Phytoplankton Fluorescence from MODIS

Jasmine S. Bartlett
Mark R. Abbott
Ricardo M. Letelier

Oregon State University

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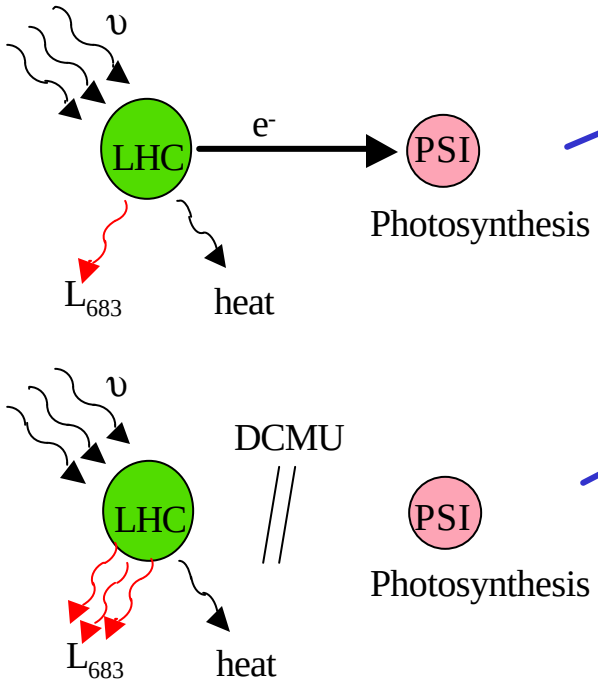
Blue light induced chlorophyll fluorescence in Tobacco leaf. A. photographed in white light. B. taken in the low steady state of fluorescence, 5 min after the onset of illumination. The bright red fluorescing upper part of the leaf is where photosynthesis has been blocked by the herbicide duiron (DCMU).

(From Krause and Weis, 1988)



Why is fluorescence important?

- describes the physiological state of the phytoplankton
- will help to determine the cause of phytoplankton bloom collapses
- will help to make more robust estimates of primary productivity on a global scale

Fluorescence & Primary Productivity

- Ocean represents about 50% of total primary productivity
- Improved models of primary productivity essential to understand the linkages between atmospheric CO_2 and ocean uptake
- Simple chlorophyll-based models of productivity will not be adequate
- MODIS represents a significant step forward in ocean remote sensing

Present Models of Primary Productivity

- focus on light **absorption** processes
  - Variability result of variations in light utilization potential of phytoplankton
  - Present models attempt to use physical data and/or climatology to estimate light utilization potential
    - Mixed layer depth
    - Season
    - Biogeographic provinces
    - SST

