INTERNATIONAL COUNCIL OF SCIENTIFIC UNIONS

No. 17 May 1964

SCAR

SCIENTIFIC COMMITTEE ON ANTARCTIC RESEARCH

BULLETIN

ARGENTINA AUSTRALIA BELGIUM

CHILE FRANCE JAPAN NEW ZEALAND

NORWAY SOUTH AFRICA UNITED KINGDOM

UNION OF SOVIET SOCIALIST REPUBLICS

UNITED STATES OF AMERICA

PUBLISHED BY

SCOTT POLAR RESEARCH INSTITUTE, CAMBRIDGE, ENGLAND

INSTITUTO ANTARTICO ARGENTINO, BUENOS AIRES, ARGENTINA

Reprinted from *Polar Record*, Vol. 12, No. 77, 1964, pp. 211–228.

Polar Record, Vol 12, *No* 77, 1964, *p* 211–28
Printed in Great Britain

SCAR BULLETIN

No. 17, May 1964

ISOTOPES IN RELATION TO POLAR GLACIOLOGY

BY C. LORIUS*

CONTENTS

Introduction

Some 99 per cent of the ice on the earth is concentrated in polar ice sheets and 91 per cent is in Antarctica. From a glaciological point of view, scientific interest in the Antarctic ice sheet arises because its vast ice mass determines natural conditions in Antarctica and influences conditions and processes over the entire earth; study of the Antarctic ice sheet provides a means of understanding processes which took place on other continents during former ice ages, and it provides a unique area of deposition and preservation of atmospheric precipitation which is almost free from local or artificial sources of contamination.

The first two points require a theoretical understanding of the growth and maintenance of the continental ice sheet, and the third calls for investigations to determine the quantity and composition of cosmic and terrestrial deposits falling on the surface of the earth during recent geological time. In addition to assisting in the understanding of many glaciological processes, these studies have an intrinsic value in connexion with scientific research in other fields. This paper will not consider glacial geology and other aspects, but will be restricted to the glaciological point of view.

Each of the elements, such as hydrogen, carbon or oxygen, is characterized by its own chemical make-up, but each of them can be further subdivided by weight; thus hydrogen exists in nature in three forms with atomic weights of 1, 2 and 3; tritium is an unstable isotope breaking up by spontaneous radioactive decay, while hydrogen and deuterium are stable isotopes.

Unstable or radioactive isotopes

Radioactivity occurs in two forms, natural and artificial. Natural radioactivity is mainly due to radon and thoron (and to their decay products such as lead 210) coming from uranium and thorium enclosed in rocks, and only a fraction comes

* Laboratoire de Géologie du College de France. Paper presented at the 7th SCAR meeting Cape Town, 1963.

from products of the interaction of cosmic rays on the constituents of atmosphere —nitrogen, oxygen and argon. Though their activity is not very important, such isotopes as carbon 14, tritium (^3H), and berylium 7 are often used for their geophysical and geochemical applications.

Artificial radioactivity is due to fission products of uranium 235 and plutonium 239 (the most important being strontium (Sr) 90 and cesium (Cs) 137) and to radioactive products from thermonuclear reactions (especially tritium). The

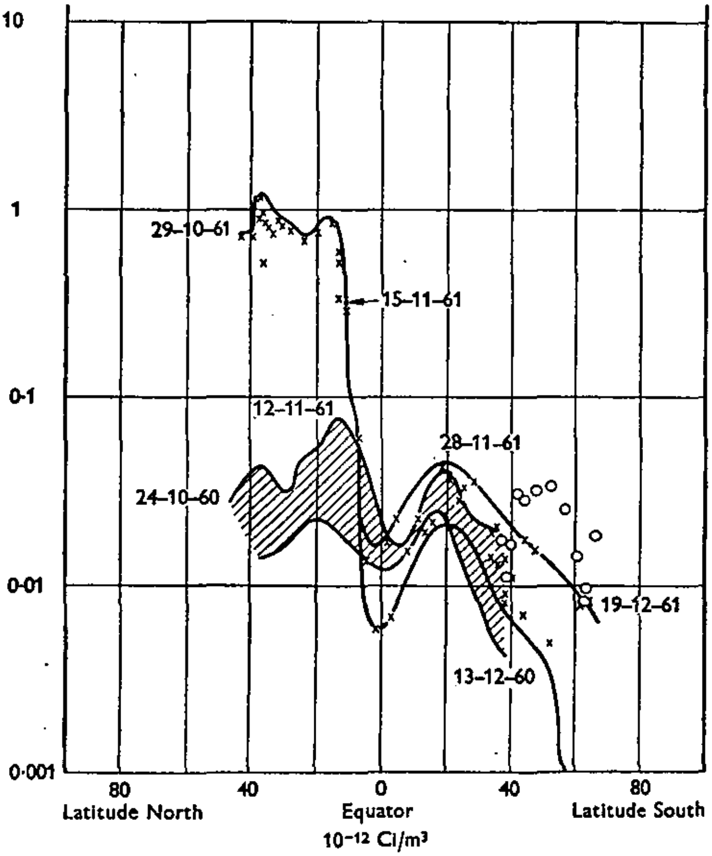


Fig 1. Geographical distribution of radioactive debris. Curve obtained October–December 1960, ▧. Outward journey October–December 1961 (measured January 1962), ×. Return journey February 1962 (measured June 1962), o.

fission products appeared in the earth's atmosphere when the first atomic bomb exploded in 1945, but they were only scattered all over the world in important quantities from 1952 to 1954, when the first thermonuclear explosions took place. An example of the geographical distribution of radioactive debris is given in Fig 1 (Labeyrie and Lambert, 1963).

Glaciological application of unstable isotopes. In glaciology, radioactive isotopes are primarily used for dating, either to give an absolute age or to mark some particular horizon.

Absolute age determinations. These are based on the decay of activity following the formula:

$$P_t = P_0 e^{-\lambda t},$$

where P_0 is the number of the original radioactive atoms at the start, and P_t is the number at time t. λ, the radioactive constant, is related to the half life (T) of the element by $\lambda = 0{\cdot}693/T$. Basic hypotheses for all these determinations are that the rate of decay is both known and constant.

In glaciology, results have been obtained by using tritium, lead 210 and carbon 14, half-life of these isotopes being respectively 12·2–21·4 and 5730 years. It is generally possible to date for periods of time between 0·1 and 6T.

