

Marine Heatwaves in coastal area: example of the Sea of Chiloé, Chile

How to detect marine heatwaves in a semi-enclosed environment

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PAMELA LINFORD, ELIAS PINILLA, AIDA ALVERA AZCÁRATE

WHAT ARE MARINE HEATWAVES ?

Anomalous **warm water** events

Formed due to
processes

Atmospheric

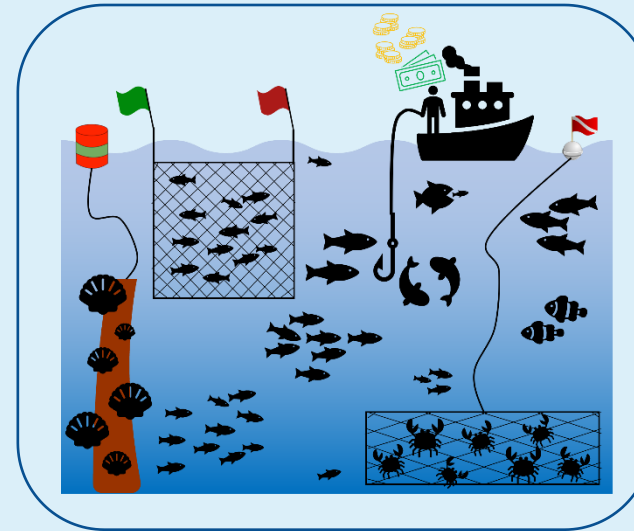
Oceanic

Recently studied phenomenon

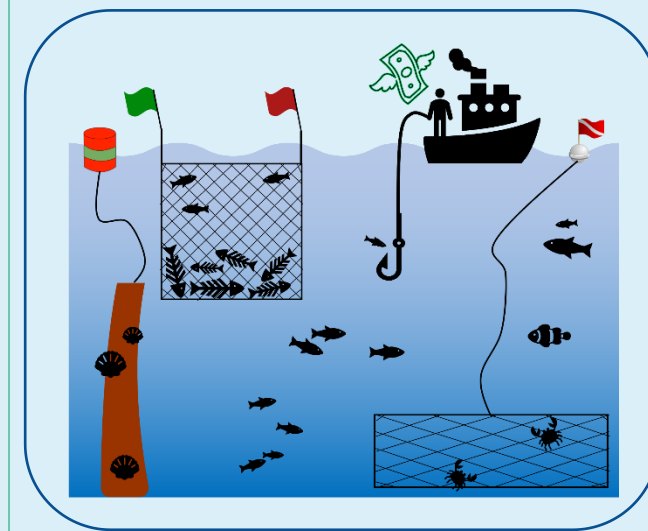
Amplification due to **global warming**

Devastating consequences

Before a MHW

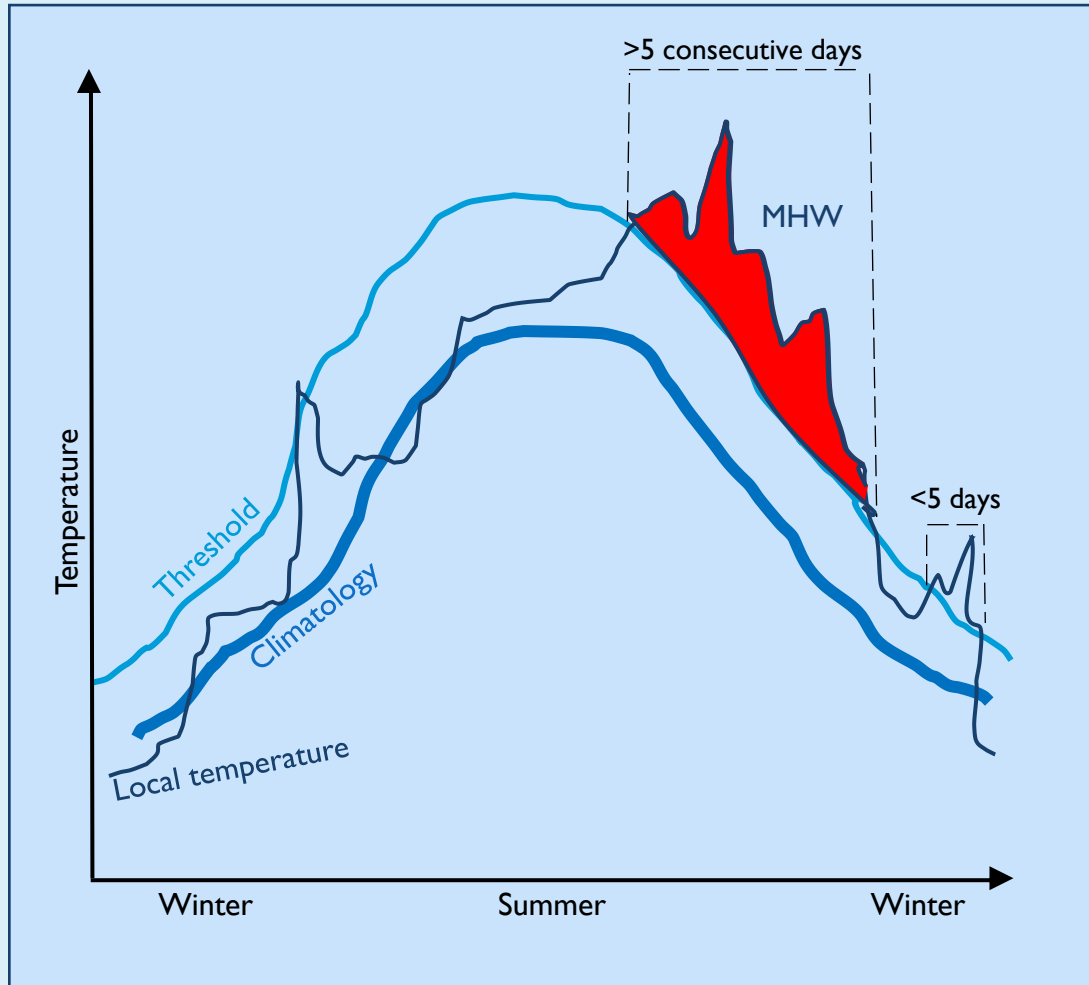


During a MHW



Human activities

HOW TO DETECT MHWS ?



Detection

Long term climatology vs Local temperature

90th percentile

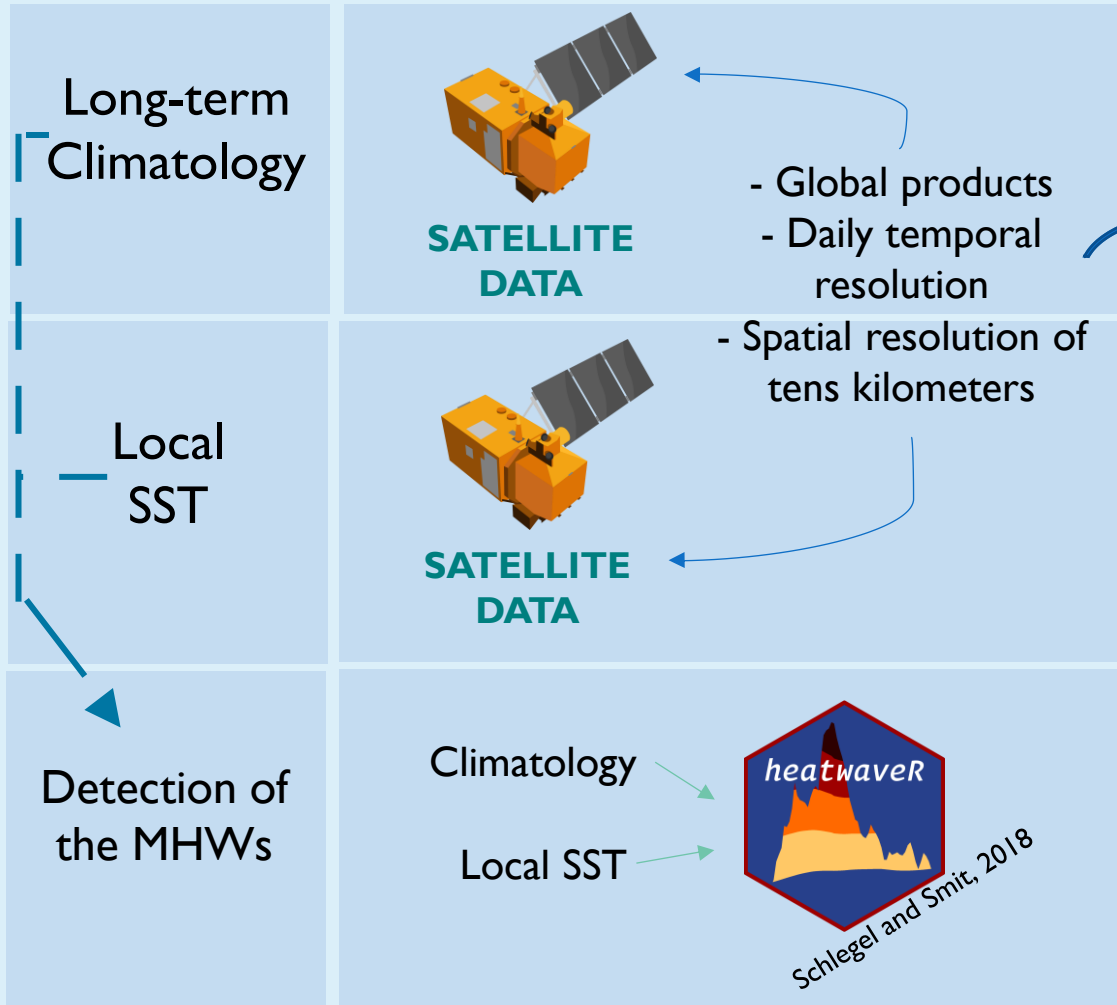
Threshold exceeded ?

if yes

MHW

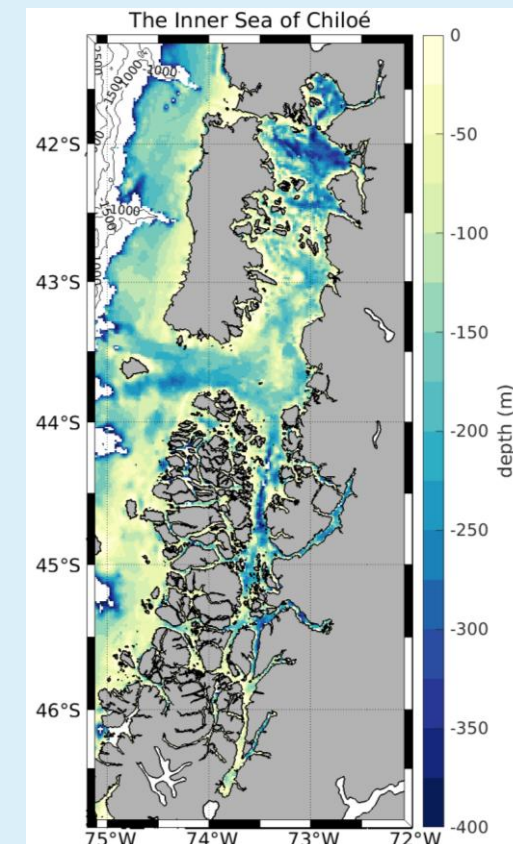
MHW TRADITIONAL DETECTION

In an open ocean-like environment

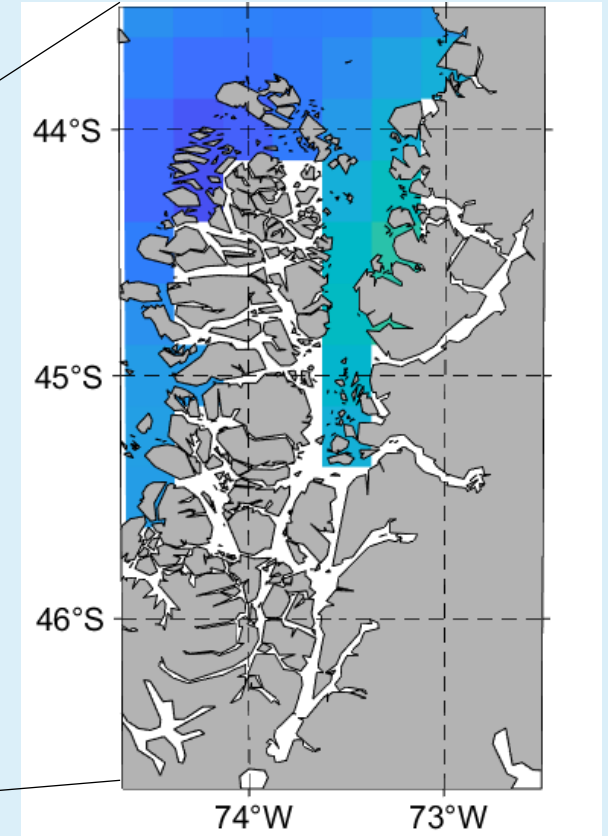
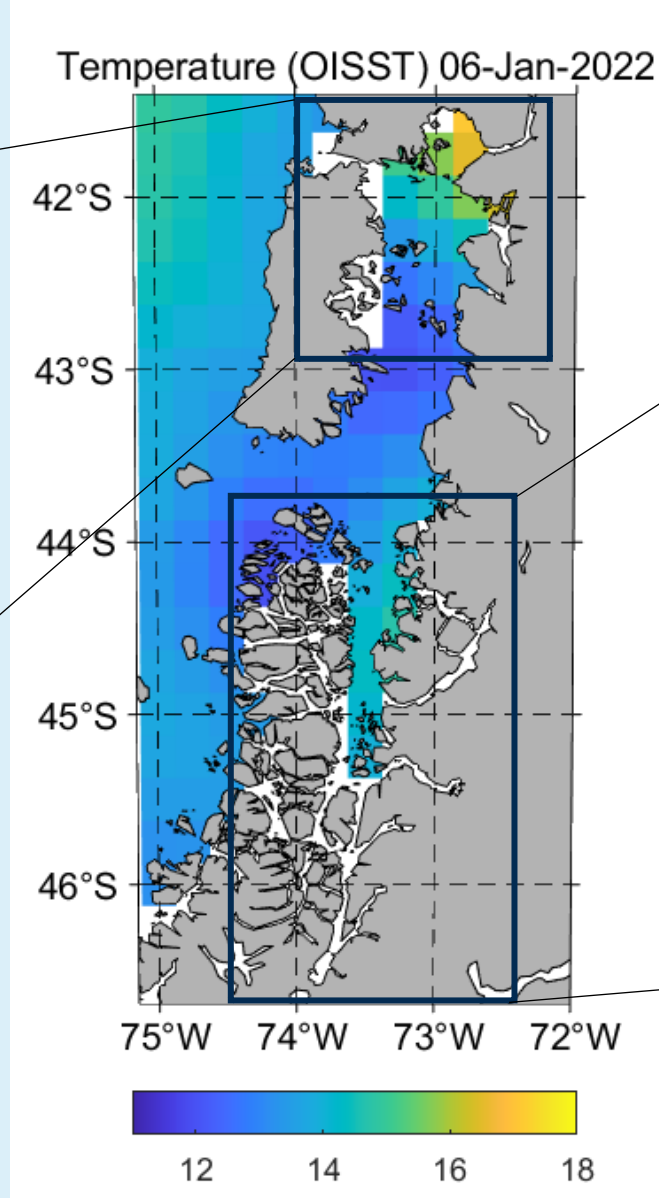
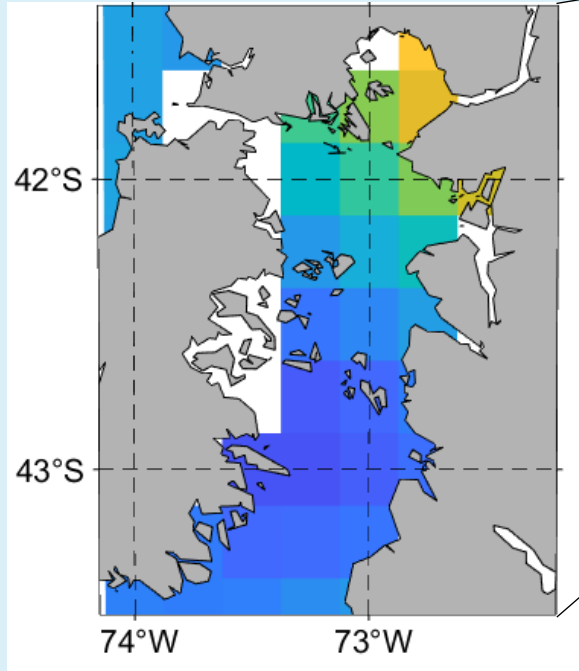


