SYMPOSIUM OP'24

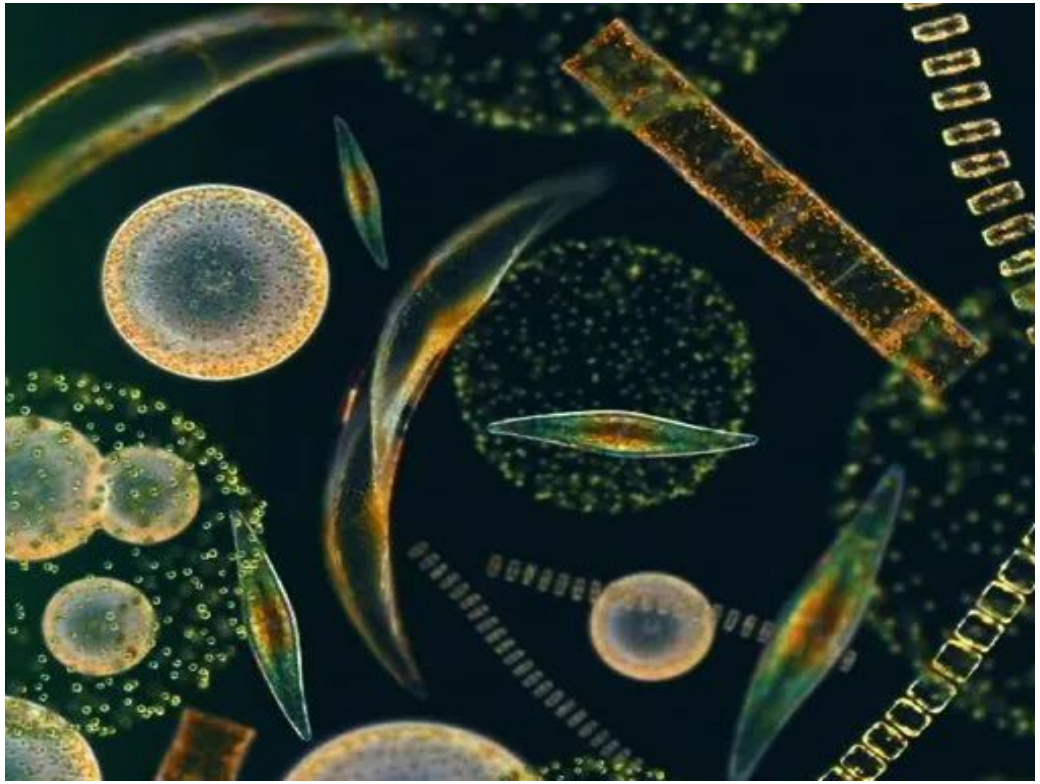
Ocean Predict

In partnership with unesco Intergovernmental Oceanographic Commission

2021 2030 United Nations Decade of Ocean Science for Sustainable Development

Predicting Seasonal Global Chlorophyll-a from Physical Ocean Forecasts with Compact Neural Networks

Gabriela Martinez Balbontin (MOi),
Julien Jouanno (LEGOS), Rachid Benshila(LEGOS),
Coralie Perruche (MOi), Julien Lamouroux (MOi),
Stefano Ciavatta (MOi)



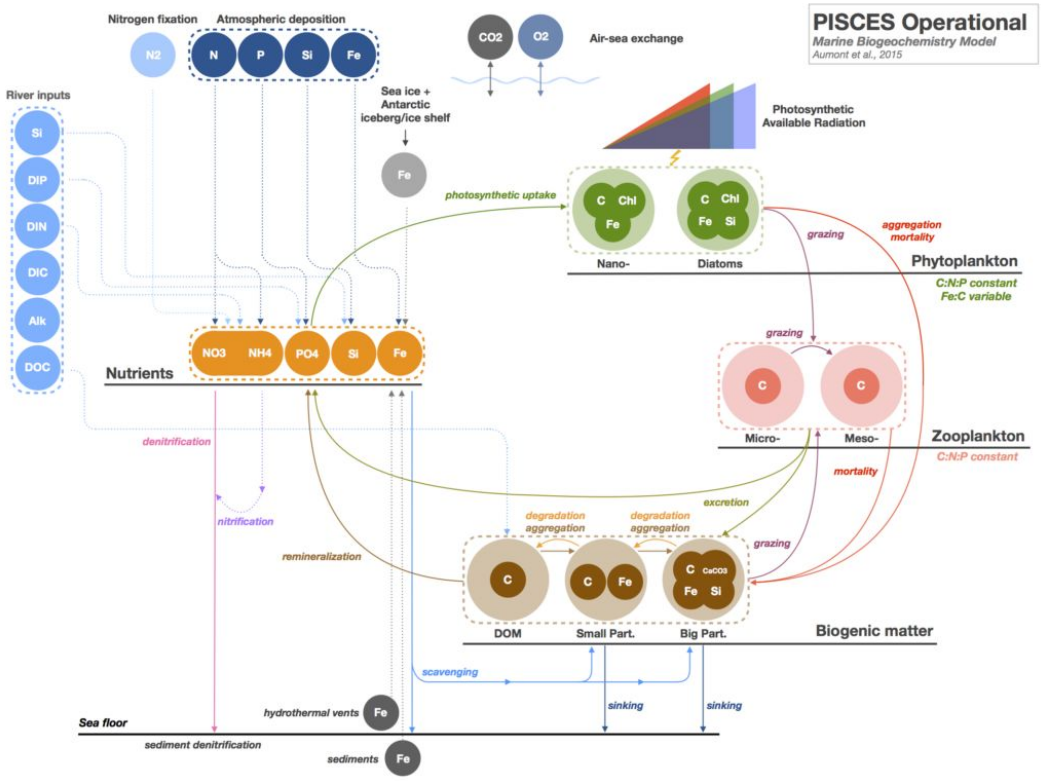
Source: planktonforhealth.co.uk

Chlorophyll-a is an important indicator of the health of marine ecosystems.

It reflects phytoplankton biomass and ecosystem productivity.

⟶ Fisheries management and biodiversity conservation

⟶ Harmful algal bloom detection



Source: PISCES

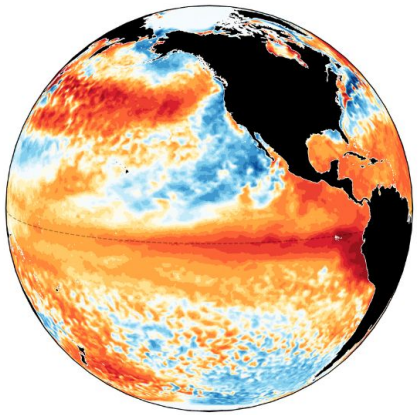
Underlying biogeochemical processes are complex and multifaceted

→ Computationally expensive and timely to model

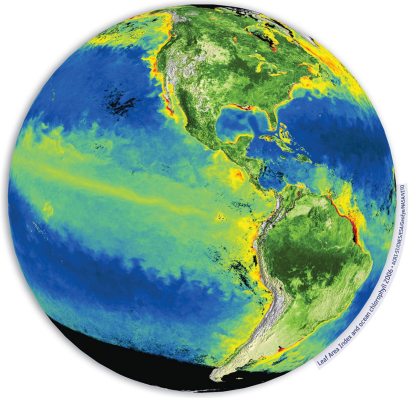
→ Difficult to parametrize

Machine learning can be used to link physical variables to biogeochemical outcomes without the need to explicitly capture these patterns.

