New Statistics to Bridge Temporal and Spatial Scales of Biological Production in the Ocean

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Spatial scales

Temporal scales

Climate Change

Seasonal Cycles

Mesoscale bio-physical interactions

Eddies

Fronts

Coastal Upwelling

Sub-mesoscale Processes

Turbulent mixing

Organisms

Hydrothermalism

Magma chambers

Mantle convection

Geodesic spreading

El Niño

NAO

Rossby waves

Barotropic variability

Scale variability

Surface tides

Internal tides

EQ fault

Capillary waves

Molecular processes

Surface gravity waves

Ruhr et al 2011
Biological Pump

Hour-week

Mixed Layer

Day-Season

Shadow Zone

Season-Century

Deep Sea

CO₂

Photosynthesis

Phytoplankton

Bacteria

Zooplankton

Fishes

Respiration

Surface ocean

Deep ocean

Remineralisation

Organic matter

Sinking

Thermohaline circulation

Ocean floor
Spatial scales

Temporal scales

Organisms

Most Biological Processes

Most Model/Satellite Studies

Ruhr et al 2011

- Spatial scales
- Temporal scales
- Organisms
- Most Biological Processes
- Most Model/Satellite Studies
- Ruhr et al 2011
Cartoon Oceanography
Modeling

Processes

Observations
Dominant timescales

Rare events
MODIS L3 4km 31°N–32°N, 64°W–65°W

Temporal Scales

Chl (mg/m³)


10^{-2} 10^{-1}
Satellite ocean color:
Great coverage but sparse
Running Standard Deviation
Mean of running STD
Start with window size=1
Increase step-wise
Zero when WS=1
Saturates for large WS
Steepness of curve corresponds to dominating timescale
Michaelis-Mentenen

\[ y = \frac{\sigma_{\text{max}} \cdot x}{b_0 + x} \]
Michaelis-Menten

\[ y = \frac{\sigma_{max} \cdot x}{b_0 + x} \]
NASA/MODIS 16km resolution

$b_0$, Chl (days)
NASA/MODIS 16km resolution

$b_0$, Chl (days)
World ocean circulation user consultation meeting
21 - 22 Feb 2019, Frascati, Italy

http://woc2019.esa.int/
Heat strokes
Ecosystem inefficiency
Export efficiency
Dominant timescales
Rare events
A new framework to estimate NCP.
Combine satellite data and numerical models
Follow Many Particles
South California Bight
CalCOFI
Quantify the importance of episodic events
50,000 random values, log-normal distribution

Fraction of values

Fraction of area

- Green line: Random values, rectangular distr.
- Red line: Random values, normal distr.
- Blue line: Random values log-normal distr.
All changes in SST
All changes in Chl
Episodic events dominates
Frequencies might be as important as means
Heat strokes
Ruhr et al 2011

Spatial scales

Temporal scales

Most Biological Processes

Most Model/Satellite Studies
Recommendations
Geostationary satellites
Ocean Circulation
Focus on Ecoregions
Joe Salisbury, UNH
Amala Mahadevan, WHOI
Michael Bender, Princeton University
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