Isolation and Connectivity
or
Sparsity in the age of AI

University of New Hampshire

esa

cbiomes
Simons Collaboration on Computational Biogeochemical Modeling of Marine Ecosystems

NASA

Schmidt Sciences

(An Ocean Color Remote Sensing perspective)

1

Marine Biogeography Can Identify Isolation

Maximal explanation of variance

Within-region homogeneity

Predictability and stability

Based on observable parameters?

Normative

vs

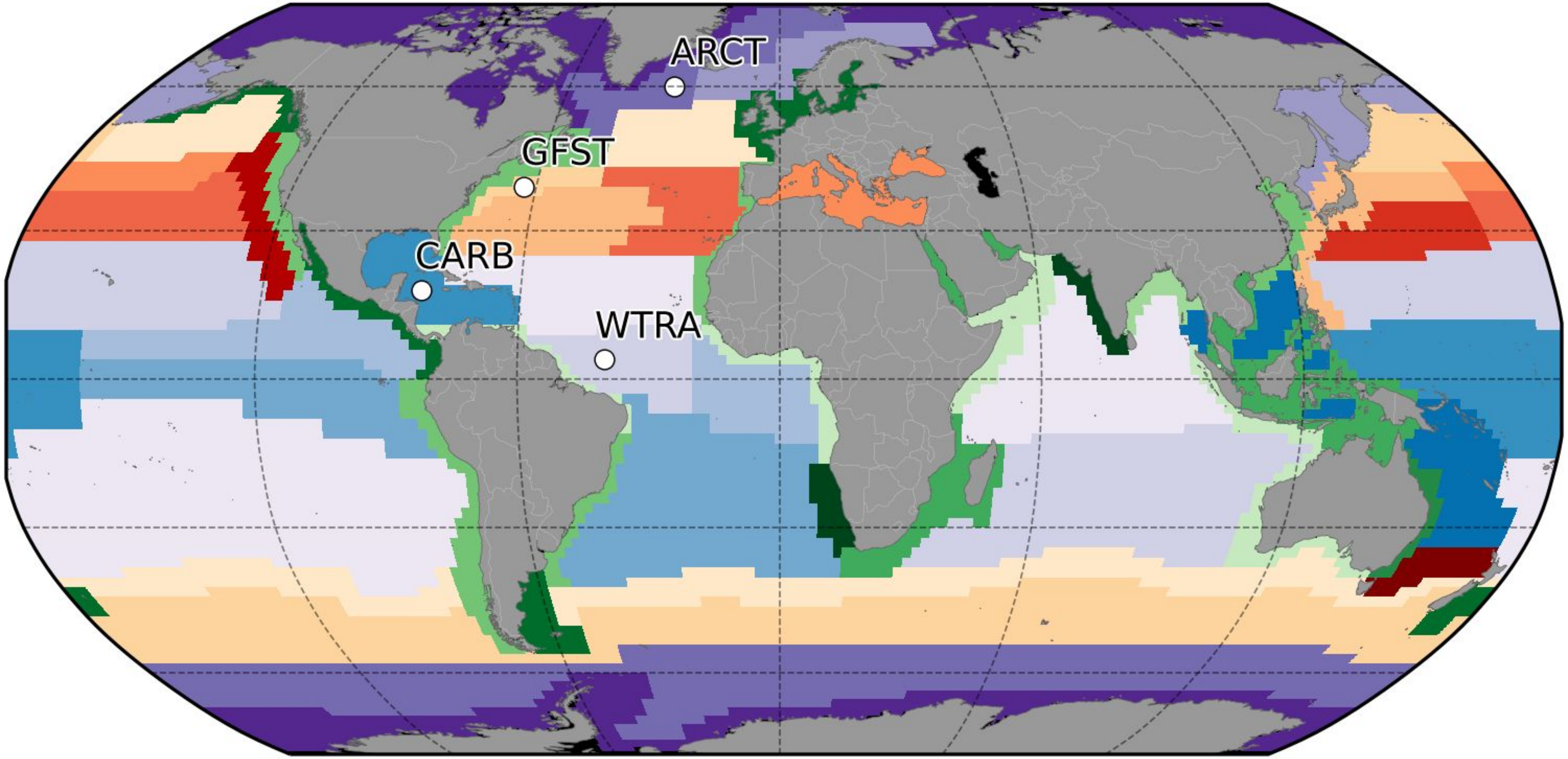
Descriptive

Subjective

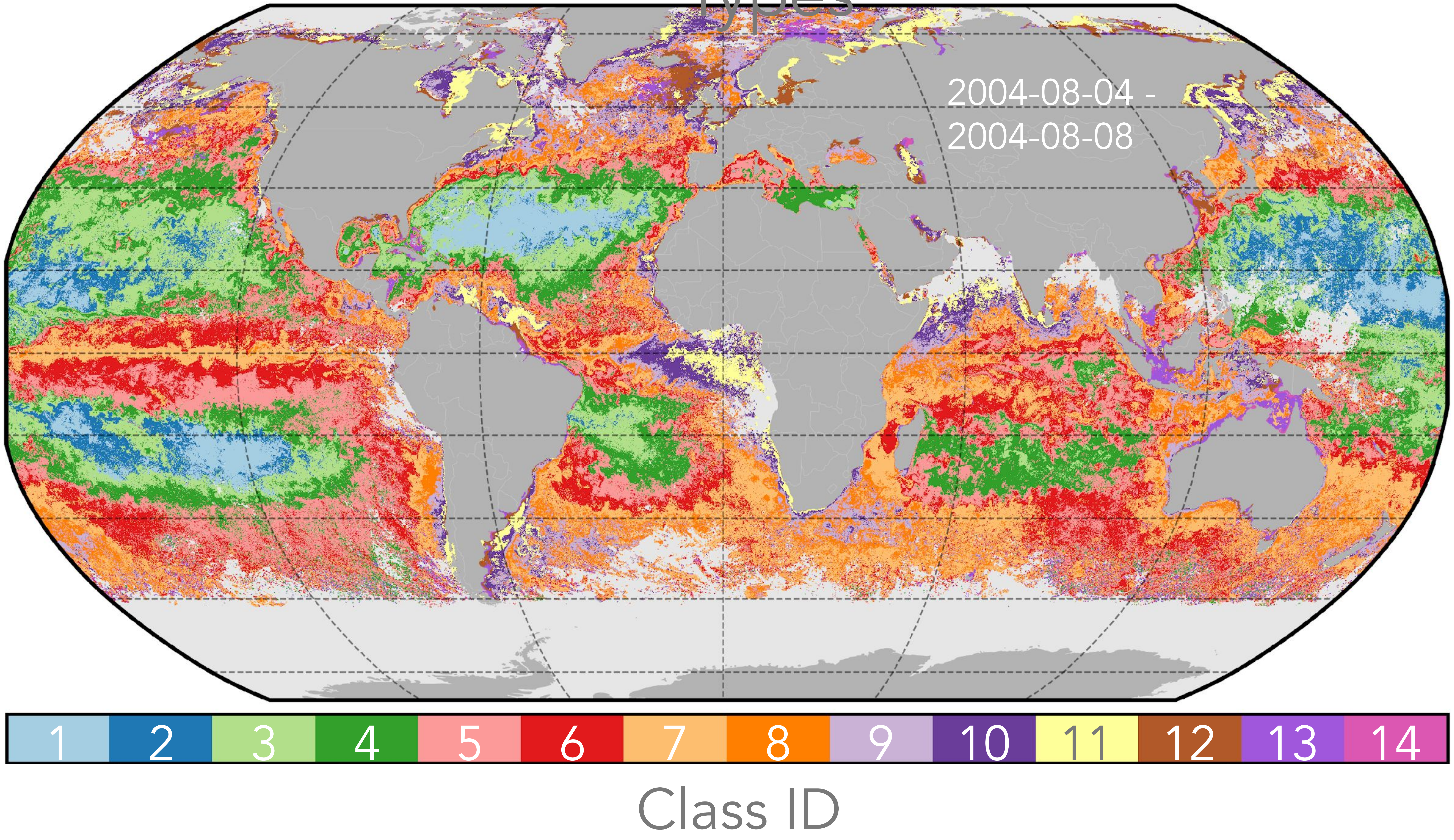
vs

Objective

Longhurst Regions

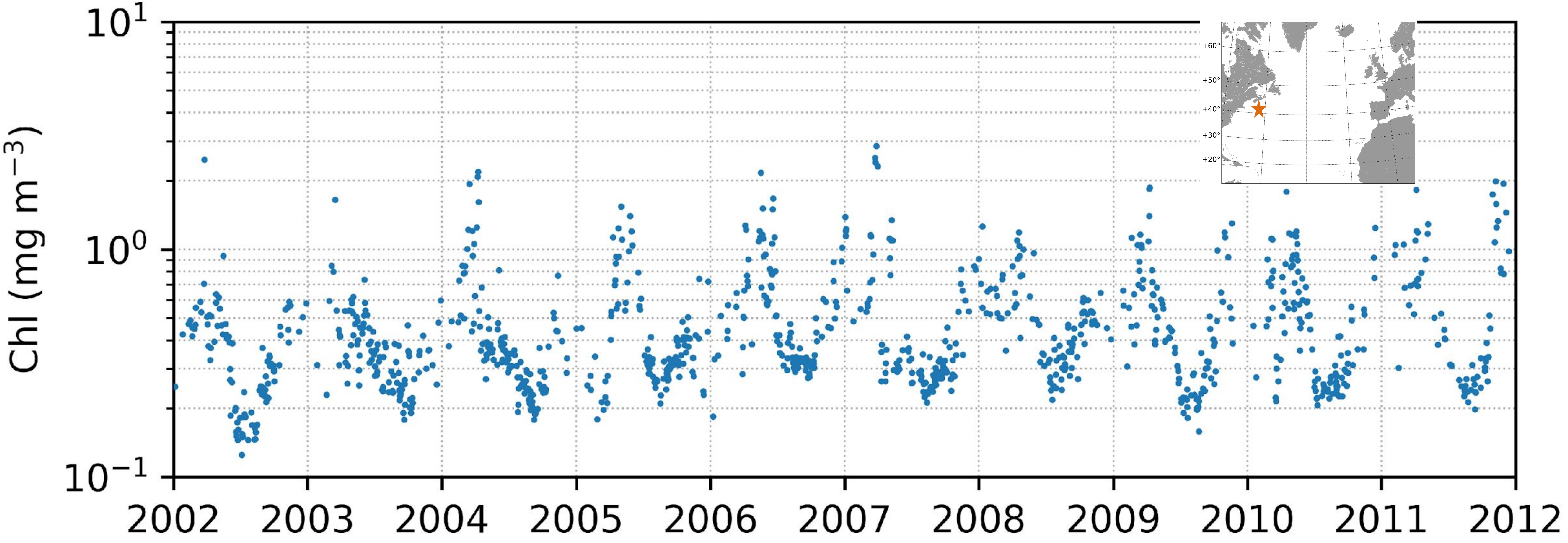


Optical Water Types

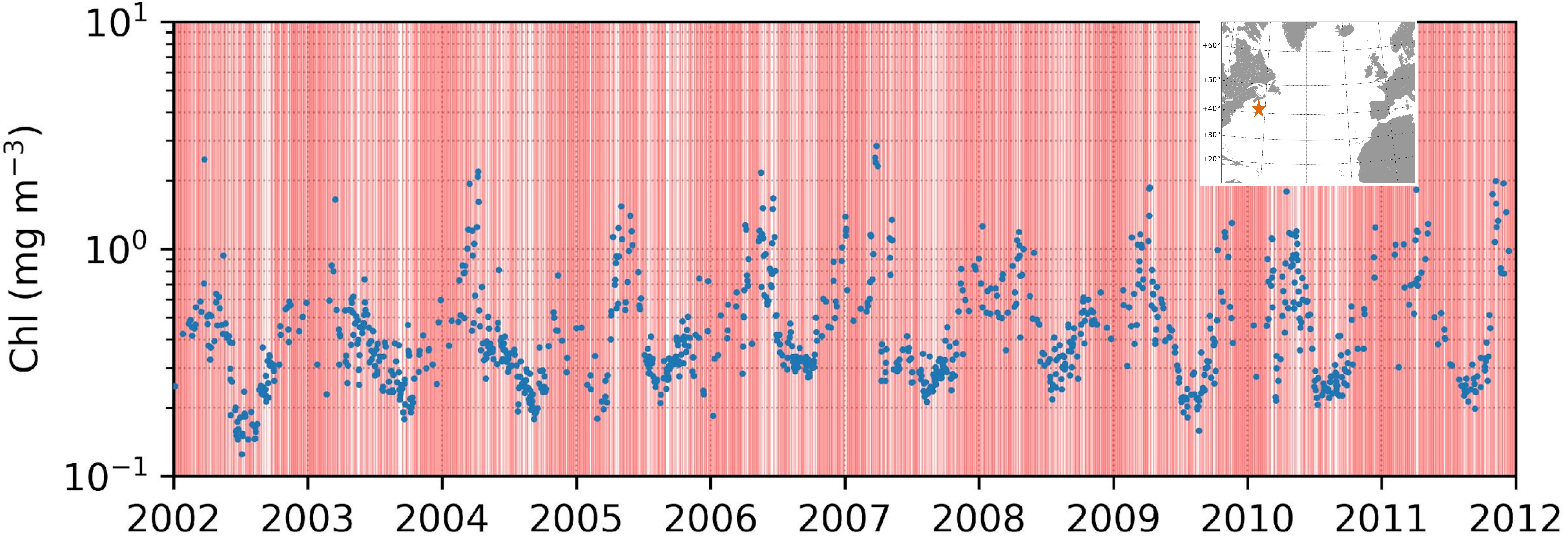


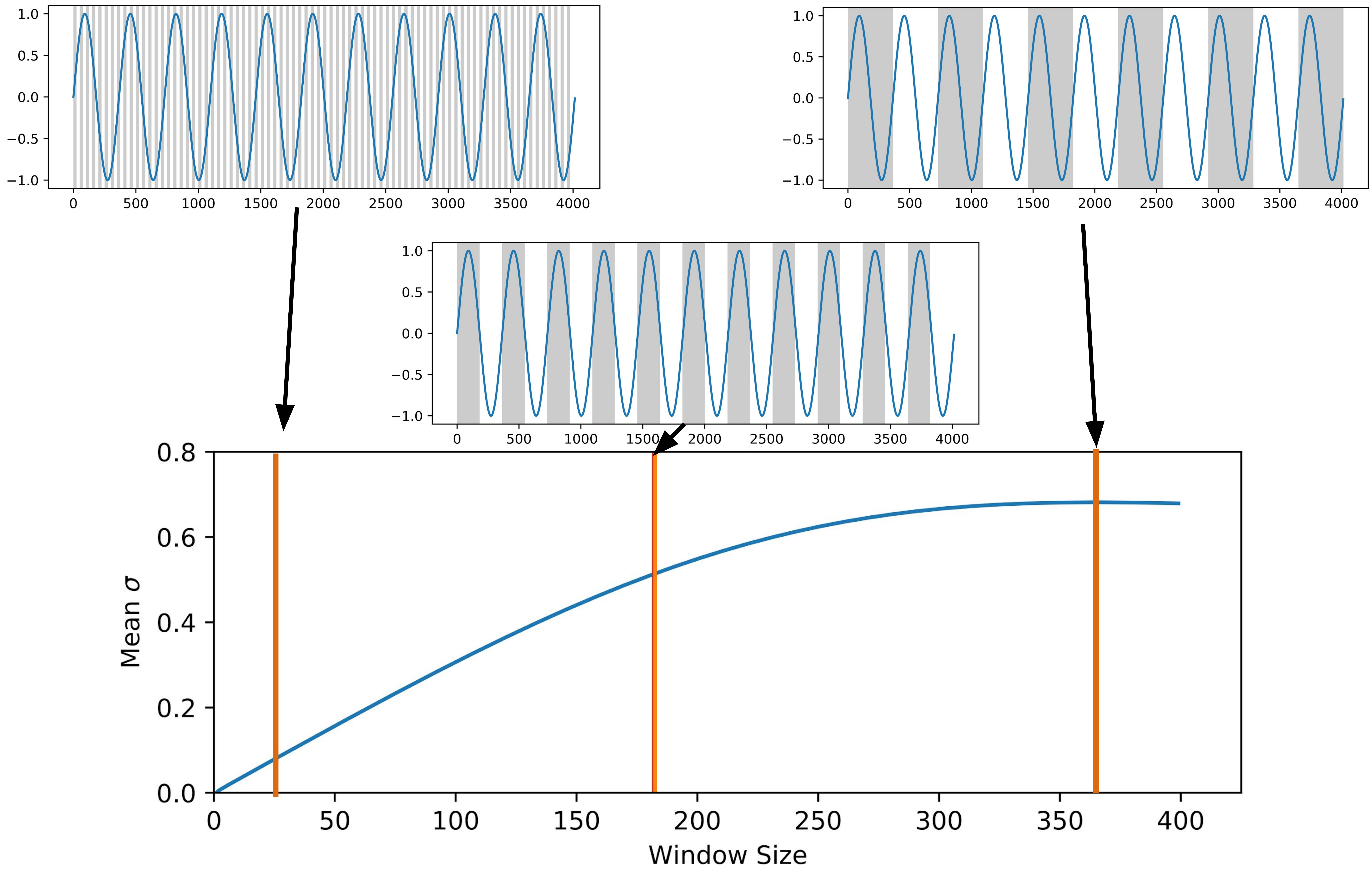
Dominating timescales of Variability

CCI 4km resolution 63°W 42°N



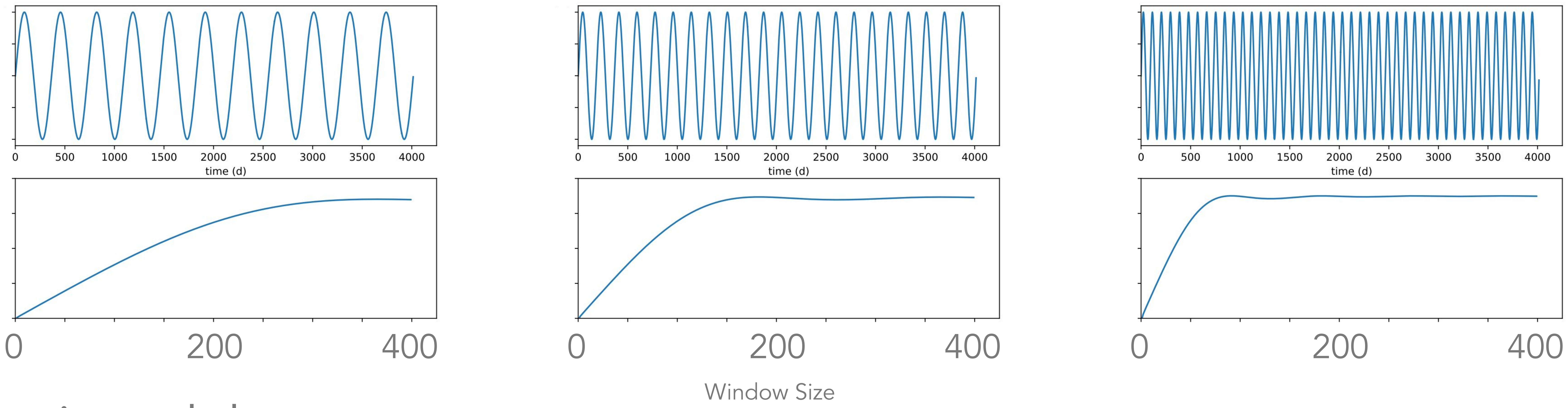
CCI 4km resolution 63°W 42°N



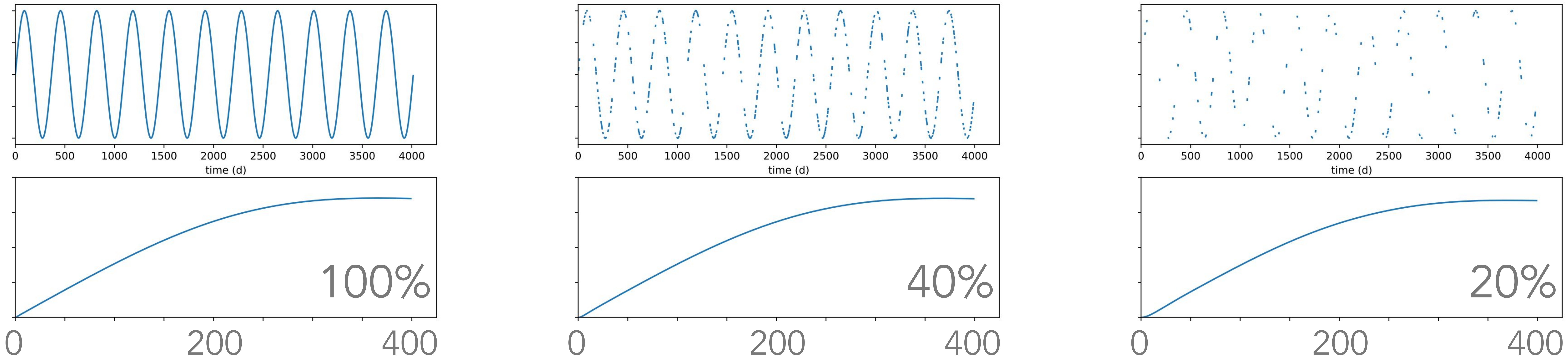


Mean σ
Window Size

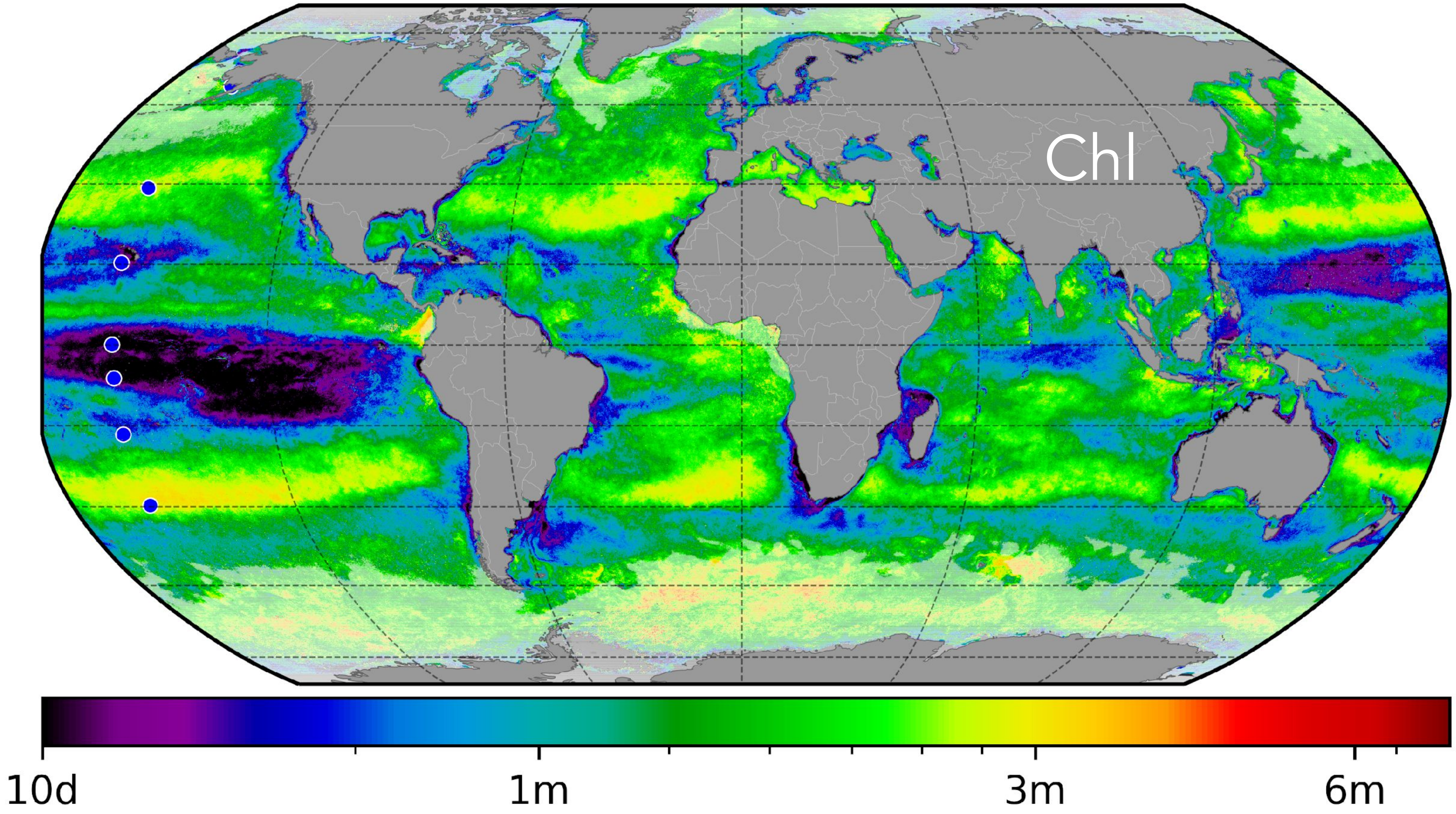
Timescales and slope

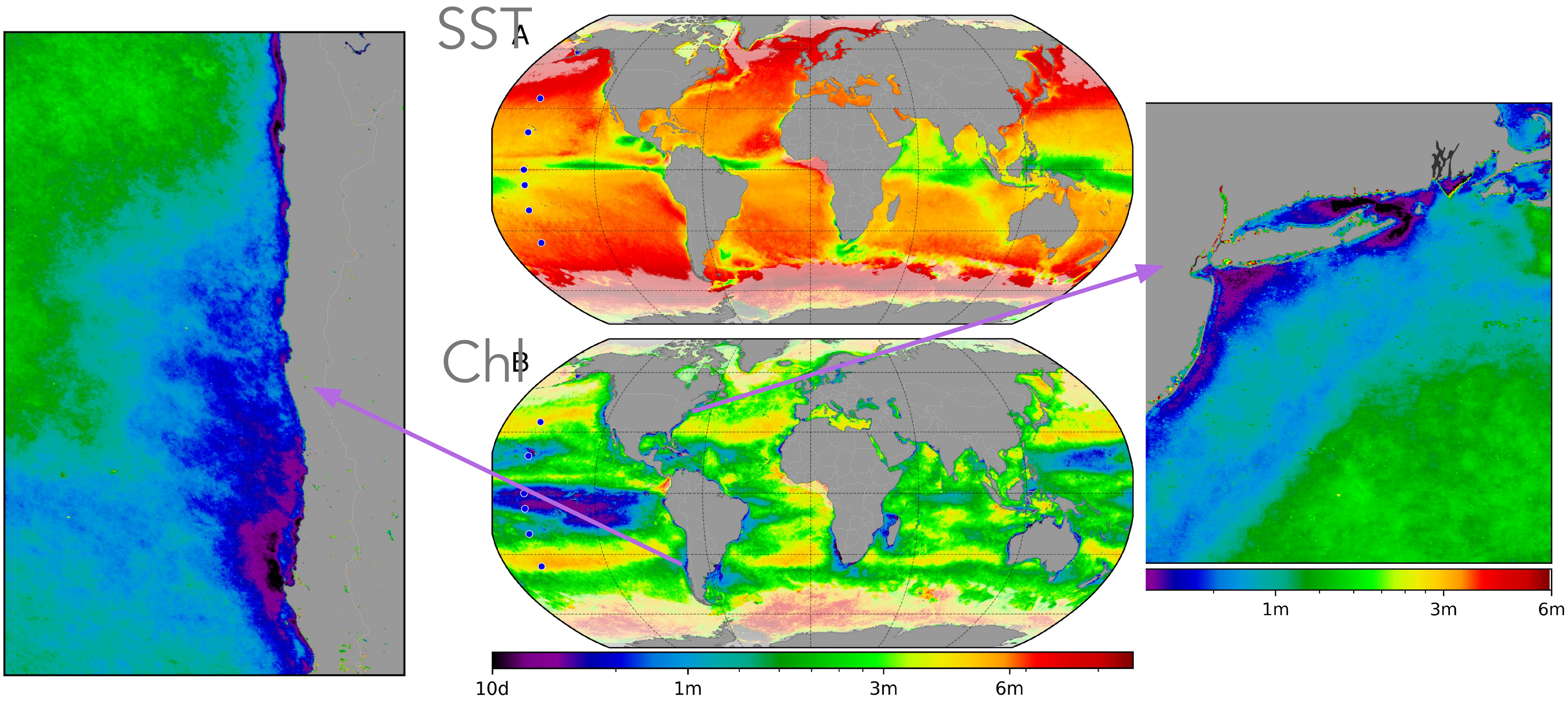


Sparsity and slope



Dominating timescale of variability





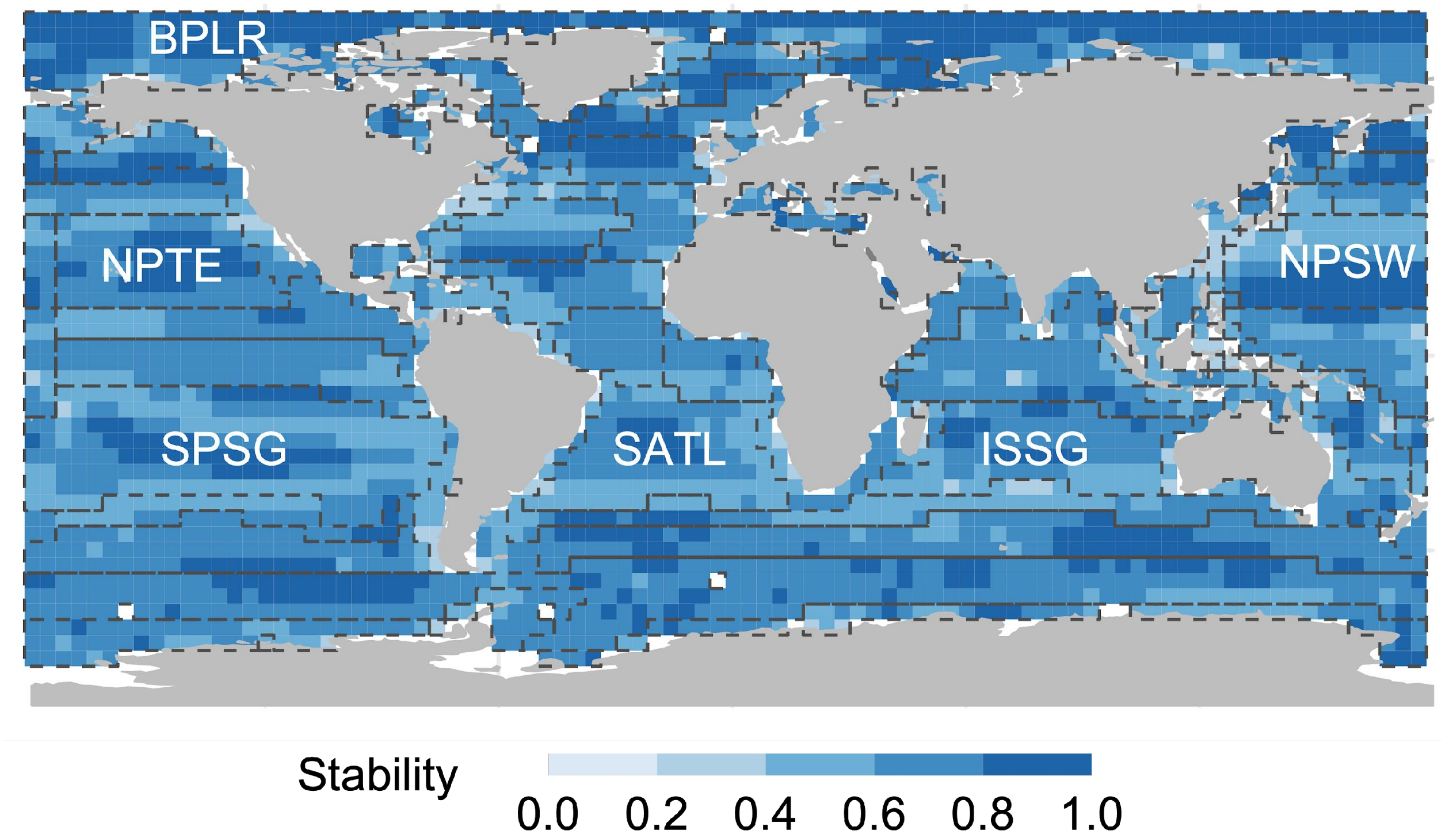
Jönsson et al. 2023

900 000 different clusters!

Step	Method	Parameter	Values
Normalization	z-score median OQ		
Dimensionality Reduction	MFPCA	Embeding size: M	5 - 15
Clustering Algorithm	k-means Hierarchical clustering clustgeo Minimum spanning tree -	Distances k Distances k Distances α k Distances k	Euclidean 2 - 60 Euclidean, Manhattan, Maximum, Canberra, Minkowski 2 - 60 Euclidean, Manhattan, Maximum, Canberra, Minkowski 0 - 0.5 2 - 60 Euclidean, Manhattan, Maximum, Canberra, Minkowski 2, 10, 20, 30, 40, 50, 54
Postprocessing	Basin adjustment		raw / basin adj.

