Acquiring and Processing AOP

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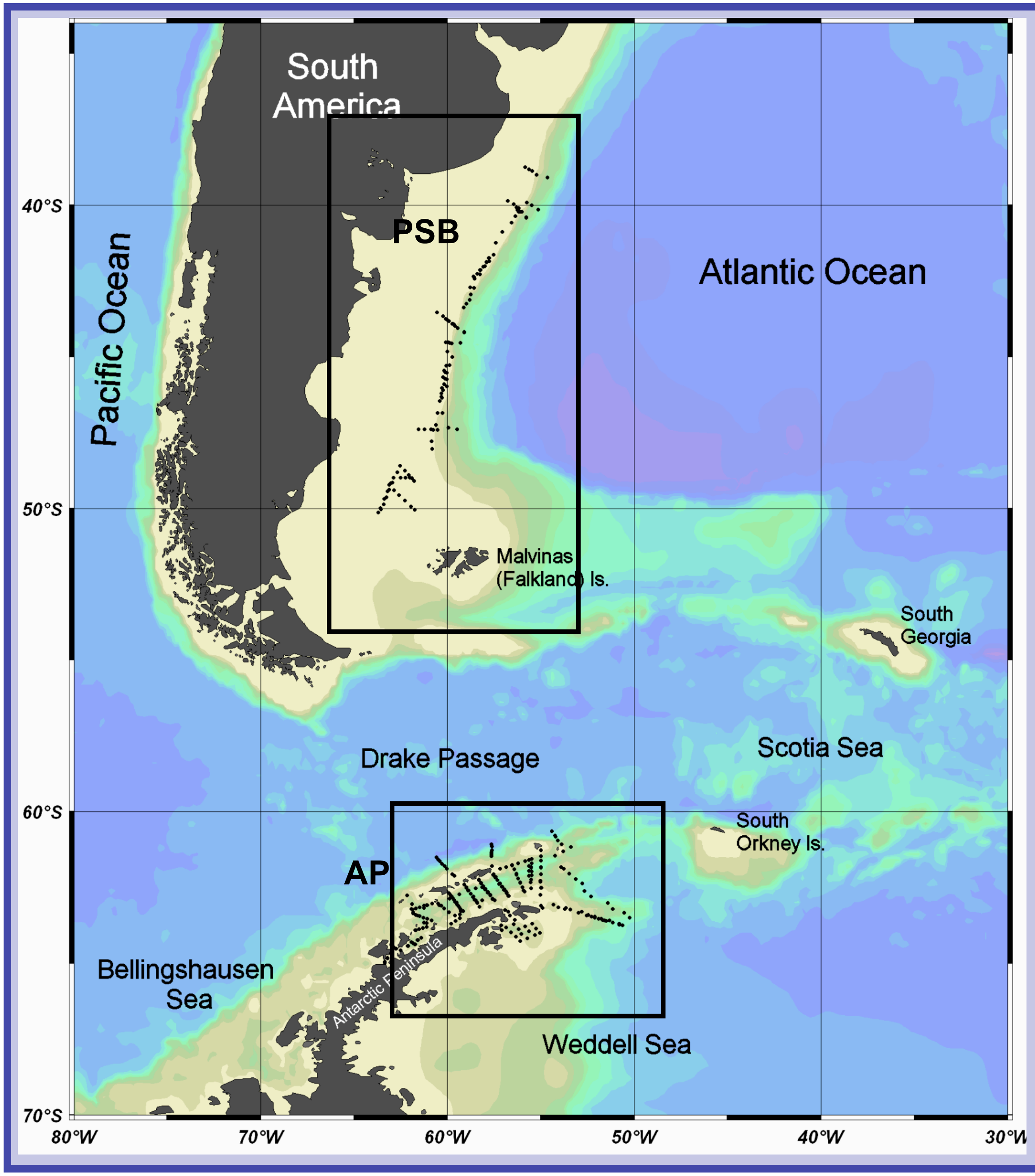
Study Areas



Patagonian Shelf-Break (PSB)

125 CTD stations

Spring	2004
	2006
	2007
Summer	2007
	2008

Antarctic Peninsula (AP)

249 CTD stations

Summer	2003
	2004
	2005
	2008

Optical Systems/Sensors

In-water (buoy)

Jan 95 - present

TSRB (Satlantic)

Multispectral system (8 bands)
L_u (SeaWiFS bands) and E_s (443,490 & 555)

In-water (profiler)

Oct 06 - present

HyperOCR (Satlantic)

Hyperspectral profiling system (136 bands)
Ed, Lu sensors (350-800 nm)
Pressure sensor
Vertical tilt sensor
Temperature sensor

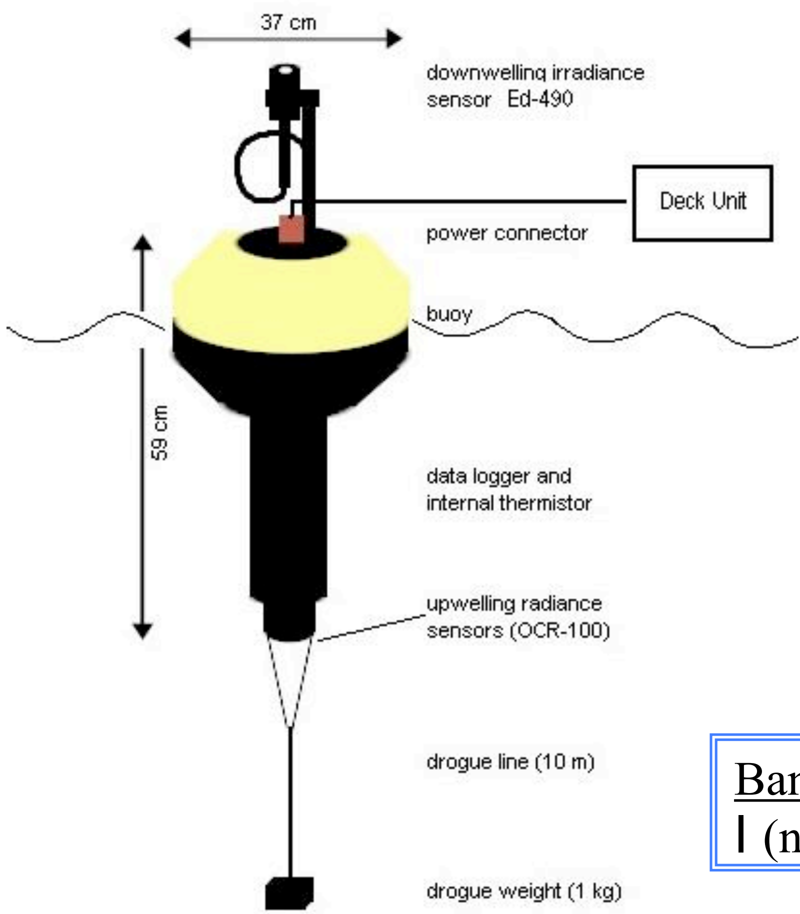
Above water

Oct 08-present

HyperSAS (Satlantic)

Hyperspectral system (136 bands)
E_s, L_t and L_i sensors (350-800 nm)
Tilt sensor

TSRB (Tethered Spectral Radiometer Buoy)



Es(λ)

Bands	2	3	5
l (nm)	443	490	555

Lu(0.5 m, λ)

Bands	1	2	3	4	5	6	7
l (nm)	412	443	490	510	555	670	683

TSRB Processing

Software: Developed at FURG (Matlab©)

- Record 15-20 minutes of data
- Calibrate digital numbers
  - calibration table provided by Satlantic
- Remove spikes by visual inspection of $L_u(0.5\text{m}, \lambda)$ and $E_s(\lambda)$
- Time interval (~3-5 min) for processing is chosen base on L_u490/E_s490:
  - difference between mean and median is minimal
  - 100 x std/mean is acceptable (< 20%)
- Calculate mean and std of L_u and E_s for all wavelengths within time interval
- Shelf-shading correction
- Propagate L_u from 0.5m to 0^{+}. We use Austin & Petzold (1981) and Morel & Maritorena (2001) relationships to find $K_{Lu}(\lambda)$.

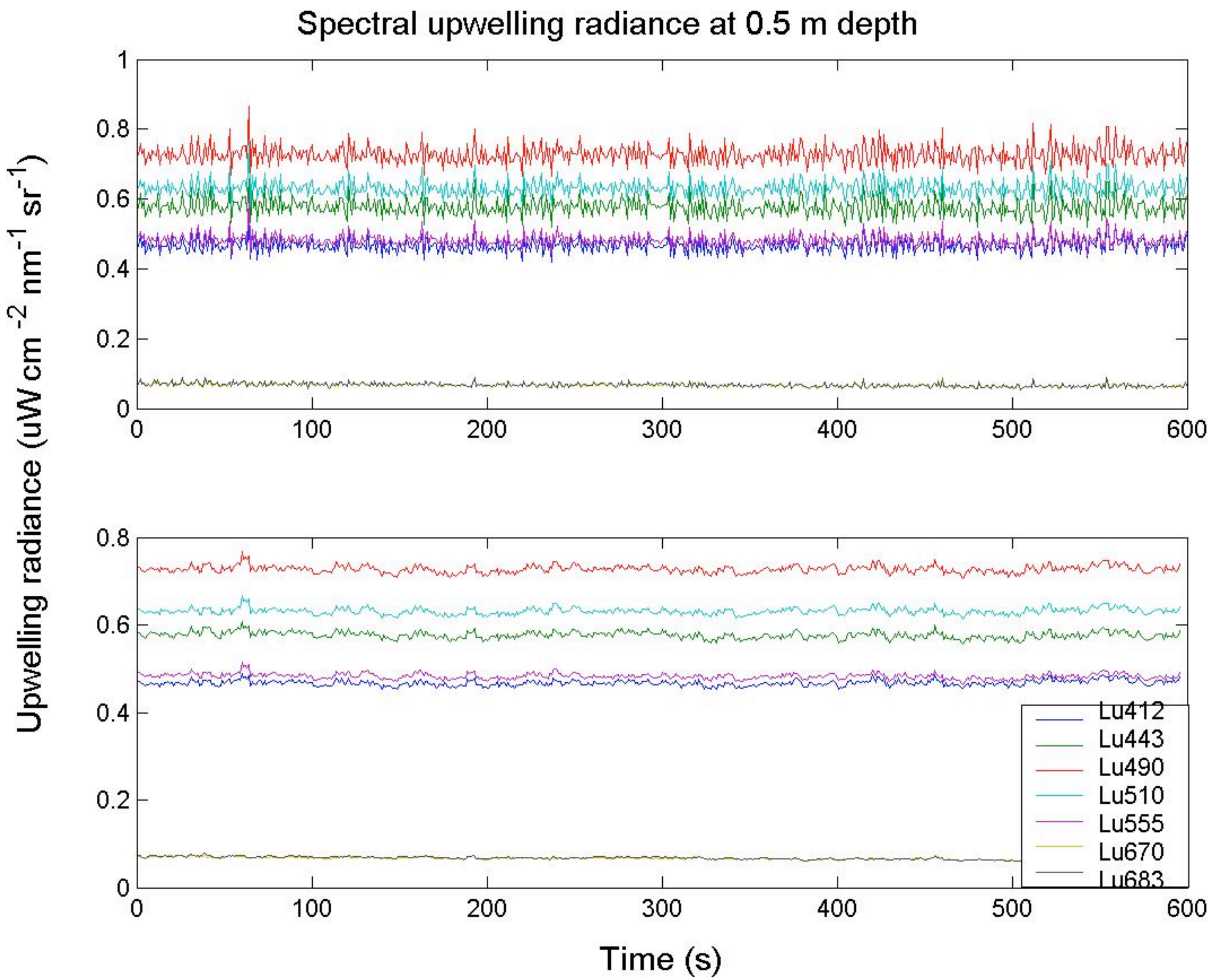
$$L_w(\lambda) = \frac{1-\rho_w}{n_w^2} L_u(\lambda, z_0) \exp(K_{Lu}(\lambda) z_0)$$

