Geophysical Research Abstracts
Vol. 16, EGU2014-12685, 2014
EGU General Assembly 2014
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Estimating Tides from a Planetary Flyby Mission

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Previous and current laser altimeter instruments (e.g. MOLA, NLR, LOLA, MLA) acquired measurements in orbit to provide global topography and study the surface and sub-surface properties of planetary bodies. We show that altimetric data from multiple flybys can make significant contributions to the geophysical understanding of the target body. In particular, the detection of the body tide (e.g. surface deformation due to the tides raised by the Sun or the parent body) and the estimation of its amplitude can yield critical information about the interior structure. We conduct a full simulation of a planetary flyby mission around Europa. We use the GEODYN II program developed and maintained at NASA GSFC to process altimetric and radiometric tracking data created using truth models. The data are processed in short two-day segments (arcs) centered on each closest approach. The initial trajectory is integrated using a priori (truth) models of the planetary ephemeris, the gravity field, the tidal Love numbers k2 and h2 (which describe the amplitudes of the time-variable tidal potential and the time-variable radial deformation respectively). The gravity field is constructed using a Kaula-like power law and scaling considerations from other planetary bodies. The global-scale static topography is also chosen to follow a power law, and higher-resolution local maps consistent with recent stereo-topography work are used to assess the expected variations along altimetric profiles. We assume realistic spacecraft orientation to drive a spacecraft macro-model and model the solar radiation pressure acceleration. Radiometric tracking data are generated from the truth trajectory accounting for geometry (occultations by Europa or Jupiter or the Sun), DSN visibility and scheduling (8h per day) and measurement noise (Ka-band quality, plasma noise). Doppler data have a 10-second integration step while Range data occur every 5 minutes. The altimetric data are generated using realistic instrument performance (frequency, maximum range, measurement noise) and an artificial topographic map of the surface. These simulated data are processed using perturbed initial states, and batched least-squares estimation yield estimated values and uncertainties for selected parameters. Preliminary results with Ka-band radiometric data alone suggest the Love number k2 can be recovered to about 1 percent with this flyby tour trajectory. Altimetric crossovers are to be constructed and used to constrain the deformational tidal Love number h2. The number, and impact, of available crossovers strongly depends on the capability of the laser altimeter, and we quantify how a larger maximum range can contribute to the recovery of the body tide.