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7.2 Initial results from real-time processing of GERESS array data

Introduction

The GERESS array (Harjes, 1990) represents the most recent addition to the network of regional seismic arrays in Europe. GERESS, which is located in the Bavarian Forest area in southern Germany, has a geometry similar to that of NORESS in southern Norway and ARCESS in northern Norway, but with a slightly enlarged instrument spacing (Fig. 7.2.1). Thus the diameter of GERESS is 4 km, compared to 3 km for the two arrays in Norway.

Real-time data from GERESS are transmitted continuously both to Bochum, Germany (by land line), and to the NORSAR Data Processing Center (NDPC) at Kjeller (by satellite). At NDPC, the data are currently subjected to continuous real-time detection processing, using the RONAPP algorithm (Mykkeltveit and Bungum, 1984). In the near future, these data will also be incorporated into the Intelligent Monitoring System (IMS) (Bache *et al*, 1990).

GERESS real-time processing

The initial processing of GERESS data is conducted at NDPC using a beam set essentially identical to that being used for NORESS and ARCESS data (see Subsection 3.4). Although several modifications will undoubtedly be desirable after more experience is gained, it is still of interest to observe how a "generic" parameter set performs when applied to a regional array in a new geological environment. Below, we give some initial examples from this processing.

Table 7.2.1 shows excerpts from the automatic GERESS phase detection list for day 293 (23 October 1990). For each phase, the detection time, beam number, SNR, phase velocity and azimuth are listed, together with a number of attributes used in further characterization of the detected phase.

In Fig. 7.2.2 we show an automatically generated event plot (Fyen, 1989) for one of the located events during the time period covered by the detection list in Table 7.2.1. This event is located in the Lubin mining district in Poland, at a distance of 344 km from GERESS, and is probably one of a large number of rockbursts known to occur in that region (Gibowics, 1987). We note that this event was too small to be detected by either NORESS, ARCESS or FINESA.

Fig. 7.2.3 shows GERESS automatic output plot from the P-wave detection of the Novaya Zemlya explosion 24 October 1990 (Δ = 30.4 degrees). The phase velocity is indicative of a teleseismic signal, and the estimated azimuth is consistent with the actual epicenter. GERESS SNR is 105 on the array beam, which is naturally lower than for the three other arrays, all of which are within regional distances from Novaya Zemlya.

An interesting feature of the GERESS recordings of this event is a very sharp PcP detection at 2 min 59.5 seconds after P (Fig. 7.2.4). The time differential between P and PcP gives a very sharp constraint on the epicentral distance, in particular when the phase onset times can be read as precisely as in this case. Thus, given appropriate calibration, very useful location information could be derived.

Conclusions

Our initial experience shows that real-time processing of GERESS data will form a very valuable contribution to the regional array monitoring research network. So far, it appears that many new events in southern Europe within 500 km distance from GERESS will be added, and GERESS data will provide further constraints on the events detected and located by more than one array. The teleseismic potential of GERESS is also quite promising.

