▶ The Radiometer for Atmospheric Measurements (RAM)

K. Lindner, B. Barry, U. Klein, J. Langer, B.-M. Sinnhuber, I. Wohltmann, K.F. Künzi

University of Bremen, Institute of Environmental Physics, PO Box 33 04 40, D-28334 Bremen, Germany
e-mail: klindner@uni-bremen.de

▶ Overview

The Radiometer for Atmospheric Measurements (RAM) is operated by the Institute of Environmental Physics at the University of Bremen in cooperation with the Alfred-Wegener-Institute for Polar and Marine Research. It is part of the Network for the Detection of Stratospheric Changes (NDSC).

The Instrument is located at the Koldewey-Station in Ny-Ålesund, Spitsbergen, at 78°55' N, 11°55' E. This observation site was chosen because of the special climatic conditions. The polar vortex is mostly located above Ny-Ålesund, which is essential for observing disturbed stratospheric chemistry.

The RAM is operational since November 1994. At present, it consists of three different radiometer frontends for measuring the ozone emission line at 142 GHz, the chlorine-monoxide line at 204 GHz and the water-vapour line at 22 GHz. One acousto optical spectrometer (AOS) is shared by the three frontends.

From the measured spectra, altitude profiles of the trace gas mixing-ratios are retrieved.

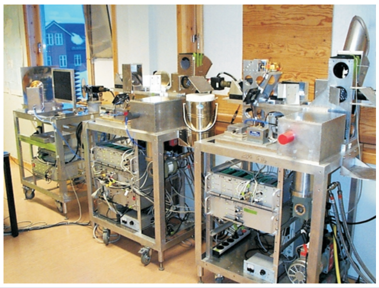

Figure 1: Inside the NDSC laboratory in Ny-Ålesund. The leftmost rack is the water-vapour radiometer, in the center is the ozone radiometer, on the right is the chlorine-monoxide radiometer. The central rack carries the intermediate frequency chain and the acousto optical spectrometer. All these instruments observe the atmosphere through windows made of styropor.

▶ Technical Data

	O_3	ClO	H_2O
Receiver temperature	ambient	13 K	ambient
System noise temperature	3400 K	1150 K	200 K
Typical signal strength	15 K	0.05 K	0.2 K
Observation scheme	total power	reference	reference
Typical integration time	1 h	24 h	tbd
Single sideband filter	MPI	MPI	coaxial
Observation frequency	142.2 GHz	204.4 GHz	22.2 GHz
Spectral bandwith	1.65 GHz	0.96 GHz	0.96 GHz
Effective frequency resolution	1.6 MHz	1.6 MHz	1.6 MHz
Altitude range	12...55 km	16...35 km	tbd
Operational since	1993	1994	1999

▶ Frontend

The idea behind microwave radiometry is the passive measurement of the rotational transition of thermal excited atmospheric trace gas molecules. The weak intensities of these signals require a special technique for amplification and detection.

The basic concept of each radiometer is the same. The atmospheric signal is collected by a mirror and fed into a quasioptical system. Common elements of our quasioptics are a path length modulator for the extinction of standing waves, Martin-Puplett Interferometers as single-sideband-filters and cold and hot loads for calibration purposes. A mixer converts the hf signal down to the intermediate frequency of 8 GHz.

We use two different observation schemes. The total power method compares the atmospheric signal to cold and hot loads. The reference beam method compares two atmospheric signals at different observation angles. A compensating plexiglass sheet in one beam accounts for the longer path length through the atmosphere in the other beam.

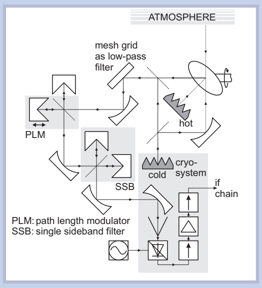

Figure 2: The schematics of the ozone radiometer in total power geometry. The mirror switches between the atmosphere, a cold and a hot calibration load. The Schottky diode mixer and the first HEMT amplifier stage are presently operated at ambient temperature.

