Associate Analysis Centers

Global Network Associate Analysis Centers

The Newcastle Global Network Associate Analysis Center Annual Report

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1 Introduction

The Newcastle Global Network Associate Analysis Center (GNAAC) continued its activities during the year 1997. It produced the weekly combined coordinate solution for the global and the regional networks, based on ACs and RNAACs data respectively. In spite of some delays in submitting few reports; the NCL GNAAC services are fully restored now.

In this report a summary of our results and analysis are described for the period of GPS week 887 through GPS week 938. During this period, we have kept the same software and algorithms, as year 1996. Therefore, the details of our methods and algorithms are described in the 1996 annual report.

2 New Strategy

In October 1997, because of the introduction of the IGS formal station log, we have stopped using the input SINEXes for station information; and started using the logistics file, updated daily, from the IGS Central Bureau. This method has saved most of the discrepancies caused by the incorrect dome number or antenna height in the input SINEXes. However, as a result of implementing this strategy, some of the stations which do not have an official IGS log file are not analyzed. The regional stations were the most affected. We have contacted our colleagues who are running these networks and now most of the RNAACs have official stations logs for all their stations. Figure 1 shows a time series of the number of stations analyzed by NCL P-network which clearly demonstrate the drop of the number of GPS stations after October 1997.

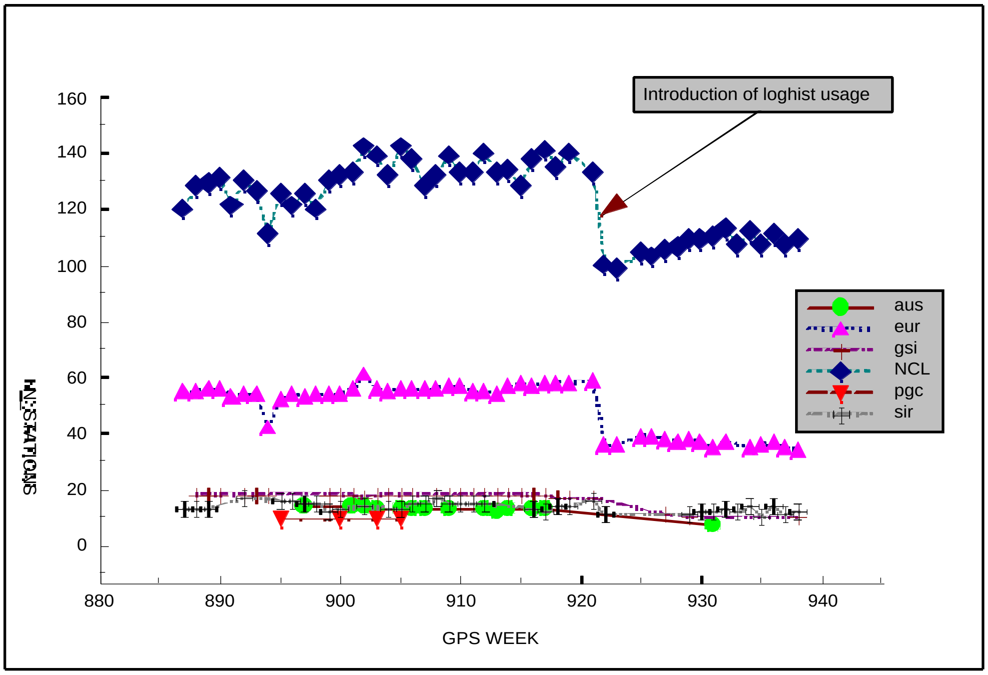

Figure 1: Time series of the number of stations analyzed by the NCL P-net.

3 GNET RESULTS

Figure 2 shows a time series of the number of input GPS stations by the ACs and the number of stations analyzed by the Newcastle GNAAC. It also shows that in 1997, we continued analyzing data from 6 Analysis Centers (COD, EMR, ESA, GFZ, JPL, NGS & SIO). It was noted that the number of stations being analyzed by the NCL GNAAC has steadily increased toward the end of the year.

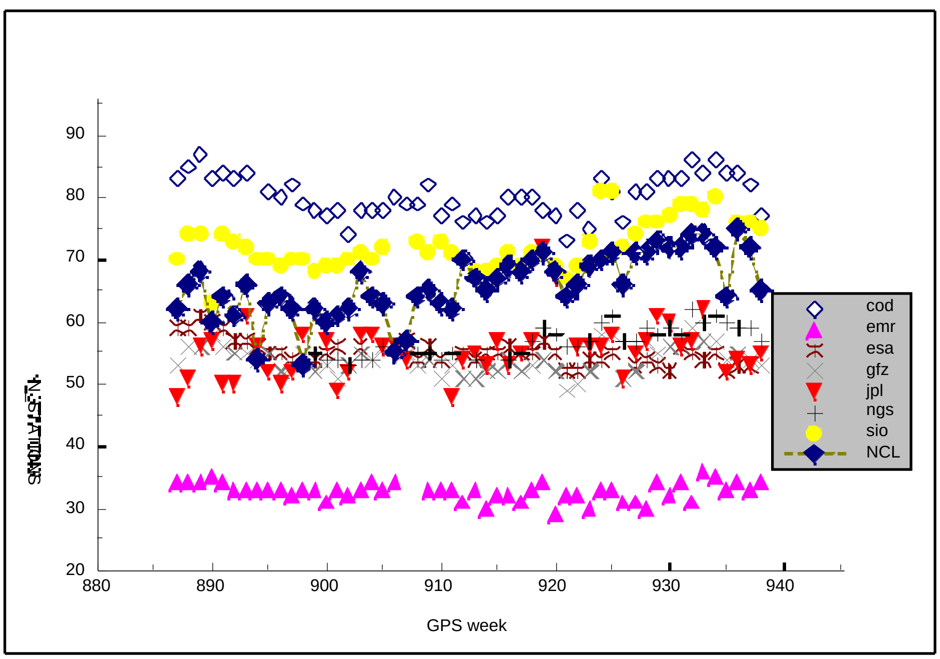

Figure 2: Time series of the number of stations analyzed by the NCL G-net.

