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From: Larry Anderson
Date: October 3, 2008

North Atlantic Report #63:
Maltrud's Simulations with 3 Phyto Groups
*****DRAFT*****

1. Phytoplankton Species Composition at PseudoBATS

Figs. 1-5 compare phytoplankton species composition at PseudoBATS (20.1°N, 72.7°W) in the 0.1° run with BATS data. Model DIAT are higher than observed, and SP_2 are lower than observed.

In Figs. 1-5, only compare Total Chl, DIAT and SP_2 (= Total Chl − DIAT), since the BATS data Cyano and SP are not analagous to model DIAZ and SP.

2. Why are DIAT High in MWE and DIAZ in AC?

Regarding responses of phytoplankton species to different types of eddies, it is here recognized that Table 5 in Report #62 does not do a good job at assessing this, because the large number of "weak" eddies outweigh the response seen in "strong" eddies, though the latter should be considered more characteristic. (Thus the difference between Fig. 3a and Table 5 in Report #62.) So Figs. 6-8 reconduct the analysis by eddy type, for 31.7°N. Anomalies from the seasonal cycle and large-scale trend are given. These relationships are discussed in the sections below.

I also tried re-analyzing the BATS data (Table 4 in Report #62) similar to Figs. 6-8 here; however so few eddies are observed that coarse binning is necessary, such that there is little difference from Table 4 in Report #62. Table 4 essentially shows high DIAT (and consequently high Total Chl and PON Flux) in MWE in response to high nutrients, with low DIAT in TH. This same response is seen in the model (Figs. 6-8).

3. Diazotrophs: Model-Data Comparision

Phytoplankton species model-data comparison can be made on two scales: large-scale distribution, and response to different types of eddies.

Regarding large-scale distributions, field observations (Carpenter et al., 2004, DSR I 51 p 173; Davis and McGillicuddy, 2006, Science 312 p 1517) show highest concentrations to the south and west of the model's Sargasso subdomain. In the model (Fig. 3b in Report #62) there are high values on the southern edge; a larger domain would need to be examined to see the extent. An east-west trend is not readily seen. Model concentrations have a local maximum just south of the Gulf Stream, which agrees somewhat with the satellite-based estimates of Westberry and Siegel (2006, GBC 20, GB4016; viz. their figs. 1 and 3).

Regarding responses of DIAZ to different types of eddies, DIAZ biomass is enhanced in anticyclones (AC; Fig. 6a)—in agreement with Davis and McGillicuddy (2007)—and their relative fraction is higher in both AC and thinnies (TH; Fig. 6b). This enhanced biomass is related to enhanced DIAZ PP in AC (Fig. 7a); the enhanced DIAZ growth rates (=PP/Chl;

Fig. 8a) indicate it is the high PP which is causing the high DIAZ biomass rather than vice versa. Interestingly, the AC seem to have high POC fluxes (Fig. 8b), though perhaps not more than cyclones (and MWE).

Why is DIAZ biomass enhanced in AC? The AC have high salinity (Fig. 8b), which means horizontal advection of DIAZ by AC remains a possibility; but the enhanced DIAZ growth rates (Fig. 8a) support the idea of *in situ* growth. In AC (and TH), the downward-displaced isopycnals at 70 m causes lower-than-average nutrients (Fig. 8b), such that the community shifts away from DIAT and toward SP and DIAZ (Fig. 8a). But how do the DIAZ get their required PO_4? Perhaps PO_4 which would have been used by DIAT is now avaiable to DIAZ and SP instead. Surface summer PO_4 at BATS in the model is severly depleted (c. 0.0001 μM), which is why DIAZ have a subsurface maximum. Thus the enhancement of DIAZ in AC appears to be related to species competition. DIAZ should aso be enhaced in TH, though no extreme 70-m density anomaly TH were in this record.

- DIAZ growth vs. advection terms would need to be compared in a Lagrangian frame. Would a large-area average be sufficient?
- Nutrient limitation terms (and PO_4 terms) would need to be examined to see how the DIAZ are getting PO_4.

4. Diatoms: Model-Data Comparision

The large-scale model DIAT concentrations are higher in the north (Fig. 1 in Report #57) which is similar to field data (Gregg and Casey, 2008) and sattelite-based estimates (Alvain et al., 2008). However the DIAT fraction of Total Chl is about an order-of-magnitude too high (Report #62). This suggests the parameter values for DIAT are not quite right.

Regarding the response of DIAT to eddies, Figs. 6-8 show enhanced DIAT in MWE and suppressed DIAT in TH. The same is true for DIAT PP and growth rates, as well as POC Flux. These appear to be related to nutrient concentrations (Fig. 8b), i.e. higher nutrients allowing more DIAT. This agrees well with BATS and EDDIES field data.

Interestingly, Fig. 8b shows that nutrients at 97 m are higher in MWE and AC than C and TH respectively; this is consistent with upwelling in MWE and AC and downwelling in C and TH caused by eddy-wind interaction.

5. Small Phytoplankton: Model-Data Comparision

In observations in the Sargasso, most (c. 90%) of the Chl is SP, rather than diatoms or *Trichodesmium* (e.g. McGillicuddy et al., 2007, Science). In the model, only about 60% of Chl is SP (Fig. 9; also fig. 3a in Report #60), indicating that the model partitioning between DIAT and SP is not quite correct. For model-data comparison in the Sargasso, observed SP can be approximated as Total Chl, which can be compared against model SP and Total Chl.

Regarding large-scale distributions, SeaWiFS Chl, model SP and model Total Chl are all highest in the north (Fig. 10; also fig. 1 in Report #57). However model surface Total Chl is generally too high at 36°N and too low at 24°N compared with SeaWiFS. (Due to patchiness, SeaWiFS probably yields a better annual estimate than BATS.)

Regarding responses to eddies, the BATS data (Table 4 in Report #62) suggests Total Chl and SP_2 are enhanced in MWE and lowest in AC. Model SP is enhanced in AC and suppressed in C, which disagrees with the BATS data. However model Total Chl is enhanced in MWE and suppressed in TH (due to model DIAT; Fig. 6a), which agrees with BATS Total Chl. Since the response of model Total Chl to eddies agrees fairly well with observations, it is hoped that model SP will improve once the partitioning between model SP and DIAT is improved. Note Lima's model has better partitioning (Fig. 9).