Table 1: Workflow parameter choices

Viet Tran et al. In Prep

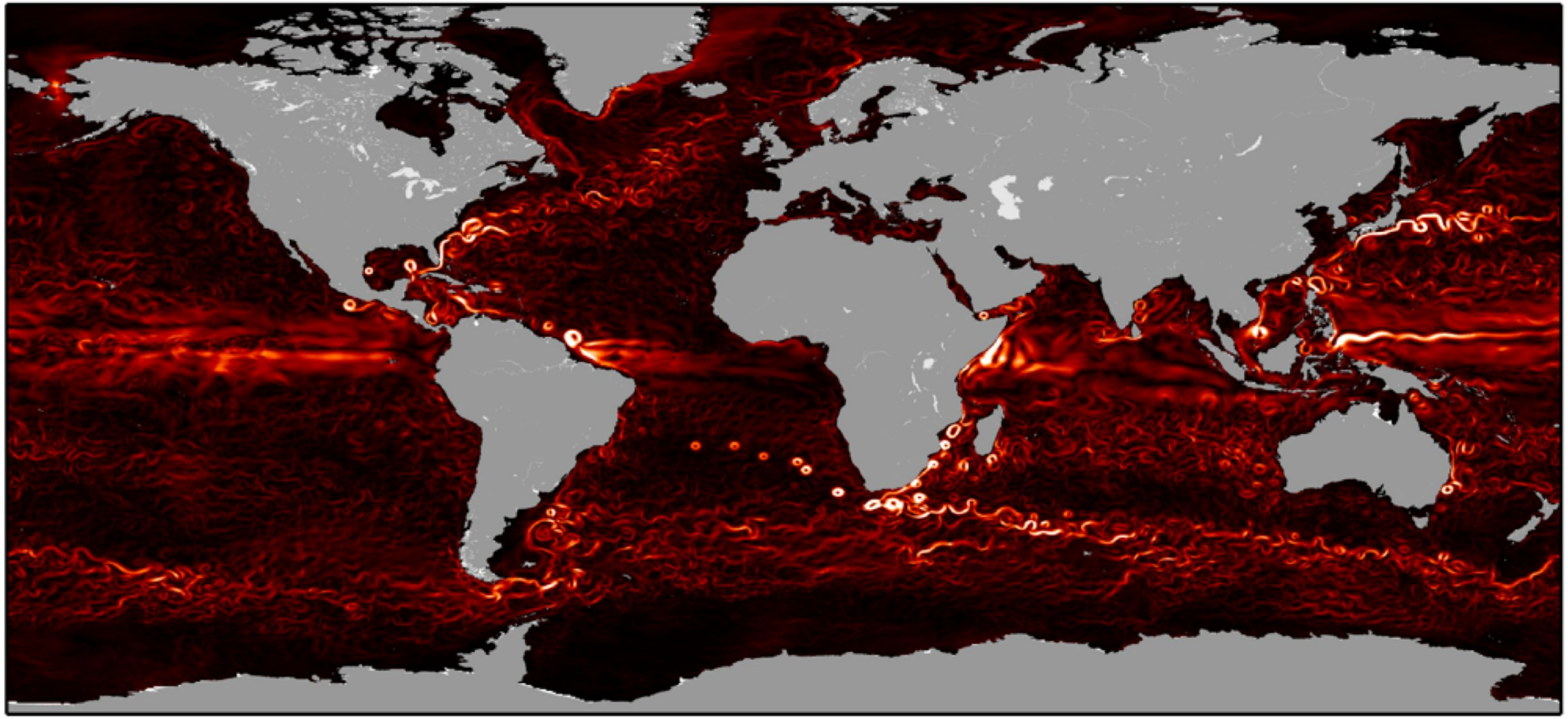


Viet Tran et al. In Prep

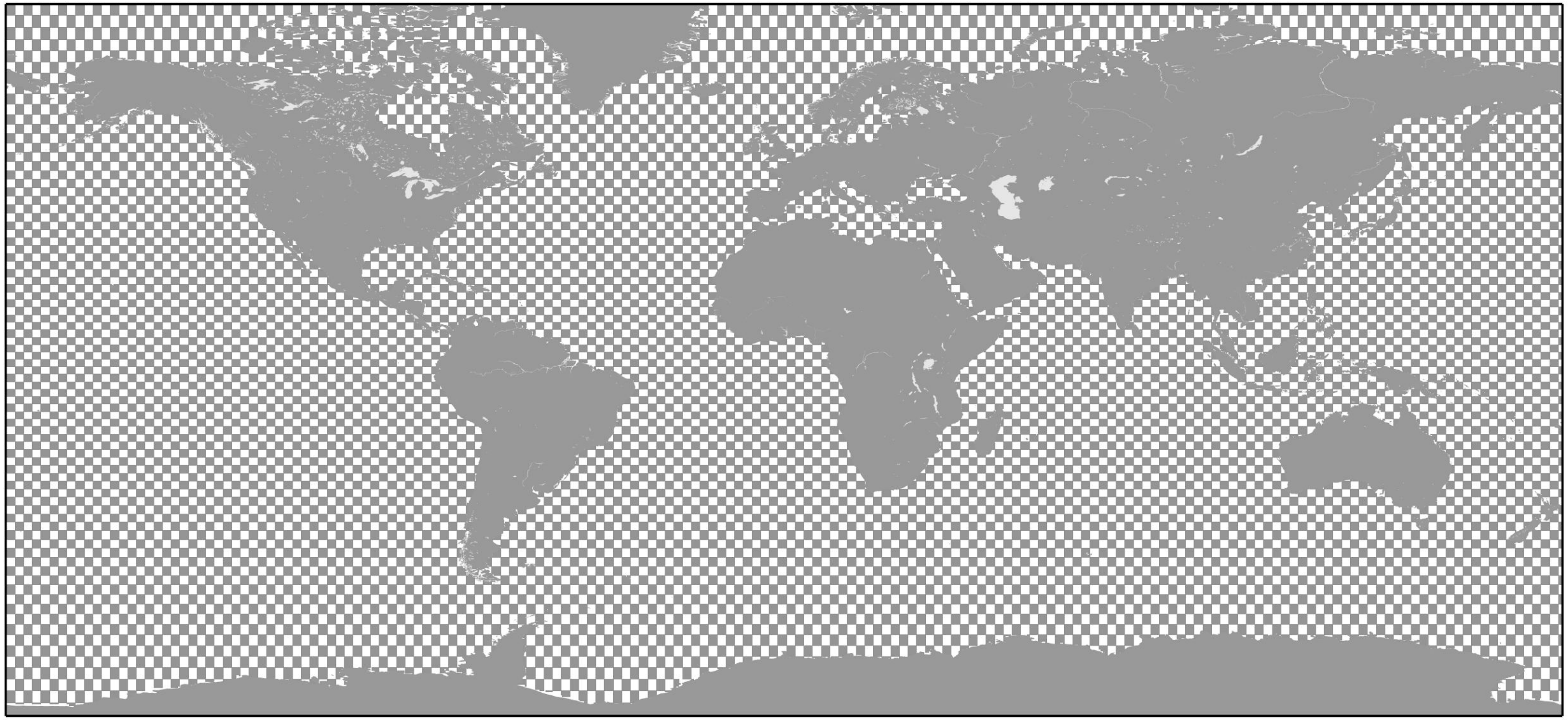
2

Global Ocean Connectivity and Refuge Regions

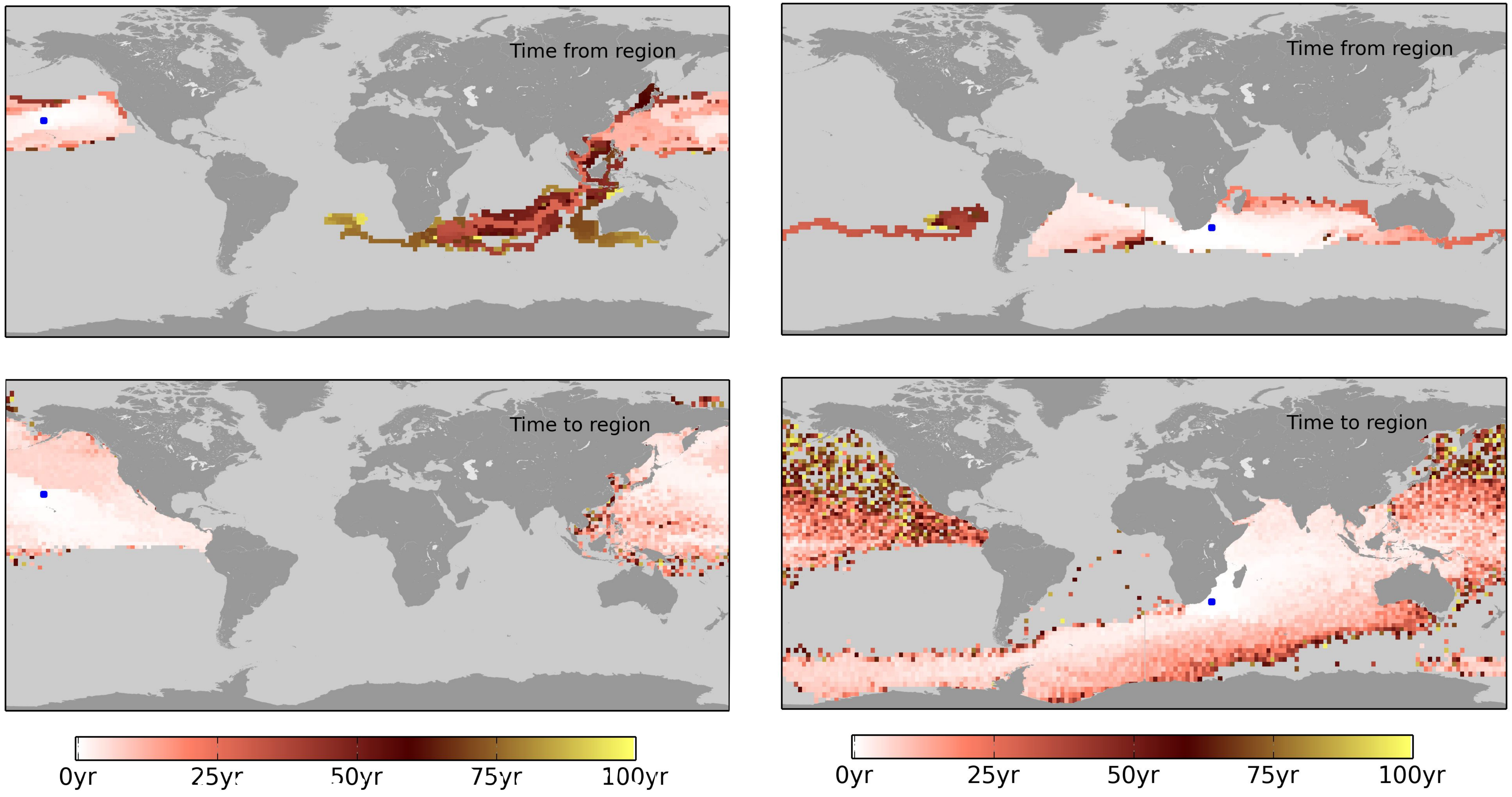
Minimum Connectivity Time



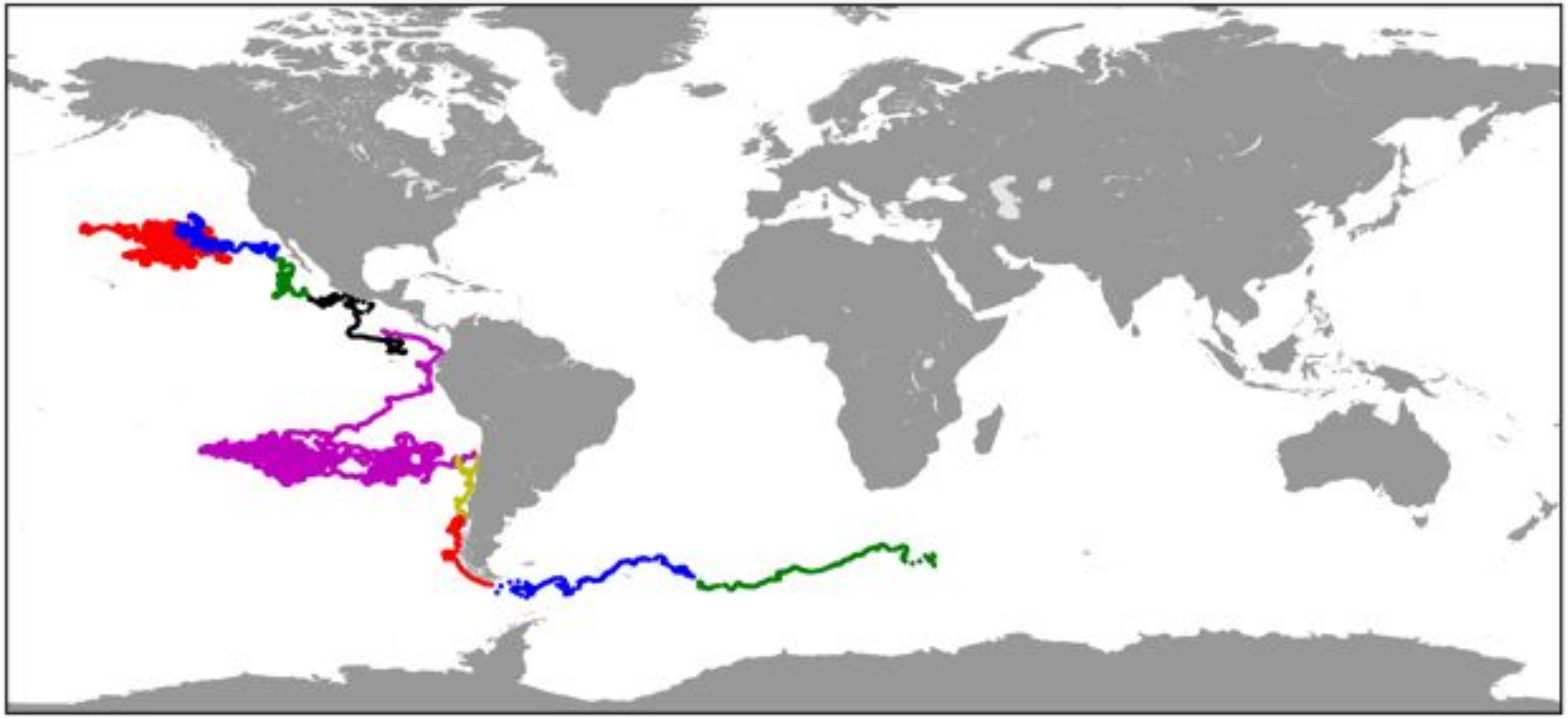
ECCO2 1/4° global state estimate

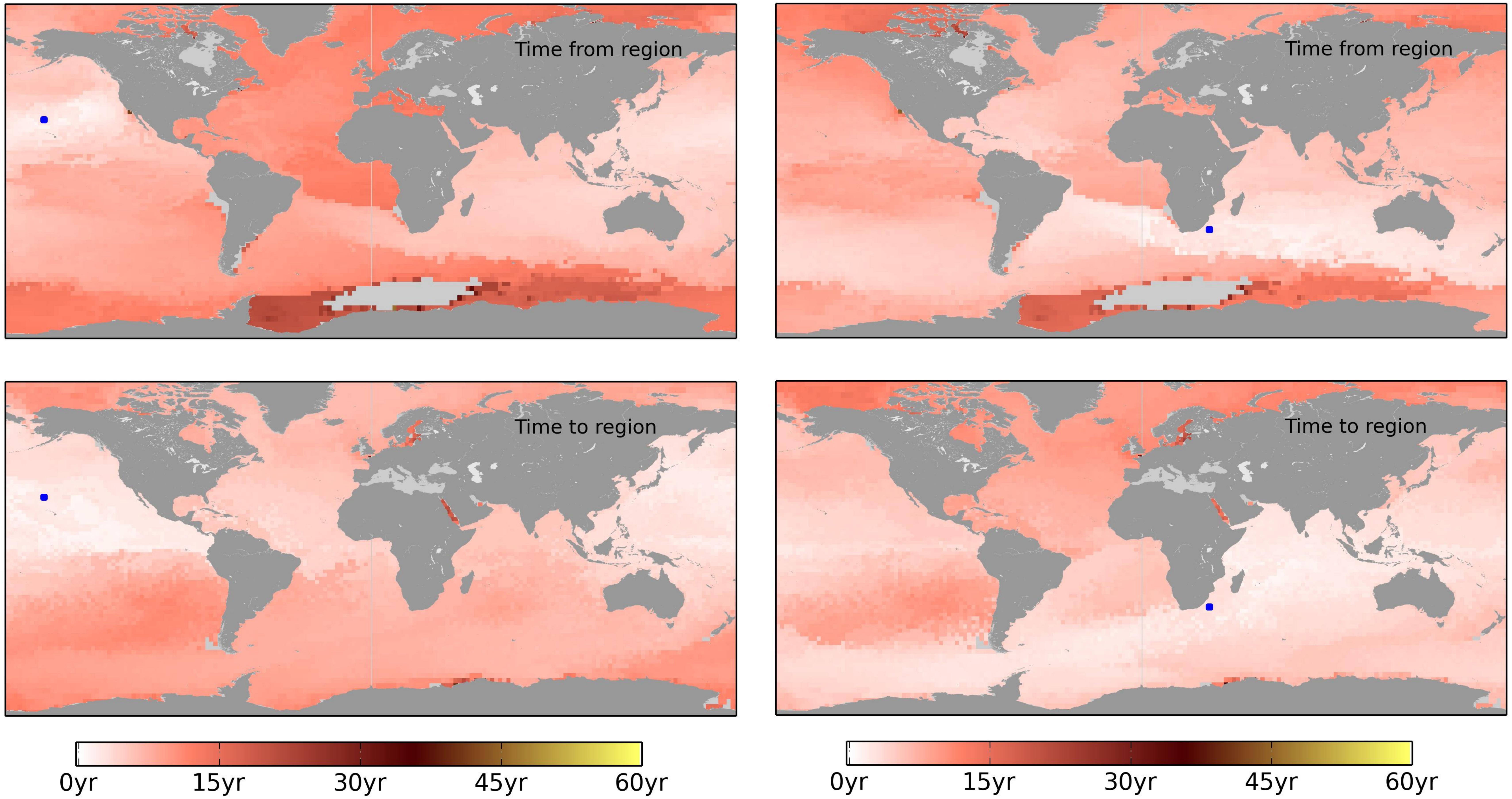


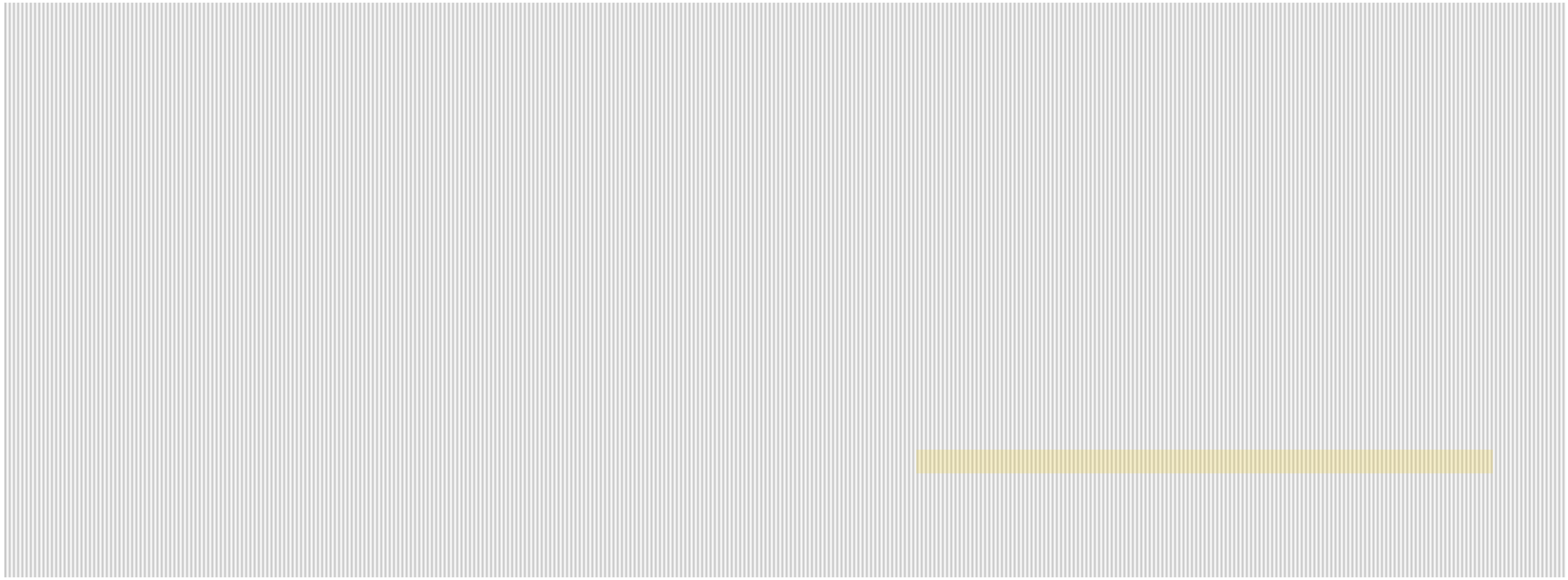
2° x 2° patches for connectivity



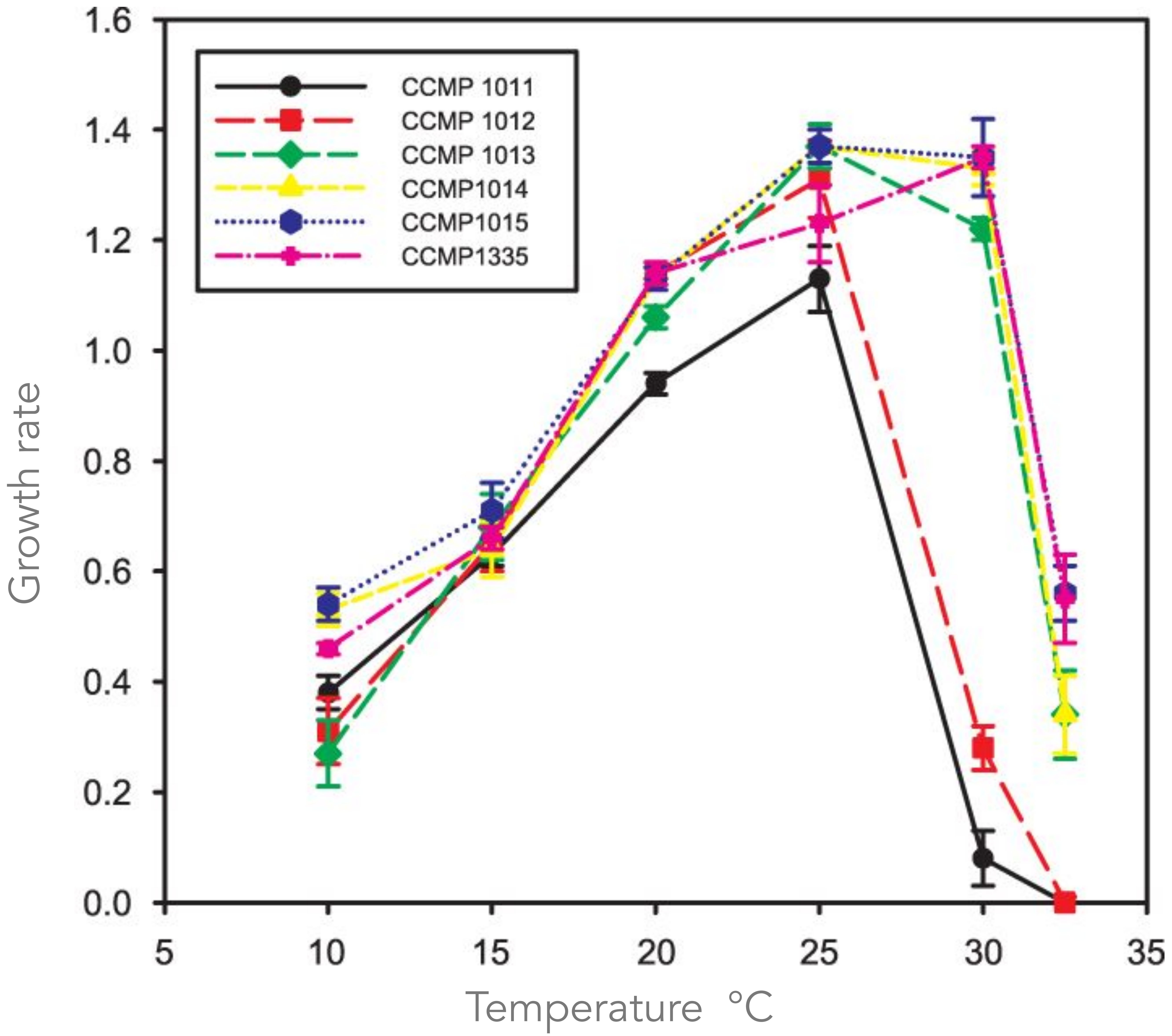
Time from region
Time from region
Time to region
Time to region
0yr
25yr
50yr
75yr
100yr
0yr
25yr
50yr
75yr
100yr



