Estimating Chlorophyll Concentrations using MODIS Fluorescence: A Preliminary Evaluation in Coastal Waters

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Natural (passive) Fluorescence

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where F = fluorescence

[chl] = chlorophyll concentration

PAR = photosynthetically available radiation

a^* = chlorophyll specific absorption

ϕ_F = fluorescence quantum yield

- Absorbed Radiation by Phytoplankton

ARP = a* x [chl] x PAR (calculated independently from [chl])

- F/ARP = Chl Fluor. Efficiency (CFE) $\alpha\ \phi_F$

If $\Phi_p + \Phi_f + \Phi_h = 1$ & $\Phi_h = \text{const.}$

then $\Phi_p = \text{const.} - \Phi_f$

$\therefore$

$$PP = \underbrace{[chl] \text{ x } (PAR \text{ x } a^*)} \text{ x } (\text{const.} - \Phi_f)$$

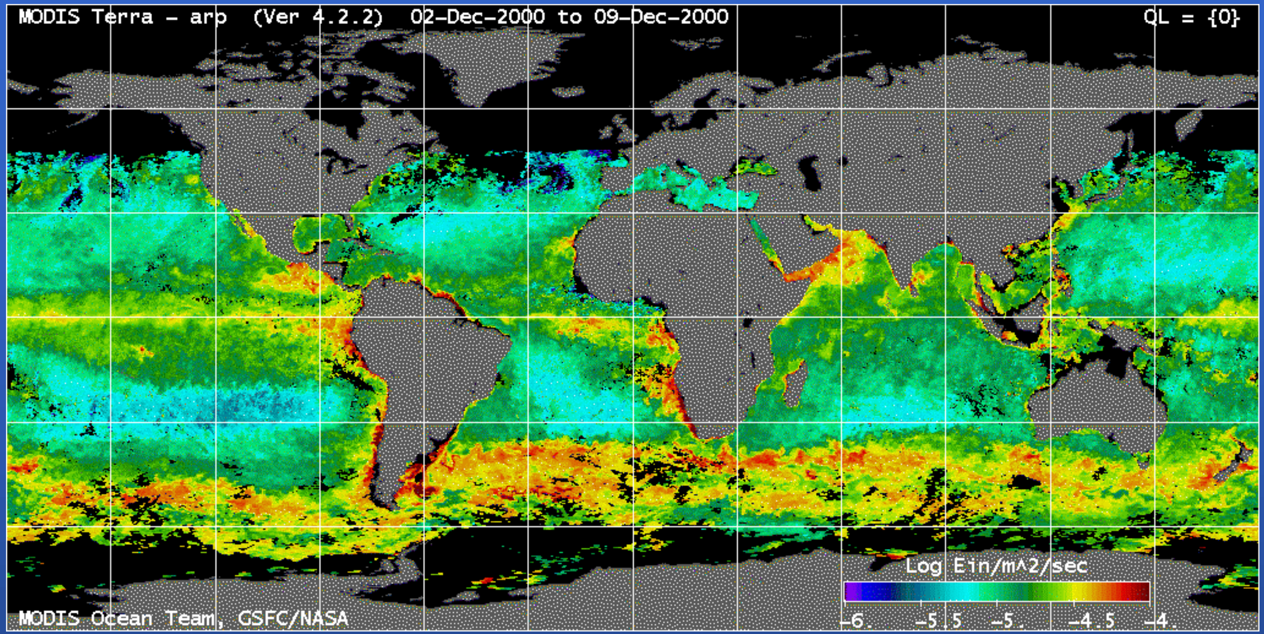
or $$PP \;\alpha\; ARP \text{ x } (\text{const.} - FLH/ARP)$$

$$\alpha\; (\text{const.}/ARP) - FLH$$

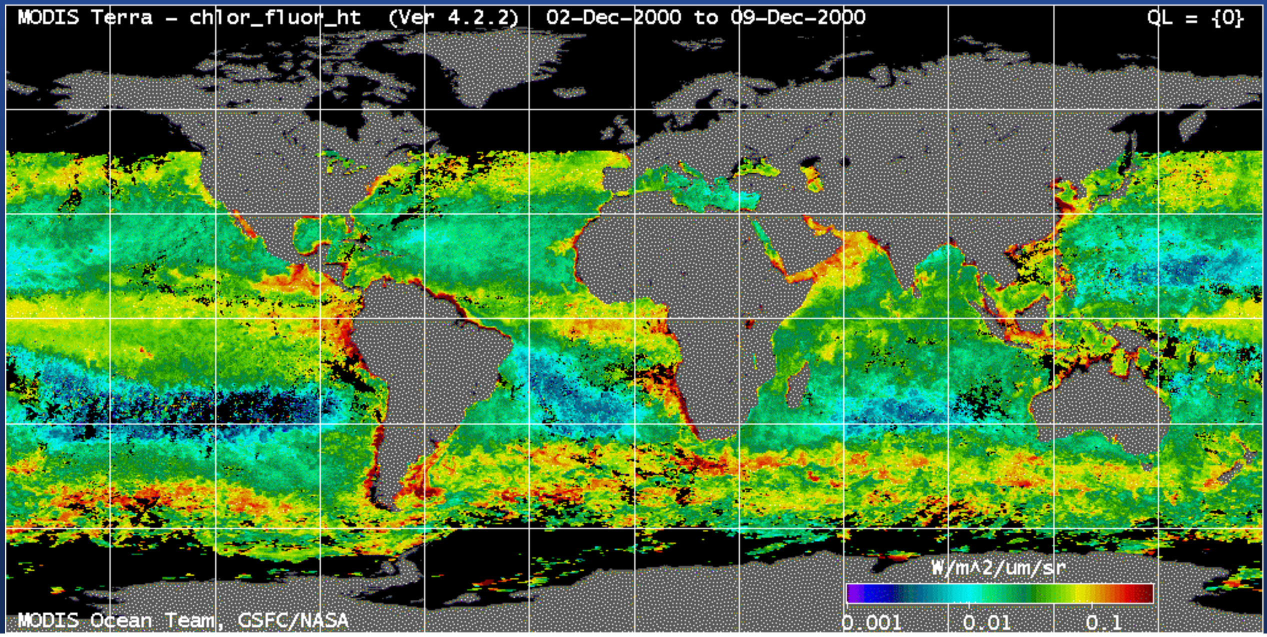
Can we use FLH to tell us about chlorophyll?

- Absorption-based algorithms fail in waters where there are other materials that absorb and scatter and are not correlated with chlorophyll
  - Sediment
  - Dissolved organic matter
- Chlorophyll fluorescence is specific to chlorophyll
  - But it also depends on physiology

Goddard DACC weekly declouded 36 km starting 12/02/2000 (Quality=0 L2 V 4.2.2)

