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Impact of time variable Earth global gravity field models on precise orbits of altimetry satellites, global and regional mean sea level trends

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Significant progress has been reached in the last decade in the investigation of the global gravity field of the Earth. Besides static, also time variable gravity field models have been recently developed. In this paper we study the influence of the recently developed time variable Earth global gravity field models on altimetry satellite orbits as well as on global and regional mean sea level trends computed using these orbits. We included in our analysis six gravity field models jointly developed by GFZ German Research Centre for Geosciences and Space Geodesy Research Group (CNES/GRGS) Toulouse: the stationary model EIGEN-GL04S, a stationary version of EIGEN-6S (EIGEN-6S_stat), a corrected version of EIGEN-6S and three enhanced versions of EIGEN-6S called EIGEN-6S2, EIGEN-6S2A and EIGEN-6S2B. Based on the analysis of precise orbits of the radar altimetry satellites ERS-1 (1991-1996), TOPEX/Poseidon (1992-2005), ERS-2 (1995-2006) and Envisat (2002-2011) computed by us totally over 20 years at the time periods shown for each satellite, the single-mission and multi-mission altimetry crossover analysis we found that the time variable models EIGEN-6S_corrected, EIGEN-6S2 and its two precursors EIGEN-6S2A/B perform notably better than the stationary models for the GRACE period from 2003 onwards. Thus, the use of the EIGEN-6S2 and EIGEN-6S2A/B models reduces the root-mean-square fits of satellite laser ranging observations for Envisat by 3.6%, as compared to the use of the EIGEN-GL04S model. However, for the pre-GRACE period (1991 - 2003) the stationary gravity field models EIGEN-GL04S and EIGEN-6S_stat and the EIGEN-6S2 model containing no drift terms for the degree 3-50 terms at this time interval perform superior to the ones containing drift terms for this period (EIGEN-6S_correct and EIGEN-6S2A/B). We also found, that the time variable gravity field models have low (0.1-0.2 mm/yr) impact on the global mean sea level trend. However, strong East/West differences up to 3 mm/yr were found in the regional mean sea level trends, while using orbits of all four satellites based on time variable and stationary gravity field models. We show a relation of these differences to the relative drifts of the centers-of-origin between the orbit solutions based on the time variable and stationary gravity field models. From the results of our detailed study, we conclude that the final version of the time variable gravity field model EIGEN-6S2 performs best for the four satellites tested. This model provides the most reliable and consistent sea level estimates for the whole time period from 1992 to 2011. This model is of the maximum spherical harmonic degree and order 260 and contains time series for drifts as well as annual and semiannual variations of the spherical harmonic coefficients up to degree 50.