Table 2 : Transformation parameters from ITRF91 to ITRF92A
(one point per site)

T1 m	T2 m	T3 m	D 10^{-8}	R1 0.001"	R2 0.001"	R3 0.001"
-1.1 ±0.2	-1.4 ±0.2	0.6 ±0.2	-0.14 ±0.02	-0.47 ±0.07	0.74 ±0.07	-1.41 ±0.05

2.2) ITRF92 velocity field

The ITRF92 velocity field has been obtained by combination of eight site velocity fields estimated by SLR and VLBI analysis centers. These eight velocity fields have been estimated together with eight SSCs among those incorporated in the ITRF92 station coordinates combined solution. The method for combining velocities is equivalent to and consistent with the method for combining SSCs into the ITRF92 station coordinates. In order to insure the condition of no-net-Rotation of the ITRS with respect to the crust, NNR-NUVEL1 was selected as the reference motion model as recommended by the IERS Standards (McCarthy, 1992). A velocity field was so constructed using NNR-NUVEL1 for those sites which are available in the eight estimated velocity fields. The temporal variation (or rate of change) of the translation and rotation parameters of the constructed NNR-NUVEL1 velocity field were fixed to zero in the global adjustement. The scale factor is assumed to be invariant with time and so the corresponding parameters are fixed to zero for all velocity fields.

NNR-NUVEL1 is a horizontal motion model. For the consistency of the three-dimensional we used it as three-dimensional model with zero vertical velocity and assumed an error of 3mm/year for the horizontal components and 1 cm/year for the vertical one. NNR-NUVEL1 velocities were deweighted in the combination (with 10 cm/year as a priori standard deviation) for sites whose motion may differ from NNR-NUVEL1, such as sites in California, Japan and the Mediterranean area. Consequently, the condition of no-net-rotation is practically applied to those sites which are located on the rigid part of the tectonic plates and whose motion are consistent with that predicted by NNR-NUVEL1.

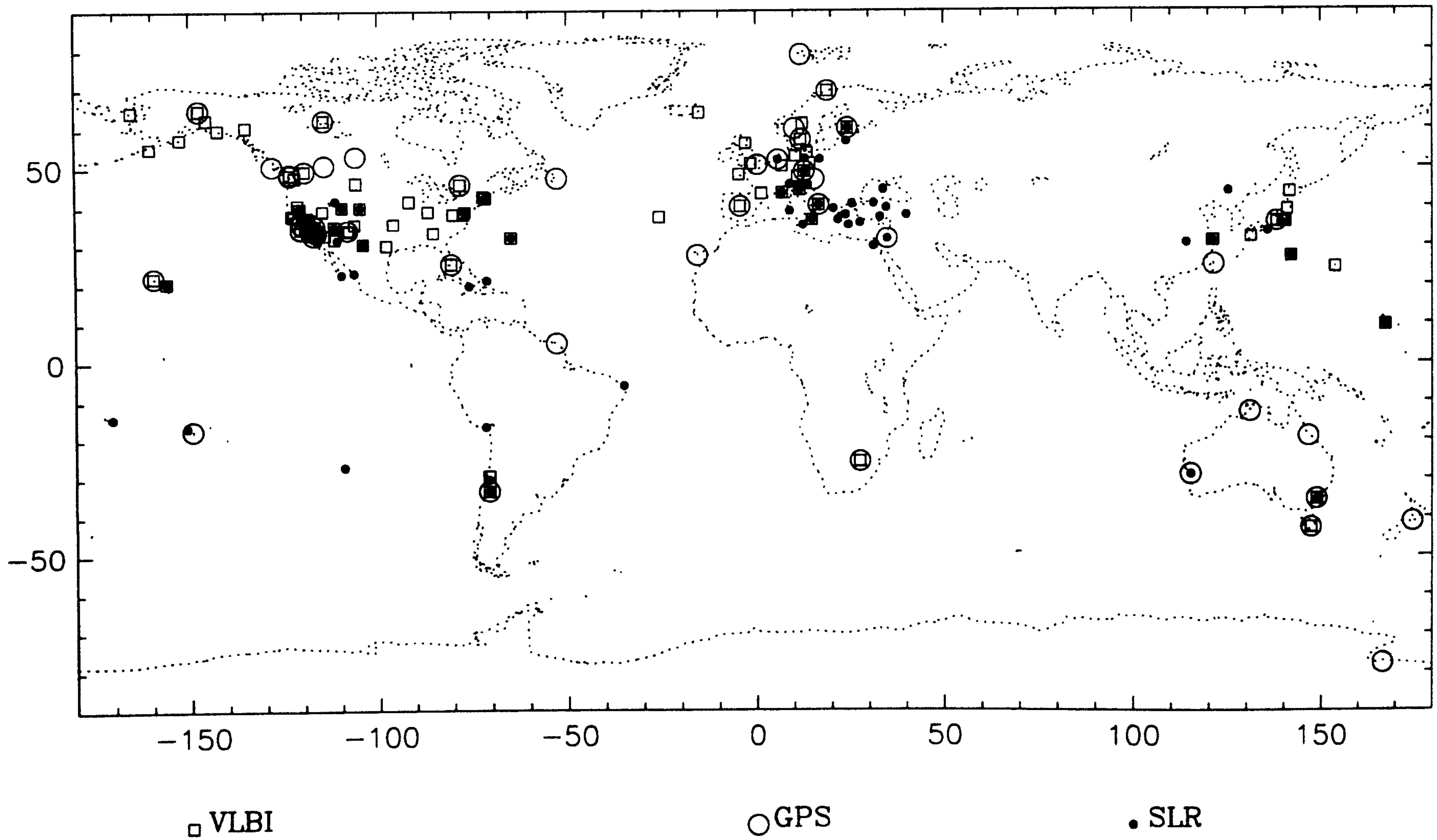
3) RESULTS

3.1) Values

We have adjusted combined coordinates in the ITRF92 solution for epoch 1988.0. In total, 287 stations located in 152 sites (see Figure 21) have been independently adjusted. These coordinates are given in Table T5 under the label SSC(IERS) 93 C 03. They are also published in Table T-3 of the 1992 IERS Annual Report.

Table T6 lists the ITRF92 combined velocity field. These velocities should be used to refer the

FIGURE 21 : DISTRIBUTION OF THE 152 SITES OF THE ITRF92



ITRF92 coordinates from the 1988.0 epoch to another desired epoch. This Table gives for each site its DOMES number, name, the individual solutions in which its velocities are available, the cartesian velocities and their standard deviations, the plate and a code : CN for Combined Velocities with NNR-NUVEL1, C for Combined velocities with NNR-NUVEL1 velocities deweighted, and N for NNR-NUVEL1 velocities.

The adjusted transformation parameters were published in Table T-2 of the 1992 IERS Annual Report. They are also available in Table T7 of the appendix.

Table T8 gives the rate of change of the translation and rotation parameters. The scale factor is assumed to be invariant with time. These values have to be considered as annual variations to the transformation parameters given in Table T7. So for a given transformation parameter T at an epoch t in years, we have:

$$T(t) = T(1988.0) + \dot{T} \cdot (t - 1988.0) \qquad (2)$$

T and $\dot{T}$ are given in Tables T7 and T8 respectively. When $\dot{T}$ is not given one can assume $\dot{T} = 0$.