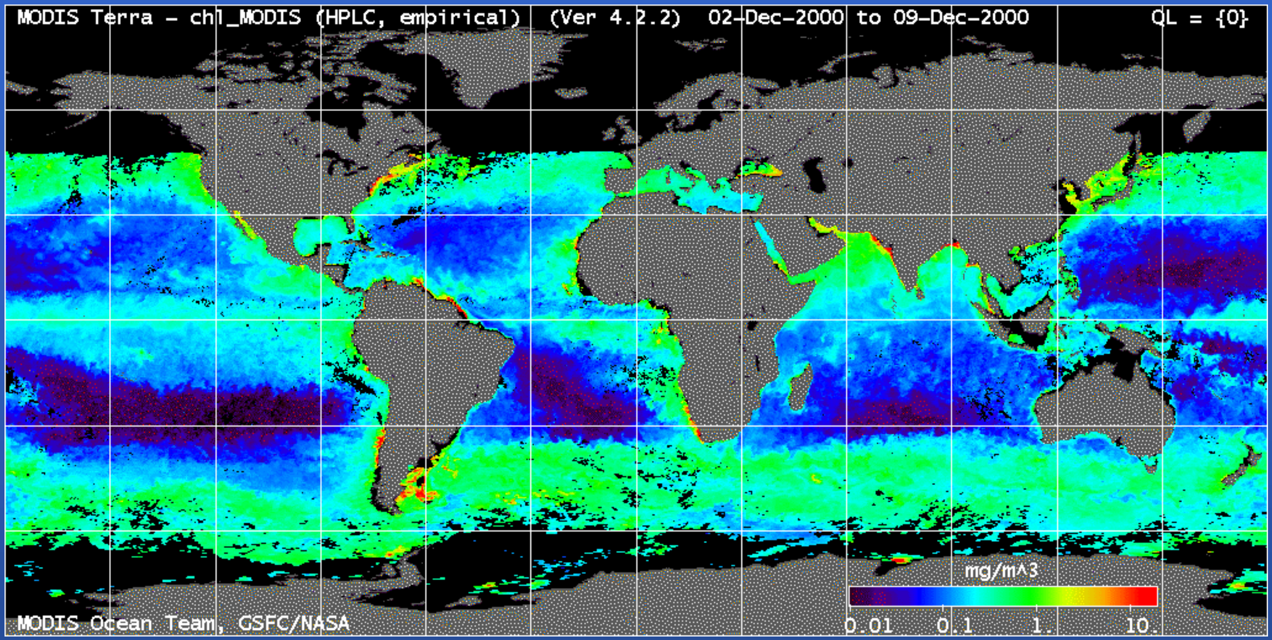


MODIS ARP

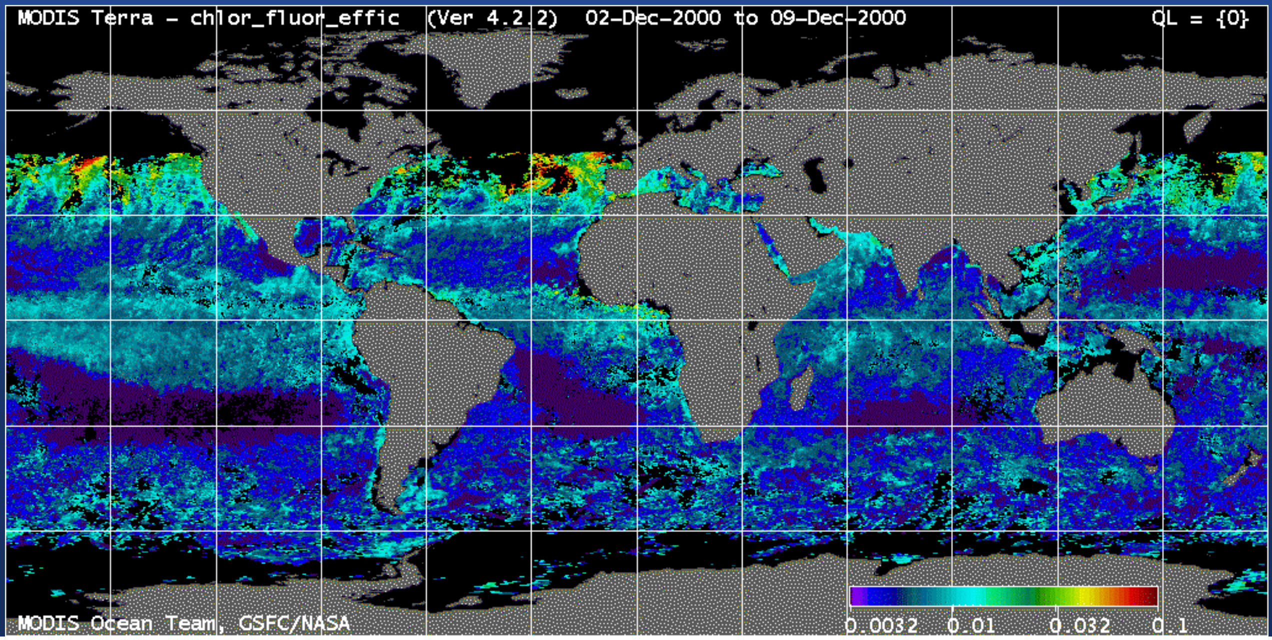


MODIS FLH

Goddard DACC weekly declouded 36 km starting 12/02/2000 (Quality=0 L2 V 4.2.2)

