Proceedings of 8 ICSHMO, Foz do Iguaçu, Brazil, April 24-28, 2006, INPE, p. 1319-1322.

ATMOSPHERIC SOUNDINGS ACROSS THE EQUATORIAL FRONT BETWEEN THE GALAPAGOS ISLANDS AND THE COAST OF SOUTH AMERICA FROM THE INOCAR CRUISE OF OCTOBER 2005

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Abstract

Special radiosonde observations were made from the INOCAR research vessel *Orion* during the second INOCAR oceanographic cruise of 2005. These observations were carried out for both operational and scientific objectives. Operationally, we sought to evaluate the feasibility of routinely making radiosonde observations from the ship, and determining what the ship might need for such observations. Since relatively few upper air observations have been made between the Galapagos Islands and the coast of Ecuador we wanted to obtain high spatial resolution soundings across the equatorial cold tongue, which has been the subject of recent research measurements farther west in the eastern Pacific. Some results of the boundary layer over the cold tongue, based on the radiosonde measurements, are reported here. With some modifications, the *Orion* is a suitable platform for routine atmospheric measurements in this poorly sampled region of the eastern Pacific.

1. INTRODUCTION

NSSL scientists were invited to participate during the fall of 2005 in an oceanographic cruise of the Ecuadorean Navy and its principal research vessel, the *Orion*. The cruise was one of two cruises that are carried out annually in conjunction with cruises by the South American countries with Pacific coastlines. These cruises are to provide routine monitoring of oceanographic conditions in the maritime zones of each

Fig. 1. The main research vessel of the INOCAR, the Orion. The Orion was constructed in 1981 and has a length of 70m and displacement of 1400 tons.

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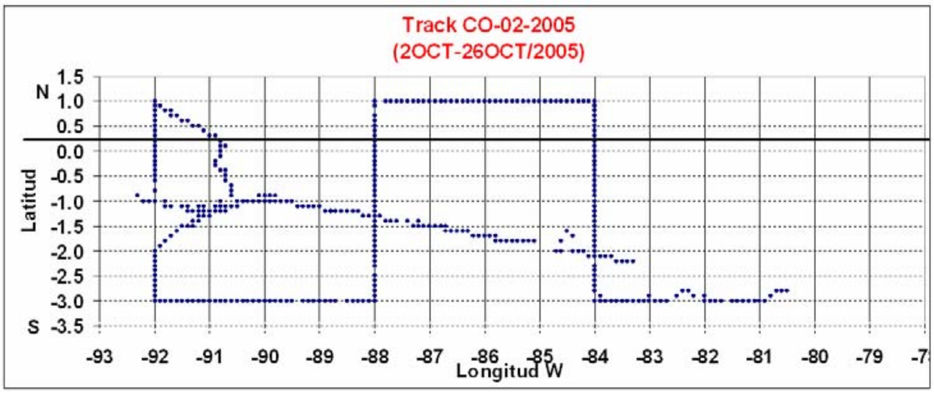
country. The initial objective of our participation was to evaluate the suitability and feasibility of using the *Orion* as a platform for making relatively routine measurements of the atmospheric boundary layer in the vicinity of the equatorial cold tongue between the coast and the Galapagos Islands. This region has been less well sampled, even by research ships, because it is off of the routine TOA buoy maintenance route along 95W, and few commercial ships pass through the region, except those to the Pacific coast of South America. The latter however, travel very close to the coast if they are proceeding through the Panama Canal.

In addition to evaluating the ship as a potential research platform, it was desirable to carry out some relevant research measurements during the cruise. Available at NSSL was a portable non-GPS Vaisala radiosonde system, without windfinding capability, using RS-80N radiosondes. As we had a large number of these radiosondes, we are able to carry out the observations without a major investment in expendables. These are old Omega radiosondes, and while the radiosondes were estimated to date from 1997, they provided, as shown below, rather acceptable thermodynamic data. System is Unfortunately, since the Omega Navigation no longer functioning there was no wind data from the sondes.

The ship track was designed (Fig. 1) to cover an East-West swath between the Ecuadorean coast and the Galapagos Islands. It ranged from 3˚S to 1˚N. Every degree of latitude and longitude (a "station") the ship would stop and make measurements that would take between one and 2 hours. These measurements included CTD soundings, plankton trawls, and a few other measurements. The meteorological measurements were made hourly, consisting of manually recorded surface observations.

