Statistical Study of the Saturation Effect in Response of GIM TEC to Solar Activity

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Abstract

This study explores the saturation effect in responses of the ionospheric total electron content (TEC) in global ionosphere maps to the solar activity of F10.7 (10.7 cm solar radio noise flux). To find F10.7 value at which TEC values became saturated, the decision tree regression is built based on the data in the descending solar activity of Cycle 23 during 2002~2008, and ascending solar activity of Cycle 24 during 2009~2015. It is found that saturation features in TEC appear more frequently at the low, especially equatorial ionization anomaly (EIA), latitudes than those at the middle or high latitudes during post-noon period. This indicates that the ionosphere intrinsically has a certain limited capacity, while over the EIA region, the dense ambient electron density has very limited room and tend to become saturated. The saturated values of F10.7 during 2002~2008 and 2009~2015 are around 180 and 150 sfu.

CODEGIM and Solar Activity

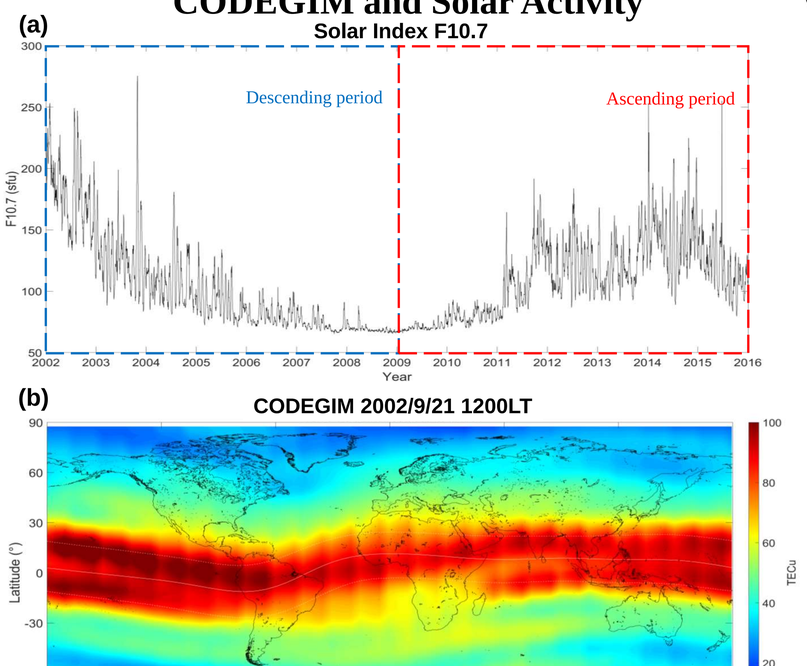

Figure 1: (a) Solar index F10.7 during 2002-2015. (b) CODEGIM TEC at 1200LT September 21, 2002.

Methodology

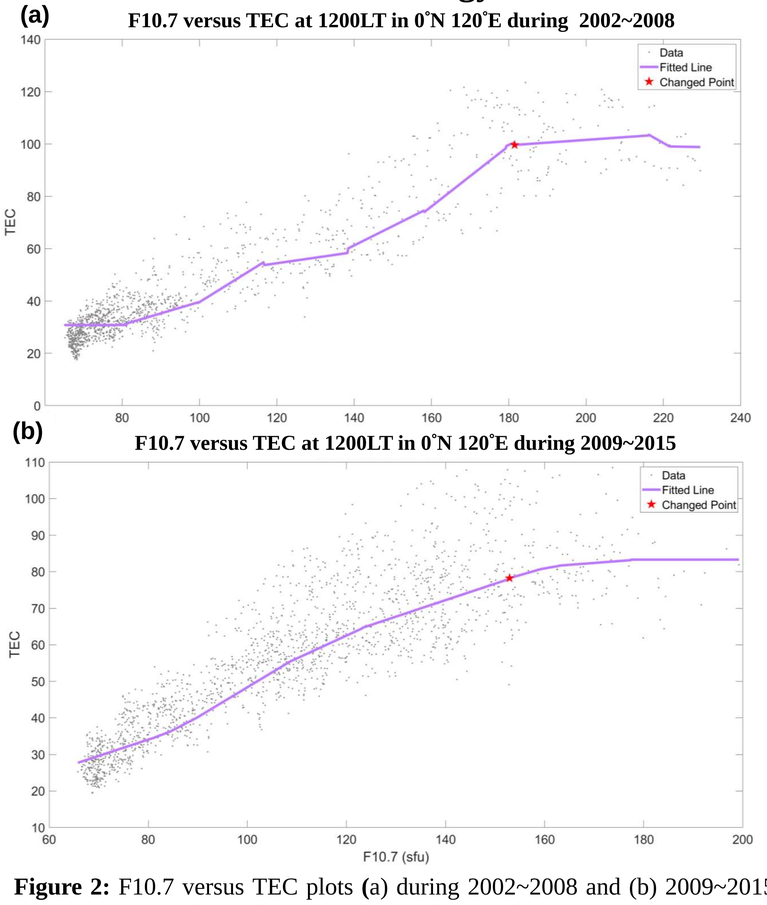

Figure 2: F10.7 versus TEC plots **(**a) during 2002~2008 and (b) 2009~2015. The grey dots indicate the original data, the purple fitted line is obtained by decision tree regression. The red star is the most possible saturation point of the purple line.