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323	293:12.43.29.700	1.10	G053	4.8	2.6	nois	298.5	0.06	4	4.02	953.3	173.9	A3_sz	-1.00	-1.00	-1.00	-1.00
324	293:12.43.39.750	1.25	GV01	3.8	12.9	P	191.0	0.17	1	0.56	76.5	404.7	C1_sz	0.59	2.06	80.33	4.28
325	293:12.45.10.987	0.31	G084	7.7	2.5	nois	310.0	0.07	4	6.31	2650.3	505.5	D5_sz	-1.00	-1.00	-1.00	-1.00
326	293:12.45.19.300	1.20	GV01	7.2	4.3	S	201.9	0.11	3	0.72	289.1	658.7	D5_sz	-1.00	-1.00	-1.00	-1.00
327	293:12.47.07.050	0.75	G043	15.5	2.4	nois	124.5	0.05	4	3.16	1472.7	268.3	C5_sz	-1.00	-1.00	-1.00	-1.00
328	293:12.47.16.475	1.02	GV06	3.2	1.9	nois	310.0	0.09	3	4.79	1713.6	609.2	C5_sz	-1.00	-1.00	-1.00	-1.00
329	293:12.47.39.300	1.00	G011	7.2	14.7	P	202.8	0.29	1	1.31	74.5	340.9	C5_sz	0.42	1.34	8.20	4.21
330	293:12.56.39.725	0.98	GV01	6.0	35.9	P	346.7	0.54	1	1.04	118.7	498.4	A3_sz	0.54	3.06	89.38	3.18
331	293:12.58.45.675	0.22	GH03	3.9	2.9	nois	45.7	0.07	3	7.74	2095.2	299.4	C1_sz	-1.00	-1.00	-1.00	-1.00
332	293:12.58.50.300	0.50	G032	4.5	37.7	P	147.3	0.09	3	3.30	167.0	85.9	C1_sz	-1.00	-1.00	-1.00	-1.00
333	293:13.01.31.481	1.12	G103	6.8	2.8	nois	339.3	0.04	4	7.74	2619.1	659.5	A0_sz	0.34	1.85	86.29	33.93
334	293:13.04.21.800	1.30	G034	7.3	2.8	nois	145.4	0.07	3	2.13	477.6	126.0	A3_sz	-1.00	-1.00	-1.00	-1.00
335	293:13.04.27.650	0.65	G021	4.7	3.2	S	3.6	0.05	4	1.94	491.2	118.1	A3_sz	-1.00	-1.00	-1.00	-1.00
336	293:13.11.29.750	0.55	G036	7.3	2.8	nois	140.6	0.08	3	2.14	349.7	134.6	A3_sz	-1.00	-1.00	-1.00	-1.00
337	293:13.11.40.075	1.12	GV01	3.1	15.6	P	30.5	0.56	1	0.79	164.7	335.2	A3_sz	0.60	3.14	88.70	5.40
338	293:13.15.50.331	0.17	GH04	3.7	2.4	nois	31.0	0.05	4	8.29	689.6	256.7	A0_sz	0.19	2.25	64.50	5.08
339	293:13.22.49.575	0.52	G033	4.6	2.8	nois	150.1	0.10	4	2.51	398.6	77.3	D8_sz	-1.00	-1.00	-1.00	-1.00
340	293:13.27.39.625	1.07	GV01	5.6	11.6	P	124.1	0.47	1	0.93	45.0	464.5	A3_sz	-1.00	-1.00	-1.00	-1.00
341	293:13.27.59.675	1.32	GV01	3.7	4.0	S	343.5	0.48	1	0.64	195.2	334.5	B3_sz	-1.00	-1.00	-1.00	-1.00
342	293:13.28.19.875	1.12	GV01	3.6	7.8	Pgn	150.7	0.47	1	0.86	72.8	329.6	B3_sz	-1.00	-1.00	-1.00	-1.00
343	293:13.30.14.306	0.59	GH04	4.2	3.1	S	333.1	0.04	4	5.64	1212.3	388.4	A3_sz	0.30	0.96	31.26	47.69
344	293:13.33.19.525	1.27	G034	17.7	8.0	Pgn	130.7	0.39	1	2.60	315.6	260.1	A0_sz	0.75	0.50	45.92	75.59
345	293:13.33.29.425	1.17	G044	6.3	8.0	Pgn	150.7	0.40	1	2.95	646.6	300.4	A0_sz	-1.00	-1.00	-1.00	-1.00
346	293:13.36.05.362	0.44	G087	11.2	4.2	S	106.5	0.06	4	6.44	2133.4	697.2	A3_sz	-1.00	-1.00	-1.00	-1.00
347	293:13.36.15.700	1.10	G051	4.9	3.0	nois	149.1	0.06	4	3.88	971.7	137.3	A3_sz	0.16	0.80	65.16	87.88
348	293:14.18.12.350	0.95	G059	12.1	7.5	Pgn	352.9	0.19	1	2.82	643.5	190.8	A0_sz	0.73	0.90	47.35	54.70
349	293:14.18.34.725	1.38	G065	8.9	4.2	SN	354.6	0.14	3	3.25	1872.5	308.1	A0_sz	0.67	1.82	85.96	10.60
350	293:14.18.38.950	1.25	GV06	4.4	4.3	S	0.7	0.12	3	3.93	1300.8	691.4	A0_sz	-1.00	-1.00	-1.00	-1.00