As mentioned in the 1996 report, the G-solution is estimated as block of normal equations composed of deconstrained network in terms of coordinates without any reference frame. This loose solution is later transferred and scaled to the CORE 13-stations of ITRF94 using 7 parameters Helmert transformations. Figures 3 through 6 show the transformation and scaling parameters for X, Y, Z & scale for the ACs and NCL GNAAC to ITRF94. These figures demonstrate the relatively smooth and low-value parameters calculated for the Newcastle GNAAC transformation and scale compared to the ACs values.

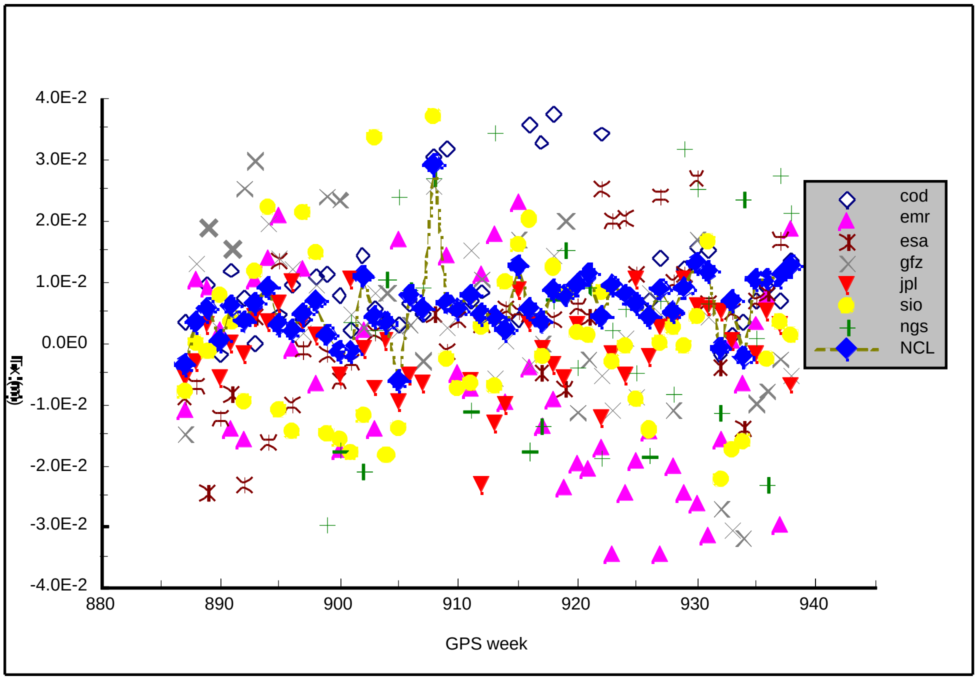

Figure 3: Time series of Tx transformation parameters for the ACs and NCL GNAAC to ITRF.

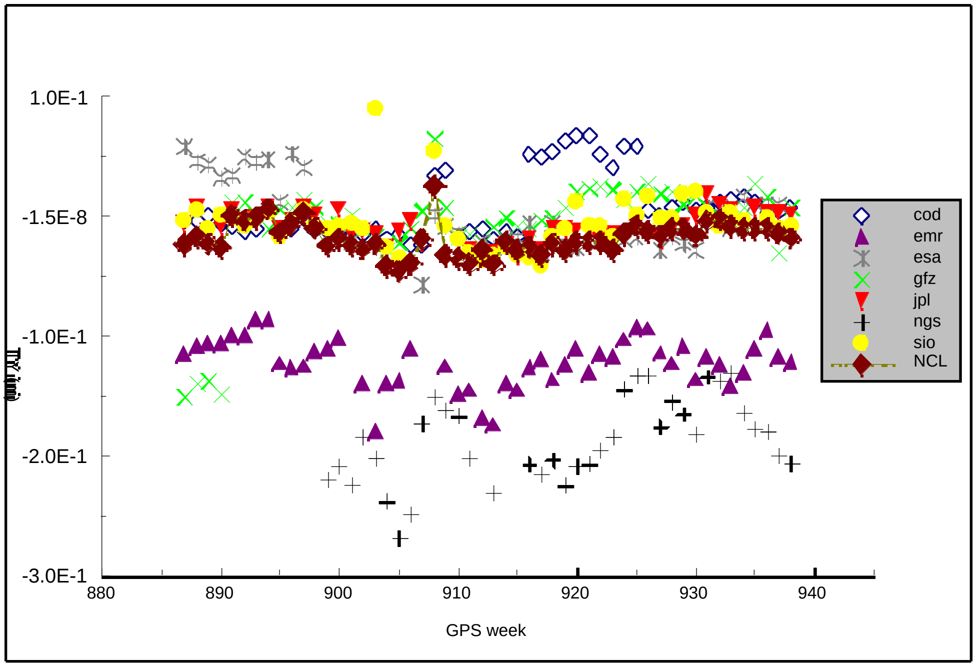

Figure 4 Time series of Ty transformation parameters for the ACs and NCL GNAAC to ITRF.

