Satellite detection of *Trichodesmium* blooms in the Southwestern Pacific

In the oceans, a large portion of the subtropical and tropical pelagic areas are dominated by oligotrophic conditions. The cyanobacterial diazotroph community, composed of unicellular, filamentous, and diatoms-symbiotic (DDAs, diatom-diazotroph associations) forms is dominant. Major species are *Trichodesmium erythraeum* Ehrenberg and *T. thiebautii* Gomont, two species of *Katagnymene* (*K. pelagica* and *K. spiralis* Lemmerman), and *Richelia intracellularis* as components of DDAs [1]. Weak winds (< 4 m s-1) and calm conditions are independent factors which allow accumulations of *Trichodesmium* on the surface of the sea, in particular *T. erythraeum,* which has a stronger positive buoyancy than *T. thiebautii* and *T. contortum* [1]. Observations of *Trichodesmium* accumulations (termed 'mats') around New Caledonia by merchant ships, French Navy, R/V *Alis* and voluntary observers are the result of positive cell buoyancy which brings together trichomes and colonies at the sea surface every summer [2]. *Trichodesmium* is mainly observed around New Caledonia and Vanuatu and a *Katagnymene* form was observed between Niue Island and Tonga in December 2002 [2].

In the southwest tropical Pacific, satellite and aerial observations showed the presence of 3000 km long surface blooms of *Trichodesmium*, mainly around islands of the Melanesian archipelago, i.e. Vanuatu, New Caledonia, and as far east as the Fijian archipelago and the Tonga trench [2]. This area coincides with high nitrogen fixation rates [3]. There are numerous correlations between the observations of surface mats in the ocean and high reflectance on the MODIS satellite, as for example at the East of New Caledonia in 2002 (Fig. 1a) and 2004 (Fig. 1b, Fig. 1c ,Fig 1 d) and in January 2017 (Fig. 1e). In summer 2003, at the peak of a moderate 2001-2003 El Niño, a *Trichodesmium* spp maximum of 4,500 trichomes L^{-1} was observed in the Loyalty Channel, a concentration much lower than in New Caledonia lagoon surface accumulations which can reach 20,000 trichomes L^{-1} [4]. *Trichodesmium* blooms may spread to cover enormous sea surface areas. In December 2014, a huge surface bloom detected by MODIS coincided with observations of *Trichodesmium* mats (Fig. 2a,b) during a SPOT cruise on board R/V *Alis* [5] and was followed until March [6]. Mat observations are