6. Data Sources

For Total Chl, the data sources used for comparison so far are SeaWiFS and BATS. (Use more than these?)

For DIAZ (i.e. *Trichodesmium*), the best data sources are Carpenter et al. (2004), Davis and McGillicuddy (2006) and Westberry and Siegel (2006).

For DIAT, the best data sources are Gregg and Casey (2008) and Alvain et al. (2008), who used NOMADS and GeP&Co data (Fig. 11). These data sets however only have surface values (except at BATS); the SeaBASS data set includes concentrations at depth. Note that Gregg and Casey (2008) only give diatom Chl as a percentage of total Chl, and that their spatial and temporal coverage is not great (Fig. 11). Thus some combination of these 4 data sets would be best.

SP can be estimated as Total Chl minus DIAT (and perhaps DIAZ).

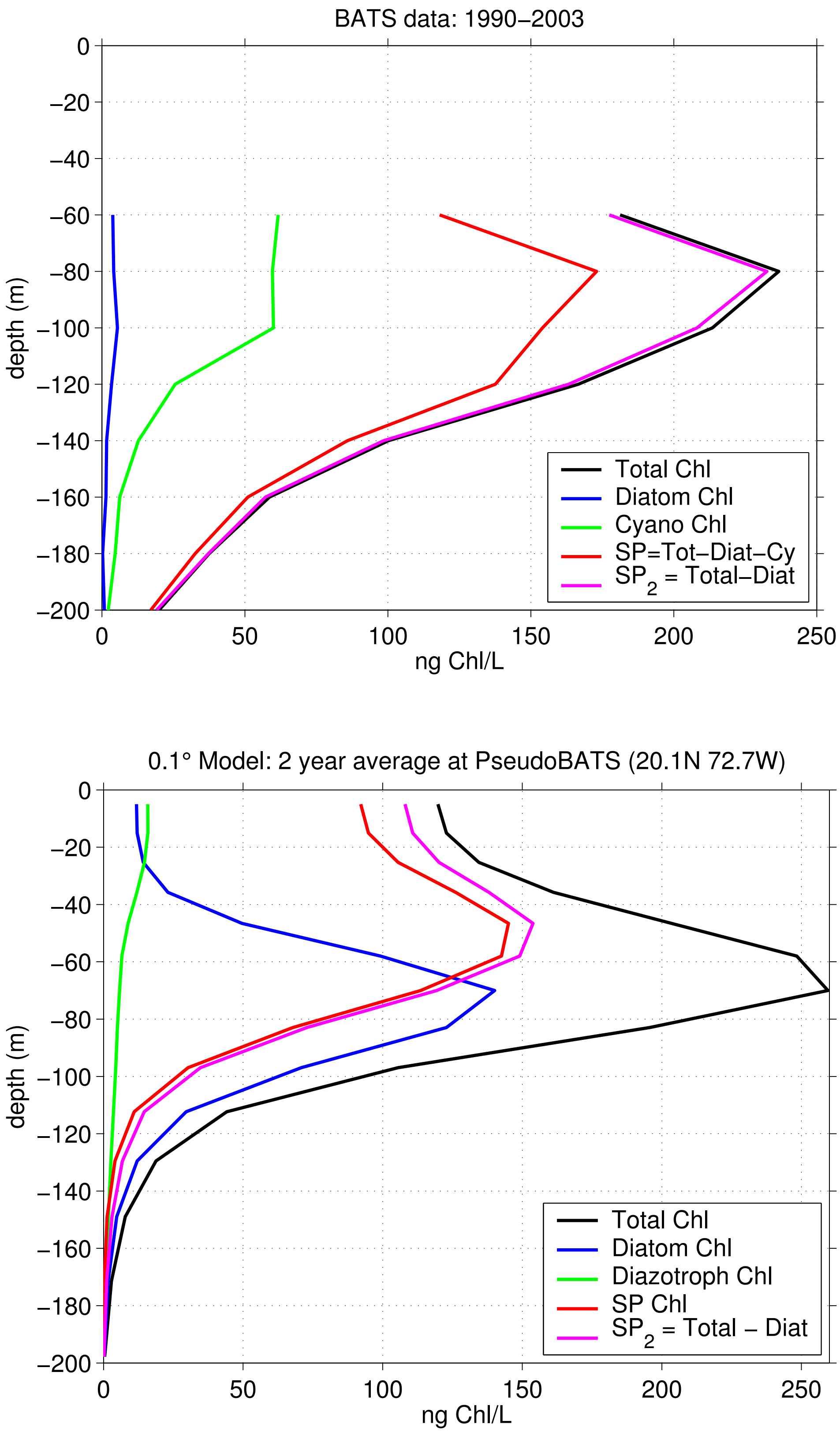

Fig. 1. (a) BATS data, (b) 0.1° Model at PseudoBATS.

