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Determination of Station Amplitude Magnitude Corrections for the Hawaiian Volcano Observatory Telemetered Seismographic Network: Data from 1992 - 1997

by

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INTRODUCTION

As an essential element of its volcano-monitoring mission, the Hawaiian Volcano Observatory (HVO) operates a regional seismographic network on the island of Hawaii. Seismographic stations are most densely distributed on the summits and along the active rift zones of Kilauea and Mauna Loa volcanoes. Signals from all remote stations are telemetered to the central recording and analysis site at HVO. As part of the routine monitoring, seismic signals are analyzed to determine regional earthquake frequency and hypocentral locations, estimate earthquake magnitudes, and catalog seismicity. We also archive the seismic data derived from the network.

HVO seismic monitoring operations have evolved from older recording and analysis systems, initially smoked-drum and photographic seismographs generating paper records, to the present, computerized recording and analysis systems using digitized seismic signals. Network instrument characteristics are described by Klein and Koyanagi, (1970), and updated in the annual seismic summaries. The first computer-based seismic processing system used at HVO was installed in 1979 and operated on a Data General Eclipse computer, with interactive analysis performed on a Tektronix 4014 graphics terminal. We currently use a version of the Caltech-USGS Seismic Processing (CUSP) system, running on a cluster of minicomputers and workstations. The system provides data acquisition, timing, and archiving tools. CUSP binary ".MEM" files are then converted to ASCII files for catalog locations. HYPOINVERSE is used as the standard location program for all data, past and present, in order to preserve consistency and maintain the ability to compare data over the long history of seismic monitoring in Hawaii.

AMPLITUDE MAGNITUDE CALCULATIONS

The Wood-Anderson and other photographic components, installed in 1956-1958 on Hawaii and Maui, form the basis for local magnitudes, M_L. Early magnitude determination for events of $M \geq 2.0$ was based on Wood-Anderson horizontals at the Hilo and Haleakala stations, and Sprengnether vertical and E-W components at the Uwekahuna station. Peak-to-peak amplitudes were read in millimeters and reduced to amplitude (x 1/2) and averaged to determine the magnitude for the given station. The event magnitude for the earthquake was an average for available magnitudes from Hilo, Haleakala and Uwekahuna. Poor or questionable readings were generally omitted. With the growth of the telemetered network, five calibrated network stations were incorporated into the amplitude magnitude determinations. The network station amplitudes were measured from the Develocorder and, starting in 1979, also from the Eclipse on a Tektronix 4014 graphics terminal. The period for the the amplitude readings was assumed to be an average of .2 seconds. In 1986, HVO converted to and installed a version of CUSP in which the capability to measure network station amplitudes on the Tektronix 4014 was not available. Amplitude magnitude calculations were then determined from the photographic records only. In July of 1992, HVO acquired VAX workstations and a generic version of CUSP that renewed the capability to measure peak amplitudes and the associated period in seconds digitally.

The same time, however, due to the escalating costs of maintenance, the existing photographic recording systems were discontinued. The instruments at the Haleakala station failed in mid-January 1992 and were never repaired. Photographic recording systems in the Uwekahuna vault, including the 3-component Press-Ewing, long-period systems, were terminated on September 9, 1992. This was followed by the termination of the Hilo station, with a Wood-Anderson seismograph, on October 13, 1993.

RE-ESTABLISH STATION AMPLITUDE MAGNITUDE CORRECTIONS

With the termination of the photographic records and the capability to read amplitudes from the CUSP system, we had to establish a method of calculating amplitude magnitude from the network stations that would be consistent with the Wood-Anderson magnitudes. This consistency would provide a hopefully seamless transition across changes in systems and platforms.

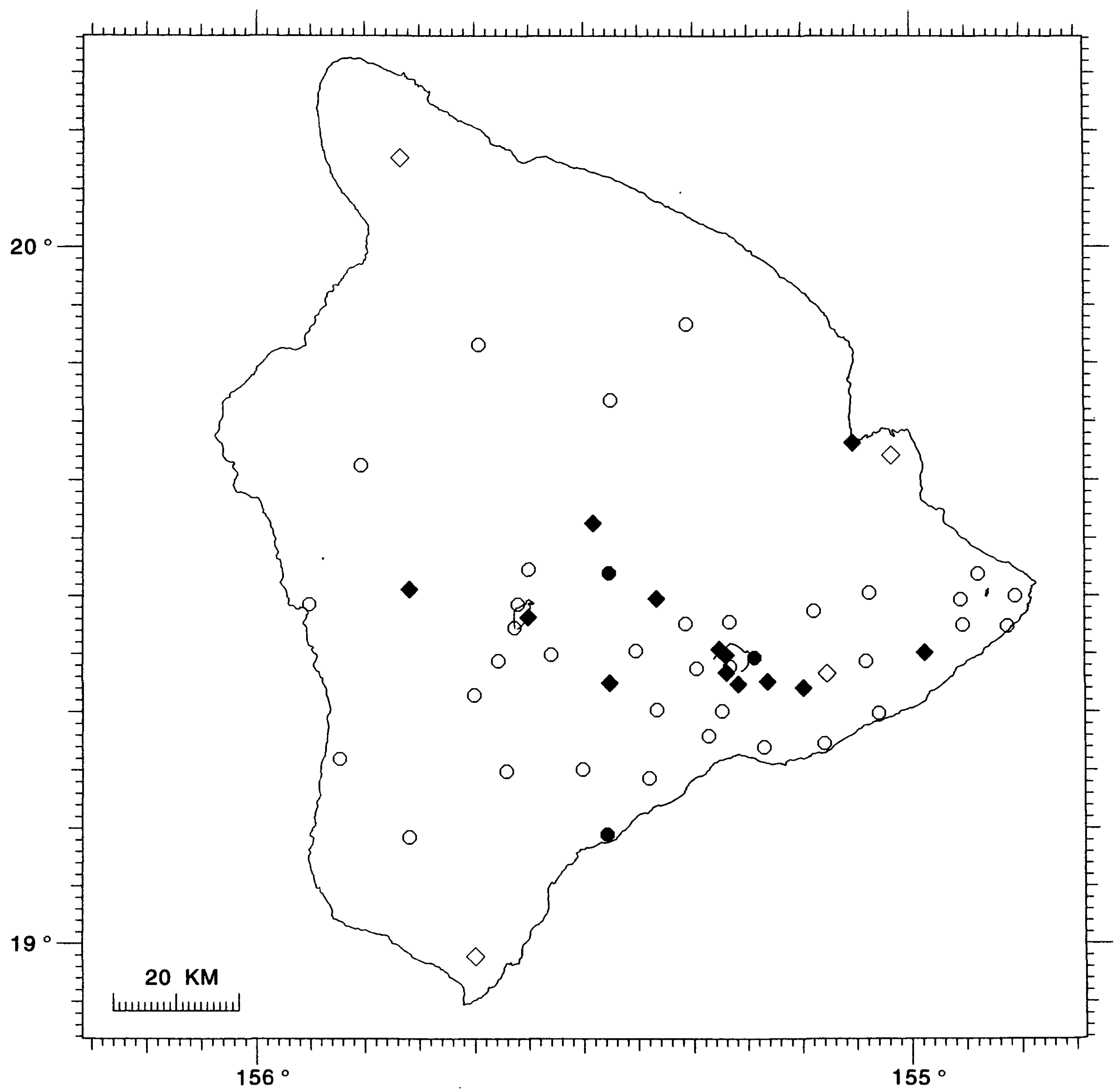
Amplitude data acquired from July 1992 to December 1993 were chosen for establishing the correspondence between Wood-Anderson magnitudes and individual network station magnitudes. During most of this period, photographic stations were in operation as was the ability to measure network station amplitudes on the computer workstation.

Magnitudes calculated by HYPOINVERSE (Klein, 1989, p 23) for the nineteen network components initially selected were compared to M_L. These components were selected because their instrument characteristics were recently determined by field or laboratory calibration. The observed differences in magnitudes would determine each network station's magnitude correction. The correction is added to the station's calculated magnitude to compensate for the difference between the station magnitude and the Wood-Anderson magnitude.

As calibration information became available, additional network components were later added to the initial nineteen network components, using a more current data set, January 1994 - July 1997. Figure 1 is a map of the station locations. Table 1 lists the coordinates and elevation of each site.

Figure 1. Map of Station Locations.

HVO SEISMIC NETWORK



Circles	= sites with vertical component only
Diamonds	= sites with more than one component
Solid Symbols	= sites with at least one component with established magnitude correction

Table 1. List of station coordinates and elevation.

Stations with vertical components only

STA	Lat	Lon	Elev
CAC	19 29.29	155 55.09	3230
CPK	19 23.70	155 19.70	10380
DAN	19 21.42	155 40.04	30030
DES	19 20.20	155 23.30	8150
ESR	19 24.68	155 14.33	11770
FEF	19 28.70	155 8.91	6910
HAB	19 31.89	154 53.89	920
HLP	19 17.96	155 18.63	7070
HPU	19 46.85	155 27.50	33960
HTC	19 14.33	155 24.02	3810
HUA	19 41.25	155 50.32	21890
KAA	19 15.98	155 52.28	5240
KAE	19 17.35	155 7.95	370
KFA	19 25.25	155 25.18	15790
KHU	19 14.90	155 37.10	19390
KKU	19 53.39	155 20.58	18630
KLC	19 24.35	155 4.08	6590
KLU	19 27.48	154 55.26	2710
KPN	19 20.10	155 17.40	9240
KPO	19 30.02	154 50.51	1340
MLX	19 27.60	155 20.70	14750
MOK	19 29.28	155 35.98	41040
MTV	19 30.25	155 3.75	4090
OKA	19 29.66	154 55.44	1800
OVE	19 9.21	155 45.92	13780
PLA	19 32.00	155 27.67	29920
POI	19 27.42	154 51.22	160
POL	19 17.02	155 13.47	1690
PPL	19 9.50	155 27.87	350
RCO	19 24.36	155 37.79	36010
RIM	19 23.90	155 16.60	11280
RSD	19 27.78	155 16.68	12700
SWR	19 27.26	155 36.30	40480
TRA	19 24.91	155 32.96	32070
WAI	19 51.58	155 39.60	14330
WHA	19 19.90	155 2.92	290
WOB	19 32.31	155 35.01	33960
WOO	19 15.08	155 30.12	9090

Stations with more than one component

STA	Lat	Lon	Elev
AHU	19 22.40	155 15.90	10700
AIN	19 22.50	155 27.62	15240
HIL	19 43.20	155 5.30	200
HSS	19 36.31	155 29.13	24450
HUL	19 25.13	154 58.72	3690
KII	19 30.56	155 45.90	18410
KOH	20 7.69	155 46.77	11660
MLO	19 29.80	155 23.30	20100
MPR	19 22.07	155 9.85	8810
NAG	19 42.12	155 1.72	180
NPT	19 24.90	155 17.00	11150
OTL	19 23.38	155 16.94	10380
PAU	19 22.62	155 13.10	9940
SPT	18 58.91	155 39.92	2440
STC	19 23.30	155 7.67	7650
URA	19 25.40	155 17.60	12401
WIL	19 28.15	155 35.02	40370

HYPOINVERSE

HYPOINVERSE uses an instruction file (.HYP). Commands and options specified in the instruction file control the parameters of the earthquake location output files. Table 2 is the HVO.HYP file that lists the commands and options exercised in the magnitude correction determinations that follow. MASTER.XMC is the file containing station amplitude magnitude corrections and MASTER.CAL is the file containing the station instrument calibrations. Station calibrations in HYPOINVERSE are expressed as the instrument magnification relative to the standard Wood-Anderson seismometer. Values in the XMC and CAL files include dates when these values changed.

Table 2 Hypoinverse command file for HVO earthquakes and .XMC and .CAL control files

```
*USE THIS FILE FOR 1993 AND LATER EARTHQUAKES
LET 4 0 0 /Use 4-letter codes, no net or comp code
H71 1 1 1 /Use old HI station & summary formats
STA 'HVOALL.STA' /Read station file
ATN F /Stations have cal factors, not attens
CAL 'MASTER.CAL' 92 1 1 0 0 /Read station calibration factors
XMC 'MASTER.XMC' T 92 1 1 0 0 /Read station amp mag corrections
UNK 4 'IRG1' 'IRG2' 'IRGE' 'WWVB' /Ignore fictitious CUSP station names
MUL T 2 /Use multiple models, #2 the default
CRT 1 'HVO.CRT' /Read gradient crust model #1 (outside)
CRT 2 'HVO.CRT2' /Read same model as crust model 2
NOD 19 22 155 10 31 6 1 /Define ring with model #1 inside
* SET MAGNITUDE OPTIONS
MAG 1 T 1 1 /Use coda duration magnitude
DUR -5.2 3.89 .013 .0037 0, -.905 2.026 .013 .0037 0, 210 0
FC1 'D' -1 /Use D label for duration mags, all comps
XC1 'N' 1 /Use N label for amp mag 1, all comps (new amp mag)
XC2 'W' 1 /Use W label for amp mag 2, all comps (Wood-Anderson mag)
XCH F /Select station for amp mag by instrument type
XTY 1 1 0 0  1 0 0 0 /Select number of instrument types for XMAG1 & XMAG2 followed by
                                 instrument type code(s)
PRE 2, 2 0 0 9, 2 0 0 9 /Preferred mag: dur (MD) before amp (MX)
* SET NETWORK OPTIONS
ERR .15 /Estimated net timing error
NET 1 /Use Hawaii region names & codes
APP F F F /Do not append to output files
JUN T /Cancel residual weighting of junk events
TOP F /No page ejects in printfile
LST 2 1 0 /Station list but no models in printfile
ERF T /Send error messages to terminal
REP T T /Log evts to term/prt unweighted stations
KPR 2 /Medium print output each event
COP 1 /Default phase format is phase
CAR 1 /Default output format is archive
DAM 8* 500. /Allow iterations out to 500 km
```

Table 2. (continued) Magnitude Correction File (MASTER.XMC)

Sta/Comp			Sta Code	Mag Corr	End * Date	Mag Corr
AHUV	HV	V	3	5.0	920101	0.60
AHUE	HV	E	0	5.0	920101	-.55
AHUN	HV	N	0	5.0	920101	-.55
AINN	HV	N	0	5.0	920101	-.62
ESRV	HV	V	3	5.0	940101	0.45
HIEE	HV	E	0	0.0		
HINN	HV	N	0	0.0		
HILV	HV	V	1	1.2		
HSSE	HV	E	0	5.0	920101	-.57
HSSN	HV	N	0	5.0	920101	-.75
HULV	HV	V	3	5.0	920101	0.75
HULN	HV	N	0	5.0	970101	-1.35
KIIE	HV	E	0	5.0	920101	-.65
KIIN	HV	N	0	5.0	920101	-.60
MLOE	HV	E	0	5.0	920101	-.40
MLON	HV	N	0	5.0	920101	-.53
MPRV	HV	V	3	5.0	940101	0.5
MPRZ	HV	Z	3	5.0	940101	0.0
NPTN	HV	N	0	5.0	920101	-.35
OTLV	HV	V	3	5.0	920101	0.55
OTLZ	HV	Z	3	5.0	940101	0.25
PAUE	HV	E	0	5.0	920101	-.56
PAUN	HV	N	0	5.0	920101	-.45
PLAV	HV	V	3	5.0	920101	0.70
PPLV	HV	V	3	5.0	920101	0.7
UEEE	HV	E	1	1.0		
UENN	HV	N	1	1.0		
UEZV	HV	V	1	1.0		
URAE	HV	E	0	5.0	920101	-.62
URAN	HV	N	0	5.0	920101	-.64
URAV	HV	V	3	5.0	940101	.40
WILE	HV	E	0	5.0	940101	-.35
WILN	HV	N	0	5.0	940101	-.35

Station codes: 0=Wood-Anderson (or Modified Wood-Anderson)
1=Network
3=Network

* Defines the end date of one magnitude correction and the beginning date of new magnitude correction.

Table 2. (continued) Calibration File (MASTER.CAL)

Sta/Comp			Cal Fac	End * Date	Cal Fac	End * Date	Cal Fac	End * Date	Cal Fac
AHUV	HV	V	0.0	74092310	2.6	96020915	3.1		
AHUE	HV	E	0.0	840406	3.0				
AHUN	HV	N	0.0	840406	3.0				
AINN	HV	N	0.0	840723	3.0				
ESRV	HV	V	1.7	76021312	2.2	94010100	2.8	96031308	3.0
HIEE	HV	E	1.0						
HINN	HV	N	1.0						
HILV	HV	V	1.0						
HSSE	HV	E	0.0	841002	3.0				
HSSN	HV	N	0.0	841002	3.0				
HULV	HV	V	3.0	78032013	1.6				
HULN	HV	N	0.0	840907	3.0				
KIIE	HV	E	0.0	840913	3.0				
KIIN	HV	N	0.0	840913	3.0				
MLOE	HV	E	0.0	851104	3.0				
MLON	HV	N	0.0	851104	3.0				
MPRV	HV	V	1.7	75110712	2.6				
MPRZ	HV	Z	0.08						
NPTN	HV	N	0.0	841012	3.0				
OTLV	HV	V	4.8	76092211	2.6	96020709	3.2		
OTLZ	HV	Z	0.08	96020709	0.1				
PAUE	HV	E	0.0	841107	3.0				
PAUN	HV	N	0.0	841107	3.0				
PLAV	HV	V	6.8	79080112	5.4	92010109	6.3		
PPLV	HV	V	2.2	79080110	1.4				
UEEE	HV	E	1.0						
UENN	HV	N	1.0						
UEZV	HV	V	1.0						
URAE	HV	E	0.0	880122	3.0				
URAN	HV	N	0.0	880122	3.0				
URAV	HV	V	0.0	940101	1.4				
UUGZ	HV	Z	.001						
WILE	HV	E	0.0	851030	3.0				
WILN	HV	N	0.0	851030	3.0				

* Defines the end date of one calibration factor and the beginning date of new calibration factor.

M_L - MAGNITUDE BASE

The 1992_93 data set (92-93 for brevity) consists of 2,623 earthquakes. Long-period earthquakes were not included in the test data set because of their low frequency and harmonic amplitude characteristics. Only Wood-Anderson components would give a true M_L. Of the 92-93 data set, just a handful of the events had Wood-Anderson (HIEE and/or HINN) readings. To improve quality and quantity of the events, the other photographic records (HILV, UEZV, UEEE, UENN) were needed to strengthen our M_L magnitude base. We compared Wood-Anderson magnitudes to magnitudes calculated from HILV, UEZV, UEEE, and UENN (network-type instruments) to determine if magnitude corrections were needed for those components.

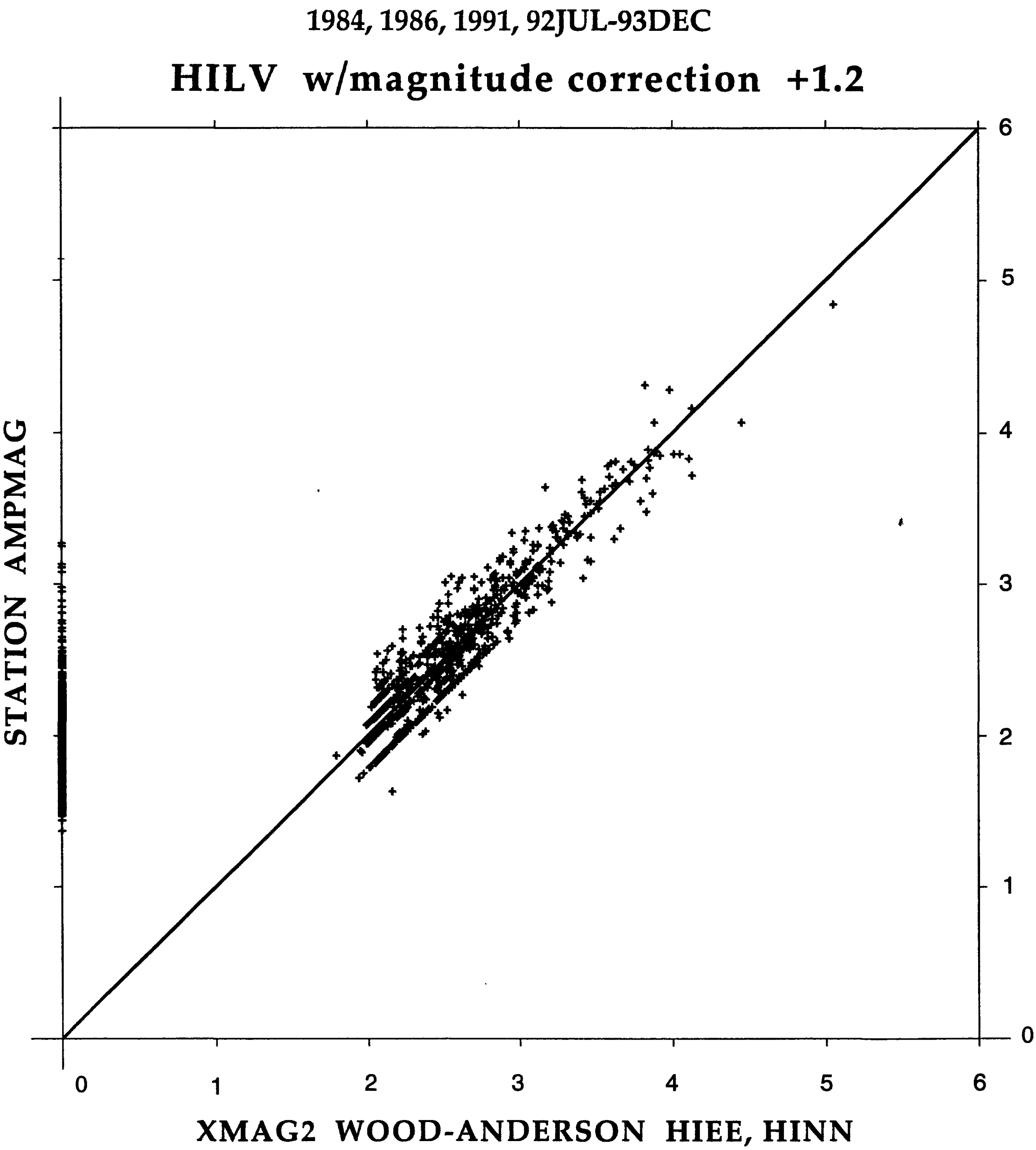
A HYPOINVERSE run using 1984, 1986, 1991 and the 92-93 phase data showed corrections were needed for HILV and the Uwekahuna components. Figures 2-5 compare each component's magnitude to Wood-Anderson magnitude, with the determined corrections of +1.2 applied to HILV and +1.0 applied to each of the Uwekahuna components. Figure 6 compares the Wood-Anderson magnitudes with the average magnitudes of the other photographic components. Together, the Wood-Anderson components and the other photographic components, with corrections applied, determine M_L.

DATA SET - JULY 1992 - DECEMBER 1993

Figure 7 is an hypocentral plot of the 92-93 data set. It illustrates the distribution of the earthquakes used for testing to determine the amplitude magnitude corrections.

The network stations chosen for magnitude correction evaluation were selected because they had recent field calibration values and a sufficient quantity of readings. Between 1984 and 1986, all the horizontal network components were modified to produce a Wood-Anderson like response, but at times-3 magnification (refer, for example, to figure 4 in Nakata et al., 1994). Thus the Modified Wood-Anderson stations are assigned the HYPOINVERSE Wood-Anderson instrument code (0), with a calibration factor of 3.0.

Figure 2.



1984, 1986, 1991, 92JUL-93DEC
HILV w/magnitude correction +1.2
STATION AMPMAG
XMAG2 WOOD-ANDERSON HIEE, HINN
0
1
2
3
4
5
6

Figure 3.

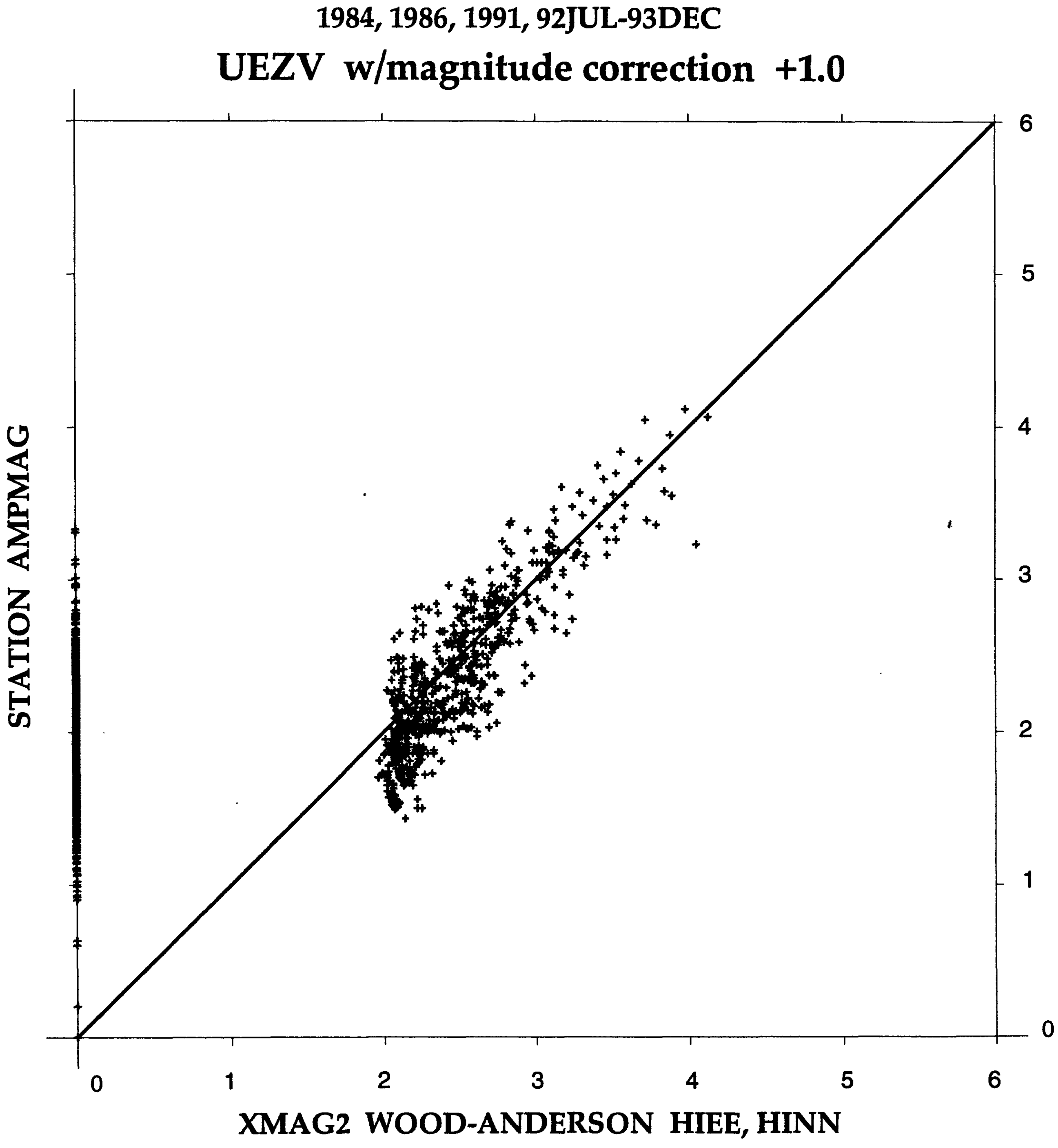

1984, 1986, 1991, 92JUL-93DEC
UEZV w/magnitude correction +1.0
STATION AMPMAG
XMAG2 WOOD-ANDERSON HIEE, HINN
0
1
2
3
4
5
6

Figure 4.

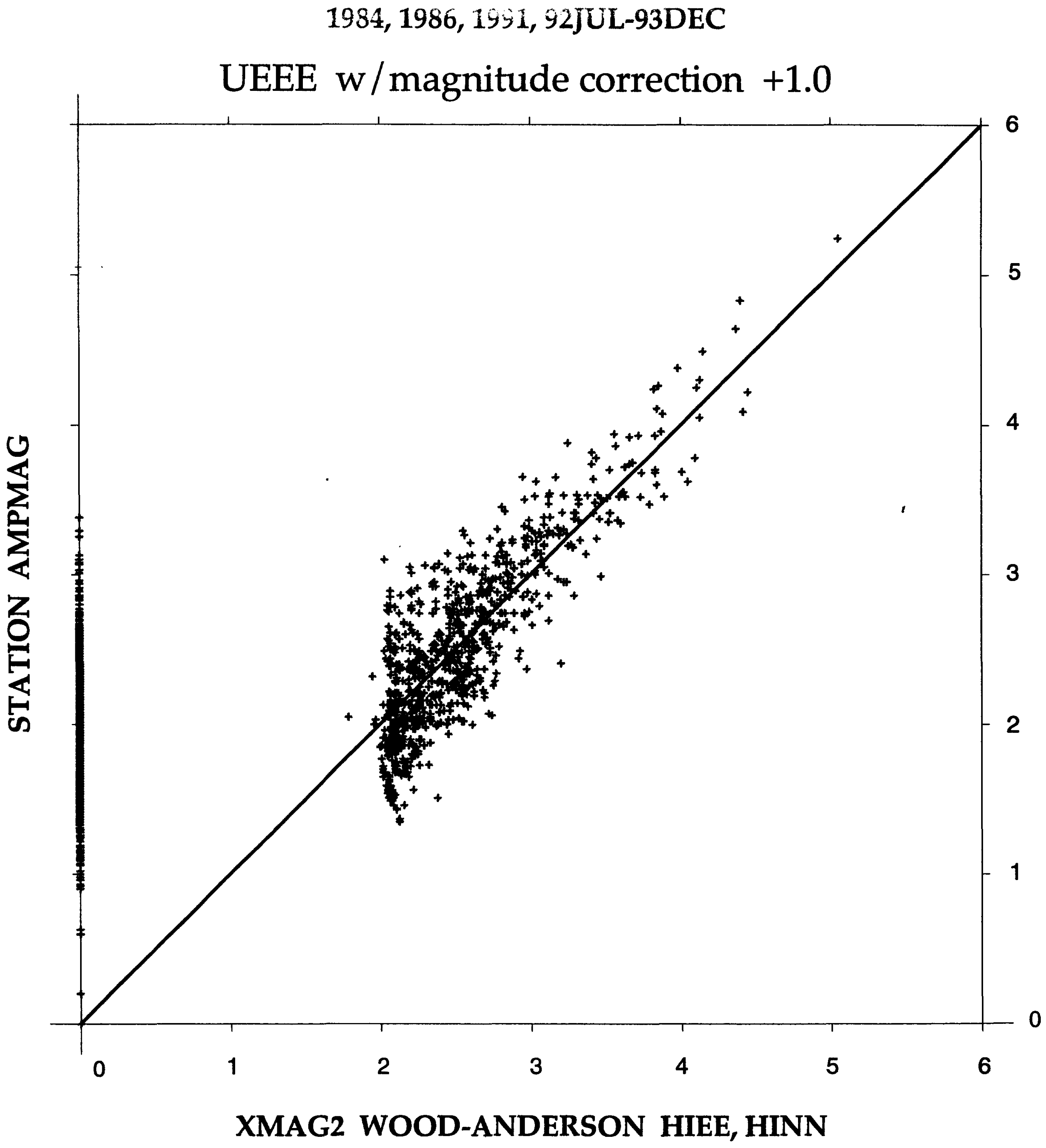
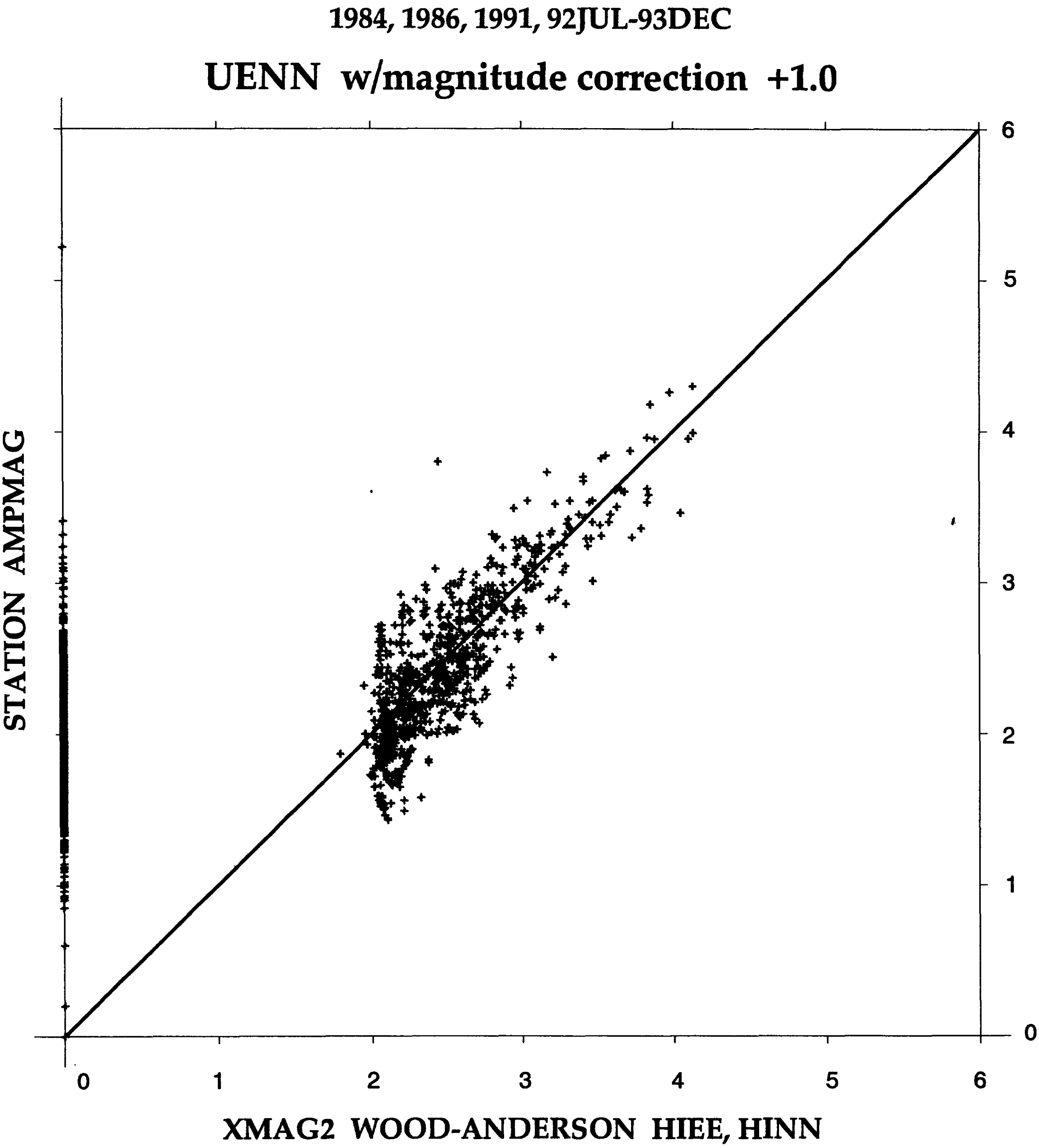

1984, 1986, 1991, 92JUL-93DEC
UEEE w/magnitude correction +1.0
STATION AMPMAG
XMAG2 WOOD-ANDERSON HIEE, HINN
0
1
2
3
4
5
6

Figure 5.