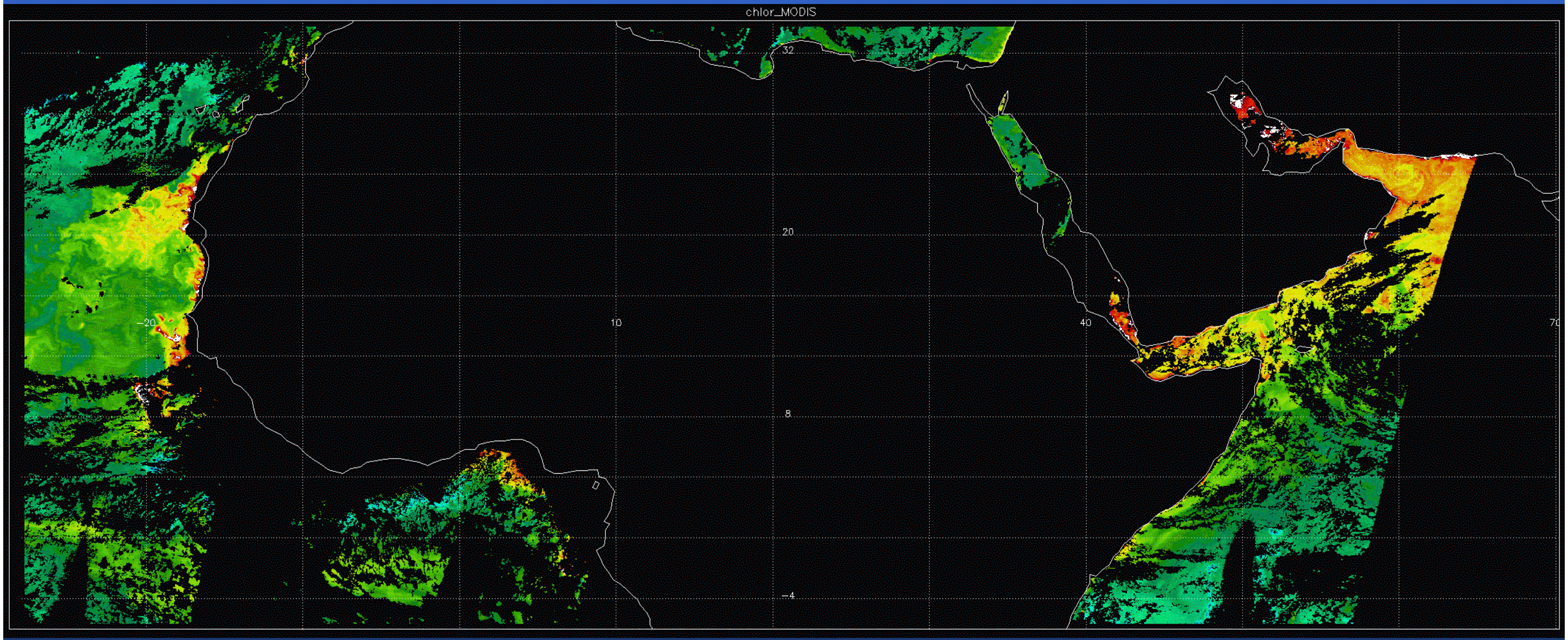


MODIS CHL

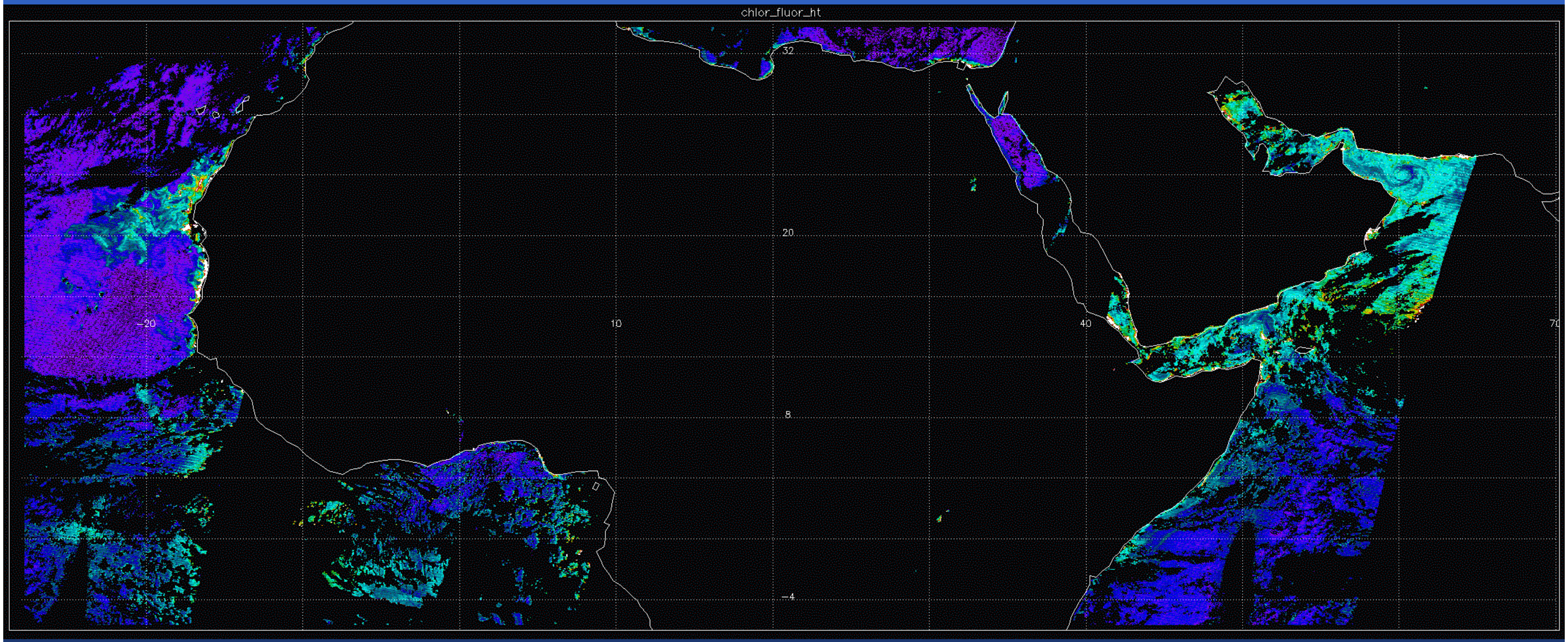


MODIS CFE

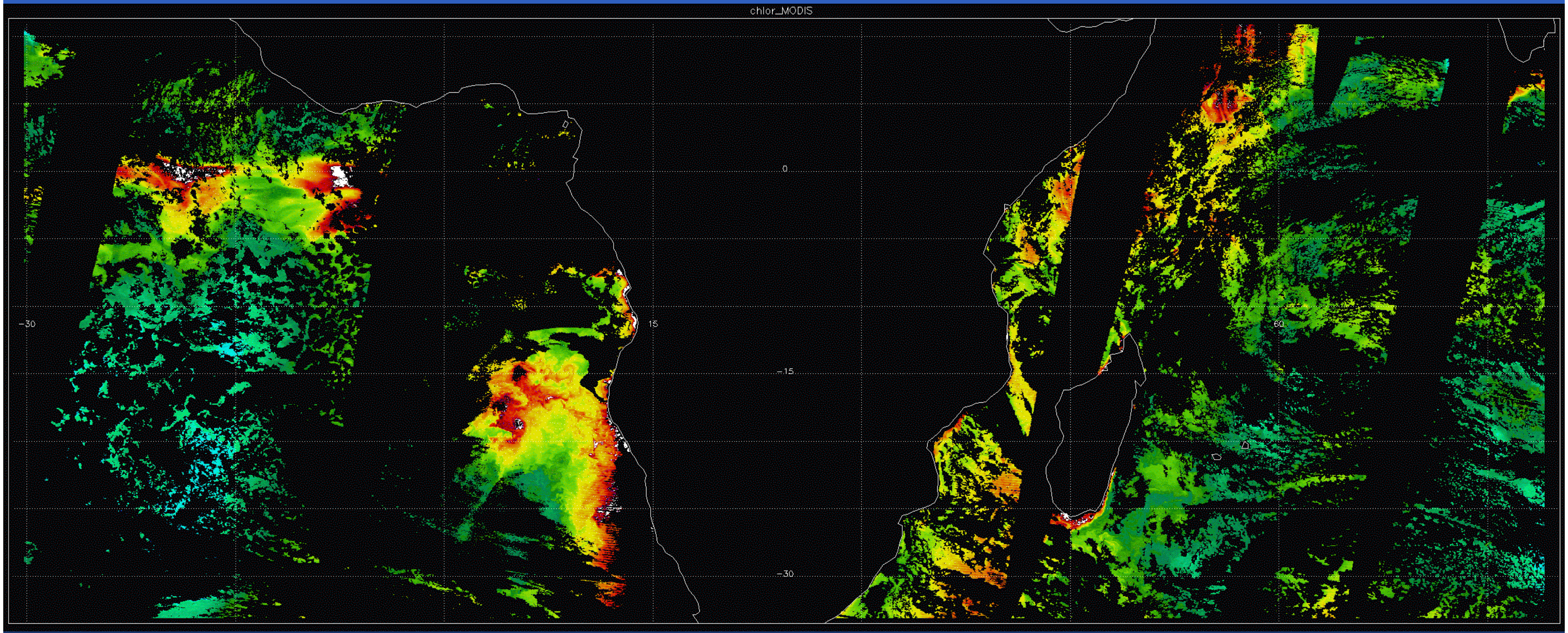
Chlorophyll December 4, 2000



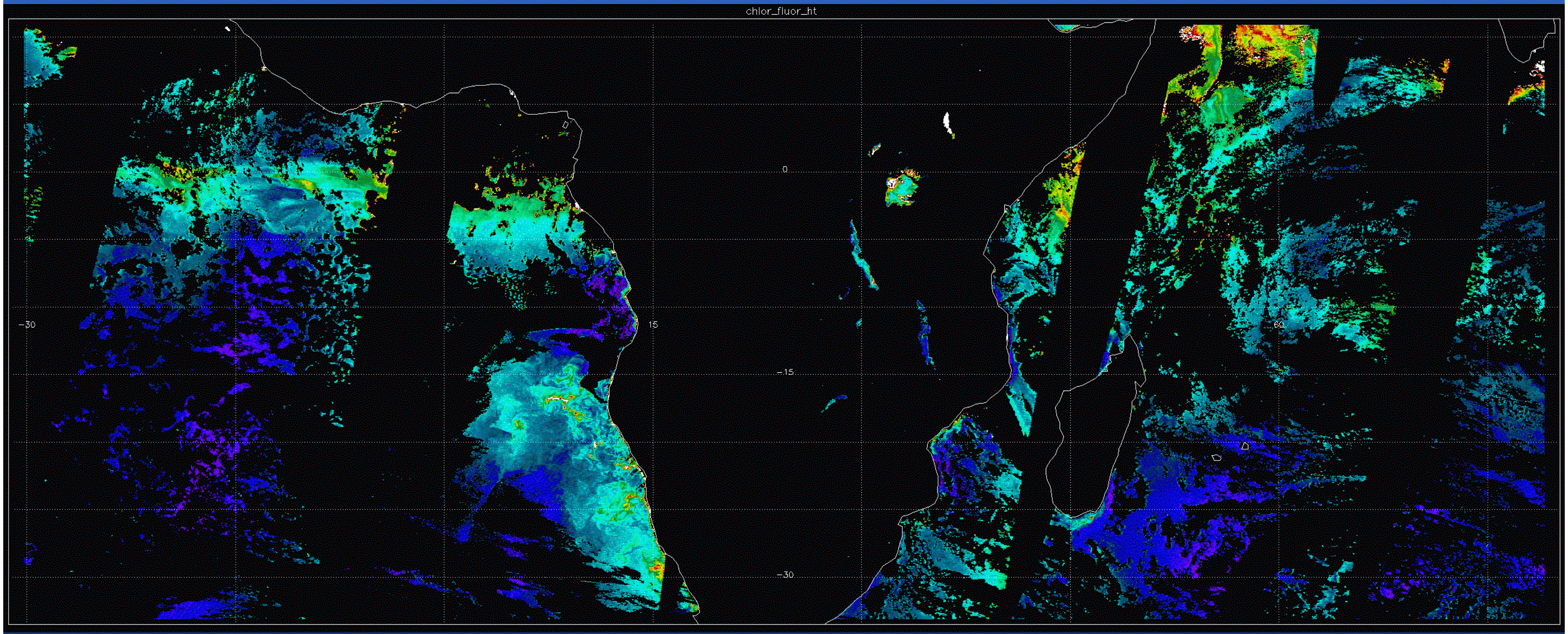
FLH December 4, 2000

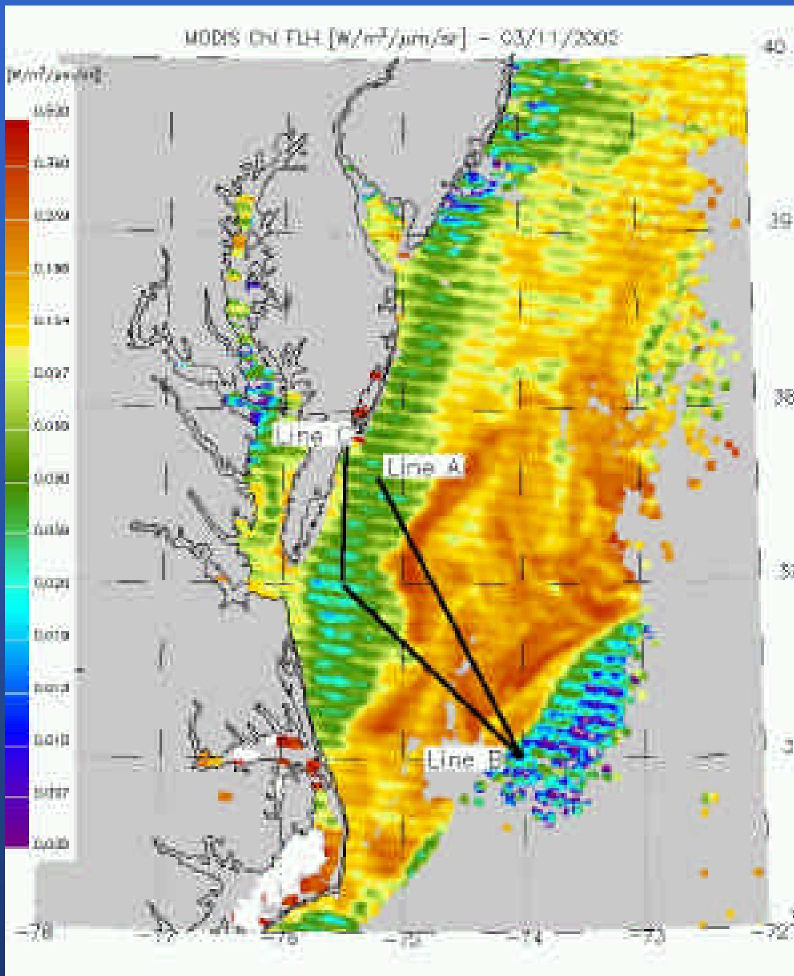


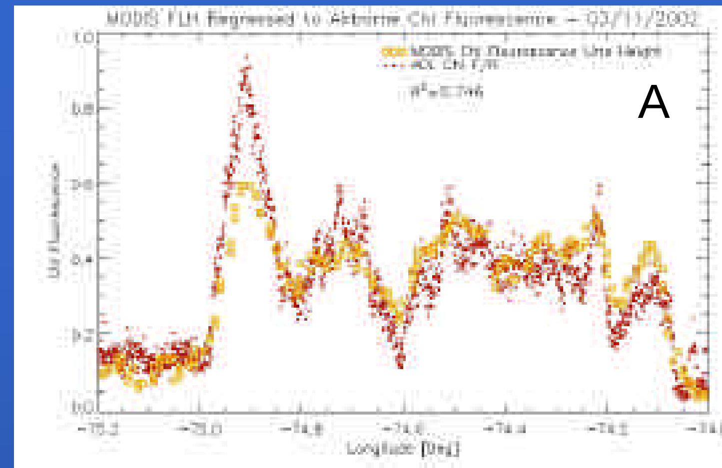
Chlorophyll June 25, 2002

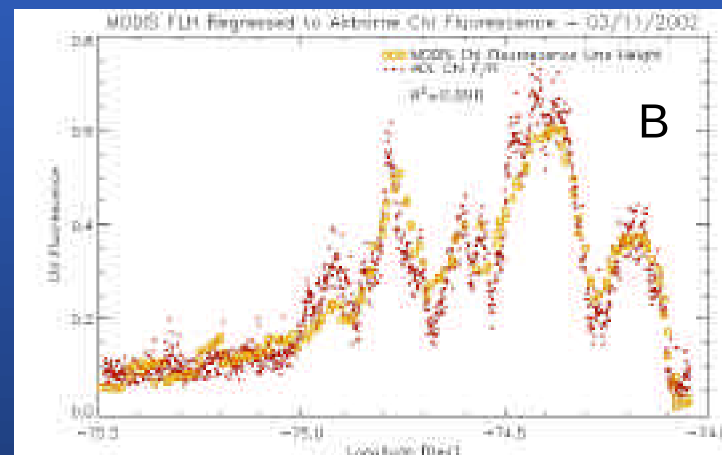


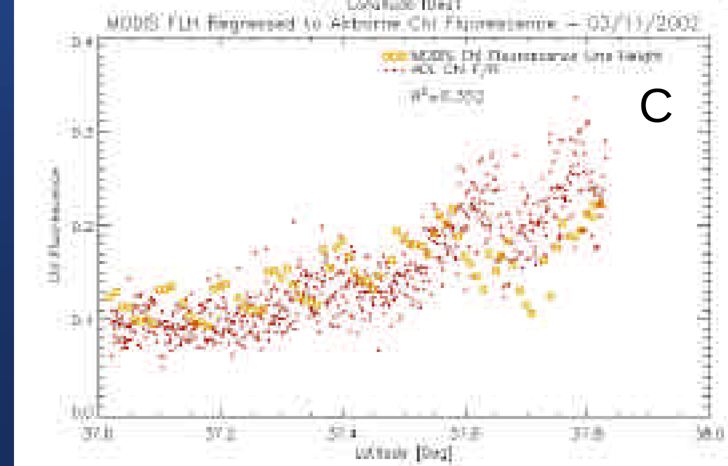
