

# Optimizing the Biogeochemical Argo Float Distribution

Paul Chamberlain

Collaborators:  
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Matthew Mazloff  
Erik Van Sebille

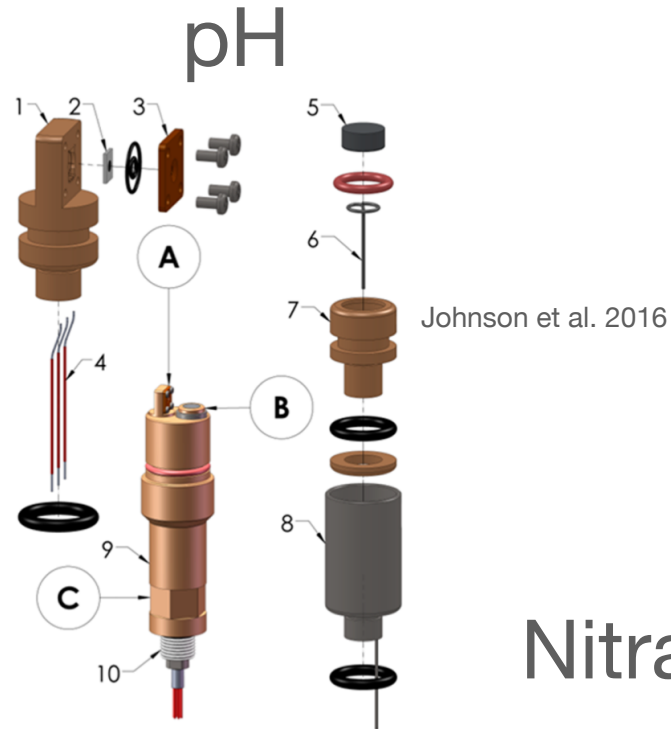


*Unlocking the mysteries  
of the Southern Ocean*

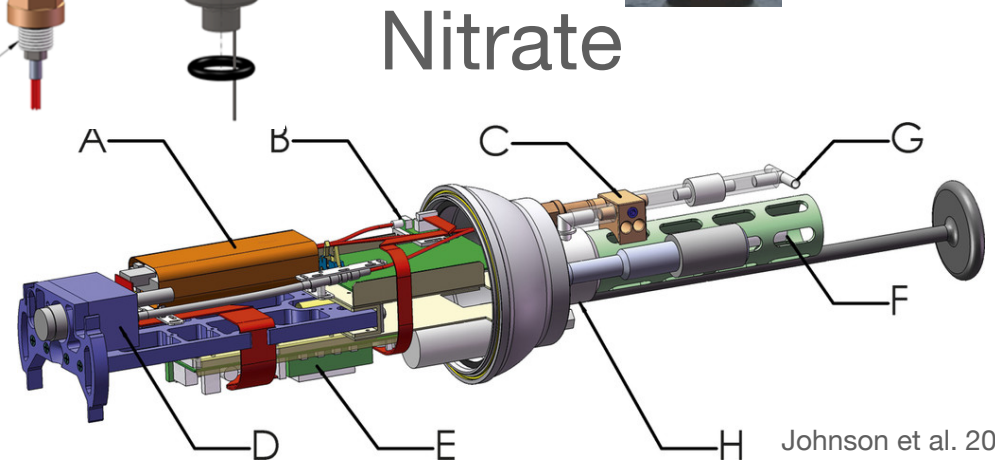


**GO-BGC**  
Global Ocean Biogeochemistry Array

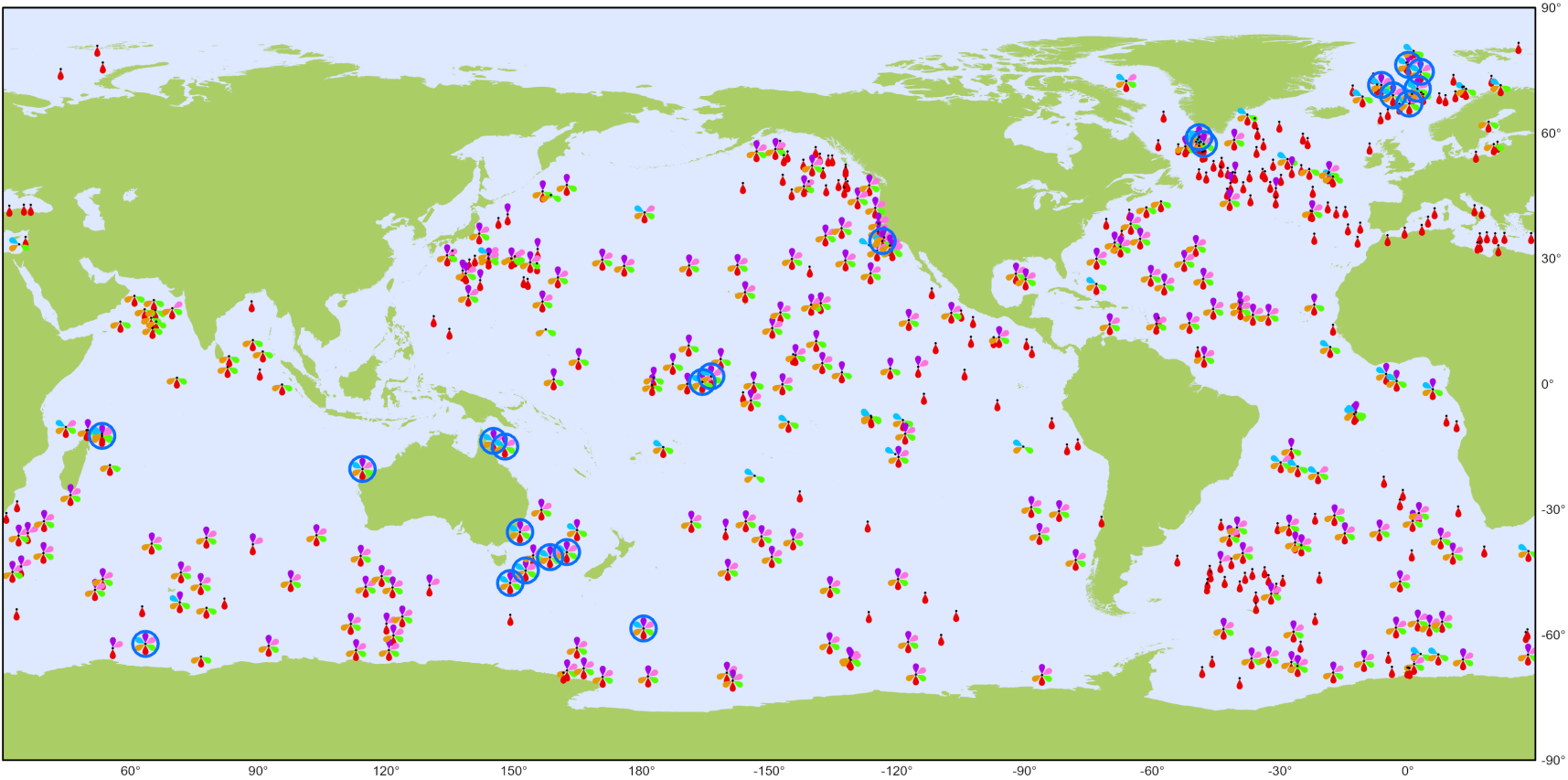
# What is a BGC Float?



Bushinsky et al. 2016



# How Many Argo Floats Do We Need and Where Should We Put Them?



Biogeochemical Argo

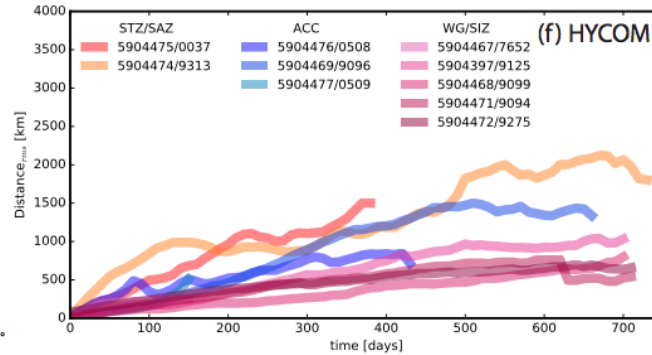
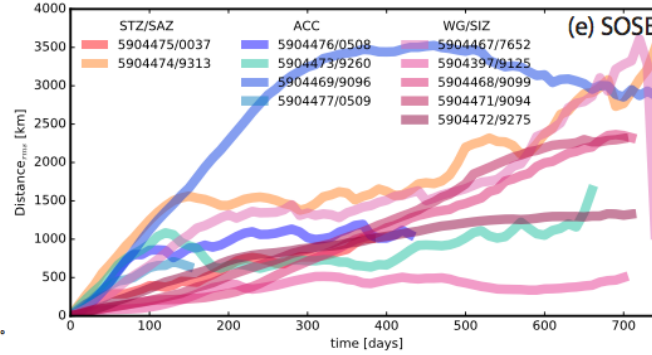
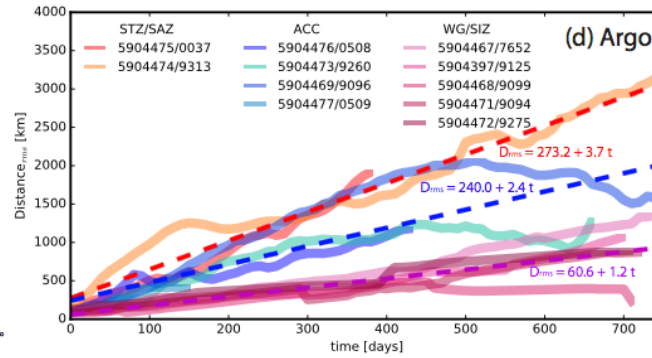
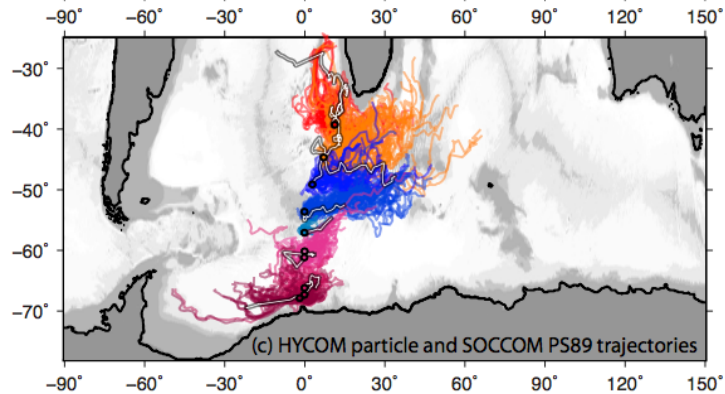
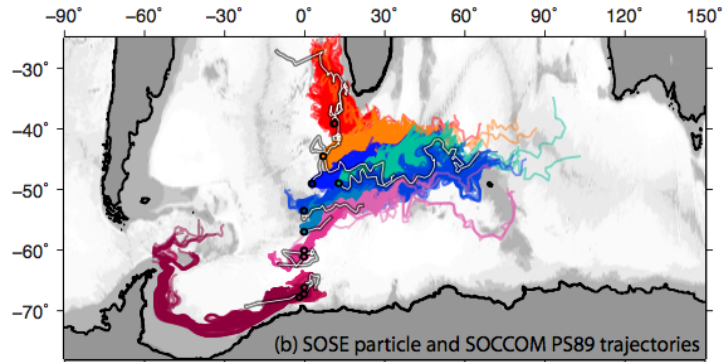
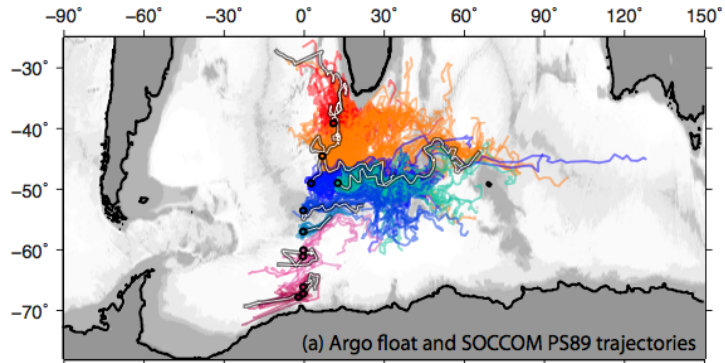
Sensor Types  
Latest location of operational floats (data distributed within the last 30 days)

