Estimating wind fields in the lower thermosphere with SIMONe, a spread-spectrum, interferometric, multistatic meteor observation network

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Specular meteor trails provide a plentiful, natural tracer of lower thermospheric winds through measurement of the line-of-sight Doppler shift of a reflected radio signal. Meteors occur sporadically in time and space, presenting a random sampling problem with fundamental limits in its use for atmospheric studies. Furthermore, meteor radars are practically limited to observing a fraction of the total meteor population by the specular reflection condition and signal-to-noise ratio detection limits. Fortunately, recent work shows that there is much room for improvement over current techniques before any fundamental limit in wind measurement is reached. The number of meteor detections within a given volume can be increased by employing a multistatic network of radar transmitters and receivers that uses an independent pseudorandom-coded continuous waveform for each transmitter, thus improving coverage of specular geometries and maximizing signal-to-noise ratio within cost and complexity constraints. The improved density of meteor detections is such that it is possible to meaningfully estimate a time- and space-resolved three-dimensional wind field. This is in contrast to most existing systems, which produce height-resolved mean winds averaged over tens of minutes and hundreds of kilometers in horizontal distance. This presentation reviews recent developments that enable MIMO-CW meteor radar, describes our novel wind field estimation technique, and details new results from our development system called SIMONe, the Spread-spectrum Interferometric Multistatic meteor Observation Network. Particular emphasis is given to our wind field estimation technique, which employs Gaussian process regression to produce an estimate of the three-dimensional wind vector, along with confidence intervals, at any time and location within the observation window.