Does bio-refractory dissolved organic matter control the global oceanic dissolved iron distribution?

(Idea & Preliminary results)

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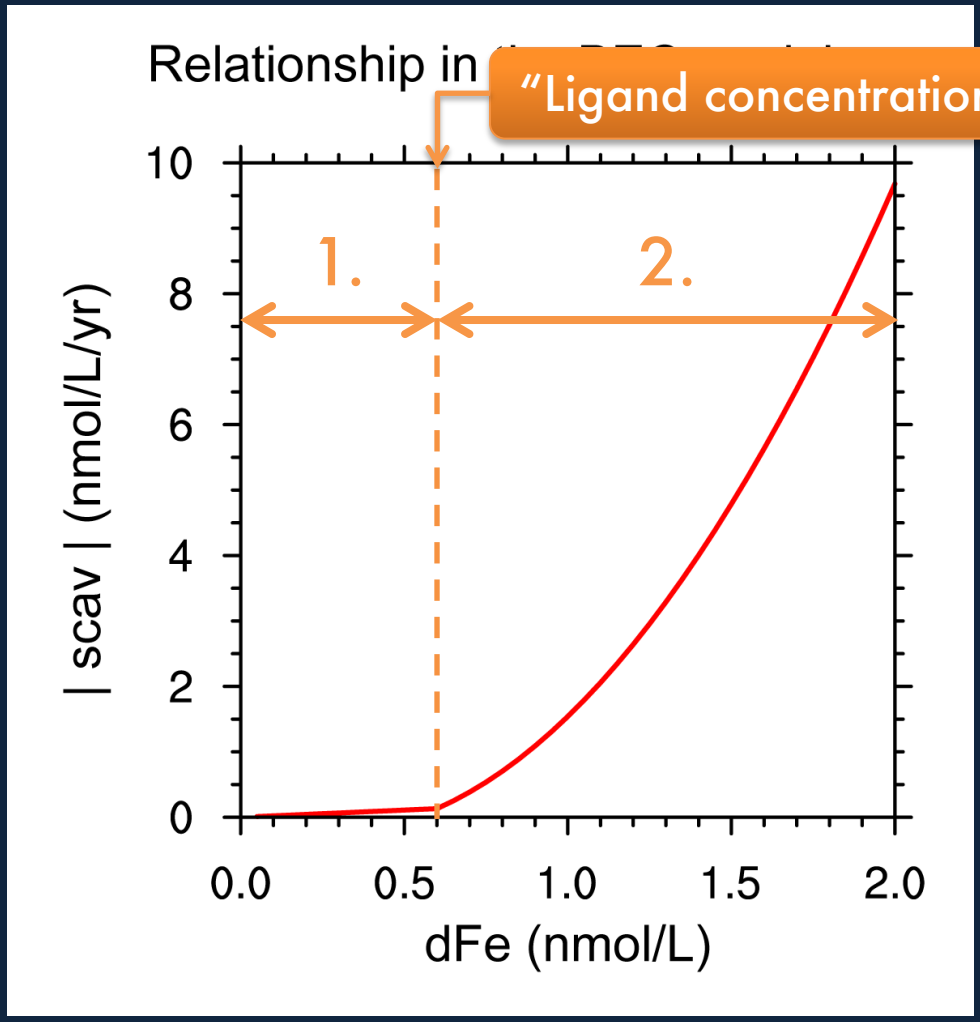
The governing equation of iron cycle in the BEC model

