Intercomparison of PFT Algorithm and Earth System Model Phenology

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Participating Algorithms

Satellite Algorithms (Optics-based approach)

Bracher et al, BG, 2009 (PhytoDOAS) (SCIAMACHY!)	Bricaud et al., GBC, 2012 (CB06)	Fujiwara et al., BG, 2011 (FUJI11)	Kostadinov et al., JGR, 2010 (KSM09)	Roy et al., RSE, 2013 (ROY13)
Diatom Chl	**Large**, Small	**Micro**, Nano,Pico	**Micro**, Nano,Pico	**Micro**, Nano,Pico

- PHYSAT (Alvain et al. 2005,2008) → **Frequency of diatom detection**
- Mouw and Yoder (2010) (MY10) → S_{fm} (fraction of large)

Satellite Algorithms (Abundance-based approach)

Brewin et al. EM, 2010 (BR10)	Hirata et al., BG, 2011 (OC-PFT)	Uitz et al., JGR, 2006 (UITZ06)
Micro, Nano, Pico	**Micro**, Nano, Pico, Diatom, Prymnesiophyte, Picoeukaryote, Cyanobacteria, Prochlorococcus	**Micro**, Nano,Pico

- SeaWiFS OC4v6 **Chl**
- SeaWiFS **PAR**

Slide courtesy of Taka Hirata with modifications by T.S.K.

