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Interactive comment on "A 40-year global dataset of visible channel remote sensing reflectances and coccolithophore bloom occurrence derived from the Advanced Very High Resolution Radiometer catalogue" *by* Benjamin R. Loveday and Timothy Smyth

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This work provides a 40-year long global record of coccolithophore (Emiliania huxleyi species) bloom observations from a meteorological satellite (AVHRR). The dataset potentially provides by far the longest record of global observations of blooms of a single phytoplankton species, Emiliania huxleyi, available to date, and thereby provides a time series long enough to detect changes due to anthropogenic climate change. The work

takes advantage from recent efforts by the meteorological community who provided a consistently calibrated record of top-of-atmosphere reflectances across all AVHRR satellite missions. Retrieval of a marine signal (remote sensing reflectance) from top-of-atmosphere reflectance, however, requires a careful removal of atmospheric effects (atmospheric correction). My major criticisms are that (1) the atmospheric correction procedure, which is the most important processing step, is not sufficiently well documented in the present paper and may need to be revised, (2) the resulting remote sensing reflectance dataset lacks validation, (3) the detection limit and uncertainties of the dataset are not quantified, which are problematic for potential users of the data. Below are my suggestions for improvement of the work on a point-by-point basis and a list of relatively minor comments and suggestions.

(1) Atmospheric correction:

I would suggest that section 3.1.3 be expanded and logically restructured to include: (1) equations documenting the appropriate corrections in each subsequent processing step, starting with a breakdown of the different component reflectances and transmittances of the top-of-atmosphere reflectance. (2) A clear mention of all assumptions made and how they impact the retrieved remote sensing reflectance. E.g., How does the assumption of equal aerosol reflectances in the NIR and the VIS affect Rrs(VIS)? (3) The relationship between transmission scaling factors and one-or-two way transmittance values. (4) A revision of Equation 1 (I believe you are missing a minus sign in the denominator). (5) A documentation of the radiative transfer code used to compute Rayleigh reflectance, atmospheric transmittances etc. (6) the relationships used between gas concentrations and gas transmittances. (7) Did you correct for CO_2 absorption (it does not appear in Figure 2)? (8) an explanation as to how and why the approach differs the one documented in Smyth et al. (2004). (9) Did you correct for aerosol transmittance (not mentioned)? (10) Is there a sunglint correction? (11) Briefly describe the whitecap correction you used.

(2) Rrs(VIS) validation :

Even though a qualitative validation is presented in Figure 3 through a visual comparison of four scenes from ocean colour satellites and corresponding AVHRR reflectance products, this work would clearly benefit from a more quantitative assessment. A cross-validation between Rrs(VIS) from appropriate ocean colour satellite bands and Rrs(VIS AVHRR) is probably the best way to validate the dataset produced. Additionally you could compare bloom extent from AVHRR with the coccolithophore bloom mask of Brown and Yoder applied to ocean colour satellites. There is about 20 years of overlapping satellite observations between AVHRR and ocean colour satellites; this should be plenty to make a quantitative assessment of the quality of your dataset. Further, many older papers provided AVHRR satellite data of Emiliania blooms at the original resolution of the sensor, 1km. A comparison with those data would allow you to estimate just how problematic the degradation of the spatial resolution by PATMOS is.

(3) Detection limit and uncertainties of the retrieved Rrs and bloom product

Just how reflective does a bloom need to be in order to be picked up by AVHRR satellites and how does the detection limit differ among missions? Can you give typical concentrations of coccolith(ophore)s corresponding to those reflectance detection limits? These questions are relevant for biologists, ecologists, and biogeochemists interested in coccolithophore blooms. Even if the detection limit would vary across sensors and with illumination and viewing geometry, it would be necessary to document this both in the paper as well as an additional variable in the dataset.

Another major comment relates to the poor spatial and temporal resolution of the remote sensing reflectance dataset which is monthly at 0.1°x0.1°. As mentioned in the paper this is a spatial coarsening by two orders of magnitude from the original resolution of AVHRR satellite data. Such a coarsening apparently results in a "dimming" of coccolithophore bloom intensity, which is even further exacerbated by making monthly composites. Uz et al. (2014) [Monitoring a Sentinel Species from Satellites: Detecting Emiliania huxleyi in 25 Years of AVHRR Imagery, https://link.springer.com/chapter/10.1007/978-94-007-5872-8_18] also used a consis-

tently calibrated dataset of AVHRR data processed with CLAVR-X at 0.25°x0.25° spatial resolution. Why is this dataset not used instead? It gives much better spatial resolution, and will partly solve your problem of "bloom dimming". Further, as your work is very similar to the work of Uz et al it is an important reference currently missing in your paper. Another (easier) way to mediate the problem of bloom dimming is by increasing the temporal resolution from monthly to weekly. I think weekly resolution data would also allow users to investigate bloom phenology which is not possible with monthly data.

My last major comment relates to the temporal filtering applied to detect blooms (P5L32-33). I think you are missing out on quite a bit of bloom area by considering as blooms only those observations which have Rrs more than two standard deviations above the corresponding monthly climatological mean. If annual blooms occur in an area in the same month almost every year and last a couple of weeks (which they typically do!) this will give rise to high climatological mean values. Your filtering will miss those blooms as they are considered "background".

Minor comments:

(1) P1L9: Rrs detection limit needs to be quantified in the abstract (2) P1L17-18: You should explain why Emiliania huxleyi blooms result in bright waters (3) P1L22: A reference to the paper by Winter et al (2014) [Poleward expansion of the coccolithophore Emiliania huxleyi, https://academic.oup.com/plankt/article/36/2/316/1500265] would be appropriate (4) P2L10: "Until now" but see Uz et al. (5) P2L28: what about the dataset used in Uz et al? (6) P2L32: worth mentioning the spectral width of Channel 2 (7) P5L14-16: Why don't you just mask high solar zenith angles? As it is now you are loosing good quality clear water, clear atmosphere data (8) P6L11: I would recommend applying a bathymetry mask poleward of 47° as well as false positives are also found on the shallow shelves of the Bering (60°N) and Barents (70°N)Seas. (9) P8L26: do you have an explanation for this? (10) P8L33: reference missing (11) P8 Section 5.2: Your maps in Figure 4 are further consistent

with other studies documenting poleward expansion of Emiliania huxleyi blooms by Winter et al. (2014) and Neukermans et al. (2018) [Increased intrusion of warming Atlantic water leads to rapid expansion of temperate phytoplankton in the Arctic, https://onlinelibrary.wiley.com/doi/abs/10.1111/gcb.14075]. Both references are missing in the paper. (12) P9L3-4: typical is used twice (13) P9L9: "By similar logic" – strange comment to make as blooms of non-calcifying phytoplankton are typically detected based on absorption features, not backscattering.

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