III. INTRODUCTORY NOTE ON ATMOSPHERIC OZONE OBSERVATIONS IN IGY AND IGC

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Nearly 60 stations took part in ozone observations during the IGY, of which 10 were in the Arctic (including a floating ice-island). There were, however, only 9 stations in the southern hemisphere, 1 near the Equator in Africa, 3 in Australia, 1 in the South Pacific, and 4 in the Antarctic.

Table 1 gives the list of stations arranged in order of latitude from north to south and Tables 2 to 6 give the monthly mean ozone amounts at each station, together with the number of days of observation on which the means are based. Data of 47 stations were available for 1957, 56 for 1958 and 55 for 1959.

Most stations used the Dobson spectrophotometer for the measurement of total ozone.

(i) In Japan, spectrophotometers of the Dobson type made in Japan were used at a number of stations, and they were all intercompared with a standard Dobson spectrophotometer at Tateno.

(ii) In U.S.S.R., a Dobson spectrophotometer was used at Leningrad. At other places, instruments developed in the U.S.S.R. were used. They included:

(a) Quartz spectrophotometer with photocell;
(b) Spectrophotometer with grating; and
(c) Instruments with optical light filters and photocells.

All the instruments were intercompared, but the differences between the results obtained with different types of spectrophotometer were apparently much larger than results with different Dobson spectrophotometers.

(iii) At Haute Province and Dumont d'Urville (Terre Adelie) observations were made by spectrophotometry of starlight.

Sir CHARLES NORMAND examined the ozone data supplied on IGY forms and found that large diurnal variations were apparent at Tamanrasset, Quetta, Caribou, Bismarck and Leopoldville. Owing to large, and sometimes surprisingly abnormal, values found at some of these places, and, in addition, at Dumont d'Urville, Elbruz and Elmas, it is suggested that the data for each individual day for these places should be scrutinized before they are used for critical work.

On the whole, the IGY observations have clearly shown that there are pronounced differences in ozone distribution, which are related to the longitude, particularly in late winter and spring. There is in general more ozone over Canada than over the East Pacific, more over Central Europe than over the East Atlantic and more over Siberia and Japan than over Central Asia and India (see Figs. 1 and 2). The observations in the southern hemisphere suggest that the spring ozone maximum near 55°S was separated from the summer maximum in the polar cap (Fig. 3).

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TABLE 1

OZONE STATIONS WITH IGY STATION NUMBERS ARRANGED ACCORDING TO LATITUDE, NORTH TO SOUTH

IGY Number	Station	Latitude	Longitude	Remarks
1	2	3	4	5
A006	Alert	N 82° 30′	W 62° 22′	Moon observations Oct.–March
A010	Murchison Bay	N 80° 03′	E 18° 18′	Observations in March–Aug. 1958 only
A015	Longyearbyen	N 78° 13′	E 15° 40′	Observations only in summer and early autumn
a030	Resolute	N 74° 43′	W 94° 59′	Moon observations Oct.–Feb.
A033	Dixon Is.	N 73° 30′	E 80° 24′	Sun observations mainly in summer
A047	Tromsø	N 69° 40′	E 18° 57′	
A103	Reykjavik	N 64° 08′	W 21° 54′	
A140	Lerwick	N 60° 08′	W 01° 11′	
b501	Leningrad–Voeikovo	N 59° 57′	E 30° 42′	
b003	Uppsala	N 59° 52′	E 17° 38′	
B367	Aarhus	N 56° 08′	E 10° 12′	Values rather high
B038	Eskdalemuir	N 55° 19′	W 03° 12′	
a156	Edmonton	N 53° 34′	W 113° 31′	
B127	Potsdam	N 52° 23′	E 13° 04′	Few observations in winter and spring
b571	Oxford	N 51° 46′	W 01° 16′	
B368	Dresden	N 51° 17′	E 13° 41′	
A168	Moosonee	N 51° 16′	W 80° 39′	
B122	Uccle	N 50° 48′	E 04° 21′	
b588	Camborne	N 50° 13′	W 05° 19′	
b600 } b156	Paris–Montsouris	N 48° 50′	E 02° 20′	In July–Sept. 1957, observations were taken at Magny les Hameaux, later at Montsouris
b118	Weissenau	N 47° 46′	E 09° 35′	
B193	Caribou	N 46° 52′	W 68° 01′	Started in March 1958. Apparent large diurnal variation.
B166	Arosa	N 46° 47′	E 09° 41′	
b628	Bismarck	N 46° 46′	W 100° 46′	
B530	Green Bay	N 44° 29′	W 88° 08′	
B247	Haute Provence	N 43° 55′	E 05° 43′	Observations made on stars
c047	Elbrus Mt.	N 43° 25′	E 42° 30′	Large variations with some abnormally low values—U.S.S.R. instrument
c050	Alma Ata	N 43° 15′	E 76° 56′	U.S.S.R. instrument
c051	Vladivostok	N 43° 07′	E 131° 54′	U.S.S.R. instrument
C052	Sapporo	N 43° 03′	E 141° 19′	
C149	Vigna di Valle	N 42° 05′	E 12° 13′	
C071	Abastumani	N 41° 45′	E 42° 50′	U.S.S.R. instrument
c083	Napoli	N 40° 53′	E 14° 17′	
C087	Elmas	N 39° 14′	E 09° 03′	Occasional large discrepancies
b313	Washington D.C.	N 38° 51′	W 77° 02′	
B399	Silver Hill	N 38° 50′	W 76° 57′	
C121	Messina	N 38° 12′	E 15° 33′	
C153	Tateno	N 36° 03′	E 140° 08′	Note large difference from Srinagar values
C337	Srinagar	N 34° 04′	E 74° 52′	
c156	Habbaniya	N 33° 22′	E 43° 34′	
c165	Fort Worth	N 32° 46′	W 97° 25′	
C243	Kagoshima	N 31° 34′	E 130° 33′	
C248	Torishima	N 30° 29′	E 140° 18′	
C251	Quetta	N 30° 11′	E 66° 57′	AD values abnormally low in July 1957–Feb. 1958 and high in March–Dec. 1958. C values compare better with Indian values.

TABLE 1 (*contd.*)

IGY Number	Station	Latitude	Longitude	Remarks
1	2	3	4	5
E498	New Delhi	N 28° 35′	E 77° 12′	
E512	Mt. Abu	N 24° 36′	E 72° 43′	
e513	Marcus Is.	N 24° 17′	E 153° 58′	Compare with Mt. Abu
C273	Tamanrasset	N 22° 48′	E 05° 31′	Large and unexpected variations. WMO sheets contain on many days noon observations only
E457	Mauna Loa	N 19° 32′	W 155° 35′	
E566	Kodaikanal	N 10° 14′	E 77° 29′	
e631	Leopoldville–Binza	S 04° 19′	E 15° 19′	
C918	Brisbane	S 27° 29′	E 153° 02′	
b894	Melbourne–Aspendale	S 38° 01′	E 145° 06′	
B973	Wellington	S 41° 17′	E 174° 46′	
A961	Macquarie Is.	S 54° 30′	E 158° 57′	
A973	Argentine Is.	S 65° 15′	W 64° 16′	Generally smaller amounts than at Macquarie Is.
A979	Dumont d'Urville (Terre Adelie)	S 66° 40′	E 140° 01′	Unusually large day-to-day variations. Winter observations on stars.
A989	Halley Bay	S 75° 31′	W 26° 36′	
A995	Little America	S 78° 11′	W 162° 10′	

Umkehr observations for determining the vertical distribution of ozone were taken at 23 stations (see for example Figs. 4 and 5), including in particular Arosa, stations in Japan, Canada and India, Quetta, Eskdalemuir, Reykjavik, Resolute and Halley Bay, but all the observations have not yet been processed. The infrared method developed by MIGEOTTE and VIGROUX was used in France and Switzerland. PAETZOLD and VASSY ozone-sondes with optical filters and photo-cells were used at a number of places for determining the total ozone between the radiosonde and the sun. BREWER and MILFORD developed a light ozone sonde based on the chemical method which could be used with the transmitter of the standard British radiosonde. These instruments give the detailed structure of the distribution of ozone in the atmosphere and ascents made with them generally showed sharp increases in ozone at or near the tropopause. Ascents with the Brewer sonde were made at Liverpool (see Fig. 6), Tromsø, Malta and Halley Bay (see Fig. 7). An intercomparison of the four different methods of determining the vertical ozone distribution was made at Arosa in July–August 1958 (see Fig. 8).

Examples of vertical distributions of ozone and of ozone-mixing ratio are given in Figs. 4 to 8. The analysis of the umkehr observations shows that higher ozone amounts almost always imply higher ozone concentrations in the lower stratosphere and upper troposphere. Ozonesonde observations confirm this. Figure 9 shows the seasonal variation in the mean vertical distribution of ozone over Arosa according to Dütsch.