Saturation Effect

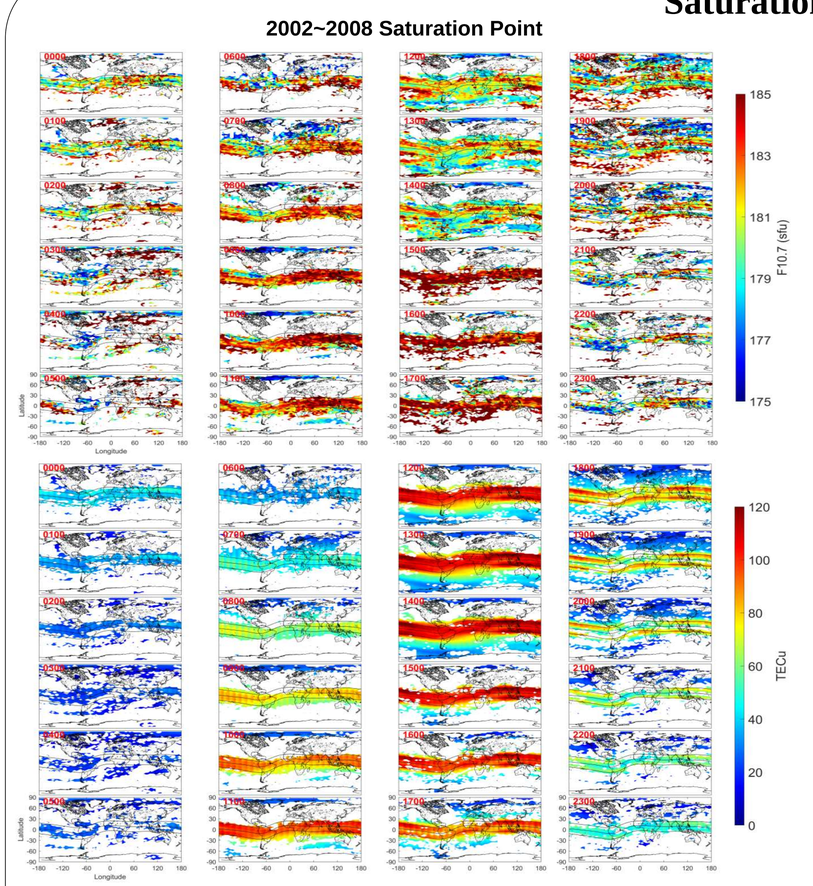

Figure 3: Global map of saturation point in F10.7 and TEC values during 2002~2008. The black lines indicate ±15° magnetic latitudes and magnetic equator.

Figure 4: Similar with Figure 3, but during 2009~2015.

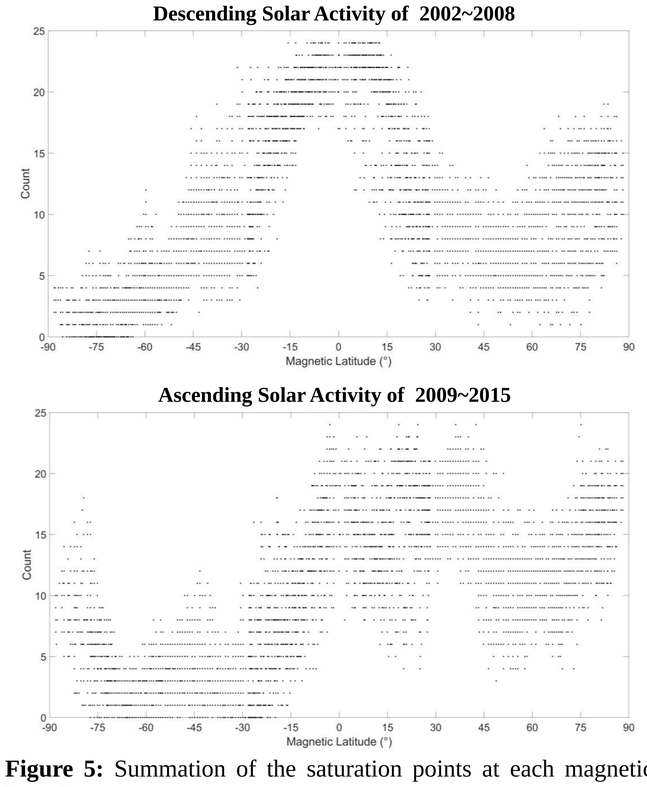

Figure 5: Summation of the saturation points at each magnetic latitude.

Conclusion

- Decision tree can be employed to examine the saturation effects with CODEGIM TEC globally as well as to precisely determine the saturated value and the changing point.
- Saturation features in TEC appear more frequently at the low latitudes, especially equatorial ionization anomaly (EIA), than those at the middle or high latitudes during daytime.
- The TEC saturation signatures become pronounced in middle latitude of the northern hemisphere and high latitude of the southern hemisphere during the ascending solar activity period of 2009~2015.
- The values of saturation points in F10.7 during descending period of 2002~2008 are greater than that during ascending period of 2009~2015.