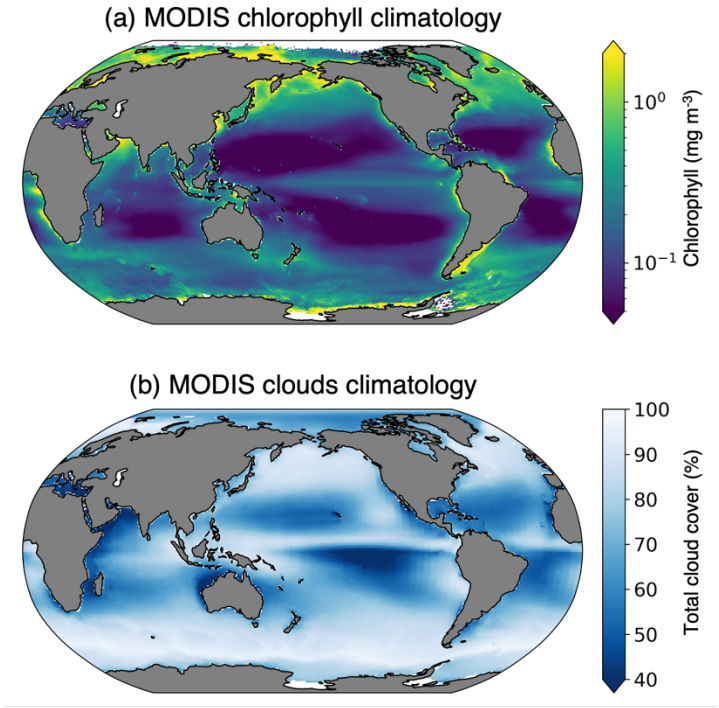
Thank you for taking the time to read our manuscript and provide constructive feedback. These comments were helpful for improving the paper. Please find our point-by-point responses to specific comments below. Reviewer comments are in black, followed by our responses in blue. Underlined portions indicate changes that were made in the manuscript. Line numbers refer to the revised manuscript.

Response to RC1: 'Comment on gmd-2023-143', John Dunne, 20 Aug 2023

Comment 1: *62 – what about the uncertainty associated with comparison of satellite optical depth and fully vertically resolved models?*
Response: This is an important point. We have added a sentence addressing this (line 55): "Satellite observations represent a vertically optically weighted chlorophyll signal, which is generally limited to the near-surface ocean due to light attenuation at depth. Therefore, the comparison with the vertically resolved model output is limited to surface layer only."

Comment 2: *Figure 1 – Cloud cover scale looks like it should only go down to 40%... how much of the oceans is the 20-40% range?*
Response: We agree that the map is clearer with the color scale bottoming out at 40%. We have updated this figure.



Comment 3: *70 – The mechanistic explanation is fairly simple and should be explained here – Areas where the ocean is cooler than the air (like upwelling regions) tend to cool the air, raise*

the humidity, and form clouds. This is in addition to all ocean areas tending to raise the humidity.
Response: We have added a sentence about this mechanism (line 73): "Ocean upwelling tends to cool the overlying atmosphere, which raises the humidity and leads to enhanced cloud cover. Upwelling also leads to increased nutrient concentrations, allowing more phytoplankton growth."

Comment 4: *187 – "equilibrium of the deep ocean can take hundreds of years" Actually, equilibrium of the deep ocean can take thousands of years.*
Response: Thank you for catching this. We have changed "hundreds" to "thousands".

Comment 5: *234 – "As expected"… It is not clear to me which of the model simulator versus real world differences make the strong difference in Fig. 4 "expected"… is it the return period of once a day in the model versus once every two days in the observations (line 178 "low latitude gaps are then filled during an orbit on the subsequent day"? More explicit attribution is needed here given the large number of differences described above… is the following sentence "The ISCCP configuration of ChlOSP samples more frequently than real-world sensors…" intended as the explanation? The connection to the previous discussion points is not clear.*
Response: Thank you for helping us clarify this paragraph. We have deleted "as expected". We also now point out that the mean daily coverage is higher for ChlOSP than in the real world, and we explain the reasons for this (line 248): "The ISCCP configuration of ChlOSP samples more frequently than real-world sensors because it samples at every sunlit time step rather than once-per-day." We then explain additional factors that result in less missing data, such as the lack of inter-orbit gaps and sun glint. The discrepancy between ChlOSP and real-world missing data is further explored in the subsequent paragraph where we discuss that an underestimation of cloud cover in the model (at low and mid latitudes) explains why ChlOSP samples more frequently at these locations compared with real-world satellites.