An important finding resulting from the IGY observations was that the spring rise in ozone in high and middle latitudes was associated with the break-up and warming of the polar stratospheric vortex. Figure 10 shows the changes in ozone amount at Reykjavik associated with the stratospheric warming in January–February 1958. The changes in the temperature structure of the atmosphere over Fort Churchill connected with the same

TABLE 2

MEAN MONTHLY OZONE AMOUNTS IN MILLI-ATMO-CM AND NUMBER OF DAYS OF OBSERVATION IN EACH MONTH (JULY–DECEMBER 1957)

Station	July	Aug.	Sept.	Oct.	Nov.	Dec.
Alert	323 (27)	298 (31)	293 (8)	235 (2)	258 (3)	263 (7)
Murchison Bay	—	—	—	—	—	—
Longyearbyen	304 (23)	288 (19)	273 (20)	282 (14)	—	—
Resolute	346 (18)	314 (22)	315 (6)	320 (1)	342 (5)	299 (6)
Dixon Is.	425 (10)	382 (16)	—	—	—	—
Tromsø	309 (29)	305 (25)	291 (26)	277 (30)	282 (27)	273 (29)
Reykjavik	323 (13)	314 (31)	293 (29)	303 (26)	272 (25)	301 (20)
Lerwick	354 (24)	327 (29)	312 (30)	276 (30)	292 (15)	238 (1)
Leningrad–Voeikovo	357 (27)	341 (20)	325 (13)	307 (8)	296 (2)	—
Uppsala	322 (31)	316 (26)	317 (16)	283 (24)	262 (24)	275 (23)
Aarhus	365 (31)	353 (31)	346 (26)	294 (30)	301 (28)	316 (27)
Eskdalemuir	332 (3)	341 (1)	311 (1)	289 (23)	297 (24)	300 (16)
Edmonton	325 (30)	306 (23)	276 (23)	281 (25)	293 (25)	315 (24)
Potsdam	306 (14)	341 (19)	318 (9)	305 (9)	293 (6)	314 (2)
Oxford	349 (31)	338 (31)	306 (28)	275 (30)	297 (28)	295 (27)
Moosonee	330 (22)	334 (30)	310 (24)	301 (26)	310 (15)	348 (30)
Uccle	306 (9)	302 (4)	308 (11)	270 (6)	338 (2)	—
Camborne	310 (30)	305 (28)	276 (27)	252 (26)	282 (29)	290 (22)
Paris–Montsouris	328 (8)	328 (10)	306 (16)	273 (13)	311 (10)	306 (13)
Weissenau	293 (14)	293 (16)	279 (15)	290 (14)	—	352 (1)
Caribou	—	—	—	—	—	—
Arosa	315 (24)	308 (26)	288 (24)	267 (28)	282 (24)	317 (18)
Bismarck	296 (29)	288 (26)	280 (22)	252 (19)	262 (18)	305 (18)
Green Bay	—	—	—	—	—	—
Haute Provence	—	—	—	263 (11)	296 (1)	292 (11)
Elbrus Mt.	—	—	—	—	272 (2)	250 (5)
Alma Ata	—	—	—	—	243 (7)	233 (5)
Vladivostok	—	270 (5)	278 (25)	269 (15)	301 (10)	—
Sapporo	—	—	—	—	—	—
Vigna di Valle	327 (31)	313 (31)	307 (30)	292 (31)	302 (30)	326 (30)
Abastumani	278 (11)	272 (24)	258 (23)	272 (21)	279 (6)	299 (10)
Napoli	—	—	—	—	—	—
Elmas	310 (31)	300 (20)	293 (28)	297 (29)	289 (27)	302 (29)
Washington D.C.	325 (17)	321 (14)	291 (9)	303 (17)	288 (12)	300 (9)
Messina	328 (25)	316 (10)	285 (30)	269 (31)	260 (30)	258 (30)
Tateno	311 (31)	285 (31)	289 (28)	274 (30)	274 (30)	311 (30)
Srinagar	263 (31)	263 (28)	265 (16)	264 (22)	258 (22)	259 (16)
Habbaniya	293 (31)	289 (30)	286 (30)	281 (31)	294 (29)	295 (31)
Kagoshima	—	—	—	—	—	—
Torishima	—	—	—	—	253 (18)	262 (22)
Quetta	215 (30)	211 (30)	220 (30)	219 (31)	218 (25)	232 (28)
New Delhi	243 (30)	257 (26)	261 (21)	247 (30)	229 (30)	241 (28)
Mt. Abu	231 (16)	229 (14)	230 (26)	226 (28)	219 (28)	224 (29)
Marcus Is.	—	—	—	—	—	—
Tamanrasset[1]	—	—	206 (1)	229 (19)	251 (18)	186 (10)
Mauna Loa	—	—	—	—	262 (1)	258 (17)
Kodaikanal	233 (14)	236 (12)	239 (24)	236 (9)	214 (11)	220 (15)
Leopoldville–Binza	—	—	—	—	—	—
Brisbane	283 (24)	302 (24)	325 (24)	315 (25)	297 (21)	302 (24)
Melbourne–Aspendale	350 (30)	355 (31)	365 (30)	349 (30)	333 (30)	318 (29)
Wellington	314 (17)	329 (18)	349 (16)	342 (18)	347 (13)	310 (14)
Macquarie Is.	356 (6)	353 (5)	373 (3)	428 (6)	381 (2)	—
Argentine Is.	284 (1)	268 (19)	274 (30)	289 (31)	313 (30)	305 (31)
Dumont d'Urville (Terre Adelie)	—	—	—	—	—	—
Halley Bay	271 (4)	298 (2)	281 (1)	319 (29)	393 (30)	346 (31)
Little America	346 (3)	535 (2)	286 (16)	333 (27)	412 (28)	—

[1] Only near-noon values.

TABLE 3

MEAN MONTHLY OZONE AMOUNTS IN MILLI-ATMO-CM AND NUMBER OF DAYS OF OBSERVATION IN EACH MONTH (JAN.–JUNE 1958)

Station	Jan.	Feb.	March	April	May	June
Alert	259 (2)	480 (4)	509 (3)	468 (25)	430 (29)	353 (29)
Murchison Bay	—	—	—	—	373 (9)	341 (27)
Longyearbyen	—	—	—	—	—	348 (23)
Resolute	377 (2)	503 (4)	500 (22)	488 (29)	419 (24)	377 (30)
Dixon Is.	—	—	—	528 (7)	576 (10)	444 (7)
Tromsø	336 (30)	476 (28)	465 (28)	425 (29)	399 (30)	362 (28)
Reykjavik	345 (21)	421 (23)	427 (28)	409 (27)	401 (30)	347 (29)
Lerwick	235 (1)	407 (24)	410 (31)	398 (30)	413 (31)	356 (30)
Leningrad–Voeikovo	—	459 (6)	467 (22)	434 (21)	389 (18)	365 (21)
Uppsala	331 (22)	429 (20)	448 (26)	413 (28)	369 (27)	356 (28)
Aarhus	366 (26)	447 (24)	471 (28)	443 (31)	405 (29)	393 (30)
Eskdalemuir	344 (18)	389 (19)	415 (25)	379 (14)	398 (28)	366 (26)
Edmonton	317 (16)	—	431 (19)	424 (29)	366 (31)	352 (30)
Potsdam	353 (5)	389 (2)	374 (1)	389 (4)	330 (14)	349 (11)
Oxford	346 (24)	352 (23)	399 (31)	406 (29)	397 (29)	379 (29)
Moosonee	360 (31)	421 (28)	400 (24)	439 (30)	422 (31)	389 (30)
Uccle	—	—	356 (4)	395 (1)	384 (4)	346 (8)
Camborne	325 (15)	348 (12)	368 (30)	378 (29)	370 (31)	356 (29)
Paris–Montsouris	376 (21)	377 (18)	410 (27)	410 (23)	367 (26)	364 (24)
Weissenau	—	—	346 (3)	385 (12)	336 (4)	337 (4)
Caribou	—	—	—	360 (6)	385 (30)	372 (23)
Arosa	344 (24)	338 (17)	394 (23)	396 (19)	359 (25)	351 (21)
Bismarck	333 (17)	375 (15)	393 (25)	406 (29)	353 (30)	349 (29)
Green Bay	—	—	383 (13)	379 (19)	361 (29)	340 (23)
Haute Provence	309 (10)	280 (2)	331 (1)	—	—	—
Elbrus Mt.	292 (7)	331 (7)	367 (5)	402 (3)	339 (19)	303 (16)
Alma Ata	280 (3)	305 (7)	289 (5)	282 (3)	286 (9)	283 (11)
Vladivostok	—	—	—	364 (10)	322 (15)	263 (8)
Sapporo	—	435 (22)	465 (27)	428 (27)	416 (31)	383 (29)
Vigna di Valle	358 (31)	368 (28)	408 (31)	412 (30)	358 (31)	352 (30)
Abastumani	314 (10)	358 (13)	365 (6)	352 (7)	309 (13)	311 (13)
Napoli	—	—	—	—	—	—
Elmas	323 (31)	338 (27)	354 (31)	374 (30)	346 (29)	334 (30)
Washington D.C.	330 (9)	373 (18)	360 (15)	367 (26)	364 (27)	333 (28)
Messina	339 (27)	378 (26)	329 (28)	346 (27)	336 (29)	346 (28)
Tateno	321 (29)	341 (27)	396 (31)	362 (30)	357 (31)	338 (29)
Srinagar	280 (20)	291 (10)	292 (21)	291 (29)	305 (30)	288 (30)
Habbaniya	314 (31)	339 (28)	—	—	—	—
Kagoshima	—	—	319 (28)	338 (22)	323 (26)	328 (27)
Torishima	277 (25)	298 (28)	336 (31)	339 (30)	339 (28)	335 (27)
Quetta[1]	245 (25)	252 (26)	291 (25)	294 (24)	298 (22)	286 (29)
New Delhi	264 (30)	267 (28)	268 (31)	247 (30)	241 (31)	257 (29)
Mt. Abu	240 (29)	243 (28)	259 (31)	258 (29)	251 (31)	253 (24)
Marcus Is.	227 (29)	245 (28)	252 (30)	269 (30)	290 (21)	298 (30)
Tamanrasset[2]	173 (25)	195 (18)	227 (19)	259 (12)	214 (18)	185 (3)
Mauna Loa	256 (29)	251 (26)	270 (25)	285 (28)	287 (28)	284 (29)
Kodaikanal	226 (25)	223 (21)	234 (28)	246 (20)	242 (17)	248 (13)
Leopoldville-Binza	257 (25)	252 (25)	251 (27)	247 (28)	237 (25)	243 (27)
Brisbane	293 (19)	273 (22)	281 (30)	201 (23)	292 (28)	301 (20)
Melbourne–Aspendale	316 (29)	295 (24)	297 (31)	280 (30)	296 (31)	348 (30)
Wellington	294 (17)	271 (16)	261 (17)	270 (18)	281 (14)	319 (19)
Macquarie Is.	332 (21)	304 (13)	331 (19)	349 (21)	337 (9)	394 (13)
Argentine Is.	295 (31)	259 (28)	242 (31)	249 (26)	289 (4)	302 (2)
Dumont d'Urville (Terre Adelie)	—	233 (5)	239 (5)	277 (3)	238 (8)	276 (14)
Halley Bay	332 (31)	299 (28)	280 (28)	254 (3)	252 (2)	253 (4)
Little America	310 (17)	300 (7)	280 (1)	295 (1)	335 (1)	—

