Riverine Carbon Loadings to the Gulf of Mexico

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Developing collaborations on the lateral fluxes

- Beth Boyer, Penn State
- Richard Alexander & Richard Smith, USGS
- Hanqin Tian, Auburn
- James Bauer, Ohio State
- Tom Bianchi, TAMU
- Paula Coble, USF
- Steve Howden, USM
- Emilio Mayora, Washington
- Sybil Seitzinger, IGBP
- Others to connect with – Ted Stets, Rob Striegl, and David Butman USGS); You? More.

Questions

- How much carbon is transported in surface waters; and how much is delivered to coastal waters?
- What are the primary sources of organic carbon in surface waters, throughout the river network?

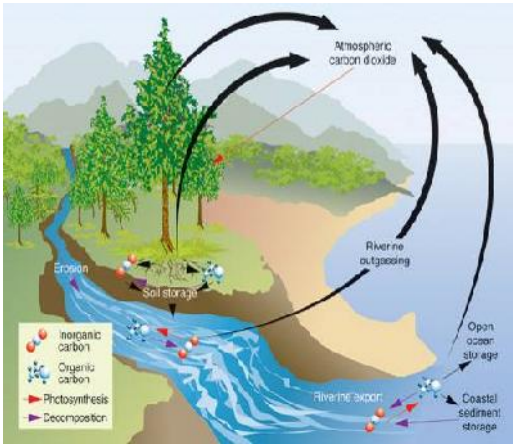
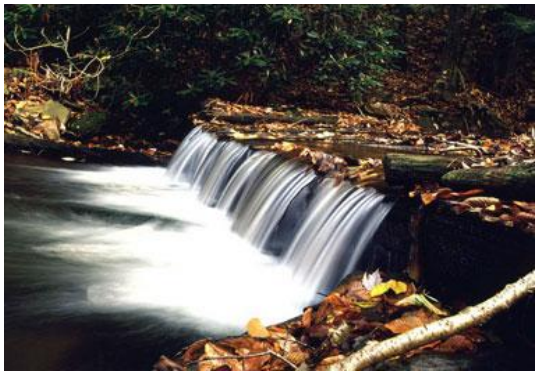


Figure by T. Brown, from https://www.llnl.gov/str/March06/Brown.html

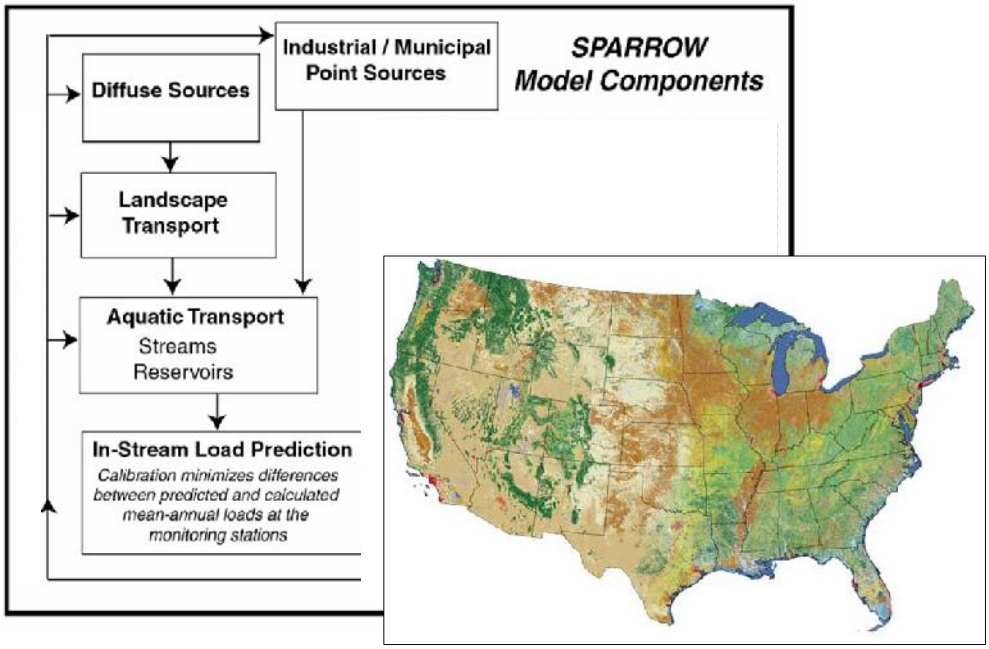
SPARROW model

Spatially Referenced Regression on Watershed attributes (SPARROW) modeling approach

