

Temporal and spatial distribution of GPS-TEC anomalies prior to the strong earthquakes

Fuying Zhu · Yun Wu · Yiyang Zhou · Yang Gao

Received: 1 March 2013 / Accepted: 4 March 2013 / Published online: 15 March 2013
© Springer Science+Business Media Dordrecht 2013

Abstract Earthquakes are one of the most destructive and harmful natural disasters, especially in recent years, the 2008/5/12 Wenchuan M7.9 earthquake, the 2011/3/11 Tohoku M9.0 earthquake and the 2012/4/11 Sumatra M8.6 earthquake have caused a significant impact to the human life. In this paper, we make a study of the temporal and spatial distribution of the Global Positioning System Total Electron Content (GPS TEC) anomalies prior to the three strong earthquakes by the method of statistical analysis. Our results show that the pre-earthquake ionospheric anomalies are mainly positive anomalies and take the shape of a double-crest structure with a trough near the epicenter. The ionospheric anomalies do not coincide with the vertical projection of the epicenter of the subsequent earthquake, but mainly localize in the near-epicenter region and corresponding ionospheric anomalies are also simultaneously observed in the magnetic conjugate region prior to the three earthquakes. In addition, the amplitude and scale-size of the ionospheric Δ TEC are different with the magnitude of the earthquake, and the horizontal scale-size of the greatest anomalies before the Tohoku M9.0 earthquake is $\sim 30^\circ$ in longitude and $\sim 10^\circ$ in latitude, with the maximum amplitude of TEC disturbances reaching ~ 20 TECu relative to the background. The peak of anomaly enhancement usually occurs in

the afternoon to sunset (i.e. between 14:00 and 18:00 local time) which lasts for approximate 2 hours. Possible causes of these anomalies are discussed, and after eliminating the effect of solar activities and magnetic storms it can be concluded that the detected obvious and regular anomalous behavior in TEC within just a few days before the earthquakes is related with the forthcoming earthquakes with high probability.

Keywords GPS TEC · Anomalies · Strong earthquakes

1 Introduction

Since the seismic-ionospheric anomalies were first discussed for the great Alaska earthquake as early as in 1964 (Davies and Baker 1965; Leonard and Barnes 1965), the ionospheric anomalies before the earthquake near the epicenter have aroused strong interest of numerous researchers and a number of papers have reported on the pre-earthquake ionospheric anomalies for some special earthquake events (Calais 1995; Chmyrev et al. 1997; Liperovsky et al. 2000; Silina et al. 2001; Liu et al. 2000, 2001, 2002, 2004, 2006, 2008, 2009, 2010, 2011; Gaivoronskaya and Pulinets 2002; Plotkin 2003; Pulinets and Legen'ka 2003; Rios et al. 2004; Afraimovich et al. 2004; Pulinets and Boyarchuk 2002; Tringunait et al. 2004; Pulinets et al. 2005; Hobara and Parrot 2005; Liperovskaya et al. 2006; Krankowski et al. 2006; Zakharenkova et al. 2006, 2007, 2008; Singh and Singh 2007; Zhao et al. 2008; Lin et al. 2009; Zhou et al. 2009; Hsiao et al. 2010; Lin 2010, 2011, 2012; Xiong et al. 2011; Yao et al. 2012). Considerable evidence has been accumulated over the years to suggest that transient disturbances in the ionosphere do exist a few days before earthquakes, and the seismic-ionospheric precursor can offer

F. Zhu (✉) · Y. Wu · Y. Zhou
Key Laboratory of Earthquake Geodesy, Institute of Seismology,
China Earthquake Administration, Wuhan 430071, China
e-mail: fy Zhu027@yahoo.com.cn

F. Zhu · Y. Wu · Y. Zhou
Wuhan Base of Institute of Crustal Dynamics,
China Earthquake Administration, Wuhan 430071, China

Y. Gao
Department of Geomatics Engineering, University of Calgary,
Calgary, T2N 1N4, Canada