

GIS IN THE TREATMENT AND ANALYSIS OF METEOROLOGICAL AND OCEANOGRAPHIC DATA

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In this work we use SPRING, a GIS package created at the Image Processing Division in the National Institute for Space Research, INPE, to develop an application to integrate, visualize and manipulate oceanographic and meteorological data. The area of study is located at the Southeast Brazilian continental shelf, between 20°S-29°S and 37°W-50°W. The area was divided in a 0.5° by 0.5° grid, for which the following data sets were generated: (1) sea temperature, salinity, air temperature, wind direction and intensity data, derived from sixteen years of data (1980-1996) obtained from the National Oceanographic Data Bank at the Directorate of Hydrography and Navigation (DHN/BNDO); (2) sea surface temperature (SST) and geographical position data collected by Low Cost Drifters (LCD) operated by INPE Remote Sensing Division during the 1993-1998 period. Temperature and salinity data were vertically interpolated using a linear method at the following standard depths: 0, 10, 25, 50, 75, 100, 150, 200 and 500 meters. In grid squares presenting less than three samples, the kriging interpolation method was used. Spring-based data integration and analysis allowed to qualitatively characterize the spatial and temporal evolution of three major water masses in the study area: Tropical Water at the eastern portion, Coastal Water at surface, and South Atlantic Central Water located below Tropical Water during the whole year, and at surface in an upwelling area during the summer period.

1-Introduction

There is a great hydrographic database collected through traditional methods that permit to carry out important studies of oceanographic phenomena. However, it is very difficult to manipulate this database due to non standard ways storage.

With the development of orbital systems to collect information about the oceans, there has been an increase in oceanographic data in the last years. Through the use of oceanographic satellites it's possible to obtain data with synoptic characteristics and high temporal resolution from great oceanic areas. Some physical parameters such as sea surface temperature, surface winds, and wave height can be measured through these satellites. Oceanographic buoys have been used as platforms to collect data and to transmit it through satellite links to land stations. Other parameters can be measured in different water column depths, providing important information about the oceans (Souza, 1992).

The way this database can be converted into important information is the main question. In many cases researchers wish to convert them in to maps of contours, diagrams of perspective or images, aiming at graphically presenting the spatial variation of this data. Therefore, it is necessary to have tools that can manipulate and analyze big amounts of data.

This difficulty in manipulating great amounts of data can be minimized through Geographical Information Systems (GIS), which allow elaborating complex analyses with the integration of different data sources and the creation of georeferenced data base (Câmara and Medeiros, 1996). Due to the increase of oceanographic database, GIS can be considered a tool with great potential in oceanographic research.

Although the development and use of GIS have been increasing in this decade, there are many research opportunities that could improve it. The incorporation of more appropriate and interconnected analytical procedure making possible the presentation of geographical data, increases the possibilities of GIS application for different areas (Camargo, 1997).

The main objective of this work is to integrate oceanographic and meteorological parameters by using available technique from SPRING, a GIS software developed by the Image Processing Division at the National Institute for Space Research (INPE). This integration is made to study the variations in time and space of these parameters from oceanographic and meteorological database.

2- Data and Methods

The study area of this paper is located in the Southeast/South Brazilian coastline between 20°S –29° S and 37°W-50°W. The general characteristics of the coastline and of the continental shelf topography, indicated by 50, 100 and 200 meters isobaths, are shown in Fig. 2.1. The area was divided in a 0.5° latitude by 0.5° longitude mesh. A research was carried out to know how much data there was in each one of these squares. Winter (June, July, August) and summer (December, January, February) were considered as the temporal scale.

