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Modal decomposition of tidally-forced internal waves

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There exist multiple mechanisms for the breaking of ocean internal waves including critical reflection, shear instabilities, etc. Wave breaking contributes to diapycnal mixing and sediment or nutrient transport. A principal mechanism of internal wave generation is tidal conversion, i.e. time-periodic sloshing of seawater over bathymetry such as the mid-Atlantic ridge. While past theoretical and laboratory experimental work has principally considered the scenario in which internal waves are forced by only one frequency, tidal flow has a range of diurnal and semi-diurnal frequency components (i.e. M_2, S_2, K_1, etc.). Correspondingly, tidal conversion may generate a broad wave spectrum comprising different frequencies and vertical wavenumbers. Such details are relevant in estimating the location and amount of mixing that occurs upon wave breaking. In this work, an algorithm has been developed that performs a spatial and temporal decomposition of polychromatic internal waves generated by tidal sloshing over topography, with constant buoyancy frequency N. Starting with vertical velocity timeseries data of a given internal wave field, a fast Fourier transform (FFT) with windowing and zero-padding is employed in order to determine the (discrete) frequencies present. Frequency-specific complex mode strengths γ_{jn} for the internal waves can then be recovered. In order to verify the results of the algorithm, synthetic laboratory experimental data corresponding to the idealized problem of tidal sloshing over 2D Gaussian topography are generated and superposed for a variety of forcing frequencies (ranging from $\omega_j/N = 1/10$ to $\omega_j/N = 9/10$). The calculated frequencies and mode strengths are compared with the known values from the synthetic data. The mode strengths γ_{jn} are either calculated directly or as a ratio normalized by the mode 1 mode strength. In either scenario, the resulting mode strengths can be sensitive to errors in the frequencies recovered via FFT. However, when exact frequencies are used the numerically calculated mode strengths show excellent qualitative and quantitative agreement with those from the synthetic data. The algorithm is currently being extended to the scenario in which the internal wave forcing frequencies form a continuous frequency spectrum rather than well-defined discrete peaks, such as those arising from fluid-fluid interactions (e.g. an intrusive gravity current propagating through a stratified ambient). Such wave fields present numerous additional challenges in the calculation of the associated mode strengths. The algorithm described above allows for the determination of the temporal and spatial structure of an internal wave field without *a-priori* knowledge of the specifics of its generation. Further adaptations such as variable N for realistic background stratification would allow for application to more geophysically relevant scenarios, and thus the analysis of observational data.