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REVIEWED BY J. VAN MIEGHEM

During the first two international campaigns of geophysical observations (First International Polar Year, 1882–83, and Second International Polar Year, 1932–33), special interest was shown in the study of the northern polar and subpolar zones. Since then, and particularly after the Second World War, the observing network of the middle and high latitudes of the northern hemisphere had been developed considerably. As a result, at the beginning of the International Geophysical Year (IGY), 1957–58, the geophysical phenomena of the low latitudes were much less known than those of the northern high latitudes; also the phenomena of the southern polar latitudes had not yet been explored on a synoptic scale. Unfortunately the tropical network has not been greatly enlarged for the IGY; it has not even been notably improved. However, the establishment and the running of a network in Antarctica, and in the islands of the sub-Antarctic seas, has been one of the most spectacular results of the IGY.

Meteorological phenomena are influenced by media outside the terrestrial atmosphere, as well as by the various parts of the atmosphere. The observing network established in Antarctica for the IGY has therefore a twofold importance; it has given the opportunity to gather synoptic data on phenomena never hitherto observed, and it also has contributed to a better global knowledge of the terrestrial atmosphere as a whole. For example, it has been possible to make a comparison between the meteorological phenomena of the two polar zones, and to show the existence of notable asymmetries in the circulation within these two zones. Such studies show the great interest of the Melbourne Symposium, where a tentative attempt has been made to present a first synthesis of the results obtained from the observations gathered in Antarctica during 1957 and 1958. In this connexion, we must note the active participation of several meteorologists just back from Antarctica where they had been living for more than a year; it was particularly interesting to hear their lectures based on results not yet processed for publication. Four Antarctic veterans, Sir Raymond Priestley, Professor F. Debenham, Captain J. K. Davis and Dr B. S. Stilwell were also present.

It was an honour and a privilege to me to attend this excellent and vivid symposium, that deeply impressed all the participants. I enjoy recalling this scientific gathering and the charming attentions of my Australian colleagues.

The symposium was divided into seven sessions, each of them being devoted to a well-defined subject. The quality of the contributions presented, and the interest of the discussions, have led me to give a short résumé of the essential points dealt with.

(1) *Local effects in the Antarctic.* It was shown (P. J. R. Shaw, Y. Morita and N. Murakoshi, B. L. Dzerdzeevskii, G. M. Tauber and B. Valtat) that local conditions (topography, surface inversions) generate small-scale non-geostrophic flow patterns, with marked diurnal and annual variations. The resultant contragradient downslope airflow is not completely independent of the synoptic weather situation off the coastline of the Antarctic continent. Studies of local winds in the vicinity of observing stations are of vital importance in order to indicate how far the recorded winds are representative of air motions on the synoptic scale. The streamlines of the airflow on the ice slopes of Antarctica have been determined theoretically (F. K. Ball) in the case of pure katabatic flow (when the katabatic force, proportional to gravity and inversion strength, overcompensates greatly the pressure gradient force above the inversion).

(2) *Synoptic analysis and forecasting.* Useful synoptic experience gained at the Antarctic Weather Central, "Little America", was reported (T. J. Gray *Jnr.*) and existing models, and models used in the synoptic analysis of southern hemisphere weather, were reviewed (W. J. Gibbs). Such models are even more necessary in the southern hemisphere where the analyst and the forecaster have to face great difficulties arising from the huge gaps in the network of observing stations. Two basic models have been suggested: (*a*) a double-fronted model (of the Antarctic Weather Central meteorologists) with a middle latitude polar front between maritime polar air and maritime tropical air, and an Antarctic front of orographic origin at the limit of the sea ice, and with polar anticyclones, generated near the sea ice boundary, in between the two associated zonal belts of frontal cyclones, moving from West to East; (*b*) a model in which the middle latitude circulation is mainly zonal, westerlies prevail in the region south of 40° S., cyclones enter these westerlies from the north, develop while drifting to the south and the east, enter the sub-Antarctic pressure trough, become stationary or move over the ice cap, and finally lose their identity (W. J. Gibbs). In order to secure uniformity among analysts and to render the analysis less subjective, methods for the construction of 500 mb. contour maps over the southern seas have been proposed (J. J. Talhaard and H. van Loon). These methods are based on the relationship between the surface flow patterns and the 1000–500 mb. thicknesses at existing upper air stations. Several synoptic case studies of weather systems over Antarctica and adjacent sea areas were presented, namely *The Little America Blizzard of May* 1957 (J. A. Alvarez and B. J. Lieske), and *The Explosive Stratospheric Warming of October* 1958 *above the South Pole* (K. J. Hanson). The explosive warmings of the Antarctic stratosphere generally occur after spring equinox, between mid-October and mid-November, in contrast with the explosive

warmings of the Arctic stratosphere, occurring generally well before the return of the sun in the stratosphere. The difficulties of synoptic weather analysis in the southern hemisphere are almost insurmountable as a result of the extremely large areas without a single observing station. Therefore automatic devices (such as automatic stations and weather buoys, dropsondes, constant level balloons) have been suggested to fill in the gaps in the synoptic network. No major improvement of our knowledge of the thermal and dynamic processes in the southern atmosphere can be expected as long as these gaps are not filled. Operational meteorological problems in the Antarctic were reviewed by W. S. Lanterman.

