

# Air-Sea Carbon Flux Report: Gulf of Mexico

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Gulf of Mexico Coastal Carbon Synthesis  
March 27-28, 2013 Saint Petersburg, FL

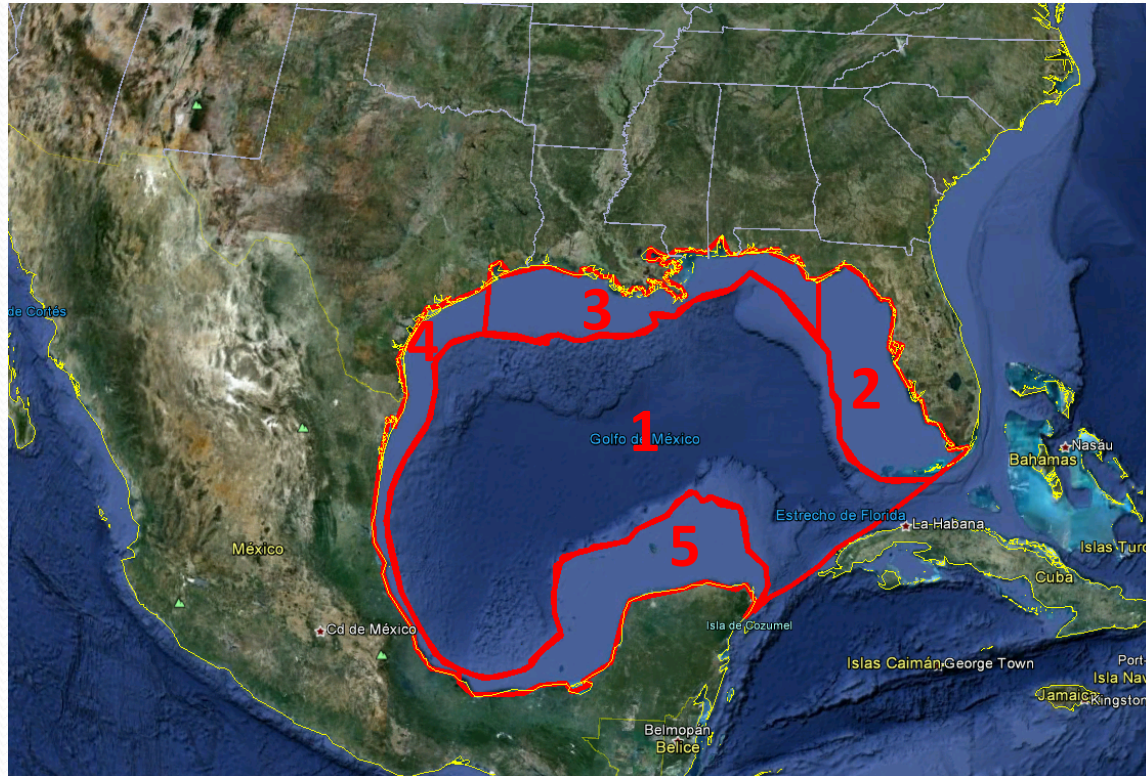
# Air- sea flux assignments

Regions	Co <sub>2</sub>	DOC	POC	VOC
1- Open				
2- WFS				
3- LA				
4- TX				
5- Mexico				

# $p\text{CO}_2$ air-sea flux

- Huge effort
- Many different cruises and ships of opportunity
- Different data formats
- Different carbon parameters (ie.,  $p\text{CO}_2$  or DIC/Alk, etc)
- Avg monthly wind speed computed
- Data gridded to 1 x 1 bins in open ocean; 0.5 x 0.5 in coastal
- Flux equation:  $F = K_o k \Delta p\text{CO}_2$ ;  $k = 0.251 \langle u^2 \rangle (Sc/660)^{-0.5}$

# Compilation of all $p\text{CO}_2$ data



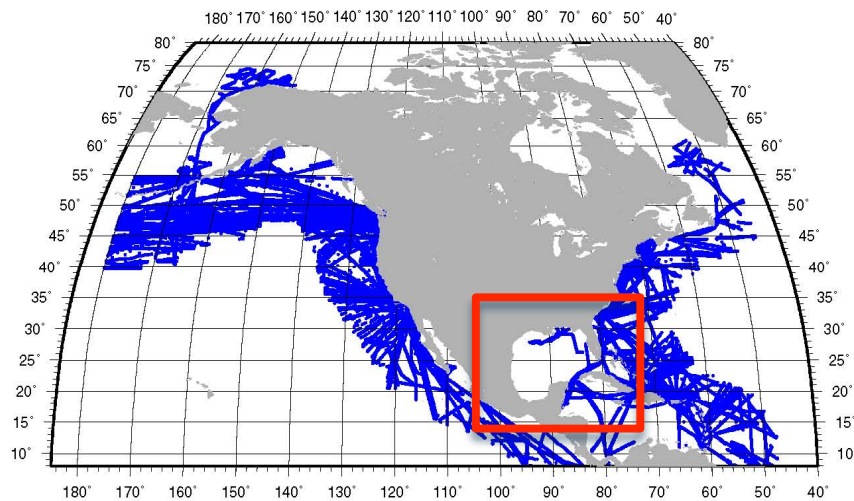
- Regions 2-5: 185,000+ points
- Region 1: 190,000+ points

