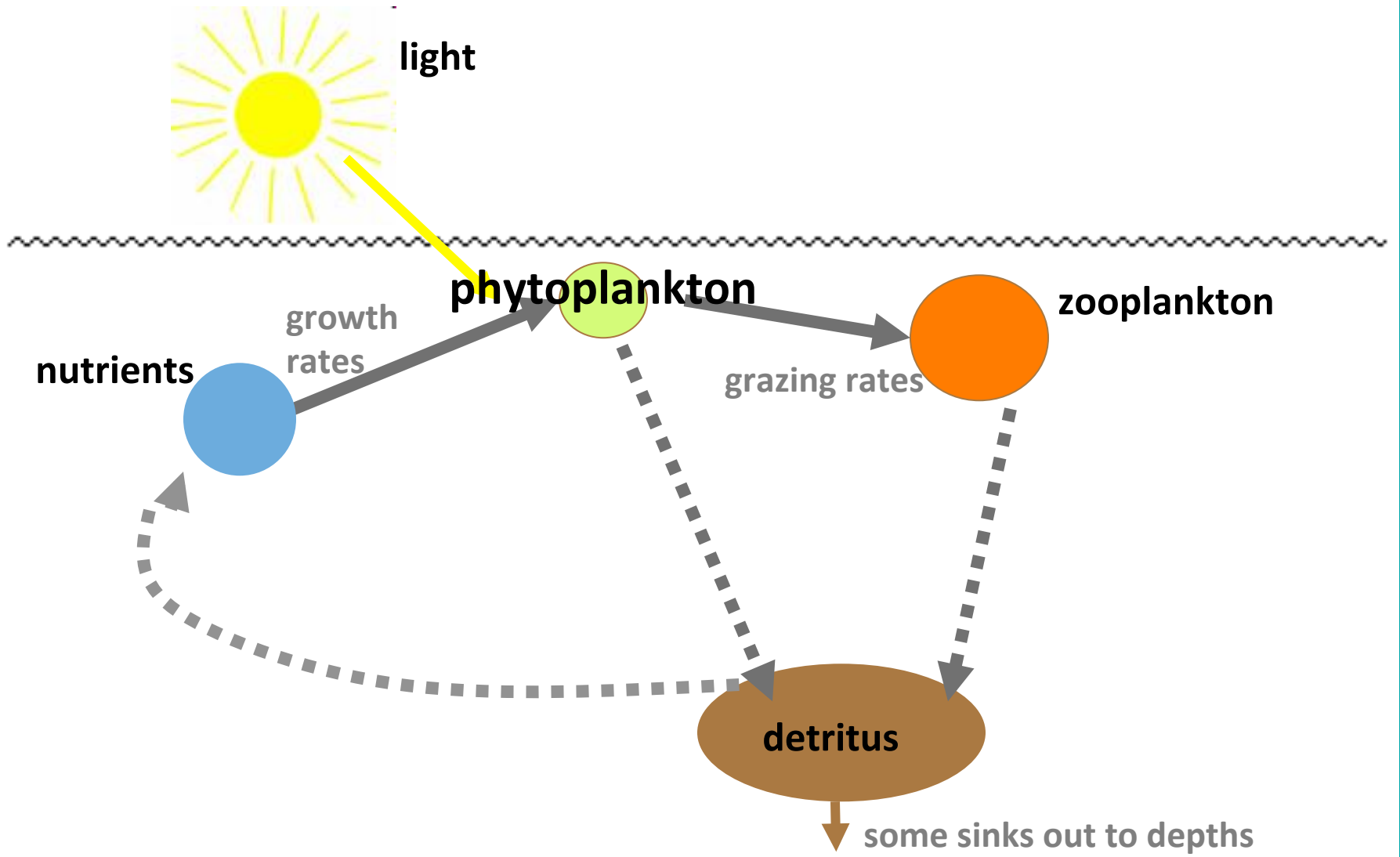


MODELING OF PHYTOPLANKTON COMPOSITION: STATUS AND REMOTE SENSING NEEDS

Stephanie Dutkiewicz
Massachusetts Institute of Technology

ANATOMY OF A MARINE ECOSYSTEM MODELS



TYPICAL ECOSYSTEM COMPLEXITY

e.g. CMIP5 models in latest IPCC
MAREMIP models

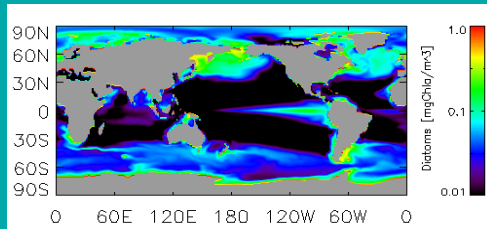
Two to Four “Functional Groups”:

- Diatoms
- Small (pico/nano)
- Diazotrophs
- Calcifiers

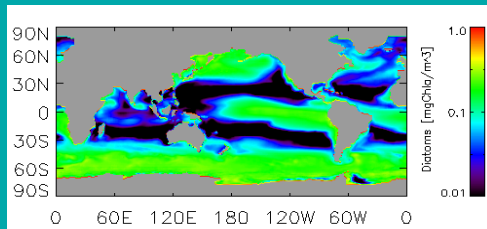
*See Review: Hood et al, DSR, 2006
LeQuere et al, Glob. Chang Bio, 2005*

TYPICAL MODEL COMPLEXITY

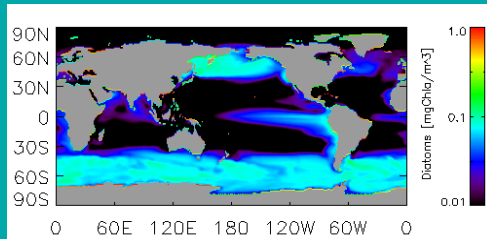
GFDL



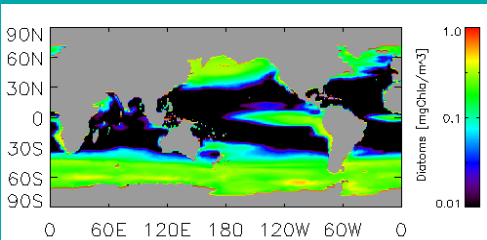
**HU/
JAMTEC**



MRI



NASA

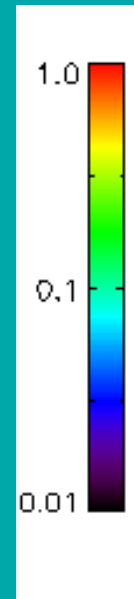


MAREMIP

**MARine Ecosystem Model
Intercomparison Project**

<http://pft.ees.hokudai.ac.jp/maremip/index.shtml>

DIATOMS (mg Chl/m³)



HOW DO MODELS USE OC PRODUCTS

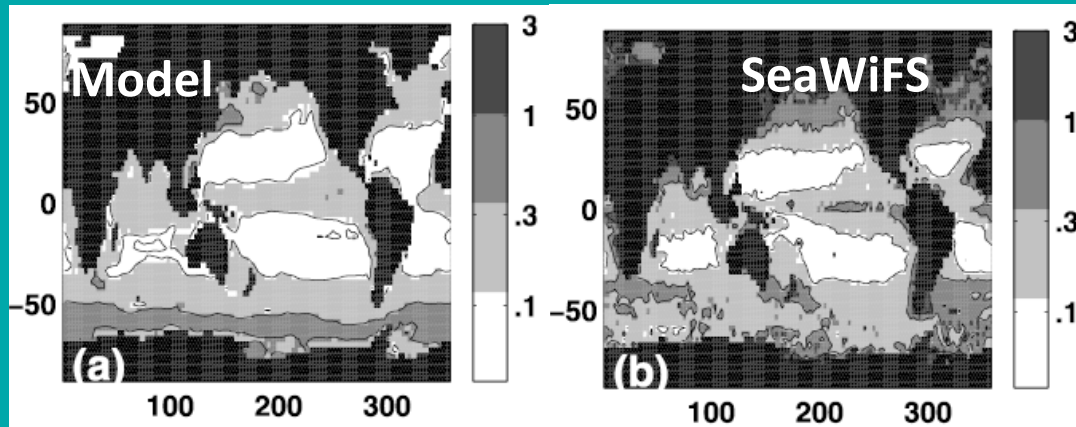
1. Motivation

2. Evaluation

3. Data Assimilation

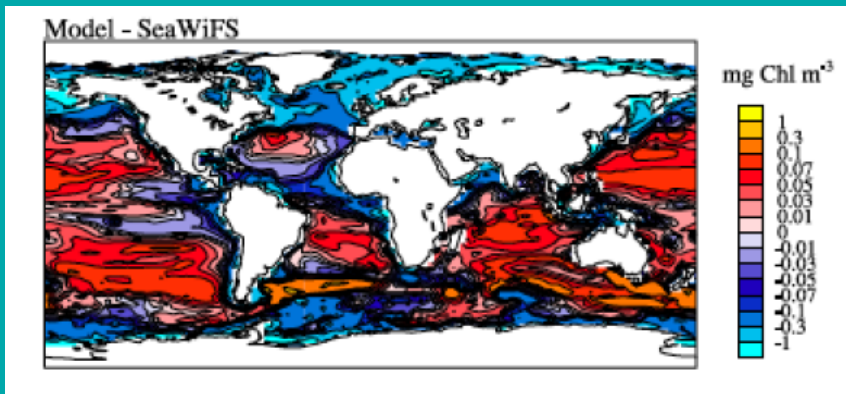
MODEL VALIDATION: CHL

“looks pretty good”



