Ozone depletion in the tropical stratosphere

Persistent ozone depletion in the tropical stratosphere: identifying possible reasons

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In Short

- Improvement of the retrieval algorithm to obtain the vertical distributions of NO_2 and BrO from measurements of the scattered solar light performed by the SCIAMACHY instrument.
- Retrieval of the stratospheric NO_2 and BrO distributions with the main focus to obtain the best possible quality of the respective time series
- Creation of the global data set of NO_2 and BrO over the entire operation time of the SCIAMACHY instrument (August 2002 - April 2012).
- Investigation of the spatio-temporal behavior and determination of trends in stratospheric NO_2 and BrO in conjunction with the results of chemical transport modeling with a particular focus to understand mechanisms of the ozone depletion and/or production as well stratospheric dynamics.
- The ultimate goal is to improve the general knowledge on tropical stratospheric ozone and understand the relation of the observed ozone decline to chemical and dynamic processes in the Earth's atmosphere.

The importance of stratospheric ozone layer has been widely discussed by many authors. Playing a key role in the radiative budget of the Earth's atmosphere the stratospheric ozone also protects the biosphere from the harmful UV radiation and is closely related to stratospheric circulation and meteorology. After the anthropogenic emission of several strong ozone depleting substances has been ruled out by Montreal Protocol and its amendments the severe ozone decline discovered in early eighties of the last century (widely known as Antarctic ozone hole) began to slow down and even some indications of the ozone recovery have been inferred from observations [8–11]. In the resent time the vertical distribution of stratospheric ozone trends has been moved into the focus [3,4,6]. Analyzing the vertically resolved time series of ozone in tropics all authors agree in their conclusions that a strong ozone recovery is seen in the middle to lower stratosphere (below about 30 km) while a significant ozone depletion is observed at altitudes about 35 km. Being vertically integrated these opposite trends result in a slightly positive contribution which explains the signatures of a recovery seen in the observations of the ozone total column.

This project utilizes measurements in limb viewing geometry from the Scanning Imaging Absorption spectroMeter for Atmospheric CHartographY (SCIAMACHY) [1,2] instrument launched on board the European Envisat satellite on March 1st, 2002 and operated until the sudden lost of the connection to Envisat on April 8th, 2012. Figure 1 shows stratospheric ozone trend as a function of the altitude and latitude as observed by the SCIAMACHY instrument during the time period from 2004 to 2012. One clearly sees a strong sharply localized peak at altitudes 30 - 38 km in the tropical region. In relation to the expected impact of the Montreal Protocol and its amendments these negative trends are quite surprising and a discussion if this phenomenon has purely dynamic or also chemical reasons is currently ongoing in the scientific community.

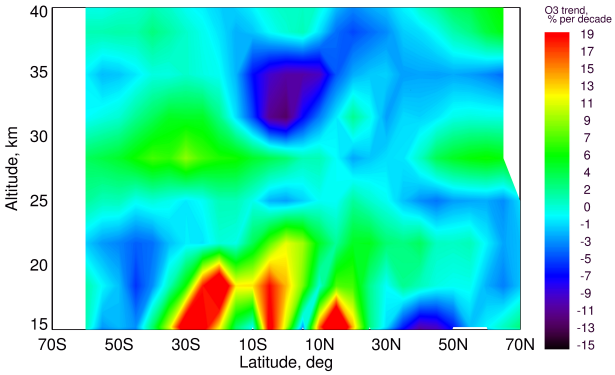

***Figure 1:** Linear trends in monthly zonal mean stratospheric ozone as retrieved from SCIAMACHY limb observations (V3.5)*

In the framework of the precursor project the quality of ozone time series retrieved from the measurements of the SCIAMACHY instrument has been substantially improved. While the complete processing is not yet finished, results of a preliminary validation with respect to measurements form Aura MLS instrument [5] and ozone sondes show that that issues identified in the previous retrieval version have been successfully fixed. A remaining drift between SCIAMACHY and MLS results in the altitude range in question is estimated at about 0.3% per decade which is far below usual uncertainties for the trends in the stratospheric ozone (1-2% per decade), see e.g. [4]. Preliminary data analysis shows that the trends obtained from both instruments for the common time period agree within error bars.

The obtained results ensure a high level of con-

fidence in the derived strength of the stratospheric ozone trends and pose the next scientific question on the possible explanations for the observed behavior. Investigations of measurements of O_3 and N_2O from HALOE, MLS and ACE-FTS instruments have recently been done by *Nedoluha et al.* [7] showing an observed decrease in N_2O associated with an increase in NO_y which can cause the observed depletion of ozone.

In this study we focus at the investigation of vertical distributions of NO_2 and BrO retrieved from SCIAMACHY limb measurements to assess if the behavior of a further member of NO_y family (NO_2) is consistent with the findings of *Nedoluha et al.* [7] and if halogen species might have a significant contribution to the ozone depletion mechanisms in this latitude/altitude region. The time series of both species will be obtained by running respective retrieval algorithms over the entire data set of SCIAMACHY measurements and the respective trends will be calculated. An investigation will include the modeling studies using a Chemical Transport Model (CTM) to evaluate if the observed behavior of the species can be reproduced by the model and if the observed trends in the tropical stratospheric ozone can be explained by the observed trends in both NO_2 and BrO. A consideration of BrO is believed to be important as on the one hand it is an ozone depleting species and on the other hand is reacts with nitrogen species to form inactive reservoir species. Thus, this additional knowledge enable us to constrain CTM in a better way. An additional approach to analyze possible mechanisms of the ozone destruction is analyzing (anti-)correlations between the time series of different species. Due to a complex interaction between different chemically active species and dynamic processes a supporting modeling study will be essential for the interpretation of the obtained results.

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More Information

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