Analysis of hydrographic data collected by Southern Elephant Seals in the Argentine Continental Shelf

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In situ data obtained from CTD sensors (Conductivity, Temperature and Depth) installed on 6 elephant seals (*Mirounga Leonina*) that crossed the Argentine Continental Shelf between October 17 and 31, 2019 are analyzed. Typical water masses of the region were identified from the analysis of temperature and salinity along the trajectories, which allowed us to identify two sections: north of 42°S and south of 42°S. In the northern section, the temperature is 1 °C warmer and 0.5 psu saltier than in the south. The high spatio-temporal resolution T and S are compared with an available reanalysis model. Then we calculated the contribution of the steric effect to the sea surface height. Preliminary results show that both data sets have a good correlation but the steric effect is not the dominant factor in the sea level.

INTRODUCTION

The Argentine Continental Shelf (ACS) is part of the Southwestern Atlantic Continental Shelf (SWACS), which is the largest continental shelf of the southern hemisphere and one of the most productive ecosystems of the world ocean.

In this work the hydrography of the ACS between 41 °S and 43 °S is analyzed (Fig. 1), according to data collected between 17 and October 31, 2019 by sensors installed on 6 female southern elephant seals (SES mirounga leonina). This high-resolution dataset is compared with the reanalysis model GLORYS12.

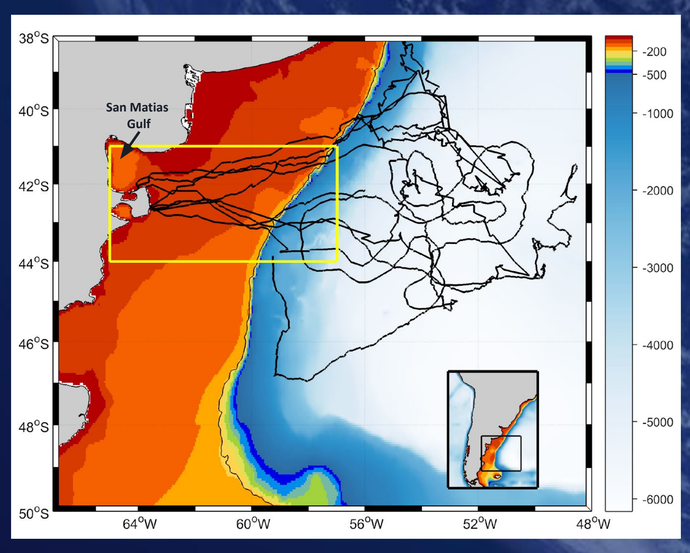


Fig 1: Trajectories from Península Valdés of 6 southern elephant seals instrumented with satellite transmitters. In colors the bathymetry (m) of the region is presented.

OBJETIVES

- Improve the knowledge of the oceanographic physical features of the Patagonian shelf thanks to the high spatio-temporal resolution of the data collected by the SES.
- Identify water masses.
- Compare basic variables between in situ data and reanalysis.
- Compare the contribution of the steric effect to sea level height from the data collected by SES and the GLORYS12 reanalysis.

METHODOLOGY

1) Linear correlation between the basic variables of the reanalysis and in situ data.
2) We calculated the potential density in each vertical profile with in situ and renalysis model and integrate the anomaly to obtain the steric height:

$$\eta'_S = \frac{1}{\rho_0}\int_{-h}^{0} \rho'(z).dz \qquad (1)$$

In the equation (1): η'_S is steric effect, $\rho'(z)$ is the time-dependent density anomaly relative to a reference profile, ρ_0 is a reference water density and h is the water depth.

In this case, the reference profile is the average along the trajectory.

3) Percentage of variance of sea surface height explained by steric height:

$$Fvar = 100\%*(1-var(y-x)/var(y)) \quad (2)$$

DATA

T, S and pressure from CTD sensors attached on elephant seals. Data are available at https://www.meop.net/database/

T, S and Sea Surface Height (GLO) from Global Ocean Reanalysis (GLORYS) from the Copernicus Marine Environment Monitoring Service (CMEMS) with daily resolution, on a standard regular grid at 1/12° (~8 km) and on 50 standard vertical levels. https://marine.copernicus.eu/

Gridded altimetry maps of Sea Surface Height (SAT) L4 product from CMEMS with a spatial resolution of 1/4° on a regular grid and a daily temporal resolution. https://marine.copernicus.eu/

Fig 2: SES female from the 2021 campaign accompanied by her calf ready to start her pelagic stage. It features a CTD with Argos antenna located on the head for data transmission.