Reanalyses, existing forecasting systems



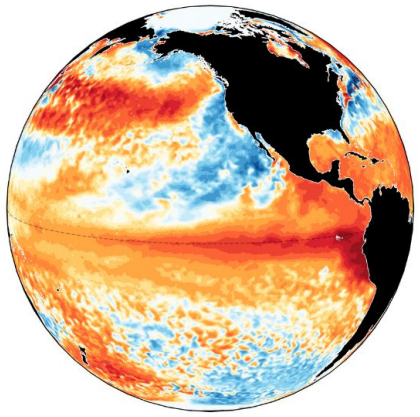
MLD, SSH, SSS, SST
(surface)



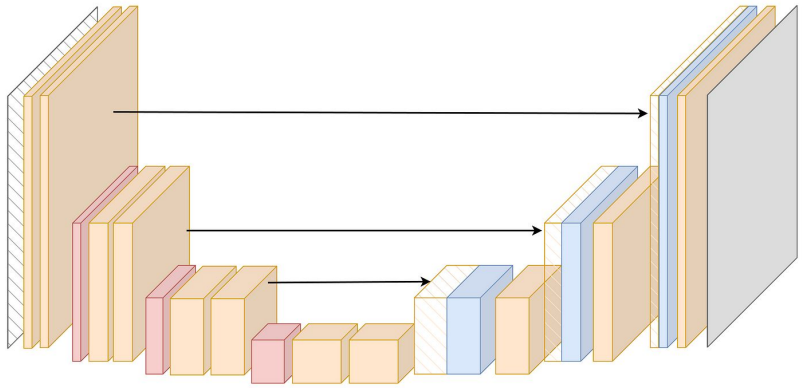
Chlorophyll-a
(surface)

Satellite-derived observations

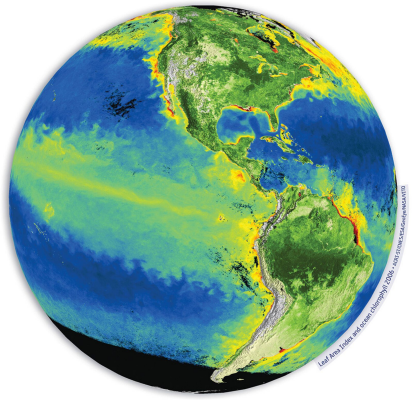
Machine learning can be used to link physical variables to biogeochemical outcomes without the need to explicitly capture these patterns.



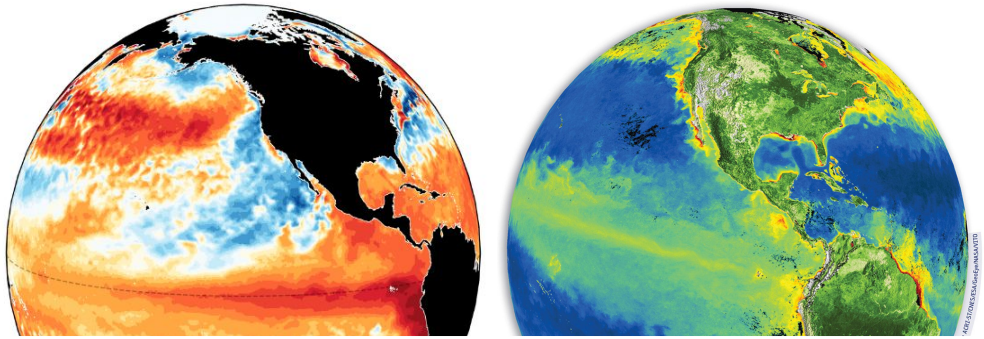
MLD, SSH, SSS, SST
(surface)



The model:
3D Unet-like CNN



Chlorophyll-a
(surface)



Training data (1998 - 2016)

Physics (MLD, SSH, SSS, SST)

GLORYS12

Chlorophyll-a

GlobColour

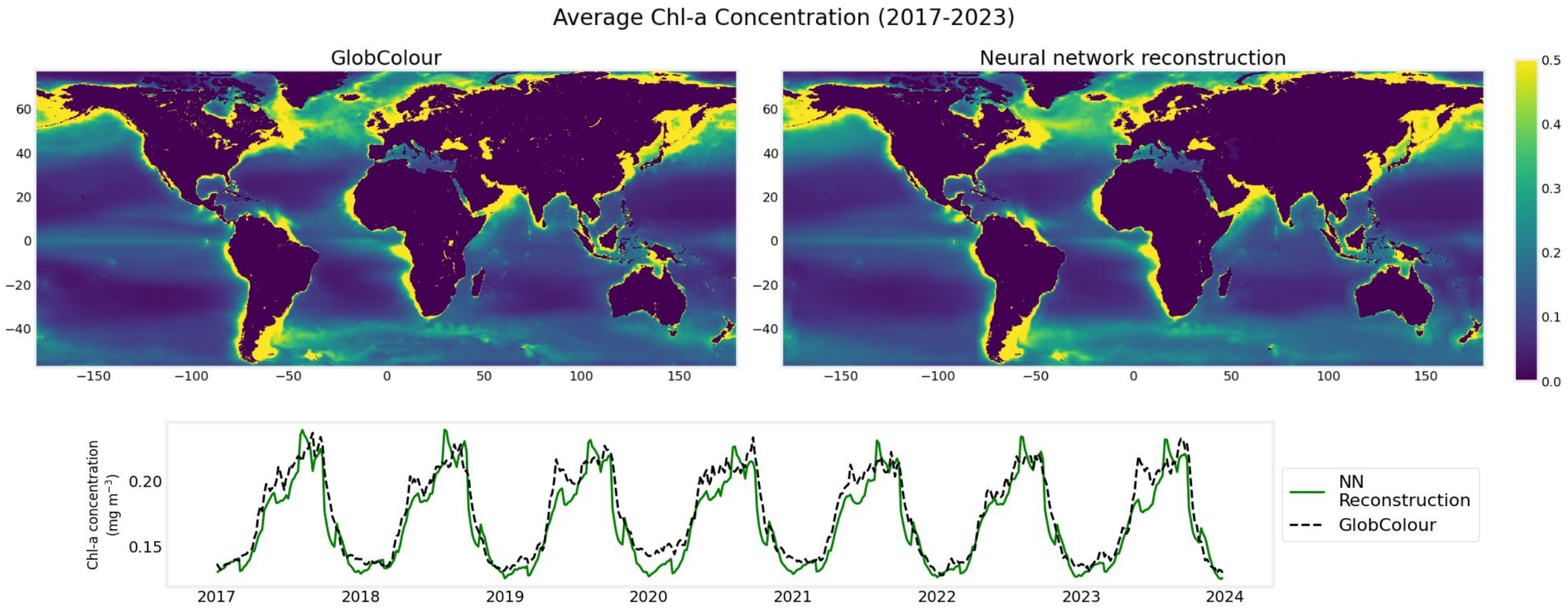
Input physics for inference

Reconstruction (2017-2023):

