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Chemistry-climate model simulations of a mesospheric source of nitrous oxide

Christopher Kelly (1), Martyn Chipperfield (1), John Plane (1), Wuhu Feng (1), and David Jackson (2)
(1) Institute for Climate and Atmospheric Science, University of Leeds, Leeds, United Kingdom (eecwk@leeds.ac.uk), (2) Met Office, Exeter, United Kingdom

The UK Met Office are 'raising the roof' of the Unified Model (UM) from 85km to 100-140km. At this increased altitude, the impacts of space weather on atmospheric chemistry become more significant. We plan to add a detailed description of the mesosphere/lower thermosphere (MLT) neutral and ion chemistry to this extended UM. The NCAR Whole Atmosphere Community Climate Model (WACCM) has an efficient neutral and ion chemistry scheme that will provide a template for this part of the development. Initial work has involved the addition of a mesospheric source of nitrous oxide into WACCM.

Nitrous oxide (N_2O) is the major precursor of odd nitrogen (NO_y) production in the middle atmosphere and hence has a significant role in the depletion of stratospheric ozone. It was previously assumed to only be produced at the Earth's surface, however a mesospheric source has since been identified. The likely reaction mechanism was first postulated by Zipf and Prasad (1982) based on laboratory experiments. They proposed that energetic electron precipitation (EEP) promotes N_2 to the excited triplet state, which is then followed by a reaction with O_2 to produce N_2O above 90km. Until recently, this mechanism was largely disregarded as there were no high-altitude satellite observations available to verify it. Sheese et al. (2016) provided initial measurements of what appears to be a 95km source, using observations from the ACE-FTS (Atmospheric Chemistry Experiment-Fourier Transform Spectrometer). N_2O VMRs of order 20-40 ppbv were reported as the typical polar winter concentration. The mechanism responsible for this observed N_2O needs to be established.

As a first stage in this work we will describe the inclusion of an additional source of N_2O in WACCM. Results from WACCM will be compared with ACE-FTS data in order to establish a plausible mechanism for the source of N_2O. Subsequent WACCM simulations will then enable the impact of descending N_2O and NO_y to be represented by the model, with the aim of quantifying the effect this source has on ozone depletion. We will then compare results from WACCM simulations with and without this additional N_2O source, and from simulations with varying levels of EEP.