Analysis of changes in coastal sea level from the new SLCCI altimetry product and tide gauge data

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The volume of the global oceans is a very sensitive indicator of climate change as it essentially reflects heat uptake by the ocean and mass addition from ice. Conversely, the link between regional sea level changes and climate change is not, in general, so straightforward because the former are the result of the interplay among different forcing mechanisms acting on a wide range of temporal and spatial scales that lead to regional changes usually differing greatly from the global mean. In addition, because the Earth's crust is also changing over time, the sea level relative to land, which is in fact the relevant quantity for coastal impacts, can change significantly as a result, even in the absence of any other forcing factors. Understanding regional and relative sea level at the coast is, therefore, crucial for improvement of future sea level change projections and thus for reaching informed decisions on coastal and adaptation planning. Here we assess the performance of the new satellite altimetry product from the Sea Level Climate Change Initiative (SL_cci) project over the period 1993-2013. We also use the new product in combination with tide gauge data to investigate relative sea level changes at a number of carefully selected tide gauge stations along the western European coast and the southeastern coast of Australia, decomposing such changes into their different long-term components, including the seasonal cycle, intra-annual and inter-annual variability, and the long-term trend. By noting that the coastal sea level from altimetry and the tide gauges only coincides if the land at the coast has no vertical motion, one can in principle derive rates of vertical land motion (VLM) at the tide gauge stations from the difference between the two types of measurements. We explore the feasibility of this approach by comparing to Global Positioning System (GPS) data where available and by conducting a realistic assessment of uncertainties. For this approach we consider the SL_cci grid element where the tide gauge is located (or closer to it). In terms of the annual cycle, we find a good agreement between the SLCCI data and the tide gauges, with differences smaller than 1.6 cm and 23 days in all cases for the amplitude and the phase offset, respectively. The correlation between the two data sets for detrended and deseasoned (and atmospherically-corrected) time series is statistically significant at all stations, with values ranging from 0.54 to 0.87. We find that large uncertainty in the trend estimates of both data sets prevents the computation of VLM rates at most stations. Finally we discuss how this investigation may be extended and possibly imprvoed by using data specially reprocessed for the coastal environment, such as those from the ALES retracker that will be available from Phase 2 of SL_cci.