A Net Primary Productivity Algorithm Round Robin (PPARR) for the Arctic Ocean: A brief introduction to the PPARR 5 adventure

Patricia Matrai[1], Yoonjoo Lee[1], Marjorie Friederichs[2], and Vincent Saba[3]

[1]Bigelow Laboratory for Ocean Sciences

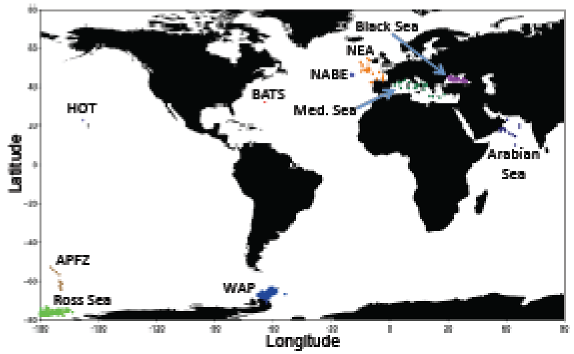
[2]Virginia Institute of Marine Sciences

[3]NMFS, NOAA

2nd FAMOS, WHOI, 23-25 October 2013, ylee@bigelow.org, pmatrai@bigelow.org

Previous NASA-funded PPARRs

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



iences

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'Rei 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

PPARR-3: Ocean color and GCM models; satellite data

ELSEVIER
Deep-Sea Research II 53 (2006) 741–770
www.elsevier.com/locate/dsr2

A comparison of global estimates of marine primary production from ocean color

Mary-Elena Carr[a,*], Marjorie A.M. Friedrichs[b,bb], Marjorie Schmeltz[a], Maki Noguchi Aita[c], David Antoine[d], Kevin R. Arrigo[e], Ichio Asanuma[f], Olivier Aumont[g], Richard Barber[h], Michael Behrenfeld[i], Robert Bidigare[j], Erik T. Buitenhuis[k], Janet Campbell[l], Aurea Ciotti[m], Heidi Dierssen[n], Mark Dowell[o], John Dunne[p], Wayne Esaias[q], Bernard Gentili[d], Watson Gregg[q], Steve Groom[r], Nicolas Hoepffner[o], Joji Ishizaka[s], Takahiko Kameda[t], Corinne Le Quéré[k,u], Steven Lohrenz[v], John Marra[w], Frédéric Mélin[o], Keith Moore[x], André Morel[d], Tasha E. Reddy[c], John Ryan[y], Michele Scardi[z], Tim Smyth[r], Kevin Turpie[q], Gavin Tilstone[r], Kirk Waters[aa], Yasuhiro Yamanaka[c]

GLOBAL BIOGEOCHEMICAL CYCLES, VOL. 16, NO. 3, 1035, 10.1029/2001GB001444, 2002

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

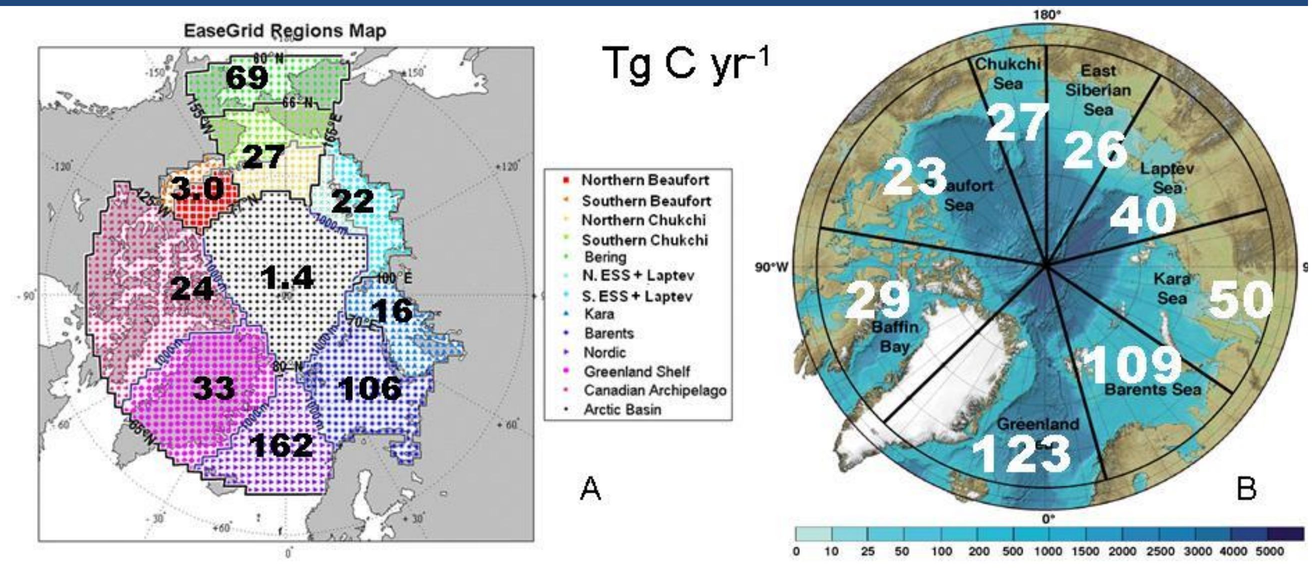
Janet Campbell,[1] David Antoine,[2] Robert Armstrong,[3] Kevin Arrigo,[4] William Balch,[5] Richard Barber,[6] Michael Behrenfeld,[7] Robert Bidigare,[8] James Bishop,[9] Mary-Elena Carr,[10] Wayne Esaias,[7] Paul Falkowski,[11] Nicolas Hoepffner,[12] Richard Iverson,[13] Dale Kiefer,[14] Steven Lohrenz,[15]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

