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6.5 Threshold Monitoring Processing Parameters for IMS Stations PDYAR and ARCES

Introduction

The processing parameters for all stations to be included in the IMS Threshold Monitoring System processing need to be tuned for reliable estimation of the detection capability. We will now report on the tuning of the IMS array stations ARCES, which required retuning due to recent upgrades, and PDYAR. We follow the procedures described in the Threshold Monitoring Operations Manual (Taylor et. al., 1998). The configuration of ARCES (shown in Fig. 6.5.1) has not changed. The configuration of PDYAR is shown in Fig. 6.5.2.

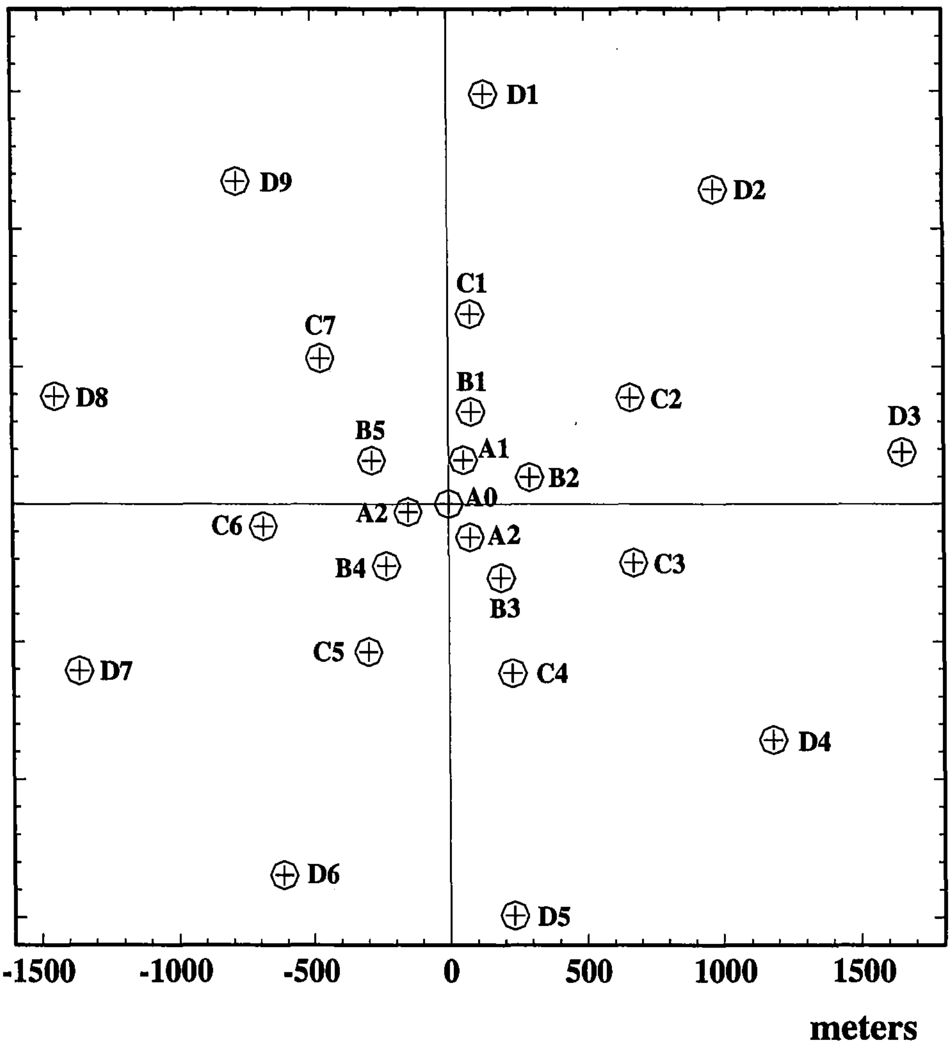

Fig. 6.5.1. Configuration of the ARCES array.

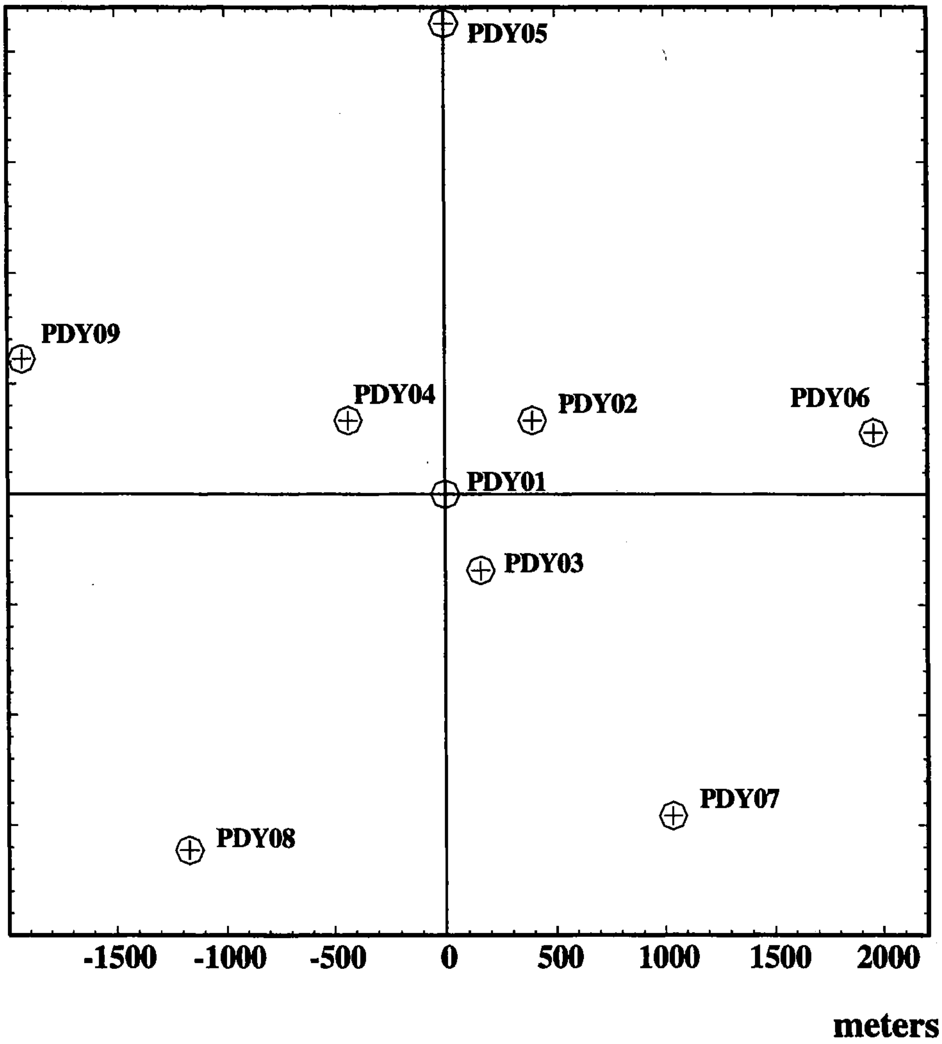

Fig. 6.5.2. Configuration of the PDYAR array.

Event Data Bases

For the tuning study we needed to find events with good SNRs, preferably occurring at various distances from the stations. This was done by searching the PIDC data base for good SNR events at various distances, and then requesting and receiving the data intervals. In order to obtain information on the background noise field, the event data segments start one minute ahead of the P arrival, with a total length of two minutes.The lists of events for PDYAR and ARCES are given in Table 6.5.1 and Table 6.5.2.

