Remote Sensing of N, P, and Si: A Deep Machine Learning Approach

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NSF Cybertraining Workshop

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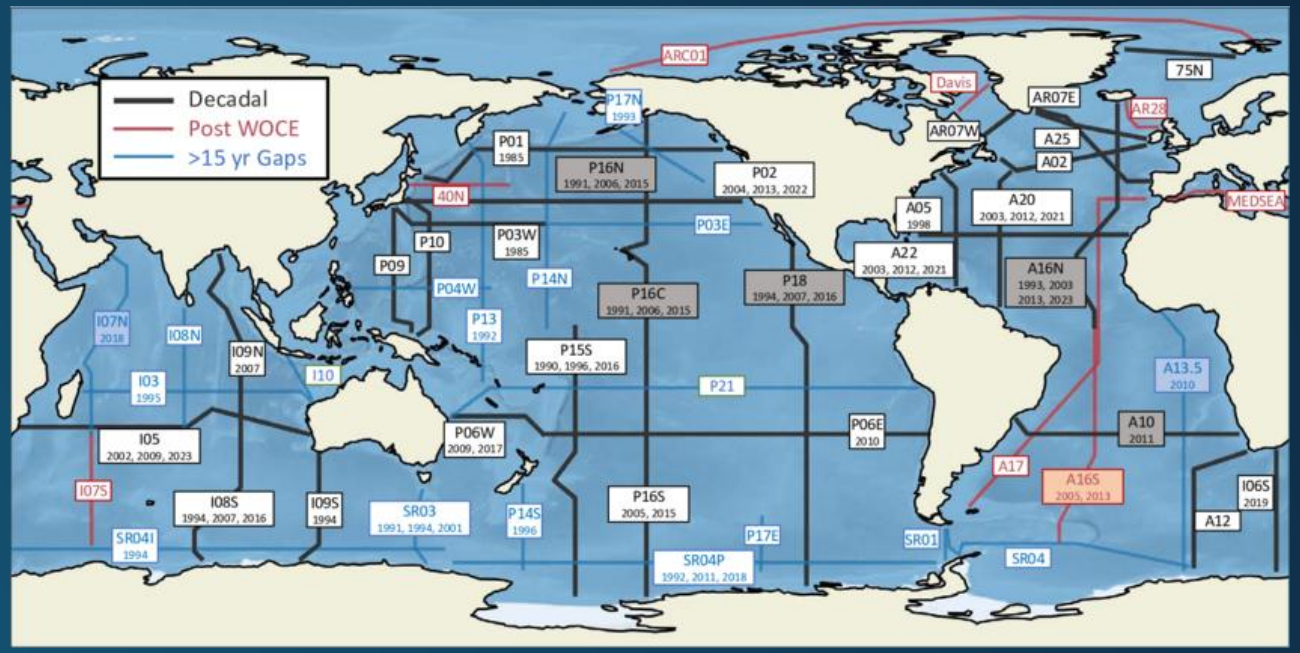
Wilmington, NC

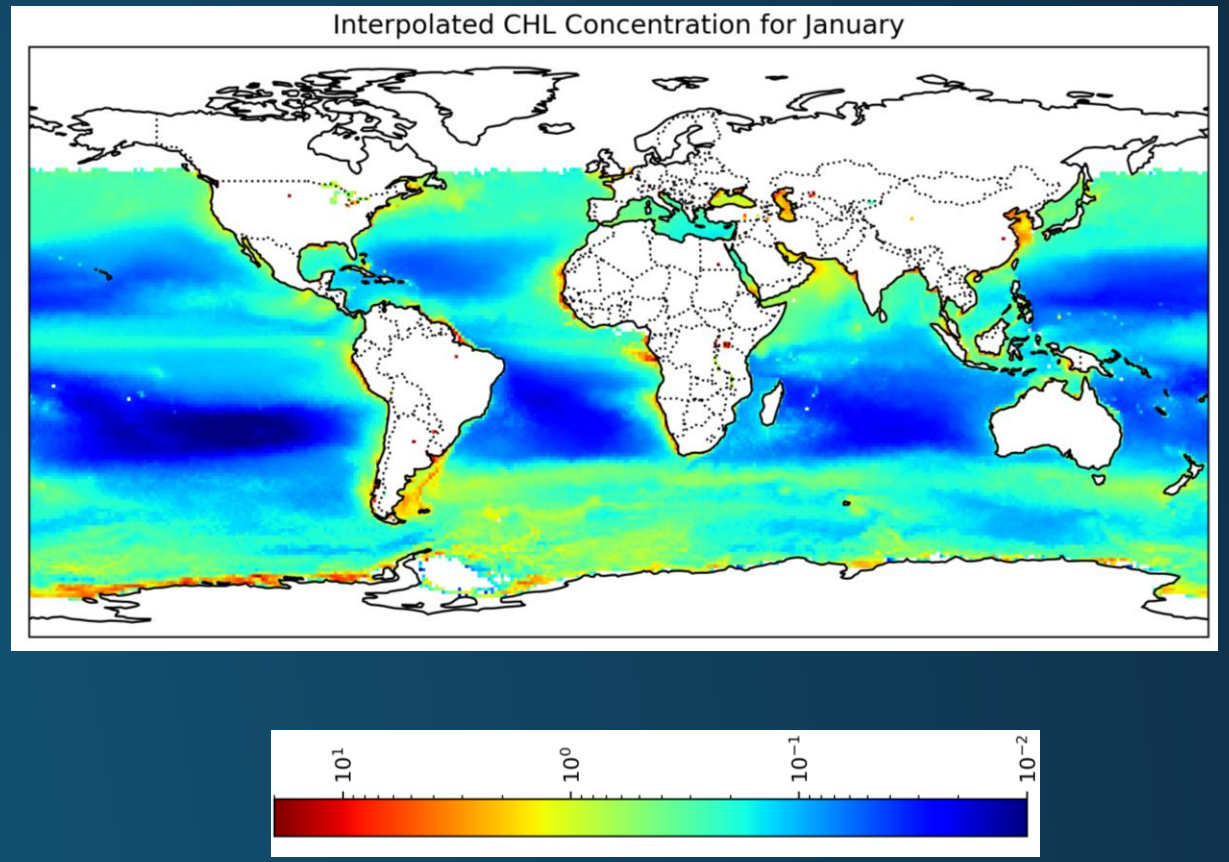
GO-SHIP

- Ship based-on observations
- nutrients measurements
- High quality, but very limited spatial coverage



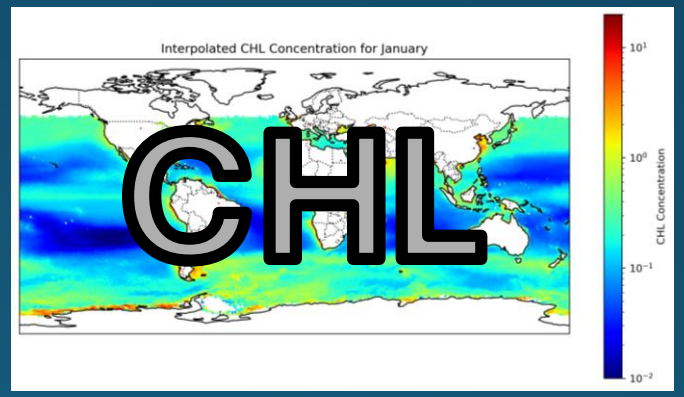
Why remote sensing?

