

Marine heatwaves in coastal environment: detection in Patagonian Fjords

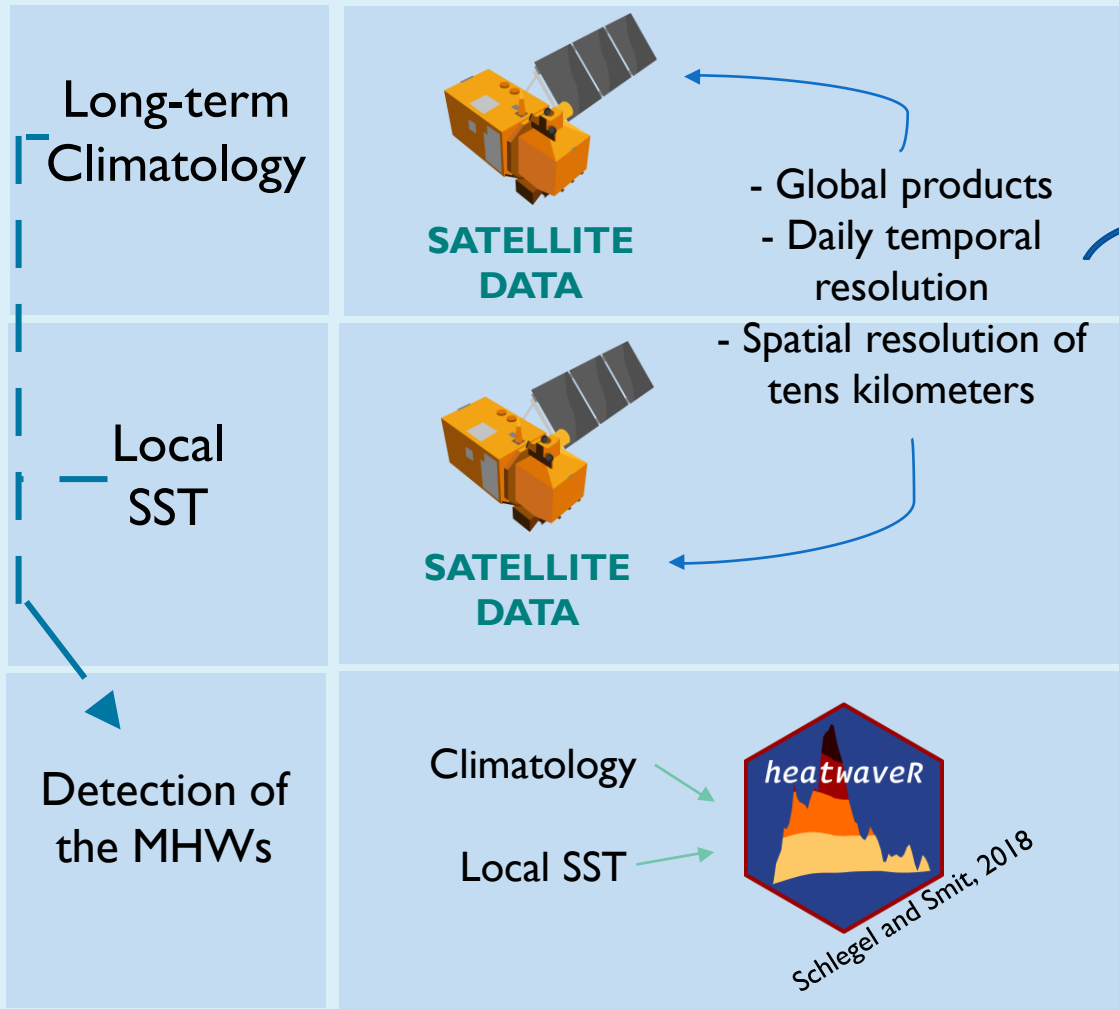
Case study of the semi-enclosed inner seas of North Chilean Patagonia

**CÉCILE PUJOL, IVÁN PÉREZ SANTOS, PAMELA LINFORD,
ALEXANDER BARTH, AIDA ALVERA AZCÁRATE**

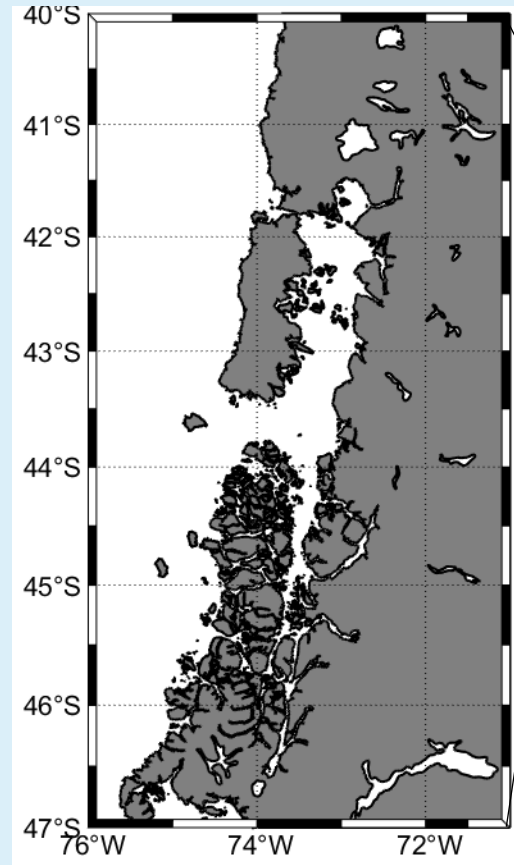
MHW TRADITIONAL DETECTION

In an open ocean-like environment

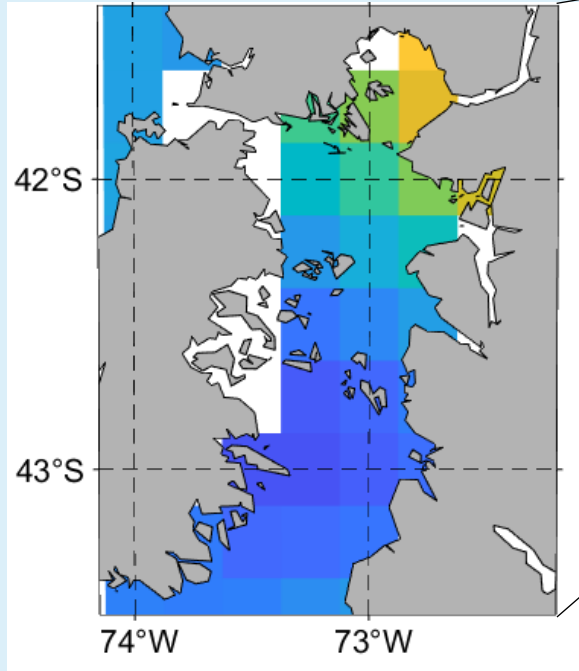
In a fjord-like environment



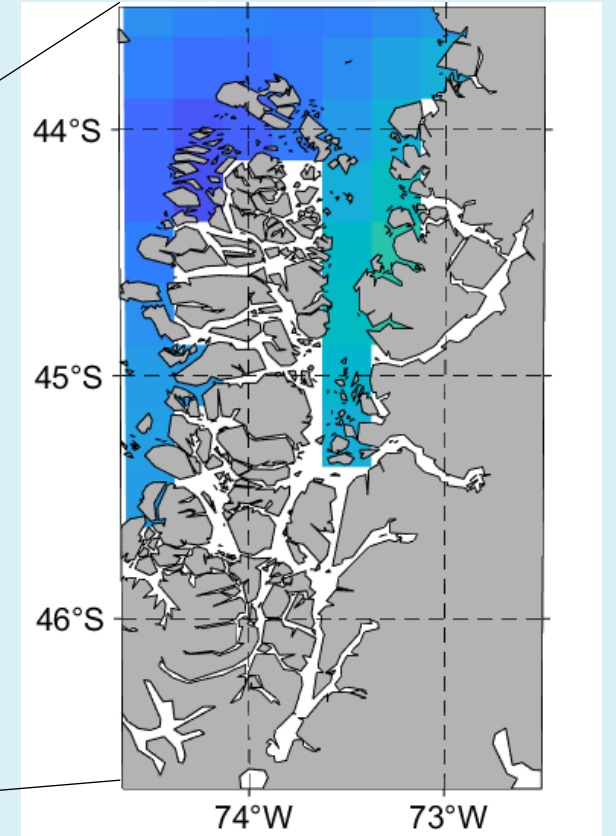
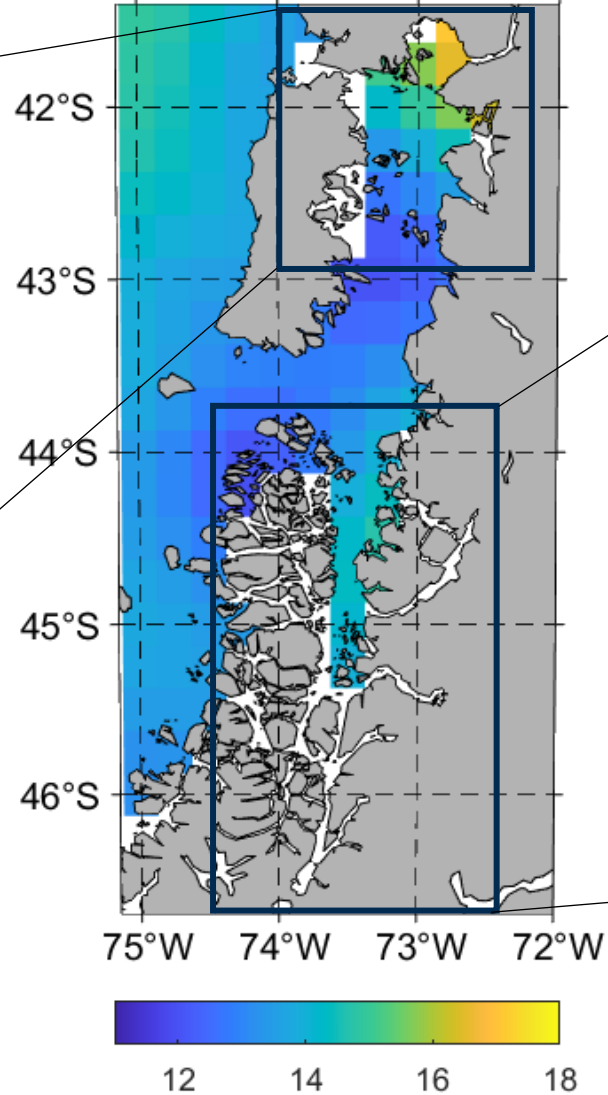
Chiloe Inner Sea



OISST PRODUCT



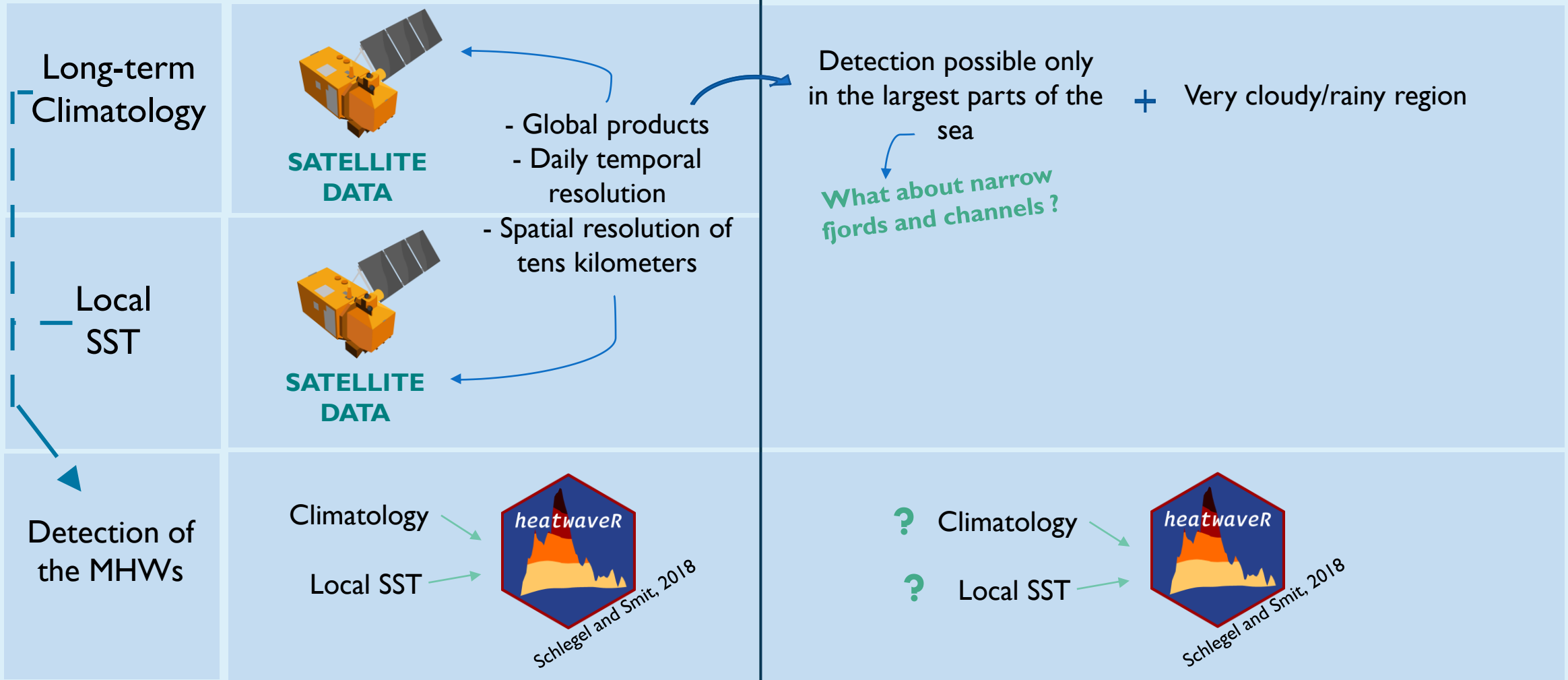
Temperature (OISST) 06-Jan-2022



MHW DETECTION IN FJORD ENVIRONMENT

In an open ocean-like environment

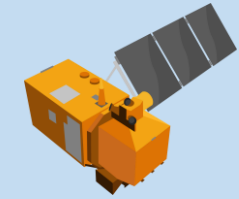
In a fjord-like environment



MHW DETECTION IN FJORD ENVIRONMENT

In an open ocean-like environment

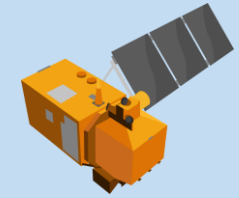
Long-term Climatology



SATELLITE DATA

- Global products
- Daily temporal resolution

Local SST



SATELLITE DATA

- Spatial resolution of tens kilometers

Detection of the MHWs

Climatology

Local SST



Schlegel and Smit, 2018

In a fjord-like environment

How to build the climatology ?

Which dataset to use for local SST ?

? Climatology

? Local SST

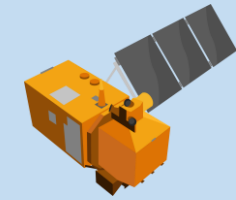


Schlegel and Smit, 2018

MHW DETECTION IN FJORD ENVIRONMENT

In an open ocean-like environment

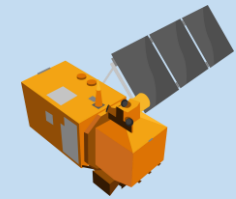
Long-term
Climatology



SATELLITE
DATA

- Global products
- Daily temporal resolution

Local
SST



SATELLITE
DATA

- Spatial resolution of tens kilometers

Detection of
the MHWs

Climatology

Local SST



Schlegel and Smit, 2018

In a fjord-like environment

How to build the
climatology ?