Participating CMIP5 Models

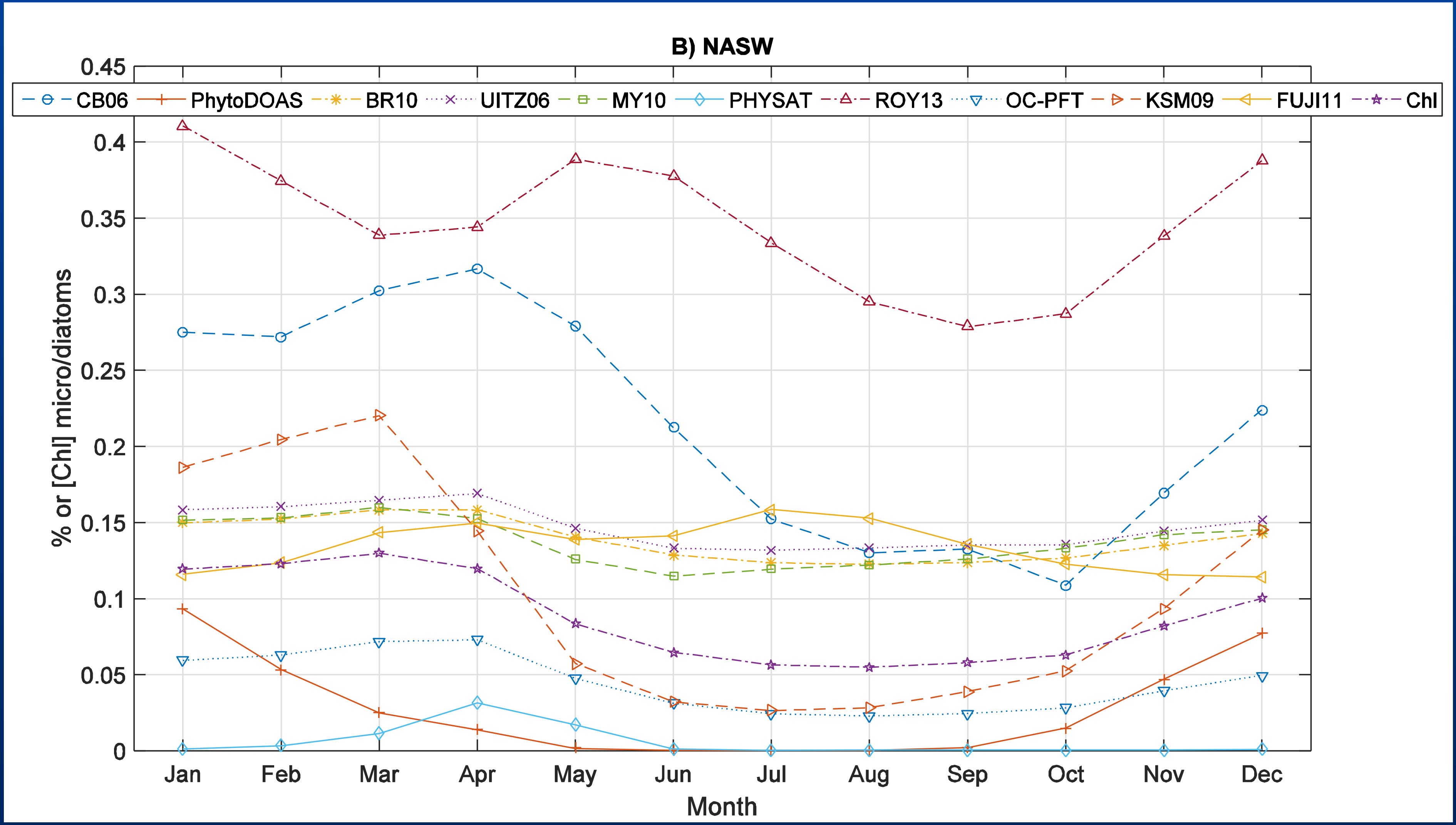
Model	Nutrients	Ecology module	Phytoplankton variables	References
CESM1-BGC	P, N,Fe,Si	MET	diatom, nanophyto, diazotroph	Moore et al. (2004), Moore et al. (2006)
GFDL-ESM2G	P,N,Fe,Si	TOPAZ2	large separated into diatoms and non-diatom, small cyanobacteria, diazotroph	Dunne et al. (2013)
GFDL-ESM2M	P,N,Fe,Si	TOPAZ2	large separated into diatoms and non-diatom, small cyanobacteria, diazotroph	Dunne et al. (2013)
HadGEM2-ES	N,Fe,Si	Diat-HadOCC (NPZD)	diatom, non-diatom	Palmer and Totterdell (2001)
IPSL-CM5A-MR	P,N,Fe,Si	PISCES (from HAMOCC5)	Diatoms, nanophyto	Aumont and Bopp (2006), Séférian et al. (2013)
GISS-E2-H-CC	N, Fe, Si	NOBM	Diatoms, chlorophytes, cyanobacteria, coccolitophores	Gregg (2008)
GISS-E2-R-CC	N, Fe, Si	NOBM	Diatoms, chlorophytes, cyanobacteria, coccolitophores	Gregg (2008)

Variable used: C biomass due to diatoms

Monthly data for 2003 – 2007 were used for both satellite data and climate models

Kostadinov et al. (in prep.)

Variables on Different Scales



Kostadinov et al. (in prep.)

Motivation for Phenology Intercomparison

- PFT algorithms retrieve variables that:
  - can be defined differently and have various units
  - even with the same units can be on different scales due to different algorithm assumptions and methodologies
- Small phase changes can make comparisons at a given moment in time meaningless (e.g. Platt et al., 2009)
- Comparing emergent properties of the ecosystem such as phenology is more meaningful

