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Short Note

On the Orientation of the Horizontal Seismometers at South Pole

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Standard seismological practice for the recording of the horizontal seismic motion at a three-component station consists of aligning the horizontal instruments along the local North-South and East-West directions, and of adjusting their polarities in order to record a positive signal for an impulsive earth motion directed to the North or to the East.

This standard runs into a problem at South Pole (SPA), where all horizontal directions point North, and East is undefined. The detailed description of the layout of the horizontal instruments is not readily available in the literature, and we thought it useful to provide an independent check of their polarities. We confirm that the so-called "North-South" instrument is oriented along the Greenwich meridian, positive towards Greenwich, and the "East-West" instrument is oriented along the 90°E meridian, positive towards the Indian Ocean and Asia (see Figure 1).

"North-South" Instrument

The large number of earthquakes in the Samoa-Tonga-Kermadec area can be used to infer the orientation of the "N-S" horizontal component by studying the 3-dimensional ground motion of their *P*-wave. Figure 2 shows the example of the Tonga earthquake of 17 June 1978 (17.1°S; 172.3°W), for which the great circle to South Pole reaches SPA within 8° of the date line meridian. The strong dilatational arrival, immediately following the minute mark at 15:23 GMT, is recorded down on the "N-S" component, indicating that the latter is oriented positive up away from the source. We verified from the CMT solutions (DZIEWONSKI *et al.*, 1987a) that the focal solution predicts a dilatational arrival at SPA. Similarly, *SV* is predicted to be strongly negative, *i.e.*, towards the source ($R^{SV} = -0.53$ in the conventions of KANAMORI and STEWART, 1976). Taking into account that at a distance of 73°, the

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Figure 1
Azimuthal equidistant map centered at South Pole, indicating the orientations of the so-called "North" and "East" components. The two dots are the epicenters of the events used in Figures 2 and 3.

incidence angle at the station is on the order of 26°, and the surface response coefficient C^{SV} positive, we conclude again that the "N-S" component is oriented positive away from Tonga.

"East-West" Instrument

Because of the general scarcity of large earthquakes around 90°E and 90°W in the Southern Hemisphere, we searched for impulsive *SH* arrivals from events with reliable focal solutions located close to 180° of longitude. Figure 3 shows the *S* arrival on the "East-West" instrument for the 17 October 1977 event on the Three-Kings ridge North of New Zealand (27.9°S; 173.1°E). The great circle from the event again reaches SPA within 7° of the date line meridian. The CMT solution (DZIEWONSKI *et al.*, 1987b), predicts a strongly positive *SH* arrival ($R^{SH} = 0.86$), in the notation of KANAMORI and STEWART (1976), i.e., to the left as the station is

