Heat and salt fluxes in the San Matías Gulf, Argentina

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Objectives:

- Implement a high resolution regional ocean model to study the heat and salt fluxes across the mouse of San Matías Gulf
- Calibrate the regional model with in-situ data obtained from observational data.
- Find which are the main mechanisms or forces that governs fluxes.
- Analyze gulf waters renewal and residential time.
- Extend mouse transport time series with altimetry data.

CNES PROJECT SABIO Studying physical processes in the Southwestern Atlantic to understand BIOlogical productivity & regional ecosystems

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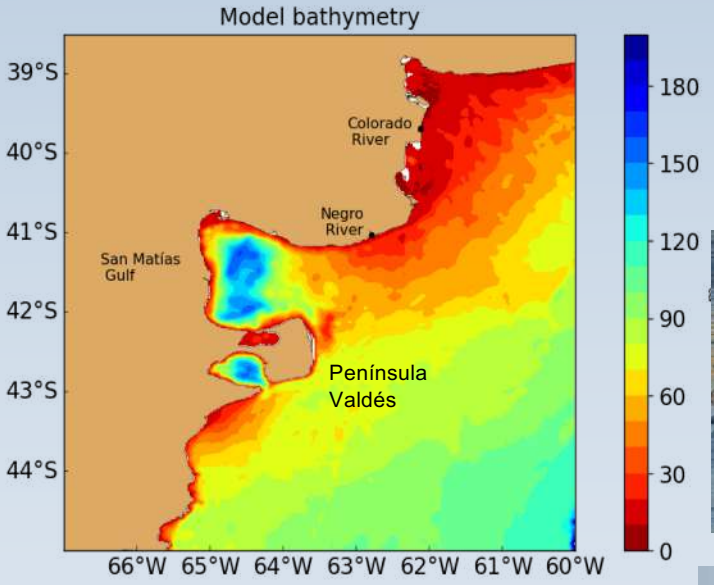
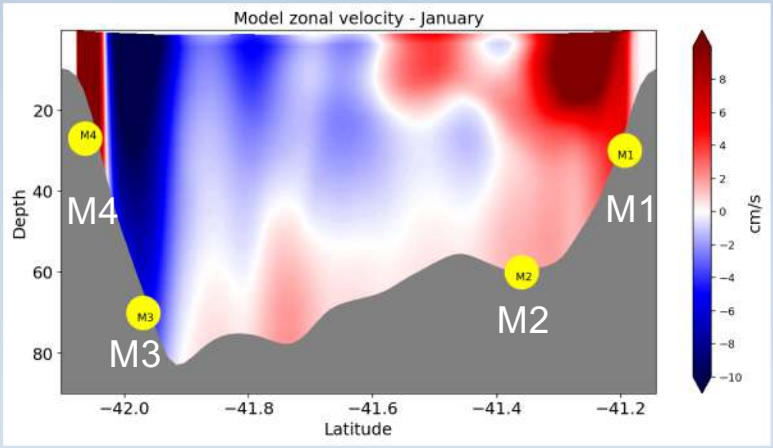
CONICET I P A T E C

Why is important?

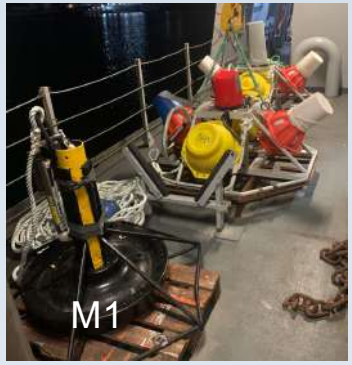
- The San Matías Gulf, located between 40-42°S and between 63-65°W, is a semi-enclosed basin with maximum depths close to 200 m in its center. Its total extension is approximately 19.500 km^2, and its mouth is about 100 kilometers long.
- Area of rich biodiversity (birds, whales, orcas, sea lions, elephant seals, Magellanec penguins).
- Larvae spawning and recruitment of marine species populations.
- Commercial and artisanal fishing (8.500 tons/yr hake, 640 tons/yr shellfish, 6.800 tons/yr of other commercial species)
- This local fisheries represent 20 million dollars and 850 jobs.
- Ecological tourism (Península Valdés is a nature reserve listed as a World Heritage Site by UNESCO in 1999).

