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Vertical ground motion from tide gauges and satellite altimetry

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Studying the evolution of Earth's shape which deforms in response to external processes such as erosion or sediment load and internal processes governed by mantle convection helps to better understand the Earth's internal dynamics. To do this one needs to study changes in relative and absolute sea level. Indeed, sea level is the intersection between the geoid and the solid Earth that are simultaneously deforming. Thus, sea level variations mirror the evolution of the Earth's shape.
Tide gauges record apparent sea level since the XIXth century for oldest stations, relative to a terrestrial reference. They are attached to the coasts so part of the signal is due to vertical ground motion. Conversely, satellite altimetry only measures true sea level change, starting with TOPEX/POSEIDON since 1992. Subtraction of tide gauges measurements to those of satellites give an estimate of the magnitude of current vertical ground motion. Here we review the variety in methods of calculation and data selection. While some authors choose to use only data that corresponds to the recording period of TOPEX/POSEIDON (1992 to 2000) and work with the sea level height like Cazenave et al. (1999) and Nerem & Mitchum (2002), others like Kuo et al. (2008) and Bouin & Wöppelmann (2010) take into take advantage of the long record of tide gauges which provide estimates of apparent sea level change more accurately than those based on shorter timescales. All previous studies perform a drastic site selection for their quality. Because individual tide gauge records are nevertheless highly variable, we instead prefer the brute force approach to go towards a statistical evaluation of global ground motion and therefore consider all stations. We subsequently extract general trends by region, which indicate that vertical movements are not satisfactorily explained by estimates of glacio-hydro-isostatic readjustment (model ICE_5G, Peltier, 2004). Comparisons with previous methods and other records such as GPS are presented. We also compare the resulting estimates of instantaneous ground motion to our recently released compilation of ground motion from MIS5e (Pleistocene) and Holocene marine terraces. Such comparison suggests constantly increasing rates of ground motion with time, unless it reveals a correlation between the timescale of observation and the apparent ground motion.

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