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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 2 for the useful comments provided and address them below.

1) Rev. 2: The study is very worth publishing. The paper itself could however be (formally) improved: - the descriptions of the algorithms and in particular of the new one (will it be given a proper name?) in §3.4 are a bit fastidious and unclear too much. A multispectral axis diagram could help?

To help the reader, a new section '3.3. Robust spectral features over and near Trichodesmium mats' has been included before section 3.4. Section 3.3. aims at giving details on the main spectral characteristics over floating blooms. We also managed to make the Figure 4 clearer, by comparing with spectra over blue water, used as refer-

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ence.

2) Rev. 2: How the tuning was performed? a simple trial and error?

Resp.: First, a bunch of MODIS spectra over Trichodesmium mats, adjacent and over blue waters pixels as a reference was inspected to detect spectral characteristics of each group. In section 3.3, we discuss the fact that Tricho detection can be achieved by 2 main criteria: a trough in the spectrum at 678nm as well as a vegetation NIR effect at 859nm resulting in positive spectral slope between 748nm and 859nm. We used these two conditions. A condition equivalent to a trough at 678nm in Rrc is Rrs (678 nm) <0 (see section 3.3 for more explanation). Hence the use of the latter condition (equation 1) as well as equation 2 for the NIR. To complete the algorithm, we searched a criteria avoiding false positive due to remaining cloud edges after cloud masking. The best criteria found to eliminate those is described in equation 3. That criteria may be understood by the fact that at these cloud edge pixels, a mixture of water and cloud signals result empirically in a positive spectral slope between 531 and 645nm. This justifies empirically the use of criterium 3.

3) Rev. 2: - the question of the spectral resolution, which differs from one MODIS band to the other must be explained with more precision and rigor. This should also increase the interest of the comments about the mesoscale spatial structuring of the mats.

In accordance to the reviewer's comment, a new table detailing MODIS bands used in this study has been provided. Section 2.2. on Satellite data has been improved as indicated in our response to Reviewer 1's comment 5), see above.

If the reviewer means spatial resolution (because of his/her mention of spatial restructuring), over Trichodesmium mats of few tens of meter large, the 748nm band (1 km resolution) would take much more surrounding water into account than the 859 nm band (250 m resolution). Therefore, even with spatial interpolation of the 748nm band to 250m, the reflectance value in this band remains lower than that at 859 nm. Hu et al. (2010) came to similar conclusions. This explanation was added to the manuscript.

Now regarding spectral resolution, a better spectral resolution (i.e., smaller bandwidth) in the 645 and 859 nm bands, which would favor longer wavelengths in the first band and shorter wavelengths in the second band, would increase the difference between Rrc at 645 and 531 nm and 748 and 859 nm for a better detection. The following sentence was added at the end of Section 3: “Note that a better spectral resolution (i.e., smaller bandwidth) for the 645 and 859 bands, keeping the longest and shorter wavelengths, respectively, would enhance the differences between Rrc at 645 and at 531 nm and Rrc at 748 and at 859 nm, facilitating Trichodesmium detection."

4) Rev. 2: - the authors might force themselves to split in two as many as possible of their sentences. Beside the gain in fluidity, most of the rather numerous illogicisms should disappear in the process.

Resp.: This was also requested by the first reviewer. The text has been changed to be clearer, see Reviewer 1, comment 1).

5) Rev. 2: - The authors write several times that wind mixing could be responsible of the non detection of Tricho. mats. Did they actually met a situation where detection disappeared after a wind event?

The situation where detection disappeared after a wind event was frequently observed in the open ocean around New Caledonia and also inside the lagoon. During the 9 Diapalis (DIAzotrophy in the PAcific zone with ALIS) cruises around New Caledonia, slicks were observed only in October 2001. Though in February 2003, abundance was 5000 trichomes /L, no slick was observed due to strong wind (25 knots) (Tenorio et al., 2018). At the inverse, in October 2003, thin slicks of Trichodesmium were observed during extremely calm conditions, while global abundance was not very high.

Tenorio, M., Dupouy, C., Rodier, M., Neveux, J.: Trichodesmium and other Filamentous Cyanobacteria in New Caledonian waters (South West Tropical Pacific) during an El Niño Episode, Aquatic Microbial Ecology, 2018

6) Rev. 2: - How the immersion effect could be unmixed from the effect of a varying abundance?