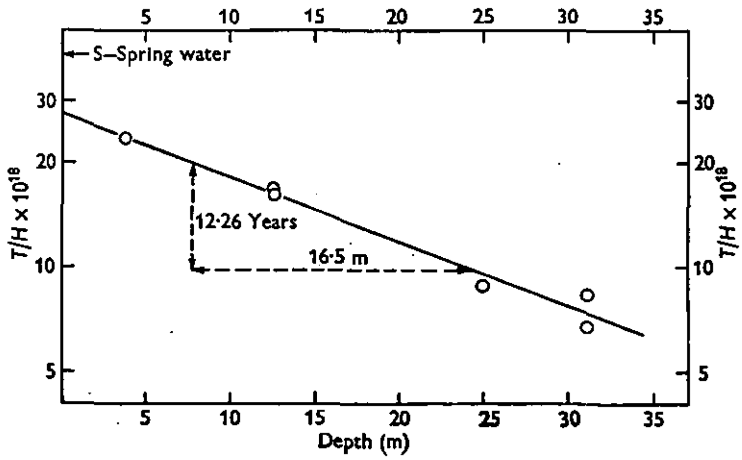


Fig 2. Tritium content of firn layers at Jungfraufirn, 1962.

Tritium measurements made by Oeschger, Renaud and Schumacher (1962) and Renaud *et al* (1962) in Switzerland and Greenland are shown in Fig 2. In addition to determining annual accumulation from the mean decrease of tritium content of different layers of snow, they discovered a correlation between fluctuations in tritium content and solar activity as reflected in the number of sun spots. From these first measurements, they conclude that the tritium production rate is in antiphase with the solar activity, being about a factor of two higher during periods of small solar activity than during periods of high solar activity.

Some results had been also reported from Antarctica by Libby (1956) and Vickers (1963) who found snow accumulation values in fairly good agreement with separate glaciological determinations. Such studies require about 10 kg of snow from each annual layer, and complicated laboratory measurements.

Lead 210, being free from its parents in rain and snow, provides a convenient time-clock for natural waters. The only reported results are from Greenland, where Goldberg (1962) was able to establish a geochronology for the formation of the ice sheet; the rate of accumulation based on decay of lead 210 being in complete agreement with that based on stratigraphic evidence.

Carbon 14 has not yet been found in organic form in polar ice, and so has to be obtained from CO_2 contained in the air bubbles enclosed in the ice. The necessary quantity of carbon needed for laboratory determination is obtained by the melting of one or more tons of ice under airtight conditions. It is, however, the only isotope which can be used to determine age of ice older than 100 years, and this information is necessary for solving very important problems, such as the age of the ice calving into the sea, or the length of time it takes for a snow crystal falling in the centre of Antarctica to reach the coast. Theoretical calculations give results which vary from 10000 to several hundreds of thousands of years, but the only experimental results, obtained in Greenland by Dansgaard (1961), gave surprisingly low values only up to a few thousands of years (see Fig 9).

Age determinations based on decay of natural radioactive isotopes are now being complicated by pollution by artificial products; for example, the quantity of tritium in the atmosphere has increased by a factor of 1000 since nuclear tests began. Methods and techniques of sampling and measurement will improve in the coming years, and researches made into the use of new isotopes will make it possible to cover a larger range of time.

Determination of particular horizons. Another way of solving the problem raised by the measurement of accumulation on polar ice sheets is to find a reference horizon of known date, easy to identify.

Recent publications by Picciotto and Wilgain (1963) and Vickers (1963) show that such an horizon was formed by the stratospheric fall-out of radioactive debris from thermonuclear bomb tests. The contribution of natural radionuclides is negligible in the gross β activity which can be taken as a measure of the fission products concentration.

Fig 3 shows the difference in average value of activity (Picciotto and Wilgain, 1963).

Prior to 1952	=	0·5 dpm/kg of snow
1953 and 1954	=	2 dpm/kg of snow
Beginning of 1955	=	22 dpm/kg of snow
1955 to 1960	=	14 dpm/kg of snow

From 1945 to 1952 only fission nuclear bombs were detonated. These explosions yielded tropospheric debris in the Northern Hemisphere which certainly did not reach Antarctica. From 1952, thermonuclear explosions have released a total amount of fission products sufficient to reach Antarctica by stratospheric circulation. The sharp increase is estimated to occur between the southern spring of 1954 and fall of 1955, and to be due to CASTLE thermonuclear tests series (March 1954); the previous thermonuclear test, IVY, November 1952, is less marked, and β activity prior to 1952 is essentially due to lead (Pb) 210 and potassium (K) 40.

From these first results it seems that radioactive horizons have been formed at about the same time over the whole ice sheet; these determinations, which need only quantities of about 1 or 2 kg of snow, can be made either by measuring concentration of one or several individual nuclides—generally Sr 90—or in a much simpler way by measuring the fission products concentration in terms of the gross β activity.

Stable isotopes

Stable isotopes can be used in geophysical and geochemical problems owing to their large natural variations compared with the precision of laboratory determinations; content in ice is very much influenced by meteorological parameters and these isotopes can be used as tracers in the study of different phenomena (Roth, 1963). Stable isotopes which are actually used in glaciology are deuterium (D) and oxygen 18; both give the same sort of information, and measurements can be made with a few cm³ of water.

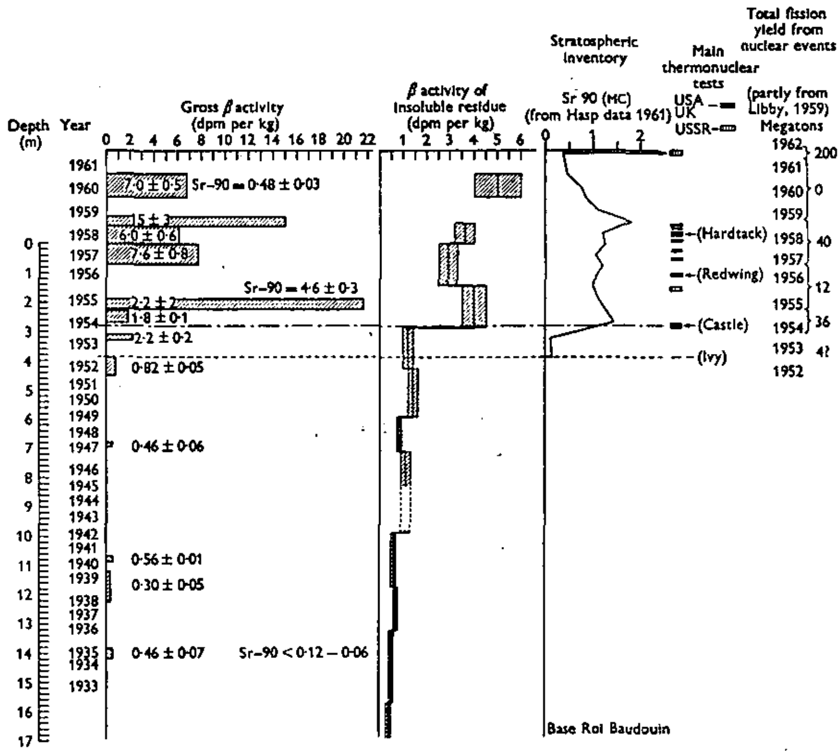


Fig 3. Fission products in Antarctic snow, "Base Roi Baudouin".