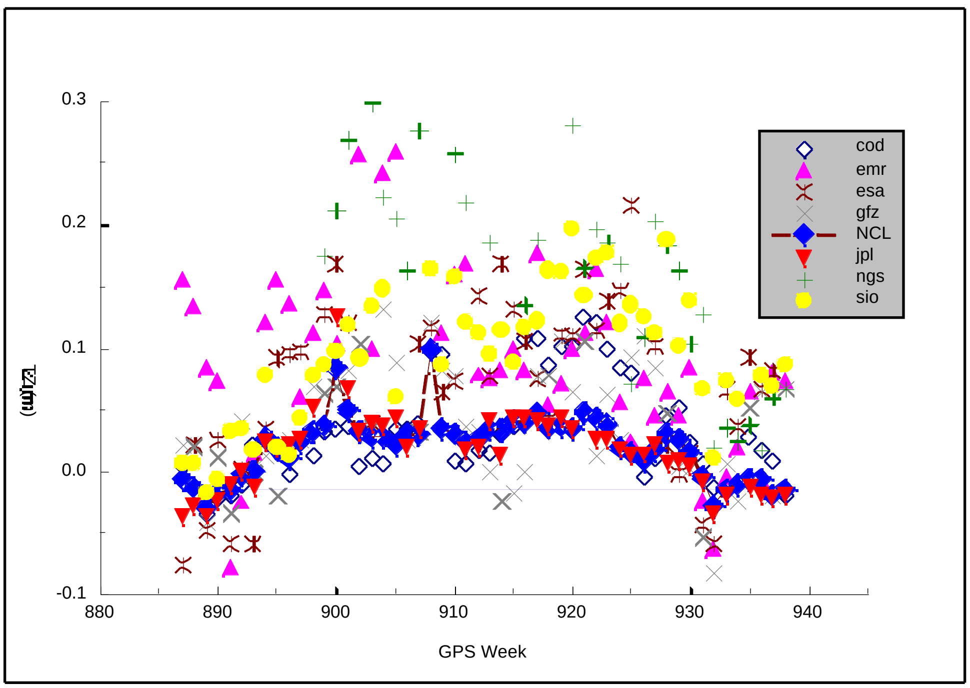

Figure 5: Time series of Tz transformation parameters for the ACs and NCL GNAAC to ITRF.

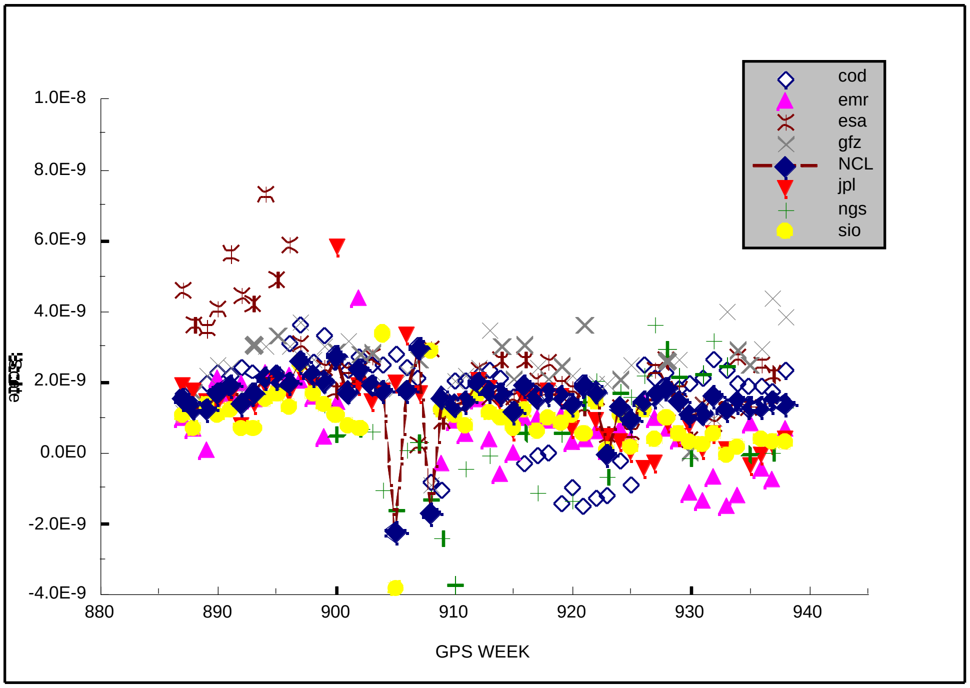

Figure 6: Time series of scaling parameters for the ACs and NCL GNAAC to ITRF.

4 RNAAC Results

In year 1997 we have also continued analyzing the RNAACs data to complete the full polyhedron. These analysis are based on the A-SINEXes input and the weekly input R-SINEXes from the RNAACs. In order to process an R-SINEX, the responsible RNAAC should submit at least three global stations in each weekly solution. However, this was not the case for most of the RNAACs and only few were analyzed on regular basis, see Figure 1.

As mentioned in the 1996 report that we use the "weight-space formulae for efficiency" to attach the R-Network to the polyhedron. This acts in turn as Helmert transformation for 3D rotation, 3D translation and scale. Figure 7 shows a time series for the Root Mean Square error of R-network transformation when attached to the global network.

