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NORSAR PHASE 3

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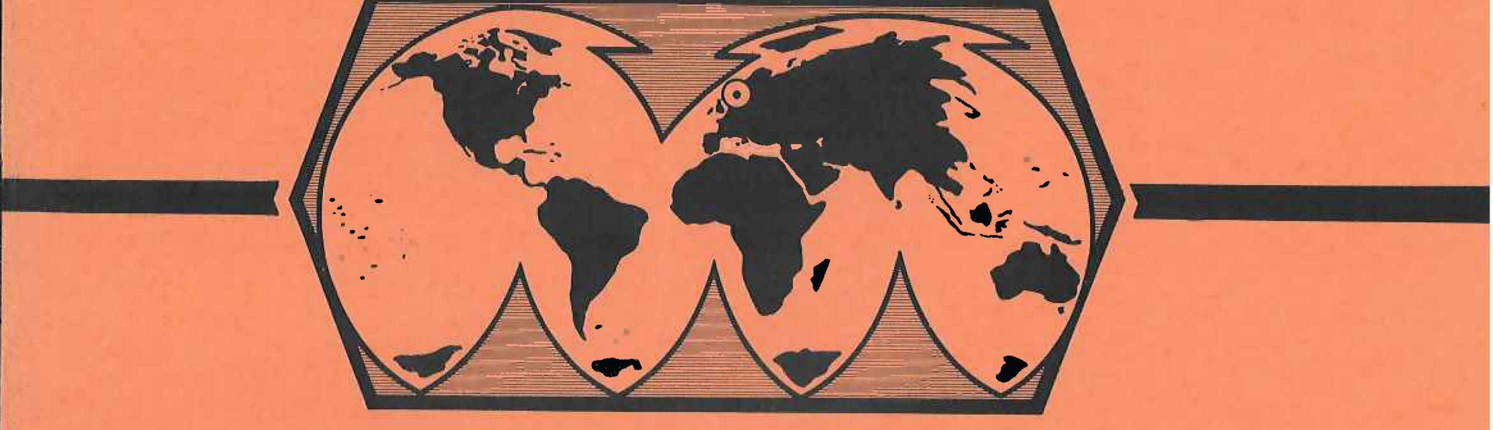

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C. WAVE SCATTERING EFFECTS IN TRAVEL TIME AND AMPLITUDE

The small-scale random variation in the body wave velocity which causes random fluctuations in travel time and log-amplitude are accounted for by the following two models:

$$T_i = T_o+\vec{R}_i\vec{U}+t_i+\varepsilon_i \qquad i = 1,\dots,n \qquad (C.1)$$

$$\log A_i = \log A_o+a_i+\varepsilon_i' \qquad i = 1,\dots,n \qquad (C.2)$$

T_i is the observed travel time at the i-th seismic station with position vector $\vec{R}_i$ in a local cartesian coordinate system. T_o is a constant. $\vec{U}$ is the travel time gradient (slowness), t_i is the random fluctuation in travel time and ε_i is measurement error or noise. $\text{Log}A_i$ is the observed logarithmic amplitude at the i-th station, $\log A_o$ is a constant (level), a_i is the amplitude fluctuation and ε_i' as before measurement error or noise.

Analytical expressions for the quantities t_i and a_i are given in Chernov's (1960) theory on scattering of acoustic waves in a random medium, which is also considered to be approximately valid for seismic P-waves. The uniform plane wave model formerly accepted, treated the terms $t_i+\varepsilon_i$ and $a_i+\varepsilon_i'$ simply as uncorrelated measurement errors . Correlation is thus a key word in the study of scattering effects.

Using very accurately determined travel time (and log-amplitude) data from 10 events filtered in time domain around 0.7 Hz, the correlation between the quantities $t_i+\varepsilon_i$ at the 132 stations comprising the NORSAR array were computed. Assuming this correlation rotational symmetric in accordance with the Chernov (1960) theory, we obtain a correlation function of the type depicted in Fig. C.1. A similar correlation function is also established for the amplitude fluctuations (Dahle et al, 1974).