The ship left Guayaquil on October 2 and followed the track shown in Fig. 2. While removing an INOCAR buoy from the water just south of Isla Isabella, a member of the crew injured his hand, which forced a detour to San Cristobal Island, for a flight to the mainland. At this point, because we had accomplished most of the planned observations, our original departure had been 1 week late, and the ship had traveled slower than expected (7 kts, instead of at least 11 kts, due to an engine problem) we decided to end the observational program.



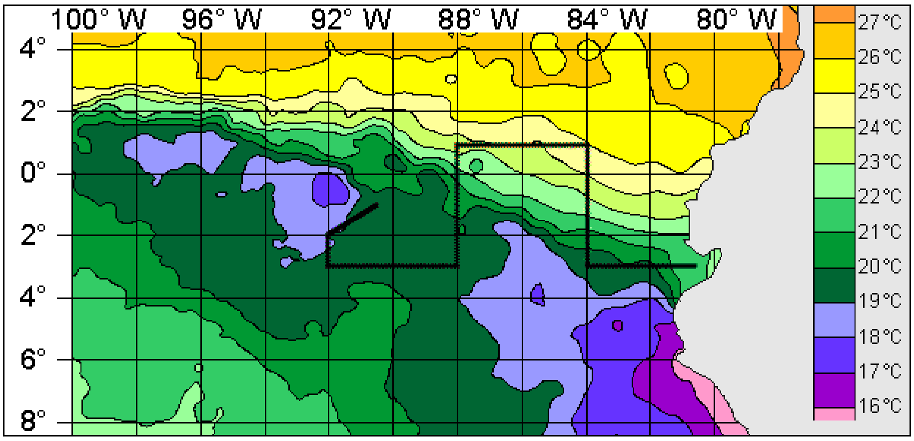


Fig. 2. Approximate track of the first part of the Orion cruise to the Galapagos Islands. Island circumnavigation and return of the Orion is not shown. Radiosonde observations were made along the track shown.Shaded contours represent average SST for the period October 1-15, 2005, obtained from IMARPE's (Instituto del Mar del Peru) web site: http://200.60.133.147/uprsig/sst_prov.html.

2. RADIOSONDE SYSTEM DETAILS

Our radiosonde system, consisting of a Vaisala PP-15 processor and a 403 Mhz receiver with preamplifier, was installed in the chart room just aft of the bridge. Here the radiosondes were prepared for launch. The antenna cable extended outside and up to an antenna on the upper deck.

The only significant complication to our radiosonde efforts was that we had to inflate the 100gm balloons in a room that, despite being especially designed for balloon inflation, had never been used for such in the ship's 25-year history. This room (the crew's weight room), was near the stern of the ship, about a one minute walk from the top deck, where we had arranged the marine theodolite for tracking the balloon to obtain the wind. Thus our procedure for launching a balloon consisted of the following steps:
1) Remove the water-activated battery from the radiosonde package, go to the bathroom (two decks down) to get water for the water-activated battery and return to the "radiosonde room".

2) prepare the receiver/processor and start the data recording

3) carry the radiosonde down to the balloon inflation room (3 decks down and to the stern of the ship)

4) inflate the 100gm balloon and tie the radiosonde to the balloon

5) send one person back to the theodolite and stand by with an assistant.

6) launch the balloon; the launcher then runs back to the top deck to help with the balloon tracking.

Initially the plan was to make radiosonde observations at every station where the ship stopped; these were at 1 degree intervals. Some stations were relatively long (almost 2 hours) while others were less than 1 hour. We had expected that this would provide the optimal arrangement for our observations, but this was not the case. The CTD measurements required that the ship's axis be oriented almost perpendicular to the wind (and swell) and this induced significant rolling to the ship. With the roll it was more difficult to use the theodolite.

Eventually, we decided to launch the balloons while the ship was underway, given the less desirable conditions when the ship was stopped on station. This eased launching complications and provided a more stable platform for tracking the balloons. However, the low cloudiness prevented wind measurements much of the time, and we eventually stopped the wind soundings, given that surface measurements were being made every hour.