[1] Only C values used. [2] Only near noon values.

TABLE 4

MEAN MONTHLY OZONE AMOUNTS IN MILLI-ATMO-CM AND NUMBER OF DAYS OF OBSERVATION IN EACH MONTH (JULY–DECEMBER 1958)

Station	July	Aug.	Sept.	Oct.	Nov.	Dec.
Alert	332 (29)	290 (31)	299 (14)	324 (4)	370 (6)	—
Murchison Bay	312 (27)	273 (7)	—	—	—	—
Longyearbyen	329 (23)	293 (28)	295 (25)	—	—	—
Resolute	347 (31)	307 (31)	323 (30)	341 (5)	428 (10)	319 (5)
Dixon Is.	336 (13)	307 (4)	—	343 (4)	—	—
Tromsø	324 (25)	287 (27)	289 (28)	279 (26)	299 (27)	293 (22)
Reykjavik	330 (31)	325 (31)	302 (30)	306 (24)	306 (9)	338 (23)
Lerwick	344 (31)	326 (31)	289 (30)	291 (31)	258 (16)	265 (3)
Leningrad–Voeikovo	357 (23)	344 (17)	301 (16)	279 (8)	268 (7)	—
Uppsala	337 (29)	312 (24)	283 (28)	282 (25)	258 (18)	323 (13)
Aarhus	367 (30)	335 (30)	310 (30)	305 (31)	301 (27)	356 (24)
Eskdalemuir	357 (27)	333 (28)	300 (29)	299 (30)	287 (25)	343 (23)
Edmonton	337 (30)	300 (31)	316 (30)	295 (31)	354 (30)	356 (30)
Potsdam	322 (15)	302 (15)	284 (11)	262 (4)	—	—
Oxford	361 (31)	336 (31)	293 (28)	292 (31)	278 (18)	320 (23)
Moosonee	360 (31)	341 (30)	318 (30)	319 (30)	361 (29)	387 (30)
Uccle	345 (5)	—	274 (21)	269 (10)	227 (2)	348 (2)
Camborne	339 (30)	319 (20)	290 (18)	278 (17)	277 (27)	340 (19)
Paris–Montsouris	335 (26)	311 (20)	286 (15)	294 (26)	309 (22)	372 (15)
Weissenau	301 (6)	288 (1)	283 (3)	268 (3)	—	295 (1)
Caribou	348 (29)	323 (29)	294 (28)	298 (26)	306 (15)	353 (26)
Arosa	337 (29)	313 (27)	287 (28)	292 (21)	289 (24)	309 (20)
Bismarck	325 (31)	296 (31)	289 (30)	285 (31)	319 (26)	328 (29)
Green Bay	318 (23)	305 (28)	279 (25)	277 (21)	293 (2)	349 (15)
Haute Provence	—	—	—	—	—	—
Elbrus Mt.	252 (19)	233 (22)	231 (13)	244 (17)	245 (13)	281 (7)
Alma Ata	258 (17)	235 (9)	247 (13)	253 (13)	247 (2)	286 (2)
Vladivostok	257 (5)	285 (10)	269 (10)	319 (10)	293 (22)	288 (17)
Sapporo	329 (29)	316 (30)	304 (28)	323 (29)	329 (30)	399 (27)
Vigna di Valle	328 (30)	307 (31)	302 (30)	295 (31)	316 (20)	329 (28)
Abastumani	287 (14)	288 (17)	266 (9)	260 (21)	277 (14)	300 (12)
Napoli	302 (27)	273 (25)	274 (25)	262 (23)	285 (21)	311 (18)
Elmas	309 (31)	297 (31)	299 (29)	299 (11)	311 (19)	318 (20)
Washington D.C.	313 (31)	313 (31)	288 (30)	296 (30)	285 (29)	316 (29)
Messina	339 (31)	324 (31)	321 (30)	296 (31)	319 (29)	351 (30)
Tateno	314 (31)	306 (31)	287 (29)	281 (28)	277 (29)	312 (30)
Srinagar	269 (22)	269 (31)	257 (27)	255 (29)	248 (28)	251 (9)
Habbaniya	—	—	—	—	—	—
Kagoshima	292 (30)	281 (30)	275 (30)	271 (29)	259 (29)	289 (28)
Torishima	320 (30)	307 (31)	286 (29)	261 (31)	244 (27)	257 (31)
Quetta[1]	270 (10)	276 (27)	262 (14)	263 (28)	263 (25)	284 (16)
New Delhi	251 (18)	243 (22)	240 (25)	246 (28)	243 (29)	267 (30)
Mt. Abu	246 (4)	238 (16)	243 (9)	237 (25)	233 (25)	242 (29)
Marcus Is.	294 (31)	283 (30)	271 (30)	272 (29)	255 (30)	251 (31)
Tamanrasset[2]	170 (15)	212 (19)	212 (20)	213 (22)	200 (11)	193 (14)
Mauna Loa	271 (29)	270 (29)	266 (30)	264 (27)	257 (27)	252 (31)
Kodaikanal	248 (13)	245 (4)	241 (20)	239 (11)	237 (20)	217 (19)
Leopoldville–Binza	246 (30)	249 (29)	254 (29)	254 (26)	250 (25)	244 (28)
Brisbane	310 (26)	320 (26)	346 (26)	329 (20)	320 (17)	326 (5)
Melbourne–Aspendale	375 (28)	369 (29)	399 (29)	386 (31)	345 (30)	328 (31)
Wellington	347 (16)	339 (15)	370 (22)	364 (14)	333 (15)	289 (13)
Macquarie Is.	378 (16)	414 (26)	411 (26)	435 (31)	391 (30)	369 (22)
Argentine Is.	278 (7)	297 (14)	323 (30)	299 (31)	349 (30)	309 (31)
Dumont d'Urville (Terre Adelie)	279 (7)	264 (5)	184 (5)	270 (17)	312 (15)	259 (14)
Halley Bay	264 (5)	301 (2)	287 (17)	301 (31)	349 (30)	381 (31)
Little America	461 (1)	—	—	334 (10)	388 (1)	—

[1] Only C values used. [2] Only near noon values.

