The International Ozone Commission (IO3C)
Its history and activities related to atmospheric ozone

Rumen D. Bojkov

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Prolegomena

The year 2010 commemorates the 80th anniversary since the first international Conference on Ozone and Atmospheric Absorption, held in Paris in 1929, with 33 participants. The first society of ozone professionals was established as a Committee on Ozone in 1933 and it was later on renamed as the International Ozone Commission (1948). That Commission was part of the International Association of Meteorology, predecessor of today's International Association of Atmospheric Sciences (IA-MAS). The International Ozone Commission as an acronym was differentiated from similar acronyms of other Commissions by Rumen Bojkov in the 80s, adapting it to be IO3C. It is indeed a lucky coincidence that Rumen Bojkov has finished his review on the history of the Ozone Commission and it was with great pleasure that I accepted introducing it.

Since its creation the International Ozone Commission started acting as an advisory body to provide guidelines for atmospheric measurement techniques and emphasizing the importance of ozone as a trace gas and as a radiative gas with emphasis to its relations with meteorology. The International Geophysical Year (IGY, 1957) has provided the basis for the creation of the first coherent global ozone observing network under the wise guidance of late professor Dobson, who has acted as the first President of IO3C.

In the past 30 years the Commission has followed a spectacular expansion, caused by new scientific findings that manmade activities could threat the ozone layer. The importance of the International Ozone Commission has been further enlarged by the discovery of the Antarctic ozone hole in 1984/85. The need to tackle the role of ozone in a globally changing environment resulted to a further expansion of the Commission to become more interdisciplinary. Today, the expanded scientific goals of the Commission include advances in understanding dynamical and chemical processes involved in the variability of the atmospheric ozone, interac-
tions of stratospheric and tropospheric processes including interactions with aerosols, air pollutants and climate. In addition, global impacts of UV changes on health have formed a growing new area of research falling within the interests of the Commission.

Since the creation of the Montreal Protocol in 1987 there have been several recommendations forwarded by IO3C which unfortunately can only be found in protocols and notes prepared mostly by the Secretaries of the Commission in documents difficult to obtain. Therefore, it is to the merit of Rumen D. Bojkov for collecting most of this scattered information and tracing the IO3C activities from 1929 until the last Quadrennial Ozone Symposium held in Tromsoe in 2008. Rumen D. Bojkov has been an extraordinarily active Secretary of the Commission for 16 years and under his leadership the WMO ozone network activities have been expanded and reached high standards. I am confident that the reader of the history written by our honorary Member, Rumen Bojkov, will find it interesting and inspiring. I should note here that Dr. Bojkov has served actively ozone science and the ozone community for more than 40 years. On behalf of the Commission I would like to extend our thanks to Rumen for undertaking the preparation of this interesting historical review in our field.

Christos S. Zerefos Athens, 3 May 2010
President
International Ozone Commission
The International Ozone Commission (IO₃C)
Its history and activities related to atmospheric ozone

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Abstract

The review of the historical development of ozone science reveals how systematic measurements using ground and space based methods provided information on ozone global behaviour and together with the advancements in atmospheric chemistry raised warning and ultimately prevented ozone destruction. In 1933 within the International Association of Meteorology (IAM) a Committee on Ozone was established to assist the exchange of scientific results. It was upgraded as independent International Ozone Commission (IO₃C) in 1948. In the first few decades the Committee and the Commission were preoccupied with improving of the measuring methods and instruments and stimulating the enlargement of the network of stations from less than a dozen before 1951 to more than 50 by the completion of the International Geophysical Year (IGY) in 1958. Thanks to data from these stations in the 1980s an actual ozone decline was discovered to be the strongest during Antarctic spring. The global coverage was achieved with the launches by NASA of satellite instruments in the 1970s supplemented by over 100 ground based Dobson instruments for which the uniformity of their operation, calibrations and data collection protocols were taken care by the World Meteorologi-

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cal Organization (WMO) since 1956. After that the Ozone Commission retained its general scientific interest in ozone work and organized more than 33 ozone symposia. The second period of activities of IO3C started in early 1970s with the explosive increase of ozone studies related to the discovery that certain anthropogenic emissions could be destroying the ozone layer. The scientific community started to work toward international agreements for saving the ozone layer which culminated with the conclusion of the Vienna Convention and its Montreal Protocol. Most members of IO3C were taking active part in these studies and three of them (Crutzen, Rowland and Molina) were awarded the Nobel Prize for Chemistry in 1995. In the last decade greater emphasis started to be given to studies of ozone and climate change interactions.

**Key words:** ozone measurements, ozone decline, ozone and climate, ozone symposia, history of ozone science, International Ozone Commission, Montreal Protocol

**Introduction**

The discovery of atmospheric ozone and the initiation of the first systematic measurements of ozone near the ground dated back to the middle of the 19th century were connected with the name of Christian F. Schönbein (Professor of Chemistry at the University of Basel). While engaged in experiments on the decomposition of water by electricity, he noticed a peculiar odor and aimed at discovering its cause. His communications to the French Academy (Schönbein, 1840a) and to Poggendorf’s Annalen (Schönbein, 1840b, 1845) drew the attention of the scientific world to the existence of an atmospheric constituent having a particular odor which he called ozone (in Greek ‘ozein’ means to smell). He considered it to belong to the halogens. Marignac and de la Rive (1845) showed that ozone contained nothing but oxygen. Houzeau (1858) chemically proved that ozone exists in the troposphere, at ground level, and that it must be denser than oxygen (Houzeau, 1865). The latter result was explained theoretically by Odling who described the ozone molecule as triatomic oxygen, which was experimentally proven by Soret (1863, 1865). Using the oxidizing capacity of the
ozone, Schönbein initiated ground-ozone measurements which spread after the mid-1850s to more than 300 places. Reliable chemical measurements of ground ozone in Montsouris (Paris) were carried by Levy from 1877 to 1907. These data show that ground ozone concentrations a century ago were three times smaller than at the present time (e.g., Bojkov, 1986).

The development of the first network of total ozone observing stations was the result of the activities of a small group of enthusiastic scientists guided by the Ozone Commission of the International Association of Meteorology (now IAMAS). Since the International Geophysical Year (IGY) the development of the ozone observing network, was taken by the World Meteorological Organization (WMO). To avoid repetitive statements in the text it should be emphasised that since 1956 all intercomparisons of instruments, ozone data collection, scientific assessments, international symposia, and numerous ozone related meetings have been sponsored by WMO. It was playing the leading role in assuring uniformity of procedures, and coordination of ozone studies, including arranging for organization of International Scientific Assessments conducted periodically since 1981. A formal agreement for collaboration between WMO and the International Association for Meteorology and Atmospheric Physics (IAMAP) has been the base for close coordination with activities of the IO3C ever since. In the following, after the few remarks on the physical basis of the ozone measurements, the history of the IO3C and related ozone activities are discussed chronologically within the context of 33 conferences and ozone symposia organized from 1929 (Paris) until 2008 (Tromsø).

Physical basis for quantitative ozone measurements.

Cornu (1879) noted the sharp limit of UV end in the solar spectrum (<300nm) received at the ground. Hartley (1881a, b) explained the cutoff in UV radiation at 293 nm as due to ozone most of which is located in the stratosphere. The UV absorption by ozone provided the basis for the development of optical instruments for measuring total ozone in a vertical column above the observing point. That was done first by Fabry and Buisson (1913) who made the first careful measurements of the ozone absorption coefficients and estimated the total amount to be ~500 matm-
cm. Few years later they returned to the subject and made the first systematic quantitative measurements of total ozone in Marseilles in May-June 1920. They used a double spectrograph able to compare the intensity of two UV wavelengths in the 305-330nm band (one strongly absorbed by the ozone and the other not absorbed) from which reasonable total ozone values of ~300matm·cm in a vertical column of the atmosphere were deduced (Fabry and Buisson, 1921). They thought correctly that ozone was formed by solar UV radiation and that if this was so it would be situated at a height of about 40km (later was corrected to 25km).

The first network for daily ozone measurements was initiated by Gordon M. B. Dobson from Oxford. Following the method established by Fab-
ry and Buisson he adopted a UV quartz spectrograph using the Fêry curved-prism and did build six such ozone spectrographs with a grand from the Royal Society London (Dobson and Harrison, 1926; Fêry, 1911). After 1925 he dispatched these to different Meteorological Services for a year or two in order to study the behaviour of atmospheric ozone in the world and its eventual use in the weather forecasting. Thus, observations were collected in 1926-27 from Abisko, Lerwick, Valentia, Oxford, Lindenberg, Arosa and Montezuma; in 1928-29-30 from Oxford, Arosa, Table Mountain, Helwan, Kodaikanal and Christchurch. More than 6000 plates of the spectrographs have been developed and analysed in Oxford. From this data base Dobson et al., (1927, 1929) deduced the basic knowledge

Figure 2. Gordon M. B. Dobson (1889-1976) was the Chairman of the Committee on Ozone (1933-1948) and first President of IO3C (1948-1959). He was a remarkable physicist, professor in Oxford, Fellow of the Royal Society. He developed the double quartz spectrophotometer used until today and pursued with unrelenting vigour ozone study all his life establishing the nuclei of the Global Ozone Observing System (GO3OS). Elected Honorary member in 1963. (Courtesy of Clarendon Lab., University of Oxford).
of meridional and seasonal ozone distribution: less ozone in the tropics and during the summer and more ozone poleward and during the spring season. In 1930 he did design his own double quartz spectrophotometer from which in the next twenty years about a dozen were produced by a firm for science-instruments *Ealing-Beck Ltd of London* (Dobson, 1931).

Before 1951 when the IO3C started to prepare for the International Geophysical Year (IGY) only less than a dozen stations were having more than 3-years of mostly sporadic observations with the standard Dobson spectrophotometer. Longer records were available only from Arosa, Oxford, Tromso and Shanghai (Zi-Ka-Wey Observatory).

The Commission succeeded to stimulate interest and at the start of the IGY there were 32 reporting stations increasing for the International Quit Sun Year (IQSY) to more than 50 and to ~100 in the late 1960s. Until today they form the backbone of the Global Ozone Observing System (GO3OS) providing ground truth for the more sophisticated satellite observations beginning their global coverage in the early 1970s and more regularly since 1979. The Ozone Commission President (G. M. B. Dobson) and Secretary (Sir Charles Normand) were directly supervising production, calibrations and distribution in a global network of the spectrophotometers to be ready for IGY ozone programme (Dobson, 1960). IO3C until the end of IGY was developing detailed operation manuals, assessing absorption coefficients to be used, providing inspections and advice on how to make vertical ozone distribution measurements using the Umkehr effect (Dobson, 1957a, b). The latter was discovered by F. W. Paul Götz (1931) during his ozone measurements at Spitsbergen starting in 1929. It consists of measurements of the ratio of zenith-sky UV intensities of two wavelengths at 12 solar zenith angles between 60° and 90°.

**Ozone conferences and symposia**

One convenient way to follow the development of ozone studies and the role played by the group of enthusiastic scientists forming the Committee on Ozone and later the IO3C is by reviewing the numerous ozone symposia and relevant discussions and recommendations in a chronological order. In Table 1 are listed conferences and symposia on atmos-
<table>
<thead>
<tr>
<th>No.</th>
<th>Event Description</th>
<th>Location</th>
<th>Date Range</th>
<th>Abstract/Papers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Confer. on Ozone &amp; Atmosph Absorp.</td>
<td>Paris</td>
<td>15-17 May 1929</td>
<td>27</td>
</tr>
<tr>
<td>2.</td>
<td>Confer. on Atmosph Ozone</td>
<td>Oxford</td>
<td>9-11 Sep 1936</td>
<td>29</td>
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<tr>
<td>3.</td>
<td>Special meeting on Ozone</td>
<td>Tharant</td>
<td>17-18 April 1944</td>
<td>14</td>
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<tr>
<td>4.</td>
<td>Symp. on Ozone</td>
<td>Oslo</td>
<td>30-31 Aug 1948</td>
<td>18</td>
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<td>5.</td>
<td>Symp. on Atmosph Ozone</td>
<td>Brussels</td>
<td>30-31 Aug 1951</td>
<td>15</td>
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<tr>
<td>6.</td>
<td>Symp. on Ozone</td>
<td>Oxford</td>
<td>2-4 Sep 1952</td>
<td>16</td>
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<tr>
<td>7.</td>
<td>Symp. on Atmosph Ozone</td>
<td>Rome</td>
<td>10-11 Sep 1954</td>
<td>18</td>
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<tr>
<td>8.</td>
<td>Confer. on Ozone</td>
<td>Ravensburg</td>
<td>25-29 June 1956</td>
<td>25</td>
</tr>
<tr>
<td>9.</td>
<td>Symp. on Atmosph Ozone and Problems of the Upper Atmosphere</td>
<td>Toronto</td>
<td>10 Sep 1957</td>
<td>10</td>
</tr>
<tr>
<td>10.</td>
<td>Symp. on Atmosph Ozone</td>
<td>Oxford</td>
<td>20-25 July 1959</td>
<td>50</td>
</tr>
<tr>
<td>11.</td>
<td>Symp. on Atmosph Ozone</td>
<td>Arosa</td>
<td>7-11 Aug 1961</td>
<td>40/60</td>
</tr>
<tr>
<td>12.</td>
<td>Session on Ozone and Circulation above 20km</td>
<td>Berkley</td>
<td>22-23 Aug 1963</td>
<td>24/70</td>
</tr>
<tr>
<td>13.</td>
<td>Symp. on Atmosph Ozone</td>
<td>Albuquerque</td>
<td>1-5 Sep 1964</td>
<td>59/83</td>
</tr>
<tr>
<td>14.</td>
<td>Session on Atmosph Ozone</td>
<td>Lucerne</td>
<td>27 Sep 1967</td>
<td>17</td>
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<tr>
<td>15.</td>
<td>Symp. on Atmosph Ozone</td>
<td>Monaco</td>
<td>1-6 Sep 1968</td>
<td>60/75</td>
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<tr>
<td>16.</td>
<td>Symp. on Atmosph Ozone</td>
<td>Arosa</td>
<td>21-26 Aug 1972</td>
<td>70/90</td>
</tr>
<tr>
<td>17.</td>
<td>Sessions on stratospheric composition and anthropogenic perturbations</td>
<td>Melbourne</td>
<td>12 Jan 1974</td>
<td>10/100</td>
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<td>18.</td>
<td>Sessions on fluorocarbons in the stratosphere and dynamic models</td>
<td>Grenoble</td>
<td>27-28 Aug 1975</td>
<td>18/90</td>
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<tr>
<td>19.</td>
<td>Symp. on Atmospheric Ozone</td>
<td>Dresden</td>
<td>9-17 Aug 1976</td>
<td>100/146</td>
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<tr>
<td>20.</td>
<td>Symp. on Conseq of Changes in the composition of the stratosphere</td>
<td>Toronto</td>
<td>26-30 June 1978</td>
<td>65/130</td>
</tr>
<tr>
<td>21.</td>
<td>NATO ASI on Atmospheric Ozone</td>
<td>Algarve</td>
<td>1-13 Oct 1979</td>
<td>53/120</td>
</tr>
<tr>
<td>22.</td>
<td>Sessions on strato &amp; mesosphere comp., circulation and modelling</td>
<td>Canberra</td>
<td>5-7 Dec 1979</td>
<td>27/90</td>
</tr>
<tr>
<td>23.</td>
<td>Symp. on Atmosph Ozone</td>
<td>Boulder</td>
<td>4-13 Aug 1980</td>
<td>190/275</td>
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<tr>
<td>24.</td>
<td>Symp. on Atmosph Ozone</td>
<td>Halkidiki</td>
<td>3-7 Sep 1984</td>
<td>161/220</td>
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<tr>
<td>25.</td>
<td>Symp. on Atmosph Ozone</td>
<td>Göttingen</td>
<td>4-13 Aug 1988</td>
<td>198/500</td>
</tr>
<tr>
<td>26.</td>
<td>Symp. on Atmosph Ozone</td>
<td>Charlottesville</td>
<td>4-13 June 1992</td>
<td>415/520</td>
</tr>
<tr>
<td>27.</td>
<td>Conf. on Ozone in the Lower Stratosphere</td>
<td>Halkidiki</td>
<td>15-20 May 1995</td>
<td>130/300</td>
</tr>
<tr>
<td>28.</td>
<td>Symp. on Atmospheric Ozone</td>
<td>L'Aquila</td>
<td>12-21 Sep 1996</td>
<td>252/622</td>
</tr>
<tr>
<td>29.</td>
<td>Symp. on Atmospheric Ozone</td>
<td>Sapporo</td>
<td>3-8 July 2000</td>
<td>403/566</td>
</tr>
<tr>
<td>30.</td>
<td>Symp. on Atmospheric Ozone</td>
<td>Kos</td>
<td>6-12 June 2004</td>
<td>694/700</td>
</tr>
<tr>
<td>32.</td>
<td>Symp. on Atmosph Ozone</td>
<td>Tromso</td>
<td>29 Jun-5 July 2008</td>
<td>470/500</td>
</tr>
</tbody>
</table>

**Table 1.** International Ozone Symposia and Conferences organized mainly by IO3C and usually attended by most of its members. In the last column are given the number of published abstracts (or papers) and when known / the number of participants.
pheric ozone organized and/or attended by most members of the Commis-

The first years of ozone observations and studies are actually less
known today for thousands of ozone scientists, because they are mostly
not included in commonly available publications of IAM-IUGG. This actu-
ally was part of my motivation to prepare this paper, identifying activities
and personalities involved and providing interesting information. Start-
ing with the 1968 symposia, presentations were published regularly in
voluminous proceedings which are available but can not be summarized
in such an article. This is true especially for the booming ozone research
period starting in the 1970s, including multi-volume proceedings exceed-
ing thousand pages for most of which references are provided under the
common name ‘ozone’ followed by the year of the symposium. Although
IO3C meetings were coinciding with the symposia the recommendations
made are to be found only in protocols and notes prepared by the Secre-
taries of the Commission scattered in various limited distribution publica-
tions of the mother Association (IAM, IAMAP, IAMAS) which are difficult to
obtain. In this work brief references are made to the Commission meet-
ings held along with the various symposia aiming to throw light on IO3C
discussions and to mention names of scientists who have made signifi-
cant contributions. More details will be posted during 2010 on the IO3C
web site (http://ioc.atmos.uiuc.edu). It should be noted as disclaimer that
in such historical review mentioning names of active scientists in most
cases is without their academic degrees and/or titles and usually their
overall contributions to the development of ozone science are not dis-
cussed in detail except in relation to the of activities of the Commission.

Committee on Ozone (1933-1948)

The first international scientific Conference on Ozone and Atmospheric
Absorption was organized by Charles Fabry in May of 1929 in Paris and
it had 27 presentations (Ozone, 1929). It was attended by 33 enthusiastic
scientists participating in the Dobson and Fabry investigations including
meteorologists and few spectroscopists. They did form the nucleus
of the first society of professionals interested of discussing ozone related questions. Following the Conference, Charles Fabry approached the Forth IUGG Assembly (Stockholm, 1930) to establish ‘an affiliation to assist exchange of scientific results in the field’. The Assembly expressed interest in the continuation of ozone observations and authorised the establishment of a sub-commission, within the existing Radiation Commission with Fabry and Dobson, to layout plans for the future and select other members notable among which were Abbot, Angström, Chalonge, Götz, Kimball, Ladenburg.

