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Hyperfast Deterministic Numerical Modeling of Nonlinear Ocean Surface Waves

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The study of ocean surface waves is important not only for the dynamical characterization of the finite amplitude sea surface itself but also for estimates of extreme events. Many methods have been developed over the past half-century for numerically generating surface waves. One of the most popular approaches is the so-called higher order method (HOM). In this approach, one assumes the sea surface to be describable by a two-dimensional Fourier transform with time varying coefficients. These coefficients are solutions of nonlinear ordinary differential equations (odes) which must be solved numerically. I introduce a new method that solves these odes by multidimensional Fourier series. These latter series can be numerically computed very rapidly on multicore computers because the algorithm is perfectly parallel. I give a rather detailed explanation of the method and show that numerical simulations over a large area of the ocean's surface can be computed about 100 N times faster than HOM models, where N is the number of cores. I give several examples of the use of the method and its utility. I also show how the extreme events, represented by 2+1 dimensional breather trains, are characterized by the spectrum of the multidimensional Fourier series.