3.2) Analysis of results

The factor of unit variance is 1.1 for both the ITRF92 station coordinates and velocity field combined solutions. Although it is close to 1, the proper weighting in the combined adjustment is a rather critical and delicate problem.

For a sample of 6 stations, Figures 22 to 27 show the evolution of their positions expressed in the local frame, from ITRF0 to ITRF92 for two epochs: 88.0 and 93.0. The Figures at epoch 88.0 represent the simple coordinate differences with respect to ITRF0, while the Figures at epoch 93.0 represent the simple coordinate differences with respect to ITRF0, but after mapping the coordinates in the different ITRF solutions from the reference epoch (88.0) to epoch 93.0 using their respective motion models (AM0-2 for ITRF-0 to ITRF90 and the respective velocity fields for ITRF91 and ITRF92).

The quality of the results is also given by examining residuals by groups. All residuals by site are given in the appendix; Table T9 for the sets of station coordinates and Table T10 for the velocity fields respectively . Table T9 gives residuals in meters, while T10 gives residuals in mm both in equatorial and local frame, as well as equatorial residuals divided by the a priori standard errors.

At the end of each site, the following RMS means are given:

SX: unweighted 3-D RMS
NSX: 3-D normalized RMS
SP: unweighted 2-D horizontal RMS
SU: unweighted vertical RMS

with,

$$SX = \sqrt{\frac{\sum_{i=1}^{N} (RX_i^2 + RY_i^2 + RZ_i^2)}{3N}} \qquad (3)$$

$$NSX = f \cdot \sqrt{\frac{\sum_{i=1}^{N} (NX_i^2 + NY_i^2 + NZ_i^2)}{3N}} \qquad (4)$$

$$SP = \sqrt{\frac{\sum_{i=1}^{N} (RE_i^2 + RN_i^2)}{2N}} \qquad (5)$$

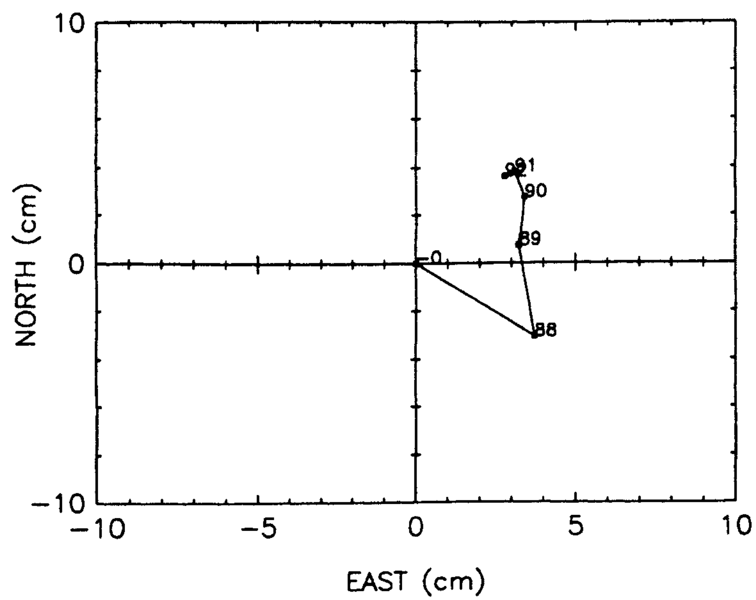
$$SU = \sqrt{\frac{\sum_{i=1}^{N} (RU_i^2)}{N}} \qquad (6)$$

with N as the number of points in the site and f a scaling factor,

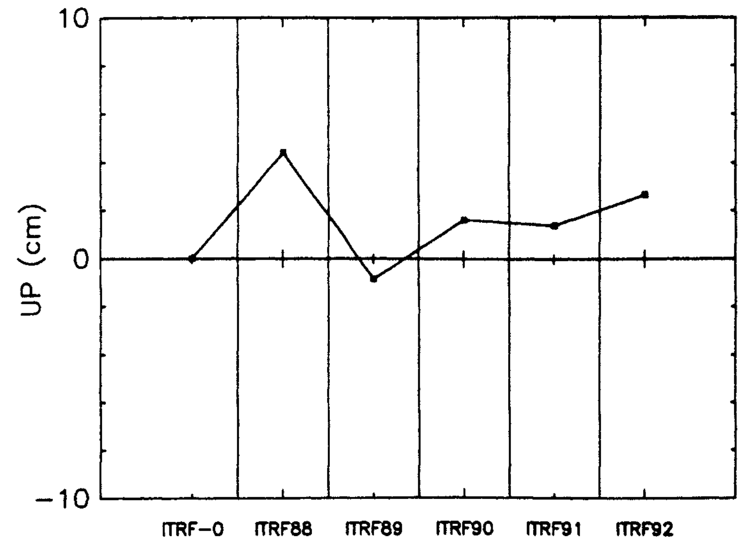
$$f = \frac{1}{\sigma_0} \sqrt{\frac{\text{Number of observations}}{\text{Number of degree of freedom}}} \qquad (7)$$

A summary of the quality of the various sites is given in Table 3, where can be found N, NSX, SP and SU in cm, the maximum standard deviation of ITRF92 coordinates for this site, also in cm.

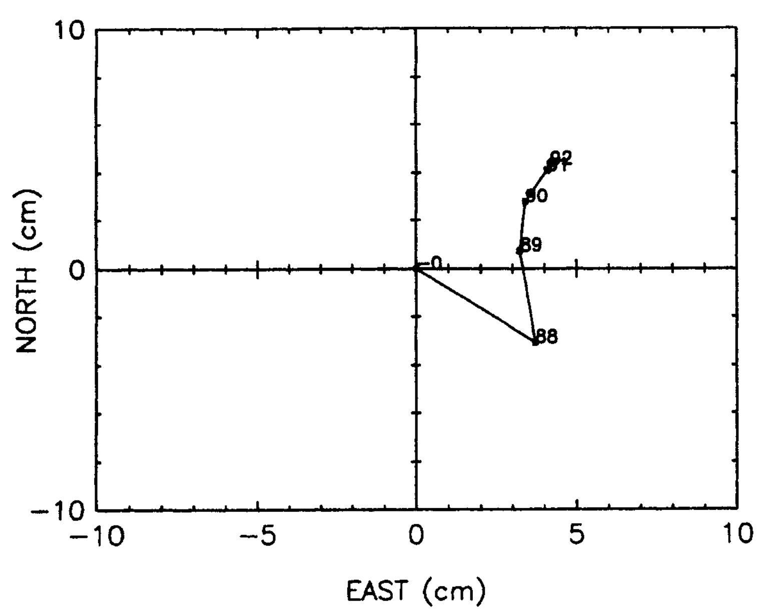
FIGURE 22 : FORT DAVIS 2-D POSITION IN THE ITRFs AT 88.0



