Monthly Averages of N_2O and O_3 Derived from Satellite Observations: A Method for the Evaluation of Atmospheric Chemical Models in the Lower Stratosphere

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1. INTRODUCTION:

Monthly averages of nitrous oxide (N_2O) and ozone (O_3) derived from satellite data can be used as a tool for the evaluation of atmospheric photochemical models. Here, we evaluate the Chemical Lagrangian Model of the Stratosphere (CLaMS) and the Karlsruhe Simulation Model of the Middle Atmosphere (KASIMA) as well as the atmosphere chemistry general circulation model ECHAM5/MESSy1 (E5M1) using data sets of monthly averaged N_2O and O_3 derived from satellite data.

2. DATA AND METHOD:

Two data sets of monthly averages of N_2O and O_3 were derived, one from the Improved Limb Atmospheric Spectrometer (ILAS/ILAS-II) and one from the Odin-Submillimetre Radiometer (Odin/SMR). Thereby, the data was partitioned into potential temperature bins and then averaged over 20 ppbv N_2O. The resulting families of curves allow to separate ozone changes due to chemistry from those due to transport.

3. CHARACTERISTICS OF THE N_2O/O_3 DISTRIBUTIONS:

• Winter ozone loss results in an inflection and thus a change of slope of the curves from positive to negative correlated.

• Summer ozone loss leads to a general decline of ozone mixing ratios.

• Diabatic descent brings down O_3 and N_2O with low mixing ratios from the upper stratosphere to the lower stratosphere. Thus, a positive correlation of the curves above 500 K is resulting.

• Reference curves are used to indentify air of polar, midlatitude and tropical origin.

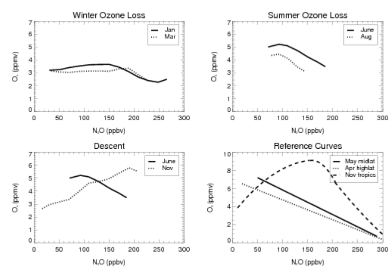

Figure 1: The figure shows schematically how ozone loss and diabatic descent change the curves derived from monthly averaged ozone and nitrous oxide.

Polar Regions (NH)

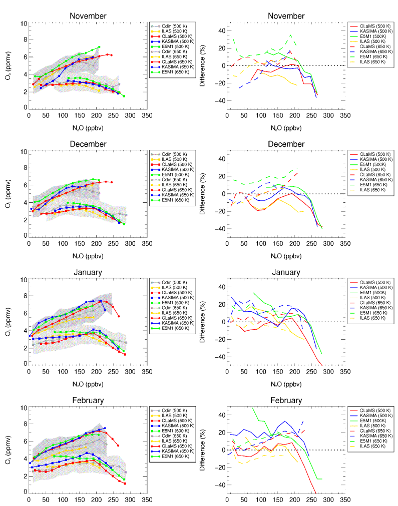

***Figure 2:** Left: Comparison of CLaMS, KASIMA, E5M1 and ILAS/ILAS-II with Odin/SMR at 500 and 650 K (NH, polar regions). Right: Differences of the O_3 averages of CLaMS, KASIMA, E5M1 and ILAS/ILAS-II from Odin/SMR.*

4. MODEL EVALUATION:

In Figure 2 the evaluation of CLaMS, KASIMA, E5M1 and ILAS/ILAS-II for the Northern Hemisphere polar region is shown (at 500 and 650 K).

• Generally, a good agreement between the models and ILAS/ILAS-II with Odin/SMR is found (differences are in the range of ±20 %).

• Differences are somewhat larger at 500 K than at 650 K.

• Larger differences (up to –40%) are found at 500 K for N_2O mixing ratios greater than 250 ppbv (which can be attributed to air of tropical origin).

• Larger differences are also found for E5M1 at 500 K in January and February for N_2O mixing ratios lower than 100 ppbv indicating that chemical ozone destruction during winter is underestimated by the model (see also plots on the left side, an increase instead of decrease is found in the curve).

• Similar results are derived when ILAS/ILAS-II is used as reference (Figure 3).

• Differences are somehat lower since ILAS/ILAS-II focuses on the polar regions and thus less air masses influenced of midlatitude and tropical air are measured.

Polar Regions (NH)

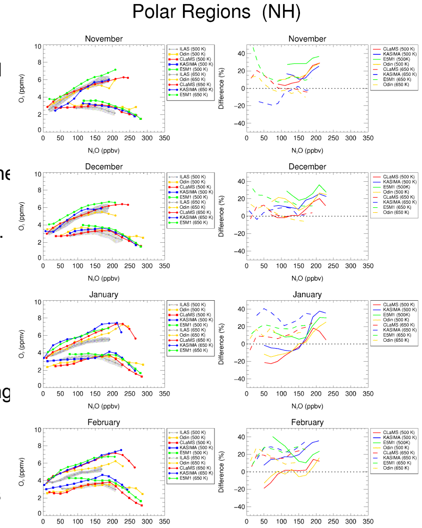

***Figure 3:** Left: Comparison of CLaMS, KASIMA, E5M1 and Odin/SMR with ILAS/ILAS-II at 500 and 650 K (NH, polar regions). Right: Differences of the O_3 averages of CLaMS, KASIMA, E5M1 and Odin/SMR from ILAS/ILAS-II.*

5. CONCLUSION:

• We presented a method which can be used for the evaluation of atmospheric photochemical models as well as for the evaluation of satellite data.

• By calculating monthly averages of N_2O and O_3 from the model and satellite data the resulting curves can be easily compared and model deficiencies can be tracked.

• Both data sets, Odin/SMR and ILAS/ILAS-II, are adequate data sets for such an evaluation, however, the ILAS/ILAS-II data is restricted to the polar regions.

• Generally, a good agreement between the models and the measurements is found. However, in E5M1 and KASIMA polar winter ozone loss is underestimated.

References:

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