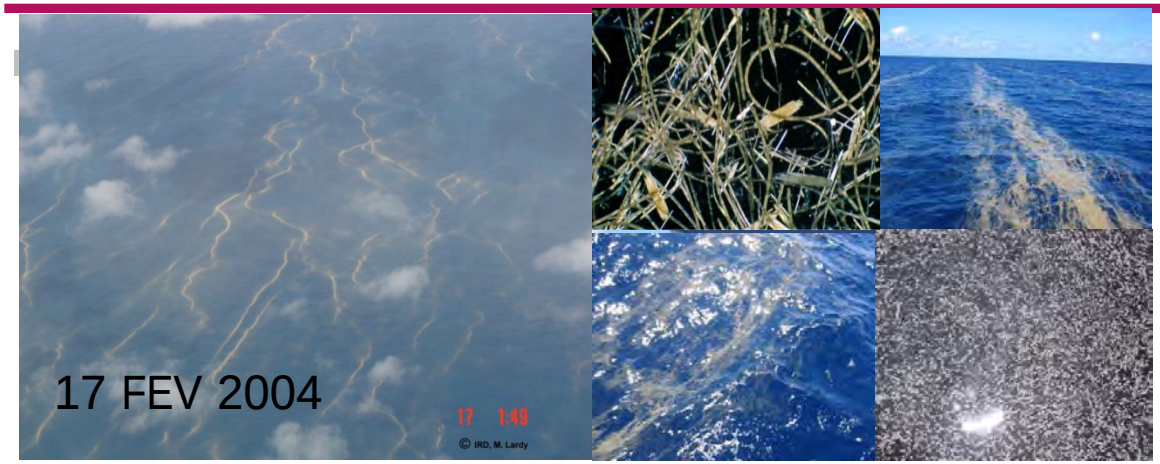
A fractal problem : surface scums how to quantify ?



POSTER IOCS 2017
Rousset et al., 2017

Patchiness (2)

Tenorio, 2006

Confined accumulations in "slicks" with a few kms extension and a few meters large concentrations show vertical low thickness of these accumulations. The 25 october 2002 **Chl*a* < x 366 higher at 1m** and 7 m depth than in the slick and the Chl*c*1+2/Chl*a* = 0 in surface increased towards the bottom (as cyanobacteria do not have accessory chlorophylls).
On the 29th October, there was a decrease of a factor of 4 between the « slick » and 3 meters deep.

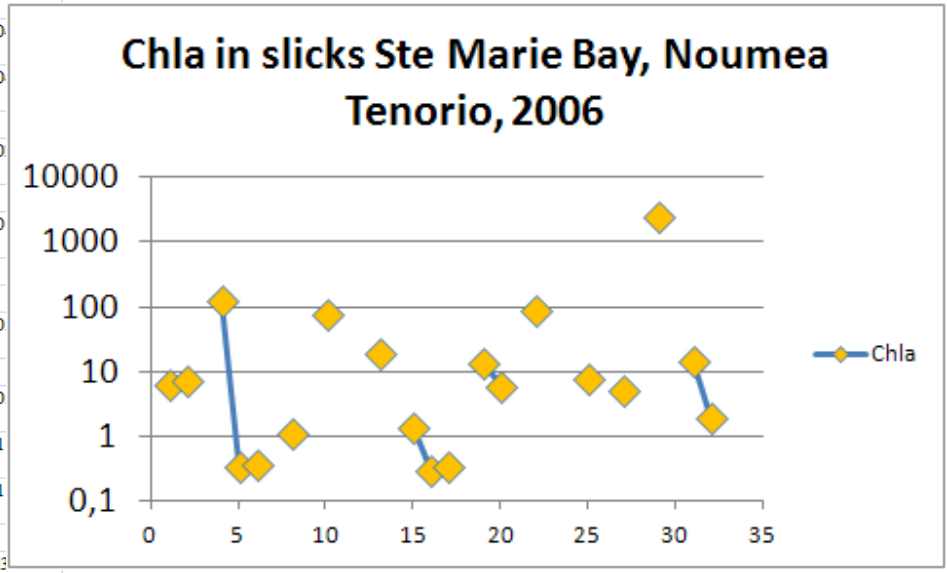
Horizontal distribution also shows abrupt decrease of Chl (a factor of 7) on the 27/12/2002 inside and outside the "slick" Increase of the Chl*b*/Chl*a* and Chl*c*1+2/Chl*a* indicate picoeucaryotic biomass outside the slick

Figure IV.25-A : Accumulations of *Trichodesmium erythraeum* Lagoon New Caledonia South West in *Tenorio 2006*

Weekly Biomass measurements in slicks (*Tenorio, 2006*)

