Thin plankton layers in the ocean

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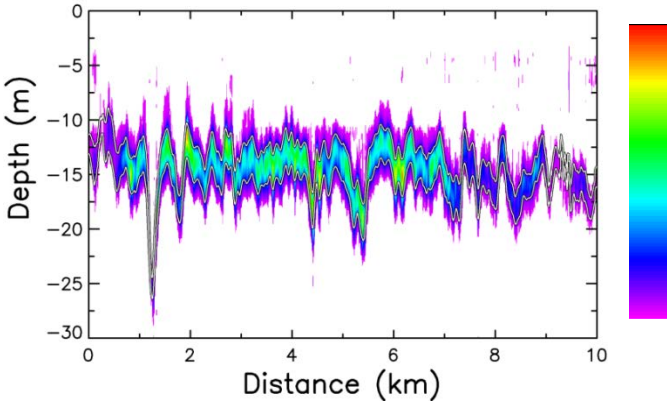
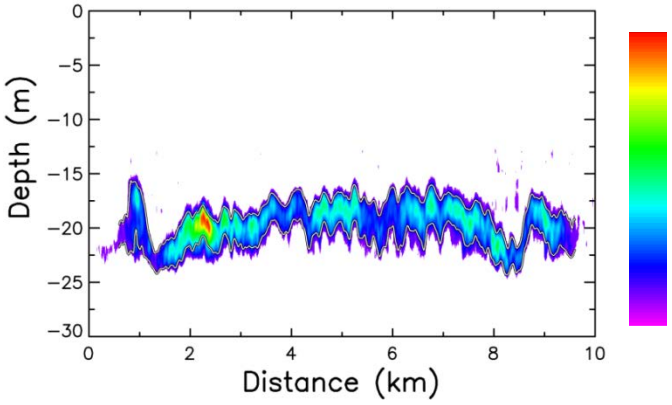
CSD Oceanographic Lidar on NOAA Twin Otter

- Motivation: Satellite estimates of column-integrated primary productivity use surface chlorophyll. What are the effects of stratification?
- Approach: Use modified atmospheric aerosol lidar to measure phytoplankton profiles. (We have measured > 100 million lidar profiles of the ocean and Great Lakes.) Infer productivity from lidar profiles.
- Results: Thin (< 3 m) layers of plankton form as a response to ocean stratification. These layers increase primary productivity.

