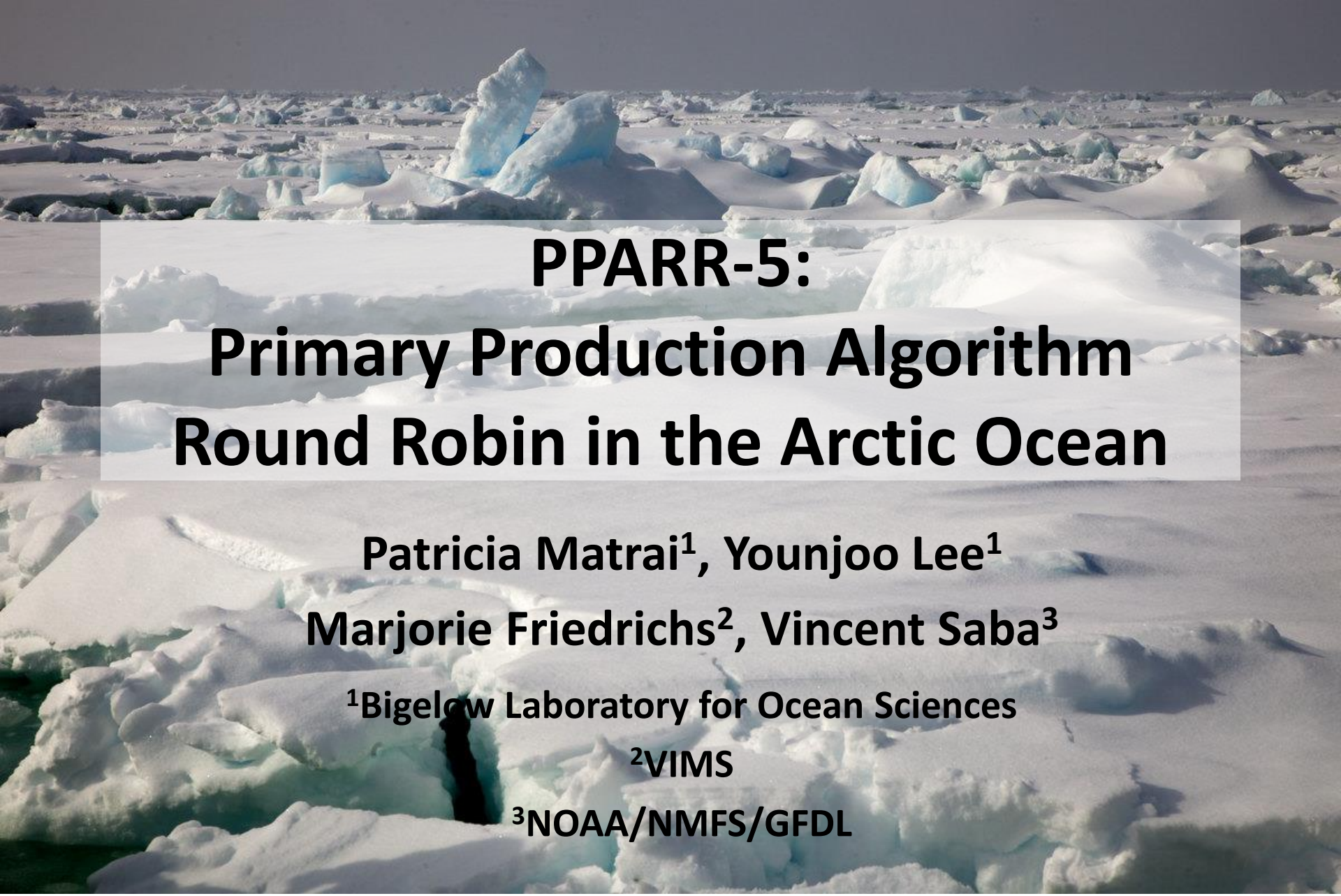


# PPARR-5: Primary Production Algorithm Round Robin in the Arctic Ocean


**Patricia Matrai[1], Younjoo Lee[1]**

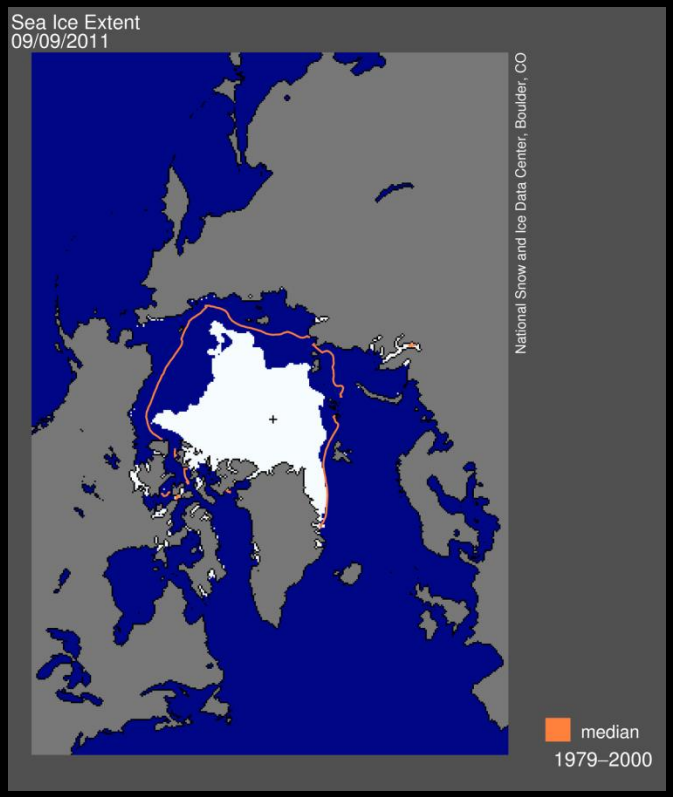
**Marjorie Friedrichs[2], Vincent Saba[3]**

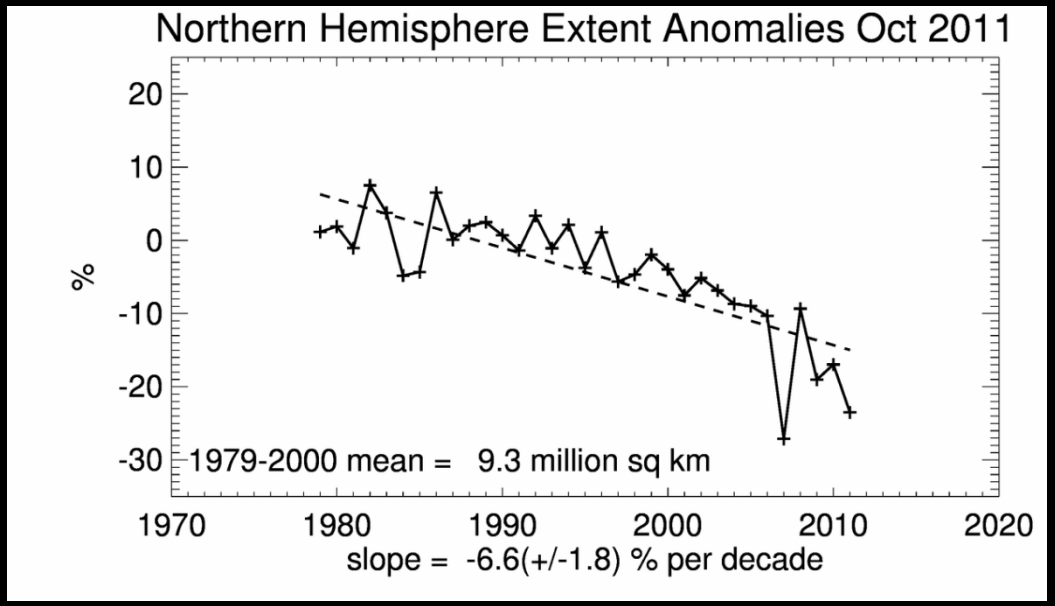
**[1]Bigelow Laboratory for Ocean Sciences**