At the First Conference Dobson had introduced the real meteorological significance of atmospheric ozone with respect to its changes with the weather systems, latitude and seasons. Daniel Chalonge and Paul Götz had reported that they did not detect any diurnal variation in the total ozone content. This was important for the scientists trying to explain ozone production. Ozone absorption cross-section was discussed (Fabry, Hoelper, Lambrey with Chalonge, Ladenburg, and E. Regener). Total ozone measuring spectrographs were described by Buisson, Götz, and Dember. The relationship between ozone and tropospheric motions was outlined by V. Bjerkness and its dependence on the climate of the stratosphere by Angström. The effect of ozone on the temperature of the stratosphere was discussed by Gowan, Gutenberg, and Rosseland. Owing to the then fairly new discovery of the large amounts of total ozone present in the atmosphere at high latitudes, some considered possible that solar corpuscular radiation and magnetic field in the Polar Regions might be a major factor in the production of atmospheric ozone which was later understood not to be the case.

Little was known at that time about the vertical distribution of ozone except the wrong impression that ozone maximum is located at 45 km above the ground (Rosseland). Also little was known about the shortwave solar spectrum and the parameters determining the dissociation and recombination of O1, O2, and O3. With a judicious choice of coefficients, partly based on the empirical fact that no diurnal variation was observed in the total ozone amount, Sidney Chapman showed that some of the known facts concerning atmospheric ozone could be explained by a pure oxygen photochemistry:
THE INTERNATIONAL OZONE COMMISSION (IO3C)

\[ O_2 + hv (\lambda < 242.4 \text{ nm}) \rightarrow O + O^1 \]

\[ O_2 + O^1 + M \rightarrow O_3 + M \]

\[ O_3 + O \rightarrow 2O_2 \]

\[ O_3 + hv (\lambda < 1180 \text{ nm}) \rightarrow O_2 + O^1 \]

In Chapman’s hypothesis no account was taken of the transport of ozone in the atmosphere, since it could not be quantitatively determined at the time. His model led to a prediction of much greater concentrations of ozone in the tropical atmosphere and much less in the polar than those actually observed. Since that time, Chapman has continued from time to time his contributions to our understanding of the photochemistry of atmospheric oxygen and of the ozone distribution in the atmosphere, but his first paper on the subject (Chapman, 1930) deserves special mention because it was the first theoretical interpretation of the distribution and time variation of ozone, and it set the pattern for later work, quickly leading him to the prediction that in the ionosphere the oxygen is largely dissociated, a conception then entirely novel. In September 1933 at the Fifth Assembly of IUGG in Lisbon, one of the themes for discussion at the International Association of Meteorology (IAM currently IAMAS) was the ‘Geophysical knowledge of the stratosphere’. The great Master of Optics - Prof. Charles Fabry (founder, with Buisson, of the modern observations of atmospheric ozone) spoke on the ozone absorption spectrum and absorption coefficients. He emphasised their fundamental importance in ozone studies. He raised the need to know better the vertical ozone distribution and the perspectives of using the light from the zenith sky for this purpose as proposed by Paul Götz as the ‘Umkehr effect’. Dobson and Götz reported that the first Umkehr observations led to the conclusion that the height of the centre of gravity of ozone in the atmosphere was at about 22 km instead of 45 km as had been thought before (Ozone, 1935). This finding made easier to understand the connection between the ozone changes and the weather systems, as well as the impact in improving of Sidney Chapman’s postulated ozone photochemistry.

To assist exchange of scientific results in the field IUGG established
ITS HISTORY AND ACTIVITIES RELATED TO ATMOSPHERIC OZONE

Figure 3. Sidney Chapman (1888-1970) was a remarkable mathematician, Fellow of the Royal Society, professor in Oxford, Alaska, Boulder. He was President of IUGG and leader of IGY and made major contributions to atmospheric physics, geophysics, and astronomy. In 1929 he outlined first four simple oxygen gas-photochemical equations for the formation and destruction of the ozone layer. He participated in many IO3C activities, had an immense influence on ozone studies until new theories emerged in late 1960s. (Courtesy: AIP Emilio Segre Visual Archives).

The Committee on Ozone within the Radiation Commission of IAM as was requested by Prof. Fabry and recommended by the IUGG Assembly at Stockholm (1930). The Committee included G. M. B. Dobson (chairman), Charles Fabry and Paul Götz. This Committee was assuring an informal connection between the few dozen scientists interested in atmospheric ozone up to the time after the Second World War when IO3C was formally established by IUGG in Oslo in 1948. The Fifth IUGG Assembly recognizing the importance of Paul Götz studies added 1000 Sw.Fr. to the pre-
viously allocated 4912 Fr.Fr. grant of support which had enabled his expeditions to Spitsbergen and maintained the ozone activities at Arosa.

In September 1936 a rather big for the time second Ozone Conference with 58 participants, organized by the Committee on Ozone, was held in Oxford. The 29 presented papers did cover methods of measurements of total and vertical ozone distribution (VO3D), absorption of radiation and temperature of the upper atmosphere, ozone and weather conditions and finally few diverging views on ozone photochemistry (Ozone, 1936a). In the next week the Sixth IUGG Assembly was held in Edinburgh. Two impressive papers on the role of ozone in absorbing radiation and warming stratospheric temperatures were presented by Rudolf Penndorf (Leipzig); Oliver R. Wolf and Lola S. Deming (Washington DC) (Ozone, 1936b).

Acting on the proposal by the Committee on Ozone ‘in order to determine the relations between the ozone variations and the meteorological conditions’ the Sixth IUGG Assembly allocated to the Committee on Ozone international funds (initially 1200£) for stepwise purchasing of three Dobson spectrophotometers (Ozone, 1936c). That was done but they were distributed together with two more instruments both by the Commission only after the end of Second World War as follows:

[Figure 4. Participants to the second Ozone Conference held in Oxford, 9-11 September 1936; many of the pioneers in ozone studies were in attendance (courtesy of archive of G. M. B. Dobson, Clarendon Lab., University of Oxford).]
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lent to Lisbon (before was shortly in Azores) used until 2002;
lent to Tromso / Spitsbergen used until 2000;
lent to Arosa (used until 1992, then in 2001 lent to Botswana);
lent to Reykjavík where is used until present;
lent to Aarhus, then in 1964/65 to Belgian-Dutch Antarctic base and in late 1960s lent to Arosa, automated in early 1970s and used until present.

It should be noted that from the mid-1930s up to 1951 only 12 stations have been taking ozone measurements for more than 3 years although irregularly. Longer series were available from Arosa and for some periods from Oxford, Tromso and Zi-Ka-Wey (Shanghai). Prof. Dobson was taking care for improving the operation and sensitivity of his instrument and providing guidance to observers. Outside UK, particularly in India, France and Germany more studies started to be directed towards various theoretical aspects related to the ozone distribution.

During the Second World War activities and communications between scientists were very limited. However, on 17-18 April 1944 despite the War situation one of the Committee on Ozone members (Paul Götz) participated in Tharandt (Germany) at an important by its content two-day Special Meeting on Ozone with more than 25 participants presenting 14 papers (Ozone, 1944) which was organised together with Prof. Helmut Weickmann. Götz provided an extensive review on the state of ozone research with emphasis on the possibilities offered by the Umkehr method and the newly established by German colleagues very cold stratosphere for explaining the observed annual, latitudinal and VO₃Ds. There were basic reviews of photochemistry (O. Hoelper, E. Schröer); first VO₃D direct measurements by stratospheric balloons establishing that the ozone maximum at middle latitudes is at ~22km, and the role of turbulence (Erich and Victor H. Regener); weather systems and related ozone changes (Moser); radiation and stratospheric temperature (Rudolf Penndorf); strato-tropospheric transport, and tropospheric ozone (Alfred and Hedwig Ehmert); and on the first optical-filter radiosonde (Dietrich Stranz). The high scientific levels of the reports are impressive even today. This was practically the first ozone meeting with so detailed discussions on basic issues of ozone photochemistry, vertical and horizontal distribution and changes, without spending unnecessary time on instrumentation and methods of measurements.
Ozone Commission and preparations for the International Geophysical Year (IGY)

In August 1948 the Seventh IUGG Assembly was held in Oslo. It formally established the International Ozone Commission with President G. M. B. Dobson and Secretary Sir Charles Normand and six other members (Daniel Chalonge, F. W. Paul Götz, Kalpathi Ramakrishnan Ramanathan, E. Tönsberg, Etienne Vassy, and Oliver R. Wolf). This was a very significant event giving official recognition to the importance of ozone monitoring and research. The aims of the Commission were defined as ‘In accordance with the programme of the Association to organise an ozone survey for Western Europe and at the same time assist the establishment of ozone stations in other parts of the world as opportunity presented itself’ and ‘to guide the stations operations to be conducted in comparable manner’ (Ozone, 1948a). It should be noted that the IO3C was only the second commission within the International Association of Meteorology (now IAMAS has ten!). An Ozone Symposium was held at Oslo at which a total of 18 papers were presented: On the ozone photochemistry, turbulence and transport in lower stratosphere (S. Chapman, H. U. Dütsch, and R. J. Reed with A. L. Julius); On the vertical ozone distribution (P. Götz, G. Walton, H. K. Paetzold and R. Tousey with K. Watanabe, J. D. Purcell, F. S. Johnson); The temperature of the ozonosphere, Huggins absorption and ozone at Edmonton (E. H. Gowan, R. H. Kay); Tropospheric ozone (E. Regener, A. Ehmert, H. Ungeheuer); Ozone and meteorological conditions (Ch. Normand, E. Tönsberg, A. W. Brewer, S. Fritz, Y. Miyake with K. Saruhashi, and by G. M. B. Dobson with Ch. Normand and R. H. Kay). Dobson reported on European ozone network studies done since 1936 (Ozone, 1948b).

In the next three years the IO3C carried in Oxford the rebuilding of nine pre-war instruments to the new standard design using photomultiplier, and a total of 24 newly build instruments were calibrated and compared in order to start the European ozone study with updated instruments. In the meantime the Meteorological Offices at number of countries had ordered new instruments i.e. Belgium (1), Canada (4), India (3), Italy (3), Japan (1), Spain (1), UK (3), and USA (5). Also the University of Uppsala (1) and the IO3C by itself purchased 2 more instruments for
eventual loan to stations of interest. At that time a new Dobson spectro-
photometer costed 1275 £. IO3C was getting each year a grant of ~300 £
for clerical assistance at Oxford related to its main task – the west Euro-
pean ozone survey with participation of 16 stations. Some similar annual
grants were made also available by the Royal Society London. The Pres-
ident and Secretary were not paid extra although they were working full
time on upgrading and calibrating each one of the produced instruments.

In August 1951 a two-day Ozone Symposium was held in Brussels
at the time of the Ninth IUGG Assembly. There were 15 presentations
(Ozone, 1951). These papers discussed the formation of ozone (Chap-
man, Dütsch, Nicolet); the VO3D (Götz, Paetzold); the mechanisms for
transport in the lower stratosphere (Reed with Julius); and ozone verti-
cal distribution up to 70km (Tousey with Watanabe). In addition there
were reports on tropospheric ozone studies (Regener, Ehmert, Ungeheu-
er); ozone in Tromso (Tönsberg); temperature of the ozonosphere and
ozone in Edmonton (Gowan); meridional variations of atmospheric ozone
(Miyake with Saruhashi). At that Commission meeting as well as at the

\[ \text{Figure 5. Stations with Dobson type spectrophotometers 1951-1956. From less than 12}
\] 
\[ \text{(before 1951) with the efforts of IO3C they were increased to 32 just by the start of the}
\] 
\[ \text{IGY (currently they are more than 100). Observations made before IGY are mostly sporad-}
\] 
\[ \text{ic and of unreliable quality for trends analysis.} \]
following in Oxford in September 1952, attention was given exclusively on ozone measurements (incl. zenith sky readings) their reductions (incl. absorption coefficients, haze and temperature effects) and instruments maintenance. At the latter ozone meeting participants from 9 European countries discussed progress of the European Survey of Ozone which concentrated mainly on relations with the weather systems. The membership of IO$_3$C was kept to members elected in Oslo but instead of Oliver R. Wolf (US Weather Bureau) Victor H. Regener was elected (University of New Mexico) and his father Prof. Erich Regener (Stuttgart) was co-opted for his extraordinary expertise in balloon measurements and in tropo-stratosphere turbulence exchange. At that time plans for organizing the International Geophysical Year (IGY 1957/58) were just starting and Prof. Marcel Nicolet as Secretary-General of the Scientific Committee for IGY urged the IO$_3$C to start implementing broad global coverage of ozone measurements.

For implementing this formidable task in 1953 Prof. Nicolet approached and convinced the World Meteorological Organization in Geneva as co-organizer of IGY to use its influence with the national meteorological services for arranging the ozone measurements and calibrations following uniform operational procedures with the understanding that the IO$_3$C will be providing the methodological guidance. These relations were formalized in 1957 and successfully implemented ever since. By 1953 the IO$_3$C did have its own five Dobson spectrophotometers used for improving the data coverage in the European region as mention above.

In September 1954 in Rome in connection with the Tenth-IUGG Assembly the next Ozone Symposium was held with 32 participants from 11 countries. Presented were 18 papers on ongoing ozone research (Ozone, 1954a). These included an extensive review on ‘Atmospheric ozone and the general circulation of the atmosphere’ by Prof. K. R. Ramanathan (as his IAMAP Presidential Address). Using availability of new VO$_3$D profiles observations he raised for the first time quantitatively the subject of possible meridional transport of ozone from the Equatorial generating region toward the polar latitudes. In the tropopause discontinuity around subtropical and polar jet-streams he assumed the possibility for stratospheric ozone being injected into the tropopause. He demonstrated that ‘the steep increase in ozone amount to the north of 30° is associated with the
steep lowering of the tropopause in the same direction'. Particular case for the insufficiency of the oxygen-photochemistry to explain alone the annual distribution without involving meridional transport of ozone was made also by Dütsch and by Paetzold. Sir Charles Normand presented detailed results from the 1950-1954, European ozone studies. Measurements and theory of the nocturnal ozone were reported by E. M. Fournier D’Albe, and D. Chalonge. Study of the ozone above 50 km was made by rockets in USA. The interest to the role of hydroxyl radical (OH) in the day/
night regime and possible catalytic ozone destruction by HOx in the upper stratosphere was discussed by Marcel Nicolet.

The meeting of the IO3C was held at the same time (Ozone, 1954b). In the past few years in accordance with the tasks outlined by IAM in 1948 and 1951 the basic aim of the IO3C has been to promote and help to maintain the ozone survey in Western Europe and to give such assistance as may be possible to ozone observers elsewhere. Analyses of the collected data were presented by Sir Charles Normand. At this time the main issues discussed by the IO3C were related to the preparations for the ozone measurements in the forthcoming International Geophysical Year (IGY). A revised Handbook for Operation of Dobson Spectrophotometers during IGY was prepared by Dobson (1957a). The use of double wavelengths method (AD) as proposed by Normand, was agreed to be the standard method for observations since it is nearly eliminating the effect of aerosol scattering. New absorption coefficients based on Ernest Vigroux studies were adopted to be used from 1 January 1956. To transfer old (Ny & Choong (1932) data to the new Vigroux (1953) scale they should be multiplied C wavelength x 1.45 and AD x 1.37.

Prof. Alfred Ehmert emphasised the usefulness of ozone-soundings. It was clear that an adequate explanation of ozone changes and transport was hopeless until more and better data on the vertical ozone distribution (VO3D) are accumulated and the Commission appeal that this should be done wherever it is possible.

IO3C noted that there are totally 34 instruments completed and 7 are under construction to be ready before the IGY. The problem with the deterioration of the optical wages of carbon-in-gelatine type required searching for new type of metal-coated wages. As it was mentioned the collaboration with WMO for the encouragement of expansion of the ozone network started in 1953. The combined efforts by IO3C and WMO were considered very fruitful. At the time of the beginning of IGY already 32 stations were reporting ozone data and WMO took the additional task of collecting and publishing the data and organizing periodic intercomparisons.

With WMO and UNESCO support the President was able to make a part-time appointment of a travelling physicist (C. D. Walshaw) with the duty to inspect and improve operations of most of the European instruments before the opening and during the IGY (Oct. 1955- July 1957). The

The interest toward our better understanding of the behaviour of atmospheric ozone that was inspired in part by the increased observational activities in preparation for the IGY stimulated the holding of another IO3C Ozone Symposium which was hosted this time by Prof. Ehmert in Max-Planck Institute, Weissenau near Ravensburg (25-29 June, 1956). About 40 scientists from 15 mostly Central European countries but also 4 from USA, 2 from India, 1 each from Canada, Pakistan, Japan and Iland attended and discussed both total and vertical ozone measurements, standardising the procedures for IGY. Ramanathan and Walton (1955) have produced a monograph for use of two methods for retrieving of VO3D from Umkehr measurements (later included in the IGY Annalen). Some prototypes for balloon-borne ozonesondes were presented (e.g. Regener photoluminiscient, Paetzold optical, Mme Vassy spectral). The Commission has appeal to all stations for conducting as many as possible Umkehr observations during the IGY. President K. R. Ramanathan reported an improvement in the retrieved ozone profiles when the secondary scattering was introduced in India. The Commission set up 3 Panels: on infra-red methods, on Umkehr evaluation and on determination of ozone concentrations near the ground, which were expected to report to the next meeting of the Commission.

In September 1957 at the Eleventh IUGG Assembly in Toronto a one-day Symposium on Atmospheric Ozone and Problems of the Upper Atmosphere was held jointly with IAGA under the chairmanship of Prof. Ramanathan (Ozone, 1957). Four of the ten presentations (Paetzold, Dütsch, Walton, and Brewer) covered VO3D with applications to atmospheric circulation for ozone and water vapor; one paper was on thermonuclear explosions and the harmful effect on ozonosphere (Schneiderov), and the rest dealt with total ozone data analyses. It was reported that UK observations showed remarkably unvarying water vapor in the lower stratosphere and that at 48,000 feet the frost-point is always very close to 190^oK.

The Commission noted that progress was made in (a) the evaluation
of the contribution by the secondary scattering to the Umkehr retrieval; (b) the development of photo-cell and optical filters for use in radiosondes; (c) the improvements of the technique for chemical measurements of ozone in airplanes and radio-sondes and (d) studies of the infrared method of determining VO$_3$D. Accurate ozone, upper air temperature and water vapor are expected to contribute toward the better understanding of circulation of upper troposphere and lower stratosphere. To the membership from Rome-Ravensburg the following scientists were added: Richard Craig, Hans U. Dütsch, Warren L. Godson, Genady P. Gustin, M. Migeotte, and Karl-Heinz Paetzold bringing the total number of scientists to 21 after the passing away in previous year of Prof. Erich Regener. It was decided to co-opt one more scientist from Italy and one from USSR. Those scientists were Prof. Giorgio Fea and Prof. Alexandar Khr. Khrgian.