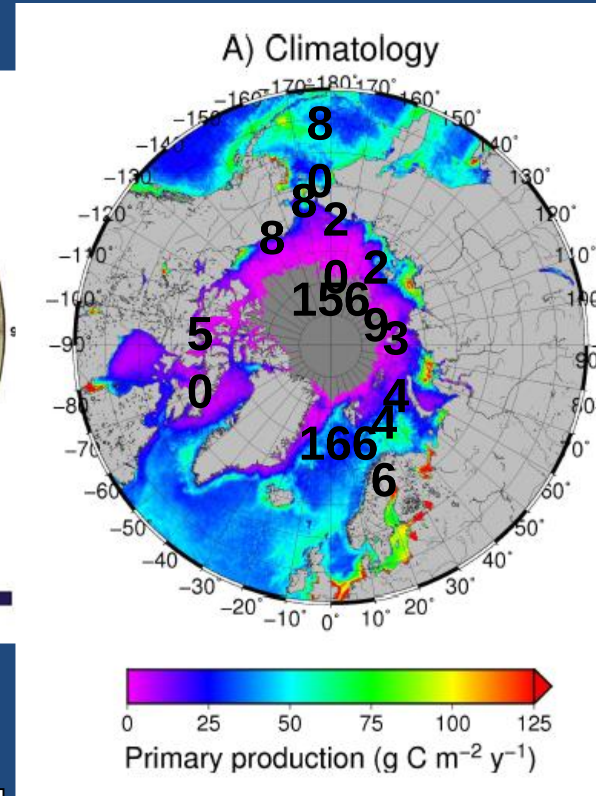
Table 3. Data Sets Used to Test Algorithms[a]

