Abstract View

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Two-Dimensional Free Oscillations in Natural Basins

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ABSTRACT

A method is designed to calculate normal modes of natural basins. The purpose is to determine the period and configuration of free oscillations in a way that provides for the full two-dimensionality of the problem, and thus avoids limitations such as are inherent in the traditional channel approximation. The method—called resonance iteration—is amenable to detailed numerical analysis.

As a test, the lowest positive and negative modes in a rotating square basin of uniform depth are calculated for a range of rotation speeds, with results that agree well with existing evaluations of this case. Similar agreement was found in an application to Lake Erie, a basin that conforms to the channel approximation. The method was then applied to two basins where it was expected to give results differing from those obtained by earlier methods: Lake Superior and the Gulf of Mexico. The fundamental gravitational mode of Lake Superior was found to have a period of 7.84 hr, which is 9% greater than the value known from the channel approximation, and is in virtually exact agreement with a recent spectral analysis. Phases of this mode also agree with observation.

The Gulf of Mexico is of particular interest because of the still-unresolved role of normal modes in the tidal regime of that basin. With the basin completely closed, the method of resonance iteration gave a period of 7.48 hr for the slowest gravitational mode and produced a single, positive amphidromic system that imparts to this mode approximately the character of a longitudinal oscillation on the nearly west-east axis of Mexico Basin. With the Gulf open through the Yucatan Channel and the Straits of Florida, the structure of this mode, is not altered qualitatively and the period is lowered to 6.68 hr. The most significant effect of these “ports” is that they elicit an additional gravitational oscillation—the so-called Helmholtz mode—which has a period much longer than that of the slowest seiche-type oscillation, and nodal points only at the ports. This co-oscillating mode is found to have a period of 21.2 hr. The proximity of its period to that of the diurnal tide points to a revival of the traditional conception that the tidal

regime in the Gulf of Mexico is affected appreciably by resonance.