Figure 7. K. R. Ramanathan (1893-1984) Remarkable physicist, honorable fellow of Royal Meteorological Society, Director-General Meteorological Service of India (up to 1948), and of Physical Research Lab in Ahmedabad (1947-1969), President of IAMAP (1954), IUGG (1957), IO$_3$C (1959-1968). In the late 1930s introduced the ozone monitoring and research in India, made major contributions to ozone relations with atmospheric circulation, biennial oscillations and to the evaluation of the Umkehr observations. Elected Honorary member 1971.
In Toronto the IO₃C and then IAM-IUGG adopted Resolution IV (1957) formally appealing to WMO in view of the expansion of ozone observing stations to take over the standardization, analysis, calibrations, data publications and related activities to be put on a permanent basis which will be of interest to many national Meteorological Services. WMO was already collaborating with IO₃C since 1953 and at the next WMO Congress it was formally agreed to extend WMO activities to include international ozone work namely by: (i) maintenance of catalogue of stations and observations; (ii) organizing intercomparisons of instruments; (iii) development of instructions, handbooks for standard observations and calibrations and (iv) provision of general guidance on instrumental and observational problems. The IO₃C retained its general scientific interest in ozone work and mainly for organizing symposia on atmospheric ozone and for developments of fields which are not yet routine and also retained the ownership of the five Dobson spectrophotometers which were on loan to various stations (at that time at Spitsbergen, Aarhus, Arosa, Santa Maria (Azores) and Reykjavik).

In the next years the IGY gave a great impetus to the study of atmospheric ozone. The network of stations for the observations of both total and vertical ozone distribution (VO₃D) widened, particularly in the polar regions of Canada, USSR and Antarctica. There has been a considerable increase in the knowledge about polar ozone and about its vertical distribution at various latitudes. In July 1959, after the end of IGY, about 160 scientists from 17 countries met in Oxford at a Joint Symposium with the Radiation Commission to discuss preliminary results. The Joint Symposium was sponsored by WMO and ICSU (Ohring et al., 2009). At the ozone part the participants presented 50 papers (Ozone 1959a). Along the usual topic for accuracy and improvements of total and VO₃D (Umkehr, balloon-borne-sondes, aircraft) measurements, for the first time in more details were considered their relations with the 100 and 25 hPa temperatures and wave disturbances in the stratosphere on a synoptic scale (F. K. Hare); the explosive increase of ozone by abrupt termination of the Arctic winter circulation with a final warming and transition to the summer easterly transport when there is practically no phase difference between ozone and 100hPa temperatures (W. L. Godson, 1960, 1963). Special attention was given to the ozone distribution and stratospheric circula-
Family-type meeting of IAMAS commissions in Oxford, UK, 20 July 1959

Figure 1, OHRING et al. 2009, Bull Amer. Meteor. Soc. 90, 1669-1681
tion with illustration for the winter vs. summer circulation in the Northern Hemisphere reflecting a very highly asymmetric distribution of the ozone in exactly opposite sense from that expected by the photochemical theory (K. R. Ramanathan). Further he considered that the noted differences in the annual course between the Arctic and Antarctic strongly suggests that the meridional mixing of stratospheric air in winter-spring is more efficient in the northern polar region than in the southern. R.J. Murgatroyd reported that measurements by aircraft up to 50,000 feet from the equator to 70°N are demonstrating rapid ozone increase and humidity decrease in the stratosphere immediately above the tropopause. The evidence of moist air rising in the upper part of the equatorial troposphere and spreading poleward between 40-50,000 feet with considerable subsidence over the subtropics was important for understanding the overall ozone transport within the atmospheric circulation as suggested by Ramanathan.

Results of calculations of total ozone by using individual (A, B, C, D) wavelengths with Vigroux-1953 absorption coefficients used since the beginning of IGY were not self-consistent. Some differences were up to 10%. The IO3C recognized that the Vigroux are better than the old Ny and Choong coefficients however did call for further study of the noted discrepancies. That task was completed by Vigroux (1967) and from January 1968 new sets started to be used. In order to transfer data from V-1953 to V-1968 one should multiply AD x 1.000, C x 1.072 and CD x 1.116.

Ozone sondes were flown by Karl-Heinz Paetzold’s group in Tromsø, Weissenau, Sahara and Belgium Congo; by Brewer and Milford in Liverpool and only few in Tromsø, Malta and Antarctica; by Viktor H. Regener in New Mexico. To avoid proliferations of different units used to represent the VO3D the IO3C appointed Warren L. Godson to propose a unifying method (after one year the Godson’s ozonogramme with ozone partial pressure as abscissa and log of air-pressure as ordinate was adopted).

By the time of the Oxford Symposium, Gordon M. B. Dobson and Sir Charles Normand had reached the age of 70 and rendered their resignations as President and Secretary (Ozone, 1959b). Then Prof. K. R. Ramanathan was elected President with Dr. Hans U. Dütsch as Secretary of the IO3C. From the Commission retired also Prof. E. Vassy and Prof. H. Kohler and as new members were added: Mme. Arlette Vassy, Prof. G. H.
Liljequist, Dr. Kaare Langlo and Dr. Alan W. Brewer bringing the membership to 23 scientists with competence in various aspects of ozone studies. After this meeting also the geographical distribution of members was better balanced (complete membership lists are available on IO3C web page http://ioc.atmos.uiuc.edu).

In August 1961 the next Ozone Symposium was held at Arosa with 75 participants from 15 countries (Ozone, 1961a). More than half of the presentations still dealt with methods of observations and analyses of data from close to 40 regularly operating stations. Other papers dealt with meteorological applications, i.e. with the use of ozone as a tracer. However, the Commission noted with regret that the importance of ozone for the energy and dynamics of the stratosphere which will become an important topic in the future had been hardly touched yet. On the positive side the meeting noted that work on development of useful methods for observing vertical ozone distribution had been intensified and a synoptic network of ozone radio-soundings would become operational guided by Wayne S. Hering from Air Force Cambridge Research Laboratories (AFCRL) in North America in 1963. In use would be Victor H. Regener's chemiluminiscent type of ozonesondes. It was recommended that measurements in the ozone-production region (>25km) should be initiated soonest.

Extensive discussions were held and concrete recommendations were made on the preparations of better global coverage of ozone measurements for the fore coming International Quiet Sun Year (IQSY) in 1964/65. In particular more Dobson equipped stations were recommended for Siberia (2-4), China (3-4), and one each in Alaska, Philippines, and southern parts of New Zealand, S. Africa and Argentina. It was emphasised that measurements with other type instruments should be calibrated against long-term measurements with Dobson using AD wavelengths on direct sun before any field measurements are initiated.

The Commission did recall that its five instruments are currently located in: Spitsbergen, Reykjavik, Aarhus, Arosa and Lisbon and requested from the President and/or Secretary to explore whether Denmark and Portugal could buy their own Dobson spectrophotometers and release the IO3C instruments for use elsewhere (Ozone, 1961b).

It was noted that following the transfer of responsibility for the stations routine observations from IO3C to WMO, the Meteorological Servic-
es in most countries have assumed obligations for observations assuring their uniformity. It was appreciated that WMO Commission on Atmospheric Sciences after Warren L. Godson has appointed as Reporter on Ozone Hans U. Dütsch also member of IO₃C thus assuring good coordination of related activities. The IO₃C appreciated that WMO has provided funds for two intercomparisons of VO₃D methods held in Arosa in the summer of 1961 and spring of 1962. WMO also collected and published all ozone data from IGY and for continuation of that work has agreement with the Canadian Meteorological Service to collect and distribute all ozone data starting with 1960 and later acting as a WMO World Ozone Data Centre. The Commission tasks were directed now mainly toward organizing symposia and stimulating ozone studies within the community.

In August 1963 at the XIII-IUGG Assembly at Berkley a two-day session on ozone and circulation above 20 km was held with 24 presentations (Ozone, 1963). Three were covering for the first time the 26-month wind/ozone oscillations (Godson, Ramanathan, Reed); continental-scale ozone distribution over North America, Europe, Northern Hemisphere (respectively by Hering, Bojkov, Khrgian); VO₃D and stratospheric warming (Paetzold, Breiland); intercomparisons of methods for measuring VO₃D (Dütsch); and UV changes and mesospheric ozone (Rasool). Abstracts from this Symposium are available in IAMP Publication No 13.

The meeting of the IO₃C in Berkley put great emphasis on expanding the measurements of the VO₃D during IQSY and in particular to measurements in the ozone production region >25 km. It was appreciated that WMO assisted further ozone research by sponsoring through IAMAP a project in Canada for uniform evaluation of existing Umkehr observations (with leader Carlton L. Mateer). Furthermore it was appreciated that WMO on proposal by Warren L. Godson as Chairman of the previous WMO-CAS working group on ozone, has started to establish ozone working groups in each of its six Regional Associations. IO₃C recommended one better equipped station in each of these Regional Associations to be designated as Regional Ozone Centre to assist calibrations and intercomparisons of instruments. In view of the increased ozone network of over 30 stations in the USSR the Commission appointed Al. Khr. Khrgian as Special Correspondent for liaison with authorities. Finally at the meeting in Berkley the IO₃C proposed to IUGG to nominate G. M. B. Dobson as its honorary pres-
ident in recognition of his enormous and still continuing work on the development of our knowledge on measurements of atmospheric ozone. As an exemption this proposal was accepted by IUGG.

In September **1964** a one week Quadrennial Ozone Symposium was held in Albuquerque (New Mexico) with 83 participants from 12 countries presenting 59 papers (Ozone, 1964). In his Presidential Address Prof. Ramanathan and after him Warren L. Godson expanded their presentations from Berkley bringing to attention the existence of ~26-month fluctuations in the ozone amount both in the tropics and middle latitudes and of their relations with the stratospheric circulation. In addition the meeting enjoyed a survey given by the host Prof. Victor H. Regener on 30-years of development in the quantitative detection of ozone. He was admired that together with his father Prof. Erich H. Regener did made assents of quartz-spectrographs on big rubber balloons reaching up to 33km first determining the height of ozone maximum as ~22 km, as early as 1934.

Other subjects discussed were: elementary instrumental issues of total ozone measurements (13); VO3D (22) including introduction of new numerical method for calculation of VO3D from Umkehr observations by Carl Mateer; photochemistry (6) including results of a 2-D ozone model by Eigil Hesstvedt; application of ozone observations in general circulation (14) including the paper by Wayne Hering and Thomas Borden Jr. on analyses of VO3D from the North American network down to the Equatorial zone indicating that ozone transfer is affected primarily by eddy processes and by long, quasi-stationary (Rossby) waves which are so prominent in the upper troposphere–lower stratosphere region; the Reginald E. Newell paper on the relationship between energy changes and mass transport based on IGY ozone data in which it was suggested that the basic reason for the spring ozone maximum is the occurrence of a greater tropospheric-stratospheric energy exchange in that season with increase of the energy flux into the stratosphere; There were also two papers on ozone and solar activities by Willet and Sekihara.

The discussion made it obvious that convincing solutions of circulation problems in connection with tracer studies can only be reached by careful **quantitative** calculations. For ozone this means that its photochemistry has to be taken into account in any attempt to use recent observations of VO3D to derive a model of the general circulation in the
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stratosphere. However, it was found that our knowledge of the photo-chemical theory is not adequate at present, mainly due to the uncertainty in the values of the reaction constants, their temperature dependence, and of the solar spectrum in the critical band around 200nm. For the first time, the active influence of ozone on stratospheric dynamics due to its radiative properties was identified to be of growing importance for circulation studies in the future.

At the Commission meeting in Albuquerque it was noted with satisfaction that there has been development of large scale programme of VO$_3$D by reliable chemical sondes. If it was extended to a more global coverage after the IQSy the data it would facilitate answering questions about the general circulation of the stratosphere. However the need of parallel measurements of the total amount with Dobson instruments is indispensable for homogenous sondes-profile evaluations. The Commission considered that in addition to the sondes the indirect Umkehr method is useful to provide the climatology of ozone in particular at higher levels than those provided by the sondes. In this respect the uniform evaluation of the Umkehr observations from all stations undertaken by Carlton L. Mateer in the World Ozone Data Centre in Canada with support by WMO was considered very useful.

The understanding of the lower stratosphere circulation would have a benefit also by the number of studies of tracers other than ozone, since an acceptable model of stratospheric circulation will have to take into account the distributions of all of them in a quantitative manner. However the Commission was concerned that knowledge of the photochemical theory is not adequate mainly due to the uncertainty in the values of reactions constants, their temperature dependence, and the solar spectrum in the critical region around 200nm and in the region important for ozone equilibrium (150-300nm). An extended period of monitoring from a satellite is needed to establish its possible variability within a solar cycle. It was noted with satisfaction that better cooperation between physical chemists and atmospheric physicists has been obtained recently and that more reliable values of reaction constants may be established in the near future. It was noted that in response to the call by the IO$_3$C, Denmark has purchased its own instrument and returned to the Commission its own one (#51). This was lent to the Belgium Antarctic expedition for two years and then lent to Arosa.

The exchange of ozone data by the WMO telecommunication network
was considered to be of interest to synoptic meteorology; however the proposal of Genady Gustin for daily exchange of ozone data from more than 25 USSR stations was not supported. This short-sighting of the IO3C was corrected only after the surprising appearance of the Antarctic spring ozone decline when near-real time data from both satellites and ground stations started to be exchanged routinely within the WMO system and the WMO Ozone Mapping Centre was established at the University of Thessaloniki (http://lap.physics.auth.gr/ozonemaps).

The Commission co-opted Y. Sekiguchi (Japan), R. Frith and C.D. Walshaw (UK) as members to be approved by the next IAMAP Assembly.

The ozone photochemistry in unsettled state

In September 1967 at the XIV-IUGG Assembly in Lucerne (Switzerland) the Commission organized only a one-day symposium since a full week quadrennial symposium was planned for 1968 in France. At that meeting 17 papers were presented (Ozone, 1967). Five of the papers were on total ozone (London, Khrgian, Brewer, Fabian, Grasnick with Hoebbel); eight on VO3D (Bojkov, Breiland, Hering, Krueger, Paetzold with Piscalar, Randhawa, Sekiguchi, Sredharan with Mani); two on surface ozone (Aldaz with Regener, Ripperton with Worth) and one extensive review on ozone absorption (Vigroux) and one on photochemistry (Dütsch). Using larger massifs of data available since IGY and IGY three of the presentations considered global distribution and circulation patterns (i.e. London, Bojkov, and Hering).

At the Commission meeting concern was expressed that improved VO3D data have raised more questions concerning the photochemical theory which seemed to be well established ten years ago but it was in a rather unsettled state. According to Hampson, Nicolet there may have been considerable interference with the odd oxygen (O and O3) reactions by H, OH, HO2 or other hydrogen components (Hunt), and possible with NOx leading to O3 destruction in the stratosphere. The reaction rates were very doubtful and conclusions were not possible. IO3C recommended that all suitable persons should be encouraged to measure the relevant reaction rate coefficients. Also the knowledge of the extraterrestrial
solar spectrum is inadequate. Numbers of authors were encountering difficulties in reconciling theoretical values with the improved knowledge of \( \text{VO}_3\text{D} \) and dropped the use of pure oxygen photochemistry.

It has been clear since few years that the absorption coefficients used in the Dobson instruments provided total ozone values which are not mutually consistent. The problem seemed to be the results of too low values for the A wavelength coefficients. In order to improve consistency of the values obtained by different wavelengths, the Commission accepted the newly measured coefficients by Prof. Ernest Vigroux. The Commission asked WMO to inform the stations that from 1 January 1968 they had to use the following absorption coefficients: \( A = 1.748; B = 1.140; C = 0.800; D = 0.360 \) and \( AD = 1.388 \) (last not changed). Thus to convert data using the V-1953 to the new V-1968 scale they had to be multiplied as follows: \( AD \times 1.000; C \times 1.072 \) and \( CD \times 1.116 \).

Another recommendation made by IO3C referred to the planned WMO/ICSU Global Atmospheric Research Programme (GARP) requesting the Joint Scientific Committee of WMO/ICSU to include ozone measurements and in particular extension of the ozone sondes network which will be of benefit to stratospheric heat balance and dynamic studies.

New members to IO3C were elected as follows: R. Berggren, A. S. Britaev, K. H. Grasnick, E. Hesstvedt, S. H. H. Larsen, L. Machta, A. Mani, C. L. Mateer and Y. Sekiguchi.

In September 1968 the Quadrennial Ozone Symposium was hosted by Mme Arlette Vassy and the late Prof. Etienne Vassy in Monte Carlo. It was marking the 40-anniversary from the first Ozone Conference organised by Prof. Charles Fabry in Paris. Over 60 papers were presented. Good half of them dealt with issues of ozone transport and the atmospheric circulation utilizing \( \text{VO}_3\text{D} \) and total ozone data. Very interesting studies of modelled ozone photochemistry were presented some including “dry” and “wet” cases (e.g. Crutzen, Dütsch, Hesstvedt, Sekihara). Preparation of satellite total and \( \text{VO}_3\text{D} \) measurements utilizing UV back-scattered radiation on Nimbus-4 (Mateer with Heat) was expected to improve tremendously the global coverage. Rocket measurements provided new information for the region between 38 and 52 km over Hawaii and over Wight Sands (Krueger, Randhawa). The global distribution of total and vertical ozone since 1957 and their relation to atmospheric circula-
tion (London with Bojkov) and over India (Mani with Sredharan) were presented. Discrepancies of mostly USSR used M-83 type broad-band-filter ozonometer data with Dobson instruments and suggestions for improvements were discussed (Bojkov, 1969). All submitted papers to this Symposium were published (Ozone, 1968a).

The Commission noted (Ozone, 1968a) that the intercomparisons of sondes at Hohenpeissenberg (February 1970) proved the usefulness of the presently available equipment for VO₃D and showed the desirability of simultaneous total ozone measurements.

One of the most exciting research in the past few years was the inclusion of photochemically produced and destroyed ozone as a tracer in a numerical model of the general circulation of the atmosphere (Hunt and Manabe) which opens a very promising field of work, including testing validity of GCM when extended into the stratosphere. A prerequisite for the application of such methods is an expedient solution of the pending problems with the ozone photochemistry.

The IO3C put emphasis on the fruitful cooperation with WMO and on the need to include an adequate ozone sondes network in the GARP Global Experiment. Finally it was agreed one of the instruments belonging to the Commission (#51) which was returned from the Belgian-Dutch Antarctic expedition to be lent to Arosa where will be automated.

IO3C elected Alan Brewer for President and did ask Hans Dütsch to continue his services as Secretary to the Commission. Four new members were elected: P. Fabian, W. Komhyr, R. W. Kulkarni and G. I. Kuznetzow.

