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Sentinel-3A/3B orbit determination using non-gravitational force modeling and single-receiver ambiguity resolution

Xinyuan Mao, Daniel Arnold, and Adrian Jäggi
Astronomical Institute, University of Bern, Bern, Switzerland

Sentinel-3 is an Earth observation satellite formation of the European Space Agency (ESA) devoted to oceanography and land-vegetation monitoring. It operates as a crucial segment of the Copernicus Programme coordinated by the European Union. Up until now, two identical Sentinel-3 satellites, Sentinel-3A and -3B, have been launched into a circular sun-synchronous orbit with an altitude of about 800 km. Their prime onboard payload systems, e.g. radar altimeter, necessitate high-precision orbits, particularly in the radial direction. This can be fulfilled by using the collected measurements from the onboard dual-frequency high-precision multi-channel Global Positioning System (GPS) receivers. The equipped laser retro-reflector allows for external and independent validation to the GPS-derived orbits.

This research will outline the recent Precise Orbit Determination (POD) methodology developments at the Astronomical Institute of the University of Bern (AIUB) and investigate the POD comparison between Sentinel-3A and -3B satellites. On one hand, a refined satellite non-gravitational force modeling strategy is newly implemented into the BERNESE GNSS software. It consists of comprehensive modeling of atmospheric drag, solar radiation pressure and Earth albedo/radiation pressure based on an 8-plate satellite macromodel. Radiation pressure is modeled considering spontaneous re-emission for non-solar plates. Besides, a linear interpolation between monthly Clouds and the Earth's Radiant Energy System (CERES) S4 grid products is specifically done for the Earth albedo/radiation pressure modeling. On the other hand, use is made of the GNSS Observation-Specific Bias (OSB) products provided by the Center for Orbit Determination in Europe (CODE), allowing for the so-called single-receiver ambiguity resolution.

A test period is selected from 7/Jun/2018 to 14/Oct/2018 (Day of Year: 158-287), when Sentinel-3A and -3B satellites operated in a tandem formation maintained at a separation of about 30 s. This foresees nearly identical in-flight environment for both satellites and thereby enables direct POD performance comparison. The single-receiver (zero-difference) ambiguity-fixed orbit solutions can also be compared with the double-difference ambiguity-fixed baseline solution. Results reveal that the implemented non-gravitational force modeling in POD leads to a reduction of empirical acceleration estimates, which are designated to compensate uncertainties in the satellite dynamic models. Single-receiver ambiguity resolution further improves the reduced-dynamic orbits and significant enhancement occurs to the kinematic orbits. This research implies promising benefits to the Sentinel-3 scientific research community.