Physiology and Community Composition in Global Elemental Cycles

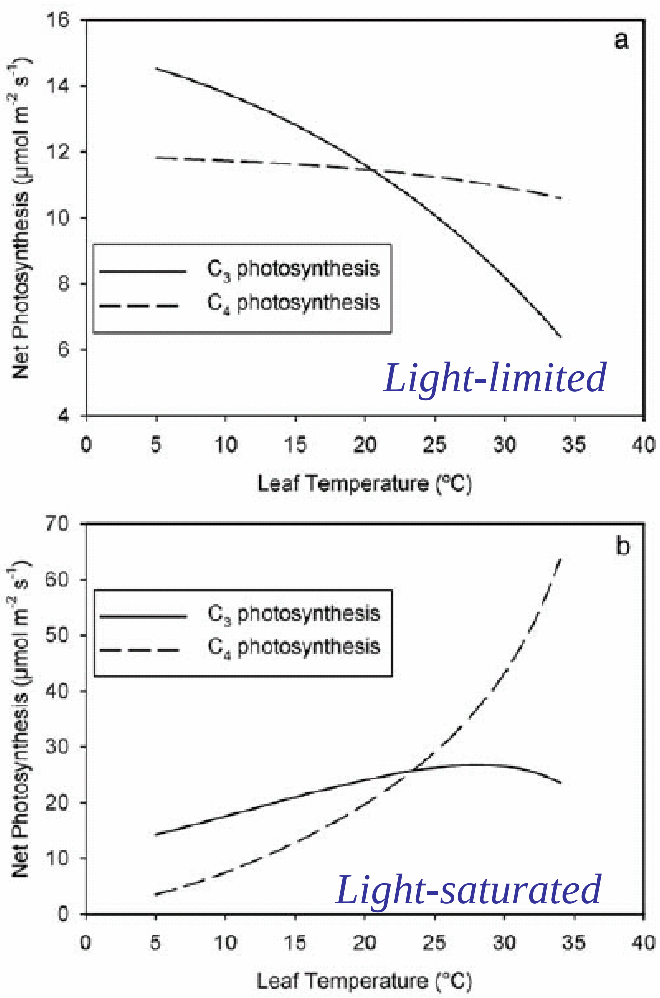
J. Aber, S. Alvain, **G. Asner**, **W. Balch**, J. Berry, K. Bidle, E. Booth, E. Boss, B. Bowler, F. Breon, J. Christian, J. Collatz, G. Dall'Olmo, Y. Dandonneau, C. Davis, R. DeFries, S. Doney, D. Drapeau, J. Dunne, P. Falkowski, G. Feldman, B. Franz, C. Goodale, N. Guillocheau, S. Hall, R. Hallett, K. Halsey, M. Hiscock, **T. Kostadinov**, A. Kustka, I. Lima, R. Letelier, N. Mahowald, S. Maritorena, M. Martin, C. McClain, **D. McGillicuddy Jr.**, **A. Milligan**, C. Moulin, R. Murtugudde, **S. Ollinger**, R. Olson, R. O'Malley, L. Plourde, J. Reinfelder, J. Sarmiento, P. Schultz, D. Shea, **D. Siegel**, M-L. Smith, **H. Sosik**, **Chris Still**, **W. Turner**, M. Vitousek, T. Westberry, J. Wiggert

CARBON

Global distribution of C_3 and C_4 vegetation: Carbon cycle implications

Christopher J. Still, Joseph A. Berry, G. James Collatz, Ruth S. DeFries

GLOBAL BIOGEOCHEMICAL CYCLES, VOL. 17, NO. 1, 1006, doi:10.1029/2001GB001807, 2003



Significance C_4 vs C_3 plants:

- Influences land-atmosphere CO2, water, and energy exchange
- Critical for interpretation of atmospheric carbon isotope composition – differential fractionation

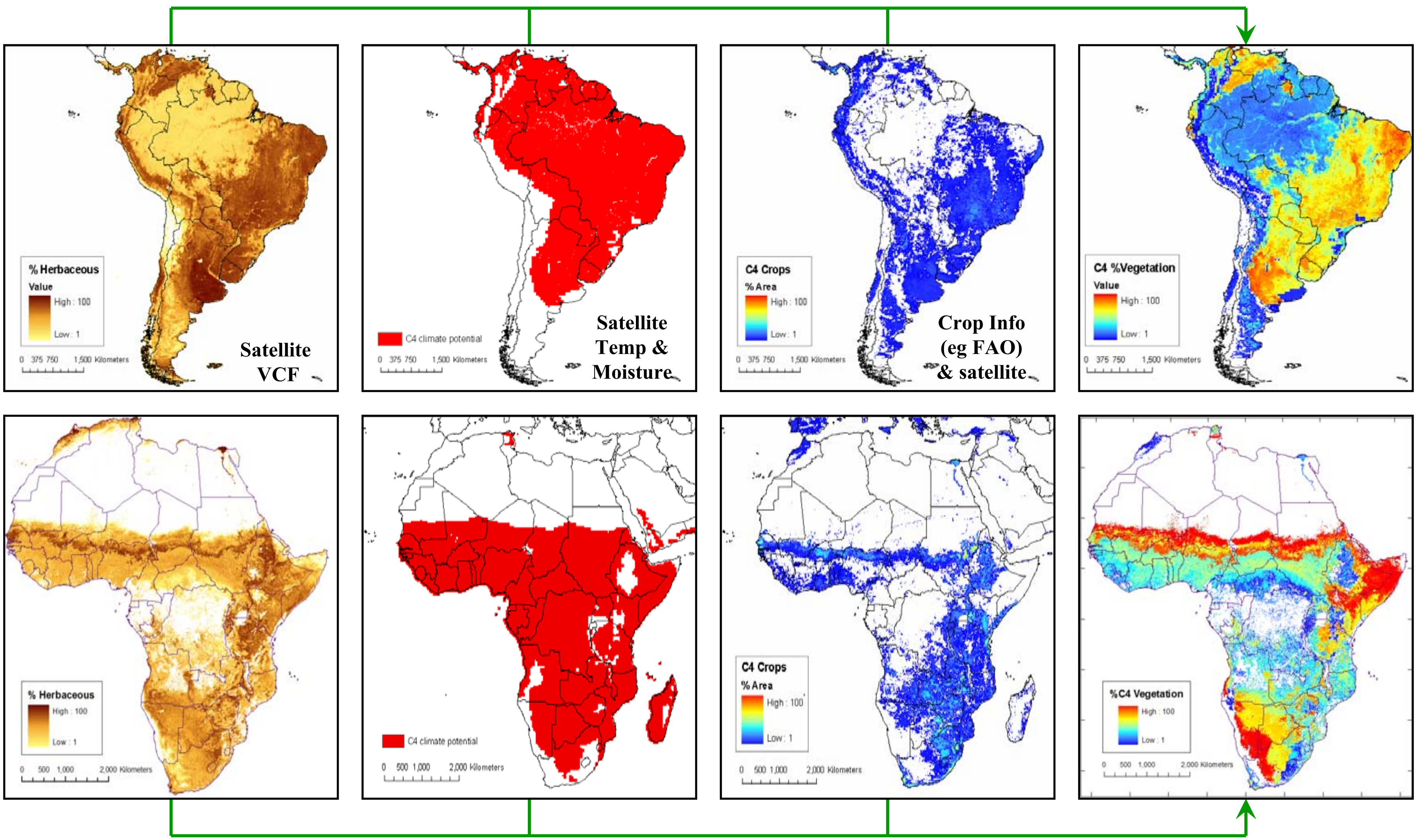
Approach

- C_4 photosynthetic performance differs from C_3 in its relation to temperature and moisture
- C_4 conditions defined by 'crossing over' points (21°C, 25 mm precipitation)
- Also incorporated crop information (FAO)

Global distribution of C_3 and C_4 vegetation: Carbon cycle implications

Christopher J. Still, Joseph A. Berry, G. James Collatz, Ruth S. DeFries

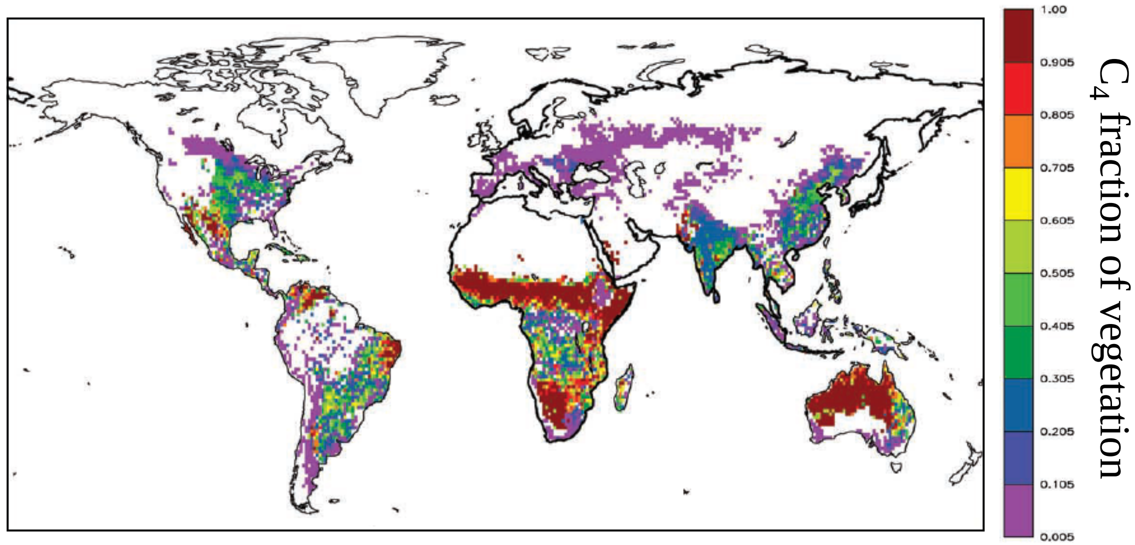
GLOBAL BIOGEOCHEMICAL CYCLES, VOL. 17, NO. 1, 1006, doi:10.1029/2001GB001807, 2003

