Modelling *Trichodesmium* optics and buoyancy in the Great Barrier Reef using the eReefs models

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Abstract: *Trichodesmium* is proposed to be an important source of nitrogen in the Great Barrier Reef (GBR) with implications for nutrient cycling and eutrophication. Effective GBR water quality management requires an understanding of the contribution of *Trichodesmium* to the total annual nitrogen budget of the GBR. Satellite ocean-colour data and the eReefs models (Bell 2021, Ani et al. 2023), have been used to estimate the annual contribution of *Trichodesmium* fixed nitrogen to the nitrogen budget of the GBR. Both approaches suggested that the nitrogen fixed by *Trichodesmium* was greater than riverine nitrogen loads exported to the GBR.

To understand the dynamics of *Trichodesmium* in the GBR ecosystem, reliable model simulations of *Trichodesmium* growth, nitrogen fixation and distribution are required. Although the eReefs models have been used to provide detailed spatial and temporal occurrences of *Trichodesmium* in the Great Barrier Reef (GBR) and to quantify its contribution to the total annual nitrogen budget of the GBR, not all important *Trichodesmium* physiological processes were represented by the *Trichodesmium* physiological model. Two key processes that were not considered are the variation of *Trichodesmium* phycobilipigments under varying light conditions and the influence of *Trichodesmium* colony shape and orientation in seawater on *Trichodesmium* buoyancy.

Trichodesmium possess light-harvesting phycobilipigments, namely phycourobilin (PUB) and phycoerythrobilin (PEB) and are the major contributors to light harvesting and photosynthesis. Changes in *Trichodesmium* pigment concentrations occur through the rapid interconversion between PUB and PEB under varying light conditions, which corresponds to the transfer of absorbed energy between photosystems II and I (PSII and PSI) in *Trichodesmium*. Therefore, to improve the modelling of absorption of light across different wavelengths by *Trichodesmium*, the interconversion between PUB and PEB, and photosystem II reaction centre dynamics were parameterised.

Trichodesmium cells aggregate and form single trichomes or larger colonies such as tufts and puffs. *Trichodesmium* possess strong intracellular gas vesicles that generate strong positive buoyancy and facilitate the vertical migration of colonies. The sinking rates of *Trichodesmium* colonies have been reported to be dependent on the shape and size of colonies. Therefore, to better simulate *Trichodesmium* buoyancy in the GBR, the form resistance factor was applied to the sinking velocities of tuft-shaped *Trichodesmium* colonies.

Our model simulations compare well with observations from the Australian Institute of Marine Science Marine Monitoring Program sensor network sites. Our model results show increased *Trichodesmium* PUB concentrations and decreased PEB concentrations in surface waters or under high irradiance. Contrarily, in deep waters or dark conditions, simulated *Trichodesmium* PEB concentrations increased whereas PUB concentrations decreased. Our model results provide improved simulations of *Trichodesmium* optics and buoyancy, and can help to improve the understanding of *Trichodesmium* dynamics for effective GBR water quality management.

REFERENCES

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