In 1971 at the XV-IUGG Assembly in Moscow a separate symposium was not held since the quadrennial was already being planned for next year in Arosa. The attending 15 members of the IO3C met and briefly considered the results from the ozone sondes intercomparisons held previous year under the supervision of Walter Attmannspacher in Hohenpeissenberg Observatory which proofed the usefulness of the present equipment in vertical soundings. It was noted that although considerable progress has been made in the ozone photochemistry of a moist atmosphere, the reliability is still not adequate. Complications arose by the indicated possibility of the importance of nitrogen oxides for odd-oxygen particle destruction in the stratosphere (Crutzen, 1970).

On the membership issue the Commission was informed that Dr.
Kaare Langlo who was permanent representative of WMO has resigned and he proposed Rumen D. Bojkov to take over these functions, it was so agreed. W. Attmannspacher and M. F. Figueira were also elected as new members. Finally in view of the tremendous contributions made to ozone science by Prof. K. R. Ramanathan and Prof. E. Vigroux they were elected honorary members of the Commission.

In view of successful launch of the backscattered UV radiation measuring instrument for determination of total ozone (theoretical design by Dave and Mateer, and implemented by Don Heath) on Nimbus-4, IO3C accepted resolution requesting ozone measurements to be included with high priority in future satellite programmes. Carl L. Mateer was to represent the Commission on the satellite related discussions in NASA.

President Brewer informed that has made a prototype spectrophotometer of new design which is to receive trials. Further he commented that the growing WMO involvement with establishing of Regional Centres with Rapporteurs or working groups for supporting ozone measurements in the six WMO Regional Associations was taking care for big portion of previous IO3C activities. Therefore, he did open a discussion on the future of the Commission. The members did not agree with him to curtail Commission status within the IAMAP but decided to appoint a committee (Brewer, Khrgian, London and Ramanathan) to consider the relation of ozone studies to those of the upper atmosphere and atmospheric chemistry and advise it be better served by uniting the IO3C with some other commission of IAMAP as the President has proposed. This committee was supposed to report to the next symposium, however dramatic developments related to the ozone budget in relation to the supersonic transport (SST) and further anthropogenic influences which could destroy the ozone caused explosive increase of ozone related studies as reported to the Arosa Symposium (1972) and other international meetings (e.g. CIAP) and made the existence of IO3C indispensable.

The IO3C and the anthropogenic influences on the ozone layer

Indeed Harold Johnston (1971) raised the concern about depletion of the ozone layer from human sources by suggesting that flying a fleet
of supersonic transport (SST) planes in the stratosphere might produce
enough NOx to do significant damage to the ozone layer from the cata-
lytic reactions as suggested a year earlier independently by Paul Crutzen
(1970). This fleet of SST was never built, but Johnston’s and Crutzen sug-
gestions raised the awareness that it was possible for humans to have a
serious negative effect on the ozone layer. Furthermore, Sherry Rowland
and his graduate student Mario Molina (1974) showed that there was a
threat to the ozone layer from chlorofluorocarbons (CFCs). The CFC mole-
cules would almost all reach the stratosphere where they would decom-
pose and liberate chlorine atoms that would then destroy ozone in a cat-
alytic reaction involving chlorine as described earlier by Stolarski and Cic-
erone (1974) similar to that involving NOx.

In August 1972 the Quadrennial Ozone Symposium was held in Aro-
sa with 90 participants and 70 papers (Ozone, 1972a). It was hosted by
Hans U. Dütsch. The most innovative were papers on stratospheric mea-
urements of trace substances such as CH$_4$, H$_2$, N$_2$O, H$_2$O, (e.g. Ackerman
with Muller, Ehhalt with Heidt, Zander), and 11 papers on new approach
to ozone photochemistry which included the role of catalytic chains of re-
actions involving NOx and HOx which may lead to ozone destruction (e.g.
Crutzen, Nicolet with Peetermans, Brasseur, Hesstvedt) making NOx the
most important factor in the global, natural ozone balance. The modelled
abundance of NOx in the stratosphere was also discussed (e.g. Isaksen;
Johnston with Whitten, London with Park). Larger part of presentations
dealt with analyses of observational result with emphasis on VO$_3$D and
atmospheric circulation, including first two years data from the UVB on
Nimbus-4 satellite. Discrepancies in the absorption coefficients used by
different wavelengths in particular wavelength A (DeLuisi, Komhyr) made
the Commission to call for continuous study of this issue. Few papers cov-
ered the surface ozone measured on a meridional stretch 70°N to the
Equator (Pruchniewicz, Fabian).

The Commission stated that it has become clear that the ozone layer
could be anthropogenically influenced (Ozone, 1972b). The ongoing CIAP
project in USA in which many members were actively participating was
addressing the issue of the role of NOx from supersonic transport (SST).
Commission strongly felt that an international monitoring and research
programme within WMO should deal with treats to the ozone layer in the
future and IO3C will have to take an active part in its organization. With the new developments in the field of photochemistry, transport models not only for ozone itself but also for other trace substances have become of great importance. 1-D models which have very largely been used are obviously unsatisfactory in the case of ozone where latitudinal transport is of great importance. The few 2-D models are hampered by the fact that the parameterization of large scale exchange by mixing coefficients is not fully adequate.

The Commission noted the results of international intercomparisons of Dobson instruments organized by WMO and conducted by members of IO3C at Siofok-Hungary in 1969 with participation from 7 countries, and between Australia, one instrument from Japan, and the USA Reference Dobson #83 in Aspendale in 1972 under the supervision of Walter Komhyr and Rumen D. Bojkov. To the membership of the Commission were added: M. Ackerman and B. W. Boville.

In January 1974 the Commission participated in a joint organization of a major Symposium on ‘Structure and Composition and General Circulation of the Upper and Lower Atmosphere and Possible Anthropogenic Perturbations’ with other commissions of IAMAP in Melbourne which especially dealt with the problem of the interaction between ozone and other trace substances. More than 50 out of total 87 of the presentations dealt with ozone photochemistry modelling. It was obvious that the explosive increase of studies confirmed the concerns of the Commission building since 1972 for possibility of anthropogenic ozone destruction. The Proceedings were published in two volumes 1294 pages by Warren L. Godson IAMAP Secretariat Office in Toronto (Ozone, 1974).

During the same year a major Dobson instruments intercomparisons with the NOAA Reference #83 was organized by WMO with IO3C in Belsk (Poland) which did show the unsatisfactory state of some of the instruments in operation. More details on Dobson performances and differences noted at number of WMO intercomparisons are given in (WMO, 1982) and Basher (1995). The Commission requested that more attention be given to the quality of the ozone measurements and their homogeneity as persuaded by Rumen D. Bojkov (WMO).

In August 1975 at the XV-IUGG Assembly in Grenoble IO3C organized two sessions on Fluorocarbons in the Stratosphere by Prof. Marcel
Nicolet and on Dynamic Models by Dr. R. J. Murgatroyd with emphasis on possible ozone reduction due to anthropogenic pollution at which were presented 18 papers. Authors and participants were well aware of the ongoing CIAP studies and in particular of the fundamental NOx effect studies of Crutzen (1970); furthermore recently Stolarski and Cicerone (1974) and Wofsy and McElroy (1974) found that chlorine as well as bromine may catalyze ozone decomposition even more effectively than NOx. Future Space Shuttle flights (function of their frequencies) may introduce few thousand tons of chlorine species into the high atmosphere. Existing and growing source of chlorine in the stratosphere through dissociation of chlorofluoromethanes (CFCs) was identified by Molina and Rowland (1974) who considered this may have a significant ozone-destructive effect.

The Commission discussed the explosive increase of interest in ozone studies related to the new aspects for photochemical ozone destruction. It felt that the relevant studies should be strongly supported. IO3C recognized that the presently available sounding material is not sufficient to establish a secured climatology of the world wide VO$_2$D and again recommended improvement of the ozone-sondes network to assist modeling work and monitoring long-term trends. It felt that for the upper stratosphere information should come from satellites and also from Umkehr techniques being important as ground truth of satellite results and especially for long-term monitoring. The Commission felt that despite availability of satellites it was essential over long periods to keep and enforce the surface part of the WMO Global Ozone Observing System (G03OS) to be used for ground truth and for determination of long term trends (Ozone, 1972b).

The Commission was informed that unfortunately already in the previous year Alan Brewer has informed the Secretary that he is retiring and he is not interested to be involved with the Commission any longer despite that his term as President would have been until 1976 Dresden Symposium. Thereafter, Hans U. Dütsch was elected President and C. D. Walshaw Secretary of the Commission. Five new members of IO3C were elected: P. Crutzen, D. Heath, A. Losiowa, A. Matthews and Harold Schiff, bringing the membership total to 28 plus 3 honorary (Dobson, Ramanathan and Vigroux).
All the above concerns and recommendations from the Grenoble meeting were submitted to WMO Commission for Atmospheric Sciences which on an initiative by Rumen D. Bojkov was calling in Geneva immediately after the Grenoble Assembly a meeting of distinguished scientists in connection with the problem of stratospheric pollution and its possible influence on the ozone layer to elaborate appropriate policy draft for intergovernmental action. The eight IO3C members (Boville, Bojkov, Crutzen, Dütsch, Machta, Murgatroyd, Nicolet, and Rowland) together with four other experts (Finger, Labitzke, McElroy, and Kellogg) drafted a statement ‘Modification of the ozone layer due to human activities and some possible geophysical consequences’ which was immediately accepted by the WMO Executive Council and distributed to all Governments.
as the first intergovernmental statement ‘presenting in an authoritative and well-balanced manner the current state in this highly important subject’. After this action in May 1976 WMO initiated the WMO Global Ozone Research and Monitoring Project aimed at clarifying the role of anthropogenic pollutants (particularly CFCs and NOx) in reducing the quantity of ozone in the atmosphere and prepares assessments. This Project is very active until today with publication of the International Assessment Reports and guidance on the GO3OS. It is implemented with participation of IO3C members and hundreds of other scientists.

In August 1976 the Quadrennial Ozone Symposium (jointly organized with the Commission on Atmospheric Chemistry) was held in Dresden with 146 participants from 28 countries presenting over 100 papers (Ozone, 1976a). The distribution by subject of the papers shows the shifting emphasis: for the first time 37 were dealing with anthropogenic influence, modelling, the necessary trace substances and one on the ozone heating of the stratosphere. The distribution of both total and \( \text{VO}_3 \text{D} \) were 24; general circulation 8 and tropospheric ozone 12. Those discussing actual measuring practices – a dominant subject in the past Quadrennials were now only 19.

The Commission noted that the past few years brought a rapid expansion of ozone research showing the importance of that trace gas to mankind in a new light. A few important dates dealing with milestones in the stratospheric ozone photochemistry and its destruction contributed to that: (i) 1964/65 introduction of the hydrogen-oxygen radicals (e.g. Hampson, Hunt, Nicolet); (ii) 1970/71 introduction of the nitrogen-oxide radicals by Crutzen and independently by Johnston; (iii) 1974 introduction of role of chlorine radicals by Stolarski and Cicerone and the potential ozone destruction by chlorine released in decomposition of CFCs by Rowland and Molina. Naturally the main discussion evolved on the role played by anthropogenic pollution on the ozone regime. Highlighting the ozone destructive potential of increasing release of CFCs was presented by Rowland and Crutzen. In this connection was appreciated that WMO has approved the Global Ozone Research and Monitoring Project concerning with: The extent to which man-made pollutants might be responsible for reducing the \( \text{O}_3 \), in particular the role of CFCs and NOx; The possible impact of the \( \text{O}_3 \) changes on climate and UV reaching the surface;
and The strengthening of the long-term monitoring quality and data reviews for detection of trends and future threats. Since these activities are of direct interest also to IO3C it was strongly recommended members to assist implementation of Project tasks as completely and as quickly as possible (Ozone, 1976b).

Further the IO3C recommended the USA Dobson instrument #83 be designated as WMO Primary Reference Standard and be regularly calibrated at clean air conditions of Mauna Loa and then compared with the Regional reference instruments and all other field stations as soon as practical. The results from all intercomparisons should be deposited to the WMO-WO3DC in Toronto. The Commission considered also that flight-comparison between the most used ozone sondes as well as between the sondes flown on rockets is necessary. Long-term comparisons between Dobson and different type new instruments were considered essential before such instruments are approved for use in the GO3OS. With supporting reference to the few years of ozone observations from satellites NASA was asked to ensure rapid processing and dissemination of data.

Considering that there is still some internal inconsistency higher ozone amount (~3 to 5%) when calculated with the A-wavelength pair even with the improved Vigroux-1968 absorption coefficients a small group under Walter Komhyr was requested to look in more details of this problem.

In September 1977 at the Second extraordinary Assembly of IAMAP at Seattle, at the symposium Meteorology of Middle Atmosphere, were made fewer presentations discussing the ozone problem probably because of the big Quadrennial Symposium held the previous year in Dresden and ongoing national ozone assessments activities (i.e. France, UK, USA). One important paper on standard ozone profiles from balloon and rocket data for satellite and theoretical models input was presented by Ernie Hilsenrath, Dunn and Mateer and should be mentioned. Not many members of IO3C attended and only an informal meeting of the Commission did review activities but did not make recommendations.

In June 1978 in Toronto WMO together with the IO3C in order to respond to the booming interest on anthropogenic ozone changes organized a ‘Symposium on Geophysical Aspects and Consequences of Chang-
es in the Composition of the Stratosphere’ hosted by the Canadian Atmospheric Environment Service. In attendance were 130 scientists including most of the IO3C members. The 64 of presented papers were published by WMO (Ozone, 1978). More than half of the papers were on chemistry, trace measurements and sources and sinks; modeling and prediction papers were 18, and ozone trends and satellite measurements were 12. That distribution by itself demonstrates that the most active ozone researchers have started to dedicate their studies on the issue for anthropogenic effects on the ozone layer. That message underlined to the Commission the need to concentrate even more on further promotion of theoretical studies on the ozone issue.

In December 1979 at the XVII-IUGG Assembly in Canberra within the framework of a symposium on Middle Atmosphere by IO3C members were organized two sessions on trace species of direct interest to ozone with 16 papers, and another 11 papers including few on satellite measurements were spread within two other sessions. The great distance, and planning already for the next Quadrennial symposium to be held in Boulder in 1980 prevented majority of the members to attend and therefore no formal meeting of the Commission was held. IAMAP adopted its Statute which “mutates mutandis” should be applied by its Commissions. Furthermore on the proposal by IO3C supported by the Commissions on Upper Atmosphere and on Chemistry and Global Pollution, IAMAP considering the worldwide concern that human activities may be producing important changes in stratospheric composition leading to serious deterioration of human environment recommended that all nations:

1. perform their own evaluations;
2. expand long-term research programs to increase knowledge of processes affecting particularly stratosphere;
3. cooperate fully in international monitoring to detect any long-term trends in the stratosphere and
4. Intergovernmental organizations, particularly WMO consider providing encouragement, support and co-ordination to the above mentioned endeavors.

In August 1980 the Quadrennial Ozone Symposium was held in Boulder, Colorado, with local host Julius London. It was attended by 275 participants from 21 countries and was so far the biggest. More than 190
papers were presented. Proceedings were published thanks to support by WMO, NCAR and University of Colorado (Ozone, 1980a). They covered in addition to the previously traditional fields such as observational techniques (49), results and ozone data analyses (59), also photochemistry of ozone and related chemical systems with interacting dynamics (35), observations of relevant trace gases (31), ozone interaction with climate and solar variability (11). Considerable extension of the ground based observing system has been reported. Of course the major break-through in global observations of total and \( \text{VO}_3 \text{D} \) has been the successful employment of various satellite observations during the past decade and in particular the flown of the TOMS instrument since November 1978. At the same time laboratory and theoretical studies have led to the realization that ozone photochemistry and the interactions with radiative and dynamic processes is woefully complex and requires communication among specialists working in various sub-disciplines dealing with these physical and chemical processes.

The Commission accepted the resignation of Hans U. Dütsch (due to his retirement) and elected unanimously for President Carlton D. Mateer from Toronto. In recognition to the enormous contribution to the studies of atmospheric ozone and of ozone monitoring and research in USSR Prof. Alexandar Khr. Khrgian was unanimously elected honorary member. Appreciation of the diligent work by Walter Attmannspacher for arranging and conducting few intercomparisons of commonly used ozone sondes and over a year-long comparison of surface ozone measuring instruments (wet ECC sensor, Hp-sensor, dry ethylene sensor and optical – UV absorption –Dasibi sensor) at Hohenpeissenberg Observatory was recorded. Results confirm that the MAST-Brewer and the ECC-Komhyr type sondes are the two most robust and suitable for operational use subject to thoroughly pre-flight calibration. The ECC sondes showed somewhat higher values in the troposphere and the carbon-iodine sonde of Japan tended to read slightly low at the top (~14 hPa).

In response to a previous call by IO3C series of 57 rocket firings in triads were conducted from Wallops Island (USA) in 1979 for intercomparisons of ozone sondes that have been used over the last several years by Australia, Canada, India, Japan and USA (NASA). Ernie Hilsenrath was co-
ordinating with participants the preparation of report for publication by WMO.

Intercomparisons of >40 Dobson instruments with reference to #83 (maintained as reference by Walter Komhyr in NOAA-Boulder) and their upgrading were sponsored by WMO in the past few years (e.g. Belsk-1974, Boulder-1977, Arosa-1978, Potsdam-1979) and IO3C recommended that this vigorous activity for improving the performance of GO3OS should be further expanded if we wish to have a solid base for ozone trends studies; the reference instruments of UK (#41) and of GDR (#71) were considered not representative and their managers were urged to plan another calibrations with World Reference #83. IO3C appreciated the preparation

**Figure 10.** Alexandar Khr. Khrgian (1910-1993), professor in atmospheric physics at prestigious Moscow State University (1943-1993) established the national ozone network and trained generations of researchers also in other fields such as cloud physics. Proliferated writer of research papers and University textbooks on Atmospheric Physics and History of Meteorology, build international respect actively participated in IAMAP and IO3C activities for 36 years (since IGY until his last days). Elected Honorary member 1980.
of Operations Handbook for Dobson Spectrophotometers by Walter Komhyr published and widely distributed by WMO as Ozone Project Report #6 (Komhyr, 1980a) and recommended his laboratory in NOAA, Boulder to be designated the Central Ozone Laboratory.

The uncertainty of the present absorption coefficients used for ozone evaluations due to possible error in the value of 306 nm (A-pair) was discussed (Komhyr, 1980b). In view of ongoing thorough work in the National Bureau of Standards by Bass and Paur (1985) on the UV absorption at low temperatures, the Commission decided to postpone its decision and to establish small working group (Hudson, DeLuisi, Mateer) which to follow developments and assess the implications of the new values and report. For Rapporteur on IR ozone absorption coefficient was appointed Alain Barbe (Reims).

A prototype of a Brewer instrument which underwent comparisons with the Toronto Dobson #77 was shown and the Commission recommended that a number of them should be manufactured and operated under the supervision of the AES and report on their performance presented before recommended for network use.

