Application of PFT satellite products in ecosystem modeling

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IOCS Meeting, Frankfurt, 6-8 May 2013

MARine Ecosystem Model Intercomparison Project (MAREMIP)

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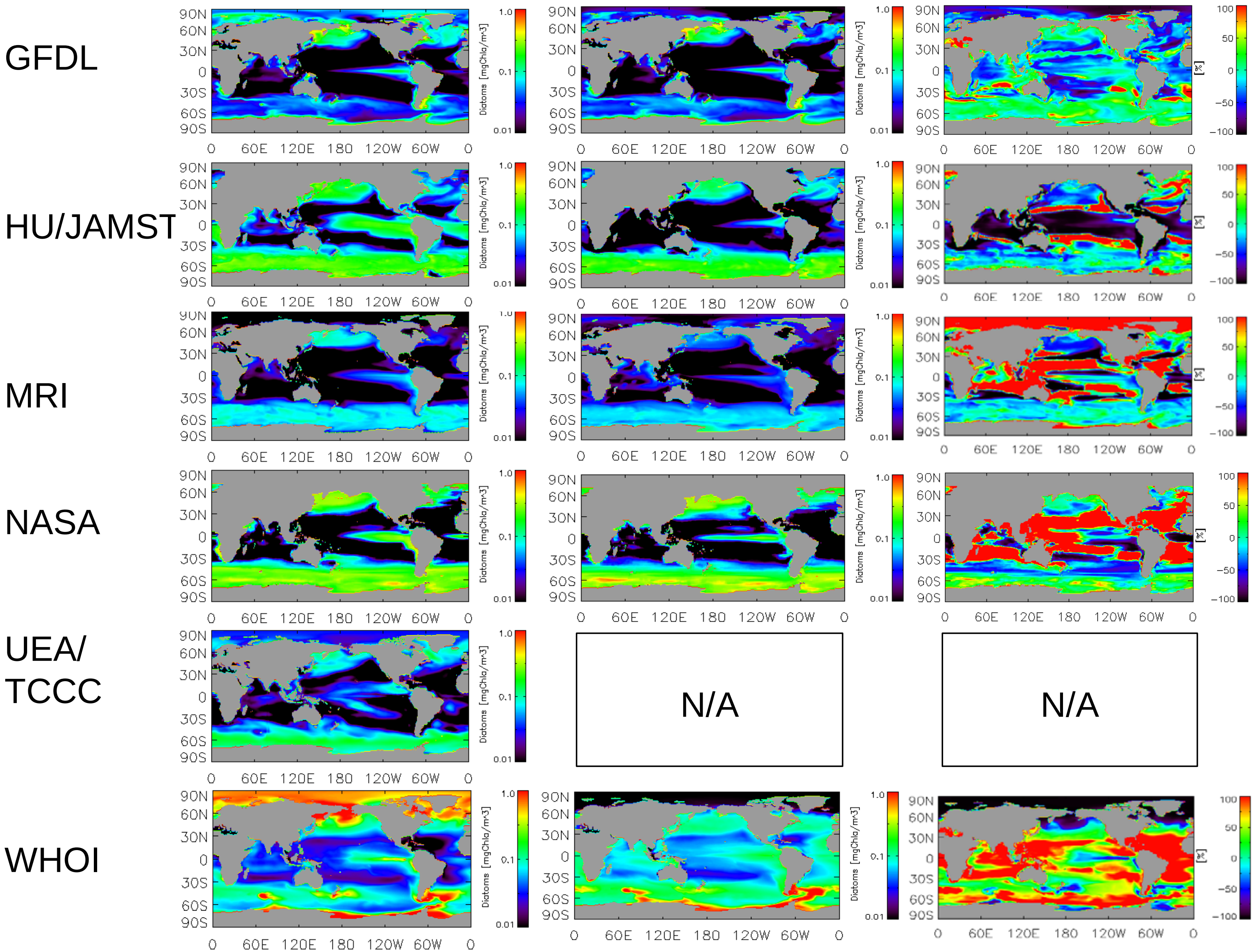
	ESM2M (GFDL)	**COCO-MEM (Hokkaido U/JAMSTEC)**	**MRI.COM-MEM (MRI)**	**NOBM (NASA)**	**PlankTOM5 (U. East Anglia /TCCCR)**	**CESM1 (WHOI)**
Historical Start year	1985	1985	1985	1985	1985	1985
Historical End year	2011	2007	2006	2010	2007	2007
Future Start year	2012	2010	2007	2010	-	2012
Future End year	2100	2100	2100	2100	-	2100

