

# **SIMULATING MARINE BIOGEOCHEMISTRY IN COUPLED CLIMATE MODELS: THE ROLE OF THE CLIMATE PHYSICS**

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# Motivations:

- **Coupled Models are currently used for near- and long-term projections.**
  - But, **uncertainties** impacting their predictive goals **are poorly constrained** (e.g., Friedlingstein et al., 2003).
- ⇒ **One** of them is related to the interactions between the biogeochemistry dynamics and the ocean dynamics.

## Background ideas:

- biogeochemical models are only as good as the physical framework in which they are set (Doney, 1996).
- Use biogeochemical tracers to evaluate and assess ocean dynamics (England, 2001)

Use **1** state-of-the-art biogeochemical model (**PISCES**) embedded in **3** ocean circulations generated by 3 different coupled models: **IPSLCM4LOOP, IPSLCM5A, CNRMCM5**

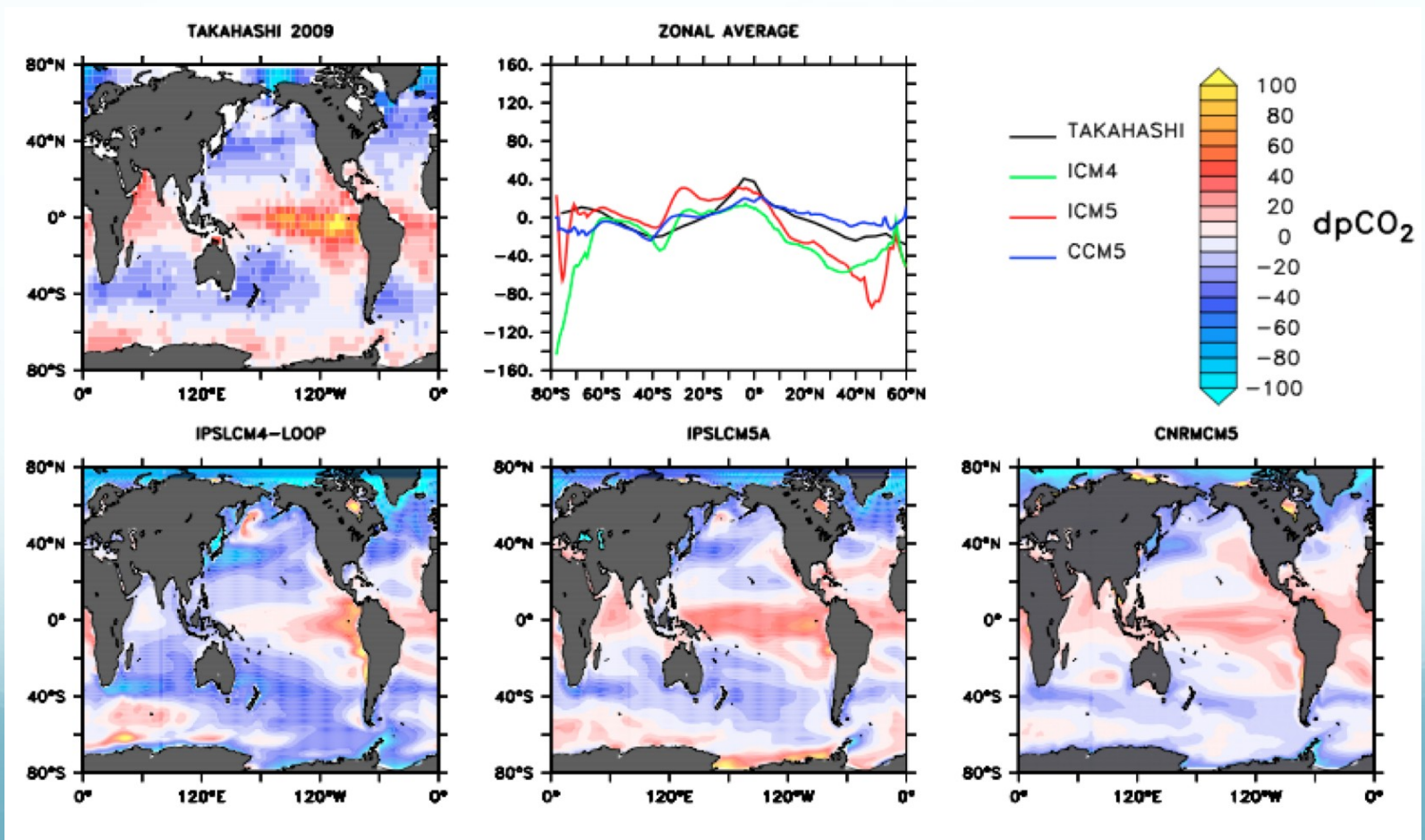


# Biogeochemical dynamics:

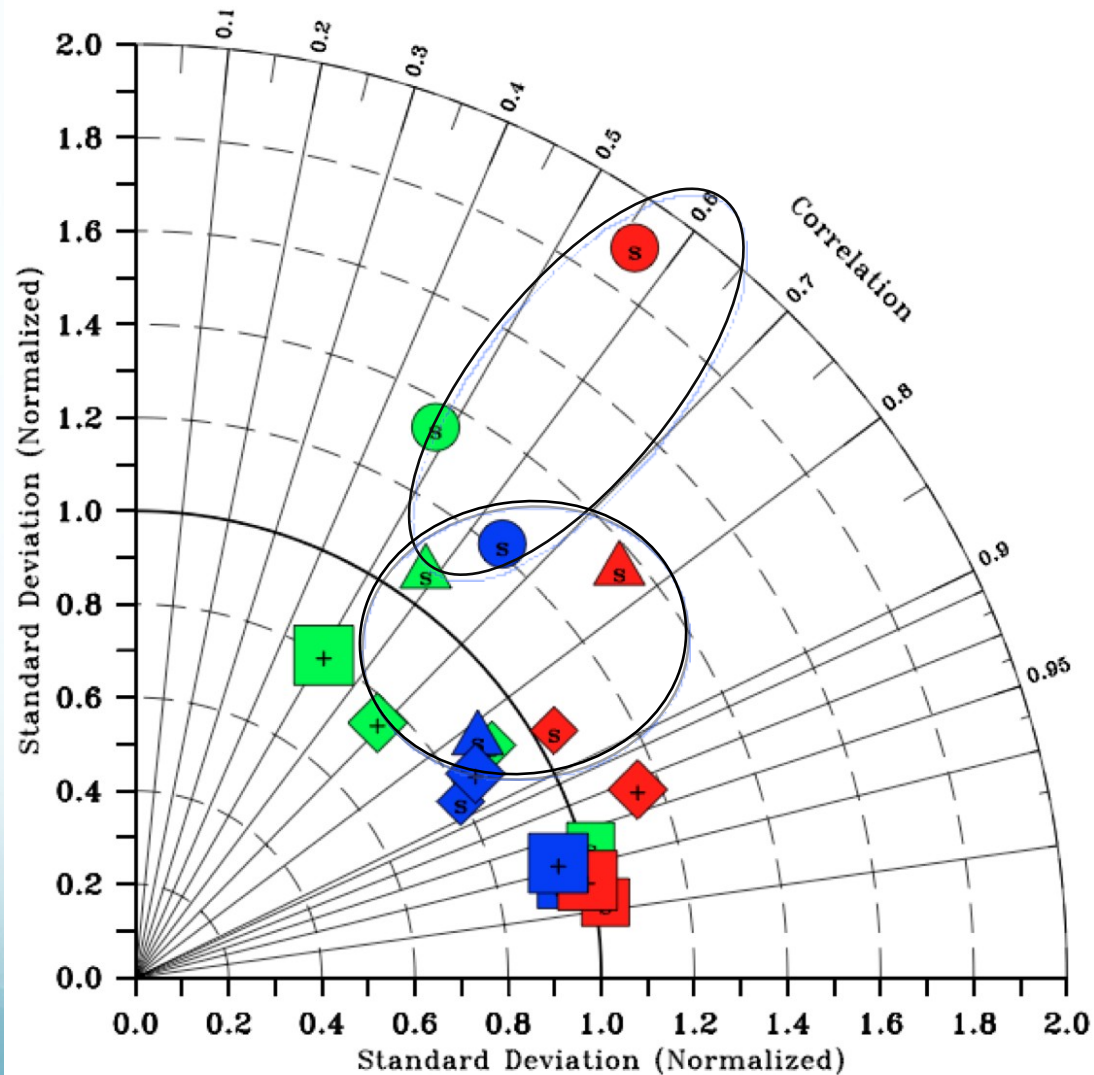
$$F_{\text{CO}_2} = K_w(v) \left( k_o(\text{SSS}, \text{SST}) \left( \text{DIC}^{\text{surf}} - p_{\text{CO}_2}^{\text{Atm}} \right) \right)$$

