Framework Partnership Agreement for Copernicus User Uptake

PORTUGAL SPACE

d.gTerritório Direção-Geral do Território

AIR CENTRE ATLANTIC INTERNATIONAL RESEARCH CENTRE

Atlantic Innovation Week

14-17 MARCH 2022
AZORES, PORTUGAL

Copernicus for Business Innovation in Portugal

Session: Ocean Monitoring

Tuesday March 15th (15:15 - 16:45)

Copernicus for Business Innovation: Ocean Monitoring

Success Cases

15.15 : Copernicus Services, Data and Tools with relevance for Ocean Monitoring

Muriel Lux

Environmental Policies and Key Account Manager

MERCATOR-OCEAN

15.30 : Harmful Algae Bloom Monitoring

Issah Nazif Suleiman

Data Scientist

EYECON Group Ltd.

15.45 : SEAPODYM offers new insights into the behaviour of large whales and informs conservation efforts

Monica A. Silva

Senior Research Associate

OKEANOS – University of Azores

Atlantic Innovation Week 14-17 MARCH 2022 AZORES, PORTUGAL

Copernicus for Business Innovation: Ocean Monitoring

Success Cases

16.00 : Ocean mesoscale eddies identification and tracking using Ocean Colour

Ana Martins

Auxiliary Professor Oceanography

OKEANOS – University of Azores

16.15 : How is Copernicus Data essential for the future of ocean observation with autonomous systems?

Renato Mendes

PhD, Physical Oceanography

CoLab+Atlantic & University of Porto

16.30 : Marine Heat Waves

Ana Oliveira

Remote Sensing Data Analyst

CoLab+Atlantic

Copernicus Framework Partnership Agreement for Copernicus User Uptake · PORTUGAL SPACE · d.g Território Direção-Geral do Território · AIR CENTRE Atlantic International Research Centre · Atlantic Innovation Week · 14-17 MARCH 2022 AZORES, PORTUGAL

Copernicus for Business Innovation: Ocean Monitoring

Workshop

Workshops 1:

Introduction to Marine Debris Detection with Sentinel-2 using Python

Emanuel Castanho

Project Developer

AIR Centre

Workshops 2:

On the use of Ocean Colour in the Western Iberia Coast

Ana C. Brito

Assistant Research

MARE-ULisboa

Atlantic Innovation Week 14-17 MARCH 2022 AZORES, PORTUGAL

Copernicus Marine Service

Implemented by MERCATOR OCEAN INTERNATIONAL

Copernicus for Business Innovation

Ocean Monitoring Session

Muriel Lux
Environmental Policies and Major Account Manager
Mercator Ocean international

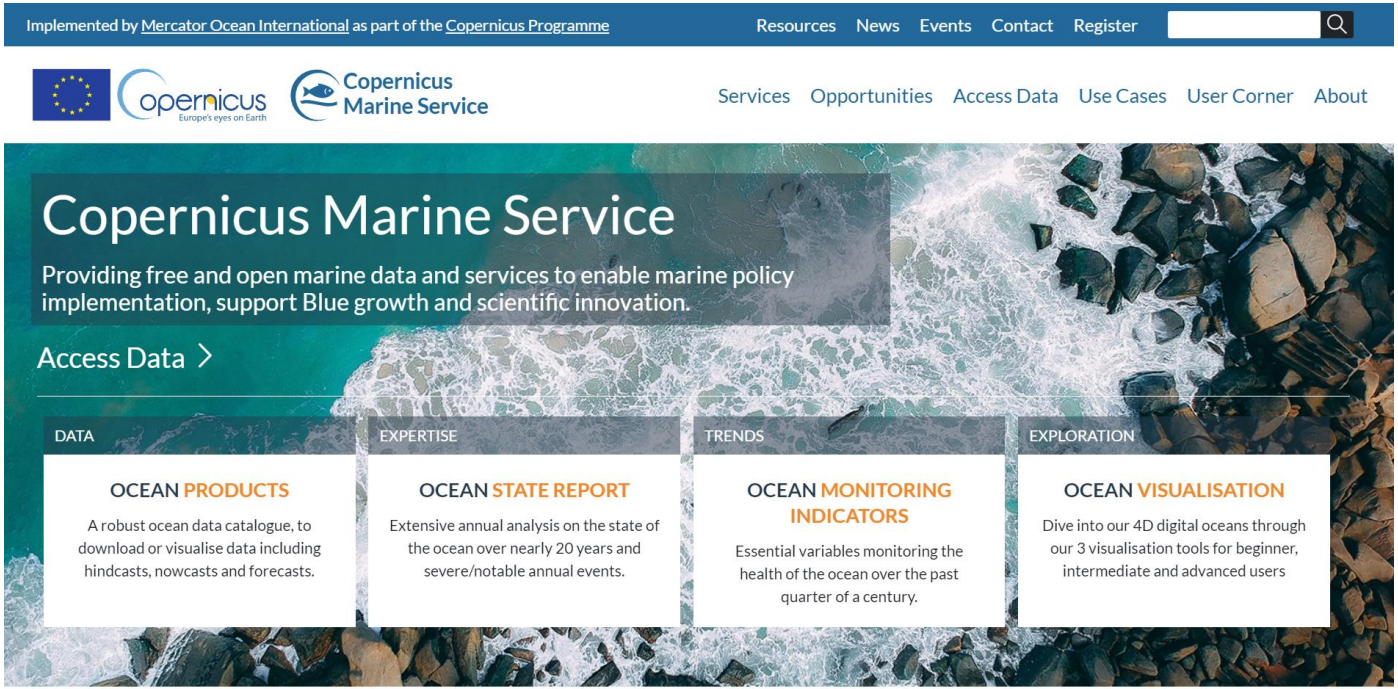
PROGRAMME OF THE EUROPEAN UNION

Copernicus Europe's eyes on Earth

implemented by MERCATOR OCEAN INTERNATIONAL

How can the Copernicus Marine Service support the different marine sectors

Single access point – marine.copernicus.eu

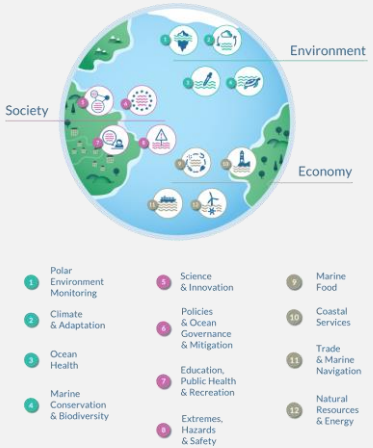


- **Online Catalogue**
- **More than 300 scientifically qualified products**
- **User-driven**
- **Common format *Netcdf***
- **Spatial resolution from 25 km to 100 m**
- **Temporal resolution from monthly to 15 min**
- **Open & Free**

From data providers to products to users

Data providers all over Europe to build ocean products centralized in Copernicus Marine Portal

Feed thousands of users on all continents

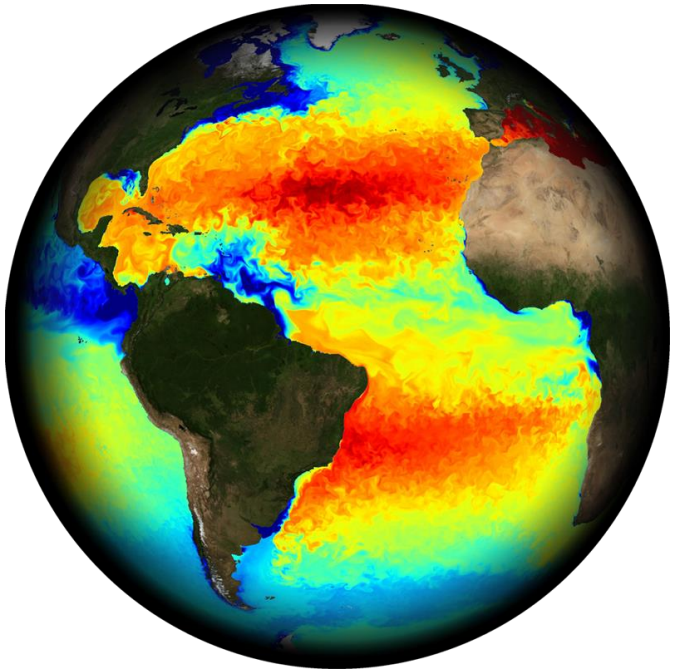


And Support a wide range of markets and environmental policies

Developing actions (instruments)

- Training and WORKSHOPS
- Practices and USE CASES
- Sectorial PARTNERSHIPS
- Marketing CAMPAIGNS
- Responses to FEEDBACKS

Ocean Observing and Forecasting



Copernicus Marine Service

Monitoring the Blue, the White and the Green Ocean

The Blue Ocean describes the physical state of the ocean. It is related to parameters such as sea surface temperature, sea surface height, ocean currents, waves, ocean heat content, salinity and mixed layers depth

Links to many videos on the blue ocean on The Blue Ocean | CMEMS (copernicus.eu)

The White Ocean refers to the life cycle of any kind of ice floating at the surface of the ocean in the polar regions. Indicators for the White Ocean includes sea ice extent and volume in the Arctic, Antarctic and Baltic oceanic areas

Links to many videos on the white ocean on The White Ocean | CMEMS (copernicus.eu)

The Green Ocean describes the biogeochemical processes in the ocean. The green ocean encompasses among other things, variations of chlorophyll-a concentrations, ocean nutrients, and primary production, as well as the ocean acidification and ocean deoxygenation

Links to many videos on the white ocean on The Green Ocean | CMEMS (copernicus.eu)

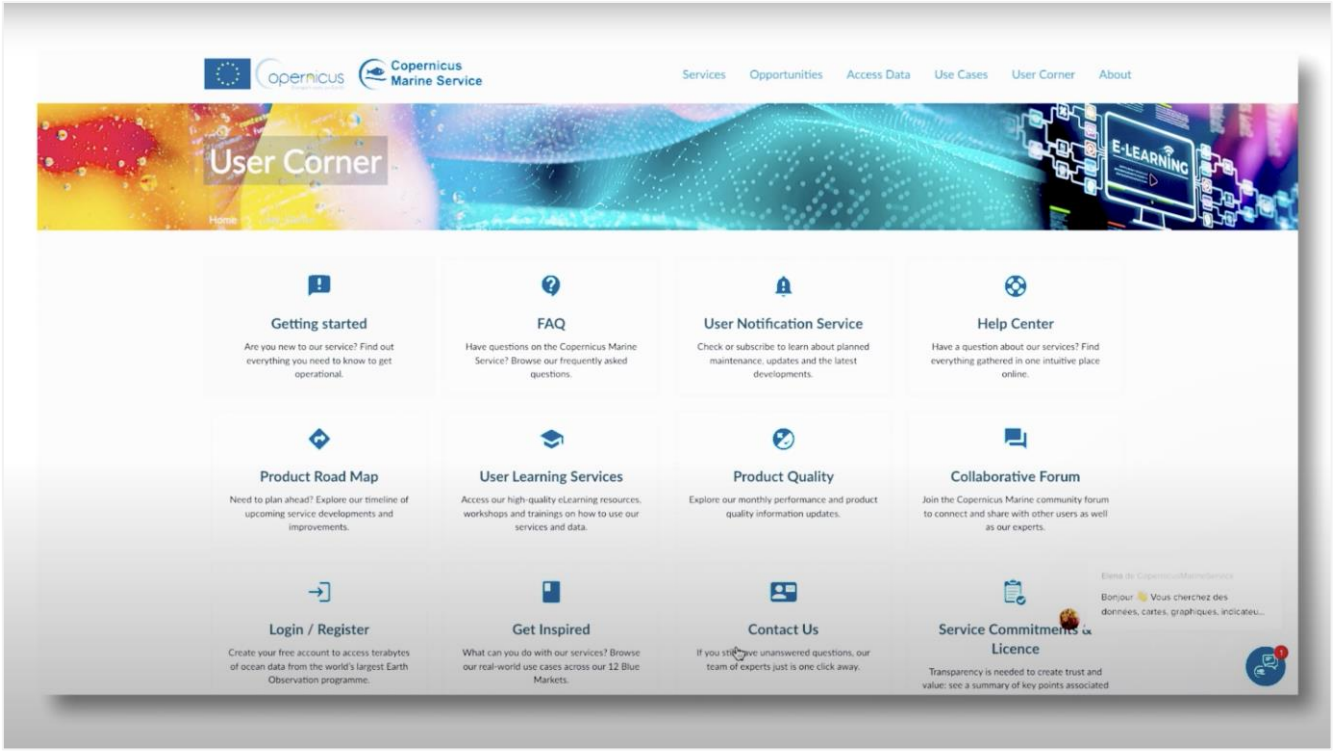
Ocean products portfolio

DATA SOURCES	TEMPORAL COVERAGE
MODEL DATA	REANALYSES >25 years
INSITU DATA	REAL-TIME Daily, hourly
SATELLITE DATA	FORECAST 10 days

GEOGRAPHICAL COVERAGE

1. Global Ocean
2. Arctic Ocean
3. Baltic Sea
4. European North West Shelf Seas
5. Iberian Biscay Ireland Seas
6. Mediterranean Sea
7. Black Sea

Single access point – marine.copernicus.eu



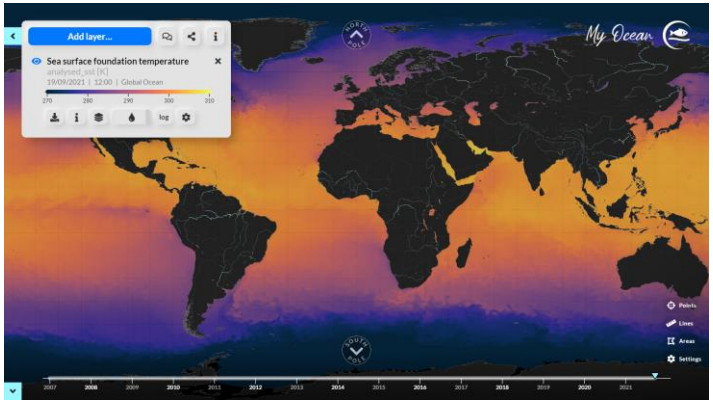
Ocean Monitoring Indicators

- ✓ Key variables used to monitor the oceanic trends in line with climate change
- ✓ Free downloadable data sets
- ✓ Covering more than 25 years

Ocean Data Visualisation tools

User-Driven

- ✓ A unique Service Desk
- ✓ FAQ & Collaborative forum
- ✓ Online visualization tool: MyOcean viewer
- ✓ More than 200 use cases online
- ✓ Elearning material available
- ✓ Online training workshops



Where to find us

marine.copernicus.eu

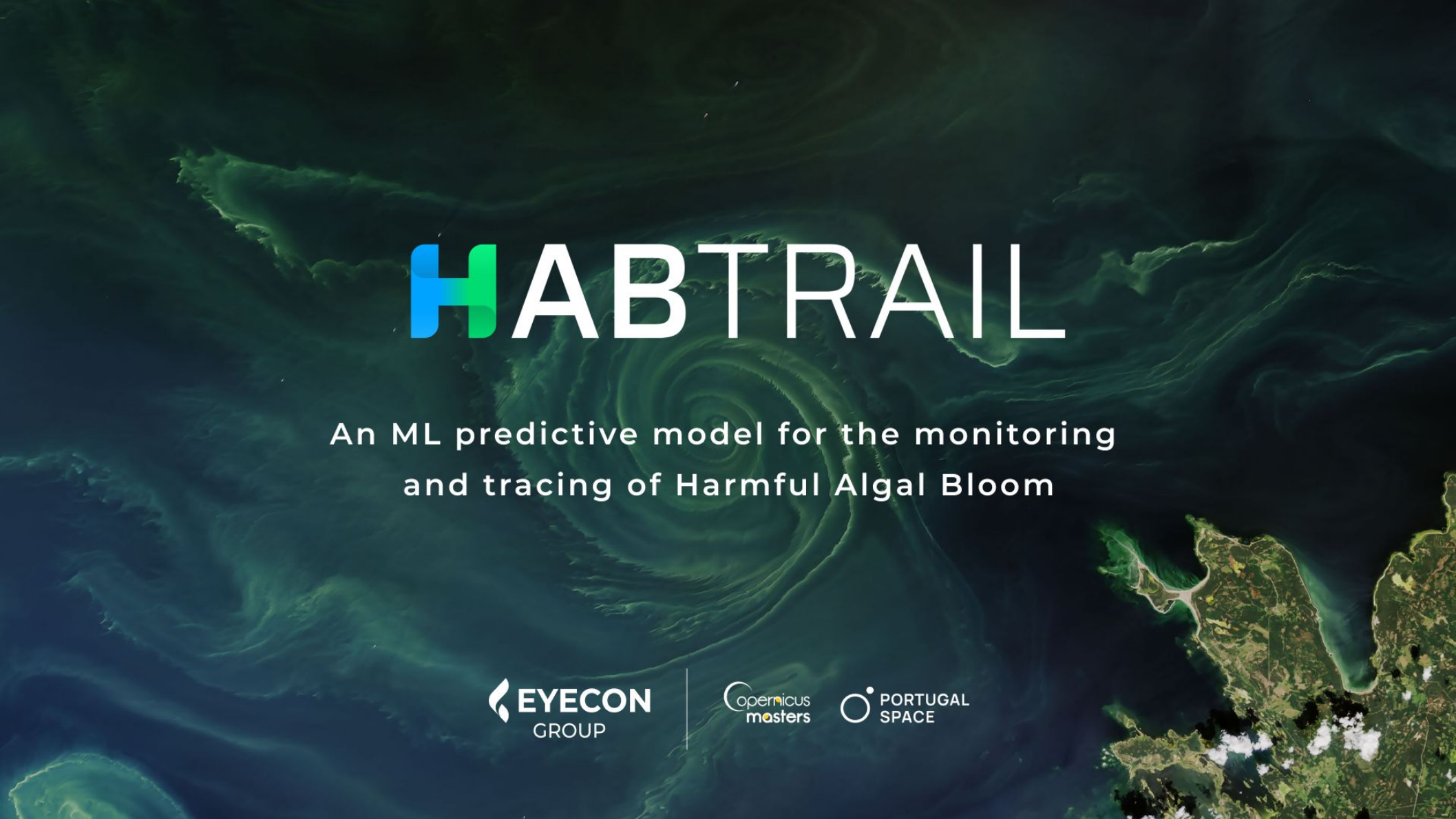
Copernicus Marine Service

@CMEMS_EU

Copernicus Marine Service

HABTRAIL

An ML predictive model for the monitoring and tracing of Harmful Algal Bloom



1. Problem: HABs

- Environmental
- Social
- Economical
- Health (loss of lives)

2. Existing Approach

- Traditional
- Remote Sensing

LIMITATIONS

- Expensive
- Time demanding
- Low Accuracy (Chl-a) Est.
- Prone calaboration Error
- Prone to Technical Error

3. Improved Solution AI Application

- Higher accuracy (Chl_a) Est.
- High AccU. (HABs) prediction
- Allow the Ass. of Var. Explo
- Cheap
- Near to real time prediction
- Allows room to address False alert (through hyperparameter tuning)

Data (S2/3 MSI OLCI)

- S2/3 MSI DATA
- Public data

4. Model

- Web & Mobile Application
- Citizen Scientist Approach
- Remote Sensing Approach
- Fully Automated Data Pipelines
- Deep Learning HAB Detection Model
- Early Warning System

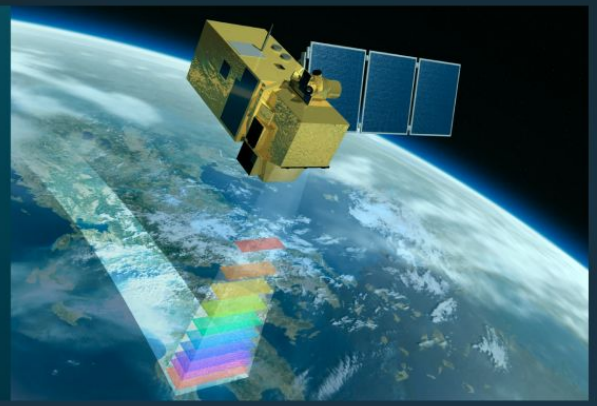
→ **Dashboard**

→ **Mobile App**

Satellite Monitoring

With Subscription Model

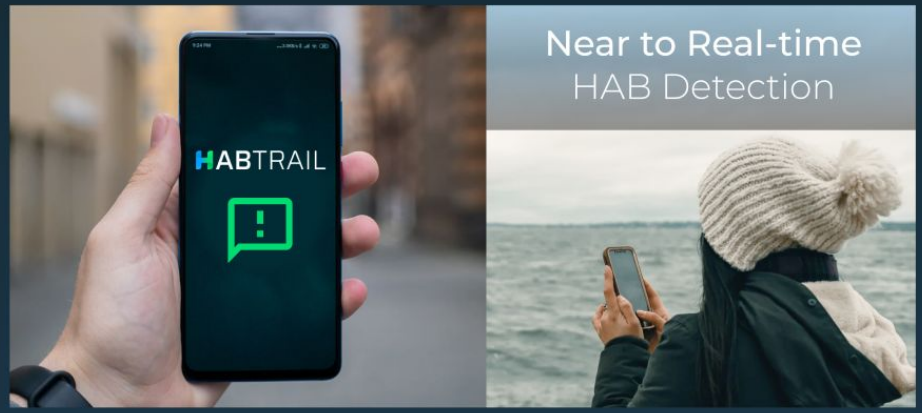
Low-Cost
Monitoring
Service



- Tackle Harmful algal blooms;
- Detect and monitor HABs expansion;
- Water quality Pigments;
- Sentinel 2 & 3.

Free mobile APP

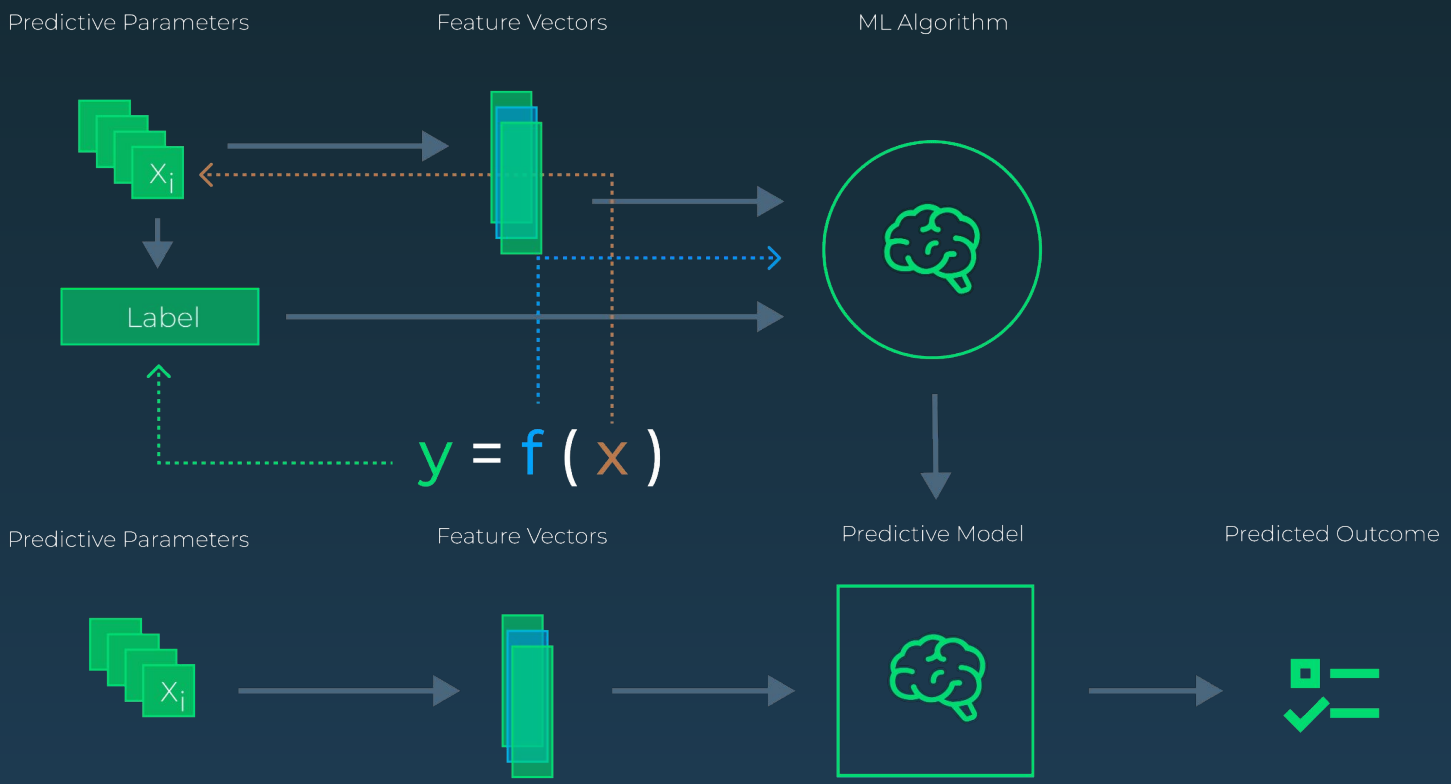
For the general public



- Upload picture of a suspicious water body;
- Quick results.

Early Warning Modelling

Machine Learning Algorithm Scheme



HABtrail System Overview

A HAB Detection, Monitoring and Warning System

HABTRAIL

Web & Mobile Application

Citizen Scientist Data Interface

Remote Sensing Data Interface

Fully Automated Data Pipelines

Deep Learning HAB Detection Model

Early Warning System

Citizen Scientist Data Interface

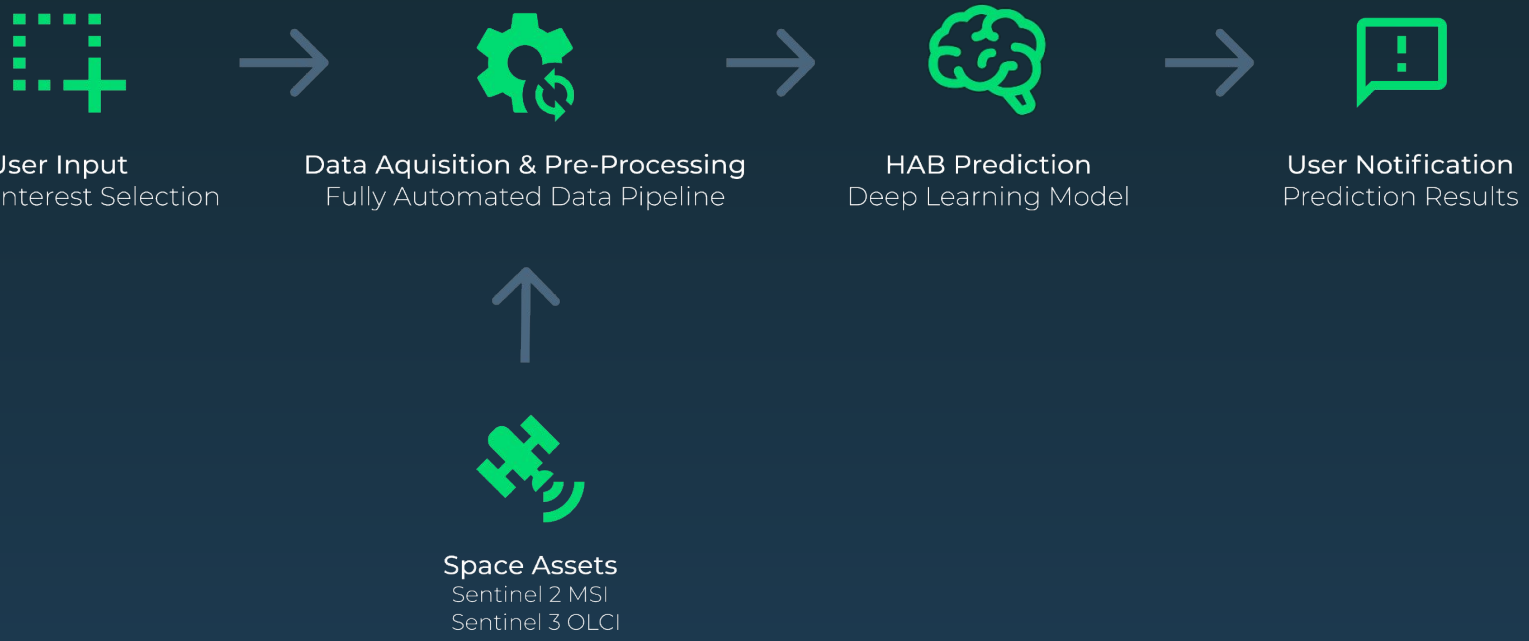
User Input
Picture of a Water Body from Smartphone or Drone

Data Pre-Processing
Fully Automated Data Pipeline

HAB Prediction
Deep Learning Model

User Notification
Prediction Results

Remote Sensing Data Interface

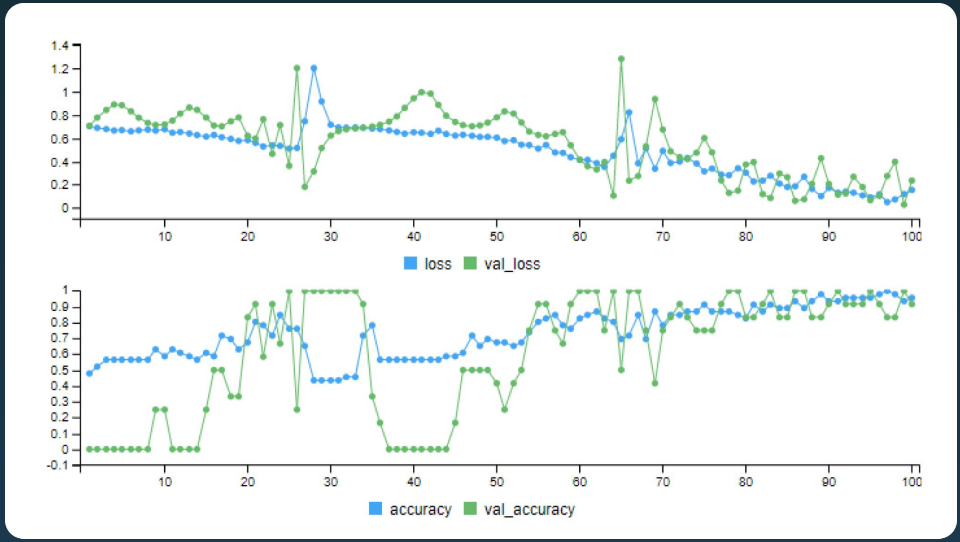


Model Assessment - Preliminary Results

Confusion Matrix and Statistics

Accuracy	0.9292
Precision	0.9231
Specificity	0.9796
Kappa Value	0.91038
P-Value	2.2e-16

Predictive Plot with epoch/batch size = 100



HABtrail Team

Issah Sulemain
Data Scientist

Ana Martins
Scientific Advisor

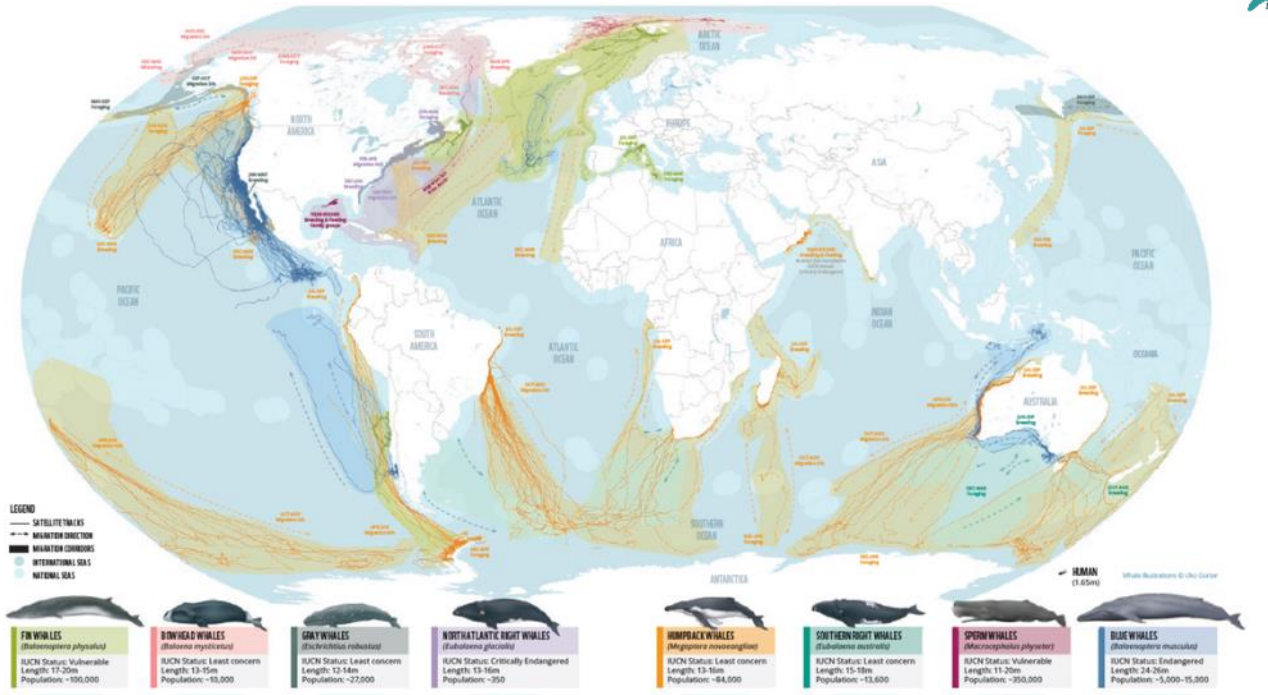
João Gonçalves
Software Engineer

Miguel Correia
Business Development

SEAPODYM-MTL offers new insights into the behaviour of large whales and informs conservation efforts

Mónica A. Silva, Miriam Romagosa, Sergi Pérez-Jorge

Atlantic Innovation Week | Copernicus for Business Innovation: Ocean Monitoring
15 March 2022

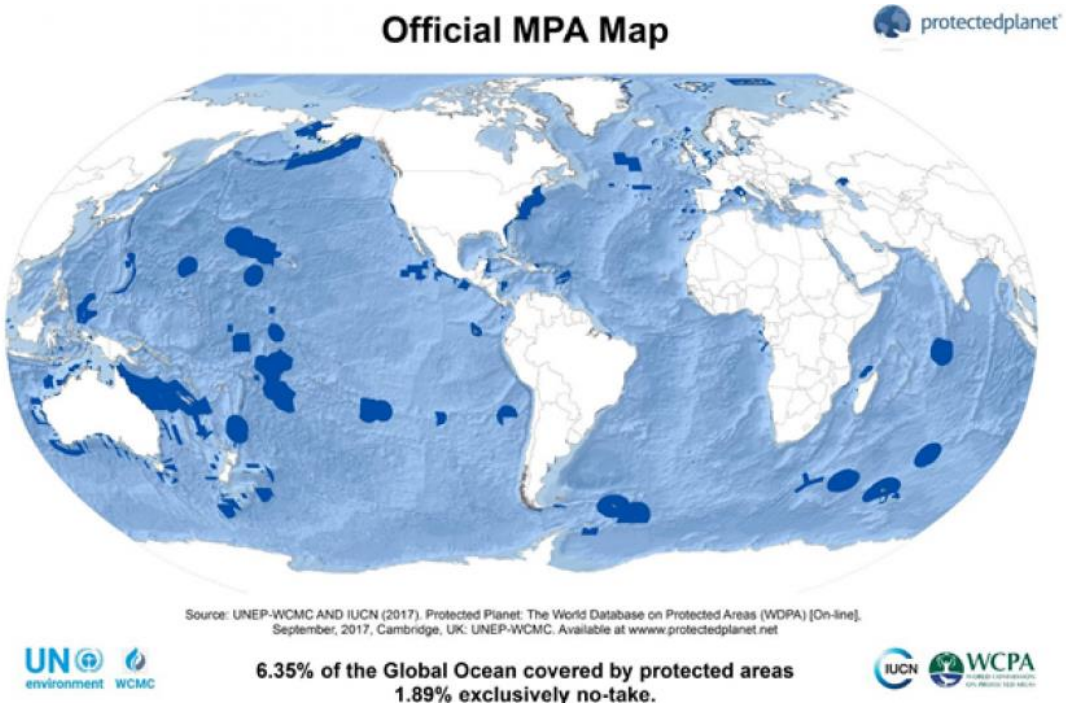


Johnson et al. (2022)

