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Measurement of tidal deformation through self-registration of laser profiles: Application to Earth's Moon

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Many moons of the Solar System, e.g. the Galilean satellites or Earth's Moon, are subject to strong tidal deformations. Measurements of the tidal Love number h2 by laser altimeters from orbiting spacecraft may provide crucial constraints on their interior structures and rheology. Using precise observations by laser altimeters estimates for h2 were obtained for the Moon (Mazarico et al. 2014, Thor et al., 2021) and Mercury (Bertone et al., 2021), and are planned for Ganymede (Steinbrügge et al., 2015). Typically, height differences at crossing points of laser profiles, so called crossover points, are used for such measurements (Mazarico et al. 2014, Bertone et al., 2021). However, a new method based on simultaneous inversion of tidal deformations and global topography has recently been demonstrated (Thor et al. 2021) using data from the Lunar Orbiter Laser Altimeter (LOLA) on board the Lunar Reconnaissance Orbiter (LRO).

Here we propose the refined "self-registration" method, which makes use of an accurate reference digital terrain model (DTM) constructed from the laser profiles themselves. This DTM is obtained by iteratively co-registering random subsets of laser profiles to an intermediate DTM produced by the other profiles. With our method we are not limited to profiles that are actually crossing themselves and can obtain height difference between all available profiles. Moreover, we can overcome the interpolation error at the crossover points as we use the entire profile with all its data points to measure the relative height differences. This method was recently successfully applied to measure the seasonal change of the ice/snow level in polar regions of Mars using Mars Orbiter Laser Altimeter (MOLA) data (Xiao et al., 2021).

In order to validate our method and assess its performance we perform a simulation of a tidal

signal in the LOLA data with an assumed value for the tidal Love number h2 of the Moon. Thereby the height measurement at the location of the LOLA footprint is derived from a DTM and an artificial tidal signal applied on it. Thereby, we consider viscoelastic effects on the tidal deformation and different tidal frequencies. With the help of these simulations we assess the accuracy of the h2 measurement and check the sensitivity to the measurement of the tidal phase lags.

References:

Mazarico et al. (2014). Detection of the lunar body tide by the Lunar Orbiter Laser Altimeter. GRL, 41(7), 2282-2288. doi:10.1002/2013GL059085

Thor et al. (2021). Determination of the lunar body tide from global laser altimetry data. JoG, 95(1). doi:10.1007/s00190-020-01455-8

Bertone et al. (2021). Deriving Mercury Geodetic parameters with Altimetric Crossovers from the Mercury Laser Altimeter (MLA). JGR-Planets, 126(4), e2020JE006683. doi:10.1029/2020JE006683

Xiao et al. (2021). Prospects for Mapping Temporal Height Variations of the Seasonal CO2 Snow/Ice Caps at the Martian Poles by Co-registration of MOLA Profiles. Under review in PSS, https://arxiv.org/abs/2109.04899