In a fjord-like environment

Chiloe Inner Sea



OISST PRODUCT

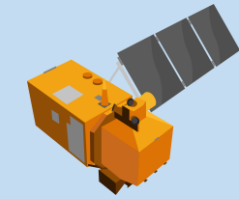


MHW DETECTION IN FJORD ENVIRONMENT

In an open ocean-like environment

In a fjord-like environment

Long-term
Climatology



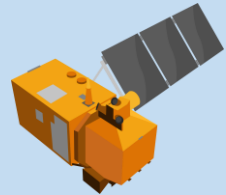
SATELLITE
DATA

- Global products
- Daily temporal resolution
- Spatial resolution of tens kilometers

Detection possible only in the largest parts of the sea + Very cloudy/rainy region

What about narrow fjords and channels?

Local
SST



SATELLITE
DATA

Detection of
the MHWs

Climatology

Local SST



Schlegel and Smit, 2018



Climatology



Local SST

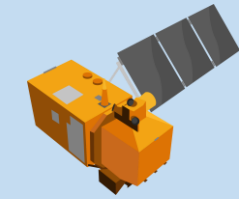


Schlegel and Smit, 2018

MHW DETECTION IN FJORD ENVIRONMENT

In an open ocean-like environment

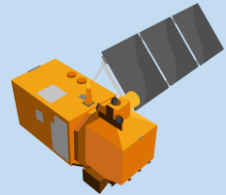
Long-term
Climatology



SATELLITE
DATA

- Global products
- Daily temporal resolution
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Local
SST



SATELLITE
DATA

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

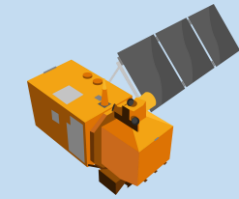


Schlegel and Smit, 2018

MHW DETECTION IN FJORD ENVIRONMENT

In an open ocean-like environment

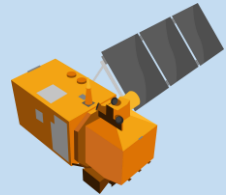
Long-term
Climatology



SATELLITE
DATA

- Global products
- Daily temporal resolution
- Spatial resolution of tens kilometers

Local
SST



SATELLITE
DATA

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

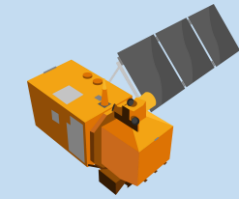


Schlegel and Smit, 2018

MHW DETECTION IN FJORD ENVIRONMENT

In an open ocean-like environment

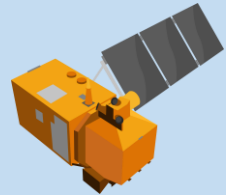
Long-term
Climatology



**SATELLITE
DATA**

- Global products
- Daily temporal resolution
- Spatial resolution of tens kilometers

Local
SST



**SATELLITE
DATA**

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

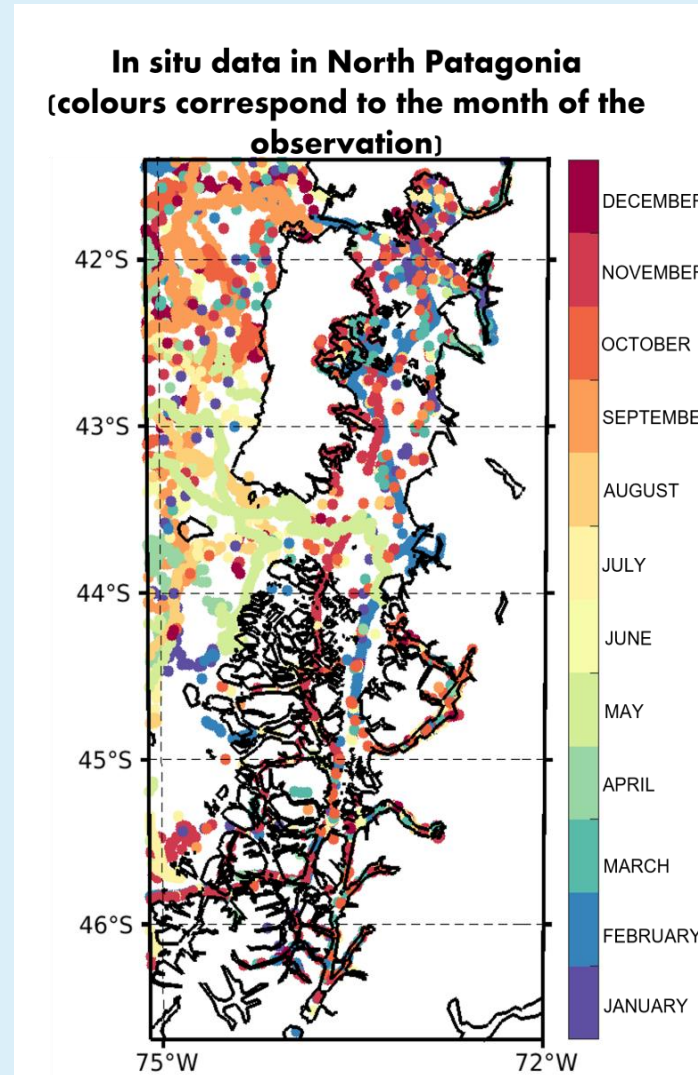


Schlegel and Smit, 2018

IN SITU DATA AVAILABLE

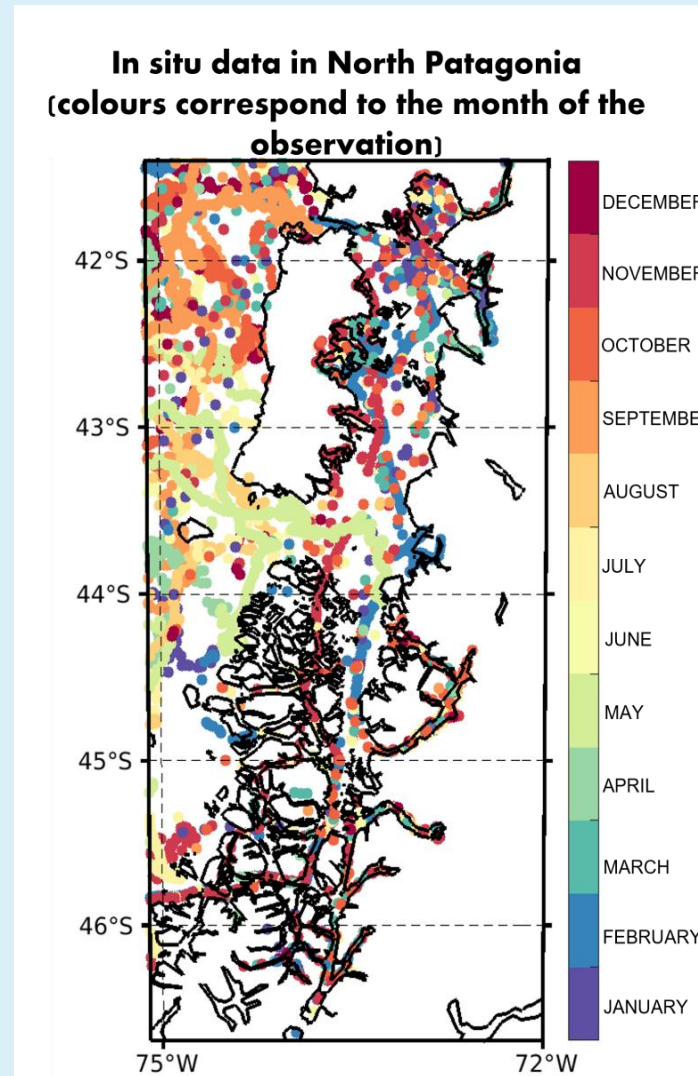
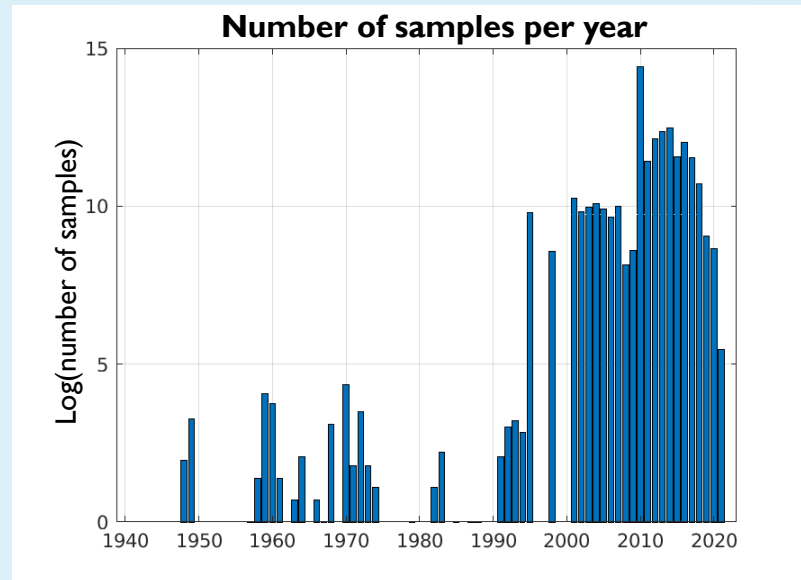
Providers/Campaigns :

