

# Skill assessment of three earth system models using NEMO-PISCES marine biogeochemistry

Roland Séférian<sup>1,2</sup>, Laurent Bopp<sup>1</sup>, Marion Gehlen<sup>1</sup>, James C. Orr<sup>1</sup>,  
Christian Éthé<sup>1,3</sup>, Patricia Cadule<sup>1</sup>, Olivier Aumont<sup>4</sup>, David Salas-y-Mé-  
lia<sup>2</sup>, Aurore Voldoire<sup>2</sup>, Gervan Madec<sup>3</sup>

<sup>1</sup> IPSL/LSCE/BIOMAC, Gif-sur-Yvette, France

<sup>2</sup> CNRM-GAME (Météo-France, CNRS), Toulouse, France

<sup>3</sup> LOCEAN, Paris, France

<sup>4</sup> LPO, Brest, France

NEMO user meeting Exeter 22-23 May 2012

# NEMO in ESMs:

| Name           | Configurations | Sea-Ice components | Biogeochemical components |
|----------------|----------------|--------------------|---------------------------|
| <b>CNRM-CM</b> | <b>ORCA1</b>   | <b>GELATO</b>      | <b>PISCES</b>             |
| EC-Earth       | ORCA1          | LIM2               | —                         |
| HadGEM         | ORCA1          | CICE               | Diat-HADOCC               |
| <b>IPSL-CM</b> | <b>ORCA2</b>   | <b>LIM2</b>        | <b>PISCES</b>             |

+ Parallel to CMIP3, models like IPSL-CM4-LOOP (first generation ESM) have contributed to C4MIP to assess Climate-Carbon Cycle Feedbacks

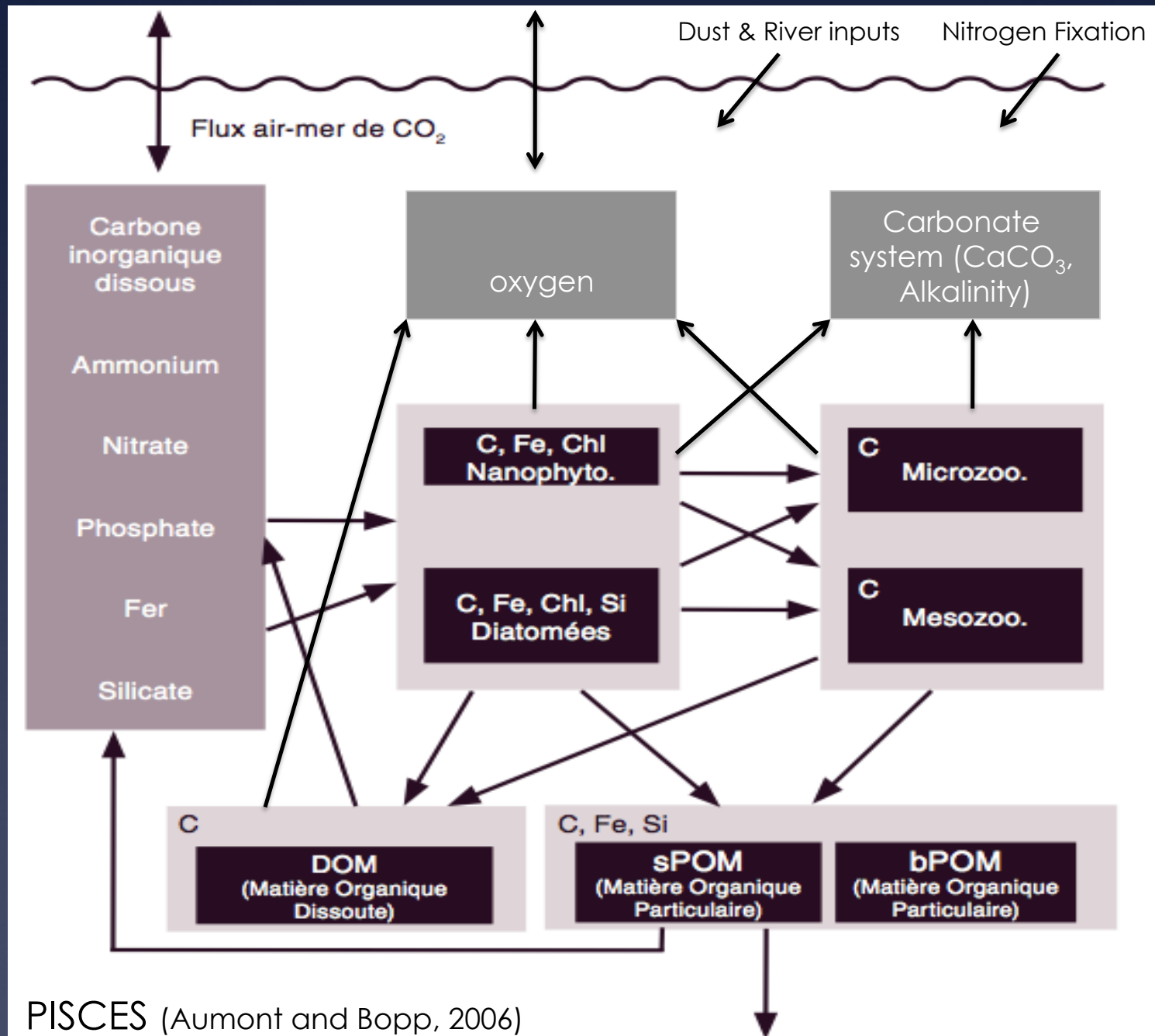
1. How good is the match between modeled fields and recent observations ? (*Skill assessment*)
2. How do they compare to each other ? (In CMIP3-to-CMIP5 PoV)? (*Improvement/Sensitivity to parametrization*)

