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Investigating N_2O produced in the mesosphere – lower thermosphere and its transport to the middle atmosphere

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Abstract: This paper will describe Atmospheric Chemistry – Experiment Fourier Transform Spectrometer (ACE-FTS) N_2O measurements in the middle atmosphere along with its production mechanisms and long-term variation. Comparisons with model N_2O simulations will also be discussed.
OCIS codes: 010.0280 Remote sensing and sensors; 010.1280 Atmospheric composition

1. Motivation

Nitrous oxide (N_2O) is an important greenhouse gas and contributes to ozone depletion in the Earth's atmosphere. Until recently, it was thought that there were no in situ atmospheric sources of N_2O. However, measurements from the ACE-FTS (Atmospheric Chemistry Experiment – Fourier Transform Spectrometer) instrument show that there is a consistent presence of N_2O in the mesosphere-lower thermosphere (MLT) [1]. These measurements are important for understanding and characterizing the global N_2O budget and its effects on the atmosphere.

2. Introduction

ACE-FTS [2] is a limb-viewing, solar occultation instrument on board the Canadian SCISAT satellite, which was launched into a high inclination orbit in August 2003. It is a high spectral resolution spectrometer that retrieves atmospheric profiles from infrared observations between 750 and 4400 cm^{-1}. One of the 50+ species that ACE-FTS measures is N_2O, which is retrieved between 5 and 95 km with ~3-4 km vertical resolution. The measurements, which span from February 2004 to the present, are made between 85°S to 85°N, with a focus on high latitudes. This study uses the most current version of the ACE-FTS level 2 N_2O data, version 3.5/3.6 [3, 4]. The ACE-FTS data are compared to simulated N_2O data from the Whole Atmosphere Community Climate Model (WACCM) [5], which is run in specified dynamics mode and has been modified to include reactions relevant to N_2O production, including ion chemistry in the D-region.

3. Discussion

Latitudinal cross sections of 2004-2018 zonal mean ACE-FTS N_2O profiles are shown in Figure 1 for January-February and for July-August. A layer of N_2O is observed at high altitudes, around 90 km, that is present at all latitudes. The largest concentrations are observed in the polar winter region on the order of 100 ppbv. At all latitudes, N_2O is indirectly produced via photoelectrons, and at the poles there is an additional source that is dependent on energetic particle precipitation [6].

Occasionally, after strong sudden stratospheric warming events, which often occur in the Arctic winter, strong descent in the polar vortex can bring NO_x and N_2O-rich air down from the upper atmosphere into the upper stratosphere. ACE-FTS has measured N_2O concentrations on the order of 1 ppbv descending from the lower thermosphere down to ~40 km [1]. NO_x, which plays a significant role in O_3 depletion, is produced from N_2O destruction. It is therefore important to understand what role atmospherically produced N_2O plays on NO_x and O_3 throughout the upper stratosphere to lower thermosphere.

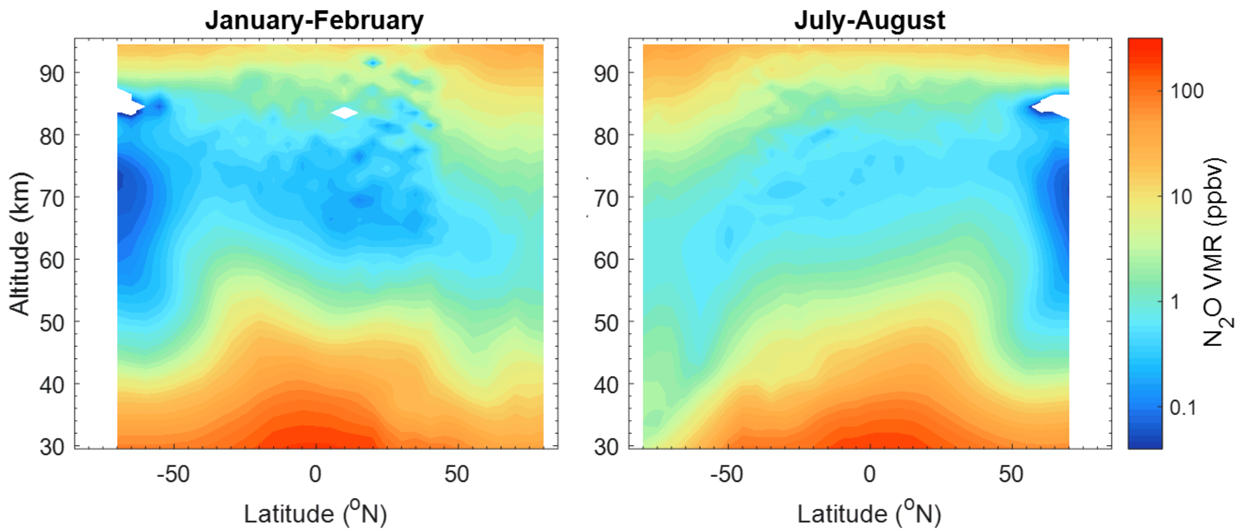

Figure 1: Latitudinal cross section of 2004-2018 zonal mean ACE-FTS N_2O profiles for January-February (left) and July-August (right). White sections are regions where no data are available or where mean concentrations are negative.

4. Summary

ACE-FTS is the only instrument that measures N_2O produced in the MLT region. Near 90-95 km, ACE-FTS measures the presence of N_2O concentrations at all latitudes, all seasons, throughout the solar cycle, on the order of 10-100 ppbv. This presentation will detail comparisons between ACE-FTS measurements of N_2O, NO_x, and O_3 with WACCM simulations in order to further the understanding of the role N_2O plays on NO_x and O_3 chemistry in the middle atmosphere.

5. References

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