The IO3C expressed appreciation of the work on the UV solar spectrum at high resolution by John DeLuisi and recommended to be further pursued with a view to improving our knowledge of the physical processes contributing to the observed spectrum and taking them into account in ozone measurements.

Furthermore in order to encourage further work on microwave measurements of atmospheric ozone which offers some advantages (e.g. cloud penetration) it was recommended that Klaus F. Künzi and J. W. Waters report to the next meeting.

For advice on the most important observations required of trace constituents related to ozone a small working group (Rowland and Fabian) was charged to report to the next meeting.

In line with the Statute of IAMAP the IO3C decided from now on the election of a member to be for one term with possibility to be extended once and with the understanding that at the end of the second term the member should step down. The officers of the Commission could keep membership for one more term after they are out of duties. It was felt these arrangements would help to maintain membership of active work-
ers on ozone, and open possibility for securing representations of new fields of developments. Following the new rules it was expected that long-term members (Ackerman, Attmannspacher, Fabian, Figueira, Grasnick, Gushchin, Heath, Isaksen, Karol, Komhyr, Kulkarni, Losiowa and Matthews) would step down by the 1984 Symposium. For new members were elected: I. Galbally, K. F. Künzi, Y. Sahai, M. Shimizu and C. R. Sreedharan.

In the week before the Symposium the WMO jointly with IO 3C hold in NCAR a meeting of experts on Assessment the Performances of the Ozone Observing Systems (WMO, 1980) and made series of recommendations for improvement of the GO3OS. These included: request for preparation of ‘Manual for ozonesondes’; publication of previous rocket-ozone soundings by the WMO-WO3DC in Toronto; the improved 3-wavelength (300, 326 and 348±2nm) ozonometer by G. P. Gustin and S. A. Sokolenko (1984) to be tested for entire scan of solar zenith angle measurements before introducing it in the USSR network; the empirical charts used in reducing zenith-sky observations to be improved for optimum quality ozone data can be obtained from observations on clear and cloudy zenith-skies. Resolution expressing appreciation to WMO for the excellent conduct of the Global Ozone Research and Monitoring Project guided by Rumen D. Bojkov was adopted by the Commission.

The President Mateer was asked to do all necessary to facilitate contribution by the Commission to the evolving Middle Atmosphere Programme (MAP) and offer the co-sponsorship to their symposia by IO 3C. At the steering Committee for MAP the IO 3C was represented by Rumen D. Bojkov, who was also representing the WMO and thus assuring smooth cooperation with this important for the Commission international MAP Programme carried under the framework of COSTEP.

The Commission also dealt with a treat that CISRO may terminate the Australian ozone observations. Letter to the Minister of Science expressing the seriousness of such action in a situation when we need every observation to assess the possible environmental consequences to the ozone layer was prepared.

Finally a recommendation was made that the total ozone unit (milli-atm-cm) be given the alternative name of Dobson (D), thereby defining one D as the amount of ozone in the vertical column which when reduced to temperature of 15°C and a pressure of 1013hPa will have a depth of
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Figure 11. Carlton L. Mateer has made major contributions to the ozone science which includes the theory and uniform numerical processing of the Umkehr profiles, theoretical design (with Dave) of satellite measuring ozone using backscatter UV, active participation in the implementation of BUV and SBUV satellite instruments with Don Heath and TOMS with Arlin Krueger. He served as President of the IO3C (1980-1984) and as early as 1984 Presidential address call to the need to focus future research on ozone-climate interactions. Elected Honorary member 1992.

$10^5$ m. It was brought to the attention of IO3C that this could be only informally because it will be impossible to get sanctioned by the International Standardization Organization (ISO) in Geneva as a preliminary inquire has shown. This recommendation was not approved by IUGG in its Resolution (August, 1983) when other units were considered. In the absolute system 1 Dobson = $2.68 \times 10^{16}$ molecules/cm$^2$.

In May 1981 a major international evaluation meeting (102 scientists from 12 countries) was held in Hampton, Virginia. It was jointly called by WMO and NASA in cooperation with NOAA and FAA to evaluate the state of the stratosphere. The over 500 pages Report ‘Stratosphere 1981–
Theory and Measurements’ (WMO, 1981) was widely distributed. It is considered as the first in the series of international assessments reports providing background for the ongoing at that time negotiations for concluding of an Ozone Convention for Protection of the Ozone Layer and in the years after for assessment the effects of measures taken by the Montreal Protocol. 18 members of the IO$_3$C took active part and as chapter leaders and two of them (Robert D. Hudson and Rumen D. Bojkov) were the joint chairmen of the meeting and co-editors of the voluminous Proceedings: The Stratosphere 1981. Big part of the Report is dedicated to understanding of the delicate interplay between chemistry and dynamics using complex mathematical models. 1-D and few 2-D models results (including effects of tropospheric NOx, N$_2$O and CO$_2$ changes) were function of changing chemical kinetics thus predicting at steady-state total ozone decline of -5 to -18% due mainly to CFCs perturbation at ~40km (!).

In August 1981 at the Third Scientific Assembly of IAMAP in Hamburg the Commission did not organize separate symposium but did cosponsor few sessions of other Commissions symposia. At the Commission meeting Rumen D. Bojkov reported the conclusions of the assessment meeting held in Hampton VG previous May recognizing imminent treat for the ozone layer. He informed that the WMO Executive Committee had approved the recommendations of Boulder meeting and specifically the concept of Global Ozone Observing System (GO$_3$OS) to include ground and space based observations and analyses; and also Walter Komhyr Laboratory to serve as World Dobson Spectrophotometer Central Laboratory and that NOAA accepted responsibility for the work involved. Report of the latest ozone sondes intercomparisons in Hohenpeissenberg (October 1980) by Walter Atmannspacher was accepted with appreciations. Disappointment was expressed of the failure by Walter Komhyr to conduct the next already funded Dobson intercomparisons during summer of 1981. It was noted that NASA (Edith Reed) has compared Dasibi, ECC sondes and ROCOZ instruments in September 1979. Gerard Mégie informed on intercomparisons of various methods (incl. lidar, Umkehr) carried in France. Reports on previous Dobson intercomparisons (Belsk-1974, Arosa-1978, Potsdam-1979) were still pending from D. Walshaw. WMO purchased 7 sets of standard lamp equipment to be circulated by the Boulder Laboratory through the stations for deductions
of the state of the instruments. President Mateer will look all information and changes due to calibration as well as from intercomparisons to be published by the WMO-WO³DC in Toronto so the researchers to get easy access to such information.

Bob Hudson as chairman of the working group on UV Absorption Coefficients informed that the work of Bass and Paur is progressing, he has contacted the few other interested scientists and he arranged a small meeting of experts in 1983 to review the results. The president encouraged members to participate in the Middle Atmosphere Programme (MAP) keeping the identity of IO³C since lately meetings organized by MAP are sometimes competing with the Commission activities without
to give proper credit. The invitation from Greece to hold next Quadrennial Symposium in Halkidiki in September 1984 was accepted and the Secretary was asked to negotiate details with the local host - Christos Zerefos.

Drastic ozone depletion during Antarctic springs

In September 1984 a week long Quadrennial Ozone Symposium was held in Halkidiki, Greece hosted by Christos Zerefos. More than 200 scientists from 30 countries attended. All 161 presentations were published with support from the European Commission in one volume (Ozone, 1984). In his Presidential address Carl Mateer noted that despite the enormous advances of ozone science over the past 5-6 years and use of sophisticated models the uncertainty which must be attached to the model-predictions of long-term ozone changes have not decreased. Improving of reaction rates used as well as of the projected emissions of substances affecting ozone are pending before this scientifically complex question for future ozone trends could be solved. He emphasized that ozone changes, and the changes in minor constituents which must accompany them will have an impact on climate and vice versa. Therefore it became clear that the ozone and climate changes should be studied with 3-D models which would married the complexities of the photochemical and meteorological processes.

In the presentations there were 19 papers on the chemical-radiative-dynamical modes (including 3 on ozone-climate relation) and 24 papers on observations of relevant to ozone trace constituents. To these 43 presentations was given proper high attention in view of increasing concerns of ozone depletion in long term due to anthropogenic perturbations. The nonlinear dependence of ozone column to changes of ClOx and NOx were studied in multiple numerical scenarios.

In a late comment to this symposium one of the most important but unfortunately unnoticed at the time was a paper by Shigeru Chubachi including plots of drastic total and stratospheric ozone decline during September-October 1982 over Syowa station in Antarctica, referring also to similar total ozone behaviour over the South Pole station. Those were the first plots of ozone depletion event which later, after Farman et al., 1985
Figure 13. The first published plots of the rapid Antarctic-spring decline of ozone over Syowa station by Shigeru Chubachi (Halkidiki Symposium, 1984). Total ozone is on the lower panel and its vertical distribution on the upper panel. The latter first documented that the ozone decline in Sep-Oct occurs in the lower stratosphere.
paper started to be referred to as the Antarctic spring ‘ozone hole’. Chubachi plots did not attract attention possibly because everybody was expecting to see ozone depletion in about 40 km altitude – not in the lower stratosphere where it is clearly seen on the vertical crosssection above Syowa on page 286 of the Proceedings. It should be noted that in early 1995 the NASA TOMS Evaluation Team (P. K. Bhartia et al.) have submitted and a few months later presented at IAGA Assembly in Prague the first space view of the Antarctic ozone depletion for October 1983, that was followed by detailed analyses of the satellite information on the ozone hole phenomenon by Stolarski et al., (1986).

In the Halkidiki QO3S the number of papers on analysis of ozone observations and relations with circulation (39), plus those on developments of observational techniques incl. intercomparisons (34) was substantial as at previous symposia. In the first group of these were discussed the available five-year long series of satellite data providing unique global coverage and in few the noticeable ozone declines as result of the 1982 eruption of El Chichon volcano. In the second group results of important field Balloon Intercomparisons Campaign (BIC) of measuring the trace constituents of interest to the ozone balance was presented by Bob Watson and in large number of oral and posters. Papers on laboratory measurements of absorption cross-sections, chemical rate constants and other radiation topics were 20. In few of them by Bass and Paur (1985) were presented new detailed determinations of ozone absorption at low temperatures which would be replacing the previously used coefficients. On the same subject Bob Hudson reported on the discussions of a meeting of experts chaired by Rumen D. Bojkov held just before the Symposium which paved the way for introducing Bass and Pour absorption coefficients in the Dobson retrievals. Much more work was left which would be completed by the group of Hudson, Mateer, Komhyr and Bojkov. A special mentioning deserves a review of solar UV irradiance of importance to the photochemistry of the stratosphere and mesosphere by Marcel Nicolet. In the 22 papers on non-urban tropospheric ozone observations from numerous stations were reported. Observed increasing trends in tropospheric ozone in the order of up to 1% per year resulting from release of nitrogen oxides and hydrocarbons were of major concern both because of their pos-
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possible influence on climate and on tropospheric chemistry in conditions of changing UV-B penetration.

At the Commission meeting in Halkidiki Rumen Bojkov informed on the successful implementation of the WMO Ozone Project and listed the large number of members who were participating in the UNEP guided discussions on development of a Convention for Protection of the Ozone Layer. The small Nomination Committee (Attmannspacher, Chang and Dütsch) proposed for President Julius S. Chang and for Secretary Rumen D. Bojkov. The latter was elected unanimously. However, a number of members considered “very unusual” that a member of the Nomination Committee was proposed for President; furthermore that in fact he was leaving the field of active ozone study. An alternative proposal was tabled (Gerard Mégie for President) but in the voting he got 36% and Chang was elected. Then for more evenly distribution of responsibility IO3C created the position of Vice-President to which Gérard Mégie was elected. It was done with understanding that the Vice-President is not necessary the next President. New members of the IO3C were elected: Dan Albritton, Reid Basher, Anver Ghazi, Jim Kerr, Arlin Kruger, A. Jim Miller, John Pyle, Paul Simon, Wei-Chyung Wang and Christos Zerefos. The Secretary was requested in the future to solicit and circulate the list of names proposed for members well before the meetings. Realizing that only small number of active scientists could be elected as members, in order to utilize the existing pool of knowledge outside of IO3C it was decided as one possible way to appoint more Rapporteurs for clearly defined tasks as already done in the two previous meetings.

The Commission appointed Prof. Alain Barbe (Reims) to represent the IO3C in a joint with IRC working group on Infrared Absorption Coefficients where he will co-chair with Rudy Zander (Brussels). Other Rapporteurs were Klaus Künzi on Microwave methods of observations; Sherry Rowland on trace species; Bob Hudson on UV ozone absorption coefficients.

In recognition of the long services to the IO3C and contributions to ozone research Hans U. Dutsch was elected unanimously honorary member. Another proposal was made from the floor Julius London who also has contributed to ozone research for many years to be elected honorary member. This was approved with 62% of the vote. Members requested the Secretary to circulate long in advance names for possible consid-
eration for honorary members. It was emphasized that considerations should be restricted to very few extremely respected scientists.

After the Symposium toward the end of 1984 the President drafted procedures which were not always in concurrence with the previous Commission practice and IAMAP Statutes and have had the potential for delaying the communications and the work of the Commission. At the initiative of the past-President and the Vice-President the four Officers met in Washington D.C. on 10 June 1985. They agreed that the nearly 40 years long successful operation of the Commission and the IAMAP Statutes offered wisdom which should be carefully considered before any attempt to establish more specific principles for operation of the Commission as proposed by the President’s letter - which failed to get approval by majority of the members. The Officers keeping in mind their collective responsibility for the better execution of the Commission affairs confirmed they will adhere to the principle of mutual collaboration and the work of the Commission proceeded. It was agreed to initiate procedures for adoption of Commission bylaws exactly in lines with the IAMAP Statutes and the Vice-President would collect the members’ opinion for preparing a draft.

Discussing the place for the 1988 Quadrennial Symposium it was noted that there is offer from University of Göttingen; the President has sensed some interest by China however due to the high costs of both travel and lodging an inquire to members exploring how many ozone researchers from their country would not be prevented to attend was in order. Thereafter will be decided the final location.

In August 1987 the XIX-IUGG Assembly was held in Vancouver. On a MAP Symposium on Differences between Arctic and Antarctic Middle Atmosphere were presented 17 papers dealing directly with the ozone behaviour (see page 190-192 in Ozone, 1987). IO3C did not have separate symposium due to preparations for the 1988-Quadrennial in Göttingen.

The Commission meeting in Vancouver was chaired by the Vice-President Gerard Mégie since the President has asked the members to be informed that he definitely will not seek re-election in 1988 and did not attend the meeting (Ozone, 1987). Members did noted that the outgoing President of IAMAP (H-J. Bolle) put for consideration future activities to be carried not by the existing eight Commissions but by four divisions: Meteorological processes, Climate studies, Atmospheric physics and Atmos-
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...pheric chemistry and pollution. The Executive Committee decided that a new structure is not necessary however cooperation between the Commissions on interdisciplinary issues should be strengthened. Members of IO3C recalled that they already expressed their deep disagreement with such restructuring at the IAMAP Executive Committee discussion in Hawaii in 1985.

All small working groups charged with specific tasks at Halkidiki were asked to submit a one-page report to the Secretary before June 1988 in order to be prepared consolidated report for Göttingen. In this connection appreciation was expressed to Uwe Feister who has already completed a draft for position paper on the need to continue the practice of adjusting the vertical ozone-sonde profiles to the measured total ozone. It was decided Carl Mateer and Rumen Bojkov to prepare formal letter to the Secretary-General of WMO for further communication to the interested countries. Following a recommendation by IUGG it was decided the papers which will be submitted for the Göttingen symposium to be subject to peer review.

With reference to the five Dobson spectrophotometers owned by the IO3C and lent to Arosa (2), Lisbon, Reykjavik and Spitsbergen/Tromso for over 30 years it was decided that operating countries should consider purchasing their own instruments and releasing the Commission owned for distribution to other more desirable locations and anyway the lending agreement should be formalized in order to keep the books in order.

The Vice-President Mégie informed the meeting that in response to the call by IUGG/IAMAP to commemorate the 30th Anniversary of the IGY, the Officers considered all proposals made by members and decided to offer a formal recognition certificate to 25 scientists who had publications in the field of atmospheric ozone in 1957 (or earlier), and/or have been actively engaged in organizing ozone research at that time, and continue to contribute to this field up to the most recent years. The scientists recognized were: Marcel Nicolet, Ernest Vigroux, Victor H. Reger ne, Rudolf Penndorf, Hans-Karl Paetzold, Hans U. Dütsch, Sorren H. H. Larsen, Arlette Vassy, Anna Mani, Alexander Khr. Khrgian, Warren L. Godson, Julius London, Carlton L. Mateer, C. Desmond Walshaw, Genady Iv. Gushtin, Walter K. Komhyr, Rumen D. Bojkov, Wolfgang Warmbt, S. Istiach Rasool, John C. Farman, R. N. Kulkarni, Edith Farkas, Tatsumi Ki...
taoka, Yashiro Sekiguchi, and Karl-Heinz Grasnick. Certificates of recognition will be handled in Göttingen. The Officers recognized that there are a number of other scientists who have made significant contributions to ozone study during the past 20-25 years but could not include them to this list which is strictly devoted to the 30th anniversary of IGY. Proposals for their recognition will be considered in due time. It was recalled that the IO3C has elected by correspondence for honorary member Prof. Marcel Nicolet for his extraordinary contributions to ozone science and continuous support to the Commission activities in nearly 40 years. The decision for recognition was handled to him on occasion of his 75 birthday.

Finally the Commission discussed how to highlight the IO3C role in the numerous activities (e.g. assessments) and/or formal programmes (e.g. MAP, IGBP) in which most members are actively contributing. The view was that the Commission should be formally involved in order to build better support and positions for ozone scientists as a whole.

Ozone decline is a global phenomenon

In August 1988 the Quadrennial Ozone Symposium was held in University of Göttingen with close to 500 participants from 34 countries who presented ~340 papers from which after peer review 198 were published in one volume (Ozone, 1988). It was by far the largest scientific gathering of ozone scientists demonstrating the increasing importance given to the ozone issue. The impact of anthropogenic emissions on stratospheric ozone regime was the major issue of this Symposium discussed in more than 160 presentations. With chemical dynamic models were dealing more than 50 presentations. Another 30 were discussing the accumulated wealth of satellite data. There were only 20 papers on standard observational techniques demonstrating the real shift in the field of ozone research.

Two invited papers review the state of the ozone depletion (Sherry Rowland et al., 1988) and the findings of the NASA/WMO Ozone-Trends Panel (Dan Albritton) in which preparation many of the IO3C members have participated (see WMO, 1988). It was demonstrated that the ozone layer has already been modified by human activities and that these changes
are bound to grow during coming years. The Panel under the chairmanship of Robert T. Watson critically reanalyse and assess the present knowledge on the chemical composition and physical structure of the stratosphere and concluded

- There is **undisputed observational evidence** that the atmospheric concentrations of source gases important in controlling stratospheric ozone levels (CFCs, halons, CH₄, N₂O, CO₂) **continue to increase on global scale because of human activities**;

- **Re-evaluated** ground-based as well as satellite data show **measurable decreases** from 1969 to 1986 in the annual average total ozone (1.7 to 3.0%) at 30-64°N. The decreases are most pronounced (2.3 to 6.2%) during the winter spring months. On the re-evaluation of all published total ozone records considering corrections deduced from instrument calibrations was given high priority;

- During Antarctic-spring large, sudden ozone decrease of more than 50% in the column (and 95% between 15 and 20 km altitude) have been observed. The weight of evidence strongly indicates that **man-made chlorine species are primarily responsible for the observed ozone decrease** within the polar vortex.

