ILRS Combination Centers activities

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ILRS Pos+EOP Pilot Project

In the mid of 2003, the ILRS Analysis Working Group promoted a Pilot Project on the combination of analysis products, the "Pos+EOP" Pilot Project, to set up an operational service able to provide each week, from the individual contributing SLR solutions, based on the observation to Lageos 1-2 and Etalon 1-2, an official ILRS set of:

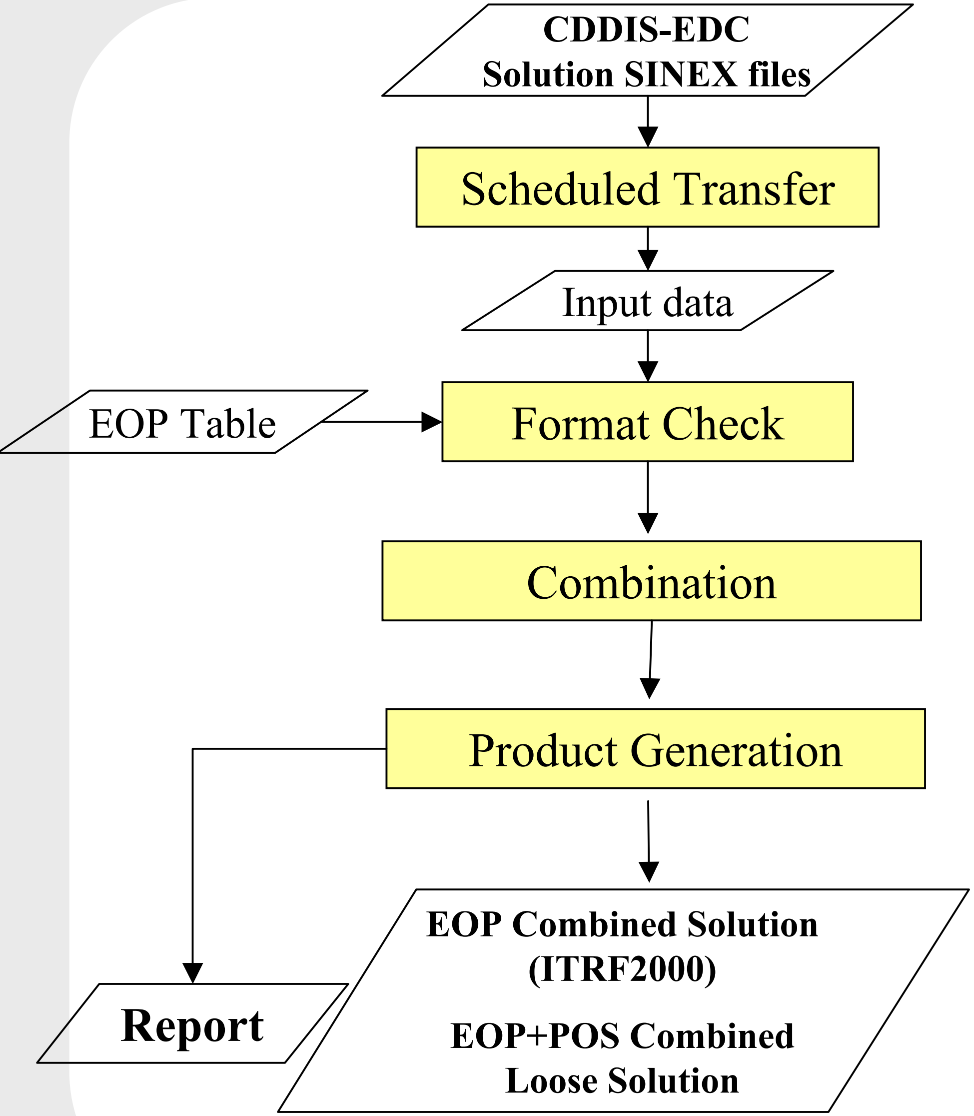
1. weekly 'loose' coordinates of the worldwide SLR tracking network

2. daily EOPs (xpole, ypole, LOD), ITRF2000-framed for IERS Bulletin B

In june 2004, **ASI-CGS** was selected (ILRS AWG Meeting, San Fernando) as the **official ILRS Combination Center** in charge of providing the primary weekly solution (**DGFI acts as back-up**) for the next two years.

The **ASI-CGS** solutions are labeled as **"ILRSA"** and the **DGFI** ones as **"ILRSB"**.

ILRS-A Procedure overview



1) Reads sequentially the SINEX solution files and verify data integrity.

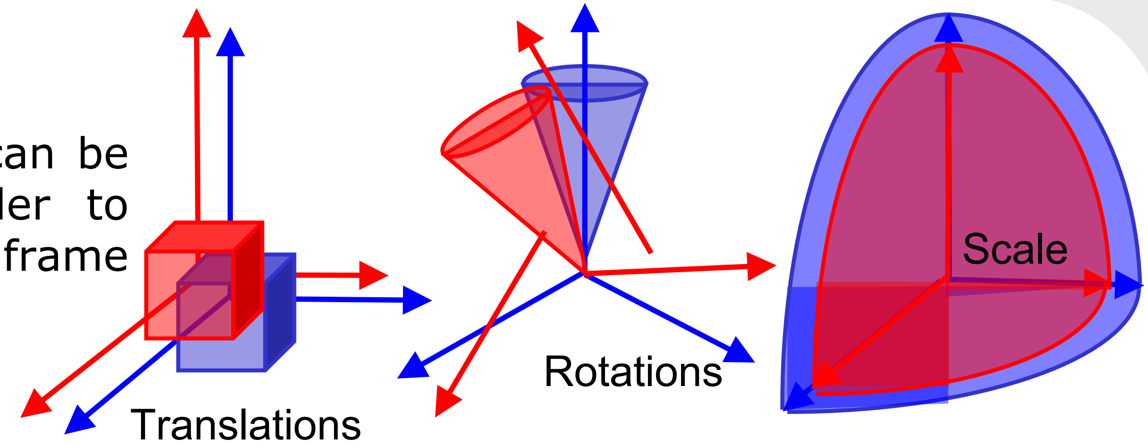
2) Combination of the loose solutions:
   - Scale factor computation
   - Solve normal equations

3) Construction of the combined products and issue of the quick look report:
   - ITRF2000 frame transformation & delivery
   - Quick look Report
   - Archiving

Combination equations

The solution covariance matrix can be <u>loosened</u> (if necessary) in order to artificially enlarge the reference frame uncertainties.

$$\mathbf{C}' = \mathbf{C} + \mathbf{A}\mathbf{L}\mathbf{A}^{\mathrm{T}}$$



where:

- $\mathbf{C}'$ is the 'loosened' covariance matrix
- $\mathbf{C}$ is the solution covariance matrix
- $\mathbf{A}$ is the design matrix as defined above
- $\mathbf{L}$ is a diagonal matrix defining the degree of looseness

Under this conditions the reference frame biases are no more estimable and the Helmert transformation parameters could be treated stochastically. The design equations are simple identities between couples of solutions.