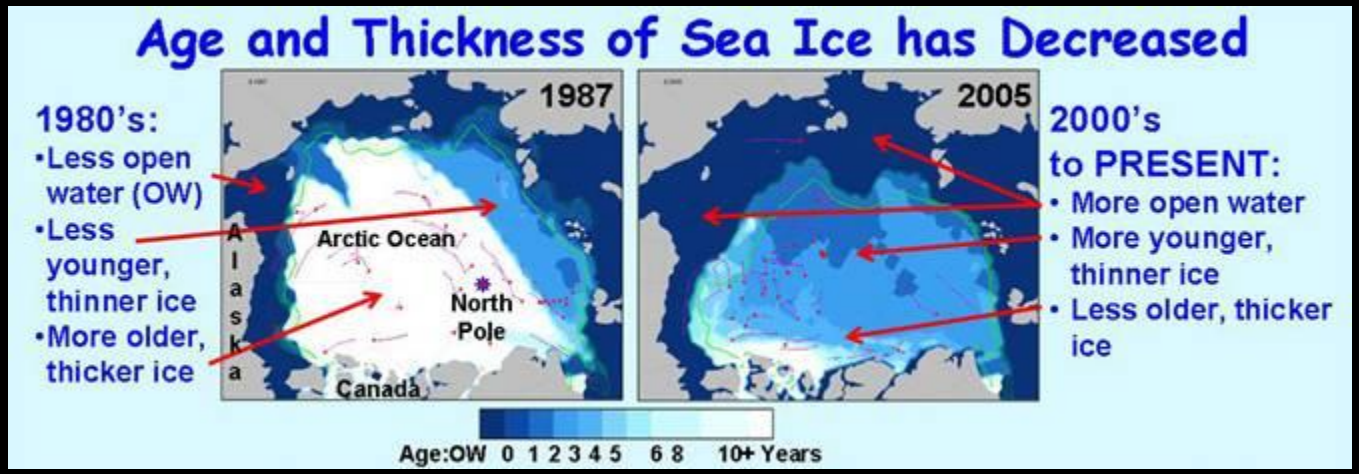
**[2]VIMS**

**[3]NOAA/NMFS/GFDL**

# Arctic sea ice loss

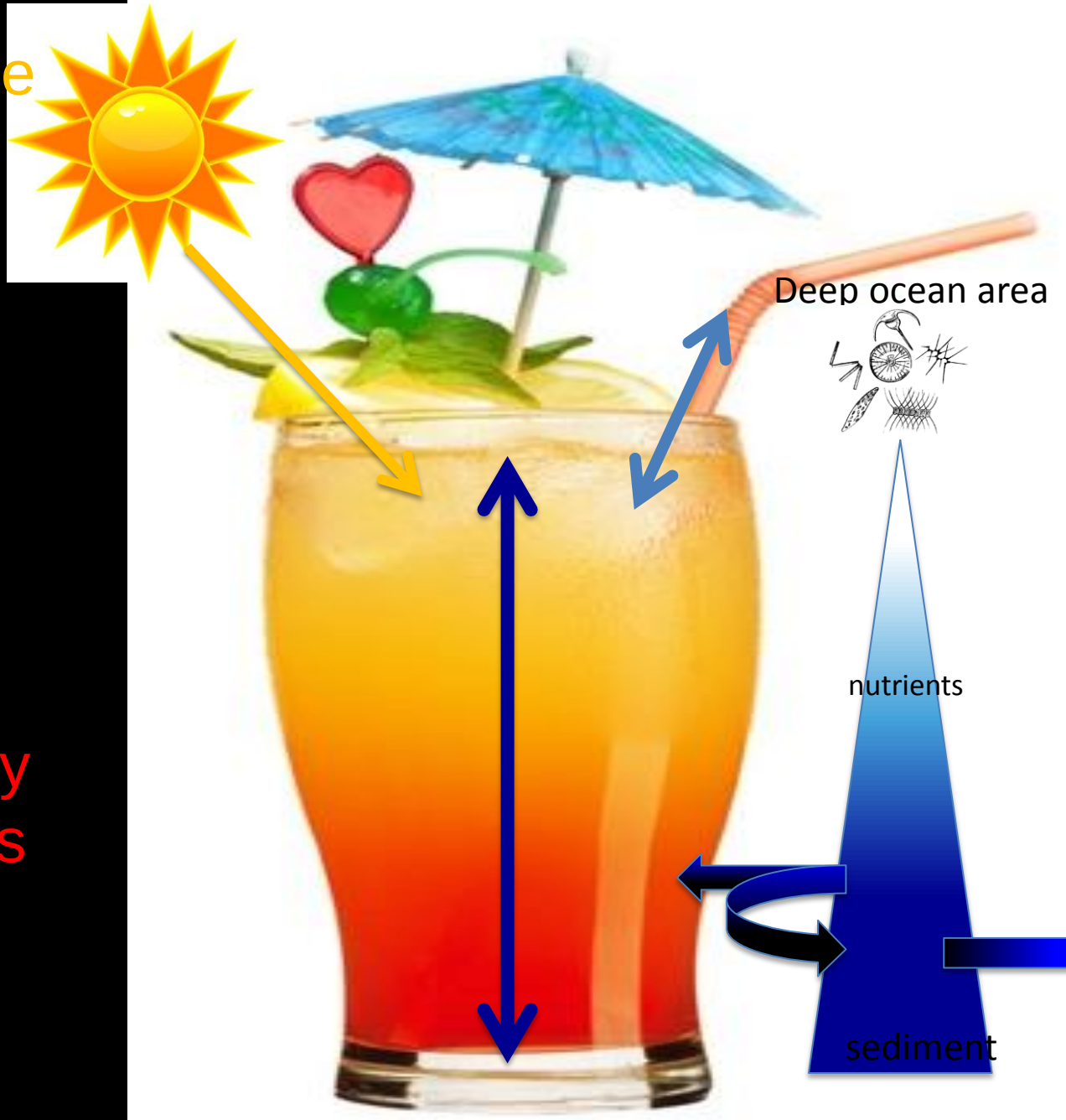


Ice melt and surface warming result in stratification that prevents vertical mixing

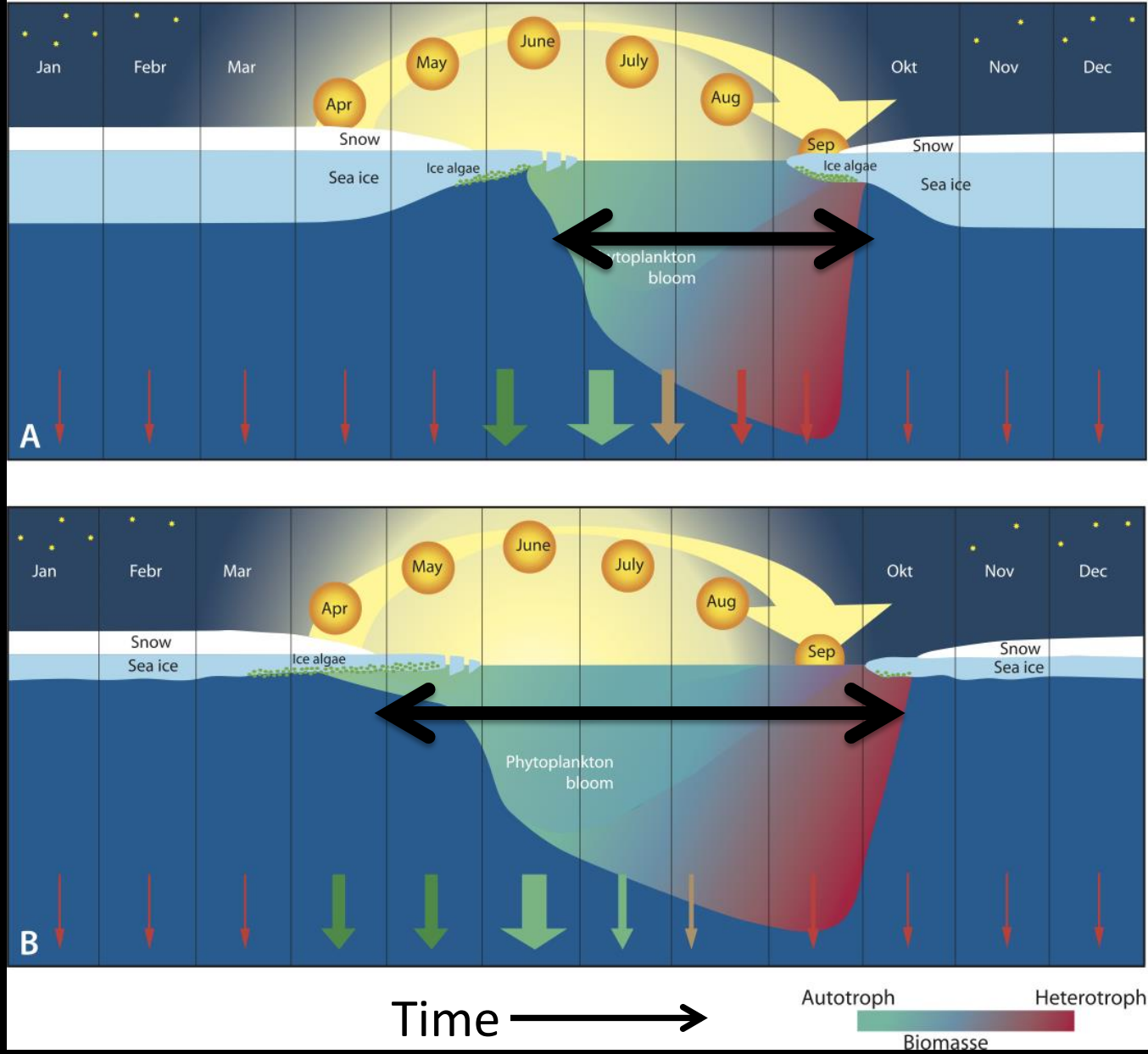
Low nutrient supply to surface and thus low harvestable productivity




*Courtesy P Wassmann*

Today's extreme seasonal variation disappears

Sub-ice blooms increase?



