Continental Shelf Research 110 (2015) 100–107

Contents lists available at ScienceDirect

Continental Shelf Research

journal homepage: www.elsevier.com/locate/csr

The Mexican Coastal Current: A subsurface seasonal bridge that connects the tropical and subtropical Northeastern Pacific

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A R T I C L E I N F O

Article history:
Received 7 July 2014
Received in revised form
15 July 2015
Accepted 14 October 2015
Available online 23 October 2015

Keywords:
Eastern boundary poleward currents
Tropical-subtropical Northeastern Pacific
Seasonal Variability
Remote forcing
Semiannual Kelvin waves

A B S T R A C T

We used a three-dimensional numerical model to analyze the seasonal variability of the coastal circulation off SW Mexico. In agreement with previous research, our model reproduced a Mexican Coastal Current (MCC) that dominates the regional poleward circulation. The modeled dynamics evidenced an energetic semiannual component that governed the subsurface seasonal variability of this poleward flow. Below the thermocline the MCC was stronger during spring and fall, when it reached subsurface seasonal-averaged velocities of ~10 cms^{-1} and flowed continuously from the Gulf of Tehuantepec to the entrance of the Gulf of California. There, the subsurface MCC bifurcated in one branch that continued along the coast of mainland Mexico and a second branch that crossed the gulf and joined the California Undercurrent. Instead of the local wind, the semiannual MCC variability was induced by the transit of equatorial Kelvin waves whose upwelling (downwelling) phase propagation strengthen (weakened) the subsurface poleward circulation along the Tropical Pacific off Mexico. The MCC dynamics reported in this study accounts for the, previously reported, semiannual variability of the alongshore transport and salinity content in the southern Gulf of California. Moreover, the subsurface bridge between the MCC and the California Current System represents an external source of momentum that helps to explain the intensification of the California Undercurrent during spring and fall.

1. Introduction

The Mexican Coastal Current (MCC), also known as the West Mexican Current (Kessler, 2006), is an eastern boundary poleward flow that runs along the southwest mexican coast, from the Gulf of Tehuantepec to the Gulf of California (Badan-Dangon, 1998). The MCC originates as a subthermocline flow at the Gulf of Tehuantepec that approaches the surface north of ~17°N (Kessler, 2006). There, the local wind strengthens the poleward circulation (Godínez et al., 2010; Zamudio et al., 2007) and the MCC reaches the surface to continue northward merged with a branch of the California Current that recirculates into the Gulf of California (Godínez et al., 2010).

Direct observations taken off Cabo Corrientes show that the MCC dominates the coastal circulation during June and December, when the MCC reaches velocities between 30 and 45 cms^{-1} and extends more than 100 km offshore (Lavín et al., 2006; Roden, 1972). Numerical models, on the other hand, indicate that the propagation of intraseasonal downwelling coastal-trapped waves can induce a stronger MCC that reaches 80 cms^{-1} near the surface (Zamudio et al., 2007). In addition, satellite observations evidence that the spring–summer propagation of high sea-level anomalies enhances the coastal poleward flow off SW Mexico (Strub and James, 2002). To the moment of writing, however, little is known about the MCC seasonal variability, especially between the Gulf of Tehuantepec and ~17°N, where the MCC generally flows below the thermocline (Kessler, 2006).

We implemented a hydrostatic three-dimensional numerical model to reproduce the MCC and analyze its seasonal variability. In agreement with previous research, our model implementation reproduced a mean MCC that flows below the equatorward coastal circulation induced by the Thermocline Tehuantepec Bowl (Fig. 1). North of ~17°N the poleward circulation was reinforced by the cyclonic circulation south of Cabo Corrientes and the MCC extended to the surface to continue into the Gulf of California. Below the thermocline the MCC was stronger during spring and fall, when it flowed as a continuous coastal jet from the Gulf of Tehuantepec to the entrance of the Gulf of California near Mazatlan (Fig. 2). There, the subsurface MCC bifurcated into one branch that continued northward along mainland Mexico and a second branch that crossed the gulf and reached the California Undercurrent

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http://dx.doi.org/10.1016/j.csr.2015.10.010
0278-4343/

