similar to that obtained by visual inspection of Fig. 2. Since the average PWV over the respective periods was 1.2 and 0.35 cm, we conclude that the fluctuation power varies considerably more rapidly than the average PWV, approximately as the square.

A matter of considerable interest in the theory of atmospheric structure is the slope of the power spectrum. Although the shape is found to change considerably with weather conditions, one can fit the slopes of spectra such as those in Fig. 2 with relationships of the form $S(F) = KF^{-x}$. However, it is clear by visual inspection of Fig. 2 that the curves can be more satisfactorily represented by two straight lines rather than one. Such being the case, the behavior of the PWV spectrum appears to change at about $F = 10$, corresponding to a period of about 2.5 hours.

A concern in power spectra measurements is the signal-to-noise ratio over the frequency range of interest. Low-frequency noise in a microwave radiometric instrument is generated by effects such as changes in the temperatures of components, gains of amplifiers, and lack of stability in power supplies. To determine the noise performance of the dual-channel system, the microwave antenna (which normally is permanently attached to generate a beam in the zenith) is disconnected and replaced by an enclosed microwave termination of known temperature. Under these conditions, the radiometer is operated over a long period of time, and data are recorded in the usual way. The spectrum of the background noise of the instrument is then obtained by the same technique, and length of interval, as that used in generating the PWV spectra. The result (Fig. 3) shows that the most objectionable noise components occur at the lower frequencies, near two to three cycles per day. A comparison of curve a of Fig. 2, the moist condition, with the noise spectrum of Fig. 3 shows that the data spectrum exceeds the noise spectrum by two orders of magnitude over most of the frequency range. In curve b of Fig. 2, the dry condition, the signal-to-noise ratio is sometimes less than 10 dB, especially at the high frequencies.

Although not yet applied, spectra of water vapor such as those discussed here are known to be of interest in areas other than meteorological research on short-term weather prediction. They may also have impact on the choice of the optimum time constant in the design of microwave radiometers, in the spacing of very-long-baseline radio interferometers, and in the design of metrology instruments that rely on radio phase, such as those of a global positioning system for monitoring the motion of the crust of the earth. The latter applications arise because the fundamental limit on phase fluctuation in such systems is set by the variation in the water vapor in the troposphere.

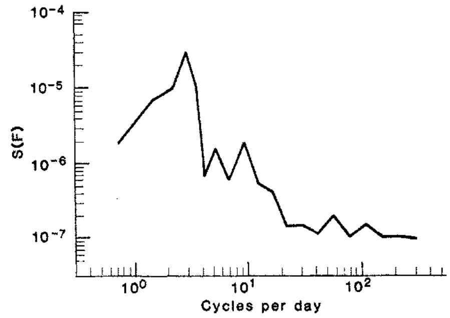

Fig. 3. A 34-hour measurement of the spectrum of the background noise of the dual-channel microwave radiometric system; the ordinate is lower by a factor of 10^3 than in Fig. 2. The units of the ordinate are square centimeters per cycle per day.

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Detection of Overflow Events in the Shag Rocks Passage, Scotia Ridge

Abstract. *During an almost yearlong period of observations made with a current meter in the fracture zone between the Falkland Islands (Islas Malvinas) and South Georgia, several overflow events were recorded at a depth of 3000 meters carrying cold bottom water from the Scotia Sea into the Argentine Basin. The outflow bursts of Scotia Sea bottom water, a mixing product of Weddell Sea and eastern Pacific bottom water, were associated with typical speeds of more than 28 centimeters per second toward the northwest and characteristic temperatures below 0.6°C. The maximum 24-hour average speed of 65 centimeters per second, together with a temperature of 0.29°C, was encountered on 14 November 1980 at a water depth of 2973 meters, 35 meters above the sea floor.*

In historic (*1*) and recent (*2*) descriptions of the position of the Polar Front (Convergence) in the Drake Passage and the Scotia Sea, its most meridional component seems to be situated between the Falkland Islands and Shag Rocks (Fig. 1). As in similar cases in the Pacific (*3*), the associated Antarctic Circumpolar Current seems to be guided there by the local bottom topography. The topographic chart from the Scotia Sea area shows a discontinuity at the site where, on the average, the Circumpolar Current leaves the Scotia Sea with a strong equatorward component.