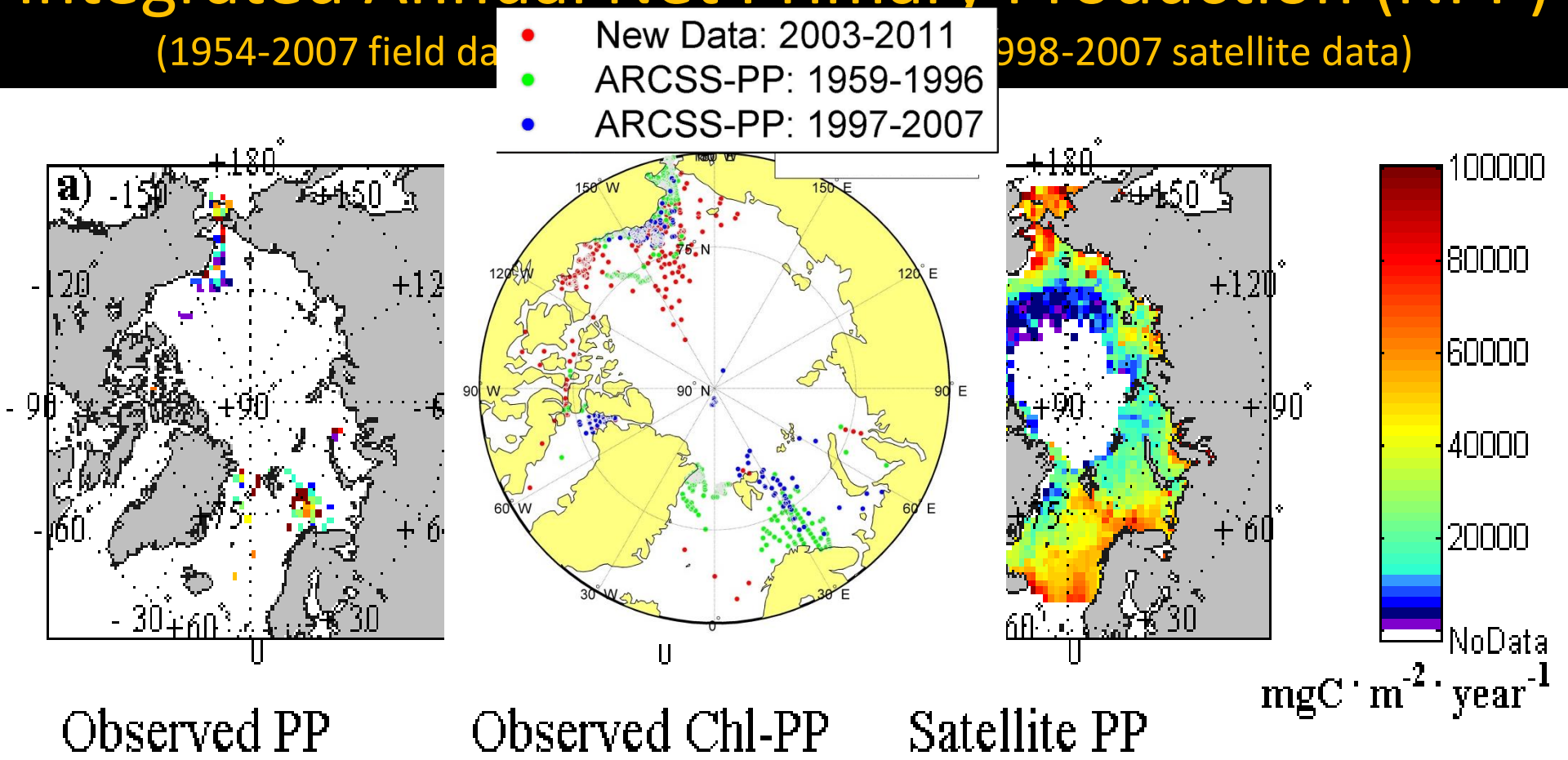



Wassmann 2011, and those before him

# Where is Arctic Primary Production now?

# Integrated Annual Net Primary Production (NPP)

(1954-2007 field da … 998-2007 satellite data)



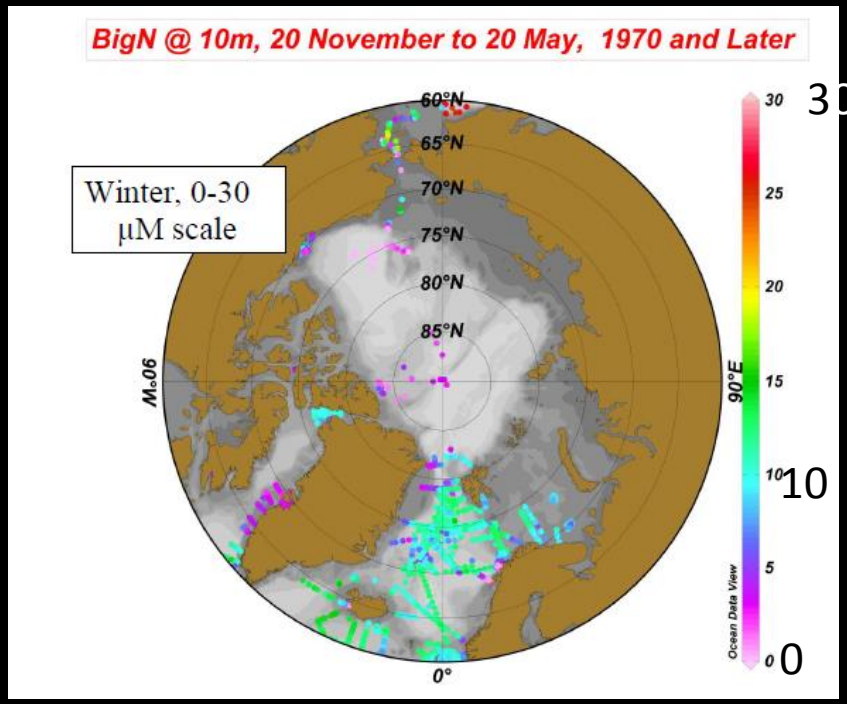

**Algorithm-estimated NPP based on:**

**Field Chl** **SeaWiFS Chl**

**0-100 gC m$^{-2}$ yr$^{-1}$**

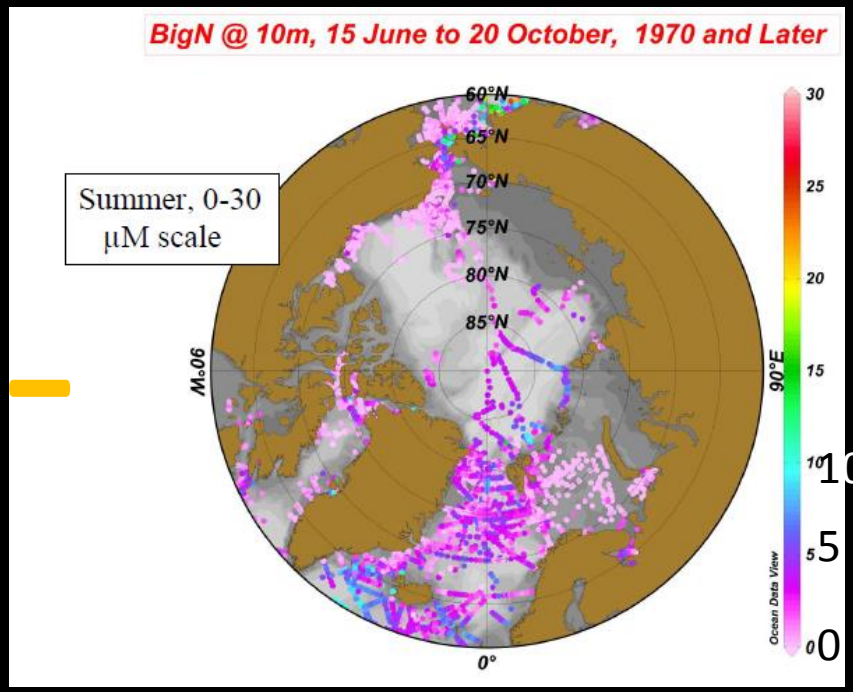
Hill, Matrai et al. 2013

# Net Community Production




30

−




10

=

10

5

0

NCP / *f* factor = NPP (or NP?)