October 2022

# Considerations:

- Argo floats move around (sometimes a lot).
- The ocean has different scales of spatial and temporal variability
- To quantify the impact of Argo observations, we need to predict their future locations and the covariance of the fields they are measuring

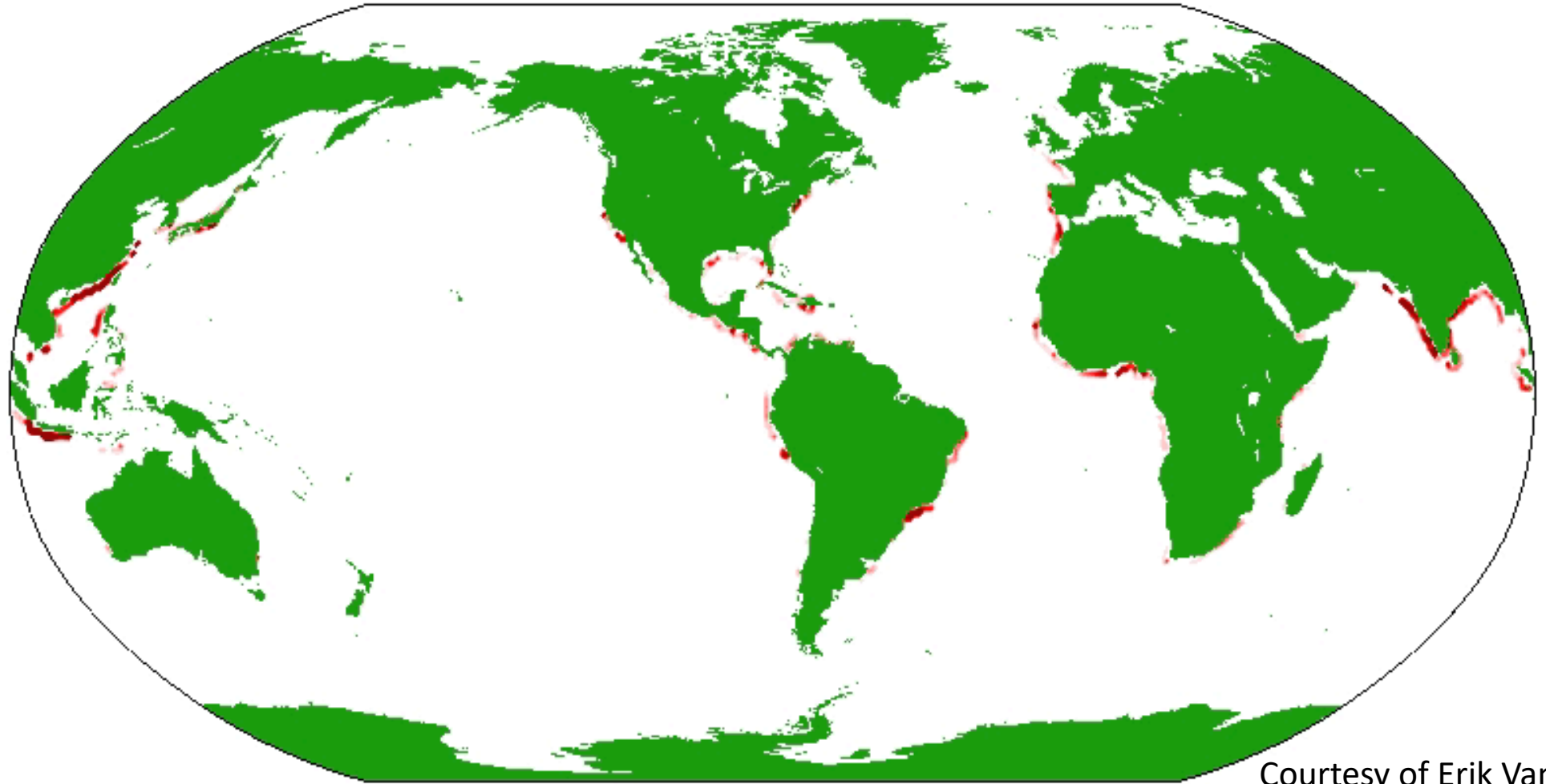




DYNAMICAL  
MODELS  
PREDICT  
FLOAT  
MOTION  
POORLY

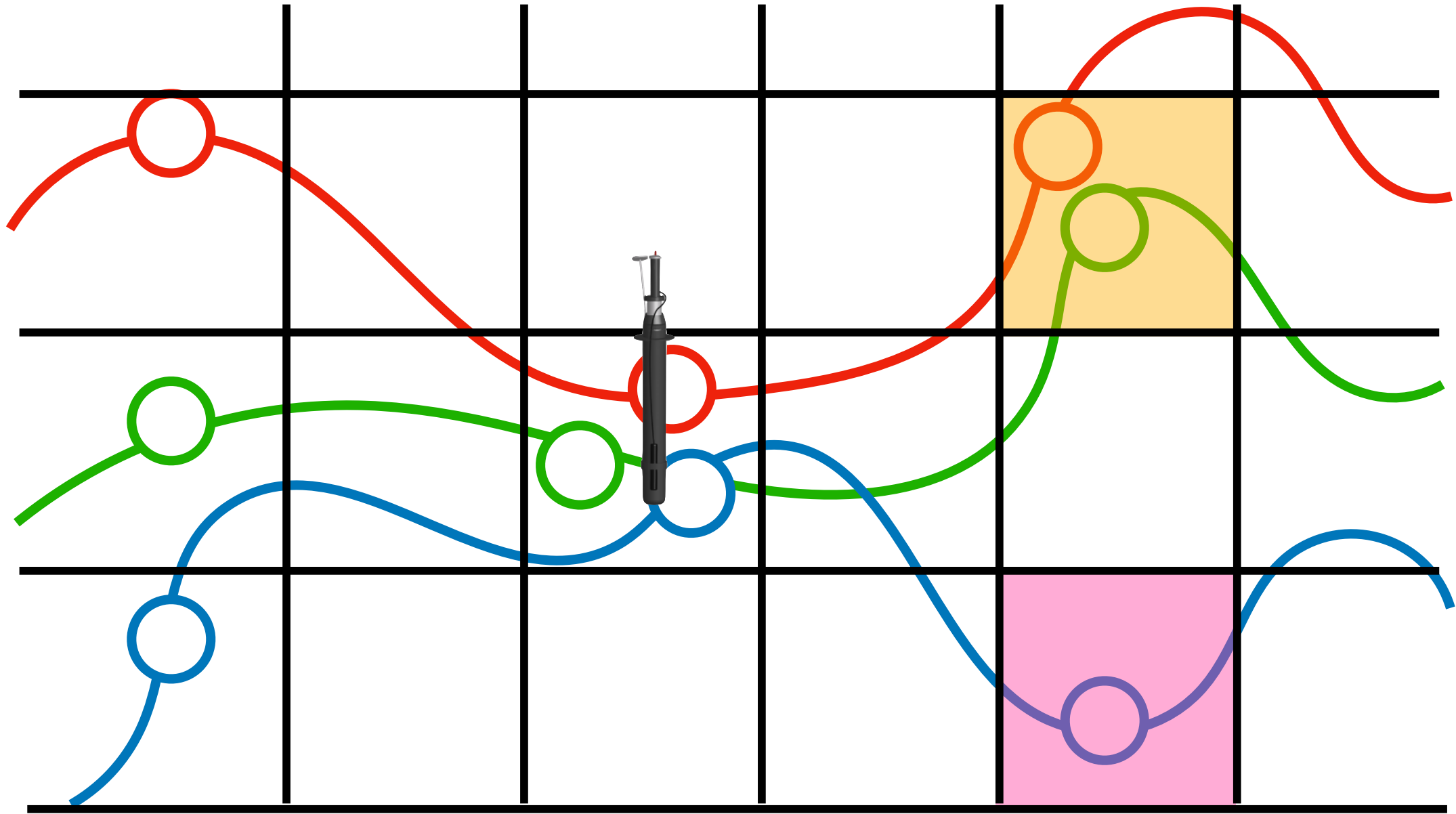
# TRANSITION MATRIX FOR PLASTICS

Tracer accumulation factor 0 years and 00 months after release

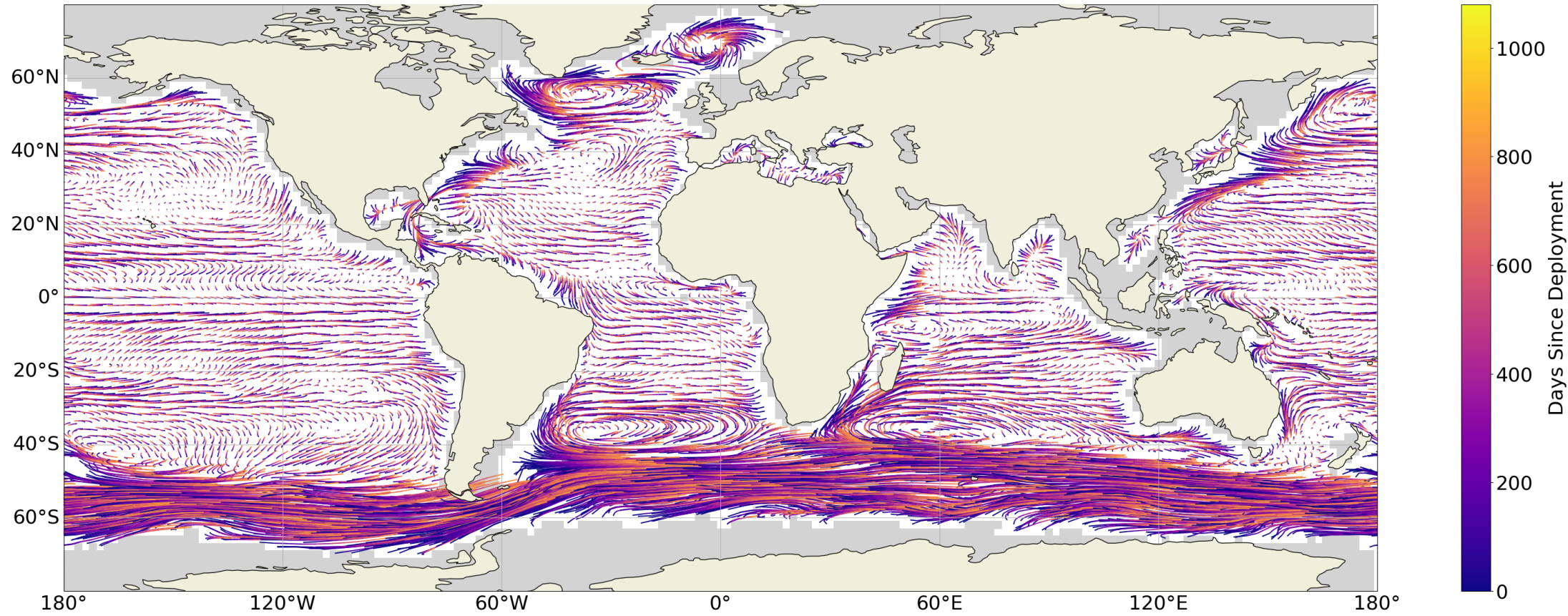


Courtesy of Erik Van Sebille





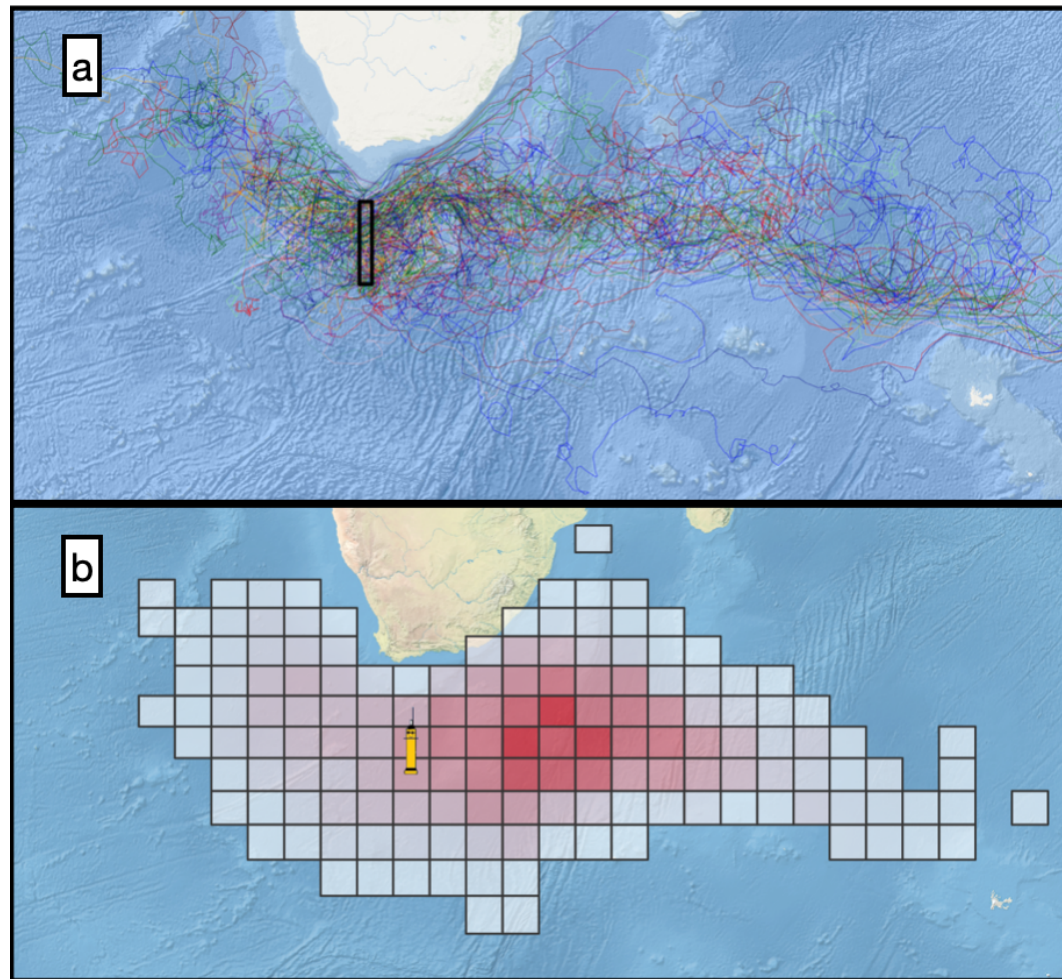
