This report contains a detailed description of the IERS products related to the Terrestrial Reference System for the period of the IERS Annual Report for 1990.

This description intends to be the continuation of the previous reports: the IERS Technical Note 4 and 6. In particular, methodological presentation will be followed here.

1) INPUT DATA

1.1) Sites included

The list of sites considered in the 1990 solution is given in Table T1 of the appendix.

A more detailed list of points and marks for these sites is also provided by the Table T2 of the appendix.

Table T3 also gives a summary of the occupancies of these sites by SLR, LLR, or VLBI instruments. We have distinguished the IERS sites into the following data sets:

1) colocation (at least two techniques)

2) multiple SLR (simultaneous or successive)

3) single SLR

4) multiple VLBI (simultaneous or successive)

5) single VLBI

1.2) Input data sets

The data sets received for the 1990 solution and included in the global combination performed by the ITFS, under the label ITRF90 are summarized in Table 1.

Distribution of corresponding coordinates for each solution are given in Table T4 of the appendix.

1.3) Description of individual data sets

For all solutions, no permanent tidal correction has been performed, and the adopted velocity of light is $c = 299792458 \text{ m s}^{-1}$.

As the formal errors σ_f provided by the analysis centers are in most cases too optimistics, the input errors σ are adopted according the following formula:

$$\sigma = \sqrt{A^2 + B^2\sigma_f^2} \qquad (1)$$

where A is an additive variance and B is a factor. Figures 1 to 13 show for all the solutions, the histograms of the formal errors and those after applying the previous formula.

1.3.1) GSFC VLBI solution

Identifer : SSC(GSFC) 91 R 02, also named GLB718

Model : CALC-7 software, with local earth relativistic scale (Hellings model).

Adjusted parameters :

X, Y, Z and $\dot{X}$, $\dot{Y}$, $\dot{Z}$ of stations with sufficient data

Constraints for the CTS :

- Westford X,Y,Z fixed at a nominal value on Oct 17 1980,
- ERP fixed on Nov 6 1986 at BIH Circular D values,
- Westford velocities fixed at AMO-2 values,
- Westford-Richmond azimut moving with AMO-2 value

Raw data :

Yearly values of positions were available, with formal errors (from 1979 to 1992).

Input data (RG) :

The 1988 values, with formal errors modified using the formula (1) with A = 0.5 cm and B = 1.5.

1.3.2) NGS VLBI solution

Identifer : SSC(NGS) 91 R 01

Model : CALC software, with Hellings relativistic model

Adjusted parameters:

Positions at 1988.0 and velocities (except for stations with short time span)

Constraints for the CTS :

- Westford velocity at AMO-2 value

- ERP fixed at 1985 Oct. 25 and 1990 Jan. 27

Raw data :

1988 positions and velocity change with respect to AM0-2 for sites with sufficient data, with formal errors

Input data (RN) :

The 1988 values, with formal errors modified using the formula (1) with A = 0.5 cm and B = 1.5.

1.3.3) USNO VLBI solution

Identifer : SSC(USNO) 91 R 02

Model : Motion with AM0-2 model

Adjusted parameters: X, Y, Z at Oct 17 1980

Constraints for the CTS :

- Richmond position fixed at ITRF89 value
- fixed AM0-2 motion

Raw data : X, Y, Z and formal errors

Input data (RO) :

X, Y, Z transformed at 1988.0 with AM0-2. Formal errors modified with A = 0.5 cm and B = 1.5

1.3.4) JPL VLBI solution

Identifer : SSC(JPL) 91 R 01, also named 1991-1

Model : Masterfit software. Motion with AM0-2 model

Adjusted parameters: X, Y, Z at 1988.0

Constraints for the CTS :

- six constraints (with 1 cm uncertainty) : 3 translations and 3 rotations between 1991-1 and ITRF88

- fixed AM0-2 motion

Raw data : X, Y, Z and formal errors

Input data (RJ) :

X, Y, Z, with formal errors modified with A = 1 cm and B = 1.0

1.3.5) CSR SLR solution

Identifer : SSC(CSR) 91 L 03

Model : Most sites fixed to AMO-2 velocities, sites in deformation zones adjusted. GM = 398600.4415 km^3/s^2

Adjusted parameters: X, Y, Z at 1988.0 and velocity change with respect to AMO-2 for sites in deformation zones.

Constraints for the CTS :

- system oriented to agree with IERS combined in a mean sense over period 1984 - 1988,
- fixed AMO-2 motion for most of sites

Raw data : X, Y, Z, velocity change to AMO-2 for selected sites and formal errors

Input data (LC) :

X, Y, Z at 1988.0 with formal errors modified with A = 1.5 cm and B = 1.0.

1.3.6) GSFC SLR solution

Identifer : SSC(GSFC) 91 L 01

Model : Motion with AMO-2 model, GM = 398600.4408 km^3/s^2

Adjusted parameters: X, Y, Z at January 15 1983

Constraints for the CTS :

- latitude and longitude of 7105, the latitude of 7210, and the longitude of 7907 were fixed
- apriori values of ERP from SL7
- fixed AMO-2 motion

Raw data : X, Y, Z and formal errors

Input data (LG) :

X, Y, Z with formal errors modified with A = 1.5 cm and B = 3.0

1.3.7) DGFII SLR solution

Identifer : SSC(DGFII) 91 L01

Model : DOGS software, GM = 398600.4394 km^3/s^2

Adjusted parameters: X, Y, Z, and horizontal velocities

Constraints for the CTS :

- forcing of rotation angles between initial and adjusted coordinates of 10 stations to becomes zero in the average
- rotation drift rates around the three coordinate axes are forced to become zero with respect to a given set of AMO-2 horizontal station position drift rates

Raw data : X, Y, Z at a given epoch for each station with error estimate

and $\dot{\text{lambda}}$*COS(phi), $\dot{\text{phi}}$

Input data (LD) :

X, Y, Z transformed at 1988.0 with their velocities and the formal errors modified with A = 1.5 cm and B = 3.0

1.3.8) DUT SLR solution

Identifer : SSC(DUT) 91 L 01

Model : GEODYN-II software, estimation of station motions,

GM = 398600.4360 km^3/s^2

Adjusted parameters: X, Y, Z, and velocities

Constraints for the CTS :

- ERP a priori values from IERS Bulletin B
- non-rotating Eurasian tectonic plate

Raw data : X, Y, Z at 1988.0 and $\dot{X}$, $\dot{Y}$, $\dot{Z}$

Input data (LU) :

X, Y, Z at 1988.0 with formal errors modified with A = 1.5 cm and B = 0.3

1.3.9) ZIPE SLR solution

Identifer : SSC(ZIPE) 91 L 01

Model : POTSDAM-5 software. Motion with AMO-2 model, GM = 398600.440 km^3/s^2

Adjusted parameters: r, lambda, phi at 1988.0

Constraints for the CTS :

- latitude fixed for stations 7105,7840
- longitude fixed for station 7105
- fixed AMO-2 motion

Raw data : X, Y, Z and formal errors

Input data (LZ) :

X, Y, Z with formal errors modified with A = 1.5 cm and B = 3.0

1.3.10) GAOUA SLR solution

Identifer : SSC(GAOUA)91 L 02

Model : KIEV-GEODYNAMICS - 3 software. Motion with AM1-2 model,

$GM = 398600.440\ km^3/s^2$

Adjusted parameters: X, Y, Z at 1988.0

Constraints for the CTS :

- fixed AM1-2 motion
- ERP values from IERS Bulletin B

Raw data : X, Y, Z and formal errors

Input data (LK) :

X, Y, Z and formal errors modified with A = 2.5 cm and B = 2.0

1.3.11) NAL SLR solution

Identifer : SSC(NAL) 91 L 01

Model : COSMOS software, motion with AM0-2 model, $GM = 398600.44089\ km^3/s^2$

Adjusted parameters: X, Y, Z at 1988.0

Constraints for the CTS :

- latitude and longitude of 7105 and latitude of 7907 fixed
- fixed AM0-2 motion
- ERP values from IERS Bulletin B

Raw data : X, Y, Z and formal errors

Input data (LT) :

X, Y, Z and formal errors modified with A = 1.5 cm and B = 3.0

1.3.12) UT/McD LLR solution

Identifer : SSC(UTXMO)91 M 01

Model : Motion with AMO-2 model, GM = 398600.4440 km^3/s^2

Adjusted parameters: lambda, phi, h at 1984.0

Constraints for the CTS :

- fixed AMO-2
- ERP fixed at 1985 Jan. 11 to CSR LGN7692 series

Raw data : X, Y, Z and formal errors

Input data (MX) :

X, Y, Z transformed at 1988.0 with AMO-2. Formal errors modified with A = 1.5 cm and B = 0.2.