(3) *Synoptic influences in lower latitudes.* This very important problem cannot be treated adequately in the absence of a network of synoptic stations between lats. 40° and 60° S. In order to study the interactions between the Antarctic, the middle latitudes and the tropical zone, a global knowledge of the southern hemisphere is necessary. At present such a knowledge is lacking; nevertheless, some very courageous attempts have been made. At first sight, Antarctic weather seems not to have a direct influence on Australian weather, as the cold waves reaching Australia seem to originate from latitudes lower than 60° S. (A. K. Hannay, H. M. Treloar). The relationship between Antarctic surges and variations in the middle latitude zonal circulation (F. A. Berson and U. Radok), and the long-term interaction between the atmosphere of the Antarctic and that of the temperate latitude (E. B. Kraus), have been discussed. It has, however, been pointed out that the sudden stratospheric warming over Antarctica after the spring equinox, and the simultaneous rapid change in the low latitude flow patterns are both manifestations of the seasonal adjustment in the general circulation of the southern hemisphere as a whole (E. B. Kraus).

(4) *Circulation studies.* From the seven contributions presented, six were based on synoptic experience and only one on model experiments. These experiments (performed by R. H. Clarke) demonstrated the influence of an elevated ice cap around the pole, and of differences in surface roughness on the temperature field; in the high levels a greater baroclinicity is created by the presence of an ice cap, the low-level temperature changes, however, are also affected by an equatorial shift of the polar front. The "dish-pan experiment" has been performed with and without a cold dome, and with a smooth and a rough bottom. In this connexion it is worth while to mention here that the introduction of a rough bottom affects the circulation much more than the introduction of a cold dome. The experiments suggest that the difference in temperature field of the two hemispheres could be ascribed to the difference in surface friction.

Thermal interaction between the very cold Antarctic surface air and the warmer air above the adjacent seas generates circulation over the Antarctic region (A. M. Gousev). According to N. E. Kochin's theory, cyclones off the coastline of Antarctica originate in the transition layer between these two air masses. This theory has been tested.

Air motion in Antarctica, in spite of local peculiarities, is not essentially different from, nor independent of, the air motion at lower latitudes; warm cyclones penetrate from the north in the South Pole region during the polar winter, showing that exchange processes between high and low latitudes persist throughout all the year (P. D. Astapenko).

Major changes in some parts of the middle latitude westerlies have been noted (J. C. Langfoed), namely a reversal of zonal circulation above the southern ocean in July, along the meridian of 160° E., in connexion with the formation of a blocking high in this longitude of the temperate zone.

The cancellation of the restrictions on whaling in the south Pacific Ocean for three years, beginning with the summer 1955–56, has given the first opportunity of a synoptic surface analysis of weather conditions, during the summer season, above this hitherto practically unexplored region of the earth's surface, with a data coverage far superior to the previous ones and better than may be expected in the near future. The main synoptic features of the summer circulation above the South Pacific were described, and the first sea level mean pressure chart for the periods 26 December 1955 to 10 March 1956, and 10 December 1956 to 17 March 1957, was presented (H. van Loon).

The technique of the five-day mean sea level pressure maps has been applied (I. S. Kerr) to southern latitudes in order to try and demonstrate a possible relationship between changes in the temperate latitude large scale weather systems, and major changes in the Antarctic circulation. This experiment has yielded encouraging results so far, but further work is necessary before definite conclusions can be reached.

A tentative description of geographical and seasonal distributions of cyclonic and anticyclonic centres above the southern seas has been given (S. Karelsky), in view of the usefulness of this information for the forecaster.

(5) *Snow and ice characteristics.* It has been pointed out (K. B. Mather) that in the Mawson region a sastrugi pattern reflects the katabatic flow pattern (south-east winds on the coast-line, south-west winds inland above the Lambert depressions). Sastrugi must be used with some care, however, as a measure of katabatic wind direction.

Puddles are formed in the interior of a snow layer when the heat gained in deeper layers by absorption of solar radiation is not compensated by the long wave nocturnal surface emission ("hot house" phenomena in snow layers (Y. Takahashi)).

A rocket-type snow trap, designed by M. Mellor for gauging Antarctic drift snow at different elevation, has been presented. Extensive series of measurements made with this instrument, together with wind profile measurements, have shown that snow drift transport is much larger than previously thought. Following M. Mellor and U. Radok, snow drift transport figures hitherto regarded as true for extreme conditions only, such as wind conditions in Terre Adélie, may be regarded as representative of almost the entire coastline of Antarctica. Drifting snow appears to be an important item in the mass budget of the Antarctic ice sheet. This conclusion must await further confirmation.