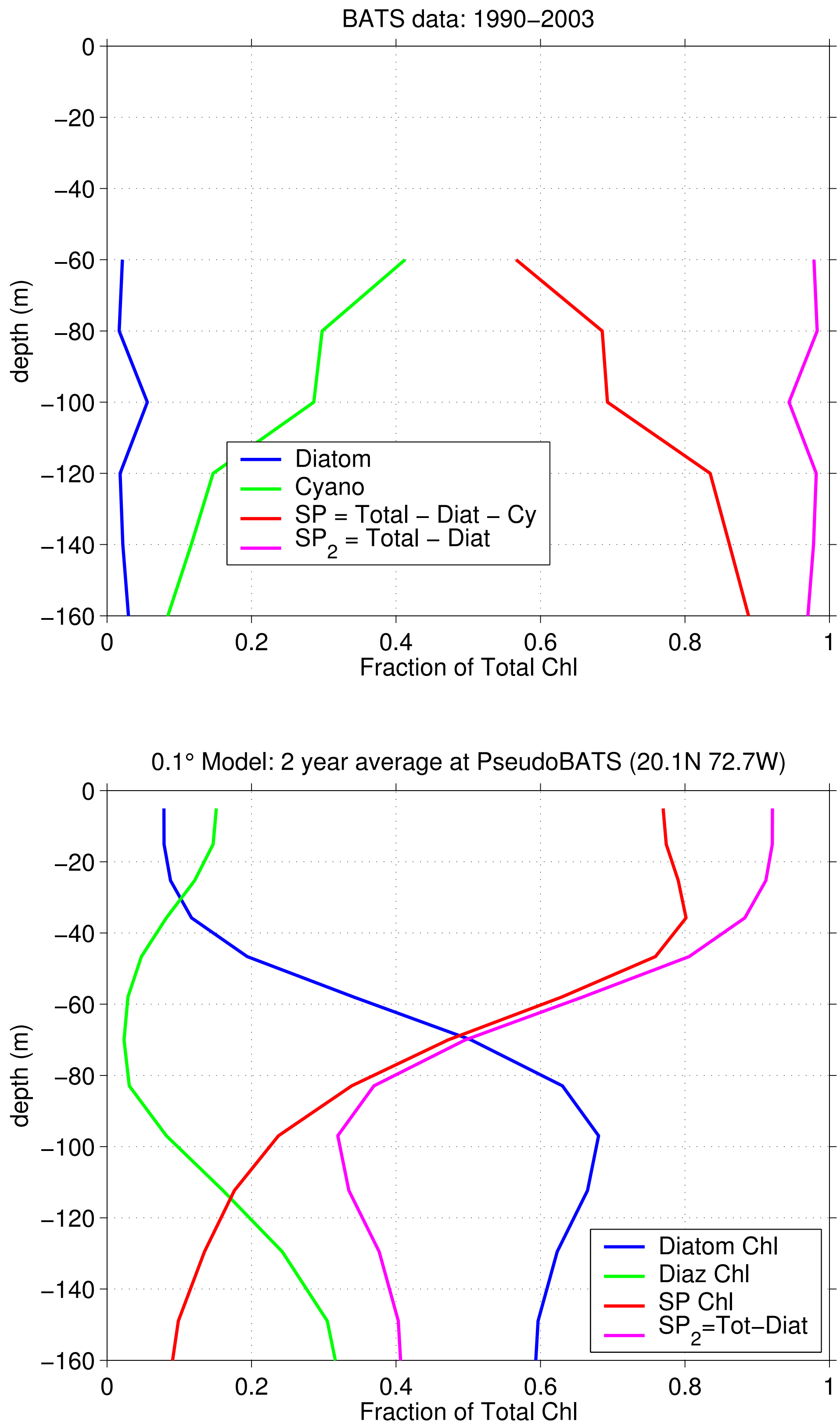

Fig. 2. (a) BATS data, (b) 0.1° Model at PseudoBATS.

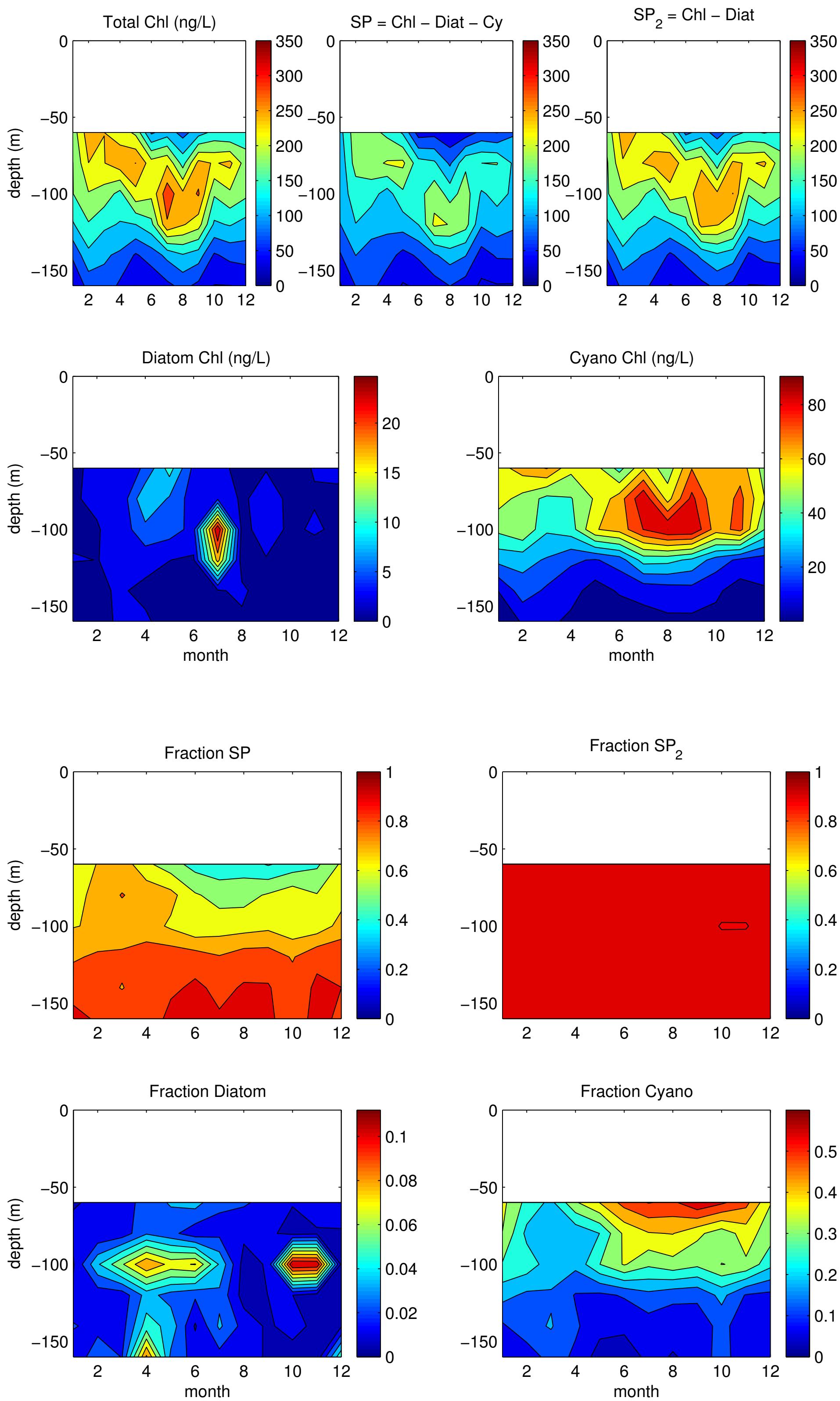

Fig. 3. 1990-2003 BATS data.