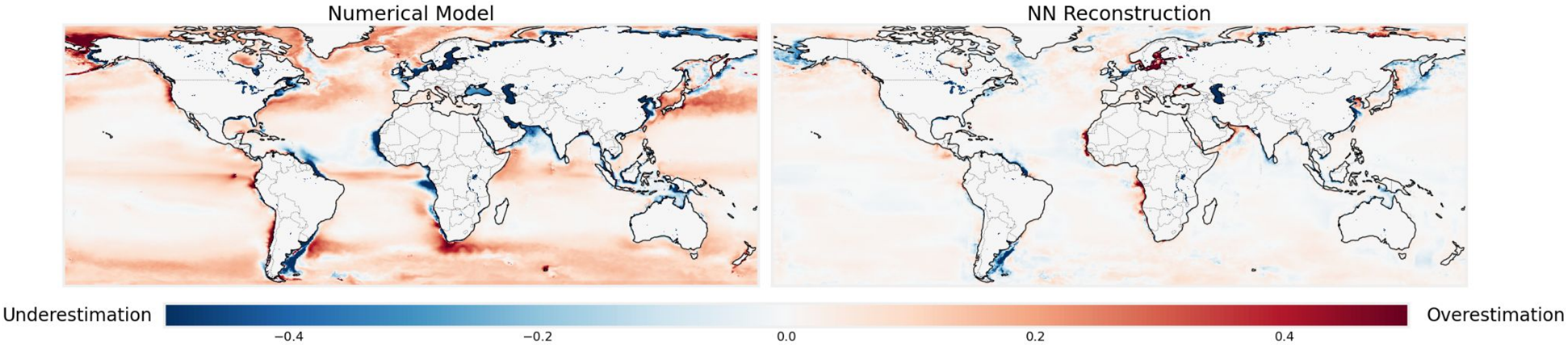
GLORYS12 (weekly, 1/4°)

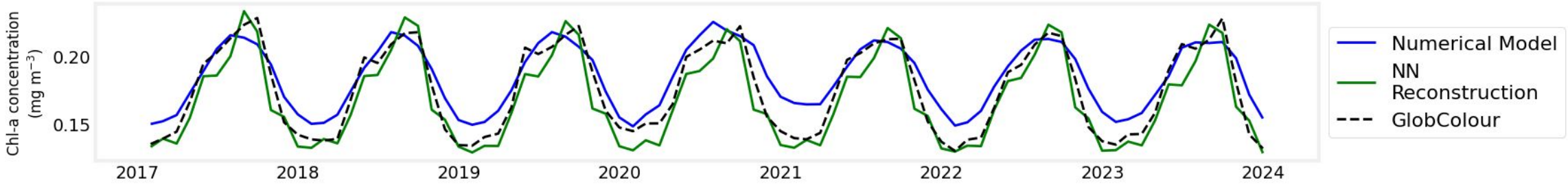
Reforecast (2017-2019)

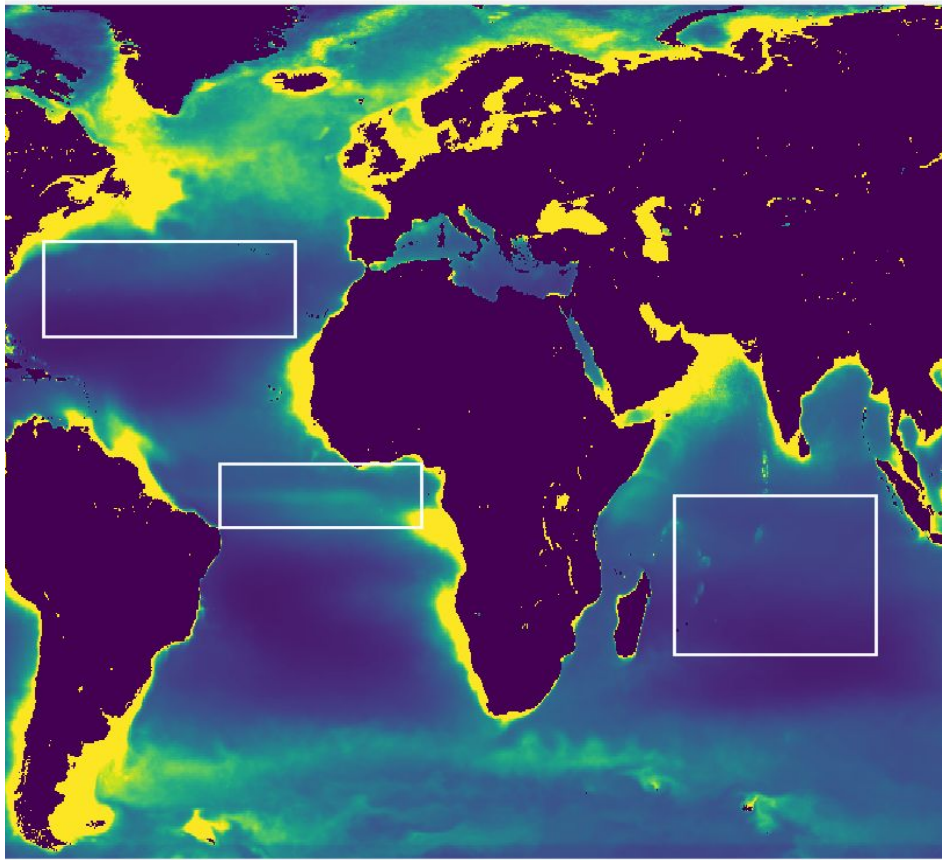
SEAS5 (ECMWF; monthly, 1/4°)

