sults are not entirely above criticism. The measurement was again taken just above the absorption cutoff, although there is ample evidence that false rotations result under conditions of marginal light transmission. Compared to Nagy's 1964 extracts, the absorption cutoff was shifted 100 mμ toward the red, suggesting even greater opacity. Because sulfur was present during saponification, colloid formation must have been hard to avoid. Finally, it is not clear how much significance can be attached to a net result of 25 mdeg if the "process blank" is as large as 59 mdeg.

I wholeheartedly endorse Nagy's appeal for "slow, careful, and systematic [work], preferably in the absence of unnecessary argument." On my part, I add the plea that all work be checked by meaningful controls, and that the plentiful evidence of artifacts in polarimetry be given due attention instead of being disregarded.

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7. Nagy *et al.* (3) indicated neither cell length nor absorbance scale in their fig. 2; nor did they respond to my request for further information. I therefore read off relative absorbances with a ruler and plotted them on semilogarithmic paper. This procedure faithfully reproduces the shape of the spectrum but leaves its vertical position undetermined. Since curves *I* and *III* (Fig. 1*b*) both consist of an absorbing and a scattering component (see below), curve *I* was placed at the position where curve *IV* correctly represents its absorbing component. The scattering component can then be found by simple subtraction of *IV* from *I*.
8. A. L. Rouy and B. Carroll, *Anal. Chem.*, in press; "On the reported optical activity for the Orgueil meteorite," in preparation.
9. The filters were measured in cylindrical holders, 39 by 22 mm outside diameter, with an aperture of 6 mm. The frosted-glass disks were inserted at the end facing the light source; the filters, at the opposite end. I thank M. E. Lipschutz, Purdue University, for these measurements.
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13. Work aided by NASA grant NsG-366. I thank Edward Anders, Benjamin Carroll, and Auguste L. Rouy for advice; and L. Katzin and E. Gulyas, Argonne National Laboratory, for use of their Rudolph spectropolarimeter.

7 March 1966

Antarctic Pack Ice: Boundaries Established from Nimbus I Pictures

Abstract. *Television and photofacsimile-constructed infrared pictures taken by the Nimbus I meteorological satellite between 28 August and 22 September 1964 were analyzed for indications of the pack-ice boundary around Antarctica. Mean ice boundaries were established around the entire continent from both TV and infrared pictures, from which were estimated pack-ice areas of 19.81 by 10^6 and 16.78 by 10^6 square kilometers, respectively; the difference is attributed to difference in subjective discernment of a boundary.*

Advanced Vidicon camera system (AVCS) television pictures and high-resolution infrared-radiometer (HRIR) photofacsimile pictures taken by Nimbus I, the first polar-orbiting, altitude-controlled, meteorological satellite, of the Antarctic continent and seas between 28 August and 22 September 1964 were analyzed for indications of the pack-ice boundary and for cloud systems. The pictures of sea ice were remarkably clear, particularly of such areas as the Weddell Sea. Both Figs. 1 and 2 (*1*) show the ice texture and the continental boundary; Fig. 2 shows also the pack-ice boundary and various cloud systems. Not all areas were as well covered; cloud systems frequently made determination of the sea-ice boundary difficult, particularly where over- or underexposure permitted little distinction between ice and cloud. But such difficulties were minor in view of the outstanding fidelity of the pictures, which were taken from altitudes between 640 and 933 km (apogee).

