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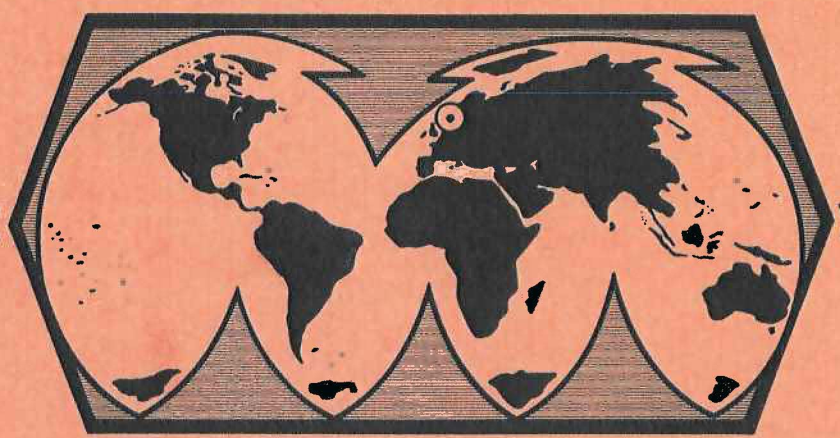

VII.4 Variance of Teleseismic P-wave Amplitudes

The large scatter between individual station m_b determinations for a given seismic event is a problem of considerable importance when estimating magnitudes from network data. Successful application of maximum likelihood techniques (Ringdal, 1976) generally requires that the standard deviation σ of the world-wide magnitude distribution is known, or at least may be assumed to lie within fairly narrow limits. In recent years, several studies have been performed to estimate σ based on world-wide m_b observations of large events, most of them using WWSSN data. The most comprehensive of these papers (Veith and Clawson, 1972) found σ=0.35 using a smoothed distance-amplitude relationship. Evernden and Kohler (1976), also using large events, have studied the effects on σ when compensating for regional crustal structure and station site geology. Their conclusion is that, with this procedure, a value of σ=0.21 can adequately represent m_b standard deviation on a world-wide basis for single stations, while σ=0.15 would be adequate for m_b observations by small arrays as specified in Evernden (1971). They also argue on the basis of these low σ values that network magnitude bias is unimportant in the context of the usage of an M_s-m_b discriminant for networks as described in Evernden (1971).

An important question is to what extent world-wide m_b scattering observed for large earthquakes (typically m_b = 6.0 and above) is representative for smaller events, which of course are the ones of most interest when considering network bias problems. In order to investigate this problem, it is clearly necessary to employ another procedure than looking at world-wide magnitudes of a given event. This is because the problem of non-detections at individual stations becomes quite severe with existing earthquake catalogues for low-magnitude events. Instead, we choose in this paper the indirect approach of comparing m_b values of the large arrays LASA and NORSAR for events from selected regions, assuming independence of their respective m_b estimates.

The results of this analysis are presented in Table VII.4.1, and show that the scatter is significant and appears to be quite region-dependent. For the six geographic regions analyzed, we have estimated an average σ=0.30 m_b units for the standard deviation around the 'true' magnitude of each array m_b. At individual regions, σ ranges from 0.21 (Central America) to 0.40 (Kurile Islands) - see also Fig. VII.4.1. It should be noted here that any systematic regional station bias, including average signal attenuation effects due to local site geology, have been eliminated prior to computing the variances. It appears that the scatter could be reduced if smaller regions are considered; however, it might be noted that Ringdal (1974) found a value of σ as high as 0.28 for an aftershock sequence from the Kurile Islands 17-30 June 1973, comparing NORSAR and LASA reported m_b values. Hence, a significant residual scatter remains, even when very small source areas are considered.

Our σ estimates are significantly higher than those of Evernden and Kohler (1976). This may reasonably be attributed to the difference in spectral characteristics of large and small earthquakes, i.e., smaller earthquakes tend to have a relatively higher corner frequency (Aki, 1967). In fact, Fig. VII.4.2 shows the standard deviation of log amplitudes across the NORSAR array in five frequency bands (each of bandwidth 0.4 Hz). The data represent average values of 10 events, listed in Table VII.4.2. A clear increase in amplitude scattering is observed with increasing frequency, with a standard deviation at 2 Hz almost double that at 0.6 Hz.

Hence, these results indicate that world-wide m_b scatter increases with decreasing magnitudes, and thus that magnitude bias studies based on large events will not necessarily be adequate at low magnitudes.