(0-200) (0-40) gC $m^{-2}$ $yr^{-1}$

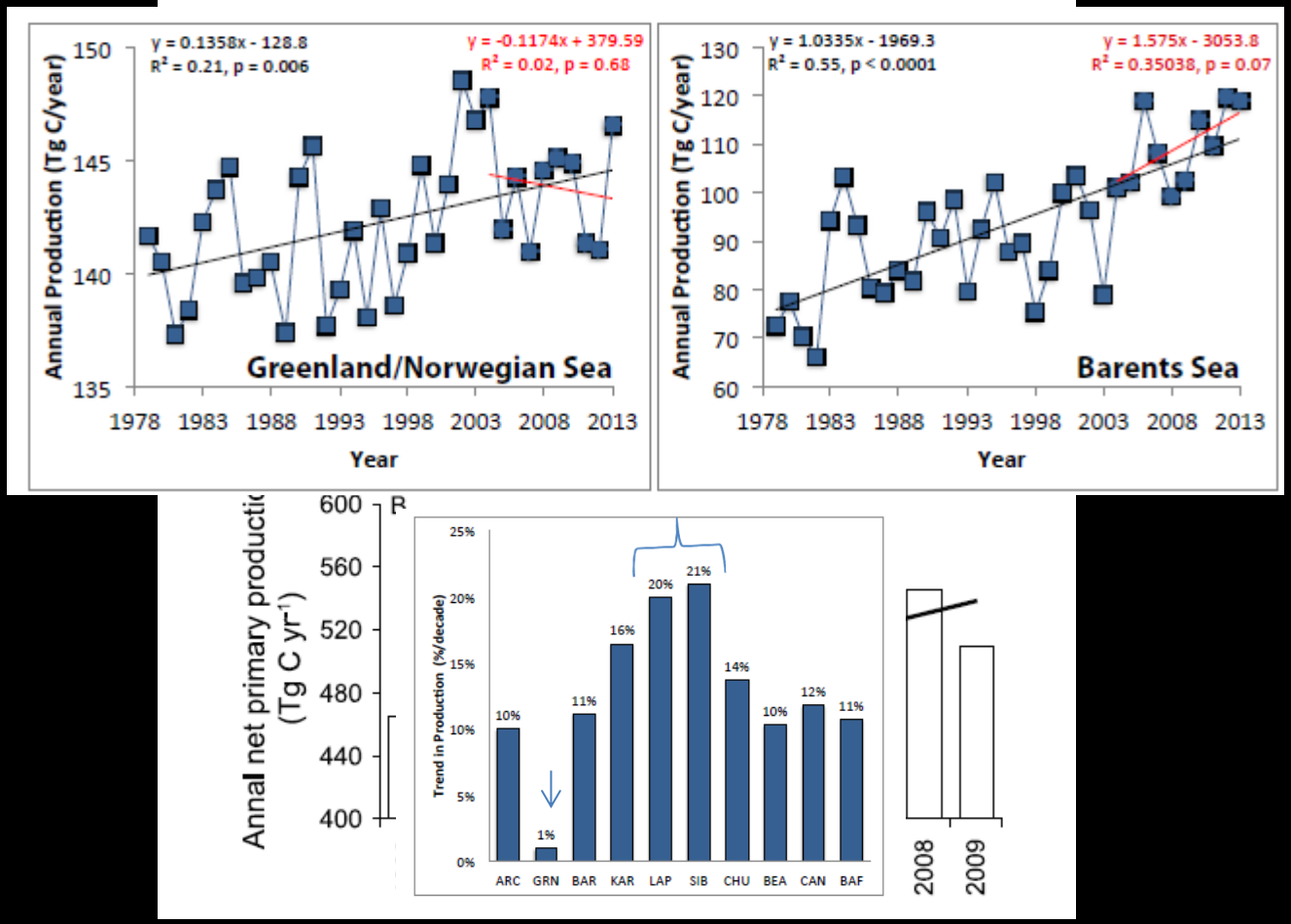


Codispoti , Matrai et al. 2013

# A biological model applied regionally… using satellite data

Variable regional decadal trends

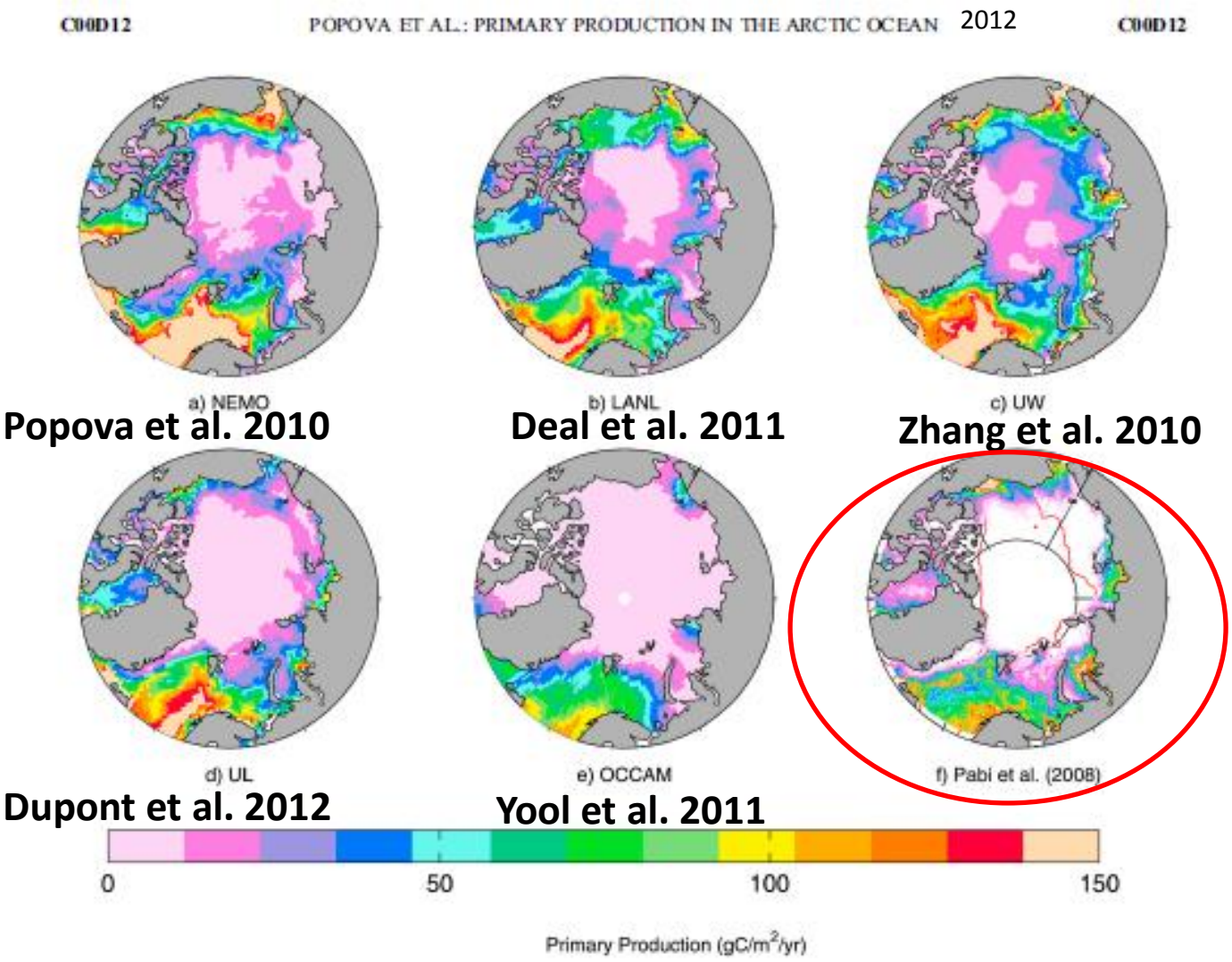
Pan-arctic decadal trend




Pabi et al. 2008; Arrigo & van Dijken 2011; Van Dijken & Arrigo 2014

# Pan-Arctic representation of the present

**Mean annual water column PP [gC $m^{-2}$ $y^{-1}$] by 5 models and a satellite-derived estimate**




Popova et al. 2010

Deal et al. 2011

Zhang et al. 2010

Dupont et al. 2012

Yool et al. 2011

field data?

**Figure 1.** Mean annual water column primary production (in g C $m^{-2}$ $yr^{-1}$) for (a) NEMO, (b) LANL, (c) UW, (d) UL, (e) OCCAM, and (f) satellite-derived estimates of *Pabi et al.* [2008].

