Space-based estimates of marine primary production in polar waters

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Biggest challenges for NPP

1) Lack of in situ data

2) Getting chlorophyll *a* right in the presence of:

   High CDOM

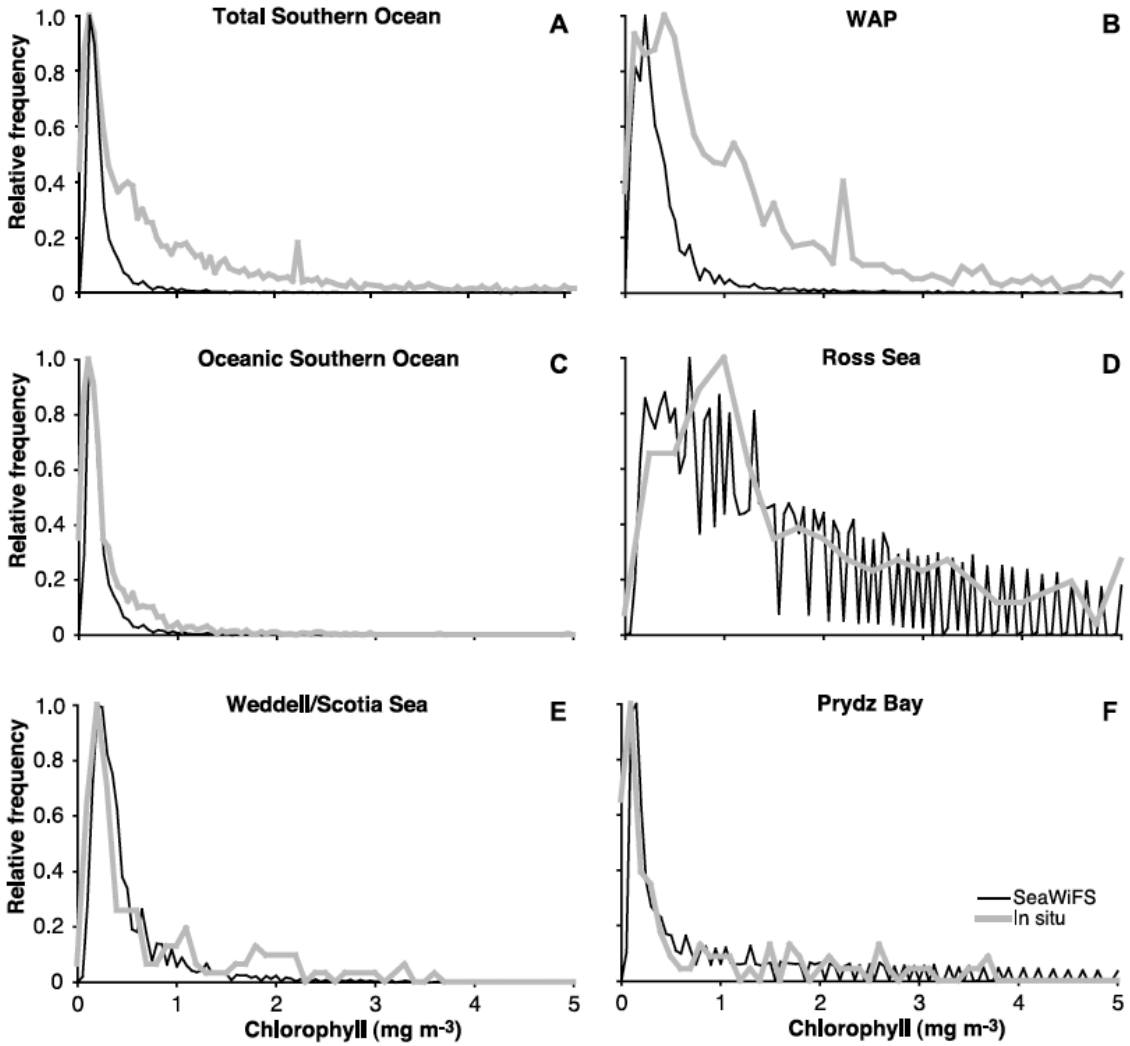
   Phytoplankton pigment packaging

3) Accounting for subsurface chlorophyll maxima

Not enough clear sky days to do direct match-ups with in situ data

Compare statistical distributions instead

Chlorophyll *a*



Arrigo et al. (2008)