1984, 1986, 1991, 92JUL-93DEC
UENN w/magnitude correction +1.0
STATION AMPMAG
XMAG2 WOOD-ANDERSON HIEE, HINN
0
1
2
3
4
5
6

Figure 6.

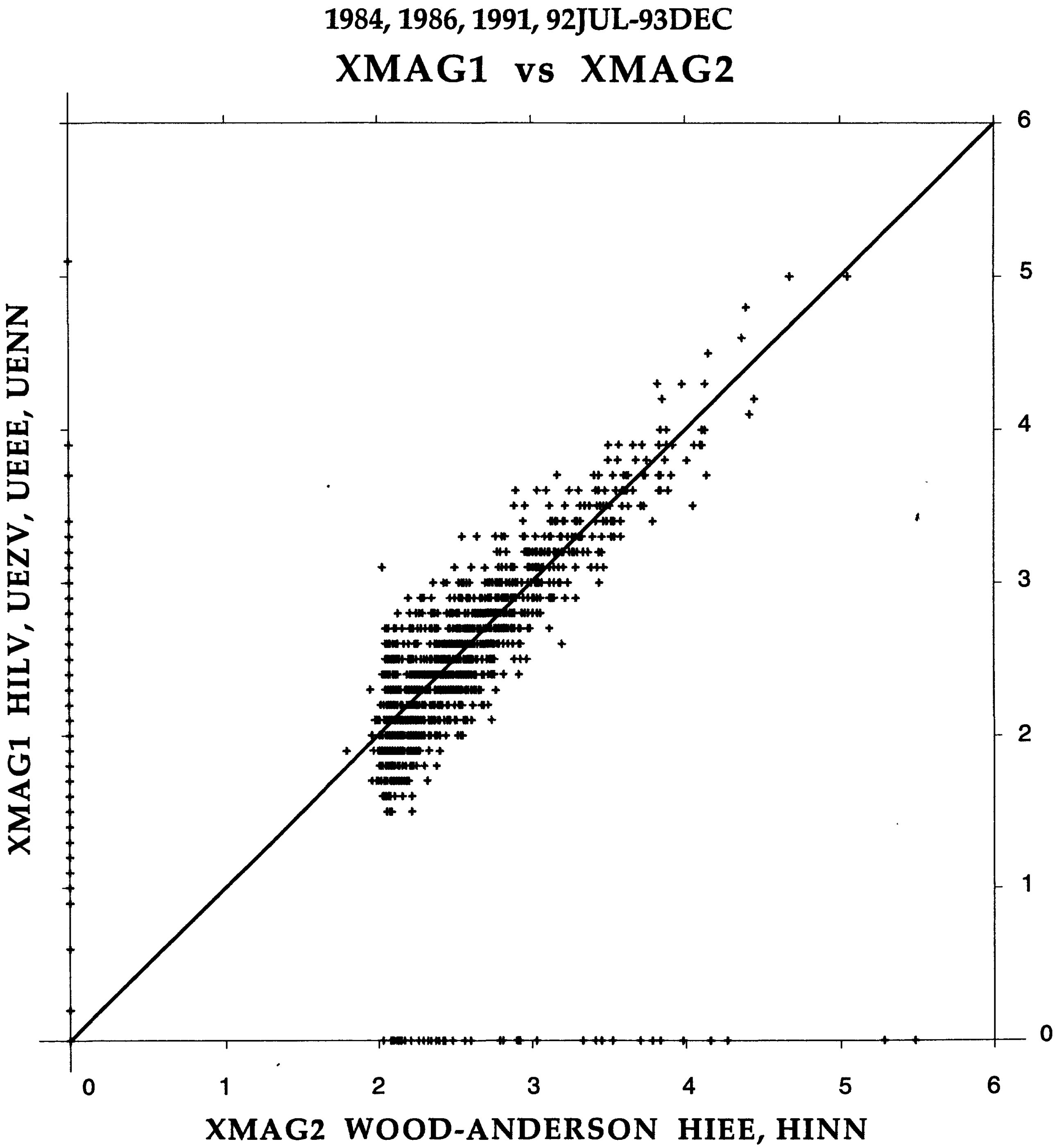
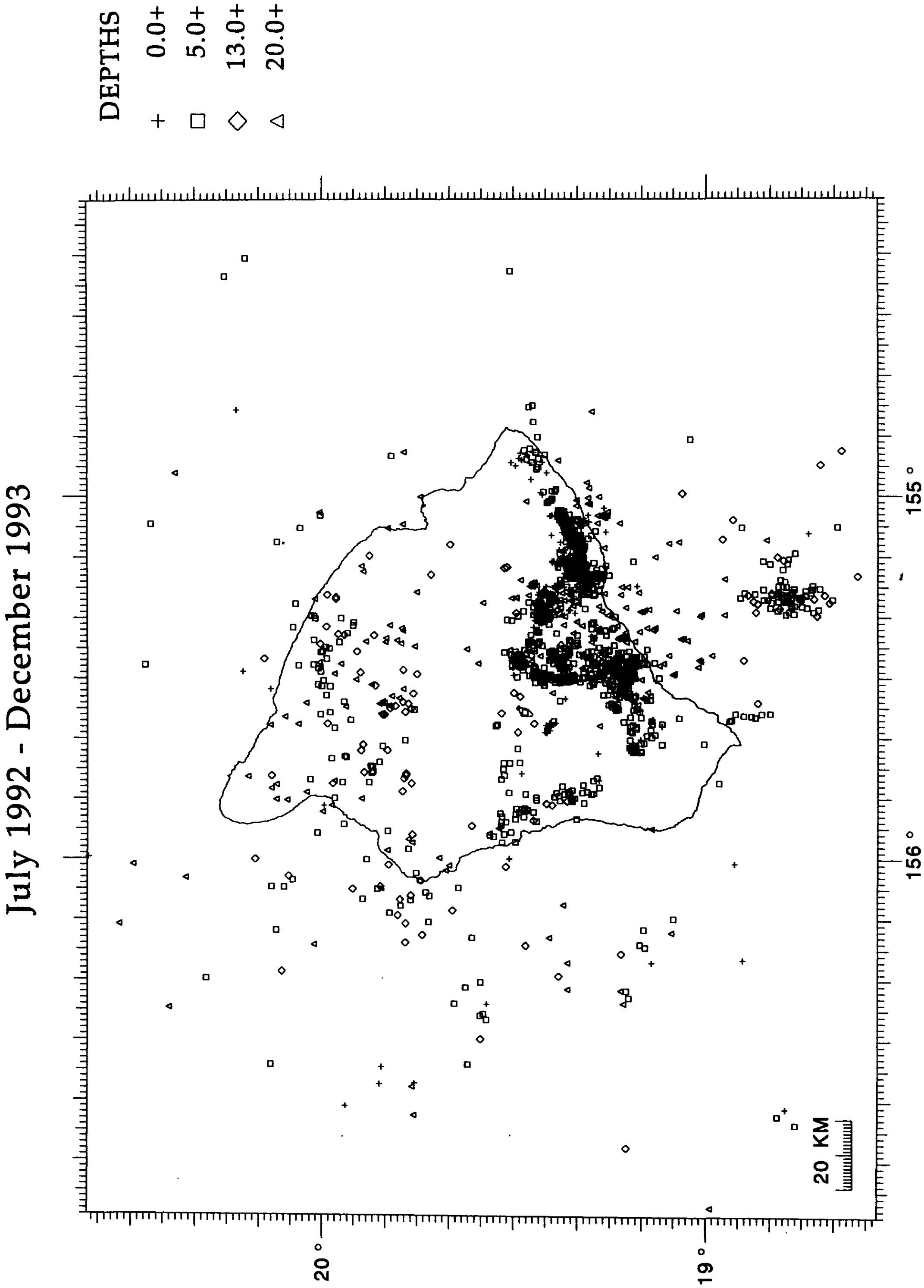

1984, 1986, 1991, 92JUL-93DEC
XMAG1 vs XMAG2
XMAG1 HILV, UEZV, UEEE, UENN
XMAG2 WOOD-ANDERSON HIEE, HINN
0
1
2
3
4
5
6

Figure 7.


July 1992 - December 1993
DEPTHS
0.0+
5.0+
13.0+
20.0+
155 °
156 °
20 °
19 °
20 KM

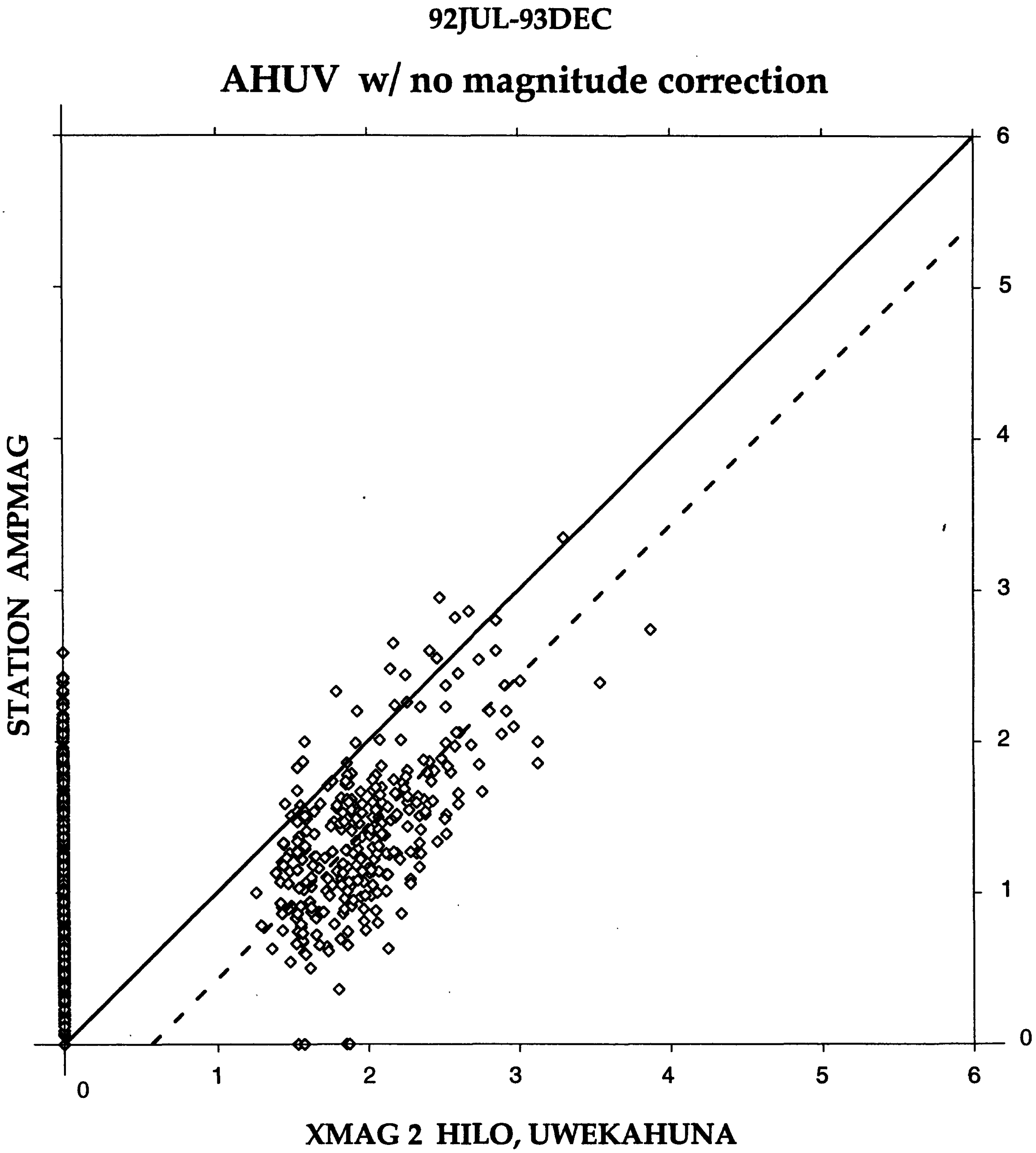
HYPOINVERSE was run on the July 1992 to December 1993 data to create an .MFL file (magnitude output file). Initially, amplitude magnitude correction values were set at 5.0 for the selected network stations in the .XMC magnitude correction file. In HYPOINVERSE, the 5.0 correction value allows a station magnitude to be calculated with a 0.0 correction applied, but is not averaged into the event magnitude. Magnitude information for each station was extracted from the .MFL file to create individual station .MAG files. Magnitude comparisons for individual components were drawn from these .MAG files. The .MAG files contain seven columns with magnitude information as follows:

1	2	3	4	5	6	7
Sta Dur	Sta Amp	Evt Dur1	Evt Dur2	Evt XMAG1	Evt XMAG2	Preferred

Individual station amplitude magnitudes were graphically compared to XMAG2 (Wood-Anderson, HILV, UE). The solid reference line is the ideal station magnitude, equal to M_L. The dotted line, drawn through the center of the cluster parallel to the solid reference line, is our prefered fit to M_L. The offset between the dotted and solid lines determined each station's magnitude correction. Figures 8-10 of the Ahua station components, vertical, E/W, N/S, compare the uncorrected station magnitude with XMAG2. For AHUV the correction determined in this way is +0.60, and for AHUE and AHUN the correction is -0.55. Plots for each of the other selected stations were created, and magnitude corrections were established in the same way. Figures 11-29 are plots of each selected station's corrected amplitude magnitudes compared with the corresponding XMAG2. The plots illustrate an acceptable relationship between the cluster and reference line. Refer to Table 2 of MASTER.XMC, which lists the correction values established for each station.

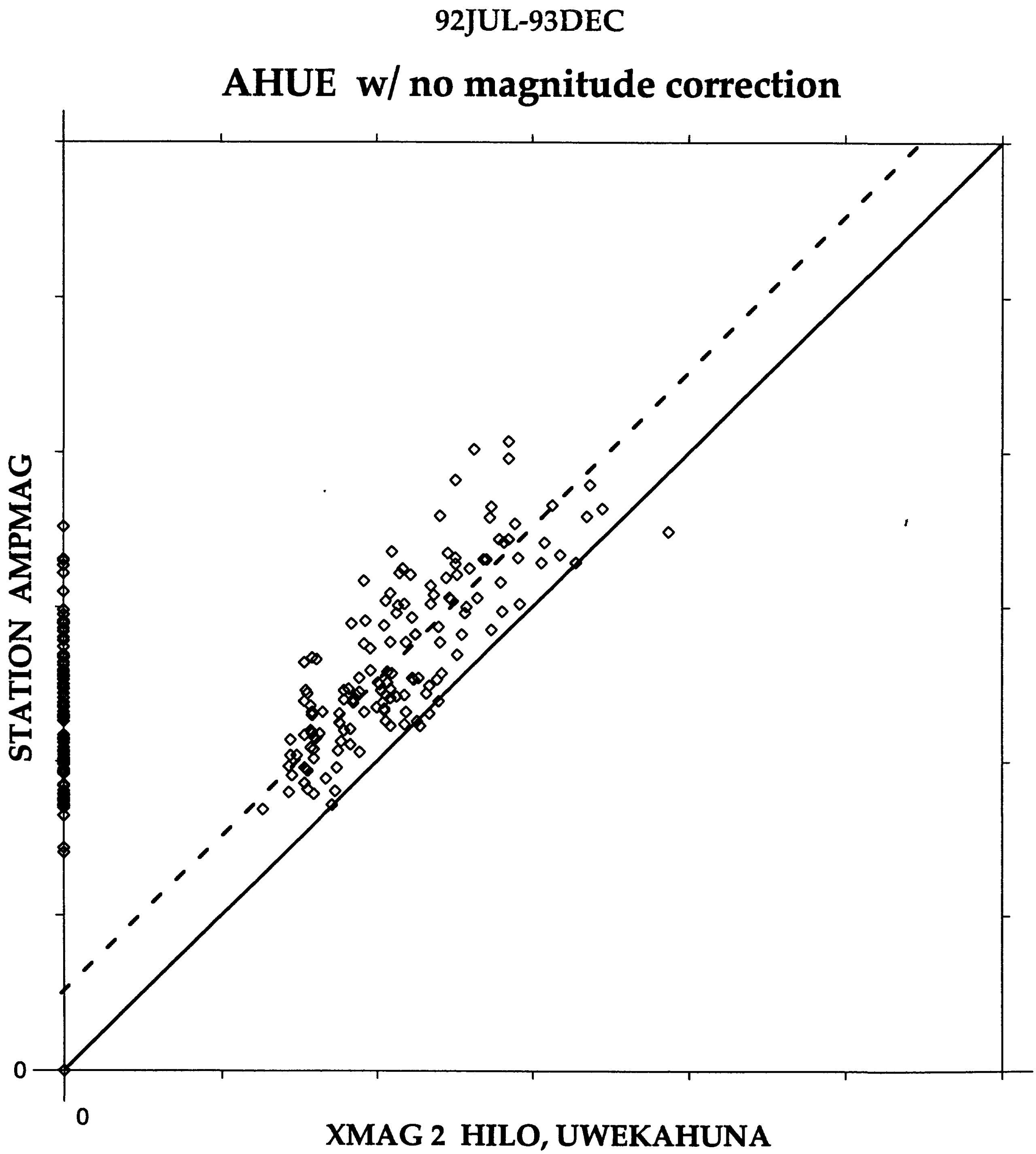
Averaged event magnitudes are compared in Figures 30 and 31. Figure 30 compares the event magnitudes from the average of the network stations, with corrections as listed in Table 2, against the average of the photographic stations, HILV, HIEE, HINN, UEZV, UEEE, and UENN. Figure 31 compares the average of the network verticals with the average of the network horizontals, excluding the Wood-Anderson instruments, illustrating the compatibility of the component types. There are more samples at the lower magnitude range in Figure 31 than in Figure 30, because the

Figure 8.



92JUL-93DEC
AHUV w/ no magnitude correction
STATION AMPMAG
XMAG 2 HILO, UWEKAHUNA
0
1
2
3
4
5
6

Figure 9.



92JUL-93DEC
AHUE w/ no magnitude correction
STATION AMPMAG
0
0
XMAG 2 HILO, UWEKAHUNA

Figure 10.

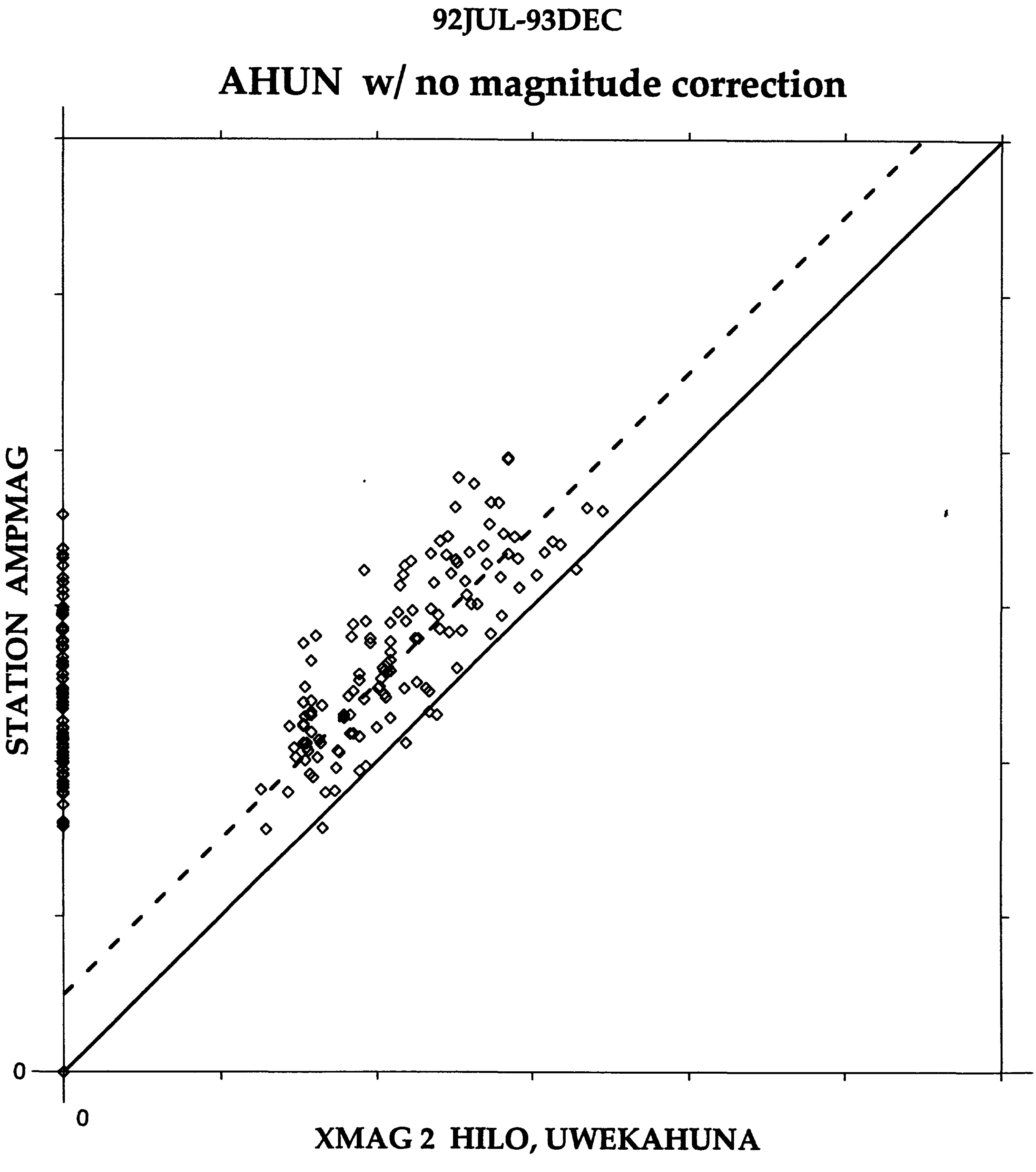

92JUL-93DEC
AHUN w/ no magnitude correction
STATION AMPMAG
0
0
XMAG 2 HILO, UWEKAHUNA

Figure 11.

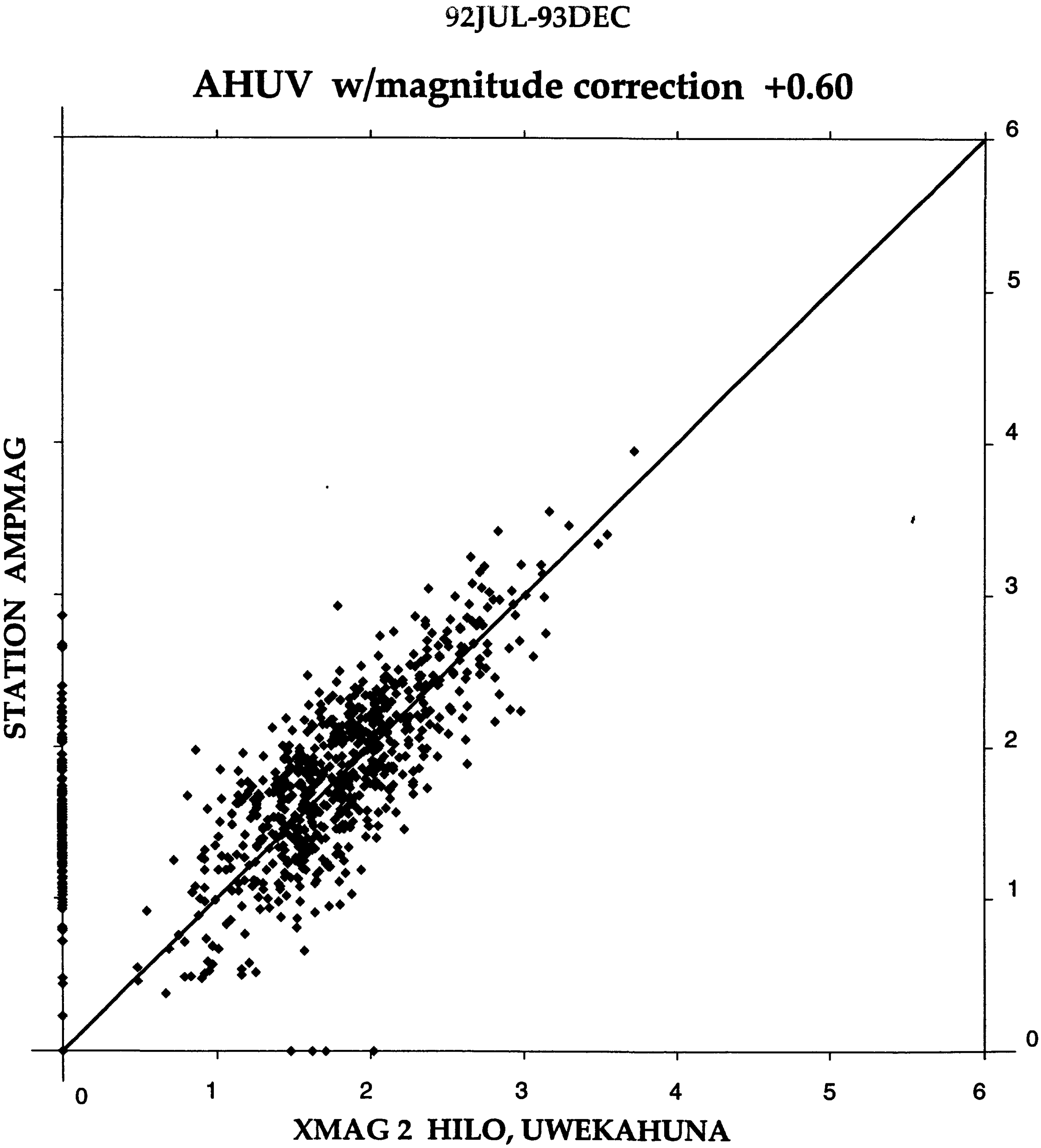

92JUL-93DEC
AHUV w/magnitude correction +0.60
STATION AMPMAG
XMAG 2 HILO, UWEKAHUNA
0
1
2
3
4
5
6

Figure 12.

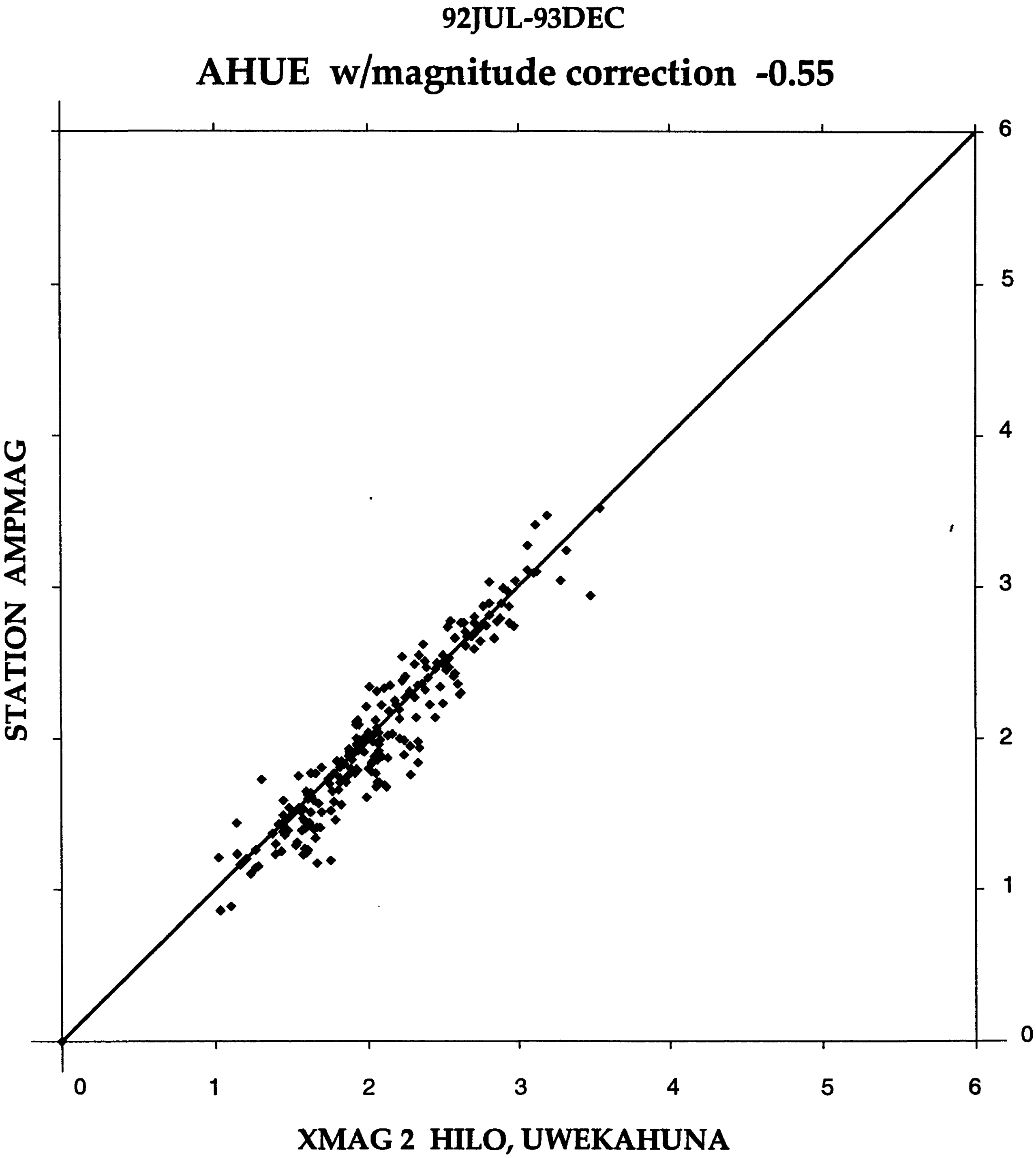

92JUL-93DEC
AHUE w/magnitude correction -0.55
STATION AMPMAG
XMAG 2 HILO, UWEKAHUNA
0
1
2
3
4
5
6

Figure 13.

