CANOZE MEASUREMENTS OF THE ARCTIC OZONE HOLE

W.F.J. Evans, J.B. Kerr and H. Fast
Atmospheric Environment Service
4905 Dufferin Street
Downsview, Ontario, Canada
M3H 5T4

Abstract

In CANOZE 1 (Canadian Ozone Experiment), a series of 20 ozone profile measurements were made in April, 1986 from Alert at 82.5 N. CANOZE is the Canadian program for study of the Arctic winter ozone layer.

In CANOZE 2, ozone profile measurements were made at Saskatoon, Edmonton, Churchill and Resolute during February and March, 1987 with ECC ozonesondes. Ground based measurements of column ozone, nitrogen dioxide and hydrochloric acid were conducted at Saskatoon. Two STRATOPROBE balloon flights were conducted on February 26 and March 19, 1987. Two aerosol flights were conducted by the University of Wyoming. The overall results of this study will be reported and compared with the NOZE findings. The results from CANOZE 3 in 1988, will also be discussed.

The appearance of the Antarctic ozone hole, which was reported in 1985, has led many scientists to speculate on the cause. It is natural to expect that a similar phenomenon will occur in the northern hemisphere since there is a cold polar vortex formed in the winter just as in the southern hemisphere. The phenomenon may be different and more difficult to research because of the higher level of planetary wave activity and the presence of stratospheric warmings. The Antarctic is a continent surrounded by oceans whereas the Arctic is an ocean surrounded by continents. It has been pointed out that the Antarctic has much colder temperatures than the Arctic; although the spring temperature is warmer in the Arctic, this is not true during December and January when the northern vortex forms and temperatures below - 80 °C are frequent. The Antarctic ozone hole has been associated with the polar stratospheric clouds through heterogeneous reactions. Polar stratospheric clouds have also been observed in the northern vortex during December. Weisburd[1] (1986) has reported on work by Heath, which indicated the presence of a developing ozone hole in the northern hemisphere from an annual analysis of SBUV satellite data, apparently located over Spitzbergen in late winter; this hole is only about a third as deep and a third as large in area. In conclusion, it is not unreasonable to expect the formation of an ozone crater in the northern hemisphere. Based on these expectations we have been conducting a search for a similar crater in the Arctic, using our Canadian network of ozone monitoring stations (Evans[2], 1987).

A modest study was conducted from Alert, 82.5 N, in conjunction with the AGASP2 project. This work consisted of a series of ECC ozonesondes from March 31 to April 23, 1986 to study the Arctic tropospheric ozone profile in spring.

In the upper altitudes of these profiles, there were layers of depleted ozone similar to those reported by Hofmann et al.[3] (1987) from McMurdo under the Antarctic ozone hole. These depleted layers were found at 100 mb and 160 mb, about 50 mb lower than in the Antarctic. This is understandable since the tropopause was 50 mb lower in the Arctic than in the Antarctic at McMurdo. These profiles are supplemented by our regular soundings from Resolute, Churchill and Goose Bay. The layers of depleted ozone are also apparent on these station profiles at the appropriate times. In order to assist the interpretation of these findings, the TOMS data for this period were processed into imagery and examined. A shallow crater in the ozone field was found over Alert on April 13. Subsequent examination of the TOMS imagery revealed that a large crater had existed in the ozone field from mid-January until April with a maximum extent in mid-March. This hole had an area about one half of the Antarctic hole and was not as deep. The ozone crater had amounts of over 500 DU in the rim and values below 225 DU in the floor of the crater.

An ozonesonde profile from a station near the floor of the crater in mid-March showed that the ozone profile was depleted from 10 km up to 15 km, an observation similar to the measurements of Kohmyr[4] (1988) from South Pole station in mid-October, 1986 in the floor of the crater. This was in marked contrast to the ozone profile from Resolute in mid-March in the rim of the crater. Again, there is a 5 km shift in altitude when comparing with the profiles in the southern hemisphere hole. The total ozone was 550 DU in the Resolute profile in the rim and 255 DU in the floor from the ozonesonde profile from northern Europe. The corresponding values in the Antarctic crater were 400 DU for the rim and 155 DU in the floor in 1986.

A more expanded program of ozone layer measurements was conducted in 1987. As well as ozone profile measurements from the four Canadian stations at Edmonton, Churchill, Resolute and Goose Bay, a special program was conducted from Saskatoon. This consisted of ground based measurements of ozone and nitrogen dioxide, ozonesonde profile measurements and STRATOPROBE balloon flights. In addition, special ground based measurements with a modified Brewer spectrometer were conducted from Alert from March 12 to March 31 to search for chlorine dioxide.

Later analysis of the TOMS imagery showed that, unfortunately, no ozone hole or crater structure was present in spring, 1987. However, depleted layers were found in the ozone profiles from Saskatoon, Churchill and Resolute during March, 1987; these appeared to be similar to the depleted layers reported by Hofmann et al.[3] (1987) from the Antarctic during September, 1986. Thus, the crater mechanism may have been operating earlier in 1987, but the hole was probably destroyed by stratospheric warmings which took place in February and March.

The STRATOPROBE balloon flights were conducted on February 26 and March 19, 1987 from 52 N at a time when the vortex was nearby over northern Hudson Bay. In particular on February 26, the air at 30 mb had been in darkness for 2 weeks as it came from over the pole. The nitric acid profile showed greatly enhanced amounts of nitric acid with a layer maximum mixing ratio of 15 ppbv peaked at 20 km. Chlorine nitrate was also enhanced by a factor of 2 over summer values at the same latitude. Moderate amounts of nitrogen dioxide and N_2O_5 were observed.

In 1988, as part of CANOZE 3, STRATOPROBE balloon flights were conducted from Saskatchewan on January 27 and on February 13. A new light-weight infrared instrument was developed and test flown. A science flight was successfully conducted from Alert (82.5 N) on March 9, 1988 when the vortex was close to Alert; a good measurement of the profile of nitric acid was obtained.

Overall, the Arctic spring ozone layer exhibits many of the features of the Antarctic ozone phenomenon, although there is obviously not a hole present every year. The Arctic ozone field in March, 1986 demonstrated many similarities to the Antarctic ozone hole. The TOMS imagery showed a crater structure in the ozone field similar to the Antarctic crater in October. Depleted layers of ozone were found in the profiles around 15 km, very similar to those reported from McMurdo. Enhanced levels of nitric acid were measured in air which had earlier been in the vortex. The TOMS imagery for March 1987 did not show an ozone crater, but will be examined for an ozone crater in February and March, 1988, the target date for the CANOZE 3 project.

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