Atlas-B: The Development and Mooring of a Brazilian Prototype of the Atlas Buoy

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Abstract*—The South Atlantic Convergence Zone (SACZ) is an important component of the ocean-atmosphere interactions over a large portion of South America. For properly monitoring the SACZ, the preliminary ideas for a southwest extension of the Prediction and Research Moored Array in the Tropical Atlantic (PIRATA) considered a set of four Atlas buoys; the last one intended to be moored near 28oS and 44oW. In its final configuration, however, the PIRATA Southwest Extension (PIRATA-SWE) deployed only three buoys in the tropical region, to the north of the SACZ. In March 2004, the occurrence of an unusually strong extra-tropical cyclone over the subtropical South Atlantic, which acquired characteristics of a Saffir-Simpson class-1 hurricane (the Catarina) around 28oS reinforced the necessity of having a monitoring platform anchored in that region. In 2009, efforts were started to assemble and deploy a Brazilian prototype of the TAO/PIRATA Atlas buoy the Atlas-B. Finally, in April 2013 the first Atlas-B, dubbed the Guariroba, was successfully moored at 28.5cS, 44oW. Similarly to the PIRATA program, this mooring site will be maintained initially as a pilot experiment, and eventually included in some long-term Brazilian monitoring program. The abstract goes here.

I. Introduction

The Brazilian climate is significantly influenced by ocean-atmosphere interactions in the tropics and in the subtropical regions of the South Atlantic. In the tropics, these interactions have been extensively studied and monitored for more than 10 years by the PIRATA Program, by means of an array of Atlas buoys. All these monitoring platforms are moored to the north of the South Atlantic Convergence Zone (SACZ), a region of high precipitation, which impacts a large fraction of the Brazilian territory. To enhance the PIRATA array in its capability of providing the data needed for better weather and climate forecast, and to understand the SACZ and its variability, the mooring of an Atlas buoy to the south of its region was initially considered as part of the rationales for the PIRATA-SWE. However, mainly because this additional buoy would be located in the subtropics (PIRATA is a tropical array), it was not included in the final configuration of the PIRATA SW extension. On March 26, 2004, an extra-tropical cyclone in the South Atlantic acquired characteristics of a tropical cyclone near 28°S and developed into a class-1 hurricane (Fig. 1). This hurricane, the Catarina, made its landfall along the southern coast of Brazil, on the 28th of March. Maximum sustained winds were estimated between 120-130 km/hr, with gusts up to 155 km/hr. The storm left at least three people dead and 38 injured. More than 2,000 were rendered homeless. This was the first documented hurricane in the South Atlantic Ocean since the beginning of geostationary satellite records. The difficulty to timely predict the evolution of that system, due to complete lack of in situ oceanographic data, reinforced the needs for the development and mooring of an observational platform in the region where the extra-tropical cyclone gained hurricane strength. This monitoring system, the Atlas-B, is similar to the TAO and PIRATA buoys in the Tropical Pacific and Atlantic.

In 2009, the development of the Atlas-B buoy started as an activity of the National Institute of Research and Development for Climate Change (INCT-MC), and was conducted at the Oceanographic Institute of the University of So Paulo (IOUSP), in partnership with AMBIDADOS and HOLOS, two Brazilian companies located in the city of Rio de Janeiro. Two buoys were completed. The first one used recovered parts of a damaged Atlas buoy. The second was entirely constructed by AMBIDADOS/HOLOS. In both cases, the integration of the entire mooring line was entirely made in Brazil, based on blueprints kindly provided by the Pacific Marine and Environmental Laboratory (PMEL) of the U.S. National Oceanic and

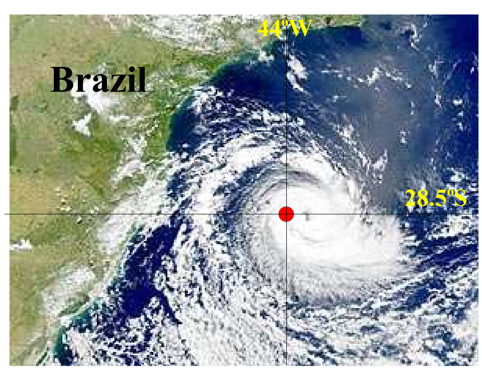

Fig. 1. Catarina, the first recorded hurricane in the South Atlantic. It started as an extra-tropical cyclone over the continent and evolved into a Saffir-Simpson class-1 hurricane near. The Atlas-B buoy Guariroba was moored at 28.5°S, 44°W.

