GLOBAL CHANGES IN THE OZONE LAYER

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Received for publication: March 1994

SUMMARY

The Antarctic Ozone Anomaly is a geographically large area with a considerable reduction of the stratospheric ozone that is repeated annually above the Antarctic. This anomaly appears around the beginning of September and lasts until mid-November. The alarming reduction of ozone above the Antarctic led naturally to considerations about the possibility of changes also over the Arctic.

KEY WORDS

ozone layer - reduction of ozone

INTRODUCTION

Total amount of ozone in the atmosphere hereafter, "total ozone", is an important and most frequently measured parameter that describes condition of the ozone layer (WMO, 1985). The role of the ozone layer in the atmosphere, the danger of its depletion resulting from human activity, and the necessity of its international protection, these topics are more and more attracting the attention of even the general public.

ANTARCTIC SPRING OF 1992

During 1992 the ozone depletion started two-three weeks earlier than in previous years and unusually low ozone, 30-35 % below the pre-ozone-hole averages of 1956-1977, was registered over a substantial region already in August and in early September. In the second part of September and in early October huge area with up to 65 % ozone destruction was persisting. This is illustrated in Fig. 1, where based on NASA-TOMS satellite data are plotted the surfaces (in million km^2) covered by ozone below 220 Dobson Units (D.U.) for 1992, for the 1987 (previous record low ozone year) and for the average surface of all ozone hole years before 1992 (UNEP, 1992).

In early October during one of the largest extensions of the ozone hole, it covered for three days a large portion of the tip of the South American continent. Than for the first time, permanently inhabited areas of southern Argentina and southern Chile were covered with ozone layer 50 % thinner than normal. Consequently, there was up to 100 % increase of the solar UV-B radiation reaching the surface, fortunately only for a very short time period.

The fact that the absolute lowest ozone values ever recorded were registered during 1992 is demonstrated in Fig. 2 . It should be noted that TOMS had observed a few ozone values below 200

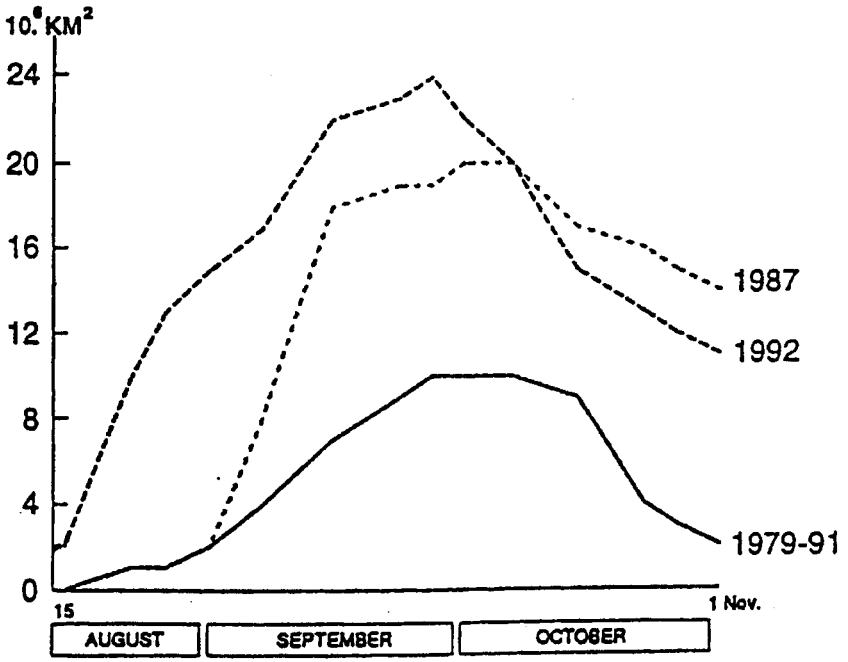

Fig. 1. Surface covered by ozone values less than 220 D.U. The 1979-1991 average (continous line) and for the two years with most severe ozone depletion (UNEP, 1992)

D.U. already in July. At the Antarctic ground stations in early October the absolute minimum daily ozone readings were registered as follows : 105 D.U. over the South Pole, 111 D.U. over the Halley Bay, 126 D.U. over Marambio, 129 D.U. over Faraday and 140 D.U. over Syowa. At the same time high but normal for this season ozone of above 360 D.U. covered the southern middle latitudes.

