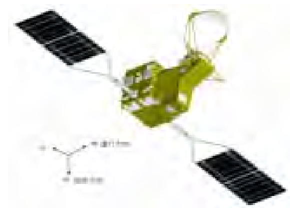
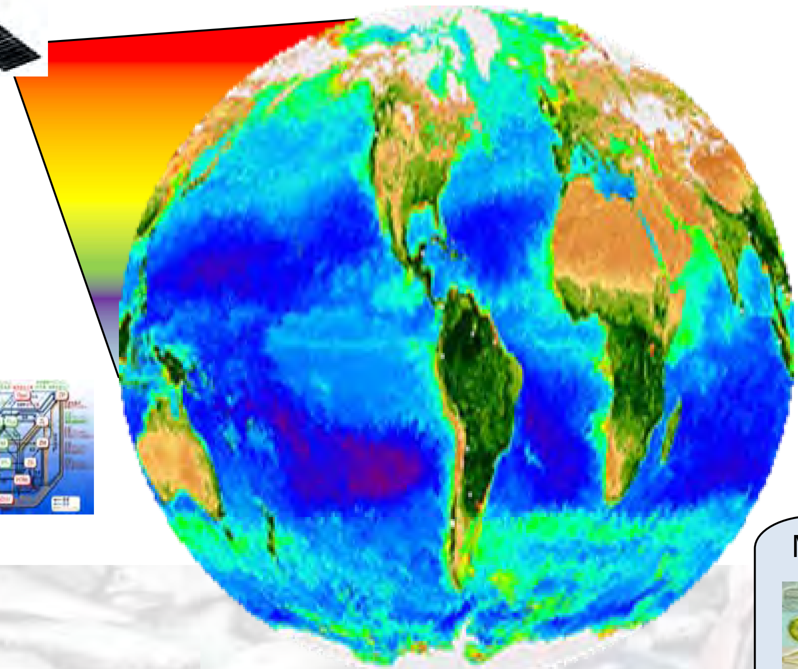
Global distribution of Phytoplankton Functional Types (PFTs) estimated from satellite ocean colour

T. Hirata (Hokkaido Univ. & CREST/JST)
and many others…

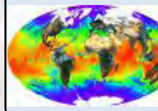
National Centre for Earth Observation
NATURAL ENVIRONMENT RESEARCH COUNCIL
JAXA Japan Aerospace Exploration Agency
CREST 戦略的創造研究推進事業 Core Research for Evolutional Science and Technology
JST 独立行政法人 科学技術振興機構
HOKKAIDO UNIVERSITY

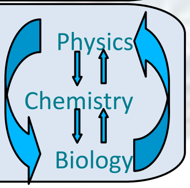




Marine Ecosystems

Climate





International Symposium
Apr. 26-29, 2010, Sendai, Japan
Climate Change Effects on Fish and Fisheries:
Forecasting Impacts, Assessing Ecosystem Responses, and Evaluating Management Strategies

Collaborators

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H. Murakami, JAXA

J. Werdell, NASA
S. Bailey, NASA

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J. Polovina, NOAA

OUTLINE

1. Introduction

2. Method

3. Spatial Distribution of Phytoplankton Functional Types (PFTs)

4. Temporal Variations of PFTs

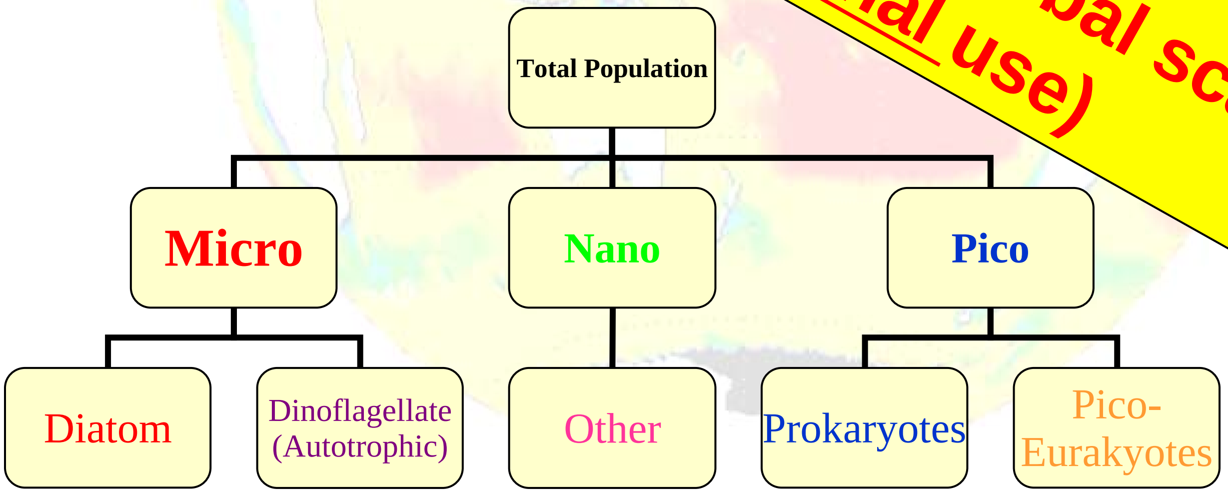
5. Link to Climate Variables

6. Summary

Different phytoplankton have different functional roles in biogeochemical cycles (“functional types”)

Taxonomic	*Biogeochem. Function*	*Ecol. Function*	*Size class*
▪Diatoms		Meso_z	Micro
▪Dinoflagellates			Micro
▪Flagellates			
Prymnesiophytes			Nano
▪Cyanobacteria			Pico

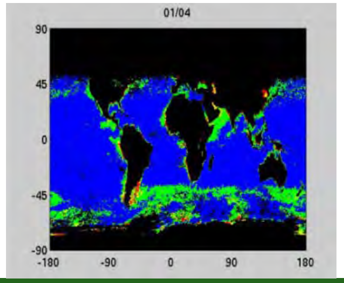
Objective:
To estimate PFTs at global scale
(for operational use)



...d by Hirata et al. (2008)

Remote Sensing of Environment

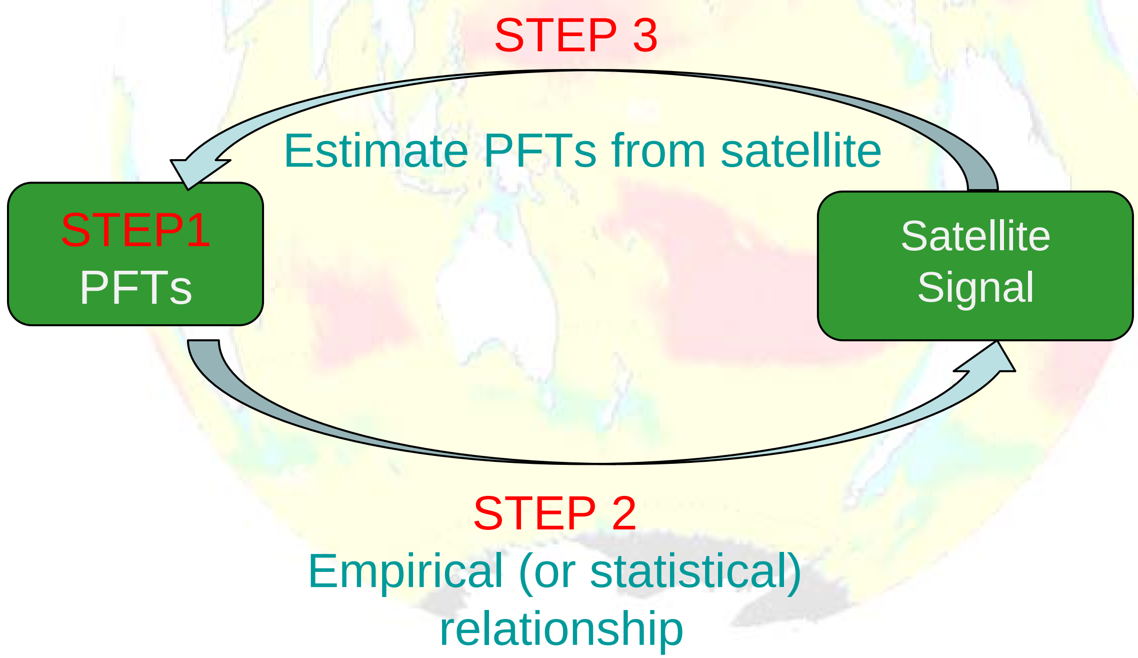
...ption model to determine phytoplankton size classes from ...e ocean colour