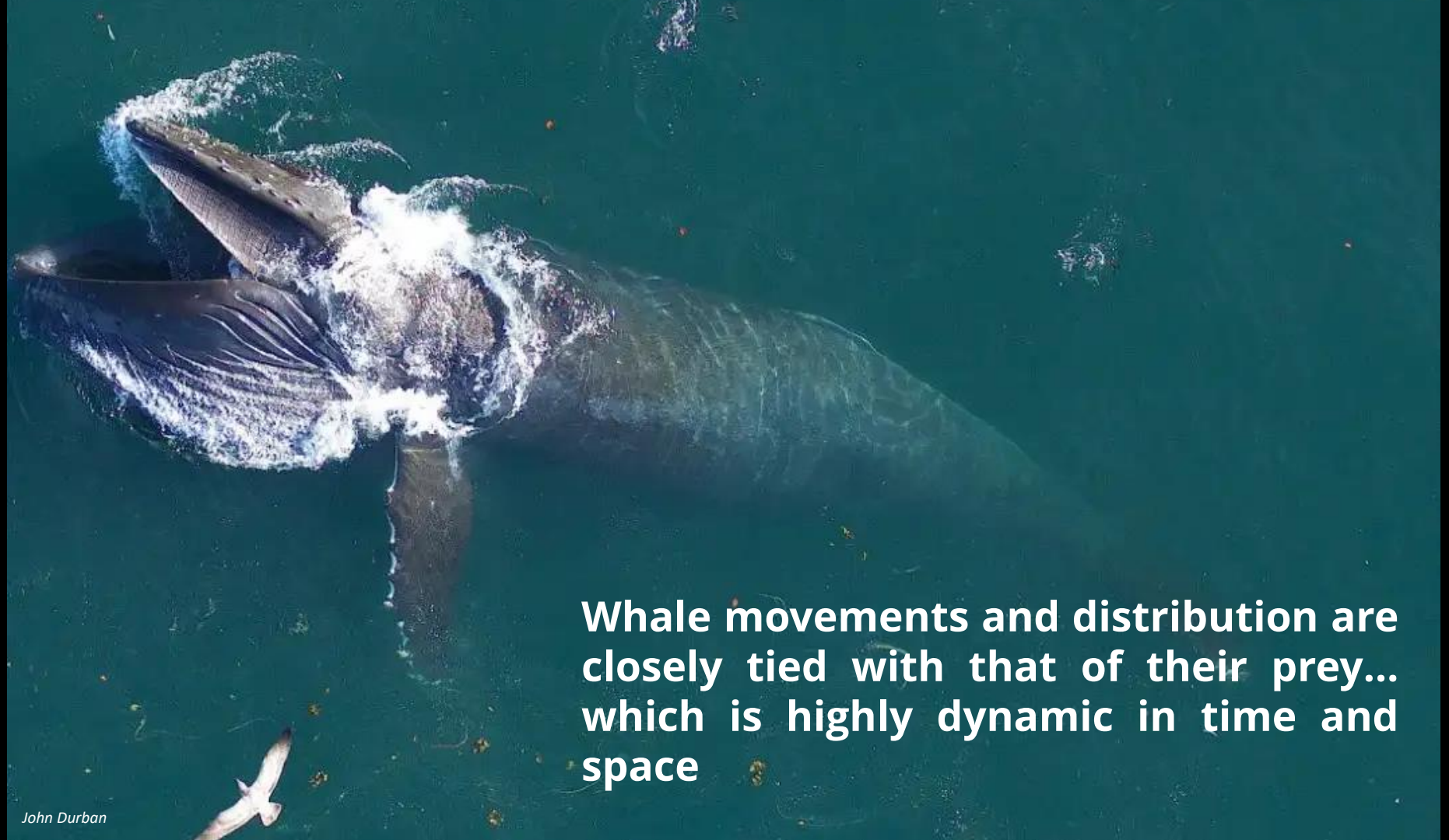
Whales move across ocean basins as they travel between critical habitats used for feeding and breeding

Navigating uncertain waters

Migrations are increasingly dangerous

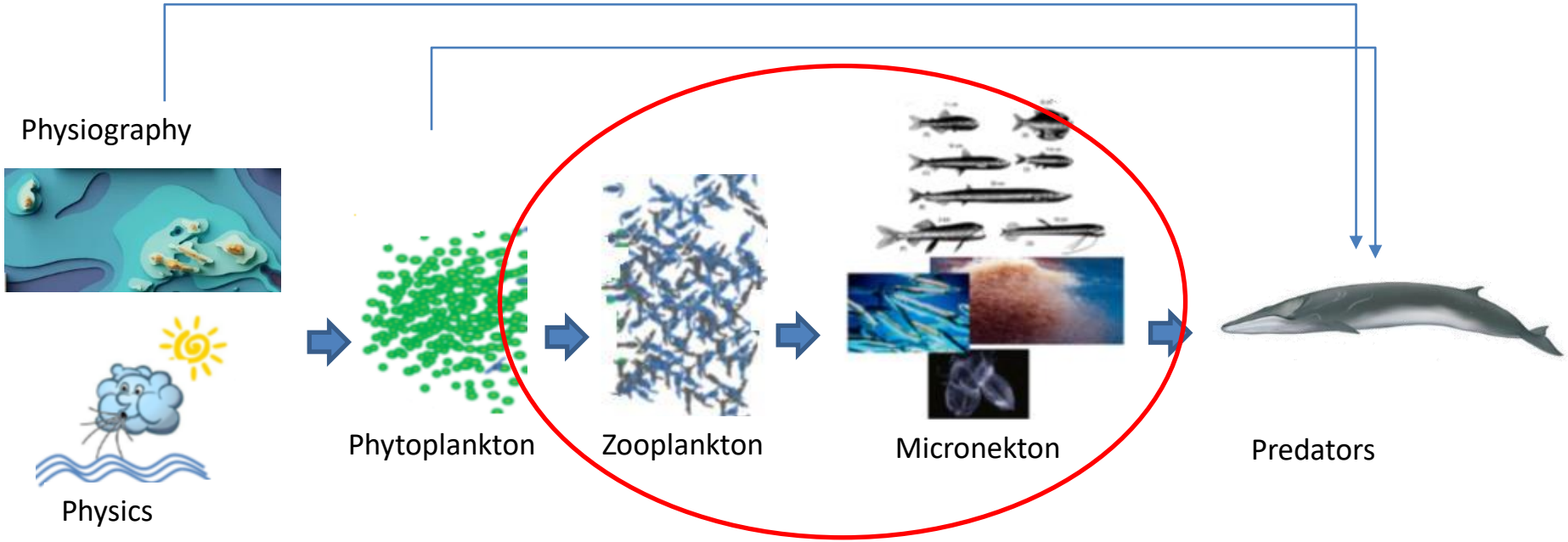


Conservation efforts largely based on static area-based management



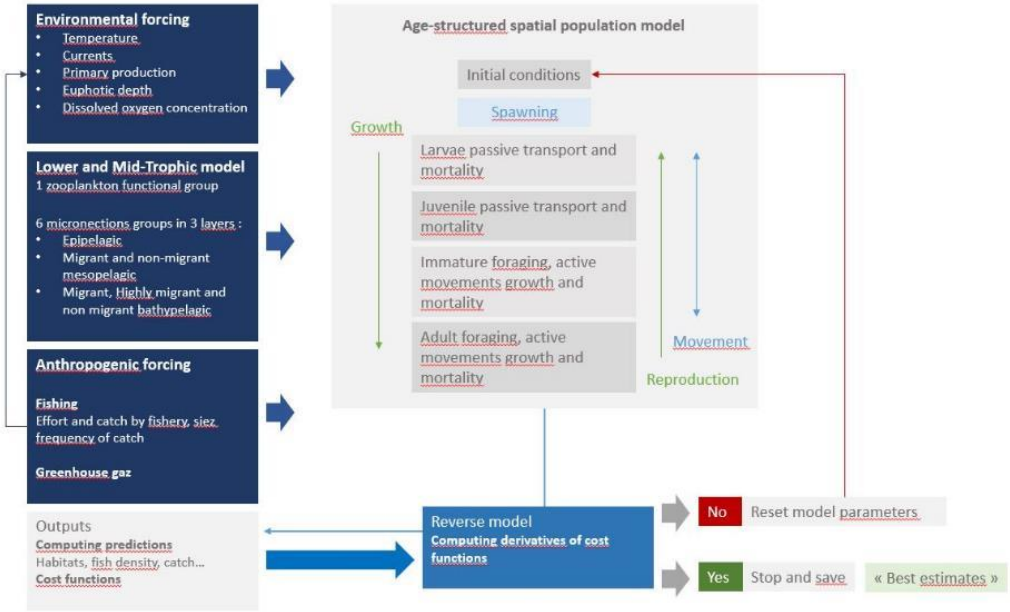
Whale movements and distribution are closely tied with that of their prey… which is highly dynamic in time and space

John Durban



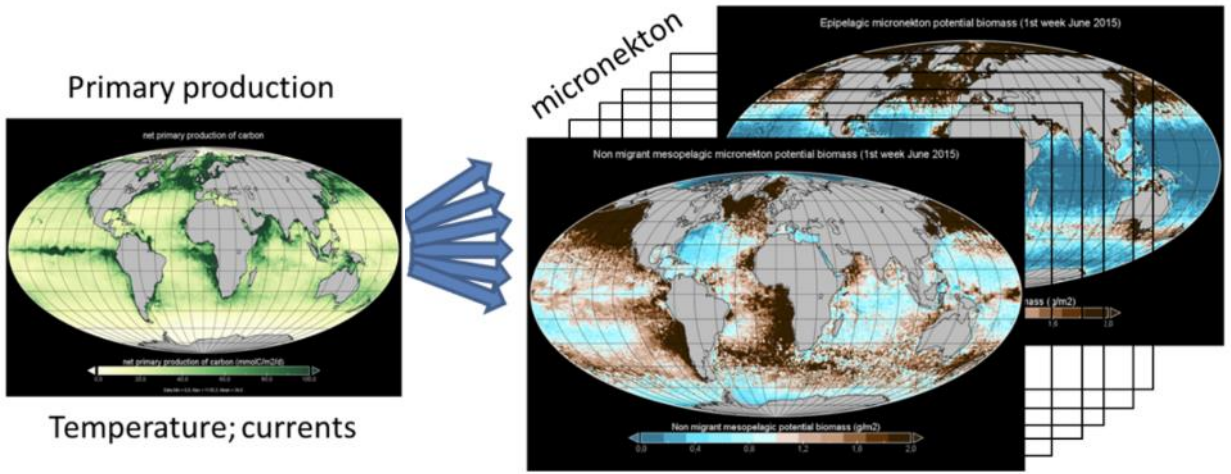
Zooplankton and Micronekton are the missing links to understand the distribution and behaviour of whales and other predators

SEAPODYM (Spatial Ecosystem And Population DYnamics Model)



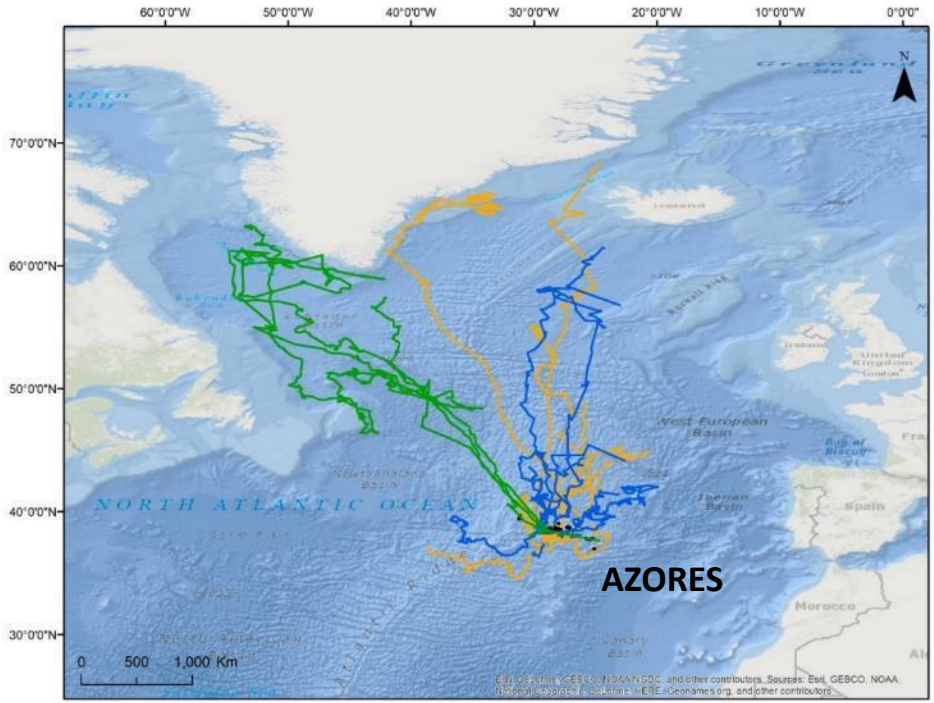
SEAPODYM is a **numerical modelling framework** for the management of marine resources and ecosystems. It includes representations of **low and intermediate trophic levels** (zooplankton and micronekton), **age-structured fish populations**, and **fisheries**

SEAPODYM – LTL (low-trophic level) and MTL (mid-trophic level)



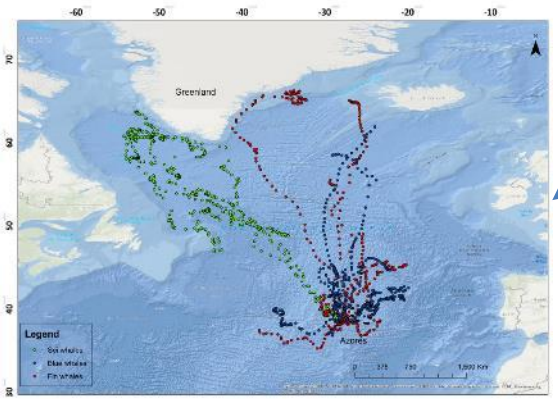
SEAPODYM-LTL and -MTL simulates **biomass distributions of 1 zooplankton and 6 micronekton functional groups**, according to their diel vertical migration behaviour and enables **hindcast and forecast simulations**

Whales Habitat Mapping

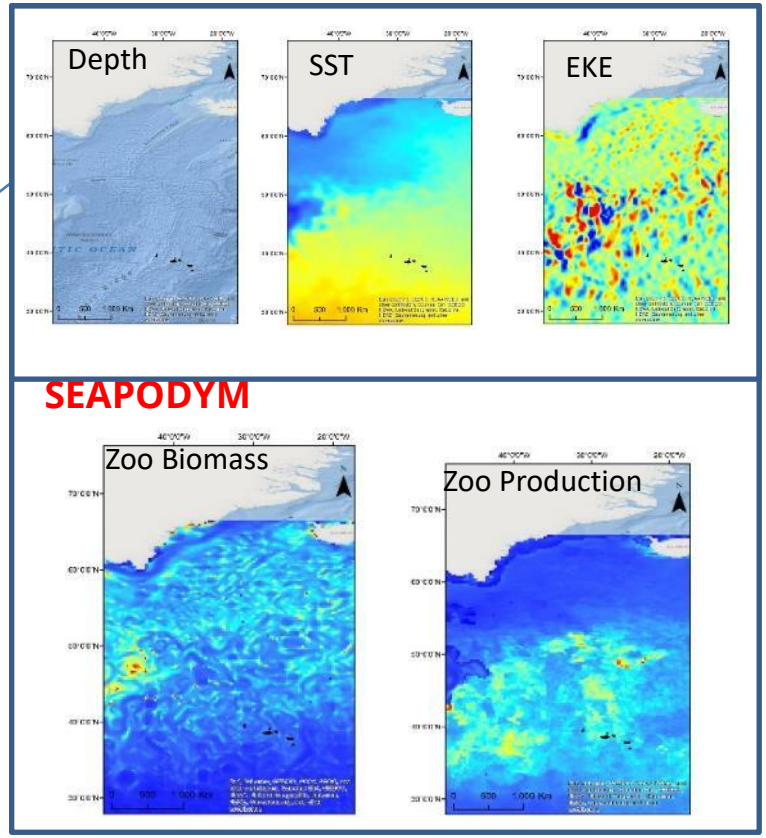


Silva et al. (2013). *PLOS One*; Prieto et al. (2014). *ESR*

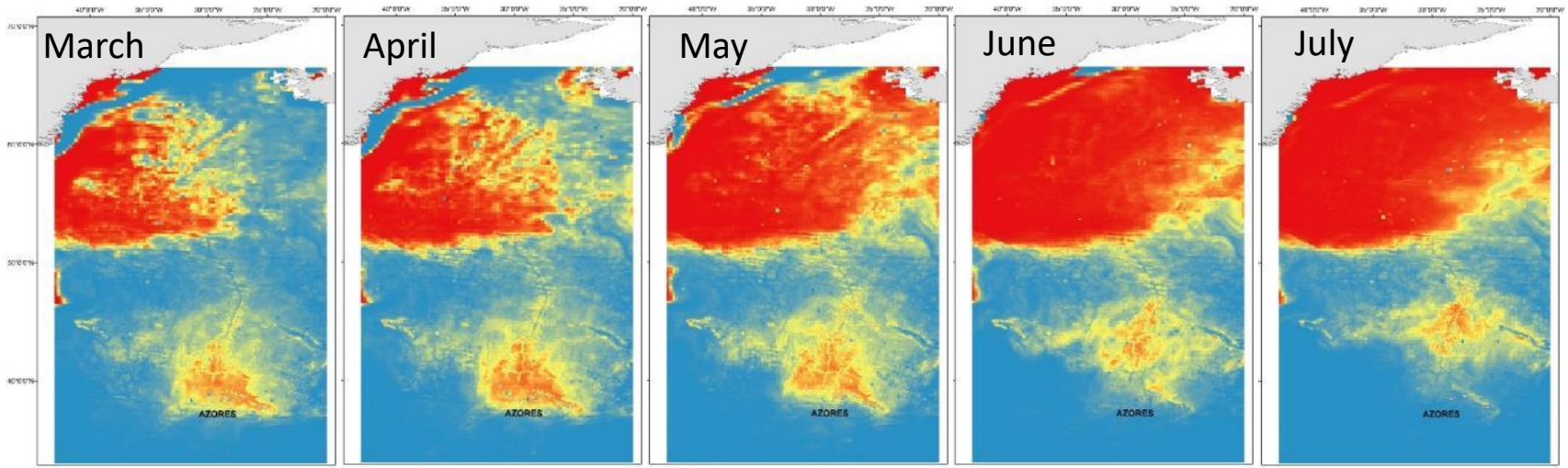
Satellite tracking data showed that the Azores is a feeding hotspot for migratory whales



Silva et al. (2013). *PLOS One*
Prieto et al. (2014). *ESR*

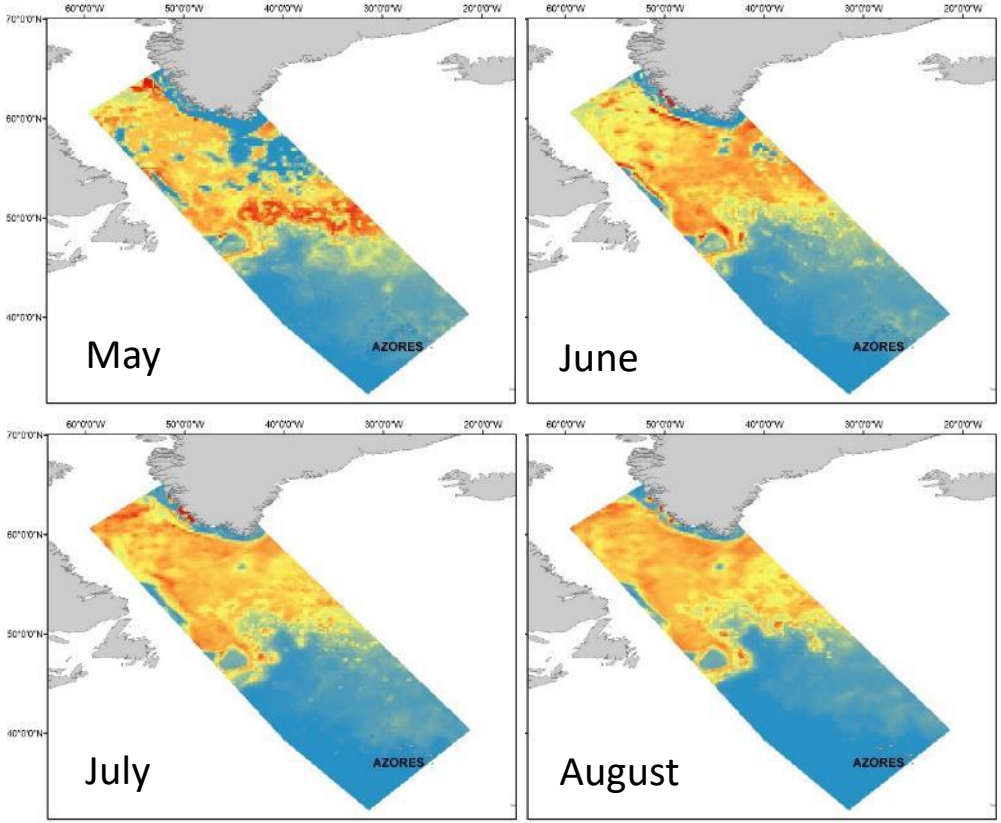


Prey variables significantly improved the model ability to accurately predict whale distribution and movements across the North Atlantic



Pérez-Jorge et al. (2020). *Diversity and Distributions*

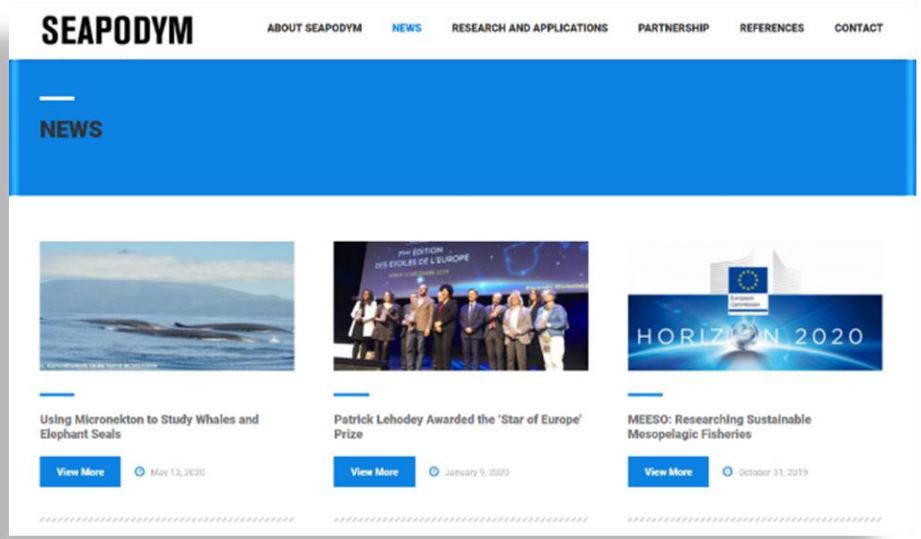
Movements of blue and fin whales followed the northward progression of zooplankton biomass



Pérez-Jorge et al. (2020). *Diversity and Distributions*

Highest predicted distribution for sei whales is in the Charlie Gibbs Fracture and Labrador Sea

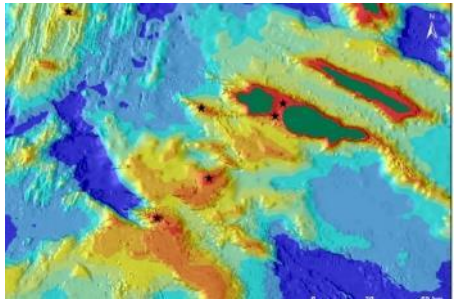
Azores is not an important feeding area and mainly serves as a migratory corridor

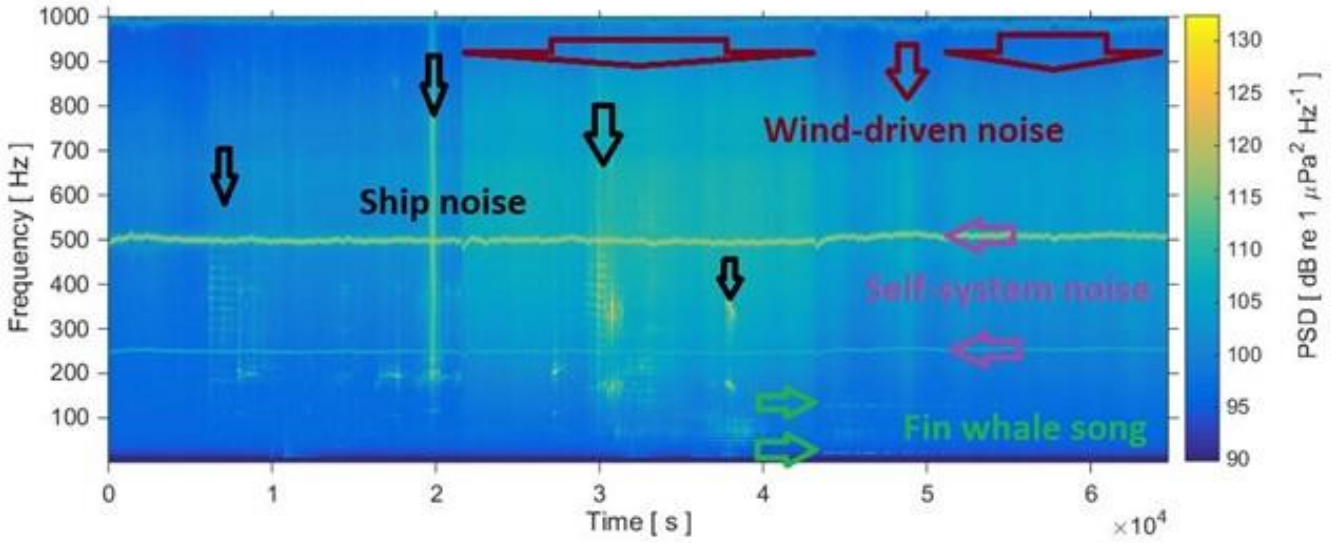


Learn more about the Whales Habitat Mapping Use Case at http://www.seapodym.eu/news/

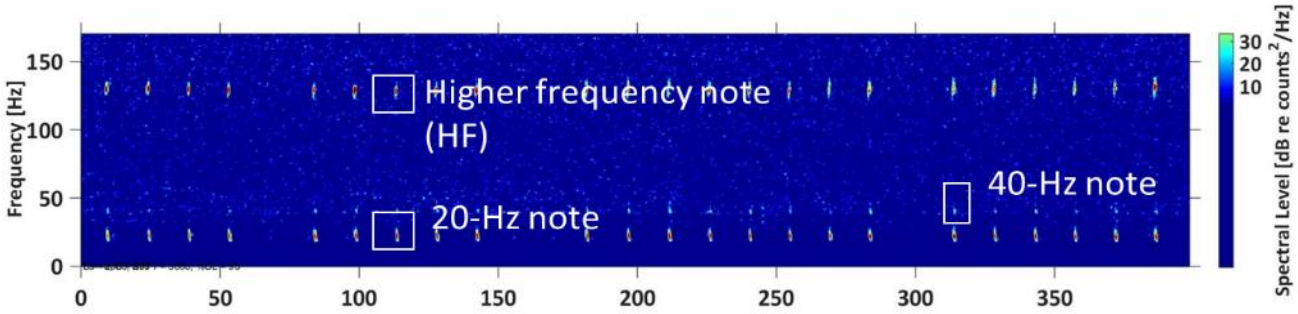
Determining the functional role of whale habitats

Miriam Romagosa, AzoresWhaleLab





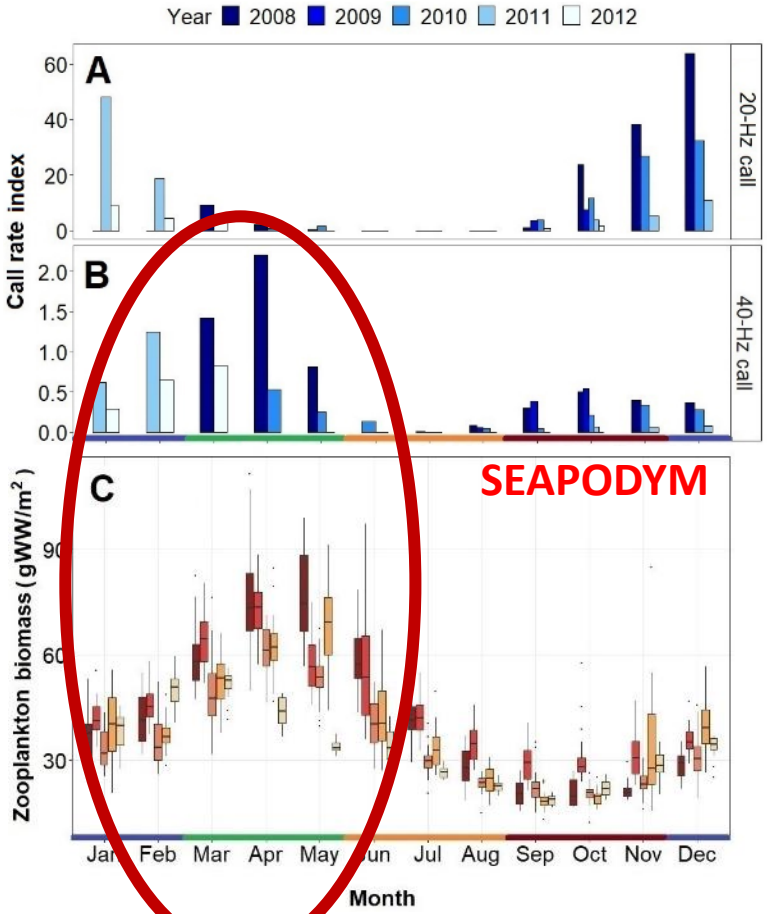
Passive Acoustic Monitoring enables continuous monitoring of natural and man-made sounds



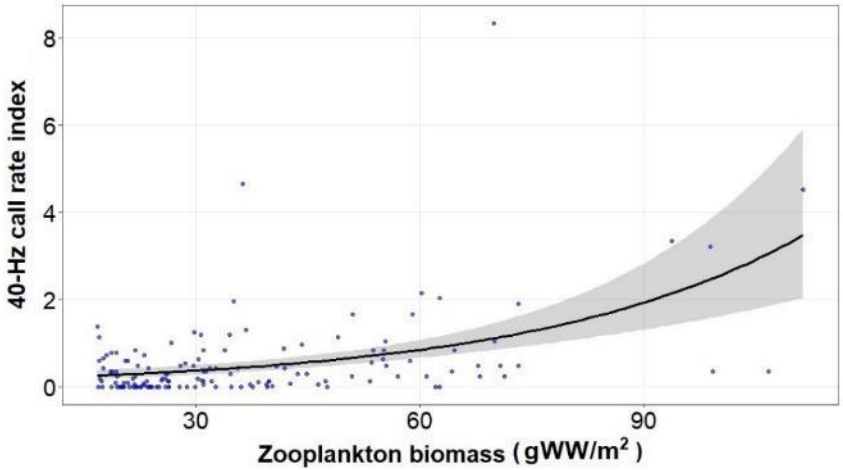
Romagosa et al. (2020). *Scientific Reports*

20-Hz Fin whale songs are believed to function as reproductive displays

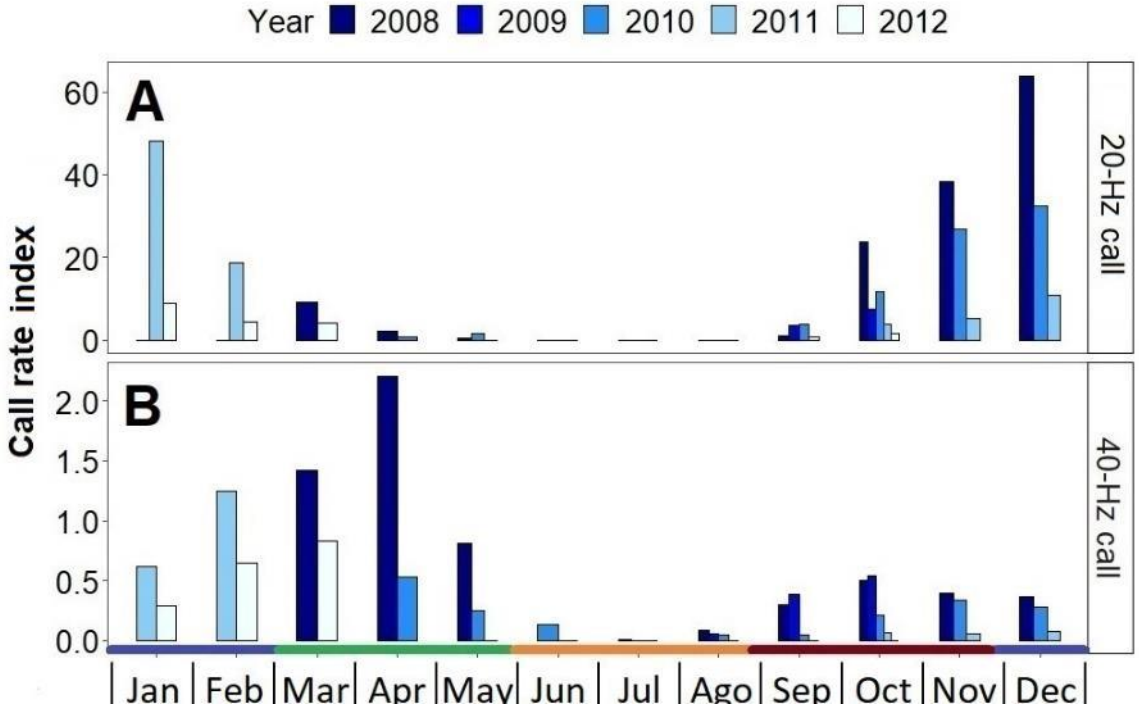
40-Hz Fin whale calls have been recorded from foraging and travelling whales



Romagosa et al. (2021). *Proc. R. Soc. B*



40-Hz Fin whale calls are related with prey biomass demonstrating a food-associated function of this call


Year 2008 2009 2010 2011 2012
A
B
Call rate index
60
40
20
0
2.0
1.5
1.0
0.5
0.0
20-Hz call
40-Hz call
Jan Feb Mar Apr May Jun Jul Ago Sep Oct Nov Dec
Breeding
Foraging
Breeding
Foraging

- SEAPODYM-LTL & MTL provides much need information on lower and mid-trophic level prey to understand the behaviour of top predators

  - Integrating modelled prey biomass with satellite telemetry/sighting data in spatially-explicit models improves understanding of drivers of movement and predictions of species distribution
  - Unveil the functional role of different habitats within the species range
  - SEAPODYM-MTL and passive acoustic data can monitor cetacean usage of remote habitats (Romagosa et al. 2019)
  - Increased resolution of modelled prey now enables looking at fine-scale foraging behaviour of predators

- SEAPODYM-LTL & MTL can be used to forecast changes in prey availability under climate change scenarios and investigate effects on top predators and highly migratory species

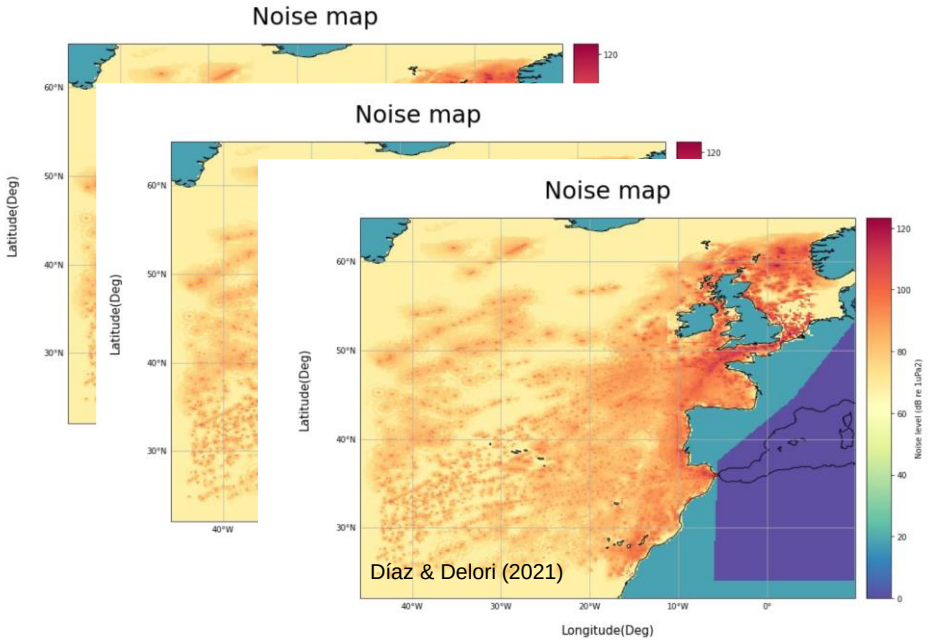
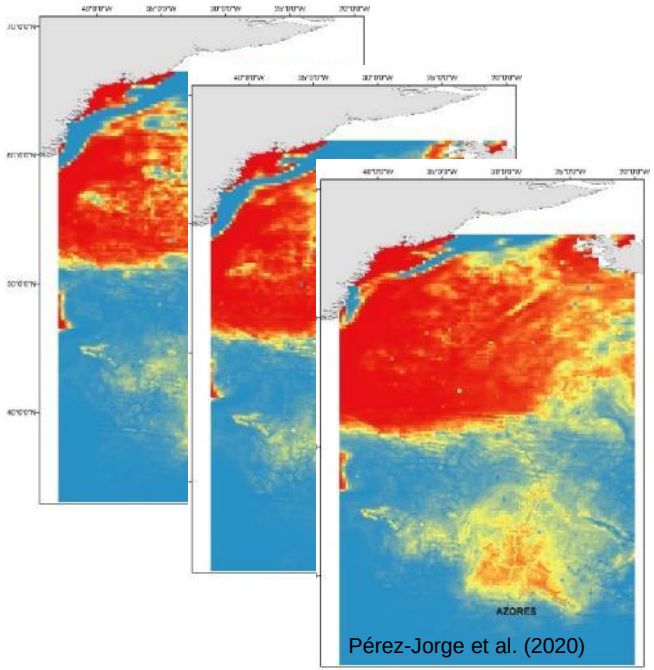


Figure 3. Noise map of the Noth-East Atlantic on Dec 10, 2019 at 125 Hz.