TABLE 5

MEAN MONTHLY OZONE AMOUNTS IN MILLI-ATMO-CM AND NUMBER OF DAYS OF OBSERVATION IN EACH MONTH (JANUARY–JUNE 1959)

Station	Jan.	Feb.	March	April	May	June
Longyearbyen	—	—	—	—	—	337 (10)
Resolute	310 (5)	413 (5)	505 (22)	490 (29)	439 (28)	371 (27)
Dixon Is.	—	—	—	413 (20)	397 (18)	312 (16)
Tromsø	343 (26)	377 (26)	405 (27)	442 (27)	388 (31)	369 (25)
Reykjavik	329 (29)	396 (19)	439 (18)	427 (18)	367 (30)	366 (24)
Lerwick	376 (5)	344 (26)	413 (31)	419 (30)	376 (30)	360 (30)
Leningrad	388 (2)	377 (8)	391 (21)	443 (18)	414 (23)	390 (23)
Uppsala	386 (12)	346 (15)	384 (20)	403 (14)	394 (17)	362 (18)
Aarhus	422 (26)	393 (28)	428 (29)	437 (28)	410 (31)	391 (30)
Eskdalemuir	375 (11)	—	413 (20)	420 (28)	388 (31)	369 (29)
Edmonton	383 (29)	417 (28)	437 (31)	421 (30)	402 (31)	361 (30)
Potsdam	—	—	353 (6)	357 (9)	363 (8)	343 (7)
Oxford	379 (27)	349 (26)	400 (30)	406 (28)	397 (27)	372 (28)
Moosonee	409 (31)	460 (28)	464 (31)	446 (30)	387 (30)	373 (28)
Dresden	—	—	408 (14)	412 (27)	398 (25)	377 (28)
Camborne	—	—	—	386 (15)	370 (28)	343 (30)
Paris–Montsouris	396 (13)	367 (19)	403 (22)	394 (25)	387 (30)	354 (30)
Weissenau	—	329 (1)	348 (11)	359 (10)	362 (2)	341 (1)
Caribou	385 (22)	401 (20)	417 (23)	389 (24)	374 (16)	354 (24)
Bismarck	354 (30)	404 (28)	414 (31)	390 (29)	380 (30)	329 (30)
Arosa	349 (21)	346 (27)	347 (25)	368 (22)	367 (26)	359 (8)
Green Bay	390 (9)	409 (13)	407 (16)	399 (18)	353 (23)	338 (25)
Haute–Provence	—	—	—	—	—	—
Elbrus Mt.	304 (4)	—	—	—	293 (1)	292 (9)
Alma–Ata	—	—	—	—	328 (6)	319 (21)
Vladivostok	330 (24)	345 (22)	378 (26)	394 (20)	400 (24)	363 (15)
Sapporo	452 (26)	435 (28)	438 (30)	429 (27)	406 (31)	395 (30)
Vigna di Valle	366 (31)	370 (27)	368 (30)	387 (30)	381 (21)	365 (30)
Abastumani	314 (11)	412 (2)	355 (7)	369 (18)	329 (14)	296 (11)
Napoli	342 (15)	309 (14)	331 (21)	348 (23)	338 (22)	337 (23)
Elmas	324 (30)	334 (25)	345 (31)	354 (29)	358 (31)	318 (30)
Washington D.C.	336 (29)	342 (27)	365 (26)	—	—	—
Silver Hill	—	—	—	—	—	—
Messina	376 (27)	387 (28)	375 (28)	396 (30)	385 (31)	366 (30)
Tateno	326 (30)	340 (28)	358 (21)	358 (30)	369 (31)	368 (30)
Srinagar	288 (10)	289 (20)	294 (27)	285 (29)	274 (16)	272 (30)
Fort Worth	—	—	—	—	—	359 (4)
Kagoshima	287 (27)	298 (24)	302 (24)	—	—	—
Torishima	259 (31)	281 (26)	304 (29)	306 (29)	327 (31)	318 (27)
Quetta	259 (21)	259 (13)	280 (26)	281 (18)	281 (16)	277 (9)
New Delhi	275 (26)	275 (28)	269 (31)	272 (28)	254 (30)	257 (27)
Mt. Abu	247 (27)	244 (25)	245 (27)	257 (29)	254 (29)	261 (23)
Marcus Is.	246 (31)	266 (28)	267 (31)	296 (30)	311 (31)	310 (30)
Tamanrasset	—	—	303 (6)	297 (21)	301 (13)	—
Mauna Loa	251 (27)	265 (22)	276 (30)	282 (15)	290 (10)	296 (11)
Kodaikanal	226 (22)	238 (20)	239 (30)	248 (16)	260 (15)	262 (10)
Bunia–Ruanpara	—	—	—	—	—	—
Leopoldville–Binza	246 (22)	247 (24)	248 (25)	253 (26)	254 (23)	266 (24)
Brisbane	288 (16)	283 (13)	288 (16)	296 (18)	293 (18)	286 (20)
Melbourne–Aspendale	296 (31)	304 (28)	301 (31)	282 (29)	310 (31)	320 (30)
Wellington	285 (13)	293 (15)	279 (14)	276 (20)	318 (10)	298 (16)
Port-aux-Francais	—	—	—	—	—	—
Macquarie Is.	329 (26)	330 (8)	—	—	—	—
Dumont d' Urville	275 (7)	—	—	—	—	—
Halley Bay	359 (31)	343 (28)	304 (31)	304 (9)	267 (1)	294 (6)

[1] Only near noon values.

TABLE 6

MEAN MONTHLY OZONE AMOUNTS IN MILLI-ATMO-CM AND NUMBER OF DAYS OF OBSERVATION IN EACH MONTH (JULY–DECEMBER 1959)

Station	July	Aug.	Sept.	Oct.	Nov.	Dec.
Longyearbyen	324 (22)	294 (16)	267 (23)	263 (14)	—	—
Resolute	325 (31)	321 (31)	315 (30)	311 (1)	282 (5)	365 (2)
Dixon Is.	284 (17)	264 (13)	260 (13)	253 (2)	—	—
Tromsø	317 (25)	301 (27)	280 (29)	267 (26)	258 (27)	203 (23)
Reykjavik	337 (27)	315 (24)	290 (21)	286 (7)	—	—
Lerwick	330 (31)	306 (31)	283 (30)	283 (31)	310 (13)	298 (2)
Leningrad	340 (27)	328 (17)	307 (12)	301 (9)	307 (5)	242 (2)
Uppsala	318 (13)	300 (19)	284 (14)	286 (12)	304 (8)	266 (4)
Aarhus	356 (31)	337 (30)	316 (30)	312 (28)	312 (28)	315 (23)
Eskdalemuir	337 (26)	312 (30)	294 (28)	293 (29)	314 (13)	333 (15)
Edmonton	337 (31)	336 (31)	312 (30)	311 (31)	307 (27)	337 (31)
Potsdam	306 (7)	289 (8)	278 (12)	301 (3)	—	—
Oxford	351 (30)	324 (31)	308 (28)	299 (30)	304 (25)	308 (27)
Moosonee	374 (10)	315 (22)	322 (26)	327 (30)	355 (30)	386 (21)
Dresden	347 (20)	339 (30)	312 (26)	309 (26)	—	—
Camborne	330 (29)	302 (29)	289 (30)	280 (25)	303 (23)	285 (11)
Paris–Montsouris	335 (30)	323 (30)	313 (30)	305 (27)	322 (29)	350 (27)
Weissenau	—	—	—	—	—	—
Caribou	333 (25)	326 (27)	317 (29)	305 (26)	309 (15)	338 (23)
Bismarck	331 (31)	305 (28)	306 (18)	301 (30)	309 (28)	347 (28)
Arosa	324 (26)	313 (23)	298 (27)	280 (22)	284 (21)	310 (17)
Green Bay	337 (27)	293 (20)	298 (16)	268 (6)	318 (13)	338 (11)
Haute–Provence	—	—	—	289 (6)	330 (4)	353 (9)
Elbrus Mt.	286 (8)	284 (11)	239 (6)	248 (11)	254 (4)	246 (5)
Alma–Ata	311 (15)	328 (18)	297 (24)	266 (12)	245 (3)	214 (4)
Vladivostok	305 (19)	285 (10)	266 (20)	286 (23)	295 (26)	294 (25)
Sapporo	351 (18)	313 (18)	315 (27)	316 (31)	349 (27)	388 (28)
Vigna di Valle	324 (31)	327 (31)	320 (29)	310 (31)	309 (26)	354 (28)
Abastumani	291 (21)	306 (15)	297 (12)	292 (15)	277 (3)	287 (7)
Napoli	278 (9)	293 (24)	286 (23)	285 (23)	281 (19)	326 (15)
Elmas	297 (31)	296 (31)	291 (30)	287 (30)	287 (28)	317 (29)
Washington D.C.	—	—	—	—	—	—
Silver Hill	344 (28)	327 (26)	319 (27)	288 (24)	307 (23)	330 (24)
Messina	342 (31)	348 (31)	330 (30)	321 (30)	320 (28)	353 (28)
Tateno	322 (31)	305 (31)	293 (30)	285 (31)	283 (29)	308 (29)
Srinagar	267 (28)	257 (30)	258 (25)	249 (28)	259 (29)	281 (31)
Fort Worth	345 (26)	322 (28)	302 (24)	284 (23)	297 (22)	306 (17)
Kagoshima	294 (18)	289 (25)	279 (29)	278 (30)	261 (28)	271 (30)
Torishima	292 (31)	278 (28)	269 (29)	262 (29)	248 (30)	255 (31)
Quetta	267 (24)	258 (19)	262 (14)	246 (26)	260 (8)	268 (13)
New Delhi	246 (24)	245 (27)	244 (28)	254 (4)	255 (15)	259 (31)
Mt. Abu	—	—	249 (5)	247 (18)	237 (24)	242 (29)
Marcus Is.	303 (31)	298 (31)	288 (29)	273 (31)	263 (30)	244 (30)
Tamanrasset	167 (15)	212 (19)	212 (20)	213 (22)	200 (11)	193 (14)
Mauna Loa	286 (25)	285 (28)	276 (19)	264 (29)	—	—
Kodaikanal	266 (8)	266 (12)	260 (13)	254 (9)	237 (13)	231 (16)
Bunia–Ruanpara	—	264 (19)	264 (26)	260 (27)	237 (28)	219 (26)
Leopoldville Binza	—	—	—	—	—	—
Brisbane	295 (22)	292 (17)	313 (22)	318 (21)	311 (18)	300 (17)
Melbourne–Aspendale	319 (31)	339 (31)	352 (27)	349 (31)	322 (30)	320 (31)
Wellington	311 (15)	328 (14)	321 (10)	339 (10)	329 (6)	318 (11)
Port-aux-Francais	259 (3)	295 (11)	456 (3)	579 (4)	506 (2)	520 (1)
Macquarie Is.	—	—	—	—	—	—
Dumont d' Urville	—	—	—	—	—	—
Halley Bay	320 (2)	278 (1)	296 (24)	313 (31)	320 (30)	354 (31)