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



Total number of samples
~ 3 millions

IN SITU DATA AVAILABLE



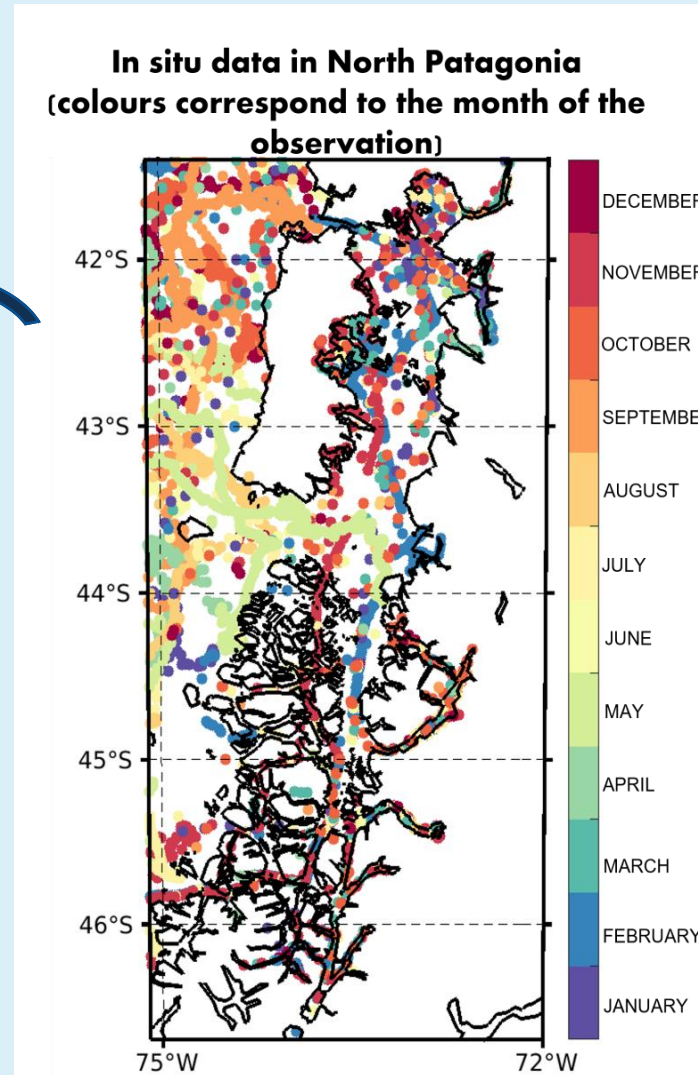
Total number of samples
~ 3 millions

IN SITU DATA AVAILABLE

Climatology from in situ data

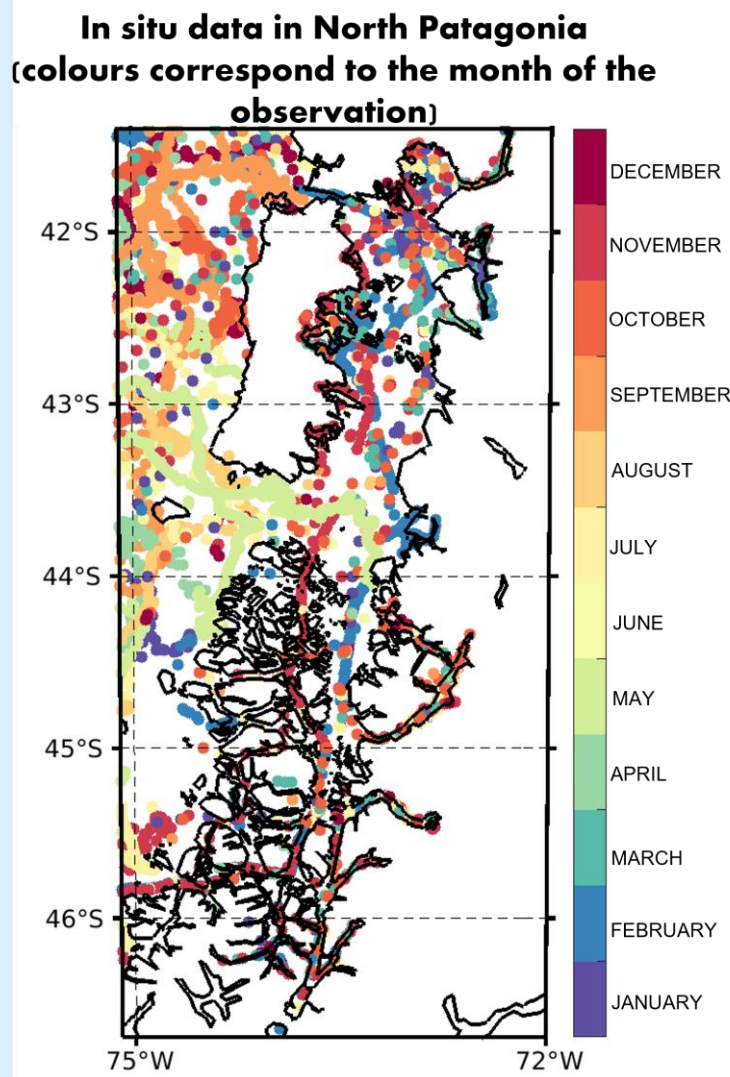


Interpolate the data



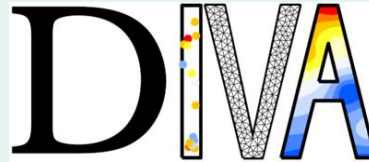
Total number of samples
~ 3 millions

INTERPOLATION OF THE IN SITU DATA



Data-Interpolating Variational Analysis

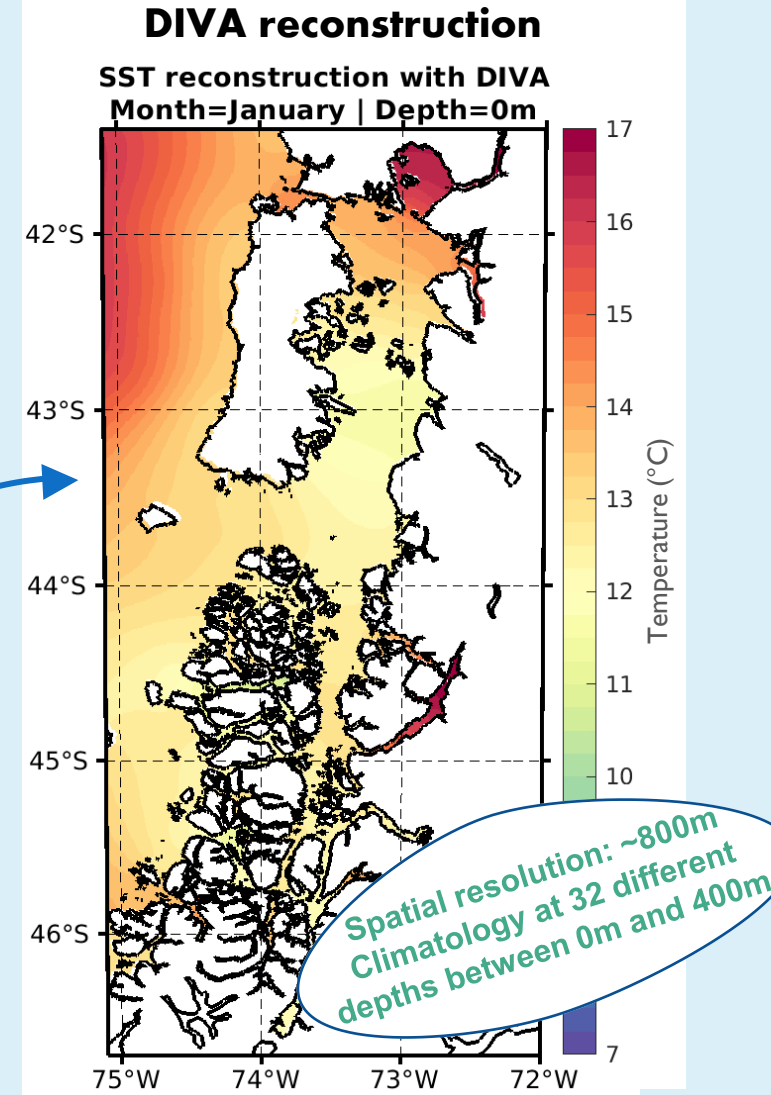
(Troupin et al., 2014)



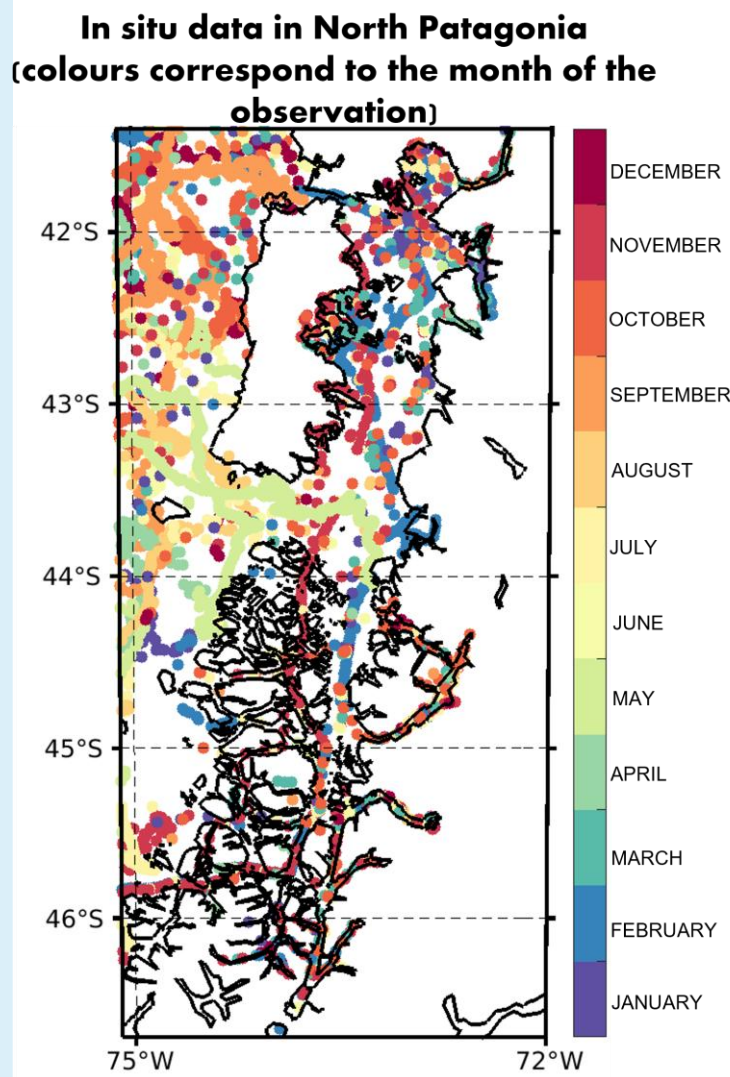
Uses scattered in situ points to generate a continuous field

4D Monthly climatology

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

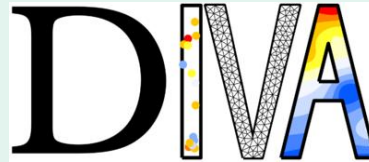


INTERPOLATION OF THE IN SITU DATA



Data-Interpolating Variational Analysis

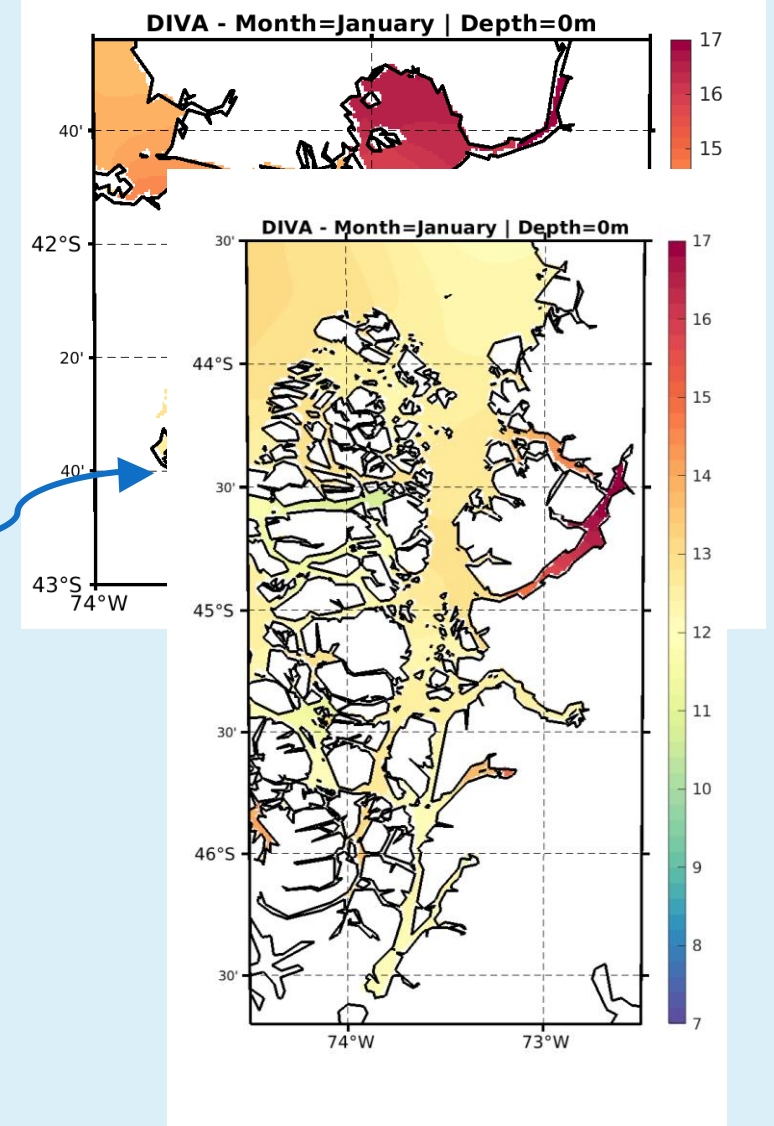
(Troupin et al., 2014)