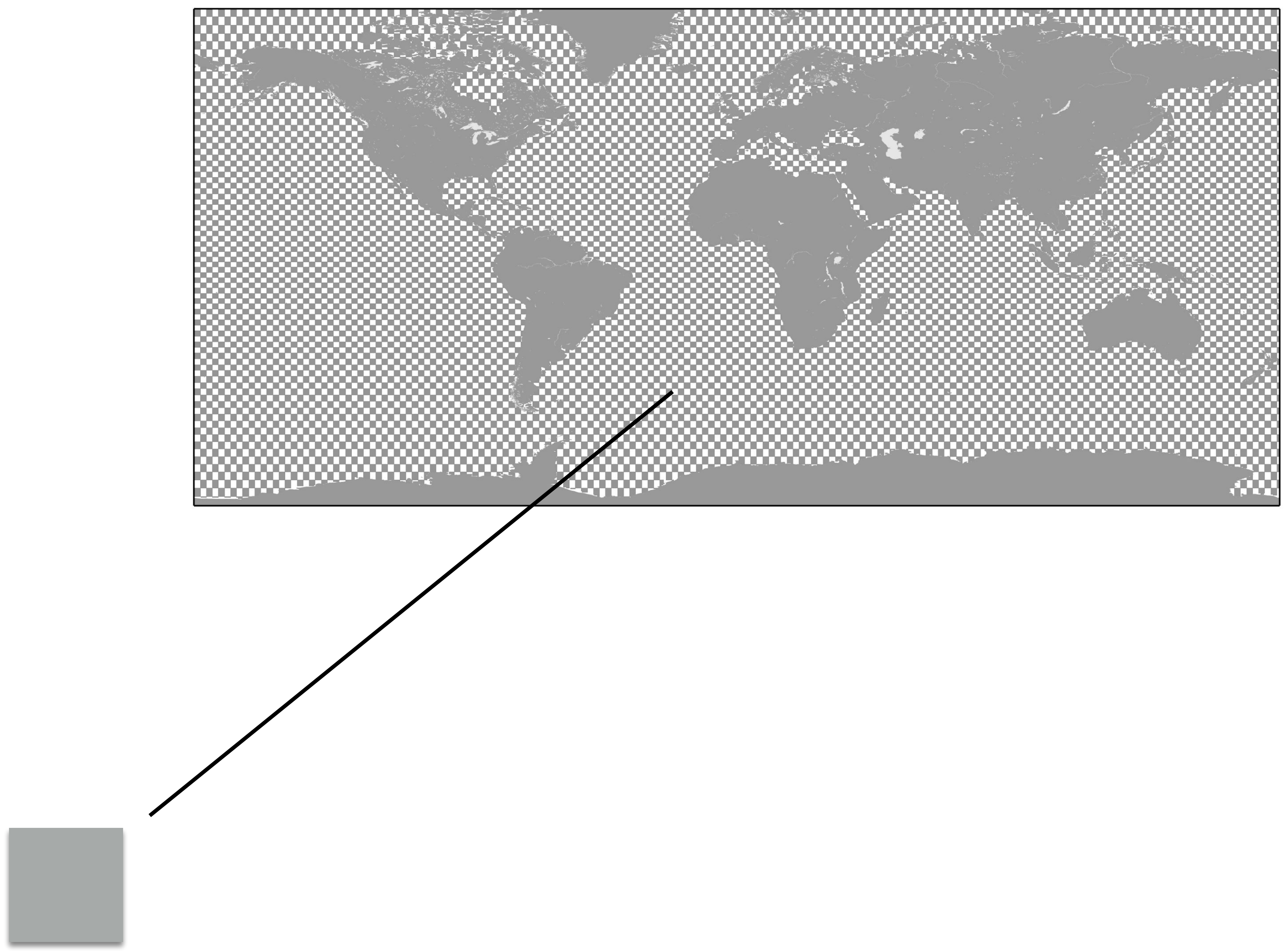

Time from region
Time from region
Time to region
Time to region
0yr
15yr
30yr
45yr
60yr
0yr
15yr
30yr
45yr
60yr