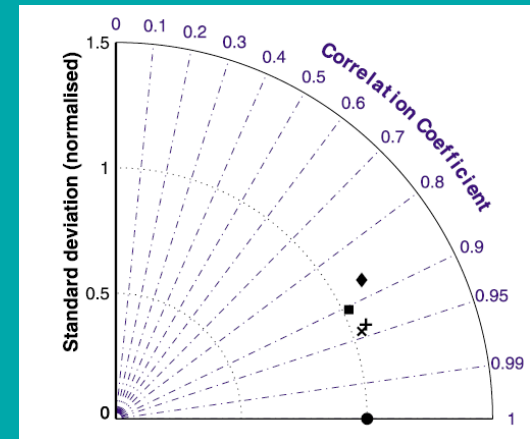
Dutkiewicz et al, GBC, 2005

bias



Doney et al, JMS, 2008

Taylor Diagram



Cole et al, JGR 2012

MODEL VALIDATION: PFTs

MODEL EVALUATION: PFTs

picophytoplankton



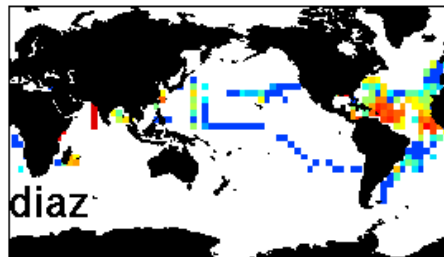
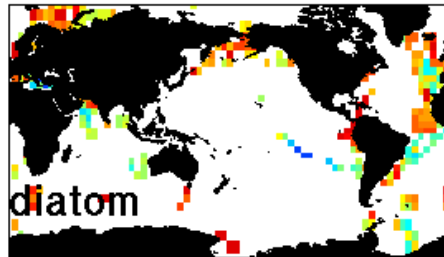
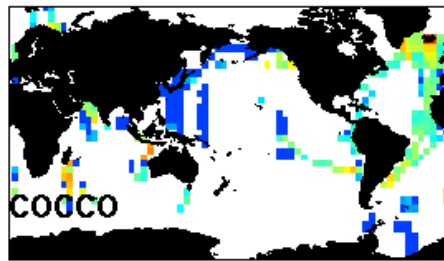
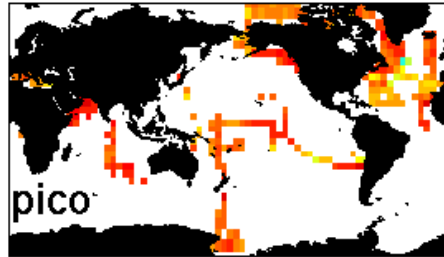
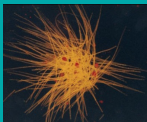
coccolithophores



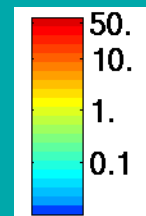
diatoms



diazotrophs



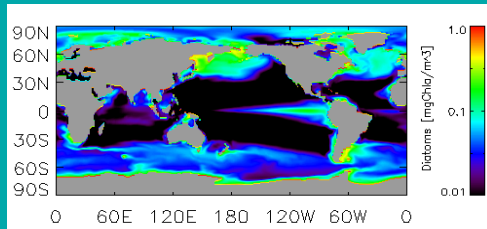
mgC/m³



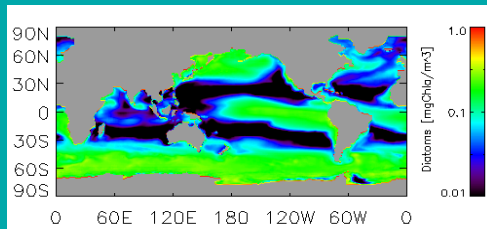
MareDAT compilation
Buitenhuis et al, ESSD, 2012
(and other papers in same issue)

MODEL EVALUATION: PFTs

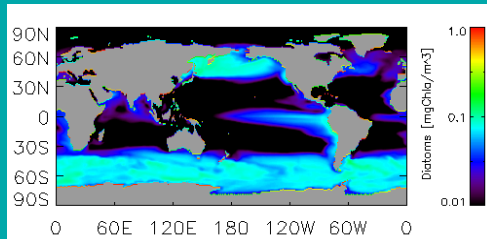
GFDL



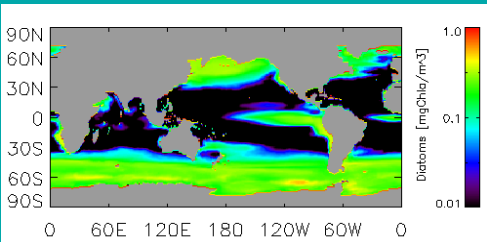
HU/
JAMTEC



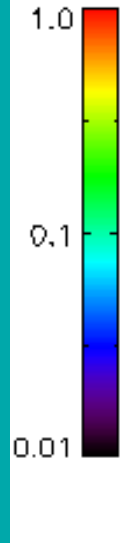
MRI



NASA



(mg Chl/m³)

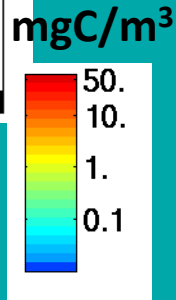
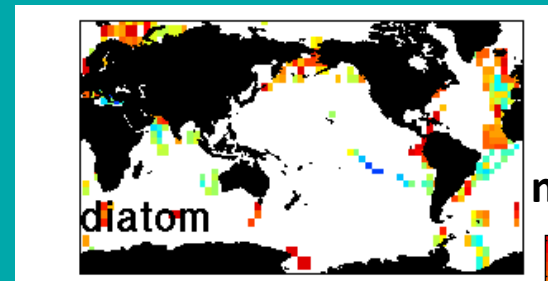


MAREMIP

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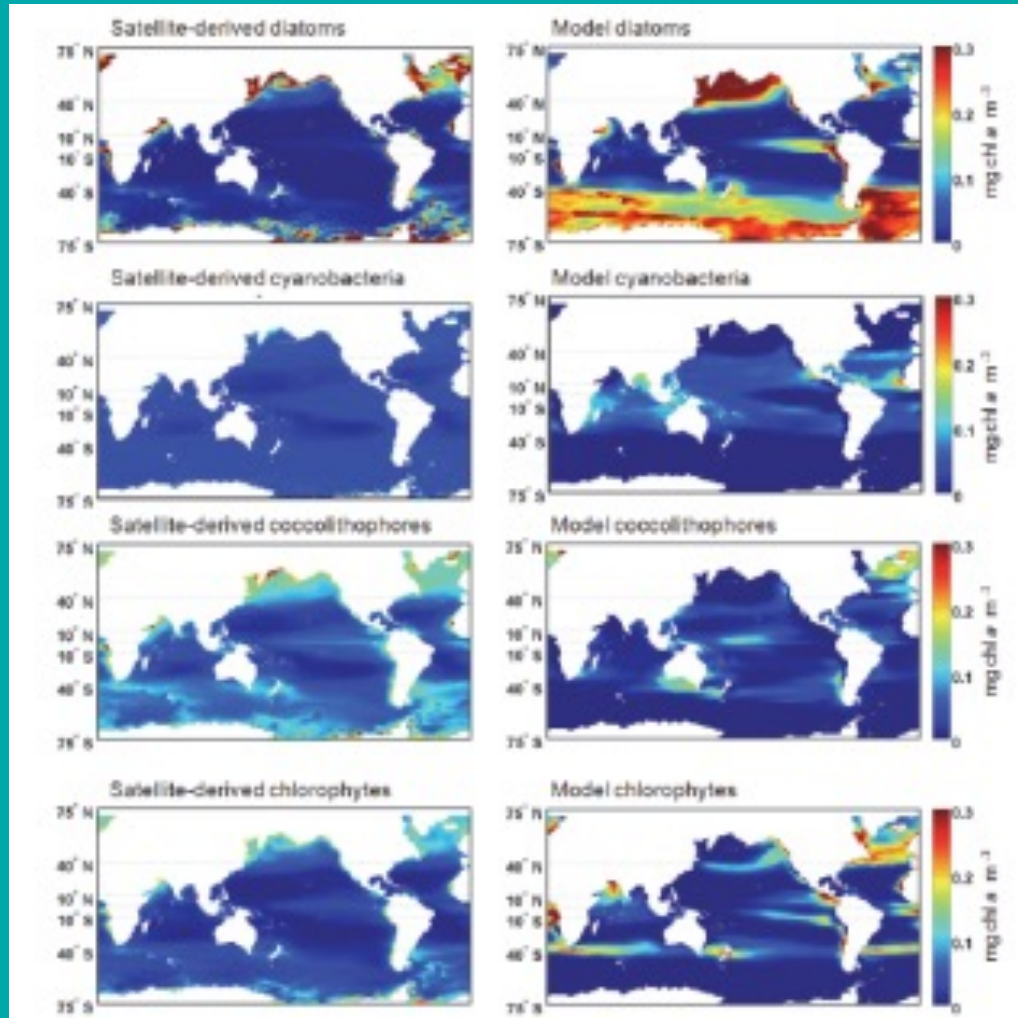
MareDAT



