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Monitoring of GNSS satellite transmit power with small radio telescopes

Grzegorz Klopotek (1), Marcus Malmquist (1), Eskil Varenius (1,2), Peter Forkman (1), Rüdiger Haas (1), and Thomas Hobiger (3)

(1) Chalmers Univeristy of Technology, Department of Space, Earth and Environment, Gothenburg, Sweden (grzegorz.klopotek@chalmers.se), (2) Jodrell Bank Centre for Astrophysics, The University of Manchester, Oxford Rd, Manchester M13 9PL, United Kingdom, (3) Institute of Navigation, University of Stuttgart, 70174 Stuttgart, Germany

Good knowledge and routine monitoring of the transmit power of all available GNSS satellites are of great importance for high-precision GNSS applications as well as GNSS reflectometry (GNSS-R). Due to a phenomenon commonly known as antenna thrust, GNSS satellite orbits are impacted by the transmission of the navigation signals. This results in small forces acting in the radial direction of the satellite's orbit. The consideration of this effect is thus vital for an enhanced GNSS orbit modeling and orbit determination. In the case of GNSS-R, information on the satellite antenna gain patterns is essential for a geophysical parameter retrieval from spaceborne missions like Cyclone Global Navigation Satellite System (CYGNSS).

Observations with the aim to determine the signal strength and gain patterns of GNSS satellites have been carried out previously on an experimental basis. However, reliable, routinely determined and publicly accessible data concerning these parameters are not yet available for the scientific community. In order to address this issue, we developed a GNSS tracking and monitoring system that makes use of two small (2.3 m) radio telescopes, referred to as SALSA. The system is located at Onsala Space Observatory in Sweden and was originally developed with the aim to allow carrying out remote astronomical L-band observations by registered users. SALSA has been recently extended with the possibility to track GNSS satellites in an automatic fashion and store all the necessary information for subsequent data analysis.

We highlight the technical specifications and measurement performance of this newly developed GNSS tracking system and present results from several test sessions, based upon which transmit power levels and antenna gain patterns of several GPS, GLONASS, GALILEO and BeiDou satellites were determined. We also compare the derived parameters with recent results from similar studies. It is expected that our investigations will form the basis of a new routine service, regularly monitoring GNSS signals and providing scientists with these satellite-based products.

Keywords: GNSS-R, GNSS orbit determination, signal monitoring, antenna gain pattern, SALSA