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RECALCULATED VALUES OF THE TOTAL OZONE AMOUNT OVER OSLO, 60° N, FOR THE PERIOD 1979-1992

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Abstract.
The total ozoneamount over Oslo has been measured with the Dobson spectrophotometer No 56. The instrument was modified, calibrated and intercompared in 1977 in Boulder. A new intercomparison was made in 1986 in Arosa. Much work has been done to make the zenith charts reliable. A new method has been introduced where one takes into account the change in the shape of the zenith chart curves which is caused by a change of the ozone profile when the ozoneamount changes. According to the conclusion derived from the intercomparison in Arosa 1986, the instrument has not been stable. The R-N tables had to be altered, but not the Q-tables. We have tried to account for this change in our handling of the observation data. No statistical analyses of these data has yet been made, but the monthly averages of the raw data show a negative linear trend of about 4% for the whole period.

1. INTRODUCTION

Dobson spectrophotometer No 56 has been operated at the University of Oslo since 1969 when we got it from The Norwegian Polar Institute. At that time the instrument required recalibration since the instrument had been damaged during an expedition to Antarctica some years before. In 1977 the instrument was sent to Boulder where W.D. Komhyr, R.D. Grass, and S.H.H. Larsen modified and re-aligned the instrument, which was in a bad shape. The optical wedge was recalibrated and a new photomultiplier was put in and adjusted. The prisms and mirrors were cleaned and the position adjusted. Also the positions of the slits and the slit-widths were checked. Afterwards the instrument was a part of an intercomparison campaign in Boulder, August 1977.

In Oslo the main observation series started in 1978. The zenith chart and the cloud correction charts had to be constructed, a task which had to take some time due to great changes in weather and ozoneamount. We decided to depend on observations carried out with the C wavelength pair because we wanted to get as many observations as possible throughout the winter season with low sun. Due to this the observations will suffer from large standard deviations because of change in the turbidity, SO_2 - amount, and clouds. The AD wavelength pair will give more accurate measurements when the sun is high enough, with an airmass less than 3.5. With lower sun, the internal scattering and skylight will influence and give too low ozone values.

In 1986 the instrument was in Arosa for a new intercomparison. In spite of satisfactory Hg-lamp tests new N-tables were required after the Arosa intercomparison. This resulted in an increase in the calculated ozoneamounts after 1986 of about 3-4%. This may be caused partly of a change in internal scattering from all optical components and a change in the photomultiplier response.

The ozone data presented here are recalculated data. The relative large data set has made it possible to construct new zenith chart where model calculation and observations have been combined. A radiative energy transfer model for the atmosphere has been used, where primary and multiple scattering from the zenith sky, are derived. The ozone distribution in the model has been selected from ozone sonde ascents carried out near Oslo.

The cloud correction charts are constructed in a similar way by using a large particle scattering model and combine the model calculations with observations.

One has to trust the intercomparisons in 1977 and 1986 where the instrument has been compared directly to the world standard No 83. We first assumed a linear drift of the instruments calibration from 1977 to 1986 and afterwards an stable instrument. The data were recalculated with changing R-N tables incorporated in the computer program. We were not quite satisfied with this procedure. Being aware of the breakdown of the instruments electronics in 1980, which took the instrument out of operation several months in 1980-81, we decided to follow another course. The 1977 R-N tables were used for the data up to the end of 1980 and the 1986-tables were used from the summer 1981 and onward. The ozone data now derived, seem to agree well with the data from nearby stations as Norrköping, Copenhagen and Lerwick. The recalculated data also agree well with the data derived from our Brewer instrument which we installed in 1990. In all our calculations we have used the ozone absorption and molecular scattering coefficients recommended by WMO, Ozone Commission, in December 1991. Our Brewer instruments calibration was checked against the travelling standard instrument in the summer 1991.

REVISION OF THE DATA SET

The measurements in Oslo. 60° N, carried out with the Dobson spectro-photometer No 56, were a supplement to the measurements which had been established in Tromsø, 70° N, in 1936 and in Longyearbyen at Spitzbergen, 78° N, in 1950. The behaviour of the atmospheric ozone over Oslo seems to be representative for the condition in the Arctic. A comparison between the winter values of the total ozone in Oslo and the mean values of 12 stations north of 58° N, agreed very well in the period 1978-1986. In 1986 the series of the 12 stations means were terminated (1,2).

