# Tradeoffs between satellite surface and Argo profile observations when optimizing a biogeochemical model for the Gulf of Mexico

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Advancing the science and application of ocean predictions

1

**Developing a physical-biogeochemical model for the GOM (2010-2015)**

-- Using the parameter optimization technique to determine the biological parameters

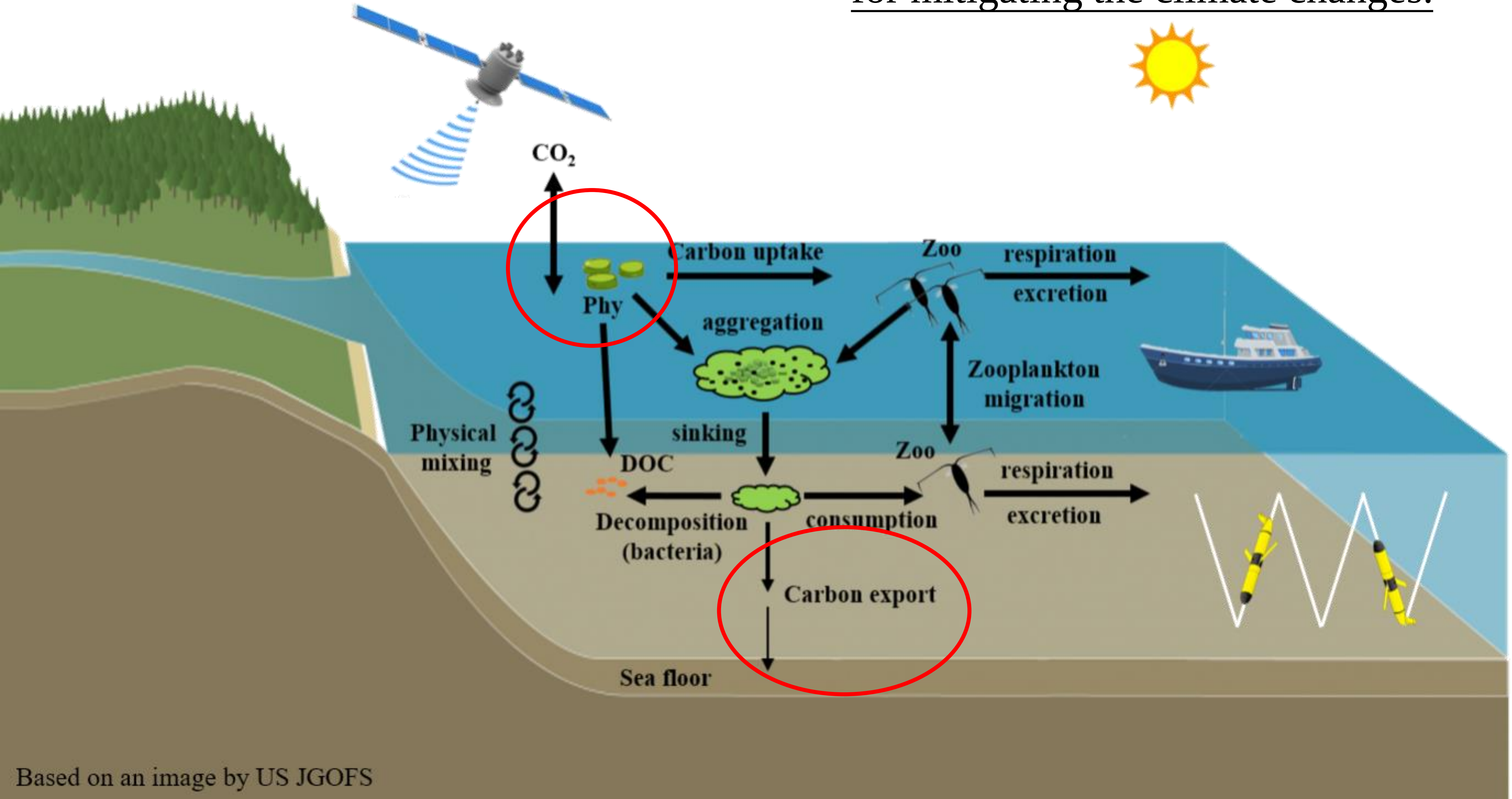
2

**To apply the data-assimilation to our physical-biogeochemical model**

3

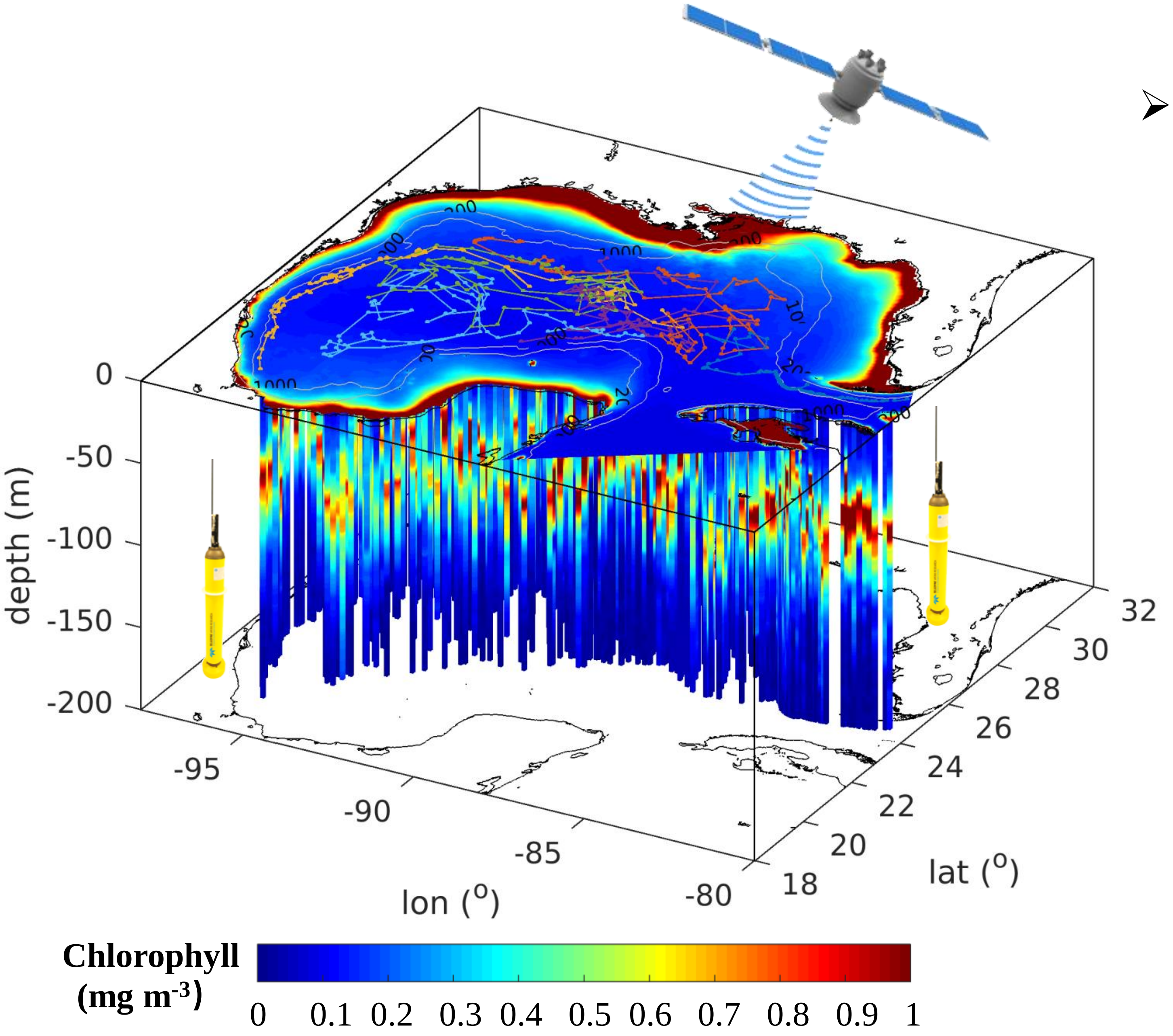
**To study the carbon cycle (e.g. primary production, carbon export) in the GOM**

The carbon cycle in the ocean is very important for mitigating the climate changes.

