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Mid-Latitudinal Topside Ionosphere Irregularities: Variations at the Different Altitudes

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High-cadence in-situ plasma density measurements from multiple spacecraft already provided many indications of small-scale ionospheric irregularities. In the last years, there has been accumulated high amount of data from devoted missions. Among them, the Formosat-5 Advanced Ionospheric Probe (AIP) provides measurements in Ion Density Mode of up to 8kHz at low- and mid-latitudes at orbital altitudes of 720km. There can be evaluated specific scales involved in irregularities observed by Chang et al. [1] as also e.g. Norsat-1 [2] results indicated interesting ionospheric disturbances at the meter-level scales at the high-latitudes.

Swarm Ionospheric Plasma Irregularities (IPIR) data product [3] using Langmuir probe 2Hz data provide plasma density gradients at ~20km, ~50km and ~100km scale sizes at altitudes of <460km for Swarm A and C and <530km for Swarm B. The spatial density gradient indices (DGRI) to characterize ionospheric irregularity distribution at similar scales (at ~20km and at ~100km) were provided for low-latitude ionosphere using plasma density data from COSMIC-2 and ICON [4], with 1Hz data representing the scale sizes of ~7.5 km.

Urbář et al. [5] have shown the cascading effect of ionospheric topside plasma irregularities when the 16Hz plasma density sampling provided by face plate detector was used at high-latitudes, there are ongoing studies to evaluate those at other latitudes as well as altitudes. The pronounced effect of altitude is clear to see using in-situ measurements by spacecraft at elliptical orbits like Swarm E (Cassiope/ePOP). Only the DMSP 16-19 satellites at Sun-synchronous orbits at altitude of 850 km provided extensive plasma variation dataset, but still in too low sampling rate of 1Hz not able to observe the smaller scales shown e.g. using Formosat-5 data.

We investigate the variability of the in-situ plasma density measured by satellites at different orbits, evaluating the dominant scales in the plasma by leveraging on the Fast Iterative Filtering (FIF) technique providing fine time-frequency representation decomposing any non-stationary, nonlinear signals, into oscillating modes, called intrinsic mode components or functions (IMCs or IMFs), characterized by their specific frequency. The comparisons are done using time-integrated instantaneous time-frequency representations, provided through the so-called "IMFogram". These IMFograms have the potential to show the greater details of the scale sizes which intensify or subdue, illustrating the time development of the multi-scale processes geospace disturbances.

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