Fig. 2. The Atlas-B buoy Guariroba just after its mooring at 28.5°S, 44°W.

Atmospheric Administration (NOAA). After the completion of the first unit, the Atlas-B was first moored for a testing period near the coast, in the seaside basis of IOUSP in the city of Ubatuba. Finally, in April 22, 2013, the definitive launching of the Guariroba (Fig. 2) was conducted in a cruise onboard the IOUSPs research vessel Alpha-Crucis.

This paper describes the construction, the structure and the mooring of the Guariroba, and presents some preliminary analysis of the data collected since its deployment.

II. The Structure of the Atlas-B

The first unit of the Atlas-B, moored in April 2013 at 28.5°S, 44°W (the Guariroba), was assembled using retired parts of an Atlas buoy, kindly provided by PMEL. A second one, which will be launched in early 2014 after the recovering of the first, was entirely built in Brazil. The floating structure of the Atlas buoy is composed by a 2.3m diameter toroid fabricated with fiberglass over a foam core. It weights 660 km and has a total volume of 3 m3 with a buoyancy reserve of 2300 kg. It is topped with a simple aluminum tower and has a rigid stainless steel bridle underneath.

As shown schematically in Fig. 3, the surface buoy is equipped with a series of meteorological sensors and, in the case of Guariroba, is anchored to the sea bottom at approximately 4000 m depth. The top 500m of the mooring line is a 3x19 urethane jacketed steel rope. A set of oceanographic sensors is clipped to this wire, transmitting data continuously to a Campbell CR1000 datalogger in the buoy by means of electromagnetic inductive modems. Near the bottom, a sensor with internal storage capacity monitors continuously small variations in pressure, temperature and salinity. All the sensors in the Atlas-B buoys are listed below.

- Weather station Vaisala WXT520: air temperature, relative humidity, barometric pressure, precipitation and wind direction and intensity;
- Eppley Precision Infrared Radiometer PIR;
- Eppley Precision Spectral Pyranometer PSP;
- Sea-Bird SBE37SMP (surface T and C);
- Sea-Bird SBE37IMP (20; 40; 60; 80; 100; 120; 140; 180 meters depth)

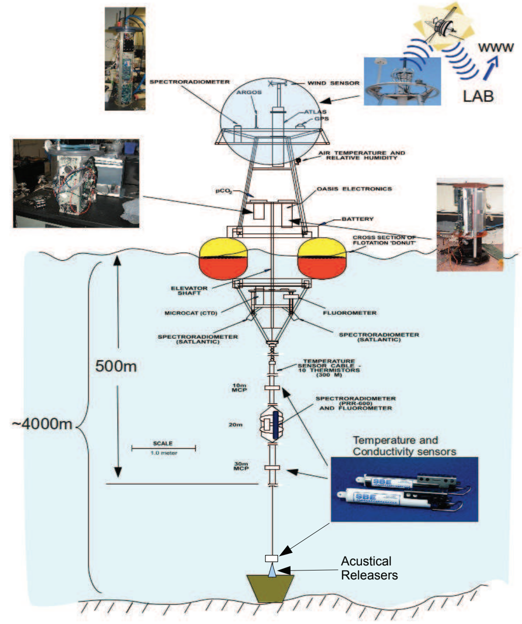

Fig. 3. Schematics of an Atlas-B mooring. A surface buoy, equipped with a series of meteorological sensors, is anchored to the sea bottom at approximately 4000 m depth. In the top 700m a cable with conducting core, to which are clipped a set of oceanographic sensors, transmits data continuously to a datalogger in the buoy by means of electromagnetic inductive modems. The data collected by the datalogger are transmitted via satellite, in real time. Near the bottom, a sensor with internal storage capacity monitors continuously small variations in pressure, temperature and salinity. The data stored in the deep sensor are retrieved by occasion of recovery and replacement of the whole system, what occurs at 12-months intervals.