351	293:14.25.06.875	0.92	G044	9.4	3.0	S	142.7	0.06	3	3.05	861.0	197.0	D2_sz	-1.00	-1.00	-1.00	-1.00
352	293:14.25.10.025	1.67	GV02	4.4	2.7	nois	149.5	0.06	3	1.86	406.4	279.0	D2_sz	-1.00	-1.00	-1.00	-1.00
353	293:14.25.36.925	1.38	G055	6.1	2.5	nois	267.7	0.06	4	4.18	645.3	128.0	D7_se	0.20	1.14	78.45	51.94
354	293:14.46.24.550	1.95	GV02	3.1	28.4	P	106.1	0.16	3	1.89	34.9	93.3	B3_sz	-1.00	-1.00	-1.00	-1.00
355	293:14.49.39.275	1.02	G058	5.6	3.2	S	167.3	0.06	3	3.47	472.1	95.7	A3_sz	-1.00	-1.00	-1.00	-1.00
356	293:14.50.26.100	1.20	G034	4.6	3.8	S	339.4	0.06	4	2.46	359.0	77.7	D2_sz	-1.00	-1.00	-1.00	-1.00
357	293:14.51.39.350	1.35	GV01	7.4	7.2	Pgn	164.6	0.30	1	0.45	96.4	572.0	C5_sz	-1.00	-1.00	-1.00	-1.00
358	293:14.53.21.975	0.82	G051	5.0	1.8	nois	226.2	0.07	4	3.96	466.9	92.2	C1_sz	0.17	1.21	72.27	33.76
359	293:14.54.31.281	0.82	G104	7.4	3.2	SN	160.4	0.04	4	8.96	3746.4	1052.4	A3_sz	0.27	2.95	89.00	4.00
360	293:14.55.49.975	0.62	G035	6.9	2.9	nois	274.0	0.05	4	2.69	537.3	110.2	D2_sz	-1.00	-1.00	-1.00	-1.00
361	293:14.57.11.050	1.05	G035	8.2	2.8	nois	140.7	0.07	3	1.98	713.8	133.3	C5_sz	-1.00	-1.00	-1.00	-1.00
362	293:14.57.19.325	1.48	G035	9.9	2.9	nois	153.5	0.05	3	2.15	881.3	225.2	C5_sz	-1.00	-1.00	-1.00	-1.00
363	293:14.57.24.750	0.95	GV02	3.6	2.9	nois	62.5	0.07	3	1.59	391.9	374.2	C5_sz	-1.00	-1.00	-1.00	-1.00
364	293:14.57.52.125	0.88	GV02	3.0	3.0	S	326.0	0.10	4	1.55	179.4	246.1	D5_sz	-1.00	-1.00	-1.00	-1.00
365	293:15.01.53.150	0.95	G034	5.3	3.0	S	153.8	0.08	3	2.18	383.9	79.6	A3_sz	-1.00	-1.00	-1.00	-1.00
366	293:15.07.29.725	0.88	G035	8.7	2.7	nois	284.7	0.05	4	2.47	846.6	144.6	D2_sz	0.35	1.61	82.97	53.64
367	293:15.09.02.475	1.12	G049	5.6	3.8	S	341.7	0.07	3	3.17	416.6	103.9	A3_sz	-1.00	-1.00	-1.00	-1.00
368	293:15.11.04.450	0.65	G042	5.1	3.1	S	254.3	0.05	4	2.82	1218.1	103.7	A3_sz	-1.00	-1.00	-1.00	-1.00
369	293:15.11.31.775	0.82	G056	6.6	35.3	P	223.5	0.06	4	3.84	118.4	170.2	A3_sz	0.30	1.61	87.77	22.09
370	293:15.18.34.575	0.52	G038	6.0	2.8	nois	147.0	0.09	3	2.08	762.8	86.8	C1_sz	0.20	0.77	83.64	79.27
371	293:15.18.39.225	1.07	G052	6.5	2.6	nois	105.5	0.09	3	4.59	647.0	147.5	D5_sz	0.17	1.60	87.76	4.35
372	293:15.45.33.575	0.52	G033	707.5	2.4	nois	295.2	0.03	4	2.26	26191.2	11225.5	A3_sz	0.26	1.46	83.60	34.12
373	293:16.08.43.925	2.17	G011	4.5	6.9	Pgn	348.1	0.19	3	1.08	320.3	183.4	D9_sz	0.39	2.50	89.11	21.66
374	293:16.12.06.075	1.23	G036	5.1	12.4	P	258.1	0.09	4	2.32	122.2	99.8	D8_sz	-1.00	-1.00	-1.00	-1.00
375	293:16.28.21.575	0.52	G049	4.8	2.9	nois	146.9	0.13	3	2.51	343.0	87.3	D5_sz	0.57	0.87	39.37	48.97
376	293:16.28.25.875	2.12	GV06	5.3	6.8	Pgn	33.3	0.19	3	4.82	880.2	566.5	D5_sz	0.59	0.94	41.68	50.28
377	293:16.28.35.800	0.50	G057	4.8	6.8	Pgn	32.3	0.21	2	3.71	417.6	147.1	D5_sz	-1.00	-1.00	-1.00	-1.00
378	293:16.29.10.675	0.52	GH01	6.2	4.6	S	40.1	0.20	3	2.88	2349.6	1100.9	B3_sz	0.22	1.45	71.53	14.51