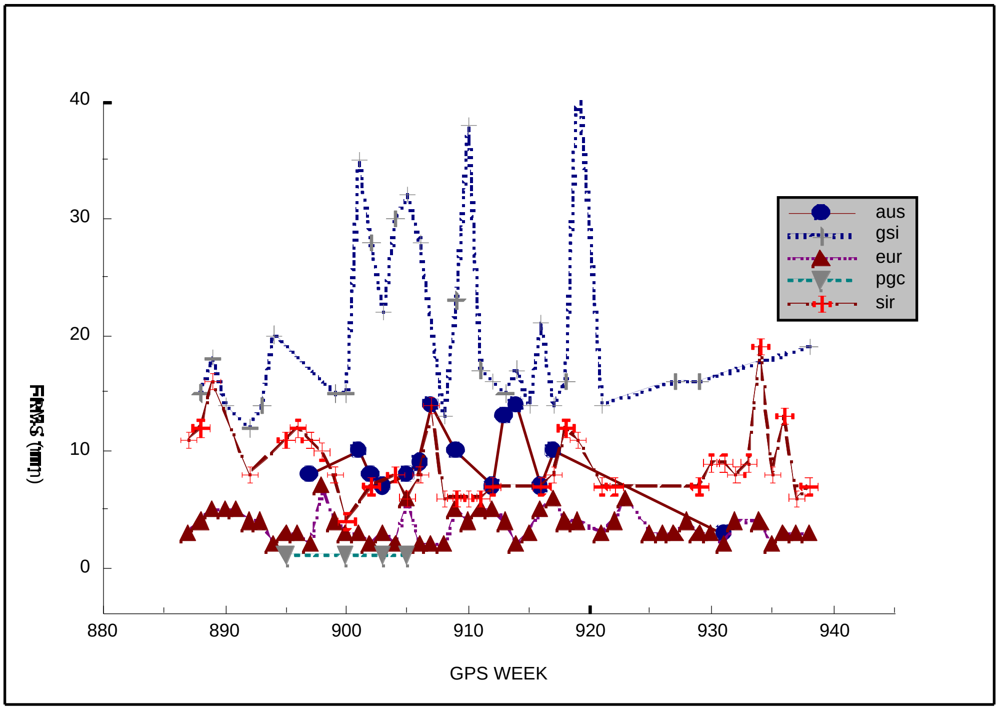

Figure 7: Time series of the RMS transformation of the RNAACs to NCL G-NET.

5 ITRF Realisation

As part of the Newcastle GNAAC contribution we submit our weekly G-SINEX and P-SINEX; which contain coordinate solution for Global and regional stations. The solution also shows better repeatability and smoother time series. Some examples of Time series of stations analyzed by NCL GNAAC are presented in figures 8 & 9.

