Manuscript review rebuttal

Manuscript Title: Hyperspectral reflectance of pristine, ocean weathered and biofouled plastics from dry to wet and submerged state
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Journal : Earth System Science Data

RC1 (Anonymous Reviewer #1)

Comment	Response	Revision Implemented
C1. The paper provides a nice overview of similar existing open access datasets. However, several experiments are very similar than those presented earlier, so a comparison with previous publications would be an added value for the reader.	**R1.** We thank the reviewer for the constructive suggestions to further improve our manuscript.	None.
C2. Both single pixel (with SEV spectrometer) and multiple pixel observations (with SPECIM hyperspectral camera 400-1000 nm) are performed. I would like to see an intercomparison of both on a pristine sample.	**R2.** Unfortunately, this comparison was not included in the scope of the campaigns, and since there is no more funding, the authors cannot set up an additional sampling campaign at this moment. We will keep this recommendation in mind for any similar follow-up studies. We do wish to highlight that the published dataset allows for comparisons at will by the future users of the data.	None.
C3. Both indoor and outdoor experiments are performed. Also here, an additional intercomparison of the same samples measured indoor and outdoor would be an added value and would help to interpret the results of the biofouling experiment.	**R3.** Thank you for your suggestion. Both the indoor and outdoor campaigns have produced relative reflectance datasets. While it is expected that the different setups will cause a difference in the quality of the dataset produced, we believe expanding the manuscript with the suggested comparison does not necessarily contribute to the main purpose of this manuscript, which is to transparently disseminate the data collected. We consider it out of the scope of our study to intercalibrate the indoor and outdoor measurements, beyond a careful description of the individual setups and datasets. It is also possible for future users of the data to draw this comparison themselves. As we wish to limit the scope of our manuscript to describe the methods and datasets themselves, we ask for your kind understanding of this.	None.

C4. For the indoor experiments, samples are supported by a black aluminum plate. In my understanding, this black plate was not used for the outdoor measurements. Please try to explain what the possible effects of this plate could be. The measurements do not include a correction for the holder, so please advise how to correct for this.	**R4.** Thank you for raising this concern. We have now included the background measurements of the water tank. We trust that makes the difference in setups transparent enough.	Figure 12 now has an added plot line for the water background of the outdoor measurement campaign. Additionally, the legend now specifies that the measurement belongs to the outdoor or indoor measurement campaigns.
C5. Line 215 and following: increase in reflectance with depth due to lighting geometry? Also the viewing geometry will have an impact as the footprint increases with depth.	**R5.** Thank you for your comment. We made changes in the text accordingly.	This line now reads: "*This effect could be caused by variation of the lighting and viewing geometry with depth, combined with specular light reflection on the sample's aluminium coating.*"
C6. Figure 14: Please include a comparison between SEV and SPECIM measurements	**R6.** As stated in R2, unfortunately, we cannot accommodate this request, since the collected data does not allow us to draw a valid comparison.	None.

RC2 (Anonymous Reviewer #2)

Comment	Response	Revision Implemented
C1. This is a well-organized and written paper providing additional measurements of plastic samples, which are an important contribution toward remote sensing of environmental plastic. The two datasets described in this study have similar formats and are available in an open-access repository. The different conditions under which the plastic samples were investigated are well described and compared in the introduction with previous studies of similar nature.	**R1.** We are grateful for the time taken by the reviewer to provide feedback on our work and encouraging words to improve the manuscript.	None.
C2. Table 1: This is crucial to illustrate an overview of what are the novelties and strengths of these measurements and compare them with similar research. However, I suggest adding two columns to the table: (i) one column including the conditions in terms of indoor/outdoor experiments and therefore the light source (artificial or natural) and (ii) a second one specifying the type of water used.	**R2.** Thank you for your suggestion. We made changes accordingly. We trust that this addresses your comment but are open to exploring a different type of text setting if this has not resolved the issue yet.	We have added the information about water type and environment (lighting) to a single column in Table 1.
C3. Table 2 & Figure 1: It is good to include a full overview of the samples analyzed, including pictures. However, as the polymer types tested in these experiments are already mentioned in Table 1, I think that this table and Figure 1 could be moved to the Annex section.	**R3.** Thank you for your comment. We have followed your suggestion, but in the process, we also identified that the text was wrongly referring to Table 1, where Table 2 was intended. We have followed your suggestion of moving Figure 1 to the appendix.	Figure 1 has now been moved to Appendix A and is now referred to as Figure A1. We have decided to leave the table in the text, we trust that this offers the best balance between the readability and cohesion. The other already existing appendix sections have been renamed to B, C and D.
C4. Line 157-158: repetition of "each panel" at the beginning and the end of the sentence.	**R4.** Thank you for noticing this. We made changes in the text accordingly.	We have changed the line to: *"Each panel possessed a unique surface biofilm distribution (**Figure 5**)."*
C5. Figure 5. This figure illustrates the outdoor experimental setup as well as an overview of the biofouled samples. To reduce the number of images present in the manuscript, and preserve the flow of the paper, I suggest splitting this image in two. Keep in the manuscript the first pictures from a) to e) describing the setup of the outdoor experiments (as Figure 5). The	**R5.** Thank you for your comment. We have reformatted the figure as suggested.	Figure 5 has been divided as suggested and the sample overview was moved to Appendix A as Figure A2.