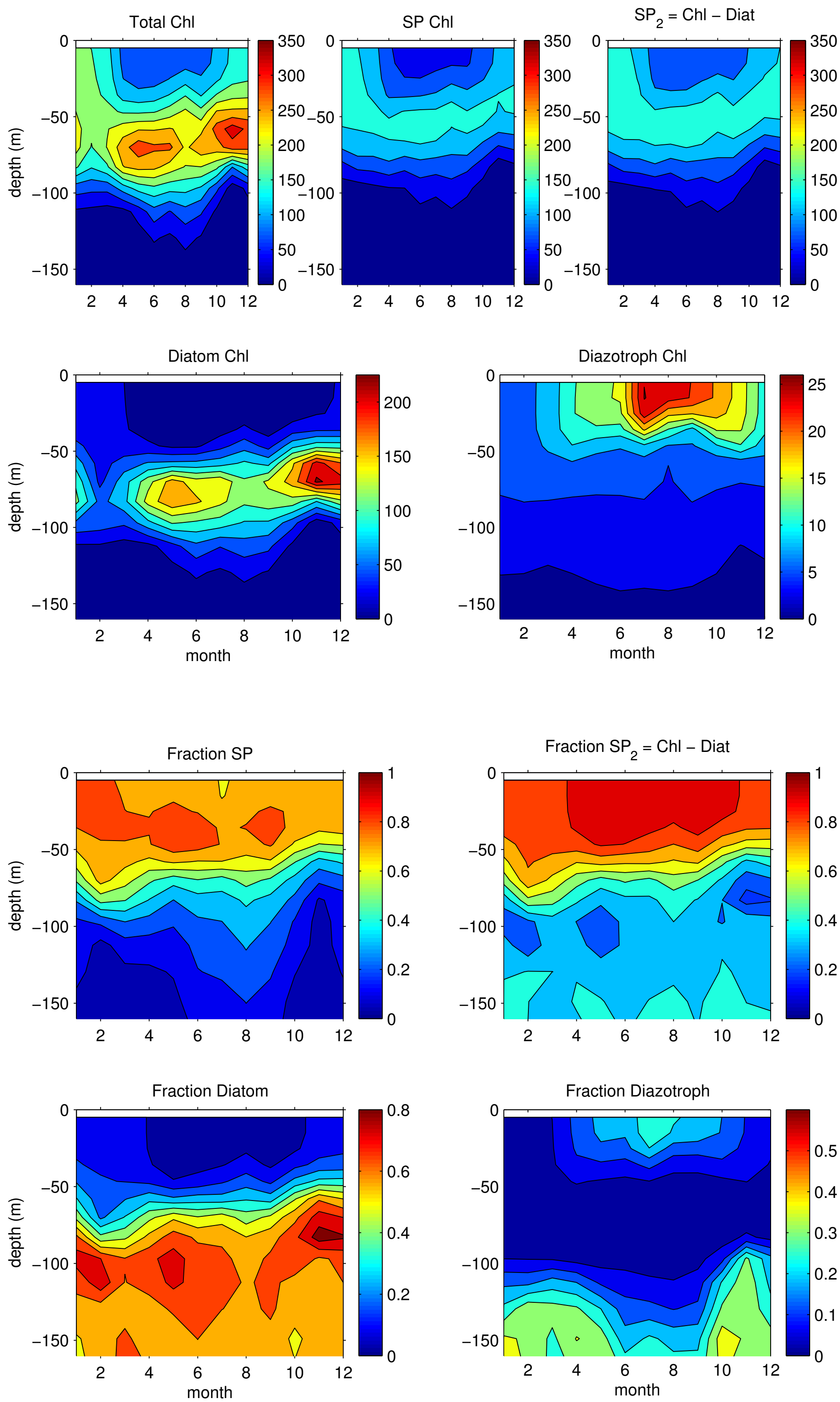

Fig. 4. 0.1° Model at PseudoBATS.