Site Coordinates
Site Velocities
E.O.P.
E.O.P. Rates

$$\begin{pmatrix} \mathbf{X}_1(t_1) \\ \dot{\mathbf{X}}_1 \\ \mathbf{Y}_1(t_{1j}) \\ \dot{\mathbf{Y}}_1(t_{1j}) \end{pmatrix} = \mathbf{P}\begin{pmatrix} \mathbf{X}_0(t_0) \\ \dot{\mathbf{X}}_0 \\ \mathbf{Y}_0(t_{0j}) \\ \dot{\mathbf{Y}}_0(t_{0j}) \end{pmatrix} = \begin{pmatrix} \mathbf{I} & (t_1 - t_0)\mathbf{I} & 0 & 0 \\ 0 & \mathbf{I} & 0 & 0 \\ 0 & 0 & \mathbf{I} & (t_{1j} - t_{0j})\mathbf{I} \\ 0 & 0 & 0 & \mathbf{I} \end{pmatrix}\begin{pmatrix} \mathbf{X}_0(t_0) \\ \dot{\mathbf{X}}_0 \\ \mathbf{Y}_0(t_{0j}) \\ \dot{\mathbf{Y}}_0(t_{0j}) \end{pmatrix}$$

Scale factor estimation

The solution **scale factor** f_i is such that the **variance factor** of the combination is close to unity and that each solution contribution is equally balanced. The first guess for the combination is obtained with $f_i = 1$ for each solution:

Condition 1:

$$\chi^2 = R_1^T C_1^{-1} R_1 + \cdots + R_i^T C_i^{-1} R_i = 1$$

Condition 2:

$$R_1^T \left(f_1 C_1 \right)^{-1} R_1 = \cdots = R_i^T \left(f_i C_i \right)^{-1} R_i$$

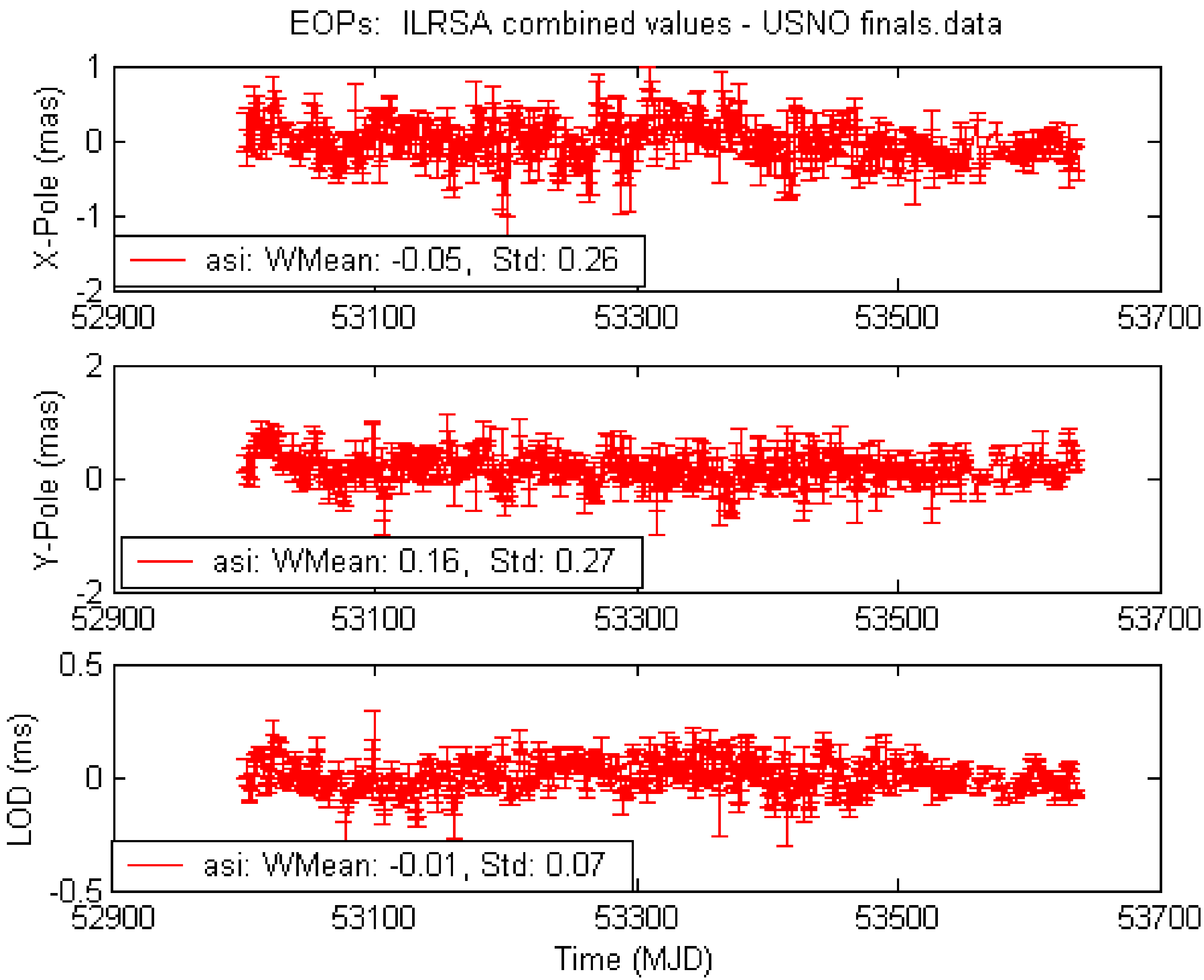
$$\Rightarrow \quad f_i = \frac{N}{DoF} R_i^T \left(C_i \right)^{-1} R_i$$

Where R_i and C_i are respectively the solution residuals and covariance matrix, N the number of contributing solutions, and DoF the solution degrees of freedom.