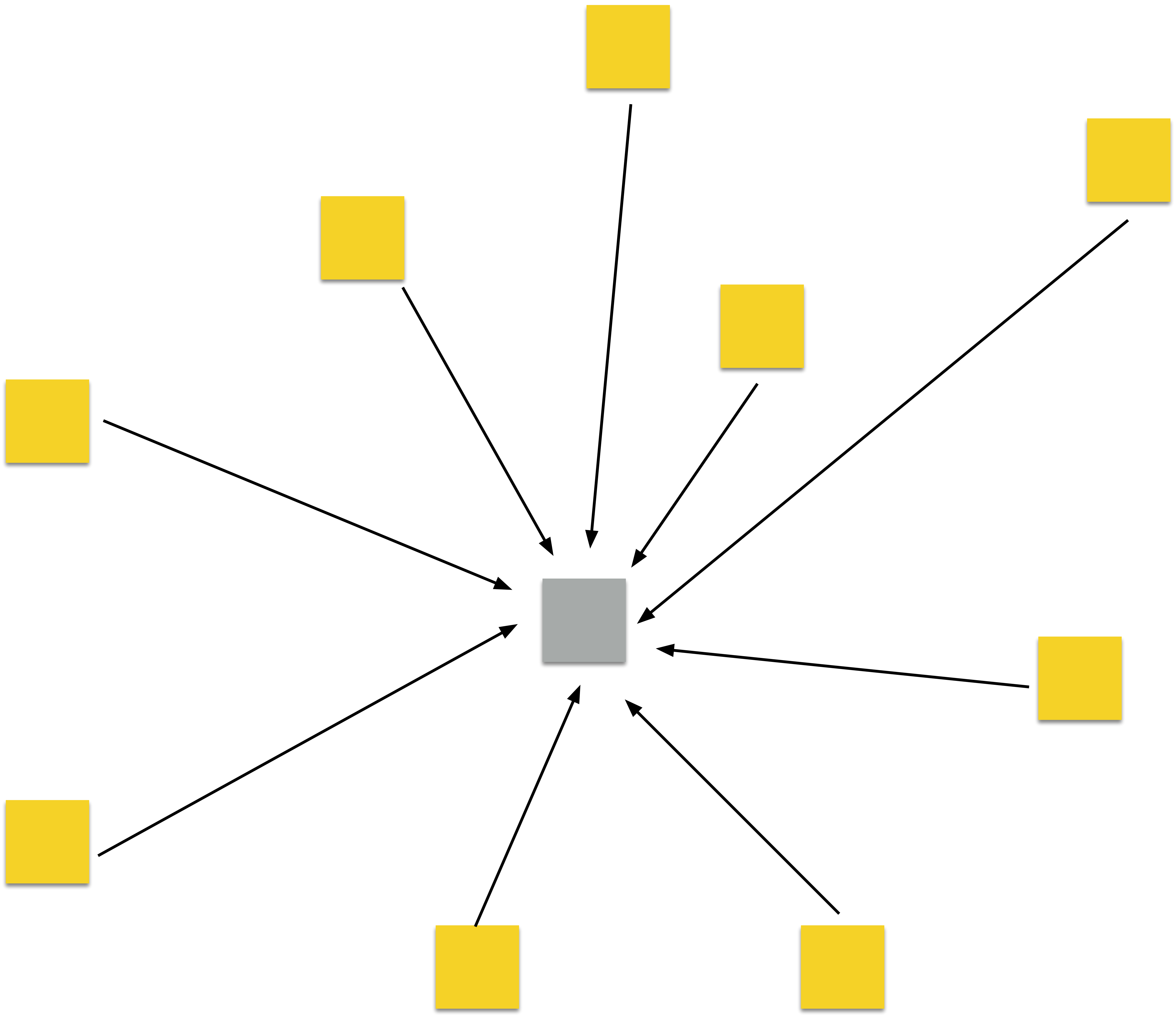


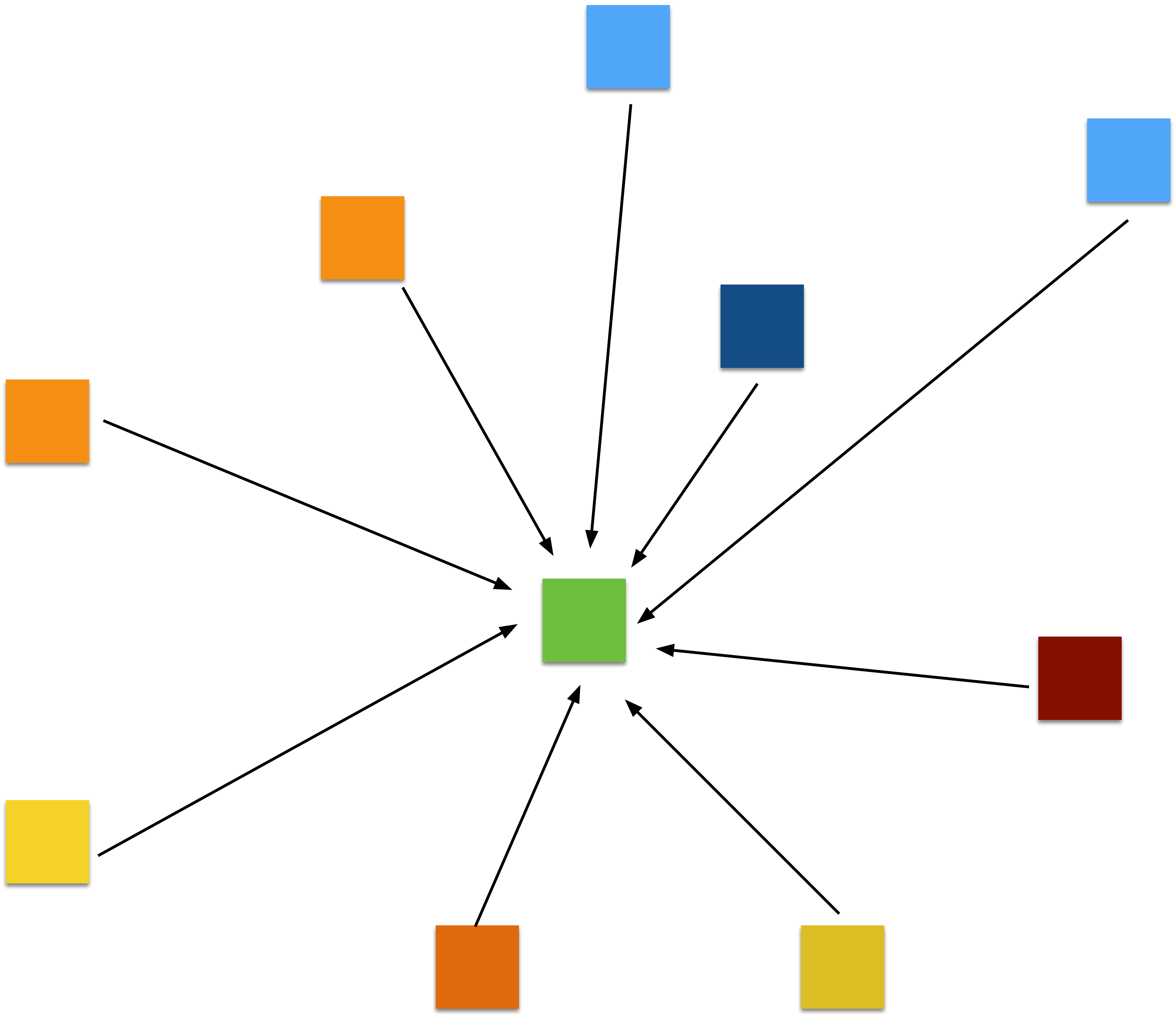
Time to travel 1°C



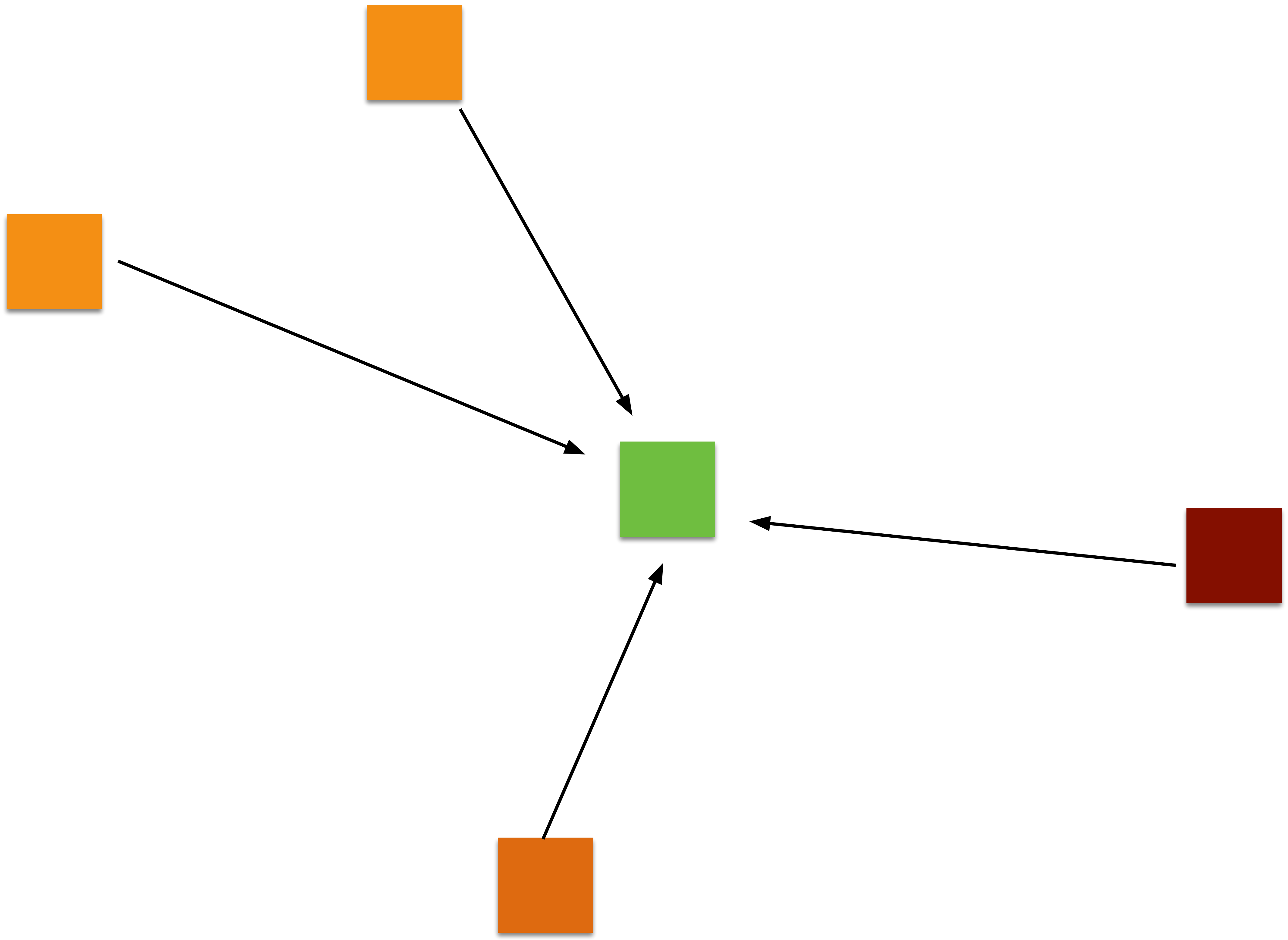
Boyd et al, PLoS ONE, 2013



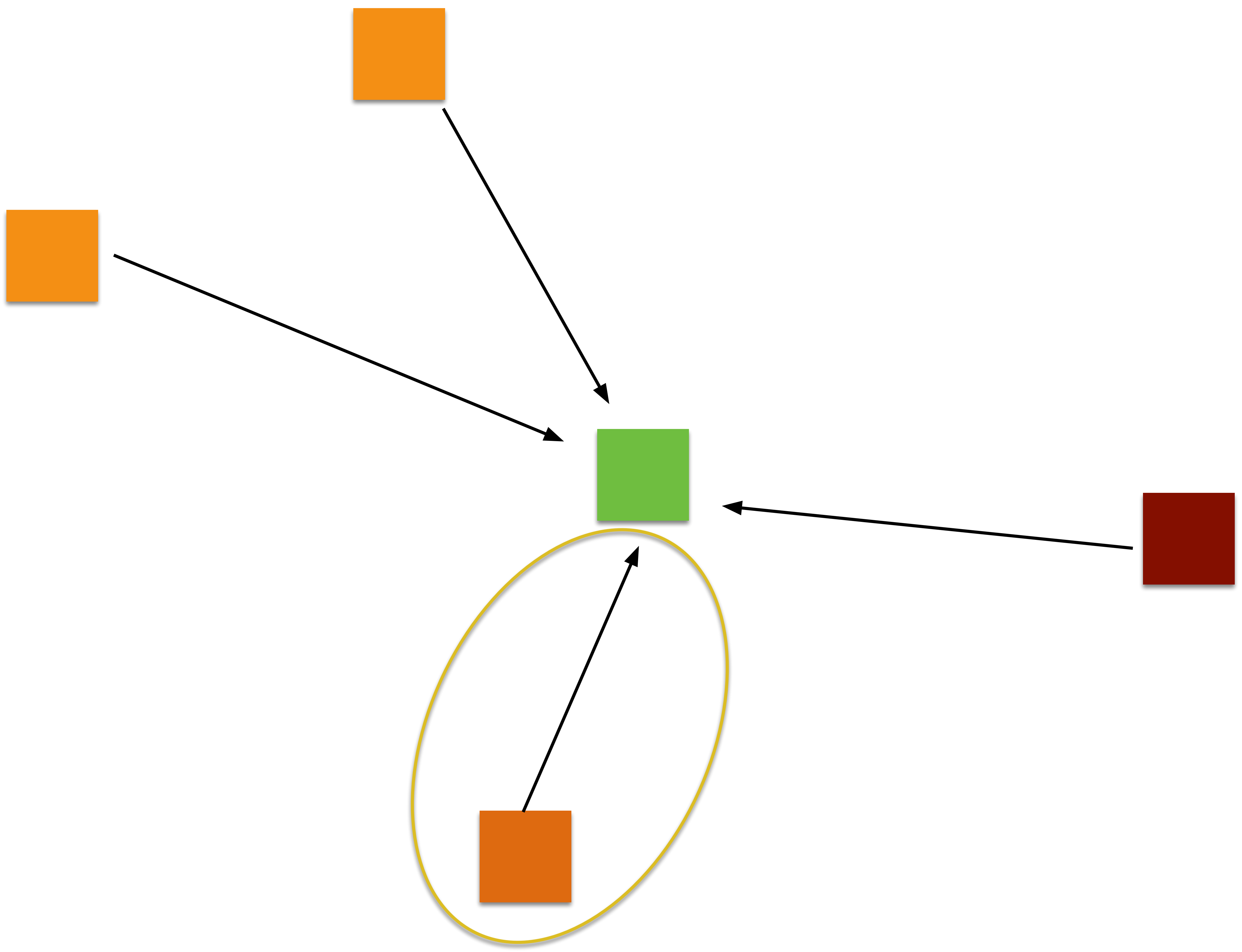




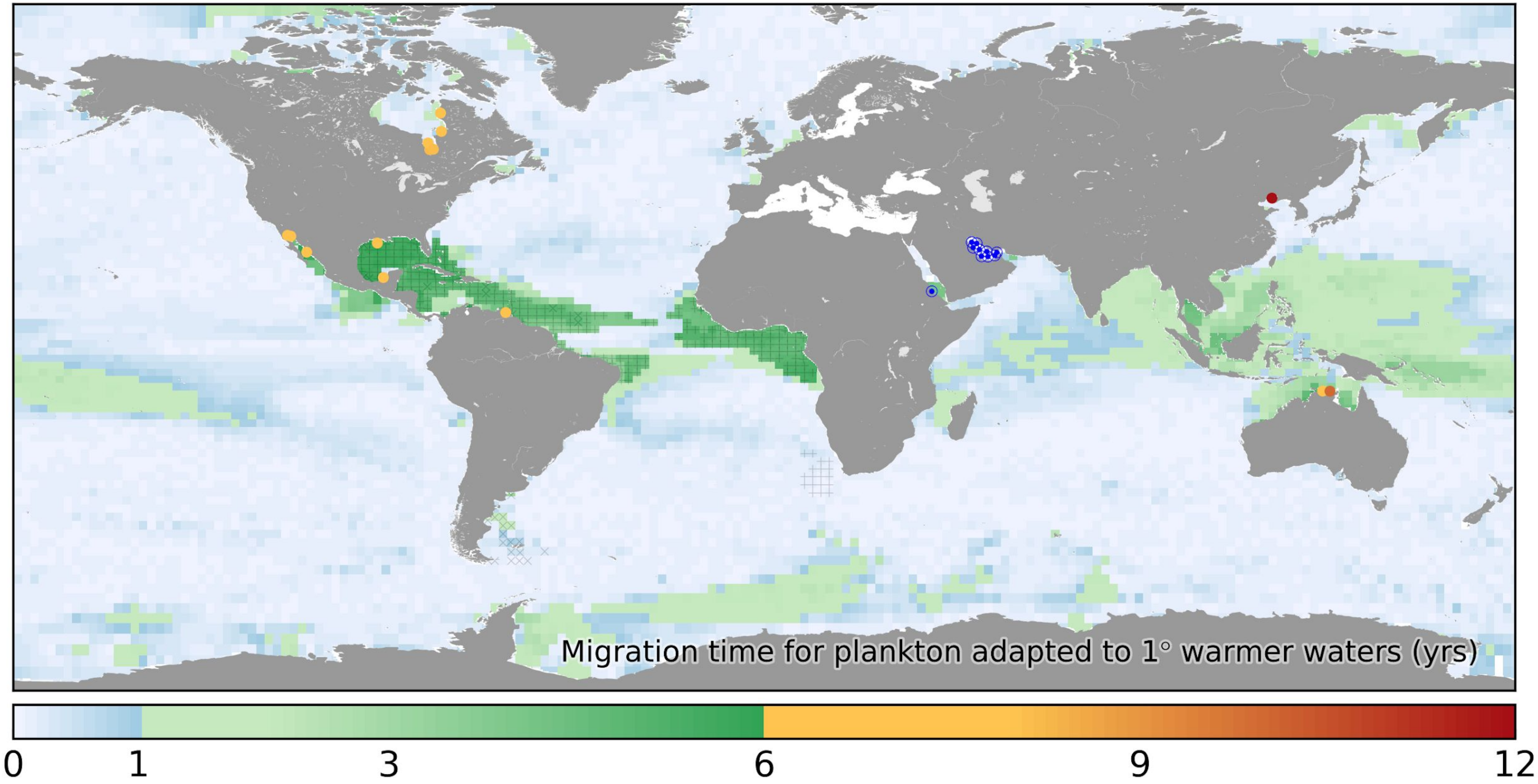
At least one degree warmer



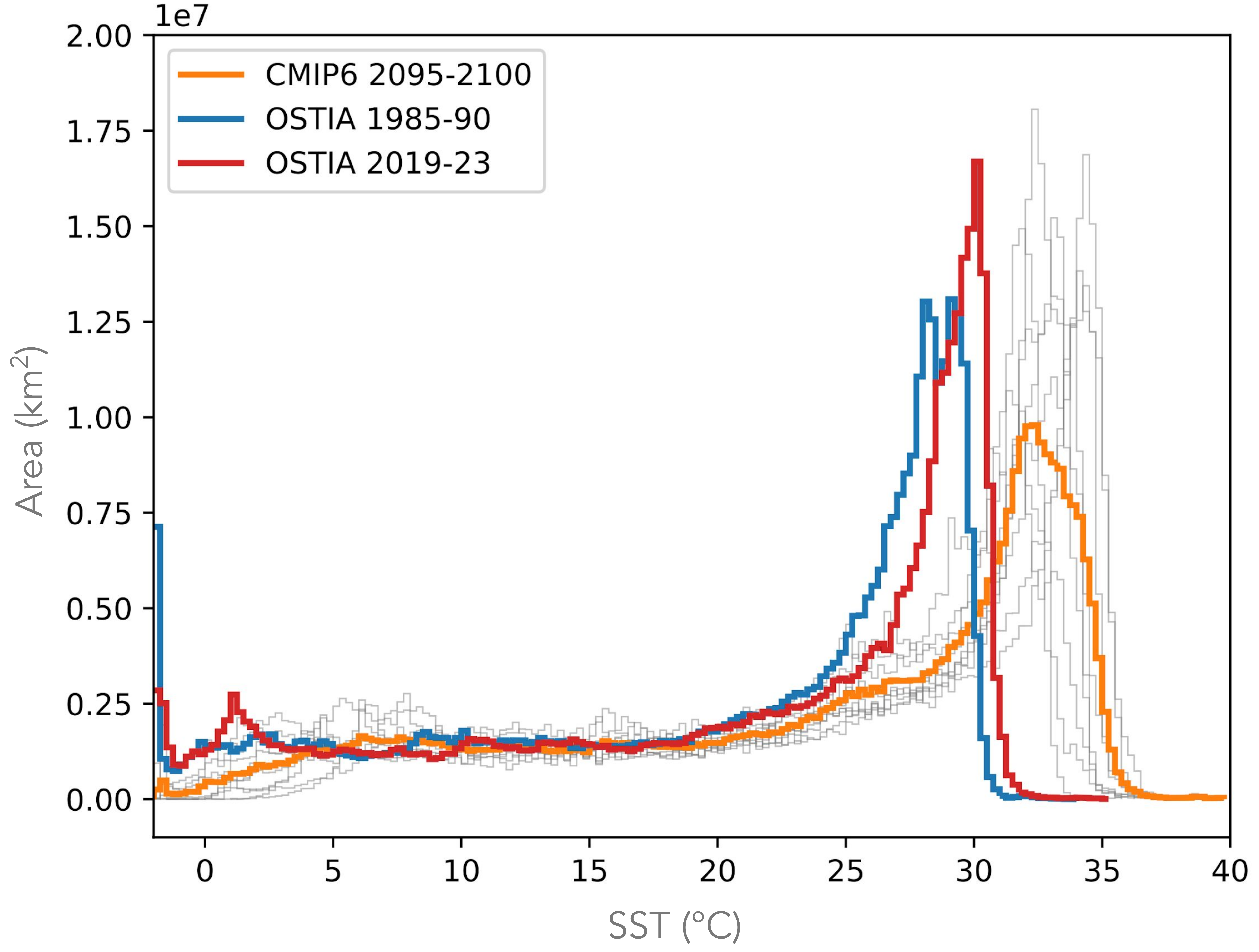
Shortest time



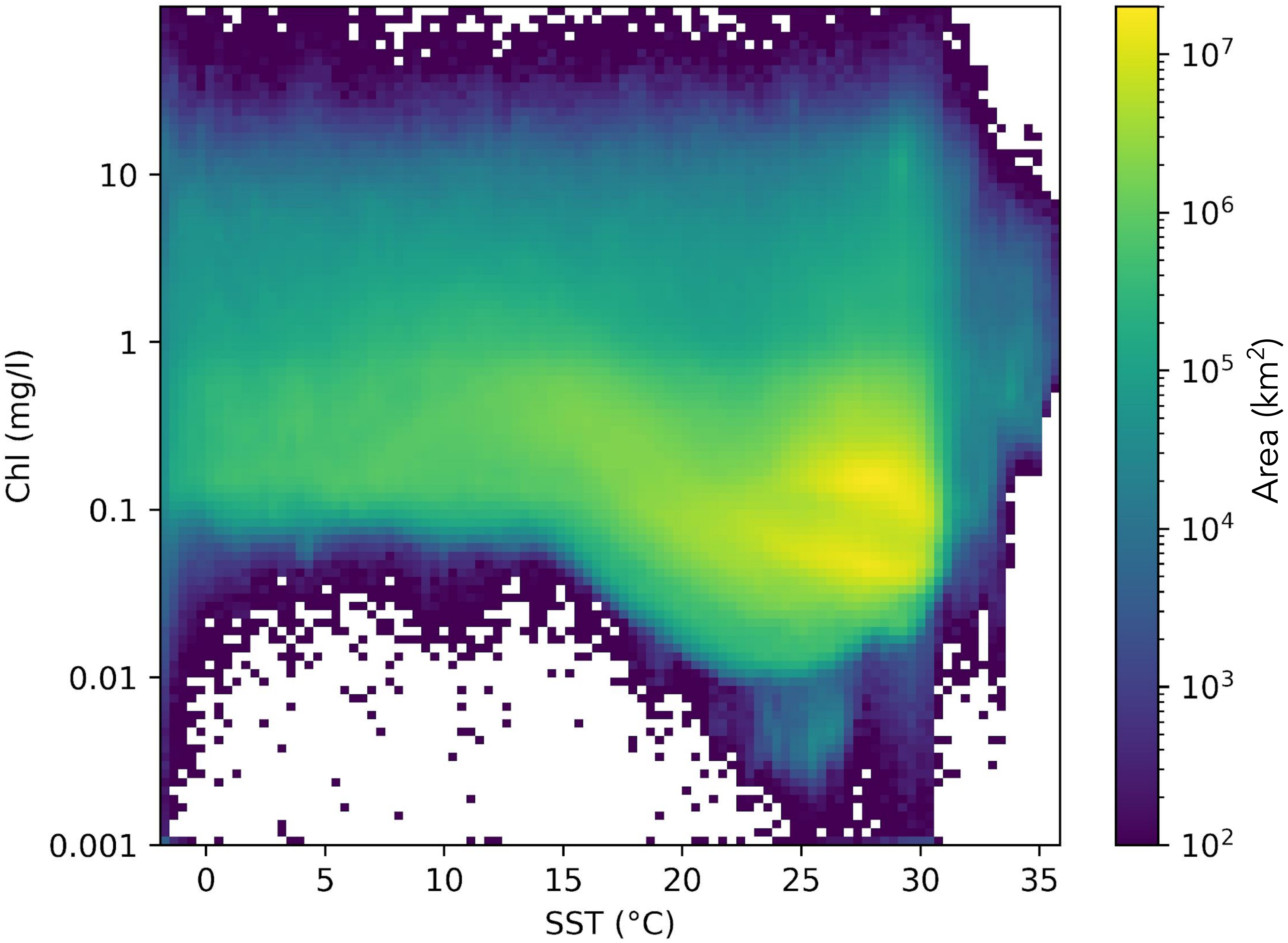
Migration time 1°C



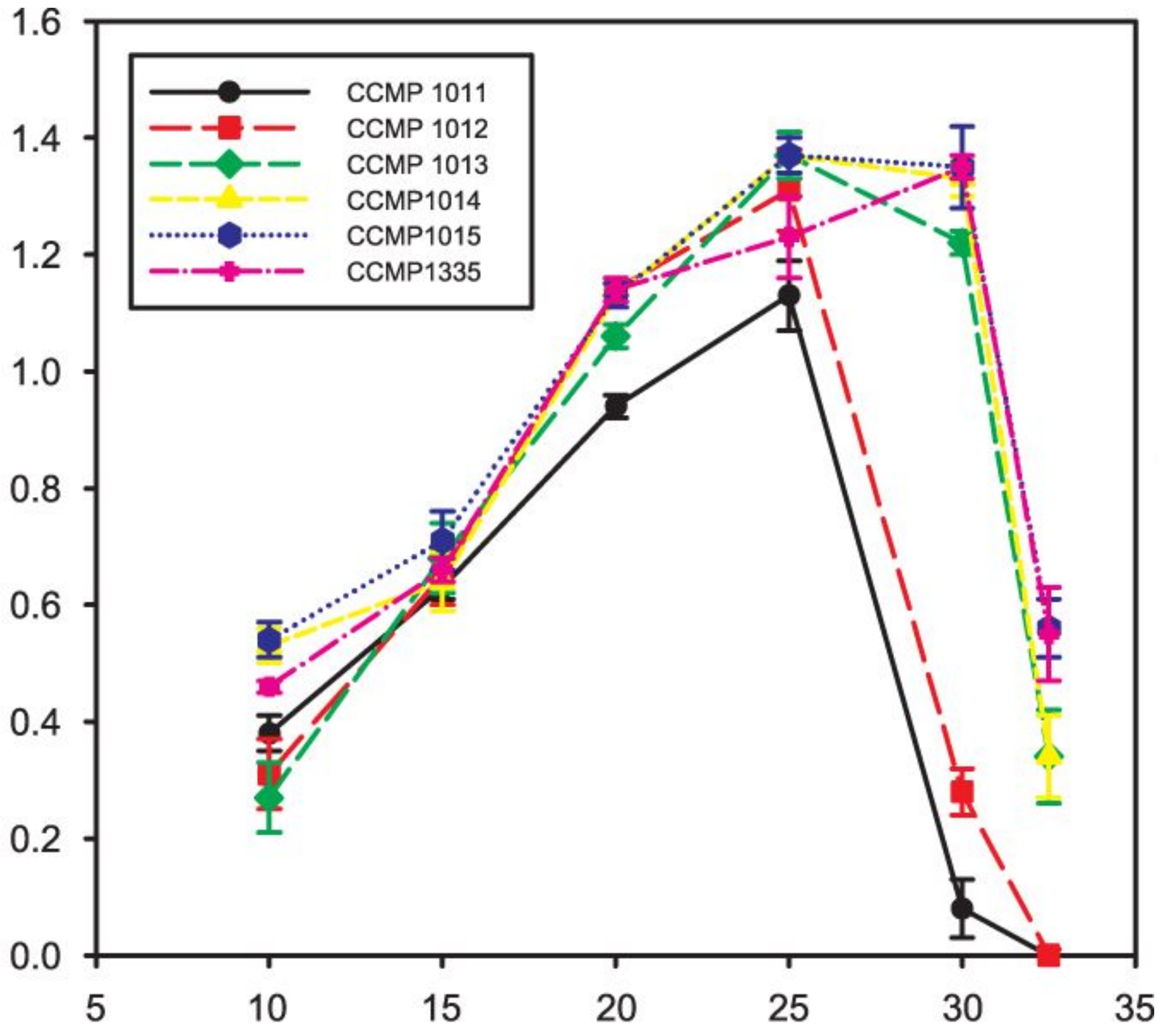
Years