where z_0=0.5m

- Calculate

$$R_{rs}(\lambda) = \frac{L_w(\lambda)}{E_s(\lambda)}$$

Typical TSRB

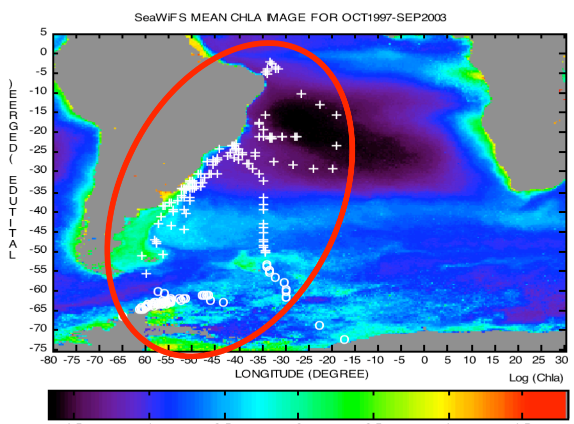


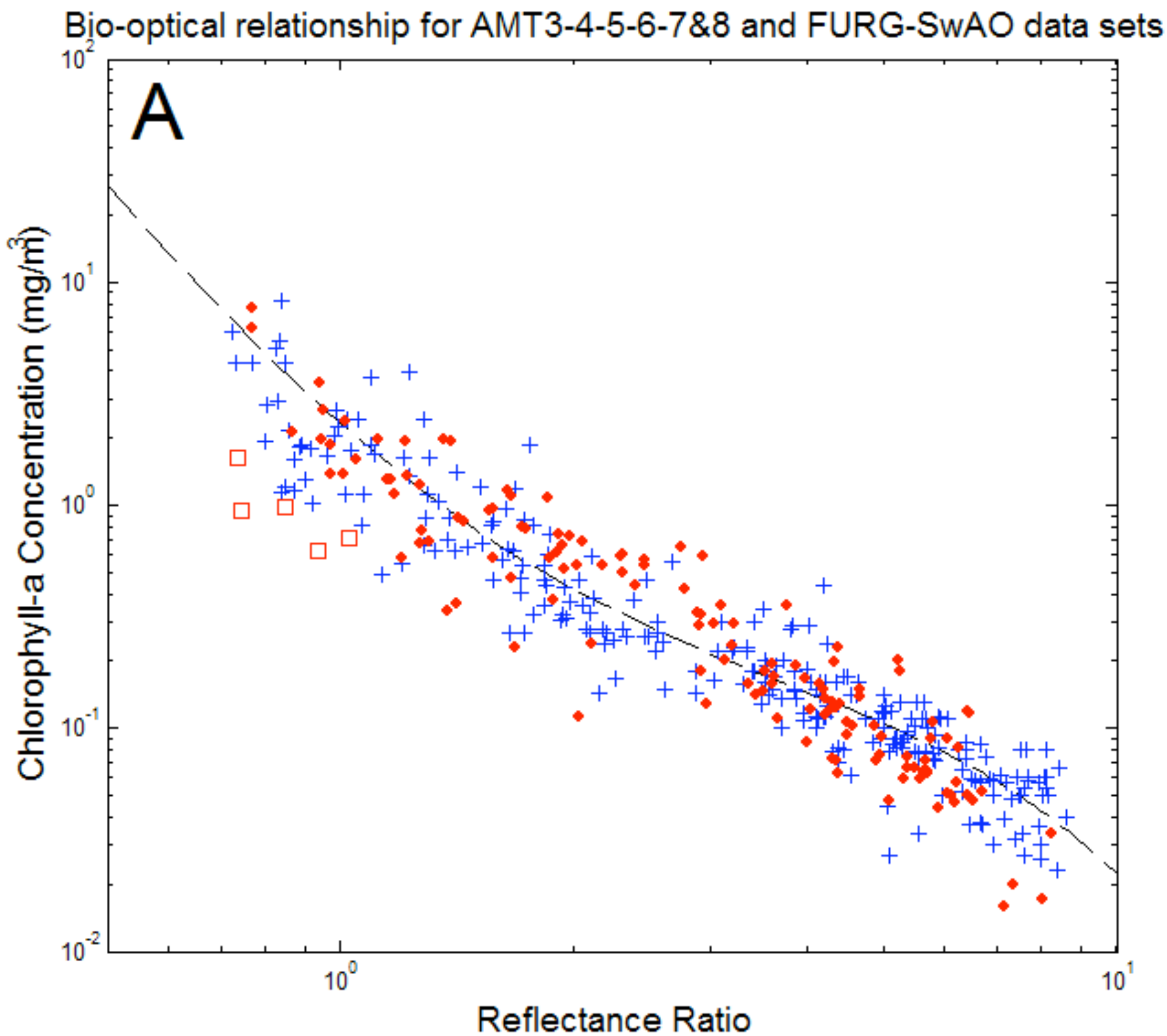
TSRB

Performance of empirical bio-optical algorithms for chlorophyll (1995-2003)

T
S
R
B

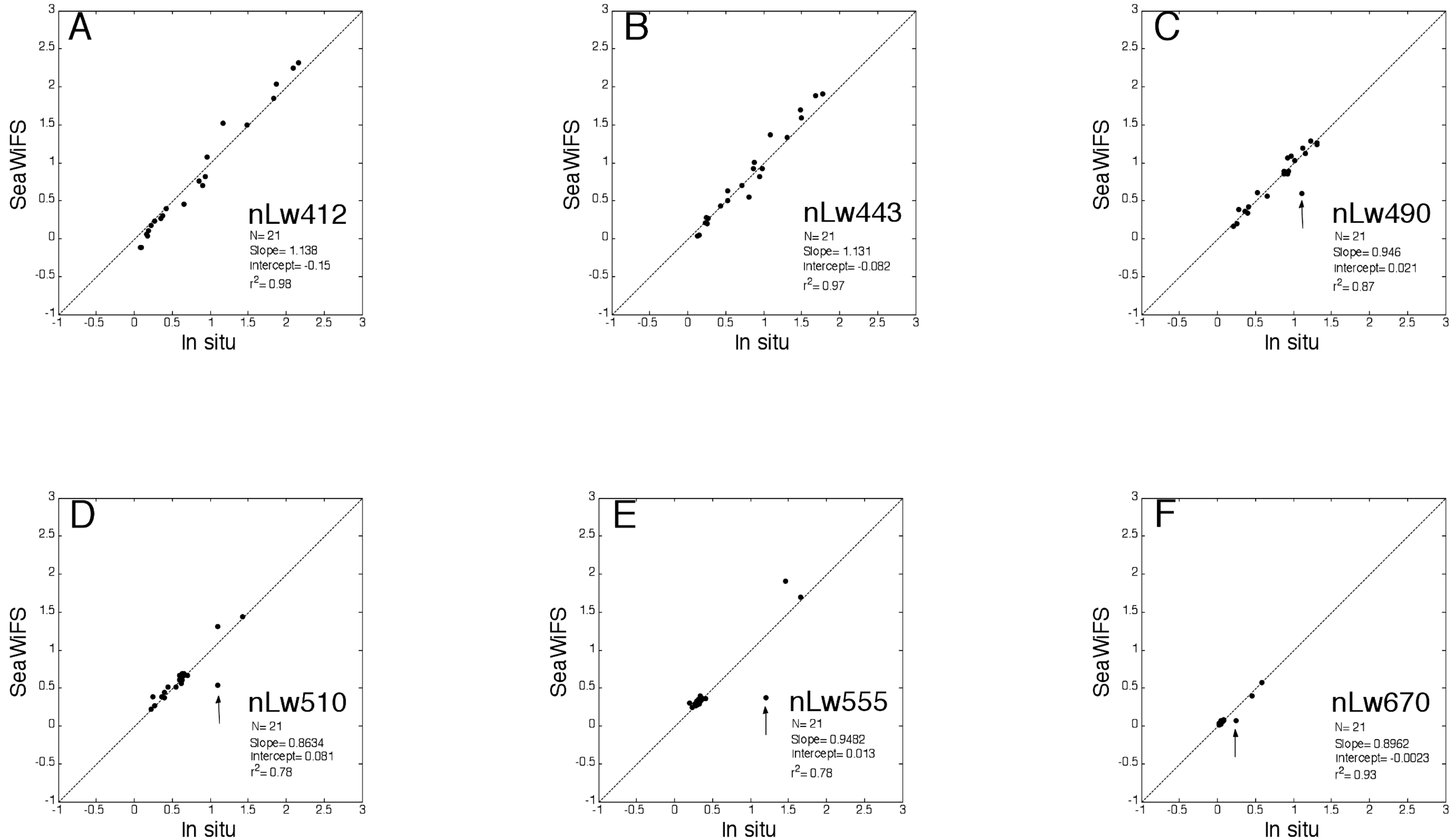
Blue - AMT
Red - FURG





Garcia et al (2005)

Matchup nLw: TSRB versus SeaWiFS

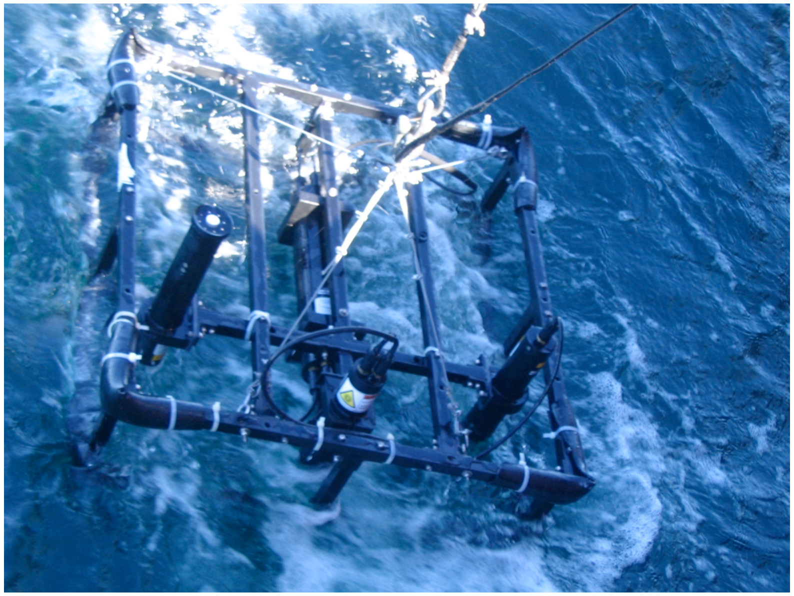


Garcia et al (2005)

HyperOCR settings

Deployment

Oct 06 – Oct 08



Oct 08 - present

2 types :

- frame with an Eco-triplet (WetLabs)
- cage with a MicroCat (C,T,p), Eco-triplet (bb532, bb660 & CDOM), c660, fluorescence (WetLab) and an ac-9 (WetLab).