# RESULTS: ARGO ARRAY PREDICTION





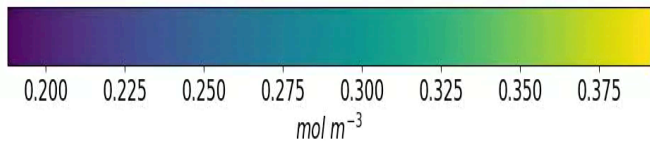
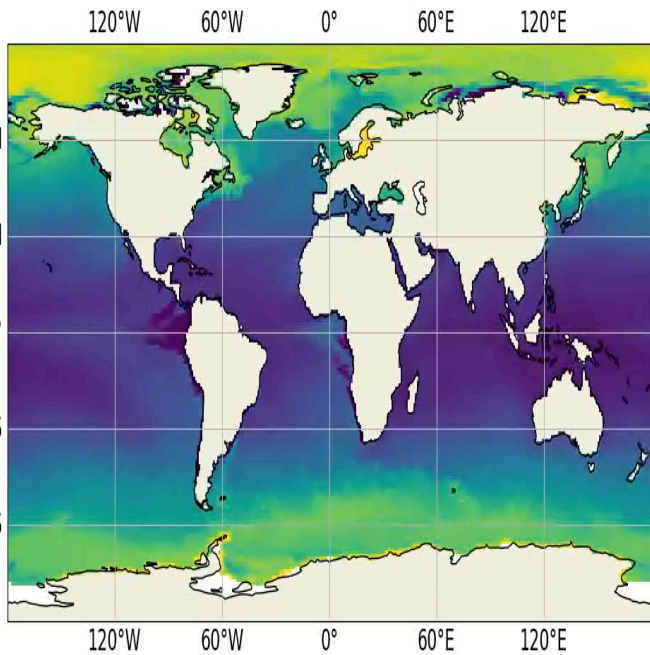
# RESULTS: ARGO ARRAY PREDICTION

<https://argovis.colorado.edu/ng/>

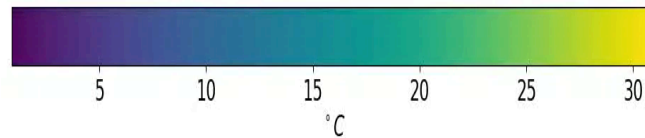
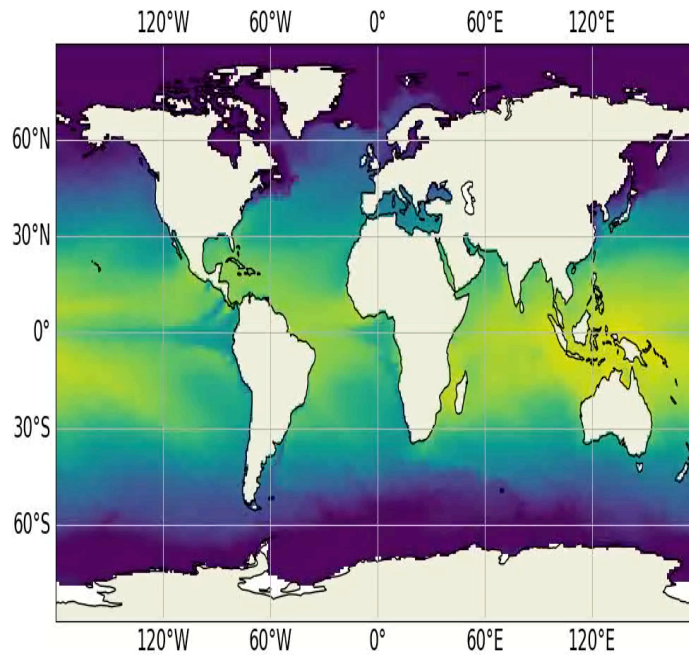


# BGC Models Provide Insight

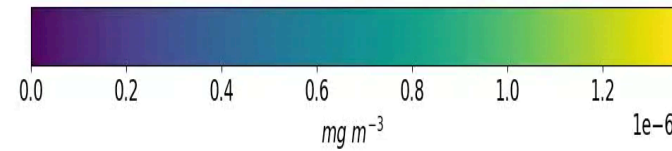
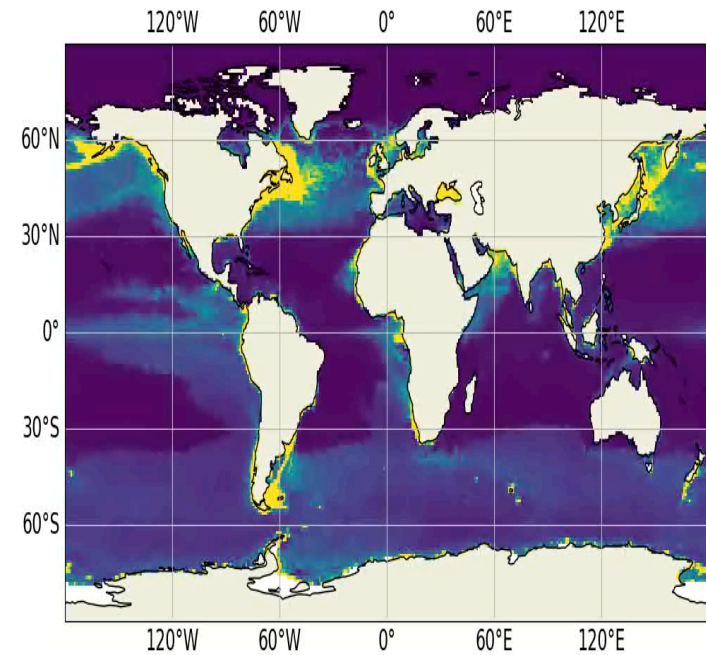
## Oxygen



## Temperature

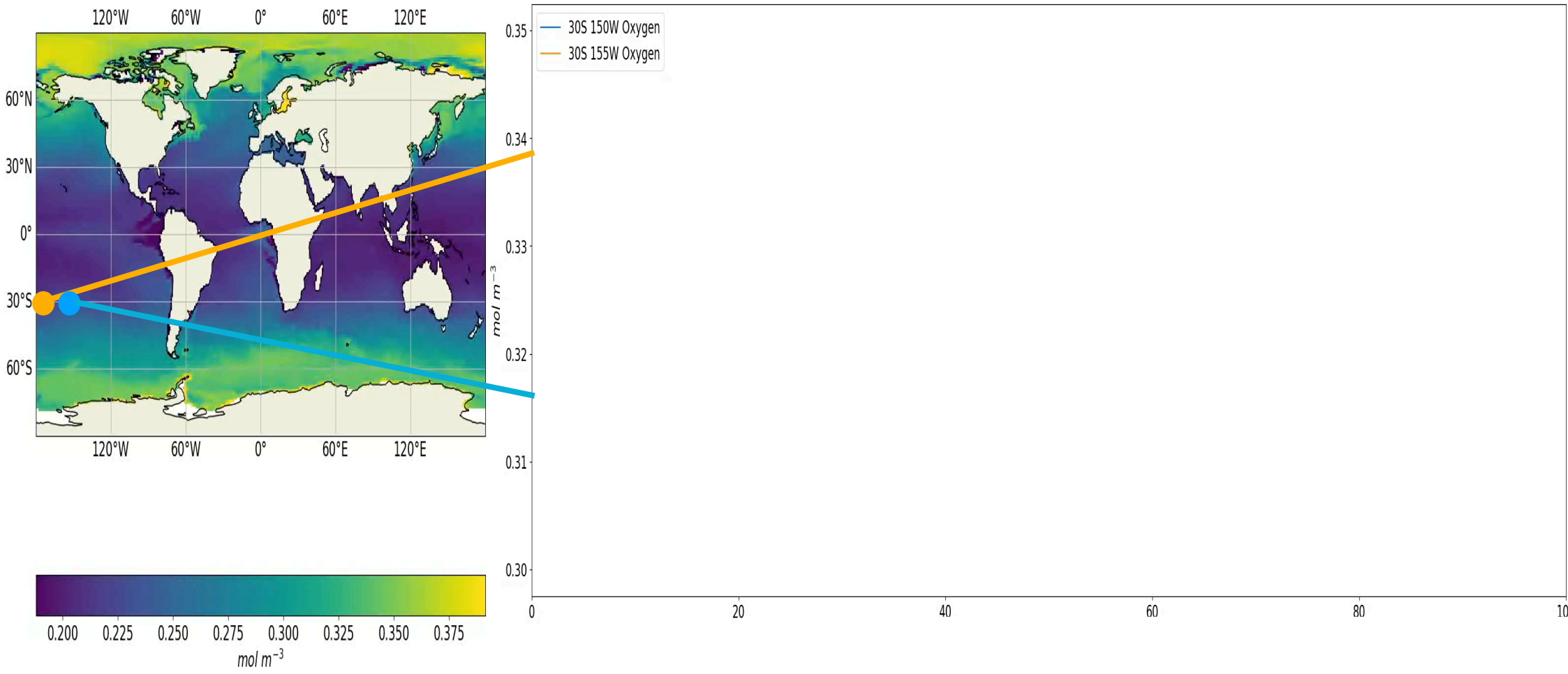


## Chlorophyll



# BGC Models Provide Location Insight

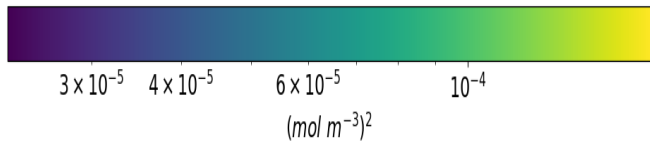
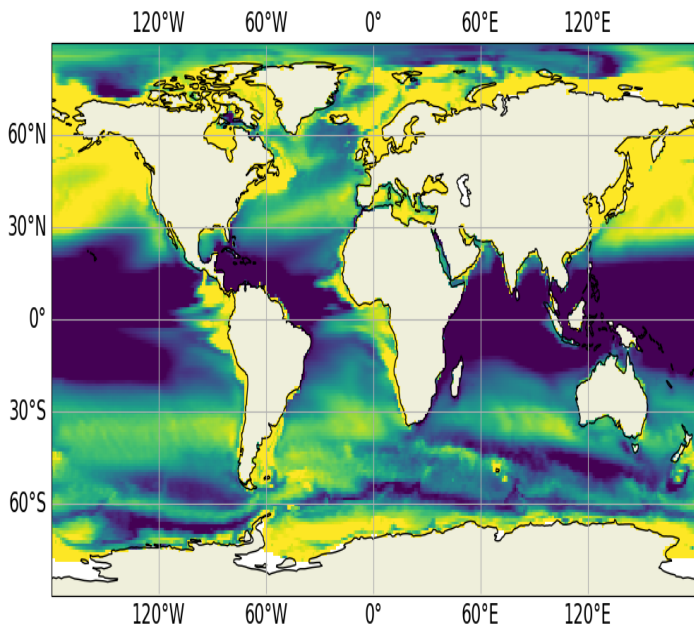
## Oxygen