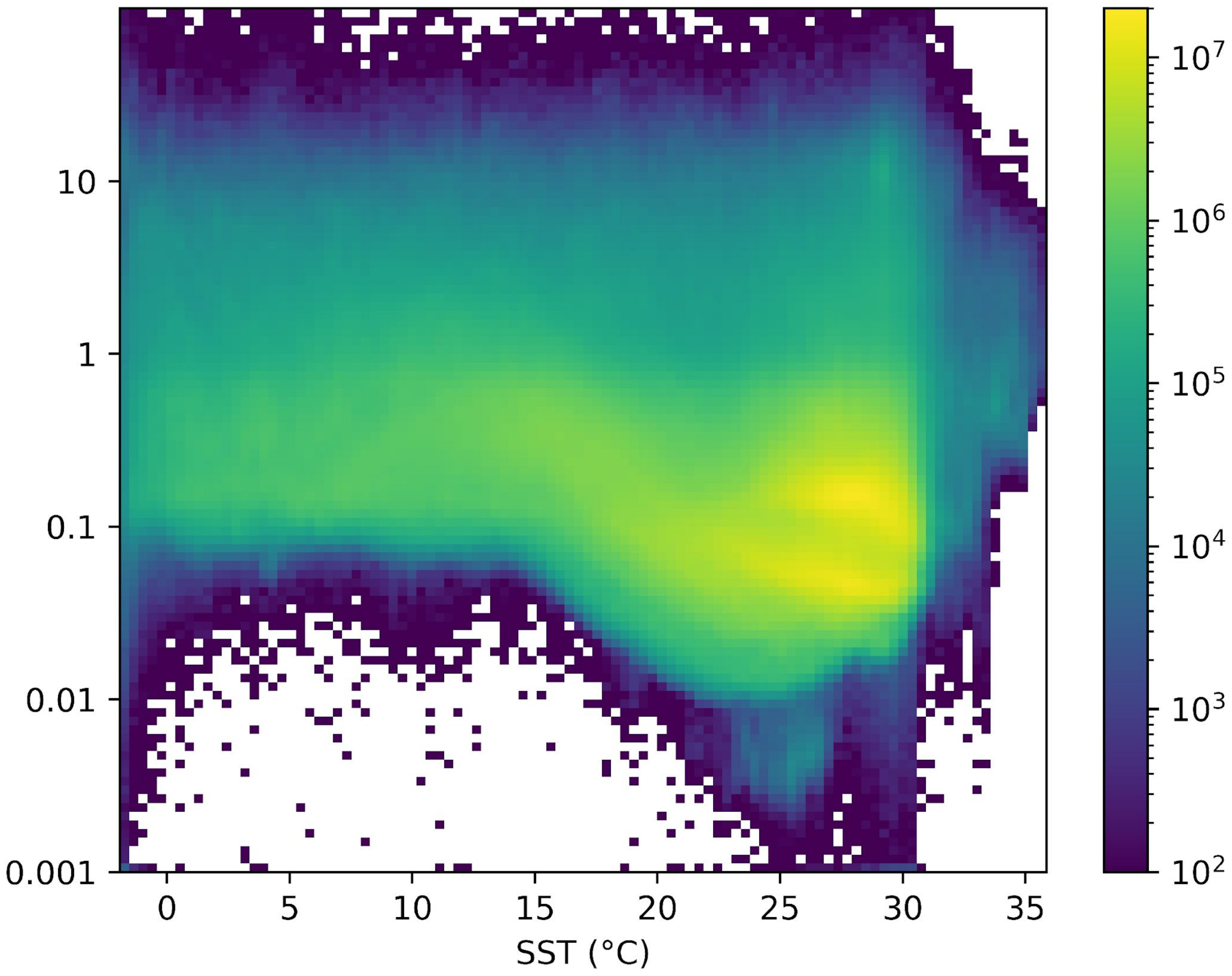
1e7
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
Area (km^2)
CMIP6 2095-2100
OSTIA 1985-90
OSTIA 2019-23
0
5
10
15
20
25
30
35
40
SST (°C)



Chl (mg/l)
10
1
0.1
0.01
0.001
0
5
10
15
20
25
30
35
SST (°C)
Area (km^2)
10^7
10^6
10^5
10^4
10^3
10^2



Boyd et al, PLoS ONE, 2013



3

Primary Production in The Age of AI

“Ocean productivity will decrease from increased stratification driven by Climate Change”