Step 1 **Establish a technique to classify PFTs using HPLC pigments (Diagnostic Pigment Analysis)**

Step 2 **Link the PFTs to satellite signal (i.e. Chla)**

Step 3 **Estimate PFTs from the satellite signal**



Step 1 Phytoplankton classification from HPLC

Diagnostic Pigment Analysis (DPA)

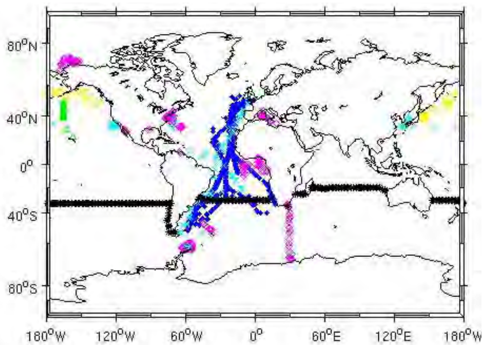
Viddussi et al.(2001), Uitz et al.(2006), Hirata et al, (2008), Brewin et al. (2010)

Detection of biomarker pigments enable identification of phytoplankton size classes

Pico (<2 μm) --- Zeaxanthin (Prokaryotes)
Chlorophyll-b (Green Algae)

Nano (2~20 μm) --- 19' Hexanoyloxyfucoxanthin (Prymnesiophyte)
Alloxanthin (Cryptophyte)
Butanoyloxyfucoxanthin (Chrysophytes)
Chlorophyll-b (Green Algae)

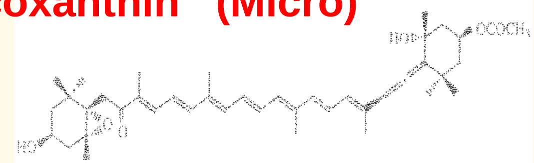
Micro (>20 μm) --- Fucoxanthin (Diatom)
Peridinin (Dinoflagellate)



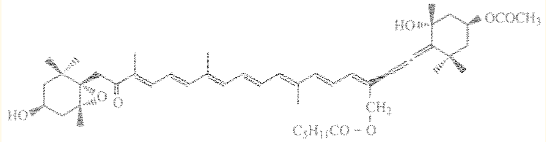
Global Data Set
BEAGLE, AMT, SEEDSII, SeaBass, Oshoro, NOMAD

DPA is useful, but not perfect. It needs correction

Fucoxanthin (Micro)



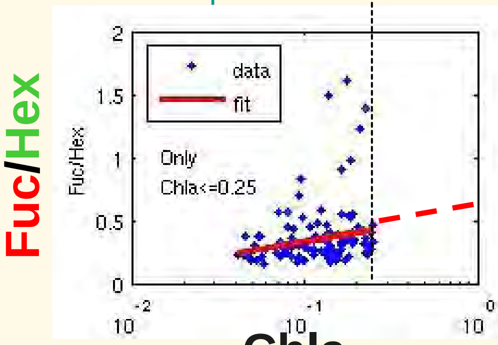
19'-Hexanoyloxyfucoxanthin (Nano)