- Sea-Bird SBE39IM (pressure sensor included - 300 and 500 meters depth);
- Sea-Bird Inductive Cable Coupler ICC;
- Sea-Bird Surface Inductive Modem SIM Card;
- KVH C100 Magnetic Compass.

The data collected by the different sensors in the upper 500m, in their original formats and protocols, are organized in the datalogger and stored in a 2GB CompactFlash memory card. The data acquisition rate varies from 1 (meteorological sensors and compass) up to 10 min-1 (CT sensors). All the data are stored with a standard temporal resolution of 10 minutes. A string composed by the data from all sources is transmitted daily by means of a satellite telemetry unit Inmarsat, Skywaves IsatData Pro terminal IDP690. This IDP690 module has an integrated GPS and was programmed to include the data position in the transmitted data string. As a redundant positioning system, a Globalstar Tracking device was installed, in a way totally independent of the buoys electronics and batteries. The data stored in the deep sensor are retrieved by occasion of recovery and replacement of the whole system, what is planned to occur at 12-months intervals.

III. The Mooring Line

The Atlas-B project adopted a semi-taut format for the mooring line (Trask and Weller, 2001), with a ratio between the length of the line and the local depth approximately equal to 1.05. The depth in the Guariroba site is of 3640 meters.

Considering the experience acquired in PIRATA, the steel wire was retained for the upper 700 meters, to avoid rupture by shark bytes. Below 700m, down to the acoustic release, which is at 50m above the sea floor, a 18mm nylon cable was used, in sections of 500 meters length, interconnected with pair of subsurface glass spheres with 17 inches diameter. Right above the pair of EdgeTech acoustic releasers it was installed a set of six of these glass spheres, for bringing these devices back to the surface. The acoustic releasers are connected to the anchor by a 20mm nylon cable and 3m of a 5/8 steel chain.

IV. Preliminary Results

The Atlas-B was deployed on April 22nd, 2013, the 112nd day of year 2013, at the position (28°30′S, 44°00′W, 3700m depth) from the *N/Oc Alpha-Crucis*. Since then, the sensors are measuring and sending data via the Skywave-Inmarsat satellite. The daily data are freely available at the site ftp://ftp.io.usp.br/labmon/ATLAS-B. As of July 27, 2013, actions were being taken to send the data to the GTS. In the meantime, some preliminary quality control and analyses are being performed.

Time series of the meteorological variables are shown in Figures 4 to 7, from Day of Year (DoY) 100 of 2013 (20-APR-2013) to 200 of 2013 (19-JUL-2013). Comparisons are made with the NCEP/Reanalis estimates (Kalnay et. al., 1996). All meteorological variables, with exception of the east-west wind and long wave radiation, show coherent mean and variability between data and NCEP estimates. The east-west winds shows varibility with oposing phases due to a problem in the datalogger program; the long wave radiation shows its mean value 25% above the NCEP estimates.

Figure 8 show vertical profiles of temperature and salinity, and the dynamic heighs computed for 0 to 250m and 50 to 250m. The temperature data from sensors below the depth 250m stopped being sent since day 185. The cause of this failure has not yet been identified.

V. Conclusion

In spite of the apparent problem with some of the underwater sensors, the development of a Brazilian alternative for the Atlas mooring can be considered a great success. This was the first time the complete cycle of assembling and deployment of such kind of deep ocean monitoring platform was carried exclusively in Brazil. The present site will be maintained as a pilot project for a few years. Afterwards, once proven its functional capability and scientific value, it will eventually be transformed into a sustained observing component of the Brazilian climate research program.