It is known from the previous Stratospheric Ozone Assessment that the changes of the ozone are pronounced in the lower stratosphere (e.g. above 10 km). Fig. 3 based on balloon ozone soundings taken at Syowa since the mid-1960s confirms current theoretical expectations. It shows that ozone was completely destroyed down to almost zero during these soundings of October 1992.

In 1992 lower stratosphere temperatures were a few degrees below the normal which caused polar vortex to be relatively strong and in Antarctica an abundance of stratospheric aerosols has been noted (mostly originating from last year's volcanic eruptions of Mt. Hudson and Mt. Pinatubo) which facilitate, on their surfaces, heterogeneous chemical reactions favouring speedy ozone destructions.

Finally it should be noted that during the 1992 Antarctic spring the lower stratosphere temperatures were of much below minus 80 °C, a few degrees colder than normal.

ANTARCTIC SPRING OF 1993

The latest bulletin on the state of the ozone layer by World Meteorological Organization (WMO) (WMO, 1993) indicates that for several days towards the end of September and early October, ozone

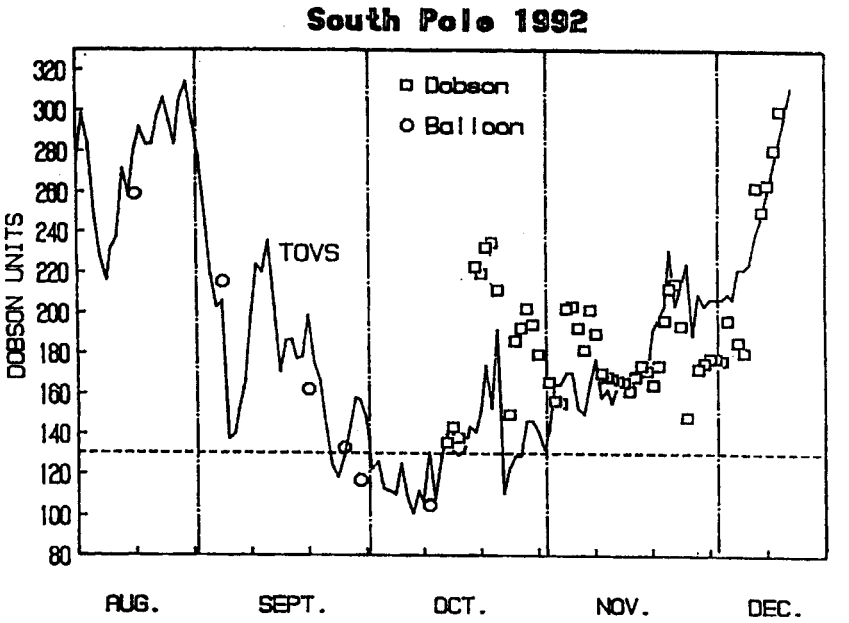

Fig. 2. Daily values during August to December 1992 of total ozone at the South Pole from TOVS (solid line), balloon ozonosonde (circles) and Dobson spectrophotometer (squares) (NOAA, 1992)

values over the Antarctic fell a few units below 100 D.U., representing the lowest absolute daily minimum ever recorded in the history of ozone observations.

Provisional data provided by WMO member countries operating the Global Ozone Observing System (GO_3OS) station and satellites show that for a period of three weeks from the end of September to the beginning of October, a region with less than 150 D.U. encircled the entire continent. Furthermore, over a huge area stretching poleward from 70°S the ozone was less than 120 D.U., representing a 70 % reduction compared to pre-ozone-hole averages.