Phenology via DFT

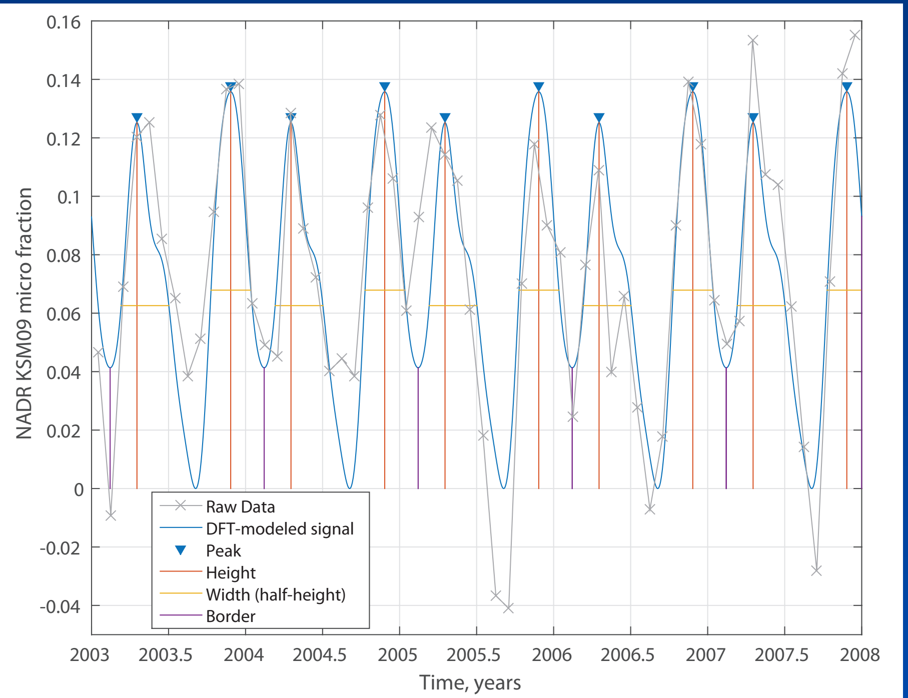
- Step 1: Obtain Fourier coefficients

$$\{a_n + b_n \mathrm{i}\}_k = \sum_{n=0}^{N-1} x_n e^{\frac{-2\pi i * k * n}{N}}$$

- Step 2: Use amplitudes of $f = 1\ \mathrm{yr}^{-1}$ and its harmonics to model seasonal cycle

$$\hat{\mathbf{x}} = a_o + a_n \cos(2\pi f t) - b_n \sin(2\pi f t); f = [1;6], f \in \mathrm{Z}$$

- Step 3: Peak analysis



Isolate most prominent peaks & derive:

- Seasonal amplitude
- % seasonal variance
- Month of maximum
- Duration
- Secondary peak analysis

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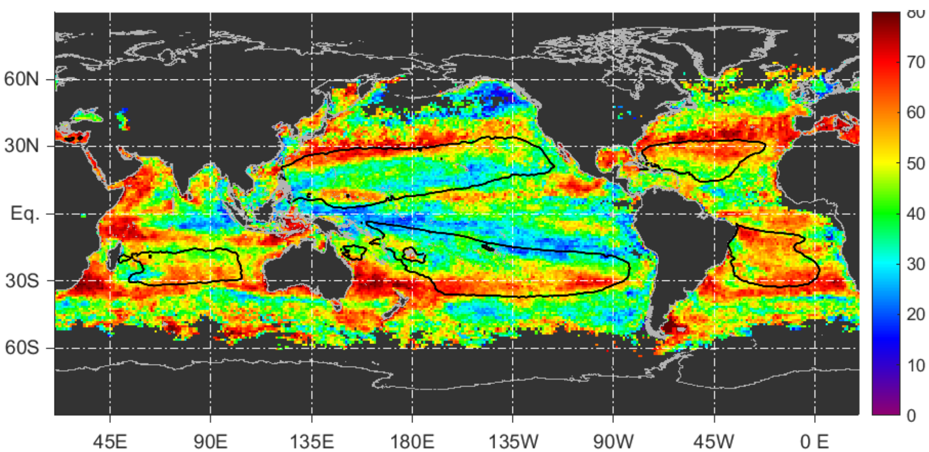
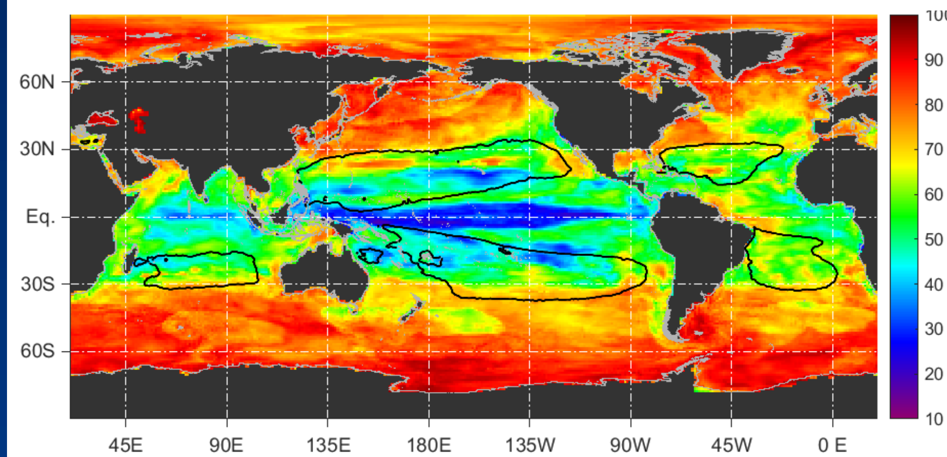
Percent Seasonal Variance Ensembles