Acknowledgment

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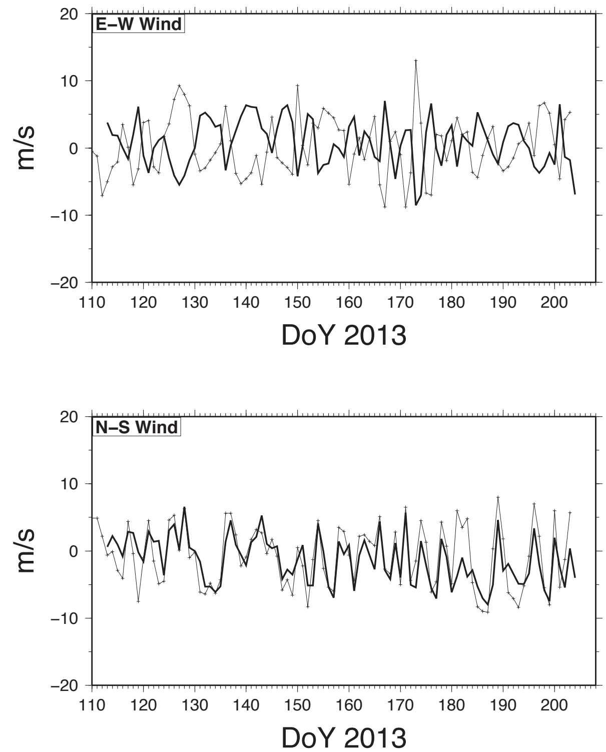

Fig. 4. The EW and NS components of the wind velocity measured by the buoy anemometer (solid), compared with the NCEP/Reanalysis wind data (dashed). Note that the EW component is out of phase with the NCEP data, due to an error in the datalogger program. This problem has been fixed for the second buoy.

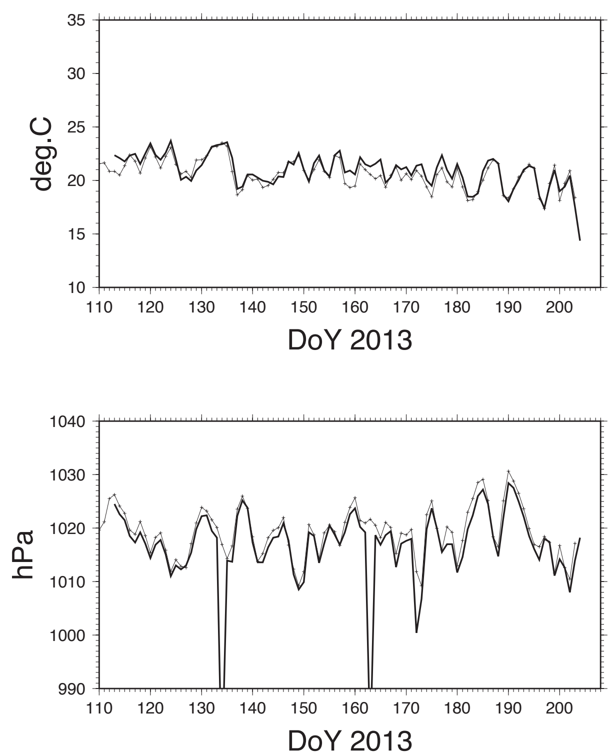

Fig. 5. Surface temperature (degree C) and air pressure (hPa), compared with NCEP/Reanalysis values (dashed line).

