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D. PRINCIPAL COMPONENT TECHNIQUES IN ANALYSIS OF SEISMIC WAVES

Beamforming or simple delay-and-sum processing is extensively used in analysis of P-waves recorded by an array of seismometers or geophones. When the underlying assumptions of well-equalized noise levels and identical signals between instruments is correct, the corresponding gain in signal-to-noise ratio (SNR) is optimum. In practice, these restrictive signal and noise models are not valid, thus degrading the final signal estimate. Recently, Christoffersson and Jansson (1974) have developed a time series analysis theory for more generalized signal models, and its practical applicability has been demonstrated by Christoffersson and Husebye (1974).

In a continuation of the above work the emphasis is on a spatial interpretation of generalized seismic signal models. The basic idea here is that an array of M sensors in principle represents an M-dimensional sampling of an incoming P wave. For example, if the signals are identical between sensors, then the signal space is one-dimensional. On the other hand, if the signals are somewhat different, the best one-dimensional signal estimate, that is the array beam using optimum sensor weights, corresponds to the main principal components of the geometrical space spanned by the observations. Another example is the polarization filter used in analysis of 3-component seismometer records (Madariaga, 1967). Such a filter essentially passes one-dimensional signals, and rejects two- and three-dimensional signals, as demonstrated in Fig. D.1. In fact, the polarization filter has proved very powerful in analysis of S and surface wave records.

For further details on the above topic, the reference is a recent paper by Husebye et al (1974).

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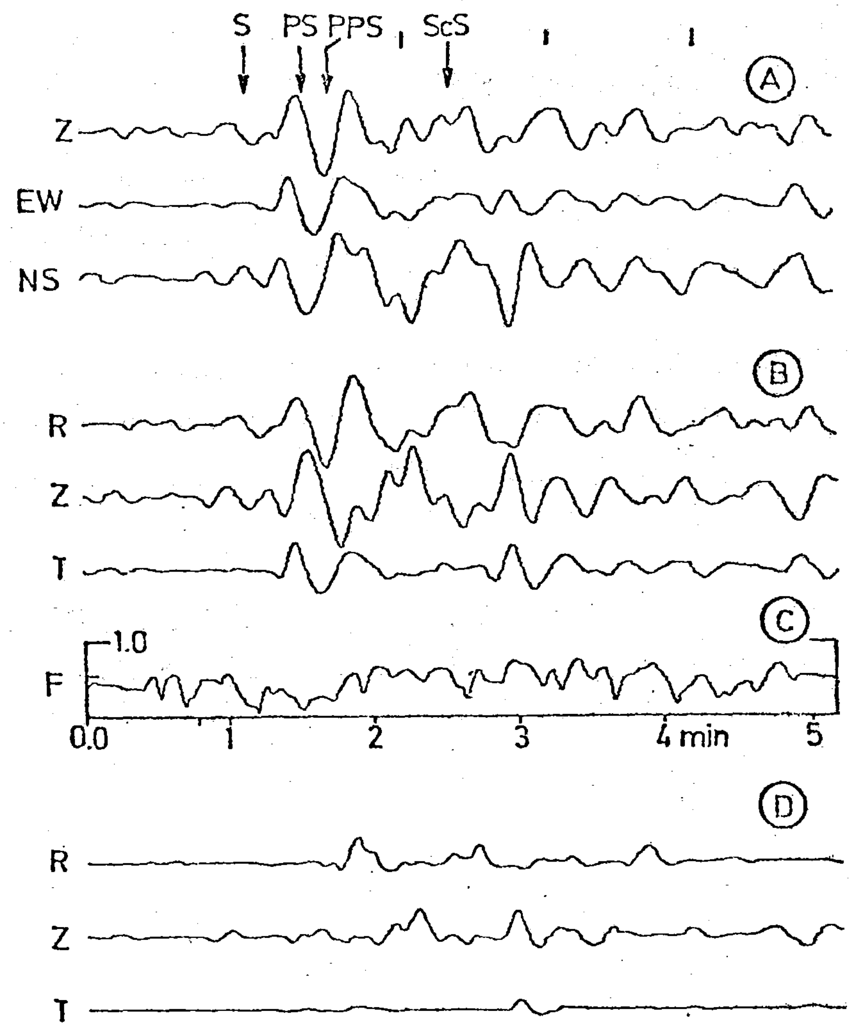

Fig. D.1 3-component records from the NORSAR subarray 01A of an earthquake in the South Atlantic 30 Sep 1971. The epicentral distance is 62.3° and the expected arrival time of different types of S-phases are shown. Section A shows the original records, section B shows the same records after rotation, i.e., the R-component coincides with the P-wave angle of incidence. Section C gives the filter weight and also the time scale of the records, and section D is the polarization filter output. Signal window is 20 sec and the projection axis remained constant during the filtering operation. The filter rejects a significant part of the signals so the particle motion is elliptical, say a combination of S and P polarized waves. Also, a phase shift between vertical and horizontal components may be important here.

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