Surface Diatom [mg/m^3]

1997-2006(h) | 2091-2100 (f) | Difference 100*(f-h)/h



- Comparing NOBM and the algorithm of Hirata et al . (2011)
- Some differences expected due to:
  - coverage
  - difference in groups
- These differences will highlight the strengths and weaknesses of both approaches (e.g. data coverage and parameterization)

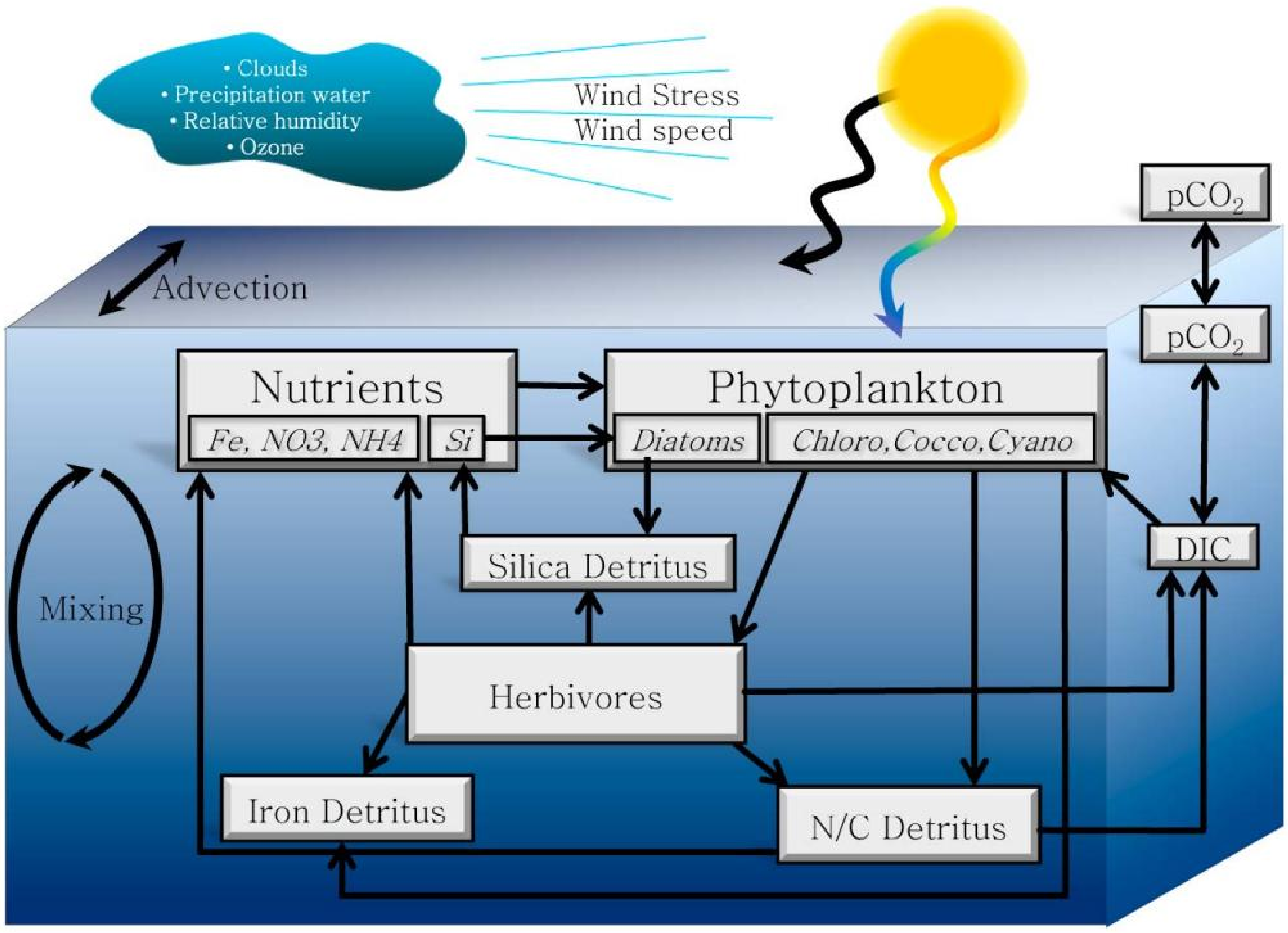
Table 2. Equations to estimate fractions [0.0–1.0] of PSCs (Micro-, Nano- and Picoplankton) and PFTs (other). Set PFT fraction to 1.0 if >1.0, and 0 if <0. To get % Chl-*a*, multiply 100 to the fractions derived.