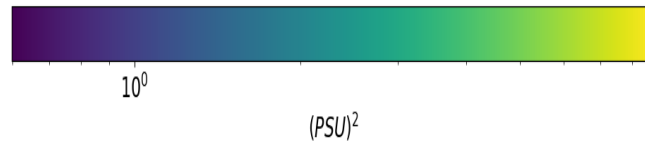
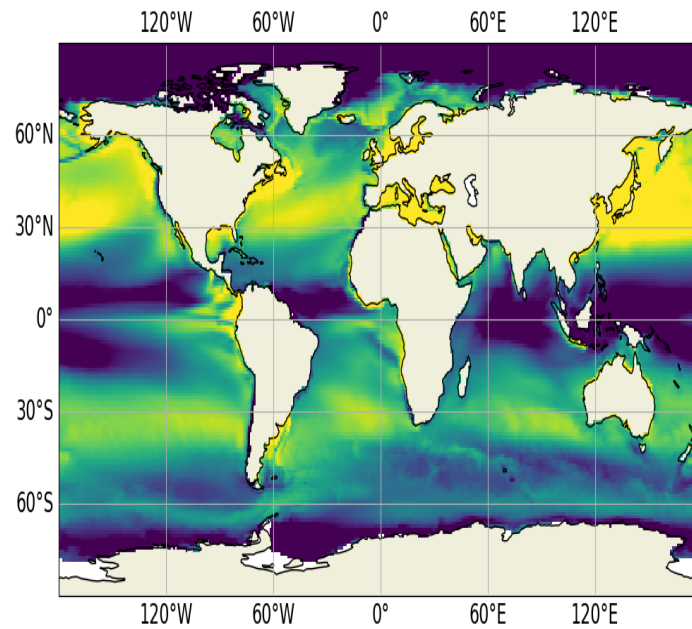


# SPATIAL SCALES OF BGC VARIABILITY

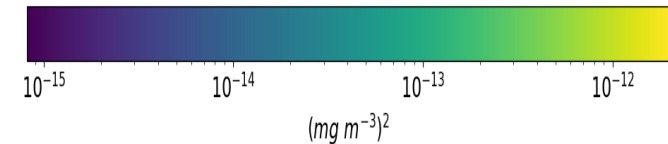
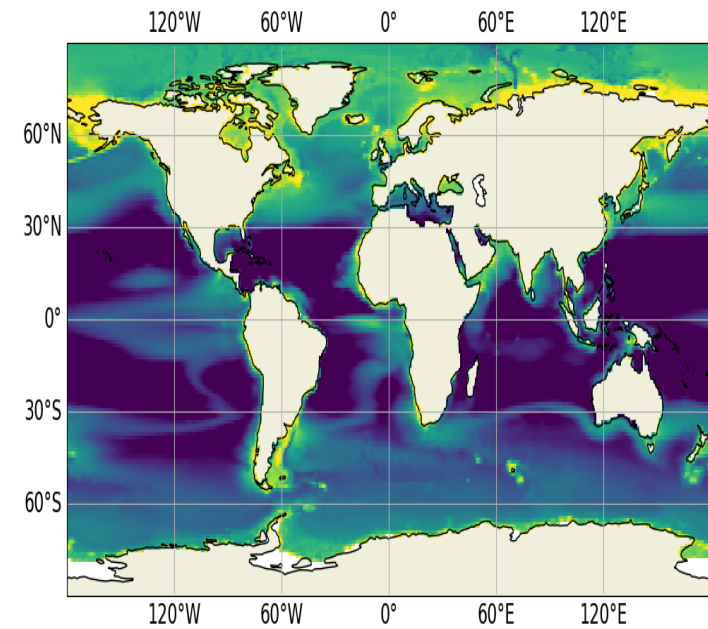
## Oxygen



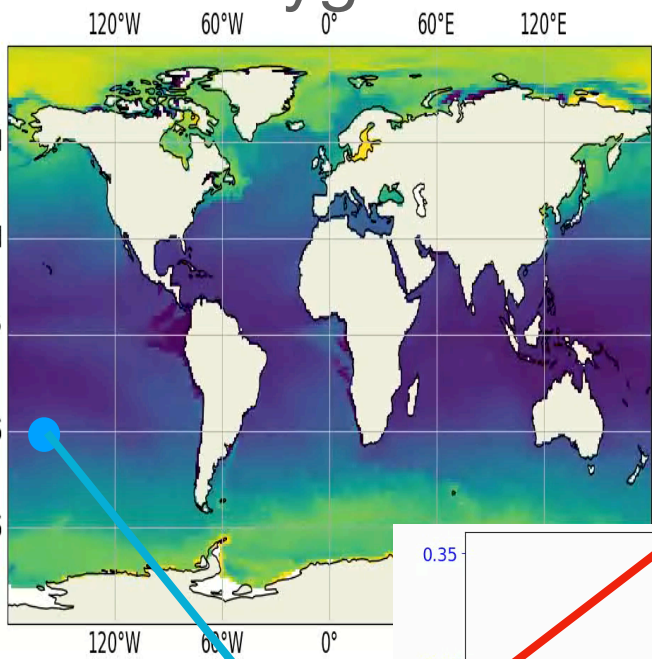
## Salinity



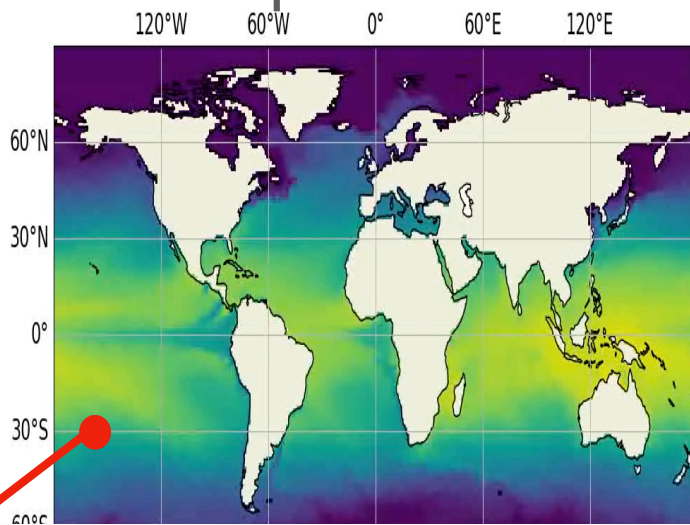
## Chlorophyll



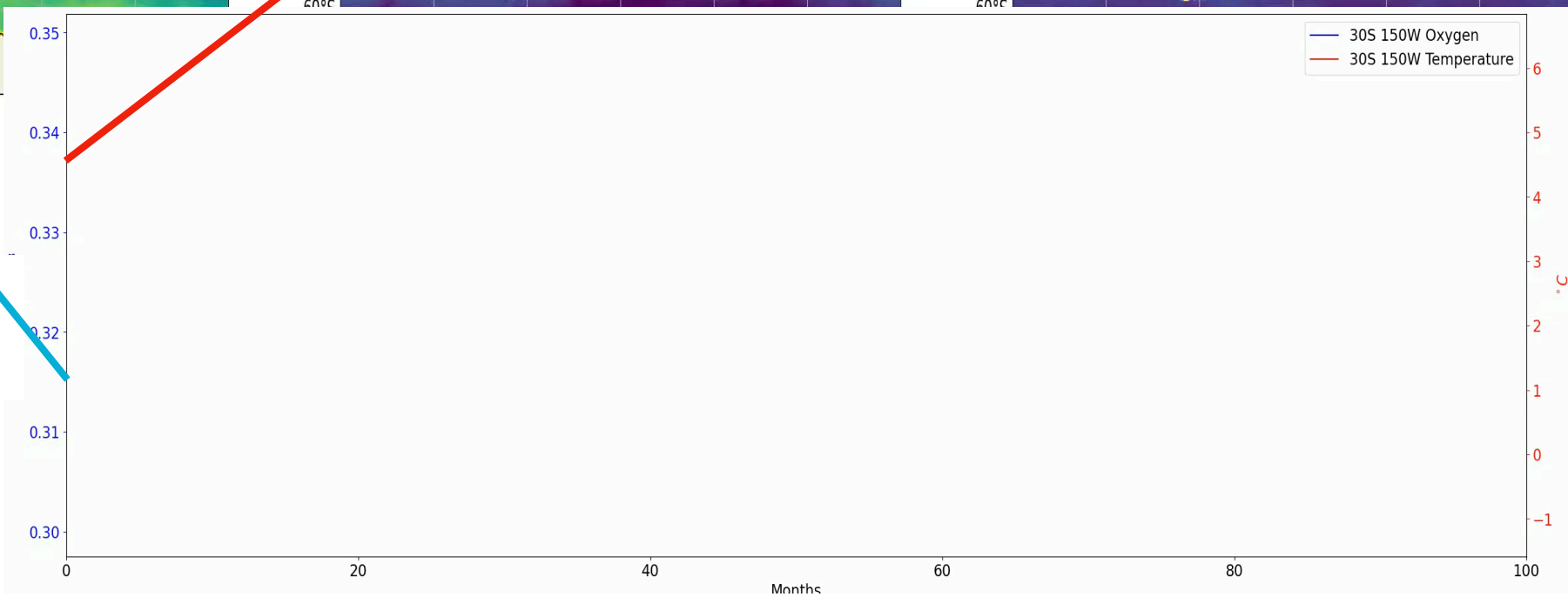
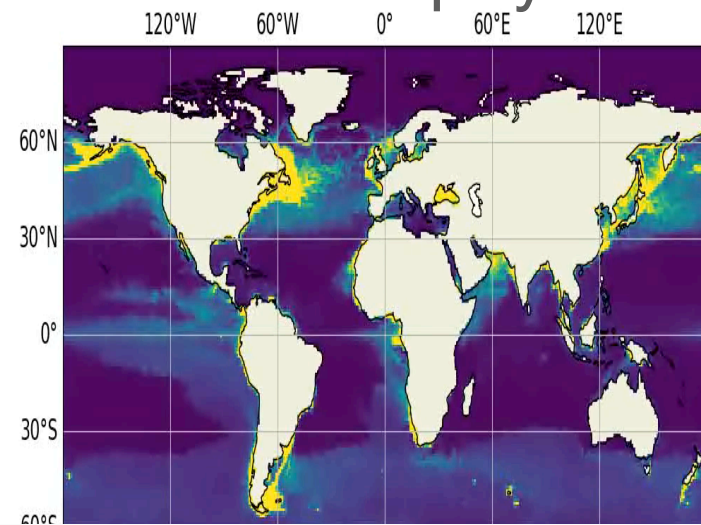
# Oxygen



# Temperature

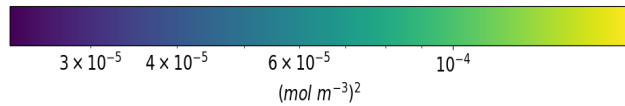
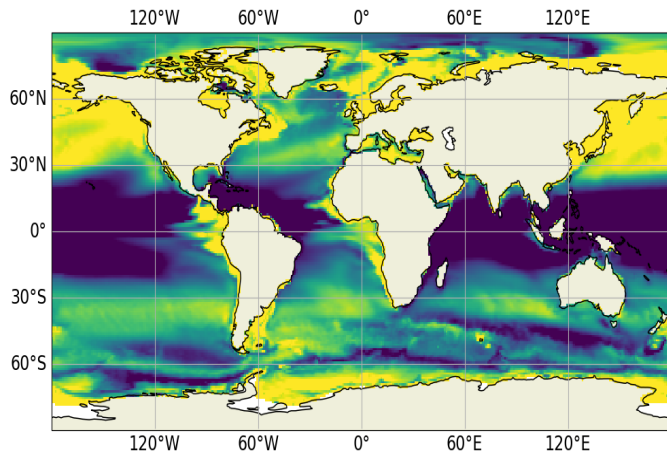