Uses scattered in situ points to generate a continuous field

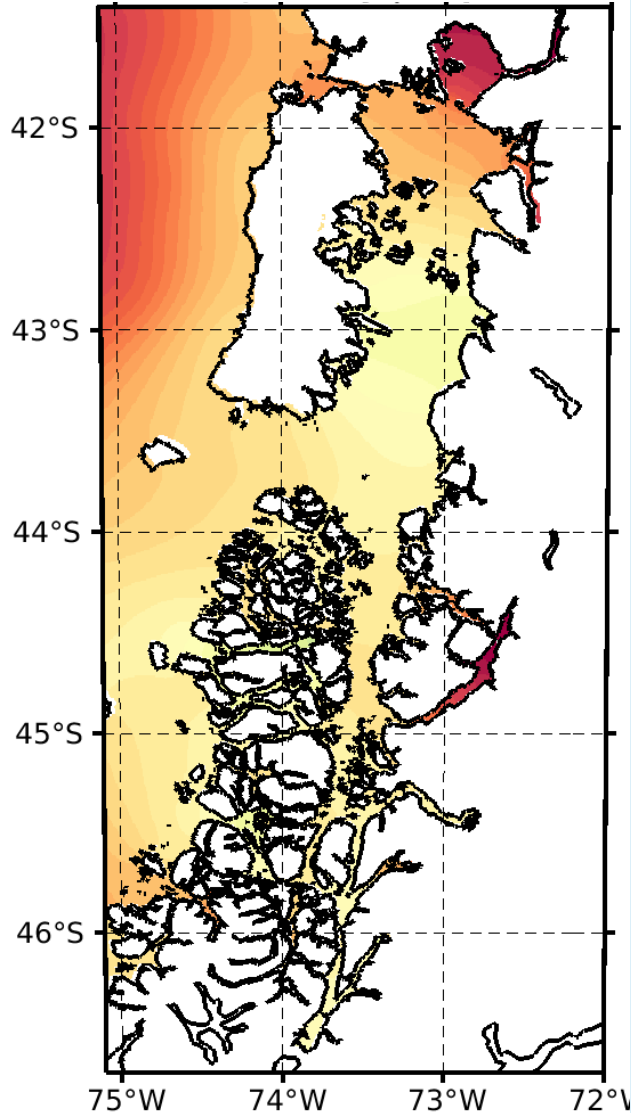
4D Monthly climatology

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

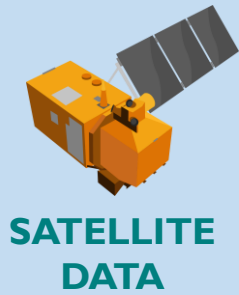
In a fjord-like environment

Long-term
Climatology



- Monthly climatology
- Moving average of 90 days

Local
SST



AQUA MODIS 4km
2003-2023

Gaps

Detection of
the MHWs

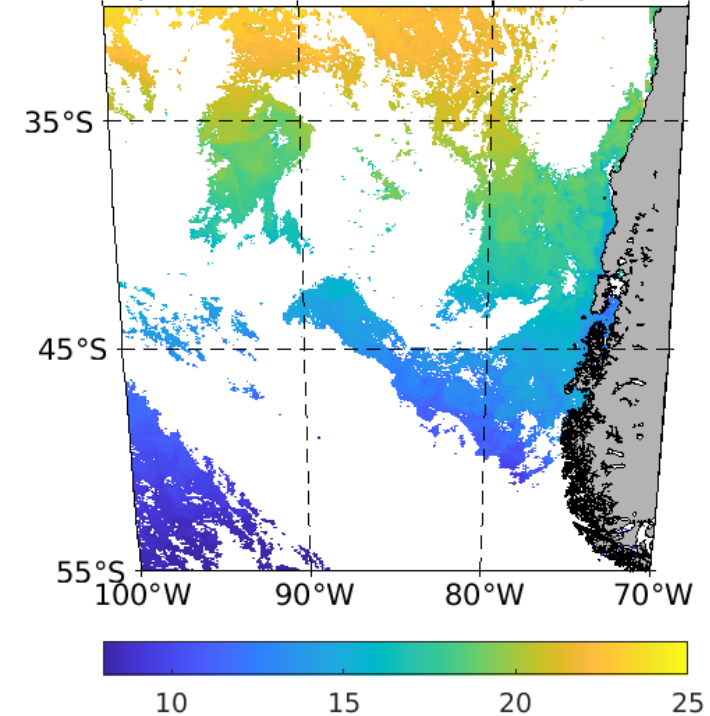
Climatology

Local SST

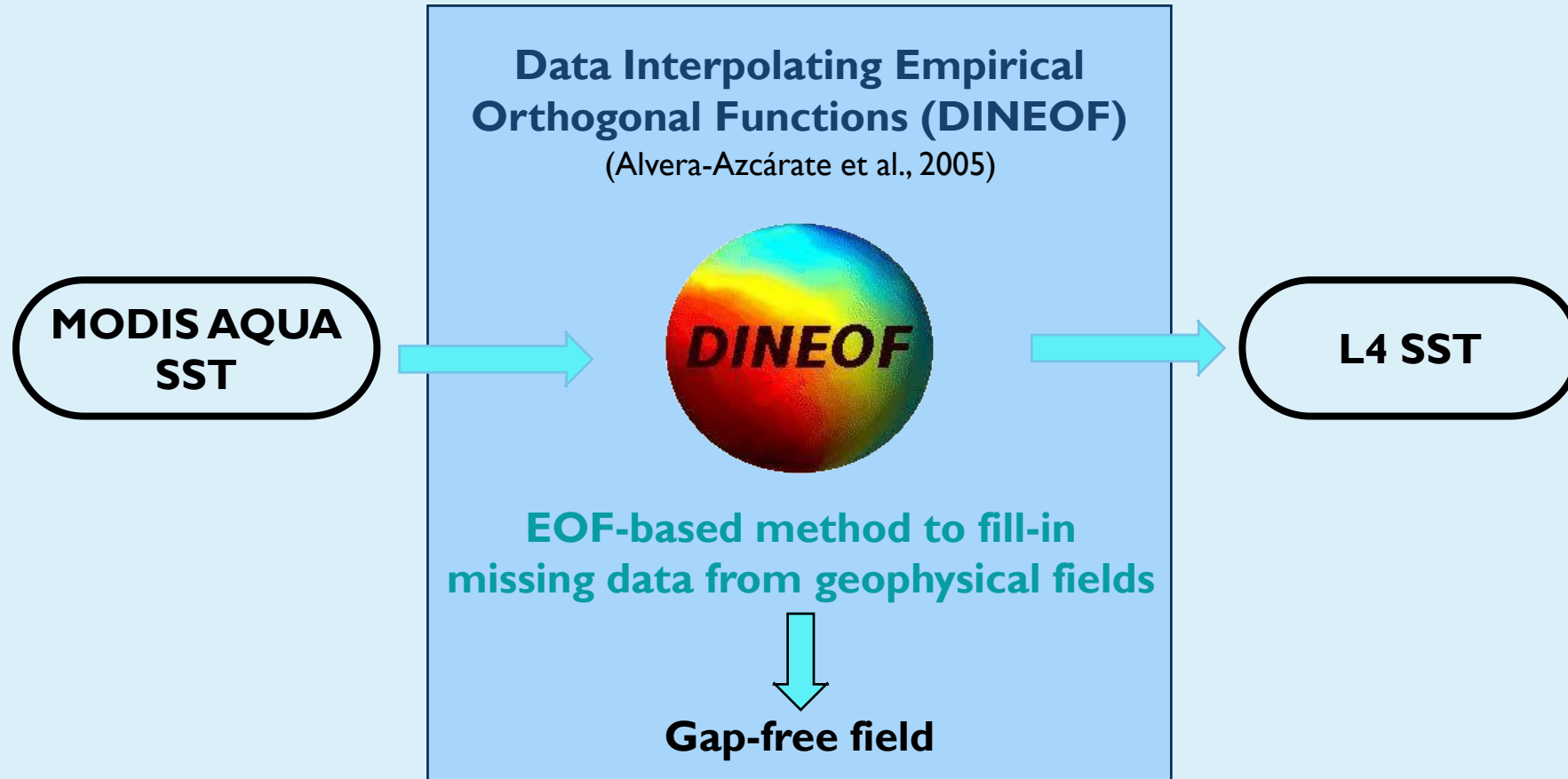


Schlegel and Smit, 2018

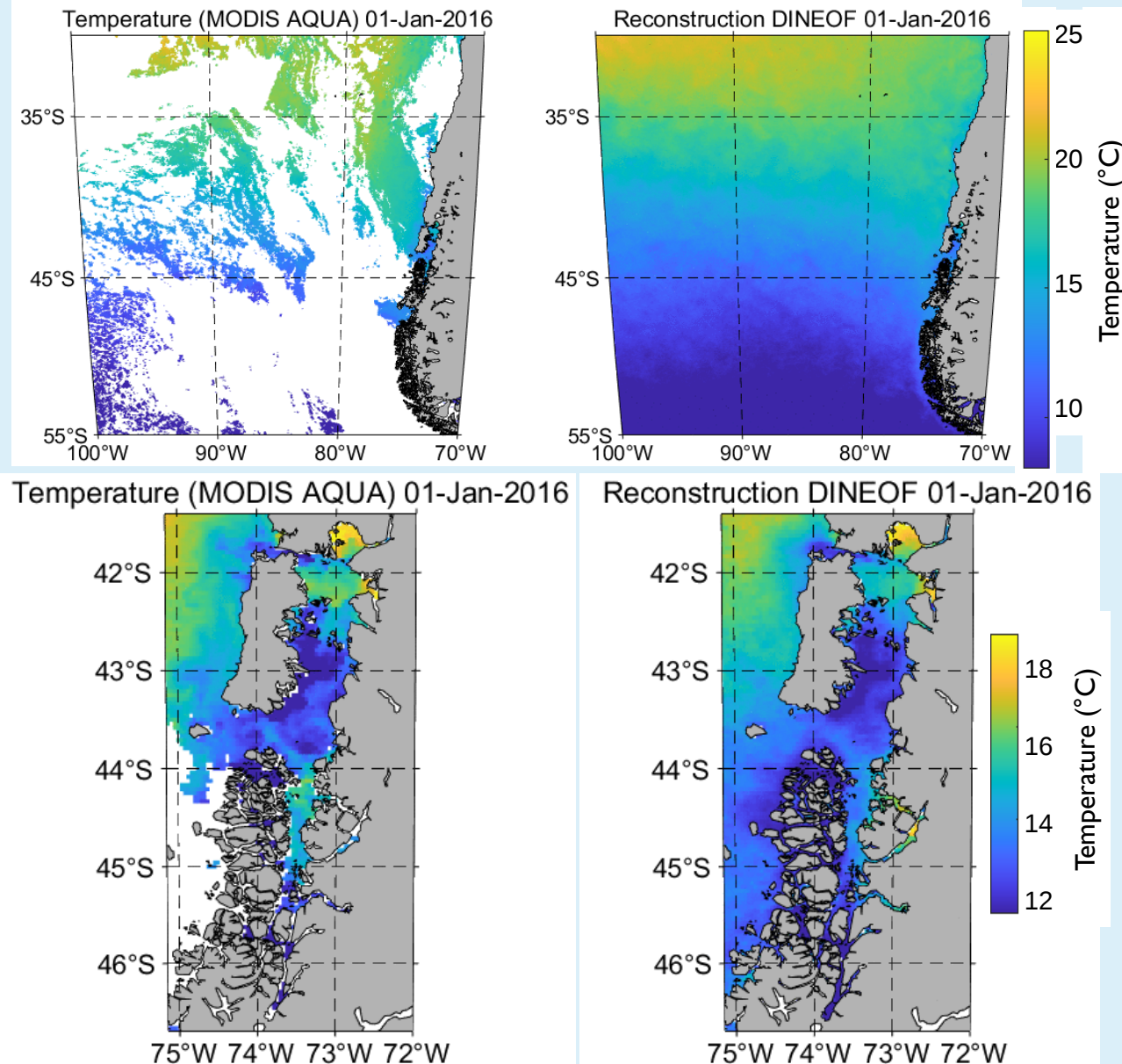
Temperature (MODIS AQUA) 30-Jan-2016



FILLING GAPS IN SATELLITE DATA

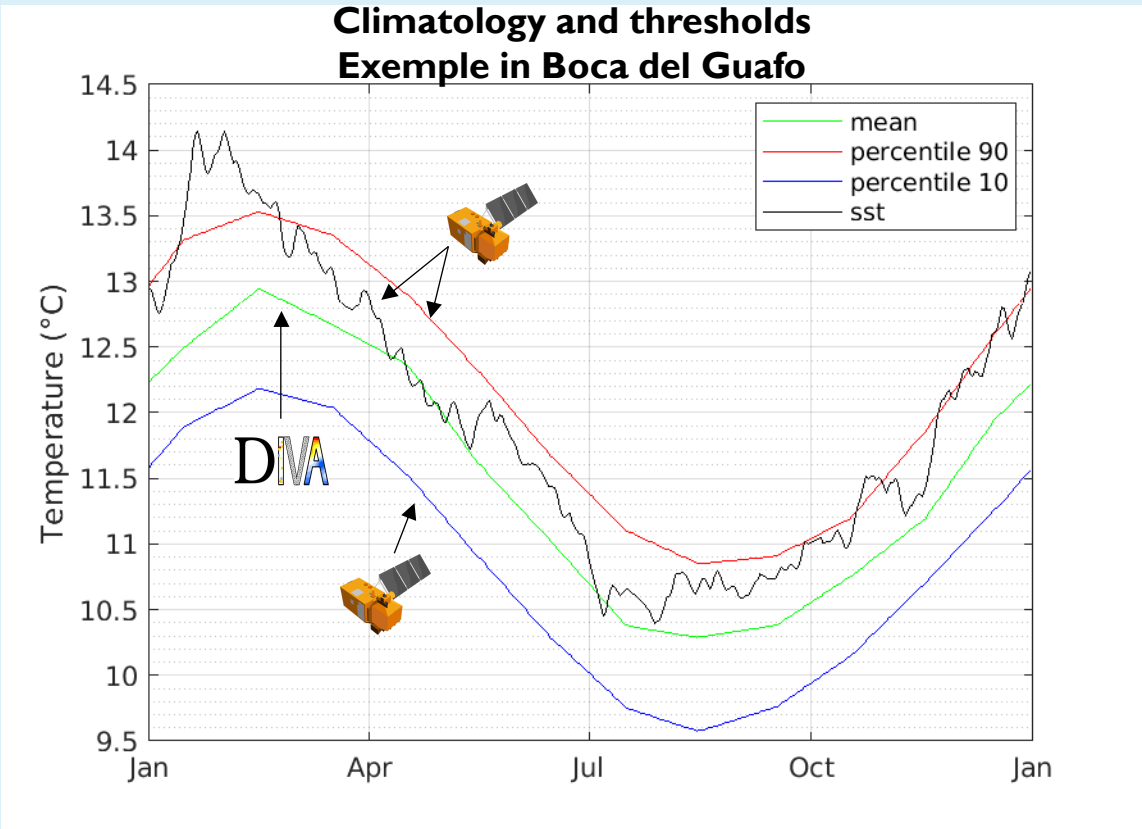
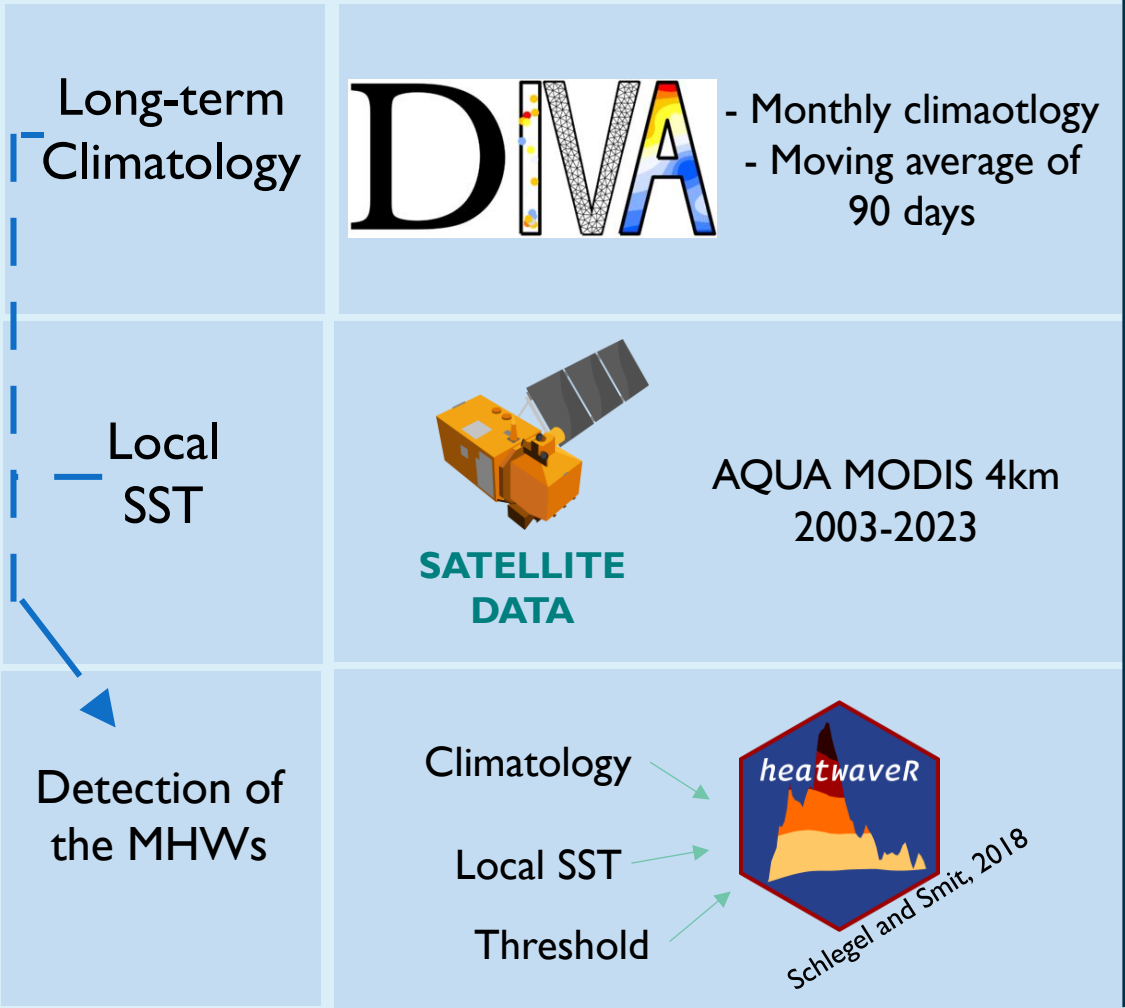


