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Internal gravity waves in the thermosphere during low and high solar activity: Simulation study

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Propagation of internal gravity waves (GWs) from the lower atmosphere into the upper thermosphere, and their dynamical and thermal effects have been studied under low and high solar activity approximated by the $F_{10.7}$ parameter. It has been done by using a nonlinear spectral parameterization in systematic offline calculations with typical wind and temperature distributions from the HWM and MSISE-90 models, and with interactive simulations using the University College London Coupled Middle Atmosphere-Thermosphere-2 (CMAT2) general circulation model (GCM) under solstice conditions. The estimates have been performed for relatively slow harmonics with horizontal phase velocities less than 100 m s^{-1}, which are not affected by back reflection and/or ducting. GW drag and wave-induced heating/cooling are shown to be smaller below $\sim$170 km at high solar activity, and larger above. The maxima of GW momentum deposition occur much higher in the upper thermosphere, but their peaks are twice as weak, 120 vs 240 m s^{-1} d^{-1}, in the winter hemisphere when the insolation is large. Instead of strong net cooling in the upper thermosphere, GWs produce a weak heating at high solar activity created by fast harmonics less affected by dissipation. Molecular diffusion increases with solar activity at fixed pressure levels, but seen in a Cartesian altitude grid it can show increasing and decreasing tendencies in the lower thermosphere with respect to low solar activity. Therefore, in pressure coordinates, in which most of GCMs operate, the influence of larger temperatures can be viewed as a competition between the enhanced dissipation and vertical expansion of the atmosphere.