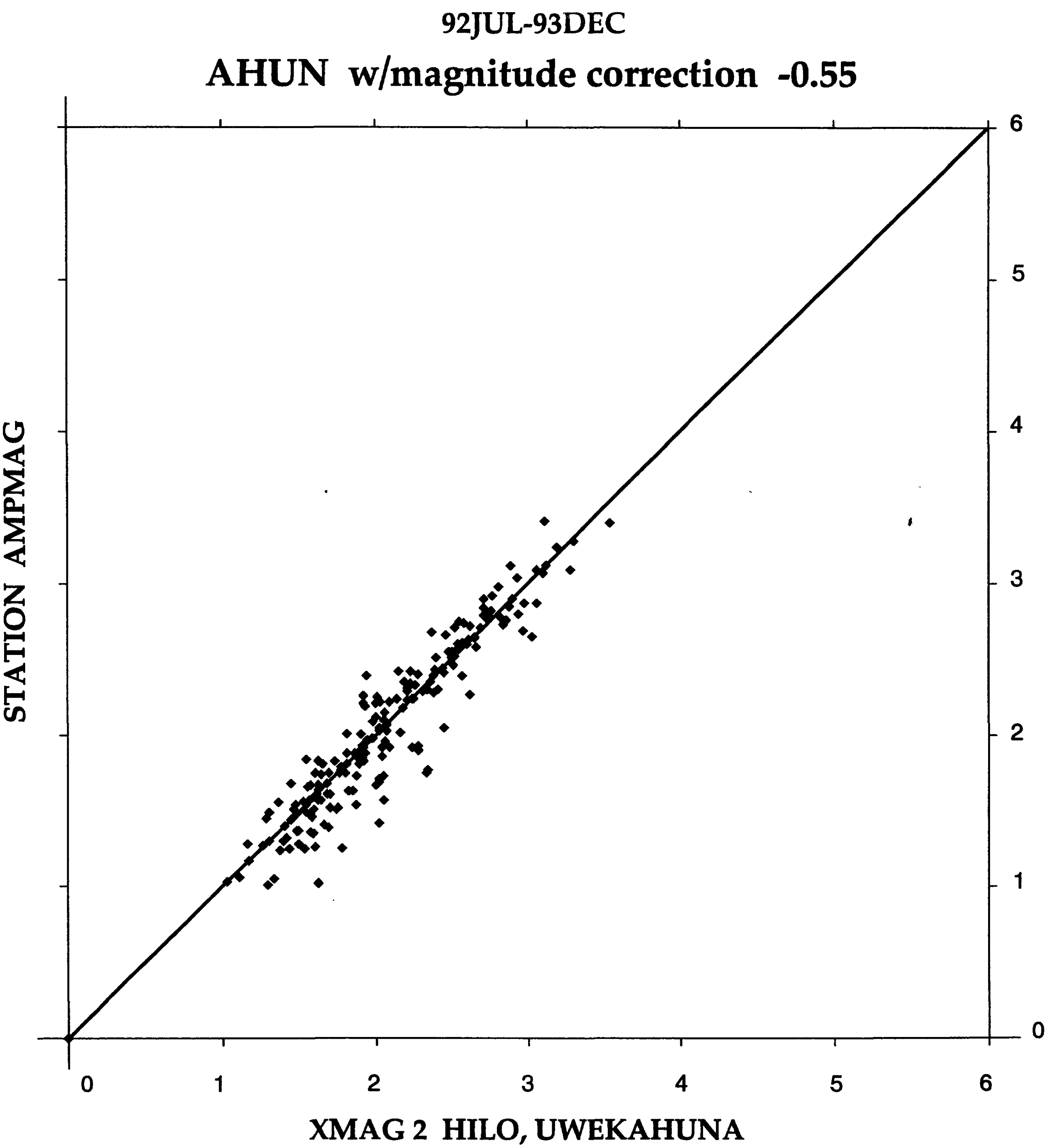

92JUL-93DEC
AHUN w/magnitude correction -0.55
STATION AMPMAG
XMAG 2 HILO, UWEKAHUNA
0
1
2
3
4
5
6

Figure 14.

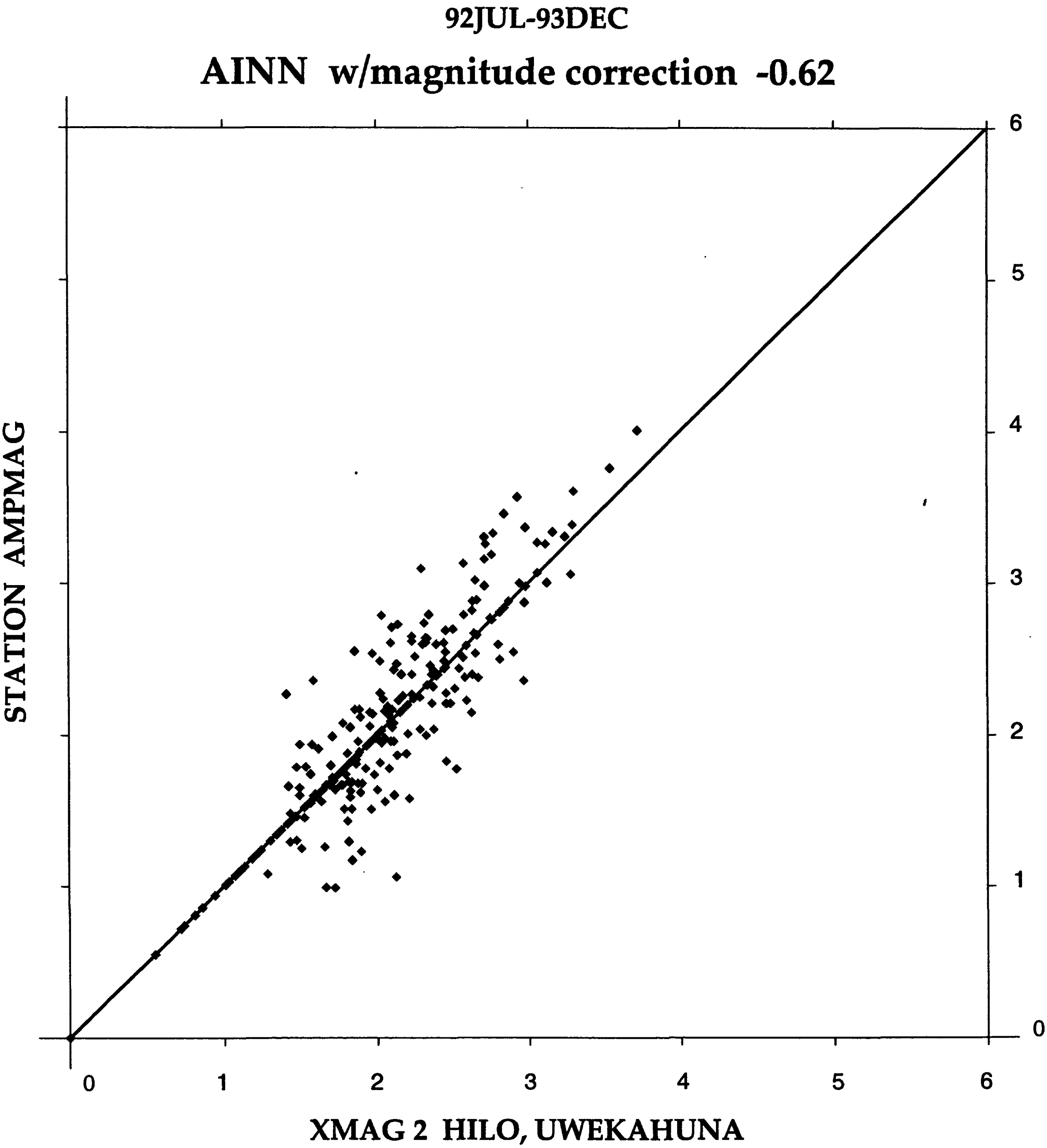
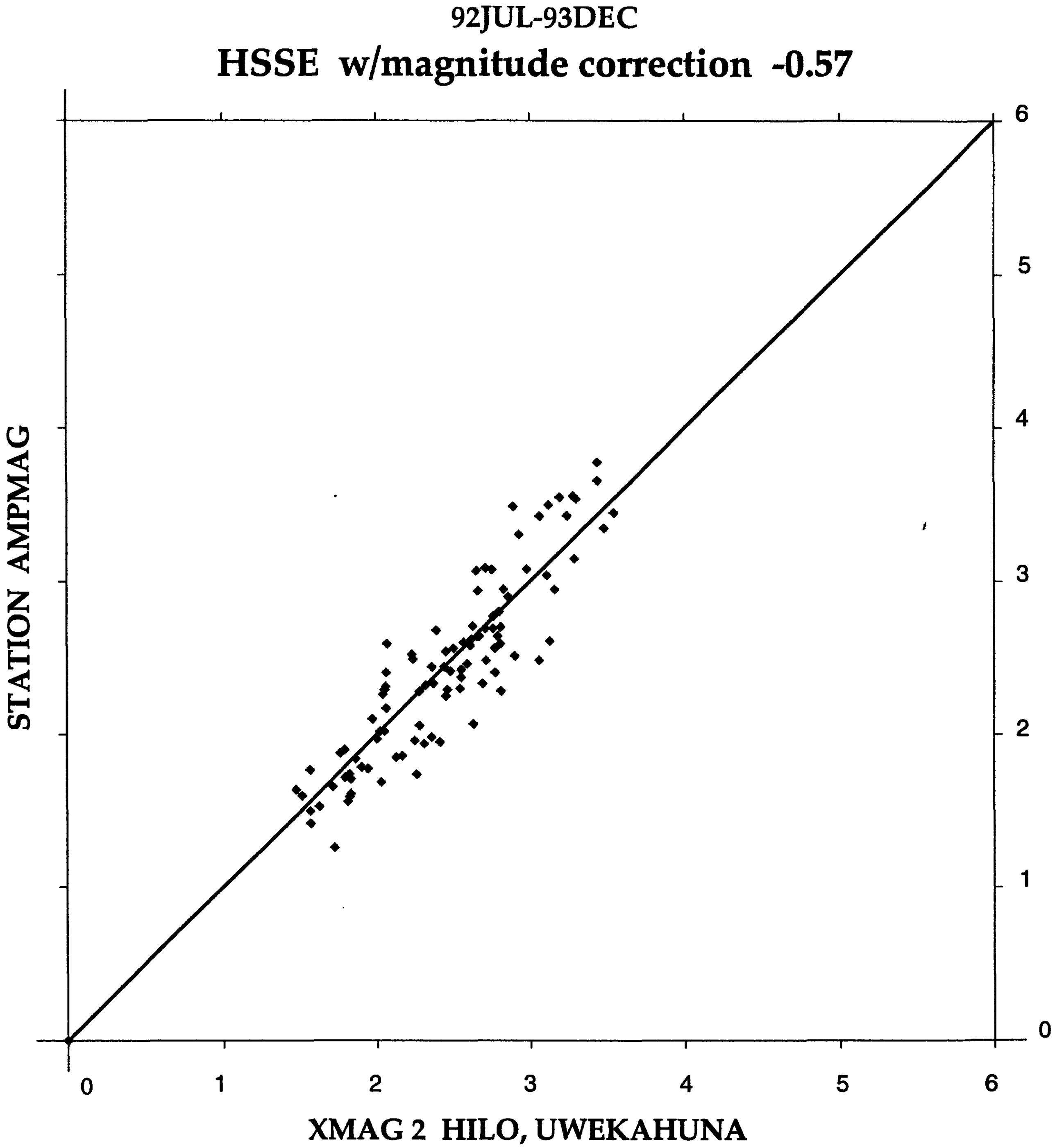

92JUL-93DEC
AINN w/magnitude correction -0.62
STATION AMPMAG
XMAG 2 HILO, UWEKAHUNA
0
1
2
3
4
5
6

Figure 15.



92JUL-93DEC
HSSE w/magnitude correction -0.57
STATION AMPMAG
XMAG 2 HILO, UWEKAHUNA
0
1
2
3
4
5
6

Figure 16.

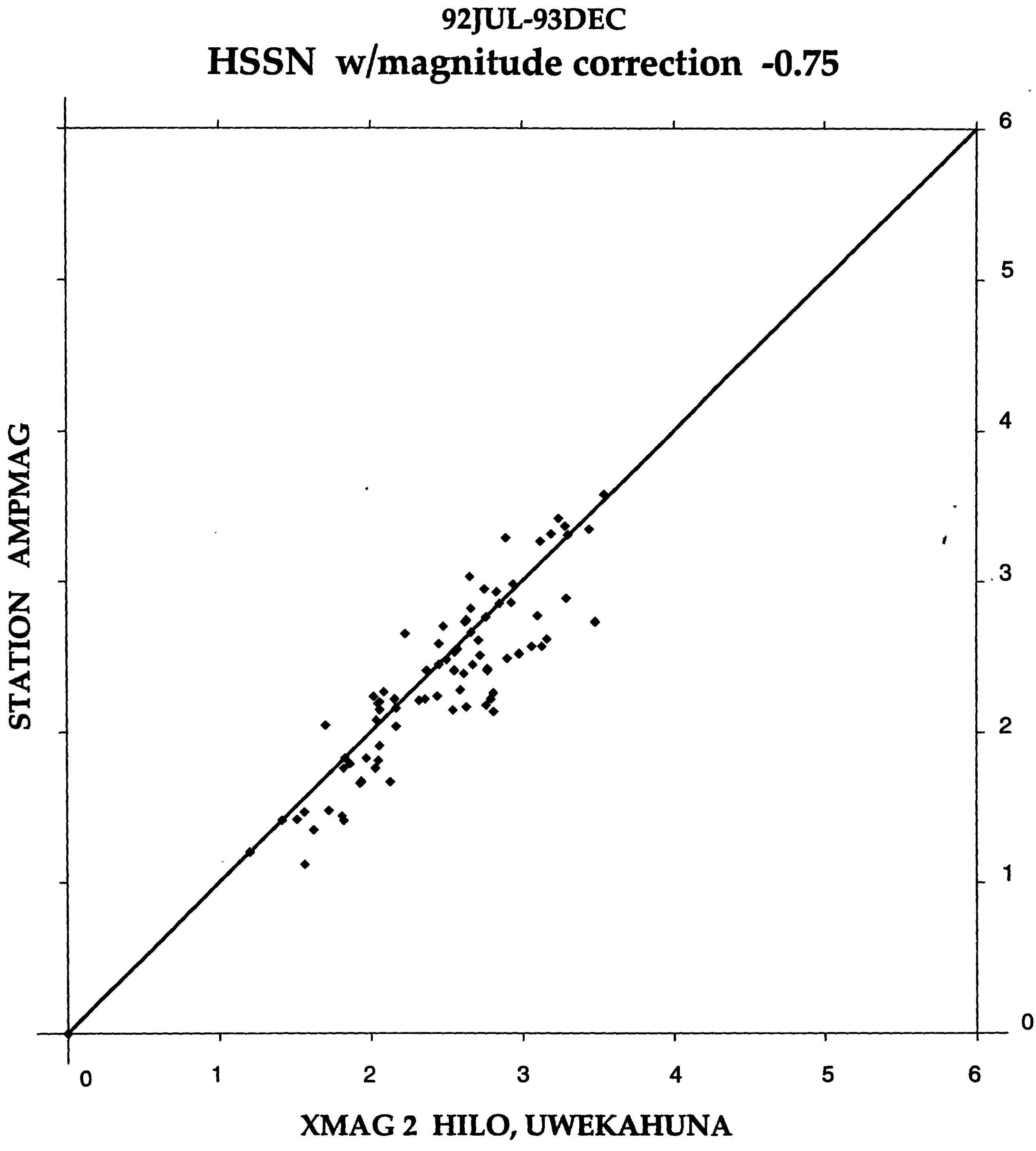
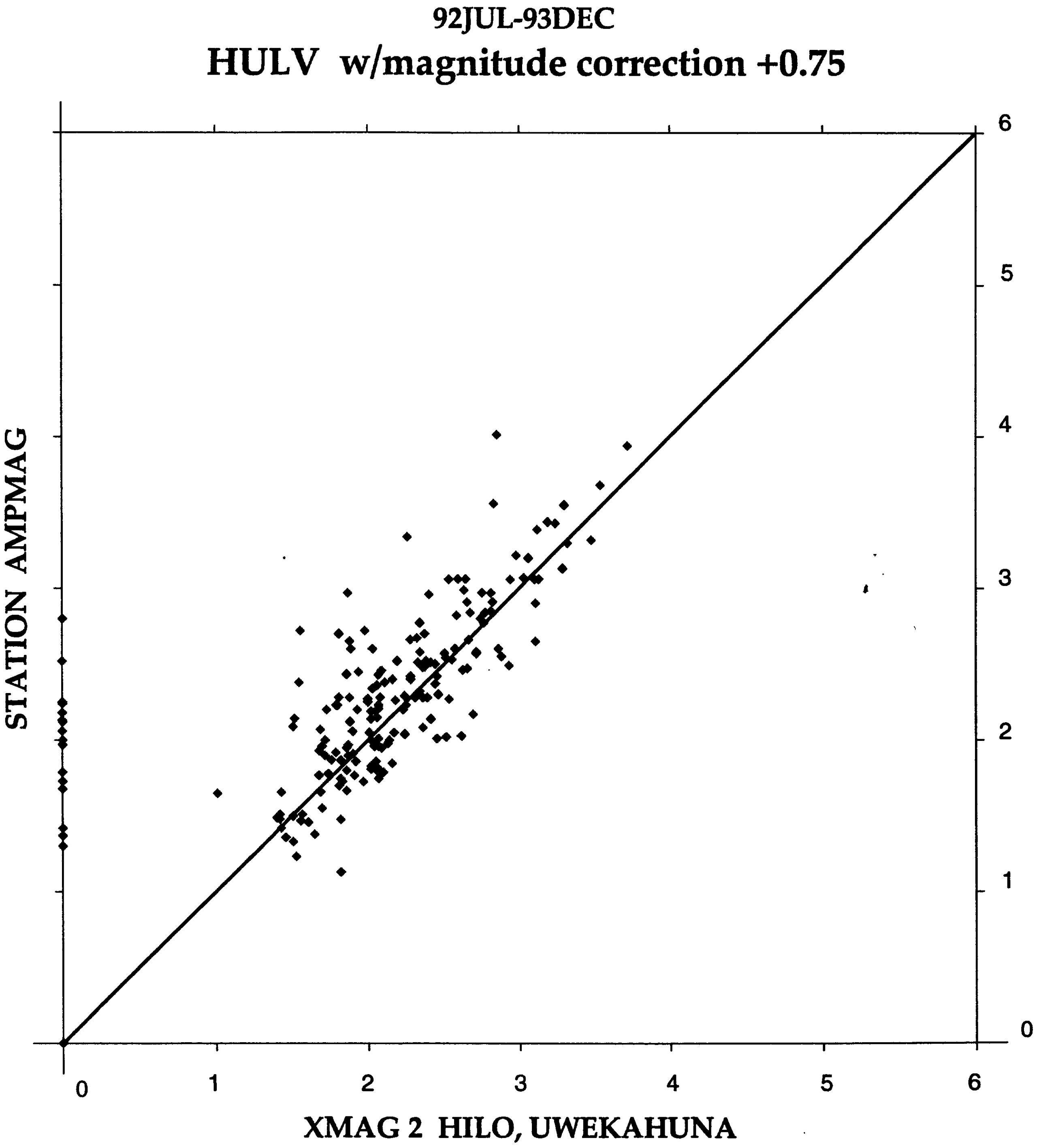
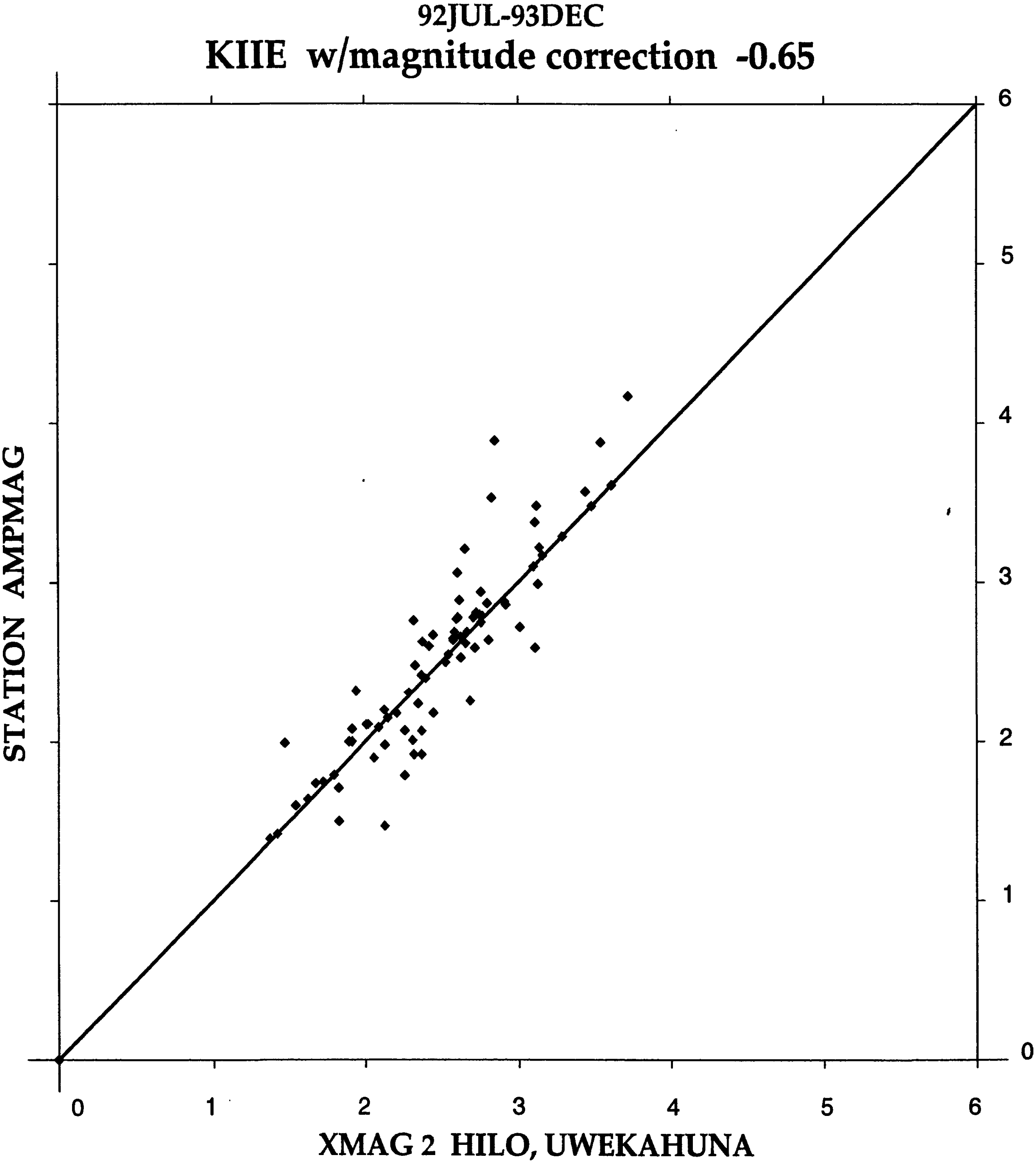

92JUL-93DEC
HSSN w/magnitude correction -0.75
STATION AMPMAG
XMAG 2 HILO, UWEKAHUNA
0
1
2
3
4
5
6

Figure 17.



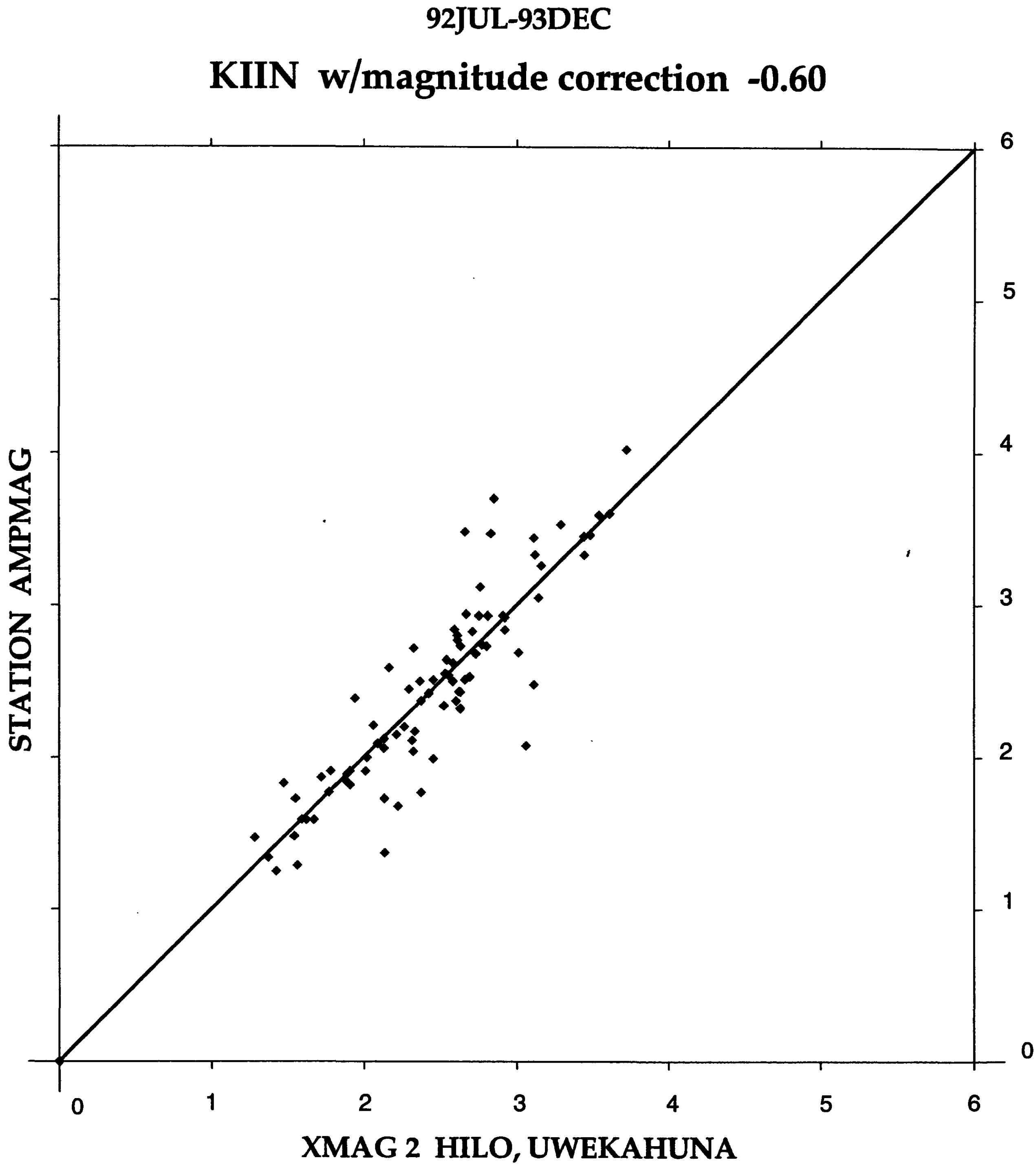
92JUL-93DEC
HULV w/magnitude correction +0.75
STATION AMPMAG
XMAG 2 HILO, UWEKAHUNA
0
1
2
3
4
5
6

Figure 18.



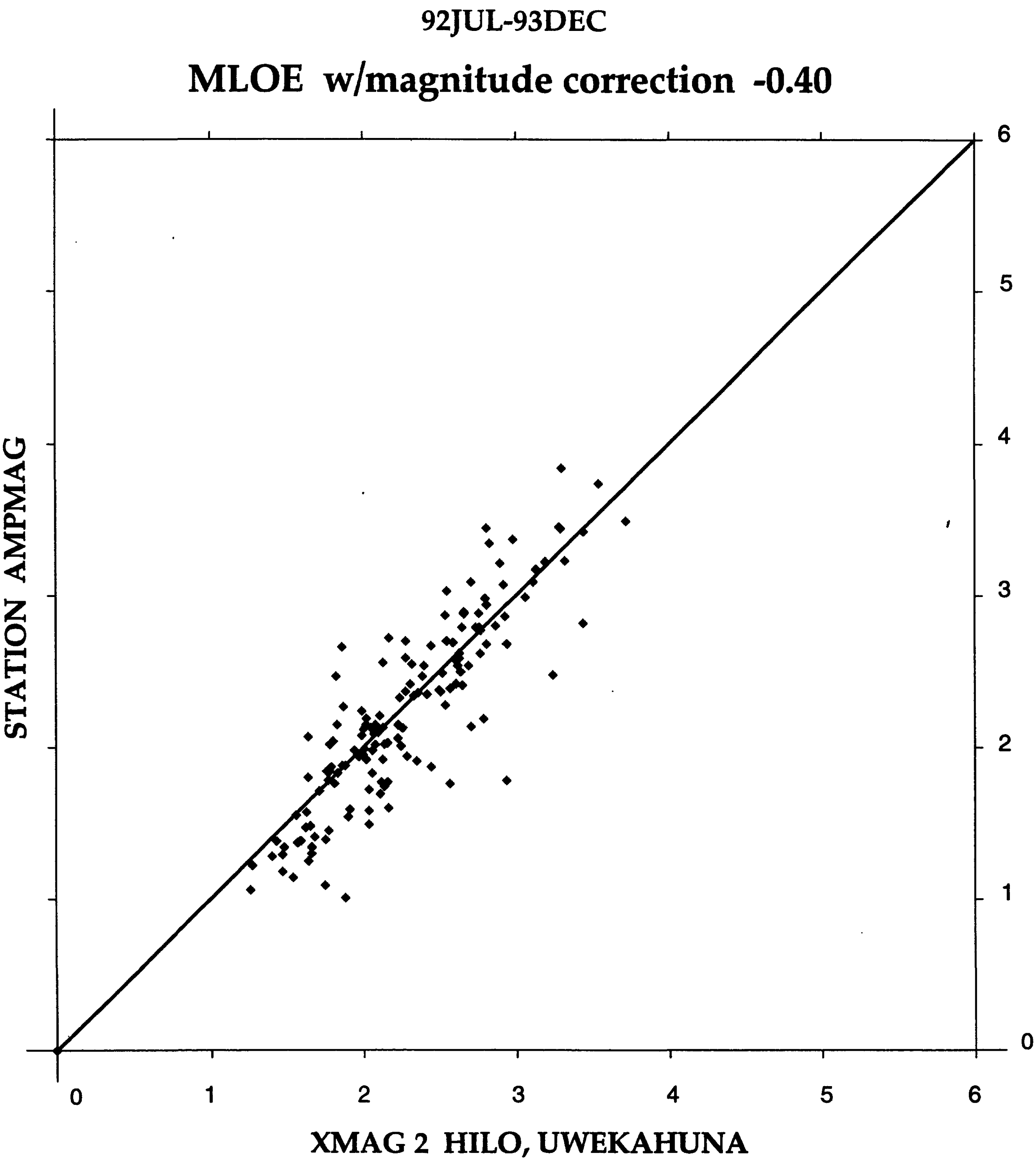
92JUL-93DEC
KIIE w/magnitude correction -0.65
STATION AMPMAG
XMAG 2 HILO, UWEKAHUNA
0
1
2
3
4
5
6

Figure 19.



