Precise point positioning degradation in the presence of a SITEC

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The ionosphere is one of the main contributors to errors in the GNSS satellite-receiver ranging. In dual frequency precise point positioning (PPP) ionospheric effect may be reduced by means of the ionospheric-free linear combination (Zumberge et al., J. Geophys. Res. 102 (B3), 1997, pp. 5005-5017). However, ionospheric irregularities (characterized by rapid total electron content (TEC) fluctuations) such as equatorial plasma bubbles, ionospheric storms or solar flares induced sudden increases in TEC (SITEC), still are a main threat on GNSS-based techniques since they may cause cycle slips which compromises ambiguities estimation and originates a position accuracy degradation.

Solar flares may emit EUV and X-ray radiation directed to the Earth and change the state of ionosphere and thermosphere in the sunlit hemisphere few minutes after the radiation emission. The sudden ionospheric disturbance caused by the flare depends on the solar zenith angle, and the major impact is expected to be in low latitude regions below the subsolar point. Many authors have studied the ionospheric response to solar flare effects (Tsurutani et al., Geophys. Res. Lett., 32, L03S09, 2005; Tsugawa et al., J. Geophys. Res., 112, A08301, 2007). Our study tries to go one step further analysing the performance of precise positioning software's under this kind of effect.

In this work we show that large SITECs may degrade PPP. We present the case study of the effect on PPP accuracy caused by the X17.2 solar flare of October 28th 2003 induced SITEC. This was one of the strongest solar flares of cycle 23, and it is the largest SITEC ever recorded by GNSS (by means of rate of change of TEC) which produced simultaneous kinematic PPP accuracy degradation in several stations. We check different PPP software results and we conclude that the observed errors are due to cycle slip misdetection, which may lead to ambiguities re-estimation. In this case geometry-free combination should not be a good cycle slip detection method since what it is "detecting" it is the actual ionosphere ionization rate and not, cycle slips. These results lead us to suggest that there may be cases in which under other kind of irregularities such as equatorial plasma depletions (which are a common ionospheric feature of low latitudes), the fast TEC fluctuations may also lead to misdetection of cycle slip and re-estimation of ambiguities even if no real cycle slips occur. Therefore, more reliable cycle slip methods seem to be needed in order to give more accurate positioning solutions under these kinds of ionospheric disturbances. This requirement would be especially important in post processing since ionospheric irregularities could be simultaneously recognized by their features making the cycle slip detection method able to discard real cycle slips from ionospheric perturbations.