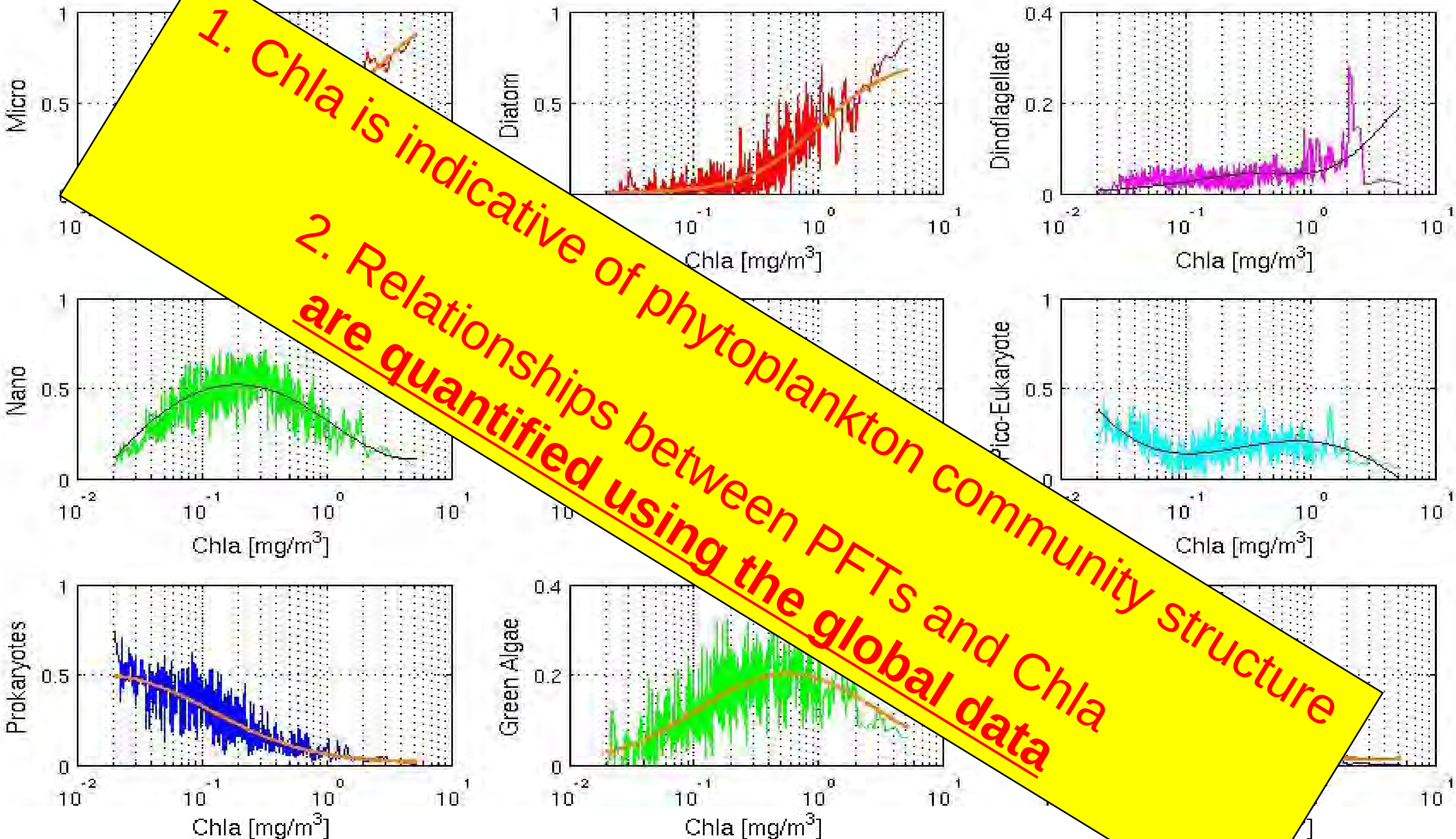
Chla<0.25 mg/m^3

Low probability of Diatom presence

Hirata et al., 2008



Step 2 Link PFTs to Chla derivable from satellite



1. Chla is indicative of phytoplankton community structure

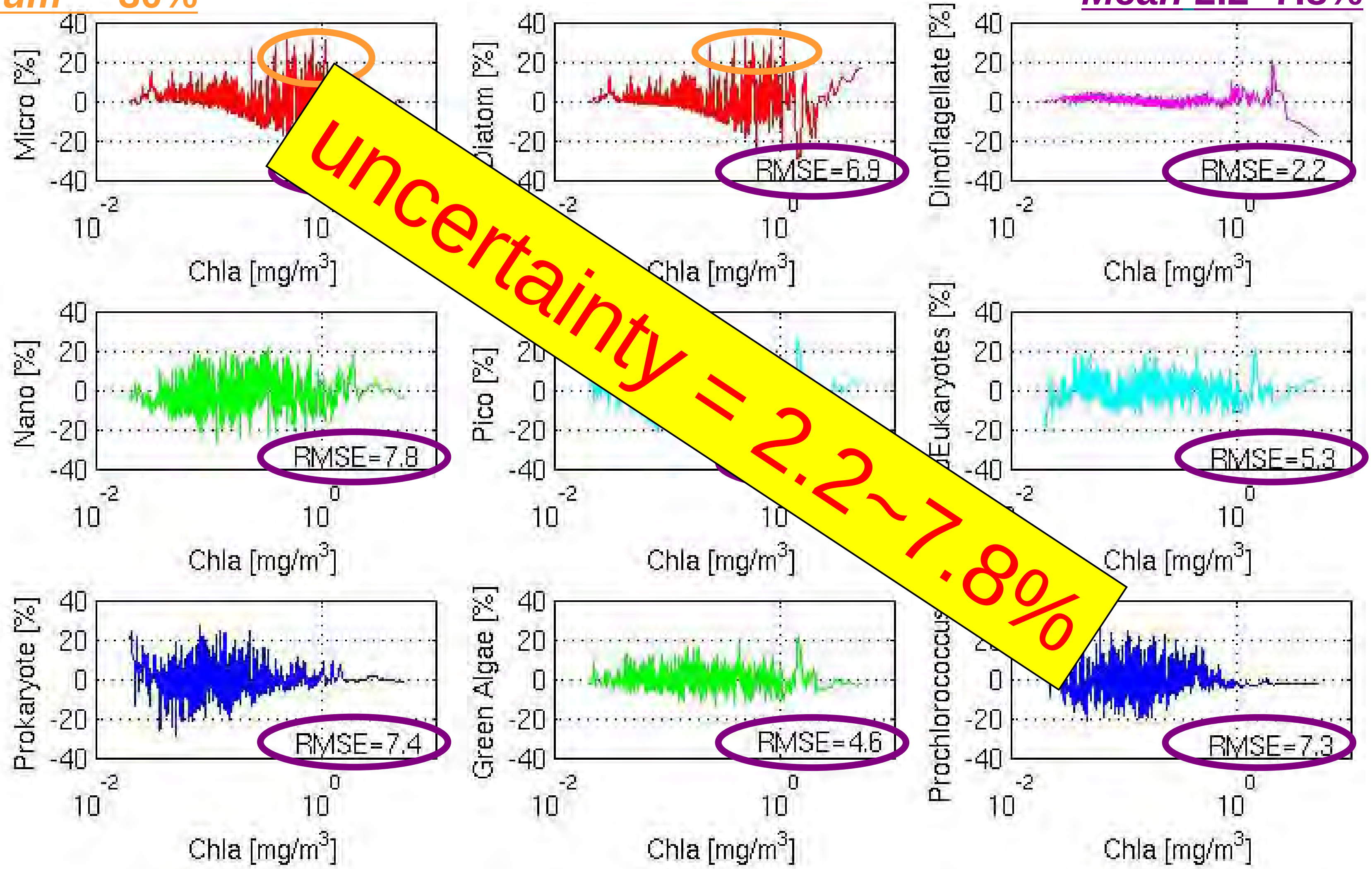
2. Relationships between PFTs and Chla **are quantified using the global data**

Mass balance is kept in the regressions
(e.g. Micro+Nano+Pico=100%)

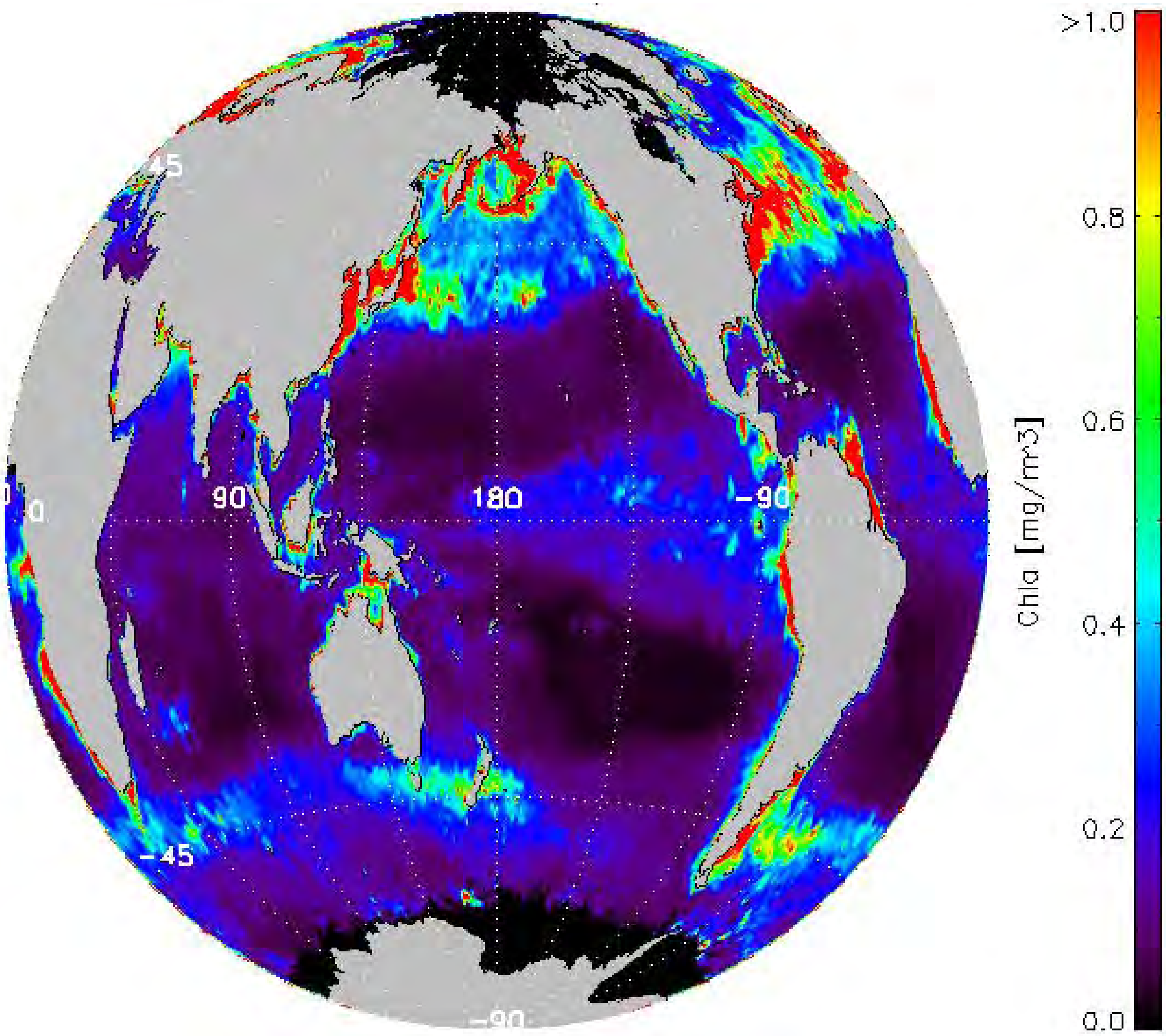
Uncertainty = f (PFT, Chla)

