Ionospheric Lunar tide induced by total solar eclipse on 21 August 2017

Tsung-Yu Wu[1,2], Jann-Yenq Liu[1,2,3], Yang-Yi Sun[4], Nicholas M. Pedatella[5], Chi-Yen Lin[1,2], Yi-Chung Chiu[1,2], Loren C. Chang[1,2], Chien-Hung Lin[6], Chia-Hung Chen[6], Fu-Yuan Chang[2], I-Te Lee[1,2,7], Andrzej Krankowski[8]

國立中央大學 National Central University

[1]Center for Astronautical Physics and Engineering, National Central University, Taiwan., [2]Graduate Institute of Space Science, National Central University, Taiwan., [3]Center for Space and Remote Sensing Research, National Central University, Taiwan., [4]Institute of Geophysics and Geomatics, China University of Geosciences, China., [5]High Altitude Observatory, National Center for Atmospheric Research, USA., [6]Department of Earth Sciences, National Cheng Kung University, Taiwan., [7]Central Weather Bureau, Taipei, Taiwan., [8]Space Radio-Diagnostics Research Centre., University of Warmia and Mazury in Olsztyn, Olsztyn, Poland.

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Abstract

The ionospheric total electron content (TEC) derived from dense ground-based GNSS (global navigation satellite system) receivers over the continent (CON) of United States are utilized to find the ionosphere response to the 21 August 2017 total solar eclipse. When the moon shadow of the eclipse swept through the midlatitude and the EIA (equatorial ionization anomaly) ionosphere, the CON TEC along seven longitudes of -130, -120, -105, -90, -75, -60, and -45°E are examined. Maximum obscurations and their associated co-located major depressions appear simultaneously in the midlatitude, while major depressions elongate toward the magnetic equator with some delays in the EIA region. The former is due to the photochemical loss process and the latter is caused by the plasma transport. TEC extrema of predawn reductions, morning enhancements, major depressions, and nighttime enhancements, as well as the early appearance of the EIA crests indicate that the semi-diurnal lunar component of the spring tide with the period of about 12.42 hours is essential on the eclipse day.

Data

The International Global Navigation Satellite System Service and Continuously Operating Reference Station (CORS) setup more than 2,200 ground-based GNSS receivers in the United States. We examine the total electron content (TEC) along seven longitudes of -130, -120, -105, -90, -75, -60, and -45°E derived from ground-based GNSS receivers over the continent US (CONUS) area to examine large scale of the 2017 total solar eclipse.

