Developing evaluation tools for a chlorophyll algorithm in the US East Coast using Autonomous Underwater Vehicles

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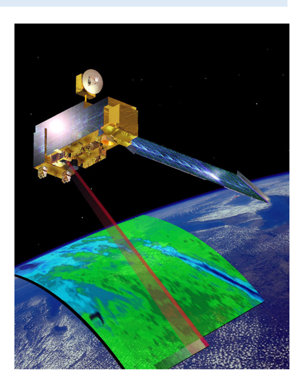
Abstract

The United States Mid Atlantic region is subject to extensive, improving observation efforts in the form of Autonomous Underwater Vehicle (AUV) surveys, fixed profiler and buoy records, terrestrial HF radar current measurements, and remotely sensed data products from satellites. Satellites provide large spatial coverage of ocean properties over regular time intervals, but these estimates are known to diverge from in-situ measurements, especially estimates of chlorophyll. Chlorophyll is the main photosynthetic pigment in phytoplankton, which form the base of all marine food webs, and is important for estimating global net primary productivity (NPP) and carbon budgets. By using AUV optical data to produce a regionally tuned remote sensing chlorophyll algorithm, a higher quality data product can be derived and included in Mid Atlantic efforts to observe and model an area of high importance to the ocean observation and ocean color community.

Problem

- Satellite remote sensing chlorophyll estimates cover large areas of the ocean but are known to overestimate by as much as 100% (Blondeau-Patissier et al., 2014).
- Accurate chlorophyll measurements on global ocean basin scales are required for global estimates of net primary production and carbon budgets (Lee et al., 2015).
- Autonomous underwater vehicles (AUVs) collect high spatial & temporal resolution in-situ data of optical properties, but no standard exists for hosting optical data and it is often omitted in online repositories.
- High quality in-situ optical data from AUVs contains physiological biases (NPQ) and diverge from the community-accepted in-situ standard, HPLC (Roesler et al., 2017).



Methods

- Define spatial extent of data acquisition and algorithm domain, latitude North 50º to 16.5º and longitude West -100º to -50º.
- Build list of potential usable glider missions from NOAA IOOS NGDAC, (National Glider Data Assembly Center) n=235.
- Obtain point of contact for eligible glider mission data providers.
- Request full raw mission records from each POC under these criteria
  - Glider mission must have recorded optical data.
  - <u>**Optical sensor must have been factory calibrated within a year of deployment date.**</u>
- Process raw glider files, examine plots of sst, chl, backscatter for continuity & re-process/exclude broken missions.
- Interpolate glider gps lat/lon, compile all glider missions into one data structure and subset top 10m. ~6M observations.
- Subset by ±3 hour time window, both sensors pass over US east coast ~1:30 pm EST. ~1.5M observations.
- Match glider [lon,lat,time] to satellite chlorophyll from MODIS and VIIRS and create plots. ~450k VIIRS , ~330k MODIS matches.
- Apply averaging by satellite pixel and perform linear regressions.

