Signatures of the multiple scales of motion in shaping marine phytoplankton biogeography

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*Dutkiewicz*: Signatures of the Multiple Scales of Motion in Shaping Marine Phytoplankton Biogeography
PROJECT GOALS

- Describing and understanding dynamic phytoplankton community biogeography from few kms to basin scales

- The observable signatures of these multiscale biogeographical patterns in satellite and in-situ data: how to monitor now and in future

- What is missed when the various scales are not resolved in observations and models
• Data constrained ocean circulation models
- Data constrained ocean circulation models
- Complex marine ecosystem model
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• Complex marine ecosystem model
• Satellite data
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• Complex marine ecosystem model

• Satellite data
• High resolution in situ data

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Tools to explore these:
• Machine learning
• Lagrangian tracking
• Subsampling techniques
• Ecological Theory

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ONGOING PROJECTS

Model Simulations:
- LLC90 (ECCO-v4) 20 year (1 degree)  
  - Forget
- CS510 (ECCO2) 20 year (18km)  
  - Jahn
- LLC4320 14 month (2km)  
  - Jahn, Hill

Projects:
- Model study of role of sub- and mesoscale affecting communities  
  (Magnolte, Levy, Dutkiewicz, Jahn, Clayton)
- Co-location SeaFlow and satellite to explore mesoscale structuring of pico-phytoplankton  
  (Cape, Ribalet, Armbrust, Hynes, Ashakezari)
- Model Study of phytoplankton decorrelations scales  
  (Kuhn, Dutkiewicz, Jahn, Clayton, Rynearson, Barton)
- Nutrient and temperature controls on Prochlorococcus growth rates  
  (Ribalet, Dutkiewicz, Armbrust, Casey)
- Defining eco-provinces with unsupervised machine learning  
  (Sonnewald, Dutkiewicz, Hill, Forget)
- Modelling the response of marine ecosystems to lava fertilization  
  (Jahn, Dutkiewicz, Hill, Wilson, Hawco, Karl et al)
- Constraining air-sea carbon fluxes in a model  
  (Carroll, Menemenlis, Dutkiewicz, et al)
- Modelling BioArgos floats for determining optimal monitoring of marine biogeochemistry and ecology (Forget)
- Determining carbon biomass of pico-phytoplankton assemblages from SeaFlow cell Counts  
  (Ribalet, Armbrust, Cape, Hynes, Ashakezari et al)
- Scales of plankton competition versus Lagrangian dispersal  
  (Rahmandan, Britten, Follows, Hill)
ECOSYSTEM MODEL

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ECOSYSTEM MODEL

Biomass of Smallest Phytoplankton (mmol C/m³)

- One-Degree (Gael)
- 1/6-Degree (Oliver)
- 2-km (Oliver)

Log-mean of phytoplankton size (ESD)

Depth (m)

1 DEGREE

18 km

2 km

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ECOSYSTEM MODEL

Biomass from Continuous Flow Cytometer

Pico-eukryotes
Synecococcus
Prochlorococcus

log-mean of phytoplankton size (ESD)

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Phytoplankton communities

18 km resolution

2 km resolution

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Phytoplankton communities

Transect in N Pacific

Dinoflagellates
Diatoms
diazotrophs
Coccolithophores
Pico-eukaryotes
Pico-prokarytes

18 km resolution
DEFINING ECO-PROVINCES

Machine learning tools to cluster similar grid cells into provinces

Dimensionality reduction

Clustering

Back-projection

using 1 degree resolution model
DEFINING ECO-PROVINCES

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see poster
DETECTING ECO-PROVINCES

Future work:
- Dynamic regions
- How much of these eco-provinces can we detect from space: use model $R_{RS}$, SST, SSH, Chl, MLD, PAR
- Scale to finer resolution models

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SCALES OF COMMUNITY STRUCTURE

Brey-Curtis dissimilarity:

\[ C_{g_i g_i+} = 1 - \frac{2 \sum_{j=1}^{n} \min(B_{j g_i}, B_{j g_i+})}{\sum_{j=1}^{n} B_{j g_i} + \sum_{j=1}^{n} B_{j g_i+}} \]

\( B_j \) biomass of each of 35 phytoplankton

\[ \sigma_j = \frac{1}{n_{B_j g_i} + \sigma_j} \]

mean of 9x9 grid cells relative to the center grid cell

identical communities

2 km resolution
SCALES OF COMMUNITY STRUCTURE

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MODEL Chl-a

18 km resolution

2 km resolution

Chl-a

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LINKS TO IN SITU DATA

Prochlorococcus
Synecococcus
Pico-eukryotes

2 km resolution

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UNDERSTANDING ECO-PROVINCES

see poster

Maike Sonnewald

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Using 1 degree resolution model