$\frac{1}{\text{mol}} \frac{\text{mol}}{\text{m}^2 \text{ day}} = \frac{\text{mol}}{\text{m}^2 \text{ day}}$

$\text{dpCO}_2$



# Ocean dynamics:



TEMPERATURE  
compared to WOA 2009

- + IPSLCM5
- + IPSLCM4
- + CNRMCM5

SALINITY  
compared to WOA 2009

- + IPSLCM5
- + IPSLCM4
- + CNRMCM5

MLD<sub>max</sub> compared to  
Boyer-Montegut

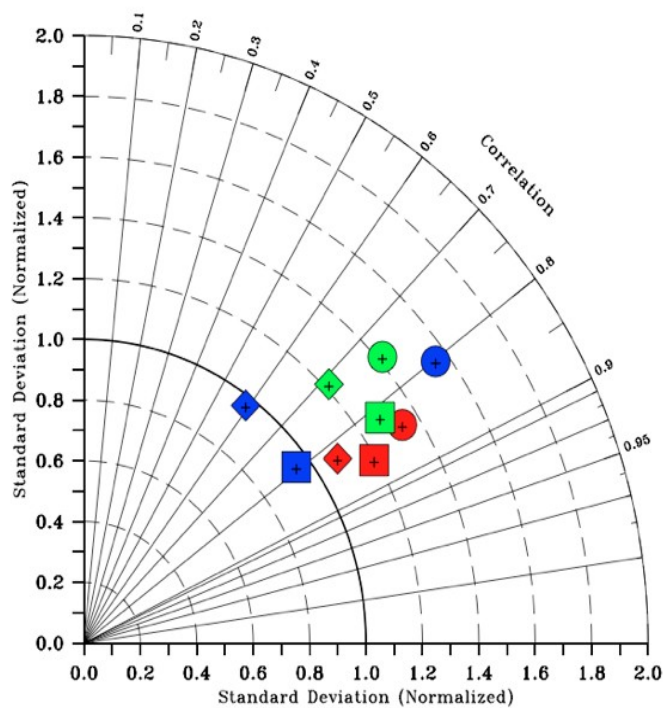