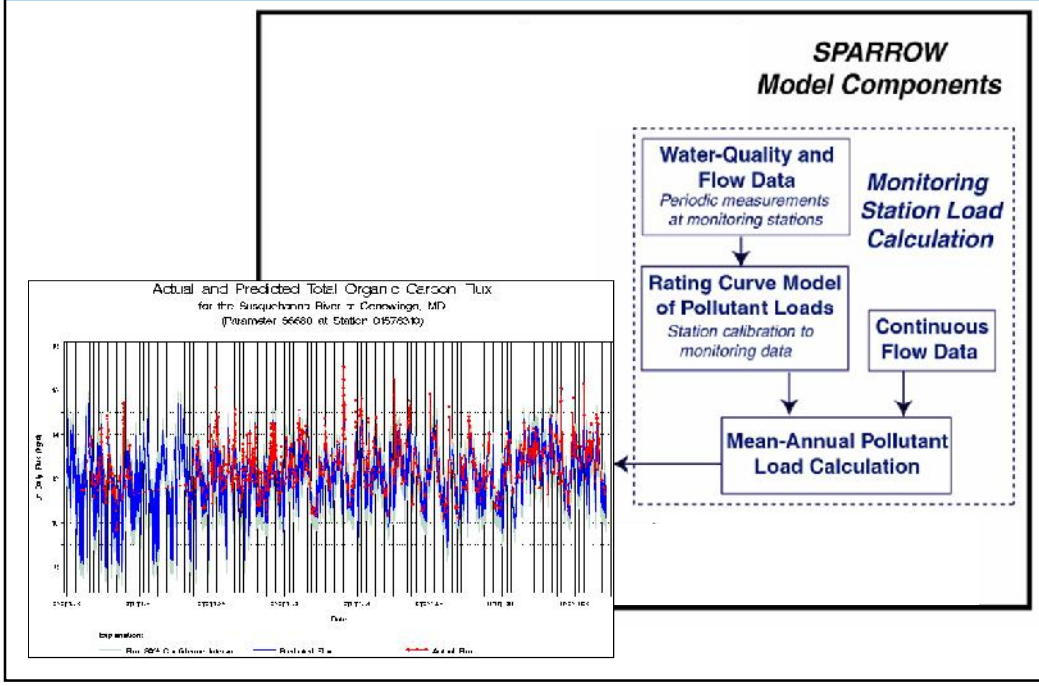
- estimate **loads** and **concentrations** of organic carbon in surface waters.
- Predict **source shares** generating hypotheses about where the organic carbon delivered to rivers & streams comes from.