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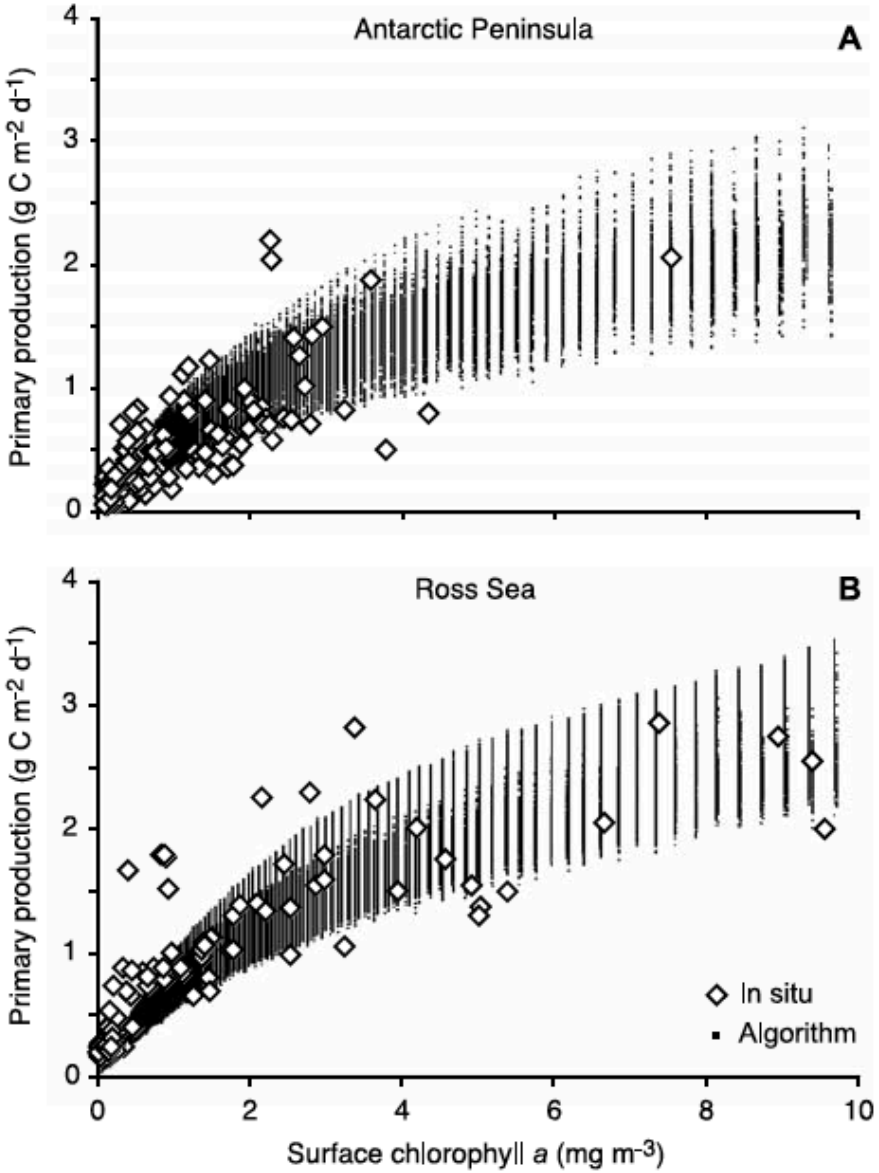
Compare statistical distributions instead