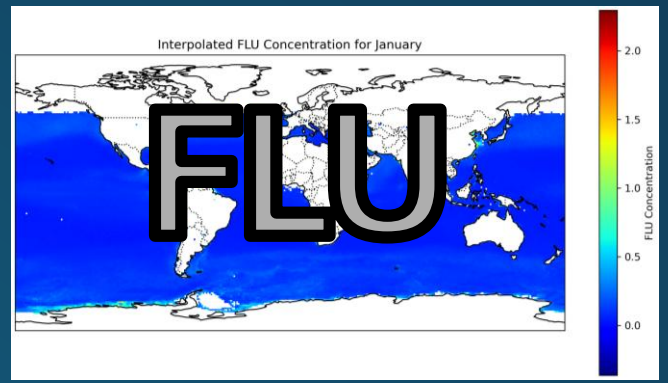
- Cover large areas of the globe
- Frequent sampling
- N, P, Si Support primary production



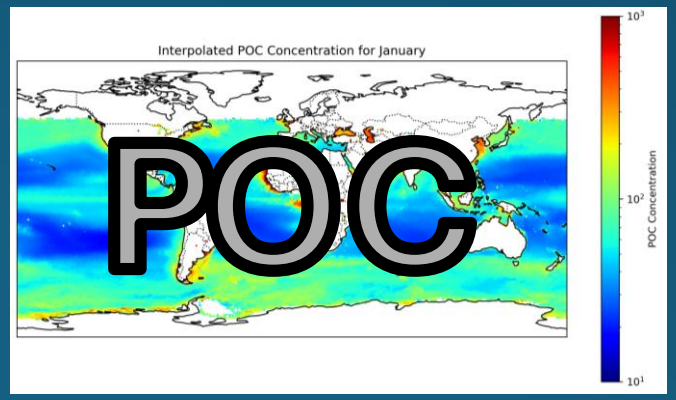
Why deep machine learning?

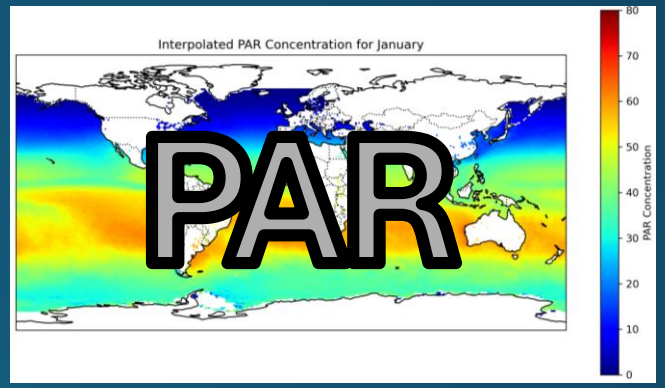
- Nutrients have weak signal
- Short wavelengths
- Direct measurements are costly, infrequent, & hazardous