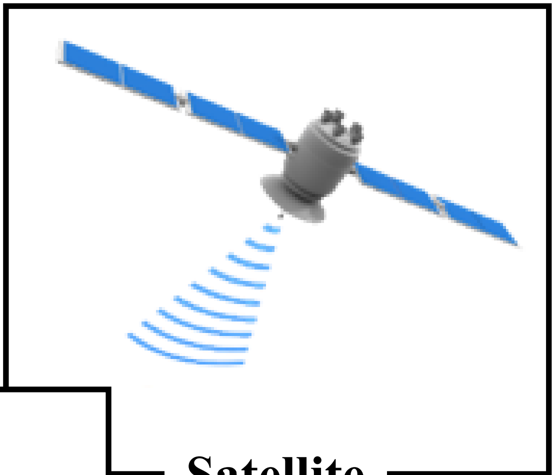



Based on an image by US JGOFS

# Motivation



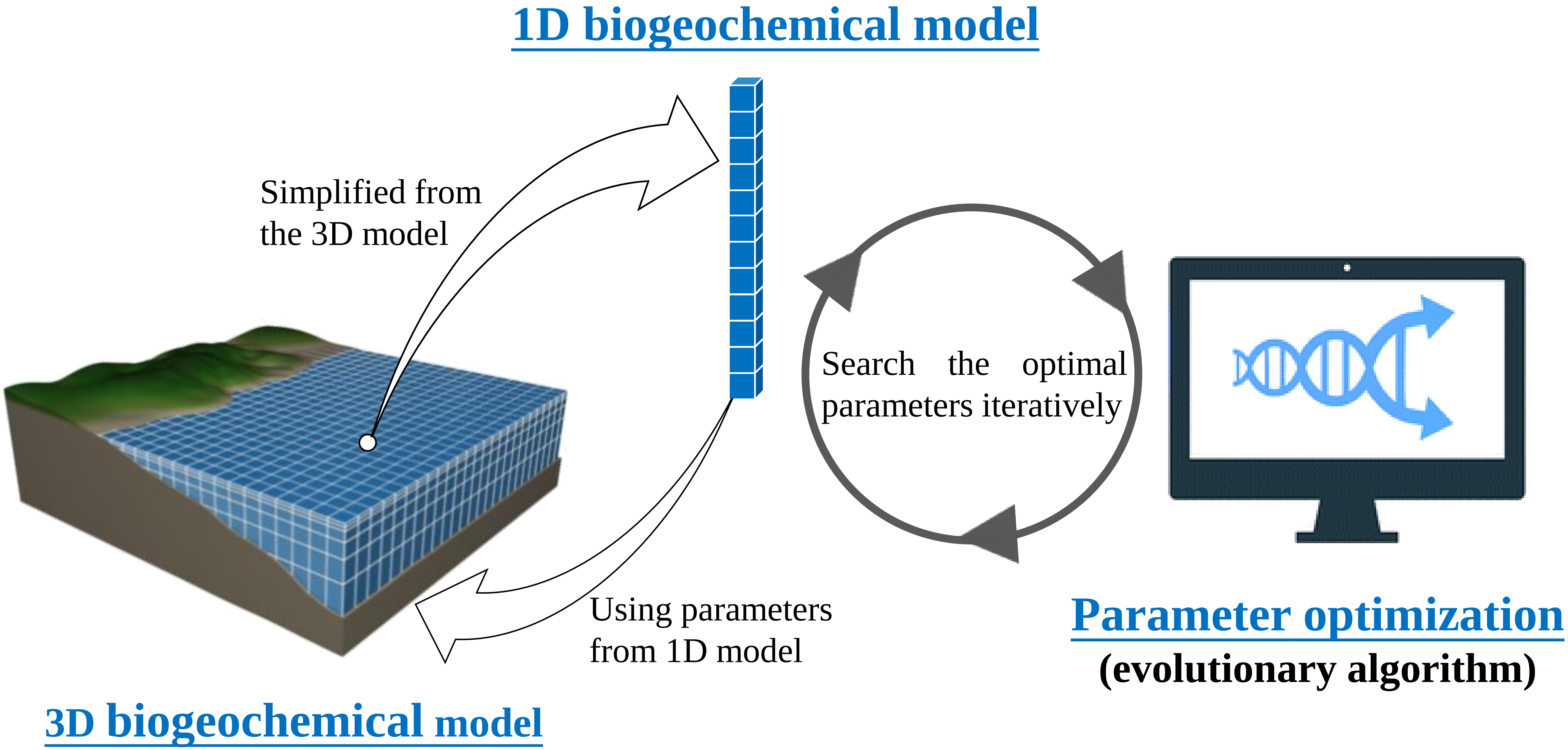

- ➢ Satellite surface chlorophyll is often available from the satellite estimates, but may not be able to resolve the vertical distributions.



**Satellite**

**Autonomous floats**

# Motivation


1D biogeochemical model
Simplified from the 3D model
Search the optimal parameters iteratively
Using parameters from 1D model
3D biogeochemical model
Parameter optimization
(evolutionary algorithm)

1

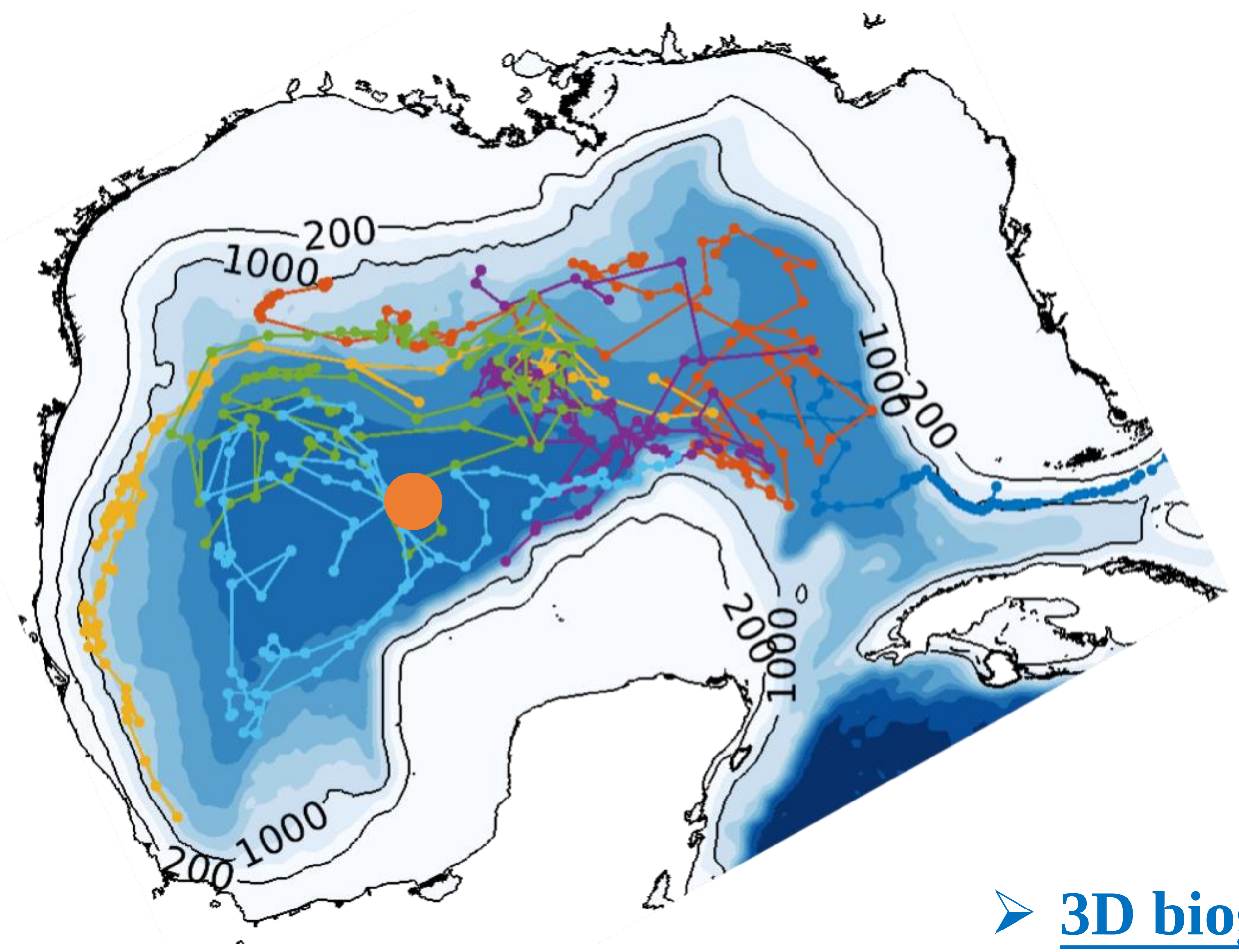
**To develop a physical-biogeochemical model for the GOM (2010-2015)**