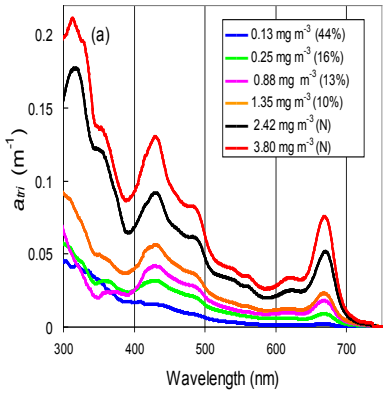
Local	Date	Heure	Filtration	Profondeur (m)	Chl*a*	Chl*b* /Chl*a*	Chl*c* 1-2/Chl *a*
Baie de Sainte Marie	23/10/2002	10h	Totale	"Slick"	6,86	0,000*	0,011*
SP3	23/10/2002	10h	Totale	"Slick"	7,94	0,000*	0,005*
Baie de Sainte Marie	25/10/2002	10h	Totale	"Slick"	131,14	0,000*	0,001*
Baie de Sainte Marie	25/10/2002	10h	Totale	1	0,36	0,042	0,0
Baie de Sainte Marie	25/10/2002	10h	Totale	7	0,38	0,042	0,0
Baie de Sainte Marie	28/10/2002	10h	Totale	0	1,17	0,008*	0,0
			%Chl*a*				
Baie de Sainte Marie	28/10/2002	10h		0	80	0,000*	0,0
			>10µm				
			%Chl*a*				
Baie de Sainte Marie	28/10/2002	10h		0	20	0,062	0,0
Baie de Sainte Marie	29/10/2002	12h	Totale	0	1,46	0,022*	0,0
Baie de Sainte Marie	29/10/2002	12h	Totale	3	0,32	0,09	0,1
Baie de Sainte Marie	29/10/2002	12h	Totale	14	0,36	0,092	0,1
Baie de Sainte Marie	07/12/2002	10h	Totale	"Slick"	13,97	0,000*	0,003
Baie de Sainte Marie	07/12/2002	12h	Totale	"Slick"	6,31	0,012*	0,049
			%Chl*a*				
Baie de Sainte Marie	07/12/2002	12h		"Slick"	92,03	0,005*	0,058
			>10µm				
			%Chl*a*				
Baie de Sainte Marie	07/12/2002	12h		"Slick"	7,97	0,054	0,087
Baie de Sainte Marie	07/12/2002	23h	Totale	"Slick"	5,51	0,000*	0,010*
Baie de Boulari	13/12/2002	13h	Totale	"Slick"	2608	0,000*	0,003*
Baie de Sainte Marie	27/12/2002	12h	Totale	"Slick"	14,85	0,000*	0,014
Baie de Sainte Marie	27/12/2002	12h	Totale	Hors "Slick"	2,01	0,017*	0,177

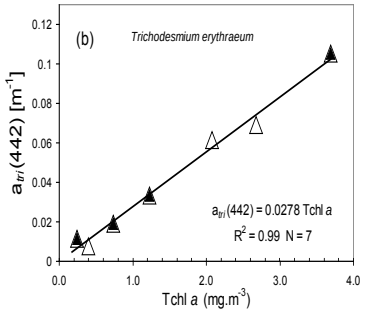
in mg.m^{-3}

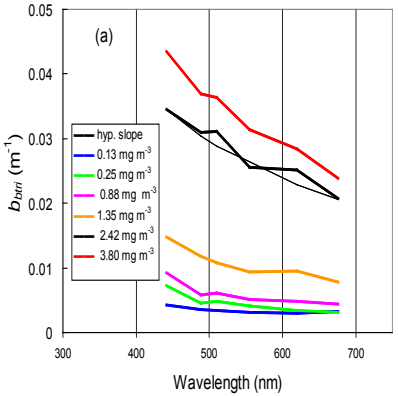


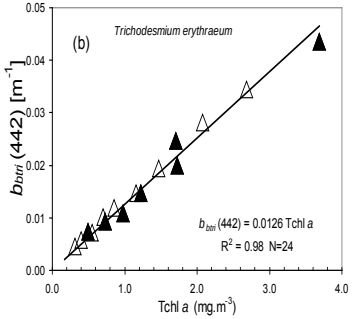
Trichodesmium IOP's (Tricho Bleu Workshop)

A_{part} m^{-1}







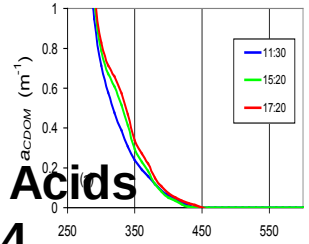


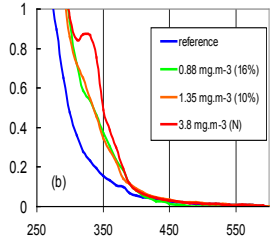
MAA's
330nm, 360nm

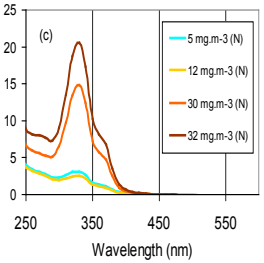
A_{cdom} m^{-1}

Troughs at 440nm, 550nm

Mycosporine-Like Amino Acids (shinorine & Porphyra-334



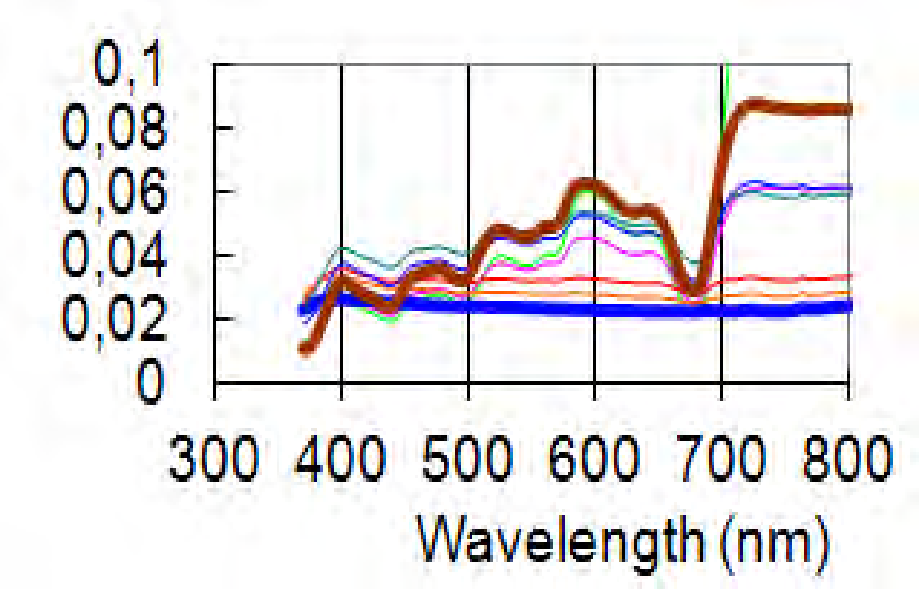




MAA's
330nm, 360nm

Dupouy et al., 2008, JARS

Trichodesmium (floating)



