On aspect sensitivity of Polar Mesospheric Summer Echoes — and its dependence on the measuring method

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The determination of aspect sensitivity — that is, the distribution of scattering strength on direction, or anisotropy — of polar mesospheric summer echoes (PMSE) has attracted the attention of many investigators ever since the first measurements of PMSE were made in the 1970's. The aspect sensitivity of the scattered signals serves as an indicator of the scattering mechanism. Various techniques have been employed: Doppler beam swing (DBS), spatial correlation analysis (SCA), mean angle of arrival (MAOA), coherent radar imaging (CRI) and their synonymous. The common attribute of these techniques is that they all give different results, ranging from high aspect sensitivity (2-3 degrees) to moderate aspect sensitivity (8-15 degrees). In one case the accidental contribution of an antenna side lobe made it possible to make a measurement at 36-38 degrees. One reason for the discrepancies is that in many cases the assumptions on which the methods rely on are not fulfilled. An example is the assumption of gaussian angular distribution of the scattering that has only three degrees of freedom in two dimensions (the major and minor axis and the orientation of the elliptically shaped iso-contours).The methods have been also constrained by what is feasible on account of availability and/or affordability of the instruments. MAARSY — the most capable aperture synthesis imaging MST radar as of today — has recently highlighted the outstanding capabilities of the radar imaging technique and the serious limitations of the other techniques. It is argued that the multi-static radar technique, as employed in incoherent scattering radar, is the method that gives correct measurements of aspect angle with a minimum of assumptions, one of them being that the beamwidth of the remote probing antenna be narrow compared to the desired aspect angle resolution, an assumption that is met reasonably well by the EISCAT tri-static VHF radar system. The multi-static method is equivalent to the standard method to measure the directional radiation pattern of an antenna or aerial employing a bright stellar radio source, unsurprisingly, since scattering aspect sensitivity is physically the same as the directional pattern of the scattering. The SCA is also a multi-static method in which the assumption of a gaussian distribution attempts (mostly unsuccessfully) to mitigate the limitation of very short baselines. The EISCAT tri-static VHF measurements show that PMSE, as a rule, is not aspect sensitive, as scattering is detected nearly routinely at unprecedented very large scattering angles. This is a pleasing result since it strengthens the theory that PMSE is induced by neutral turbulence and as such it should agree with Kolmogorov's hypothesis that turbulence in the inertial sub-range — and in its extension due to high Schmidt number — should in general be isotropic.