High Power Radar Studies of Low Latitude Plasma Irregularities

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High power high resolution VHF radars have proven to be powerful diagnostics to study ionospheric plasma irregularities, a space weather phenomenon of immense importance in view of its impact on space communication and navigation. The VHF radars at Jicamarca, Peru and Trivandrum, India have contributed greatly over the past four decades in arriving at the current understanding of the basic characteristics of the equatorial spread-F (ESF) and equatorial electrojet (EEJ) irregularities and the underlying plasma instability processes. Recent advances, involving high resolution radar observations of equatorial plasma irregularities, include the detection of supersonic plasma bubbles rising to heights beyond 1000 km, 150 km echoes and kilometric scale waves. The new and more recent developments in plasma irregularity studies came from the middle and upper atmosphere (MU) radar at Shigaraki, Japan, the mesosphere-stratosphere-troposphere (MST) radar at Gadanki, India and the equatorial atmosphere radar (EAR) at Kototabang, Indonesia. In this talk, we present the new types of plasma irregularity structures observed over low latitudes by the Gadanki radar and EAR and the current understanding of the underlying processes for their origin. The most striking of the observations cover the well known quasi-periodic (QP) echoes first reported by the MU radar, 150 km echoes originally thought to be a phenomenon confined just to the magnetic equator, tidal ion layers of the kind first detected by the incoherent scatter radar at Arecibo, kilometric scale waves believed to be of non-local non-linear GDI orgin, and structures in the collision dominated lower E region. While several interpretations in terms of potential source mechanisms have been advanced to account for the above kind of diverse phenomena, a complete understanding has yet to emerge on any of them. On the low latitude F region irregularities, new insights provided by the VHF radar observations include the up and down drafting plasma bubbles, the evolution of shorter scale finger-like structures riding over the primary bubble structure, the effect of interplanetary electric field on the development of equatorial spread F events during magnetic storms, and the coupling effects of the F region plasma bubble associated polarization electric fields on the development of the E region irregularities. The most interesting aspect of the low latitude plasma irregularities observed by these radars is that they display both kinds of phenomena that were considered exclusive to either equatorial or mid latitudes.