OCEANOGRAPHIC CRUISES CARRIED OUT IN THE CONTEXT OF SAC-D/AQUARIUS MISSION. PRELIMINARY RESULTS

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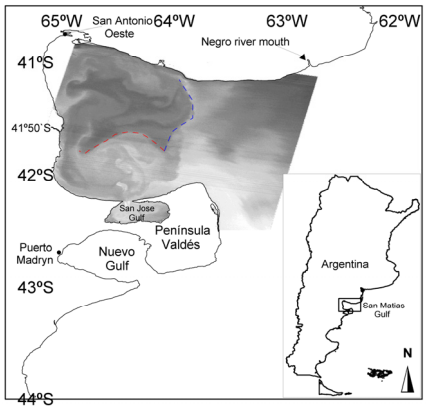

INTRODUCTION

San Matías Gulf (SMG) presents several environmental scenarios generated by the physical, weather and topography conditions (Piola & Scasso, 1988, Gagliardini & Rivas, 2004; Williams *et al*., 2010, Pisoni, 2012). These scenarios influence the reproductive success of species through processes such as injection of nutrients (upwelling), aggregation and accumulation of food particles (stability of water column and coastal fronts) and retention of eggs and larvae (Bakun, 1996). The identification and characterization of these scenarios are essential to link environmental information and biological-fishery data.

We have taken advantages of remote sensing and technological tools based on satellite services, as well as oceanographic cruises to improve our knowledge of the environmental variables in relation to biological resources in the gulf, identifying the patterns of species distribution in relation to environmental and oceanographic phenomena (Williams *et al.*, 2010, Ocampo-Reinaldo *et al.*, 2013, Romero *et al.*, 2013).

Two oceanographic cruises were carried out in San Matías Gulf (SMG), in the north of the Argentine Patagonian Continental Shelf (between 40º47 'S and 42º13' S) in the context of the first surveys in the study zone under the SAC-D/Aquarius mission. The aim of this work is to present temperature *in-situ* records obtained in the mentioned cruises and compare them with temperature estimates by the NLSST-MODIS algorithm.

We propose the use of NIRST data from SAC-D/Aquarius mission for supporting research in fisheries and ecosystem management in SMG. The ability to access NIRST data will allow us to have higher spatial detail of oceanographic processes in SMG. Also the results presented in this work show part of our experience in the use of infrared remote sensing data in order to consider it as a basis for future comparisons involving NIRST data.

Figure 1: a) Study area and Landsat ETM+ brightness temperature image (March 8, 2004, adapted from Gagliardini and Rivas, 2004) showing the northern (warmer) and southern (colder) areas and the thermal fronts on the entrance (dashed blue line) and along 41º50´ (dashed red line) identified in previous studies. Northern, Southern and Mouth area (NA, SA, and MA, respectively) are also indicated.

MATERIAL AND METHODS

In-situ data

Two oceanographic surveys were carried out on board GC Río Paraná and B/O B. Houssay. The main characteristics of each cruise are detailed in table 1.

Table 1. Dates, number of stations and source characteristics of physical and chemical parameters .

Date	Nº of stations	Temperature	Chlorophyl and nutrients	Satellite data (yyyy-mm-dd-hhhh)
1-January, 30-31 2013	10	Profiles using YSI probe 6600v2	Water samples collected at 0-20-50-90 m depth	2013-01-30-1905
2-March 18-22 2013	16	Discrete depth using TOA-DKK probe Model WQC-24	Water samples collected at 0- 10-20 m depth	2013-03-18-1820 2013-03-19-1905 2013-03-21-1905 2013-03-22-1755

The location of the oceanographic stations on January 30, 2013 was defined in order to perform transects perpendicular to the thermal front. One of the transects is located in the northern sector of the mouth (from west to east) and the other in the interior of the Gulf (from north to south)(Fig. 2a).On March 18-22, 2013, stations were located along the coast (Fig. 4a).

Satellite data

MODIS-Aqua spatially extracted Level-2 files were acquired for the study area (Figure 1) from the NASA ocean color web page (http://oceancolor.gsfc.nasa.gov) for the dates with concurrent *in-situ* SST. The daytime SST 11 µm product (which uses the 11 and 12 µm bands), were obtained. This SST product uses the standard MODIS 11µm non-linear sea surface temperature (NLSST) algorithm with coefficients derived by the Rosenstiel School of Marine and Atmospheric Science (RSMAS) and input SST guess from Reynolds OISST product (http://www.cdc.noaa.gov/cdc/data.reynolds_sst.html). All MODIS images, with a pixel size of 1.1 km, were corrected for geometric distortion, mapped to a WGS84 reference system (datum WGS84, ellipsoid WGS84) and co-registered with a reference landmask using SeaDAS v7 software.