PSCs/PFTs	Formula	a_0	a_1	a_2	a_3	a_4	a_5	a_6
Microplankton	$[a_0 + \exp(a_1 x + a_2)]^{-1}$	0.9117	−2.7330	0.4003				
Diatoms	$[a_0 + \exp(a_1 x + a_2)]^{-1}$	1.3272	−3.9828	0.1953	–	–	–	–
Dinoflagellates	(= Micro-Diatoms)	–	–	–	–	–	–	–
Nanoplankton	(= 1-Micro-Pico)	–	–	–	–	–	–	–
Green Algae	$(a_0/y) \exp[a_1(x + a_2)^2]$	0.2490	−1.2621	−0.5523	–	–	–	–
Prymnesiophytes (Haptophytes)	(≃ Nano-Green Algae)	–	–	–	–	–	–	–
Picoplankton	$-[a_0 + \exp(a_1 x + a_2)]^{-1} + a_3 x + a_4$	0.1529	1.0306	−1.5576	−1.8597	2.9954	–	–
Prokaryotes	$(a_0/a_1/y) \exp[a_2(x + a_3)^2/a_1^2] + a_4 x^2 + a_5 x + a_6$	0.0067	0.6154	−19.5190	0.9643	0.1027	−0.1189	0.0626
Pico-eukaryotes	(= Pico-Prokaryotes)	–	–	–	–	–	–	–
Prochlorococcus sp.	$(a_0/a_1/y) \exp[a_3(x + a_4)^2/a_1^2] + a_4 x^2 + a_5 x + a_6$	0.0099	0.6808	−8.6276	0.9668	0.0074	−0.1621	0.0436

