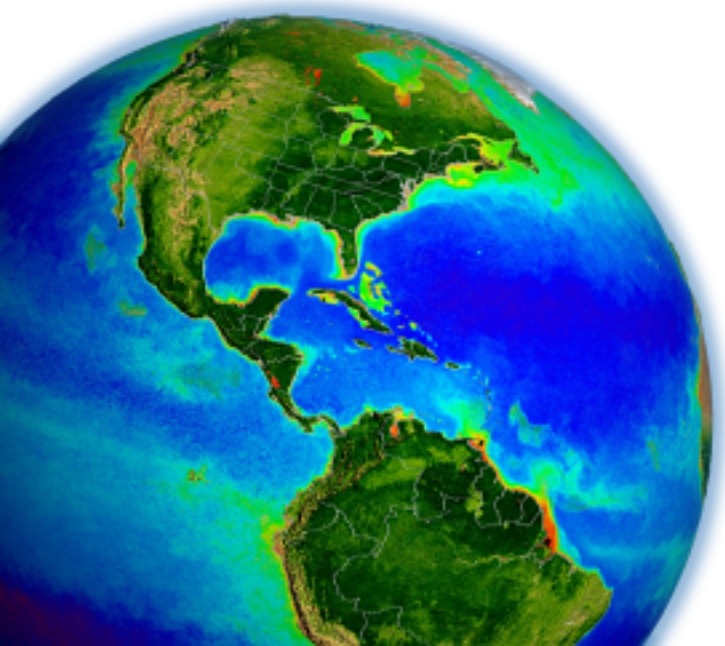
Passive remote sensing surface expressions of *Trichodesmium*:

State-of-the-art, limitations, and future work



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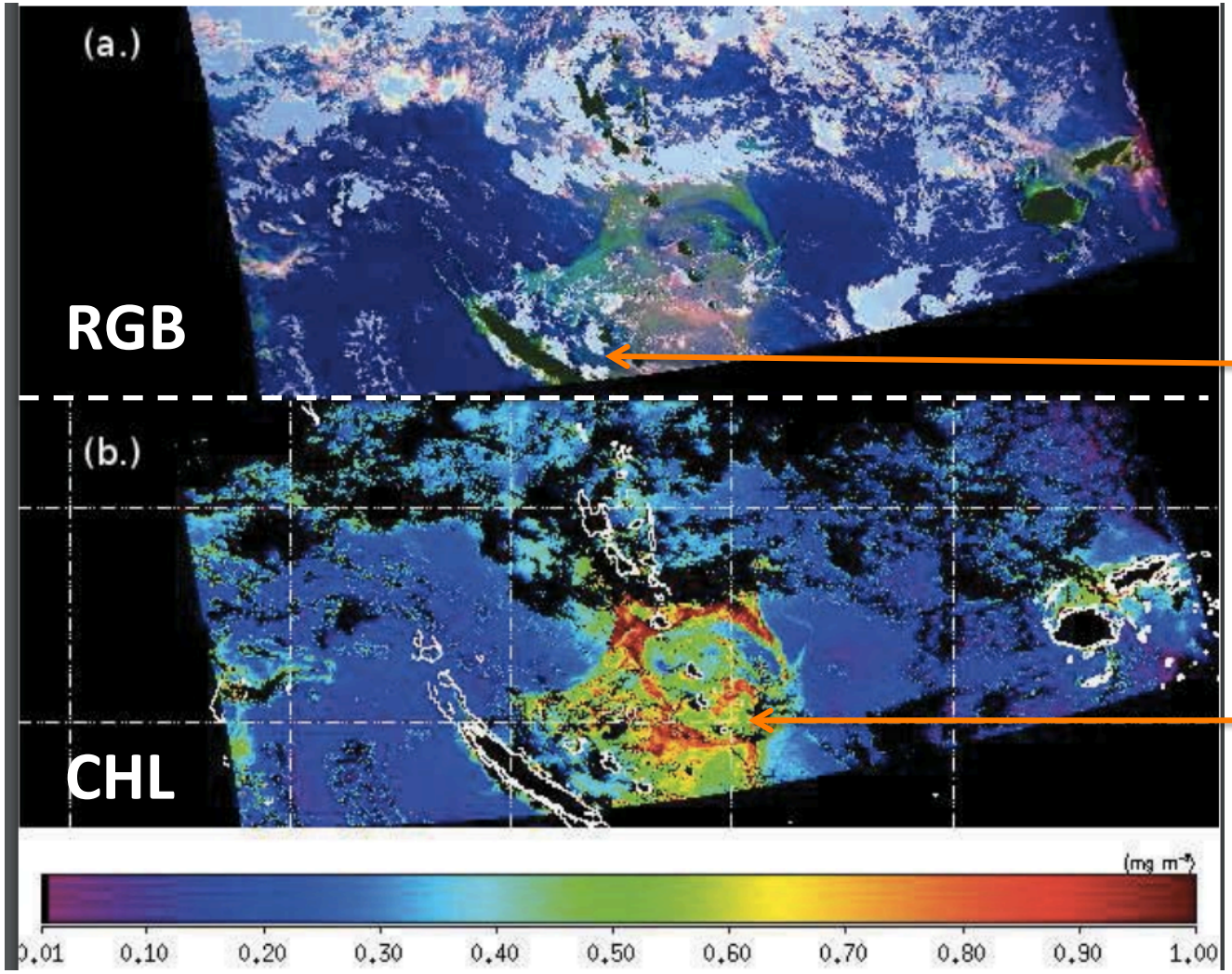
IOCS Meeting
Lisbon, Portugal
15 – 18 May, 2017

