ECCO2 & Arctic Ocean : Physical and Biogeochemical Applications

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EAPS-MIT

Thanks to :

MIT : Mick Follows, Stephanie Dutkiewicz, Chris Hill, Oliver Jahn, Jean-Michel Campin, Patrick Heimbach, John Marshall

JPL : Dimitris Menemenlis

WHOI : Alan Condron (also MIT), Peter Winsor (now at UAF)

U. TEXAS-Austin : Jim McClelland

MBL : Bruce Peterson

TALK OUTLINE

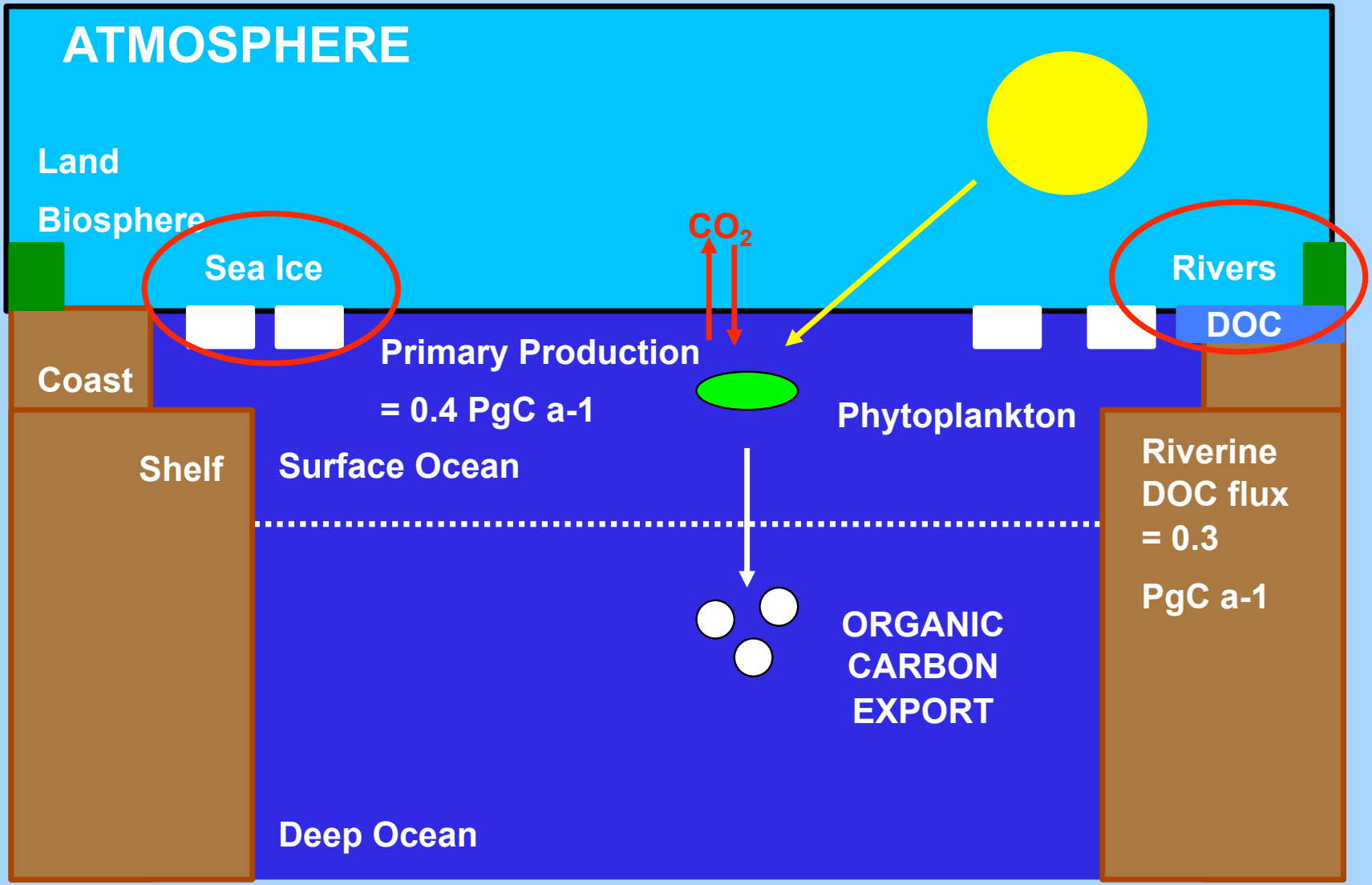
I) The Arctic Ocean Carbon Cycle (AOCC)

II) Transport, Fate & Lifetime of riverine DOC in the Arctic Ocean: Model-Data Fusion.