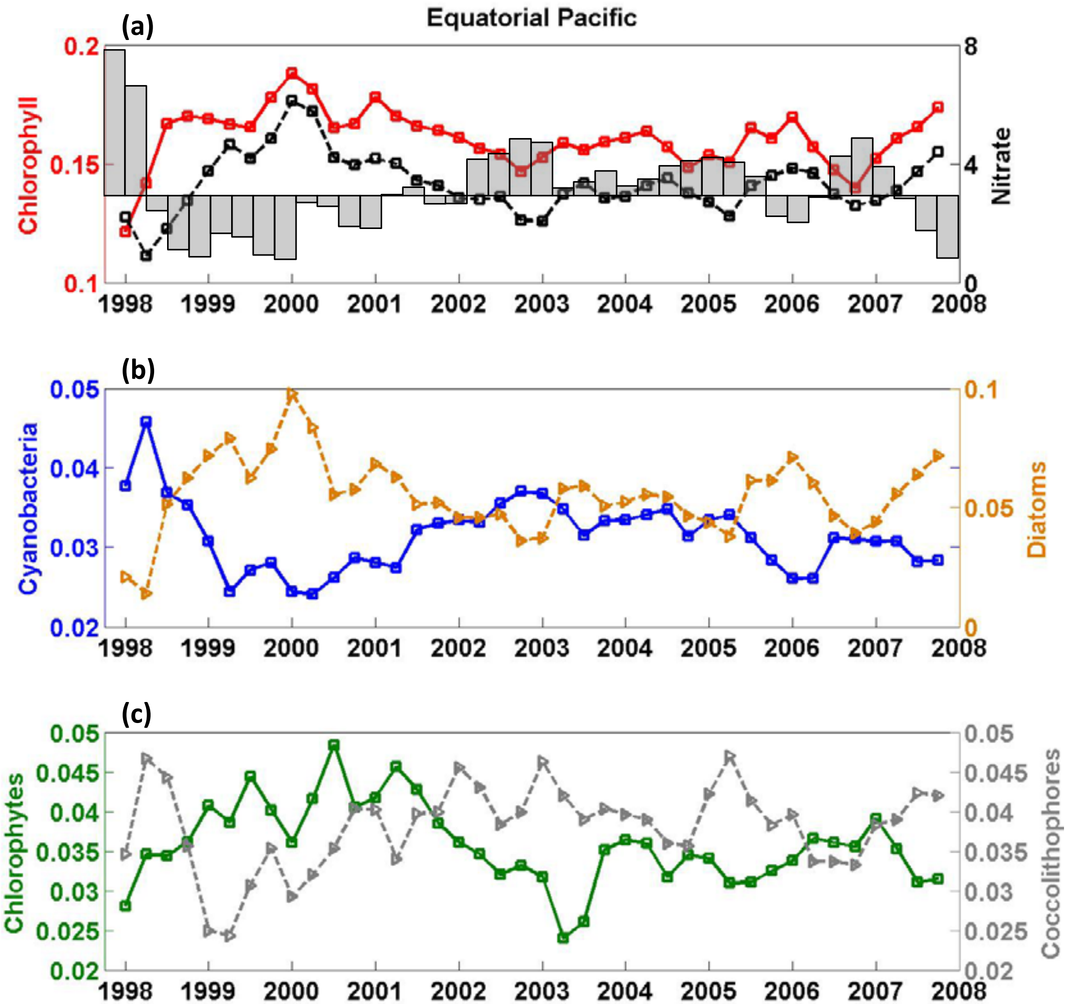
$x = \log_{10}$(Chl-*a*); y = Chl-*a*

Hirata *et al.* 2011

NASA Ocean Biogeochemical Model (NOBM)



An example of the similarities and difference you get using a model versus satellite-based approach in the Equatorial Pacific



Rousseaux & Gregg 2012

Equatorial Pacific

Model

	MEI	Diatoms	Chlorophytes	Cyanobacteria	Coccolithophores
MEI	1.00	-	-	-	-
Diatoms	**-0.87***	1.00	-	-	-
Chlorophytes	**-0.39***	0.29	1.00	-	-
Cyanobacteria	**0.69***	**-0.81***	**-0.46***	1.00	-
Coccolithophores	**0.33***	**-0.53***	**-0.42***	**0.57***	1.00