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

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



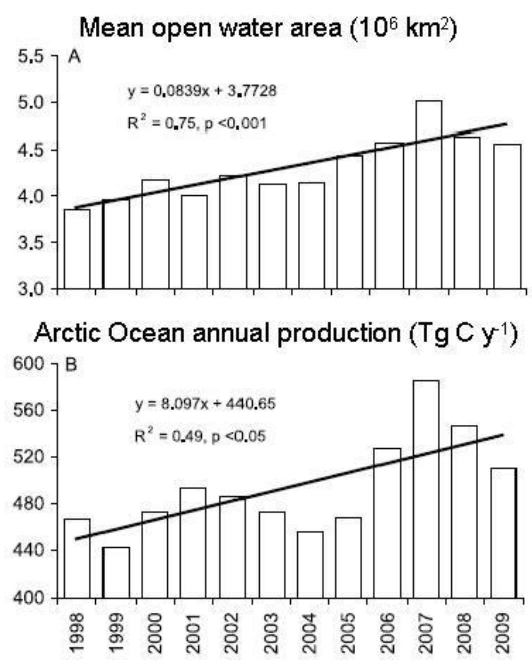


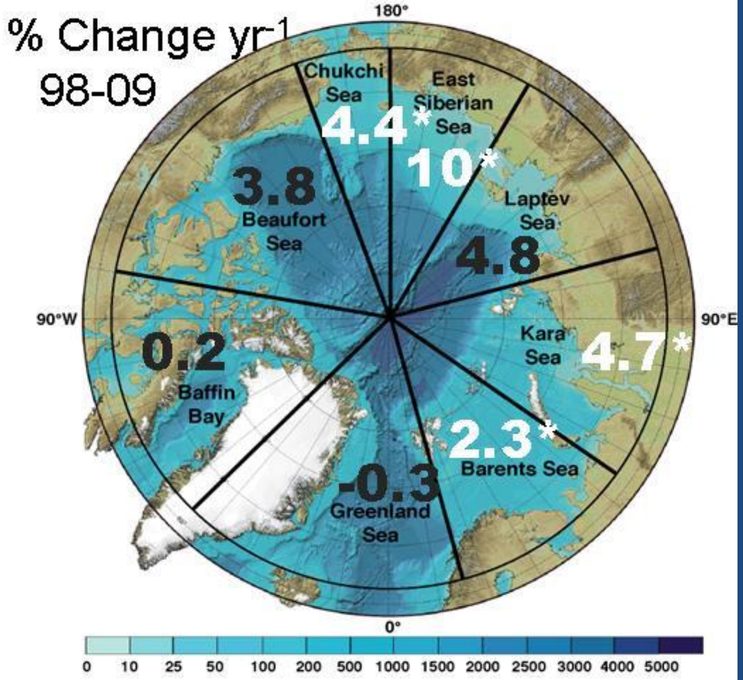
Combining *in situ* PP historical measurements, *in situ* chlorophyll-derived PP and satellite-derived PP (1998-2007). An arctic-specific empirical algorithm was used for the satellite derivations. Note that the Arctic Basin is separated [Hill et al. 2013].

Satellite-derived PP (1998-2009) . A polar algorithm was used for the satellite derivations. Note that the Arctic Basin is included in each of its individual regions [Pabi et al. 2008; Arrigo and Dijken 2011].

Satellite-derived PP (1998-2010) . Different algorithms were used for the satellite derivations. [Bélanger et al. 2013].

Changing!

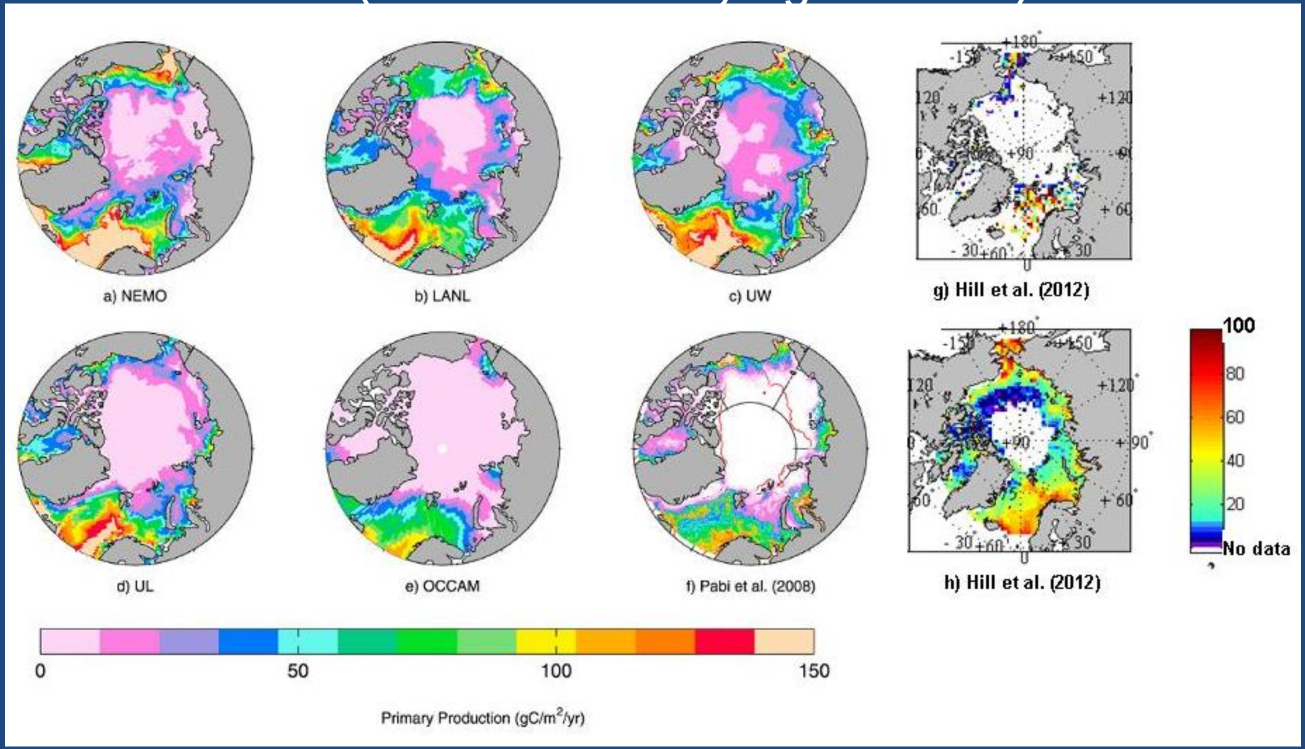




Pan-Arctic mean open water area and annual production increasing trends in the Arctic Ocean (1998-2009), estimated from remotely-sensed parameters [Arrigo and Dijken 2011]