FLH June 25, 2002



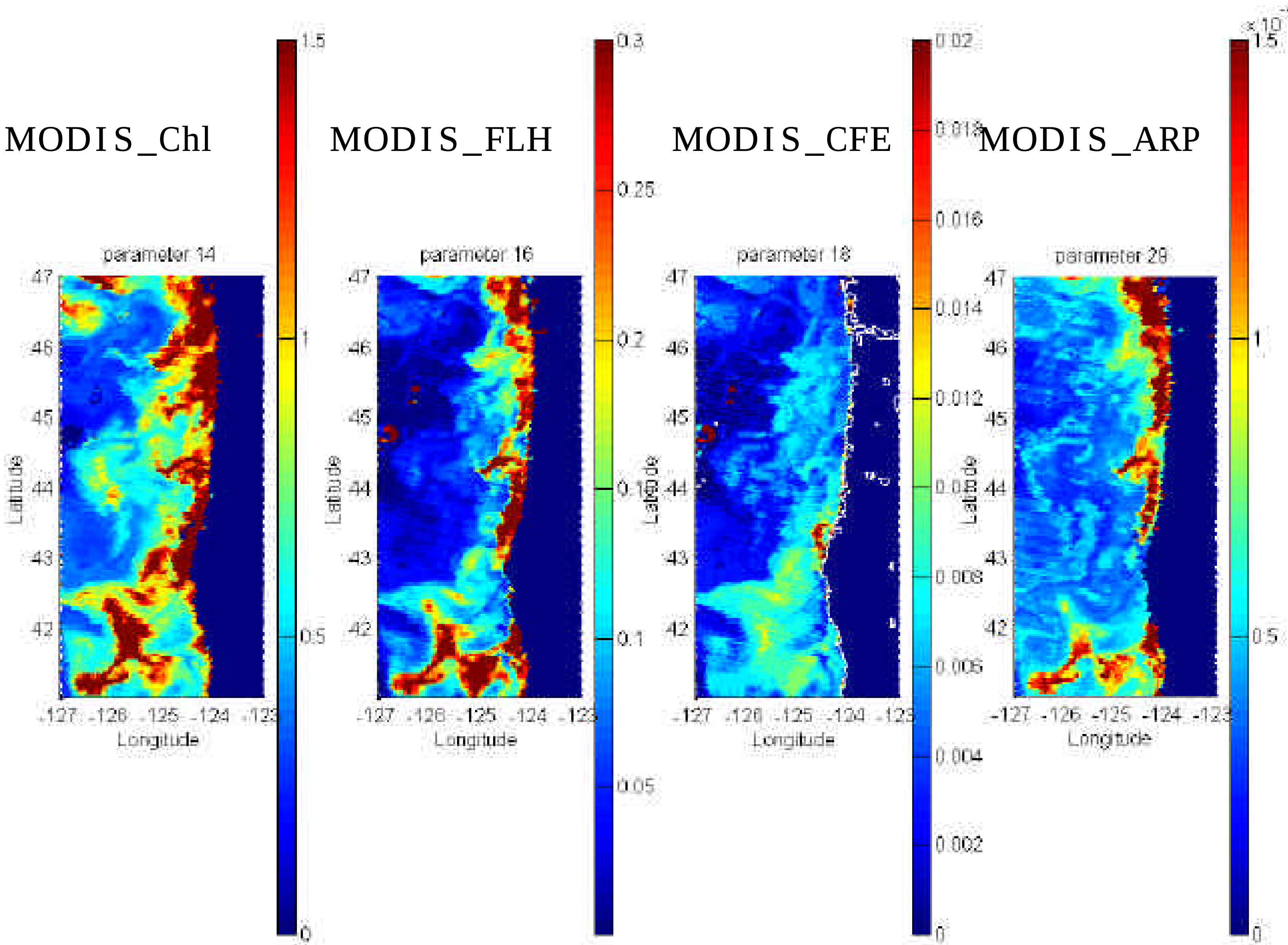








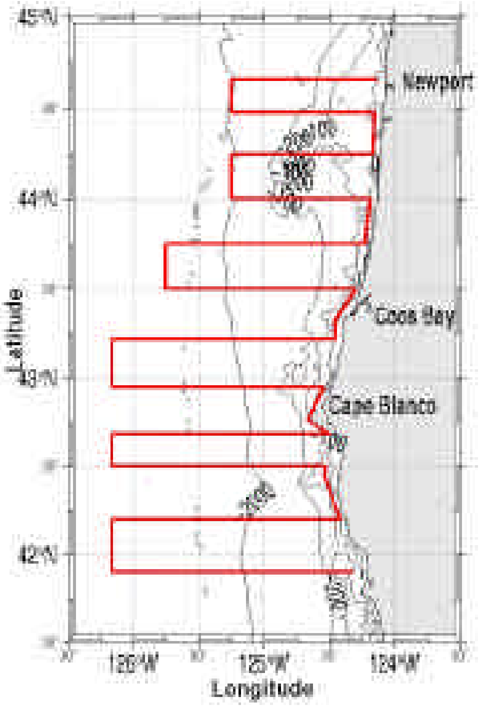
(From Frank Hoge)

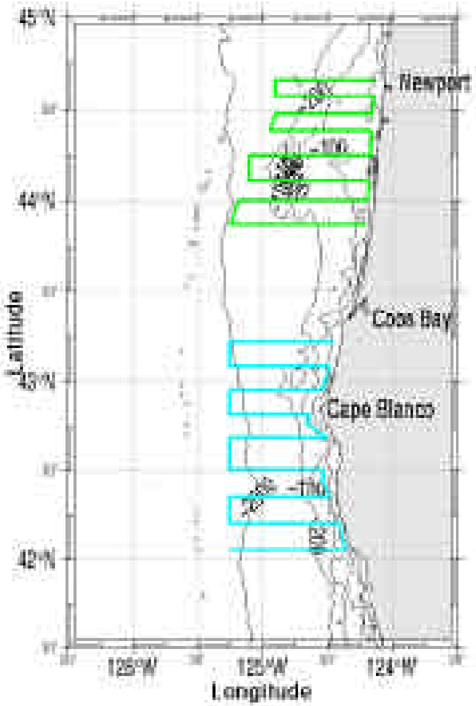


OSU Direct Broadcast October 04, 2001

Field Approach

- Mesoscale Surveys (Cowles/Barth)





Some Survey Measurements

-Continuous from Flow-through system

- -Temperature/ Salinity
- - Active Fluorometry
- - Fast Repetition Rate Fluorometry
- - Total and dissolved absorption and attenuation