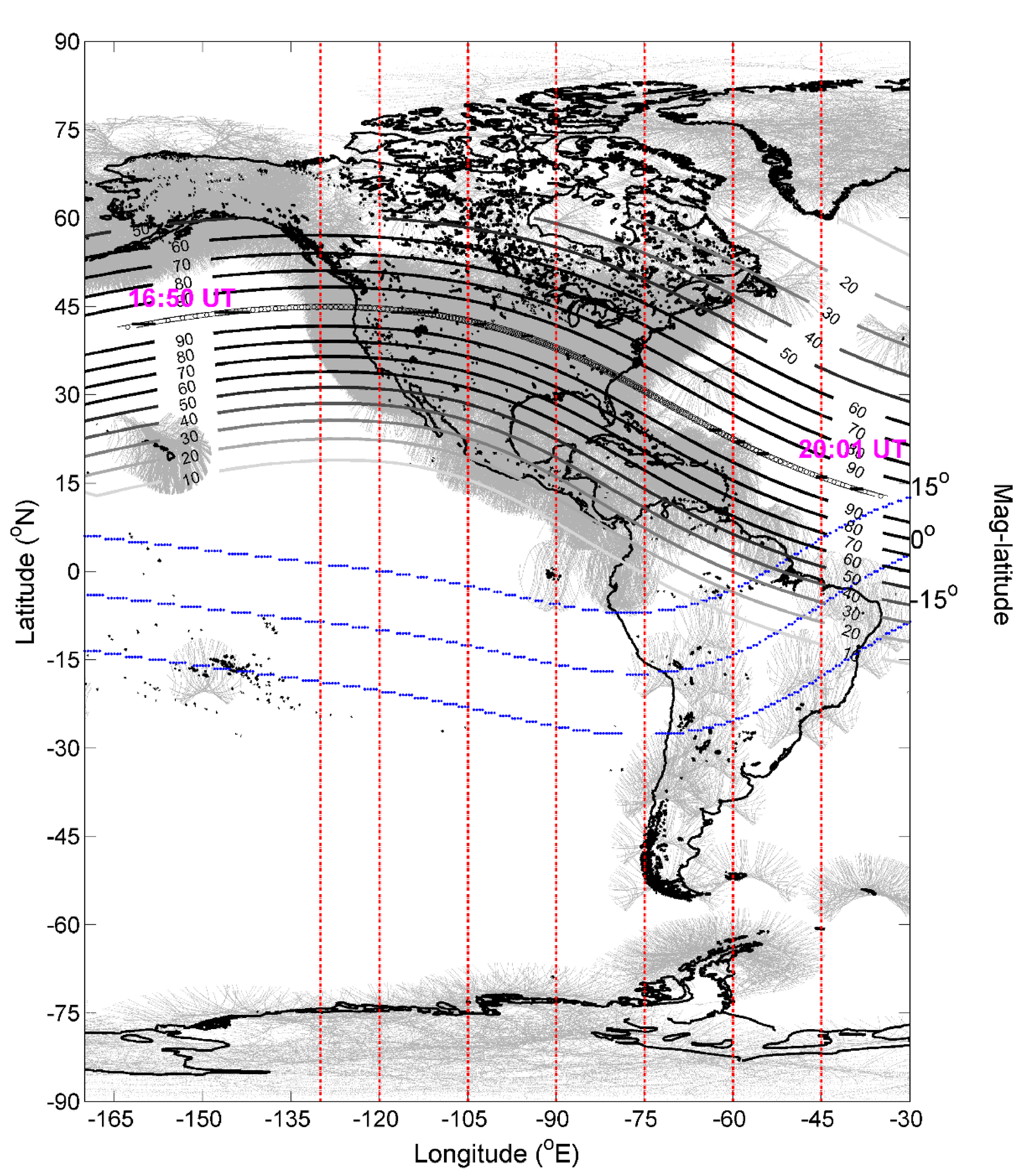

Figure 1 Coverage of 2200 ground-based GNSS receivers and the 2017 solar eclipse path/obscuration. The blue curves denote the magnetic equator and ±15° magnetic latitude. Red lines stand for the -110, -120, -105, -90, -75, -60, -45°E longitude.

Methodology

Running median of 1-15 days before and after the observed have been extracted from GNSS TEC as reference TEC. Furthermore, the difference in both observed and reference have been analyzed.

