



LSCE

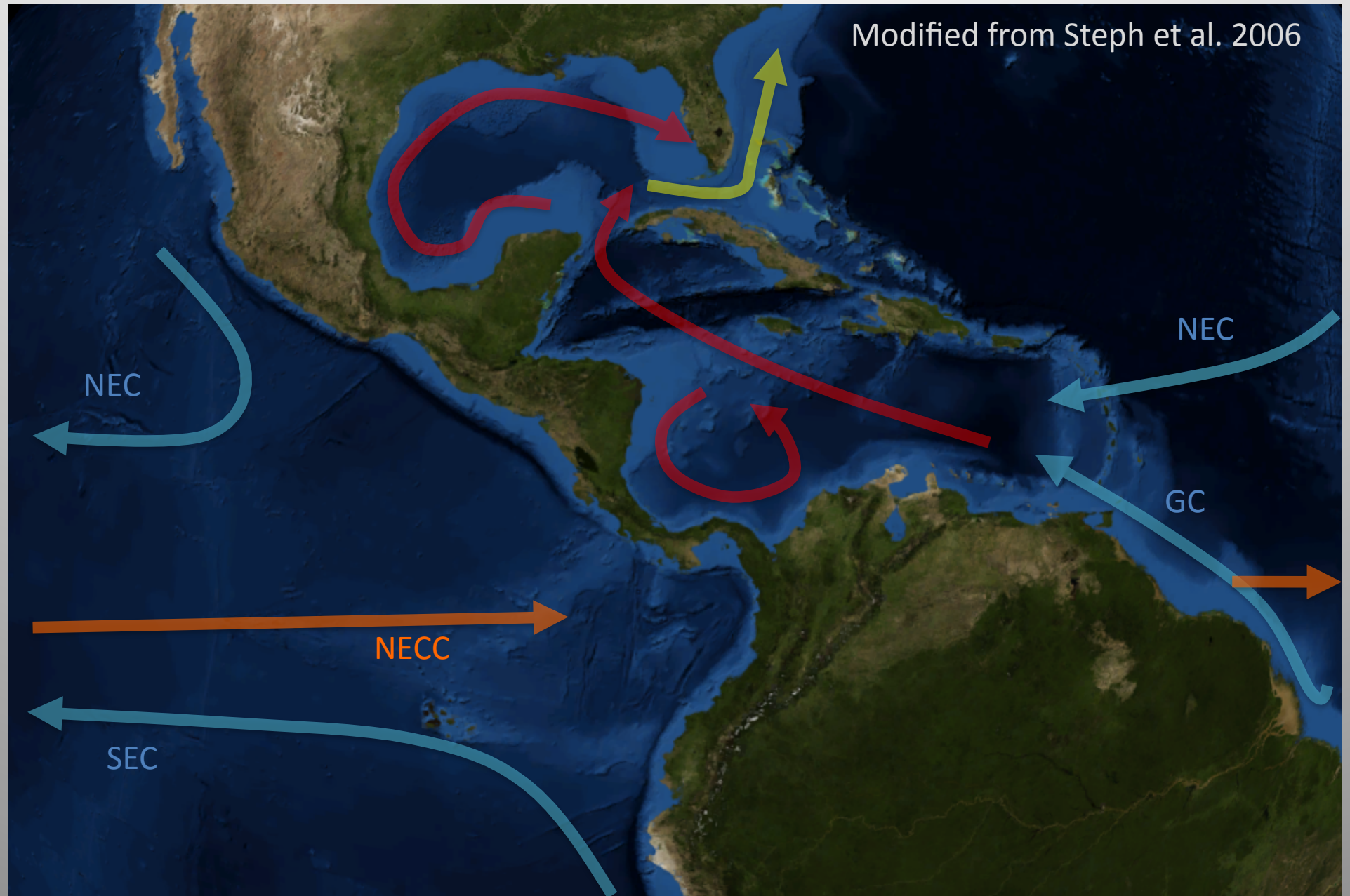
LABORATOIRE DES SCIENCES DU CLIMAT
& DE L'ENVIRONNEMENT

Shoaling of the central american seaway: simulating climate and epsilon-neodymium response

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Panama isthmus closure



Opening Panama: a playing field for modelers (see Molnar 2008, synthesis)

Zhang et al., 2012

Butzin et al., 2011

Steph et al., 2010

Lunt et al., 2008

Von der Heydt & Dijkstra, 2006

Steph et al., 2006

Schneider & Schmittner, 2006

Motoi et al., 2005

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Nisancioglu et al., 2003

Murdock et al., 1997

Mikolajewicz et al., 1997

Mikolajewicz et al., 1993

Maier-Raimer, 1990



2012



1990's

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Maier-Raimer, 1990



- Increasing complexity

- Increasing resolution

- Modeling proxies ($\delta^{18}\text{O}$)

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Zhang et al., 2012

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Schneider & Schr

Motoi et al., 2005

Klocker et al., 200

von der Hey

Prange & Schultze

Omta & Dijkstra,

Nof & Van Gorder, 2003

Misancioglu et al., 2003

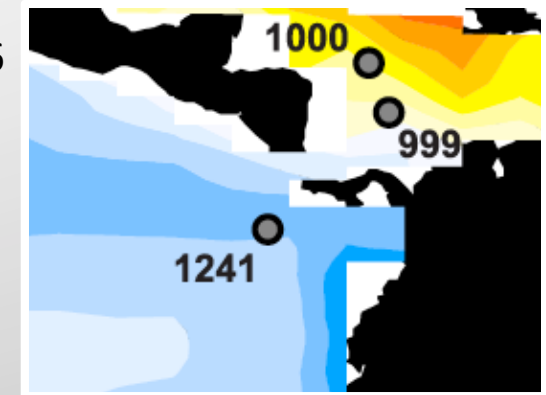
Munoz et al., 1997

Mikolajewicz et al., 200

Mikolajewicz et al., 1993

Maier-Raimer, 1990

Steph et al., 2006

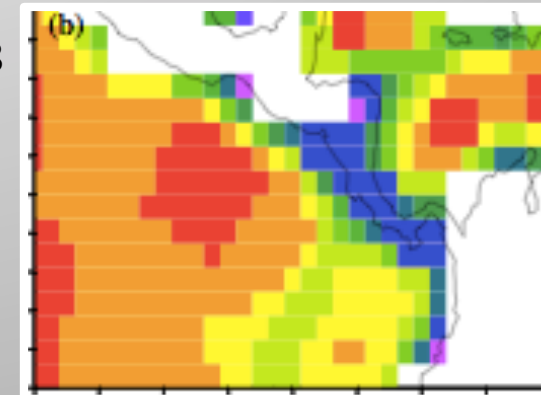


(Almost) common response :

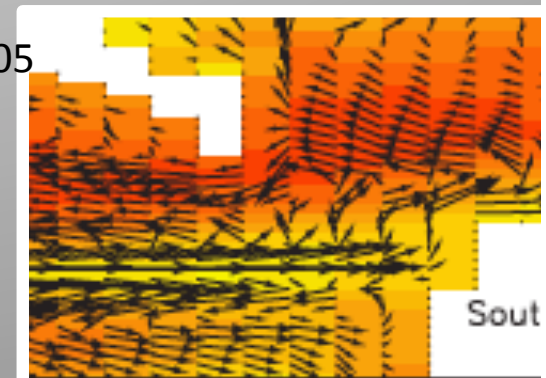
→ Collapse/decrease of the Atlantic Meridional Circulation

→ Eastward water flux through the seaway

2008



von der Heydt & Dijkstra, 2005

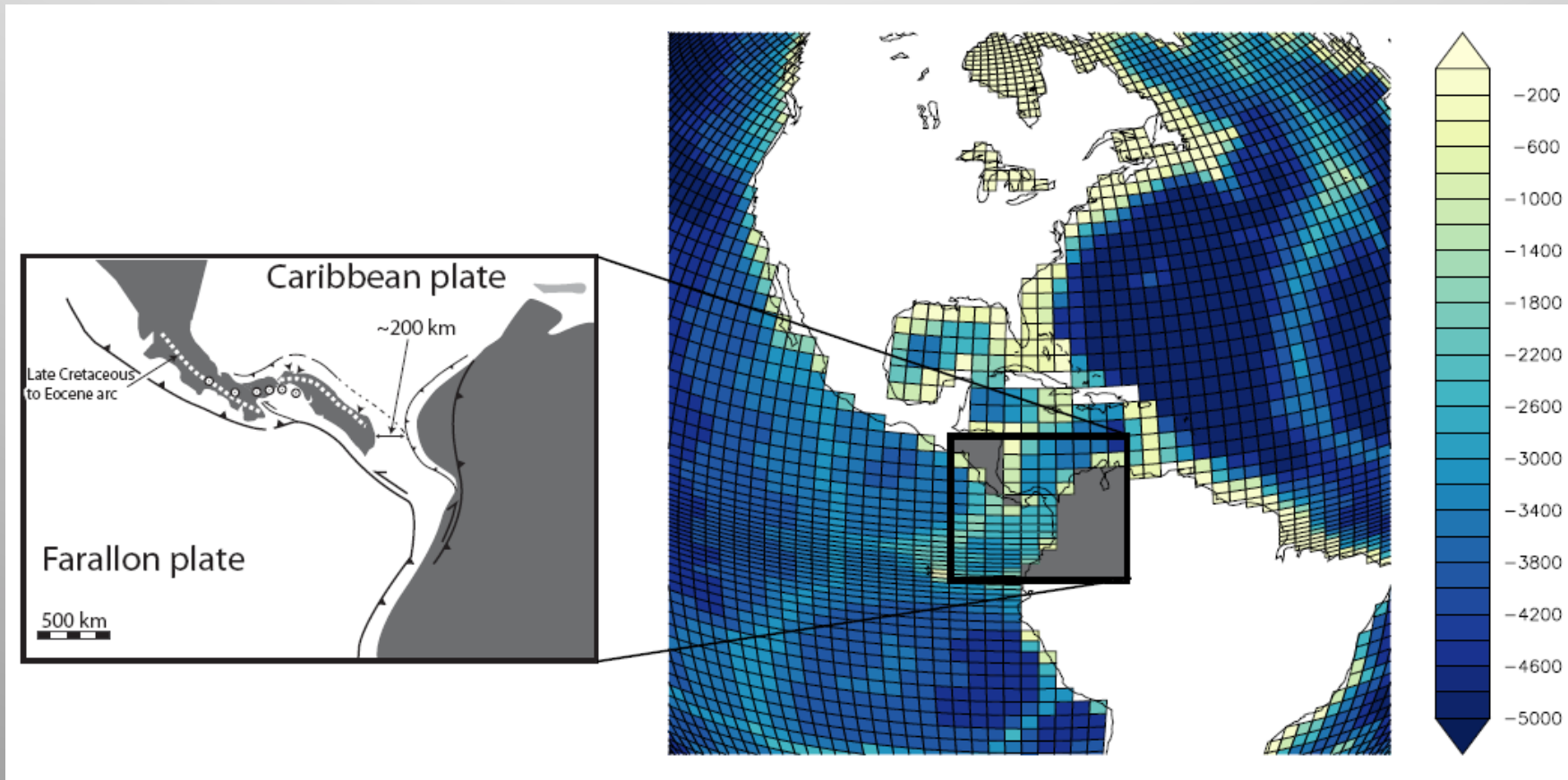


New story about isthmus shoaling

- First, use constrained paleobathymetry
- Second, provide data-comparable simulations

