Blue-Cloud

Piloting innovative services for Marine Research & the Blue Economy

Test the Blue-Cloud Virtual Labs

Zoo & Phytoplankton Essential Ocean Variables Products

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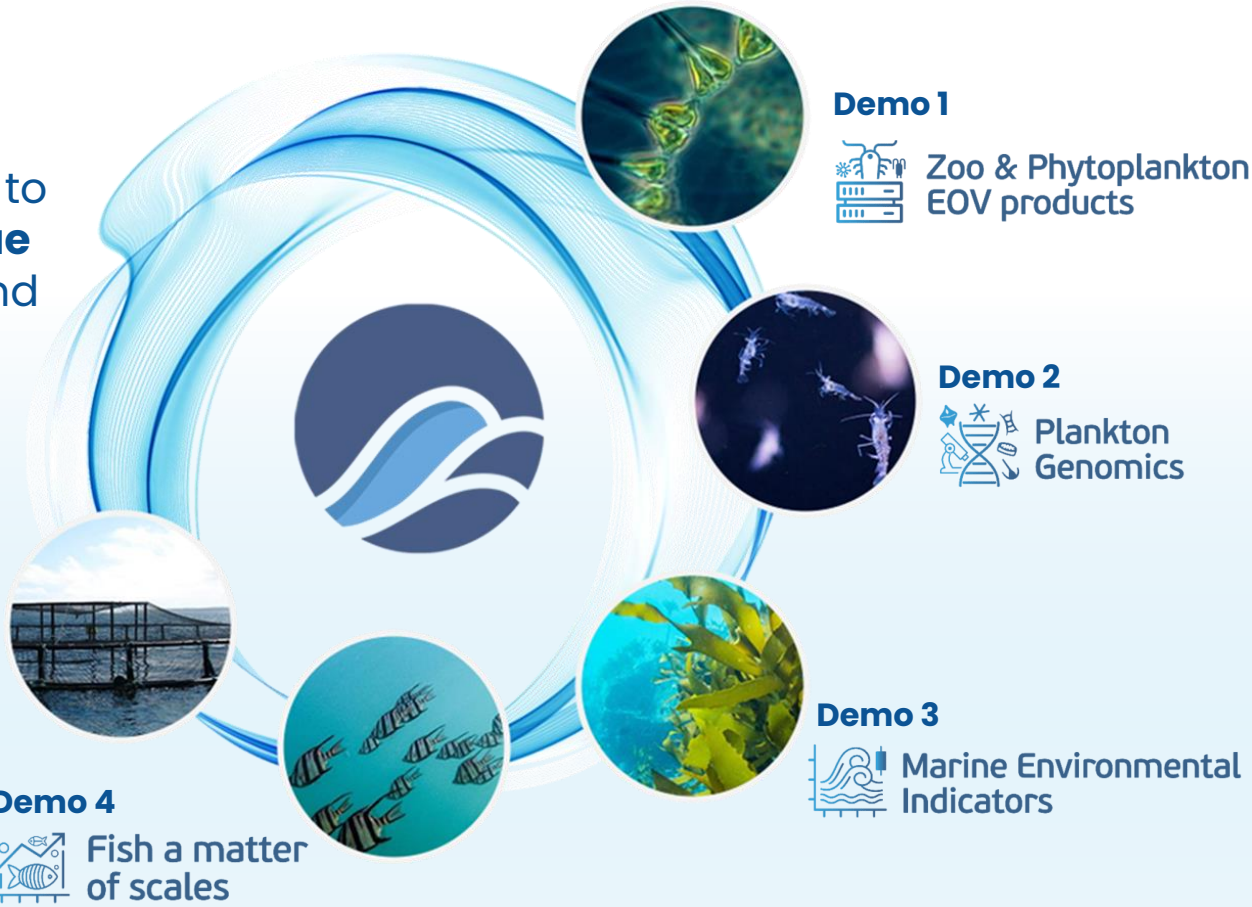
Blue-Cloud: your Open Science platform for collaborative marine research

Blue-Cloud aims to promote the **sharing** of *data, processes and research findings* in the marine domain by delivering a **collaborative web-based environment** that enables *open science*, underpinned by simplified access to **an unprecedented wealth of marine data resources** and **interoperable added-value services and products**”

Funding: H2020: The ‘Future of Seas and Oceans Flagship Initiative’ (BG-07-2019-2020) topic: [A] 2019 - Blue Cloud services
October 2019- September 2022
20 partners + **13 Blue federated Infrastructures**

Blue-Cloud

5 demonstrators to showcase the **Blue Cloud** Services and its potential in promoting the Blue economy



Agenda

11:30	**Blue-Cloud project introduction,** by Sara Pittonet, Blue-Cloud Coordinator
11:35	**Demo and VLab Introduction** - Patricia Cabrera, Flanders Marine Institute, VLIZ. Belgium
11:45	**Phytoplankton EOV** - Julia Uitz, Laboratoire d'Océanographie de Villefranche, LOV. France
11:55	**Zooplankton EOV** - Charles Troupin, University of Liège-GHER, Belgium
12:05	**Modelling phyto-zooplankton interactions** - Steven Pint, Flanders Marine Institute, VLIZ. Belgium
12:15	**Q&A**


Blue-Cloud
HACKATHON
DECODE THE OCEAN!
7, 8 and 9 February 2022

Zoo and Phytoplankton EOV products

Home / Vlabs / Zoo and Phytoplankton EOV products

The Zoo and Phytoplankton EOV Products Virtual Lab is developed by the Flanders Marine Institute (VLIZ), in collaboration with the Faculty of Science and Engineering at Sorbonne University and GeoHydrodynamics and Environment Research (GHER) at the University of Liège.

This demonstrator aims to provide a methodology to generate:

- **zooplankton products** based on in situ observations of the abundance of different zooplankton species in a region encompassing the North-East Atlantic;
- **global ocean three-dimensional (3D) key phytoplankton products** of chlorophyll-a (Chla) concentration, as a proxy for total phytoplankton biomass and phytoplankton functional types, as a proxy for phytoplankton diversity;
- **a mechanistic model using near real-time data** to quantify the relative contributions of the bottom-up and top-down drivers in phytoplankton dynamics.

The Zoo and Phytoplankton EOV demonstrator provides a description of the current state of the plankton communities and forecasts their evolution, representing valuable information for the modelling, assessment and management of the marine ecosystem. It is useful for a variety of communities:

- **Fisheries advisory organisations** can use these plankton products to study the availability of food resources for fish stocks and assess the effects on fish stocks.
- **Marine policy officers** will have the needed support to address threats such as food insecurity, as foreseen under the EU Biodiversity Strategy for 2030.
- **Fundamental research** (e.g. researchers and consultants from environmental agencies) contributing to the understanding of the environmental conditions and top-down factors at new scales of observations (e.g. regional/global, seasonal and time series).