Regional % change in annual production per year (1998-2009), estimated from remotely-sensed parameters. White, starred numbers indicate a significant change. Blue scale bar indicates depth (m) [Arrigo and Dijken 2011]

An AOMIP/FAMOS experiment:
Recent ocean model estimates
(and the underlying controls)



Popova et al. 2012

Hill et al. 2013

Nutrients
?
MLD?

Mean annual integrated PP estimates from (a-e) 5 models [*Popova et al*. 2012], (f) a satellite-derived estimate and estimates derived from (g) *in situ* chlorophyll and (h) satellite-chlorophyll by *Hill et al*. [2013] . The latter two share the color bar in the lower right (gC/m^2/yr).

ESMs in the Arctic: CMIP5 simulation for 2100

Stratification index -> NO_3

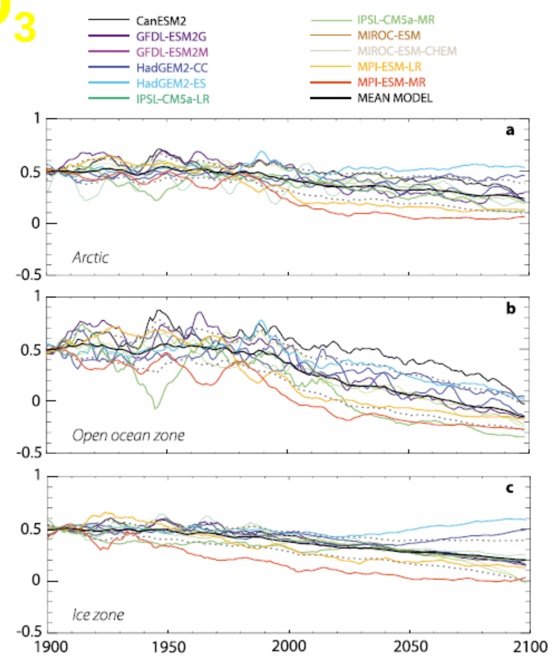


Figure 9. Time series of the stratification index (a normalized measure of the seasonal maximum mixed layer depth, see text for definition) for (a) the entire domain, (b) the open ocean zone, and (c) the ice zone; for all models and the mean model.

 (2013)