RESULTS

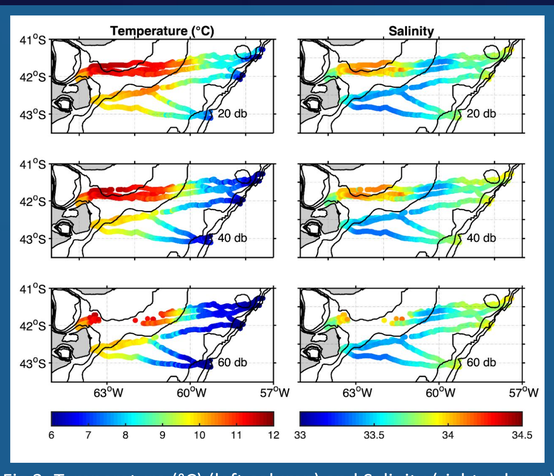


Fig 3: Temperature (°C) (left column) and Salinity (right column) collected by sensors attached on 6 elephant seals during October 2019. Variables are presented at 3 pressure levels: Top panel at 20db, middle panel at 40db and lower panel at 60db.

Temperature

inner shelf (depth<75m): The temperature north of 42°S is 1°C warmer than south of 42° S.

outer shelf (depth> 75 m): The temperature of all the trajectories decreases towards the outer edge of the continental shelf.

Salinity

In the northern trajectories, a salinity maximum (34<S<34.2) is observed for depths less than 60 m (Fig .3).

As the elephants move away from the coast, the salinity increases from 33.2 to 33.9 at the edge of the shelf.

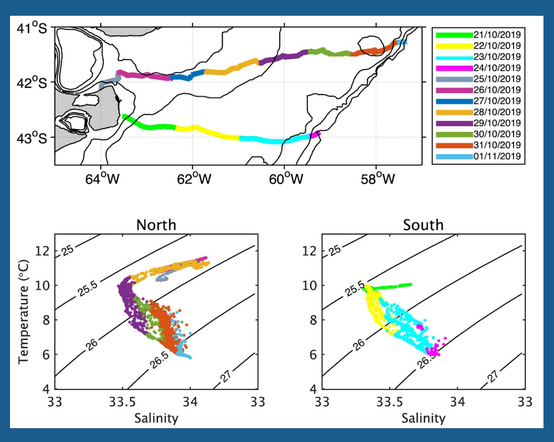


Fig 4: Representative trajectories of the northern and southern regions, respectively. The TS diagrams are presented in the lower panel. The colors correspond between the upper and lower panels for each elephant and represent the segment of trajectory per day traveled by each elephant.

North of 42°S

Low salinity coastal waters (LSCW)
High Salinity Coastal Waters (HSCW)
Malvinas waters (MW)
Water from the San Matías Gulf (SMGW)

South of 42°S

Low salinity coastal waters (LSCW)
High Salinity Coastal Waters (HSCW)
Malvinas waters (MW)

- Two different regions can be identified, north and south of 42°S
- Warmer and saltier waters in the north are very likely associated to the export of waters with similar characteristics (Piola and Scasso, 1988) from the San Matias Gulf

North of 42°S

Up to a distance of 300 km from the coast, the vertical structure of the northern section (Fig. 5) is homogeneous in temperature, salinity and density but varies abruptly along the track.

From 300 km towards the edge of the shelf, a weak vertical stratification begins that is accentuated towards the slope.

Near the coast and on the outer shelf, the density is modulated in the same way by T and S.

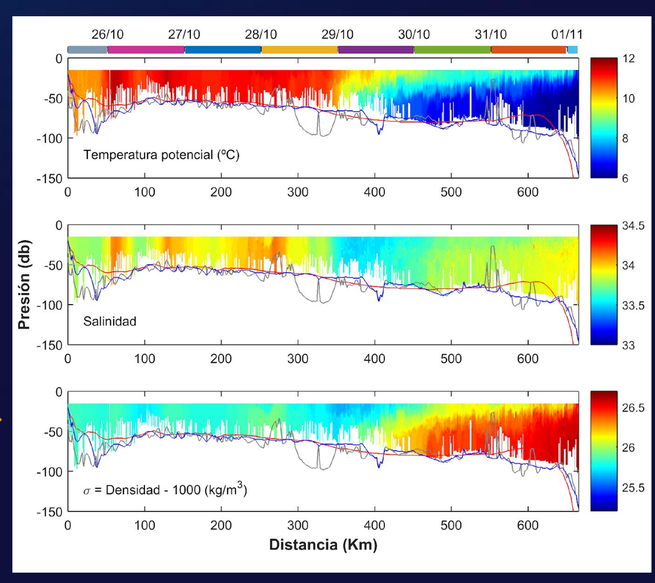
In the middle shelf (350km), a minimum density modulated mainly by salinity is observed.