Table 7.2.1. (Page 1 of 2)

379	293:16.29.14.425	1.57	GV02	4.0	3.3	LG	31.5	0.31	2	1.47	1019.1	508.0	B3_sz	0.55	1.41	79.68	77.38
380	293:16.29.18.375	1.62	GV02	3.1	4.4	S	24.5	0.32	1	1.59	1159.0	505.8	B3_sz	-1.00	-1.00	-1.00	-1.00
381	293:16.29.19.725	0.98	GV01	5.6	3.5	S	19.1	0.23	2	1.51	764.1	915.5	A0_sz	-1.00	-1.00	-1.00	-1.00
382	293:16.35.18.525	2.48	GV01	3.4	29.9	P	277.5	0.14	3	0.83	114.9	304.4	D4_sn	-1.00	-1.00	-1.00	-1.00
383	293:17.12.59.500	1.20	GV01	5.6	26.4	P	146.9	0.45	1	1.08	158.6	681.5	B3_sz	-1.00	-1.00	-1.00	-1.00
384	293:17.15.23.700	0.90	G093	7.1	6.3	Pgn	113.5	0.05	4	7.43	1175.0	453.0	A3_sz	-1.00	-1.00	-1.00	-1.00
385	293:17.36.39.750	0.95	GV01	7.6	5.0	S	206.3	0.14	4	1.03	286.6	902.8	B2_sz	-1.00	-1.00	-1.00	-1.00
386	293:17.48.42.350	0.95	G049	5.3	4.4	S	145.0	0.06	3	3.27	506.9	100.5	A3_sz	-1.00	-1.00	-1.00	-1.00
387	293:17.51.19.950	0.75	GV01	6.0	9.4	Pgn	315.4	0.24	1	0.57	94.2	460.0	A0_sz	-1.00	-1.00	-1.00	-1.00
388	293:18.38.37.850	3.15	GV01	3.4	8.2	Pgn	187.5	0.42	1	0.86	44.2	400.8	C1_sz	0.25	1.78	88.86	8.36
389	293:18.46.16.650	1.45	G042	4.9	2.9	nois	138.2	0.14	3	3.05	597.5	88.7	B5_sz	-1.00	-1.00	-1.00	-1.00
390	293:18.48.49.825	0.48	G071	5.0	3.3	S	121.9	0.05	4	4.77	435.7	166.8	A3_sz	-1.00	-1.00	-1.00	-1.00
391	293:18.49.08.950	1.55	GV04	3.1	2.7	nois	140.1	0.08	3	2.37	294.5	212.6	C5_sz	-1.00	-1.00	-1.00	-1.00
392	293:18.49.19.525	0.77	G054	5.2	13.0	P	290.4	0.06	4	4.01	86.6	103.2	D5_sz	-1.00	-1.00	-1.00	-1.00
393	293:18.51.32.550	1.55	G053	5.6	2.8	nois	321.8	0.07	4	3.68	521.0	101.3	A0_sz	0.54	2.47	85.13	18.21
394	293:18.56.19.125	1.57	GV01	4.0	4.8	S	294.2	0.16	3	1.02	369.7	423.5	D2_sz	-1.00	-1.00	-1.00	-1.00
395	293:19.08.01.150	1.55	GV02	3.1	2.2	nois	129.2	0.08	3	1.68	283.3	186.2	D2_sz	-1.00	-1.00	-1.00	-1.00
396	293:19.08.39.500	1.20	GV01	6.4	8.3	Pgn	162.1	0.42	1	0.63	130.4	774.7	D5_sz	-1.00	-1.00	-1.00	-1.00
397	293:19.10.00.175	0.82	GV01	3.8	5.8	S	23.0	0.32	1	0.64	251.0	385.7	B4_sz	-1.00	-1.00	-1.00	-1.00
398	293:19.19.29.750	0.55	G021	4.6	16.4	P	132.7	0.06	4	1.98	176.5	102.9	A3_sz	-1.00	-1.00	-1.00	-1.00
399	293:19.21.18.775	2.42	GV01	3.3	5.8	S	185.7	0.29	1	0.87	324.8	368.5	D8_sz	-1.00	-1.00	-1.00	-1.00
400	293:19.31.39.900	1.10	GV01	3.9	7.1	Pgn	167.2	0.26	1	0.85	64.1	377.5	D2_sz	-1.00	-1.00	-1.00	-1.00
401	293:19.40.59.925	1.07	GV01	3.3	22.8	P	14.2	0.44	1	0.93	65.9	314.0	A3_sz	1-1.00	-1.00	-1.00	-1.00
402	293:19.48.59.775	0.92	GV02	4.0	2.2	nois	29.2	0.08	3	1.97	211.5	213.5	C1_sz	-1.00	-1.00	-1.00	-1.00
403	293:20.07.57.375	2.92	G011	5.1	34.3	P	310.0	0.17	3	1.06	241.5	234.1	D2_sz	-1.00	-1.00	-1.00	-1.00
404	293:20.10.40.450	0.55	GV05	3.3	2.9	nois	146.0	0.13	3	2.16	285.6	256.6	C1_sz	-1.00	-1.00	-1.00	-1.00
405	293:20.18.48.525	0.77	G065	5.0	2.1	nois	218.7	0.06	4	4.11	363.7	89.4	D7_sn	-1.00	-1.00	-1.00	-1.00
406	293:20.20.40.025	0.98	GV02	3.0	6.1	Pgn	359.9	0.08	4	1.79	55.2	173.2	D9_sz	0.27	1.47	85.01	40.82
407	293:20.51.39.850	0.75	G053	4.8	3.2	SN	266.1	0.06	3	3.93	252.0	57.4	D2_sz	0.28	1.81	86.86	14.22
408	293:21.08.19.750	1.25	GV01	3.6	16.4	P	179.1	0.53	1	0.57	135.1	387.1	D8_sz	-1.00	-1.00	-1.00	-1.00
409	293:21.15.19.675	1.32	GV01	3.4	13.8	P	228.6	0.15	3	0.48	63.1	325.8	D5_sz	-1.00	-1.00	-1.00	-1.00
410	293:21.27.39.925	1.07	GV01	4.2	12.1	P	278.5	0.32	3	0.88	170.9	317.6	A3_sz	0.28	2.03	84.67	15.54
411	293:22.09.09.175	2.62	G021	5.1	48.6	P	329.0	0.32	2	1.33	179.7	110.9	A0_sz	-1.00	-1.00	-1.00	-1.00
412	293:22.40.00.225	0.77	GV01	4.0	4.8	S	317.6	0.33	1	0.96	229.5	341.6	B3_sz	-1.00	-1.00	-1.00	-1.00
413	293:23.17.59.375	1.62	GV01	3.1	8.8	Pgn	227.4	0.37	1	0.96	82.7	237.1	D5_sz	-1.00	-1.00	-1.00	-1.00
414	293:23.21.19.750	1.25	GV01	3.2	4.6	S	315.9	0.49	1	0.75	203.8	242.9	A3_sz	-1.00	-1.00	-1.00	-1.00
415	293:23.49.17.775	3.23	GV01	3.2	10.4	P	85.5	0.10	3	0.86	65.2	326.6	D9_sz	-1.00	-1.00	-1.00	-1.00

