Western Boundary Sea-Level: A Theory, Rule of Thumb, and Application to Climate Models

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In order to better understand coastal sea-level variability and changes, a theory that predicts sea-levels along a curved western boundary using interior ocean sea-level information is proposed. The western boundary sea-level at a particular latitude is expressed by the sum of contributions from interior sea-levels propagating onto the western boundary by long Rossby waves between that latitude and a higher latitude, and from the western boundary sea-level at the higher latitude. This theory is examined by using a linear, reduced gravity model. A comparison between the theory and the model shows good agreement. A simple scaling law (or rule of thumb) derived from the theory provides a measure of the higher latitude sea-level and ocean interior sea-level contributions. The theory is then tested using data from 34 climate models in Coupled Model Intercomparison Project Phase 5 (CMIP5) for dynamic sea-level changes between the end of the 20th and 21st centuries. The theory captures the nearly uniform sea-level rise from the Labrador Sea to New York City (NYC), with equatorward reducing sea-level increase further south, qualitatively consistent with CMIP5 multi-model ensemble, even though the theory underestimates the equatorward reduction rate. Along the South American east coast, the theory successfully reproduced the spatial pattern of the sea-level change. The theory suggests a strong link between sea-level rise hotspot along the northeastern coast of North America and the sea-level increase in the Labrador Sea, consistent with that rates of NYC sea-level rise are highly correlated to those in the Labrador Sea in CMIP5 models.

Keywords: New York, Labrador Sea, CMIP5, wave propagation