International Ocean Colour Science Meeting 2017

Lets go back to…. 4 January 1982
CZCS Image of the southwest tropical Pacific



New Caledonia

Elevated Chl ~90,000km^2

Dupouy et al. (1988)

Historical perspective….

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Review

Three decades of ocean-color remote-sensing *Trichodesmium* spp. in the World's oceans: A review

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Table 9
Chronologically ordered efforts to detect *Trichodesmium* using various satellite ocean-color sensors. Within this table, Y = yes, N = No.

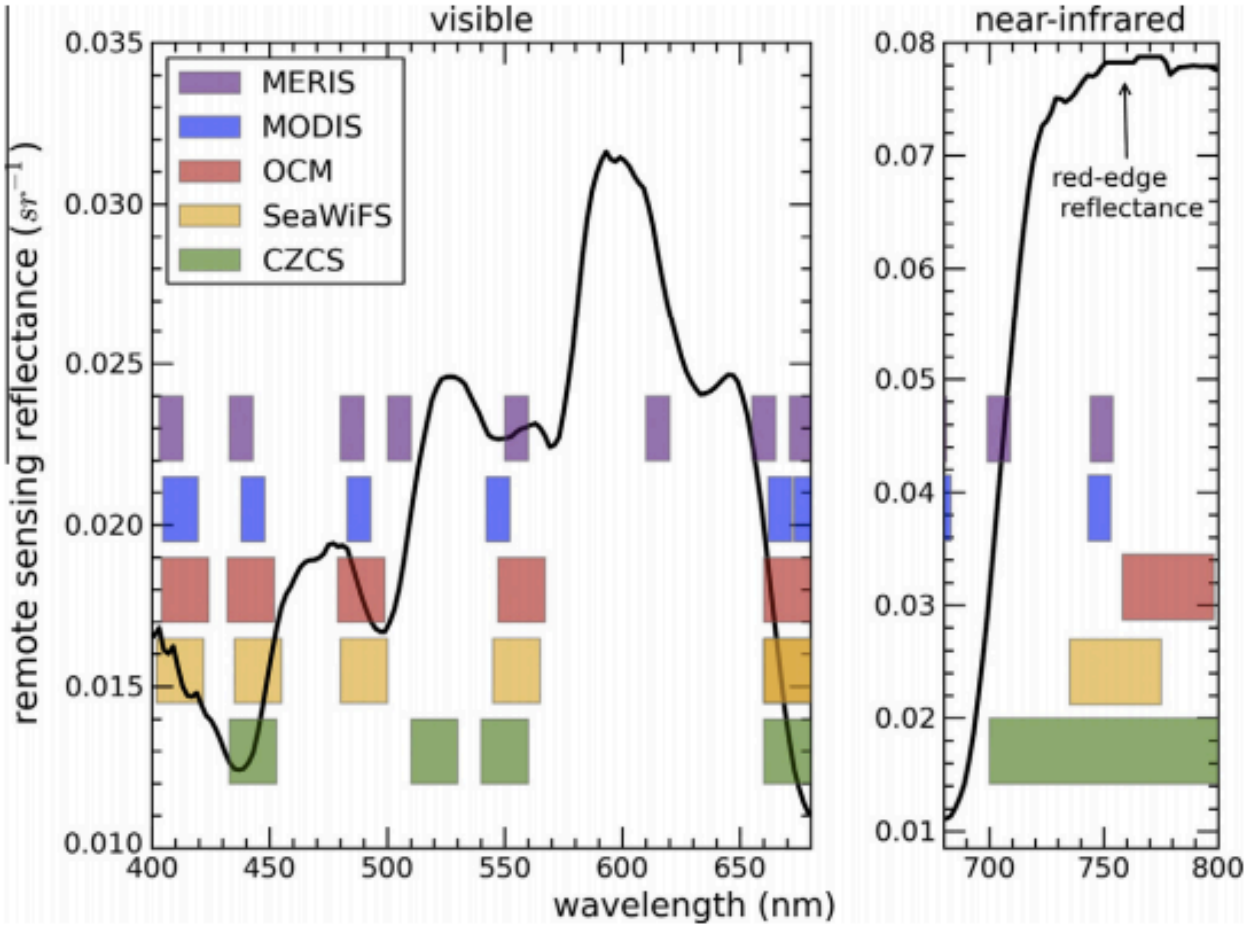
Ocean-color sensor	Year	Location	Coastal zone	Sea-truth	Automated discrimination[a]	References
CZCS	1988; 1992	SW Tropical Pacific	N	N	N	Dupouy (1992) and Dupouy et al. (1988)
CZCS	1992	Western Indian Coast	Y	N	N	Borstad et al. (1992)
CZCS	1994	Western Australia	Y	Y	Y	Subramaniam and Carpenter (1994)
SeaWiFS	1995	Theoretical Study	–	–	–	Tassan (1995)
SeaWiFS	2000	SW Tropical Pacific	N	Y	N	Dupouy et al. (2000)
SeaWiFS	2002	South Atlantic Bight	Y	Y	Y	Subramaniam et al. (2002)
SeaWiFS	2005	Global Dataset	Y	Y	Y	Westberry et al. (2005)
SeaWiFS	2006	Global Dataset	N	N	Y	Westberry and Siegel (2006)
SeaWiFS	2008; 2011	SW Tropical Pacific	N	Y	Y	Dupouy et al. (2008b, 2011)
OCM	2005	Western Indian Coast	Y	N	N	Sarangi et al. (2005)
OCM and SeaWiFS	2005	Western Indian Coast	Y	Y	N	Desa et al. (2005)
MERIS	2008	SE Australia	Y	N	N	Gower et al. (2008)
MODIS	2010	SW Florida Shelf	Y	N	Y	Hu et al. (2010)
MODIS	2011	NE Australia	Y	Y	Y	McKinna et al. (2011)
MERIS	2014	SW Tropical Pacific/Red Sea	N	N	N	Gower et al. (2014)

