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Thermal Influence on the LRI Scale Factor

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In this talk we present the current status of our investigations regarding variations of the LRI scale factor with spotlight on the thermal environment of the LRI. Furthermore, we describe an alternative derivation of the scale factor through LRI telemetry data.

In the current SDS processing scheme for deriving the LRI scale factor, a cross-calibration to the KBR range is employed, which numerically estimates the LRI scale and a time-tag offset by minimizing the difference between KBR and LRI range. Typical numerical values are in the order of $2.2*10^{-6}$ for the scale and a few tens of microseconds for the time-tag offset. The scale shows some recurring features on large time scales, which we were investigating in depth.

At first, we use a LRI telemetry based model for the nominal laser frequency (see https://doi.org/10.5194/egusphere-egu2020-15569), which already reduces the LRI scale to below $\pm5*10^{-8}$, but does not suppress the features occurring on a 3-month time scale. To address these, we investigate thermal variations of the LRI instrument and its subsystems. We do not expect the temperatures to directly influence the laser frequency, but rather assume a proportionality of temperature and phase, which would manifest in tone errors at 1 CPR and 2 CPR. With our analysis, we were able to derive linear coupling factors for mapping temperature variations to errors in the LRI ranging data. With this tone error correction applied, the difference between LRI and KBR range can be reduced by about 60% at low frerquencies. Currently, we're investigating the influence of our correction on the 1 CPR and 2 CPR amplitudes and their differences w.r.t. the KBR range.

Our goal is to derive a model for the LRI scale factor, which uses only LRI telemetry and temperature sensors. That would be especially beneficial in case the KBR observation become unavailable in GRACE-FO, and is furthermore helpful for the design of future laser ranging instruments.