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Zakharov simulations of Langmuir turbulence: effects on waves observed by incoherent scattering

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We present a numerical study of the effect of Langmuir turbulence on incoherent scatter spectra. The Langmuir turbulence is driven by low energy beams of electrons in the Earth's upper ionosphere above 300 km. The nonlinear coupling between Langmuir waves and ion-acoustic waves is governed by the Zakharov system of equations. The model is enhanced with stochastic forcing in order to estimate by how much over the thermal level the spectrum seen by an incoherent scatter radar will be enhanced. This also allows to compare directly the modelled spectra to the observed spectra collected by the incoherent scattering technique, as well as to investigate statistically the signature of the modelled spectra through an exploratory data analysis. Results for different beam energies are presented, covering the regimes of weak as well as strong turbulence. The incoherent scatter spectra signature is discussed in light of these regimes. It is shown that incoherent scatter radar observations of enhanced ion-acoustic and/or Langmuir waves compared to thermal level can provide good estimates of the beam parameters and of the type of turbulent regime. The cascade regime leads to strongly asymmetric spectra with enhancements over a limited range of wavenumbers. The cavitation regime leads to marginally asymmetric spectra, with enhancement over a wide range of wavenumbers, and features a central peak for a limited range of wavenumbers. Finally, it is shown that the Langmuir turbulence should be preferentially observed for scattering wavelengths large compared to the Debye length.