[a] Automated discrimination – if the method could discriminate *Trichodesmium* from other marine constituents without user interpretation.

State-of-the-art

- Supervised detection of **floating aggregations** (blooms) most common approach
- Aggregations exhibit distinct red-edge and spectral features
- Difficult to detect concentrations >3200 trichomes/L O(1 mg Chl m^{-3})

Remote sensing *Trichodesmium surface* aggregations (scums/slicks/blooms/mats…)



Red-edge line height

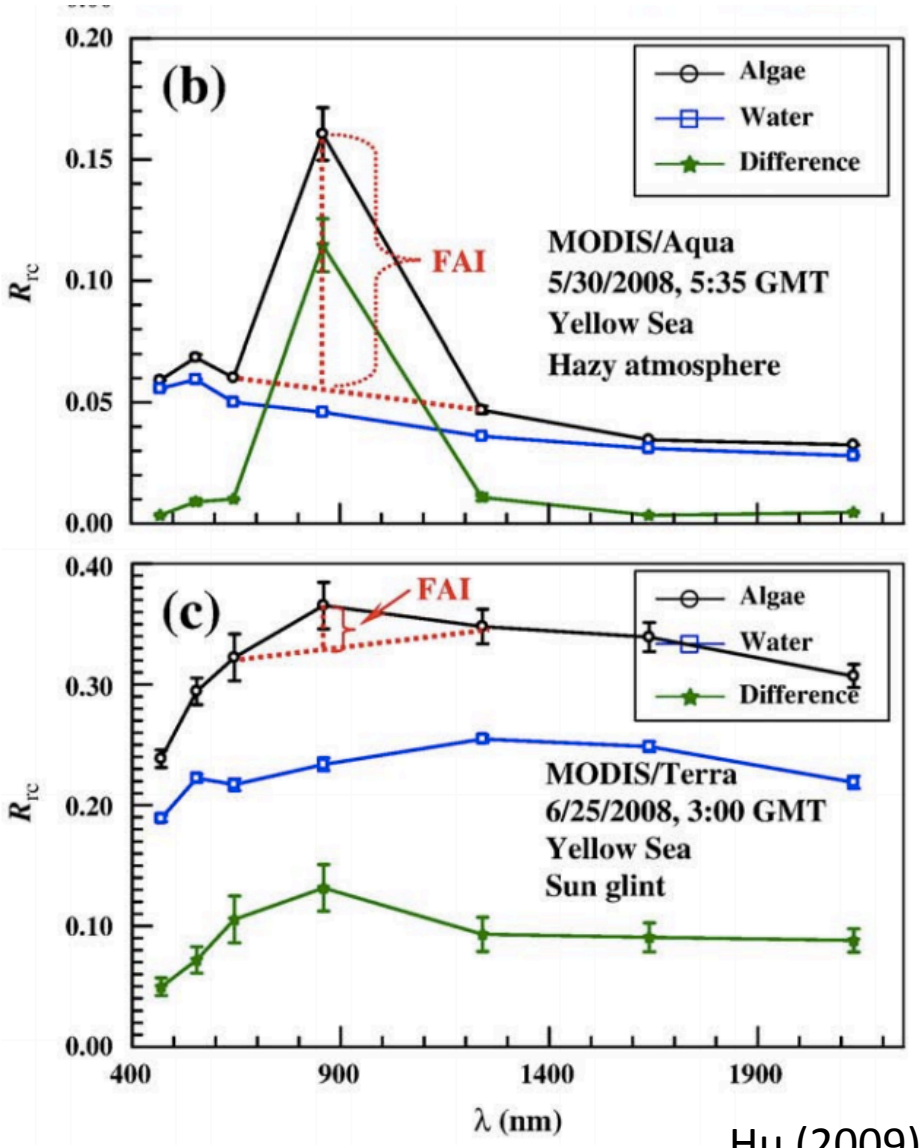
McKinna (2015)