+



Dynamic Ocean Management: predict distribution and density hotspots for whales and probability of risk from human activities in near real-time

Thanks

AZORES WHALE LAB

www.whales.scienceontheweb.net

zWhaleLab

Funding

Fund 01-0145-FEDER-000140- MarAZ Researchers of the EU
TRACE-PTDC/MAR/74071/2006
IF/00943/2013/CP1199/CT0001
AWARENESS-PTDC/BIA-BMA/30514/2017
MAPCET-M2.1.2/F/012/2011
SUMMER-EU-H2020 GA 817806
UIDB/05634/2020, UIDP/05634/2020
M1.1.A/REEQ.CIENTÍFICO UI&D/2021/010

monica.silva.imar@gmail.com

How is Copernicus data essential for the future of ocean observation with autonomous systems?

Renato Mendes

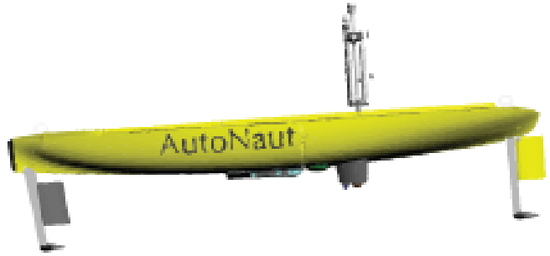
CoLAB +ATLANTIC

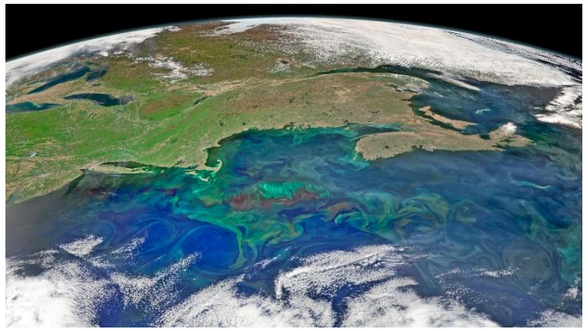
LSTS

U.PORTO

FEUP FACULDADE DE ENGENHARIA UNIVERSIDADE DO PORTO

Data Cycle?





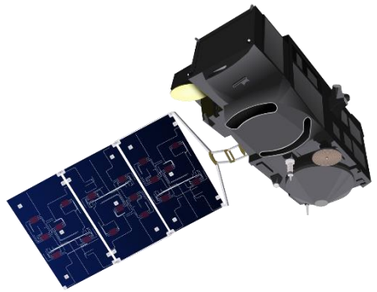
Phenomena Characterization

Ocean Databases

Forecast and Reanalysis Models

?

Cal & Val Satellite Data



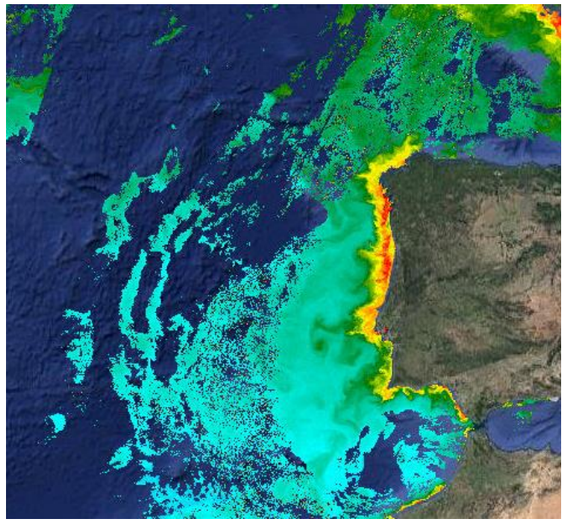
CoLAB +ATLANTIC

How?

L3/L4 Satellite data, CMEMS Reanalysis model, etc

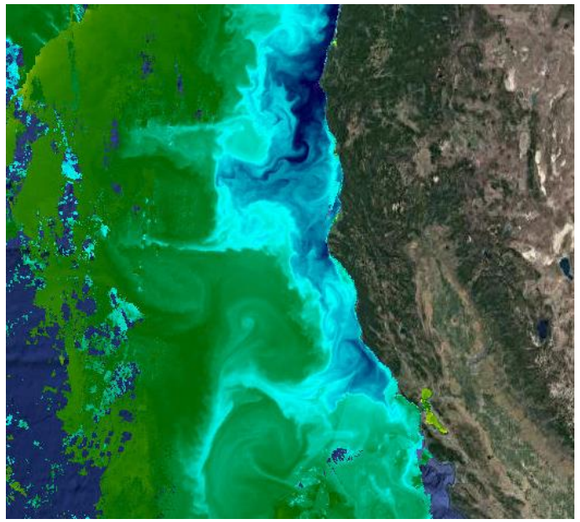
Before fieldwork

Where?



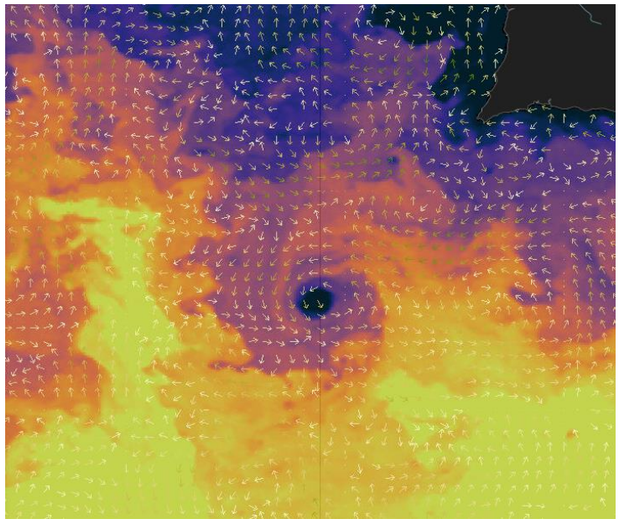
- Look for hotspot areas

When?



- Study temporal variability
- Best logistical time-window

How?



- Perform simulations
- Planning logistics
- Training the assets (ML, AI, etc)

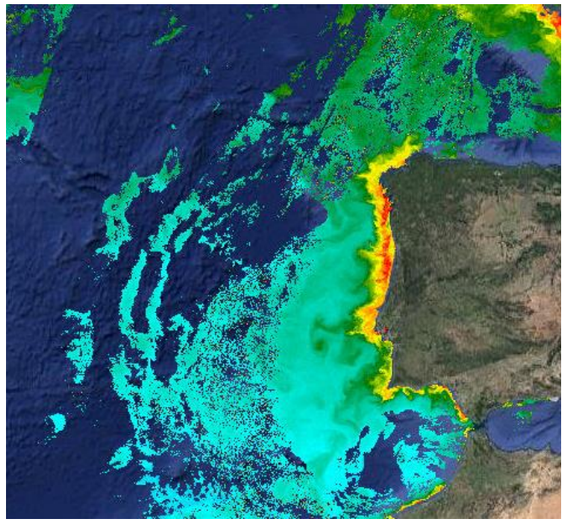
https://ovl.oceandatalab.com
https://myocean.marine.copernicus.eu

How?

Near-real time Sat data, CMEMS forecast ocean model, Weather forecast etc

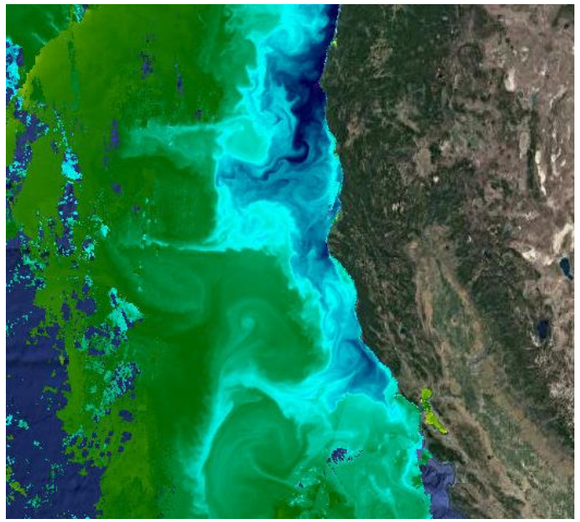
During fieldwork

Where?



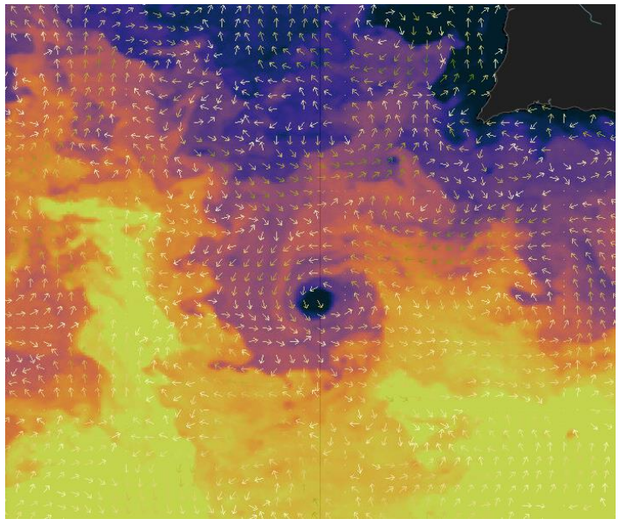
- Placing the assets in the best location to get the best data according to their capabilities and limitations

When?



- Deploy the assets in the best time-frame to collect the best data

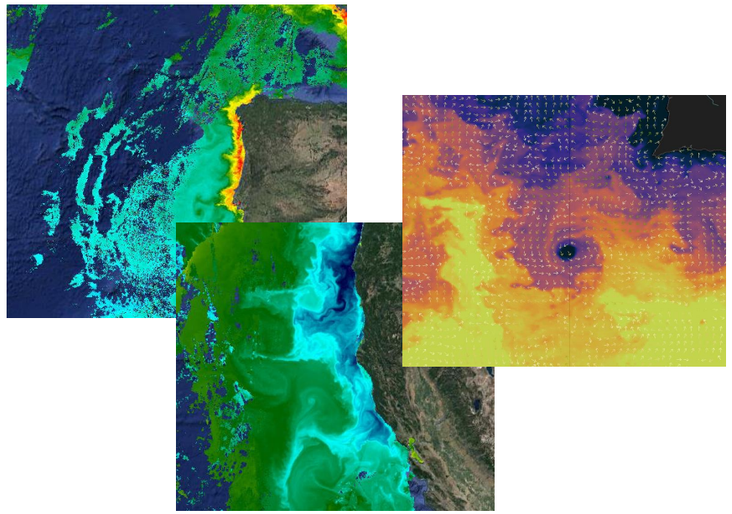
How?



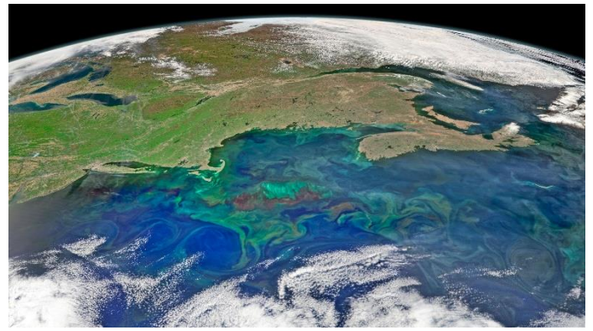
- Using forecast and near-real-time data to gain more autonomy in the assets
- Trajectory optimization, energy harvesting, adaptive sampling, avoiding bad metoc conditions, etc

How?

After fieldwork



- Lessons-Learned
- New Simulations
- New Case-studies

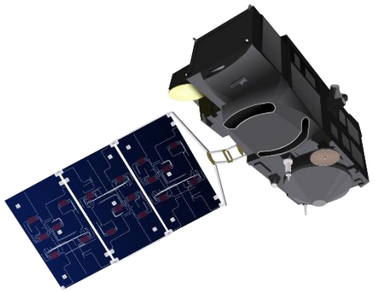


Phenomena Characterization

Ocean Databases

Forecast and Reanalysis Models

Cal & Val Satellite Data



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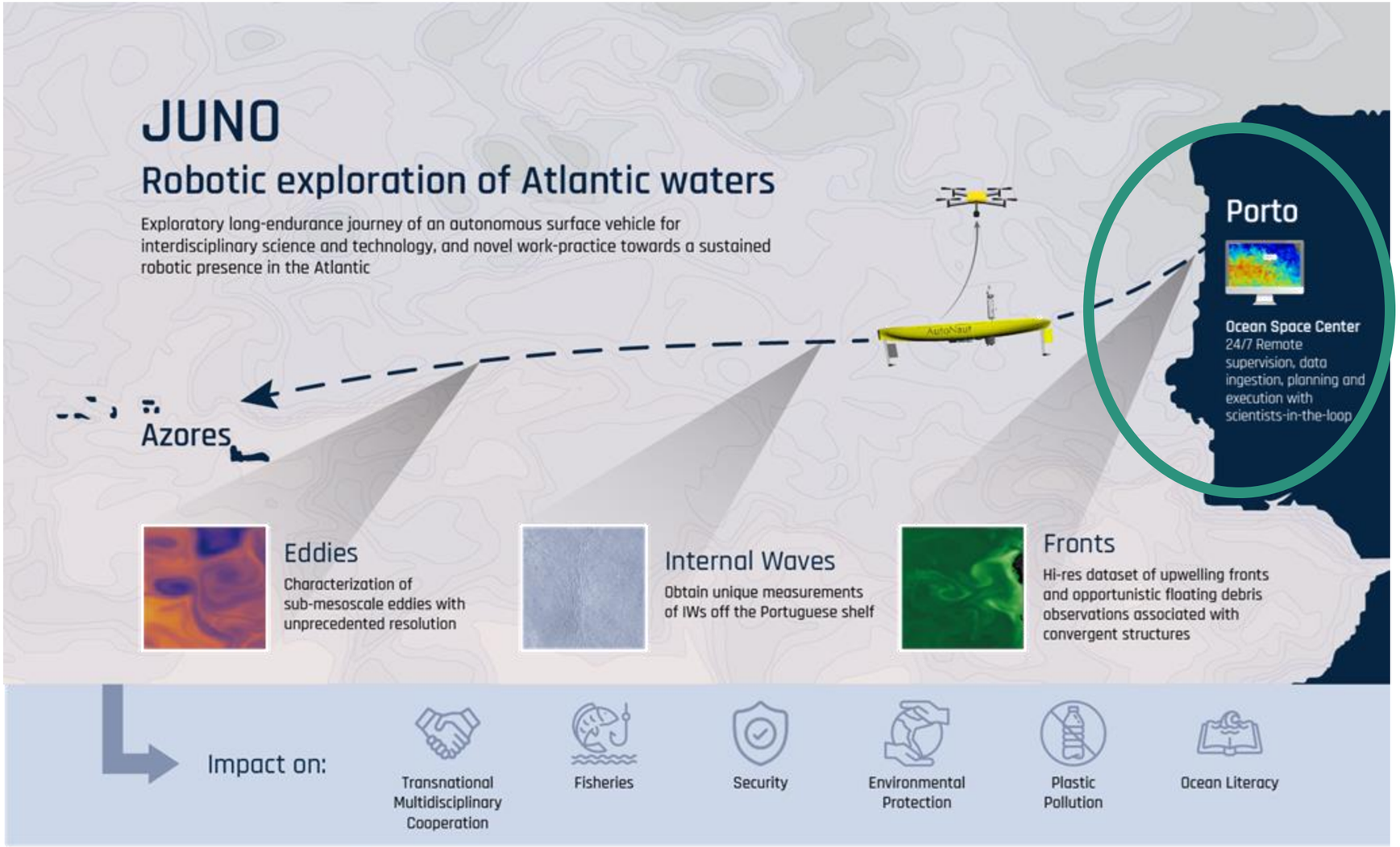
Projects

FLAD FUNDAÇÃO LUSO-AMERICANA PARA O DESENVOLVIMENTO

2ª edição

SCIENCE AWARD_ ATLANTIC '21



Example of *Data Cycle* concept

FLAD LUSO-AMERICAN DEVELOPMENT FOUNDATION

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MITMECHE

Massachusetts Institute of Technology

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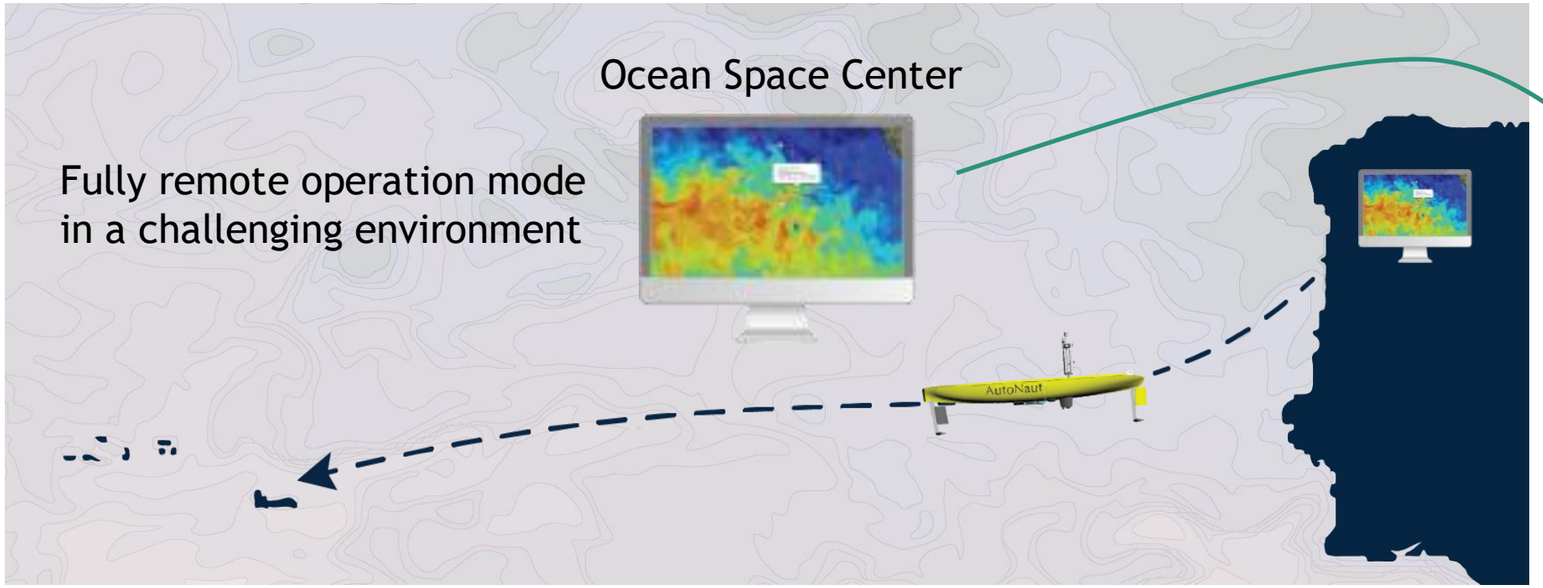
Projects



Multi-system Command & Control

Data Ingestion

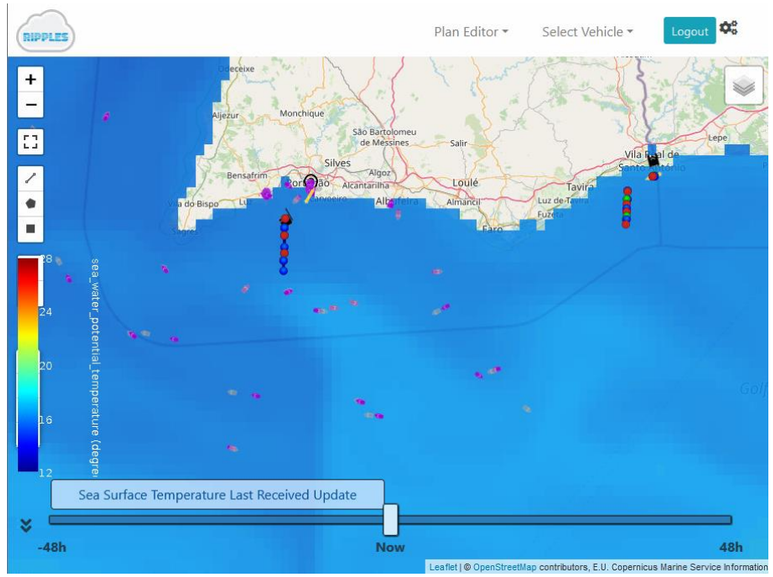
Optimized decisions

Risk-Management

Deploy autonomous systems for long-endurance operations in a robust manner

Allow oceanographers in planning and control loop to adapt the mission in a science-driven way

Ripples.lsts.pt – web infrastructure that is used for improving the situational awareness of operators as well as keeping external collaborators in the loop.



Most of the Information layers are derived from COPERNICUS data

Projects

SMART - diStributed AI systeM for mArine plastic debRis moniToring

Winner of AI Moonshot 2020 Edition

PORTUGAL SPACE

Example of *Data Cycle* concept

AI MOONSHOT CHALLENGE

TÉCNICO LISBOA

U.PORTO FEUP FACULDADE DE ENGENHARIA UNIVERSIDADE DO PORTO

universidade de aveiro

hidrográfico marinha·portugal

MIT Portugal

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Projects

Based on Sentinel 2 and 3 Missions

CMEMS models used as input for higher-resolution models

New algorithms' validation

Using forecast and near-real-time data to gain more autonomy in the assets

New in situ data

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Take home message

- Autonomous vehicles are not only data providers.
- Copernicus data are essential to optimise their missions
- Data managers and providers should also pay attention to the Autonomous Vehicles Community's needs.
- More optimised and safer missions can increase the quality of data from the ocean.

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FEUP FACULDADE DE ENGENHARIA
UNIVERSIDADE DO PORTO

info@colabatlantic.com

lsts@fe.up.pt

North Atlantic Marine Heatwaves: climatology and trends

Atlantic Innovation Week

Ana Oliveira | ana.oliveira@colabatlantic.com

14-17 March 2022
Azores, Portugal

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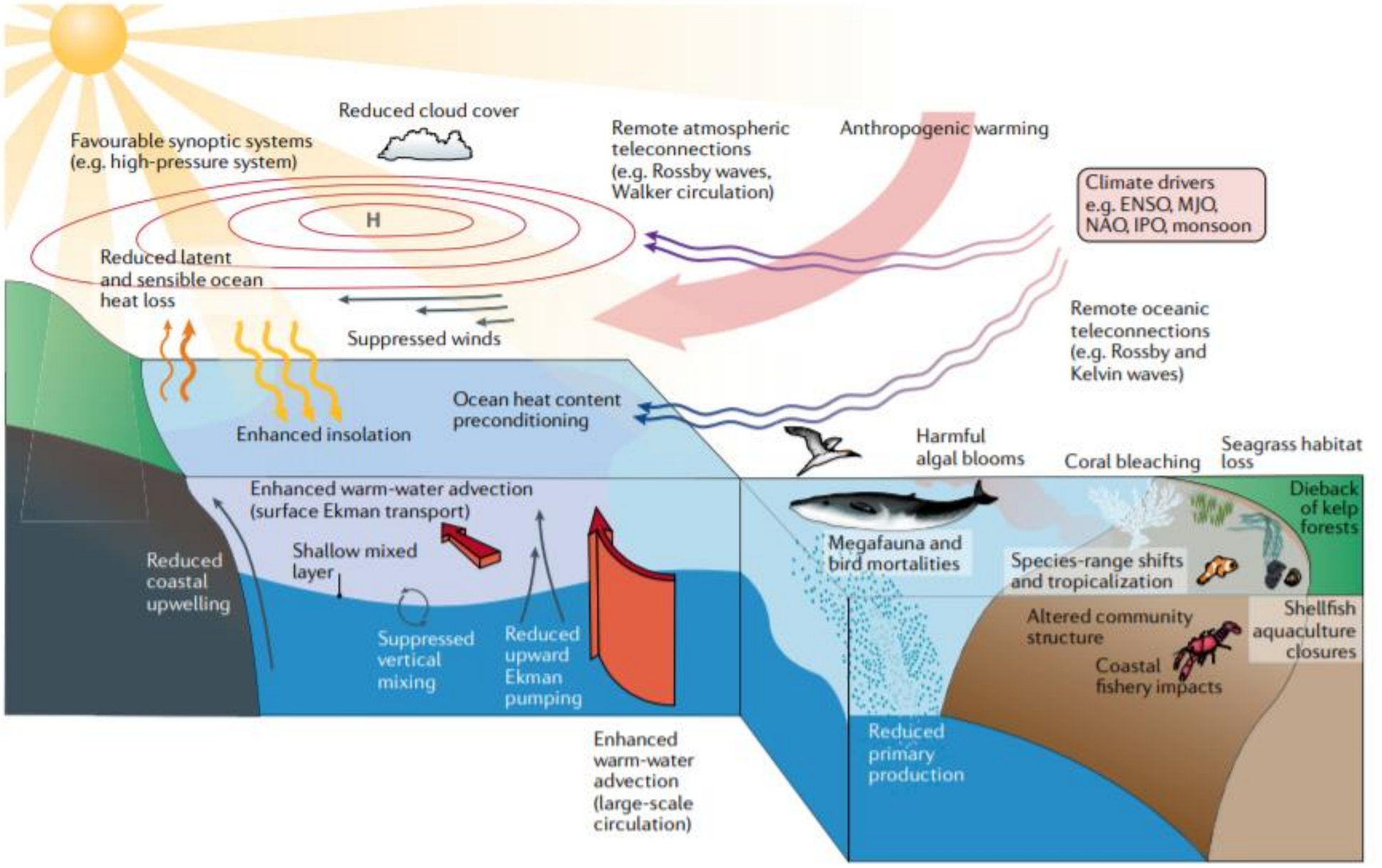
+ DEFINITIONS

Marine Heatwaves (MHWs) Definition

"prolonged discrete anomalously warm water event that can be described by its duration, intensity, rate of evolution, and spatial extent" (Hobday et al., 2016).



+ DEFINITIONS

Atmospheric Contributors:

1-2 weeks or season ahead

Extends to 1000 km

Vertical propagation within mixed-layer

(up to 10s of meters)

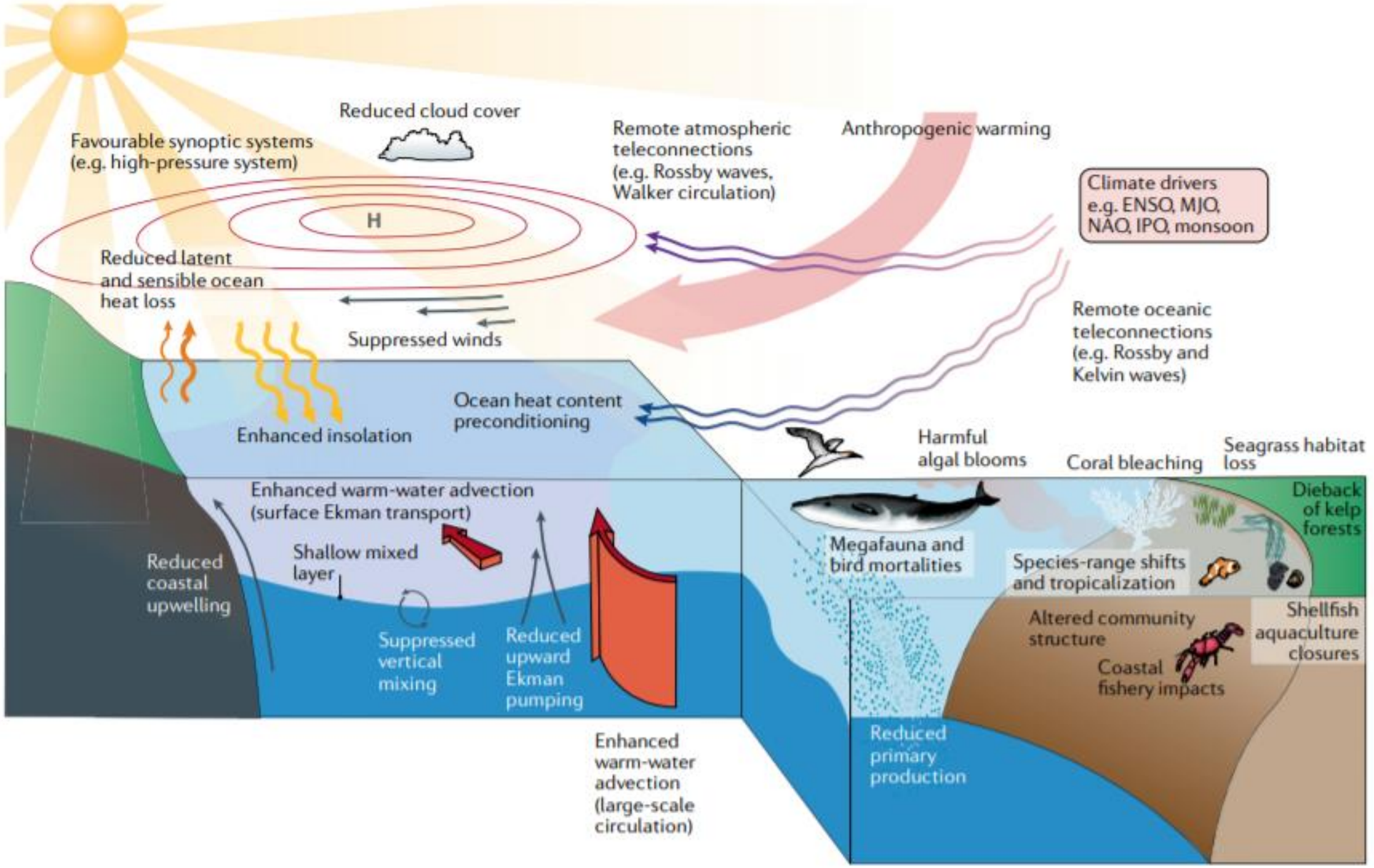
Oceanic Contributors:

Months to years

Extends to 100 km

Vertical propagation from surface to benthic

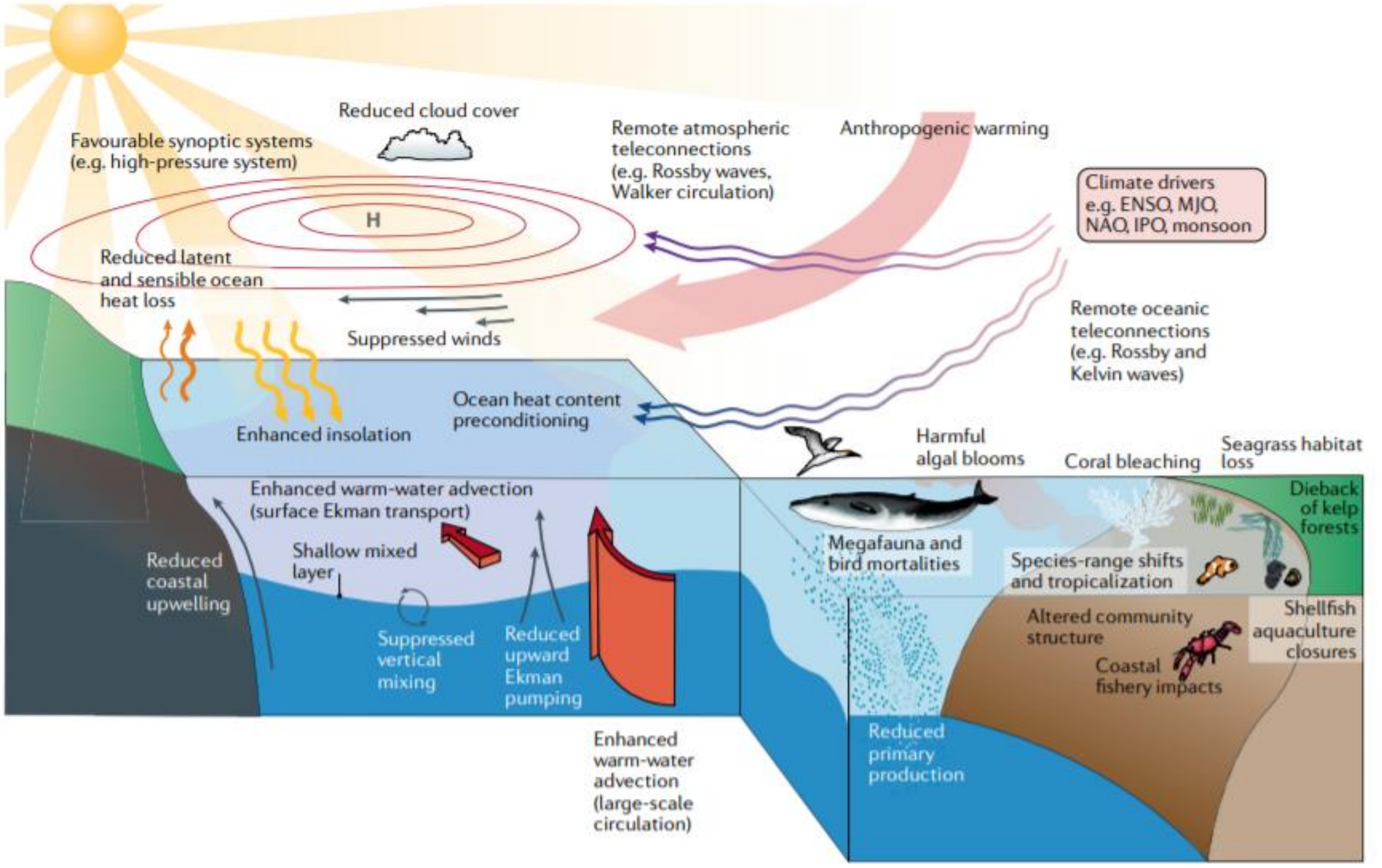
(up to 100s of meters)



+ DEFINITIONS

Impacts:

- Species-range shifts
- Coral Bleaching
- HAB's
- Megafauna mortality
- Seabirds mortality
- Fishery losses
- Aquaculture/shellfish reduced production
- Kelp mortality

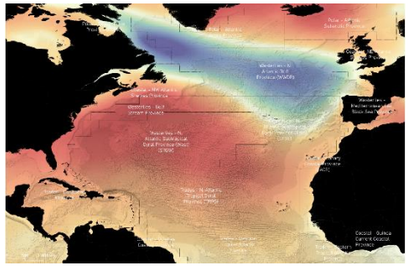


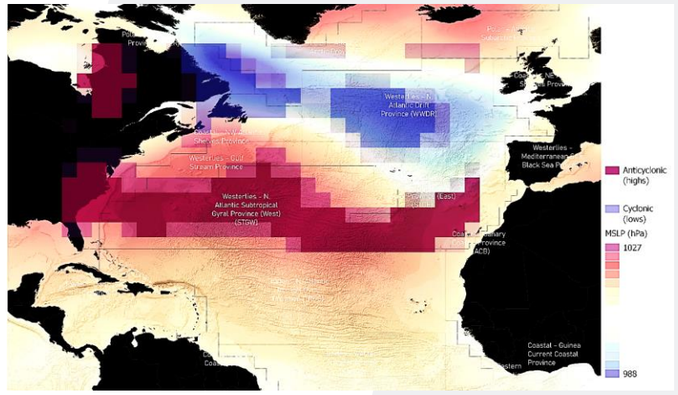
+ DATA & METHODS

OISST: observations-based SST

- 1982-2019 climatology
- 1982-2019 90th percentile anomaly
- Discrete identification of MHW events (yes/no)
- Annual statistical summaries of MHW events (frequency, duration, intensity)
- Linear trend analysis

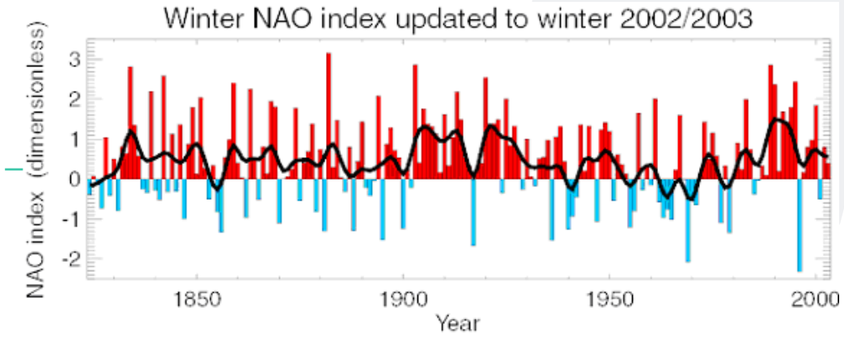
ERA5: mean surface level pressure reanalysis



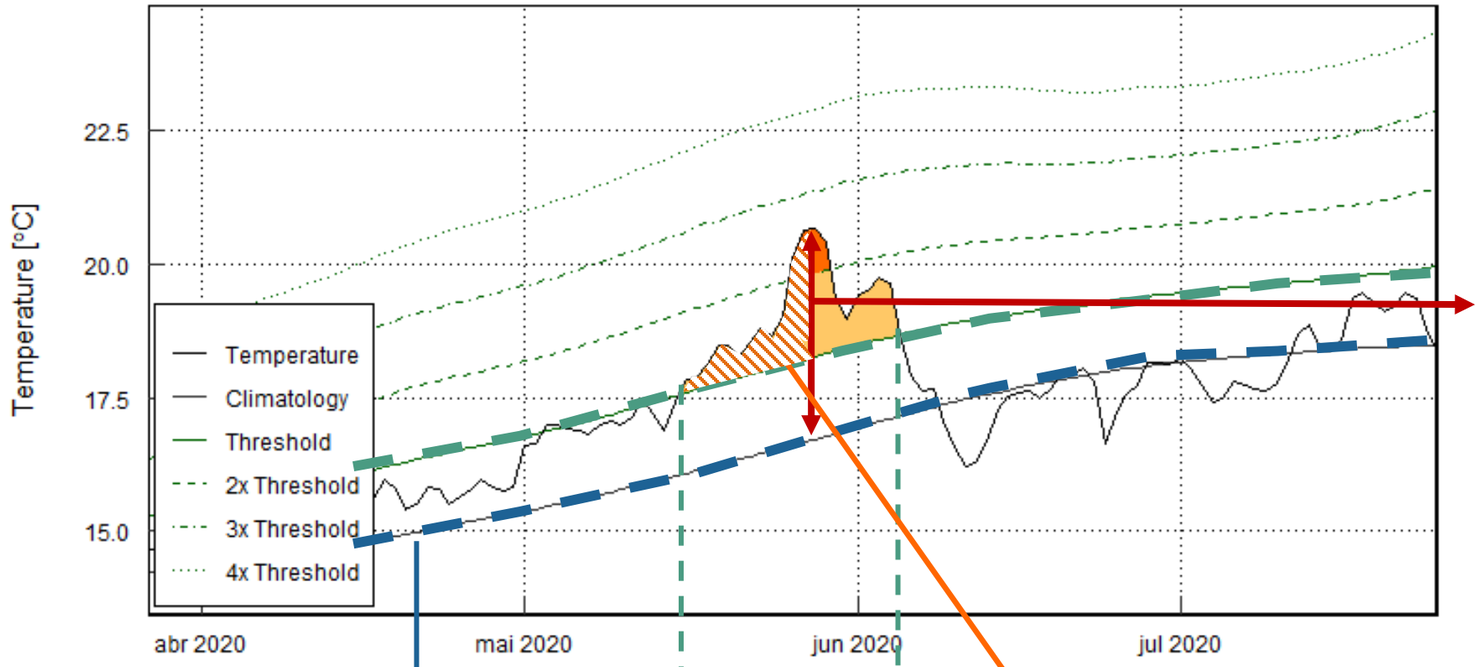


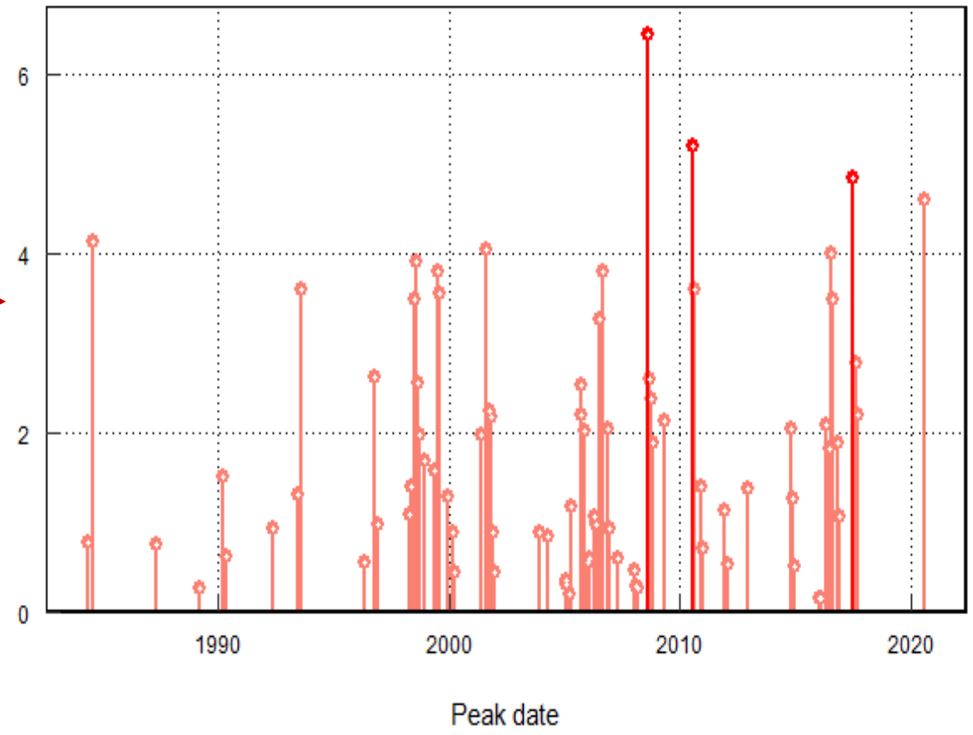
Relation?