High resolution
satellite ?

Not sufficient
temporal resolution

High resolution satellite product

? Climatology

? Local SST

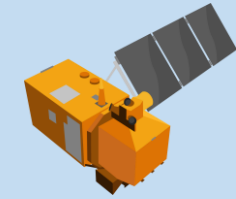


Schlegel and Smit, 2018

MHW DETECTION IN FJORD ENVIRONMENT

In an open ocean-like environment

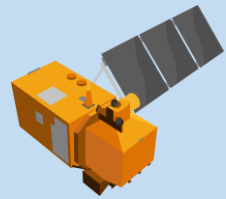
Long-term
Climatology



SATELLITE
DATA

- Global products
- Daily temporal resolution

Local
SST



SATELLITE
DATA

- Spatial resolution of tens kilometers

Detection of
the MHWs

Climatology

Local SST



Schlegel and Smit, 2018

In a fjord-like environment

What if the
area has
been sampled
a lot ?



High resolution satellite product



Climatology



Local SST

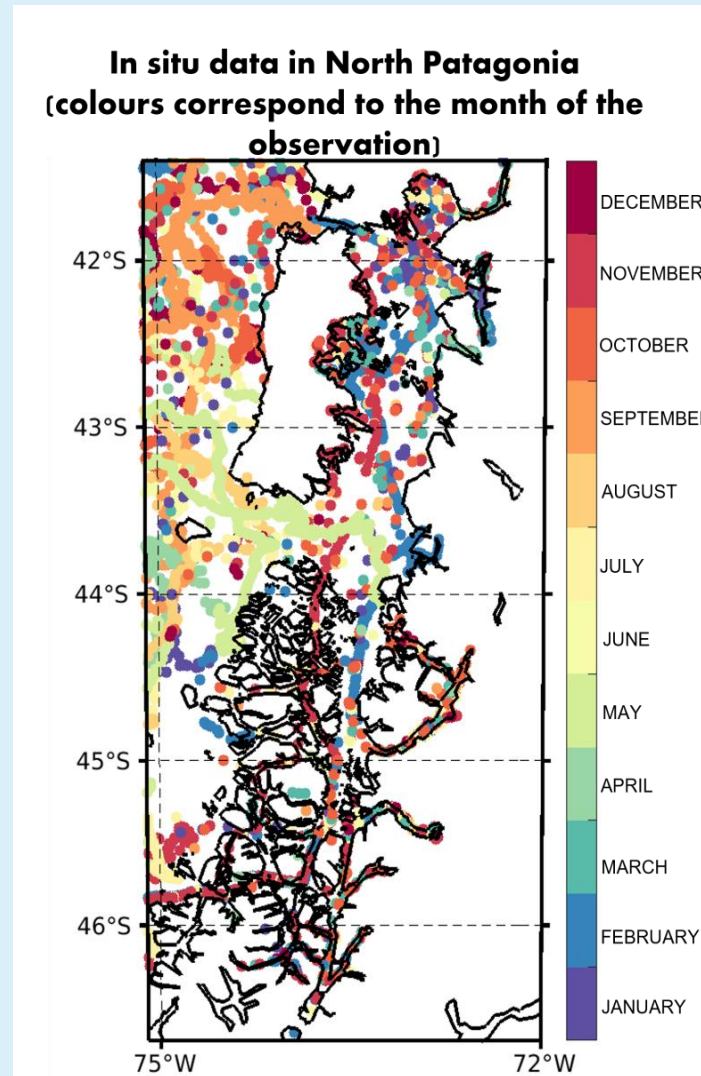


Schlegel and Smit, 2018

IN SITU DATA AVAILABLE

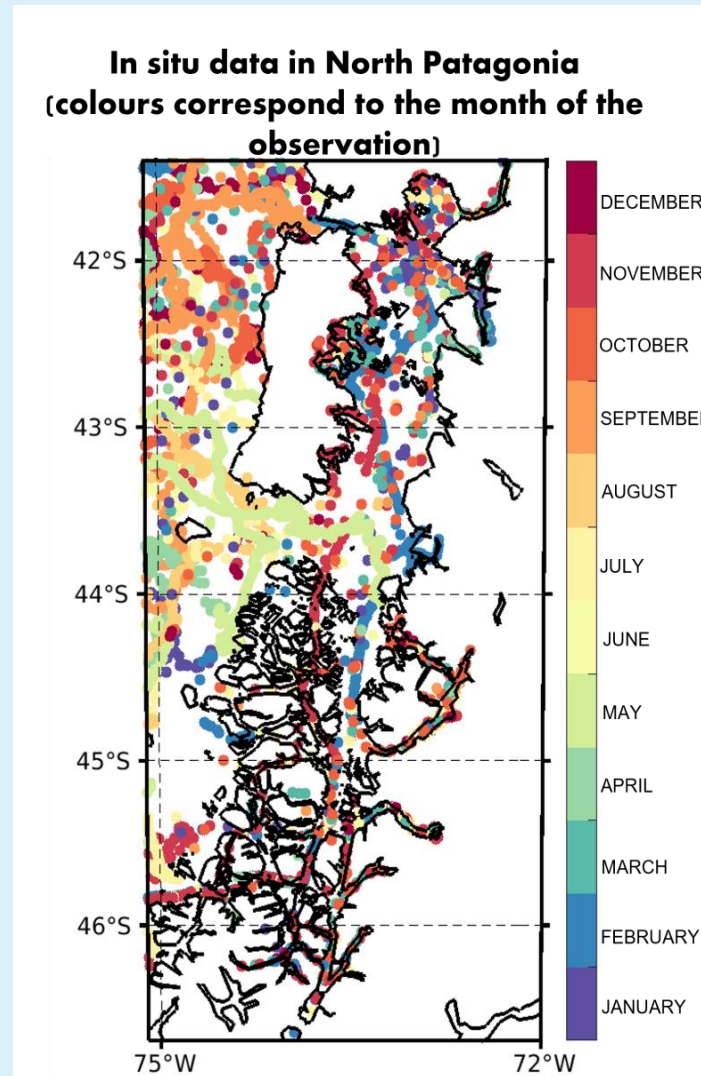
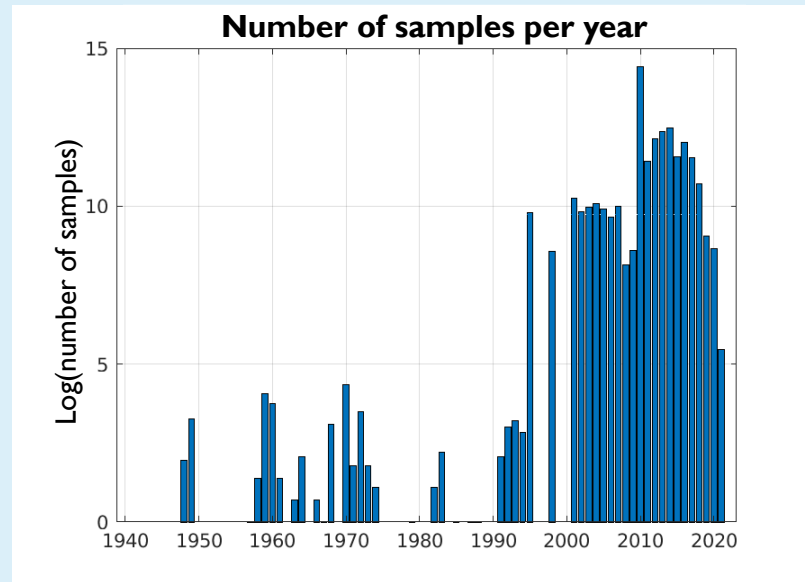
Providers/Campaigns :

- CIMAR Cruise
- IFOP monitoring system
- i~mar institute campaigns
- Fondecyt
- Huinay Foundation



Total number of samples
~ 3 millions

IN SITU DATA AVAILABLE



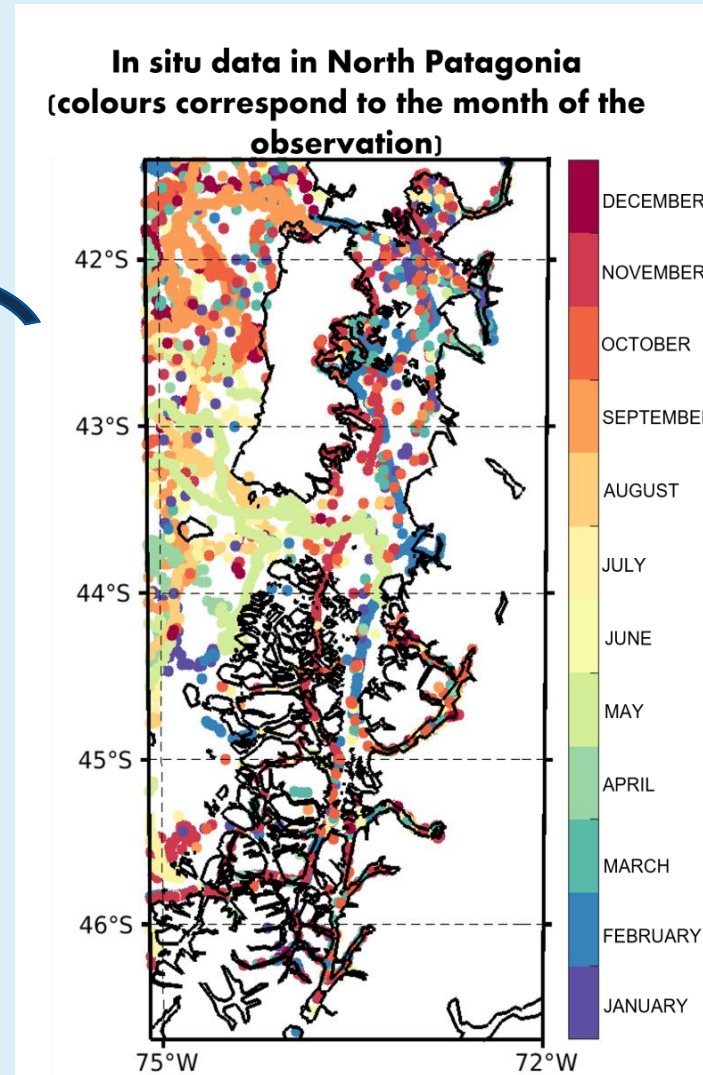
Total number of samples
~ 3 millions

IN SITU DATA AVAILABLE

Climatology from in situ data

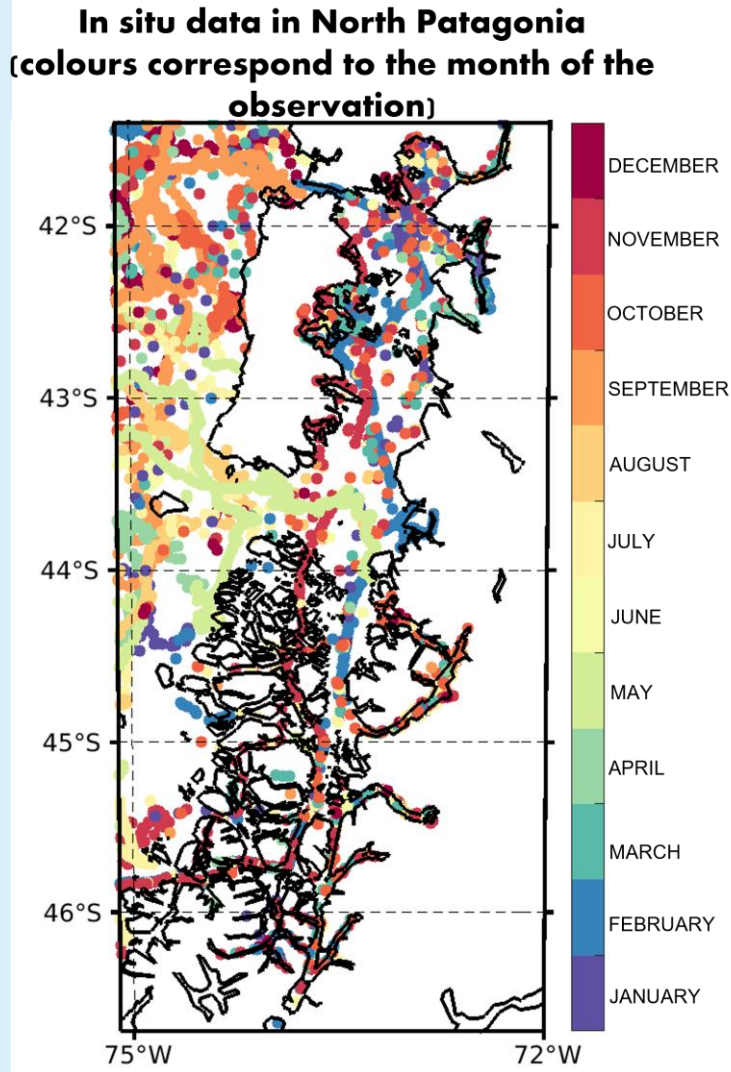


Interpolate the data



Total number of samples
~ 3 millions

INTERPOLATION OF THE IN SITU DATA



Data-Interpolating Variational Analysis

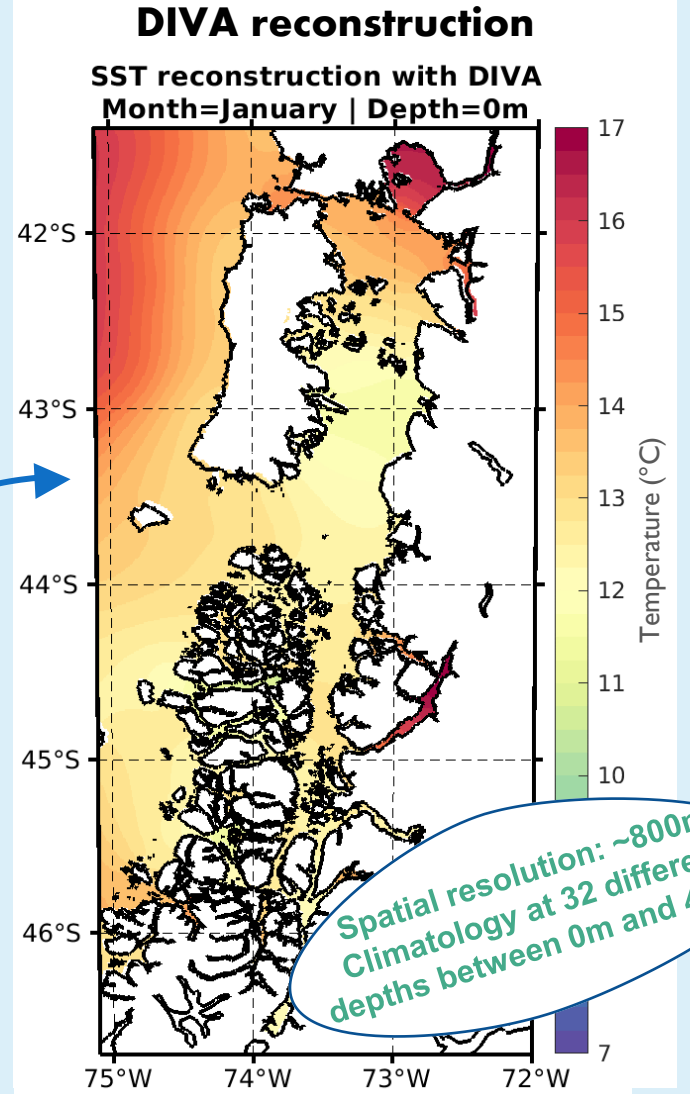
(Troupin et al., 2014)

