This study investigates how solar flares affect the ionosphere, focusing on changes in electron density and temperature. Solar flares, known to cause disturbances in the ionosphere, are significant for radio signal propagation and satellite communication. This research analyzes data from Solar Cycles 24 and 25, examining 50 of the strongest solar flares from Cycle 24 and nine from Cycle 25 to assess how these events influence the ionosphere's physical properties. The primary objective is to explore the relationship between solar flare intensity and the resulting changes in electron density and temperature, using the International Reference Ionosphere (IRI) 2016 model alongside Python-based analysis.

Data for these events were sourced from various space-based observatories, including the SOHO/LASCO satellite, which monitors Coronal Mass Ejections (CMEs) often associated with solar flares. The study focused on intense X-class flares and analyzed these events over Dhi Qar Governorate in Iraq, applying the IRI model to simulate ionospheric responses to solar flares.

Results showed a notable increase in electron density during intense solar flares, particularly in the F2 layer (260–275 km altitude), where electron concentrations peak. However, the relationship between flare intensity and electron density was complex. During Solar Cycle 24, a moderate inverse correlation (-0.465) was observed, suggesting that electron density did not consistently increase with flare intensity. This finding challenges the assumption that stronger flares always lead to higher ionization levels in the ionosphere. Factors like initial gas density, flare duration, and geomagnetic conditions likely influenced these variations.

In contrast, Solar Cycle 25 showed a much weaker correlation (0.02) between flare intensity and electron concentration, indicating almost no linear relationship. This may be due to the generally lower flare intensities in Cycle 25