Table 7.2.1. Automatic event processor detection log for the GERESS array. From left to right the columns give arrival identification number, estimated onset time, difference in seconds between STA/LTA trigger time and onset time, beam name, SNR, velocity in km/sec, phase name, azimuth, broadband FK relative coherence measure and quality of FK (1=good), frequency in Hz of estimated maximum amplitude of the phase, phase maximum amplitude in uncorrected digital counts, STA. The next column with channel names gives, in case of many data gaps, the name of one channel that due to gaps/spikes, etc., may have contributed to a false detection. The four last numbers are result of three-component polarization analysis, and give rectilinearity, horizontal/vertical ratio, angle of incidence 1 and 3. (Page 2 of 2)

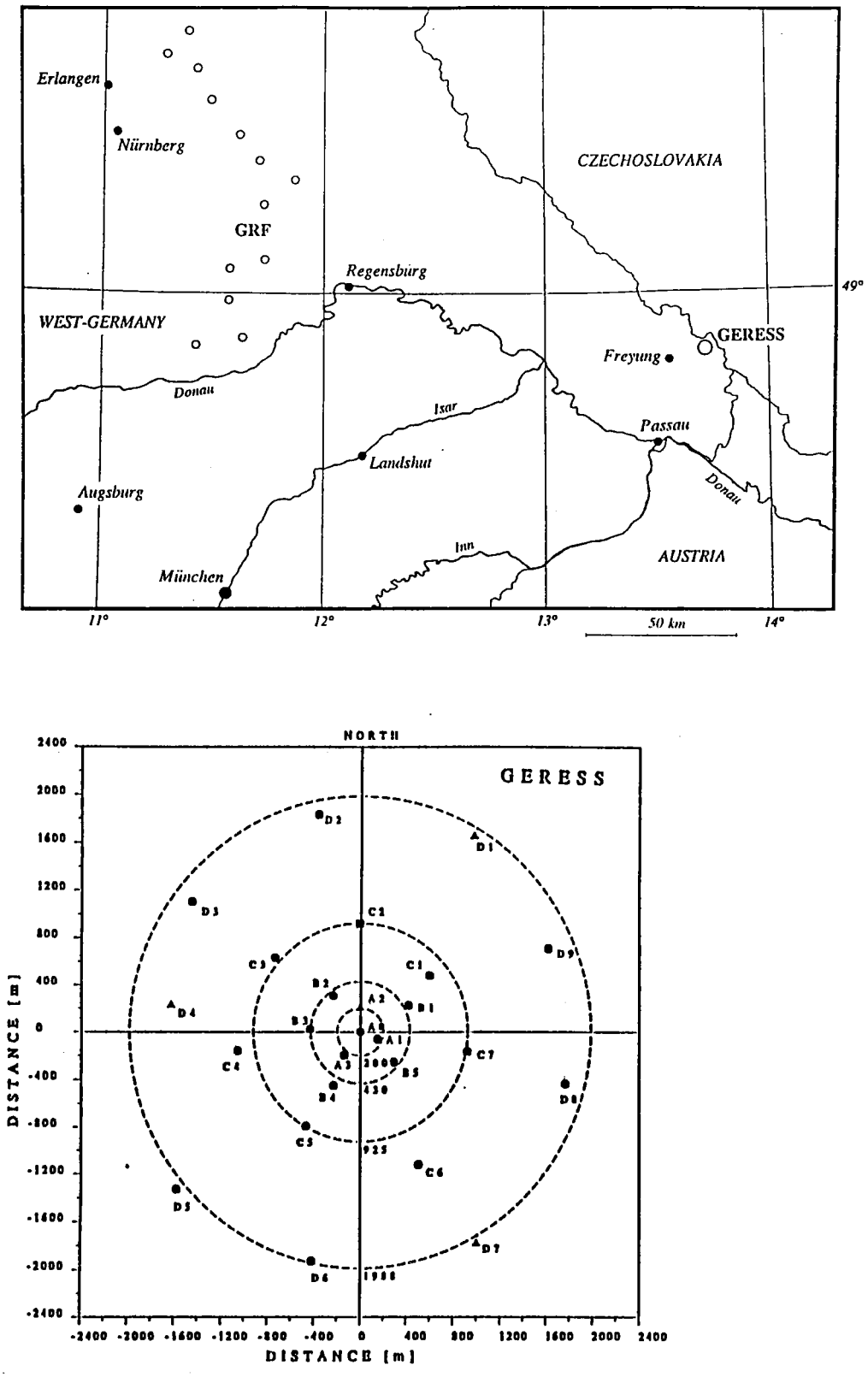

Fig. 7.2.1. Geographical location and geometry of the GERESS array in Germany (after Harjes, 1990).