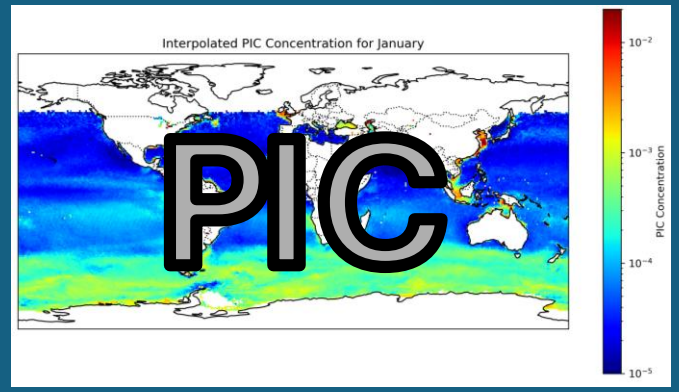

Interpolated CHL Concentration for January
CHL
CHL Concentration

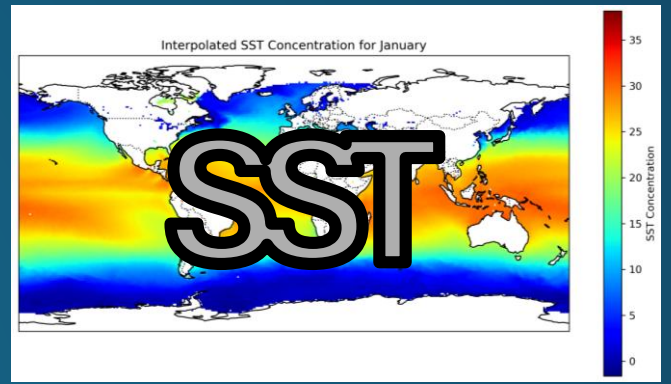

Interpolated FLU Concentration for January
FLU
FLU Concentration

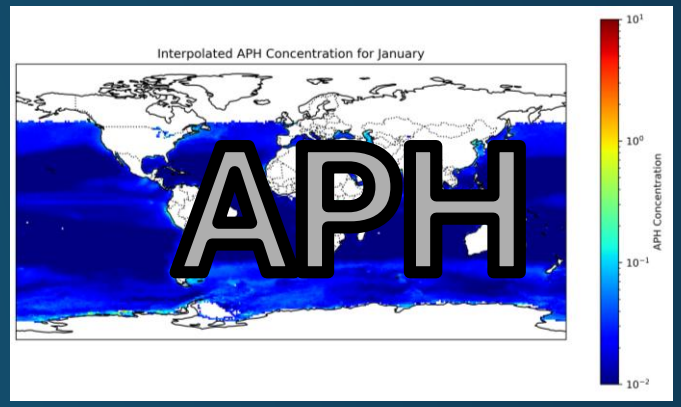
7 Inputs

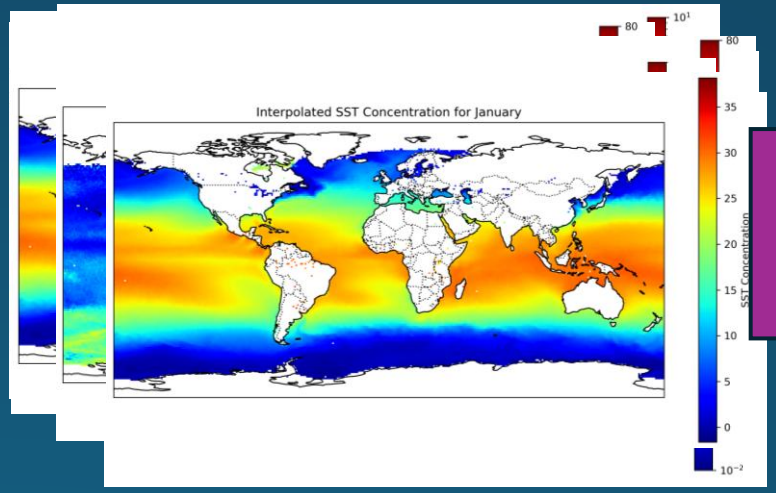

Interpolated POC Concentration for January
POC
POC Concentration


Interpolated PAR Concentration for January
PAR
PAR Concentration

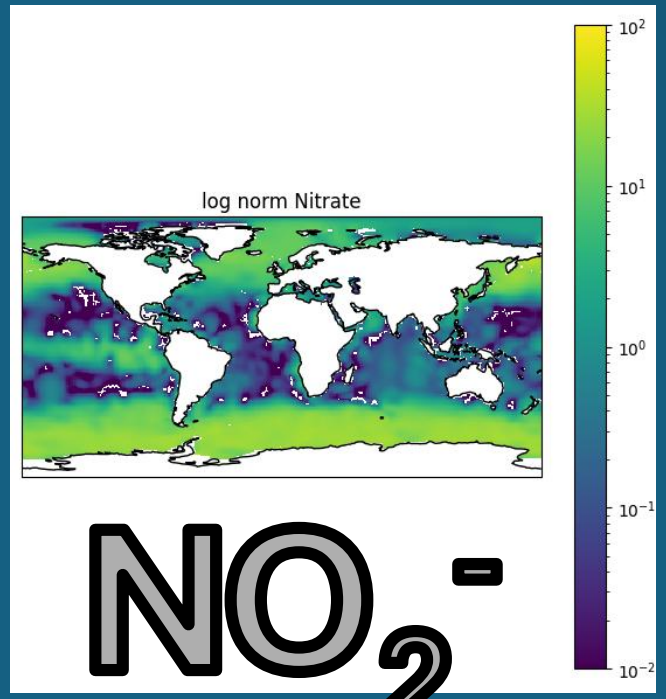

Interpolated PIC Concentration for January