Impacts?



+ DATA & METHODS





Threshold = Climatological Mean SST (1982-2019) (30-days moving window)

#1 event

#22 days

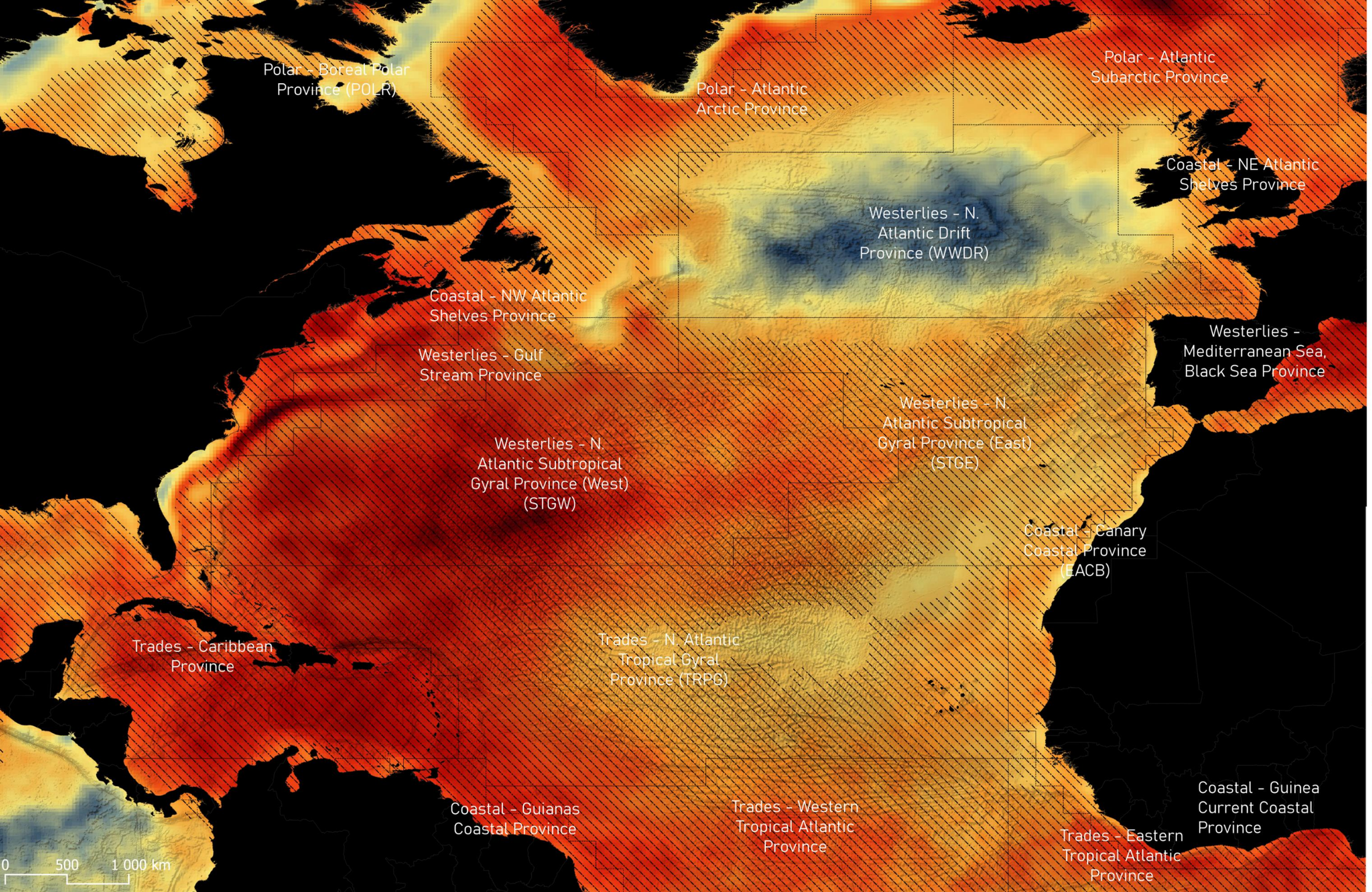
Max. Intensity = Max. (STT - Climatological Mean SST (1982-2020))

Mean Intensity = Mean (STT - Climatological Mean SST (1982-2020))

Cumulative Intensity = $\int_{s}^{e-1}$(STT - Climatological SST)

MHW

- lasts for five or more days
- temperatures warmer than the 90th (30-year baseline period)



+ RESULTS

Significance Level

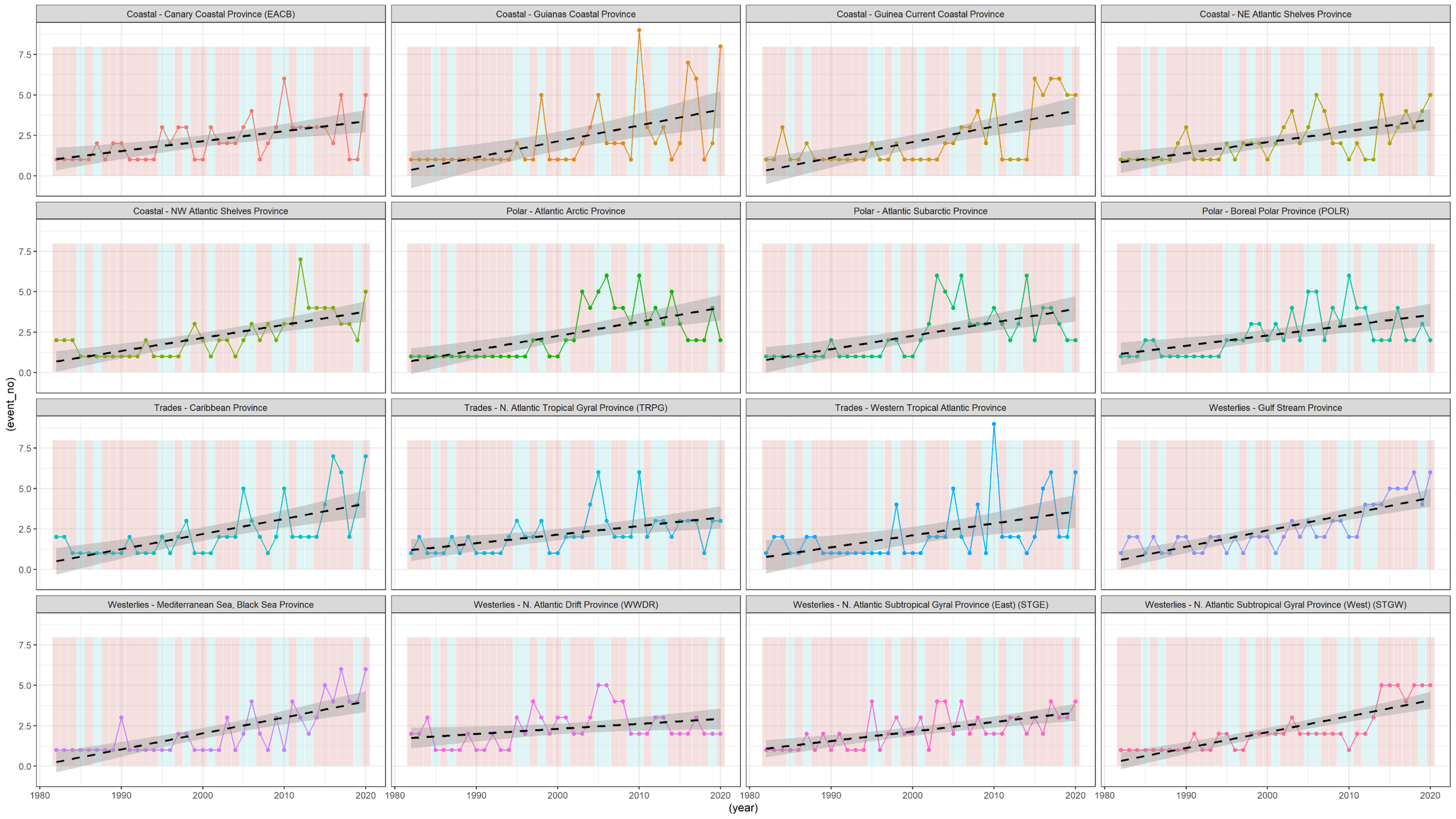
95%

HW number trend (events/decade)

>= +1.0

0.0

<=-1.0


Coastal - Canary Coastal Province (EACB)
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Coastal - NW Atlantic Shelves Province
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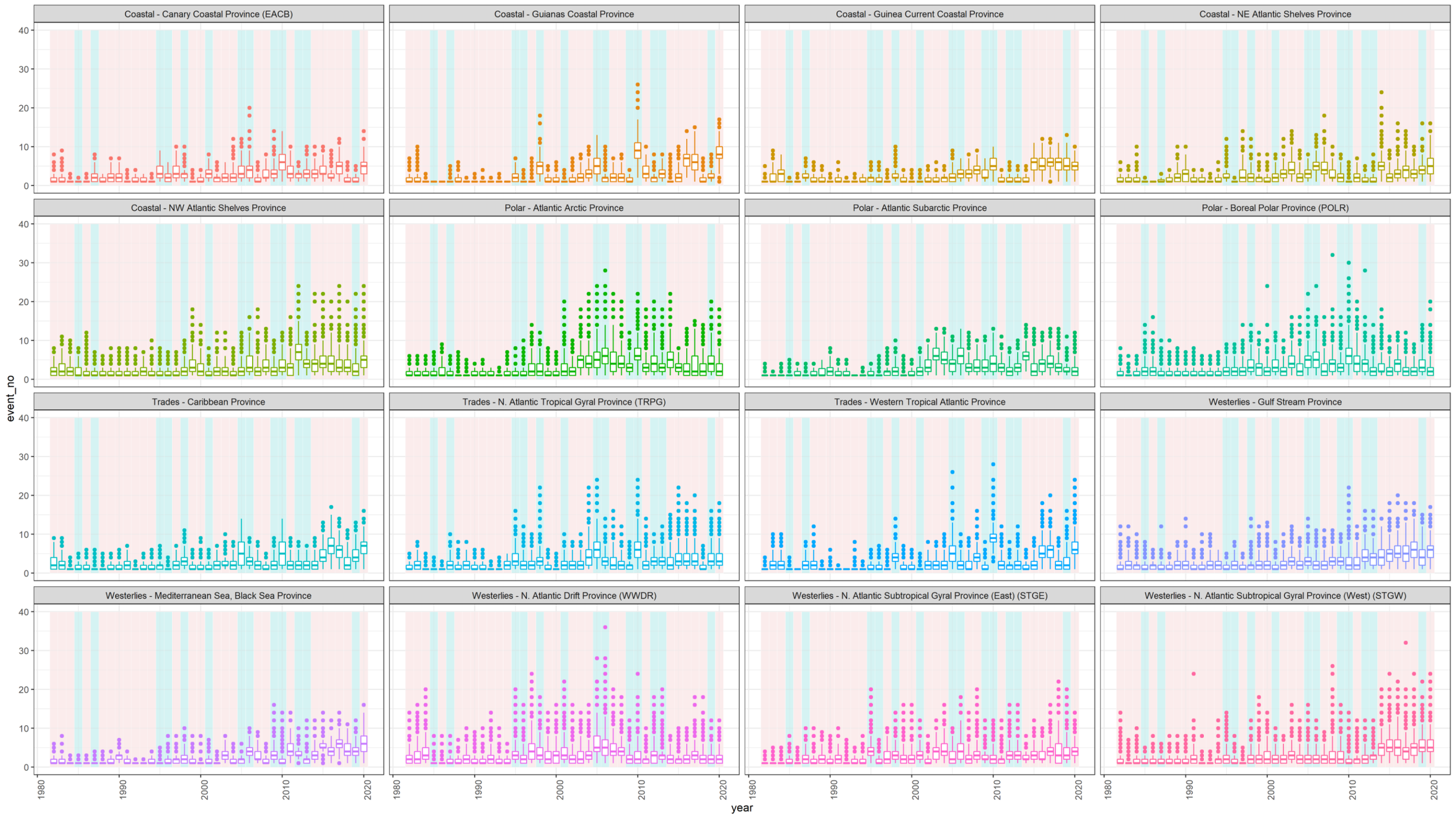
Westerlies - Mediterranean Sea, Black Sea Province
Westerlies - N. Atlantic Drift Province (WWDR)
Westerlies - N. Atlantic Subtropical Gyral Province (East) (STGE)
Westerlies - N. Atlantic Subtropical Gyral Province (West) (STGW)
(event_no)
0.0
2.5
5.0
7.5
1980
1990
2000
2010
2020
(year)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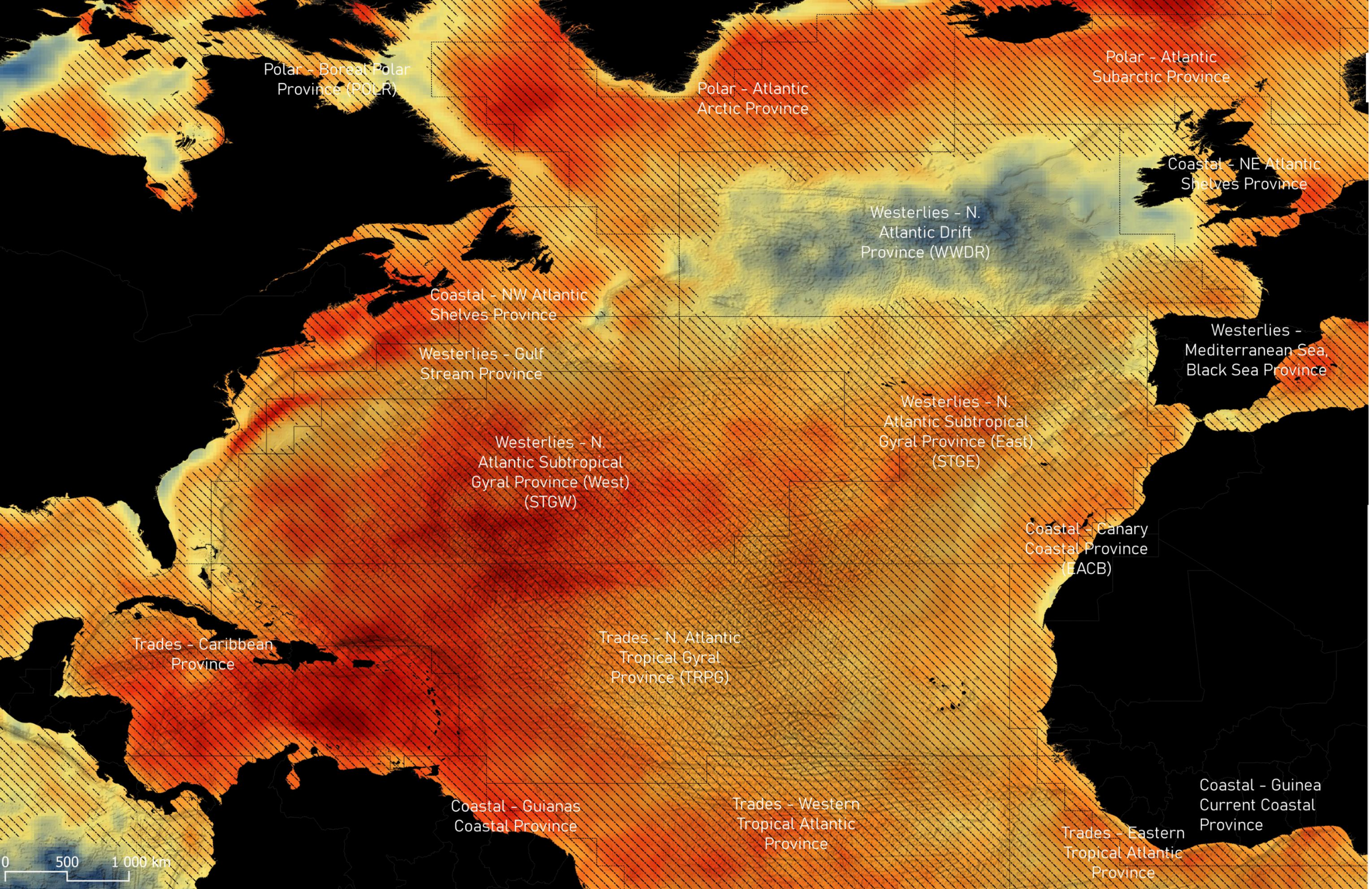
Westerlies - N. Atlantic Subtropical Gyral Province (West) (STGW)
event_no
0
10
20
30
40
1980
1990
2000
2010
2020
year



+ RESULTS

Significance Level

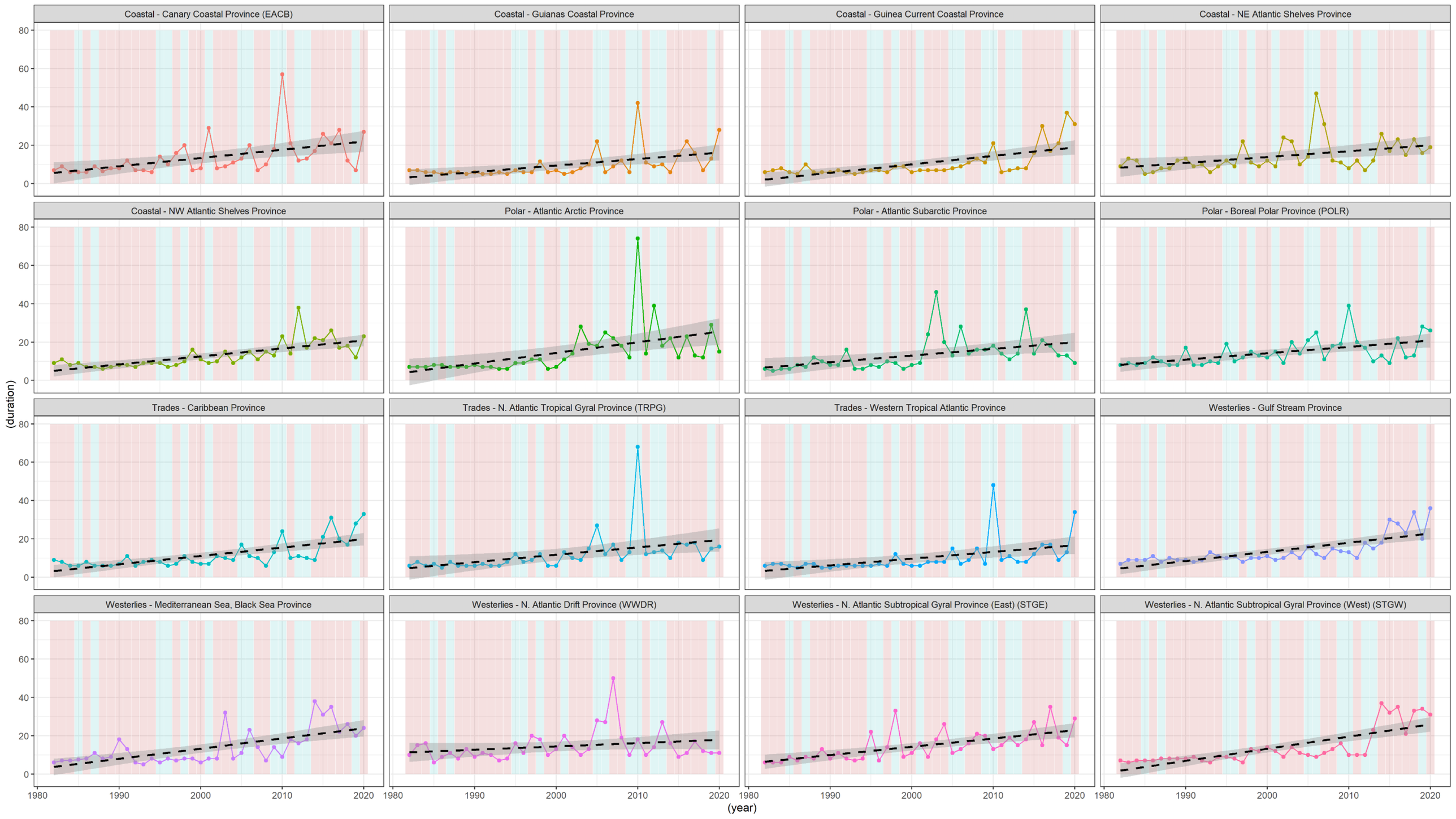
95%

HW duration trend (days/decade)

>= +1.0

0.0

<=-1.0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Westerlies - N. Atlantic Subtropical Gyral Province (East) (STGE)
Westerlies - N. Atlantic Subtropical Gyral Province (West) (STGW)
(duration)
0
20
40
60
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1980
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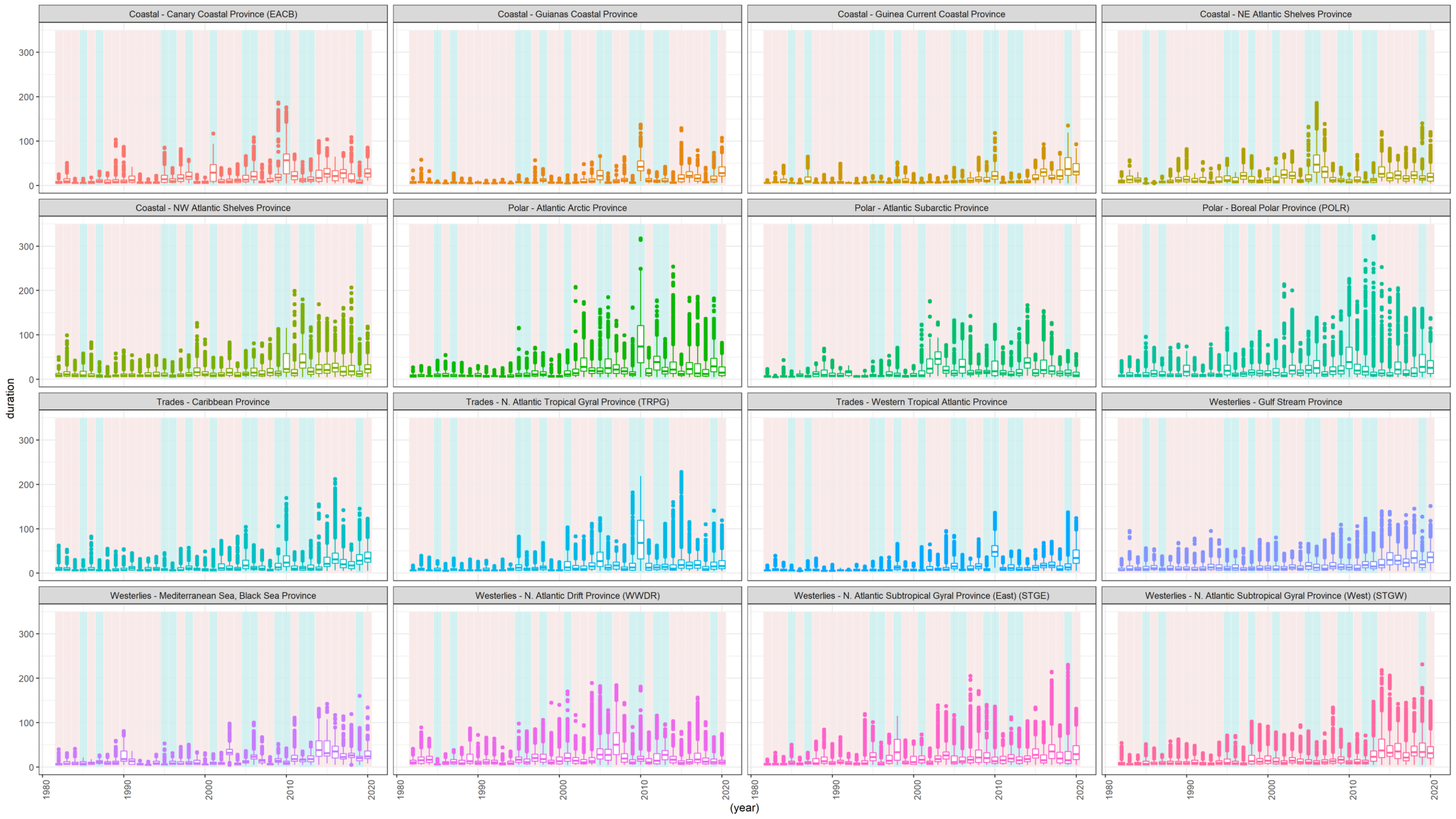
(year)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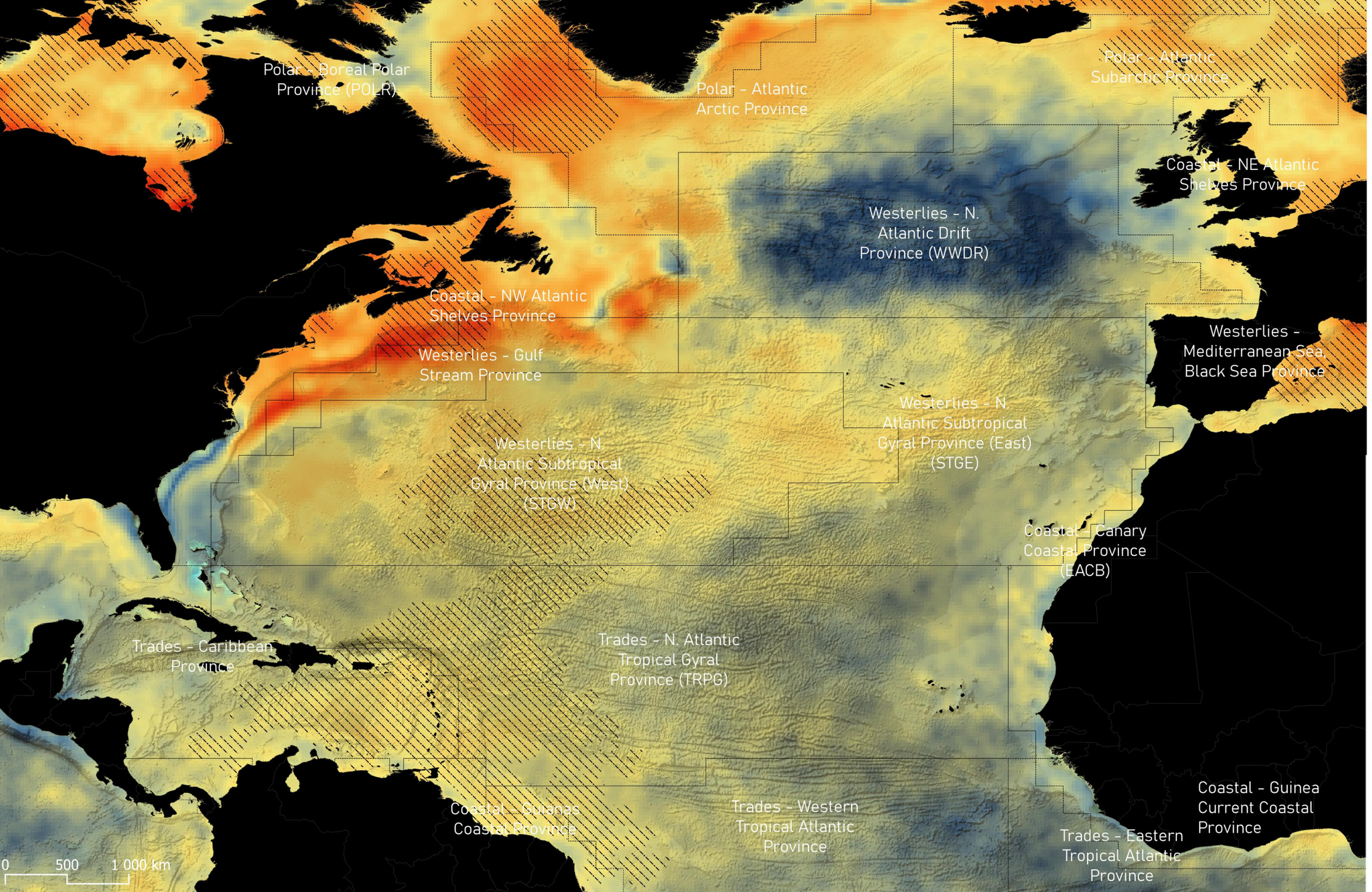
Westerlies - N. Atlantic Subtropical Gyral Province (West) (STGW)
duration
0
100
200
300
1980
1990
2000
2010
2020
(year)



+ RESULTS

Significance Level

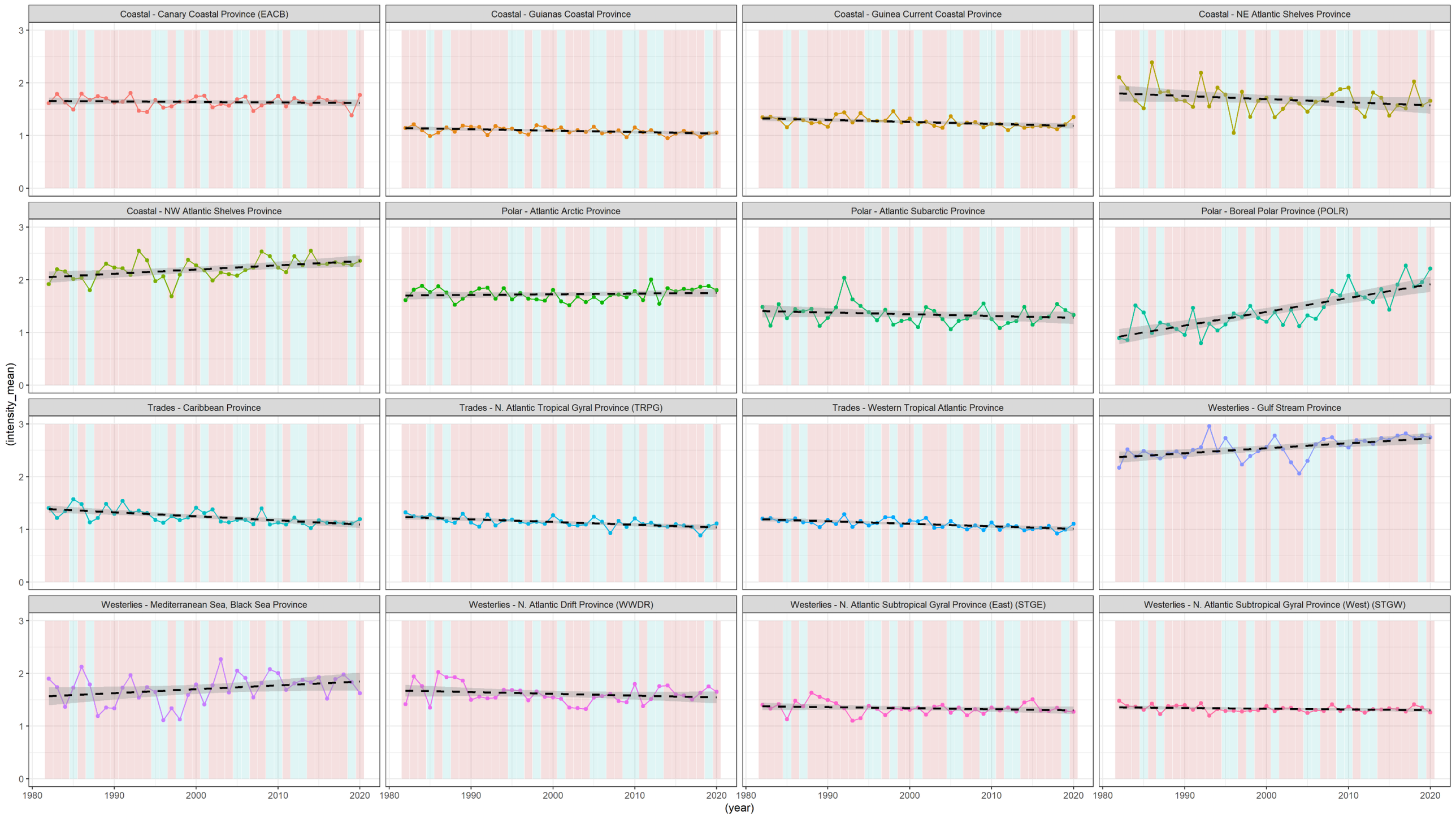
95%

HW mean intensity trend (°C/decade)