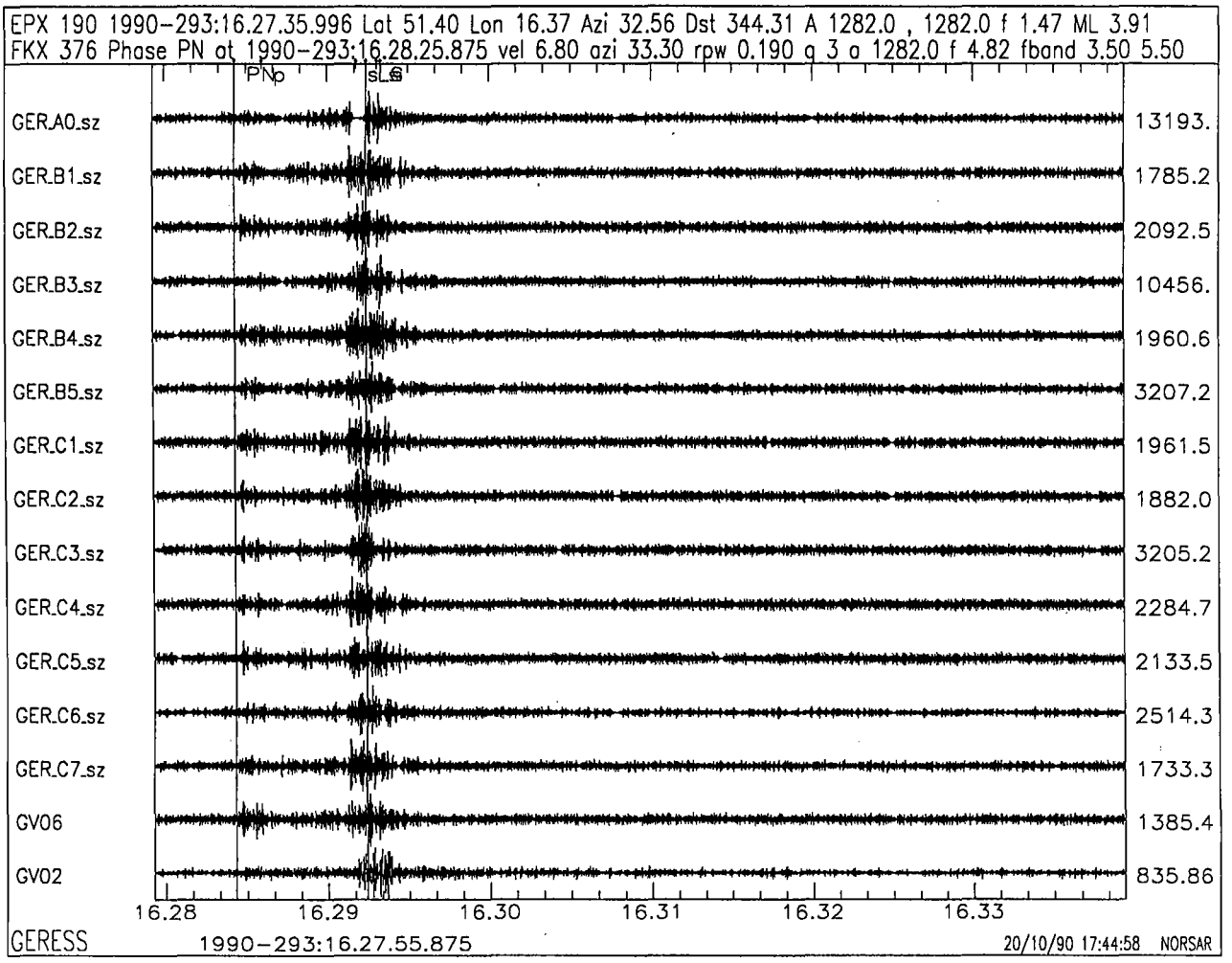

Fig. 7.2.2. Automatically generated event plot for GERESS. The traces shown are a selection of single instruments filtered in the band 3.5–5.5 Hz. The bottom two traces are the P- and S-beams using the velocities and azimuths determined by broadband F-K analysis. (The S-beam, which is the lowermost trace, is filtered in the band 1.0–2.0 Hz). The time window is 6 minutes.