DIVA

Uses scattered in situ points to generate a continuous field

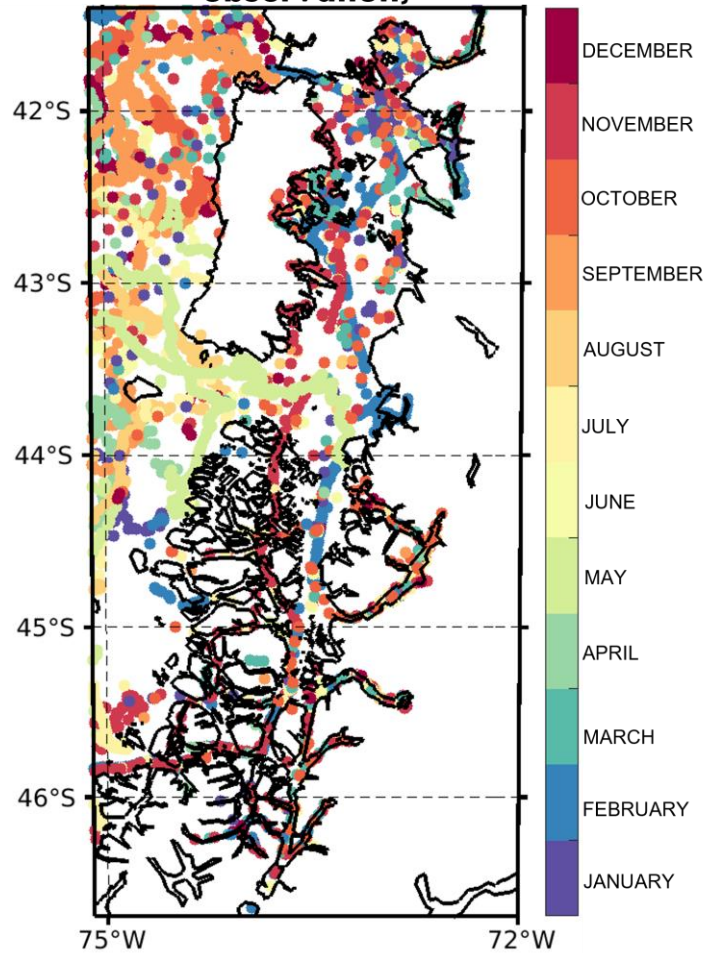
4D Monthly climatology

Horizontal correlation length: 50km
Lower weight attributed to data clusters



INTERPOLATION OF THE IN SITU DATA

In situ data in North Patagonia
(colours correspond to the month of the observation)



Data-Interpolating Variational Analysis

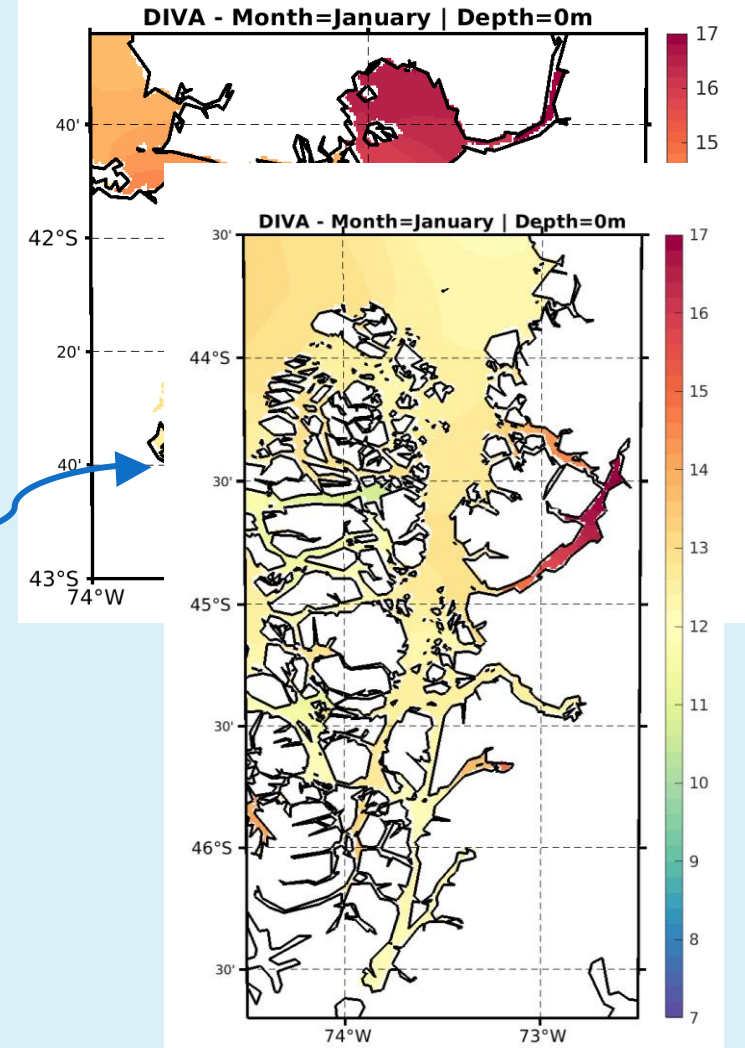
(Troupin et al., 2014)

DIVA

Uses scattered in situ points to generate a continuous field

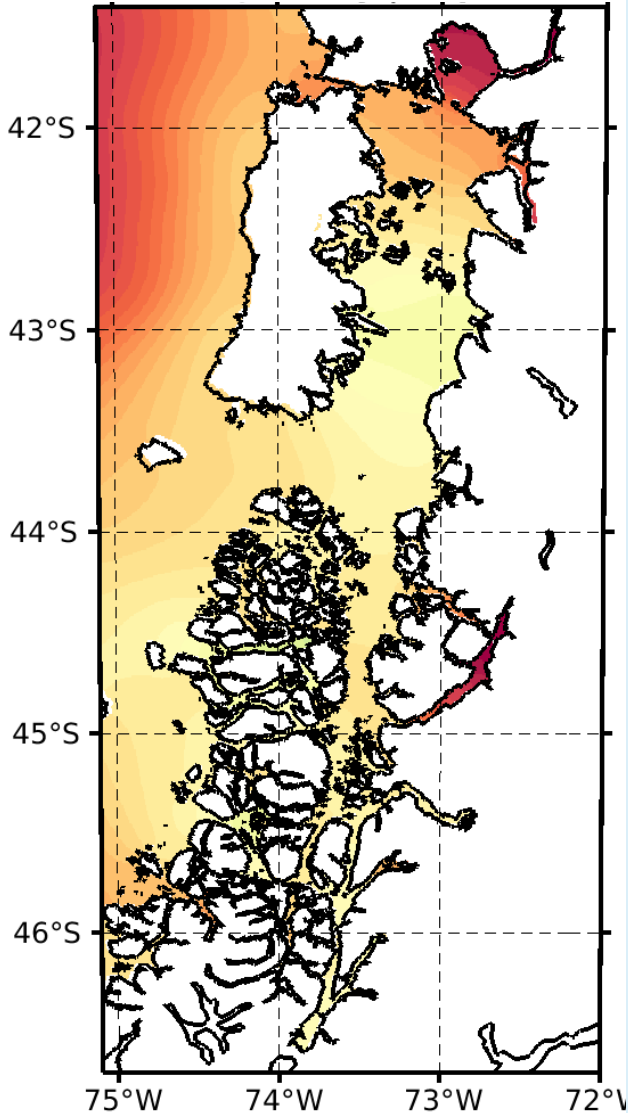
4D Monthly climatology

Horizontal correlation length: 50km
Lower weight attributed to data clusters



VALIDATION OF THE CLIMATOLOGY

DIVA reconstruction
Climatology | Month=1.

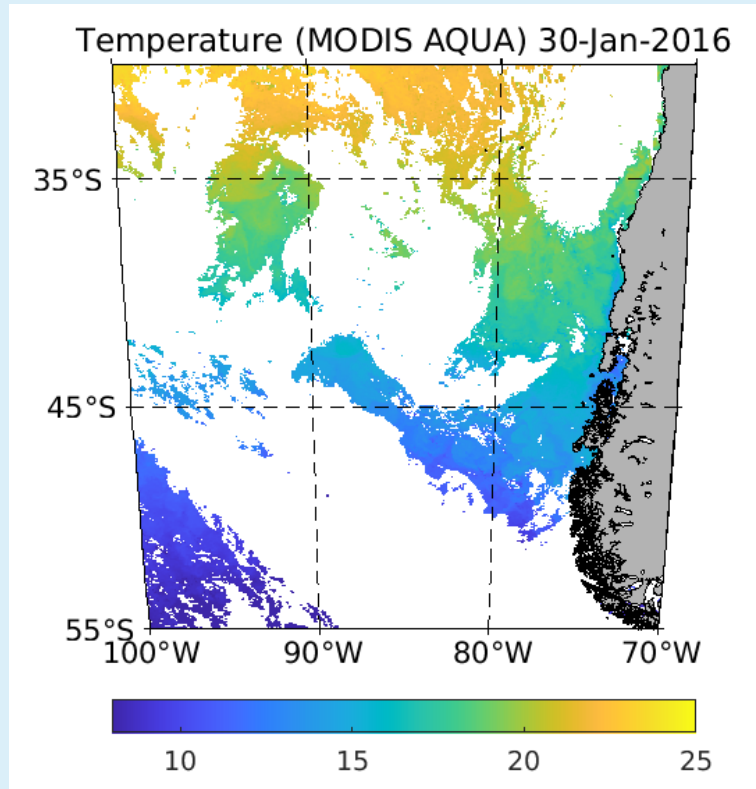
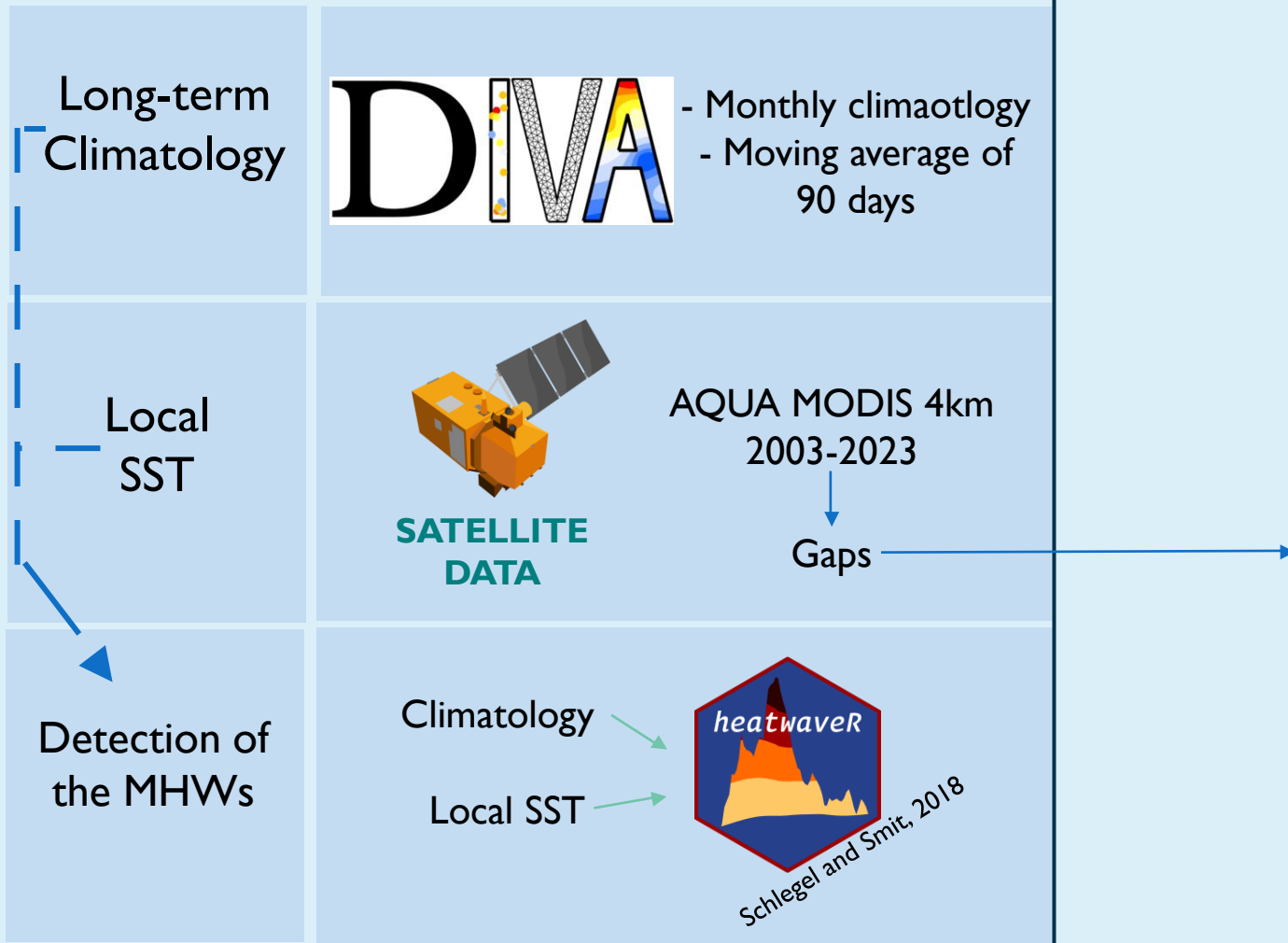


5% of the in situ data kept apart for validation

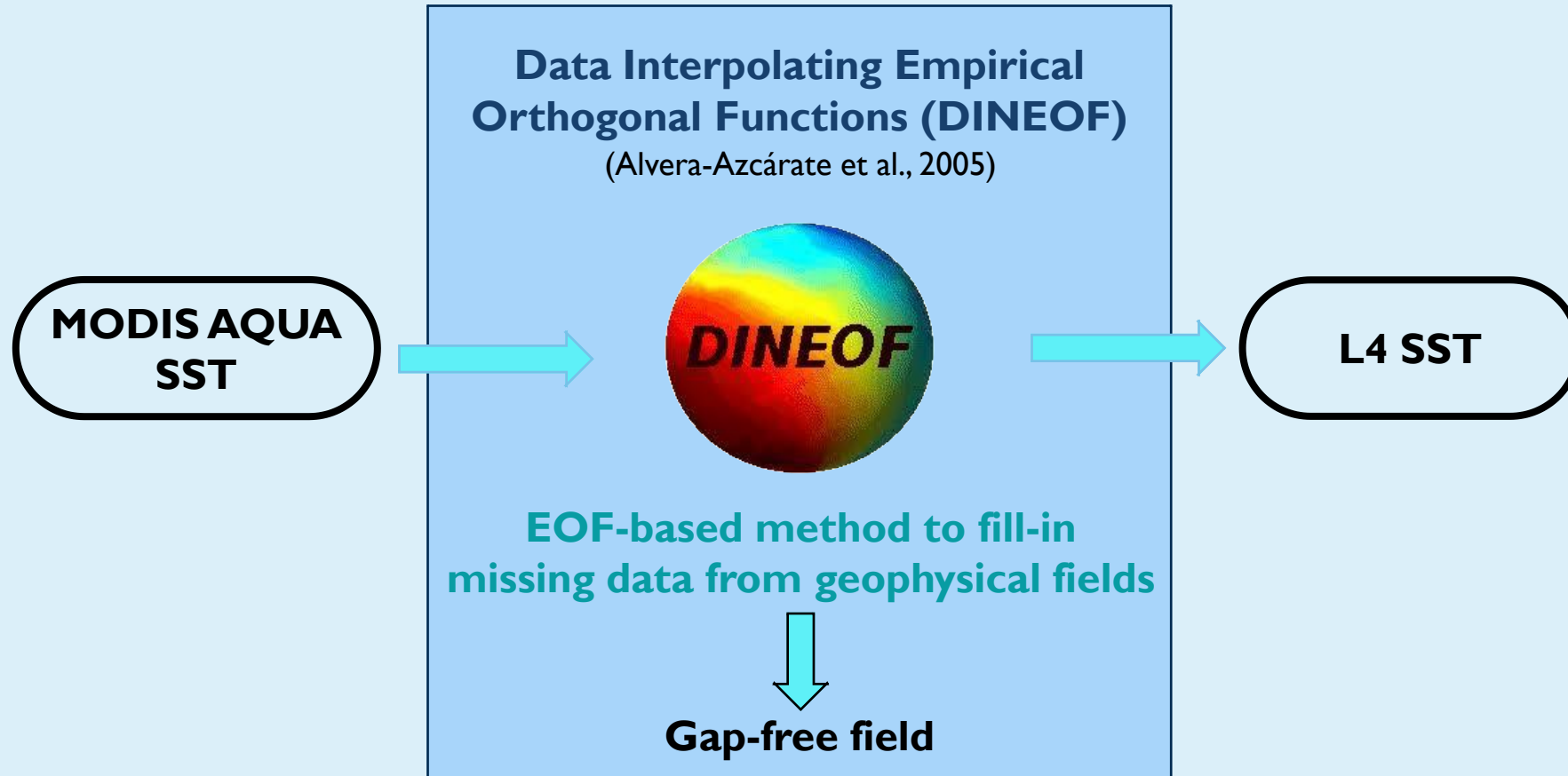
	Bias between DIVA and in situ (°C)	rms	crms	Standard deviation in situ data
Jan	0,21	1,85	1,83	1,97
Feb	0,04	1,43	1,43	2,05
Mar	0,11	1,14	1,14	1,68
Apr	-0,07	1,01	1,00	0,83
May	-0,08	0,78	0,78	0,77
Jun	-0,08	0,71	0,70	0,46
Jul	0,06	0,87	0,87	0,59
Aug	-0,14	0,71	0,69	0,58
Sep	0,01	0,73	0,73	0,51
Oct	0,20	0,95	0,93	0,82
Nov	0,09	1,23	1,23	1,23
Dec	0,10	1,42	1,42	2,18