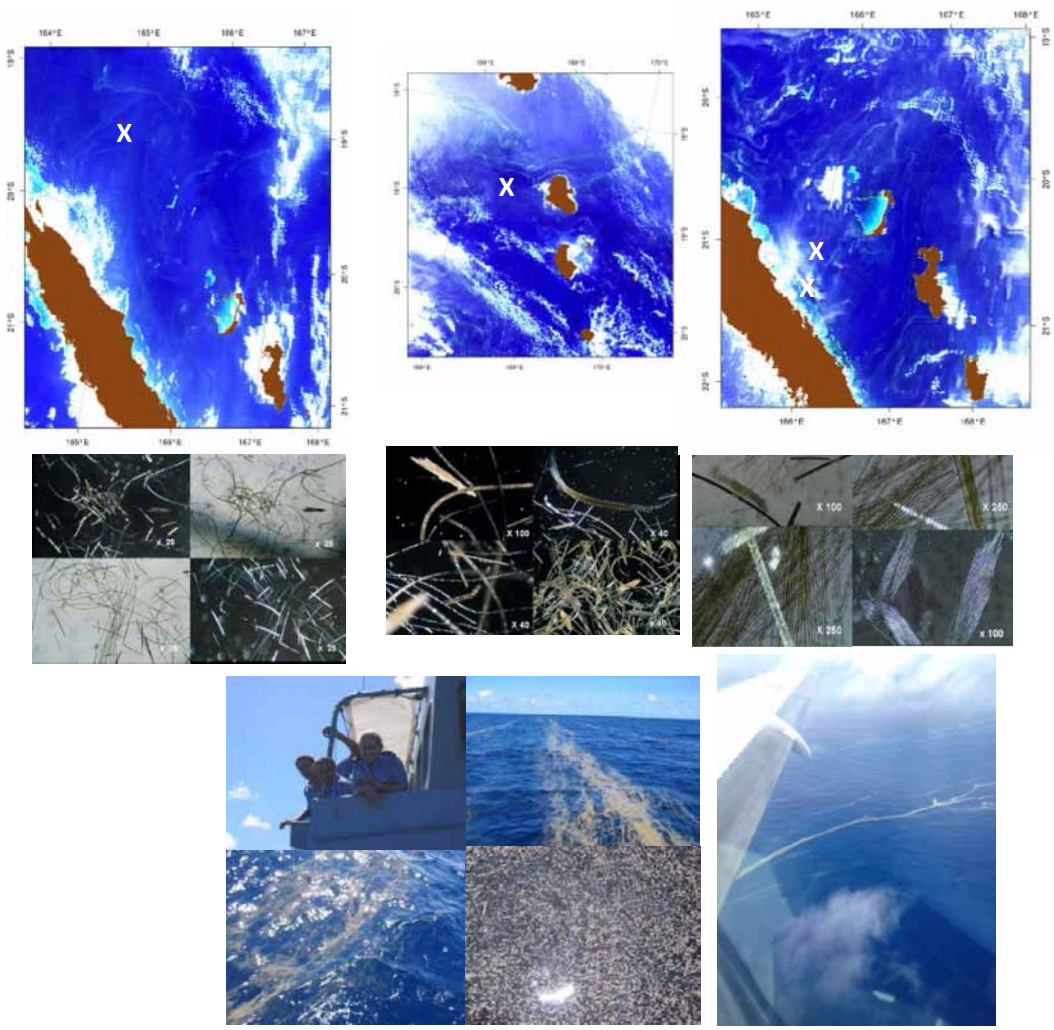

Fig. 1a-c) "True color" MODIS images off New Caledonia showing mats as high reflectance in white around the islands. White crosses: Visual observations corresponding to microscope micrographs of Trichodesmium in formalin fixed samples collected by the French Navy in: November 2002 (a); January 2004 (b); February 2004 (c). d-f): A mixture of different forms of Trichodesmium observed: T. erythraeum, T. thiebautii, and Katagnymene spiralis found in observations on satellite images indicated by a cross. g) Surface Trichodesmium mats (from the French Navy ship La Glorieuse in January 2004). h) Picture of a mat captured during a New Caledonia Gardian airflight in January 2017 (courtesy Jérôme Aucan).