Table 6.5.1. TM tuning events for PDYAR

STA	ORID	LAT	LON	DEPTH	UTM	MB	DELTA	PHASE	SNR	AZI	VEL
PDYAR	20598919	42.3655	143.8172	43.8	1999-295:18.28.25.5	3.8	25.886	P	80.21	124.07	11.826
PDYAR	20598919	42.3655	143.8172	43.8	1999-295:18.28.25.5	3.8	25.886	PcP	4.16	128.05	42.553
PDYAR	20598947	-38.1664	-93.9545	0.0	1999-295:21.28.02.8	4.5	152.704	PKPbc	50.14	70.37	128.172
PDYAR	20600614	34.6268	-116.1812	0.0	1999-298:18.26.00.7	4.3	77.846	P	38.19	30.30	27.984
PDYAR	20600651	54.6569	-161.1353	24.6	1999-299:05.19.40.4	4.6	43.982	P	94.23	59.00	15.246
PDYAR	20600651	54.6569	-161.1353	24.6	1999-299:05.19.40.4	4.6	43.982	PcP	4.06	74.78	29.743
PDYAR	20601358	79.2520	124.0420	0.0	1999-300:05.05.07.4	4.5	20.022	P	81.15	4.60	11.863
PDYAR	20601411	52.0667	-171.3684	0.0	1999-300:08.38.48.3	3.9	41.185	P	51.69	62.81	14.473
PDYAR	20601411	52.0667	-171.3684	0.0	1999-300:08.38.48.3	3.9	41.185	PcP	3.39	78.75	20.984
PDYAR	20601517	39.4603	144.7751	0.0	1999-301:06.58.37.4	4.9	28.664	P	56.77	122.59	13.027
PDYAR	20603408	-22.8358	-69.7273	38.0	1999-302:17.13.31.9	4.2	143.179	PKP	41.22	5.07	32.542
PDYAR	20605733	19.8008	147.7117	0.0	1999-307:16.08.52.2	4.5	47.123	P	100.05	127.90	12.968
PDYAR	20605733	19.8008	147.7117	0.0	1999-307:16.08.52.2	4.5	47.123	PcP	4.51	140.89	26.483
PDYAR	20606490	51.9315	98.4437	0.0	1999-308:23.37.25.9	4.4	11.024	Pg	6.08	226.65	6.663
PDYAR	20606490	51.9315	98.4437	0.0	1999-308:23.37.25.9	4.4	11.024	Pn	168.05	230.46	9.028
PDYAR	20608186	-11.2438	114.2544	0.0	1999-309:17.03.58.5	5.0	70.673	P	60.81	198.03	11.459
PDYAR	20610056	43.8572	148.2533	0.0	1999-313:05.38.46.5	4.7	26.789	P	60.96	96.63	12.943
PDYAR	20611652	40.7401	30.2928	0.0	1999-315:14.41.23.5	5.1	52.209	P	95.15	301.80	20.052
PDYAR	20627225	.4584	125.9873	0.0	1999-332:00.53.39.4	5.1	59.971	P	63.56	181.03	13.068
PDYAR	20627237	41.5826	19.7109	0.0	1999-332:00.59.43.7	4.8	56.530	P	44.01	292.40	17.357
PDYAR	20627928	-1.2360	88.8923	0.0	1999-332:10.17.18.8	4.7	63.456	P	66.69	63.44	3.513
PDYAR	20628633	36.1573	81.2239	0.0	1999-334:10.08.05.0	4.7	30.966	P	57.46	230.66	12.321
PDYAR	20632411	32.3170	-40.1577	0.0	1999-341:02.35.48.5	4.4	85.602	P	35.91	339.37	26.215
PDYAR	20636222	-36.1486	-97.6442	0.0	1999-344:20.07.00.2	4.6	149.491	PKPbc	61.42	56.24	99.020
PDYAR	20637061	-5.7533	151.3126	0.0	1999-347:02.10.49.4	4.4	72.089	P	49.80	163.65	22.675
PDYAR	20642062	55.7126	110.2462	0.0	1999-351:12.00.21.7	4.2	4.125	Pg	48.13	191.12	7.199
PDYAR	20642062	55.7126	110.2462	0.0	1999-351:12.00.21.7	4.2	4.125	Pn	121.65	185.68	9.557
PDYAR	20654532	51.3504	-176.4437	0.0	1999-363:16.21.45.1	4.1	39.275	P	54.25	52.46	19.342
PDYAR	20654532	51.3504	-176.4437	0.0	1999-363:16.21.45.1	4.1	39.275	PcP	4.57	77.62	36.980
PDYAR	20654685	47.0925	141.9507	0.0	1999-364:14.51.44.7	3.7	21.415	P	35.64	115.67	19.080
PDYAR	20654792	18.2315	-101.3410	48.3	1999-363:05.19.45.8	5.5	97.654	P	78.24	37.90	20.562
PDYAR	20655891	36.9270	69.8463	0.0	2000-001:06.26.00.8	4.4	35.424	P	60.98	262.95	13.040
PDYAR	20667265	43.7660	-128.8626	0.0	2000-019:20.23.18.1	3.9	65.342	P	40.38	51.48	12.866

Table 6.5.2. TM tuning events for ARCES

STA	ORID	LAT	LON	DEPTH	UTM	MB	DELTA	PHASE	SNR	AZI	VEL
ARCES	20748712	67.1724	21.6042	0.0	2000-096:16.47.28.5	-999.0	2.779	Pn	66.40	209.60	7.981
ARCES	20642591	67.2049	20.7676	0.0	1999-352:10.51.18.2	-999.0	2.925	Pg	21.28	215.67	6.397
ARCES	20642591	67.2049	20.7676	0.0	1999-352:10.51.18.2	-999.0	2.925	Pn	92.01	216.10	7.870
ARCES	20689326	67.0984	21.0218	0.0	2000-046:17.10.33.1	-999.0	2.960	Pg	8.51	214.94	7.762
ARCES	20689326	67.0984	21.0218	0.0	2000-046:17.10.33.1	-999.0	2.960	Pn	48.66	214.51	8.026
ARCES	20655723	67.6755	33.3921	0.0	1999-365:11.25.03.5	-999.0	3.441	Pg	15.75	115.07	7.091
ARCES	20655723	67.6755	33.3921	0.0	1999-365:11.25.03.5	-999.0	3.441	Pn	90.71	122.49	7.524
ARCES	20624125	73.9421	13.1160	0.0	1999-328:19.54.07.6	3.6	5.884	Pn	87.36	325.68	9.892
ARCES	20657653	72.7508	4.6900	0.0	2000-005:21.08.27.2	3.2	7.450	Pn	41.48	309.94	10.037
ARCES	20689380	72.7741	4.6605	0.0	2000-046:18.37.21.0	3.5	7.464	Pn	58.76	307.29	9.455
ARCES	20656603	76.4794	8.1999	15.1	2000-002:11.10.59.0	3.7	8.570	Pn	57.92	331.22	9.419
ARCES	20637912	77.8335	7.5103	0.0	1999-347:21.34.22.2	3.6	9.680	Pn	28.97	322.96	9.519
ARCES	20731076	59.0957	18.5772	0.0	2000-074:09.57.29.6	-999.0	10.892	Pn	43.32	200.16	8.275
ARCES	20617789	81.2118	-4.1285	0.0	1999-320:19.06.56.1	3.7	13.593	Pn	13.93	8.15	14.386
ARCES	20628623	84.4093	1.7543	0.0	1999-334:09.24.01.7	4.4	15.598	Pn	21.55	358.00	10.968
ARCES	20671000	51.5575	16.2164	0.0	2000-022:20.30.58.1	3.9	18.564	P	20.50	197.15	9.634
ARCES	20667369	48.0585	26.8734	41.7	2000-019:23.09.43.5	3.6	21.552	P	20.17	180.50	9.094
ARCES	20654598	80.4997	121.9986	0.0	1999-364:06.46.55.4	4.5	23.581	P	45.57	36.78	11.391
ARCES	20654598	80.4997	121.9986	0.0	1999-364:06.46.55.4	4.5	23.581	PcP	12.52	34.82	49.270
ARCES	20753648	45.7120	26.4893	134.2	2000-097:00.10.40.0	4.6	23.894	P	76.69	181.82	9.832
ARCES	20627237	41.5826	19.7109	0.0	1999-332:00.59.43.7	4.8	28.181	P	12.98	183.75	10.273
ARCES	20615746	40.9257	31.3416	33.9	1999-316:16.57.24.9	5.5	28.838	P	113.05	162.61	27.029
ARCES	20611652	40.7401	30.2928	0.0	1999-315:14.41.23.5	5.1	28.969	P	47.35	171.73	13.862
ARCES	20622226	39.6134	20.7906	0.0	1999-328:03.38.49.8	4.6	30.089	P	35.24	186.25	9.790
ARCES	20631578	35.8479	22.1214	0.0	1999-340:01.28.27.5	4.0	33.794	P	51.13	188.13	11.522
ARCES	20651185	55.7226	110.1668	0.0	1999-362:01.19.44.3	4.1	37.778	P	42.01	67.55	12.848
ARCES	20633388	42.2840	76.9051	21.3	1999-340:07.33.10.1	4.9	37.784	P	79.03	101.73	12.638
ARCES	20610083	35.6821	61.2042	0.0	1999-312:21.37.20.5	5.3	39.093	P	57.05	136.35	12.537
ARCES	20610083	35.6821	61.2042	0.0	1999-312:21.37.20.5	5.3	39.093	PcP	2.78	102.28	27.928
ARCES	20610083	35.6821	61.2042	0.0	1999-312:21.37.20.5	5.3	39.093	PP	4.95	132.35	12.125
ARCES	20617150	36.9184	69.8054	0.0	1999-319:19.05.01.5	4.7	40.393	P	73.69	115.86	15.136
ARCES	20628633	36.1573	81.2239	0.0	1999-334:10.08.05.0	4.7	44.748	P	52.57	98.60	15.819
ARCES	20701883	60.3979	-145.9958	18.9	2000-058:02.22.15.0	4.6	50.216	P	66.07	4.41	14.431
ARCES	20639628	54.6320	-160.9635	35.7	1999-350:23.51.29.9	5.0	56.051	P	66.71	18.41	15.196
ARCES	20639628	54.6320	-160.9635	35.7	1999-350:23.51.29.9	5.0	56.051	PcP	2.53	29.83	27.242
ARCES	20665029	25.7086	101.1317	0.0	2000-014:23.37.04.8	5.2	61.142	P	22.96	79.15	14.386
ARCES	20622113	9.6720	57.1961	0.0	1999-327:14.37.56.7	5.3	63.172	P	54.92	144.62	17.466
ARCES	20667321	19.7346	101.3614	0.0	2000-019:20.59.24.0	4.9	66.723	P	22.44	86.12	25.381
ARCES	20604467	23.3651	121.6230	39.8	1999-305:17.53.02.5	5.4	70.445	P	33.23	62.05	15.262
ARCES	20647972	16.5885	119.1092	0.0	1999-358:22.53.52.2	4.7	75.853	P	18.11	78.99	22.135
ARCES	20636414	15.7492	119.8326	19.5	1999-345:18.03.36.2	5.9	76.882	P	116.84	77.94	28.050
ARCES	20636414	15.7492	119.8326	19.5	1999-345:18.03.36.2	5.9	76.882	PKKPbc	4.74	273.12	37.443
ARCES	20616307	-1.3429	88.9331	0.0	1999-319:05.42.42.9	5.8	82.213	P	58.22	104.45	55.813
ARCES	20739324	15.8981	147.3181	0.0	2000-085:04.47.55.0	4.3	85.616	P	52.62	60.72	19.002
ARCES	20628689	3.1374	126.6989	0.0	1999-335:05.29.07.7	5.2	90.990	P	38.41	77.33	17.021
ARCES	20669588	-1.0589	127.3430	0.0	2000-022:19.42.13.0	4.8	95.124	P	11.46	62.59	15.358