(6) *Heat and mass exchanges.* Four contributions were devoted to budget studies and transport phenomena. From available data, admittedly scanty and doubtful, it may be concluded (F. Loewe) that accumulation of ice (snowfall) in the Antarctic exceeds ablation (snow drift across the coastline and removal at the front of the ice shelf). This conclusion needs to be checked with more reliable data.

Estimates on a monthly basis of individual terms of the heat budget (effective solar radiation, outgoing long-wave radiation, heat storage in atmosphere and ocean, latent heat) of 5° latitude zones from 40° to 90° S. were presented (J. F. Gabites). The southward transport of heat to maintain balance appears to be little higher than at corresponding northern latitudes; the meridional heat flux reaches, in winter and early spring, a maximum value of over 5×10^{10} cal./day, cm., of latitude circle in the latitude belt 40°–60° S. (yearly average; about $3{\cdot}7 \times 10^{10}$ cal./day, cm., in latitude 60° S.).

In the upper troposphere, cyclonic circulation may exist throughout the year, reaching the 300 mb. level before winter solstice (June 1958) and the 500 mb. level before summer solstice (December 1958), with variable intensity of inflow at high levels and outflow at low levels. Meteorological conditions are strongly influenced by meridional advection along the coastline. Surface conditions, including advection, vary considerably from month to month and from year to year (M. J. Rubin).

The winter thermal structure of the Antarctic stratosphere is primarily controlled by infra-red radiation processes (W. B. Moreland). Dynamic processes, such as advection and vertical motion, are of much less importance in the Antarctic than in the Arctic stratosphere. The Antarctic cyclonic polar vortex in winter seems to be much more stable than the corresponding Arctic polar vortex. The spring maximum of ozone content observed in November (1958) at "Little America V" seems to be related to circulation changes in the stratosphere. Ozone measurements in "Little America V" are in accordance with the Halley Bay measurements (J. MacDowall). Maximum amounts of ozone are also observed in Halley Bay in November, that is to say 2–3 months after the seasonal maximum in northern latitudes (February–March). Moreover the highest values observed in the high southern latitudes are lower than in the corresponding northern latitudes. Ozone ascents in Halley Bay (1957–58) have shown that the first increase in ozone content occurs at the tropopause level, that the ozone layer moves down from winter to summer, and that the summer values are lower than the winter values.

(7) *Climatological aspects.* Detailed local climatological studies were presented in the form of notes on the climatology of "Wilkes" station (J. R. Zimmerman), of Halley Bay (J. MacDowell), of the South American Antarctic sector (W. Schwerdtfeger, L. M. de la Canal and J. Scholten), and of "Dumont d'Urville" and Port-Martin stations (B. Valtat). Such local studies are not particularly important of course from the practical point of view, but are essential to the understanding of meso, and large-scale, processes. Two important contributions were made to the upper air climatology, namely, a preliminary note on mean monthly pole-to-pole cross sections of the tempera-

ture field near 170° E., for 1957, showing some marked thermal asymmetries between the two hemispheres (R. C. Taylor); and a climatography of the atmosphere above the South Pole during 1957 from the surface to the 50 mb. level, pointing out some peculiar surface conditions and the difference in behaviour between the stratosphere and the troposphere regarding the seasonal temperature changes.

Differences in temperature changes in the surface layer (kernlose winter), the troposphere (yearly temperature change of 10° C.) and the stratosphere (yearly temperature change of 50–60° C.) over Antarctica were tentatively explained (H. Wexler), and the main difference between the abrupt warming in the Arctic (30°–40° C., 6 weeks before spring equinox) and Antarctic stratosphere (50° C., in 1 month after spring equinox) was demonstrated. A secular trend of temperature since 1912 of +2·6° C. at "Little America V" (78° 12′ S., 162° 15′ W.) is compared with a 6·2° C. trend at Spitzbergen (78° 04′ N., 13° 38′ E.). Finally the effect of downward cloud radiation on surface temperature was shown.

A preliminary analysis of wind measurements made by a new constant level balloon technique (V. O. Hopper and J. E. Laby) during the WMI's at lat. 38° S. showed no reversal above 25 km., from east wind in summer to west wind in winter. The importance of global wind studies in the 30 km. layer was stressed.

Antarctic meteorology shows the considerable enrichment of meteorological understanding which occurs when an important gap of the observing network has been filled. This particular enrichment must be put on the IGY credit.

Meteorologists will be grateful to the Director of the Commonwealth Bureau of Meteorology and to their colleagues in Melbourne for the great care they have taken in publishing the contributions presented during the symposium and the discussions which took place at the end of each session.

Satellite studies over the Southern Ocean

The above review by Professor Van Mieghem stresses the difficulties of meteorological analysis over southern oceans in the absence of a reasonably spaced observational network. The successful launching and operation of the meteorological satellites Tiros I and Tiros II, since the symposium on Antarctic Meteorology was held in Melbourne, has provided a new type of observational material which is not covered by the volume on Antarctic meteorology. The secretary of the SCAR permanent working group on meteorology (W. J. Gibbs) was asked to provide information of interest to readers of *SCAR Bulletin* on this new technique. H. Phillpot, the officer-in-charge of the International Antarctic Analysis Centre in Melbourne has adapted an article by G. T. Rutherford published in the *Australian Meteorological Magazine*, No. 32, March 1961, for this purpose.