1.3.13) JPL LLR solution

Identifer : SSC(JPL) 91 M 01

Model : Motion with AMO-2 model

Adjusted parameters: X, Y, Z at 1988.0

Constraints for the CTS :

- ERP from 1976 to 1991 taken from a file provided by R. Gross
- fixed AMO-2

Raw data : X, Y, Z without error estimate

Input data (MJ) :

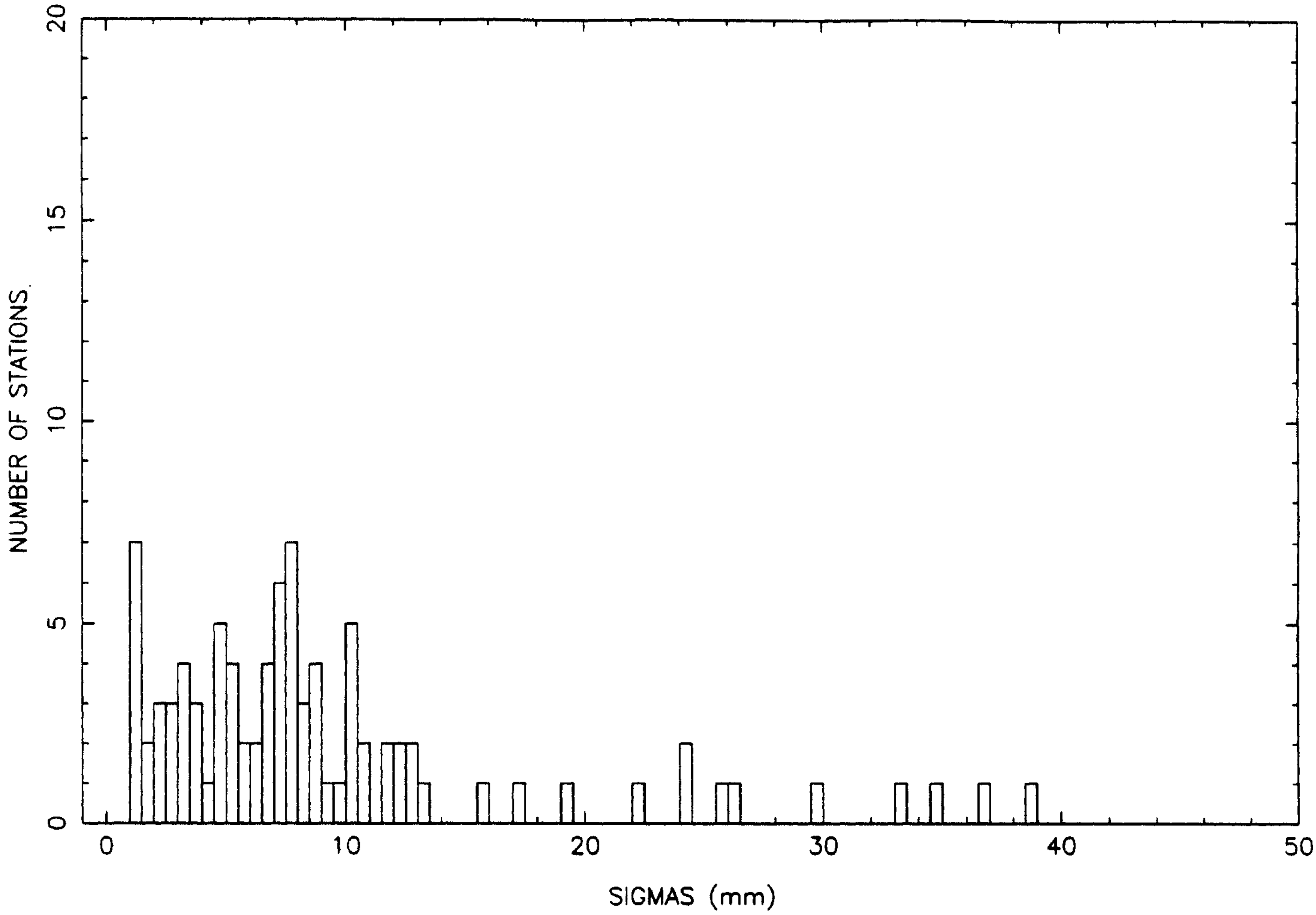
X, Y, Z with 3 cm as error.

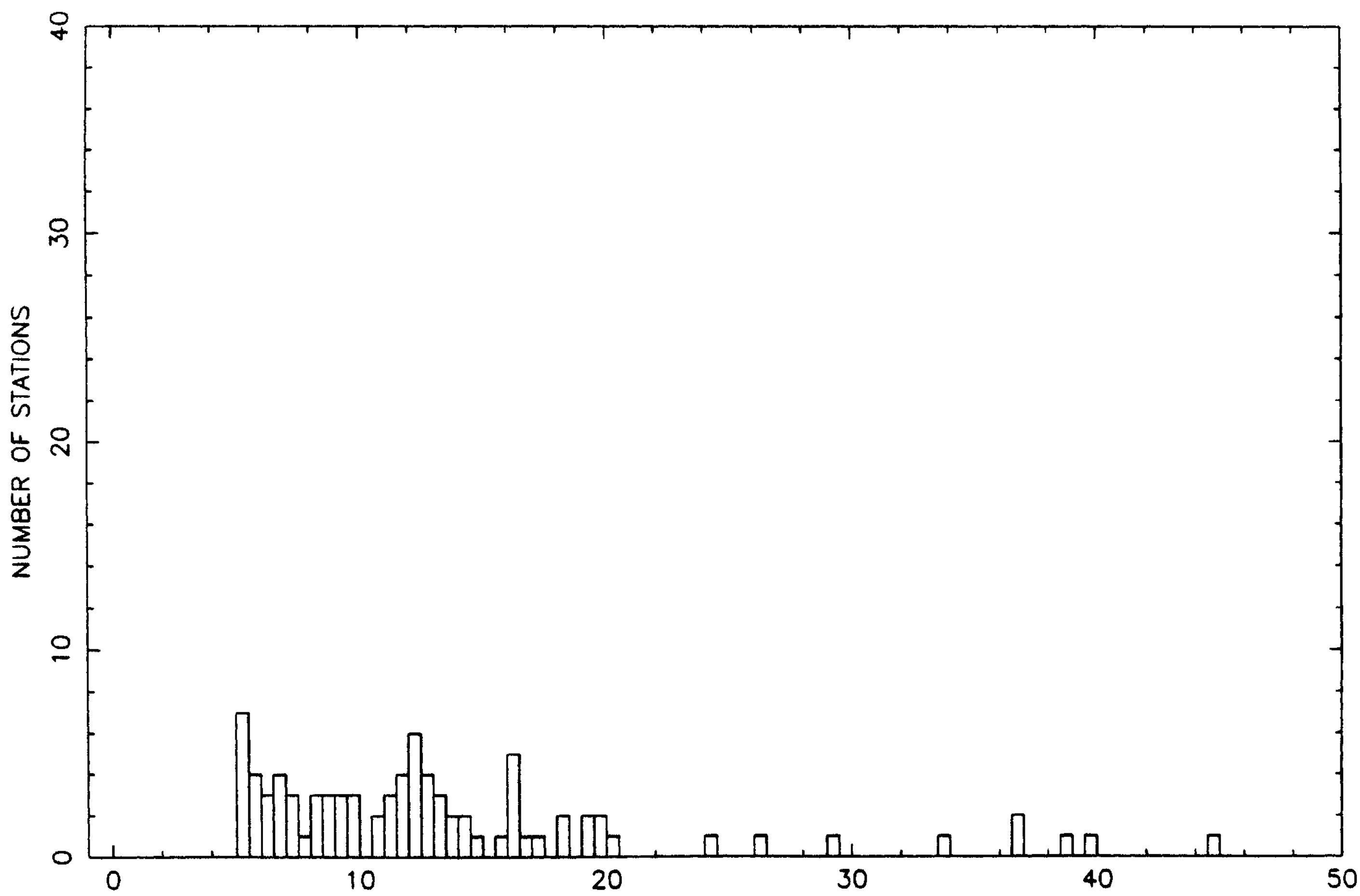
Table 1

Input data sets

label	designation	other name
RG90	SSC(GSFC) 91 R 02	GLB718
RN90	SSC(NGS) 91 R 01	
RO90	SSC(USNO) 91 R 02	
RJ90	SSC(JPL) 91 R 01	1991-1
LC90	SSC(CSR) 91 L 03	
LG90	SSC(GSFC) 91 L 01	
LD90	SSC(DGFII)91 L 01	
LU90	SSC(DUT) 91 L 01	
LZ90	SSC(ZIPE) 91 L 01	
LK90	SSC(GAOUA)91 L 02	
LT90	SSC(NAL) 91 L 01	
MX90	SSC(UTXMO)91 M 01	
MJ90	SSC(JPL) 91 M 01	