NPP

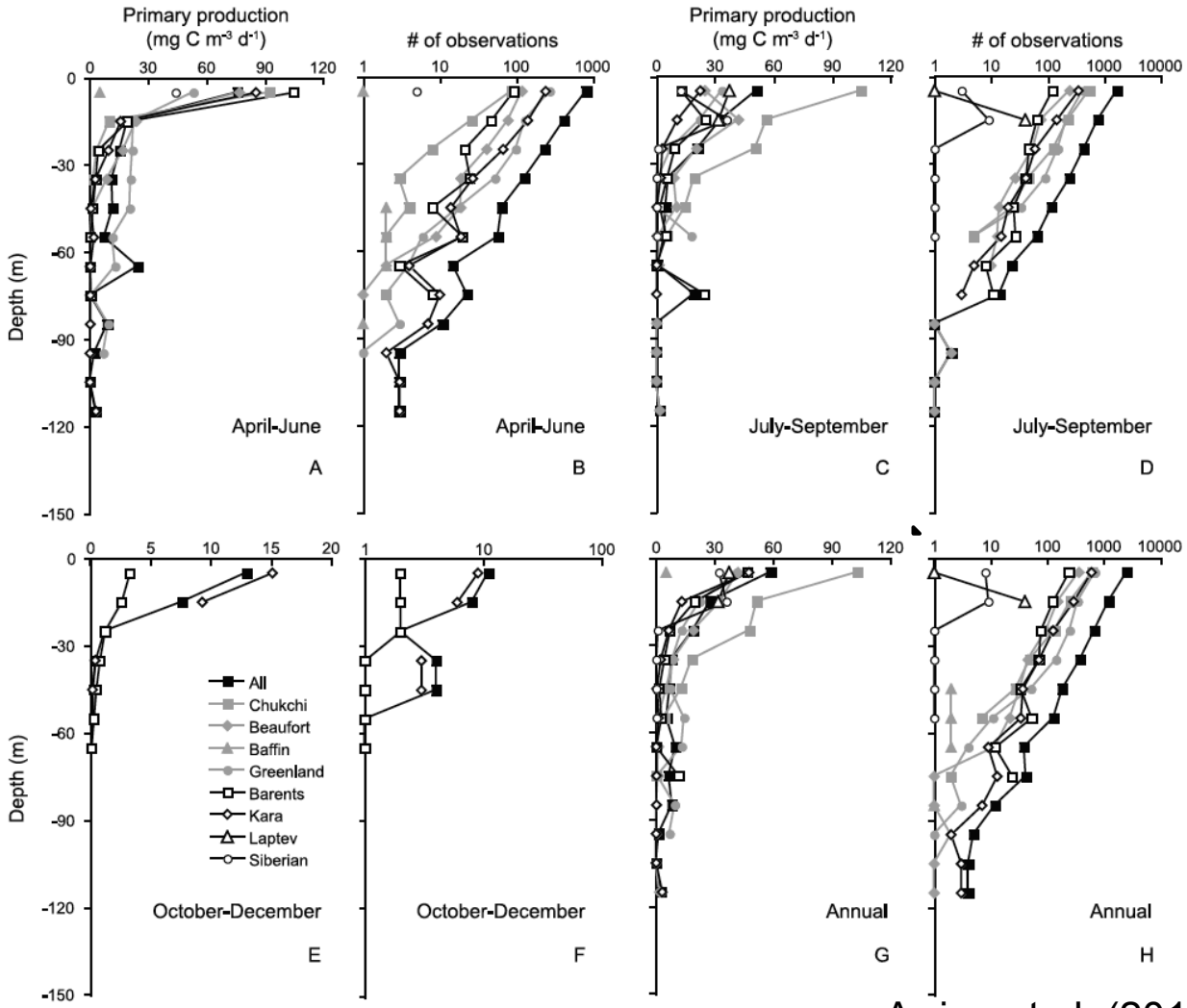


Arrigo et al. (2008)

Lack of NPP data

Some sectors of the Arctic have virtually no available NPP data

Siberian
Laptev
Baffin



ARCCS-PP database
(Matrai et al. (2013)

Arrigo et al. (2011)

Biggest challenges for NPP

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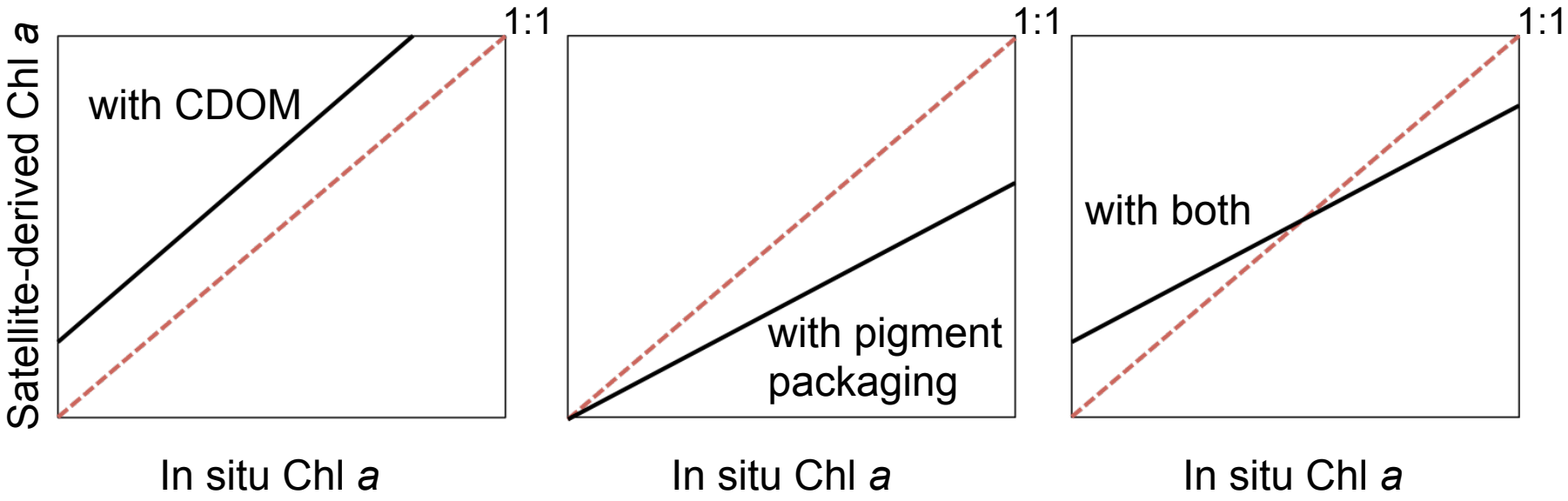
CDOM and pigment packaging affect Chl *a* estimates



