Marine heatwaves in Patagonia

From large-scale to regional-scale

Cécile Pujol

15/07/2022

Workshop en IFOP

What are marine heatwaves?

Anomalously warm water events

(Hobday et al., 2016)

Formed due to processes

Atmospheric
(slow/no wind, high air temperatura, lower heat transfer)

Oceanic
(advection of warm waters)

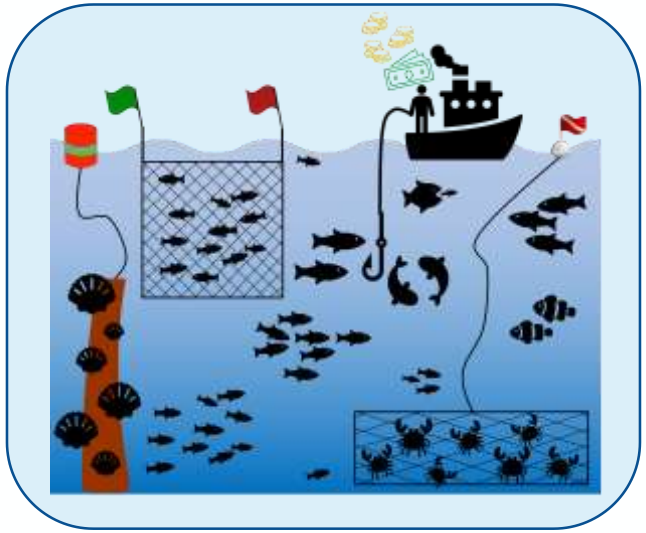
Recently studied

↓

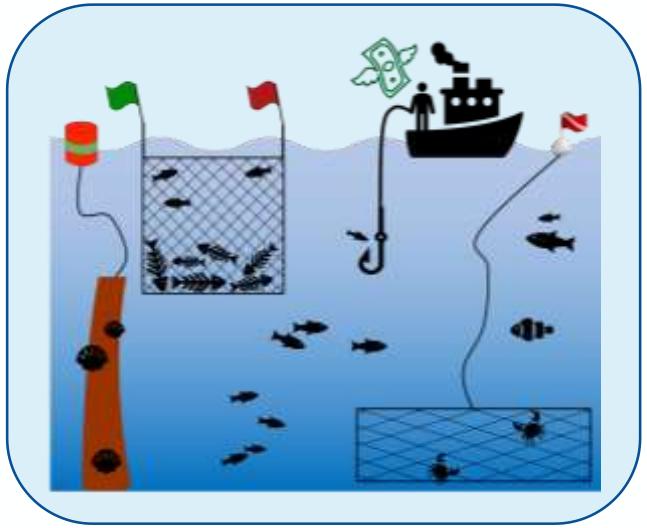
Amplification linked to human induced global warming

Devastating consequences

Before a MHW



During a MHW



Objectives

1st part:

MHWs at large scale:

the Southeastern Pacific (offshore Central and South Chile)

Pujol et al. (2022) Marine Heatwaves Offshore Central and South Chile: Understanding Forcing Mechanisms During the Years 2016-2017. Front. in Mar. Sci.

2nd part:

MHWs at smaller scale:

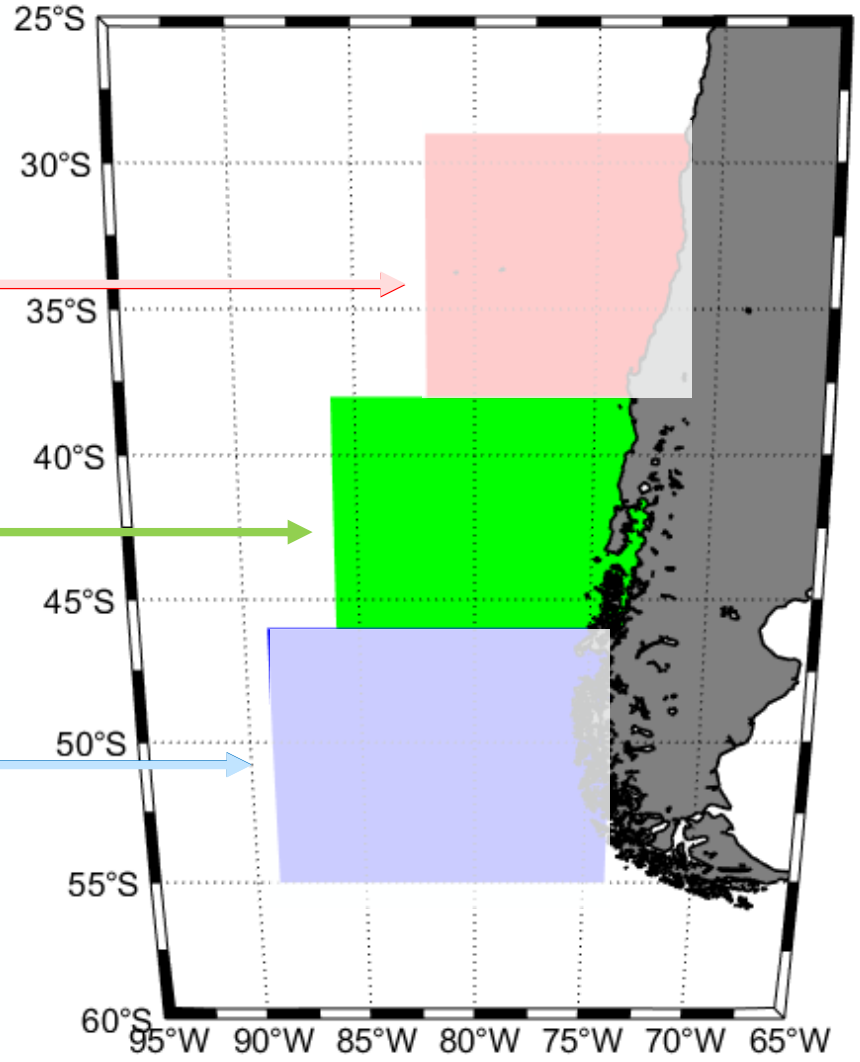
the inner Sea of Chiloé

Study area

Central Chile

North Patagonia

South Patagonia



Further information: Pujol C., Pérez-Santos I., Barth A. and Alvera-Azcárate A. (2022) Marine Heatwaves Offshore Central and South Chile: Understanding Forcing Mechanisms During the Years 2016-2017. Frontiers in Marine Science.

Method: Detection of MHWs at large scale

How to detect MHWs?

SST
NOAA Optimum Interpolation Sea Surface Temperature (OISST)

NOAA SATELLITES

1982 to 2020 with daily resolution

Spatial resolution: 1/4 degree

heatwaveR

Schlegel and Smit, 2018

Climatology: 1982-2020

Threshold: 90th percentile

Detection of the MHWs

How were MHWs formed?

