Continuous ozone measurements over Kiruna during winter/spring 2002: A new millimeter wave radiometer operated at the Swedish Institute of Space Physics, Kiruna, Sweden

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1 Introduction

A new millimeter wave radiometer has started operation at the Swedish Institute of Space Physics, Kiruna, Sweden. The location of the instrument (67.8 N, 20.4 E) allows continuous observation of the evolution of ozone and ozone loss related trace gases in the Arctic polar stratosphere. It is designed for measurements of thermal emission lines between 200 and 224 GHz. Observations include ozone, chlorine monoxide, nitrous oxide, and nitric acid. From the measurements profiles between 15 and 60 km altitude can be retrieved.

2 The IRF millimeter wave radiometer

The IRF millimeter wave radiometer consists of a cryogenically cooled Schottky mixer with a noise temperature of between 800 and 1600 K (single sideband). The Schottky mixer together with the HEMT amplifier is mounted in a vacuum dewar (pressure at around 10^{-7} mbar) and cryogenically cooled down to 22 K in order to decrease electronical noise. The atmospheric signal is coupled to the mixer via a periscope system (on the roof top of the institute) which can be pointed into any direction of interest (c.f. fig. 1). The local oscillator signal from a PLL stabilized Gunn oscillator is heterodyned with the atmospheric signal by a Martin-Puplett interferometer. The balanced calibration technique [1] with an internal adjustable reference load [2] is used for the measurements. The signal is amplified, downconverted twice, and fed into the acousto-optical spectrometer at a center frequency of 2.1 GHz. The total bandwidth of the spectrometer, 1.2 GHz, limits the altitude range to the lower limit of about 15 km. Standing waves due to mismatch of the beam are suppressed by a moving mirror, while contribution in the cross polarization is effectively filtered out by a wire grid right in front of the vacuum dewar.

System parameters	
Frequency range	200 – 224 GHz
Local oscillator coupled via Martin-Pupplett-Diplexer	Gunn diode (208 – 216 GHz)
1st and 2nd IF center frequency	8 resp. 2.1 GHz
Receiver noise temp. @ 22 K	800 – 1600 K
Antenna opening angle (FWHM)	2.5°
Spatial coverage of the measurements	360° azimuth 90° zenith
Pointing resolution Pointing accuracy azimuth/elevation	0.045° 0.5° / 0.01°
Acousto-optical Spectrometer	
Number of channels	2048
Total bandwidth	1.2 GHz
Spectral resolution (effective)	1.4 MHz

Table 1: The radiometer system.