92JUL-93DEC
KIIN w/magnitude correction -0.60
STATION AMPMAG
XMAG 2 HILO, UWEKAHUNA
0
1
2
3
4
5
6

Figure 20.



92JUL-93DEC
MLOE w/magnitude correction -0.40
STATION AMPMAG
XMAG 2 HILO, UWEKAHUNA
0
1
2
3
4
5
6

Figure 21.

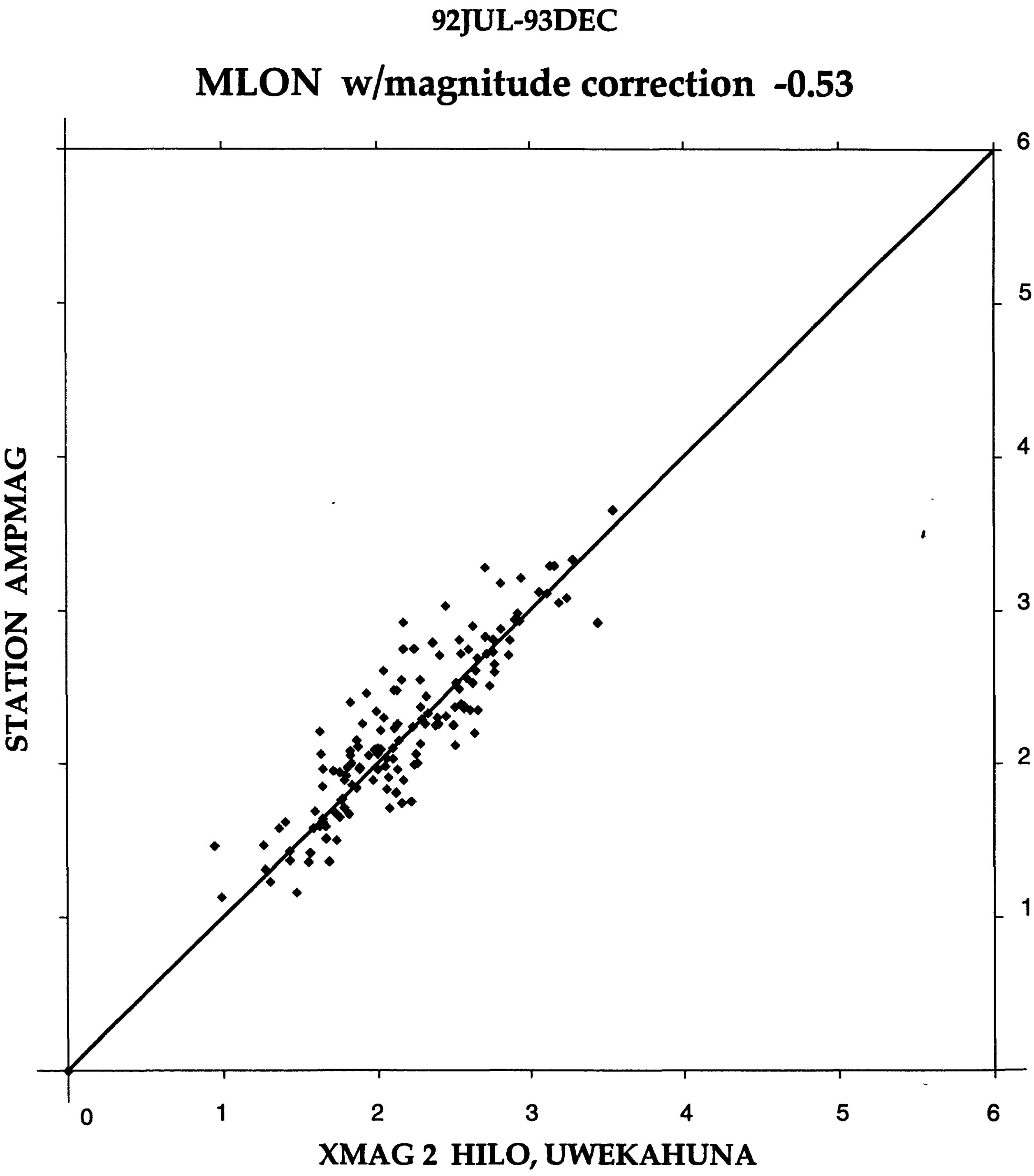
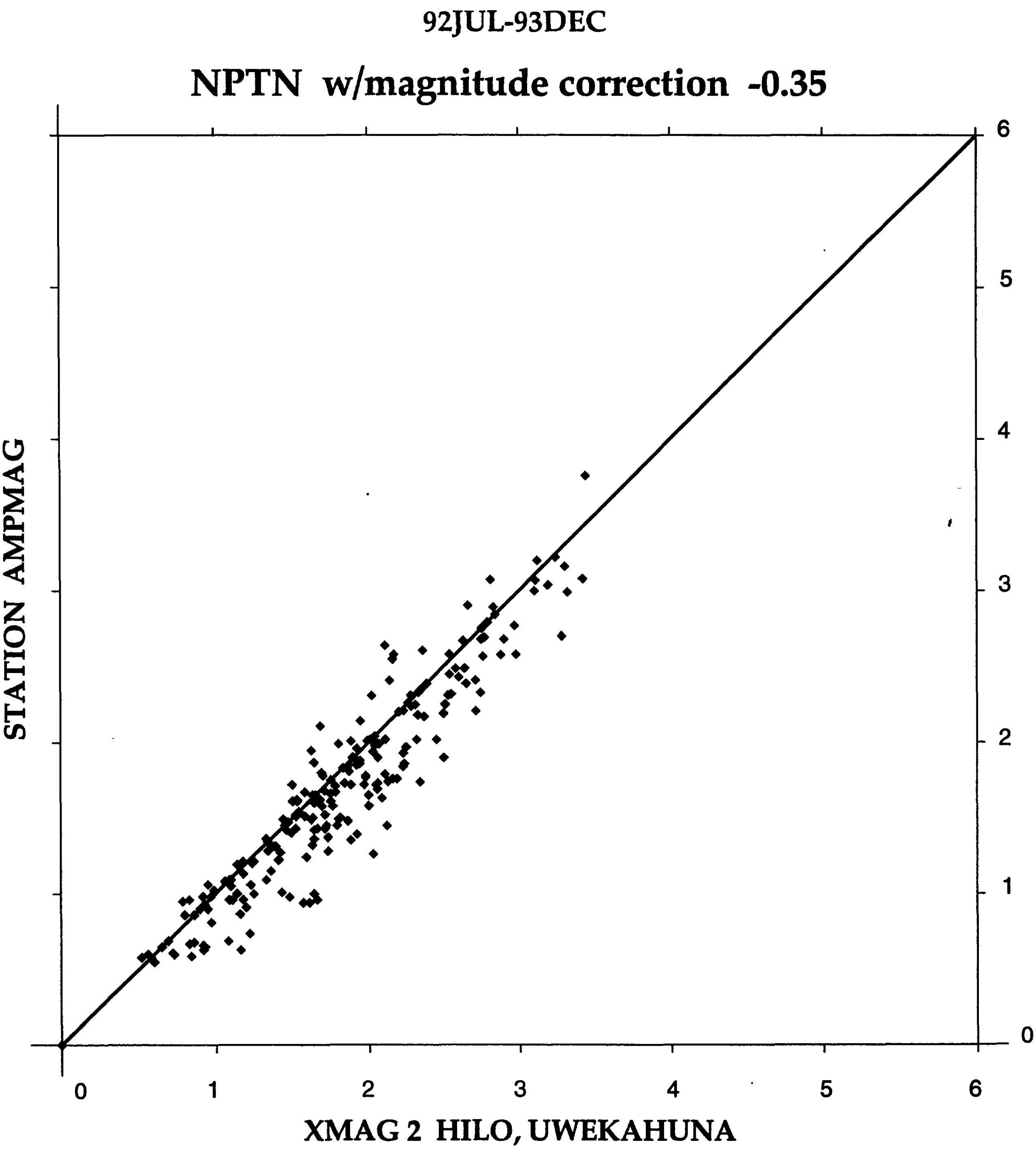

92JUL-93DEC
MLON w/magnitude correction -0.53
STATION AMPMAG
XMAG 2 HILO, UWEKAHUNA
0
1
2
3
4
5
6

Figure 22.



92JUL-93DEC
NPTN w/magnitude correction -0.35
STATION AMPMAG
XMAG 2 HILO, UWEKAHUNA
0
1
2
3
4
5
6

Figure 23.

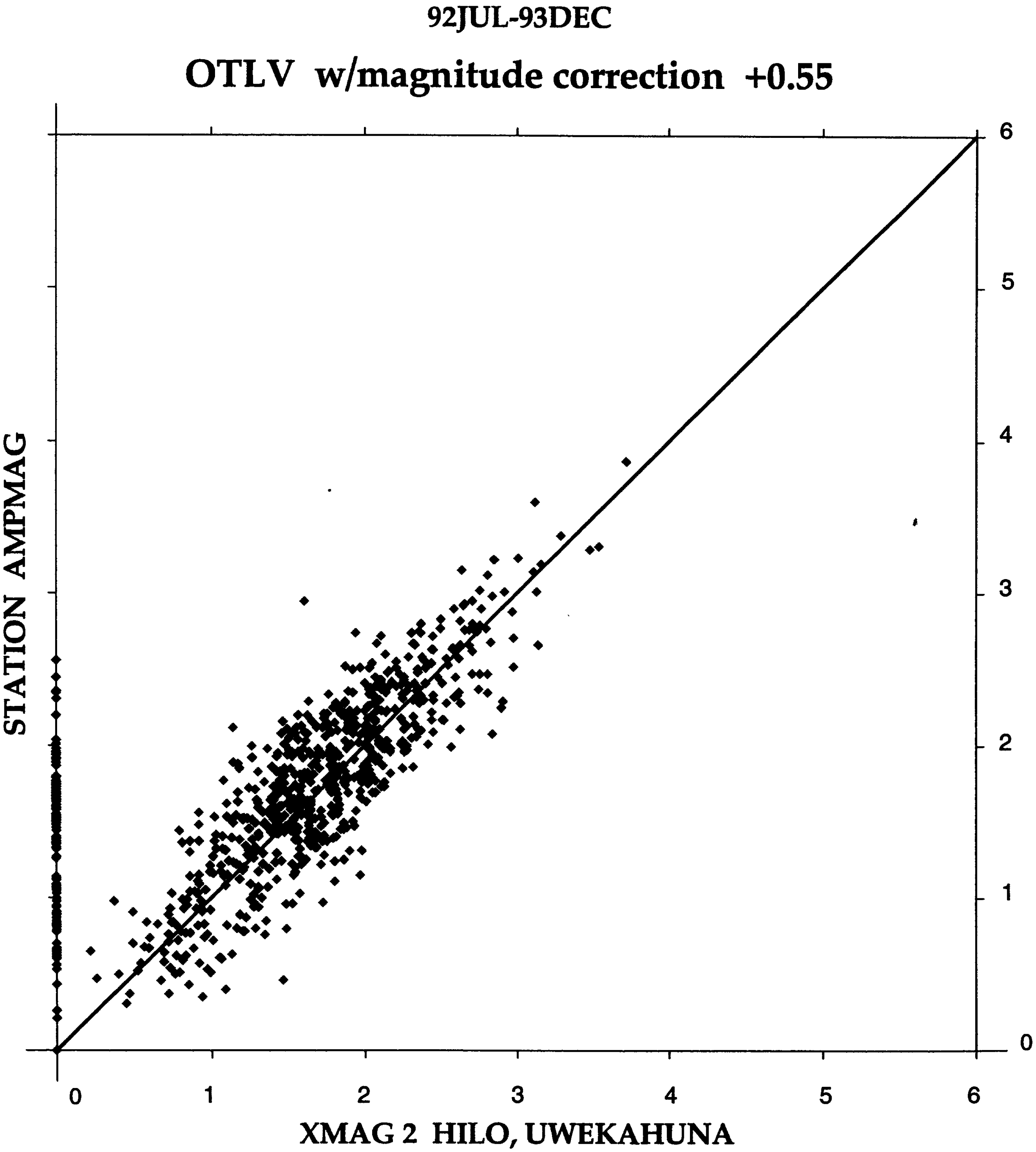
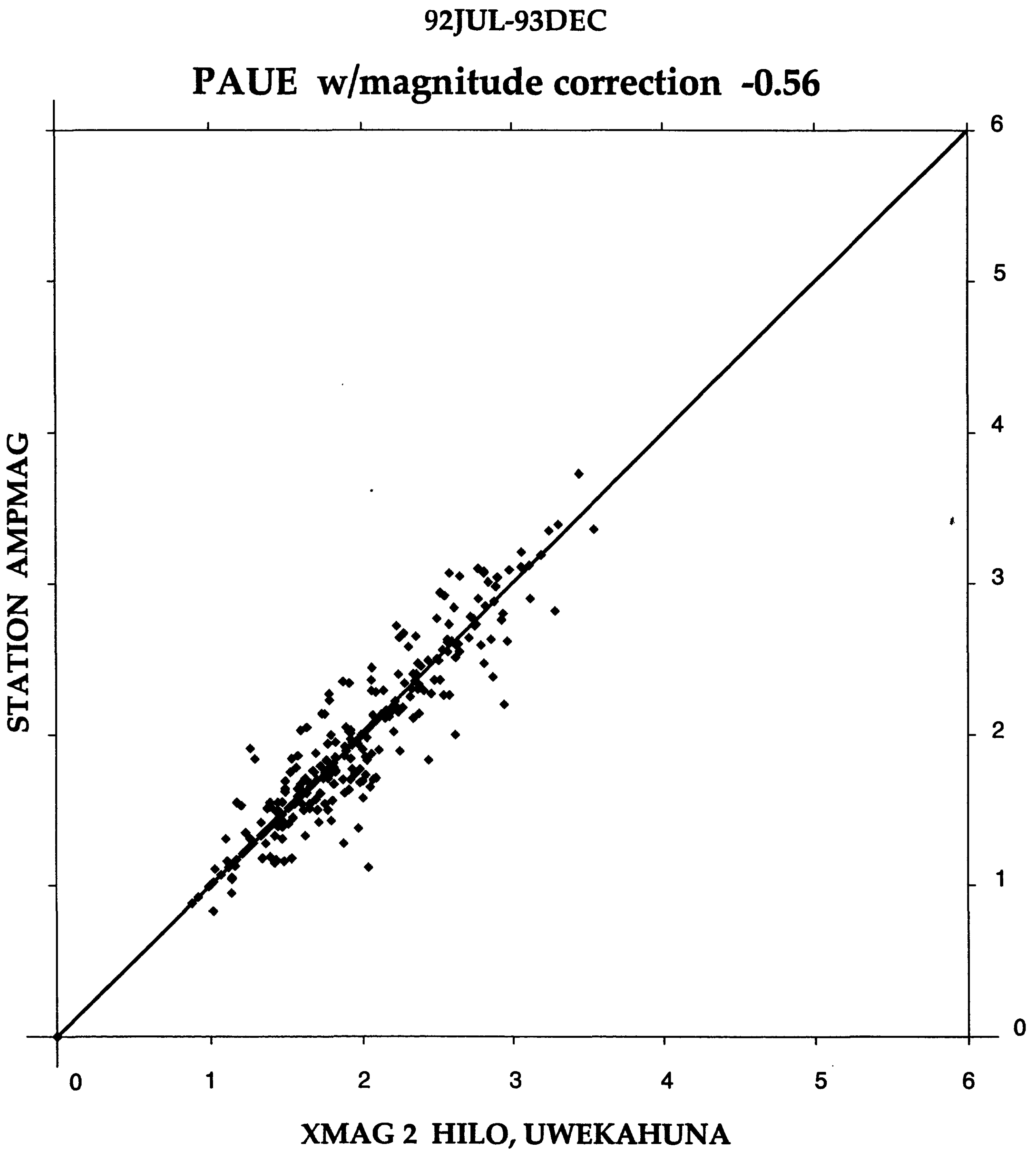
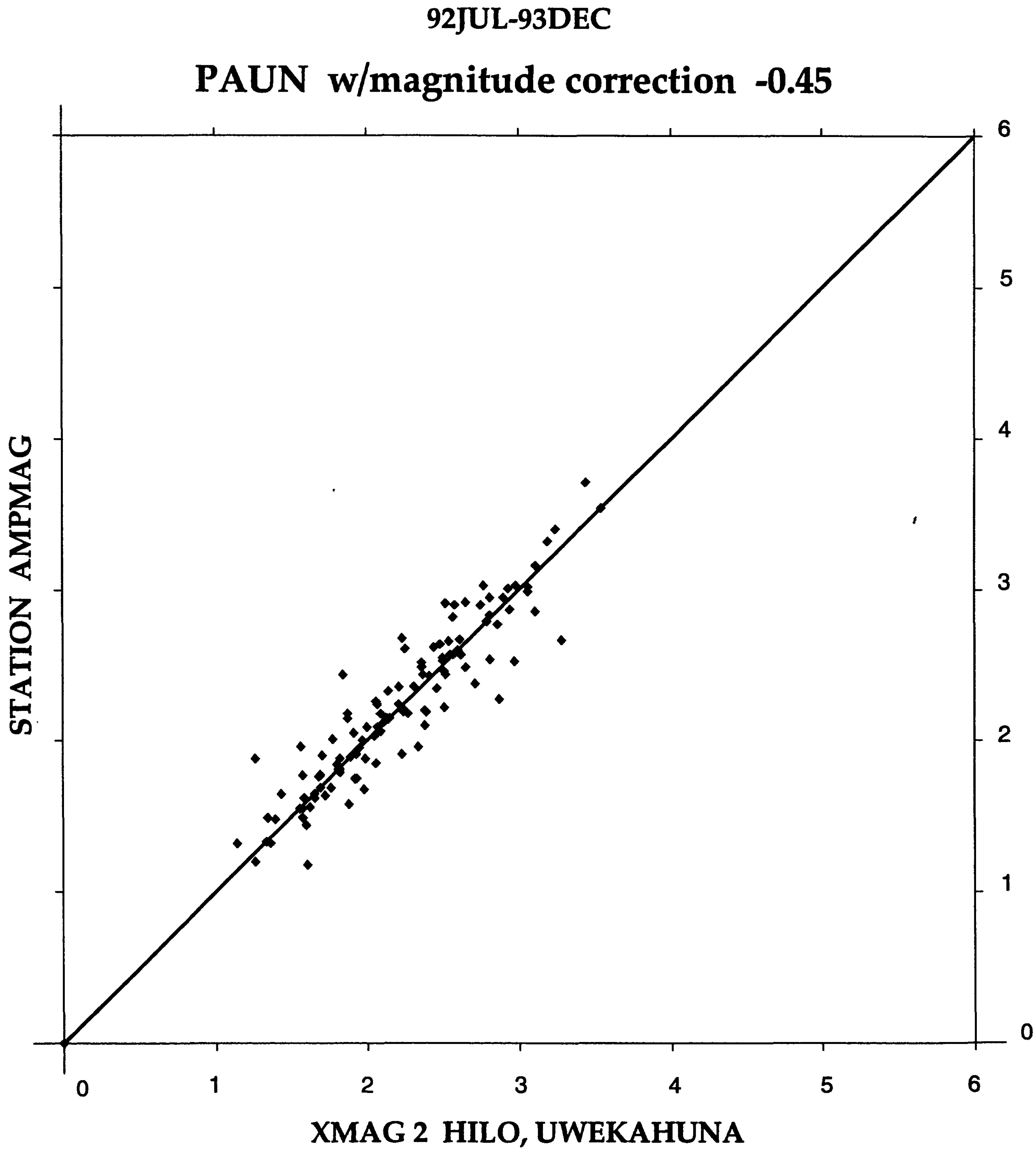

92JUL-93DEC
OTLV w/magnitude correction +0.55
STATION AMPMAG
XMAG 2 HILO, UWEKAHUNA
0
1
2
3
4
5
6

Figure 24.



92JUL-93DEC
PAUE w/magnitude correction -0.56
STATION AMPMAG
XMAG 2 HILO, UWEKAHUNA
0
1
2
3
4
5
6

Figure 25.



92JUL-93DEC
PAUN w/magnitude correction -0.45
STATION AMPMAG
XMAG 2 HILO, UWEKAHUNA
0
1
2
3
4
5
6

Figure 26.

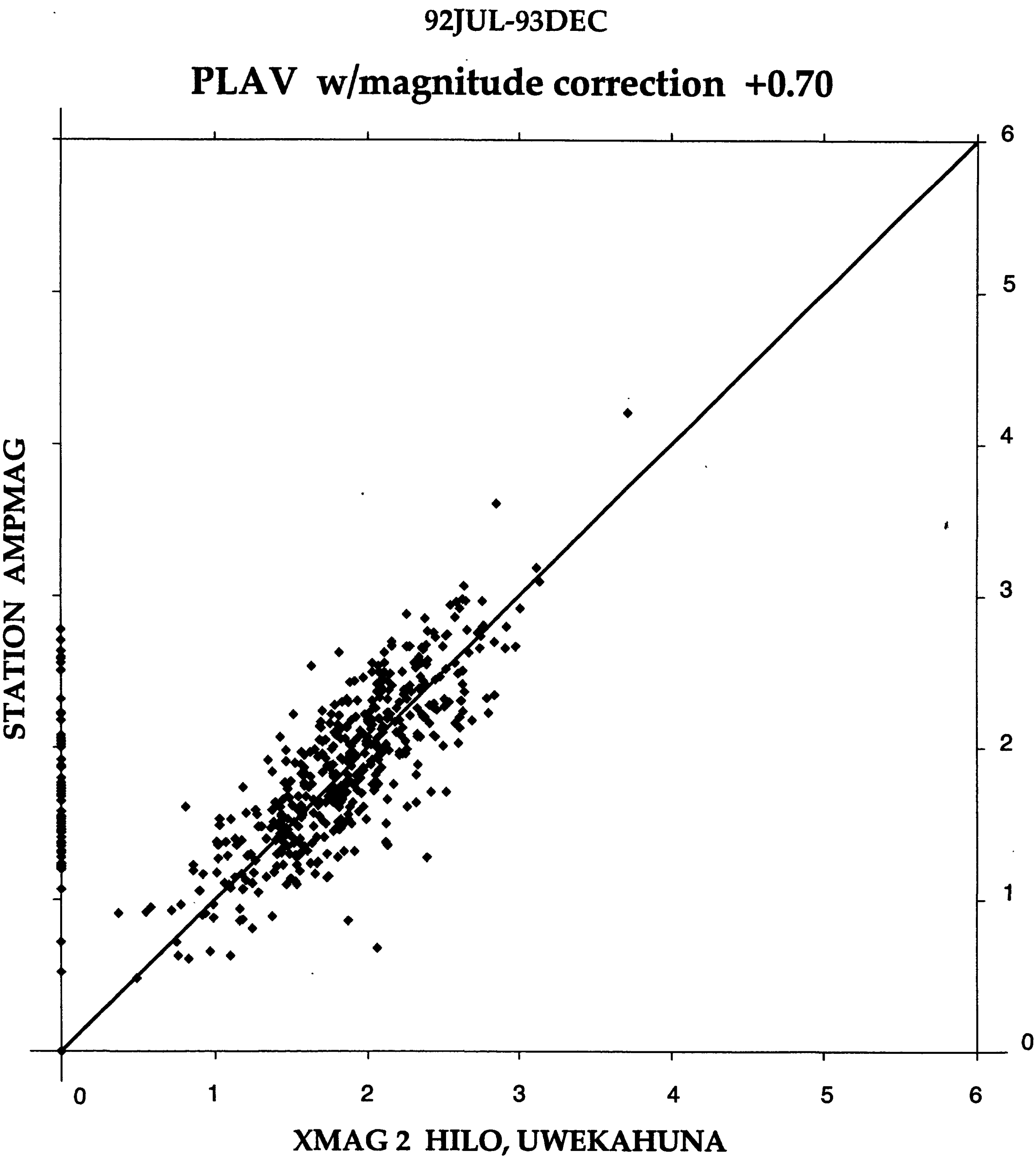

92JUL-93DEC
PLAV w/magnitude correction +0.70
STATION AMPMAG
XMAG 2 HILO, UWEKAHUNA
0
1
2
3
4
5
6

Figure 27.

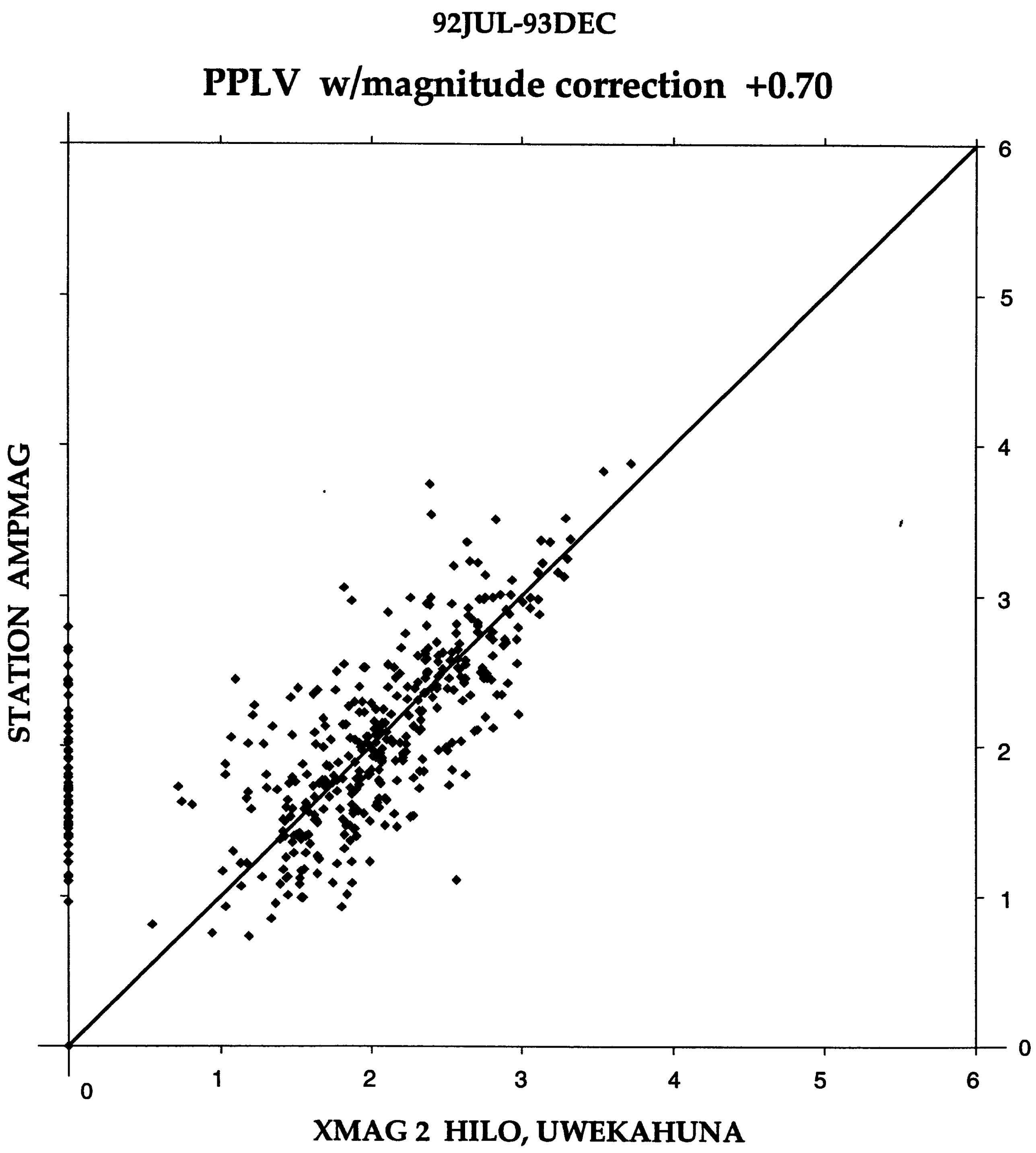
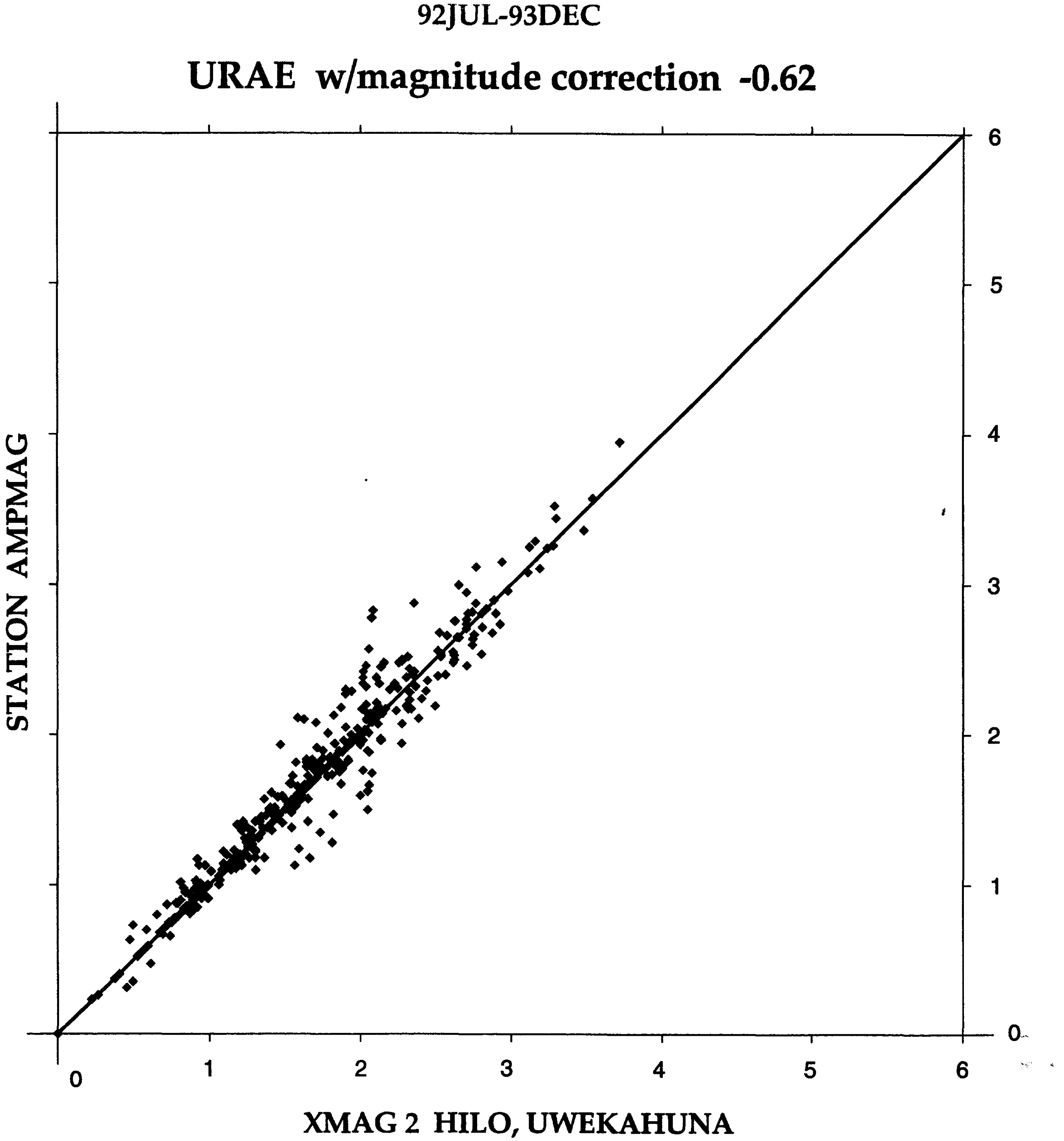

92JUL-93DEC
PPLV w/magnitude correction +0.70
STATION AMPMAG
XMAG 2 HILO, UWEKAHUNA
0
1
2
3
4
5
6

Figure 28.



92JUL-93DEC
URAE w/magnitude correction -0.62
STATION AMPMAG
XMAG 2 HILO, UWEKAHUNA
0
1
2
3
4
5
6

Figure 29.