III) Coupling Terrestrial and Marine Carbon Cycles

IV) On-going & Future Work/Applications

I - Arctic Ocean Carbon Cycle



II - Data-Model Fusion Approach for DOC problem

To reproduce the DOC distribution in the Arctic we need:

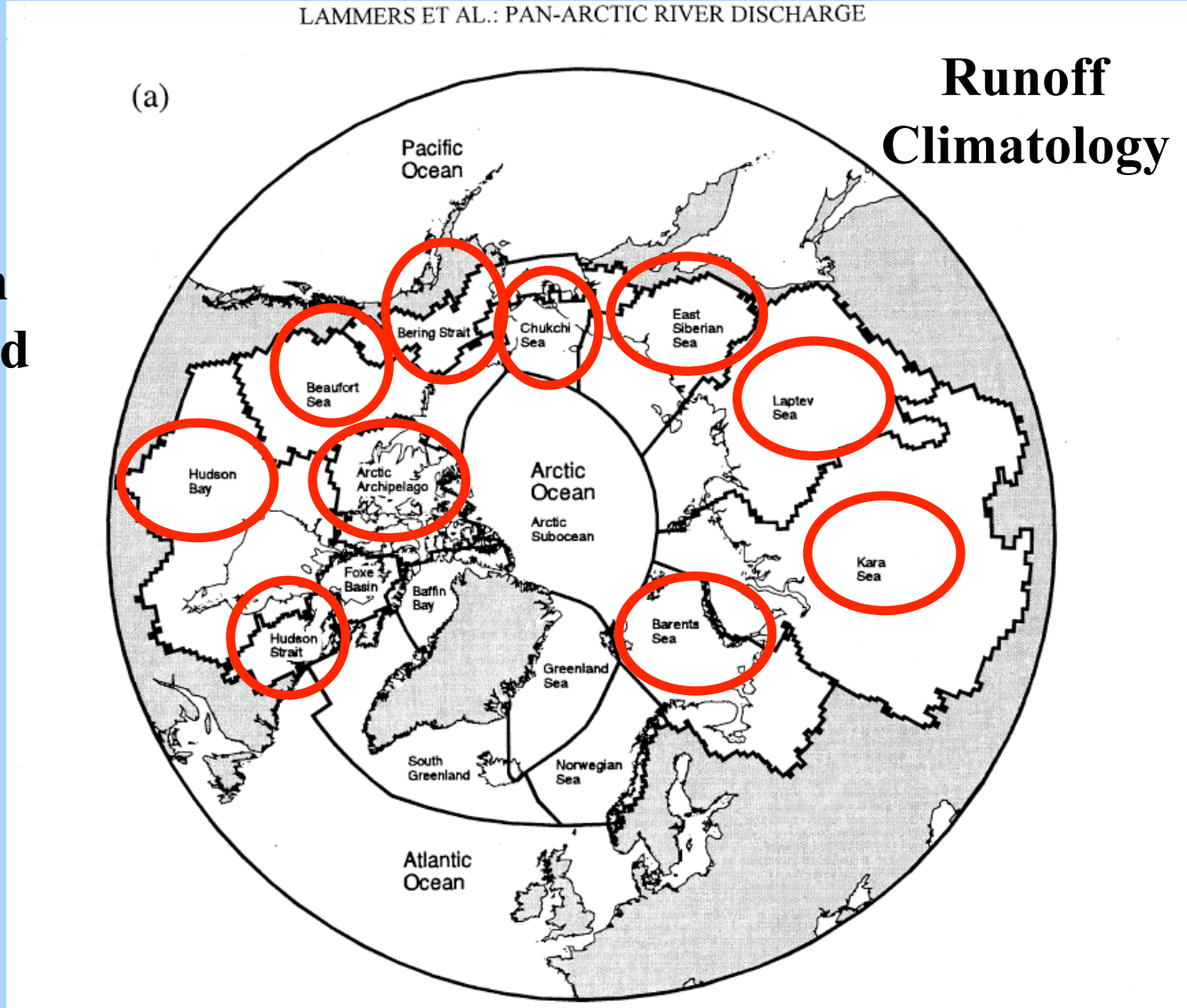
1) Realistic riverine DOC flux from land to ocean.