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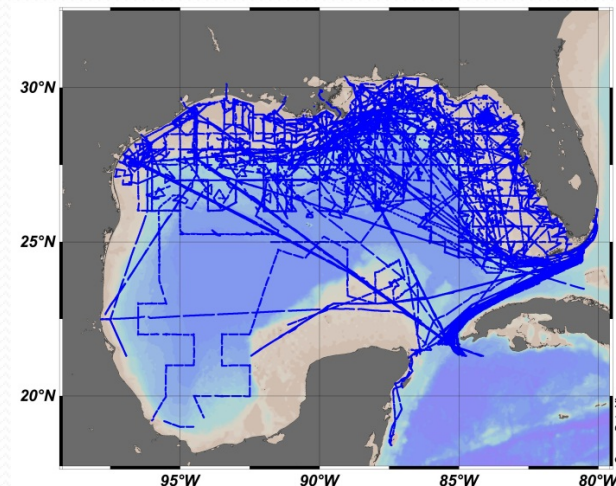
# pCO<sub>2</sub> air-sea flux data

Takahashi, 2009  
Data up to 2007



Locations where pCO<sub>2</sub> data were obtained around North America as presented in the SOCCR report (Chavez et al., 2007). Note the lack of data in the Gulf of Mexico.

Our newly compiled data,  
up to 2012



- Over 375+K data points
- Years 1996-2012
- 196 cruises, (more to be added shortly)
- Combined result of Ships of Opportunity and dedicated research cruises

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# Air-to-sea CO<sub>2</sub> fluxes

	10 <sup>12</sup> g C yr <sup>-1</sup>	mol m <sup>-2</sup> yr <sup>-1</sup>	Reference
Summer		0.48 0.186-0.230(Aug. '04) 2.71-3.32 (Oct. '05)	Robbins, unpub. Lohrenz et al. 2010 Lohrenz et al. 2010
Winter		-0.22 -0.97 - -1.18	Robbins, unpub. Lohrenz et al. 2010
N of 24°	-11.8		Wanninkhof (unpub.)
Total?	-17.7		

Red numbers are sinks

# pCO<sub>2</sub> Flux Calculations

## pCO<sub>2</sub>

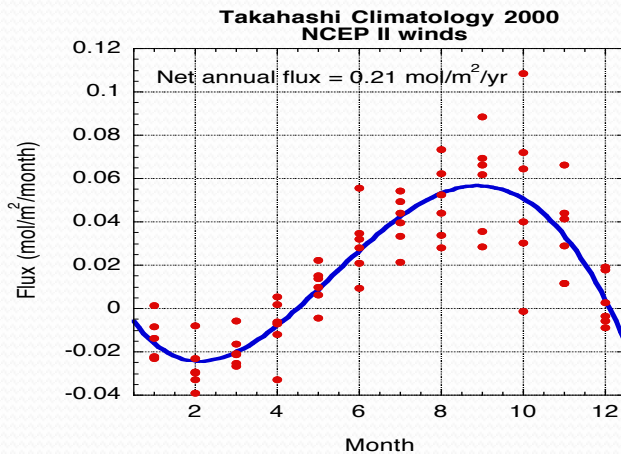
	Flux (molC/m <sup>2</sup> y)	std	wind source	ΔpCO <sub>2</sub>	Max ΔpCO <sub>2</sub>	Min ΔpCO <sub>2</sub>	N
WFS	0.37	0.11	CCMP monthly avg	16.90	963.80	-240.83	>35K
Northern GOM	-0.44	0.37	CCMP monthly avg	-5.01	2423.51	-333.17	~95K
Western Gulf	0.18	0.05	CCMP monthly avg	18.83	121.04	-115.39	>10K
Mexico- Yucatan	-0.09	0.05	CCMP monthly avg	18.30	390.18	-236.5	~8K
Open GOM	-0.48	0.07	CCMP monthly avg	3.22	407.82	-306.76	>150K
Total	-0.19	0.08	CCMP monthly avg				>300K

Wind product used: CCMP monthly average, binned to 1x1° grid in region 1 (open ocean) and 0.5x0.5° grid in coastal areas (regions 2-5).

$$F = K_0 k \Delta pCO_2; \quad k = 0.251 \langle u^2 \rangle (Sc/660)^{-0.5}$$

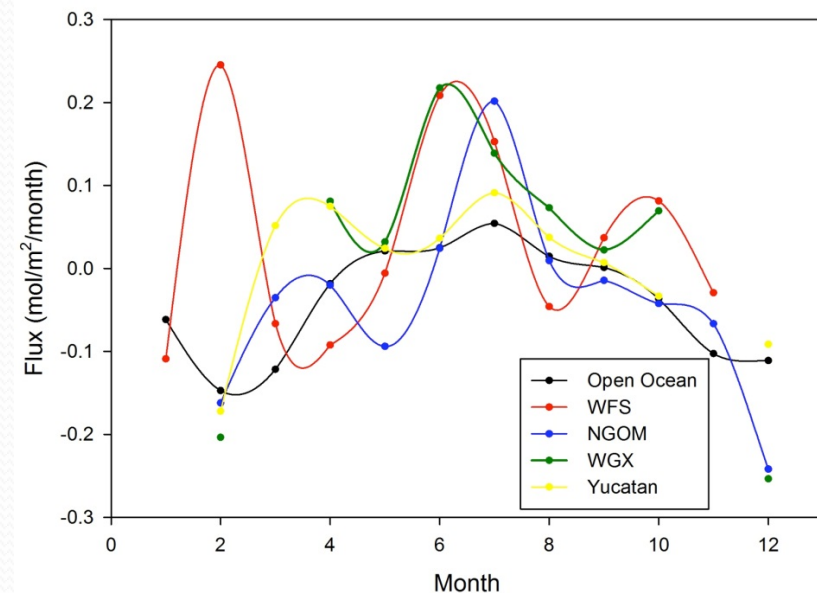
# Flux Monthly Variability

The Gulf is a sink with a Net Annual Flux of  $-0.19 \text{ mol C/m}^2/\text{year}$   
( $-3.57 \text{ Tg C/year}$ )