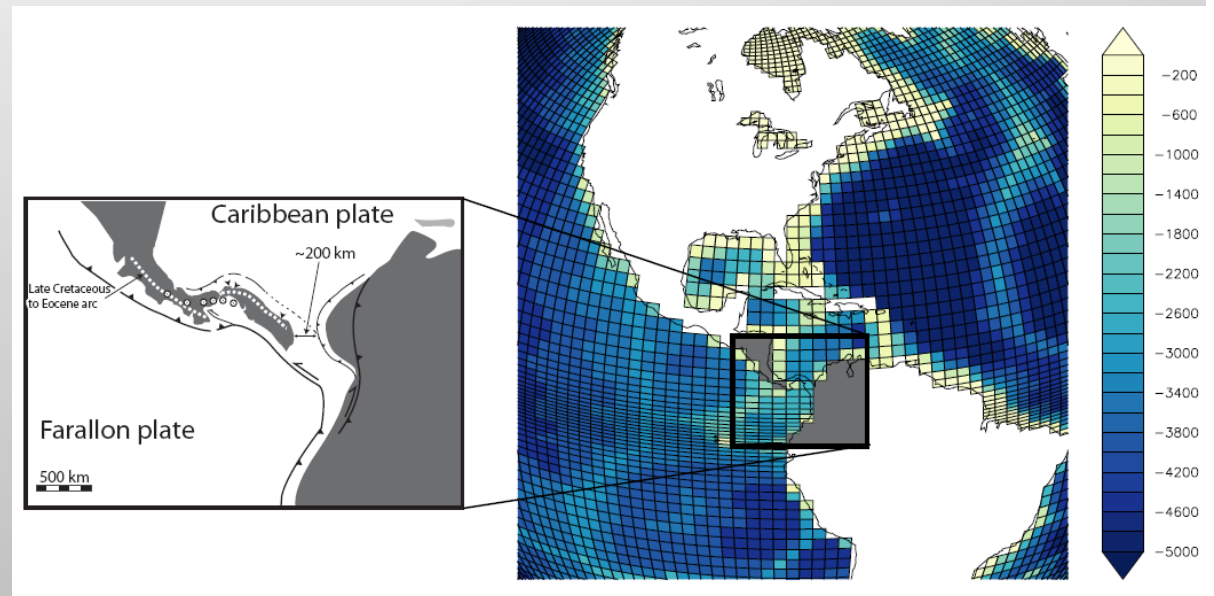
Experimental design 1/3

- Changing the bathymetry within IPSL-CM4



Experimental design 2/3

- Changing the bathymetry



- Changing the depth

Sill depth (m)

2700m

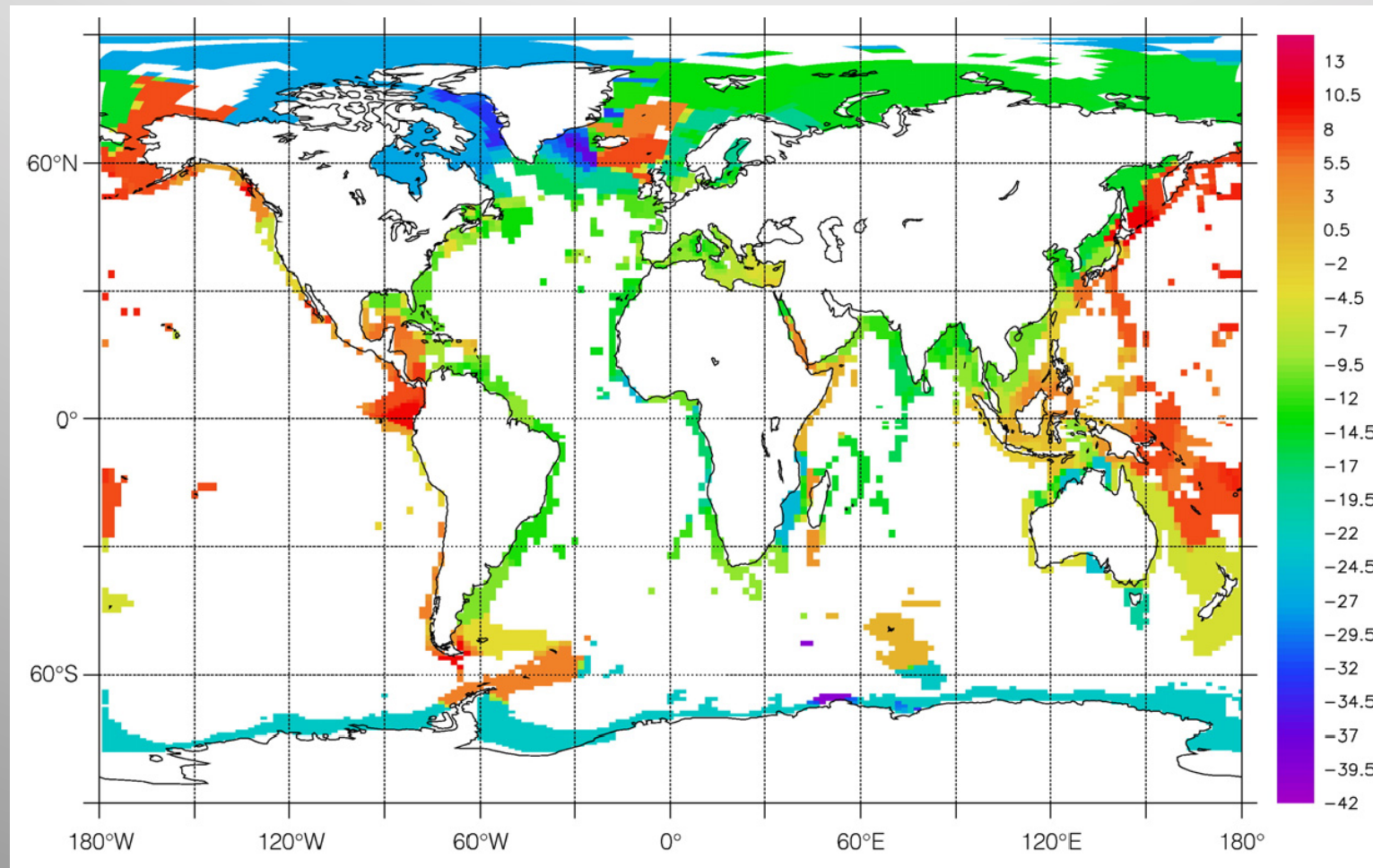
500 m

200 m

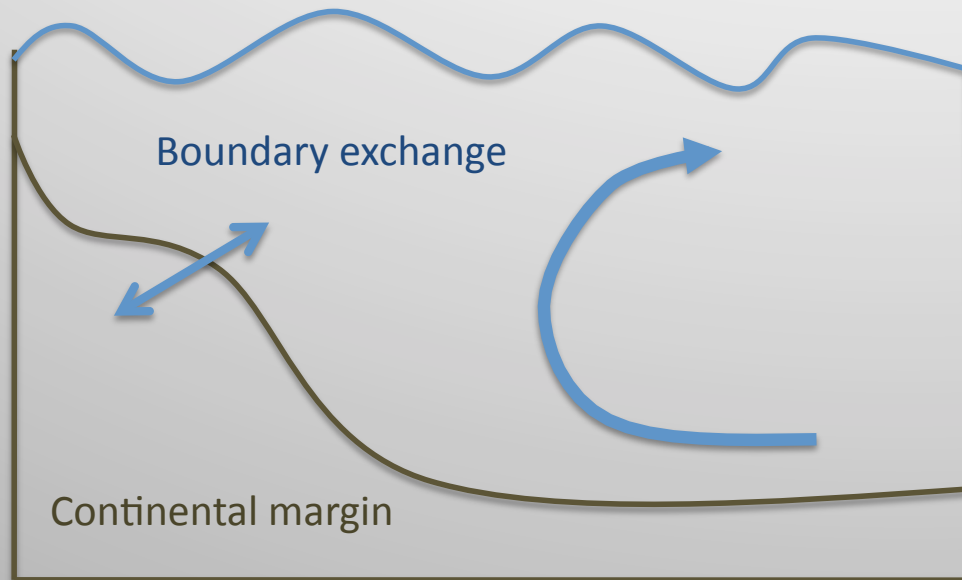
50 m

Experimental design 3/3

- Simulating ϵNd : Boundary exchange



Experimental design 3/3



Conservative Passive tracer :

$$\frac{\partial \varepsilon_{Nd}}{\partial t} = S(\varepsilon_{Nd}) - U \cdot \nabla \varepsilon_{Nd} + \nabla \cdot (K \cdot \nabla \varepsilon_{Nd})$$