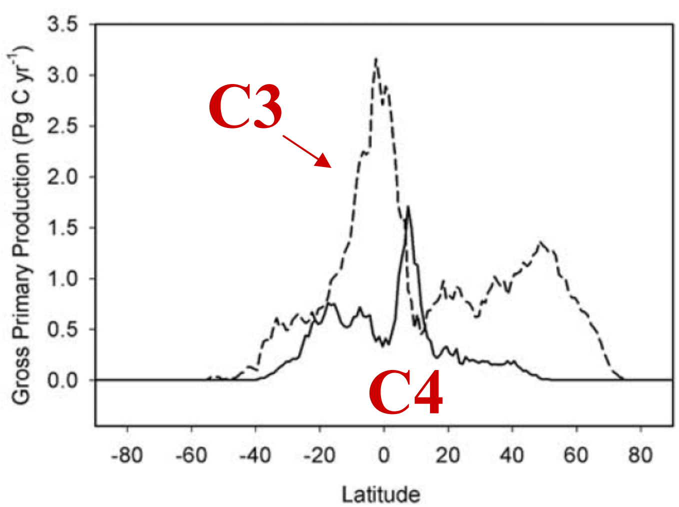


Global distribution of C_3 and C_4 vegetation: Carbon cycle implications

Christopher J. Still, Joseph A. Berry, G. James Collatz, Ruth S. DeFries

GLOBAL BIOGEOCHEMICAL CYCLES, VOL. 17, NO. 1, 1006, doi:10.1029/2001GB001807, 2003





	C_4	C_3
Vegetated Land	18%	82%
% crops	16%	84%
GPP	35 Pg	115 Pg

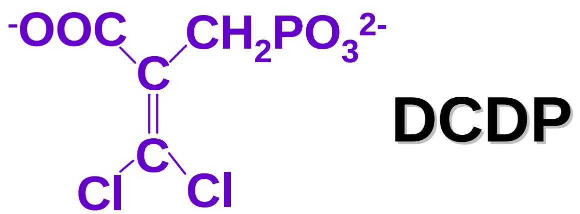
Net carbon sink Land = 2.4 Pg y^{-1}

Net carbon sink Ocean = 1.4 Pg y^{-1}

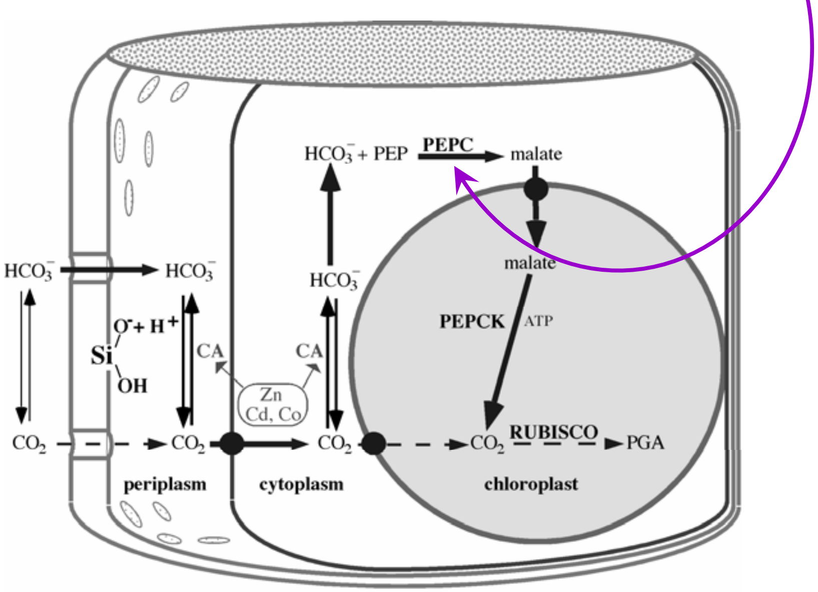
C_4 in the Oceans:

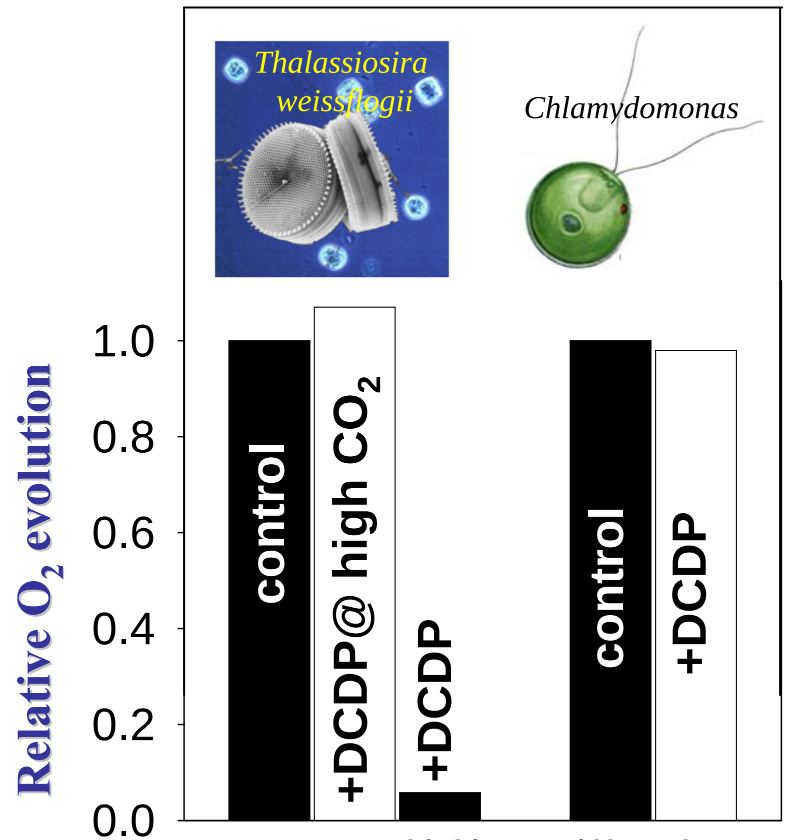
Linking satellite taxonomy to diatom physiology

Adam Kustka, Allen Milligan, Kay Bidle, John Reinfelder

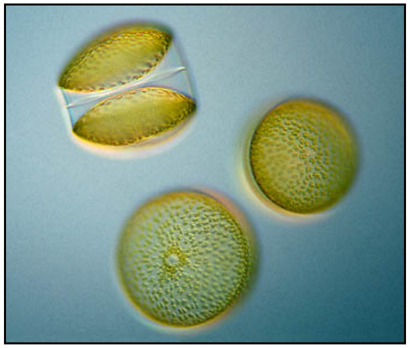


(3,3-dichloro-2-dihydroxyphosphinoylmethyl-2-propenoate)





modified from Reinfelder et al. 2002



Coscinodiscus granii

Remote sensing of phytoplankton groups in case 1 waters from global SeaWiFS imagery

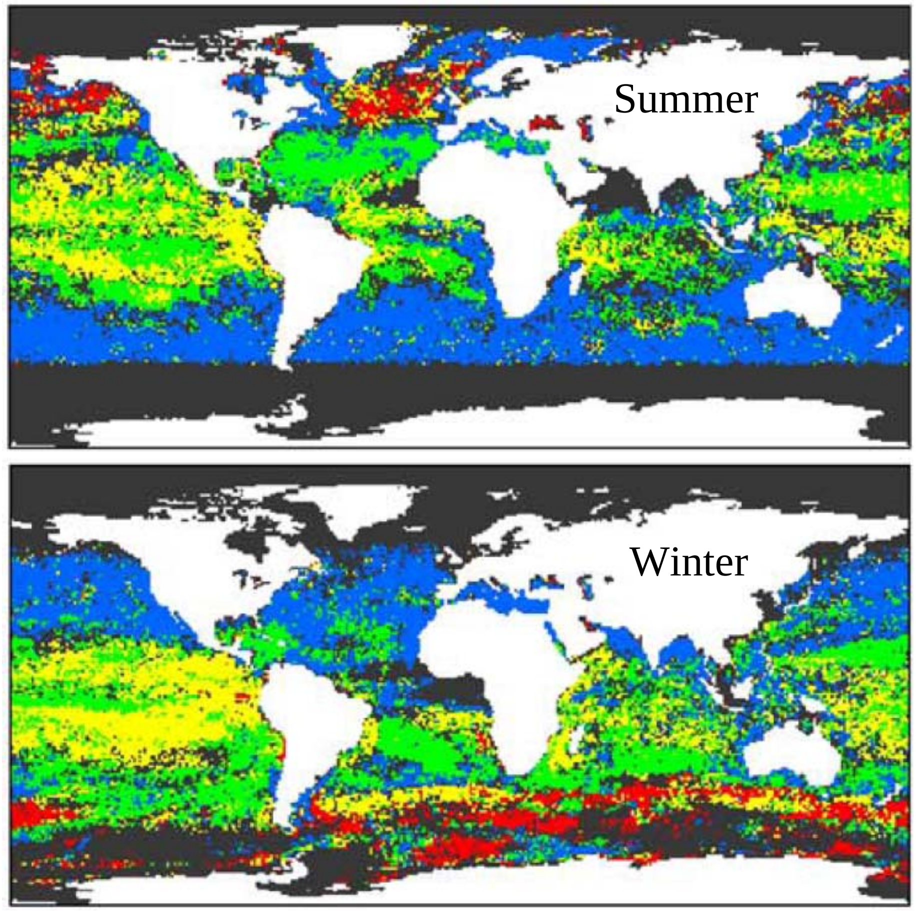
ELSEVIER

S. Alvain[a], C. Moulin[a,*], Y. Dandonneau[b], F.M. Bréon[a]

DEEP-SEA RESEARCH PART I

52 (2005) 1989–2004

- ❑ Spectral signatures of phytoplankton assemblages with differing dominant groups



Haptophytes

Prochlorococcus

Synechococcus-like

Diatoms

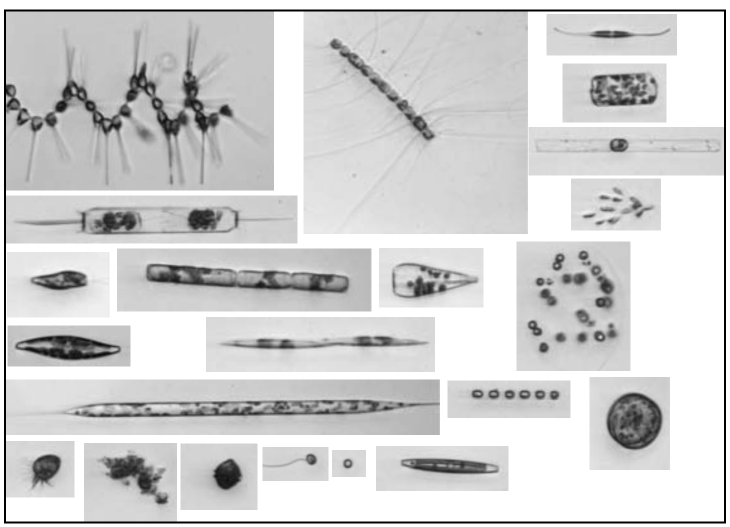
LIMNOLOGY
and
OCEANOGRAPHY: METHODS

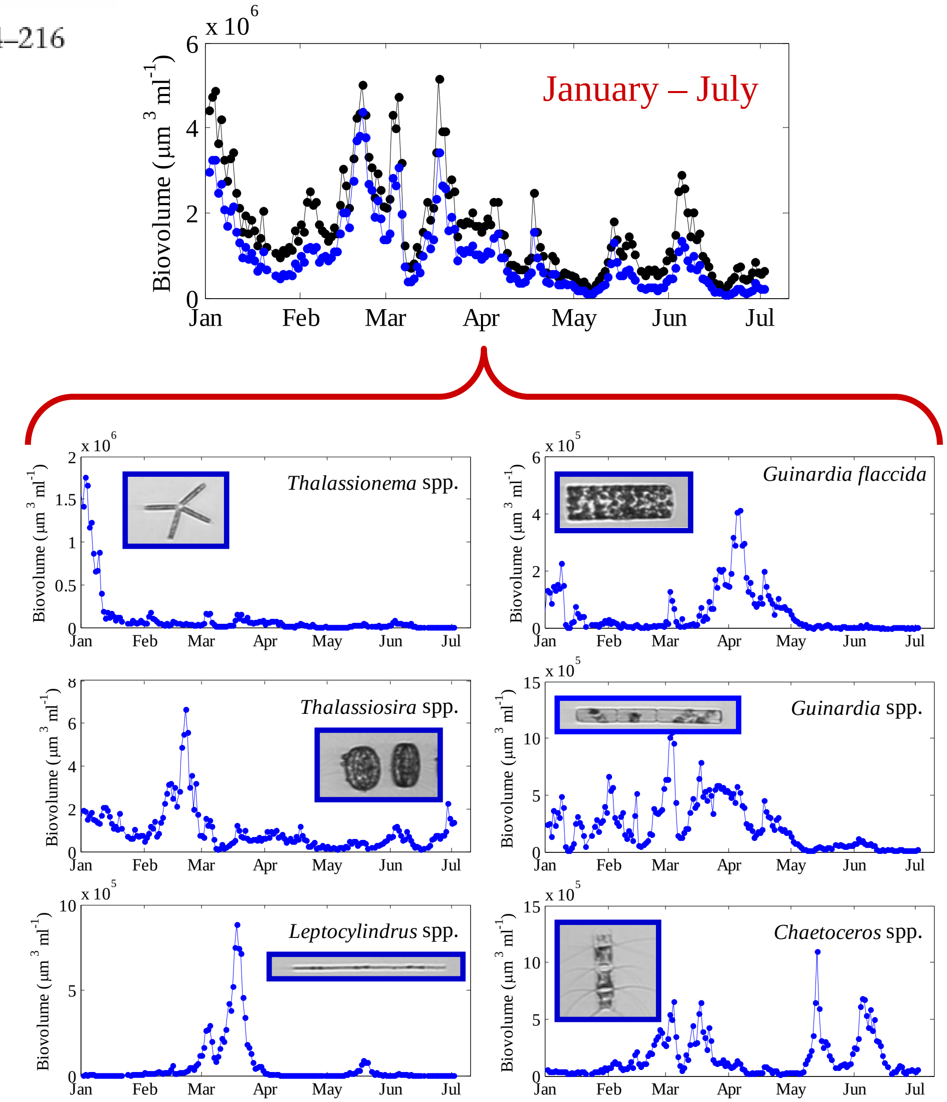
Automated taxonomic classification of phytoplankton sampled with imaging-in-flow cytometry