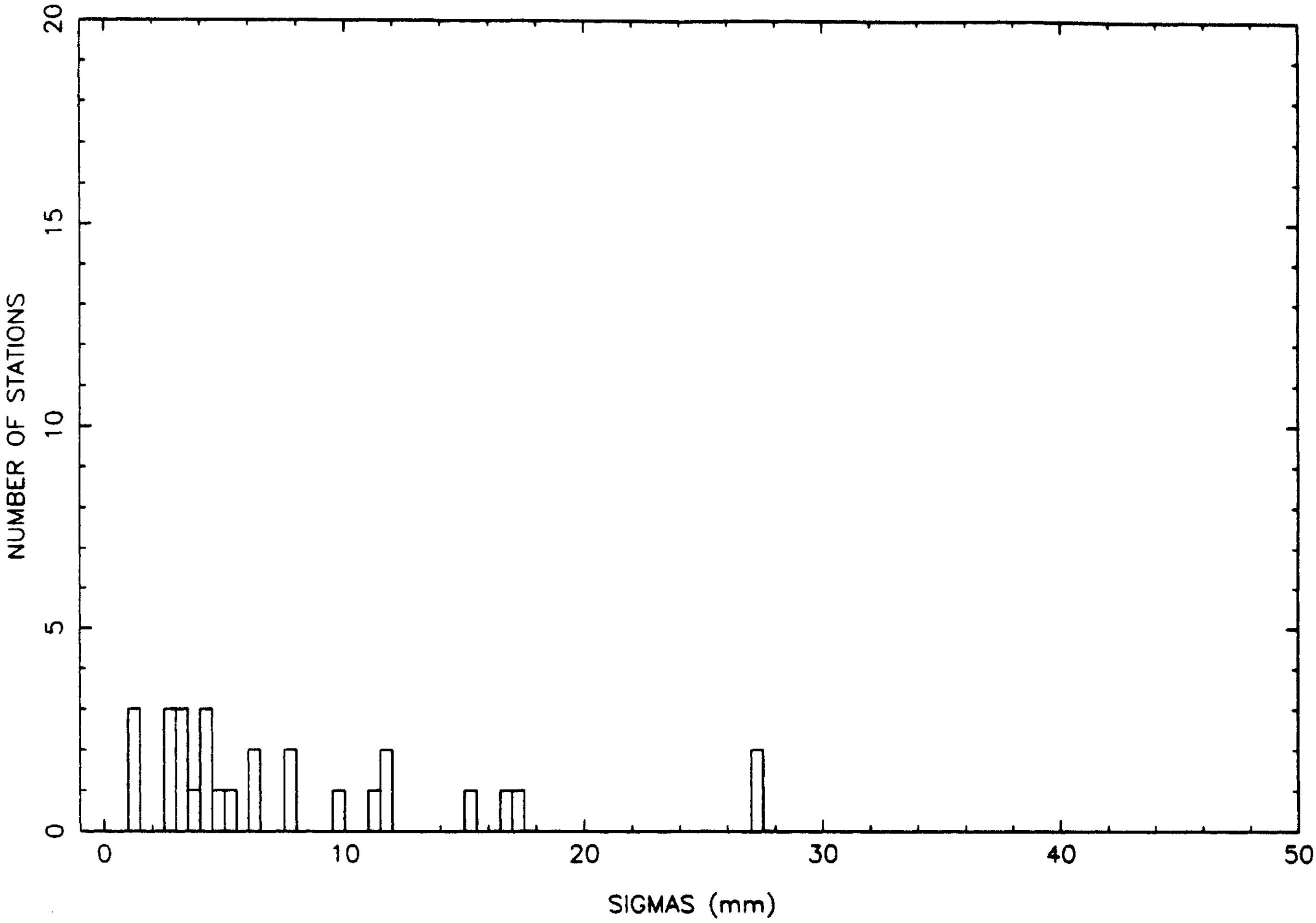
FIGURE 1 SSC(GSFC) 91 R 02





SIGMAS (mm) A(cm) = 0.5 B = 1.5