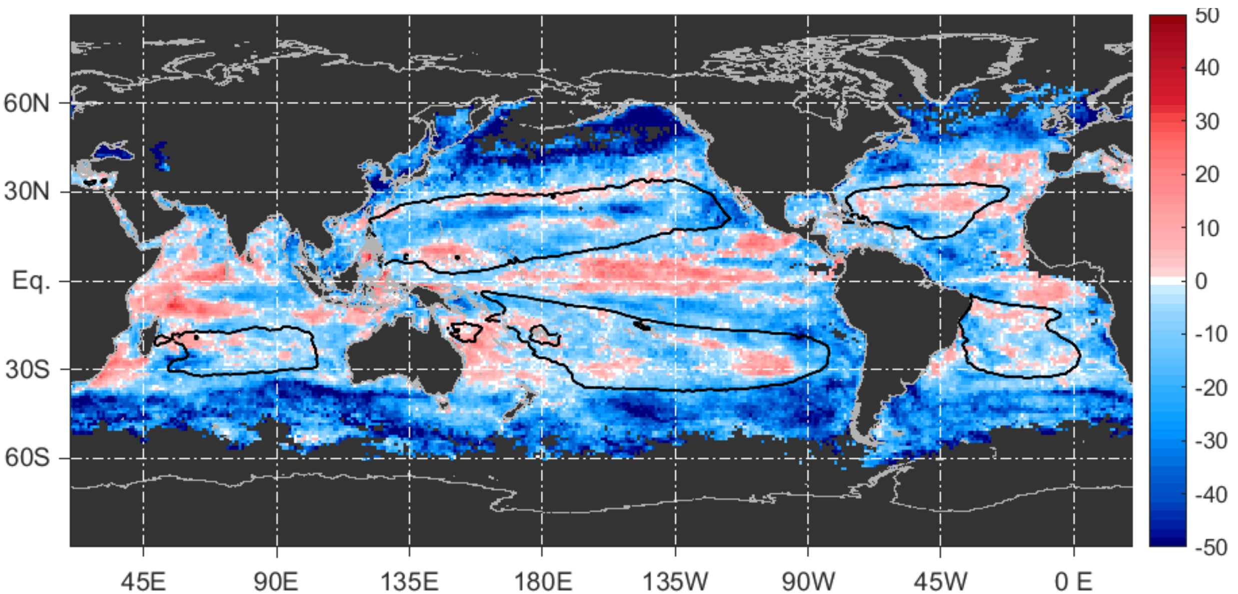
10 PFT Algorithms



7 CMIP5 Models



Data – Models, RED = Data Has Larger % Variance



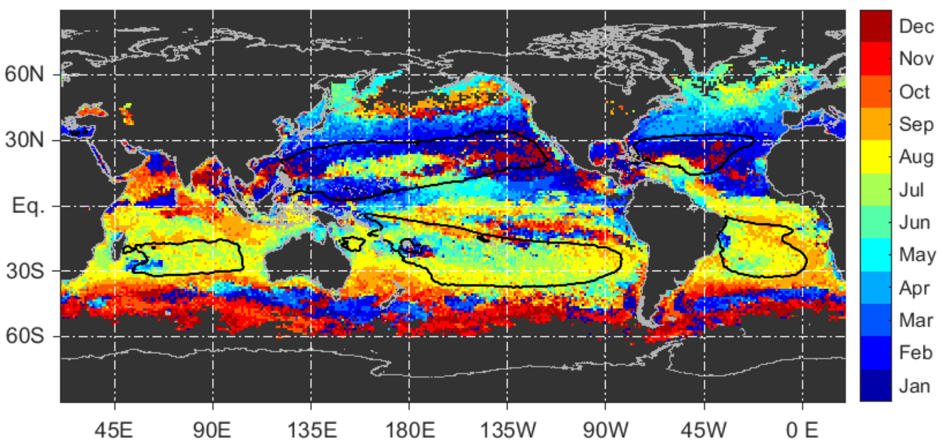
Models exhibit "cleaner" seasonal cycles in most places, especially high latitudes.

Data map generally agrees w/ *Sapiano et al. (2012)*

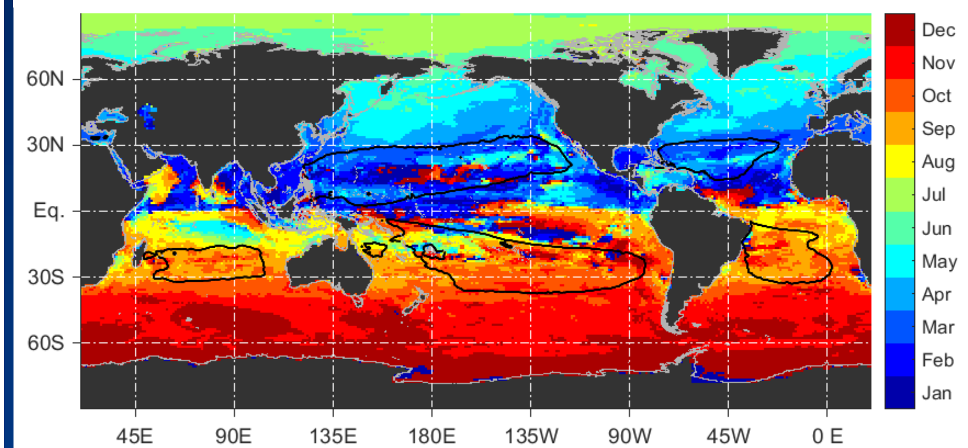
Kostadinov et al. (in prep.)