FILLING GAPS IN SATELLITE DATA

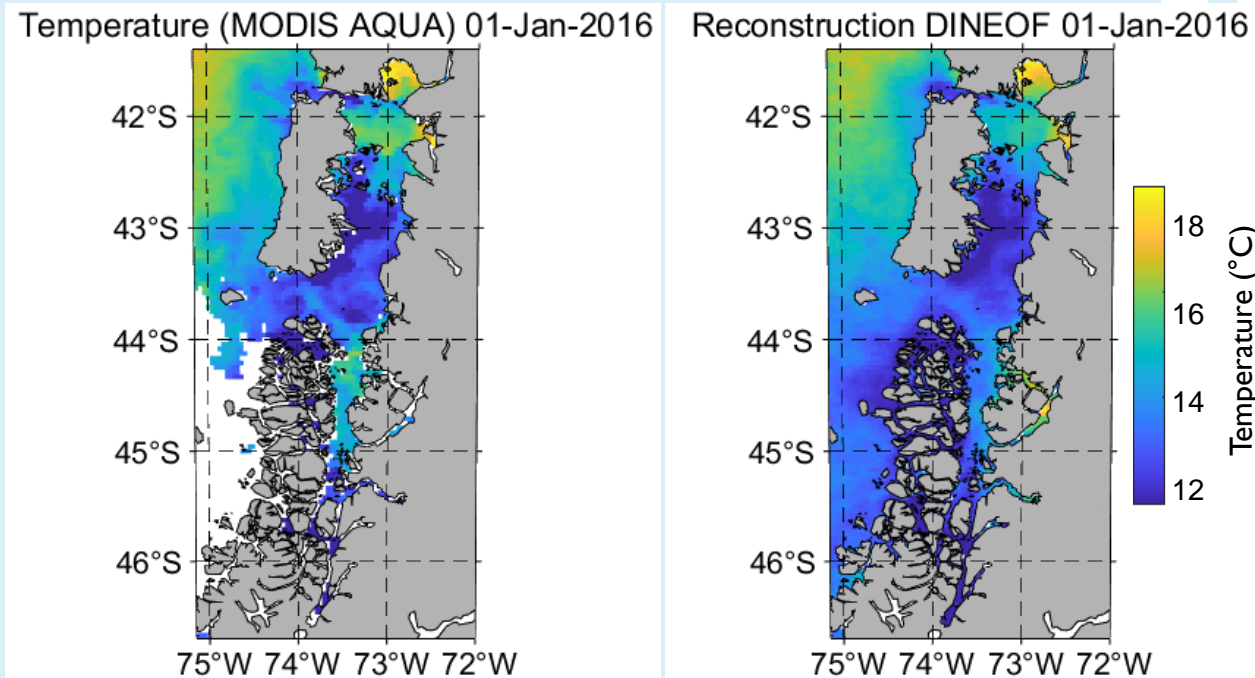
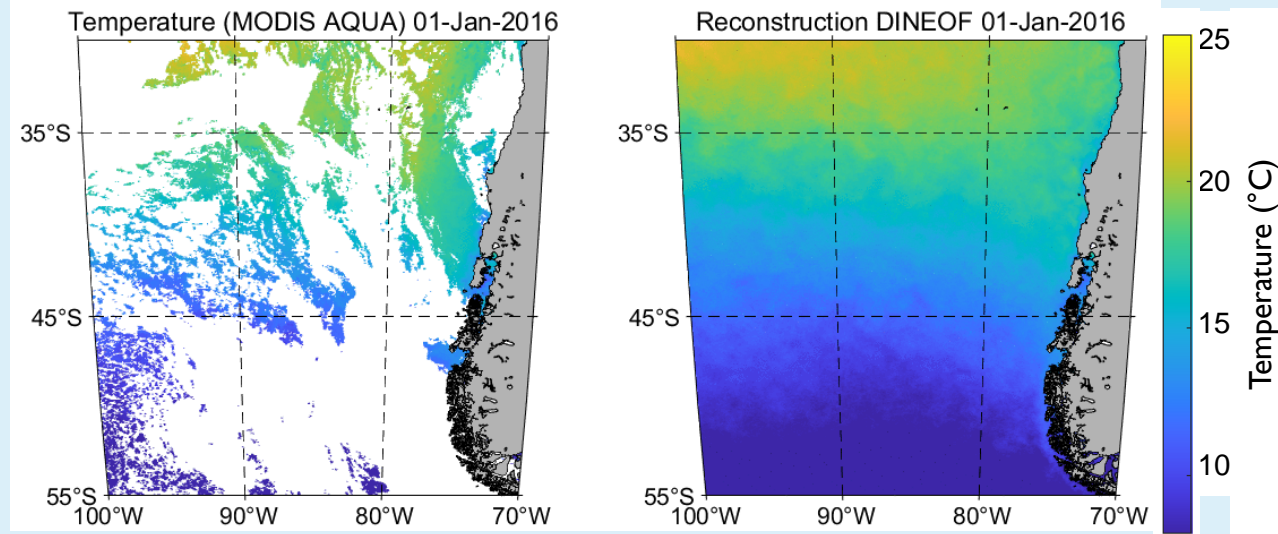
In a fjord-like environment



FILLING GAPS IN SATELLITE DATA



FILLING GAPS IN SATELLITE DATA



HOW TO DETECT MHWS?