FIGURE 2 SSC(NGS) 91 R 01



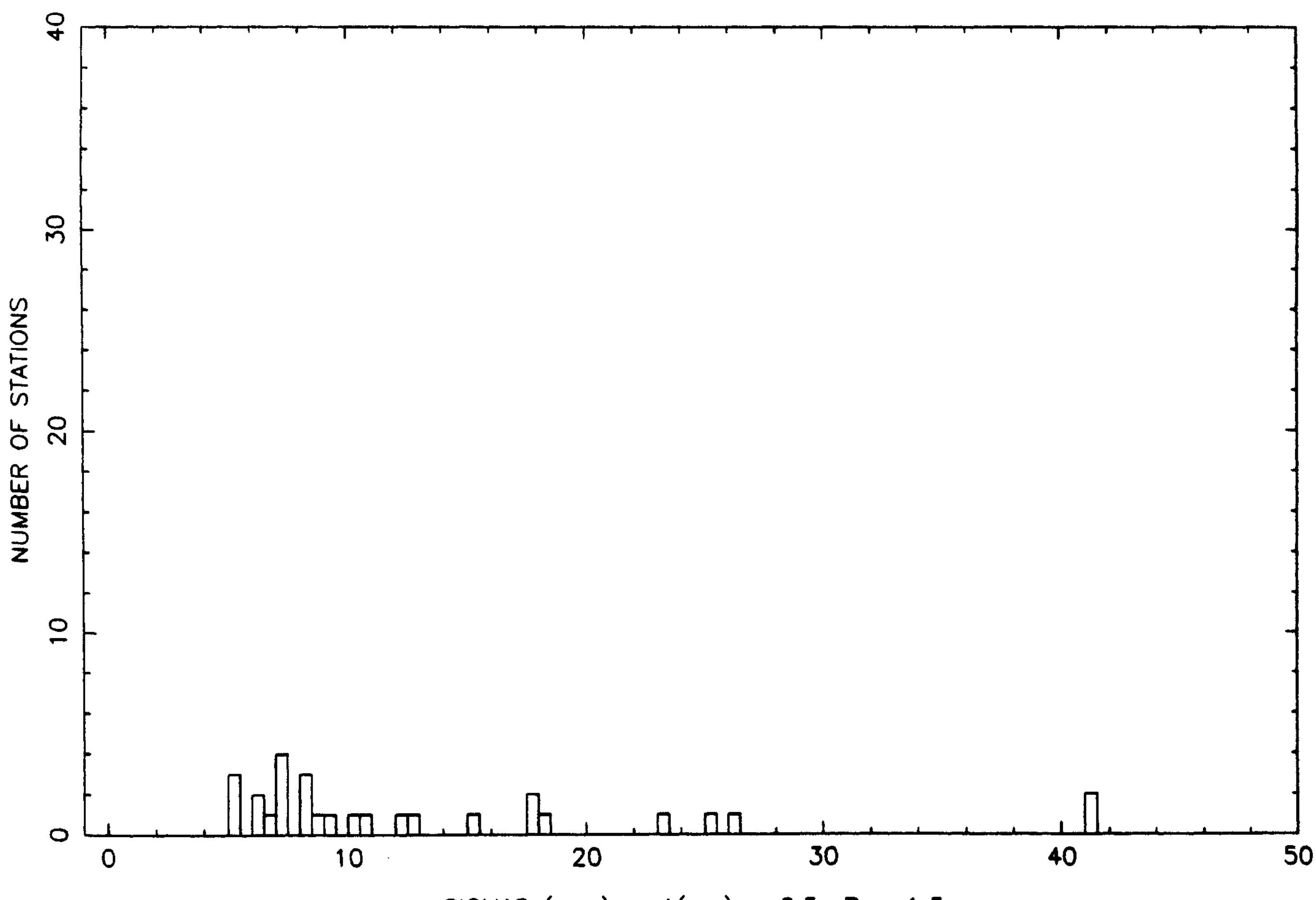
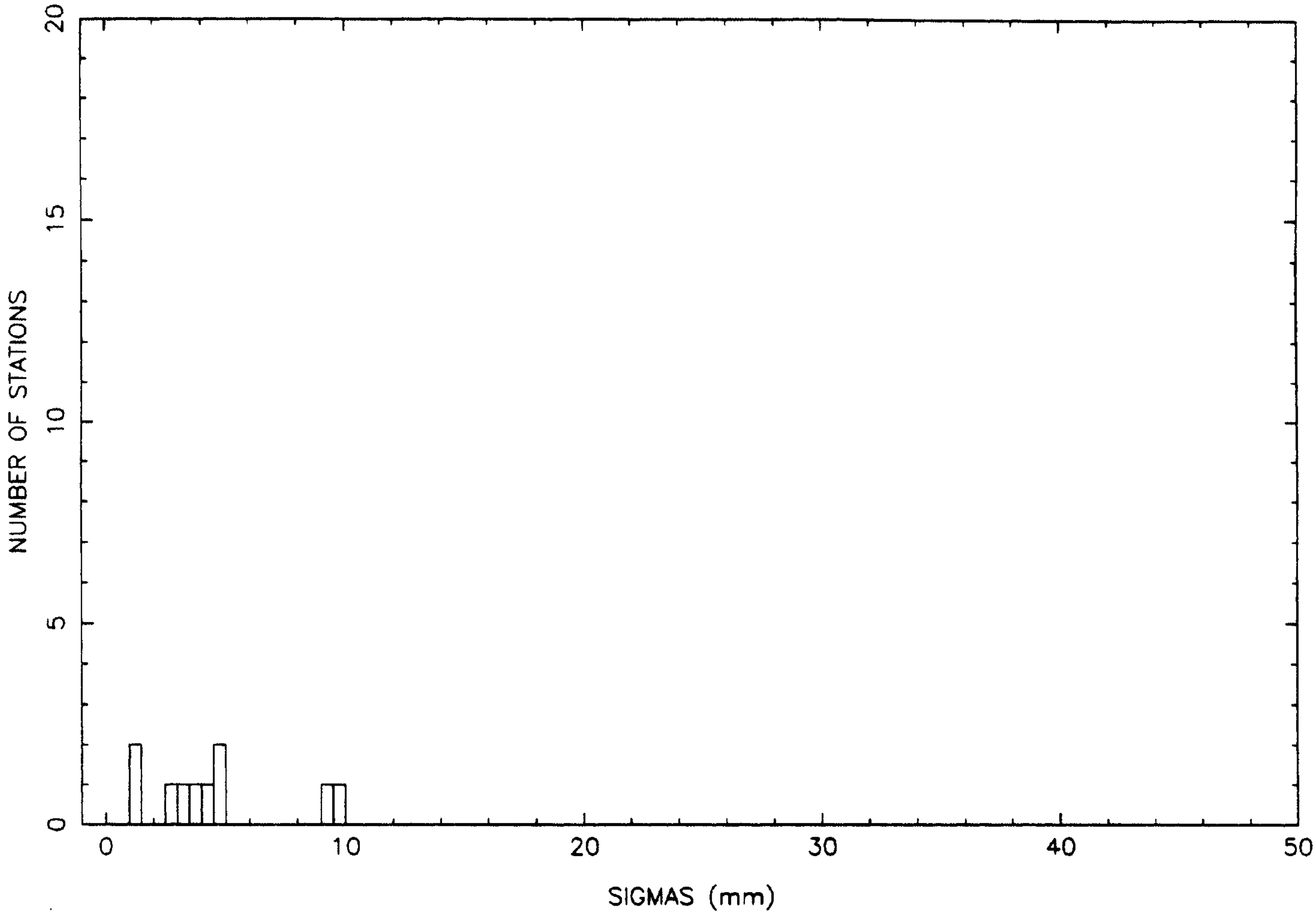


