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Variation of Total electron content during June 21, 2020 annular solar eclipse monitored using ground based and satellite measurements and comparison with IRI-2016 model

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The annular solar eclipse of June 21, 2020 provided an opportunity to understand ionospheric electron density variation along the annularity path during solar minimum and geomagnetically quiet period. For this, various ground based GPS stations located along the annularity line is selected and are divided into four major regions namely: Africa, Arab, Indian and Taiwan regions. The local time for respective regions during eclipse varies from early morning, pre-noon, noon and late evening thus, an exceptional event to study ionospheric variability during varying ionization conditions. The June 21, 2020 eclipse has a magnitude of 0.994 and begins ~04:50 UT in the African region and ended in the Pacific Ocean ~08:30 UT after crossing west Africa, Arabia, India, China, Taiwan. The maximum eclipse occurred at 06:40 UT in the north India. The two most appropriate PRNs 06 & 19 were used in the analysis. The TEC decrease was studied by comparing eclipse day TEC with mean of TEC before and after eclipse days. The TEC on eclipse day for both PRNs at all the stations show decrease which generally start few minutes before the totality at the station. The decrease in TEC signifies the attenuation of EUV radiation from the Sun due to eclipse. Further, the magnitude of decrease in TEC is different for different region and also vary with the PRNs. Thus, the study additionally reveals that the eclipse effect at a given location depends on the local conditions and also on the path of the satellite used to estimate the TEC. Further, the analysis of TEC height profile derived from the COSMIC (Constellation Observing System for Meteorology, Ionosphere & Climate) satellite over three major regions show significant reduction from ~80 km altitude up to 400 km altitude with a maximum reduction around F region altitude. The reduction also varies with regions and show maximum over Indian region. Furthermore, we have used the ionospheric reference model (IRI-2016), to simulate and understand solar eclipse effect in the ionosphere. Cross-comparisons between the model results and observations show that IRI do not show any eclipse effect and also fails to simulate the normal time variations at many stations. Thus, the study suggests to include ground-based GPS measurements to improve the IRI performance.