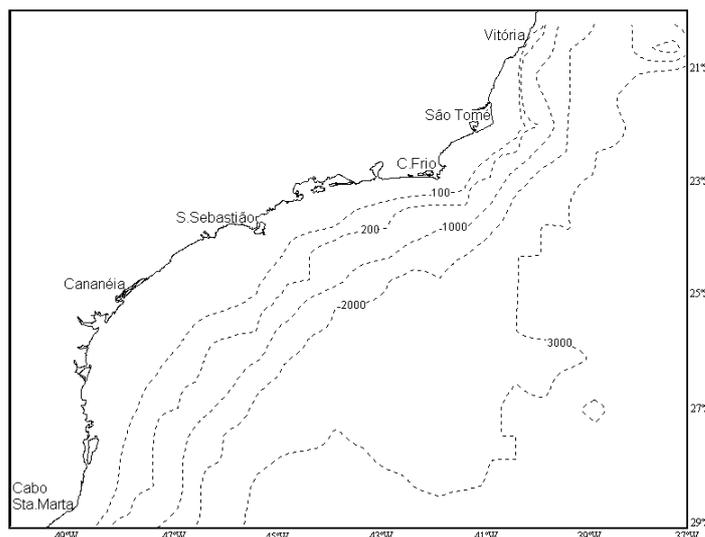


Fig. 2.1 Study area

2.1 Data

The hydrographic and meteorological data was obtained from the National Oceanographic Data Bank (BNDO) at the Brazilian Navy Directorate of Hydrographic and Navigation (DHN), from 1980 to 1996. Oceanographic data collected by using XBT (1057 stations), CTD (387 stations) and Nansen's bottle (1076 stations) was used. Wind, pressure, and air humidity were used as meteorological data. Positions and Sea Surface Temperature (SST) collected by Low Cost Drifters, launched in the study area during 1993, 1994, 1997 were also used.

2.2 Data Processing

2.2.1 Filtering

The hydrographic data from each oceanographic station was sampled to correct erroneous or spurious data. Spread TS diagram method was used to eliminate spurious data collected by CTD and Nansen's bottle. For data collected by XBT the criterion used was the temperature limits found in the Atlantic Ocean according to Sverdrup et al. (1942).

2.2.2 Vertical Interpolation

As the data was collected at different depths, it was necessary to interpolate it to standard depths, 0, 10, 25, 50, 75, 100, 150, 200 and 500 m. Despite the fact that during this task several tests using different methods were performed, the best results were reached by using the linear method.

2.2.3 Horizontal Interpolation

At least three pieces of data were adopted as samples for each sub-square (0.5° latitude x 0.5° longitude). For sub-squares with more data than this minimum, an arithmetic mean in the sub-square's center was calculated. For the sub-square that presented fewer than three samples, the kriging interpolation method was applied to fill in these gaps. We tried to use other different methods to elaborate the horizontal grid, but the best result was obtained through the kriging method.

2.3 SPRING

SPRING is a GIS and a remote sensing image processing system with an object-oriented data model which provides tools for the integration of raster and vector data representations in a single environment (www.dpi.inpe.br/SPRING). SPRING was developed at Brazil's National Institute for Space Research (INPE) with assistance from: EMBRAPA/CNPq – Brazil's Agricultural Research Agency -, IBM Brazil and TECGRAF-PUC Rio – Computer Graphics Technology Group.

SPRING Main Features are

- An integrated GIS for environmental, socio-economical and urban planning applications
- A multi-platform system, including support for Windows 95/98/NT, Linux and Solaris
- A mechanism for knowledge diffusion developed by INPE and its partners with the introduction of new algorithms and methodologies.

3. Results and discussions

Temperature and salinity are very important oceanographic parameters to identify water masses in the oceans. Emilson (1961) identified Coastal Water (CW), Tropical Water (TW), and South Atlantic Central (SACW) masses in the study region. Those were confirmed by other authors, such as Miranda (1982), Miranda (1985), Castro Filho (1996).

Aiming at showing the potentiality of SPRING software in oceanographic area, we used temperature and salinity data to draw horizontal maps of the three principal water masses present in the region through a data crossing operation. Different temperature and salinity intervals based on the spread TS diagrams were defined to identify the CW, TW and SACW. For TW and SACW we used the same intervals defined by Mamayev (1975); i.e. TW, $T > 18^\circ\text{C}$ and $S > 35.9$, SACW, $6^\circ < T < 18^\circ\text{C}$ and $34.5 < S < 35.9$, for CW we used $T > 18^\circ\text{C}$ and $S < 34.5$. Castro Filho et al. (1987) and other authors showed that these water masses present a marked seasonal variability in this region. Then, to observe the space/time evolution of these water masses, the maps were drawn in the standard depths for summer (December, January, and February) and winter (June, July, and August).

In Fig. 3.1 it is possible to observe areas that CW is present for summer and winter. As this water is present only in the surface layer, we drew maps for zero meter depth. Fig. 3.1 shows that during the summer season the CW is present in the continental shelf more southern than 24°S . During the winter time, the area occupied by these water masses is larger and reaches the 200 m isobath. Lentini (1997) showed that this inner portion of the continental shelf is occupied by these water masses due to the arrival of fresh water from Prata river and Patos lagoon. We can observe that during the summer the concentration of this water is bigger than that of the winter time. According Castro Filho (1987) this fact happens because the region presents a weak stratification during the winter whereas during the summer the stratification is typically of two layers. The upper layer is the one that constitutes the WC has less than 20 m depth. Emilson (1961) showed that the rainy indexes are bigger during the summer time acting like a less saline source and increasing the WC concentration.