$$\frac{\partial[dFe]}{\partial t} = phys + bio + scav + desorp$$

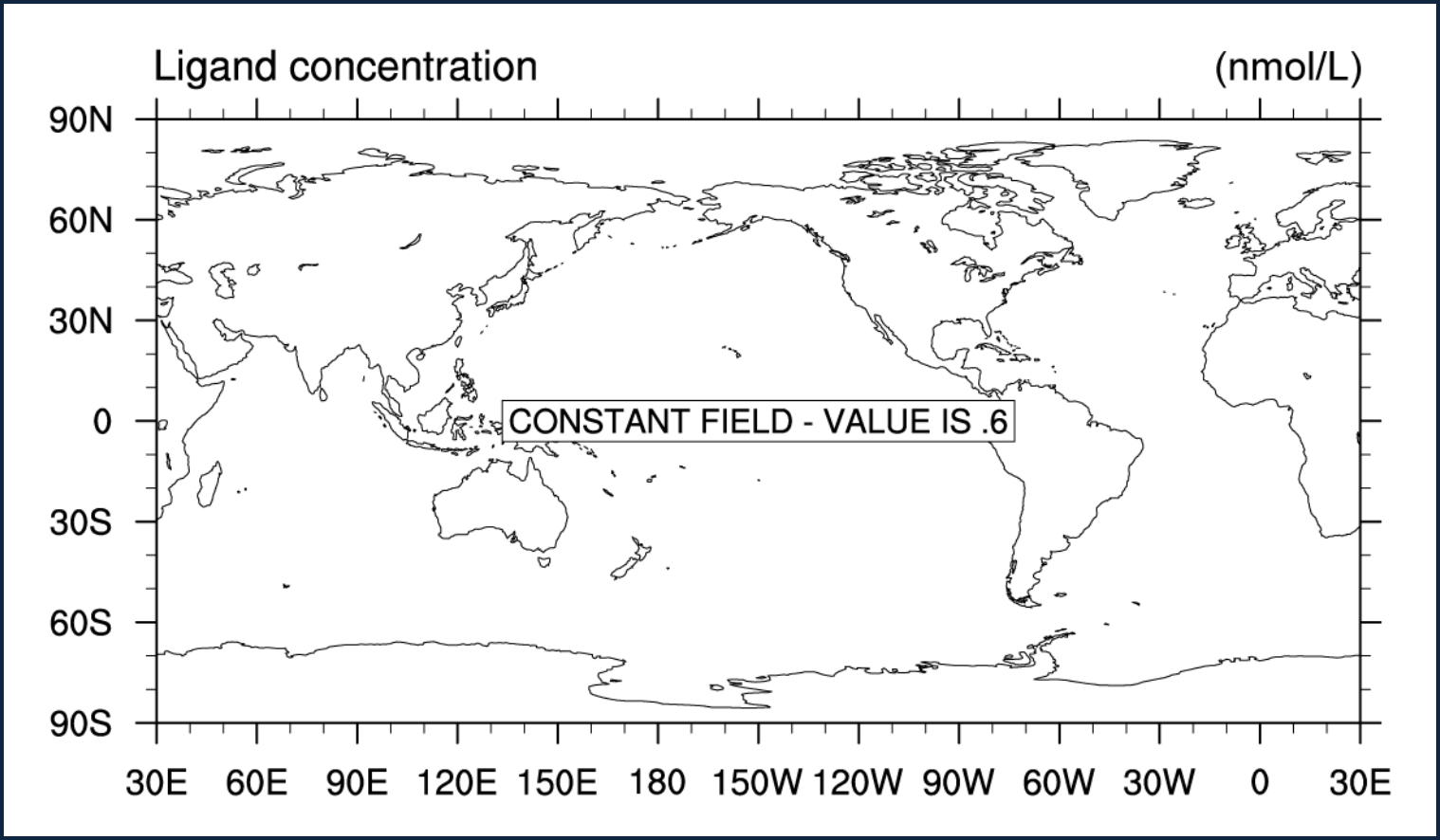
dFe: dissolved iron

phys:	advection by large-scale flows & subgrid-scale mixings
bio:	biological uptake (sink) and remineralization (source)
scav:	precipitation and adsorption to sinking particles (sink)
desorp:	desorption from sinking particles (source)



1. Lower scav regime: dFe is stabilized by forming complexes with organic ligands
2. Higher scav regime: Free dFe is rapidly removed