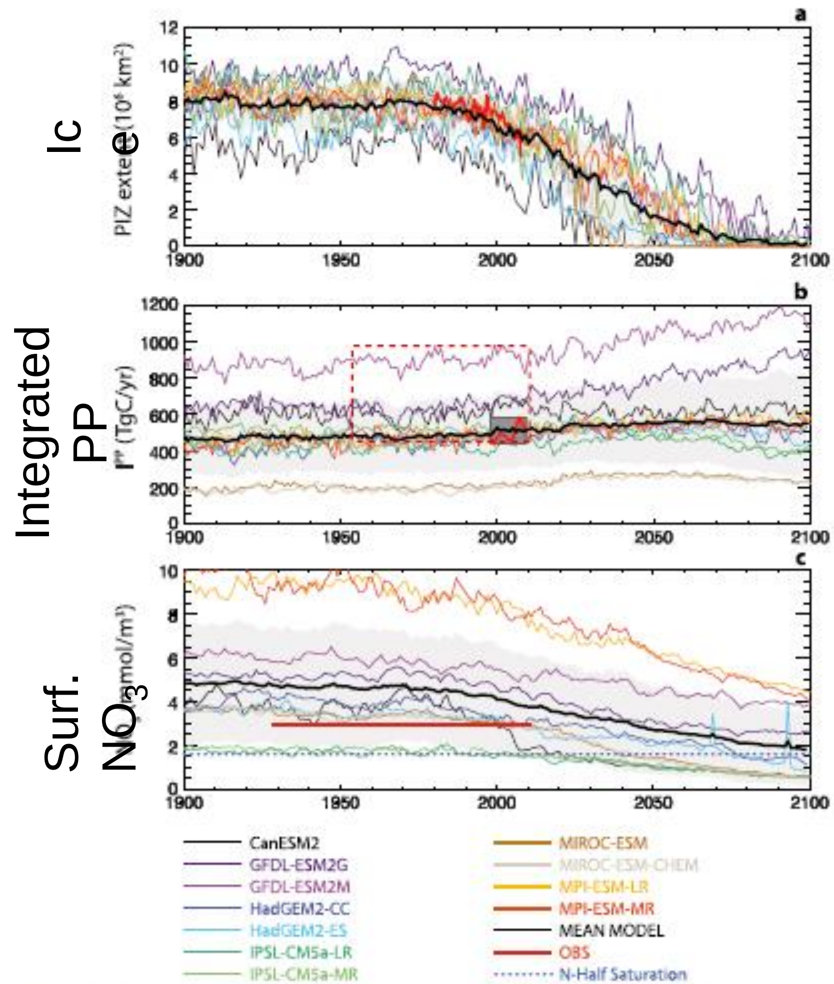


Figure 2. 1900–2100 yearly time series of (a) perennial ice zone (PIZ) extent, (b) integrated PP (I^{PP}), and (c) mean surface NO_3 over the whole Arctic, shown for the individual models (colored thin lines) and the mean model (thick black line), with the one standard deviation range (grey surface). Thick red lines are observations: (a) European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT)-Ocean and Sea Ice Satellite Application Facility (OSISAF) passive microwave sea ice extent [*Tonboe et al.*, 2011], (b) satellite ocean-color PP [*Arrigo and van Dijken*, 2011] (solid) and in situ estimates [*Hill et al.*, 2013] (dash), and (c) World Ocean Atlas (WOA) NO_3 [*Garcia et al.*, 2010], which is not representative of the entire domain, due to low data coverage in the Arctic Basin. The half-saturation concentration for diatom NO_3 uptake [*Sarthou et al.*, 2005] uptake on Figure 2c indicates the oligotrophic threshold.