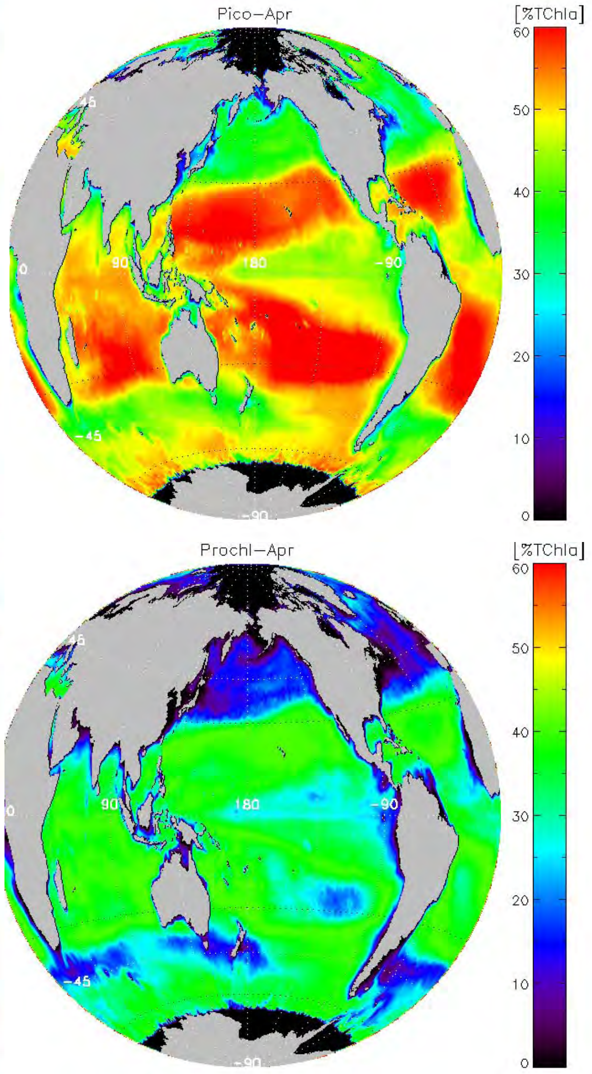
Maximum ~ 30%

Mean 2.2~7.8%



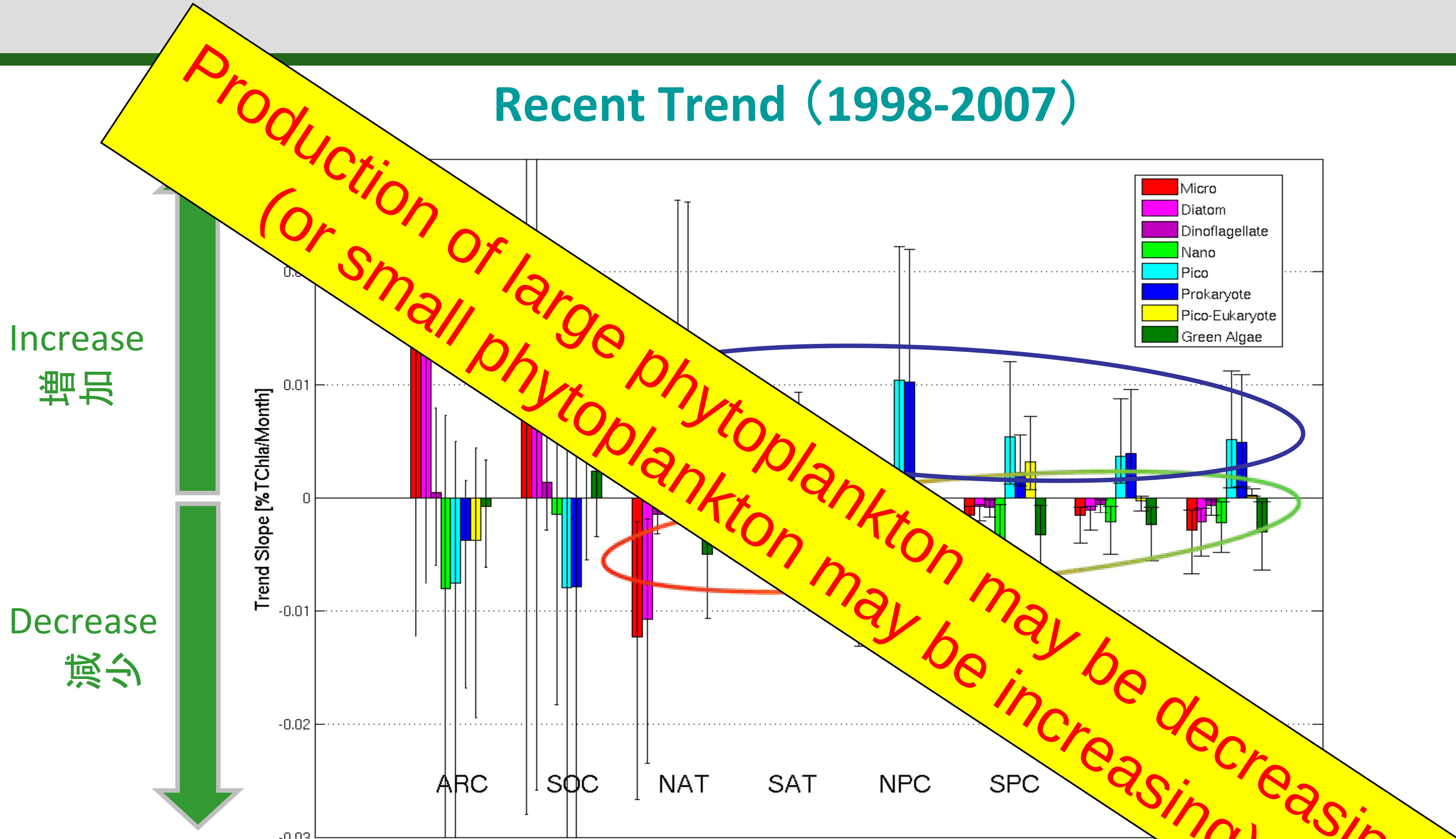
Step 3 Estimate PFTs from satellite Chla