Several investigators have emphasized the significance of this fracture zone—henceforth called Shag Rocks Passage (SRP)—for water exchange between the Pacific and Atlantic (*4–6*). Analyzing potential temperature and dissolved oxygen data from higher southern latitudes between 20°W and 170°W, Gordon (*6*) deduced the circulation patterns of Antarctic bottom water. He showed that the circumpolar bottom flow originates from the Ross Sea, passes through the Drake Passage, and mixes with Weddell Sea water in the eastern Scotia Sea. He calculated strong (> 20 cm sec^{-1}) currents transporting bottom water through the SRP into the Argentine Basin. His arguments have since been supported by bottom photographic observations indicating murky water in the deep layers of the SRP associated with abundant evidence for strong contour currents (*7*).

During the German Antarctic Expeditions of 1979–1980 and 1980–1981 with research vessels *Polarsirkel* (*8*) and *Meteor* (*9*), I had the rare opportunity to obtain an almost yearlong direct observation of bottom current speed, direction, and temperature from the SRP.

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Two Aanderaa current meters were moored at 53°S, 48°W, one at 35 and the other at 85 m above the sea floor at a water depth of 3008 m (Fig. 1a). The hourly records of both instruments extended from 23 December 1979 to 19 November 1980. The results reported here are limited to the daily average data of the lower instrument, consisting of transtidal and transinertial fluctuations only.

The progressive vector diagram (Fig. 1b) shows a predominant current direction toward the northwest, which is consistent with the local bottom topography of the mooring site. The 3000-m isobath (Fig. 1a) was adapted from Gordon (*6*). At the mooring position it is parallel to the mean bottom current direction. The current series (Fig. 2) shows pulsations with a periodicity of approximately 2 to 3 weeks. During the 11-month period, a vector-averaged speed of 17.1 cm sec^{-1} toward 291° true course was recorded, which would correspond to a water displacement of 4900 km (*A–B* in Fig. 1b) if no bathymetric restrictions were present. A more detailed inspection of the current speed and direction record reveals that, with increasing currents, stabilizing westerly directions were always observed. In quite a number of cases current onsets coincided with reductions in temperature. The correlation coefficients of temperature and scalar speed ($r = -.59$) or temperature and the westward component ($r = .67$) were well above the 95 percent significance level for uncorrelated processes.

From Gordon's (*6*) work we know that the water leaving the SRP in the direction of the Argentine Basin has a temperature of approximately 0.6°C. For clarity we have reproduced his 0.5°C bottom isotherm in the Scotia Sea (Fig. 1a). The frequency distribution of all current speeds shows a flat minimum around 25 cm sec^{-1}, separating two speed ranges. Considering only the high-speed range (≳ 28 cm sec^{-1}), we find that 24 percent of all recorded speeds fall into this category. If as a further restriction on this class we impose the additional requirement that T be ≤ 0.6°C, we find that 15 percent of all daily values meet this condition. The direction of each of these high-speed vectors lies in the range 270° to 315° true course.

On the average, the overflow through the SRP is characterized by west-northwesterly currents with speeds of 38.2 ± 8.8 cm sec^{-1} and associated temperatures of 0.47° ± 0.11°C. In Figs. 1b and 2c the important overflow events are marked by numbers; peaks in the speed and temperature series are represented by the dark areas in Fig. 2b. The digits in Fig. 2c represent the frequency of overflow days. They seem to be correlated with the seasons, since we find pronounced occurrences in early fall (area 1) and winter (areas 2 and 3). Area 5 corresponds to the spring, immediately before the recovery of our mooring. During this event the extreme values of 65 cm sec^{-1} and 0.29°C were obtained (on 14 November 1980). Exactly at that time, the upper instrument lost its rotor as a result of the extreme speed.