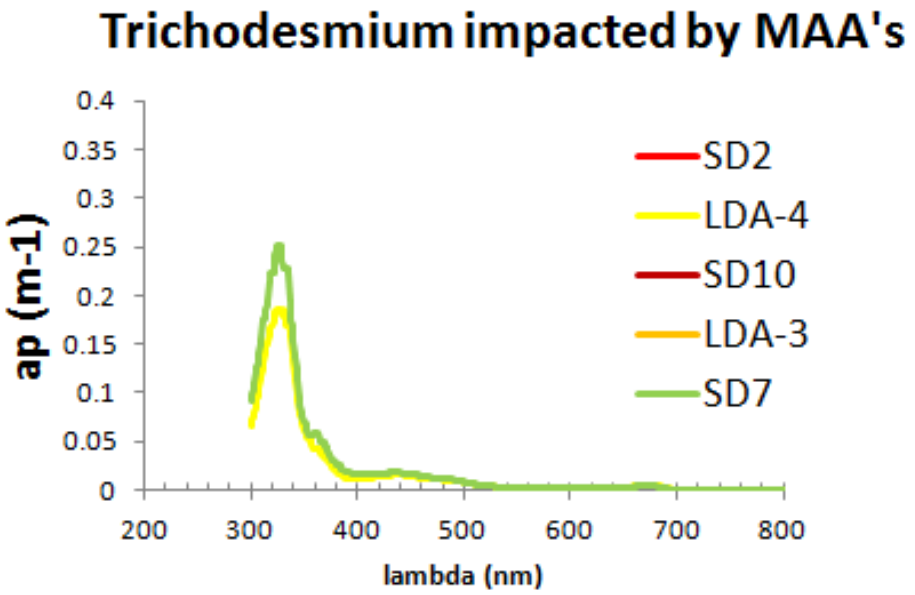
Need a Hyper-Spectral sensor

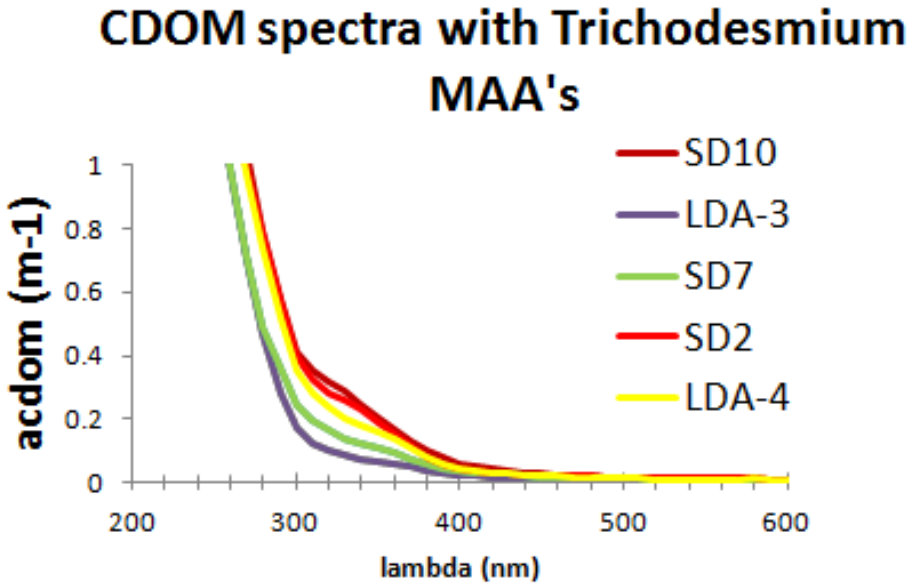
Rrs of accumulation above water

- maximum at 555 nm
- minimum at 443, 490, 520, 670
- increasing suspensions
- above water blooms