2) Realistic representation of Large Scale Ocean Circulation in the Arctic basin.

3) Proper time scale regulating the rate of decay for riverine DOC while in the ocean

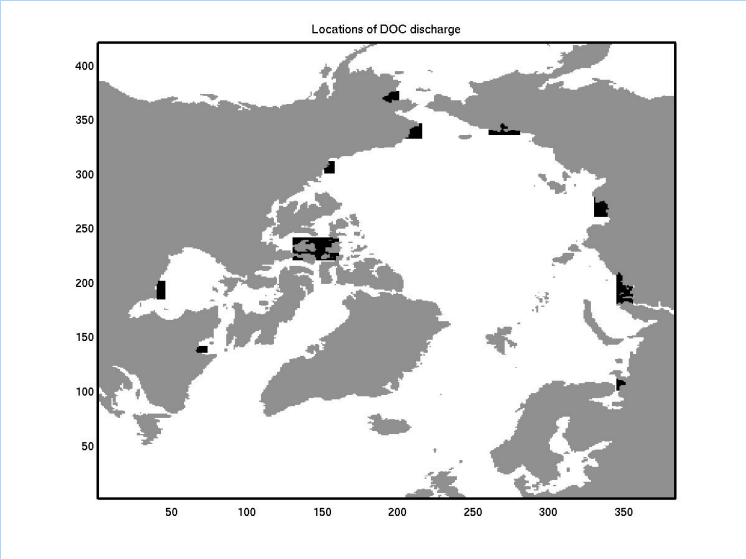
1- Riverine Discharge of DOC in the Arctic

DOC data from McClelland Peterson



3754 Hydro-stations **From Lammers *et al*., JGR 2001**

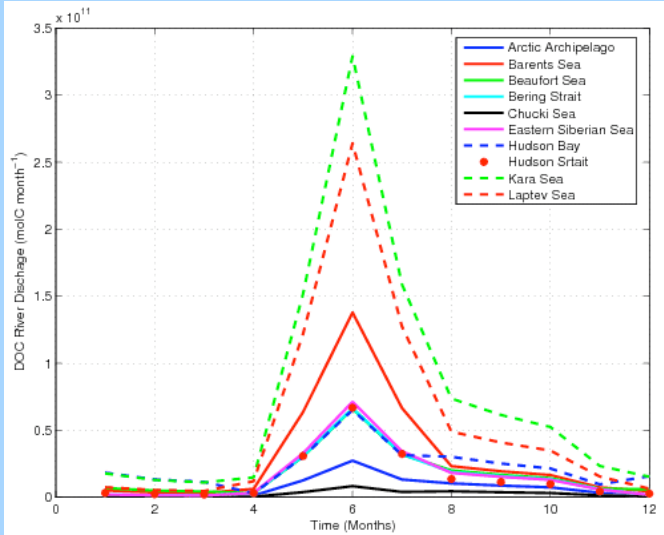
Pan-Arctic DOC Riverine Flux



3.5

10^{11}molC month^{-1}

0



Time (months)

