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Exploring the potential of optical clocks for detecting the Earth's time-variable gravity signals

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The successful application of GRACE, now continued by GRACE-FO, has made remarkable contributions to detecting the Earth's time-variable gravity field. This improved our understanding on mass changes, such as the variation of groundwater and the melting of ice sheets, which has drawn much public attention. In recent years, atomic clocks, especially optical clocks, have experienced rapid development. Meanwhile, frequency-link technologies that are crucially important to connect distant clocks have greatly developed as well. These developments open the door to realize "relativistic geodesy" with clocks in practice, which provides relative gravity potential values through the comparison of clock frequencies. This will be the first technique ever to directly obtain gravity potential differences rather than its derivatives that were observed by previous satellite missions. It is thus expected to improve the gravity field, particularly in the long wavelengths where the big temporal gravity signals mostly appear. In this work, we will explore the potential of clocks on mapping the temporal gravity field using dedicated simulations. We propose to use clocks on-board satellites and on ground to derive gravitational potential values in space. The procedure for comparing clocks in space and on ground will be elaborated. The requirement on the clocks' precision as well as the link performance will be studied. In order to obtain observations with a homogeneous and global coverage, the number of space- and ground-based clock observations, the spatial distribution of clocks, the inclination and altitude of the satellite orbit, etc. will be discussed in detail.