Highlights of the MaCWAVE program to study the polar mesosphere

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MaCWAVE (**M**ountain **A**nd **C**onvective **W**aves **A**scending **Ve**rtically) was a highly coordinated rocket, ground-based, and satellite program designed to address gravity wave forcing of the mesosphere and lower thermosphere (MLT). The MaCWAVE program was conducted at the Norwegian Andøya Rocket Range (ARR, 69.3˚N) in July 2002, and continued at the Swedish Rocket Range (ESRANGE, 67.9˚N) during January 2003. Correlative instrumentation included the ALOMAR MF and MST radars and RMR and Na lidars, ESRANGE MST and meteor radars and RMR lidar, radiosondes, and TIMED satellite measurements of thermal and constituent structures. The data have been used to define the wave field structure, fluxes, and turbulence generation leading to forcing of the large-scale flow, down to a description of small-scale turbulence. In summer, launch sequences coupled with ground-based measurements at ARR addressed the forcing of the summer mesopause environment by anticipated convective and shear generated gravity waves. The summer program demonstrated that the mean state of the upper mesosphere was unusually warm, slowing the formation of Polar Mesospheric Summer echoes (PMSE) and noctilucent clouds (NLC). The winter program was designed to study the upward propagation and penetration of mountain waves from northern Norway into the MLT at a site favored for such penetration. As the major response was expected to be downstream (east) of Norway, these motions were measured with rocket sequences and ground-based instrumentation similar to those used in the summer campaign, but this time at ESRANGE. However, a polar stratospheric warming just prior to the rocket window induced stratospheric wind shears, which prevented mountain wave penetration into the mesosphere. Instead, the observed wave structure in the mesosphere originated from other sources. For example, a large-scale wave was observed in the mesosphere prior to January 24 and reached maximum intensity on January 28, when it appeared to contribute to local instability and turbulence near 85 km. The resulting energy deposition was found to be competitive with summertime values. A brief program description including current results will be discussed.