FORT DAVIS VERTICAL COMPONENT IN THE ITRFs AT 88.0



FORT DAVIS 2-D POSITION IN THE ITRFs AT 93.0



FORT DAVIS VERTICAL COMPONENT IN THE ITRFs AT 93.0

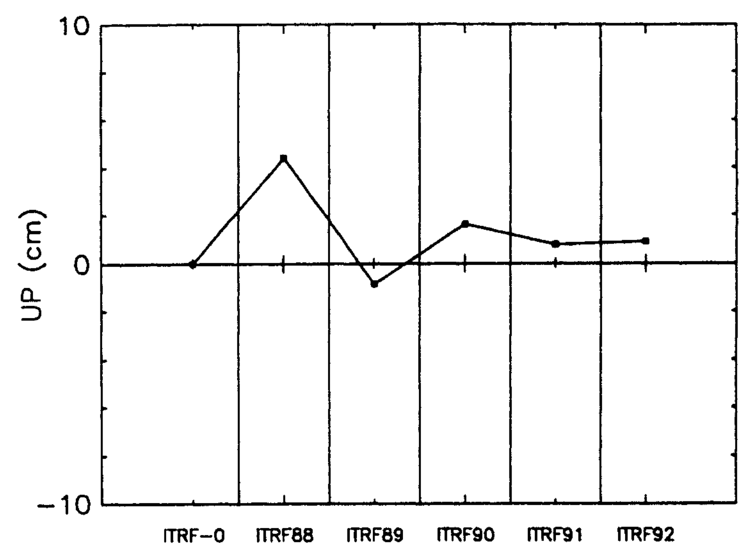
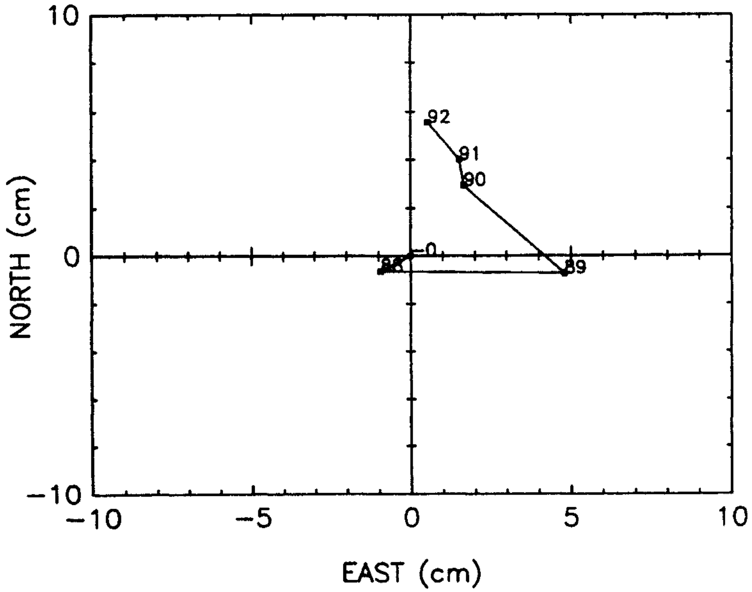
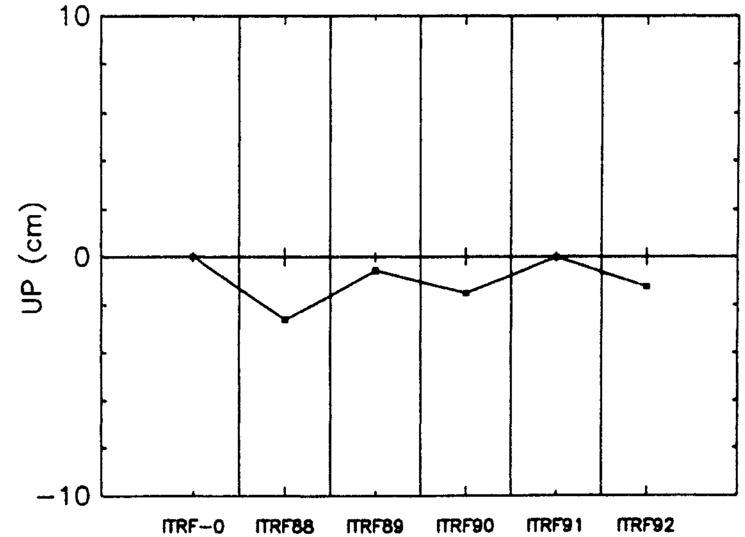


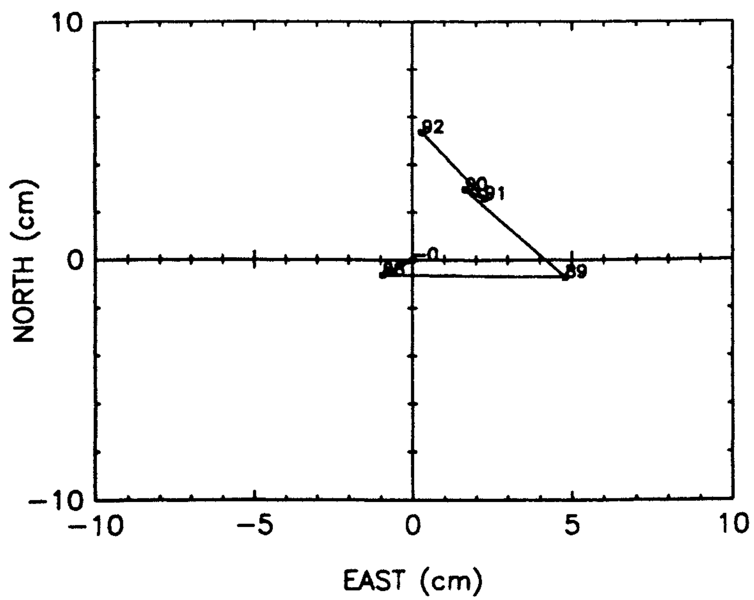
FIGURE 23 : WETTZELL 2-D POSITION IN THE ITRFs AT 88.0