VLIZ

SORBONNE UNIVERSITÉ

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Related articles

Introduction to Zoo and Phytoplankton EOV Products - 10 April 2020

Webinar on the Blue-Cloud

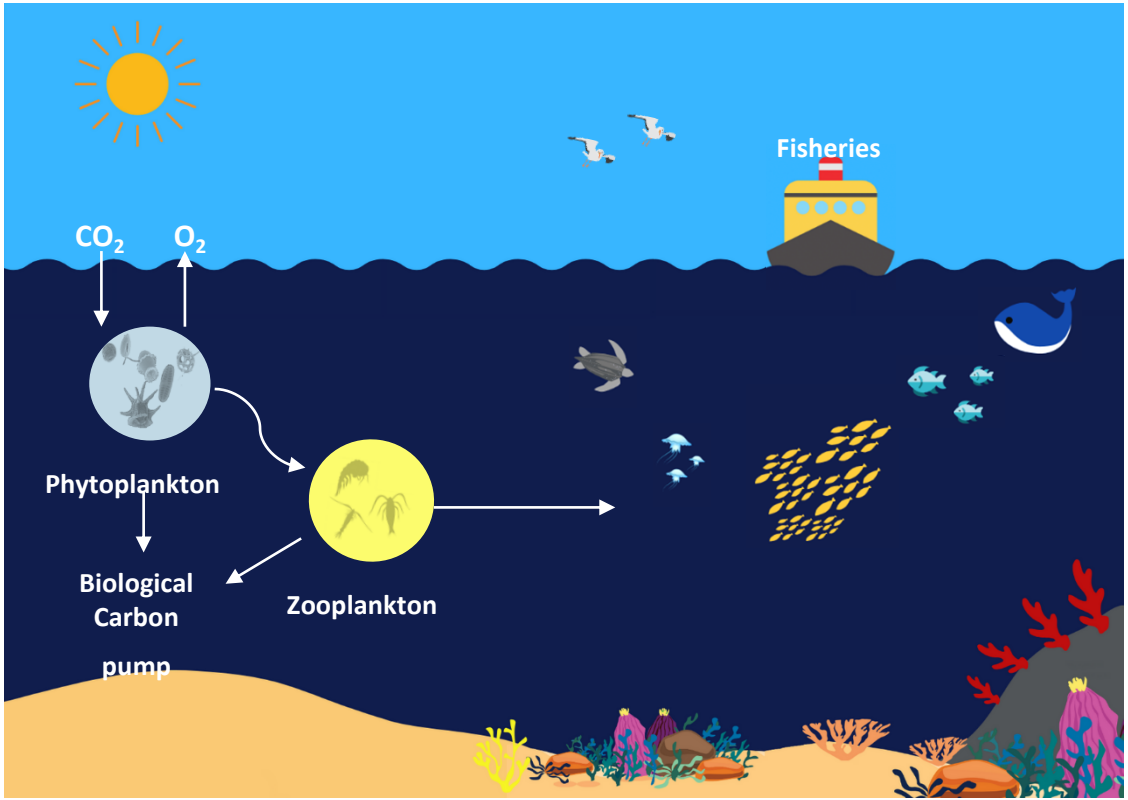
Services

Zooplankton EOVs

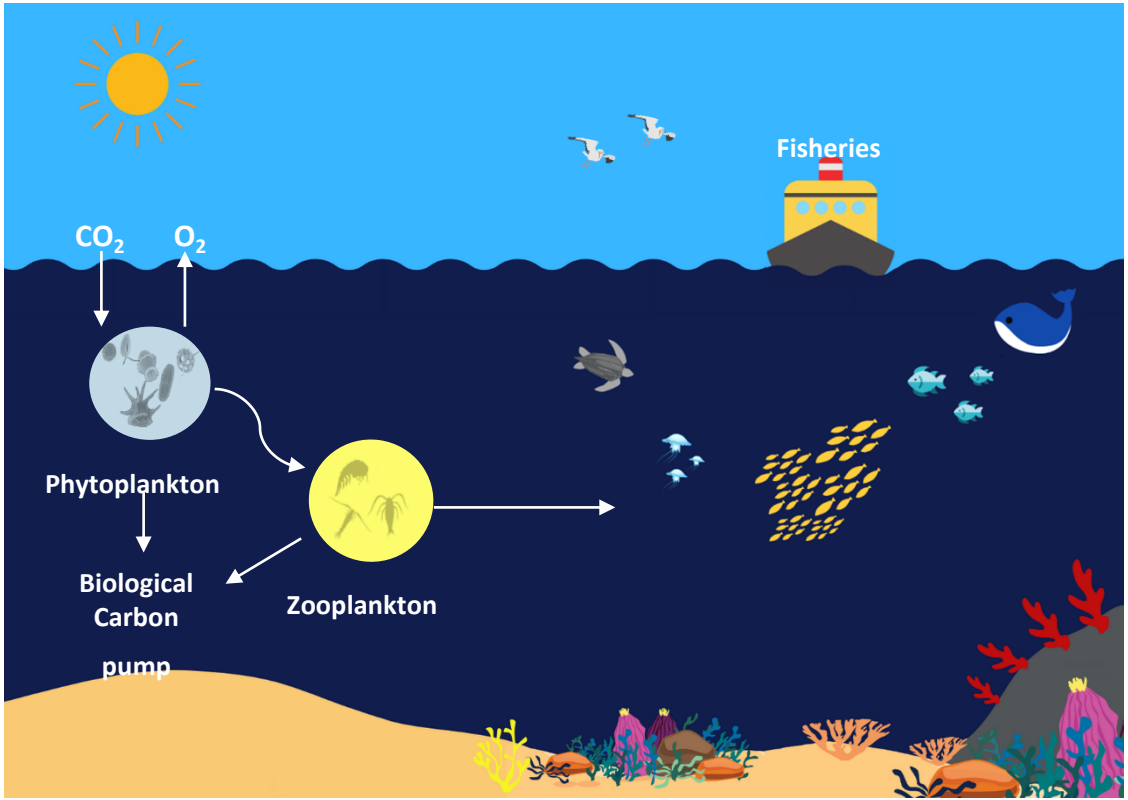
Phytoplankton EOVs

Scientific validation

Why plankton?



Why plankton?



The marine observation landscape

Photo credit: IOC GOOS

The marine observation landscape

How BC helped to develop the demonstrator?

Access Blue-Cloud data

Blue-Cloud VRE

Easier integration of data sources

Heavy computation analyses

Exploitation of results through dissemination

Access to re-usable methodologies

Blue Data Catalogue

Blue-Cloud Virtual Lab

Blue-Cloud

Phytoplankton EOV

Phytoplankton EOV

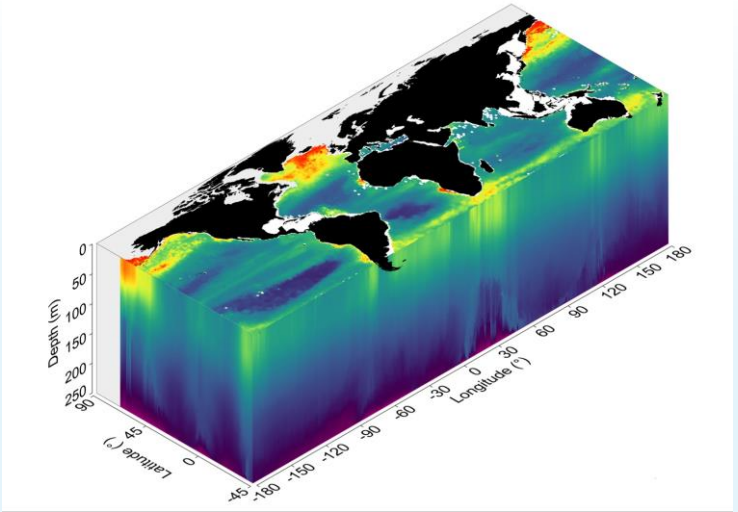
Introduction

- Phytoplankton are key to several **scientific** and **socio-economic** questions. Not only their **biomass** but also their **composition** affect critical processes in the oceans, in particular the capacity of the ocean to **sequester carbon** and the flow of carbon energy through the **marine food webs**
- Developing a **global 3D view of the biomass and composition of phytoplankton assemblages** in the oceans appears critical to: (1) Reduce uncertainties regarding the status of marine ecosystems in the **present ocean**; (2) Gain knowledge to improve our ability to **predict** their **evolution** under **climate change**
- The **BGC-Argo global observation network** has largely expanded in recent years, and now provides the databases required for **training and validating a new generation of algorithms**, which are essential for obtaining global 3D biogeochemical products

Phytoplankton EOV

Principle of the SOCA* algorithm

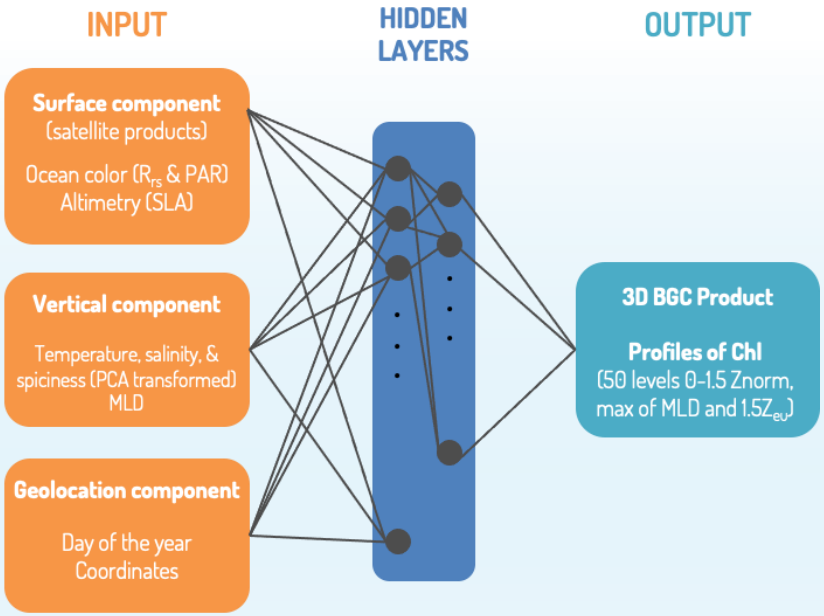
- Our approach relies on the **neural network-based SOCA algorithm** developed by Sauzède et al. (JGR-Oceans 2016)
- The algorithm **merges surface satellite observations** with **depth-resolved hydrological properties** to provide global 3D fields of bbp (POC) as the output product
- The algorithm has been adapted to the retrieval of **global 3D fields** of **Chla** and **Phytoplankton Functional Types** (PFT) expressed in terms of Chla associated with 3 main groups (pico-, nano- and microphytoplankton)