Thin Plankton Layers



Continental shelf off Portugal



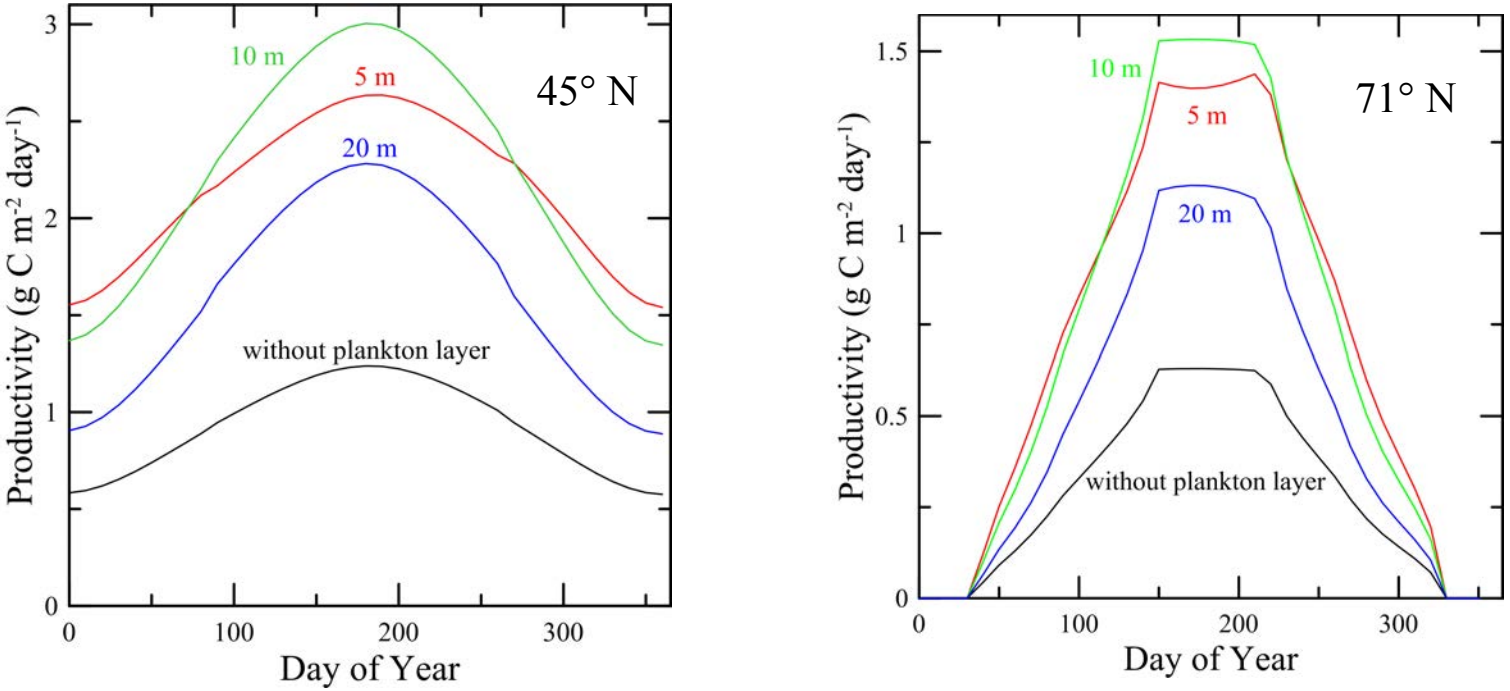
Deep water in Gulf of Alaska

Relative lidar return

- We demonstrated that thin (< 3 m) phytoplankton layers can extend for > 10 km, even in the open ocean (Churnside & Donaghay, 2009) and in large internal waves (Churnside et al., 2012).
- These layers are a response to stratification in the water column.
- They are characterized by enhanced primary productivity, Harmful Algal Bloom (HAB) growth, secondary productivity, fisheries recruitment, and carbon export.

Stratification produces persistent, thin plankton layers.

Primary Productivity

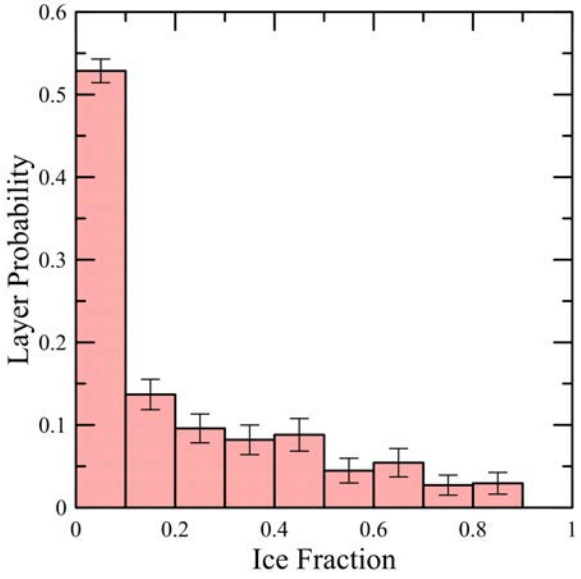


Modeled primary productivity (photosynthesis by phytoplankton) by year day with 3 m thick layer at various depths.

A thin plankton layer can increase the total column-integrated primary productivity by a factor of 2 – 3.

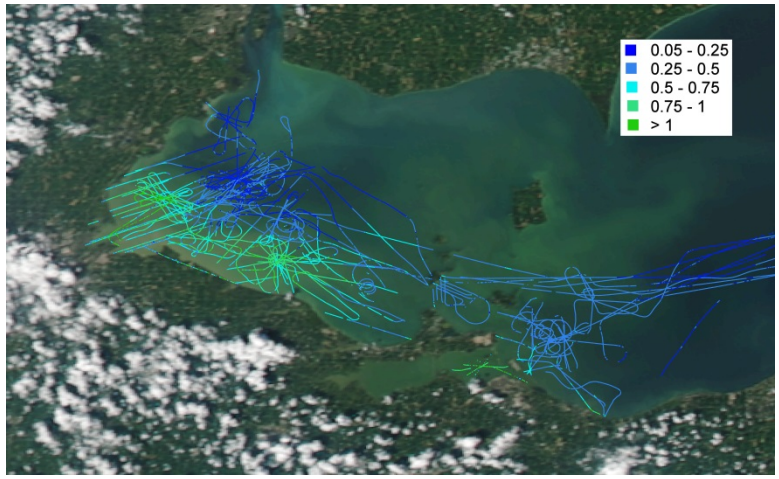
Recent Observations

We detected subsurface plankton layers in the Arctic Ocean, where stratification is associated with retreating sea ice.