NB. Note
difference in
units

MODEL VALIDATION: PFTs

MODEL METRIC: CHL IN PFTs

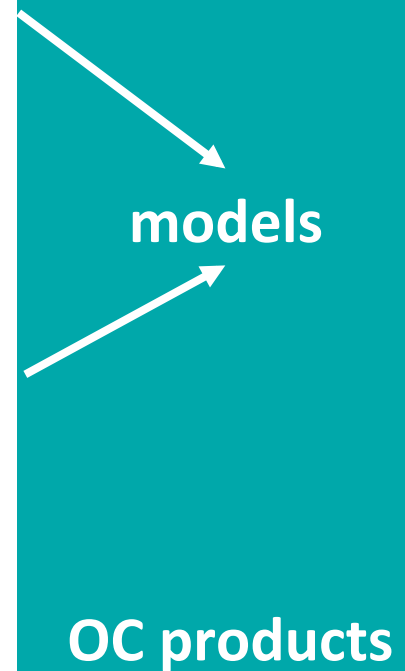
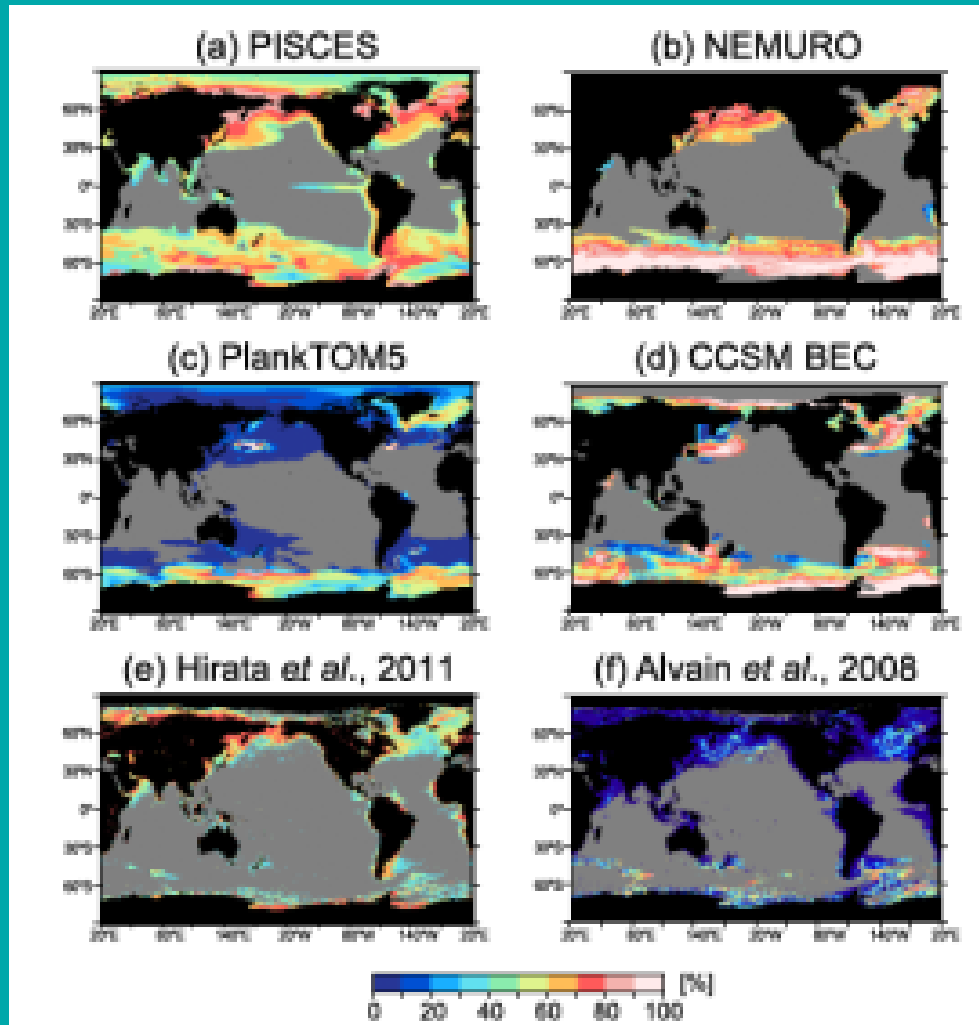


Hirata et al, BG, 2011

Satellite View of Phytoplankton Community Distributions: Rousseaux et al, BGD, 2013

MODEL VALIDATION: PFTs

**MODEL
METRIC :
% of Chl
made up of
diatoms at
peak bloom**

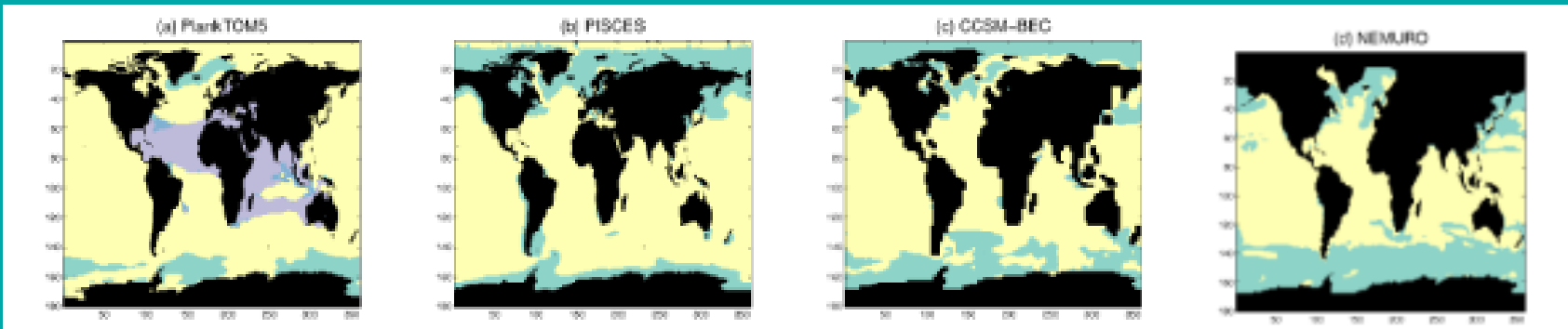


Phytoplankton competition during the spring bloom in 4 PFT models: Hashioka et al, GBC, 2013