SPARROW model



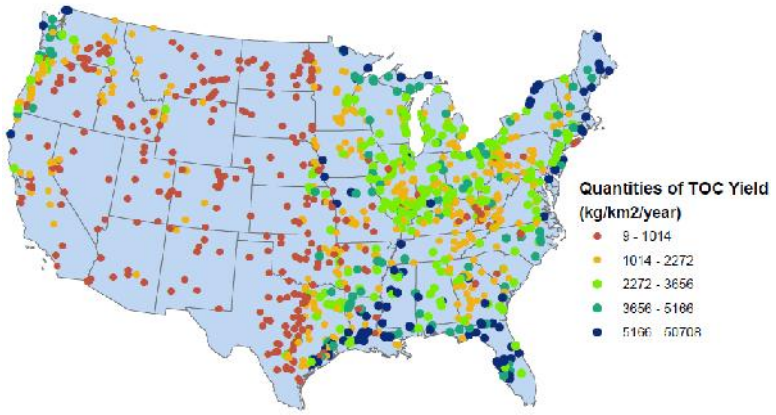
SPARROW model



Initial OC simulations w/ SPARROW

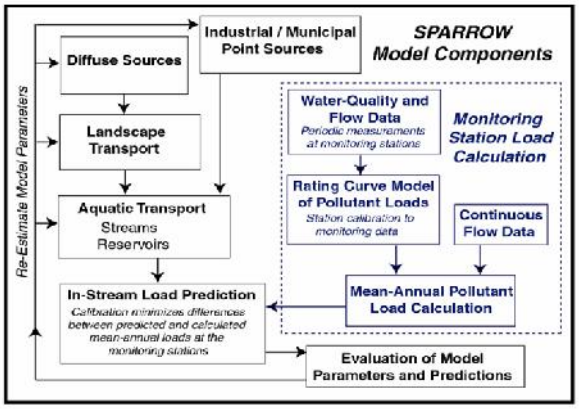
Mean annual riverine OC loads estimated from long term monitoring data in an intial model (Shih et al. 2011).

- Total organic carbon data retrieved for 1970-2008.
- 1125 sites (of ~5000 sites w/ TOC data) met criteria for use.



Shih et al. 2011

SPARROW model



- A river-reach-scale mass balance is used, **statistically relating watershed data to monitored loads**
- An optimal set of coefficients are estimated, balancing the mass of the OC source inputs, stream loads, and storage/losses on land & in water.

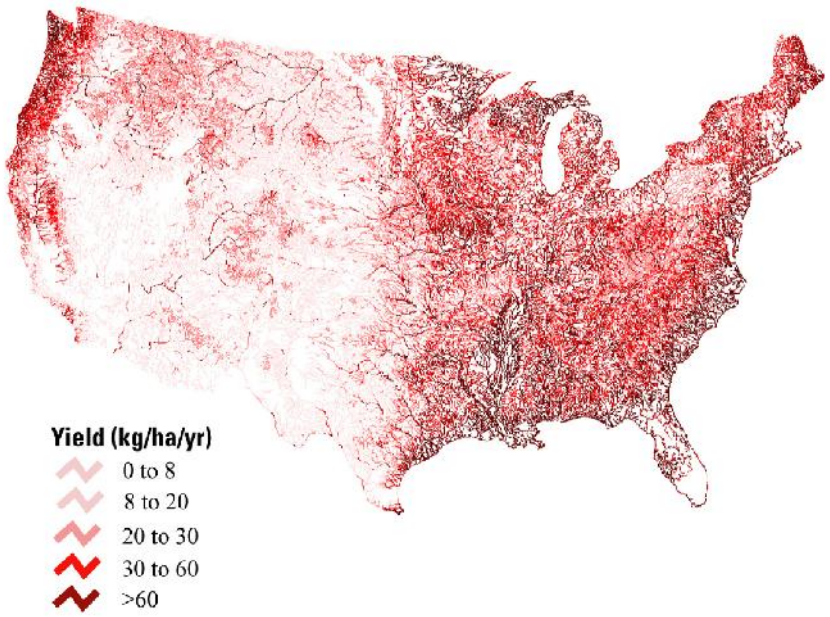
Statistically significant source & transport features.

Parameter	Units	Estimate	Std Err	p value
Land Area source proxies				
Agricultural Land	kg km^{-2} yr^{-1}	1454	167	0.000
Forest - deciduous	kg km^{-2} yr^{-1}	1061	191	0.002
Forest - evergreen	kg km^{-2} yr^{-1}	1378	167	0.000
Forest - mixed	kg km^{-2} yr^{-1}	2568	627	0.001
Urban land	kg km^{-2} yr^{-1}	4777	778	0.000
Wetlands	kg km^{-2} yr^{-1}	25008	2529	0.000
Land-to-water delivery				
Permeability rate	log (cm hr^{-1})	-0.1407	0.0368	0.000
Annual precipitation	cm/yr	0.0047	0.0006	0.000
Tile drained area %	% area	0.0116	0.0031	0.001
Drainage density	log (km^{-1})	0.4407	0.0545	0.000
Land slope		-0.0023	0.0040	0.001
In-stream fate				
Production, photosynthesis	dimensionless	1.1	0.13	0.000
Loss, mass transfer	per day	0.029	0.003	0.000
Log RMSE		*0.54*		
No. Obs.		*1125*		
Adjusted R-squared		*0.928*		
Yield R-squared		*0.77*		