# Simulated mixed layer depth examples

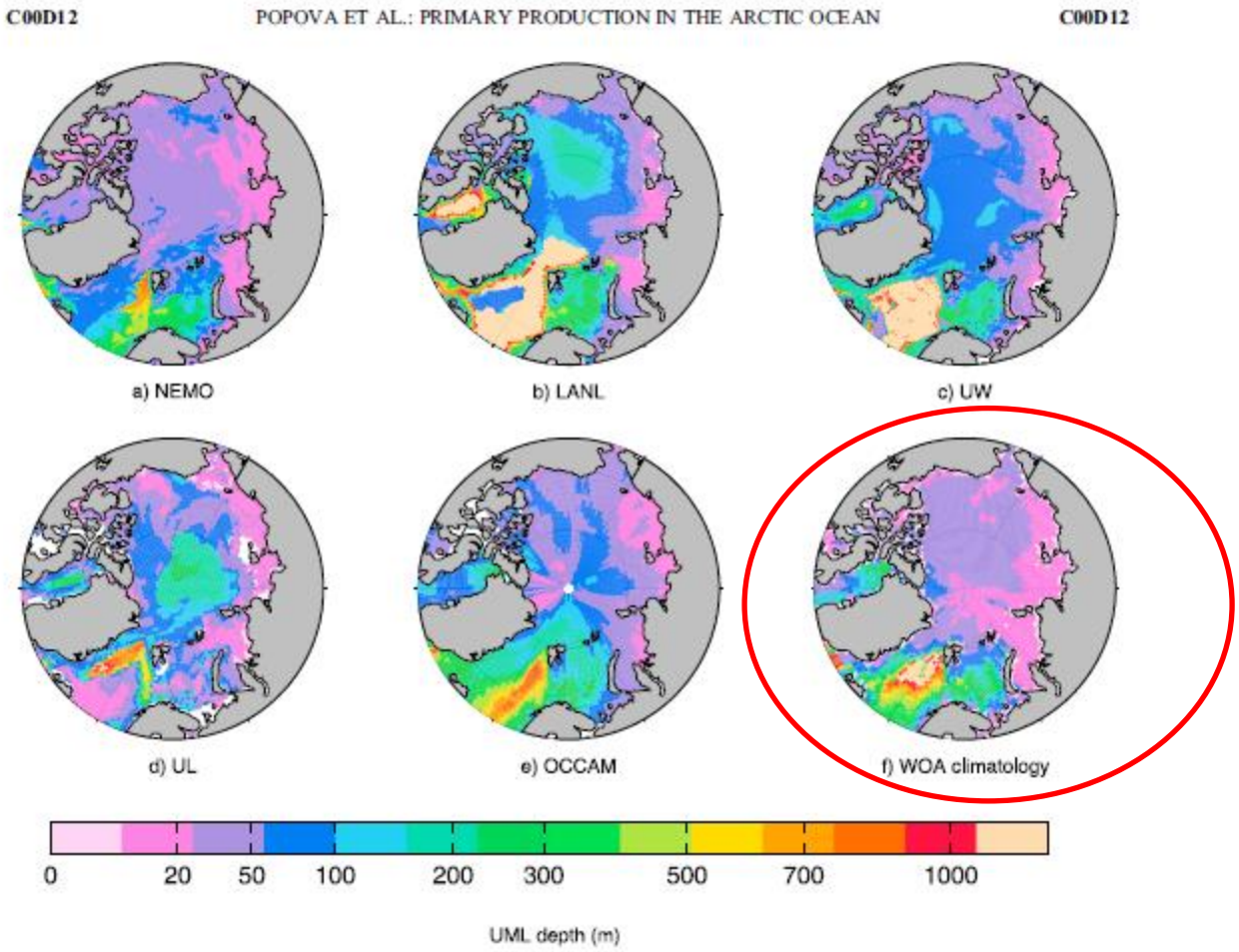
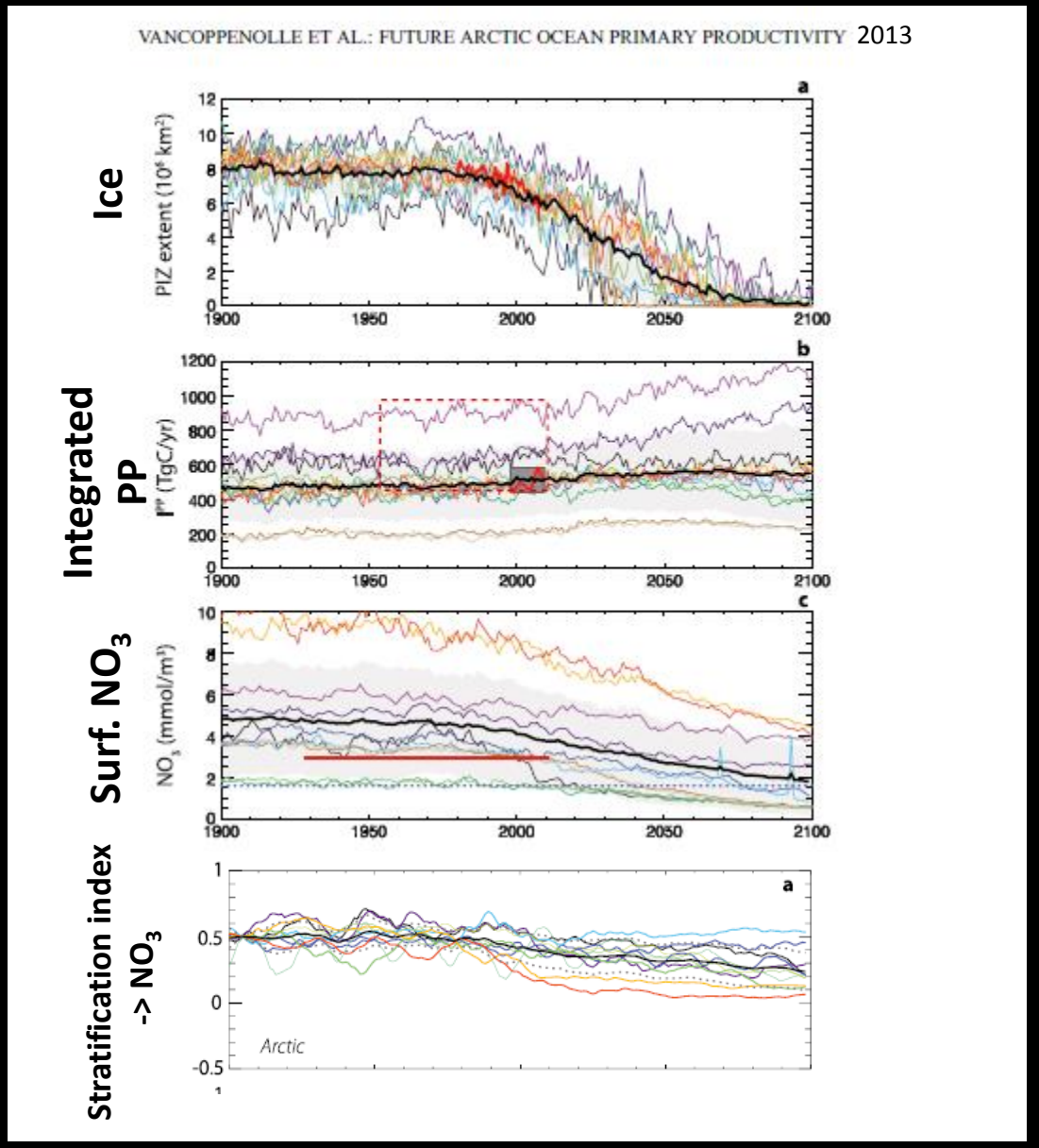



**Figure 4.** Maximum depth of UML during the year on the basis of monthly averaged values (m; note non-linear color scale) for (a) NEMO, (b) LANL, (c) UW, (d) UL, (e) OCCAM, and (f) WOA climatology.