- + IPSLCM5
- + IPSLCM4
- + CNRMCM5

TAU compared to  
NCEP

- + IPSLCM5
- + IPSLCM4
- + CNRMCM5

# Nutrients & Carbon Chemistry components:

Intermediate Layer (1000m) concentrations



$\text{NO}_3^-$   
compared to WOA

ICM4

ICM5

CCM5

$\text{PO}_4$   
compared to WOA

ICM4

ICM5

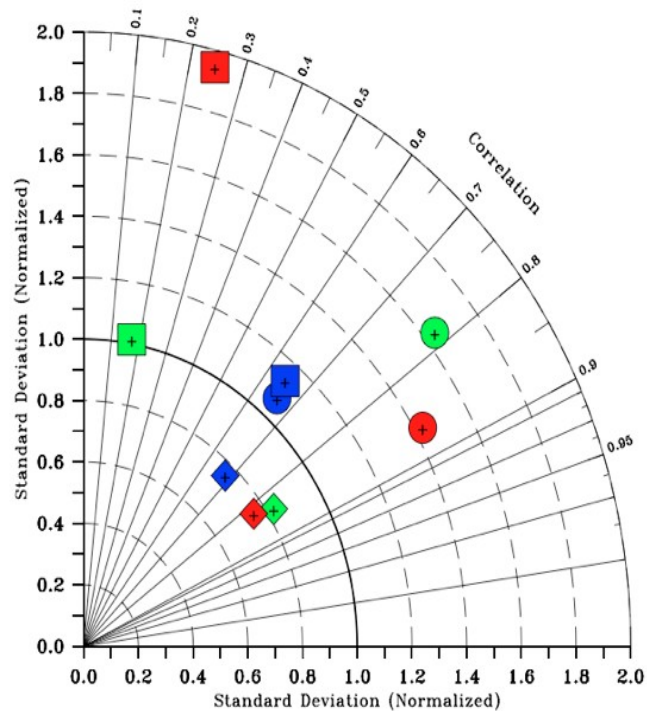
CCM5

$\text{SiO}_2$   
