Variability of the Cross-Equatorial Flow over the Eastern Pacific Ocean from 8 years of Pilot Balloon Observations at Piura, Peru

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Introduction

Pilot balloon observations have been made at Piura, Peru (~ 5.2˚S), since 1997 as part of the PACS-SONET project. These observations were begun as an effort to measure possible cross-equatorial flow variations that might be related to rainfall variations in Central America. Originally, observations were to have lasted for 6-months, but observations were extended because of the 1997-8 El Niño event, and then variously extended until the present.

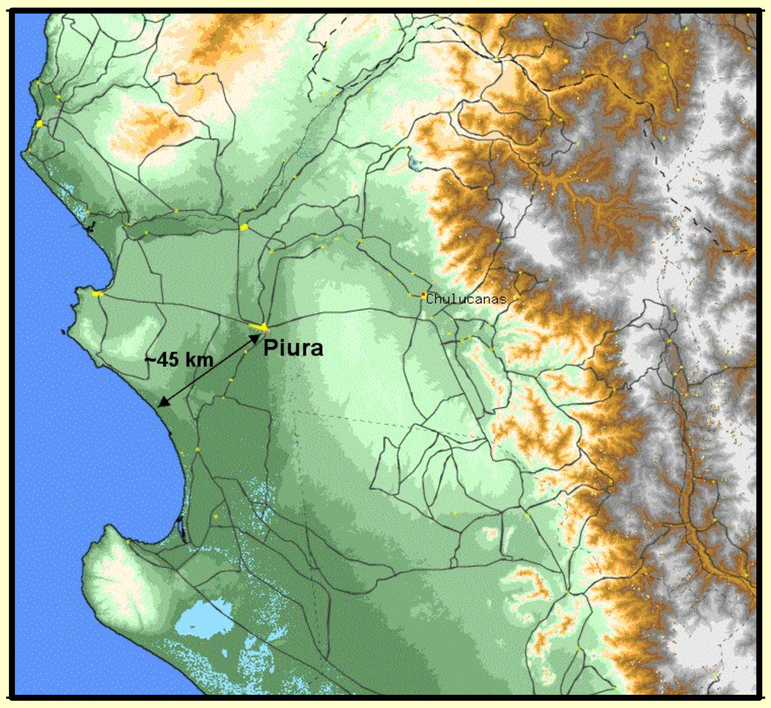

Fig. 1 Geography and topography of the Piura site. Highest terrain is about 3 km (white area). Shading interval is 100m near sea level.

Observations

The pilot balloon observations are made by an observer (or usually two) who inflates a pilot balloon of 30gm mass, which is filled correctly when it lifts a specified weight from the floor. This balloon is then released and tracked by an optical theodolite until lost due to cloud cover or poor visibility. The main problem with the Piura observations is the high frequency of low clouds that prevents most observations from reaching high levels. Initially, observations were made twice-daily, the results (Fig 2) showed that it was far more effective to make routine once-daily observations only in the afternoon.

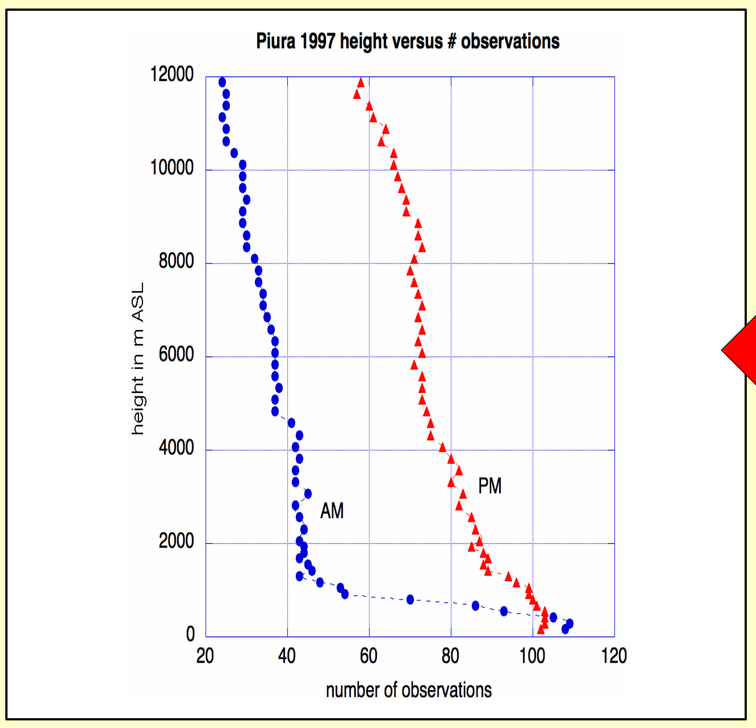

Fig. 2 number of observations at Piura during a 4-month period during 1997 when observations were made twice-daily. Note the very rapid drop-off in observations during the AM due to a persistent low cloud layer present on most days. The cloud layer generally dissipated by the afternoon observation time. Above the low-cloud layer, the decrease in observations with height is similar in both morning and afternoon.