The cycle of deuterium in nature is represented in Fig 4 (from Craig, published by Boato, 1960), variations in concentration being due to fractionation processes.

If we consider the condensation of water vapour, theory leads to the following relation

$$C_s = C_s^0 \left(\frac{e_w}{p}\right)^{\alpha-1} \left(\frac{p^0}{e_w^0}\right)^{\alpha-1},$$

in which C_s is the content in the solid phase, α the factor of fractionation, e_w the water vapour pressure, p the total pressure, and indicates ^{0} the initial stage.

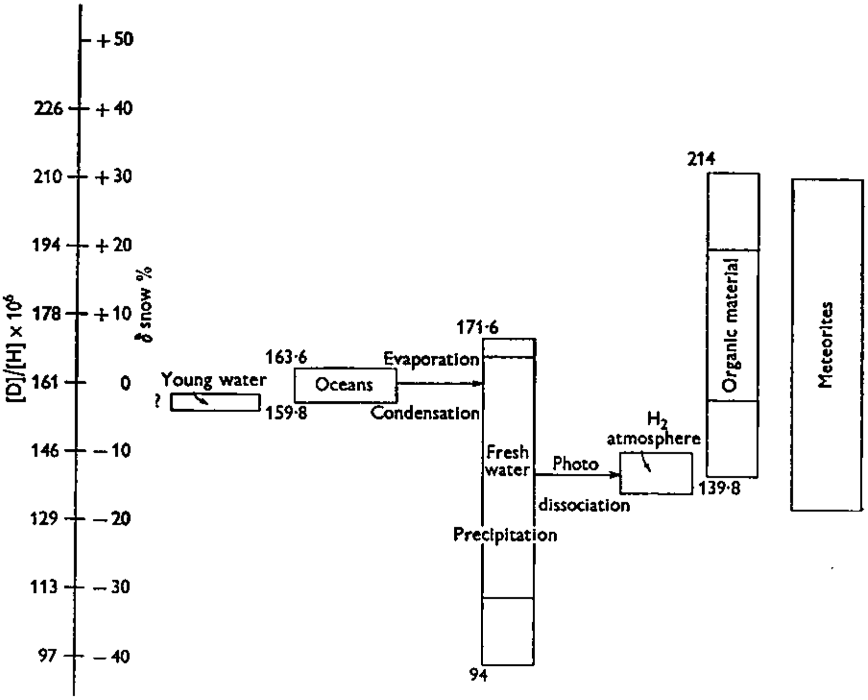


Fig 4. Isotope hydrogen cycle.

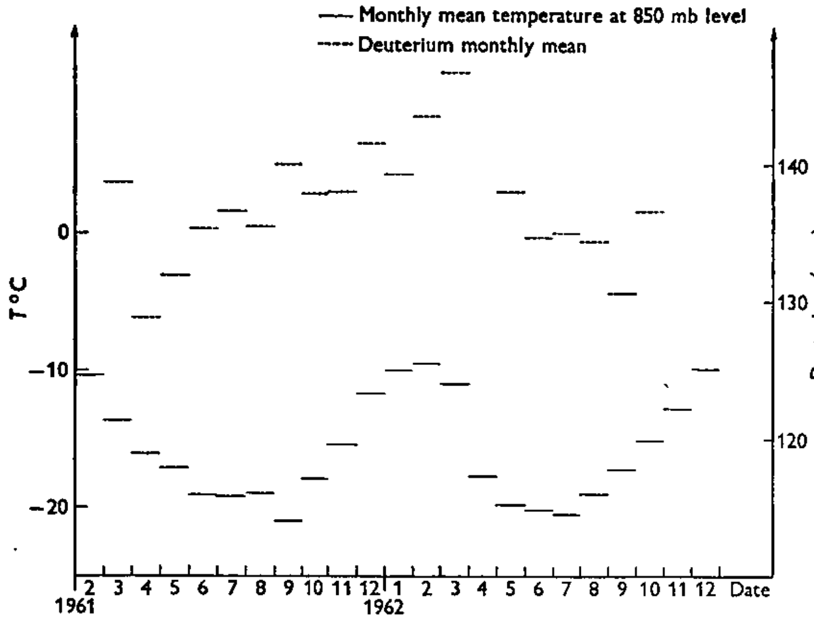


Fig 5. Seasonal variation of deuterium content of precipitations, "Base Dumont d'Urville", 1961–62.

The fact that isotope content is primarily dependent on the temperature (Picciotto, de Maere and Friedman, 1960; Botter, Lorius and Nief, 1960) leads to two important conclusions:

In a station there is a seasonal variation in the concentration of precipitation (Picciotto *et al* 1960; Gonfiantini *et al* 1963; Lorius, 1963), see Fig 5.

Isotopic content changes with geographical location (Picciotto *et al.* 1963) and mean annual temperature (Dansgaard, 1961; Lorius, 1961, 1963), see Fig 6.

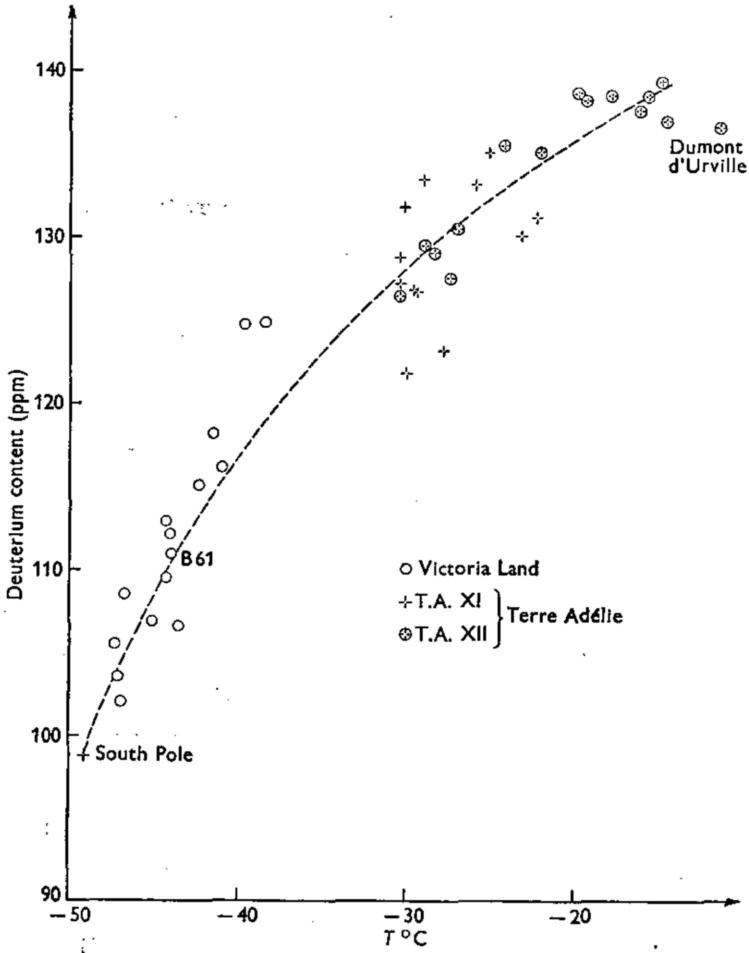


Fig 6. Relationship between deuterium content and mean annual temperature, Antarctica.