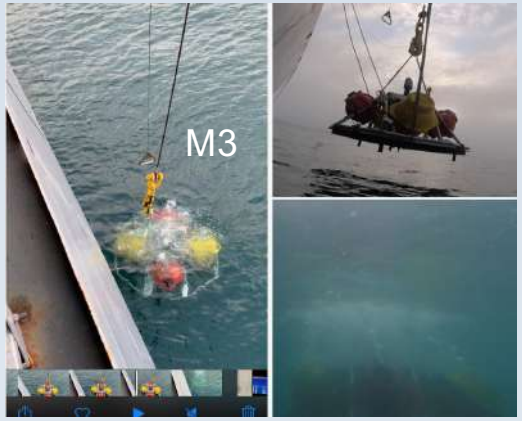


Moorings in the gulf mouse

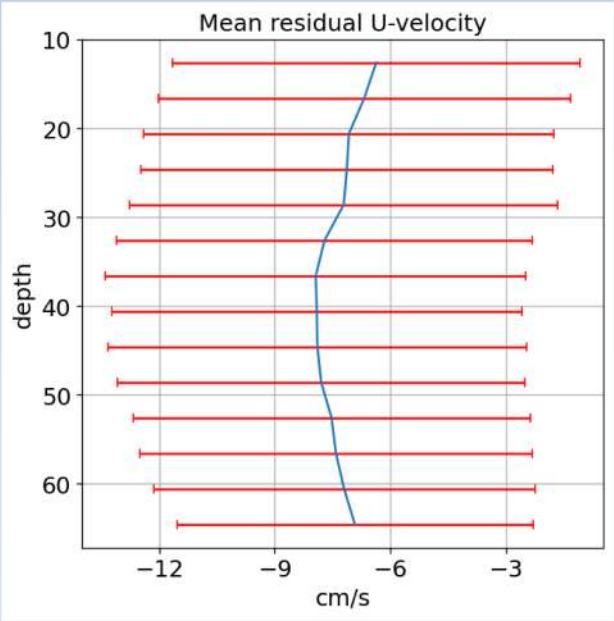


Mooring	Instruments	Recording
M1	CTD (SBE 37)	Start : 6-sept-2021 Stop : -
M2	ADCP (Aquadopp 400) CT (SBE 37)	Start : 6-sept-2021 Stop : -
M3	ADCP (Aquadopp 400) CTD (SBE 37)	Start : 6-sept-2021 Stop : 9-Nov-2021
M4	CT (SBE 37) P (SBE 26)	Start : - Stop : -

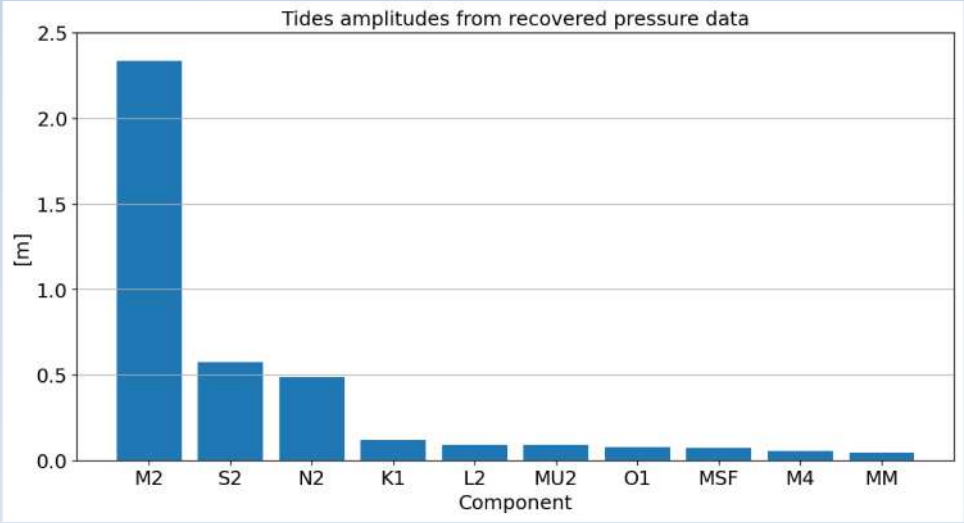




M3 recovered instruments data



Mean and std of de-tided zonal velocity profiles from ADCP, 2 hs frequency outputs from 6/9 to 9/11.



Tide amplitudes from harmonic analysis using CTD pressure data, 10 minutes frequency from 6/9 to 9/11.

- **ADCP**: barotropic structure, large tidal currents (± 2 m/s), first in-situ confirmation of input of waters to the SMG. **This profiles were used to calibrate the model bottom friction parameter**.
- **Pressure**: M2-S2-N2 representing more than 90% of tidal energy.

San Matías Gulf – Model Setup

Regional Ocean Model : CROCO

Type : Climatological run

Spin-up : 3 Years

Horizontal resolution : 1.3 km

Vertical levels : 20 (terrain following)

Bathymetry : Gebco 2021

Boundary forcings : Climatological data (2011-2020)