HyperOCR Processing

Software:	ProSoft 7.7.11
Instrument:	Calibration files (Manufacter)
	Distance to pressure sensor for correction
Parameters:	- Analize whole profile
	- Auto Dark Shutter Correction
	- Data interpolation: 0.1 m
	- No profile deglitching filter

HyperOCR Processing

Default processing (provided by Satlantic)

Level 3: - Average data every 1m

- Using a bin width 0.5 m
- No wavelength interpolation

Level 4:

- K_Ed(z, λ); K_Lu(z, λ); local slope of ln[L(z, λ)] in 5m depth interval (5 points)

Extrapolate to surface

-Lu(0^-,λ), Ed(0^-,λ): exponential fitting; intercept of the slope using K(3m,λ)

Transmit through the sea interface

- $Lw(\lambda) = Lu(0^-,\lambda)*[(1-\rho)/\eta^2]$; where ρ= 0.021 and η=1.345
- $Ed(0^+,\lambda) = Ed(0^-,\lambda)\,(1-\alpha)^{-1}$; where α= 0.043

Calculate nLw and Rrs

- $nLw(\lambda)= Lw(\lambda)*(Fo/Ed(0+,\lambda))$; where Fo is from Neckel and Labs (1984)
- $Rrs(\lambda)= Lw(\lambda)/Ed(0^+,\lambda)$

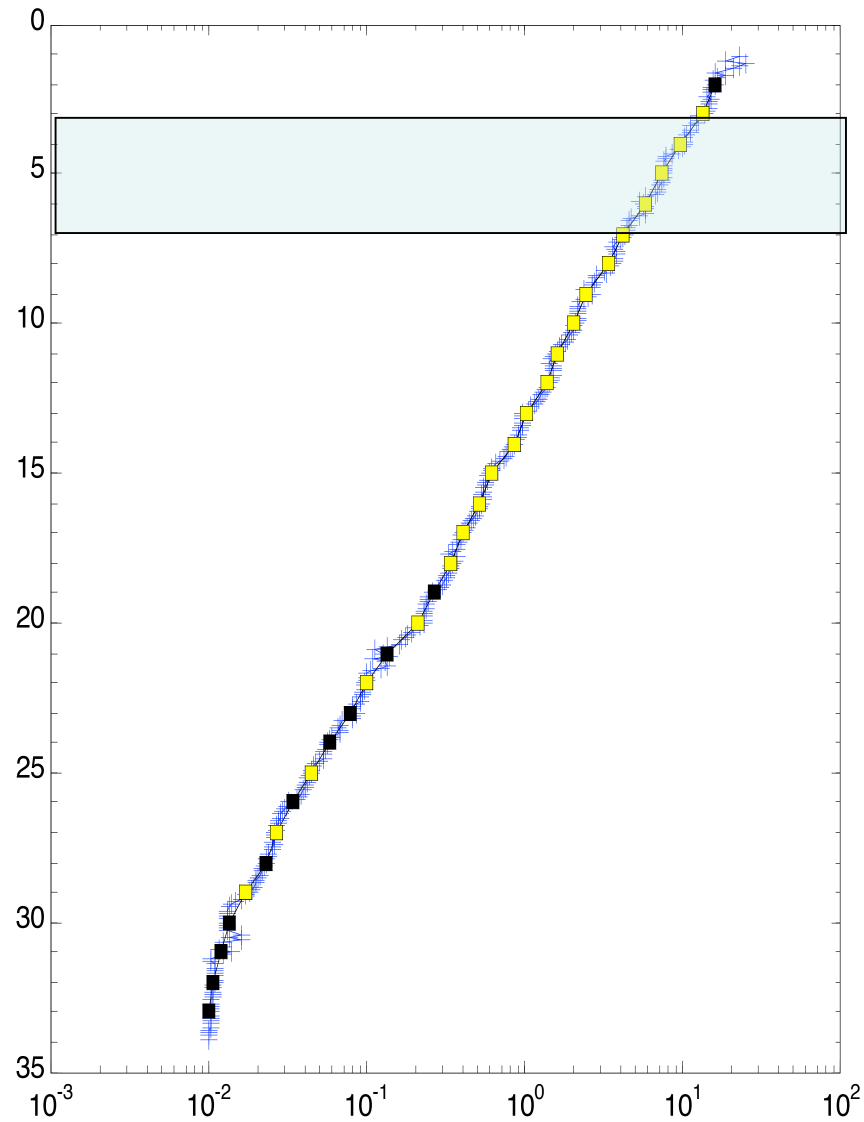
HyperOCR Processing

Alternative processing (FURG)

Level 3 Processing

Profile Analysis (412, 443,490,510, 555 nm)

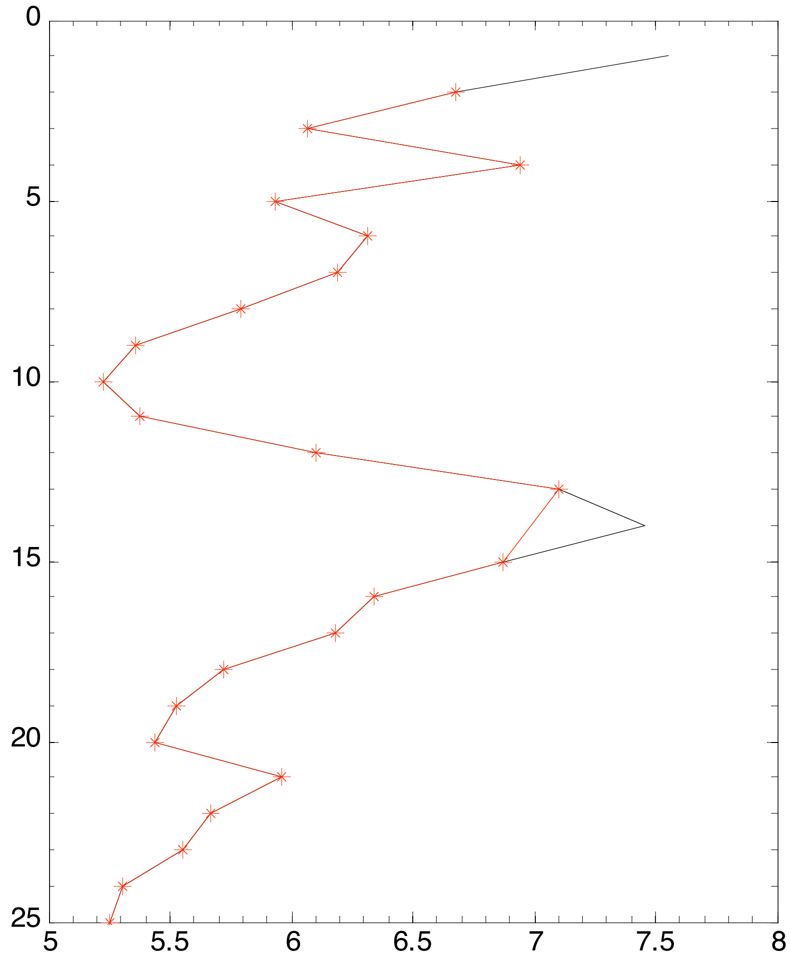
- 0.1 m (blue) and 1m (black)
- Data with tilt angle < 5° (yellow)
- Depth interval: 5m
- Reject data with tilt >5° (typically near the surface within the first 5 m)