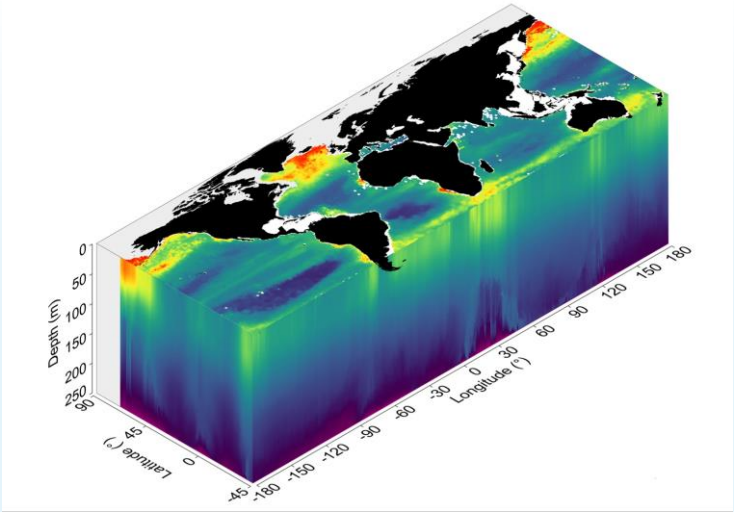


**SOCA: Satellite Ocean Color merged to Argo data*

Phytoplankton EOV

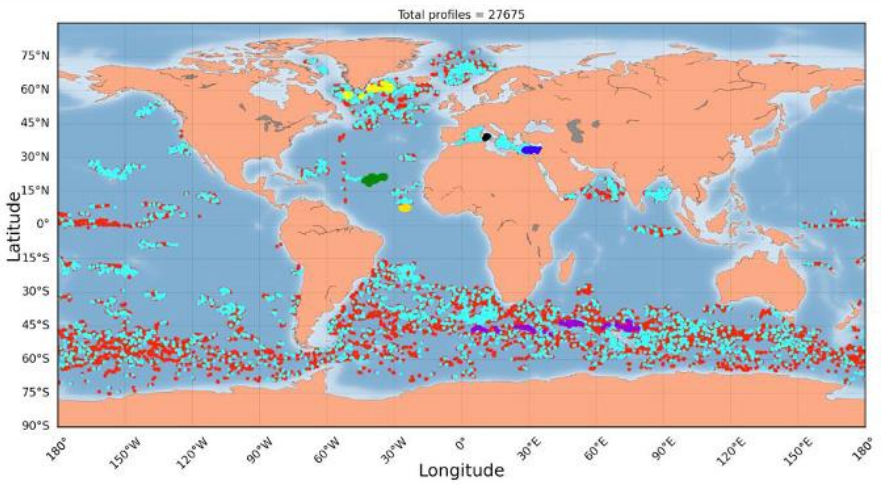
Principle of the SOCA algorithm

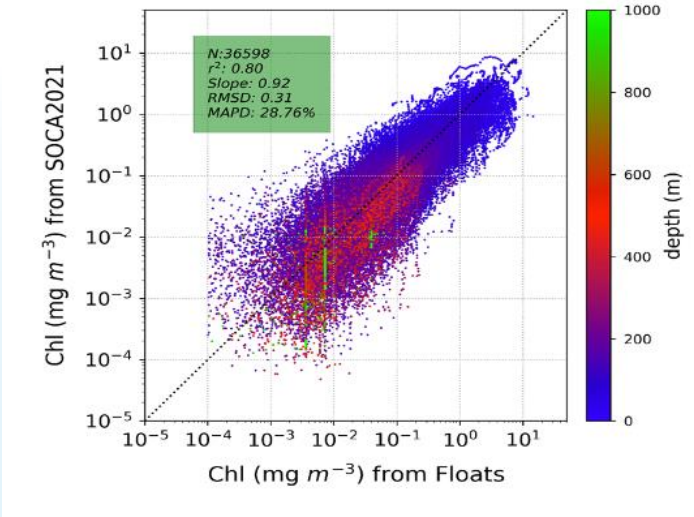




Phytoplankton EOV

Validation of the SOCA Chla product



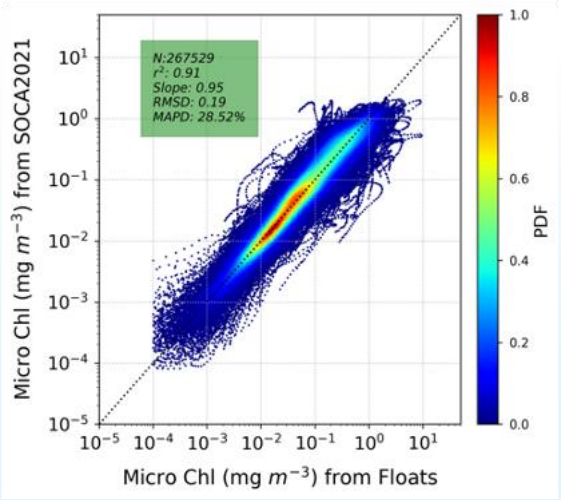


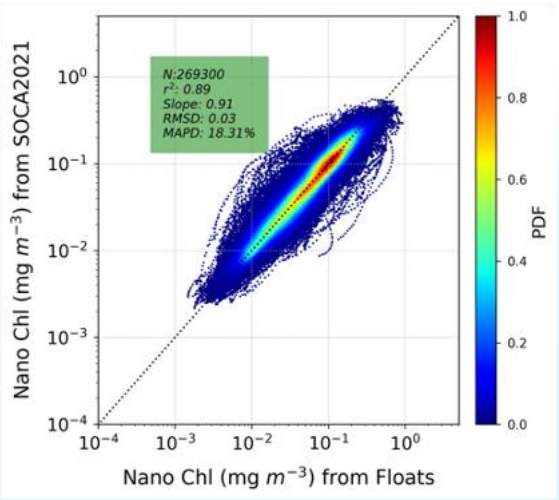
- A **database** representative of the **global** open ocean
- ~28,000 **satellite** (Rrs, PAR, SLA) / **BGC-Argo** (Chl, T/S + PFT) **matchups**: 80% for training / 20% for validation

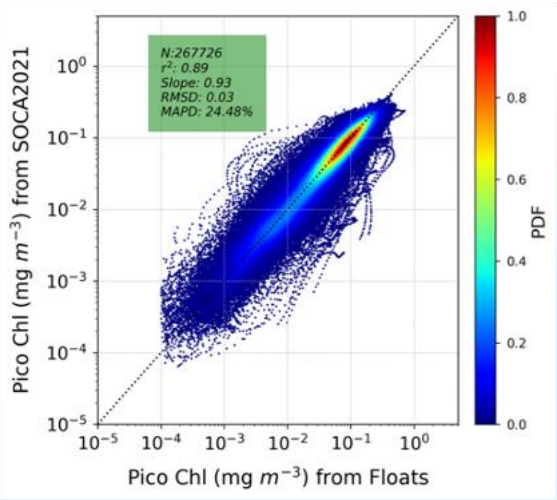
- Global error (MAPD) of 29%
- No systematic bias with depth

Phytoplankton EOV

Validation of the SOCA PFT product



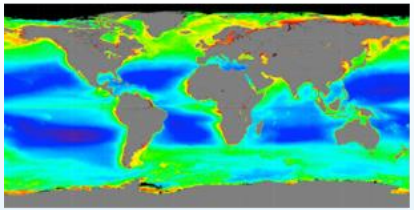




- Relatively low mean error (18-29%)
- Good representation of the group-specific Chla over the biomass gradient

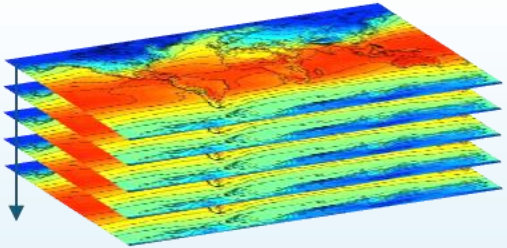
Phytoplankton EOV

Generating the desired EOV products



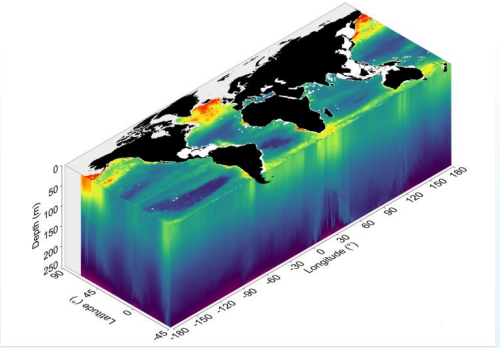
CMEMS satellite fields
(GlobColour & DUACS)

