THE SURFACE CIRCULATION AROUND CRETE INFERRED FROM SATELLITE, DRIFTER BUOYS, AXBTS DATA AND A PHYSICAL MODEL

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Abstract

The long term (1987 through 1997) surface circulation around Crete is described using drifter buoy trajectories, AXBTs, satellite thermal imagery and altimetry data. The long term data is provided by weekly satellite images and altimetry data augmented by the three-month trajectories of four satellite-tracked drifter buoys. These buoys were air-dropped into prominent frontal features and eddies around Crete that had been noted as a result of a pre-drop two-year study of satellite thermal imagery. Permanent changes that appear to have occurred after late 1995 in one of the more prominent of the eddy features are discussed and a physical model is presented to show its possible relation to the surrounding circulation.

Keywords: Remote Sensing, Circulation, Cretan Sea

Introduction

A brief report on the surface circulation around Crete as inferred from satellite imagery and drifter buoy trajectories was presented by Price *et al.* (1) at the CIESM meeting in Perpignan, France in October 1990 (Fig. 1). The report concentrated on the three-month trajectories of four satellite-tracked drifter buoys (2) air-dropped on 25 February 1990 into prominent frontal features and eddies around Crete that had been noted as a result of a two-year study of satellite thermal imagery. Price *et al.* discussed in particular several prominent thermal features that were noted in the study of the satellite imagery and that appeared to control the trajectories of the buoys. The 1990 report indicated that the region contained permanent cyclonic and anticyclonic sub-basin scale gyres that were fed and interconnected by jet-like currents. Although the features appeared to be permanent (within the two-year time scale of the report), they showed wide temporal variation, displaying broad shifts in the location of their centers as well considerable deformations in their boundaries.

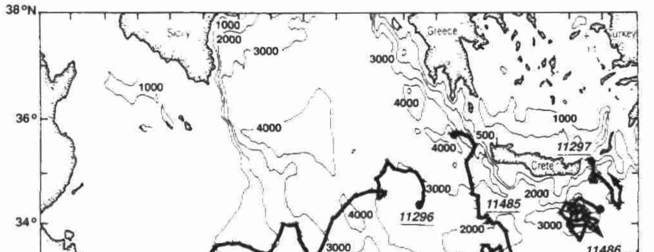

Figure 1 : Vertical distribution of a cross-transect current component for winter. Transect location is shown in the insert map.

In this report we will 1) discuss in more detail the trajectories of the buoys and their relation to the satellite-derived thermal field; 2) update the persistence of these eddies using a broader temporal base of satellite imagery and altimeter data (1987 through 1997), and airborne expendable bathythermograph data; 3) show that although one of the most prominent of the eddies were generally present to late 1995, it has since disappeared; 4) use a physical model to show the possible ramifications of this change in the local circulation in relation to the regional circulation.

There is a difficulty in using single buoy drops in characterizing a region's circulation in that some anomalous perturbation may influence the drift in away that does not describe the general regional movement. Our examination of the co-incident thermal satellite imagery has helped alleviate that problem and we believe the trajectories, as a whole, represent pertinentcirculation features.

The pre-fall 1995 circulation

The preliminary study of satellite imagery by Price *et al.* indicated that a large cool band of surface water flowing out from the Aegean Sea constitutes much of the surface water mass found in the area to the west and east of Crete. For lack of a previous reference to this current feature, Price *et al.* termed this the Aegean Sea Outflow. The buoy deployment in their report was designed to study this outflow and help in determining its relationship with the general Cretan circulation, especially the strong and variable eddy-field found south of Crete. In this part of our study, we will present an expanded description of the trajectories. Although temporally short (90 days), the description will show the general regional circulation as it was prior to the fall of 1995. Data details such as the daily imagery or buoy thermal and wind data are not presented due to space constrains. Instead the following will summarize comparisons of the buoy trajectories (Figs 1 and 2) with simultaneous satellite thermal imagery, and the regional bathymetry, wind conditions as reported by the individual buoys and the regional winds. Note that the single-day image in Figure 2 was chosen to best depict the overall circulation during the three-month buoy deployment. Altogether, 62 cloud-free images were examined during the three month period. It is important to note that the day-to-day depiction of the thermal field by these 62 images varied considerably during the three months (this will be presented in Dubrovnik). In the buoy discussions that follow, the remarks are based on specific segments in the trajectories in direct comparison with the satellite images for the periods of those segments.

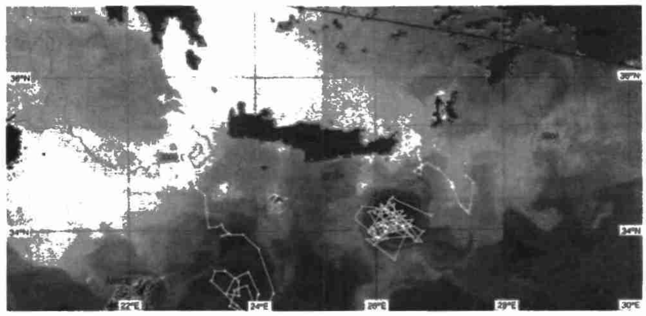

Figure 2. **See color figure p. 215.**

The Eastern Mediterranean East-West Frontal (Buoy 11296). Figures 1 and 2 shows that Buoy 11296 traveled in a general southeast direction after leaving its initial drop point southeast of Crete. The buoy drifted at speeds between 20 and 56 cm/sec. The thermal imagery showed that weak anti-cyclonic eddies inhabiting the Afro-Sicilian Basin and that the highly variable circulation associated with these features were effecting the track of the buoy. Although the buoy followed the deep isobaths of this gradually slopped region on occasion (e.g., see the initial track of the buoy), it just as often crossed the isobaths of the gradual sloped area. Once the buoy crossed 15°E, it turned south, following the Libyan coast until it ceased transmitting on 26 April.

The Pelops Gyre (Buoy 11485). Buoy 11485 was dropped just southwest of a warm anticyclonic permanent eddy located northwest of Crete that had been noted in all of the two years of satellite imagery - Robinson *et al.* (3) termed the feature, the Pelops Gyre, and this terminology is used here. Thedrift of the buoy was influenced by this eddy for a short period, moving at 25 cm/sec along its eastern side before becoming entrained in a flow indicated by the daily imagery to have initiated in the Aegean Sea. Typical speeds in this flow were slower:15 cm/sec. Upon crossing 34°N, the buoy became entrained in a large jet associated with a warm eddy lying north of Libya and speeded up to 46 cm/sec. The buoy became trapped by this warm eddy, moving deep into its interior drifting at 15 cm/sec along its outerwall and 35 cm/sec nearer the core. The buoys last transmission was also on 26 April.

The Cretan - Ierapetra Eddy (Buoy 11486). Of especial interest was the drifter entrapped for 50 days in a well defined semi-permanent eddy located at the southeastern end of Crete which Price et al. termed the Cretan Eddy.This eddy was also noted in the POEM ship data (3 and 4) and termed the Ierapetra Gyre. To avoid confusion, we will term the eddy the Cretan -Ierapetra Eddy. Price *et al.* thought it odd that the buoy remained entrained in the eddy for such a long period (approximately 60 days), despite at times coming quite close to the thermal rim (as detailed in the overlays of the driftertrack on simultaneous AVHRR imagery). The data shows the buoy making a complete loop within the eddy every five