Fluorescence-Based Models of Primary Productivity

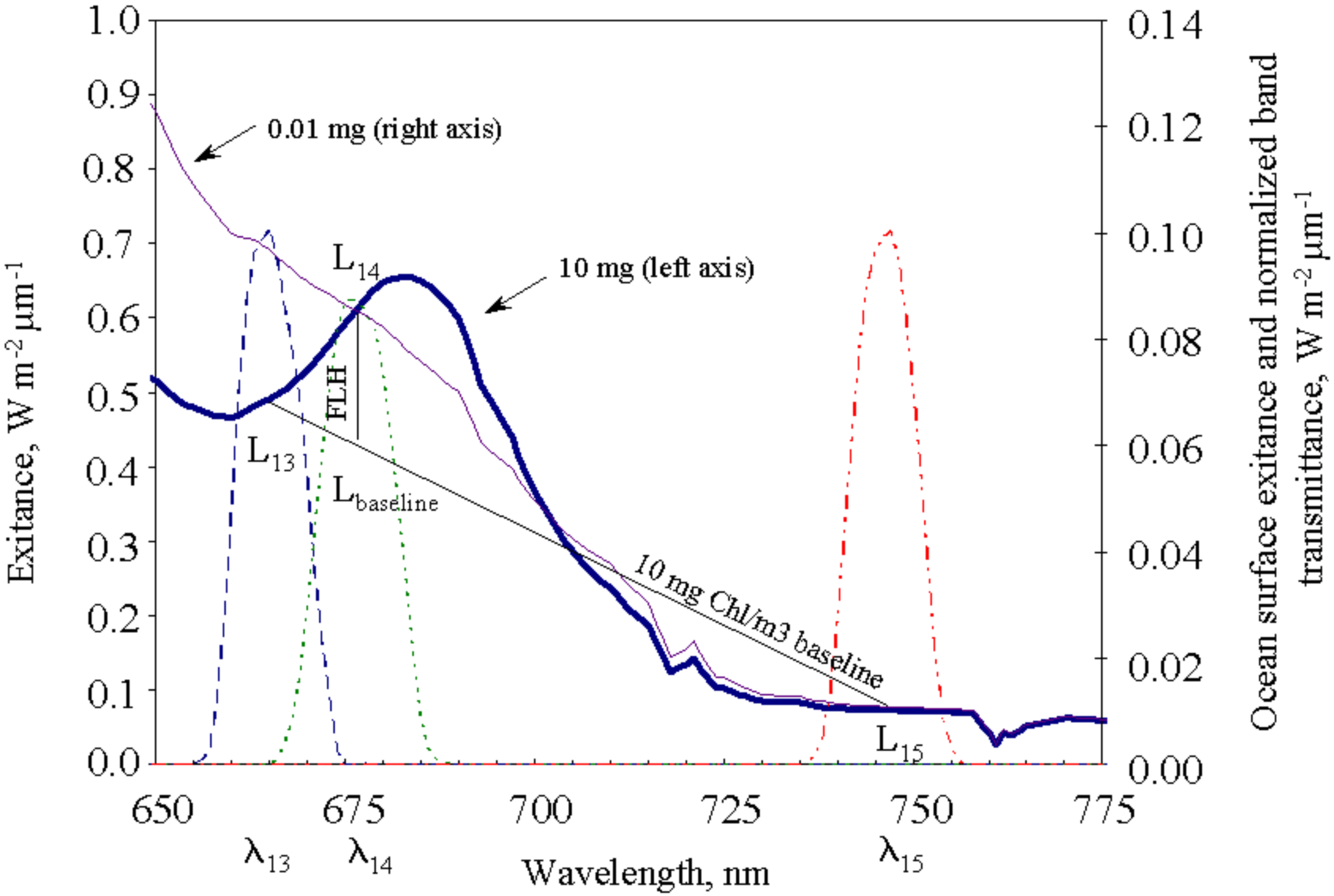
- Variations in fluorescence quantum yield are related to light **utilization**
  - Related to nutrients and species composition
  - Require averaging over some time period or spatial domain
  - Exploit this variability to improve estimation of primary productivity

MODIS fluorescence parameters

#16 chlorophyll fluorescence line height

#17 chlorophyll fluorescence baseline

#18 chlorophyll fluorescence efficiency


1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
650
675
700
725
750
775
Exitance, W m-2 µm-1
Ocean surface exitance and normalized band transmittance, W m-2 µm-1
Wavelength, nm
0.01 mg (right axis)
10 mg (left axis)
L14
L13
Lbaseline
FLH
10 mg Chl/m3 baseline
L15
λ13
λ14
λ15

$$F = [chl]\ (PAR\ a^*)\ F_f$$

where

F : chlorophyll fluorescence
[chl] : chlorophyll concentration
PAR : photosynthetically available radiation (radiation between 400 and 700 nm)
a^* : specific absorption coefficient
Φ_f : fluorescence quantum yield (fluorescence efficiency)