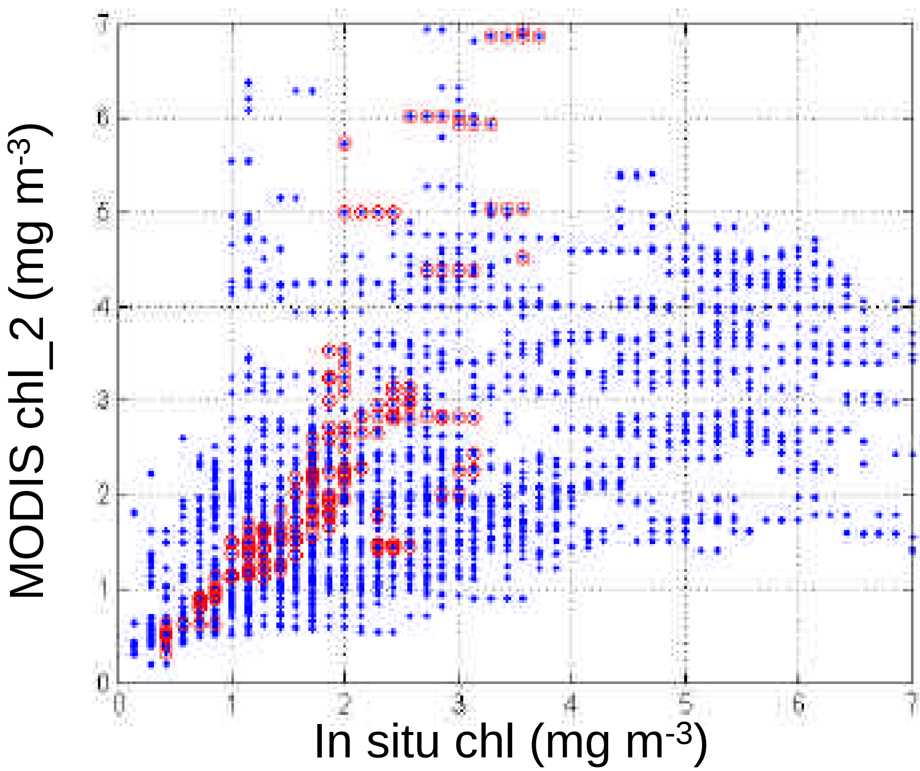
-Discrete

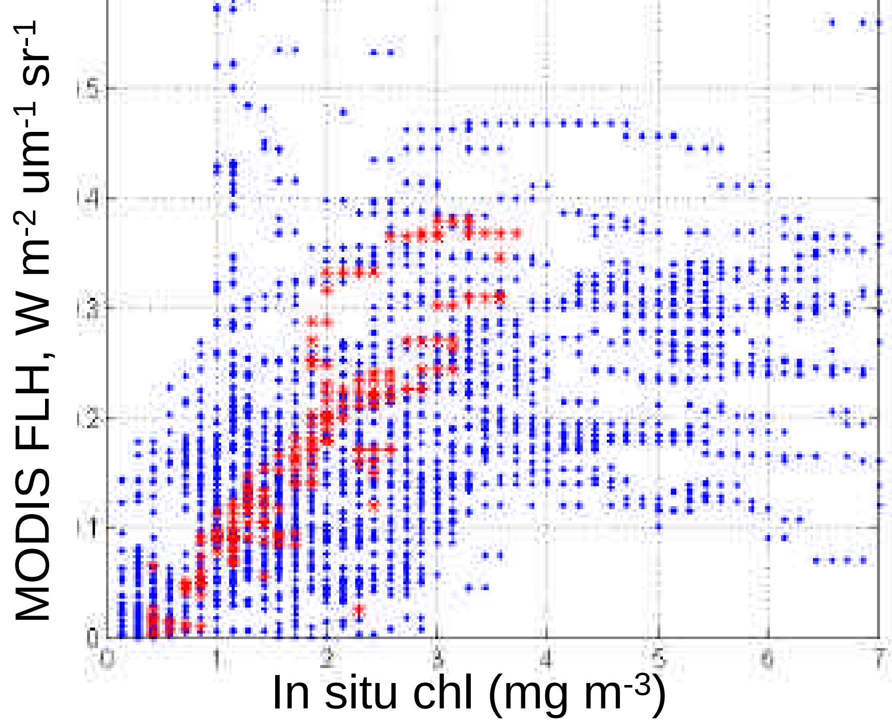
- - Pigments (Fluor/HPLC)
- - Nutrients (autoanalyzer)
- - Particulate absorption

- Other Platforms

- - Optical Drifters, tethered buoys
- - Moorings
- - Satlantic MicroSAS underway reflectance

Comparison between field measurements and Remote Sensing data (Mesoscale Survey August 2000 And MODIS Image from August 2nd)