+



CMEMS ARMOR3D fields

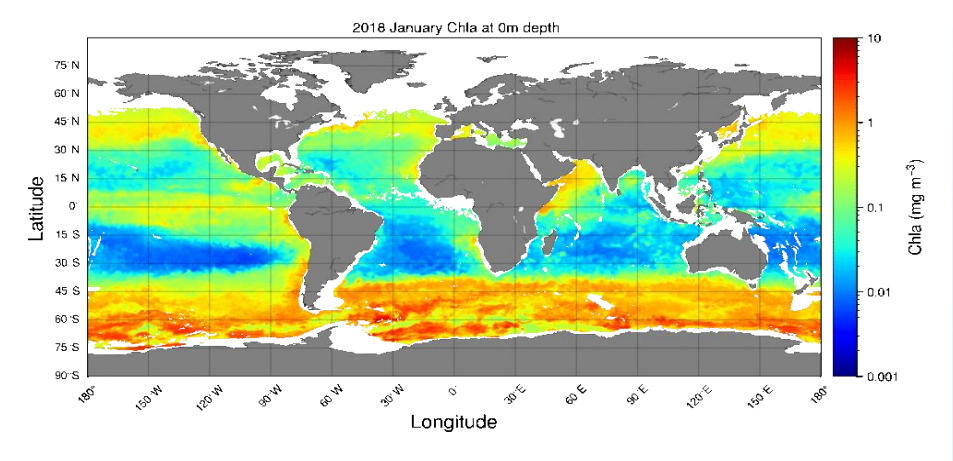
→

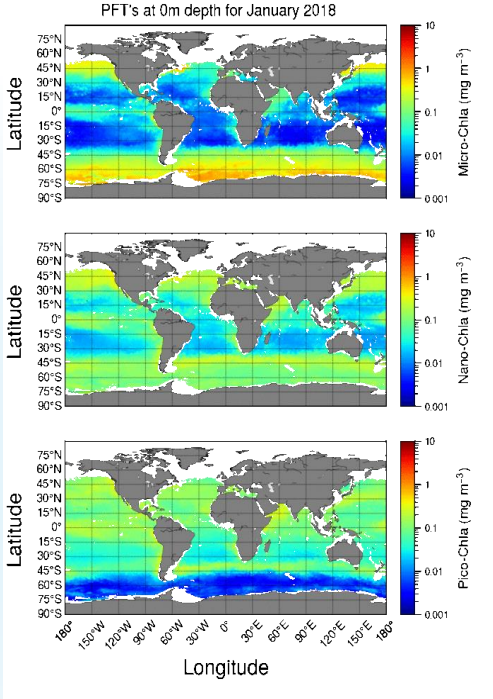


Output EOV products of
Chla & PFT

Phytoplankton EOV

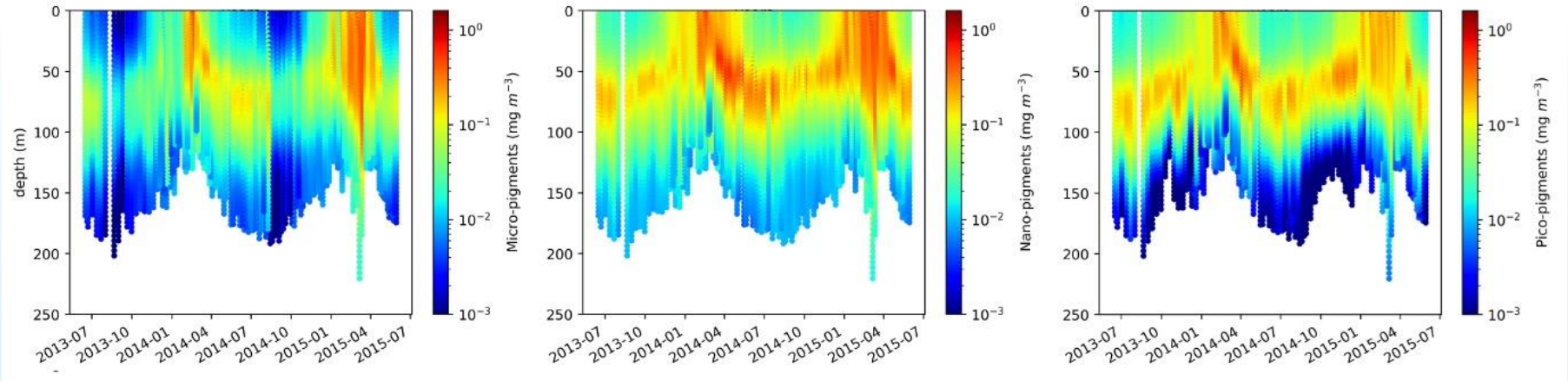
Example results: Global distribution of Chla & PFTs





Phytoplankton EOV

Example results: Cross section of PFT in the Western Med Sea



Phytoplankton EOV

Conclusion

- Additional efforts must be made to improve the PFT product, which is currently in its beta version
- The final global 3D Chla and PFT products may find a large range of applications. For example: process studies and biogeochemical budgets; initialization and validation of, or assimilation in, biogeochemical/ecosystem models; QC reference for remote observations

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Zooplankton EOV

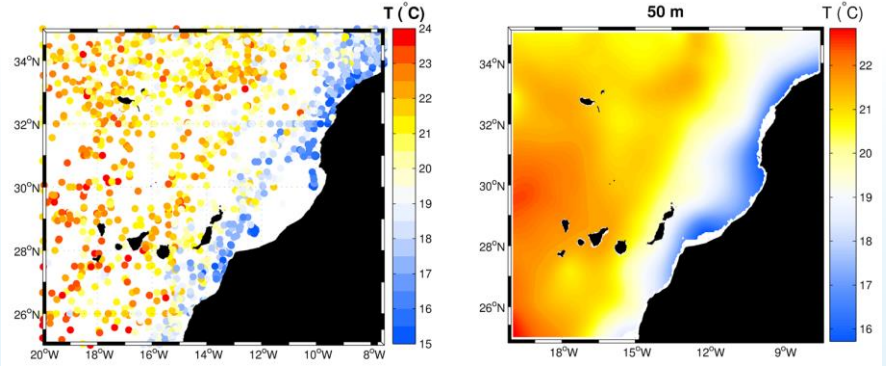
Zooplankton EOV

Interpolation and data analysis:

Difficulties in oceanography:

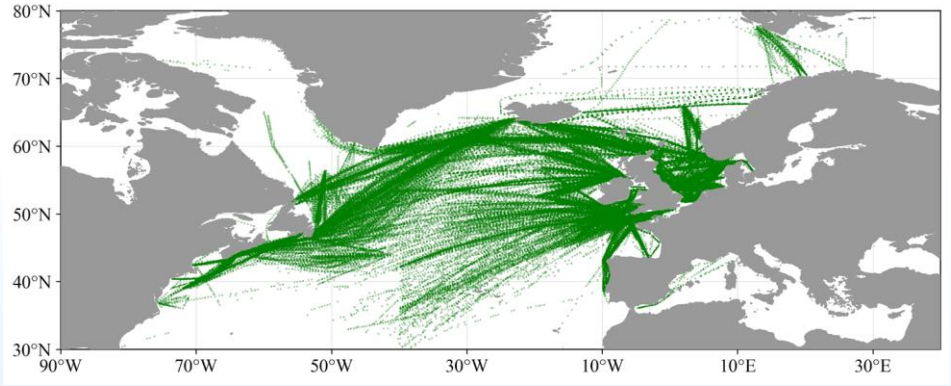
- Data distribution/scarcity
- Confidence in measurements
- Representativity error

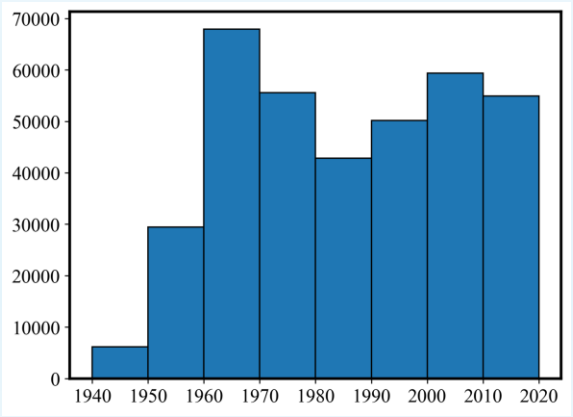
Possible usage: climatologies, reference state, model validation, assess long term changes



The dataset

- Data from the continuous plankton recorder operated by the Marine Biological Association, UK
- Heterogeneous distribution
- Data since 1940
- Data | position | number of ind/m³





The method

DIVAnd: Data Interpolating Variational Analysis in n dimensions https://github.com/gher-ulg/DIVAnd.jl

Code written in Julia (https://julialang.org/)

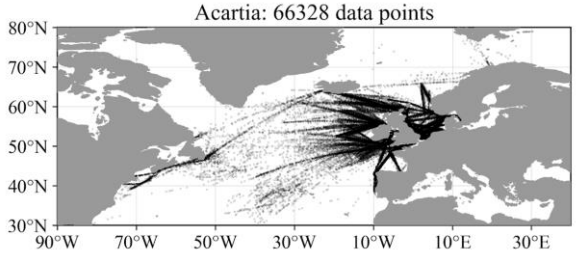
DIVAnd

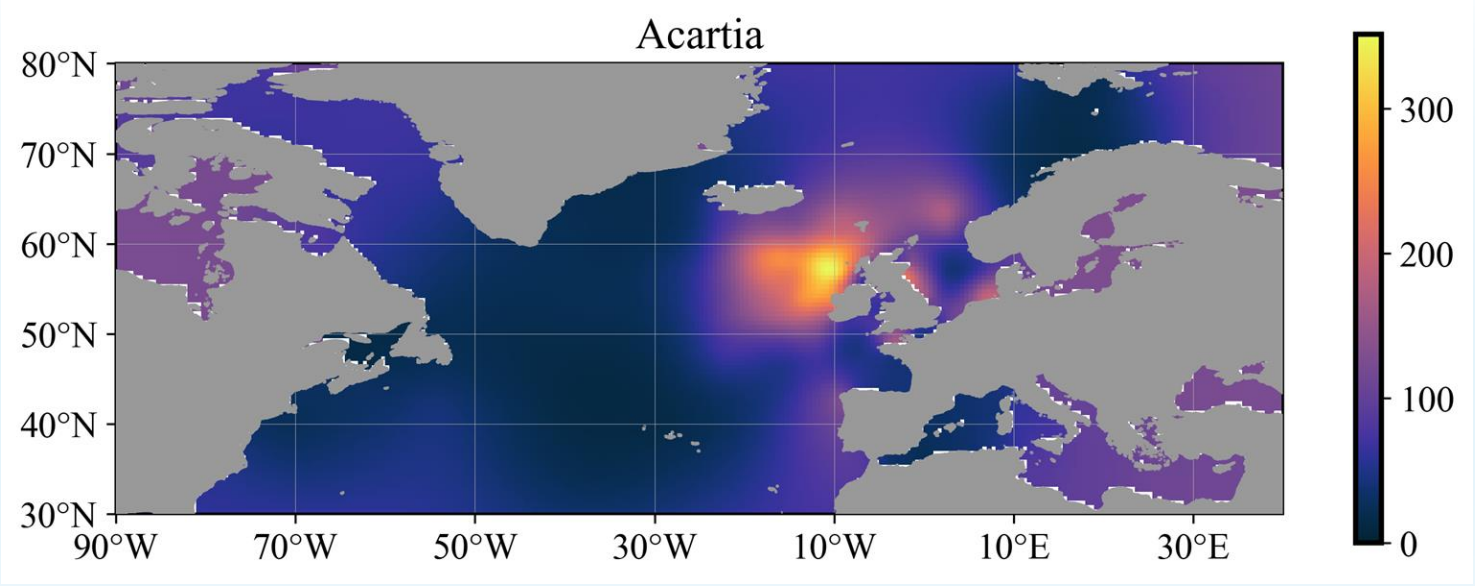
CI passing | codecov 80% | docs stable | docs latest | DOI 10.5281/zenodo.4400206

`DIVAnd` (Data-Interpolating Variational Analysis in n dimensions) performs an n-dimensional variational analysis/gridding of arbitrarily located observations. Observations will be interpolated/analyzed on a curvilinear grid in 1, 2, 3 or more dimensions. In this sense it is a generalization of the original two-dimensional DIVA version (still available here https://github.com/gher-ulg/DIVA but not further developed anymore).