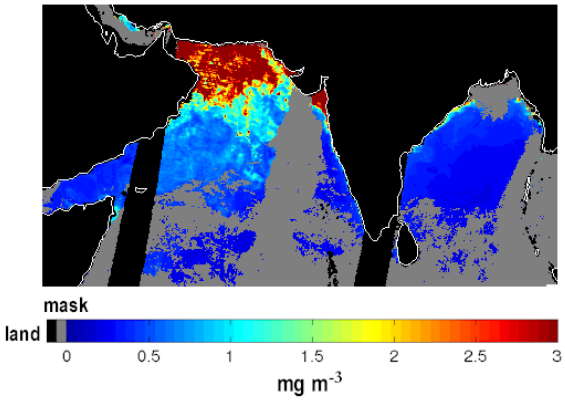
$$F_f = \frac{F}{(PAR\ a^*)\ [chl]}$$

$$\frac{F}{[chl]} = (PAR\ a^*)\ F_f$$

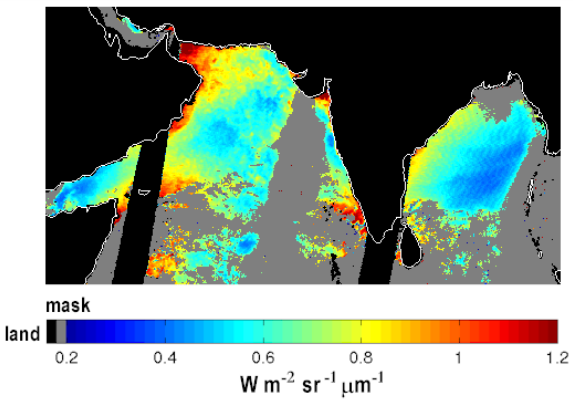
MODIS

Chlorophyll-a and Fluorescence
Arabian Sea & Bay of Bengal
March 1, 2000

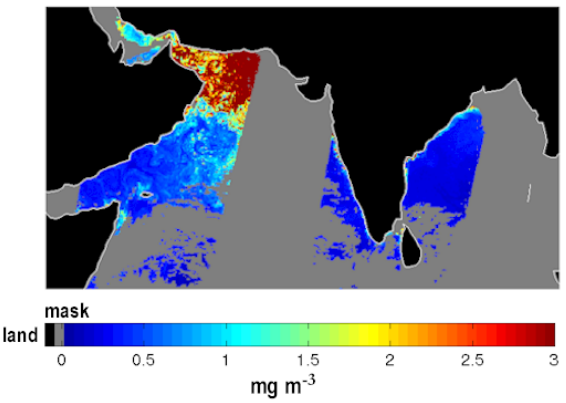
MODIS Chlorophyll-a (Chl)



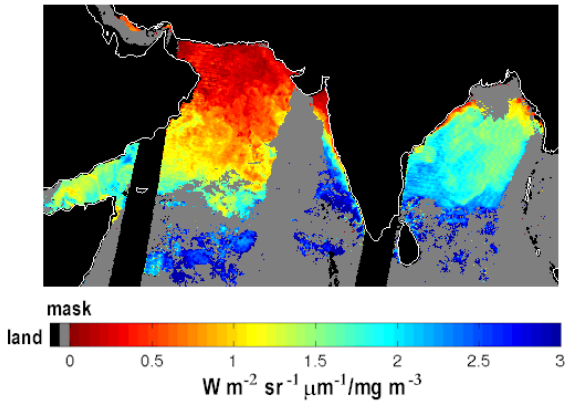
Fluorescence Line Height (FLH)



SeaWiFS Chlorophyll-a



FLH/Chl



Principal Investigators
Dr. Mark R. Abbott, Dr. Ricardo M. Letelier, and Jasmine S. Bartlett
Oregon State University

These 4 km resolution L3 mapped products from (4-29°N, 44-96°E) were processed at the University of Miami Rosenstiel School of Marine & Atmospheric Science.

