On the Evolution of Arctic Lower Stratospheric Ozone in Spring 97, Ground-Based Microwave Measurements at Ny-Ålesund, Spitsbergen

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Radiometer for Atmospheric Measurements (RAM)

As primary station of the Network for the Detection of Stratospheric Change (NDSC), Ny-Ålesund (78,9°N 11,9°E) plays an important role in the ground-based monitoring of the Arctic stratosphere. A microwave radiometer belonging to the standard instrumentation of each station is operated at Ny-Ålesund by the Institute of Environmental Physics (University of Bremen) on behalf of the Alfred-Wegener-Institute for Polar and Marine Research.

The principle of microwave radiometry is based on the detection of a pressure broadened emission line of trace gases in the microwave frequency range. From the shape of the detected line volume mixing ratio (VMR) profiles are retrieved.

Instrument Parameters

Table 1.

trace gas/ frequency	ozone / 142.175 GHz
system noise temperature	3200 K
bandwidth	1.65 GHz
frequency resolution	1.17 MHz

Ozone retrieval characteristics

Table 2.

time coverage	all year round, nearly weather independent
time resolution	1-5 profiles per hour
vertical resolution	10-15 km, altitude dependent
altitude range	12 - 55 km
precision	0.1 ppm at 20 km

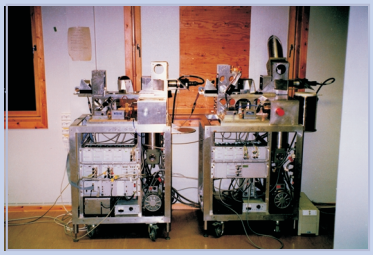

Figure 1. Photo of the RAM. The left rack holds the ozone section, the right rack the ClO section. The atmospheric radiation is received through styrofoam windows. The top parts of the instrument are the quasi-optics, the lower parts contain the amplifier chain, control electronics and the spectrometer.

Results 96/97

In early 1997 microwave measurements at Ny-Ålesund show a substantial ozone decrease at lower stratospheric levels. For a layer centered at the 475 K isentropic level an ozone decrease of about 30 % is observed from mid February to mid April. Taking into account that microwave retrievals lead to averaged results over a 10 km altitude range, depletion in thin layers is expected to be even higher. With regard to the vertical resolution of our measurements, we found ozone depletion over an altitude range extending at least 475 K to 675 K (20 to 25 km). Calculations of potential vorticity on the 475 K isentropic level revealed that in early 97 Ny-Ålesund was located well inside the polar vortex, except for two periods in mid February and mid April (day 107) when the vortex edge moved across Ny-Ålesund. Especially for the outer-vortex situation around day 107 higher ozone values were measured. After the breakdown of the vortex at the end of April ozone values returned back to normal.

We conclude that the strong ozone decrease is due to chemical ozone depletion. This is confirmed by low stratospheric temperatures necessary for PSC formation and the observation of enhanced ClO at Ny-Ålesund by the RAM (see Raffalski et al.). Vortex dynamics inculding diabatic vertical movement are excluded as major cause for the ozone decrease.

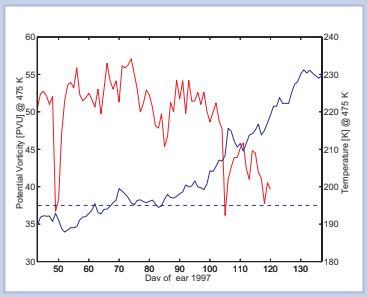

Figure 2. Temperature (blue) and potential vorticity (red) at the 475 K isentropic level for Ny-Ålesund. The approximate PSC formation temperature is indicated by the dashed blue line.

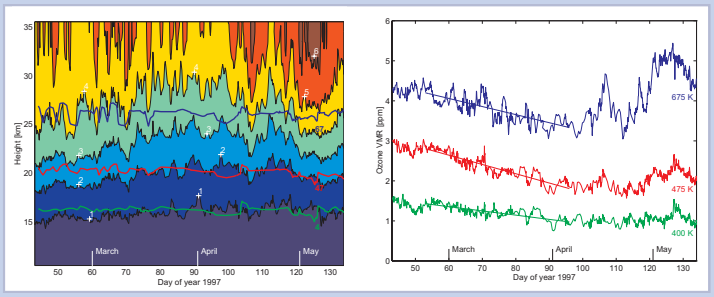

Figure 3. Microwave measurements of ozone in the lower stratosphere at Ny-Ålesund for mid February to mid May 1997.
In the left part the colorcoded ozone VMR between 12 and 35 km is shown. Contour lines indicate levels of constant VMR [ppm]. Heights corresponding to isentropic levels 400 K, 475 K and 675 K are indicated by thick colored lines. Isentropic levels were calculated using daily NMC pressure and temperature profiles.
In the right part the measured ozone evolution on layers centered at 400 K, 475 K and 675 K isentropic levels is displayed. A linear regression was performed to estimate the mean ozone decrease on the three isentropic levels during spring 1997. The regression covers the period between day 53 and day 96 while Ny-Ålesund was located well inside the polar vortex as indicated by high and nearly constant PV on the 475 K isentropic level (Figure 2). Solid lines represent linear regressions. Errors (not indicated) are summarized in Table 3.

Mean ozone decrease in spring 97

	daily loss	total loss
400 K isentropic level	10 ± 1 ppb	0.45 ± 0.04 ppm
475 K isentropic level	24 ± 1 ppb	1.05 ± 0.04 ppm
675 K isentropic level	20 ± 2 ppb	0.91 ± 0.08 ppm
total column above 12.5 km	1 ± 0.1 DU	44 ± 4 DU

Table 3. Summarized mean ozone decrease derived from microwave measurements in spring 1997. Ozone decreasing rates were calculated by applying a linear regression to data for the period between day 53 and day 96. Given errors are due to the uncertainties of the linear regression.

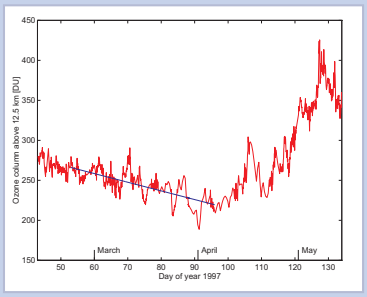

Figure 4. Ozone columns above 12.5 km at Ny-Ålesund as calculated from microwave VMR-profiles. The VMR-profiles are transformed to number densities using NMC pressure and temperature profiles. Number density profiles are integrated above 12.5 km taking into account the characteristics of the VMR retrieval. The precision is about 5%. The blue line indicates mean ozone decrease (see also Figure 3).

This work is supported by: Alfred Wegener Institute for Polar and Marine Research – European Community: European Stratospheric Monitoring Stations in the Arctic II – German Federal Ministry of Education and Research (BMBF): Ozonforschungsprogramm