On the basis of these findings, I conclude (i) that the overflow through the SRP has an intermittent character which well meets Gordon's (*6*) prediction of a "strong" current, and (ii) that the extreme currents causing visible signals on the sea floor, as seen in Hollister and Elder's (*7*) photographs, are rare, and long-term current observations are needed for their detection. Further studies combining topographic details and more detailed current meter data and stratification data will be necessary before we will be able to estimate the significance of the SRP to the circulation of bottom water in the Scotia Sea.

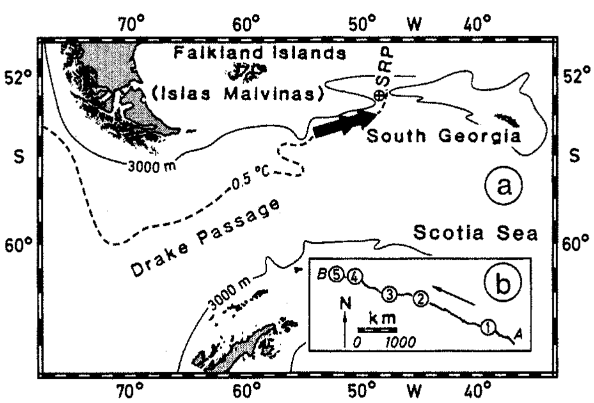

Fig. 1. (a) Position of the near-bottom, long-term current meter mooring in the Shag Rocks Passage (*SRP*), Scotia Sea; (b) the progressive vector diagram of the 2973-m instrument, 35 m above the sea floor. The 3000-m isobath and 0.5°C isotherm have been adapted from Gordon (*6*), who has predicted strong bottom currents (double arrow) west of the SRP. The numbers in (b) denote periods of oveflow as seen in Fig. 2c.

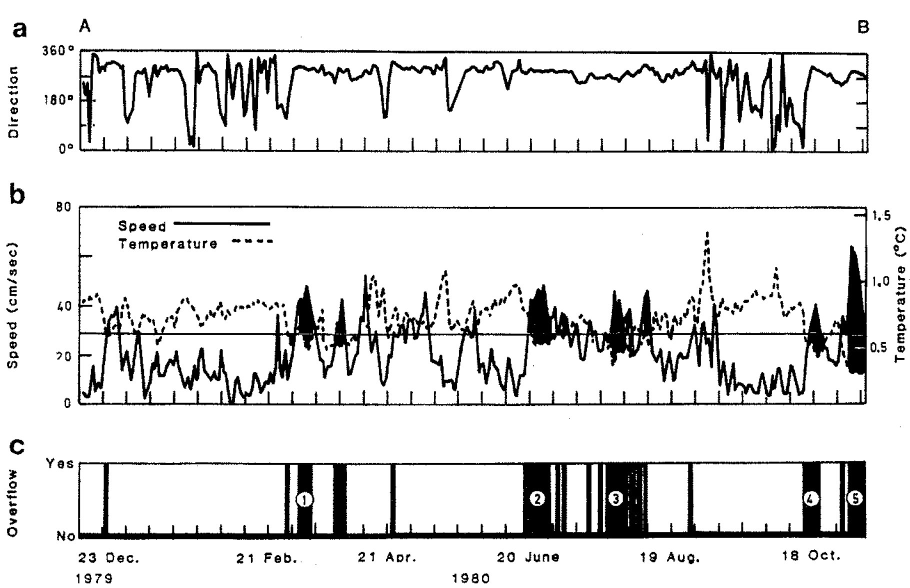

Fig. 2. (a) Direction and (b) current speed and temperature of the bottom water in the SRP. Simultaneous high speed–low temperature occurrences are marked by dark peaks and are interpreted as overflow events in the form of a digital time series (c). Prior to plotting, the hourly data were averaged daily.

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