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Wind-forced oscillations near the critical latitude for diurnal-inertial resonance

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Sea breezes are characteristic features of coastal regions that may extend large distances from the coastline. Oscillations at or close to the inertial period are thought to account for over half the kinetic energy in the global surface ocean and play an important role in mixing at the base of the ocean mixed layer. In the vicinity of 30oN/S, diurnal winds may force enhanced anti-cyclonic circular motions by a resonance between the diurnal and inertial frequencies. Simpson et al. (2002) documented observations of strong anti-cyclonic motions with a phase difference of Ÿ180o. between the upper and lower layers at a location 133km off the Namibian coastline at 28.6oS at a depth of 175m. A two layer frictionless model incorporating diurnal wind forcing and its associated coast-normal pressure gradient (after Craig) was used to explain the key features of the observed vertical current structure. We analyse observations of strong diurnal a/c (anti-cyclonic, a/c) currents at the same location over the annual cycle. A maximum in the diurnal anti-clockwise current amplitude is observed during the austral summer. Annual observations at Elizabeth Bay suggest that the diurnal wind is also strongest during summer. Both the diurnal a/c current and wind stress components have approximately consistent phase throughout the annual cycle. This provides additional evidence that the currents appear to be forced by the diurnal wind. During a ten-day period of strong diurnal a/c currents, diurnal a/c velocities were around 0.33m/s and 0.21m/s at 21m and 130m depth, respectively, with a phase difference of Ÿ203o. General Ocean Turbulence Model (GOTM) 1-D simulations confirm that

diur- nal winds near to a coast in relatively shallow water are expected to force oscillations similar to those observed. However, the GOTM simulations suggest the a/c diurnal winds at the mooring location could be at least 50% stronger and lead the diurnal winds observed at the coast at Elizabeth Bay by several hours. GOTM simulations in half the water depth imply that in shallower water increased diurnal surface slope variations inhibit the strength of the a/c diurnal currents and reduce the thickness of both current layers. Two-dimensional cross-shelf simulations suggest that the Craig approximation for diurnal coast-normal surface slope response to diurnal winds applies away from the coast ($>$140km). Close to the coast, however, additional surface slope variations associated with spatial variations in the simulated velocity field (estimated from Bernoulli theory) appear to be significant and result in transfer of energy to higher harmonics.