The Fourth Meeting of SCAR drew attention to the increased knowledge to be gained from satellite studies of cloud and pack ice cover in Antarctic and sub-Antarctic regions, and asked that arrangements should be made to distribute the results of the analyses of such data for operational and research purposes. An effective arrangement has clearly been put into operation between the United States and the Australian Commonwealth Bureau of Meteorology. Although the studies covered by the following article barely reach as far south as the Antarctic convergence, the development of the new technique is so important for Southern Ocean analyses that the article submitted has been reproduced in full, even though it stretches northwards to cover sub-tropical cyclones. Some of the difficulties in adapting the technique to the study of pack ice distribution become apparent from this article, although the problem is not specifically discussed. Although the detailed meteorological problems described in the article will mainly interest meteorologists, it is believed that the general technique will interest a wide circle of scientists.

Synoptic meterological application of neph-analyses from Tiros II

BY G. T. RUTHERFORD*

Short period or 24-hour forecasting in Australia, as well as the longer range forecasts, is often difficult due to the presence of extensive ocean regions to the west and south of the continent where synoptic data is almost non-existent.

Over the 2000 miles of Indian Ocean to the west, reports are available as routine only from Amsterdam Island (38° S., 78° E.) and Îles Kerguelen (49′ S., 70° E.) roughly 1500 miles distant, and from Marion Island (47° S., 38° E.) a farther 1000 miles westward. To the south and south-west reports are available from a few stations on the Antarctic coastline, 1500 miles distant. Reports from ships are quite inadequate to bridge these gaps since the shipping lanes for the most part skirt the coastline of the Australian Bight, and ships *en route* from South African ports to Melbourne or Perth are relatively few.

Australian meteorologists therefore approach the task of analysis over the Indian and Southern Oceans with no great confidence. Such success as is achieved is a product of long experience and of the meticulous care with which the sequence of reports from each station is studied. The passage of the polar frontal systems through Marion Island, Amsterdam Island and Îles Kerguelen is closely watched by detailed study of the 3-hourly reports from these stations and linked where possible to the great depressions which skirt the 'coastline' of Antarctica.

The validity or otherwise of these analyses is frequently not evident until demonstrated by conditions some 24–36 hours later over western or southern Australia. It is abundantly evident also that a careful analysis of frontal systems in the Amsterdam Island and Îles Kerguelen region is not necessarily

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adequate for forecasts over southern Australia. Information is generally lacking concerning the development of waves on fronts in the region between Amsterdam Island and the west Australian coast. Even in the southern areas of the Australian Bight cyclogenesis has occurred unexpectedly on not infrequent occasions with resultant forecast failures in the south-eastern States. A major factor here is perhaps the frequency of occurrence of jet maxima at latitudes south of the continent with consequent uncertainty of analyses at upper levels.

It can be seen from the foregoing that the introduction of an aid such as cloud photographs from artificial satellites is an epoch-making event in Australian and world meteorology. The location of significant cloud patterns over the oceans has application not only to the frontal systems affecting southern Australia but with equal importance also to the detection and tracking of tropical cyclones.

The ultimate aim of cloud photography from satellites is to locate significant synoptic patterns over the earth's surface and particularly over the oceans. It is not certain at this stage how far this conception may be extended to the point where particular cloud patterns on photographs may be recognized as 'models' which may be immediately associated with various types of fronts, or whether absence of cloud or the presence of strato-cumulus cloud may be associated with regions such as the forward or rear portions of anticyclones. However it is already evident that the major rain and wind systems in both tropical and extra-tropical regions have in many cases characteristically significant cloud features on satellite photographs. These features are the spiralling cumuliform lines and the well-defined vortex.

It is reasonable to expect that accuracy in synoptic analysis over oceanic regions will depend on the extent to which these models may be applied and to the experience which has been acquired in interpretation of the cloud photographs both as regards patterns of cloud and cloud types.

A project, designed to gain experience in interpretation from satellite neph-analyses, was carried out by the Australian Bureau of Meteorology at the invitation of the National Aeronautics and Space Administration and the United States Weather Bureau during observations with the meteorological satellite Tiros II.

The Tiros II artificial weather satellite was an 18-sided polygon, shaped like a pill box, with dimensions of 42 in. diameter by 19 in. height, weighing 280 lb. and powered primarily by solar cells.

The satellite was launched on 23 November 1960 and achieved its objective of a roughly circular orbit with an altitude of about 400 miles. The period of rotation of such an orbit around the earth is 98 minutes and the satellite speed about 17,000 miles per hour. Tiros II was spin-stabilized.