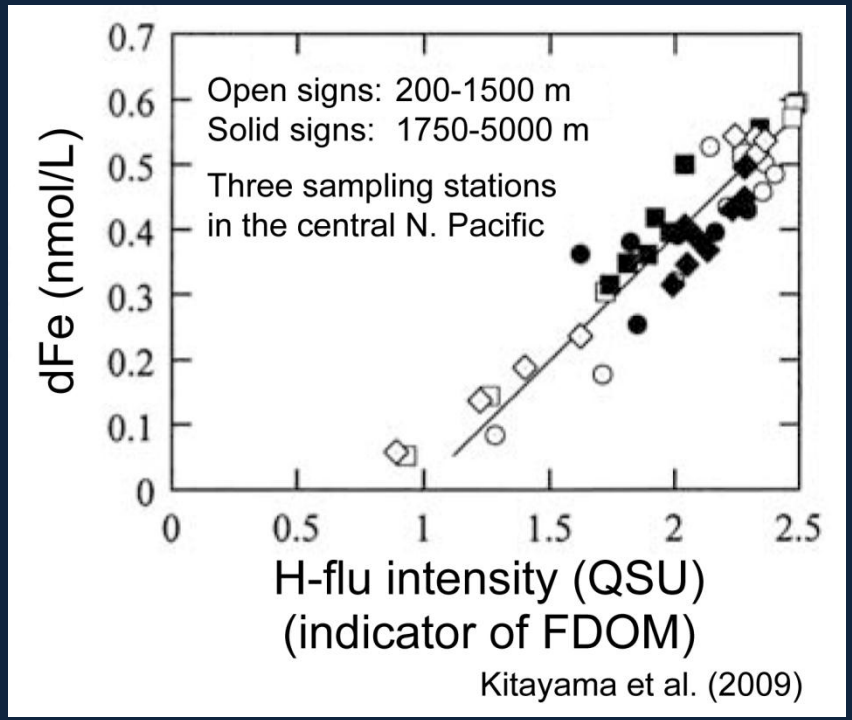
Distribution of “ligand concentration” in the BEC model



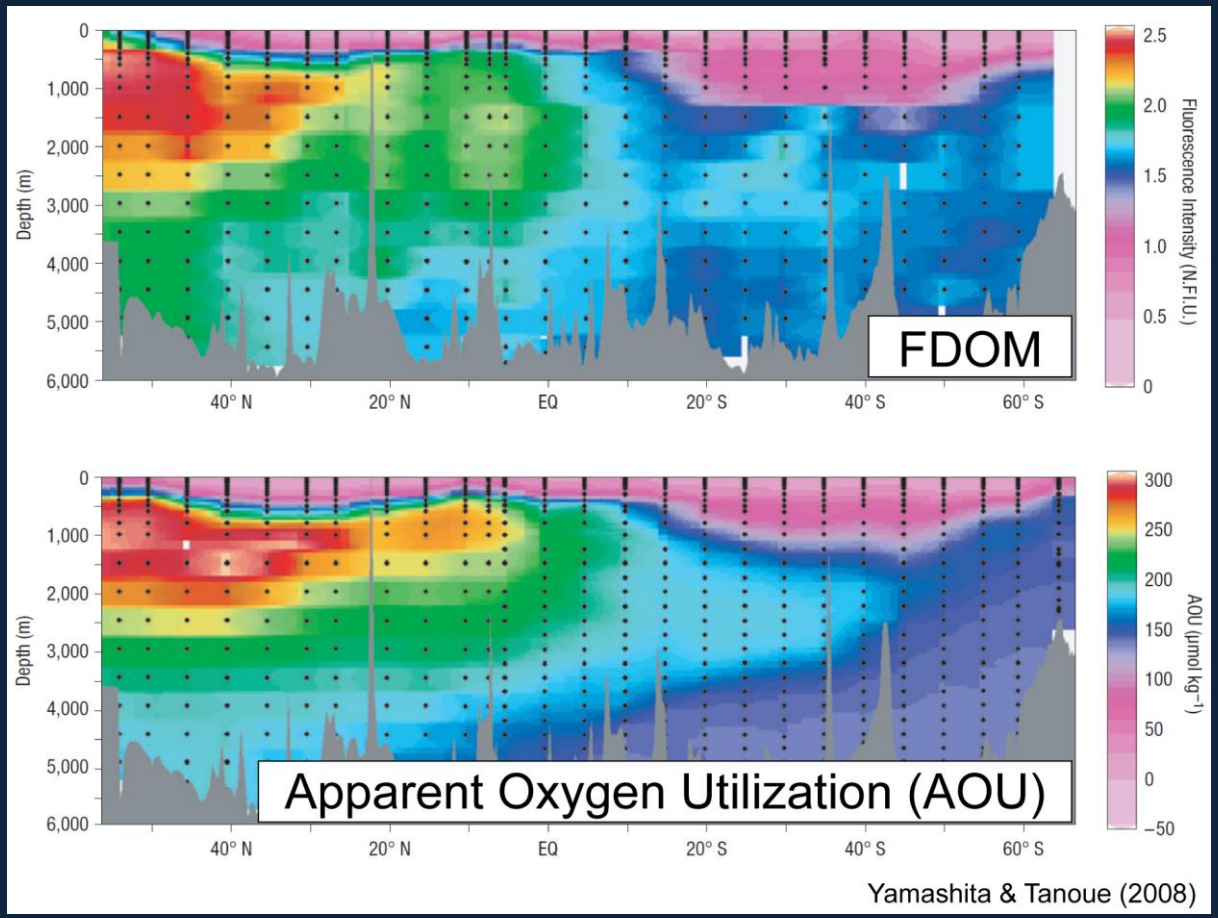
Possible proxy utilized for distribution of "Ligand concentration"