Results: Model includes statistically-significant Sources, Land-to-water delivery factors, and In-stream factors

Shih et al. 2011

Total organic carbon **incremental yields** to river network



TOC loadings to coastal areas from 7 water regions

Generates estimates of mean annual OC concentrations & loads along the river network

Region	Drainage area (km^2)[1]	Delivered yield ($kg\ ha^{-1}\ yr^{-1}$)
North Atlantic	446,500	34
SouthAtlantic- Gulf	730,000	59
Miss.-Atch.-Red[4]	3,248,700	32
Texas-Gulf	925,400	11
Pacific Northwest	713,700	17
California	234,200	15
Great Lakes	313,100	38

Shih et al. 2011

TOC source shares (%) to coastal areas from 7 water regions

Generates testable hypotheses for source shares along the river network; comparing to other data such as riverine C isotopes and EEMs

Total organic carbon source shares (%) delivered to coasts from major regional watersheds

Region	In-Stream	Terrestrial	----------Terrestrial----------			
			Ag	Forest	Urban	Wetland
North Atlantic	22	78	7	29	10	32
SouthAtlantic- Gulf	21	79	5	13	3	58
Miss.-Atch.-Red	54	45	14	7	2	22
Texas-Gulf	36	65	14	12	5	34
Pacific Northwest	48	53	6	39	3	5
California	37	64	8	39	10	7
Great Lakes	10	90	15	11	4	60

Shih et al. 2011

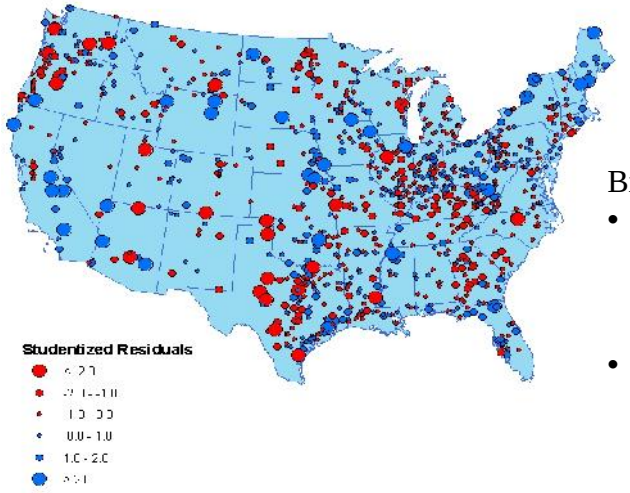
Relation between TOC and DOC in water regions

Can be used from appropriate regions to scale TOC to DOC/POC estimates

		Mean Concentration (mg/L)		
Name	Number of Sites	DOC	TOC	Ratio
Northeast	34	13.65	14.24	0.90
Mid-Atlantic	131	4.58	5.63	0.83
Southeast	142	9.86	11.15	0.86
Great Lakes	66	8.62	9.75	0.89
Ohio	64	3.49	4.59	0.79
Tennessee	27	3.24	4.29	0.80
Upper Miss.	52	6.60	8.80	0.76
Lower Miss.	30	6.70	8.71	0.78
Souris-Red-Rainy	23	13.41	14.51	0.92
Missouri	100	7.88	10.52	0.79
Red-White	44	5.53	7.48	0.80
Texas Gulf	34	6.70	8.34	0.83
Rio Grande	8	5.33	9.52	0.74
Upper Colorado	14	5.33	8.60	0.77
Lower Colorado	16	6.84	17.31	0.73
Great Basin	16	5.56	6.35	0.85
Pacific Northwest	37	2.89	3.41	0.85
California	22	5.87	7.08	0.85

toward improving predictability

Need improved long-term estimates of riverine OC loads.