Example of estimated variance-covariance scale factor

Solution week	ASI-	DGFI	GFZ-	NERC	JCET
031008	7	15	11	32	-
031015	12	25	10	29	-
031022	11	30	10	39	-
031029	25	-	6	-	-
...					
040310	5	5	6	4	2
040317	4	6	2	2	5
040324	4	8	5	5	3
040331	6	4	4	2	3

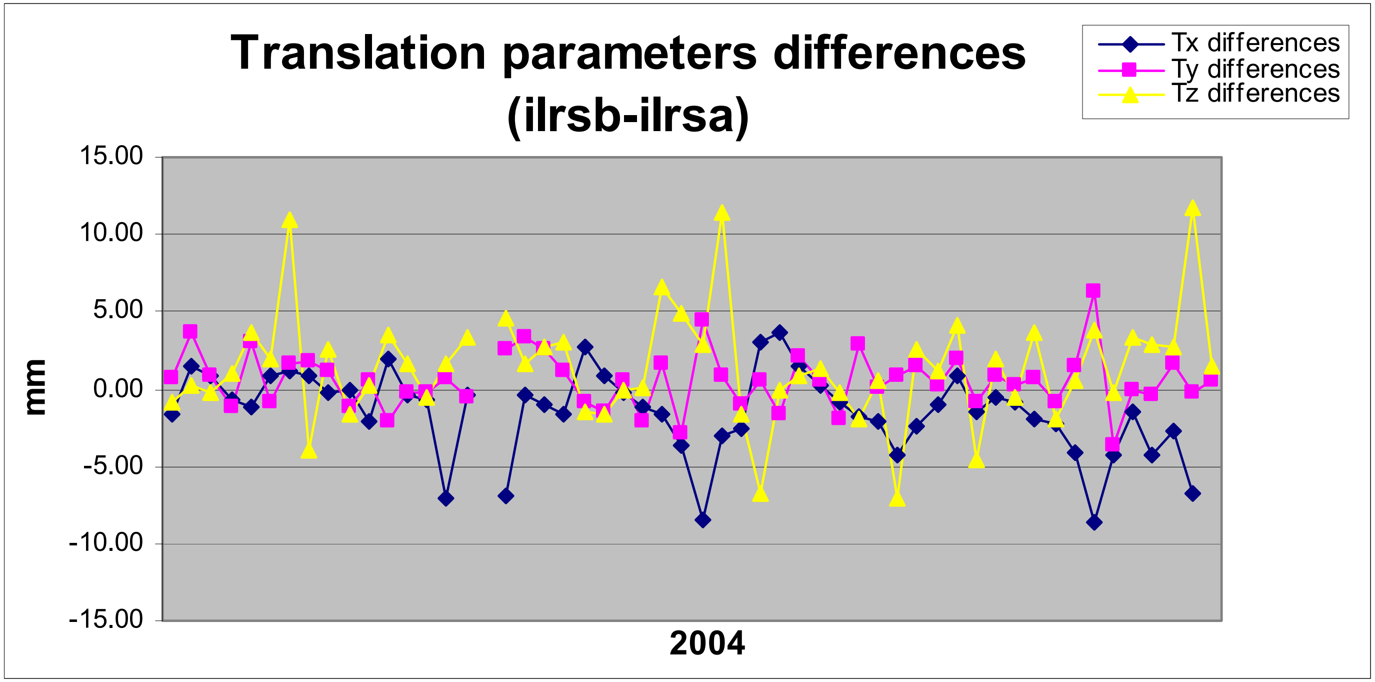
ILRSA EOPs for IERS B Bulletin



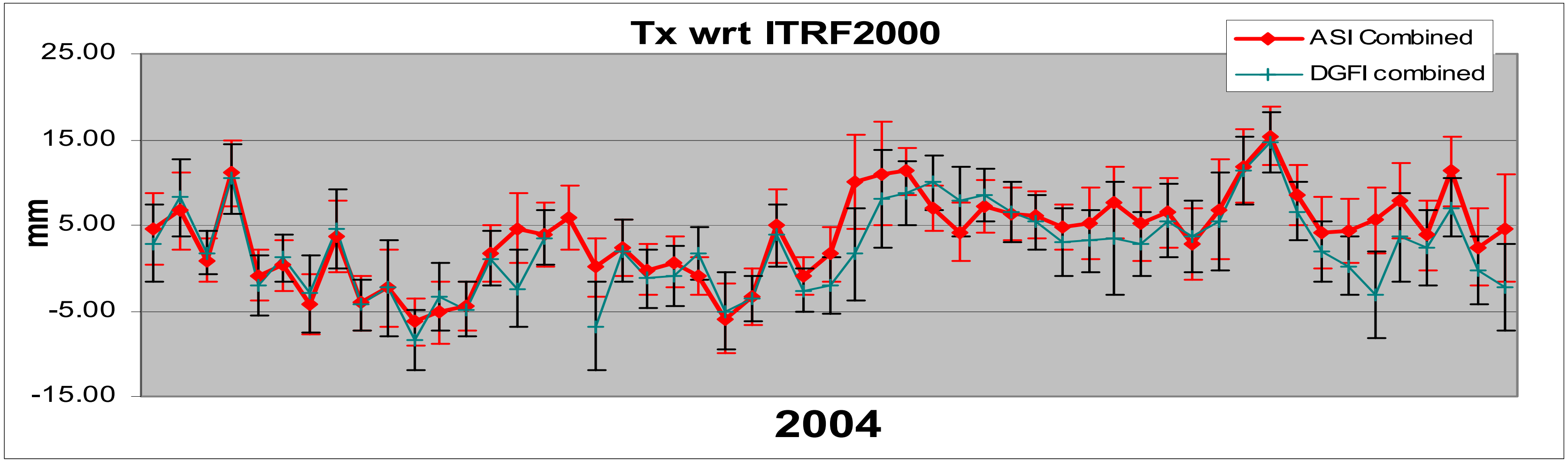
ILRSA & ILRSB

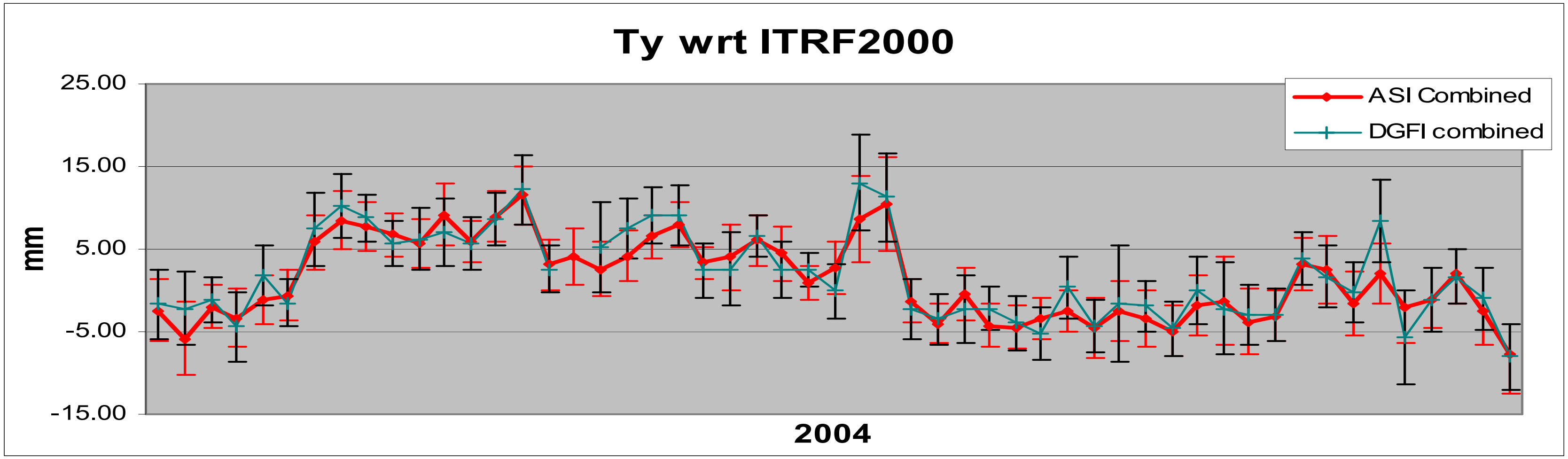
A quick (2004) comparison in terms of Translation parameters wrt ITRF2000 has been performed on the two ILRS solution time series; the comparison is homogeneous: the same SW procedure has been used to evaluate those parameters.