FILLING GAPS IN SATELLITE DATA

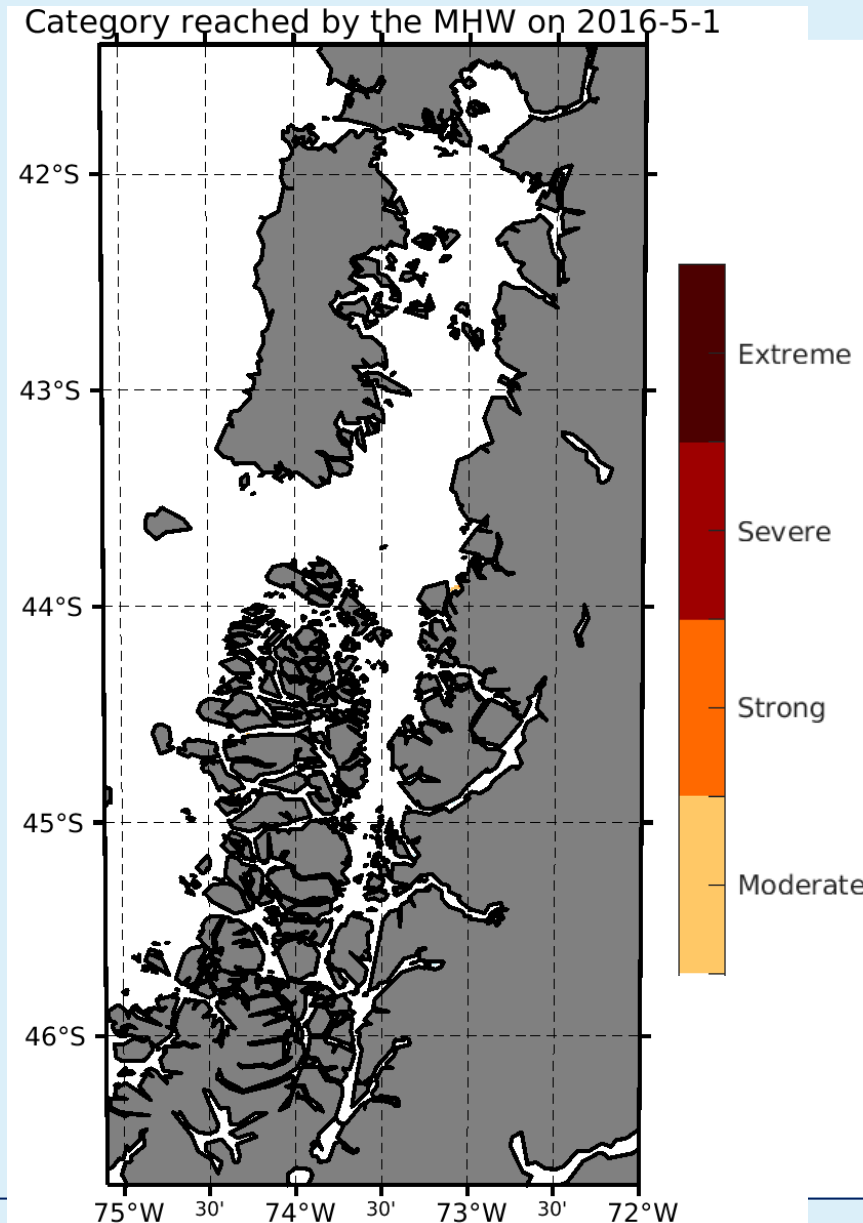


HOW TO DETECT MHWS?

In a fjord-like environment

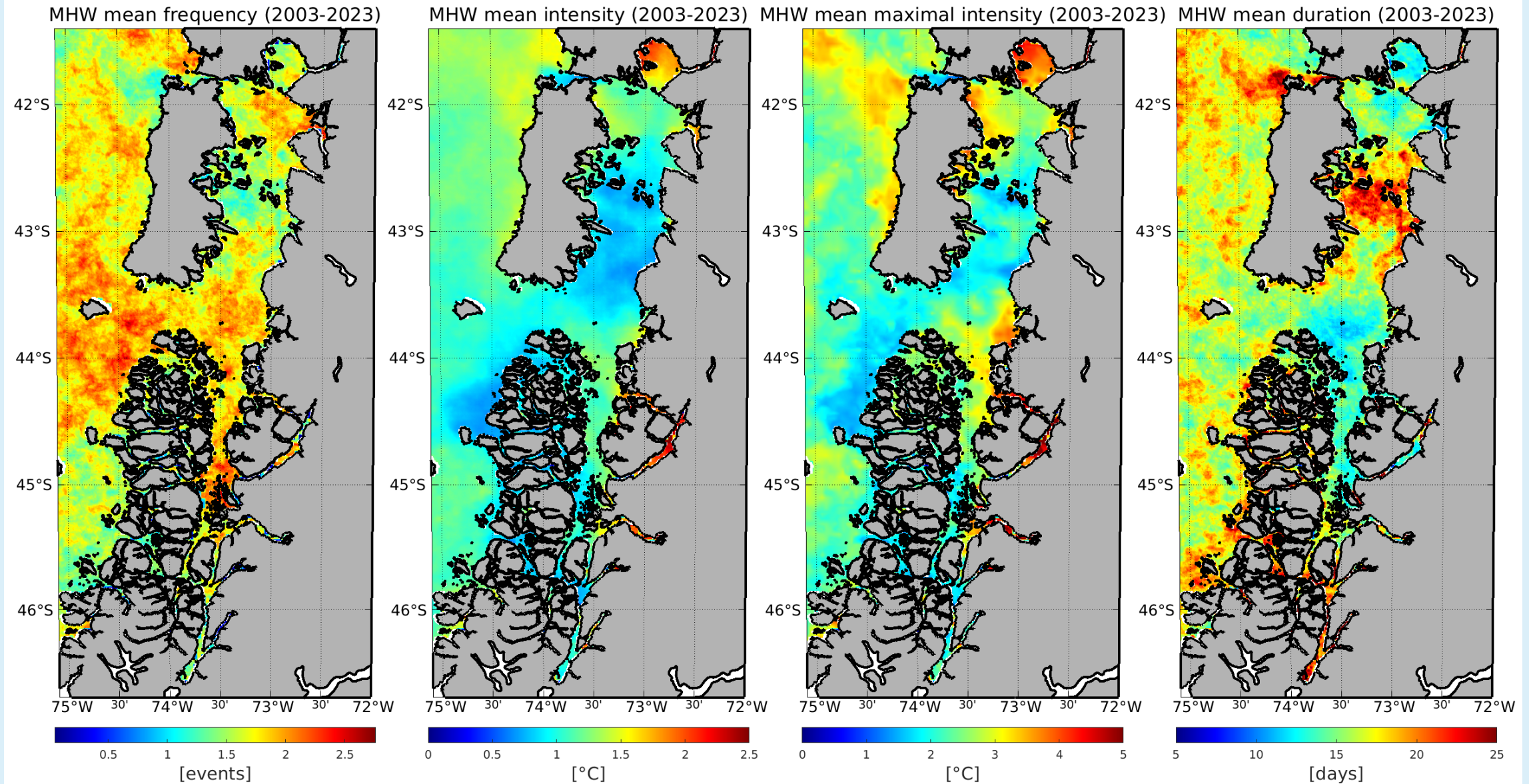


EXAMPLE OF MHW

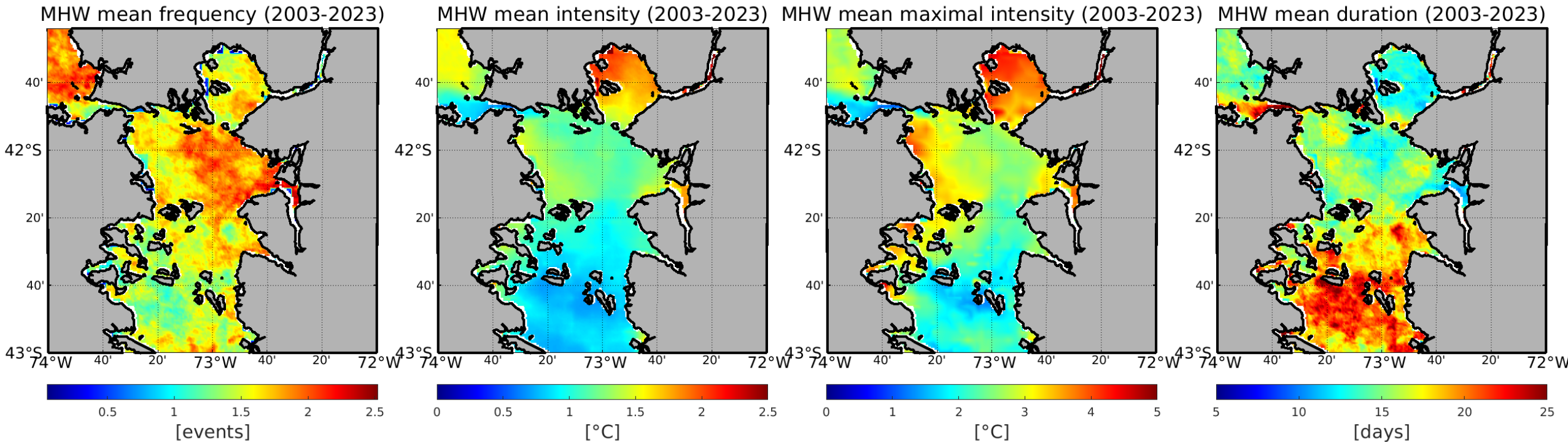


MHW conditions from May 2016
to August 2017

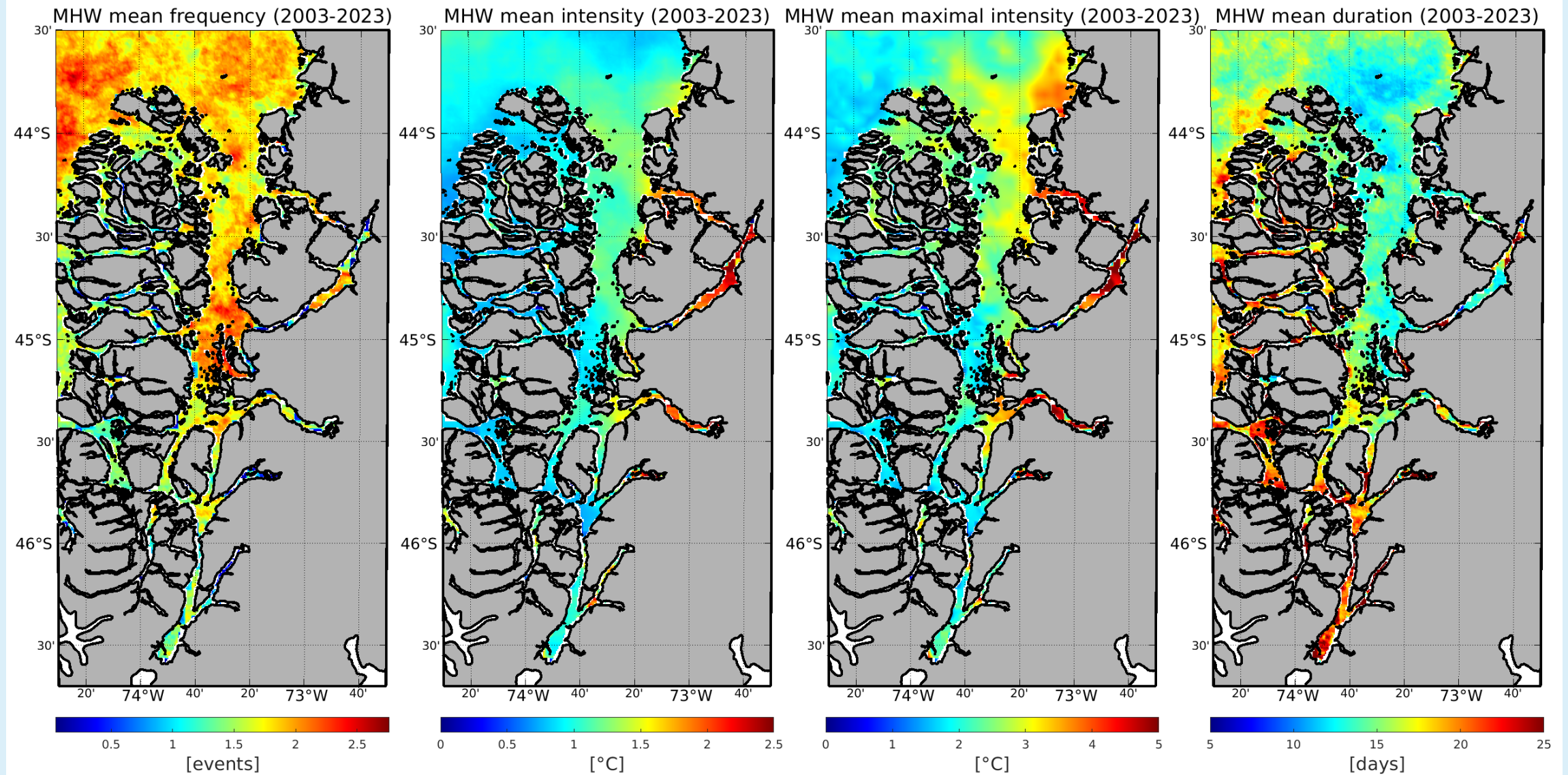
MHWS DURING THE LAST 20 YEARS



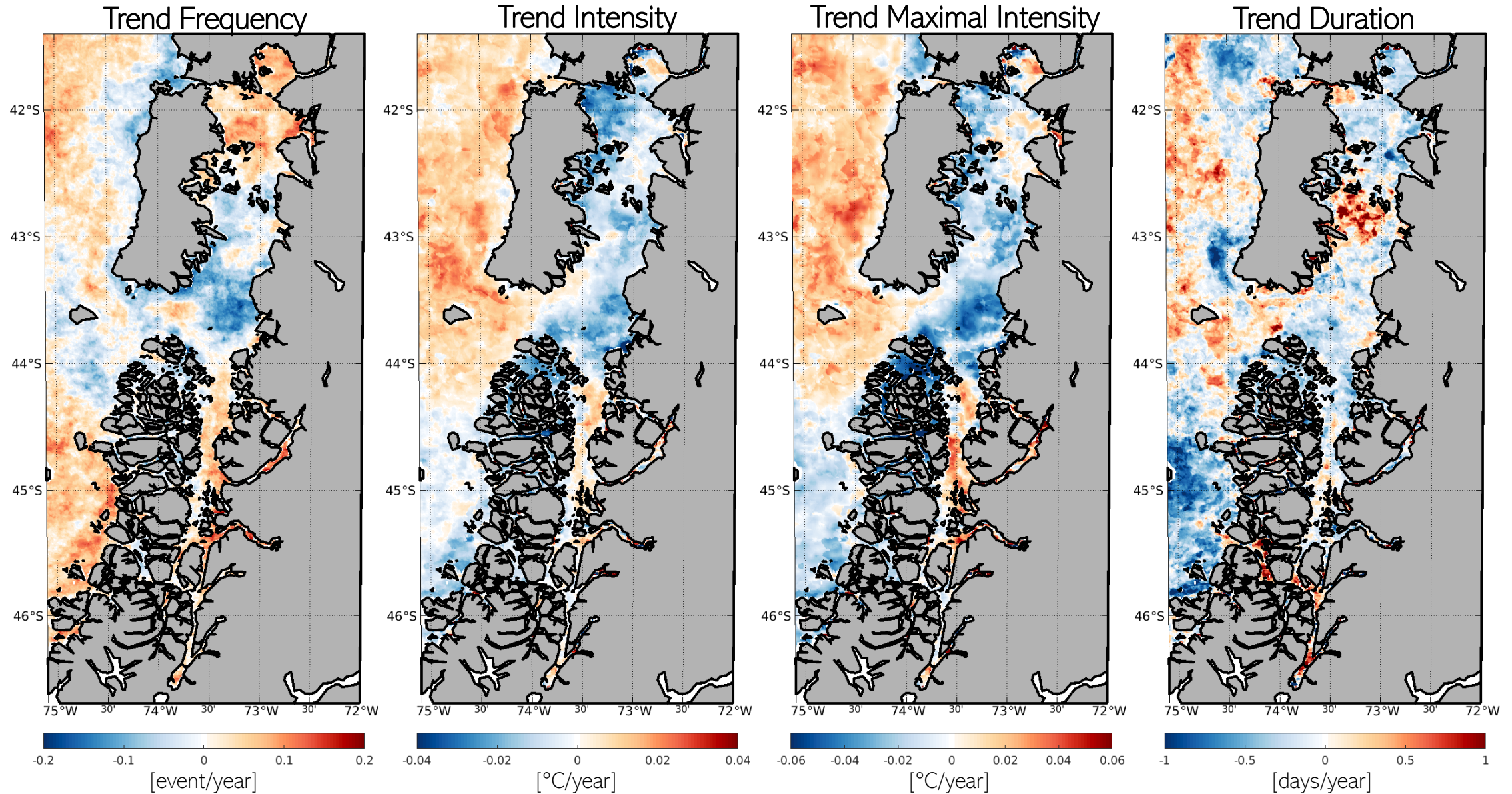
MHWS DURING THE LAST 20 YEARS



MHWS DURING THE LAST 20 YEARS



MHW TREND (2003-2023)