Floating Algae Index (FAI)

$$FAI = R_{rc,NIR} - R'_{rc,NIR}$$

where,

$$R'_{rc,NIR} = R_{rc,RED} + (R_{rc,SWIR} - R_{rc,RED}) \times (\lambda_{NIR}-\lambda_{RED})/(\lambda_{SWIR}-\lambda_{RED})$$



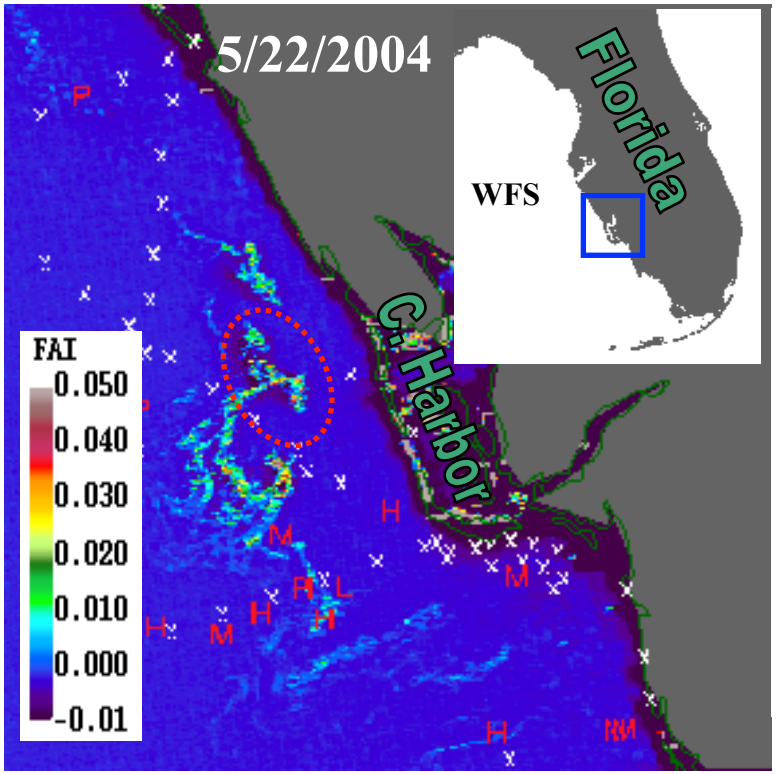
Hu (2009)