Comparison between MODIS NLSST algorithms and *in situ* records

The relationship between *in situ* SST and AVHRR derived SST was analyzed through linear regression analyses. Besides r^2, slope and intercept, the statistical parameters used were the mean difference (MD), the standard deviation of the mean difference (SD) and the root mean square error (RMSE) between the algorithm-derived and the *in situ* SST. The parameters are defined as:

$$MD = \frac{\sum_{n=1}^{N}(x_{sat} - x_{situ})}{n} \qquad SD = \sqrt{\frac{\sum_{i=1}^{n}(MD - \overline{MD})^2}{n}} \qquad RMSE = \sqrt{\frac{\sum(x_{sat} - x_{situ})^2}{n}}$$

where X is SST, X_{sat} is the satellite-derived value, X_{situ} is the *in situ* measured value and *n* is the number of pairs of data analyzed. Bias, slope and the determination coefficient (r^2_{SMA}) were calculated following a type II linear regression model, Standard Major Axis (SMA) (McArdle, 1988; Sokal & Rohlf, 1995).

The MCSST algorithms were first evaluated over the whole AVHRR dataset. Afterwards, fixed and oceanographic stations were considered separately, as well as the different satellites and overpass times.

RESULTS

The spatial representation of in situ surface temperature records of both oceanographic cruises corresponding to the spatial distribution of SST obtained by MODIS sensor is shown in Figs. 2 and 3. These maps show, in January, the spatial distribution characteristics of the Southern Hemisphere summer season, with warm and cold waters in the northwestern and the south of SMG, respectively (Fig. 2); while in March a general decrease in SST and less differences between areas is observed .

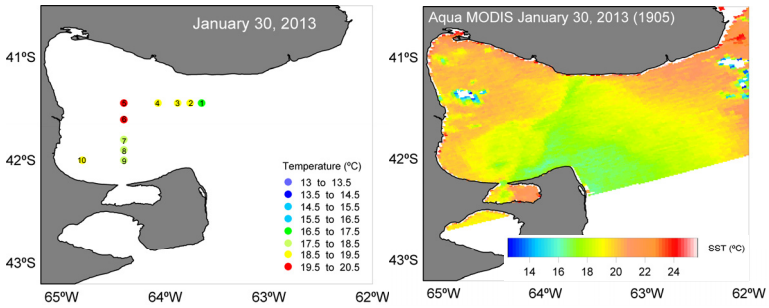

Figure 2. Location and values of surface temperature records of the sampling stations (numbers on points identify the station) (a). MODIS-SST map for Jan 30, 2013 (b).

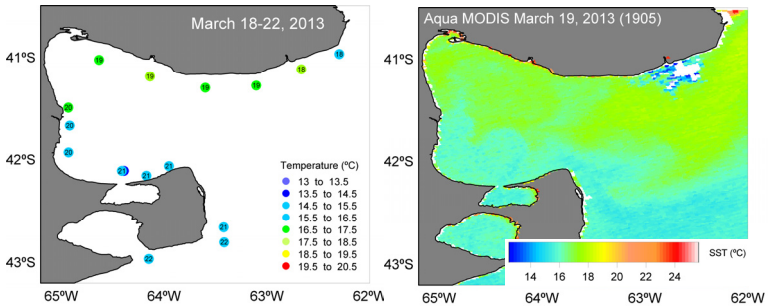

Figure 4. Location and values of surface temperature records of the sampling stations (numbers on points identify the date of the temperature record) (a). MODIS-SST map for Mar 19, 2013 (b).

The profiles of temperature in January, 2013 (Fig. 3) show a strong vertical stratification in the northern sector of SMG (E5). The profiles of the southern and southwest sectors (E7 and E10) show lower stratifications while in the adjacent shelf (E1) the water column is mixed.

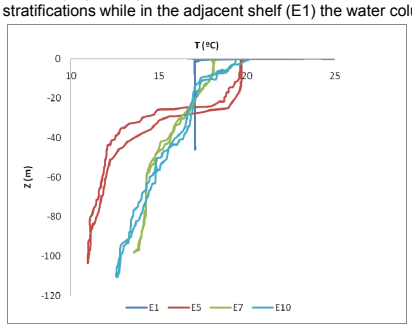

Figure 3. Location and values of surface temperature records of the sampling stations (numbers on points indicate stations) (a). MODIS-SST map for Jan 30, 2013 (b).

Match-up results showed good fit and statistical significance ($P < 0.05$) (Table 2), however the mean differences between satellite and *in-situ* data for the second cruise were higher than in the first one (Table 2).

Table 2. Statistical results for the comparison between *in situ* oceanographic cruise data and for estimates from NLSST algorithms from MODIS-AQUA system.

Data	b	a	r^2	RMSE	Mean difference (ºC)	SD difference (ºC)	*in situ*	*SST*	n
1-January, 30-31 2013	0.71	5.79	0.90	0.56	0.44	0.37	18.65	19.10	10
2-March 18-22 2013	0.31	11.54	0.68	1.07	0.88	1.08	16.240	16.63	10

DISCUSSION AND CONCLUSIONS

There was a good correlation between the remotely sensed SST and the *in situ* temperature records from SMG. However, SST derived from the MODIS-NLSST algorithm showed positive biases.

The ability to obtain in-depth temperature records allowed to observe the vertical structure of the water column in different sectors of the gulf and perpendicular to the thermal front identified and characterized by different authors (Piola and Scasso, 1988, Gagliardini and Rivas, 2004, Williams et al 2010, Pisoni, 2012).

The results of this study show that MODIS sensor can be used to analyze spatio-temporal patterns in SMG despite the overestimation of the algorithm.

Temperature data presented here may be taken as a reference point in future studies involving the sensor NIRST of SAC-D/Aquarius mission.

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