Mean differences (ILRSB-ILRSA): Tx, -1.5 mm; Ty, 0.5 mm; Tz, 1.5 mm

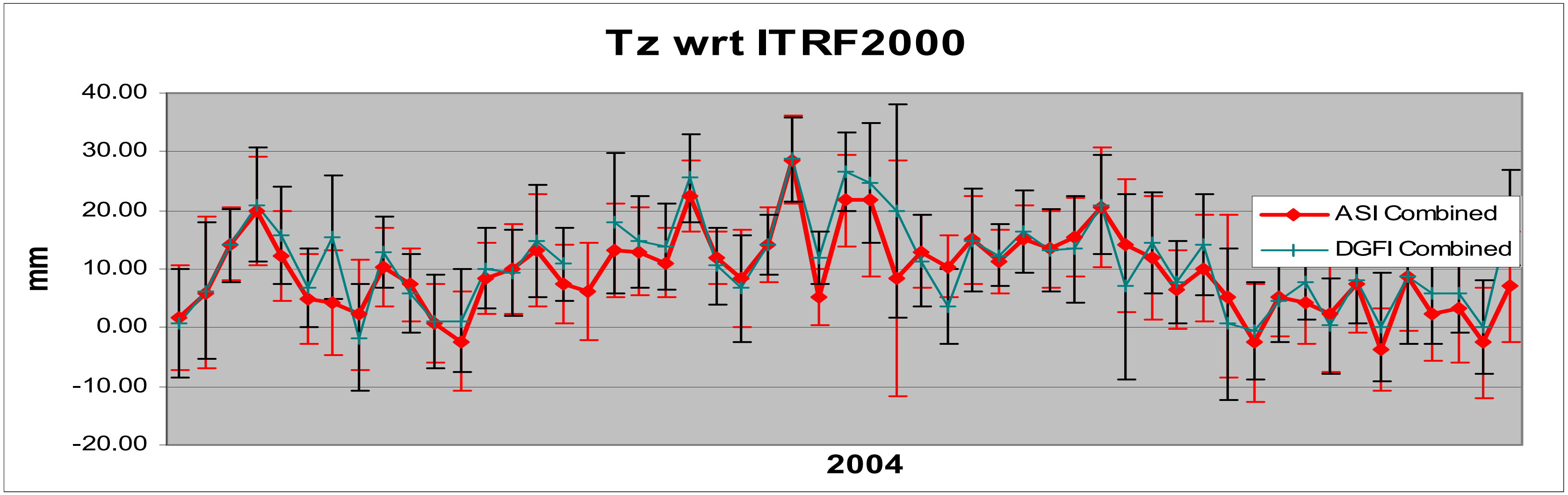


ILRSA & ILRSB


Tx wrt ITRF2000
25.00
15.00
5.00
-5.00
-15.00
mm
2004
ASI Combined
DGFI combined


Ty wrt ITRF2000
25.00
15.00
5.00
-5.00
-15.00
mm
2004
ASI Combined
DGFI combined

ILRSA & ILRSB



Tz wrt ITRF2000
40.00
30.00
20.00
10.00
0.00
-10.00
-20.00
mm
2004
ASI Combined
DGFI Combined

ILRS activities for the new ITRF: 'backward' solutions

The combination procedures used and refined during the "ILRS Pos+EOP Pilot Project" by **ASI-CGS** and **DGFI** have been applied to the **1993-2003** set of individual contributing SLR weekly solutions, to generate **ILRS official contribution to the next ITRF**.

The available **SLR individual solutions** for the period are:

- **asi**.pos+eop.yymmdd.v#.snx
- **dgfi**.pos+eop.yymmdd.v#.snx
- **geos**.pos+eop.yymmdd.v#.snx
- **gfz**.pos+eop.yymmdd.v#.snx
- **jcet**.pos+eop.yymmdd.v#.snx
- **nsgf**.pos+eop.yymmdd.v#.snx

Several versions may exist for each weekly solution from ACs: it takes into account decisions by ILRS AWG.

The latest available **SLR combined solutions** for the period are:

- **ilrsa**.pos+eop.yymmdd.v3.snx
- **ilrsb**.pos+eop.yymmdd.v3.snx

ILRSA "V3"

The **ILRSA v3** combined solution (1993-2005) is based on the weekly solutions as submitted by **asi, dgfi, gfz, jcet** and **nsgf**, i.e. the ones officially **'benchmarked'** by ILRS at the end of june '05.

The ILRSA v3 solution is a refinement of previous solutions, taking into account suggestions and ideas from the last ILRS AWG meeting, both from SLR analysts and from IERS members.

In ILRSA v3 solution, **rigorous editing** has been introduced: **any estimated parameter in the incoming solutions being not site coordinates nor EOP** (e.g. range bias, ...) has been rigorously **pre-eliminated** (cfr *"Combination of solutions for geodetic and geodynamic applications of the Global Positioning System*", E. Brockmann, PhD thesis, AIUB).

The same technique has been used to eliminate **outliers** (core sites/eop **5**σ far from the reference values and/or from the combined ones); 'bad' parameters were really very few, anyway.