Atmospheric forcing : ERA 5

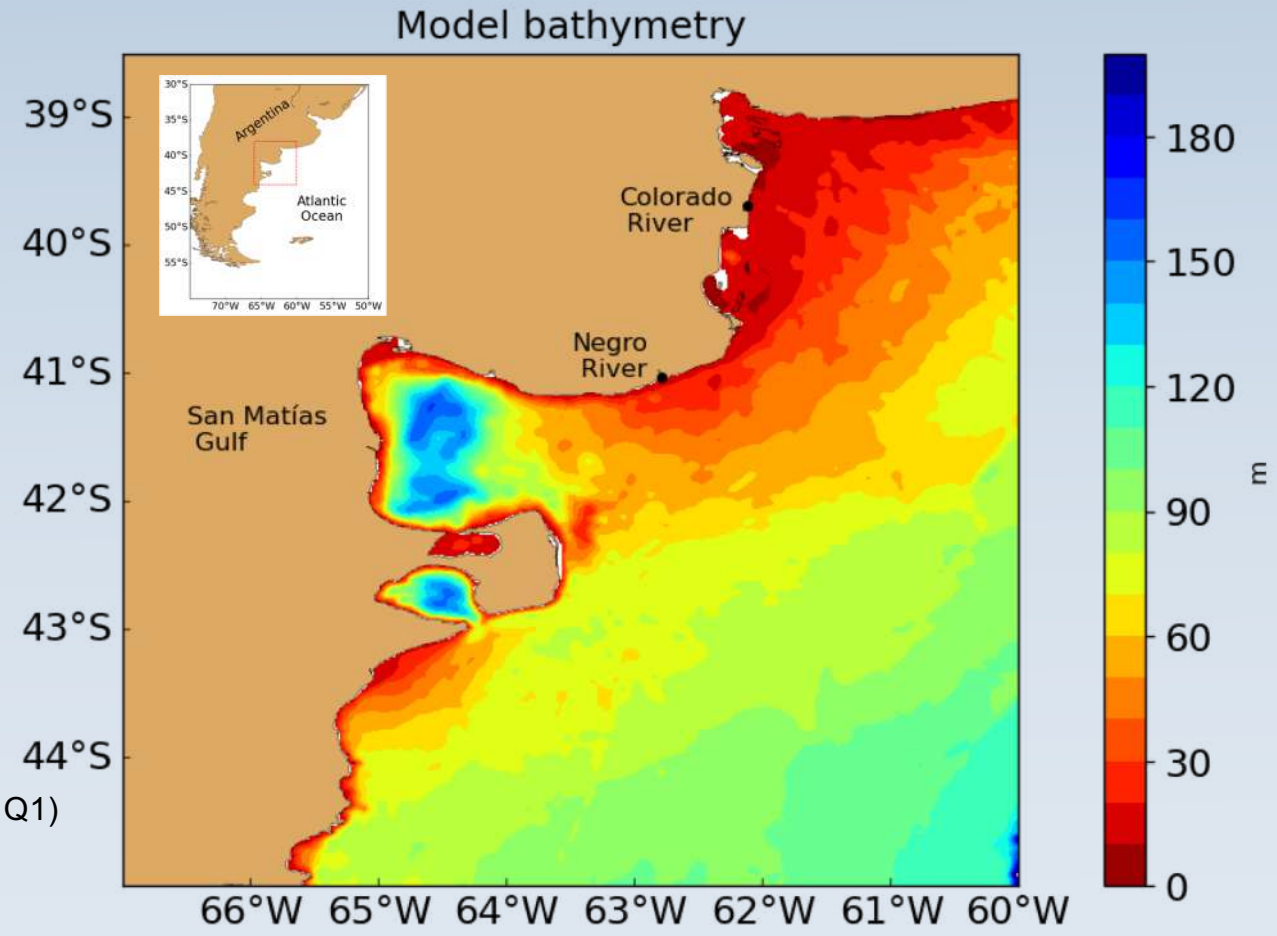
Ocean forcing : Mercator Glorys 12

Tidal forcing : TPXO9 (M2 S2 N2 K1 K2 M4 Mm O1 P1 Q1)

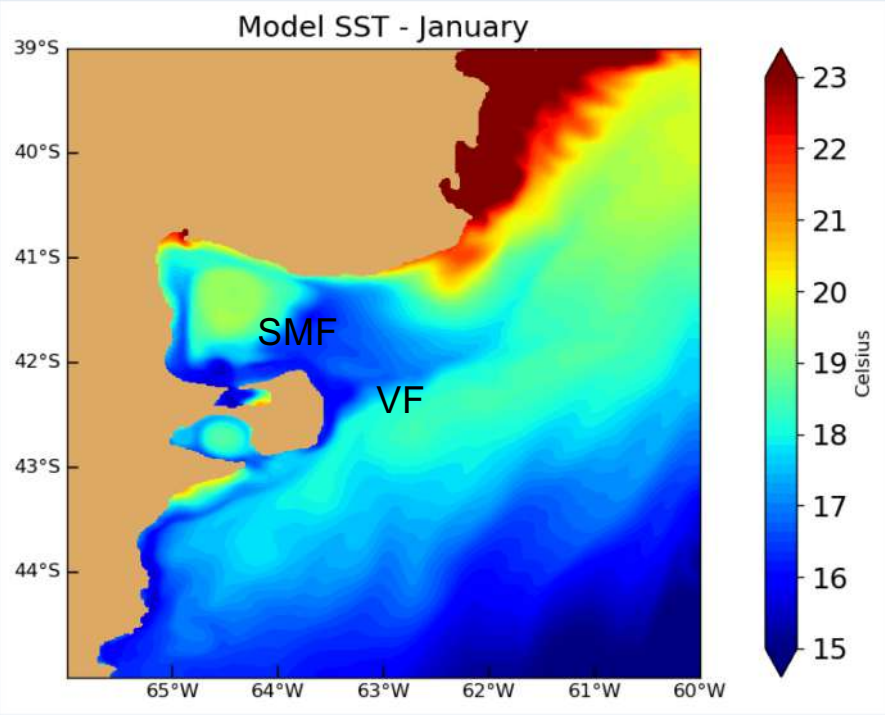
Surface heat flux : Relaxing towards MODIS SST