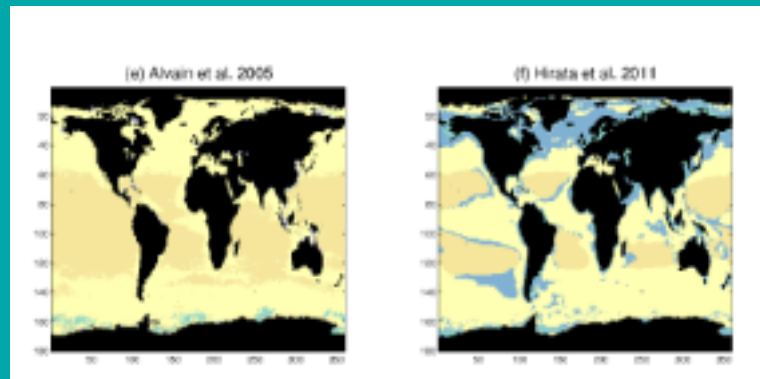
MODEL VALIDATION: PFTs

MODEL METRIC: ANNUAL DOMINANCE

models



OC products

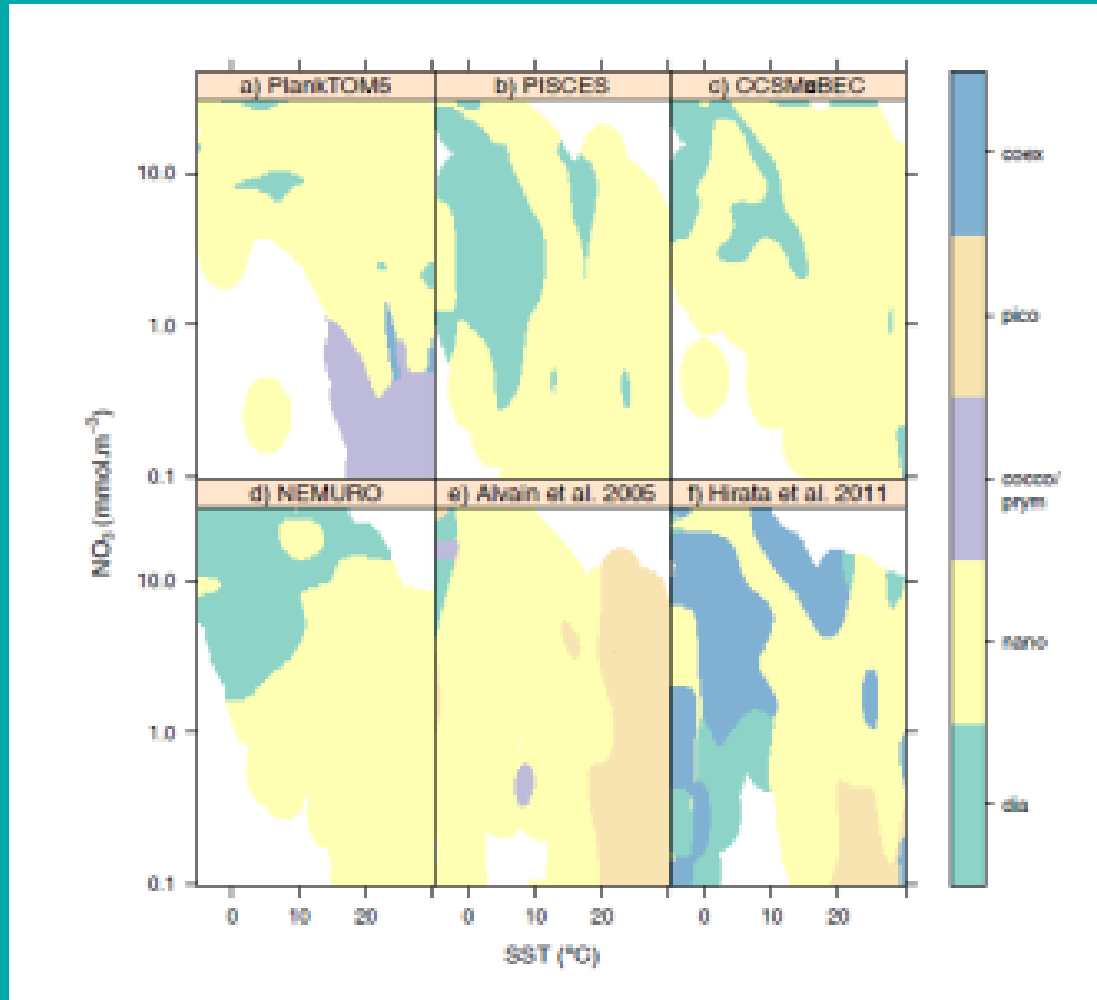


The distribution, dominance patterns and ecological niches of PFTs in Models: Vogt et al, BGD, 2013

MODEL VALIDATION: PFTs

MODEL METRIC: NICHES

models

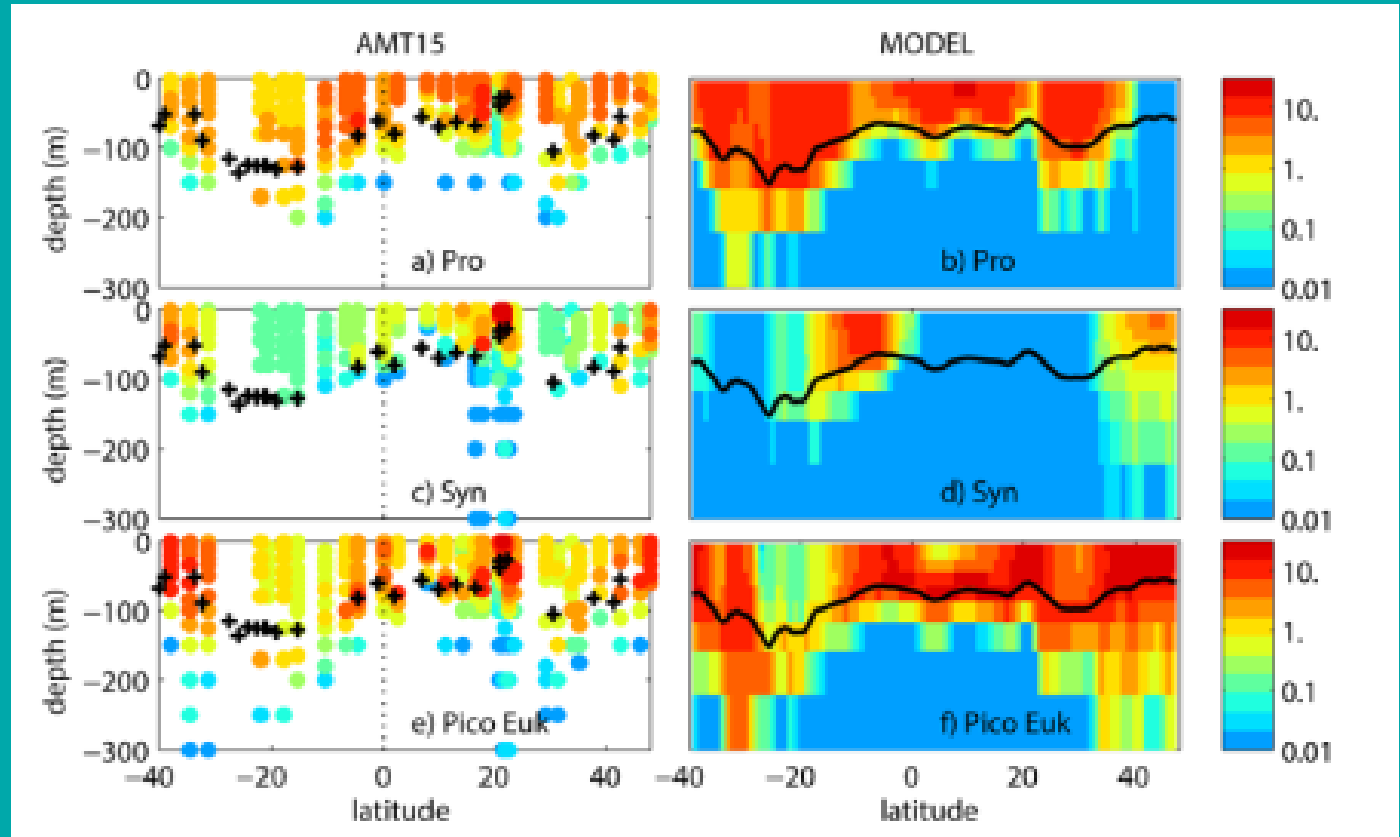


OC products

The distribution, dominance patterns and ecological niches of PFTs in Models: Vogt et al, BGD, 2013

MODEL VALIDATION: PFTs

**MODEL
METRIC :
biomass
(mg C/m³)**



models need to validate with depth too

Dutkiewicz et al, GBC, 2015

NOT JUST PFT MODELS

Trait-based approaches:

- Many types of phytoplankton, environment selects

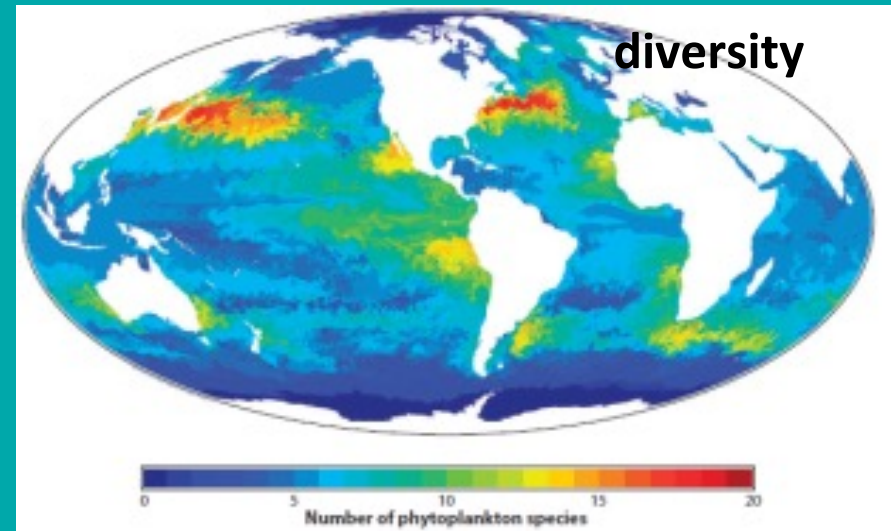
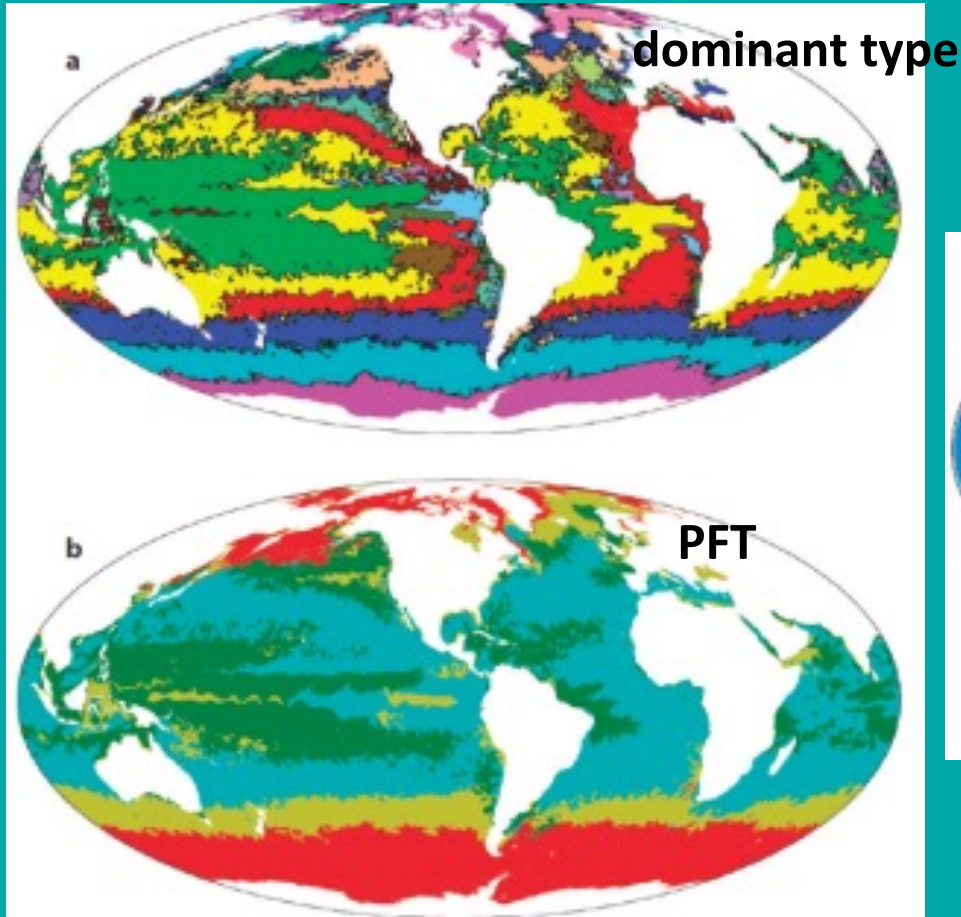
Energy-balance models:

- DEB model (Kooijman 2001)

Others....

NOT JUST PFT MODELS

Trait-based approaches: TEMPERATURE AND LIGHT

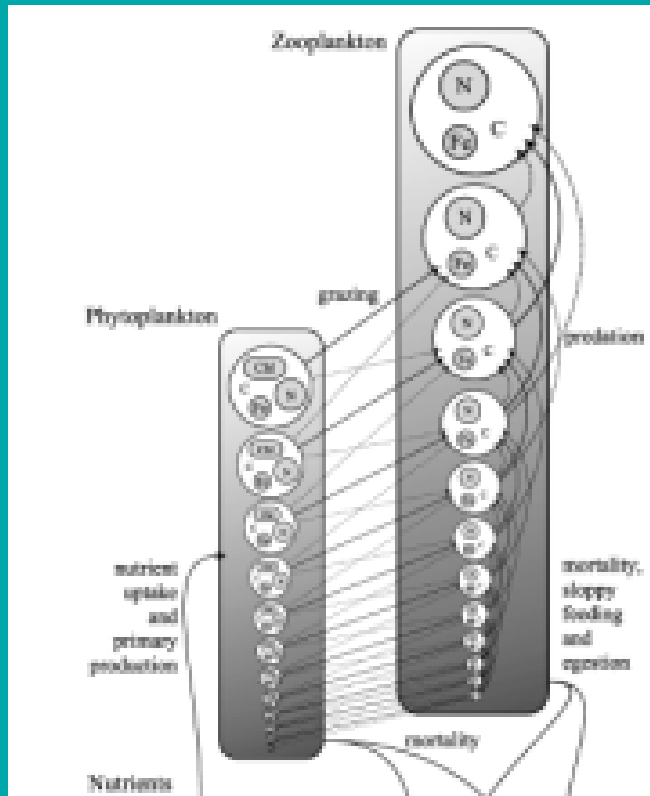


Follows et al, Science 2007

Follows and Dutkiewicz, Ann Rev Mar Sci, 2011

NOT JUST PFT MODELS

Trait-based approaches: SIZE

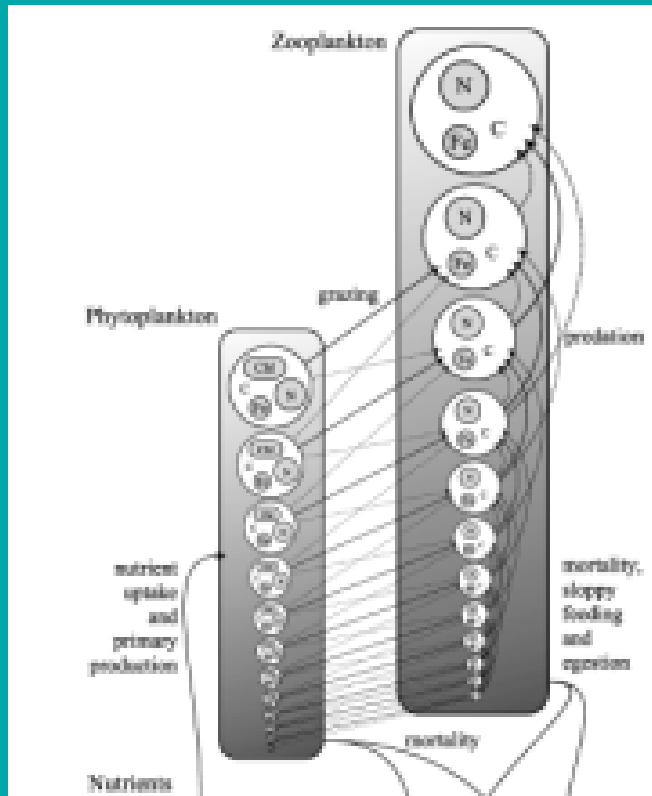


Ward et al, L&O, 2011

NOT JUST PFT MODELS

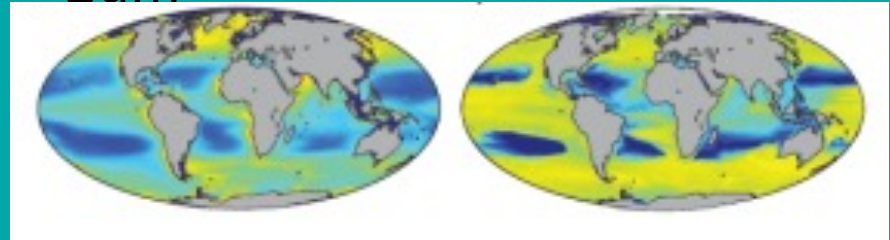
Trait-based approaches: **SIZE**

METRIC: CHL IN SIZE GROUPS

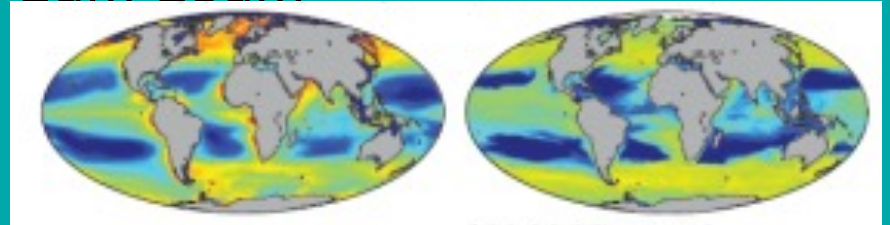


Ward et al, L&O, 2011