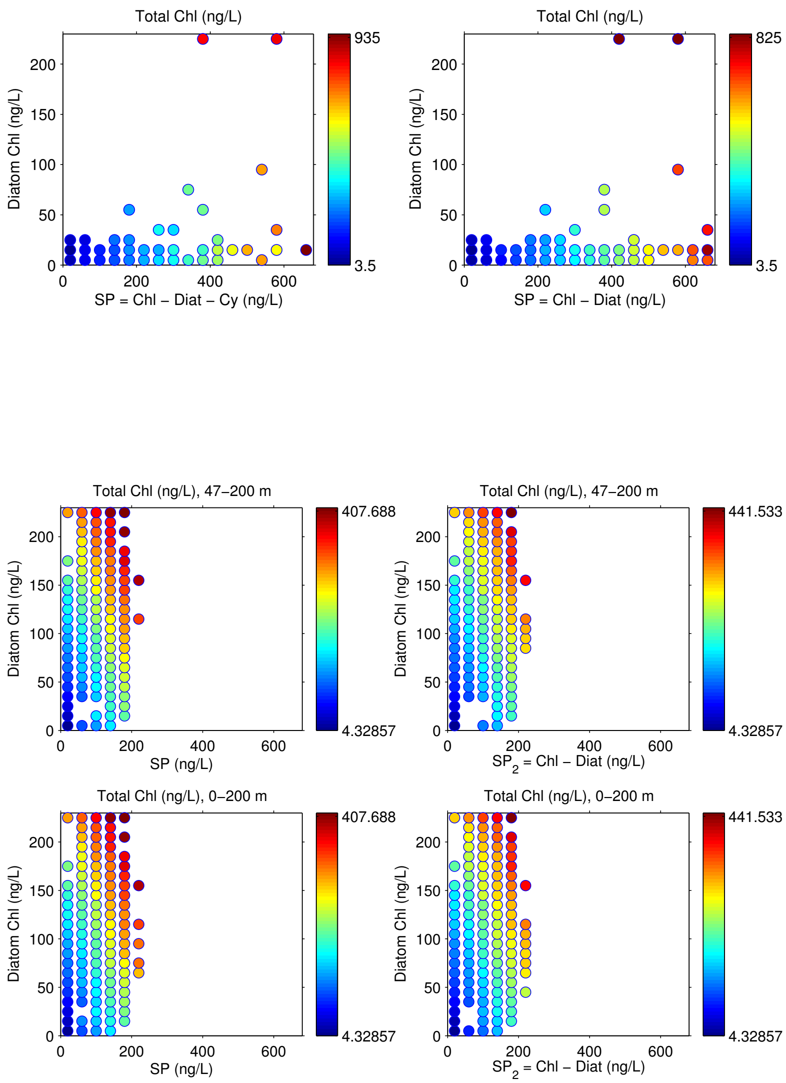

Fig. 5. (a) BATS data, (b) 0.1° Model at PseudoBATS.

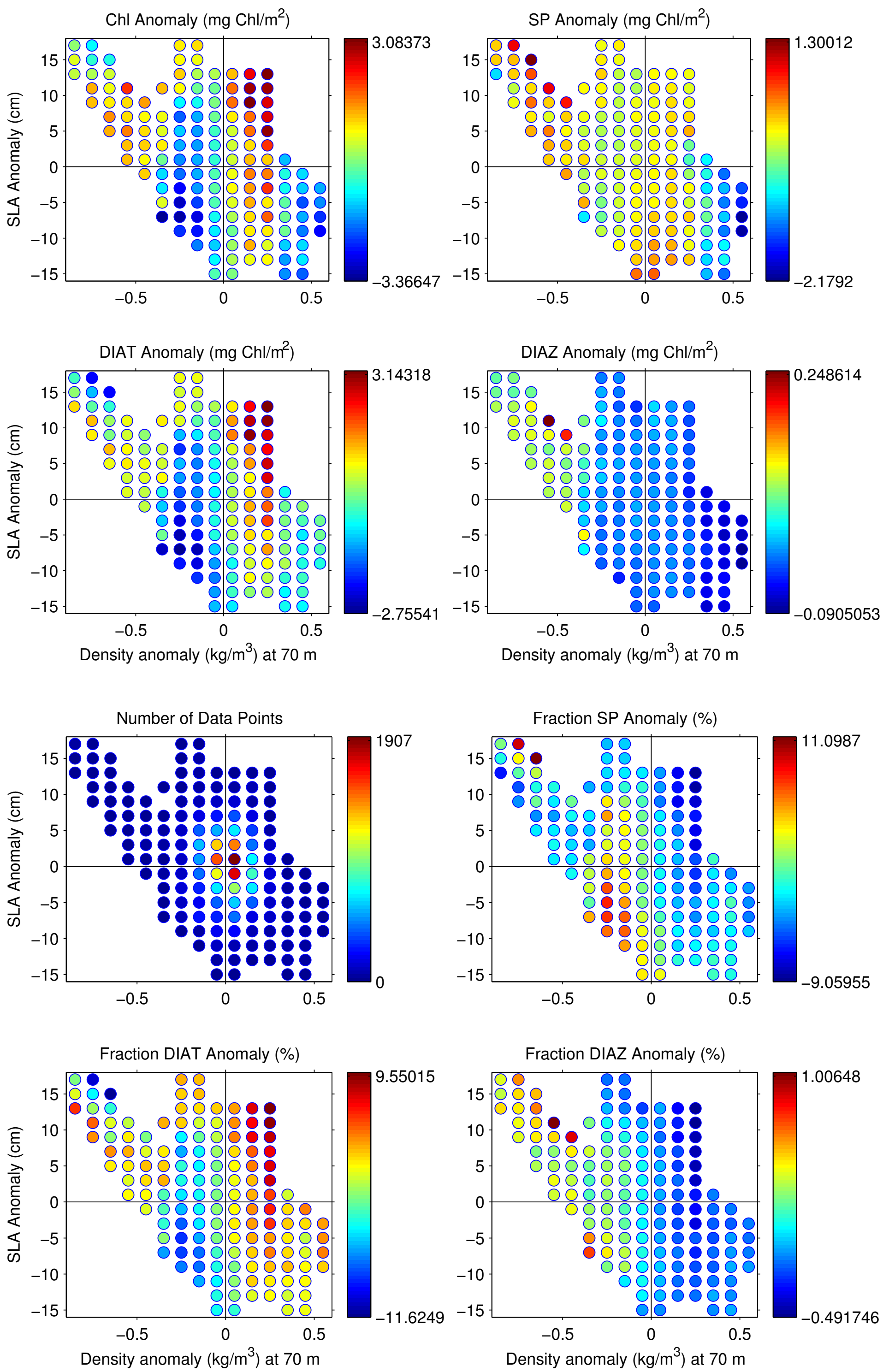

Fig. 6. 0.1° Model, 31.7°N 35-75°W, yeardays 150-300 from 2 years of output.