# Chlorophyll

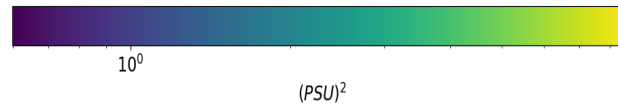
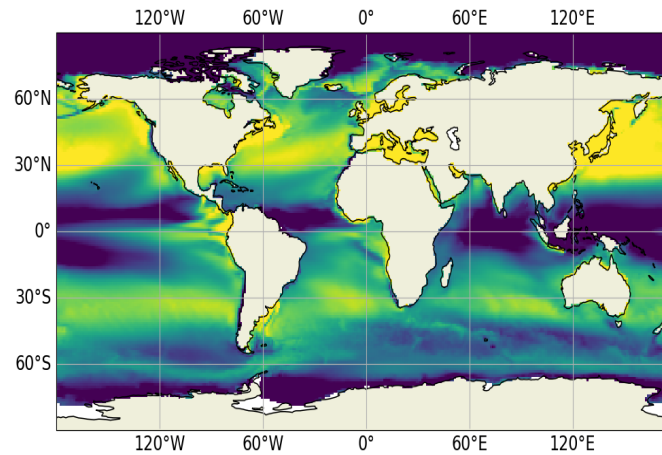


# METHODS: OBJECTIVE MAPPING

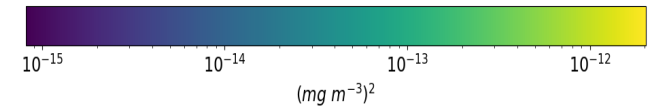
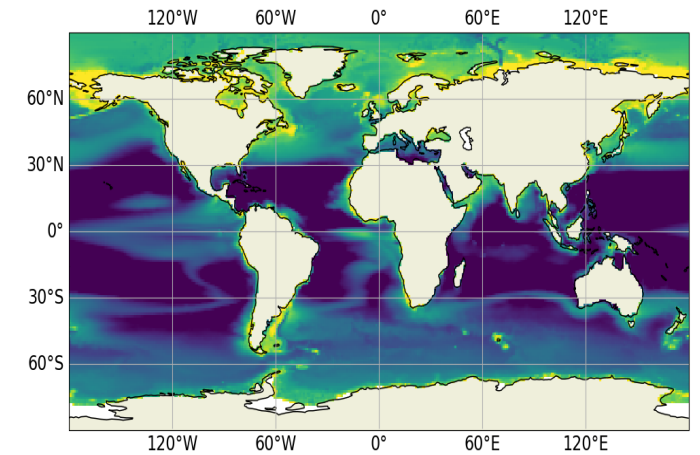
## Oxygen



## Salinity



## Chlorophyll



- CM4 Modeled Variables
- 24 Depth Levels
- Gaspari and Cohn Localization
- Variance Normalized
- Eigenvector Scale Separation

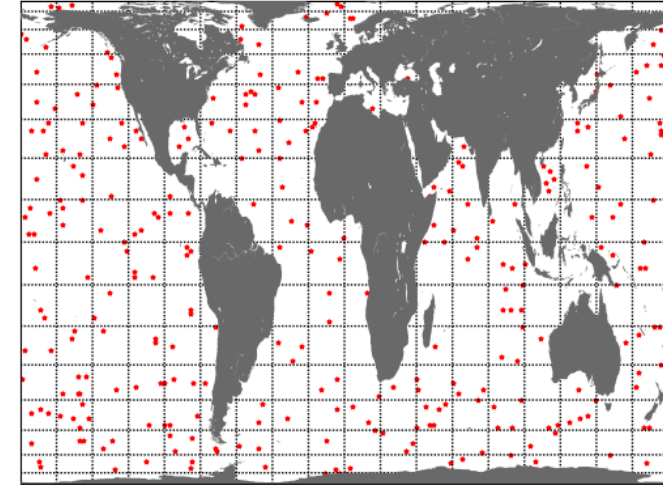


# METHODS: OBJECTIVE MAPPING

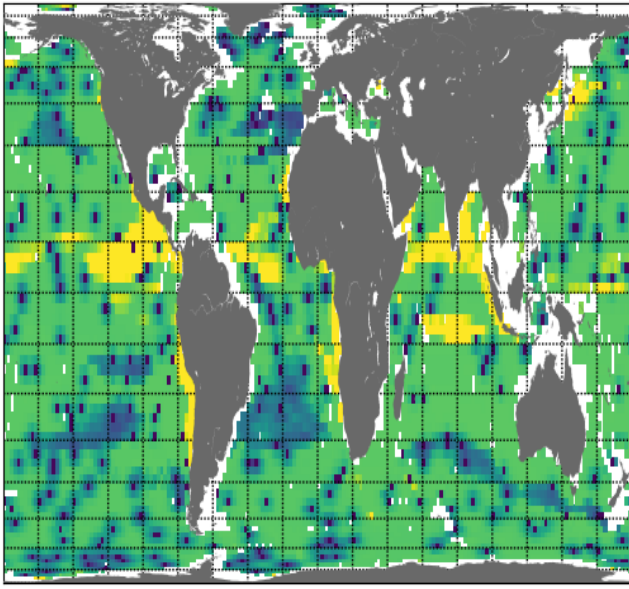
Covariance of the  
Expected Error

Covariance  
of state

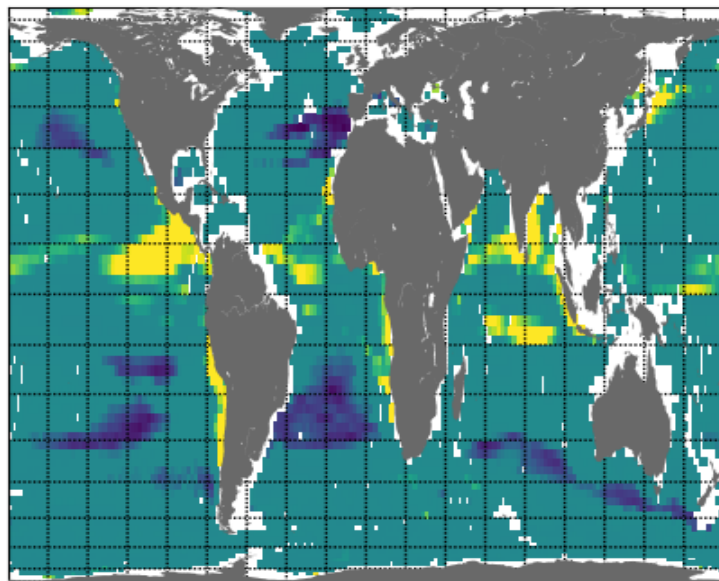
Covariance constrained  
by observation



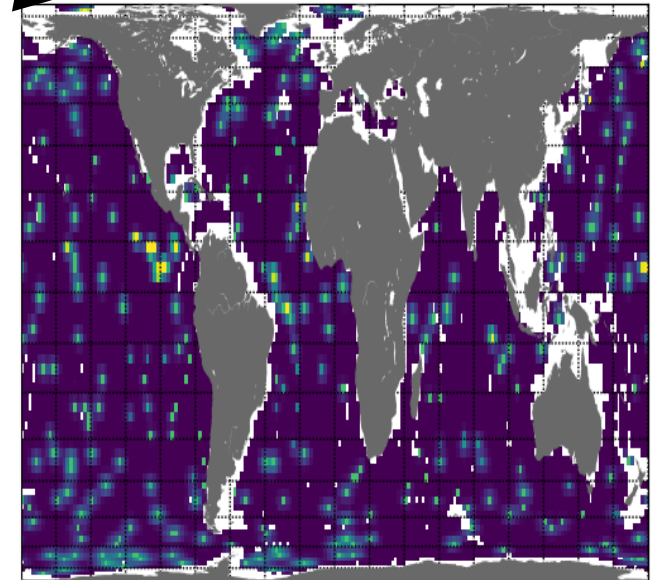
$$\hat{P} = P - \underbrace{KHP}$$



=



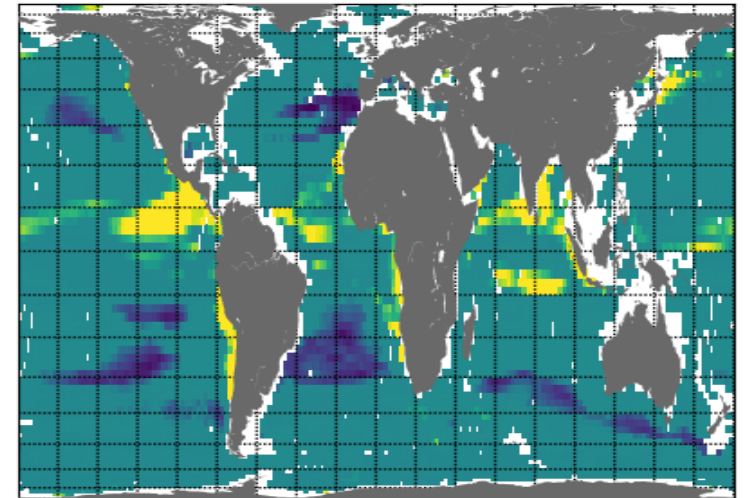
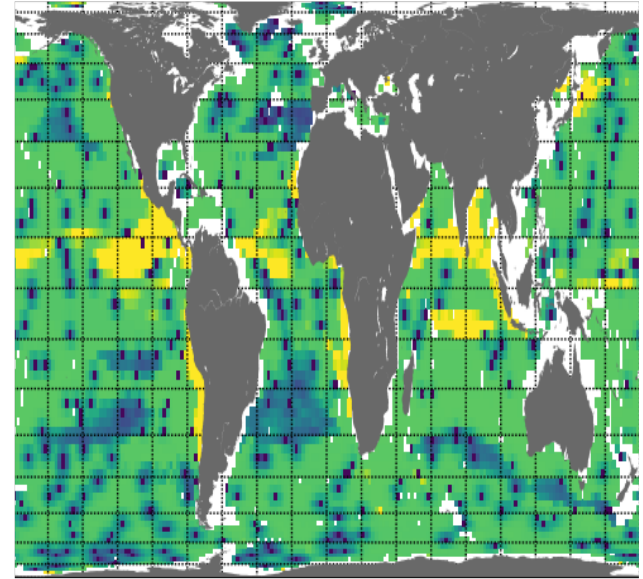
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# METHODS: OBJECTIVE MAPPING