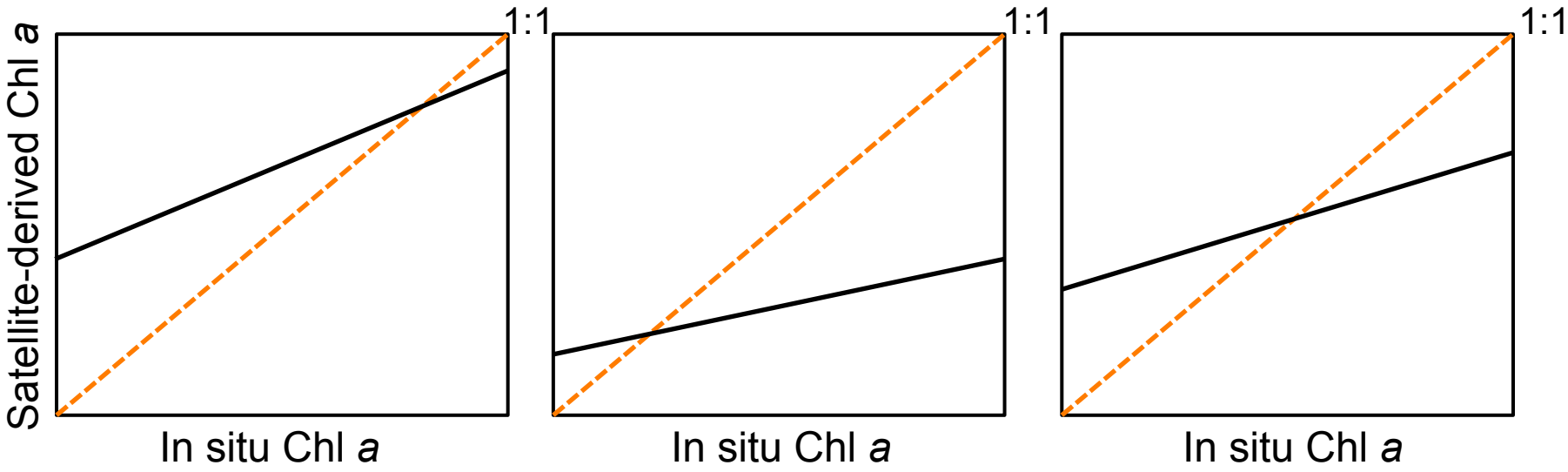
Arctic only

Arctic and Antarctic

Arctic only

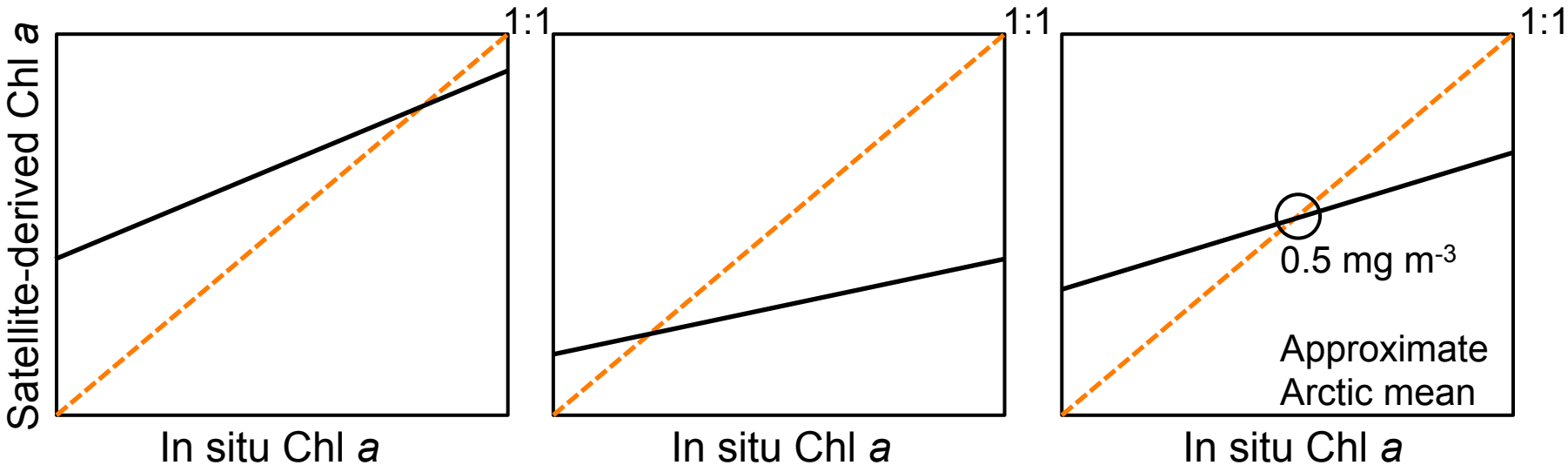
Lewis et al. (in prep.)