# 3 different Earth System Models ...

| Component    | IPSL-CM4-LOOP          | IPSL-CM5A-LR               | CNRM-CM5.1                 |
|--------------|------------------------|----------------------------|----------------------------|
| Atmosphere   | LMDZ-4<br>3°x3°x19L    | LMDZ<br>1.8°x1.8°x39L      | ARPEGE-v5<br>1.4°x1.4°x31L |
| Land Surface | ORCHIDEE               | ORCHIDEE                   | SURFEX (ISBA)<br>& TRIP    |
| Ocean        | OPA8<br>2°x2°-0.5°x31L | NEMO-3.2<br>2°x2°-0.5°x31L | NEMO-3.2<br>1°x1°-0.3°x42L |
| Sea-Ice      | LIM2                   | LIM2                       | GELATO                     |

⇒ Strong differences in the atmospheric component:  
Architecture, resolution, parametrizations...

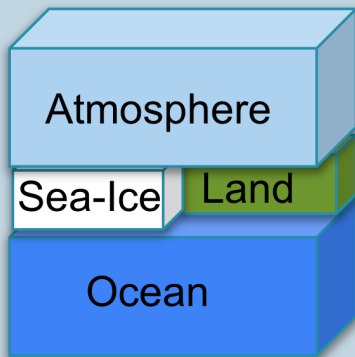
# ... with a common Marine Biogeochemistry



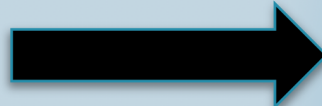
# Spin-up Strategy

Step 1:

Physic-  
only  
Climate  
Model



Preindustrial  
Seasonal  
Climatology



IC: LEVITUS

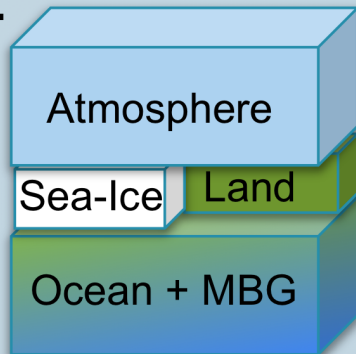


3000 y

Preindustrial  
Spin-up  
(Model-dependant)

Step 2:

Earth  
System  
Model



Preindustrial  
Spin-up  
(Model-dependant)

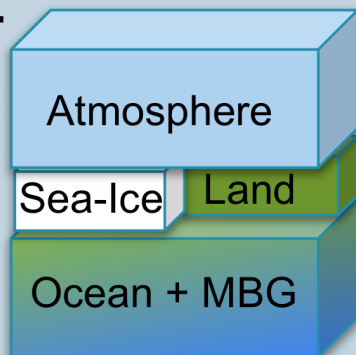
Preindustrial  
On-line  
Simulation



Preindustrial  
State of  
Marine  
biogeochemistry  
(Model-dependant)

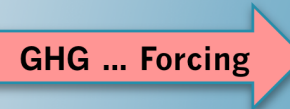
Step 3:

Earth  
System  
Model



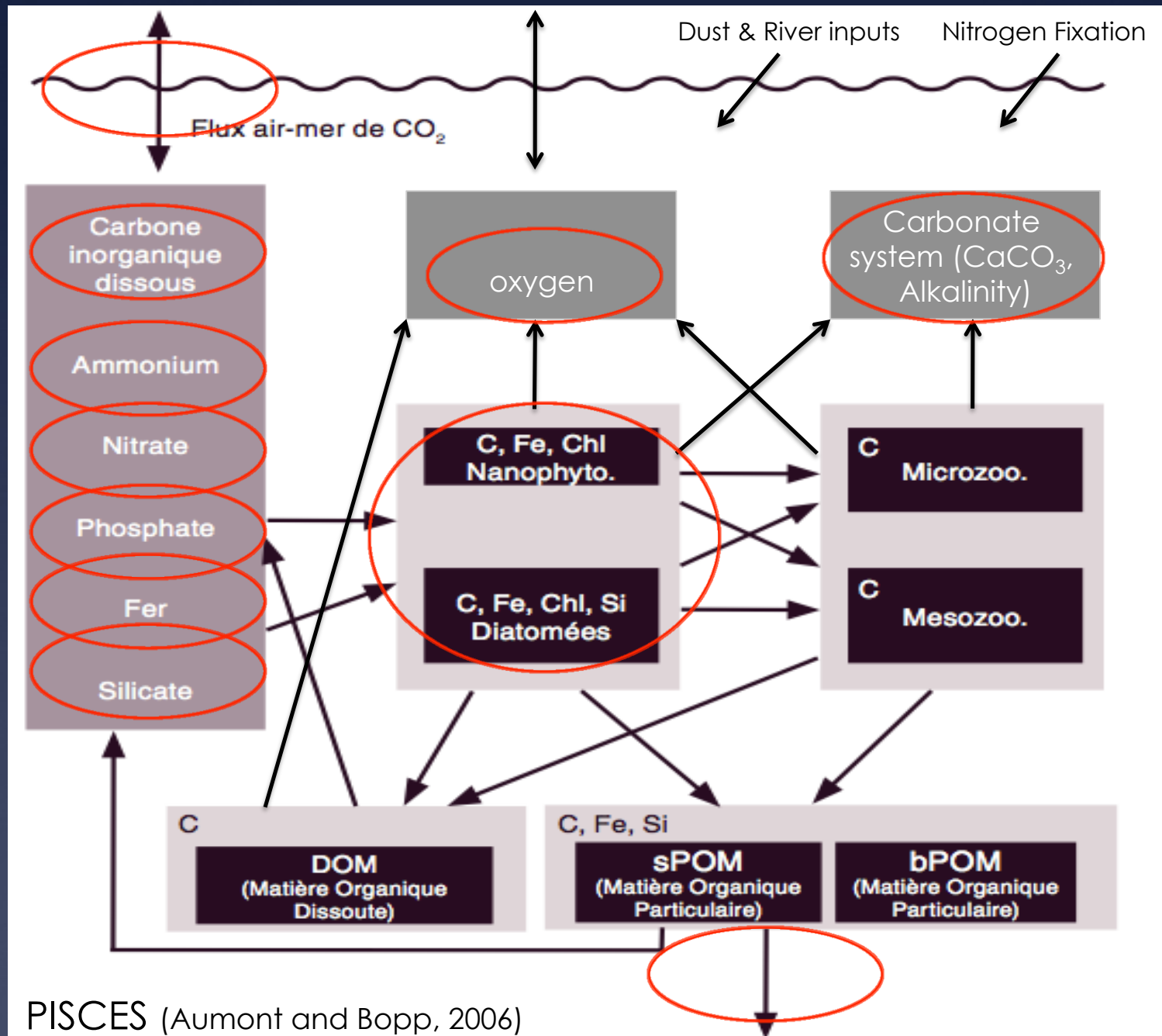
Preindustrial  
State of  
Marine  
biogeochemistry  
(Model-dependant)