The immersion effect is a major problem for slick and mat detection. Indeed, the interpretation of Remote sensing reflectances (Rrs) is complicated by the vertical structure of inherent optical properties in the ocean surface layer. The influence on reflectance of a thin deep layer (at 2.5 m) versus a surface layer has been discussed in Petrenko et al. (1998). They conclude that the deeper the layer, the more unreliable the estimation of the chlorophyll concentration derived with algorithms based on reflectance ratios. For example, during Diapalis cruises, deep chlorophyll peaks measured in-situ due to thin layers of Trichodesmium colonies observed at 5 and 10 meters were associated with no or low surface abundance derived using ocean color algorithms. Having said that, we agree that at this stage it is not possible to distinguish between the two effects. In this article, we concentrate on the special case of surface accumulations by convergence of winds or currents. Our algorithm is not suited for detection of subsurface accumulations.

Petrenko, A.A., J.R.V. Zaneveld, W.S. Pegau, A.H. Barnard, and C.D. Mobley. 1998. Effects of a thin layer of reflectance and remote-sensing reflectance. Oceanography 11(1):48–50, https://doi.org/10.5670/oceanog.1998.15.

7) Rev. 2: line 31-32 page 6: the sentence does not make sense/ 709 nm instead of 700 nm ? and MERIS instead of SeaWiFS ?

Resp.: The confusion between SeaWiFS and MERIS has been corrected, as well as the wavelength used in the MCI algorithm by Gower et al. (2014).

8) Rev. 2: line 15-23 page 12: Âń MODIS-Terra and MODIS-Aqua satellite sensors are acquiring data since 2000 and 2002 respectively. However, the data quality of these sensors is becoming more and more uncertain with time going by, as their mission was not expected to last more than 6 years. " Âż mainly the older TERRA is affected. did the authors meet difficulties with AQUA?

It is well known that MODIS/Terra (and Aqua) is suffering from multiple issues detailed by Franz et al. (2008), but efforts were conducted by the NASA OBPG to provide Ocean Color retrievals based on Terra, to complete the time serie from Aqua. Cross-calibration operations and validation of MODIS /Aqua and /Terra reflectances with in-situ data are periodically updated by NASA OBPG. For example, results from the last R2018.0 reprocessing of MODIS/Terra show that Terra reflectances compare well with in-situ observation (see https://oceancolor.gsfc.nasa.gov/reprocessing/r2018/terra/). We were not concerned by issues affecting the quality of water-leaving radiances derived from Aqua and Terra, and we did not make any comparison between Aqua and Terra to judge the detection performance of Trichodesmium.

Byran A. Franz, Ewa J. Kwiatowska, Gerhard Meister, Charles R. McClain, "Moderate Resolution Imaging Spectroradiometer on Terra: limitations for ocean color applications," Journal of Applied Remote Sensing 2(1), 023525 (1 June 2008). https://doi.org/10.1117/1.2957964

9) Rev. 2: " The new algorithm could be adapted to other satellite instruments with similar spectral bands, for example VIIRS onboard NPP and NOAA-20 (1 km resolution) and OLCI onboard Sentinel-3 " Âż OLCI inherited from MERIS the 709 nm band on which the Gower MCI is based. Are the authors sure that their new algorithm would improve on OLCI-MCI ?

Resp.: This algorithm has been created with the automatization process for MODIS in mind. The algorithm is tuned to avoid false positive and likely underestimates the Trichodesmium abundance compared to others, such the Gower MCI based on radiances at 709 nm with spatial resolution 300m or OLCI with similar resolution.

10) Rev. 2: " The 300 m spatial sampling of Sentinel 3 would be perfectly adapted to the detection of mats as we do it on the 250m-resolution MODIS channels. Indeed, studies of small parts of the mats with a better spectral and spatial resolution may lead to better performances with MSI onboard the Sentinel-2 series (10 to 60 m resolution).

"Âż is not the spatial resolution first a problem for the interpretation of the detection itself? (fractional coverage of a pixel by an heterogeneous distribution of algae).

Resp.: As we understand the question, indeed the spatial resolution is the first problem when detecting Trichodesmium. Figure 4 shows the difference in the detection between 1 km and 250 m resolution. At 1 km the Trichodesmium signal is barely recognizable from the water signal. Moreover as discussed in this article the Trichodesmium mat width does not exceed 50 m, and with the decrease of the spatial resolution, the Trichodesmium signal is drown in the water signal. Nevertheless more there are spectral band to analyse the signal better it is. However, if a better spatial resolution is foremost important, a better spectral resolution (e.g., hyper-spectral measurements) would allow, for example, a better detection of the red edge. We deleted “spectral and” and “, at least regarding spatial resolution.” in the second sentence of the text quoted by the reviewer.

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