Abstract View

Volume 17, Issue 12 (December 1987)

Journal of Physical Oceanography
Article: pp. 2203–2218 | Abstract | PDF (1.05M)

Interaction of Ocean Tides through a Narrow Single Strait and Narrow Multiple Straits

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(Manuscript received June 23, 1986, in final form June 9, 1987)

DOI: 10.1175/1520-0485(1987)017<2203:IOOTTA>2.0.CO;2

ABSTRACT

The tidal interaction between two constant depth oceans joined by a rectangular strait of length *d*, width 2*a* and constant depth *h* was analyzed. The strait is narrow in the sense that the scale of the ocean tide in the absence of the strait is much greater than the width of the straight. The following results were obtained.

(i) Under the mild restriction that the strait is narrow enough, sea level tidal constants change linearly from one end to the other. If the tides in each ocean differ, steep sea level gradients occur in the strait. These gradients tend to be much steeper than those in the ocean near the strait.

(ii) The steep sea level gradients in the strait drive strong along-strait currents which are uniform in the middle part of the strait but change considerably within 0.4*a* of the ends.

(iii) Because of end effects, strong gradients in sea level can occur across the strait even when the width of the strait is much smaller than the strait barotropic radius of deformation.

(iv) When the tide in one ocean is much larger than the tide in the other, the tide in the strait propagates toward the low tide end with some turning in the Kelvin wave sense.

(v) The deep sea tide “sees” the strait as a point source at distances greater than 1.2*a* from the center point of the entrance to the strait.

(vi) If the strait is very narrow and/or shallow, we expect that the ocean tide near the strait will not be significantly distorted. Criteria were obtained to determine precisely when the distorting effect is negligible.

(vii) Application of the theory to the interaction of the M_2 tide between the Atlantic Ocean and Mediterranean Sea through the Strait of Gibraltar showed that the Atlantic tide is unaffected by the Moditerranean tide but that the Mediterranean tide is distorted by the Atlantic tide. In agreement with observations, the theory correctly predicts the steep sea level slope and associated volume transport in the strait, as well as the southeastward phase propagation.

Theory was also developed for tidal interaction between two oceans separated by several straits. Such an interaction occurs, for example, between the Atlantic and Caribbean tides through the Windward and Leeward islands at the eastern end of the Caribbean Sea. The theory indicates that the coupled distorting effects of two or more nearby straits can result in different tidal results to those if the straits are considered individually. In the Windward and Leeward Caribbean Islands case these coupling effects are significant. As in the single strait case, large changes in the tide occur in the straits between the islands. Tidal constants at the islands are therefore not representative of the large-scale ocean tide and should not be used as boundary values in large-scale numerical models.

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