Net Annual Flux:  
 $+0.21 \text{ mol C/m}^2/\text{year}$

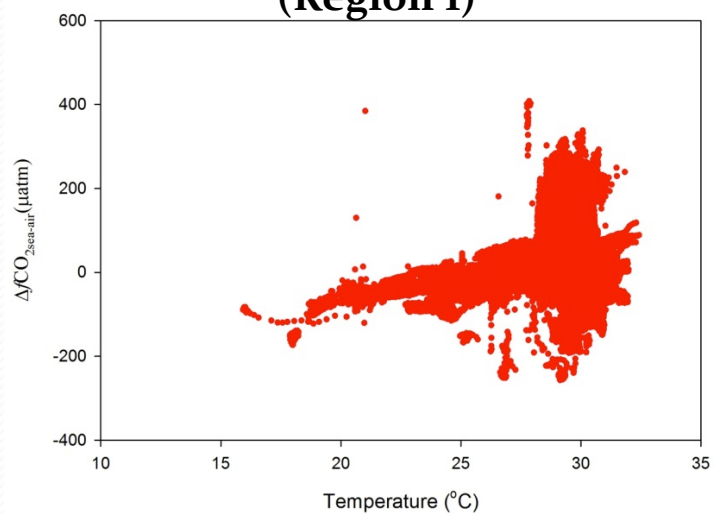
-2 cruises  
-summer data



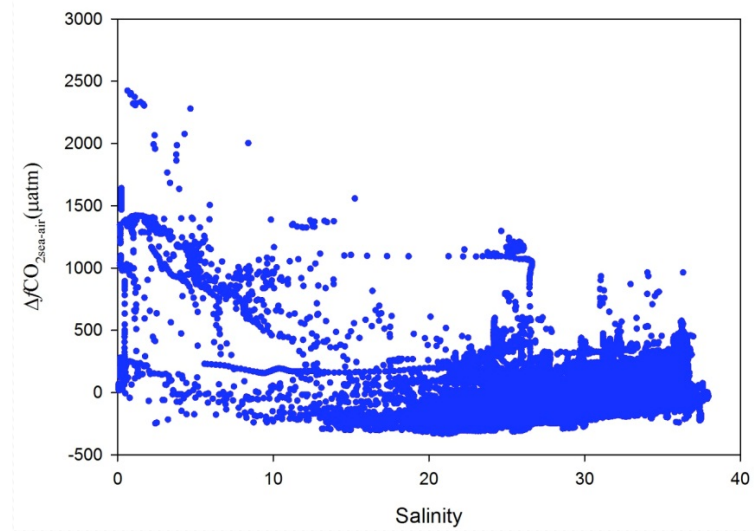
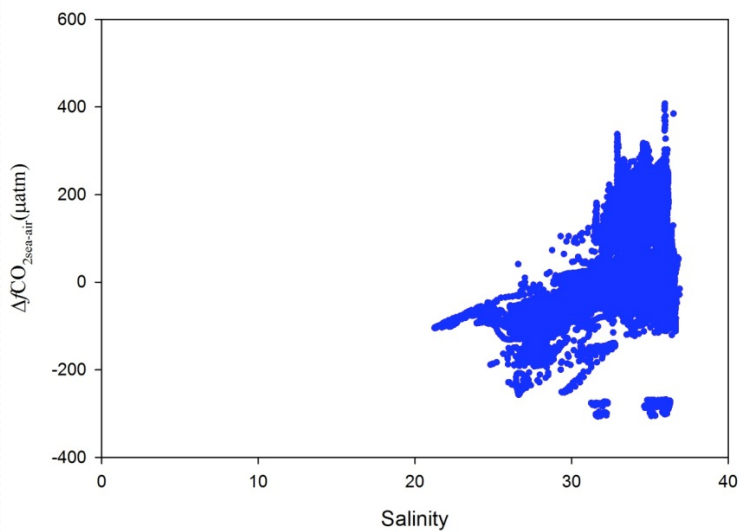
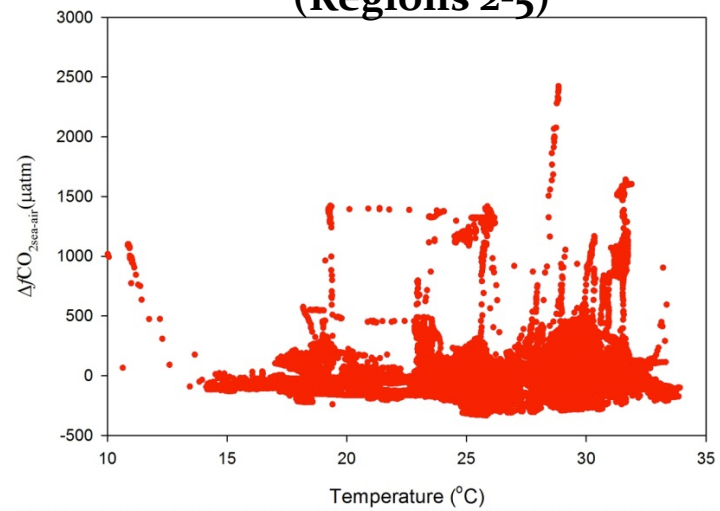
Net Annual Flux (including coastal regions):  
 $-0.19 \text{ mol C/m}^2/\text{year}$



