D-region perturbation associated with the solar flares as observed at a low latitude station Agra, India

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The results of solar flare induced D-region perturbation studies along a short great circle path (GCP = 6690 km) lying entirely in the low and equatorial latitude region are presented. We use softPAL receiver at Agra (Geograph. lat. 27.2^{o}N, long. 78°E), India and monitor NWC signal (f = 19.8 kHz) transmitted from Australia. We analyze the data for the year 2011 and find that the results of amplitude and phase perturbations, time delay, zenith angle independence, and electron density variation in the lower ionosphere are consistent with those observed along similar paths at low and high latitudes. The new work in this paper includes the study of the distribution of X-ray flares responsible for clear and measurable sudden phase anomaly and their variation with hardening factor (ratio of the intensities in two channels 0.05 - 0.4 nm and 0.1 - 0.8 nm) in the mixed solar cycle period 2011. The results show that the distribution is different from that obtained during minimum solar periods. The phase anomalies are re-evaluated in terms of X-ray fluence (J/m^2) and the results are compared with thereof earlier workers. Further, the perturbations due to X-class of flare are utilized to calculate the electron density in 70-60 km height range and compare the results with those obtained in the polar region where X-ray flare is followed by solar proton events. The results show that the electron densities calculated by us are lower by 60-80 % in the polar region. The increase in electron density at the lower height in the polar region is due to additional ionization due to solar proton event.