second Figure including the pictures from 01 to 18, showing the biofouled samples could be added to the Annex.		
C6. 2.2.2 In this section you describe experiments conducted outdoors with measurements taken with natural light. I was wondering if you have information on the sky conditions of the days of the measurements as this might influence your light conditions. In addition, I would make it clearer in this section that the light source is natural light opposed to the one in the laboratory tank experiments.	**R6.** Thank you for this helpful suggestion for adding more detail and transparency to the methodology section. We edited the text by adding the information suggested.	Lines 184 – 186 now read: "*The relative reflectance measurements were collected under natural light, and white referencing was performed with a SphereOptics Zenith Polymer® SG3120 ≈ 99 % full material PTFE standard panel before each measurement. During the campaign, the sky conditions ranged from cloudy to scattered clouds. Measurements were only collected when the conditions were stable (i.e. steady state cloud cover, or a steady window of clear sky).*"
C7. 3.1.1. - 3.1.2 - 3.1.3 and 3.1.4 sections: Although by going back to the material and methods and introduction sections you can retrieve this information, I would suggest clearly stating that these results come from either the tests performed in the tank, and therefore in freshwater and under artificial light, or in the outdoor tank with natural light. I would clarify this within the text and maybe even in the captions of Figures 10 and 11.	**R7.** Thank you for noticing this. We made changes in the text accordingly.	In each results section header, it is now clearly stated whether it belongs to the indoor campaign or the outdoor mesocosm campaign. In the method section (line 177), we have now specified that freshwater was used in the measurement tank for the indoor and outdoor measurement campaigns.
C8. Line 225: Can you specify the depths?	**R8.** Yes, thank you. We added the depths.	Line 225 (now 254) has been changed to: "*Blue foam, white, brown, and green sail pieces (items 14 – 17 in Error! Reference source not found.) spectral reflectance measurements were only done in dry configuration (Error! Reference source not found.).*"
C9. Figure 10: At which depths were these measurements taken? Or are these dry measurements, and you additionally have collected the spectral reflectance measurements at selected depths, but they are not reported in the figure? If you can, add the depths within the graph's legend or in the caption of the figure to clarify. For the white sail, the (a) is missing	**R9.** Thank you for the comment. The blue foam piece was measured at 50 mm and 715 mm depth but only the dry measurement is reported in the figure. The green, brown, and white sail samples were only measured in dry conditions.	Regarding the depth, please see the response to C8. The (a) has been added to the caption.
C10. Figure 11: The caption needs to be checked as the mask and glove are swapped. (a) is the glove according to the legend of the graph. However, in the	**R10.** Ok, thank you, we made the change.	The caption has now been corrected.