Month of Maximum Ensemble Means

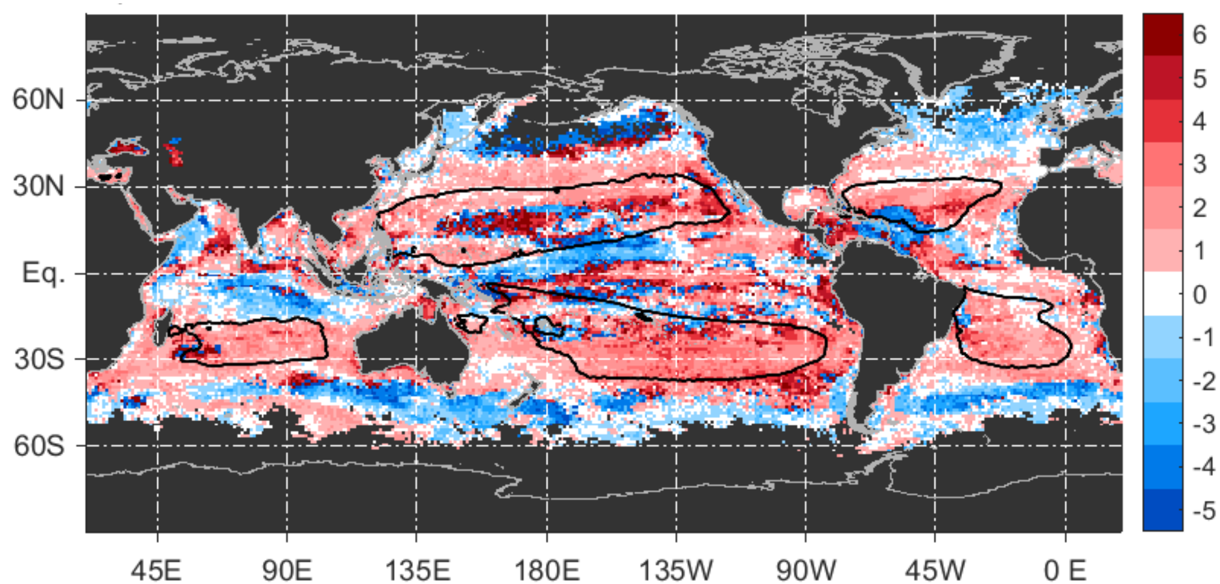
10 PFT Algorithms



7 CMIP5 Models



Data – Models, RED = Data leads



Data generally peaks 1-2 months before models