>= +1.0

0.0

<=-1.0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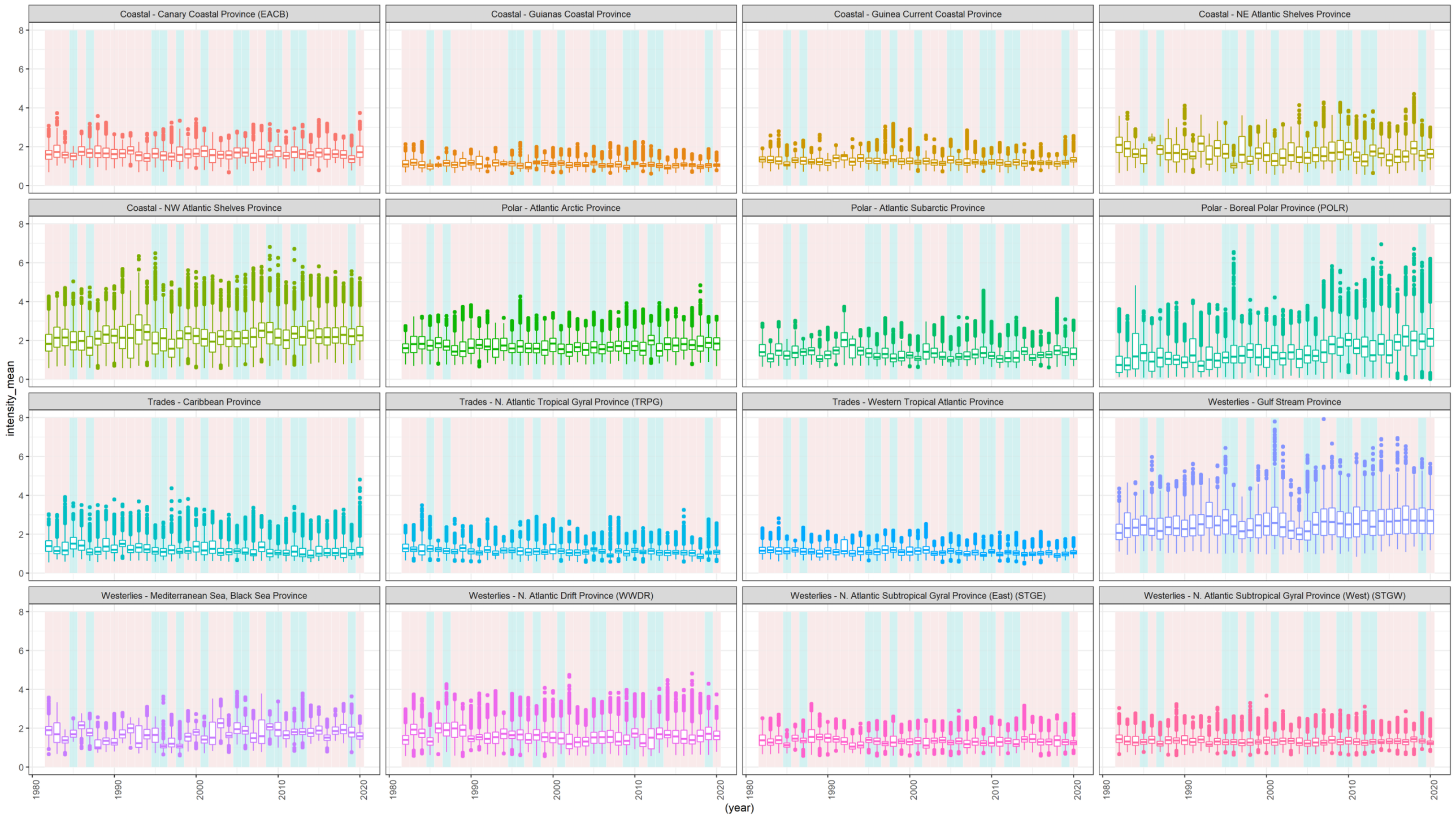
Westerlies - N. Atlantic Subtropical Gyral Province (West) (STGW)
(intensity_mean)
0
1
2
3
1980
1990
2000
2010
2020
(year)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intensity_mean
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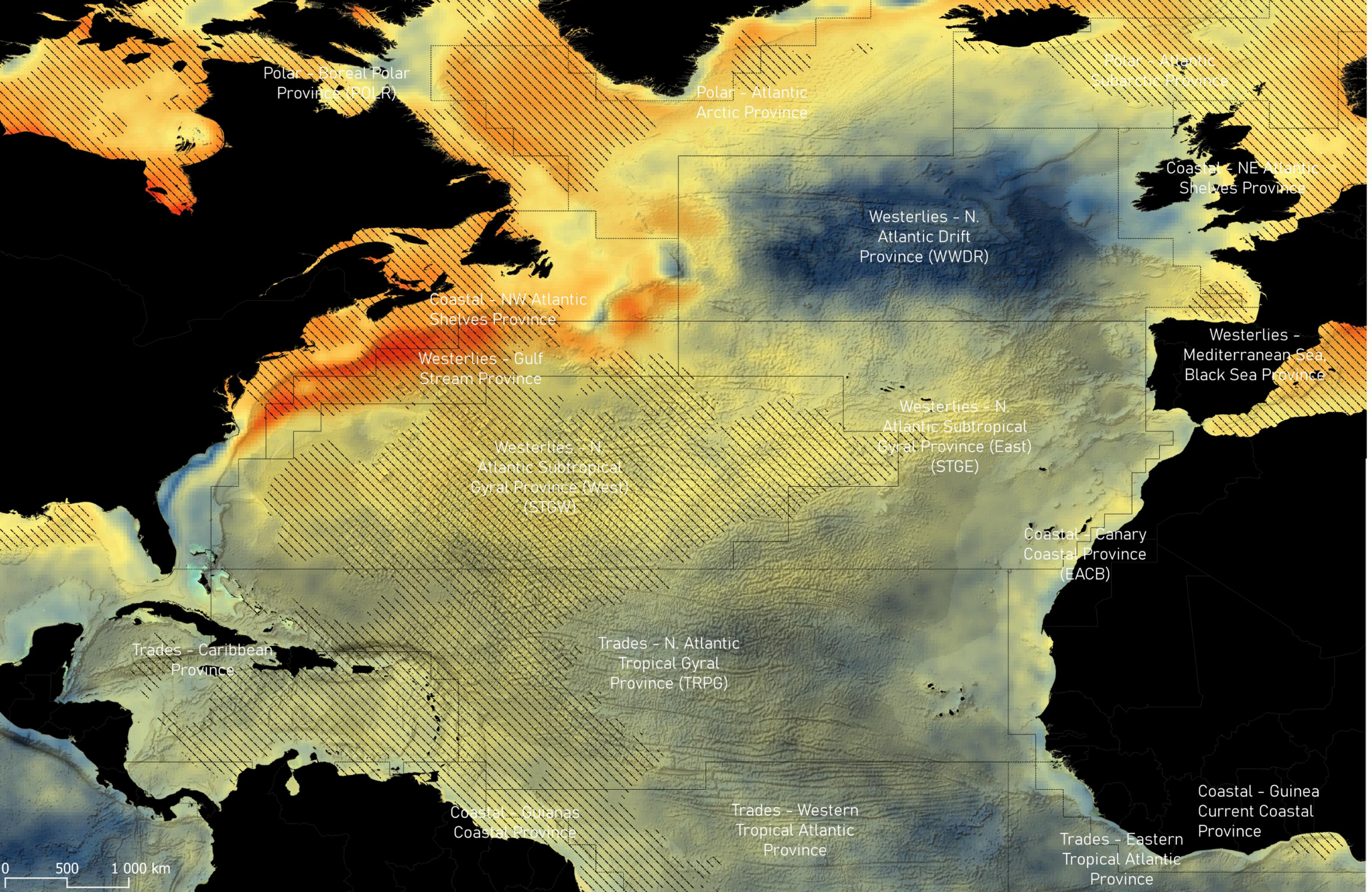
2
4
6
8
1980
1990
2000
2010
2020
(year)



+ RESULTS

Significance Level

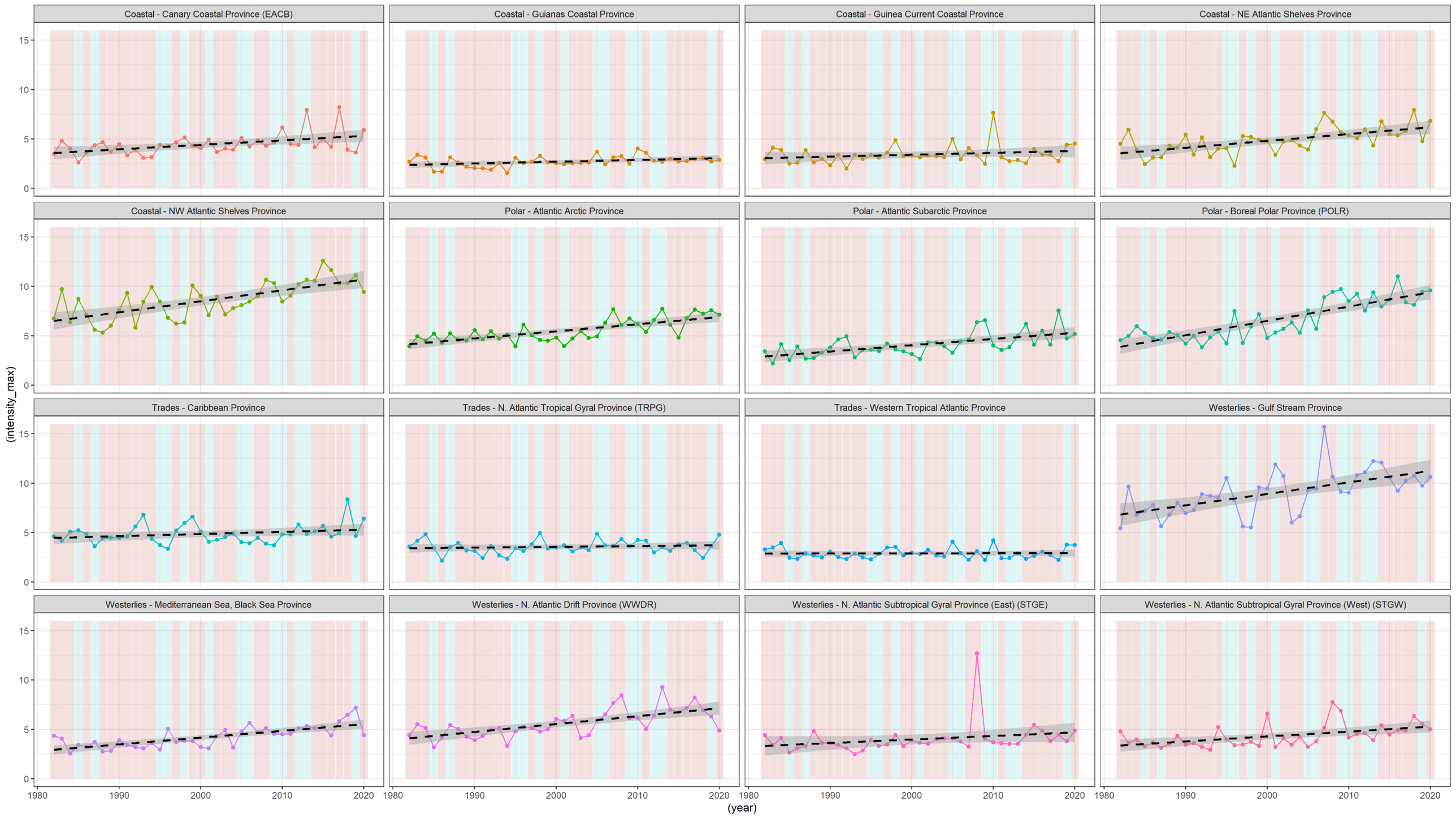
95%

HW maximum intensity trend (ºC/decade)

>= +2.0

0.0

<=-2.0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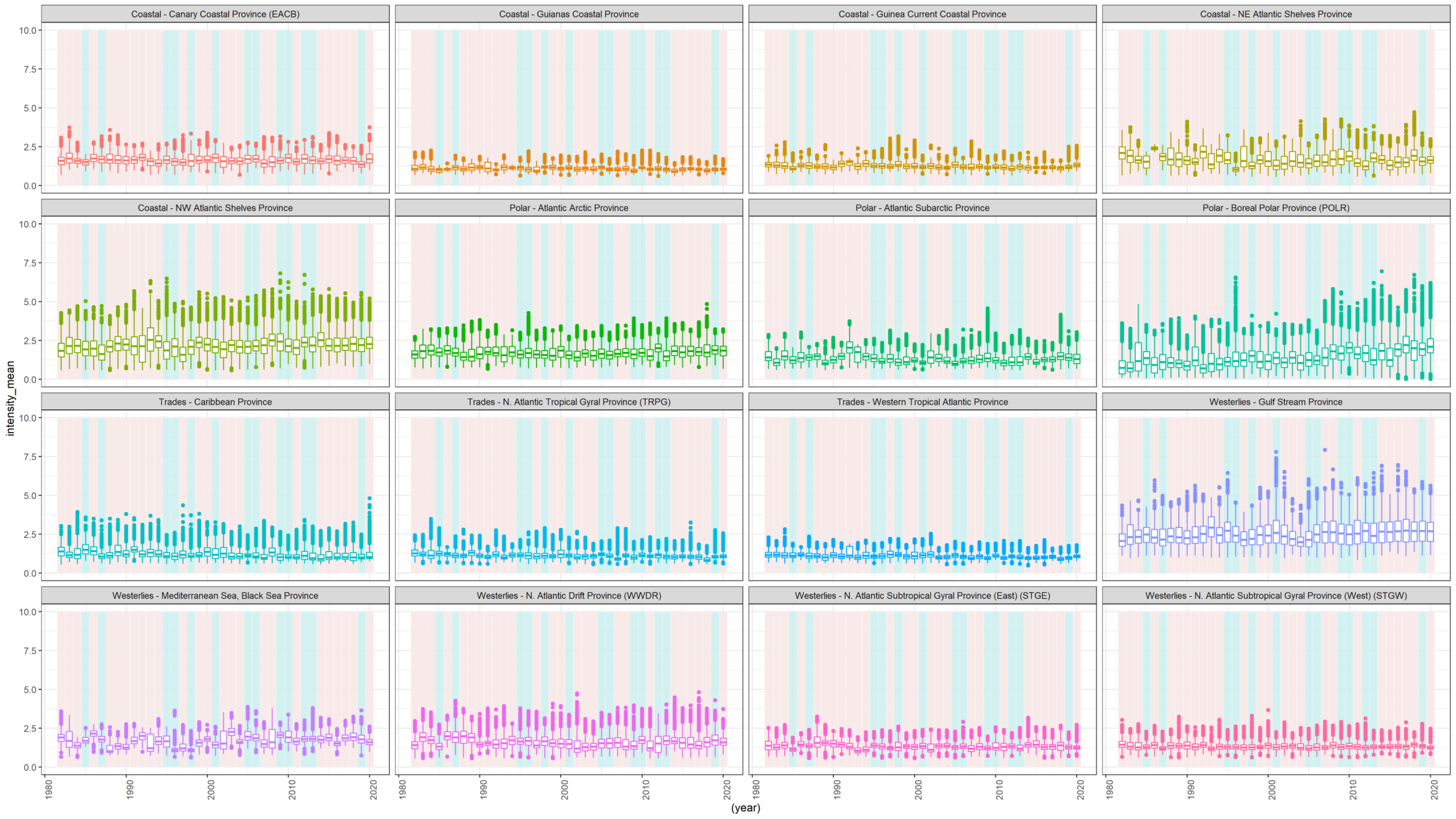
Westerlies - N. Atlantic Subtropical Gyral Province (East) (STGE)
Westerlies - N. Atlantic Subtropical Gyral Province (West) (STGW)
(intensity_max)
0
5
10
15
1980
1990
2000
2010
2020
(year)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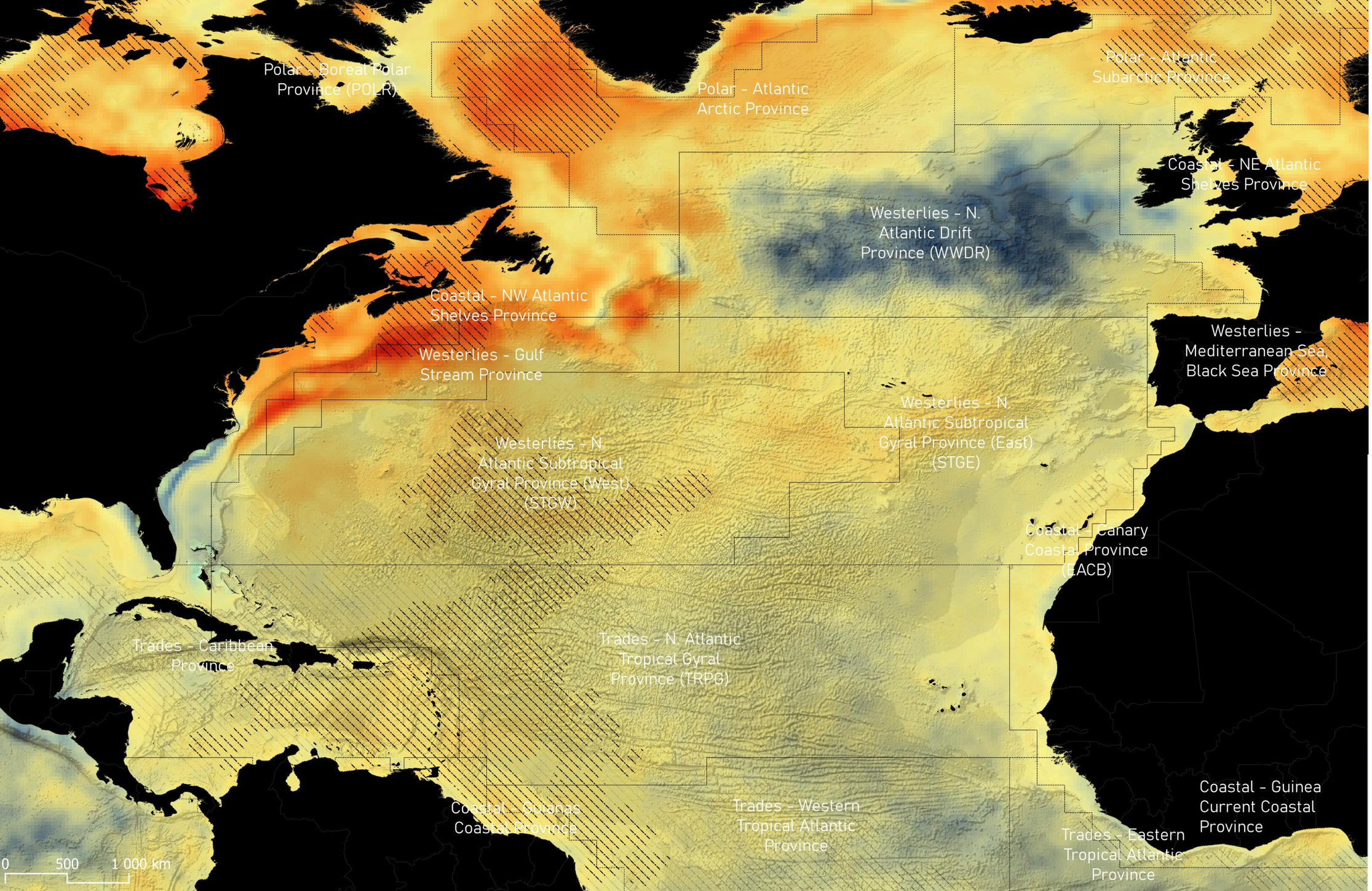
Westerlies - N. Atlantic Subtropical Gyral Province (West) (STGW)
intensity_mean
0.0
2.5
5.0
7.5
10.0
1980
1990
2000
2010
2020
(year)



Significance Level

95%

HW cumulative intensity trend (°C/decade)

>= +20

0.0

<=-20


Coastal - Canary Province (EACB)
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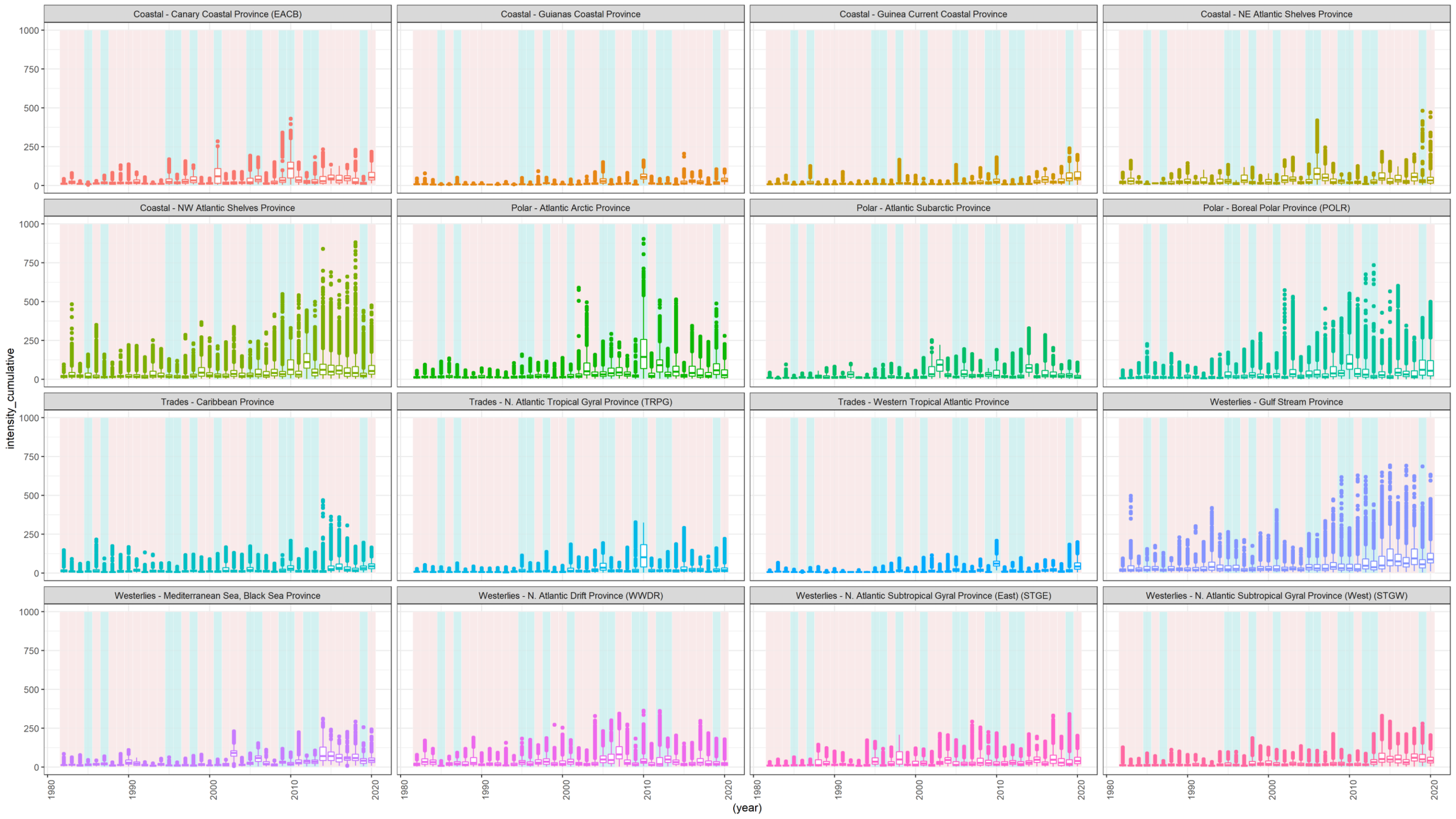
Westerlies - N. Atlantic Subtropical Gyral Province (West) (STGW)
(intensity_cumulative)
0
250
500
750
1000
1980
1990
2000
2010
2020
(year)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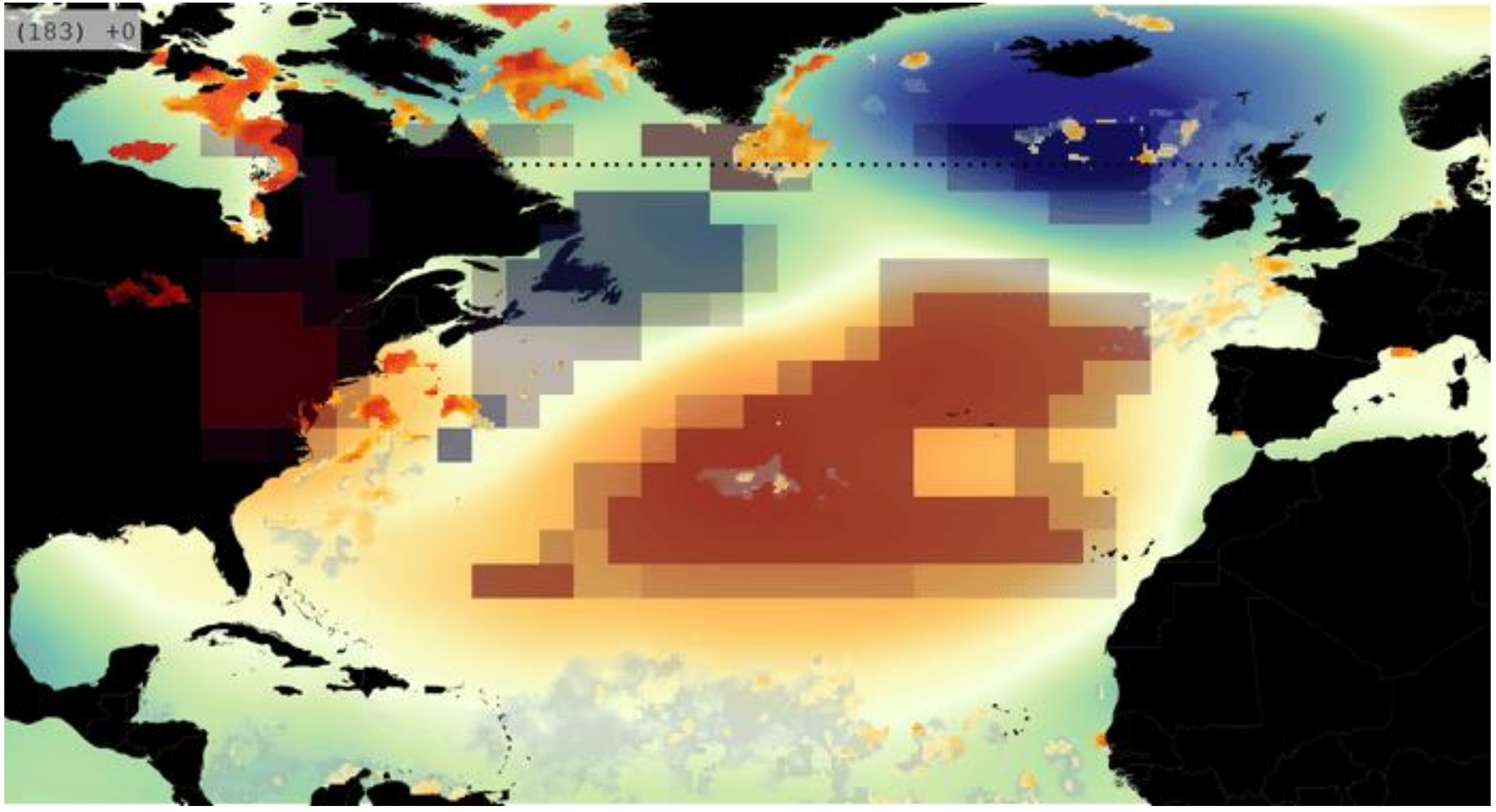
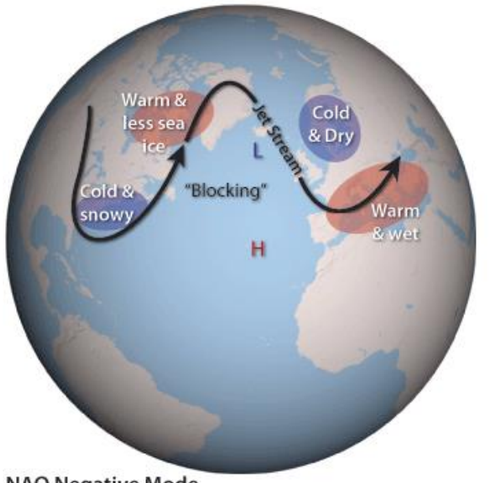
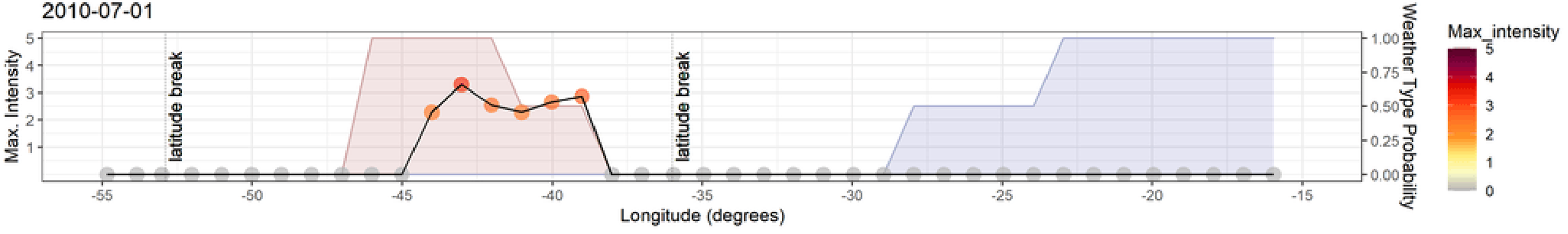
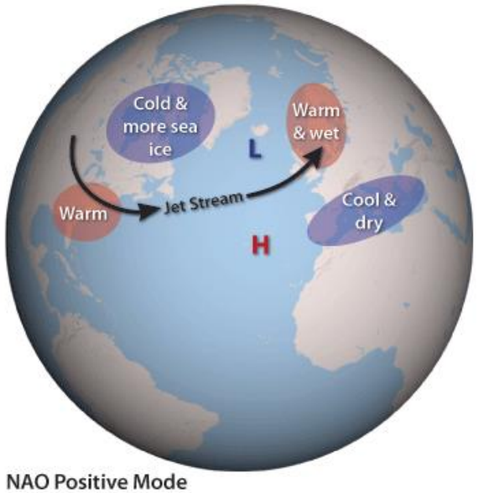
intensity_cumulative
0
250
500
750
1000
1980
1990
2000
2010
2020
(year)



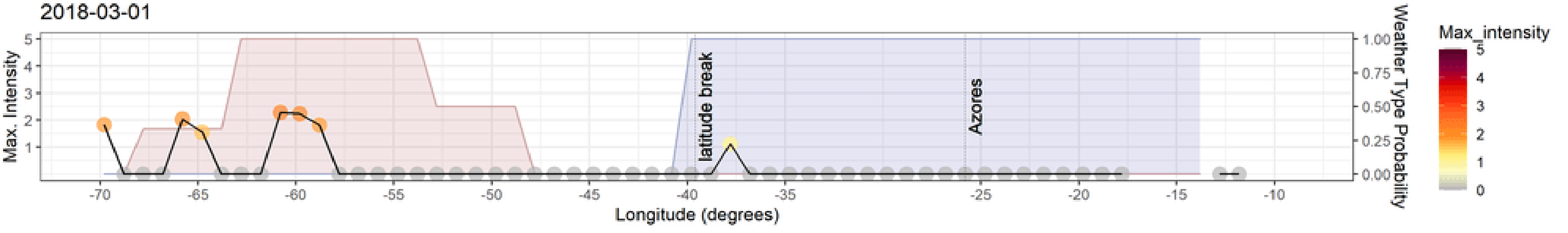


NAO Negative Mode





NAO Positive Mode



+ FUTURE WORK

SST input data

Revised ‘Hobday Method’

MHW Atlas/MHW-4D

- Frequency/duration/intensity?
- Confounding/mediators factors?

Biological Response?

Impact Assessment

WP5100: Fisheries Impact Assessment [CSL]

- SPECIES: skipjack and bigeye, tropical tunas
- LOCATION: South Pacific Subtropical

WP5200: Aquaculture Impact Assessment [+ATL]

- SPECIES: seabream and kelp
- LOCATION: Subtropical and Subarctic North Atlantic

WP5300: Marine Protected Area Impact Assessment [ENEA]

- SPECIES: endemic coral, sea urchin and marine bird
- LOCATION: Mediterranean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Cascais, Portugal

Workshops 1:

Introduction to Marine Debris Detection with Sentinel-2 using Python

Emanuel Castanho

Project Developer

AIR Centre

Workshop Material :

https://github.com/EmanuelCastanho/Atlantic_Innovation_Week-Workshop

Framework Partnership Agreement for Copernicus User Uptake

14-17 MARCH 2022
AZORES, PORTUGAL

Ciências ULisboa
Faculdade de Ciências da Universidade de Lisboa

COASTNET
COASTAL MONITORING NETWORK

MARE

On the use of Ocean Colour in the Western Iberia Coast

Atlantic Innovation Week

Terceira, 15 de março 2022

Ana C Brito

ERTO
Copernicus Evolution – Research for Transitional-water Observation

PRIMUS

esa

On the use of Ocean Colour in the Western Iberia Coast

Importance of Phytoplankton & Primary Production

Introduction to Ocean Colour Remote Sensing

Online Platforms & Demo

Case Studies: Phytoplankton in the WIC

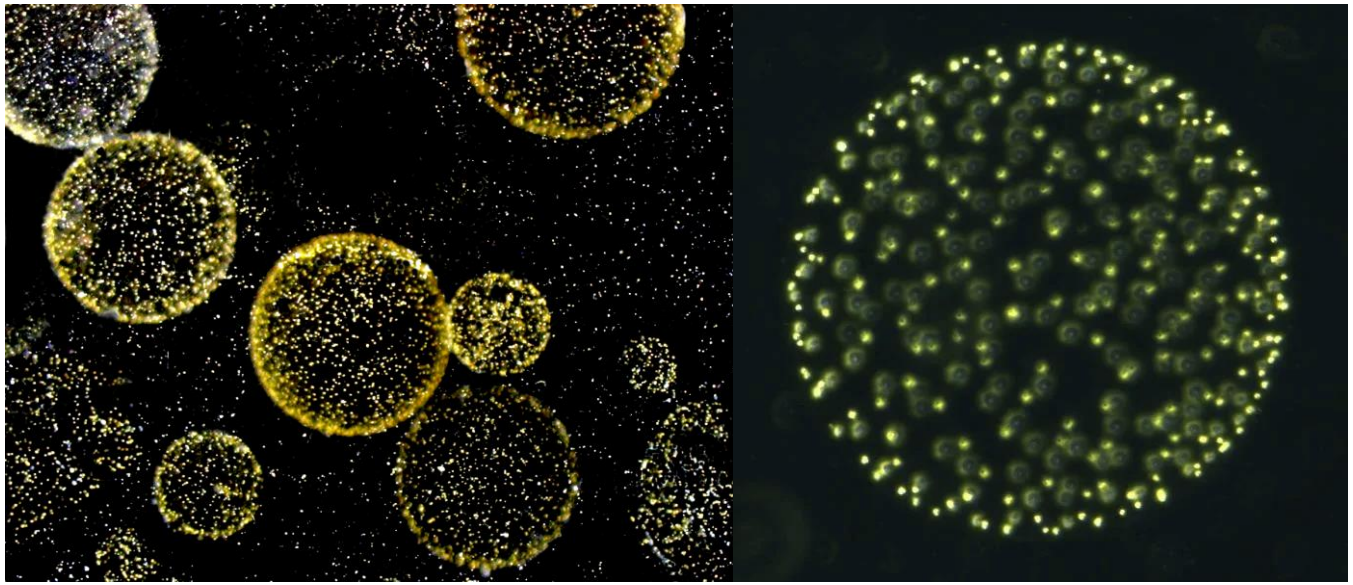
Conclusions

What is Phytoplankton?

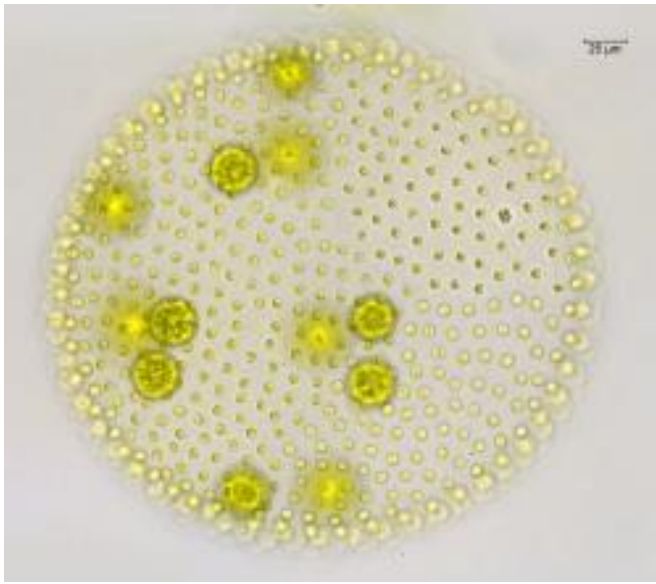
Microscopic organisms that live in the aquatic environment

Phyto (refers to the Greek word for plant) + *Plankton* (that drift in the water column)

Unicellular .. But can be colonial !

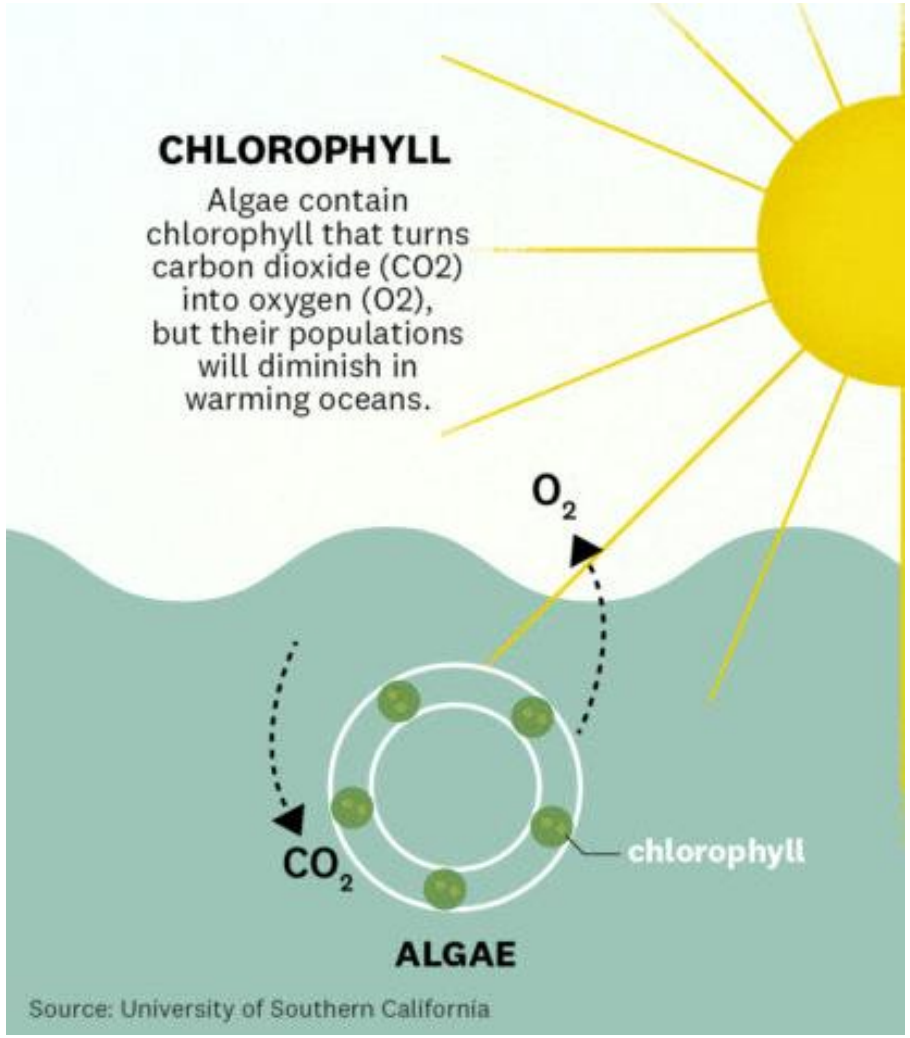


Phaeocystis sp.



