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Simulating and understanding the gap outflow and oceanic response over the Gulf of Tehuantepec during GOTEX

Xiaodong Hong[a,*], Melinda Peng[b], Shouping Wang[a], Qing Wang[c]

[a] Naval Research Laboratory, Monterey, CA 93943, United States
[b] CSRA Inc., Falls Church, VA 22042, United States
[c] Naval Postgraduate School, Monterey, CA 93943, United States

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ABSTRACT

Tehuantepecer is a strong mountain gap wind traveling through Chivela Pass into eastern Pacific coast in southern Mexico, most commonly between October and February and brings huge impacts on local and surrounding meteorology and oceanography. Gulf of Tehuantepec EXperiment (GOTEX) was conducted in February 2004 to enhance the understanding of the strong offshore gap wind, ocean cooling, vertical circulations and interactions among them. The gap wind event during GOTEX was simulated using the U.S. Navy Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS®). The simulations are compared and validated with the observations retrieved from several satellites (GOES 10–12, MODIS/Aqua/Terra, TMI, and QuikSCAT) and Airborne EXpendable BathyThermograph (AXBT). The study shows that the gap wind outflow has a fanlike pattern expending from the coast and with a strong diurnal variability. The surface wind stress and cooling along the axis of the gap wind outflow caused intense upwelling and vertical mixing in the upper ocean; both contributed to the cooling of the ocean mixed layer under the gap wind. The cooling pattern of sea surface temperature (SST) also reflects temperature advection by the nearby ocean eddies to have a crescent shape.

Two sensitivity experiments were conducted to understand the relative roles of the wind stress and heat flux on the ocean cooling. The control has more cooling right under the gap flow region than either the wind-stress-only or the heat-flux-only experiment. Overall, the wind stress has a slightly larger effect in bringing down the ocean temperature near the surface and plays a more important role in local ocean circulations beneath the mixed layer. The impact of surface heat flux on the ocean is more limited to the top 30 m within the mixed layer and is symmetric to the gap flow region by cooling the ocean under the gap flow region and reducing the warming on both sides. The effect of surface wind stress is to induce more cooling in the mixed layer under the gap wind through upwelling associated with Ekman divergence at the surface. Its effect deeper down is antisymmetric related to the nearby thermocline dome by inducing more upwelling to the east side of the gap flow region and more downwelling on the west side. Diagnostics from the mixed layer heat budget for the control and sensitivity experiments confirm that the surface heat flux has more influence on the broader area and the wind stress has more influence in a deeper region.

* Corresponding author at: Naval Research Laboratory, 7 Grace Hopper Avenue, Monterey, California, 93943, United States.
E-mail address: Xiaodong.hong@nrlmry.navy.mil (X. Hong).