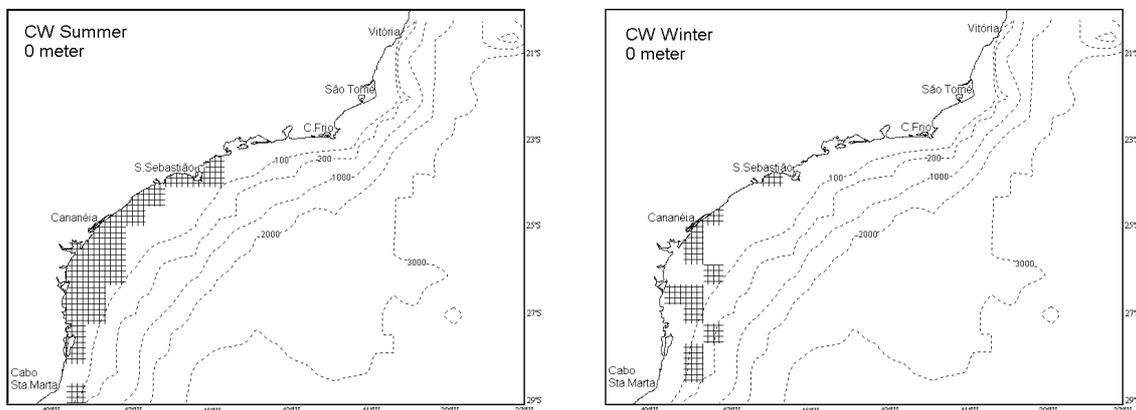


Fig. 3.1 CW observed (dashed) in the summer and winter seasons at 0 m depth.

Fig. 3.2 shows the areas occupied by TW during summer and wintertime at 0, 100 and 200 m depth. It can be observed that from 0 m to 100 m depth, the TW occupies the region from the isobath 100 m depth to east boundary. In the inner shelf neither in the winter nor in the summer these water masses are present. In the 200 m depth the TW practically disappears, principally during the summer time. These results agree with Miranda (1982) who observed TW being transported towards South/Southwest by Brazil Current in the upper layer (0-200m), in the shelf break region. Campos et al. (1995) studying the water masses and geostrophic circulation during the 1991 summer concluded that the area beyond the shelf break in the surface layer (0-200 m) is totally occupied by TW in this region. During the winter time in the northeast part of the study area the concentration of TW increases and tends to decrease towards the higher latitude in the Brazil Current area.

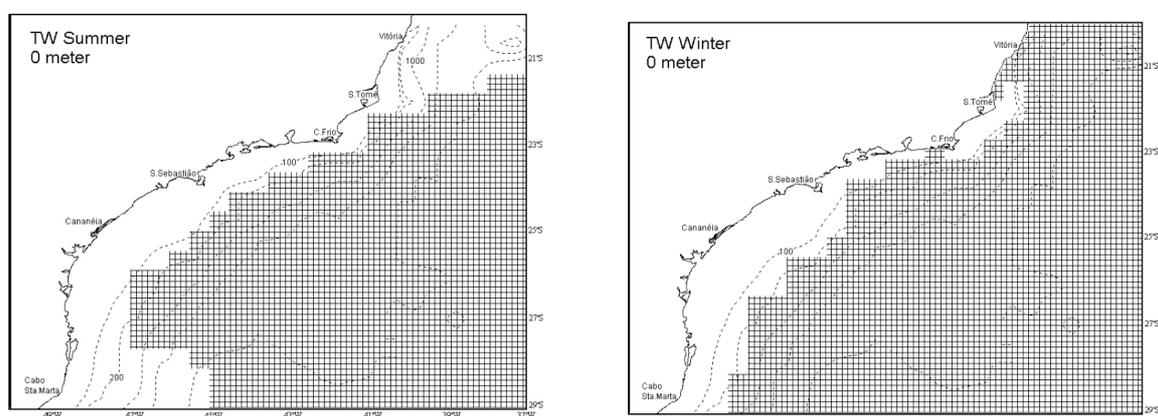
Fig. 3.3 shows the maps SACW occupied areas in the study region, for 0, 100 and 500 m depth in the summer and in the winter. We can observe that the SACW is present in the entire layer (0-500 m) during the summer. However, only from 100 to 500 m during winter time. During the summer the SACW penetrates towards the coastline while in the winter time it moves away to the shelf break region. This behavior was observed by some authors, such as Emilson (1961), Miranda (1982), Matsuura (1983), Castro Filho et al. (1987), Campos et al. (1996b), Castro Filho et al. (1998). These authors observed that SACW is typically a termohaline variation with a seasonal scale. Another important feature observed, is the presence of SACW in the surface layer near Cabo Frio (~23°S, ~42°W) during the summer time, which is associated with upwelling processes forced by wind blowing from NE. Miranda (1982) identified the water from upwelling processes as SACW. For depths equal or greater than 200 m, the SACW is present in the whole study area, see Fig. 3.3.