Table 6.5.2. TM tuning events for ARCES

STA	ORID	LAT	LON	DEPTH	UTM	MB	DELTA	PHASE	SNR	AZI	VEL
ARCES	20642632	-2.4472	139.7918	0.0	1999-352:17.44.54.2	5.7	100.616	P	28.55	67.74	18.463
ARCES	20642632	-2.4472	139.7918	0.0	1999-352:17.44.54.2	5.7	100.616	PKiKP	6.63	104.81	47.469
ARCES	20708431	-6.7413	144.1117	0.0	2000-063:22.22.40.6	5.8	106.046	Pdiff	17.25	64.57	19.172
ARCES	20708431	-6.7413	144.1117	0.0	2000-063:22.22.40.6	5.8	106.046	PKiKP	3.69	74.36	24.059
ARCES	20682978	-5.8018	151.1546	27.0	2000-037:11.33.53.0	6.2	107.334	Pdiff	8.85	47.12	17.338
ARCES	20682978	-5.8018	151.1546	27.0	2000-037:11.33.53.0	6.2	107.334	PKiKP	88.11	106.38	67.308
ARCES	20682978	-5.8018	151.1546	27.0	2000-037:11.33.53.0	6.2	107.334	PKKPab	5.12	220.23	99.187
ARCES	20682978	-5.8018	151.1546	27.0	2000-037:11.33.53.0	6.2	107.334	PKKPbc	10.01	256.08	63.391
ARCES	20657541	-11.4416	165.5249	0.0	2000-005:12.12.04.1	4.7	116.661	PKP	21.78	98.09	172.096
ARCES	20690379	-13.7422	167.7477	0.0	2000-047:22.11.20.1	4.0	119.418	PKP	48.33	75.47	50.840
ARCES	20626420	-16.3801	168.2151	0.0	1999-330:19.36.05.6	5.2	122.070	PKP	34.15	89.85	67.309
ARCES	20672510	-17.2153	-173.8116	0.0	2000-026:13.26.46.5	5.6	126.340	PKP	20.04	15.44	73.672
ARCES	20647915	-56.2004	146.6543	0.0	1999-358:19.26.05.7	5.2	151.396	PKPbc	49.74	126.43	98.126
ARCES	20720795	-62.8570	146.0535	0.0	2000-065:23.57.03.4	5.8	156.041	PKP	4.71	308.86	38.180
ARCES	20720795	-62.8570	146.0535	0.0	2000-065:23.57.03.4	5.8	156.041	PKPab	23.49	99.59	29.682

Signal-to-noise ratio vs. distance

We would like the TM procedure for estimating the network detection capability to resemble the IDC procedure for estimating m_b. At the IDC, a third order Butterworth filter with a passband between 0.8 and 4.5 Hz is applied to the data prior to the estimation of signal amplitude and period. The same prefilter should ideally be applied prior to the generation of the STA envelopes, but we also have to take into consideration the frequency band where we expect the highest SNR.

In Figs. 6.5.3 and 6.5.4 we have plotted the average log(STA) for all noise segments preceding the P-phases versus frequency to see if there are noise peaks that should be avoided. To find the frequency range in which we expect the highest SNR, we have plotted the SNR (STA/LTA) measured in narrow frequency bands vs. the distance to the events in Figs. 6.5.5 and 6.5.6. For each event we have normalized the maximum SNR to 50 dB. For ARCES we see that the frequency with the maximum SNR changes significantly with distance, and we will therefore generate separate tuning parameters for the regional (0 - 15 degrees) and teleseismic (15 - 180 degrees) cases. The best SNR for PDYAR is more consistent, being below 3.0 Hz at all distances.

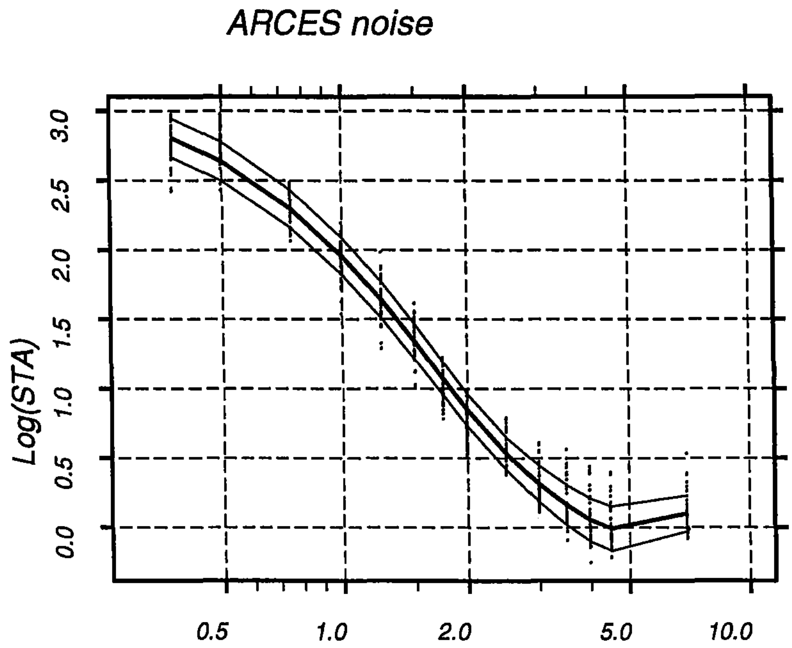

Fig. 6.5.3. Average narrowband log(STA) of the ARCES noise segments plotted versus frequency. Lines ±1σ around the mean are also shown.

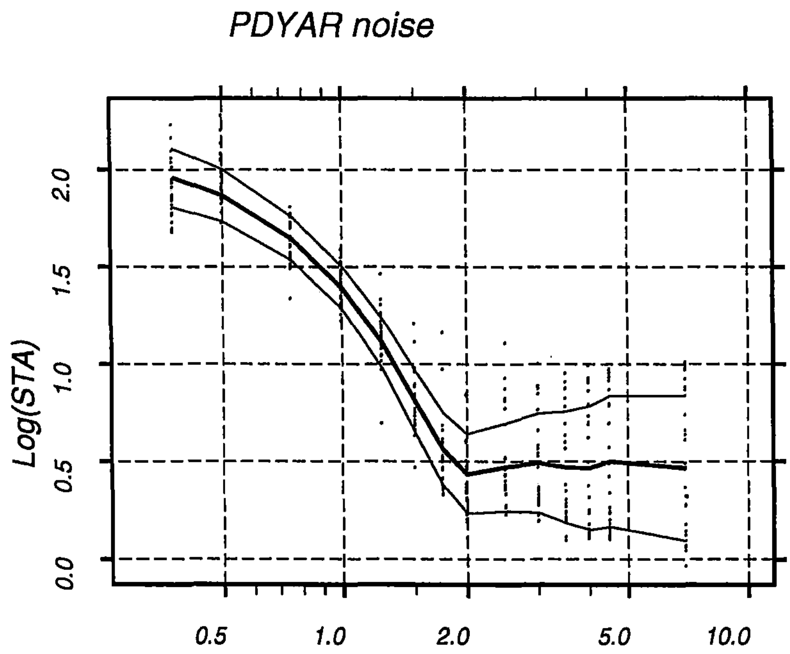

Fig. 6.5.4. Average narrowband log(STA) of the PDYAR noise segments plotted versus frequency. Lines ±1σ around the mean are also shown.