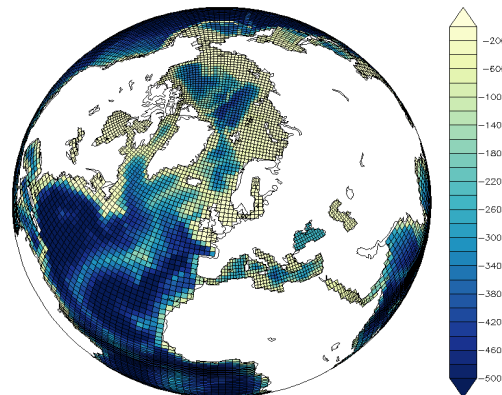
with BE Source S:

$$S(\varepsilon_{Nd}) = \gamma \left(\varepsilon_{Nd_{margin}} - \varepsilon_{Nd} \right)$$

||
 $\frac{1}{\tau}$

τ = Characteristic time

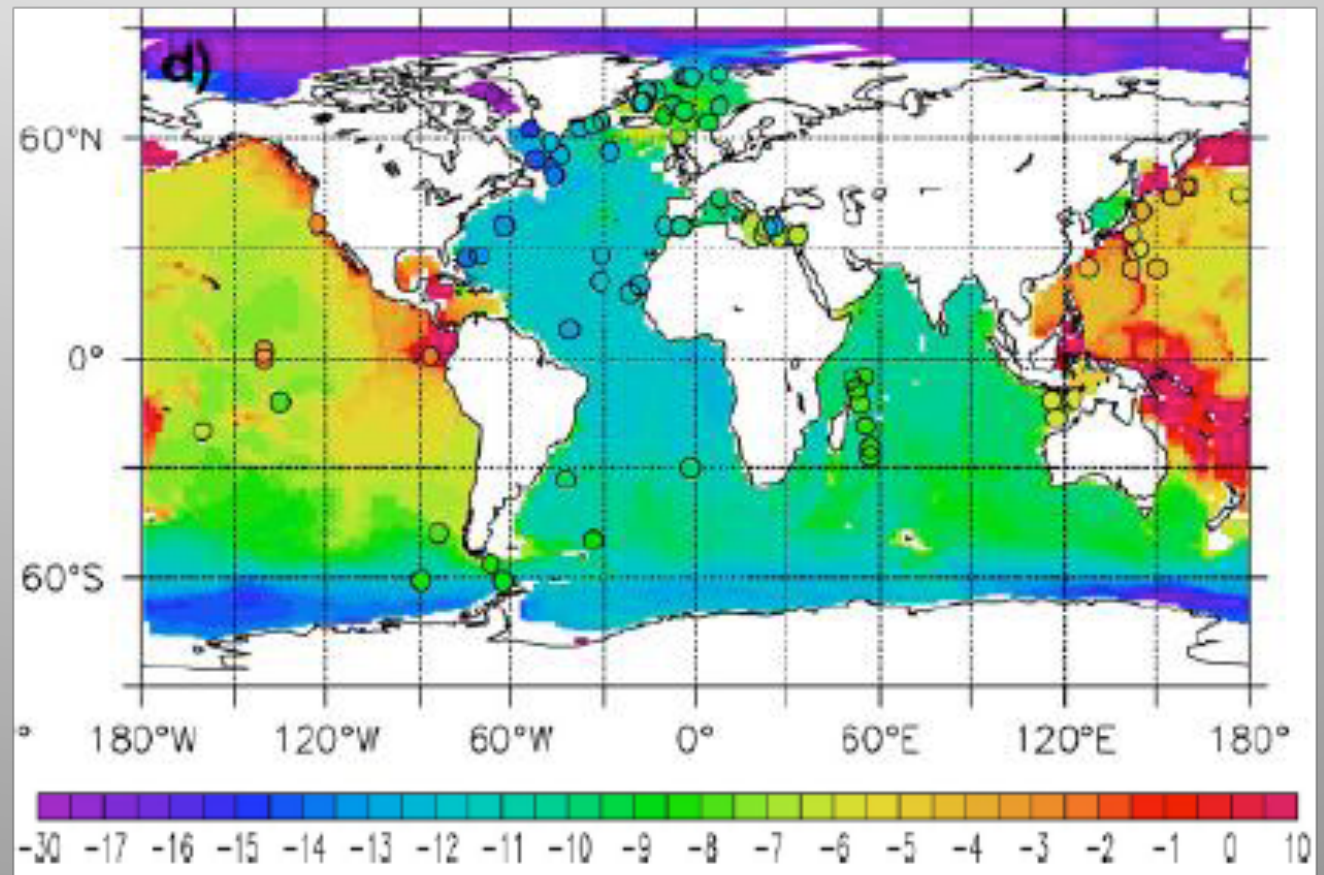
Dynamical model Nemo
(ORCA2: Hor. Resolution $\sim 2^\circ$)