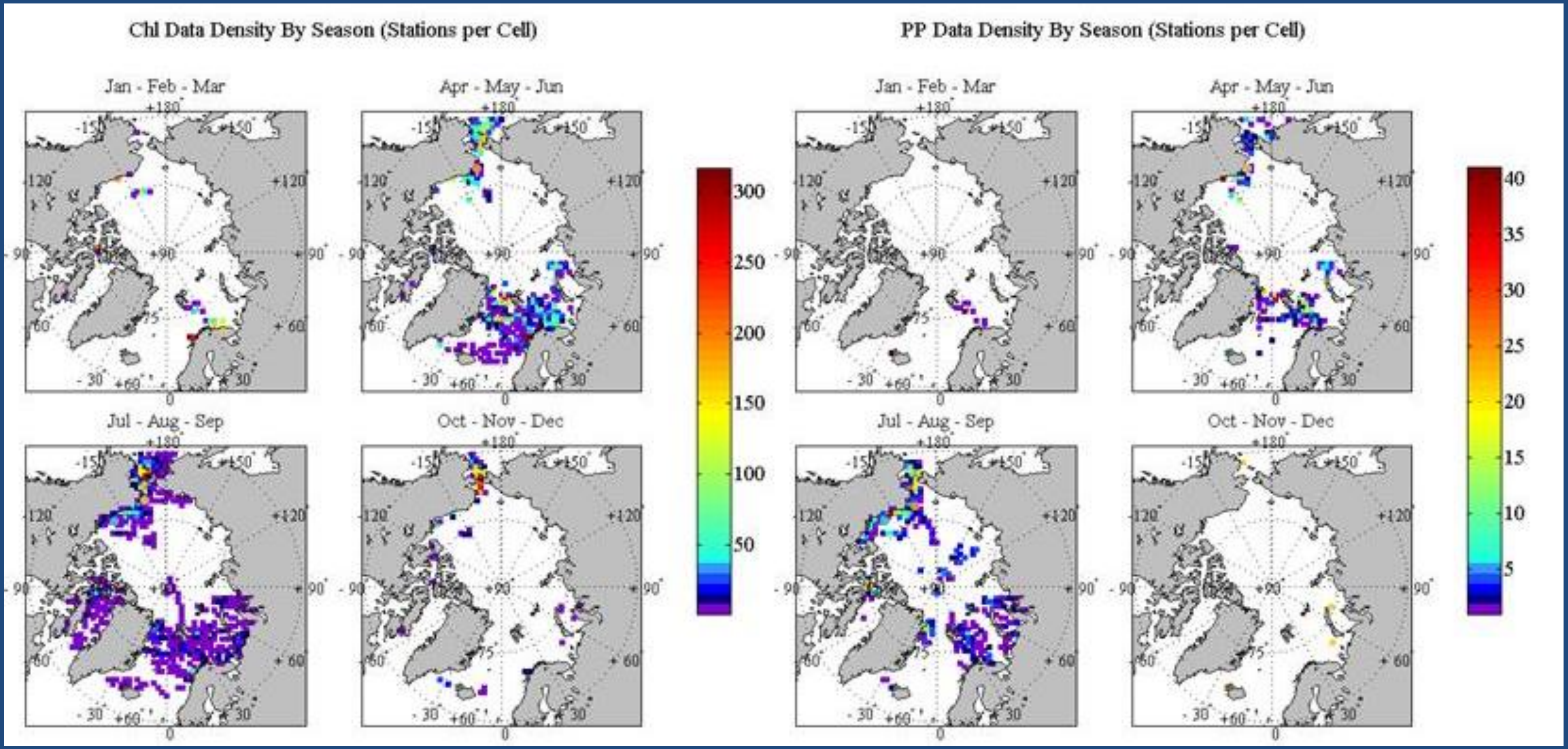
PPARR-5 Arctic Ocean Strategy

- Compilation, quality control, and characterization of field and remotely-sensed data: Now

Over the next 2 years:

- 0-D and 1-D biological or biogeochemical; ocean color; phys-biol coupled ocean; GCM; ESM models to be invited
- 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

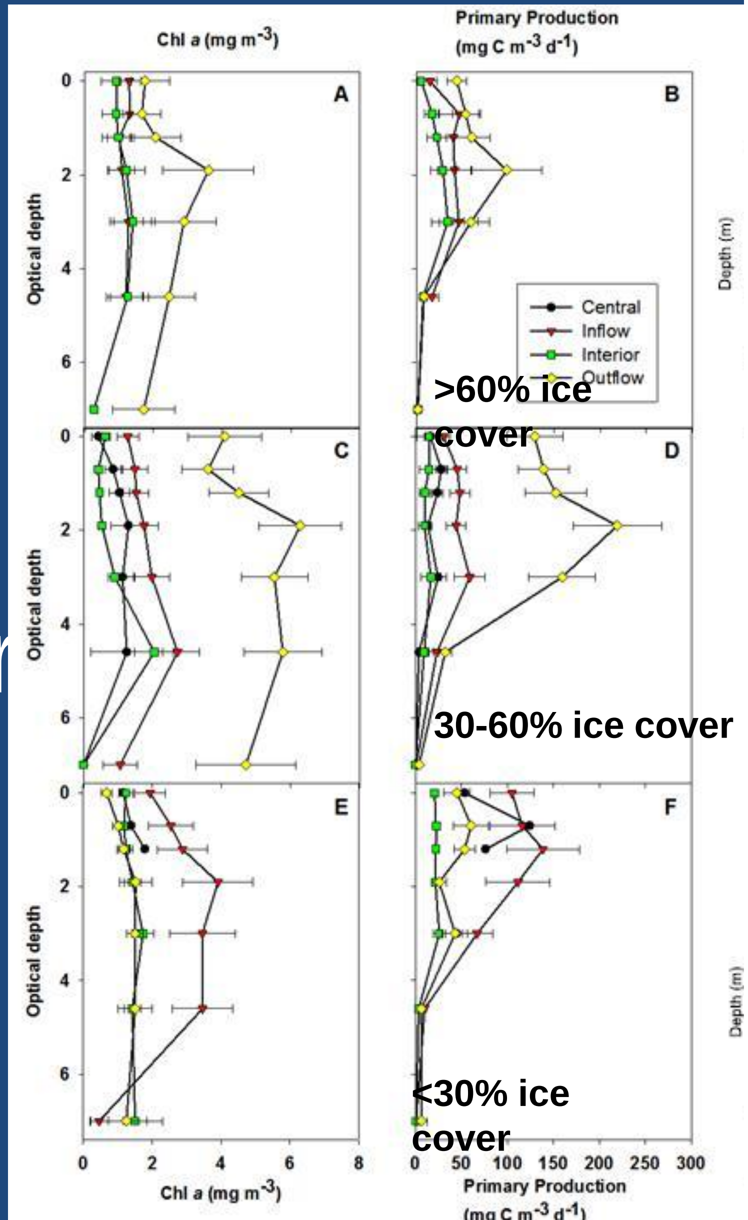
Ah! An appeal for data…



ARCSS-PP: Spatial and seasonal distribution of in situ data of chlorophyll *a* (Chl) and PP data in the Arctic Ocean, 1954-2007. Color scale indicates the number of data points in each grid cell [*Matrai et al.* 2013]. Also **ARCSS-NUT** for nutrients [*Codispoti et al.* 2013].

