentinel-2 and Sentinel-3 missions will provide a thorough background on available ocean colour datasets which can be applied to address each application and research problems of interest. As such, improvements have been made from Line 91-100, as follows:

Other sensors offering ocean colour measurement capabilities include Landsat-8, which, in comparison with MODIS-Aqua, has a 16-day revisit time and high spatial resolution of 30 m. Additionally, Sentinel 2-MSI (10 - 60 m) and Sentinel 3-OLCI (300 m) missions provide global coverage of high resolution of ocean and land observations, with revisit time of 10-day and 2-

day, respectively (European Space Agency, 2022a, 2022b). Despite Landsat 8 and Sentinel-2's powerful ability in capturing higher resolution images, the longer revisit interval may not be suitable for characterizing and studying large swath of coastal water bodies with high dynamics of various water constituents. While Sentinel 3-OLCI enhances in a shorter revisit time, this mission has a relatively smaller collection of ocean data stored, with the mission launched in 2016, in comparison to the MODIS-Aqua data collection.

Line 98 – "less satisfactory" than what? There is no comparison. Perhaps the Authors mean "unsatisfactory", which is demonstrated by their validation with in-situ data.

Response: Received with thanks on the correction made. The change has been made in Line 104.

Line 101 - the Authors introduce the notion of a 'water class type', without explaining it. If this paper is addressed to policy makers and water resource managers, this type of term should perhaps be clearly defined. If the readership is expected to be scientists only, then you may leave it as it is.

Response: Thank you for highlighting this remark. As this study aims to connect to a broader readership, such as policy makers and water resources managers, an explanation of the water class type has been added, from Line 106-109, as follows,

Generally, optical water types are categorised based on the water reflectance signatures, which are influenced by varying optical water constituents such as the coloured dissolved organic matter, suspended sediment and phytoplankton presence in the water column (Aurin and Dierssen, 2012; Balasubramanian et al., 2020; Moore et al., 2009). While these global TSS remote sensing models address the need to improve TSS retrievals and to monitor global TSS trends in various water class types, they tend to underperform in more localised and regional studies (Mao et al., 2012; Ondrusek et al., 2012).

Line 114 – "of a band ratio TSS model when applied in…" (i.e., add 'a', replace "to be" with 'when' and replace "within" with 'in').

Response: Thank you for the correction made. Amendments are found in Line 124.

Line 120 – “at river mouths” in general? Or of your study area? If so, I would specify with names or at least say “at the river mouths located within the study case area”.

Response: Received with thanks on these corrections. Changes have been made from Line 130-131, with the changes made as follows, “at the river mouths located within the study case area”.

Methodologies
Line 122 – “The figure below”

Response: Thank you for correcting this phrase. The amendment is shown in Line 146.

Line 123 – “using an atmospherically-corrected”. (i.e., you need an article and correct it to read ‘atmospherically’).

Response: Thank you for the correction made. The amendment is shown in Line 147.

Figure 1: Box 5 - as above for line 123. Box 6 - Readers may be confused here by the choice of terminology. Did the Authors retrieve GPM datasets, or source/extract them? Retrieval in remote sensing is generally used to describe the process when one applies a model to remote sensing data to estimate (i.e., retrieve) a parameter value. But as they describe below, they sourced ready-made GPM products for this study, in which case I would replace the noun “retrieval” with the verb “source” or the noun “extraction” (the latter is also used later on in the text, see Line 305).

Response:

(i) Received with thanks on the correction made in Box 5.

(ii) Thank you for highlighting the choice of word. The noun ‘Sourcing’ has been replaced in Box 6.

I find ODC mentioned a couple of times already before it is introduced and described in Line 285. I believe it would greatly improve the paper if ODC was introduced much earlier, i.e., a sentence in the Abstract and some background context in the Introduction before it is fully described in the Methods.

Response: With reference to the previous remark, thank you for your suggestions to highlight the concept of ODC in the Abstract, as well as in the Introduction part. Hence, the improvement can be found in Line 17 (under Abstract) and from Line 131-135 (under Introduction).

Line 161 – “which comprise**s**” (please add final ‘s’ to the verb)

Response: Thank you for the correction made. The amendment is shown in Line 185.

Line 162 – “consists of a tidal river channel”

Response: Agreed with thanks. The amendment is shown in Line 186-187.

Please replace “oil palm” with “palm oil” throughout the manuscript.

Response: Thank you for the correction made. The amendment is shown in Line 183, 190, and 199.

Line 174 – “Sadong river **is** about 150 km **long** and…”

Response: Noted with thanks on the correction made. The amendment is shown in Line 198-199.

Line 185 – “prior to **the** weighing process”
Response: Thank you for the correction made. The amendment is shown in Line 210.