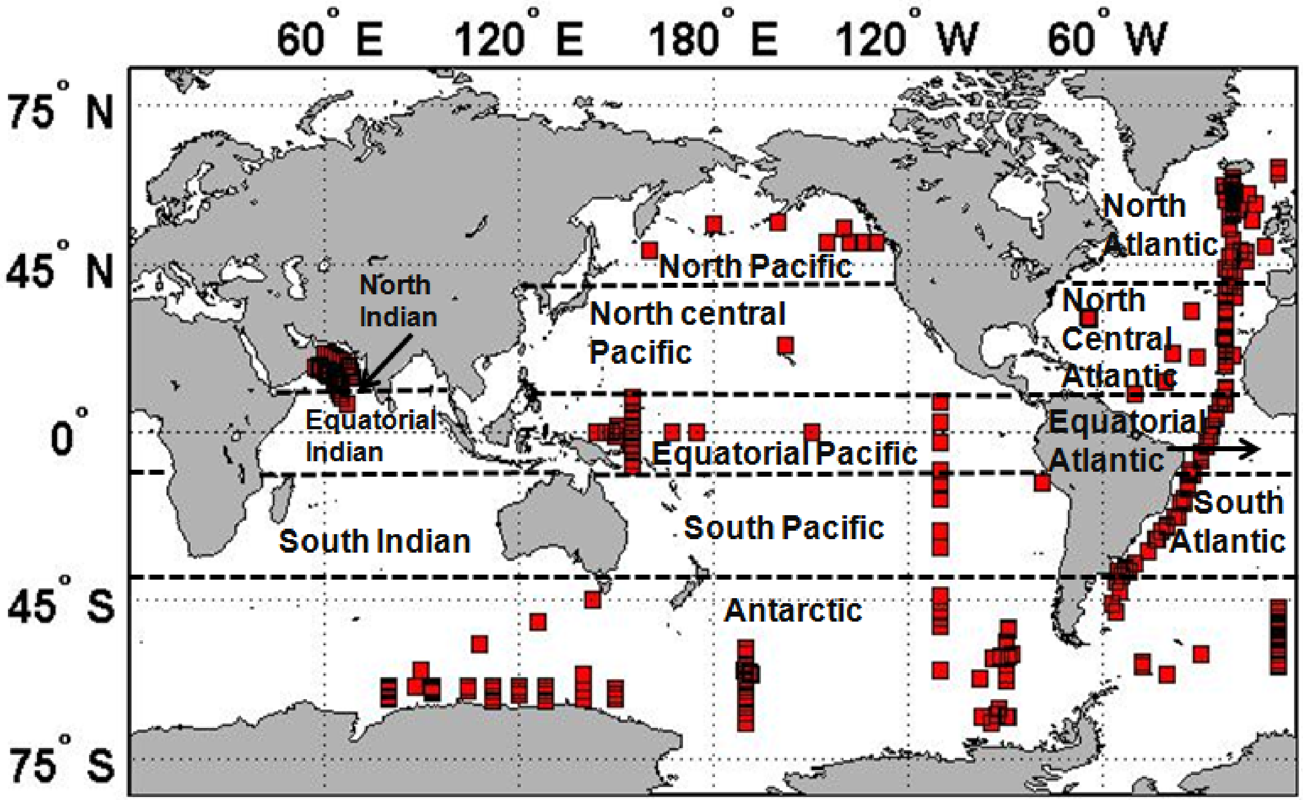
Satellite-derived

	MEI	Diatoms	Chlorophytes	Cyanobacteria	Coccolithophores
MEI	1.00	-	-	-	-
Diatom	**-0.66***	1.00	-	-	-
Chlorophytes	**-0.77***	**0.60***	1.00	-	-
Cyanobacteria	**-0.76***	**0.70***	**0.72***	1.00	-
Coccolithophores	**-0.88***	**0.71***	**0.84***	**0.86***	1.00

- Both approaches agreed that climate variability had most impact in the Equatorial Pacific and the least impact in the South Pacific.
- Despite the differences in the absolute concentration, the relative abundance from the model and the satellite-derived approach showed a similar shift in phytoplankton community in the Equatorial Pacific.