Atmospheric pressure

Winds

Heat fluxes

ECMWF ERA5

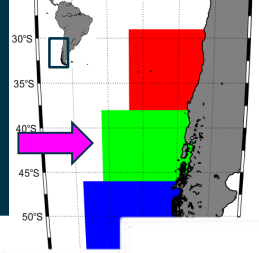
Spatial resolution: 1/4 degree

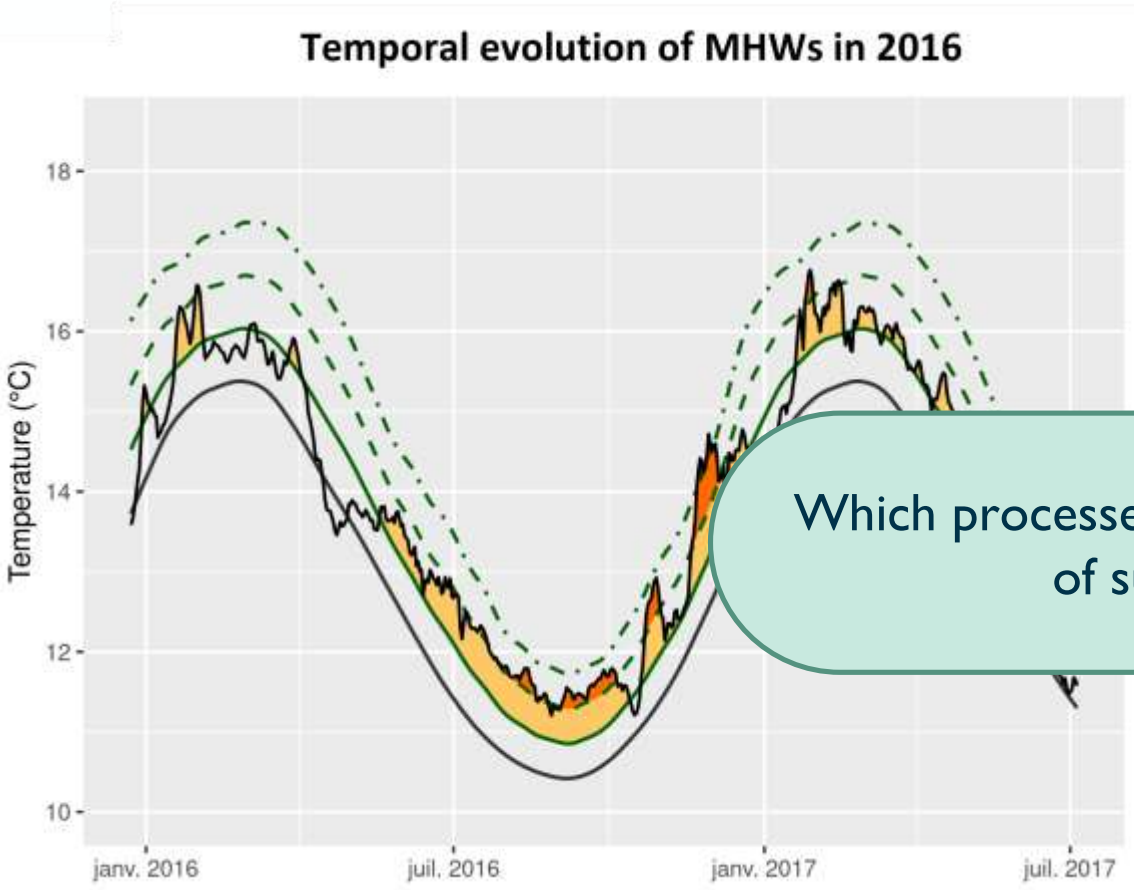
SST anomaly

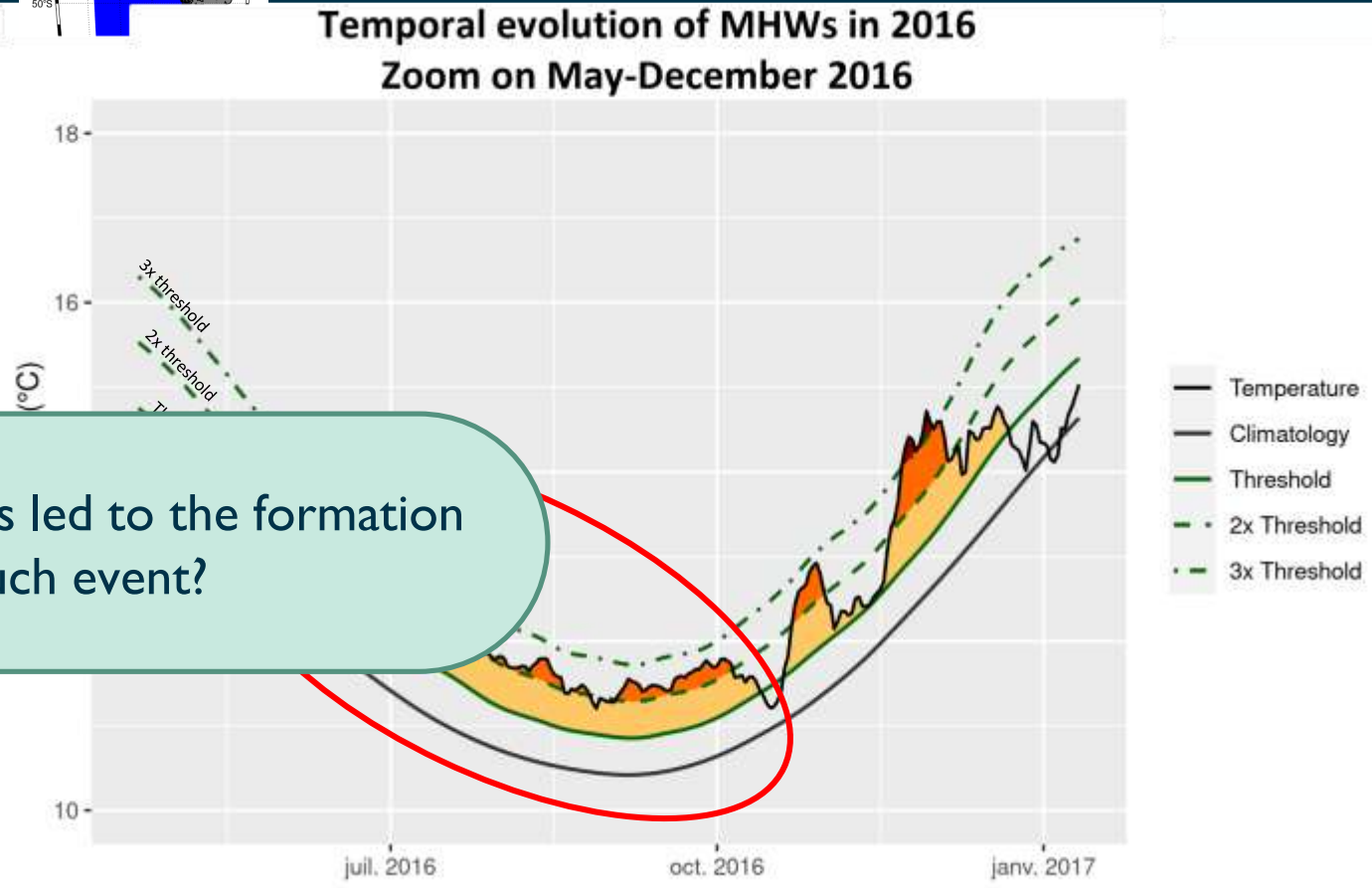
GCOM-W1 Global Change Observation Mission 1st-Water

AMSR-2 instrument
Microwave sensor

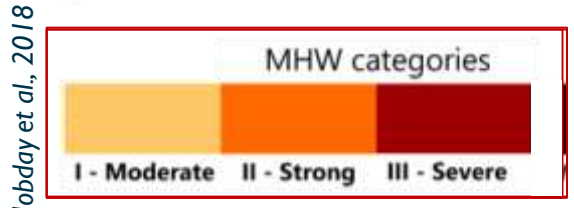
Detection of the MHWs







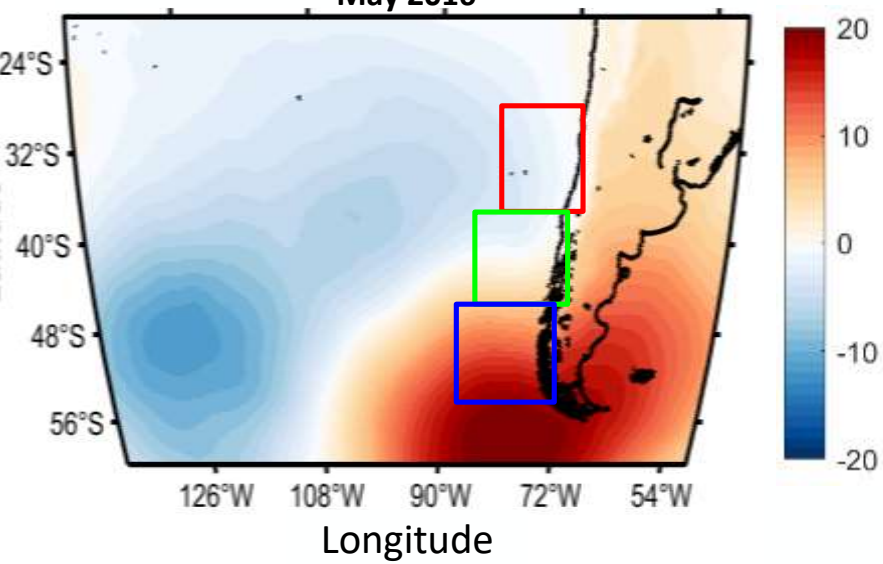
Which processes led to the formation of such event?



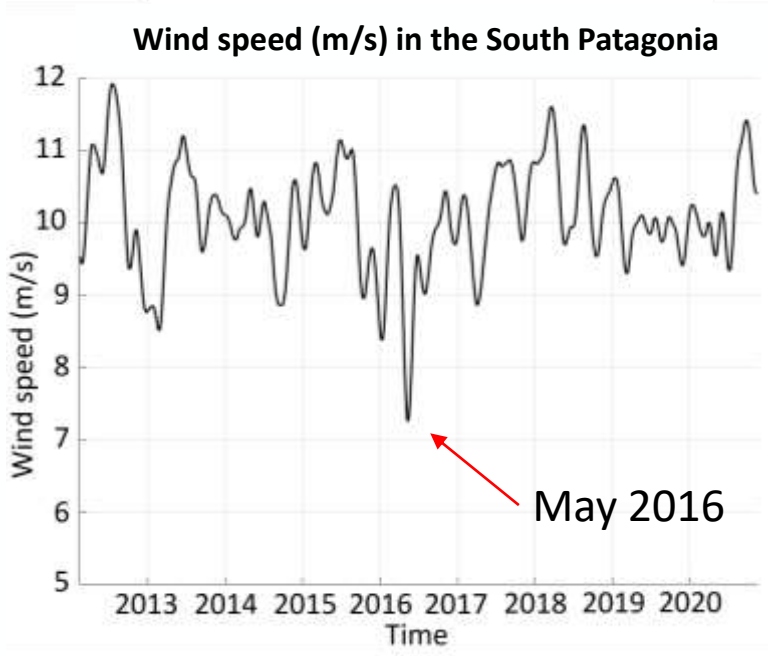
Hobday et al., 2018

Atmospheric processes involved

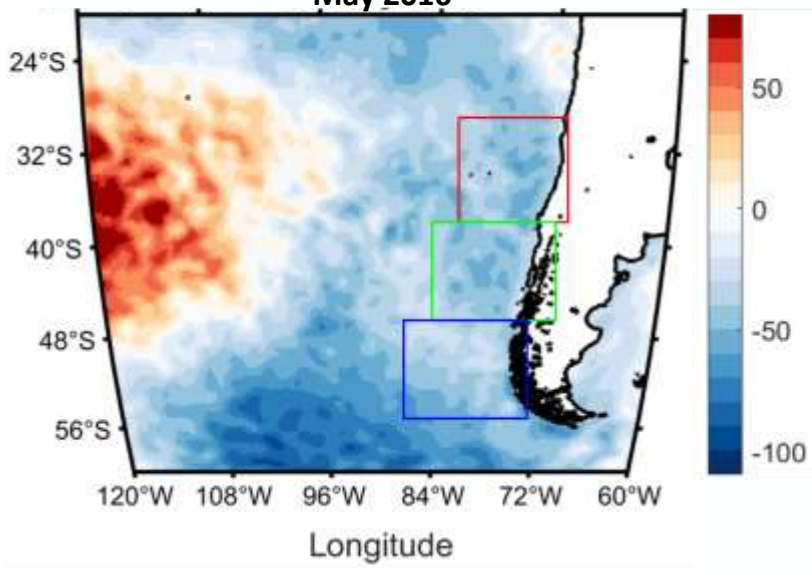
Sea level pressure anomaly (hPa)
May 2016



Wind speed (m/s) in the South Patagonia



Heat transfer anomaly from the ocean to the atmosphere (W/m²)
May 2016



High pressure system → **Reduced winds** → **Weaker heat transfer**

MHW !

Objectives

1st part:

MHWs at large scale:

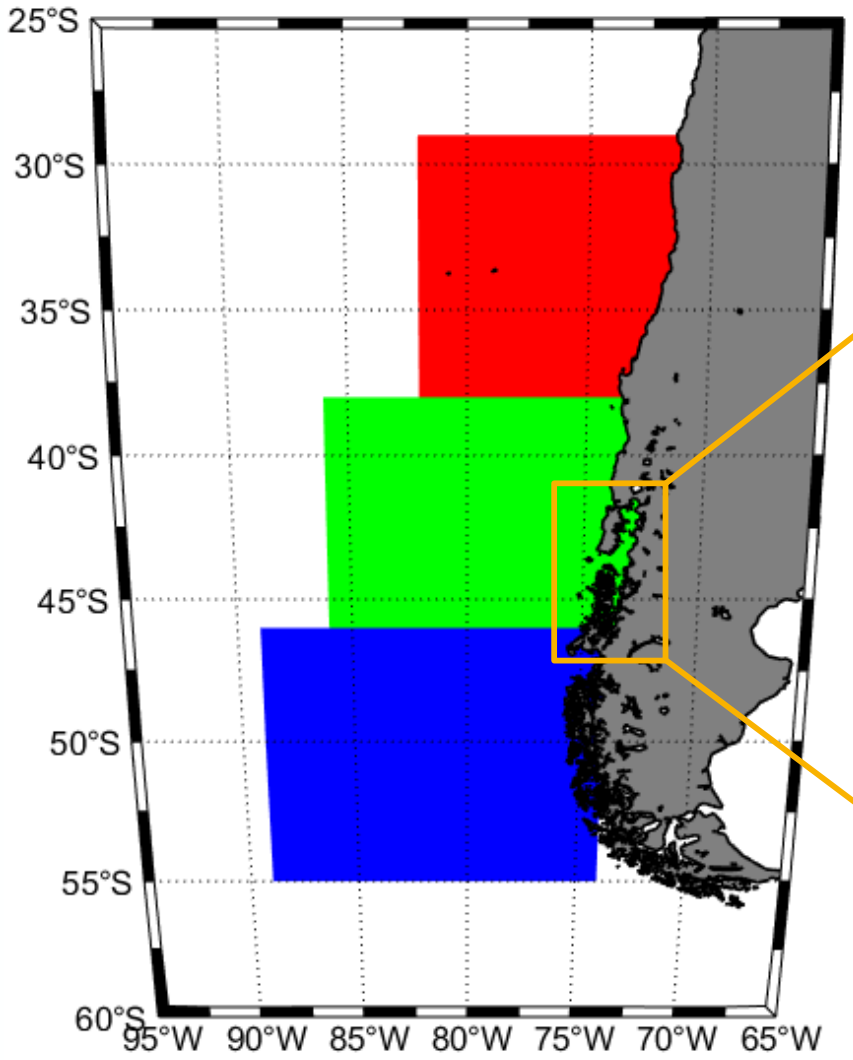
the Southeastern Pacific (offshore Central and South Chile)