PIC
PIC Concentration


Interpolated SST Concentration for January
SST
SST Concentration

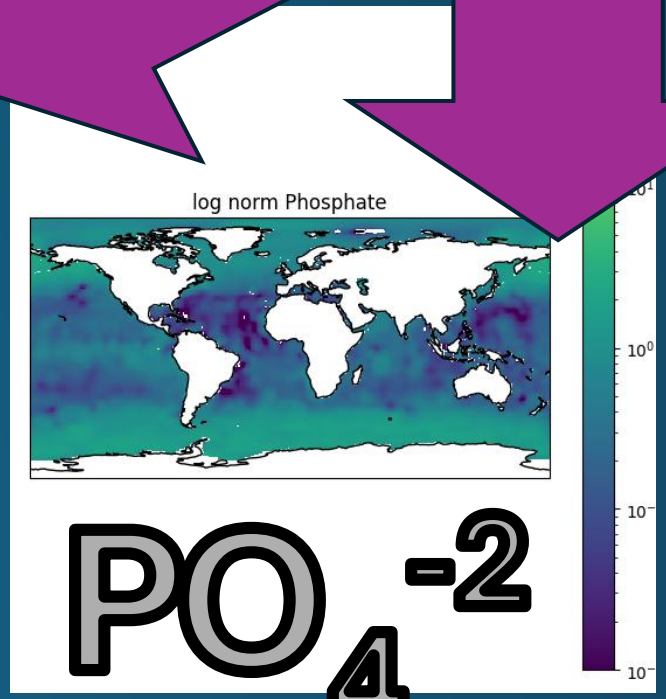

Interpolated APH Concentration for January
APH
APH Concentration



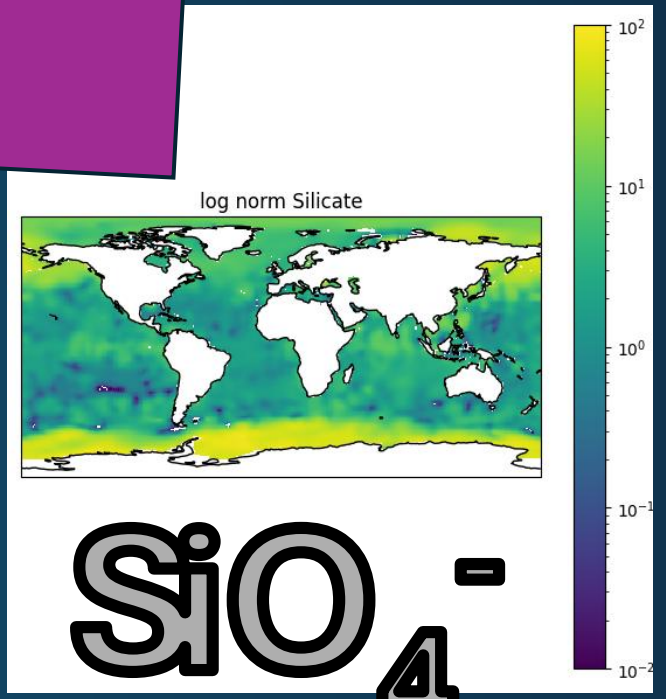
3 Outputs



NO_2^-



PO_4^{-2}

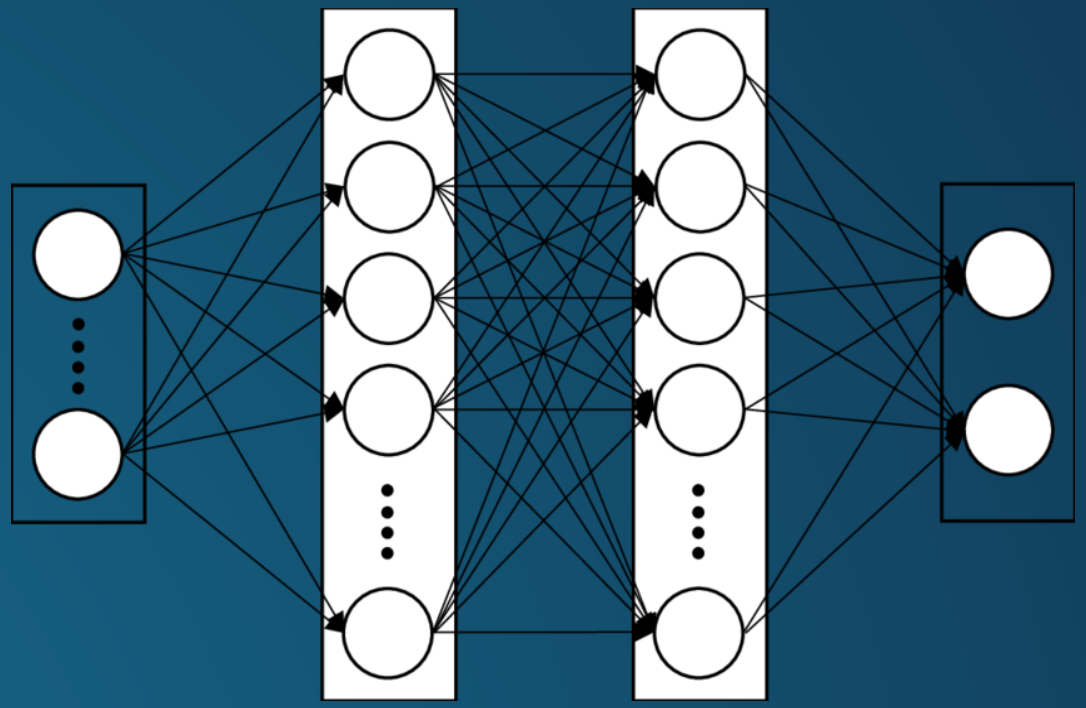


SiO_4^-

Our Model

CNN

- CHL
- SST
- PIC
- POC
- PAR
- Fluorescence
- SST



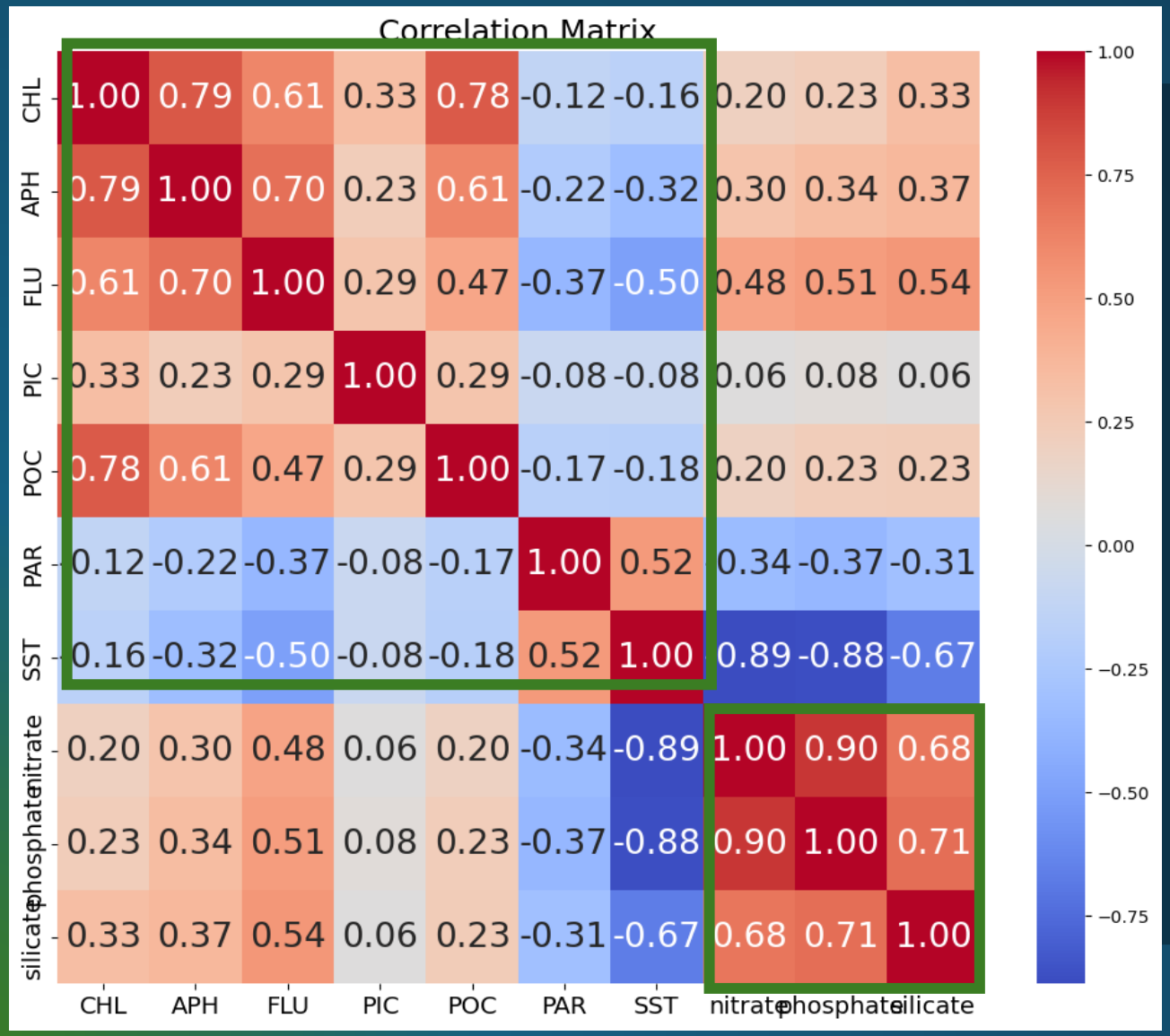
64 neurons 32 neurons

Nitrate
Phosphate
Silicate