- Addition of humic acid to NaCl solutions increases iron solubility near pH 8 (Liu & Millero, 1999).

- Humic-type Fluorescent Dissolved Organic Matter (FDOM) correlates well with dFe concentrations in intermediate & deep waters (Tani et al., 2003; Takata et al. 2005; Kitayama et al. 2009).

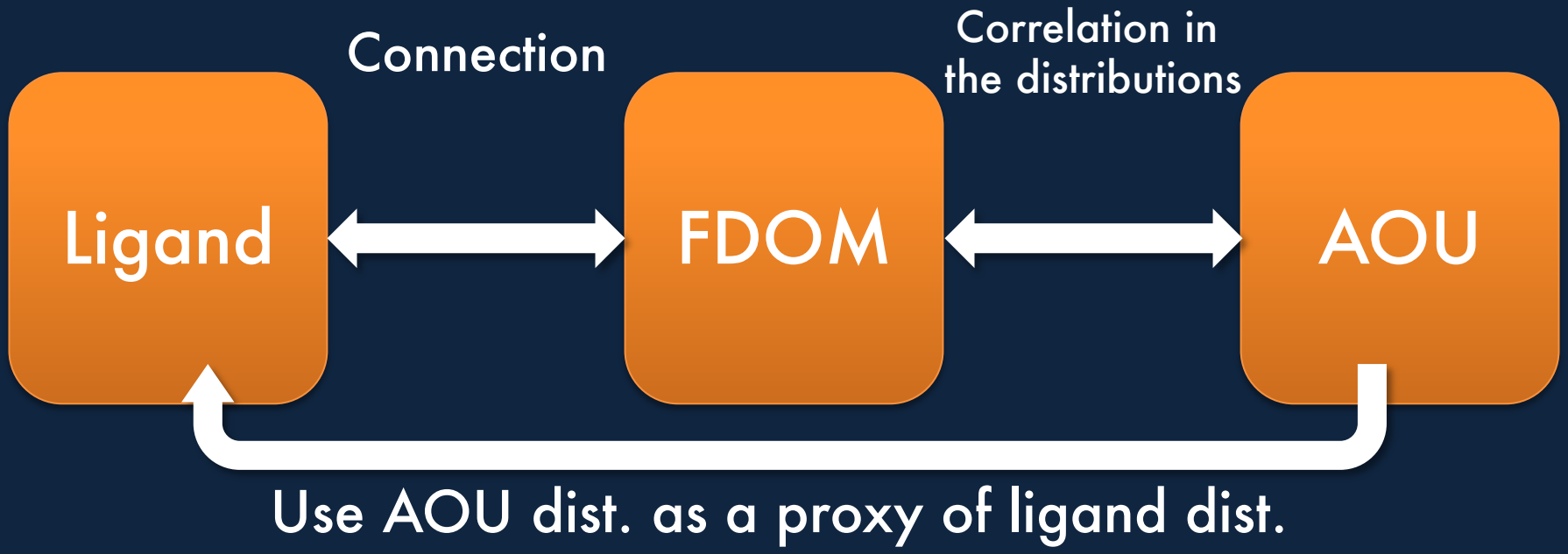


Possible proxy utilized for distribution of "Ligand concentration"



AOU increases during water flowing abyss owing to degradation of sinking organic matter.