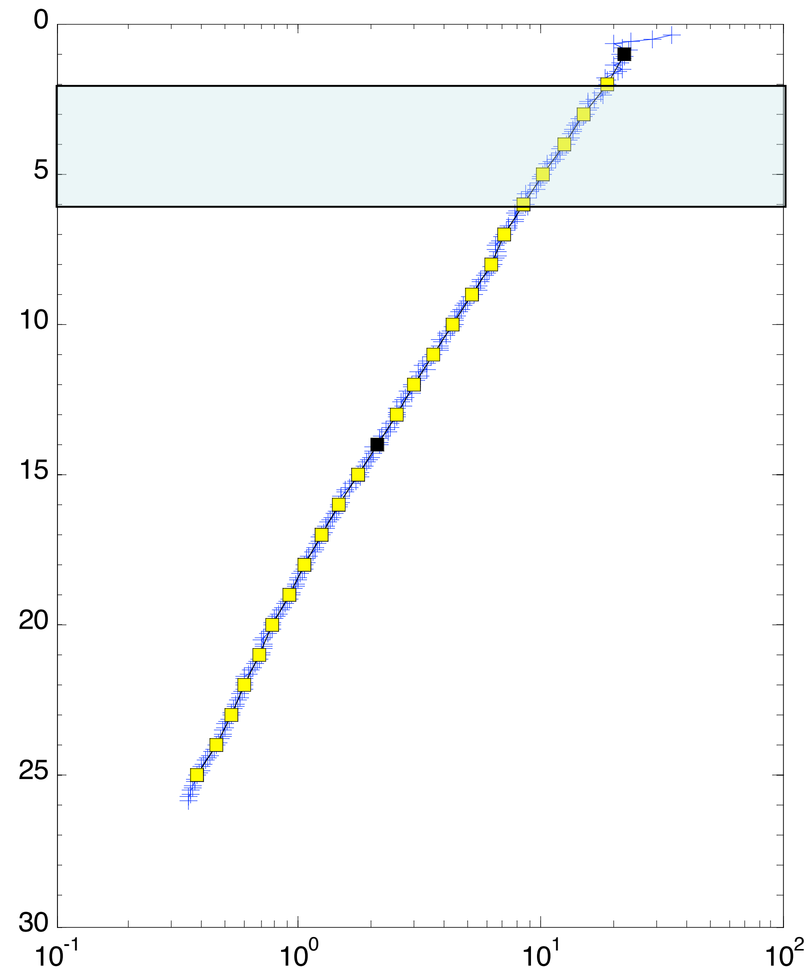


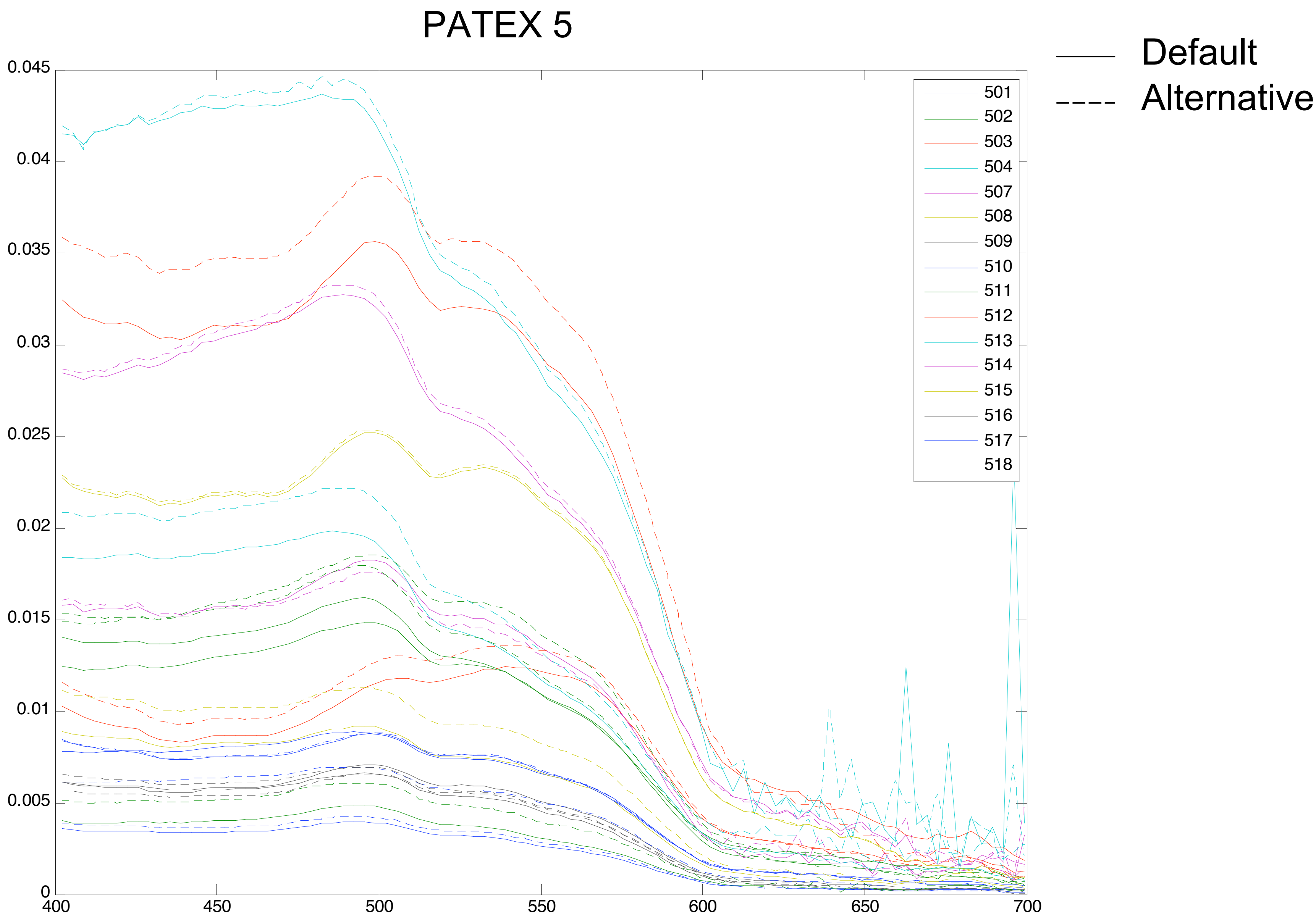
If tilt>5°

- Median angle (2-10m)
- Data within +/- 1 std in red

All the L4 products are calculated as the default processing







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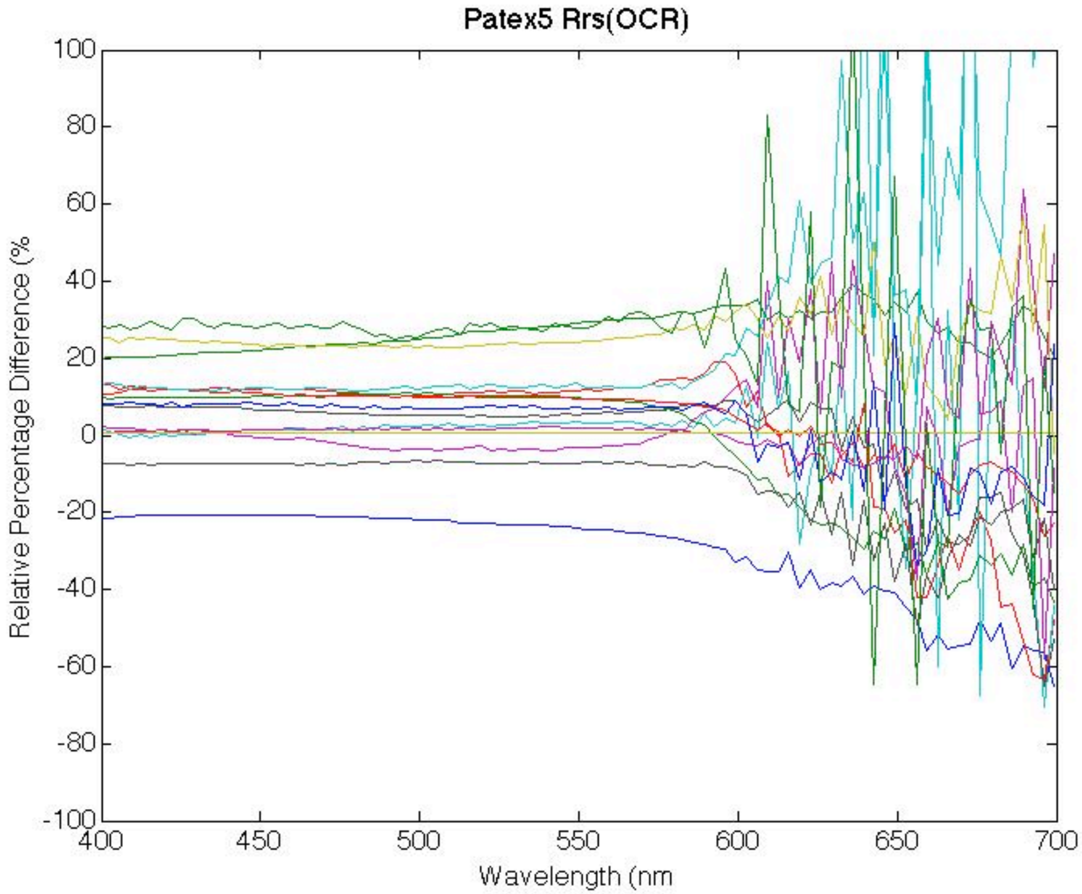
Differences between both processing with respect to wavelength

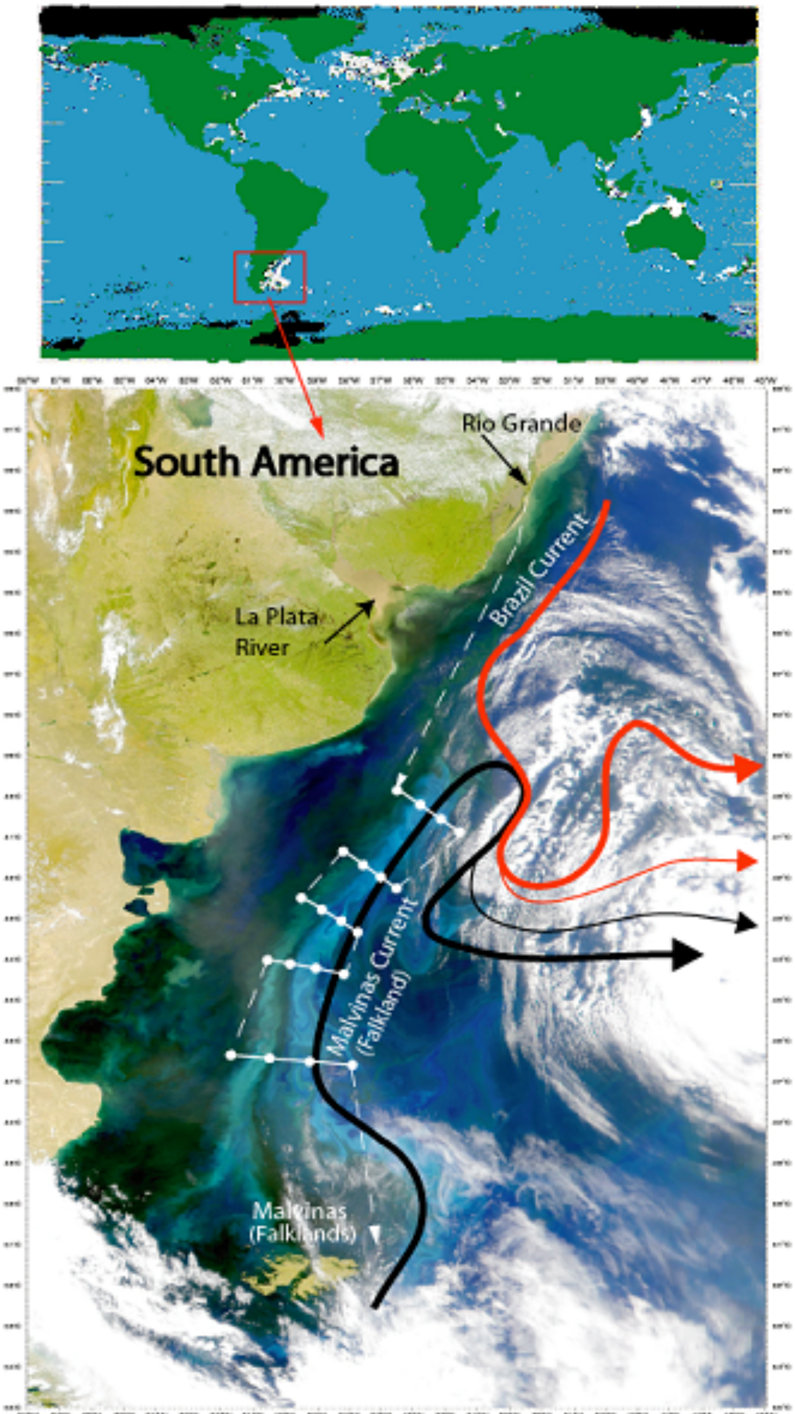


- RPD ranges from -20 to +20%
- RPD too noise above 600 nm (as expected)
- RPD is nearly flat in the 400-600 nm range. Band ratios are not affected.