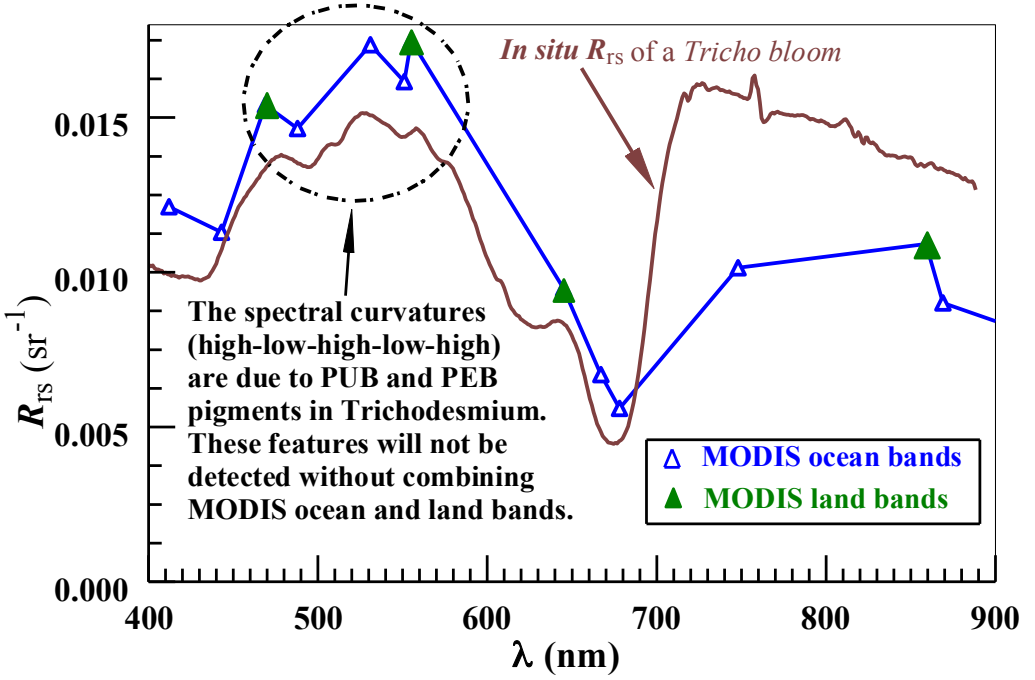
MODIS detects *Trichodesmium* mats

Two steps:

1. **Look for red-edge (Hu, 2009, RSE), then**
2. **Check spectral variations in the blue-green wavelengths using both ocean and land bands (Hu et al., 2010, RSE)**

Requirement: fractional coverage within a pixel must be sufficiently large, otherwise the 2nd step would not work (Hu et al., 2015, RSE)





