Abstract View

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Equatorial Solitary Waves. Part I: Rossby Solitons

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ABSTRACT

Using the method of multiple scales, I show that long, weakly nonlinear, equatorial Rossby waves are governed by either the Korteweg-deVries (KDV) equation (symmetric modes of odd mode number *n*) or the modified Korteweg-deVries (MKDV) equation. From the same localized initial conditions, the nonlinear and corresponding linearized waves evolve very differently. When nonlinear effects are neglected, the whole solution is an oscillatory wavetrain which decays algebraically in time so that the asymptotic solution as $t \to \infty$ is everywhere zero. The nonlinear solution consists of two parts: solitary waves plus an oscillatory tail. The solitary waves are horizontally localized disturbances in which nonlinearity and dispersion balance to create a wave of permanent form.

The solitary waves are important because 1) they have no linear counterpart and 2) they are the sole asymptotic solution as $t \to \infty$. The oscillatory wavetrain, which lags behind and is well-separated from the solitary waves for large time, dies out algebraically like its linear counterpart, but the leading edge decays faster, rather than slower, than the rest of the wavetrain. Graphs of explicit case studies, chosen to model impulsively excited equatorial Rossby waves propagating along the thermocline in the Pacific, illustrate these large differences between the linearized and nonlinear waves. The case studies suggest that Rossby solitary waves should be clearly identifiable in observations of the western Pacific.

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