Loss Function: Mean Squared Error

Correlation Matrice

Model Results

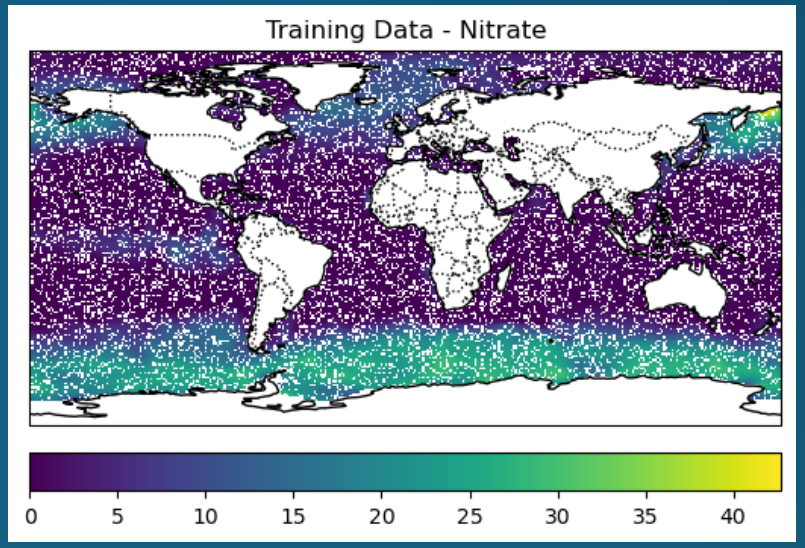


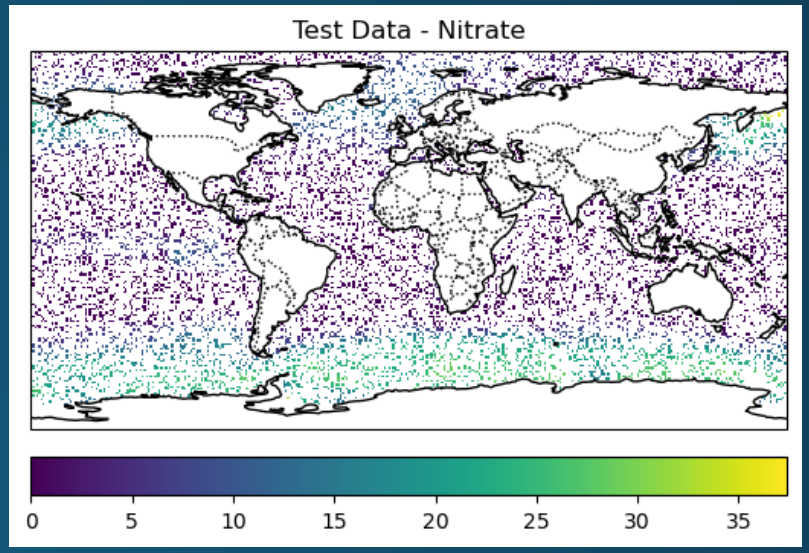
Our Model

CNN

Training data: 80%

Test data: 20%





Autokeras

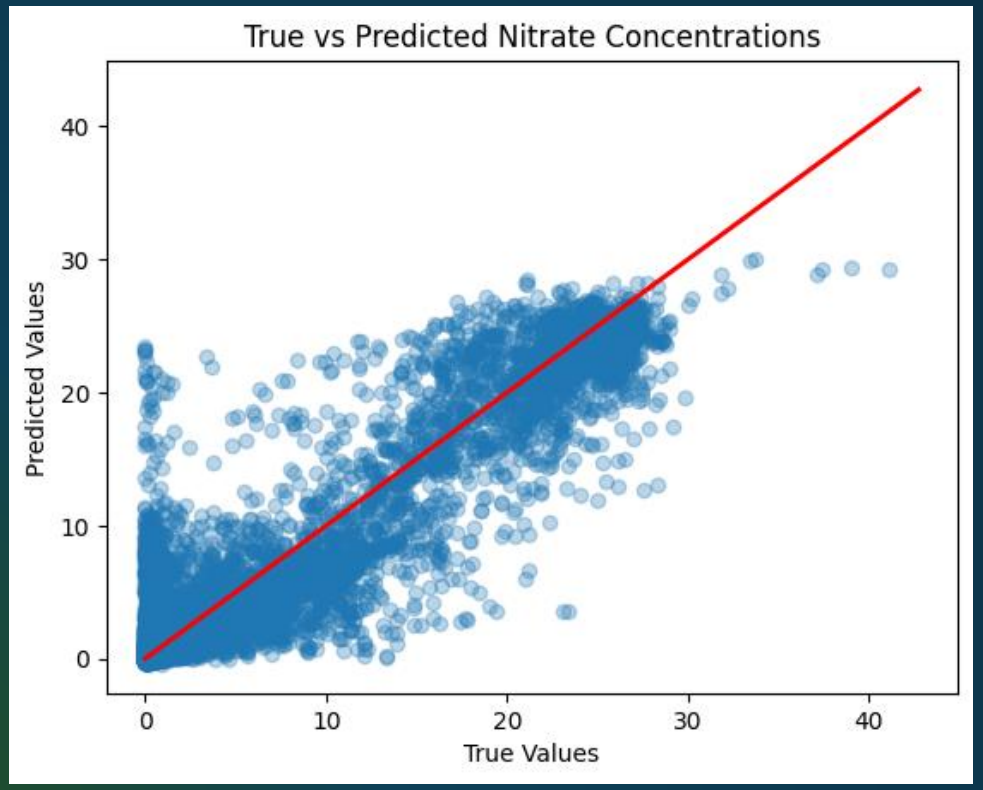
Automated Machine Learning (AutoML)

- **Specialize in DEEP LEARNING**
- **Prepare data**
- **Select model**
- **Tune parameters**
- **Write code**

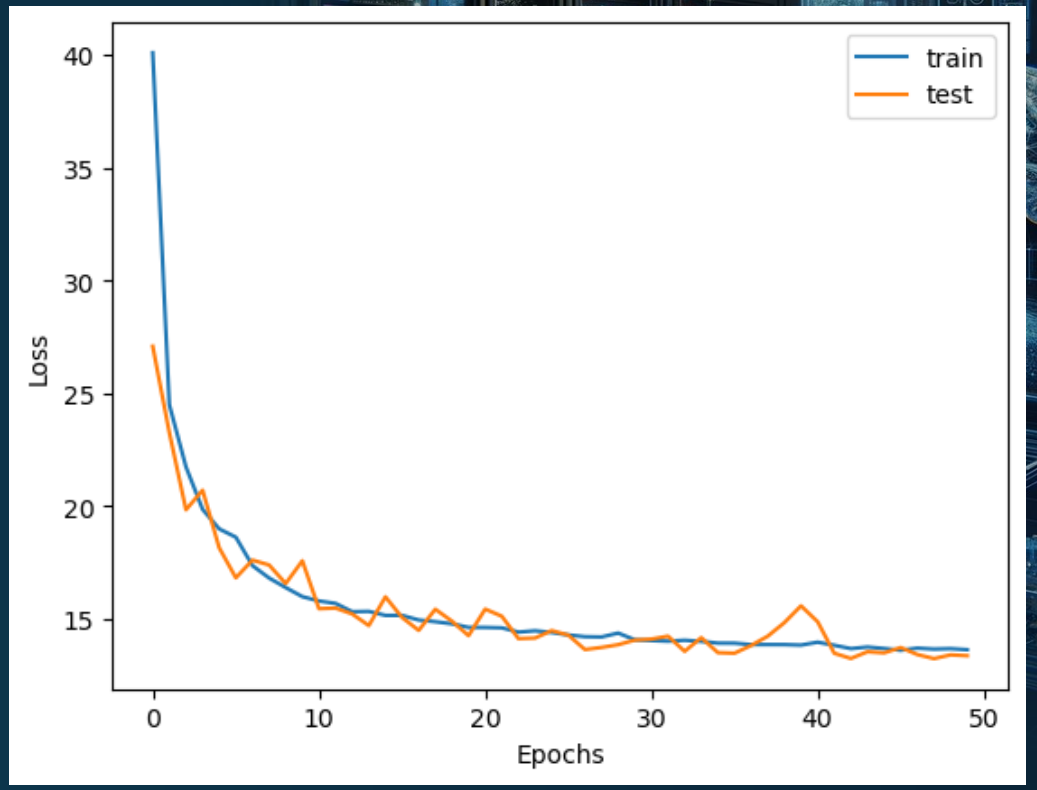
We don’t need to build the architecture by ourselves!