Heidi M. Sosik and Robert J. Olson

Limnol. Oceanogr.: Methods 5, 2007, 204–216

- Automated image analysis and classification
- Picoplankton to microplankton capabilities
- 22 taxonomic categories
- 88% overall accuracy



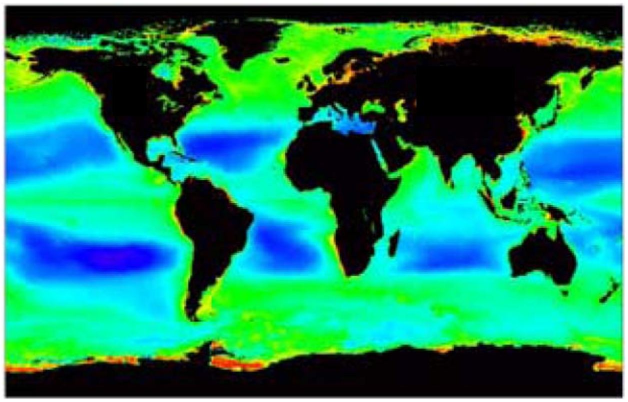


Carbon-based ocean productivity and phytoplankton physiology from space

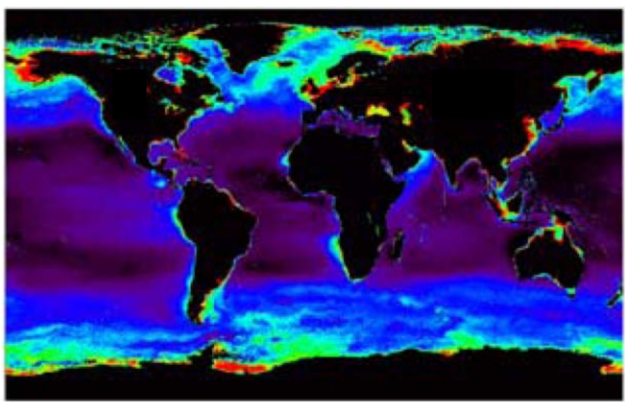
Michael J. Behrenfeld,[1,2] Emmanuel Boss,[3] David A. Siegel,[4] and Donald M. Shea[5]

GLOBAL BIOGEOCHEMICAL CYCLES, VOL. 19, GB1006, doi:10.1029/2004GB002299, 2005

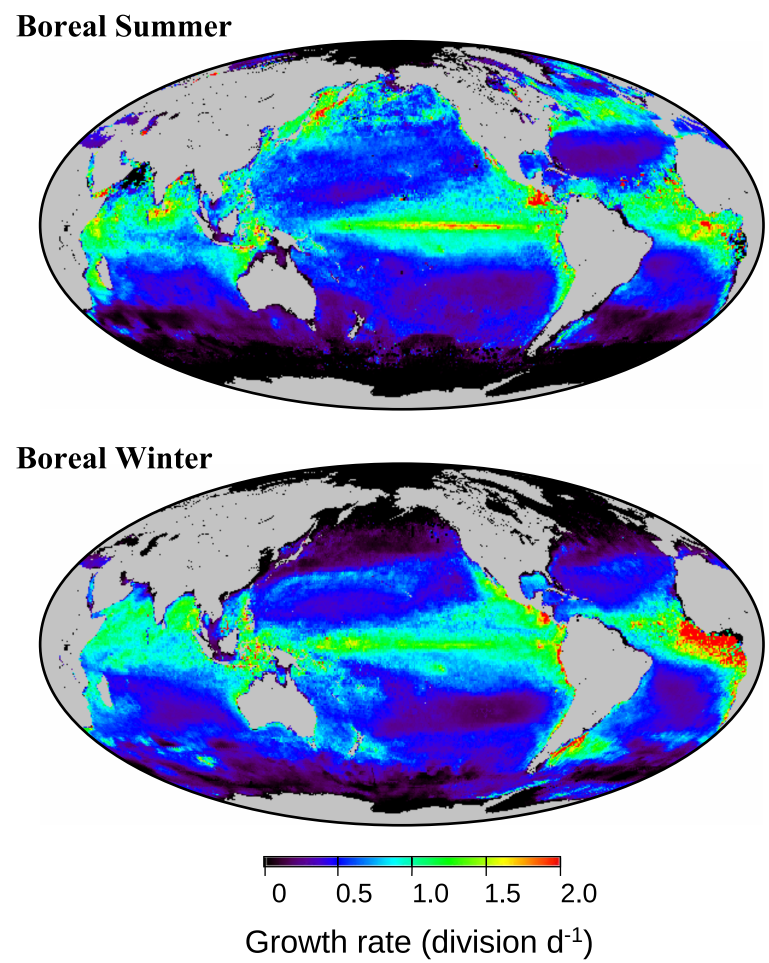
Insights from ratio of two phytoplankton properties



Chlorophyll
- biomass
- physiology



Phytoplankton Carbon
- biomass



PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B

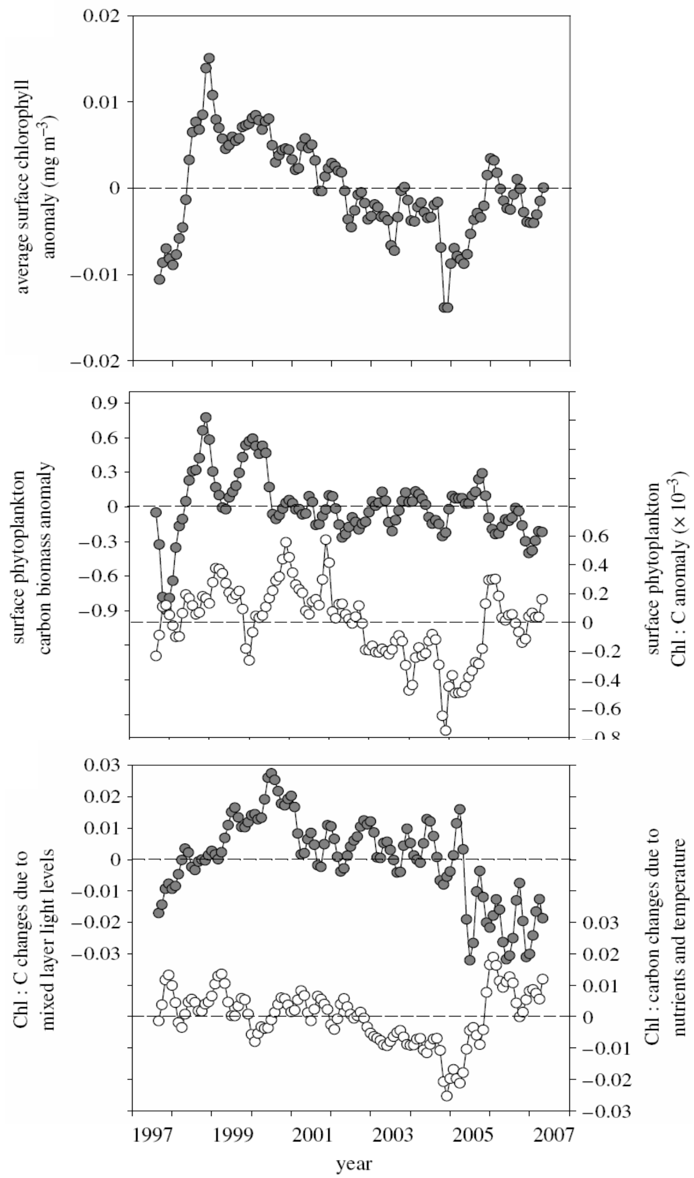
Phil. Trans. R. Soc. B
doi:10.1098/rstb.2008.0019

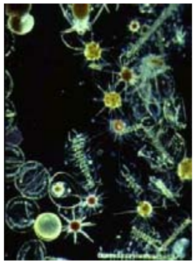
Evolved physiological responses of phytoplankton to their integrated growth environment

Michael J. Behrenfeld*, Kimberly H. Halsey and Allen J. Milligan

Step #1
Separate biomass & physiology using satellite Chl:C data

Step #2
Separating nutrient & light effects using MLD data and satellite PAR & attenuation coefficients





Retrieving the Particle Size Distribution Using Global Ocean Color Satellite Observations

Tihomir Kostadinov, David Siegel, Stéphane Maritorena, Nathalie Guillocheau

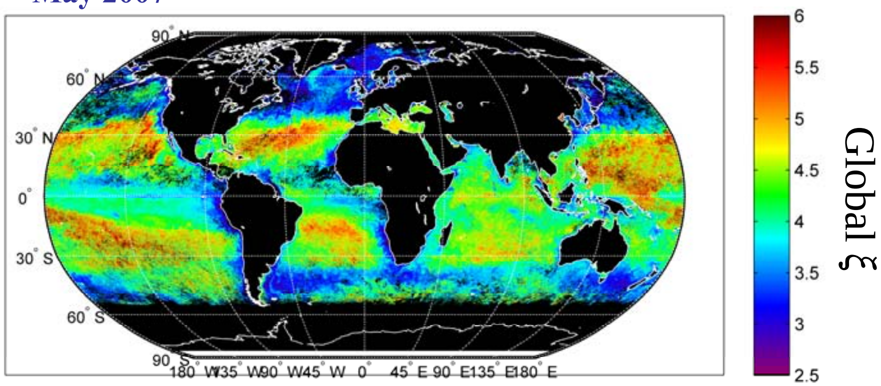
$$b_{bp}(\lambda) = \int_{D_{\min}}^{D_{\max}} \frac{\pi}{4} D^2 Q_{bb}(D,\lambda,m) N_o \left(\frac{D}{D_o}\right)^{-\xi} dD$$