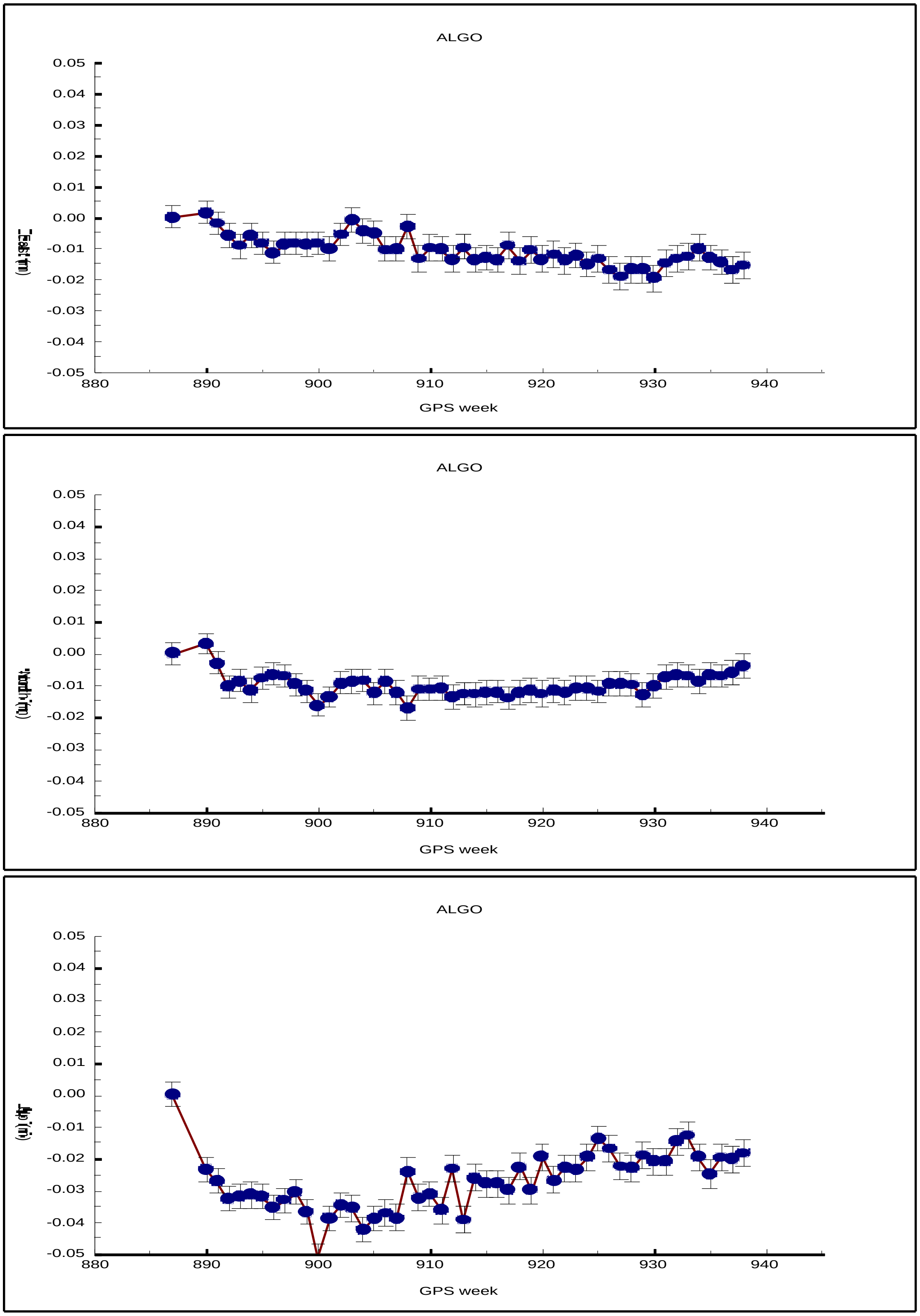

Figure 8 : ALGO Time series for East, North and Up components

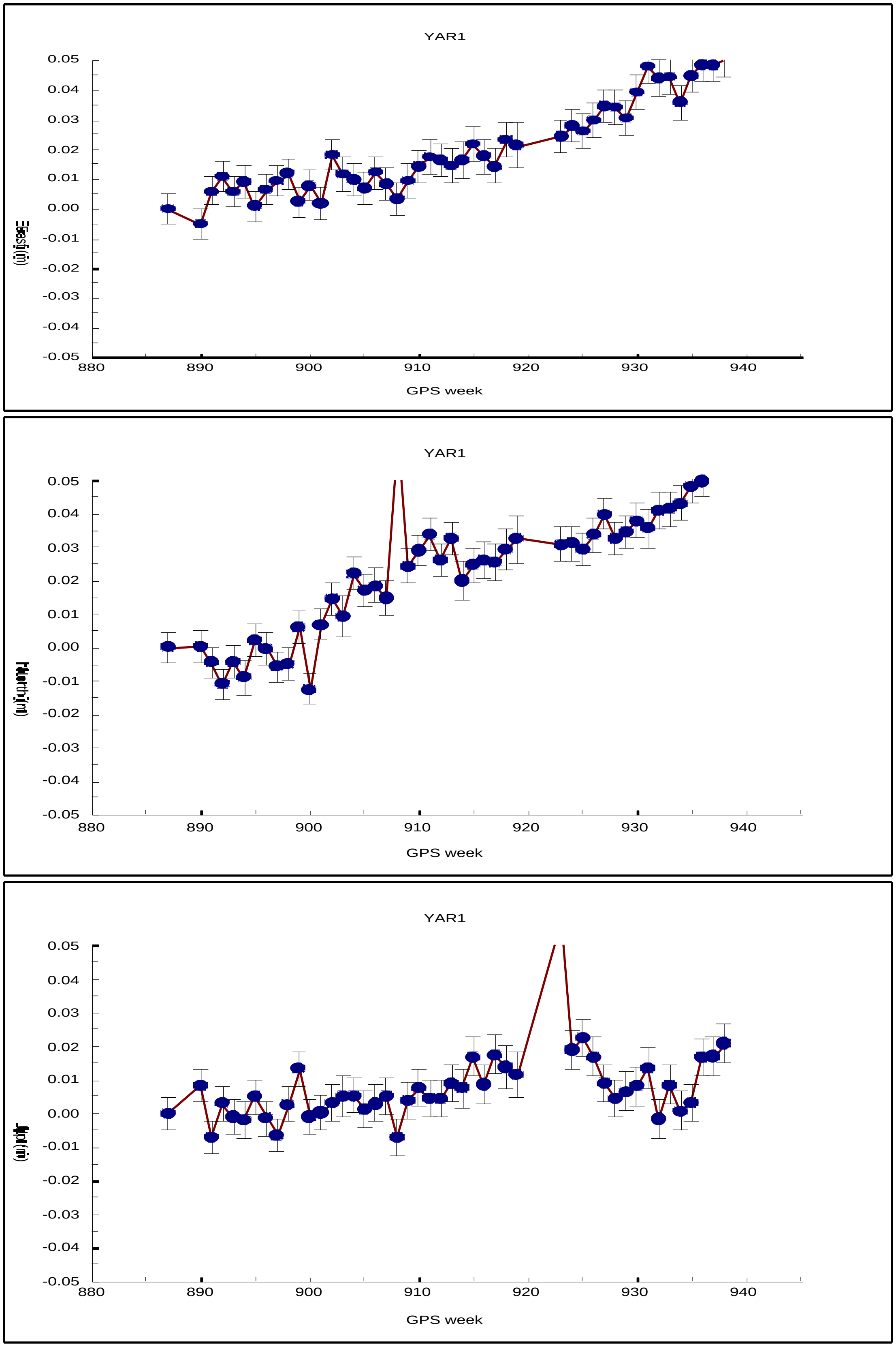

Figure 9 : YAR1 Time series for East, North and Up components

6 Conclusions

Based on the analysis and diagrams presented in this report; it became obvious that Newcastle GNAAC contributes a smooth and low rms error margin coordinate solution for the IGS and IERS, each week. This solution is also used for tectonic and geophysical studies, to understand the plate kinematics and boundary conditions.

7 References

International GPS Services for Geodynamics, 1996 Annual Report, edited by J.F. Zumberge, D.E. Fulton and R. E. Neilan. JPL Publication, Jet Propulsion Labratory, Pasadena, California, 1997.

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MIT T2 Associate Analysis Center Report

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1 Abstract

We discuss the analysis of the 1997 combined solutions generated from the SINEX files submitted by the IGS analysis centers. We highlight the changes to the analysis procedures reported in previous annual reports. Analysis of our combined solutions shows mean fits to the (up to) 49 ITRF96 reference sites of 4.0 mm. For the G-SINEX combinations the median RMS repeatability in north, east, and height are 2.1, 2.6 and 6.7 mm, respectively for 124 sites. For the P-SINEX combinations, the RMS repeatabilities are 2.2, 3.0, and 7.6 mm, respectively for 181 sites.

2 Analysis Procedure Changes

As reported previously [Herring, 1996,1997], two analyses are performed each week. One of these uses the IGS Analysis Center (AC) weekly A-SINEX files to generate a combined G-SINEX file and the other uses the T1 Associate Analysis Center (AAC) R-SINEX files combined with the G-SINEX file to generate a weekly P-SINEX files. In 1997, the G-SINEX files contain 124 sites that were used more than 10 times during the year and 82 sites that were used every week. The corresponding values for the P-SINEX files are 181 and 114 sites, respectively. The G- and P-SINEX analyses are performed 3 and 7 weeks delays.

The basic procedures we use have not been changed and are documented in the weekly summary files submitted with the combined SINEX files. The three changes of note that have been are associated with (a) deconstraining SINEX files, (b) translation and scale estimation, and (c) generation of a weekly residual file for the G-SINEX combination.