FIGURE 3 SSC(USNO) 91 R 02



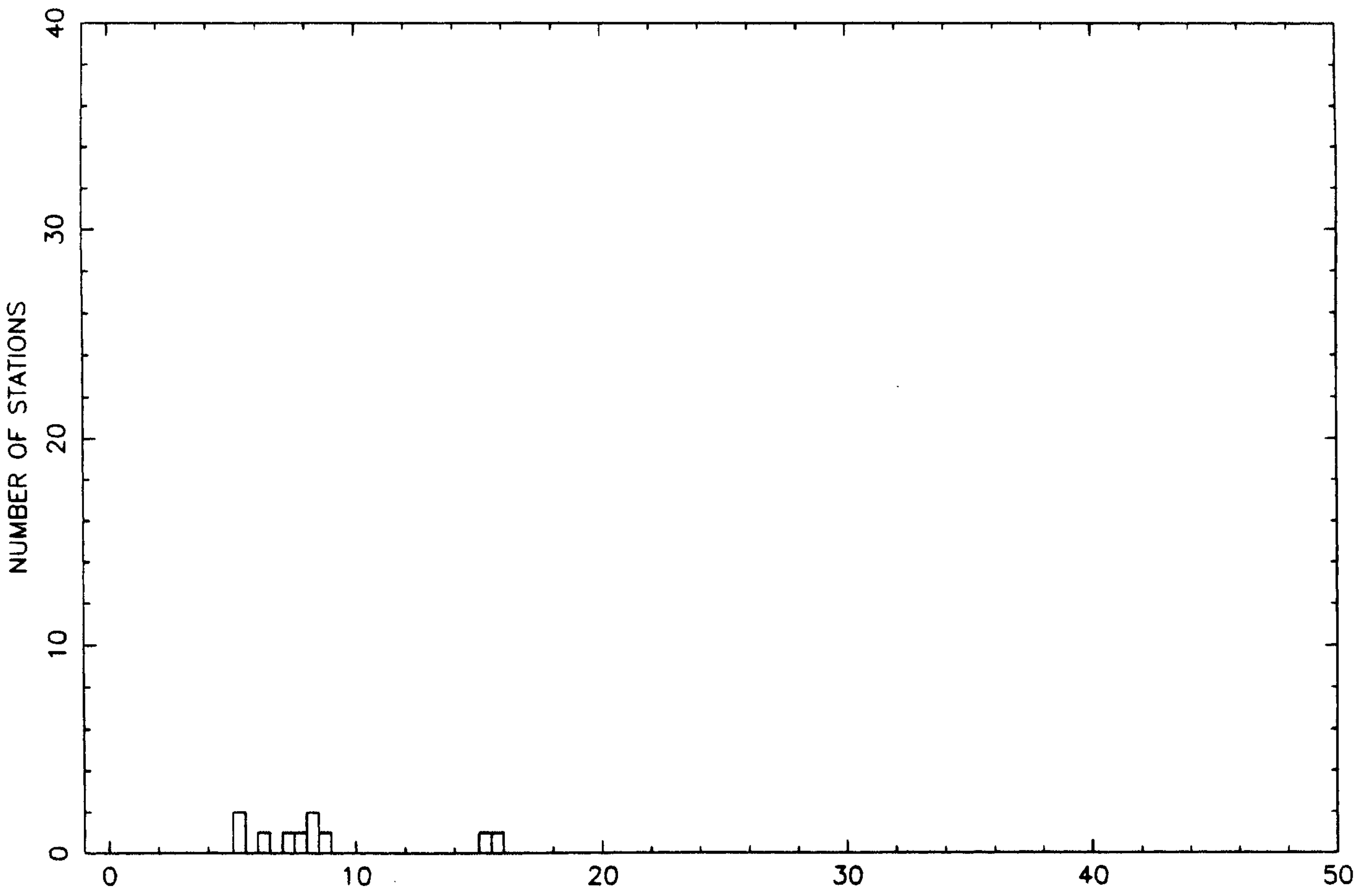
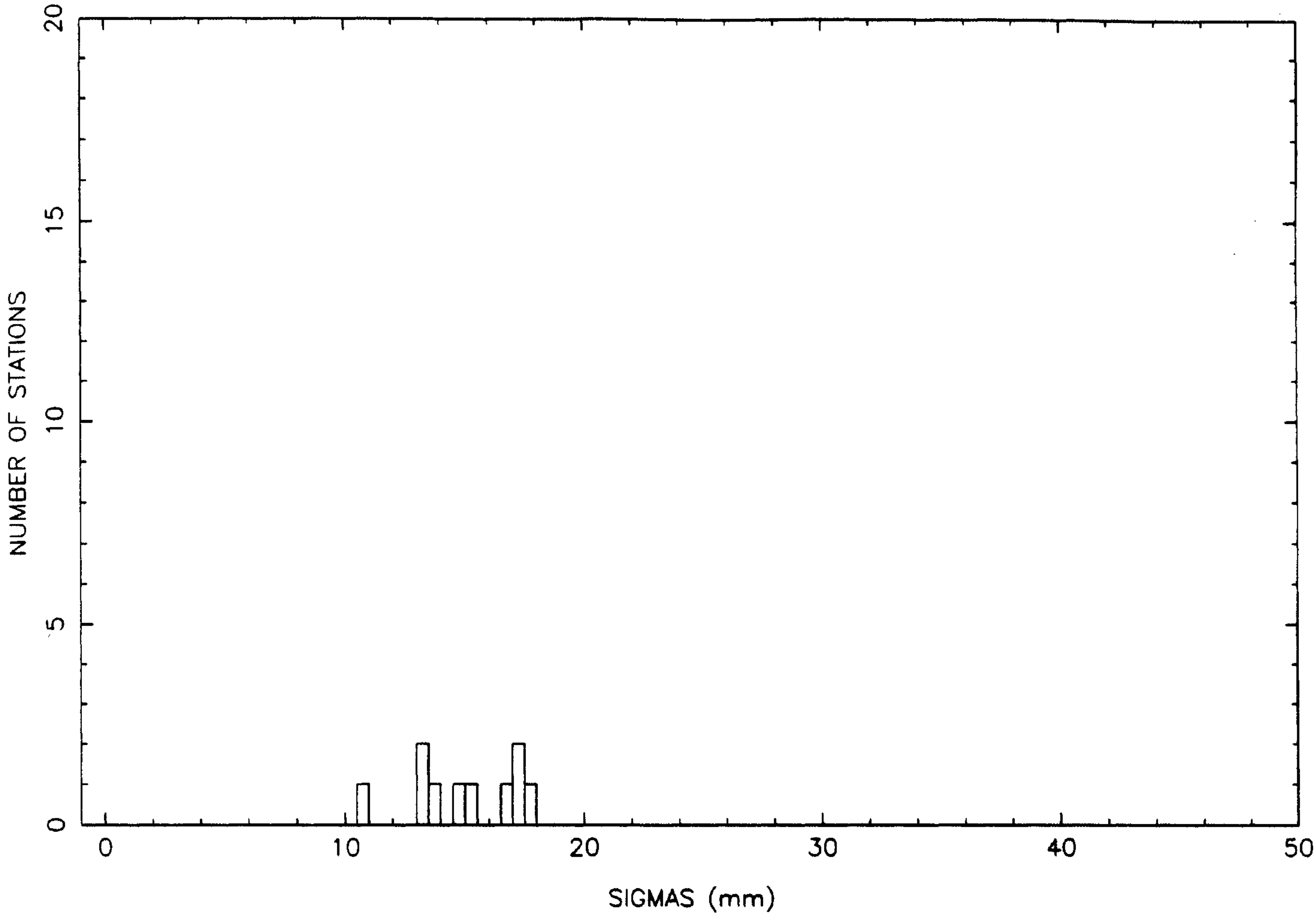