Credit: C. Hu

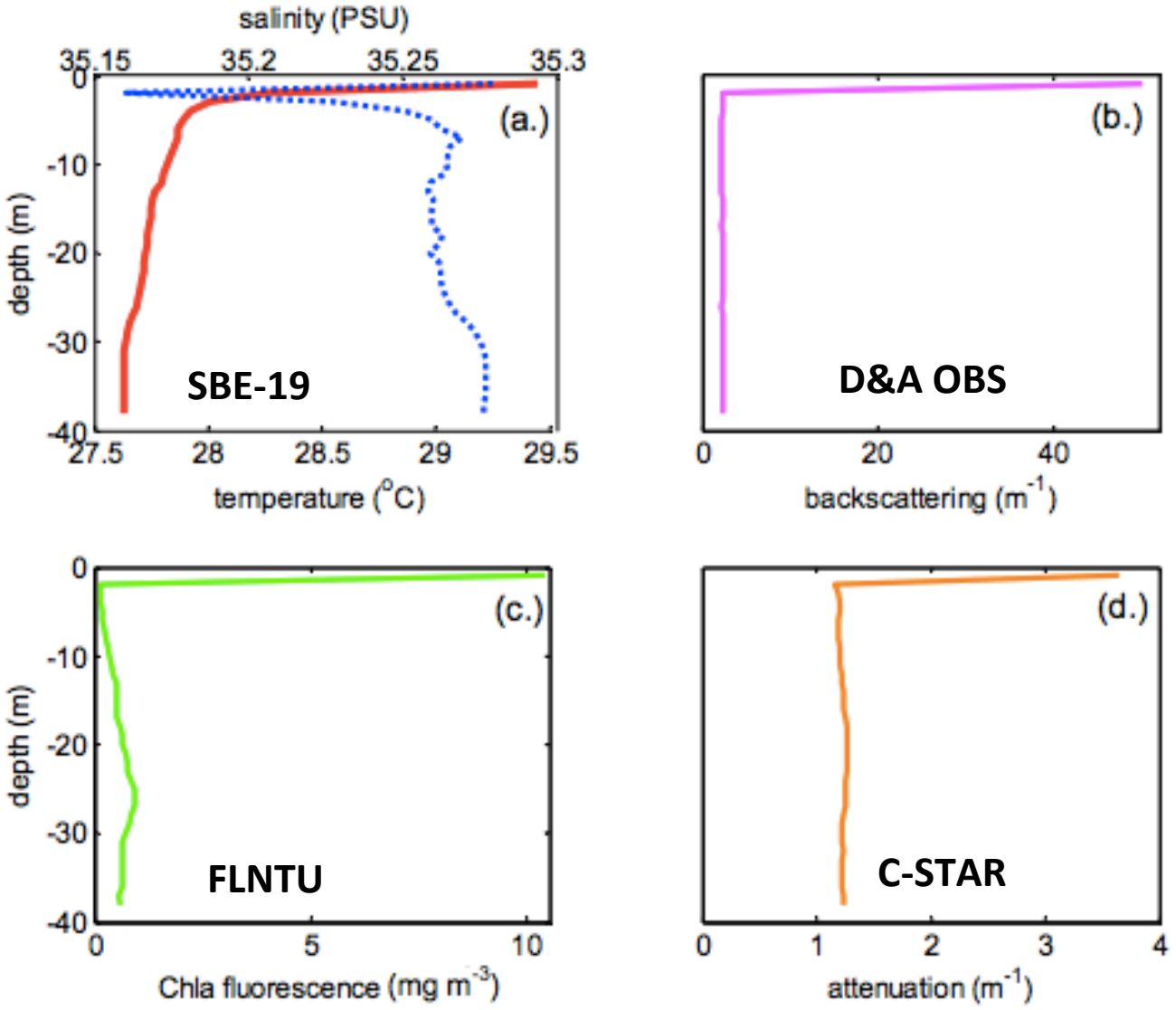
Caveats/limitations

- Vertical distribution

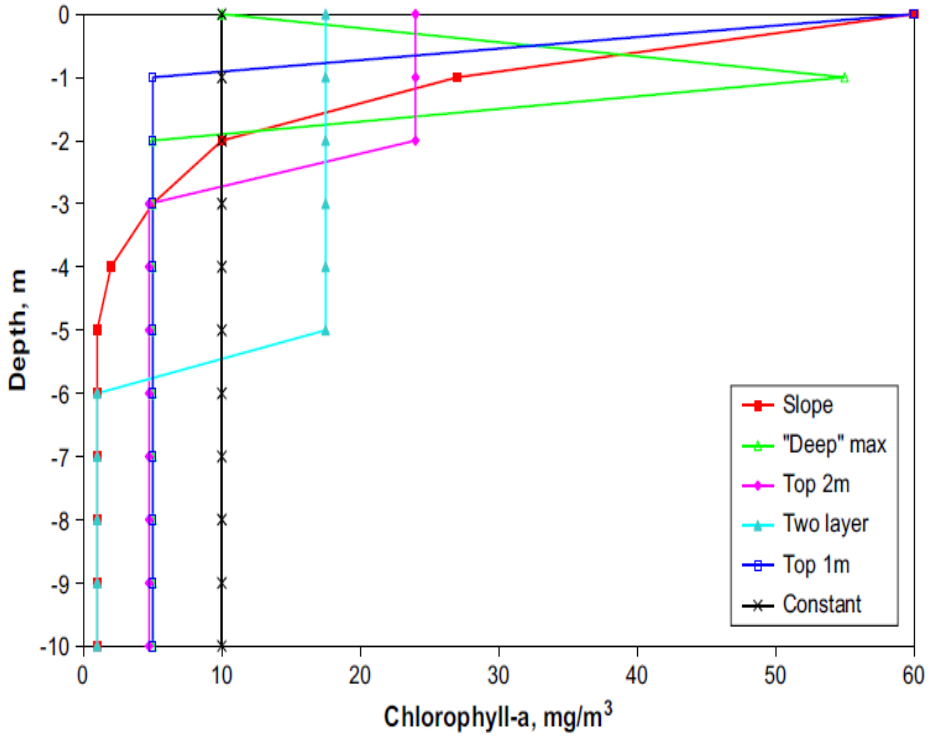
Remote sensing *Trichodesmium surface* (scums/slicks/blooms/mats…)

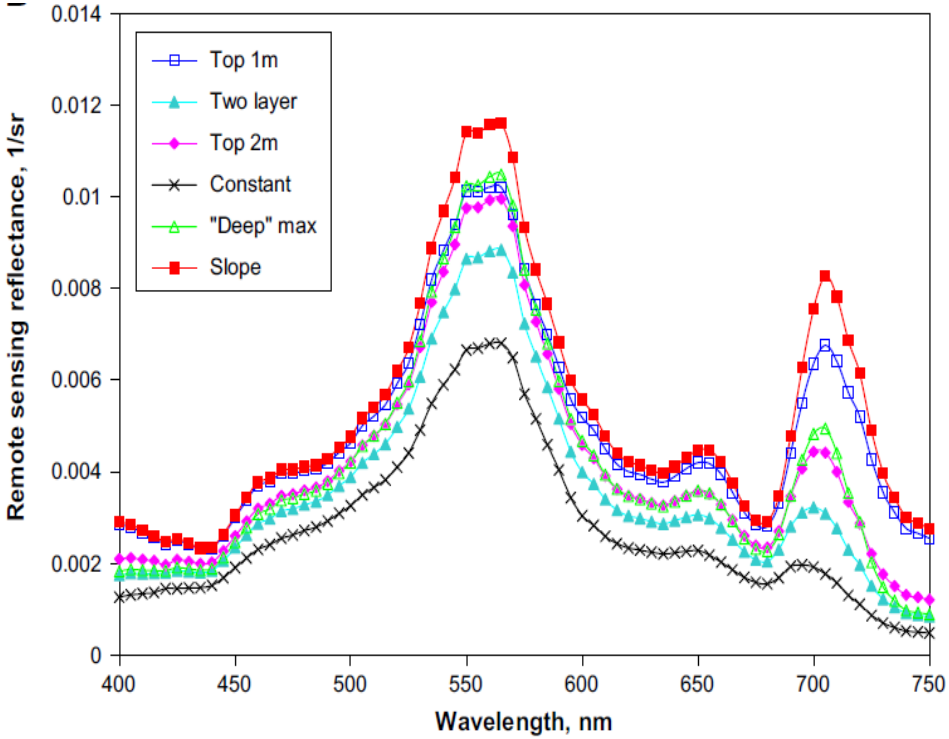
Extreme case O(100 mg Chl m^{-3})
This was pungent!!