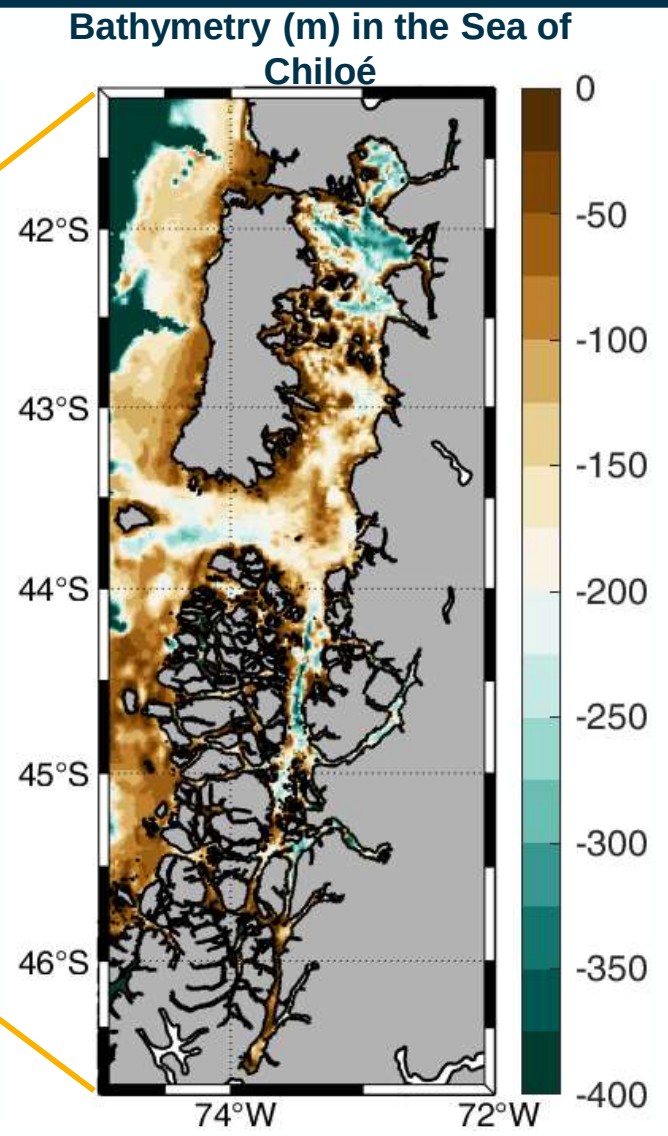
2nd part:

MHWs at smaller scale:

the inner Sea of Chiloé

Study area: the Sea of Chiloé





How to detect MHWs in the Sea of Chiloé?

How to detect MHWs in the Sea of Chiloé ?

Build the monthly climatology of the sea temperature → Detect days during which temperature exceeds a threshold

But with what kind of data ?

Satellite data ?

Temporal coverage at low resolution

Quite recent data

Depends on satellite orbit

Spatial coverage depends on clouds, rain, satellite swath…

In situ data ?

Temporal coverage depends on sampling frequency

Old data available

Spatial coverage depends on oceanic missions (some parts of the sea very well sampled and others with very few sampling)

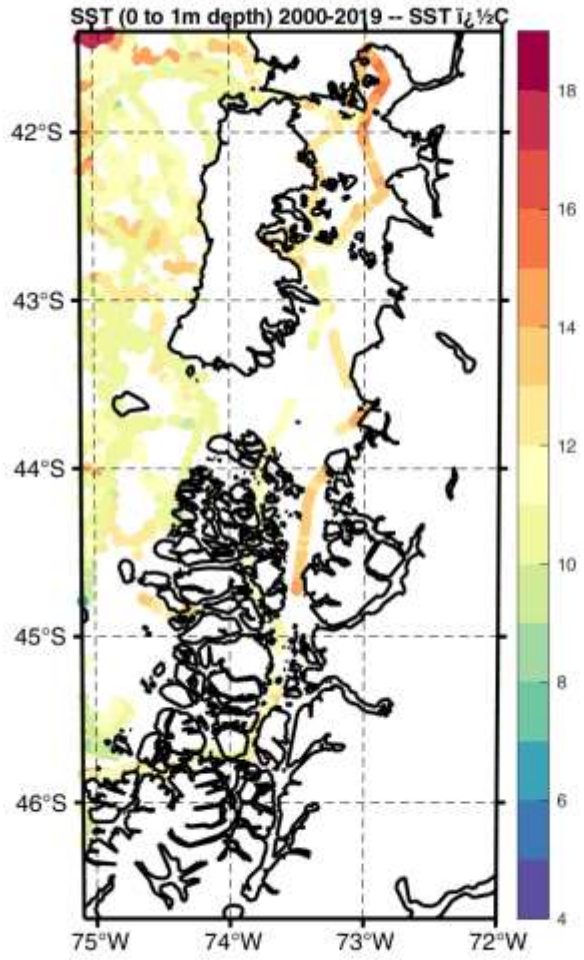
Which in situ data ?

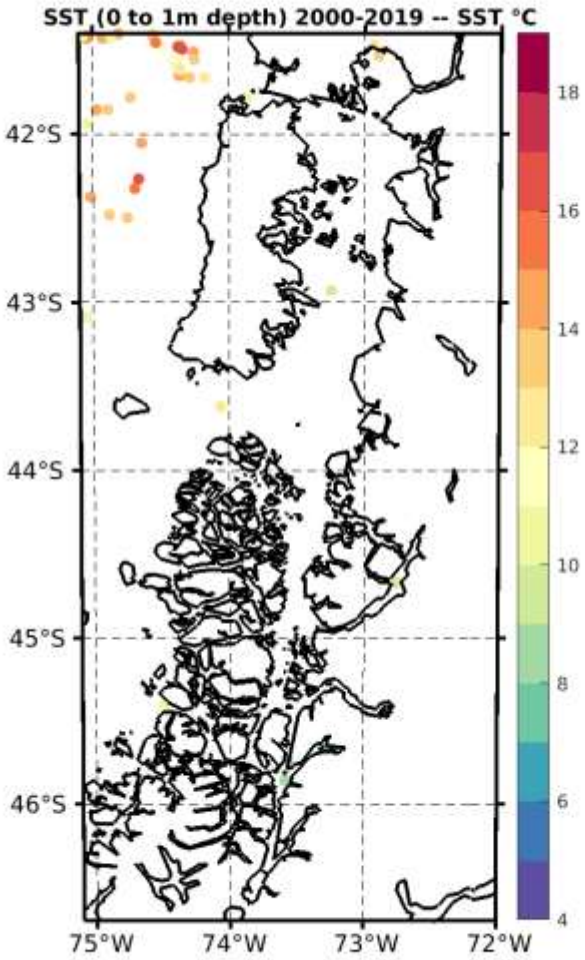
CMEMS Cora

Surface (0-1m)

> 1m depth

Data from 0 to 1m depth
Total = 3168 samplings
2315 different localisations
Samplings over 280 different days





Data from 1 to 9m depth
Total = 50 samplings
47 different localisations
Samplings over 44 different days

CMEMS Cora

Data from 0 to 1m depth
Total = 3168 samplings
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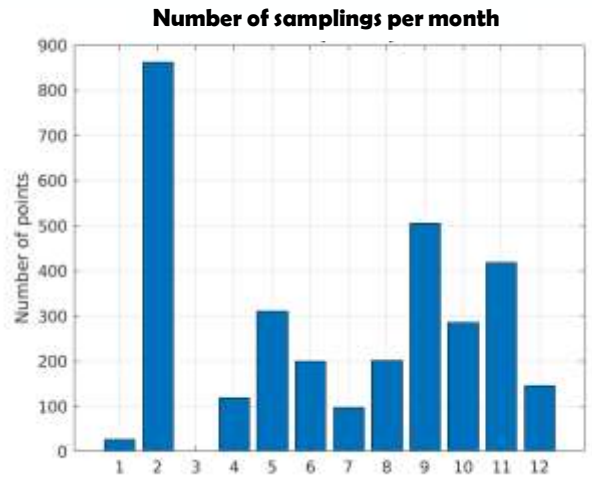
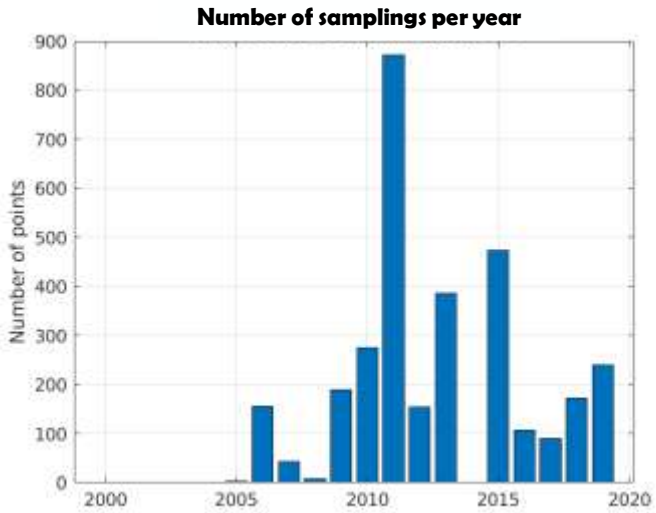
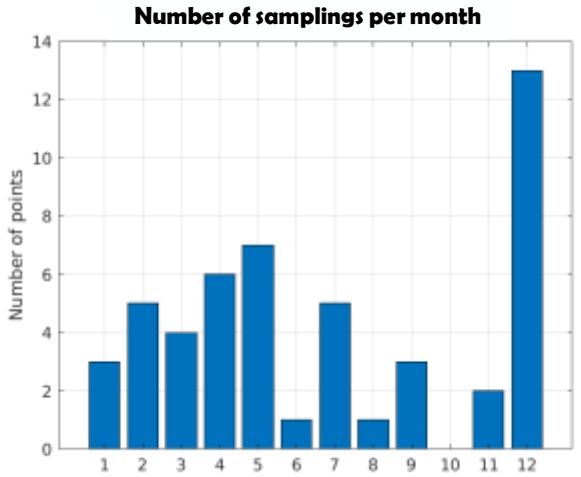
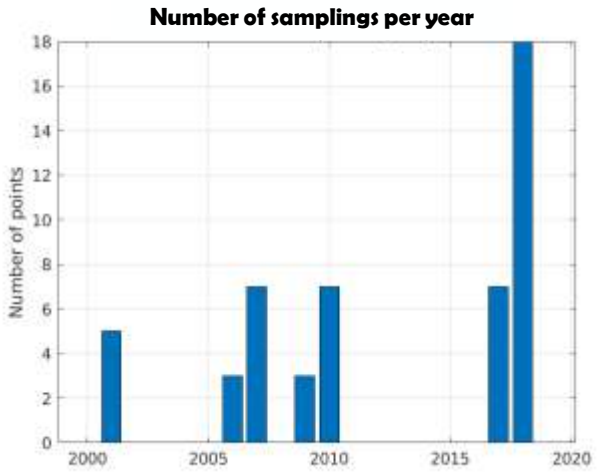
Surface (0-1m)