CDOM and pigment packaging affect Chl *a* estimates



High CDOM Low packaging	Low CDOM High packaging	High CDOM High packaging
Satellite over-estimates at most Chl *a* levels	Satellite under-estimates at most Chl *a* levels	Balance between under- and overestimates

CDOM and pigment packaging affect Chl *a* estimates



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CDOM and pigment packaging affect Chl *a* estimates

Requires regional algorithms that can account for unique bio-optical properties of high latitude waters

Antarctic: SPGANT (Mitchell and Kahru 2009)

Arctic: OC4L (Cota et al. 2004)

But regional algorithms may not work equally well in all regions

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Accounting for subsurface chlorophyll maxima

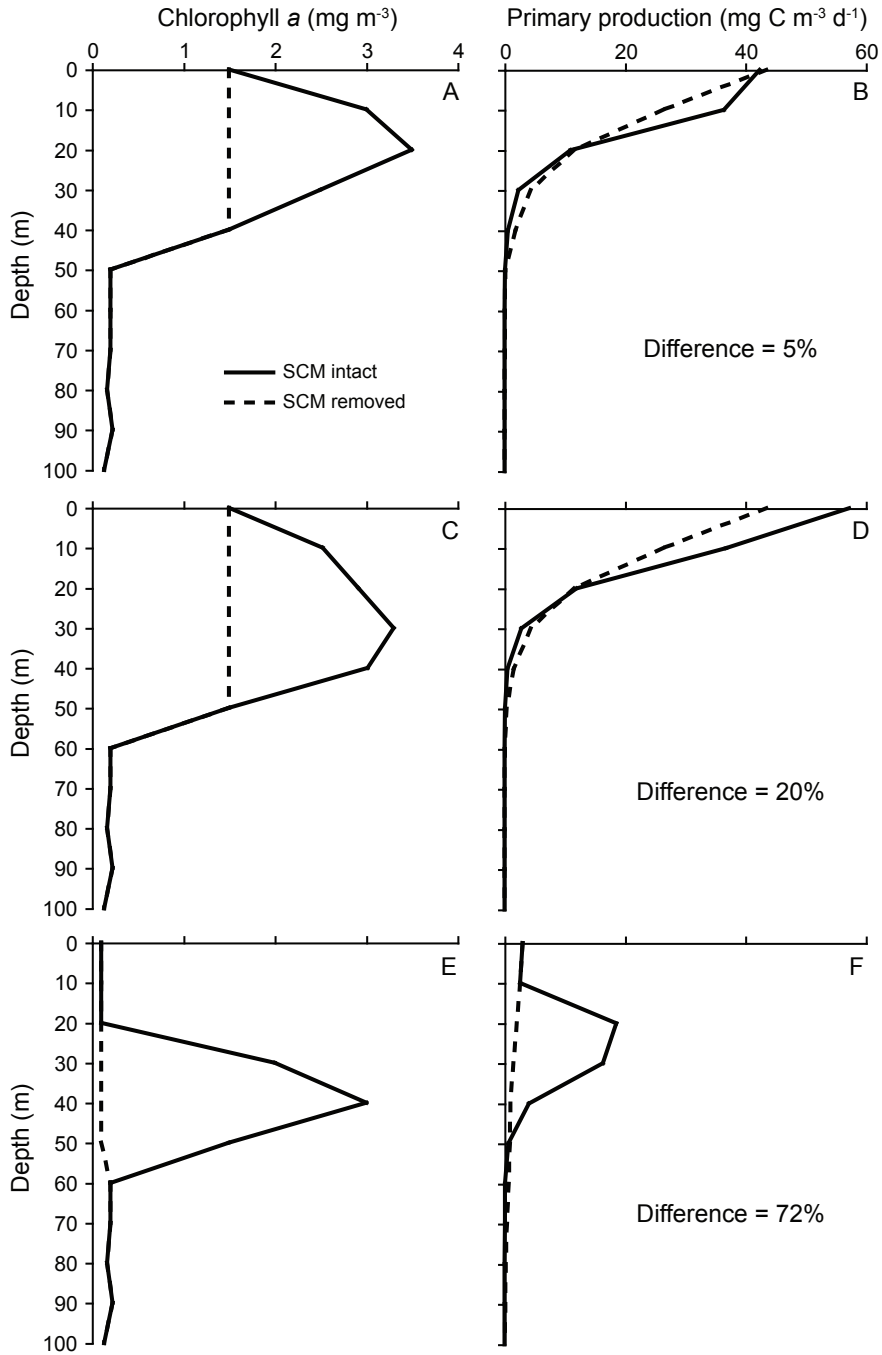
Satellites only “see” upper optical depth
(4.6 optical depths in euphotic zone)