2.1 Deconstraining AC SINEX files

The procedure we use to deconstrain SINEX files is to invert the covariance matrices for the estimates and apriori constrains, and to subtract the apriori constraints from the estimates. New weak constraints (±5 meters for most centers) are applied to the station coordinates and the system re-inverted. For some analysis centers, this procedures leads to numerical stability problems which results in the deconstrained covariance matrices being non-positive definite. To diagnose and correct this problem, we now compute the eigenvalues of the deconstrained covariance matrix and, if negative eigenvalues are found, scale the diagonal by increments of 1 part-per-million until all the eigenvalues are positive. Throughout 1997, the COD and NGS analysis centers generated negative eigenvalues when their SINEX files were deconstrained to ±5 m. (After April 1998, COD SINEX files generate all positive eigenvalues).

Our analysis of the numerical stability problems indicates that it probably arises from large negative correlations in the deconstrained covariance matrices. The negative correlations arise from the implicitly determined center-of-mass origin for the GPS coordinate system. Sites that are located on opposite sides of the Earth have negatively correlated Cartesian coordinates so that if one coordinate increases, the other must decrease in order to keep the center of the coordinate system in the same location. These negative correlations (which unlike positive correlations that simply must always be less than unity) generally can not exceed specific negative values if the whole complete covariance matrix is to be positive definite.

2.2 Translation and Scale Estimation

We modified slightly the method used to estimate translations and scale of the SINEX files from individual analysis centers. As in the past, during variance rescaling and the combination solution we do not explicitly estimate translation and scale parameters. However, now when we compare each center individually to ITRF94 (during 1997 and now ITRF96) and to the combined solution, we explicitly estimate translations and scale parameters. The advantage of this approach is that generates more realistic standard deviations for the estimates of the translations and scale. The estimates of the center of mass position and the coordinates of the sites did not seem to be greatly effected by this change. The standard deviations of the translation and scale parameters were effected, and for most centers increased by generally at least a factor of three and became most consistent with the week-to-week scatter of the values. For some centers the standard deviations decreased when change was made.

At the end of 1997, we started using ITRF96 as the basic coordinate system in which our analysis is performed. We increased also from the 13-IGS core sites (which were reduced to less than 10 at the time of change) to 49-IGS reference sites defined in the ITRF96 coordinate system for variance rescaling and translation estimation. In our analyses presented here we used this new system to evaluate our 1997 combined SINEX files.

2.3 G-SINEX Residual file

Near the end of 1997, we introduced a new file in our submission that contains residuals by station for each of the seven IGS analysis centers. The files are named mitwwwwg.res where wwww is the GPS week number. For the coordinate components (north, east and up) of each site the root-mean-square (RMS) scatter of the residuals for each center to the combined solution coordinate estimate, the square root of c^2 per degree of freedom of these residuals, and the individual center residuals and standard deviations are given. At the bottom of the file the statistics for each center are given based on all the sites analyzed by the center.

3.0 Analysis of Combined Solutions

Our analysis of 1997 combined SINEX files examines the internal consistency of these combinations and their agreement with ITRF96. (At the time the combinations were made, the ITRF94 system was used). Figure 1 we show the RMS agreement between the 49 ITRF96 reference sites (list of sites given in weekly summary files) for each weekly combination in 1997 and the number of sites used in the realization. This RMS is computed from the combination of the north, east, and height differences after a translation, rotation, and scale are removed from the weekly combination. In computing the RMS, the height is down-weighted by a factor of 3, i.e., we construct a weight matrix with the heights given one-tenth the weight of the horizontal components. This weight matrix is used in the computing the RMS. In Figure 2, we show the values of the translations and scale factors estimated for each weekly G-SINEX file. As we have seen in the past, the Y- and Z-components of the translation appear to have significant annual signatures. The procedures used to determine the transformation between coordinate systems are discussed in *Dong et al.*. [1997].

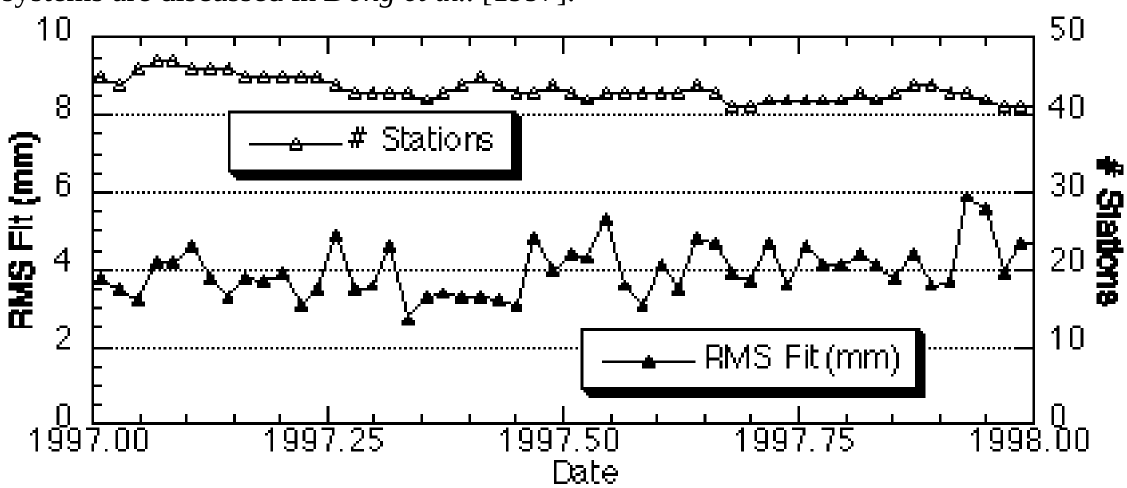

Figure 1: RMS fit of the weekly combinations to the (up to) 49 ITRF96 reference sites. The mean RMS fit is 4.0 mm with a median of 43 stations form the reference site list used.