Eurasian Load > North-American Load

2- Regional Arctic Set-up of MITgcm

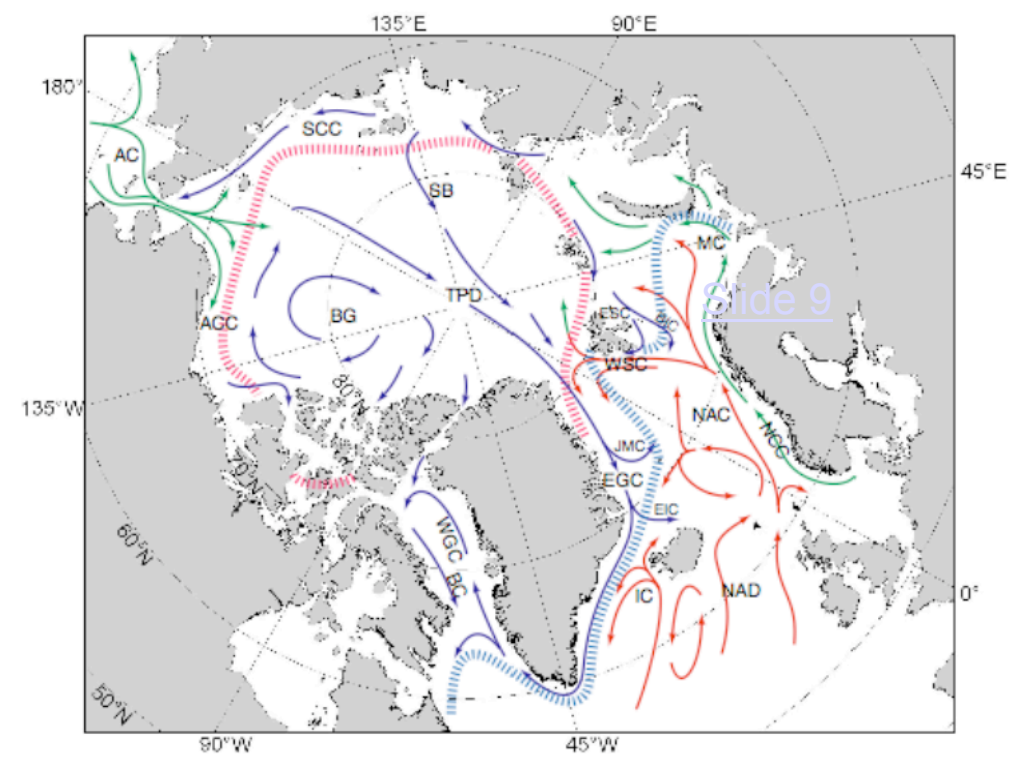
2.1 - Regional version of MITgcm (cubed sphere) for the Arctic domain with open boundary conditions (global runs).

2.2 - Horizontal Resolution ~20 Km, using 1992-2001 NCEP Atmospheric Forcing - 3 repeated simulated decades.

2.3 - Dynamical/Thermodynamic Sea-Ice Model coupled to the Ocean GCM.

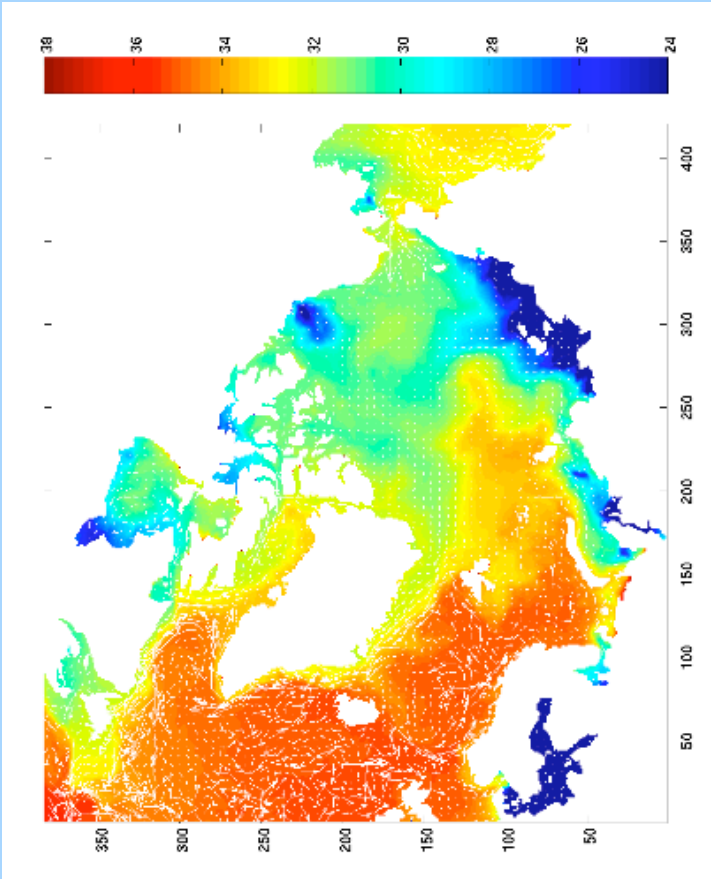
2.4 - ON-LINE version of MITgcm for tracer transport (and ocean biogeochemical processes).

