7.3 OCEAN CURRENTS EVIDENT IN SATELLITE WIND DATA

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Satellite-mounted radar scatterometers designed to quantify surface winds over the ocean actually measure the relative motion between the air and the ocean surface (Fig. 1). A comparison of wind vectors measured by the TAO array in the equatorial Pacific Ocean with the vectors estimated from data gathered by NSCAT and QuikSCAT shows that ocean currents make a large contribution to the mean differences between the scatterometer and buoy winds.

NSCAT winds from the onset of the 1997–98 El Niño were compared with TAO winds and 10-m currents at 140°along the equator. During this period, the daily averaged anemometer winds adjusted to 10-m height were always easterly. Before the outbreak of El Niño, the currents at 10 m depth were aligned with the wind (both westward) and the TAO winds exceeded the NSCAT winds by approximately 1 m s^{-1}. Beginning in December 1996, the currents along the equator reversed to eastward. During the latter period, the NSCAT winds exceeded the TAO winds by approximately 1 m s^{-1}, the expected effect of the scatterometer measuring relative motion. The correlation between the zonal components of the difference in the winds and the currents is 0.61 (95% significance level is 0.48).

The TAO array samples currents at only a few meridians on the equator, which severely limits the region of comparison. However, acoustic Doppler current profilers (ADCPs) mounted on the TAO vessels provide twice-yearly vertical sections of currents along eight TAO meridians. These current measurements, extrapolated to 5-m depth, were compared with the difference between the TAO and QuikSCAT wind vectors from three ADCP sections taken during boreal Fall 1999 along 155°, 140°, and 125°W. The early part of the QuikSCAT mission was during the 1998-99 La Niña, so mean winds (at the locations and times of available ADCP data) were consistently easterly. Zonal currents in the tropical Pacific Ocean had little temporal variation, but significant meridional structure. The average zonal surface current (Fig. 2, line) reveals maximum westward speeds of 1.1 m s^{-1} in the South Equatorial Current (SEC) at 2°N and maximum eastward speeds of 0.6 m s^{-1} in the North Equatorial Countercurrent (NECC) at 7°N. This current structure is strikingly similar to the difference of the TAO and the QuikSCAT zonal winds during the time period of the sections (Fig. 2, dots). Scatterometer winds are less than TAO winds in the SEC (2°N) and greater than TAO winds in the NECC (8°N), with the difference being nearly equal to the zonal currents.

The fact that the scatterometer measures the relative motion between the atmosphere and the ocean has important implications for understanding and modeling air–sea coupling, particularly for ENSO prediction. Using relative motion (the correct variable) reduces the stress about 20% at the core of the westward SEC, and increases the stress about 10% at the core of the eastward NECC, compared to stress computed from an anemometer wind. These differences are large enough to affect ocean circulation models. The modification in the curl of the wind stress, essentially the difference between the wind stress at the two latitudes, would be even larger than the stress modification. A previous comparison of the stress fields from NSCAT and from the European Centre for Medium-range Weather Forecasts (ECMWF) showed that the curl of the NSCAT wind stress was systematically more positive at about 7°N than the ECMWF curl, consistent with our estimates of the effects of ocean currents on the stress.

Scatterometer wind stress estimates have the potential to greatly improve our understanding of climatically vital air–sea fluxes, including momentum, heat, and gases. In addition, the large differences between stress estimates based on scatterometer data and stress estimates based on wind data alone highlight the importance of including currents in coupled atmosphere–ocean models, especially in the tropical Pacific.

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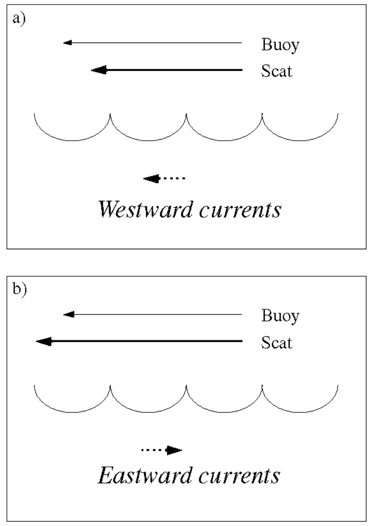

Figure 1: Schematic of the buoy wind vectors, scatterometer vectors, and ocean currents (a) for winds in the same direction as the currents and (b) for winds opposing the currents.

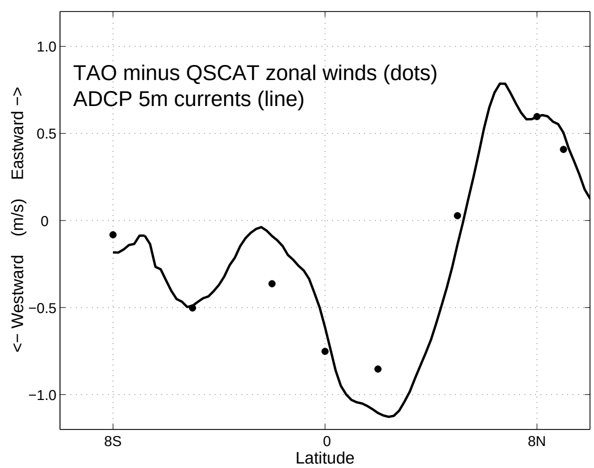

Figure 2: Zonal winds and currents averaged over three meridians (155°W, 140°W, 125°W). ADCP zonal currents extrapolated to 5-m depth (solid line) from TAO buoy servicing cruises between 16 September and 31 October 1999. Average difference between TAO and QuikSCAT zonal wind components at TAO buoys (dots).