Banded structures in Southern Ocean

Only meaningful if percent seasonal variance is high!!!

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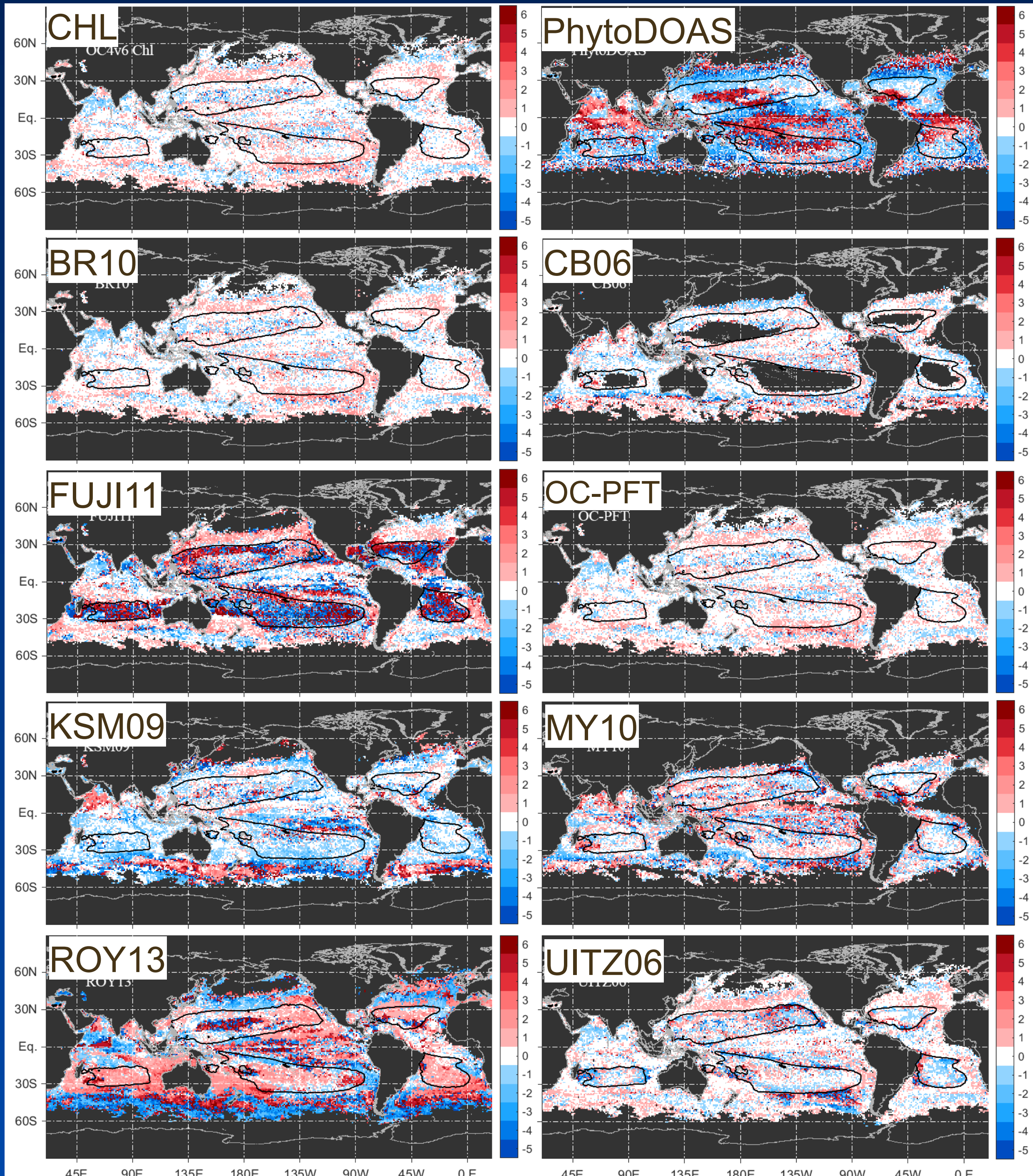
Month of Maximum Differences