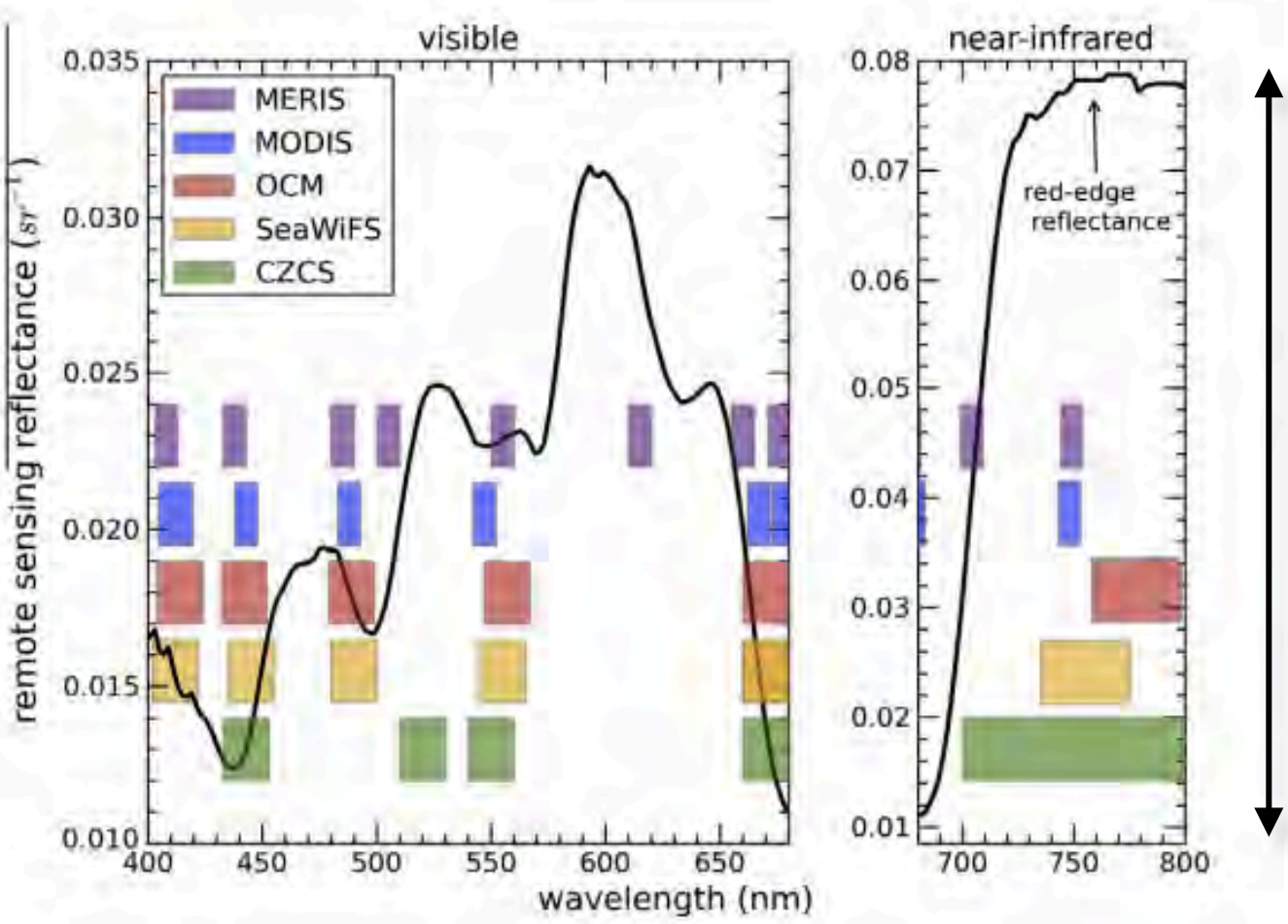
Dupouy, Neveux, Ouillon et al., 2008, JARS
McKinna et al., 2011

Outpace cruise Aps & CDOM in Trichos patches





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

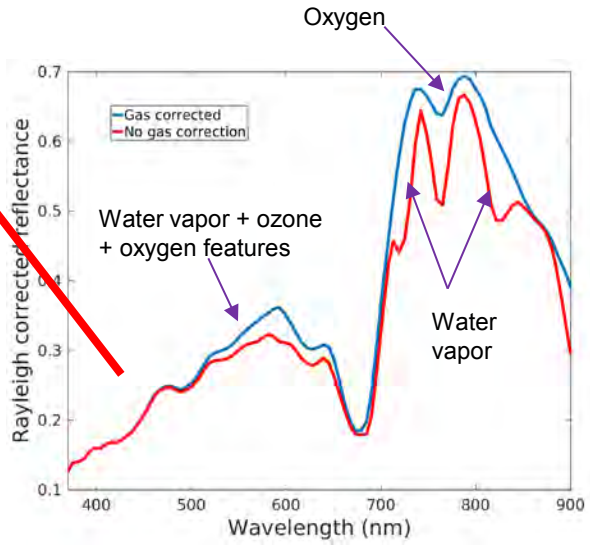


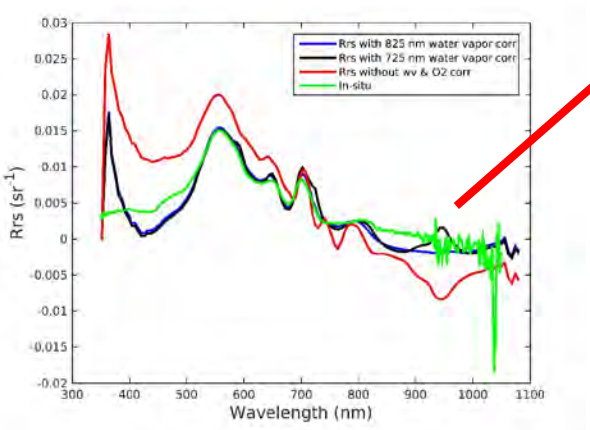
Red-edge line height

McKinna (2015)

Why do we need to compensate for absorbing gases in the AC?

- Absorbing gases including: water vapor, oxygen, ozone and nitrogen dioxide modulates the measured TOA radiance significantly within the visible spectrum.
- A correction algorithm for gases is need to remove the unwanted spectral features in ocean reflectance.
- Erroneous correction of gases can significantly degrade ocean color data quality and plankton type algorithms