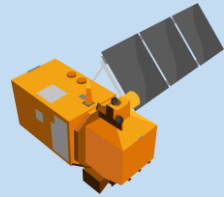
In a fjord-like environment

Long-term
Climatology



- Monthly climatology
- Moving average of 90 days

Local
SST



SATELLITE
DATA

AQUA MODIS 4km
2003-2023

Detection of
the MHWS

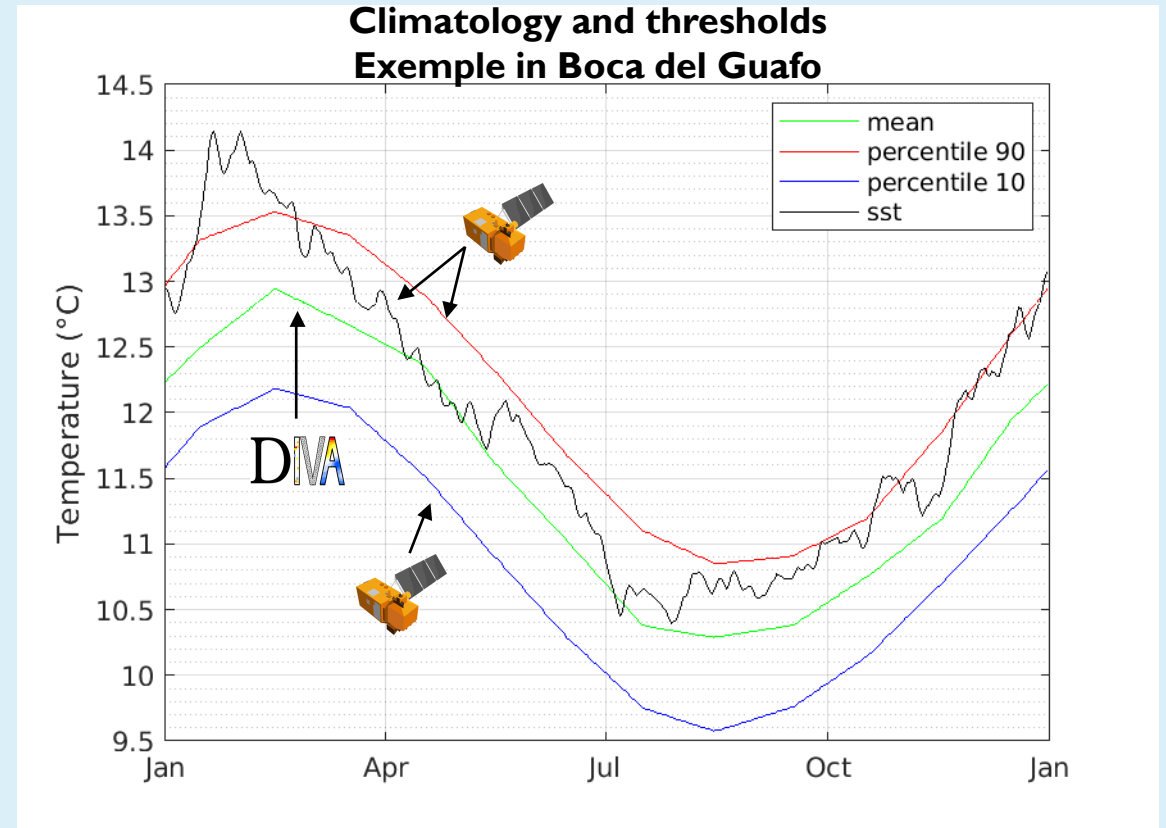
Climatology

Local SST

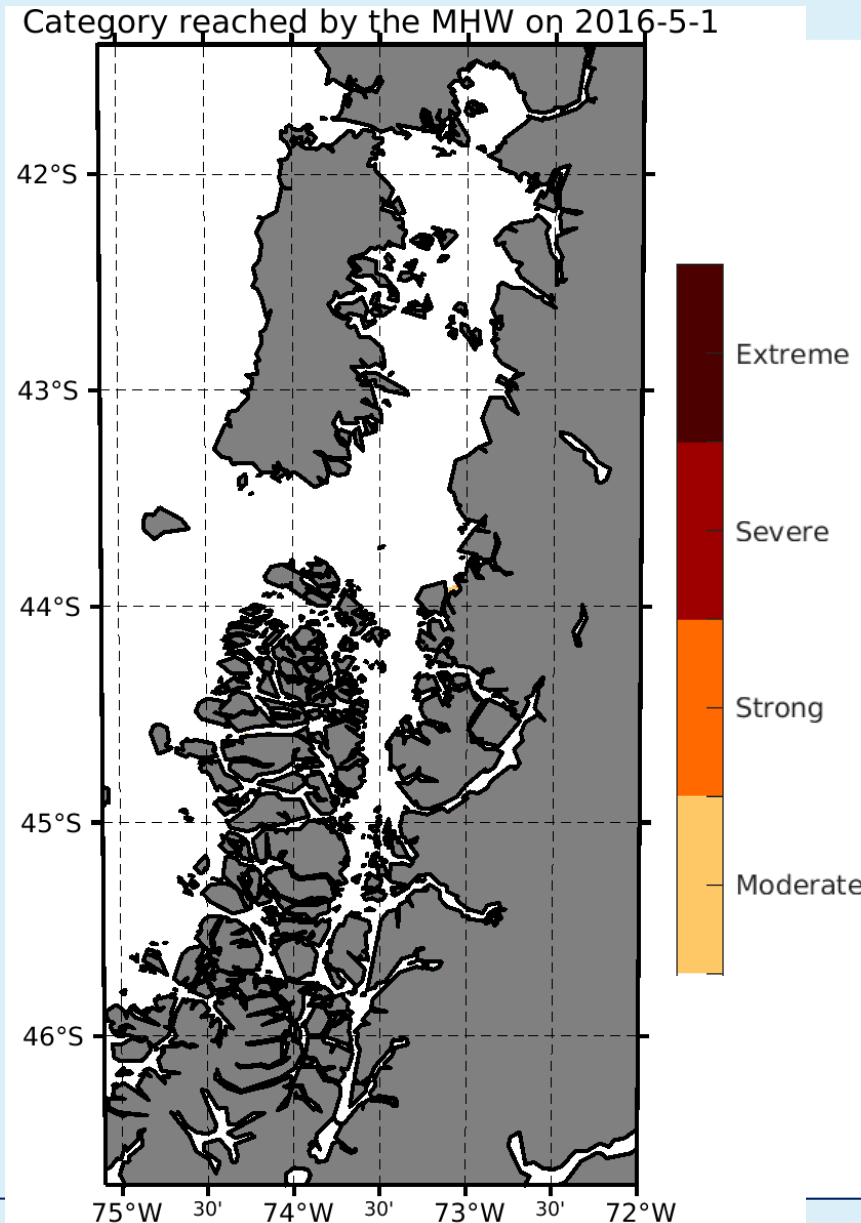
Threshold



Schlegel and Smit, 2018

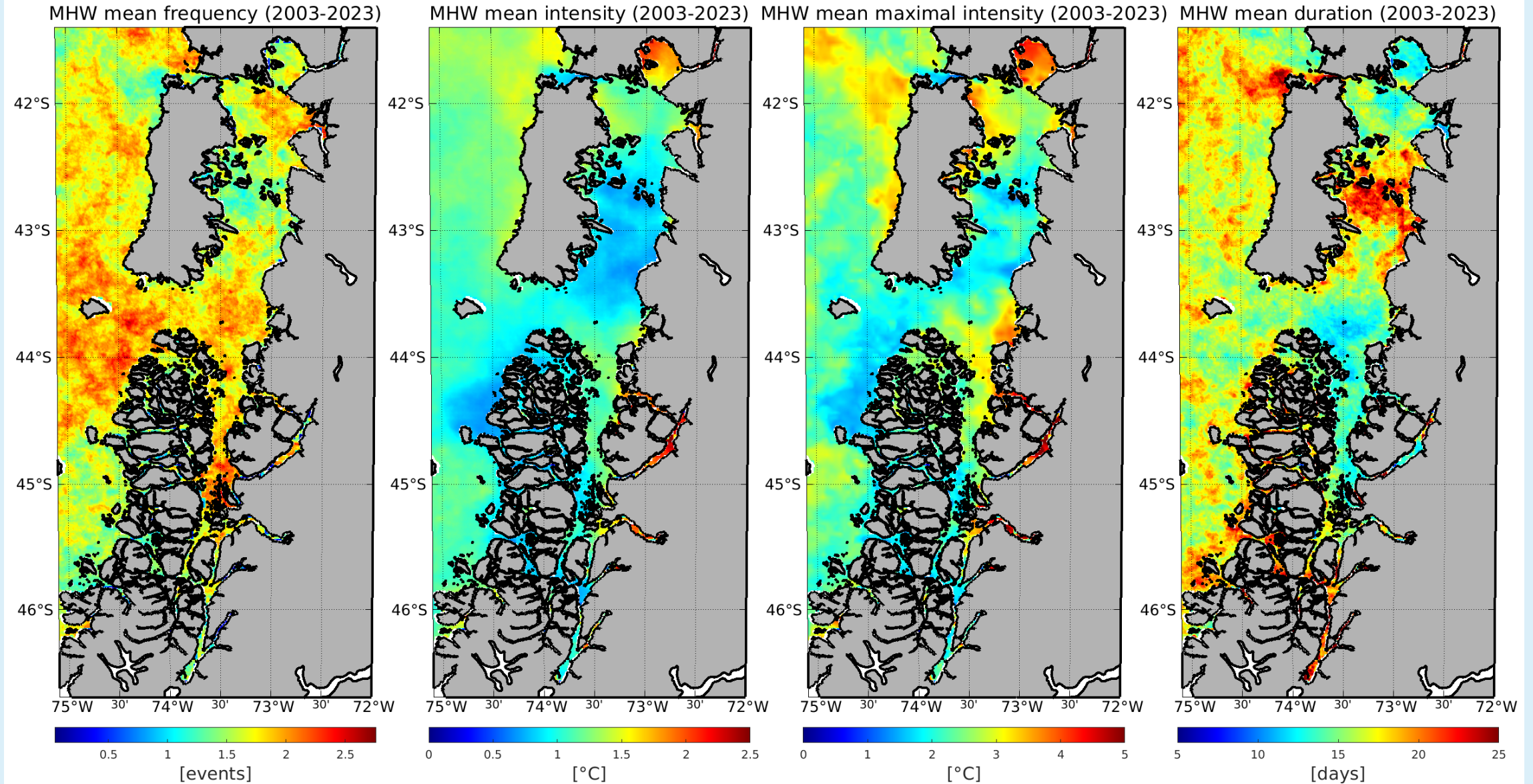


EXAMPLE OF MHW



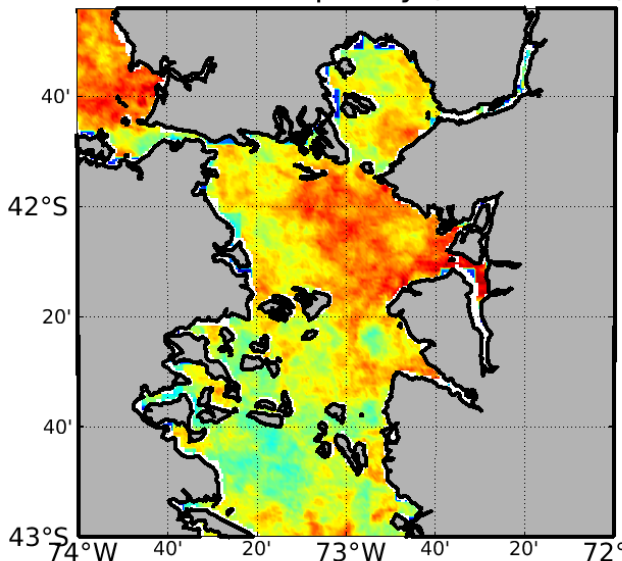
MHW conditions from May 2016
to August 2017

MHWS DURING THE LAST 20 YEARS

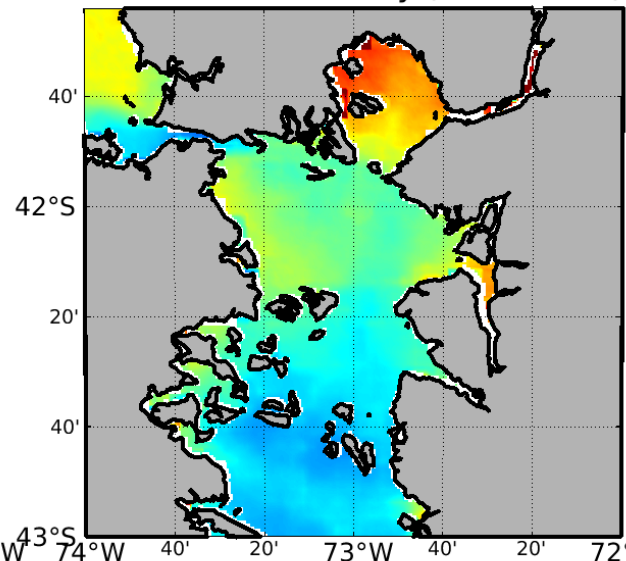


MHWS DURING THE LAST 20 YEARS

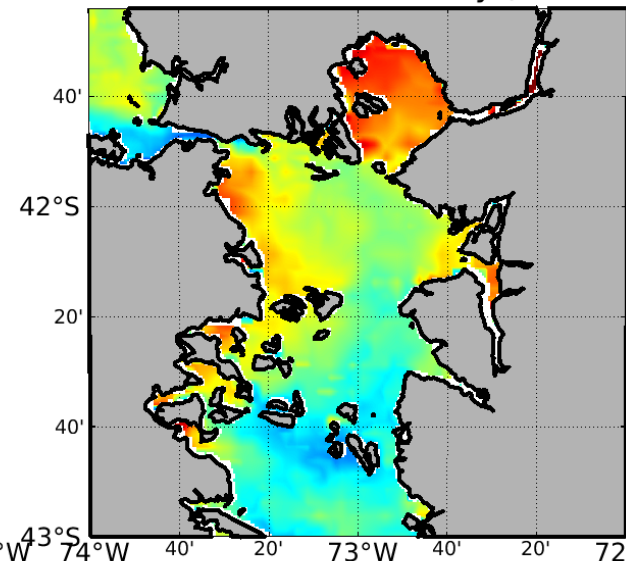
MHW mean frequency (2003-2023)



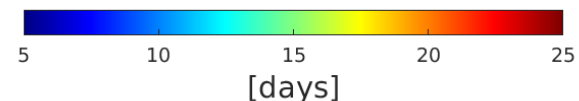
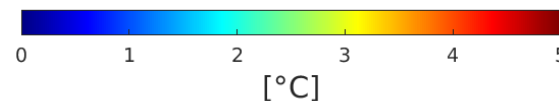
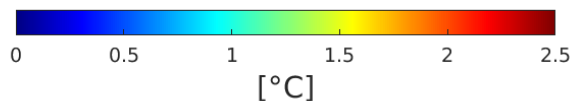
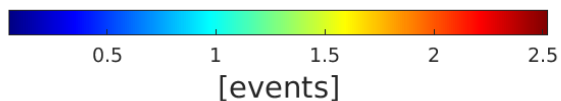
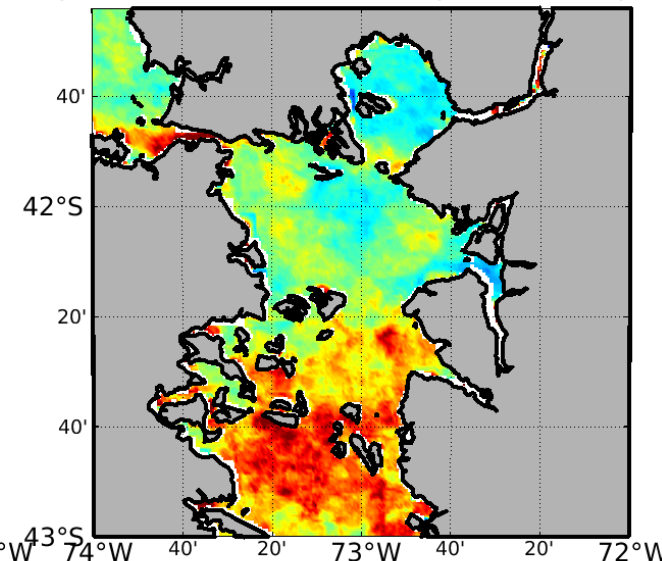
MHW mean intensity (2003-2023)



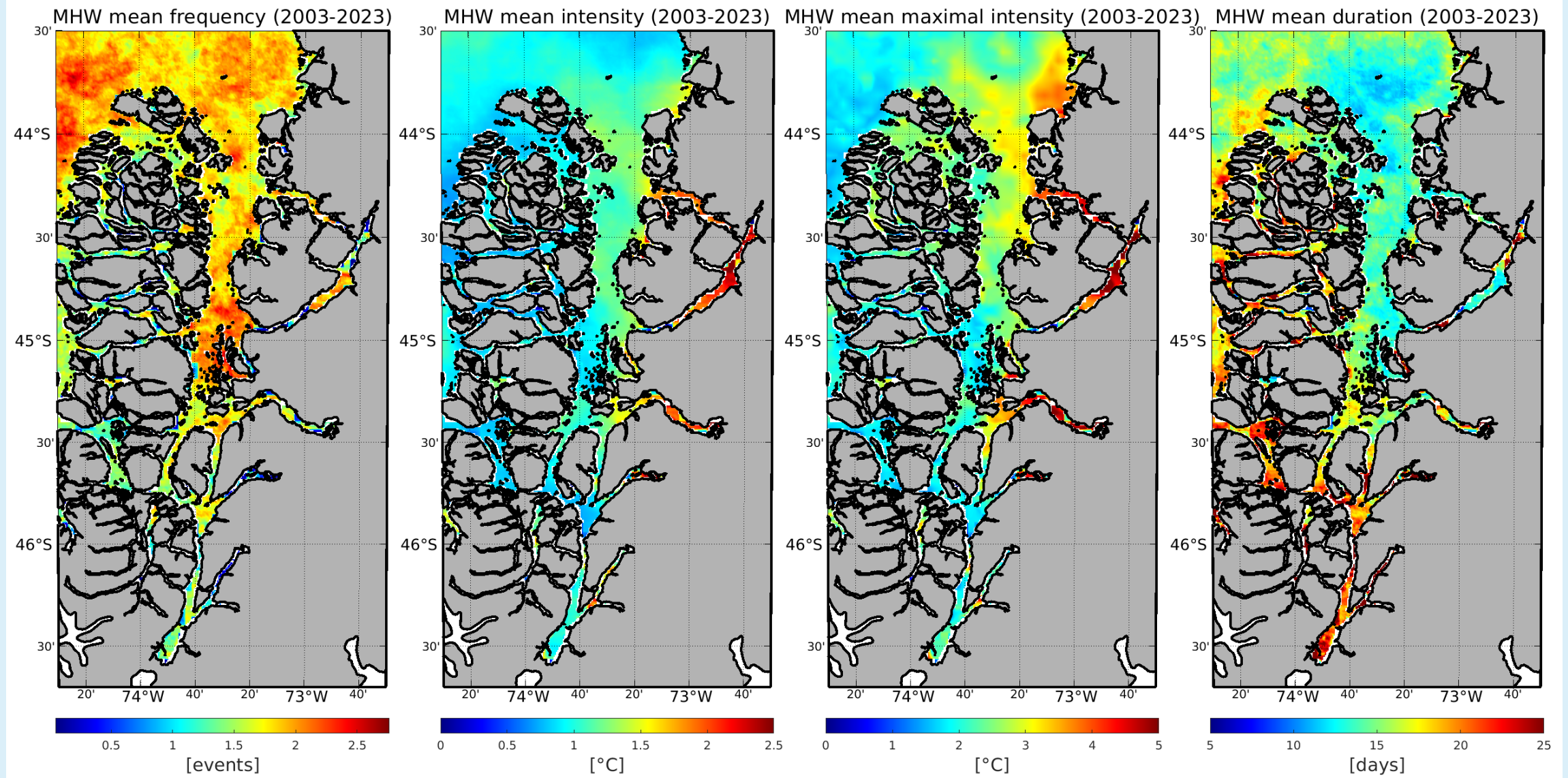
MHW mean maximal intensity (2003-2023)



MHW mean duration (2003-2023)