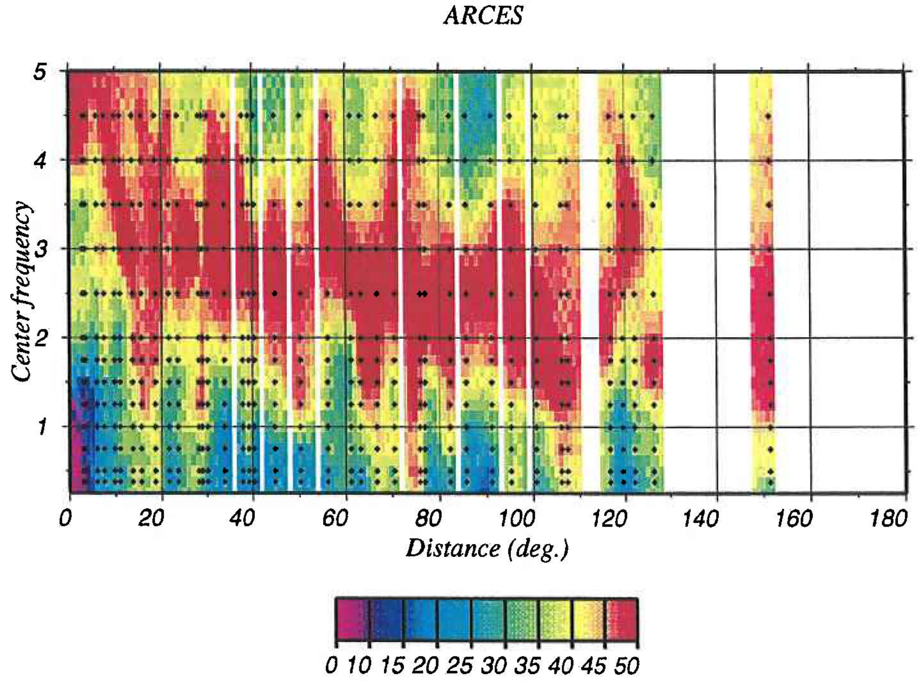

Fig. 6.5.5. SNR (STA/LTA) versus distance for events recorded at ARCES. The maximum SNR is normalized to 50 dB.

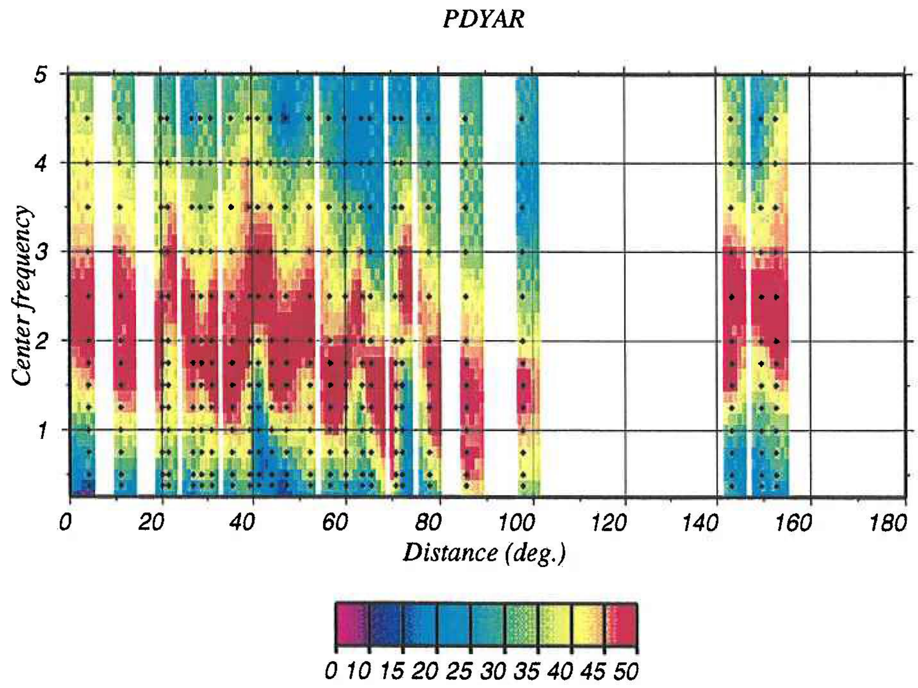

Fig. 6.5.6. SNR (STA/LTA) versus distance for events recorded at PDYAR. The maximum SNR is normalized to 50 dB.

Prefiltering

When choosing the prefilter cutoffs from the tuning events, we try to balance low amplitudes during noise conditions with a good recovery of the signal amplitudes. The frequencies may be different from those used for routine magnitude estimation.

To be able to relate the log(STA) estimates used by the TM system to the log(A/T) estimates used for magnitude estimation at the IDC, we manually measure log(A/T) of the tuning events. A/T is measured on beams steered with the azimuths and slownesses of the P-phases, and filtered between 0.8 and 4.5 Hz. The A/T measurements are made on the maximum amplitude occurring within 8 seconds of the first arrival.

Based on the average noise characteristics (see Figs. 6.5.3 and 6.5.4) and the frequency range with the highest SNR (see Figs. 6.5.5 and 6.5.6), we will test a series of filters for subsequent use in the TM system. For PDYAR, the frequency ranges with maximum SNR show no significant distance dependent trend, and we therefore propose to use the same prefilter for all distances. ARCES, on the other hand, will require separate prefilters for the regional and teleseismic cases.

For ARCES (regional and teleseismic) and PDYAR we show in Figs. 6.5.7, 6.5.8, and 6.5.9 results from comparing the reference measurements in the 0.8 - 4.5 Hz filter band with the $\log((\pi/2) \cdot STA \cdot calib)$ measurements in three different filter bands (several other filters have also been tested). This average difference is later referred to as ATcomp. Mean and Median (ATcomp) give the average difference for the events. St.dev. gives the standard deviation of the differences and Noise gives the average STA level of the preceding noise.

For PDYAR we see that for STAs measured in the 0.8 - 4.5 Hz filter band (upper panel) there is, as expected, a very good correspondence with the reference A/T values. The median difference is -0.05 with a standard deviation of 0.05 and average noise value of -0.59 (all values given in m_b units). As expected, the best filter band for ARCES at regional distances (2.5 - 8.0 Hz, median -0.07 mb, standard deviation 0.203 m_b, and average noise value -1.12 m_b) is higher in frequency than that for teleseismic distances (1.5 - 6.0 Hz, median 0.21 m_b, standard deviation 0.176 m_b, and average noise value -0.427 m_b).

When deciding which prefilter to use, we find that the filter bands described above best combine low amplitudes during noise conditions with a good and stable recovery of the signal amplitudes for the three cases. When processing data in these frequency bands we should subtract the relevant median values (ATcomp) from the estimates to make them compatible with the magnitude estimation procedure at the IDC.