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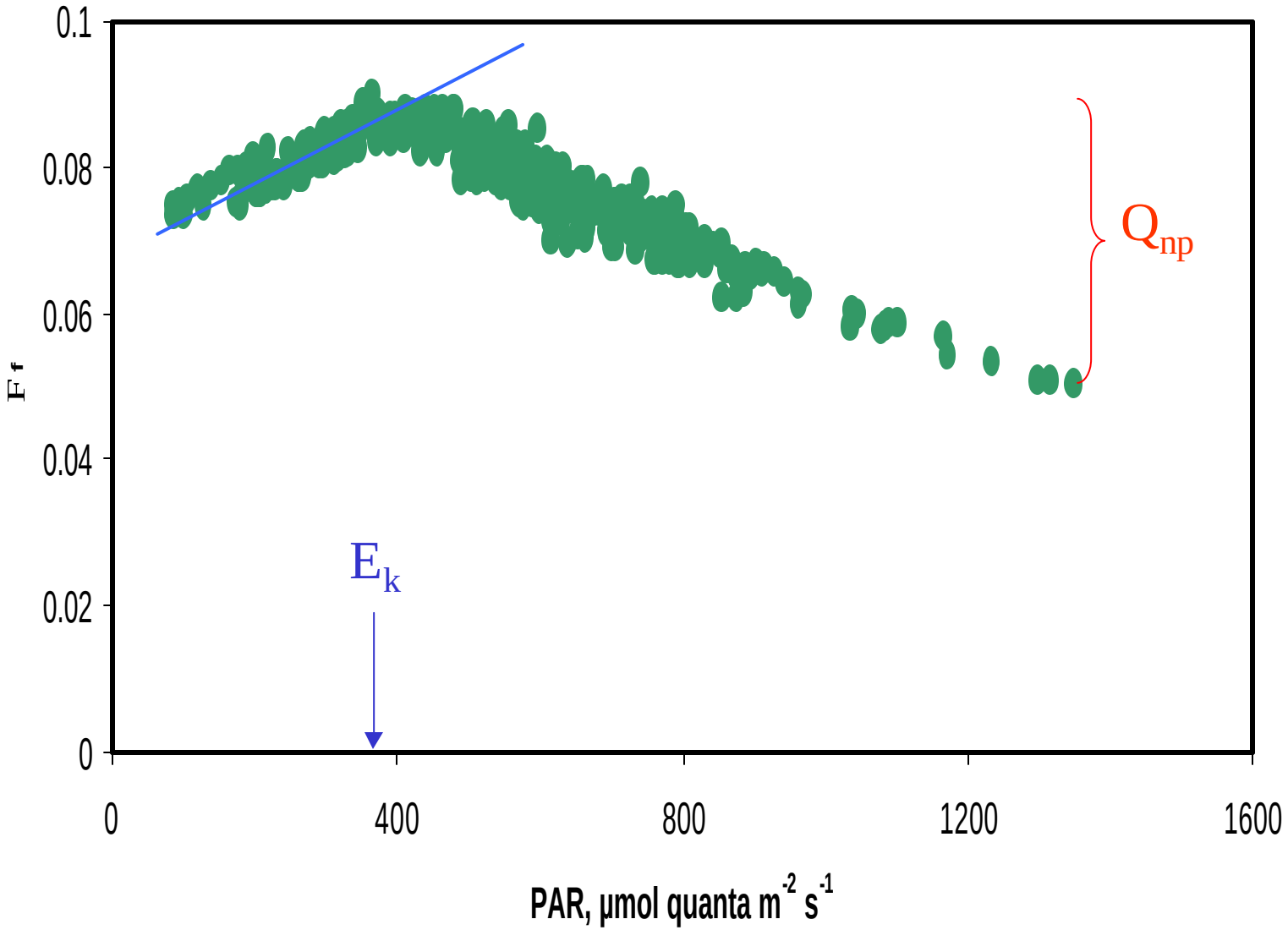
0.1
0.08
0.06
0.04
0.02
0
Ff
0
400
800
1200
1600
PAR, µmol quanta m-2 s-1
Ek
Qnp

Issues to be resolved

How does F_f vary as a function of light and nutrient limitation in surface waters?

How does the relationship between F_f and F_p vary?

$$\Phi_f + \Phi_p + \Phi_h = 1$$

How can F_f be used to help determine primary productivity?