Solved by Mie theory

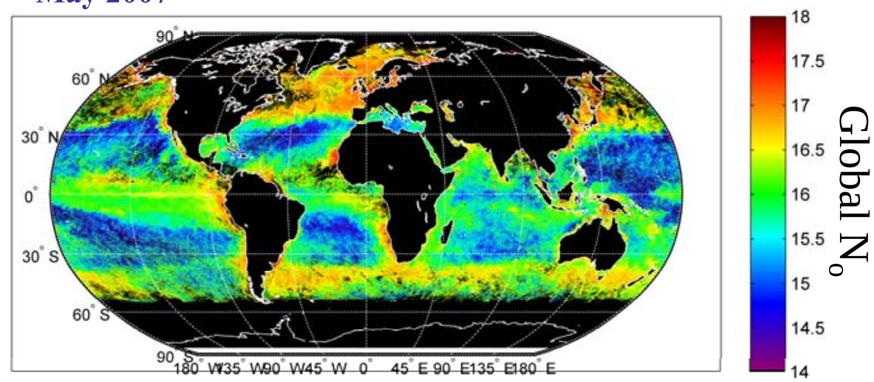
Derivation of particle size distribution (PSD) & abundance from satellite ocean color

- PSD ecological significance:
  - Size structure of pelagic ecosystems
  - Energy transfer across trophic levels
  - Sinking rates / burial of organic C

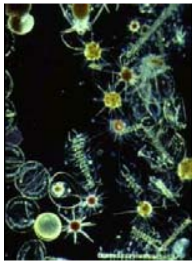
May 2007



May 2007



log10 (particles/m^{-4})



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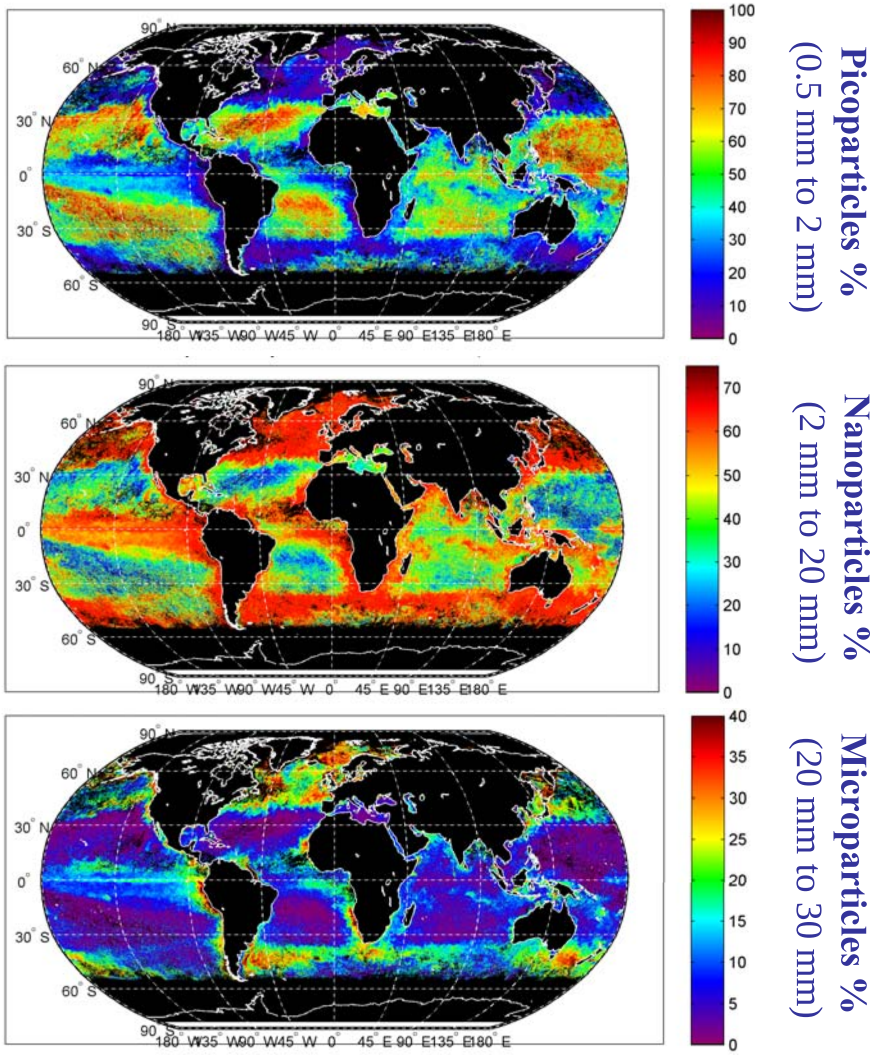


Biovolume

Pico’s dominate oligotrophic ocean (>90%)

Nano’s in transition regions (65%)

Micro’s found in upwelling zones &
high latitudes (<35%)

Number Concentration

Pico’s vary ~100 times

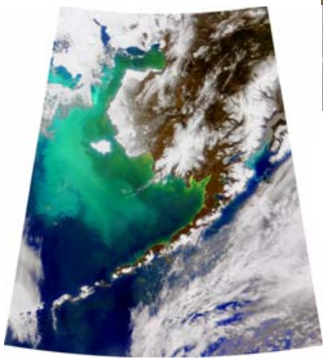
Nano’s vary ~ 10,000 times

Micro’s vary ~ 10^6 times

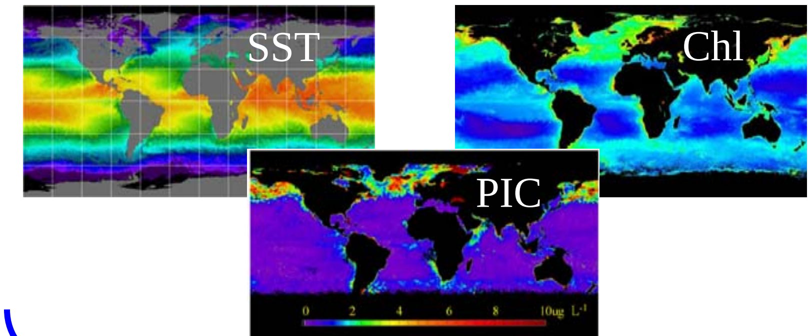
Prediction of pelagic calcification rates using satellite measurements

William Balch*, David Drapeau, Bruce Bowler, Emily Booth

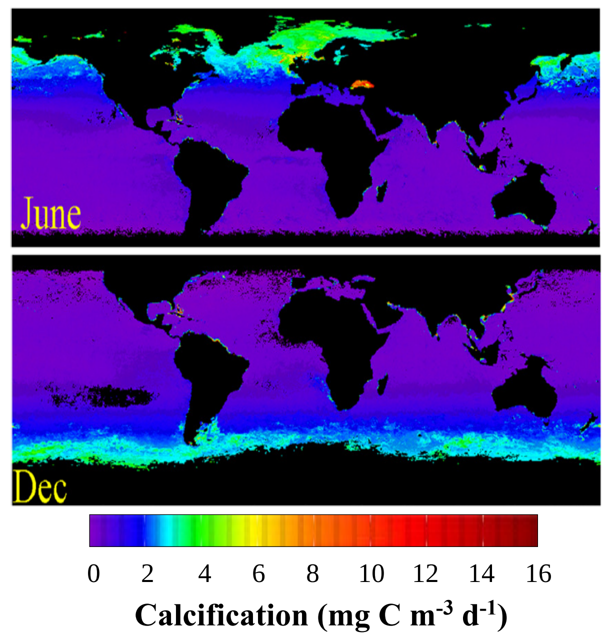
ELSEVIER
DEEP-SEA RESEARCH
PART II
54 (2007) 478–495



"The Other Carbon Fixation"



- Calcification (1) impacts regional & global carbon budgets, (2) is impacted by ocean acidification, (3) critical to ocean carbon export
- MODIS & field data analysis
- Satellite estimate of 1.6 Pg y^{-1} close to 1.1 Pg y^{-1} estimates from seasonal cycle in alkalinity & coupled circulation-ecosystem modeling
- New tool for studying temporal changes
- S. hemisphere summer calcification summer is almost twice that of the N. hemisphere summer



NITROGEN

PNAS

Remote analysis of biological invasion and biogeochemical change

Gregory P. Asner*† and Peter M. Vitousek‡

March 22, 2005 | vol. 102 | no. 12 | 4383–4386

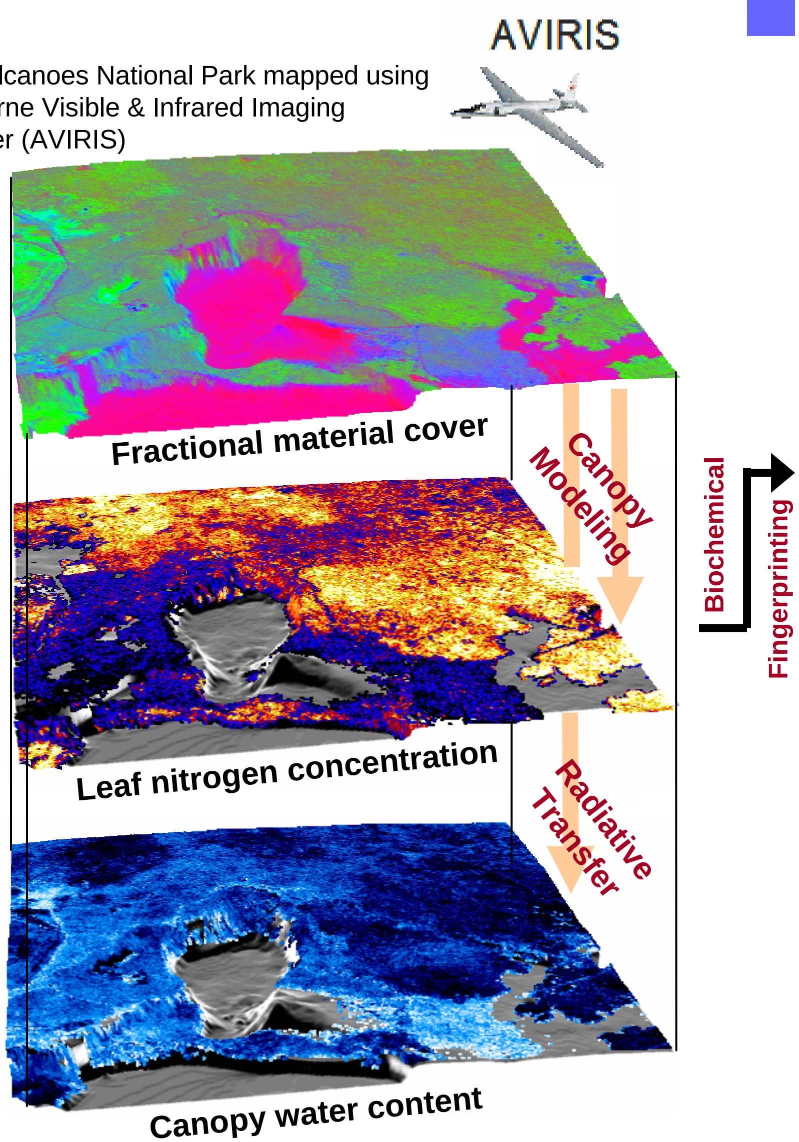
GBC

Biological invasion alters regional nitrogen-oxide emissions from tropical rainforests