After the dataset for Oslo has been revised, the ozone data should be more reliable and a more structural picture of the ozone behaviour appears. The variations in the ozone amount can be large and rapid and are well correlated with the movements of the polar front. This change in weather condition will influence the quality of the observations. In cloudy weather one has to depend on zenith light observations which are less accurate than the basic direct sun observations. A rapid change of weather may also alter the vertical ozone profile which introduces uncertainties in the method of observation. This is, however, the situation.

In order to improve the zenith sky method of observation, we plan to introduce another type of measurements. Our Brewer spectrophotometer, M4, measures the global UV irradiation. From a calculated or empirical constructed radiation chart, one can estimate the ozone values. This has been done in Antarctica and in Tromsø (3). It seems as if clouds will make very little influence.

Most of our direct sun measurements are made with the C wavelengthpair. Since 1990 the AD combination has been a regular routine in our observing program.

The AD measurements are recommended since they are least dependent of atmospheric scattering. However, our routine observing program is always, C, A, D, C and C C'. This means C, A, D, C direct sun and CC' zenith sky observations. The difference between C and AD direct sun has decreased since we started to use the new absorption coefficients. The difference C-AD seems to have seasonal variations with a higher value in the Spring. If the C-AD difference is large, C direct sun usually gives a higher ozone amount than the corresponding zenith light observation when the revised zenith blue charts are used.

When the solar zenith angle is less than 75° we think that an AD measurement gives the true ozone value. For higher solar zenith angles, however, they may be too small due to the very low intensity in the A wavelength pair. In the autumn when the clear sky is more common, one would expect the C direct sun to give reliable ozone values for solar zenith angles up to 78°, and still higher with the focused image method. Due to this, the C direct sun measurements have been used to revise the zenith charts.

PRESENTATION OF THE RECALCULATED OZONE DATA IN OSLO

As declared, we decided to use two set of R-N tables. We used the 1977-tables for the data from February 1, 1978 to November 6, 1980. The 1986-tables were used from July 1, 1981 and onward. In the meantime we used the Dobson instrument no 14 which we had in Oslo at that time.

To get more reliable ozone values from the zenith sky observation, much work has been done to make the zenith charts better. We checked the quality of the zenith chart, by calculating the difference between zenith sky and direct sun measurements. The difference should be as near zero as possible.

The method used to obtain reliable ozone values from the zenith sky observations is to make the first attempt with chart No 1.

If the ozone value obtained is above 400 DU one goes to chart No 2 to derive the best value. If the ozone value is under 300, one goes to chart No 3 to get the best value. In this way one has counted for the fact that the vertical distribution of the atmospheric ozone changes when the total ozone amount increases or decreases. This method could be refined further. In figure 1 and 2 the ozone difference between zenith -and direct sun measurements for the two charts are shown.

With the new zenith charts applied, together with the revised cloud correction charts, revised ozone values over Oslo have been calculated. The data series cover the period from February 1978 to January 31. 1992. In figure 3 the monthly averages of total ozone are given in a diagram. The estimated linear trend is calculated. It is negative and it amounts to 4%. In the diagram in fig. 4 the TOMS monthly averages over Oslo are plotted. The linear trend is calculated. It is negative and it amounts to 10% (4).

A twelve months running mean for the Dobson measurements in Oslo has also been calculated and is plotted in the diagram in figure 5. The diagram gives an exaggerated picture of the ozone behaviour of the period around 1982 and probably the beginning of a period around 1991. Both periods will count heavily in any estimate of a trend in the ozone data.

The data set which is presented here is not ready to be used in a statistical model. There are still unsolved problems with the C direct sun and C zenith sky measurements, especially in Spring. However, the data set, which is available on disks, should be more reliable than the values given in the "Red Book", the ozone data for the world. In due time these will be revised.

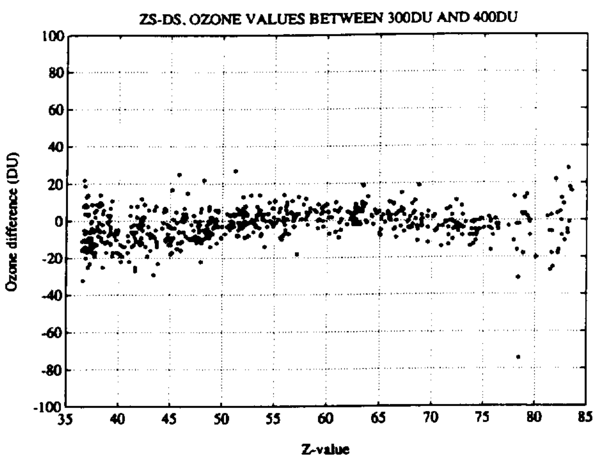

Figure 1: Ozone differences between zenith (zs) and direct sun (ds) measurements for ozone values between 300 and 400 DU. Chart No 1. (Z: solar zenith angle).