Purpose of this study

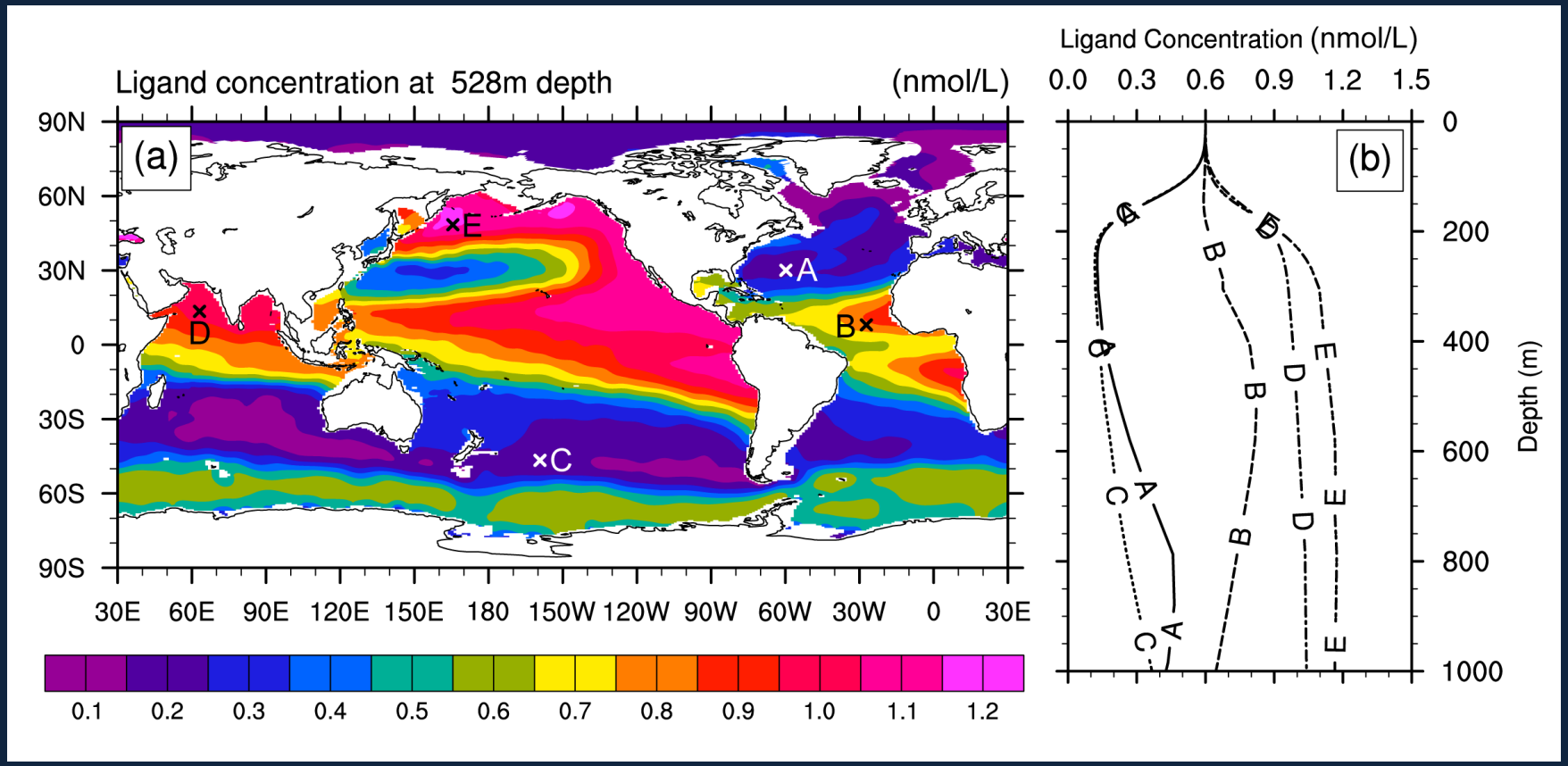


Evaluating impact of incorporating spatially variable "ligand concentration" on the global dissolved iron distribution using the BEC model.