FIGURE 4 SSC(JPL) 91 R 01



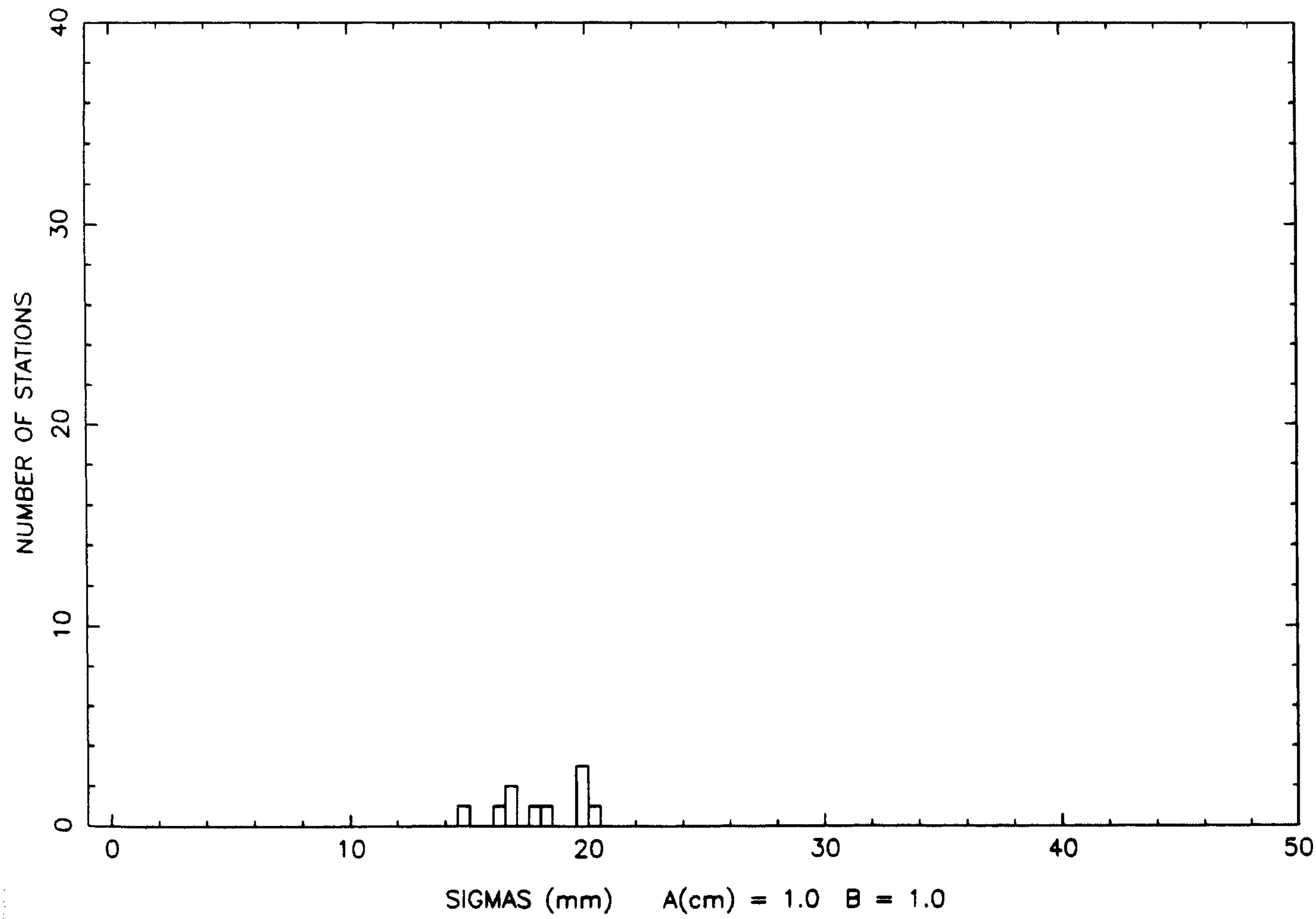
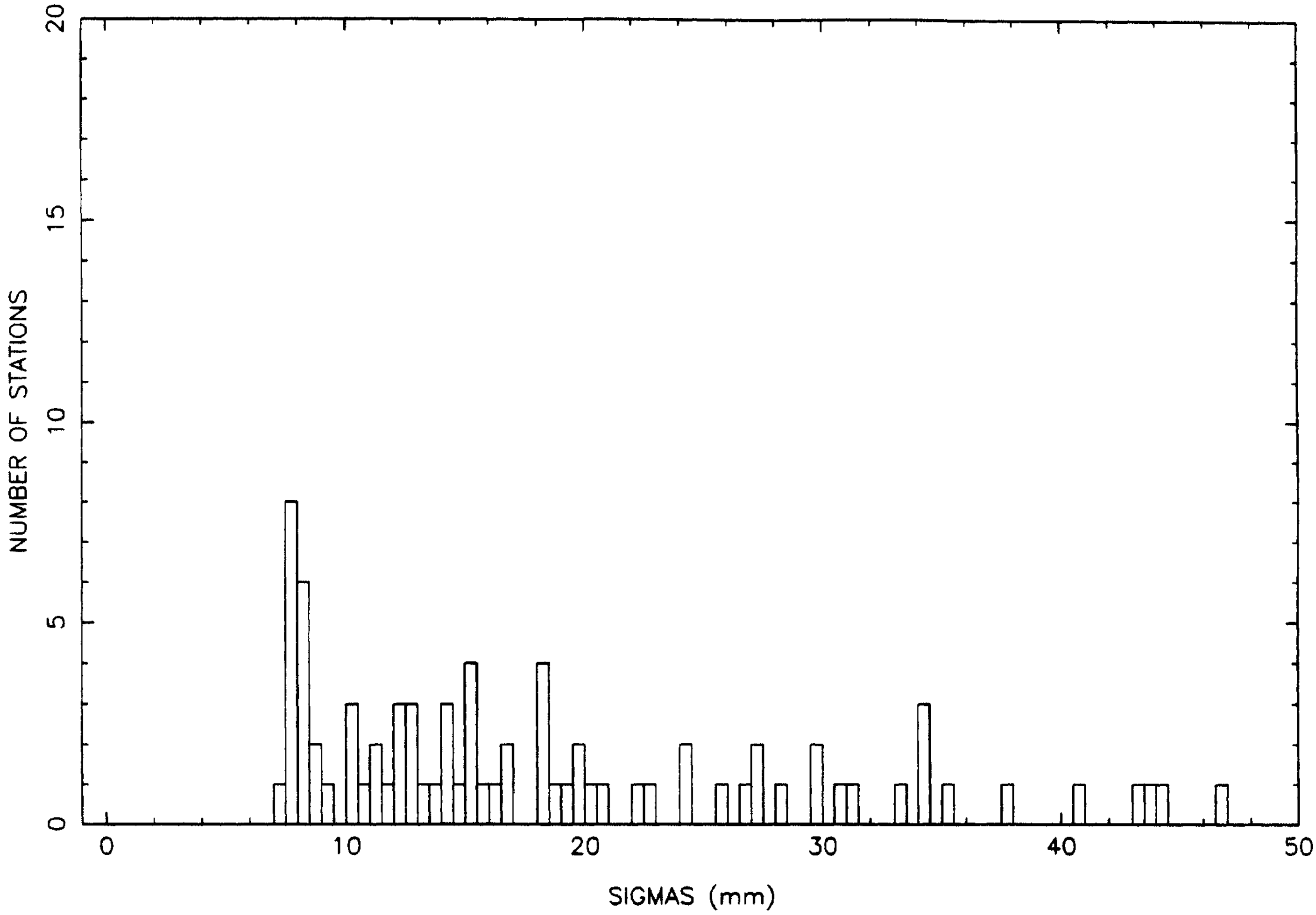


