Characterization of a Secondary Upwelling in the Southeastern Caribbean

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Introduction

The southeastern Caribbean Sea (Fig. 1) is a major upwelling region, characterized by high biological production and a rich fisheries. The CARIACO time-series station (10.5°N and 64.66°W, red star, Fig. 1b) has collected monthly hydrographic observations since November 1995 in this region. The data have allowed characterization of the upwelling process. It is clear that there is a primary upwelling event driven by strong Trade Winds between about December and May each year. The time series also shows a short-lived secondary upwelling between June and August (Rueda-Roa 2000, Muller-Karger et al. 2004) that has not been documented by earlier studies. The secondary upwelling occurs when the Trade Winds in the southern Caribbean are weaker due to the northward migration of the ITCZ. Other mechanisms are being explored, as possible Ekman pumping associated with wind stress curl, and influence from offshore eddies.

Here we explore various datasets that evidence the seasonal occurrence of the secondary upwelling in the southeastern Caribbean upwelling system.

CARIACO Time Series

Seasonal changes in the temperature structure at the CARIACO time-series station (Fig. 2) were compiled from monthly CTD measurements. The main upwelling generally exhibits two to three pulses, starting in December-January. The strongest pulse is generally in March and typically subsides around May. The secondary upwelling has one pulse usually observed between July to August (around white vertical lines in Figure 2), with the 22°C isotherm rising to or above 30m depth. In general, the secondary upwelling is short-lived and less intense than the main event, although in some years it has been as strong (i.e.: 1997, 2000, 2002 and 2004).

Satellite Sea Surface Temperature

Sea Surface Temperature (SST) is a good proxy for upwelled waters in this region. Weekly SST composites of Advance Very High Resolution Radiometer satellite images (Fig.3) show the SST distribution during the main upwelling (a), intermediate period (b), secondary upwelling event (c) and relaxation period (d). The secondary upwelling plume covers about the same surface area as the main upwelling.

Data were extracted from the weekly SST composites for 41 stations distributed along the southeastern Caribbean (~13 km from the coast, red dots in Fig.1b) and were used to generate a SST time series (Fig.4, 1994-2005). Blue shows water bellow 25°C (upwelling). The secondary upwelling can be seen around June-July as a single pulse or as an extension of the main upwelling, and it occurs at the same locations as the main upwelling. The interannual variability of the intensity and duration of the upwelling cycle is evident in the SST time series.

Tide Gauges Records

Wind-driven Ekman coastal divergence decrease the sea surface elevation near the coast causing upwelling. Therefore, a direct relationship may be expected between SST and sea level at the coast. A high correlation (R: 0.87) was found between seven years of monthly average sea level records at Punta de Piedras (Fig. 1b) and SST off northern Araya Peninsula (yellow triangle, Fig.1b). Tide gauge records can therefore serve as a proxy to follow the upwelling cycle in the area. Three decades of monthly sea level anomalies from Cumaná (Fig.5, location in Fig.1b), clearly show the annual upwelling cycle of the area, including the secondary summer peak (June to August periods are highlighted in red).

Conclusion

The secondary upwelling event is evidently in 11 years of Caribbean SST records, the 12 years of CARIACO time series station observations, and in 30 years of sea level (back to 1948). Clearly this is a regular feature of the southeastern Caribbean upwelling system. Although this secondary upwelling is short-lived and less intense than the primary event, it leads to a longer period of productivity in the region (7 months or more). We believe this has important fisheries implications. This is the focus of a new study conducted jointly between Venezuela and US scientists under the CARIACO project.

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