Historical  
On-line  
Simulation



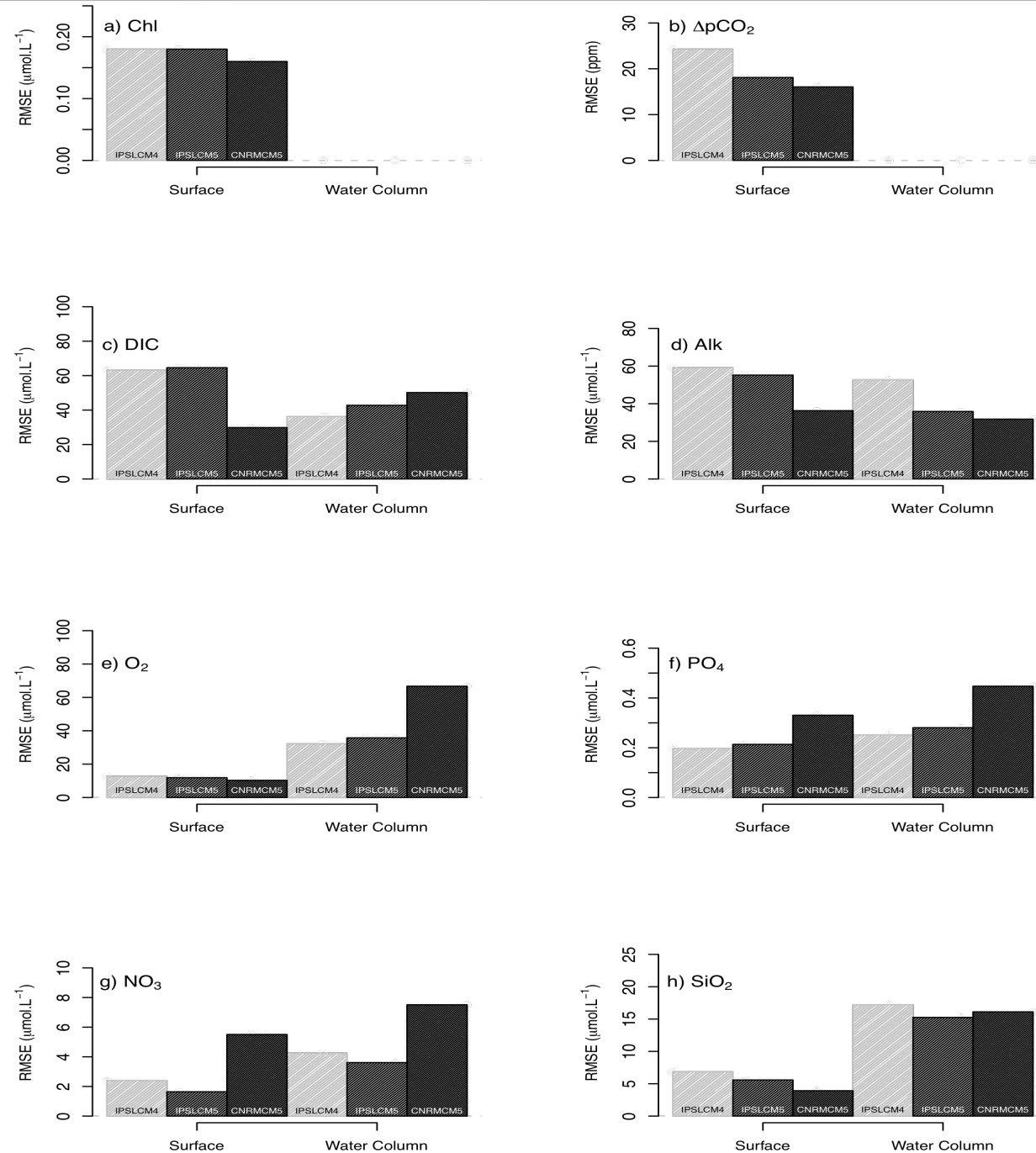
Historical  
Scenario of  
Marine  
biogeochemistry  
(Model-dependant)