Volvox sp.

What is Phytoplankton?



They are able to do photosynthesis…!

They use the light energy (from the sun) to produce their own organic matter, by assimilating CO_2 and releasing O_2.

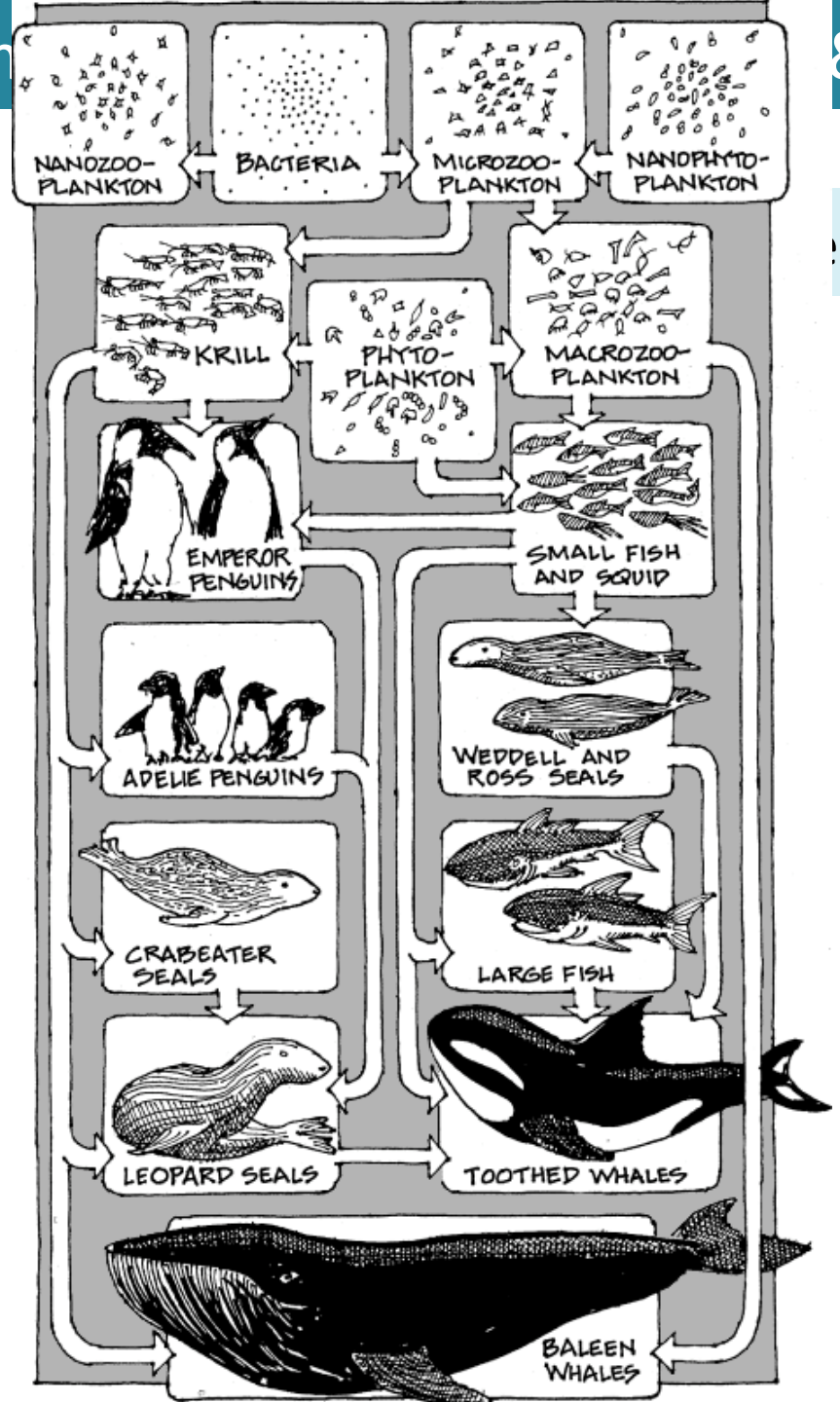
The pigment chlorophyll *a* is essential to capture sunlight

What is Phytoplankton?

Who are they … ?

1. Size Classification – Micro- (20-200 um), Nano- (2-20 um) & Picophytoplankton (0.2-2um)
2. Classification based on filogenetic relationships
3. Classification based on their functional role - PFT

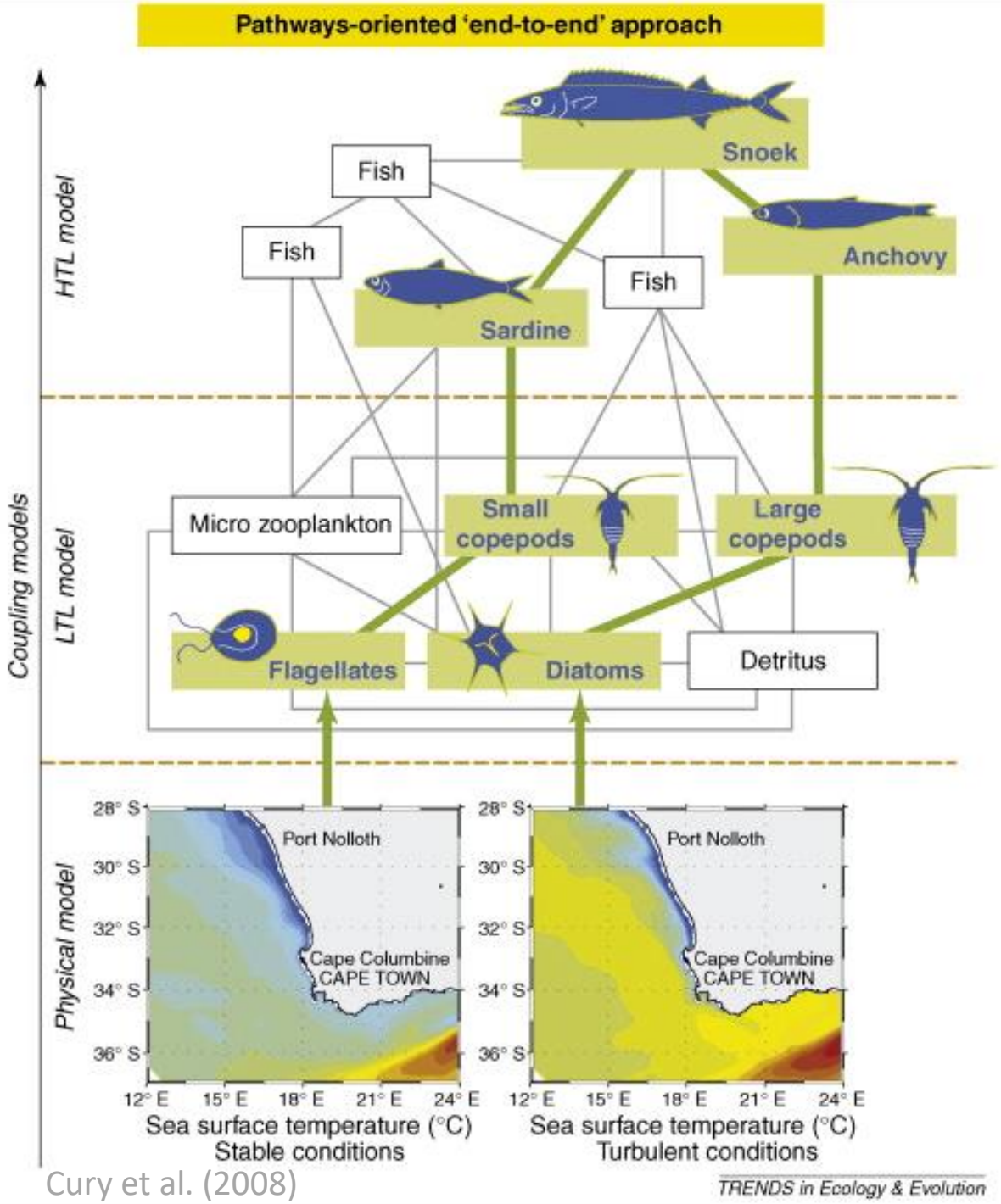
By Sally Bensusen, NASA EOS Project Science Office



importance of Phytoplankton

They form the base of the aquatic food webs

They are eaten by primary consumers like zooplankton, small fish and crustacean



Cury et al. (2008)

of Phytoplankton

Changes in the relative dominance of phytoplankton groups can have huge implications in food chain

Thus, implications for the overall ecosystem functioning..!

The importance of Phytoplankton

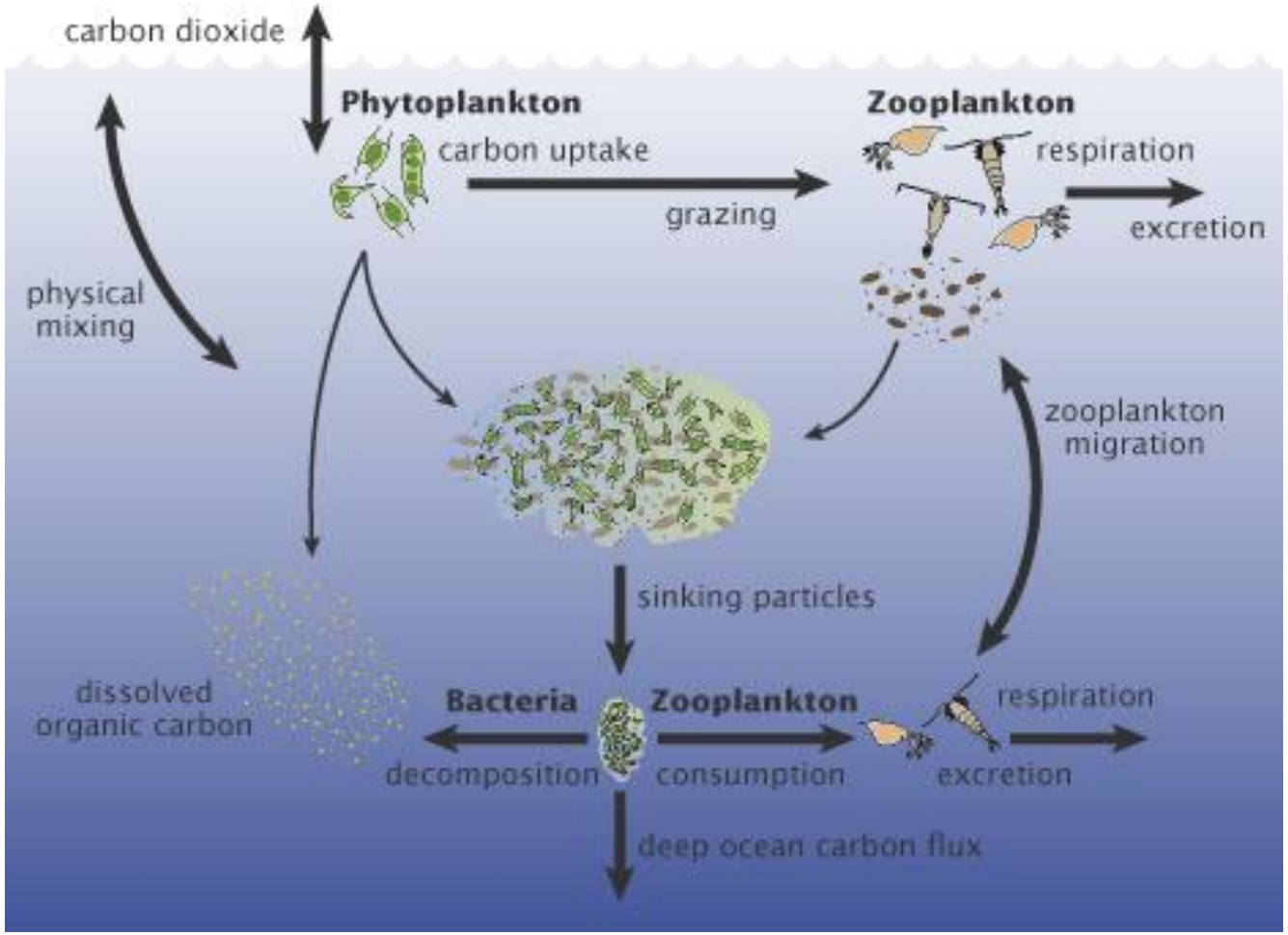


Illustration adapted from A New Wave of Ocean Science, U.S. JGOFS.)

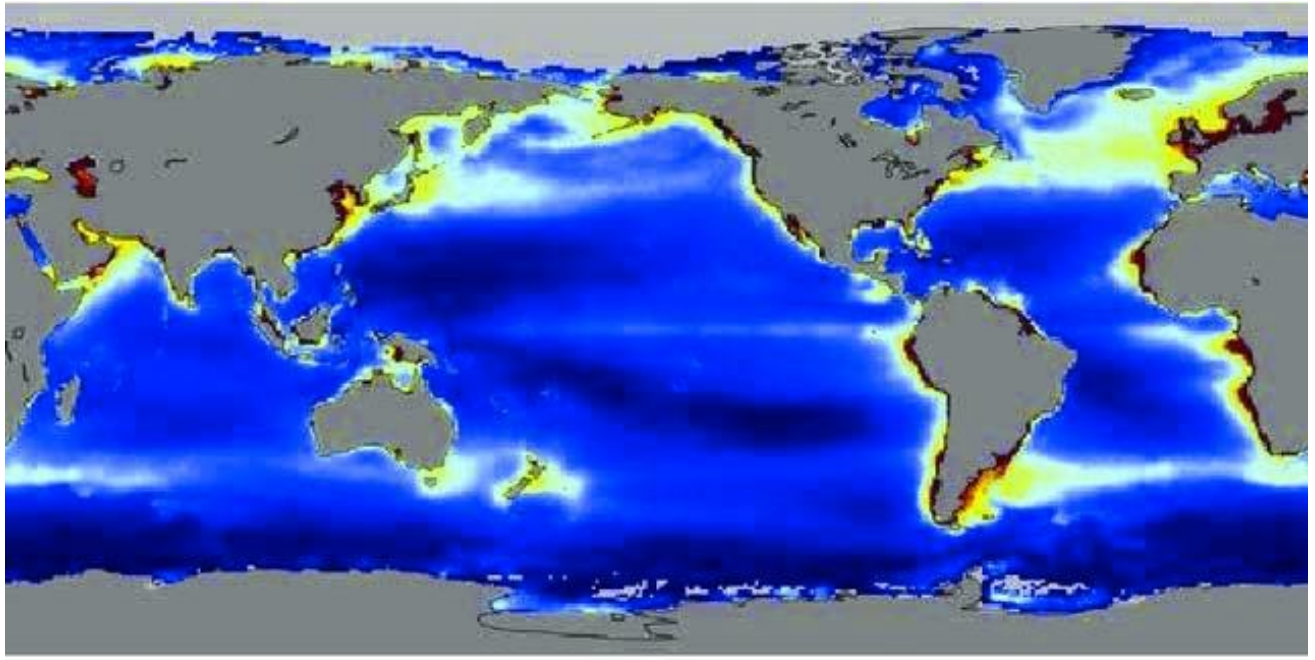
Phytoplankton has a great importance to the Earth's carbon cycle, through the biological pump

Carbon is carried to the deep ocean!

The importance of Phytoplankton

Marine Primary Production represents **~ 50% of Earth's Primary Production**

50% Marine vs 50% Terrestrial



Net Primary Productivity (grams Carbon per m^2 per year)

0 200 400 600 800

What is Ocean Colour Remote Sensing ?

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SOPHIA
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www.sophia-mar.pt

Título
Observação da Terra: uso de imagens de temperatura da superfície do mar e cor do oceano para a monitorização de águas costeiras e oceânicas

Autores
Ana Sutcliffe[1], Ana C. Brito[1], Carolina Sá[1], Fátima Sousa[2], Dmitri Boutov[3], Vanda Brotas[1]

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Coordenação do Guia Técnico
Vanda Brotas

Coordenação do Projeto SOPHIA na FCUL
Ana C. Brito

Edição
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Edição Eletrónica - 2016

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Referência ao Guia Técnico
Sutcliffe, A., Brito, A.C., Sá, C., Sousa, F., Boutov, D., Brotas, V., (2016). Observação da Terra: uso de imagens de temperatura da superfície do mar e cor do oceano para a monitorização de águas costeiras e oceânicas. DGRM, Lisboa, Portugal. E-book disponível em www.sophia-mar.pt.

ISBN
978-989-99601-4-5

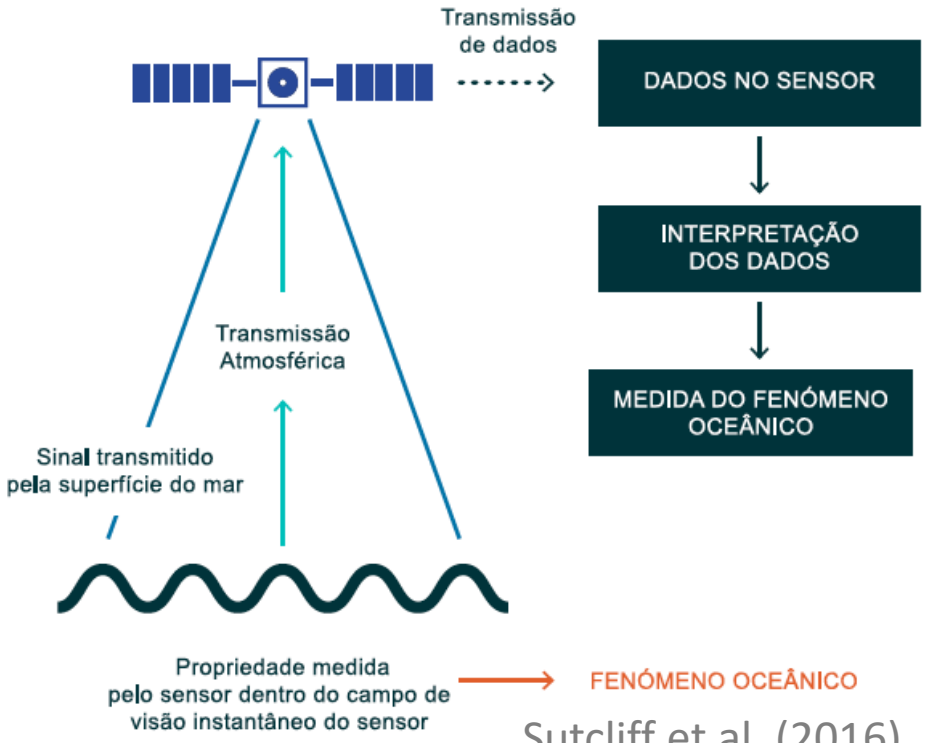
Documentação de apoio ao módulo de formação SOPHIA – Deteção remota: temperatura da superfície do mar e cor do oceano

Technical Guide available at:

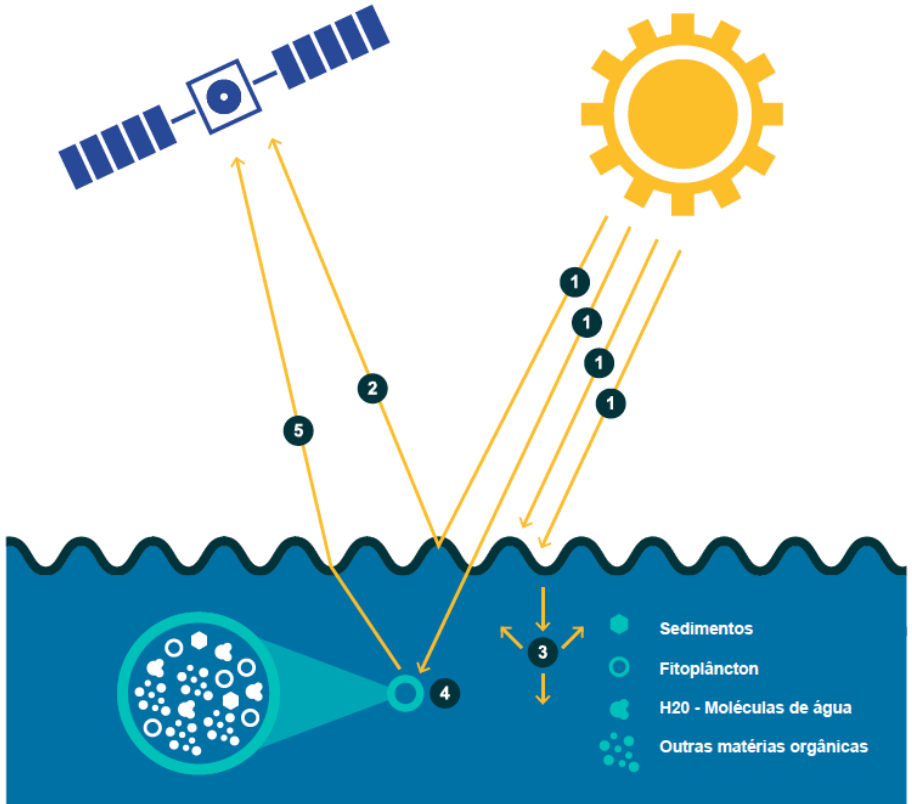
www.sophia-mar.pt

What is Ocean Colour Remote Sensing ?

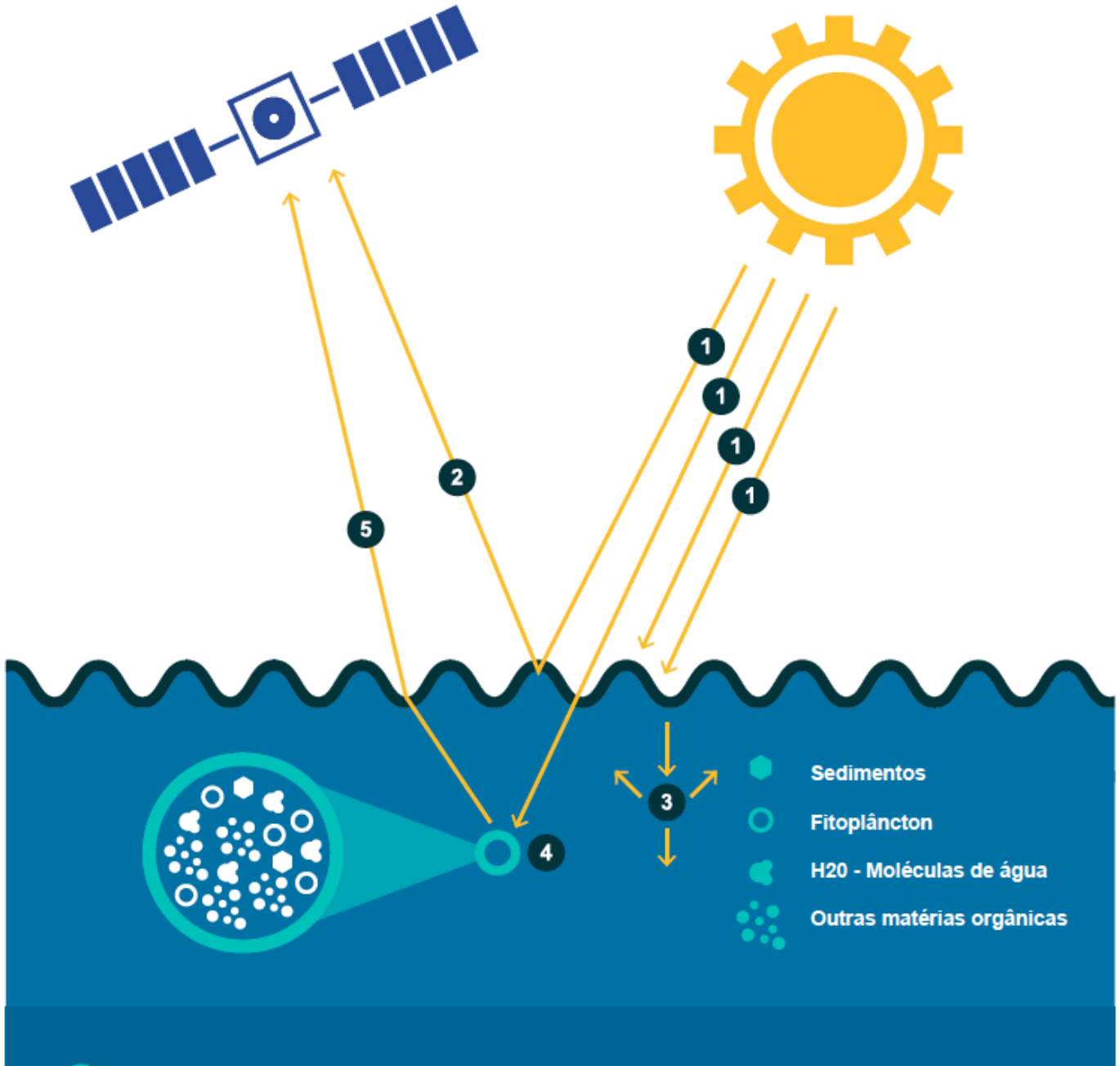
Remote Sensing is the remote technique for data acquisition on objects or processes, through an instrument that is not in direct contact.



Sutcliff et al. (2016)



What is Ocean Colour Remote Sensing ?



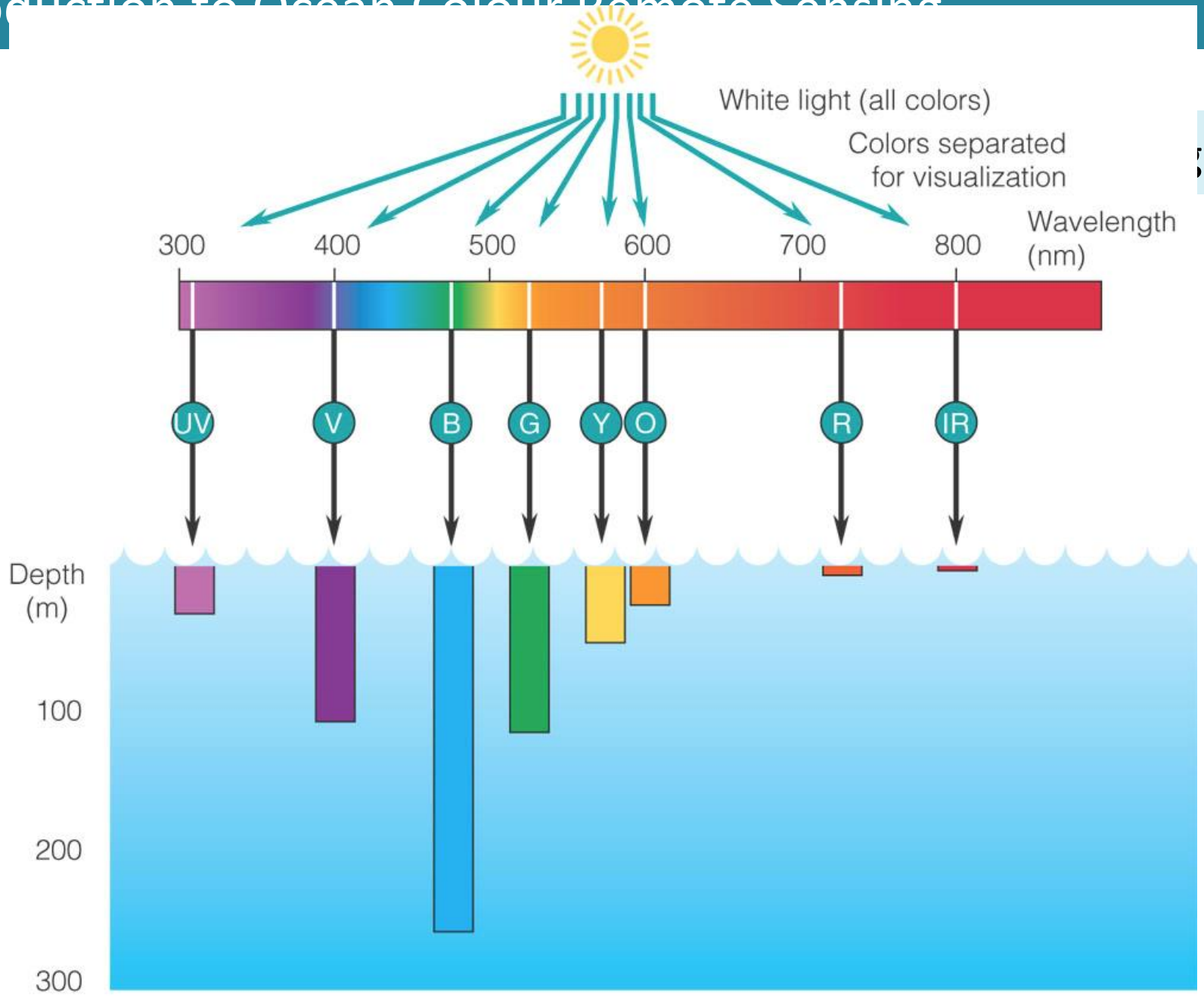
Sensing ?

Optically Active Components (OACs):

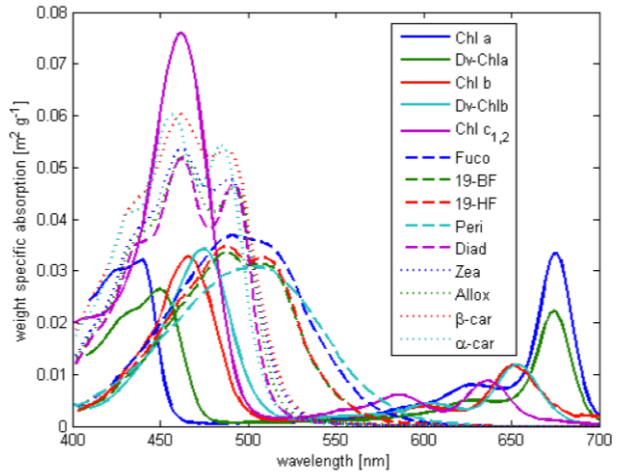
i. Phytoplankton

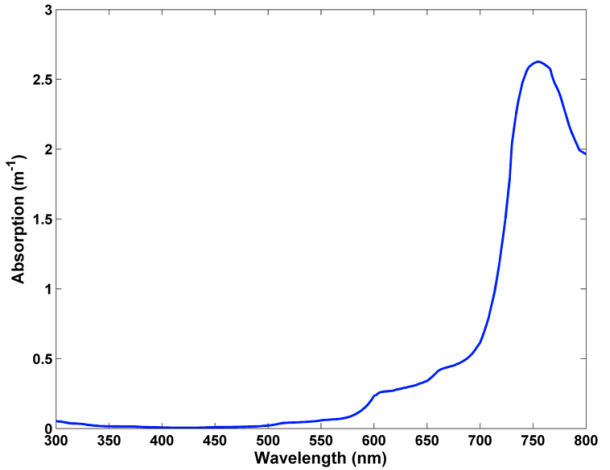
ii. Inorganic particles

iii. Coloured Dissolved Organic Matter (CDOM)


White light (all colors)
Colors separated
for visualization
Wavelength
(nm)
300
400
500
600
700
800
UV
V
B
G
Y
O
R
IR
Depth
(m)
100
200
300

?