## Open Ocean (Region 1)



## Coastal Waters (Regions 2-5)



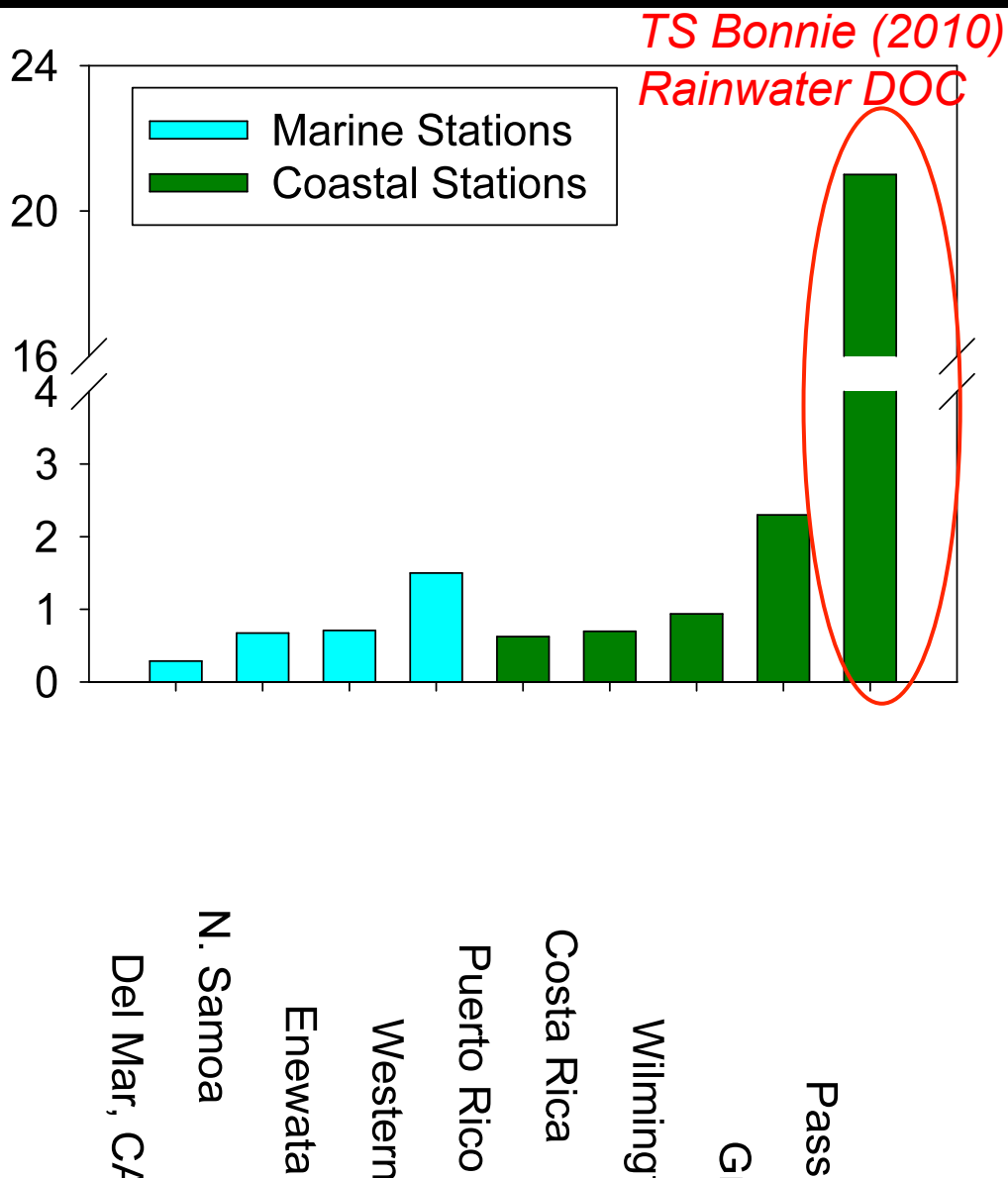
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# DOC flux

- **No information in GOM**
- Calculated using other available coastal and marine rainwater [DOC] (avg 0.72 mg/L  $\pm$  0.47) and lowest & highest Avg annual rainfall (mm) in GOM
- Wet deposition= 0.3375-3.1 Tg C/yr
- Mitra data – unfiltered rainwater DOC collected during TS Bonnie subsequent to its crossing across Deep Water Horizon oil slick