> 1m depth



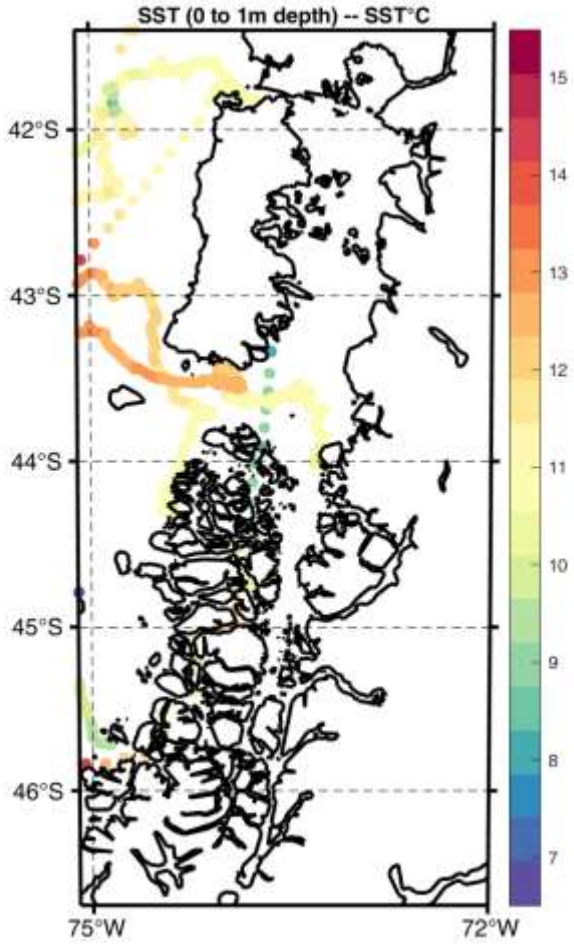


Data from 1 to 9m depth
Total = 50 samplings
47 different localisations
Samplings over 44 different days

EMODnet

Data from 0 to 1m depth
Total = 1347 samplings
950 different localisations
Samplings over 66 different days

Surface (0-1m)



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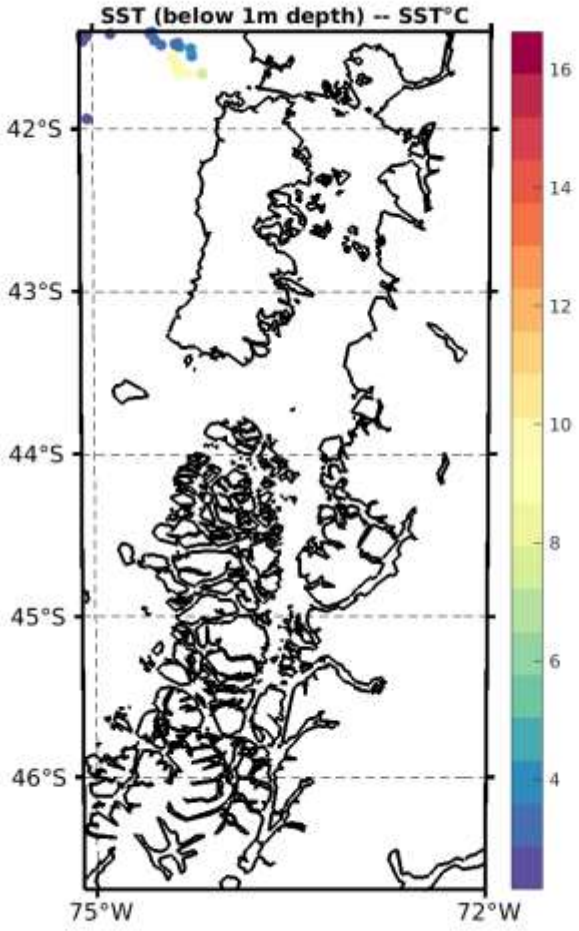
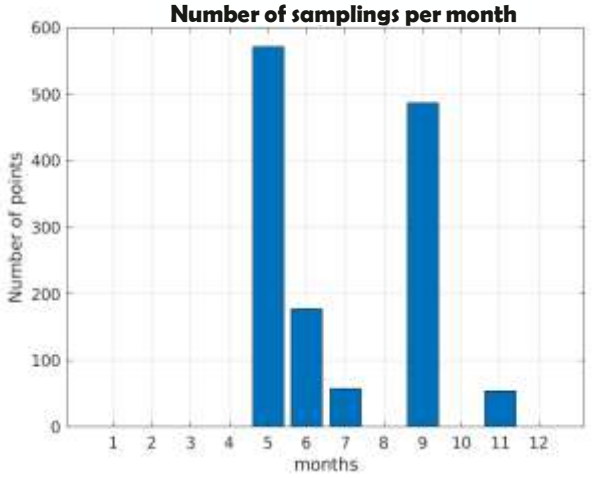


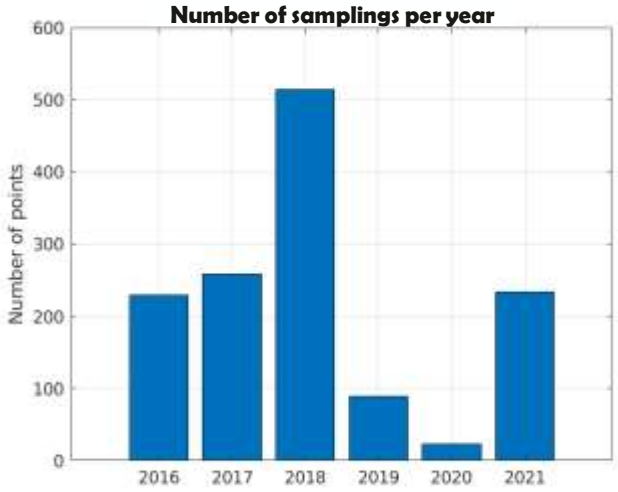
Data from 1 to 9m depth
Total = 8540 samplings
23 different localisations
Samplings over 23 different days

EMODnet

Data from 0 to 1m depth
Total = 1347 samplings
950 different localisations
Samplings over 66 different days

Surface (0-1m)





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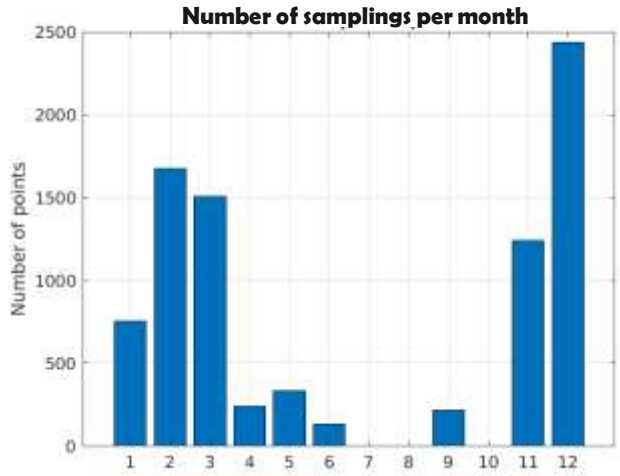
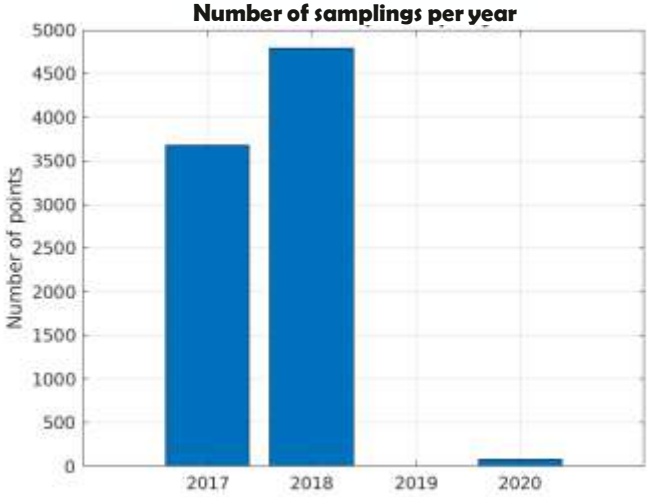


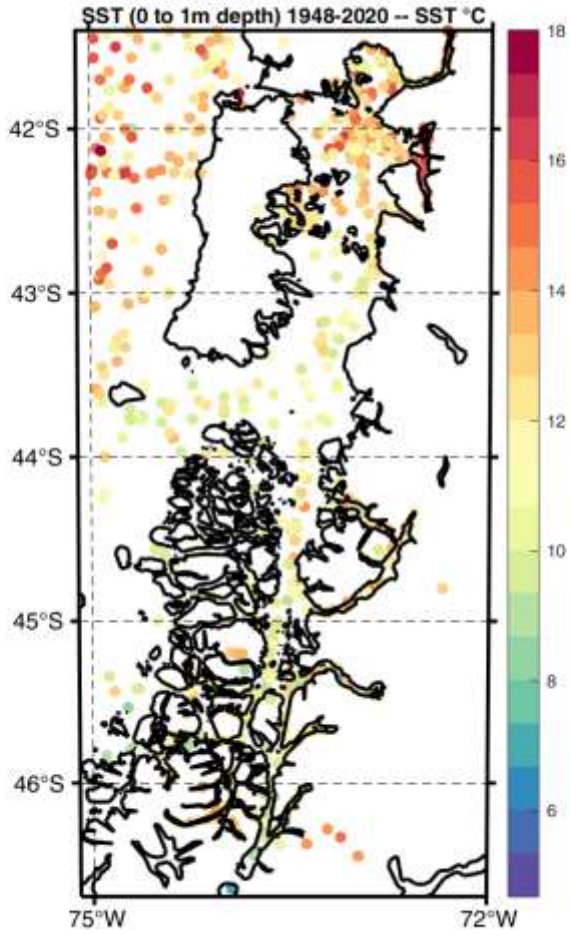


Data from 1 to 9m depth
Total = 8540 samplings
23 different localisations
Samplings over 23 different days