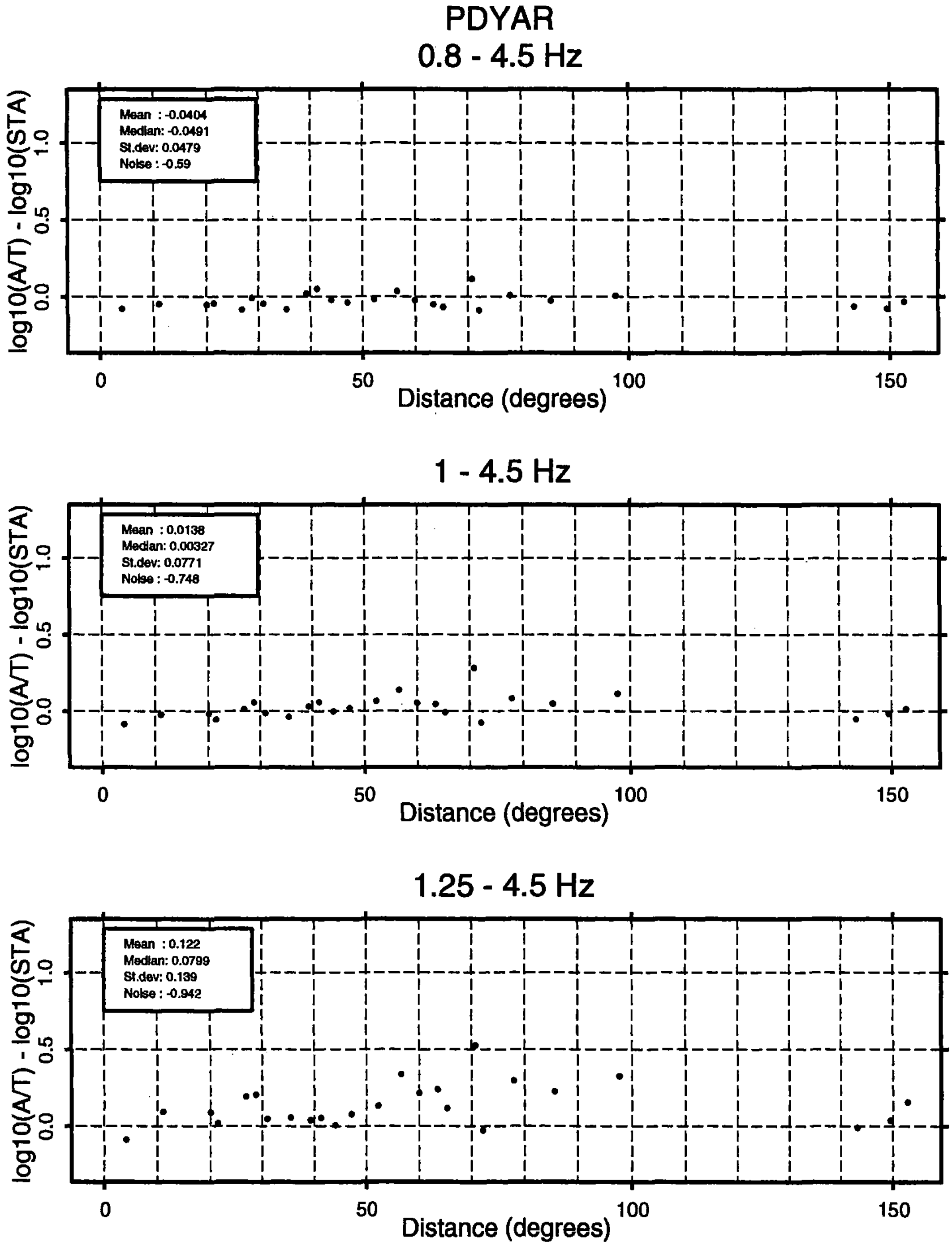

Fig. 6.5.7. Panels showing the differences between the reference $\log(A/T)$ measurements (0.8-4.5 Hz) and $\log((\pi/2) \cdot STA \times calib)$ measured in three different filter bands. All tuning events at PDYAR have been considered. The mean and median differences and standard deviations are shown for the events along with the average STA level of the preceding noise.

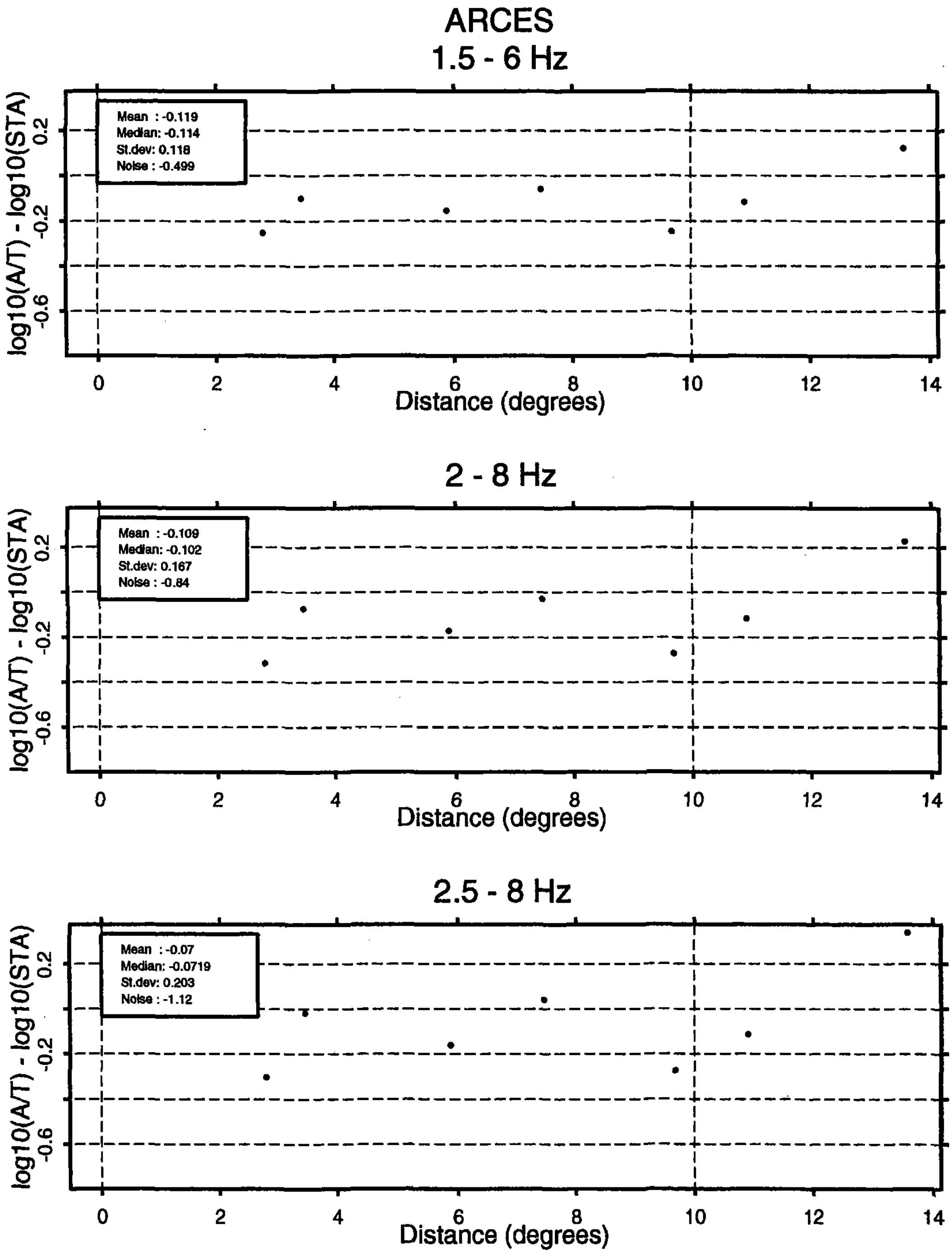

Fig. 6.5.8. Panels showing the differences between the reference $\log(A/T)$ *measurements (0.8-4.5 Hz) and* $\log((\pi/2) \cdot STA \times calib)$ *measured in three different filter bands. All regional tuning events at ARCES have been considered. The mean and median differences and standard deviations are shown for the events along with the average STA level of the preceding noise.*