We applied SPRING to study surface current and temperature field obtained by using data collected through 37 Low Cost Drifters launched in the Southeast Brazilian Continental Shelf in 1993, 1994, 1997 and 1998. SPRING was utilized to study the seasonal variations of wind field and of air-sea temperature differences. Due to lack of space these results are not shown in this paper.

4- Summary and concluding remarks

By using SPRING software, temperature, and salinity data, three water masses were identified. Tropical Water (TW) present in the east portion of the study area, Coastal Water (CW) located in the surface layer of the inner shelf and South Atlantic Central Water (SACW) in the sub-surface layers under the TW, except for Cabo Frio region where this water mass was present in the surface layer during the summer time. The CW was predominant in the inner shelf and in the surface layer for both winter and summer seasons. The presence of the TW was observed in the 100 m depth.

Through wind surface maps (not shown here) elaborated with SPRING software as well as available database we observed that the wind blew predominantly from the first quadrant during summer and winter periods. Moreover, maps of the difference between SST and air temperature above sea surface were produced, showing negative values during summer in upwelling areas and positive values in the Brazil Current. From Low Cost Drifter data, we calculated SST and average surface current (intensity and direction) for each season. The SST values calculated from LCD, presented up to 5°C variation from summer to winter, and the currents showed more instability during winter and spring periods.



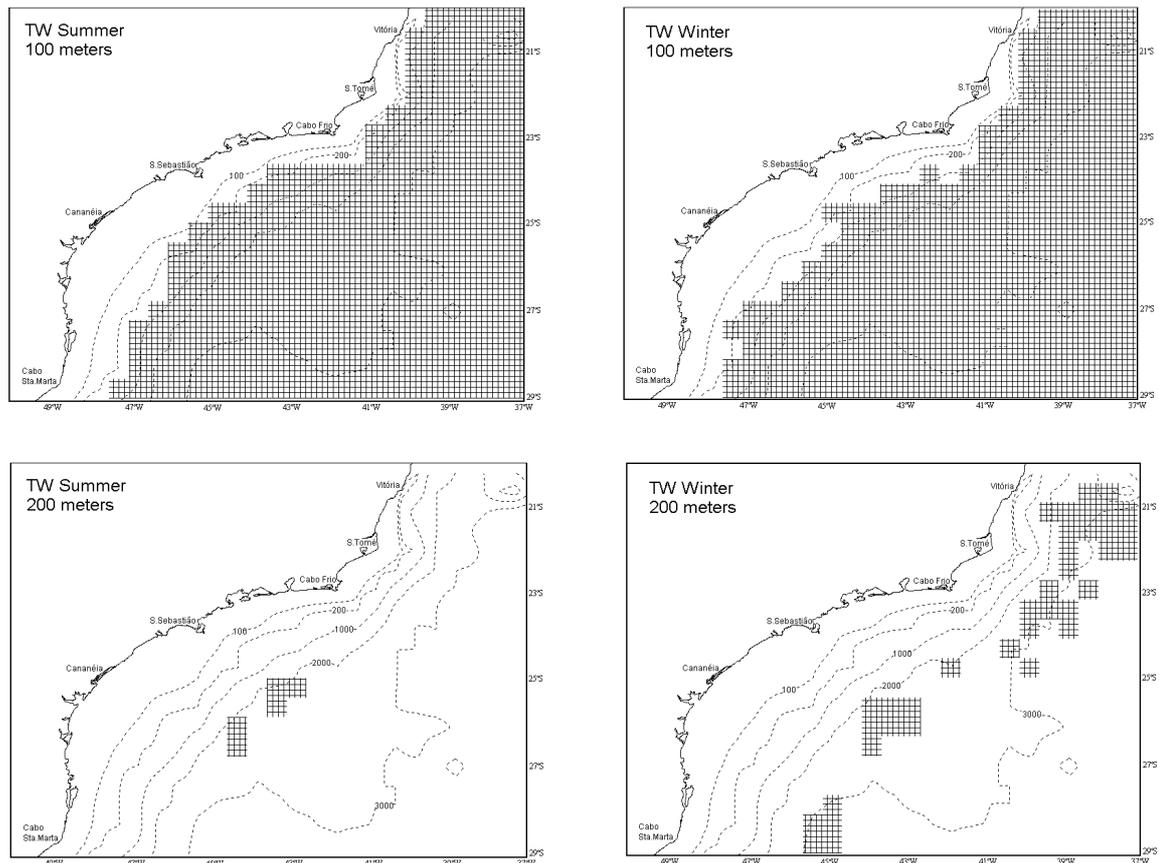
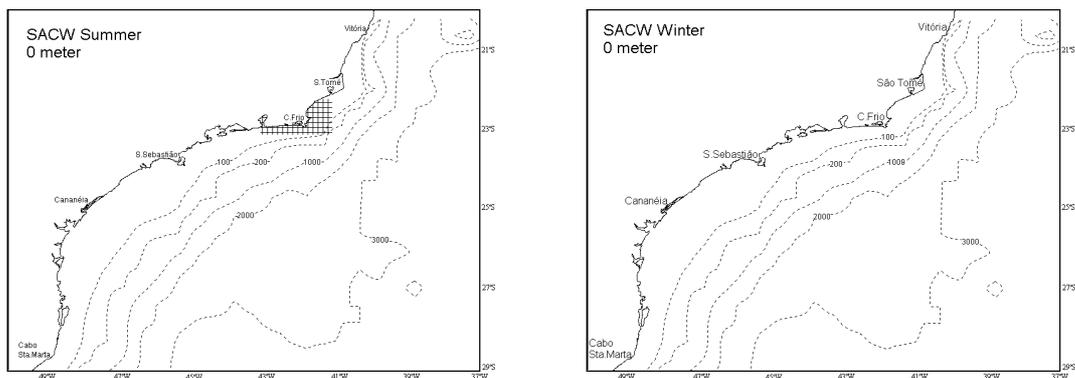