Glaciological application of stable isotopes

Accumulation studies. Due to the fact that there is a seasonal variation in the stable isotope content of snow, it is possible to count the years by analysing samples from superimposed layers. Rates of accumulation based on these

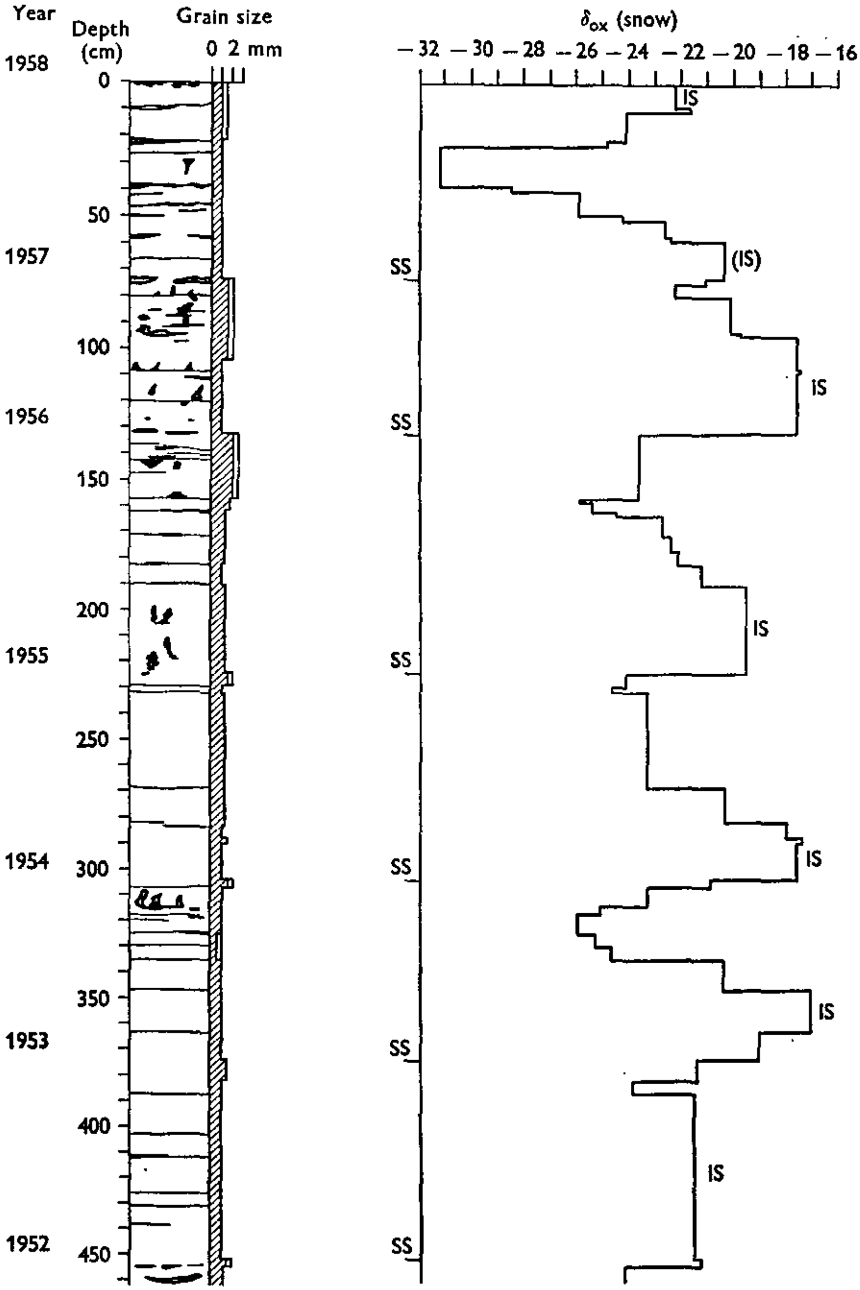


Fig 7. Snow stratigraphy and oxygen isotope ratios, "Base Roi Baudouin", 1952–58.

analyses are in good agreement with those based on stratigraphic evidence in Greenland (Epstein and Benson, 1959; Langway, 1962) and for some stations in Antarctica (Botter *et al* 1961; Gonfiantini *et al* 1963), see Fig 7. Other studies from the Antarctic plateau (Sharp and Epstein, 1962; Lorius, 1963) show that isotopic determinations lead to an accumulation which is much greater than the value we can get from stratigraphy, the discrepancy can be as much as 50 per cent (Fig 8).

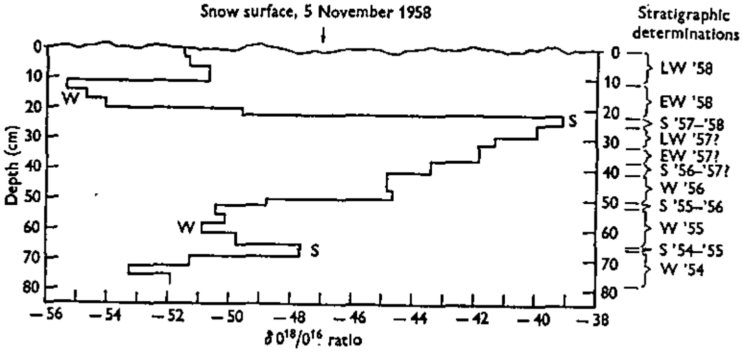


Fig 8. Snow stratigraphy and oxygen isotope ratios, South Pole, 1958.

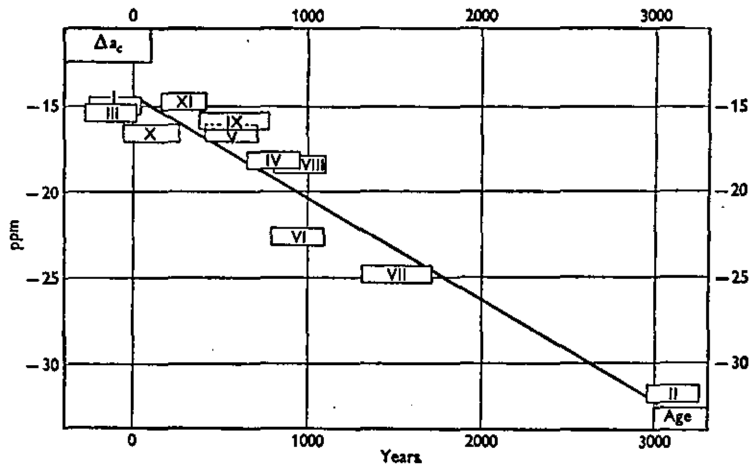


Fig 9. Relationship between age of ice and oxygen 18 content, West Greenland.