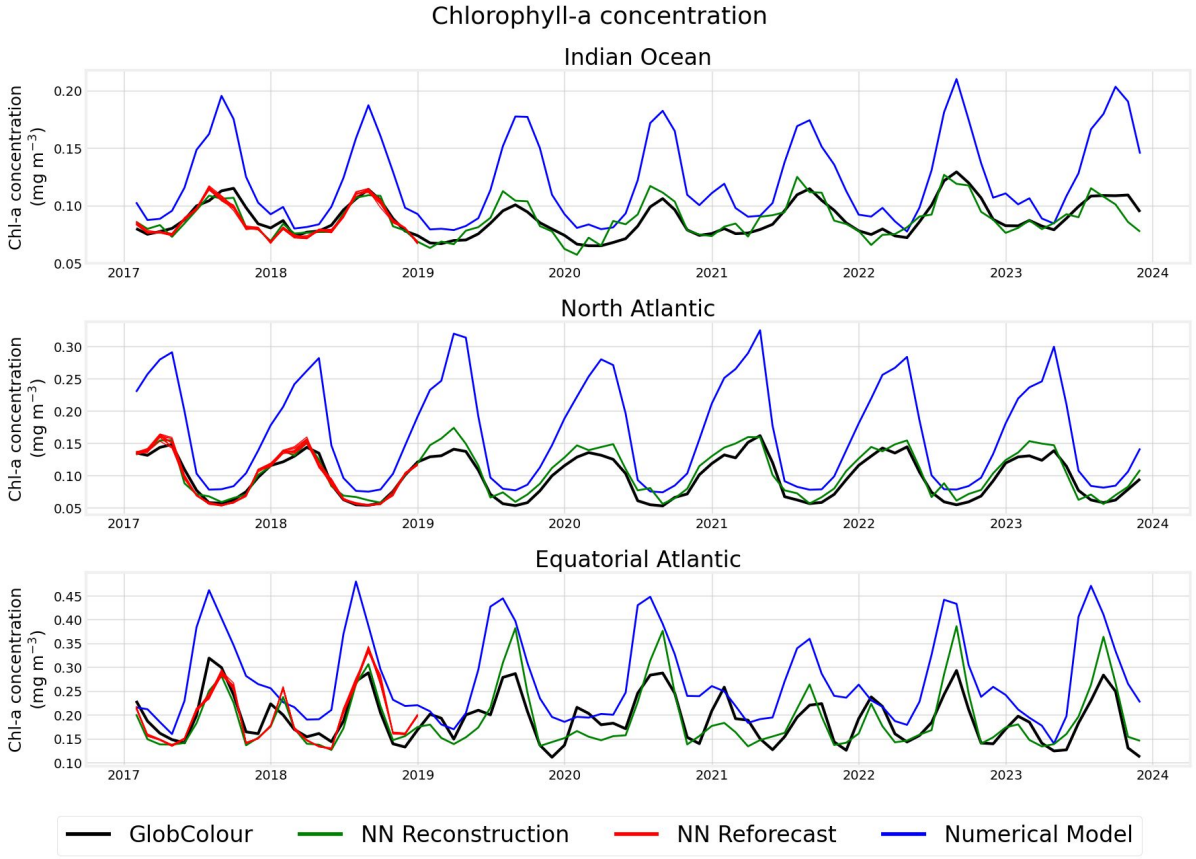

Average Chl-a Concentration (2017-2023)
GlobColour
Neural network reconstruction
60
40
20
0
−20
−40
−150
−100
−50
0
50
100
150
0.5
0.4
0.3
0.2
0.1
0.0
Chl-a concentration (mg m^{-3})
0.20
0.15
2017
2018
2019
2020
2021
2022
2023
2024
NN Reconstruction
GlobColour

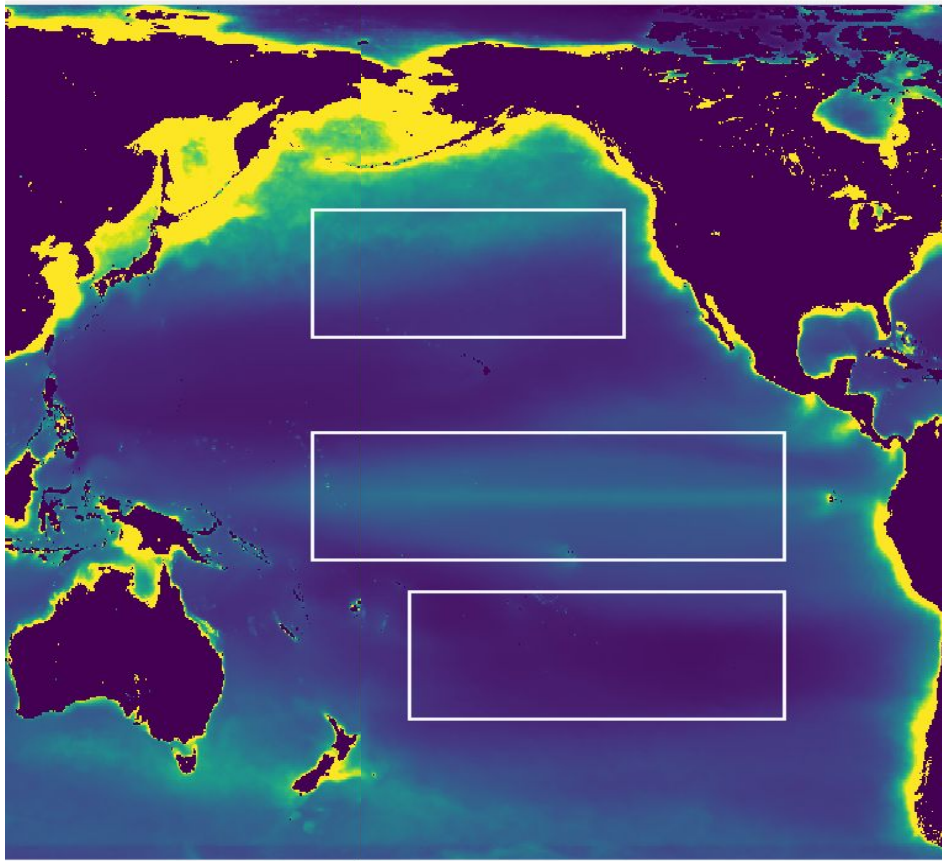
Bias with respect to GlobColor (2017-2023)

