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Initial Results from the DEEPWAVE Airborne and Ground-Based Measurement Program in New Zealand in 2014

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The deep-propagating gravity wave experiment (DEEPWAVE) was performed on and over New Zealand, Tasmania, the Tasman Sea, and the Southern Ocean with core airborne measurements extending from 5 June to 21 July 2014 and supporting ground-based measurements beginning in late May and extending beyond the airborne component. DEEPWAVE employed two aircraft, the NSF/NCAR GV and the German DLR Falcon. The GV carried the standard flight-level instruments, dropsondes, and the Microwave Temperature Profiler (MTP). It also hosted new airborne lidar and imaging instruments built specifically to allow quantification of gravity waves (GWs) from sources at lower altitudes (e.g., orography, convection, jet streams, fronts, and secondary GW generation) throughout the stratosphere and into the mesosphere and lower thermosphere (MLT). The new GV lidars included a Rayleigh lidar measuring atmospheric density and temperature from ∼20-60 km and a sodium resonance lidar measuring sodium density and temperature at ∼75-100 km. An airborne Advanced Mesosphere Temperature Mapper (AMTM) was also developed for the GV, and together with additional IR "wing" cameras, imaged the OH airglow temperature and/or intensity fields extending ∼900 km across the GV flight track. The DLR Falcon was equipped with its standard flight-level instruments and an aerosol Doppler lidar able to measure radial winds below the Falcon where aerosol backscatter was sufficient. Additional ground-based instruments included a 449 MHz boundary layer radar, balloons at multiple sites, two ground-based Rayleigh lidars, a second ground-based AMTM, a Fabry Perot interferometer measuring winds and temperatures at ∼87 and 95 km, and a meteor radar measuring winds from ∼80-100 km.

DEEPWAVE performed 26 GV flights, 13 Falcon flights, and an extensive series of ground-based measurements whether or not the aircraft were flying. Together, these observed many diverse cases of GW forcing, propagation, refraction, and dissipation spanning altitudes of 0-100 km. Examples include strong mountain wave (MW) forcing and breaking at flight level and in the lower and middle stratosphere, weak MW forcing yielding MW penetration into the MLT having very large amplitudes and momentum fluxes, MW scales at higher altitudes ranging from ∼10-250 km, large-scale trailing waves from orography refracting into the polar vortex and extending to high altitudes, GW generation by deep convection, large-scale GWs arising from jet stream sources, and strong MWs in the MLT arising from strong surface flow over a small island. DEEPWAVE yielded a number of surprises, among them the tendency for the strongest MLT responses under the weakest forcing conditions, frequent GW penetration to the highest altitudes, and often remarkable abilities of the various forecast models to provide good qualitative agreement with observed GW fields for those sources that were resolved, especially orography and jet streams.