Remote sensing *Trichodesmium surface* (scums/slicks/blooms/mats…)



Identical cyanobacerial biomass creates very diferent reflectance





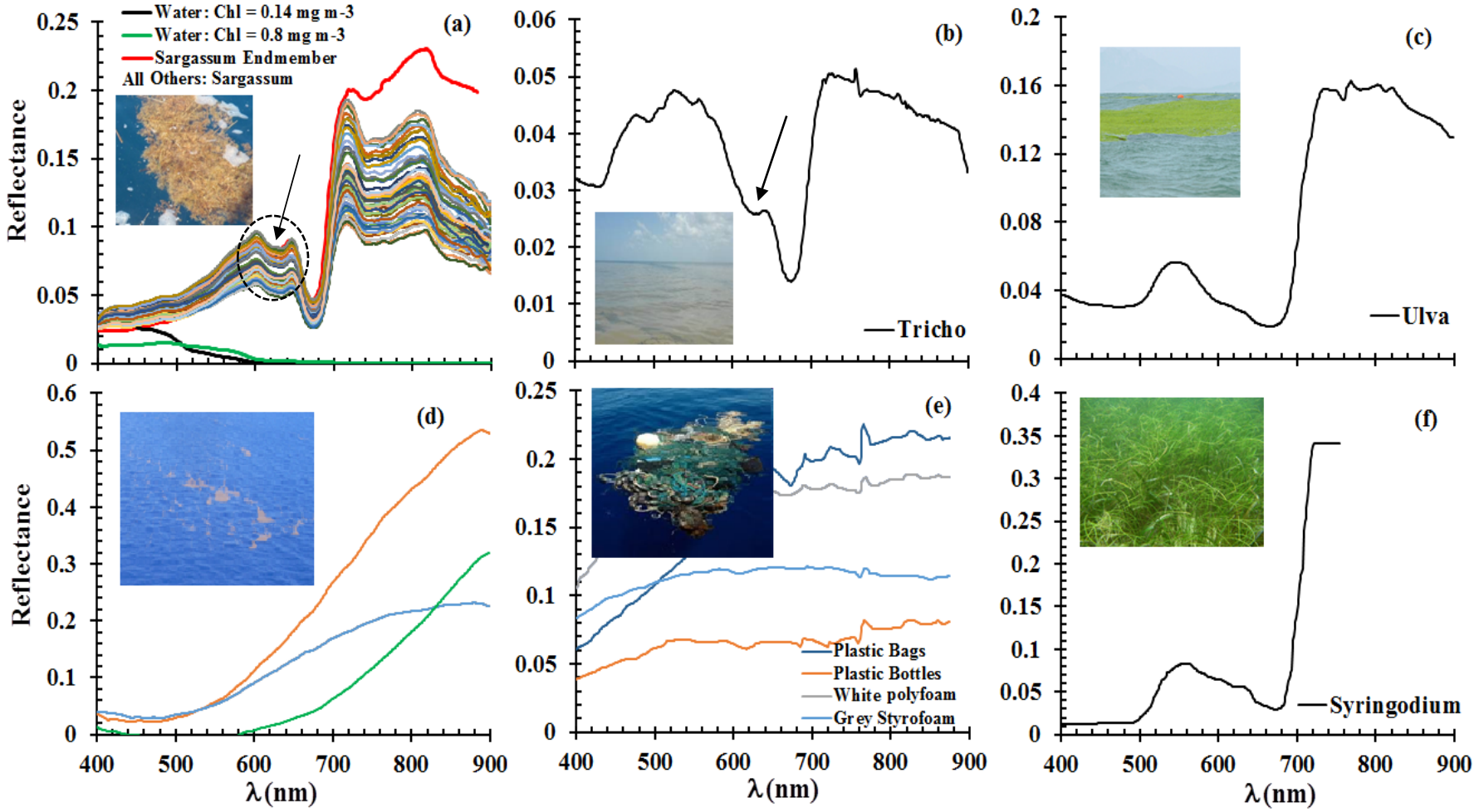
Kutser et al. (2008)

Caveats/limitations..