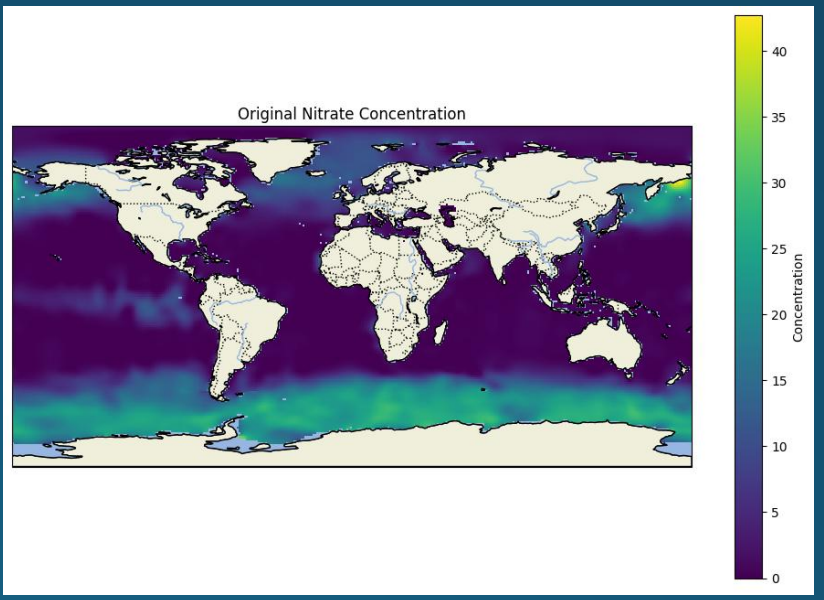
Model Results

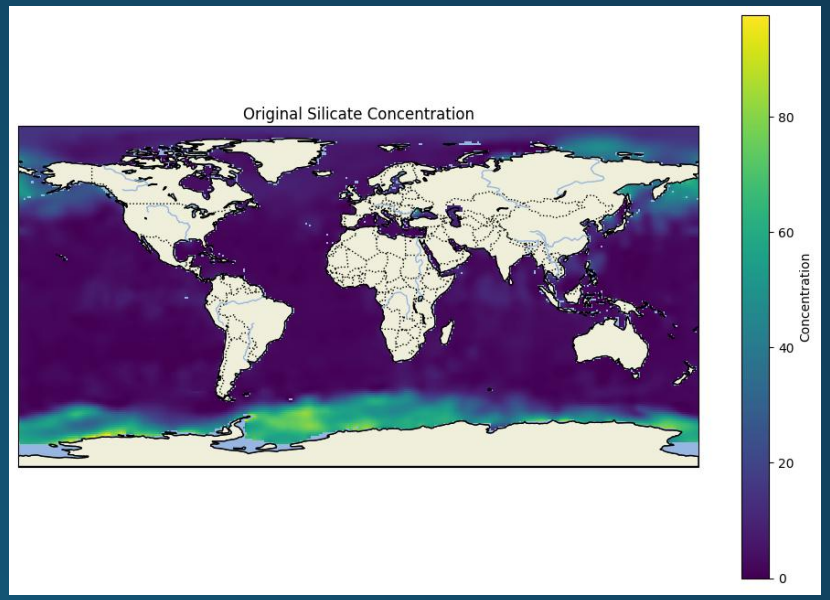
True VS predictions

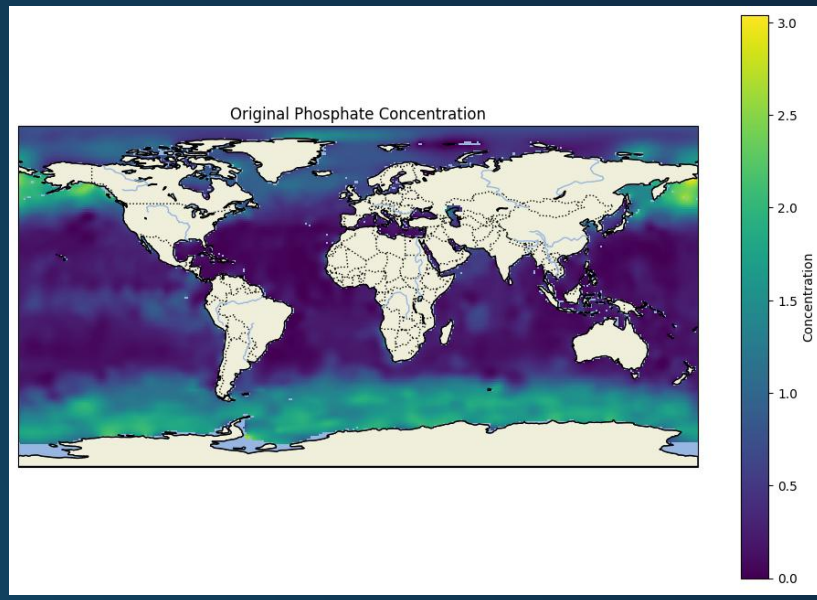


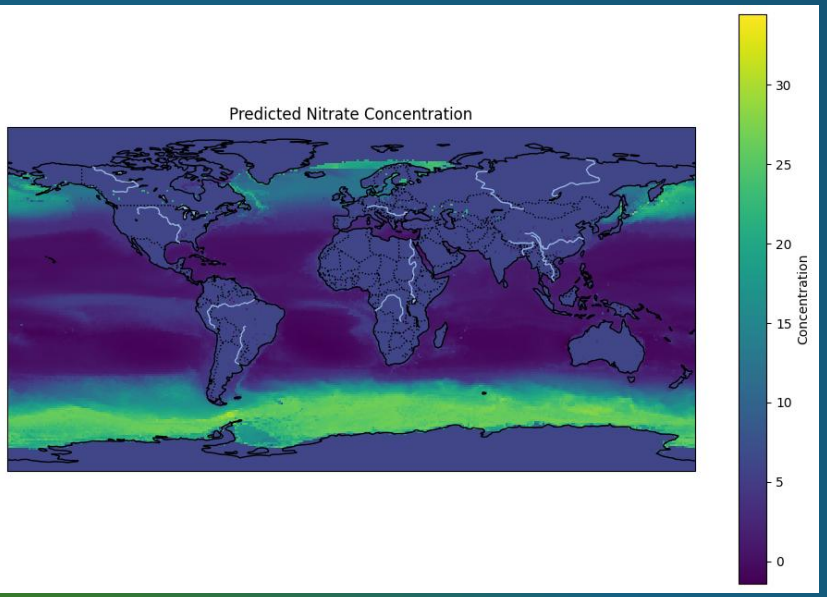
Model Convergence

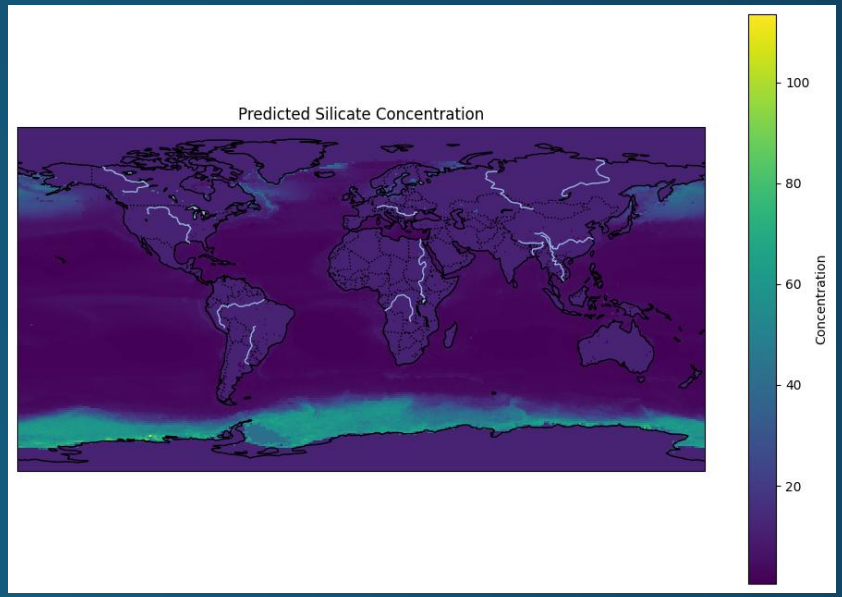


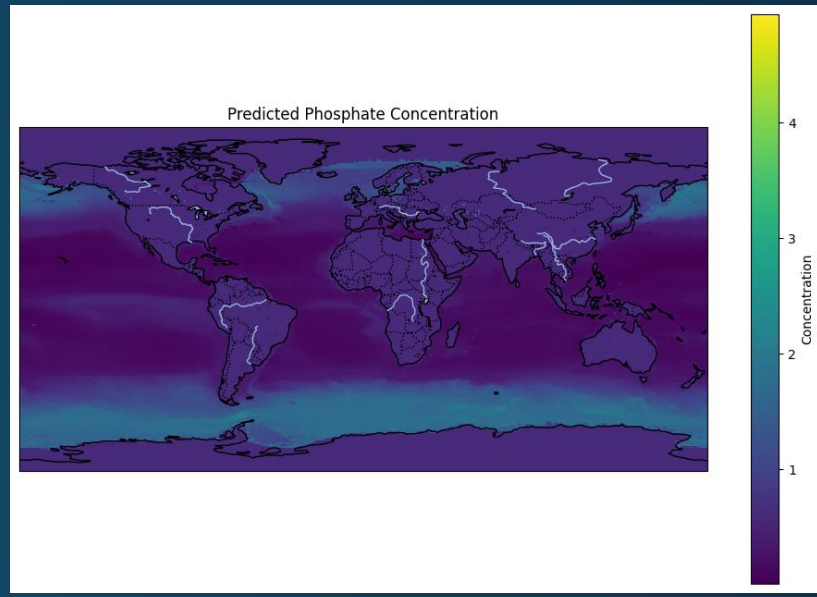

Original Nitrate Concentration
Concentration
0
5
10
15
20
25
30
35
40


Original Silicate Concentration
Concentration
0
20
40
60
80


Original Phosphate Concentration