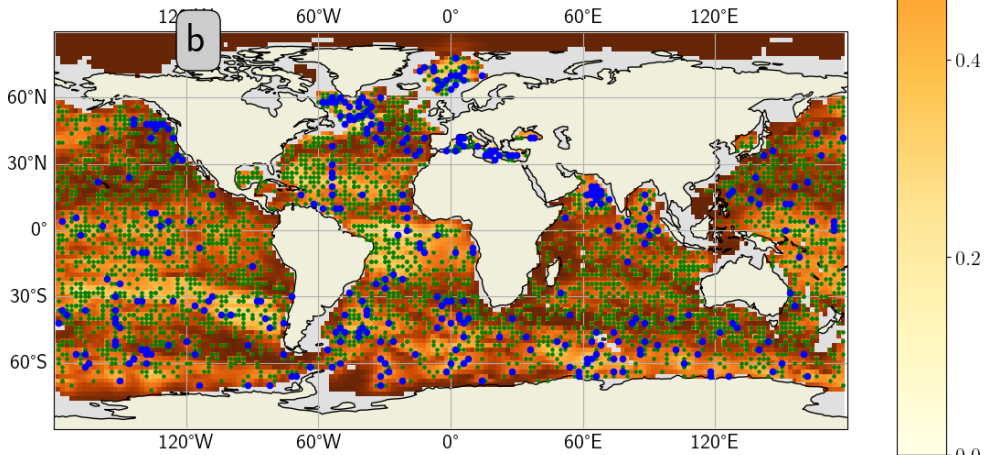
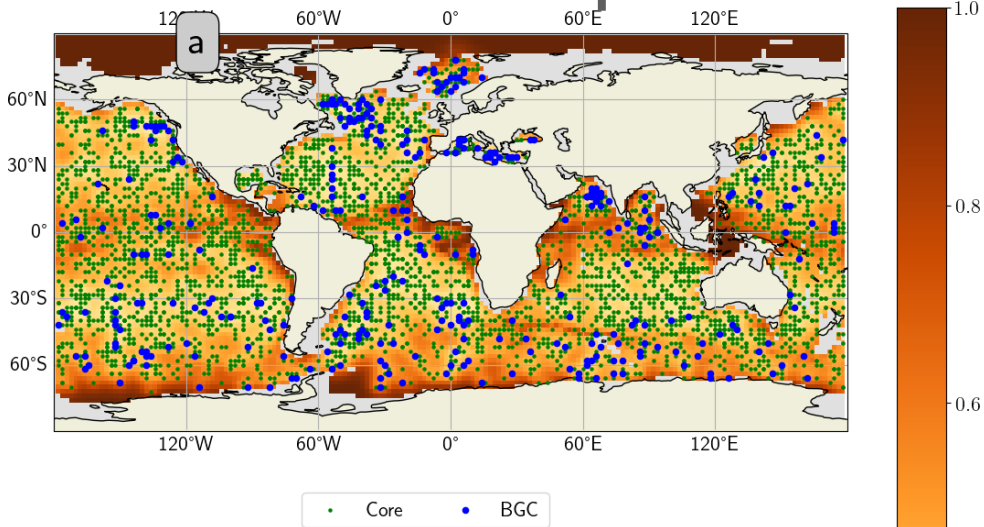
$$E_{map} = \frac{tr(\hat{\mathbf{P}})}{tr(\mathbf{P})}$$

Formal  
Mapping  
Error



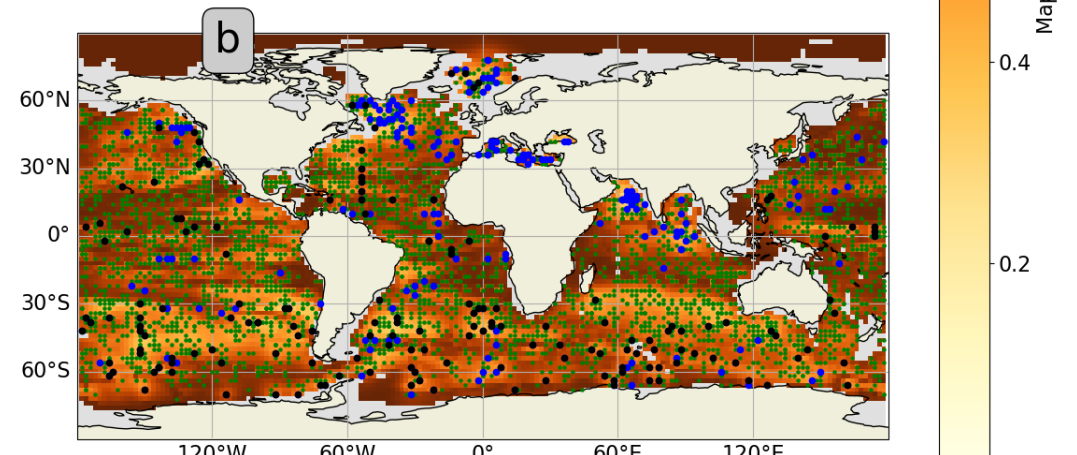
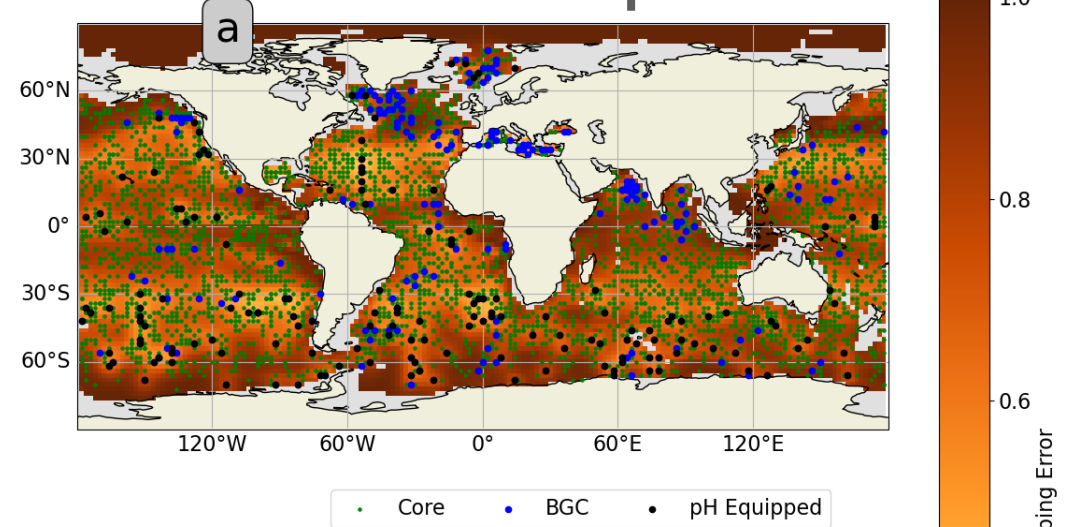
# RESULTS: CURRENT ARGO FLOATS