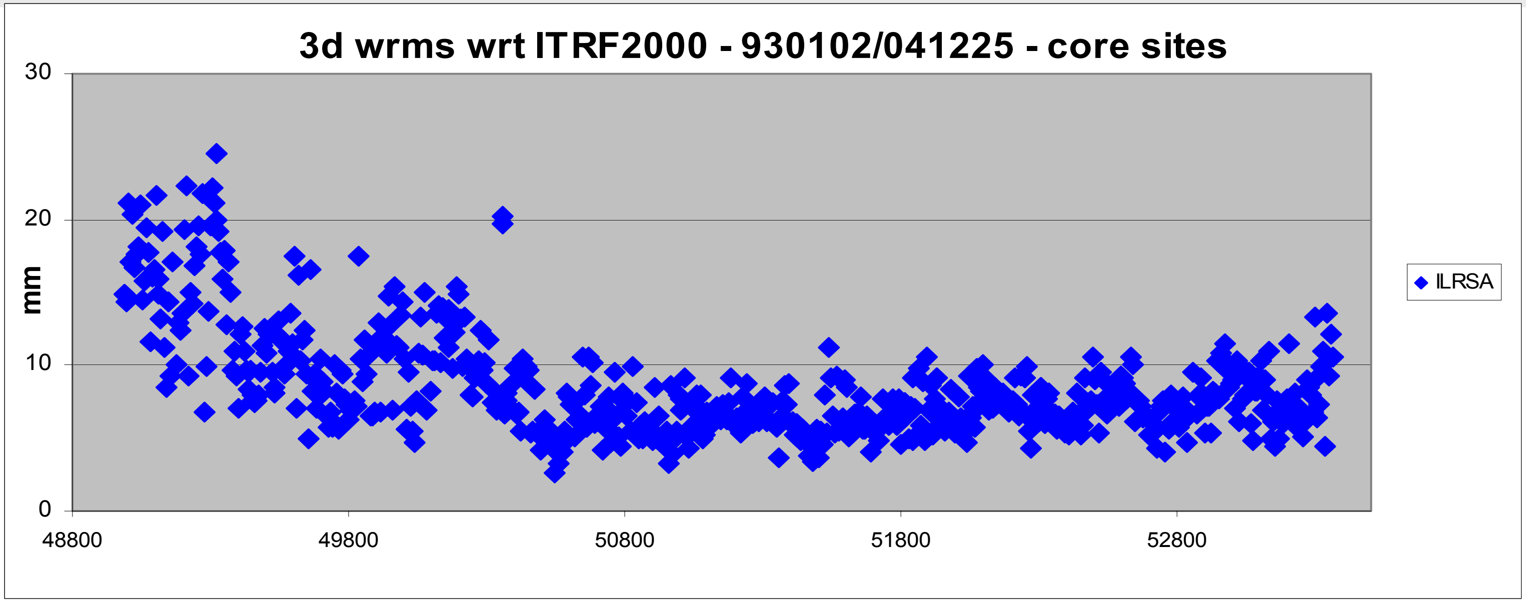
ILRSA "V3"

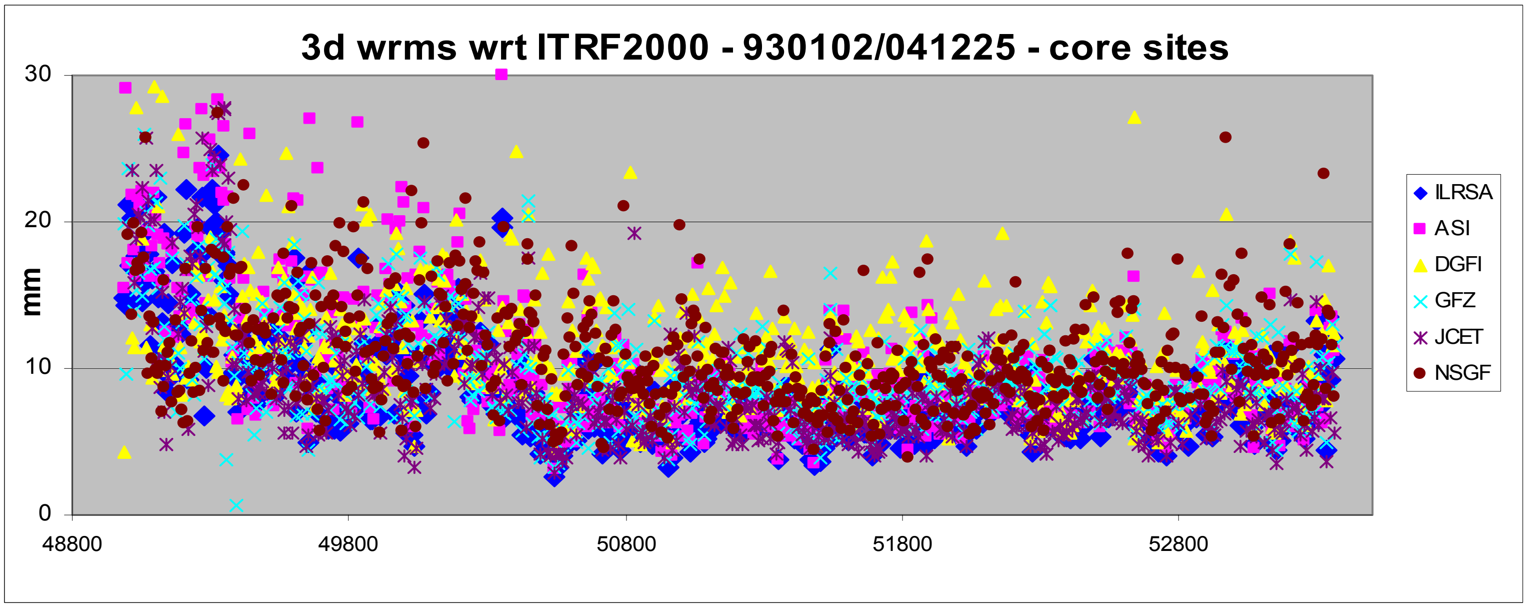
ILRSA v3 combined solution includes, as available at 15/06/05 the following solutions for the period 1993-2004 :

- **asi**.pos+eop.yymmdd.v2.snx, asi.pos+eop.yymmdd.v3.snx (9301-9504, 9705-9811), operational series for 2004
- **dgfi**.pos+eop.yymmdd.v3.snx (9301-0312), operational series for 2004
- **gfz**.pos+eop.yymmdd.v2.snx
- **jcet**.pos+eop.yymmdd .v2.snx
- **nsgf**.pos+eop.yymmdd.v1.snx