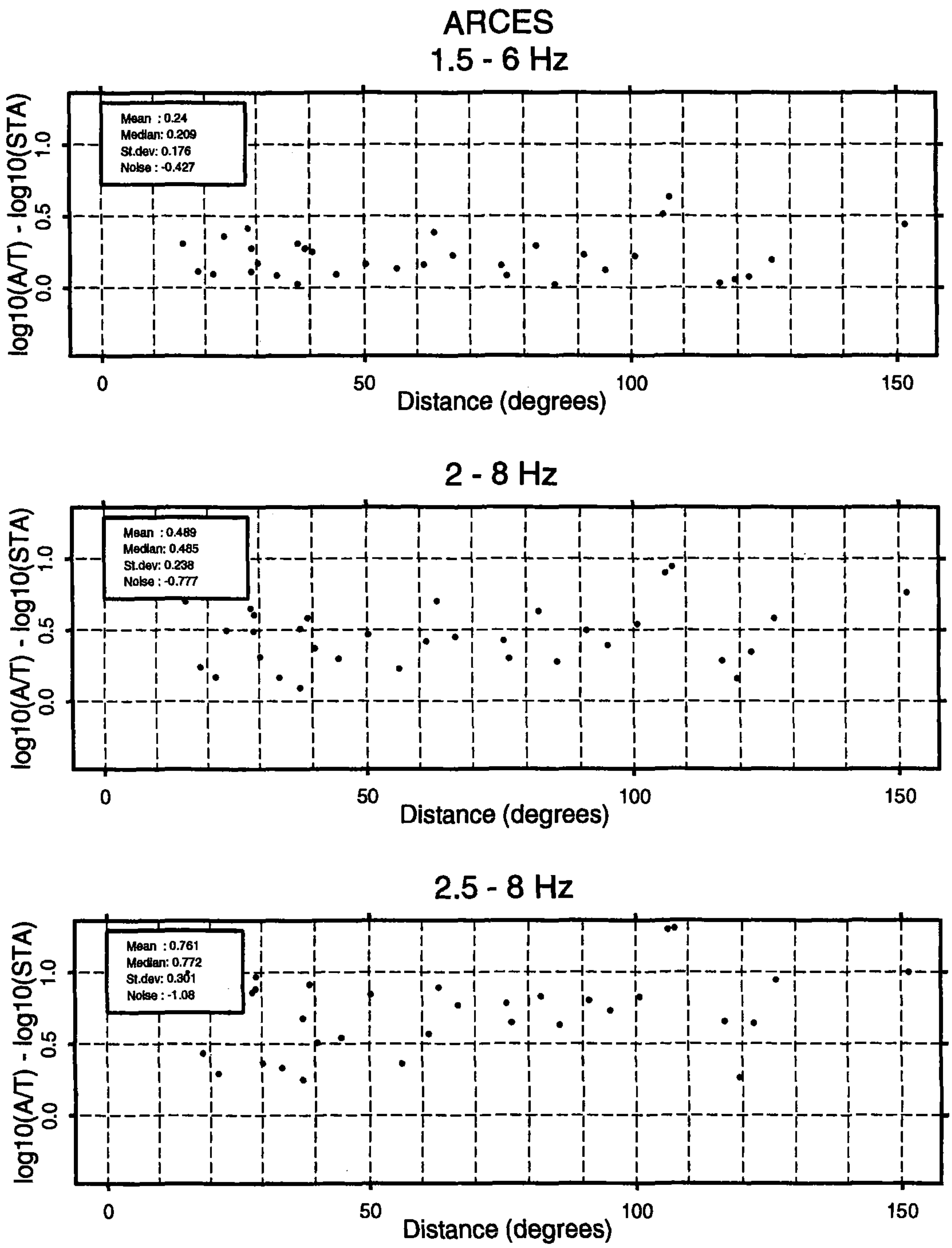

Fig. 6.5.9. Panels showing the differences between the reference $\log(A/T)$ *measurements (0.8-4.5 Hz) and* $\log((\pi/2) \cdot STA \times calib)$ *measured in three different filter bands. All teleseismic tuning events at ARCES have been considered. The mean and median differences and standard deviations are shown for the events along with the average STA level of the preceding noise.*

Signal Loss and Mis-steering

As outlined in the Threshold Monitoring Operations Manual (Taylor et. al., 1998), we need to have available estimates of the expected beamforming signal loss as a function of the mis-steering of the beams for each array. This is done by measuring the signal loss as a function of the mis-steering of the filtered beams, according to the relation:

sloss=(beam STA)/(Average STA of individual sensors)

where STA is taken to be the maximum within 8 seconds of the first arrival.

In Fig. 6.5.10 we show the signal loss as a function of mis-steering for all regional ARCES events. As discussed in the preceding section, the prefilter passband 2.5 - 8.0 Hz was applied to the data. We see from the figure that the average signal loss for correct beam steering is 1.37 dB, and that an additional 3 dB signal loss is expected to be found at a mis-steering of 0.0432 s/km.

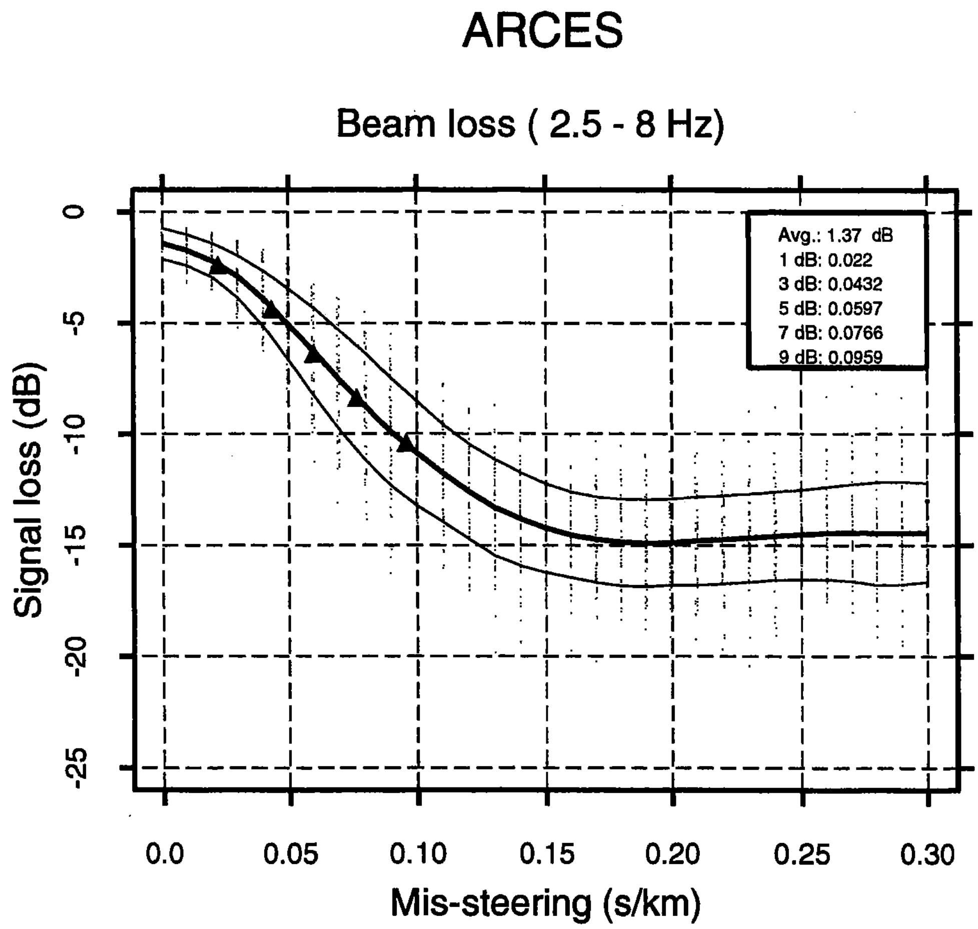

Fig. 6.5.10. Signal loss for ARCES regional events prefiltered in the passband 2.5-8.0 Hz. The three lines show the average and the 1 σ levels of the signal loss. For no mis-steering the average signal loss is 1.31 dB. An additional 3 dB signal loss is expected at a mis-steering of 0.0432 s/km.

In Fig. 6.5.11 we show the signal loss as a function of mis-steering for all teleseismic ARCES events for beams filtered in the passband 1.5 - 6.0 Hz. The average signal loss for correct beam steering is 0.541 dB, and an additional 3 dB signal loss is expected to be found at a mis-steering of 0.106 s/km.

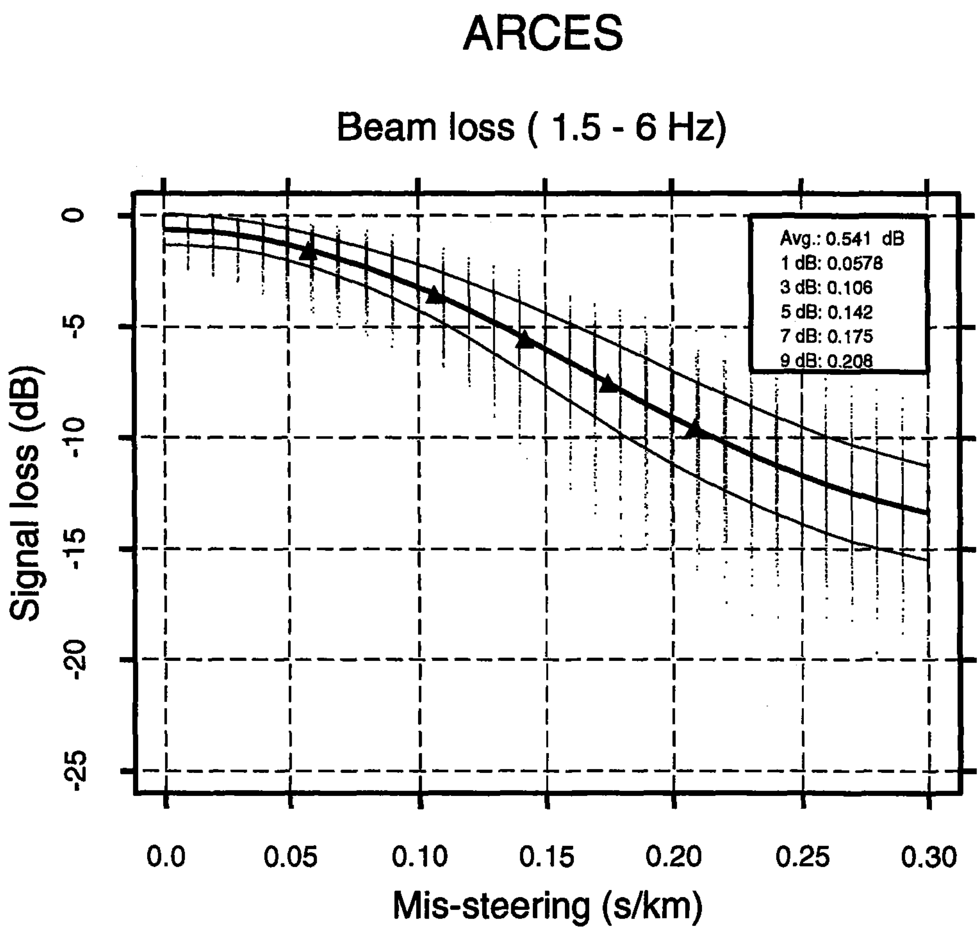

Fig. 6.5.11. Signal loss for ARCES teleseismic events prefiltered in the passband 1.5-6.0 Hz. The three lines show the average and the 1 σ levels of the signal loss. For no mis-steering the average signal loss is 0.541 dB. An additional 3 dB signal loss is expected at a mis-steering of 0.105 s/km.