WETTZELL VERTICAL COMPONENT IN THE ITRFs AT 88.0



WETTZELL 2-D POSITION IN THE ITRFs AT 93.0



WETTZELL VERTICAL COMPONENT IN THE ITRFs AT 93.0

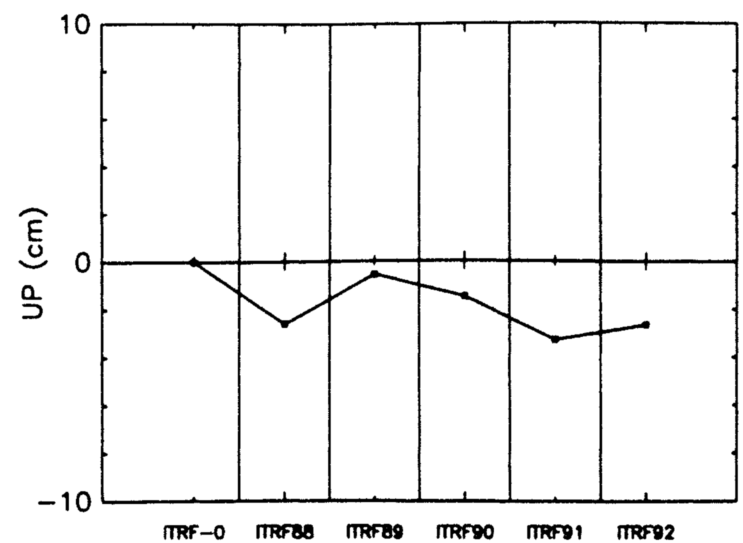
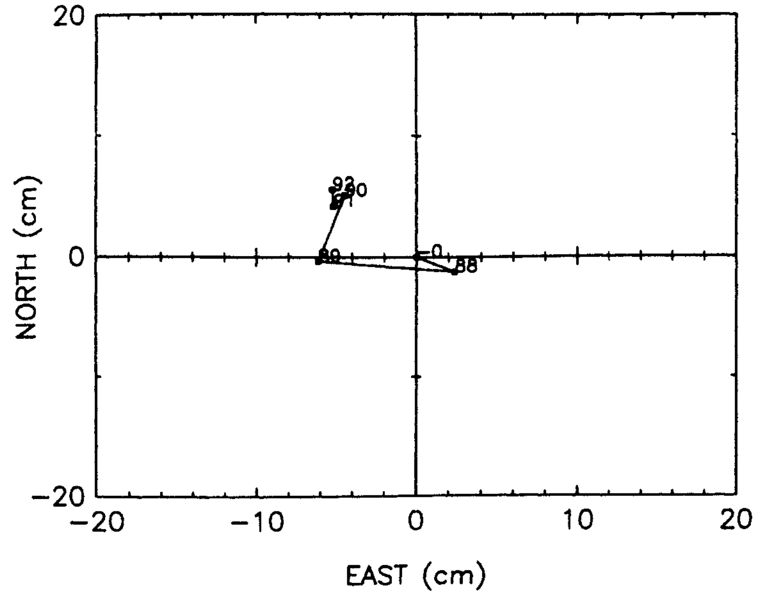
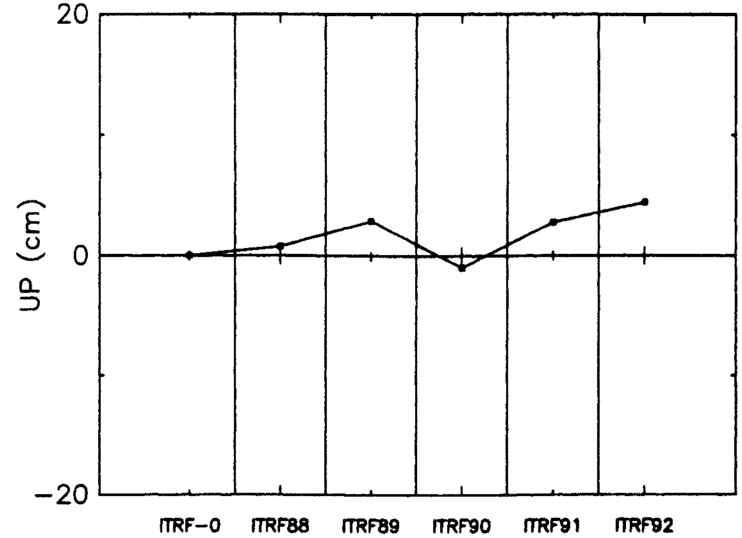


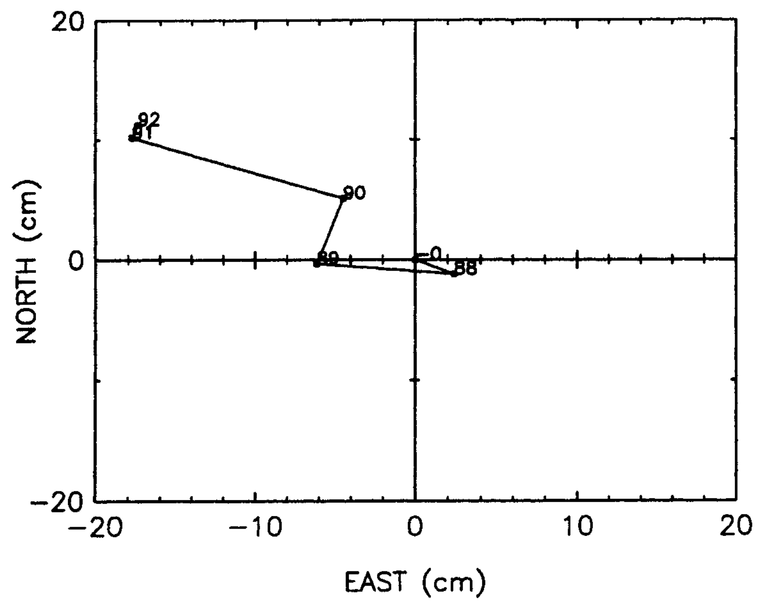
FIGURE 24 : SIMOSATO 2-D POSITION IN THE ITRFs AT 88.0



SIMOSATO VERTICAL COMPONENT IN THE ITRFs AT 88.0



SIMOSATO 2-D POSITION IN THE ITRFs AT 93.0



SIMOSATO VERTICAL COMPONENT IN THE ITRFs AT 93.0

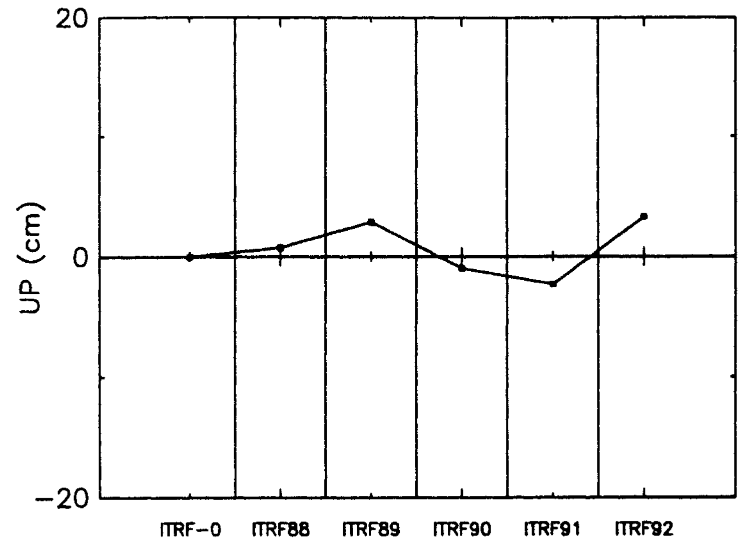
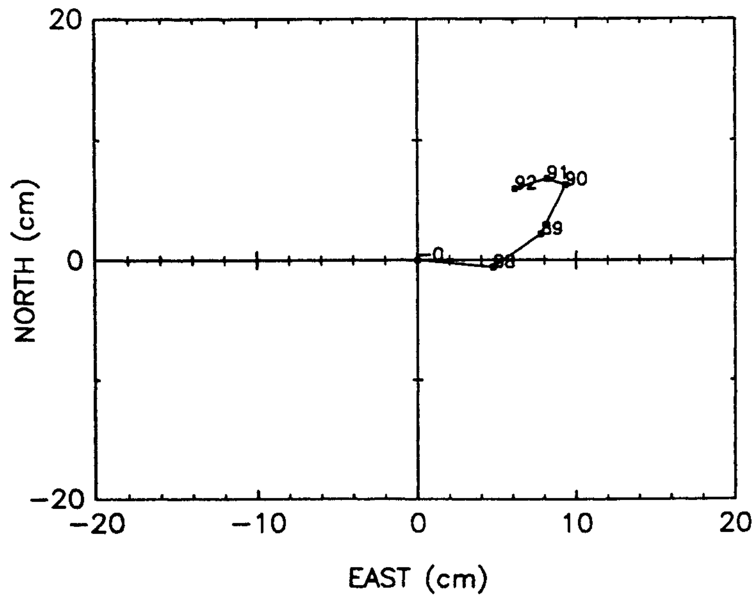
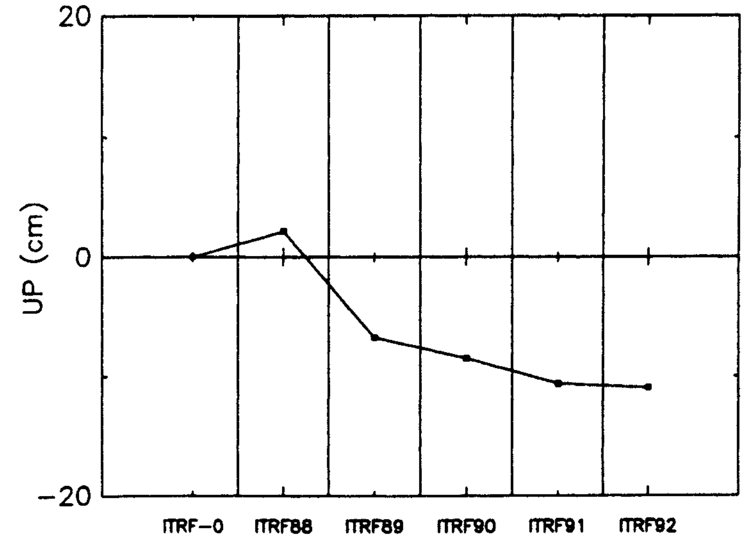