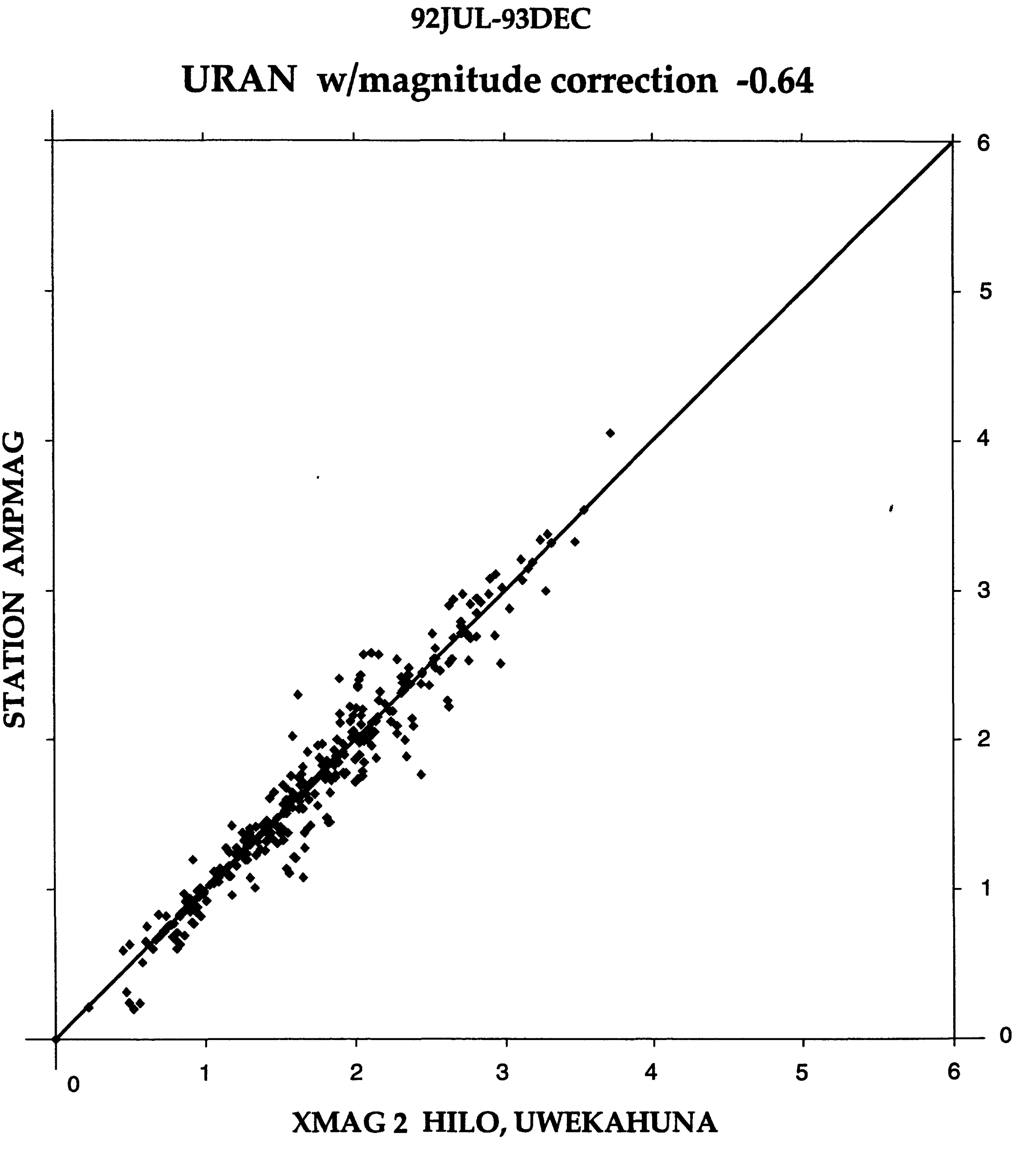
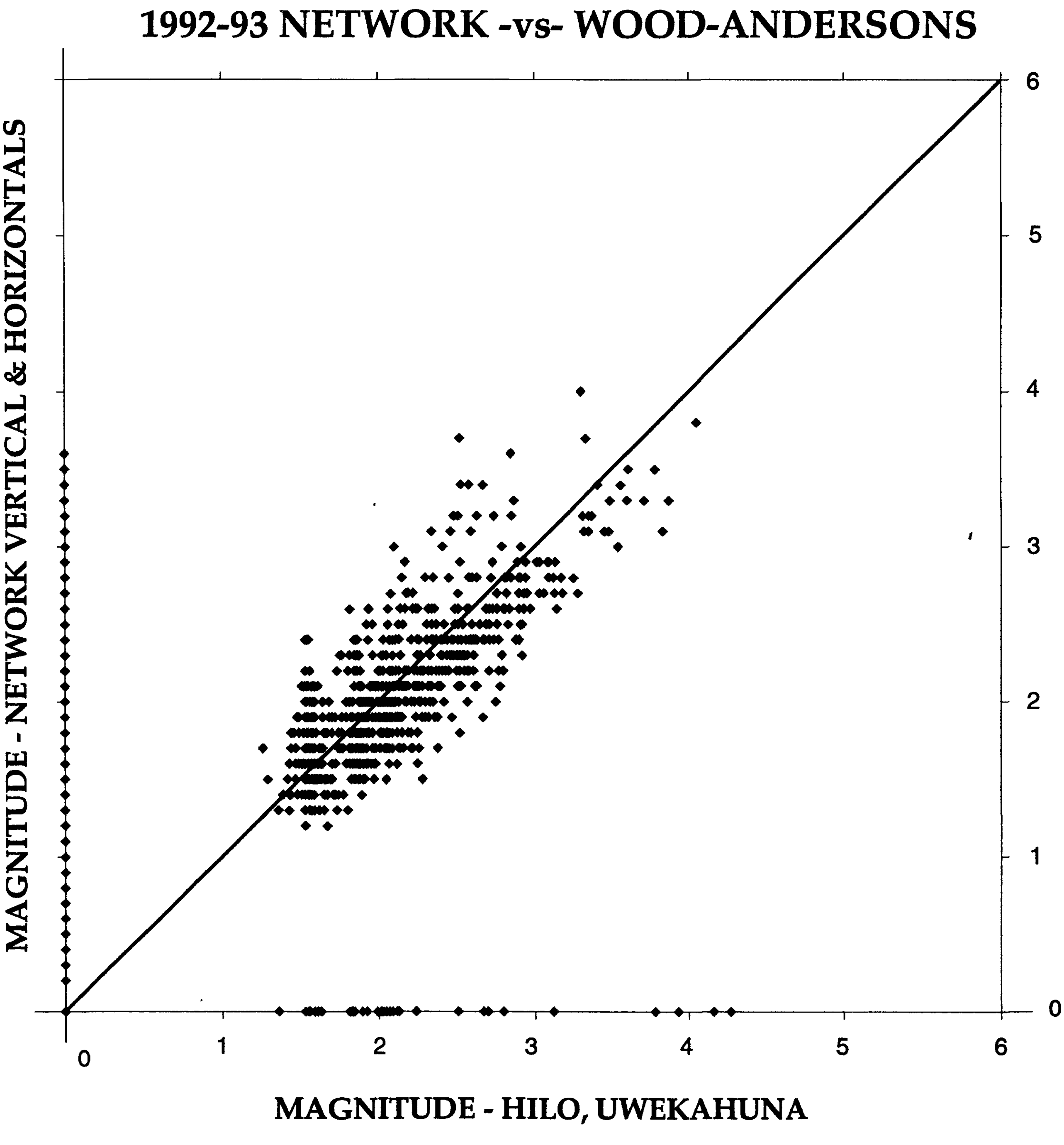
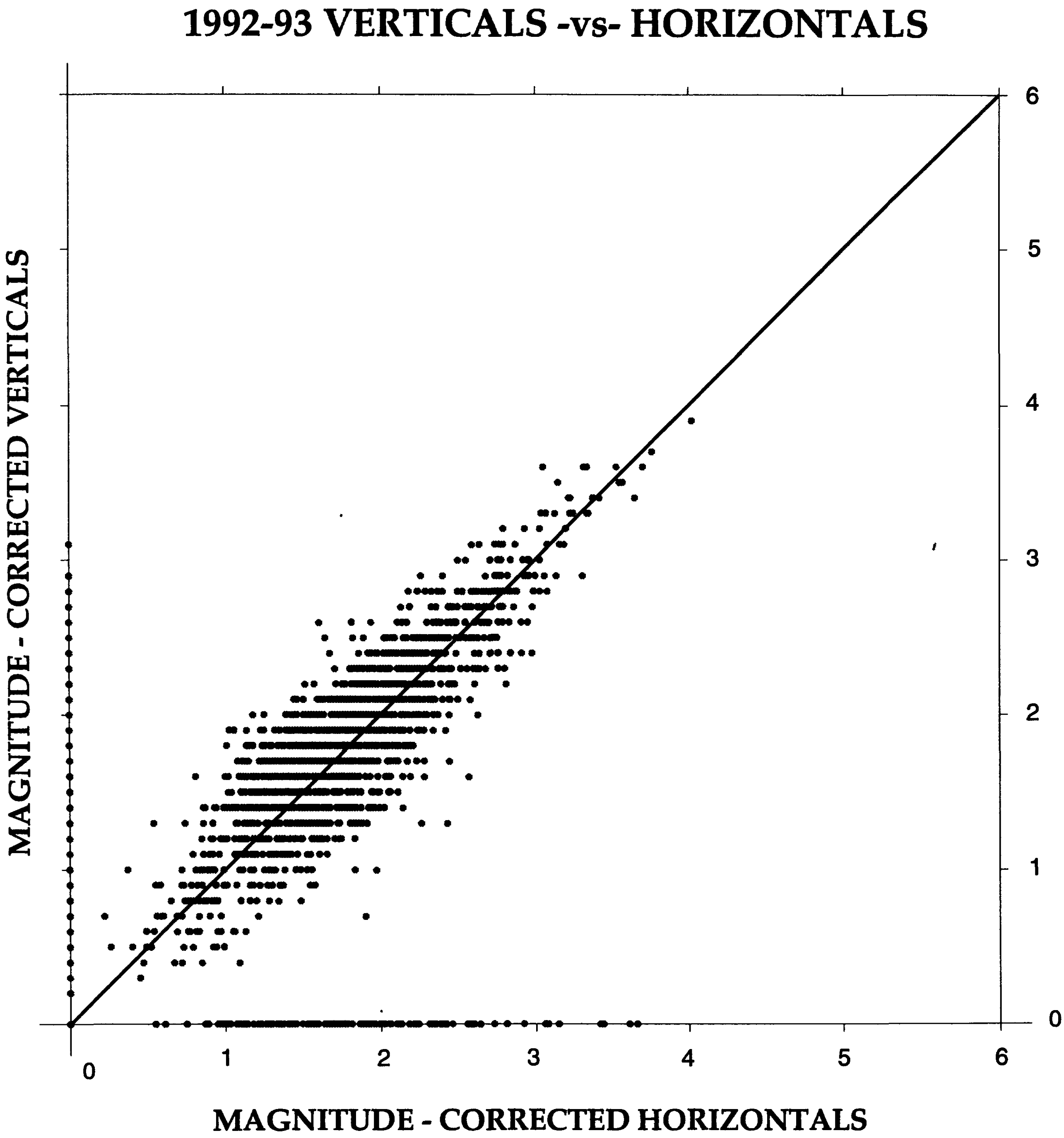

92JUL-93DEC
URAN w/magnitude correction -0.64
STATION AMPMAG
XMAG 2 HILO, UWEKAHUNA
0
1
2
3
4
5
6
0
1
2
3
4
5
6

Figure 30.



1992-93 NETWORK -vs- WOOD-ANDERSONS
MAGNITUDE - NETWORK VERTICAL & HORIZONTALS
MAGNITUDE - HILO, UWEKAHUNA
0
1
2
3
4
5
6

Figure 31.



1992-93 VERTICALS -vs- HORIZONTALS
MAGNITUDE - CORRECTED VERTICALS
MAGNITUDE - CORRECTED HORIZONTALS
0
1
2
3
4
5
6

network stations run at a higher gain than the Wood-Anderson stations. Both figures illustrate reasonable agreement between the calculated magnitudes.

DATA SET - JANUARY 1994 - JULY 1997

With the discontinuation of the Wood-Anderson and other photographic instruments, the selected network stations of the 92-93 data set, with the established corrections applied, now become the source of amplitude magnitude and the reference base. Magnitudes for the selected network stations were calculated for the January 1994 - July 1997 data to verify the corrections using a more current data set. A hypocentral plot (Figure 32) show the earthquake distribution of the 94-97 earthquakes. Figures 33-51 are plots comparing each station's magnitude with the average magnitude of all the selected network stations. The relationship between the cluster and reference line for each station's magnitude is an acceptable fit.

The 94-97 data set presented calibration information and enough amplitude readings for additional stations to be included. Using the new magnitude reference base, we were able to determine corrections for six more network vertical and horizontal components with the same procedure used for the 92_93 data . Between 1994 and 1997, HVO added modified VCO's, with dual gain setting, at several existing vertical component sites. This allowed dual signal outputs, one at normal gain and one at low gain from a single component. A single vertical component (UUGZ), operated at unity electronic gain, was also installed at the Uwekahuna vault. Enough data were gathered for magnitude correction determination from two of the low gain sites, OTLZ and MPRZ. However, there were not enough samples to confidently determine a magnitude correction for UUGZ.

Figures 52-59 are magnitude plots for the additional eight components. Each station's magnitude is compared to the average or event magnitude. Figure 60 again compares the network vertical with the network horizontals for compatibility.

Figure 32.

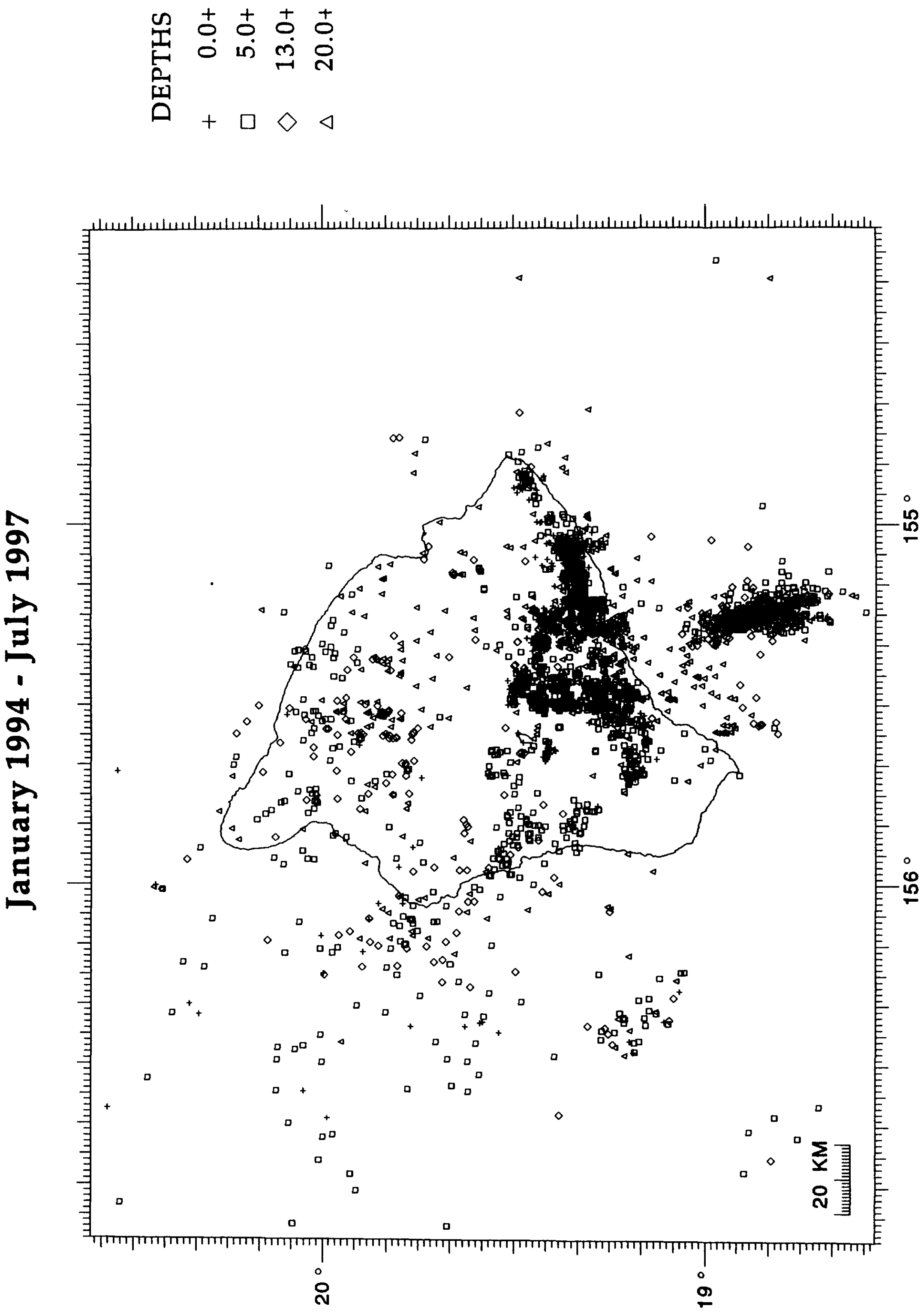


Figure 33.

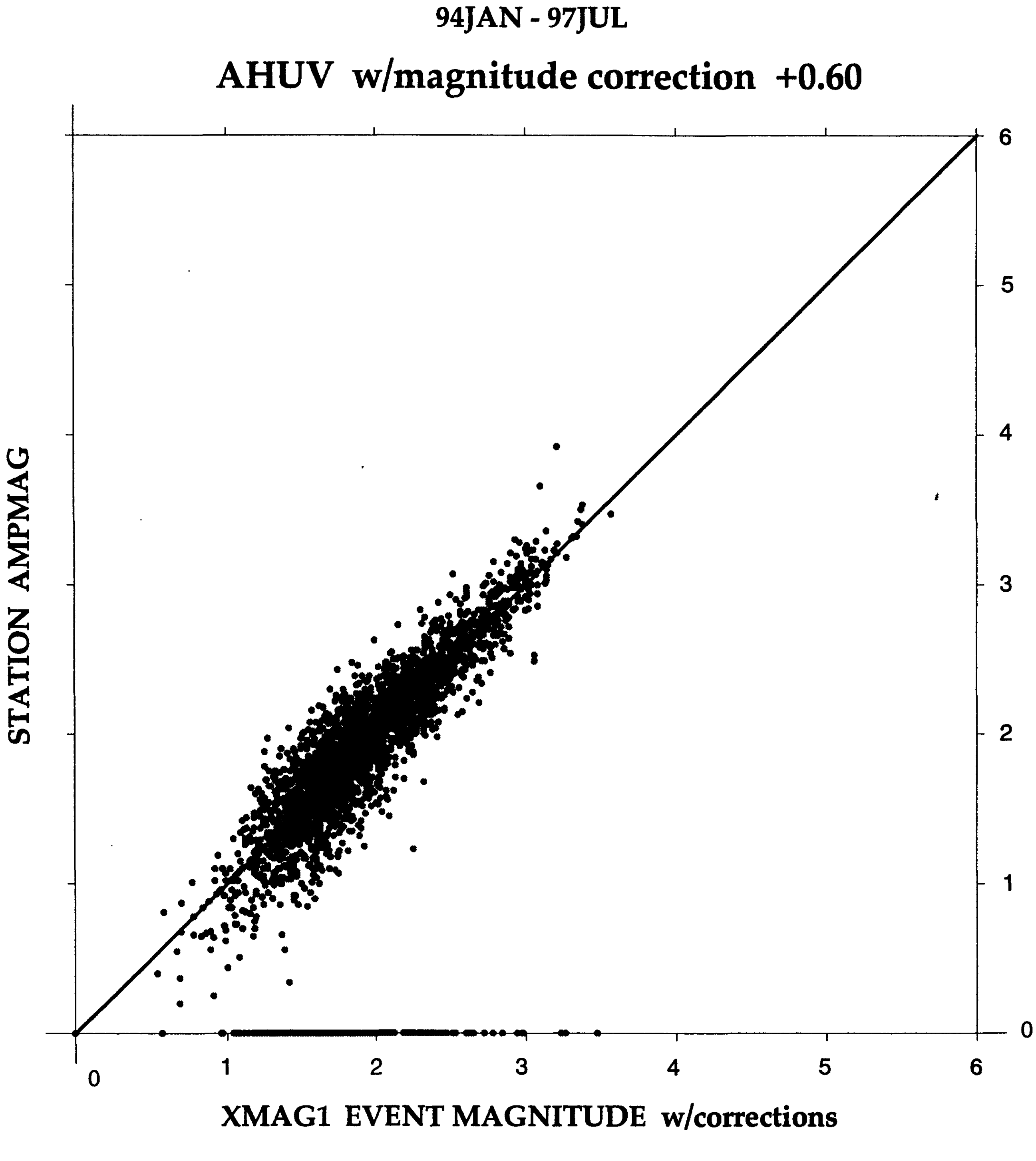
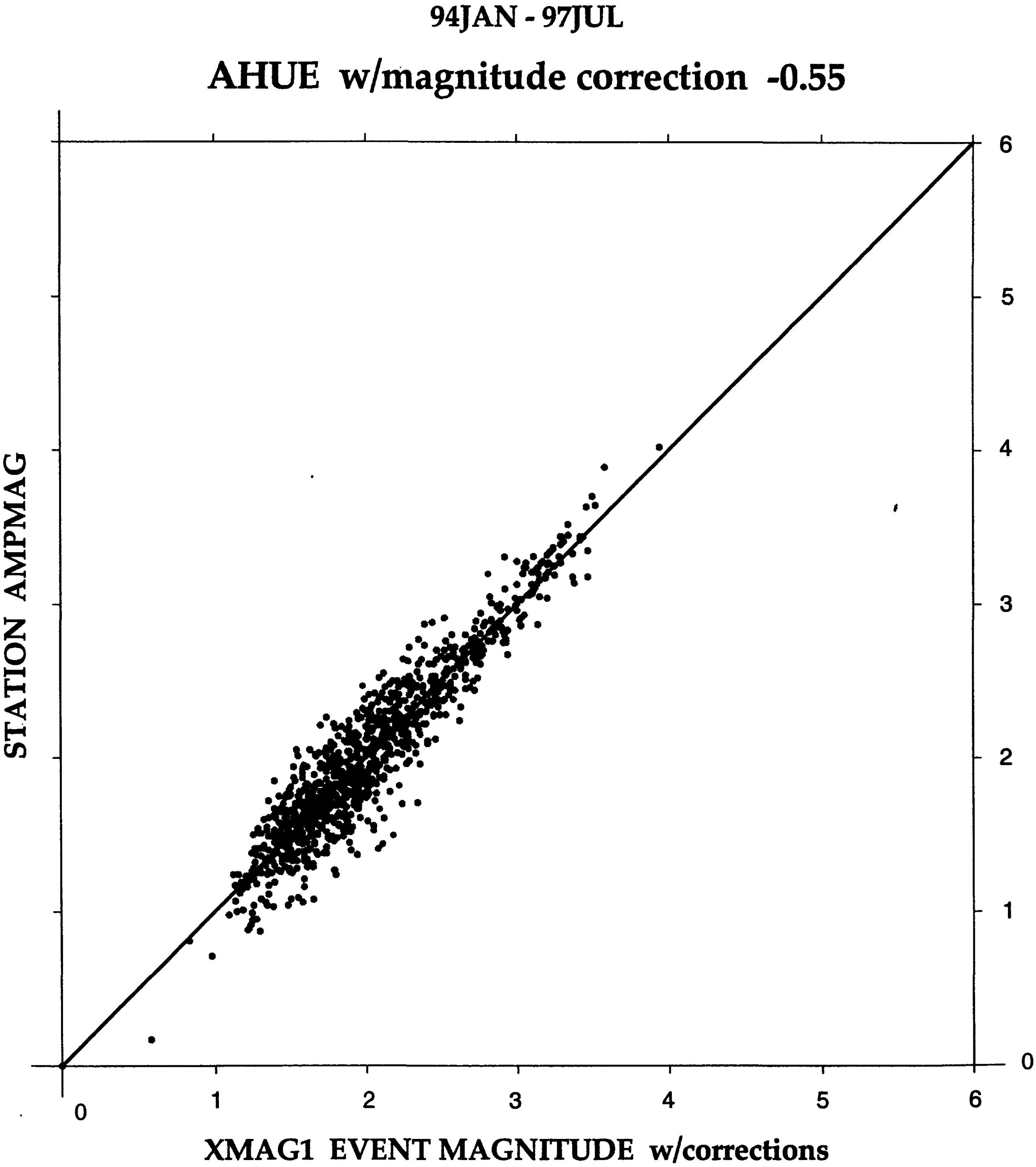
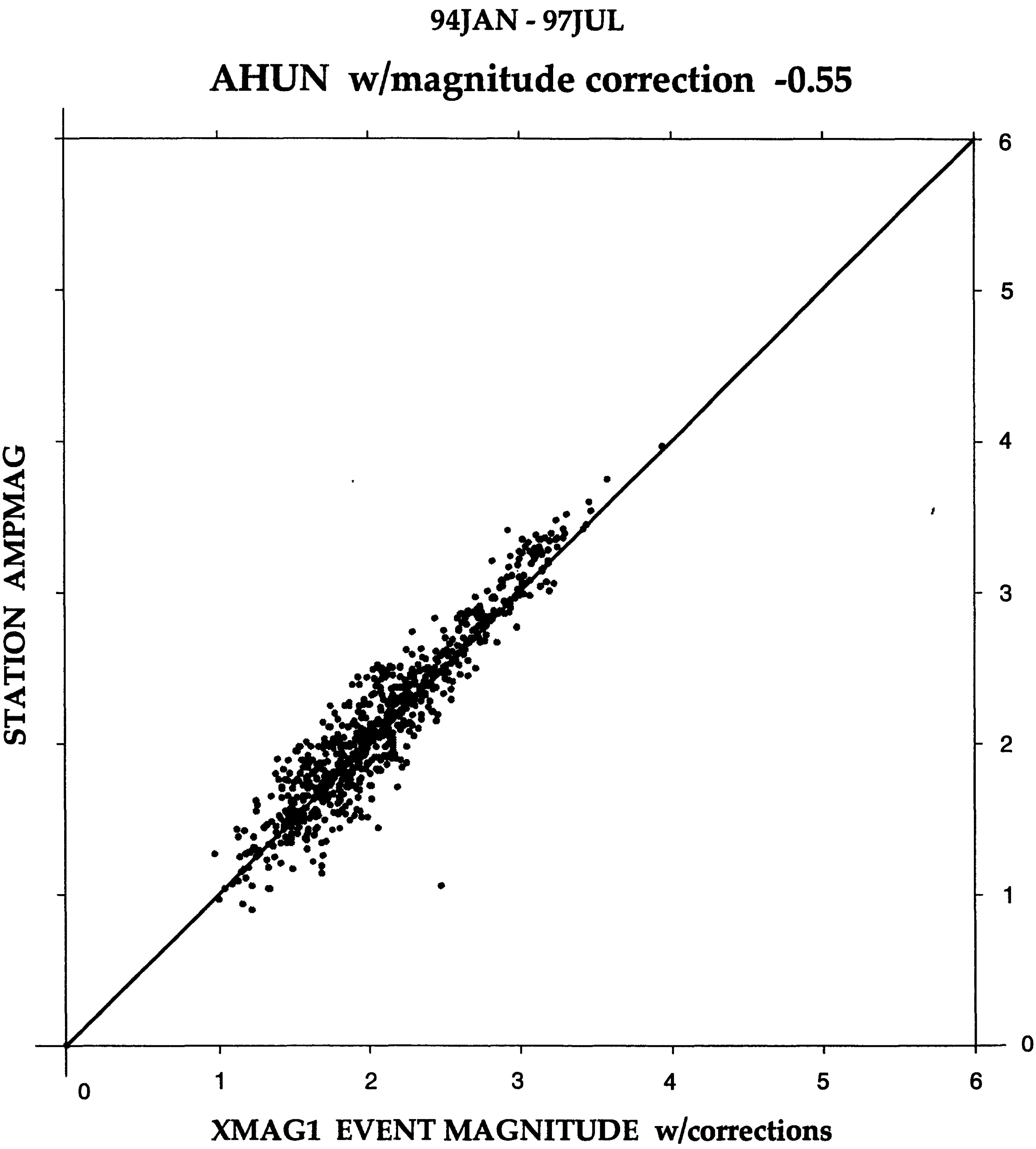

94JAN - 97JUL
AHUV w/magnitude correction +0.60
STATION AMPMAG
XMAG1 EVENT MAGNITUDE w/corrections
0
1
2
3
4
5
6

Figure 34.



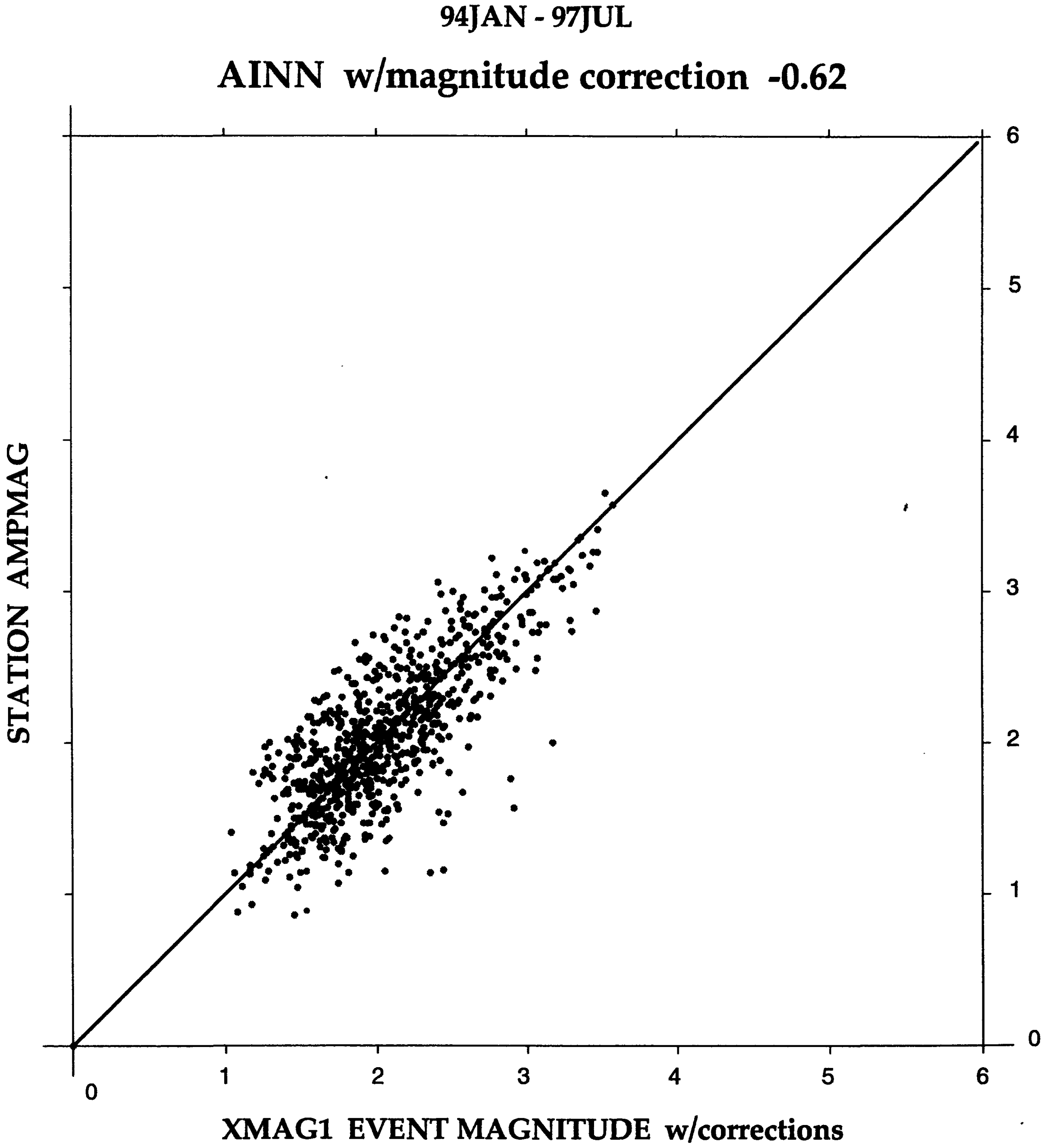
94JAN - 97JUL
AHUE w/magnitude correction -0.55
STATION AMPMAG
XMAG1 EVENT MAGNITUDE w/corrections
0
1
2
3
4
5
6

Figure 35.