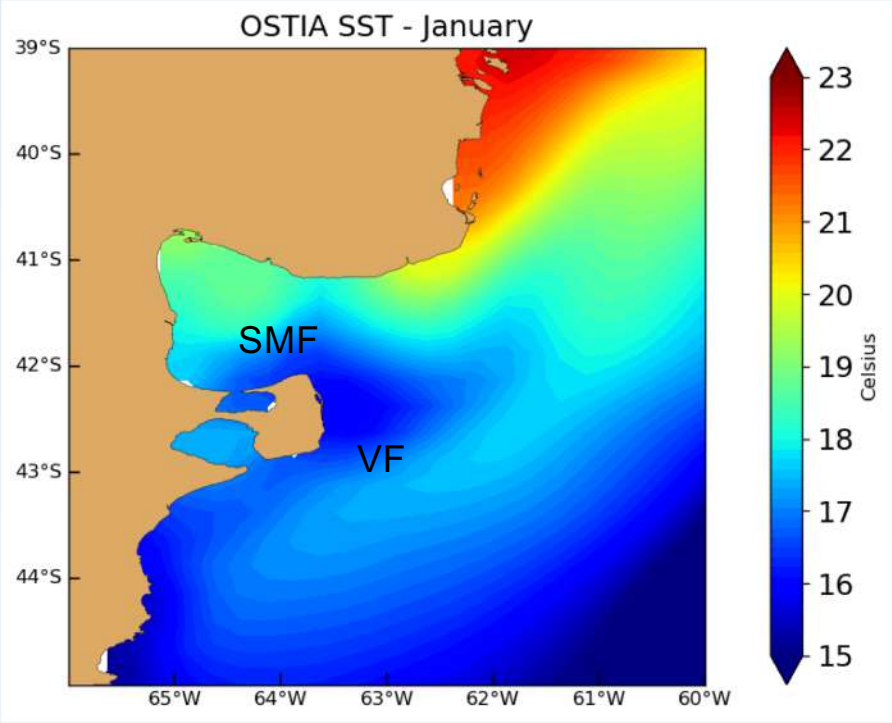
Botton friction : Logarithmic profile

River discharge : Sistema Nacional de Información Hídrica



San Matías Gulf – Model Validation



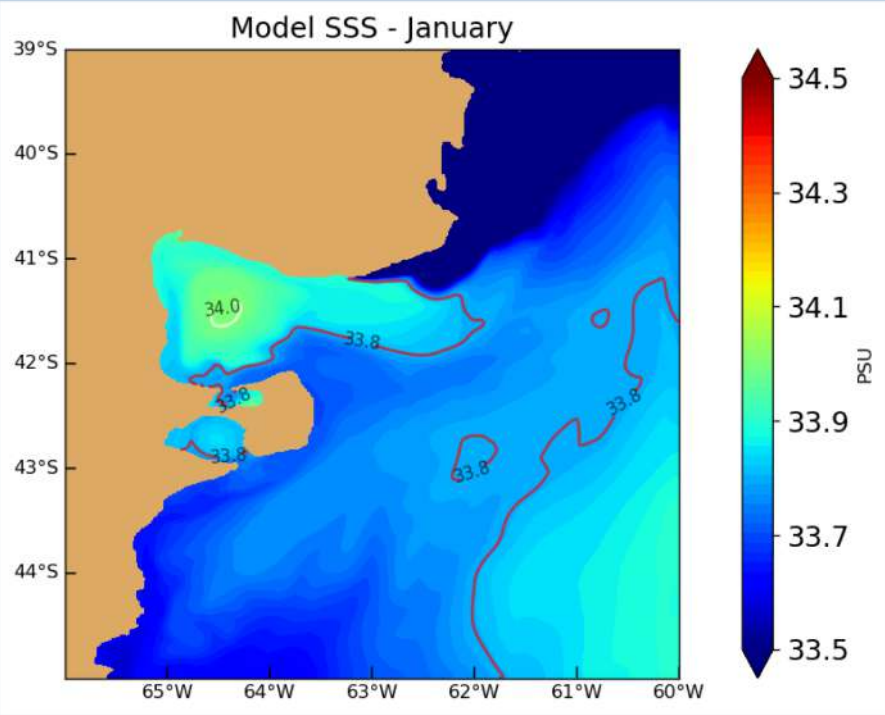


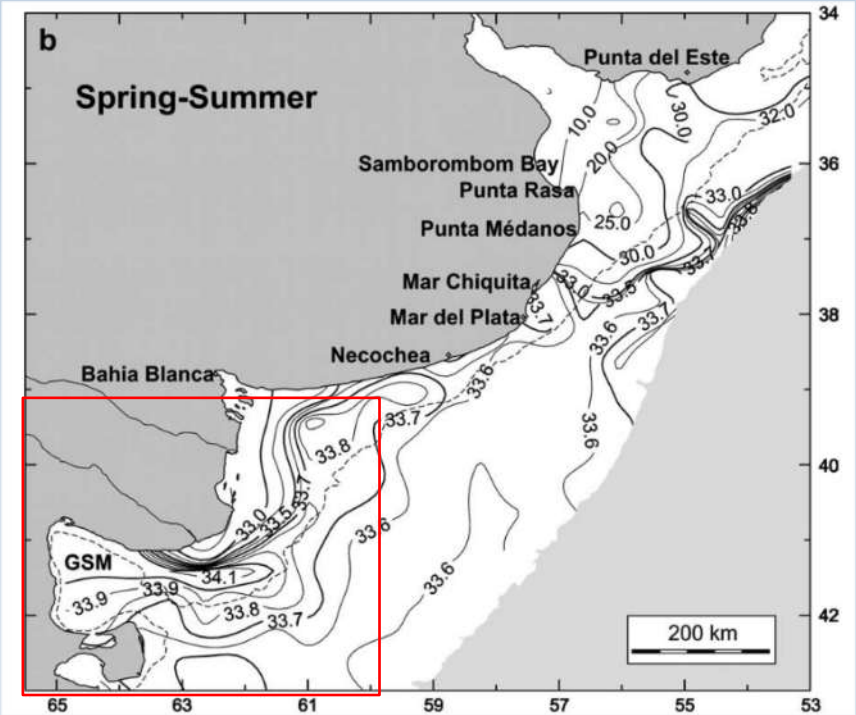
- The model outputs show agreement with the observations, although the temperature values are slightly higher.
- The main characteristics of the domain are well represented, i.e.,maximum SST in the northern