WMO also announced that during the last days of September, the stratospheric polar vortex elongated in the direction of the southern end of the South American continent and for the two days the ozone amount over its most southern tip was down nearly to 200 D.U. The normal value is usually 330-340 D.U. for this time of year.

To illustrate the severity of the problem, that more than 60 % of the ozone was destroyed in the central part of the Antarctic over an area greater than all of Europe.

According to the NOAA, temperatures in the stratosphere of below -80 °C continue to dominate over the continent, thus facilitating ozone-destructive chemical reactions.

How much longer the ozone hole will continue, this year will depend on the stability of the vortex. Under the influence of solar heating and exchanging with warmer mid-latitude air masses the vortex usually disintegrates by the mid-November.

The nations of the world agreed to prohibit the production of chlorofluorocarbons (CFCs) and other ozone-depleting chemicals from the end of 1995 through the UNEP-negotiated Montreal

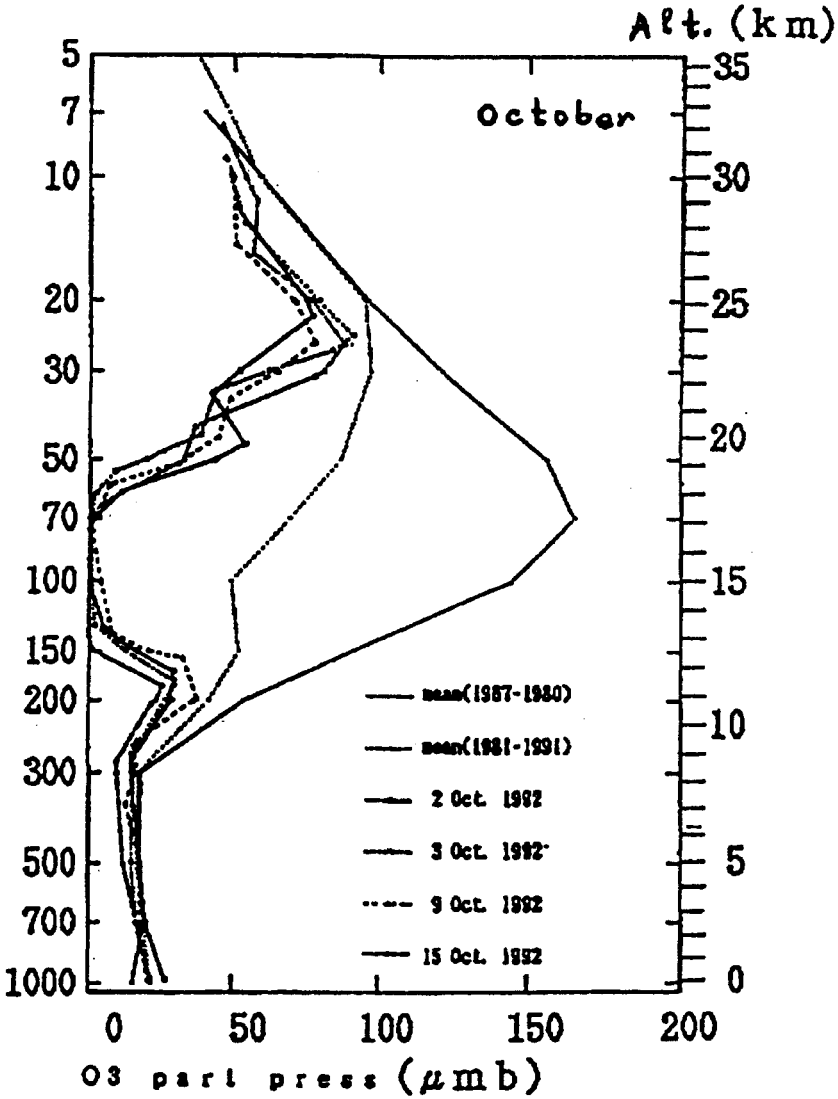

Fig. 3. Vertical ozone distribution in October over Syowa for the pre-ozone hole years (continuous line), for the ozone hole year (1981-1991 dotted) and four balloon sonde assessments of October 1992 showing complete destruction of the ozone between 13 and 18 km and substantial reduction in the immediate layers below and above (UNEP, 1992)

Protocol. Many countries have undertaken specific measures such as removing CFCs from aerosol cans and food packing foam, and avoiding the use of CFC-dependent air-conditioning system.