-- Using the parameter optimization technique to determine the biological parameters

- **To assess the tradeoffs between satellite surface and autonomous profiling observations for parameter optimization**

- **To examine the feasibility of improving a 3D biogeochemical model in the GOM by applying the local-optimized parameters from the 1D model**

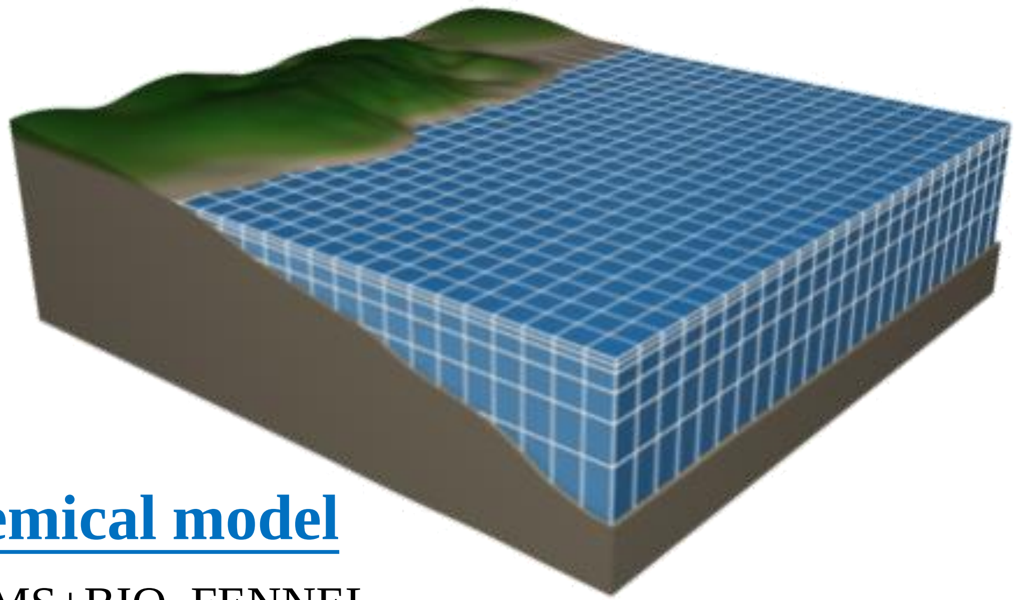
# Motivation




## Gulf of Mexico

## ➤ 1D biogeochemical model

| | |
|---|---|
| **Model version** | BIO_FENNEL |
| **Physics** | From 3D model (temperature and solar radiation) |
| **Model domain** | Upper 200m of one station in the deep ocean |
| **Model period** | 2010 |

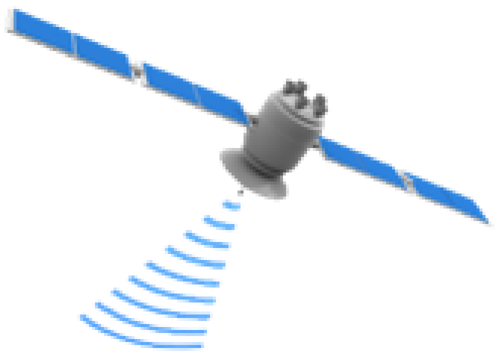


## ➤ 3D biogeochemical model

| | |
|---|---|
| **Model version** | ROMS+BIO_FENNEL |
| **Model domain** | Gulf of Mexico |
| **Model period** | 2011 to 2015 |

# Experiment settings

| | Satellite Surface Chl | Profiles of Chl | Profiles of Phy and POC |
|---|---|---|---|
| **A** | √ | | |
| **B** | √ | √ | |
| **C** | √ | √ | √ |



**Satellite**

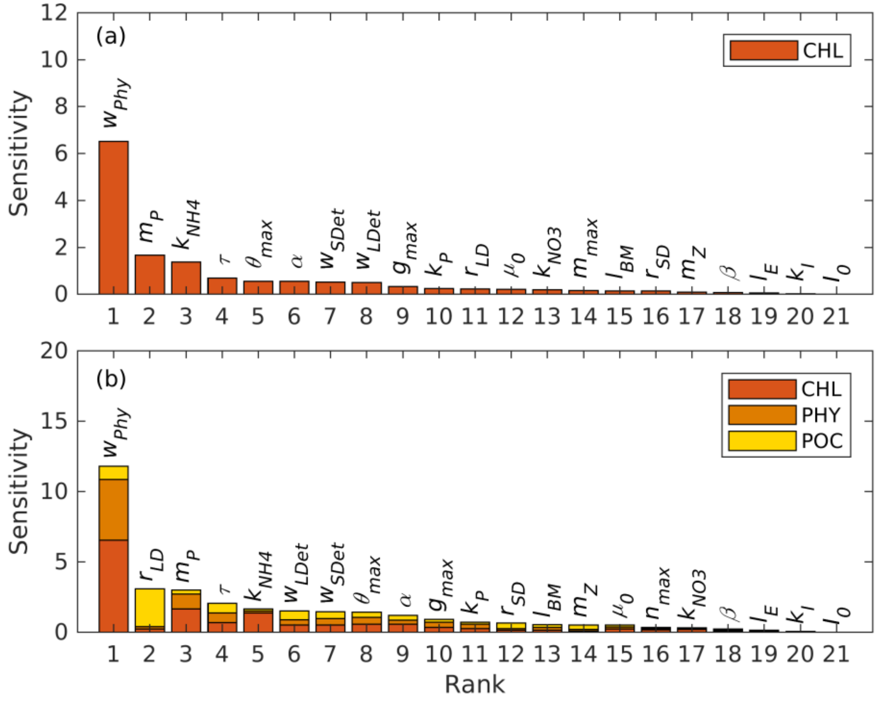
**Autonomous floats**

- ❑ 520 profiles
- ❑ 2011-2015
- ❑ Chlorophyll fluorescence → <u>Chlorophyll</u>
- ❑ Backscatter at 700nm → <u>Phytoplankton and POC</u>
- ❑ ……