DIVAnd Application

Spatial interpolation

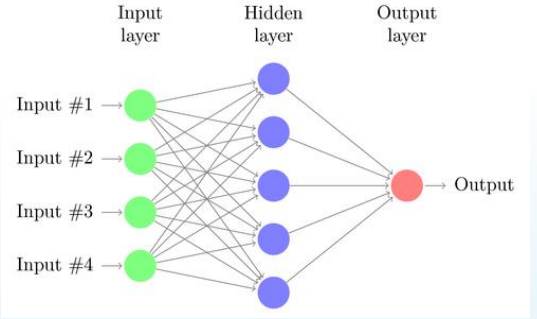




DIVAnd with a Neural Network

$$g(x) = f(v_1, v_2, \ldots v_n) + x'$$

- $v_1, v_2, \ldots v_n$ are environmental variables related to the probability
- $f(v_1, v_2, \ldots v_n)$ is a neural network
- x' is a residue varying of a specified length-scale (DIVAnd)
- Also applicable to occurrence probability with a slightly different formulation



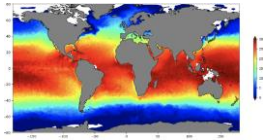
Neural network (Multilayer perceptron)

Neural network technique

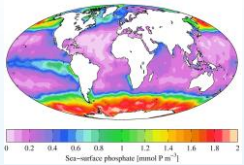
Using other sources of information to improve the interpolation. Used “Co-variables”:

- Sea water temperature (SeaDataCloud)
- Salinity (SeaDataCloud)
- Distance from coast (NASA Goddard Space Flight Center)
- Bathymetry (GEBCO)
- Nitrate, Silicate and Phosphate (World Ocean Atlas 2018)

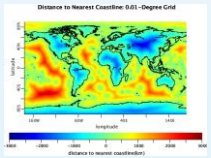
SeaDataCloud
T/S climatology



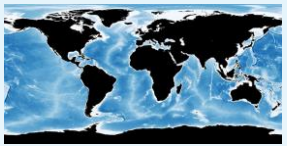
World Ocean Atlas



Distance from coast

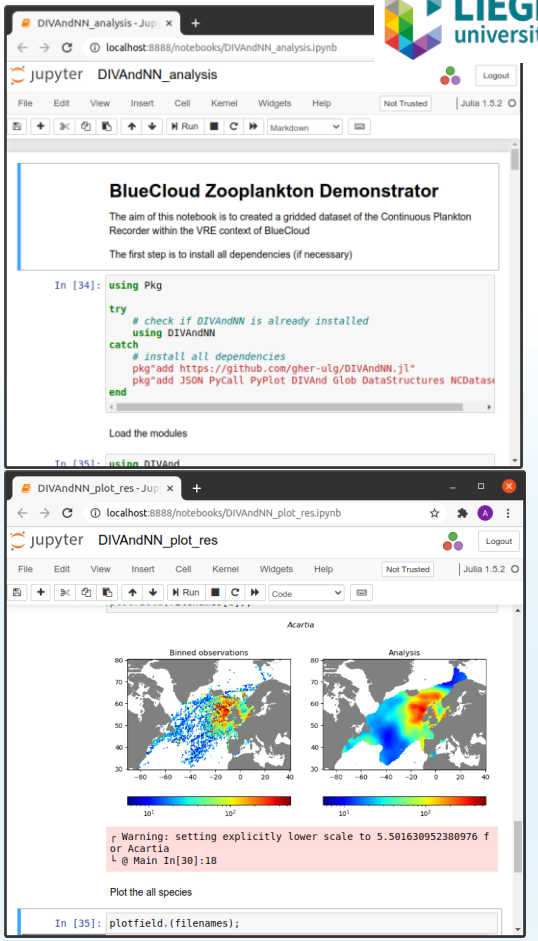


GEBCO Bathymetry



Workflow

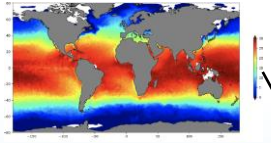
- Reproducible approach:
  - **Version control** using GitLab (at ULiege)
  - **Continuous integration** (testing that the code still runs after every pushed commit)
  - Declare all necessary **direct software dependencies**
  - **Full snapshot of the dependency tree** (direct and indirect dependencies)
  - Projects can be easily **instantiated** (i.e. the exact Julia environment can be replicated with a single command)
- Using two jupyter notebooks
  - **Analysis**
    - Preparation of covariables
    - Split data into training and validation dataset
    - DIVAnd + neural network analysis
  - **Visualization of the results**



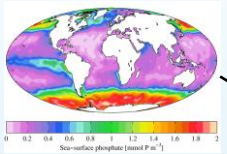
Overview

Blue-Cloud

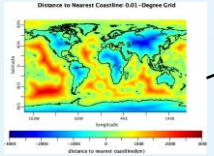
SeaDataCloud T/S climatology



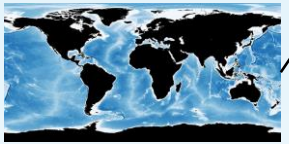
World Ocean Atlas (nutrients)

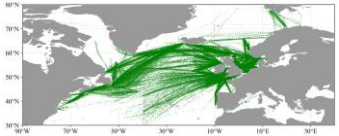


Distance from coast



GEBCO Bathymetry

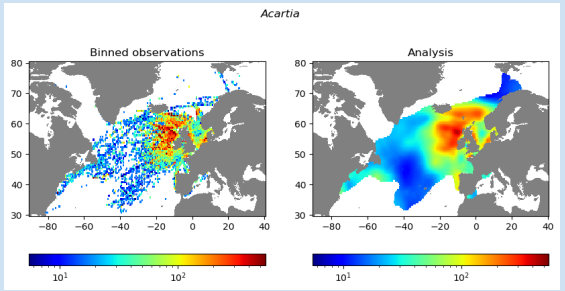




CPR data

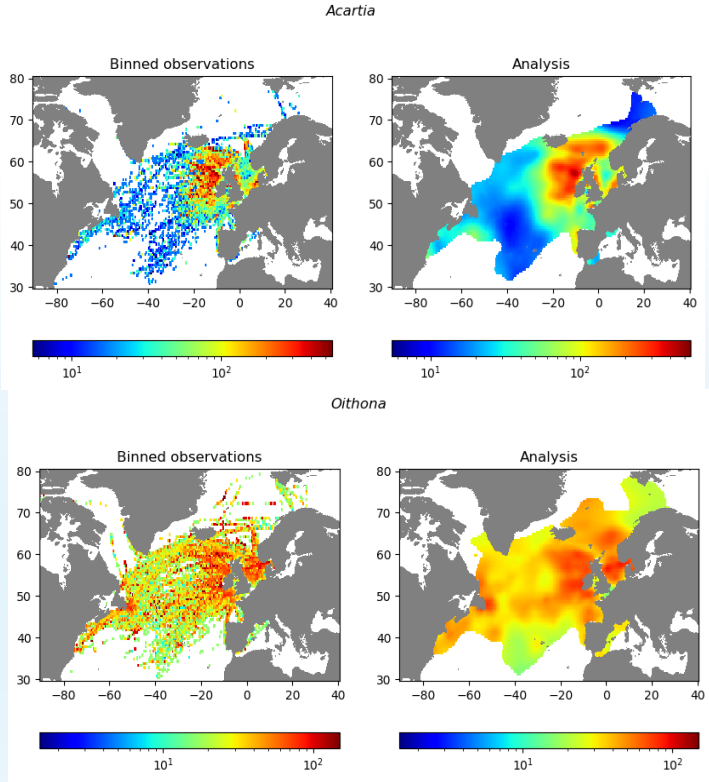
jupyter

julia DIVAnd + Neural network



Blue-Cloud Gateway

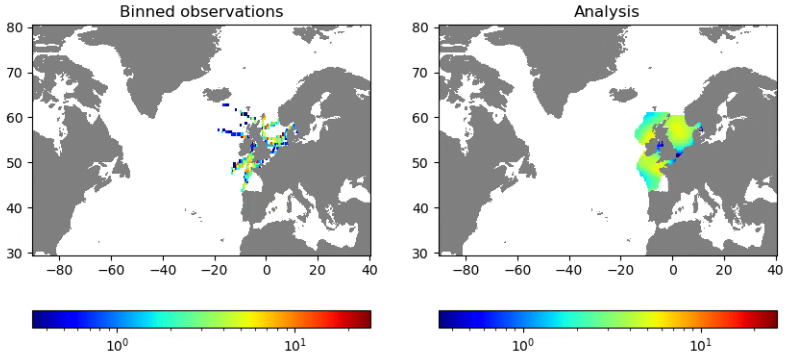
Some example results



- Inhomogeneous sampling -> inhomogeneous error spatially
- A relative error map is derived allowing to mask the value far away from the observations
- Time dimension:
  - All years combined
  - Analysis per year (with a time correlation)