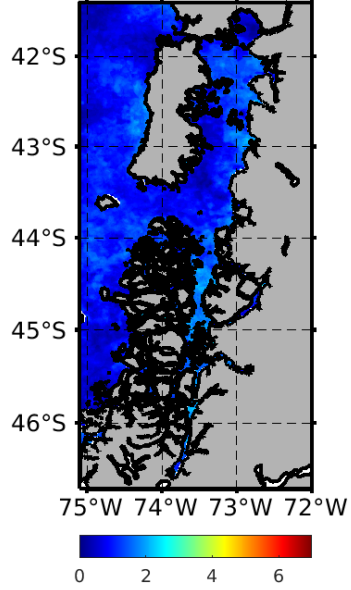


MHWS DURING THE LAST 20 YEARS

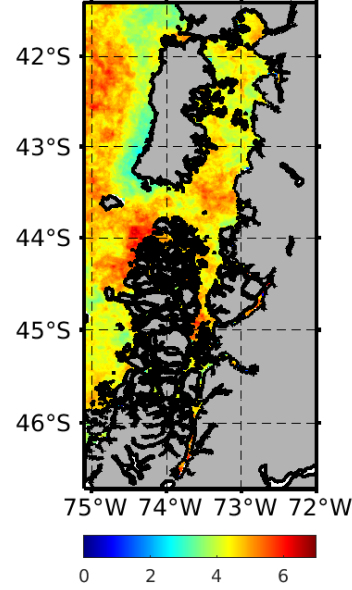


MHW SEASONALITY

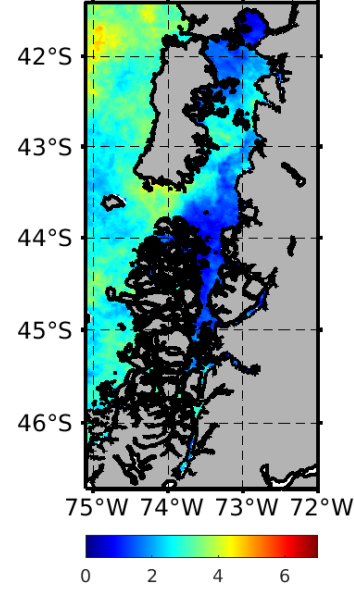
MHW days/month-SPR



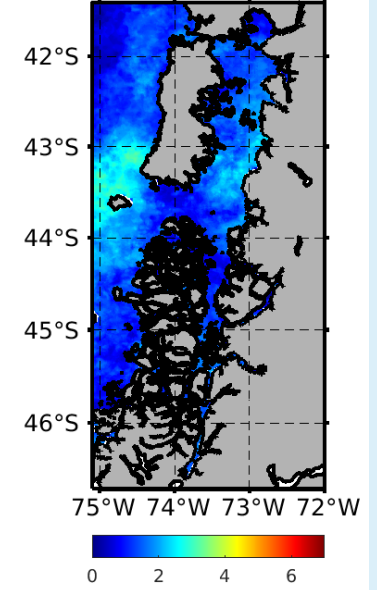
MHW days/month-SUM



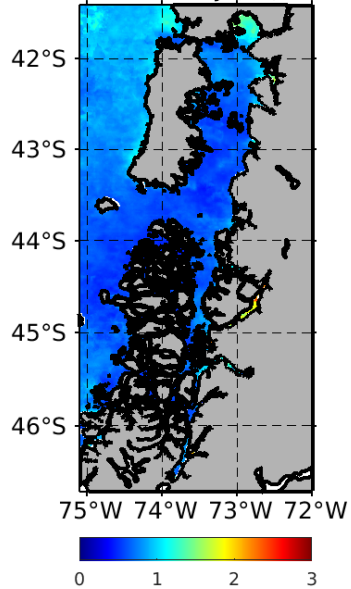
MHW days/month-AUT



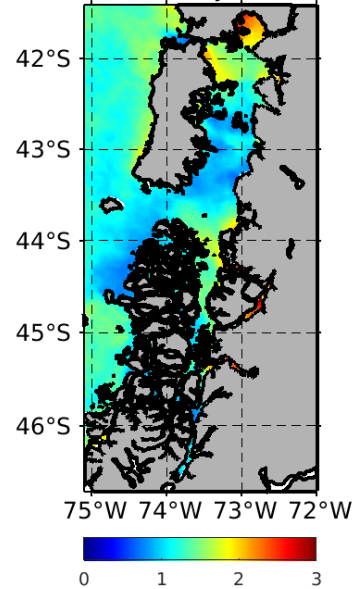
MHW days/month-WIN



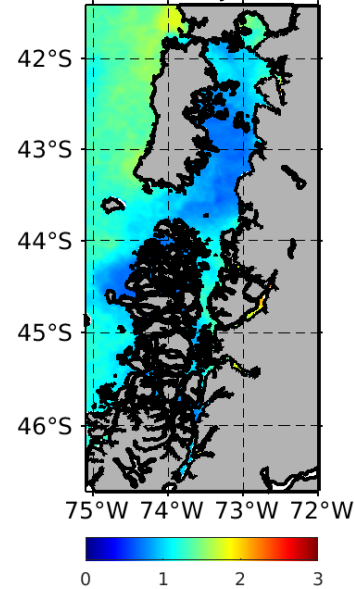
MHW intensity (°C)-SPR



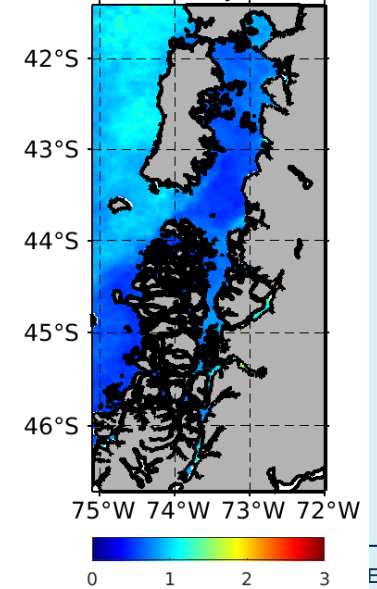
MHW intensity (°C)-SUM



MHW intensity (°C)-AUT



MHW intensity (°C)-WIN



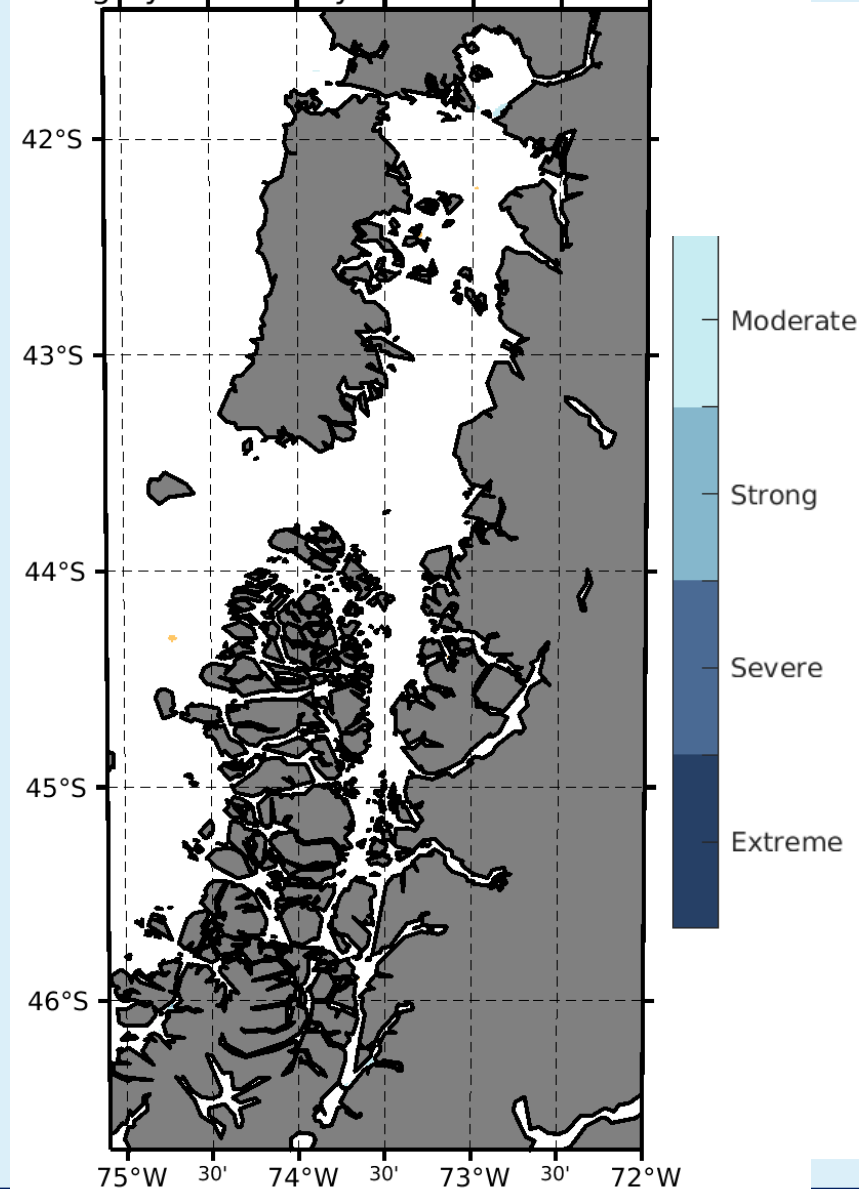
YES, BUT...

MHWs are cool but...

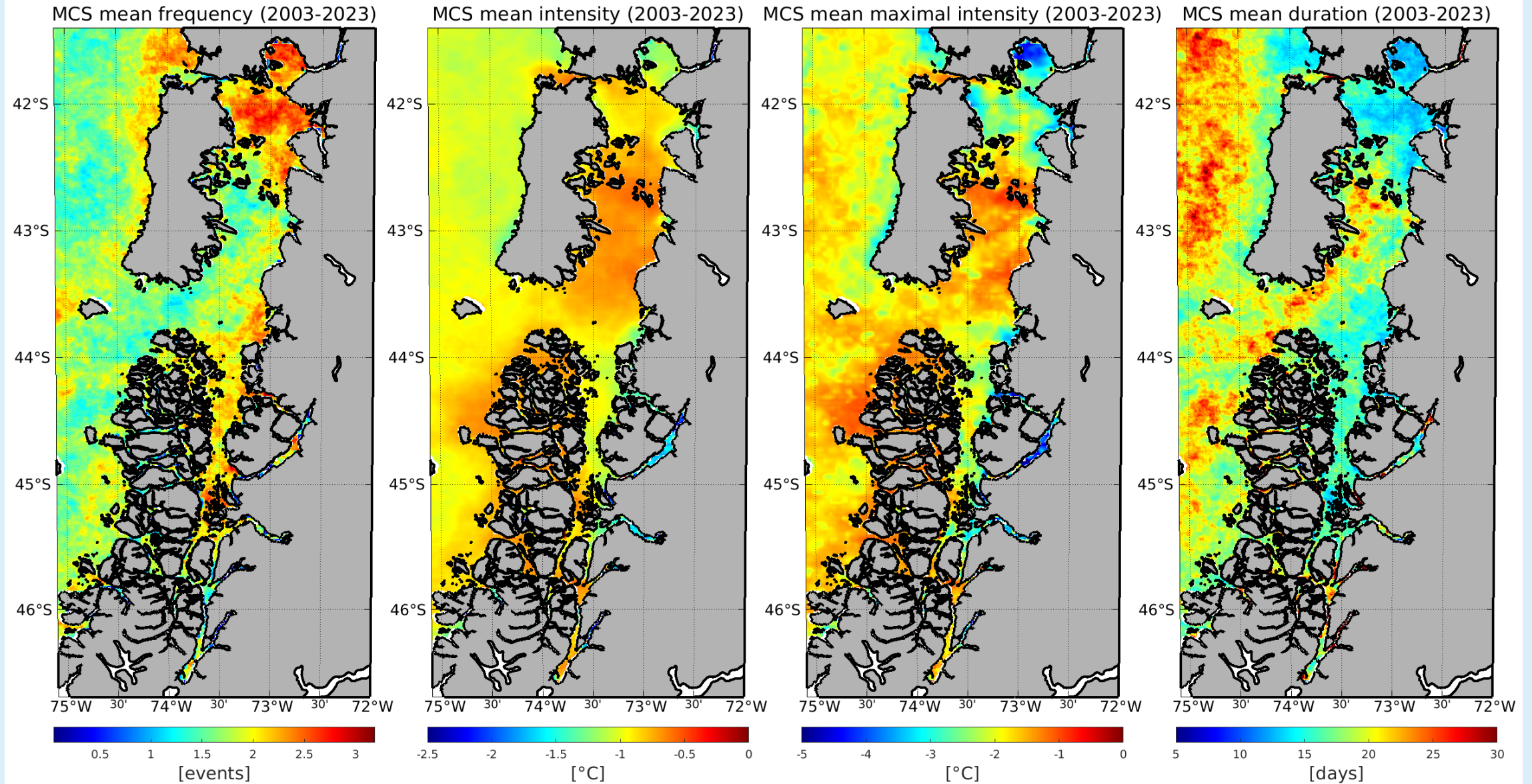
What about **Marine Cold Spells** ?