Boundaries for the ice edge were decided for the various longitudinal sectors from the overlapping orbital picture passes. For some sectors of which many picture sequences were available, variations in the ice boundary could be studied; other sectors barely appeared in the fringes of pictures, and still others were not pictured at all (they were spanned by simple interpolation). Grid lines of latitude and longitude were generated by computer at the time of read-out for some of the pictures. This, however, did not aid in proper location of the ice boundary in all instances: in many picture composites having a well defined grid

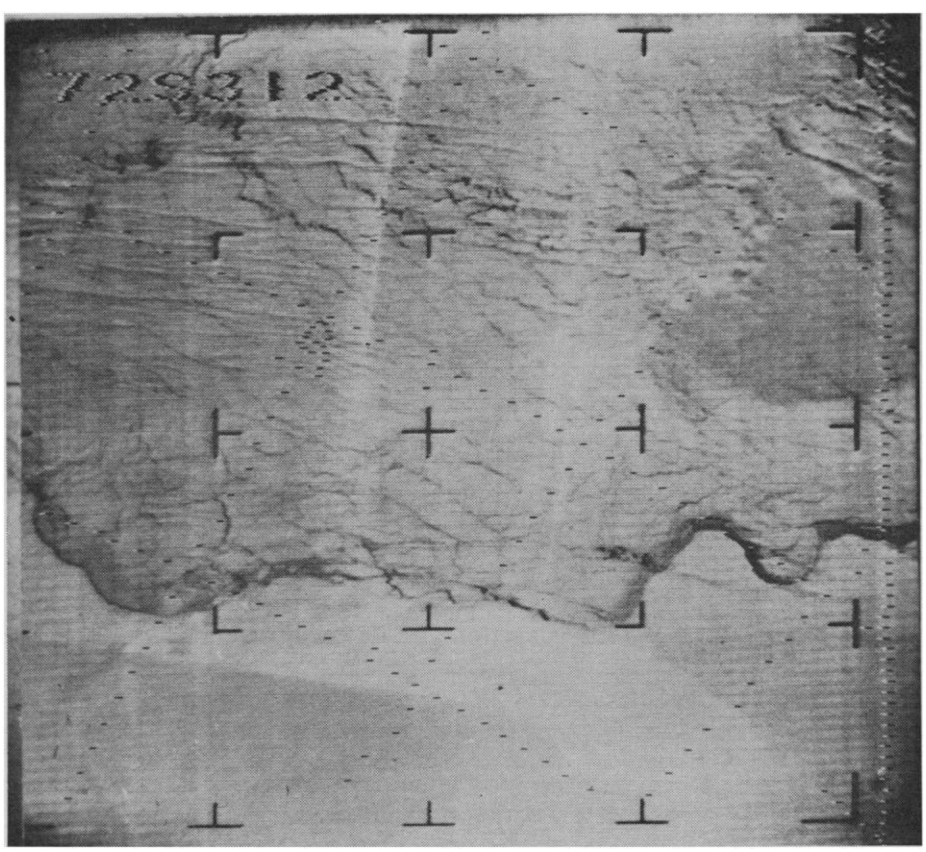
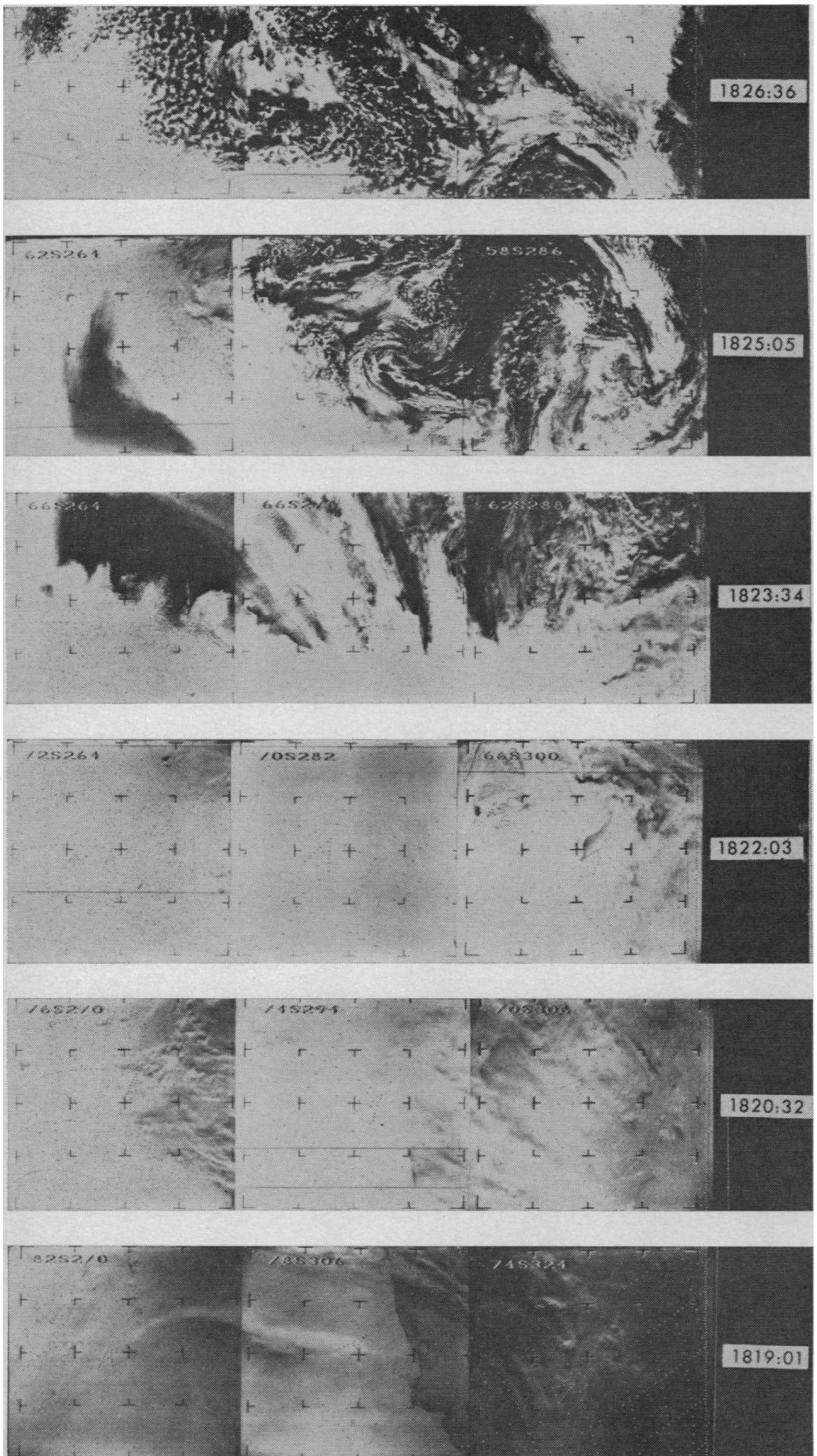