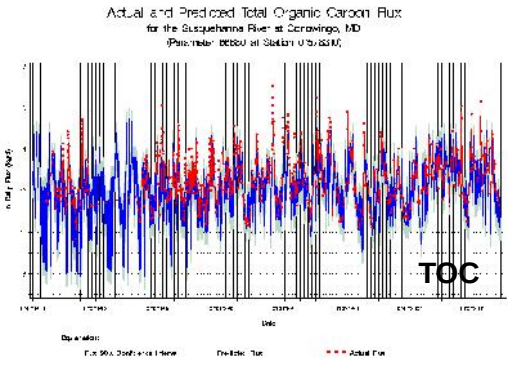
Bias in initial simulations:

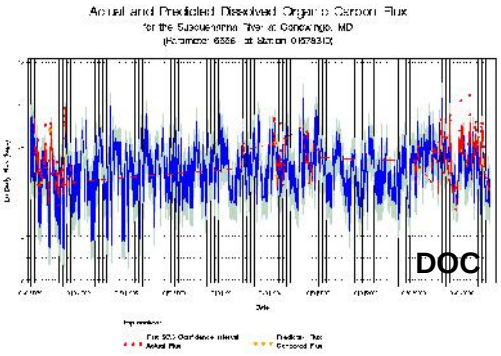
- Red (-): over prediction; & Blue (+): under prediction of mean annual TOC loading.
- Related to temporal differences in the environmental conditions reflected by the period of record covered by the various monitoring stations.

toward improving predictability

Riverine organic carbon loadings:

Need more calibration sites for TOC & DOC; improved load estimates.

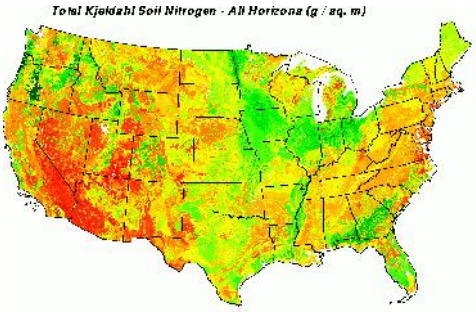




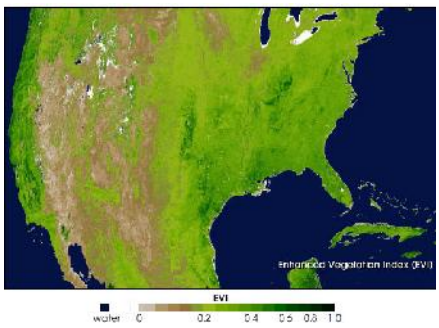
toward improving predictability

Exploring additional data sources to describe OC sources, land-to-water delivery, and aquatic transport.