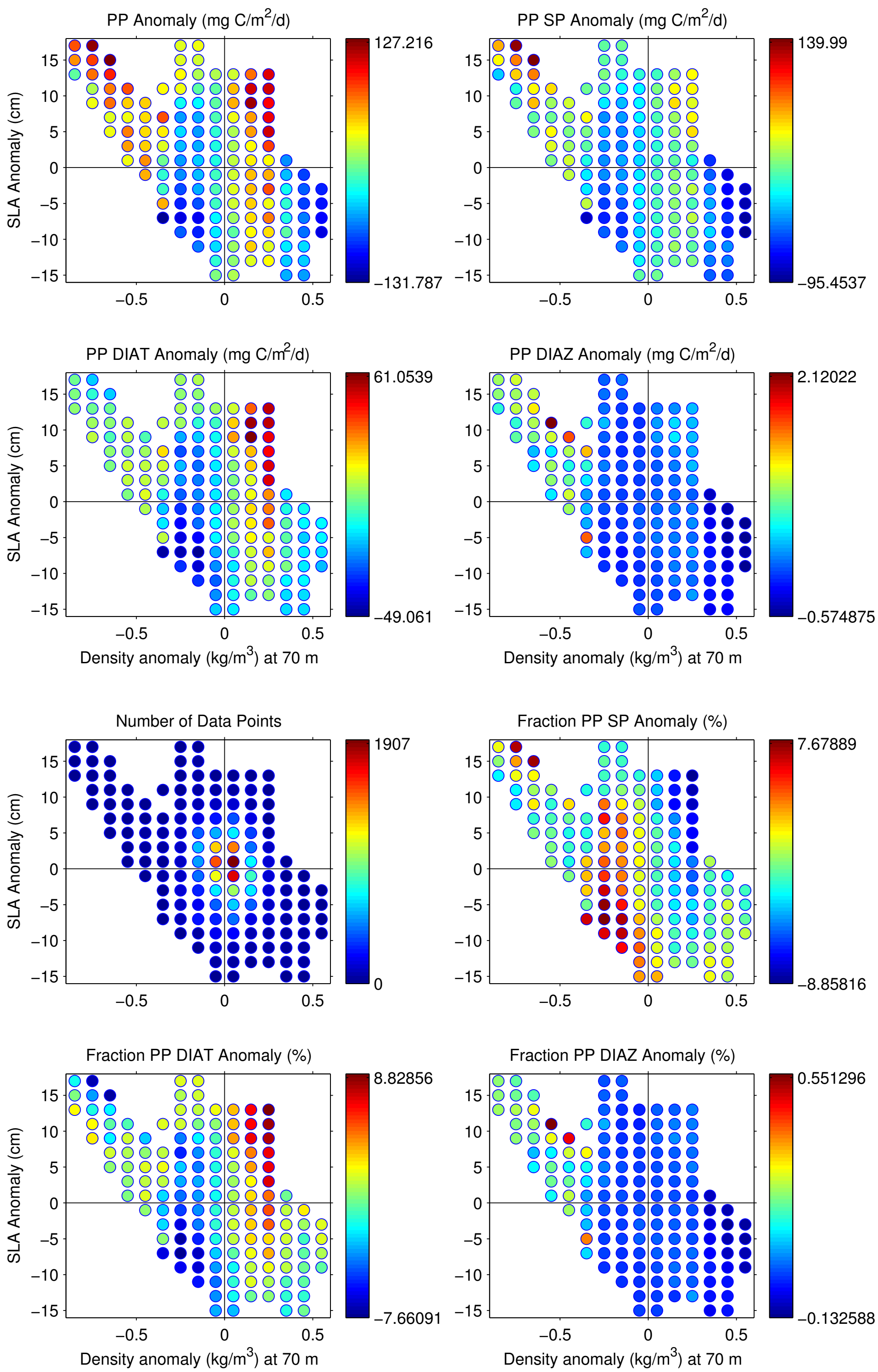

Fig. 7. 0.1° Model, 31.7°N 35-75°W, yeardays 150-300 from 2 years of output.

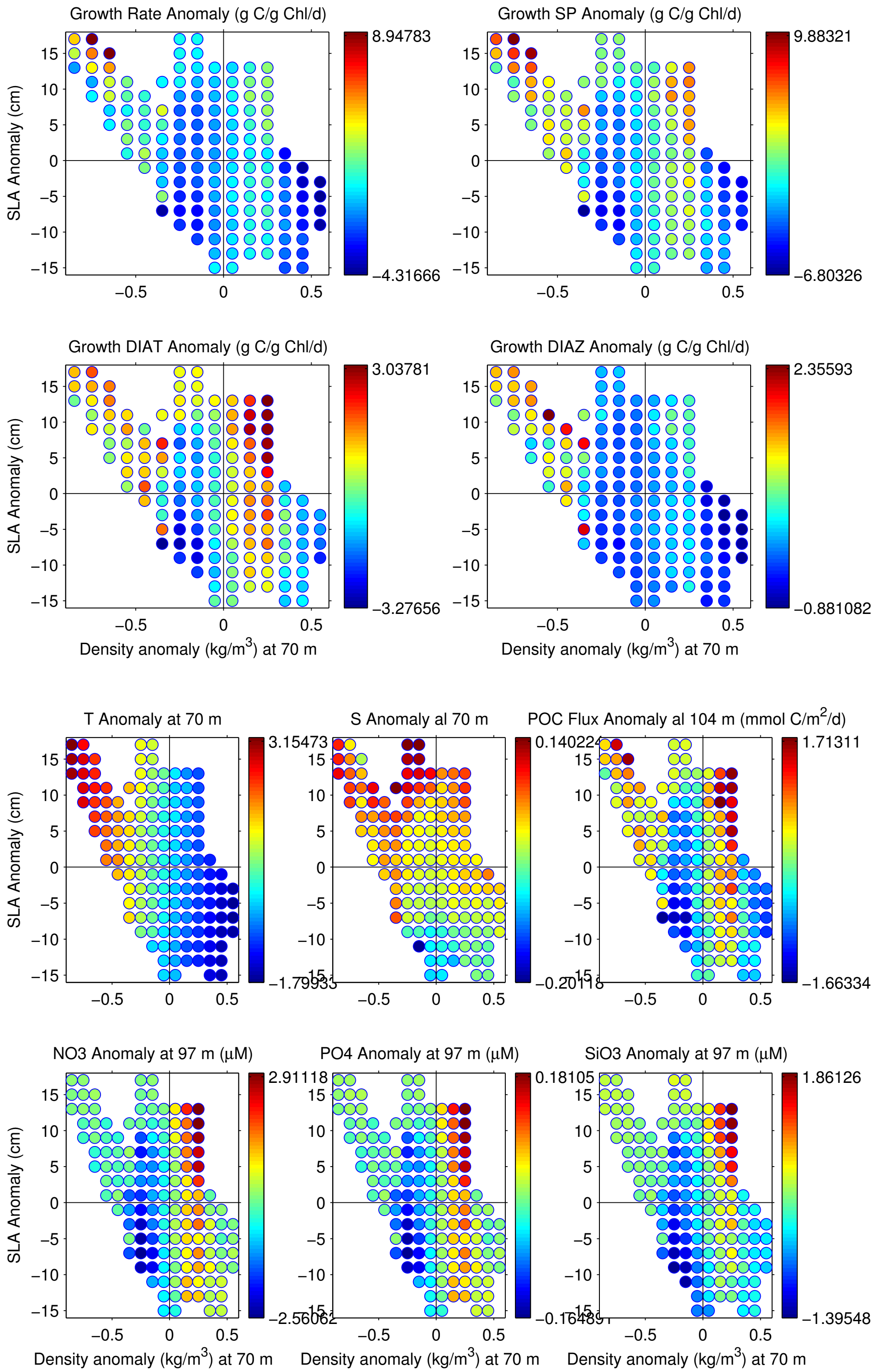

Fig. 8. 0.1° Model, 31.7°N 35-75°W, yeardays 150-300 from 2 years of output.