World Ocean Database

Data from 0 to 1m depth
Total = 669 samplings
461 different localisations
Samplings over 645 different days

Surface (0-1m)



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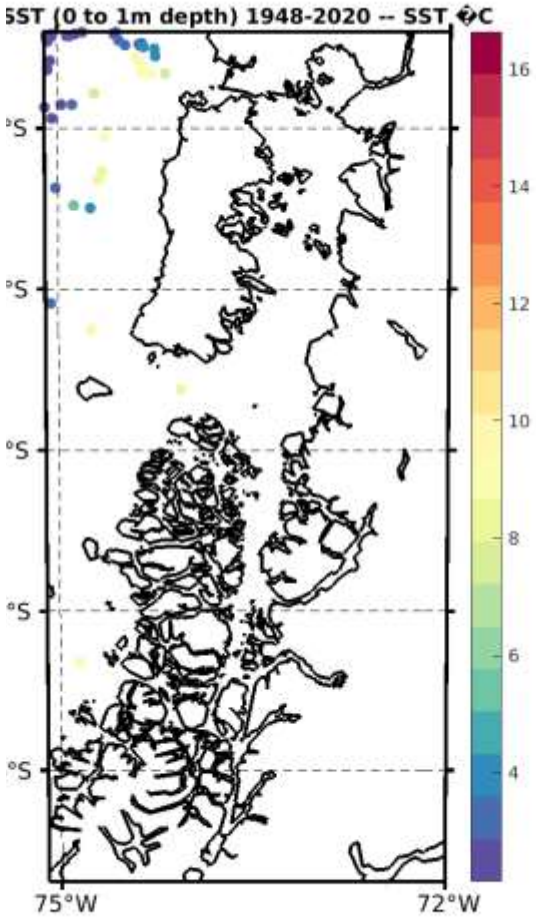
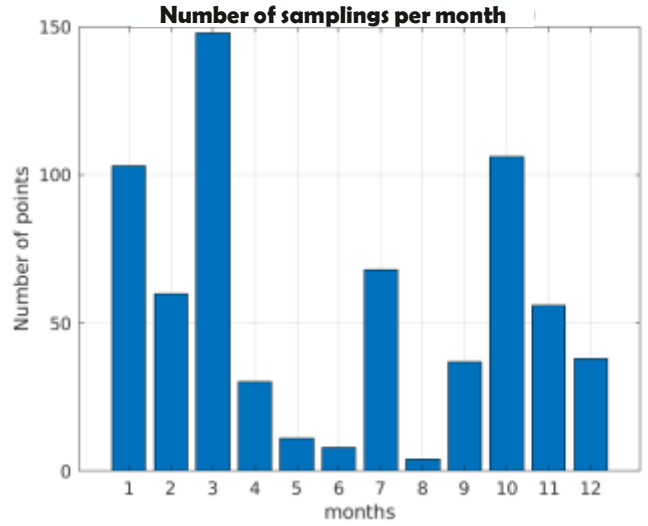


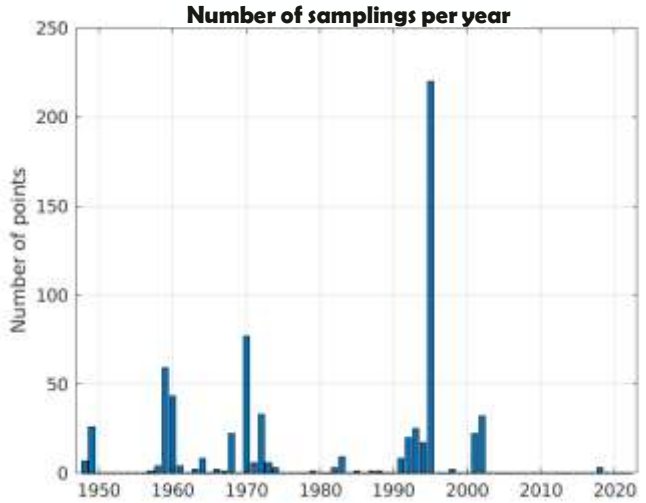
Data from 1 to 9m depth
Total = 12909 samplings
43 different localisations
Samplings over 44 different days

World Ocean Database

Data from 0 to 1m depth
Total = 669 samplings
461 different localisations
Samplings over 645 different days

Surface (0-1m)





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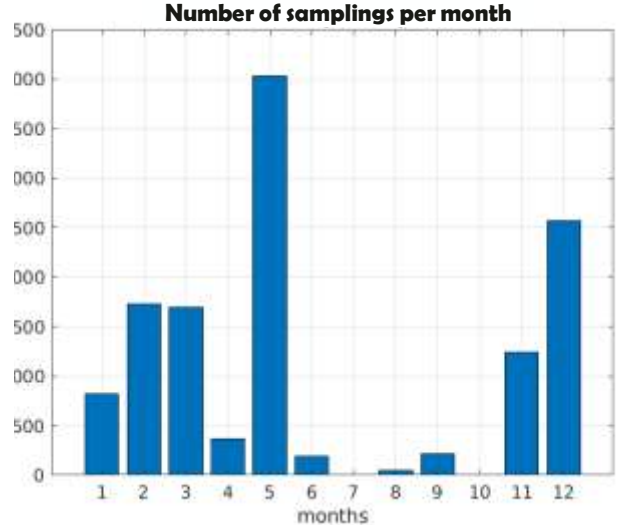
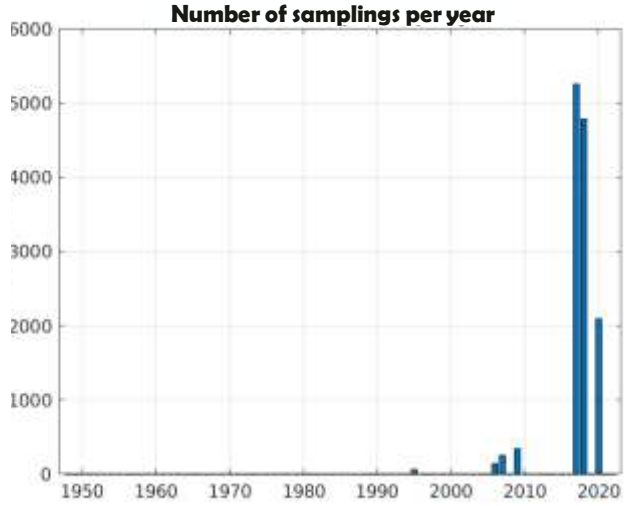


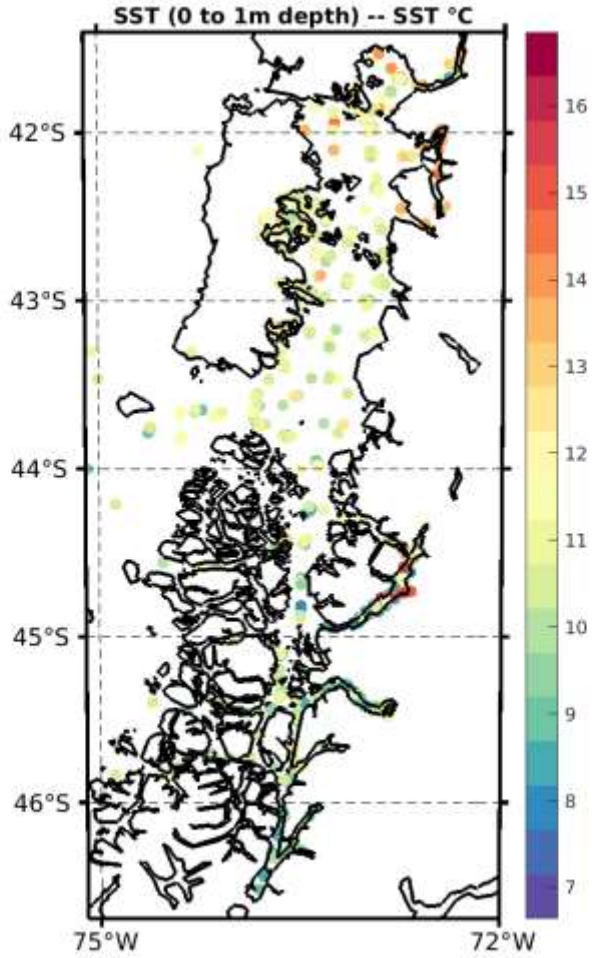


Data from 1 to 9m depth
Total = 12909 samplings
43 different localisations
Samplings over 44 different days

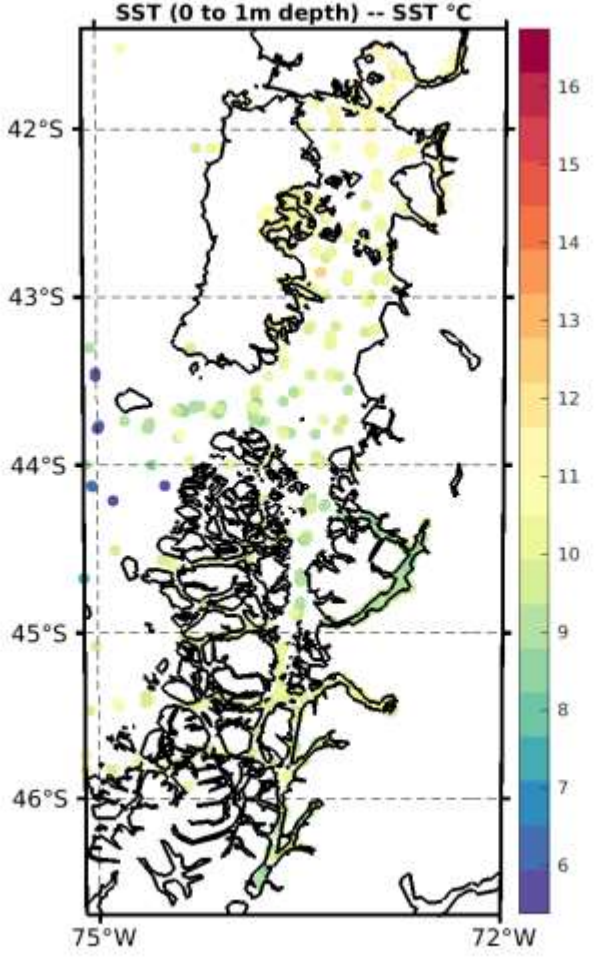
Ivan's

Data from 0 to 1m depth
Total = 1257 samplings
841 different localisations
Samplings over 158 different days

Surface (0-1m)