# Variables of interest...



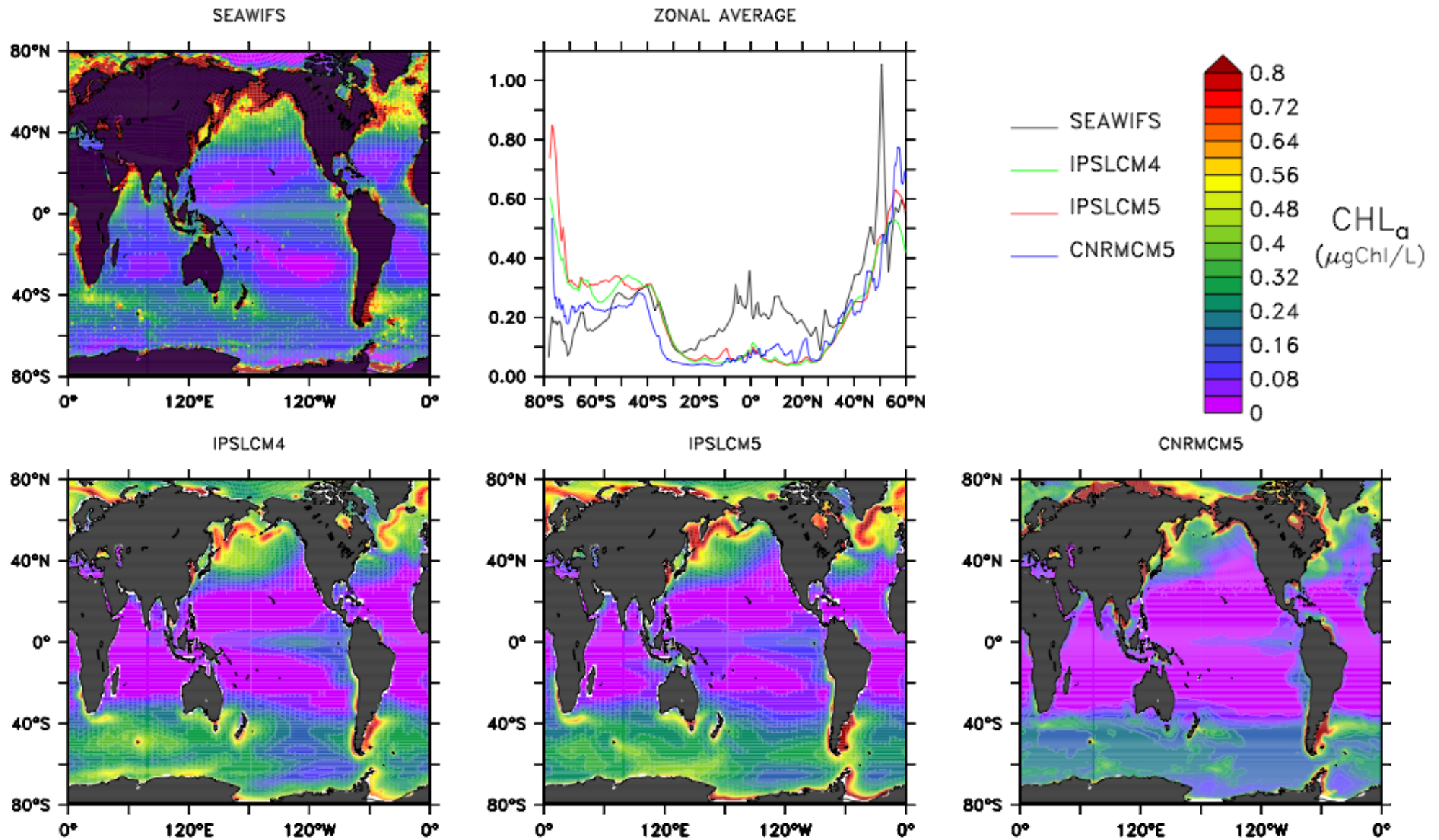
PISCES (Aumont and Bopp, 2006)

# Skill assessment using basic statistical