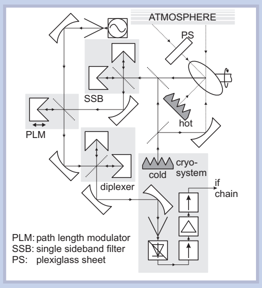

Figure 3: The schematics of the chlorine-monoxide radiometer in reference beam geometry. In contrast to the ozone radiometer, the local oscillator is optically coupled into the mixer. The whisker contacted diode mixer and the first HEMT amplifier stage are mounted inside a 13 K cryo system.

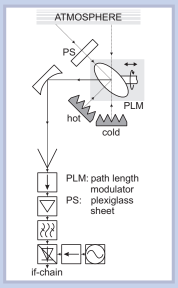

Figure 4: The schematics of the water vapour radiometer. It is operated in the reference beam mode. In contrast to our other radiometers, a low noise preamplifier is located in front of the mixer.

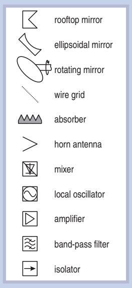

Figure 5: Symbols of quasioptic and microwave components.

▶ Backend

Our three radiometers share one backend, which consists of the intermediate frequency chain and an acousto optical spectrometer.

The purpose of the if-chain is the downconversion from the first intermediate frequency of 8 GHz to the spectrometer input frequency of 2.1 GHz and the adjustment of the input power levels.

About 20% of the observation time is used by the ozone radiometer, the remaining 80% are shared by the ClO and H_2O radiometers. Although we measure throughout the year, ClO can only be measured in the arctic spring, because we subtract day- and night-time measurements to eliminiate instrumental effects. Whenever the weather conditions are to bad for ClO, we measure H_2O instead.

A computer receives the data from the AOS and drives the attenuator, the mirror positioning units and the switches.

Our instrument is highly automated and requires only little technical attention.

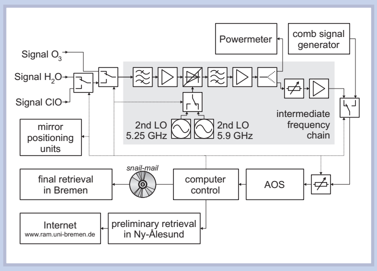

Figure 6: The structure of our backend. A pair of switches selects the input signal. A portion of the signal is fed to a Powermeter. A comb signal generator can be coupled in for frequency calibration of the spectrometer. Once in a month, our data is stored on CD-ROM and shipped to Bremen for processing.

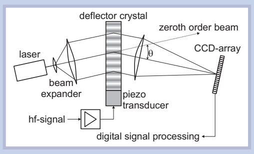

Figure 7: The schematics of an acousto optical spectrometer. The hf signal drives a piezo electrical transducer which generates a density grid in the connected deflector crystal. An expanded laser beam is defracted and the first order beam is projected on a CCD-array. The deflection angle of the beam depends on the microwave-frequency and the intensity on the microwave-power.

▶ Typical Results

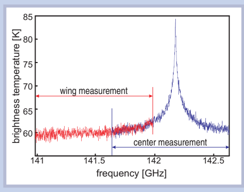

Figure 8: Spectral measurement of the ozone rotational line at 142.175 GHz. March 20th 1997 at 17:00.

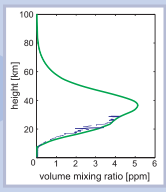

Figure 9: The retrieved ozone VMR profile and an ozone sonde profile from the previous day.

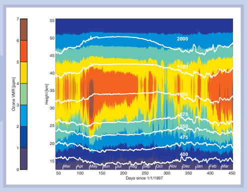

Figure 10: Ozone volume-mixing-ratio profile timeseries from February 1997 to March 1998 over Ny-Ålesund.

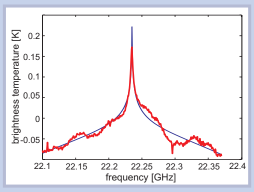

Figure 11: A typical spectral measurement of the water-vapour line at 22 GHz. The blue line is a radiative transfer calculation of a given water-vapour distribution.

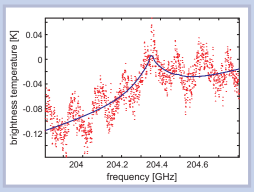

Figure 12: The red dots are a typical ClO measurement with a superimposed baseline structure. In comparison the blue line – a radiative transfer calculation of a given ClO distribution.