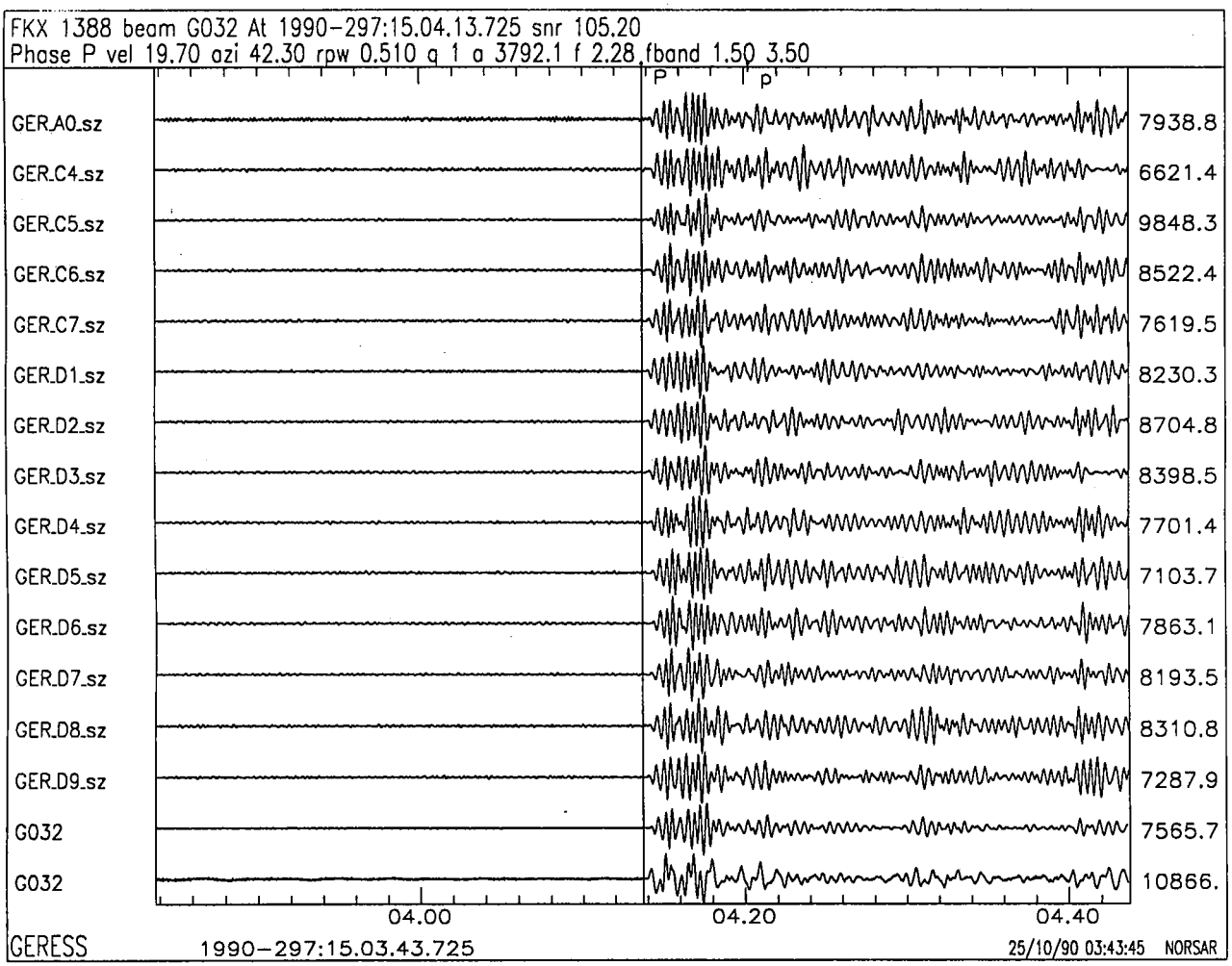

Fig. 7.2.3. Automatically generated teleseismic phase plot for GERESS, corresponding to the P-wave detection of the Novaya Zemlya explosion on 24 October 1990. The traces shown are a selection of single instruments filtered in the band 1.5–3.5 Hz. The bottom two traces are the P-beam filtered and unfiltered, using the velocity and azimuth determined by broadband FK analysis. The time window is 60 seconds.