Phytoplankton may be concentrated below the surface
Especially in the Arctic (only small issue in the Antarctic)
Especially later in the season

Need to account for this “missed” subsurface NPP

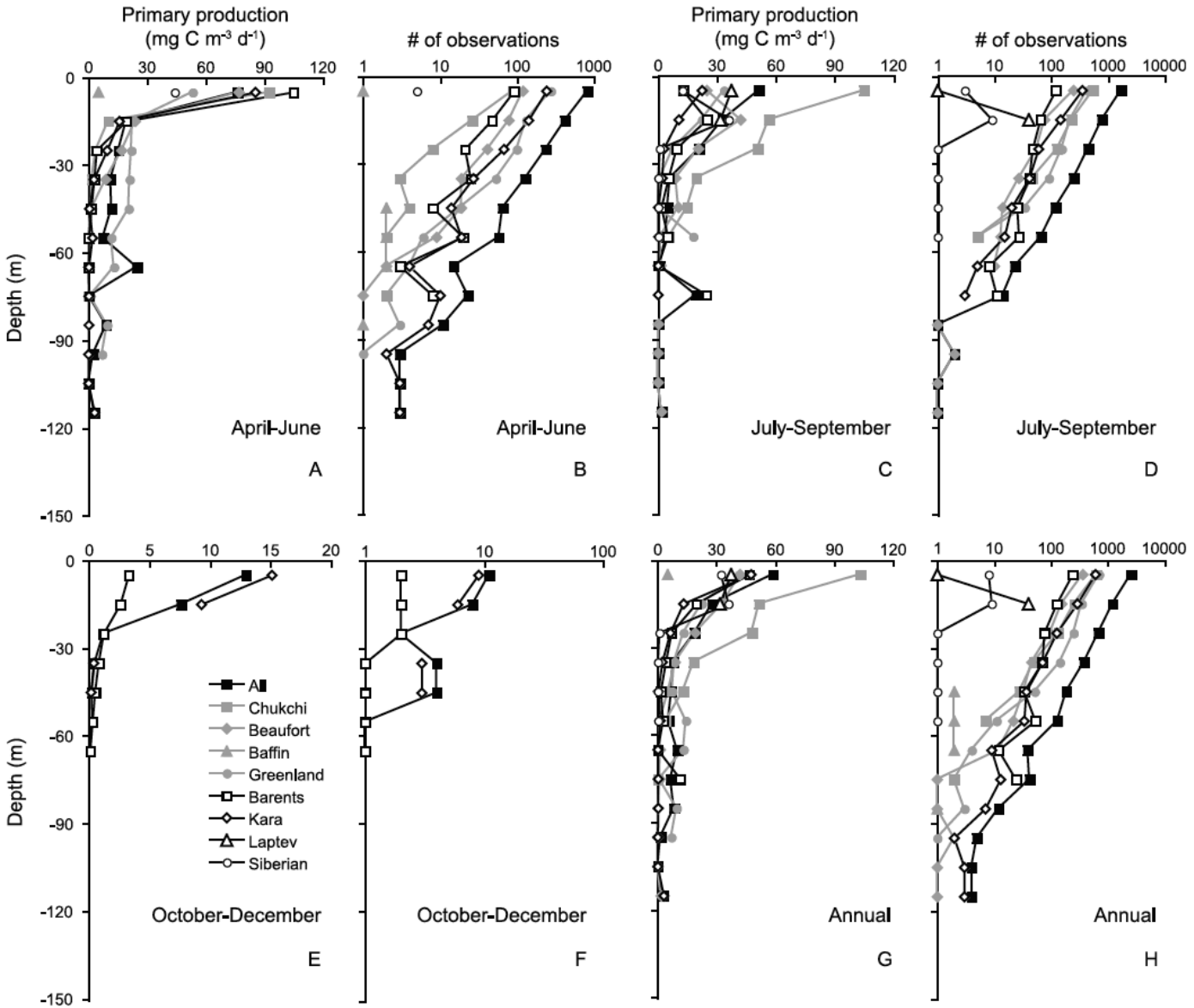
Magnitude of NPP error depends on vertical distribution of biomass