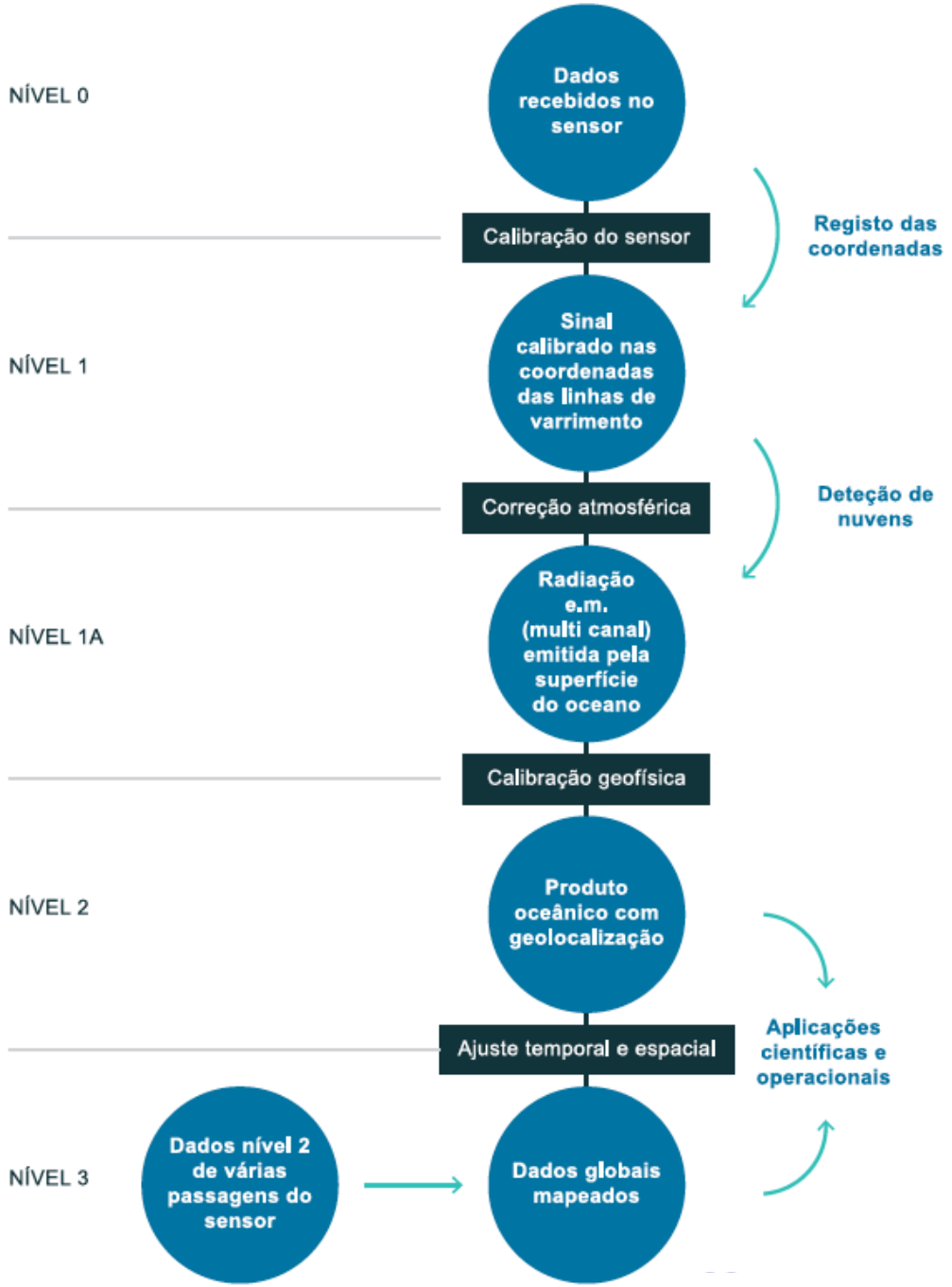

weight specific absorption [m² g⁻¹]
wavelength [nm]
Chl a
Dv-Chla
Chl b
Dv-Chlb
Chl c1,2
Fuco
19-BF
19-HF
Peri
Diad
Zea
Allox
β-car
α-car


Absorption (m⁻¹)
Wavelength (nm)

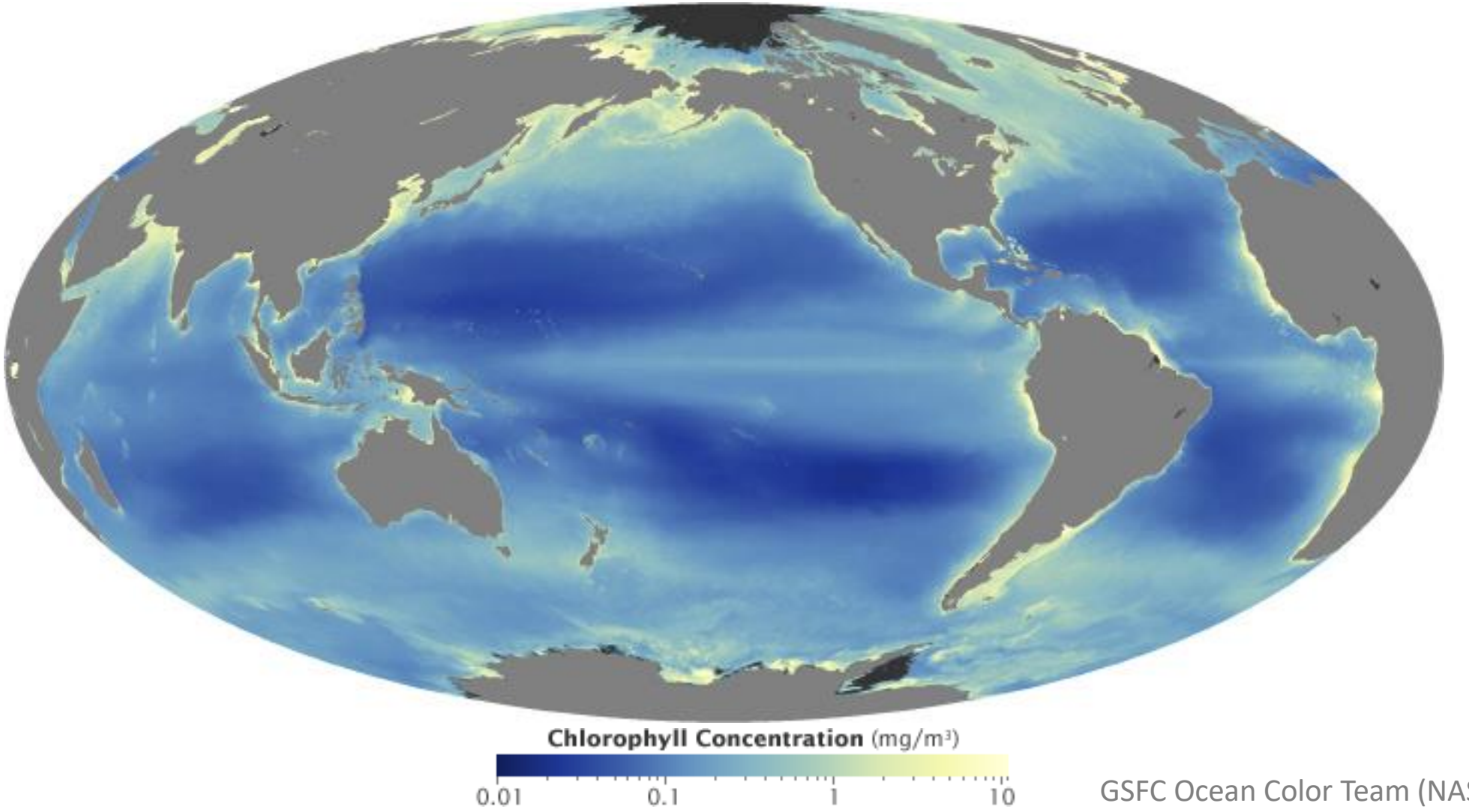
What is Ocean Colou

There are several levels of satellite data processing:

i. Sensor calibration
ii. Atmospheric correction
iii. Geophysical calibration
iv. Temporal and spatial integrations
v. Integration of different sensors

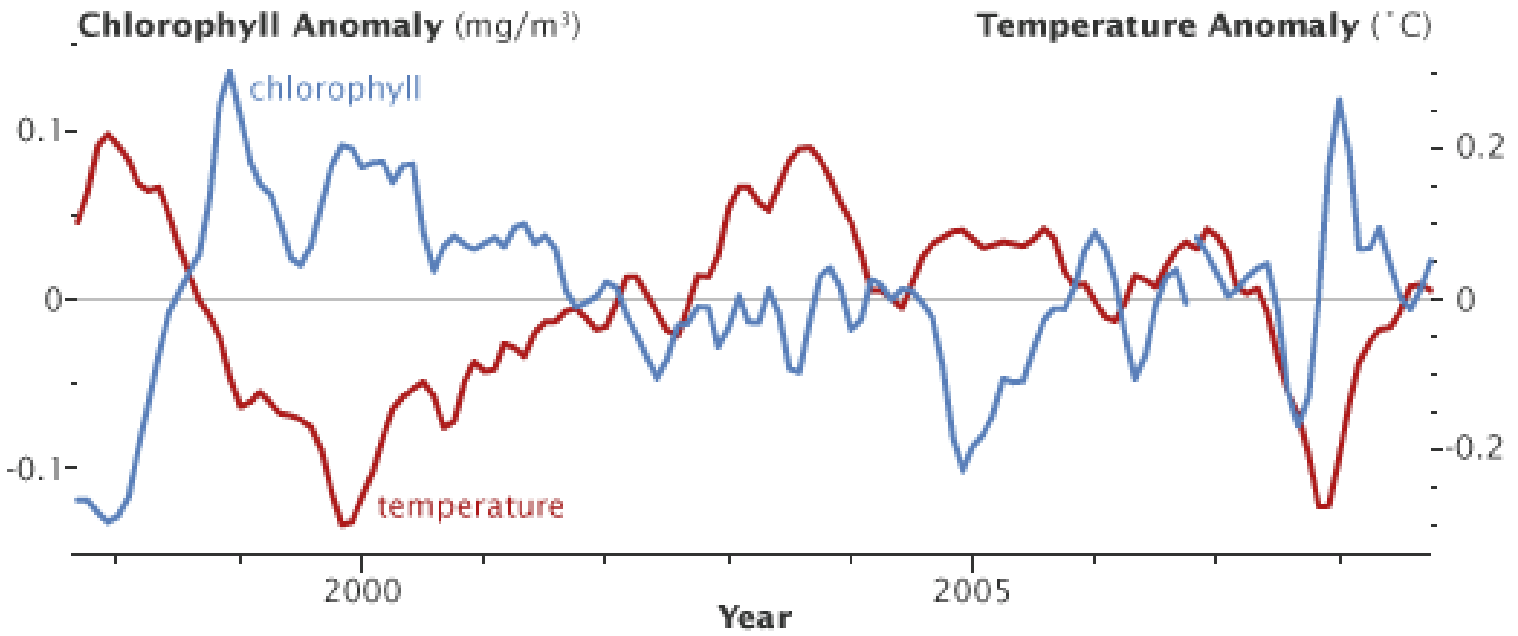


What is Ocean Colour Remote Sensing ?



GSFC Ocean Color Team (NASA)

What is Ocean Colour Remote Sensing ?



Adapted from Behrenfeld et al. (2009)

Advantages *vs* Disadvantages of OCRS

Advantages of OCRS

i. high temporal resolution (daily?)
ii. Coverage of large areas (global ocean)
iii. Now, relatively high spatial resolution (~10-60 m)
iv. Allows reaching inaccessible areas

Disadvantages of OCRS

i. Surface Waters
ii. Can derive only few parameters
iii. In-situ samples always required
iv. Presence of clouds
v. Cost of missions

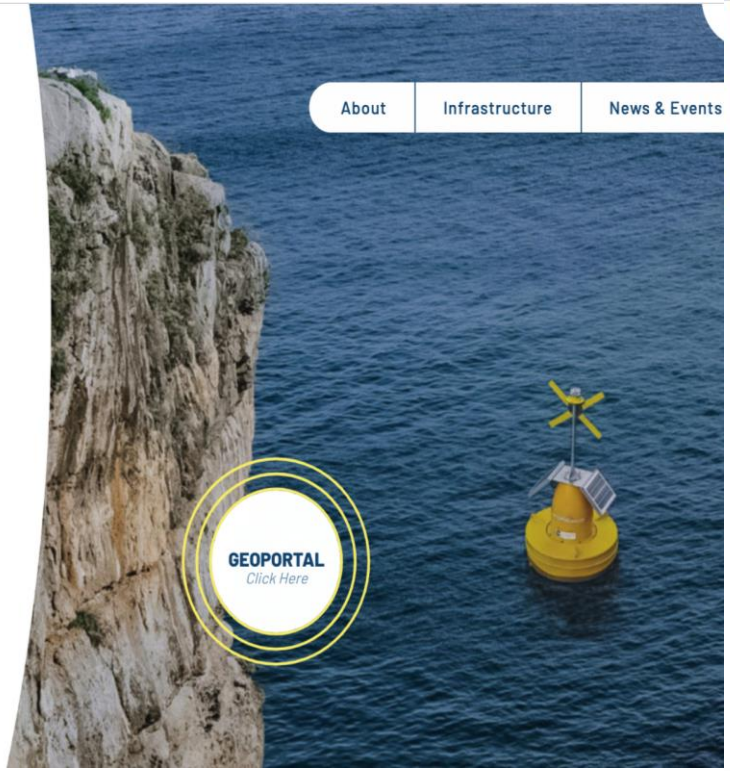
Examples of Online Platforms for OCRS

COASTNET
COASTAL MONITORING NETWORK

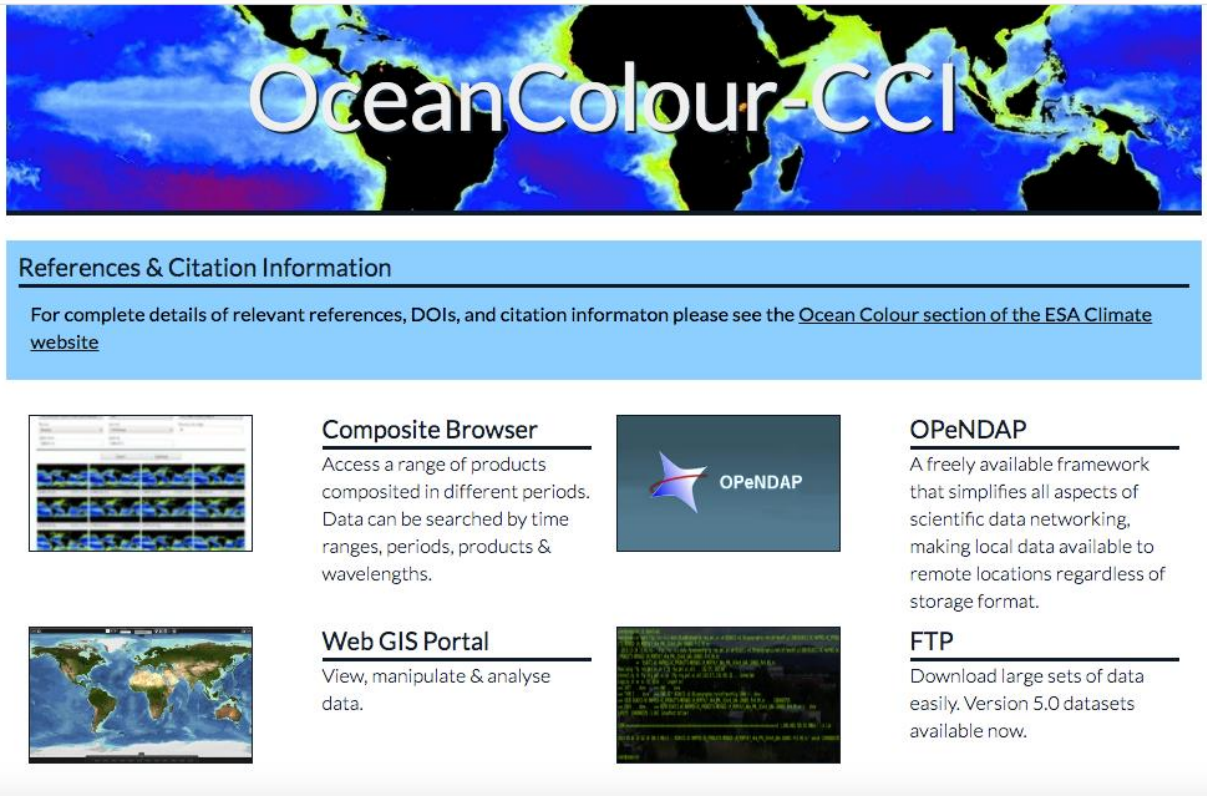
CoastNet - Portuguese Coastal Monitoring Network

CoastNet aims at monitoring important ecosystems of the Portuguese coast through relevant chemical, physical and biological parameters, collected remotely in near real-time.

Read more +



http://geoportal.coastnet.pt



https://www.oceancolour.org

Examples of Online Platforms for OCRS

i. Development and validation of consistent and stable satellite data products from multi-sensor data archives;

ii. Data reprocessing paradigm utilising on-going research an developments in atmospheric correction, in-water algorithms, data merging techniques and bias correction;

iii. Strengthen inter-disciplinary cooperation between Earth Observation, Climate research and modelling communities, in pursue of scientific excellence.

Examples of Online Platforms for OCRS

i. Chlorophyll data: daily, 5-day, 8-day averages, monthly

ii. Best spatial resolution: 1km

iii. Water Turbidity indicators

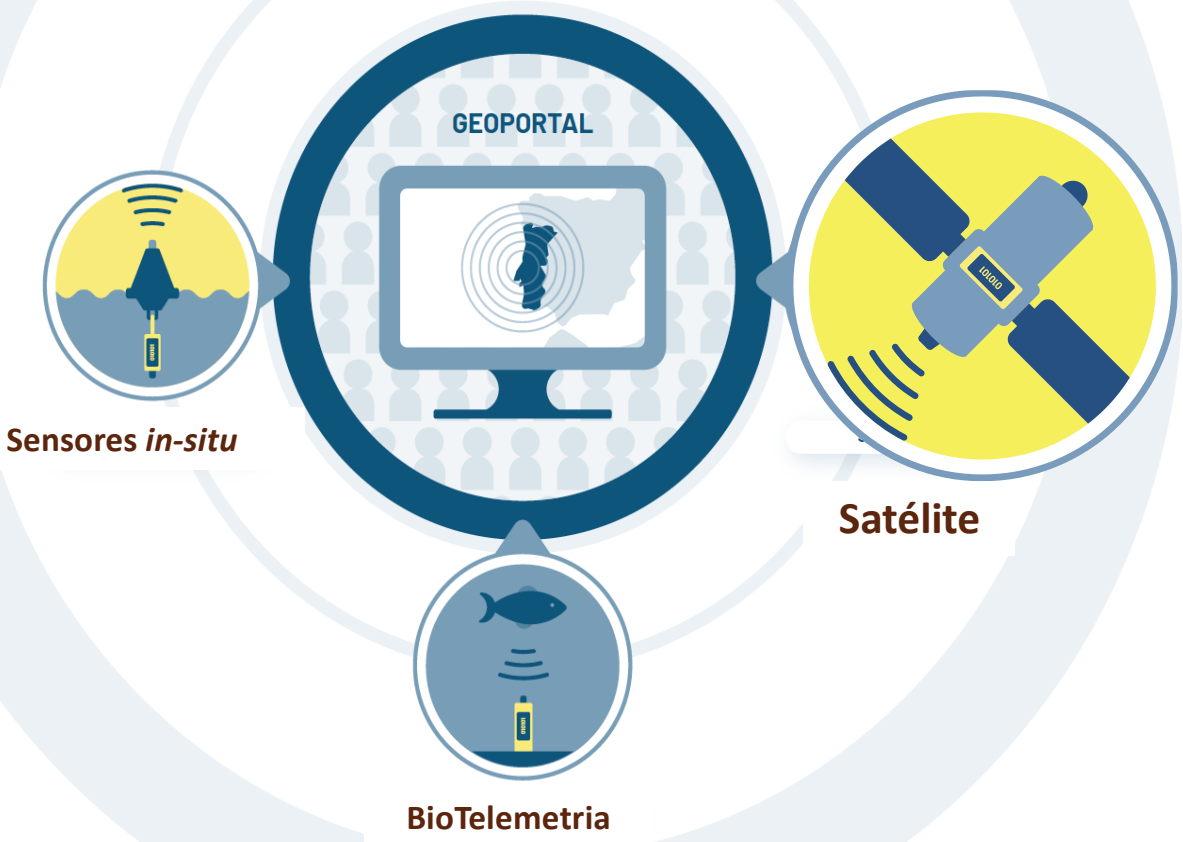
Examples of Online Platforms for OCRS

COASTNET
COASTAL MONITORING NETWORK

Aims at monitoring important ecosystems of the Portuguese coast, integrating:

i. A near real-time Earth Observation data centre
ii. A set of sensors to collect in-situ data on environmental and biological parameters transmitted in near real-time to the data centre
iii. An array of acoustic receivers to track marine fauna movements
iv. A web-based platform, integrating the whole database and providing open access to the information.

Examples of Online Platforms for OCRS



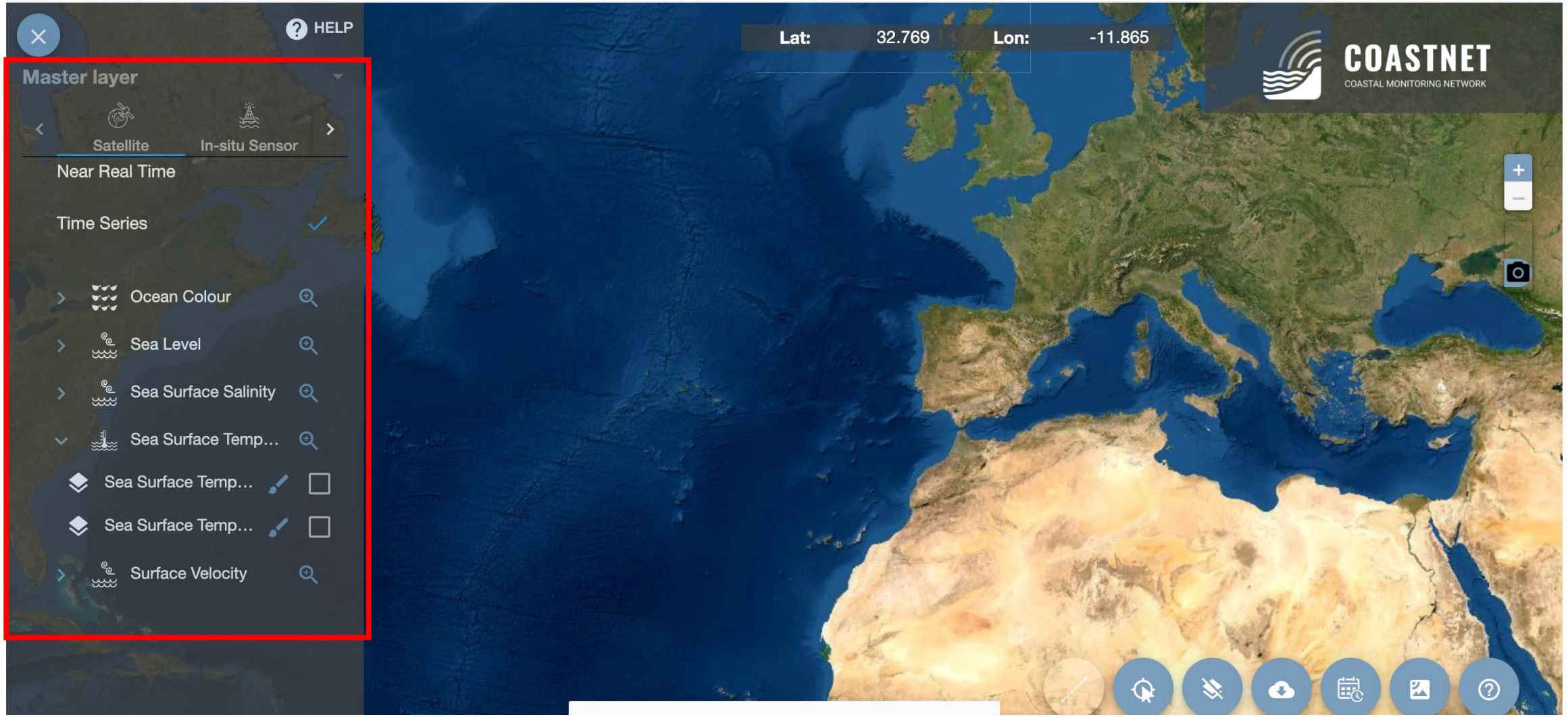
https://coastnet.pt

Examples of Online Platforms for OCRS

COASTNET
COASTAL MONITORING NETWORK

i. Chlorophyll – daily & monthly OC-CCI data, 1 & 4 km spatial resolution
ii. Sea Surface Temperature (SST)
iii. Sea Surface Salinity (SSS)
iv. Wind Speed
v. Surface Velocity
vi. Wind Stress
vii. Sea Level

DEMO – CoastNet Geoportal



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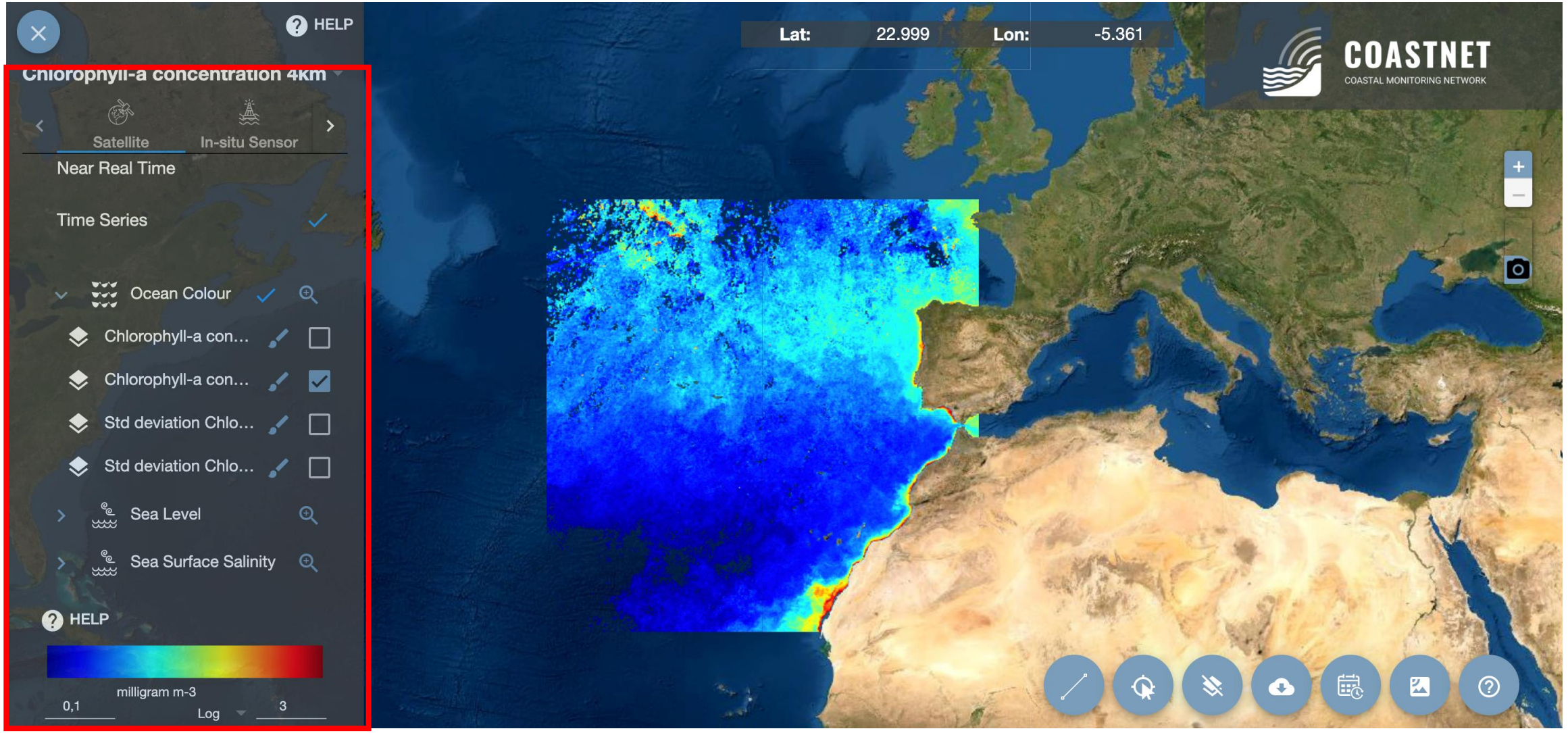

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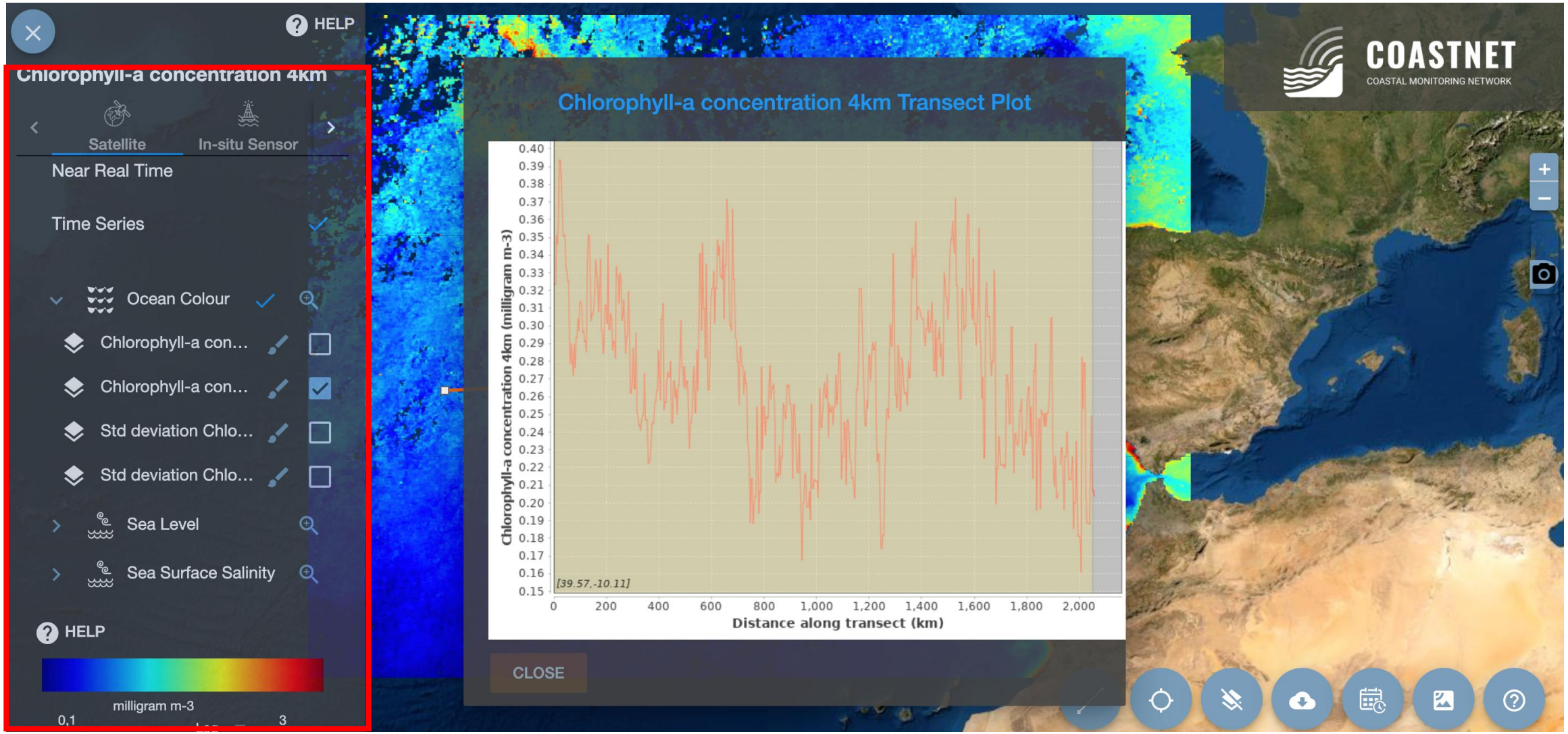
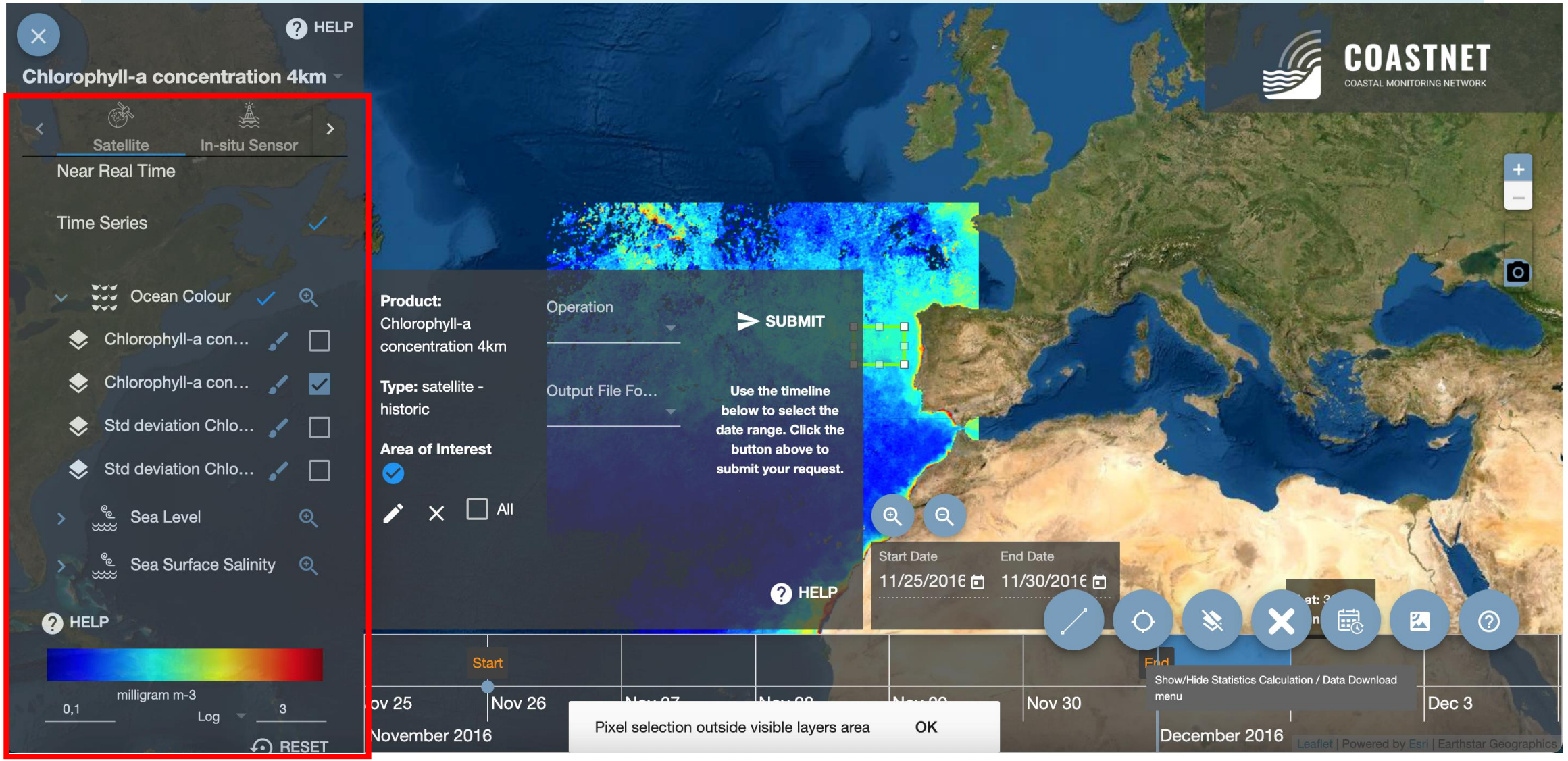
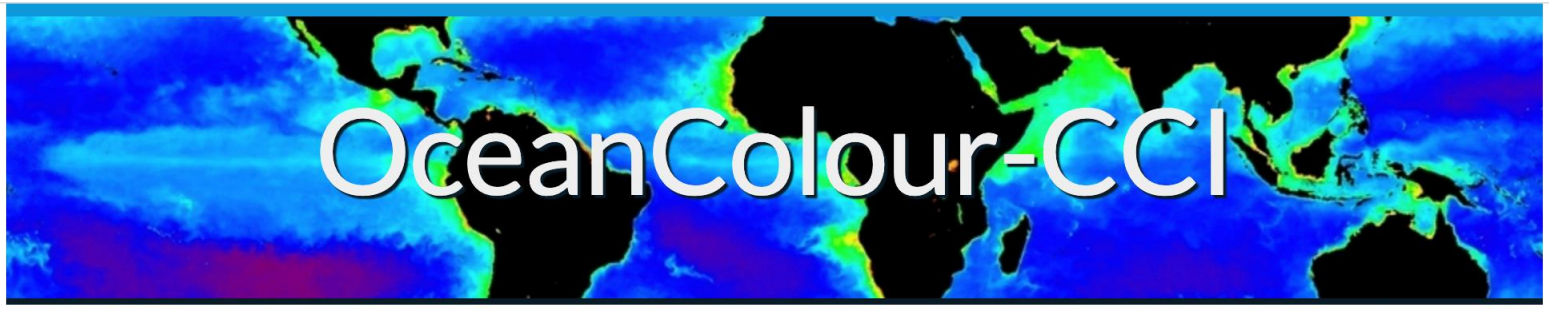


DEMO – CoastNet Geoportal

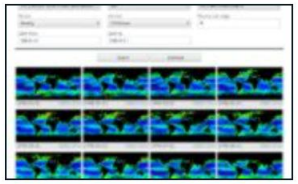


DEMO – OC-CCI Geoportal



References & Citation Information

For complete details of relevant references, DOIs, and citation informaton please see the Ocean Colour section of the ESA Climate website

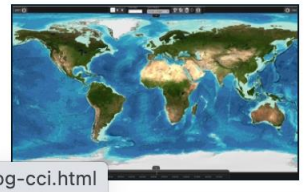


Composite Browser

Access a range of products composited in different periods. Data can be searched by time ranges, periods, products & wavelengths.

OPeNDAP

A freely available framework that simplifies all aspects of scientific data networking, making local data available to remote locations regardless of storage format.



Web GIS Portal

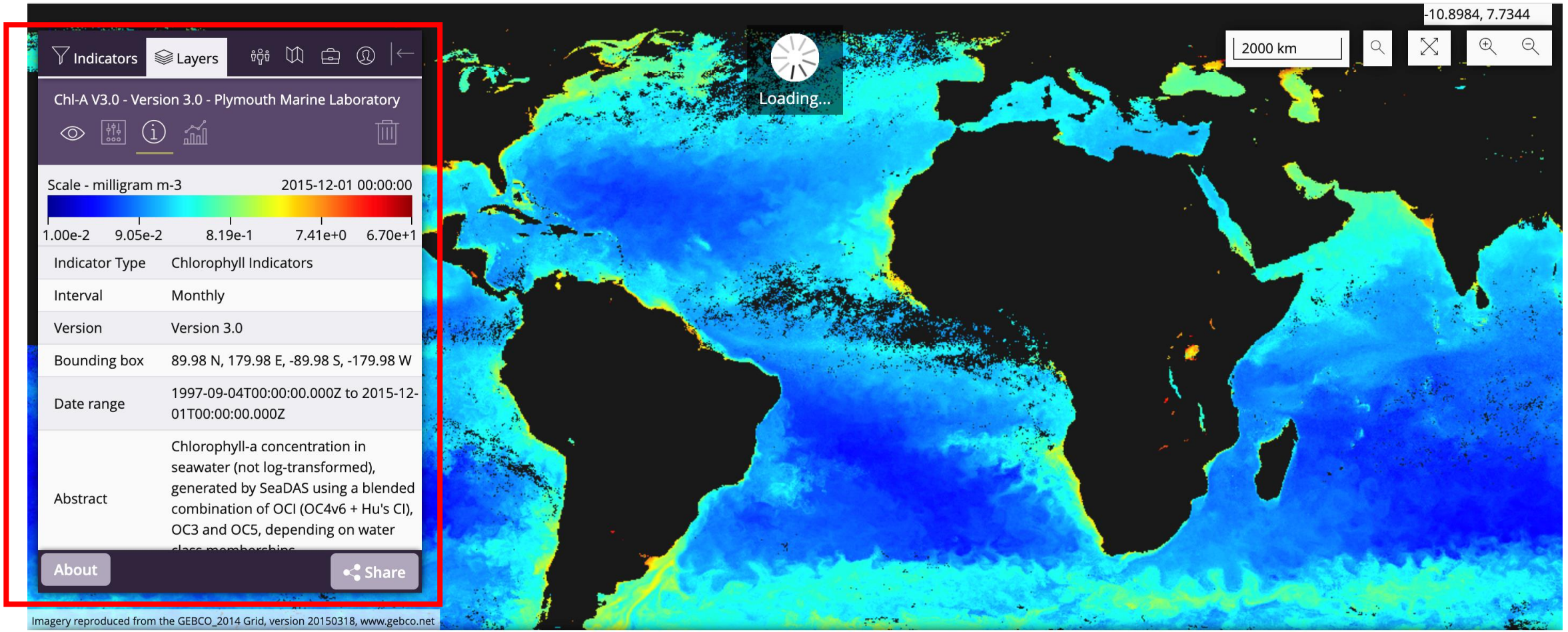
View, manipulate & analyse data.