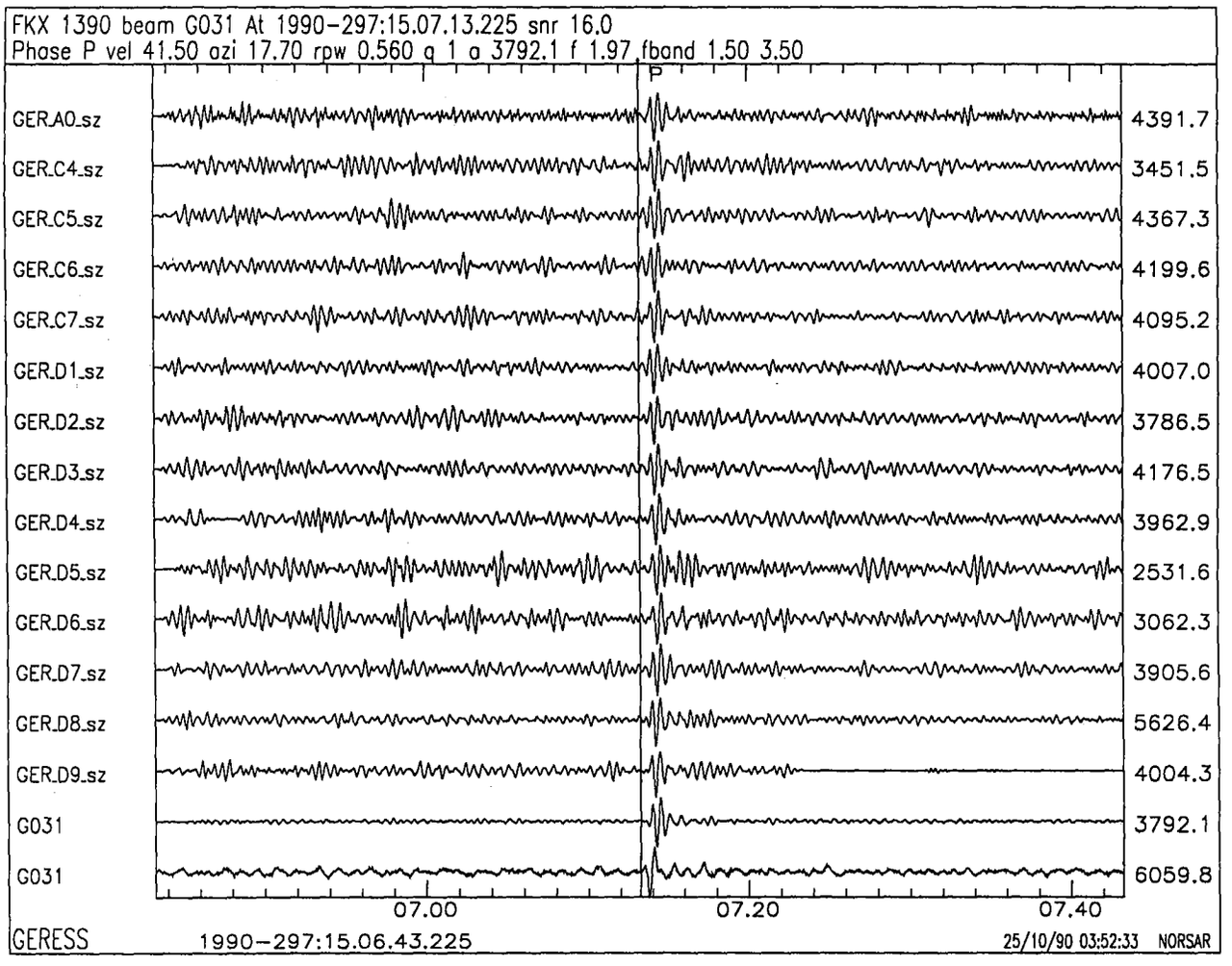

Fig. 7.2.4. Similar to Fig. 7.2.3, but showing the automatic plot for the PcP phase of the Novaya Zemlya explosion. Note the clear onset and the significant noise suppression on the filtered beam (second trace from bottom). Also note that the high estimated phase velocity (41.50 km/s) is a clear indication that this is indeed a core phase.