



North
American
Carbon
Program



Lateral fluxes: Shelf-open ocean exchange

Part 2: Tracer-based approaches

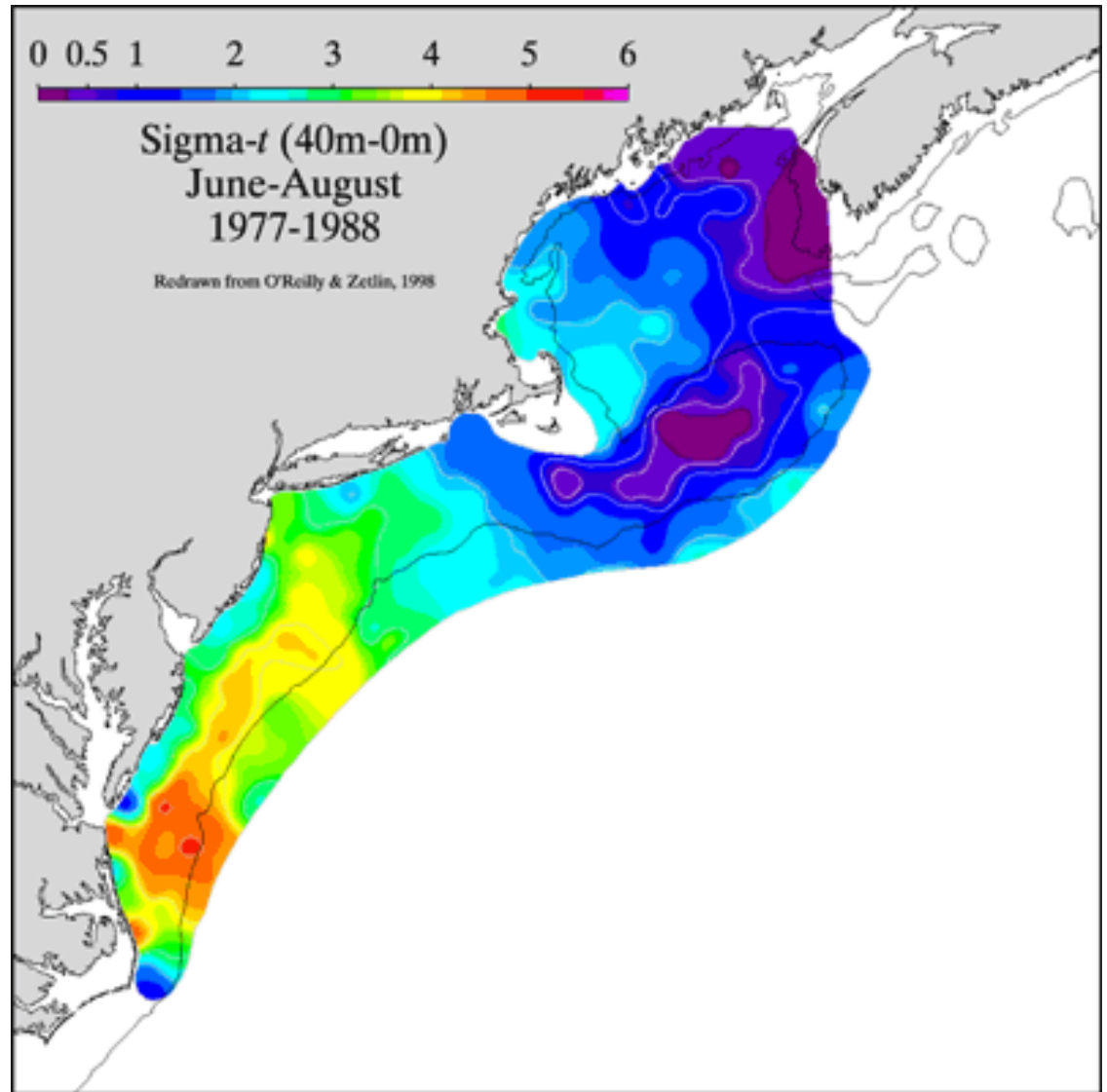
Cross-shelf exchange – What is the net transfer of carbon between coastal and open oceans?

