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Solving the long-standing problem of estimating the atmospheric temperature at 90 km altitude with meteor radar

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For two decades meteor radars have been routinely used to monitor atmospheric temperatures around the 90 km altitude. A common method, based on a temperature-gradient model, is to use the height dependence of meteor decay time to obtain a height-averaged temperature in the peak meteor region. Traditionally this is done by fitting a linear regression model in the scattered plot of $\log_{10}(1/\text{tau})$ and height, where 'tau' is the half-amplitude decay time of the received signal. However, this method was found to be consistently biasing the slope estimate. The consequence of such bias is that it produces a systematic offset in the estimated temperature, and thus requiring calibration with other colocated measurements. The main reason for such a biasing effect is thought to be due to the failure of the classical regression model to take into account the measurement error in decay time or the observed height. This is further complicated by the presence of various geophysical effects in the data, as well as observational limitation in the measuring instruments. We demonstrate an alternative regression method that incorporates various error terms in the statistical model. An initial estimate of the slope parameter is obtained by assuming symmetric error variances in normalised height and $\log_{10}(1/\text{tau})$. This solution is found to be a good prior solution for the core of this bivariate distribution. However, depending on the data selection process the error variances may not be exactly equal. A first-order correction is then carried out to address the biasing effect due to asymmetric error variances. This allows to construct an analytic solution for the bias-corrected slope coefficient for this data. With this solution, meteor radar temperatures can be obtained independently without using any external calibration procedure. When compared with colocated lidar measurements, the temperature estimated using this method is found to be accurate within 7% or better and without any systematic offset.