MIPAS OBSERVATIONS OF STRATOSPHERIC AND UPPER TROPOSPHERIC TRACE GASES: AN OVERVIEW

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ABSTRACT

The Michelson Interferometer for Passive Atmospheric Sounding (MIPAS) observes multiple stratospheric processes, as well as such involving the upper troposphere and the mesosphere as its upper and lower boundary regions. These processes include upper tropospheric pollution, stratospheric tropospheric exchange, tropical tape recorder effects, the Brewer-Dobson circulation, intrusions of thermospheric and mesospheric air into the stratosphere, energetic particle precipitation, and polar vortex ozone chemistry.

Key words: MIPAS; trace gases, stratosphere; overview.

1. INTRODUCTION

The Michelson Interferometer for Passive Atmospheric Sounding (MIPAS) is a mid-infrared thermal limb emission sounder designed to observe the Earth's composition [3]. The limb measurement geometry results in good vertical resolution, Envisat's polar orbit provides global coverage, and the measurement of thermal emission results in measurements independent of daytime.

To complement ESA's operational MIPAS data processor [48, 47], IMK together with IAA operate a scientific data processor [62]. This relies on the KOPRA forward model [58, 54], involving innovative approaches to raytracing [20] and Voigt-line-computation [32]. The forward model underwent various intercomparison exercises [60, 69]. The retrieval is based on constrained inversion [50]. Methods to cope with the problem of a priori content in the data [67] and information interference [68] have been developed.

Similar as the operational ESA processor, only small spectral are used to extract the information from the measurement rather than the spectrum as a whole [61, 2]. Since the retrieval of temperature and elevation pointing [62] is crucial for limb emission measurements, particular care has been spent related validation exercises [74, 28, 18, 31]. The finite along-track resolution of MIPAS [59] and the implication of horizontal temperature structures [30] have been analyzed.

Due to the failure of the interferometer slide, the spectral resolution of MIPAS was degraded in 2005. Trace gas abundances retrieved from the reduced resolution measurements were found to have better altitude resolution [70, 1]. To cope with the resulting inhomogeneous data set in trend estimation, a dedicated method has been developed [71]. In this paper we summarize scientific research based on MIPAS data generated with the IMK/IAA scientific data processor.

2. POLLUTION OF THE UPPER TROPOSPHERE

Thermal infrared limb sounding of the upper troposphere is a challenge because of enhanced opacity, frequent occurence of clouds and the need to consider line-mixing effects [11]. Pollutants observed by MIPAS include C_2H_6, O_3 [65], CO [8], C_2H_2 and PAN [15], HCN [17] and HNO_4 [57]. Recently, an annual cycle of formic acid has been observed [19].

3. STRATOSPHERIC - TROPOSPHERIC EXCHANGE

Stratospheric - tropospheric exchange events can be identified by enhanced values of tropospheric gases in stratospheric air or vice versa. The Asian monsoon anticyclone has been identified to be a candidate region where tropospheric air enters the stratosphere. Enhanced CO [8] along with enhanced H_2O and reduced O_3 [33] has been observed in this region.

4. STRATOSPHERIC H_2O AND THE TROPICAL TAPE RECORDER

Slow stratospheric updraft transports the humidity signal at the stratospheric entry point to higher altitude like an audio tape. This atmospheric tape recorder effect can be analyzed on the basis of MIPAS H_2O data [46]. These data have been validated against various independent measurement systems [45]. Also in HDO a tape recorder effect has been detected in MIPAS data [53, 52]. H_2O is also a product of CH_4 oxidation, which also leads to H_2CO [49]. The stratospheric hydrogen budget is still an issue [75].

5. THE BREWER-DOBSON CIRCULATION

MIPAS offers many species suitable to trace atmospheric dynamics, but the ideal candidate is SF_6 because it increases monotonically and nearly linearly, and it has no stratospheric sinks. MIPAS provides global multi-year SF_6-based distributions of the mean age of stratospheric air[56].

6. STRATOSPHERIC MESOSPHERIC EXCHANGE AND ENERGETIC PARTICLE PRECIPITATION

Retrieval of mesospheric species requires consideration of non-local thermodynamic equilibrium effects [41, 35] of CO [5], O_3 [42, 12, 29], N_2O [34], CH_4 [40], NO and NO_2 [6, 10] The effect of energetic particle precipitation on the stratosphere and mesosphere has been studied with MIPAS data with emphasis on nitrogen chemistry [36, 37, 38, 4] and chlorine chemistry [64]. A key question is to distinguish between transport of processed air from above on the one hand and stratospheric in situ production on the other hand [55, 9, 7]. Mesospheric H_2O is also important with respect to the formation of polar mesospheric clouds [39].

7. POLAR VORTEX CHEMISTRY

MIPAS ozone measurements have been compared to independent measurements for reason of validation [51, 13] and used to study polar vortex dynamics [73] and chemistry. Many further species related to ozone chemistry have been derived from MIPAS spectra validated and used for ozone research . [57, 24, 26, 63, 66, 72, 14, 43, 16, 44, 27] The MIPAS trace gas measurements are complemented with measurements of polar stratospheric clouds [25, 21, 22, 23].

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