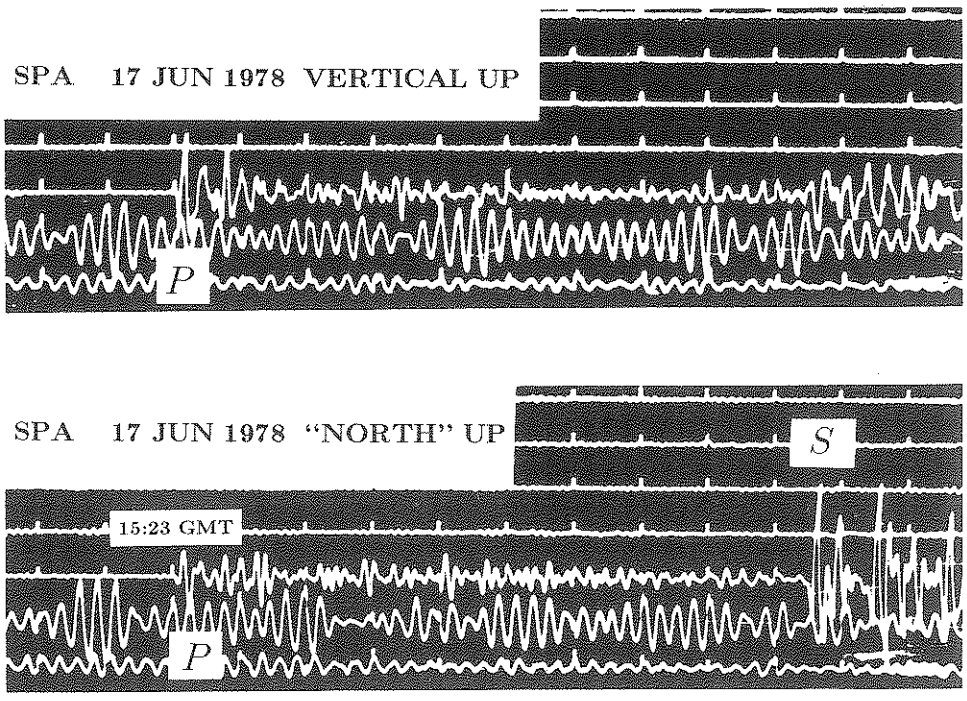

Figure 2
Vertical and "North" long-period components recorded at SPA for the event of 17 June 1978 in Tonga. The dilational *P* arrival immediately follows the minute mark at 15:23 GMT. Note also the sharp *SV* arrival, positive to "south".

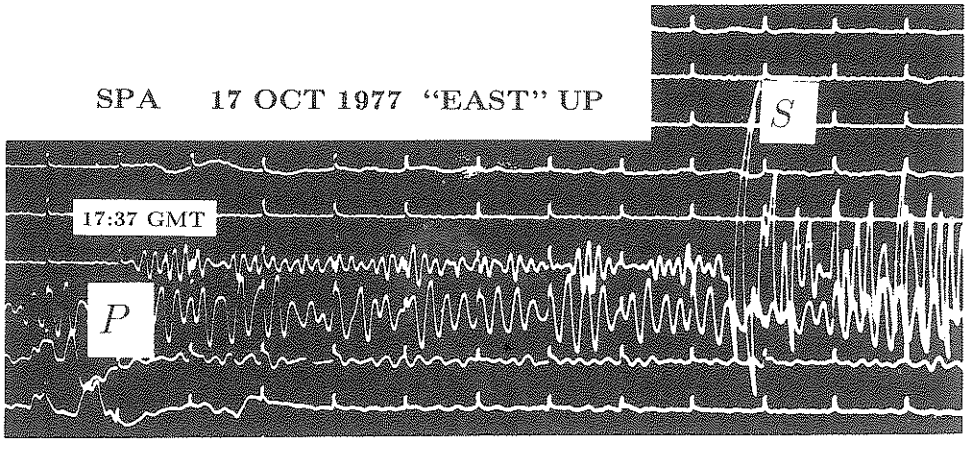

Figure 3
Long-period "East" component recorded at SPA from the 17 October 1977 event North of New Zealand. Note the sharp *SH* motion to "West".

approached along the great circle. The sharply negative arrival on the record indicates that the "E-W" component is oriented to the right, or positive along the 90°E meridian (see Figure 1). Additional random checks on more than a dozen events, using both short- and long-period components, *P*, *SV* and *SH* polarities, as well as the ellipticity of long-period Rayleigh waves, have confirmed these orientations.

In conclusion, the frame of reference used at SPA is oriented as shown on Figure 1. This orientation keeps the frame *Z*, *N*, *E* indirect, and provides continuity with that of a standard station approaching the pole *along the Greenwich meridian*. As a result, we have found that all routine seismological programs (e.g., computing back-azimuths and rotating horizontal components into radial and transverse) will perform flawlessly if the SPA coordinates are adjusted slightly, from ($\lambda = -90°$, ϕ indeterminate) to ($\lambda = -(90 - \varepsilon)°$; $\phi = 0°$E). In practice, we have found that $\varepsilon = 0.001$, i.e., moving SPA 100 m closer to Greenwich, is sufficient.

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