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The forced and free response of the South China Sea to the large scale monsoon system

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Non-tidal sea level anomalies (SLAs) can be produced by many different dynamical phenomena over many time scales, and they can induce serious damages in coastal regions especially during extreme events. In this work we focus on the SLAs in the South China Sea (SCS) to understand whether and how they can be related to the large scale, seasonal monsoon system which dominates the SCS circulation and dynamics.
We have two major objectives. The first one is to understand whether the NE (winter) and SW (summer) monsoons can be responsible for the persistent SLAs, both positive and negative, observed at the SCS ends along the main monsoon path. The second objective is to understand the SCS response as a free system upon onset/relaxation or sudden changes in the forcing wind. It is well known that sudden changes in the forcing mechanism induce free oscillations, or seiches, in closed, semi-enclosed basins and harbors, and we want to identify the possible seiche modes of the SCS. To our knowledge, these two objectives have not been previously addressed.
We address these objectives both through observational analysis and modeling simulations. Multi-year tide-gauge data from stations along the coastal regions of the SCS are analyzed examining their spatial correlations. Strong negative correlations are found between the northeast and southwest stations at the two ends of the SCS under the path of the NE/SW monsoons. They correspond to wind-induced positive/negative sea level set-ups lasting for the entire monsoon season and changing sign from winter to summer. Short periods of negative correlations are also found between the SLAs at eastern and western stations during El Nino years in which the monsoons are weaker and have an enhanced E/W component inducing corresponding sea level set-ups.
The tide gauge station at Tanjong Pagar at the southwest SCS end near Singapore is chosen to study four extreme SLAs events in the observational record during 1999. Modeling simulations are carried out to reproduce them. The observed and modeled extreme SLAs agree quite well, both in the amplitude of the highest peak and in phase.
Three main peaks are identified in the observational energy spectrum of the de-tided SLAs at the same station in 1999. Using Merian's formula to evaluate the periods of seiches in idealized basins (Wilson, 1972) the first two peaks (24.4h and 11.9 h) are found to correspond to the first two seiche modes in the direction of the main, longer axis of the SCS. The third peak (8.5h) is found to correspond to the seiche in the transversal, shorter axis.
Finally, modeling simulations are carried out by suddenly dropping a circular bump of water in the quiescent basin at different locations to excite the seiches. The periods of the modeled peaks agree quite well with the observational ones, the first two periods being actually identical.