## Surface Temperature



## 1000m Temperature

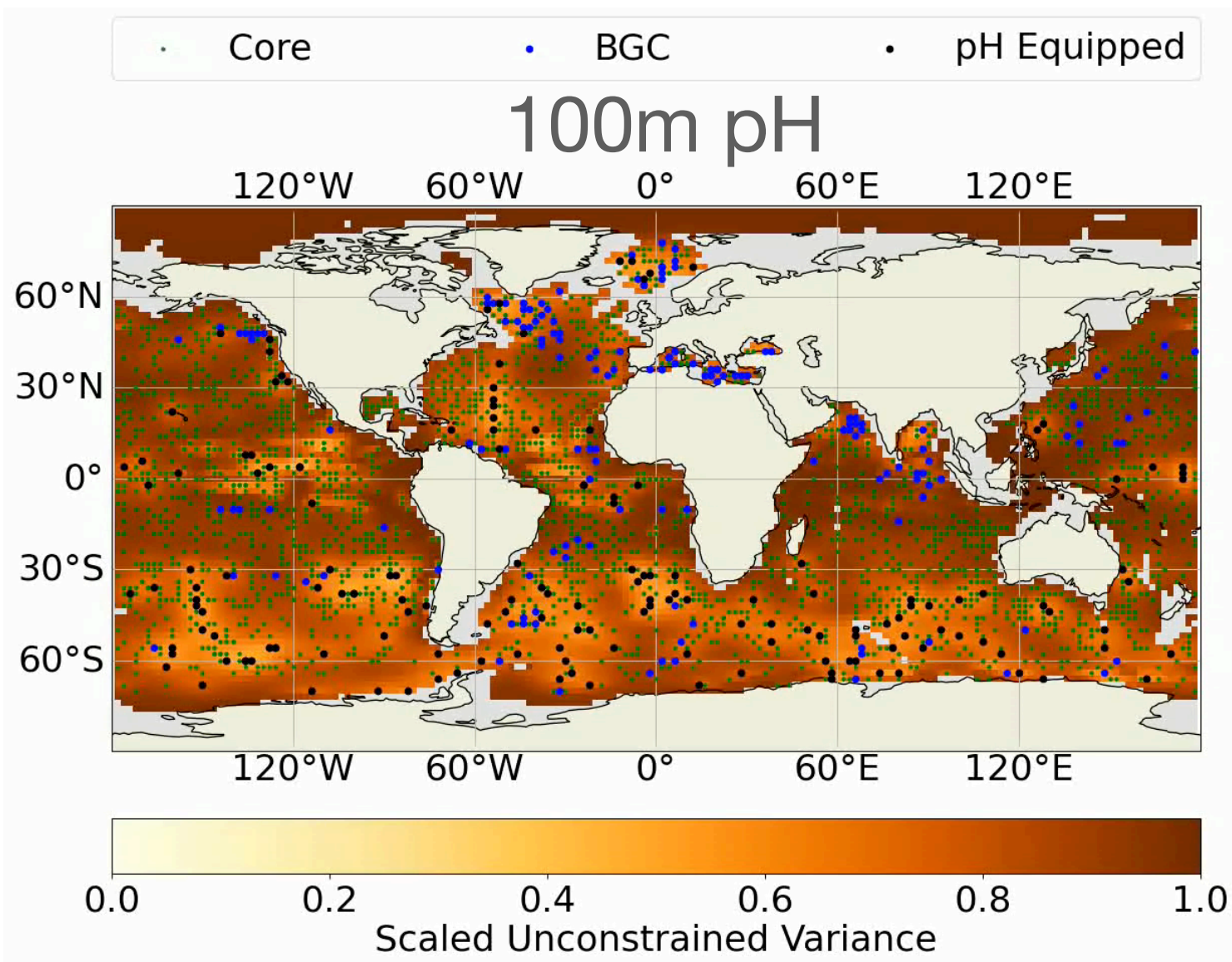
## Surface pH



## 1000m pH



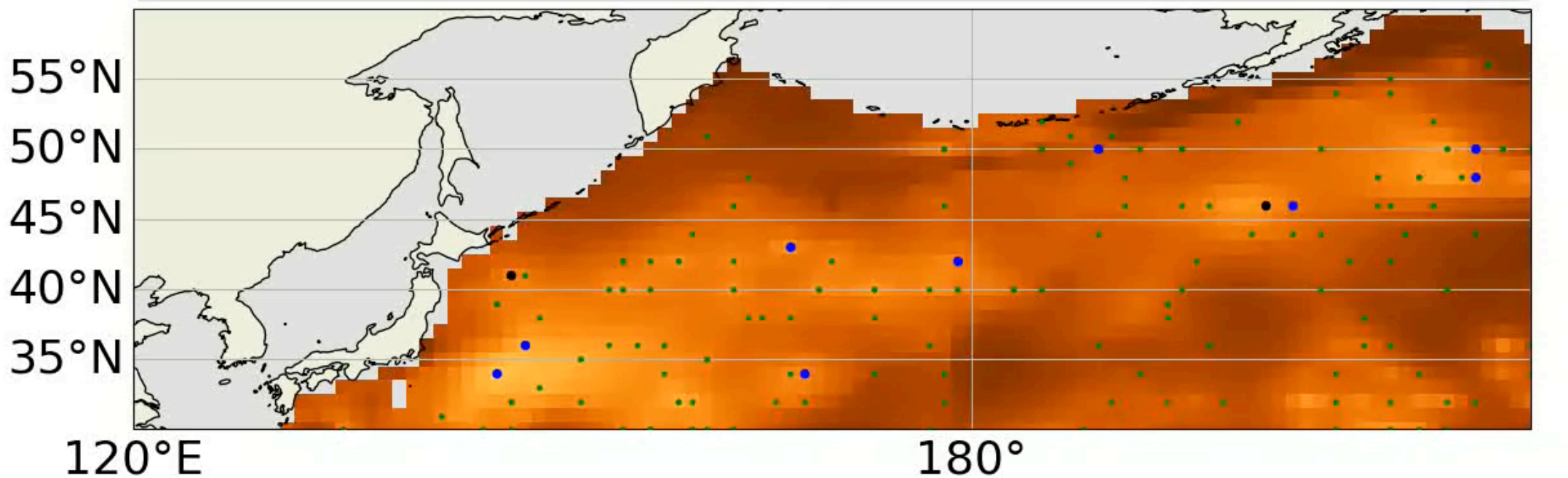
# RESULTS: FUTURE ARGO FLOATS



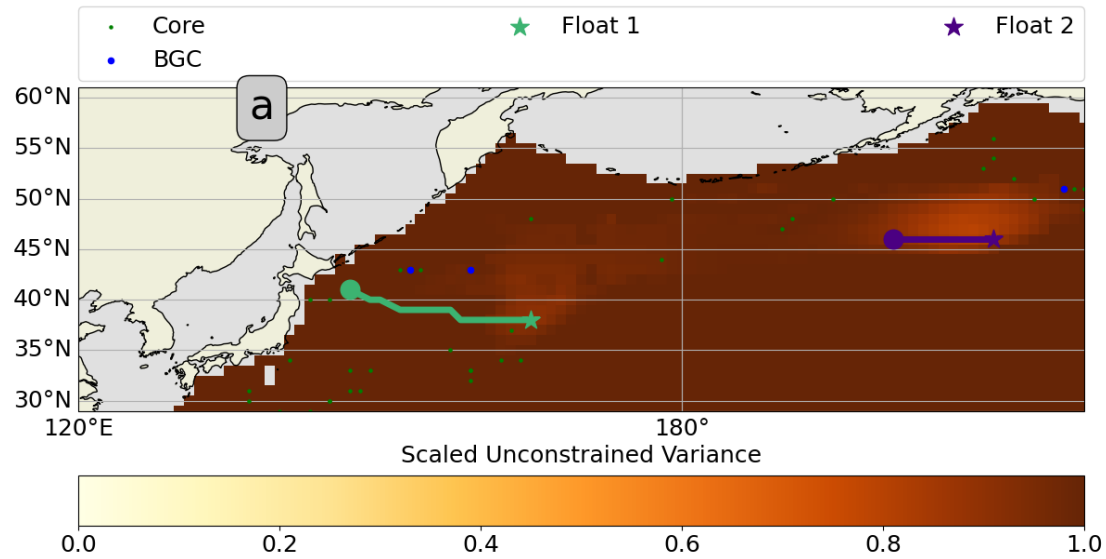


# RESULTS: FUTURE ARGO FLOATS

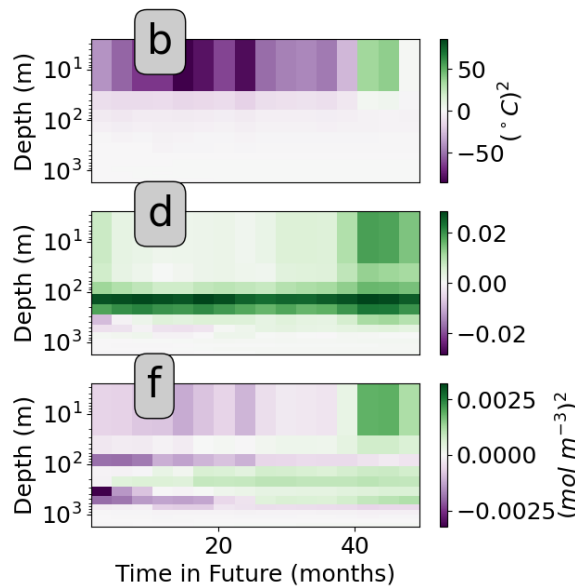
• Core      • BGC      • Hypothetical Floats



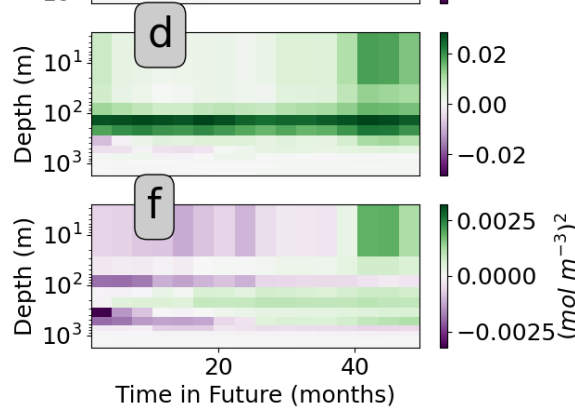
# RESULTS: FUTURE ARGO FLOATS



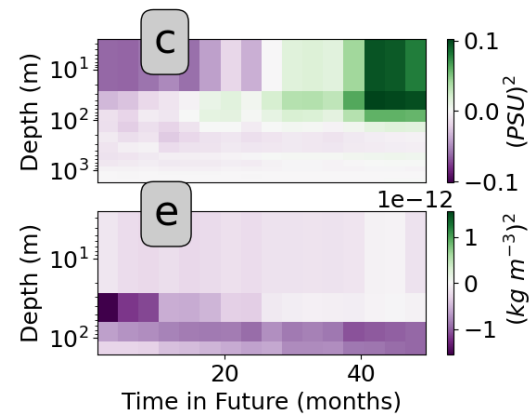
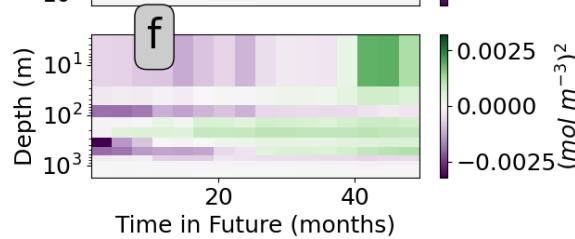
Temperature



pH

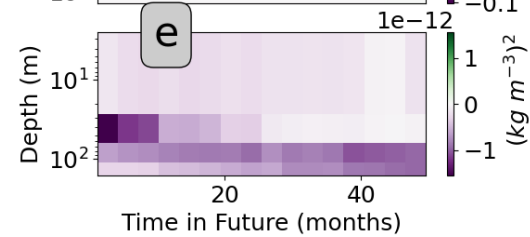


Oxygen



Salinity

Chlorophyll



# RESULTS: MONTE CARLO DISTRIBUTIONS

## Model Setup

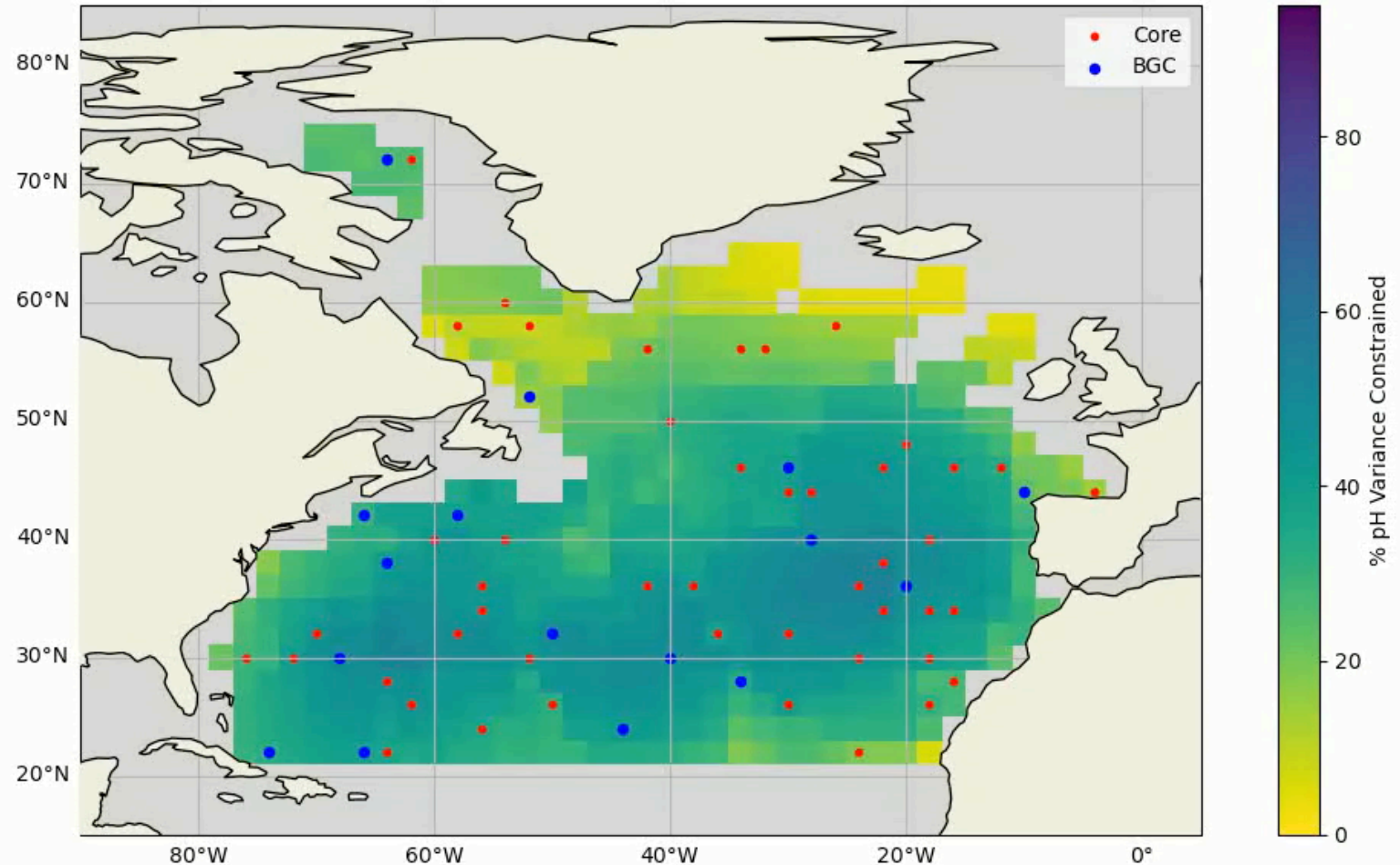
All Depths:  
14 levels  
0-2000 m

All Variables:

- Temperature
- Salinity
- Chlorophyll
- pH
- Oxygen

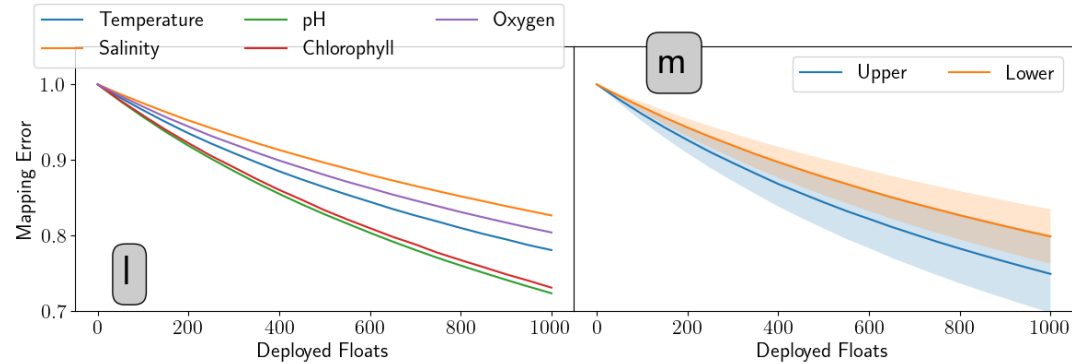
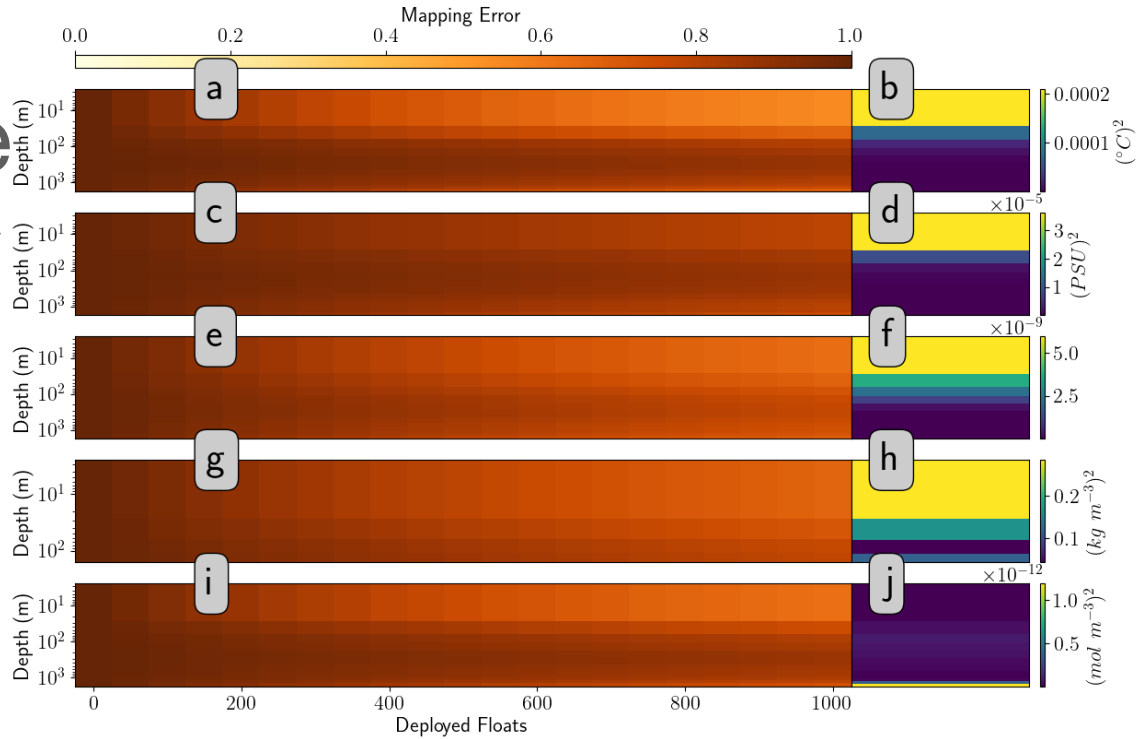
Global