Different factors, such as irregularities of the distribution of accumulation and meteorological season and snow drift, could explain the divergence of results. There is, however, no very strong reason why one method should be preferred to another and our feeling is that accumulation studies need more extensive comparative determinations based on known factors, using as many methods as possible—stakes, stratigraphy, stable isotope content, and natural and artificial radioactivity. In any event, when the depth increases glaciological methods become useless.

Characteristics of the ice. Another application of isotopes to glaciology was reached when a relation was found between mean annual air temperature and mean stable isotope content in the same station, see Fig 6. This relation can be affected by local conditions, such as topography and distribution of snow accumulation.

From analyses of samples of Greenland icebergs and maps of isotherms, Dansgaard (1961) was able to locate the origin of the ice of these icebergs and correlate the age of the ice and stable isotope content, see Fig 9.

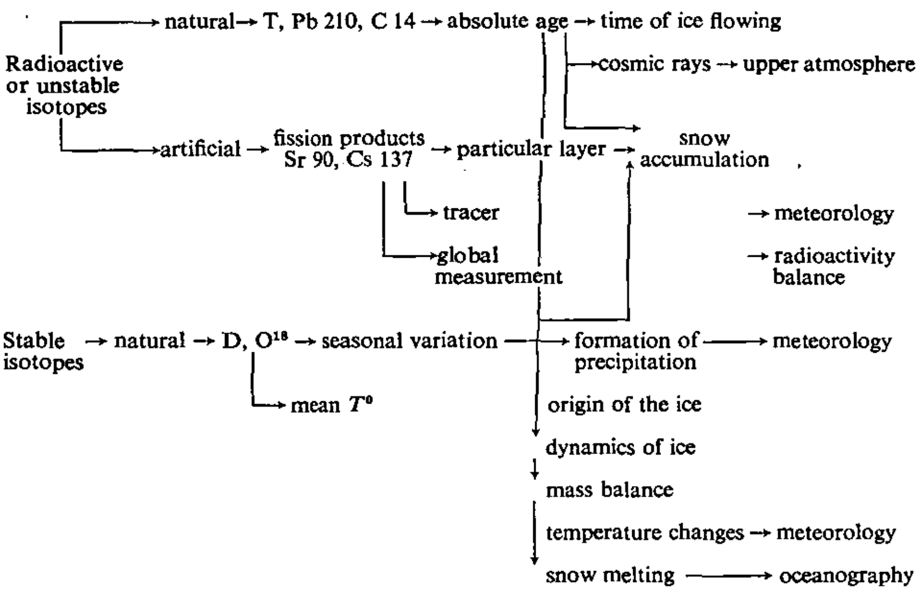
In Terre Adélie, Lorius and Merlivat (1963), and Lorius (1963), found that:

the Glacier de l'Astrolabe is nourished by local precipitations which fell on an area less than 50 km from the coast; most of the ice calving in this zone is of the same origin;

ice which was found to have a very low deuterium content near a moraine can be expected to come from distances increasing from 50 to 800 km; absolute age determination on this ice would give new information about the maintenance of the ice sheet.

In these studies, deuterium content was the only means used to characterize different kinds of ice. From these first results, it seems that many glaciological problems could be studied with stable isotopes, such as:

formation of precipitations (Facy *et al* 1963); snow accumulation; dynamics of the ice, including representative velocities for the whole ice sheet and laws of ice movement; zones of accumulation to be considered in mass balance studies, an example of which would be the study of thc Ross Ice Shelf; secular temperature changes; and bottom melting of the ice (Berthois, 1963).



Conclusion

Isotopic applications are relevant to glaciological studies. It is important to emphasize the fact that the Antarctic ice sheet provides a unique area of deposition and preservation of cosmic and terrestrial deposits falling on the surface of the earth during recent geological time, and gives evidence of past conditions on our earth.

The study of all material included in the ice, either in solid, liquid or gaseous form, is connected with other disciplines such as meteorology, upper atmosphere physics and oceanography. A picture of the actual lines of researches in isotopic glaciology is summarized in the diagram at the foot of the previous page.

References

BERTHIOS, L. Sedimentologie du Kangerdlugssuaq. *Meddelelser om Grønland* (in press).

BOATO, G. Unpublished. *Isotope fractionation process in nature.* Summer course in nuclear geology, Varenne, 1960. Comitato Nazionale per l'Energia Nucleare, Laboratoria de Geologie Nucleare.

BOTTER, R., LORIUS, C. *and* NIEF, G. 1960. Sur la teneur en deutérium des précipitations en Terre de Victoria, Antarctique. *Comptes rendus Hebdomadaires des Séances de l'Académie des Sciences* (Paris), Tome 251, No 4, p 573.

BOTTER, R., LORIUS, C. *and* NIEF, G. 1961. Sur la datation des couches de névé dans l'Antarctique à partir de leur concentration en deutérium. *Comptes rendus Hebdomadaires des Séances de l'Académie des Sciences* (Paris), Tome 252, No 3, p 437.

DANSGAARD, W. 1961. The isotopic composition of natural waters with special reference to the Greenland Ice Cap. *Meddelelser om Grønland*, Bd 165, Nr 2.

EPSTEIN, S. *and* BENSON, C. 1959. Oxygen isotope studies. *Transactions of the American Geophysical Union*, Vol 40, p 81–84.

FACY, L., MERLIVAT, L., NIEF, G. *and* ROTH, E. 1963. Étude de la formation d'un grelon par une méthode d'analyse isotopique. *Journal of Geophysical Research*, Vol 68, No 13, 3841–48.

GOLDBERG, E. D. Unpublished. *Geochronology with lead 210.* Symposium on radio active dating, Athens, November 1962. International Association for Atomic Energy.

GONFIANTINI, R., TOGLIATTI, V., DE BREUCK, W., PICCIOTTO, E. *and* TONGIORGI, E. 1963. Snow stratigraphy and oxygen isotope variations in the glaciological pit of Base Roi Baudoin, Dronning Maud Land, Antarctica. *Nature, Lond.*, Vol 197, p 1096.

LABEYRIE, J. *and* LAMBERT, G. 1963. Sur l'existence d'une barrière de diffusion entre les troposphères des hémisphères Nord et Sud. *Comptes rendus Hebdomadaires des Scéances de l'Académie des Sciences* (Paris), Tome 56, p 2664.