At the QO₃S in more than 40 presentations was discussed the Antarctic-spring ozone decline. It was confirmed that the unique features of atmospheric circulation establishing an isolated circumpolar stratospheric vortex with temperatures lower than 80°C lead to the condensation of water and nitric acid to form “polar stratospheric clouds” (PSCs). Laboratory and aircraft measurements determined that through chemical reactions on the surface of the cloud particles large quantities of chlorine and bromine, derived from CFCs and other industrially produced gases, are liberated facilitating heterogeneous ozone destructive reactions. As the ultraviolet light increases during the spring months reactions are activated and there is an increased depletion of ozone. In the 12-22 km layer for few weeks in September–early October practically all ozone is destroyed.

Whereas four years ago less than twenty papers were discussing the tropospheric ozone, in Göttingen there were more than 70 presentations demonstrating increased importance given to its regime showing **increase by 1 to 3% per year** in the Northern middle latitudes during
past two decades. Concerns of tropospheric ozone further modification by human activities releasing precursors such as NOx, CO and hydrocarbons have increased also due to its noticeable contribution to augment the greenhouse effect.

The Commission meeting on recommendation by the Nomination Committee chaired by Marcel Nicolet elected unanimously Gérard Mégie for President, Alvin Jim Miller for Vice-President and re-elected Rumen D. Bojkov for Secretary. New elected members were: J. DeLuisi, P. Fabian, P. Fraser, R. D. Hudson, V. Kirchhoff, D. Kley, Shaw Liu, Y. Makino, C. L. Matteer, S. Perov, U. Schmidt, B. H. Subbaraya and Ding-Wen Wei. IO3C adopted its own By Laws for operations which are subject to approval by IA-
MAP. It was noted that they are based on the 40-years experience of IO3C and IAMAP Statutes and thus would not necessitate any changes. The By Laws are posted on the IO3C web page http://ioc.atmos.uiuc.edu

Review of the work performed by IO3C numerous Rapporteurs did follow. On new UV absorption coefficients Bob Hudson has compared values of Bass and Pour with Brion et al., Freeman et al., and Molina and Molina concluding they are in agreement (relative ±1%, absolute ±2.5%). With reference to the wavelengths used in Dobson spectrophotometer the temperature dependence at 253.7nm taken as average provides best data set. He would need instrument slit-function from Walter Komhyr and then with Carl Mateer would provide final recommendation. Rapporteurs on IR Spectroscopic Applications (A. Barbe/R. Zander) were asked to continue their studies as until now jointly with the Radiation Commission. The Rapporteur on performance of Brewer type instrument Jim Kerr informed that 4-years intercomparisons in Toronto and Edmonton with the Dobson spectrophotometers there show agreement within ±1%.

The Rapporteur on Climatic Effects of Trace Constituents Wey Chyung Wang informed that the radiative aspects of ozone are not jet fully recognized. He was asked to contact the Radiation Commission group on similar subject and jointly to produce list of necessary actions referring specifically to the ozone effect. On related issue on model comparisons Ivar Isaksen agreed to be the focal point.

The idea of a network of dozen stations with more sophisticated observational technique (lidar, microwave, IR/Visible/UV spectrometers) for Detection of Stratospheric Change (NDSC) was evolving rapidly. It has been endorsed by WMO as contributing network to the WMO Global Atmosphere Watch (GAW). Number of Commission members were involved in its planning and in the Steering body and all others were encouraged to participate when occasion arise.

Notting that the International Geosphere Biosphere Programme (IGBP) is in its definition phase and many members are associated at national and international levels since the ozone problem is one of its corner stones; IO3C should act to promote the ozone research in IGBP and be represented to the relevant Steering Groups. In this connection IO3C was informed that the Commission on Atmospheric Chemistry and Glo-
bal Pollution was proceeding unilaterally of formulation of International Global Atmospheric Chemistry activities (IGAC) although in Vancouver (1987) between the two Presidents was agreed the need of joint approach. The Secretary of IO3C has send letter to their Secretary (Henning Rhode) underlining the interest of IO3C and demanding to be considered for active contribution to the coming planning meeting in Australia (November 1988).

The new President suggested that the IO3C should be considered as an independent reviewer of future WMO/UNEP International Ozone Assessments with this to give some recognition to the numerous members’ contributions in the process of their preparations. This has been accepted by WMO.

Figure 15 Jérard Mégie (1946 -2004) Internationally recognized scientist he contributed to the development and operation of laser for observations of ozone and other atmospheric components and worked enthusiastically for European and global co-operation in atmospheric sciences. As Vice-President (1984-1988) and as President of IO3C (1988-1996) he assured active participation of its members in the WMO-Ozone Assessments, in comparisons of VO3D methods, in joint work with SPARC and IGAC, and in support to NDSC. In 2000 was named to the top science position in France – Chairman of CNRS.
In connection with the proposed IAMAP reorganization amalgamating the existing Commissions, the IO3C reconfirmed its deep disagreement and adopted a formal Resolution to be send to the IAMAP in which explained its strong stand against modification of this Commission charter. The Resolution is published by IAMAP (Ozone, 1989) and will be posted in 2010 on the IO3C web page http://ioc.atmos.uiuc.edu). There was no objections the proposal for change the name of the Association from IAMAP to IAMAS although was not obvious the need to change the word ‘Physics’ with ‘Sciences’.

As venue for the next Quadrennial Ozone Symposium Bob Hudson offered on behalf of US science community to be considered the University of South Carolina in Charlottesville with understanding that responsible host will be NASA. This proposal was appreciated however the Officers were asked to explore opportunity if any from the Far East and then to be decided.

Finally the Commission benefiting from the reported new findings on the ozone issue after many years of research concluded that there is now clear evidence of mankind having affected the global ozone layer. This is the first firm evidence that humans have significantly and harmfully altered the atmosphere on global scale. IO3C urged all national and international Agencies to continue to support and develop further their programmes on research and monitoring of ozone and associated atmospheric parameters and after further considerations by mail adopted a Statement on The State of the Ozone Layer for wide distribution (full text will be posted in 2010 at the IO3C web page http://ioc.atmos.uiuc.edu).

Ozone mega-symposia, ozone assessments and international projects

In August 1989 during the IAMAP/IUGG Assembly in Reading the Commission held short meeting for exchange of information. More than half of the IO3C members have been actively participating in the writing and review of the WMO/UNEP Ozone Assessment–1988 which will be published as WMO Ozone Project Report #20 toward the end of the year. For IUGG Assembly in Vienna in 1991 were planned two symposia of potential interest to IO3C. Especially relevant would be 6-days symposium on Middle At-
mosphere Sciences to which ozone papers would be welcomed. Paul Simon will be representing the Commission on the programme committee.

Formal invitation for 1992 Ozone Symposium at the University of South Carolina was received from the chairman of US Organizing Committee Bob D. Hudson. In the University campus in early June will be available more than 600 units all with kitchenette at a price per room of 20-30$ per night. In the meantime Officers also received a tentative invitation from Prof. Ding-Wen Wei for Beijing, however he could not provide commitment for support by Meteorological Administration and/or Academia Sinica (needed for visa and assuring proper accommodations) therefore he withdrew hoping that could master support for 1996. In view of above Secretary would ask all members to express their approval for holding next symposium in U.S.A.

In the planning for the IGAC more than half of IO3C members have participated as subject-group leaders and reviewers. Although the President of the sister Commission ACGP has assured in letter the Secretary that the active collaboration of IO3C will be reflected, recognition was missing in the final draft. Neither the 4-pages of suggestions provided by the Secretary were taken into consideration. Since ozone figures prominently in number of projects, the Officers were asked to re-emphasise the interest of the Ozone Commission on earliest occasion.

The brief report by Bob R. Hudson - Rapporteur on ozone UV absorption coefficients indicated that he is preparing a normalized data set and in very near future will send it first to Carl Mateer who needs it for finalizing the new algorithm and Umkehr retrieval. Indeed the application of Bass-Paur 1984 ozone absorption coefficients to ozone measurements with Dobson spectrophotometers was elaborated by Carl Mateer (13 pages) and is available from http://www.esrl.noaa.gov/gmd/ozwv/DOBSON/papers/bass-paur_1984_abs_coeffs.html

In November 1989 WMO hosted the planning meeting for Network for Detection of Stratospheric Change (NDSC) organized by NASA, other national agencies and with participation of IO3C. More than 60 scientists from all over the world including number of IO3C members attended. Potential sites, instruments, data protocol and near-term tasks were discussed. For Chairman was elected Mike Kurylo (later member of IO3C). Four of the six Principal Investigators were from the IO3C (Mégie, Mat-
thews, Susan Solomon and A. Jim Miller); from the ten Peers for standing review the affairs of NDSC five were IO3C affiliated (Albritton, Bojkov, Ehhalt, Khattatov and Rodgers). The network is established on an international base under the auspices of international societies and programmes (e.g. WMO-GAW, IO3C, NASA, NOAA, CNRS, CMA). Its Goals were defined as: (a) to make observations with which changes in the physical state of the stratosphere can be determined and understood; (b) to provide independent calibration of satellite sensors and (c) to obtain data that can be used to assess multidimensional stratospheric chemical and dynamical models.

In June 1992 in Charlottesville, SC more than 500 participants from 35 countries presented 415 papers covering: stratospheric ozone and climate, ozone in Arctic and Antarctic, measurements, trends, theory and modelling, volcanic effects, tropospheric ozone trends, global and regional modelling and the human impact. The Proceedings of the Symposium contained 332 peer-reviewed papers and was published by NASA (Ozone, 1992). By its size this Symposium was slightly bigger than the Göttingen-1988. The emphasis of ongoing studies was on observed ozone changes and they presented a useful background for the next international review prepared for the Parties to the Montreal Protocol - Scientific Assessment of Ozone Depletion - 1994 in which preparations most of the IO3C members participated (WMO, 1994b). The enormous volume and variety of presented papers make it difficult to provide a sensible summary in the limited space here, that why interested researchers should refer to the mentioned NASA publication #3266.

The Commission meeting appreciated that as decided earlier, at the Vienna IAMAP-IUGG Assembly (1991) its members have organized ozone session in Middle Atmosphere Sciences symposium (convener Paul Simon), on Modelling of Tropospheric Ozone and its Precursors with 43 papers presented (conveners Julius Chang and Shaw Liu), and two days Workshop on Climatic Effects of Atmospheric Trace Constituents incl. Ozone (conveners Wei-Chyung Wang, Ivar Isaksen, Julius London and Anver Ghazi).

At the 1991 IUGG Assembly the Officers made again point that there is no reason to amalgamate the IO3C with its sister Commission on Chemistry and Global Pollution (ICACGP) as suggested by the latter possibly looking for involvement in the most attractive current field of research.
Ozone is not only ‘pollutant’ but the unique species which link chemistry, dynamics and radiation in the stratosphere and the IO$_3$C has specific traditional tasks carried successfully since the 1930s which could not be absorbed in an amalgamation. The important role played by the IO$_3$C in international science field including preparations of scientific backgrounds for the Vienna Convention for Protection of the Ozone Layer and its Montreal Protocol was emphasized as a strong rationale for not modifying the IAMAP Commissions structure.

In the winter **1991/1992** very large efforts were brought to organize co-ordinated experiment in the Arctic to study the potential depletion of the ozone layer and its influence on middle latitudes. The Commission through its members from Europe, US and Canada was strongly involved. The results were reported in hundred of papers in JGR, JRL and other major journals as well as being used in the Ozone Assessment-1994 (WMO, 1994b). WMO and IO$_3$C did collaborate to assure daily submissions, mapping and redistribution of total ozone data from GO$_3$OS by the WMO Ozone Mapping Centre operated by University of Thessaloniki (http://lap.physics.auth.gr/ozonemaps).

In an effort to create the best possible quality assured ozone records, a joint project between NOAA, WMO and the IO$_3$C was initiated to prepare a ‘Handbook for Dobson Ozone Data Re-evaluation’. The first meeting of experts was held in Greenbelt MD in September 1991 (WMO, 1991a); the second in Charlottesville (before the Ozone Symposium) and the third meeting was planned for Hradec Kralove in May 1993. As final result the Handbook was prepared by Bojkov, Komhyr, Lapworth and Vanicek, published (WMO, 1993) and widely used by the stations with long observational records for their re-evaluation. The corrected data were deposited by the stations to the WMO-WO$_3$DC in Toronto.

With reference to the introduction of the Bass and Pour ozone absorption coefficients, the responsible Commission members (Hudson, Mateer, Komhyr) in collaboration with WMO (Bojkov), have prepared the necessary instruction which was introduced worldwide by WMO starting 1$^{st}$ January 1992 (see transfer instruction at http://www.esrl.noaa.gov/gmd/ozwv/dobson/papers/coeffs.html).

For uniformity and improving of observations by the newly introduced in GO$_3$OS Brewer type spectrophotometers WMO jointly with members of
IO\textsubscript{3}C have organized Consultations between the operators in Arosa in August 1990 and in Charlottesville in June 1992. The reports of these Consultations were published in the WMO Ozone Project Reports \# 22, and \# 30 respectively (WMO, 1990, 1992).

The upgrading of WMO GO\textsubscript{3}OS stations, which are presently the only ground stations continuously providing data for trend assessments, was performed with efforts by numerous members of IO\textsubscript{3}C. In August 1990, 18 Dobson spectrophotometers were intercompared in Arosa with very good results. Also one ozonesonde intercomparisons was carried out in Vanscoy, Saskatoon, Canada in May 1991, jointly organized by WMO and IO\textsubscript{3}C (WMO, 1991b).

A critical assessment of the information content in the Umkehr observations for the ozone profile has been carried by WMO in collaboration with the Commission (by Bojkov, Mateer, Kosmidis, Zerefos, DeLuisi, Petropavlovskikh and Godin). Meeting of experts were held in Toronto, Tenerife and in NASA-Goddard and new algorithm was tested. The undisputable usefulness of Umkehr derived information was established and the reanalysis of more than 44000 ozone profiles including the necessary aerosol and total ozone re-evaluation corrections was progressing and later an extensive review was published (Bojkov et al., 2002).

After the above review of the work of IO\textsubscript{3}C and its Officers (Mégie, Miller and Bojkov) in the past four years the Commission unanimously re-elected them for the next period (1992-1996). In recognition of nearly 40-years of continuous ozone research and in particular for major contributions to the Umkehr retrieval and work with the IO\textsubscript{3}C Carlton L. Mateer was unanimously elected honorary member. The following new members were elected: G. Brasseur, M. Degorska, G. Fiocco, G. K. Y. Hassan, G. Hov, T. Ito, V. Khattatov, W. A. Matthews, C. T. Mc Elroy, S. Penkett, J-P. Pomereau, C. Rodgers, S. Solomon, J. Stachelin, R. Stolarski, K. Vanicek, R. DeZafra and Xiuj Zhou.

In July 1994 in Tenerife the IO\textsubscript{3}C jointly with NOAA, Environment Canada and WMO has organized workshops on Brewer operations and on Ozone Data Re-evaluation and Use of Dobson and Brewer instruments in the GO\textsubscript{3}OS. About 70 scientists from 27 countries participated. Emphasis was on quality of data and on vertical ozone distribution evaluations. The Brewer consultation was guided by three Commission members: J. Kerr, T. McElroy and E. Cuevas who published the results in WMO
Ozone Project Report #36 (WMO, 1994a). One important recommendation was directed to the IO3C to organize small group to prepare a Handbook on Brewers Operations. Bob D. Hudson (NASA) and Walter Planett (NOAA) attended in particular the data re-evaluation and VO3D workshop and their satellites groups provided essential data support. The attending dozen Commission members strongly endorsed the proposal to be organized special workshop to discuss together with modellers the VO3D profile issues probably before the Quadrennial Symposium-1996. Later it was found convenient and detailed study of the state of the VO3D was completed in collaboration with SPARC and GAW (WMO, 1998).

In May 1995 in Halkidiki was held an International Conference on Ozone in the Lower Stratosphere. It was jointly organized by the European Commission, NASA, NOAA, IO3C and WMO and hosted by Christos Zerefos. The newly established within the WMO/ICSU Climate Research Programme SPARC project (Stratospheric Processes And their Relation to Climate) has also assisted in preparation of the programme. More than 300 scientists from 40 countries attended. The emphasis by such international forum was given on interpretation of new measurements and trends of ozone, NOy, HOx, halogen compounds, aerosols and on critical uncertainties in atmospheric chemistry and transport models. In recent years, ozone depletion has reached unprecedented levels. Considerable progress in both measurements and theory has been made, allowing an improved understanding of the processes responsible for the ozone loss. The participants reported on and discussed results from major field campaigns (e.g. EASOE, AASE, SESAME, ASHOE) and from space-based atmospheric chemistry measuring instruments or platforms such as UARS, ATLAS, POAM, TOMS, SAGE and SBUV/2 all of which have provided essential information.

With reference to the global decline of the ozone the availability of more data both from ground-based and satellite instruments permitted the establishment of long-term zonal as well as hemispheric and global variations for the 1964-1994 period (e.g. Stolarski et al., 1992; Bojkov with Fioletov, 1995). The difference between the estimations of monthly zonal variations from ground-based and TOMS data for the overlapping period of 1979-1993 is less than 1% in latitudes 40°S-60°N. The ozone changes are several times larger than possible errors of the estimated
values; therefore the observed decline is highly reliable. The changes show that the northern hemisphere average ozone was ~312 and the southern average was ~300 matm-cm in the pre-ozone-hole decades (1964-1980) and that the global average for the 1984-1993 period was lower by ~3% (from 306.4±1.0 down to 297.7±2.2 matm-cm. Noticeable is the levelling of the secondary ozone maximum during Sep-Nov of the later period due to the drastic Antarctic-spring decline. The levels of annual ozone maximum have been reduced by 5.8% in the southern hemisphere and 3.2% in the northern hemisphere, and the levels of ozone minimum have been reduced by 2.1% and 1.2%, respectively. The cumulative year-round global ozone decline is 4.8±0.6%; however, the cumulative year-round decline over middle and polar latitudes is close to 8%. In the northern belt it is higher in the winter-spring and is 4-6% in summer and fall. In the southern belt the cumulative decline is ~10%, reaching 40% in Sep-Nov in Antarctica. The southern hemisphere contributed ~64% of the overall ozone decline.