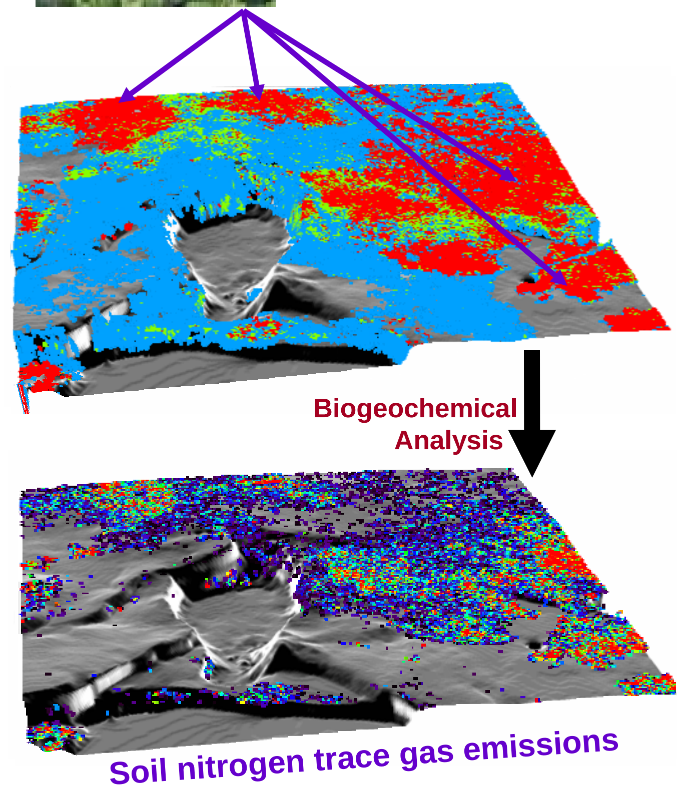
SHARON J. HALL* and GREGORY P. ASNER

Global Change Biology (2007) 13, 2143–2160

- Hawaii Volcanoes National Park mapped using NASA Airborne Visible & Infrared Imaging Spectrometer (AVIRIS)



- Native forest canopy is low water, low N
- Invasive tree canopy is high water, high N
- Invasive understory herb is high water, low N



PNAS PNAS

Remote analysis of biological invasion and biogeochemical change

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March 22, 2005 | vol. 102 | no. 12 | 4383–4386

GBC GBC

Biological invasion alters regional nitrogen-oxide emissions from tropical rainforests

SHARON J. HALL* and GREGORY P. ASNER

Global Change Biology (2007) 13, 2143–2160

- Invasive tree doubled canopy N and severely altered ecosystem biogeochemical functioning
  - faster leaf turnover and decomposition
  - greater N availability and fluxes of N-containing trace gases
  - invasion by nutrient-demanding species

- Invasive understory herb appears to lower the N content in the native overstory tree canopy and proliferates to exclude native plants from the understory

IEEE Trans. Geosci. Rem. Sens.

Analysis of Hyperspectral Data for Estimation of Temperate Forest Canopy Nitrogen Concentration: Comparison Between an Airborne (AVIRIS) and a Spaceborne (Hyperion) Sensor

Marie-Louise Smith, Mary E. Martin, Lucie Plourde, and Scott V. Ollinger

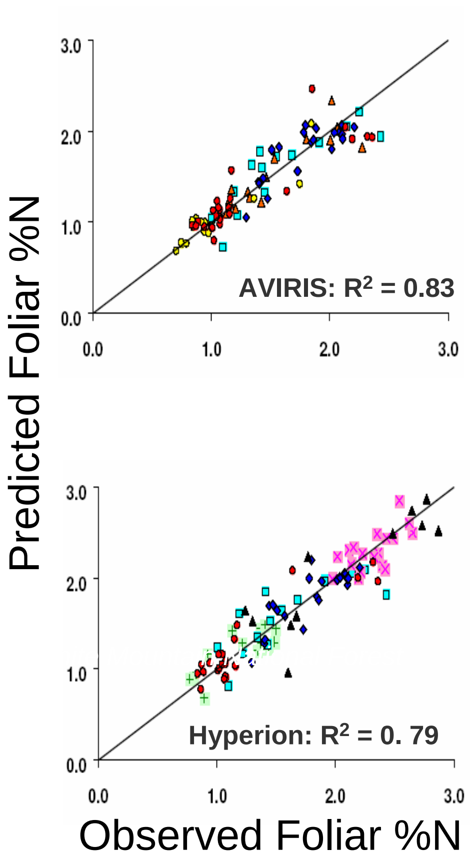
VOL. 41, NO. 6, JUNE 2003

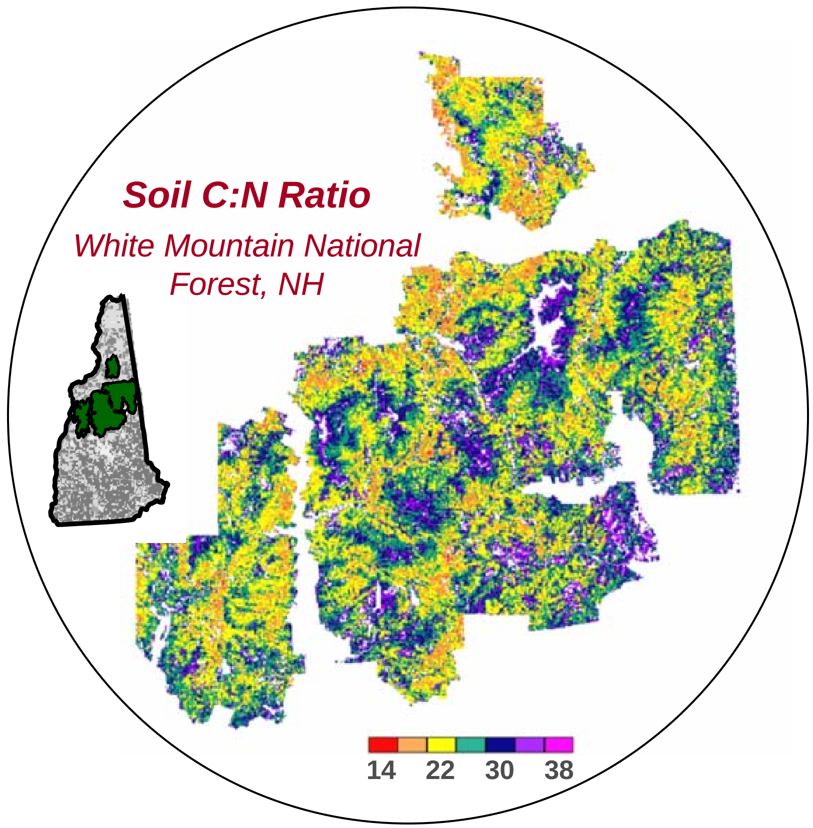
Ecology

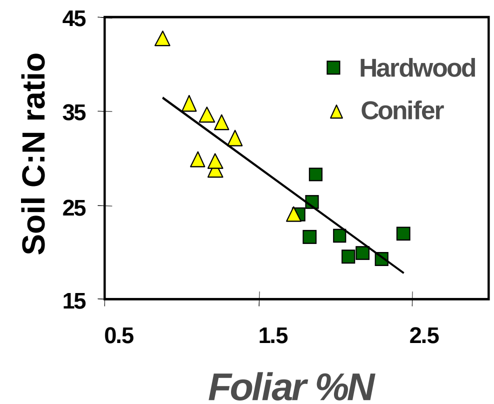
REGIONAL VARIATION IN FOLIAR CHEMISTRY AND N CYCLING AMONG FORESTS OF DIVERSE HISTORY AND COMPOSITION

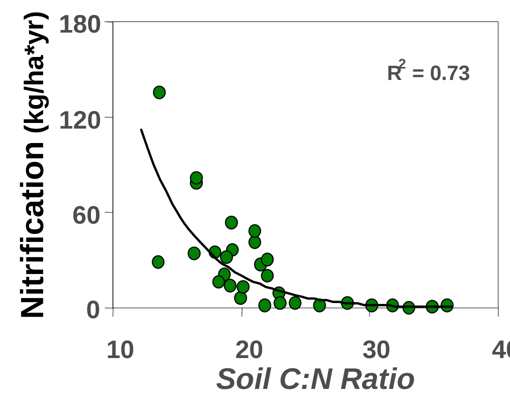
S. V. Ollinger,[1,4] M. L. Smith,[2] M. E. Martin,[1] R. A. Hallett,[2] C. L. Goodale,[3] and J. D. Aber[1]

83(2), 2002, pp. 339–355









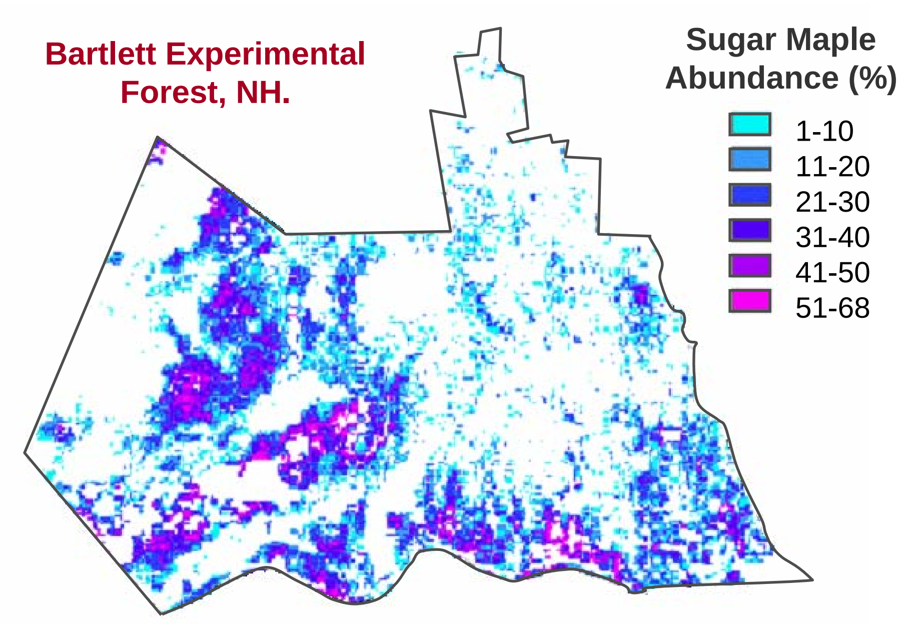
Field Sites: ▲ DF ○ ACMF ◆ HF ● HOW ■ BEF + BAGO ✕ LS ▲ AP

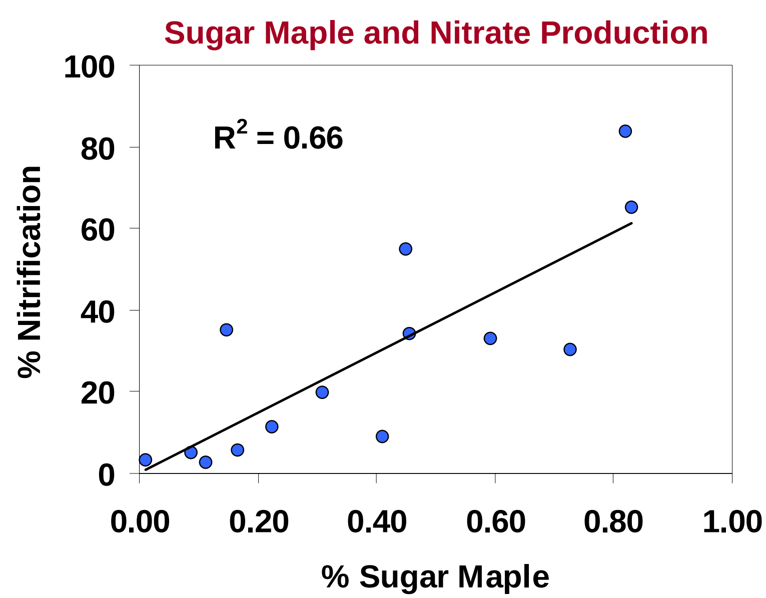
Estimating Species Abundance in a Northern Temperate Forest Using Spectral Mixture Analysis

Lucie C. Plourde, Scott V. Ollinger, Marie-Louise Smith, and Mary E. Martin

Photogrammetric Engineering & Remote Sensing
Vol. 73, No. 7, July 2007, pp. 829–840.