LANGWAY, C. 1962. Some physical and chemical investigations of a 411 meters deep Greenland ice core and their relationship to accumulation. International Association of Scientific Hydrology Publication No 58, p 101.

LIBBY, W. F. 1956. Radioactive strontium fallout. *Proceedings of the National Academy of Sciences*, No 42.

LIBBY, W. F. 1959. Radioactive fallout particularly from the Russian October series. *Proceedings of the National Academy of Sciences*, No. 45, p 959–76.

LORIUS, C. 1961. Concentration en deutérium des couches de névé dans l'Antarctique. *Annales de Géophysique*, Tome 17, No 4, p 378.

LORIUS, C. 1963. Le deutérium: possibilités d'application aux problèmes de recherche concernant la neige, le névé et la glace dans l'Antarctique. *Comité national français pour les recherches antarctiques*, No 8.

LORIUS, C. *and* MERLIVAT, L. 1963. Sur la caractérisation de la glace des Inlandsis à partir de la teneur en deutérium. *Comptes rendus Hebdomadaires des Séances de l'Académie des Sciences* (Paris), Tome 256, No 2, p 475–77.

OESCHGER, H., RENAUD, A. *and* SCHUMACHER, E. 1962. Essai de datation par le tritium des couches de névé du Jungfraufirn et détermination de l'accumulation annuelle. *Bulletin de la Société vaudoise des sciences naturelles*, Vol 68, No 306, p 49.

PICCIOTTO, E., DE MAERE, X. *and* FRIEDMAN, I. 1960. Isotopic composition and temperature of formation of antarctic snows. *Nature, Lond.*, Vol 187, p 857.

PICCIOTTO, E., TONGIORGI, E., GONFIANTINI, R., TOGLIATTI, V. *and* DE BREUCK, W. 1963. Geographical variations of oxygen 18–oxygen 16 ratio in surface snow and ice from Queen Maud Land, Antarctica. *Nature, Lond.*, Vol 197, p 1096.

PICCIOTTO, E. *and* WILGAIN, S. 1963. Fission products in Antarctic snow—A reference level for measuring accumulation. *Journal of Geophysical Research*. In press.
RENAUD, A., SCHUMACHER, E., HUGHES, B., MUHLEMANN, C. *and* OESCHGER, H. 1962. Tritium variations in Greenland ice. Symposium on trace gases and natural and artificial radioactivity in the atmosphere. I.U.G.G., W.M.O. Utrecht.
ROTH, E. 1963. L'utilisation des mesures de teneur en deutérium pour l'étude des phénomènes météorologiques et géologiques. *Journal de Chimie Physique*, Tome 60, No 1–2, p 331.
SHARP, R. P. *and* EPSTEIN, S. 1962. Comments on annual rates of accumulation in West Antarctica. *International Association of Scientific Hydrology Publication*, No 58, p 273.
VICKERS, W. W. 1963. Geochemical dating techniques applied to Antarctic snow samples. *International Association of Scientific Hydrology Publication*, No 61, p 199.

INTERNATIONAL YEARS OF THE QUIET SUN (IQSY) 1964–65: STATIONS IN THE ANTARCTIC

[A general outline of the programme of the IQSY appeared in *Polar Record*, Vol 12, No 76, 1964, p 3–9.]

The following four maps, prepared in the Scott Polar Research Institute, show the distribution of IQSY stations in the Antarctic in the disciplines: aurora, meteorology, ionospherics, and geomagnetism.

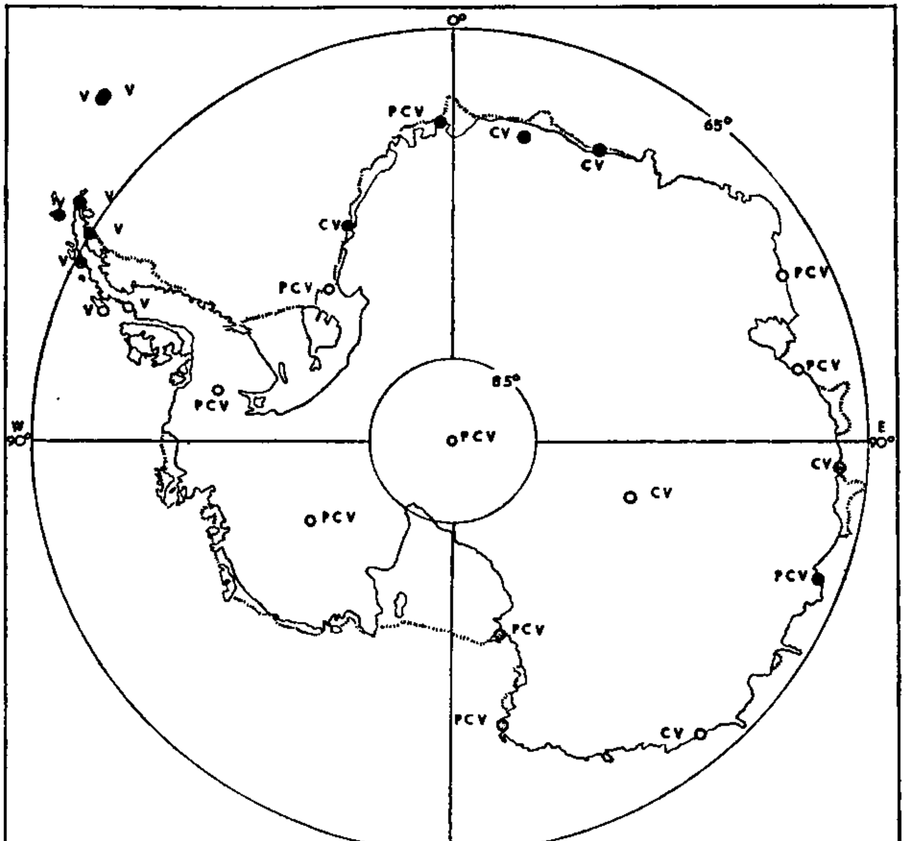


Fig 1. IQSY. Auroral stations in the Antarctic. Photometer, *P*; all sky camera, *C*; visual observations, *V*.