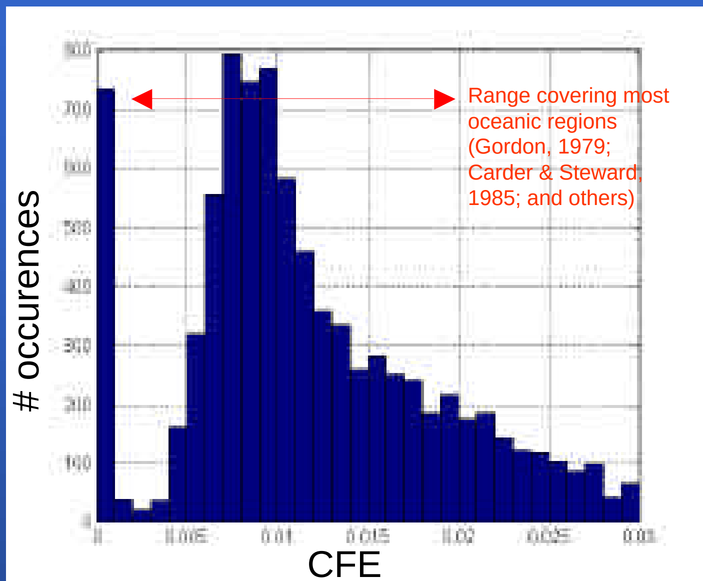


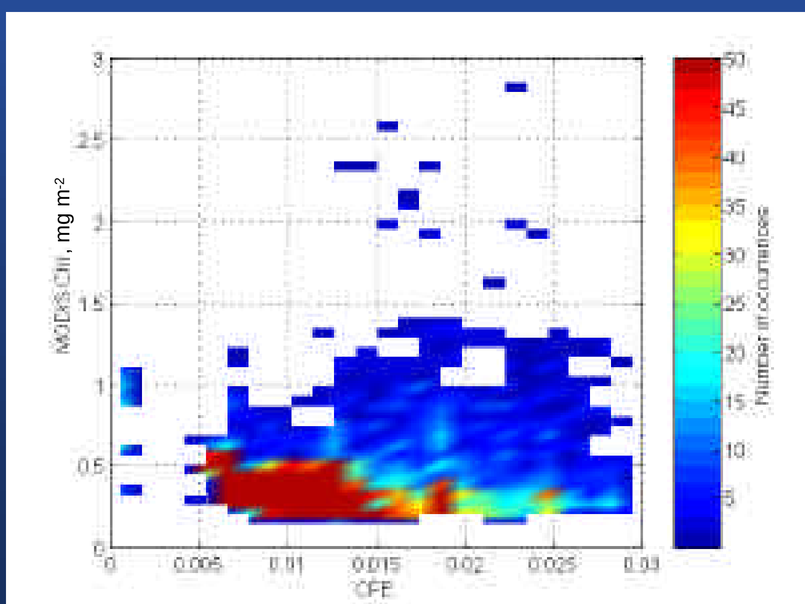


(In situ chl derived from the calibration of the flow through fluorometer with HPLC chlorophyll determinations)

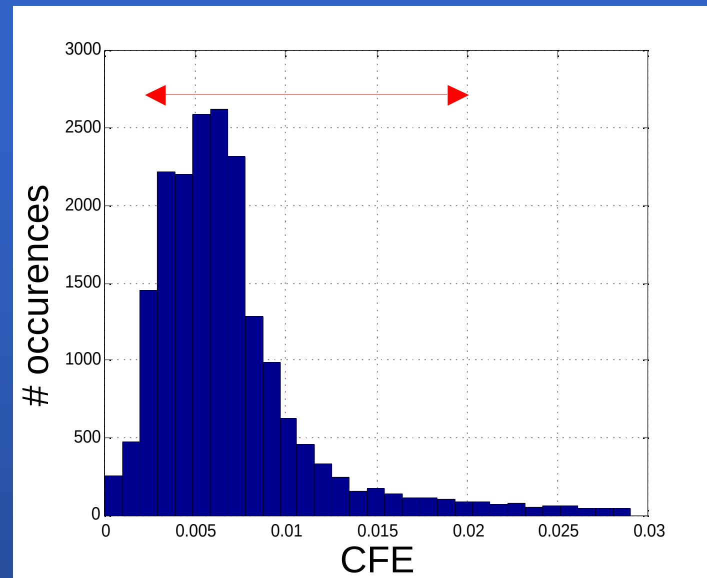
-Blue = all mesoscale survey data (July 31st – August 7th)