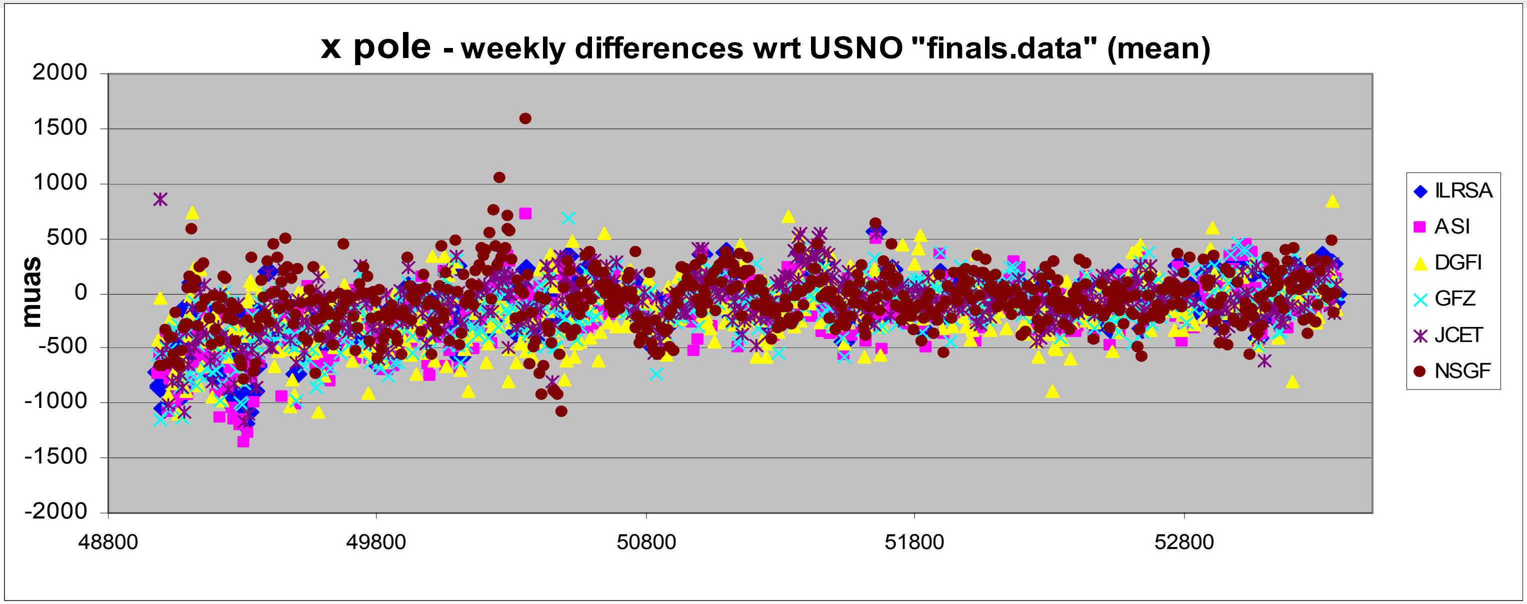
ILRSA "V3" overall checks

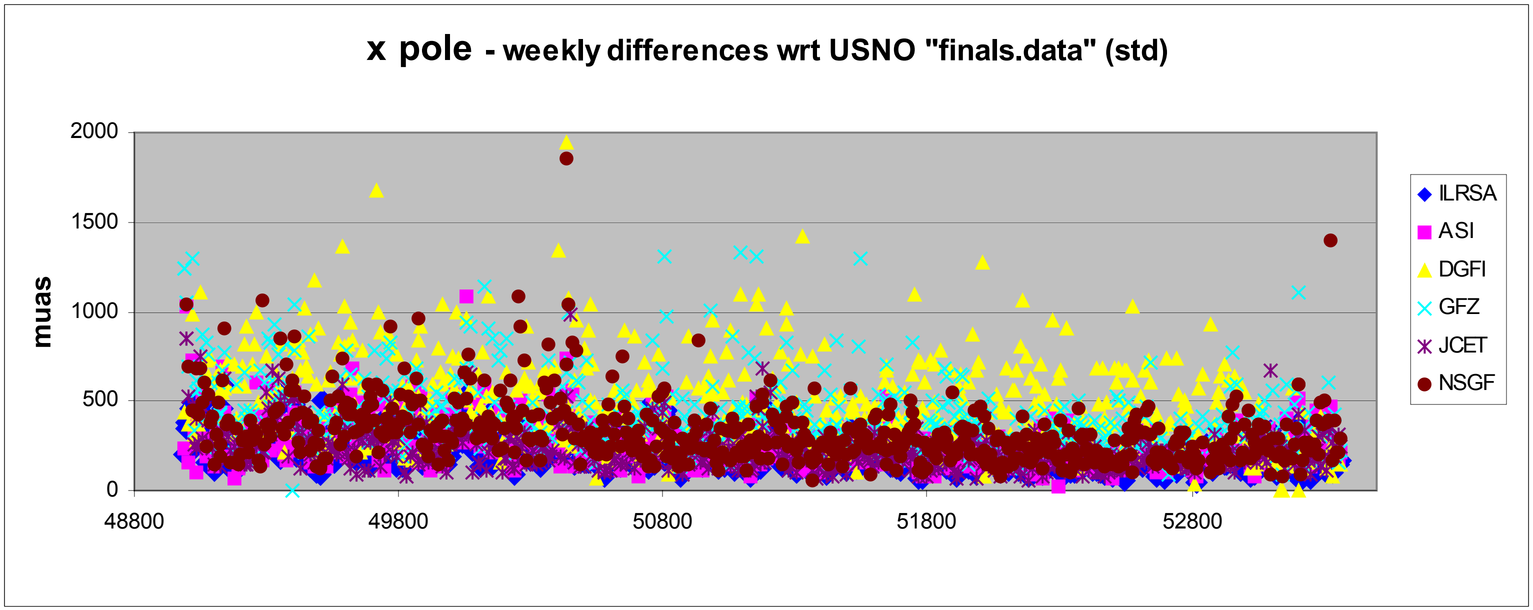
ITRF2000