Vertical distribution of biomass varies seasonally and regionally



Arrigo and Van Dijken (2011)

Data in the ARCSS-PP database shows most NPP at surface



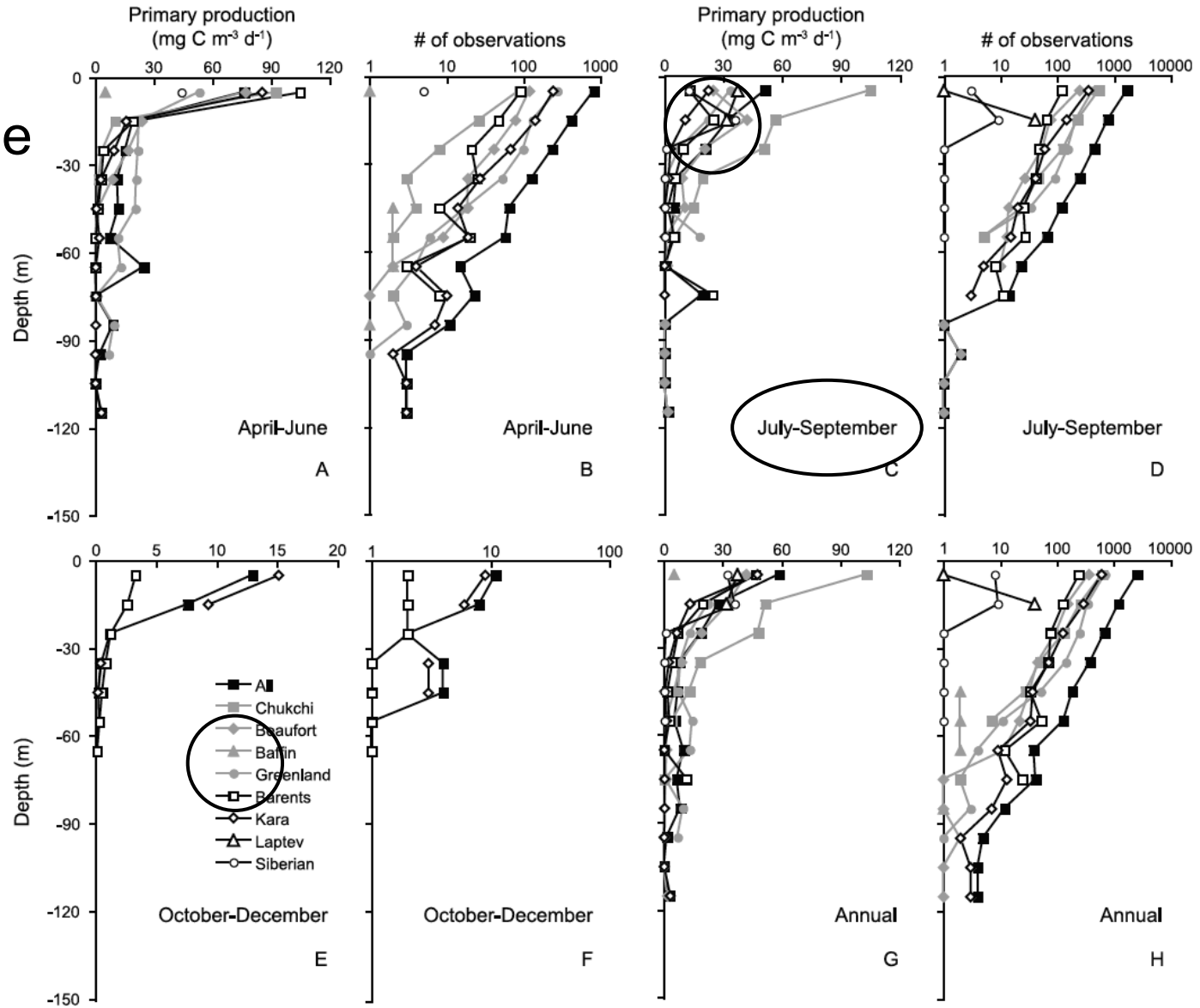
Arrigo and Van Dijken (2011)

Data in the ARCSS-PP database shows most NPP at surface

There are some exceptions:

Summer

In
- Beaufort
- Baffin
- Greenland
- Barents



Arrigo and Van Dijken (2011)

Fortunately, the magnitude of annual NPP error is quite small
But spatially and temporally variable

Table 5.2 Percent change in depth-integrated daily net primary production due to removal of the subsurface Chlorophyll-a maximum for different geographic sectors and different time periods. Chlorophyll-a was distributed vertically as shown in Figure 5.4a. Seasonal and annual values in parentheses were calculated using the productivity algorithm of Hill et al. (2013). ND indicates no *in situ* data available.