HyperOCR

Performance of empirical bio-optical algorithms for chlorophyll in Patagonian shelfbreak waters

Obs: Radiometric measurements were rejected if tilt > 5 deg



PATAGONIAN EXPERIMENT "PATEX"

Motivation:

High reflectance patches have been attributed to coccolithophore blooms in the past (Brown and Yoder, 1994; Brown and Podesta, 1997).

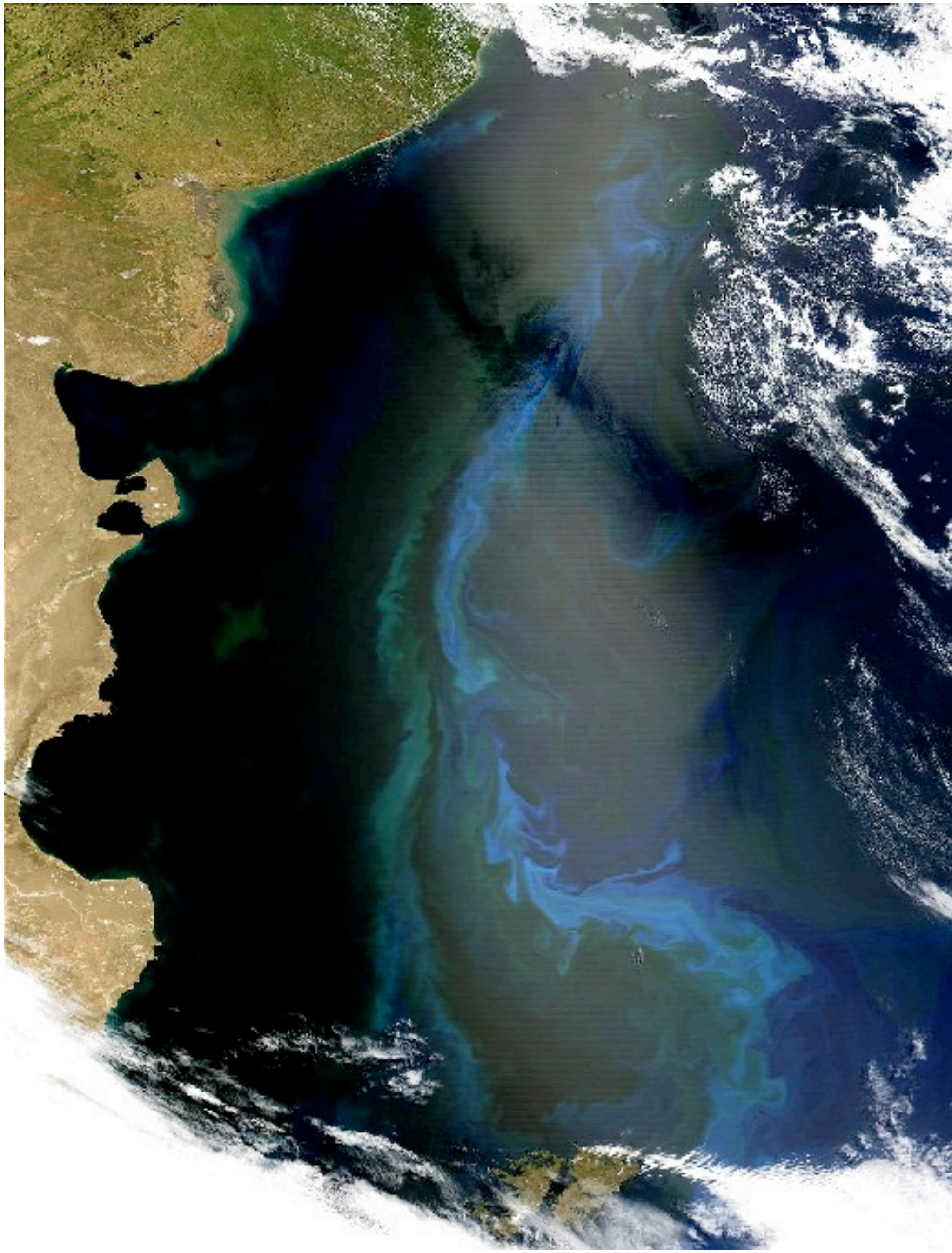
Objectives:

(1) to investigate the environmental factors that control the occurrence of these blooms;

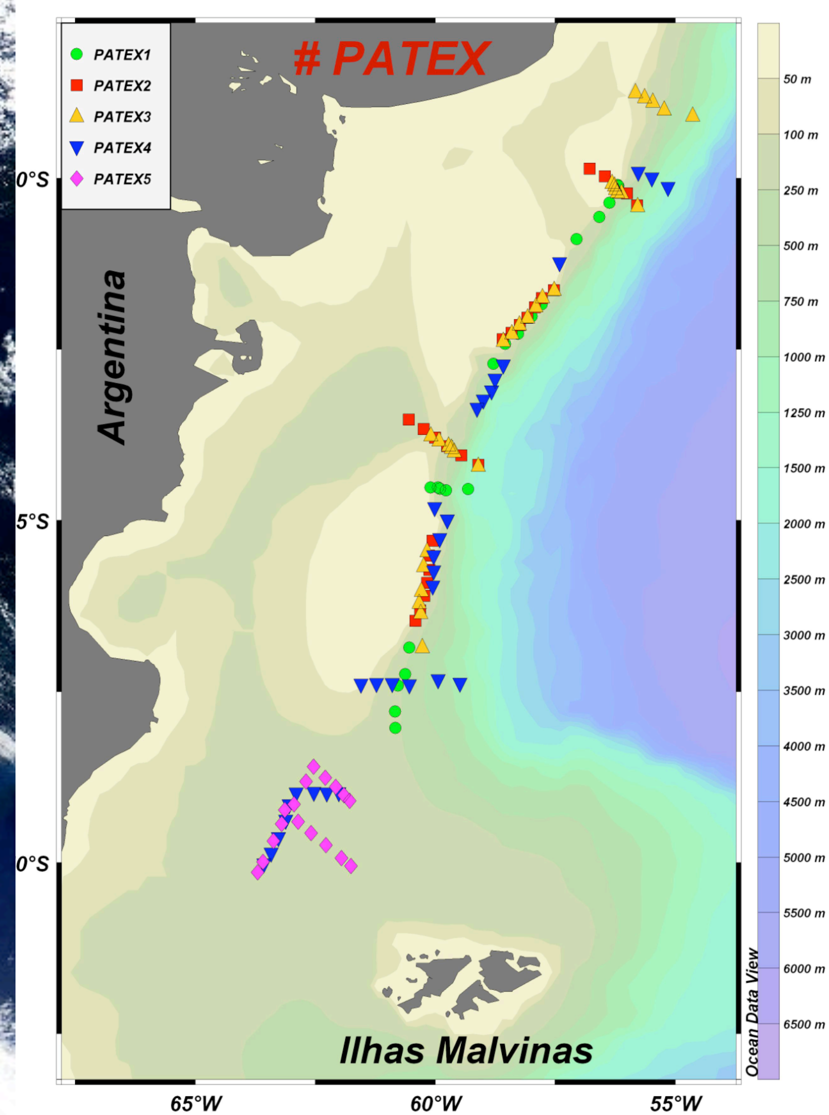
(2) to characterize the phytoplankton assemblage and primary production rates;

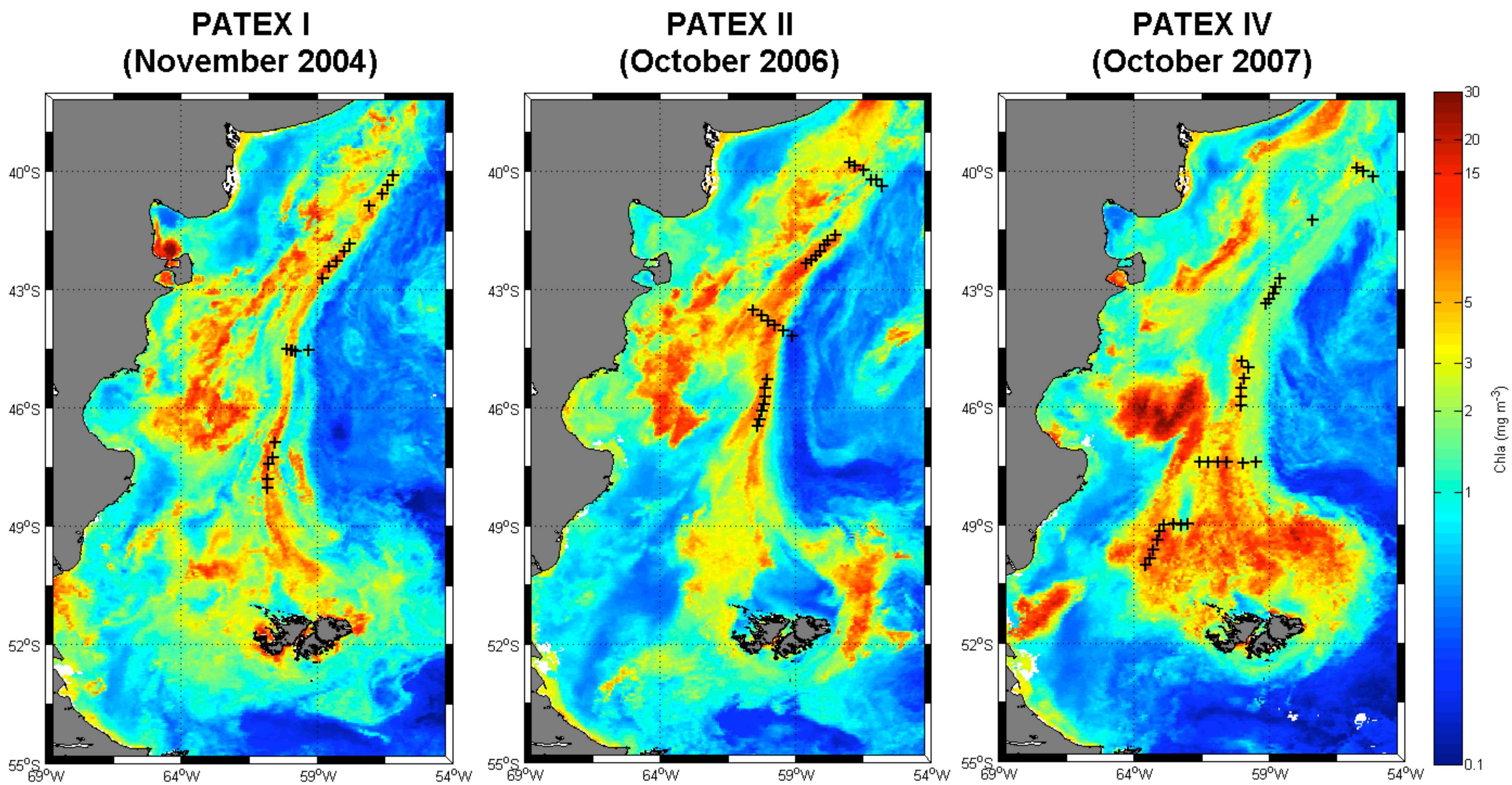
(3) to determine the main nutrient levels and ratios associated with the bloom waters;

(4) to determine their bio-optical characteristics.