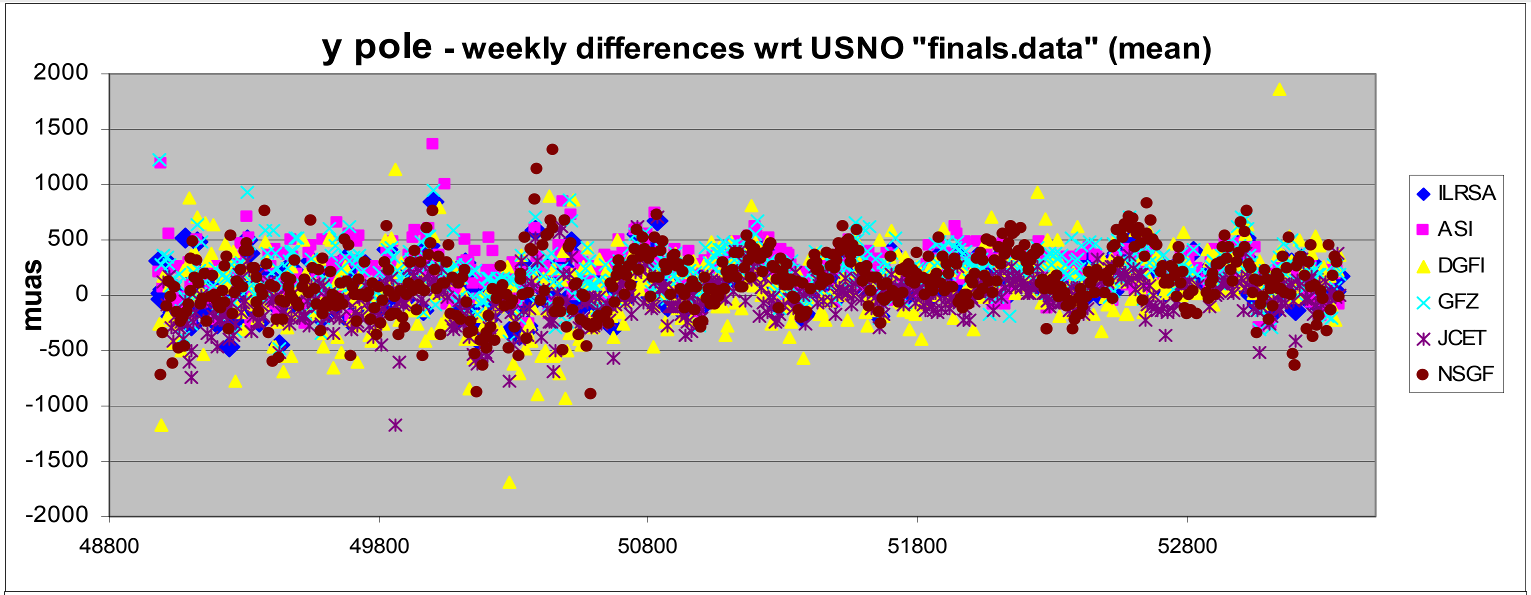


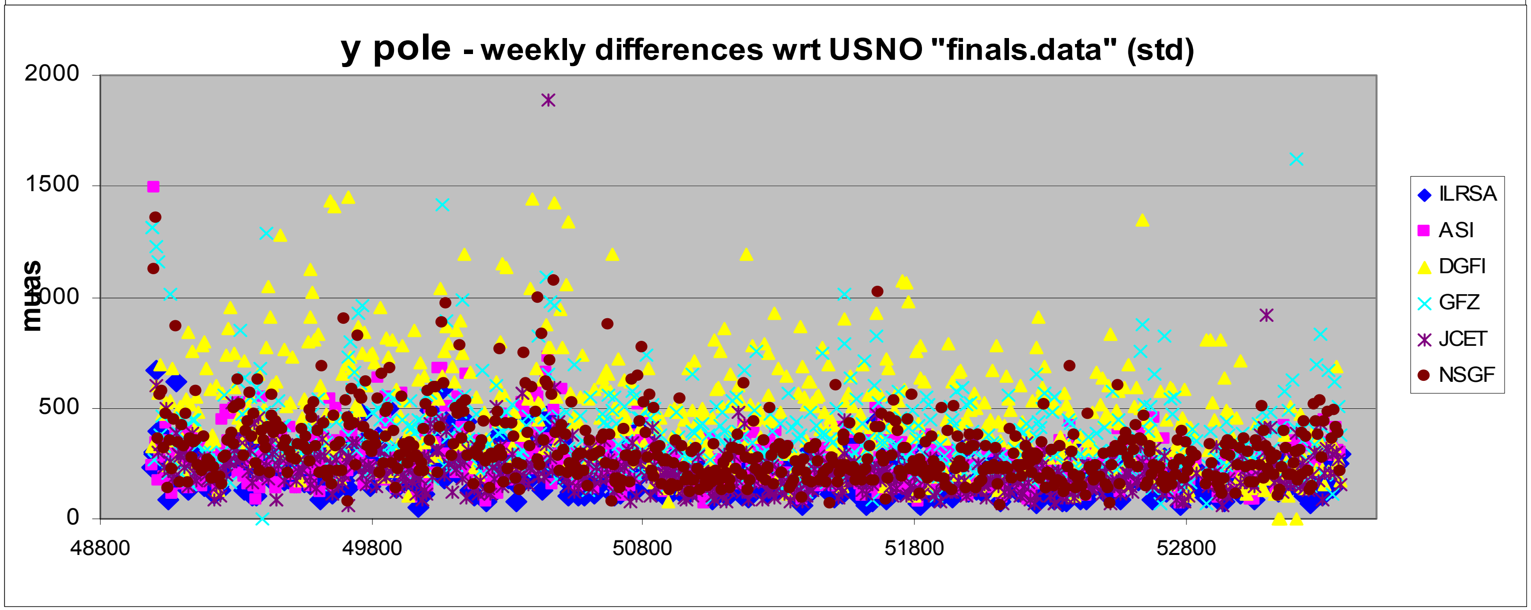
ILRSA "V3" overall checks



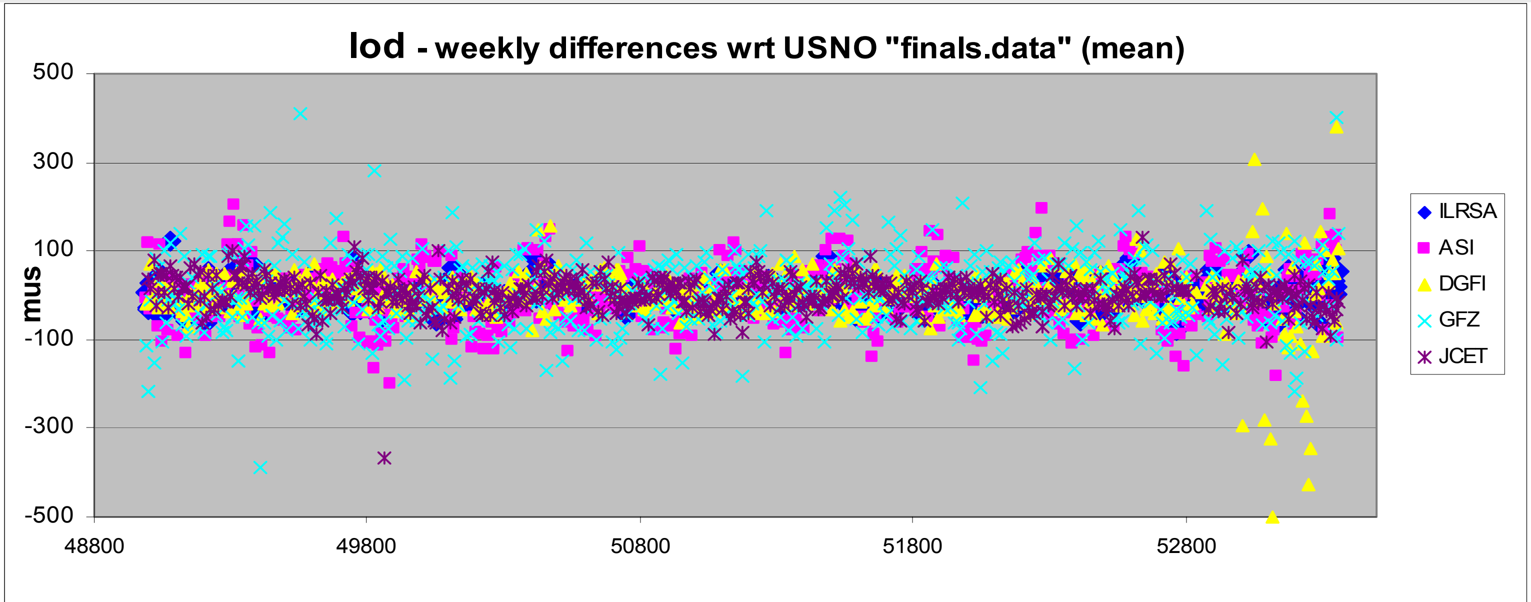