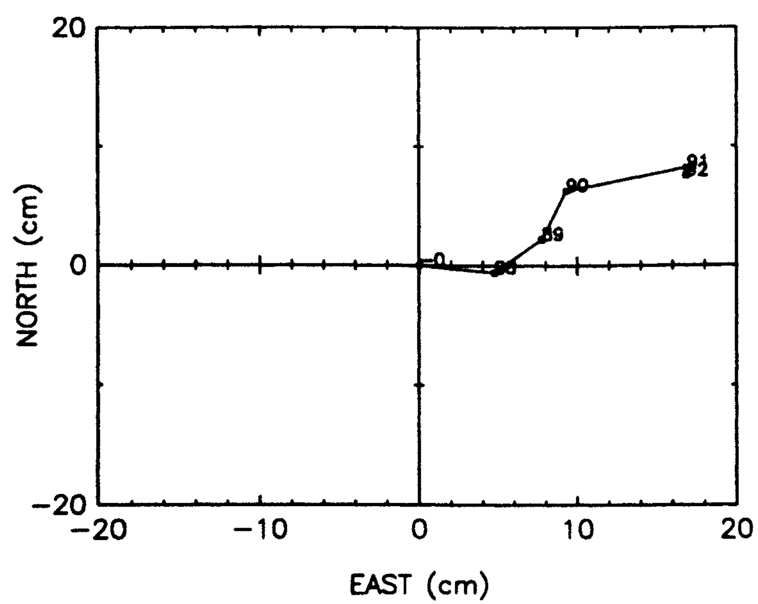
FIGURE 25 : AREQUIPA 2-D POSITION IN THE ITRFs AT 88.0



AREQUIPA VERTICAL COMPONENT IN THE ITRFs AT 88.0



AREQUIPA 2-D POSITION IN THE ITRFs AT 93.0



AREQUIPA VERTICAL COMPONENT IN THE ITRFs AT 93.0

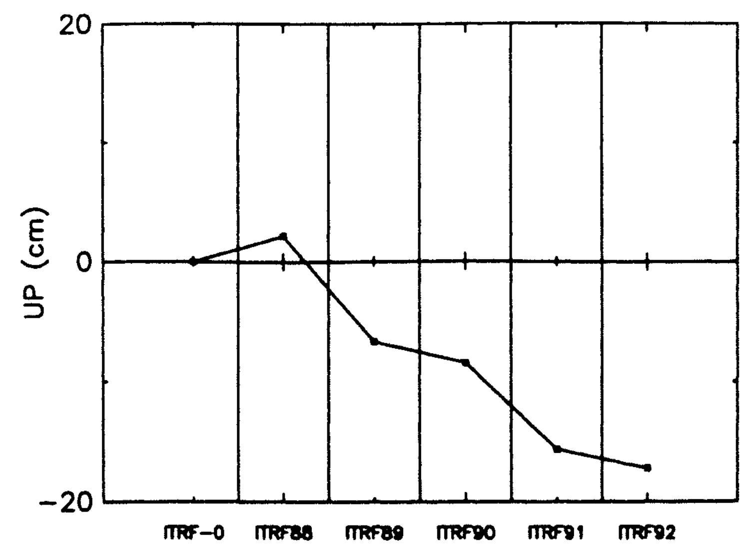
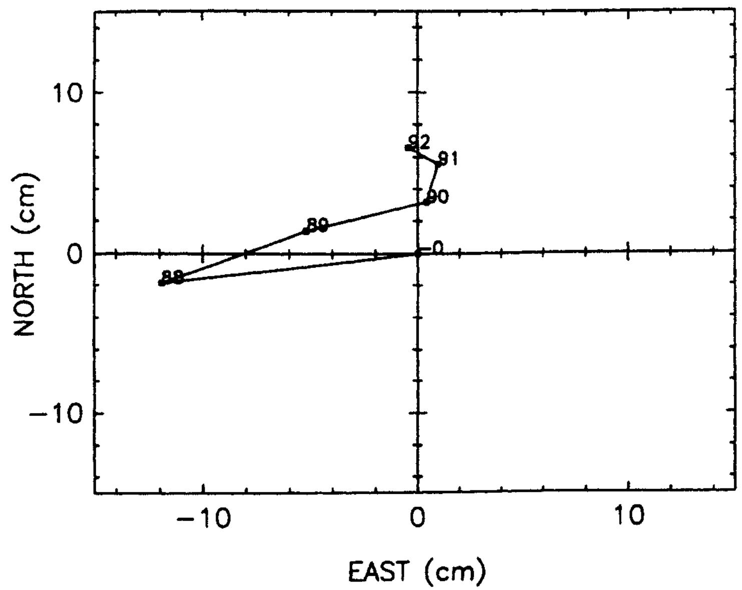
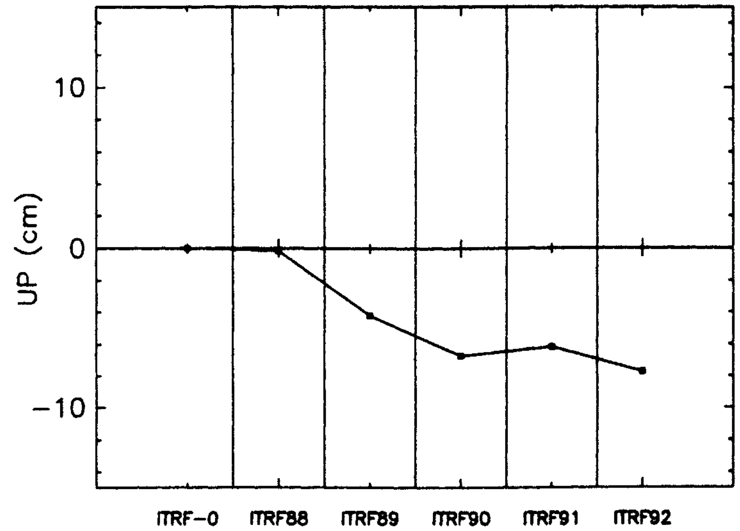