FTP

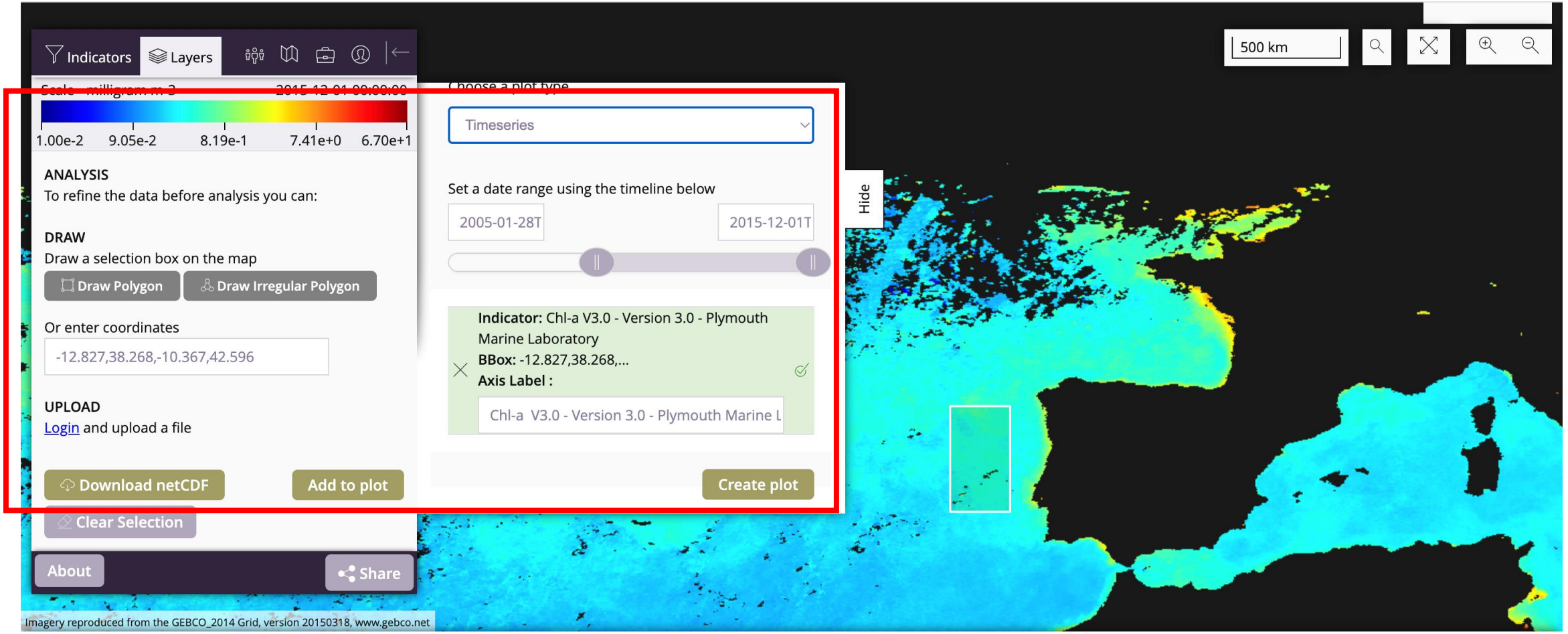
Download large sets of data easily. Version 5.0 datasets available now.

https://www.oceancolour.org/thredds/catalog-cci.html

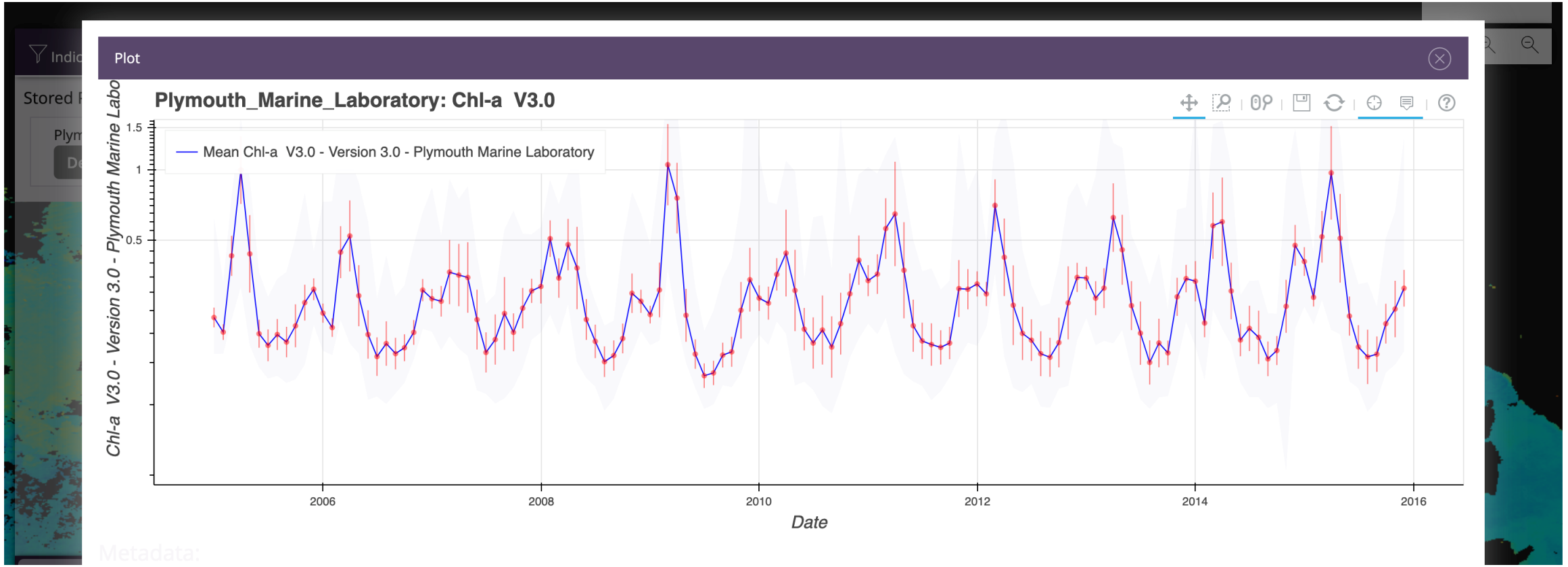
DEMO – OC-CCI Geoportal



DEMO – OC-CCI Geoportal



DEMO – OC-CCI Geoportal



Case Study: Natural Variability of Phytoplankton

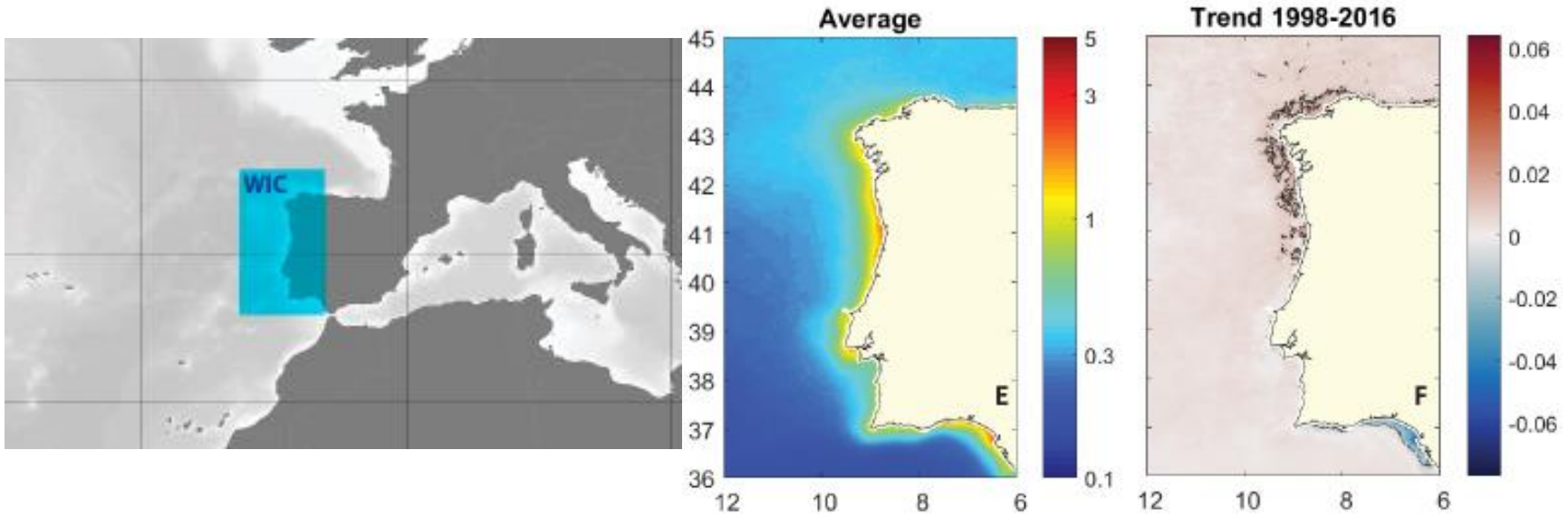
frontiers in Marine Science

ORIGINAL RESEARCH
published: 28 February 2019
doi: 10.3389/fmars.2019.00044

Disentangling Environmental Drivers of Phytoplankton Biomass off Western Iberia

*A. Ferreira[1], P. Garrido-Amador[1] and Ana C. Brito[1,2]**

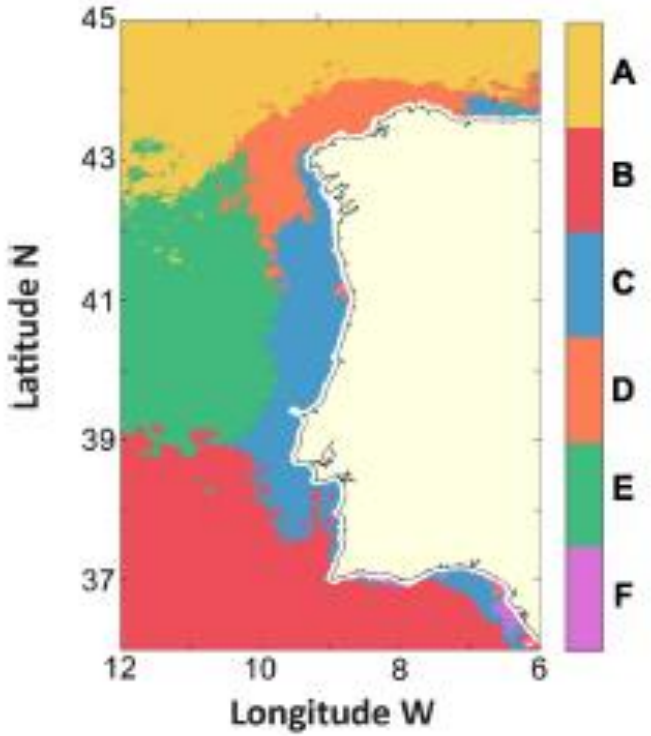
Ferreira et al. (2019)



OC-CCI Data

L4 (7-day) product
1 km spatial resolution
Years – 1998 to 2016

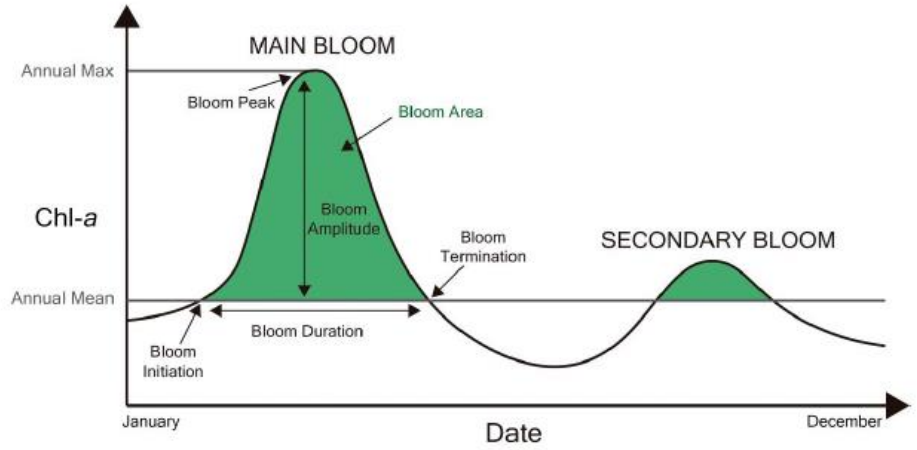
Case Study: Natural Variability of Phytoplankton



GAM Analysis

Region	MEP (%)	R^2 (adj)	Model predictors
A	40.6	0.29	NAO***, MLD***, PAR***, SSH**, EA**, V*, PO_4^{3-}*
B	51	0.43	DIN***, MLD***, AMO***, SSH***, V**, WeMO*
C	36.1	0.29	AMO***, MLD***, SST**, V*, EA*, SAL*, U*
D	39.9	0.31	AMO***, EA***, V***, SSH**, NAO**, U**, SST*
E	22.8	0.16	AMO***, MLD**, U*
F	52.8	0.44	SAL***, V***, DIN***, MLD*, SST*, NAO*

Case Study: Phenology of Phytoplankton



OC-CCI Data

daily product
4 km spatial resolution
Years – 1997 to 2018

remote sensing

MDPI

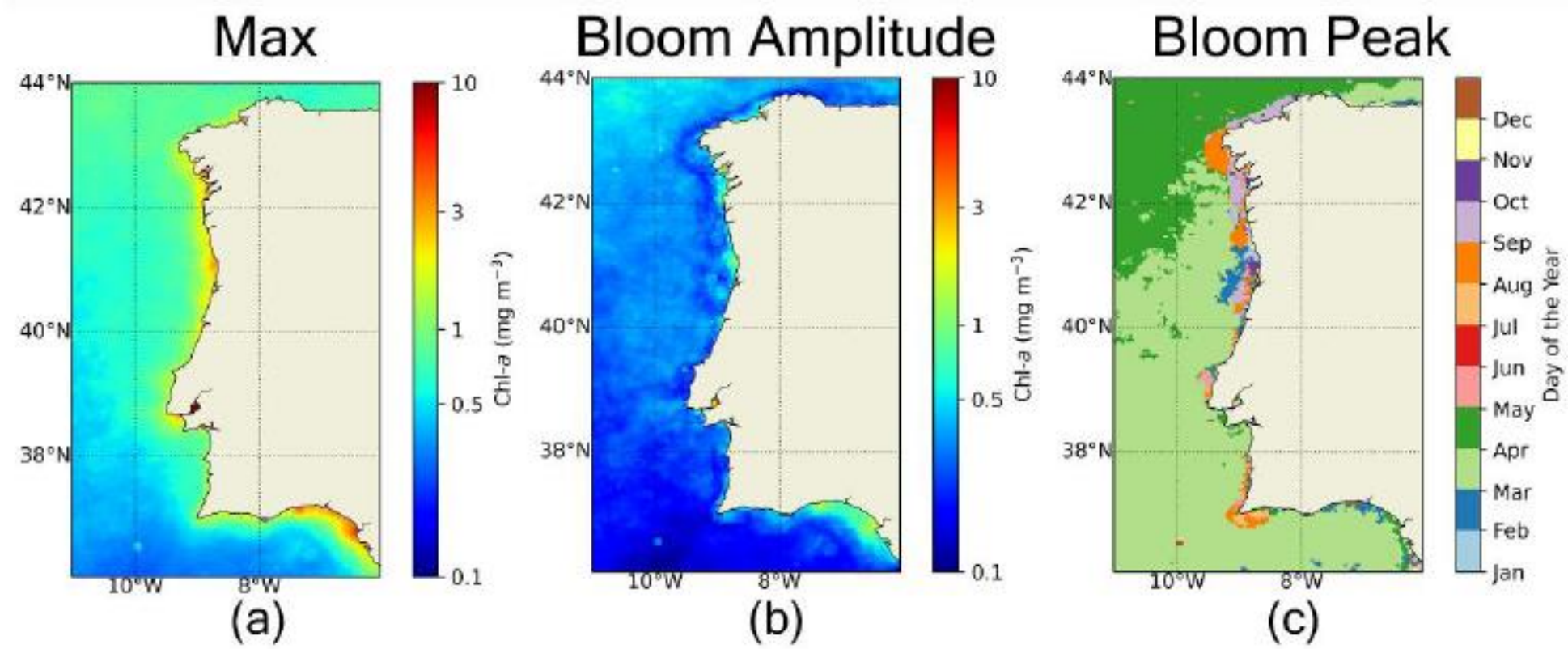
Article

Assessing Phytoplankton Bloom Phenology in Upwelling-Influenced Regions Using Ocean Color Remote Sensing

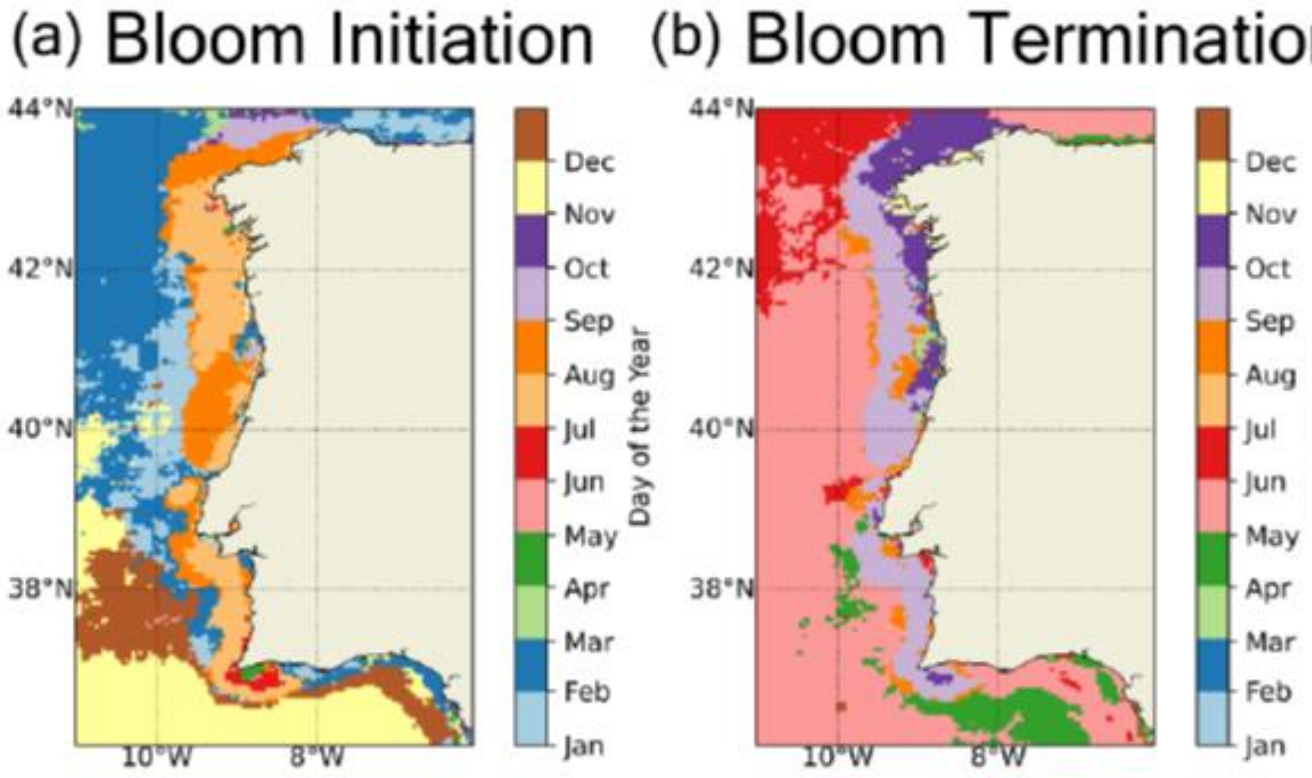
Afonso Ferreira [1,2,*], Vanda Brotas [1], Carla Palma [2], Carlos Borges [2] and Ana C. Brito [1]

Ferreira et al. (2021)

Case Study: Phenology of Phytoplankton



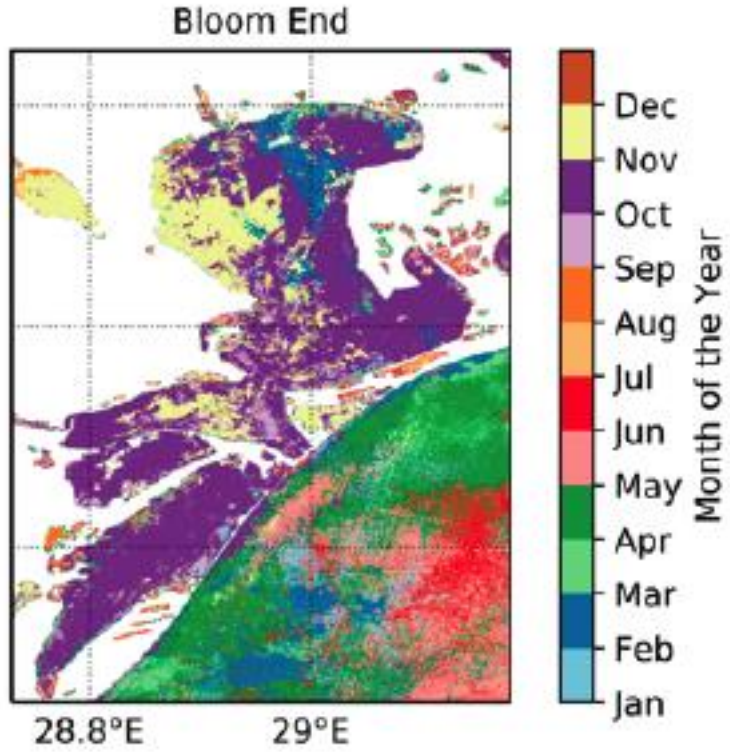
Case Study: Phenology of Phytoplankton



Random Forest Analysis (~ GAM)

Metric	R^2	RMSE	Model Predictors
Mean	0.75	0.01	**DIN** *, AMO, U_o, MEI, Fe, NAO
Max	0.75	0.09	**Si** *, MLD, NAO, DIN, Sal, MEI, SSH
BAmp	0.76	0.08	**Si** *, NAO, MLD, DIN, Sal
BPeak	0.71	9.2	**MLD** *, Fe, V_o
BInit	0.63	11.45	**DIN** *, V_o
BTerm	0.8	8.39	**AMO** *, Fe, NAO, DIN, Sal, V_o
BDur	0.73	9.33	**AMO** *, Si, U_o, MLD
BArea	0.87	4.09	**Si** *, U_o
YArea	0.77	4.3	**DIN** *, AMO, U_o
BFreq	0.61	0.45	**AMO** *, **MEI** *, V_o *

Case Study: Phenology of Phytoplankton

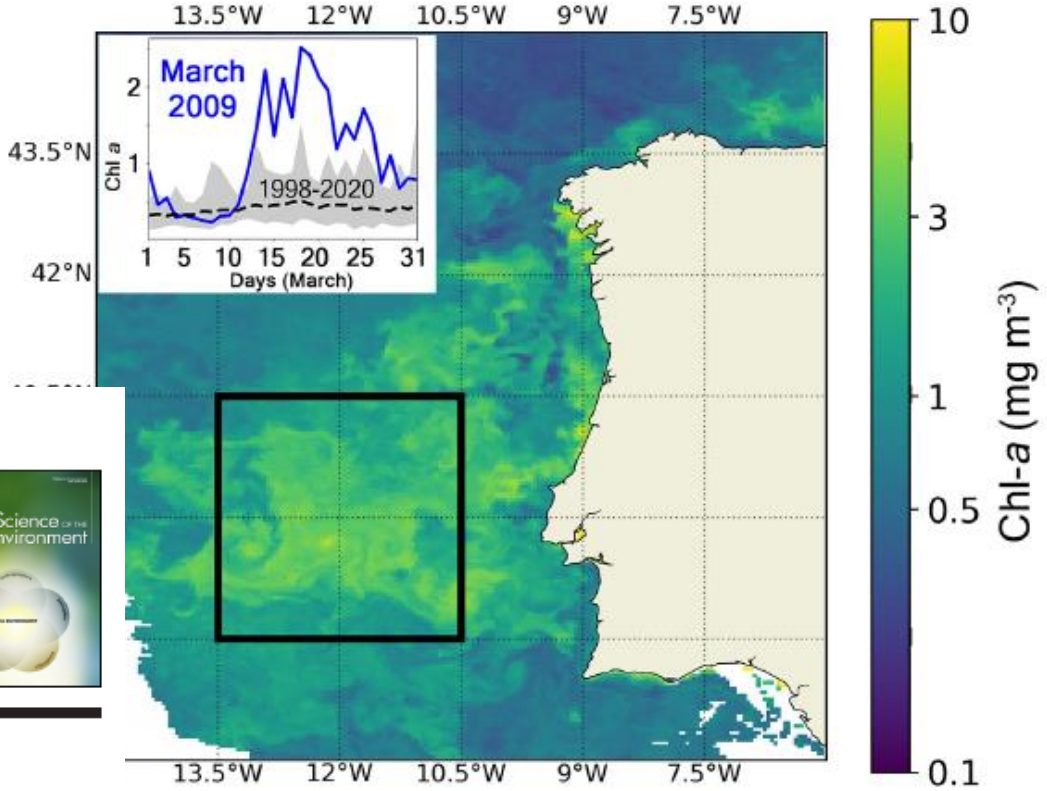


Can we evaluate phenology in transitional systems?

Using high resolution satellite data (Sentinel 2)

(H2020 CERTO Project)

Case Study: Anomaly of Phytoplankton



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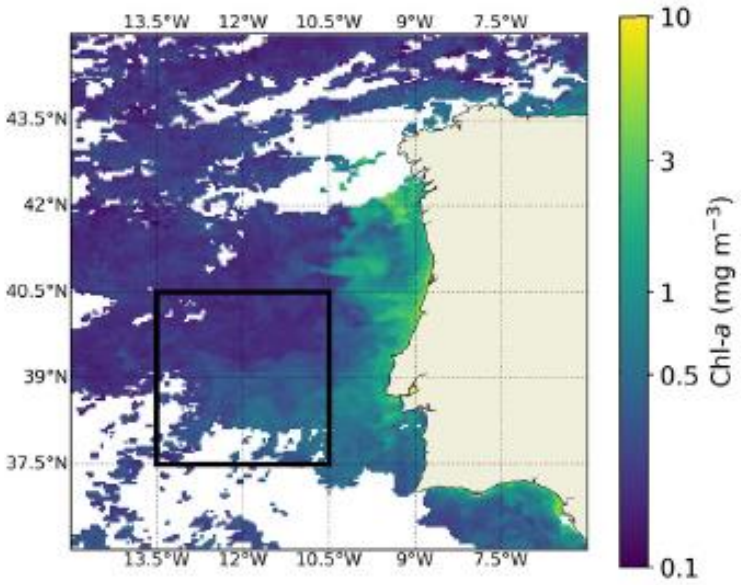
journal homepage: www.elsevier.com/locate/scitotenv

A perfect storm: An anomalous offshore phytoplankton bloom event in the NE Atlantic (March 2009)

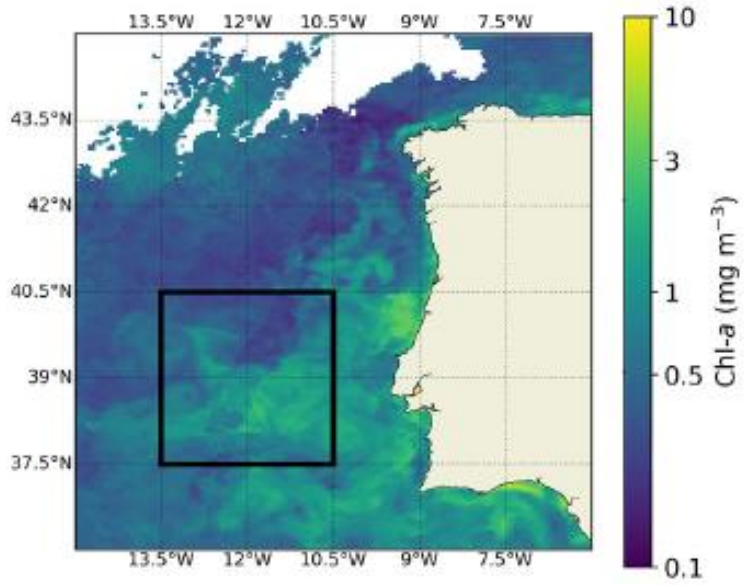
Afonso Ferreira [a,*], Joaquim Dias [a,b], Vanda Brotas [a,c], Ana C. Brito [a,c]

Case Studies: Phytoplankton in the WIC

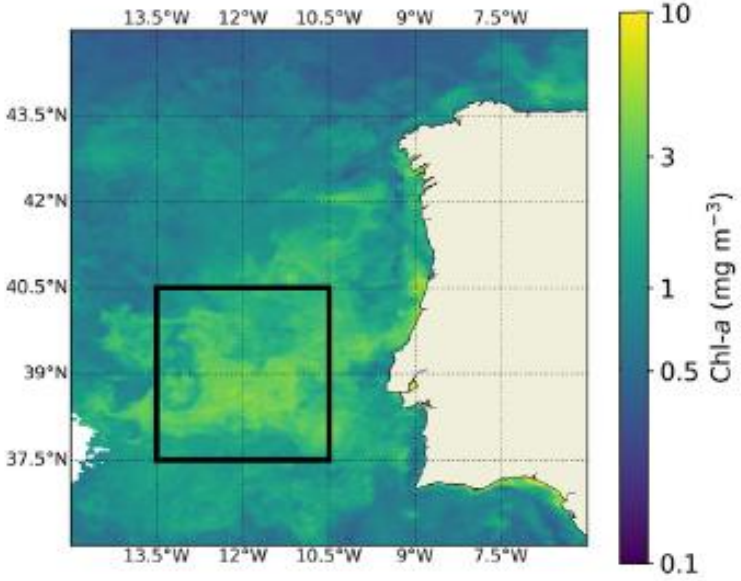
March 4-9



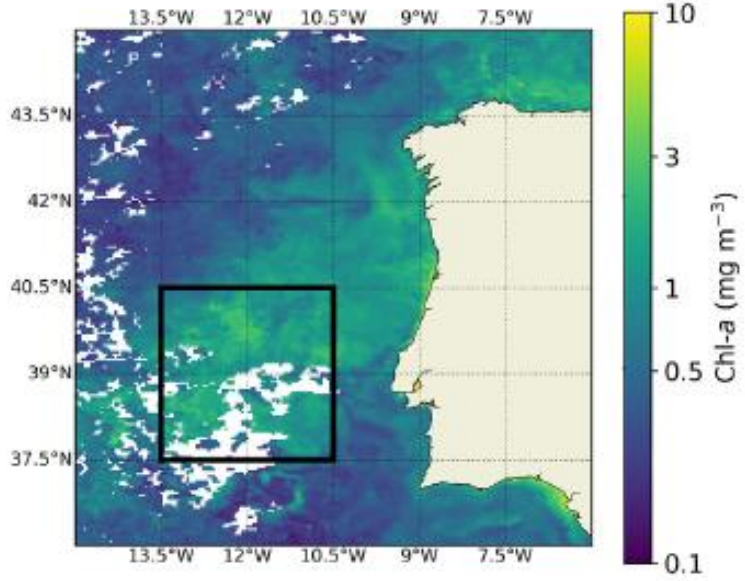
March 10-13



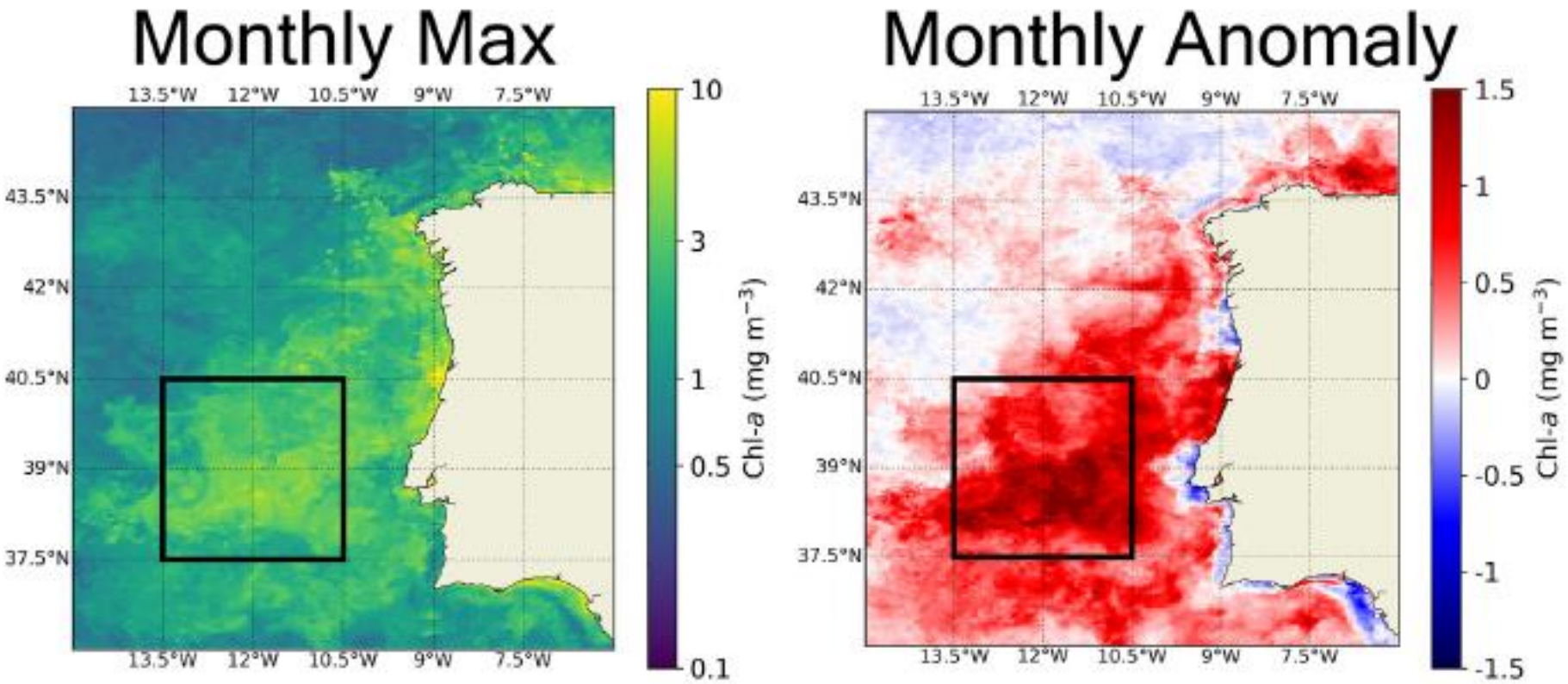
March 14-20



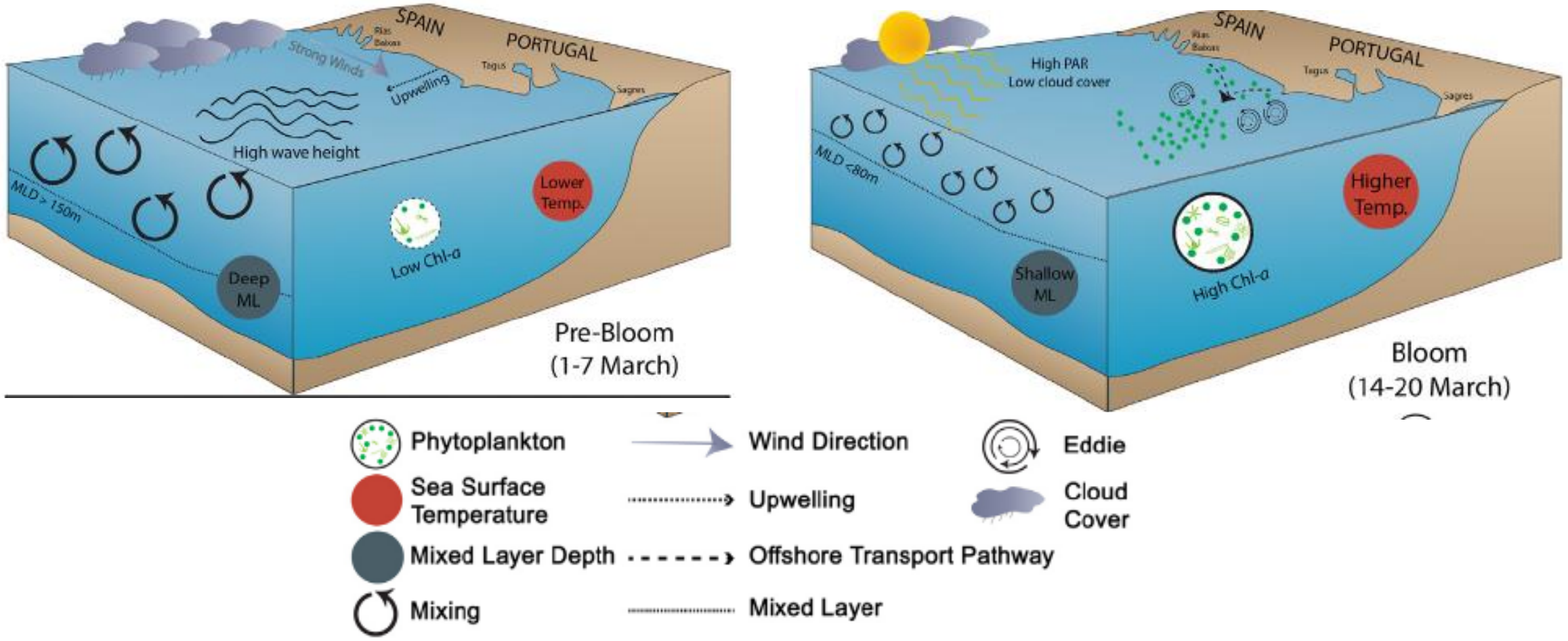
March 25-31



Case Study: Anomaly of Phytoplankton



Case Study: Anomaly of Phytoplankton



What is the Take-Home Message ?

i. Ocean Colour Remote Sensing is a valuable tool to study the most important marine primary producer – phytoplankton

ii. The use of Ocean Colour Remote Sensing can be very simple

iii. Data on chlorophyll can be obtained and visualised in simple platforms – e.g. CoastNet GeoPortal and OC-CCI Portal

iv. Geoportals allow studying spatial, seasonal and long-term variability of phytoplankton.

Thank you!

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