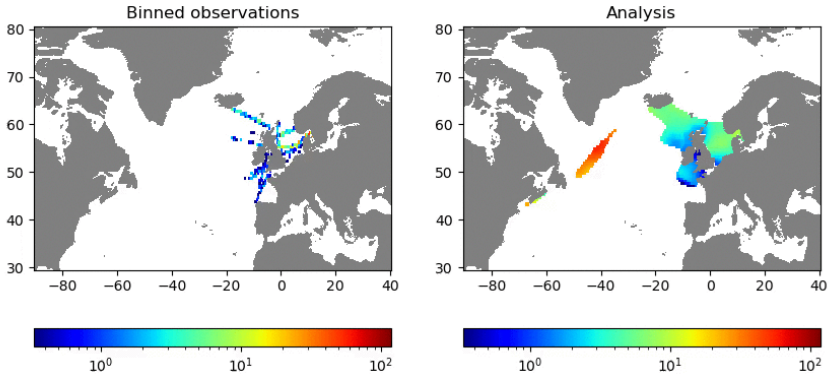
Variation over time

Calanus helgolandicus 1990



- Animation over time for the species distribution
- Difficulty to disentangle the sampling effort from changes of the distribution (at the yearly time scale)
- Per default, only the gridded results are shown where the confidence is high (near the observations) but full fields are available

Calanus finmarchicus 1990



Conclusions

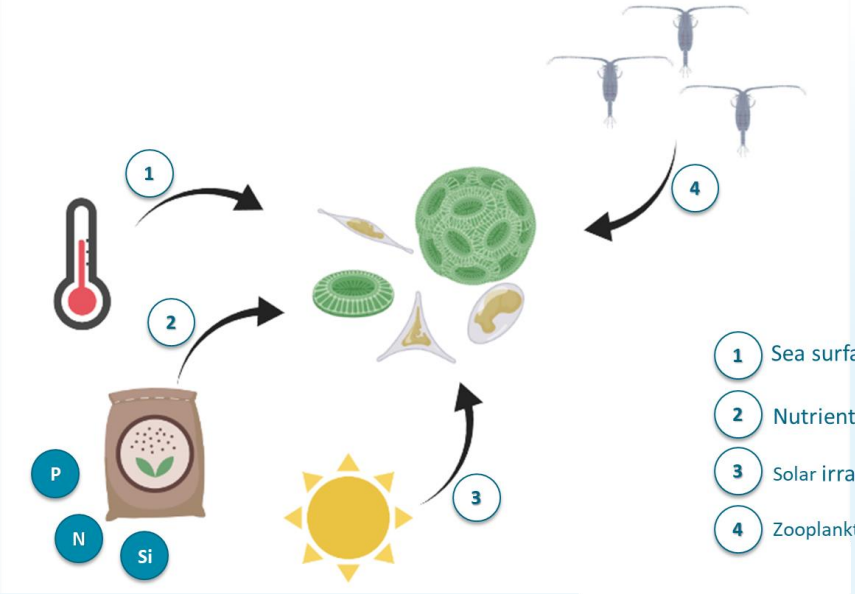
- Collaborative virtual research environments have a large potential to **boost scientific productivity**
- Capture the **relationship** between specie distribution and environment parameters using a **neural network**
- **Spatial (and temporal) coherence**: constraints used in variational inverse methods
- Possibility to use **irregularly sampled observations**
- **Difficulty to disentangle** variability and sampling effort (in particular for yearly results)
- Perspective: explore the potential of **convolutional** neural networks (e.g. DINCAE, Data INterpolating Convolutional Auto-Encoder)

Modelling phyto- & zooplankton Interactions

Modelling phyto- & zooplankton Interactions

Introduction

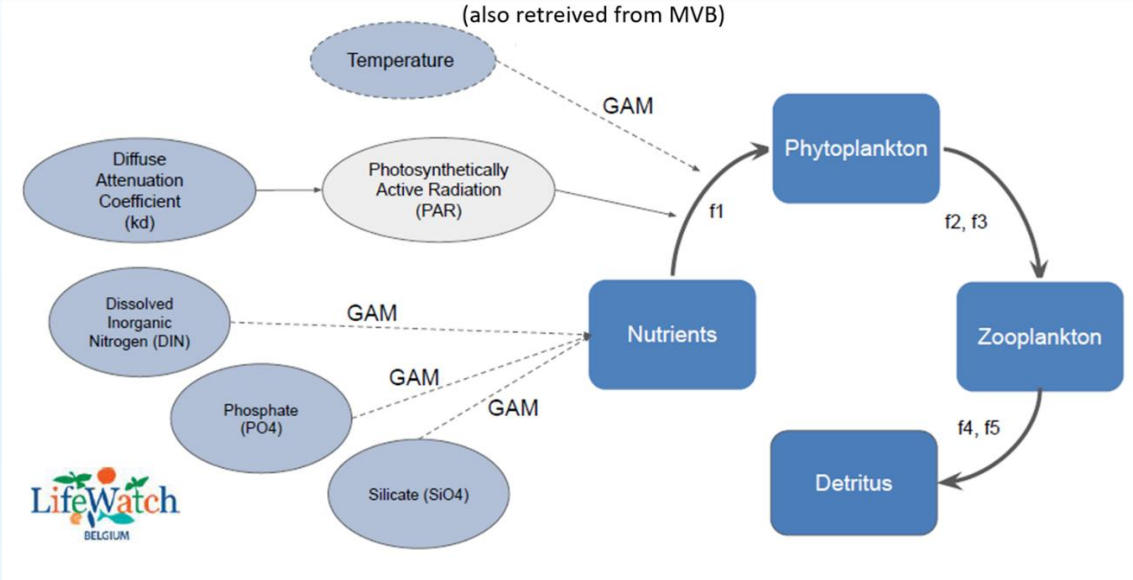
- Changing environmental conditions due to Climate Change
- Predict and mitigate potential effects of Blue Economy activities
- Additional to field observations
- Low-cost and quick method



Modelling phyto- & zooplankton Interactions

Methodology

- GAM to create daily input data
- Nutrient-Phytoplankton-Zooplankton (NPZ) model



Modelling phyto- & zooplankton Interactions

Data sources

Data sources

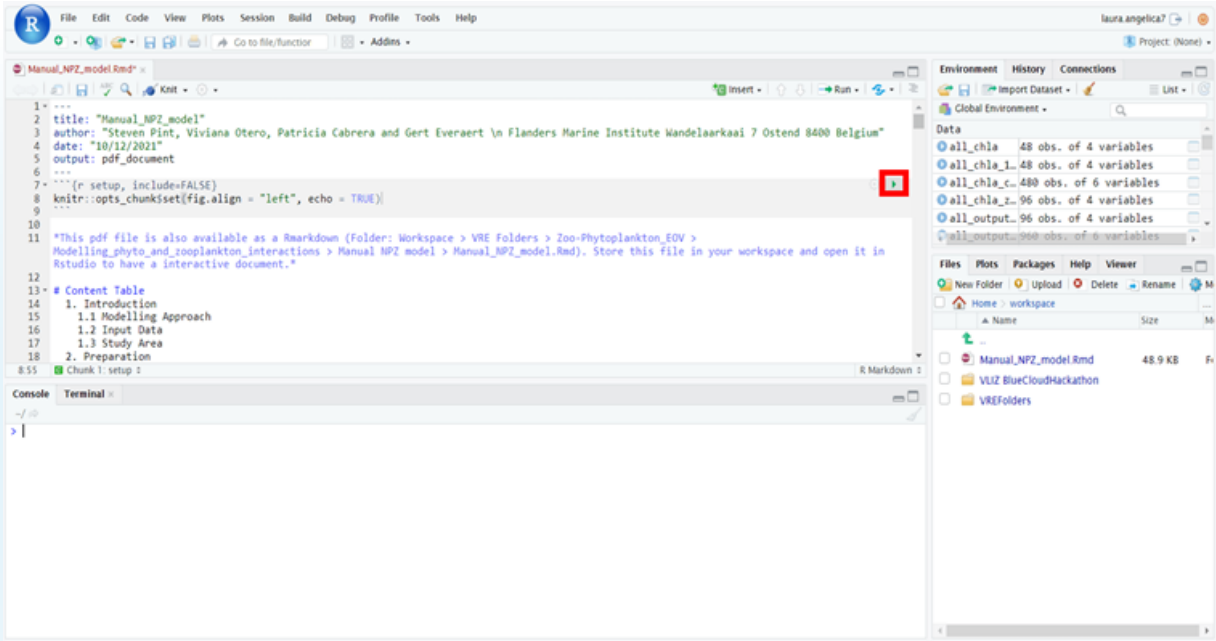
VARIABLES	DATA SOURCES	DATA ACCESS
Phytoplankton abundances (Chla)	https://rshiny.lifewatch.be/station-data/	LifeWatch/Blue-Cloud Vlab*
Zooplankton abundances	http://rshiny.lifewatch.be/zooscan-data/	LifeWatch/Blue-Cloud Vlab*
Nutrients	http://rshiny.lifewatch.be/station-data/	LifeWatch/Blue-Cloud Vlab*
Photosynthetically active radiation (PAR)	https://rshiny.lifewatch.be/ctd-data/	LifeWatch/Blue-Cloud Vlab*
Sea-surface Temperature (SST)	https://rshiny.lifewatch.be/ctd-data/	LifeWatch/Blue-Cloud Vlab*
	https://rshiny.lifewatch.be/mvb-data/	Meetnet Vlaamse Banken

*Blue-Cloud Vlab= Data also available in the 'VRE Folders' in the Vlab.