- ❑ Application of imaging spectroscopy in northeastern forest
- ❑ Allows derivation of sugar maple distribution and leaf nitrogen
- ❑ Nitrate production is a product in these forests of sugar maple abundance and soil nitrogen – which is related to leaf nitrogen

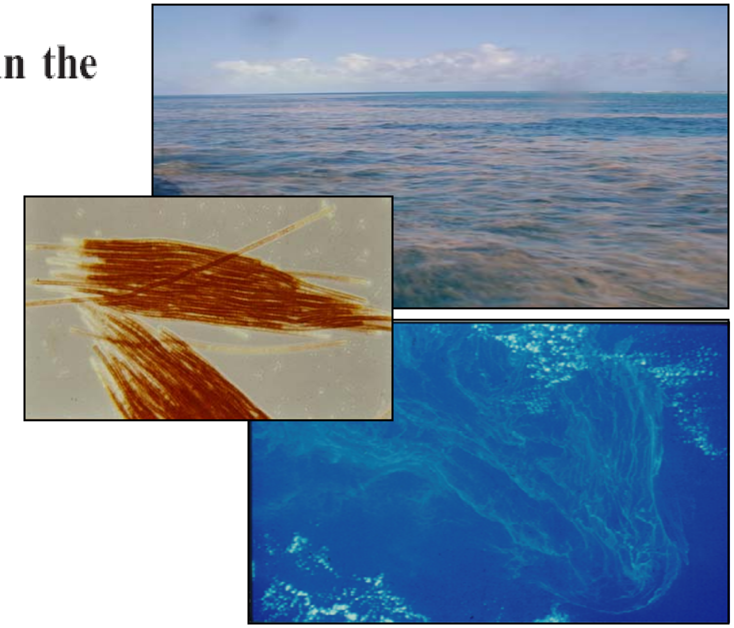


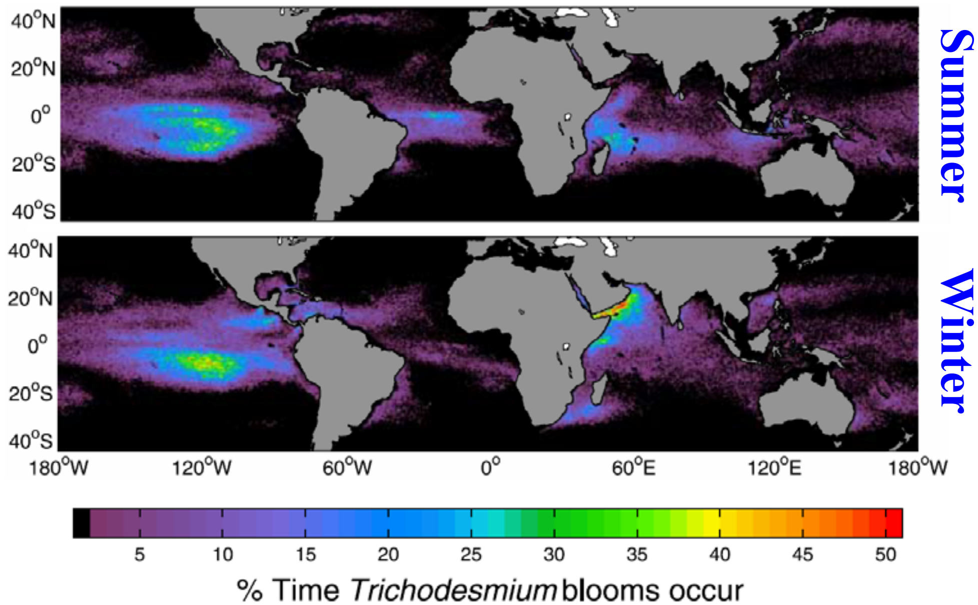


Spatial and temporal distribution of *Trichodesmium* blooms in the world's oceans

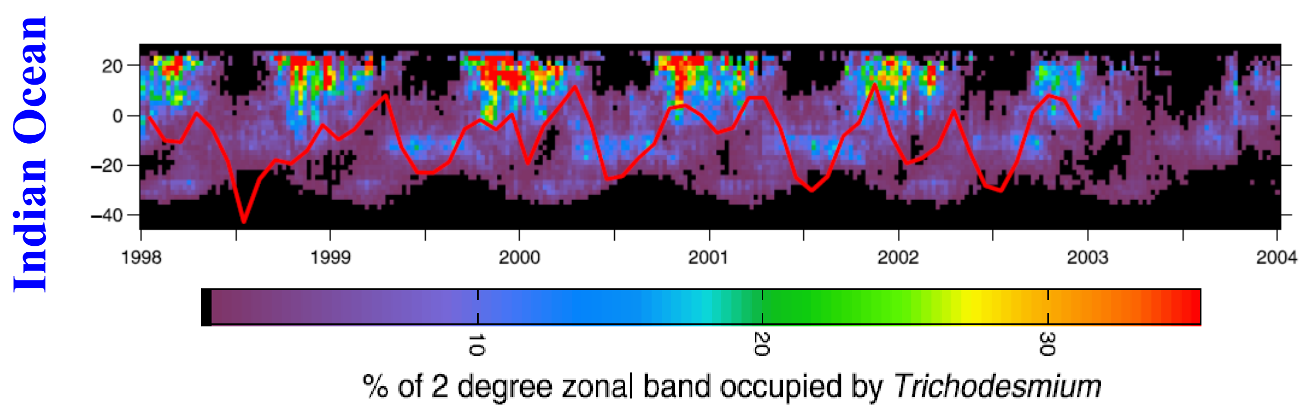
Toby K. Westberry[1,2] and David A. Siegel[1]

GLOBAL BIOGEOCHEMICAL CYCLES, VOL. 20, GB4016, doi:10.1029/2005GB002673, 2006





Ocean Nitrogen Fixation



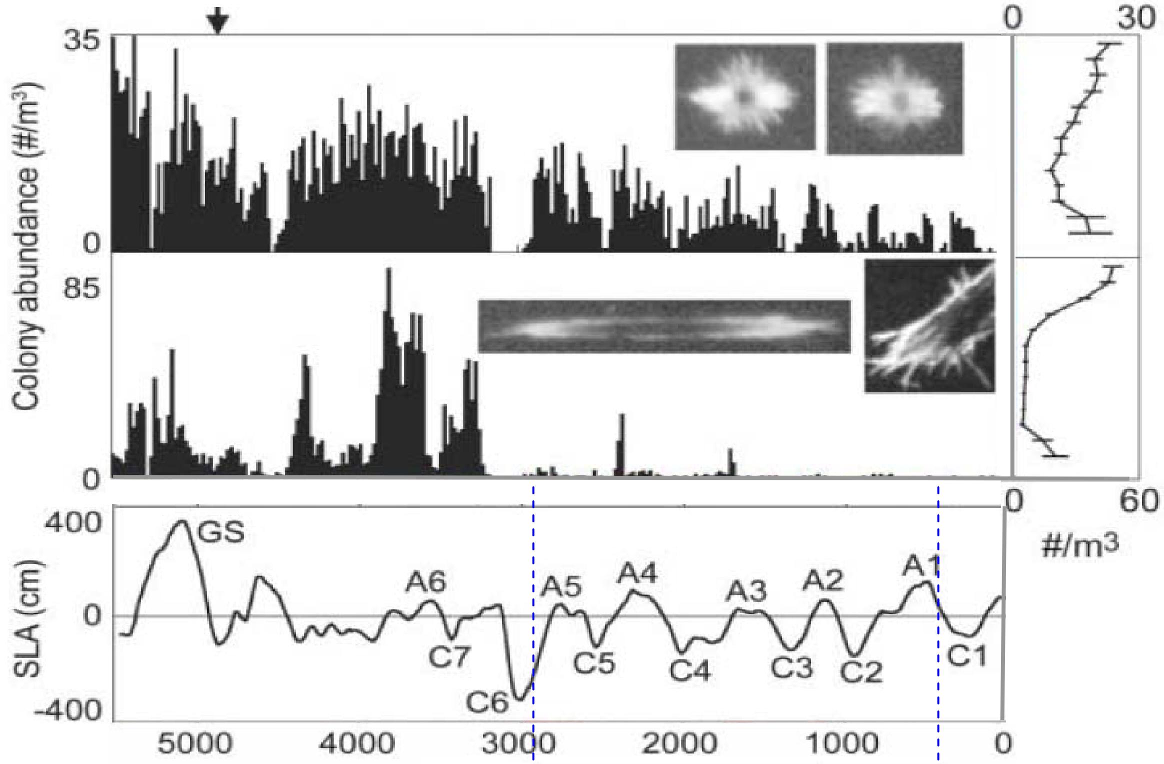
Red Line

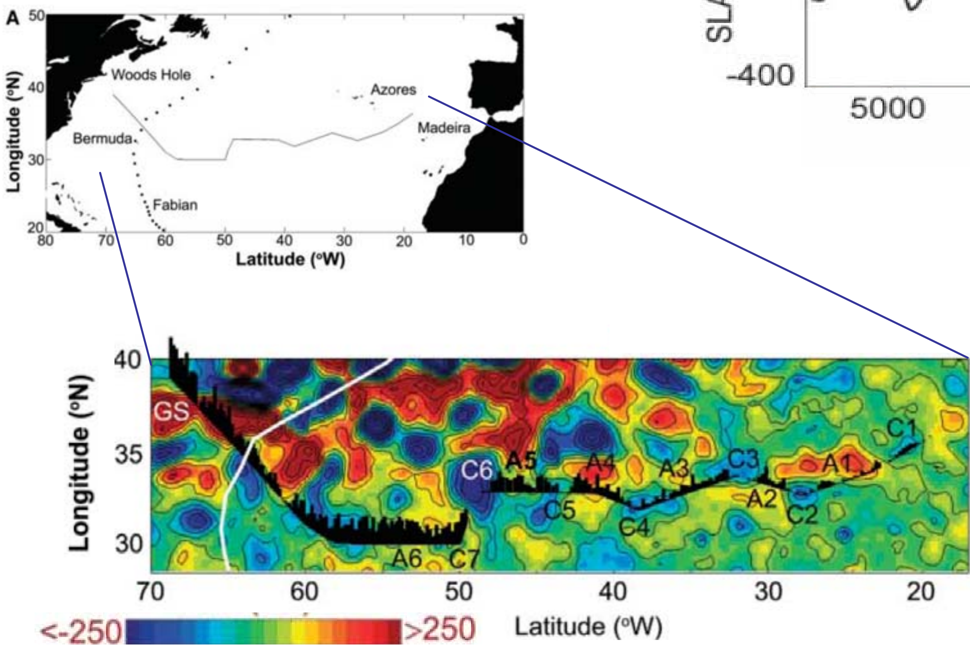
Measure of east-west SST gradient across the Indian Ocean and has been related to interannual variability in monsoon strength and other aperiodic phenomena such as ENSO

Transatlantic Abundance of the N_2-Fixing Colonial Cyanobacterium *Trichodesmium*