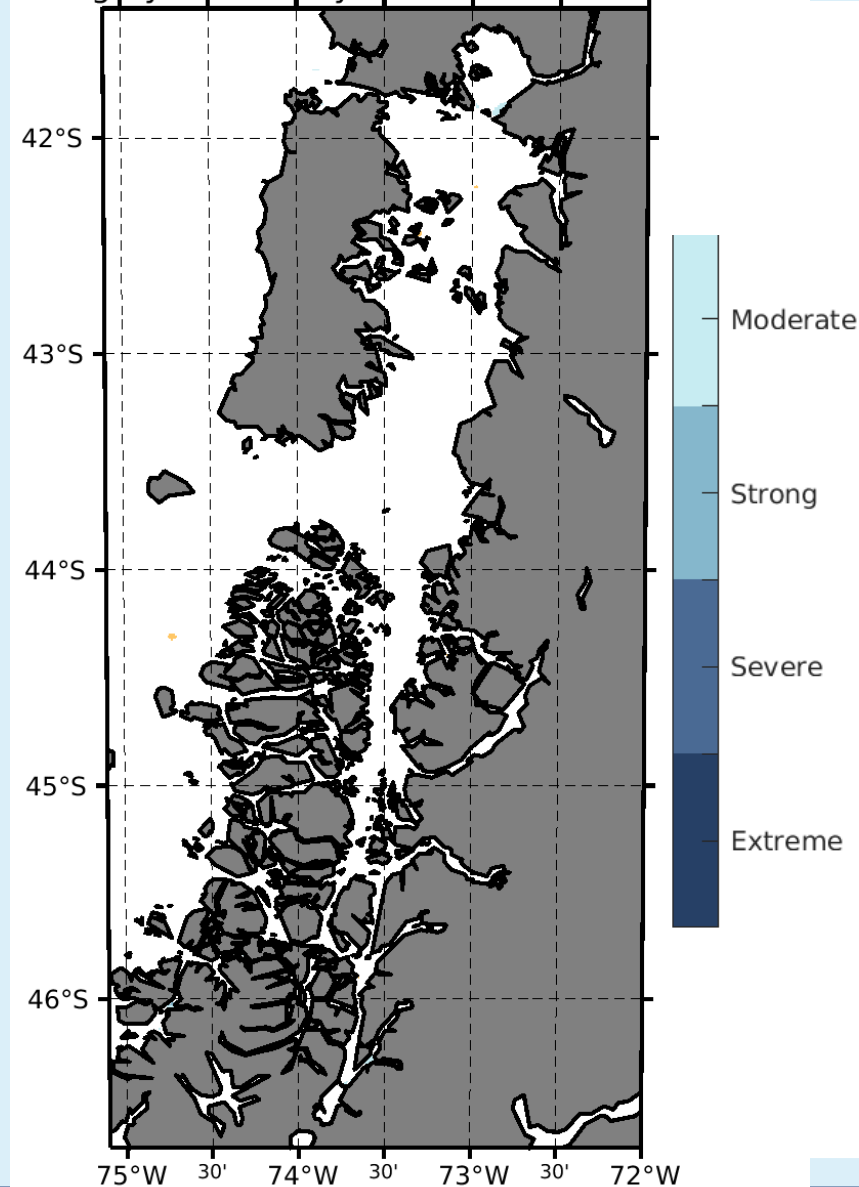
YES, BUT...

MHWs are cool but...

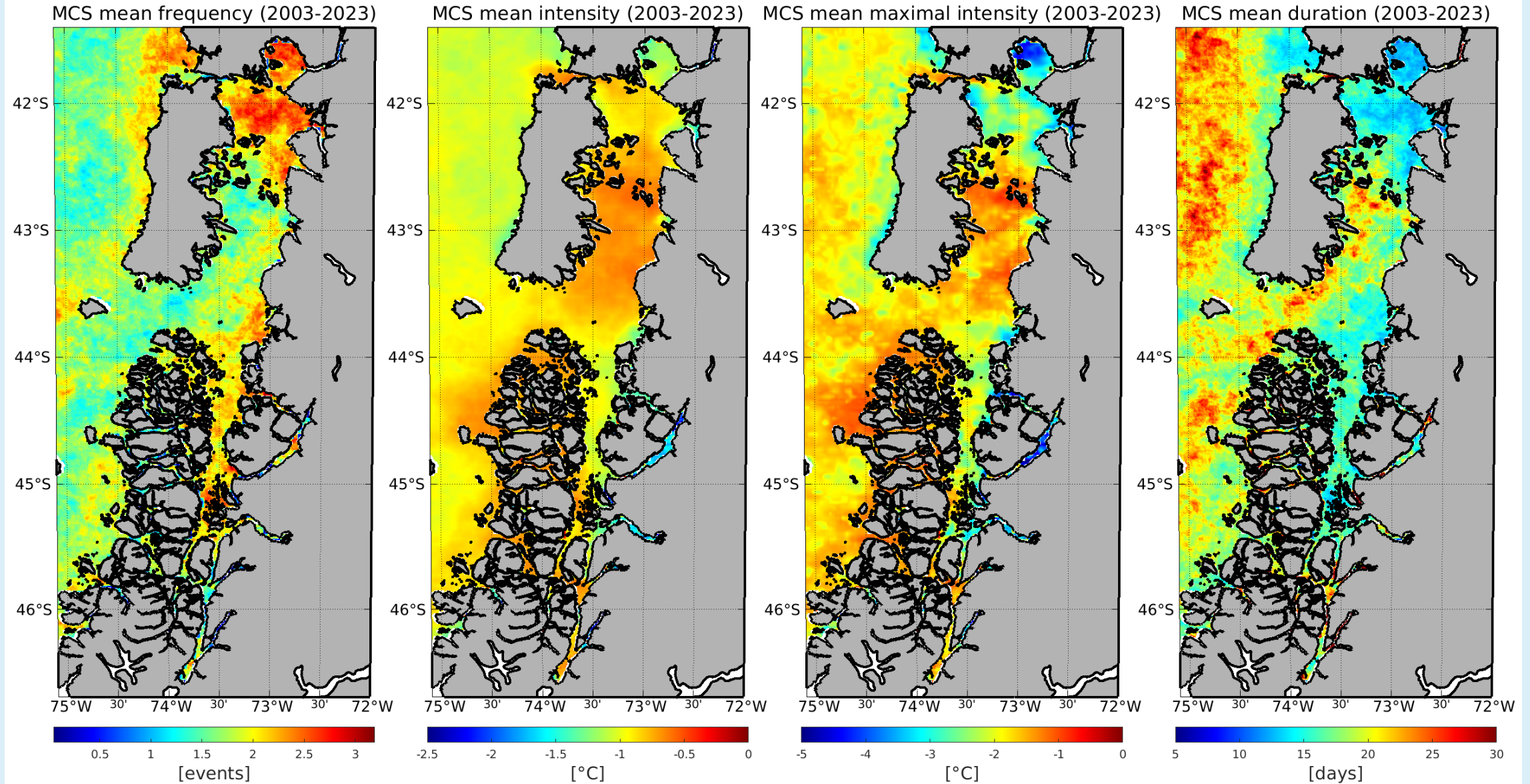
What about **Marine Cold Spells** ?

MARINE COLD SPELLS

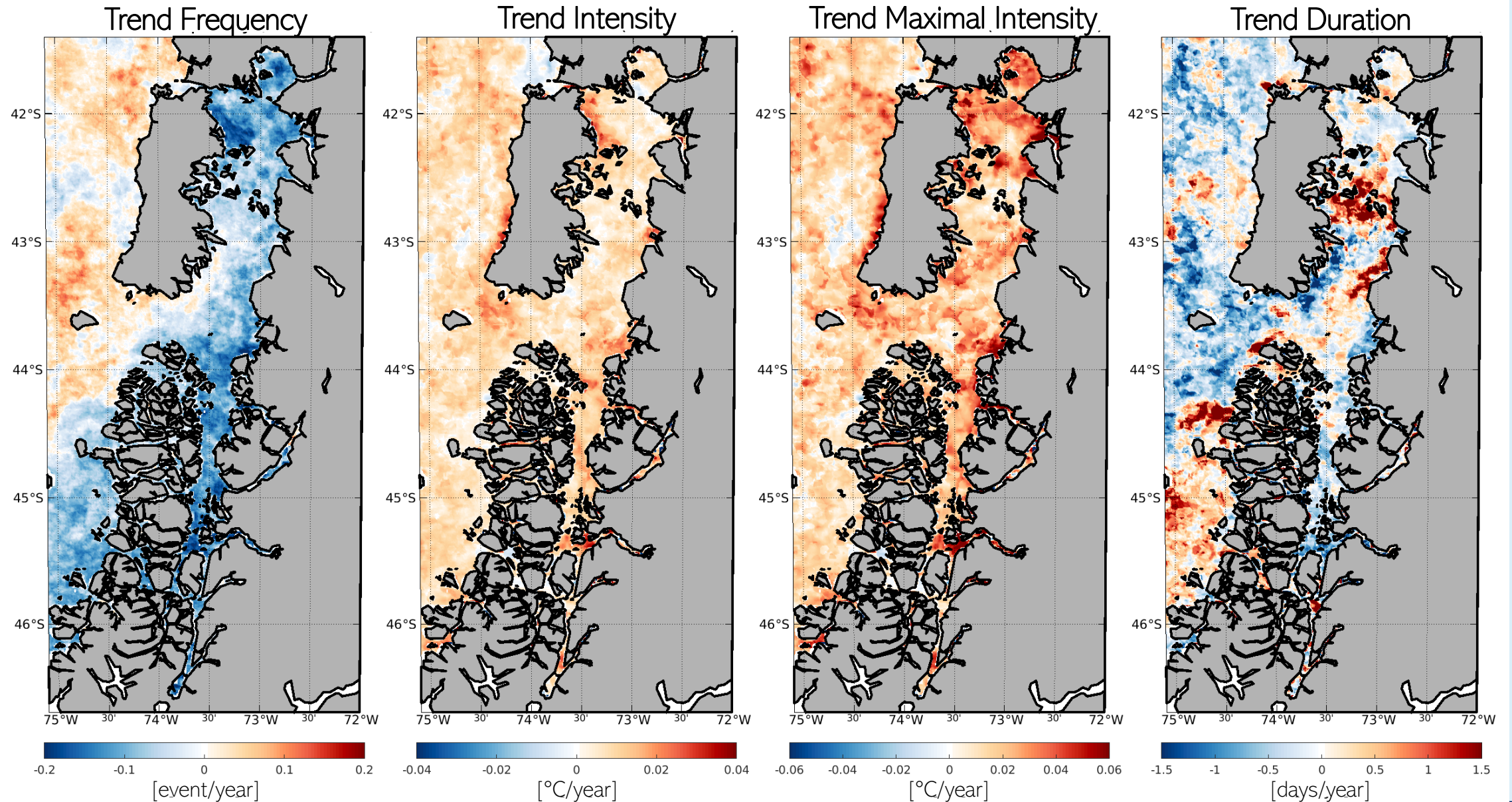
Category reached by the MHW on 2007-3-27



MCS DURING THE LAST 20 YEARS



MCS TREND (2003-2023)

