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Comparison of a parallel installation of laser and quartz tube strainmeters at the Geodynamic Observatory Moxa in Thuringia, Germany

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High-resolution continuous deformation measurements provide an important data base for studies on deformation of the solid Earth (e.g. due to tides or hydrologically-induced deformation) that has strain amplitudes from μm to nm. Time series can be obtained by different strainmeters that measure relative changes in length between two fixed points on the Earth's surface with a resolution up to 10^{-10} m. In order to improve the signal-to-noise ratio strainmeters are installed in galleries or caves with a thick mountain overburden.

The Geodynamic Observatory Moxa operates beside seismological and gravimetrical sensor systems an extensive strainmeter array. It consists of a borehole extensometer, two quartz tubes at right angles and one diagonally-installed laser strainmeter. In 2011, two new laser strainmeters were added in cooperation with the company SIOS/Ilmenau. They are installed parallel to the quartz tubes and fixed to the bedrock by the same pylon.

This kind of parallel installation is unique in the world and allows the direct comparison of measurements of horizontal length changes with different types of strainmeters for the first time. For the comparison of the data we used mainly the tidal analysis of three-years long time series, as well as the signal from a research borehole on the observatory's perimeter. The first results show a decrease of the long lasting device-specific drift by a factor of $2.3 - 2.5 \times 10$ of the laser strainmeters (LS) with respect to the quartz systems (QS). Furthermore, the signal-to-noise ratio of the LS is significantly higher than for the QS, as can be seen, for example, in the tidal amplitude factors (AF). In the north-south direction we determined AF ≈ 1.0 (LS) and AF ≈ 0.6 (QS) that yields $\frac{LS}{QS} \approx 1.66$. In the east-west direction we found AF ≈ 0.67 (LS), AF ≈ 0.16 (QS), and therefore $\frac{LS}{QS} \approx 4.3$. The tidal parameters are used to evaluate the new laser strainmeter system. Furthermore the determination of $\frac{LS}{QS}$ provides a method to calibrate the quartz tubes for the first time. The comparison of other deformation signals in the time series reveals that $\frac{LS}{QS}$ changes with the considered signal period. A transfer function is required to calibrate QS using LS.

The new laser strainmeter array is a significant step towards the measurement of subsurface deformation at the Geodynamic Observatory Moxa. Furthermore it is presently being used to develop a transportable laser strainmeter system for areal applications, for example, across fault zones.