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Analysis on the extreme sea levels changes along the coastline of Bohai Sea, China

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Using hourly sea level data from four tide gauges, the changes of the extreme sea level in the Bohai Sea were analyzed in this work. Mean sea level, tide, surge and tide-surge interaction were studied separately to assess their roles in the changes of extreme sea level. Mean sea levels at all four tide gauges show significant increasing trends during the past few decades (1980-2016), with the rate ranging from 0.2 to 0.5 cm/year. The mean high tide levels show positive trends at four tide gauges, the increasing rate (0.1 to 0.3 cm/year) is not small compared with the long term trends of the mean sea levels. Meanwhile, the mean tidal ranges show negative trends at Longkou, Qinhuangdao and Tanggu, with the rate at about -0.7 $\sim$ -0.2 cm/year. In terms of storm surge intensity, there are distinct inter-annual variability and decadal variability at all tide gauges. At Qinhuangdao and Tanggu, the annual surge intensity shows explicit long-term decreasing trend. Tide-surge interactions exist at all four tide gauges, while no evident temporal variation was found. Convincing evidences imply that the extreme sea levels increase during the past decades from 1980 to 2016 at all tide gauges, with the increasing rate differing at different percentile levels. The extreme sea level changes in the Bohai Sea are highly affected by the changes of mean sea level and tide level, especially the latter. The surge component variation contributes to the changes of extreme sea level at locations where the tide-surge interaction is relatively weak.