Fig. 1. A single vertical AVCS television picture over the Weddell Sea during orbit 195, 10 September 1964. From an altitude of about 900 km, much of the texture of the sea ice is apparent.



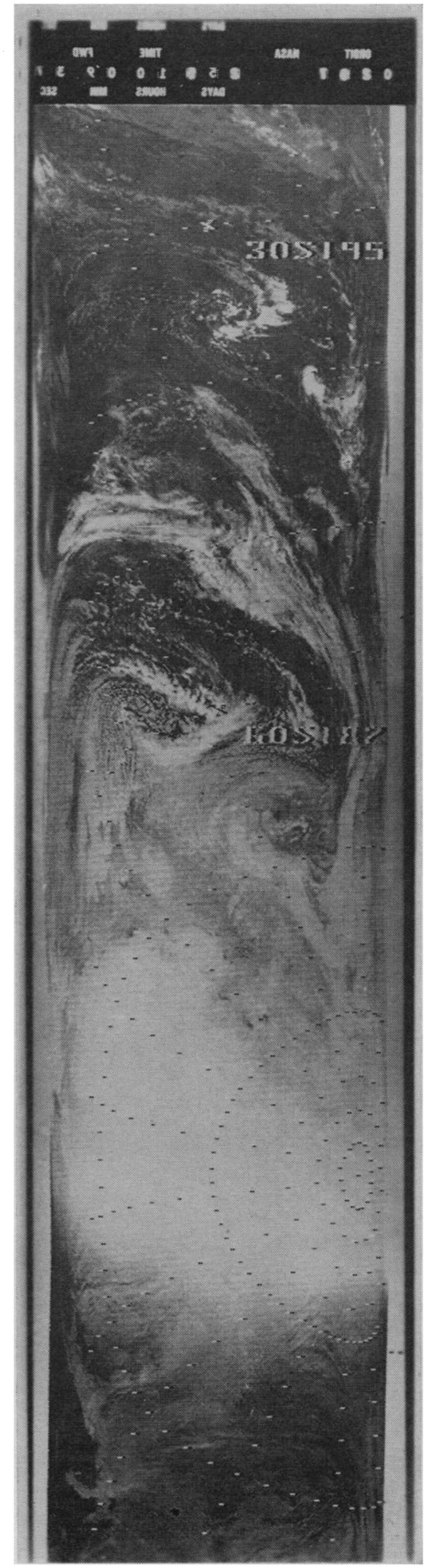


Fig. 2 (above). A sequence of AVCS television-picture triads (orbit 240, 13 September 1964) from the Filchner Ice Shelf northwestward to the open sea. The height of the satellite decreased during the picture from about 920 km over the continental area to about 830 km over the open sea. The edge of the pack ice and various cloud systems are visible in the upper half of the sequence. Fig. 3 (right). An example of a HRIR photofacsimile film strip, showing photographic recreation of the temperature patterns sensed by the radiometer as it scanned from side to side while moving forward in orbit. Dark areas are warm surfaces such as the ocean; white areas are cold surfaces such as high clouds and the Antarctic continent in the lower half of the picture. The grid lines indicate distortion in the view.

system, clouds or light saturation obscured the boundary; in other instances there was a well-defined boundary without a grid. We then resorted to other methods of positioning the ice boundary with respect to the continental boundary (if this was visible).

The frequency of orbits was naturally uniform over all areas but, as I have mentioned, factors combined to give a rather nonuniform amount of information over all sectors. Nevertheless the combined and connected data provided an ice boundary for late August and most of September 1964 that compared exceptionally well with the published mean boundary for September (*2*).

When the sea-ice boundary had been estimated from the AVCS pictures, I obtained a catalog (*3*) of the photofacsimile-imaged data from the high-resolution infrared radiometer, a rotating-mirror sweep-scanning device operating aboard Nimbus I principally at night. Though not of the same quality as photocopies of the HRIR facsimile pictures would be, the catalog print displays contained the same information, including a computer-generated grid of latitude and longitude. The highly homogeneous coverage of the longitudinal sectors by these pictures revealed an apparent ice boundary of considerable variation in space and time; in Fig. 3, a photoprint of an HRIR facsimile picture, Antarctica, but not the pack-ice edge, is visible.

There is an essential difference between the boundaries as viewed in the AVCS pictures and in the HRIR pictures. The boundary from the AVCS pictures is what the eye sees either directly or by photograph; it is described (*2*) as a "tortuous course with many bays and projections extending for many miles into and out of the pack," and Fig. 2 supports this description. In the HRIR pictures, on the other hand, the edge as viewed is not so clearly delineated; it is seen as a change in brightness corresponding to a change in temperature sensed by the radiometer. This change takes place gradually from the warmer to the colder areas but abrupt changes are readily noticeable—for example, at the edge of the Antarctic continent where a large temperature gradient exists. The sharpest temperature gradient in the ring of pack ice that could be interpreted as an outer boundary might occur within the visually defined ice boundary. Thus the amounts of ice determined by these two methods are not necessarily the same.