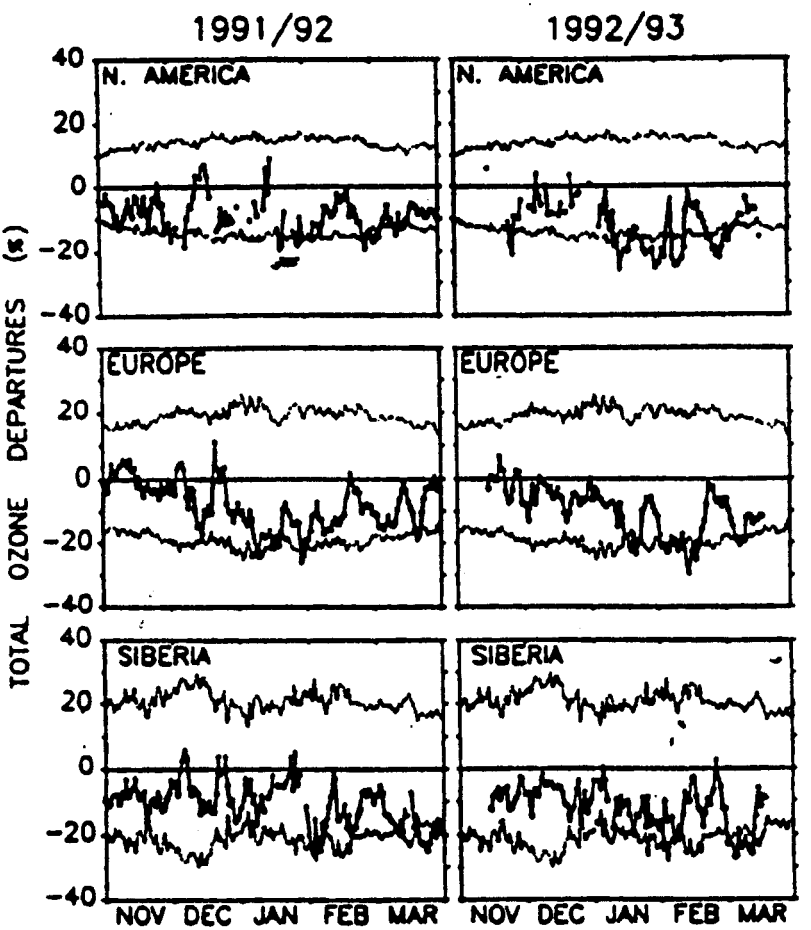

Fig. 4. Daily average (45°N - 65°N) of total ozone and 5-day running means of the 2d envelopes expressed as percent departures from the 37-year mean for 1991-1992 (left column) and 1992-1993 (right column) (Bojkov et al., 1993)

TOTAL OZONE DURING NORTHERN WINTERS OF 1992-1993

It is well know from the WMO Ozone Assessments (WMO, 1989, 1991) and other studies (Bojkov et al., 1990; Stolarski et al., 1992) that total ozone above the Northern Hemisphere middle and polar latitudes has been declining in the past two decades, i.e. after the chlorine loading of the stratosphere exceeded certain levels.