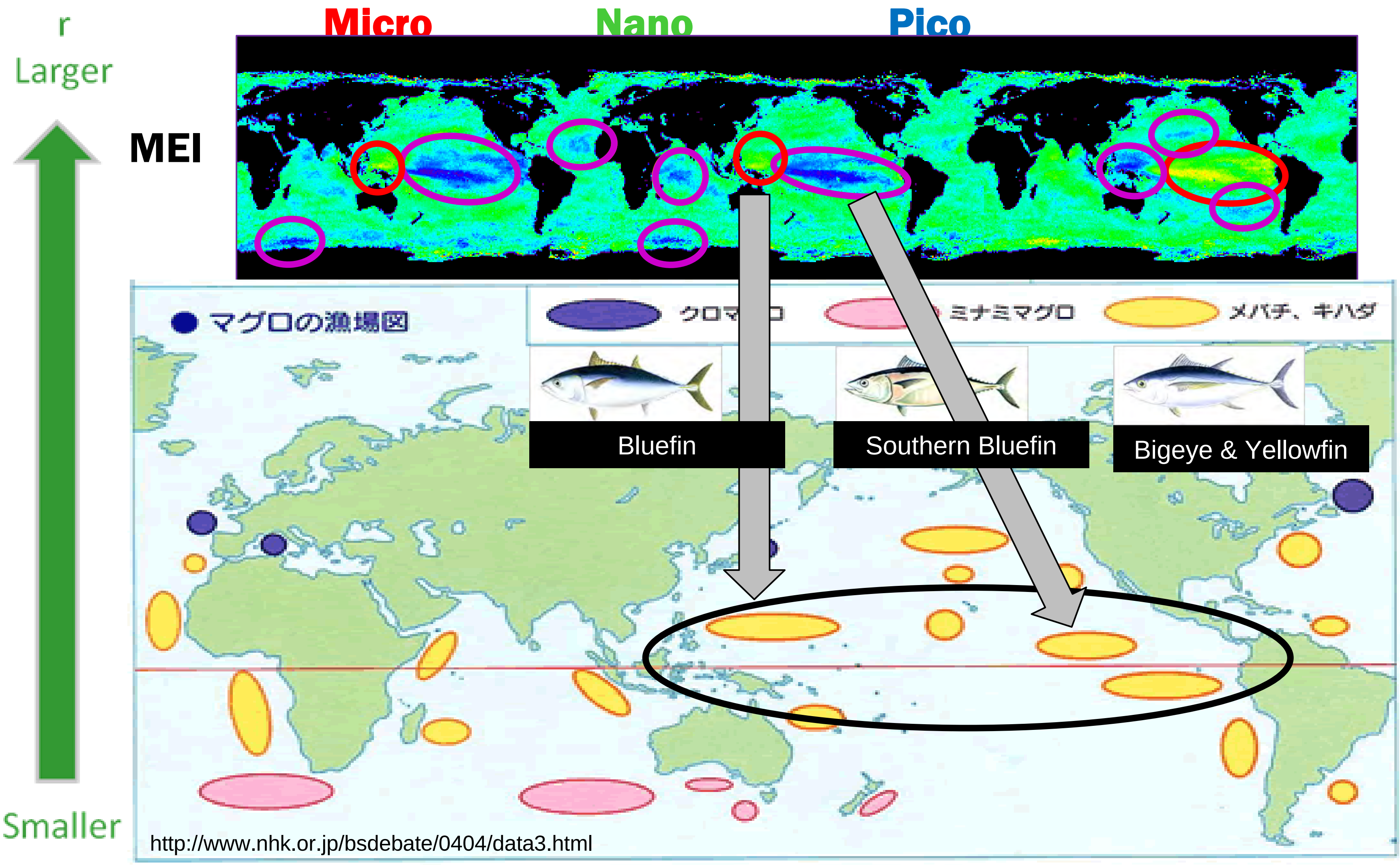
%Chla: neither %Carbon nor %Cell Count

Recent Trend（1998-2007）



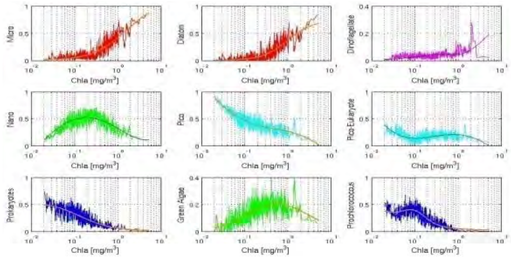
The Arctic & The Southern Oceans
Statistically *not* significant

Small --- Increase
Large /Middle --- Decrease

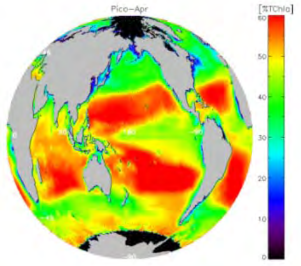


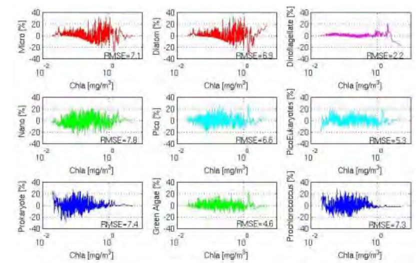
http://www.nhk.or.jp/bsdebate/0404/data3.html

1. Chla is a signature of not only phytoplankton abundance but also community structure

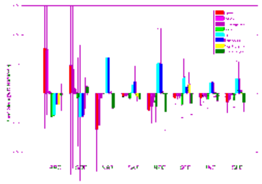


2. %Chla of each PFTs can be estimated from satellite, with uncertainty of 2.2-7.8% (+ uncertainty of Sat. Chla)