RED = Ensemble leads

Abundance-based approaches & those parameterized with Chl (BR10, OC-PFT, UITZ06,) are most similar to it & drive the mean.

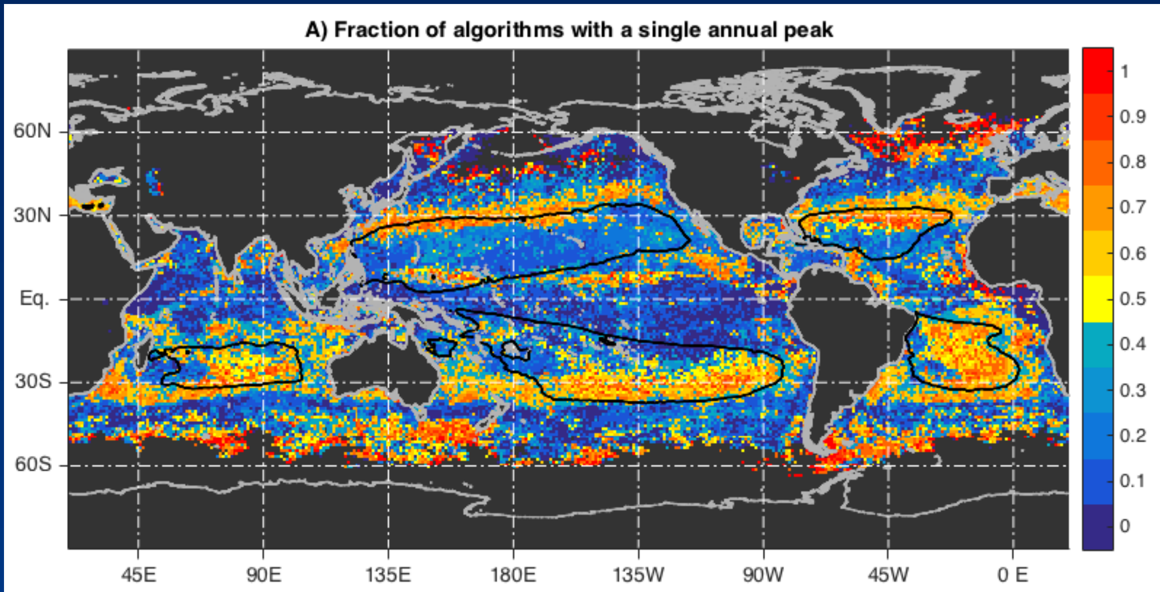
PhytoDOAS, ROY13 & FUJI11 are most different