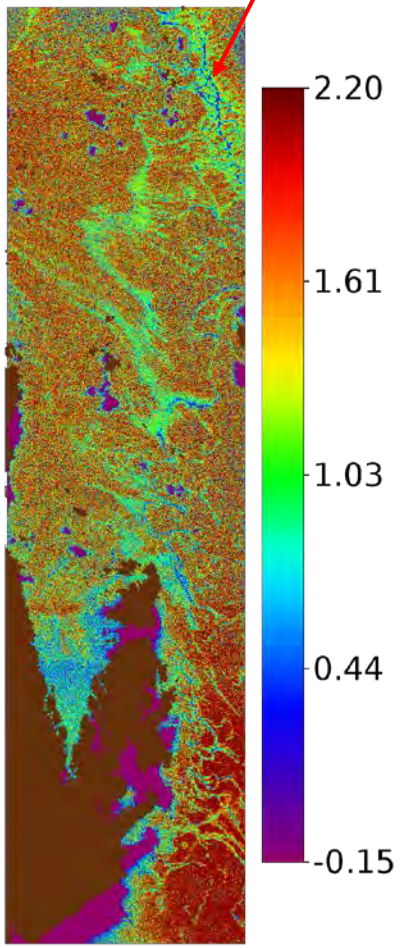




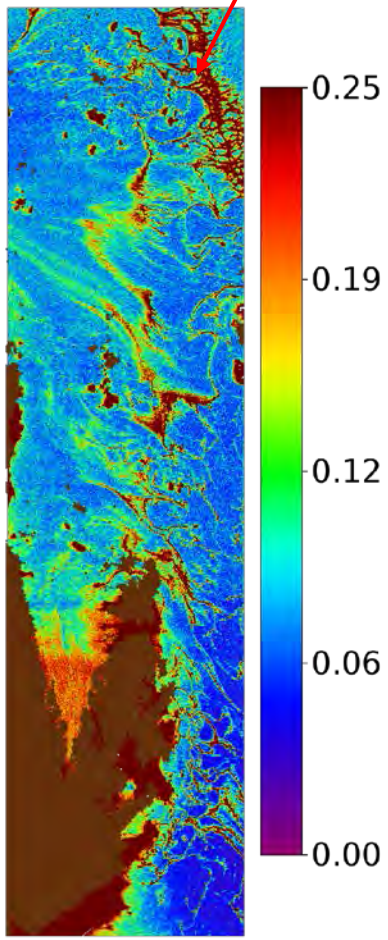
HICO Example

Surface Trichodesmium blooms

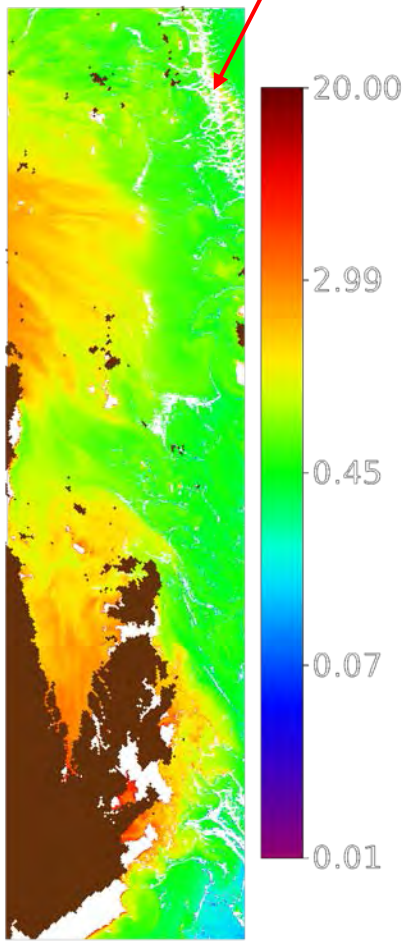
Erroneous aerosol model selection



Over estimation of aerosol optical thickness

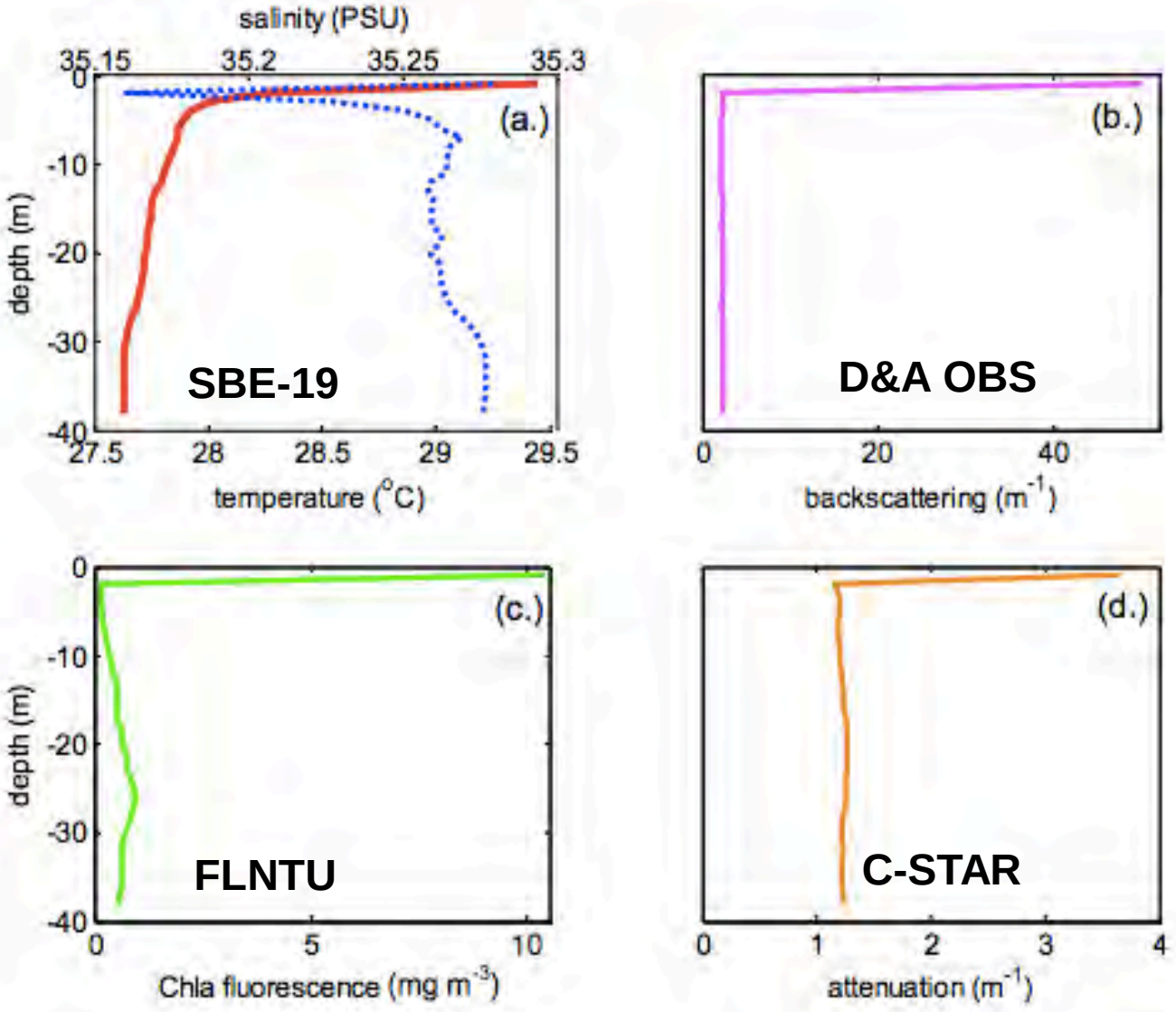


CHL product because of negative Rrs