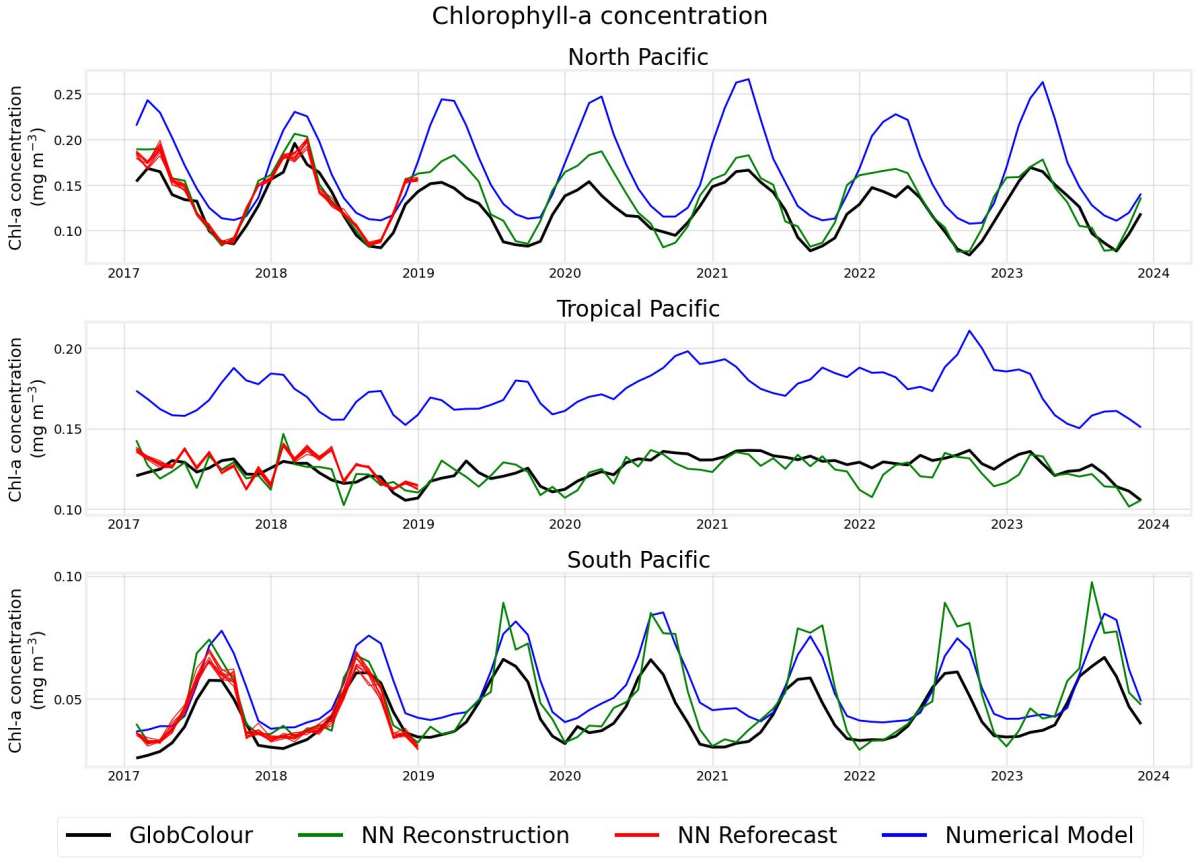




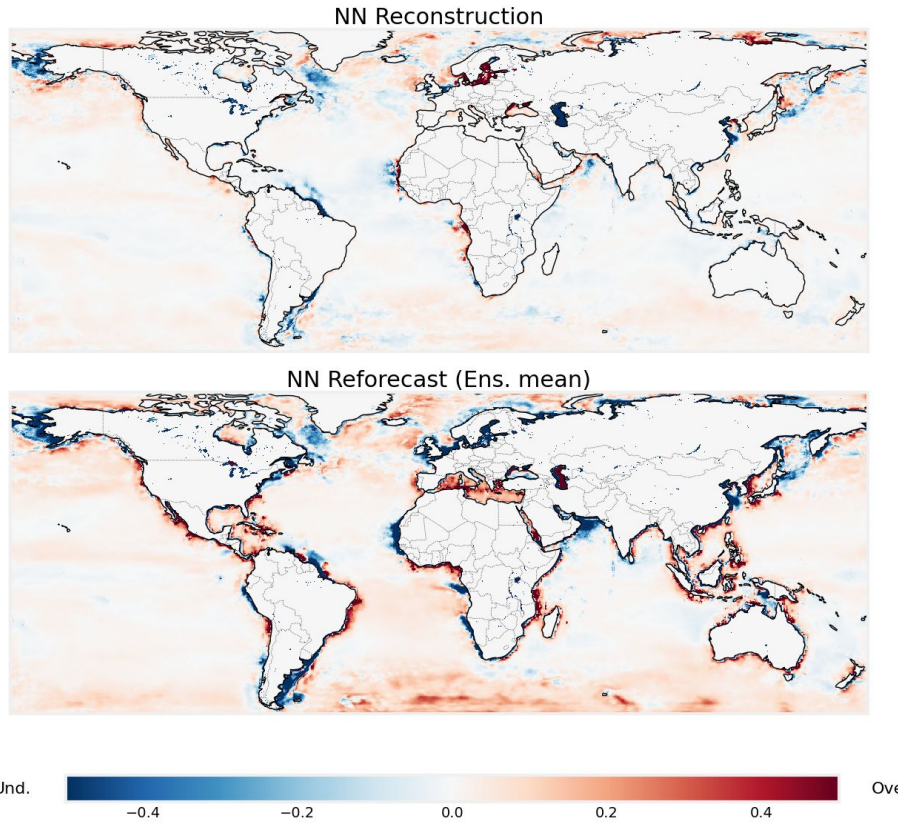



Chlorophyll-a concentration
Indian Ocean
North Atlantic
Equatorial Atlantic
Chl-a concentration (mg m^{-3})
2017
2018
2019
2020
2021
2022
2023
2024
GlobColour
NN Reconstruction
NN Reforecast
Numerical Model

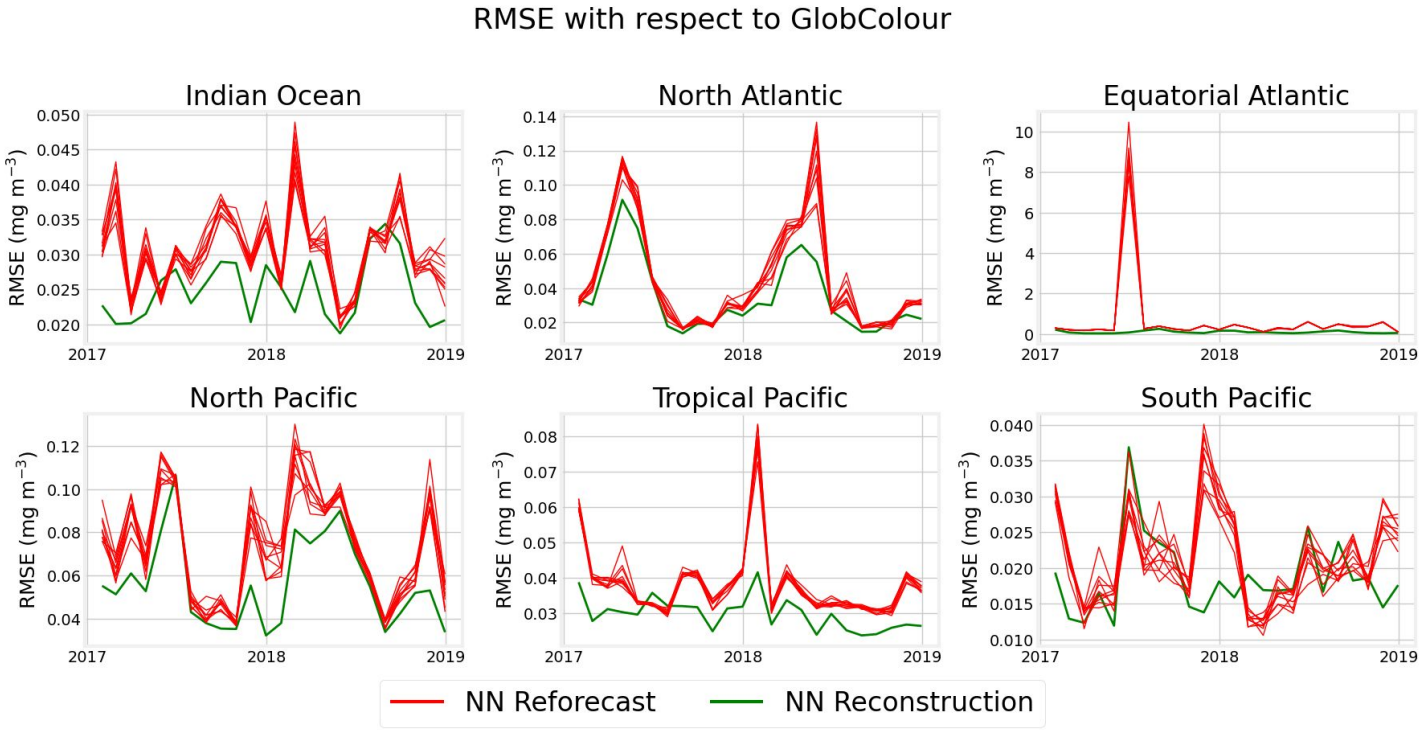



Chlorophyll-a concentration
North Pacific
Tropical Pacific
South Pacific
Chl-a concentration (mg m⁻³)
2017
2018
2019
2020
2021
2022
2023
2024
GlobColour
NN Reconstruction
NN Reforecast
Numerical Model

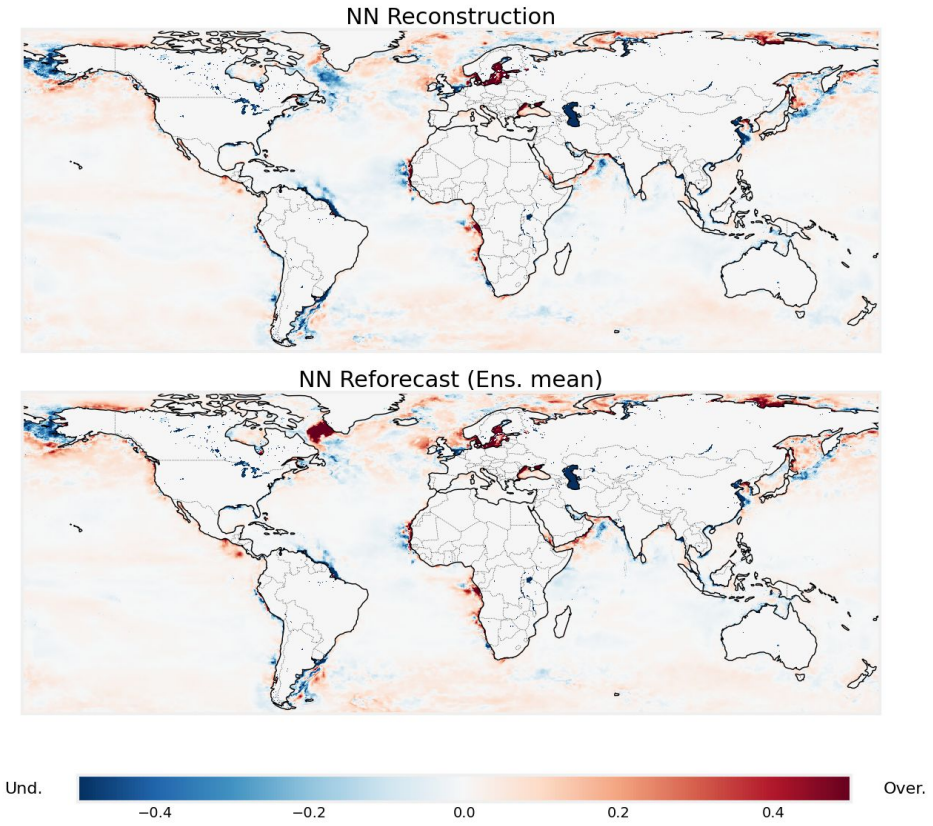
Bias with respect to GlobColor (2017-2019)