caption, it says that a is the medical mask. The same goes for the mask. Graph (b) has "mask" in the legend, but in the caption is "gloves". The (c) is missing the opening bracket.		
C11. 3.1.4 Blank measurements: are these measurements taken in the tank or the outdoor settings? In other words, what was the experimental setting and therefore the light source used?	**R11.** Thank you for noticing this hiatus. We made changes in the text accordingly.	The section now clarifies that blank measurements were collected for each setting and background type. We have added to line 284: *"For the indoor campaign (...)"* We have added in line 289: "*Blank measurements were also collected separately during the outdoor mesocosm campaign. However, no holder plate was used. Therefore, the outdoor mesocosm blank measurements simplify to only water background, which is not shown in Figure 14."* Figure 12 (now 14) caption now reads: "*Comparison of different blank measurements above water, for both the indoor laboratory and the outdoor mesocosm campaign. All sample measurements during the indoor laboratory campaign were taken with the 'Glass' or 'No glass' option, depending on the required setup. The black background plate has a higher reflectance than water. All measurements reported in this paper are raw measurements, meaning that the blank signal can still be subtracted to obtain material-specific reflectances with higher accuracy. Each curve is accompanied by a 3σ confidence interval and individual measurement lines (colored hairlines).*"
C12. 3.1.5 section. As with the previous sections, I suggest that it is clearly stated that these measurements were taken in seawater and that natural light was used, as opposed to the artificial light used in the laboratory tank tests.	**R12.** Thank you for your suggestion. We wish to clarify that, while the outdoor samples were grown and stored in seawater, the measurement tank contained freshwater during both the indoor and outdoor measurement campaigns.	In each results section header, it is now clearly stated whether it belongs to the indoor campaign or the outdoor mesocosm campaign. In the method section, we have now specified that freshwater was used in the measurement tank for both indoor and outdoor measurement campaigns. Line 129 now states: *"The tank was filled with fresh water."* Line 177 now states: *"A customized, cylindrical water*

		tank was filled with freshwater. Using a seawater medium was considered but omitted, due to the lack of equipment to characterize the seawater at the measurement site."
C13. Figure 13: These measurements are recorded in outdoor conditions, with natural light as a light source. How did you calculate the reflectance? Did you subtract the reflected skylight? Which equation did you use?	**R13.** Thank you for the questions. Like in the indoor laboratory campaign, we measured relative reflectance and used a white reference plaque to obtain the white reference spectrum in advance of collecting the relative spectral reflectance of the samples. We took special care to observe during stable conditions, i.e. steady clear sky or steady cloud cover. As you can see in comparison to the indoor laboratory results, some of the atmospheric variability still propagates into the result dataset, which can be observed most notably in Figure 13a , having a large spread in magnitude. However, this does not affect the spectral reflectance curve shape.	Lines 184 – 187 now read: "*The relative reflectance measurements were collected under natural light, and white referencing was performed with a SphereOptics Zenith Polymer® SG3120 ≈ 99 % full material PTFE standard panel before each measurement. During the campaign, the sky conditions ranged from cloudy to scattered clouds. Measurements were only collected when the conditions were stable (i.e. steady state cloud cover, or a steady window of clear sky).*"
C14. Overall this paper is a great effort toward remote sensing of plastic litter, and the datasets presented in this paper are important for the scientific community given the significance of monitoring plastic pollution.	**R14.** We thank the reviewer for their recognition of our effort to contribute to the science of plastic pollution monitoring using open-access data and publication.	None.

RC3 (Samantha Lavender)

Comment	Response	Revision Implemented
C1. Thanks for this paper, which will be a valuable addition to supporting the remote sensing of waste plastics. Having read the feedback from the other reviewers, I feel they've already addressed many of the queries I would have asked. Therefore, I have the following additional comments.	**R1.** Thank you for taking the time to review our submitted manuscript.	None.
C2. From having undertaken such measurements, I'm missing the number of acquisitions per spectrum presented. To get the final spectrum did you average? If so, for plots such as Figure 10, I would like to see the variation between the duplicate acquisitions. Confidence intervals are mentioned in the legend of Figure 14, but outside of this, I have no information on the measurement variability.	**R2.** Thank you for the comment. We have made adjustments accordingly.	Line 208 now states: "*In this section of the results and each of the following sections, each of the spectral reflectance curves is the average of a group of five measurements, unless mentioned otherwise."* Line 303 now states: "*The shading around the lines indicates the standard deviation, obtained from the ensemble of 5 measurements.*" Line 332 reads: "*The displayed reflectance curves are obtained by averaging the data from ten points on each sample.*" We have also added to several captions: "Each reflectance curve is the average of five measurements.". Finally, we have updated Figures 10, 11 and 14 to display individual measurement lines and include (exaggerated) confidence intervals.
C3. I'm also struggling to see the detail of the spectrum for Figures 7 to 9. Could each figure be followed by a comparison plot, similar to the current Figure 10, showing the surface values for each of the individual panels?	**R3.** Thank you for the comment, we now made changes to the manuscript accordingly. Due (or thanks) to the setup stability during the indoor laboratory measurements, the variability is very low. We had considered plotting confidence intervals earlier but had omitted them for the reason stated above.	Following each of the original Figures 7 to 9, we have now added comparison plots for the surface spectral reflectance, which also include a 10σ confidence interval, and lines showing the individual measurements. Additionally, we have updated the original Figures 10, 11, and 14 to include individual measurement lines.

