

EGU22-9807

<https://doi.org/10.5194/egusphere-egu22-9807>

EGU General Assembly 2022

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N₂O temporal variability from the middle troposphere to the middle stratosphere based on airborne and balloon-borne observations during the period 1987-2018

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Nitrous oxide (N₂O) is the third most important greenhouse gas in the atmosphere and is now considered as the most important depleting source gas of stratospheric ozone (O₃). Its sources are both natural and anthropogenic, mainly as an unintended by-product of human food production activities. Scientifically, a major issue is the identification and quantification of trends in the N₂O concentration from the middle troposphere to the middle stratosphere (MTMS) by in-situ and remote sensing observations due to the paucity of measurements. To address the temporal variability of N₂O, we assembled the first comprehensive dataset for in-situ and remote sensing N₂O concentrations from 1987 to 2018, based on aircraft and balloon measurements in the MTMS. Using statistical methods, we quality-controlled all the measurements to exclude outliers and particular dynamic cases (tropospheric intrusion, stratospheric descent). This allowed us to determine N₂O trends in the MTMS, based on selected observations during the period 1987-2018. This consistent dataset was also used to study the N₂O seasonal cycle in order to investigate the relationship with its emission sources through zonal means and atmospheric dynamic. The results show a long-term (30 years) increase in global N₂O concentration in the MTMS with an average of 0.89 ± 0.09 ppb/yr in the troposphere and 0.95 ± 0.13 ppb/yr in the stratosphere, consistent with 0.80 ppb/yr derived from ground measurements and ACE-FTS satellite measurements.

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