Seasonal and monthly evolution of the meridional flow

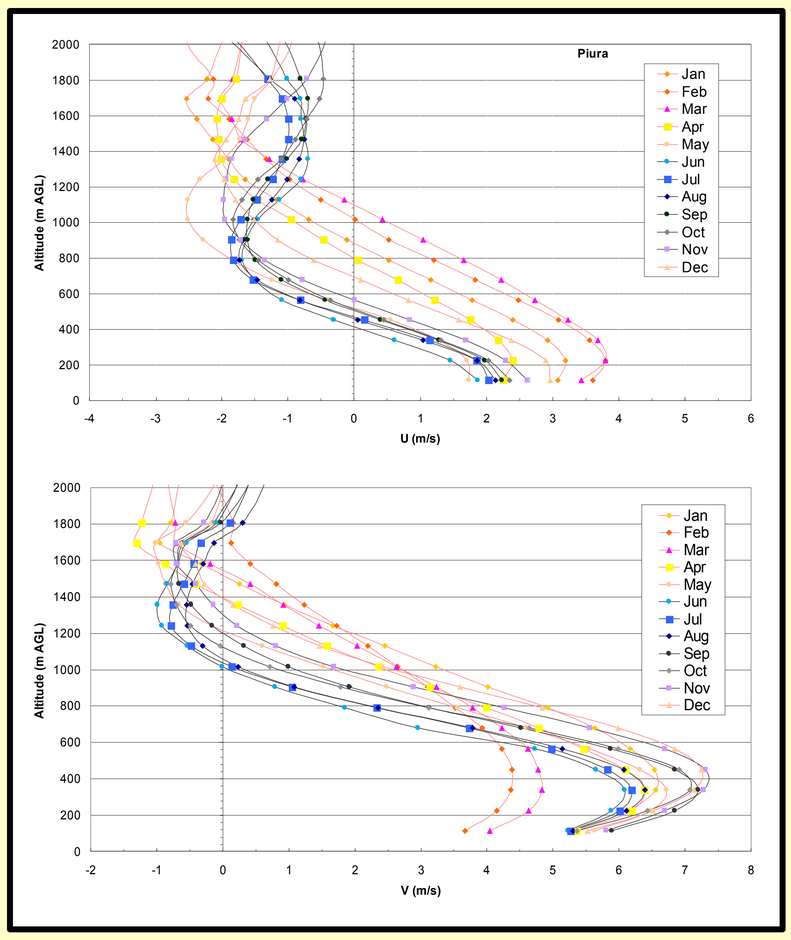

Fig. 3. Monthly mean profiles of zonal and meridional wind. Top is zonal profiles. Bottom is monthly mean meridional wind profiles. Pink curves indicate warmer months, black curves cooler season months.