Large Scale Circulation of the Arctic Ocean



Surface flow (0-200 m)

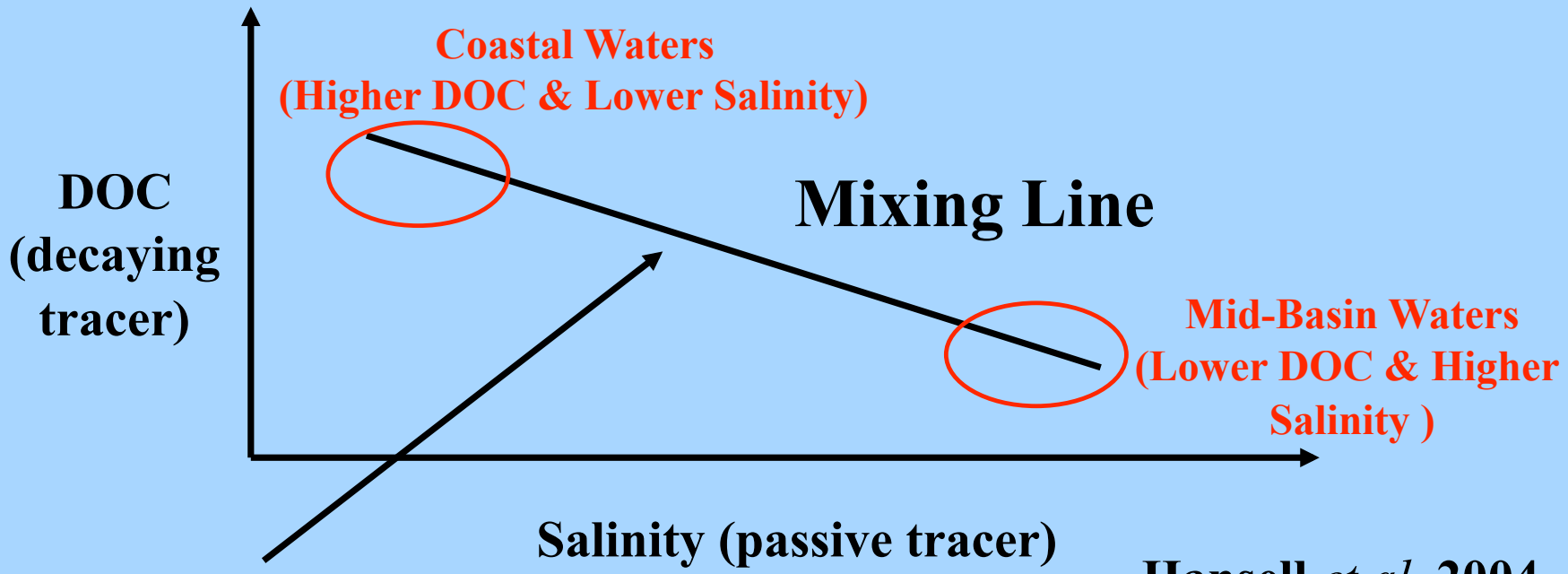
(Figure from Rudels, 2006)



Regional Arctic MITgcm

Surface Salinity & Surface velocity

Cross-Shelf Transport, Mixing, and Decay of DOC

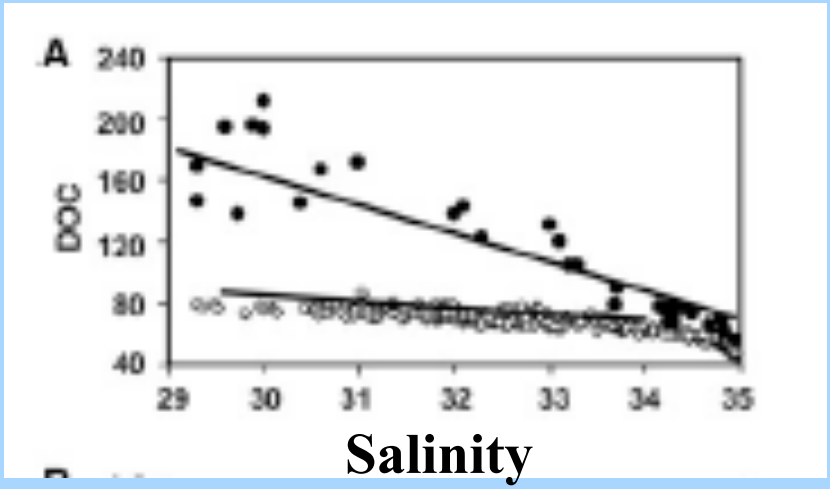


Hansell *et al.* 2004

τ governs the mixing line.