	January – March	April – June	July – September	October – December	Annual
Chukchi	−19.7 (−25.6)	−12.0 (−18.0)	−6.1 (−9.0)	0.0 (0.0)	−7.6 (−11.2)
Beaufort	−10.7 (−11.2)	0.0 (0.0)	−20.4 (-22.8)	-3.4 (-2.6)	−11.7 (−13.5)
Baffin	−6.6 (−6.2)	−0.2 (−0.2)	−4.1 (−6.5)	−7.5 (−8.2)	−4.1 (−5.9)
Greenland	−20.4 (−24.1)	−2.0 (−1.9)	−6.8 (−6.1)	0.0 (0.0)	−4.5 (−4.1)
Barents	0.0 (0.0)	−2.1 (−2.0)	−2.5 (−2.4)	−4.1 (−4.0)	−1.2 (−1.1)
Kara	ND	0.0 (0.0)	0.0 (0.0)	−1.9 (−2.0)	0.0 (0.0)
Laptev	ND	ND	0.0 (0.0)	ND	0.0 (0.0)
Siberian	ND	ND	−0.5 (−0.5)	ND	−0.5 (−0.5)
All	0.0 (0.0)	−8.8 (−12.4)	−6.8 (−9.1)	−7.4 (−8.7)	−7.6 (−10.4)

Chapter 5
IOCCG Report Number 16, 2015
Ocean Colour Remote Sensing in Polar Seas

Conclusions

Despite magnitude errors, NPP trends over time are likely robust

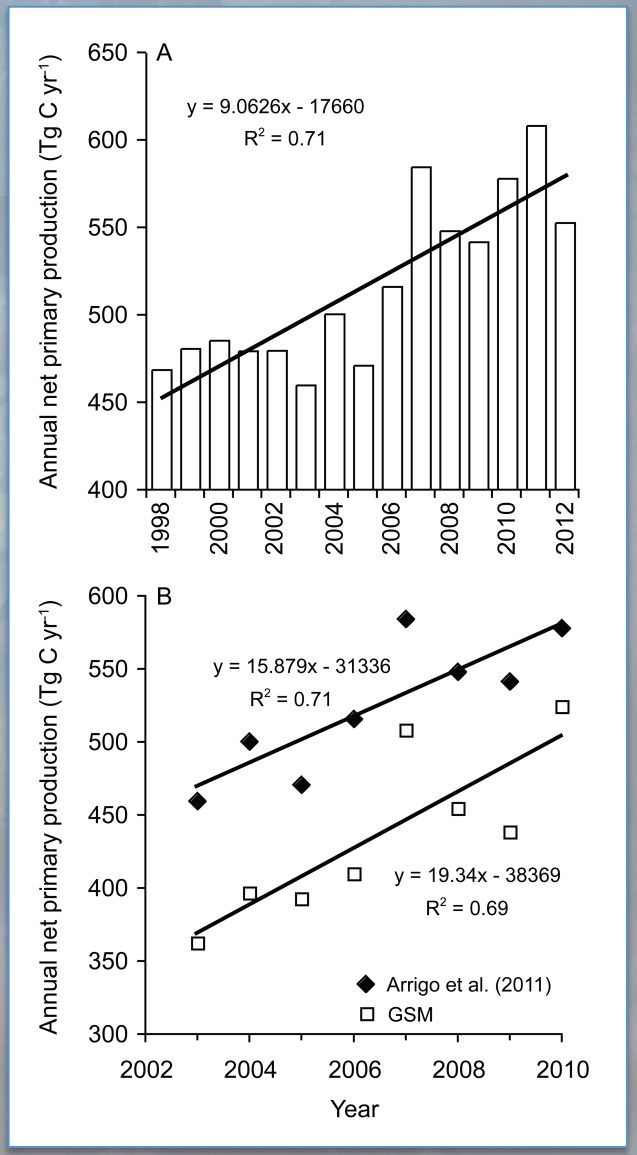
Regional differences in CDOM and pigment packaging make large-scale algorithm development difficult

Most difficult in the Arctic (CDOM, pigment packaging, SCM)

Less so in Antarctic (packaging only)

Requires semi-analytical algorithms

Need more in situ data!



Arrigo and Van Dijken (2015)