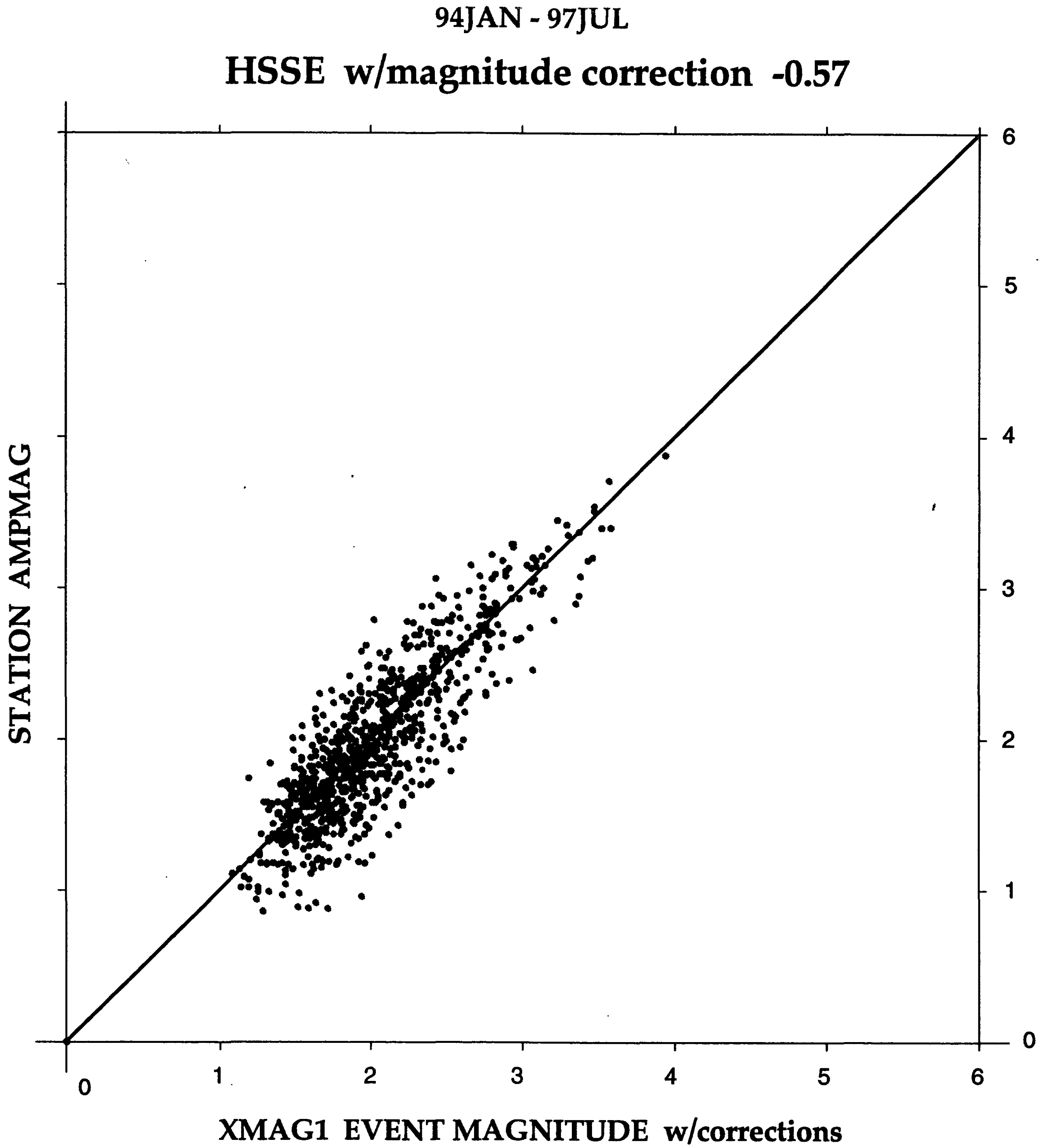
94JAN - 97JUL
AHUN w/magnitude correction -0.55
STATION AMPMAG
XMAG1 EVENT MAGNITUDE w/corrections
0
1
2
3
4
5
6

Figure 36.



94JAN - 97JUL
AINN w/magnitude correction -0.62
STATION AMPMAG
XMAG1 EVENT MAGNITUDE w/corrections
0
1
2
3
4
5
6

Figure 37.



94JAN - 97JUL
HSSE w/magnitude correction -0.57
STATION AMPMAG
XMAG1 EVENT MAGNITUDE w/corrections
0
1
2
3
4
5
6

Figure 38.

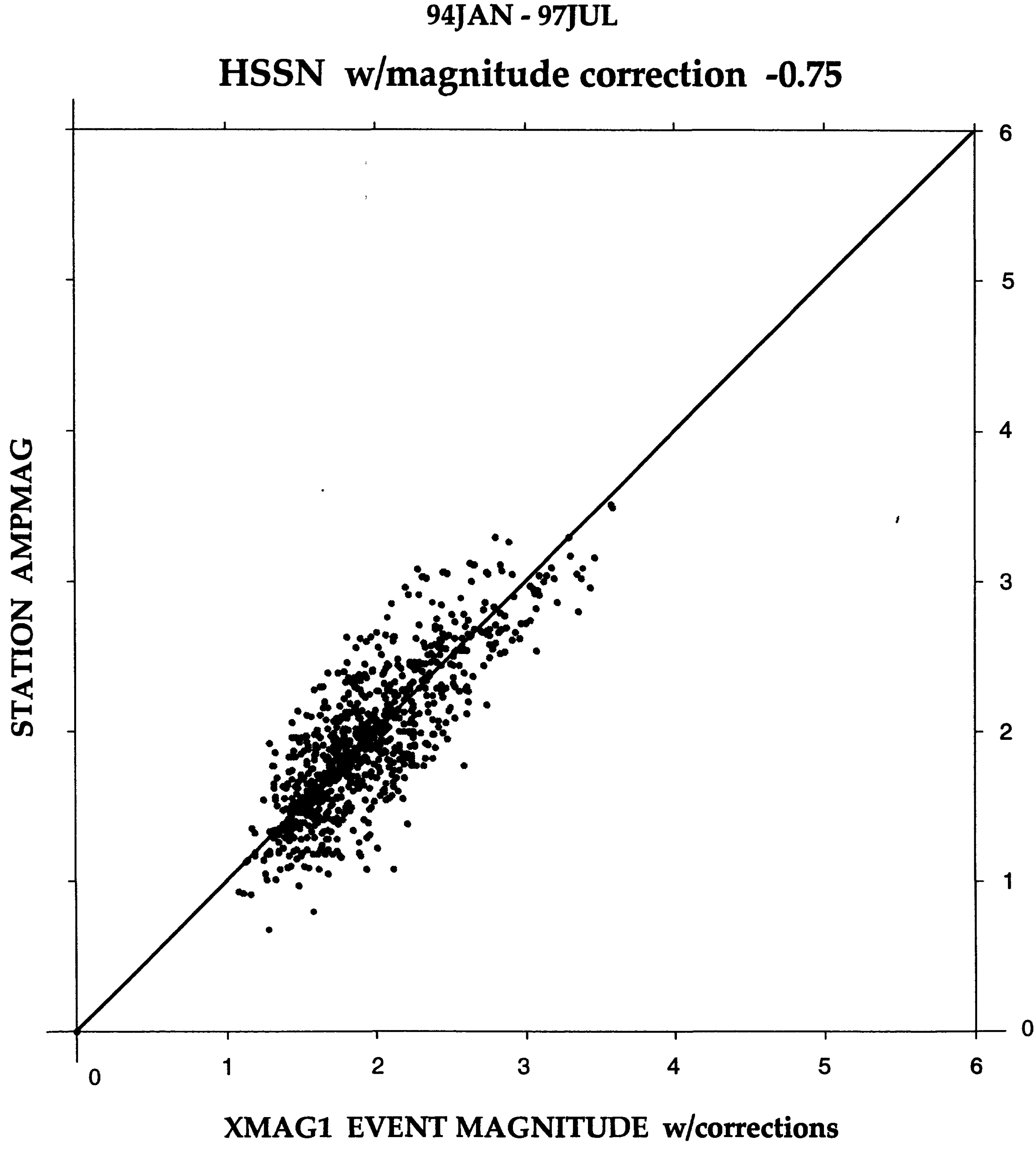
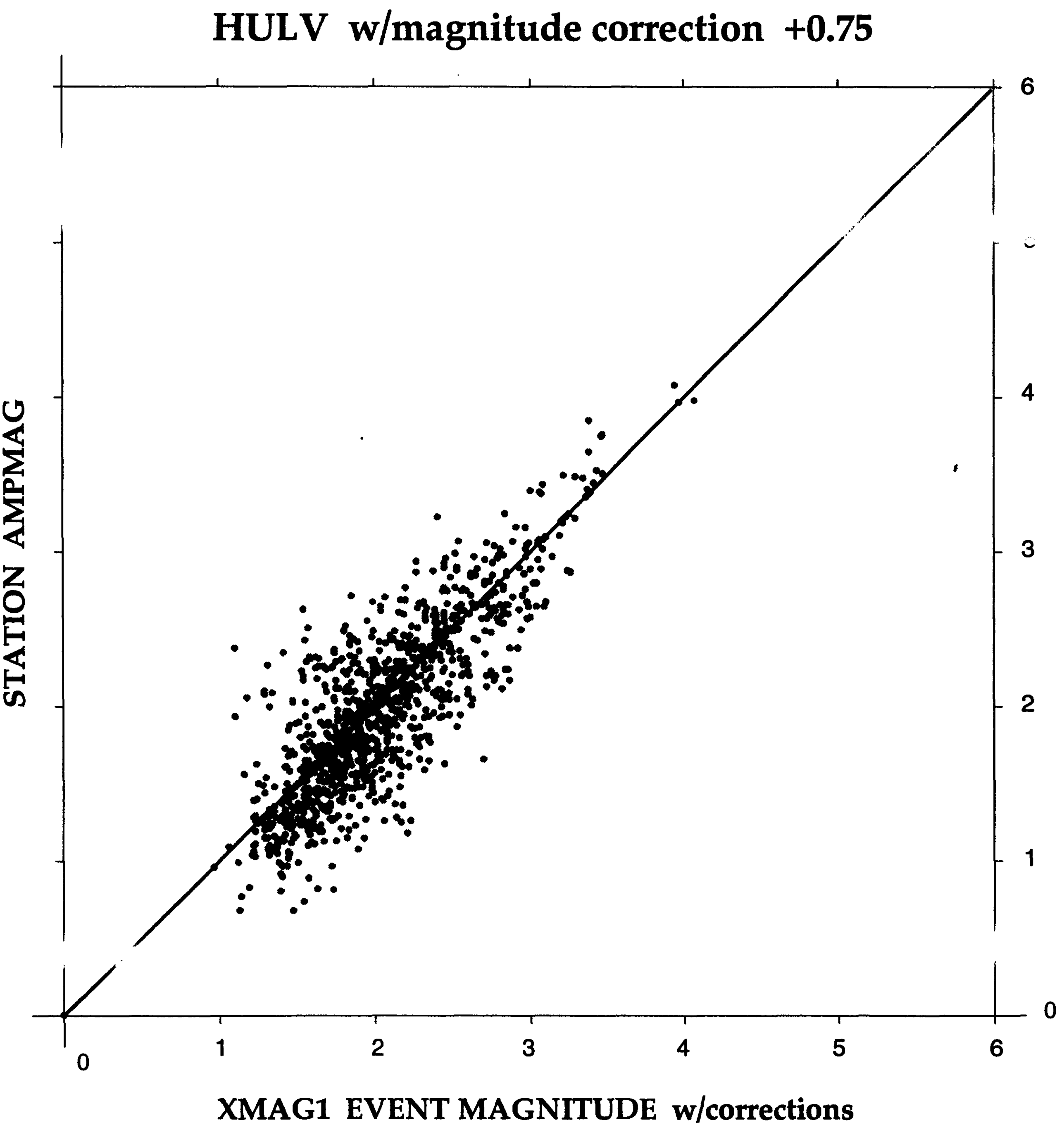

94JAN - 97JUL
HSSN w/magnitude correction -0.75
STATION AMPMAG
XMAG1 EVENT MAGNITUDE w/corrections
0
1
2
3
4
5
6

Figure 39.



HULV w/magnitude correction +0.75
STATION AMPMAG
XMAG1 EVENT MAGNITUDE w/corrections
0
1
2
3
4
5
6
0
1
2
3
4
6

Figure 40.

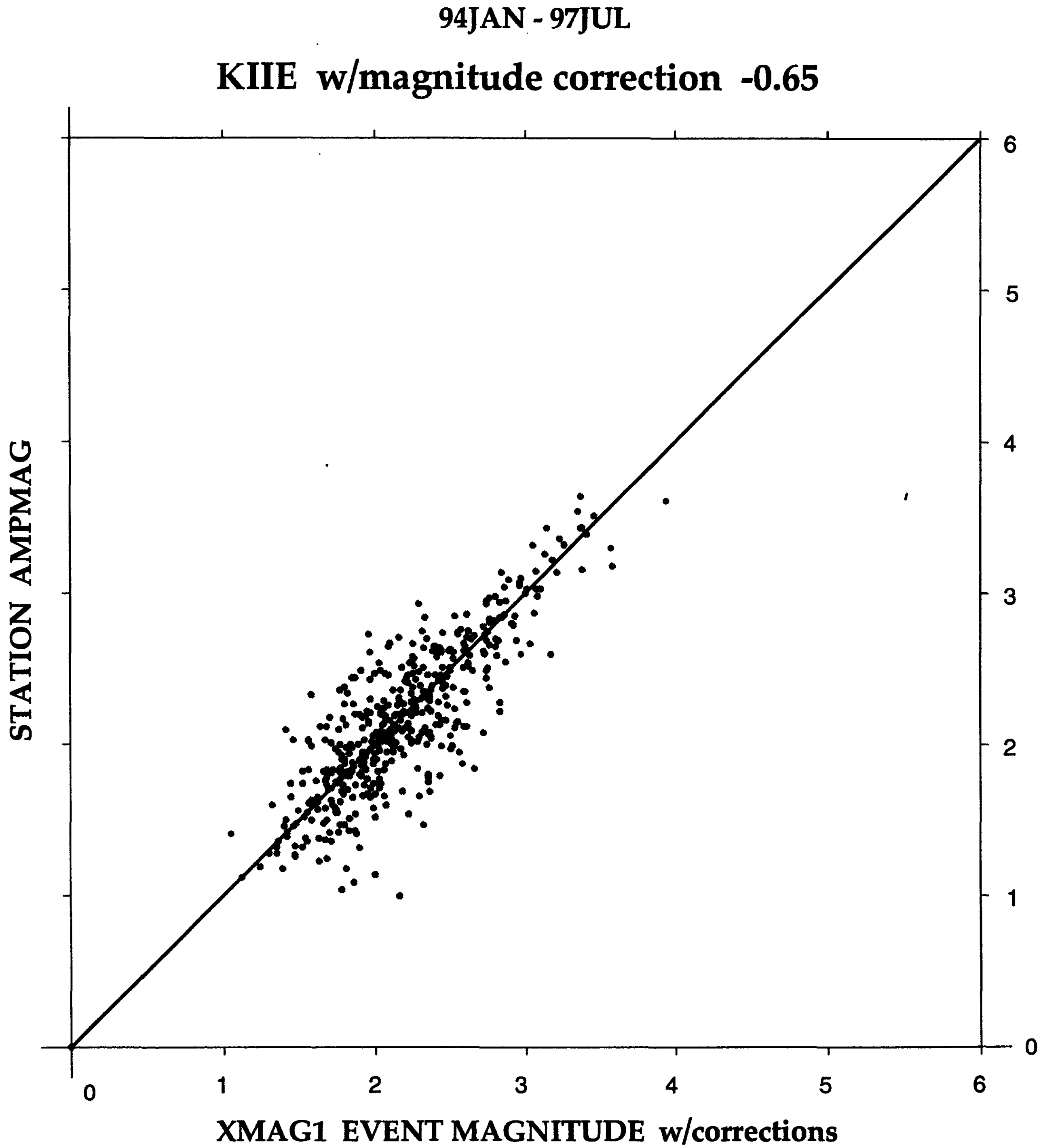

94JAN - 97JUL
KIIE w/magnitude correction -0.65
STATION AMPMAG
XMAG1 EVENT MAGNITUDE w/corrections
0
1
2
3
4
5
6

Figure 41.

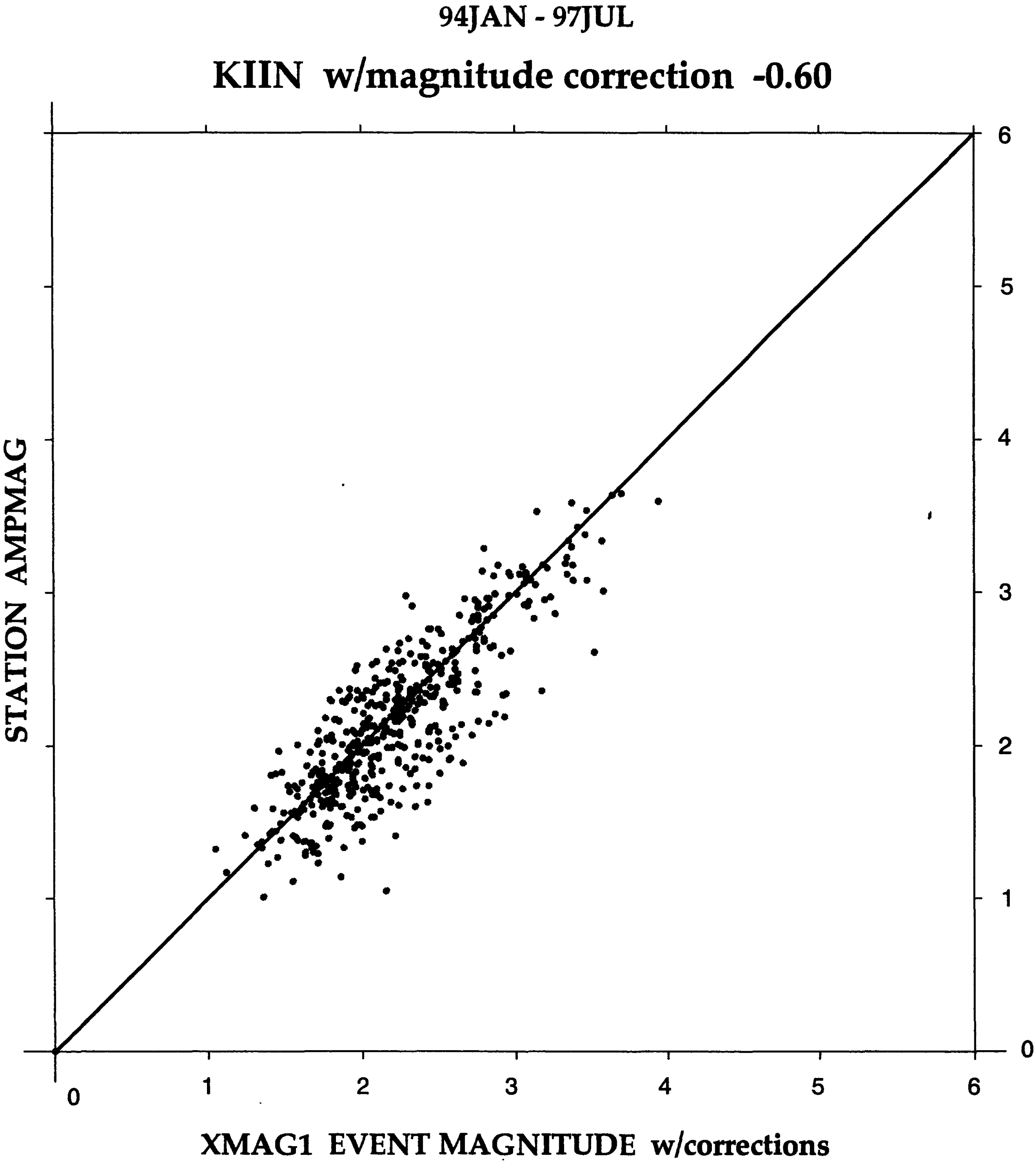
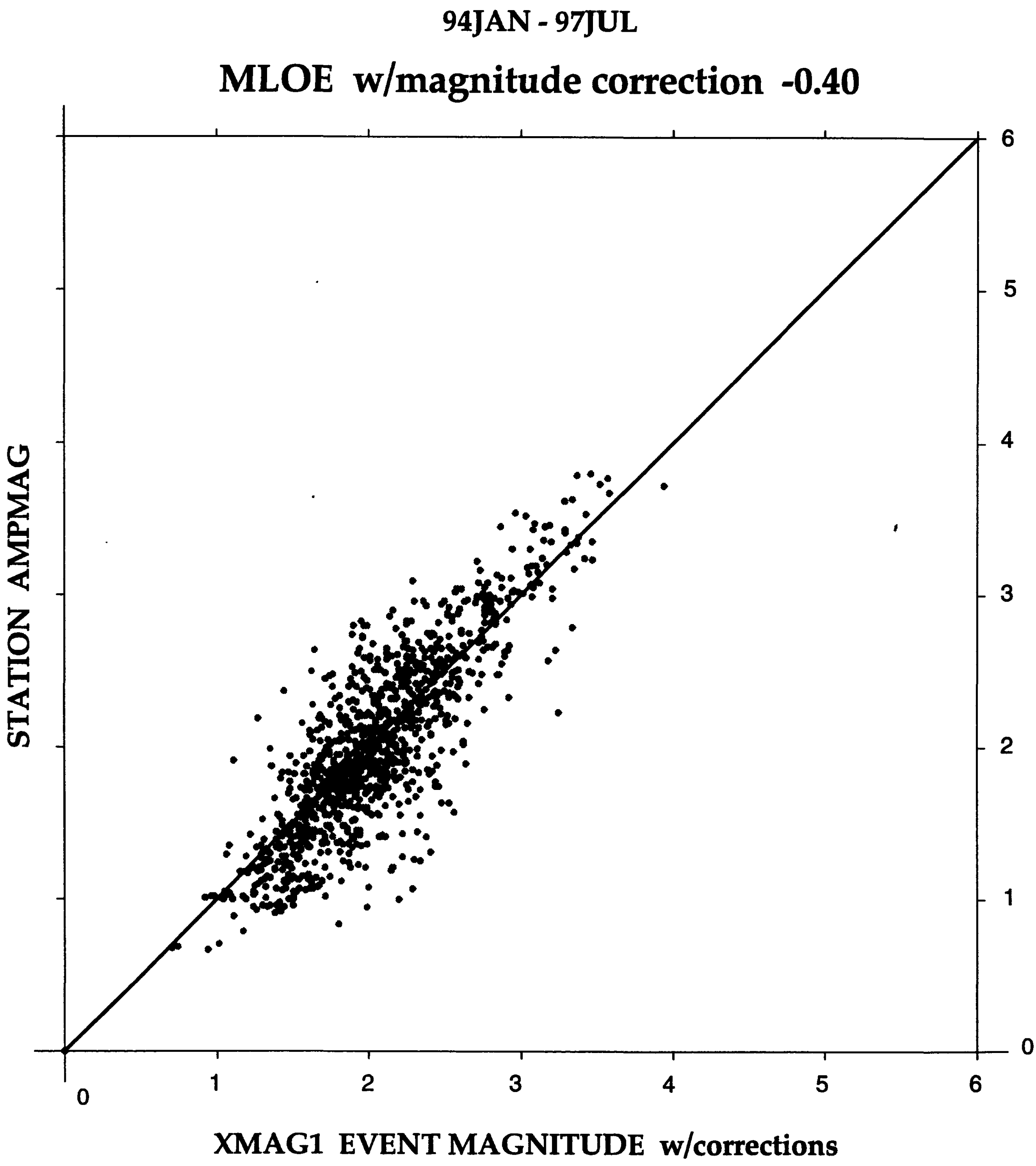

94JAN - 97JUL
KIIN w/magnitude correction -0.60
STATION AMPMAG
XMAG1 EVENT MAGNITUDE w/corrections
0
1
2
3
4
5
6
0
1
2
3
4
5
6

Figure 42.



94JAN - 97JUL
MLOE w/magnitude correction -0.40
STATION AMPMAG
XMAG1 EVENT MAGNITUDE w/corrections
0
1
2
3
4
5
6

Figure 43.

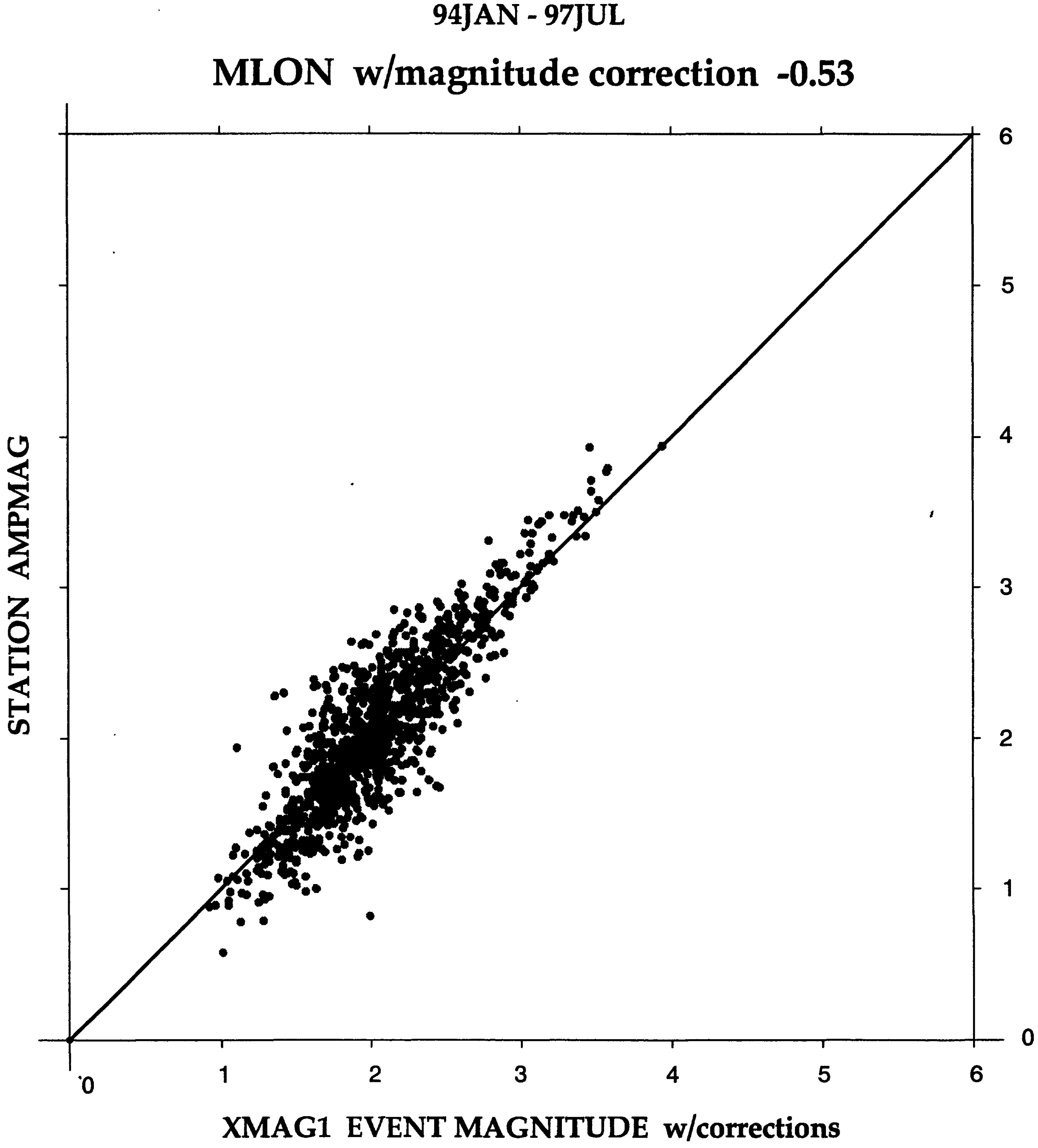
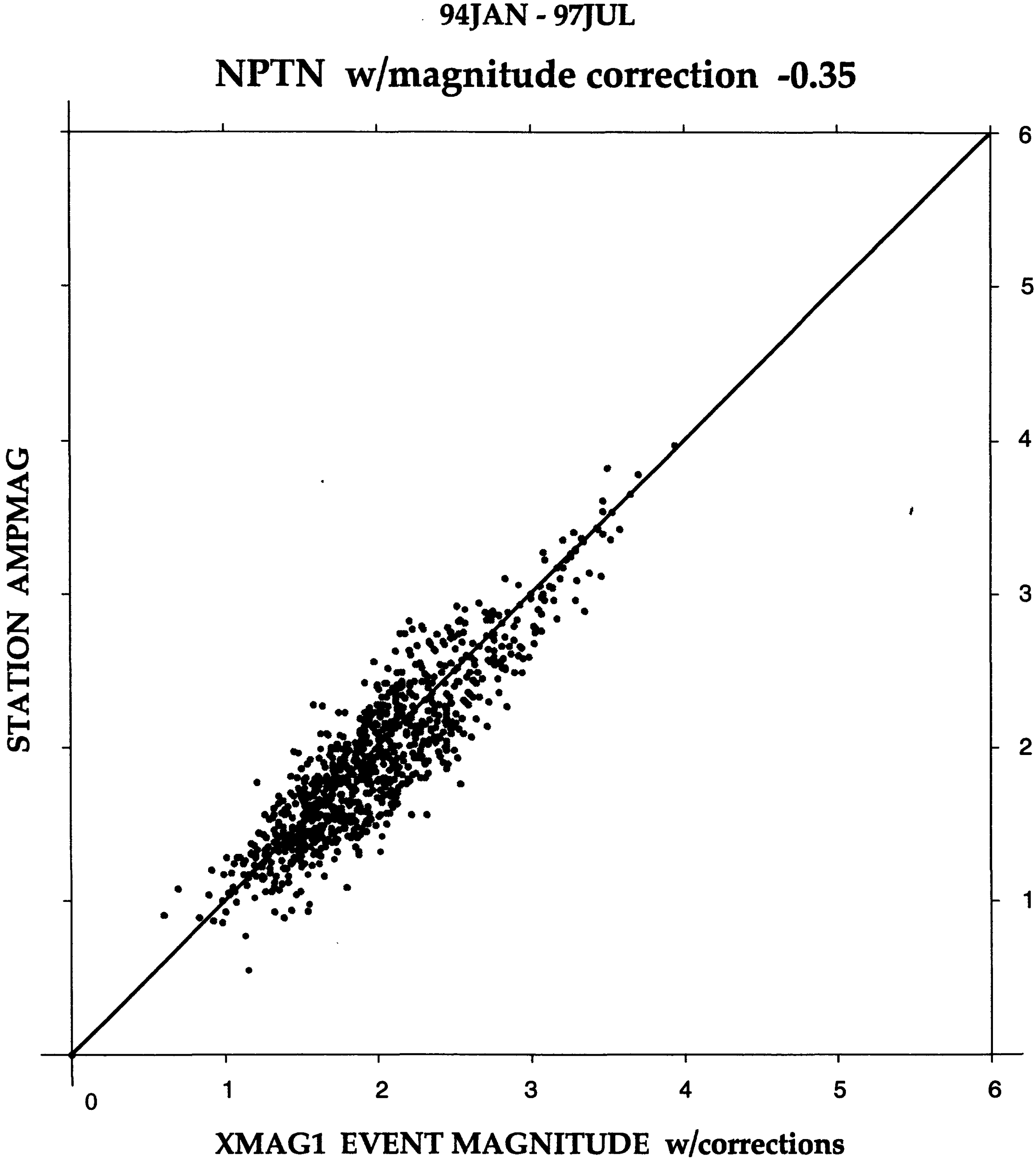

94JAN - 97JUL
MLON w/magnitude correction -0.53
STATION AMPMAG
XMAG1 EVENT MAGNITUDE w/corrections
0
1
2
3
4
5
6

Figure 44.