# Rainwater Dissolved Organic Carbon

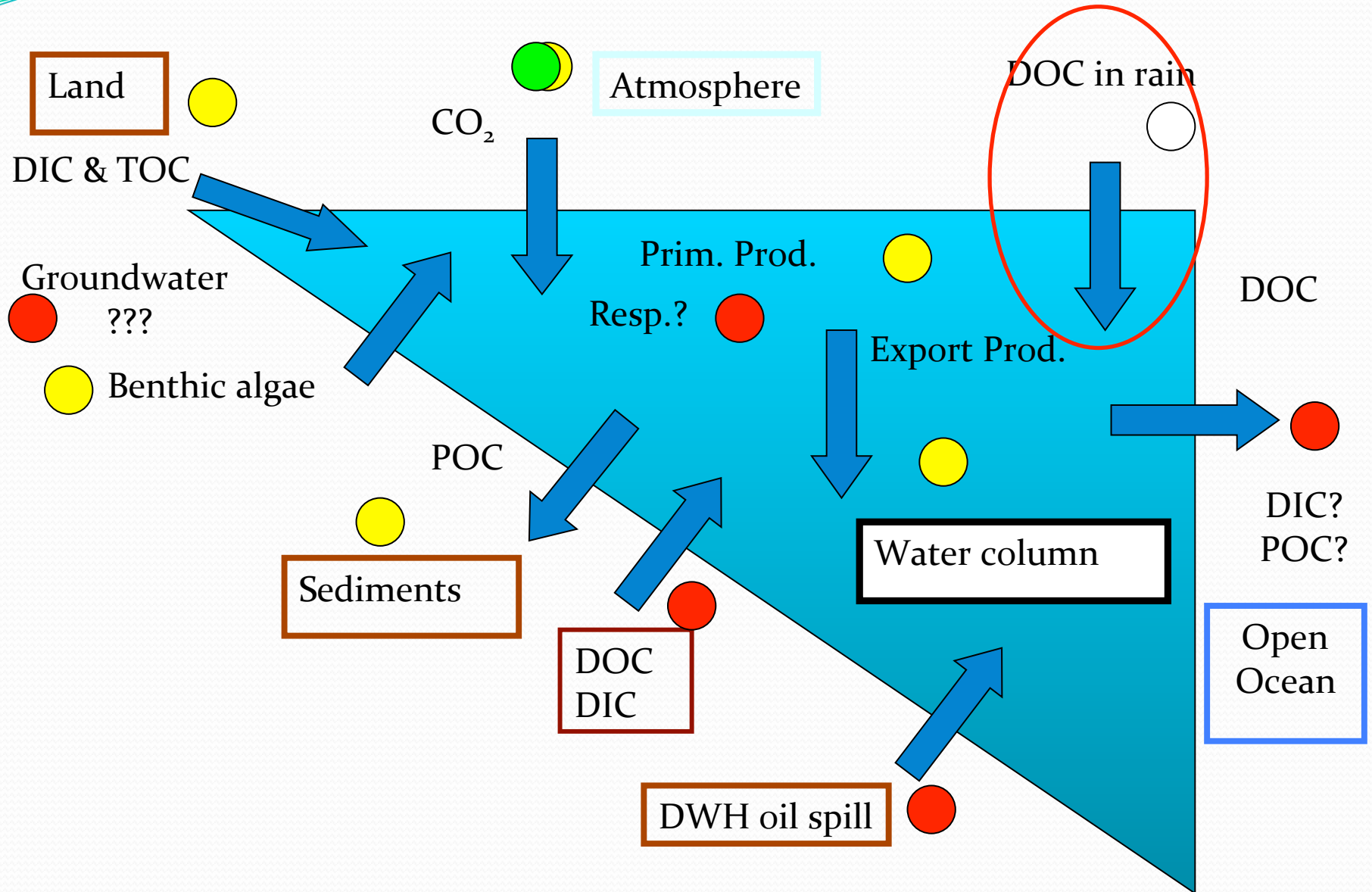


Mitra Organic Geochemistry

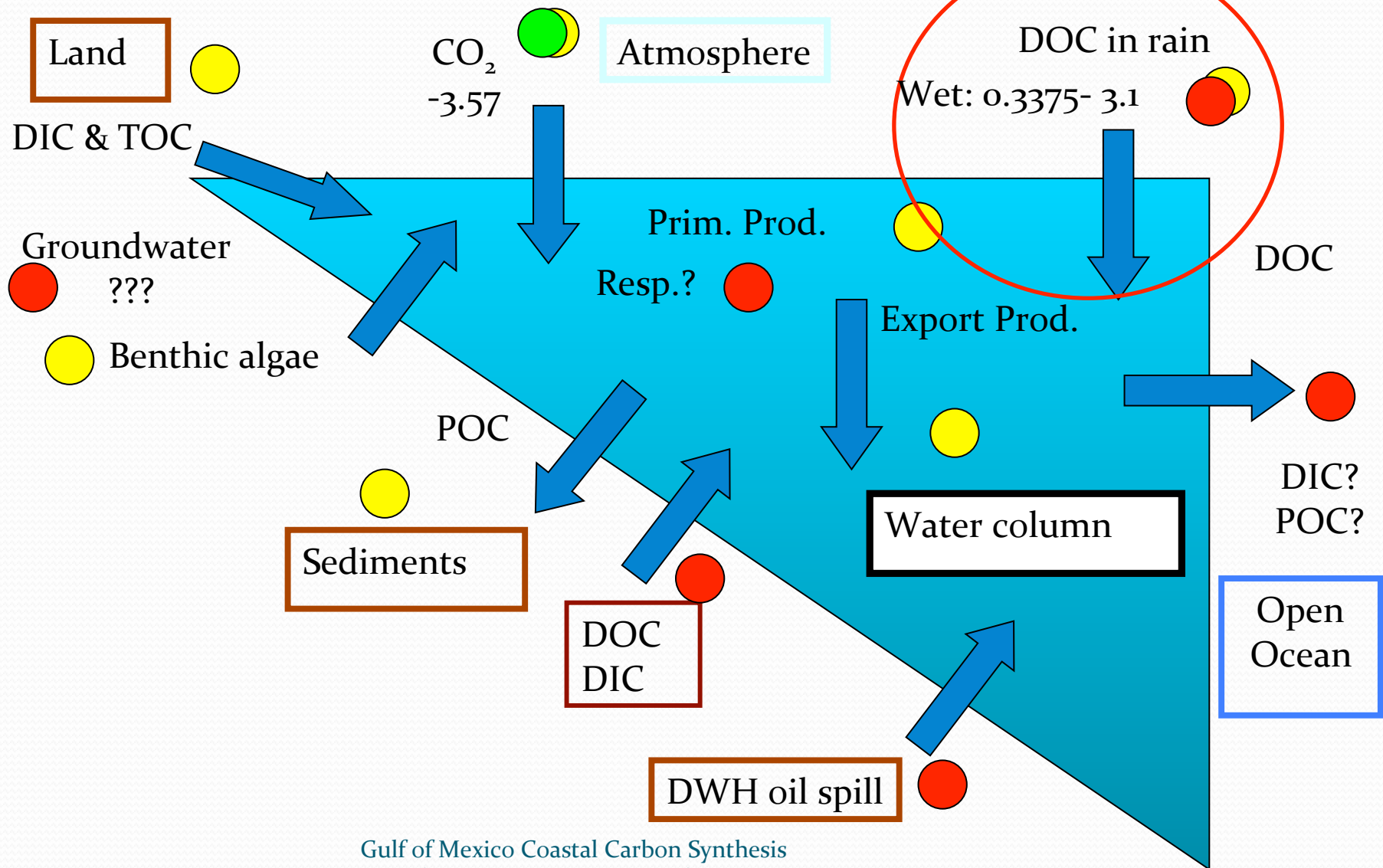
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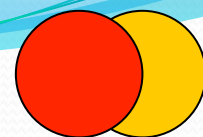
# Previous Shelf-wide budget ( $10^{12}$ g C yr<sup>-1</sup>)