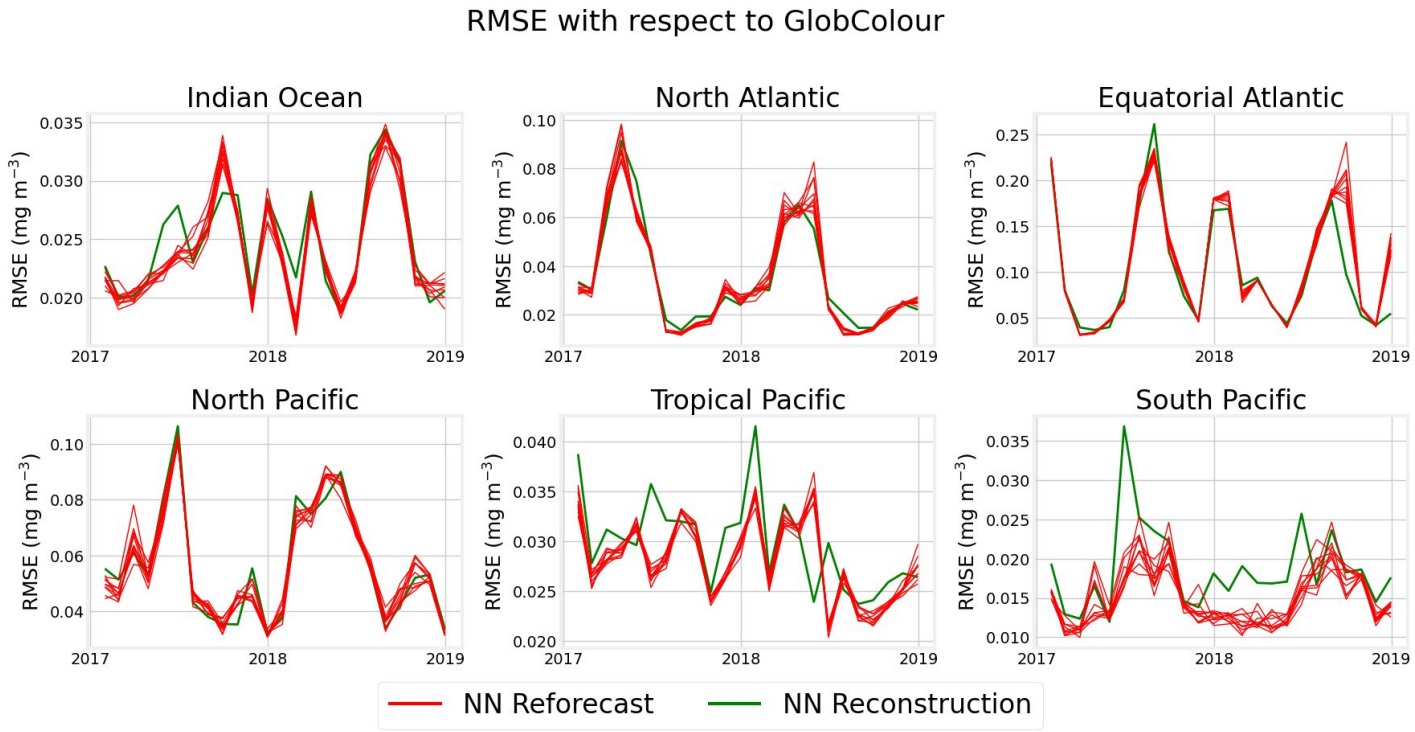
Error from using SEAS5 forecast as input as is



Bias with respect to GlobColor (2017-2019)



