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Nonhydrostatic gravity waves in the presence of directional wind shear

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Three research aircraft were deployed to observe modest-amplitude gravity waves over the southwestern French Alps on 13 November 1999 during the Mesoscale Alpine Programme (MAP). Radiosonde ascents and upstream GPS dropsondes deployed by research aircraft indicate the flow was characterized by topographic blocking and stagnation below 2500 m and low-level directional wind shear that extends above mountain top.

The in situ vertical velocity data from the NCAR Electra and backscatter from the downlooking SABL indicated the presence of gravity waves at 5500 m that were characterized by relatively short horizontal wavelengths of approximately 8 km. Backscatter data from the downlooking DLR DIAL lidar onboard the Falcon and in situ vertical velocity data from the aircraft transects indicate that a rapid decrease in the wave amplitude with height was present in the 5.5-6.5 km layer. Factors that may contribute to the rapid decay of wave amplitude include: decrease in the Scorer parameter with height that results in evanescent waves, gravity wave breaking in the shear layer, and a directional critical level partially absorbs wave energy.

Numerical simulation results from COAMPS using a horizontal resolution of 556 m are in general agreement with the in situ aircraft and lidar observations. Low-level topographic blocking results in a reduction of the amplitude and dominant horizontal wavelength of the mountain waves. Relative roles of the directional critical level and the wave trapping are explored using linear analytic solutions with a reference state based on composite upstream dropsonde data.