Community Commenter #1 (Chuanmin Hu)

Comment	Response	Revision Implemented
C1. This is a great contribution towards remote detection of plastics in natural environments. The data are made available to the community, which is particularly important to reference against other measurements and to develop algorithms.	**R1.** We wish to thank you for taking the time to read our submission and for recognizing our effort in contributing to open-access science.	None.
C2. My biggest concern is how these data can be applied to remote sensing applications. In other words, which spectra can be used as the endmember spectra to interpret remote sensing imagery? Why?	**R2.** We wish to articulate that our manuscript is a data paper, and we simply wish to accurately describe the dataset and the way it was collected. We trust that the background given in the introduction is sufficient to understand the relevance of the collected spectra.	None.
C3. Leone et al. (2023) did very similar experiments except with a limited depth range of 0 – 0.08 m. So what's the motivation to do it again? Is the additional depth range of 0.08 – 0.7 m that important? If so, why 0.7 m? Actually both Figs. 8 & 9 show that after 0.08 m, there is nearly no information in the SWIR wavelengths.	**R3.** Thank you for your comment. We recognize that the preprint left a gap concerning the context of our study. We have added clarifications to the text accordingly.	In the introduction, we have now added, starting from line 42: "*Beyond spectral matching techniques, depth-related spectral reflectance datasets may lead to methods for detecting physical characteristics such as the buoyancy and subsequently windage of plastic litter. (… original text …)* *Among recent studies in Table 1, (Leone et al., 2023; Knaeps et al., 2021) have examined submerged plastics in depths of up to 0.08 m and 0.32 m, respectively. Because plastic litter in the open ocean frequently occurs in the water column down to 5 m depth (Kooi et al., 2016; Law et al., 2014), it remains relevant to extend remote sensing research to larger water depths beyond existing datasets. By including measurements of up to 0.715 m water depth, this study aims to expand knowledge of spectral reflectance of deeply submerged plastic litter, simultaneously adding a finer resolution of depth. The study of (Leone et al., 2023) was conducted in parallel with this study, and the pristine plastic samples used there were created and provided by the authors of this study to enable cross-comparison between datasets. Parallel*

		measurement campaigns with identical samples can assist other researchers in the comparison of setups and bring valuable insights into implications of study and instrumentation design."
C4. For the same reason, how are the experimental results compared with those of Leone et al. (2023) for the same depth range of 0 – 0.08 m? Are they the same or different? If they are different, why?	**R4.** Thank you for your comment, please see our response to C3.	None.
C5. Same question applies to Knaeps et al. (2021). It's great to list previous efforts to establish spectral libraries in Table 1 (line 44). But so? Are these earlier efforts not enough? In what way?	**R5.** Thank you for this comment, please see our response to C3.	None.
C6. What's the purpose to use take the measurement in Fig. 2? Just to record a photograph of each type?	**R6.** Thank you for your comment. The methodology and purpose of the measurement in the original Figure 2 are explained in lines 100 – 106. Due to the lack of reference to another figure, we understand that this motivation and detail could have been unclear in the preprint. We have added clarifications about the value of these measurements to the conclusions. We trust that this clarifies enough.	In the conclusions, we have added the following, at line 373: "*The hypercube scans of the heterogeneous samples are intended to further enrich the dataset, by enabling inspection of the spectral effects of spatial heterogeneity in material ageing and biofouling."*
C7. Fig. 3 shows Halogen tungsten lamps but Figs. 5&6 shows natural illumination. Then, for the reported spectral library, which light source was used? Fig. 3 is not cited but described in the text (line 108 – 117). But what's the purpose of this experimental setting? My experience with lamps is that they don't provide collimated beams, meaning that the amount of light received by the target (irradiance) depends on the distance between the target and the light source. Then it will introduce errors when calculating reflectance because the target and the reference plaque may be placed in different positions relative to the light source.	**R7.** Thank you for your comment. We have made changes to the manuscript accordingly.	We have changed the title section of 2.1 from "*Laboratory experiment*" to "*Indoor laboratory experiment*". We have added a reference to the indoor laboratory setup figure on line 110: "*Figure 1 shows the indoor laboratory setup (design and as-built impression)"*. An additional reference to Figure 1 is made in line 120: "*As illustrated in Figure 1 (…)*" We have switched the order of original Figures 2 and 3, so that the indoor laboratory setup now comes first with order of reference. Regarding light sources, we have now clarified on line 104: "*To minimize inconsistencies in light intensity, related to the use of indoor scattered light sources, the white*