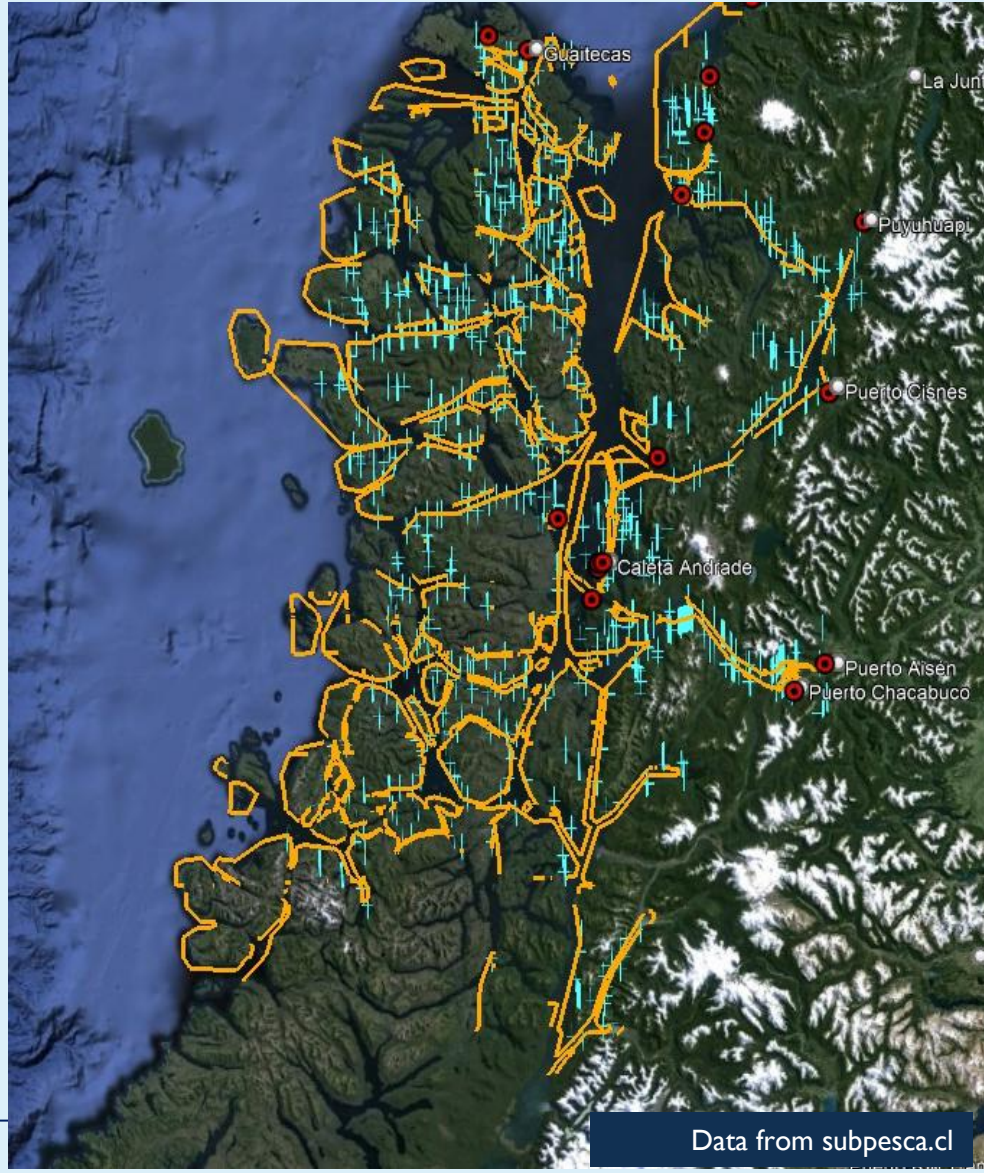
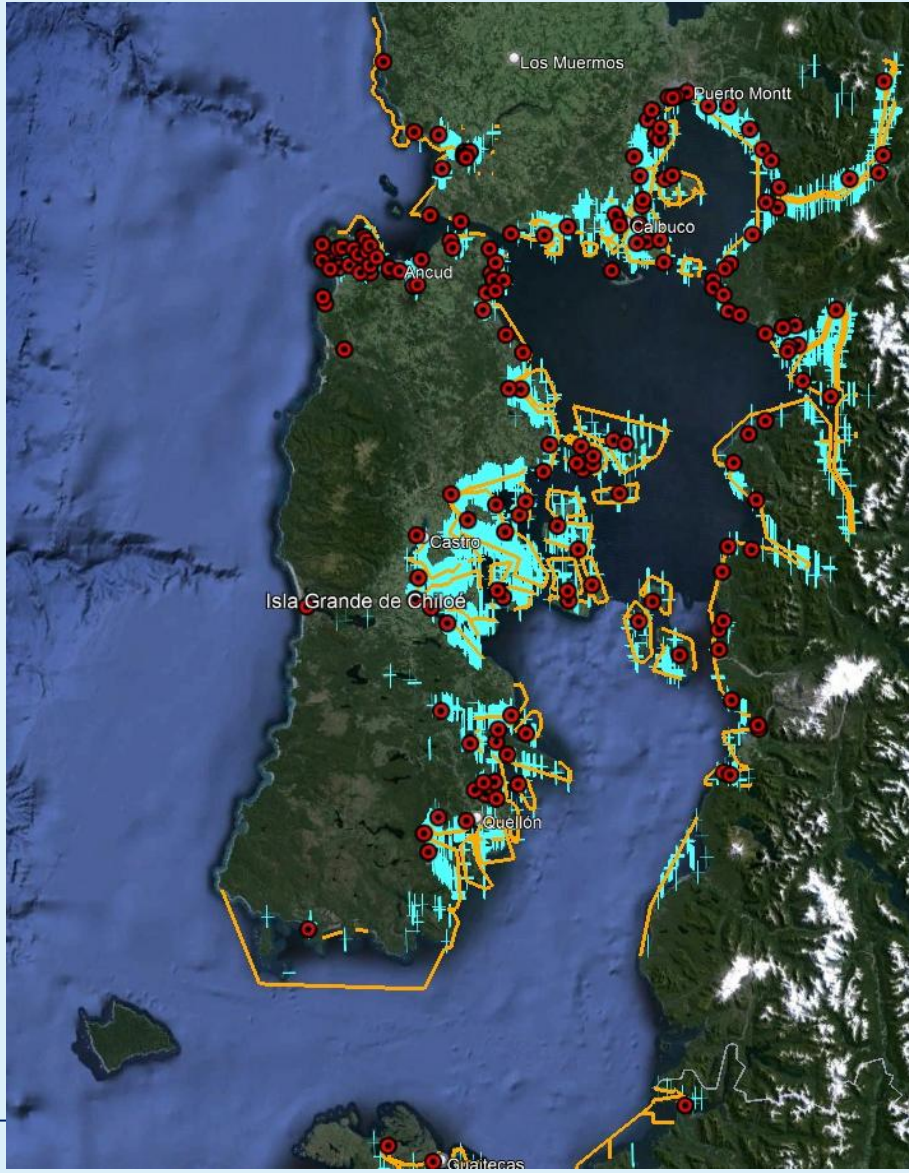


Why is it so important to understand
MHWs/MCSs at high resolution in
coastal environments ?



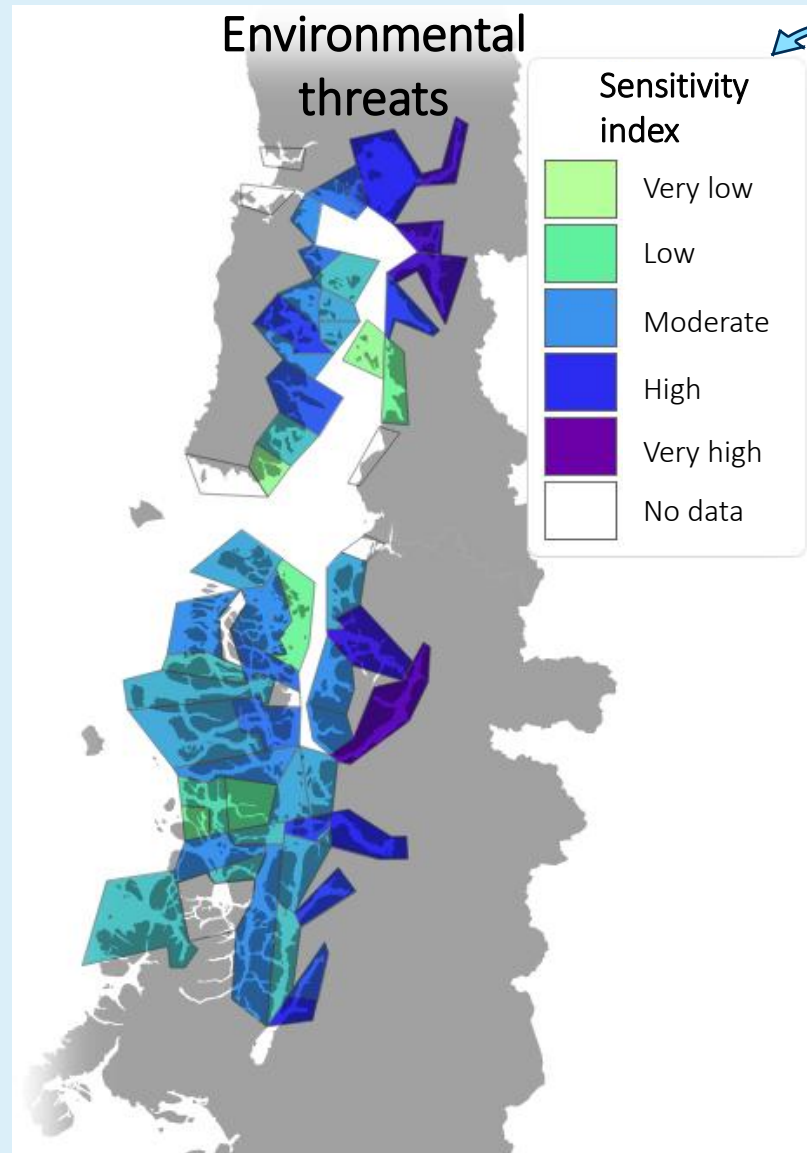
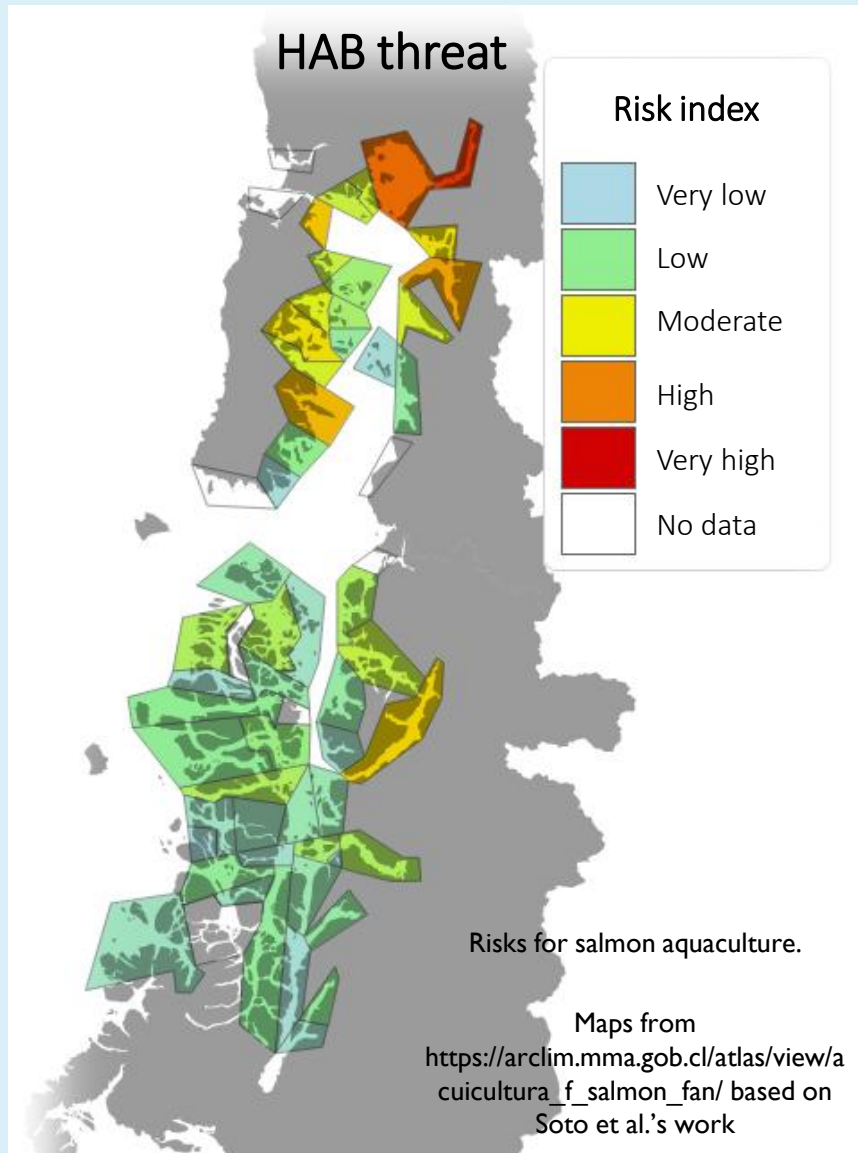
MHWS AND HUMAN RESSOURCES

High productivity area !!



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

RISKS

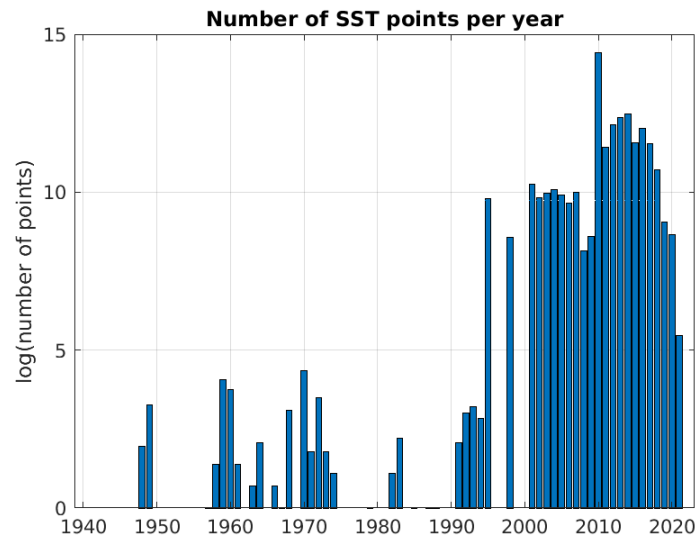
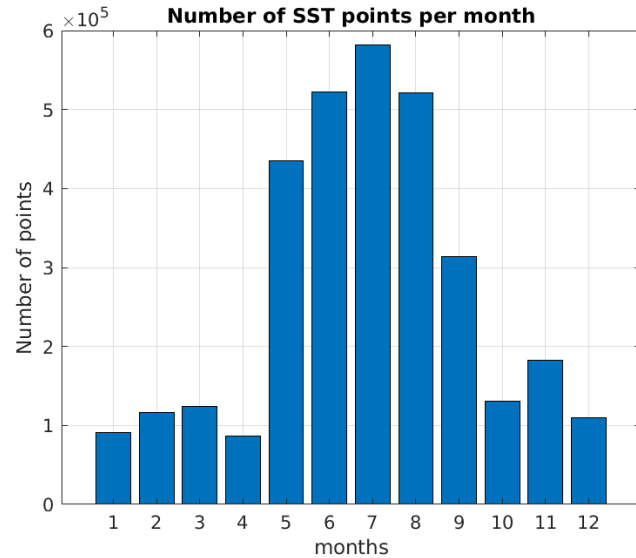


- Water age
- Pre-existence of red tides
- Spatio-temporal variability of surface temperature
- Freshwater inputs