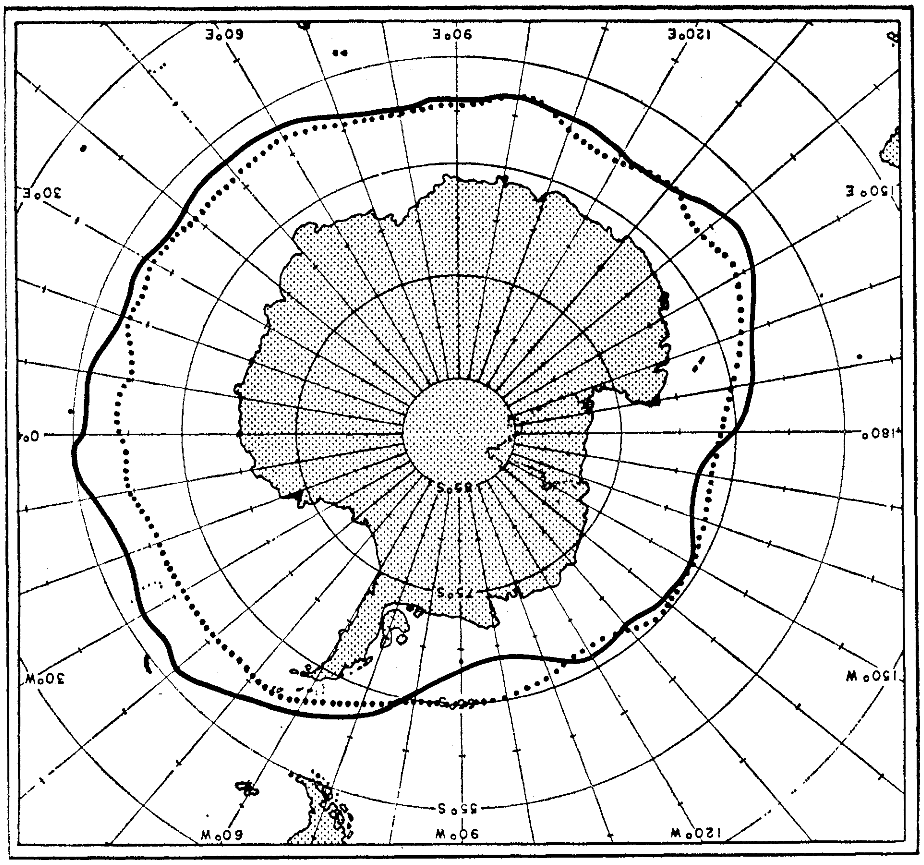


Fig. 4. Pack-ice boundaries between 28 August and 22 September 1964: solid line is the boundary indicated by AVCS pictures; broken line is the boundary derived from HRIR pictures.

Base maps used to plot and sketch the manifold ice boundaries from the HRIR pictures were slightly different from those used for the AVCS pictures, but the method of reducing the multiple boundaries to an average boundary was the same for both: one simply drew by eye a boundary through the thickest cluster of individual boundaries. Although this method lacks elegance, it is probably as accurate as any in view of the uncertainty in selection of the individual boundaries; more tedious approaches were no more successful.

Upon selection of mean boundaries from the two types of pictorial data, the areas within the boundaries were integrated graphically (Fig. 4). The areas enclosed by the boundaries derived from the two sources [19.81 (AVCS) and 16.78 (HRIR) $\times 10^6$ km^2] differ mainly in the area just north of the Weddell Sea, where the AVCS boundary extends farther north and is in closer agreement with (*2*).

Though clouds were evident in both sets of pictures, analysis of their mean coverage and variations during the period in question would require more skill and probably yield less-reliable results than the information on the ice boundary. More detailed information on the types and distribution of sea ice will be needed for radiation and heat-budget studies of the Antarctic, for which purpose the amount, type, and distribution of cloud cover are also vital.

This measurement of the ice is only a first step, but promising; I believe that, by applying improved techniques to the AVCS and HRIR pictures now being taken by Nimbus II over this area, both extent and type of clouds and ice could be synoptically mapped over a long period.

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References and Notes

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4. I thank R. W. Popham, NESC, for helpful contributions.

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