		reference panel was positioned at the surface level position, as close as possible to the sample position. Since the main focus of this study is on relative changes in the spectral reflectance curve shape, any potential further imperfections in light intensity were accepted in exchange for the benefits of an indoor laboratory environment, which include stability of lighting and the absence of adverse weather influences." Line 184 now clarifies the outdoor measurement campaign: "*The relative reflectance measurements were collected under natural light, and white referencing was performed with a SphereOptics Zenith Polymer® SG3120 ≈ 99 % full material PTFE standard panel before each measurement.*"
C8. After all, which experimental setting was used to measure reflectance, Fig. 3 or Figs. 5&6? These settings would give different reflectance, with the latter being more realistic. This needs to be made very clear in the methodology, including what are these experimental settings used for.	**R8.** We kindly refer to response R7.	None.
C9. In the tank experiment, what are the optical properties of water? To a minimum, what type of water is that? How the spectra of submersed targets change with depth depend on the water's optical properties, and therefore it is important to know what water type is used.	**R9.** Thank you for the questions. The outdoor experiment we conducted was located in Hawaii in a tropical environment with productive coastal waters with high chl a and nutrient contents. The tank in which the measurements were conducted contained fresh water. We have updated the text accordingly.	On line 177, we have added: "*A customized, cylindrical water tank was constructed and filled with freshwater. Using a seawater medium was considered but omitted, due to the lack of equipment to characterize the seawater at the measurement site."*
C10. How was reflectance calculated from the measurements? Was reflected skylight subtracted? Or is it just a ratio of two measurements (one from the target, either on surface or submerged, and the other from the reference plaque)? This needs to be described with an equation.	**R10.** Thank you for identifying this ambiguity. To clarify, we have now included references in the text. We trust that this clarifies the method sufficiently.	To line 103, we have added: *"in line with recent studies (Knaeps et al., 2021; Leone et al., 2023; Garaba et al., 2021)."*
C11. Fig. 10. White sail is missing in the caption? Need to explain in the caption. Are these reflectance spectra measured	**R11.** Thank you for the comments, we made changes in the text accordingly.	The caption of Figure 10 (now figure 11) has been corrected. Additionally, we have now added clarification that these measurements were taken at the