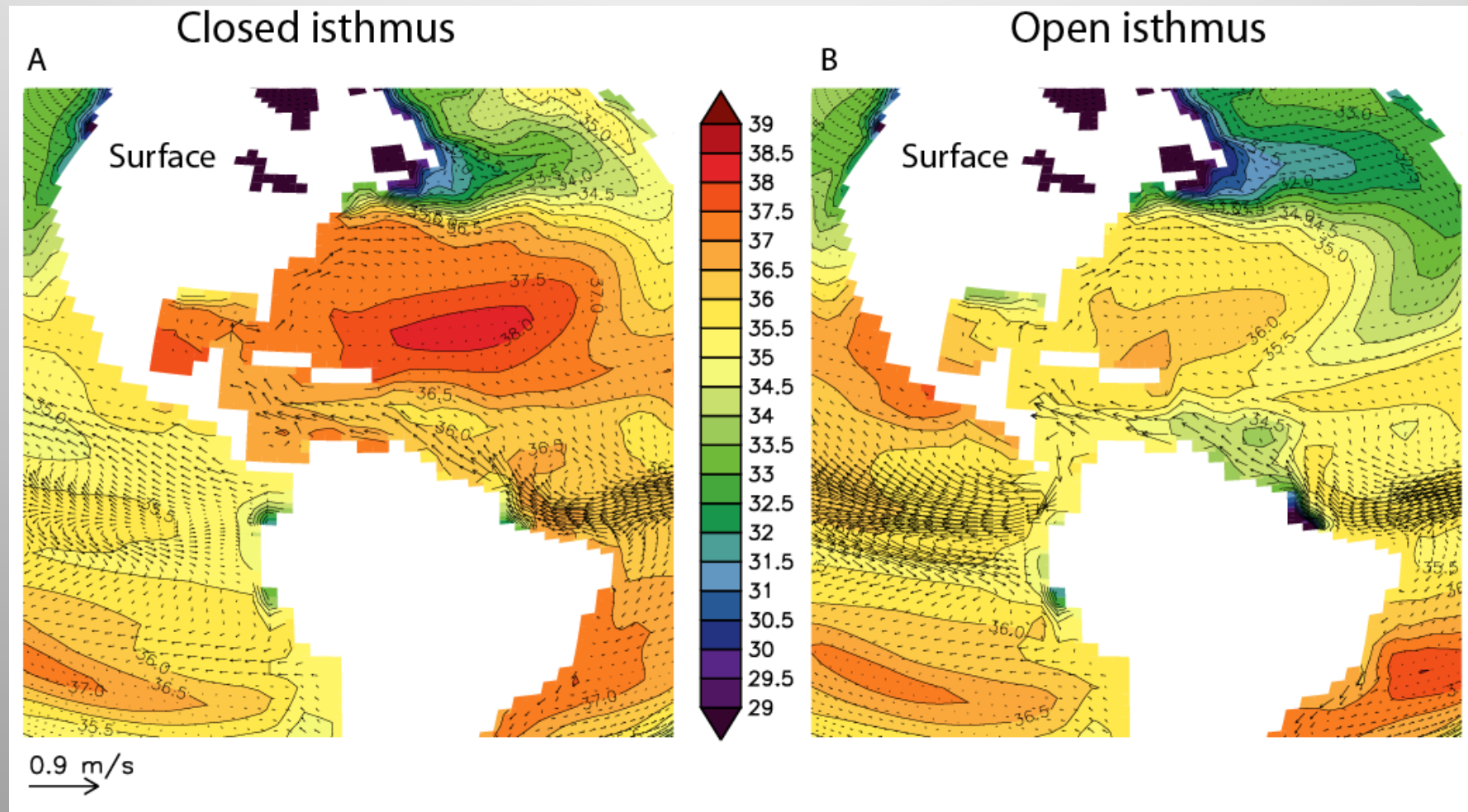
Experimental design 3/3

-Arsouze et al., 2007, 2009

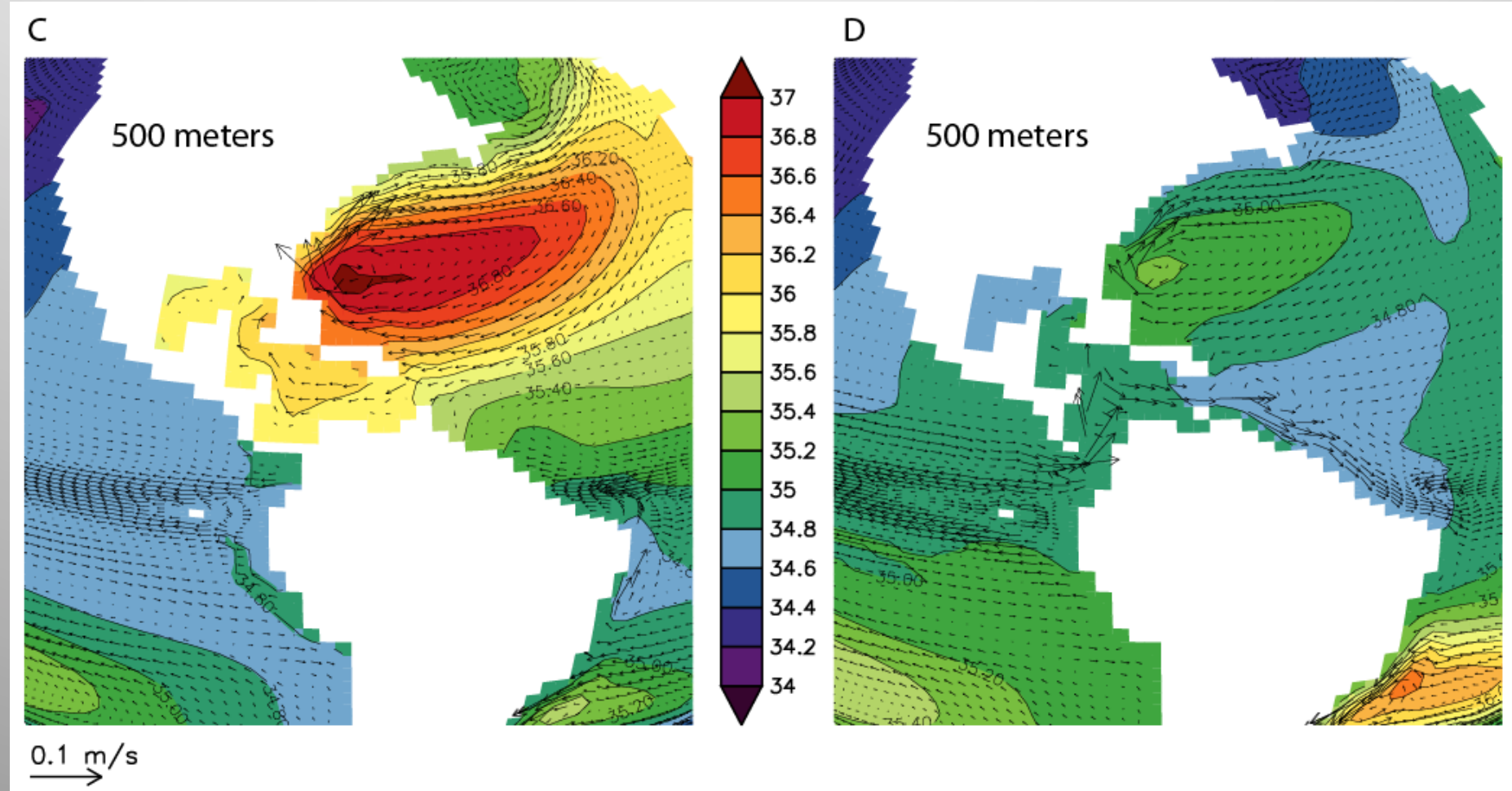
ϵ_{Nd} averaged between 800 and 5000 m depth



Results : Sea-surface salinities (psu) and current (m/s)

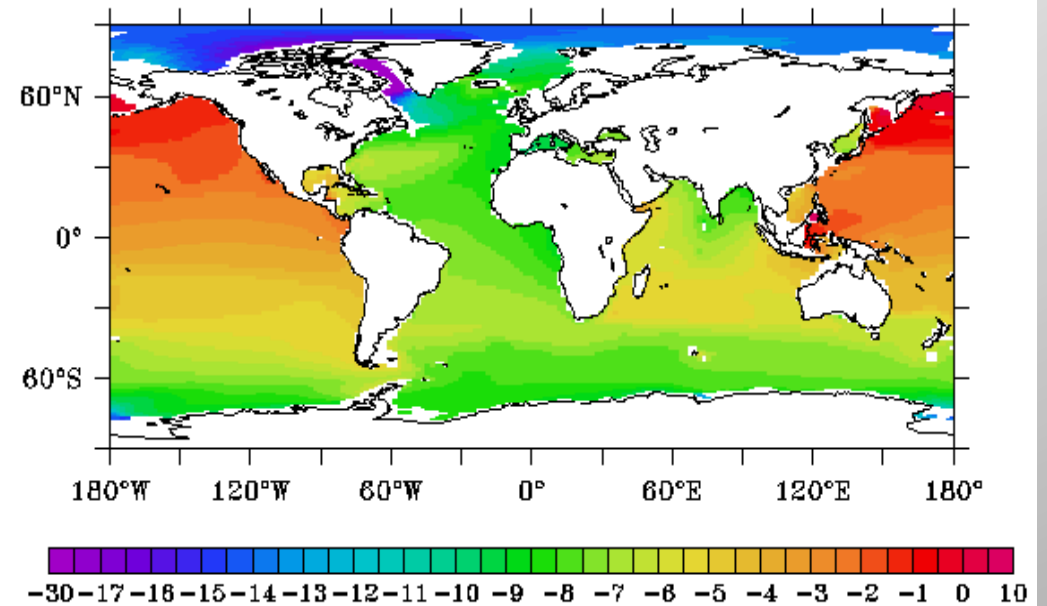


Results: Sea-surface salinities (psu) and current (m/s)