3. Pico-phytoplankton seems a “winner” in recent climate change



THE END

r

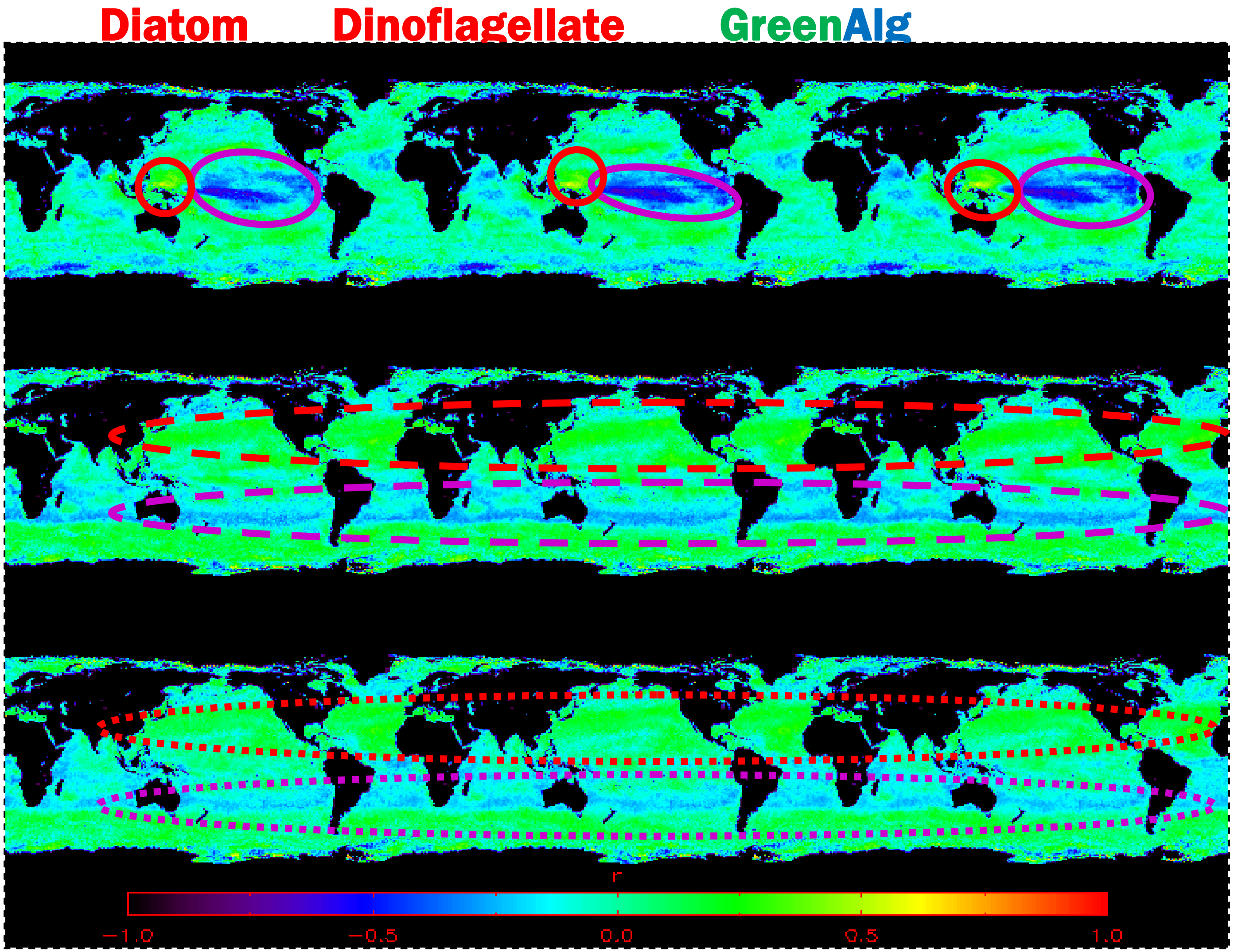
Larger

MEI

NAO

PDO

Smaller



r
Larger

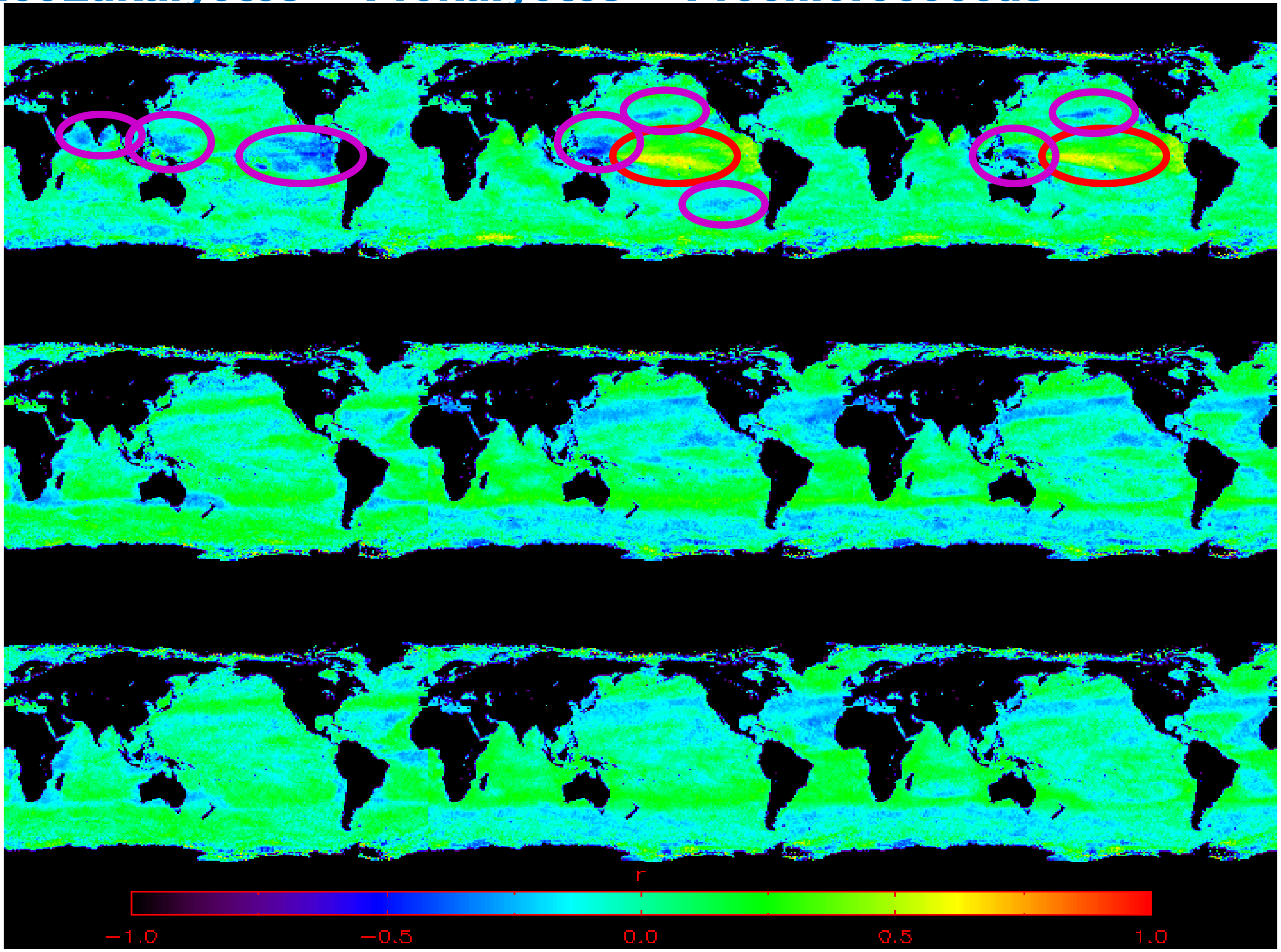
PicoEukaryotes Prokaryotes Prochlorococcus