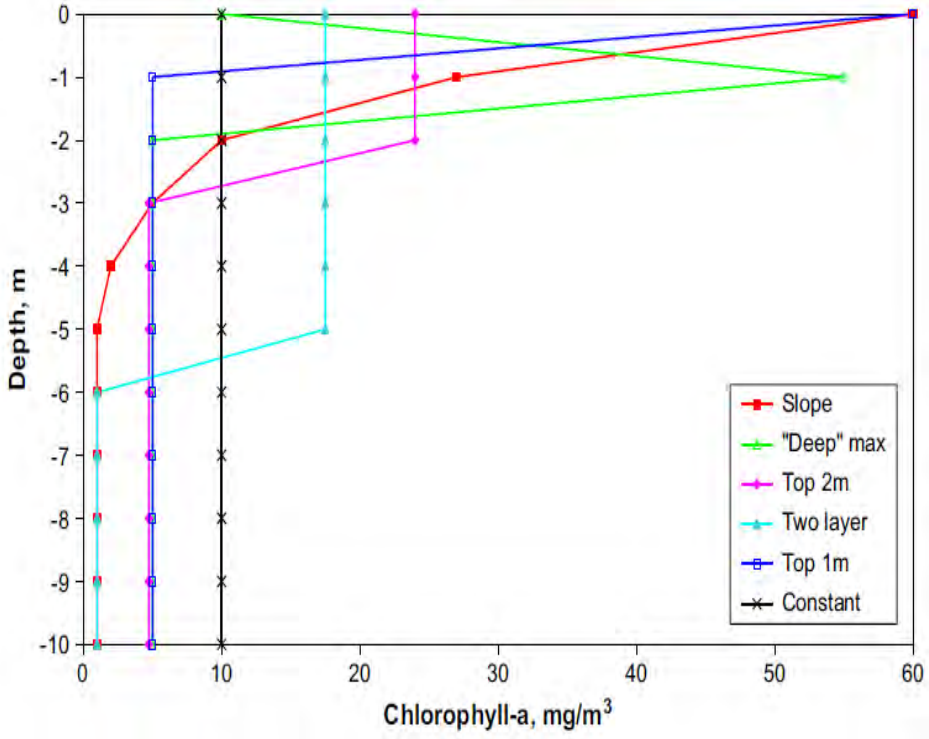


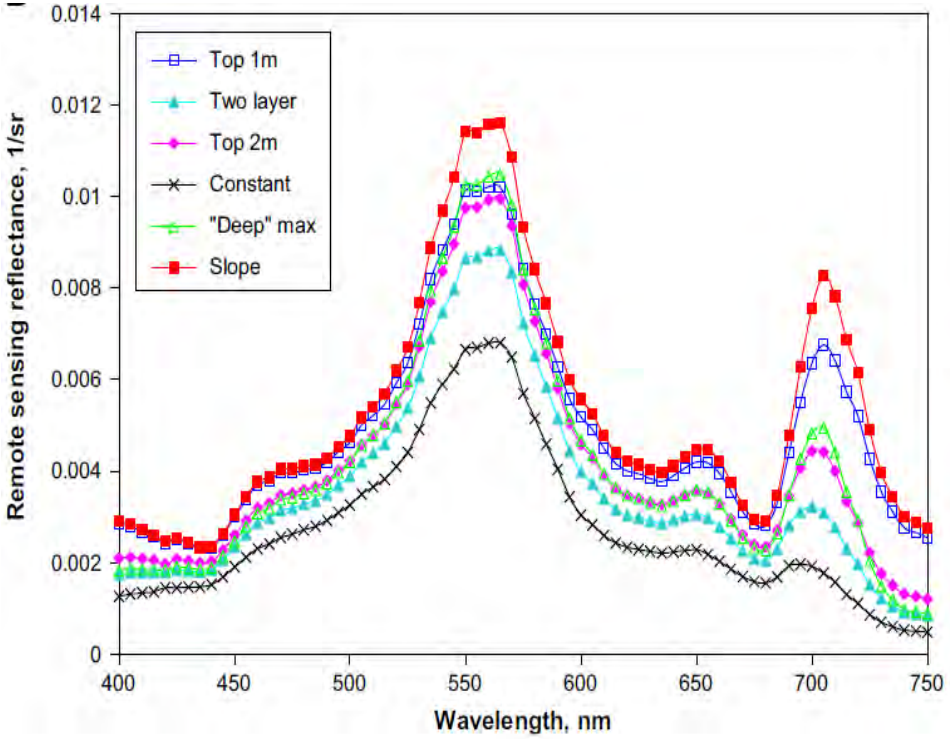
If the AC algorithm does not flag bright pixels as clouds, the algorithm treats the bright water as an increased in aerosols concentration in the atmosphere, and therefore over correcting for aerosols leading to negative reflectance of the ocean

