Lidar observations and automated extraction of persistent gravity waves with periods of 3-10 h at McMurdo (77.83°S, 166.67°E) utilizing two-dimensional Morlet wavelet transform

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Persistent, dominant, and large-amplitude gravity waves with 3–10 h periods and vertical wavelengths ~20–30 km are observed in temperatures from the stratosphere to lower thermosphere with an Fe Boltzmann lidar at McMurdo, Antarctica. We characterize these 3–10h waves in the mesosphere and lower thermosphere using lidar temperature data in June from 2011 to 2015. A continuous 65 h lidar run on 28–30 June 2014 exhibits a 7.5 h wave spanning ~60 h, and 6.5h and 3.4h waves spanning 40 and 45 h, respectively. Over the course of 5 years, 323h of data in June reveal that the major wave periods occur in several groups centered from ~3.5 to 7.5 h, with vertical phase speeds of 0.8–2 m/s. These 3–10 h waves possess more than half of the spectral energy for ~93% of the time. Rigorous prewhitening, postcoloring technique is introduced for frequency power spectra investigation. The resulting spectral slopes are unusually steep (–2.7) below ~100km but gradually become shallower with increasing altitude, reaching about –1.6 at 110 km. Corrections to the commonly used 1-D Morlet wavelet transform code by Torrence and Compo (1998) are provided to ensure that the power of the wavelet transform in the frequency domain is equivalent to the mean power of its counterpart in the time domain. We then extend the Morlet wavelet transform to two dimensions by rotation, dilation and translation with a full mathematical description. Applying the transform and reconstruction to lidar temperature data in May, June and July 2014, we demonstrate the validity of 2-D wavelet transforms and their utility to studying recently discovered persistent gravity waves in Antarctica.

Key words: Persistent gravity waves with periods 3–10 h, 2-D wavelet, AR spectral analysis, lidar