Line 186 – “Full details of **the** water sapling and TSS analysis **are** available…”

Response: Noted with thanks on the correction made. The amendment is shown in Line 210-211.

Line 199 – Isn’t the “visible/ultraviolet” part of the spectrum already mentioned when you say “covers the spectrum of ultraviolet and visible light” earlier in the same sentence? It looks like an error here and I think the authors probably mean the ‘near-infrared’, which starts approx. at 800 nm and goes beyond their measured 950 nm. Please revise accordingly.

Response: Yes, you are right. Thank you for pointing out this mistake. Revision is made and shown in Line 223.

Line 205 – “to MODIS-Aqua product” should be revised. Do the Authors mean ‘to MODIS-Aqua data’? The product would be the output of the Authors’ new TSS retrieval model after it is applied to the satellite data. So, “MODIS-Aqua data” is your satellite data used to retrieve the “MODIS-Aqua TSS product”.

Response: Thank you for the explanation made. Agreed with the suggested revision and the correction is found in Line 230.

Line 207 – “convolved to generate MODIS-Aqua data” – please explain. Do the Authors mean that they used the in-situ remote sensing reflectance measurements to simulate MODIS-Aqua wavebands? If so, can they please (1) describe how the simulation was performed and (2) correct this sentence so that it refers to the in-situ spectral data (now it mentions the in-situ TSS concentrations, i.e., the samples). From reading the manuscript, it looks to me that they derived a model by correlating in-situ remote sensing reflectances and TSS sampling data (boxes 1-2 in Fig 1), and then applied that model to MODISAqua.
If so, can they please mention (1) which Aqua wavebands were used instead of the original (very narrow) TriOS-RAMSES spectral bands in the application of the model to the satellite images, and (2) what implications this approach may have on the final outputs and the output accuracy? If the Authors did not take this approach, can they please explain the benefit of

using in-situ reflectances to build their model instead of using directly satellite data for the model development?

Response: Thank you for seeking further clarification in this section to strengthen the manuscript. Yes, the model was developed by correlating in situ remote sensing reflectances and TSS sampling data and applied the model to MODIS-Aqua bands. Noted with thanks on the suggested revision for (2) correcting the sentence so that it refers to the in-situ spectral data. As such, the aforementioned correction, as well as additional explanation to clarify this approach, is added as follows (Line 230 – 242). Reference to the NASA web page in regard to the details relating to the convolution of band is cited in the discussion.

With the intention to apply a regional TSS remote sensing model to MODIS-Aqua data, a total of 35 in situ spectral data of different TSS datasets, which were collected in coastal conditions (salinity > 15 PSU), were convolved with MODIS-Aqua spectral response function values (Pahlevan et al., 2012) at each centre wavelength of individual band channels (NASA official, 2022). MODIS-Aqua offers visible bands of violet/blue (412, 443, 469, and 488 nm), green (531, 547, and 555 nm), red (645, 667, and 678 nm) and near-infrared wavelengths (748, 859 and 869 nm) for remote sensing of coastal waters (NASA official, 2022). The in situ spectra data were resampled to MODIS-Aqua's central spectral bands based on the aforementioned information. Measurements of in situ spectral data enhance the understanding of bio-optical water characteristics of a localised region, and increase the sensitivity of radiometric measurements without atmospheric interferences, while subject to the radiometer's calibration condition (Brezonik et al., 2015; Cui et al., 2010; Dorji and Fearns, 2017; Slonecker et al., 2016).

Line 212 – "of **the atmosphere** and irradiance ...".

Response: Thank you for the correction made, the amendment is shown in Line 247.

Line 216 – "as **the** dependent variable"

Response: Noted with thanks on the correction made, the revision is shown in Line 251.

Line 217 – "logarithm**ic** functions"
Response: Noted with thanks on the correction made, the revision is shown in Line 252.

Line 242 – “the log-transform**ation**”

Response: Noted with thanks on the correction made, the revision is shown in Line 277.

Table 2 - “a log-transform**ation**” and “**The p**ower function model is selected…”

Response: Noted with thanks on the correction made, the revision is shown in Line 281 and 283.

Comment: The authors used 35 samples to develop their model, which is quite low number for statistical significance.

Figure 4 is concerning. Are these 35 measured TSS points the same as the ones used to train the model (model TSS points)? One would naturally expect a good fit given that the modelled TSS points are based on these observed 35 points! This figure should be removed.

Response: Thank you for highlighting this remark. Agreed to the suggested revision. With the removal of Figure 4, subsequent numbering of figures found in the labels and discussions have been corrected throughout this manuscript.

I very much welcome the discussion in lines 259-272 to explain the limitation of non-transferability of this empirical model.