Modelling phyto- & zooplankton Interactions

Workflow

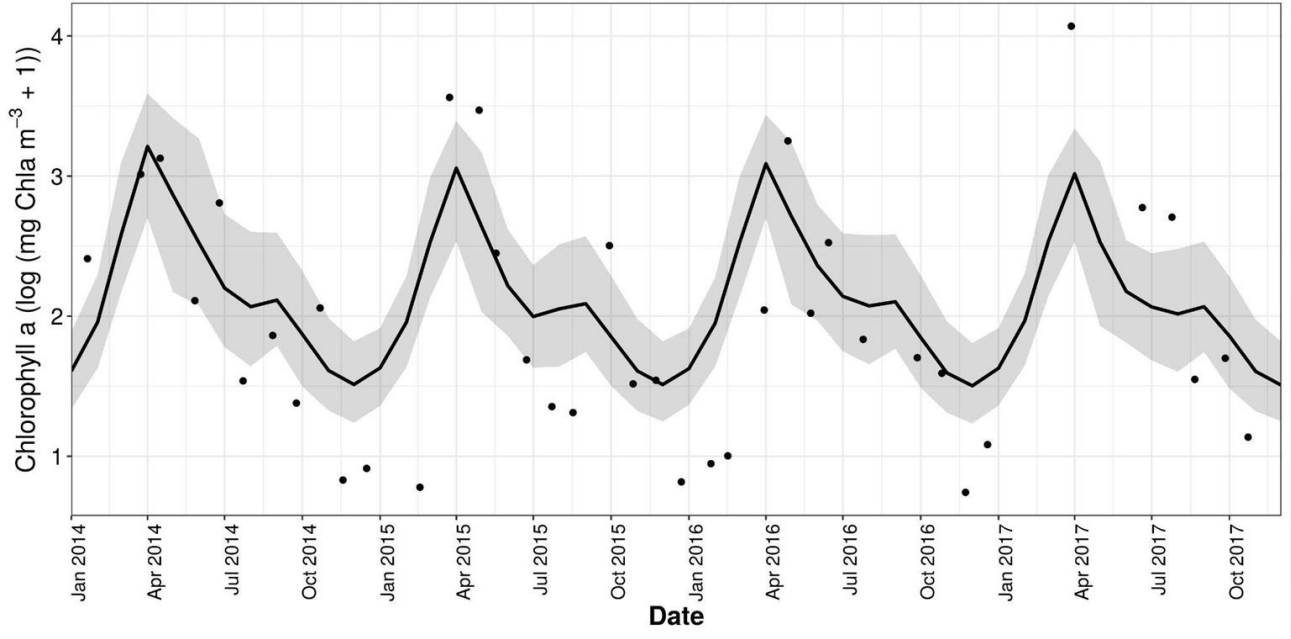
- Rstudio
- Rmarkdown
  => Step by step guideline
  - Introduction
  - Preparation
  - NPZ model
- Workspace
  - NPZ folder
  - Subfolder (code, results, graphs)



Modelling phyto- & zooplankton Interactions

Results

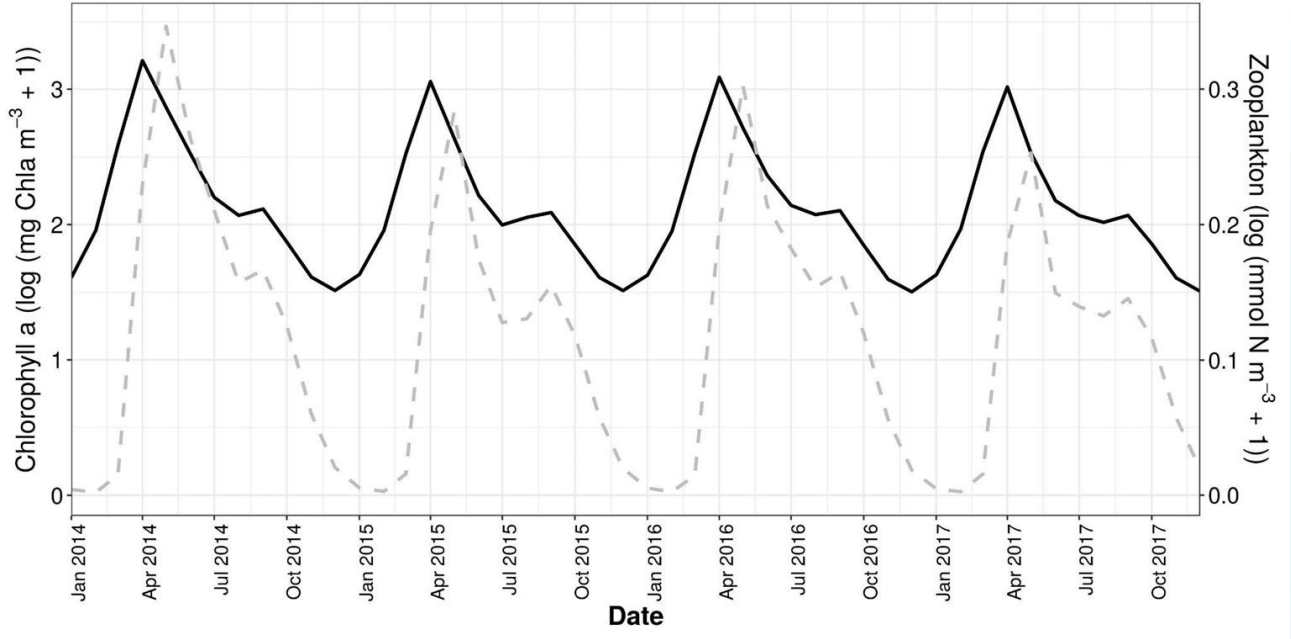
Phytoplankton biomass dynamics



Modelling phyto- & zooplankton Interactions

Results

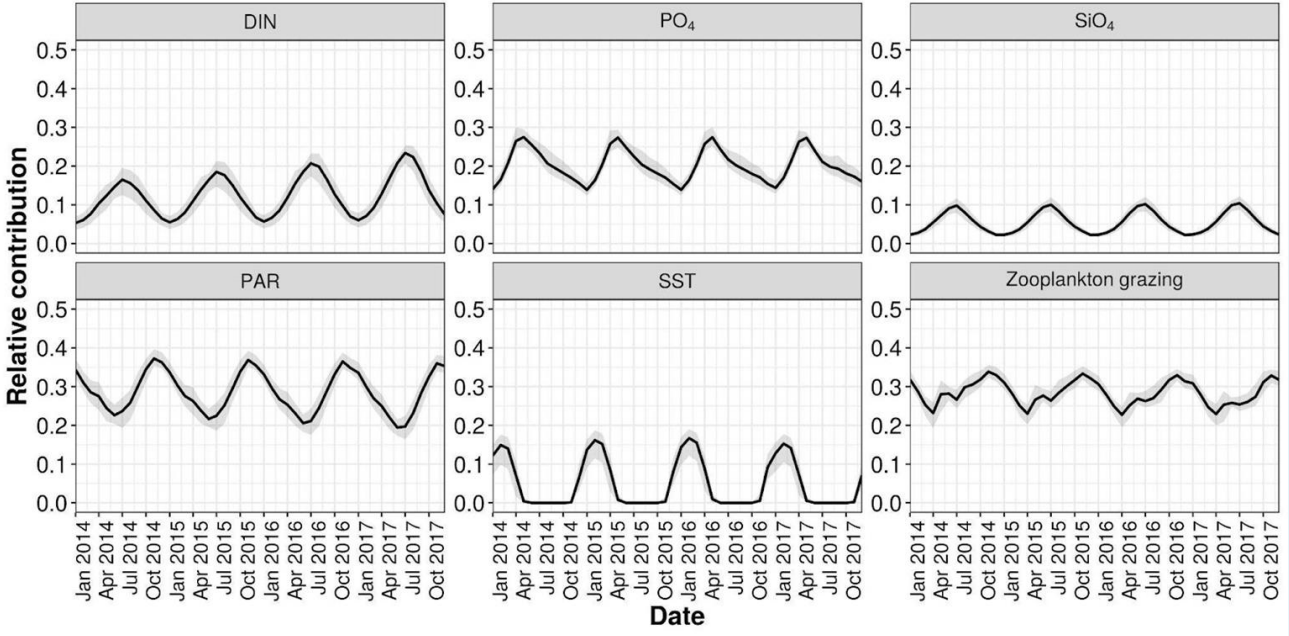
Phyto- and zooplankton biomass dynamics



Modelling phyto- & zooplankton Interactions

Results

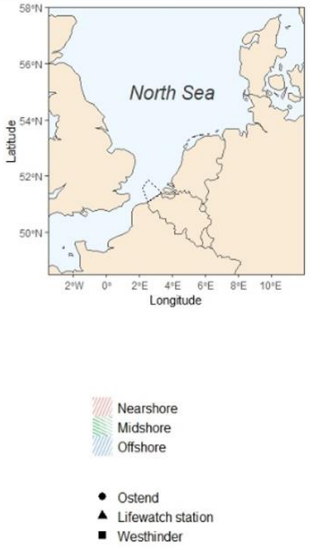
Relative contribution
- Per determinant
- Per region