94JAN - 97JUL
NPTN w/magnitude correction -0.35
STATION AMPMAG
XMAG1 EVENT MAGNITUDE w/corrections
0
1
2
3
4
5
6

Figure 45.

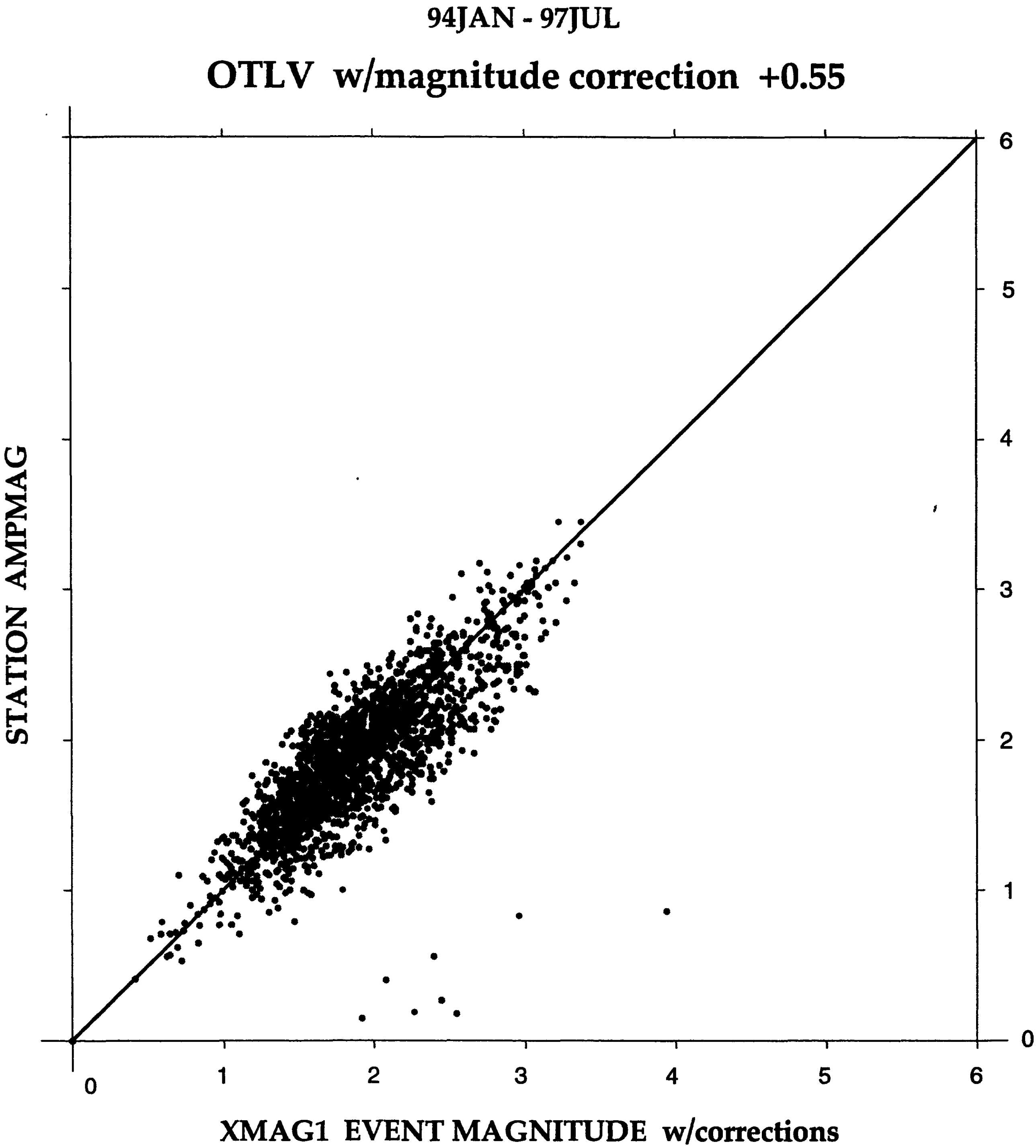
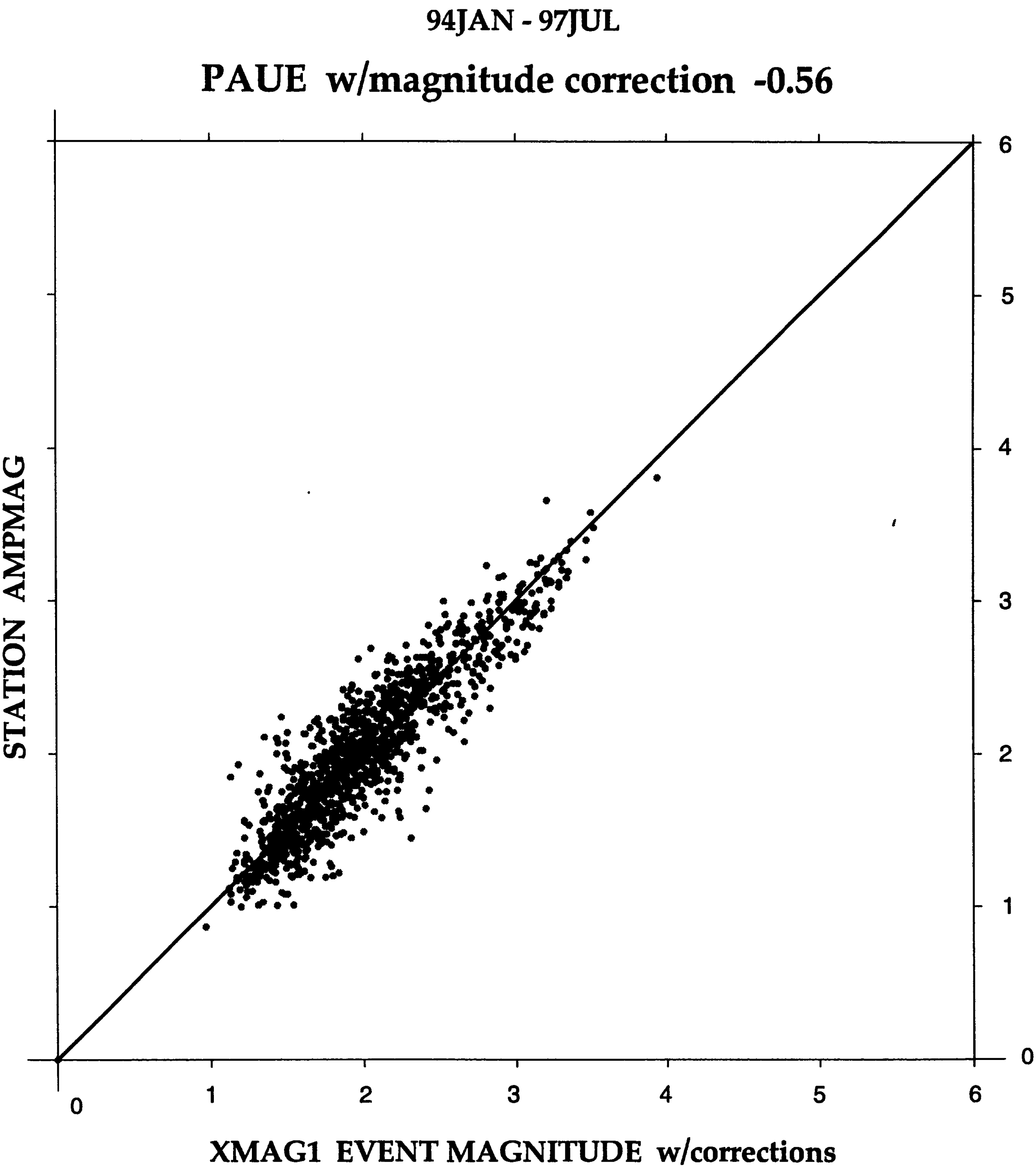

94JAN - 97JUL
OTLV w/magnitude correction +0.55
STATION AMPMAG
XMAG1 EVENT MAGNITUDE w/corrections
0
1
2
3
4
5
6

Figure 46.



94JAN - 97JUL
PAUE w/magnitude correction -0.56
STATION AMPMAG
XMAG1 EVENT MAGNITUDE w/corrections
0
1
2
3
4
5
6

Figure 47.

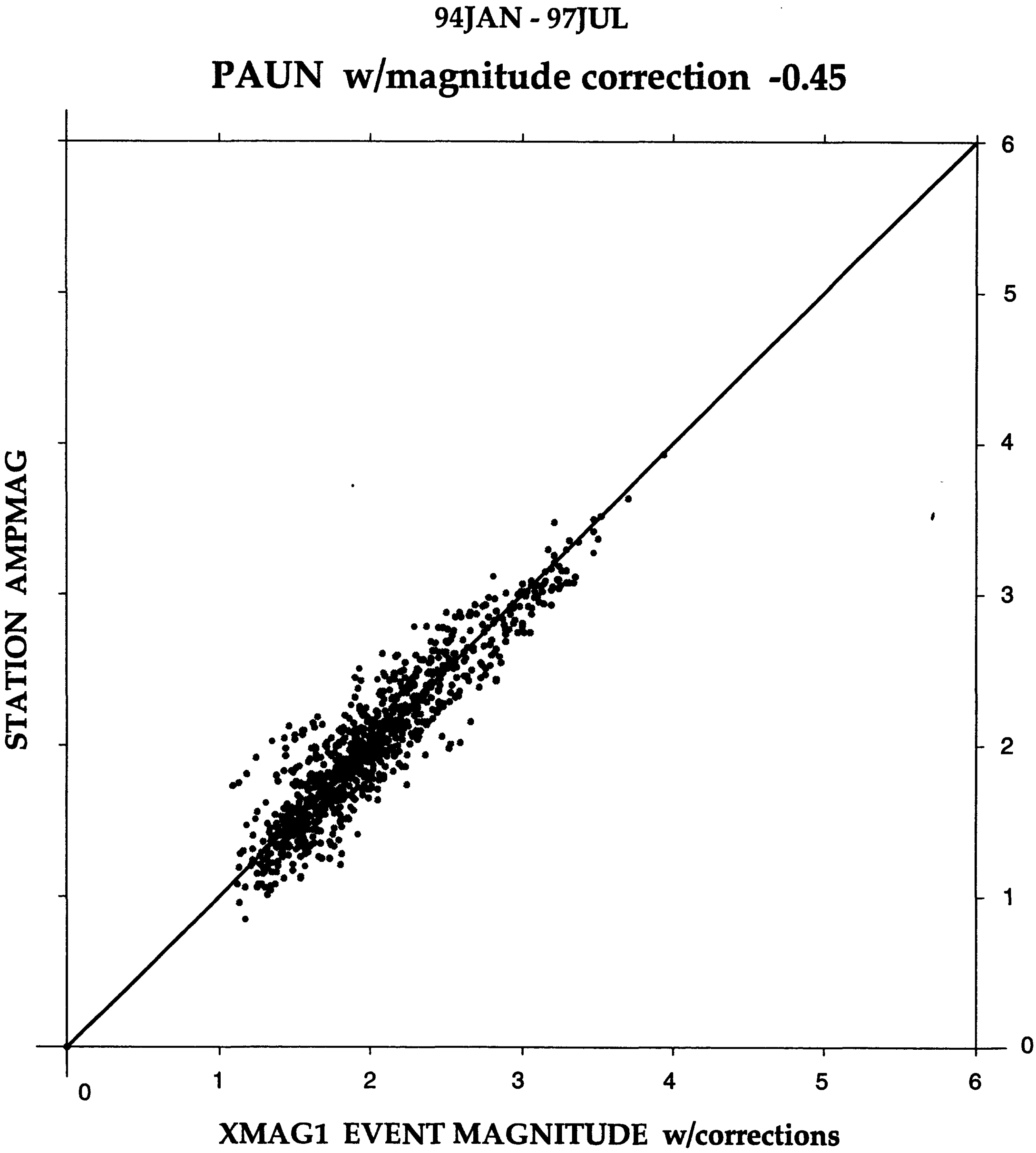

94JAN - 97JUL
PAUN w/magnitude correction -0.45
STATION AMPMAG
XMAG1 EVENT MAGNITUDE w/corrections
0
1
2
3
4
5
6

Figure 48.

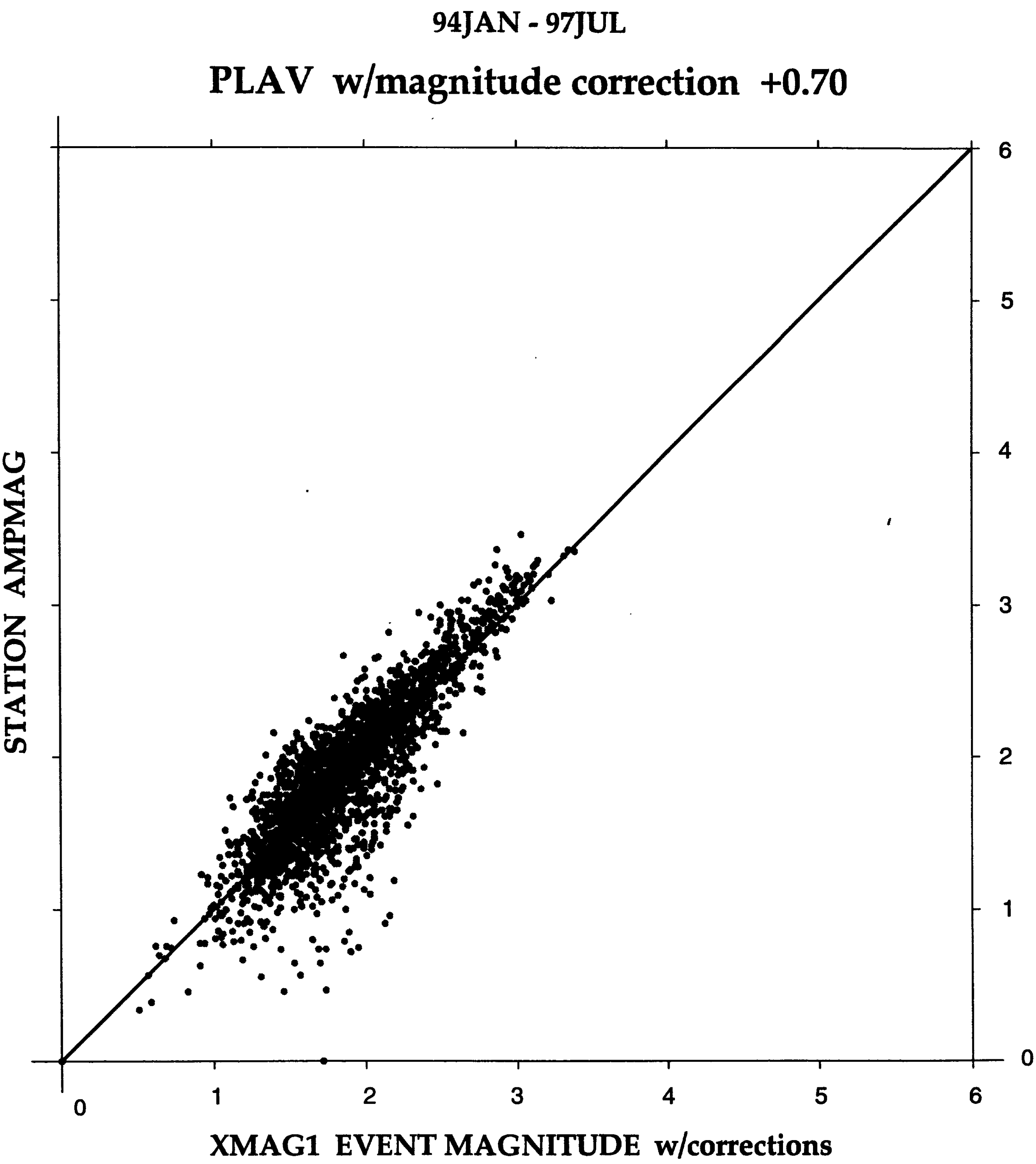
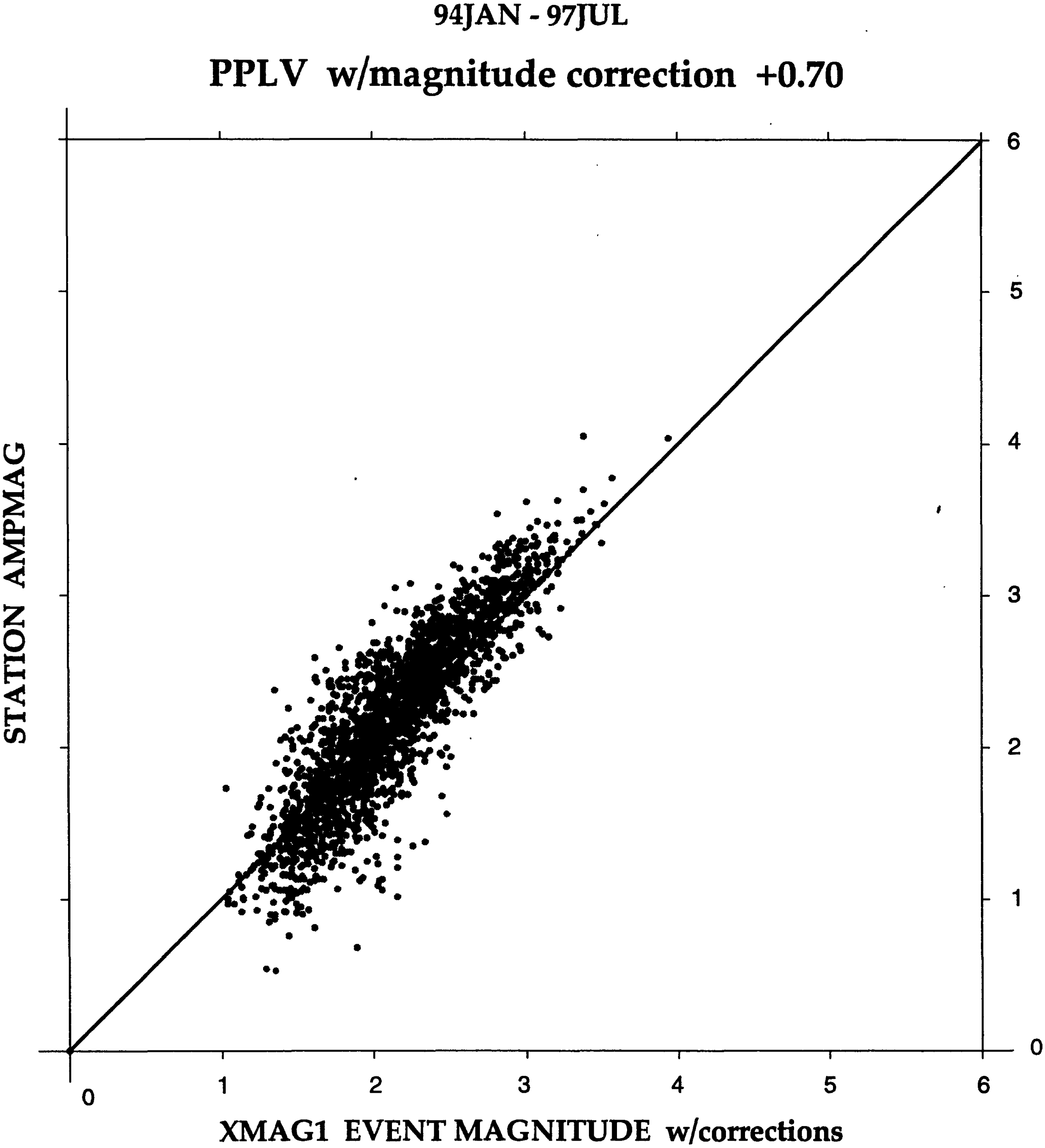

94JAN - 97JUL
PLAV w/magnitude correction +0.70
STATION AMPMAG
XMAG1 EVENT MAGNITUDE w/corrections
0
1
2
3
4
5
6

Figure 49.



94JAN - 97JUL
PPLV w/magnitude correction +0.70
STATION AMPMAG
XMAG1 EVENT MAGNITUDE w/corrections
0
1
2
3
4
5
6

Figure 50.

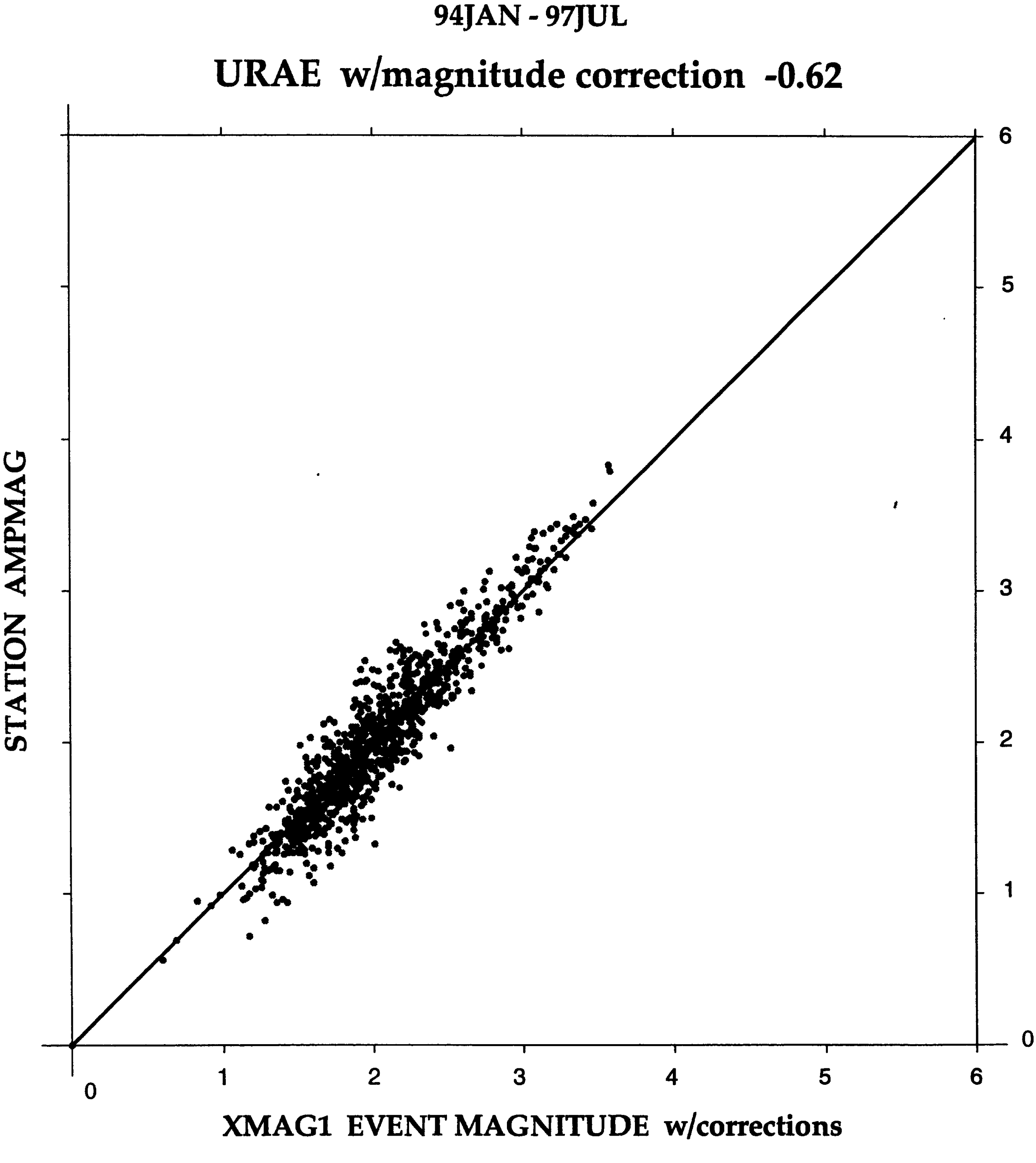

94JAN - 97JUL
URAE w/magnitude correction -0.62
STATION AMPMAG
XMAG1 EVENT MAGNITUDE w/corrections
0
1
2
3
4
5
6

Figure 51.

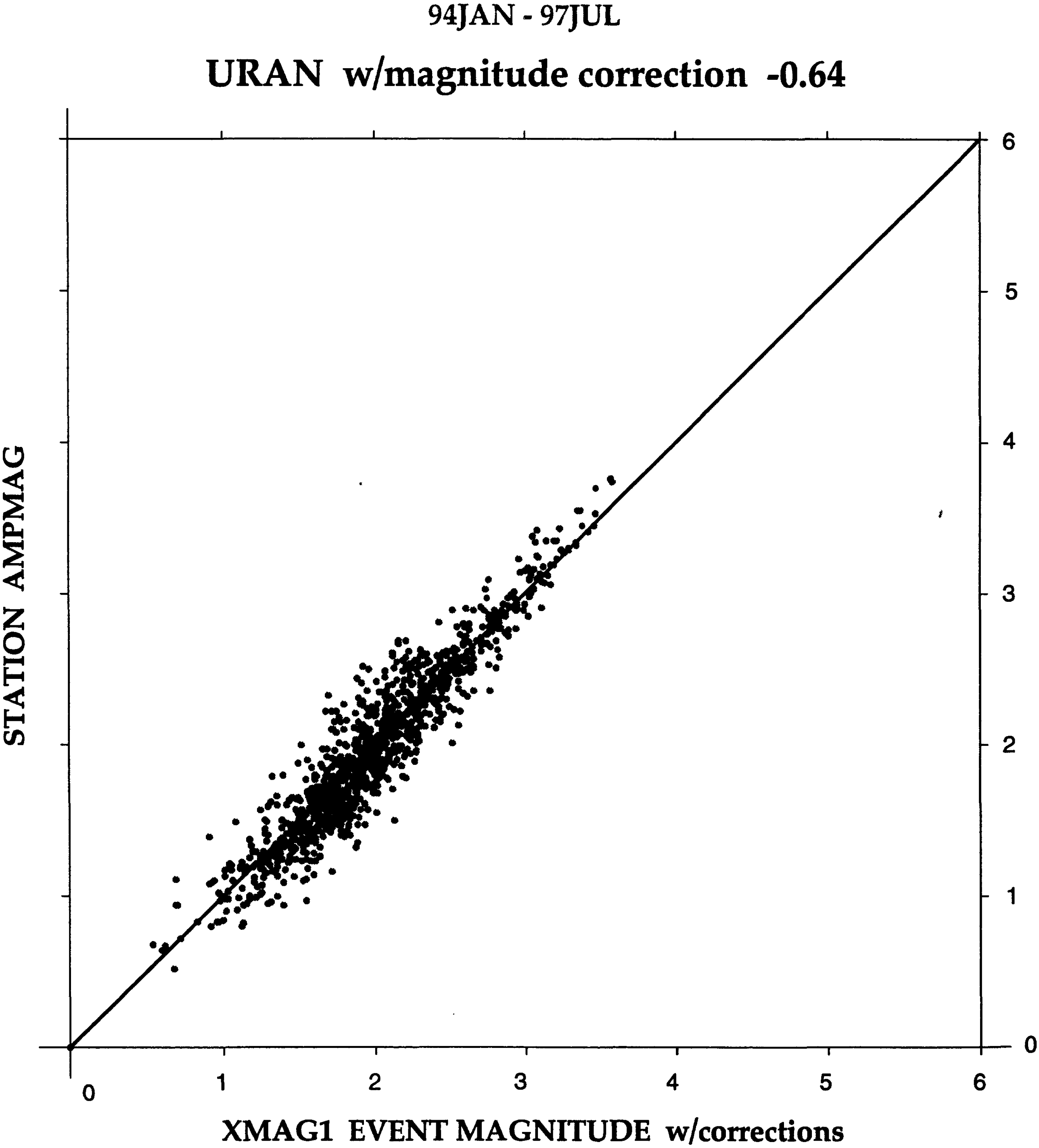
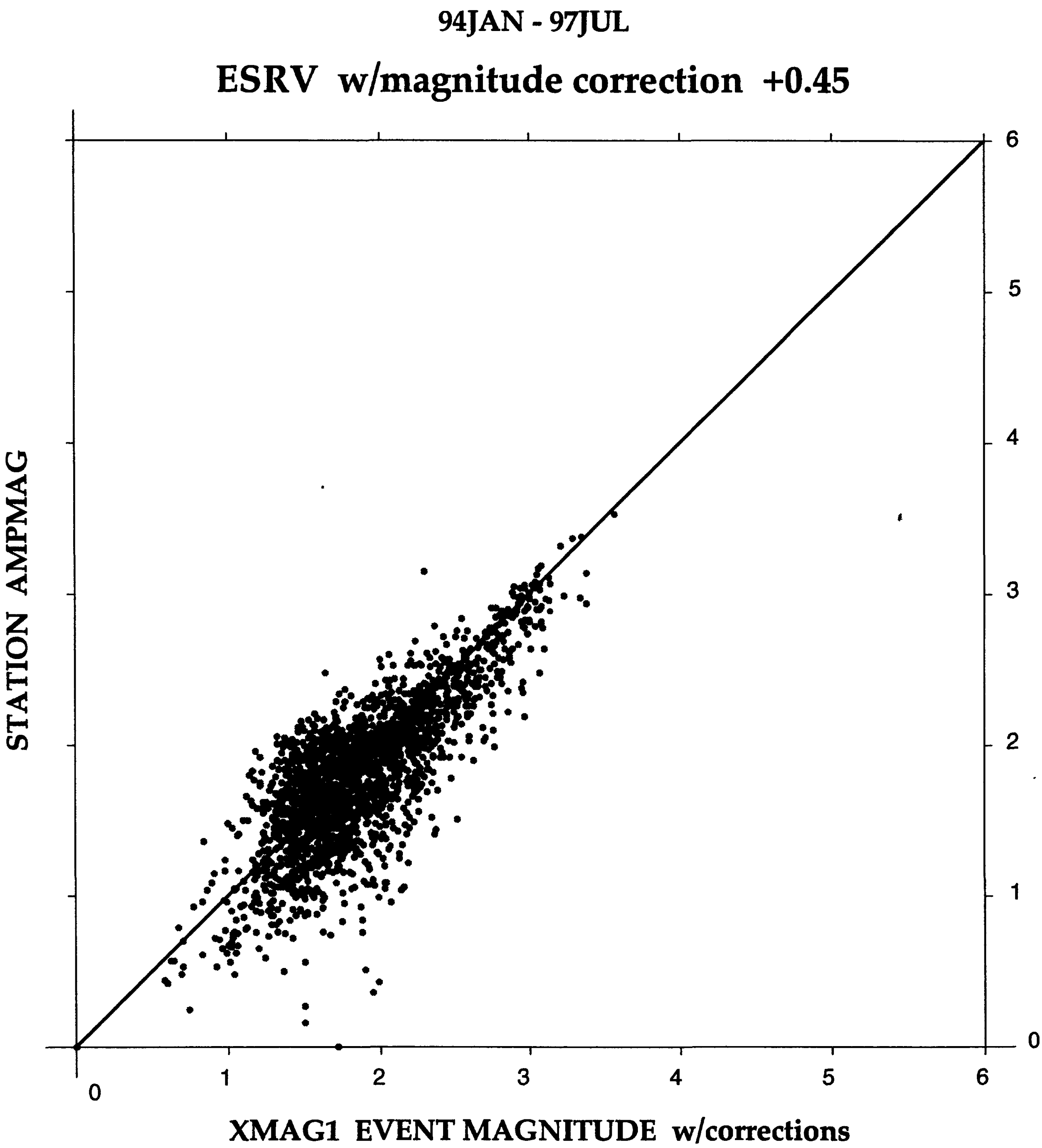
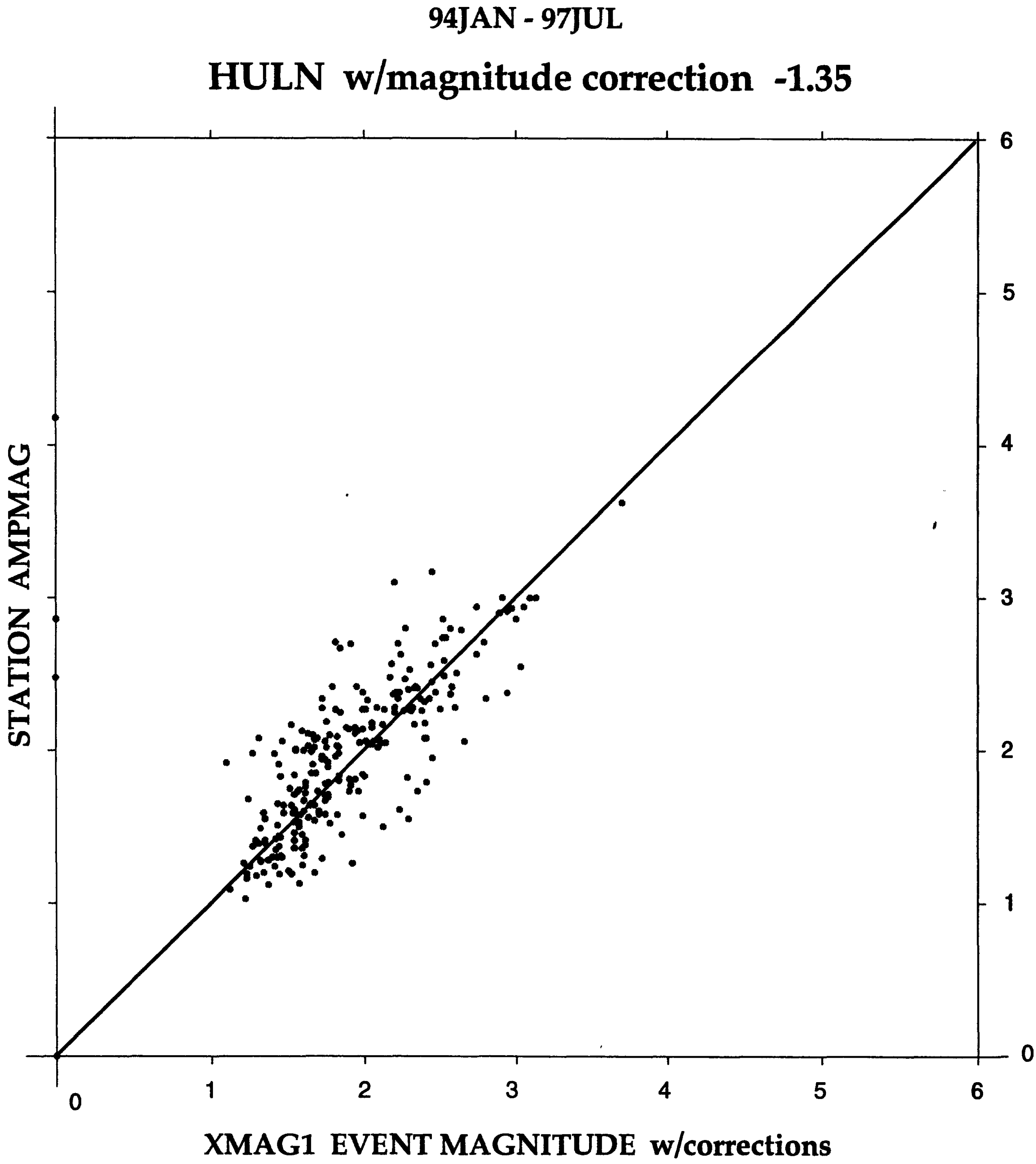

94JAN - 97JUL
URAN w/magnitude correction -0.64
STATION AMPMAG
XMAG1 EVENT MAGNITUDE w/corrections
0
1
2
3
4
5
6

Figure 52.