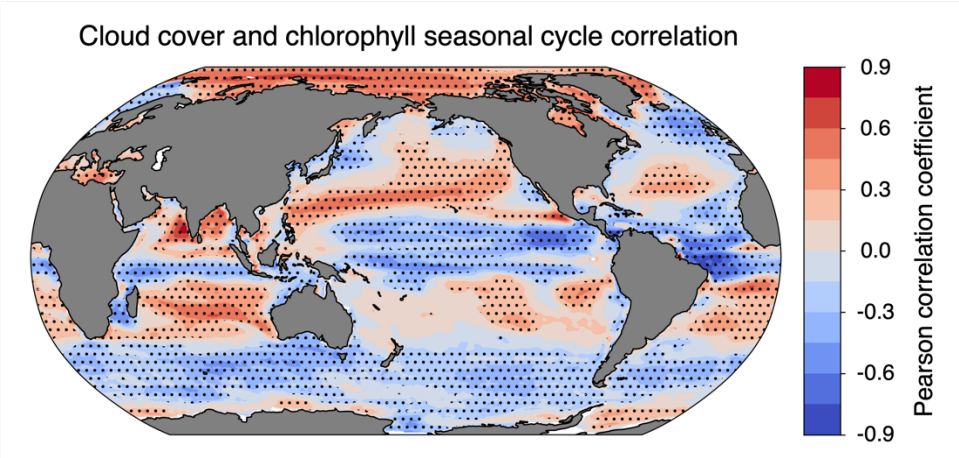
Comment 6: *241 – "white caps, coccolithophores, and aerosols are already simulated in some capacity in CESM and could be added to ChlOSP with minor modifications" if this would have improved the model with only "minor modifications" why was it not done in the present study?*
Response: We deleted "and could be added to ChlOSP with minor modifications." Although these factors are simulated in CESM, it would take significant effort to include these parameters in ChlOSP. Here we focus on the factors with the largest impact, and we believe that these contributions would be quite small compared with clouds, sea ice, and solar zenith angle.

Comment 7: *Table 1 – My interpretation of the longer e-folding time scales in the simulator than the observations is that the underlying model is missing important local scale forms of variance such as eddies, fronts, jets, etc. such that there is little correlation between the values separated two days apart. It is not clear the mechanism to which the authors are attributing this difference. In the simulator which is sampling daily, there is a resolved signal of autocorrelation. In the observations, there is not which contradicts the model behavior of signals persisting for 4 days. It is hard to know how to interpret the value of the model as an autocorrelation simulator in this case.*

Response: This is an excellent point. Thank you for bringing up your concerns. We previously had not considered how the spatial resolution may impact the e-folding time scales and hope to explore this in our next study. After further discussion, we decided that Table 1 was not necessary for validating the simulator and it has been removed from the manuscript.

Comment 8: *273 – "We have also shown that the missing data leads to a more realistic modeled representation of the chlorophyll variance." I do not see this assertion being supported anywhere as autocorrelation and variance are different things… has the variance in both the underlying model and simulator been assessed?*
Response: Thank you for mentioning this. Our language was inaccurate here, and we have deleted this sentence. This was referring to the e-folding timescale table that we have since deleted. In the Applications section, we assess the variance in monthly anomalies between the Standard and Cloudy chlorophyll outputs in Figure 12, in order to highlight the implications of variance in calculating the time of emergence.

Comment 9: *Figure 9 – I am not sure the meaning or value of this figure. The title refers to "chlorophyll temporal correlation, but I think the authors intend "chlorophyll bias correlation"… Are positive values where cloud cover leads to a positive bias in chlorophyll, and negative where it leads to a negative bias or is it truly the temporal correlation of high clouds when chlorophyll is temporally increasing as the title suggests? If the latter, than what is the significance? More clarity is needed.*
Response: We apologize for our lack of clarity here. We changed the title of the figure to highlight that we are taking the correlation of the seasonal cycles. We have also added a sentence to further explain the relevance of this figure (line 316): "The spatial pattern in all three panels can be largely explained by the correlation between the seasonal cycle of cloud cover and Clear-Sky chlorophyll (Fig. 9). The similarity in the spatial patterns between Figure 9 and Figure 7c suggest that correlations on monthly timescales play an important role in the resulting cloudy chlorophyll climatology."



Comment 10: *319-320 – "If satellite sensors could see through clouds (as in the Clear-Sky configuration), the global chlorophyll mean would be overestimated by 14 to 22 %." Is this due to the diurnal sampling bias, the seasonal sampling bias, or something else? The following*

sentences discuss mechanisms and may be connected. Answering this may simply involve switching the order of the sentences such that the mechanisms are attributed directly to the result… e.g. "… As a result, if satellite sensors could see through clouds (as in the Clear-Sky configuration), the global chlorophyll mean would be overestimated by 14 to 22 %."
Response: Thank you for helping us make this paragraph more clear. We have added a sentence to clarify why the Clear-Sky mean is higher (line 328): "This is because the Clear-Sky mean is heavily biased towards the productive summer months in high latitude regions due to solar zenith angle limits in the wintertime."