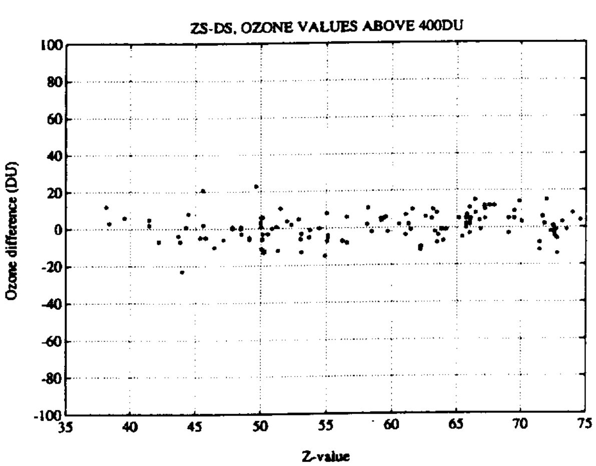

Figure 2: Ozone differences between zenith and direct sun measurements for ozone values above 400 DU.

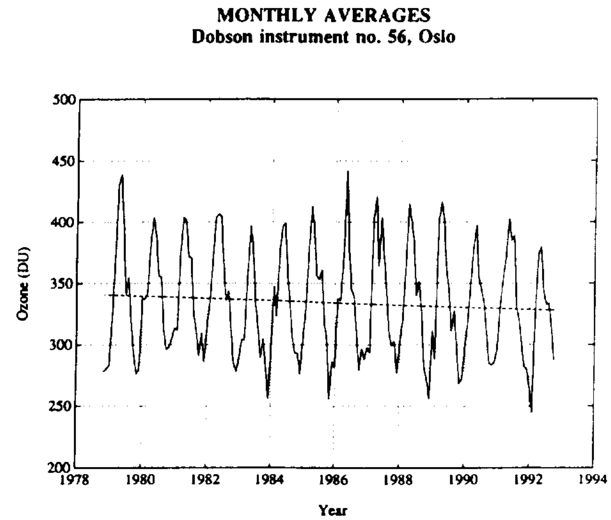

Figure 3: Total ozone amount at Oslo, monthly averages from Dobson measurements.

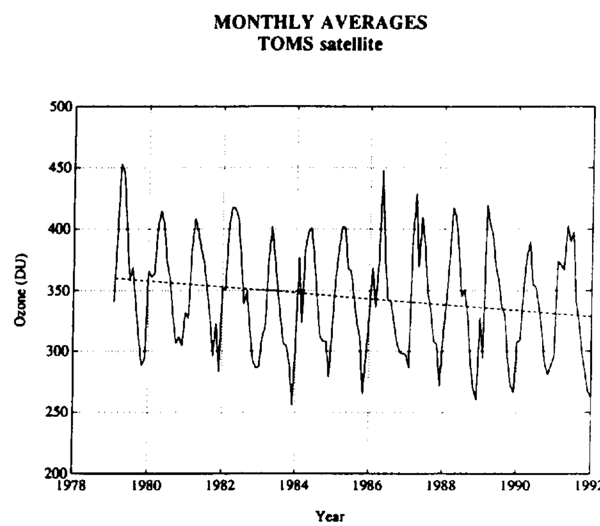

Figure 4: Total ozone amount at Oslo, monthly averages from TOMS data.

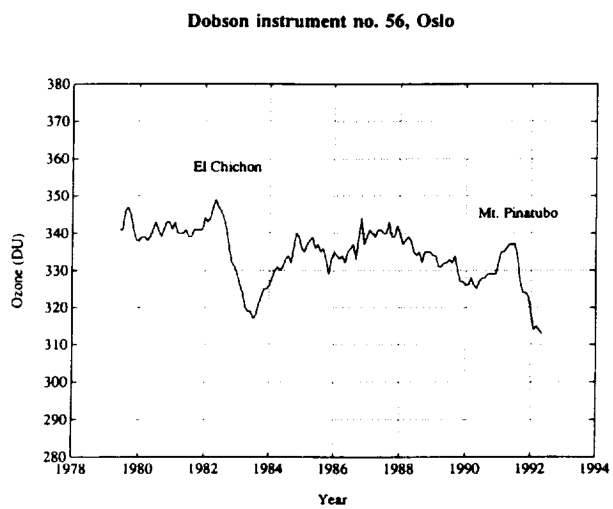

Figure 5: The twelve months running mean of the total ozone amount from Dobson measurements in Oslo.

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