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



Identical cyanobacerial biomass creates very diferent reflectance

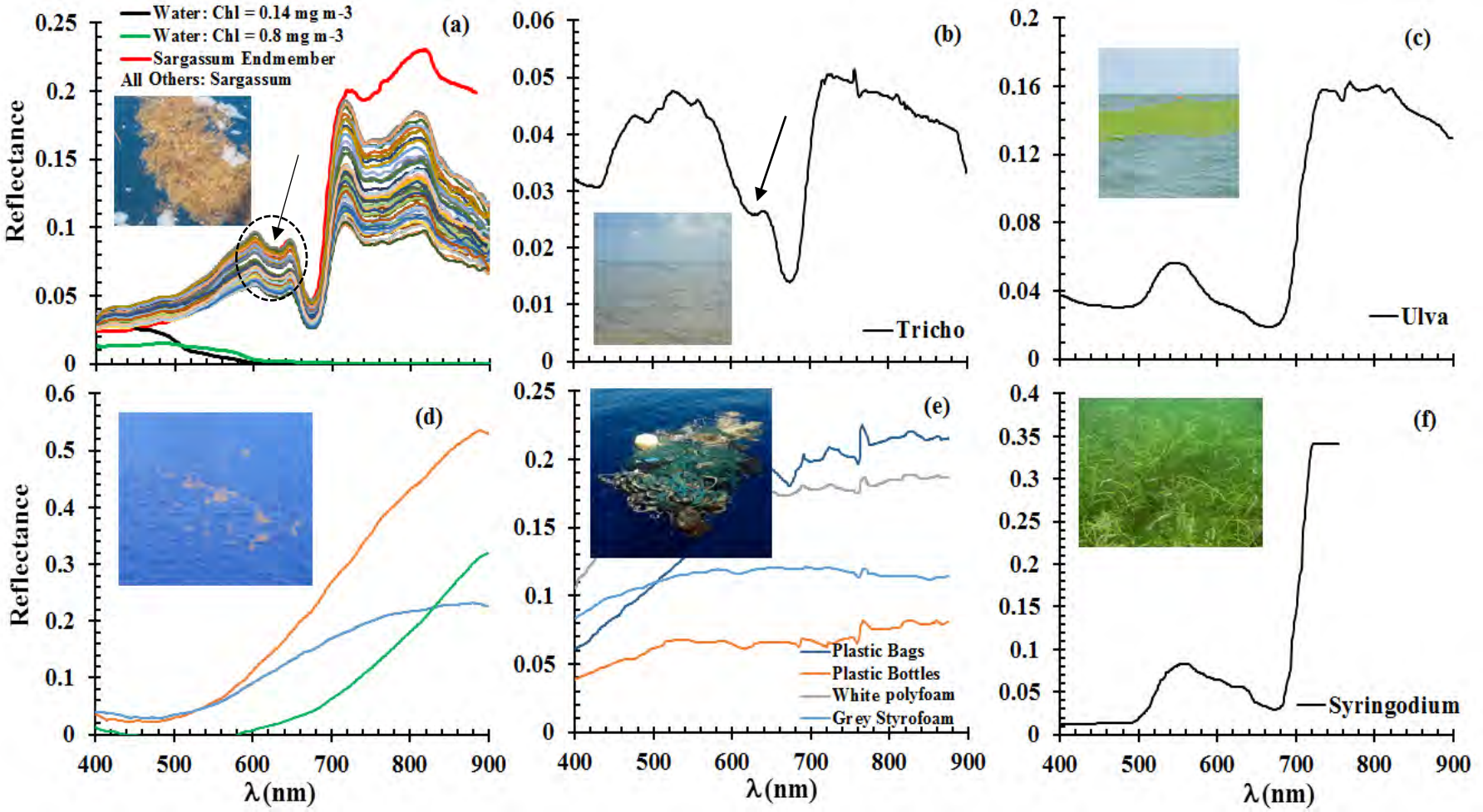




Kutser et al. (2008)

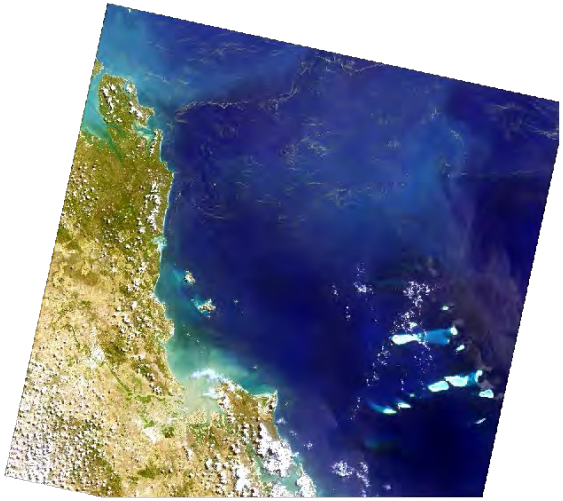
Challenge discriminating from other floating material