# Experiment settings

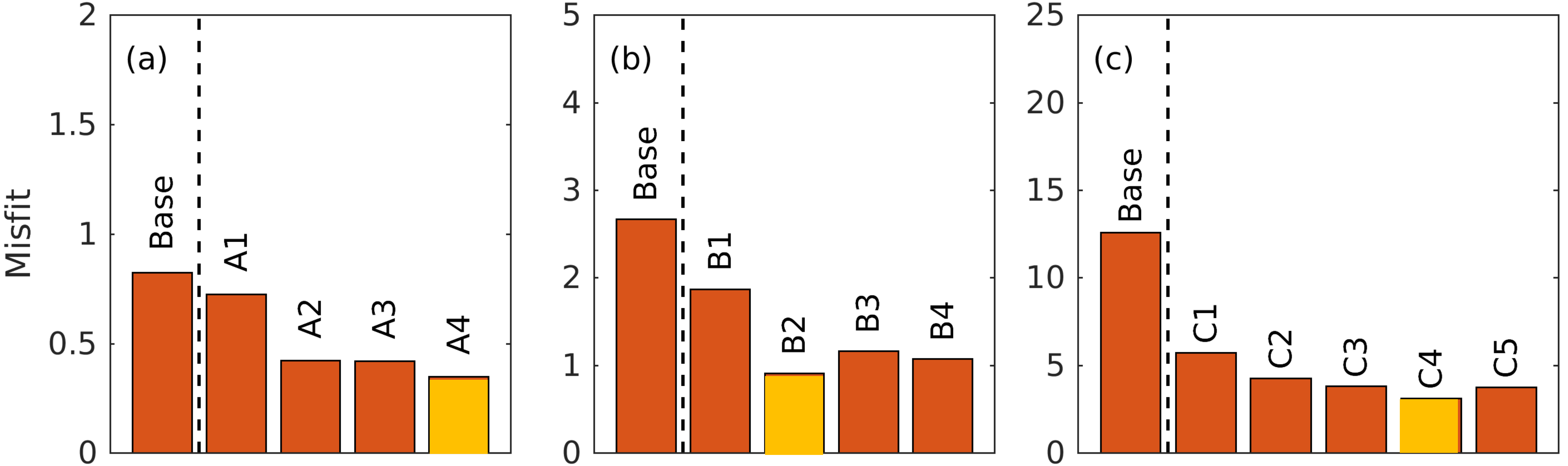
| | $w_{Phy}$ | $m_P$ | $k_{NH4}$ | $\theta_{max}$ | $\alpha$ | $w_{LDet}$ | |
|---|---|---|---|---|---|---|---|
| A1 | √ | √ | √ | -- | -- | -- | |
| A2 | √ | √ | √ | √ | -- | -- | |
| A3 | √ | √ | √ | √ | √ | -- | |
| A4 | √ | √ | √ | √ | √ | √ | |
| B1 | √ | √ | √ | -- | -- | -- | |
| B2 | √ | √ | √ | √ | -- | -- | |
| B3 | √ | √ | √ | √ | √ | -- | |
| B4 | √ | √ | √ | √ | √ | √ | |
| | $w_{Phy}$ | $r_{LD}$ | $m_P$ | $\tau$ | $k_{NH4}$ | $w_{LDet}$ | $\theta_{max}$ |
| C1 | √ | √ | √ | -- | -- | -- | -- |
| C2 | √ | √ | √ | √ | -- | -- | -- |
| C3 | √ | √ | √ | √ | √ | -- | -- |
| C4 | √ | √ | √ | √ | √ | √ | -- |
| C5 | √ | √ | √ | √ | √ | √ | √ |

Parameters sensitivities to model results




$$Q(y,P) = \frac{1}{m}\sum_{i=1}^{m}\frac{1}{n}\sum_{j=1}^{n}\frac{|y_{Base} - y_{Test}|}{y_{Base}}$$

# Results of 1D models



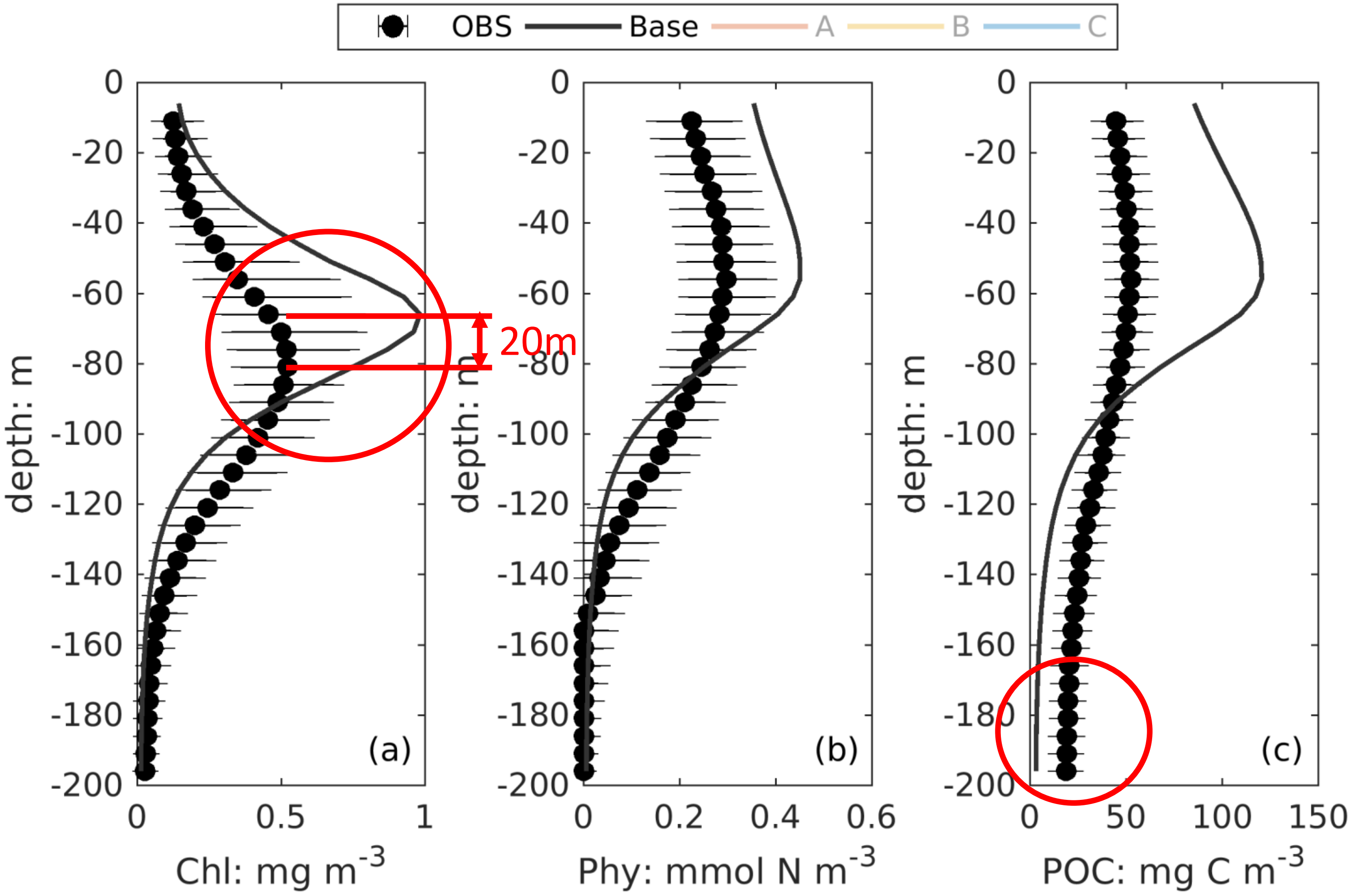

$$\mathrm{F}_v(P) = \frac{1}{N\sigma_v^2}\sum_{i=1}^{n}\left(\hat{y}_{i,v} - y_{i,v}(P)\right)^2$$

$$\mathrm{F}_A(P) = \mathrm{F}_{SurfCHL}(P) \qquad \mathrm{F}_B(P) = \mathrm{F}_{SurfCHL}(P) + \mathrm{F}_{CHL}(P)$$

$$\mathrm{F}_C(P) = \mathrm{F}_{SurfCHL}(P) + \mathrm{F}_{CHL}(P) + \mathrm{F}_{Phy}(P) + \mathrm{F}_{POC}(P)$$

# Results of 1D models

| | Satellite Surface Chl | Profiles of Chl | Profiles of Phy and POC |
|---|---|---|---|
| A | √ | | |
| B | √ | √ | |
| C | √ | √ | √ |



