EXport Processes in the Ocean from RemoTe Sensing (EXPORTS): Predictability

Scott Doney (WHOI)
Ocean Carbon & Biogeochemistry Summer Meeting
Woods Hole, MA (July 2016)
Reduce uncertainties in contemporary & future estimates of the export and fate of upper ocean net primary production

SQ3-A,B,C

EXPORTS Sub-Question 3 Schematic

Export & Fate

Key Properties

Surface Properties

Remote Sensing
Reduce uncertainties in contemporary & future estimates of the export and fate of upper ocean net primary production.

EXPORTS Sub-Question 3 Schematic

SQ3-A,B,C

Export & Fate

Key Properties

Surface Properties

Remote Sensing

SQ3-D

Future Projections
EXPORTS, remote sensing & historical data

Statistical & diagnostic models

Prognostic & assimilation models

Food-web & particle process models

EXPORTS Model-Data Hierarchy
Sinking Phytoplankton, Aggregates & Fecal Pellets

Siegel et al. Frontiers Marine Science 2016
Statistical & Diagnostic Model Estimates

Calibration dataset

Comparison to observables

Statistical algorithm evaluation

Li and Cassar
Global Biogeochemical Cycles 2016
Li and Cassar
Two-size class food-web model forced with satellite estimates of NPP & biomass

$234\text{Th} \text{ disequilibrium}$

Siegel et al. Global Biogeochemical Cycles 2014
Two-size class food-web model forced with satellite estimates of NPP & biomass

Export ratio = Total Export / NPP

Siegel et al. Global Biogeochemical Cycles 2014
Earth System Models & Climate Sensitivity

Sinking Particle Export (mol C/m²/y)

- (a) BEC
- (b) PISCES
- (c) TOPAZ
- (d) REcoM2
- (e) Henson
- (f) Dunne

ΔParticle Export (%) Future Climate

- BEC
- PISCES
- TOPAZ
- REcoM2

See also Hauck et al. GBC 2015

MARine Ecosystem Model Inter-comparison Project
Elements of Export Ratio

Laufkötter et al. Biogeosci. 2015; 2016
Model Food Webs

Laufkötter et al.
Biogeosci. 2016
Mesopelagic Transport & Remineralization

Siegel et al.
Frontiers Marine Science 2016
Particle Flux Attenuation & Transfer Efficiency

Export ratio NPP/Export

Transfer efficiency Export (shallow/depth)

Base of thermocline

Henson et al. GBC 2012
See also Francois et al. GBC 2002
Lutz et al. JGR 2007
Empirical Particle Remineralization Curves

Martin curve

\[ f_z = f_{z_0}(z/z_0)^{-b} \]

Median Temp. 0-500m

\[ f_z = f_{z_0} \exp\left(-\frac{(z - z_0)}{z^*}\right) \]

Exponential curve

Martin curve exponent “b”

Marsay

Henson

Marsay et al. PNAS 2015
Particle Size, Composition & Ballast Hypotheses

Armstrong et al. DSR II 2002
Francois et al. GBC 2002

Length-scales & Biogeochemistry

Kwon et al. Nature Geoscience 2009
see also Marinov et al.
Particle Dynamics Process Models

stochastic, Lagrangian aggregate model of sinking particles

Jokulsdottir & Archer Geosci. Model Dev. 2016
Export from Physical Transport

Levy et al.
Global Biogeochem. Cycles 2013
Model of Diel Vertical Migration

Water column fluxes POC respiration Migrators

Bianchi et al. Global Biogeochemical Cycles 2013
Predictability of Fate & Export of Net Primary Production

**Export flux:**
- remote sensing algorithms & diagnostic models
- incorporation of food web & size structure
- large differences in prognostic model patterns, dynamics & climate sensitivity
- some pathways missing in Earth System Models

**Mesoscale transport & remineralization**
- empirical curve fitting used in most diagnostic & prognostic models
- mechanistic process models (particle dynamics and to lesser extent food web)
Extra Slides
Net Primary Productivity

Bopp et al. Biogeosciences 2013
Role of Large-scale Circulation on Productivity

Najjar et al.  
Surface Nitrate

Preformed vs. Remineralized Nutrients

Preformed

Remineralized

Gruber and Sarmiento
The Sea
2002
Upper Ocean Productivity Estimates Dependent on Process & Technique

Climate Effects on Ocean Biogeochemistry