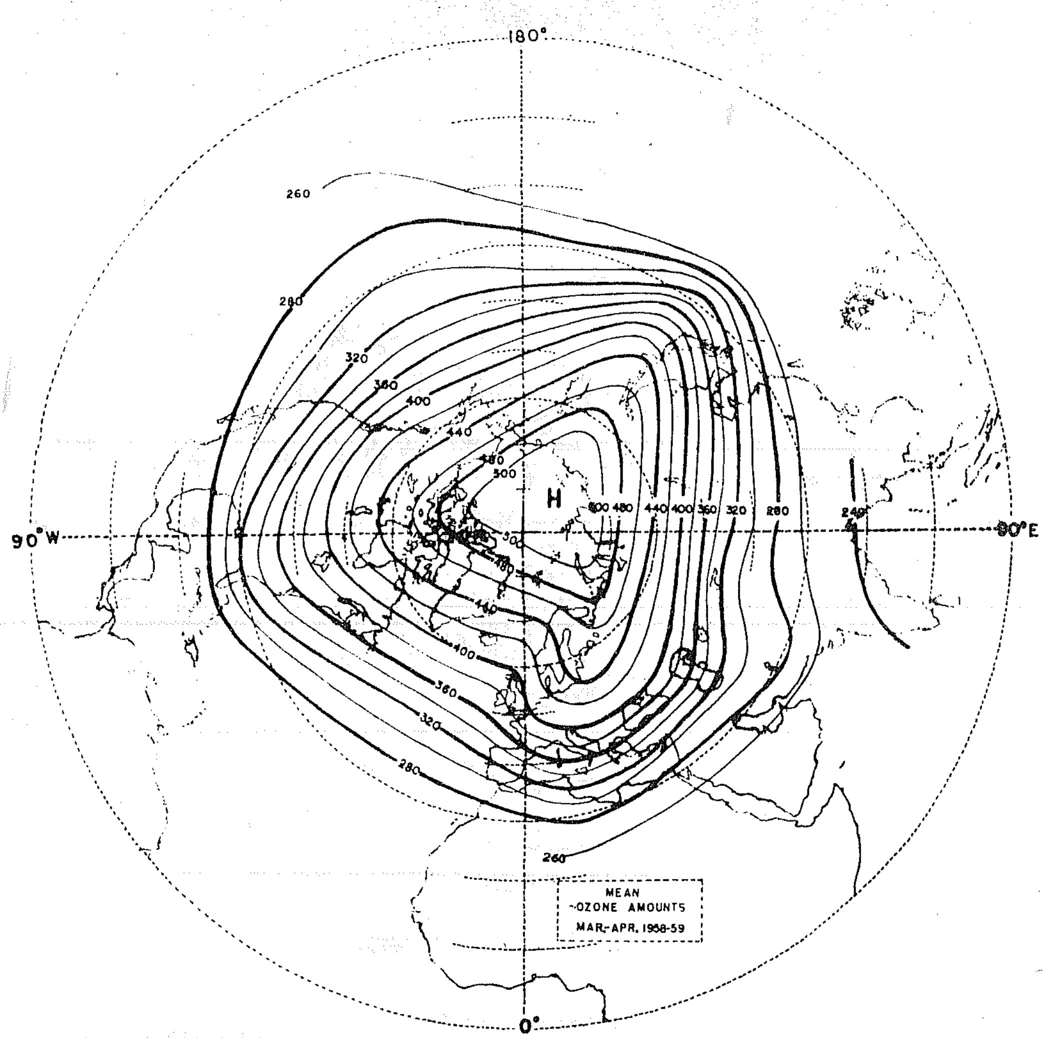

FIG. 1. Total ozone amounts in the northern hemisphere in spring (1958–59) on a polar projection chart. All the available ozone data have been used in preparing these diagrams. J. LONDON presented diagrams similar to Figs. 1 and 2 at the ozone symposium at Arosa. The mean ozone amounts are not distributed symmetrically round the pole. More ozone is found over the eastern parts of Canada, over Central Europe and over NE Asia. India is a region of deficient ozone.

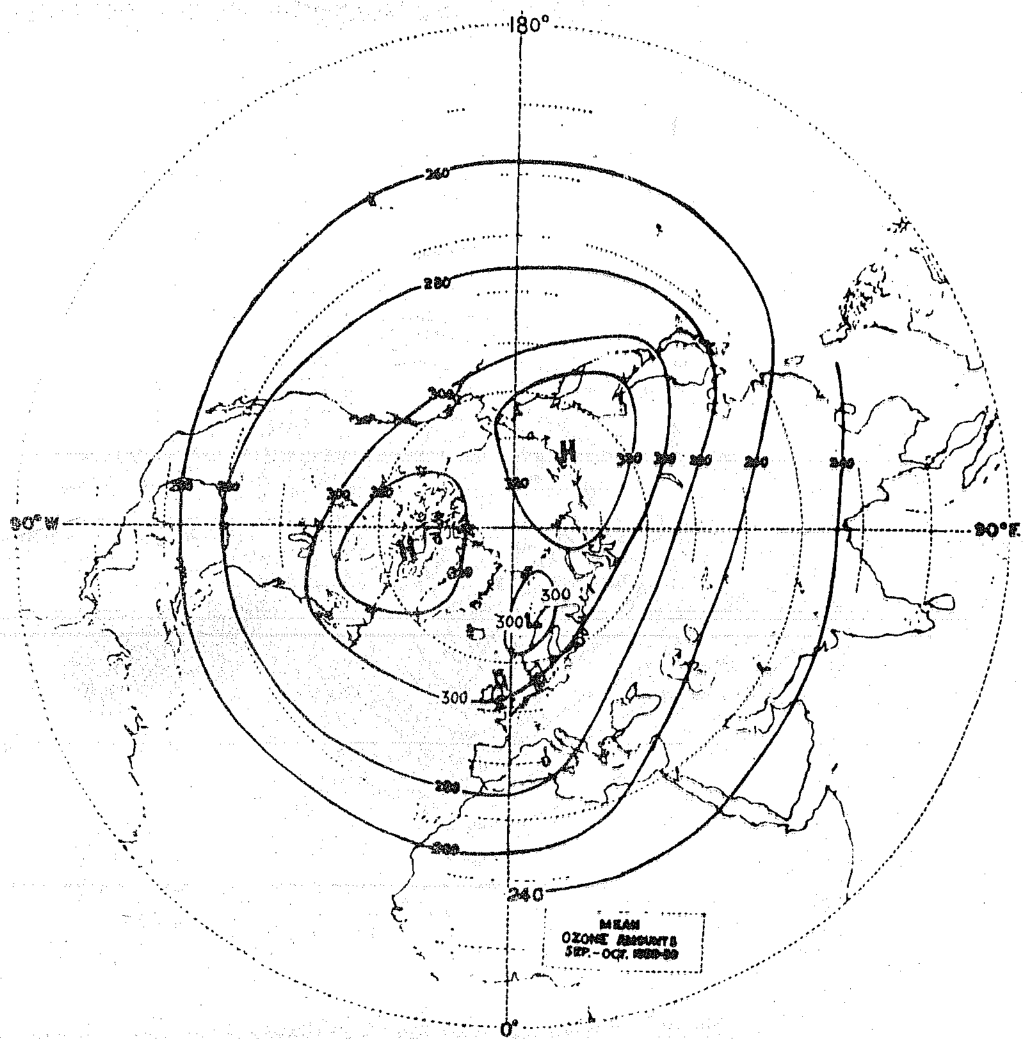

FIG. 2. Total ozone amounts in autumn. There appears to be a comparative deficiency of ozone over NE Atlantic and Scandinavia.