- Lateral transport
- Physical features (currents, gyres, eddies, etc.) and defining a non-stationary ocean boundary
- Approaches: Numerical models, tracer-based approaches, event-scale process studies (10s kms, days to weeks)

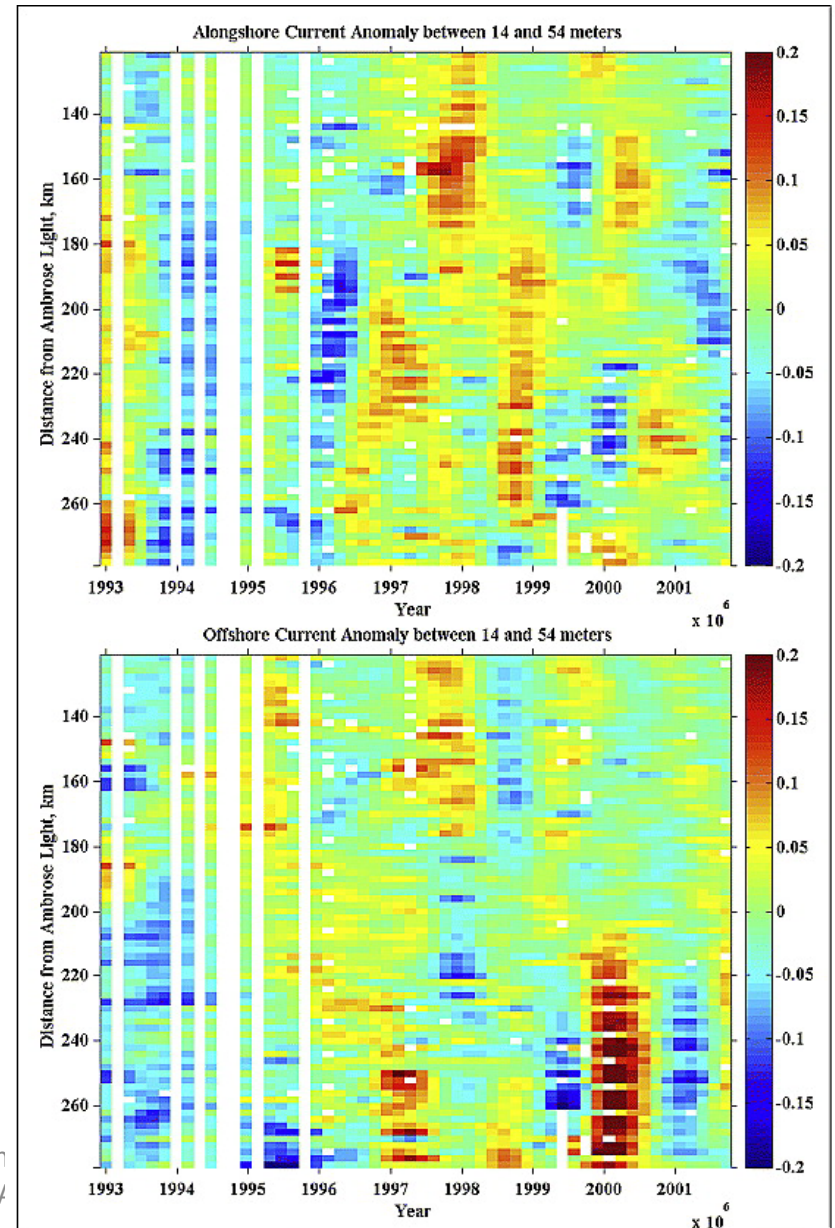
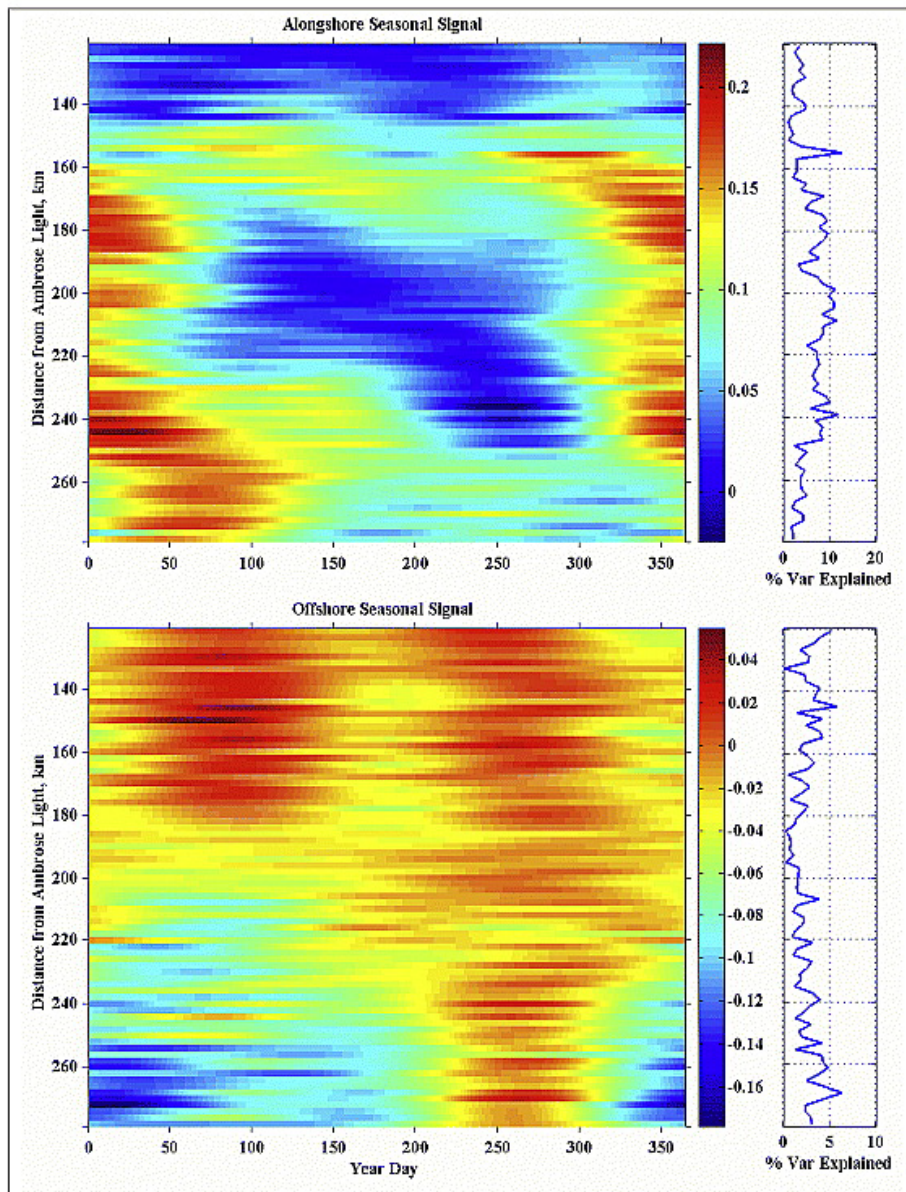
Coupling Models & Tracers

