

# ***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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## **Response to RC1**

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**Reviewer comments in black**  
**Author responses in blue**  
**Manuscript changes in green**

*Anonymous Referee 1*  
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### **General appraisal:**

Loveday and Smyth have generated a 40-year long dataset of coccolithophore blooms occurrence over the global ocean, from observations of the Advanced Very High Resolution Radiometer (AVHRR) visible bands.

This is a very timely effort, inasmuch as generating long-term, consistently calibrated satellite time series is absolutely needed for studies about how global environment changes affect marine ecosystems.

The paper is overall well written, concise, and including the appropriate level of details. Illustrations are of good quality. So, overall, an excellent paper.

### **Major comments:**

My only reservation would be about the attribution of the high reflectance signal to coccolithophore blooms. The authors themselves recognise that they cannot always ascribe the reflectance anomalies to the presence of such blooms (their discussion on limitations, page 9).

I do not think that referring simply to highly scattering waters instead of coccolithophore

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blooms would undermine the paper value. Any subsequent user of the data set can bring his own interpretation of what these high-scattering waters are, depending on the area and season under investigation (even if, admittedly, they are probably most of the time caused by the presence of coccoliths). It might even prevent potential users to actually negatively comment on this data set because they would have found a clear example of such high-scattering waters not being due to the presence coccoliths, whereas the data set "claims" that they are.

The specific goals of this paper are two fold:

1. To produce an atmospherically corrected visible channel  $R_{rs}$  product from the PATMOS-X processed AVHRR climate data record of top of atmosphere reflectances; and
2. To introduce a filtering procedure that isolates the occurrence of coccolithophorid blooms in this record.

Consequently, we would agree with the reviewer with regard to the attribution of the high-reflectance signal, had the filtered product not also been provided. Our feeling is that recasting the paper as isolating 'high-scattering waters' somewhat undermines the work taken to isolate the coccolithophorid blooms through the filtering procedure, and reduces the appeal of the paper.

Previous work by Uz et al., 2013 (Monitoring a sentinel species from satellites: detecting *Emiliana huxleyi* in 25 years of AVHRR imagery), Smyth et al. 2004 (Time series of coccolithophore activity in the Barents Sea, from twenty years of satellite imagery) would not satisfy the reviewers suggestion, despite applying broadly similar, if not less stringent, approaches.

The point regarding the discussion of false positives in the limitations is well taken. However, extensive care has been taken to remove erroneous data, bathymetric and

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high-sediment load effects, low signal contamination at high solar zenith angle and all semi-permanent or 'bright background' signals. Over time, it may prove that the discussion of the limitations of the filtered product may not be exhaustive. However, we maintain that the vast majority of filtered detections would be due to coccolithophorid blooms (as the reviewer themselves kindly notes).

#### **Some minor comments:**

Lines 20-27 page 2: this whole paragraph is rather unclear to me. Not sure what has been done at the end. Maybe this could be expanded a bit.

This paragraph has been entirely re-written to improve clarity, add further information and make better references to how our approach differs from previous work.

Previous, efforts to derive visible channel  $R_{rs}$  from the AVHRR catalogue (e.g. Groom and Holligan (1987) and Smyth et al. (2004)) typically use the raw, instrument counts as a starting point to calculate per-channel TOA radiance. In order to apply this approach across the lifetime of a single AVHRR sensor, the radiance must be calibrated according to the sensor degradation parameters. However, as sensor degradation parameters are only available for AVHRR sensors on NOAA-7, 9, 11 and 14 (Rao and Chen, 1995, 1996), the approach is not applicable for analysis of long-term global signals. Consequently, here we adopt a modified version of the approach used by Groom and Holligan (1987), and updated by Smyth et al. (2004), which uses the TOA reflectances as a starting point for the atmospheric correction procedure. The approach is fully detailed in section 3.1.3.

Per channel TOA reflectances are extracted directly from version 5.3 of the Pathfinder Atmospheres - Extended (PATMOS-x) data set (Heidinger et al., 2014) (available at <https://doi.org/10.7289/V56W982J>) and subsequently referred to here as Px5.3). Px5.3 reflectances are inter-calibrated across AVHRR sensors, and are corrected for sensor degradation throughout. Px5.3 is the first consistently gridded, climate quality data

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record of cross-calibrated AVHRR reflectances. It spans the period from 1979 to the present and contains between two and ten passes per day, dependent on the number of AVHRR instruments operational on the TIROS-N, NOAA and MetOp platforms at the time (Figure 1). The  $R_{rs}$  dataset derived from this record spans from 1979 to 2017, and includes the analysis of 62359 orbits. To calculate  $R_{rs}$ , we use the 0.63  $\mu\text{m}$  (visible; channel-1) and 0.86  $\mu\text{m}$  (near infra-red (NIR); channel-2). Channel-2 is predominantly used to correct for atmospheric aerosol effects, as the ocean is assumed to be dark in the NIR (e.g.  $R_{rs}=0$ ).

Line 21 page 3: could the authors have used a lower threshold, to account for the fact that observations will anyway be hardly exploitable for large sun zenith angles, roughly above  $70^\circ$ ?

The implementation of a solar zenith angle cut-off is implemented solely as a first pass quality control in the initial data ingestion phase and removes erroneously reported angles throughout the data set. Implementation of a stricter filter (e.g.  $70^\circ$ ), would result in a substantial loss of data coverage, especially at high latitudes, where blooms are common. Later filtering of the data in the quality control 2 stage removes points where the signal becomes unusably low due to the radiometric sensitivity of AVHRR.

Eq. (1): I suspect a “-“ sign is missing before the 0.5 in the denominator.

The reviewer is correct. This has been updated.

Eqs. (1) and (2): maybe Eq. (2) should actually come first, because that is where R is defined, and then the computation of  $R_{rs}$  from R would be Eq. (2). My other comment here is that these equations could maybe be split into a few more equations, to more clearly show the logic.

We agree with both reviewers that the previous presentation of the equations used was not overly logical, and significantly more information on the approaches used is required.

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The order in which equations 1 and 2 were presented has been reversed, and more information is given on the treatment of the data as a whole. As part of this process, the equations which are used to correct various atmospheric contributions are now presented separately. These changes have resulted in extensive changes to section 3.1.3, which are too extensive to replicate here.

Line 4 page 5: I guess it is “affect”, not “effect”

The reviewer is correct. This has been updated.

Line 7 page 5: “are discarded”

Corrected

Line 19, page 5: “between two and ten”

Corrected

Line 20, page 5: I do not understand the point here. I do not see how missing values could anyway be included in an average. Maybe rephrase.

The phrase: “Missing values are not included in the averaging process”, has been re-written to “Values recorded as missing or filled values in the individual netCDF4 products are masked, and are therefore not included in the averaging process”

Line 19 page 6: “set to zero”

Corrected

Line 25 page 6: “are missing”

Corrected

Line 26, page 6: “not included”

Corrected

First line of the paragraph page 7: “archived on a “

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Corrected

Line 20 page 8: maybe this CZCS map could be included here to facilitate comparison.

Unfortunately, it has not proven possible to obtain a copy of this panel in sufficiently high resolution to be suitable for inclusion in this publication.

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Interactive comment on Earth Syst. Sci. Data Discuss., <https://doi.org/10.5194/essd-2018-81>, 2018.