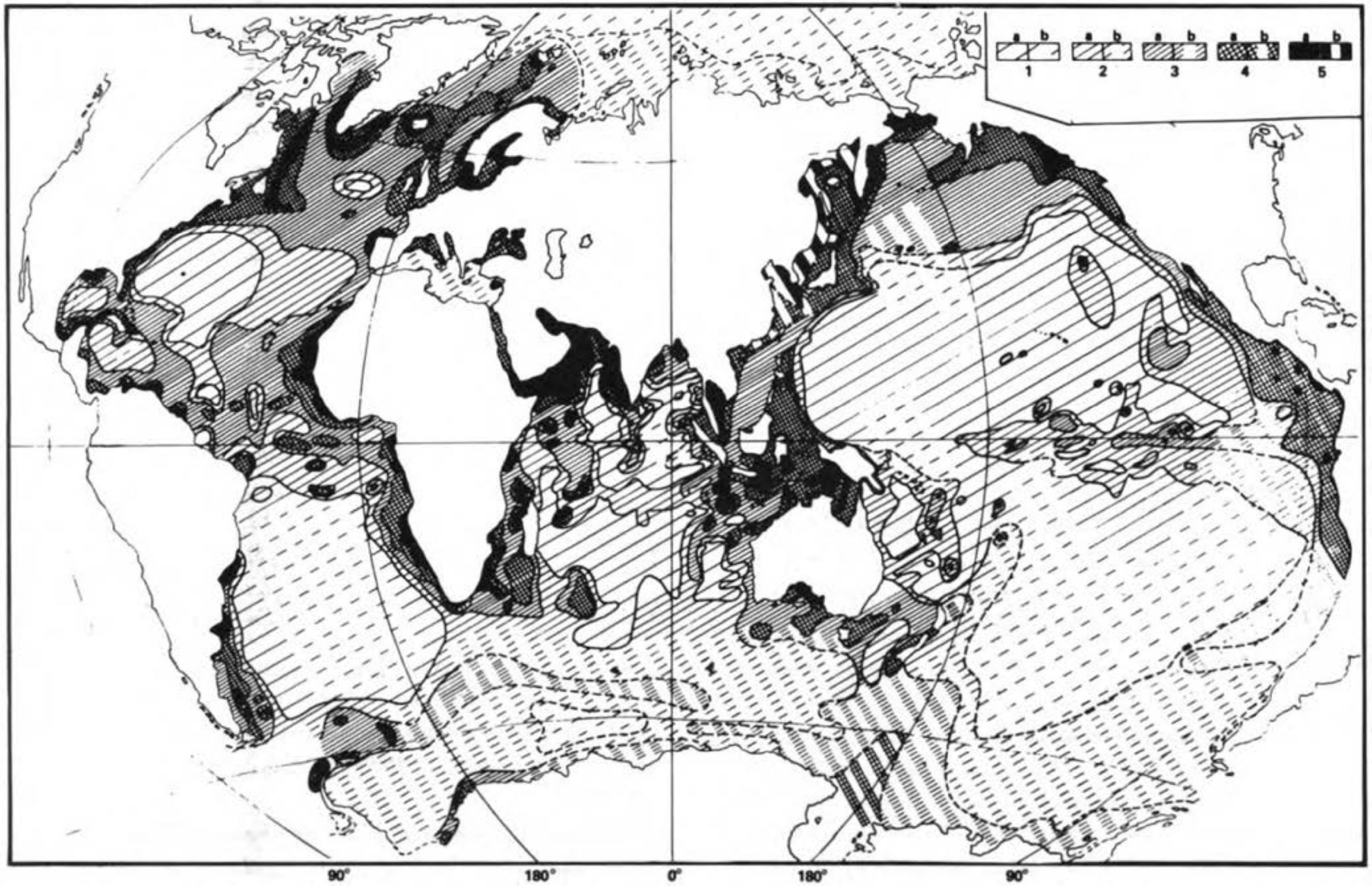


FIGURE 1 Distribution of primary production in the World Ocean. Units are in mg of C per m^2 per day. (1) Less than 100; (2) 100–150; (3) 150–250; (4) 250–500; (5) more than 500. *a* = data from direct ^{14}C measurements; *b* = data from phytoplankton biomass, hydrogen, or oxygen saturation.

Koblentz-Mishke 1970

Global Biogeochemical Cycles

Regular Article | Free Access

Combined constraints on global ocean primary production using observations and models

Erik T. Buitenhuis, Taketo Hashioka, Corinne Le Quéré

First published: 31 July 2013 | https://doi.org/10.1002/gbc.20074 | Citations: 115

Earth System Science Data

Article

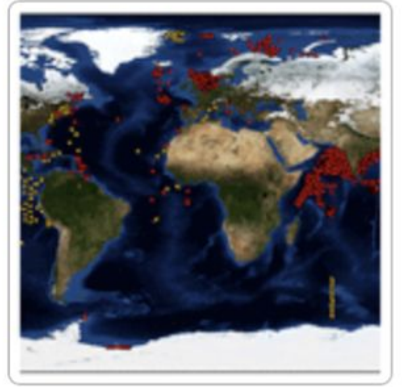
Search

https://doi.org/10.5194/essd-13-4967-2021

Data description paper | 27 Oct 2021

Collection and analysis of a global marine phytoplankton primary-production dataset

Francesco Mattei and Michele Scardi



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- Full-text XML
- BibTeX
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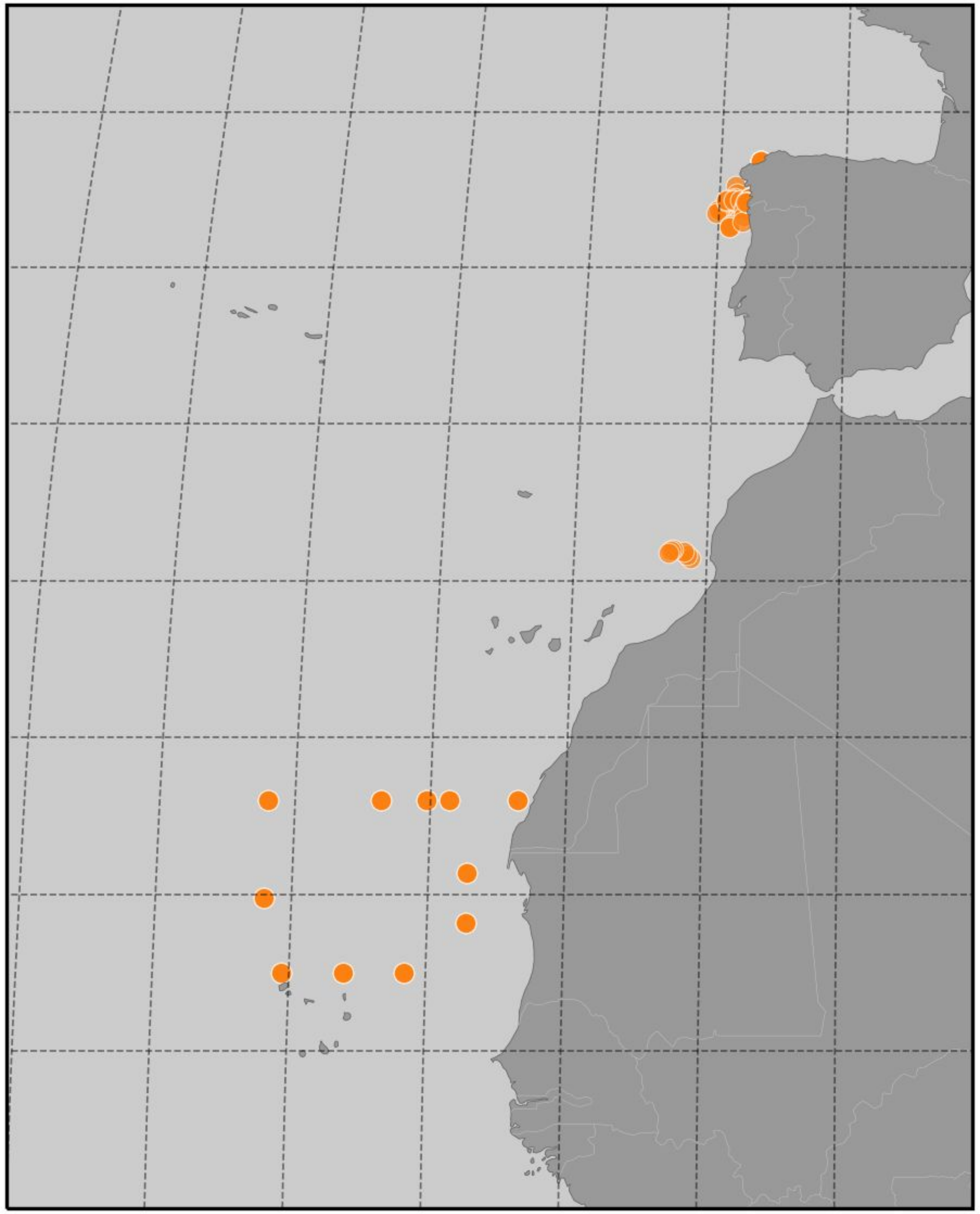
Short summary
Data paucity hinders the understanding of natural processes such as phytoplankton

PRIMary-productivity in Upwelling Systems (PRIMUS)

ESA | Regional Initiatives | 4D Atlantic | Science

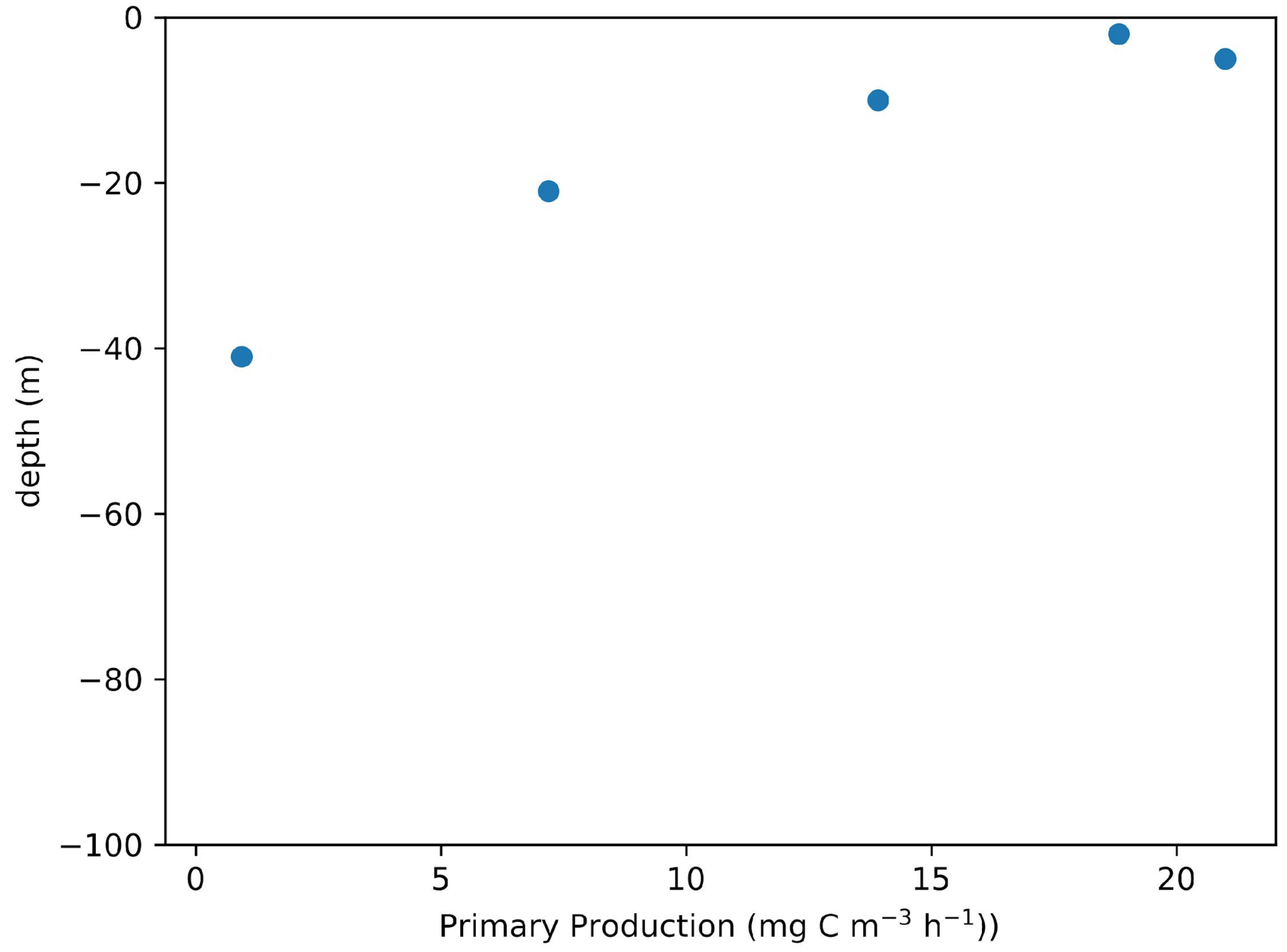
http://primus-atlantic.org

PRIMUS PP



^{14}C method

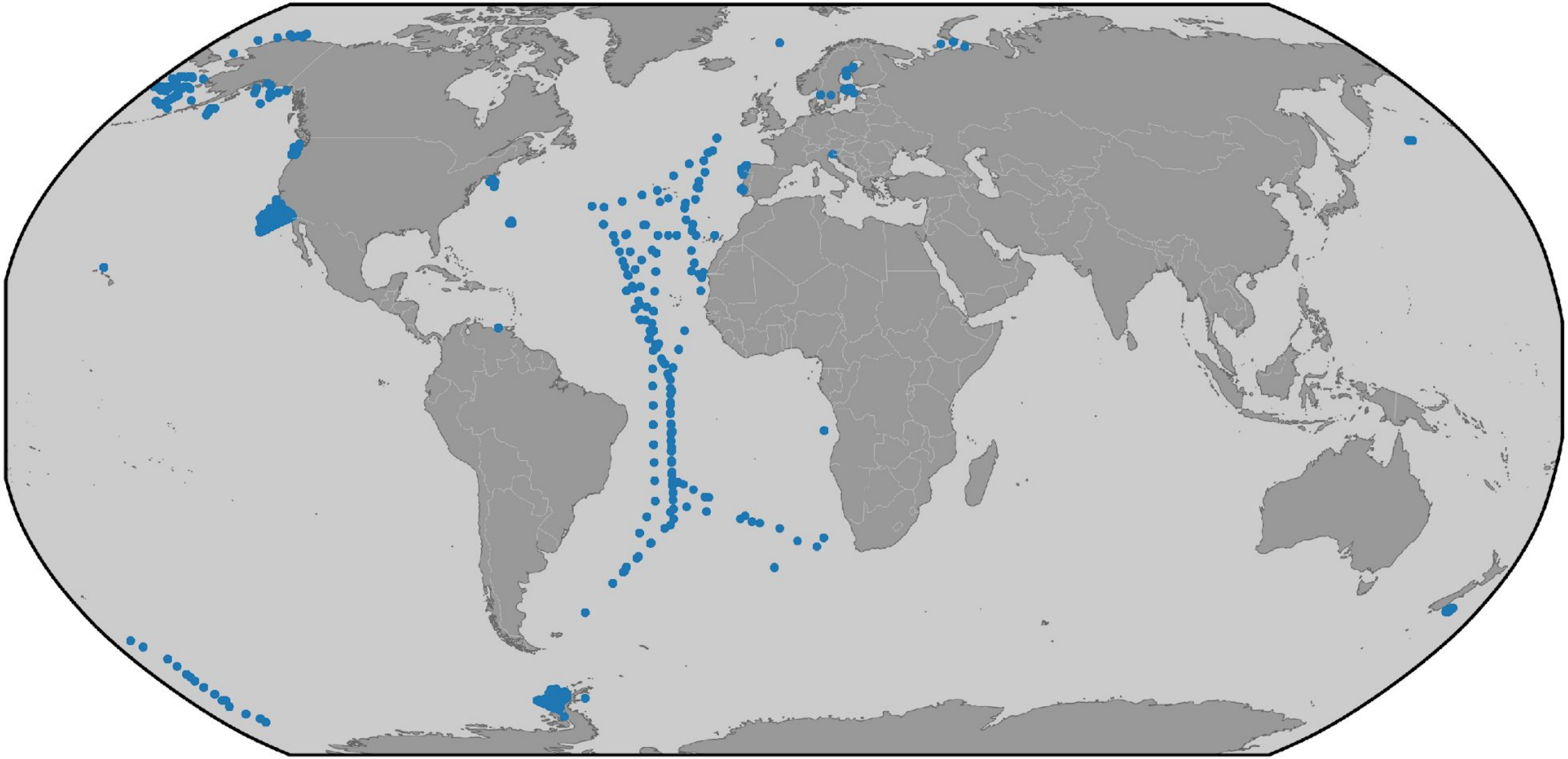
2 and 24 hr incubations

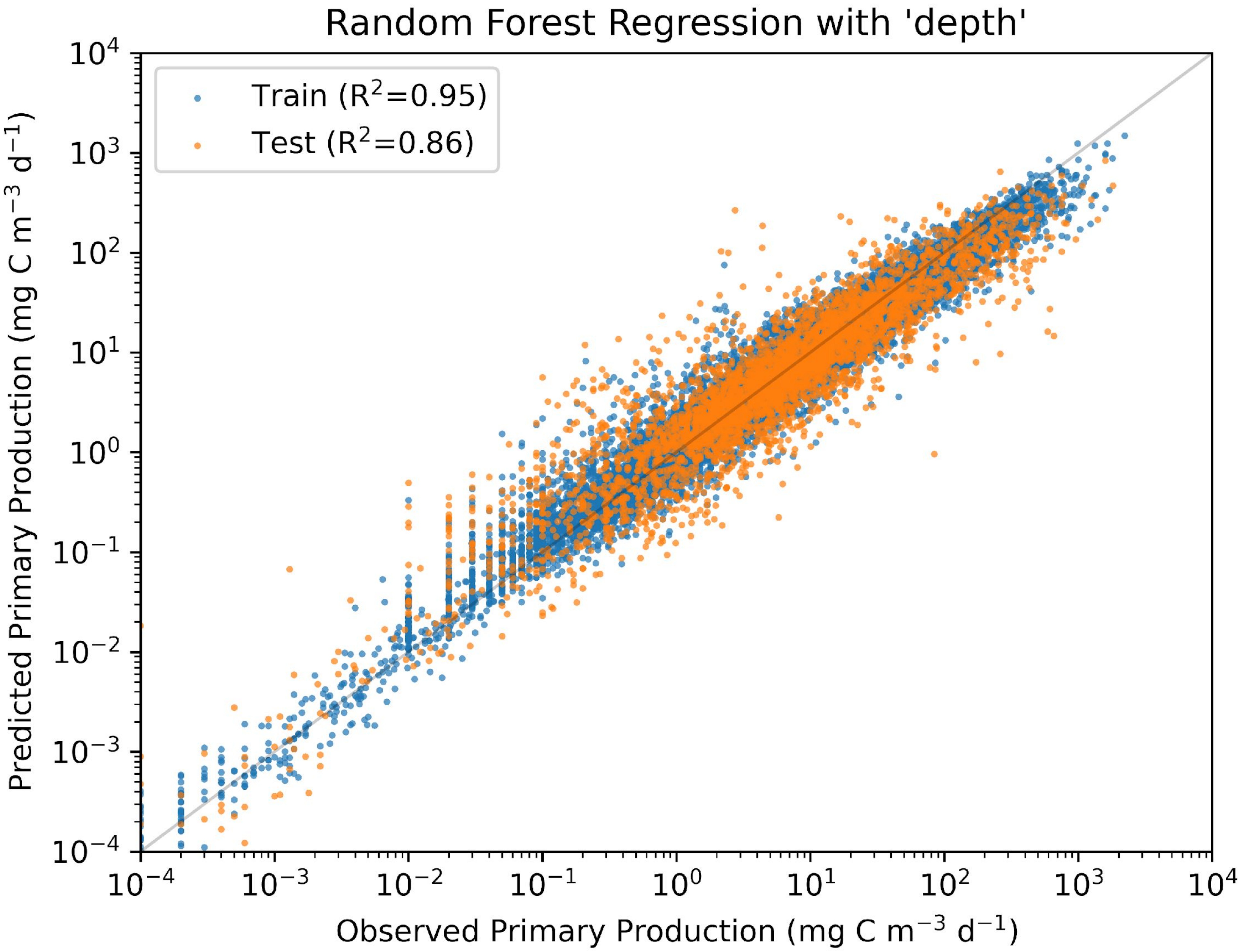


Can we estimate Primary production from satellite-derived properties using Random Forest Regression?