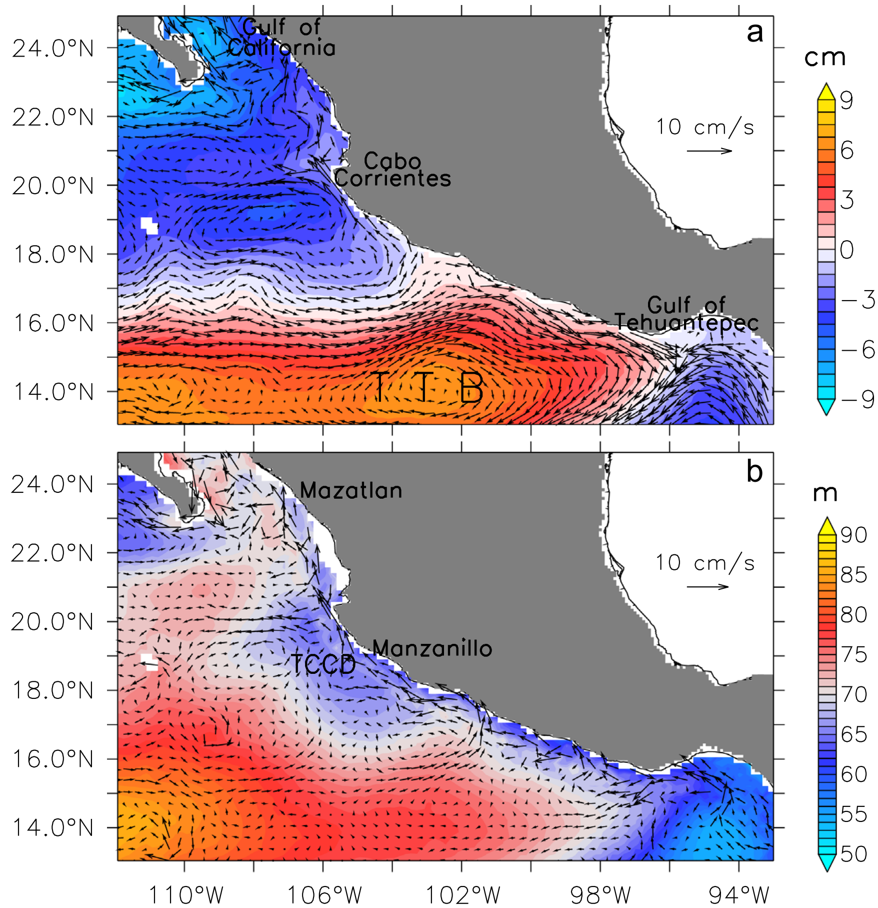

Fig. 1. Mean dynamics off SW Mexico. (a) Sea level anomaly and circulation at 10 m depth. (b) Thermocline-depth and circulation at 100 m. Kessler (2006) shows similar circulation patterns (see his Fig. 2); the resolution of the data he used, however, was too coarse to reproduce the coastal circulation north of 17°N.

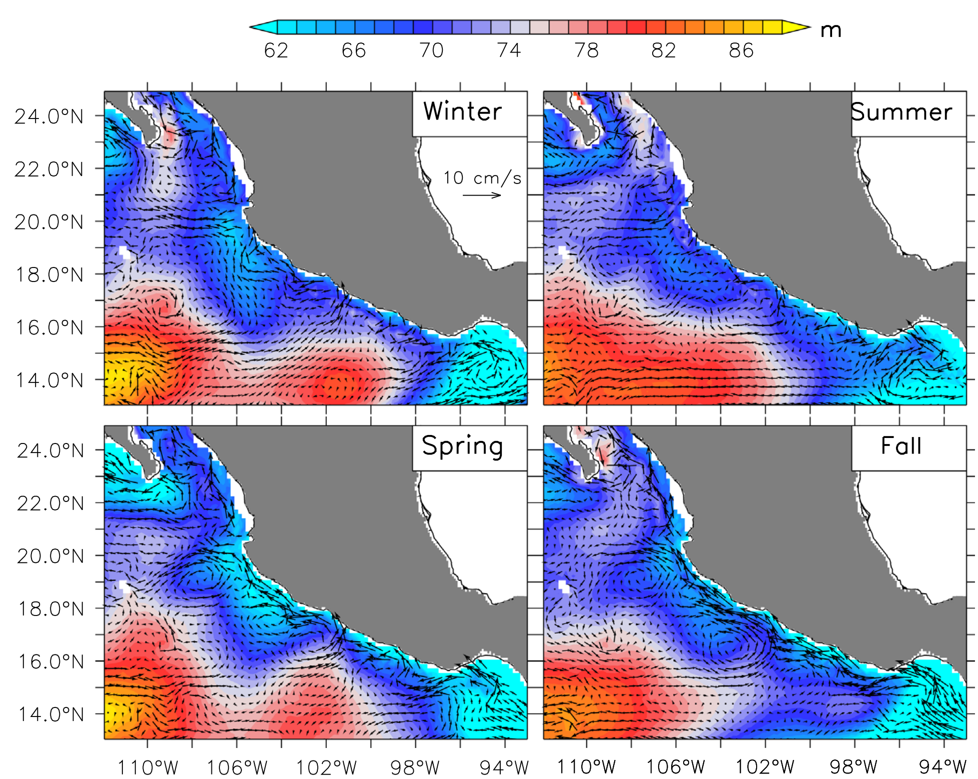

Fig. 2. Long-term seasonal averages of the thermocline-depth (m) and the circulation at 100 m. The vector key is in the upper-left panel.