It was equipped with two television cameras designed to photograph the earth's cloud cover during daylight conditions. These cameras were different in coverage and resolution. The camera axes were parallel to the spin axis, which was in general not normal to the earth's surface. On those occasions when the spin axis and the camera were pointing downwards towards the centre of the earth (zero nadir angle) the wide-angle camera viewed an area approximately 750 miles on a side with a resolution of 1·5–2 miles; the narrow-angle camera viewed an area approximately 75 miles on a side in the zero nadir angle position but with resolution of about 0·15–0·2 mile. When the camera was looking at higher nadir angles the extent of the coverage was increased while the resolution decreased.

The command and data acquisition centres were located at Belmar, New Jersey and San Nicolas Island, California. When the satellite was on orbit within a certain range of either of these stations, instructions were issued to the cameras to take pictures at a specific future time and to store them in a magnetic tape recorder. The pictures were read out at the next orbital pass within range of the data acquisition station, recorded on tape and in parallel on film by photography of a monitor screen.

It was not practicable to obtain transmission to Australia of the actual satellite photographs. However the United States Meteorological Satellite Laboratory was most co-operative in the despatch of coded neph-analyses as interpreted from the photographs. These coded messages which indicated areas of overcast, broken or scattered cloud and clear sky were received by teletype at Central Analysis Office, Melbourne, in some cases as early as four hours after satellite photograph time.

The function of the Central Analyses Office in this experiment was to identify particular areas of interest coincident with satellite orbits and to request photographs where practicable in relation to solar illumination. Decisions as to practicability in regard to programming requirements and to camera orientation were made by the U.S. Weather Bureau. The extent to which the Australian requests were met was most gratifying. A large number of neph-analyses were, in fact, forwarded without specific request on a routine basis and these will be the subject of exhaustive study and correlation with Australian analyses over ocean regions to the west and south of the continent. In the meantime several situations have been selected for preliminary discussion below.

(a) Cessation of heat wave conditions over south-east Australia

The most prolonged heat wave in December for forty-three years persisted over south-east Australia from 24–31 December 1960 with temperatures exceeding 100° F (38° C) daily in most districts.

The heat wave was associated with a blocking high over the Tasman Sea. The "block" was typically represented on upper charts although not in the classical sense of a zonal flow upstream splitting into two westerly branches with approximately equal mass transport north of the upper cold low and south of the warm high. Nevertheless, the Tasman anticyclone at M.S.L. remained blocking from 25–30 December 1960 when it commenced to move eastward and lose intensity.

There was no evidence of any strong jet upstream nor any indications (having regard to the subjectivity of the analysis) of strong shear or curvature changes in the Australian Bight. In any event, a wave which formed on the front west of Tasmania during 29 December 1960 moved slowly eastward without deepening. This cool change moved over the Victoria coast on 31 December 1960, accompanied by a fall in temperature of 25–30° F.

A neph-analysis obtained by Tiros II at 0257 Z, 29 December 1960, indicated a belt of overcast cloud orientated from north-west to south-east. The 0600 Z Southern Ocean analysis for this date (as analysed without reference to the satellite picture) indicated a front with similar orientation. The location of the front on the analysis was arrived at largely by historical extrapolation over Southern Ocean waters from Amsterdam and Îles Kerguelen reports, together with indications of frontal passage through stations along the southern coastline of the continent.

The satellite neph-analysis implied that the front was located further east along lat. 40° S. than analysed. This was largely substantiated later when the cool change moved into southern Tasmania earlier than anticipated.

However there are difficulties in interpreting these neph-analyses. In this case, although the satellite picture appeared to call for the amendment of the analysis, only scattered cloud was reported from stations in southern Tasmania at the time of the satellite photograph, which had been interpreted to show overcast conditions in this region. Also it was to be expected that the cold centre of the occluded cyclone would be associated with overcast cloud, but in the neph-analysis clear skies were reported. The centre of the cold low was definable with some precision in the isobaric analysis on this occasion due to the observation from the ship *Magga Dan, en route* with the 1961 expedition to Antarctica. The *Magga Dan* reported heavy overcast conditions in the vicinity of 55° S., 130° E.

These apparent inconsistencies perhaps highlight a factor which must be considered in the interpretation of the neph-analyses from Tiros II, i.e. the translation picture boundary error of about ± 2 or 3 degrees of latitude.

An interesting feature associated with this particular case concerned the belt of overcast cloud which was lying roughly parallel to the front. This cloud was located, as far as could be ascertained, ahead of the surface frontal boundary (allowing also for the time difference between the isobaric—and neph-analyses) and at 0257 Z, 29 December 1960, was pictured as almost entering the continent along the coastal fringe to the south-east. The speed of the front at these latitudes was about 12 knots towards the east. Nevertheless, overcast conditions did not become apparent over the southern states at any time during the following 48 hours until almost immediately prior to the cool change, when skies became overcast due to rapidly developing cumulo-nimbus.