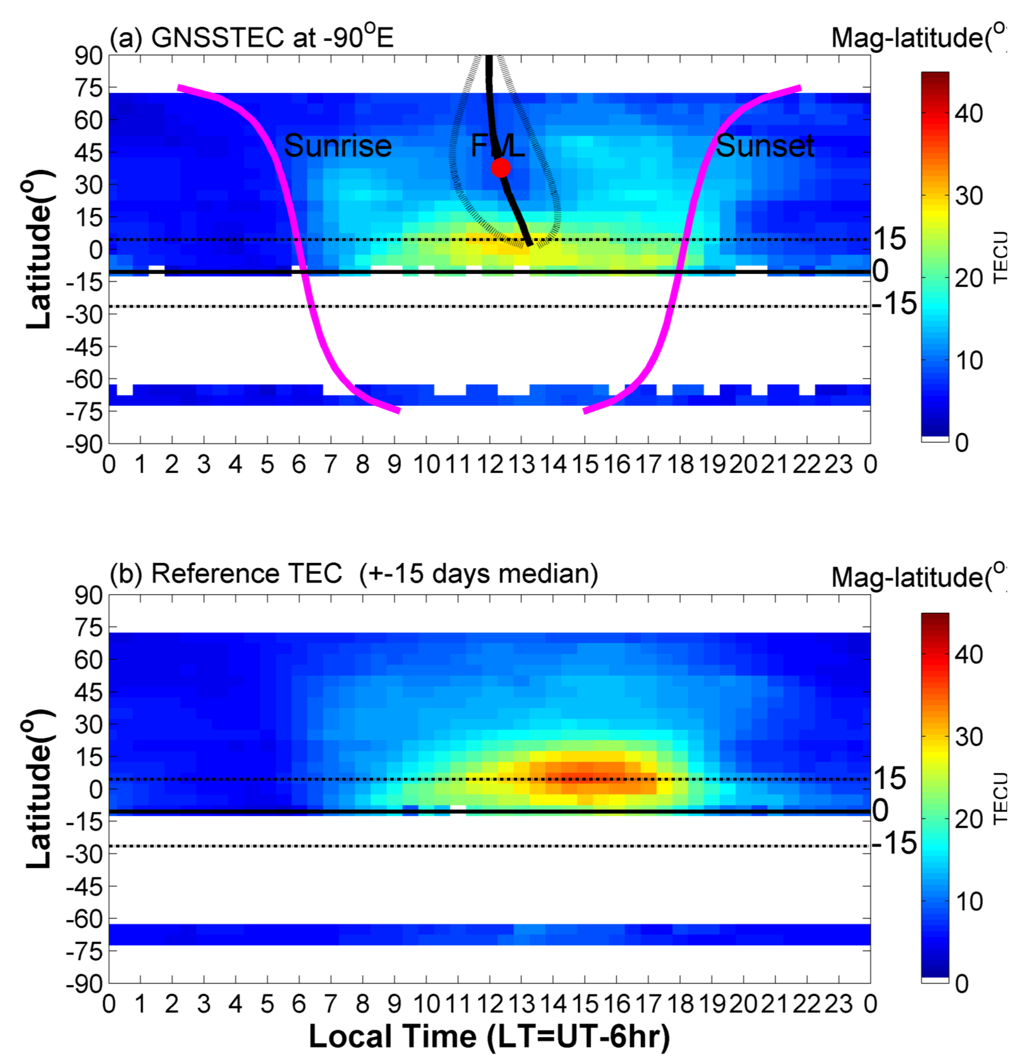

Figure 2 Latitude-time-TEC (LTT) plots of the CON TEC extracted along the -90°E on the eclipse day and reference day. The CON LTT plot on the eclipse day (a) and reference day, the median of 15 before and after the eclipse day (b). Pink curves denote the local sunrise and sunset, while gray, red-dot black, and gray curves stand for the first contact, the maximum obscuration, and the last contact of the solar eclipse, respectively. The red dot on the maximum obstruction curve denotes the totality.