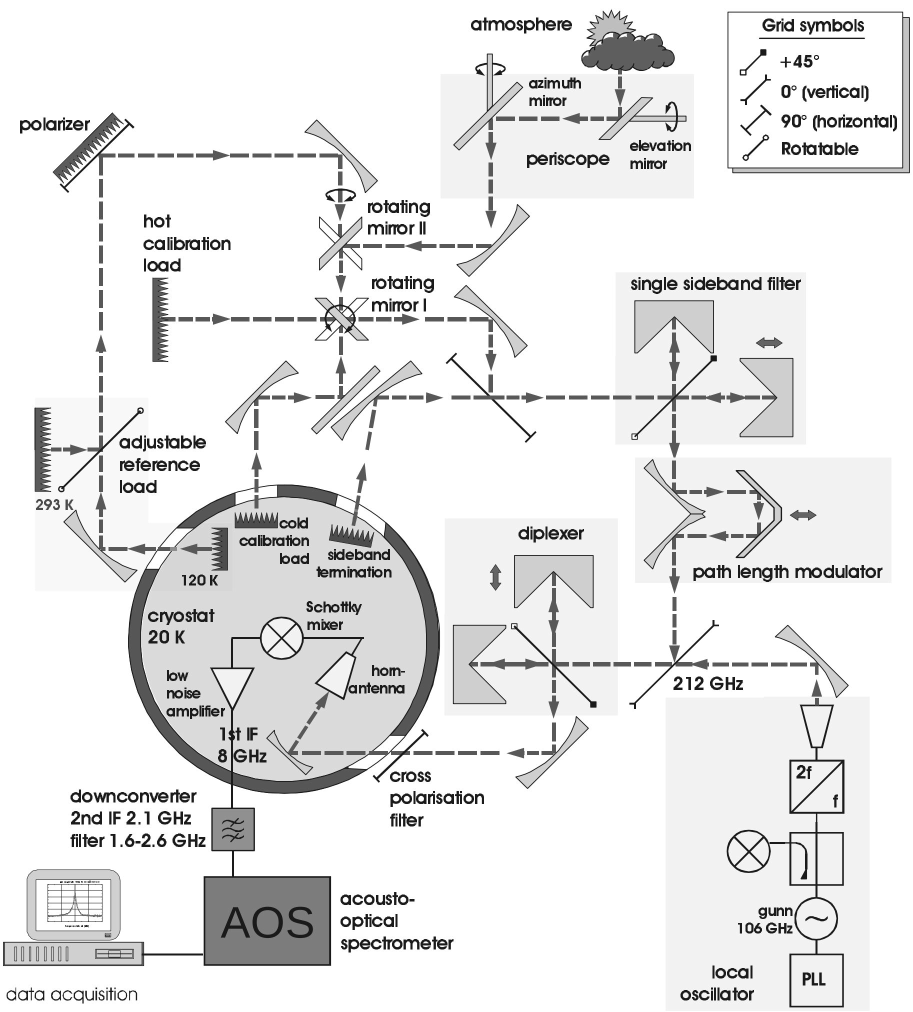

Fig. 1: Sketch of the IRF millimeter wave radiometer.

3 Measurements

Measurements of the trace gases can be done continuously. Seasonal variation as well as year-to-year changes can be observed. The instrument is tuned to ozone at 208 GHz as default, the strongest emission line of ozone in the tunable range. The integration time for ozone measurements is about 15 min, but can be reduced significantly if needed. Due to the faint signature of the emission lines of the other trace gases longer integration times (c.f. table 2) are needed to reduce thermal noise in the spectra. The mirror system on top of the institute's roof, the periscope, can point in any azimuth and elevation angle above the horizon. We have tested the pointing by performing ozone measurements simultaneously with an ozone sonde launch from nearby Esrange on Feb 7, pointing into the direction the sonde was flying. As shown in figure 3 measurements fit nicely along the flight track of the ozone sonde at least in the lower altitude. The deviation at higher altitudes still needs to be investigated.

Measurement characteristics	
Integration time (roughly)	
Ozone	15 min
Chlorine monoxide	120 min (estimated)
Nitric acid	90 min (estimated)
Nitrous oxide	90 min (estimated)
Altitude range	15 - 60 km
Altitude resolution (c.f. fig. 3)	7 - 20 km

Table 2: Measurement characteristics of the IRF radiometer system.

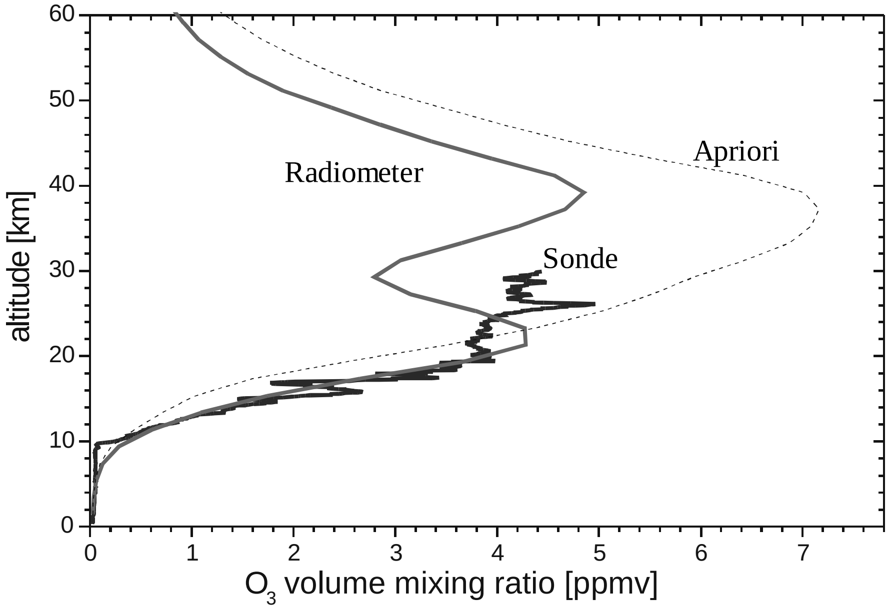

Figure 2: Ground based ozone measurements and simultaneous measurements by an ozone sonde launched Feb 7 from nearby Esrange.

Altitude profiles have been retrieved using the Optimal Estimation method described by Rodgers [3]. The vertical resolution of the measurement varies with altitude between 7 and 20 km as can be seen in fig. 3. However, at the altitude of interest between 15 and 25 km the vertical resolution is around 8 km. The region of the Arctic ozone layer with its chemical key components is thus captured very well.