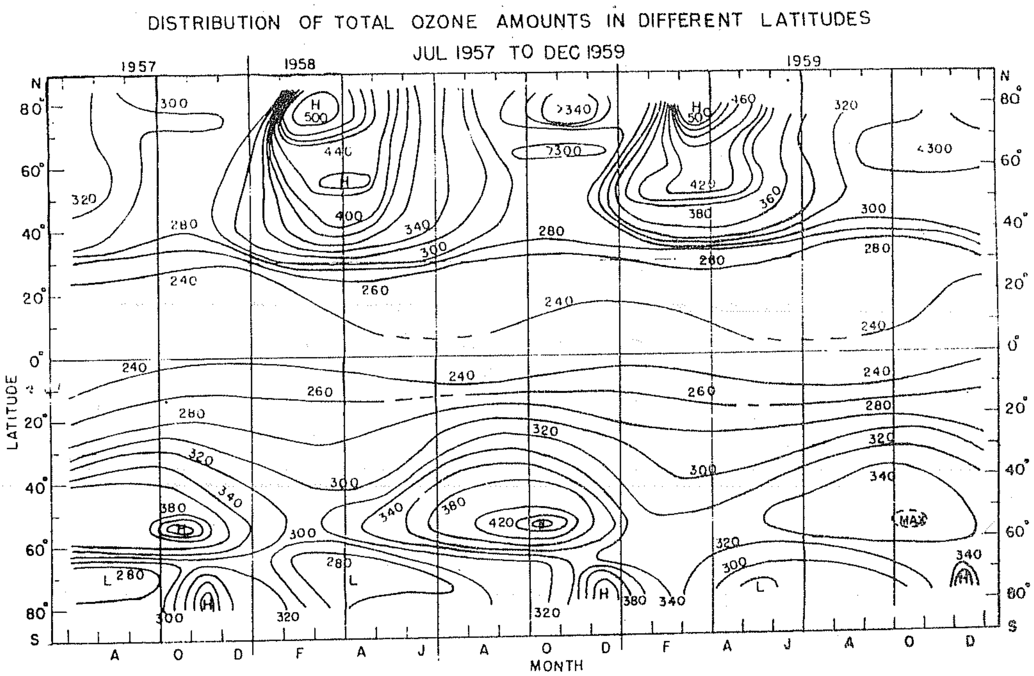

FIG. 3. Distribution of total ozone in different latitudes: the difference between the ozone distributions in the northern and southern hemispheres may be noted.

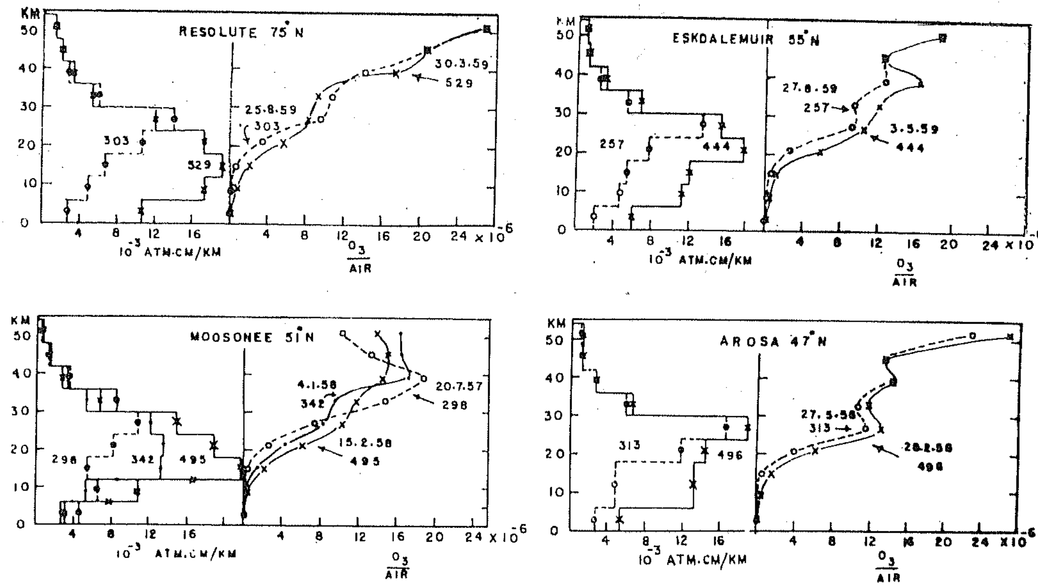

FIG. 4. Vertical distribution of ozone over Resolute 75°N, Eskdalemuir 55°N, Moosonee 51°N and Arosa 47°N, calculated from umkehr observations by Method B. Sample distributions corresponding to high and low values of ozone are shown. Curves of ozone-mixing ratio are also given. The lowering of the C.G. with increasing ozone amounts may be noted.

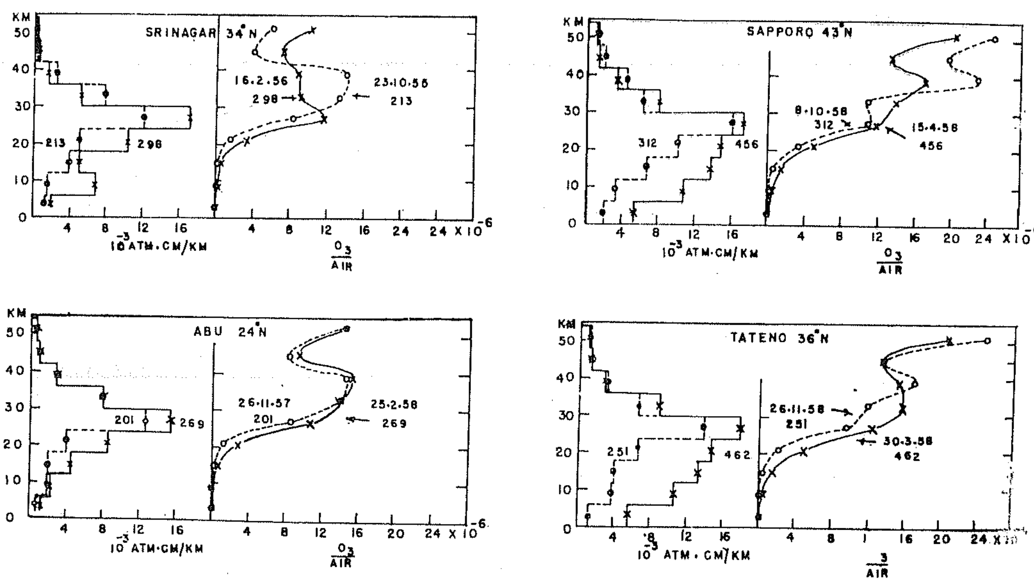

FIG. 5. Vertical distributions over Sapporo 43°N, Tateno 36°N, Srinagar 34°N and Abu 24°N. Note the difference between Srinagar and Tateno.

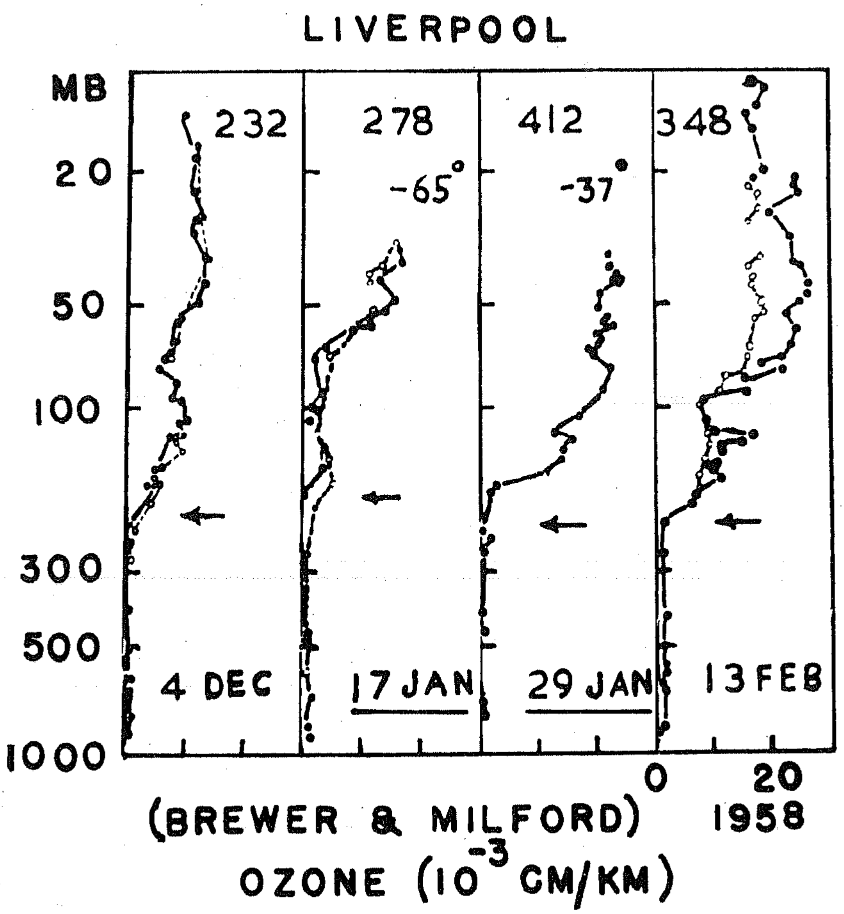

FIG. 6. Ozone distributions over Liverpool obtained by BREWER and MILFORD[1] with the Oxford–Kew chemical ozonesonde. The arrows indicate tropopause levels. Note the large difference in ozone amounts and in ozone distributions on 17 Jan. and 29 Jan. 1958. The stratosphere at the top of the flight had warmed up considerably by the 29th. (The authors and the Royal Society have kindly authorized the reproduction of this diagram.)