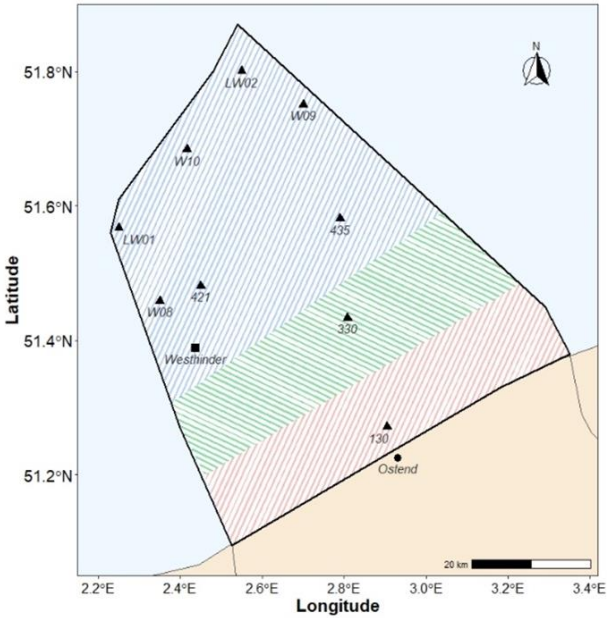


Modelling phyto- & zooplankton Interactions

Case study

- BPNS
- Dynamic coastal area
- 3 regions
  - Nearshore
  - Midshore
  - Offshore



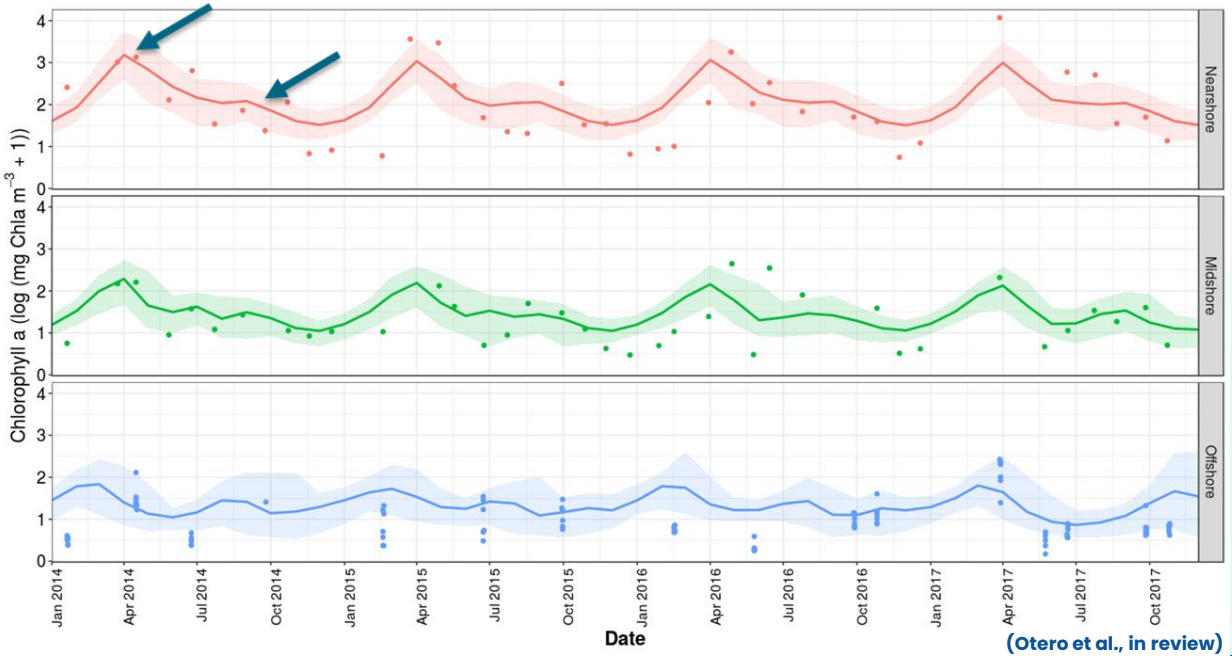


Modelling phyto- & zooplankton Interactions

Case study

Phytoplankton biomass dynamics

Per region



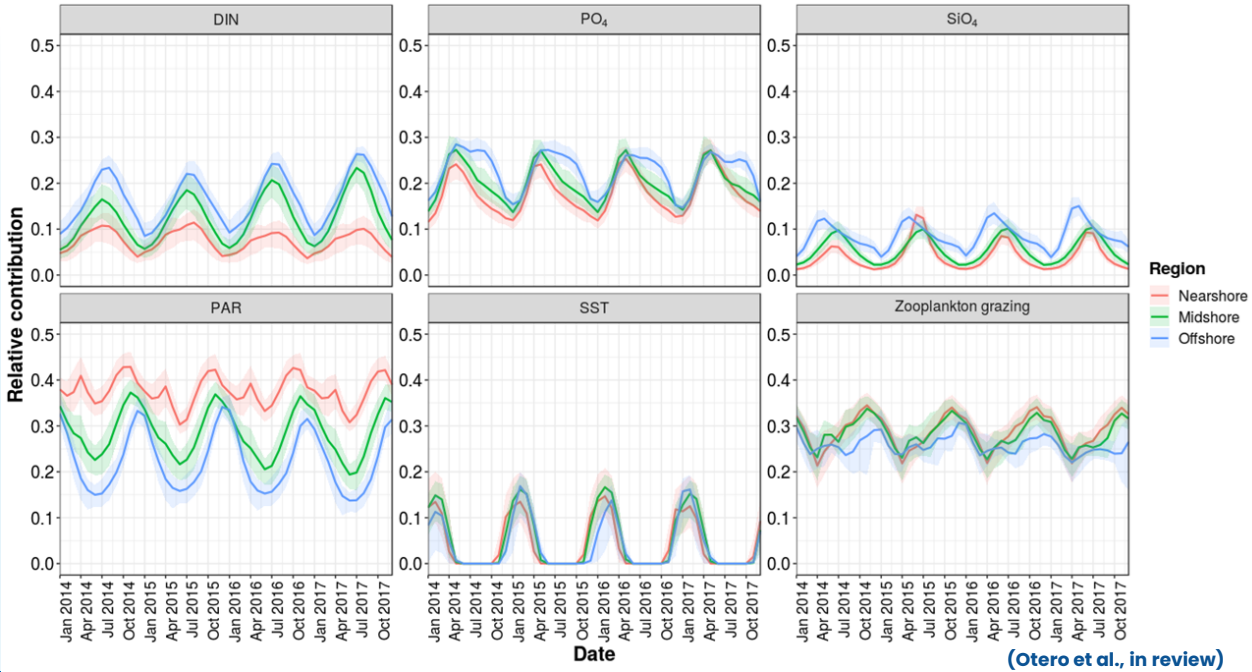
(Otero et al., in review)

Modelling phyto- & zooplankton Interactions

Case study

Relative contribution
- Per determinant
- Per region

=> Spatiotemporal variability



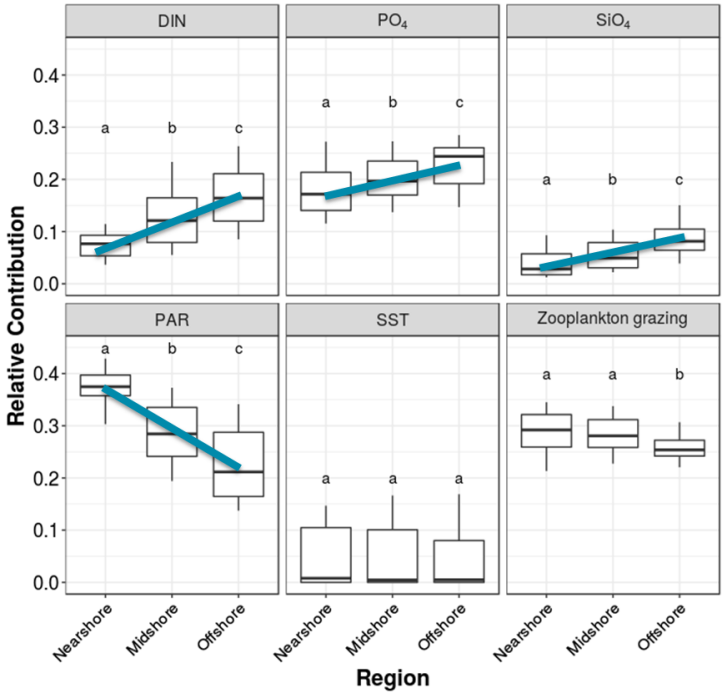
(Otero et al., in review)

Modelling phyto- & zooplankton Interactions

Case study

Relative contribution
- Per determinant
- Per region

=> Spatial variability



(Otero et al., in review)

Modelling phyto- & zooplankton Interactions

Conclusions

- Contribute to a better mechanistic understanding of the spatiotemporal dynamics of phytoplankton biomass
- Predict whether the ecosystem will change under future climate scenarios and/or Blue Economy activities
- Additional to field observations in monitoring programs
- Powerful tool that has great scientific potential

Useful materials for users

- To explore the demo register at https://blue-cloud.d4science.org/web/zoo-phytoplankton_eov
- "Users' Handbook": Guidelines for each Virtual Lab: https://data.d4science.net/NyS7
- Video tutorials in Blue-Cloud youtube channel: www.youtube.com/c/BlueCloudorg
- News & articles: www.blue-cloud.org/vlabs/zoo-and-phytoplankton-eov-products

@BlueCloudEU

Blue-Cloud

Behind the demonstrator:

Thank you!

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