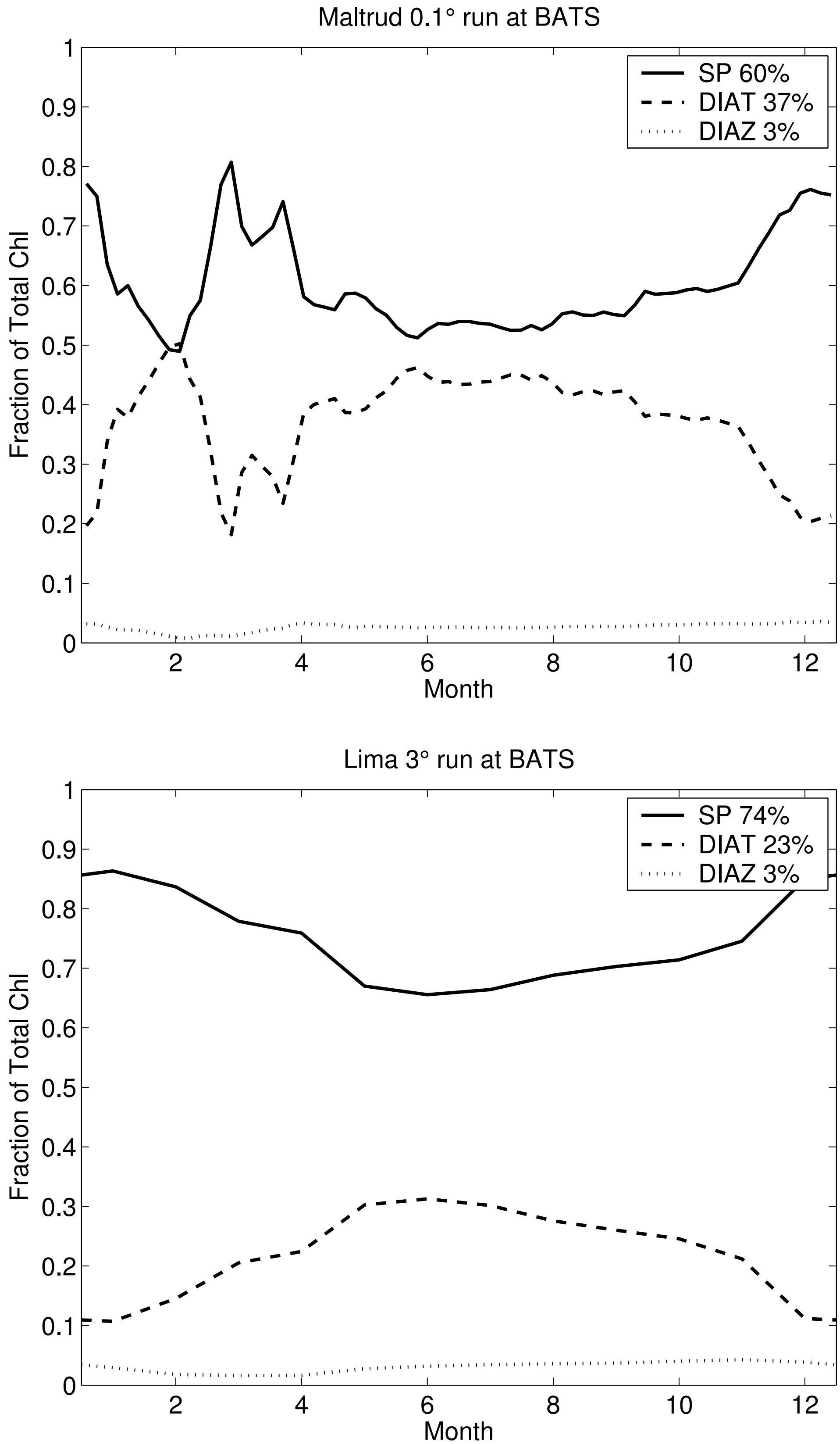

Fig. 9. Model phytoplankton.