Model

- CCSM3.5, ocean only w/ the BEC model
- gx1v5 (roughly 1°) and 60 levels
- Surface boundary conditions are NYF (Large & Yeager, 2004)
- The model spin up for 120 years w/ the spatially uniform ligand (0.6 nmol/L); then two experiments are conducted
  - UNIFORM case (for 50 years): conventional method
  - AOU case (for 50 years): new method
- Only discuss the results of the last year and for depth of 200-1000m

Ligand concentrations in the AOU case



- Concentrations are determined the global avg. to be 0.6 nmol/L.
- Surface concentrations are kept to uniform 0.6 nmol/L.

Quality control on obs. data

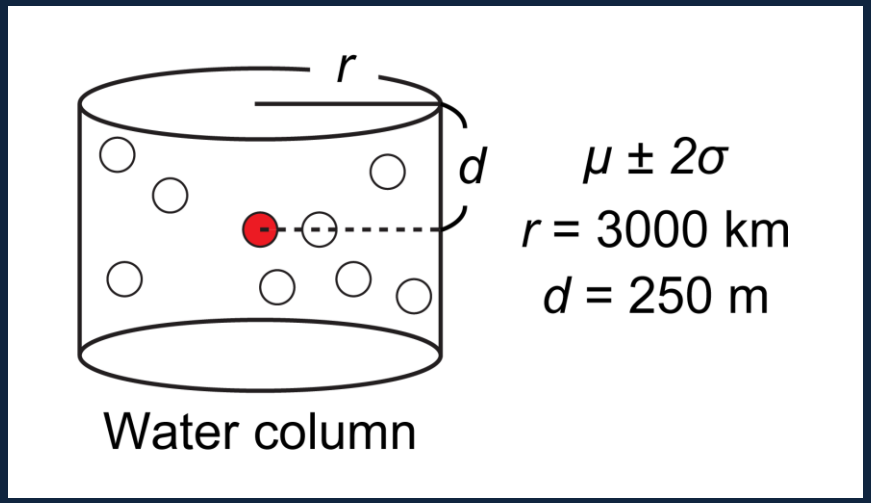
Simulated results (200-1000 m depth) are compared with compiled data (Moore & Braucher, 2008).

Some data are excluded from the comparison.

- Data from near the coast
  (N=1122 → N=597)
- Data from
  - Mackey et al. (2002)
  - Blain et al. (2001)
  - Bucciarelli et al. (2001)
  - Löscher et al. (1997)
  - Boye et al. (2006)