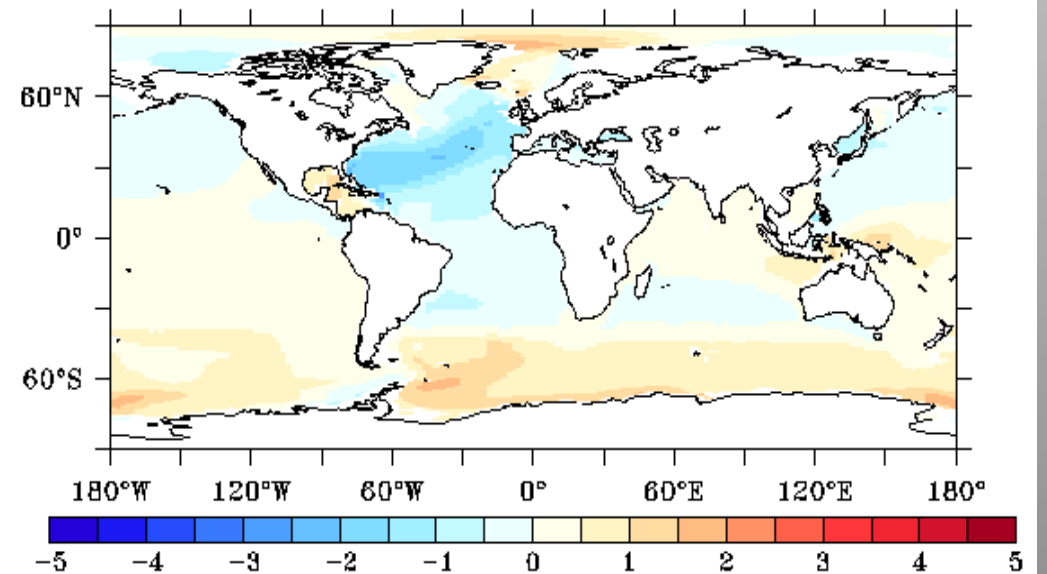


Results: Nd anomalies at 500m

ϵ_{Nd} for Control experiment

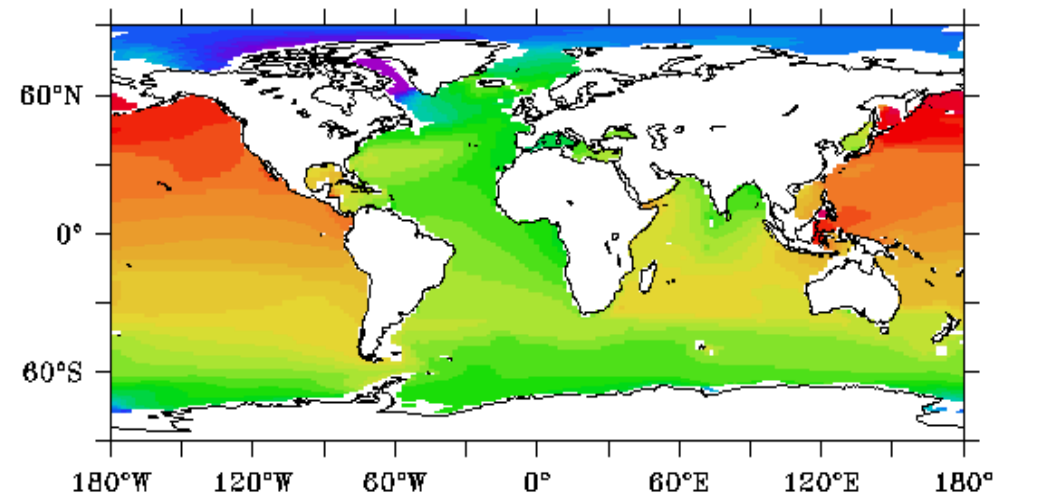


$\epsilon_{\text{Nd open-isthmus50}} - \epsilon_{\text{Nd Control}}$

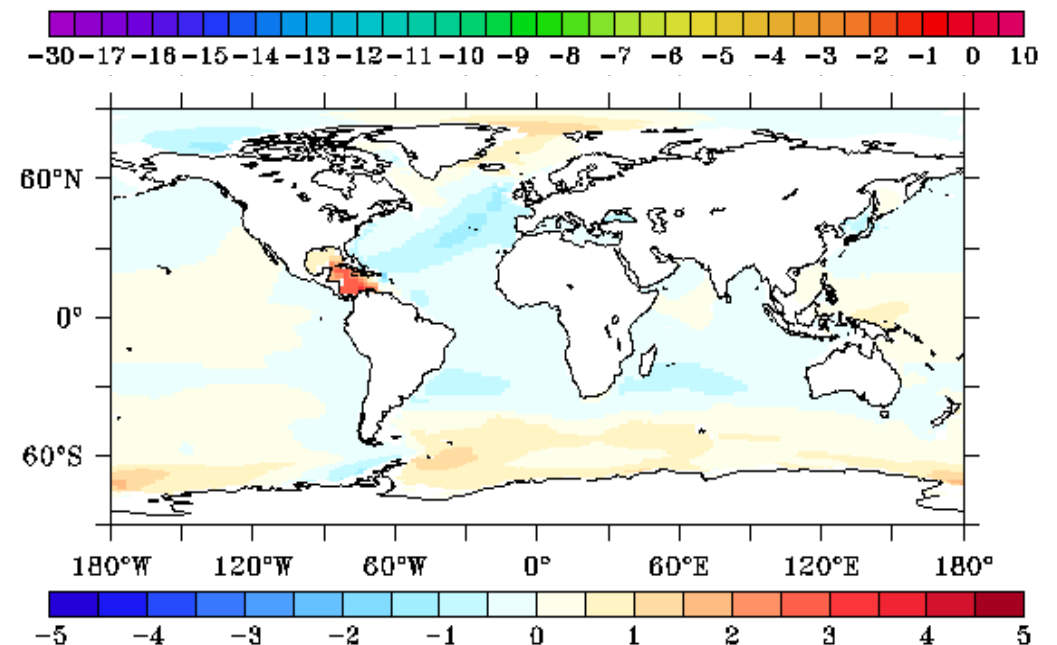


Results: Nd anomalies at 500m

ϵ_{Nd} for Control experiment

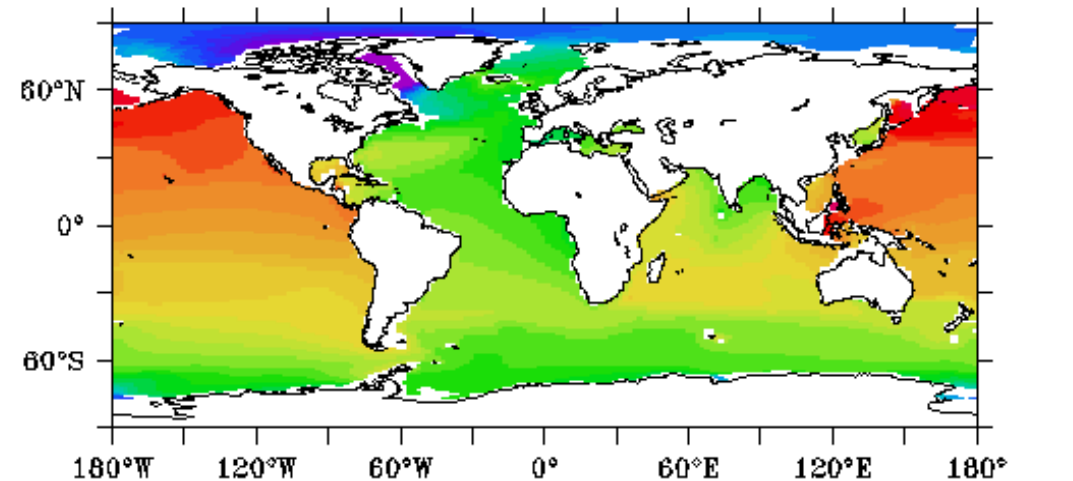