under natural sunlight illumination? Line 225 states that they are from selected depths – but what depths? Why not measuring them at the surface?		surface. The section titles now clarify which results correspond to natural sunlight versus artificial illumination.
C11a Also, does each target occupy 100% FOV of the sensor (i.e., equivalent to full coverage of a satellite image pixel)? This is super important because the magnitude of the reflectance in the NIR and SWIR is impacted by the % coverage within the FOV. If half of the FOV is filled with this target debris and the other half being the black background, then the magnitude may be halved.	**R11a** Thank you for your comment. We have added clarifications accordingly.	On line 256, we have added: "*As can be seen in Figure A1, each sample of this group is large enough to fully cover the sensor pixel swath.*"
C11b In this regard, why do these spectral magnitudes differ so much in the NIR and SWIR? For example, at 800 nm, the green sail reflectance is < 0.1, but blue foam reflectance is 0.8. This doesn't appear realistic because most solid materials have similar NIR reflectance magnitude.	**R11b** Thank you for your comment. We have added additional clarifications to the text.	From line 258, the text now reads: "*The blue foam had the highest reflectance in the SWIR whilst the lowest reflectance appears with the green sail. The overall reflectance magnitude differs between the materials and specifically in the NIR and SWIR, which could be explained by differences in material thickness (e.g. the sails being a film-like material versus the blue foam being a solid), as well as material brightness (e.g. the green sail being a darker material than the brown and white sail). The effect of material brightness, even in NIR and SWIR was also identified earlier in (Garaba et al., 2021).*"
C11c Are these single measurements or repeated?	**R11c** Thank you for the comment. Clarifications have been added to the text.	Please see our response to RC3
C11d It's better to show mean and standard deviation for each type.	**R11d** Thank you for the comment. Changes have been made accordingly.	Please see our response to RC3
C11e Are these all dry or wet materials?	**C11e** These were all dry materials and this info has now been added to the text.	Line 254 now states: "Blue foam, white, brown, and green sail pieces (items 14 – 17 in Error! Reference source not found.) spectral reflectance measurements were only done in dry configuration **(**Error! Reference source not found.**)**."
C11f These questions are important because they will determine whether these spectra can be used as the endmember spectra in interpreting mixed pixels of remote sensing images.	**R11f** Thank you, we appreciate your detailed review and questions.	None.

C12. Fig. 11. Apparently these are just one type of gloves and one type of masks. There are other types with different colors and possibly different materials. This needs to be clarified in figure caption.	**R12.** Thank you for your comment. We have adjusted the figure caption accordingly.	To the figure (now Figure 13) caption, we have added: "*Note that this study only examines one type of medical gloves and one type of medical masks, while medical PPE made of other types and materials also exists.*"
C13. Fig. 13. Again, why do these spectral magnitudes differ so much in the NIR-SWIR wavelengths, from 0.6 in (a) to 0.02 in (c)? 0.02 is actually approaching the blank reflectance of Fig. 12 – then, is it trustable?	**R13.** This comment has already been addressed under item **R11.**	None.
C14. Fig. 13a. Why is the shading area of the dotted purple curve so wide, but there is no shading area in (b) – (f)?	**R14.** The shading illustrates the standard deviation, obtained from the ensemble of five scans. In the case of Figure 13a, one of the measurements was compromised by the variability of the sky cover. This is one of the intrinsic difficulties of spectral reflectance measurements under natural light.	To line 303, we have added *"The shading around the lines illustrates the standard deviation, obtained from the ensemble of 5 measurements. In the case of Figure 13a, the variability of the sky cover influenced the 5 measurements belonging to the bioufouled measurement at 0 mm depth. This effect mainly impacts the reflectance magnitude but leaves the shape of the spectral reflectance curve unaltered. The same confidence intervals are also generated for the other subfigures, but are nearly invisible due to very low signal variability during most of the measurements."*
C15. Fig. 14. Why do these spectral magnitudes in the NIR differ so much from those of Fig. 11? Aren't those the same materials (gloves and masks)?	**R15.** Thank you for noting this gap in our results text. We have added clarifications accordingly.	To line 335, we have added: "*Figure 16 also includes the mean and standard deviation of each sample, each obtained from an ensemble of 10 points extracted from the sample hypercube.* *When comparing Figure 16 with the point measurements data in Figure 11 (weathered white plastic), Figure 13 (medical PPE), and Figure 15d (biofouled HDPE), the spectral reflectance magnitudes are different. Observing the spread in individual measurement lines in Figure 16, the difference in reflectance magnitudes is likely caused by differences in sampling location. The SPECIM IQ reflectance curves are based on the mean of a point ensemble, while a SEV point measurement is based on the average of the sensor pixel swath."*
C16. Supplemental figures: When absorbance is presented, the	**R16.** Thank you for your comment. In this case, the FTIR spectra are only	None.

pathlength or the thickness of the material also needs to be reported. Otherwise the values (not the relative spectral shapes) are meaningless.	illustrative to the purpose of the polymer classification. We trust that the current figures provide sufficient information to understand that.	