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Study of low-latitude ionospheric irregularities with the Sanya VHF radar
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A 47.5 MHz VHF radar with a peak power of 24 kW has been set up at Sanya (18.3 N, 109.6 E, dip latitude 12.8 N), China in 2009. The radar can work alternately in coherent scatter and all-sky meteor modes for observing ionospheric irregularities and meteor trails, respectively. In the coherent scatter mode, the radar works like a Doppler coherent backscatter radar to detect ionospheric irregularities. In this study, data from the continuous observations of ionospheric E and F region irregularities are analyzed. It is shown that the daytime E region continuous echoes descend slowly with a descent rate of 1 km/hour, and are highly correlated with the descending of the bottom height of Es trace (hbEs). The Doppler velocity and spectral width of the echoes range from -50 to 25 m/s, and from 20 to 70 m/s, respectively. While at nighttime, the E-region multiple echo layers, echo layer disruption and upper E-region echo layer generation are frequently observed. On the other hand, the radar observations show that the quasi-periodic (QP) echoes occurred above 110 km, and coexisted with E region continuous echo layers. The altitude extent of the QP striations is in a range of about 5-20 km and the duration is about 5-15 minutes. The QP echoes first appeared at higher altitude and then descended to the height close to the continuous echoing region, with a descent rate of 20-30 m/s and a period of about 8 minutes. Further, the Doppler velocities of QP echoes change in time and range and are not related to the striation slop. The zonal drift velocities derived from radar interferometric analysis of QP echoes show apparent variations with altitude. Possible factors responsible for the E region continuous and quasi-periodic echoes are discussed. Additionally, the radar five-beam scanning measurements in east-west direction were used to characterize the longitudinal difference in establishing the initial conditions for equatorial spread-F (ESF) development. Correlative studies between the large scale wave structures (LSWS) and ESF activities are presented. It is shown that the LSWS and ESF have nearly a one-to-one relationship when the F layer undergo an abrupt post-sunset rise (PSSR). However, in the absence of the PSSR, the ESF and GPS scintillation did not always occur following the appearance of LSWS. Sometimes the LSWS events preceded the generation of bottom type spread-F (BSF) that did not develop vertically into ESF and radar plumes. This result may indicate that under inexpressive, weak, or even moderate PSSR conditions, the appearance of the LSWS alone may not be sufficient to produce the post-sunset F region irregularities responsible for ionospheric scintillations.

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