FIGURE 5 SSC(CSR) 91 L 03



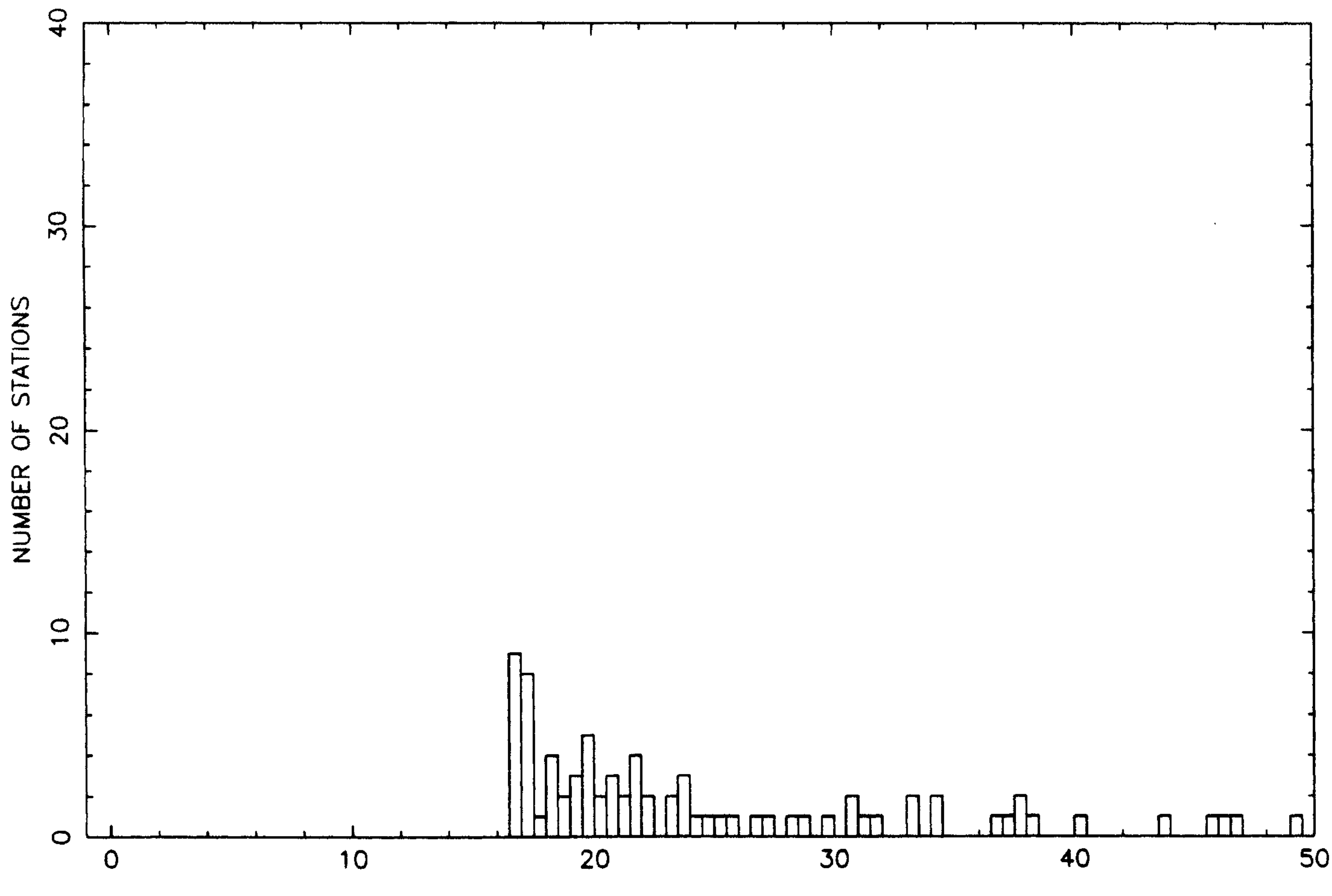
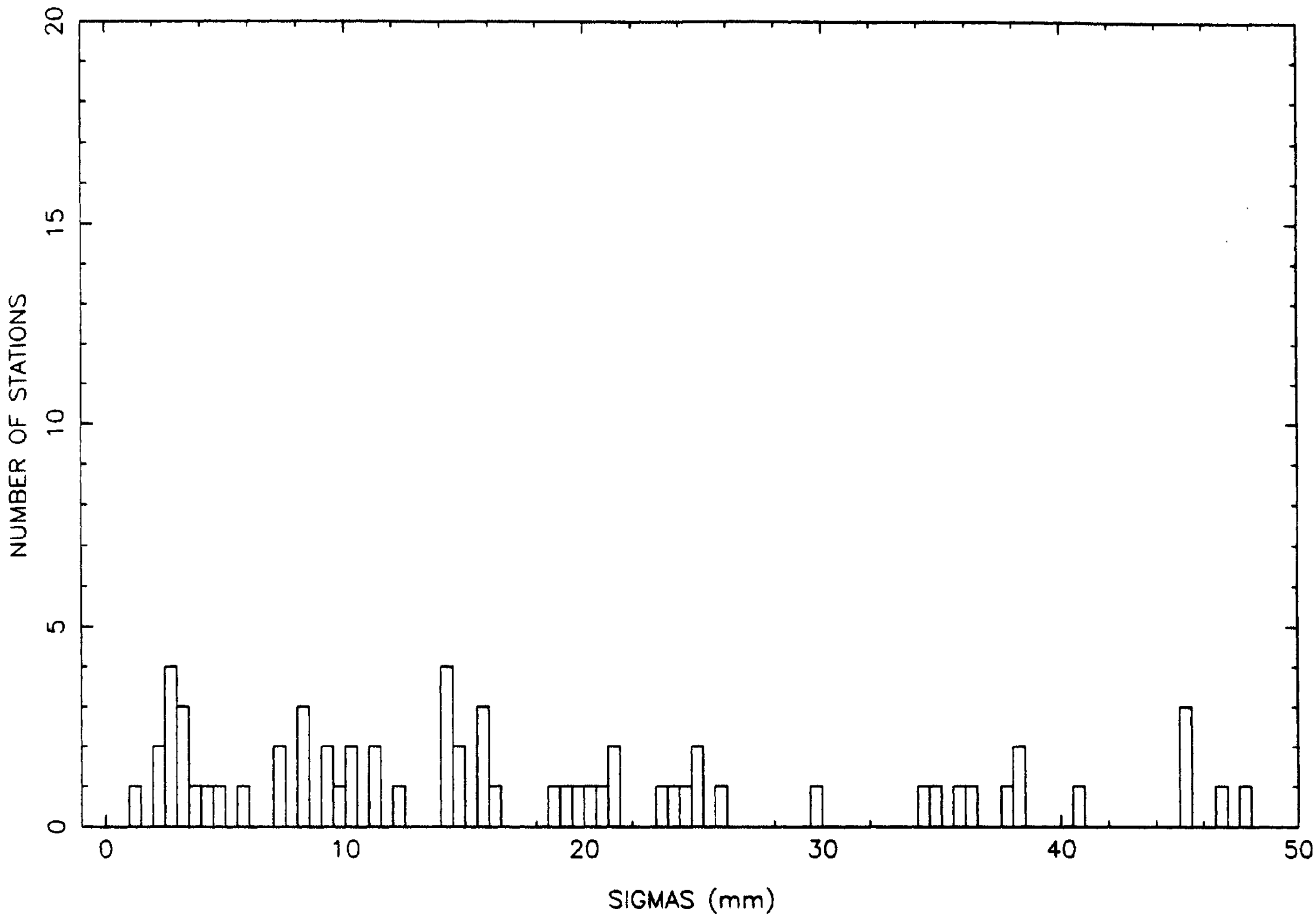
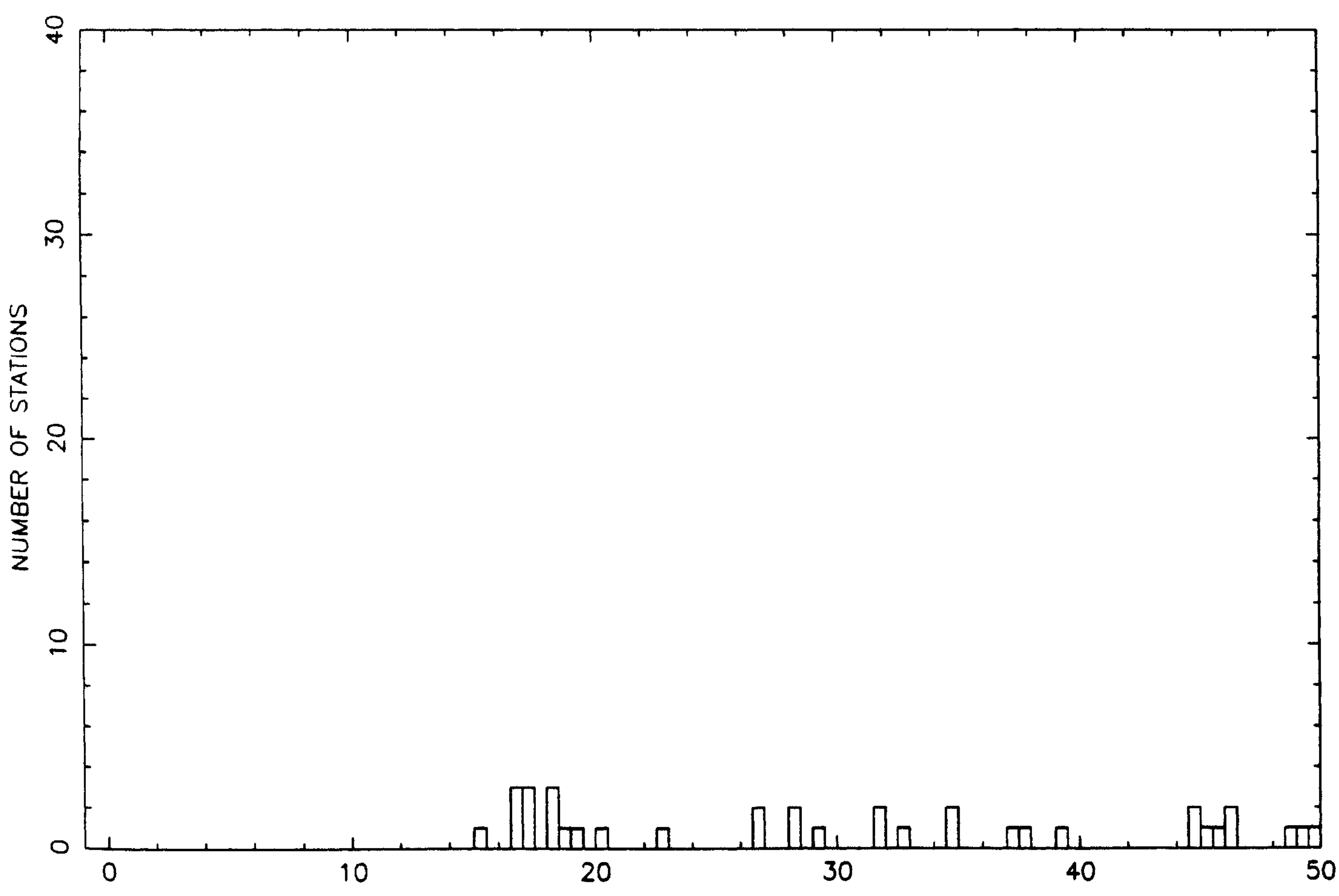