**Same for DIN fields**

Popova et al. 2012

# ESMs in the Arctic: CMIP5 simulation for 2100



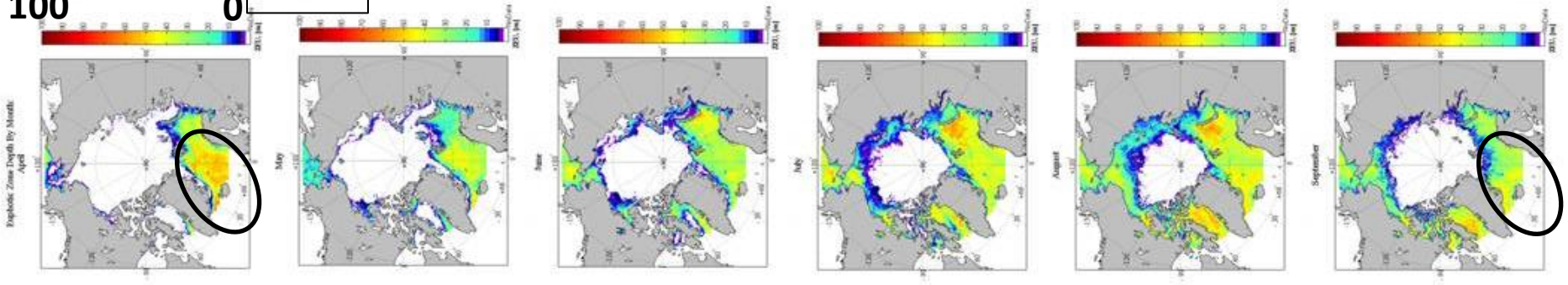
# How deep? Light vs. nutrient balance

## Seasonal distribution of euphotic zone and mixed layer depths from spring to fall in the Arctic Ocean

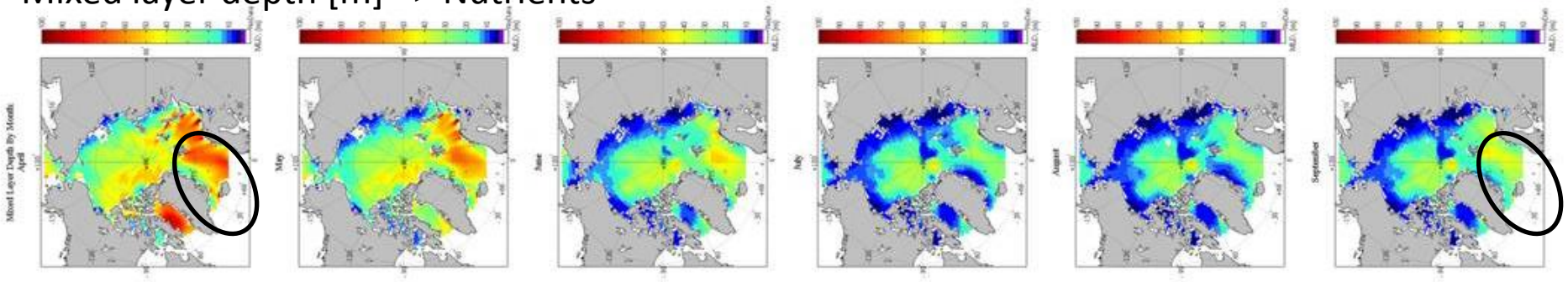
**Satellite-based and field data monthly averages (1998-2007)**

Euphotic zone depth [m] => Light

100 0 No data



Mixed layer depth [m] => Nutrients



April May June July August Septe mber

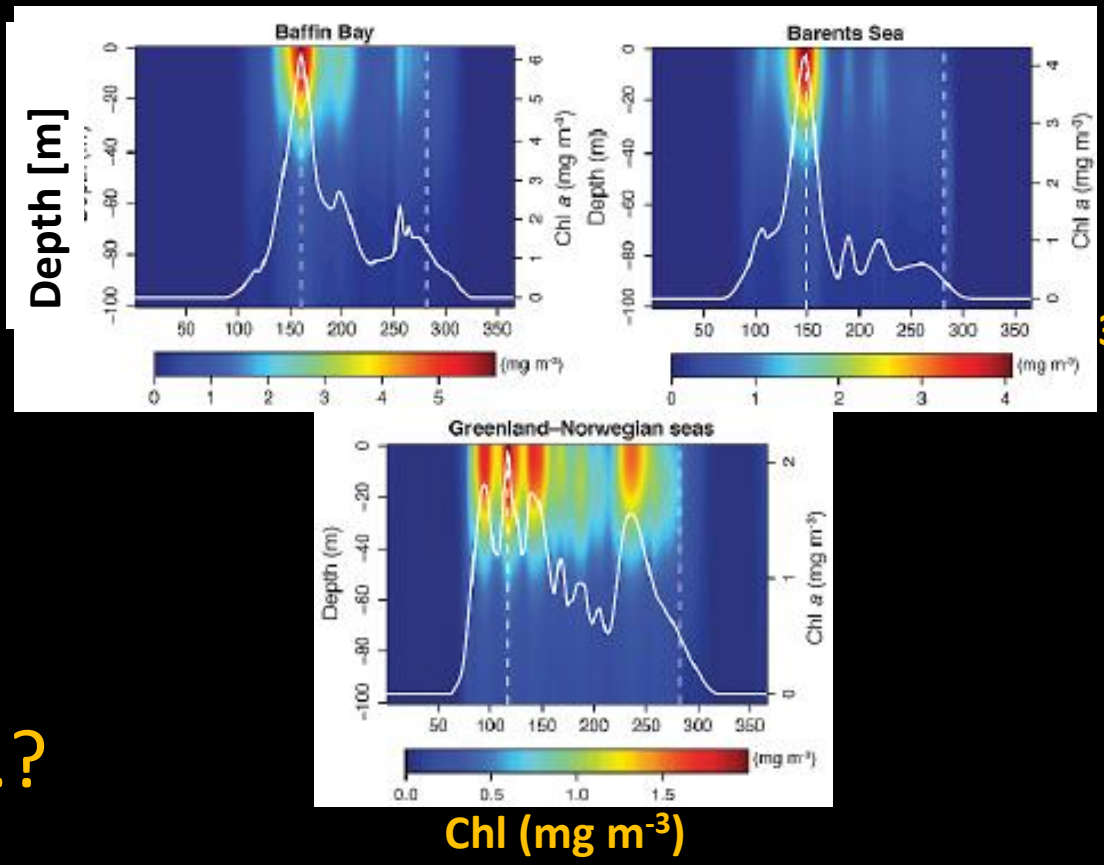


Hill, Matrai et al. 2013

# Simulated subsurface chlorophyll maximum (surf. Chl + Ardyna, Bélanger, Babin et al. 2013 model):

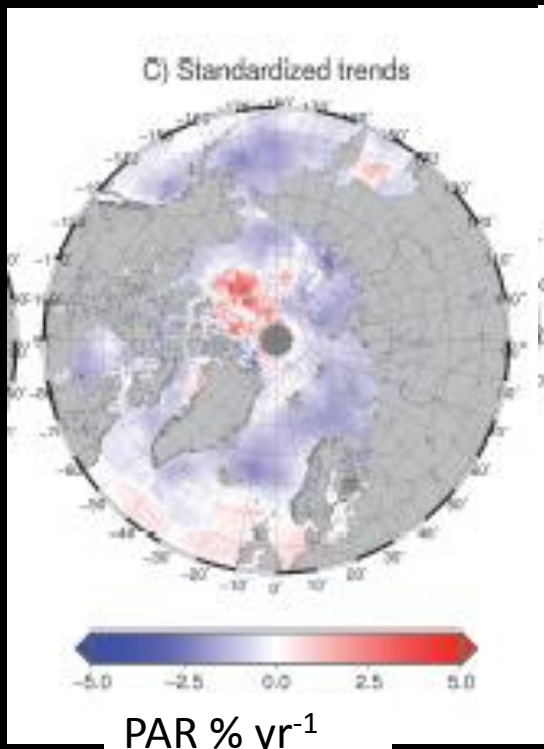
Where are the phytos and when?

Which spp.?