PATagonian Experiment
- PATEX -





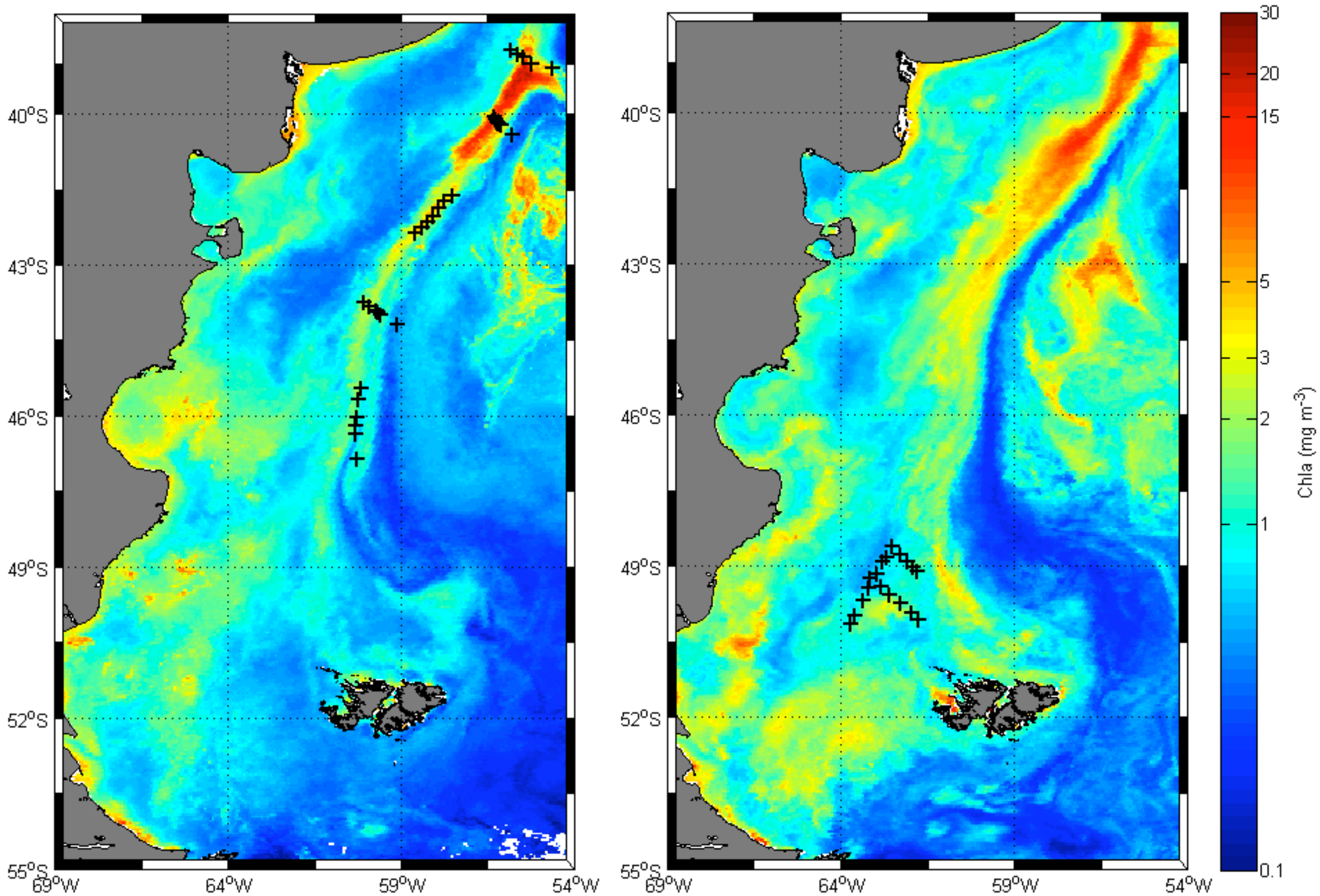
TSRB

TRSB
HyperOCR

TRSB
HyperOCR

PATEX III
(March 2007)

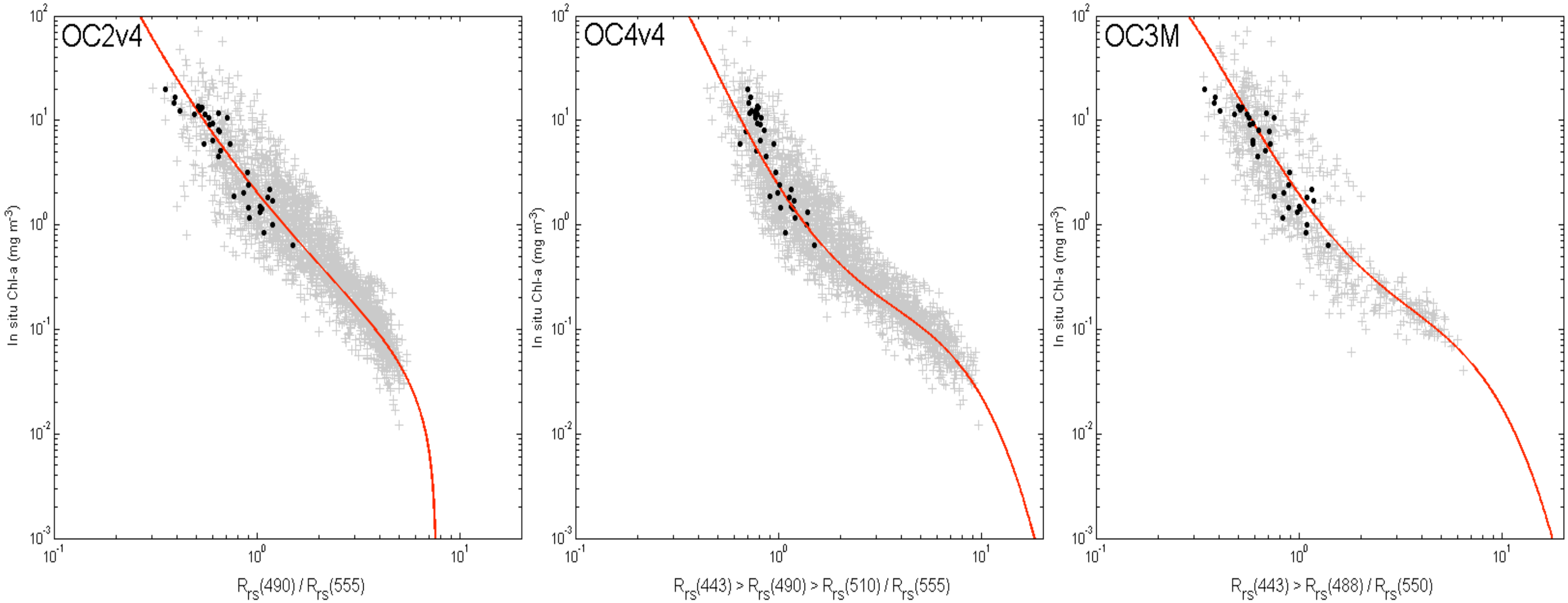
PATEX V
(January 2008)



TRSB
HyperOCR

TRSB
HyperOCR

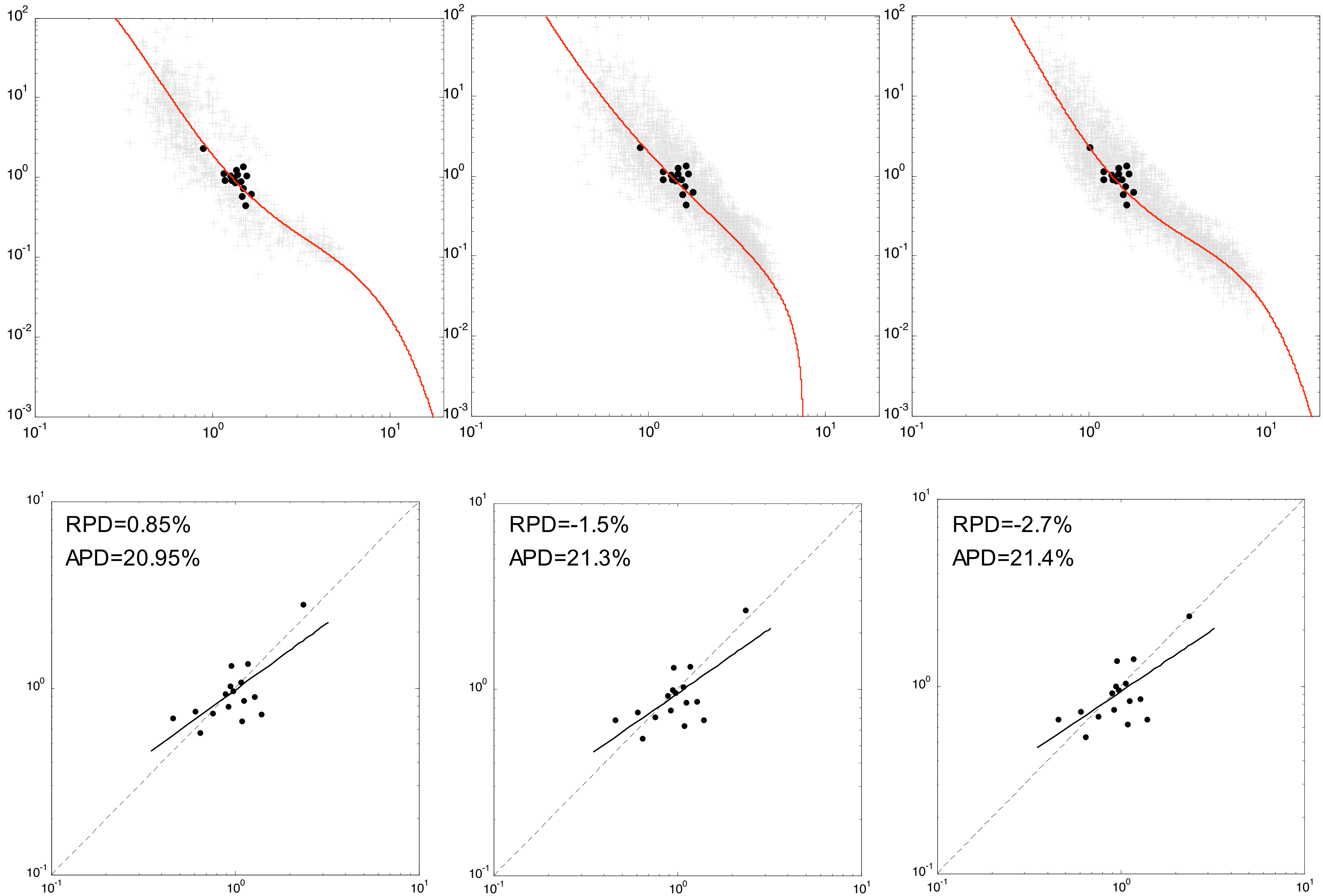
Performance of empirical bio-optical algorithms for chlorophyll (PATEX I,II, III, IV and V)