Concentration
0.0
0.5
1.0
1.5
2.0
2.5
3.0


Predicted Nitrate Concentration
Concentration
0
5
10
15
20
25
30


Predicted Silicate Concentration
Concentration
20
40
60
80
100

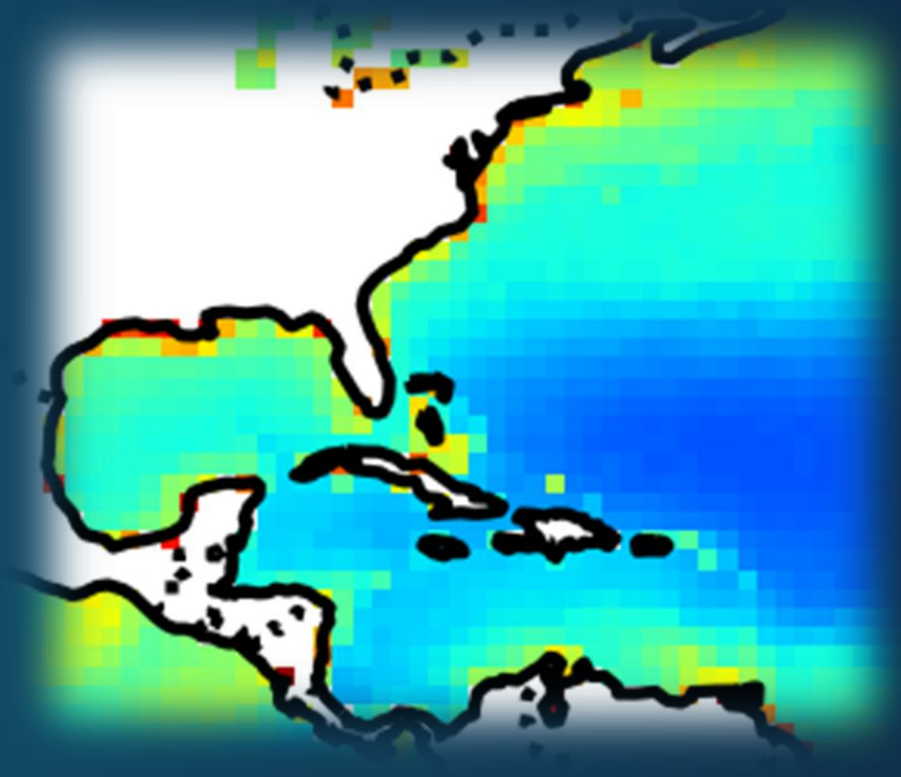

Predicted Phosphate Concentration
Concentration
1
2
3
4

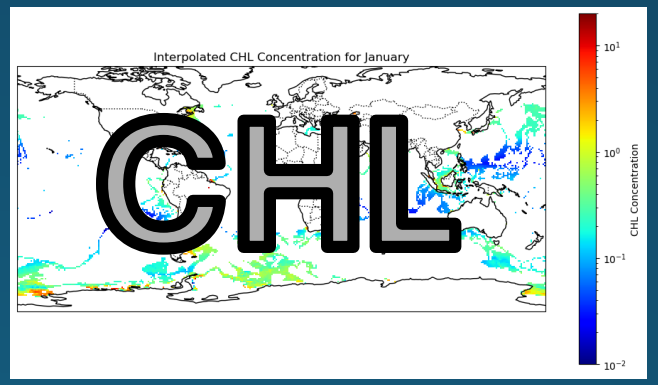
Model Results

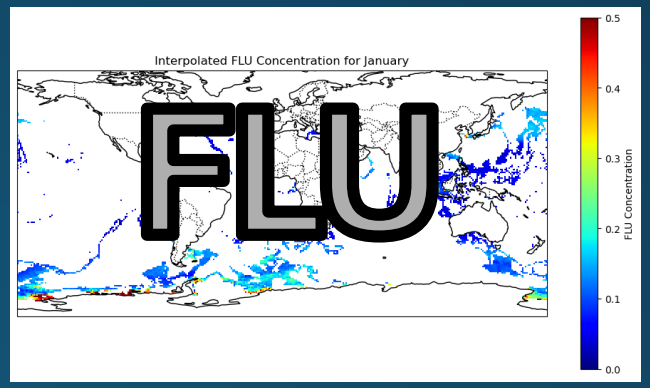
Feature:	Importance:
PIC	2.009414
FLU	1.060042
APH	0.950182
CHL	0.575627
SST	0.480510
PAR	0.203841
POC	0.107854