- Requires appropriately placed bands

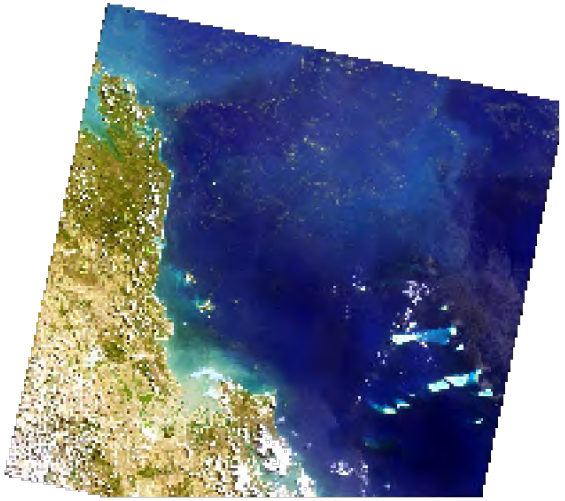


Credit: C. Hu

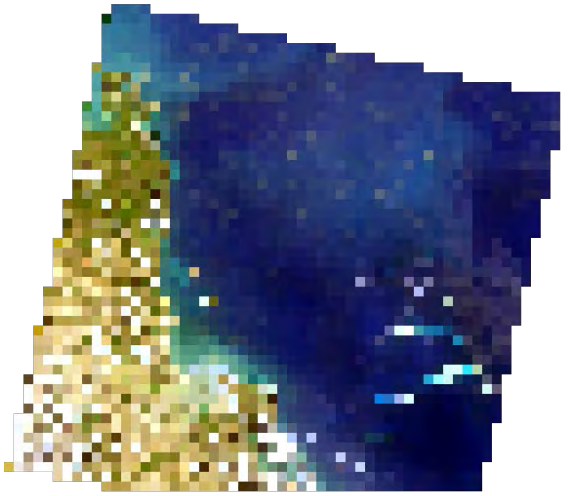
Sensor spatial resolution



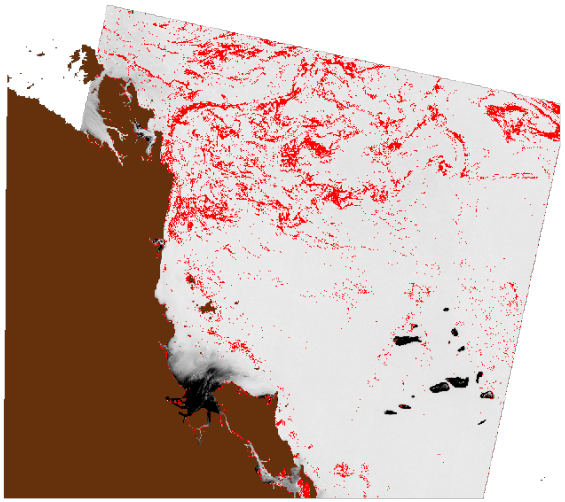
30 m; bloom=2198 km^2

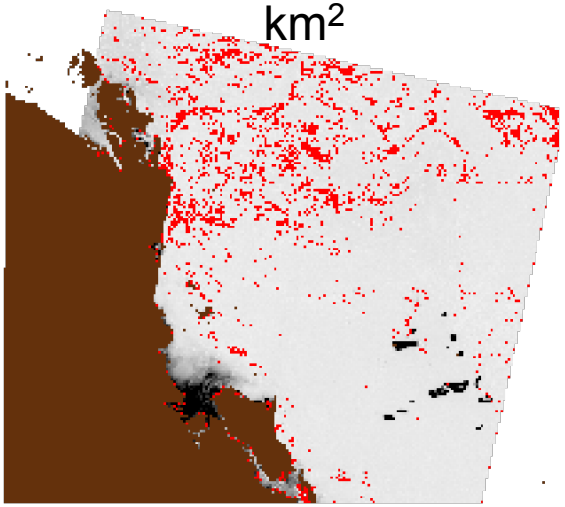


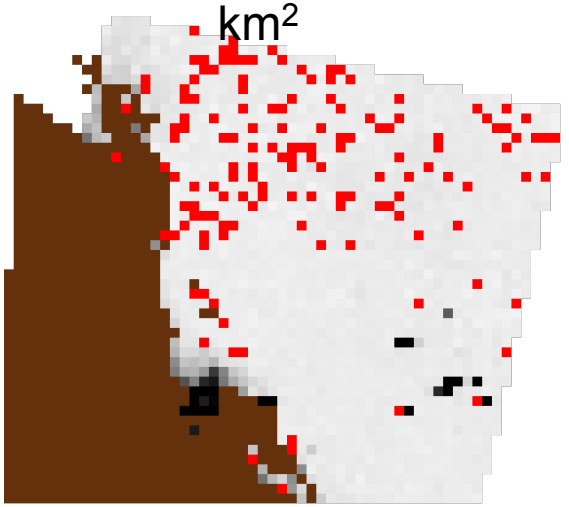
1 km; bloom = 2151 km^2



4 km, bloom=568 km^2







Landsat OLI, 19 September 2014. Capricorn Channel, Australia

Caveats/limitations

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

Standing problems with AC

- AC typically fails over bright surfaces such as extreme turbidity and surface blooms
- NASA's operational AC algorithm relies on the dark pixel assumption when detecting light in the near infrared (NIR)
- To mitigates bright ocean problems, an iterative NIR correction based on radiative transfer model is successfully utilized
- In extreme bloom conditions or surface blooms such as *Trichodesmium*, the NIR correction method fails due to improper modeling of the bloom spectral signature.
- Also the AC algorithm tend to flag bright surface blooms as clouds.
- In some cases ocean color detectors (bands) saturates, rendering these bands useless for detection due to loss of sensitivity

Future outlook

- Hyperspectral information can improve the flagging that can discriminate between clouds and extreme blooms or floating vegetation.
- The appropriate flagging of *Trichdesmium* would allow an improved AC capabilities based on an improved radiative transfer modeling of NIR reflectance in bloom conditions.
- Future efforts are needed to improve the radiative transfer modeling of bloom conditions and surface vegetation

Recommandations Biomass estimates

- *E*ncourage the community to routinely sample accessory phycobilin pigments !

- Phycoerythrin algorithms will need more spectral resolution that we have in any sensor right now but is a hope for the future.

- Determine all biomass parameters in at least a 8L volume
- Spectrofluorometry (cheap!). Nets do not provide quantitative measurements ! PE < and > 10 µm fractions

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}?