Non-LTE effects in the polar summer mesosphere and lower thermosphere and TIMED SABER temperature retrievals

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The mesosphere/lower thermosphere (MLT) is one of the most intriguing regions of Earth's atmosphere. In past decades, a large number of rocket and lidar experiments have been performed to explore, catalogue, and explain the thermal structure of MLT. However, the description of this region is sophisticated due to the large number of processes which govern the vibrational molecular levels populations. The frequency of inelastic molecular collisions in MLT becomes low, and one has to take into account various other processes which populate and de-populate the levels (absorption and emission of radiation in molecular bands, redistribution of excitation between colliding molecules, chemical excitation). The populations must be found by solving the system of rate equations expressing the balance of all these processes (non-LTE). Therefore, the interpretation of radiance measurements in MLT depends on accuracy of non-LTE model.

Non-LTE effects for the CO_2 ν_2 manifold levels responsible for the 15μm CO_2 emission are more pronounced in the polar summer MLT than in other regions due to the cold mesopause and high vertical temperature gradients both below and above the mesopause region. This case provides an example of a very strong infrared radiative coupling between warm stratosphere and cold mesosphere.

The SABER[a] instrument on board the TIMED[b] satellite is a limb scanning infrared radiometer designed to measure temperature and minor constituent vertical profiles and energetics parameters in the MLT. Temperatures in the MLT are retrieved from the 15μm radiance of CO_2 and are, therefore, dependent on the aforementioned non-LTE effects. We have demonstrated that an improved model of the ν_2 quanta vibrational-vibrational (V-V) exchange between CO_2 isotopes applied to the TIMED/SABER 15 μm broadband polar summer radiance data provides better agreement between retrieved temperatures in the MLT with the available in situ measurements.

a) Sounding of the Atmosphere using Broadband Emission Radiometry (SABER)
b) Thermosphere, Ionosphere, Mesosphere, Energetics, and Dynamics (TIMED)