The translational error could hardly have been responsible in this case for such delay in appearance of an overcast cloud region of largely frontal origin. On the other hand, the neph-analysis indicating, perhaps significantly, "overcast" instead of "heavy overcast" may well have been the interpretation of photographed strato-cumulus cloud which formed in the warm northerly stream ahead of the front—a warm stream moving over a considerably cooler ocean surface. Such cloud would not be expected to form over any land areas as the front moved slowly eastward. It seems probable that the extensive cloud formation which was photographed as preceding the front over the eastern Bight was not due primarily to frontal activity. This was supported to some extent by a "nil sferics" report in this region and to a greater degree by the subsequent observations of predominantly clear skies over land stations right up to the arrival of the cold front. The very rapid build-up of cumulus cloud to the thunderstorm stage was apparently largely triggered by diurnal heating due to prefrontal temperatures of about 100° F.

While it is not reasonable to draw general conclusions from a particular case, it is evident that interpretation will require not only familiarity with types of cloud patterns associated with various frontal systems but will re-emphasize the influence of locality, of heat and moisture exchanges and of stability on cloud formation.

(b) *Location of a tropical cyclone over north-east Australian waters*

By 27 December 1960 the thermal trough had become well established with east–west orientation at about 12° S. From 27 December 1960 to 2 January 1961 a few weak cyclonic circulations appeared to form in this trough. On 3 January 1961 there were indications (from "sferics" reports) of a deep moist layer in the region adjacent to the north-east Australian coast. On this date also the M.S.L. analysis for 0200 Z showed a weak cyclonic circulation centred just off the Queensland coast at about 20° S.

Since an initial cyclonic circulation and a deep moist layer are two of the basic requirements for tropical cyclogenesis, the satellite pictures for 0225 Z, 3 January 1961 were of particular interest. These showed three regions of "heavy overcast" cloud (the neph-analysis elsewhere within the picture boundary indicated only scattered to broken cloud over the ocean) and all of these regions coincided with positive "sferic" areas.

It was perhaps significant that at 2000 Z, 3 January 1961, the cyclonic centre appeared to be located farther north at 17° S., 149° E.

The Tropical Cyclone Warning Centre at Brisbane subsequently issued cyclone warnings as the disturbance moved east to south-east, away from the continent, with only slight intensification prior to its filling by 7 January 1961. No further satellite pictures were available.

This case is an example of accurate determinations of regions of heavy overcast cloud and augurs well for detection of cyclones by satellite photographs.

(c) *Frontal analysis over the Indian Ocean*

The analysis over the Indian Ocean area in the vicinity of reporting stations at Amsterdam and Îles Kerguelen is often capable of some objectivity. On other occasions, however, the nature of the frontal passages is obscure and the analysis cannot be uniquely determined.

An example of such a situation occurred on 2 January 1961 when the satellite neph-analysis showed an area of "overcast" south-west of Amsterdam Island. This could be much more satisfactorily explained on the frontal analysis by advancing an occluded front some 400 miles farther east of the position originally postulated.

This case is typical of the application of many satellite pictures to the Île Amsterdam—Îles Kerguelen area.

However, once again this example illustrates the difficulty encountered in satisfactorily interpreting satellite data, because an area of "overcast" was observed between lats. 25° and 35° S. and longs. 99° and 105° E. This was supported by two ship reports—one of which also reported showers, but whilst it was probable that this activity was the result of convergence in a trough extending southward from a cyclone centred further to the north, no frontal interpretation could be presented.

(d) Location of fronts and convective cloud over the Australian continent

On 31 December 1960, it was necessary to move an occluded frontal system some 300 miles farther east to obtain consistency between the neph- and frontal analyses.

The location of the northern cold front was confirmed as lying just inland from the Australian Bight. The "heavy overcast with breaks" confirmed the widespread reports from ground observers of convective thunderstorm activity in a trough over Queensland.

This example emphasizes the uses of the satellite pictures for forecasting over settled areas. At a glance the forecaster can form an opinion as to the probable duration of rain from the width of the frontal cloud band. Also the widespread nature of convective storms can be much better appreciated through the camera eye than through the reports of sometimes widely distant ground observers.

(e) Location of an extra-tropical vortex over the Indian Ocean

As stated above, one of the three synoptic reporting stations in the South Indian Ocean is Marion Island. In the 36-hour period preceding 0600 Z, 18 December 1960, there was strong ionospheric activity which caused a "blackout" of radio transmissions of weather reports from this particular station. During this period the 0600 Z M.S.L. analysis for the Southern Ocean was completed for the Marion Island region by extrapolation but this was necessarily highly subjective since it was taken from the far south-west Indian Ocean, a region where analysis cannot be done with confidence from Australia. When the neph-analysis was obtained it indicated a cloud area containing a vortex and spiralling cumuliform clouds in a region where a ridge of high pressure had been indicated. The Southern Ocean analysis was accordingly amended to indicate a strong circulation about an occluded low centred at the vortex. The subsequent history of frontal passage through Amsterdam Island verified the existence of the low in the general locality indicated by the picture.

This is an example of the magnitude of errors which can be made in analysis over ocean regions. In this case the error was due to the absence of reports from Marion Island, through or near which the low must have passed during the "blackout" period. However, the potential value of satellite photographs can be gauged when it is appreciated that for Australian meteorologists wide regions of the Indian and Southern Oceans are in a condition approaching a permanent "blackout".