τ = Tracer Life-Time

Black Dots = Eastern Arctic
White Dots = Western Arctic



Assessing Lifetime of Riverine DOC

$\partial C/\partial t = \text{Adv.} + \text{Diff.} + RS_C$

Circulation Only

Passive Tracer

$\partial C/\partial t = \text{Adv.} + \text{Diff.} + RS_C - \lambda C$

Circulation + Decay

Decaying Tracer

C = Idealized (DOC-like) Tracer

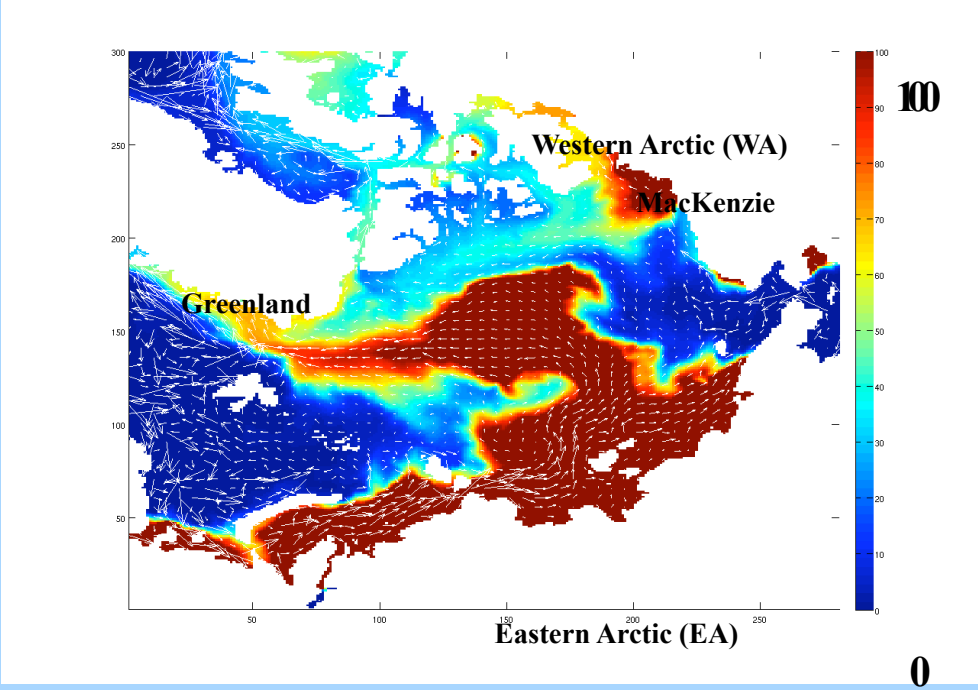
$\tau = 1/\lambda$ = DOC Life-time (3-10 years, Hansell *et al.*, 04)

λ= Tracer decay rate

RS_C = Tracer Riverine Source

Riverine Tracer Fluxes & Ocean Dynamics

30th simulated year - annual mean



[Passive Tracer] & Surface velocity

(Units : microM)

1) Atlantic Waters : Low [TRC]

2) EA Coastal Waters : High [TRC]

3) Pacific Waters : Low [TRC]

4) WA Coastal Waters : High [TRC]

(I) Evident link between :
Location of riverine tracer fluxes

Ocean circulation patterns

(II) Strong haline gradients set the differences in both water masses and

[trc] distributions

Data-Model Comparison (I)

Without any decay

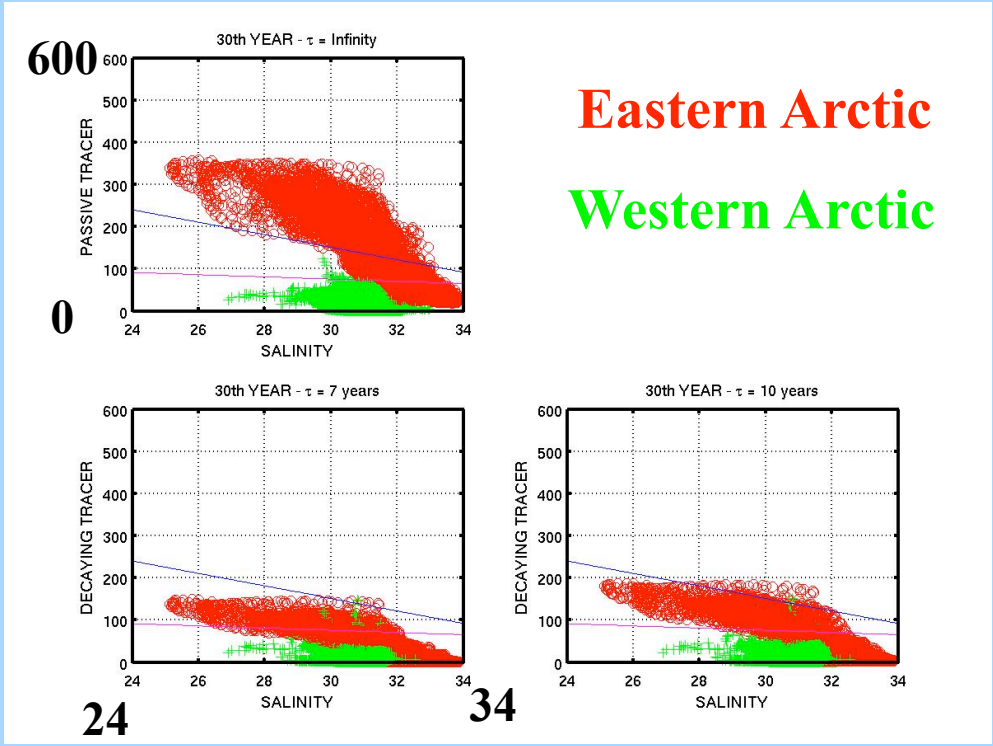
Tracer values too high !!