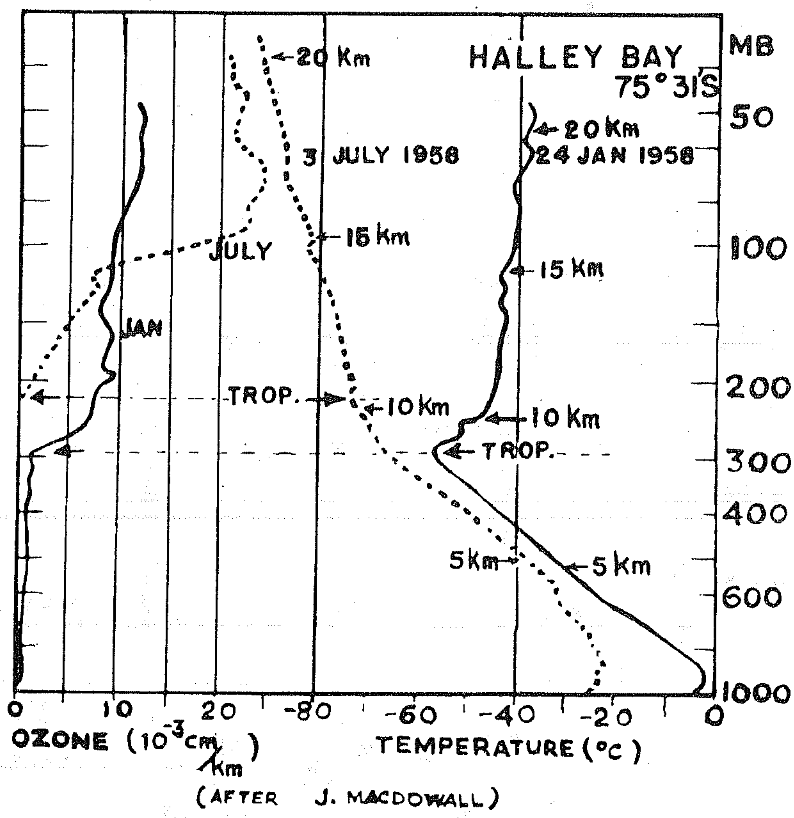

FIG. 7. Vertical distribution of temperature and ozone over Halley Bay in Antarctic summer and winter obtained by J. MACDOWALL.[2] Note the two steps in the rise of ozone with height in the winter ascent. (The authors and the Royal Society have kindly authorized the reproduction of this diagram.)

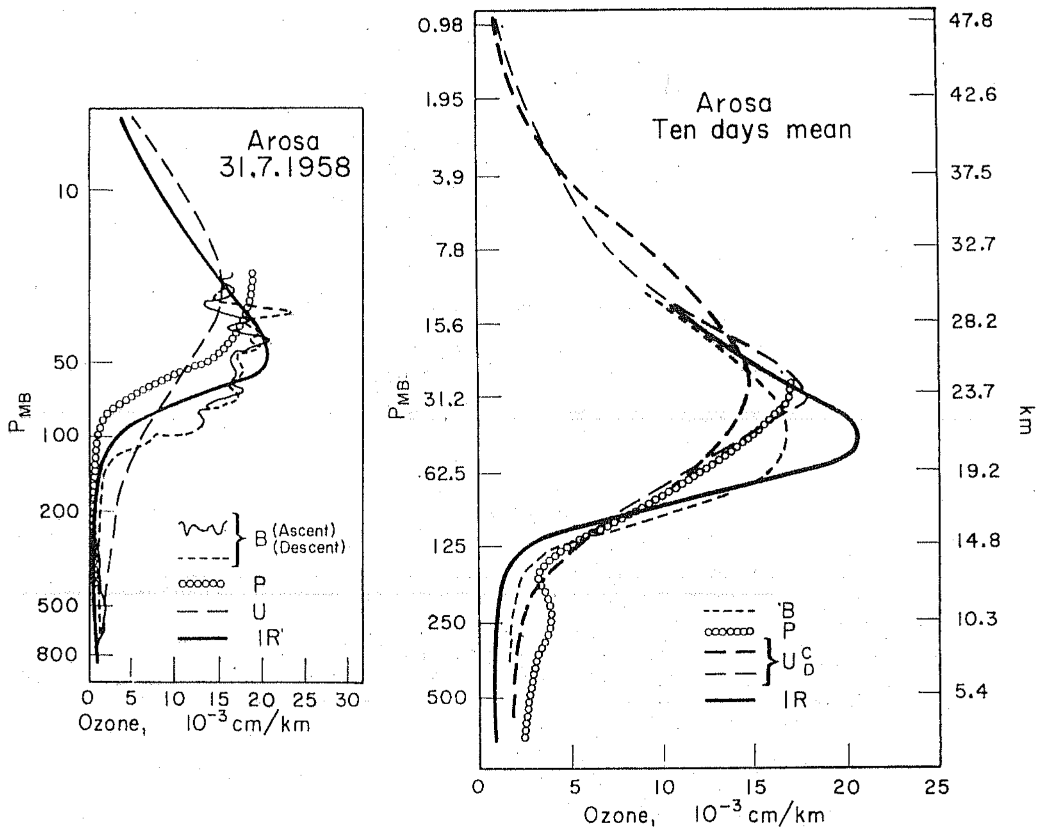

FIG. 8. Results of a comparison made at Arosa in July to August 1958 of four different methods of determining the vertical distribution of ozone: infrared emission and absorption of 9·6 band (VIGROUX[3]), Umkehr (DÜTSCH[4]), optical radiosonde (PAETZOLD) and chemical ozonesonde (BREWER).

In the diagram, B, P, U and I.R. stand for Brewer, Paetzold, umkehr and infrared. C and D refer to the wavelengths used for the umkehr observations. The umkehr with C gave a higher level for the C. G of ozone than the chemical sonde. (The authors and the Centre National de la Recherche Scientifique, Paris, have kindly authorized the reproduction of these diagrams.)

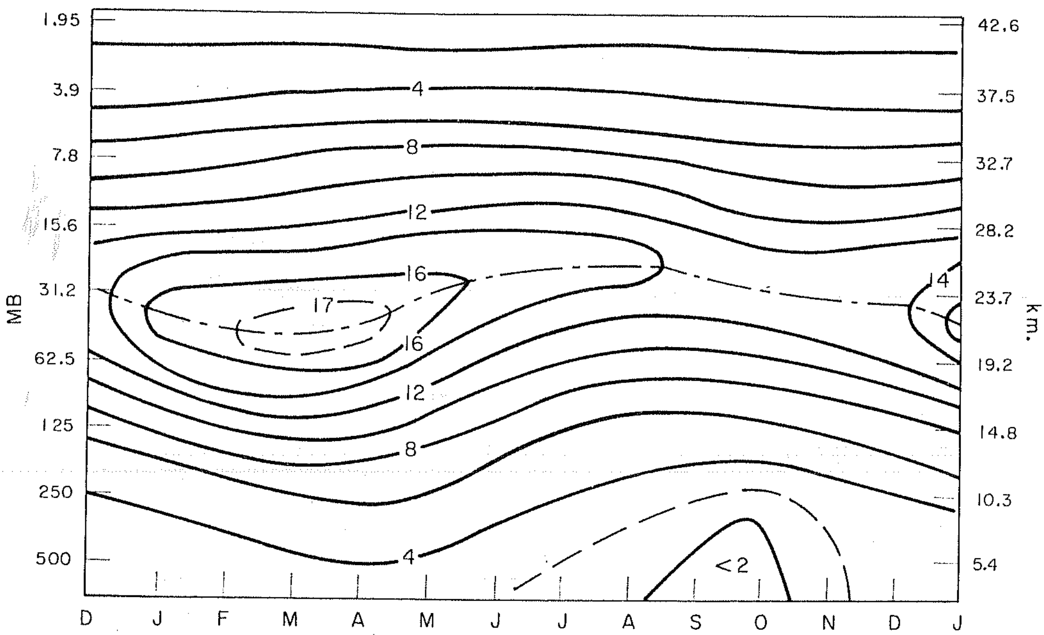

FIG. 9. Seasonal variation in the vertical distribution of ozone over Arosa (DÜTSCH). DÜTSCH used a somewhat different technique than method B for analysing the umkehr observations.

