Upscale transfer of waves in one dimensional rotating shallow water

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This study investigates the inverse flux of waves in one of the simplest geophysical fluid dynamics model: one dimensional rotating shallow water equations. Based on direct numerical integration of the governing equations, waves injected at small scales are seen to get transferred upscale predominantly via resonant quartic interactions between wave modes. The waves' upscale transfer is nonlocal and involves turbulent transfer between disparate scales of the flow. Detailed analysis reveal that the upscale transfer of waves is extremely intermittent and is a result of localized-in-time bursts in wave action flux. These intermittent events of flux-bursts leads to shallower waves' spectrum and relatively higher amplitude wave fields in physical space. On examining statistics of the flow fields, it is found that low-energy high wavenumbers more or less comply with the assumptions used in wave turbulence theory, such as uniformly distributed wave phases and Gaussian distribution of fields, while nonuniform distribution of wave phases and non-Gaussian statistics dominate at large scales or low wavenumbers that contain major share of the flow energy. These new findings point out that the one dimensional rotating shallow water equations, despite being a simple geophysical fluid dynamic model, harbors complex and intricate features associated with the upscale transfer of waves that have not been recognized in the past.

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