# Measurements of Ozone in the Stratosphere and lower Mesosphere at the Tropical Mérida Atmospheric Research Station (MARS) by ground-based Microwave Radiometry


Universität Karlsruhe (TH)

Forschungszentrum Karlsruhe
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**G. Kopp (1), E. Diez y Riega V. (2), J. Groß (1), G. Hochschild (1), P. Hoffmann (2)**
(1) Institute of Meteorology and Climate Research, Forschungszentrum und Universität Karlsruhe, Germany
(2) Faculty of Science, Universidad de Los Andes, Mérida, Venezuela

UNIVERSIDAD DE LOS ANDES
MERIDA-VENEZUELA


**Fig. 1:** Satellite picture of the northern part of South America taken by the MERIS instrument on board ENVISAT (left hand side, © ESA 2003). Clearly visible are the Gulf of Venezuela and Lake Maracaibo. The arrow marks the position of Pico Espejo in the Sierra Nevada de Mérida.
The right hand picture shows the "Estación Alejandro de Humboldt" on Pico Espejo which houses the Mérida Atmospheric Research Station (MARS).

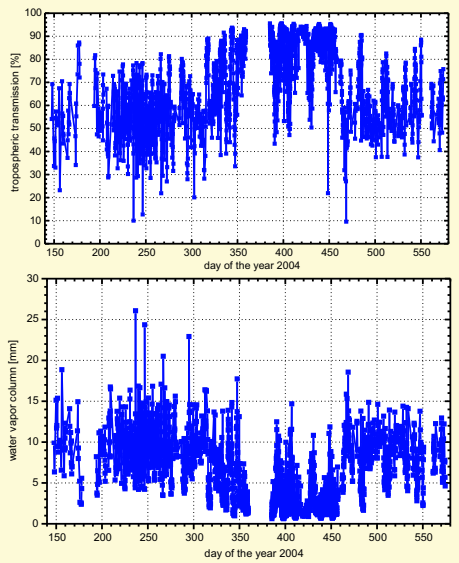


**Fig. 2:** Tropospheric transmission (upper panel) and tropospheric water vapor columns (lower panel) as measured by MIRA 2 on Pico Espejo.

## Introduction

Since March 2004 the millimeter wave radiometer MIRA 2 is in operation at the inner tropical Mérida Atmospheric Research Station (MARS) on Pico Espejo (8.53°N, 71.05°W, 4765 m asl) at Mérida in the Venezuelan Andes (Fig. 1). Due to its high elevation this site provides a high tropospheric transmission during long periods of the year and is therefore well suited for ground-based microwave observations. The upper panel of Fig. 2 shows the tropospheric transmission as measured by MIRA 2 on Pico Espejo. A very dry period with tropospheric transmissions over 90% from December to March is obvious, but even during the less dry periods a high tropospheric transmission was measured on many days.
The changing humidity on this site is also obvious in the tropospheric water vapor columns which are derived from the tropospheric contribution to the MIRA 2 measurements (lower panel of Fig.2).

## The MIRA 2 Measurements

MIRA 2 is a heterodyne radiometer with a cryogenically cooled Schottky mixer and uses a balanced calibration technique to improve the contrast in the measured spectra. The instrument observes spectral signatures caused by thermally induced rotational transitions of the stratospheric trace gases ozone, ClO, $HNO_3$, and $N_2O$ in the frequency range 268-280 GHz. Spectral analysis is performed by an Acousto Optical Spectrometer with a bandwidth of about 1 GHz and a spectral resolution of about 1.2 MHz.
Vertical volume mixing ratio profiles are retrieved from the measured spectra using a modified Optimal Estimation Method. The measurements contribute at least 70 % to the information content in the retrieved profiles in the vertical range of 17 to 65 km. Using the FWHM of the averaging kernels as criterion the vertical resolution is at best 7 km at an altitude of about 20 km.

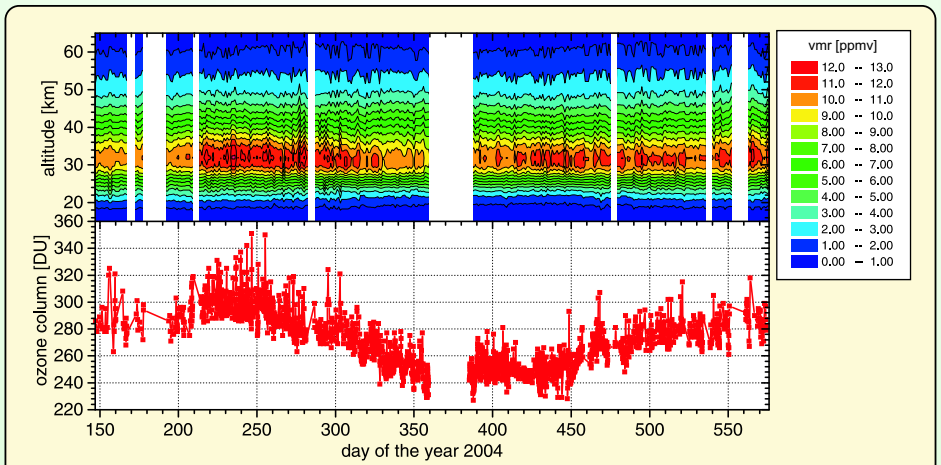


**Fig. 3:** Ozone between May 27, 2004, and July 28, 2005, over Pico Espejo as measured by MIRA 2. The upper panel shows the vmr profiles of the single days, the lower panel the ozone column amounts. Note the seasonal variation in the profiles as well as in the column amounts. This variation is mainly a result of the changing dynamic situation in the stratosphere over the measurement site.

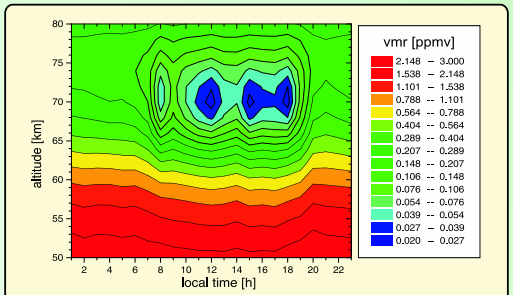


**Fig. 4:** Diurnal variation of ozone in the upper stratosphere and lower mesosphere as measured by MIRA 2 on 26 January 2005 on Pico Espejo.

## Ozone over Mérida

From the measurements of MIRA 2 a time-series of ozone vmr-profiles and stratospheric column densities covering the time span May 2004 to July 2005 has been retrieved (Fig. 3). In the middle stratosphere a variation in the ozone concentrations on a time scale of several months was observed which is probably due to dynamical effects.
In the upper stratosphere and lower mesosphere the diurnal variation of ozone due to photochemical dissociation after sunrise and recombination after sunset can also be detected by MIRA 2. Fig. 4 shows a time series of measured ozone vmr profiles on 26 January 2005. Part of the real variation is smoothed by the limited vertical resolution and sensitivity of MIRA 2 in these altitudes. This will be further investigated by comparison to model calculations in the framework of the CAWSES project.


### Acknowledgements

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