Since 2007, additional data available from or collected by CASES, CFL, Korean expeditions, Chinese expeditions, ATOS-1, MALINA, ICESCAPES, NAACOS, ??? Let us know!

Special Arctic Ocean Issues for PPARR, or not…



Hill et al. 2013

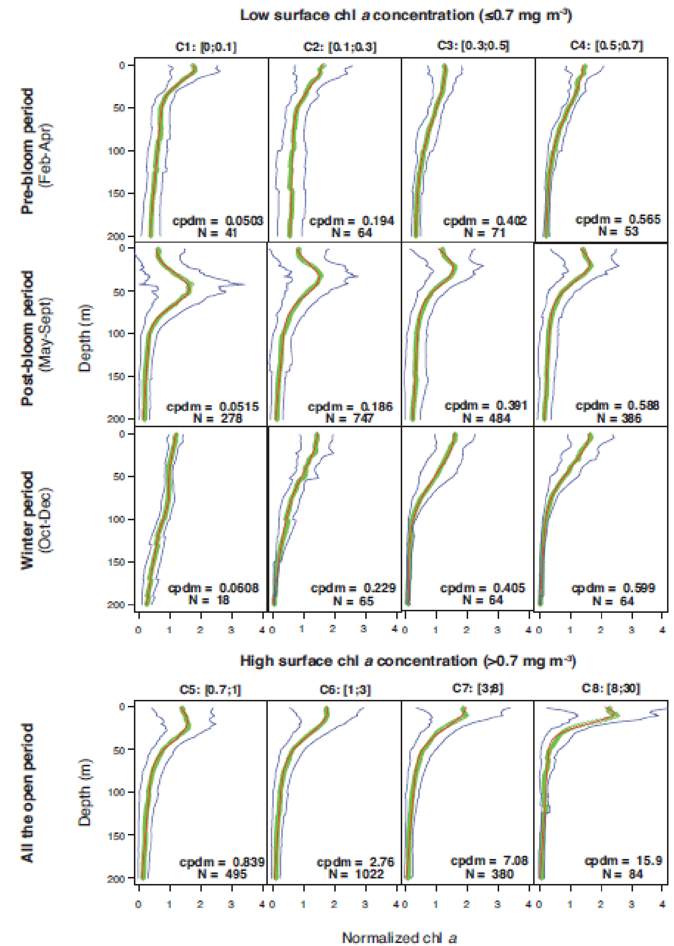


Fig. 5. Average dimensionless chlorophyll a (Chl a) profiles (green lines) obtained for each category (C1–C8) during pre-bloom, post-bloom, and winter periods as well as over the open water period (i.e., when surface Chl $a > 0.7\,\mathrm{mg\,m^{-3}}$) at deep ($> 50$ m) Arctic stations. Red and blue lines represent the parameterized vertical Chl a profiles and standard deviation, respectively. N and cpdm represent the number of stations and the averaged Chl a_{surf} value, respectively.

Ardyna et al. 2013

Arrigo & Dijken 2011

Building from PPARR-4: Understanding NPP simulations

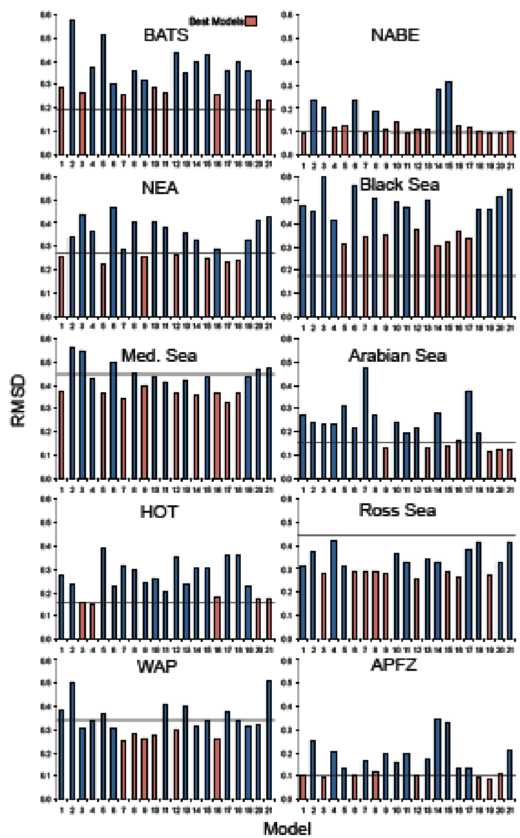


Fig. 3. Model skill (RMSD) for each model at each region. Solid black line is the RMSD when using the mean of the observed data. Models that have a RMSD below the solid black line have a Model Efficiency >0 thus they estimate NPP more accurately than using the mean of the observed data.