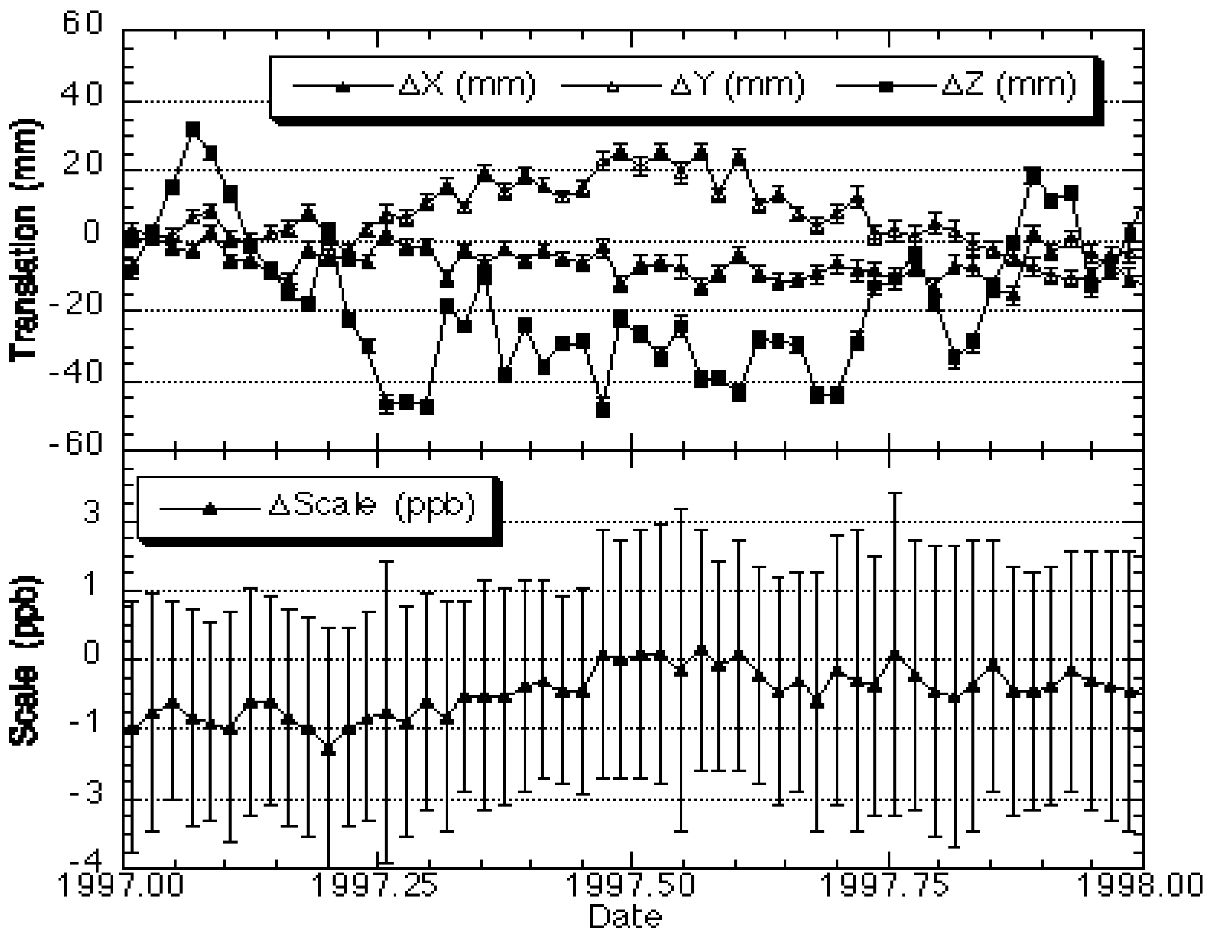

Figure 2: Estimated translation and scale factors to bring the weekly G-SINEX files into alignment with the ITRF96 reference sites. The error bars on the scale are inflated due to our down weighting the heights in the coordinate system realization.

In Figure 3, we show the histograms for the repeatabilities of the sites in the G- and P-combinations. Although the RMS scatters are small, they are typically three-times larger than the standard deviations of the estimates. The time series of the position estimates also show systematic variations as previously reported.