We detected toxic blue-green algae in Lake Erie, where growth rates are associated with terrestrial nutrients.

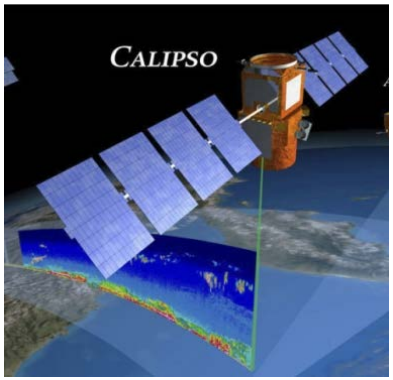
Will calibrate with in situ data from GLERL.



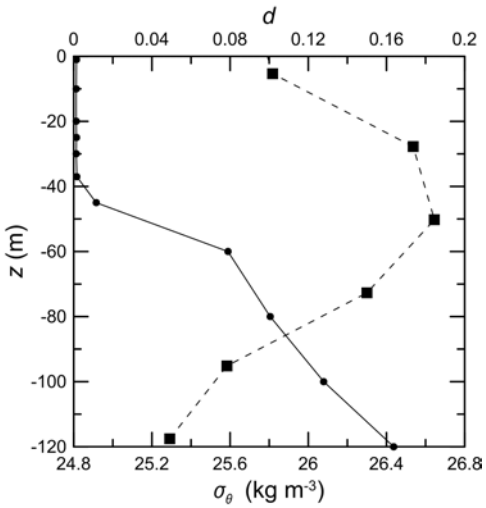
Lidar data over MODIS image of western Lake Erie.

Aircraft can identify rapid changes.

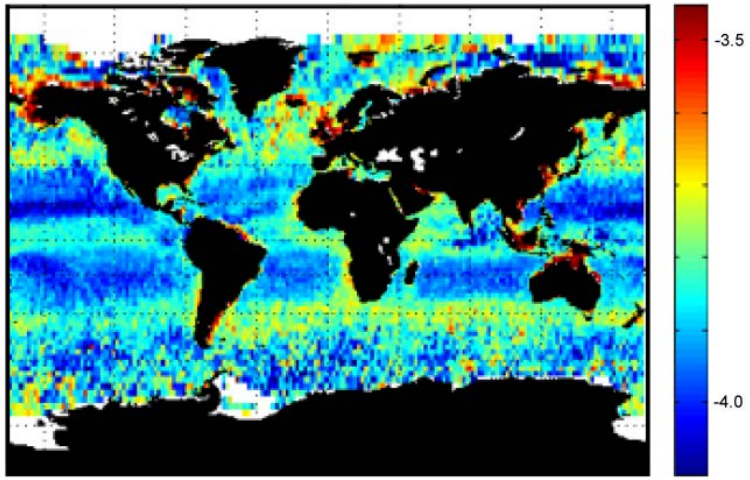
Detection from Space?



- Lidar on CALIPSO satellite has all the necessary performance except range resolution.
- We demonstrated that it can detect sub-surface ocean returns (Churnside et al, 2013; Lu et al, 2014).



Lidar and in situ density profiles.



Global subsurface lidar return

Global measurements from satellite are feasible.

Future Directions

- Improve quantitative retrievals of chlorophyll concentration profiles based on existing forward model (Churnside, 2008; Lee et al, 2013).
- Continue investigation of layer formation in the Arctic.
- Develop (with GLERL) pilot-only HAB monitoring system for transition to unmanned aircraft.
- Improve primary-productivity model.
- Explore bio-aerosol production using atmospheric portion of lidar return.