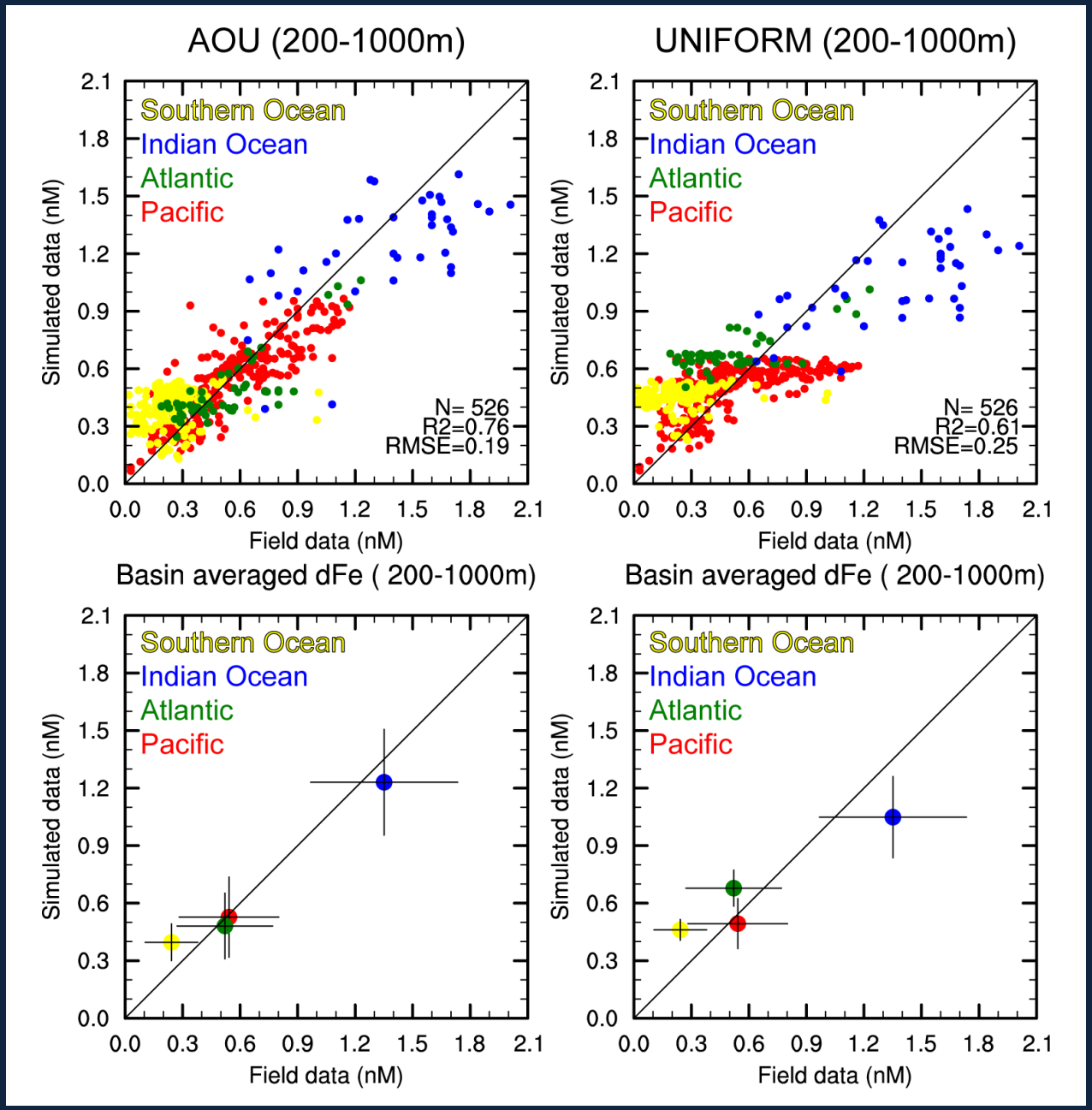
  (N=597 → N=561)