> 1m depth

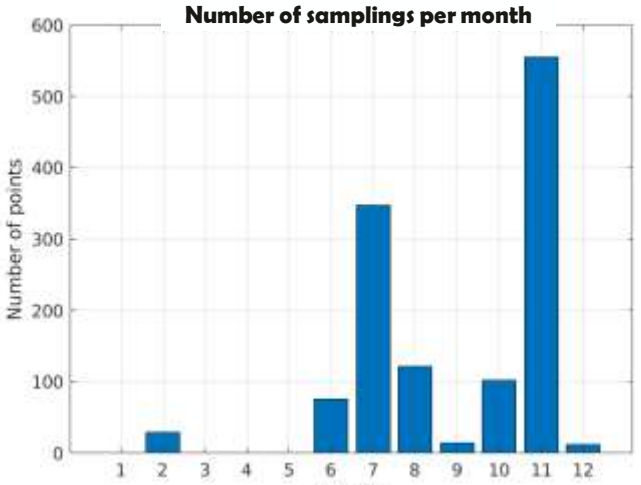


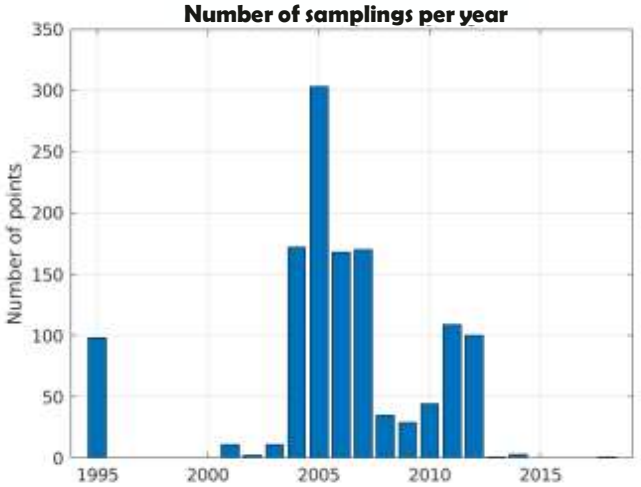
Data from 1 to 400m depth
Total = 297128 samplings
1167 different localisations
Samplings over 283 different days

Ivan's

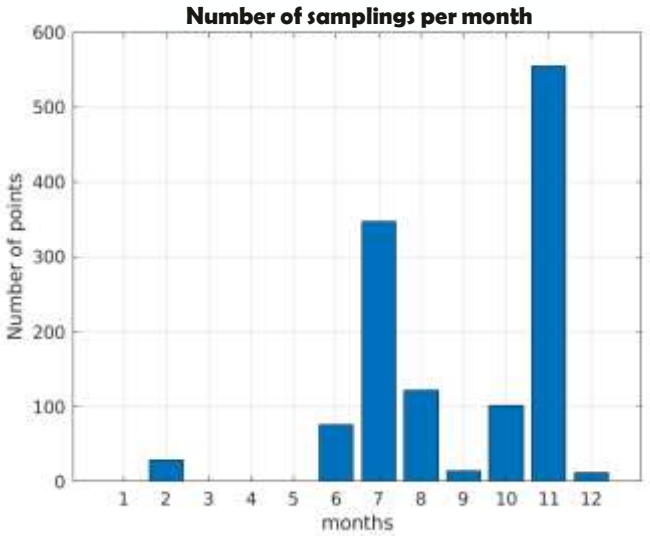
Data from 0 to 1m depth
Total = 1257 samplings
841 different localisations
Samplings over 158 different days

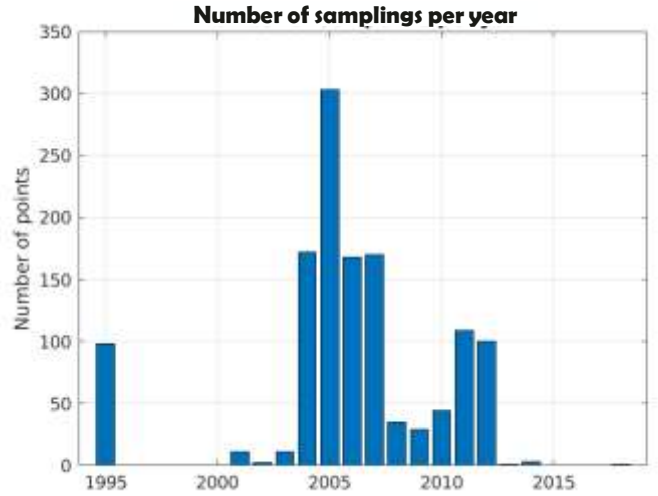
Surface (0-1m)





> 1m depth



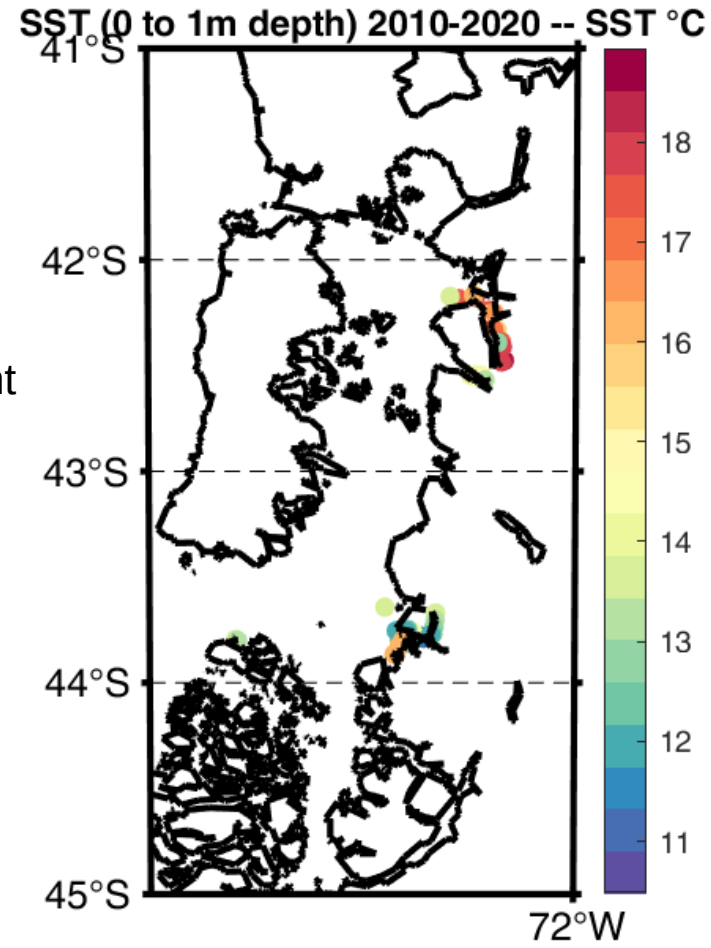


Data from 1 to 400m depth
Total = 297128 samplings
1167 different localisations
Samplings over 283 different days

Pangaea

Data from 0 to 1m depth
Total = 10196 samplings
82 different localisations
Samplings over 40 different days

Surface (0-1m)



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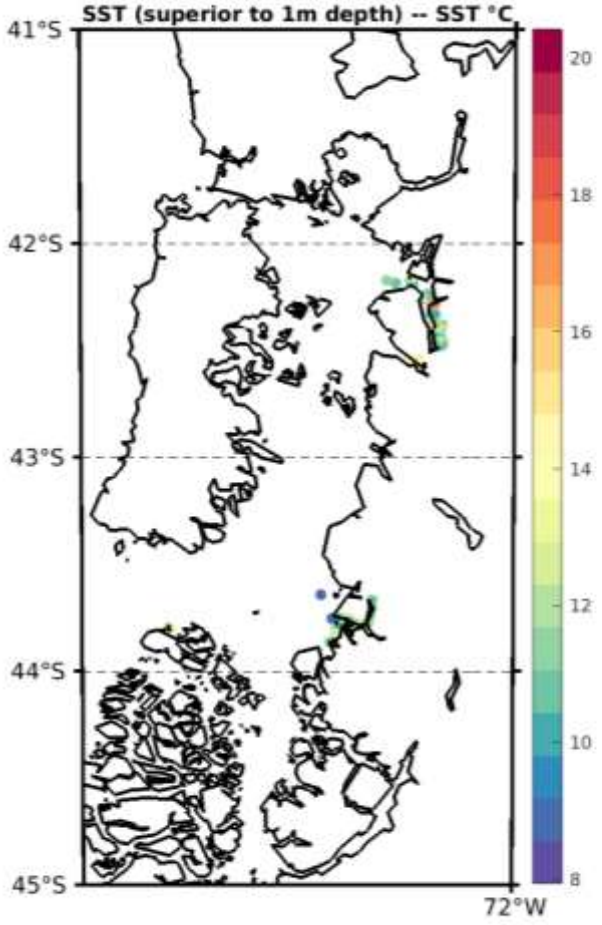
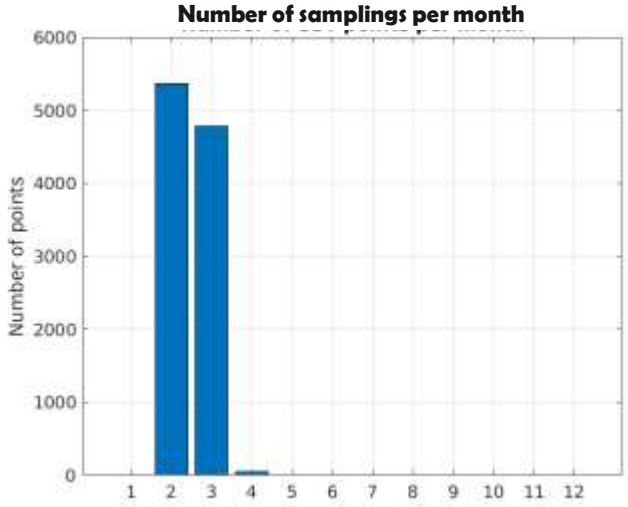


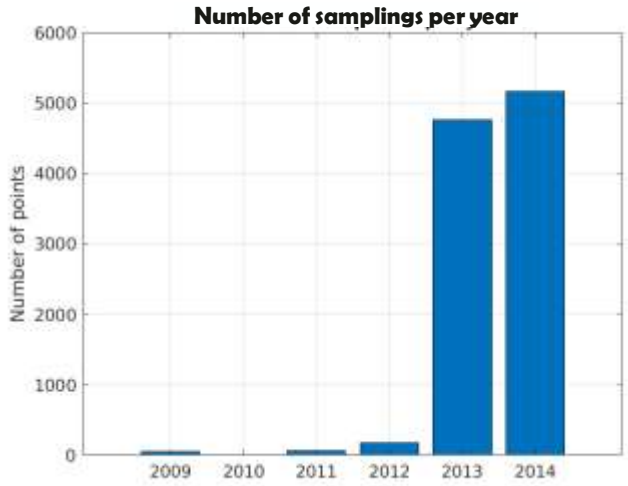
Data from 1 to 422m depth
Total = 2843398 samplings
96 different localisations
Samplings over 2777 different days

Pangaea

Data from 0 to 1m depth
Total = 10196 samplings
82 different localisations
Samplings over 40 different days

Surface (0-1m)





