First mesospheric turbulence study using coordinated rocket and MST radar measurements over Indian low latitude region

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Abstract. A campaign to study turbulence in the mesosphere, over low latitudes in India, using rocket-borne measurements and Indian MST radar, was conducted during July 2004. A rocket-borne Langmuir probe detected a spectrum of electron density irregularities, with scale sizes in the range of about 1 m to 1 km, in 67.5–78.0 km and 84–89 km altitude regions over a low latitude station Sriharikota (13.6° N, 80.2° E). A rocket-borne chaff experiment measured zonal and meridional winds about 30 min after the Langmuir probe flight. The MST radar located at Gadanki (13.5° N, 79.2° E), which is about 100 km west of Sriharikota, also detected the presence of a strong scattering layer in 73.5–77.5 km region from which radar echoes corresponding to 3 m irregularities were received. Based on the region of occurrence of irregularities, which was highly collisional, presence of significant shears in zonal and meridional components of wind measured by the chaff experiment, 10 min periodicity in zonal and meridional winds obtained by the MST radar and the nature of wave number spectra of the irregularities, it is suggested that the observed irregularities were produced through the neutral turbulence mechanism. The percentage amplitude of fluctuations across the entire scale size range showed that the strength of turbulence was stronger in the lower altitude regions and decreased with increasing altitude. It was also found that the amplitude of fluctuations was large in regions of steeper electron density gradients. MST radar observations showed that at smaller scales of turbulence such as 3 m, (a) the thickness of the turbulent layer was between 2 and 3 km and (b) and fine structures, with layer thicknesses of about a km or less were also embedded in these layers. Rocket also detected 3-m fluctuations, which were very strong (a few percent) in lower altitudes (67.5 to 71.0 km) and small but clearly well above the noise floor at higher altitudes. Rocket and radar results also point to the possibility of existence of thin layers of turbulence (<450 m). The turbulence parameters estimated from rocket-borne measurements of electron density fluctuations are consistent with those determined from MST radar observed Doppler spectra and the earlier works.

Keywords. Ionosphere (Ionosphere-atmosphere interactions; Ionospheric irregularities) – Meteorology and atmospheric dynamics (Turbulence)

1 Introduction

It is known that dynamical and convective instabilities contribute significantly to the dissipation of large-scale motions and the generation of turbulence in the middle atmosphere. The atmospheric gravity waves, which attain saturation amplitudes in the mesosphere, play a dominant role in the generation of instabilities leading to generation of turbulence. The dissipation of gravity waves and tides occurs due to cascade of wave energy to smaller scales via wave-mean flow and non-linear wave-wave interactions. As the gravity waves carry significant amount of momentum/heat fluxes, process of their breaking and resulting generation of turbulence is important for understanding the energetics and dynamics of the middle atmosphere. Larger scales of turbulent motion draw energy from the mean flow, and then a cascade of energy transfer to smaller scales takes place in the inertial sub-range and dissipation of smaller scale occurs due to viscous forces. In the mesosphere, the ion-neutral and electron-neutral collision frequencies are much higher than ion and electron gyro-frequencies, respectively and hence any perturbations produced in neutral density as a result of turbulence will also

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