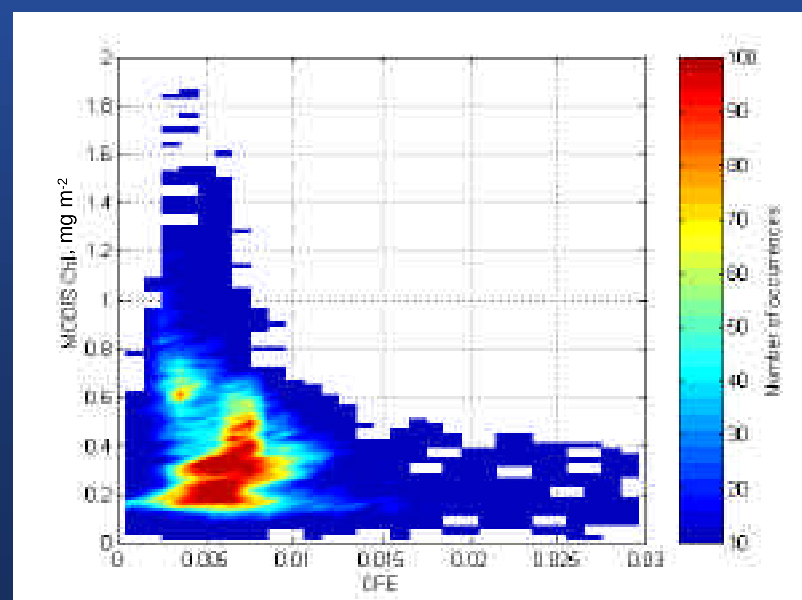
Oregon Coast DB Image 2001150



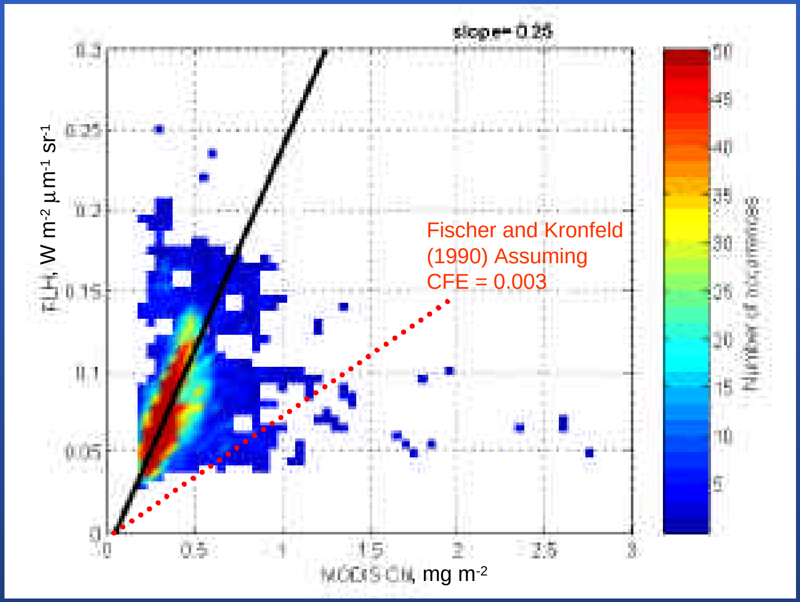


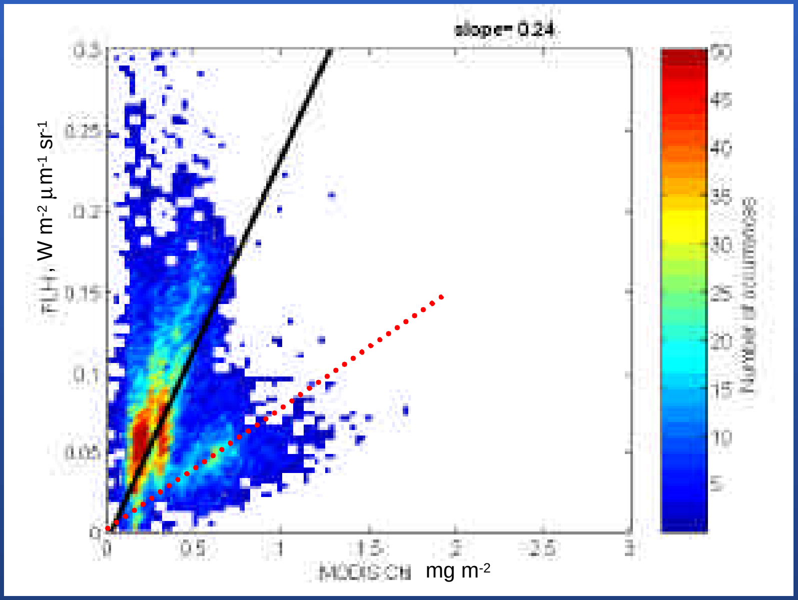
East Coast Image 2001095.1605



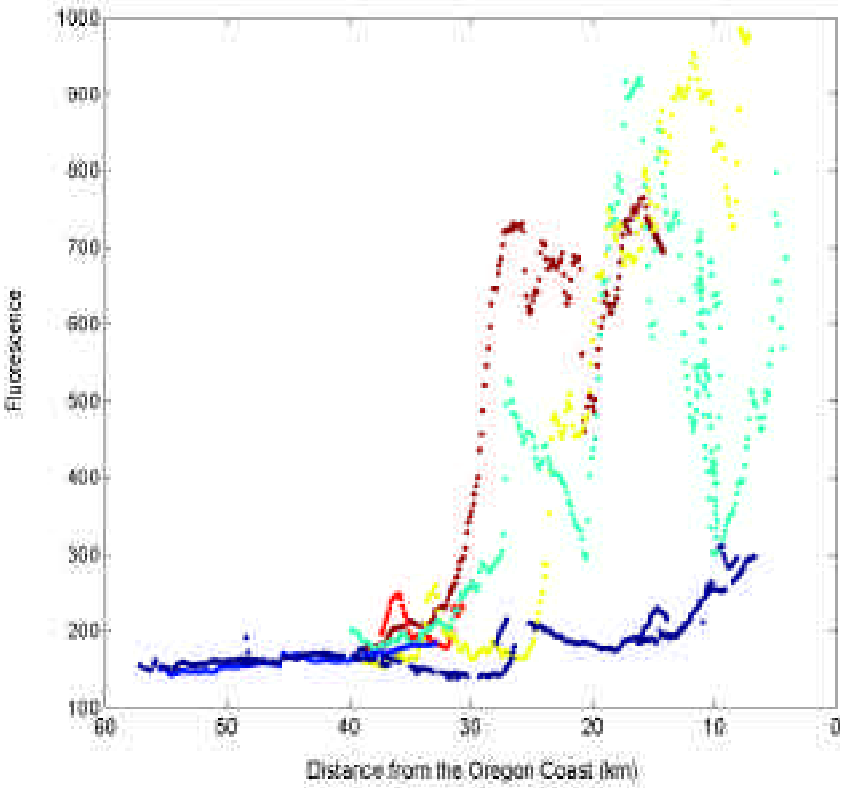


Oregon Coast DB Image 2001150 East Coast Image 2001095.1605

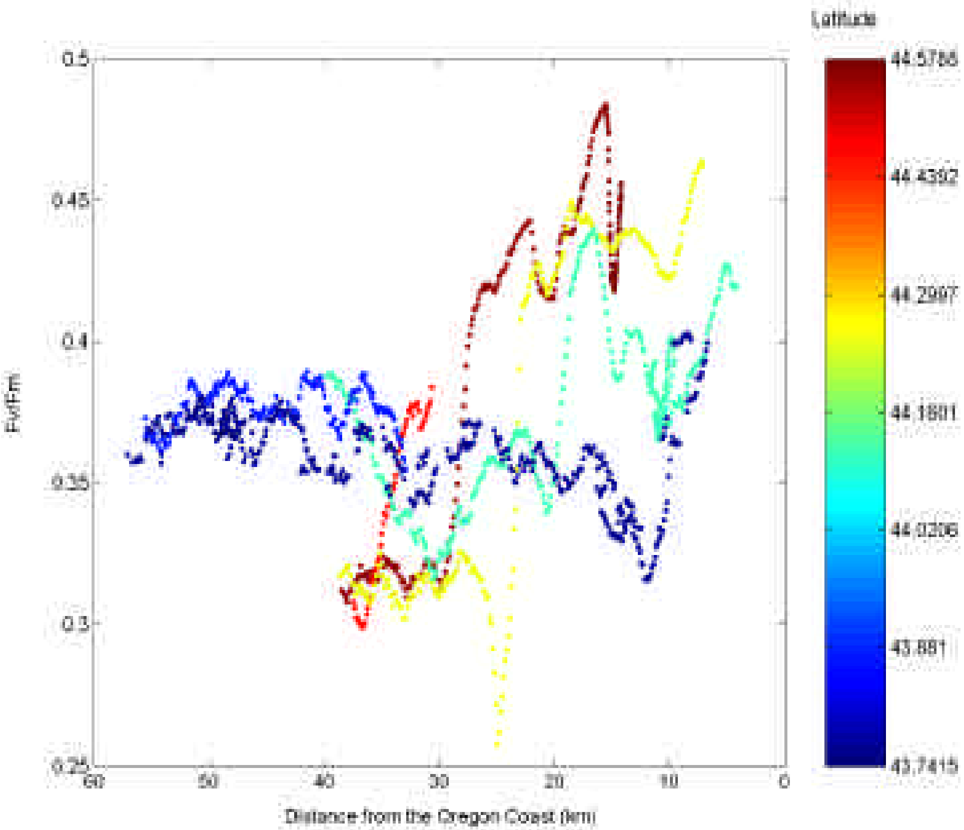




Chlorophyll biomass proxy



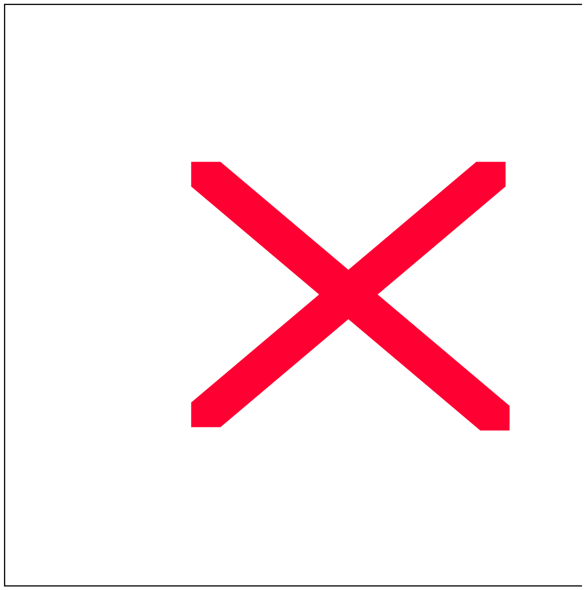
Optimum photosynthesis max yield

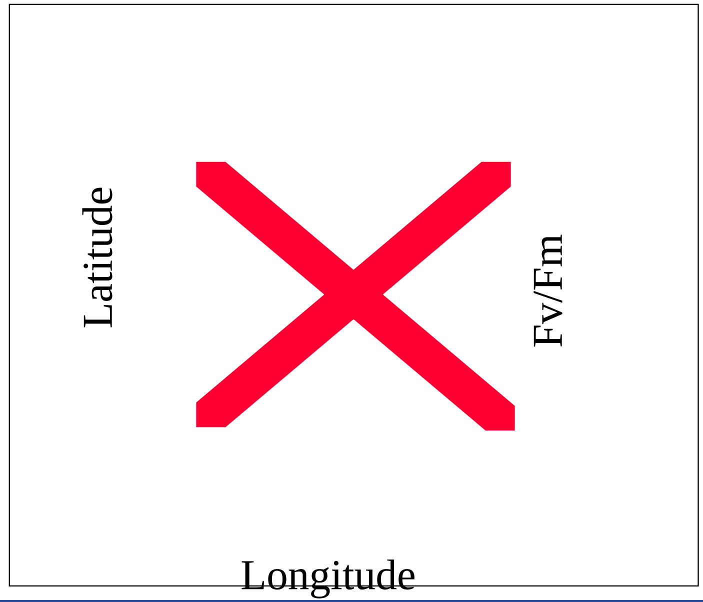


(From Rachel Sander's work)

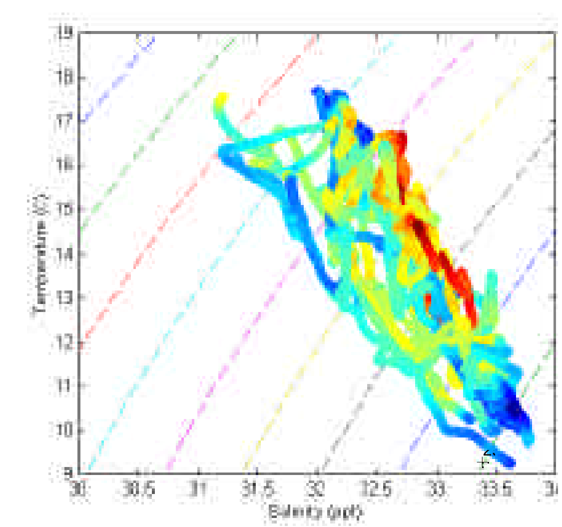
August 2000
(Nighttime)