- Model forcings (physical): wind stress, heat and salt fluxes
- Boundary conditions (chemical) – mass balance
- Limitations
 - Observations
 - Depth resolution
 - Decoupling of physical and chemical rates

Challenges



MAB cross shelf flux (Flagg et al 2006)



Conceptual Model & Mass Balance

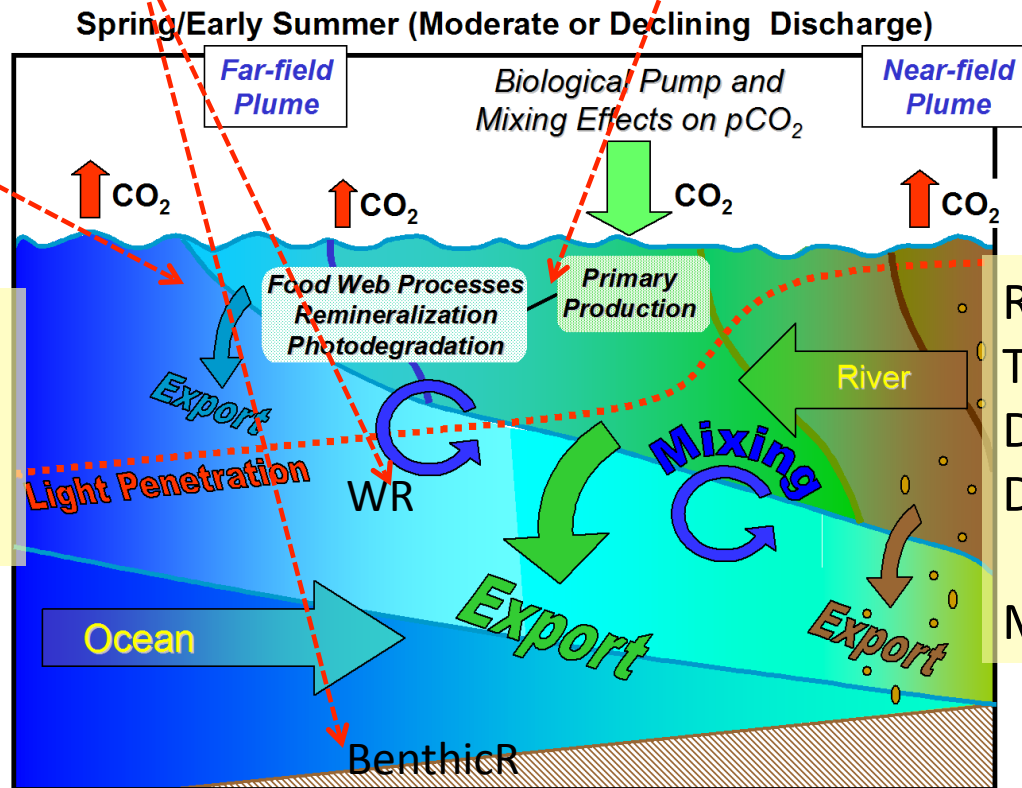
(45-m; A=35,000 km²)

WR+benthicR = 22.5 TgC/yr

- GPP = 16.5 TgC/yr

= 6

Air-Sea flux=
0.6 TgC/yr



River Input:
TOC = 5-6 TgC/yr
DIN*6.6 = 7 TgC/yr
DIC = 17 TgC/yr

Marsh input: ?

The shelf is heterotrophic, burning terrestrial TOC and releasing CO₂.
NCP = - 6.0 TgC/yr (exceeds GPP by 36%).

Tracer Based Approaches trace metals

- The relative importance of particulate fluxes follows the order
Fe>Mn>Pb>Co>Zn>Ni>Cd>Cu (Windom et al., 1989,) associated with POC
- Dissolved metals >> particulate metals
- Useful for terrestrially/sediment derived sources (Weinstein and Moran 2004)

Tracer Based Approaches isotopes (C,N,O,S)

- Coupled isotopes
- Additional mass balances based on isotopes
- Identify sources at slope (East China Sea shelf, Kao et al. 2002 using C and N)
 - Terrestrial vs in situ
 - Useful in comparing both transport and transformation rates

Tracer Based Approaches

Radium

- Burt et al., (2013) off Scotian Shelf
- relatively high activities at large distances offshore (>100 km),
- gradients in both offshore and onshore directions
Vertical mixing above shallow
- offshore banks allows for Ra enrichments in offshore surface waters,
- horizontal dispersion of this bottom-generated signal can transport Ra off the shelf break in surface waters

Tracer Based Approaches

Vertical fluxes

- $^{234}\text{Th}/^{238}\text{U}$ disequilibrium (Weinstein and Moran 2004)
- Sediment traps - mechanistic decoupling from the flux of organic carbon and macronutrients (Lamborg et al., 2008)

Lessons from Vertigo (Buesseler et al., 2008)