(*f*) *Cases presenting apparent inconsistencies*

Although specific cases of inconsistency will not be discussed here in detail, reference should be made to neph-analyses which have not lent themselves readily to interpretation. This may be due largely to a newly-found inadequacy of appreciation of the various conditions, other than frontal, under which clouds may occur over ocean regions.

However, neph-analyses over the continent on some occasions appeared inconsistent with ground observations of cloud (e.g. neph-analysis of 0510Z, 30 December 1960, when clear skies reported by neph-analysis appeared at variance with broken cloud reported by observers). Also the location of the vortex referred to under (*e*) did not fit, as well as expected, the mutually consistent observations of two whaling ships in the locality. In this regard the picture translation error may have been an important consideration.

In considering such cases also regard must be taken of the NASA News Release Statement of 6 December 1960 to the effect that only 5–10 per cent of wide-angle pictures were meteorologically useful. (The decision of the Bureau of Meteorology to request wide-angle pictures was based on an expectation of limited access to programmes and the greater likelihood of coverage of a particular area of interest with a camera whose picture frame was of the order of 750 miles in width as against 75 miles for a narrow-angle camera.) 'Meteorological usefulness' of satellite pictures is a relative quality which must be considered in relation to availability of data from other sources. It cannot be doubted that over our ocean regions, a very large proportion of the wide-angle pictures were useful to Australian meteorologists.

From this study it will be seen that some of the neph-analyses obtained from Tiros II have provided general confirmation of the conventional analyses of the Southern Ocean areas prepared in the Commonwealth Bureau of Meteorology, some have presented features which have called for re-analysis in a manner which has been verified by later history, whilst some which have not lent themselves to ready interpretation will require further study. A few have apparently been at variance with observations.

Interpretation of neph-analyses or cloud photographs for use in analysis will involve not only a study of cloud patterns for models to be associated with various types of fronts and cyclonic vortex-spiral systems, but also an attempt to identify the types of cloud represented and the nature of the cloud producing mechanism, i.e. whether fronts, convergence, turbulence or convection. The utility of satellite cloud photographs is likely not only to have far-reaching and scarcely foreseeable effects on extended range and day to day forecasting in Australia, but for organizations like the International Antarctic Analysis Centre offers very great potential benefits indeed. However, it is again emphasized that the interpretation of the data must be more thoroughly understood and this can only be achieved in the Centre if adequate professional staff is available to undertake the essential investigatory work.

In the Bureau of Meteorology the opportunity of participating in the Tiros II experiments has laid the groundwork to this end.

Science in Antarctica

In *SCAR Bulletin*, No. 7, 1961, there appeared, as an appendix to the report on the Fourth Meeting of SCAR, an "Assessment of the progress of Antarctic research during 1959–60". The United States Committee on Polar Research of the National Academy of Sciences has recently produced a work which forms a valuable supplement and amplification to this in *Science in Antarctica* (Publication 839, National Academy of Sciences—National Research Council, 1961, Washington).

It is published in two parts, "The life sciences in Antarctica" and "The physical sciences in Antarctica" and its aims are set out by Dr Lawrence Gould in the Foreword: (1) to outline promising areas of scientific research in the Antarctic; (2) to indicate the value and interest of Antarctic studies to scientists throughout the nation: and (3) to suggest the general importance of the United States Antarctic Research Program as a national effort.

The Committee has drawn on leading scientists in the United States to write individual chapters, in each of which the present state of knowledge in a particular discipline is outlined, and the possibilities of future developments of research in that field are discussed. The length of the individual chapters, excluding the useful bibliographies at the end of each one, varies from two pages on "General ecology and physiology of Antarctic fish" to sixteen pages on "Antarctic glaciology".

Part 1, "The life sciences in Antarctica" contains chapters on fossil plants, lichens, bryophytes, freshwater and marine algae, insects and other land anthropods, seals, whales, fish, birds, invertebrates, microbiology and man. Part 2, "The physical sciences in Antarctica" is divided into three sections; Heat and water budget in Antarctica; Earth's crust and core; and The upper atmosphere. It is of interest to note that Part 1 covers 162 pages compared to the 131 pages in Part 2. This is partly due to more detailed bibliographies in the former, but it also indicates the increased emphasis which the Committee on Polar Research would like to place on biological disciplines, which received little support during the IGY. Geological disciplines and cartography, also omitted from the IGY programme, are similarly recommended as fields for special future study.

The distribution of such reports outlining views of leading scientists on promising lines of research is in keeping with the best traditions of science, and the general atmosphere of international scientific co-operation now prevailing in matters of Antarctic interest. A copy of the report has been sent to the SCAR delegate in each member-country and others, and a limited number of copies are available from the National Academy of Sciences, Washington, at $1.50 for each of the two parts.

Stations occupied in the Antarctic, Winter 1961

[Stations marked * are north of lat. 60° S.]