Figure 1

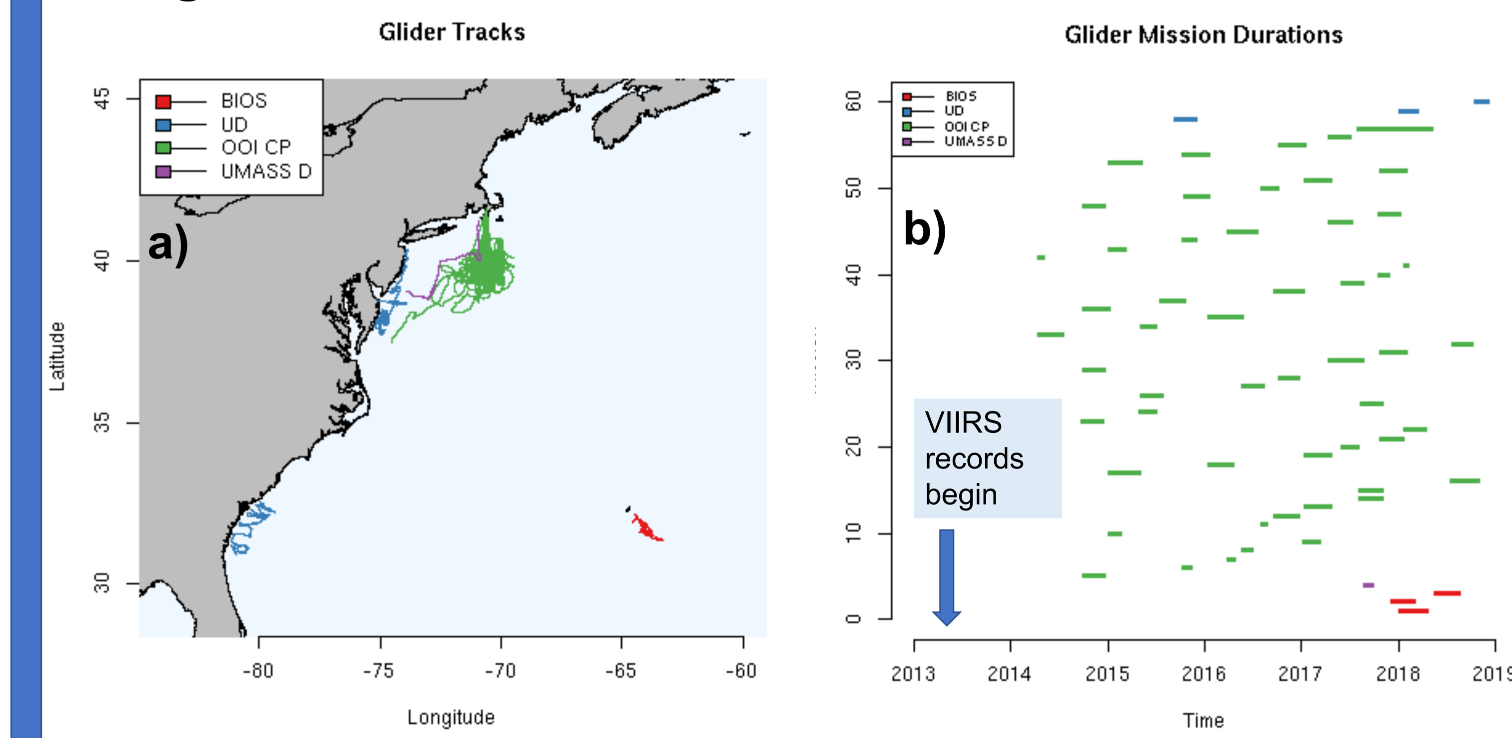


Figure 1: a) Compiled mission tracks and b) timeline of mission durations.

Figure 2 **Glider/satellite match up**

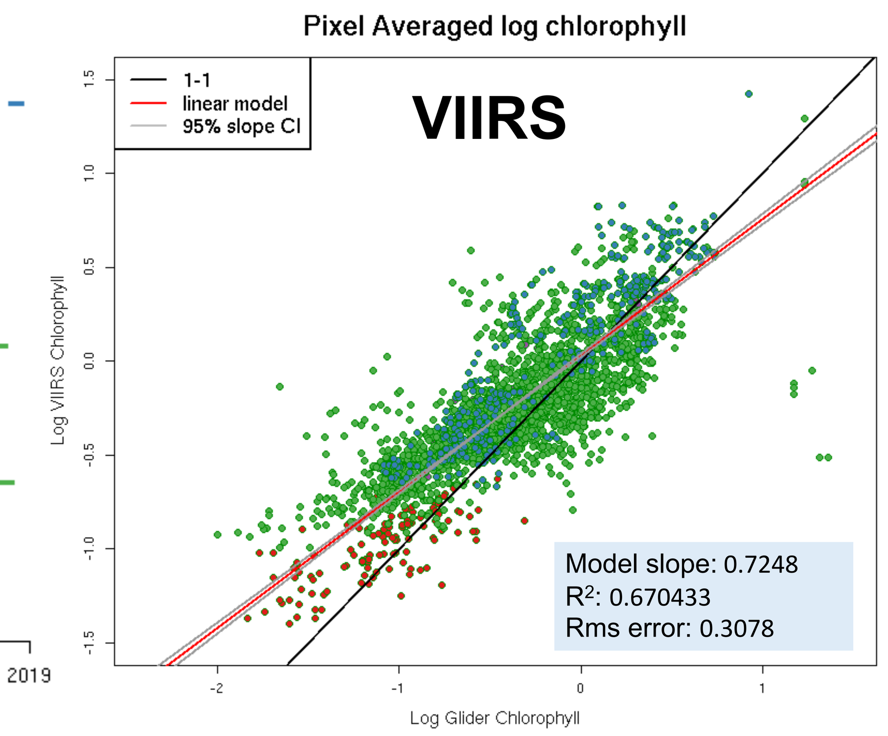


Figure 2: Spatially averaged log10 glider chlorophyll against matched VIIRS 1-day log10 chlorophyll.