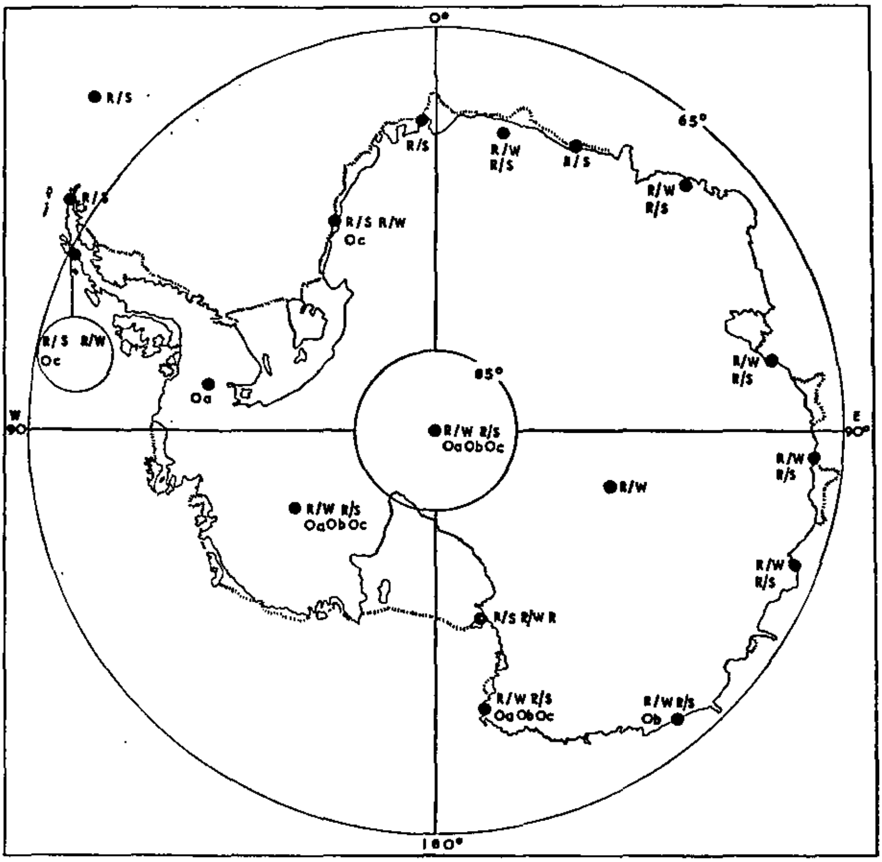


Fig 2. IQSY. Meteorological stations in the Antarctic, excluding surface synoptic observations. Surface ozone, *Oa*; ozone sondes, *Ob*; ozone spectrophotometer, *Oc*; radio sonde, *Rs*; radar winds, *Rw*; rockets, *R*.

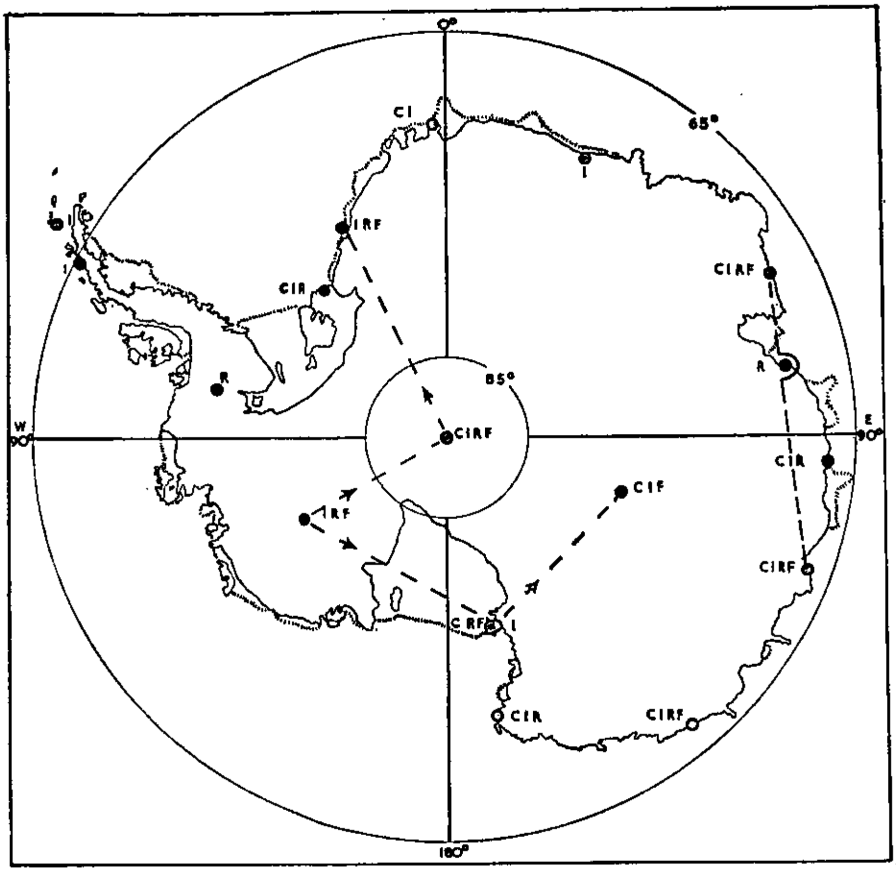


Fig 3. IQSY. Ionospheric stations in the Antarctic. Cosmic rays, *C*; ionospheric height sounders, *I*; riometers, *R*; forward scatter links, *F*— → —.

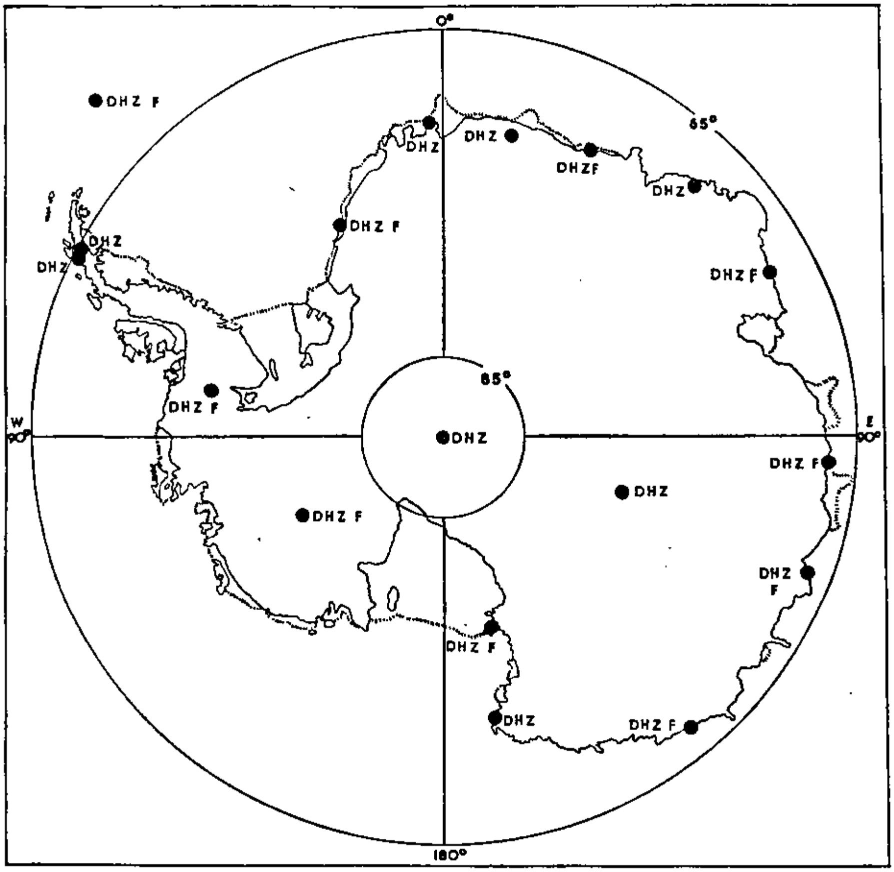


Fig 4. IQSY. Geomagnetic stations in the Antarctic. Three component measurements, *DHZ*. Fast run instruments, *F*.

