**Supplementary material 1: atmospheric correction of harmful algal blooms (ACHABs)**

Field data of remote-sensing reflectance, *R*rs(), was acquired during 3 massive blooms (Fig. S1) respectively dominated by the dinoflagellate *Lepidodinium chlorophorum* (16 July 2019, Vilaine estuary, French Atlantic coast), the ciliate *Mesodinium rubrum* (29 March 2021, Vie estuary, French Atlantic coast), and an unknown assemblage of cyanobacteria (2 September 2021, Bolmon lagoon, Mediterranean Sea). The analysis of water samples revealed that the chlorophyll *a* concentration ranged from 4.8 – 24.8 g l-1 during the ciliate red tide, and was around 116.2 g l-1 during the cyanobloom. During the *L. chlorophorum* green seawater discoloration, cell abundance was as high as 33 106 cells l-1.

 

**Figure S1-1.** Examples of field *R*rs() measurements acquired during a bloom of *L. chlorophorum* (in green), *M. rubrum* (in red), or cyanobacteria (in blue), at native hyperspectral resolution (a), and downgraded at MSI spectral resolution (b).

During these 3 blooms, above-water hyperspectral radiometric measurements were performed with an ASD field spectro-radiometer from 350 – 1075 nm at the time of S2 acquisition. The upwelling radiance, *L*u(), downwelling radiance, *L*d(), and sky radiance, *L*sky(), were sequentially measured following a standard protocol (Muller et al., 2000). Following Burggraaff et al. (2020), hyperspectral radiances were then resampled to S2 spectral resolution using MSI spectral response function prior to compute *R*rs(). The air-water interface reflection coefficient of the sky radiance was calculated as a function of wind speed at the time of field measurements (Ruddick et al., 2006).

Concomitant top-of-atmosphere Sentinel-2 images were processed using four different atmospheric correction (AC) methods: GRS (Harmel et al., 2018), ACOLITE (Vanhellemont and Ruddick, 2018), POLYMER (Steinmetz, et al., 2011), and the Case 2 Regional CoastColour (C2RCC) algorithms. For each image, the pixels corresponding to the *in situ* stations were extracted. The performance of the four ACs was evaluated by comparing the satellite-derived vs. *in situ* *R*rs() using standard statistical metrics such as the coefficient of determination (*R*2), root mean square difference (RMSD), bias, and mean absolute difference (MAD). Ten field stations were available for match-up. The nine S2 spectral bands from 443 – 865 nm were pooled together, yielding a total of 90 match-up points. Overall, the performance of the four AC methods was satisfactory (*R*2 > 0.8) and the degree of AC uncertainty was generally low in terms RMSD, bias, and MAD (Table S1). The GRS and ACOLITE algorithms performed best, followed by POLYMER, and C2RCC.

**Table S1.** Performance of the GRS, ACOLITE, POLYMER, and C2RCC AC algorithms. *N* corresponds to the total number of match-up points.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | *N* | *R*2 | RMSD  | bias  | MAD  |
| GRS | 90 | 0.92 | 0.0016 | -0.0007 | 0.0013 |
| ACOLITE | 86 | 0.93 | 0.0017 | 0.0002 | 0.0013 |
| POLYMER | 85 | 0.88 | 0.0018 | -0.0014 | 0.0019 |
| C2RCC | 80 | 0.84 | 0.0026 | -0.0012 | 0.0020 |

The number of points available for match-up varied between the different ACs (Table S1) because some AC occasionally failed or retrieved negative *R*rs() in the near-infrared spectral spectral bands. Among the four ACs tested here, only the GRS algorithm was able to retrieve consistent *R*rs() for all stations and all spectral bands (Fig. S2). The GRS algorithm was therefore selected because it performed well in the case of massive blooms, and contains a robust deglinting algorithm (Harmel et al., 2018).



**Figure S1-2.** Match-up between S2-derived and concomitant field *R*rs() measurements, using the GRS AC. Each color represents a single S2 spectral band. The solid black line shows the linear fit for all bands; the 1:1 line is in dashed.

**References**

Harmel, T., Chami, M., Tormos, T., Reynaud, N., and Danis, P.A. 2018. Sunglint correction of the Multi-Spectral Instrument (MSI)-Sentinel-2 imagery over inland and sea waters from SWIR bands. Remote Sens. Environ. 204, 308-321.

Mueller, J.L., Davis, C., Arnone, R., Frouin, R., Carder, K.L., Lee, Z.P., … and McLean, S. 2002. Above- water radiance and remote sensing reflectance measurement and analysis protocols, NASA Tech. Mem., TM-2002-210004, 171–182.

Ruddick, K., De Cauwer, V., Park, Y.-J., Moore, G., 2006. Seaborne measurements of near infrared water-leaving reflectance: The similarity spectrum for turbid waters. Limnol. Oceanogr. 51, 1167-1179.

Steinmetz, F., Deschamps, P.-Y., and Ramon, D. 2011. Atmospheric correction in presence of sun glint: application to MERIS. Opt. Express 19, 9783-9800.

Vanhellemont, Q., Ruddick, K., 2018. Atmospheric correction of metre-scale optical satellite data for inland and coastal water applications. Remote Sens. Environ. 216, 586-597.