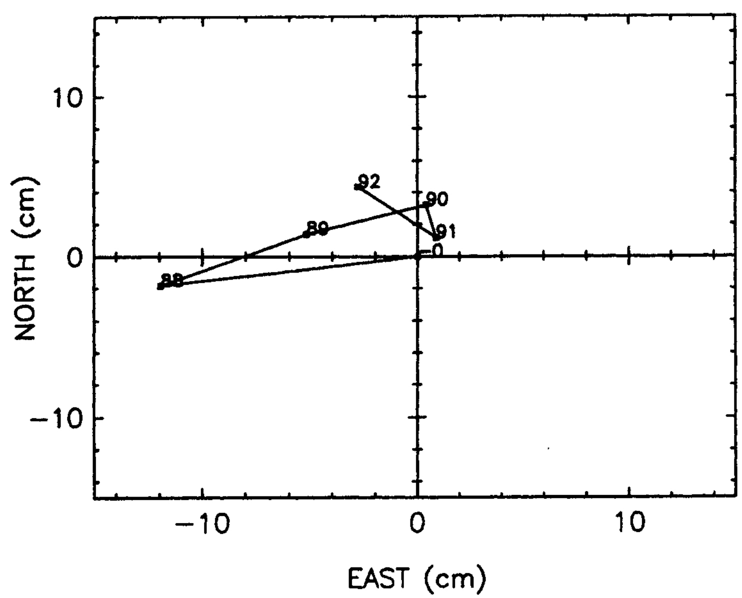
FIGURE 26 : HART 2-D POSITION IN THE ITRFs AT 88.0



HART VERTICAL COMPONENT IN THE ITRFs AT 88.0



HART 2-D POSITION IN THE ITRFs AT 93.0



HART VERTICAL COMPONENT IN THE ITRFs AT 93.0

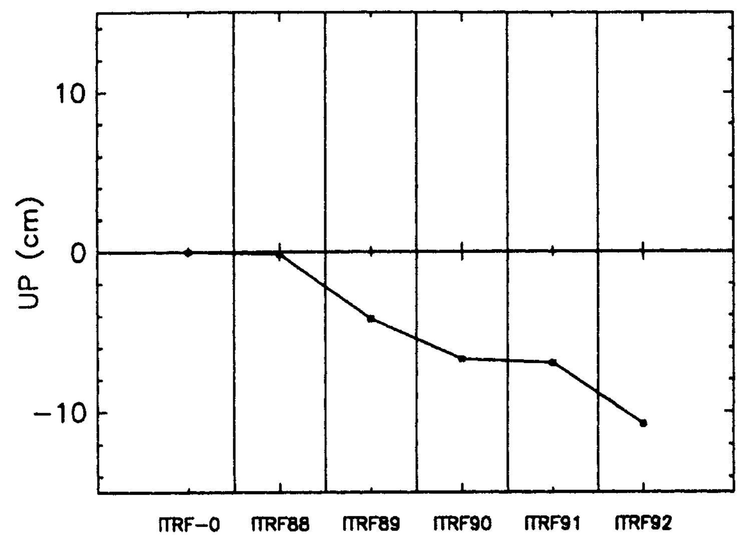
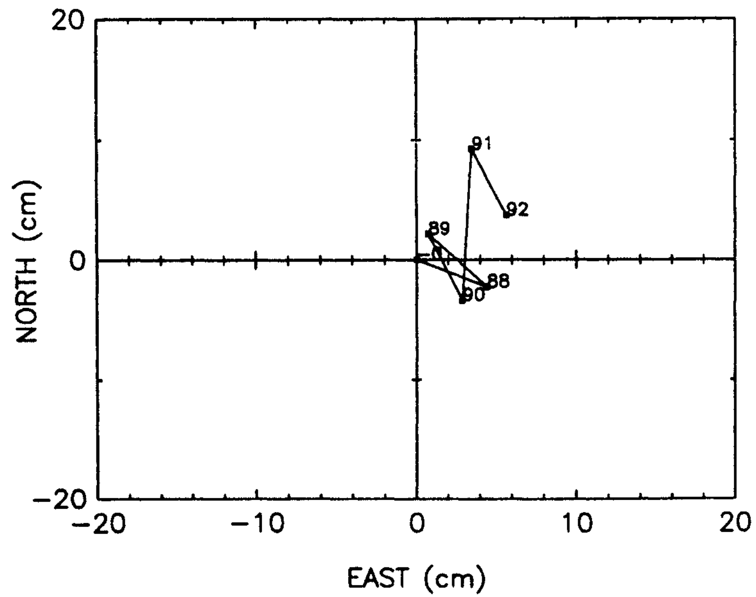
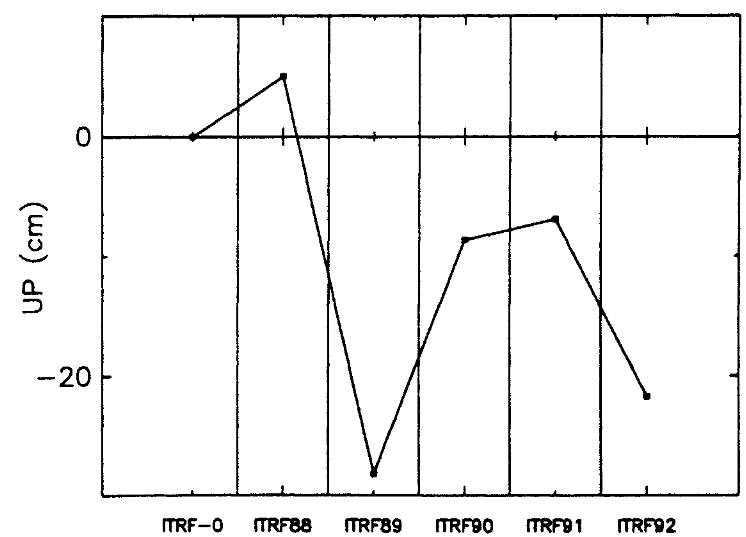


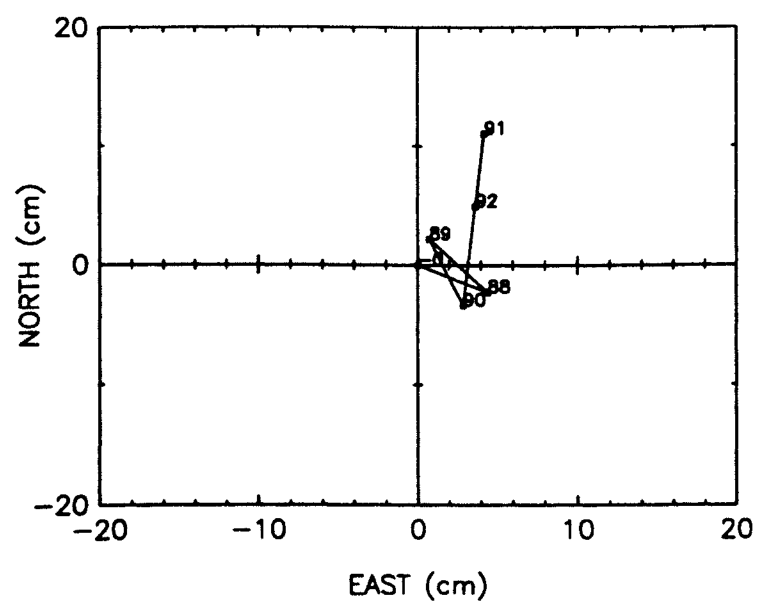
FIGURE 27 : CANBERRA 2-D POSITION IN THE ITRFs AT 88.0