F. Ringdal

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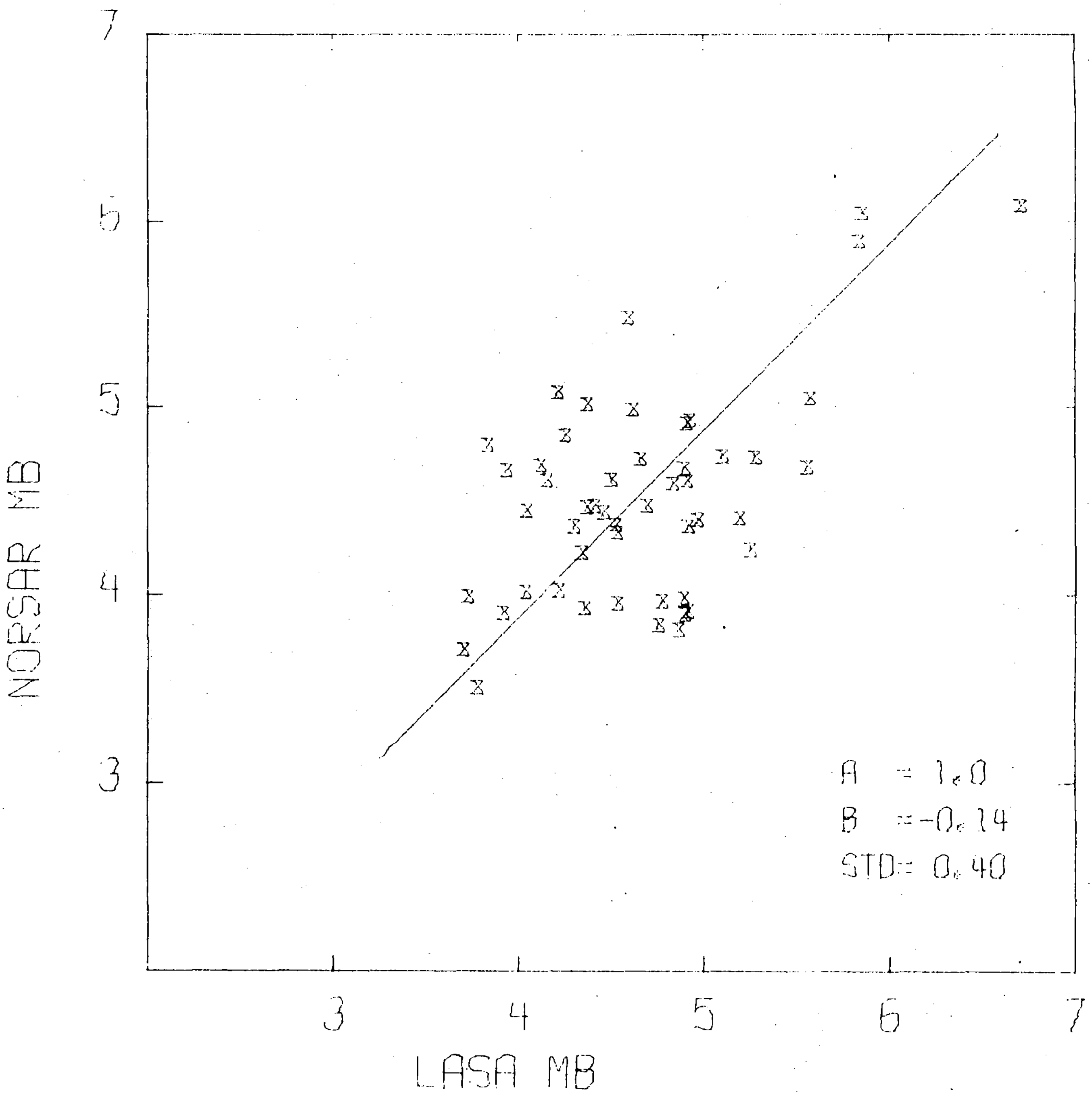

Fig. VII.4.1 Comparison of NORSAR and LASA reported m_b for 50 events randomly selected from the Kurile Islands area (Flinn-Engdahl regions 220-222). The straight line has a slope of A=1.0, and its intercept B (denoting the average difference m_b(NORSAR)-m_b(LASA)) and the orthogonal standard deviation relative to this line are also specified.