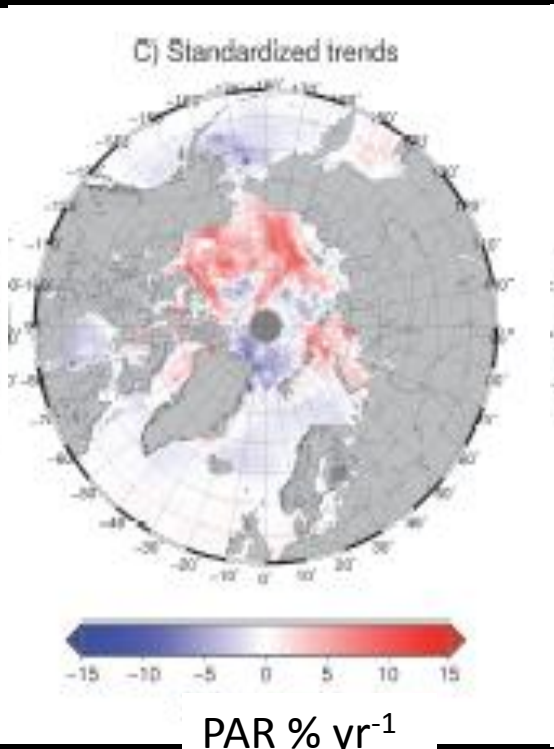

and also
Hill, Matrai et al. 2013
Arrigo, Matrai, van Dijken 2011

# Clouds and light (1998-2009)



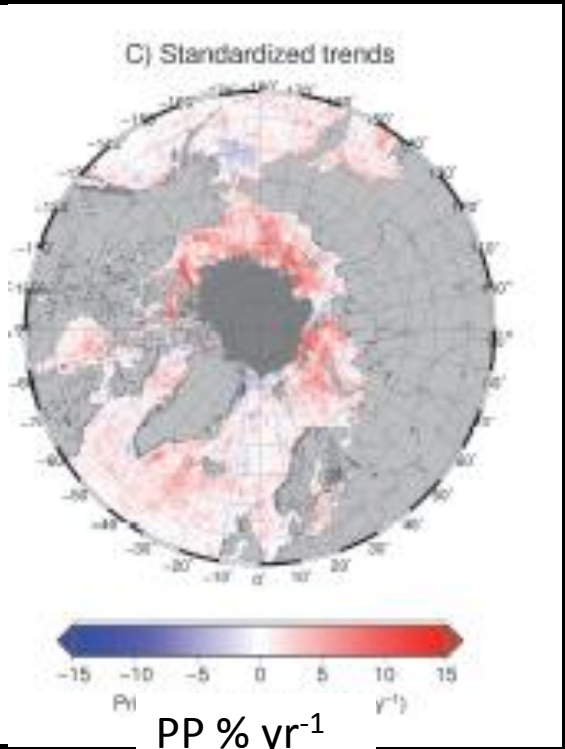

PAR % $yr^{-1}$

+ clouds =
Light decrease
(8-20%)
**ABOVE**
sea (ice) surface




PAR % $yr^{-1}$

+ clouds =
Light change
(+3 to -3%)
**JUST BELOW**
sea (ice?) surface



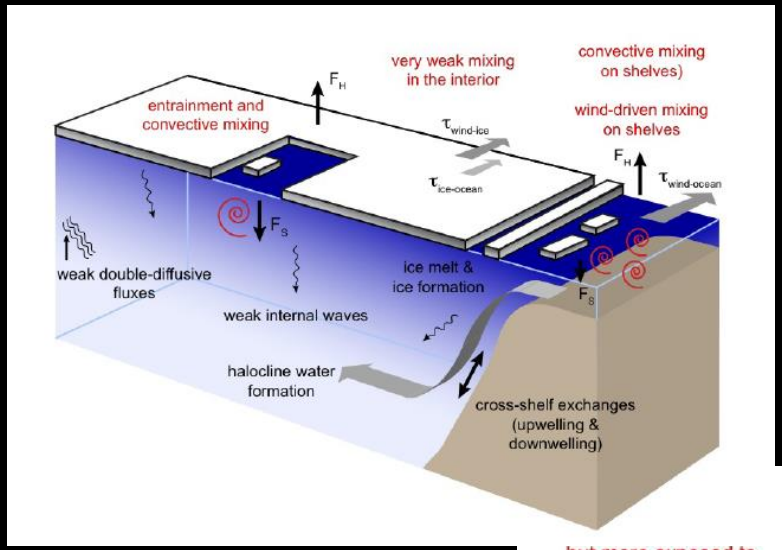

PP % $yr^{-1}$

PP increase estimated
below sea (ice?) surface

- GIN/Barents Sea ~21-
26% reduction

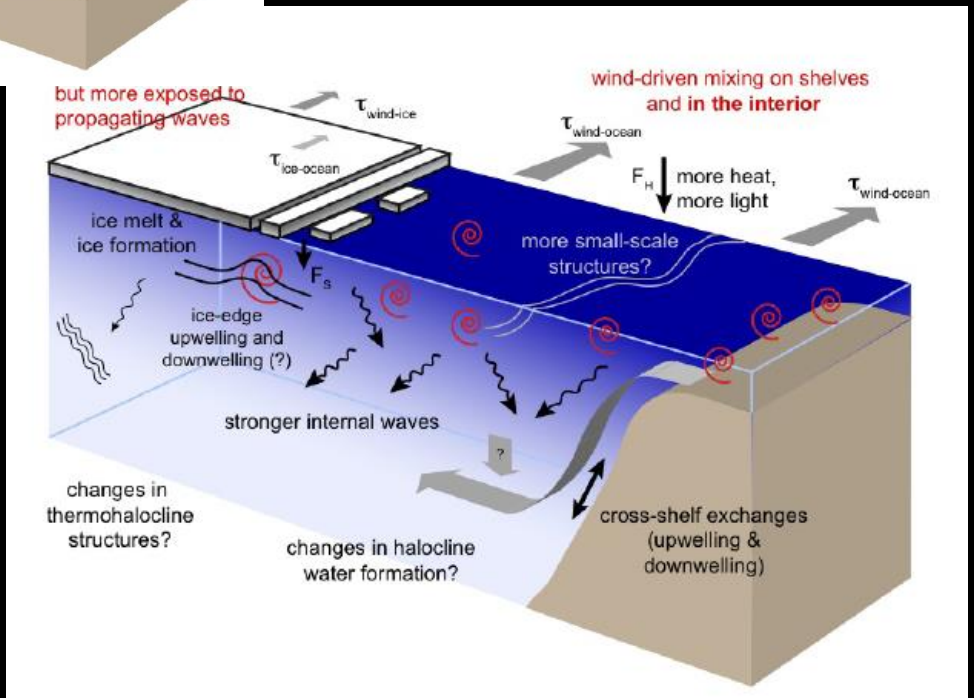
Bélanger et al. 2013 BG

# Wind! => wind-driven turbulence and eddies => mixing, nitrate consumption



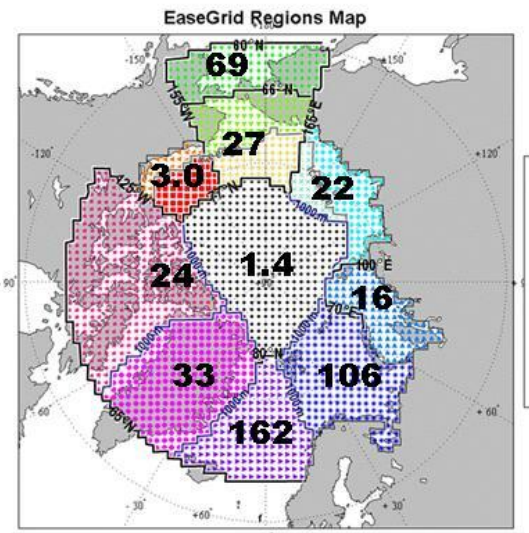

With ice

Mahadevan, Woodgate, Rainville, Wang, Matrai, in prep

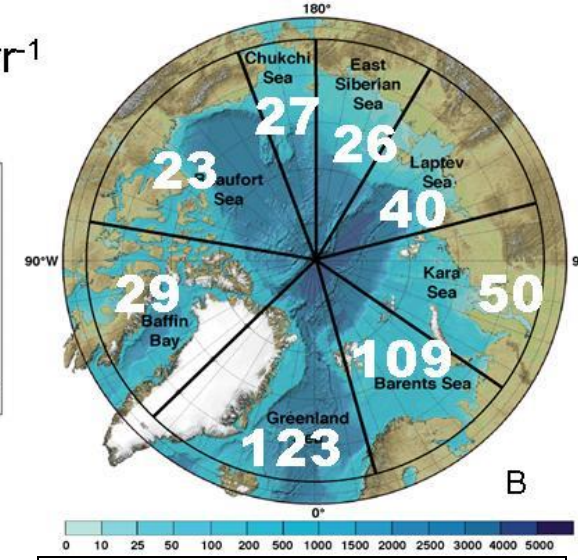



Without ice

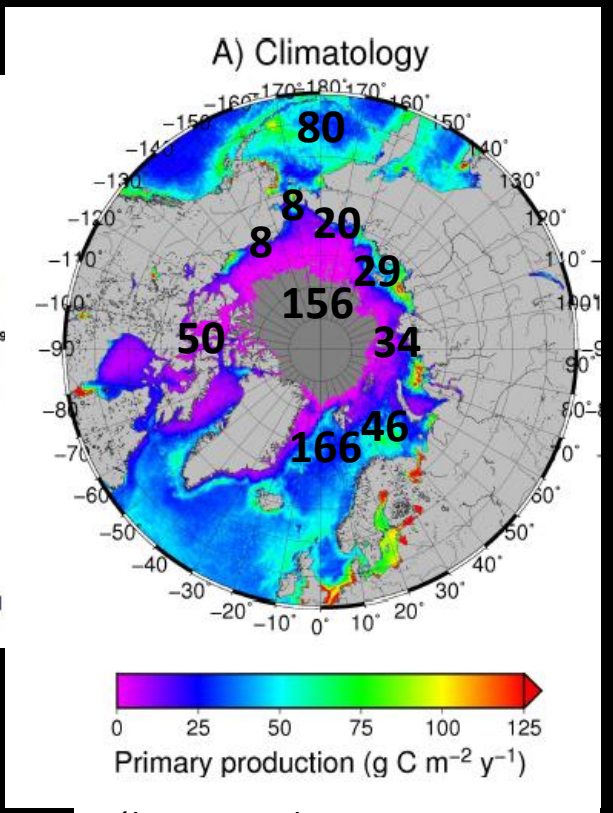
# Three empirical estimates of Arctic annual, regional, integrated PP…