Algorithm	*Slope*	*Intercept*	R^2	*N*	*RPD (%)*	*APD (%)*
OC2v4	0.88	0.13	0.85	36	20.2	40.26
OC4v4	0.81	0.084	0.81	17	11.14	32.95
OC3M	0.96	0.13	0.81	36	42.9	57.0

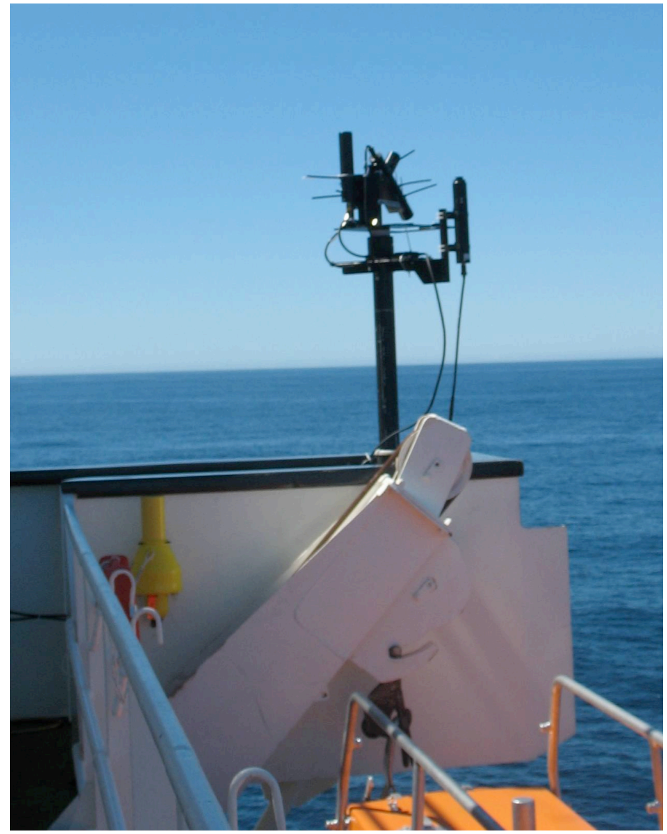
$$RPD = \frac{1}{n}\sum_{n=1}^{N}\left(\frac{(Chla_{sat} - Chla_{situ})}{Chla_{situ}}\right)\times 100 \quad ; APD \frac{1}{n}\sum_{n=1}^{N}\left|\frac{(Chla_{sat} - Chla_{situ})}{Chla_{situ}}\right|\times 100$$

All stations – PATEX 5 with tilt above 5 degrees – used alternative processing



HyperSAS settings

Position:



Geometry:

L_t and L_i viewing nadir/zenith angle ~ 45° (θ_v)

Relative azimuth angle (to sun) varies between 90-180°

HyperSAS Processing

Software: ProSoft 7.7.11 (older version RC3)

Instrument: Calibration files (Manufacter)

R_{rs} is calculated using calibrated radiance and irradiance measurements (Method 1, NASA/TM Protocol, 2003)

$$R_{rs}(\lambda) = (L_t(\lambda) - \rho' L_i(\lambda)) / E_s(\lambda)$$

$L_t(\lambda)$ – Total surface radiance

$L_i(\lambda)$ - Sky radiance

$E_s(\lambda)$ – Irradiace above sea surface

ρ' – Surface reflectance

Products obtained from current software version:

$E_s(\lambda,t)$, $L_t(\lambda,t)$, $L_i(\lambda,t)$

Further processing:

- Select part of the time series of each station (coincident with in-water measurements and stable sky conditions)
- L_t Sunglint filtering using the lowest 5-10% of the data, based on the 780 nm band (Hooker et al, 2002)
- Sky glint correction using $\rho'=0.028$

Working in progress …

Underway work

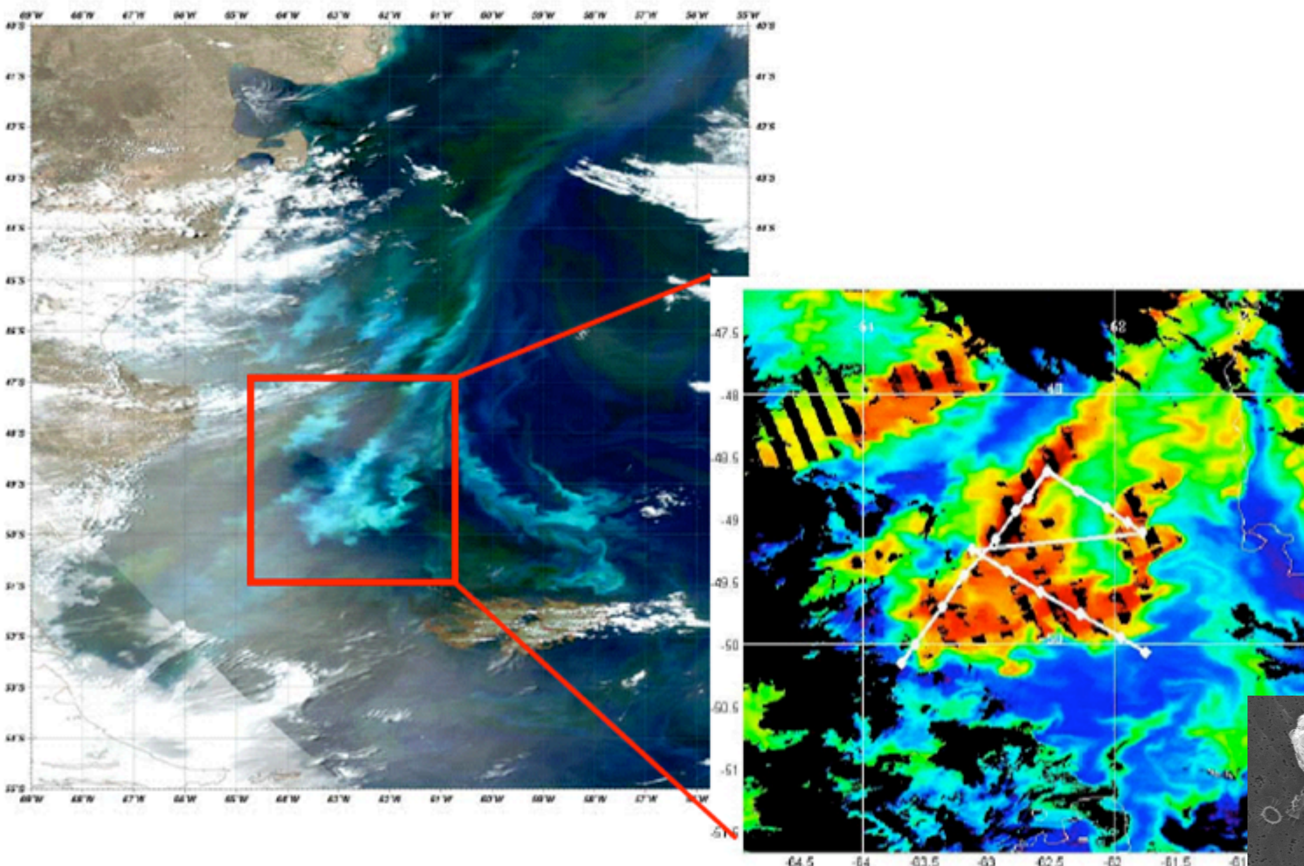
- Compare Rrs, obtained by different instruments
- Use $E_s(\lambda)$, obtained by HyperSAS, in HyperOCR
- Use $K_{Lu}(\lambda)$, obtained by HyperOCR, in TSRB

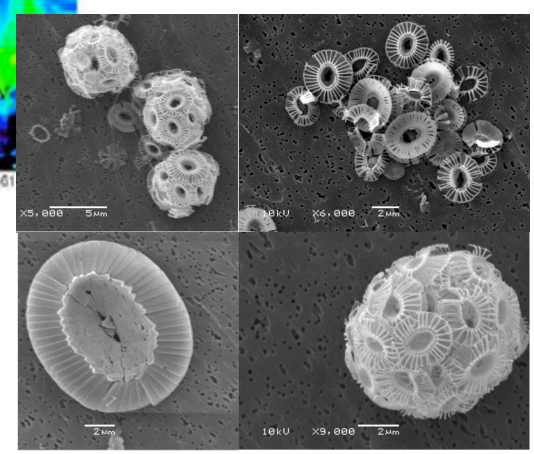
- Acquire a free fall system for HyperOCR to decrease the “tilt factor” and self-shadow effects on measurements