South of 42°S

Up to a distance of 150 km from the coast, the vertical structure of the southern SES is homogeneous in salinity and density. The temperature presents a gradient that decreases as the SES moves away from the coast and the depth increases.

The vertical sections show:

- vertically mixed waters close to the coast and in the mid-shelf region, typical of large tidal regimes
- the influence of the MC waters in the outer portion of the shelf
- in the North, large variations of both T and S are observed close to the coast (see explanation below)



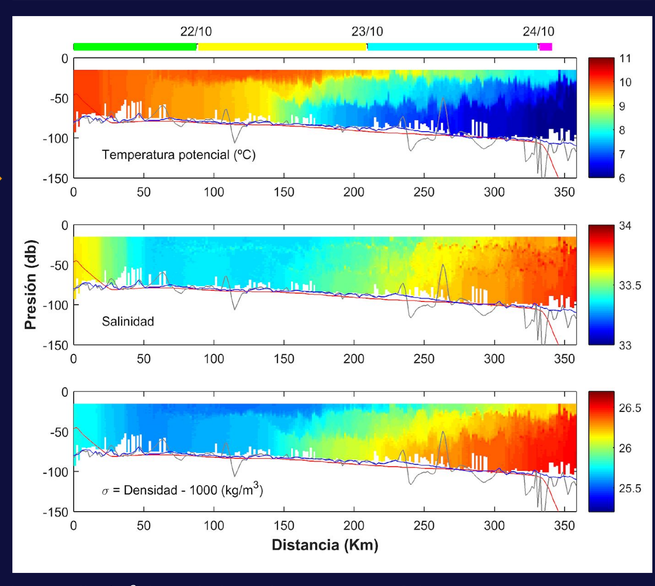


Fig 5: Profiles of potential temperature (°C, upper), salinity (middle) and sigma (kg/m^3, lower) along the trajectory of the representative SES from the North (upper) and South (lowet) regions. Profiles are reconstructed from SES dives from the surface to the bottom. The horizontal axis is the distance in km from PV. The red, gray and black lines show the sea floor using the GEBCO-SHN 2019, GEBCO 2020 and GEBCO 2021 bathymetries respectively. The top color bar refers to the time since the elephant left PV.

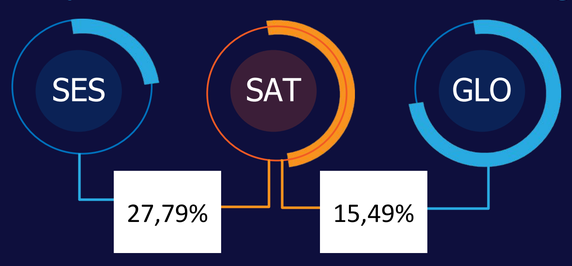
CONCLUSION

- Validation of the reanalysis T and S with in situ data
  - ✓ The comparison of the basic variables between both data sets is better for temperature (r= 0.87) than for salinity (r=0.64).
  - The comparison of the anomalies of the basic variables present significant and similar correlation values.
- Calculation of the steric effect
  - ✓ **The steric height comparison between both data sets is high and significant (r=0.82)**

Glorys reanalysis resolves steric effect in ACS

- How much does the steric effect contribute to sea level height?

Comparison of data sets with sea surface height



The percentage of variance of the sea surface height explained by the steric height is low, both for the model and for the in situ data, indicating that the steric effect is not the dominant factor in the sea level.

SES data allows to identify:
- the water masses of the region (Fig.4).
- the influence of SMGW on the inner shelf north of 42°S (Fig.3).
- two regions, south and north of 42°S
SES data allows also to validate the Global Ocean Reanalysis (GLORYS) in ACS
- Glorys reanalysis resolves steric effect in ACS
- Steric height is not the dominant contributor in the SSH in ACS

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