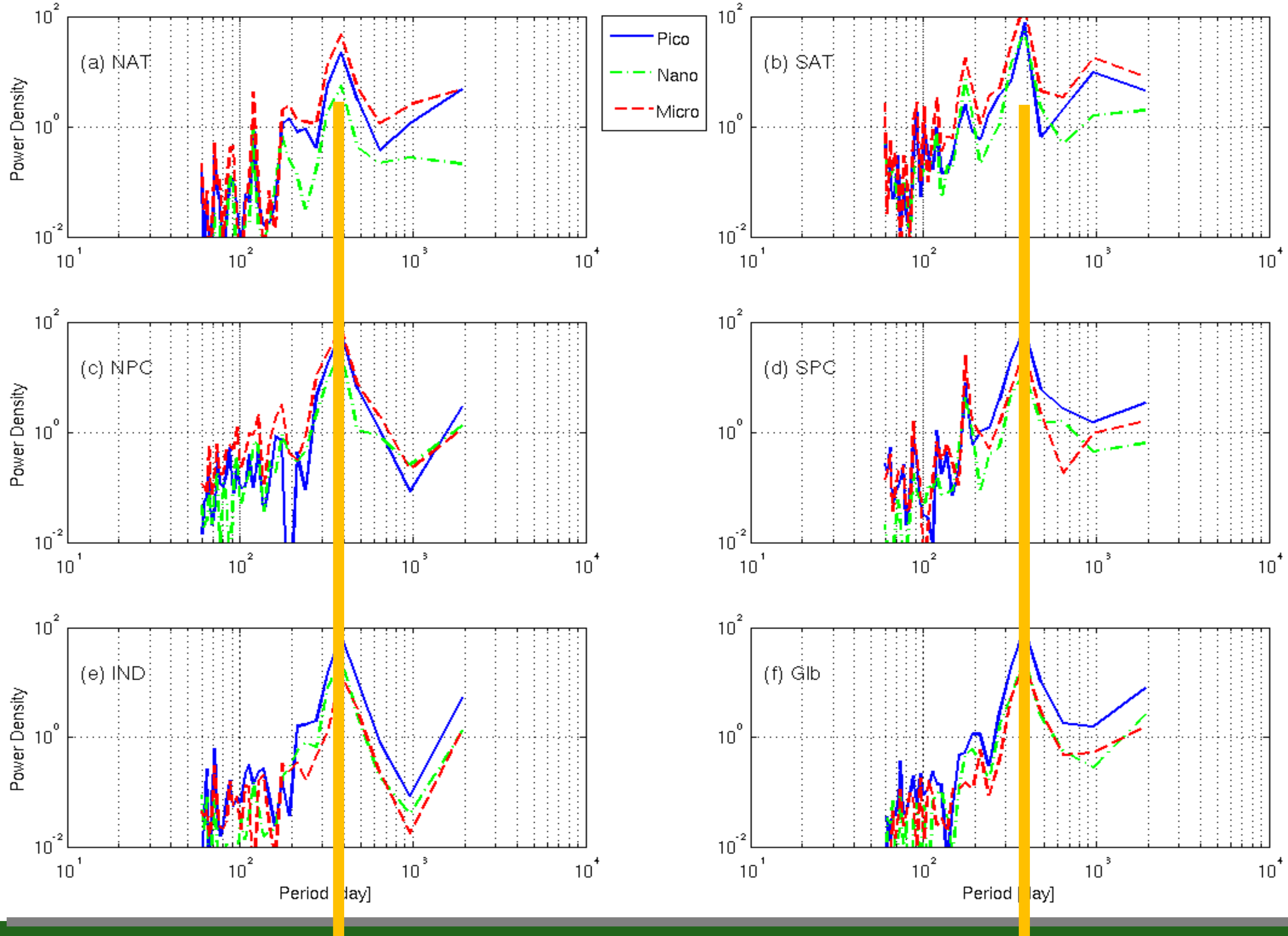
MEI

NAO

PDO

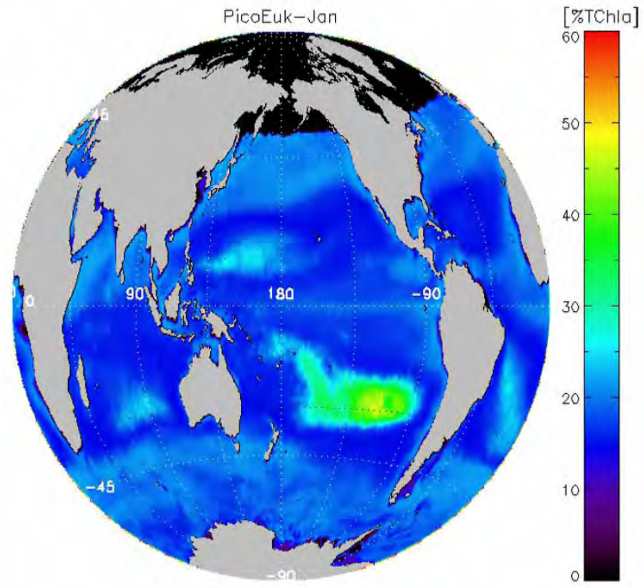
Smaller





(a) NAT
(b) SAT
(c) NPC
(d) SPC
(e) IND
(f) Glb
Pico
Nano
Micro
Power Density
Period [day]

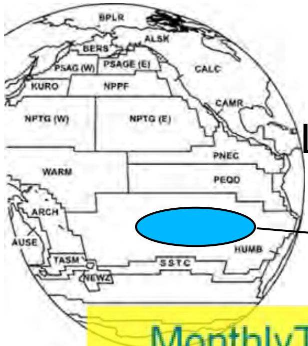
Spatial distribution of PFTs



Monthly climatology over 1998-2007

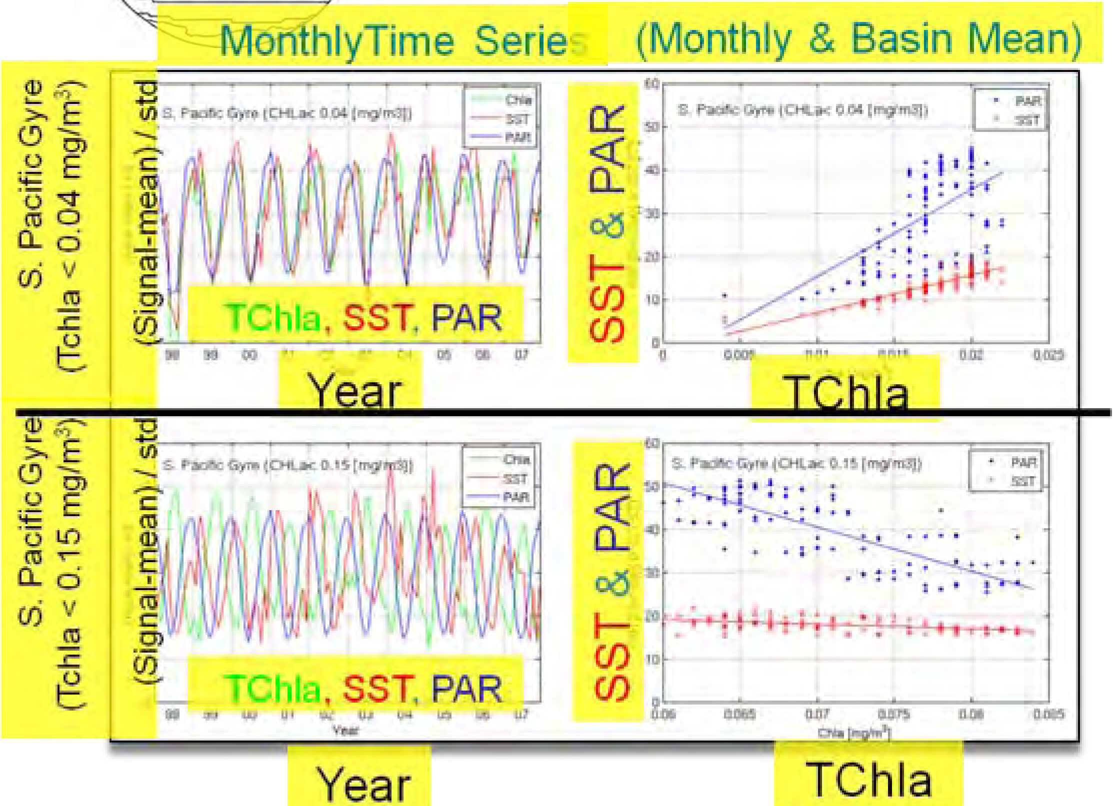
Pico-Eukaryotes hot spot?!