From Fig. 4 one can easily follow the departures of total ozone from the long-term daily normals over the three regions. There have been only one or two short episodes with low ozone values during December but in January 1992 over Europe the average deficiency between 50°N and 60°N exceeded -20 % registering record low values through the beginning of February. Than a tendency for recovery

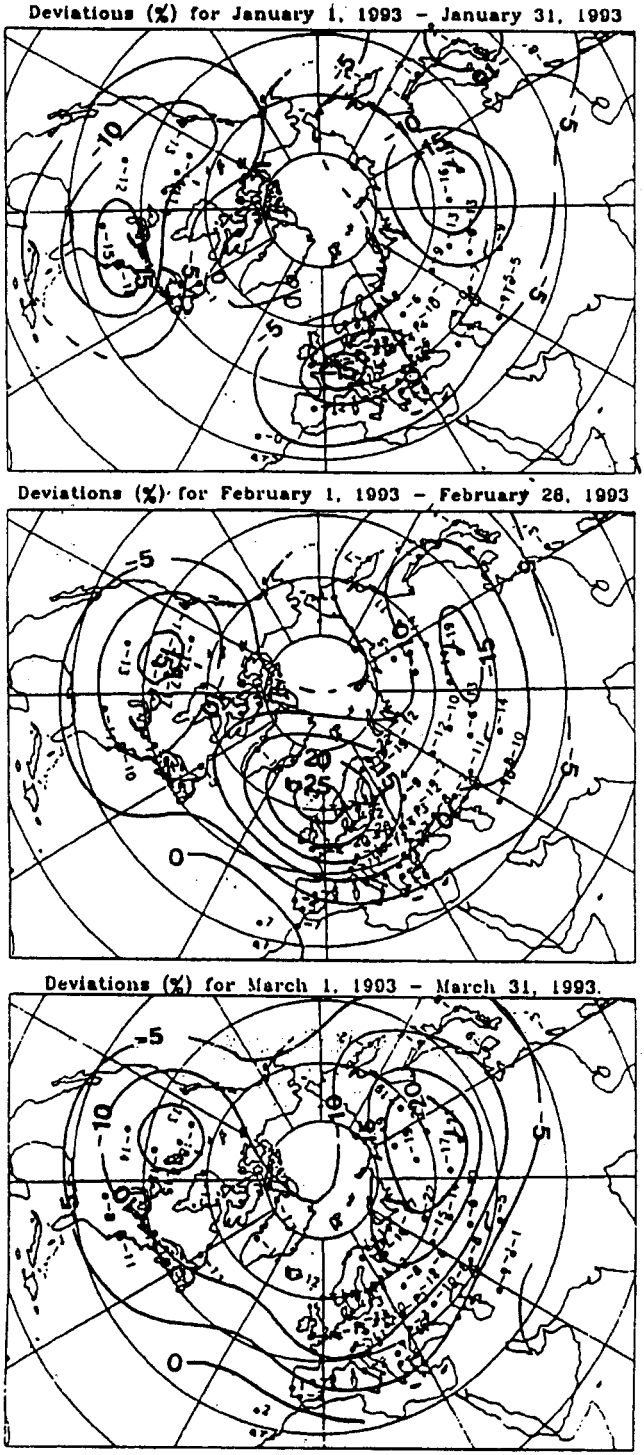

Fig. 5. Summary maps of ozone deviations from long-term mean in percent for January (upper), February (middle) and March (lower) (Bojkov et al., 1993)