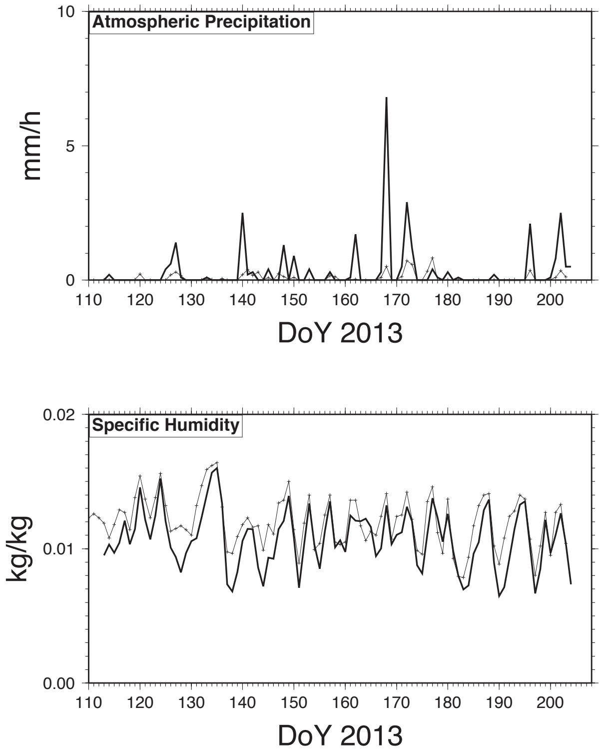

Fig. 6. Precipitation rate and relative humidity

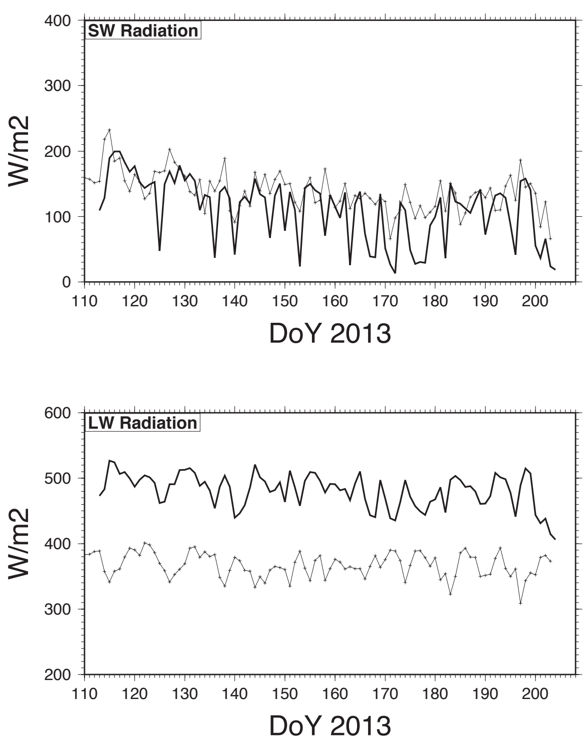

Fig. 7. Short and long wave radiations

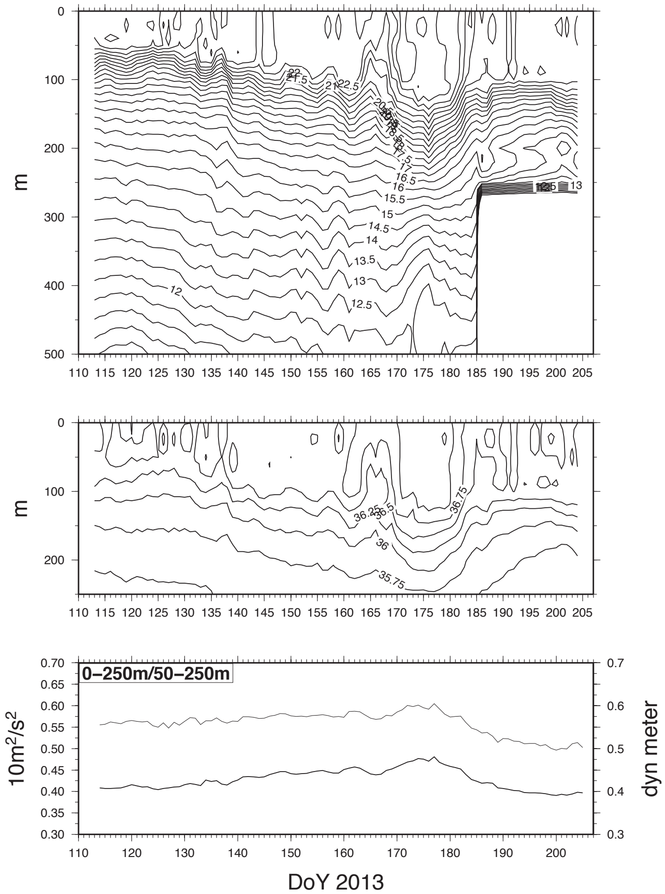

Fig. 8. Vertical profiles of Salinity and Temperature, and the dynamic height 0-250m and 50-250m

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