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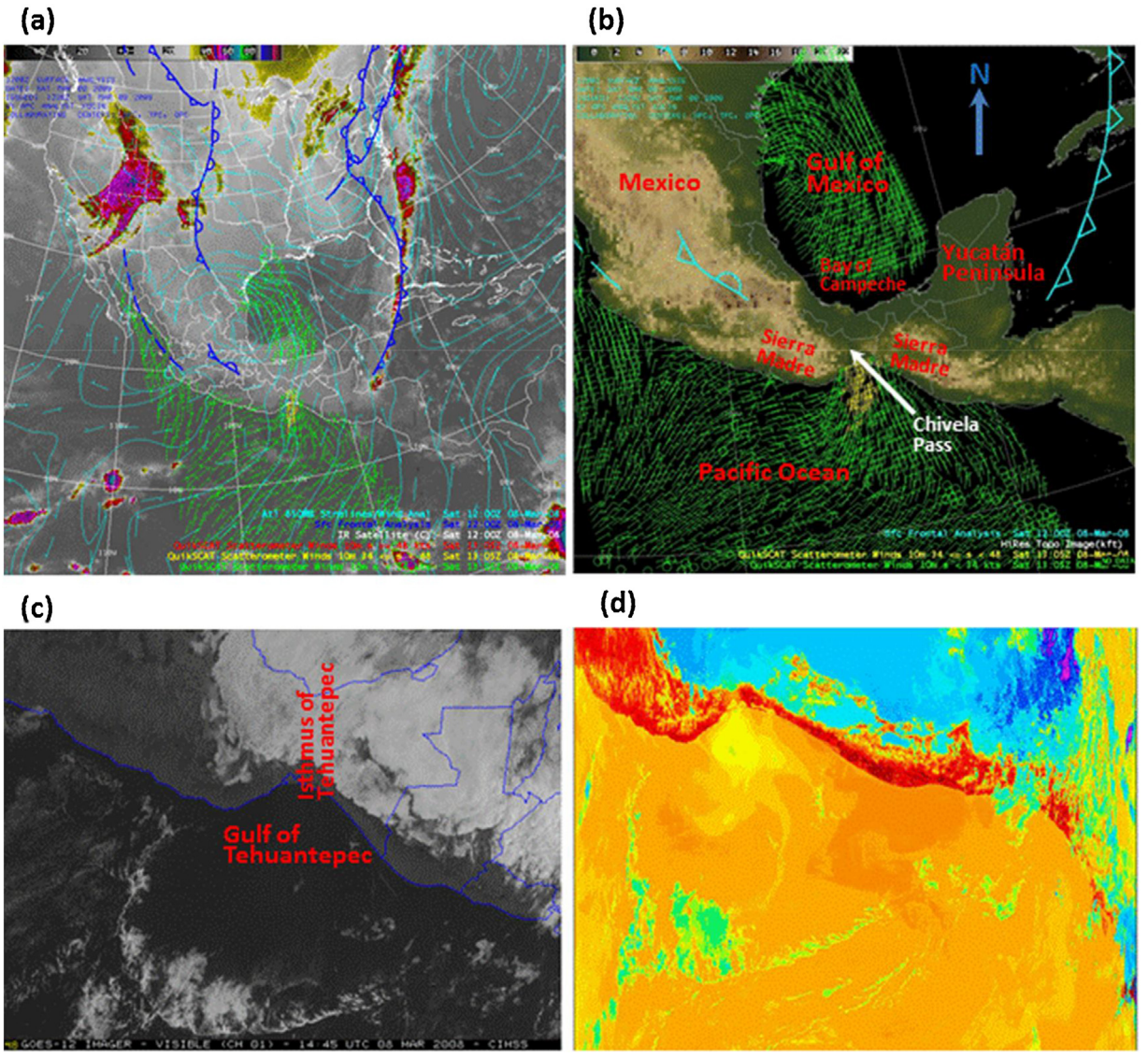

Fig 1. Observation images on 08 March 2008 (available on http://cimss.ssec.wisc.edu/goes/blog/archives/618): (a) An AWIPS image of the GOES-12 10.7 μm IR channel including plots of the surface frontal positions, polar-orbiting microwave scatterometer winds from the QuikSCAT instrument, and the 850 mb wind streamlines. (b) An AWIPS image of the wind from the QuikSCAT SeaWinds scatterometer instrument overlaid on the topography. (c) GOES-12 visible image during the daylight hours. (d) Land Surface Temperature (LST) image from the MODIS Rapid Response System.

1. Introduction

Isthmus of Tehuantepec is a narrow strip of land connecting the Yucatán to the rest of Mexico with the Sierra Madre occupies the southern half of the Isthmus. In the middle of the Sierra Madre is a sizable gap known as the Chivela Pass (Fig. 1). The Gulf of Tehuantepec is located off southeastern Mexico's Pacific coast. Tehuantepecer or Tehuano wind, the term dates back to the early 20th century (Frankenfield 1917; Hurd, 1929), is a strong mountain gap wind traveling through Chivela Pass, most commonly between October and February. The synoptic condition is usually associated with high-pressure system forming north of Sierra Madre in the wake of an advancing cold front in the United States. Post-frontal northerly wind with cold air damming from eastern Mexico and the Bay of Campeche accelerates southward and blows through the gap of the Chivela Pass. The strong winds can reach gale (13.9–28.4 m s^{-1}), storm (28.5–32.6 m s^{-1}), and hurricane force (≥32.7 m s^{-1}) on the Beaufort Wind Scale (https://en.wikipedia.org/wiki/Beaufort_scale). They influence waves which then propagate as swell and are sometimes observed as far as 1600 km away. The strong winds bring cooler sub-surface waters to the surface in the ocean and may last from a few hours to several days over the tropical eastern Pacific Ocean. Tehuantepec winds usually reach 10–24 m s^{-1}, and on rare occasions even 50 m s^{-1}. The wind's direction is from the north to north-northeast and can blow out for 500–600 km offshore for several days. These strong winds and waves have dramatic effects on the local