Hill et al. 2013




Pabi et al. 2008; Arrigo and Dijken 2011



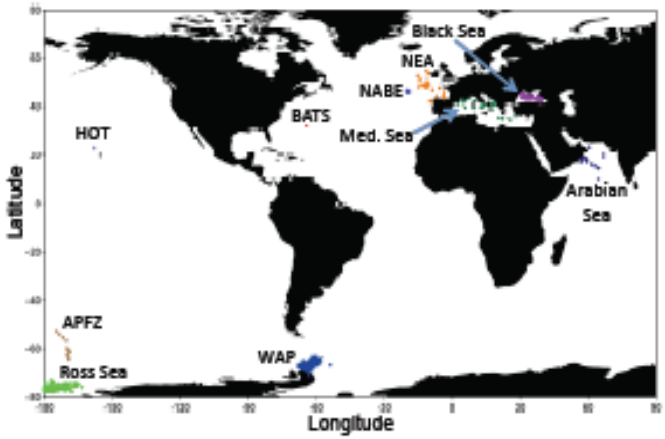

Bélanger et al. 2013

| | GIN Seas (Tg C $y^{-1}$) |
|---|---|
| Sakshaug 2004 | 42 |
| Arrigo & van Dijken 2011 | 148 |
| Hill et al. 2013 | 118 |
| Ardyna et al. 2013 | 230 (104 gC $m^{-2}$ $y^{-1}$) |
| Wassmann et al. 2014 | 70-100 gC $m^{-2}$ $y^{-1}$ |

**SOLAS/SCOR BEPSII**
**FAMOS, IOC…**

**PPARR-5 Arctic Ocean!**

# Previously NASA-funded PPARRs




Biogeosciences, 8, 489–503, 2011
www.biogeosciences.net/8/489/2011/
doi:10.5194/bg-8-489-2011


## An evaluation of ocean color model estimates of marine primary productivity in coastal and pelagic regions across the globe

V. S. Saba[1,2], M. A. M. Friedrichs[1], D. Antoine[3], R. A. Armstrong[4], I. Asanuma[5], M. J. Behrenfeld[6], A. M. Ciotti[7], M. Dowell[8], N. Hoepffner[8], K. J. W. Hyde[9], J. Ishizaka[10], T. Kameda[11], J. Marra[12], F. Mélin[8], A. Morel[3], J. O'Reilly[9], M. Scardi[13], W. O. Smith Jr.[1], T. J. Smyth[14], S. Tang[15], J. Uitz[16], K. Waters[17], and T. K. Westberry[6]

PPARR-4: Ocean color and GCM models; field and satellite data; spatial or temporal resolution

## Comparison of algorithms for estimating ocean primary production from surface chlorophyll, temperature, and irradiance

Janet Campbell,[1] David Antoine,[2] Robert Armstrong,[3] Kevin Arrigo,[4] William Balch,[5] Richard Barber,[6] Michael Behrenfeld,[7] Robert Bidigare,[8] James Bishop,[9] Mary-Elena Carr,[10] Wayne Esaias,[7] Paul Falkowski,[11] Nicolas Hoepffner,[12] Richard Iverson,[13] Dale Kiefer,[14] Steven Lohrenz,[15] John Marra,[16] Andre Morel,[2] John Ryan,[17] Vladimir Vedernikov,[18] Kirk Waters,[19] Charles Yentsch,[5] and James Yoder[20]

Table 3. Data Sets Used to Test Algorithms[a]

| Data Set | Region |
|---|---|
| AMERIEZ | Antarctica |
| SUPER | North Pacific |
| EqPac nonequator | Tropical Pacific |
| NABE | Northeast Atlantic |
| EqPac equator | Equatorial Pacific |
| Arabian Sea | Arabian Sea |
| PROBES | Bering Sea |
| MARMAP | Northwest Atlantic |
| Palmer LTER | Antarctica |

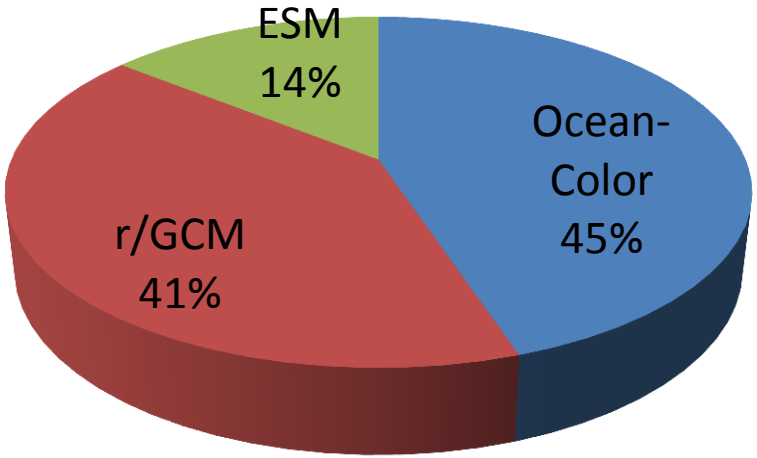
PPARR-1, 2: Ocean color models; field data only

# PPARR-5 Arctic Ocean Strategy

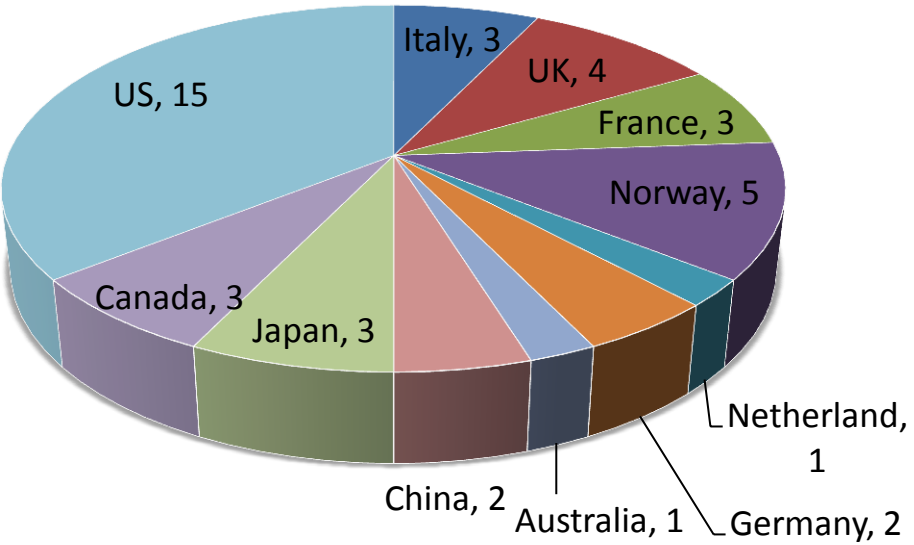
- Compilation, quality control, and characterization of field and remotely-sensed data: Done
- 1-D biological or biogeochemical, ocean color, phys-biol coupled ocean, GCM, ESM models invited : Now

# 5th Primary Production Algorithm Round Robin

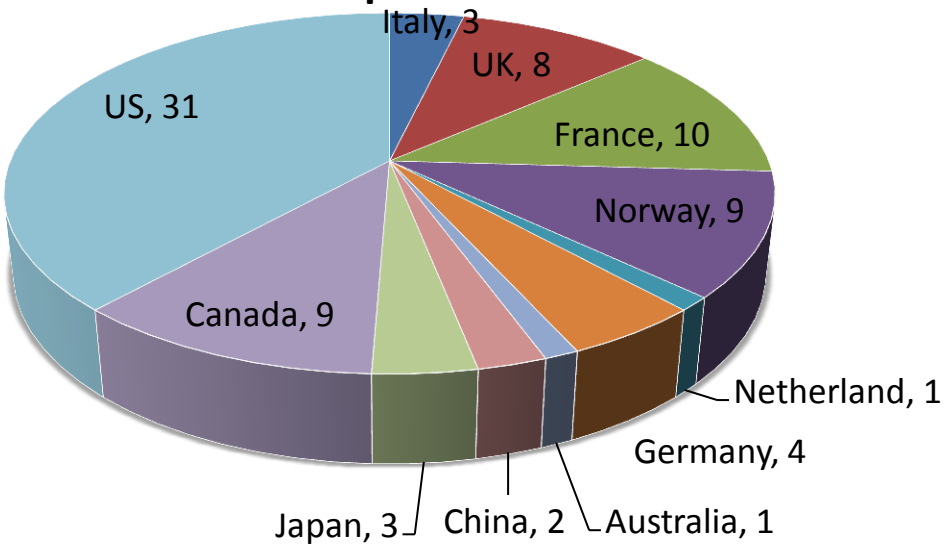
## Participating Model Types




## # of Modeling Groups: 42 + 3!




## # of Participants: 81+



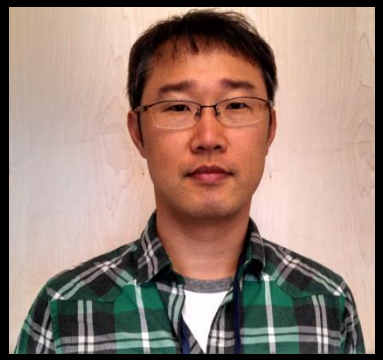
# Over the next 1.5 years:

- Statistical analyses of the observed and modeled NPP
- Feedback and iterations with the modelers on model performance
- Inter-model comparisons of Arctic NPP historical and future projections

- Contact us!

Younjoo Lee

ylee@bigelow.org




Thank you!