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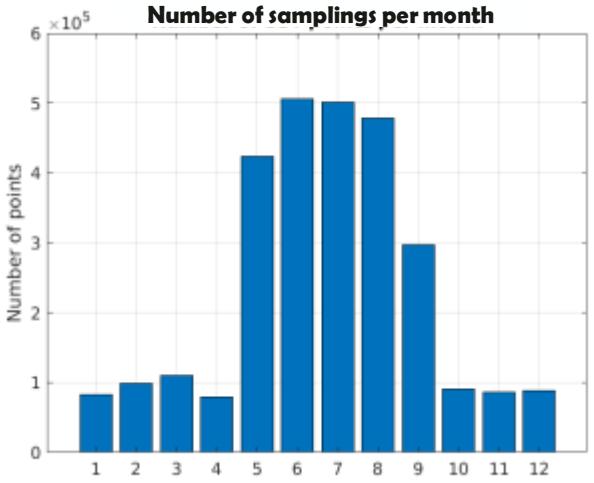
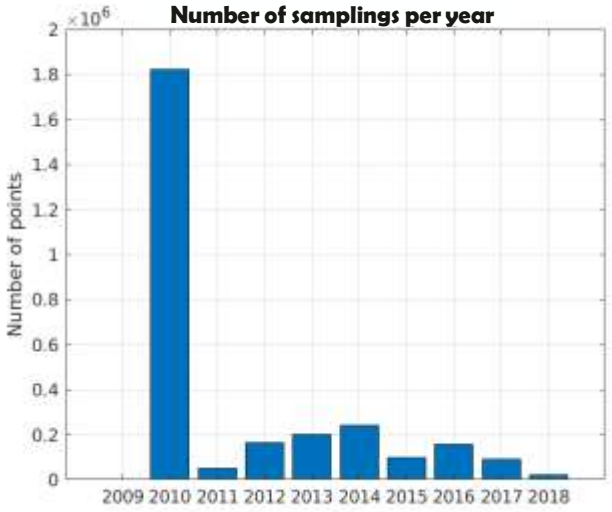




Data from 1 to 422m depth
Total = 2843398 samplings
96 different localisations
Samplings over 2777 different days

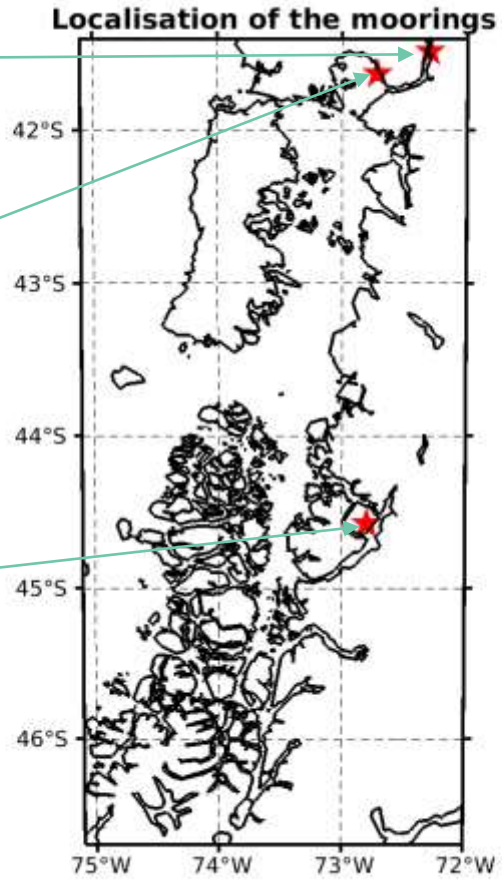
CDOM (moorings)

Surface (0-1m)

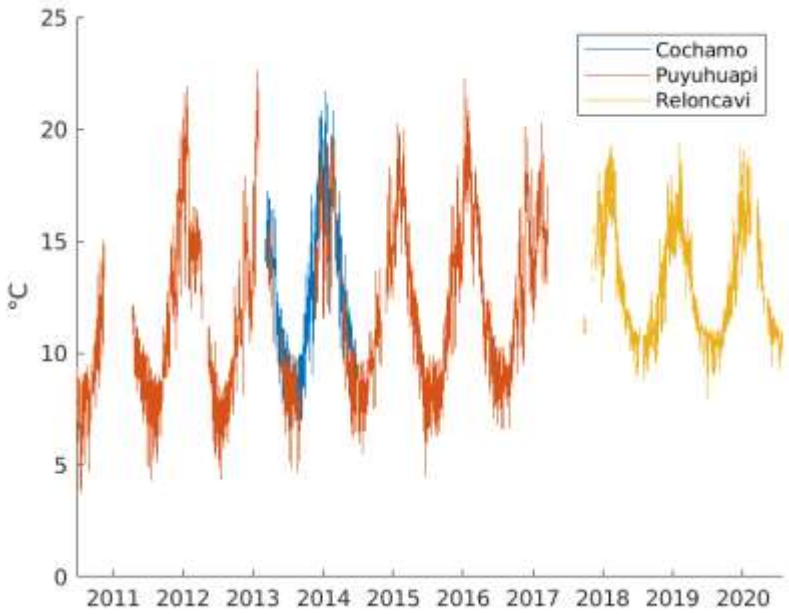
Cochamo
(10541 samplings)

Reloncavi
(19983 samplings)

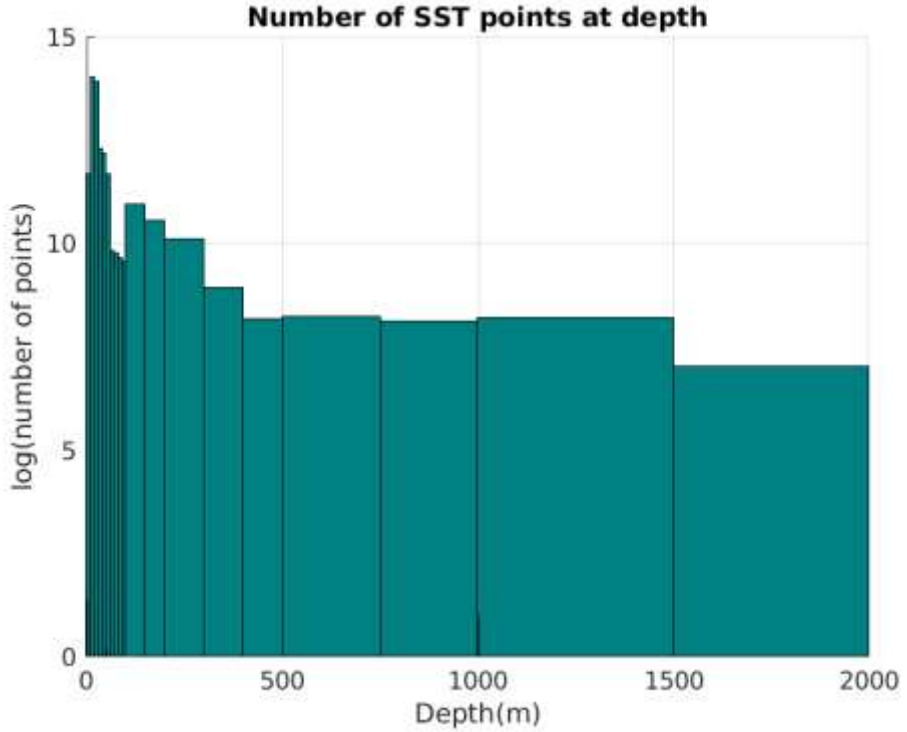
Puyuhuapi
(48838 samplings)

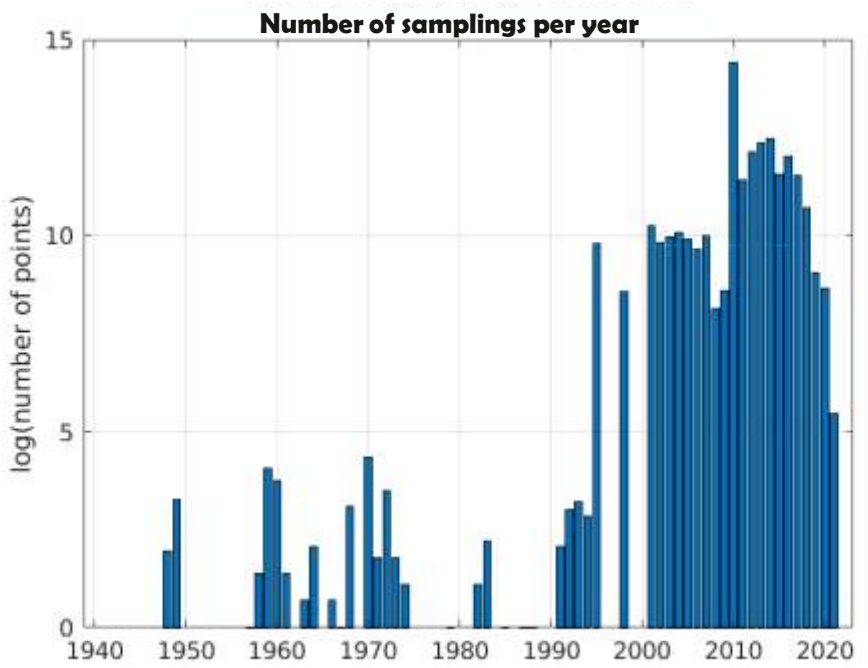


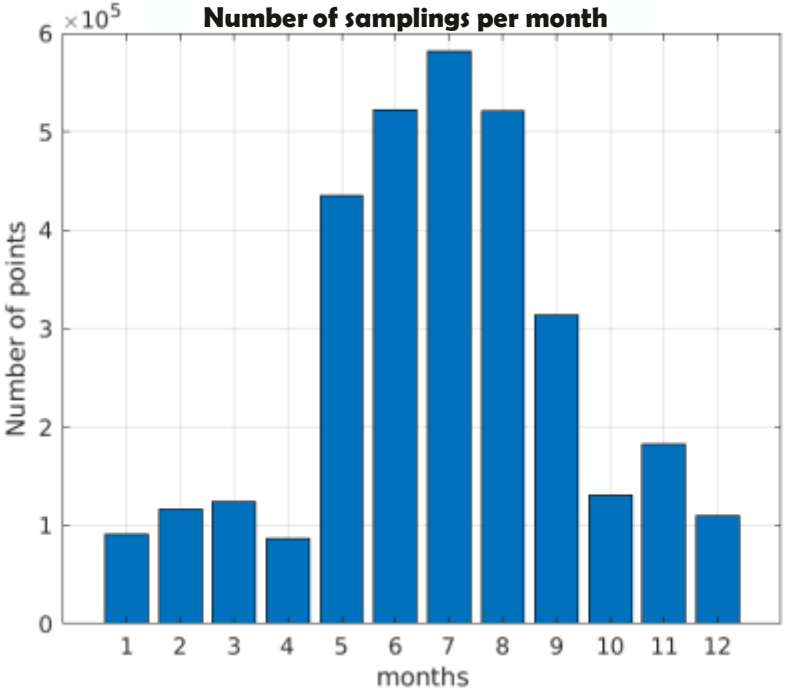
SST



Total in situ data







Total :
3 216 605 samplings
4187 different localisations
Samplings over 4070 different days

