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Side-effects of a bad attitude: How GNSS spacecraft orientation errors affect solar radiation pressure modelling

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Solar radiation pressure (SRP) is the largest non-gravitational perturbation for Global Navigation Satellite System (GNSS) satellites, and can therefore have substantial impact on their orbital dynamics. Various SRP force models have been developed over the past 30 years for the purpose of precise orbit determination. They all rely upon the assumption that the satellites continuously maintain a Sun-Nadir pointing attitude with the navigation antenna boresight (body-fixed z-axis) pointing towards Earth center, and the solar panel rotation axis (body-fixed y-axis) being normal to the Sun direction. However, in reality, this is not perfectly the case. Reasons for a non-nominal spacecraft attitude may be eclipse maneuvers, commanded attitude biases and Sun/horizon sensor measurement errors, for example due to mounting misalignment or incorrectly calibrated sensor electronics.

In this work the effect of GNSS spacecraft orientation errors on SRP modelling is investigated. Simplified mathematical functions describing the SRP force acting on the solar arrays in the presence of yaw-, pitch- and roll-biases are derived. Special attention is paid to the yaw-bias and its relationship to the SRP dynamics, particular in direction of the spacecraft y-axis ("y-bias force"). Analytical and experimental results gathered from orbit and attitude analyses of GPS Block II/IIA/IIF satellites demonstrate how sensitive the SRP coefficients are to changes in yaw.