# Results of 1D models

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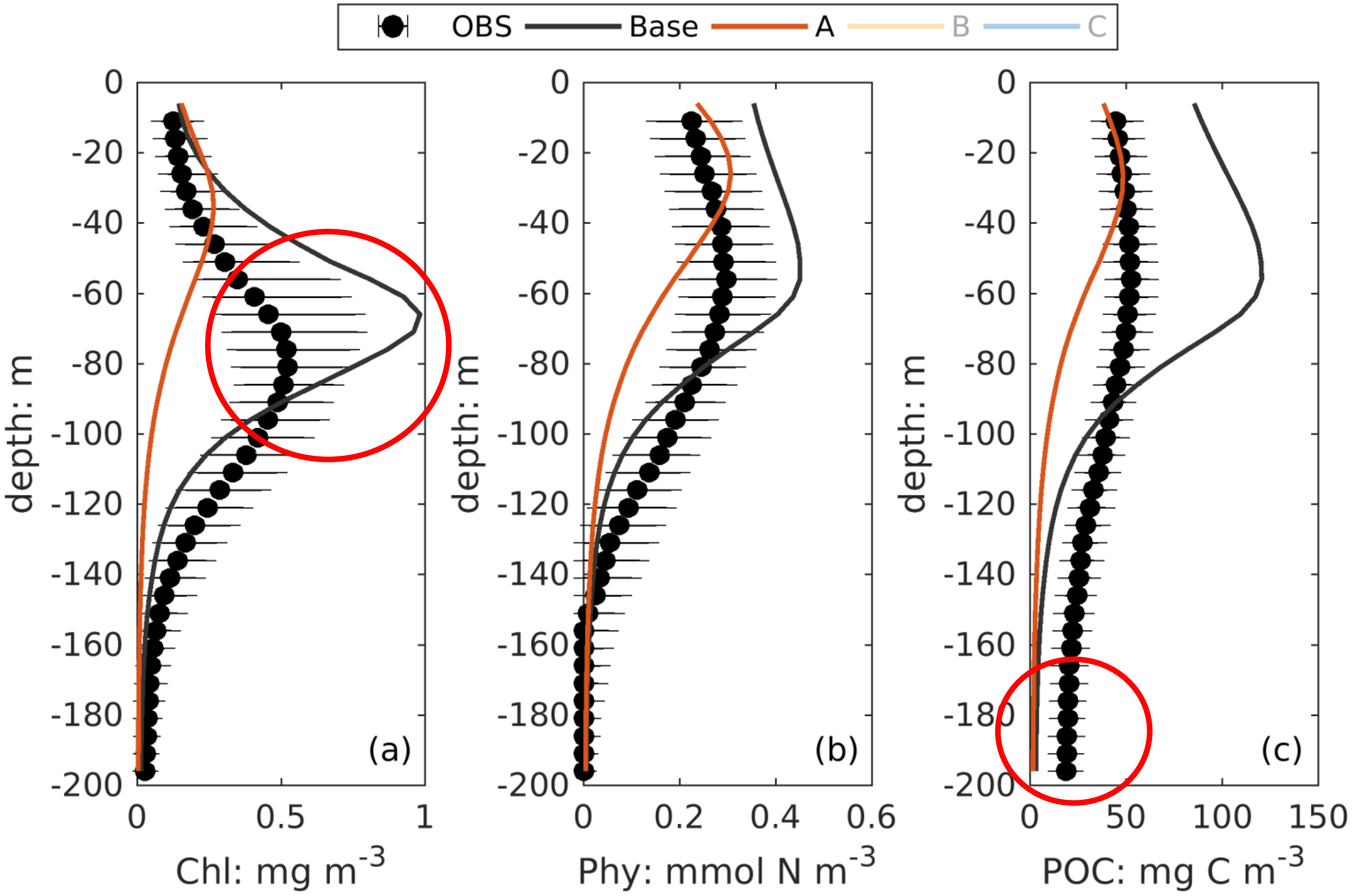

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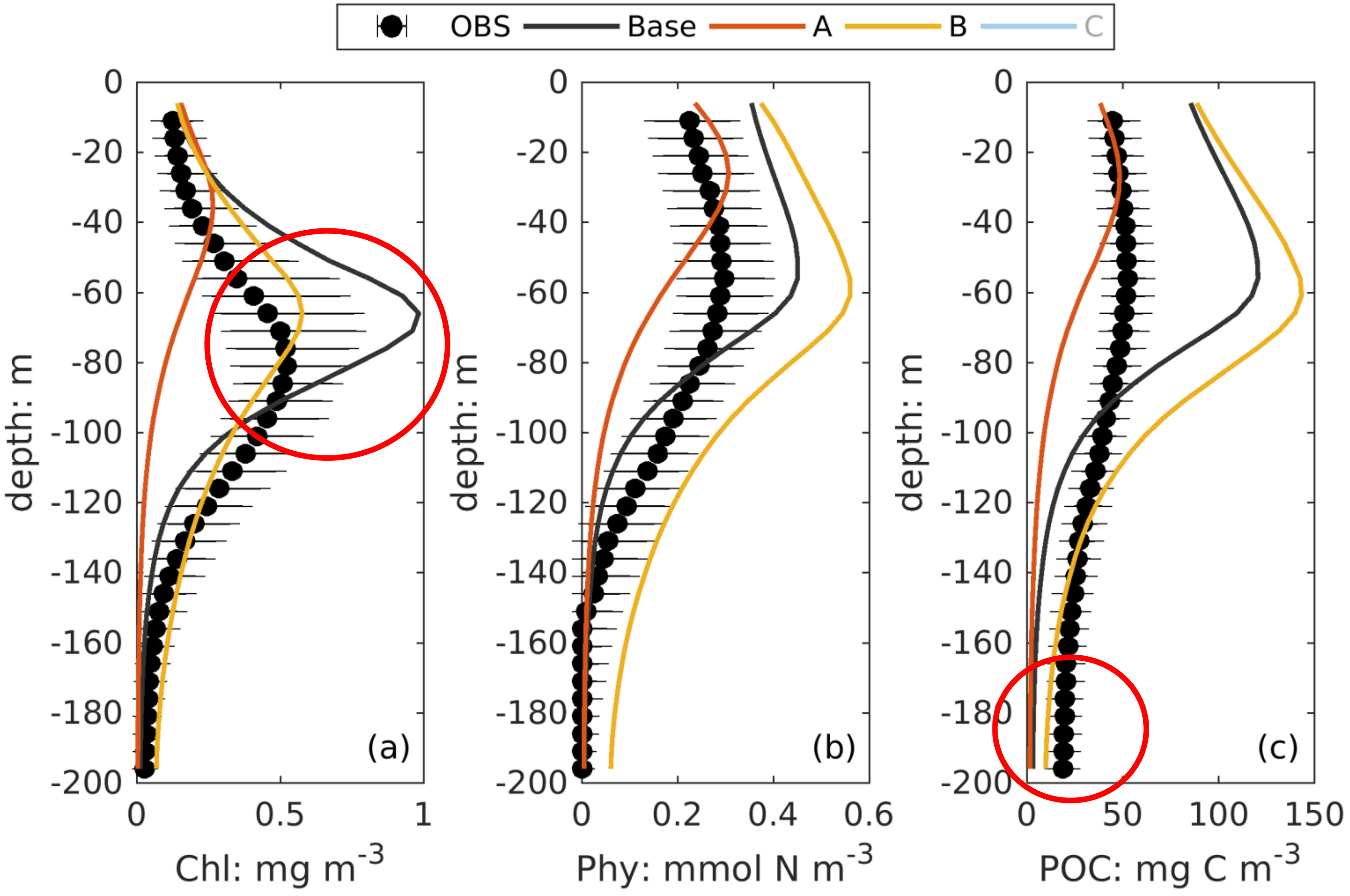

