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An optical clock network for height system unification: a simulation study

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An International Height Reference System (IHRS) has been demanded for many years by various scientific studies and engineering applications such as the monitoring of global sea level changes and the determination of mass variations. One solution to IHRS is to consistently unify local height systems of the world. The main challenges to this solution are the estimatation of discrepancies between different height datums and the adjustion of accumulated errors along spirit levelling lines. In this study, we propose a new approach to handle these challenges with a novel clock network. After their deployment in the near future, the clock networks are expected to deliver frequency comparison between clocks with an accuracy of 1.0×10^{-18}, which approximates to 1.0 cm in height difference. Thus, they can serve as a powerful tool to connect local height systems. In order to verify this idea, we design and carry out an end-to-end simulation based on the published European Unified Vertical Network (EUVN) solution. First the EUVN is divided into several local height systems by introducing individual biases and tilts. The simulated local height systems are then re-unified using measurements in an optical clock network. The result indicates that the clock network has a great potential for height system unification. Specifically, one to four clocks for each region can fulfil the unification task well. An optimisation of the clock network is also important to improve the performance of the unification, which in principle should be ensured to sense the accumulated levelling errors. Our results also indicate that the clocks nowadays still lack the necessary accuracy to meet the requirements for height system unification. However, the gap will hopefully be filled soon considering the recent and fast developments in quantum optics instrumentation.