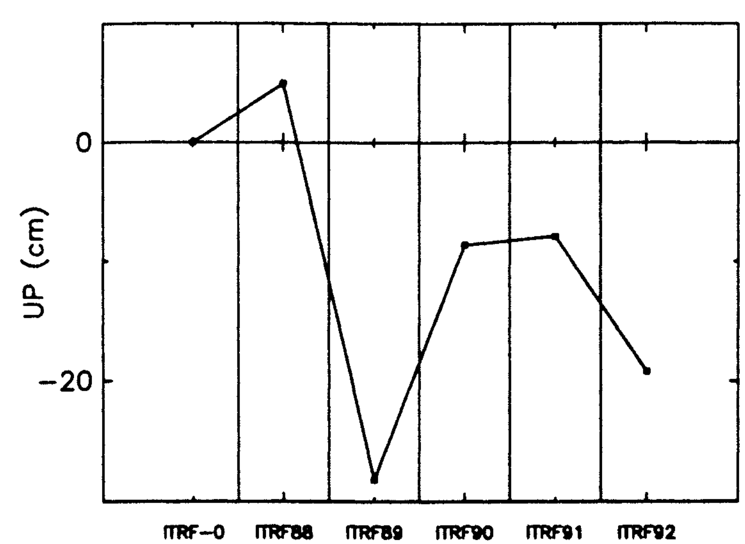
CANBERRA VERTICAL COMPONENT IN THE ITRFs AT 88.0



CANBERRA 2-D POSITION IN THE ITRFs AT 93.0



CANBERRA VERTICAL COMPONENT IN THE ITRFs AT 93.0



A similar analysis has been done by solution. Table 4 gives the results for the sets of station coordinates and Table 5 for the velocity fileds. Statistics presented in these two tables involve the following parameters:

N	: number of points common to other solutions
SP, SU and NSX	: as defined in page 37
WSX	: weighted 3-D RMS
A and B:	: the two weighting parameters of the formula (1), page 2

In addition, one can analyze transformation parameters as given in Table T7, and also compare ITRF92 to previous solutions, such as ITRF91. This global transformation is obtained taking into account one point per site only. The values are (from ITRF91 to ITRF92) :

T1(cm)	= -1.1	(±0.2)
T2(cm)	= -1.4	(±0.2)
T3(cm)	= 0.6	(±0.2)
D (10^{-8})	= -0.14	(±0.03)
R1(0.001")	= 0.00	(±0.07)
R2(0.001")	= 0.00	(±0.07)
R3(0.001")	= 0.00	(±0.05)

Finally, in order to analyse the ITRF92 combined velocity field, we illustrated in figures given in the appendix, site velocities in the local frame given by the combined solution, NNR-NUVEL1 as well as the individual solutions.

Table 3 : Summary of the quality of the ITRF92 sites

SITE	N	NSX	SP cm	SU cm	Max(*) cm
GRASSE	14	1.4	1.9	2.0	0.8
TOULOUSE	2	0.2	0.3	0.2	1.6
BREST	2	0.1	0.2	0.1	1.3
HOFN	2	0.3	0.3	0.4	2.0
TROMSO	13	0.9	1.6	2.0	0.6
NY-ALESUND	5	1.0	1.8	3.7	0.7
TRYSIL	2	0.4	0.2	0.6	0.9
ONSALA	9	0.7	0.5	1.0	1.0
METSAHOVI	12	0.9	22.6	28.0	0.8
GRAZ	12	0.9	1.2	3.8	0.6
BOROWIEC	4	1.5	5.4	15.5	4.6
RIGA	8	0.7	3.3	9.3	6.5
KATZIVELY	12	1.1	7.2	14.3	5.2
DIONYSOS	7	0.4	4.7	2.7	46.7
ASKITES	5	0.4	0.9	0.4	1.1
ROUMELLI	5	0.8	1.8	0.7	1.1
KARITSA	5	0.8	1.3	5.1	1.3
KATAVIA	6	0.8	2.1	3.4	1.1
XRISOKALARIA	5	0.6	1.9	1.0	1.1
LAMPEDUSA	6	0.7	2.1	4.0	1.2
BOLOGNA	9	1.1	7.8	2.6	0.9
NOTO	10	0.9	1.9	1.0	0.8
TRIESTE	5	0.5	2.2	2.0	2.3
CAGLIARI	5	0.5	2.4	5.3	1.3
MATERA	24	1.0	1.3	2.5	1.5
MONTE VENDA	4	0.5	2.8	2.0	2.4
CHILBOLTON	2	0.7	0.4	1.0	1.2
HERSTMONCEUX	11	0.7	0.7	1.1	0.6
CARNUSTY	2	0.5	0.4	1.5	1.8
MADRID	13	1.1	1.0	2.5	3.9
KOOTWIJK	16	0.8	3.4	4.2	3.5
ZIMMERWALD	7	0.9	1.9	1.3	0.7
MONTE GENEROSO	3	0.6	1.5	1.8	2.1
POTSDAM	6	1.3	2.7	7.3	7.3
WETTZELL	28	0.8	1.8	2.7	2.0
HOHENBUNSTORF	2	0.9	0.2	1.2	0.9
EFFELSBERG	2	0.5	0.2	0.2	0.8
HOHENPEISSENBERG	2	0.1	0.2	0.1	1.8
KARLSBURG	2	0.5	0.4	1.0	2.4
KIRSCHBERG	2	0.3	0.2	0.0	1.2
BAR GIYYORA	5	1.4	6.0	10.3	3.0
DIYARBAKIR	5	0.7	2.7	4.6	1.5
YOZGAT	5	0.6	3.7	2.1	1.6
MELENGICLICK	5	0.8	2.5	10.0	1.3
YIGILCA	5	0.6	1.7	1.6	1.3
WUHAN	2	1.5	4.3	12.3	3.4
SHANGHAI	10	1.2	2.5	5.4	18.2
CHANGCHUN	2	0.2	7.0	8.6	8.4
KASHIMA	6	0.9	2.5	2.1	1.1