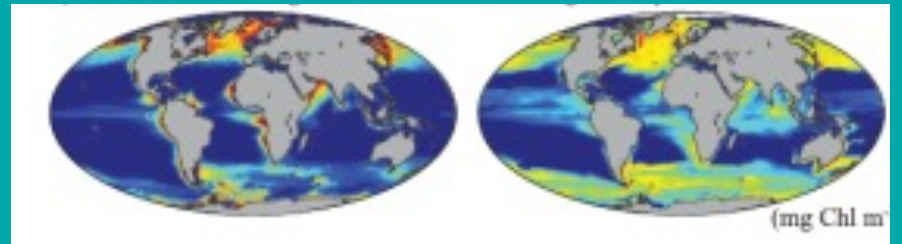
<2um



2um-20um



>20um



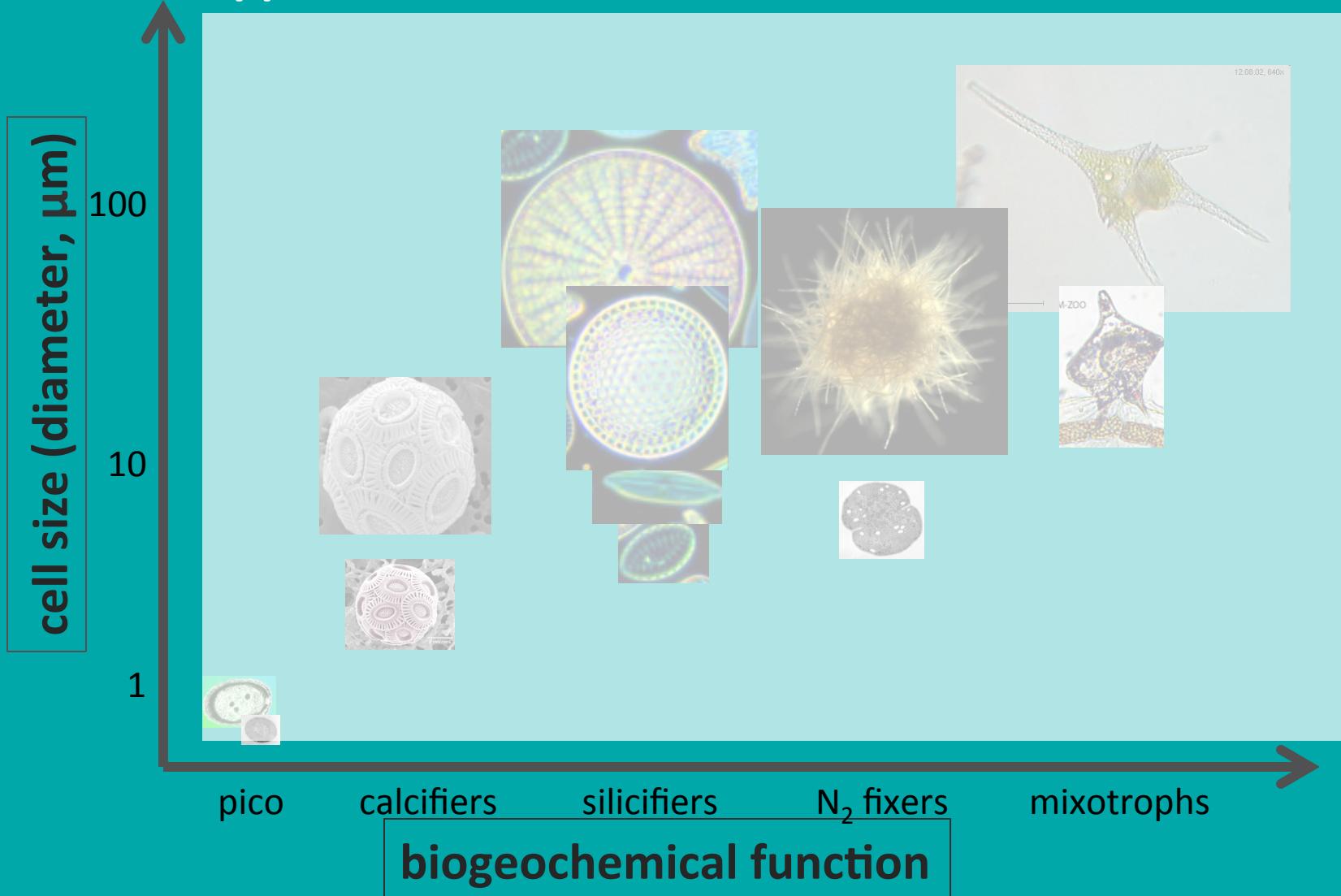
OC PRODUCT

MODEL

Hirata et al, BG, 2011

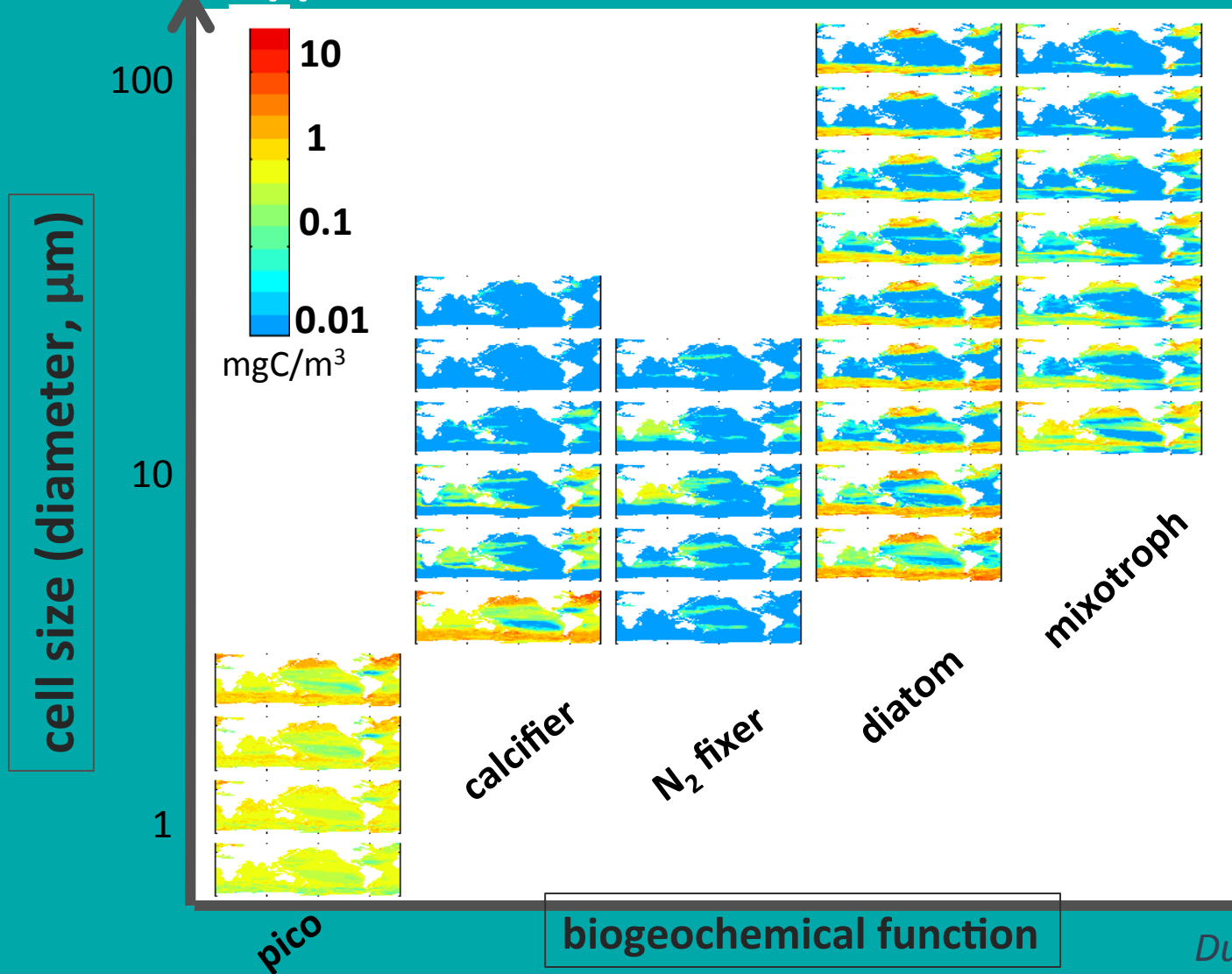
NOT JUST PFT MODELS

Trait-based approaches: SIZE+FUNCTION



NOT JUST PFT MODELS

Trait-based approaches: SIZE+FUNCTION

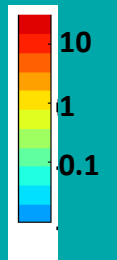


Dutkiewicz et al., in prep

NOT JUST PFT MODELS

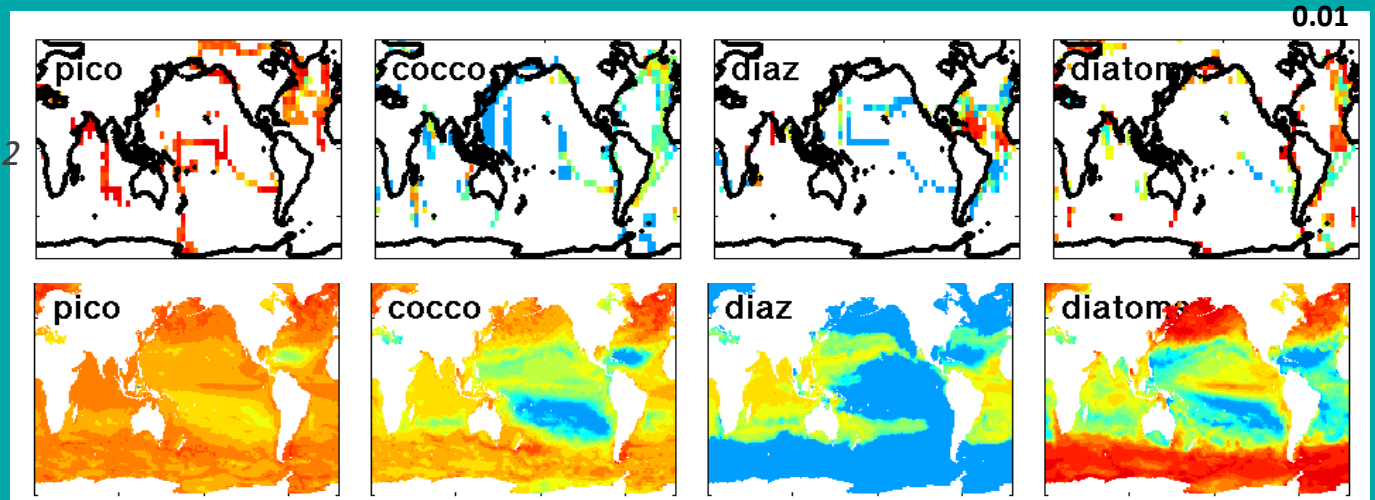
Trait-based approaches: SIZE+FUNCTION

mgC/m³



MAREDAT:
Buitenhuis et al, ESSD, 2012
(and other papers in same issue)