metrics:



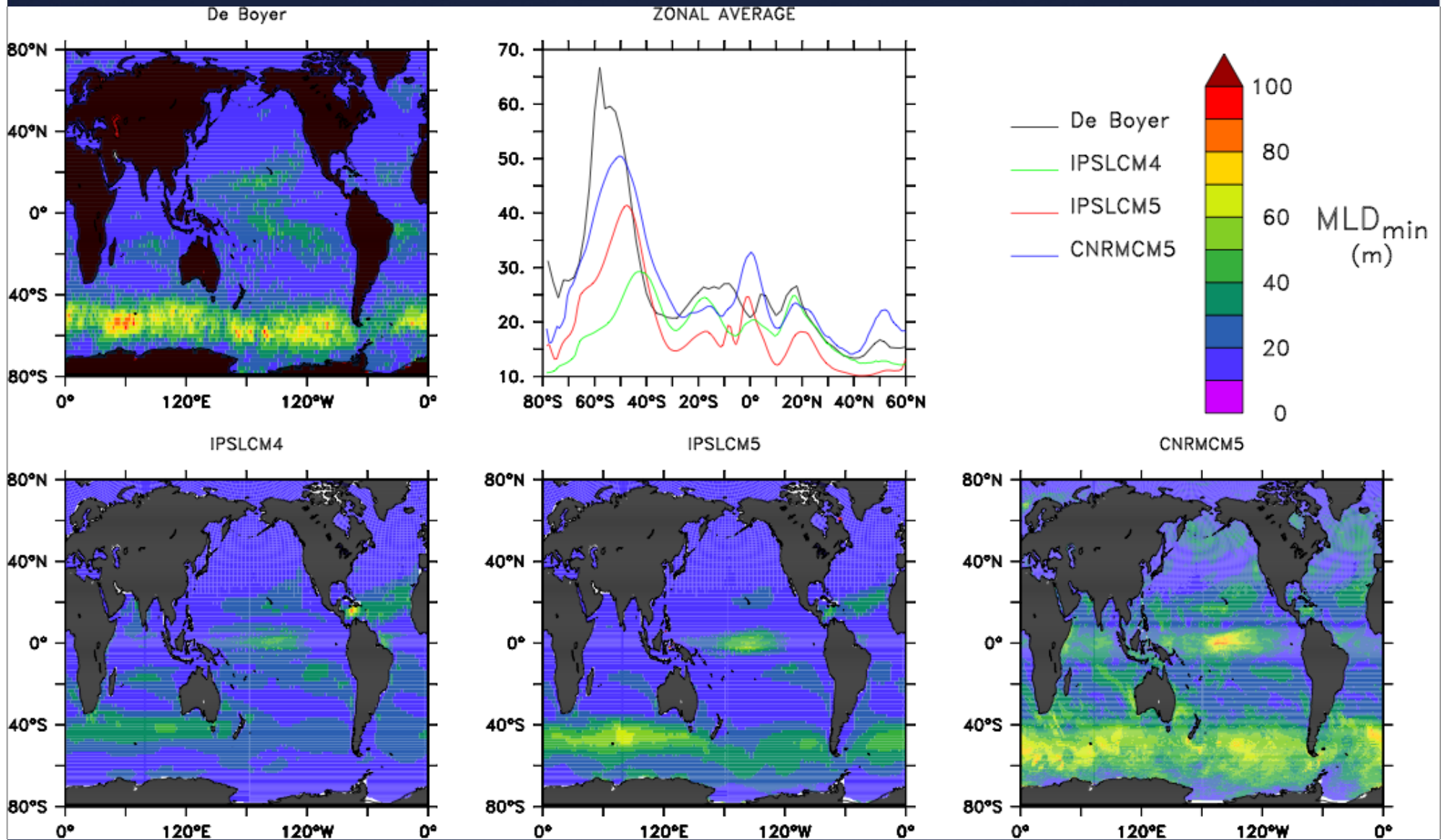
1. Good surface agreement ! (+ an improvement in CMIP5 models)
  2. Poor agreement at depth !
- ⇒ Why ?