- Work on AOP and IOP relationships
- And so on…

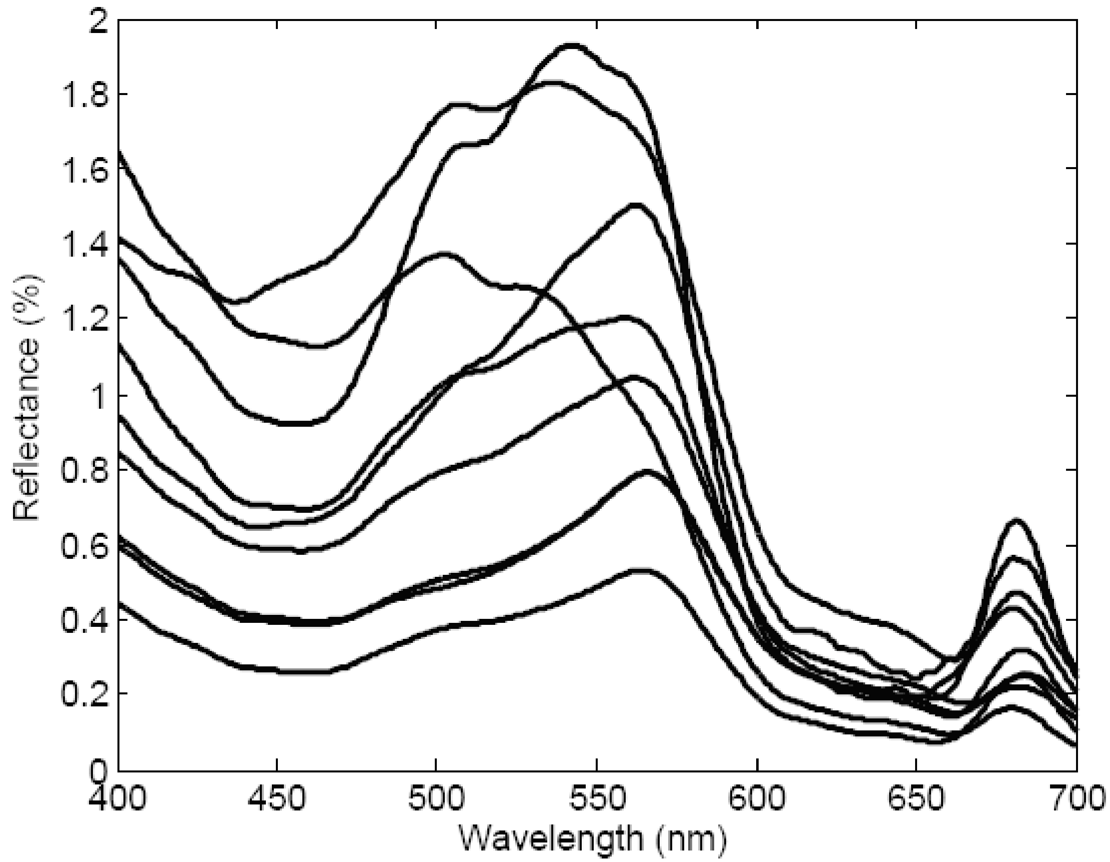
Patagonian Shelf Field Sampling and NASA Ocean Satellites Reveal Presence of Calcifying Phytoplankton

Jan 2008





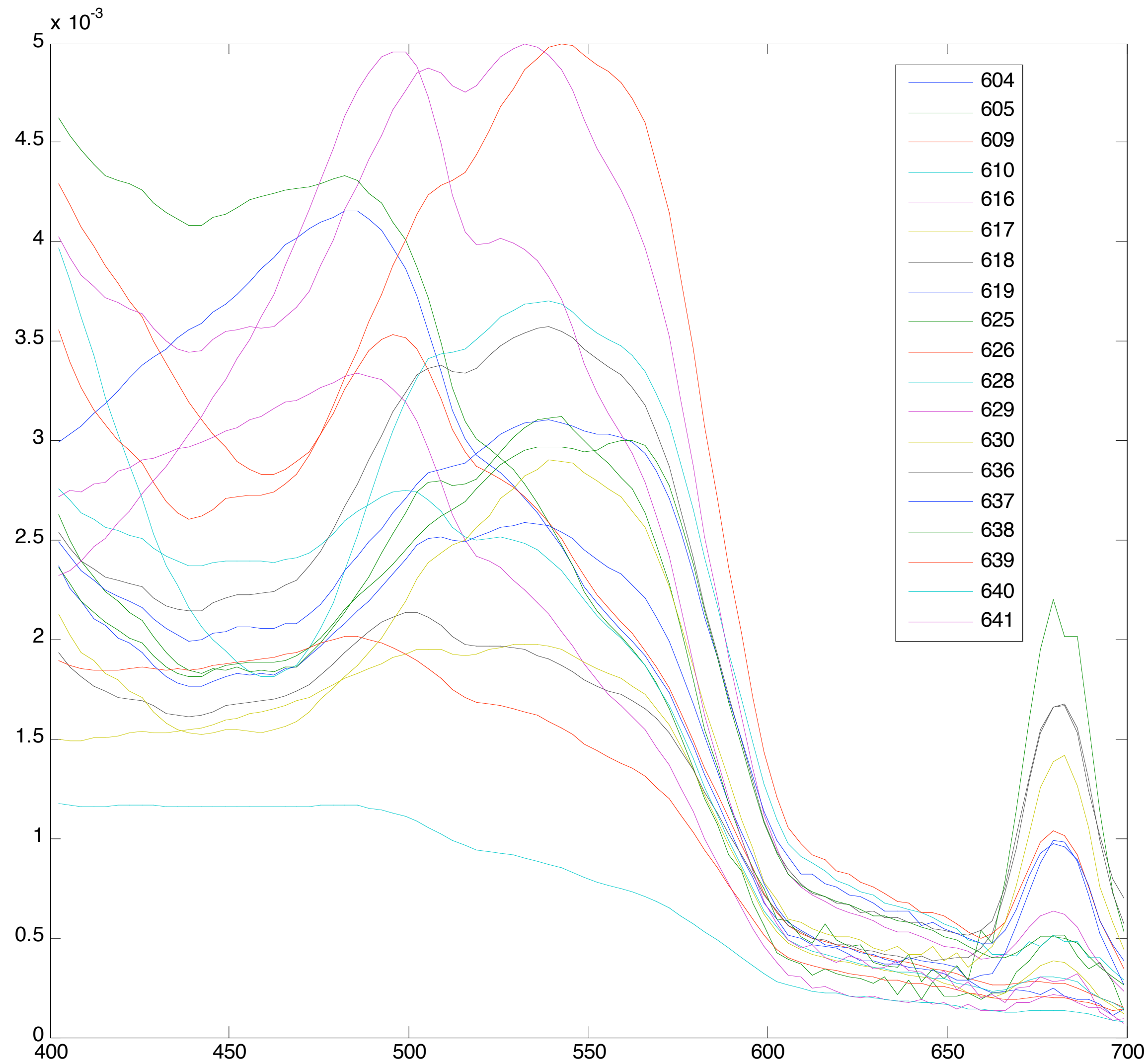
Photomicrographs of *Emiliania huxleyi* and one plate of *Coccolithus pelagicus* found in the bloom samples



Reflectance (%)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
400
450
500
550
600
650
700
Wavelength (nm)

PATEX 6 (OCR)

Be careful with the station numbers! They are not all the same for SAS and OCR sensors!



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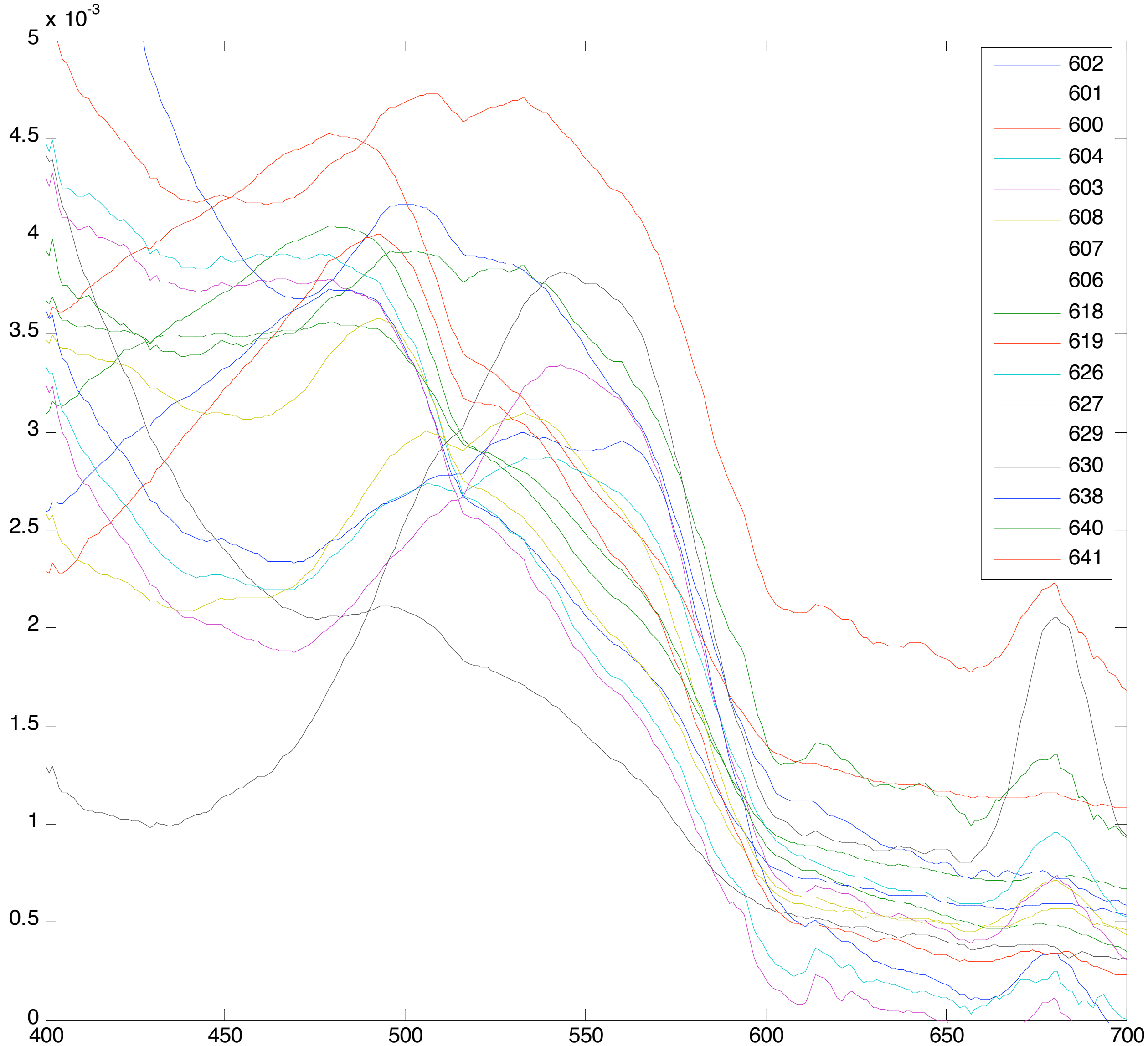
PATEX 6 (SAS)



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