- Outliers



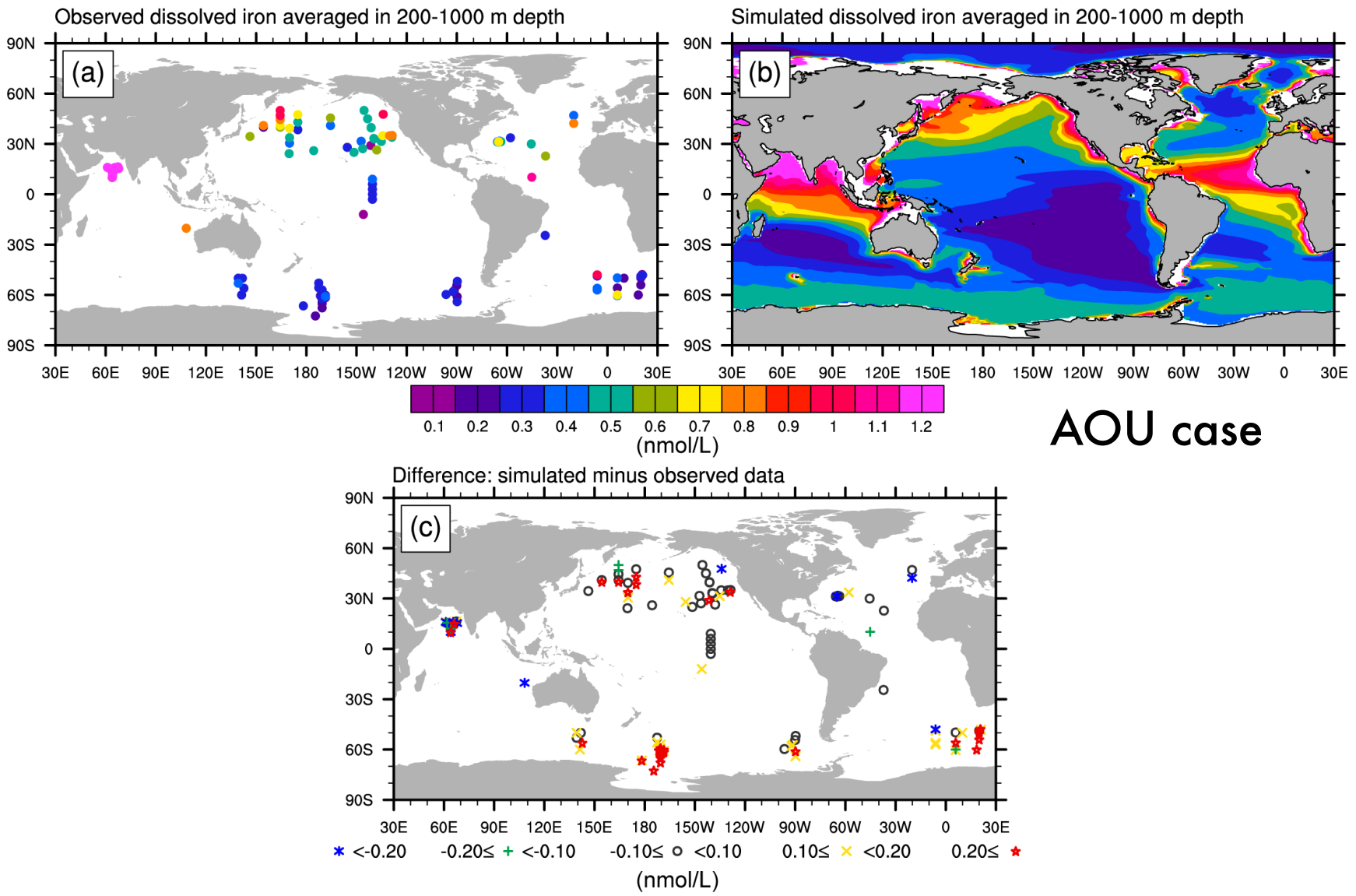
(N=561 → N=526)

N: number of data within 200-1000 m depth.


AOU (200-1000m)
UNIFORM (200-1000m)
Basin averaged dFe (200-1000m)
Basin averaged dFe (200-1000m)
Southern Ocean
Indian Ocean
Atlantic
Pacific
N= 526
R2=0.76
RMSE=0.19
N= 526
R2=0.61
RMSE=0.25
Simulated data (nM)
Field data (nM)
0.0
0.3
0.6
0.9
1.2
1.5
1.8
2.1

R2	Pacific	Atlantic	Indian	Southern	Global
AOU	0.69	0.65	0.41	0.03	0.76
UNIFORM	0.40	0.36	0.40	0.02	0.61

RMSE (nmol/L)	Pacific	Atlantic	Indian	Southern	Global
AOU	0.14	0.15	0.32	0.22	0.19
UNIFORM	0.21	0.26	0.42	0.26	0.25


Observed dissolved iron averaged in 200-1000 m depth
(a)
Simulated dissolved iron averaged in 200-1000 m depth
(b)
90N
60N
30N
0
30S
60S
90S
30E 60E 90E 120E 150E 180 150W 120W 90W 60W 30W 0 30E
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1 1.1 1.2
(nmol/L)
Difference: simulated minus observed data
(c)
* <-0.20 -0.20≤ + <-0.10 -0.10≤ o <0.10 0.10≤ × <0.20 0.20≤ ★
(nmol/L)

AOU case

Summary

- Incorporating ligand distribution into the BEC model improves simulated dFe field both in global and basin scales.

- The results support the hypothesis that FDOM (or something correlating with AOU) is playing a role as an iron-binding ligand.