# New GOM budget ( $10^{12}$ g C yr<sup>-1</sup>)







# POC flux

- Available coastal and marine [POC] from Gulf (5 refs)  
0.32-15.2  $\mu\text{g}/\text{m}^3$
- Dry deposition flux= $[\text{vd}] * [\text{Cp-oc}]$ 
  - Dry aerosol flux: 0.0094 – 14.9 TgC/yr
- Wet deposition flux= $I * [\text{Wp}] * [\text{Cp-oc}]$ ; I=ppt rate (m/d),  
Wp=washout ratio, Cp-oc=aerosol particulate carbon
  - Wet aerosol deposition: 0.0898 - 8.05 TgC/yr
- Total (dry + wet) = 0.0094 – 22.95 TgC/yr

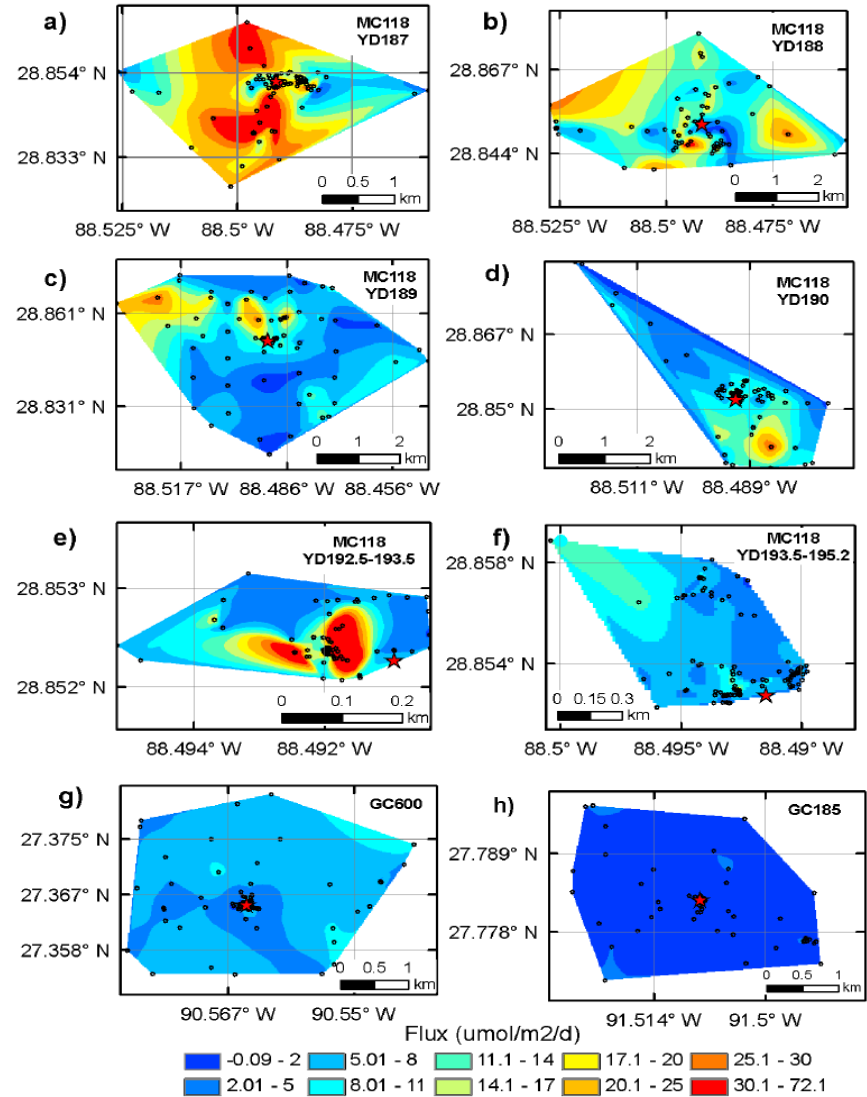
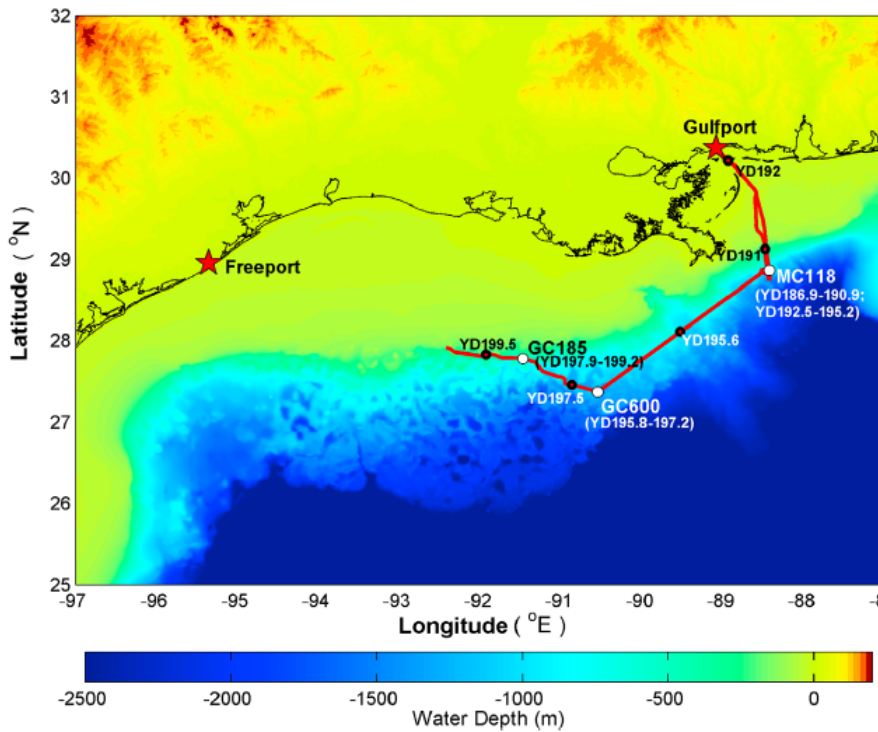
# VOC flux

