Geophysical Research Abstracts,
Vol. 10, EGU2008-A-05689, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-05689
EGU General Assembly 2008

Additional Radiative Cooling of the Mesopause Region due to Small-Scale Temperature Fluctuations Associated with Gravity Waves

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We address a previously unknown effect of the radiative cooling of the mesosphere and lower thermosphere (MLT) produced by small-scale irregular temperature fluctuations (ITFs) associated with gravity waves. These disturbances are not resolved by present GCMs, but they alter the radiative transfer and the cooling rates significantly. We apply a statistical model of gravity waves superimposed on large-scale temperature profiles, and perform direct calculations of the radiative cooling/heating in the MLT in the IR bands of CO_2, O_3 and H_2O molecules taking into account the breakdown of the local thermodynamic equilibrium (non-LTE). We found that in the periods of strong wave activity the subgrid ITFs can cause an additional cooling up to 3 K/day near the mesopause. The effect is produced mainly by the fundamental 15 μm band of the main CO_2 isotope. We derived a simple expression for the correction to mean (resolved by GCMs) temperature profiles using the variance of the temperature perturbations to account for the additional cooling effect. The suggested parameterization can be applied in GCMs in conjunction with existing gravity wave drag parameterizations.