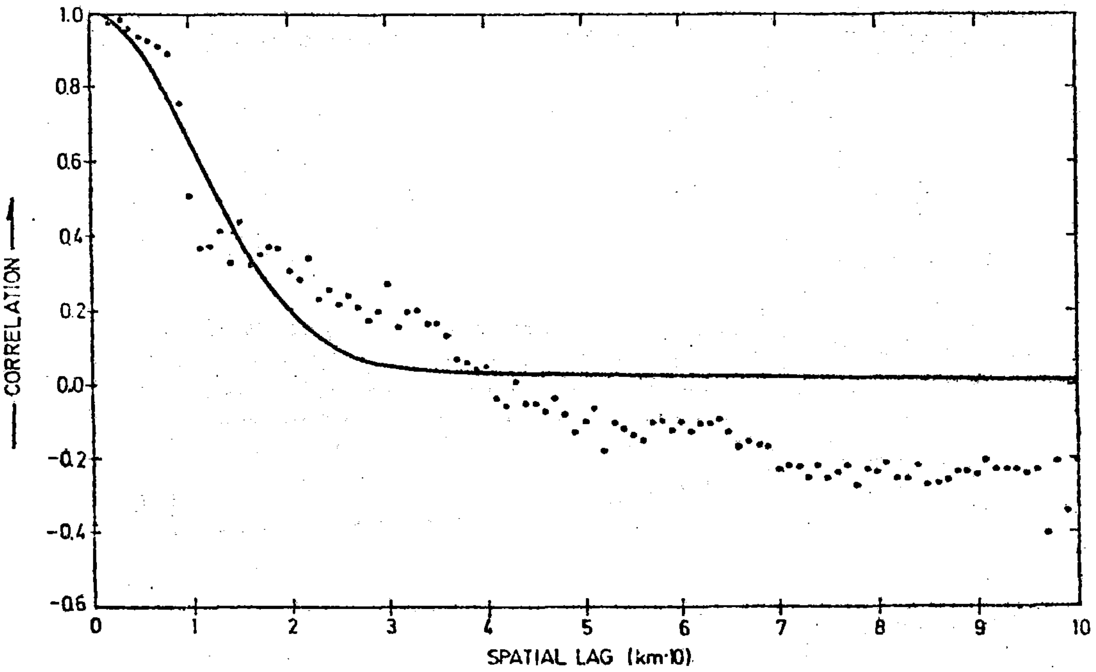

Fig. C.1 Estimated correlation function for travel time together with the theoretical Chernov (1960) function (solid line).

In order to test the importance of the t_i (or a_i) term, least squares linear estimation and prediction were used (Heiskanen and Moritz, 1967). This procedure takes advantage of the covariance between fluctuations in the anomalies $(t_i+\varepsilon_i)$ shown in Fig. C.1.

The theoretical covariance matrices estimated from Chernov's analytical expressions are given as function of the average size of the inhomogeneities causing scattering (correlation distance) and a dimensionless quantity called "wave parameter" which is proportional to the depth of the inhomogeneous medium. The difference between squared observed minus predicted travel times (or logamplitudes) for a network of stations relative to the conventional plane wave residual variance is shown in Fig. C.2 for a typical event. In fact, the main part of the anomalies seems to be explainable in terms of correlated fluctuations superimposed on a plane wave front as actually done in Chernov (1960) and Dahle et al (1974). The presence of correlated

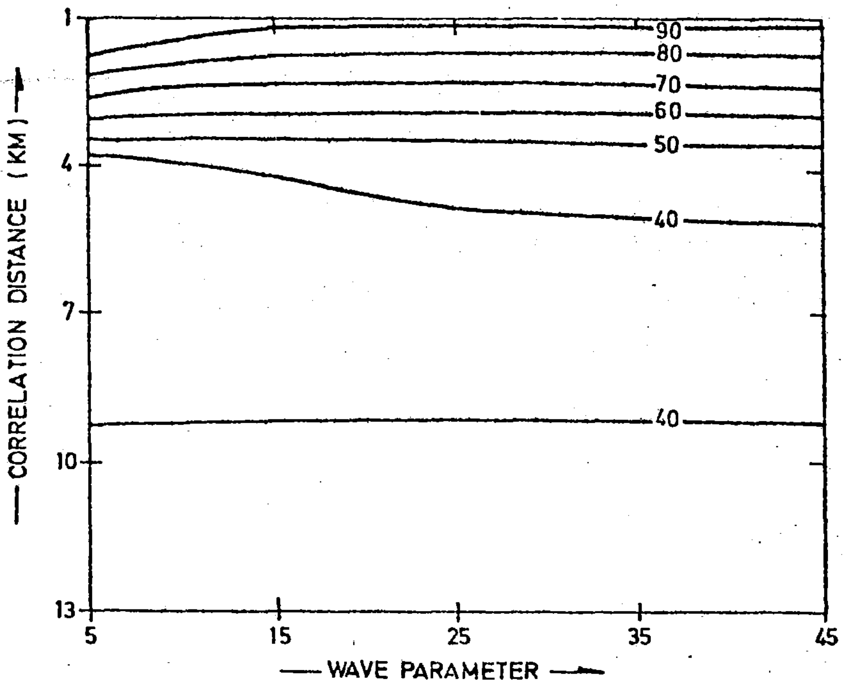

Fig. C.2 Contour plot showing per cent variance in observed-predicted travel times relative to the conventional plane wave residual variance.

residuals implies that slowness estimates for small-scale arrays are highly unreliable, but that a transformation of the observed travel times into uncorrelated observations improves such estimates. For further details on these topics, see Dahle (1974) and Dahle et al (1974)

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