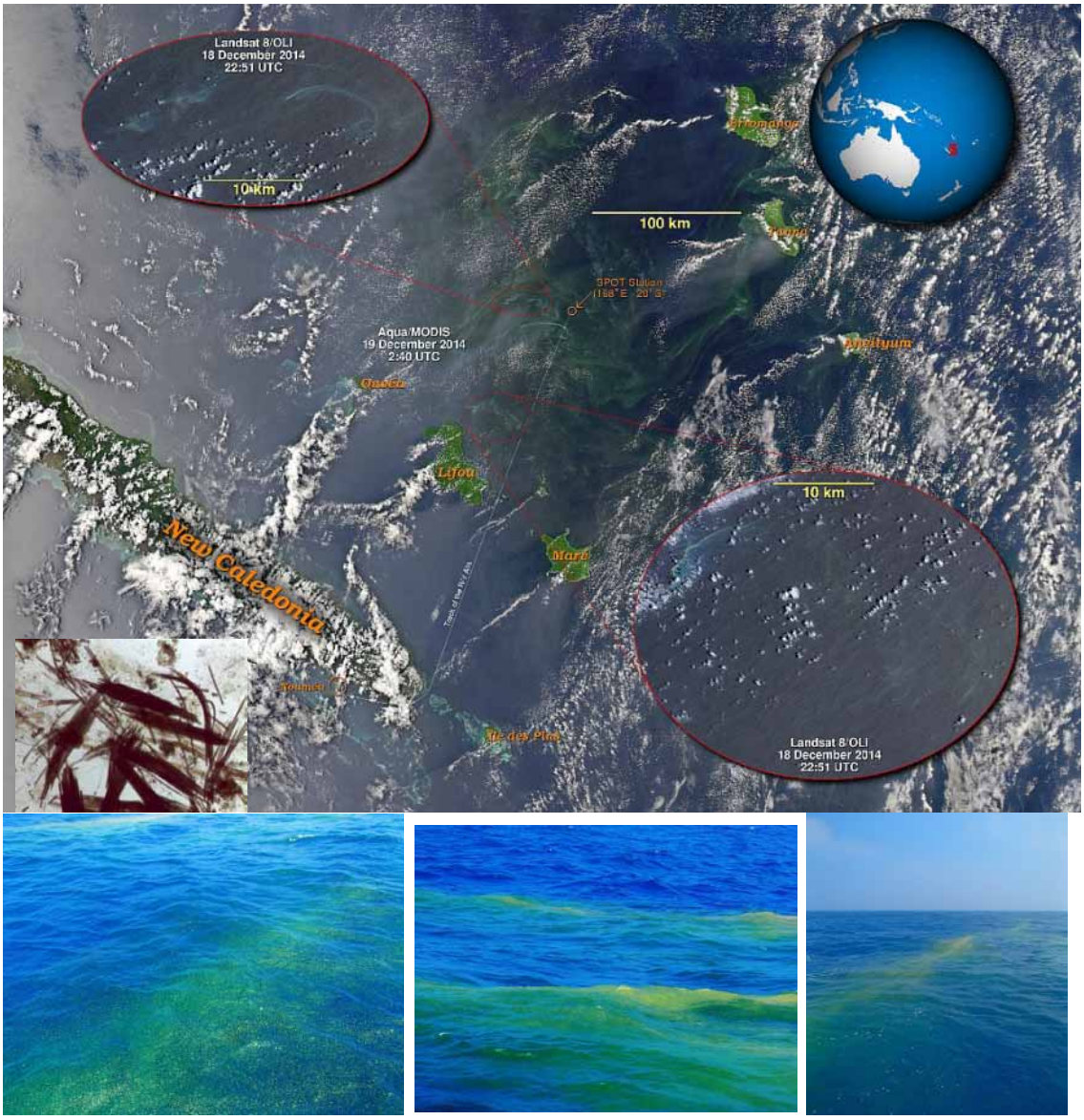

Fig. 2a) MODIS image of the Trichodesmium bloom with white and green mats between Vanuatu Islands and New Caledonia in December 2014; with Landsat 8 zooms on mats superimposed and the microscopic observation of Trichodesmium colonies in surface samples at the SPOT station visited with R/V Alis; b) Pictures of Trichodesmium mats as photographed from R/V Alis. http://earthobservatory.nasa.gov/IOTD/view.php?id=85073

essential for calibrating ocean colour algorithms aimed at detecting filamentous diazotrophs from their particular optical properties. Some of those are pigments (mainly phycoerythrins) absorption and particles backscattering [7] or their ability to float at the surface and present a characteristic optical signature [8]. Application of an algorithm for the satellite detection of *Trichodesmium* mats in oceanic waters of the South Western Tropical Pacific is in progress at the Centre IRD of Noumea [9]. Other phytoplankton blooms around islands in the Tropical Pacific can be detected by MODIS and recent satellite Sentinel sensors. Microscopic identifications of the species involved should be more systematic and observation data centralized.

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