compared to WOA

ICM4

ICM5

CCM5



DIC  
compared to GLODAP

ICM4

ICM5

CCM5

ALK  
compared to GLODAP

ICM4

ICM5

CCM5

Omega C  
compared to GLODAP

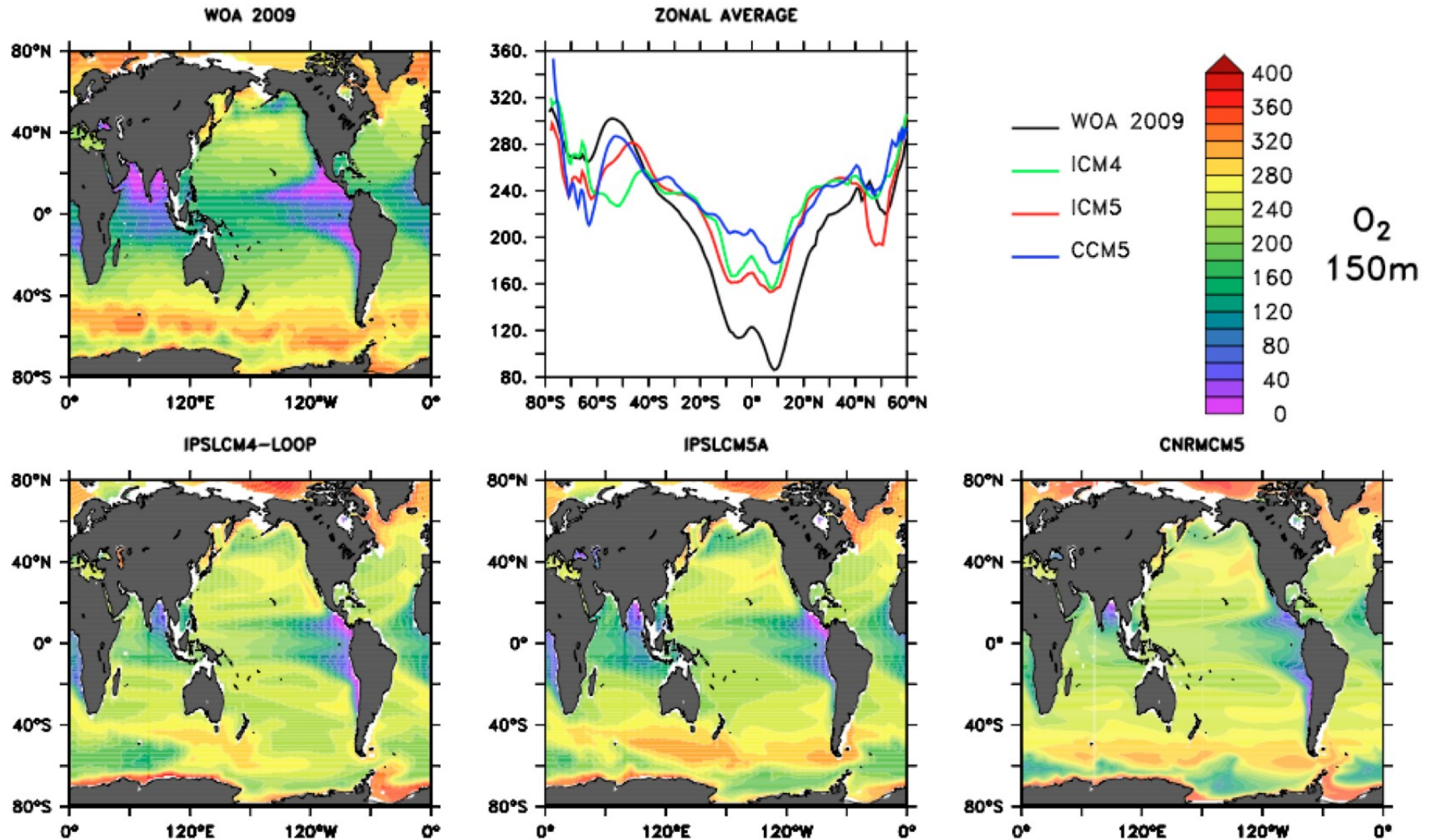
ICM4

ICM5

CCM5



# Oxygen concentrations ~ Oxygen Minimum Zone:



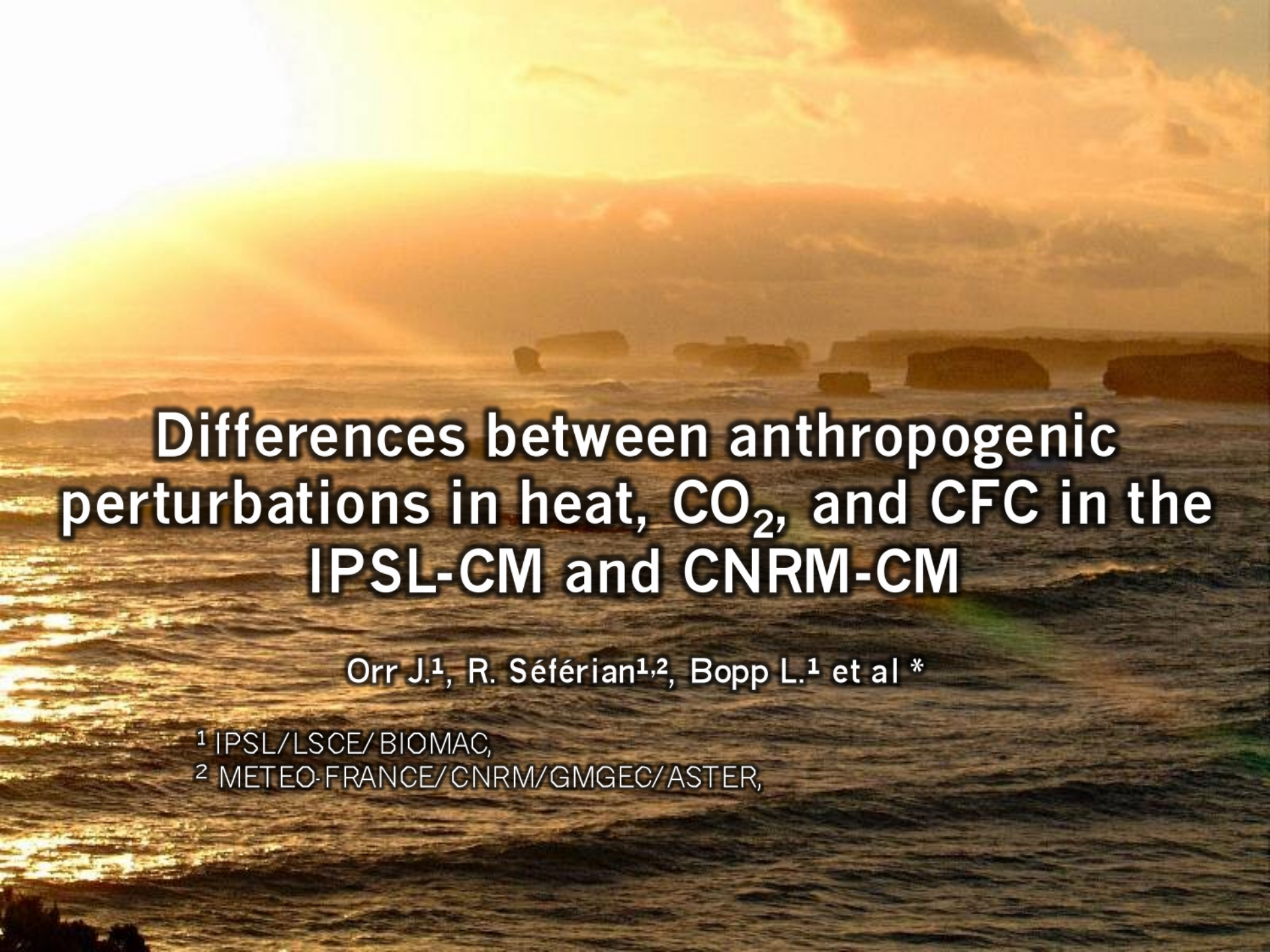
# Oxygen concentrations ~ Oxygen Minimum Zone:

Volume Of Oxygen Minimum (10 <sup>16</sup> m <sup>3</sup> )	Obs	ICM4	ICM5	CCM5
surface-1200m	3.54	2.33	0.818	5.49
1200-bottom	7.65	1.08	3.73	24.0

# Conclusions:

- **Large-scale ocean dynamics** appears to be sufficient for simulating **the major patterns of the global ocean carbon cycle** (based on models-data and models-models comparison)
- BUT, **local physics** (co-generated by atmosphere and ocean models) has to be improved for increasing the reliability of ocean carbon models in term of **sensitivity and impacts**.
  - ⇒ **Mixed layer depth, wind stress and shortwave** (and its co-variables) !
  - ⇒ **Vertical profiles of DIC and Alkalinity** are important players of the ocean carbon uptake (water masses)
  - ⇒ Weak impact of the horizontal resolution of the ocean models (?)





# Differences between anthropogenic perturbations in heat, CO<sub>2</sub>, and CFC in the IPSL-CM and CNRM-CM

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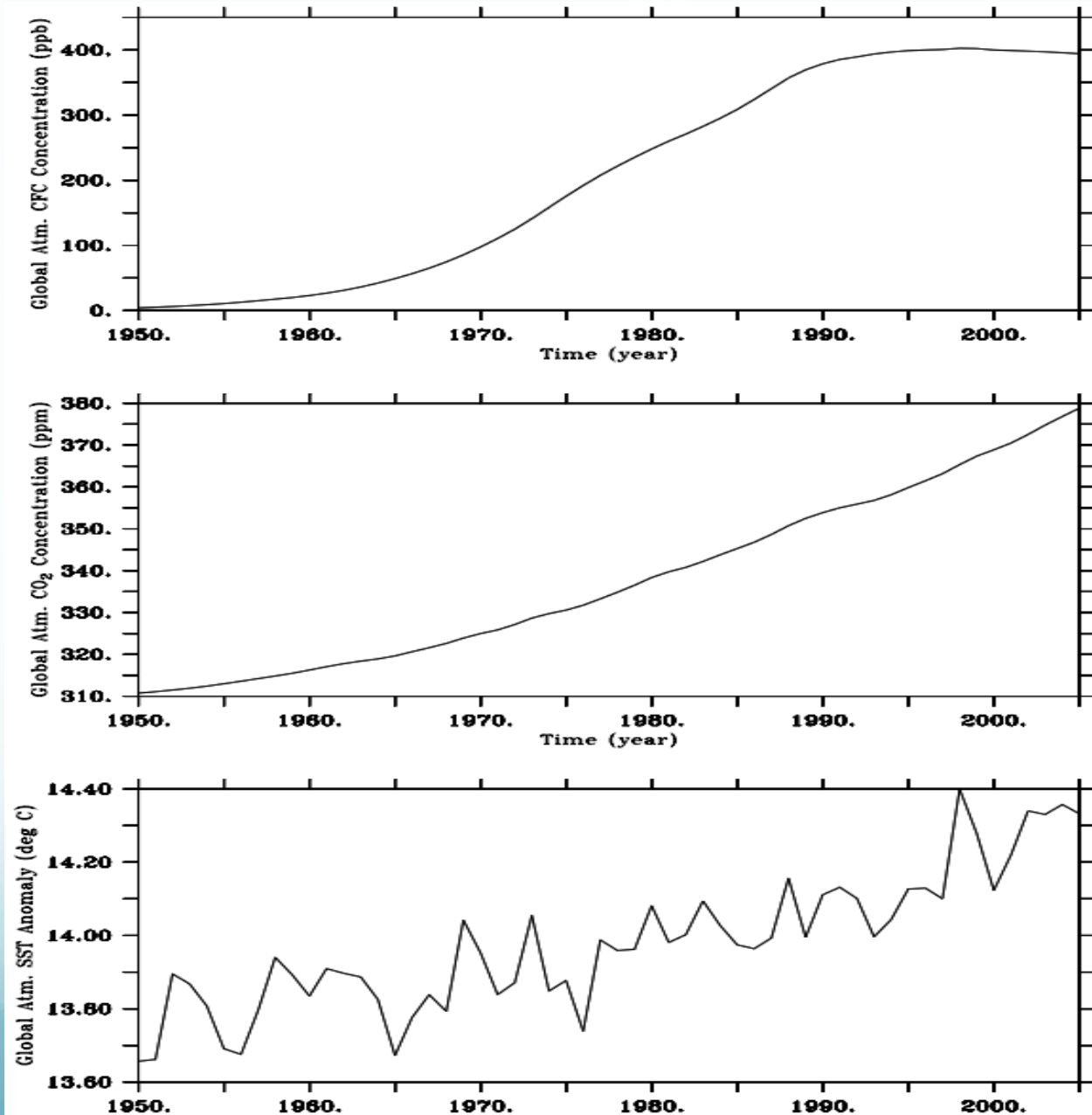
# Motivations:

- Ocean Heat content (**OHC**), **CO2** and **CFC** are **3 anthropogenic perturbations**.
  - Ocean Heat content (**OHC**), **CO2** and **CFC** have **3 different “stories”**.
- ⇒ How models **simulate** and **capture** these different anthropogenic perturbations.

## 2 simulations:

- **Historical (CMIP5) 1850/1860 – 2005**
- **Historical (OCMIP) 1950 – 2005 for CFC only**

# Anthropogenic perturbations





# CFC concentrations evolution

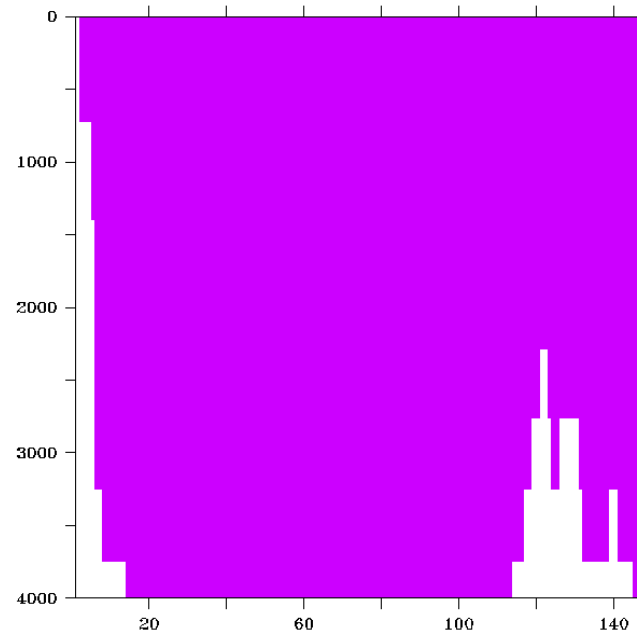
IPSLCM4-LOOP

Year 0



IPSLCM5A

Year 0



CNRMCM5

Year 0