MARINE COLD SPELLS

Category reached by the MHW on 2007-3-27

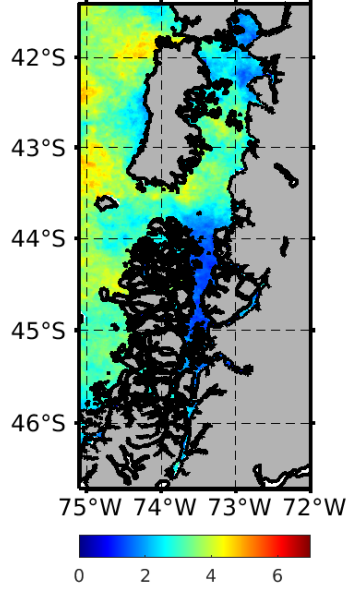


MCS DURING THE LAST 20 YEARS

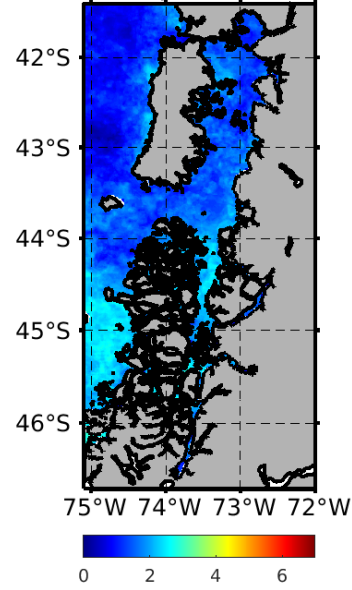


MCS SEASONALITY

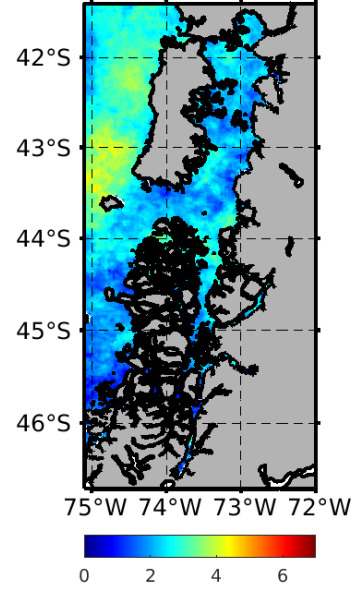
MCS days/month-SPR



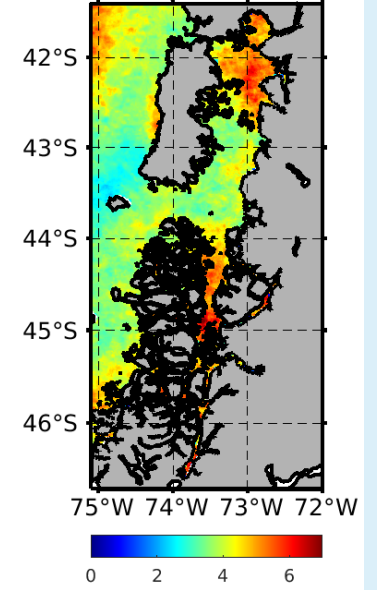
MCS days/month-SUM



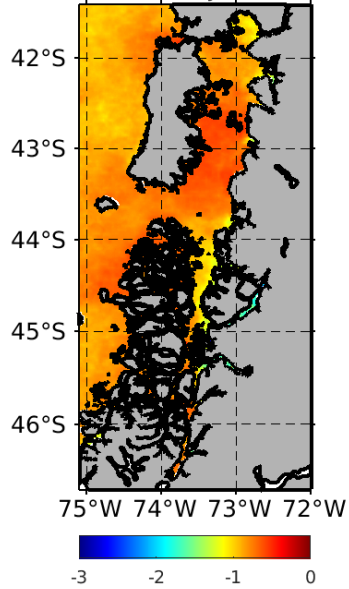
MCS days/month-AUT



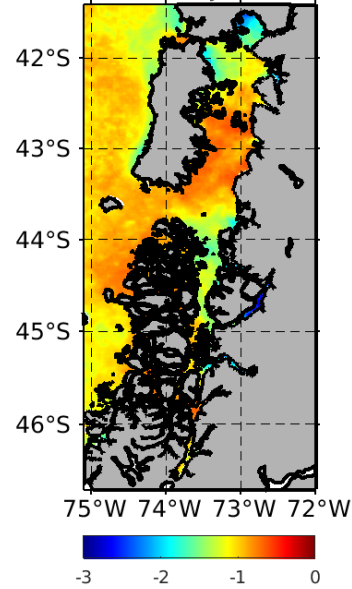
MCS days/month-WIN



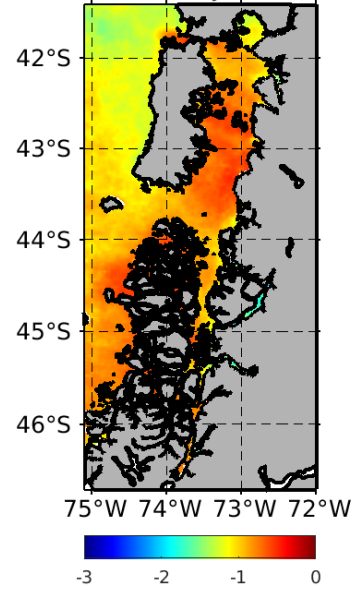
MCS intensity (°C)-SPR



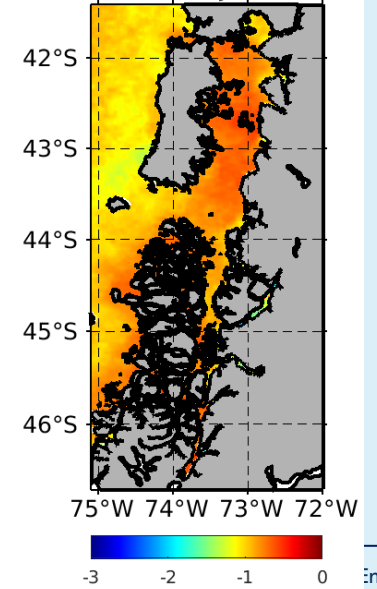
MCS intensity (°C)-SUM



MCS intensity (°C)-AUT



MCS intensity (°C)-WIN

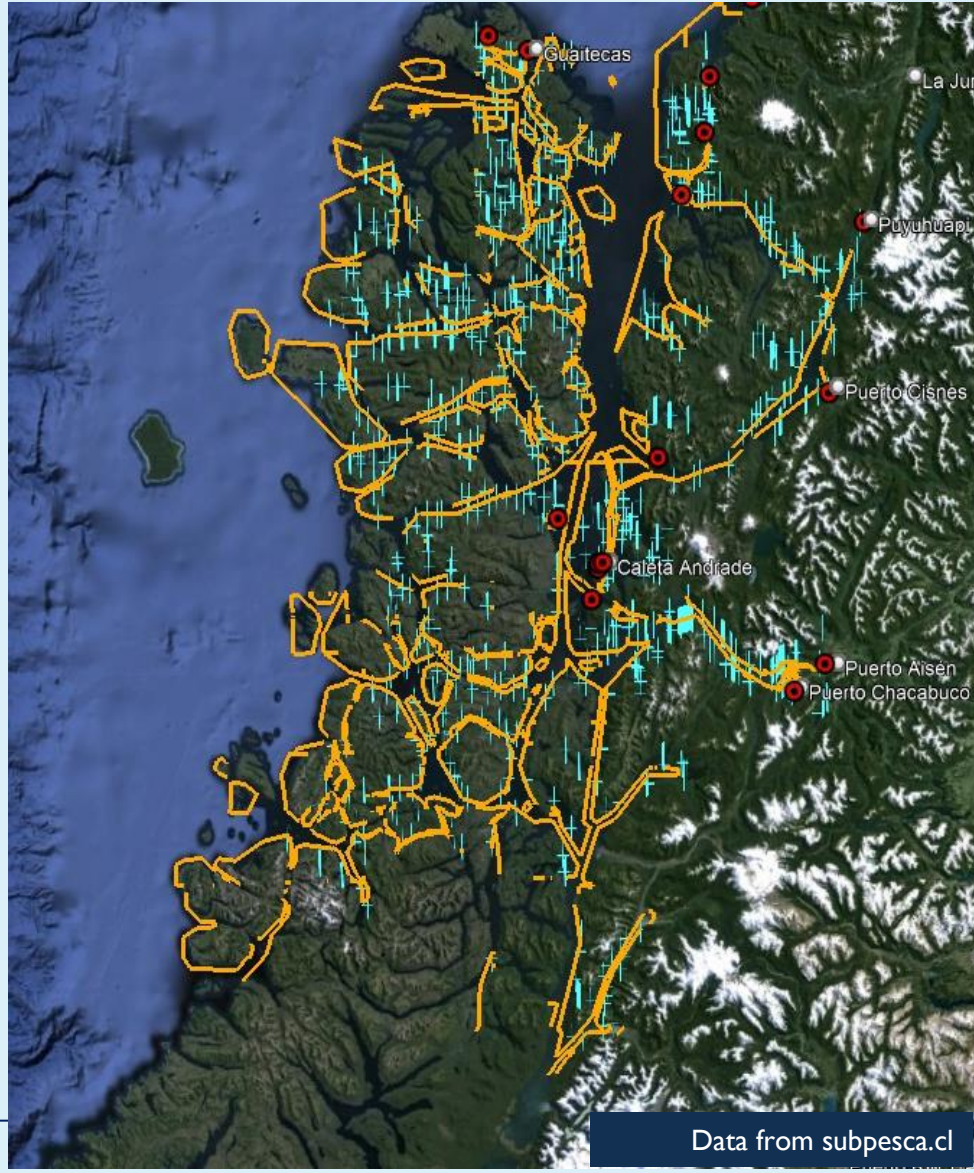
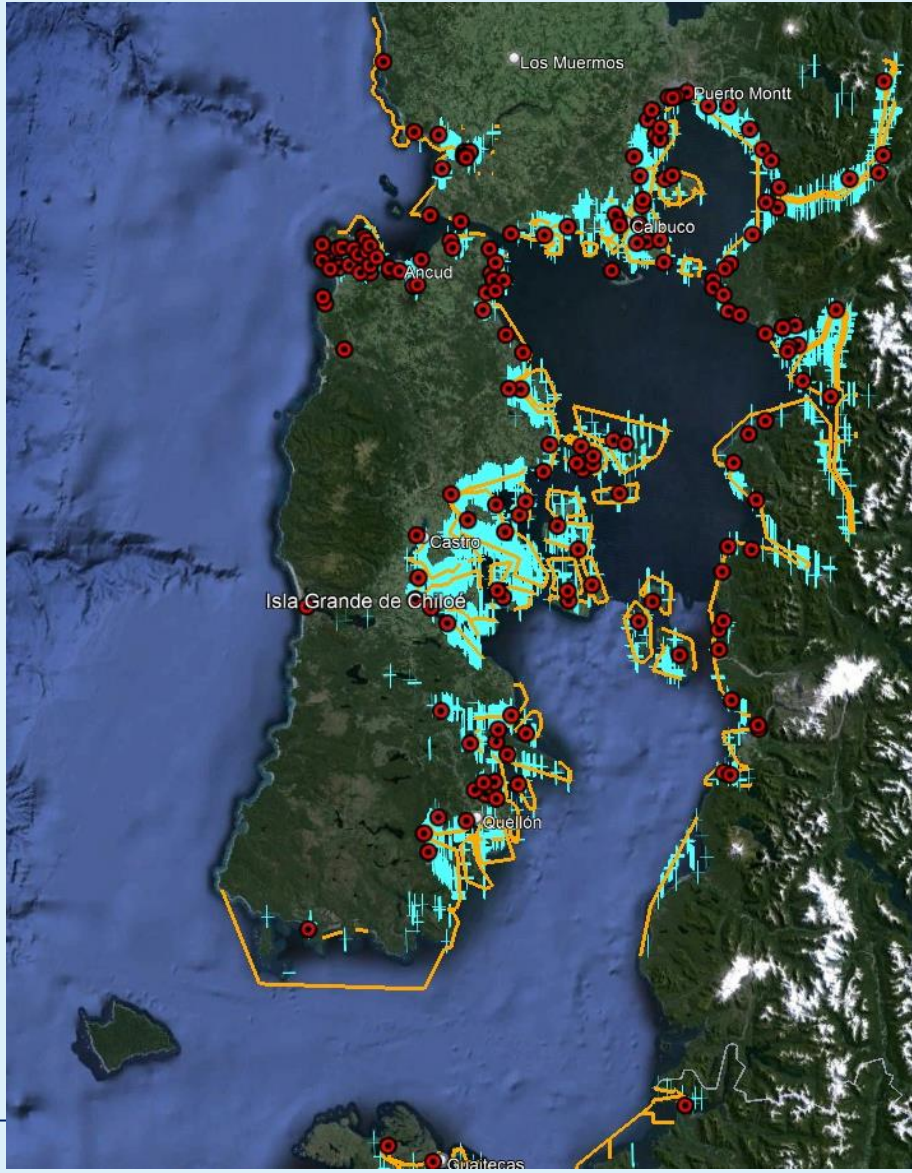


Why is it so important to understand
MHWs/MCSs at high resolution in
coastal environments ?



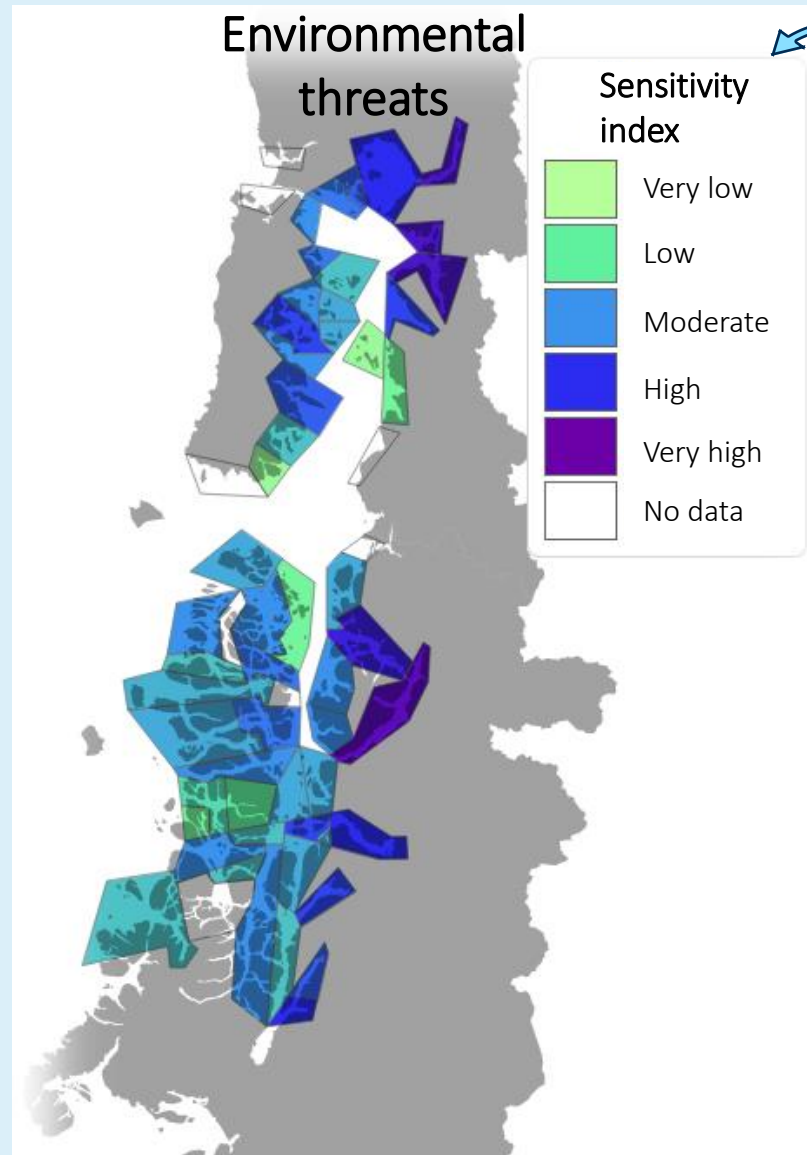
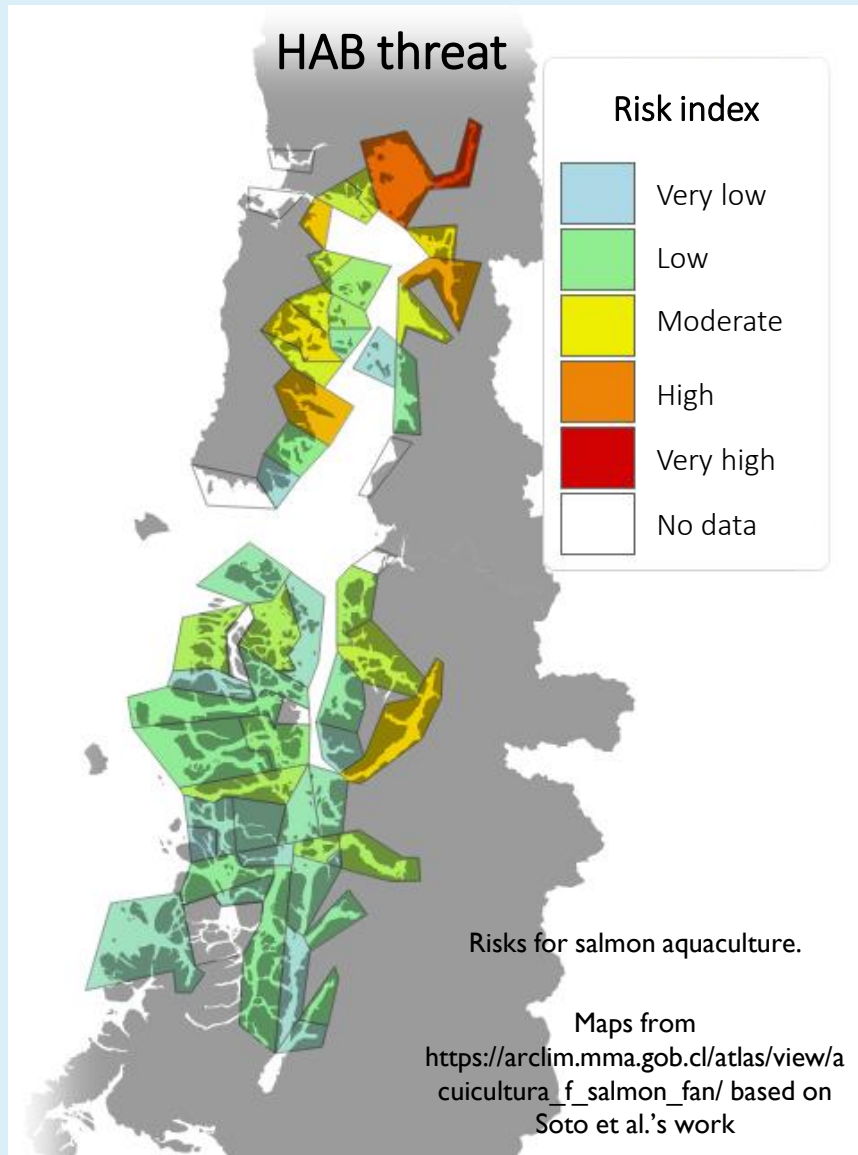
MHWS AND HUMAN RESSOURCES

High productivity area !!



- Artisanal fishing cove
- Area suitable for aquaculture
- + Aquaculture centre

RISKS



- Water age

- Pre-existence of red tides

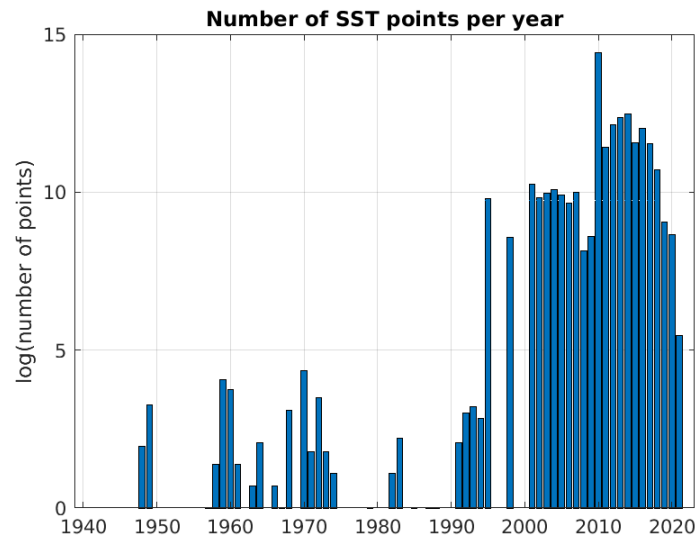
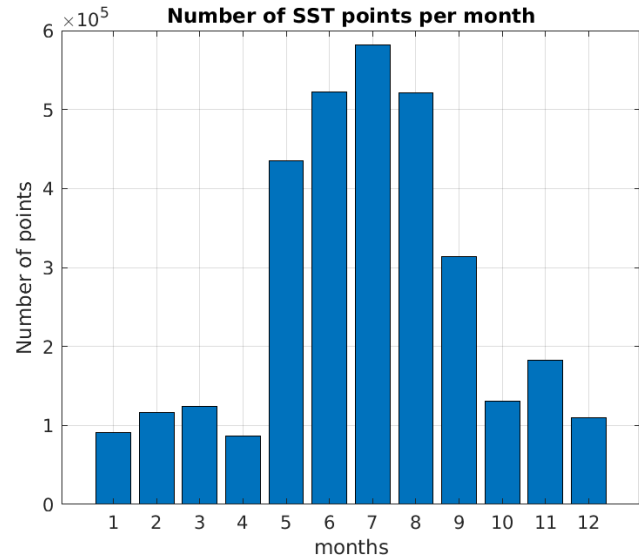
- Spatio-temporal variability of surface temperature

- Freshwater inputs

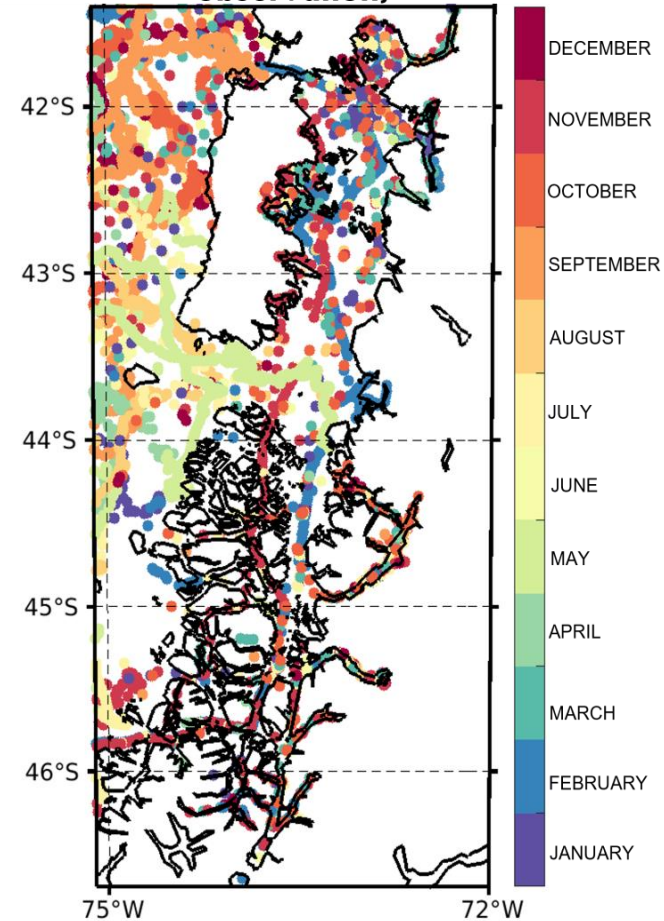
Risks that can be enhanced by MHWs/MCSs

Importance of studying MHWs in coastal environment and at small scales !