After correcting with a climatology from the reanalysis

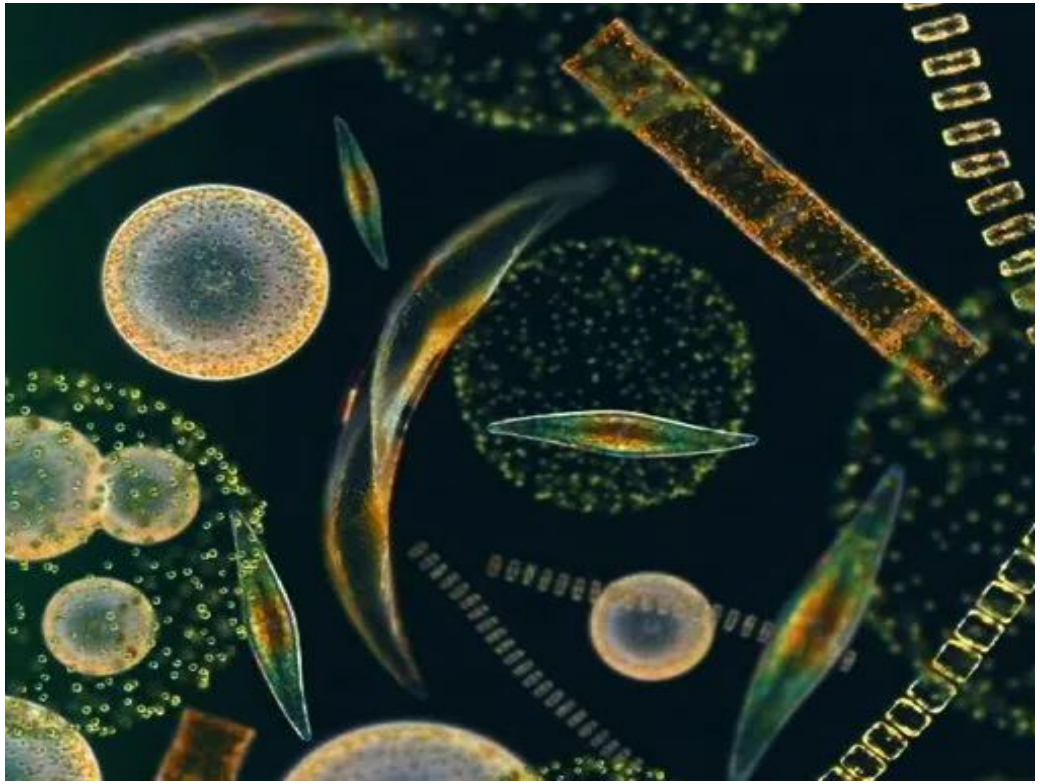


SYMPOSIUM OP'24

Ocean Predict

In partnership with unesco Intergovernmental Oceanographic Commission

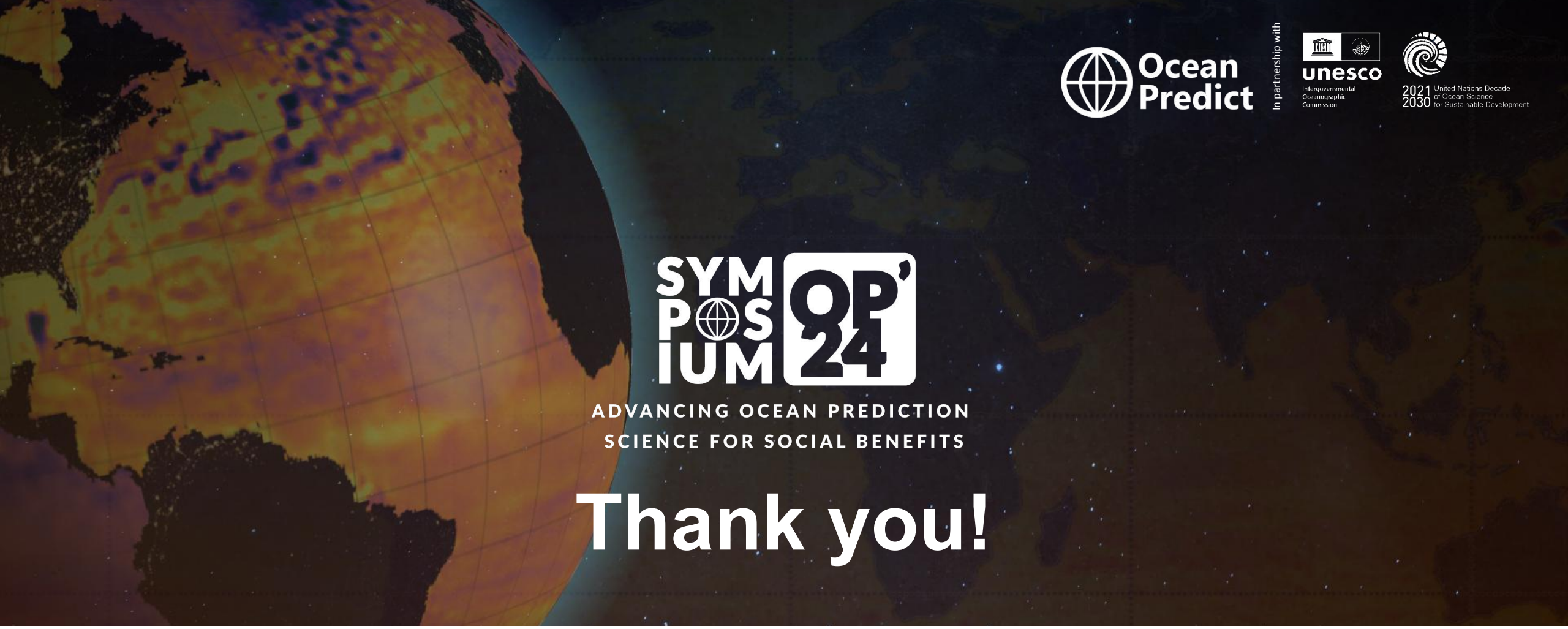
2021 2030 United Nations Decade of Ocean Science for Sustainable Development



Source: planktonforhealth.co.uk

We can use machine learning to reconstruct surface-level chlorophyll-a from physical ocean forecasts.

This has an accuracy that rivals that of the numerical model while requiring only a single GPU.



Ocean Predict

In partnership with unesco Intergovernmental Oceanographic Commission

2021 2030 United Nations Decade of Ocean Science for Sustainable Development

SYMPOSIUM OP'24

ADVANCING OCEAN PREDICTION
SCIENCE FOR SOCIAL BENEFITS

Thank you!