part of the gulf and the San Matías and Valdés fronts (SMF and VF respectively).
- Shallow areas (< 10 m) show anomalous higher temperatures (>23°C).
- The cold jet along the western coast of the gulf is not perceptible in OSTIA data, probably due to resolution limit (0.25°)

San Matías Gulf – Model Validation

From Lucas et al., 2005

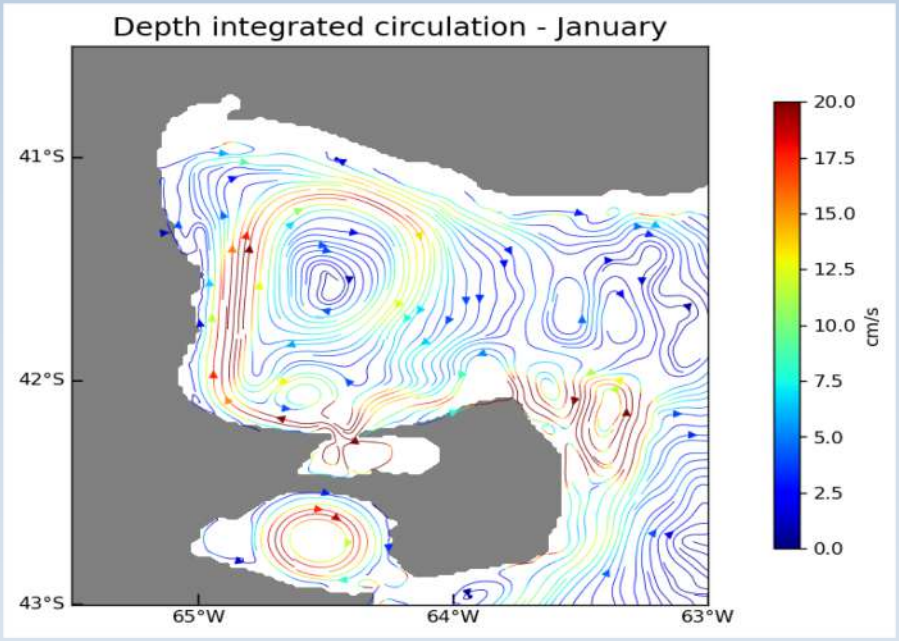
Coastal oceanographic regimes of the Northern Argentine Continental Shelf (34-43ºS)