Monte Carlo with Varying  
Float Densities



# RESULTS: MONTE CARLO DISTRIBUTIONS

Temperature  
Salinity  
pH  
Chlorophyll  
Oxygen



# RESULTS: OPTIMAL ARRAY

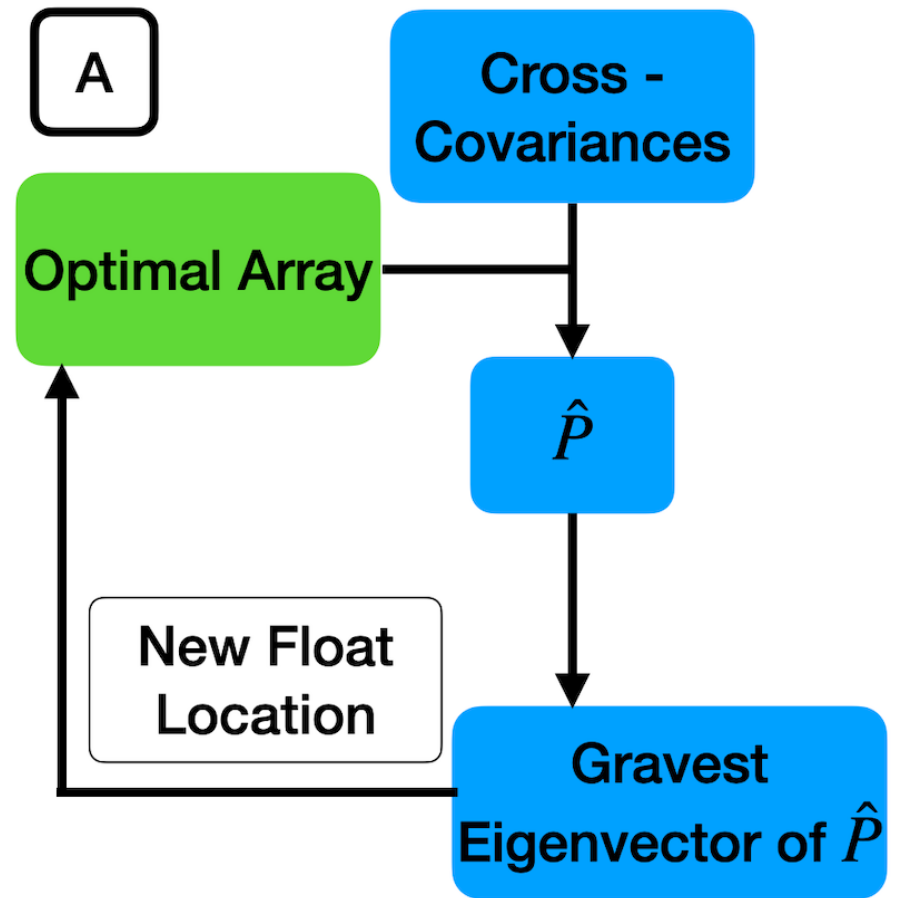
## Optimal Array Design: Constrain Anomaly

4 Depths:  
Surface, 200m,  
500m, 1000m

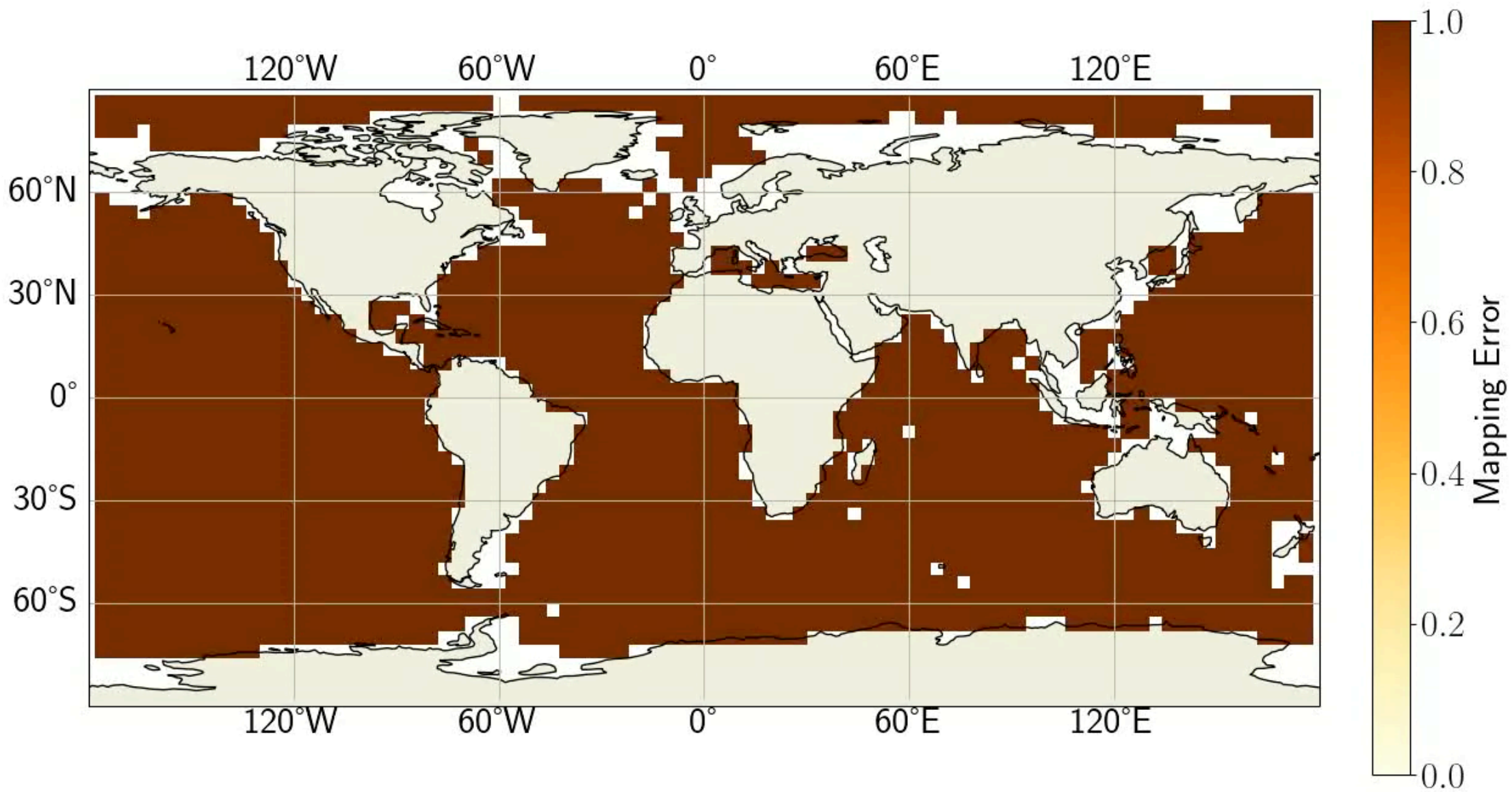
All Variables:  
• Temperature  
• Salinity  
• Chlorophyll  
• pH  
• Oxygen

Global

4x4 Resolution

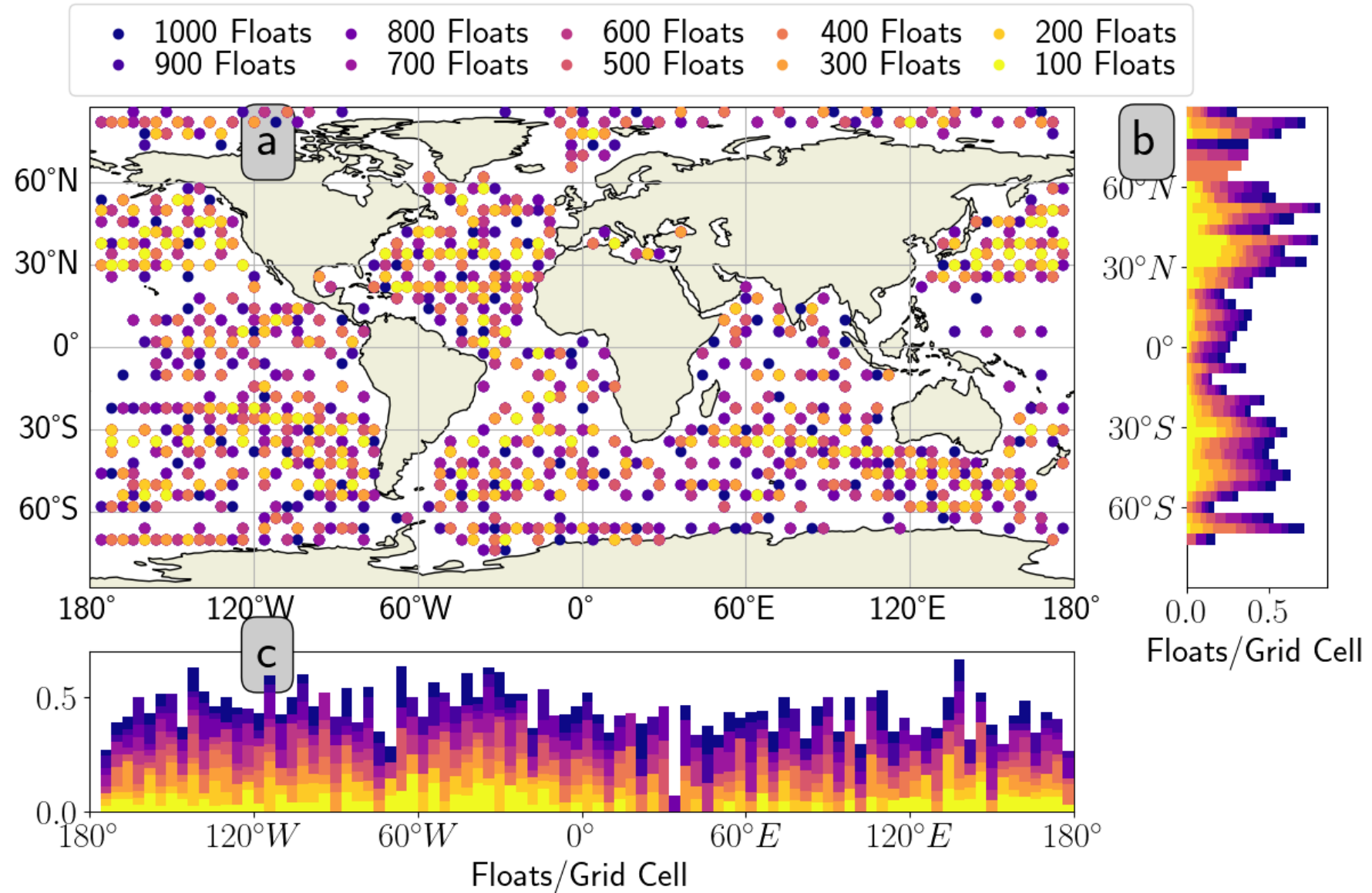


# RESULTS: OPTIMAL ARRAY





# RESULTS: OPTIMAL ARRAY





- Constrained variance estimated for current Argo array and future Argo arrays
- Monte-Carlo distributions show that pH is the easiest and oxygen is the hardest BGC variable to constrain
- Optimal arrays have large distributions in subtropical gyres and reduced density in western tropical pacific