

FAILURE OF GPS FUNCTIONING CAUSED BY EXTREME SOLAR RADIO EVENTS

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We investigate the GPS performance quality during the 2006 December 6 and 2006 December 13 solar flares (soft X-ray class X6.5 and X3.4, respectively), which produced solar radio bursts with unprecedented radio flux density. According to data from the Owens Valley Solar Array (OVSA) and the RSTN spectrograph at Learmonth, the level of solar radio noise during the 6 December and 13 December events in the GPS frequency range exceed 10^6 s.f.u. and 10^5 s.f.u. (background noise is 10^2 s.f.u.). We used GPS data from a global network of dual-frequency receivers (for the 6 December event, more than 1500 sites; <http://sopac.ucsd.edu/other/services.html>) and data of Nationwide GPS array of Japan GEONET (for the 13 December event; 1225 sites; ftp://163.42.5.1/data/GPS_products/). We found significant experimental evidence that during more than 10 minutes the high precision GPS positioning on the entire sunlit side of the Earth has been partially paralyzed. We show that the high level of phase slips and count absences are caused by wideband solar radio noise. Our results provide serious grounds for revision of the role of space weather in the functioning of modern satellite systems and suggest the need for a more careful accounting of space weather factors in engineering development and operation. Other important conclusion of our paper is the need for continuous monitoring, by well-calibrated instruments, of the level of integrated flux of solar radio emission. Such monitoring should be carried out by a number of solar radio spectrographs, distributed to cover the entire range of longitudes, to be used for determining the level of radio noise of solar origin in the range of frequencies used by GPS-GLONASS-GALILEO. This paper is supported by the Program of basic researches of Presidium of the Russian Academy of Science № 30 “Solar activity and physical processes in the Sun-Earth system,” and by US NSF grants AST-0352915 and AST-0607544 to New Jersey Institute of Technology.