IN SITU DATA AVAILABLE



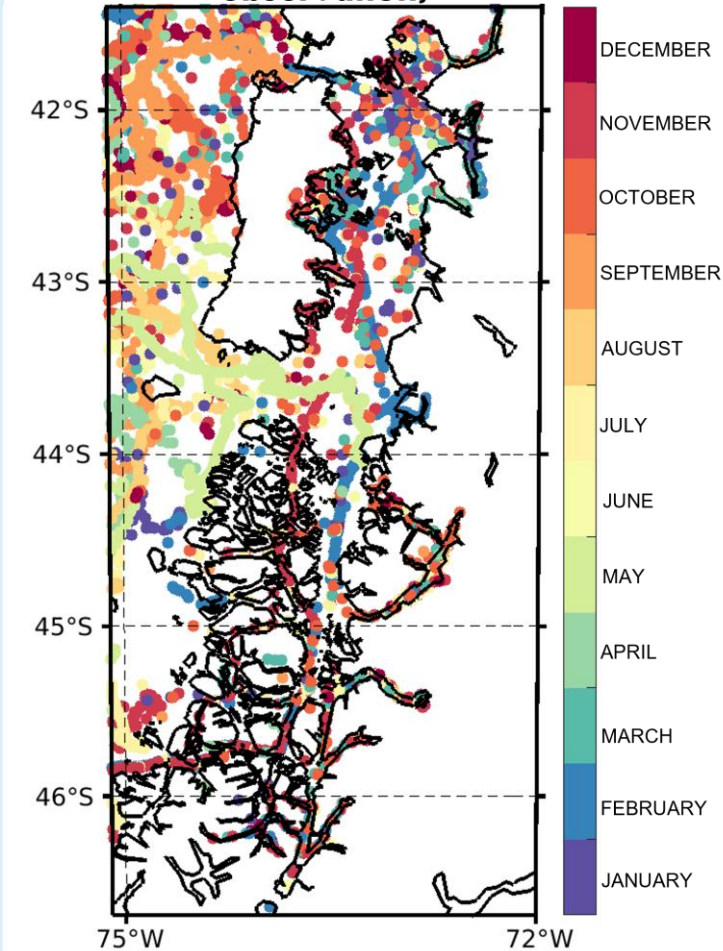
**In situ data in North Patagonia
(colours correspond to the month of the
observation)**



Total number of samples
~ 3 millions

INTERPOLATION OF THE IN SITU DATA

In situ data in North Patagonia
(colours correspond to the month of the observation)



Data-Interpolating Variational Analysis

(Troupin et al., 2014)

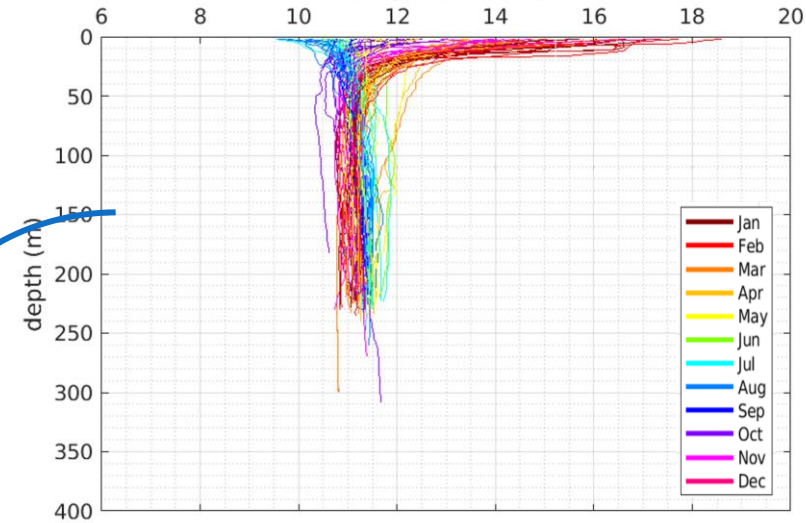
DIVA

Uses scattered in situ points to generate a continuous field

4D Monthly climatology

Horizontal correlation length: 50km
Lower weight attributed to data clusters

Profil plot Reloncavi (in situ data)
temperature (°C)



Profil plot Reloncavi (climatology DIVA)
temperature (°C)

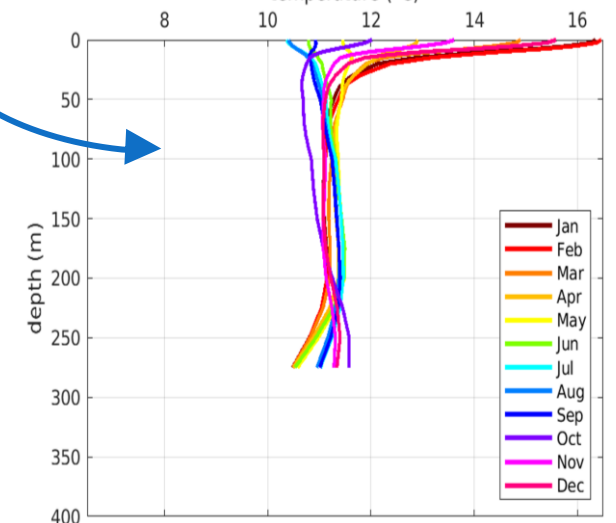
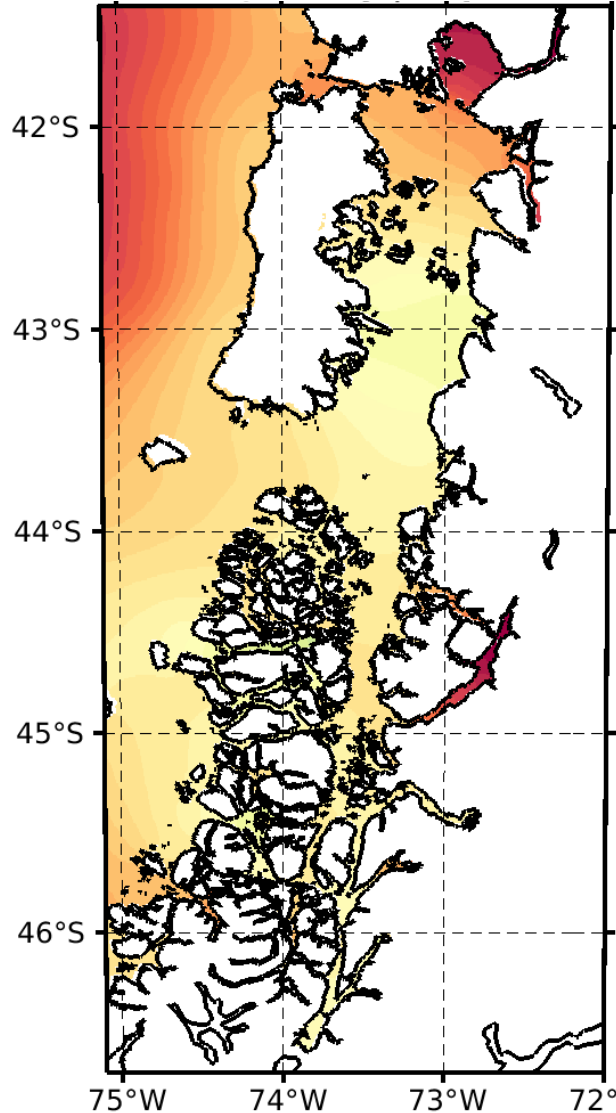


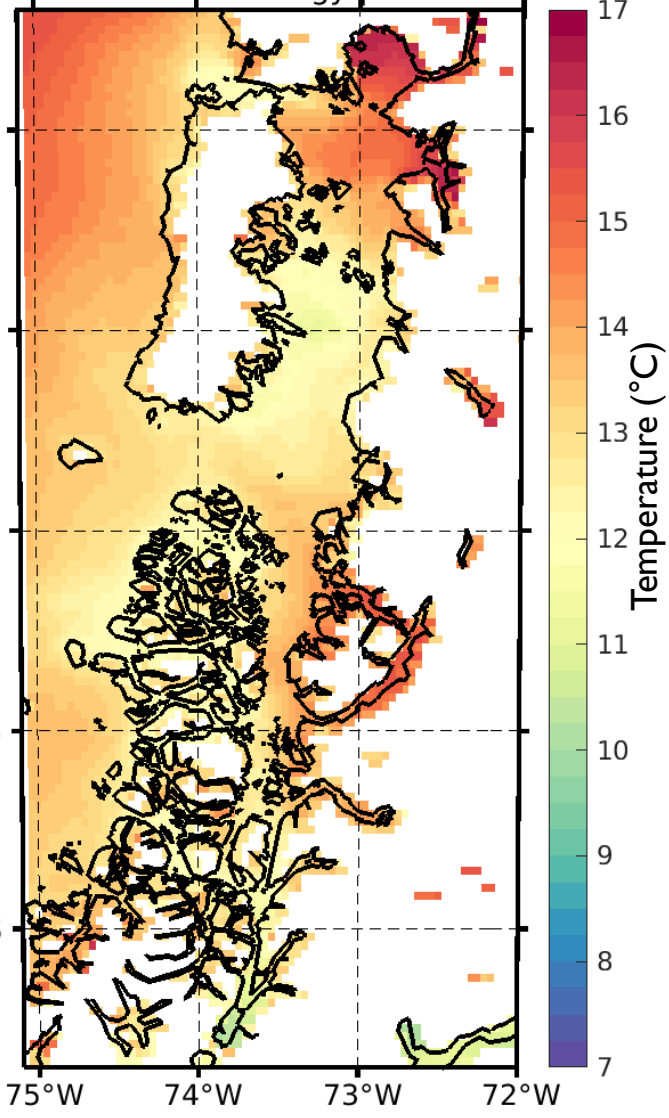
Fig.3. Comparison between profil plots from in situ (up) and DIVA climatology (down) in the Reloncavi Sound

VALIDATION OF THE CLIMATOLOGY

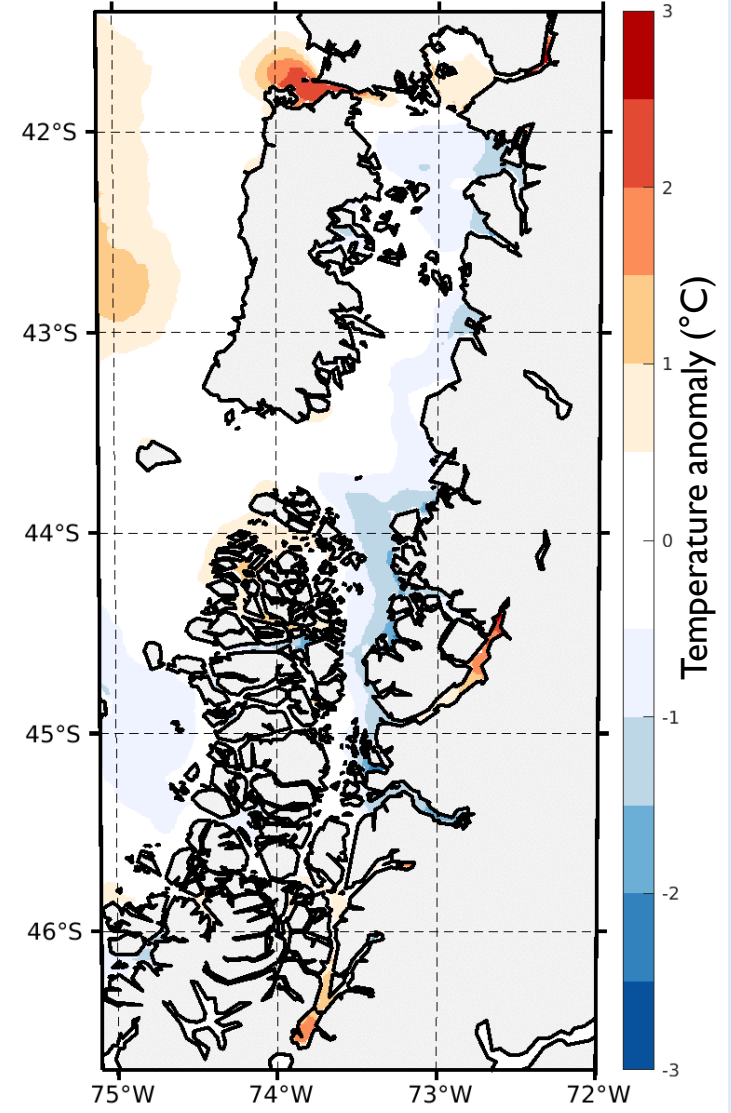
DIVA reconstruction
Climatology | Month=1



MODIS AQUA temperature
Climatology | Month=1



Difference between DIVA and MODIS AQUA
Climatology | Month=1



VALIDATION OF THE CLIMATOLOGY

5% of the in situ data kept apart for validation



Month	Total data	Whose mooring	Whose not from mooring	Total data kept apart	Data kept appart for validation (whose mooring)	Data kept appart for validation (whose not mooring)
Jan	9128	8693	435	104	99	5
Feb	14369	13685	684	1045	995	50
Mar	14397	13711	686	221	210	11
Apr	8792	8373	419	169	161	8
May	9952	9478	474	633	603	30
Jun	9531	9077	454	349	332	17
Jul	9798	9331	467	519	494	25
Aug	8985	8557	428	488	465	23
Sep	10017	9540	477	786	749	37
Oct	9633	9174	459	509	485	24
Nov	8086	7701	385	1062	1011	51
Dec	9471	9020	451	229	218	11

FILLING GAPS IN SATELLITE DATA