Future Directions

- Analyzing spectral data
- Testing Coastal Zones

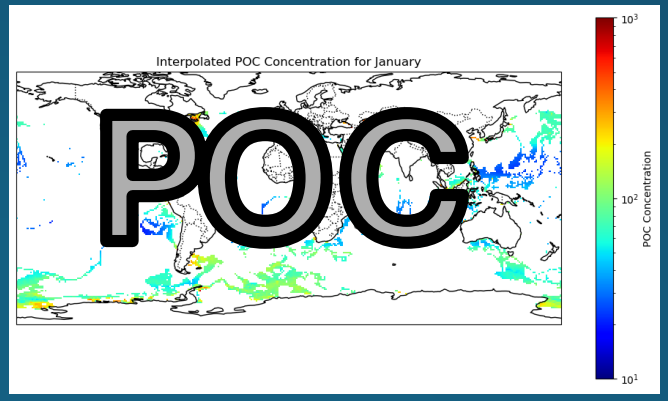


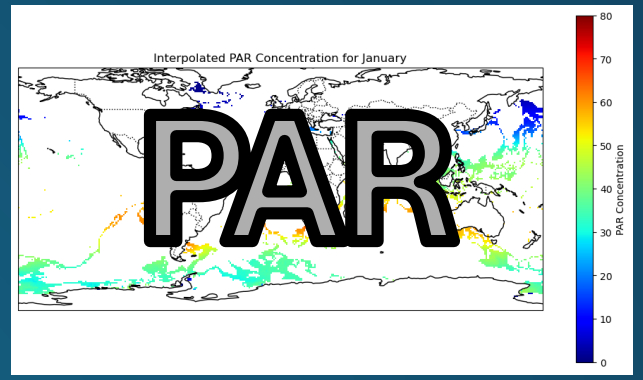


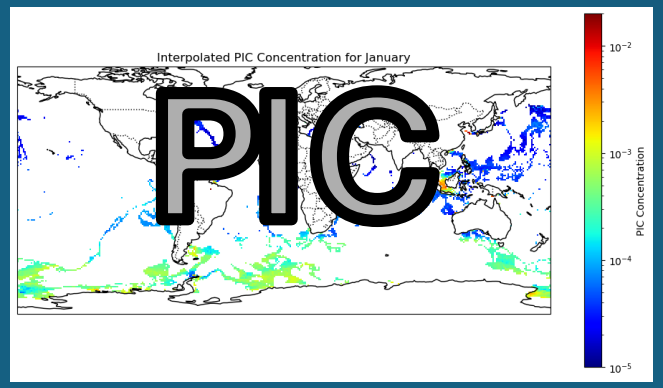


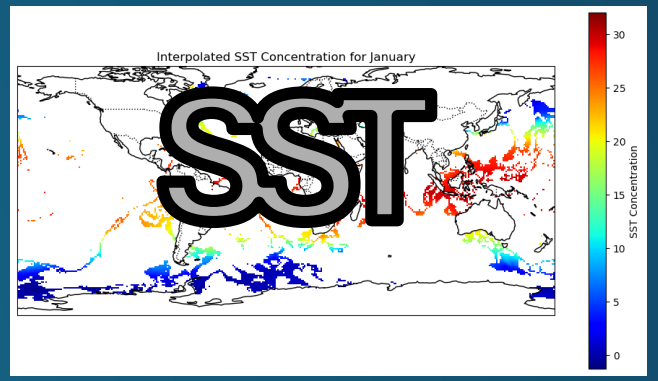
7 Inputs

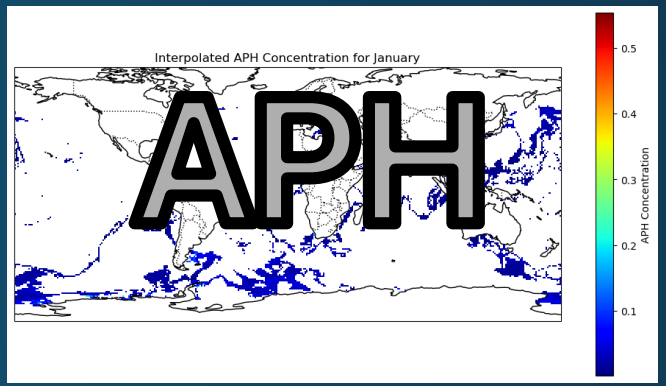
depth<2km

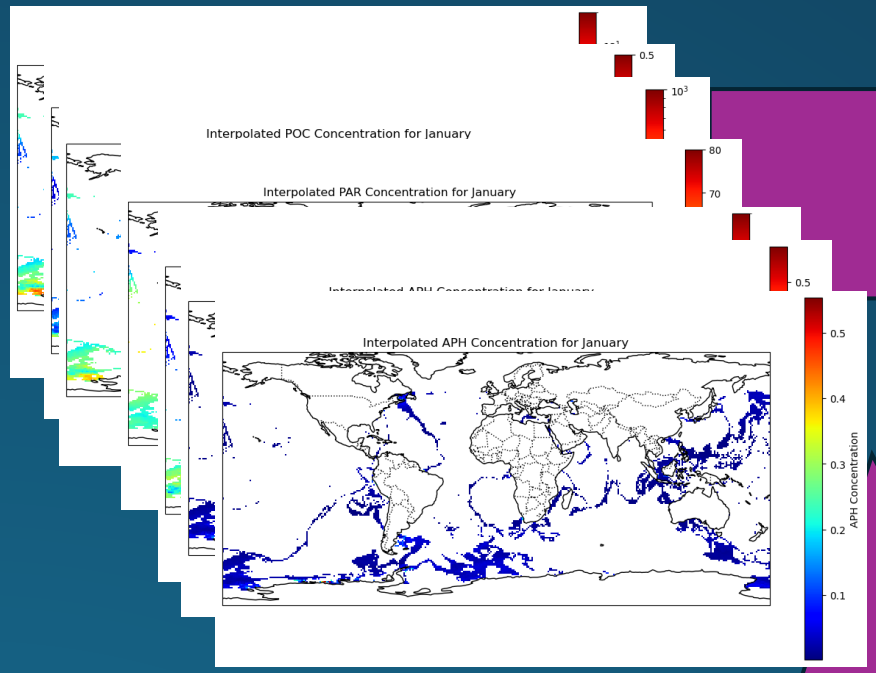






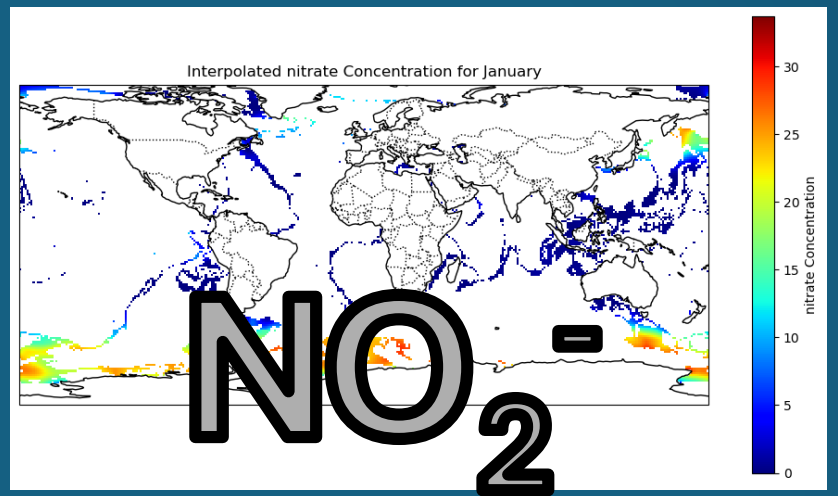


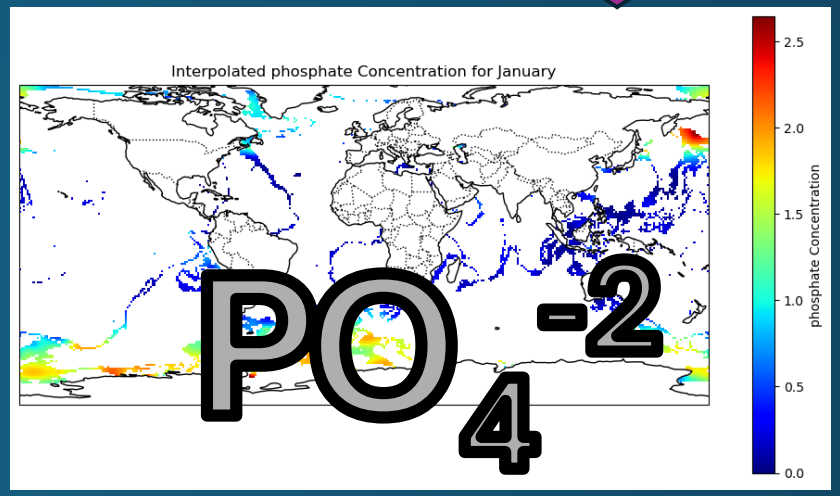


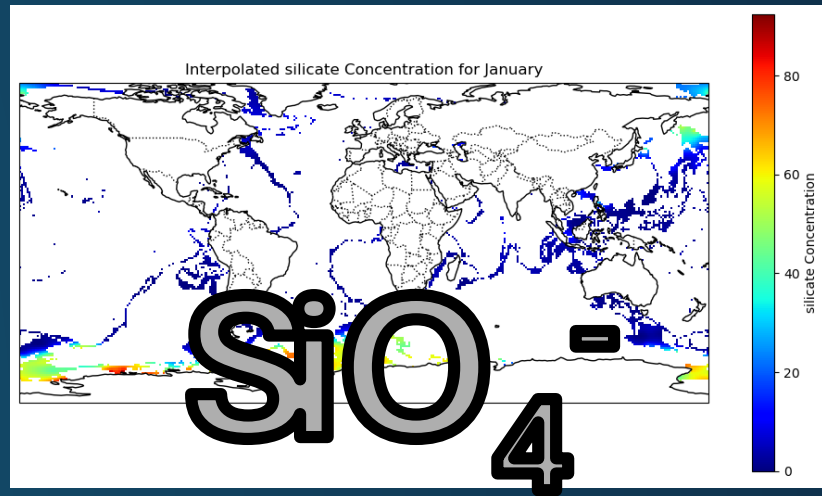


Only coastal data

Can We?







Packages Used & References

- Inputs (from Level 3 & 4 Aqua-MODIS satellite products, monthly, 9km, global)
- Monthly averages from 2002-2012
- Data download link: https://oceancolor.gsfc.nasa.gov/l3/

- Outputs (Monthly averages from 1955-2012 WOA13 data, 1 degree, monthly, global)
- Data download link: https://www.ncei.noaa.gov/data/oceans/woa/WOA13/DATAv2/nitrate/netcdf/all/

```
model = Sequential()
model.add(Dense(64, activation='relu', input_shape=(len(features),)))
model.add(Dense(32, activation='relu'))
model.add(Dense(3))  # 3 output neurons for the 3 target variables
```