94JAN - 97JUL
ESRV w/magnitude correction +0.45
STATION AMPMAG
XMAG1 EVENT MAGNITUDE w/corrections
0
1
2
3
4
5
6

Figure 53.



94JAN - 97JUL
HULN w/magnitude correction -1.35
STATION AMPMAG
XMAG1 EVENT MAGNITUDE w/corrections
0
1
2
3
4
5
6

Figure 54.

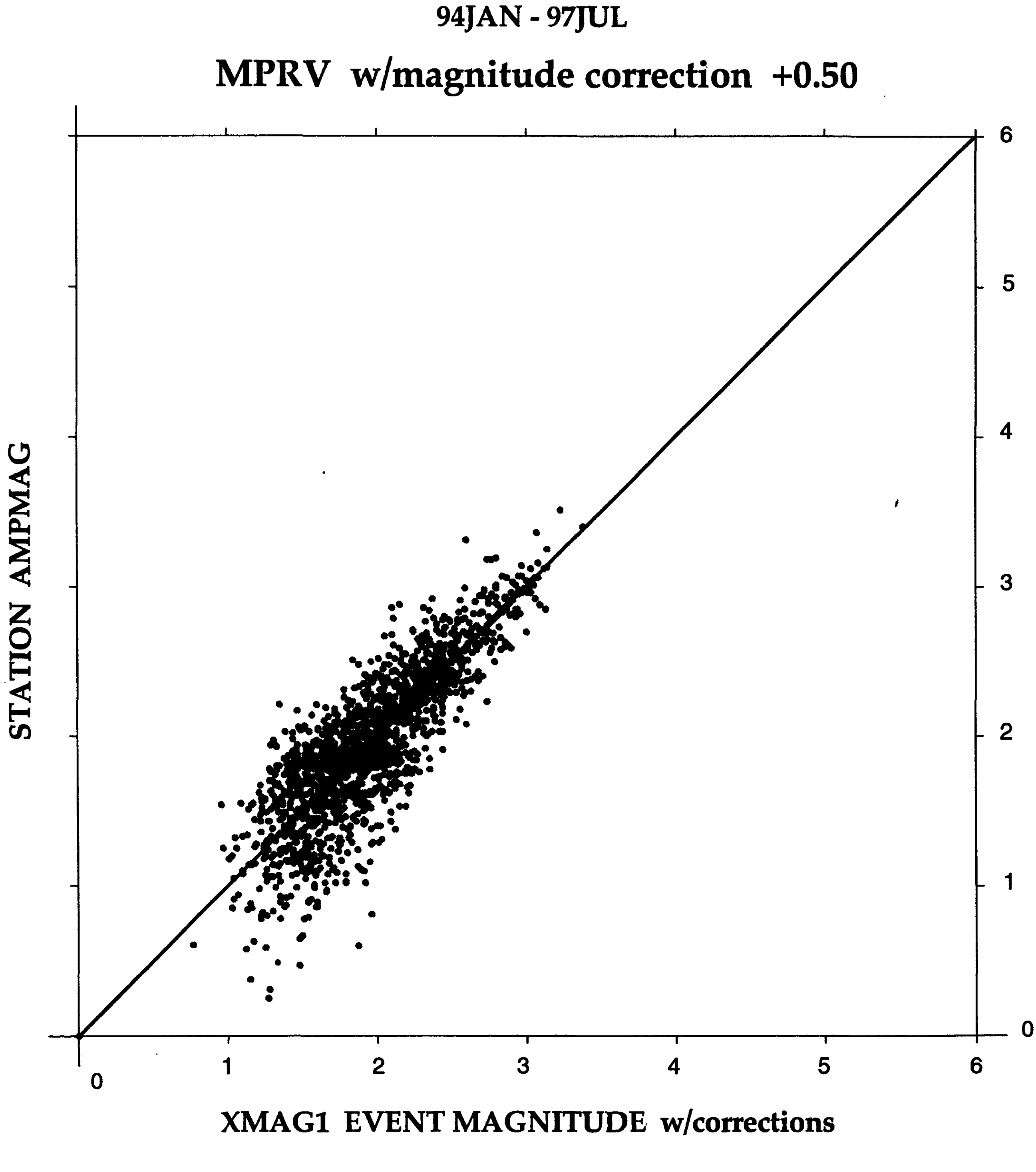
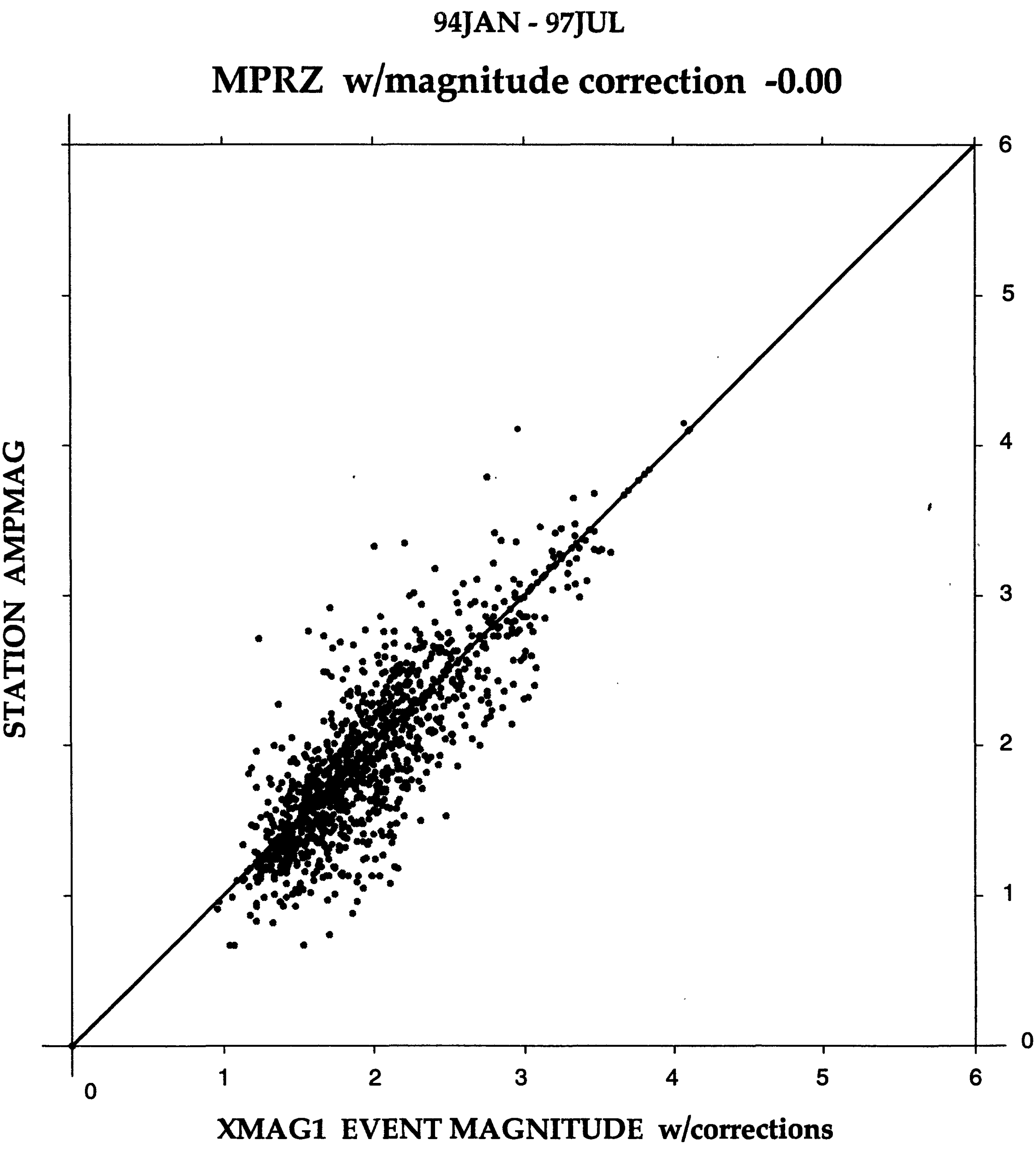

94JAN - 97JUL
MPRV w/magnitude correction +0.50
STATION AMPMAG
XMAG1 EVENT MAGNITUDE w/corrections
0
1
2
3
4
5
6

Figure 55.



94JAN - 97JUL
MPRZ w/magnitude correction -0.00
STATION AMPMAG
XMAG1 EVENT MAGNITUDE w/corrections
0
1
2
3
4
5
6

Figure 56.

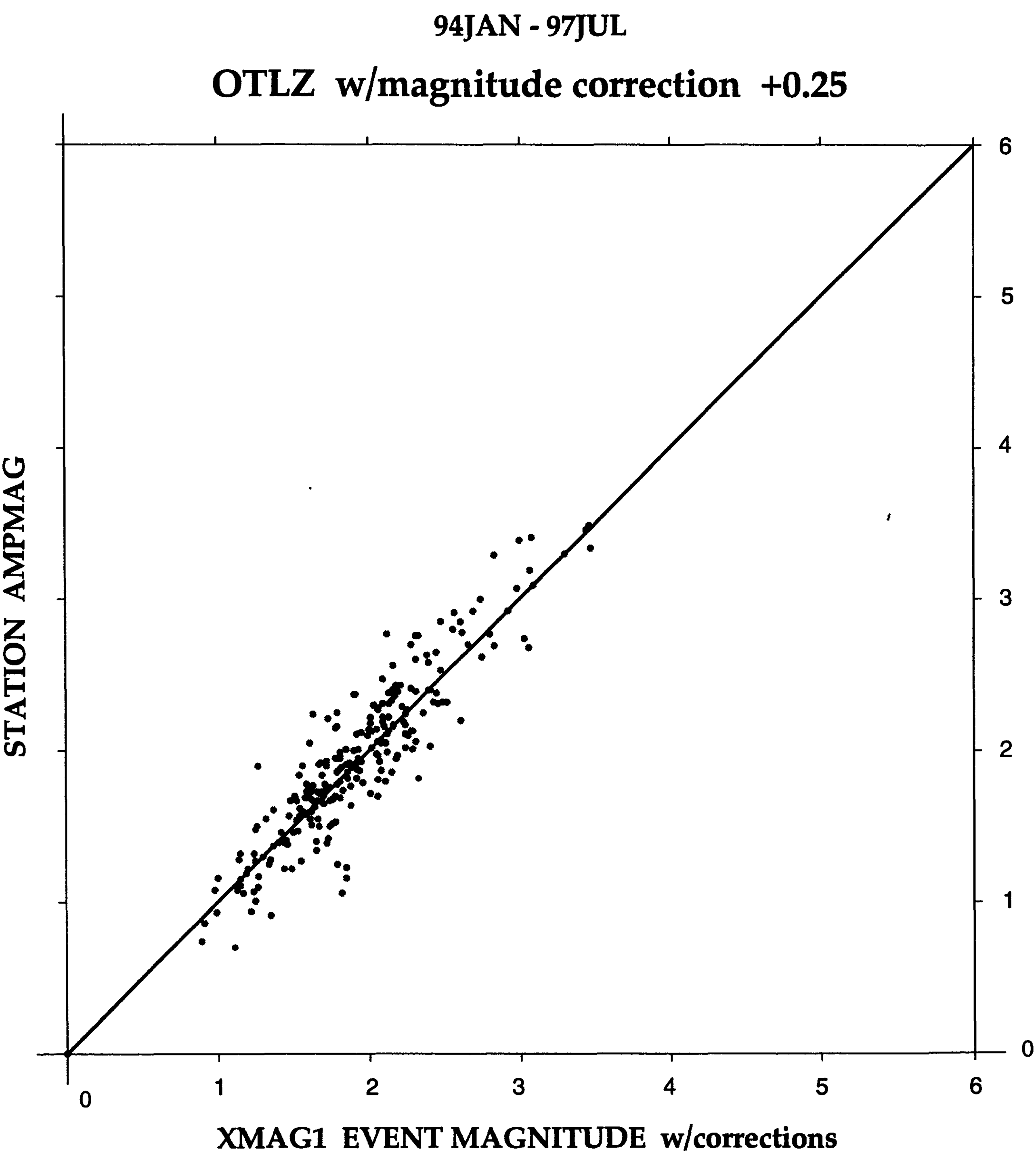

94JAN - 97JUL
OTLZ w/magnitude correction +0.25
STATION AMPMAG
XMAG1 EVENT MAGNITUDE w/corrections
0
1
2
3
4
5
6

Figure 57.

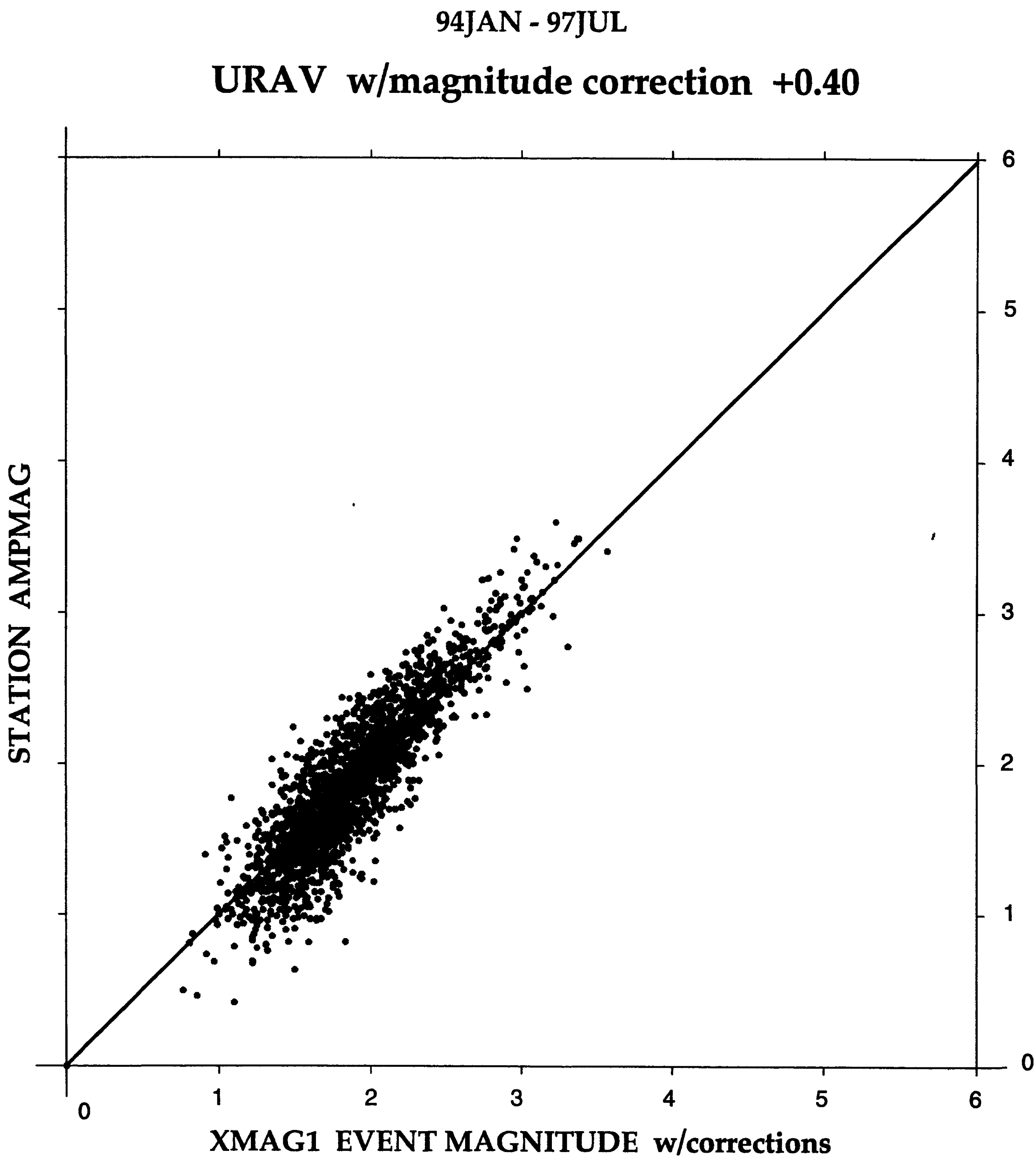
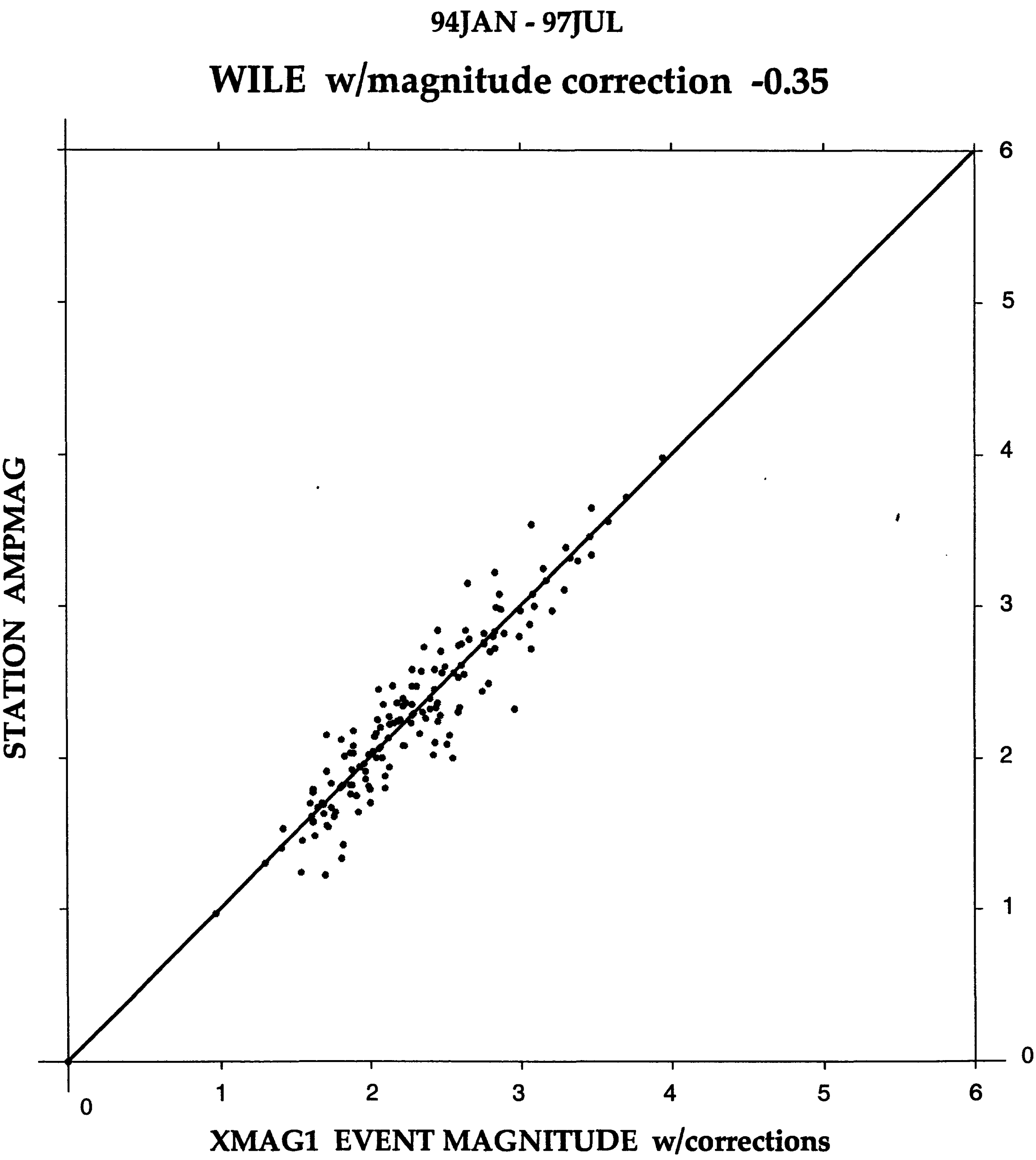
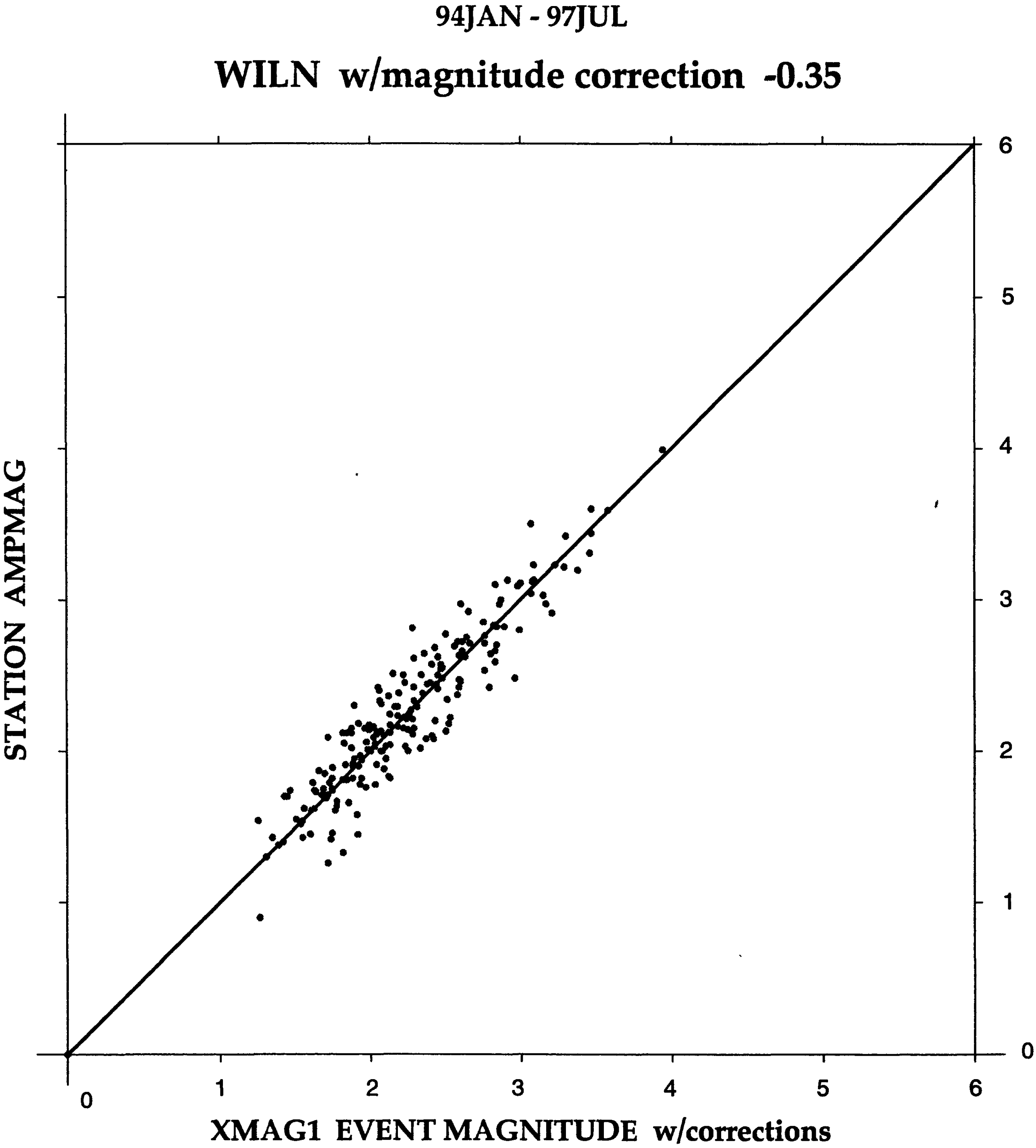

94JAN - 97JUL
URAV w/magnitude correction +0.40
STATION AMPMAG
0
1
2
3
4
5
6
0
1
2
3
4
5
6
XMAG1 EVENT MAGNITUDE w/corrections

Figure 58.



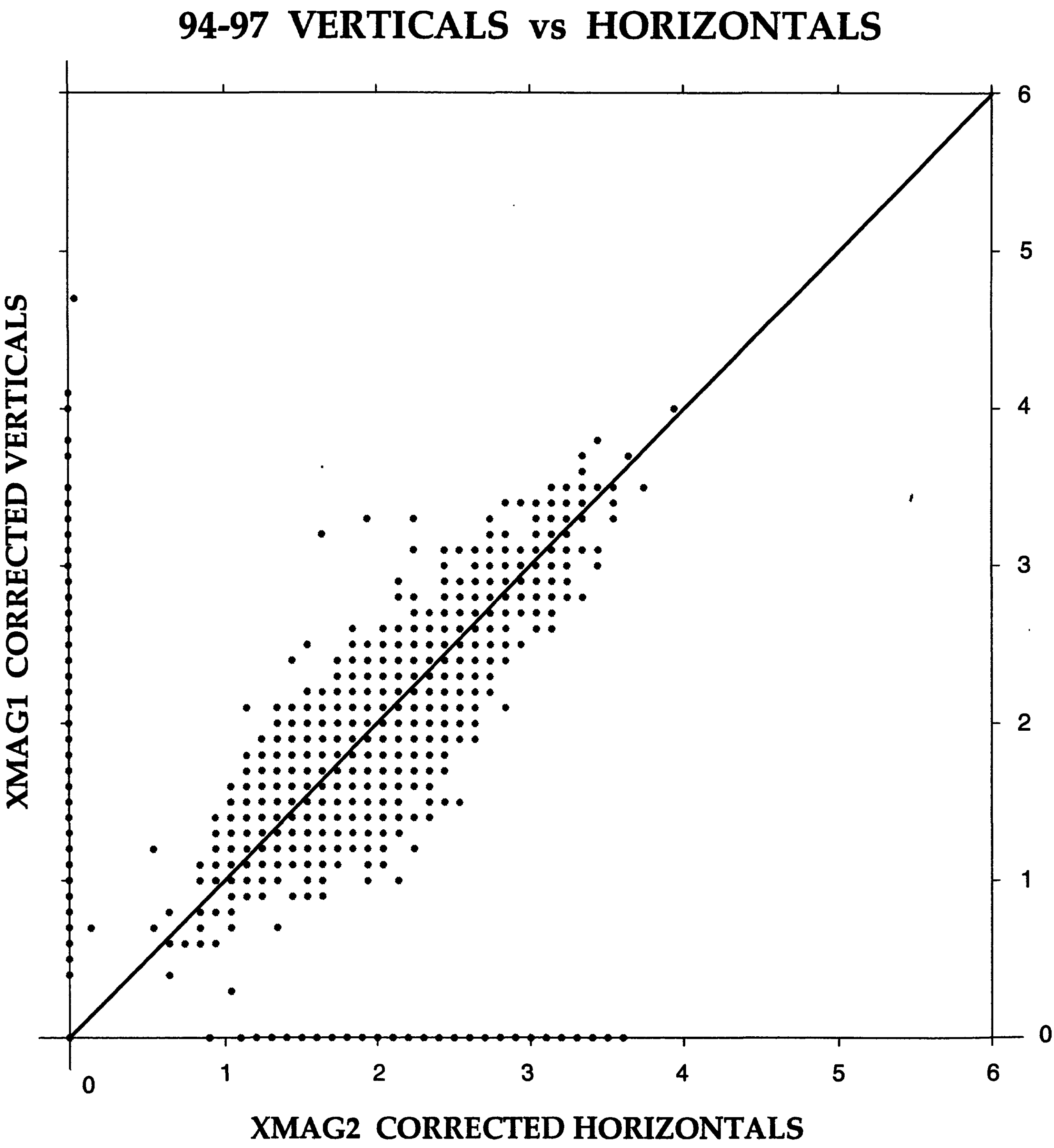
94JAN - 97JUL
WILE w/magnitude correction -0.35
STATION AMPMAG
XMAG1 EVENT MAGNITUDE w/corrections
0
1
2
3
4
5
6

Figure 59.



94JAN - 97JUL
WILN w/magnitude correction -0.35
STATION AMPMAG
XMAG1 EVENT MAGNITUDE w/corrections
0
1
2
3
4
5
6

Figure 60.


94-97 VERTICALS vs HORIZONTALS
XMAG1 CORRECTED VERTICALS
XMAG2 CORRECTED HORIZONTALS
0
1
2
3
4
5
6
0
1
2
3
4
5
6

CONCLUSIONS

The magnitude clusters for some of the network stations are more diffuse than for others. Some reasons that may account for the scatter include the characteristics of a given station and/or the station site, the location of the earthquake [illegible] to the station location, the number of samples taken, and the variation in amplitude selection within the coda.

This report documents the steps taken and methods used to determine amplitude magnitude corrections for network stations based on Wood-Anderson magnitudes. The report will be our guide or handbook for future magnitude correction determinations. It will also provide magnitude information for other users of HVO's seismic data.

We would like to eventually update calibrations for the entire network. As each station's calibration value becomes available, we can determine amplitude magnitude corrections once enough samples have been read.

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