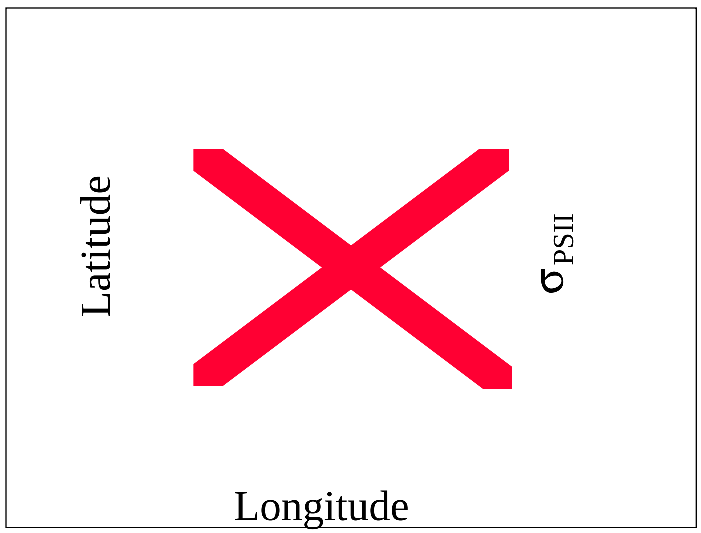
Optimum Absorption Quantum Yield



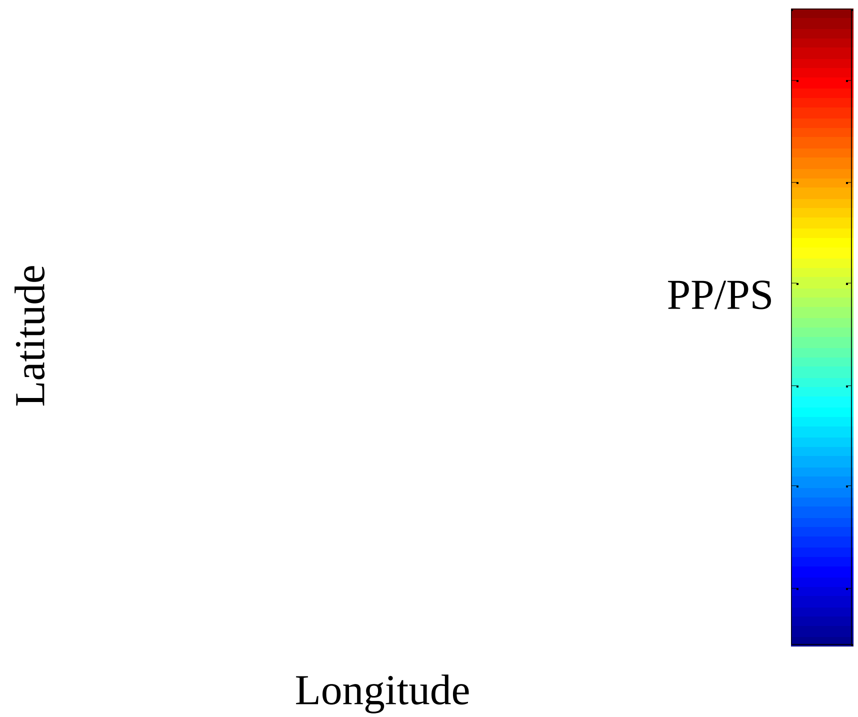


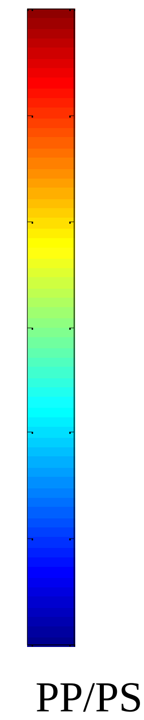
Absorption Cross-section of Photosystem II





Photoprotective:Photosynthetic pigment ratio





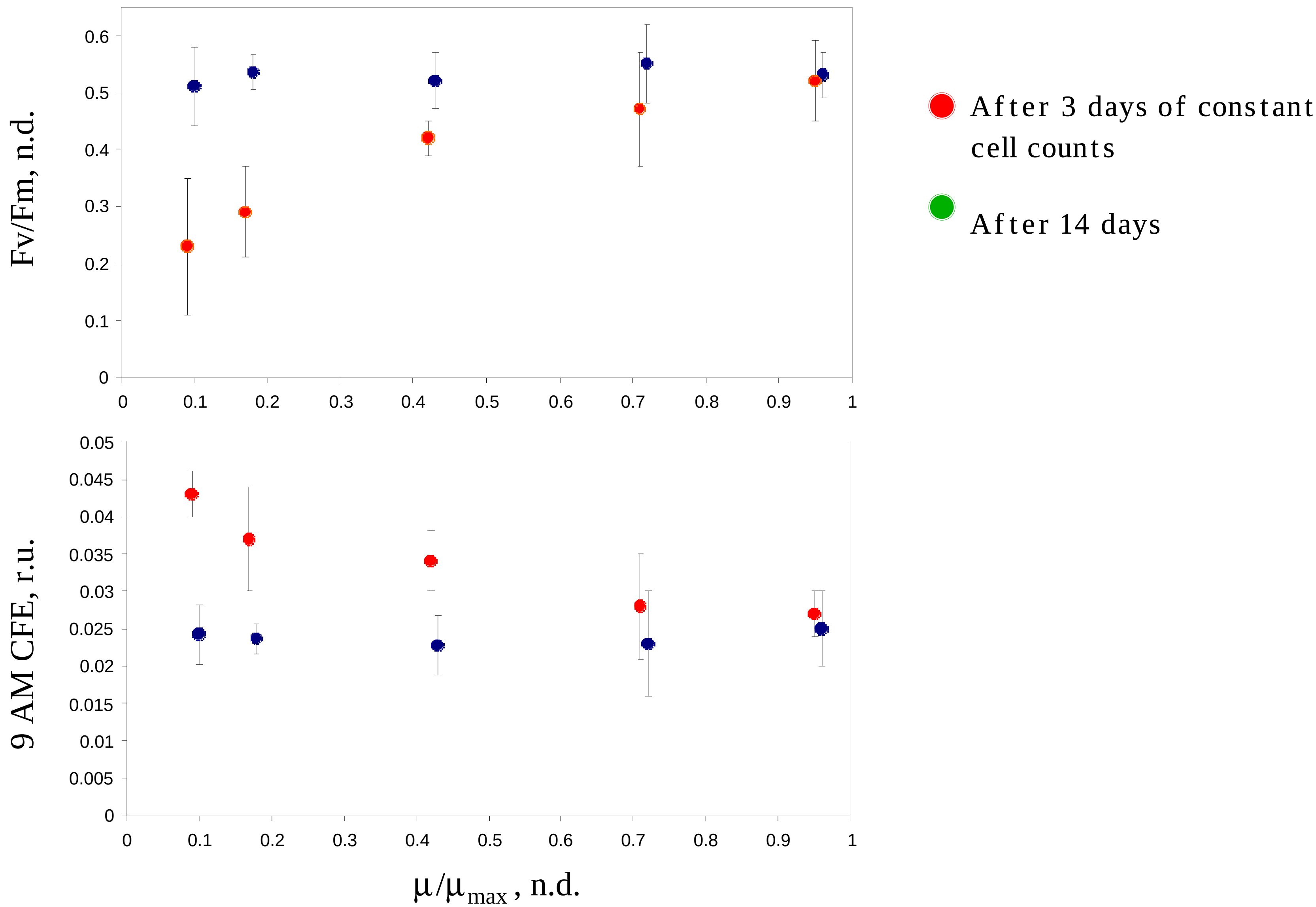
Other alternatives :

- Changes in ARP (We just finished analyzing the filter pad particulate absorption samples)
- Heat dissipation processes not accounted for

However:

- FLH and CFE are very different MODIS products in terms of validation.
  - FLH is based on nLw at 678 nm after baseline correction
  - CFE is a proxy for Φ_f (a physiological parameter) that requires the previous validation of ARP ([chl] x a*).
  - Further use of Φ_f to infer Φ_p requires the characterization of the variability in energy distribution within the photosystem

Thalassiosira weissflogii
Chemostat results 2001-2002



Summary

- Fluorescence and chlorophyll
  - Generally a linear relationship between absorption-based estimates and fluorescence-based estimates of chlorophyll
    - Exceptions are apparent, for example near the coast
  - Slope of line relating FLH to chl is related to CFE
- Can we estimate chlorophyll from FLH?
  - Challenge is that many processes affect ϕ_F
    - Photoprotective pigments, absorption cross-section
  - Appears, though, that CFE appears to fall into 2 clusters so problem may be tractable
  - High values of CFE appear to be associated with communities far from equilibrium