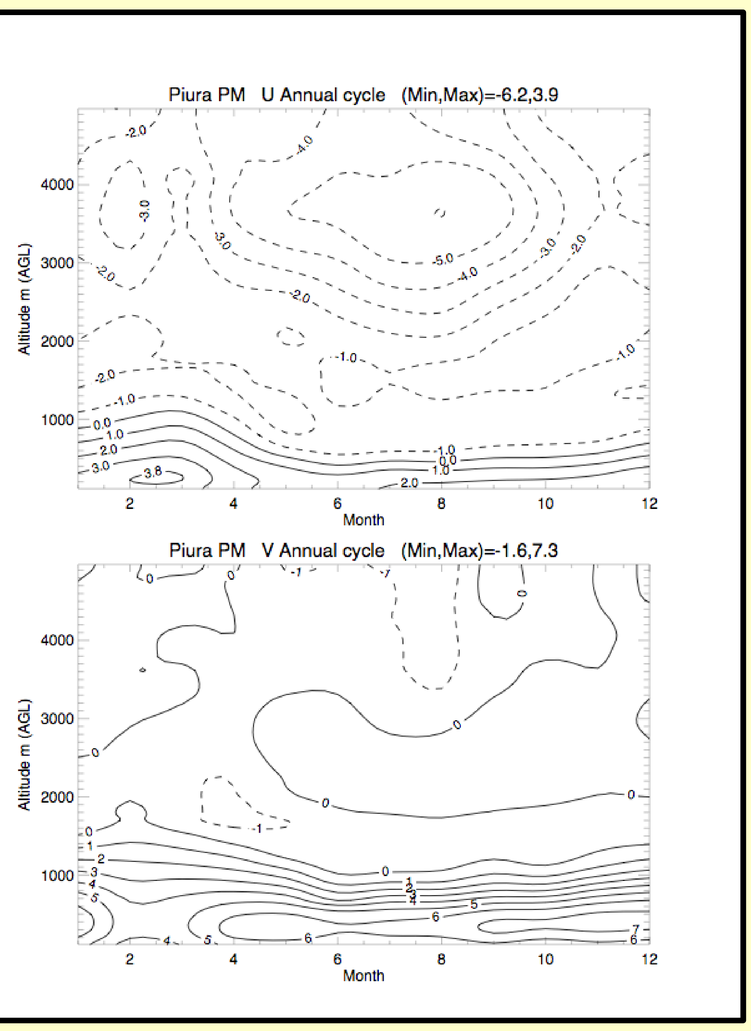

Fig. 4 Height-time sections of monthly mean zonal (top) and meridional (bottom) winds at Piura, averaged over all observations. Highest levels show noisy pattern, reflecting few observations. Vertical scale is maximum of 5000m to highlight annual cycle in lower troposphere.

Acknowledgements

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Annual mean profiles of meridional wind

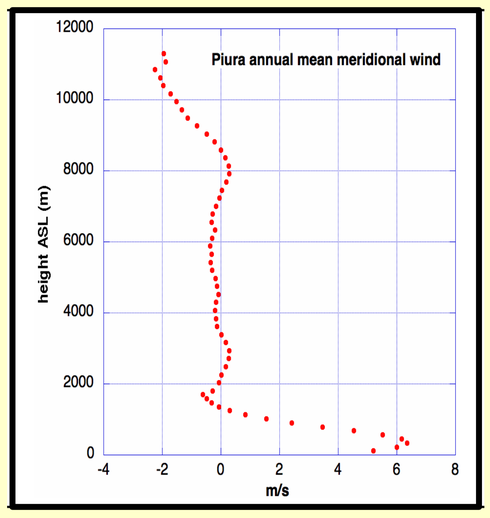

Fig. 5 Annual mean meridional wind profile, based on ~2900 observations at Piura from 1997 to 2006. The annual mean meridional wind profile shows very clearly the shallow northward flow that is inflow into the ITCZ, whose climatological position is north of the Equator.

Land-sea breeze circulations

There is a strong sea-land breeze circulation at Piura; the 1997-8 cool season monthly mean observations show that this is a very regular feature. Using all available observations when both AM and PM observations were made, the 0000 UTC profiles show both a stronger onshore flow, and a stronger southerly flow (Fig. 6). From Fig. 6a, the PM profiles have about a 25% greater northward mass flux than the mean values, and almost 3 times the AM values.

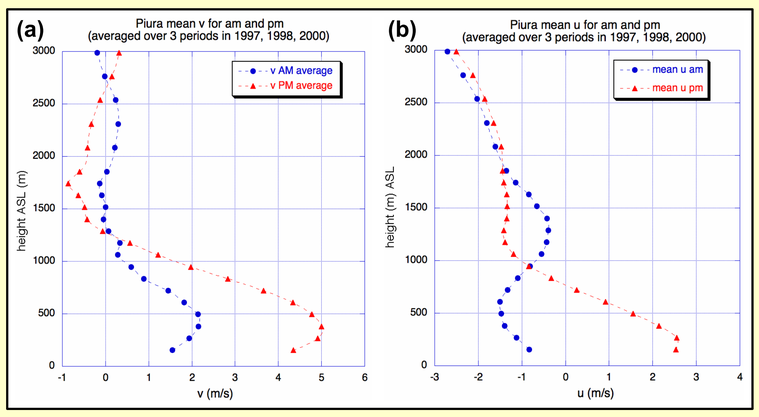

Fig. 6. a) Diurnal variation of meridional wind at Piura, based on all observations when months had am and pm soundings. **b)** same as "a" but for zonal wind component.

Summary and implications of the results

The mean winds at Piura show that even with unfavorable cloudiness conditions it is possible to obtain monthly mean values of the wind that are sufficiently accurate to describe intraseasonal to interannual variations. The requirement is of course that the standard deviation of the winds about the mean be not excessively large compared with the variations which one seeks. The large signal associated with the 1998 El Niño event stands out as the most prominent feature of the 8-year record, although the cool year of 2005 showed a significant departure from the 8-year mean in the opposite sense.

WEB:

http://www.nssl.noaa.gov/projects/pacs/