Similarities and differences you get using a model versus satellite-based approach at a global scale *(Rousseaux et al. 2013)*

Validation with in situ data



http://gmao.gsfc.nasa.gov/research/oceanbiology/data.php

Table 1: *Percent difference in relative abundance between the model (NOBM) or the satellite-derived approach and in situ data. Differences greater than 20% are in bold. The column denominated # represents the number of months when observations were present. The South Indian region is not included in this table since there was no in situ data available for comparison in this region.*

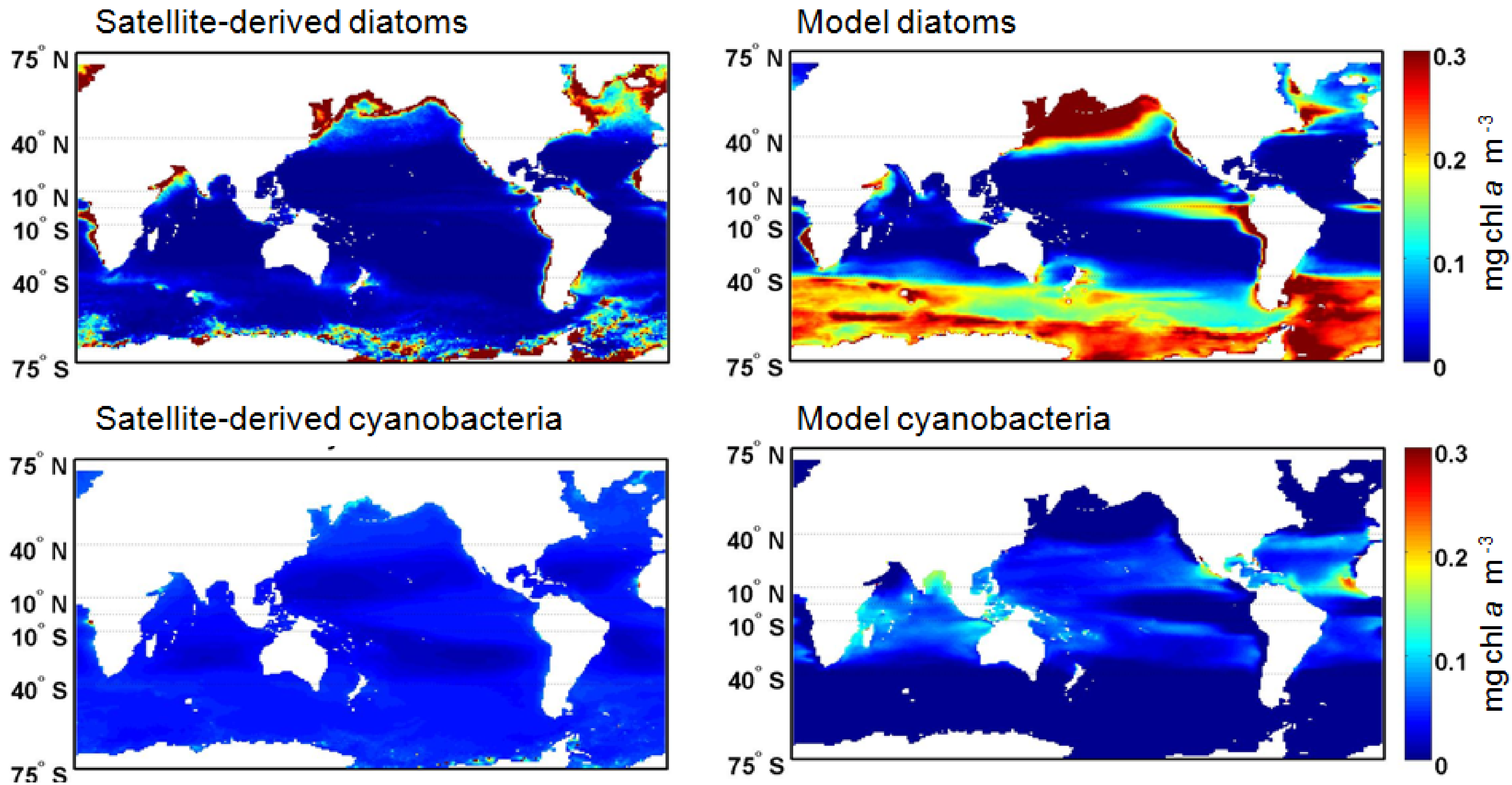
	Diatoms			Cyanobacteria			Coccolithophores			Chlorophytes		
	Satellite	NOBM	#	Satellite	NOBM	#	Satellite	NOBM	#	Satellite	NOBM	#
Global	-2.1	15.0	64	-12.1	-6.5	69	11.1	2.2	39	**-21.5**	-10.3	34
r	0.44	0.77		0.75	0.81		-0.16	0.35		0.45	-4.71×10^{-2}	
p	< 0.001	< 0.001		< 0.001	< 0.001		NS	< 0.05		< 0.01	NS	