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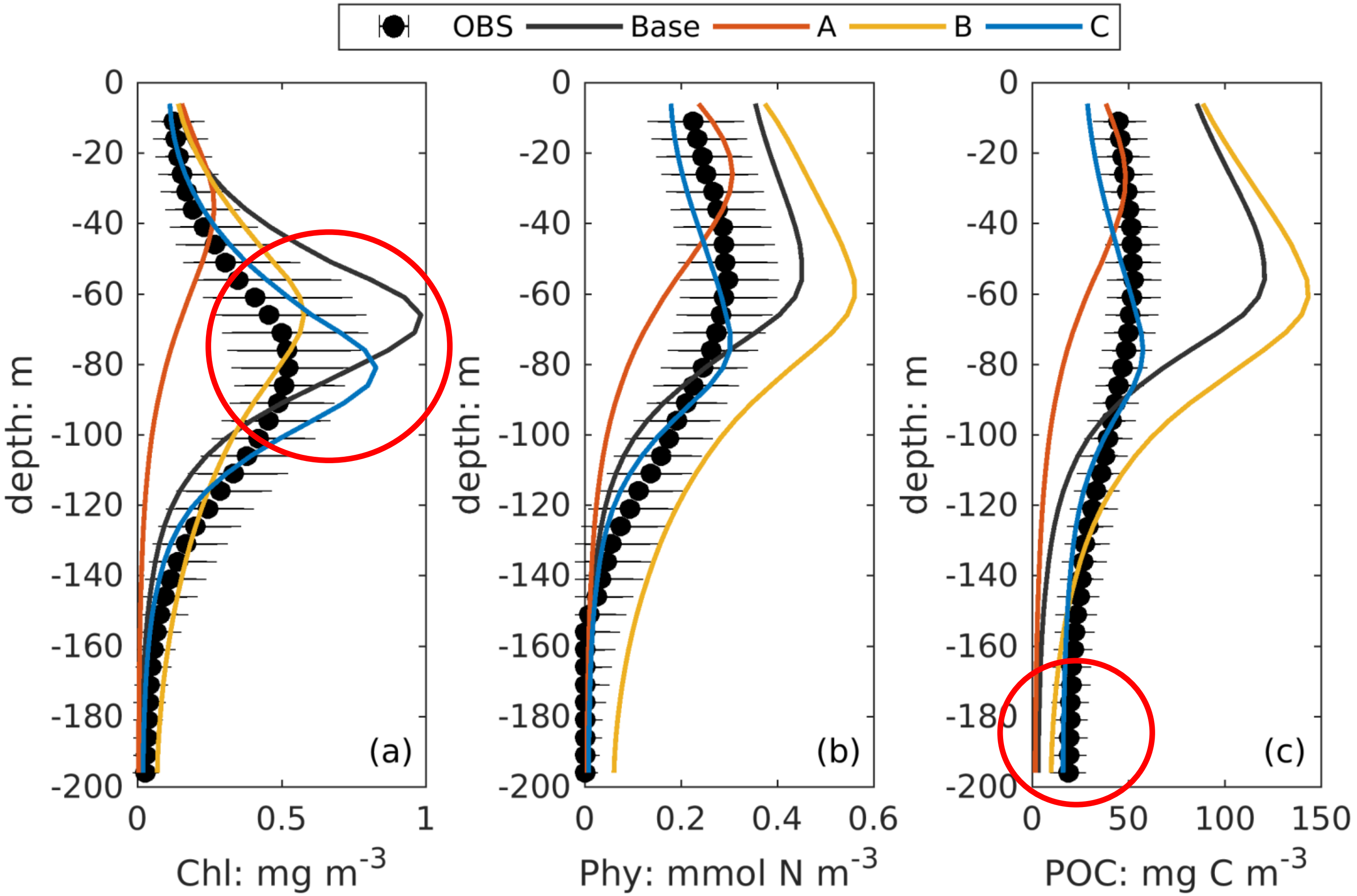
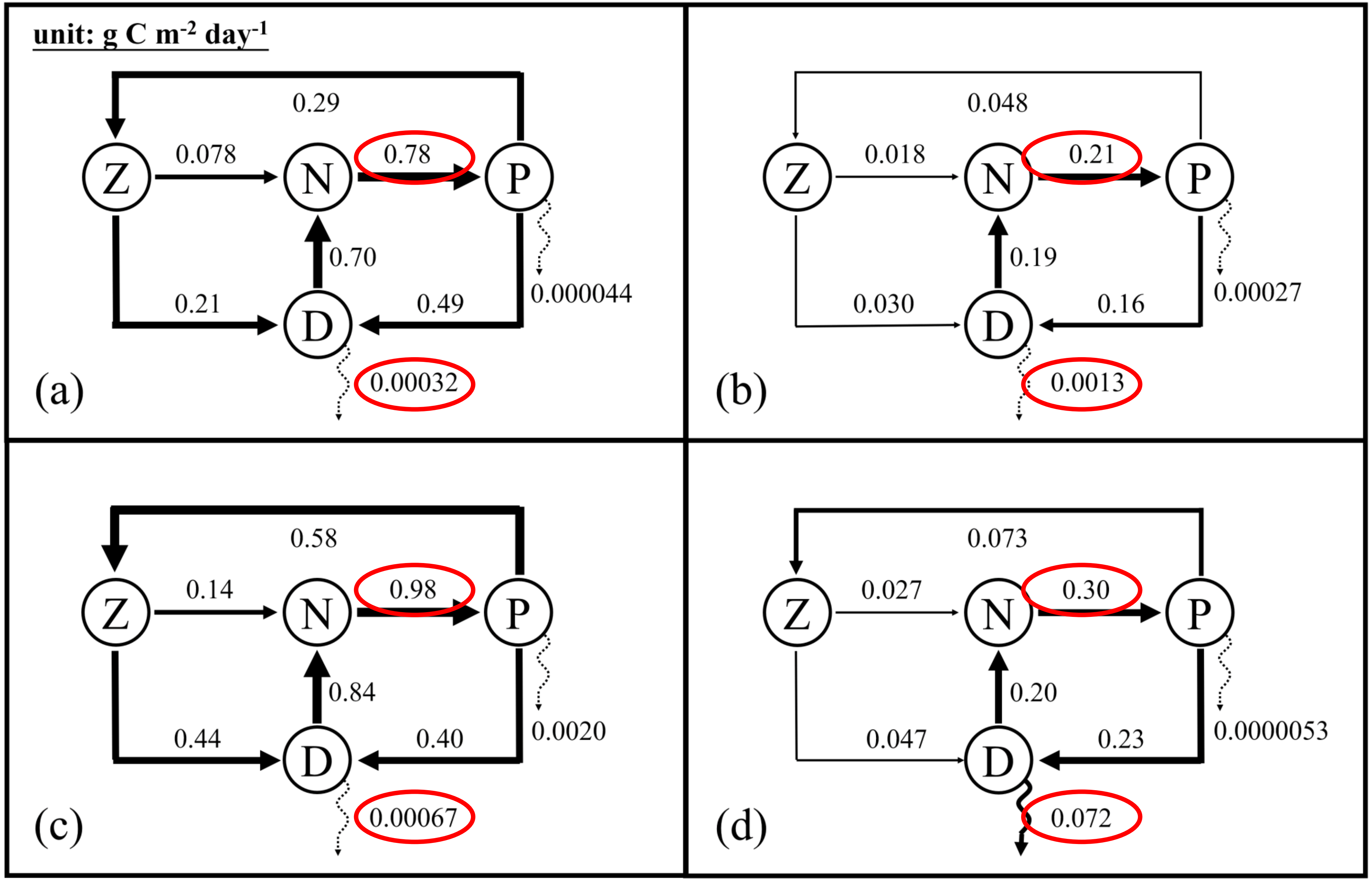