Depth resolved Primary Production

$$\log(PP) \sim f(\log(Chl), SST, Z_{eu}, Kd490, PAR, month, depth)$$

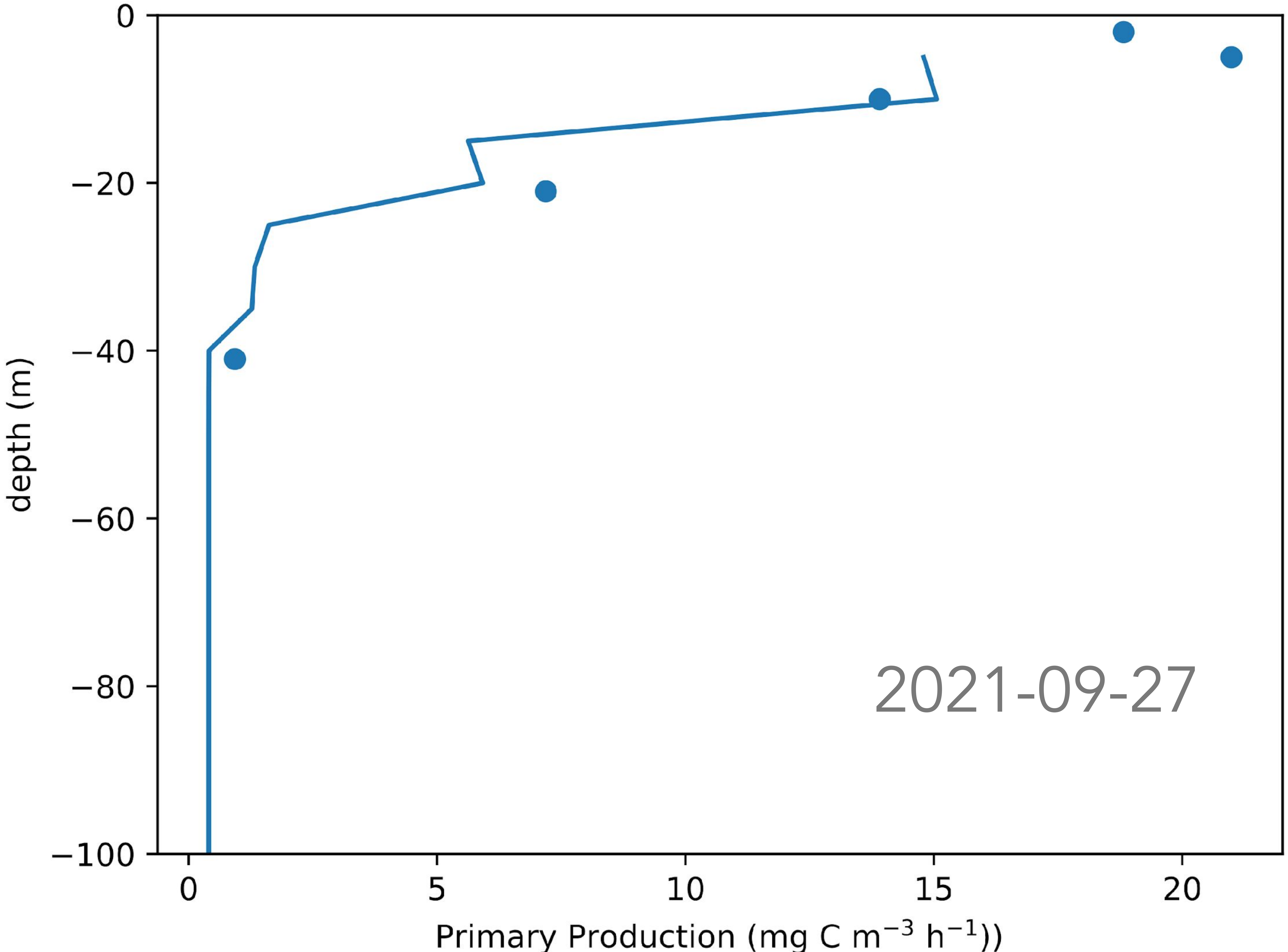


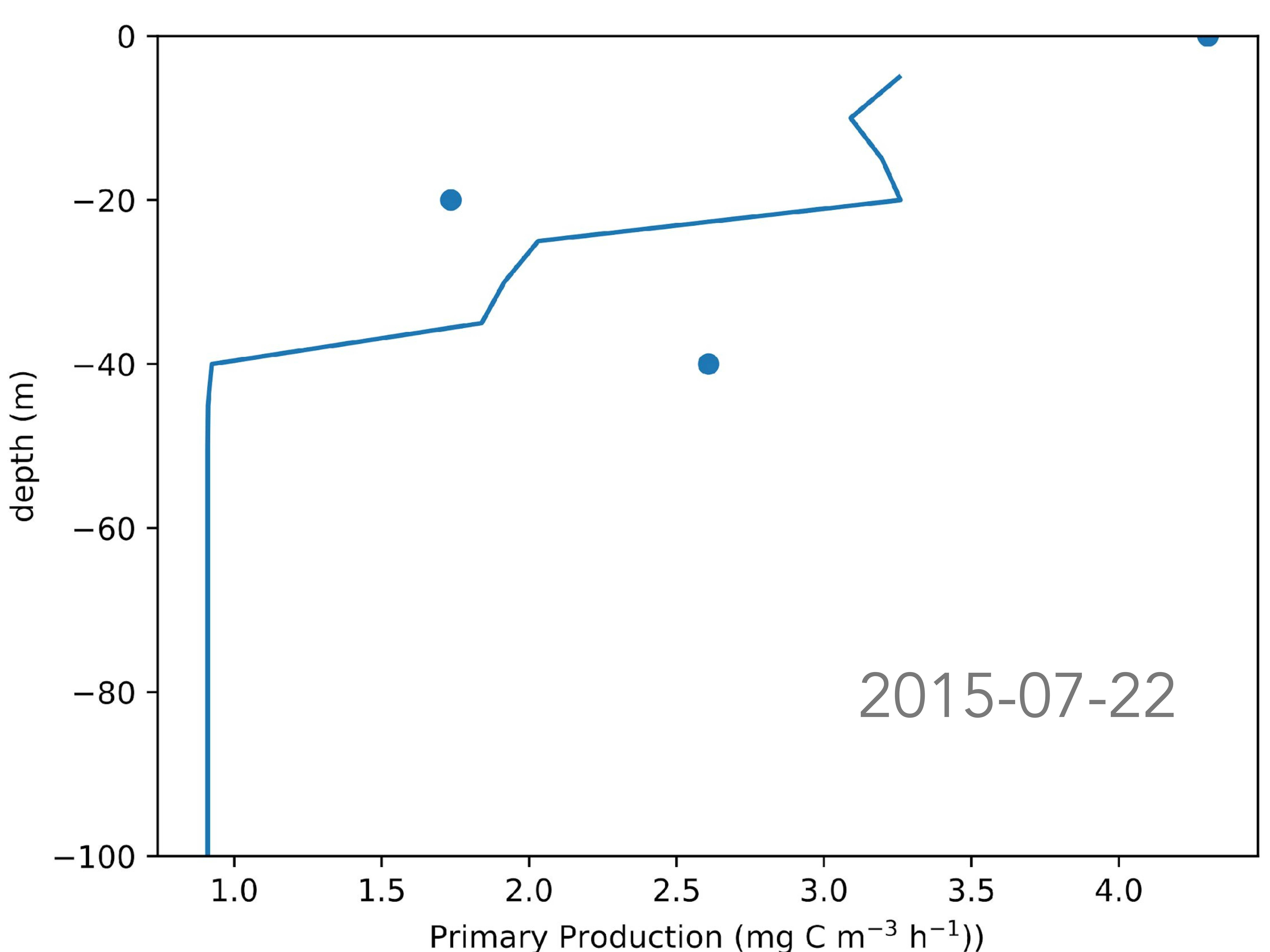

Random Forest Regression with 'depth'
Train (R^2=0.95)
Test (R^2=0.86)
Predicted Primary Production (mg C m^{-3} d^{-1})
Observed Primary Production (mg C m^{-3} d^{-1})
10^{-4}
10^{-3}
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}
10^{4}

Depth resolved Primary Production

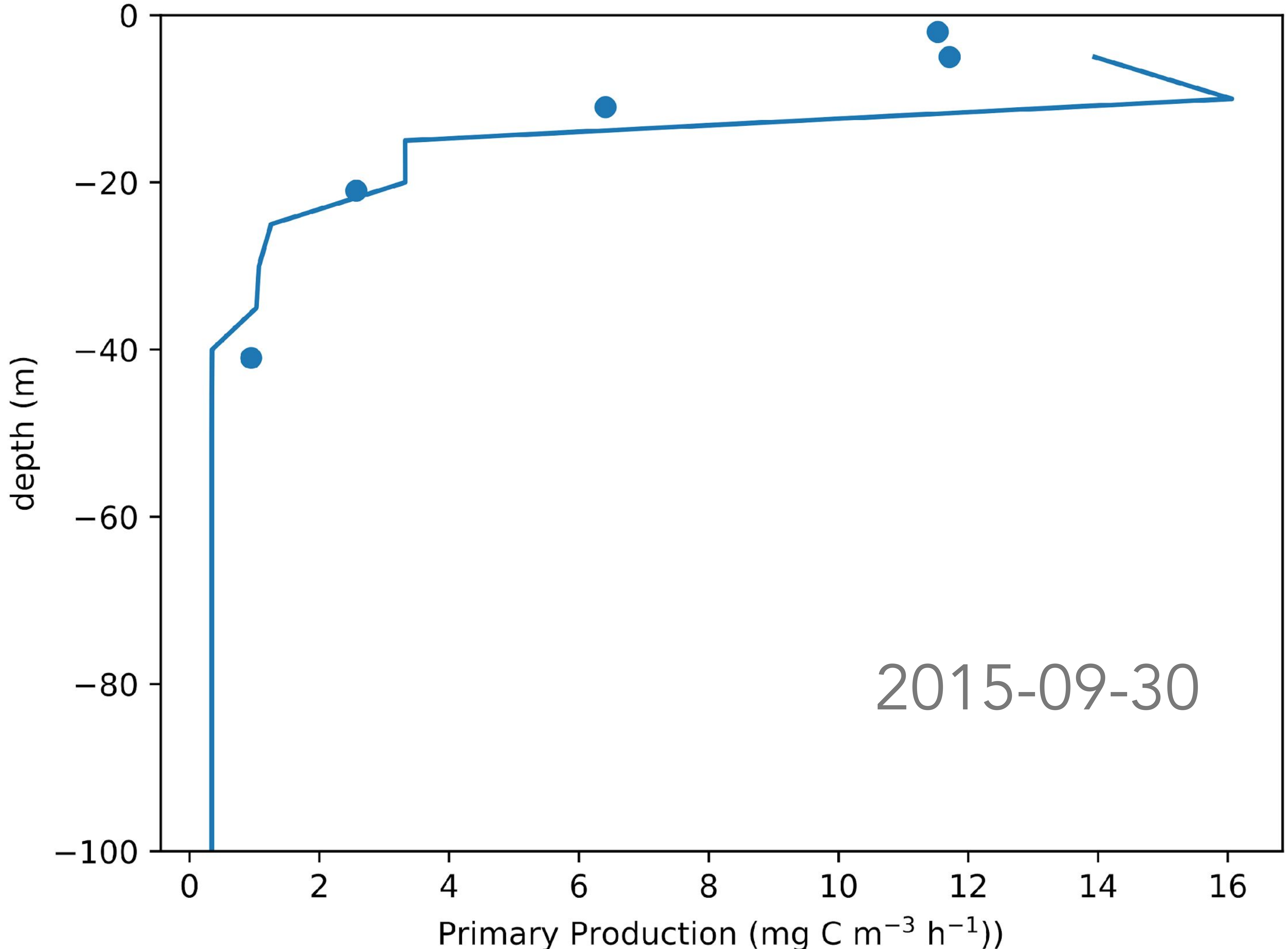
$$\log(PP) \sim f(\log(Chl), SST, Z_{eu}, Kd490, PAR, \text{month}, \text{depth})$$

Defined at Sea Surface

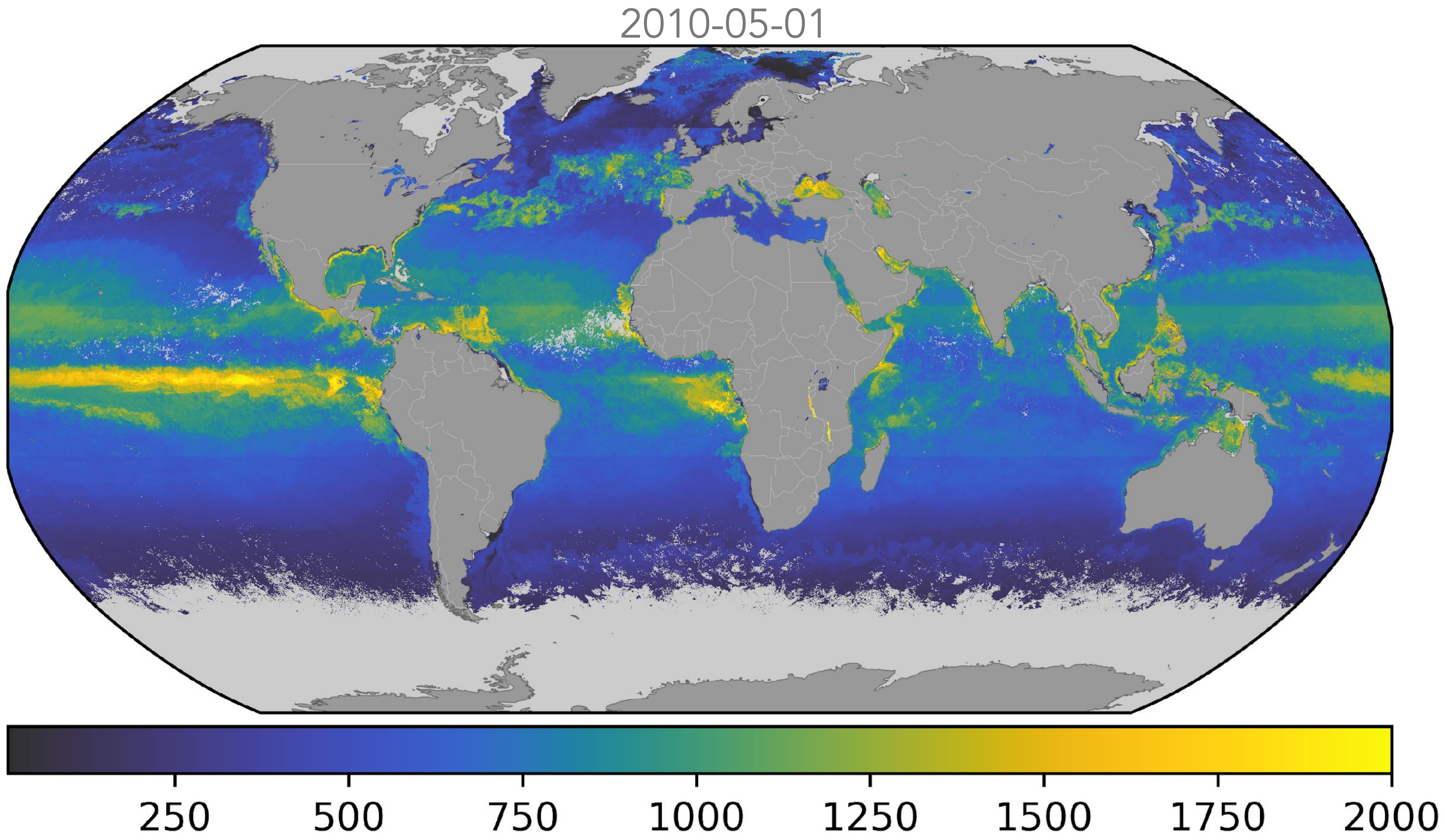

0
−20
−40
−60
−80
−100
depth (m)
0
5
10
15
20
Primary Production (mg C m^{-3} h^{-1}))
2021-09-27

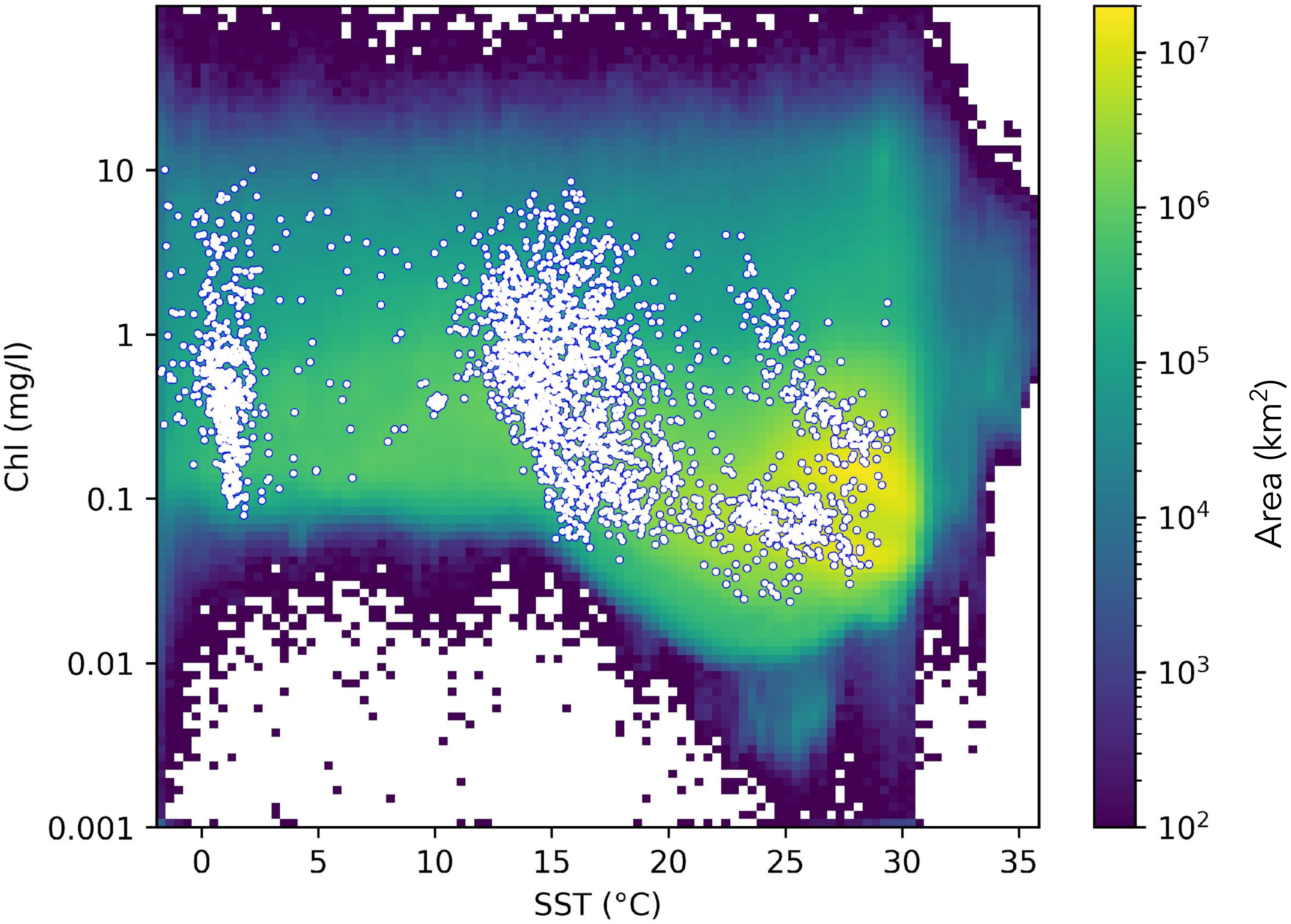


0
−20
−40
−60
−80
−100
depth (m)
1.0
1.5
2.0
2.5
3.0
3.5
4.0
Primary Production (mg C m−3 h−1))
2015-07-22

