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Warning System for GNSS Signal Degradation Caused by Solar Radio Bursts

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1. Extended Abstract

Intense solar radio bursts (SRBs) emitted at L-band frequencies are a source of radio frequency interference (RFI) for Global Navigation Satellite Systems (GNSS) and consequently impact the quality of the GNSS signal reception [1, 2]. Such space weather events are critical for GNSS-based applications requiring real-time high-precision positioning [3]. Despite the fact that solar observatories routinely monitor solar radio emissions, the direct impact of SRB at the GNSS frequencies are not determined in real-time.

To remedy to this shortcoming, the Royal Observatory of Belgium (ROB) started to monitor in near-real time the carrier-to-noise density (C/N_0) observations from regional GNSS networks. The monitoring consists in estimating abnormal fade of the C/N_0 for each GNSS satellite-receiver pair with respect to the normal quiet state defined as the C/N_0 median of the seven previous satellite repeat ground tracks. To distinguish the C/N_0 fade due to SRBs among all other potential radio frequency interferences and ionospheric scintillations, we estimate a unique $<\Delta C/N_0>$ fade over the regional network at the L1 and L2 frequencies at each epoch (30s). It allows detecting and quantifying the impact of SRBs on GNSS signal quality at a regional level.

To validate this method, the degradation of GPS and GLONASS C/N_0 on the GNSS stations of the entire EUREF Permanent Network (EPN) was investigated during 11 intense SRBs close to the GNSS frequencies occurring between 1999 and 2015 in the sunlit of Europe. The analysis shows that: (1) the most intense SRB reached a $<\Delta C/N_0>$ fade of 12 dB.Hz and the least intense SRB was detected with 1 dB.Hz $<\Delta C/N_0>$ fade, while during quiet time the $<\Delta C/N_0>$ remains stable at 0.0±0.1 dB.Hz level; (2) GPS and GLONASS $\Delta C/N_0$ fades agree at the 0.1±0.2 dB.Hz level.

Finally, a near-real time 4-level index warning system indicating the impact of a SRB on GNSS signal reception is now operational at ROB for the European region using real-time data of the EPN. It already permitted detecting the last SRB event of the 4th November 2015 with a C/N_0 fade of -5.8±2.2 dB.Hz (Figure 1). In addition, first results for South America and Africa, obtained using GNSS data from the real-time IGS network, will also be shown.

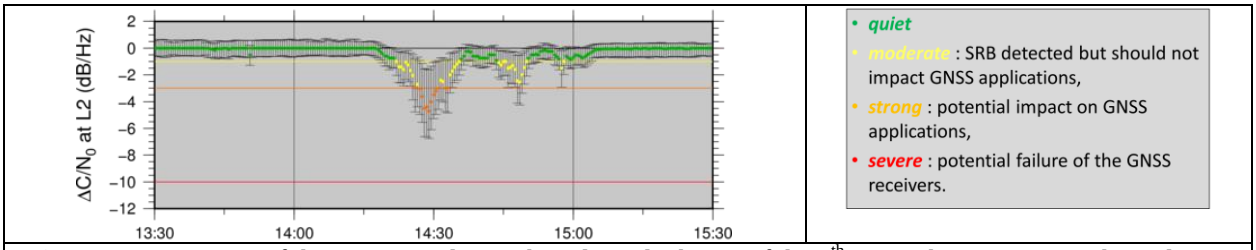

Figure 1. Time series of the $<\Delta C/N_0>$ during the solar radio bursts of the 4th November 2015 using the real-time GPS data from the EPN. On the right-hand side, the legend of the different levels of the warning system.

References

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