Rousseaux et al. 2013

- Global mean differences of all groups were within ~15% of an independent observation data base for both approaches except for satellite-derived chlorophytes.
- Diatoms and cyanobacteria concentrations were significantly ($p < 0.05$) correlated with the independent observation data base for both methods.
- Coccolithophore concentrations were only correlated with the in situ data for the model approach and the chlorophyte concentration was only significantly correlated to the in situ data for the satellite-derived approach.

Diatoms

	NAtl	NPac	NCAtl	NCPac	NInd	EAtl	EPac	EInd	SAtl	SPac	Ant
Satellite	3.2	-7.7	-0.4	-2.9	8.3	-0.9	-7.8	0.2	9.8	1.6	**-26.2**
NOBM	-5.3	**59.7**	-2.6	-3.4	20	-2	1.6	-3.8	13.4	**25.5**	**61.6**
# months	5	12	12	3	5	3	6	2	3	3	*10*

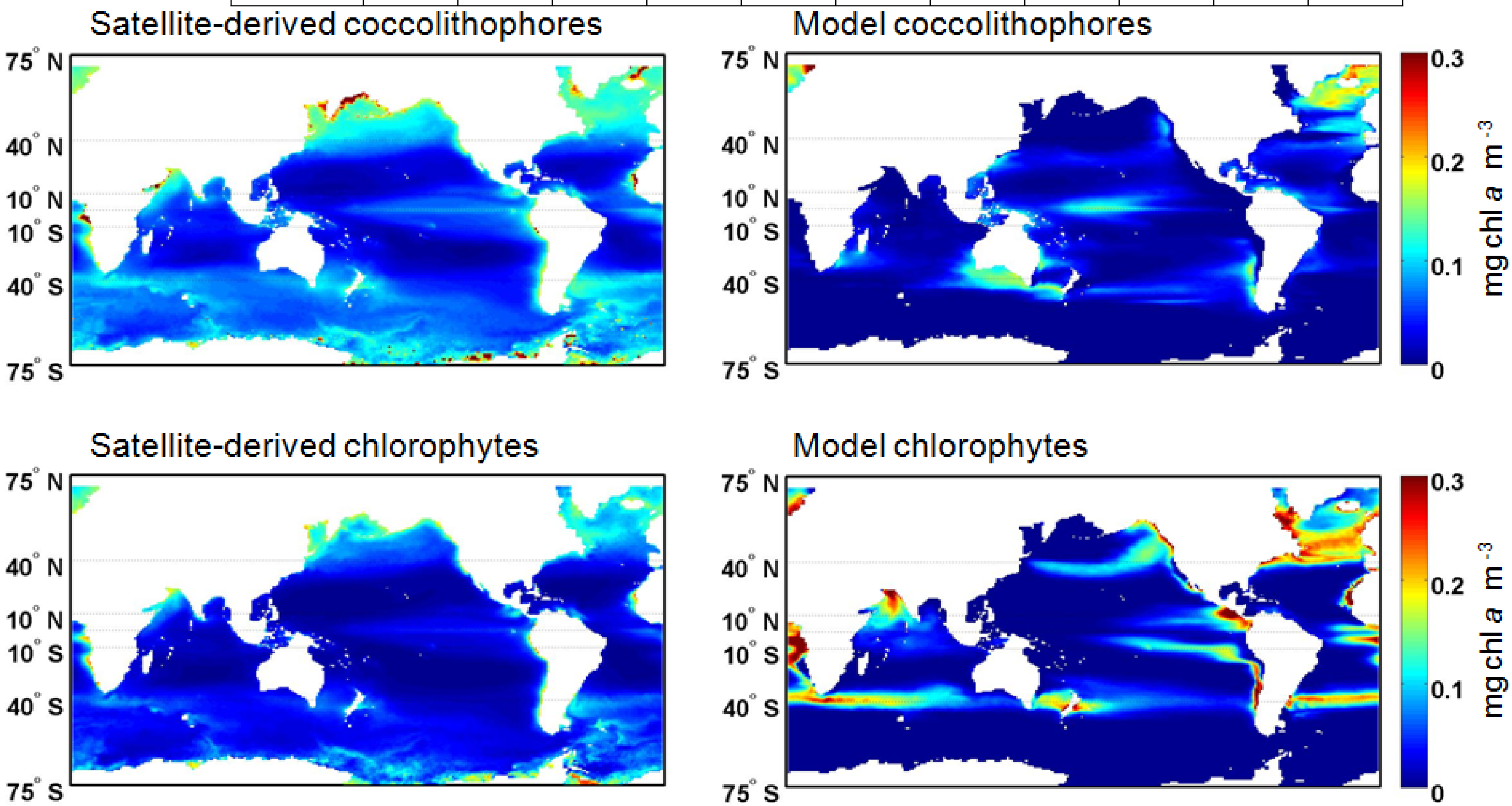


	NAtl	NPac	NCAtl	NCPac	NInd	EAtl	EPac	EInd	SAtl	SPac	Ant
Satellite	0.6	8.1	-12	**-25.4**	**-22.8**	**-31.5**	-13.8	**-30.9**	-14.1	-5.4	13.4
NOBM	-7.5	-1	19.1	9.4	**-29.7**	0.6	-8.6	**-52.7**	0	1.7	-2.3
# months	5	12	12	11	5	3	5	2	3	2	*9*

Cyano

Cocco

	NAtl	NPac	NCAtl	NCPac	NInd	EAtl	EPac	EInd	SAtl	SPac	Ant