MODEL



pico

calcifiers

N₂ fixers

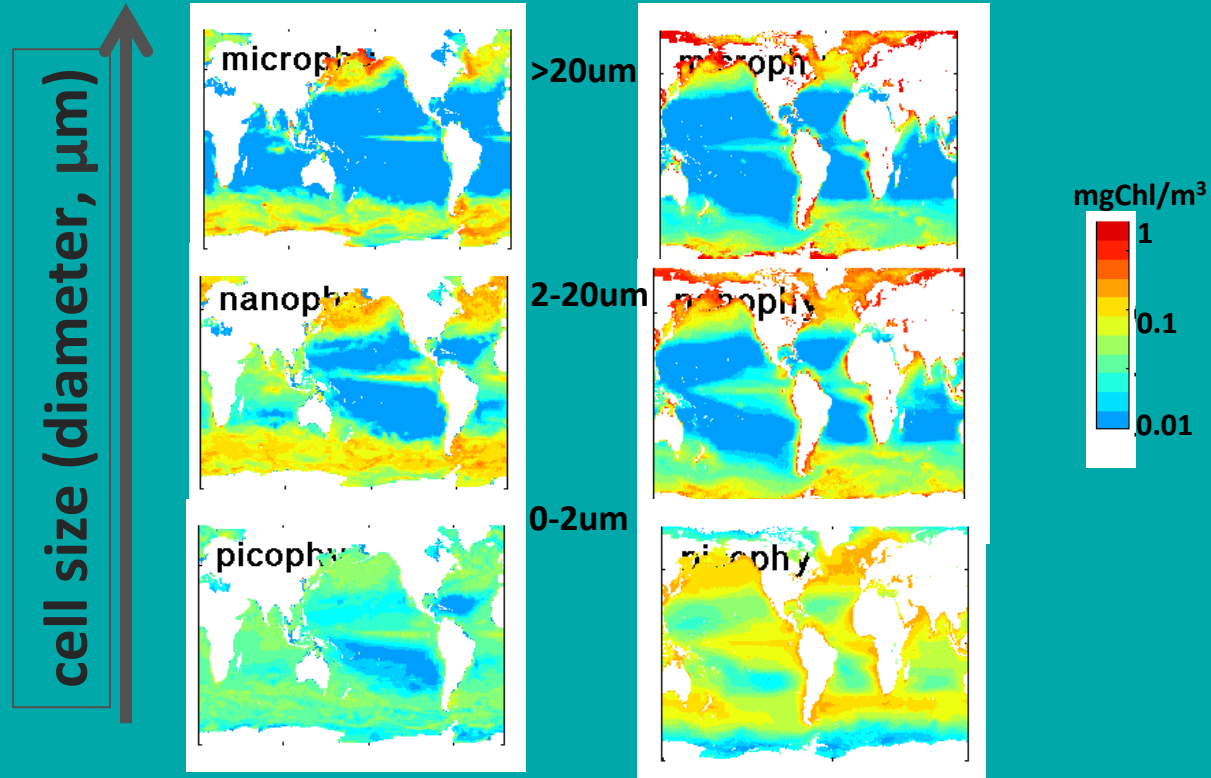
silicifiers

biogeochemical function

Dutkiewicz et al., in prep

NOT JUST PFT MODELS

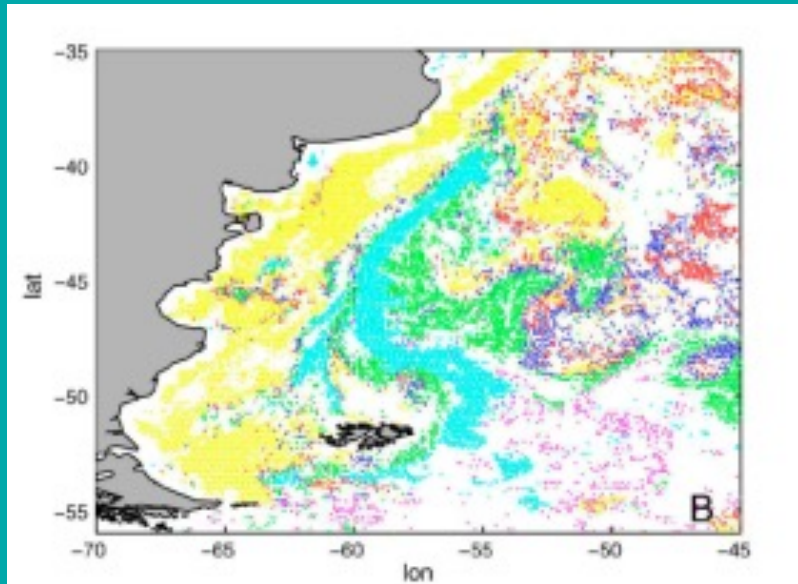
Trait-based approaches: SIZE+FUNCTION



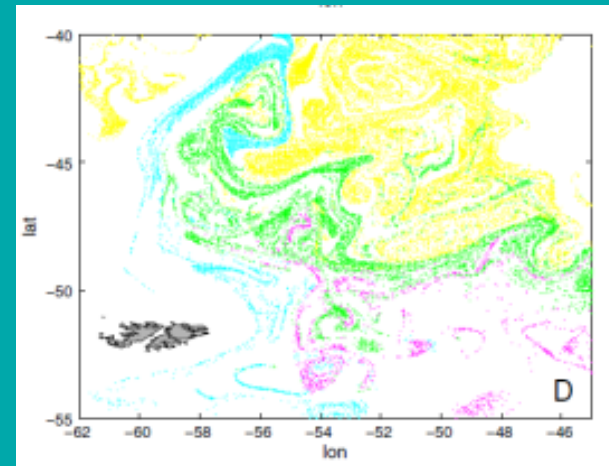
*Satellite Derived Size Fractions:
Ward, in review*

NOT JUST PFT MODELS

Not even PFTs



OC derived PFTs



Model tracers

HOW DO MODELS USE OC PRODUCTS

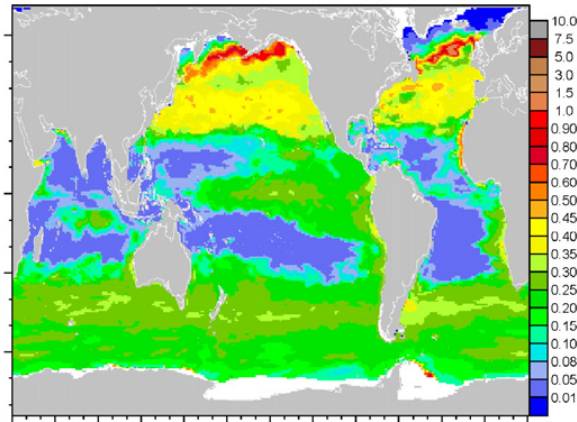
1. Motivation

2. Evaluation

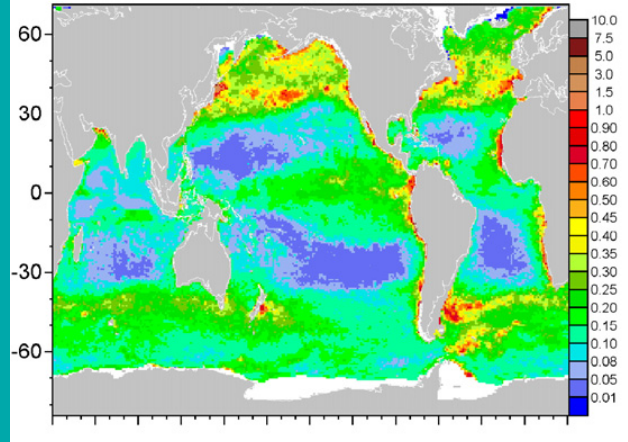
3. Data Assimilation

DATA ASSIMILATION

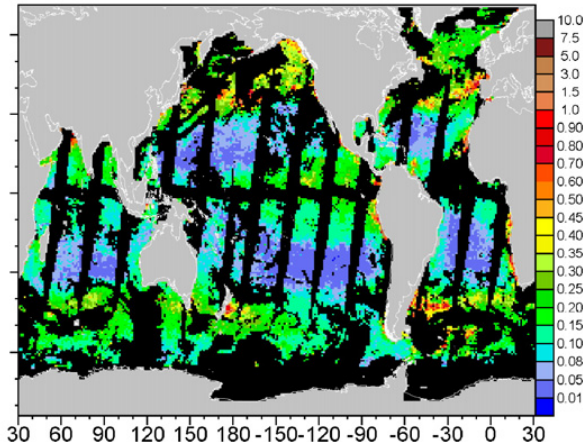
Free Run Model Chlorophyll Apr 1 2001



Assimilated Chlorophyll Apr 1 2001



Daily SeaWiFS Chlorophyll Apr 1 2001



**Daily assimilation of SeaWiFS data
using sequential method:**

-Improvement in bias (4x) of Chl

Gregg, JMS, 2008

WHAT DO MODELS NEED TO MOVE FORWARD?