In October 1995 the Nobel Prize for Chemistry was granted to Crutzen, Molina and Rowland. That was an unprecedented recognition of the pioneering work on the ozone issue carried out by those colleagues. This was accepted with admiration by all ozone scientists as recognition of the efforts of the whole ozone community. Later in December 1995 the Intergovernmental Conference of the Parties to the Vienna Convention for Protection of the Ozone Layer on occasion of its 10-years anniversary has recognized 7 atmospheric and 2 biology scientists, as well as few negotiators and technology transfer assisting institutions by granting them ‘United Nations Award for Outstanding Contribution to the Protection of the Ozone Layer’. In the field of atmospheric sciences those recognized were: Albritton, Bojkov, Crutzen, Farman, Molina, Rowland and Watson (five of them members of IO3C).

In September 1996 the Quadrennial Ozone Symposium was held at the University of L'Aquila (Italy) with local host Guido Visconti. 622 participants submitted 486 abstracts and 252 peer-review papers were published in two volumes (Ozone, 1996). The two opening talks were given by the Nobelists Paul Crutzen and Sherry Rowland. Those were moving moments which lifted the spirit of the hundreds of attending ozone scientists. At the symposium in Charlottesville the effect of the Mt. Pinatubo
eruption in 1991 was barely discussed. In L’Aquila there was an occasion to review the changes induced on the composition of the stratosphere by this eruption which turned out to have only one-two year’s long effect on the ozone. Here was the first time when indications of reduced growing and even start of levelling in the concentrations of some harmful to the ozone compounds were reported and interpreted as positive result of the Montreal Protocol measures to contain the ozone losses.

About 30% of the papers were devoted to observations and analysis of total and vertical ozone distributions. Results for polar ozone changes mainly referred to Antarctica where surface of the ozone hole has been expanding reaching 24-25 million km² during September-October and nearly 70% ozone decline during week’s long intervals when in the 14-20 km layer 95% of the ozone has been destroyed. A very interesting study of behaviour over sub-Arctic regions did show that in the last seven wintersprings the deficiencies over Siberia have been ~15% and for short time have exceeded 30%; in Europe or North America in the same time defi-

**Figure 16.** In October 1995 the Nobel Prize for Chemistry was granted to Paul Crutzen, Mario Molina and F. Sherry Rowland. That was an unprecedented recognition of the pioneering work on the ozone issue carried out by those colleagues. This was accepted with admiration by all ozone scientists as recognition the efforts of the whole ozone community. They have been members actively supporting the work of the Commission for many years and lately were elected also Honorary members.
ciencies were somewhat smaller. The negative decadal trend is estimated to be of the order of few percent. Typical ozone changes over North America and Eurasia range between -7 and -3% per decade. Over the Tropics the trend is almost negligible and not significant.

Data on trace gases which determine the ozone concentrations are still sparse, however more than 50 papers were on such data analysis or demonstration of new instruments for trace gas measurements. In the modelling section there are 33 papers. In number of them results presented were using the Chemical Transport Model (CTM). A few dealt with reconstruction of composition before the industrial era and a few with effects of aviation which overall effect seems quite small. Although the observational data has increased they remain still too sparse to be useful for realistic verification of most of the modelling results. A particular lack of data was noted in connection with heterogeneous chemistry.

The section on tropospheric ozone contains also papers on more general aspect of tropospheric chemistry as connected to the ozone problem. The reported ozone increase mostly over Northern Middle latitudes is difficult to generalize due to lack of sufficient observations, although it is well established that the increase is related to the urban pollution which can be transported to long distances. Another important report concerns the influence on tropospheric ozone by large and wide-spread tropical fires obtained using satellites data (e.g. UARS, TOMS).

At the end of the Proceedings are included 33 papers dealing with experimental techniques and results of intercomparisons and problems of calibrations of Dobson’s, Brewers, ozonesondes, etc).

At the Commission meeting in L’Aquila the President report on the past activities was accepted with appreciation for Commission Officers dedicated services to the ozone community. The Proposal of the Nomination Committee (Mégie, Solomon, Mateer) for election of Officers was Bob D. Hudson for President, Andy Matthews for Vice-President and Rumen D. Bojkov for Secretary. After some discussions these proposals were accepted with a secret balloting. The Commission noted the continuous and significant contributions to the work of the Commission during past twenty years by the two Nobel laureates Paul Crutzen and Sherry Rowland and was pleased to elect them as honorary members. Furthermore, recognizing the pioneering work in the ozone field done in 1950-
1970s by one of the past presidents (1968-1974), Alan W. Brewer, the Commission also elected him as an honorary member. The following new members were elected: R. Atkinson, H. Claude, N. Elanski, M. Ginzburg, I. Isaksen, C. Mauersberger, D. McKenna, T. Ogawa, M. Prather, P. Simon, A. Thompson, G. Visconti and Ch. Zerefos.

As concern the location of the next Symposium the Secretary has received only one written proposal by Japan which include promises for substantial local support. From the floor were made two tentative proposals offering Montreal and Melbourne. It was agreed each of the groups should submit to the Secretary of the Commission written offers describing the conditions and clearly stating the expected national support before the end of November 1996. Then a summary would be circulated to the members for a final decision.

On the related issue for the publication policy of the Proceedings and organizing the future QO3S discussion revealed that the Quadrennial Symposiums became extremely big and their organization lately escalated to more than 400 000$ plus work and cost of publishing the proceedings which is a big burden for the organizers. Question raised included: duration to be 5.5 days with no more than two invited reviews; availability of University accommodations and/or not expensive lodging facilities; to published without (or with long time taking peer-review), short (four page) papers or two page extended abstracts - because many scientists prefer long papers in refereed journals; consider use of internet for submissions and then CD ROM for ‘printing’. However, it was recalled that for many scientists the Proceedings are the only printed summary of the state of the ozone. It was decided the past Vice-President A. Jim Miller to collect opinions and prepare summary before May 1997 for decision by mail of the Commission.

Concerns were expressed that ozonesonde data from important stations like South Pole and Mauna Loa are not deposited to the WMO-WO3DC. The ozone data from the British Antarctic Survey, although available on personal request, are also not deposited in the Data Centre. This is in contradiction with the Vienna Convention for immediate exchange of ozone information for research purposes and the respected National institutions should be asked to amend their practice.

The need for expanding ground based ozone and related species observations in the tropical belt and southern hemisphere was stressed. In
connection with the later it was noted that WMO Ozone Project has got funds from the Global Environment Facility (GEF) for expanding the ozone network in South America and establishing of total and surface ozone stations along with some GAW programme measuring stations in Argentina, Brazil, Chile, Paraguay and Uruguay was in progress under the supervision of the IO3C Secretary.

In the Ozone Assessment:1994 were reported large discrepancies between ozone trends in the lower stratosphere estimated by the sondes (0±3% per decade), Umkehr and SAGE (0±8% per decade) as was already reported at the WMO/IO3C meetings at Tenerife (1994). Therefore strong recommendation was made to consider detailed review of the

Figure 17. Robert D. Hudson was leader of NASA satellite ozone measurements, analysis and calibrations for nearly two decades. Internationally respected scientist he organized number of stratospheric-ozone national and international assessments which have had great impact on the ozone science and the move to save the ozone layer. He played the leading role for the physical model and adjustments of the Bass-Pour ozone absorption coefficients for use in the GO3OS and in the efforts for keeping high quality of ozone measurements from the ground and from the space. He served as President of the IO3C 1996-2004.
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quality of the different VO3D profiles. The outline of the assessment was
determined by an international group of scientists during a WMO/IO3C/
SPARC sponsored Workshop held at the Observatory at Haute Provence
in France in July 1996. Bob D. Hudson and Neil Harris were the co-chairs.
The drafts of the chapters were prepared in the following year. The draft
report was examined by an international panel of reviewers both by mail
and at a meeting at Abingdon, UK in October 1997. The resulting 298
pages document SPARC/IO3C/GAW Assessment of Trends in the VO3D
was published in May 1998 (WMO, 1998). The re-analysis provided for
the first time also confidence limits for the different systems measuring
VO3D very useful for the next assessments on the state of the ozone.

In September 1997 the United Nations Environment Programme on
the occasion of the 10th anniversary of the Montreal Protocol has recog-
nized the contribution to the protection of the ozone layer by offering the
global ozone award to Ralph Cicerone, Susan Solomon, Richard Stolarski
and Christos Zerefos at an official ceremony in Montreal.

In July 2000 the Quadrennial Ozone Symposium was held in Hokkai-
do University, Sapporo on a kind invitation by the ozone researchers of Ja-
pan. Registered were 566 participants and the Proceedings of the Ozone
Symposium-2000 contained 403 two-page extended abstracts out of
more than 600 originally submitted titles (Ozone, 2000). Organizers were
faced with enormous workload both in preparation of the Programme and
in the actual conduct of such size of scientific gathering. Fortunately the
content of the Proceedings was made available also on the internet after
the event and is posted on the IO3C web site.

The Commission meeting heard the proposal by the Nomination Com-
mittee chairman Gérard Mégie for the next four years to re-elect for Pres-
ident Robert D. Hudson and to elect for Vice President Toshihiro Ogawa
and for Secretary Christos Zerefos. From the floor was proposed the
name of Andrew Matthews to be considered for President; however he
received only few votes. Thereafter, the proposal for Officers by the Nomi-
ation Committee was carried with majority. The President proposed that
Rumen D. Bojkov who has been an extraordinarily active Secretary for 16
years and as leader in the international scene has guided the expansion
of WMO ozone network activities and contributed to the ozone science for
more than 30-years be elected honorary member. This was unanimously

The President suggested that in view of the rapid developments in the overall field of ozone science one should consider *redefining and broadening the role of the IO\textsubscript{3}C*. He referred to the history of the IO\textsubscript{3}C established by IUGG in 1948 as an upgrading of the Committee on Ozone existing since 1933 (IUGG Lisbon). In the first four decades the main preoccupation of the Committee and the Commission was to build a functioning Dobson network which was one of the main components of the IGY (1956-57). Together with WMO the IO\textsubscript{3}C established common observational practices and initiated the central collection of all ozone data. Within the following years the Commission brought together scientists from the observations community with theoreticians and atmospheric chemists and became an Organization concerned with the broad aspects of the ozone issue including the interactions of chemistry-dynamics and radiation. IO\textsubscript{3}C is the arm of IAMAS (which is part of IUGG-ICSU science family) providing the authoritative scientific information on the ozone issue and coordinating the international scientific activities in this field. What message comes out from the Sapporo symposium was that we have to broaden the scope of what we are doing and demonstrate the leading role of the Commission, concluded the President. For this purpose, the Commission established a small sub-committee consisting of experienced members (G. Brasseur, G. Mégie, T. Ogawa, M. Prather) who were charged to propose for further discussion in 2001 redefining the role of IO\textsubscript{3}C.

For hosting of the next Quadrennial Ozone Symposium in 2004 there are two formal proposals: one from Greece (Halkidiki or 80 km from Athens) and the other from Egypt (Cairo). There was also an informal suggestion from New Zealand. To host a Symposium with 500-600 participants is a fairly costly and demanding work as already noted in 1996 and by the review made by A. Jim Miller in 1997 on the conditions for arranging Quadrennial Ozone Symposia. Therefore, the Commission established a small subcommittee to define what should be included in any proposal based on what we expect to have in a Symposium. Past symposia requested substantial support to be provided to scientists from developing
countries and to graduate students. So availability of less expensive students type accommodation is an important aspect that IO3C should take into consideration when deciding on the future location. Ivar Isaksen is the chairman of that sub-committee. After collecting the necessary additional information the Commission should decide on place and time possibly at its next meeting at Innsbruck IAMAS Assembly in July 2001. There is planned to be held an IO3C co-sponsored Symposium on NOx generation by electric discharges jointly with the IAMAS Commission on Atmospheric Electricity.

Following a proposal from the President and Secretary a web site will be created – with some history of the Commission (by Rumen D. Bojkov) – and information on plans and/or ongoing activities. The aim will be to try to make IO3C more open and visible. Don Wuebbles offered to construct and maintain the site at http://ioc.atmos.uiuc.edu in collaboration with the Secretary of the IO3C.

It was recalled that IO3C owns 5 Dobson instruments lent for use to a few stations: #13 Lisbon, #14 Tromso, #15 was in Arosa and without agreement of the IO3C this year sub-lent to Botswana, #50 Reykjavik and #51 Arosa (automated in 1971). The Commission requested Officers to assure that the instruments are being properly used; otherwise they should be refurbished and placed on loan in data sparse areas like Siberia and/or in developing counties carefully selected on discretion of the Commission.

The Commission decided that it should be involved and took lead in specific projects similarly to the joint WMO SPARC-IO3C excellent report on assessment of trends in the vertical ozone distribution (WMO, 1998) and its members involvement in the International Ozone Assessments should be made more visible. Initial proposals in the area of improvements of the Umkehr retrievals, ozone and climate issues etc will be developed by the Officers for further consideration by the Commission. Hans Claude suggested to be prepared a press release with the highlights of Sapporo Symposium which could also be published in EOS and the IGAC newsletter. The newly elected Secretary was asked to take the initiative for this. All these are thought will increase the visibility of IO3C.

A discussion followed as to what is the role of the Commission as part of IAMAS and the distinction which should be made between projects.
with limited longevity (such as SPARC) and an international scientific coordinating body such as the IO3C. It was felt that the overall structure should not be changed. IO3C has an obligation to see that scientific activities continue even after SPARC and IGAC come to an end. Speakers were G. Brasseur, R. Bojkov, R. McKenzie, G. Mégie, R. Stolarski, and the President Bob D. Hudson.

The attendees were informed that over 20 papers which for various reasons were missing in the Proceedings although accepted by the Programme Committee will be printed as a supplement and will be distributed to the registered participants of the Sapporo Symposium. The Proceeding will be made accessible also by internet.

In June 2004 the Quadrennial Symposium on Atmospheric Ozone was hosted by Christos Zerefos at the island of Kos with nearly 600 participants submitting ~700 abstracts (all available on the IO3C web page http://ioc.atmos.uiuc.edu). This symposium coincided with the 20th anniversary of the discovery of the springtime drastic ozone decline over Antarctica reported by Chubachi at the Halkidiki Symposium, now commonly called the ozone hole. It also did mark two decades of intense research in atmospheric chemistry and physics and in global atmospheric monitoring. The progress in understanding of the impact of human activities on the chemistry and physics of the global stratosphere since the Ozone Symposium-2000 was presented in hundreds of papers and posters. It is difficult to refer to individual contributions therefore attempt is made to summarize the important topics discussed at the symposium in the following few paragraphs.

**The search for ozone recovery** in long-term data records of ozone was inspired by the observed decline of many of the ozone-depleting CFCs in the troposphere. Levelling off of the chlorine content of the stratosphere started also to be visible. The next step naturally was to search for the response of ozone to this change in chlorine concentrations. Overall, it appears that ozone in the last few years is a percent or two higher than was expected from earlier projections based on sensitivity of ozone to influences of halogen compounds, aerosols and the solar cycle. Making an early detection of ozone response to the levelling off and future decline of chlorine compounds requires a clear definition of terms. In the presentations were defined at least three stages of recovery for ozone.
These are: (1) statistically significant slowing of the downward trend; (2) statistically significant upward trend after removal of all other known influences such as solar cycle and volcanic aerosols; and (3) reaching pre-1978 ozone levels in the stratosphere. It has been shown that achieving the second of these stages will take more than few decades of measurements with well-calibrated instruments. The discussion in Kos has centred around the criteria for stage 1. Has the trend slowed down by a statistically significant amount? At that time the answer is negative. It was emphasized that the search for the response of ozone is complicated by a number of factors: (a) year-to-year variability in meteorology and related atmospheric dynamics; (b) response of meteorology to changes in ozone, greenhouse gases and changes in the radiation balance and (c) interference between recovery from volcanic eruptions of El Chichon in 1982 and Pinatubo in 1991 and the 11-year solar cycle. Most participants agreed that the detection of ozone recovery still requires patience and dedicated studies. Its detection will depend on availability of continued quality observations.

**Use of satellite and ground-based data in evaluation the models of ozone loss and recovery.**

Indeed, in the past four years significant developments have been achieved in quality satellite observations based on the continuation of international collaboration involving ESA, NASA and JAXA. Significant data from European ENVISAT instruments such as GOMOS, SCIAMACHY, MIPAS was reported along with data from the Swedish/Canadian/French ODIN/OSIRIS, the Japanese ILAS/ILAS II, and the United States' TOMS/SBUV, SAGE, HALOE, and AIRS. Several contributions addressed the rapid development of chemical data assimilation techniques. The validation of these measurements has emphasized the need for long term quality ground-based data as provided by the GOMES in general and NDSC in particular.

The extension of long-term quality data records made by satellites and by ground-based stations around the world was appreciated. Satellite records of ozone on a global scale are now more than 25 years in length. TOMS and SBUV improved version-8 was officially released at the Kos Symposium. The GOME instrument now has 9 years of data that have been evaluated for trend quality and can be added to the record.
The ground-based data extends, in a few places, back for five decades (the Dobson spectrophotometers), fewer ozonesondes and only lately of increasing number of Brewer instruments. The continued maintenance of the calibration of the ground stations was discussed with emphasis on expanded intercomparisons, data re-evaluations and comparisons with satellite records.

_Evaluation of the future of ozone recovery in an atmosphere with changing climate and the effect of ozone on that climate using coupled climate/chemistry models._ Numerous chemistry/climate models were presented. They did address the problem of how changes in the meteorology and/or climate interact with changes in the chemistry of ozone. One problem is how changes in meteorology over the last 25 years may have contributed to observed ozone changes and feedback mechanisms. Models can then be used to extrapolate that knowledge to what may happen in the future with the expected increase in methane, nitrous oxide, and carbon dioxide and their radiative effects. Understanding of ozone loss and its future recovery requires knowledge of the distributions and budgets of the compounds that contribute to ozone loss. Significant new work that combines satellite and _in situ_ observations with model calculations was presented at the Symposium providing an insight into the budget of oxides of nitrogen and a range of halogen species, which are indispensable to our understanding of the global carbon and hydrological cycles. Water vapour presents a particularly important challenge: satellite data, shown at the meeting, is not consistent in trend with previous ground-based data. Understanding the feedback mechanism between water vapour content, ozone, and polar stratospheric clouds is critical to the evaluation of predictions of ozone in a future warmer climate.

The developing capability of satellites to measure the composition of the troposphere and observe the effects of long range transport of pollution was best demonstrated in the _studies of tropospheric ozone budget_ which is influenced by a variety of ozone precursor sources, long-range transport in the troposphere and intrusions from the stratosphere. The evaluation of these processes at global scale makes the determination and attribution of the positive trends in tropospheric ozone difficult. Yet, significant progress was made with the development of new satellite retrieval techniques combined with the use of tropospheric models. Num-
bers of satellites (TOMS, GOME, MOPPIT, SCHIAMACHY, MERIS, MODIS and AIRS) have provided significant new information in monitoring tropospheric pollutants. NASA’s satellites and ozone soundings revealed that seasonal episodes of high ozone over south Atlantic begin with pollution sources located thousands of miles away. Examination of the long-range transport of tropospheric pollution and its coupling to climate is being studied using climate/chemistry models. Long-range transport of pollutants maintains regionally high background levels of tropospheric ozone.