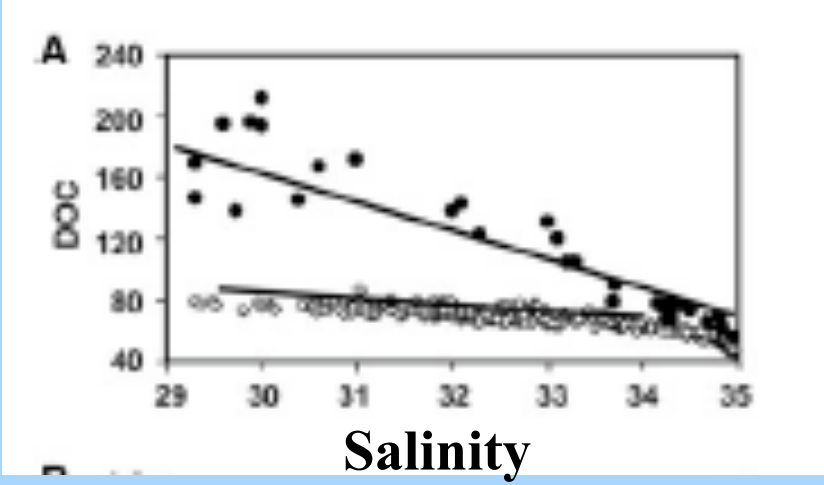
Tau =10 years :

Model approaches data

BUT values are OFFSET

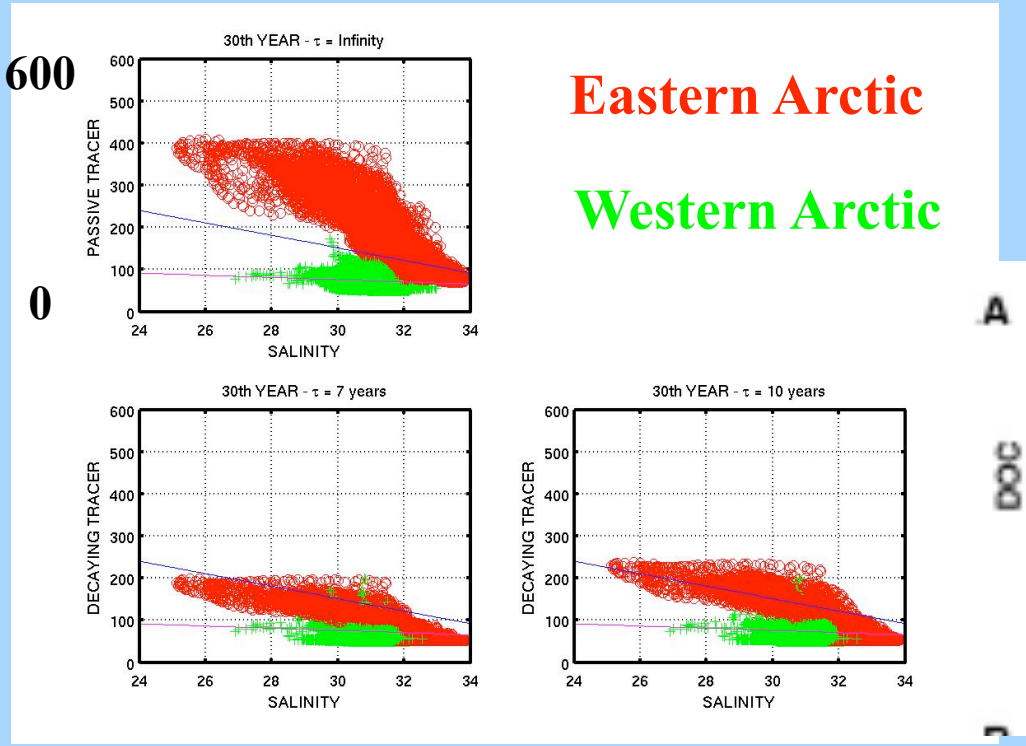
Why ? ==> next slide !!