INTERNATIONAL ANTARCTIC ANALYSIS CENTRE

BY H. R. PHILLPOT*

An account by W. J. Gibbs of the establishment of the International Antarctic Analysis Centre (IAAC), with details of facilities, analysis programme and output, and a summary of the problem presented by communications, was given in *SCAR Bulletin*, No 4, 1960, p 54–57. The Centre has now been operating for five years, and in this article the project is reviewed and the achievements assessed.

The Centre was opened on 2 February 1959 with H. R. Phillpot (Leader) and

* Meteorologist in charge, International Antarctic Analysis Centre, Melbourne, Australia.

K. T. Morley of the Commonwealth Bureau of Meteorology as the initial professional staff. Twelve assistants were also provided by Australia.

Other professional meteorologists who have been attached to the Centre from its establishment are:

Name	Representative of	Attachment to centre
K. T. Morley	Australia	February 1959 to August 1959
T. I. Gray	United States of America	June 1959 to February 1962
Lieut Cr J. Timbs	Australia (RAN)	August 1959 to July 1961
M. Morin	France	February 1960 to April 1961
Dr J. A. Hoffmann	Argentina	September 1960 to August 1961
Lieut Cr K. T. Foley	Australia (RAN)	July 1961 to July 1963
Lieut R. Montes	Argentina	July 1961 to July 1962
W. K. Wilhelm	United States of America	January 1962
A. R. Weiller	France	January 1962 to July 1963
A. J. Troup	Australia (CSIRO)	May 1962 to April 1963
Cr G. W. B. Mackinlay	Argentina	March 1963
Dr F. A. Berson	Australia (CSIRO)	August 1963

W. L. Kelly, Southern Rhodesia, joined the Centre early in July 1963 for a period of 12 months, on a United Nations Fellowship to study synoptic analysis over the high southern latitudes. L. A. Zhdanov, USSR Hydnological Service, began duty in March 1964 and Kikuji Yoshida, Japanese Meterological Agency, a month later.

The analysis programme currently maintained by the Centre comprises the contour analysis of the surface (1000 mb contours), 700, 500 and 300 mb constant pressure charts for 00 GMT over the area extending from the South Pole to about lat 30° S. These analyses are done on a "7-day delay" basis, i.e. a period of seven days is allowed for the receipt of data before the analyses are made. Each month's analysed charts are therefore completed seven days after the close of the month when they are microfilmed, and copies distributed by airmail to each member country of SCAR and five other interested organizations.

A research programme has been begun comprising separate but related projects investigated by individual meteorologists. Because of the complexity of the analysis problem, almost all the investigations have been directed to work with an important analysis application i.e. the aim has been to achieve the maximum "feed-back" from the investigations to the analysis programme.

It is impracticable here to discuss in detail all the work done, including as it does aspects of the general circulation over the high southern latitudes and extending up to about the 30 km level; the behaviour of surface pressure in the Antarctic, i.e. a study of the behaviour of pressure pulsations; synoptic aspects of the katabatic wind problem; an attempt to draw inferences in the South American sector about the upper wind regime from the established precipitation wave; and in addition climatic assessments of Antarctica.

The success of a Centre of this type depends directly on an efficient communications system. Prior to the establishment of the IAAC, the Commonwealth Bureau of Meteorology had not regularly received weather reports from South Africa or South America, nor had reports from all the national bases established in the Antarctic been received on prompt and regular schedules.

The work of the Centre has been very greatly assisted, particularly by the considerable practical assistance on communications given by Argentina, France, New Zealand, South Africa, the United Kingdom and the United States of America, and generally by the co-operation of all the national bases in the Antarctic.

However, the problems have by no means been resolved, and the continental areas of South America and South Africa are most difficult, but considerable attention is being given continuously to these problems by all the authorities concerned and it is hoped that within the not too far distant future greater success will be achieved.

The achievements of this project are impressive, particularly having regard to the degree of professional support provided. At an informal meeting of the SCAR Working Group on Meteorology, Berkley, California, August 1963, it was generally agreed that four analysts would constitute a minimum team whilst six were required to carry out a satisfactory synoptic analysis programme. Even this staff level includes no margin for research. At no time has the professional strength of the Centre exceeded four competent analysts, and for a great part of the time has not exceeded three. On 1 August 1963, only two analysts of sufficient skill and experience were available, and on this date it was therefore necessary to suspend the regular daily broadcasts of analysis statements, which from April 1961 had been prepared from the 700, 500 and 300 mb charts and released 8–9 hours after the synoptic hour.

The operational product is recognized as a valuable and important part of the work of the Centre, but the primary task is to produce a series of well analysed circumpolar charts which can form the basis of research and investigation into problems of Antarctic and high southern latitude meteorology.

At the Fifth Meeting of SCAR, 1961, the President reported that the Bureau of ICSU had agreed that the IAAC was an international undertaking which had their full support, and at SCAR's Sixth Meeting, 1962, a recommendation was passed that SCAR should request the Executive Board of ICSU to set up a special fund for an initial period of five years to assist the operation of the IAAC in various ways. It was also suggested that ICSU should seek WMO support. Subsequently, the Executive Board of ICSU, in October 1962, agreed to set up a fund, particulars of which are on p. 228.

At its Fourth Congress in Geneva in April 1963, WMO considered the problem of Antarctic meteorology and

(1) noted that IAAC was carrying out many of the functions of a southern hemisphere analysis centre,

(2) agreed that WMO should encourage research in Antarctic meteorology by encouraging the organization of symposia and seminars,

(3) noted with appreciation the establishment of the ICSU fund, and agreed that the Secretary-General should act as a trustee,

(4) agreed that WMO should encourage the successful operation of the IAAC either by Members seconding staff to the Centre or, if it is insufficient, by WMO arranging for financial support to enable staff to be recruited.

The next meeting of the WMO Executive Committee (May 1964) will decide the allocation of available funds.

At the Seventh Meeting of SCAR, Cape Town, September 1963, it was announced that the United Kingdom had contributed $1000 to the ICSU Fund,

Printed in Great Britain at the University Printing House, Cambridge