$\epsilon_{\text{Nd open-isthmus200}} - \epsilon_{\text{Nd Control}}$

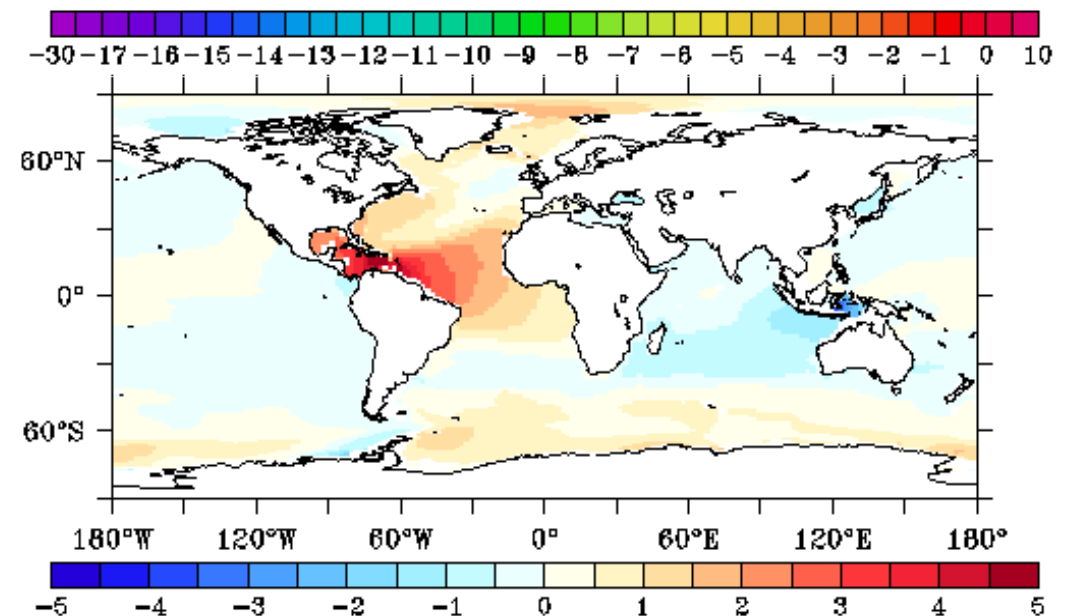


Results: Nd anomalies at 500m

ϵ_{Nd} for Control experiment

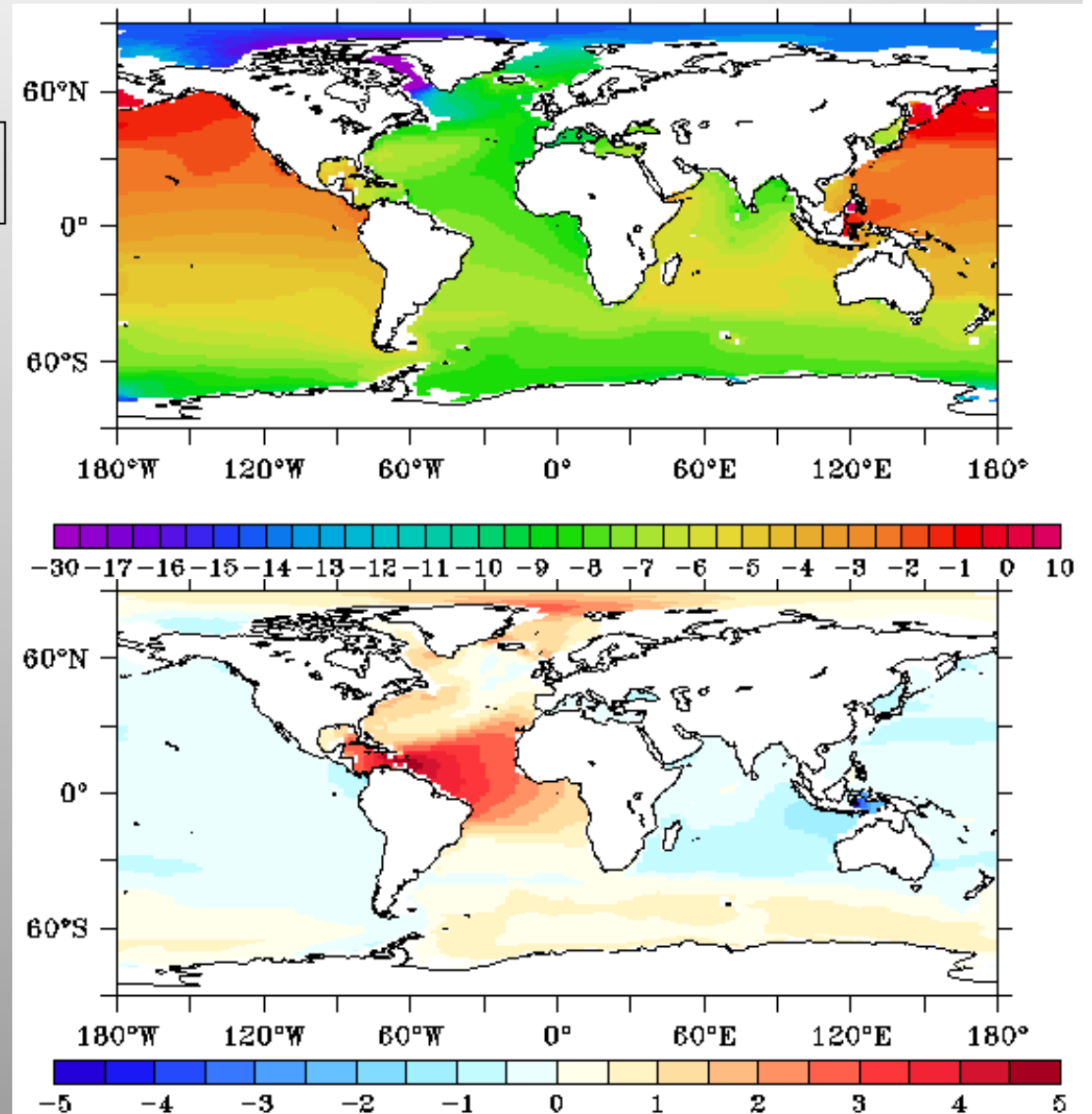


$\epsilon_{\text{Nd open-isthmus500}} - \epsilon_{\text{Nd Control}}$

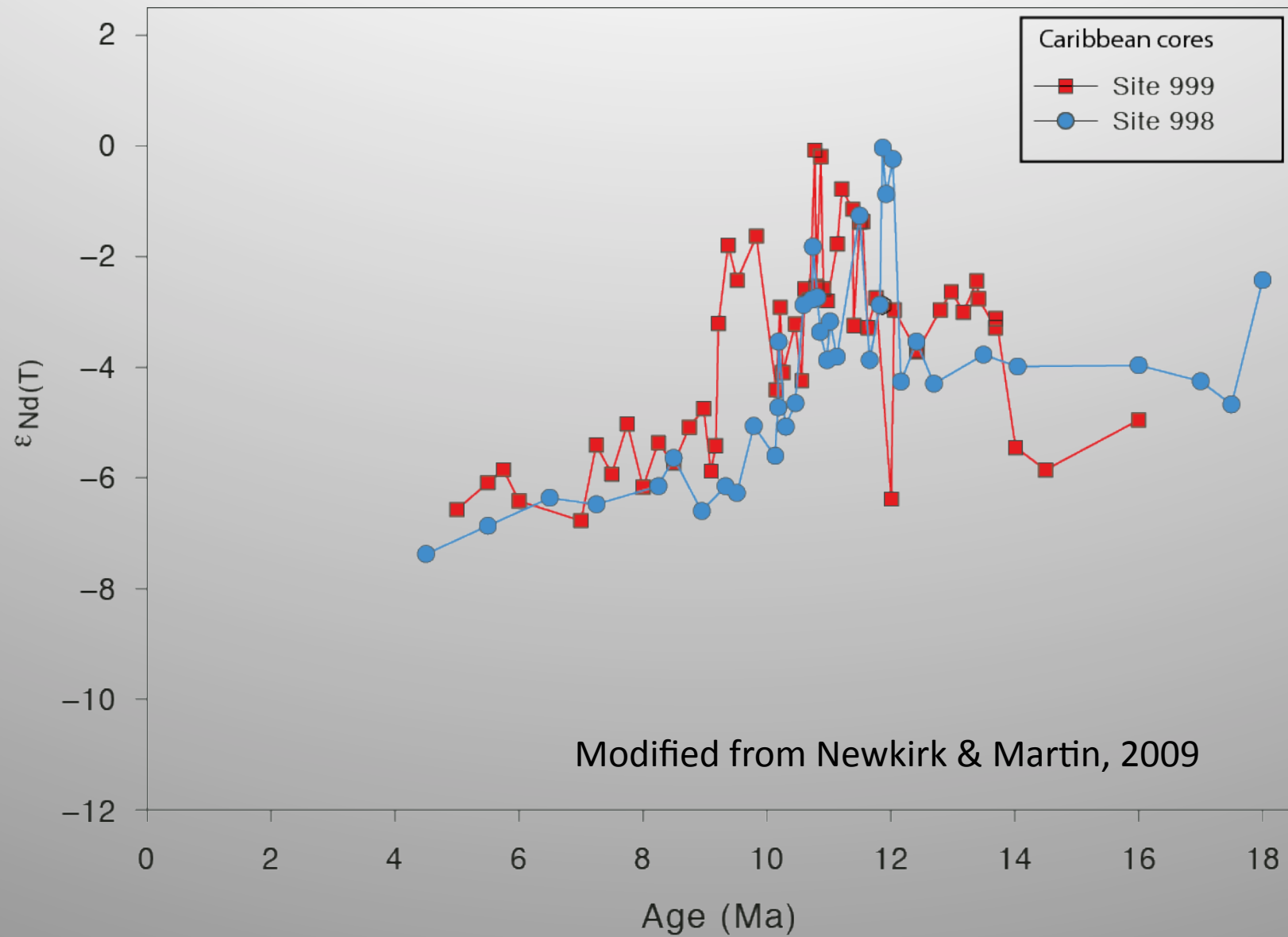


Results: Nd anomalies at 500m

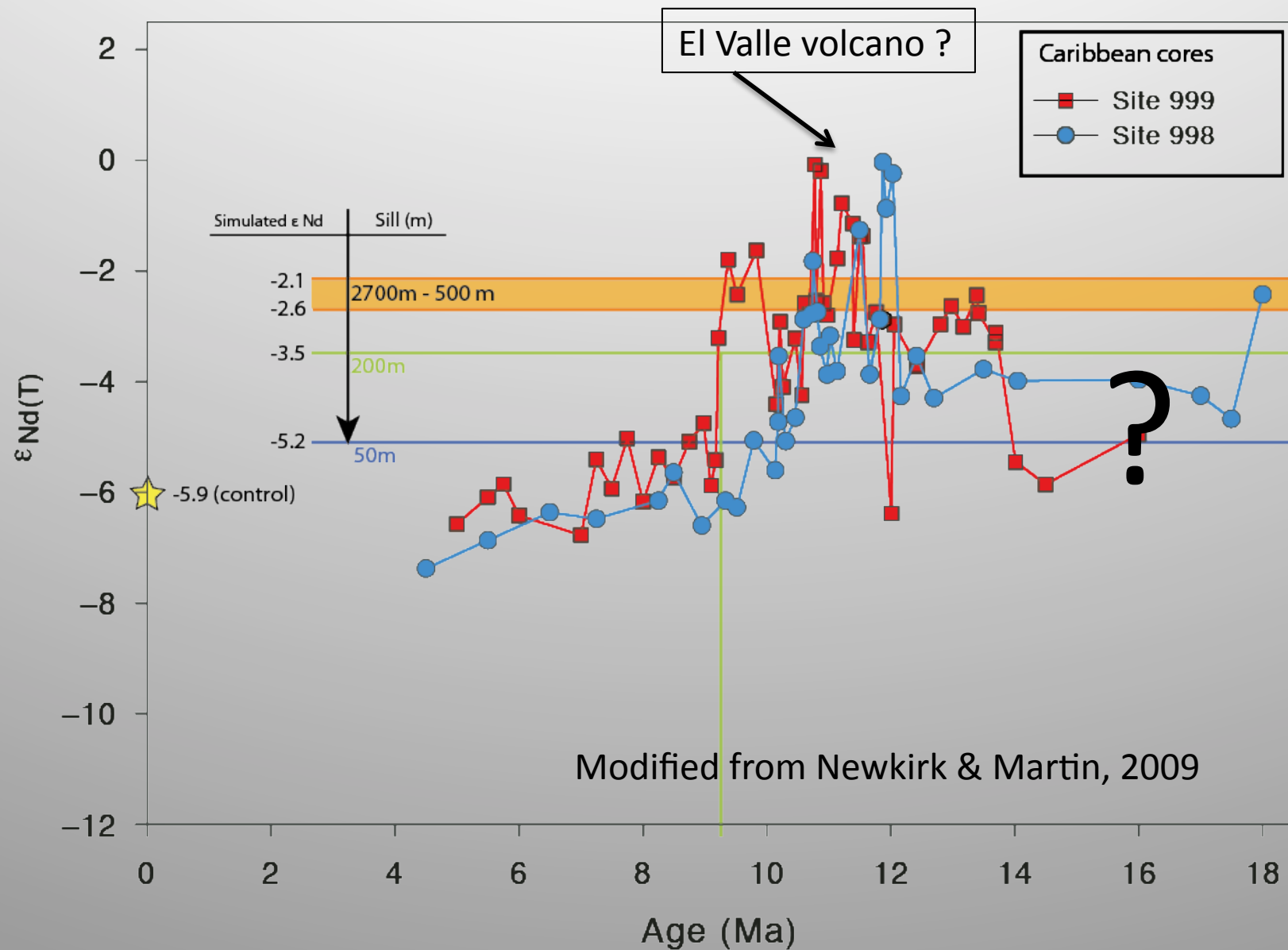
