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Interactive comment on "Remote Sensing of *Trichodesmium* spp. mats in the Western Tropical South Pacific" *by* Guillaume Rousset et al.

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We thank Reviewer 1 for the useful comments provided and address them below.

1) Rev. 1: This is an interesting paper introducing new ship and airborne spotter observations of Trichodesmium and comparing them with MODIS satellite data, but it is at present poorly prepared and written in rather bad English. Text at the start of section 5.1, for example, seems especially confusing and repetitive. Text and logic both need to be made clearer.

Resp.: The text has been changed accordingly, in several places. For example section 5.1., first paragraph:

"Even with a very strong algal concentration, it is possible that with oceanic weather

conditions such as sufficient wind, Trichodesmium scatters and mixes vertically, i.e., we lose the strong signal in the infrared due to the red-edge linked to mats. We are then in the presence of Trichodesmium concentrations that cannot be detected completely with our algorithm. It is successful to locate highly concentrated surface mats, but is not suited for revealing Trichodesmium when scattered under the surface. These are successful to locate the surface mats, but do not succeed in revealing Trichodesmium filaments and/or colonies when they are not aggregated in sea surface mats. We would need, in such situations, a new algorithm, which would allow estimation of Trichodesmium abundance over the whole upper layer. By examining the Rrs spectra of scattered Trichodesmium, obtained during OUTPACE and other cruises, it was not possible to identify clearly characteristics allowing Trichodesmium detection. We find ourselves dealing with a complex problem and a number of variables that, with our current knowledge, do not allow us to create a new bio-optical algorithm and identify robustly Trichodesmium below the surface. [...] One should notice that only the densest mats of Trichodesmium are detected with this algorithm. The goal was to provide an algorithm that could detect automatically Trichodesmium in a global scale, and thus limiting the false positive detection as best as possible. Finally, the new algorithm is unable to determine the existence of thin superficial slicks and diffuse Trichodesmium in the water column. Trichodesmium quantification carried out during the OUTPACE campaign (Stenegren et al., 2017) revealed high Trichodesmium abundances near the Fiji island, while our algorithm did not detect them (Figure 8)."

Have been changed into a shorter and clearer version:

"The proposed algorithm was designed to detect strong concentrations of floating Trichodesmium mats and limit wrong detections. However, floating Trichodesmium mats are occurring when sea surface is flat as they tend to sink and disperse for rough conditions (Cecile Dupouy, pers. comm.). In such a case, because of the low penetration depth of NIR irradiance (below 1 m), our algorithm failed to detect sinking Trichodesmium mats even in strong concentration. This situation occurred during

OUTPACE cruise, where measurements reveal high Trichodesmium abundances near the Fiji island (Stenegren et al., 2017), while our algorithm was unable to detect Trichodesmium mats (Figure 8).”

2) Rev. 1: The proposed algorithm needs to be better described. Criterion 1 at the bottom of page 7 is dismissed in later text (section 5.1) at “fundamentally a nonsense.” This is a bad start.

Resp.: Because of inappropriate atmospheric correction, near-zero or negative atmospheric corrected reflectances at 678 nm are observed over bloom mats, as already discussed in Hu (2010) and Shanmugam (2011). The result of the overcorrection is indeed “fundamentally a nonsense”. By using the 5-min MODIS scene ‘granule_id_Mkin’, we have tried MUMM (Ruddick et al., 2006), NIR-SWIR (Wang and Shi, 2007) and SWIR (Bailey et al., 2010) more adapted for case 2 waters but we find no improvements and still got negative Rrs. Finally, we used negative Rrs at 678 nm as a convenient threshold to detect bloom mats. To render the algorithm more physical, we also tried to use Rrc at 678 nm only. A new paragraph is added in the discussion section, showing the pros and cons of this simplification.

Hu, C., Cannizzaro, J., Carder, K. L., Muller-Karger, F. E. and Hardy, R.: Remote detection of Trichodesmium blooms in optically complex coastal waters: Examples with MODIS full-spectral data, Remote Sens. Environ., 114(9), 2048–2058, 2010.

Shanmugam, P.: A new bio-optical algorithm for the remote sensing of algal blooms in complex ocean waters, J. Geophys. Res. Ocean., 116(4), 1–12, doi:10.1029/2010JC006796, 2011.

Ruddick Kevin G. , De Cauwer Vera , Park Young-Je , Moore Gerald , (2006), Seaborne measurements of near infrared waterâĂŘleaving reflectance: The similarity spectrum for turbid waters, Limnology and Oceanography, 51, doi: 10.4319/lo.2006.51.2.1167.

Menghua Wang and Wei Shi, "The NIR-SWIR combined atmospheric correction ap-

proach for MODIS ocean color data processing," Opt. Express 15, 15722-15733 (2007)

Sean W. Bailey, Bryan A. Franz, and P. Jeremy Werdell, "Estimation of near-infrared water-leaving reflectance for satellite ocean color data processing," Opt. Express 18, 7521-7527 (2010)

3) Rev. 1: Criterion 2 is said to be concerned with the red edge, but the criterion uses bands at 748 and 859 nm, while the red edge is at wavelengths shorter than 748 nm, so this cannot be correct.

Resp.: We agree that 748 nm is the upper bound of the red-edge, and the lower bound is <= 700 nm. According to figure 5B of McKinna et al. (2011) and Fig.5 in Hu et al (2010), a positive slope between these wavelengths is observed only over the strongest concentrations of Trichodesmium. Such bloom features (spectral characteristics) have already been pointed by Hu et al. (2010) (high reflectance in NIR (748, 859, and 869 nm)). Rather than using “red-edge” term, we now use “a vegetation effect” in NIR channels only.