Response: Noted with thanks on this exchange. The model was developed from water bodies rich in suspended solids and dissolved organic matter. As such, this model presents limitation when applied to other optical water types, especially on phytoplankton-rich waters owing to the different spectral properties of these water bodies. Backscattering properties of phytoplankton-rich waters dominate from 600 to 800 nm and tends to interfere with other optically dominant materials such as the suspended solids and dissolved organic matter. Considering the empirical relationship the model was developed on, between in situ spectral data and TSS concentrations, this model is restricted to relatively sediment and organic matter rich waters as discussed in this study. Relevant references describing various water types are cited from Line 295 to 308.

Line 277 – please refer to the input data as “data” not “products”. The products in this manuscript are the TSS estimates based on the Authors’ power function model. Please apply this throughout the manuscript, where needed.

Response: Noted with thanks on the correction and explanation. Amendment is found in Line 313, as well as in Line 157.

Line 430 – “there **are** no apparent patterns …”

Response: Noted with thanks on the correction made. Amendment is found in Line 466.

Lines 507-521 are a repetition of Lines 496-506. I propose the Authors merge these two paragraphs into one and delete all repetitive statements.

Response: Thank you for these suggestions. These two paragraphs have been restructured and revised into one paragraph, as follows, which can be found from Line 534 to 549.

Discrepancies between TSS estimates and river discharge were identified in both the Lupar and Rajang coastal regions in these annual time-series, where river discharge was inversely correlated with TSS estimates. These discrepancies are not uncommon, as previously highlighted in a study by Zhan et al. (2019). Especially in 2010 for the Lupar river, Fig. 9a shows a drop in TSS release in relation to the steady increase of river discharge from the river basin. In 2011 and 2012, a negative correlation can be seen between river discharge and TSS estimates, while in subsequent years from 2013 until 2015, there is a clear positive correlation. The TSS output from the Lupar basin recorded a correlation coefficient of $r = 0.15$, while river discharge from the Rajang basin did not substantially influence the TSS release either, with $r = 0.27$ throughout the seasons (Supplementary Materials, Fig. S8a and b). Although there is no obvious environmental factor that would explain these discrepancies and poor correlation between river discharge and TSS estimates in this study, these findings may imply a complex interaction and process between human interventions, such as damming and deforestation activities, which are largely occurring within the Rajang basin (Alamgir et al., 2020), as well as varying hydrological and atmospheric conditions (wind and tidal mixing) in regulating TSS dynamics in a localised region (Espinoza Villar et al., 2013; Fabricius et al., 2016; Ramaswamy et al., 2004; Valerio et al., 2018; Wu et al., 2012; Zhan et al., 2019; Zhou et al., 2020).

Line 580 – the Authors should mention that uncertainty in their TSS retrievals mean that this small trend cannot be interpreted as fake or real, because such small variability in TSS retrievals lie within the error of their power function model (see table 2).

Response: Noted with thanks on the remark. Additional discussion has been added and this change is found in Line 635 – 637.

A reversed trend can be seen in the plot corresponding to the Sematan coastal river systems, although the absolute increase in TSS estimates across water zones (0.2 mg/L in total) here is only marginal (Fig. 12d). Such slight trend in TSS retrievals recorded (Figure 12) generally offers a synoptic understanding of the trend conditions, considering such small variabilities in TSS retrieval were captured by the power function TSS retrieval model given its extent of uncertainties (Table 2).

Conclusion – I would like to see a paragraph talking about the limitations of the Authors' model, e.g., it is not transferable to other water optical types, it was developed on very few sampling points from only two months in the year (June and Sept), more data points should be used to train the model, more seasons covered, more vigorous validation would be required. Also, what are the Authors' future plans to overcome some of these limitations? This is not an approach that can yet be relied upon by policymakers, according to my opinion, but would first require improvements.

Response: Thank you for these suggestions made to strengthen the conclusion of the manuscript. Limitations of the models are presented and highlighted in the manuscript, and are found in Line 724 – 740, as follows:

While these findings derived from this work can potentially be used to support local authorities in assessing TSS water quality status in the coastal areas of concern, the developed TSS retrieval model presents some limitations. Given the consideration that the model was developed from sediment and organic matter rich waters, the model is not transferable to other optical water types. This model is most applicable to be applied in waters with similar optical characteristics such as the southwest coastal waters of Sarawak region. There is a need to further optimize the model with larger datasets covering more coastal water points, as well as data points from varied seasonal patterns, to improve its performance on a spatial and temporal scale. As these data points were collected within the southwest region of Sarawak's coastal waters, further testing and validation of the model in other regions of Sarawak's

coastal waters is essential to develop a more robust TSS retrieval model and be applied to a broader regional scale.

Ultimately, with the demand to enhance coastal management and conservation strategies in Sarawak's coastal waters, the application of remote sensing technologies, as demonstrated in this study, is a great benefit in the development of sustainable sediment management in the Sarawak coastal region.