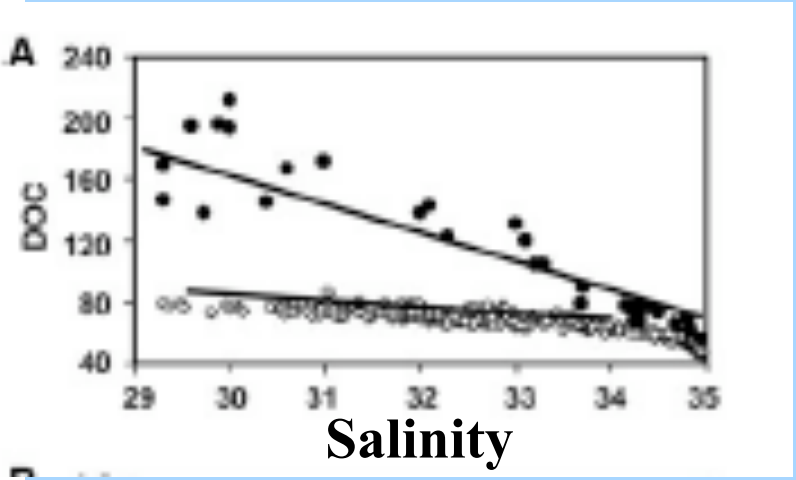


Data-Model Comparison (II)

$$DOC_{total} = DOC_{river}\ (modeled) + DOC_{refractory}\ (missing)$$



DOC_{refrac} ~ 50 microM
(Anderson , 2002)

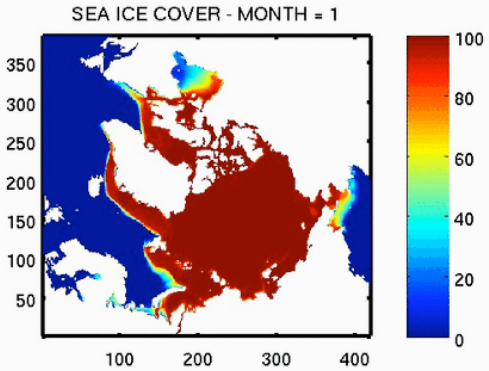


Manizza *et al.*, to be submitted to GBC

III - Coupling Land and Ocean Carbon Cycles

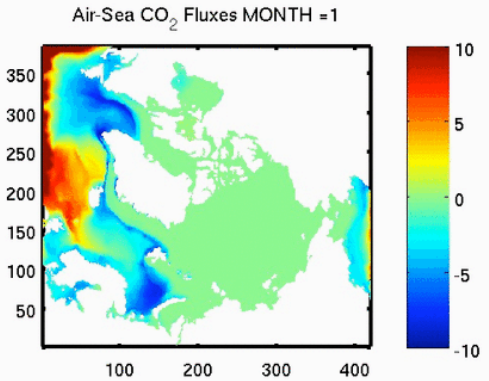
Non-coupled version of MITgcm&OCC

30 years spin-up



(%)

Fixed Atm. pCO_2



OUTGASSING

($gC\ m^{-2}\ a^{-1}$)

INGASSING

5+1 Tracers Ocean Carbon Cycle Model :

1) DIC
2) ALK
3) PO_4
4) DOP
5) O_2
6) DOC

$\partial DIC/\partial t$ = Physics + SMS + airsea flux + λ DOC (new term)

IV) ON-GOING & FUTURE WORK

1 - Using ECCO2 set-up with coupled C-cycles to assess the impact of terrigenous DOC on air-sea CO_2 fluxes in steady and transient scenarios (1991-2001) of atm. pCO_2.

2 - Identifying ventilation patterns in the ECCO2 solution (with P. Winsor & C. Hill).

3 - Exploring the long-term impact of North Pacific Iron Fertilization on the Arctic Ocean Productivity (expected collapse).