Non Photochemical Quenching (NPQ) corrections

Figure 3

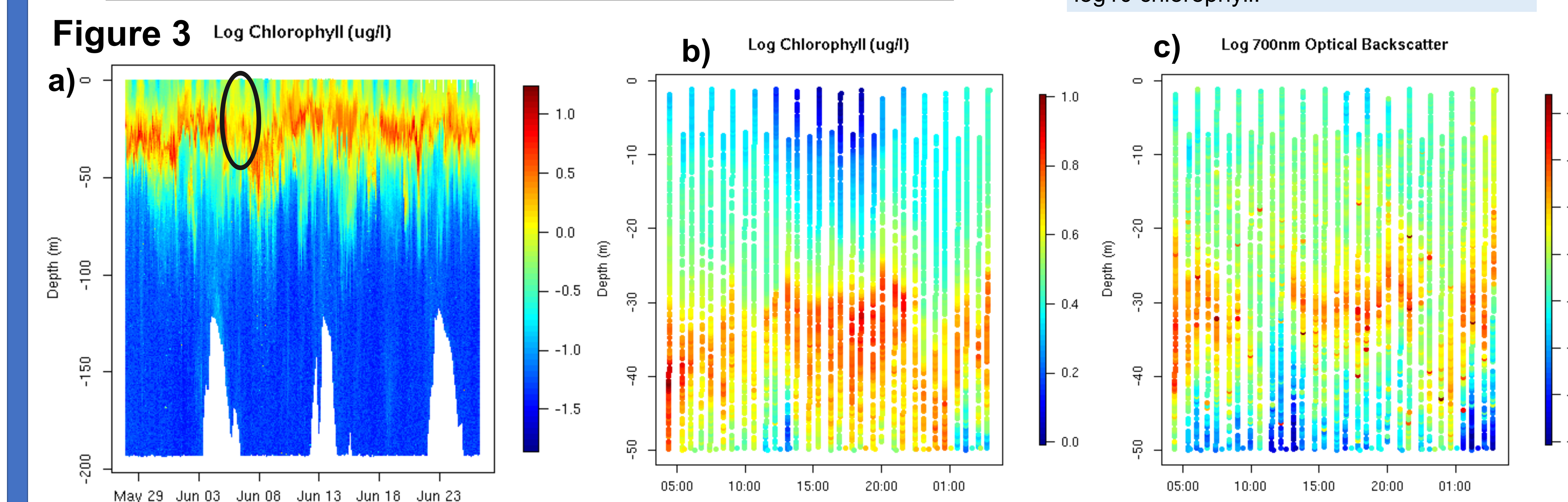
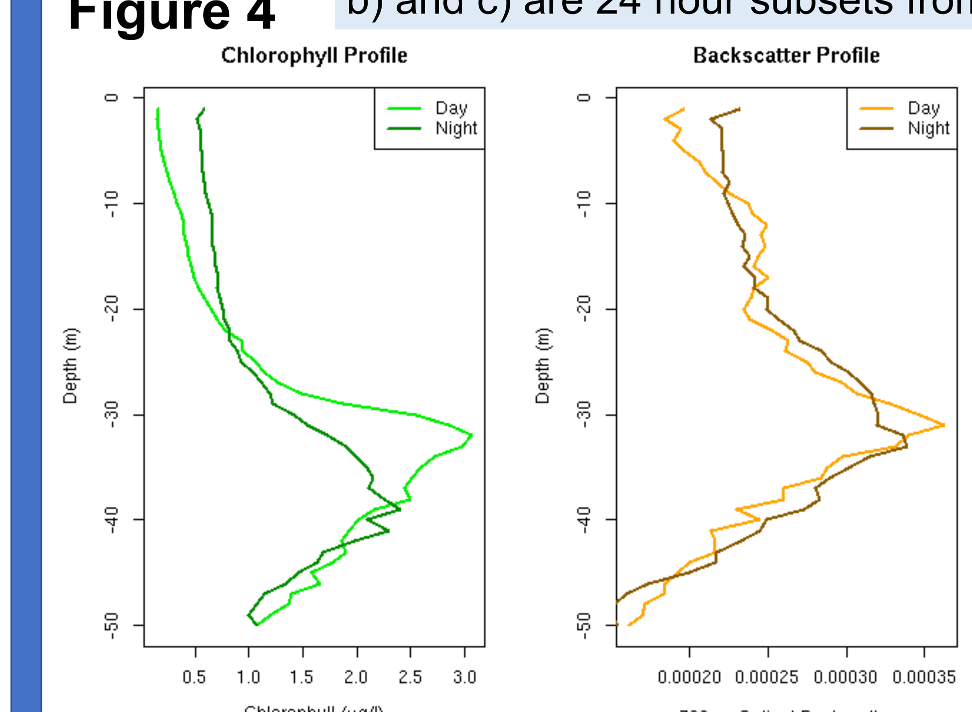


Figure 3: a) Full profile log chlorophyll from OOI mission cp_335-04 with clear NPQ effects on a daily period. b) and c) are 24 hour subsets from selection in a) showing log chlorophyll and backscatter in an NPQ event.

