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The signature of the tropospheric gravity wave background in observed mesoscale motion

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How convection couples to mesoscale vertical motion and what determines these motions is poorly understood. We diagnose profiles of area-averaged mesoscale divergence from measurements of horizontal winds collected by an extensive upper-air sounding network of a recent campaign over the western tropical North Atlantic, the Elucidating the Role of Clouds-Circulation Coupling in Climate (EUREC^{4}A) campaign. Observed area-averaged divergence amplitudes scale approximately inversely with area equivalent radius. This functional dependence is also confirmed in reanalysis data and a global freely-evolving simulation run at 2.5 km horizontal resolution. Based on the numerical data it is demonstrated that the energy spectra of inertia gravity waves can explain the scaling of divergence amplitudes with area. At individual times, however, few waves can dominate the region. Nearly monochromatic tropospheric waves are diagnosed in the soundings by means of an optimized hodograph analysis. For one day, results suggest that an individual wave directly modulated the satellite observed cloud pattern. However, because such immediate wave impacts are rare, the systematic modulation of vertical motion due to inertia-gravity waves may be more relevant as a convection-modulating factor. We propose an analytic relationship between energy spectra and divergence amplitudes, which, if confirmed by future studies, could be used to design better external forcing methods for regional models.