Absolute and relative sea level change

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Abstract

Coastal sea level rise is one of the major threats of a warming climate, therefore measuring accurately and monitoring sea level rise right at the coast is of utmost importance. Satellite altimetry is essential to monitor coastal sea level where in-situ tide gauge sampling is insufficient or absent. It measures the absolute sea level change which differs from the coastal sea level rise relative to land measured by tide gauges due to the land vertical motion.
Here we first investigate if the rate of absolute sea level rise is in average the same at coast and in open ocean. Further on we inquire on the difference between absolute and relative sea level change, which is an estimation of land vertical motion. Finally, we compare vertical motion derived from tide gauge and altimetry to the GPS rates at fiducial stations. We use conventional and improved altimeter datasets which include technological innovations such as Delay Doppler altimetry and coastal dedicated retracking.

The statistical model estimates constant trends and annual signals and accounts for climate modes. We also consider time-varying trend and error of trends using various noise models.

We find that the global average of absolute sea level rise over the altimetry era 1993-2015 is about 3.3 +/- 0.5 mm/yr, where the uncertainty in the linear trend includes both the error in trend estimation and measurement errors. We analyse monthly sea level time series from altimetry and tide gauges over time intervals of different lengths starting from 1993. Time-series correspond to averages of (1) altimeter data in coastal zone for different coastal distances, (2) altimeter time-series co-located to selected tide gauge stations, (3) tide gauge records corrected for vertical land motion, (4) global altimeter data.

For time-series longer then 15 years the rate of sea level in open ocean and at the coast is similar in average and indicates a homogeneous long-term sea level rise regionally affected by climatic modes. Accounting for the non-linearity of the vertical land motion, altimetry and corrected tide gauge records agree better.

We finally show better agreement between the tide gauge corrected for the GPS vertical motion and the coastal altimeter data improved by dedicated retracking and by the enhanced Delay Doppler (SAR altimetry) technique. We suggest that the new data fill part of the gap between open ocean and tide gauge sea level and lead to an improved estimation of land vertical motion from altimetric and tide gauge sea level differences.

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