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Wave dynamics and hydrodynamics in Potter Cove, King George Island, Antarctica

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Wave and hydrodynamic models are established to study the wave dynamics and circulation in Potter Cove, King George Island, Antarctica and their interactions with the surrounding physical and benthic environments. Wave generation, propagation and transformation from deep ocean over complex bathymetric terrains to coastal waters around Potter Cove were simulated using the SWAN wave model. A nesting approach was implemented from an oceanic scale to a high resolution coastal scale around the cove. The propagation and amplification of tides were studied using a multiscale unstructured grid, finite-volume coastal ocean model FVCOM. Tidal harmonic analysis was performed to obtain the estimates for the amplitudes and phases of tidal constituents, which enable the construction of cotidal and corange charts of the major tidal constituents (M_2, S_2, K_1 and O_1) for the Bransfield Strait and Northern Antarctic Peninsula region. A comprehensive set of FVCOM simulations consisting of current circulations with respect to different physical forcings, i.e. tides, winds and waves, through the study area was implemented to investigate the circulation patterns in Potter Cove and to assess the relative importance of the various forcings on the flow patterns in the cove. Bed shear stresses due to waves and currents were also calculated to provide a general insight on the bed sediment erosion characteristics and to identify the potential bed erosion prone regions in Potter Cove. The estimated local residence times and flushing times provide an idea of the efficiency of the water mass transport and exchange with the external waters.

The results of the wave simulations were compared with buoy observations obtained from the National Data Buoy Center, the WAVEWATCH III model results and GlobWave altimeter data. Sea level data from tide gauges were used for the assessment of the modelled results. The quality of the model results is also assessed. Under various wave conditions, the significant wave heights at the inner cove were found to be about 40-50% smaller than the ones near the mouth of Potter Cove. This study also gives some results on global ocean applications of SWAN. The tidal regime is mixed, predominantly semi-diurnal in Potter Cove. In general, tides propagate from the Weddell Sea, enter the Bransfield Strait and move further southwestward. While tides have minimal influence on the circulation in Potter Cove, wind plays a significant role in the circulation patterns which are highly dependent on the wind speed and direction. The wave contribution to the flow is also important. In general, a cyclonic circulation pattern where the waters enter the cove through the northern sector and exit through the southern sector can be observed. Wave-induced bed shear stress is a potential major driving force for the bed sediment erosion in Potter Cove, especially in shallow water regions. In contrast, the bed shear stress due to currents was found to be less significant. Under the combined action of tides and winds, the flushing time in Potter Cove is estimated to be in the range of 3.2 to 5.2 days.