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RESEARCH ARTICLE - SOLID EARTH SCIENCES

Integrated observations on crustal strain-ionosphere total electron content anomalies before the earthquake

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Abstract

Changes in strain (Linear and triangular) rate and Ionosphere Total Electron Content (TEC) before Mw 7.9 2018 Alaska Earthquake are investigated. Ten years of global positioning system (GPS) time series solutions were used for strain estimation in the region before the occurrence of the earthquake using the Haversine formula and triangulation method. Linear strain values suggest an anomaly in strain variation trend near the epicenter. Additionally, daily TEC variations for 30 days before the earthquake occurred were monitored and analysed. Analysis suggests TEC depletion on December 26 2017, and January 16 2018, respectively. TEC values from 60 GPS stations data were interpolated to study the spatial variations of TEC anomaly. Hourly TEC data derived from GPS stations on December 26 2017, and January 16 2018, suggest low TEC zone concentration near to the earthquake epicenter during 1 to 4 UTC. Spatial distribution of TEC values in 2-Dimension corresponding to anomaly time at 60 GPS stations in the vicinity of study area suggests lowest TEC values at stations that lie closer to the epicenter. The study suggests Lithosphere-Ionosphere coupling before Mw 7.9 2018 Alaska Earthquake and recommends developing a TEC-Strain Monitoring System for further validation of the work and for the better study of earthquake precursors based on TEC-Strain anomalies.

Keywords Total electron content (TEC) · TEC anomaly zone (TAZ) · Strain anomaly · TEC anomaly time (TAT) · Geomagnetic storm · Continuously operating reference station (CORS)

Introduction

Studies on the physical mechanism of ionosphere perturbation due to earthquakes have given significant information on atmosphere—ionosphere variability before earthquakes based on observation, experimental and theoretical data (Akyol et al. 2020; Grant et al. 2015; Kumar and Singh 2012; Pulinets 2004; Shuang-Gen et al. 2004). Promising studies that uses global positioning system (GPS) data have reported pre-earthquake irregularity in total electron content (TEC) in the ionosphere within the vicinity of earthquake preparation zone (Dogan et al. 2011; Heki and Enomoto 2013; Jhuang et al. 2010; Jin et al. 2014; Liu et al. 2004; Mansilla 2019; Priyadarshi et al. 2011; Pulinets et al. 2005; Shah and Jin 2015). On the other hand, GPS-based crustal deformation has suggested strain development as a major cause for earthquake occurrences (Dumka et al. 2019; Kannaujiya et al. 2022; Pan et al. 2020; Zheng et al. 2017). Therefore, it is evident that by studying the ionosphere TEC and crustal strain variation, information about an impending quake may be derived. However, in order to study the extent of TEC and Strain variations, a large network of GPS observations is required. Additionally, factors other than seismic activities that may possibly perturb TEC, such as solar flares and geomagnetic storms (Mostly TEC enhancement), need careful segregation and analysis (Danilov 2001;

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