In Fig. 6.5.12 we show the signal loss as a function of mis-steering for all PDYAR events for beams filtered in the passband 0.8 - 4.5 Hz. The average signal loss for correct beam steering is 1.28 dB, and an additional 3 dB signal loss is expected to be found at a mis-steering of 0.0962 s/km.

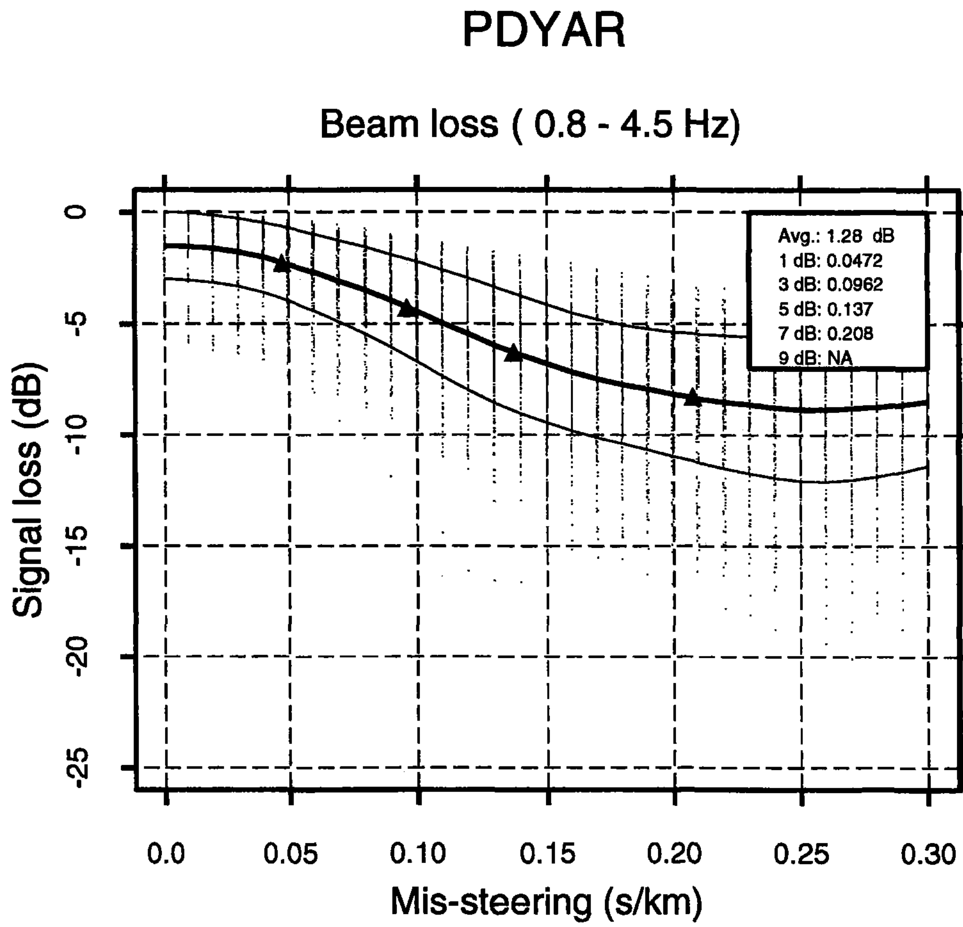

Fig. 6.5.12. Signal loss for PDYAR events prefiltered in the passband 0.8-4.5 Hz. The three lines show the average and the 1 σ levels of the signal loss. For no mis-steering the average signal loss is 1.28 dB. An additional 3 dB signal loss is expected at a mis-steering of 0.0962 s/km.

Beam Deployment

According to the IASP91 travel-time tables, the P phases used for estimation of network detection thresholds span the slowness range 0.0 - 0.124 s/km. This range corresponds to the distance range (0 - 180 degrees) appropriate for PDYAR. For ARCES, we divide this range into two parts corresponding to the regional (0 - 15 degrees, 0.098 - 0.124 s/km) and teleseismic (15 - 180 degrees, 0.0 - 0.098 s/km) cases. Beams must be deployed such that no part of the relevant slowness range will experience more than a 3 dB signal loss.

For ARCES regional beams we expect the 3 dB signal loss at a mis-steering of 0.0432 s/km (see **Fig.** 6.5.10). The procedure for deploying the beams is illustrated in Fig. 6.5.13, where the dashed circles with radii of 0.0432 s/km (3 dB level) cover the slowness range 0.098 - 0.124 s/km. The center points of the small circles correspond to the steering parameters of the beams.

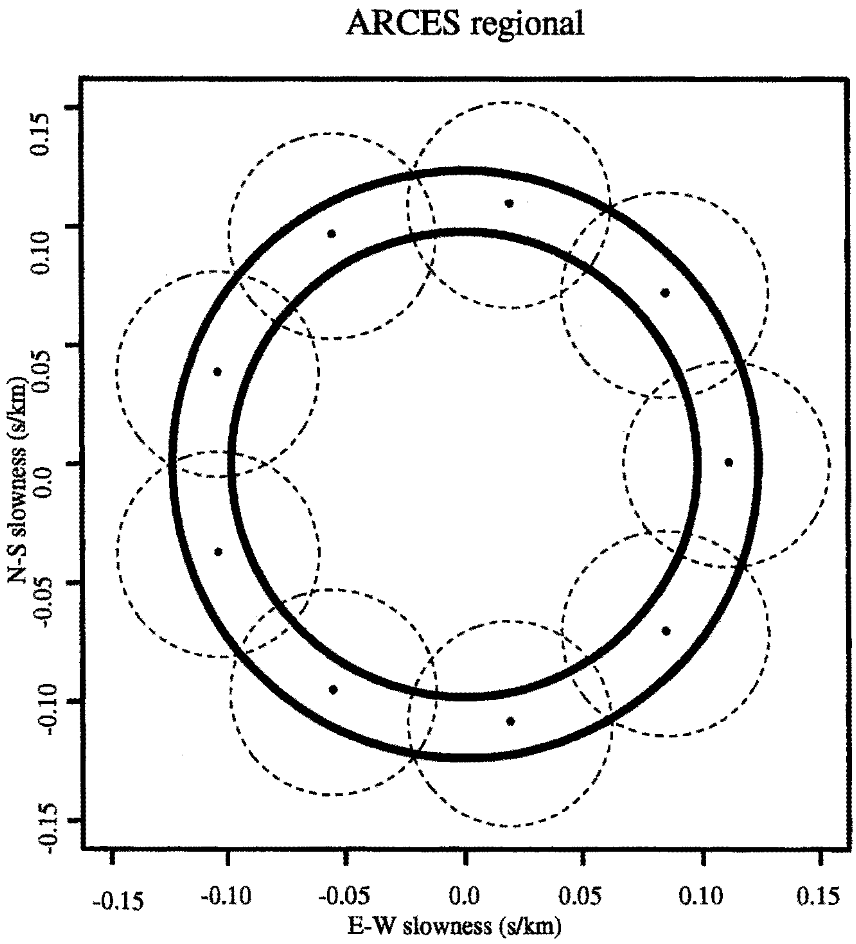

Fig. 6.5.13. Regional ARCES beam deployment used in the TM system for assessing the detection capability in the distance range 0-15 degrees. The area between the solid circles corresponds to the expected slowness range of P-phases from surface events in this distance range. In order to ensure complete coverage within the 3 dB level, it was necessary to deploy 9 beams, represented by the centers of the dashed circles. The radius of each small circle is 0.0432 s/km, corresponding to the expected mis-steering associated with the 3 dB signal loss.

For ARCES teleseismic beams we expect the 3 dB signal loss at a mis-steering of 0.106 s/km (see Fig. 6.5.11). The procedure for deploying the beams is illustrated in Fig. 6.5.13, where the dashed circles with radii of 0.106 s/km (3 dB level) cover the slowness range 0.0-0.098 s/km. The center points of the small circles correspond to the steering parameters of the beams.