WHAT DO MODELS NEED TO MOVE FORWARD?

- Connection between metrics of model and satellite products need to be considered carefully

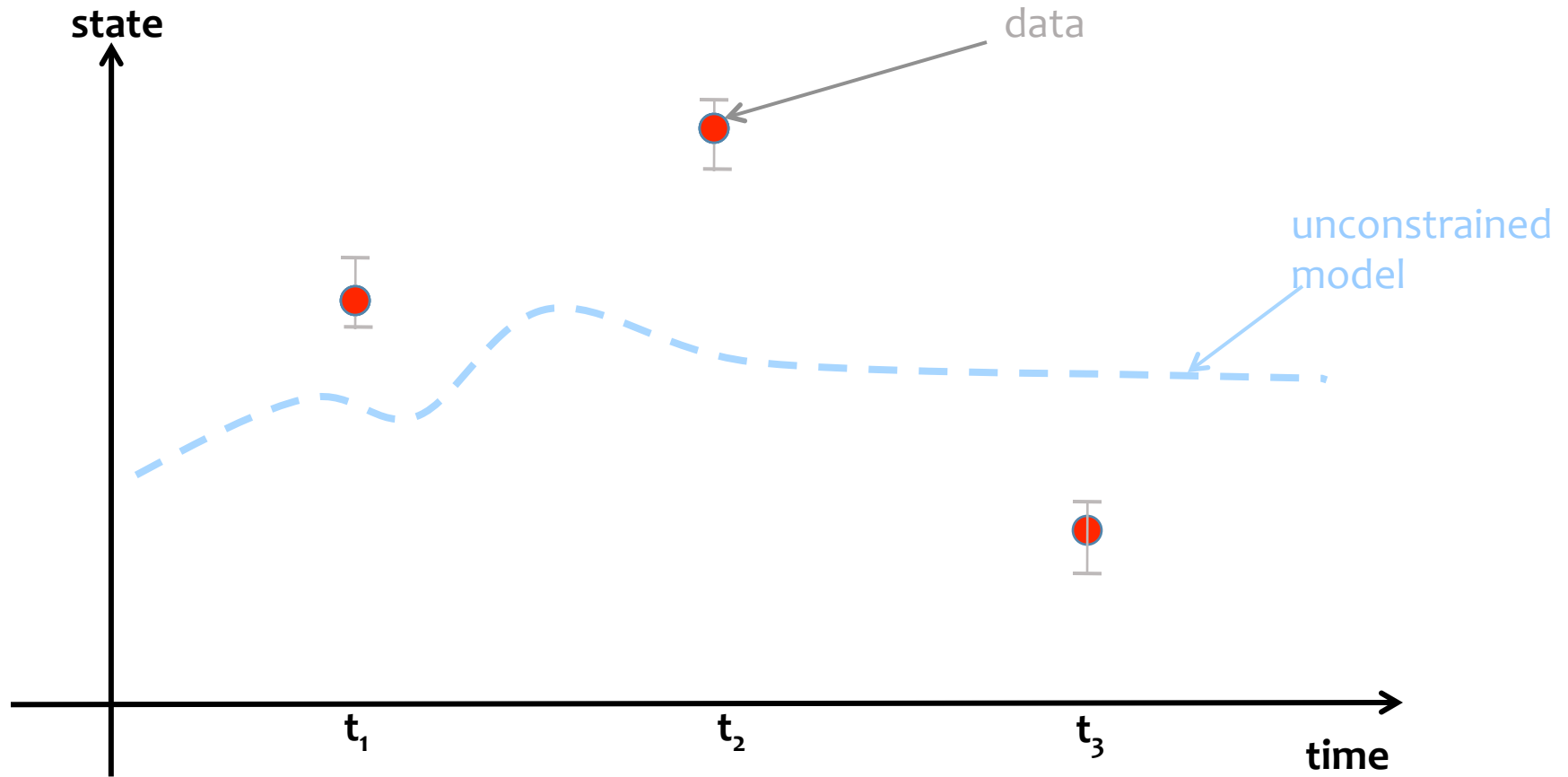
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- Connection between metrics of model and satellite products need to be considered carefully
- Metrics of biodiversity

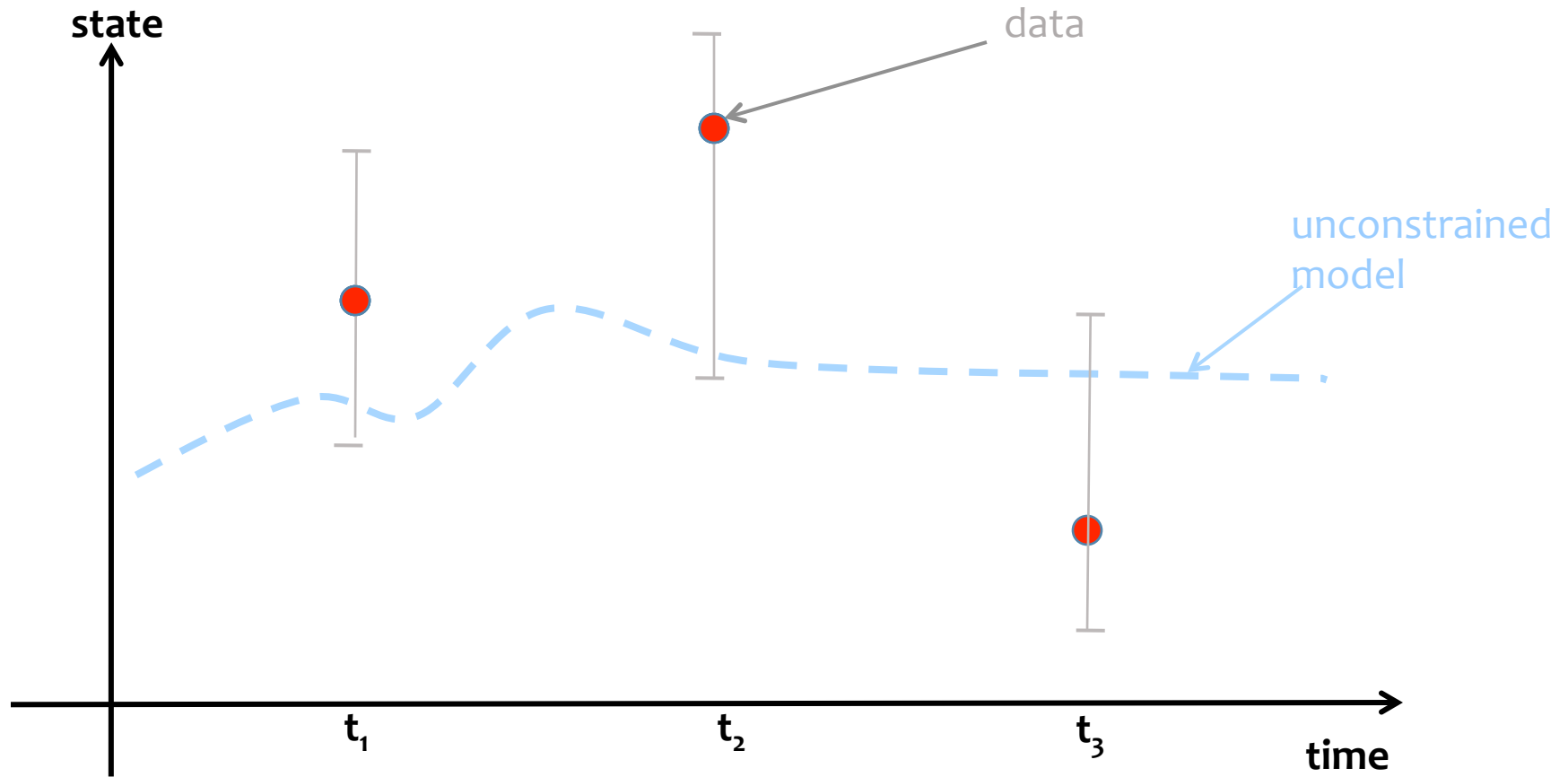
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- Connection between metrics of model and satellite products need to be considered carefully
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IMPORTANCE OF UNCERTAINTY ESTIMATES



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WHAT DO MODELS NEED TO MOVE FORWARD?

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- What PFT products should a modeler use?

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More dialogue needed between modeling and OC communities.

Can models be useful to OC community?