Total kjeldahl soil nitrogen



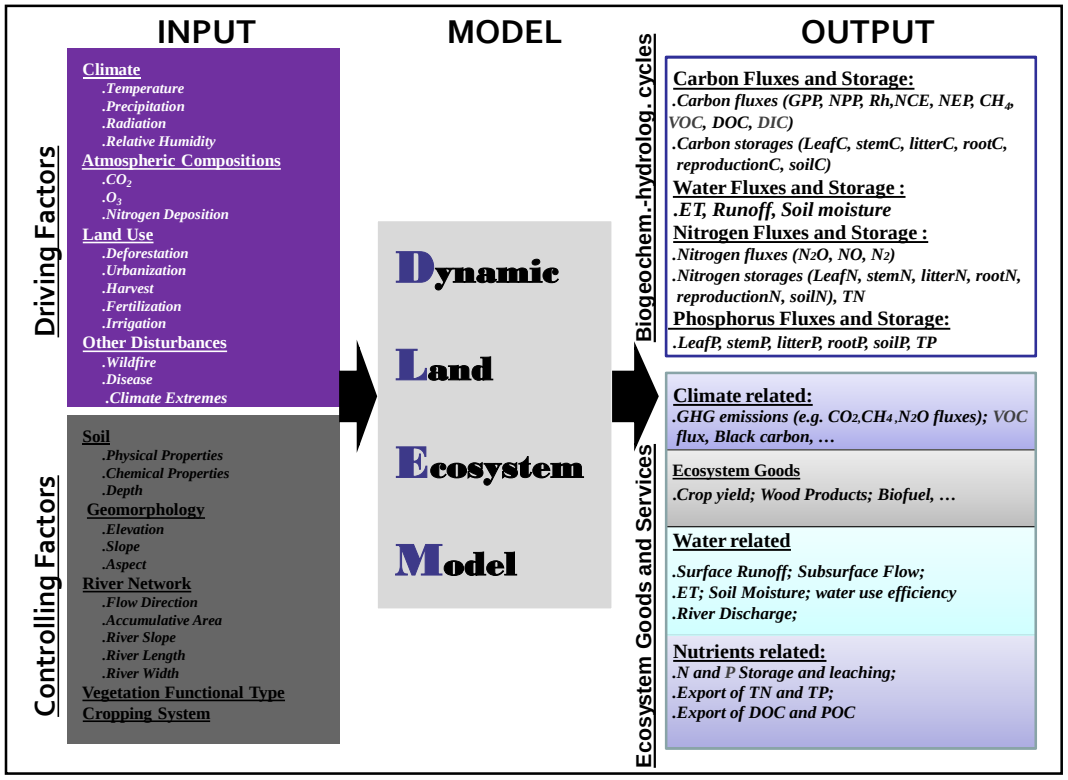
Enhanced vegetation index



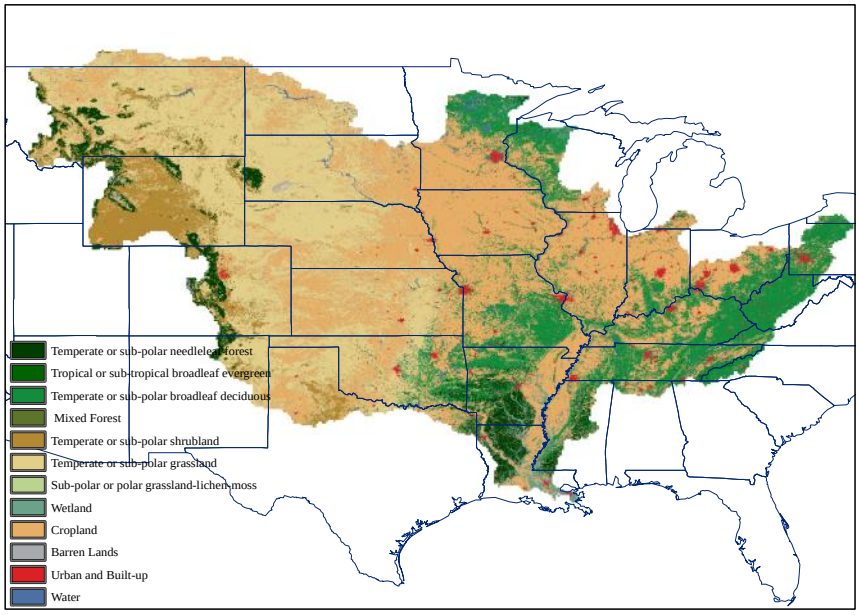
Riverine Fluxes of Caron, Nitrogen, and Water from the Mississippi-Atchafalaya River Basin (MARB) to the Northern Gulf of Mexico as simulated by DLEM: Results from the NASA IDS Project

Hanqin Tian
International Center for Climate and Global Change Research
Auburn University