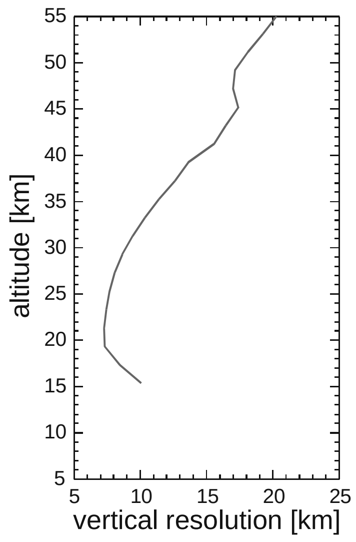

Figure 3: Vertical resolution of the ground based measurements depending on altitude.

As default the instrument points northward with elevation angles between 10° and 50° depending on the tropospheric water vapor content. A time series of stratospheric ozone observations in figure 2 shows the development of the ozone between 10 and 60 km during the winter/spring period 2002. Along with the ozone contour plot figure 2 presents ECMWF temperature and potential vorticity (PV) data at 475 K isentropic surface above Kiruna. Low PV values with relatively high variation and high temperature indicate a weak and unstable polar vortex during that winter. Consequently the contour plot shows no significant ozone depletion during this period.

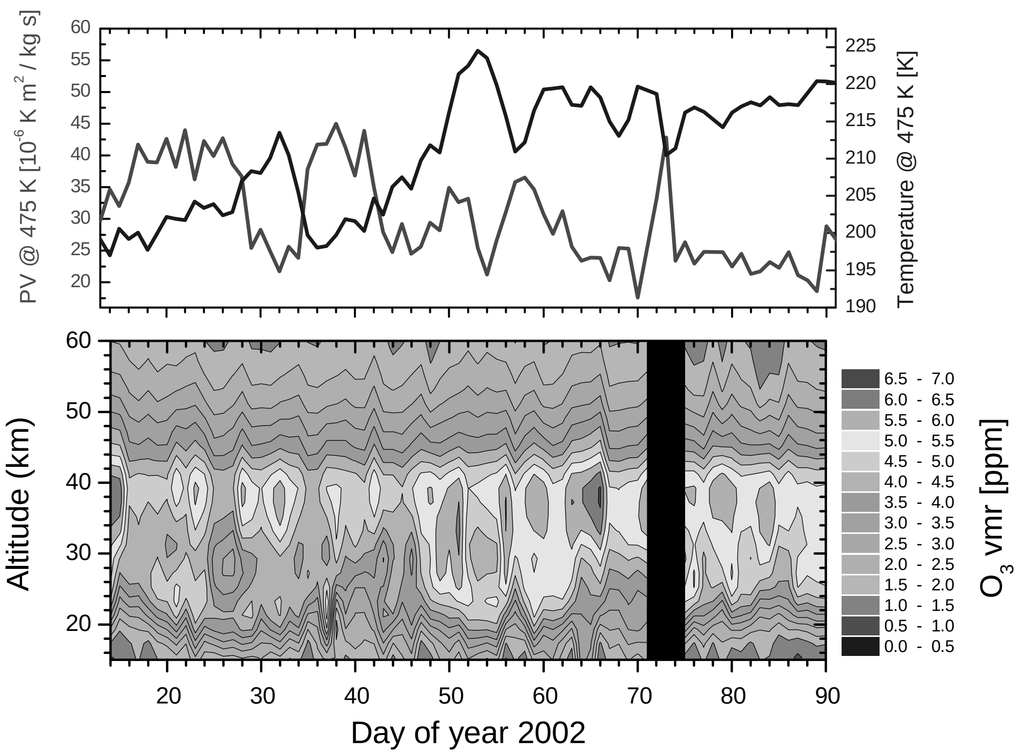

Figure 4: ECMWF potential vorticity and temperature at 475 K isentropic surface (upper panel) and Ozone time series (lower panel).

4 Concluding remarks and outlook

The new millimeter wave radiometer at the Swedish Institute of Space Physics has started operation in Kiruna in January 2002. The radiometer was operated continuously and proved to be a suitable instrument for monitoring purposes in the future. Given the advantageous location 68° N it will provide valuable information about Arctic ozone. The measurements of this first winter season showed no substantial ozone loss during the winter period. Since the radiometer is designed for observation of chlorine monoxide, nitrous oxide and nitric acid as well, there will be interesting information about these stratospheric trace gases as well, once the radiometer is fully operational.

Acknowlegdements

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