- Vertical distribution
- Spectral resolution of sensor

Challenge discriminating from other floating material

- Requires appropriately placed bands

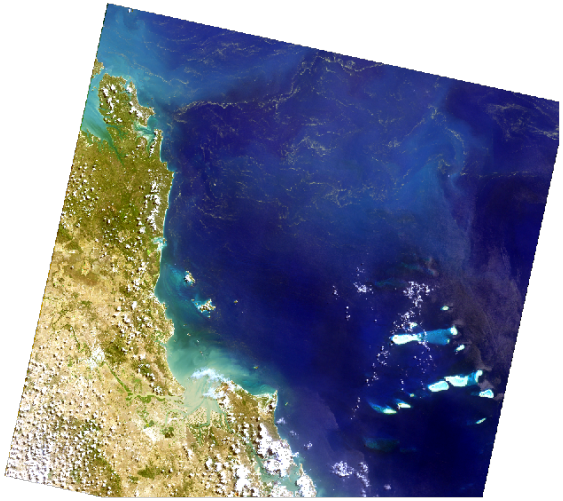


Credit: C. Hu

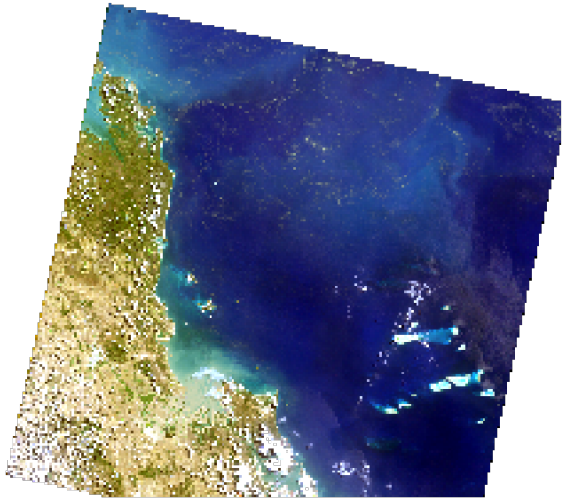
Caveats/limitations

- Vertical distribution
- Spectral resolution of sensor
- Spatial resolution of sensor

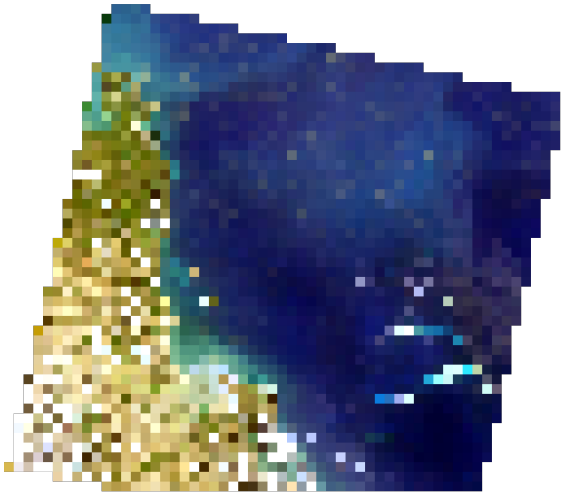
Sensor spatial resolution



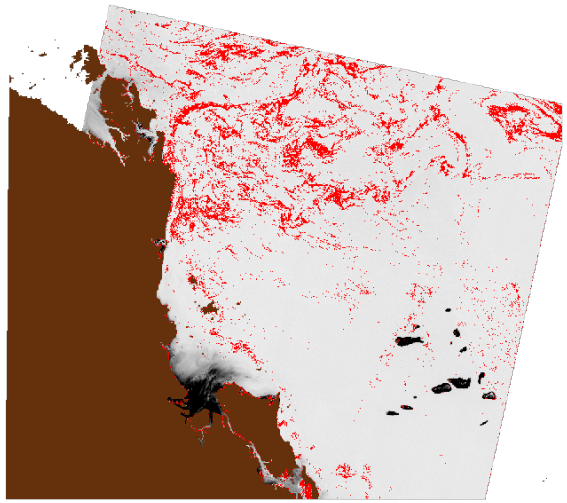
30 m; bloom=2198 km^2

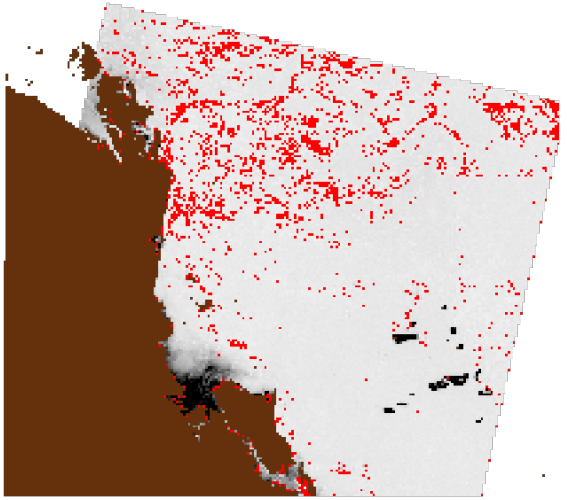


1 km; bloom = 2151 km^2



4 km, bloom=568 km^2





Landsat OLI, 19 September 2014. Capricorn Channel, Australia

Final thoughts….

Exciting times!

- New sensors in orbit or in development
  with improved capabilities

Remaining challenges

- Mixed assemblages
- Atmospheric correction
- Sub-bloom concentrations
- Algorithms are hard to validate
- We are seeing a surface expression, not a volume

  Units: mg Chl m^{-3} OR mg Chl m^{-2}?