Jan. 04th, 2013



Study area - MARB

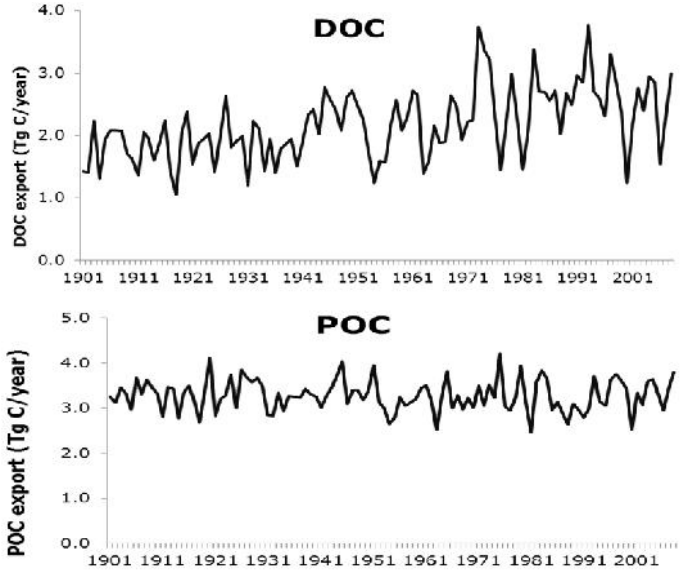


Contemporary land cover distribution across Mississippi-Atchafalaya river basin

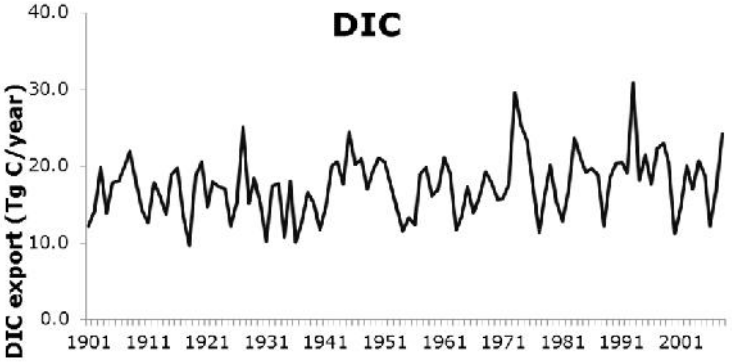
Decadal mean of carbon export from MARB

	DOC	POC	TOC	DIC
	(Tg C/year)			
1950s	2.0	3.4	5.4	16.6
1980s	2.5	3.2	5.7	17.8
1990s	2.8	3.4	6.2	21.4
2000s	2.4	3.1	5.5	17.3

Temporal changes in DOC and POC



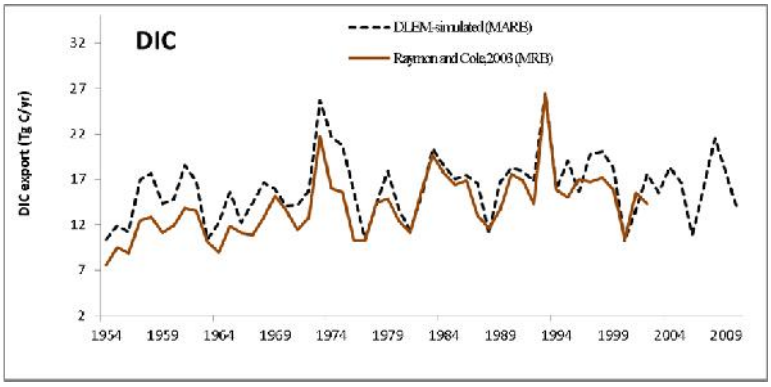
Temporal changes in DIC



Comparisons of terrestrial C inputs

Chemical	Region	Annual Flux ($Tg\ y^{-1}$)	Period	References
TOC	MARB	4.61	Mean	Smith et al., 2005
	MARB	5.32	Mean	Ludwig et al., 1996
	MARB	3.9	Mean	Green et al., 2006
	MARB	5.7±0.8	1980-1996	DLEM2.0
DOC	MARB	3.08	Mean	Smith et al., 2005
	MARB	4.28	Mean	Ludwig et al., 1996
	MARB	2.6	Mean	Harrison et al., 2005
	MARB	2.61±0.5	1980-1996	DLEM2.0
DIC	MRB	21	2002	Cai et al., 2003
	MRB	20	2002	DLEM2.0
TN	MARB	1.1 (0.4-2.7)	1992	Alexander et al., 2008
	MARB	1.1+0.28	1986-1996	DLEM2.0

DIC Evaluation



Next Steps

- GOM synthesis
  - Synthesize data output from sparrow, dlem, global news, and load models (some in hand)
    - By NOAA EDA's and GOM regions
    - Weak on estimates from Mexico portion
  - Synthesize literature (in hand)

- Related Paper
  - Fluxes of OC, N, P from sparrow models → coastal waters
  - Predictions of OC sources from sparrow models → compare to measurement information (pigments, C isotopes, etc)