- Few data sets, VOCs not significant other than CH<sub>4</sub>

Cruise	PI	Dates	VOC available	
Milagro	various	Mar 1-30, 2006	Atm VOC	
TexAQS/ GoMACCS	various	Aug 2- Sept 11, 2006	Atm VOC	
TexAQS/ GoMACCS	various	Aug 31 –Oct 6, 2006	Atm VOC	
CalNex	various	June 6-8, 2010	Atm VOC	
HYFLUX	S. Yvon- Lewis	July 4-19, 2009	Underway CH <sub>4</sub> , C <sub>2</sub> H <sub>6</sub> , C <sub>3</sub> H <sub>8</sub>	
PLUMES	S. Yvon- Lewis	June 2010	Underway CH <sub>4</sub> , depth profiles C <sub>2</sub> H <sub>6</sub> , C <sub>3</sub> H <sub>8</sub>	

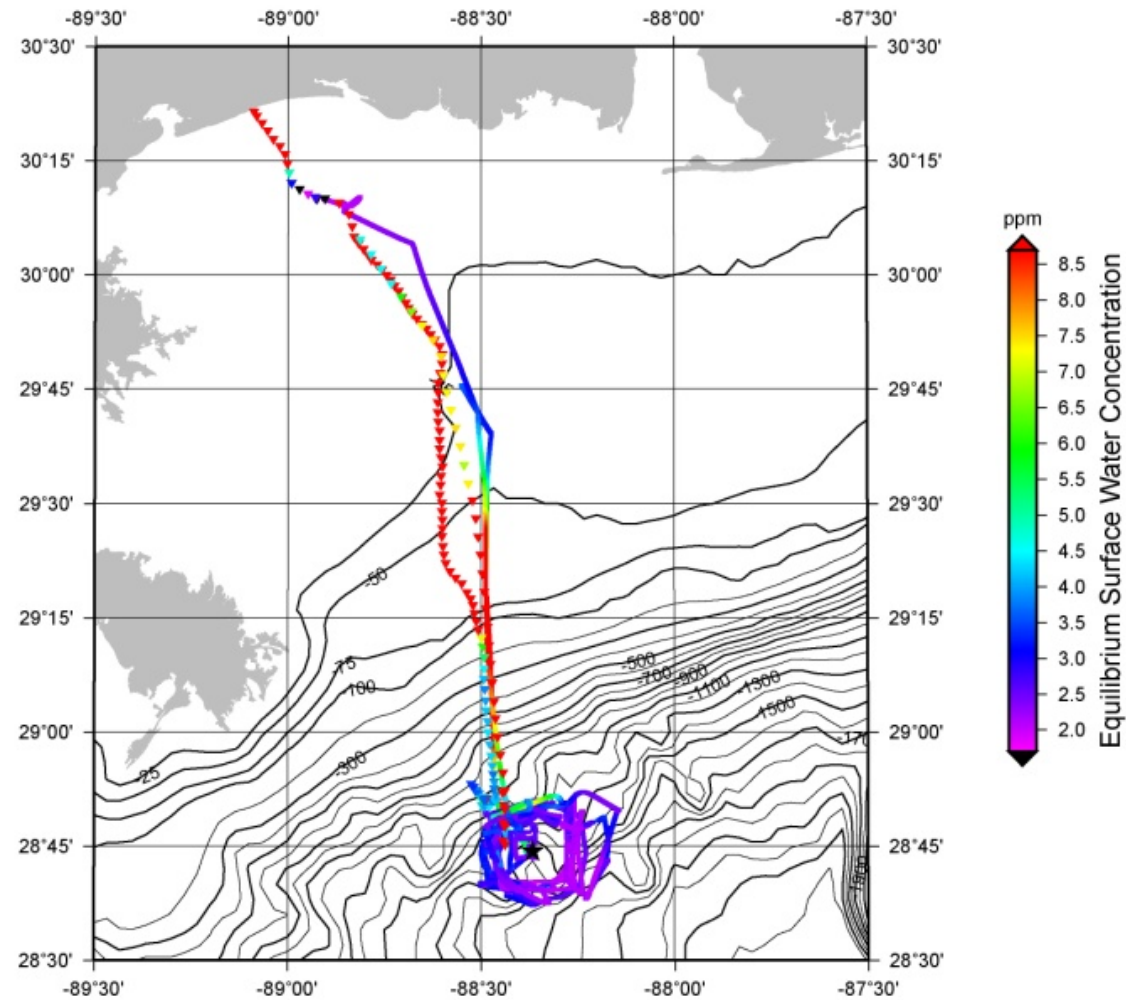
# Methane Fluxes to the Atmosphere (Northern Gulf of Mexico)