Figure 4

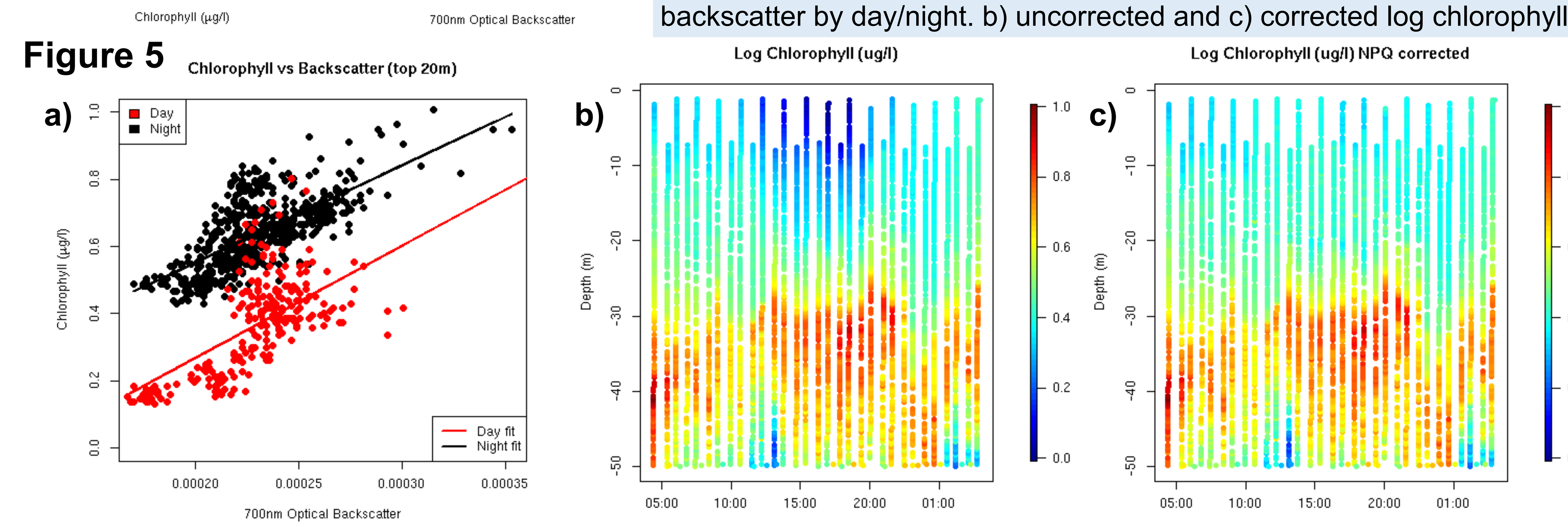


<u>NPQ correction scheme</u>: Backscatter is a physiology-independent optical proxy for biomass. NPQ corrections of chl can be performed in this way:

1. Isolate a single 24 hour period and define where NPQ is suspected (daytime). Day defined as sun angle >60º, night as sun angle < -5º.
2. Model the chlorophyll response as a function of backscatter where NPQ is observed (top 20m from Figure 4).
3. Calculate corrected chlorophyll from non-NPQ model and backscatter where sun angle > 10º to avoid overcorrecting transitionary values.

Figure 4: Vertical profiles of chlorophyll show the depression of chl from NPQ to 20 meters. Backscatter, an IOP, shows little day/night change.
Figure 5: a) Scatter and model 2 regressions of chlorophyll vs backscatter by day/night. b) uncorrected and c) corrected log chlorophyll.

Figure 5



Conclusions

1. AUV observations provide high resolution in-situ data that can potentially validate remote sensing products when processed to similar spatial and temporal resolutions.
2. Preliminary match-ups between in-situ chlorophyll from AUVs and remote sensing chlorophyll could be biased due to NPQ effects.
3. NPQ correction is necessary for confidence in in-situ fluorometric chlorophyll but difficult to generalize.

Future Work

- Increase in-situ spatial coverage by acquiring more glider missions or including other in-situ datasets.
- Generalize NPQ corrections to be applied to each glider mission.
- Investigate additional fluorometric corrections (FDOM).
- Seed and train a MODIS & VIIRS chlorophyll algorithm.
- Test how algorithm recreates past & future chlorophyll imagery.

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See my web app that inspired this research!
http://basin.ceoe.udel.edu/shiny/sample-apps/glider/