ϵ_{Nd} for Control experiment



Comparing with data

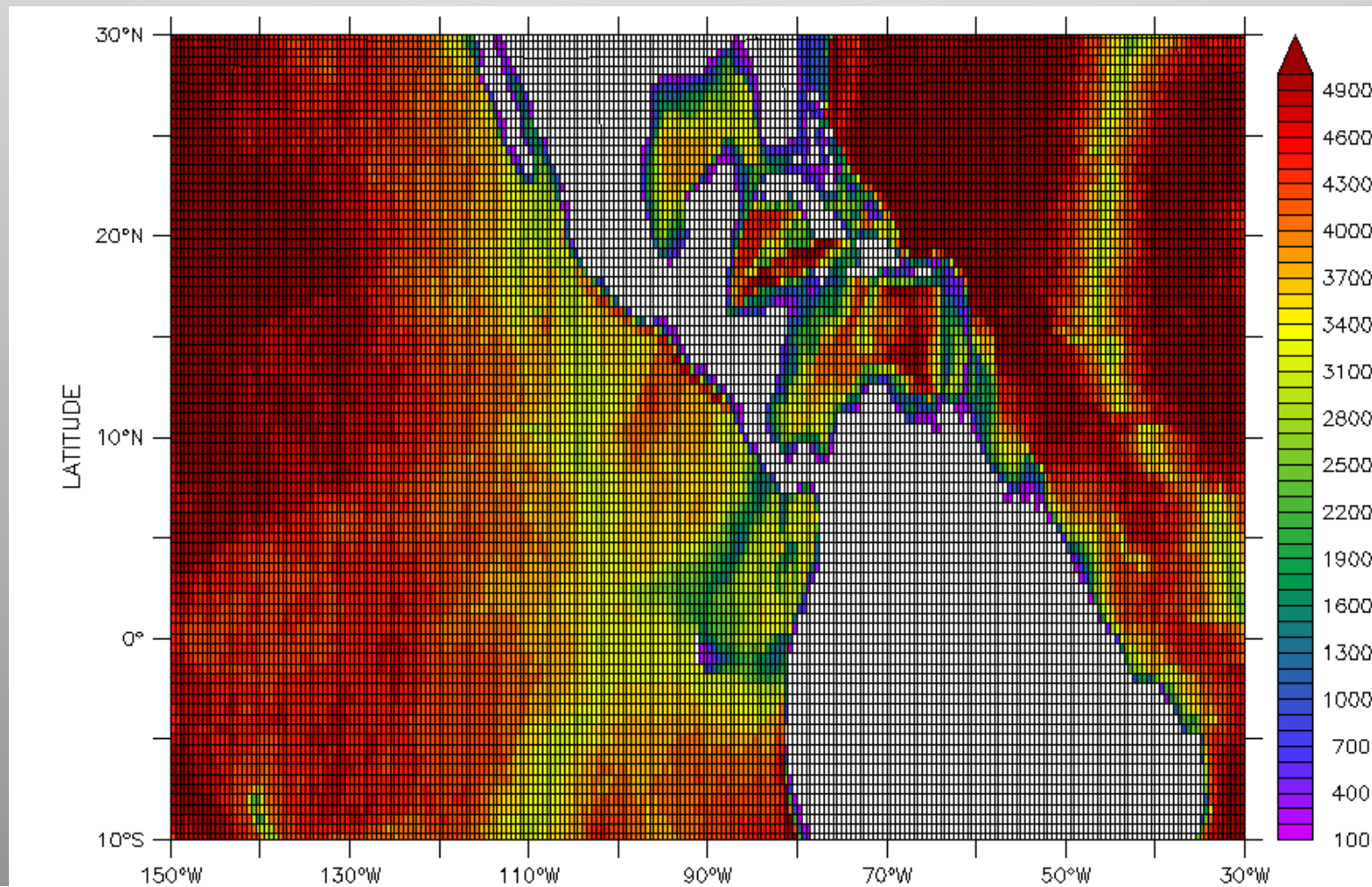


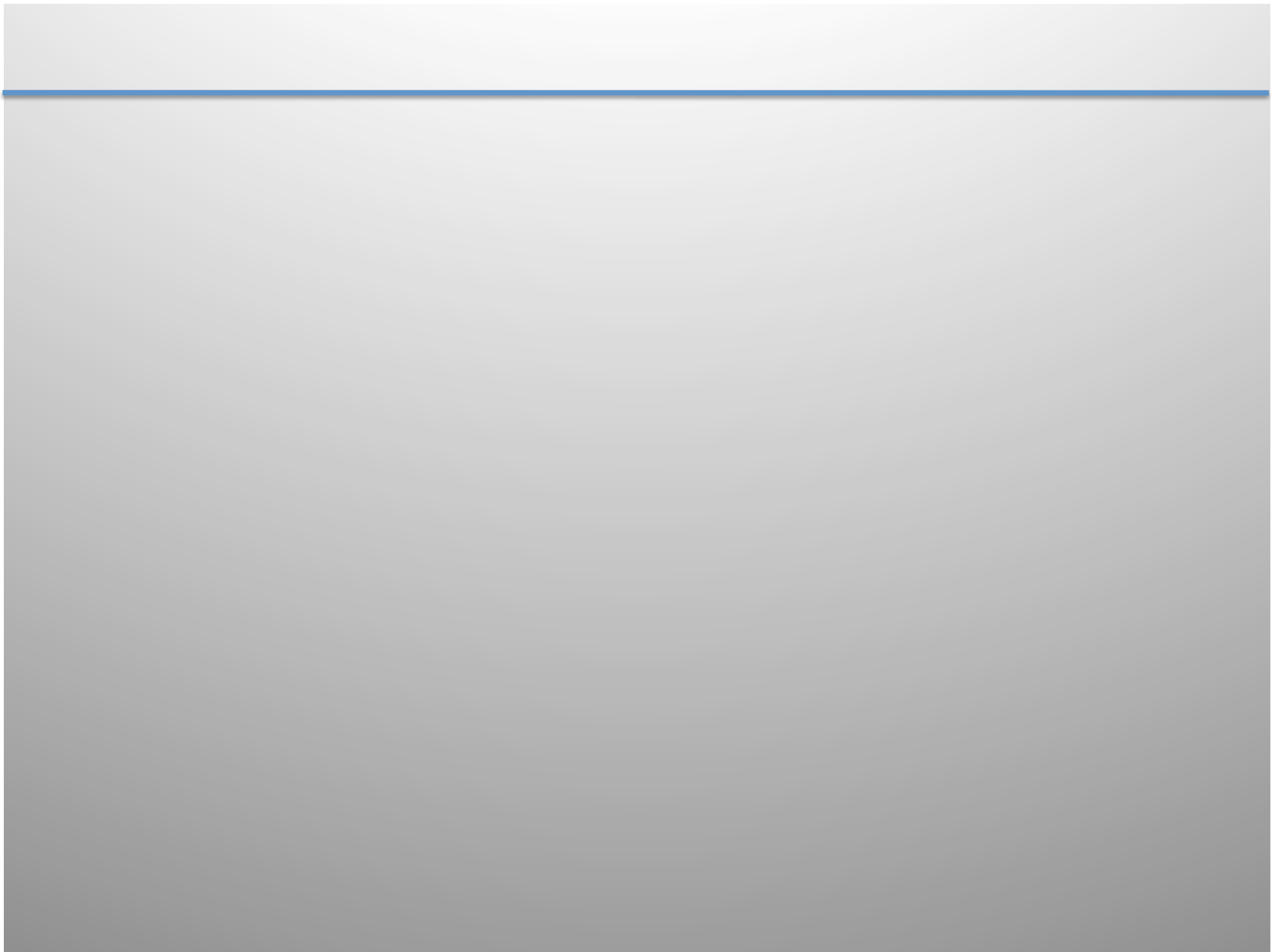
Comparing with data



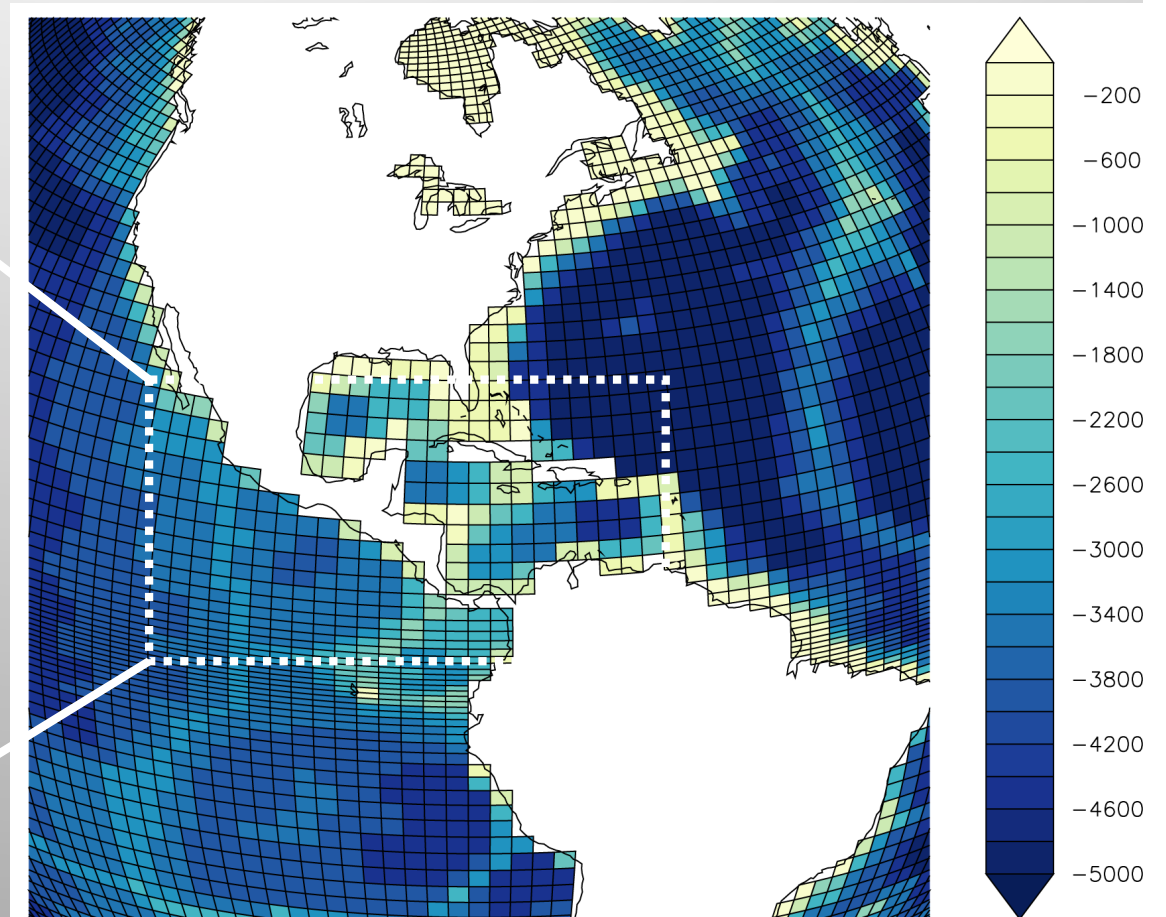
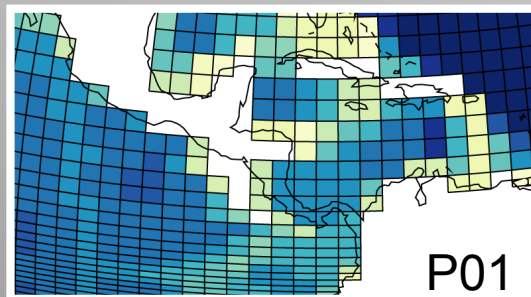
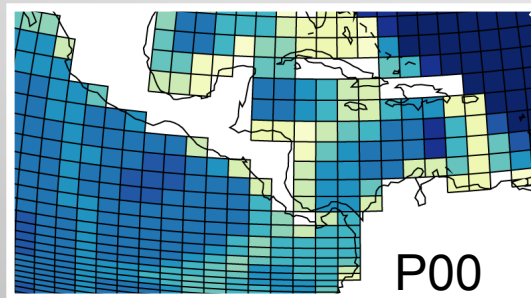
Limitations & Perspectives

- Need to increase model resolution ?
- Need constraints on End on margins in the past