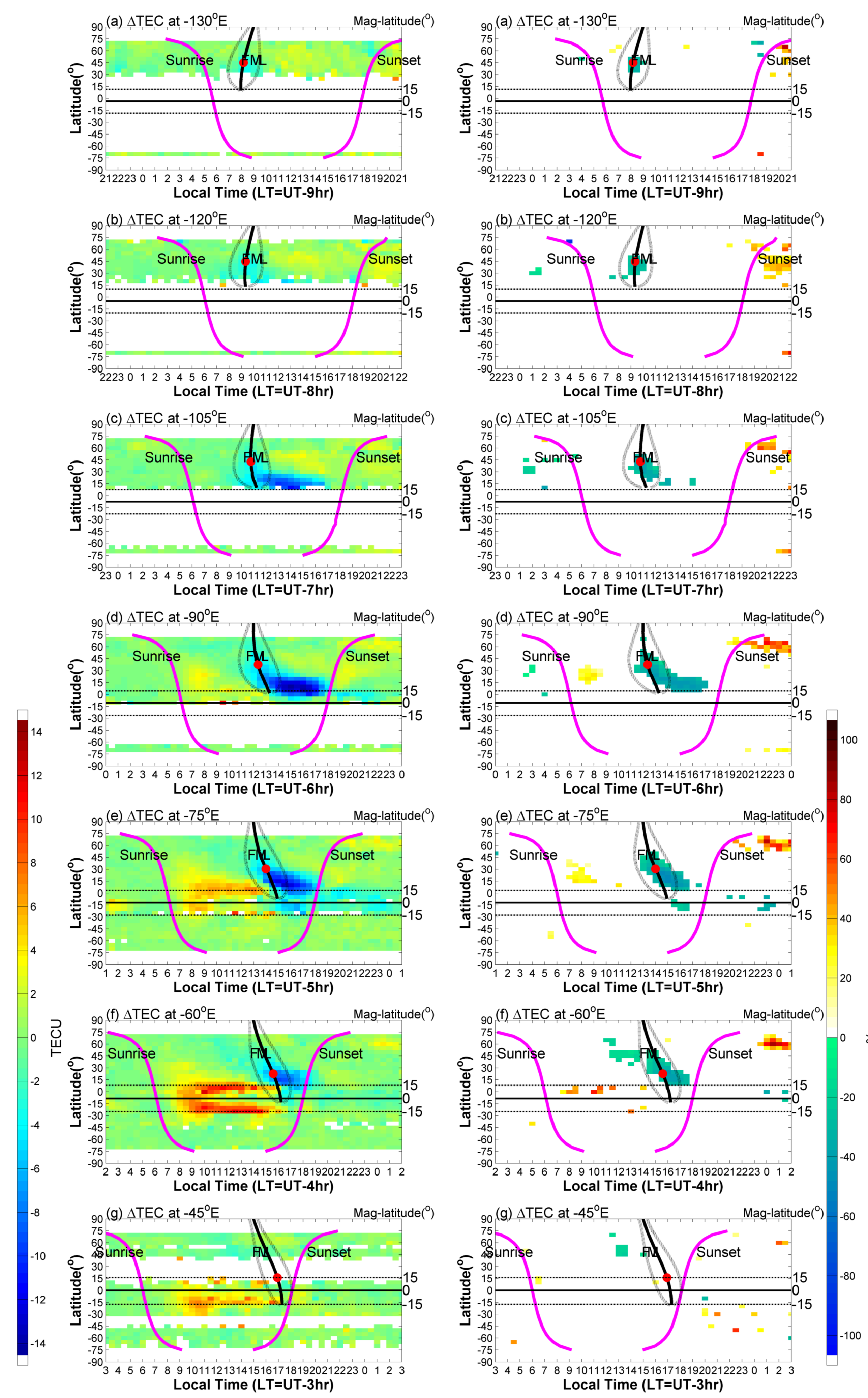

Figure 3 CON LTT plots in TEC, the TEC on the eclipse day subtracting by that of the reference day along the seven longitudes (left panels: -130°E (a), -120°E (b), -105°E (c), -90°E (d), -75°E (e), -60°E (f), and -45°E (g) longitude); as well as the associated ratio (right panels: 130°E (h), -120°E (i), -105°E (j), -90°E (k), -75°E (l), -60°E (m) and -45°E (o) longitude). The ratios are defined as an extreme maximum or minimum TEC among the 31 TECs of both the reference and the eclipse day appearing on the eclipse day divided by the associated median/reference.

Analysis

To confirm the TEC enhancement and reduction are related to lunar tide, the daily TEC along -75°E has been extracted to analyze the TEC fluctuation and equatorial ionospheric anomaly (EIA) crest occurring time.