New ecosystem?



Longhurst (1988)

Missing Province?

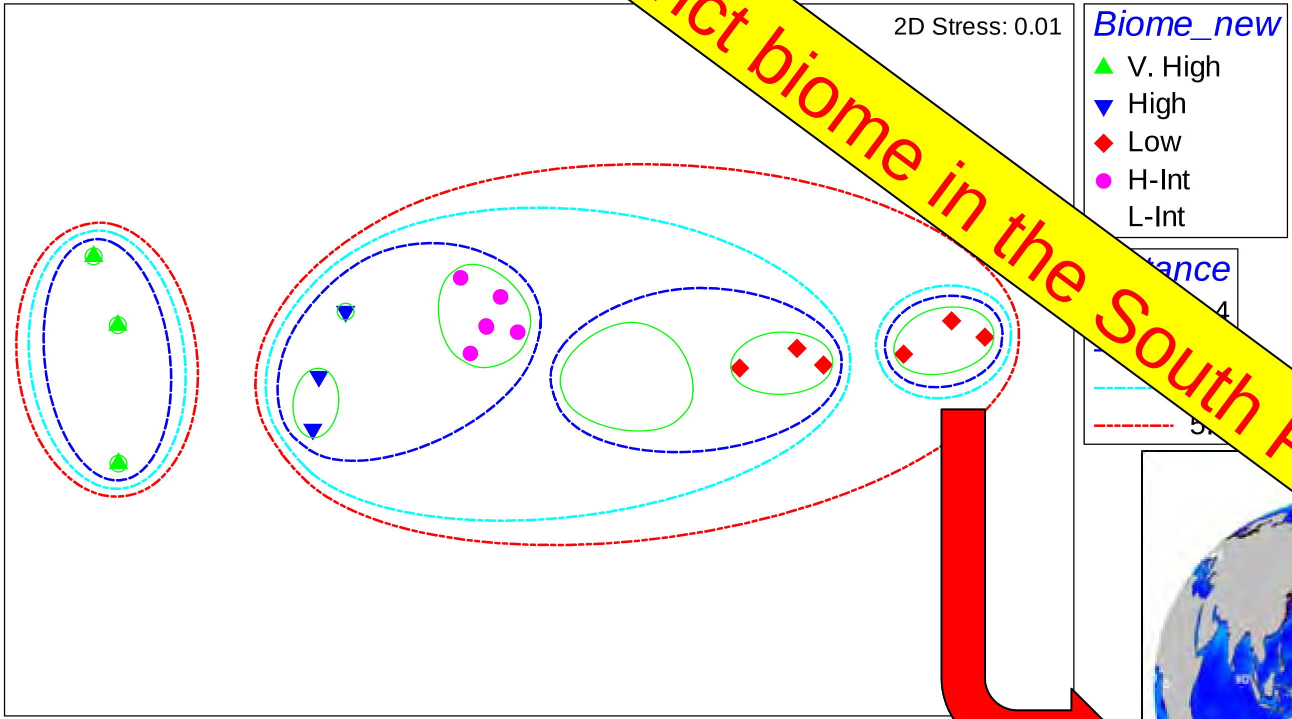


ANOSIM test of significance

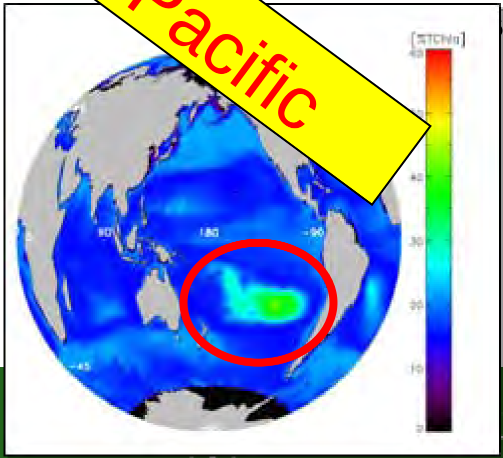
27 samples

2° x 2° boxes f r open ocean, 1° x 1° boxes for coast

Distinct biome in the South Pacific



- **Biomes hold for Pacific samples**
- **Strong split within 'Low' biome**
- **South Pacific gyre has 'Very low' chl-a → new biome**
- **Global R = 0.916, ignificant)**



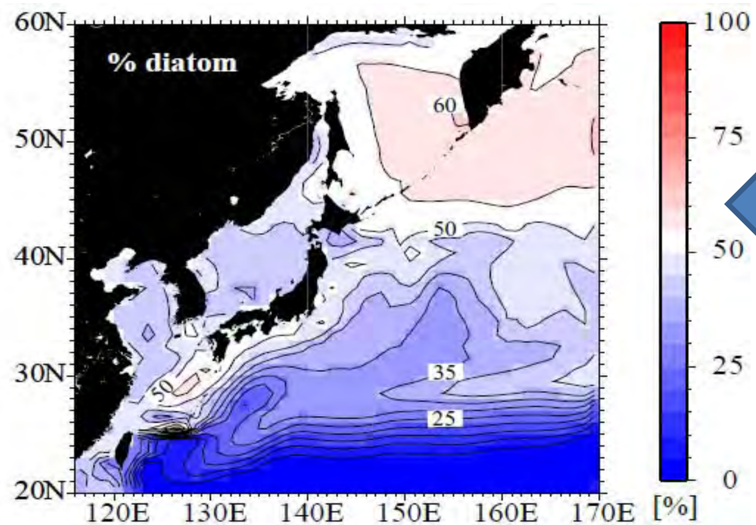
Hardman-Mountford et al, RSE, 2008

MARine Ecosystem Model Inter-comparison Project (MAREMIP)

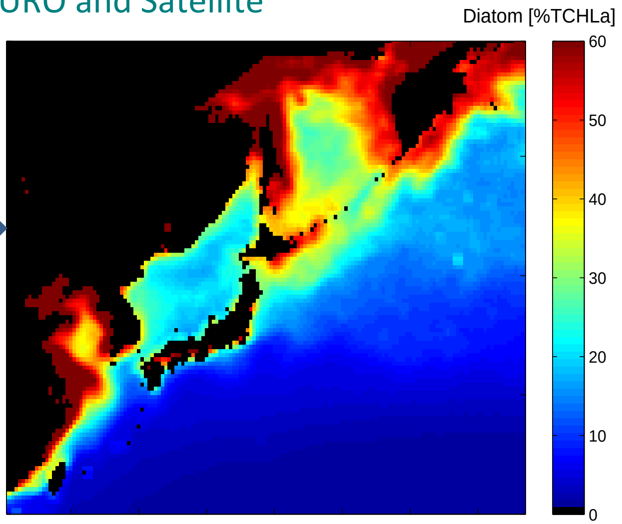
AIMES · GLOBAL IGBP CHANGE · IMBER (Integrated Marine Biogeochemistry and Ecosystem Research) · QUEST (Quantifying and Understanding the Earth System)

MEM (Extended version of NEMURO), PlankTOM, PISCES, BEC… + satellite PFTs

Diatom populations estimated by NEMURO and Satellite



Hashioka & Yamanaka, EM, 2007



Hirata et al. in prep.

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