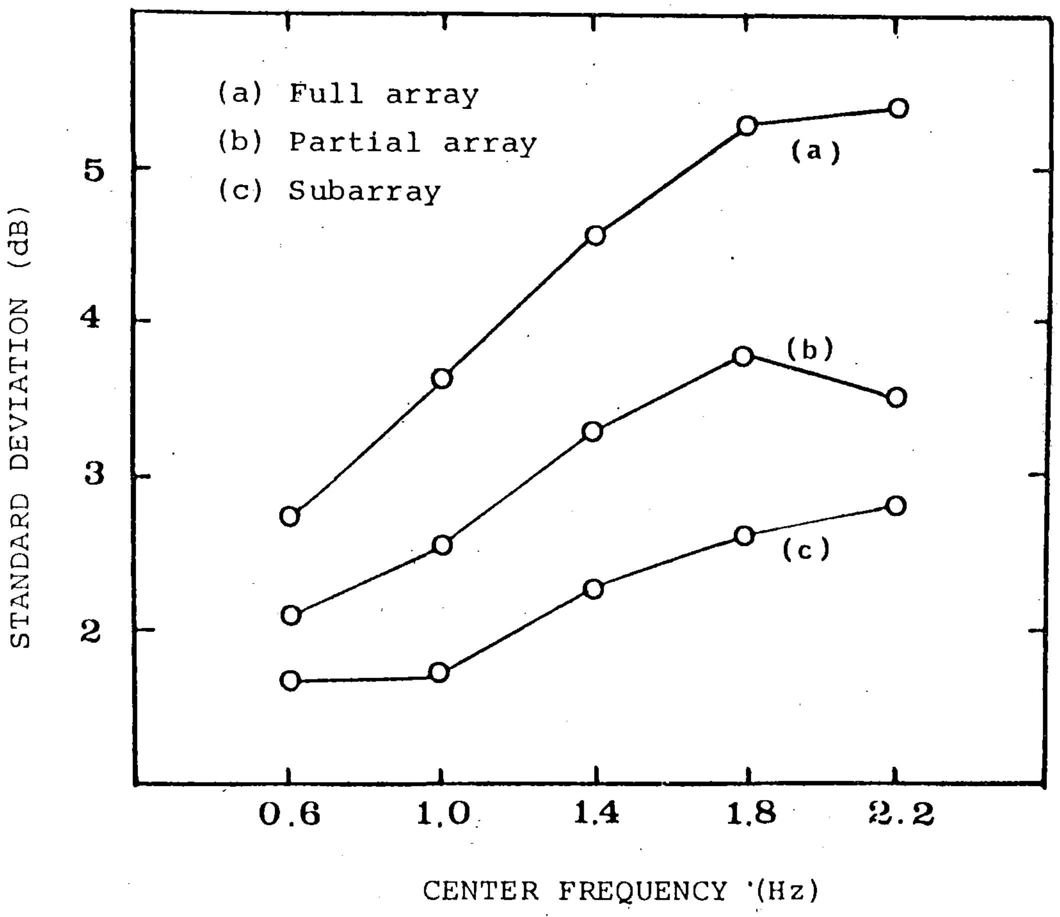

Fig. VII.4.2 Standard deviation of amplitudes (in dB) as a function of narrow-band filter frequency within the NORSAR array (a), within a partial array consisting of three neighboring subarrays (b) and within a subarray (c). The numbers represent average values over a set of 10 events.

TABLE VII.4.2

Events used for studying NORSAR amplitude variations.

Event No.	Region	Reported by PDE						Reported by NORSAR			
		Date	Origin Time GMT	Latitude	Longitude	Depth	m_b	m_b	T (S)	Dist (deg)	Azi (deg)
1	Afghanistan-USSR Border	06/26/71	22.23.29	36.3N	71.4E	127	5.0	5.3	0.5	45	95
2	Eastern Kazakh SSR*	06/30/71	03.56.57	50.0N	79.1E	0	5.4	5.2	1.0	40	77
3	Szechwan Province, China	08/16/71	04.58.00	28.9N	103.7E	N	5.5	5.6	1.0	64	75
4	Honshu, Japan	04/26/75	03.14.37	39.6N	141.1E	100	5.3	5.3	0.8	72	45
5	South of Honshu, Japan	05/06/75	10.18.20	31.0N	141.7E	N	5.7	5.6	0.7	81	49
6	Southern Nevada*	06/03/75	14.40.00	37.3N	116.5W	0	5.7	5.6	1.2	72	323
7x	Kirgiz-Sinkiang Border	03/16/76	06.19.09	41.0N	77.0E	N	-	5.2	0.7	44	88
8x	Kurile Islands	04/03/76	19.14.17	45.0N	149.0E	N	-	4.9	0.8	69	35
9x	Uzbek, SSR	04/08/76	12.03.59	42.0N	62.0E	N	-	5.2	0.9	36	98
10x	Off Coast Hokkaido, Japan	04/11/76	02.52.50	43.0N	147.0E	N	-	5.4	0.7	71	38

* Presumed explosion

x All parameters reported by NORSAR

TABLE VII.4.1

Regional statistics of LASA-NORSAR magnitude differences.

General Region	Corresponding Flinn-Engdahl Regions	Number of Events	Average m_b(LASA)-m_b(NORSAR)	St. dev. of m_b(LASA)-m_b(NORSAR)	St. dev. of each array m_b
S. Honshu	226-233	50	0.03±0.04	0.31±0.03	0.22±0.02
Kurile Islands	220-222	50	0.14±0.08	0.56±0.06	0.40±0.04
Kamchatka	217-219	50	-0.04±0.06	0.39±0.04	0.27±0.03
Aleutian Islands	4-10	50	0.05±0.07	0.46±0.05	0.33±0.03
North Atlantic Ridge	402,403,406	50	-0.08±0.07	0.46±0.05	0.32±0.03
Central America	54-82	50	-0.09±0.04	0.30±0.03	0.21±0.02
All above regions combined		300	0.00±0.03	0.42±0.02	0.30±0.01