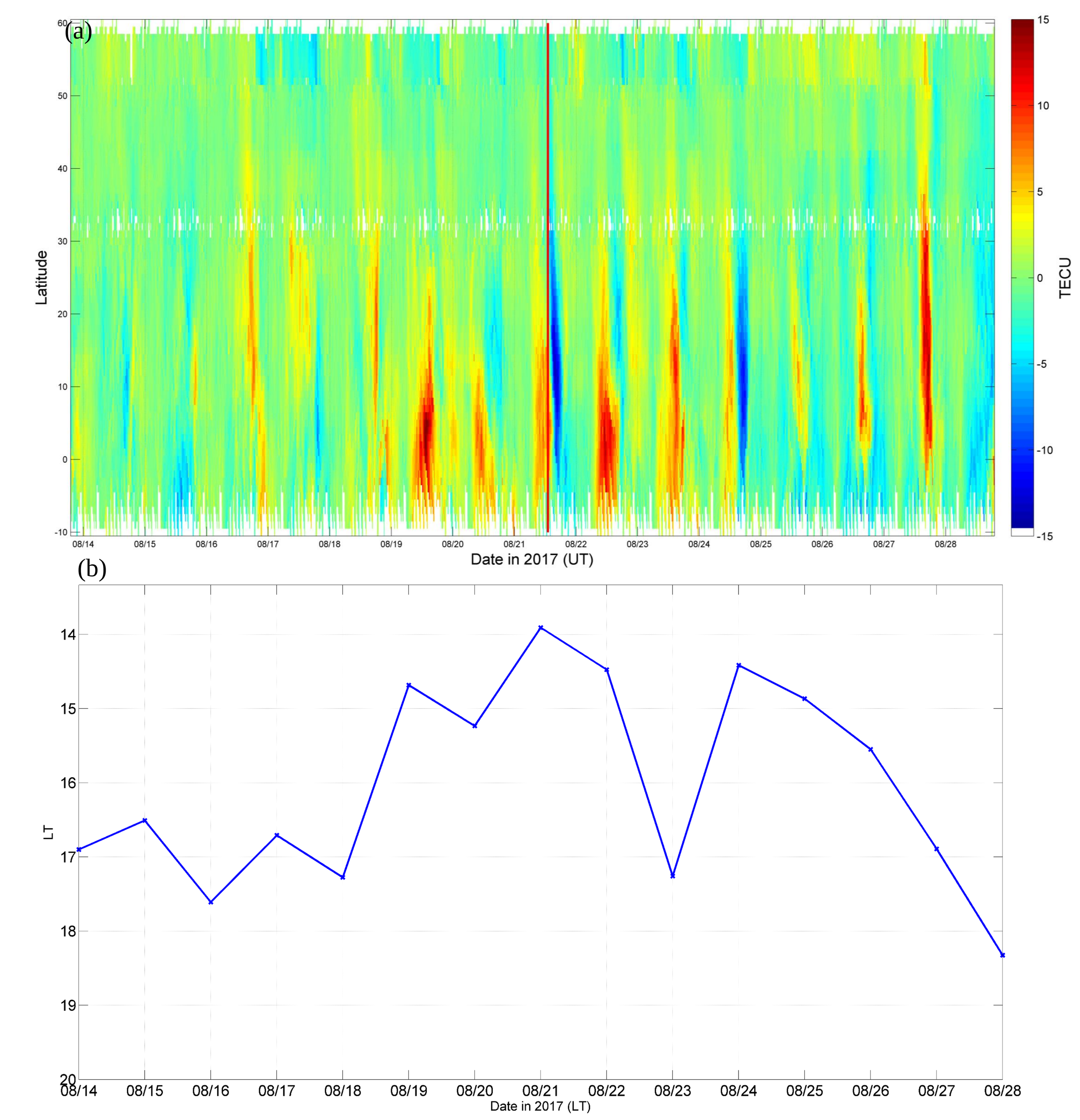

Figure 4 (a)Difference TEC along -75°E, and the red vertical line denotes the first contact of eclipse. (b) Daily EIA crest occurring time.

Conclusions

The 21 August 2017 solar eclipse not only decreases TEC by losing photochemical process, but also affects ionosphere by lunar tide. Because of the lunar tide, ionosphere would be modulated so that EIA occurring time on eclipse day was earlier than reference days. EIA happening earlier would lead to TEC increase and decrease more earlier, too, and that's the reason TEC enhance and decrease before and after the eclipse, respectively.