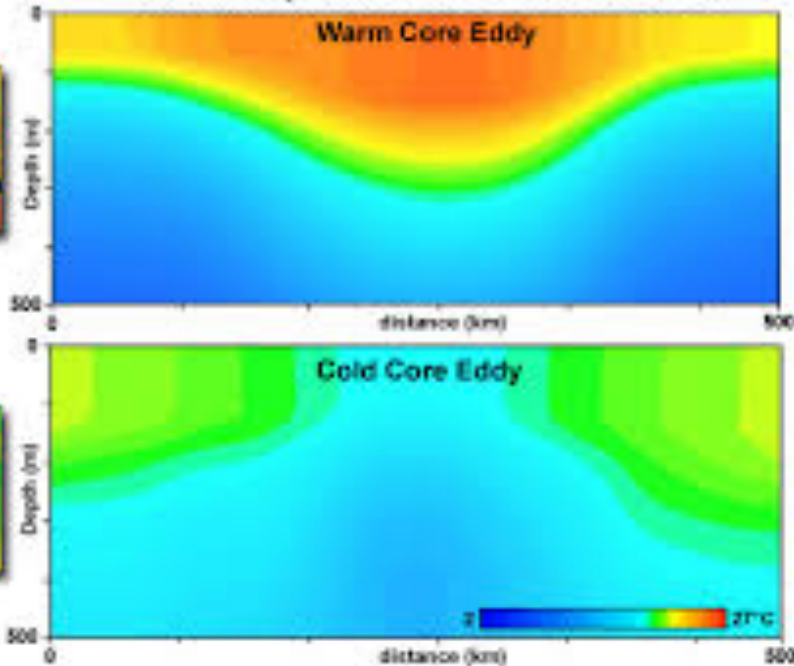
- shallow remineralization above 150-m trap is significant, especially for N relative to Si
- considerably lower transfer efficiency of particulate organic carbon (POC), POC flux between 500/150m, at ALOHA (20%) vs. K2 (50%)
- at least three types of processes need to be considered:
 - heterotrophic degradation of sinking particles,
 - zooplankton migration and surface feeding
 - lateral sources of suspended and sinking materials.

Event Scale Processes

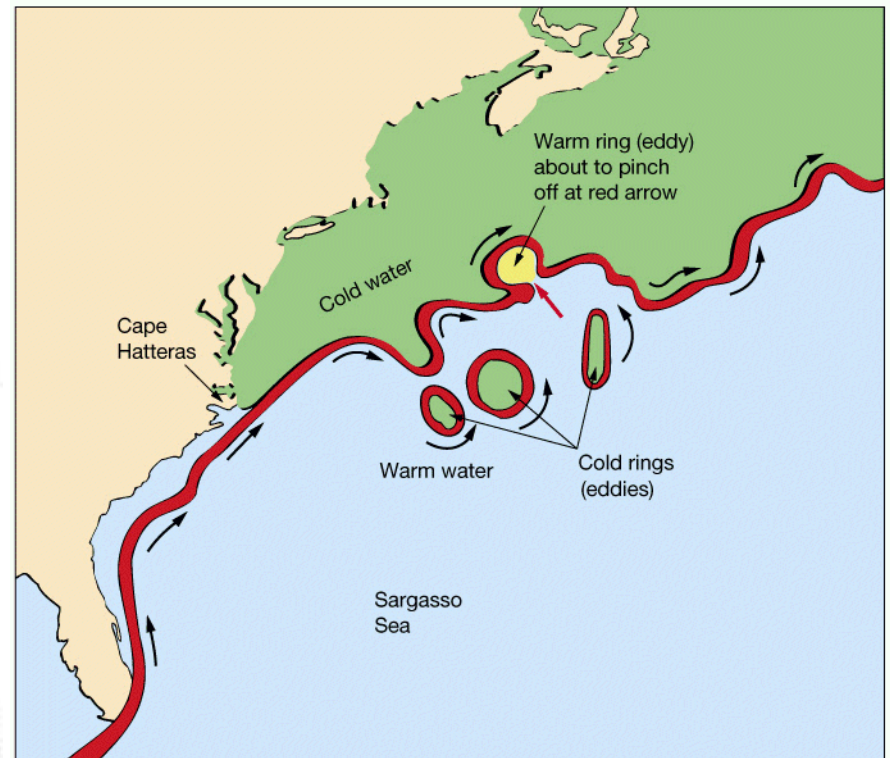
- Terrestrially derived matter exported vs on-shelf processes
- Seasonal and bloom events
- Re-suspension events
- Boundary features including rings and filaments
- Large scale storm events

Event scale export

Vertical Cross Sections of Temperature
NCOM Analysis Valid 0000 UTC 23 Jan 2009



Naval Research Lab / Northern Gulf Institute / The COMET Program



Scaling up

- Identify key locations of transport off the shelf break
 - Correlation between curvature of the shelf break and the volume transport across it (Antarctic Peninsula momentum term balance, Dinniman and Klinck, 2004)
 - Onshelf intrusion frequency

Approaches

- Detailed hydrographic studies at open boundaries
- Focus on shifting hydrographic arrays
- Depth resolution of physical dynamics with oxygen, pCO₂, chlorophyll and transmissometry
- Whole carbon approaches (OC and IC and alkalinity)
- Coupled isotope studies