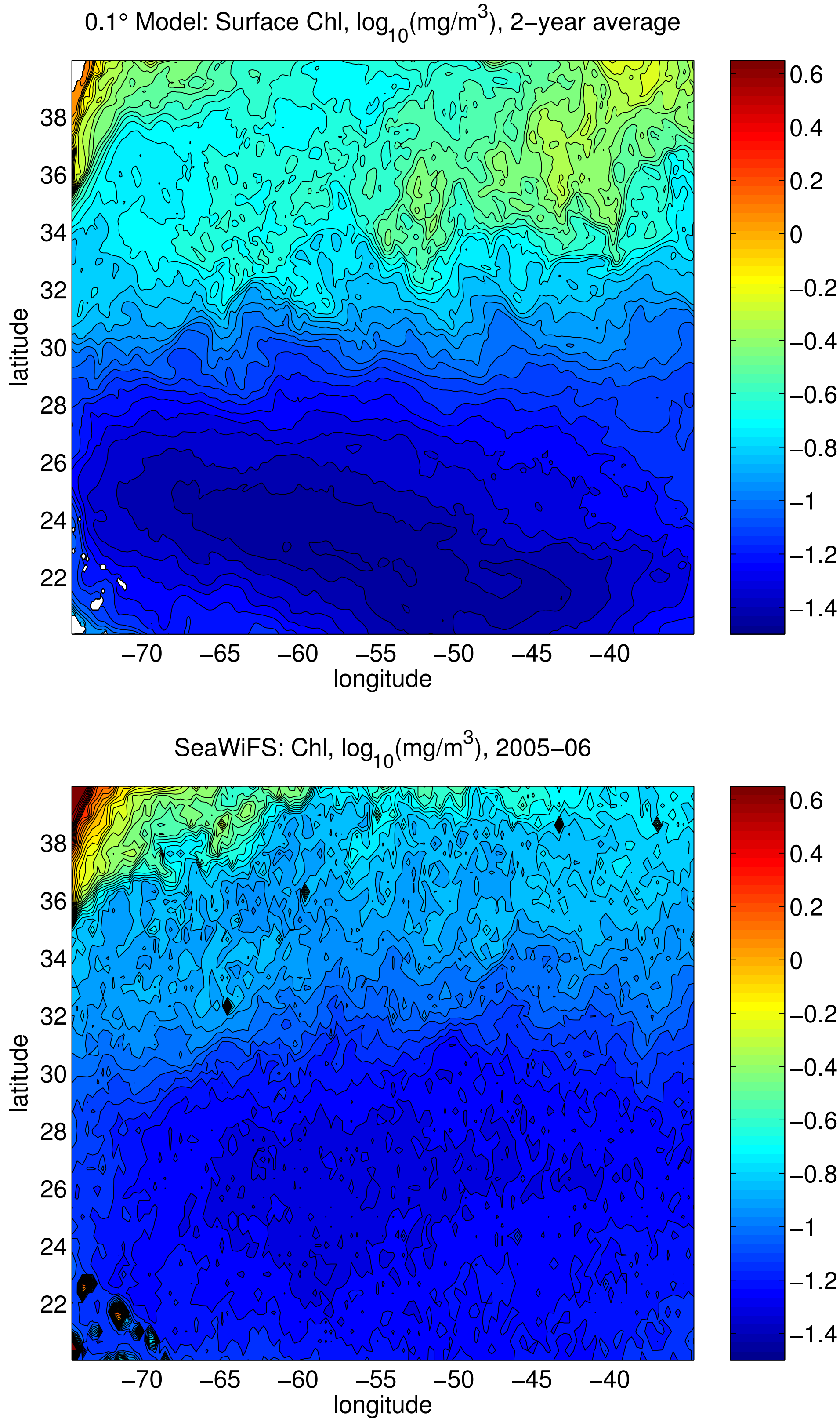

Fig. 10. Surface Chl.

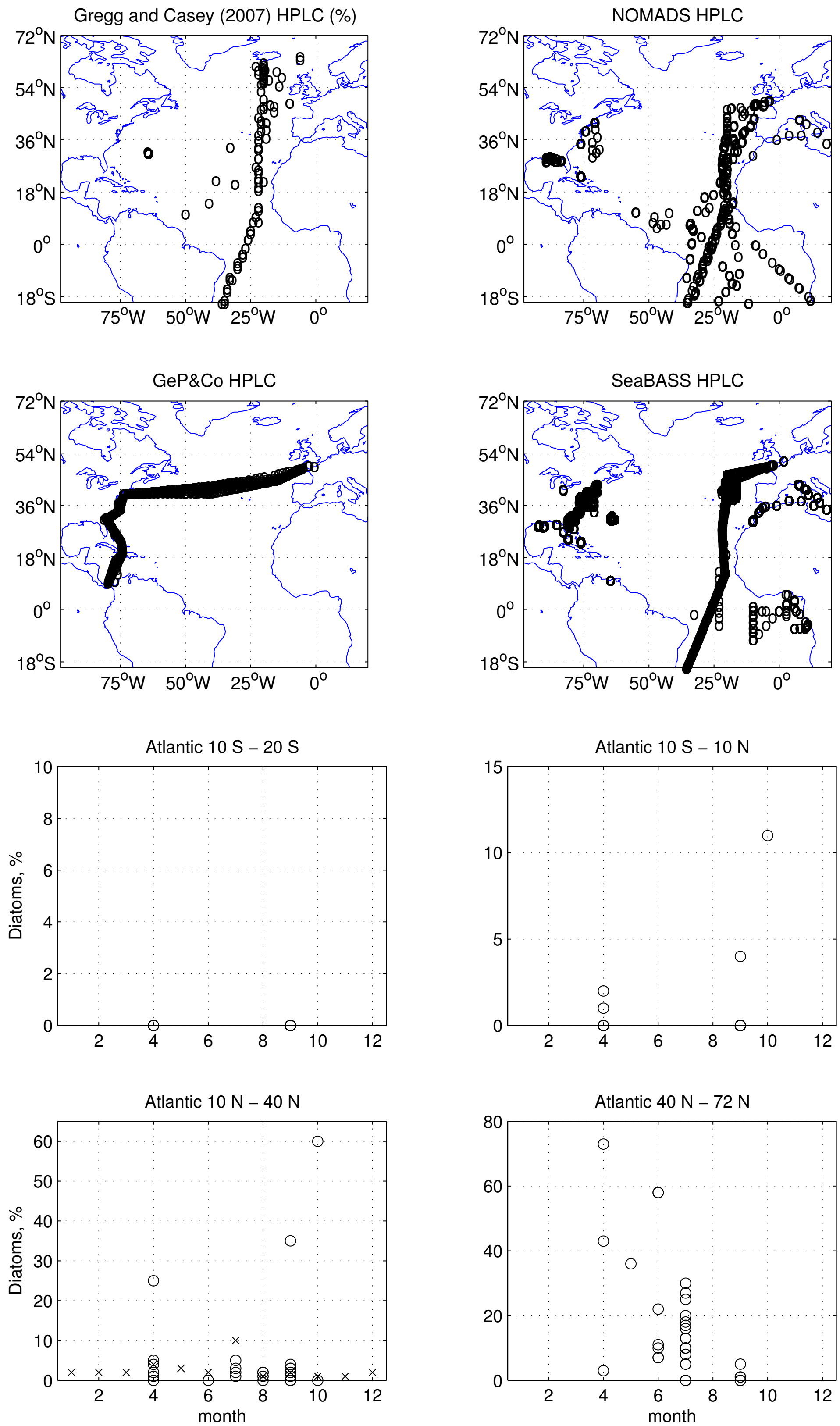

Fig. 11. (a) HPLC Data sets (b) coverage of Gregg and Casey data.