Hu, C., Cannizzaro, J., Carder, K. L., Muller-Karger, F. E. and Hardy, R.: Remote detection of Trichodesmium blooms in optically complex coastal waters: Examples with MODIS full-spectral data, Remote Sens. Environ., 114(9), 2048–2058, 2010.

McKinna, L., Furnas, M. and Ridd, P.: A simple, binary classification algorithm for the detection of Trichodesmium spp. within the Great Barrier Reef using MODIS imagery, Limnol. Oceanogr. Methods, 9, 50–66, doi:10.4319/lom.2011.9.50, 2011.

4) Rev. 1: Spectra are shown in Figure 4, and look very similar for Tricho and for “nearby water.” A and B show spectra of Tricho mats, but the red edge is hardly detected. The band at 748nm is not visible in A since its error bars are missing. Similarly for the band at 870nm. All 5 spectra look very similar and detection of Tricho is not made clear.

Resp.: By means of the atmospheric corrections at 859 nm and 748 nm, Rrs at these wavebands are set to zero (explaining the lack of error bars). However it is still possible to observe strong values at 859 nm and 748 nm in the RRc spectrum (Figure 4B). In addition to a negative value for the Rrs (or the clear trough for the Rrc at 678 nm) over mats, the difference between Trichodesmium mat spectrum and "nearby water" (Figure 4C-D) is, according to us, quite visible. The error bar of the figure have been expanded to be more visible. The water spectrum has also been added, helping the comparison between the spectra. Additional information are indicated on the figure for a better comprehension. The legend and the text explaining the figure have been changed accordingly.

5) Rev. 1: The authors need to better describe the relevant properties of the MODIS satellite imagery. At present, the spatial resolution of 250m is mentioned frequently, even though most spectral bands used have a resolution of 1000m. In both cases, resolution degrades significantly off nadir. Text, for example page 4, lines 15 to 20, seem to suggest that resolution can be chosen and varied for all bands. Text at line 10 on page 9 suggests 250m is the only relevant number. Text at lines 10 to 15 on page 11 expresses it better.

Resp.: The text has been changed to reflect this (section 2.2), see below. Moreover an additional table (Table 1) has been added to show the different bands used, their resolution and their key use by NASA Ocean Biology Processing Group (OBPG).

"We used MODIS atmospheric corrected (aerosol+Rayleigh) reflectances (Rrs) in visible, near-infrared (NIR) and short wavelength infrared (SWIR) at different resolutions: 250 m resolution for bands 1 (645 nm) and 2 (859 nm), 500 m resolution (bands 3-7, visible and SWIR land/clouds dedicated bands), and 1 km resolution (bands 8-16). Bands 8 to 16 are dedicated ocean color bands (Table 1), but we also use information in high-resolution bands located in the visible-NIR region to track floating blooms. To evaluate the influence of resolution on detection performances, Level-2 remote sensing data was produced at both 250 m and 1 km resolutions, with interpolation of 500 m and 1 km channels and aggregation of 250 m resolution channel respectively. The

consequences of these processing are discussed in Section 5. "

6) Rev. 1: Possible confusion with Sargassum is mentioned at several points in the text. This needs further discussion. Are Sargassum mats commonly/occasionally observed in this area? Have pelagic Sargassum species (Natans or Fluitans) ever been observed in the area?

Resp.: To our knowledge Sargassum (natans, fluens) form rafts in open ocean waters only in the Atlantic Ocean. Pelagic Sargassum species were never observed in the studied area (Payri and Richer de Forges, 2000). Sargassum rafts have only been observed in lagoons of French Polynesia (S. polycystum; Andrefouet et al., 2017).

Payri C. and B. Richer de Forges, 2000. Compendium of marine species from New Caledonia. ISSN 1297-9635, Second edition, N° 117, ORSTOM editions, IRD Center of Noumea, 480 pages.

Andréfouët S., Payri C., Van Wynsberge S., Lauret O., Alefaio S., Preston G., Yamano H., Baudel S. The timing and the scale of the proliferation of Sargassum polycystum in Funafuti Atoll, Tuvalu. Journal of Applied Phycology, 29 (6), 3097-3108 (2017).

7) Rev. 1: Something is wrong at the bottom of page 6. MODIS includes all SeaWiFS bands. Gower et al., used MERIS. Was this also a red-edge algorithm?

Resp.: Gower et al. in his algorithm use a little fluctuation near 709 nm to detect Trichodesmium. However in MODIS this fluctuation is not present because the bandwidth is much larger (650-700 nm) and thus cannot be used. The mistake about using SeaWIFS instead of MERIS for the Gower reference has been corrected.

8) Rev. 1: The study area needs better definition. From its name, the Western Tropical South Pacific must be 0 to 23S, 120E to 180E, which is much larger than the area shown in most Figures. Excessive use of acronyms makes the paper harder to read. What are LDB, line 25 on page 9, FSLE at the bottom of page 11? Even WTSP is confusing to those of us who do not live there.

Resp.: Correction made. The acronyms has been explicitly described. The WTSP refers to the Western Tropical South Pacific and is the OUTPACE area which had been set as the default area for the various papers of this special edition.

9) Rev. 1: Descriptions of Figures needs to be improved. Panels B and C are interchanged in Figure 2. Figure 4 is mentioned above. “Research distance” is a strange variable name in Figure 7. It needs to be explained in the caption. Figure 8 seems to show Tricho as light blue areas, but the caption refers to cyan dots.

Resp.: The changes in Figure 4 are mentioned above. Others figures have been updated in accordance to this comment.

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