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Radar Measurements of Gravity Wave Characteristics in the MLT

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Originality declaration

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Abstract

This thesis examines medium frequency (MF) partial reflection and very high frequency (VHF) meteor radar estimates of wind variances and covariances in the altitude range 70-100 km. The quantities estimated form the components of the Reynolds Stress Tensor (RST) for an atmospheric flow; non-zero values of them are are considered to arise in the presence of propagating gravity waves and/or turbulence. Vertical fluxes of horizontal momentum, which correspond to the covariance of horizontal and vertical wind fluctuations, are of particular interest.

A 14-year data set of Full Correlation Analysis (FCA) velocities from the large-aperture Buckland Park MF radar was firstly probed for long-term trends in wind variance. A negative trend in the wind variance due to waves with periods in the range 20-480 minutes during summer was found to coincide with a weakening of the wind jet around 70 km altitude. This result adds to a very limited collection of studies of gravity wave activity trends in the middle-upper atmosphere.

Potential biases in a number of RST component measurement techniques were then investigated. A simple computer model was created, in which the spatio-temporal distributions of effective beam positions (EBPs) from multi-beam MF Doppler and meteor radar experiments were used to estimate the RST components of a gravity wave field with known input parameters. Systematic biases were found in both techniques if insufficient integration times were used. These biases could be removed entirely from the meteor technique by increasing the integration time, although the Doppler techniques slightly underestimated horizontal variances and horizontal-vertical covariances, and overestimated vertical variances, regardless. However, the Doppler estimates, especially vertical-horizontal covariances, were seen to be substantially less affected by random errors than the meteor estimates.

RST components from historical multi-beam MF Doppler campaigns were then estimated. Hybrid Doppler Interferometry (HDI) had been applied during these campaigns to estimate the EBP. The results were compared with those obtained from a simpler older technique (in which interferometric measurements of the beam position were not available), and were found to be in reasonable agreement. Noteably, the results also indicate that reasonable RST component estimates can be attained by simply applying interferometry to a vertically transmitted beam.

A setup of a similar multi-beam MF Doppler experiment using the Buckland Park radar is then described, along with the procedure used to correct for receiver gain differences. It is intended that this configuration will be used in future, in conjunction with the co-located meteor radar, for an intercomparison of MF and meteor radar estimates of RST terms.

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