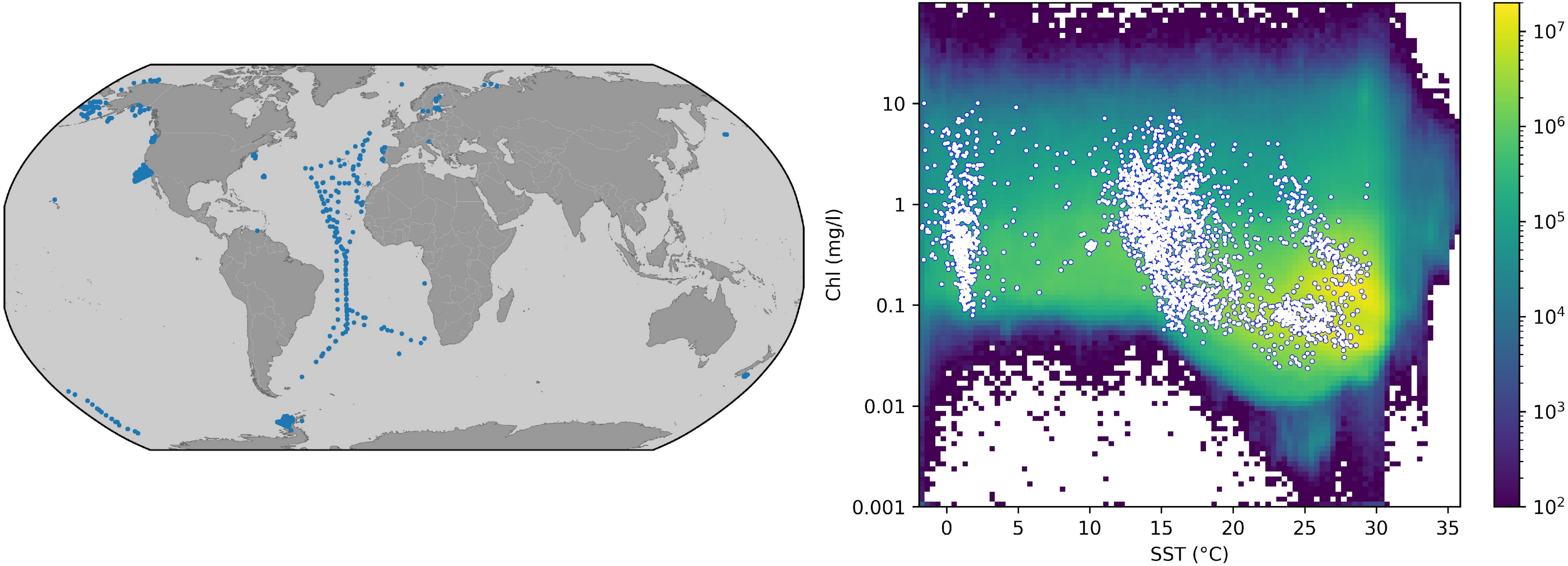


0
−20
−40
−60
−80
−100
depth (m)
0
2
4
6
8
10
12
14
16
Primary Production (mg C m^{-3} h^{-1}))
2015-09-30

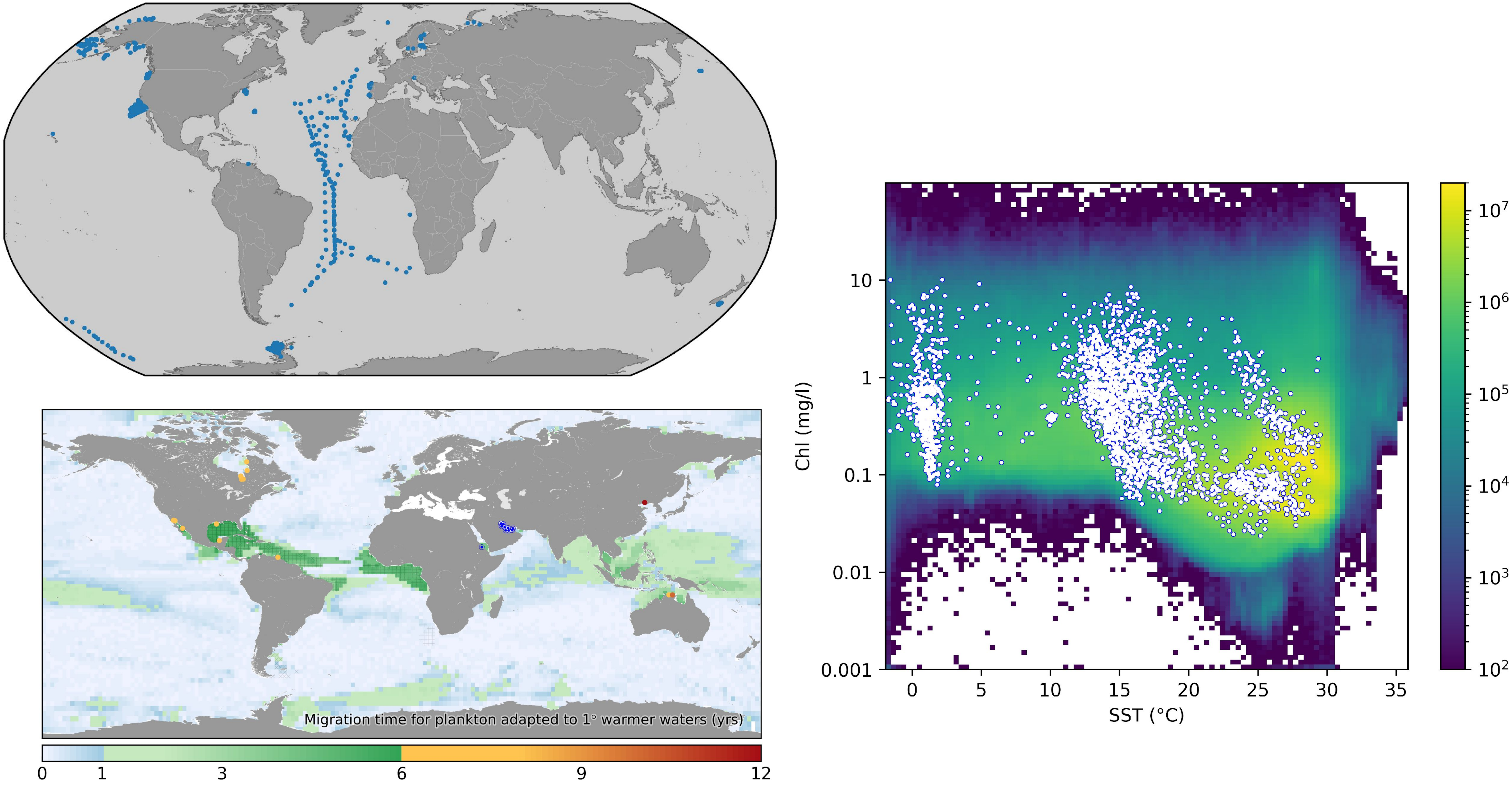

2010-05-01
250
500
750
1000
1250
1500
1750
2000



Chl (mg/l)
10
1
0.1
0.01
0.001
0
5
10
15
20
25
30
35
SST (°C)
10^7
10^6
10^5
10^4
10^3
10^2
Area (km^2)



Chl (mg/l)
10
1
0.1
0.01
0.001
0
5
10
15
20
25
30
35
SST (°C)
10^7
10^6
10^5
10^4
10^3
10^2

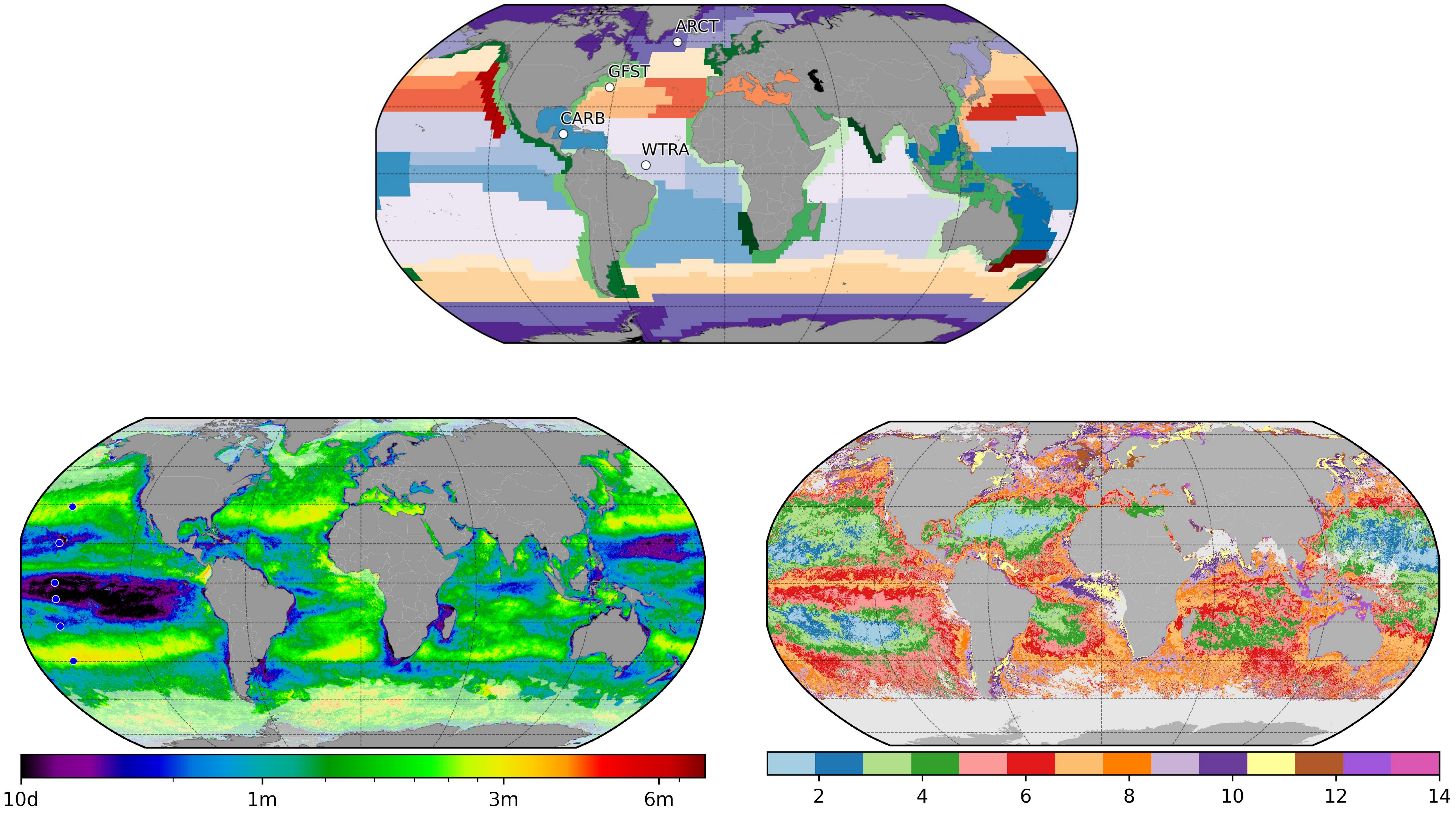

Migration time for plankton adapted to 1° warmer waters (yrs)
0
1
3
6
9
12
Chl (mg/l)
10
1
0.1
0.01
0.001
SST (°C)
0
5
10
15
20
25
30
35
10^7
10^6
10^5
10^4
10^3
10^2

The tropical ocean is critical and undersampled

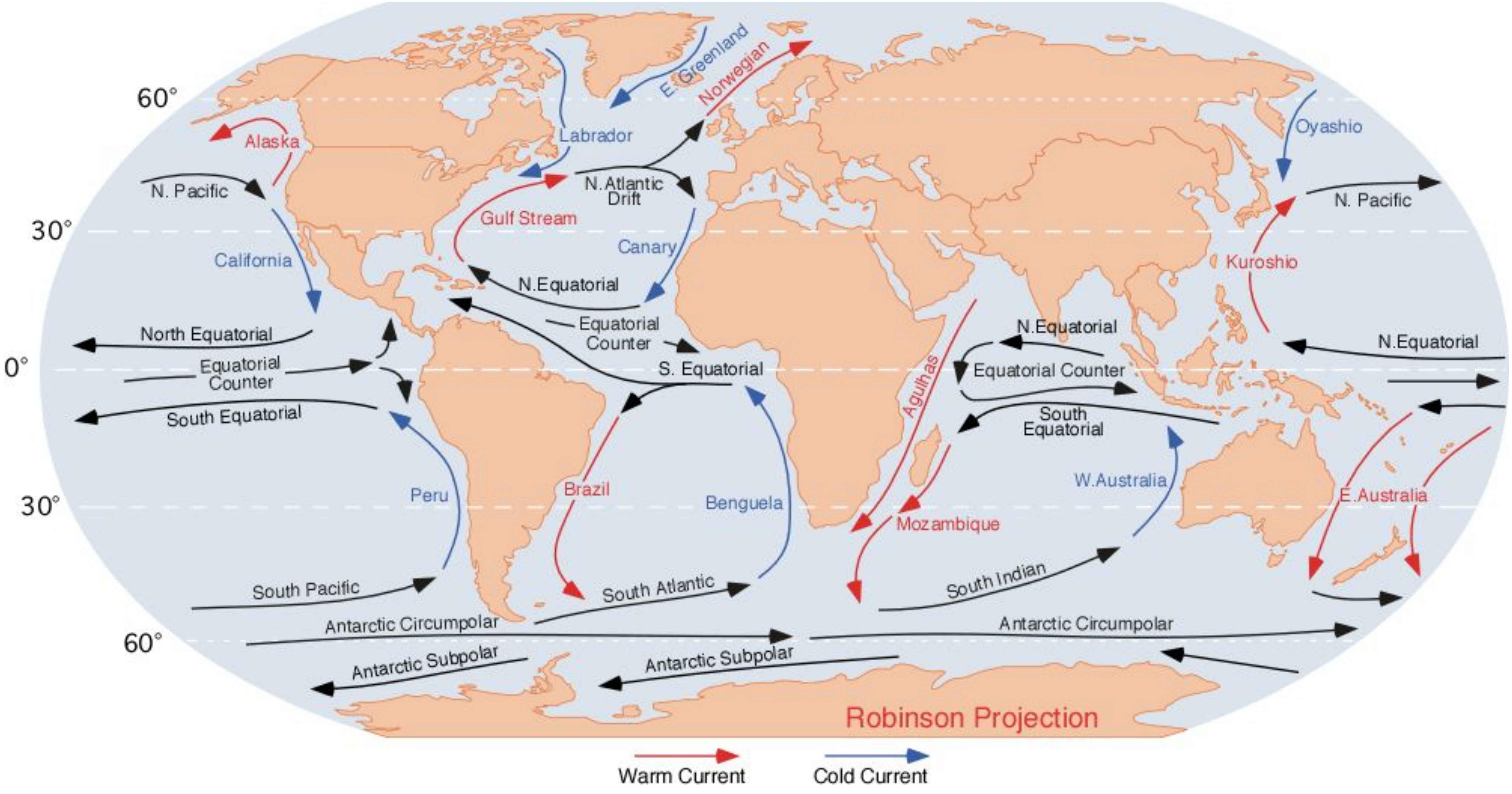
Coastal regions are forgotten

Seedbanks provide information about the future

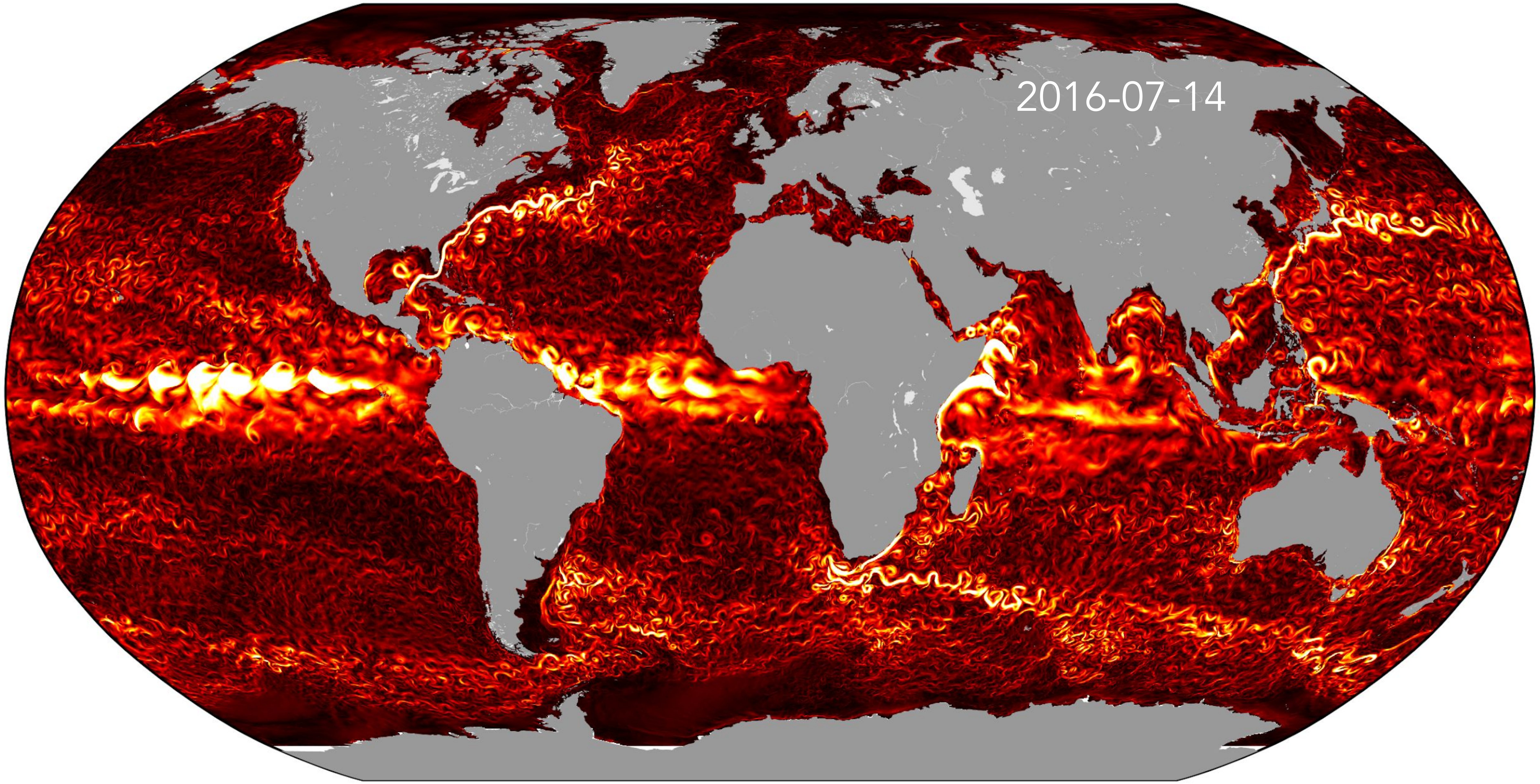
Global primary production is poorly constrained


ARCT
GFST
CARB
WTRA
10d
1m
3m
6m
2
4
6
8
10
12
14

Cartoon Oceanography



http://www.physicalgeography.net



Copernicus/Mercator 1/12° simulation

bror.jonsson@unh.edu

Primary Production Using a Lagrangian Frame

Dominating timescales of variability

Global Ocean Connectivity and Refuge Regions