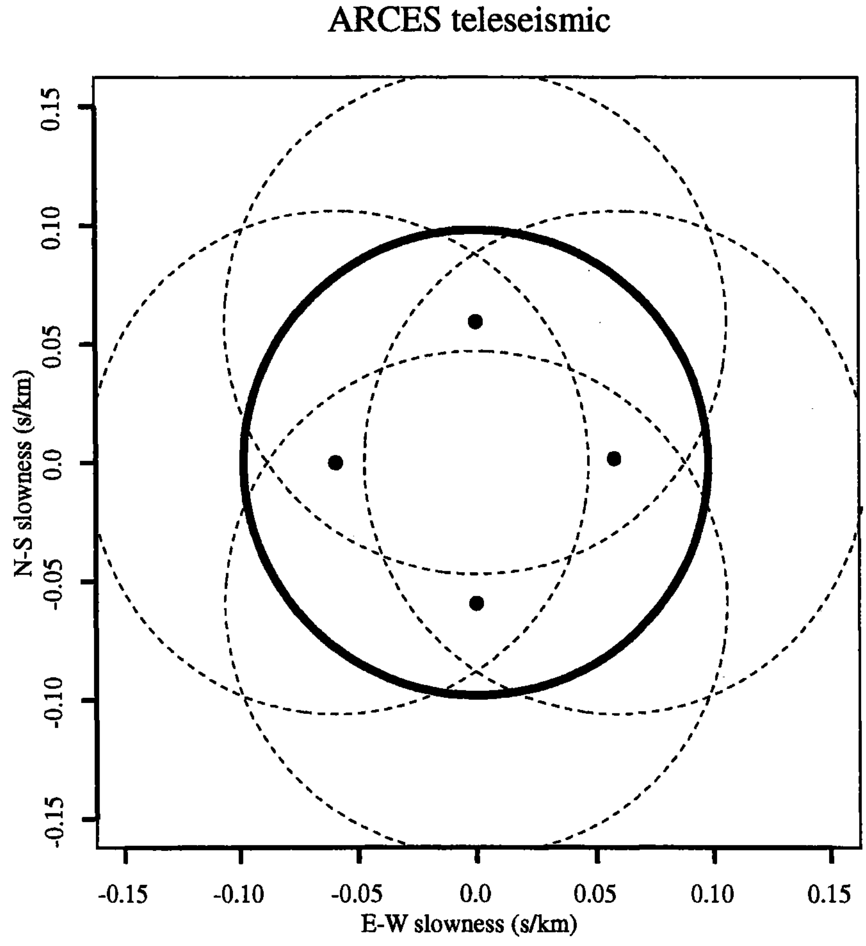

Fig. 6.5.14. Teleseismic ARCES beam deployment used in the TM system for assessing the detection capability in the distance range 15-180 degrees. The area within the solid circle corresponds to the expected slowness range of P-phases from surface events in this distance range. In order to ensure complete coverage within the 3 dB level, it was necessary to deploy 4 beams, represented by the centers of the dashed circles. The radius of each small circle is 0.106 s/km, corresponding to the expected mis-steering associated with the 3 dB signal loss.

For PDYAR beams we expect the 3 dB signal loss at a mis-steering of 0.0962 s/km (see Fig. 6.5.12). The procedure for deploying the beams is illustrated in Fig. 6.5.15, where the dashed circles with radii of 0.0962 s/km (3 dB level) cover the slowness range 0.0-0.124 s/km. The center points of the small circles correspond to the steering parameters of the beams.

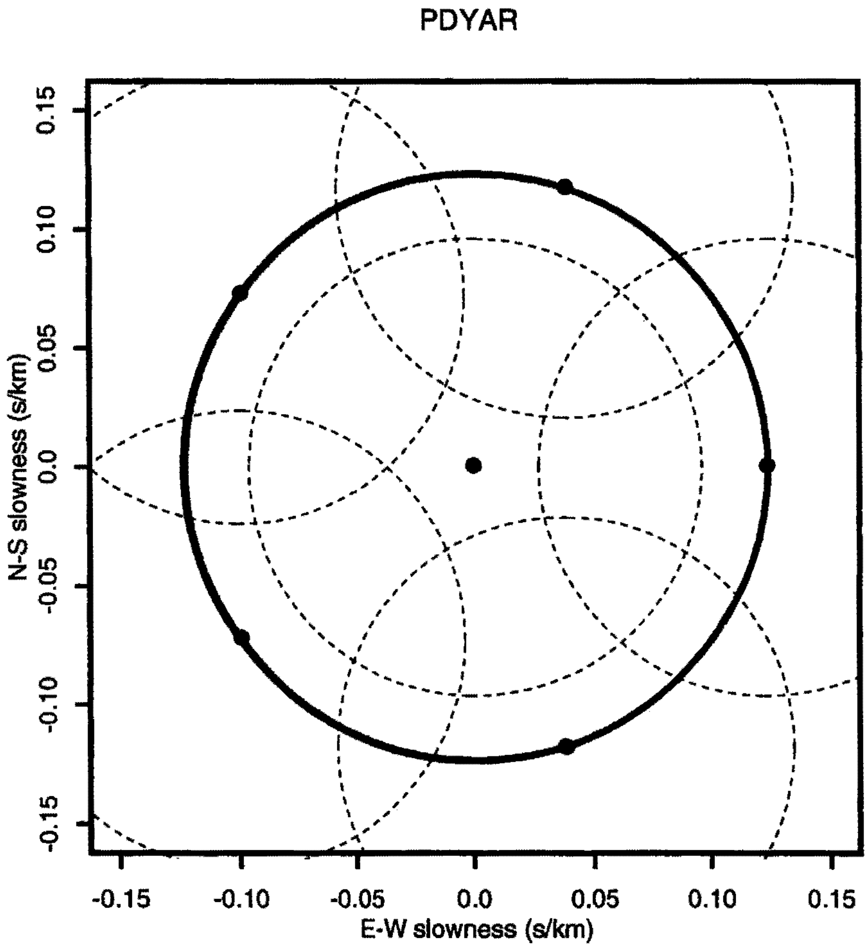

Fig. 6.5.15. PDYAR beam deployment used in the TM system for assessing the detection capability in the distance range 0-180 degrees. The area within the solid circle corresponds to the expected slowness range of P-phases from surface events in this distance range. In order to ensure complete coverage within the 3 dB level, it was necessary to deploy 6 beams, represented by the centers of the dashed circles. The radius of each small circle is 0.0962 s/km, corresponding to the expected mis-steering associated with the 3 dB signal loss.

Details on the tuned processing parameters for ARCES and PDYAR are given in Tables 6.5.3-6.5.5 below.

Table 6.5.3: Definitions of Array Configurations

Array	Configuration	sta_chan
ARCES	vertical	ARA0_sz ARB1_sz ARB2_sz ARB3_sz ARB4_sz ARB5_sz ARC1_sz ARC2_sz ARC3_sz ARC4_sz ARC5_sz ARC6_sz ARC7_sz ARD1_sz ARD2_sz ARD3_sz ARD4_sz ARD5_sz ARD6_sz ARD7_sz ARD8_sz ARD9_sz
PDYAR	vertical	PDY01_sz PDY02_sz PDY03_sz PDY04_sz PDY05_sz PDY06_sz PDY07_sz PDY08_sz PDY09_sz

Table 6.5.4: TM Tuning Parameters

Array	Distance interval (deg)	Config.	Frequency band (Hz)	A/T correction (m_b units)	Signal loss (dB)	3 dB level (s/km)	Number of beams
ARCES	0-15	vertical	2.5 - 8.0	-0.072±0.203	1.370	0.043	9
ARCES	15-180	vertical	1.5 - 6.0	0.209±0.176	0.541	0.106	4
PDYAR	0-180	vertical	0.8 - 4.5	-0.049±0.048	1.280	0.096	6

Table 6.5.5: Beam Steering Parameters

Array	Distance interval (deg)	Azimuth (deg) and slowness (s/km) of beams					
ARCES	0-15	0.0, 0.111	40.0, 0.111	80.0, 0.111	115.0, 0.111	160.0, 0.111	150.0, 0.111
		240.0, 0.111	280.0, 0.111	315.0, 0.111			
	15-180	0.0, 0.059	90.0, 0.059	180.0, 0.059	270.0, 0.059		
PDYAR	0-180	0.0, 0.0	0.0, 0.123	72.0, 0.123	144.0, 0.123	216.0, 0.123	288.0, 0.123

References

Taylor, L., T. Kværna, and F. Ringdal (1998). Threshold Monitoring Operations Manual. NORSAR Contribution No. 639.

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L. Taylor