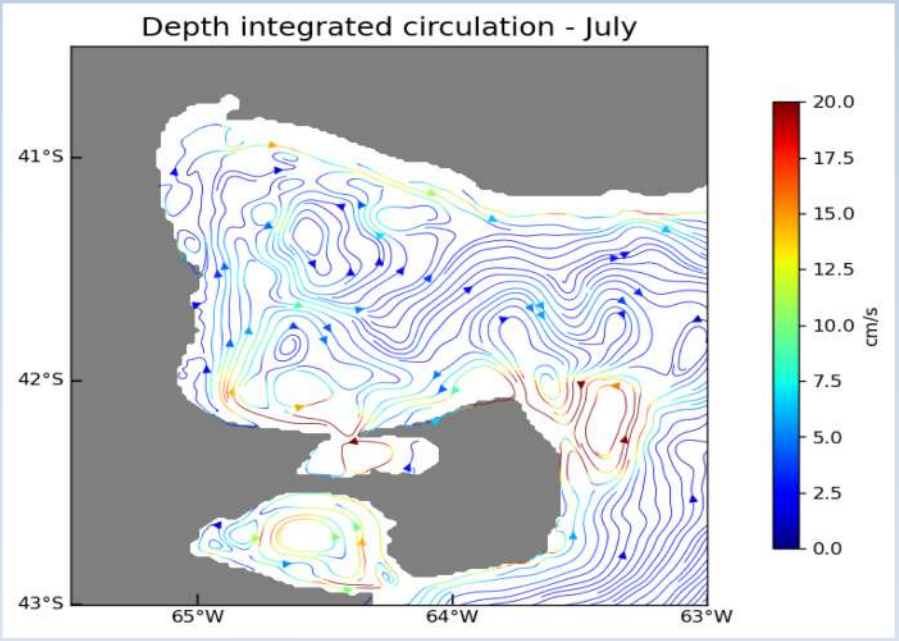




- Model surface salinity is compared with summer observational data from Lucas et al., 2005 (red rectangle).
- The model represents well the maximum salinity inside the northern San Matías gulf, with values reaching 34 PSU.
- Also a plume of maximum salinity leaving the gulf and flowing northward can be seen in both panels.
- Fresher water enters the gulf through its south section and reaches the west coast.

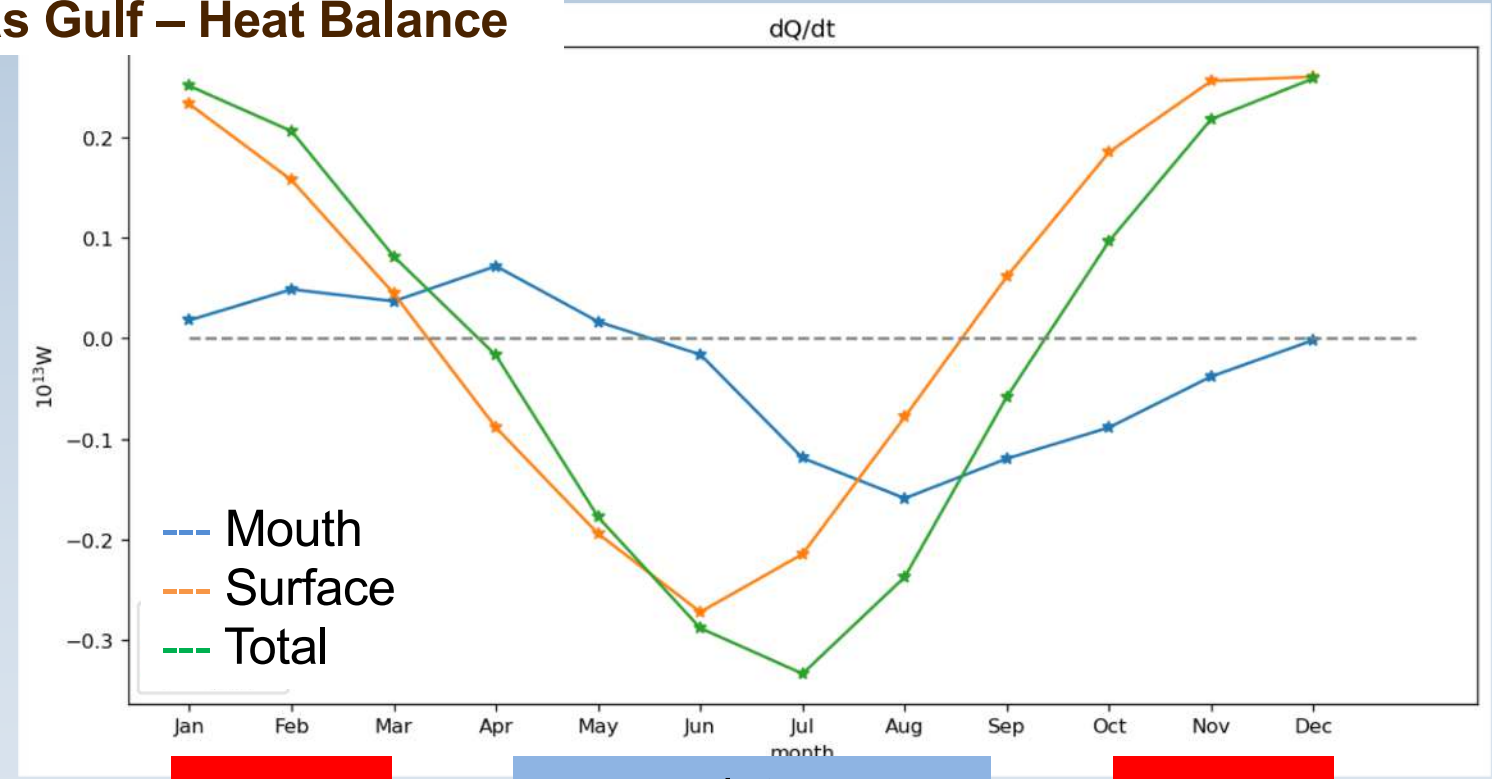
San Matías Gulf – Main barotropic circulation (streamlines)





- Streamlines show a closed cyclonic circulation inside the San Matías Gulf in summer (January).
- Colder and fresher water enters the gulf from the south and exits through the north across the mouth.
- The southern section and west coast exhibits the strongest currents (January).
- In winter (July) the closed circulation breaks and water leaves the gulf through its north and middle section.