Satellite	-13.3	13.5	17	9.5	17.1	0	18.5	**29**	-9.6	10.3	19.3
NOBM	17.2	-16.3	12.9	4.3	-5.2	0	**31.2**	-7	-13.7	-0.7	-0.7
#months	2	3	12	3	2	0	5	2	1	3	*6*



Chloro

	NAtl	NPac	NCAtl	NCPac	NInd	EAtl	EPac	EInd	SAtl	SPac	Ant
Satellite	**-23.1**	**-56.8**	-8.6	-11.9	-8.4	0	-8.7	-5.4	**-34.3**	**-30.8**	**-27.5**
NOBM	-4.8	**-72.6**	-16.2	-19.4	**23.3**	0	-18.1	**76.4**	5.8	**-35.8**	**-41.5**
# months	2	1	12	2	2	0	5	2	1	3	*4*

Conclusions

- Overall good agreement of spatial and seasonal distribution
- Doing best for the functional extreme
- Some regions such as North Pacific and Antarctic can be improved
- Model has issues because of lack of knowledge/data on certain groups leads to issues for parameterization
- Satellite on the other hand is less sensitive to phytoplankton composition shifts
- Further improvements of the model could be achieved by assimilating satellite-derived phytoplankton groups in the model
- Future satellite ocean color missions may improve satellite-derived estimate by increasing the number of wavelength available

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