3. THE OBSERVATIONS

During our 12 days at sea, 31 radiosondes were launched and all worked well to approximately 50mb. We noted that there were apparent differences in the boundary between clear and cloudy conditions, despite limitation of the radiosondes to register saturated conditions. However, they did reach approximately 95-98% in low-cloud conditions.

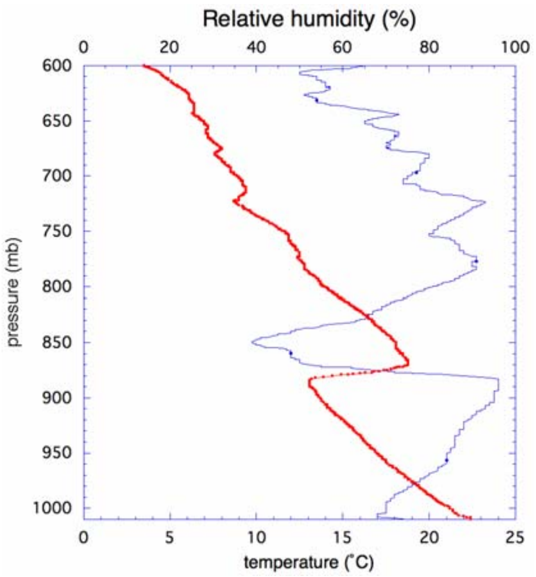


Fig. 3 An example of a radiosonde sounding in relatively warm SST conditions, near 1˚N. Note that the low RH layer is very shallow, and the sounding is moist at higher levels.

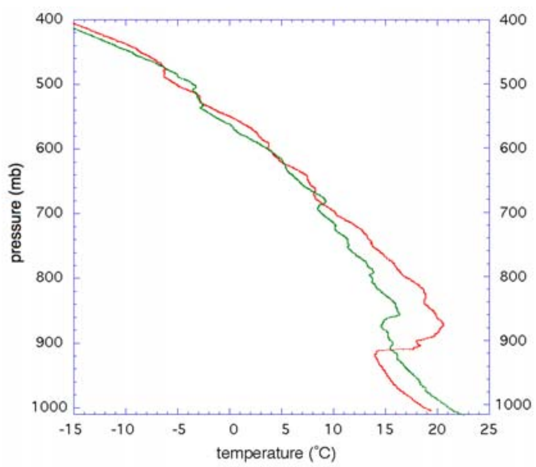


Fig. 4. Comparison of two soundings along 84˚W, the cooler one (red) at 3˚S and the warmer one (green) at 1˚N. The warmer sounding has a deeper boundary layer, but is cooler than the cool sounding above the inversion.

4. CONCLUSIONS

The Orion is a suitable platform for launching radiosondes; a GPS-sounding system is needed to obtain winds in this region of frequent low cloud overcast. Theodolite tracking is not suitable for these low cloud conditions.

The ship needs a thorough modernization to become a more suitable platform for researchers and their equipment. These would include:

1) an automatic weather station to measure all basic meteorological variables at least every minute, or averaged over some suitably short period. Solar radiation and several thermometers (to assure minimizing deck heating concerns) are needed.

2) continuous recording of position orientation and other ship positioning information, accurate to GPS limits.

Hopefully the planned overhaul in 2006 will bring the ship back to original conditions.

Strategies for effective use of the ship in International waters would be advantageous to develop and coordinate with neighboring countries. Many questions can only be addressed by measurements outside the confines of the maritime exclusion zones of each country. The Orion cruise might have benefited from greater latitudinal coverage than permitted by prior agreement (the Colombian cruises covered waters north of 1˚N).

While routine measurements at the same locations can be valuable for monitoring oceanographic changes, there could be benefits to a more coordinated and science-focused approach to using the ships as observing platforms. Given that Colombia, Ecuador, and Peru all carry out these cruises in relatively close geographical proximity, it could be beneficial if discussions were held to discuss how specific objectives could be addressed by joint use of this research fleet. A meteorological activity could be coordinated with land-based observations that might include island sites in Colombia (Malpelo), in Ecuador (the Galapagos Islands), and possibly Costa Rica (on Cocos Island).

Acknowledgments

The first and second authors wish to thank the Instituto Oceanografico de Ecuador (INOCAR) for inviting them to participate in the 2nd INOCAR Cruise of 2005: CO-02-2005.