Argentina

"Decepción", lat. 62° 59′ S., long. 60° 43′ W.
"Melchior", lat. 64° 20′ S., long. 62° 59′ W.
"General Belgrano", lat. 77° 58′ S., long. 38° 48′ W.
"Esperanza", lat. 63° 23′ S., long. 56° 59′ W.
"Orcadas", lat. 60° 45′ S., long. 44° 43′ W.
"Teniente Matienza", lat. 64° 58′ S., long. 60° 03′ W.
"Ellsworth", lat. 77° 43′ S., long. 41° 07′ W.

Australia

*Macquarie Island, lat. 54° 30′ S., long. 158° 57′ E.
Mawson, lat. 67° 36′ S., long. 62° 53′ E.
Davis, lat. 68° 34′ S., long. 77° 57′ E.
"Wilkes", lat. 66° 15′ S., long. 110° 31′ E.

Chile

"Arturo Prat", lat. 62° 29′ S., long. 59° 38′ W.
"Pedro Aguirre Cerda", lat. 62° 56′ S., long. 60° 36′ W.
"General Bernardo O'Higgins", lat. 63° 19′ S., long. 59° 38′ W.
"Presidente Gabriel Gonzalez Videla", lat. 64° 49′ S., long. 62° 51′ W.

France

*"Camp Heurtin", lat. 37° 50′ S., long. 77° 34′ E.
*Port aux Français, lat. 49° 21′ S., long. 70° 12′ E.
"Dumont d'Urville", lat. 66° 40′ S., long. 140° 01′ E.

Japan

"Syowa", lat. 69° S., long. 39° 35′ E.

New Zealand

"Scott", lat. 77° 51′ S., long. 166° 48′ E.

New Zealand/United States

"Hallett", lat. 72° 18′ S., long. 170° 18′ E.

South Africa

*Marion Island, lat. 46° 53′ S., long. 37° 52′ E.
*Tristan da Cunha, lat. 37° 03′ S., long. 12° 19′ W.
*Gough Island, lat. 40° 19′ S., long. 9° 51′ W.
"Norway station", lat. 70° 30′ S., long. 2° 52′ W.

United Kingdom

Port Lockroy (Base A), lat. 64° 50′ S., long. 63° 31′ W.
Deception Island (Base B), lat. 62° 59′ S., long. 60° 34′ W.
Hope Bay (Base D), lat. 63° 24′ S., long. 56° 59′ W.
Stonington Island (Base E), lat. 68° 11′ S., long. 67° 00′ W.
Fossil Bluff, lat. 71° 20′ S., long. 68° 17′ W.
Argentine Islands (Base F), lat. 65° 15′ S., long. 64° 15′ W.
Signy Island (Base H), lat. 60° 43′ S., long. 45° 36′ W.
Adelaide Island (Base T), lat. 67° 46′ S., long. 68° 54′ W.
View Point (Base V), lat. 63° 32′ S., long. 57° 23′ W.
Halley Bay (Base Z), lat. 75° 31′ S., long. 26° 36′ W.
*South Georgia, lat. 54° 17′ S., long. 36° 30′ W.

United States

"Amundsen–Scott", South Geographical Pole.
"Byrd", lat. 79° 59′ S., long. 120° 01′ W.
McMurdo Sound, lat. 77° 51′ S., long. 166° 37′ E.

Union of Soviet Socialist Republics

Mirny, lat. 66° 33′ S., long. 93° 00′ E.
"Vostok", lat. 78° 27′ S., long. 106° 52′ E.
"Novolazarevskaya", lat. 70° 45′ S., long. 11° 58′ E.

Exchange of foreign observers in the Antarctic, 1960–61

Name	Country of origin	Occupation	Host country
W/C W. Addison, R.A.A.F.	Australia	Pilot	Argentina
Capt. M. P. Bamman	Australia	Aeronaut	United States
J. P. van Bellinghen	Belgium	Economist	United States
Rear-Admiral R. B. Black, U.S.N. Retd.	United States	Operations research analyst	Belgium
W. L. Boxell	United States	Hydrographer	Japan
A. de Cailleux	France	Geologist	United States
Lt.-Col. H. Danyau	Chile	Army Officer	United States
H. M. Dater	United States	Historian	Argentina
J. W. Finklang	United States	Geodesist	U.S.S.R.
J. R. Hays	United States	Geographer	Australia
L. Kuperov	U.S.S.R.	Physicist	United States
Lt. N. D. A. Lopez	Argentina	Oceanographer	United States
Comm. C. J. F. Netterberg, S.A.N.	South Africa	Naval Officer	United States
R. M. O'Hagan	United States	Oceanographer	South Africa
B. B. Roberts	United Kingdom	Ornithologist	United States
R. J. Villela	Brazil	Oceanographer	United States
W. W. Watkins	United States	Polar test officer	France

NOTICE

The SCAR Bulletin is published in England in January, May and September each year as part of the *Polar Record*, the journal of the Scott Polar Research Institute.

Contributions are invited, and should consist of factual notes on the membership, equipment and activities of Antarctic parties; articles on matters of particular interest in connection with these activities are also welcome. Contributions should be sent to the Editor, Scott Polar Research Institute, Lensfield Road, Cambridge, England.

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