

Rayleigh and Resonance Lidar Studies of the Arctic Middle Atmosphere

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The activity, propagation, and vertical coupling of gravity waves in the Arctic stratosphere, mesosphere and thermosphere are investigated in this study. We use a Rayleigh Density and Temperature Lidar (RDTL) and a Sodium Resonance Wind Temperature Lidar (SRWTL) installed at Poker Flat Research Range (PFRR), Chatanika, Alaska (65°N, 147°W) based on three altitude regions. These are the: Upper Stratosphere and Lower Mesosphere (USLM, 40-55 km), Middle Mesosphere (55-65 km), and Upper Mesosphere and Lower Thermosphere (UMLT, 80-95 km). The current observations extend the scope of previous studies at PFRR. Previous studies at PFRR have shown decreased level of wave activity in the USLM in winters that are disturbed by Sudden Stratospheric Warmings (SSWs). Furthermore, these studies have indicated that reduced levels of wave activity coincide with low levels of turbulence in the UMLT. These results have implications for understanding wave- and turbulent-transport in the middle atmosphere. The current Rayleigh lidar system employs a larger telescope and a three-channel receiver system to achieve high fidelity and higher signal-to-noise ratio and thereby extend the altitude range of the gravity wave measurements to the middle mesospheric region. The addition of the SRWTL provides measurements of gravity waves in the UMLT region. With lidar measurements of the temperature and density fluctuations over these altitude ranges, we explore the gravity wave activity, propagation, breaking, and coupling over altitude. By analyzing the gravity waves during disturbed winters with SSWs and undisturbed winters, we explore variations in the wave activity to determine if there are systematic variations in the wave activity and coupling associated with these disturbances. We investigate recently developed lidar retrievals to reduce the instrumental biases in the lidar estimates of gravity wave activity. The use of these retrieval methods allows us compare the gravity wave activity in the Arctic with the wave activity in Antarctic where SSWs are rare, and thus determine if there are significant wave-driven asymmetries that influence the structure and circulation of the middle and upper atmosphere polar regions.