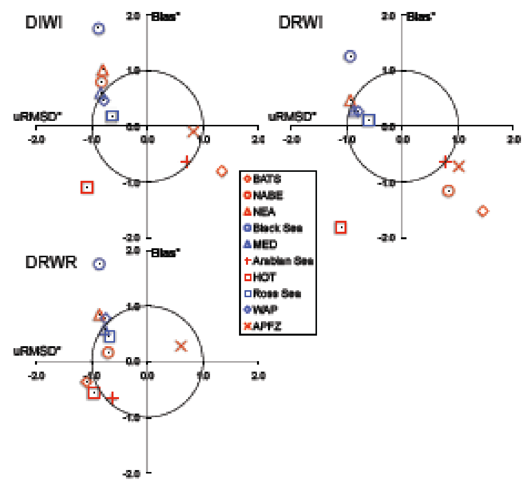


Fig. 4. Target diagrams representing average model skill at each region for DIWIs (11 models), DRWIs (4 models), and DRWRs (6 models). Bias* and uRMSD* are normalized such that Bias and uRMSD are divided by the standard deviation of in situ NPP data (σ_d) at each region. The solid circle is the normalized standard deviation of the in situ NPP data at each region. Symbols falling within the circle indicate that models estimate NPP more accurately than using the mean of the observed data (Model Efficiency >0) at each region. Red symbols are the pelagic regions and blue symbols are coastal.

The ME statistic was not consistent between regions (Figs. 3 and 4). In the Ross Sea, all models estimated NPP more accurately than using the mean of the observed data (ME > 0) whereas none of the models did better than the observed data mean in BATS and the Black Sea (ME < 0) (Figs. 3 and 4).

3.2.2 Bias and variance

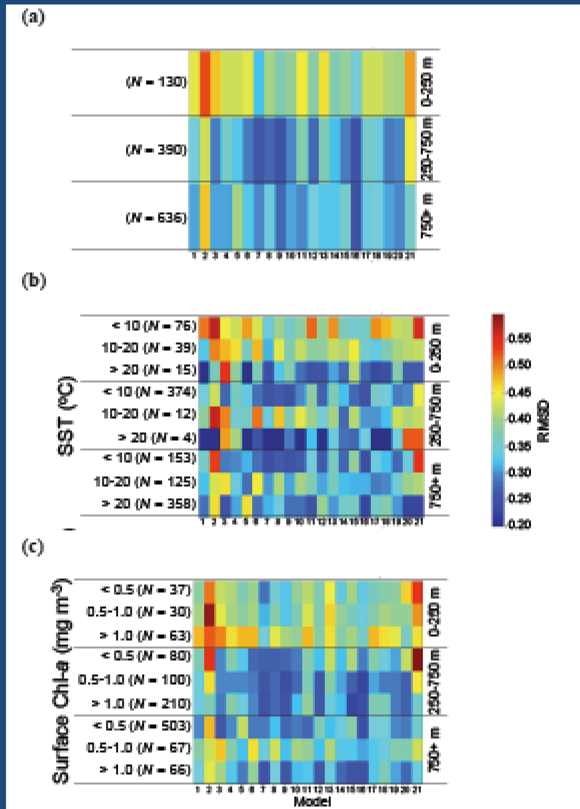


Fig. 10. Model skill (RMSD) for each model at (a) three depth ranges, (b) three SST ranges at each depth range, and (c) three surface Chl-*a* ranges at each depth range. The station sample size (*N*) for each depth range and SST/surface Chl-*a* range is also listed.

Saba et al. 2011

PPARR-5 Arctic Ocean Strategy

- **0-d and 1-d biological and biogeochemical; ocean color; phys-biol coupled ocean; GCM; ESM models are invited**
- **Open to new questions arising from FAMOS discussions**

Please contact Yoonjoo Lee (ylee@bigelow.org) or Paty Matrai (pmatrai@bigelow.org) for details.

We'll contact you in early 2014!