**Measurement and trends in the UV radiation** reaching the surface of the Earth and its complex relationship to ozone change, cloudiness, and aerosols was subject of few papers. UV-B levels for 2000-2019 are predicted to decrease for all seasons but the trends are not statistically significant, except during spring over both hemispheres. UV-B trends are mainly caused by the total ozone trends because in the future cloud changes are predicted to be small in the coupled chemistry climate model used in these studies. Nonetheless, there is a region over Western Europe which is predicted to show an increase in UV-B due primarily to a decrease in cloudiness.

**The Montreal Protocol and its amendments led to a fast decrease of the emissions of ozone depleting substances (ODS).** There is evidence that the effect of anthropogenic emissions of ODS peaked in the last years of the 20th century. A very slow decrease of stratospheric ODS concentrations is expected to take place in the coming decades. Assuming undisturbed climatological and physical atmospheric conditions, model calculations presented expectations that the full compliances with the requirements of the Montreal Protocol will lead to the recovery of the ozone layer. However, due to the large interannual variability connected with long-term climate variability the identification of the turn around of stratospheric ozone trends is a challenging task. The ozone layer will remain particularly vulnerable during the next two decades or so especially in the Polar Regions, even with full compliance. Relative to the pre-ozone-hole abundances the losses in total column ozone amounts are ~4% at northern midlatitudes in wither/spring and ~6% at southern midlatitudes on a year-round basis. Continued compliance with the Montreal Protocol is expected to lead to a recovery of the ozone layer in the second half of this century. The meeting highlighted the progress toward that goal and
the difficult question how the future of ozone may evolve in a changing climate.

The Commission elected for President Ivar Isaksen, for Vice-President Sophie Godin-Beekmann and re-elected Christos Zerefos for Secretary. In view of the significant contributions to ozone science and to the work of the Commission Mario Molina was elected *honorary member*. The newly

Figure 18. Ivar S. A. Isaksen main area of research is modelling of the chemical composition of the stratosphere and the troposphere, and the perturbations caused by human activities with emphasis on processes of importance for ozone depletion, changes in greenhouse gases, and climate chemistry interactions. He assisted late Eigil Hesstvedt and further developed the first two-dimensional strato-tropospheric models. Well respected scientist and University of Oslo professor he contributed to all International Ozone Assessments reports and tutored many young students in above mentioned fields. Isaksen was elected in Kos for President of IÖ3C served from 2004 to his resignation in 2008 at the Tromso Symposium which he successfully hosted.

The Commission was informed that on an initiative of the Officers was established a “Dobson Award for Young Scientists”. It will be granted for one or more outstanding research paper(s) in atmospheric sciences published or accepted in a refereed journal since the preceding QO3S by a young scientist (within 10 years of their Ph. D). The person nominated for the Award should be the first author of the cited paper. Complete nomination packages (an electronic copy of the paper, brief curriculum vitae of the candidate, and two endorsement letters describing the impact and innovation of the paper) should be e-mailed to the Secretary of the Commission who will arrange for review. The announcement of the winner will be made at the time of QO3S.

In September 2007 in Athens was held a Symposium on ‘Ozone Depletion: from its discovery to ENVISAT and AURA’ at an invitation from the Academy of Athens, the National Observatory of Athens, IO3C, EESC, UNEP and WMO hosted by Christos Zerefos. The framework was a core group of invited speakers who have played an important role in the preparations and success of the Montreal Protocol from its very beginning to get to-

Figure 19. Participants in the Symposium on 20-years Montreal Protocol - Ozone Depletion - from its discovery to ENVISAT and AURA (Athens, September 2007). First row in the centre (starting 8th from left) are: Shigeru Chubachi, Christos Zerefos, Mario Molina, Sherry Rowland, P. K. Bhartia, Anne Douglass and Guy Brasseur.

BASED ON THE PRESENTATIONS AT THE SYMPOSIUM, A STATEMENT WAS PREPARED BY 13 WORLD RENOWNED SCIENTISTS (ONLY THREE OF THEM NOT AFFILIATED WITH IO3C) AND PRESENTED TO THE INTERNATIONAL COMMUNITY. IT HIGHLIGHTED THE VITAL ROLE OF SCIENTIFIC CONTRIBUTIONS OF THE LAST FEW DECADES IN ESTABLISHING THE REALITY OF THE OZONE THREAT AND DRAWING ATTENTION TO THE NEED FOR ACTION; THE NECESSITY FOR TECHNOLOGICAL INNOVATION IN PROVIDING SOLUTIONS; AND THE VALUE OF OBJECTIVE ASSESSMENT OF SCIENTIFIC, ENVIRONMENTAL, TECHNOLOGICAL AND ECONOMIC FACTORS IN FOSTERING CONSENSUS AND THE EXPERIENCE GAINED TO ADDRESS FUTURE GLOBAL ENVIRONMENTAL THREATS. IT CONFIRMS THAT THE MONTREAL PROTOCOL IS PERHAPS ONE OF THE MOST ILLUSTRIOUS EXAMPLES OF A SUCCESSFUL GLOBAL COLLABORATION BETWEEN SCIENTIFIC, INDUSTRIAL AND ENVIRONMENTAL ORGANIZATIONS AND POLICY MAKERS. THE DECREASE IN OZONE-DEPLETING SUBSTANCES IS A DOMINANT FACTOR IN THE EXPECTED RETURN OF OZONE LEVELS TO PRE-1980 VALUES. HOWEVER CHANGES IN CLIMATE WILL INFLUENCE IF, WHEN, AND TO WHAT EXTENT OZONE WILL RETURN TO PRE-1980 VALUES IN DIFFERENT REGIONS. FUTURE INCREASES OF GREENHOUSE GAS CONCENTRATIONS WILL CONTRIBUTE TO THE AVERAGE COOLING IN THE STRATOSPHERE. CHEMICAL REACTION RATES IN THE ATMOSPHERE ARE DEPENDENT ON TEMPERATURE, AND PLUS THE CONCENTRATION OF OZONE IS SENSITIVE TO CLIMATE CHANGES. THE FULL TEXT OF THE STATEMENT CAN BE FOUND ON THE IO3C WEB PAGE HTTP://IOC.ATMOS.UIUC.EDU

IN JULY 2008 THE QUADRENNIAL OZONE SYMPOSIUM (QO3S) WAS HELD IN Tromsø A PLACE KNOWN OF ITS TRADITION OF OZONE MEASUREMENTS BEHIND THE POLAR CIRCLE STARTING IN THE 1930S. MORE THAN 500 PARTICIPANTS HAVE SUBMITTED 470 ABSTRACTS COVERING THE ENTIRE FIELD OF OZONE SCIENCE INCLUDING FEW ON THE ISSUE GETTING MORE ATTENTION LATESTLY THE DETECTION OF START
of ozone recovery and climate change interaction. The Opening session featured tutorial presentations on History of IO\textsubscript{3}C, Ozone depletion and CFCs, Importance of Montreal Protocol for ozone and climate and how did it work. The oral presentations were distributed in the following sessions: New Developments in Observation Techniques -10; Observations from ground and space of Total, VO\textsubscript{3}D their Analysis and Evaluation -14; Ozone Depleting Substances -8; UV Changes -5; Tropospheric Ozone -14; Climate-ozone Interaction -7; New Processes and Uncertainties -8; Polar Ozone -11; Ozone Recovery -6. The fractional distribution of the oral presentations approximately reflects the topics distribution of the remaining 350 posters. Many of the papers introduced new ideas and it is a pity that their enormous volume prevents us of giving here details. All abstracts were distributed on CD ROM and are posted on the Commission web page http://ioc.atmos.uiuc.edu

At the Commission meeting the President Ivar Isaksen informed that he has reached age of 70 and decided to retire. Then the Nomination Committee (Bojkov, Crutzen and Koeler) reported that after exploring members proposals, eligibility and willingness of the persons to serve as new Officers submitted for decision as follows: for President Christos Zerefos, for Vice-President Richard Stolarski and for the demanding post of Secretary to IO\textsubscript{3}C Sophie Godin-Beekmann. They were elected unanimously. Proposal was made by Nail Harris (seconded by Rumen Bojkov) to elect Dan Albritton as honorary member in recognition of his outstanding contribution to ozone science and to IO\textsubscript{3}C in guiding preparations of numerous international Ozone Assessment Reports. This was unanimously agreed. Then the Commission held a secret balloting for election of new members out of a list of 55 scientists proposed. Elected were: A. Bais, P. K. Bhartia, G. Braathen, D. Fahey, J-C Lambert, P. Newman, J. Pyle, W. Randel, M. Santee, M. Shiotani and K. Vanicek. Sherry Rowland supported by few other members expressed concern that the membership is too heavily cantered on Europe and N. America and the new Officers were requested to explore possibility of approaching active ozone scientists in particular from China, India and Russia with which working contacts could be established.

In order to strengthen the availability and spread of information about the work of the Commission the elected President proposed Don Wueb-
bles as an ad-hoc member to be named Director of Information of IO$_3$C. He has served IO$_3$C for many years and his particular efforts to keep up the website of the Commission are acknowledged by all. This was unanimously accepted. A proposal by the Secretary-General of IAMAS Dr. Hans Volkert sent to the Officers inquired of the willingness of Rumen D. Bojkov to expand his opening presentation on the history of the IO$_3$C which will benefit the atmospheric science community and popularize the 75 years of organized ozone activities. Bojkov agreed to attempt such a task and as first step will expand the part posted on the IO$_3$C web page and collect relevant inputs.

The outgoing Secretary announced that the Dobson Award Committee has decided to split in two the 2008 Dobson Award. Recipients were B.-M. Sinnhuber for papers on bromine in the stratosphere, and V. Eyring for assessments and use of chemistry-climate models for projections of future levels of stratospheric ozone.

On the question for location of the next QO$_3$S a proposal was made by Don Wuebbles to be organized in the United States. Some more details were requested to be provided to the Secretary for informing all members. At the same time she should issue a call for proposals by e-mail giving a few months time for response.

In the general discussion has been suggested that in between the consecutive QO$_3$S would be useful to have a meeting or two organized by IO$_3$C focused on important issues such as the 20$^{th}$ anniversary of the Montreal Protocol meeting which took place in Athens in September 2007.

Concerns were expressed on the short time-span between QO$_3$S, SPARC and other large meetings (i.e. IGAC) targeted to similar segments of science community. Timing of the next QO$_3$S for example will be 2012, but an exact date is desirable to be decided considering also SPARC assembly (in case the WCRP agrees this project to continue). It was emphasized that IO$_3$C should play a closer role on ozone-climate interactions and the new President and Secretary will ask for proposals from members for creations of ad-hoc working groups on specific topics. The continuous review of the quality of ozone data and another on ozone trends were examples proposed from the floor.
Concluding remarks

It is amazing how dedicated efforts by only few scientists like Fabry, Buisson, Dobson in the 1920s succeeded to establish reliable methodology for measurements of the total ozone and to deduce some of its basic seasonal, and latitudinal characteristics. During 1930s and 1940s ozone measurements were carried only by less than a dozen of interested scientists and in most places not regularly. At that time interest was not in systematic measurements but to explore for any weather predicting relations between ozone and weather patterns. The network based on inter-

Figure 20. Christos S. Zerefos has been host to number of the best organized Ozone Commission meetings and Symposia since 1984 for which he is internationally known and respected. He has contributed to the studies of ozone and the changing UV radiation, organized very active ozone research Laboratory in University of Thessaloniki including the operation of the WMO Ozone Mapping Centre there. Lately as Director of the famous National Observatory of Athens he continues his research activities. He was Secretary of IO3C (2000-2008) and in Tromsø was elected President for the 2008-2012.
national cooperation was established only 50-years ago in preparation for the International Geophysical Year and it evolved in the WMO Global Ozone Observing System (GO3OS). It is supplemented by satellites since about 30 years. Without the dedicated efforts of numerous scientists developing and supervising the ozone measurements and starting to control their quality it would have not been possible to make any assessment on the state of the ozone layer when some theory for its possible destruction started to appear.

Until a truly global picture of ozone distribution was obtained, measurements of ozone (instrumentation and theory) were preoccupying the Committee and IO3C for more than 40 years. This first period of the Commission activities included number of fundamental developments done by members and discussed and promoted by the Commission e.g. perfection of the double quartz spectrophotometer by Dobson (1931-1950); Umkehr method for indirect vertical ozone distribution (VO3D) by Götz in 1931-1934; balloon spectrograph proof the ozone maximum is at ~22 km provided by Erich and Victor Regener in 1934; sondes for measurements of VO3D (optical by Stranz, Paetzold in 1940-48; chemiluminiscent by Victor Regener in 1960; electro-chemical by Brewer and Milford in 1960s); Rocket-sondes measurements of VO3D by Hilsenrath, Krueger, Watanabe in the 1960s and 1970s. To these should be added the numerical method for uniform evaluation of the Umkehr profiles developed by Carl Mateer and Hans Dütsch in mid-1960s providing the base for more than 70,000 compatible profiles available now; Postulate and theory for measurement of ozone from a satellite (e.g. Mateer and Dave in late-1960s), implemented as UVB, SBUV and TOMS instruments by Heath and Krueger at NASA Goddard with Mateer et al.

On the question of ozone production and destruction Sidney Chapman (1930) developed the ozone-oxygen photochemistry which was not able to explain the ozone minimum in the tropics neither the spring maximum at the polar latitudes. It was K. R. Ramanathan who in 1953-1959 suggested existence of meridional cell and large-scale transport of ozone in order to explain the observed ozone distribution, an idea further developed in Dobson-Brewer circulation scheme. Since then the developments of ozone photochemistry were an issue permanently on the agenda of the IO3C with initial contributions by Nicolet, Dütsch and others. The work
evolved by including new reactive spices (e.g. in mid-1960s HOx chemistry by Hampson, Hunt, Hesstvedt, Nicolet; In 1970 NOx chemistry by Crutzen also Johnston, Nicolet; in 1974 Stolarski and Cicerone published on possible ozone decomposition by ClOx; Rowland and Molina on the role of CFCs). Developments involved directly many IO3C members, three of whom (Crutzen, Molina and Rowland) got for their achievements the Nobel Prize in Chemistry in 1995.

With the introduction of NOx reactions by Crutzen and of the CFCs role by Rowland and Molina started new era of understanding of global ozone variations, and the second period of activities of the Commission. The new photochemistry indicated potential environmental disastrous destruction of ozone layer started an explosive increase in ozone studies after mid-1970s. The discovery of an abrupt and major ozone decline during the Austral spring in the Antarctica (since known as the ozone hole) and its explanations (e.g. Susan Solomon, Crutzen and Arnold, Molina and Molina) passed few stages with number of contributors many of whom were members of the IO3C. It should be also recall that the Ozone Trends Panel Report (1988) based on the most thorough scientific evaluation of the ozone data first provided significant and undisputable evidence that the ozone is decreasing not only in Antarctica but also over the Northern middle and upper latitudes. It provided scientific support for the need of strengthening of the Montreal Protocol which was signed September 1987. Many members of IO3C made also substantial contributions to its content.

The Ozone Committee and later the Commission in the past 75 years until the Tromso meeting have been served by nine Presidents (Dobson, Ramanathan, Brewer, Dütsch, Mateer, Chang, Mégie, Hudson and Isaksen), five Secretaries (Sir Charles Normand, Dütsch, Walshaw, Bojkov and Zerefos). Since 1984 have had five Vice-Presidents (Gerard Mégie, A. Jim Miller, Andy Matthews, Toshi Ogawa and Sophie Godin-Blackman). As members have been listed more than 160 scientists. Three of them (Crutzen, Molina and Rowland) were distinguished with Nobel Prize in 1995. In IO3C work on one stage or another have been involving hundreds of scientists who participated in various working groups and/or Rapporteurs on particular issues. Furthermore, there are numerous other scientists outside of the formal frame of the IO3C who contributed to
the progress in the ozone studies and have left a permanent mark during the past 75-years of development. In this line of thoughts it should be noted that until now the IO3C has organized more than 30 international symposia and conferences with close to 4000 scientific presentations with more than 3000 of these submitted after it became clear there is imminent threat for ozone catalytic destruction by NOx and chlorine in the stratosphere i.e. after mid-1970s.

Tasks of Ozone Committee and IO3C as formulated by the IUGG:

1933 To explore the relations between the ozone variations and the meteorological conditions (IUGG);

1948 To conduct an ozone-weather survey over West Europe and assist establishment of ozone stations with uniform procedures (IUGG);

1957 To retain its general scientific interest in ozone, in developments in fields which are not yet routine and to remain responsible for organizing international symposia (IUGG);

1970 To consider the relation of ozone studies to those of the upper atmosphere and atmospheric chemistry (accepted); and to decide whether the objects of IO3C would be better served by merging with some other commission of IAMAP (that merging was rejected by science developments and members)

1988 To provide scientific expertise for the improvement of the GO3OS, to clarify questions of ozone variability by rigorous review of measurements and photochemical models as inputs to WMO Ozone Assessments and to development of global control measures (IAMAS);

1990 To promote research in atmospheric ozone-related issues as well as application of that research to practical problems concerning the composition and changes of the earth-atmosphere system (current Commission bylaw).
The tasks of the Ozone Committee and the Commission as defined by the IUGG are listed in the box. They show the evolution from group charged to establish what the ozone-weather relations are and to assist organization of global observing facilities. Later demands increased to include clarification of questions on ozone variability by rigorous review of measurements and complex photochemical models to make inputs to WMO Ozone Assessments and to development of global control measures.

The IO3C evolved from a highly specialized group of scientists with common interest in the measurement techniques of atmospheric ozone to the present body representing expanded scope of diverse scientific interests. This includes meteorology, atmospheric chemistry and physics, laboratory chemistry, statistics and environmental sciences in general. This phenomenal expansion occurred mostly in the last 30 years. The advances in understanding the dynamical and chemical processes involved in atmospheric ozone formation, response and influence made the modern ozone research a totally interdisciplinary subject with fully coupled interactions of stratospheric and tropospheric processes having both local and global impacts.

As a final note it should be recalled that as early as in 1984 Presidential Address Carl Mateer did bring the attention of the ozone community to the need to consider ozone-climate relations. He emphasized that ‘ozone changes, and the changes in minor constituents which must accompany them will have an impact on climate and vice versa. Therefore it should be clear that the ozone and climate changes should be studied with 3-D models which would married the complexities of the photochemical and meteorological processes’. Thereafter the Commission did have a working group on that issue for many years. It is now clear that there are multiple interactions between changes in ozone, UV radiation, aerosols, increased tropospheric photochemical pollution, and the changing climate. As the main environmental issue with potential disastrous consequences for the mankind now is recognized to be the climate change, the IO3C should continued to encourage and vigorously stimulate studies directed to the ozone and climate change interactions.
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THE INTERNATIONAL OZONE COMMISSION (IO\textsubscript{2}C)


Ozone, (1957) see page 27.


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Ramanathan and Walton (1955) see page 27.