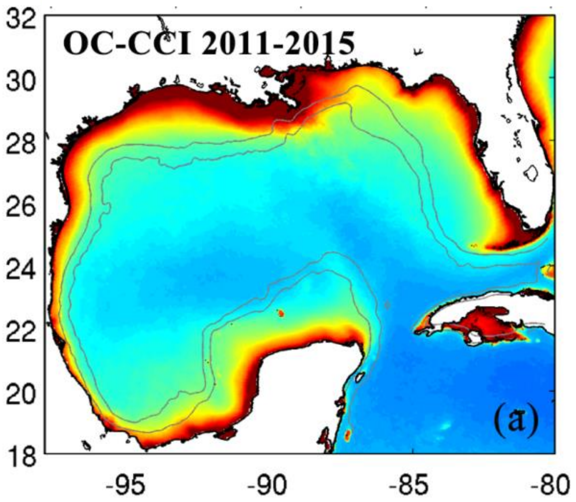
# Results of 1D models



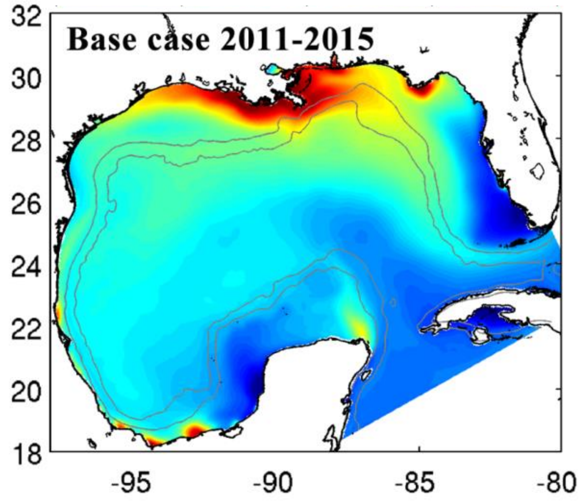
# Results of 3D models

**Annual climatology of chlorophyll from 2011-2015**

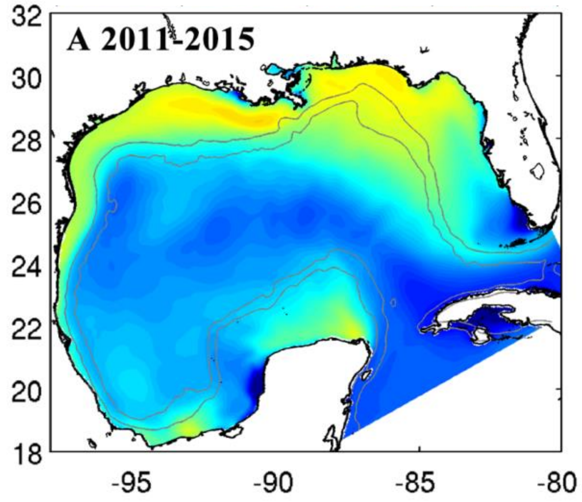
**Satellite estimates**



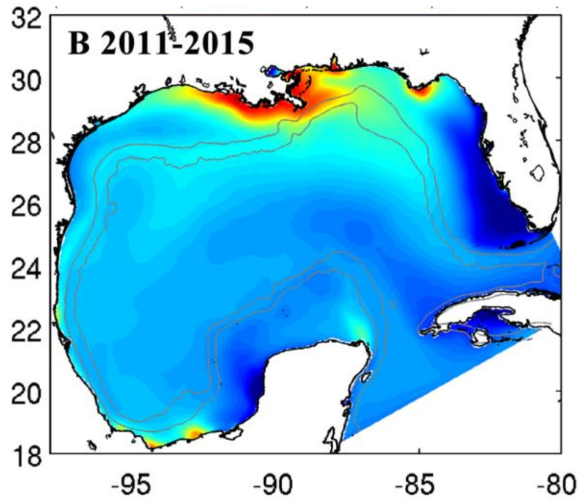

**Base case**



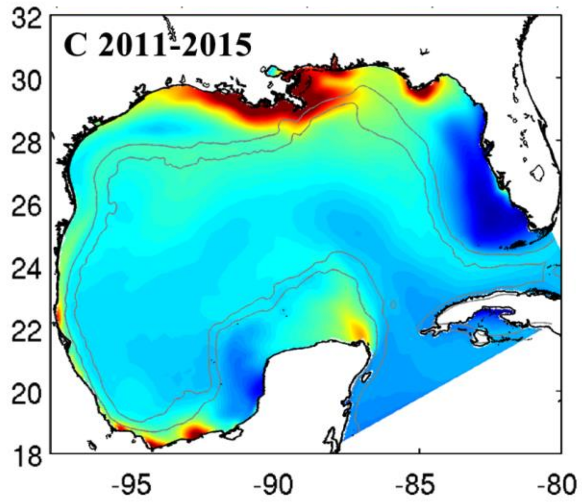

**A**

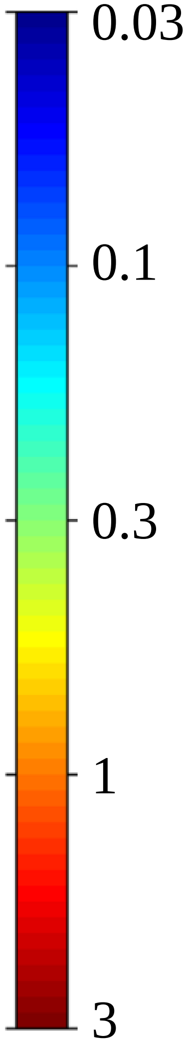



**B**

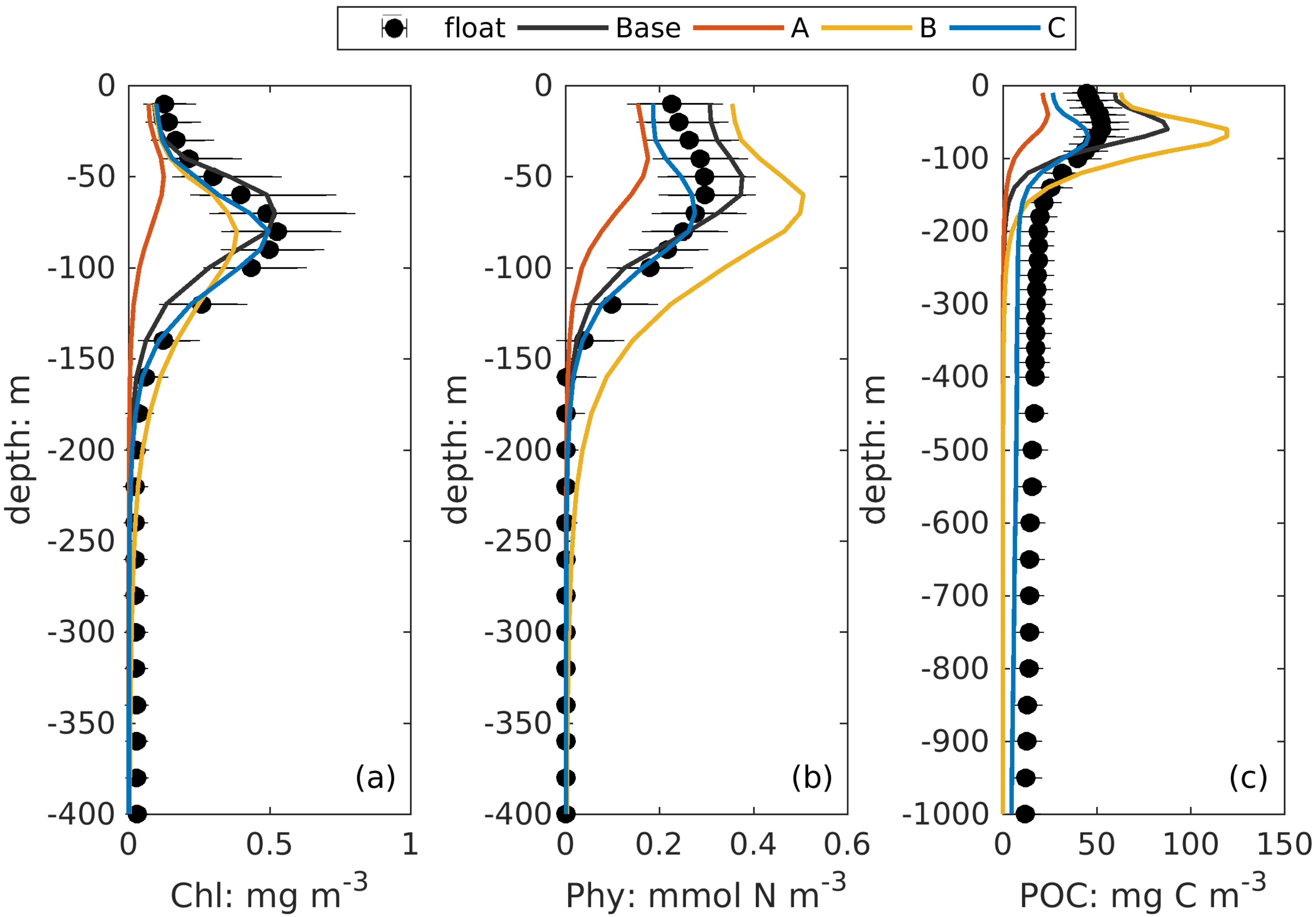



**C**



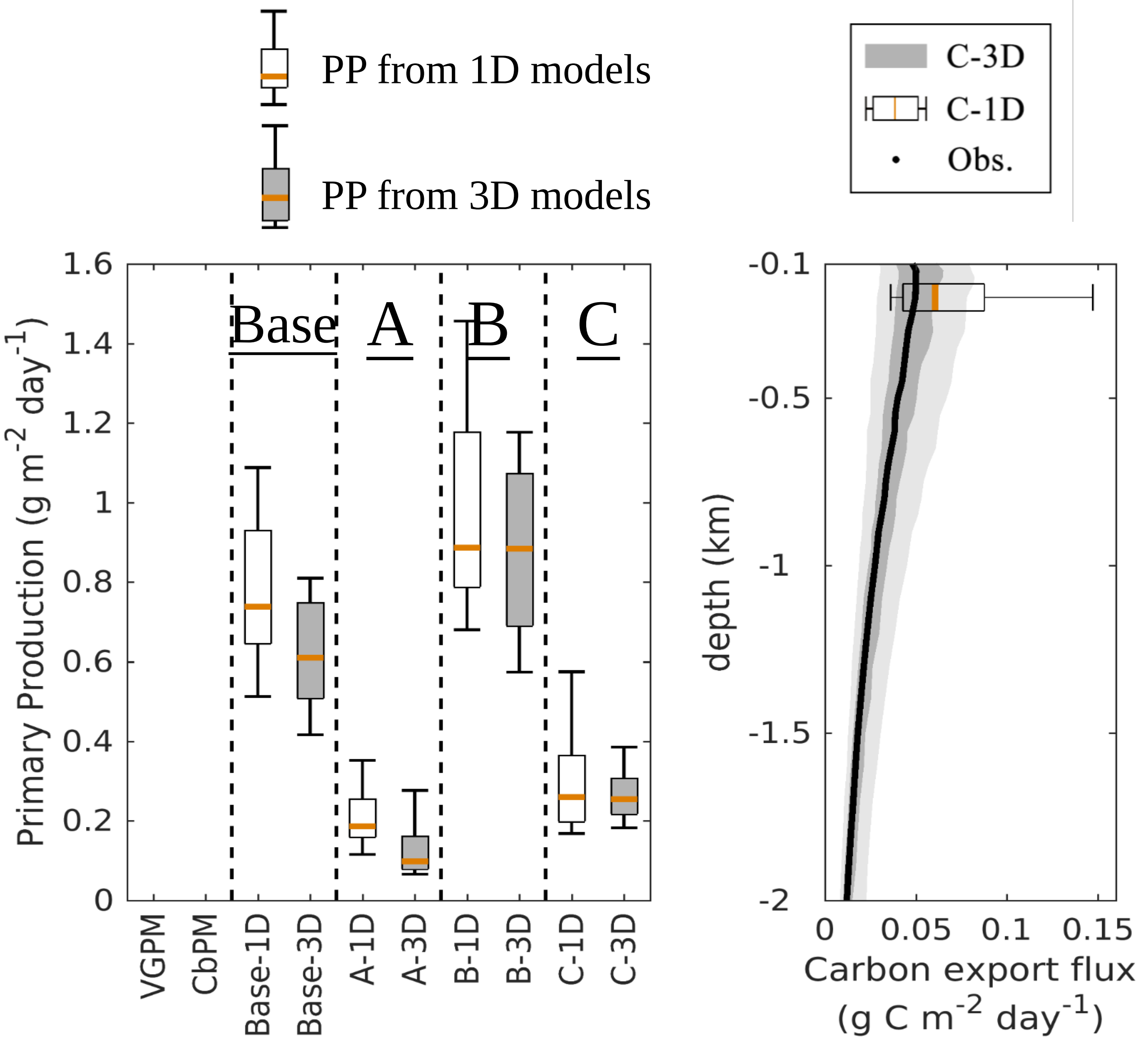



# Results of 3D models



# Results of 3D models

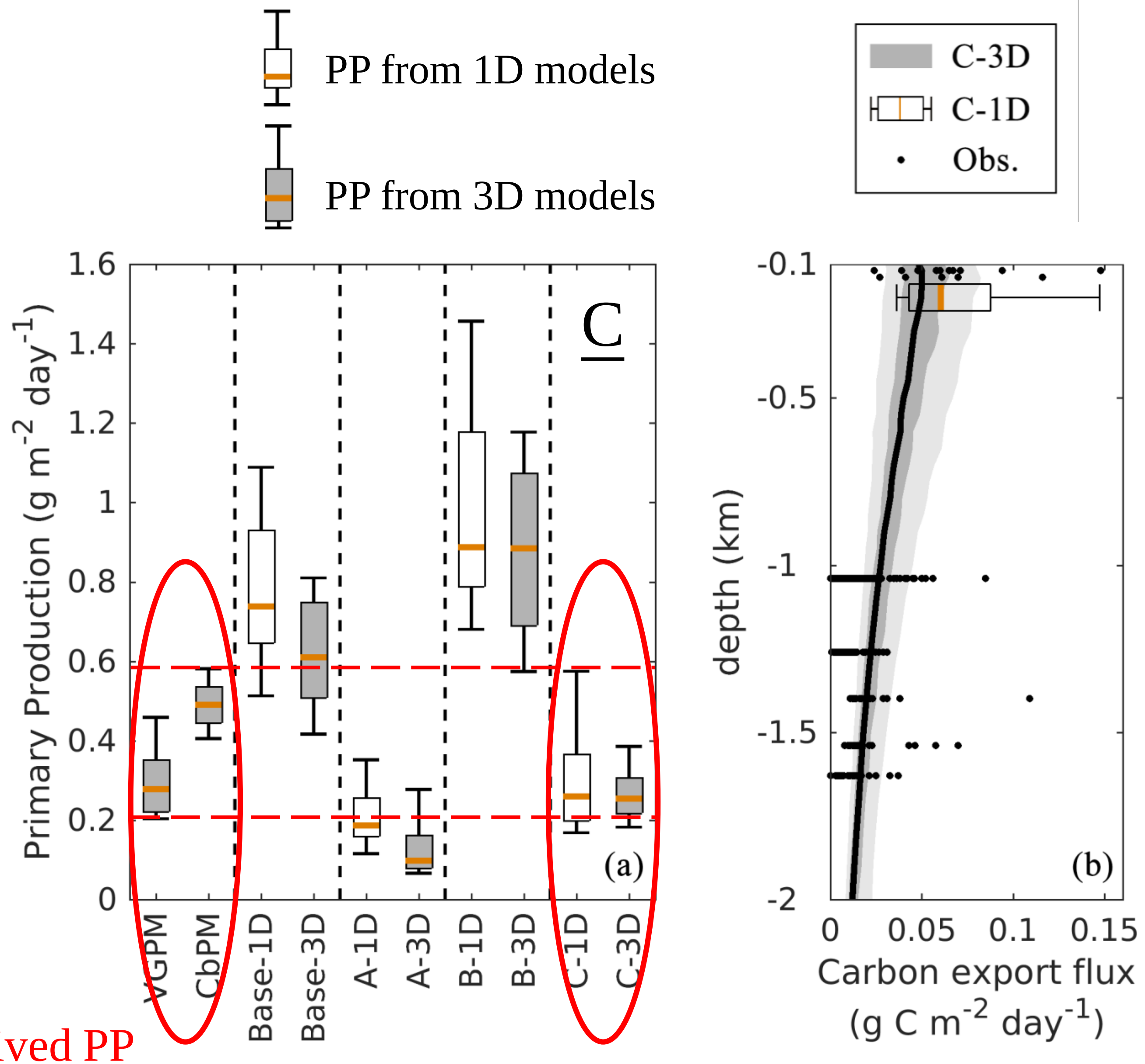
- It is feasible to improve our 3D models by applying the local-optimized parameters from the 1D model



# Results of 3D models

- It is feasible to improve our 3D models by applying the local-optimized parameters from the 1D model

- The experiment C is robust for our future study on the carbon cycles in the Gulf of Mexico




Satellite-derived PP

## Study purposes

- To assess the tradeoffs …

- To examine the feasibility…

## Conclusions

- The satellite surface chlorophyll is not enough for parameter optimization to constrain the biogeochemical models
- Autonomous floats provide useful observations for the parameter optimization to have a better estimations of the carbon cycles both in the upper layer and deep layer. However, only the chlorophyll is not sufficient

- It is feasible to improve our 3D models in the GOM by optimizing the 1D models

1

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2

**To apply the data-assimilation to our physical-biogeochemical model**