## HYFLUX (2009)

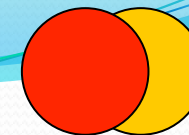


# Methane Concentrations

(Deepwater Horizon Event - 2010)



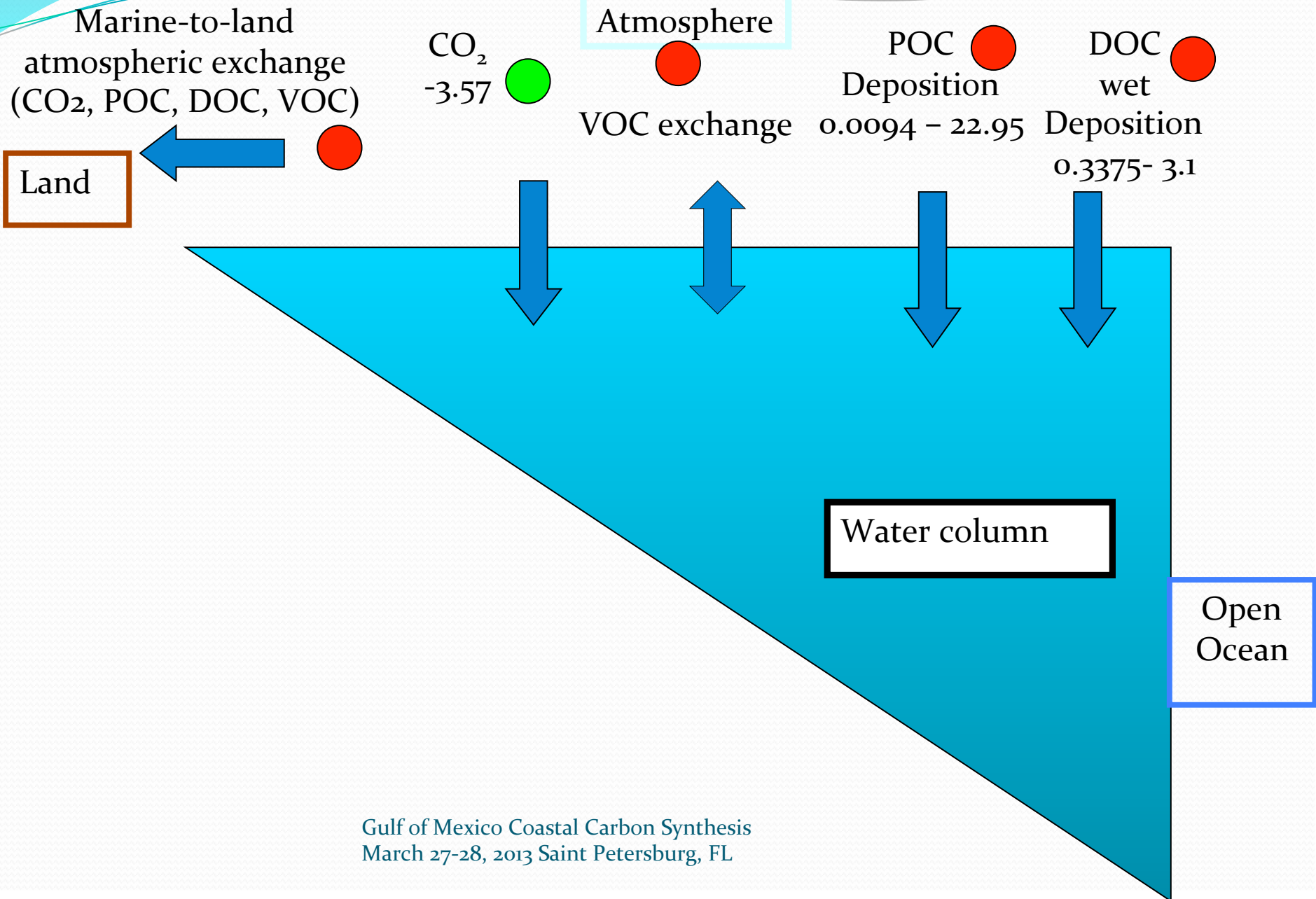
# Methane in Northern Gulf of Mexico (Regions 3 and 1)



Study Region	Surface Concentration (nmol L <sup>-1</sup> )	Flux (μmol m <sup>-2</sup> d <sup>-1</sup> )	Reference
Mississippi/Alabama Shelf	22		Brooks (1975)
Northern Gulf of Mexico	2.4		Kelley and Jeffery (2002)
Northern Gulf of Mexico	9.9 - 343		Kelley (2003)
Northern Gulf of Mexico	0.8 - 1609	200 - 10,500	Solomon et al. (2009)
DWH	3.3	-0.055 - 1.83	Yvon-Lewis et al (2011)
HYFLUX	1.72 -156	-4.19 - 86.1	Hu et al. (2012)



# Gulf wide budget ( $10^{12}$ g C yr<sup>-1</sup>)



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- Put onto PC and Mac and on your smart phone!