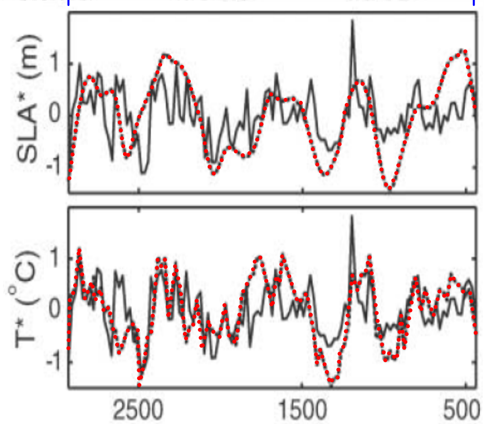
Cabell S. Davis[1*] and Dennis J. McGillicuddy Jr.[2]

SCIENCE VOL 312 9 JUNE 2006





Sea Level Anomaly

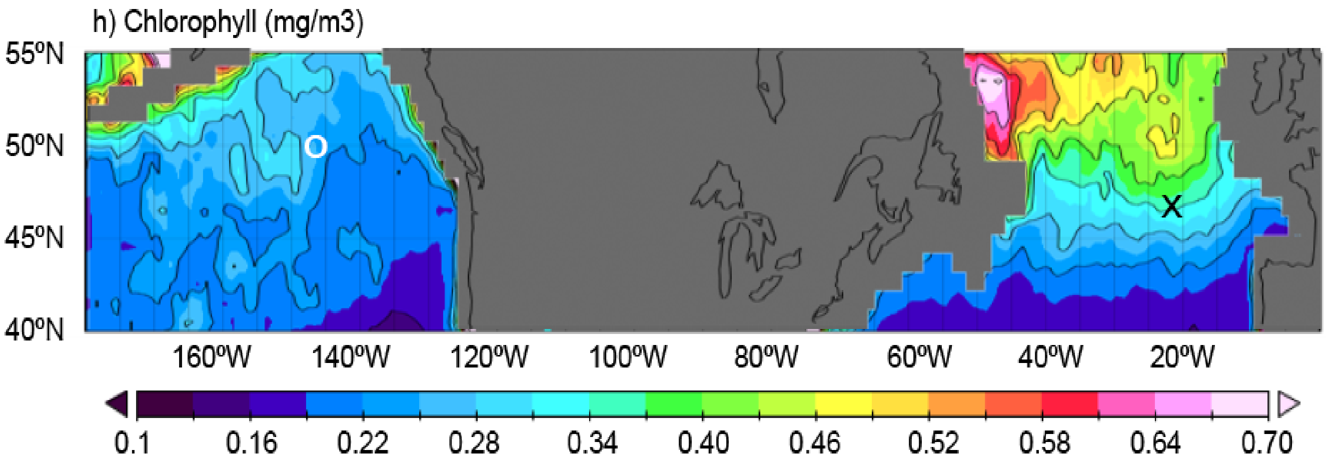


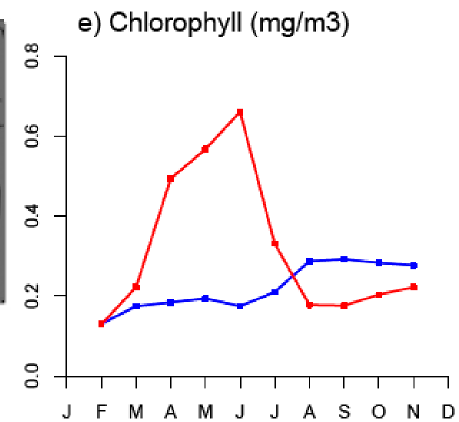
Distance (km)

IRON

A New Perspective on Seasonal Phytoplankton Cycles in the Subarctic Atlantic and Pacific

P. Schultz et al.





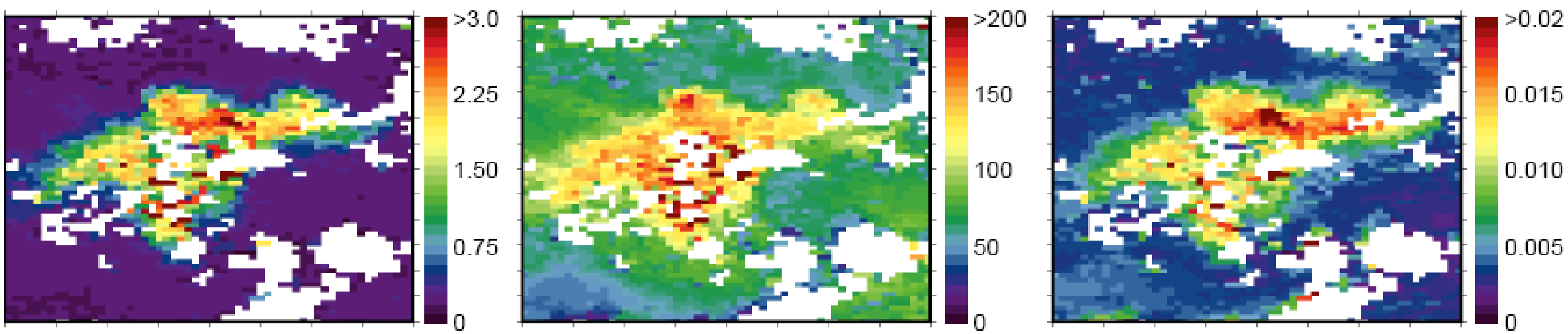
Summer average (Jun, Jul, Aug)

Investigating experimental & natural iron enrichment responses

P. Schultz, D. Siegel, and colleagues

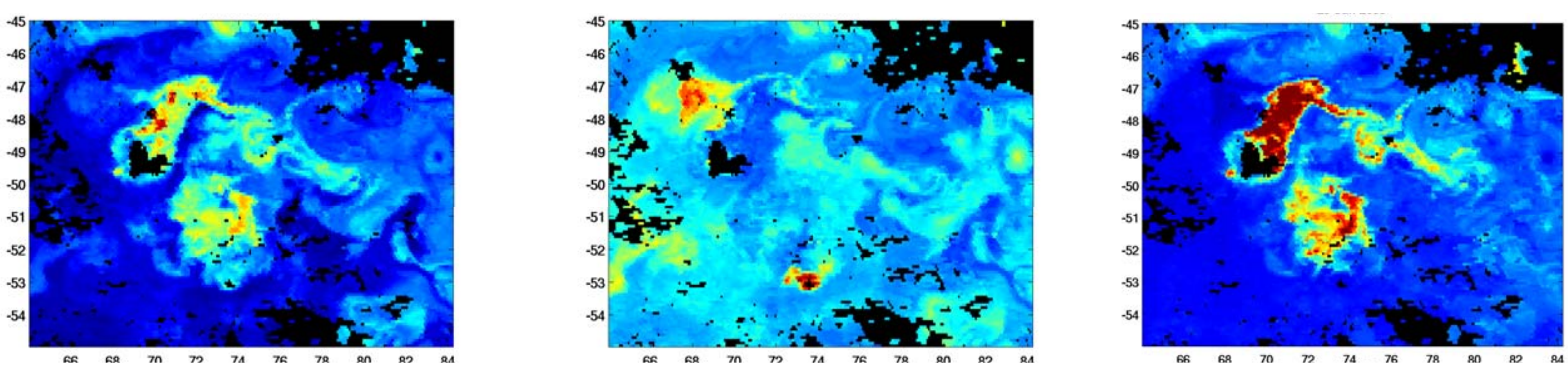
- Implications for carbon trading?
  dust responses?

SERIES Fe enrichment experiment

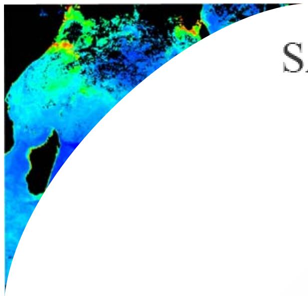


Chlorophyll | Phytoplankton Carbon | Chl:C

Natural Iron Enrichment in the Southern Ocean



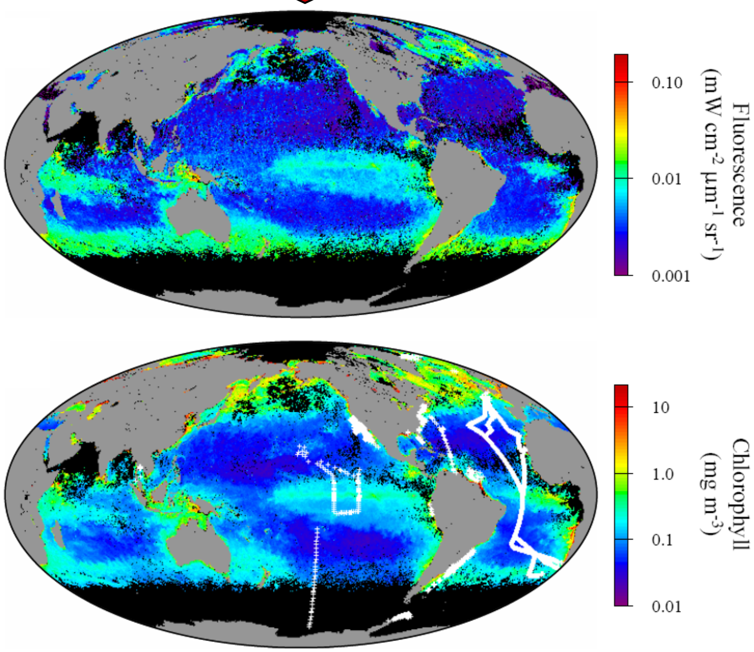
Chlorophyll | Phytoplankton Carbon | Chl:C



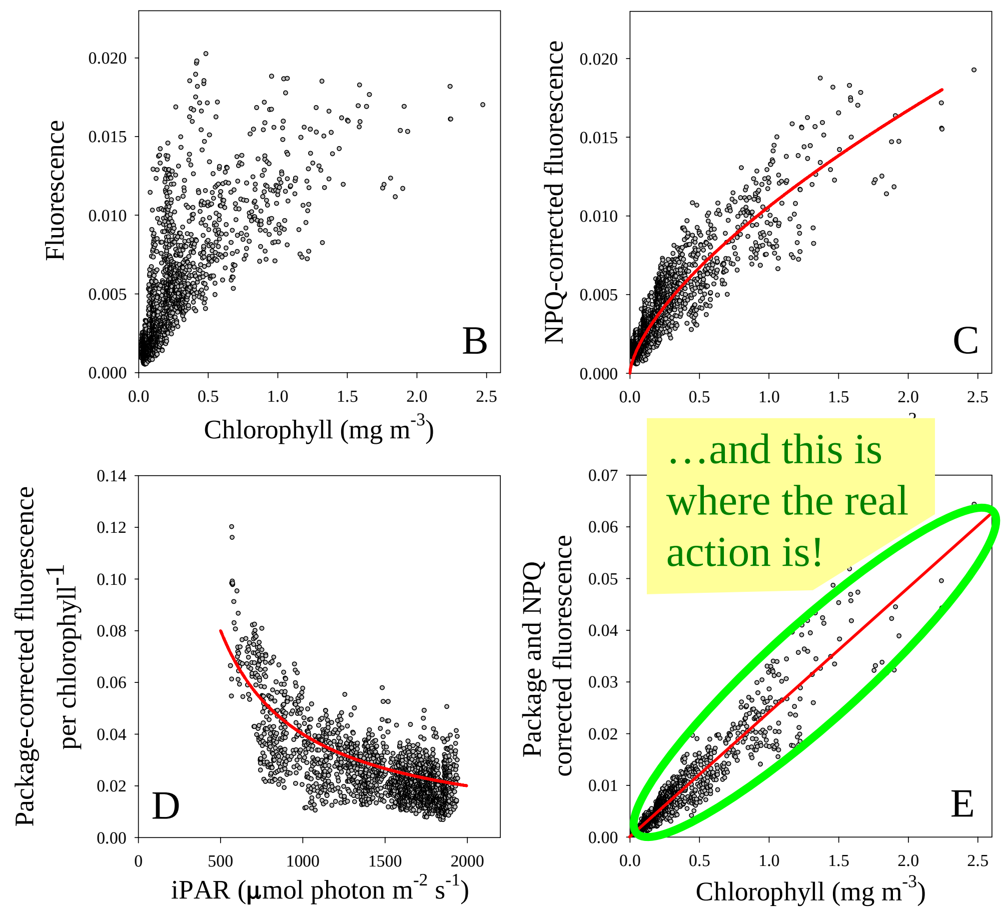
SATELLITE-DETECTED CHLOROPHYLL FLUORESCENCE REVEALS PHYSIOLOGY AND PHOTOSYNTHETIC PIGMENTS OF GLOBAL OCEAN PHYTOPLANKTON

