The role of bio-optical traits for phytoplankton biogeography
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1. Motivation
Phytoplankton community structure results from competition and selection between species with different characteristics, or traits. For example, they contain species-specific combinations of pigments that absorb different wavelengths of light. The efficiency of light absorption is important for phytoplankton growth rates at low light. However, the exact role of pigments for setting phytoplankton biogeography on global scales remains unclear.

…we assess the importance of pigments for driving phytoplankton distributions in the ocean.

2. The model
Phytoplankton with realistic (species-specific) pigments are resolved in a global biogeochemical and ecosystem model [Dutkiewicz et al. 2015]:
- 1° resolution, 23 levels, ECCO-GODAE (Wunsch & Heimbach 2007)
- Radiative transfer in 25nm wavebands between 400-700nm (Gregg & Casey 2007)
- Absorption and/or scattering by water, CDOM, detritus and 9 phytoplankton types (Fig1, Fig2) (Dutkiewicz et al. 2015, Hickman et al. 2010)
- Phytoplankton have unique growth dependences (e.g. on N, P, Si, Fe), growth and grazing rates (Ward et al. 2012). LLPro are susceptible to photo inhibition, Diatoms have high max Chl-a. Each phytoplankton is assigned realistic pigments and light absorption spectra.

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3. Pigment distributions
Model fields including phytoplankton pigment concentrations and community structure compare well to observations made along an Atlantic meridional transect and globally.

Fig 3. Primary production
Fig 4. Pigment concentrations along Atlantic meridional transect

…the model captures key patterns in community structure and pigments.

4. Role of bio-optical traits
We used a suite of experiments to explore how the pigments help set the biogeography.

Maps of dominant phyto: Diaton, Cocicos, Pro
SeaWiFS

- Default

- Expt1: …the only difference between phyto is their absorption spectra (all other trait values the same, black dot in Fig2).
- Expt2: …all phyto have same light attenuation (i.e. have same effect on shading).
- Expt3: …six phyto each absorb with only one pigment (all other trait values the same, black dot in Fig2).

Maps of annual mean biomass (mg C m⁻²) of each phyto along the Atlantic transect.

- North Atlantic
  40°N (high biomass)
- South Atlantic Gyre
  20°S (low biomass)

5. Conclusions
• Pigments are important for biogeography but can act either in concert with or antagonistically to other traits
• Self shading by particular pigments is less important for distributions than efficient absorption of available light.
• The light spectrum is principally set by the total concentrations of phytoplankton, CDOM and non-algal particles
• The common pigments are not very well suited to the bluest light at at depth in the oligotrophic gyres

References: