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Consistent radiation pressure modelling for LEOs

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Non-gravitational forces interact with the surface of satellites and lead to orbit perturbations. In LEO orbit, besides the atmospheric drag, the two most important non-gravitational forces are caused by the radiation pressure of the Sun and the Earth. With increasing distance of the satellite from the Earth's surface, the acceleration due to the Earth radiation pressure (ERP) becomes less relevant, whereas the effect of the solar radiation pressure (SRP) increases. Depending on whether the satellite carries an accelerometer payload or not, accurate modeling of these forces is required for precise orbit determination, satellite gravimetry or thermospheric density estimations.

In this study, we re-assess potential systematic errors in radiation pressure force modelling. We discuss limitations and inconsistencies of conventional approaches with an emphasis on (1) systematic errors in time-dependent radiation data products for the Sun and the Earth, and (2) modeling the reflection properties of the satellite and the Earth's surface. We suggest a consistent model of the ERP and SRP accelerations, which is based on investigating hourly fields of the Earth's outgoing radiation instead of utilzing global monthly albedo and emission fields.

This refined radiation pressure force model, which in principle is applicable to all satellites, lends itself to estimating offset parameters and to providing an error budget. We apply this approach to data from the satellite mission Gravity Recovery and Climate Experiment (GRACE). Finally, we assess the magnitude of remaining errors, e.g., due to aging of the satellite's material.