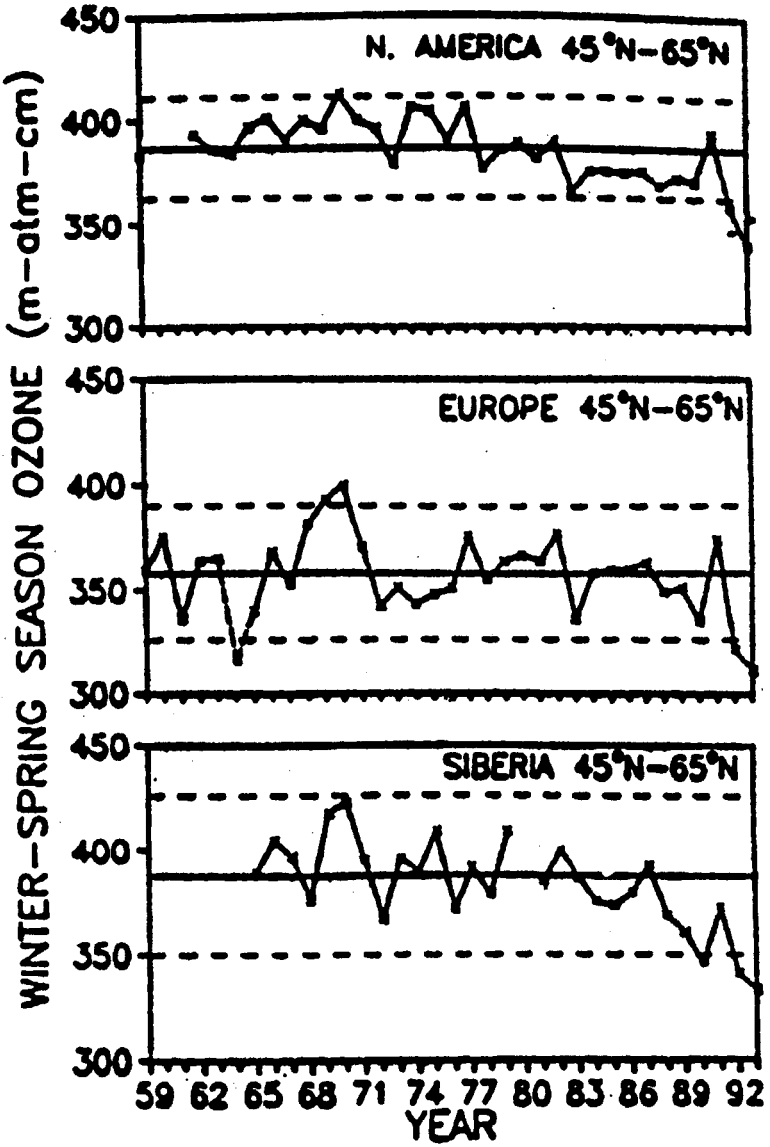

Fig. 6. Time series of mean (December, January, February, March) total ozone and its 2d confidence limit during the period 1959-1993 (Bojkov et al., 1993)

was noted but until the end of the season the values were always below normal; 5-10 % over northern and central Europe and 10-15 % over western Canada. In February and March 1992 the region with the largest total ozone anomalies -15 % to -20 % appeared eastward over Asia.

Looking at the 1992-1993 records of the ozone deviations in Fig. 4 one is struck by the extremely low values during mid-January and especially the first half and end of February over Europe and North America and end of January and end of February through mid-March over Siberia.

At the Fig. 5 are plotted summary maps of the ozone deviations from the long-term means established by Fioletov and Kadygrova (1990) for January, February and March 1993, which again demonstrates that the observed negative departures are encompassing nearly the entire mid-latitude belt. The departures are notably smaller over the polar region and over the ocean areas. While in January over the central part of three continents there was 10 % to 15 % deficiency, in February, over northern Europe and in the first half of March over Siberia, it exceeded 25 %, which overstep the 2δ limits for the given regions.

In order to put the extremely low ozone values of the last two winter-spring seasons in perspective, in Fig. 6 are plotted for each of the three regions their seasonal values and the 2δ confidence limits (derived from all the seasonal values during 1959-1990). It is clear that the values of the last two seasons are the lowest ever observed. Statistically they are even below the 2δ mark which assure us that they can be classified as extreme events (Bojkov et al., 1993).

CONCLUSION

It should be noted that during the last two years, the winter-spring seasons (and there are indications that also the other seasons of the last year) have had with record low total ozone over the most of the 45°N - 65°N latitudinal belt and that the number of days with negative deviations below 2δ has been ten times larger than the average during the past 35 years.

Finally it should be noted that more than 70 % of the ozone was destroyed in the central part of the Antarctic over an area greater than all of Europe.

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