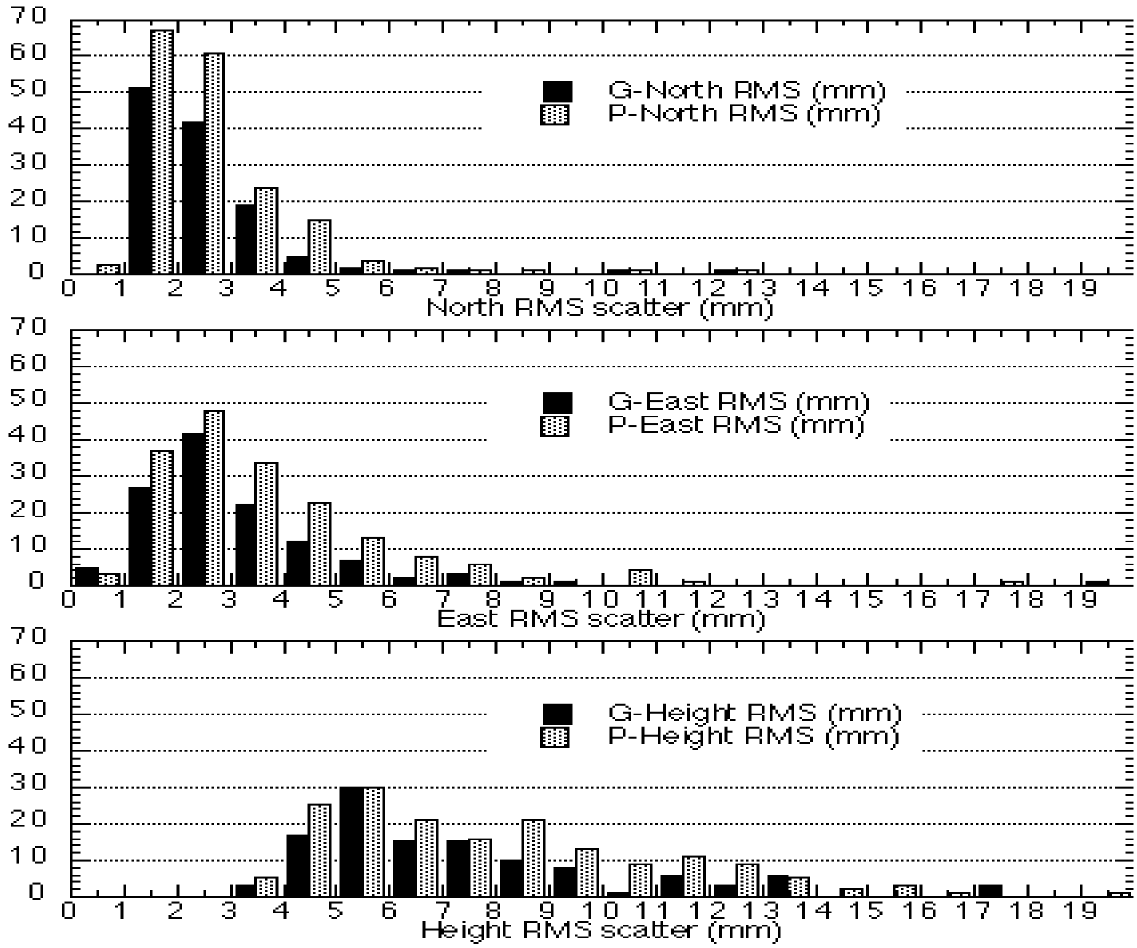

Figure 3: Histogram of the repeatabilities from the G- and P-SINEX combinations. For the height, six and eight sites are of the range for the G- and P-SINEX files. The median values are 2.0, 2.6, and 6.7 for the north, east and height in the G-SINEX combinations and 2.2, 3.0, and 7.6 mm in the P-SINEX combinations. The scatters are typically 3-times larger than the standard deviations for indicate.

4 References

Dong D., T. A. Herring, and R. W. King, Estimating Regional Deformation from a Combination of Space and Terrestrial Geodetic Data, *J. Geodesy*, *72*, 200–214, 1997

Herring, T. A., MIT Global Network Associate Analysis Center Report, *International GPS Service for Geodynamics (IGS) 1995 Annual Report*, pp. 203-207, 1996.

Herring, T. A., MIT T2 Associate Analysis Center, *International GPS Service for Geodynamics (IGS) 1996 Annual Report*, pp. 255-267, 1997.

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GNAAC Coordinate Comparisons at JPL for GPS Weeks 813-964

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Global Network Associate Analysis Center (GNAAC) activities began at JPL starting with GPS week 813. Constraint removal was implemented on week 821 and a fully rigorous combination was computed starting with week 837. Sinex 1.0 format was implemented on week 890. A total of 152 weekly comparison reports have been produced to date.

Many improvements are either completed or in progress. Standard antenna heights are now provided by the IGS central bureau and incorporated into the weekly coordinate solutions. Each center will implement a weak or minimal constraint method for all products. Daily eop estimates and their full covariance information will be included with the coordinate solutions each week. These changes were implemented at JPL starting with GPS week 964. All parameters including orbits, clocks, tropospheres, coordinates, and eop are estimated daily with weak constraints of no more than 10 m on any coordinate. Orbits, coordinates, and eop are rotated into alignment with ITRF96. The geocenter and scale are left at their estimated values.

Solutions submitted from COD, EMR, ESA, GFZ, JPL, NGS, and SIO are obtained from the CDDIS each week. If necessary, a-priori constraints are removed to the level of about 10 m. Each pair of solutions is compared after application of internal constraints by estimating a 7-parameter Helmert transformation to minimize the least-squares coordinate residuals. All common sites are used. The errors from each solution are scaled to make CHI^2/DOF roughly equal to one for all pairs and four sigma outliers are removed. The transformation parameters for each pair are given in the report along with the WRMS of residuals.

A free-network combination of solutions from all centers is also computed. Each solution is scaled and edited according to the results of pair-wise comparisons. Then all free-network solutions are rigorously combined using their full covariance matrices. The free-network combination is submitted to the CDDIS along with the summary report. Sites common to all solutions are used to compare each solution with the combination. The comparison is carried out by application of internal constraints and estimation of a 7-parameter Helmert transformation. The WRMS residuals are tabulated in the report.

Results for weeks 837-964 are summarized in Tables 1 and 2. Table 1 indicates the mean WRMS for weekly comparisons of each center with the combination rounded to the nearest mm. The full strength of all common sites is used for the pairwise comparisons and the transformation parameters are well determined for each pair. The mean geocenter and scale offsets are given for each center relative to JPL in Table 2.

Table 1. Mean WRMS for GPS weeks 837-964.

Center	North mm	East mm	Vertical mm
COD	2	3	8
EMR	5	9	12
ESA	4	7	23
GFZ	3	7	11
JPL	2	2	7
NGS	11	15	14
SIO	3	4	8

Table 2. Mean geocenter and scale offsets with respect to JPL for GPS weeks 837-964.

Center	TX cm	TY cm	TZ cm	Scale ppb
COD	0.8	-0.3	0.3	0.5
EMR	0.4	-11.5	7.9	0.0
ESA	0.3	1.7	2.7	1.8
GFZ	-0.4	-6.0	2.4	0.3
NGS	0.4	-19.2	9.4	-1.7
SIO	-0.1	-0.2	6.4	-0.4

Mean geocenter offsets range from the mm level to more than 10 cm. Mean scale differences are less than 1 part per billion for all but two centers. Overall, weekly comparisons show agreement in horizontal coordinates at the mm level, agreement in vertical coordinates at the 1 cm level, agreement of geocenter estimates at the 1-10 cm level, and agreement of scale estimates at the level of a few parts per billion.

This work was performed at the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration.