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Gravity Wave Investigations During DEEPWAVE Using An Advanced Mesospheric Mapper

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DEEPWAVE was a highly successful international program designed to quantify gravity wave (GW) dynamics and effects from the ground to ∼100 km in unprecedented detail utilizing a range of airborne and ground-based measurements. DEEPWAVE was based on the South Island, New Zealand, and orographic GWs over the Southern Alps, were a primary target, but multiple flights were also conducted over the Southern Ocean and Tasman Sea to quantify other GW sources, such as jet streams and frontal systems.

During DEEPWAVE two Advanced Mesospheric Temperature Mappers (AMTM's) were deployed; one sited at the NIWA Observatory, Lauder (45°S), on the South Island, and one on the NSF GV Gulfstream aircraft. The AMTM is a high-performance digital imaging system that measures the mesospheric OH (3,1) band to create high-quality intensity and temperature maps of a broad spectrum of gravity waves at the ∼87 km level. These instruments formed part of a comprehensive measurements capability including airborne Rayleigh and Na lidars, dropsondes, ground-based Rayleigh lidar, all-sky imagers and spectrometer wind measurements. A total of 25 long duration (typically 7-8 hours) nighttime flights were conducted during DEEPWAVE, together with 40 nights of ground-based measurements creating an exceptionally rich data set.

Here we present detailed measurements of the evolution of a large-amplitude mountain wave (MW) and its intermittent wave breaking signatures observed on the night of 21 -22 June 2014. The MWs displayed a range of horizontal wavelengths from ∼10-90 km, and associated temperature perturbation amplitudes as large as ∼30K. They were also characterized by an unusual, pronounced "saw-tooth" pattern in the temperature wave field indicative of strong overturning and instability development. Estimates of the associated momentum fluxes (MF) during the course of this remarkable event revealed a strong periodicity with peak MF amplitudes ranging from ∼200-850 m2s-2, among the largest ever inferred at these altitudes. MW were observed on many occasions during the mission suggesting that wave forcing at small horizontal scales (< 100 km) can play large roles in the regional momentum budget of the MLT. These results are contrasted with novel measurements of large-field open-ocean mesospheric GWs and their near-identical stratospheric wave signatures using AIRS satellite and model forecasting data.