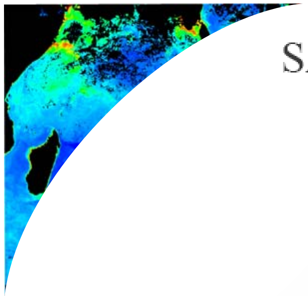
Michael J. Behrenfeld[1*], Toby Westberry[1], Robert O'Malley[1], Jerry Wiggert[2], Emmanuel Boss[3], David Siegel[4], Bryan Franz[5], Chuck McClain[5], Gene Feldman[5], Giorgio Dall'Olmo[1], Allen Milligan[1], Scott Doney[6], Ivan Lima[6], Natalie Mahowald[7]

Fluorescence is from PSII alone



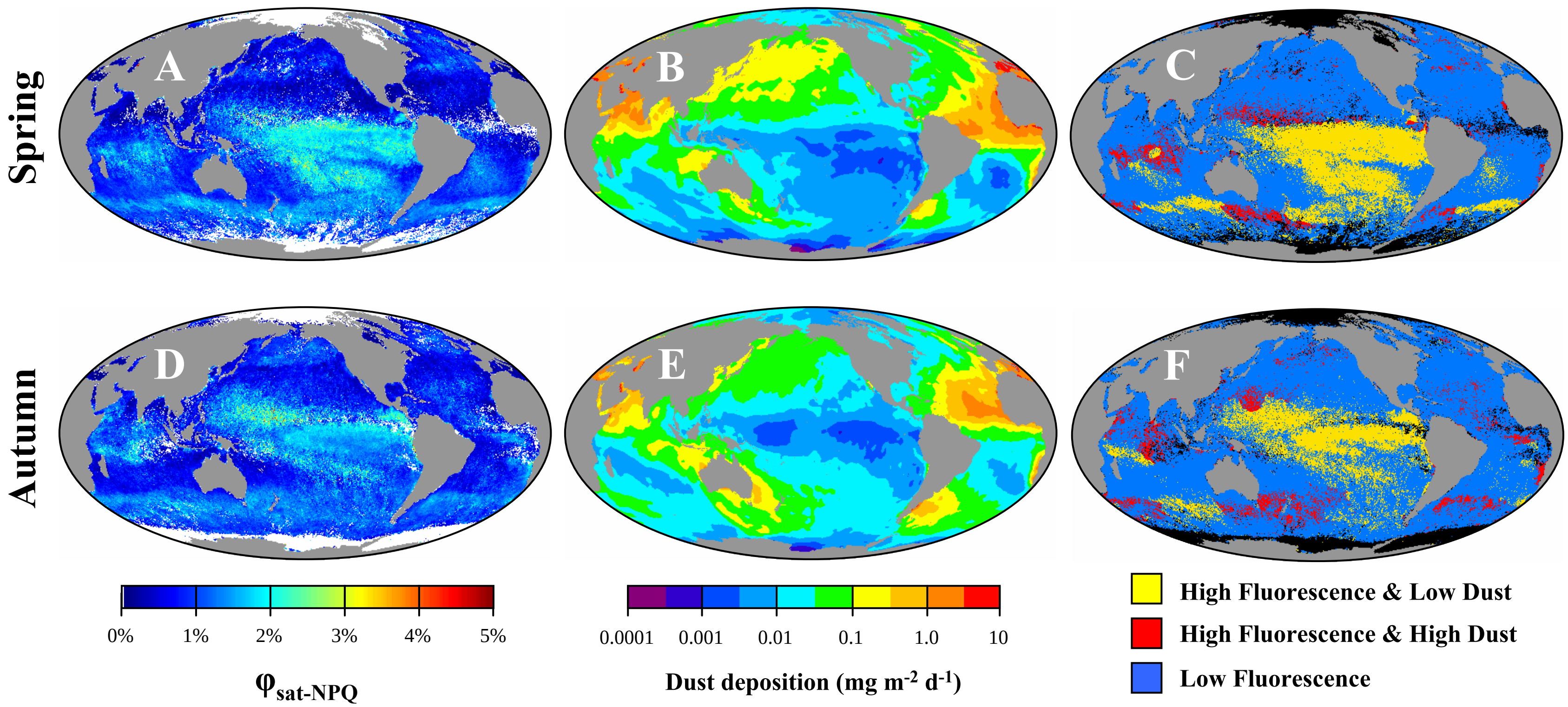
Chlorophyll is from PSII & PSI

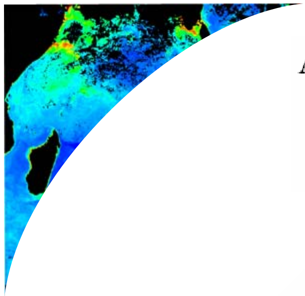




Satellite-detected Chlorophyll Fluorescence reveals Physiology and Photosynthetic Pigments of Global Ocean Phytoplankton

Michael J. Behrenfeld[1*], Toby Westberry[1], Robert O'Malley[1], Jerry Wiggert[2], Emmanuel Boss[3], David Siegel[4], Bryan Franz[5], Chuck McClain[5], Gene Feldman[5], Giorgio Dall'Olmo[1], Allen Milligan[1], Scott Doney[6], Ivan Lima[6], Natalie Mahowald[7]





Annual ecosystem variability in the tropical Indian Ocean: Results of a coupled bio-physical ocean general circulation model

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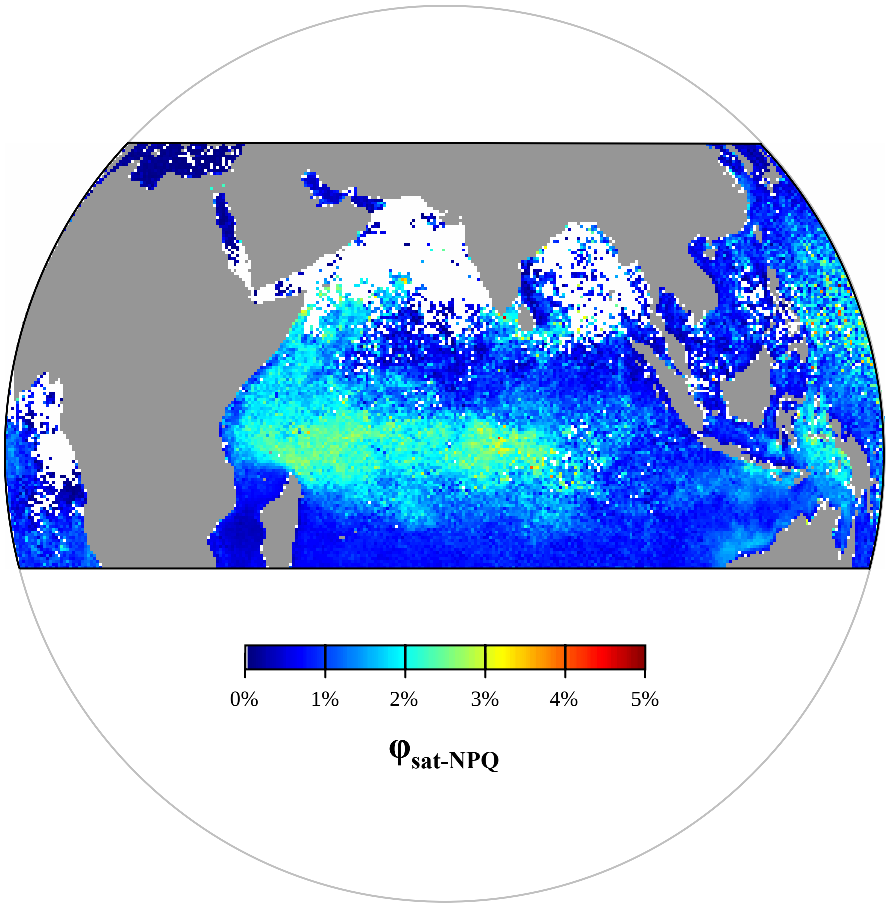

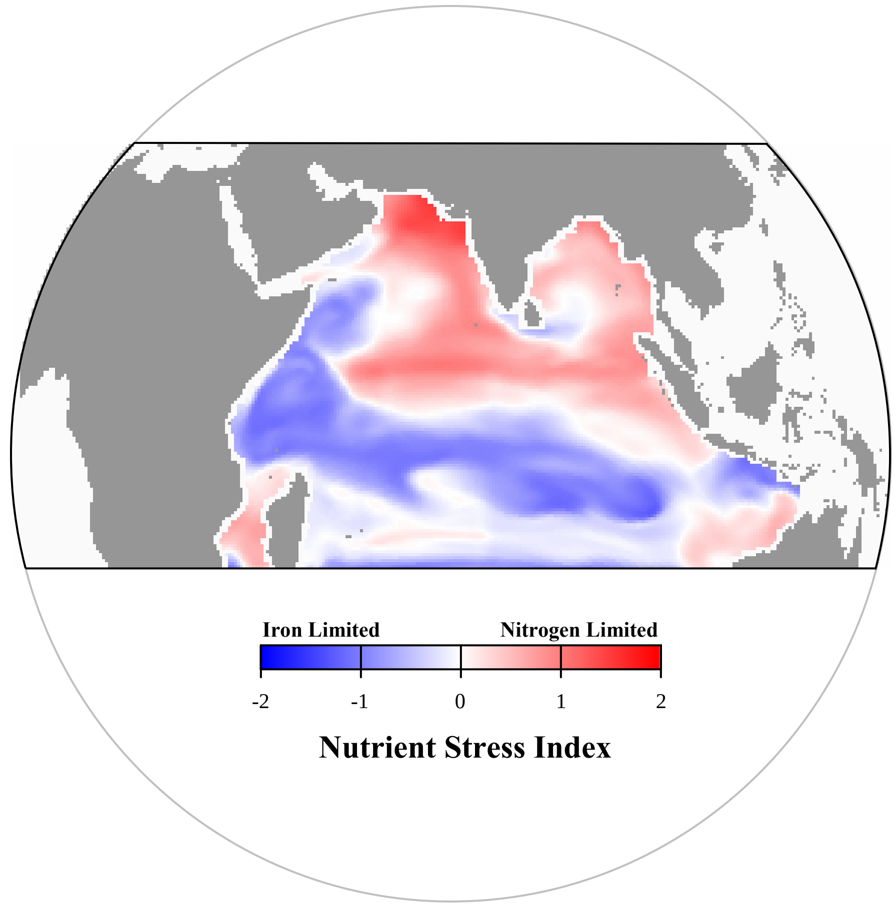

Thank You

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