Fig. 3.2 TW observed (dashed) in the summer and winter seasons at 0, 100 and 200 m depth.



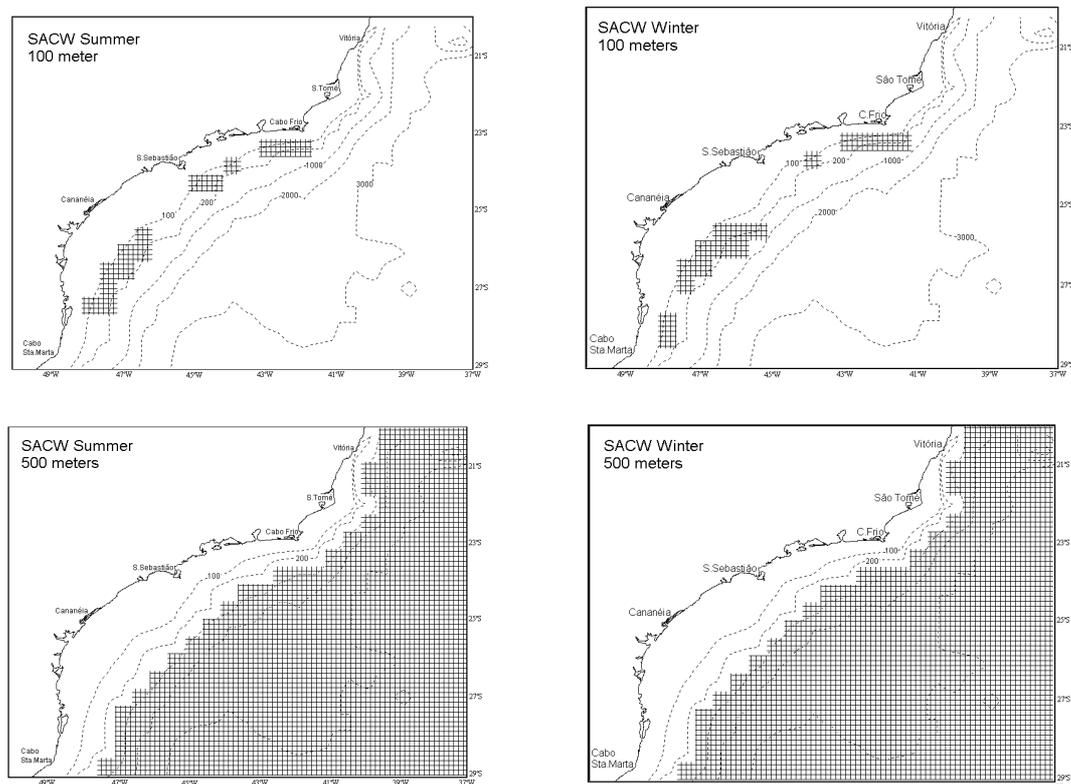


Fig. 3.3 SACW observed (dashed) in the summer and winter seasons at 0, 100 and 500 m depth.

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