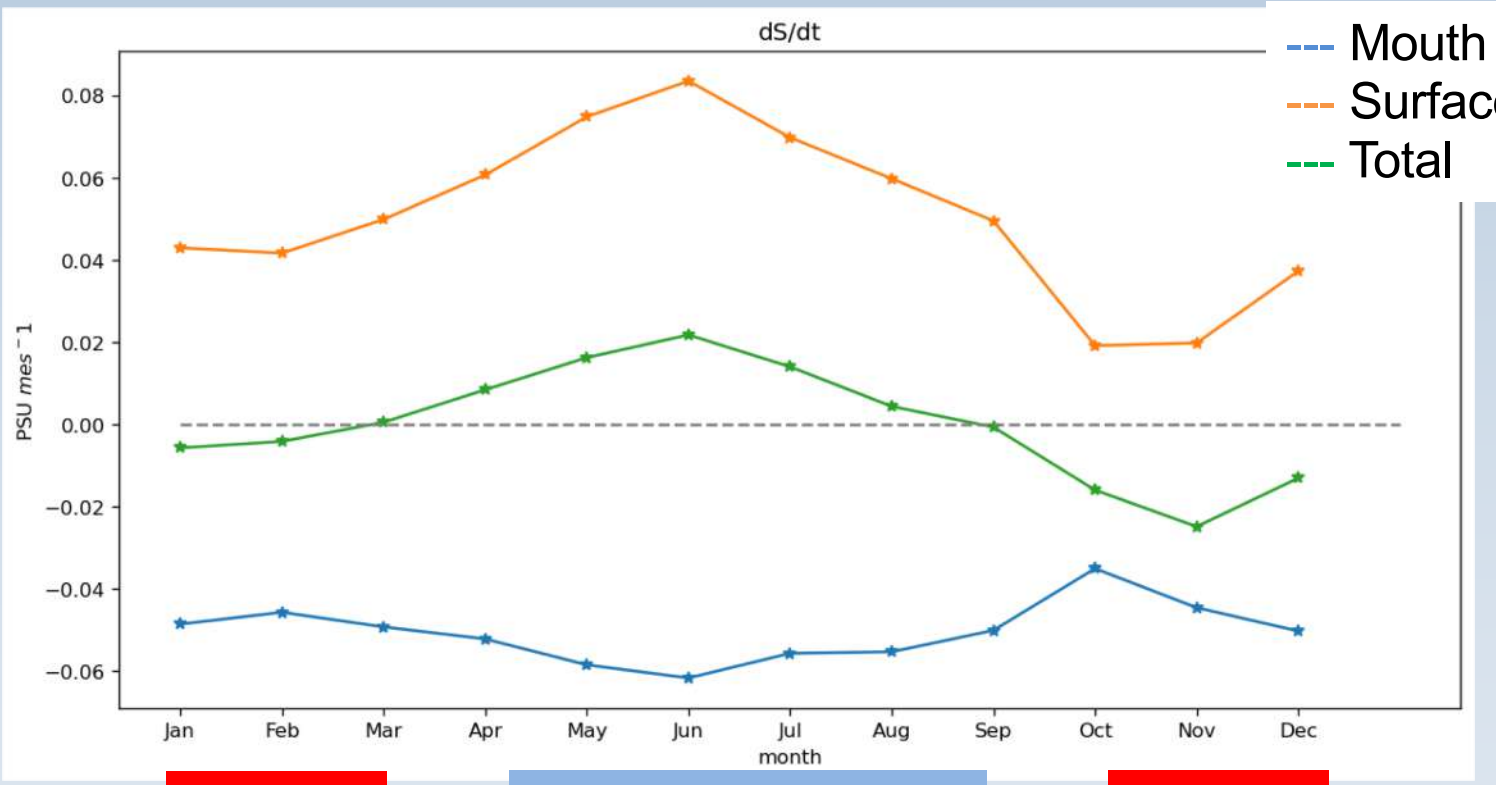
San Matías Gulf – Heat Balance



summer | winter | summer

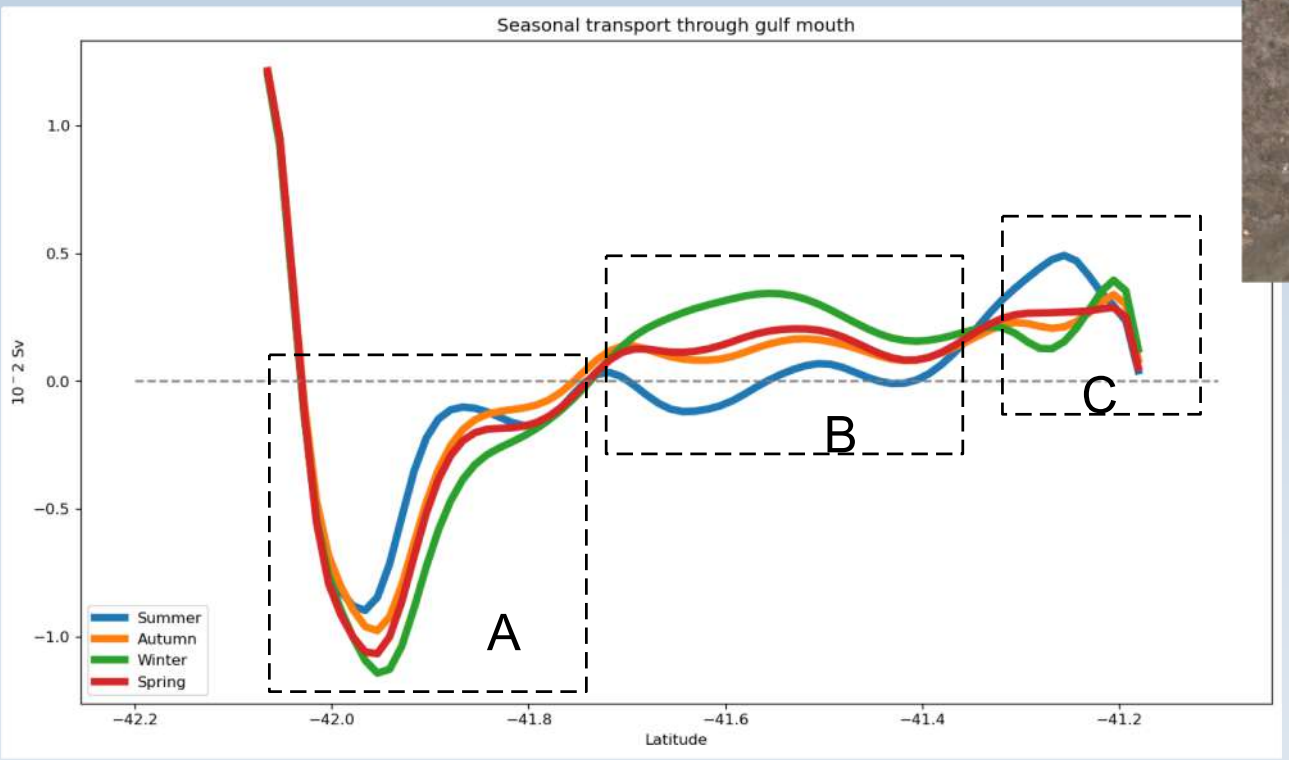
- Heat content variation shows an annual cycle with the ocean gaining heat in summer and loosing heat in winter (green line).
- The total annual cycle is modulated by the surface heat flux that follows a typical seasonal pattern (orange line).
- Mouth flux also has an annual cycle, but with a 3-month lag (blue line).
- The ocean flux through gulf's mouth is positive in summer/spring (Dec-May) and negative in winter/autumn (Jun-Nov).
- During December and January mouth heat content variation is almost zero, in line with the closed cyclonic gyre seen before.
- Mouth advection is more important in winter when it reaches its minimum, cooling the gulf.

San Matías Gulf – Salt Balance



- Salinity variation shows an annual cycle with the ocean getting fresher in summer and saltier in winter (green line).
- The surface variation is governed by the E-P regime, which is positive all year round in this region.
- The salt advection through the mouth is negative all year and balances the salinity excess imposed through the surface.

San Matías Gulf – Zonal Volume Transport



- The volume transport in the mouth shows that water enters the gulf through a narrow south section as part of the permanent anticyclone gyre seen before in the circulation figures (A). Maximum values in winter.
- In the middle of the mouth section, water mainly exits the gulf, with a few exceptions in summer (B).
- Gulf waters exits in the northern part towards the adjacent platform all year round (C). Maximum values in summer.

San Matías Gulf – Conclusions and future goals

- This preliminary analysis shows that the model simulation respond quite well in reproducing surface patterns compared to in situ and satellite data.
- A cyclonic re-circulating gyre is formed in summer which in turn forms the San Matías front, separating colder and fresher water in the south from northern saltier and warm water.
- Water enters the gulf through its south section and exits in the northern part.
- Heat advection through the mouth is positive in January-May and negative in June-December.
- The salt advection acts to balance the excess salinity gain due to evaporation all year round.

- **What's next:**

Once all in-situ data are recovered:

- Validate coastal satellite altimetry products.
- Estimate mouth volume transport with satellite altimetry data.
- Re-calibrate the model with data recover from moored instruments.
- Run an interannual simulation to study long term patterns.
- Add a biogeochemical model to monitor primary biological tracers inside the gulf.

- Thank you!