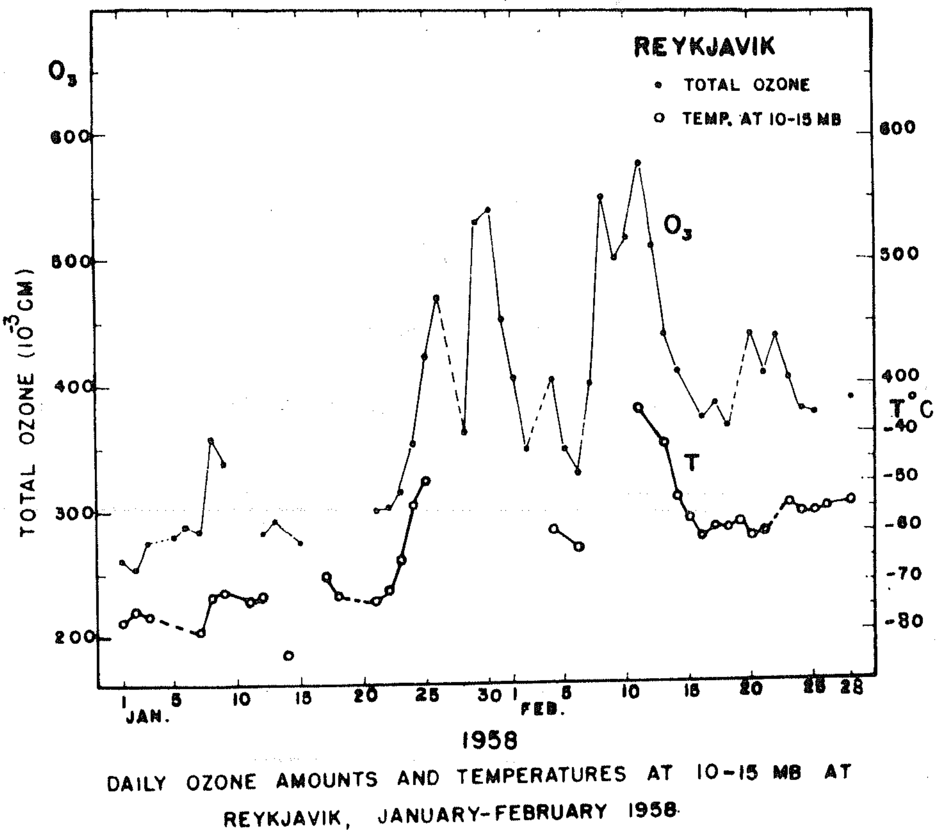

FIG. 10. Daily ozone amounts and temperatures at 10–15 mb (taken from Berlin charts) over Reykjavik in Jan.–Feb. 1958.

event are shown in Fig. 11. As elucidated by W. L. GODSON and his collaborators, some of the larger ozone changes in high latitudes in winter and spring are associated with stratospheric waves. There is evidence of a large-scale slow descent of air from the upper stratosphere of middle latitudes towards lower levels in the polar stratosphere in late winter or spring. The very valuable ozone observations made at Halley Bay and at Argentine Islands suggest a fundamental similarity, with a difference in timing, between the Arctic and Antarctic stratospheric circulations (for example see Fig. 12). More ozone stations are needed in the southern hemisphere and in Continental Asia.

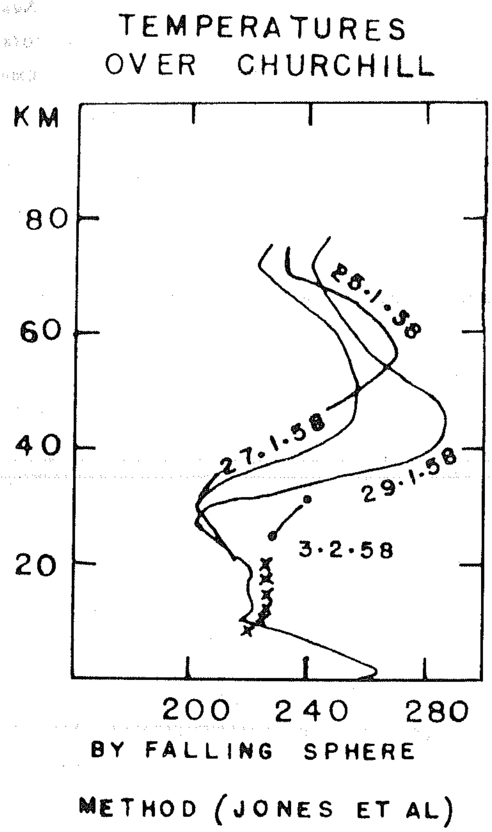

FIG. 11. Temperature changes in the mesosphere and stratosphere over Churchill from 25 to 28 Jan. and temperatures in the stratosphere on 3 Feb. 1958. Note steady descent of warm air from 25 Jan. to 3 Feb. The ozone amount over Moosonee showed a sudden rise from 0·372 to 0·427 cm on 30 Jan. 1958.

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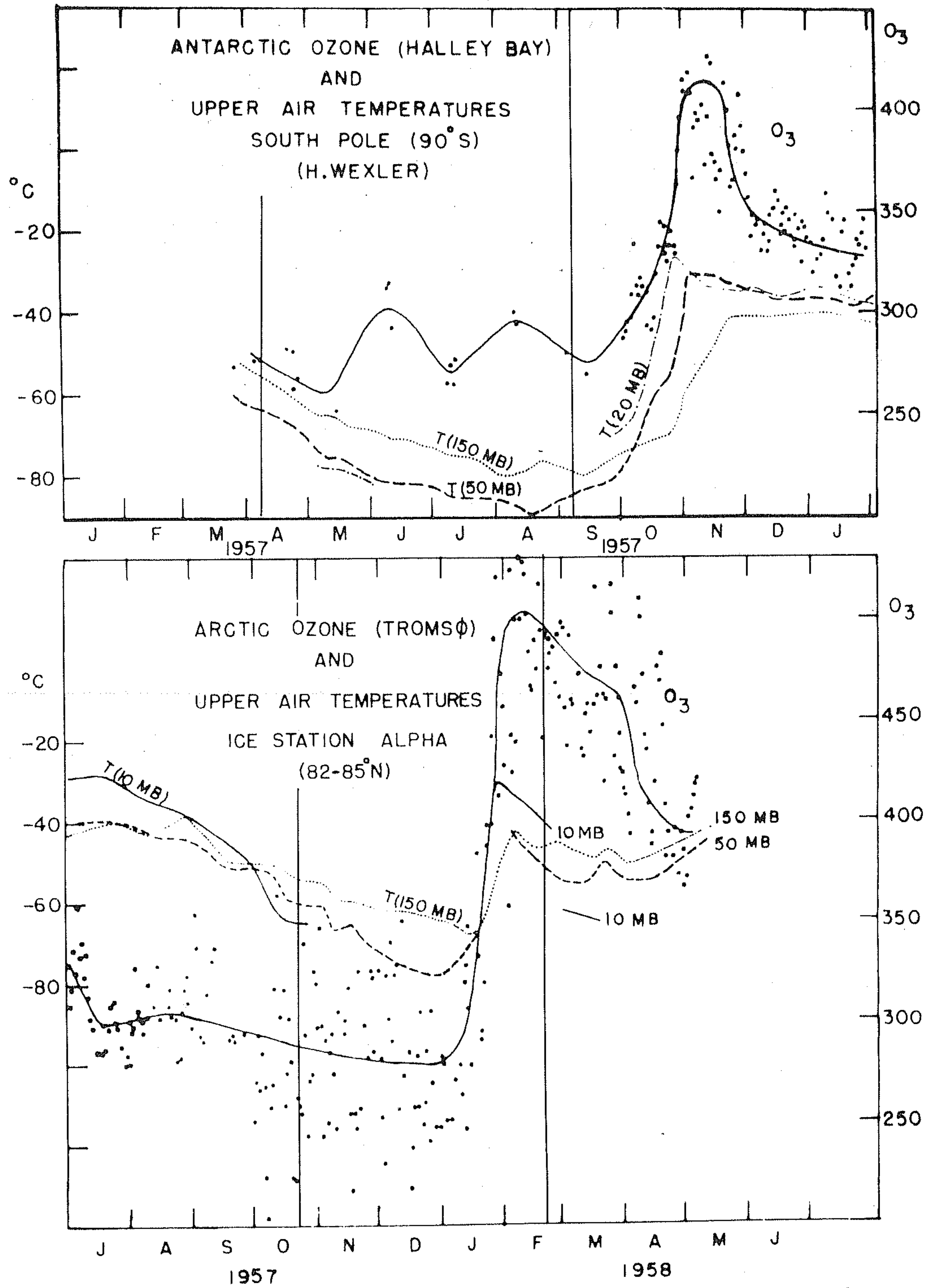

Fig. 12. Rapid rise in ozone and middle stratosphere temperatures at Tromsø in the Arctic and at Halley Bay in the Antarctic in 1957–58. The Arctic rise in ozone took place before the end of the polar night, while the Antarctic rise took place in early summer. It has been found that in general the breakdown of the polar stratospheric vortex in the Antarctic takes place later in the season than in the Arctic.

9

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