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Effect of wind direction and orography on flow structures at Baja California Coast: A numerical approach

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ABSTRACT

In order to study the effect of orography and wind variability on flow structures at Baja California Coast, the momentum primitive equations describing an atmospheric flow over that region were solved numerically employing the General Curvilinear Atmospheric Model. Simulations were performed for varying wind direction and compared to available observations. Wind field and related variables of interest for oceanography were also calculated.

1. Introduction

Baja California Coast (BCC) is characterized by the abundance of mesoscale atmospheric eddies evidenced by cloud trails shown in several satellite images (True colour composites images from MODIS-Aqua, http://earthobservatory.nasa.gov/) of the region. These features are related to the interaction of prevailing winds, local and seasonal, with the complex orography over which they flow. Particularly, strong cyclonic and anti-cyclonic eddies have been observed to emerge from major capes in BCC such as Point Baja (PB), Point Eugenia (PE), Cabo San Lucas (CSL), and lee of Guadalupe Island (GI) and Cedros Island (CI). Winds over the coast of California and BCC have been modelled with ∼10 km grid resolution by several mesoscale atmospheric models [1–4]. The coarse spatial resolution of these simulations is not adequate to describe the locally driven processes evident in the Baja California region with detail. However, the near-field implications of atmospheric wake need to be accurately resolved.

Recently, a high resolution, non-hydrostatic 3D curvilinear wind model, has been used successfully in the region [5,6]. In particular, Torres et al. [5] simulated winds over the BC region using a fixed NW wind direction and intensity as initial and boundary conditions. Modelled winds showed the characteristic Von Karman Vortex Streets (VKVS) in the lee of GI and CI as well as the modification of the wind field, and resulting jets, due to flow–topography interactions. Important parameters for biology such as wind generated ocean surface currents, wind stress curl, and associated Coastal Upwelling Index (CUI) were also estimated. Additionally, that study revealed the location of upwelling sites which coincided remarkably well with those previously observed in the region [7,8]. However, winds from several directions were not taken in account in [5]. The cloud trails observed in the satellite images for June 11–13, 21, 2009 (Fig. 1), show that winds could vary from one day to another influencing in some way the response of physical parameters at the coast as shown in the sea surface temperature

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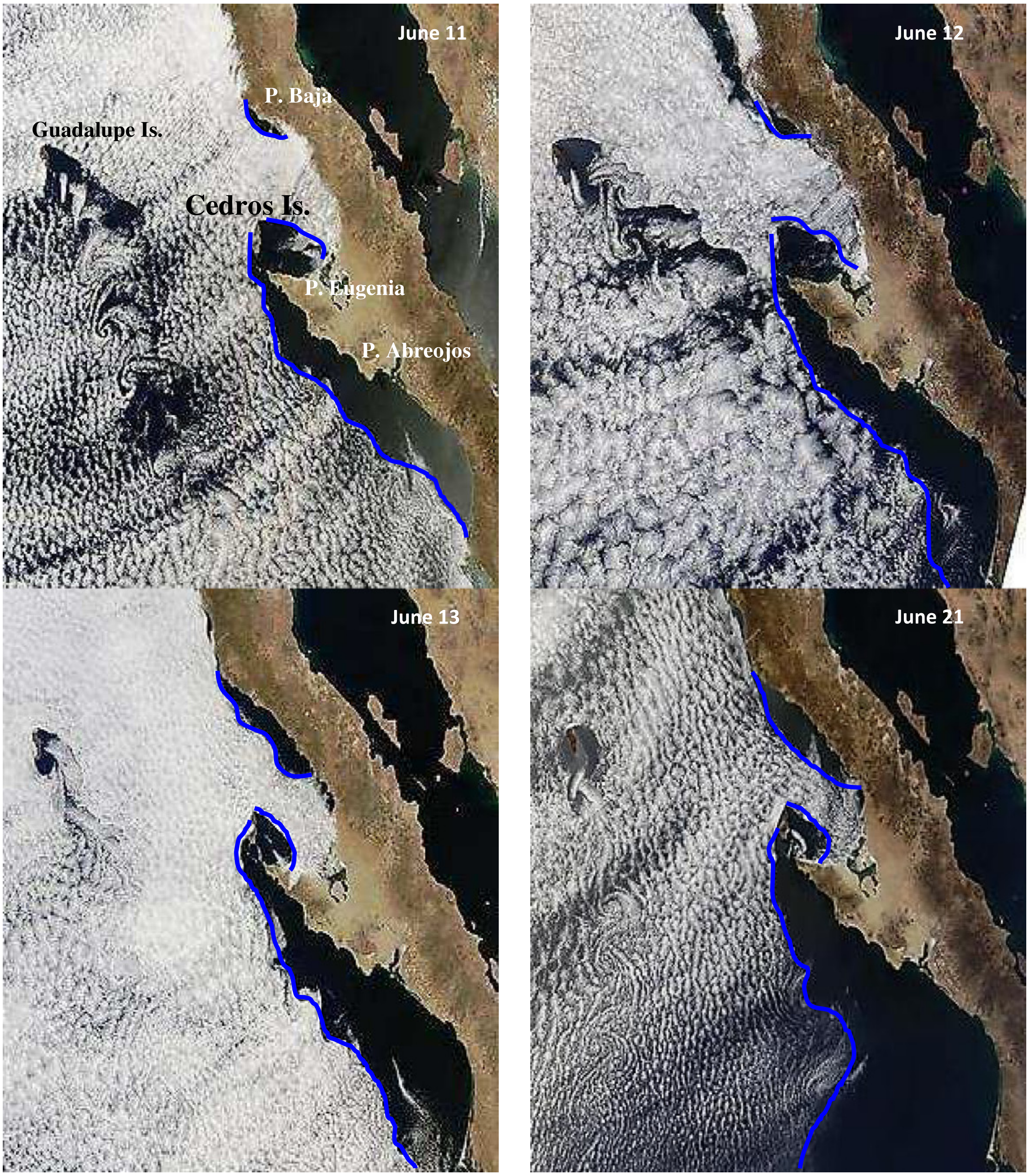

Fig. 1. Atmospheric manifestation of a Von Kármán Vortex Street (VKVS) in the lee of Guadalupe Island (GI), Baja California Coast during several days of June 2010 captured by MODIS-terra (http://earthobservatory.nasa.gov/).

(SST) field depicted in Fig. 2 for the same dates. Here, cool waters (approximately 19 °C) surround the cores of cold waters (approximately 18 °C) found at south of Punta Baja, Punta Eugenia region and Magdalena Bay, MB (Fig. 2). The absence of clouds near the coast, mainly south of CI, is associated with a cool sea surface [9,10]. The hypothesized mechanism for this relationship is a destabilization of the lower troposphere by the warming SST, reducing static stability and entraining more dry air into the cloud layer [11]. Along the coast, wind intensity differences could generate upwelling zones by bringing cold, nutrient-rich bottom water to the surface where sunlight fuels high primary production and fisheries for sardines and anchovies [12]. Upwelling also advects of small micro-organisms that drift in the water column.

Although structures as large as mesoscale VKVS may have significant implications on other meso/microscale atmospheric processes, as well as for societal operations (i.e. dispersion of contaminants, aviation, etc.) [13,14], in this contribution we are focused in the formation of VKVS and its effects on the coastal zone; particular attention is given to the influence of wind