# Better representation of surface properties:

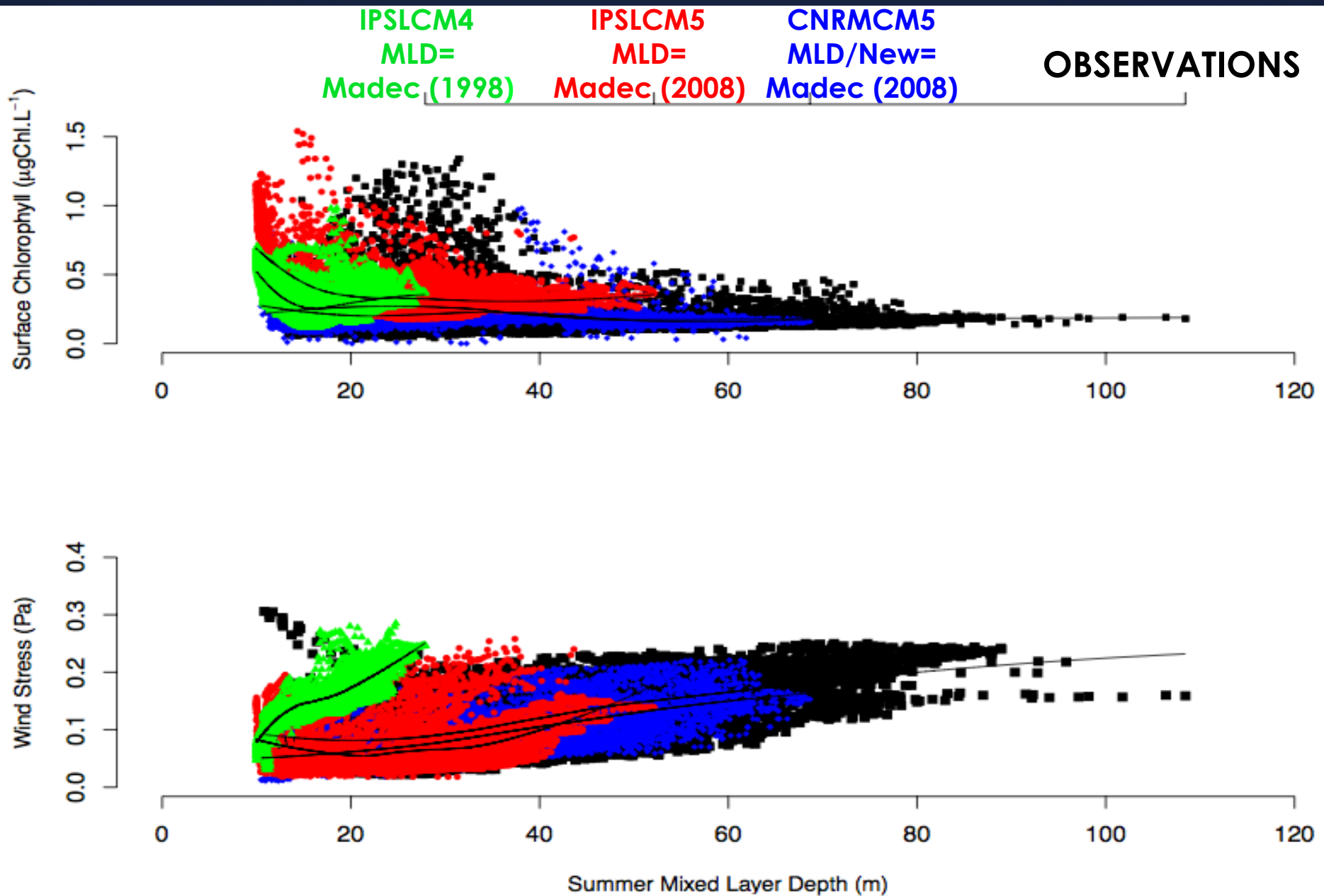




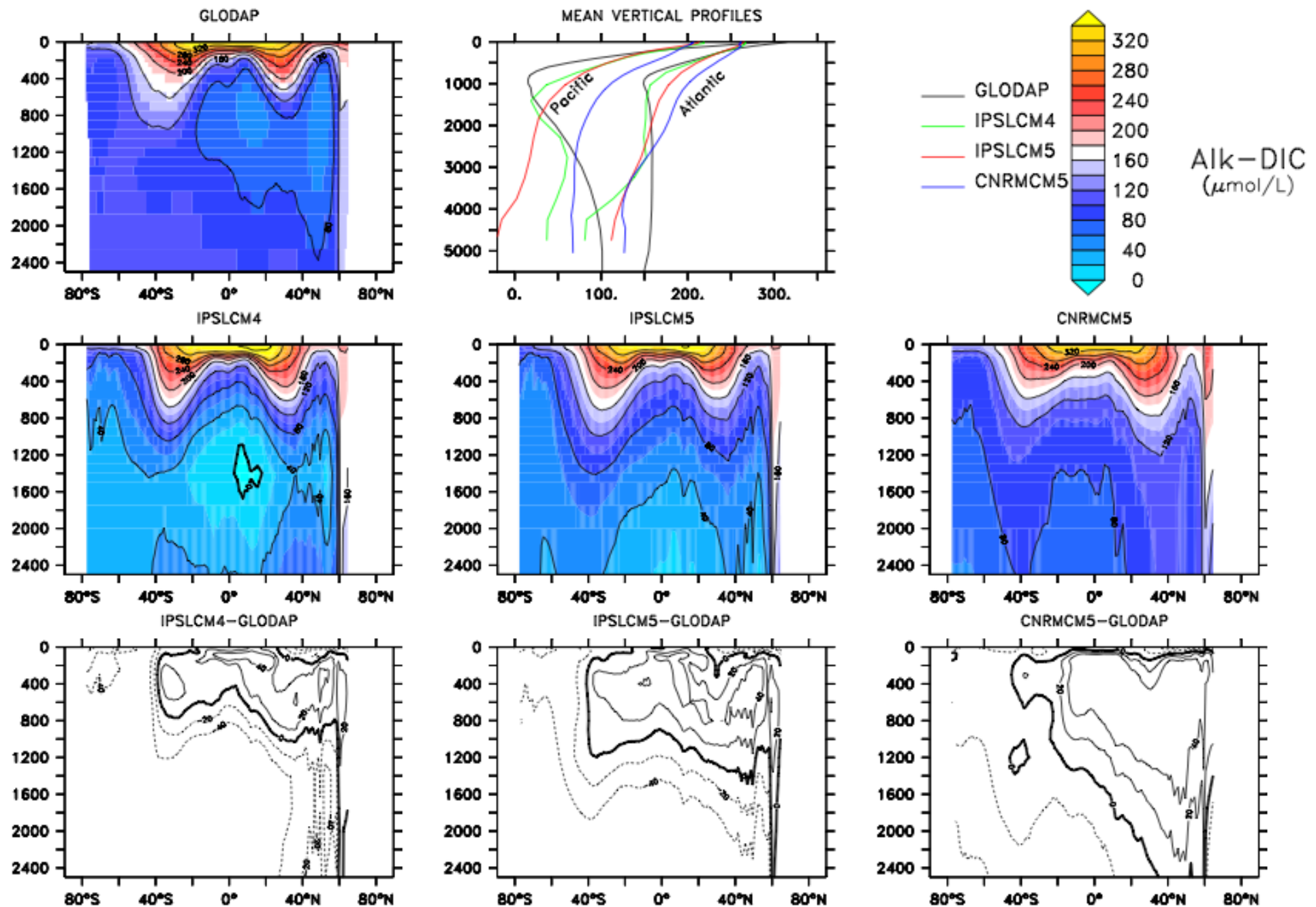
# Better representation of surface properties:



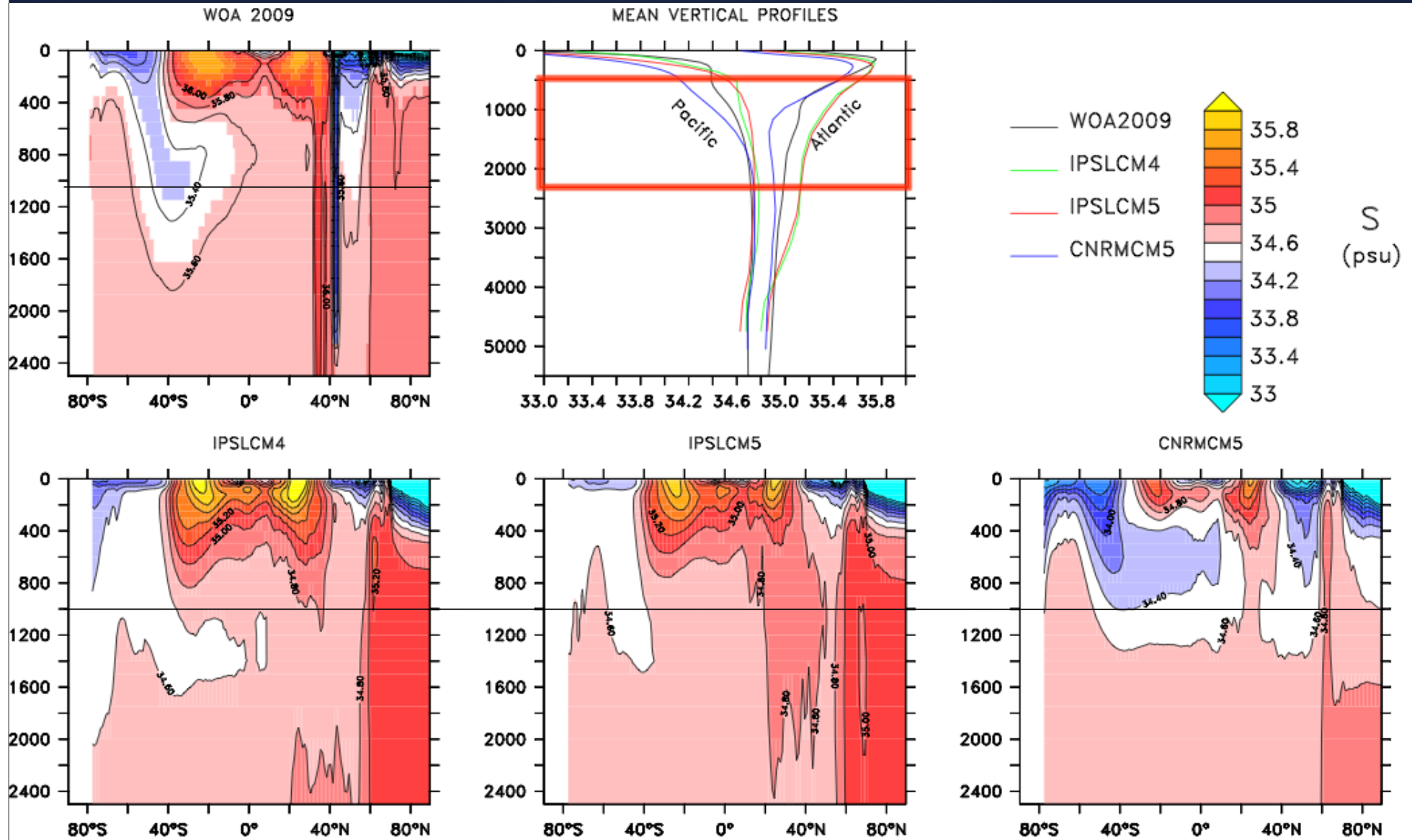
# Better representation of surface properties:



# Poor representation of deep ocean circulation:



# Poor representation of deep ocean circulation:



# Conclusions:

- \* A better representation of surface coupling [mixed-layer depth] lead to better represent key biogeochemical variables (e.g., surface chlorophyll, nutrient gradient...)
- \* Poor representation of water-mass hydrodynamics and biogeochemical properties induce large biases at depth
  1. Surface forcings & atmospheric biases  
⇒ Resolution & New Physics
  2. Representation of sea-ice and its coupling with the ocean  
⇒ LIM3 (multi-layers SIC)
  3. Representation of the biological pump (Remineralization length is **40% deeper** than those estimated from observations)  
⇒ Parameters optimization and evaluation in coupled mode