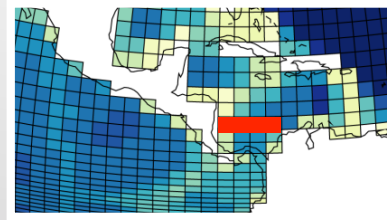




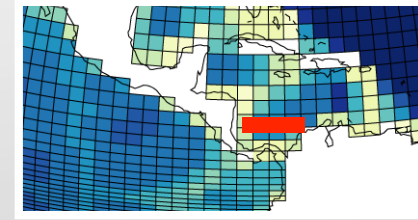
Opening the isthmus in IPSLCM4v2



Northward Meridional Flux at 14°N

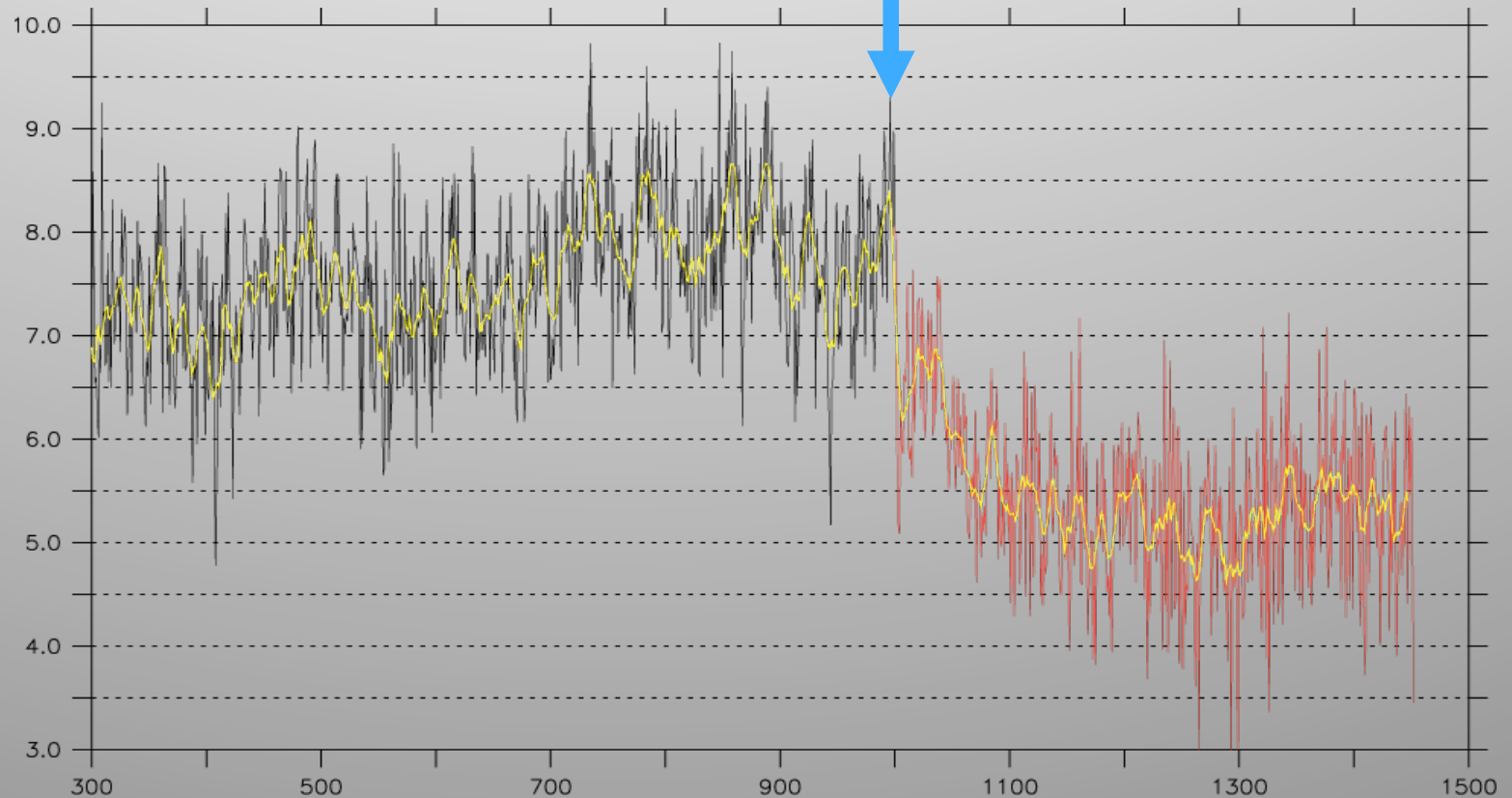


2500m seaway



500m seaway

Northward
Meridional Flux
14°N
(Sv)



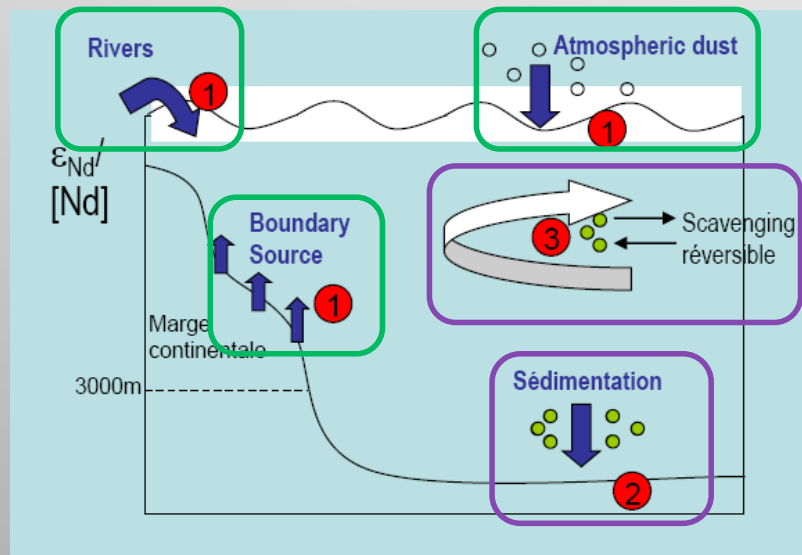
Years of simulations

Modelling Nd oceanic Cycle

Arsouze et al, 2009

➤ More explicit modelling and quantifying of Nd oceanic cycle:

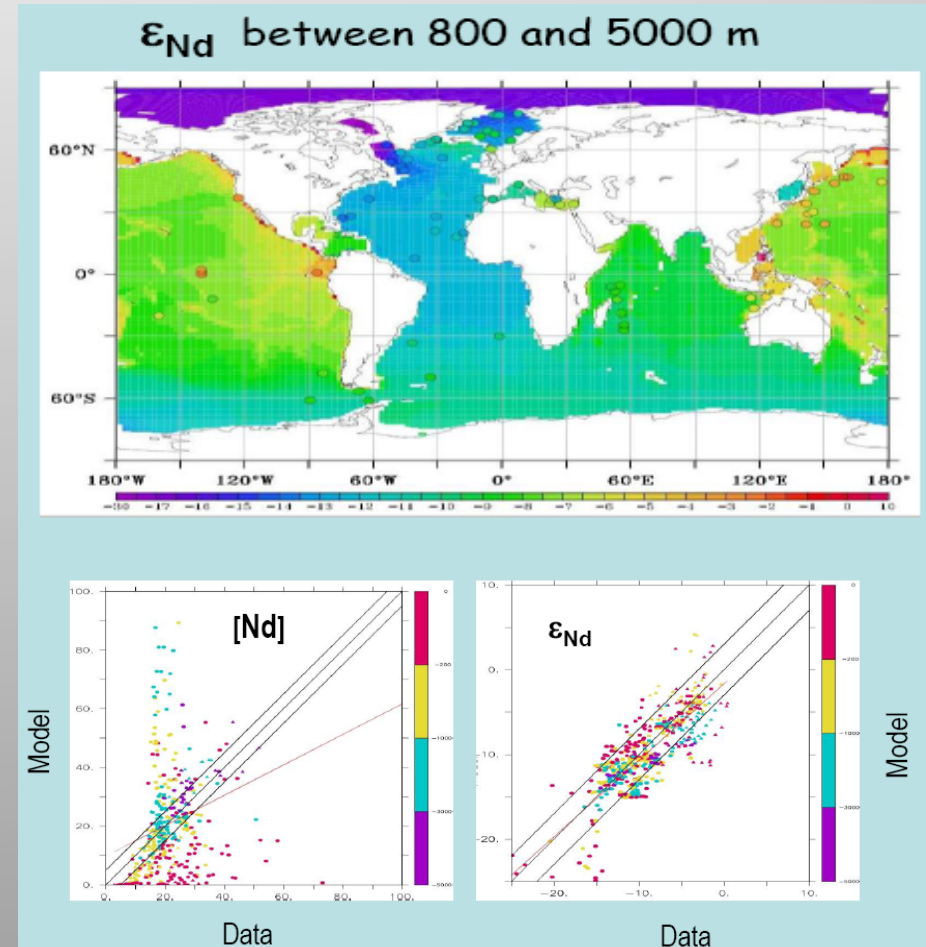
- All the sources are explicitly simulated: rivers, dust , BE
- Internal cycle is explicitly simulated with a biogeochemical model (PISCES)



➤ Conclusions:

- BE is the main source for Nd in the ocean
- Its magnitude is 10 times greater than other sources (dust, rivers)

BE: $1.1 \cdot 10^{10} \text{ g(Nd)/an}$
 River: $2.6 \cdot 10^8 \text{ g(Nd)/an}$
 Dust: $1.0 \cdot 10^8 \text{ g(Nd)/an}$

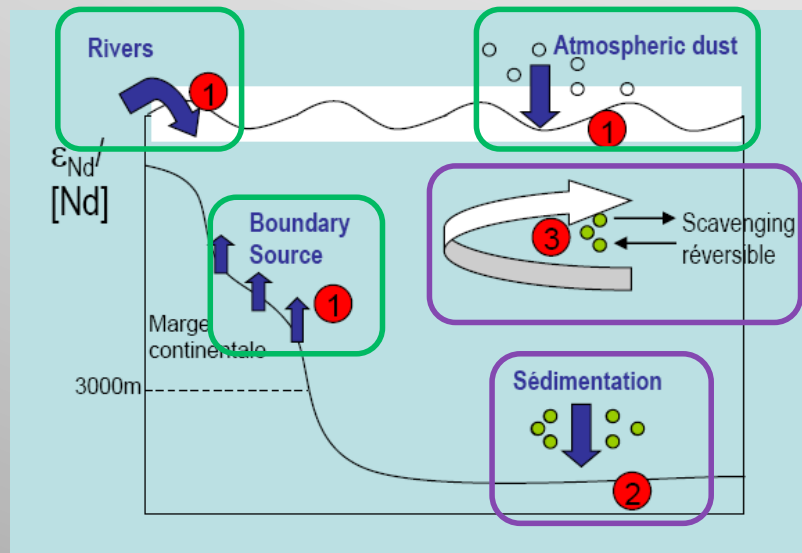


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Arsouze et al, 2009

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