NOBEYAMA	2	0.6	0.9	0.3	1.5
SIMOSATO	6	1.3	5.6	4.5	1.1
USUDA	9	1.2	3.8	4.5	2.9
CHICHIJIMA	4	1.3	19.7	3.3	6.0
TAIPEI	3	1.1	4.4	0.2	1.4
HELWAN	5	1.4	16.8	5.5	2.0
HARTEBEESTHOEK	11	0.8	6.8	10.2	1.1
MASPALOMAS	5	1.9	1.9	3.6	0.9
SAO MIGUEL	2	0.9	0.8	0.1	1.1
ST. JOHNS	5	1.0	1.5	2.7	0.8
ALGONQUIN	10	1.0	1.0	1.5	0.5
PENTICTON	7	1.1	0.8	2.7	0.7
YELLOWKNIFE	10	1.5	1.1	5.0	0.9
ALBERT HEAD	3	0.9	1.3	2.2	3.3
PASADENA	12	1.0	9.1	3.9	1.2
GOLDSTONE	42	1.0	2.7	4.4	3.4
PINYON FLATS	9	0.6	3.5	1.7	0.9
FAIRBANKS	10	1.1	1.4	1.6	0.6
VANDENBERG	5	1.2	0.6	2.5	1.8
KAUAI	10	1.5	1.8	3.9	0.7
QUINCY	18	1.2	2.3	5.1	0.6
MOUNT HOPKINS	2	0.4	2.4	1.4	9.0
SAN DIEGO	9	0.8	3.3	2.0	1.1
BEAR LAKE	7	1.1	7.5	8.2	2.2
OWENS VALLEY	13	0.9	1.9	1.7	1.4
WESTFORD	14	1.1	3.4	2.9	0.5
GREENBANK	5	0.7	0.3	0.4	1.0
FORT DAVIS	34	1.3	2.5	2.8	0.7
MAUI	16	1.3	3.8	2.7	0.8
WASHINGTON	38	1.0	4.7	6.4	1.6
PIETOWN	5	1.4	0.4	1.1	0.6
SCRIPPS 1	2	0.3	0.4	0.2	3.2
LOS ALAMOS	2	2.4	0.6	2.7	1.8
HAT CREEK	2	0.3	0.0	0.2	0.6
MARYLAND POINT	3	0.7	0.3	1.1	0.7
FLAGSTAFF	5	1.4	1.9	17.2	1.6
VERNAL	2	0.4	2.8	1.3	2.8
YUMA	3	0.5	2.3	0.2	1.0
PLATTEVILLE	10	0.9	1.0	2.7	0.6
MONUMENT PEAK	14	1.0	2.5	1.7	0.7
RICHMOND	13	0.9	1.2	1.5	0.6
MAZATLAN	6	1.1	2.4	5.3	0.8
CABO SAN LUCAS	5	1.1	3.3	3.4	1.3
ENSENADA	4	0.7	1.4	3.3	1.7
SANTIAGO DE CUBA	4	1.0	7.6	4.2	3.9
NATAL	2	0.5	4.9	6.0	4.4
EASTER ISLAND	6	1.2	10.6	4.0	1.2
SANTIAGO	17	1.1	10.3	11.1	1.1
CERRO TOLOLO	5	1.3	5.2	2.7	1.1
SEST	2	0.4	0.8	1.1	2.2
AREQUIPA	11	1.4	4.8	2.7	1.1
BERMUDA	2	0.2	0.3	0.5	1.6
CANBERRA	24	1.2	3.8	6.8	3.8
YARRAGADEE	12	1.2	4.6	3.8	0.9
HOBART	7	1.3	2.5	7.7	1.3
TOWNSVILLE	2	0.8	5.2	10.5	2.1
WELLINGTON	2	1.5	1.6	5.1	1.9

5MERICAN SAMOA	2	0.7	2.9	2.8	3.3
KWAJALEIN ATOLL	6	0.9	5.4	5.5	1.3
MC MURDO	5	1.3	6.5	7.4	1.6
PAMATAI	5	1.2	7.7	5.5	1.6
HUAHINE	10	1.3	4.2	4.4	1.5
KOUROU	2	1.4	4.4	5.2	1.6

(*) Max: Maximum standard deviation of ITRF92 coordinates

Table 4 : Statistics of the ITRF92 combined solution

Tech.	Solution	N	WSP cm	WSU cm	WSX cm	NSX	A cm	B
VLBI	SSC(GIUB) 93 R 01	6	0.6	1.1	0.7	1.15		1.0
	SSC(GSFC) 93 R 04	70	0.4	1.0	0.6	0.97	0.5	1.5
	SSC(JPL) 93 R 01	7	1.1	2.6	1.5	0.84	0.5	2.0
	SSC(NOAA) 93 R 02	55	0.3	0.8	0.5	1.02	0.0	1.5
	SSC(USNO) 93 R01	15	0.7	0.8	0.7	1.11	0.5	1.5
LLR	SSC(JPL) 93 M 01	5	3.6	2.2	3.1	1.12	3.0	
	SSC(SHA) 93 M 01	4	3.6	3.5	3.4	1.05	3.5	
	SSC(UTXMO) 93 M 01	5	4.3	3.5	3.9	1.22	3.5	
GPS	SSC(CODE) 92 P 01	12	0.4	1.0	0.7	0.91	0.8	
	SSC(CSR) 92 P 03	24	1.2	1.7	1.3	1.22		8.0
	SSC(EMR) 93 P 01	17	0.4	0.8	0.6	1.07		4.0
	SSC(ESOC) 93 P 01	32	3.1	4.4	3.4	1.22		1.0
	SSC(JPL) 93 P 01	39	0.6	0.9	0.7	0.90		0.8
	SSC(SIO) 93 P 01	40	1.3	2.4	1.8	1.14	1.5	
SLR	SSC(CLG) 93 L 01	36	4.8	7.2	5.8	1.26	3.0	3.0
	SSC(CSR) 93 L 01	101	1.7	2.6	2.0	1.02	1.0	1.0
	SSC(DUT) 93 L 01	69	1.3	1.9	1.5	0.87	1.0	1.0
	SSC(GAOUA)93 L 01	73	3.0	3.5	3.1	1.13	2.5	2.0
	SSC(GFZ) 93 L 01	95	1.8	2.1	1.9	1.01	1.5	1.5
	SSC(GSFC) 93 L 01	35	1.8	2.3	2.0	1.12	1.0	3.0

(*) : A is the additive variance in cm and B is the factor of the formula (1).

Table 5 : Statistics of the ITRF92 combined velocity field

Tech.	Solution	N	WSP mm/Y	WSU mm/Y	WSX mm/Y	NSX	A mm/Y	B
	NNR-NUVEL1	95	2.5	6.1	3.5	0.78	3.0* 10.0	
VLBI	SSC(GSFC) 93 R 04	63	0.6	0.5	0.7	0.80	0.5	1.5
	SSC(JPL) 93 R 01	3	1.0	2.9	1.1	0.68	0.0	1.0
	SSC(NOAA) 93 R 02	35	0.7	2.0	1.5	1.08	0.5	1.5
SLR	SSC(CSR) 93 L 01	47	1.1		0.9	0.70	0.5	1.0
	SSC(DUT) 93 L 01	35	2.4	2.6	2.5	0.89		0.5
	SSC(GAOUA)93 L 01	36	5.0	4.6	4.8	1.25	1.5	3.0
	SSC(GFZ) 93 L 01	43	1.5	2.3	2.0	0.79	0.5	1.5
	SSC(GSFC) 93 L 01	34	1.8		1.5	0.87	1.0	2.0

* The adopted value of A for the construcetd NNR-NUVEL1 velocity field is 3mm for the horizontal components and 10mm for the vertical one.

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