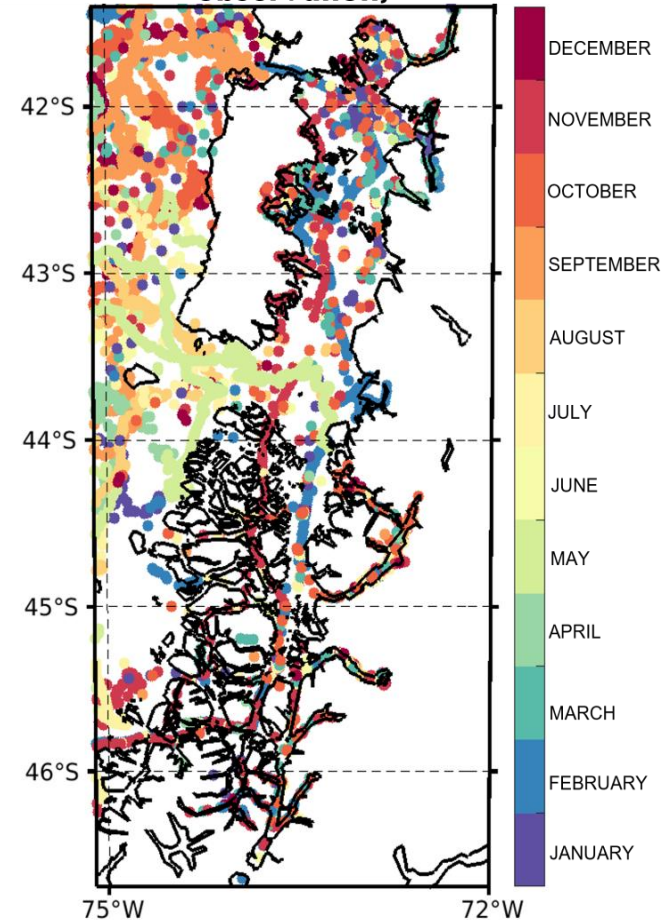
Risks that can be enhanced by MHWs/MCSs

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

IN SITU DATA AVAILABLE

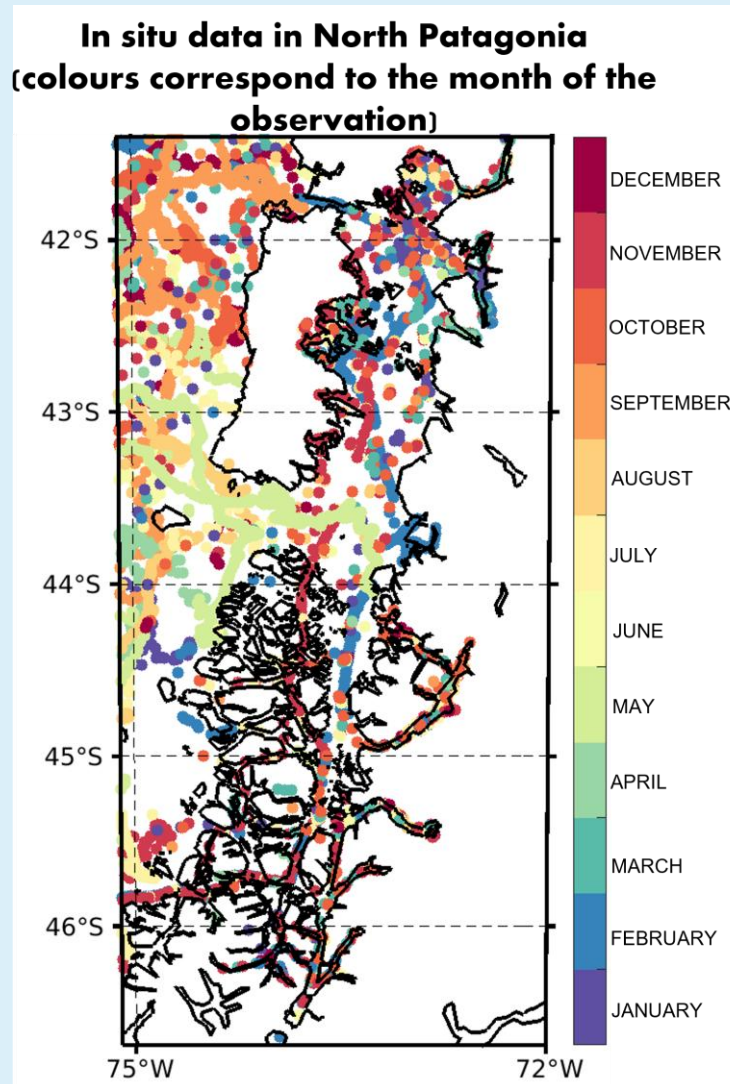


**In situ data in North Patagonia
(colours correspond to the month of the
observation)**



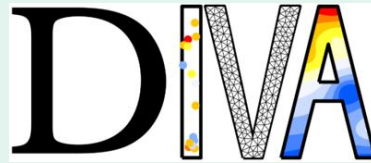
Total number of samples
~ 3 millions

INTERPOLATION OF THE IN SITU DATA



Data-Interpolating Variational Analysis

(Troupin et al., 2014)



Uses scattered in situ points to generate a continuous field

4D Monthly climatology

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

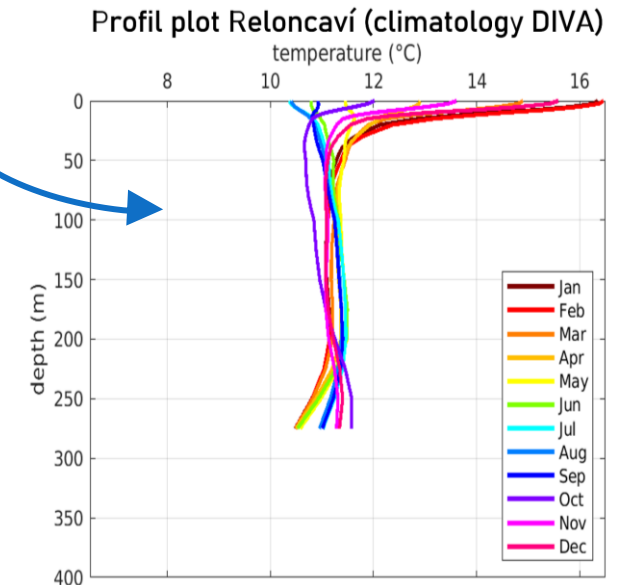
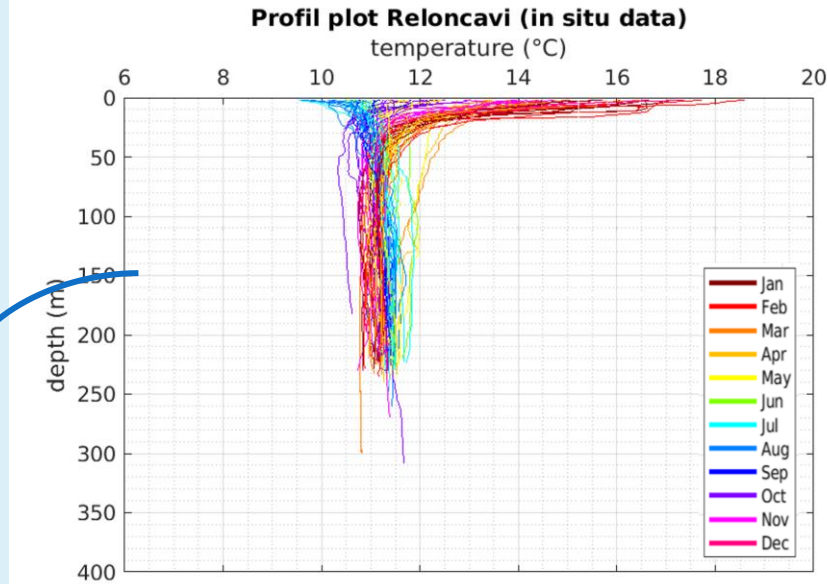
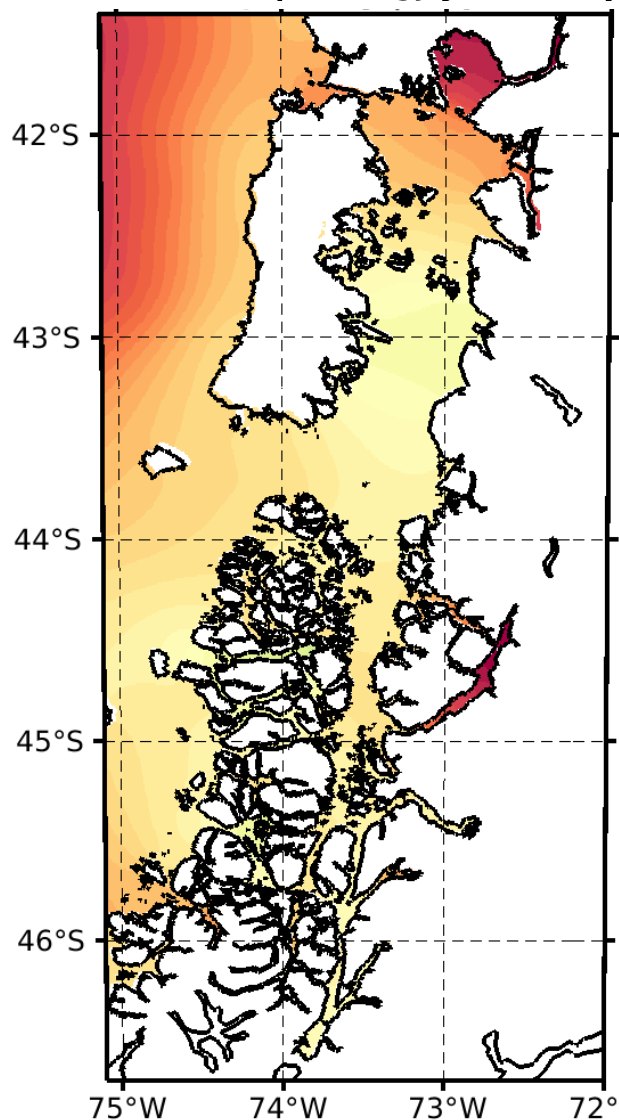


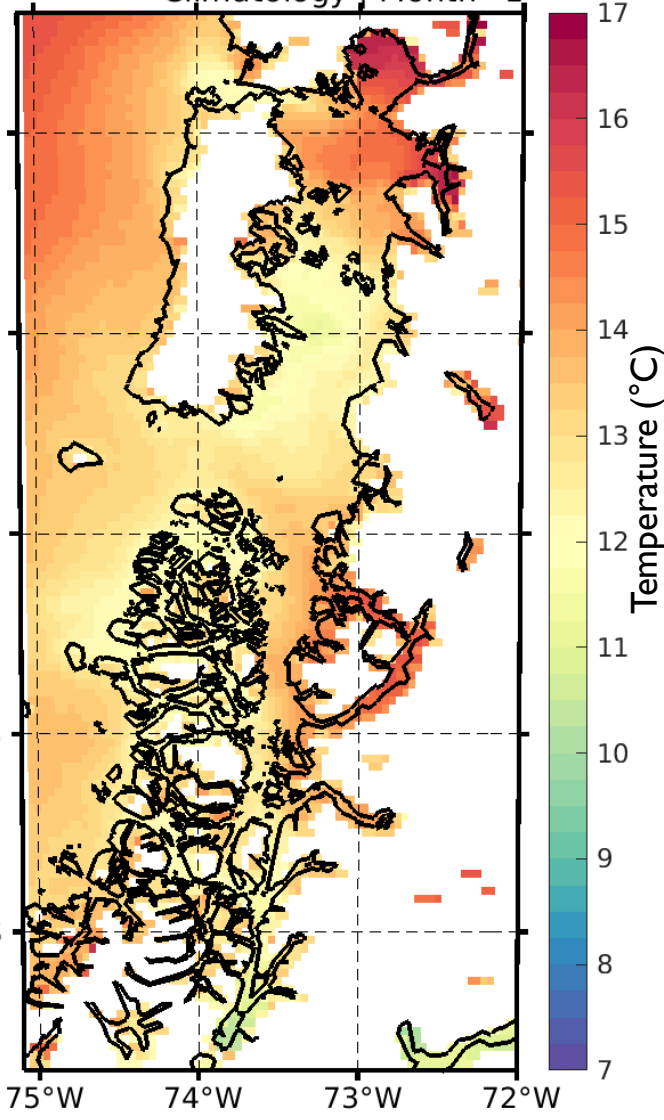
Fig.3. Comparison between profil plots from in situ (up) and DIVA climatology (down) in the Reloncavi Sound

VALIDATION OF THE CLIMATOLOGY

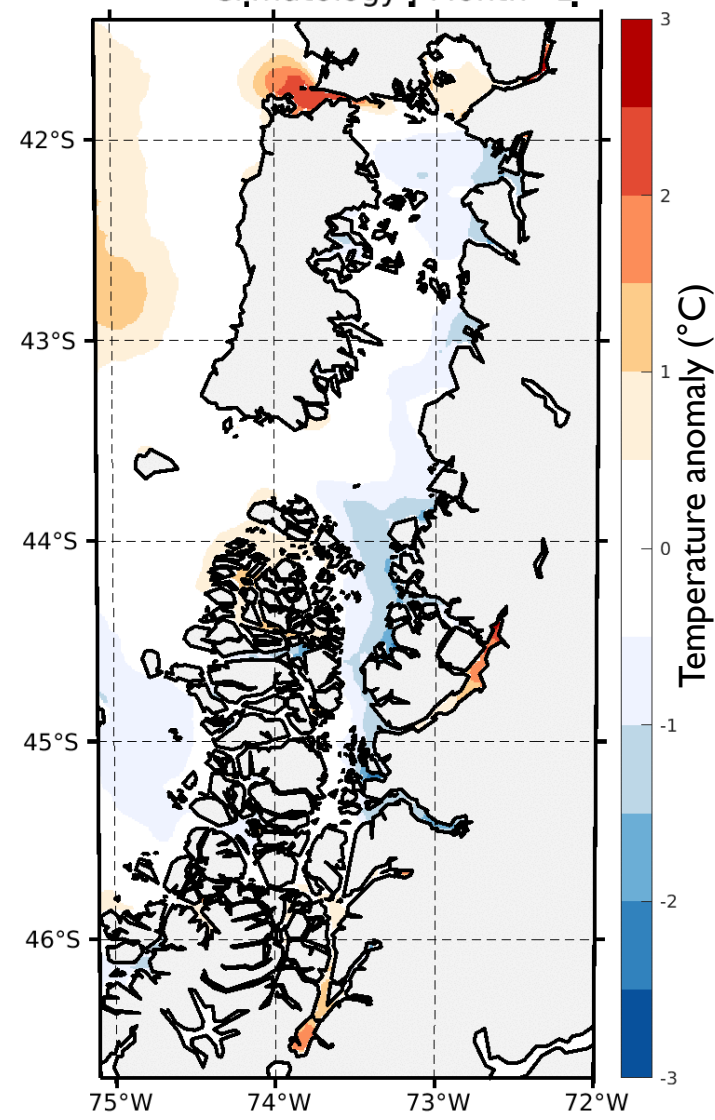
DIVA reconstruction
Climatology | Month=1



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