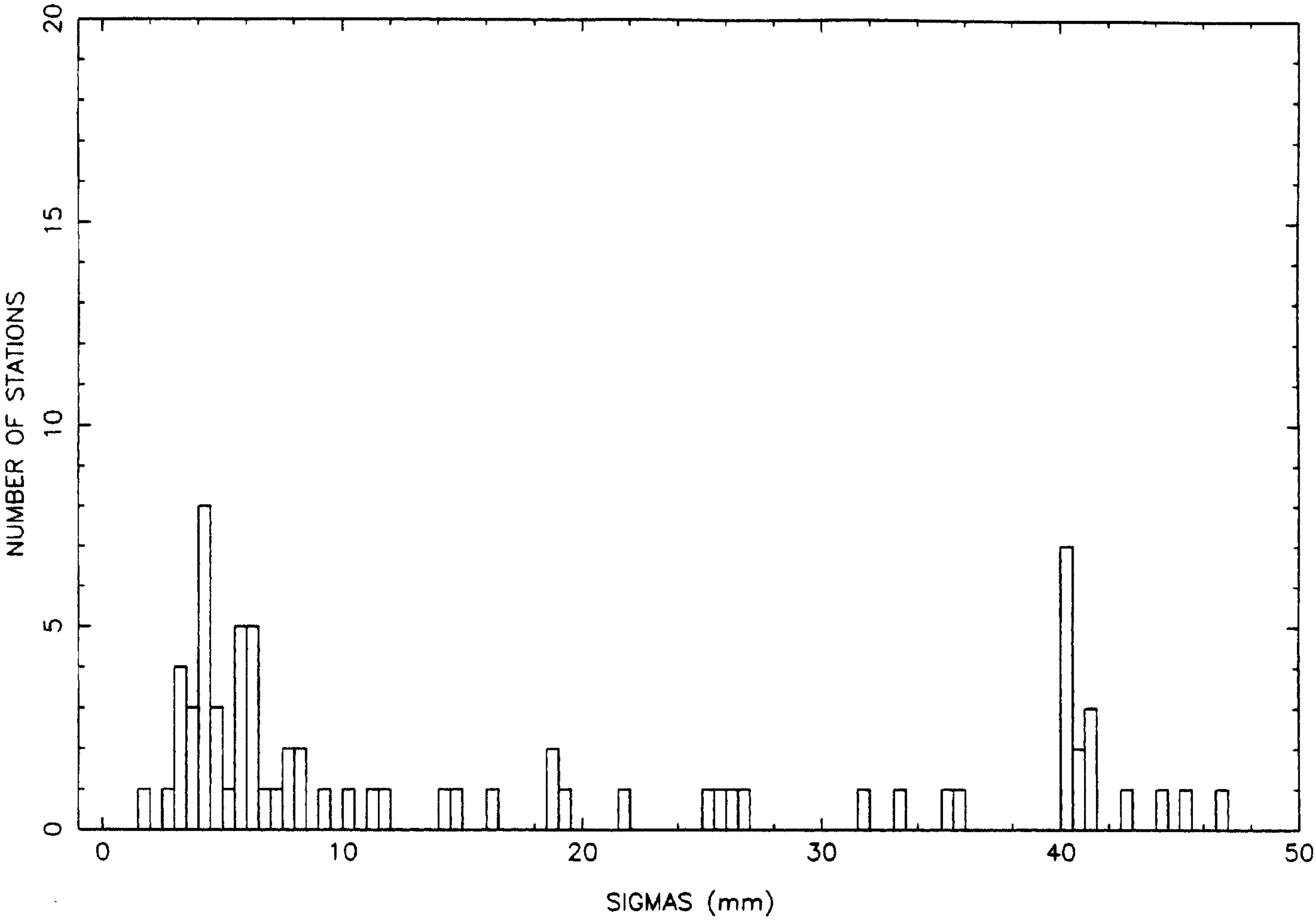
FIGURE 6 SSC(GSFC) 91 L 01

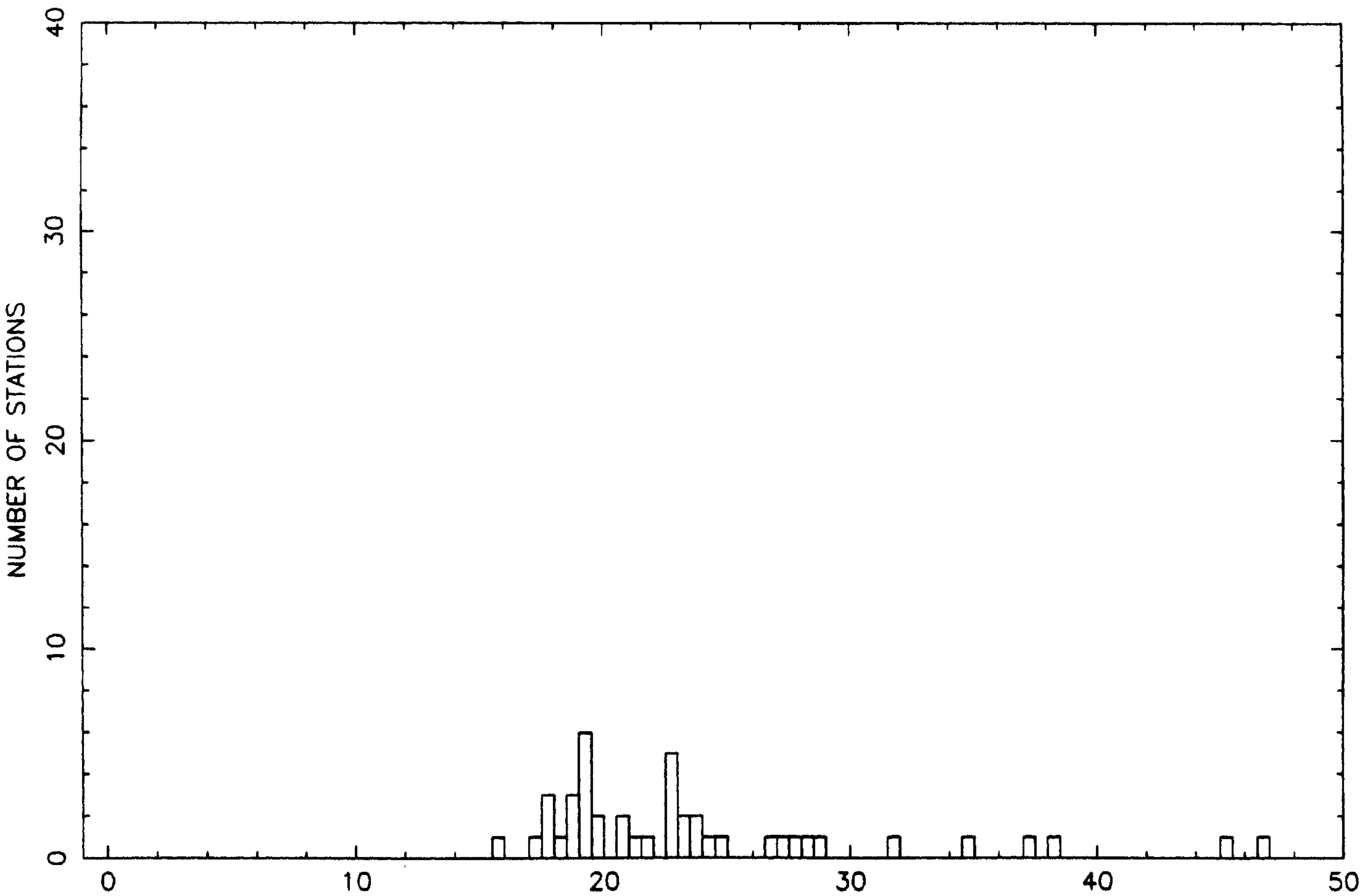




SIGMAS (mm)   A(cm) = 1.5 B = 3.0

FIGURE 7 SSC(DGFII)91 L 01





SIGMAS (mm) A(cm) = 1.5 B = 3.0

1.4) Excentricites

The excentricities used for ITRF90 are given in Table T5 of the appendix.

2) DATA ANALYSIS

The ITRF90 solution consists of a combined adjustement of station positions and transformation parameters for the epoch 1988.0.

The adjustment were performed using the SSCMIX software developped by IGN. The options used were:

- reduction of individual data sets at a common epoch,

- least square estimation of station coordinates and 7 transformation parameters for each solution,

- local surveys used with a priori variances (see 1.4)

- station coordinates used with a priori variances (see 1.3)

It was decided that:

- origin should come from SLR

- scale should also come from SLR noting that the VLBI scale (GSFC and NGS) is now consistent with SLR,

- orientation should be such that no global rotation should exist with respect to ITRF89.

To ensure that, a first global adjustment of all selected data was done, holding the LC transformation parameters fixed to zero. The solution was labelled ITRF90A.

Then ITRF90A was compared to ITRF89 in order to estimate corrections to rotation angles. This comparison has been done incorporating only one point per site. Table 2 gives the transformation parameters between ITRF90A and ITRF89. The global adjustment was finally repeated with LC translation and scale put to zero and rotation angles fixed to the values derived from the previous computation.