Inside the Sea of Chiloé :
3 161 656 samplings
2339 different localisations
Samplings over 3887 different days

Build the climatology

Reconstruction of the surface temperature

DIVA

Uses scattered in situ points to generate a continuous field

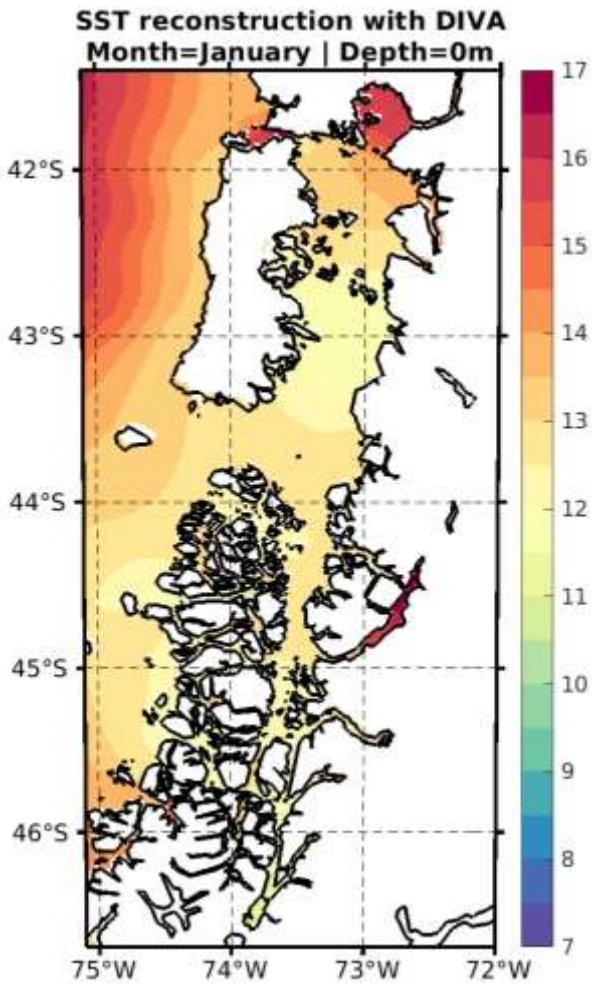
Monthly climatology

Horizontal resolution: 0,02° (~2km)

Horizontal correlation length: 50km
Vertical correlation length : 50m

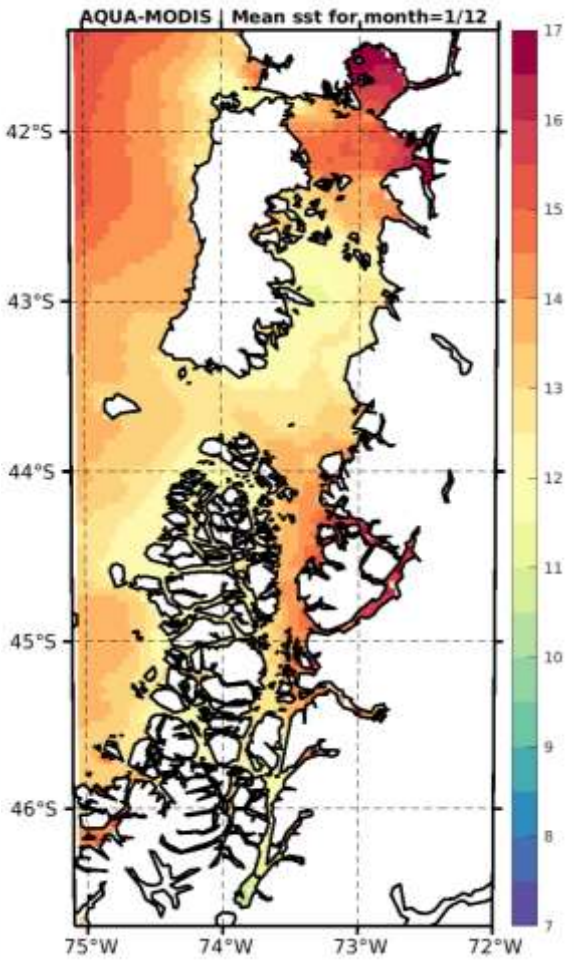
Lower weight attributed to data clusters

DIVA reconstruction



Satellite data

L4 level (MODIS Aqua)
Monthly averaged SST (resolution 4km) over the last 20 years

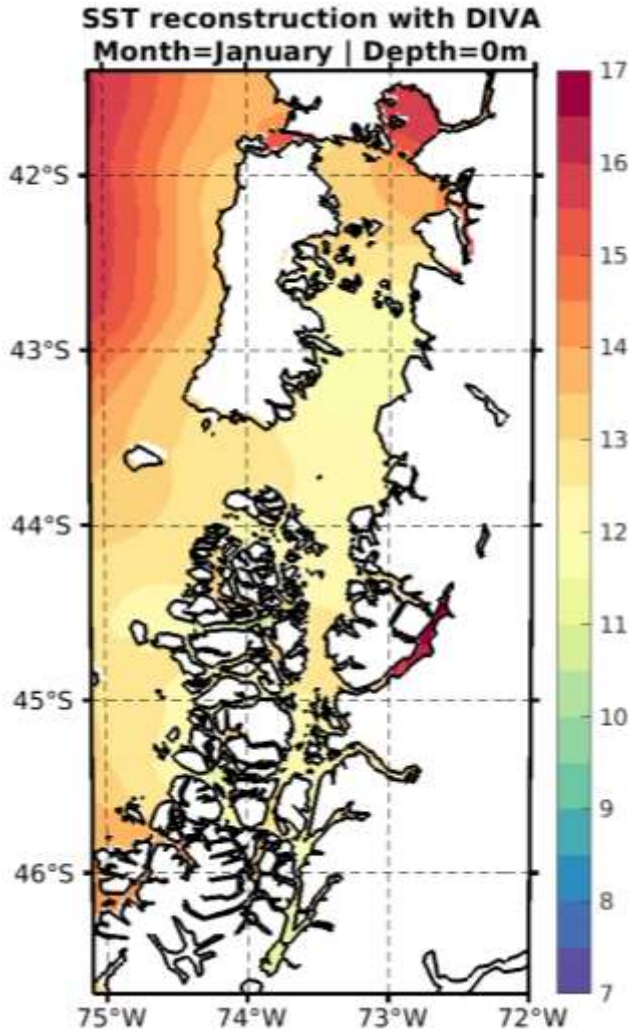


Reconstruction of the subsurface temperature

DIVA

Uses scattered in situ points to generate a continuous field

Monthly climatology



Horizontal resolution: 0,02° (~2km)

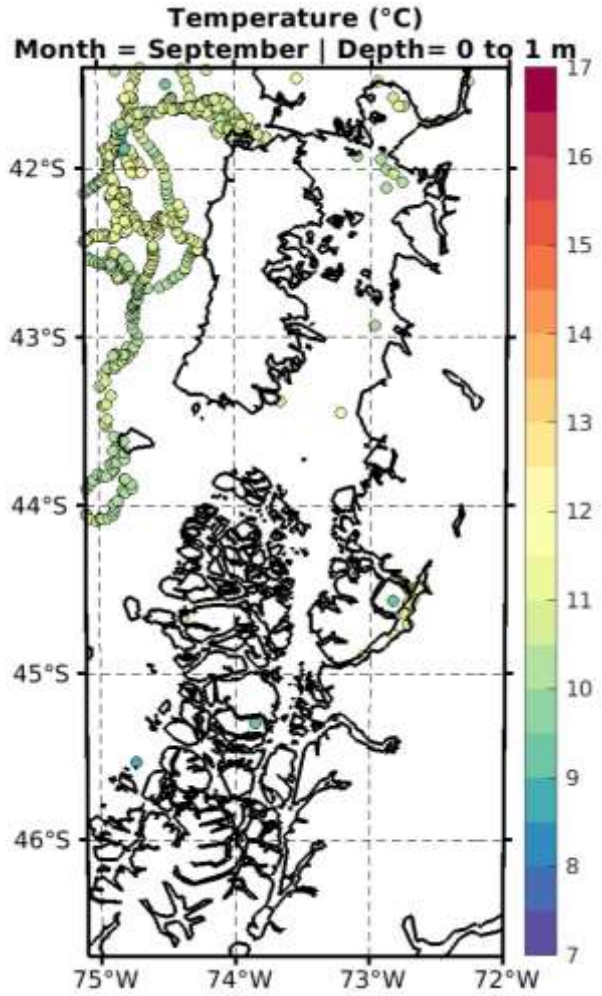
Horizontal correlation length: 50km
Vertical correlation length : 50m

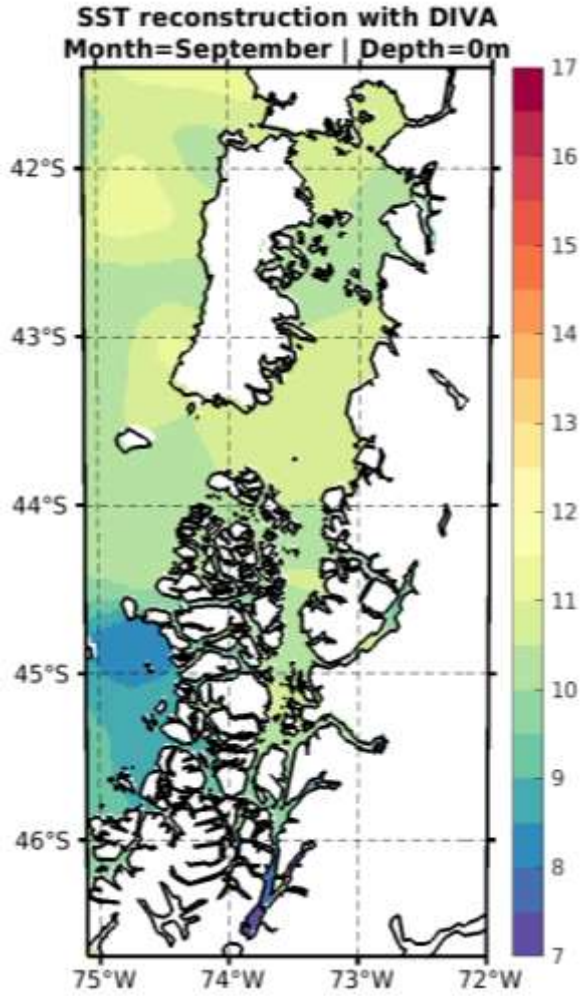
Lower weight attributed to data clusters

Reconstruction of the temperature

Problem:

Lack of data during certain months imply less good reconstruction





Ongoing work…

Find more in situ data to improve the climatology

Use model output to corroborate the climatology

Detect the MHWs in the Sea of Chiloé

Connection between MHWs observed offshore Chile and in the Sea of Chiloé ?

Impacts of MHWs on ocean properties