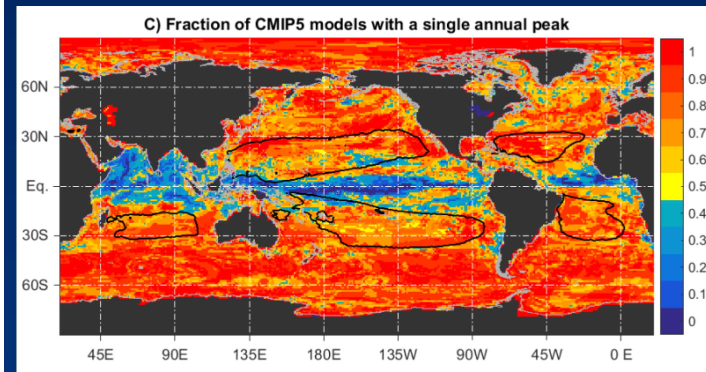
ROY13 & KSM09 are very different in Southern Ocean

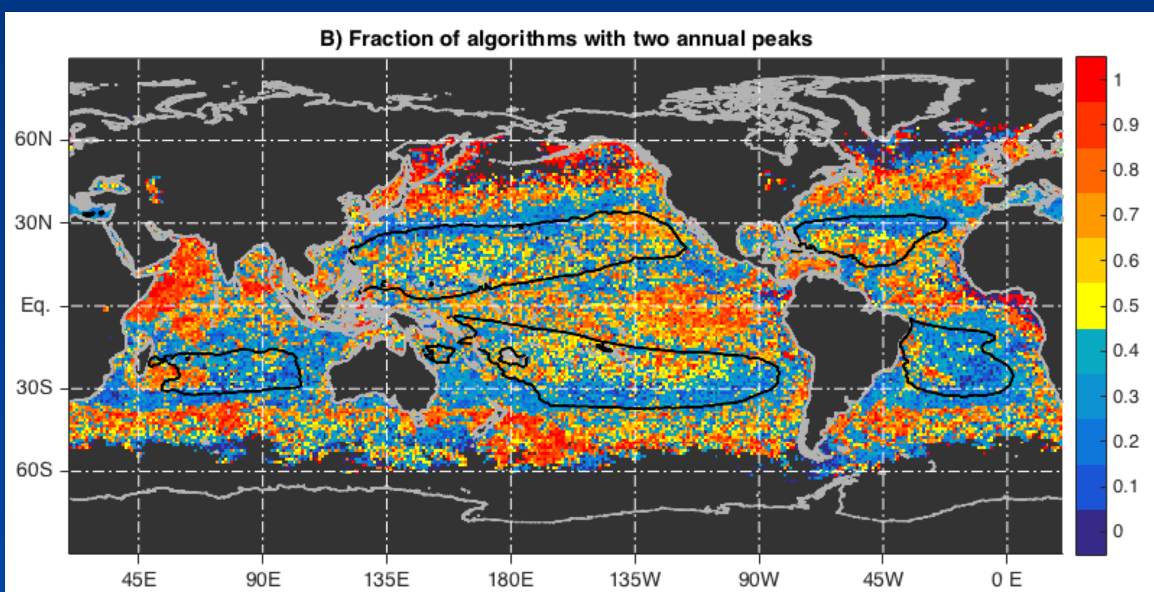
Only meaningful if percent seasonal variance is high!!!

Kostadinov et al. (in prep.)

Secondary Blooms







Three distinct bands:

1) Single peak at subtropics near ~30^{o} N/S
2) Double peak (fall bloom) in temperate zones ~45 o N/S
3) Single peak at subpolar locations

Consistent with *Platt et al. (2009)* model

Kostadinov et al. (in prep.)

Thank You!
Questions?