European Commission

Copernicus Marine Service

EU4oceanobs
INTERNATIONAL OCEAN GOVERNANCE
EU COMPONENT TO GLOBAL OCEAN OBSERVATIONS

esa

cnes
CENTRE NATIONAL D'ÉTUDES SPATIALES

Met Office

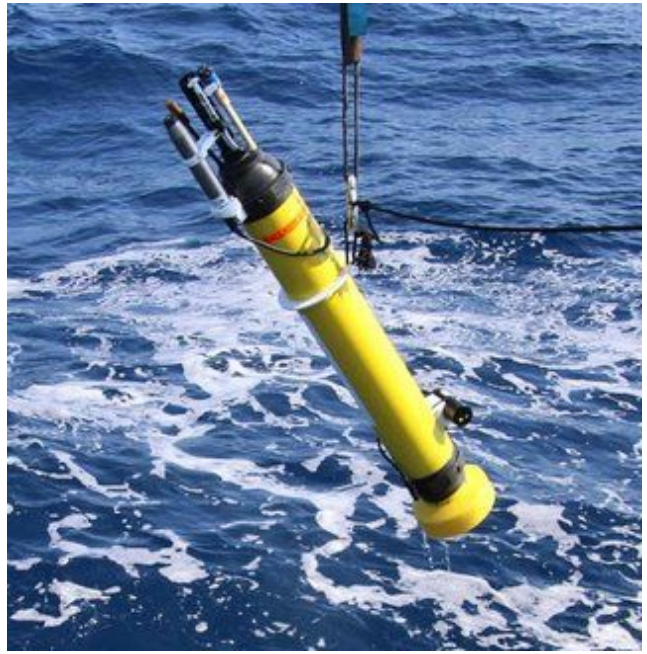
NERSC

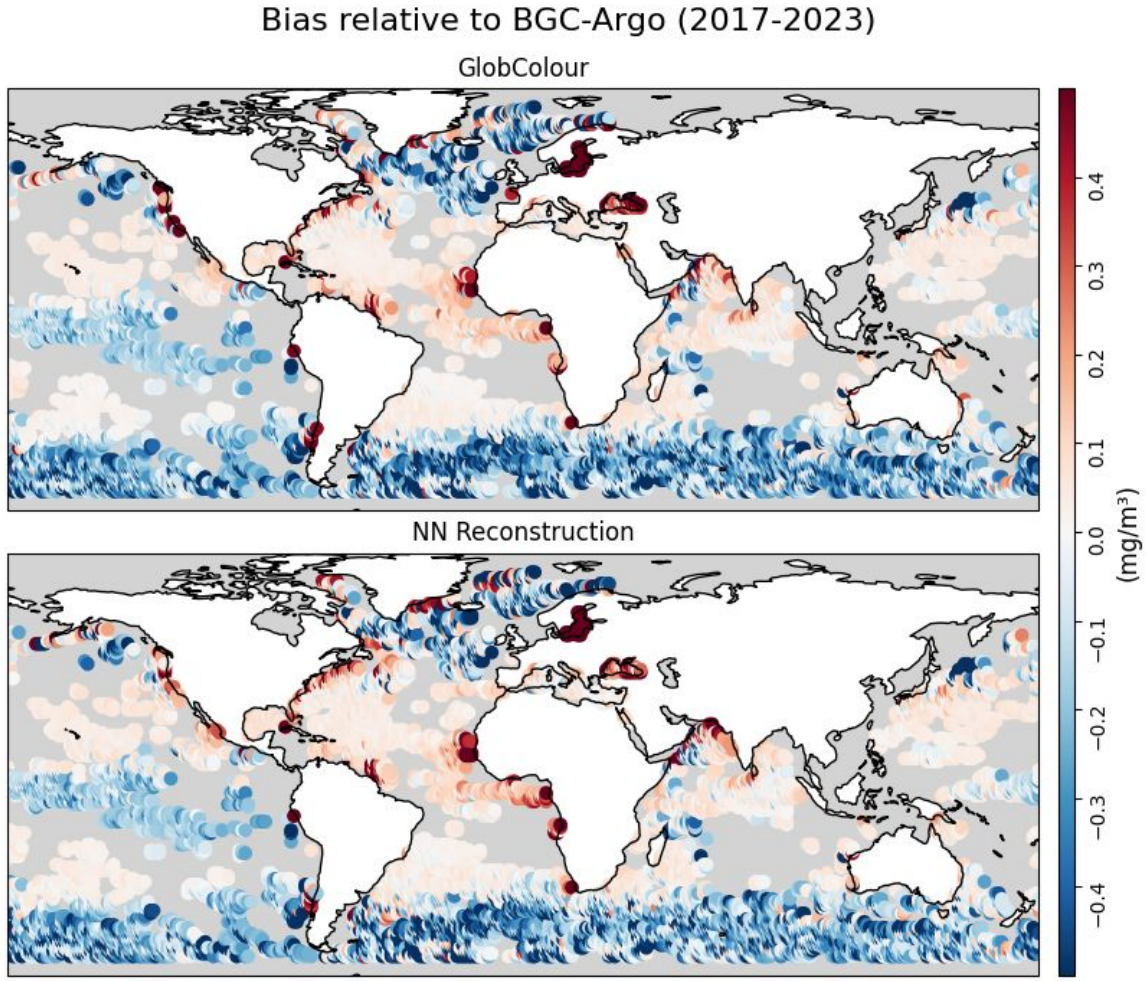
MERCATOR OCEAN INTERNATIONAL

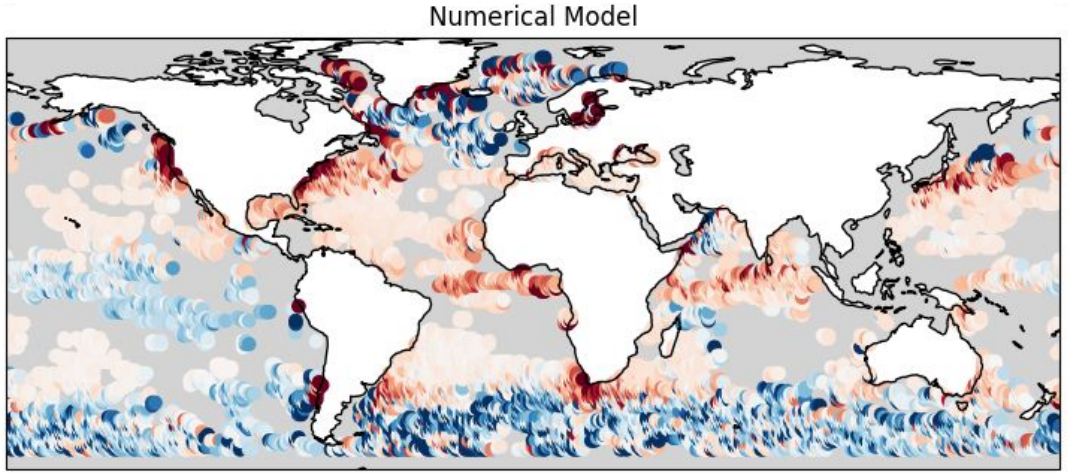
Australian Government
Bureau of Meteorology

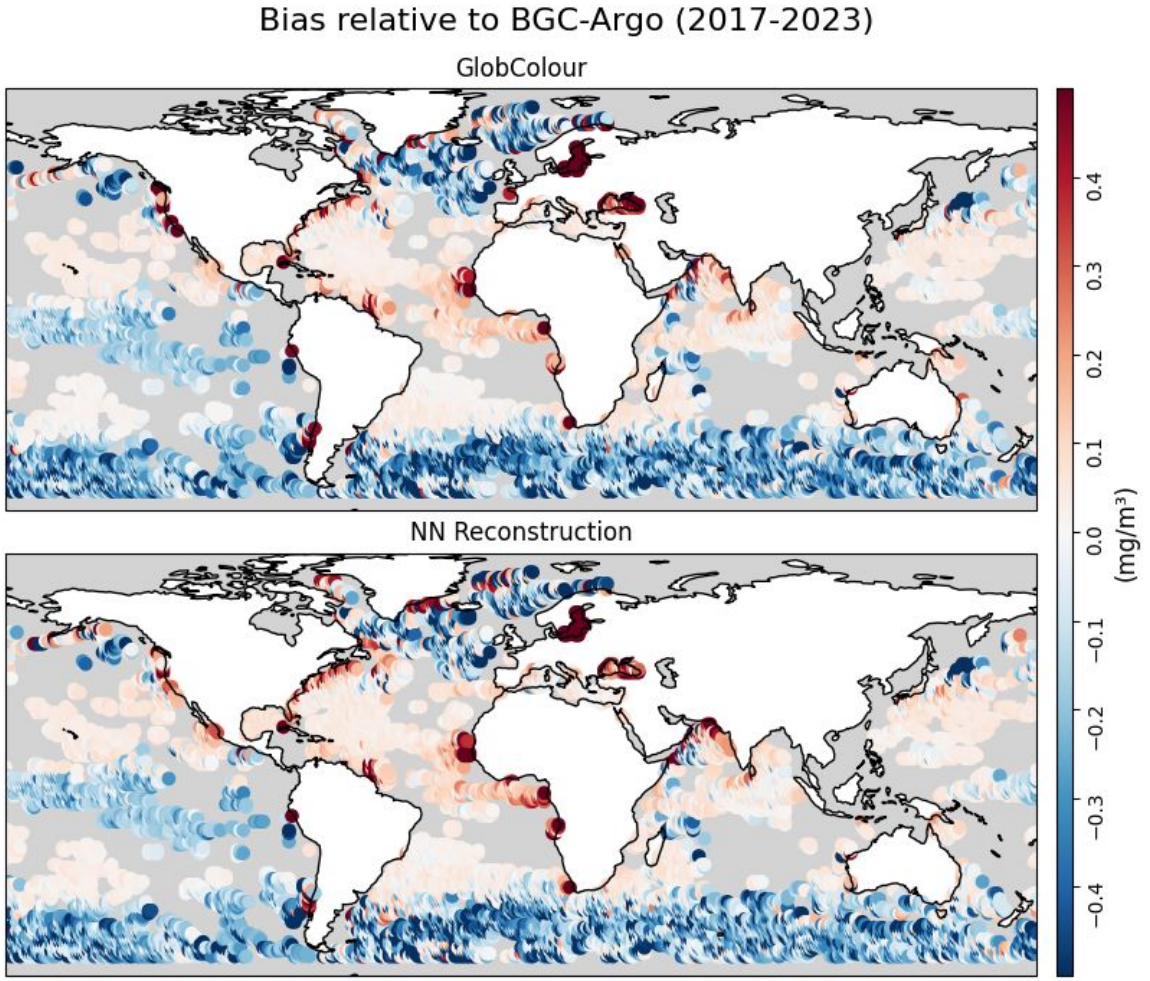
Canada

The neural network acts like a GlobColour emulator






Numerical Model


Bias relative to BGC-Argo (2017-2023)
GlobColour
NN Reconstruction
0.4
0.3
0.2
0.1
0.0
−0.1
−0.2
−0.3
−0.4
(mg/m³)