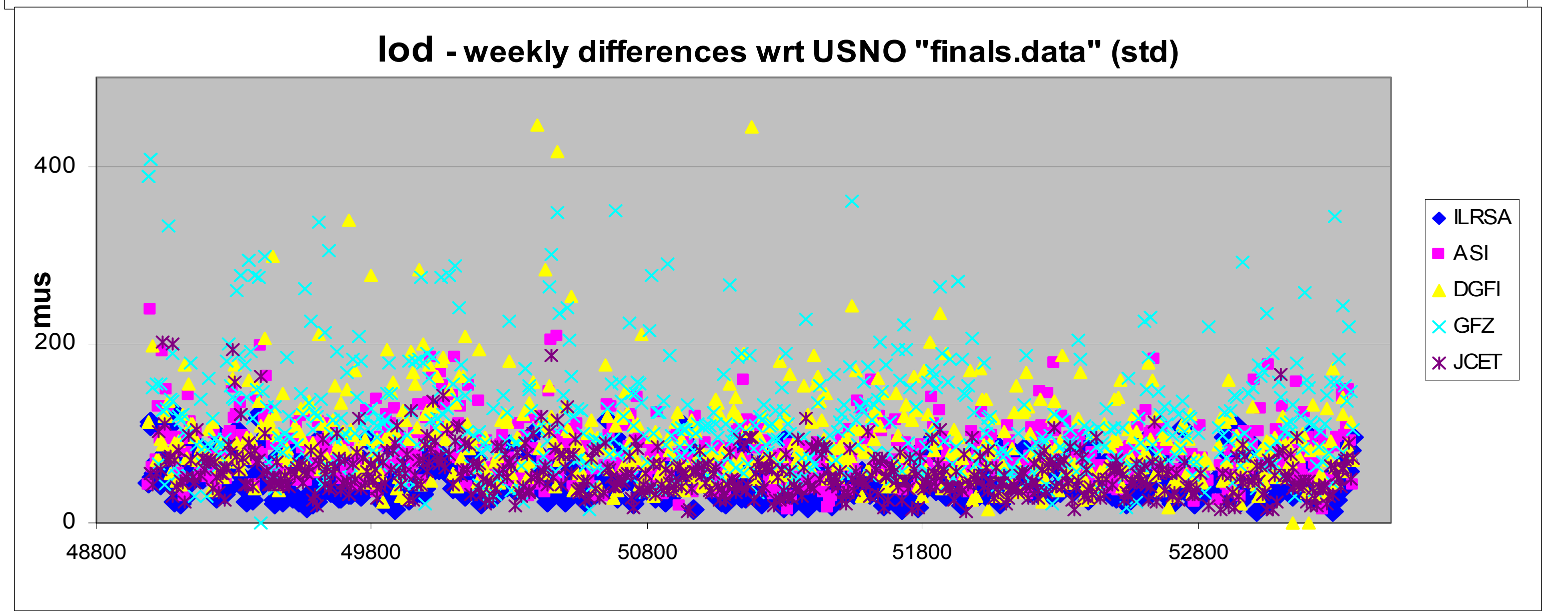
ILRSA "V3" overall checks



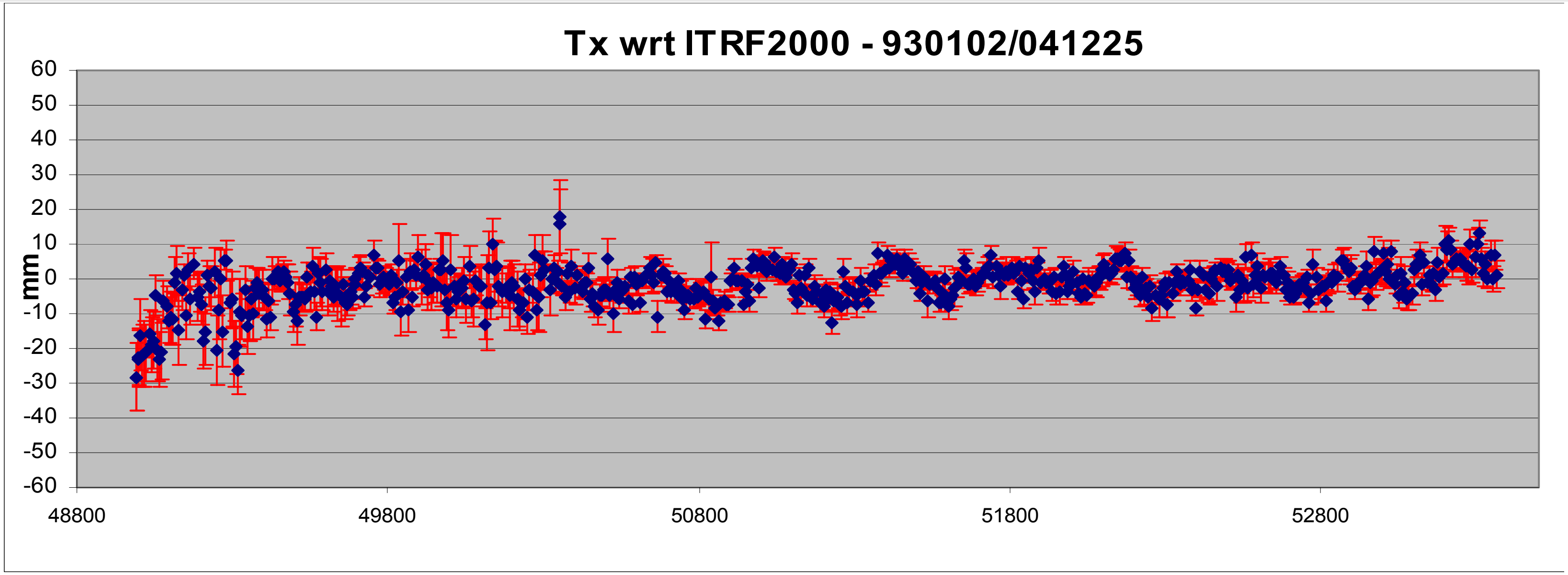


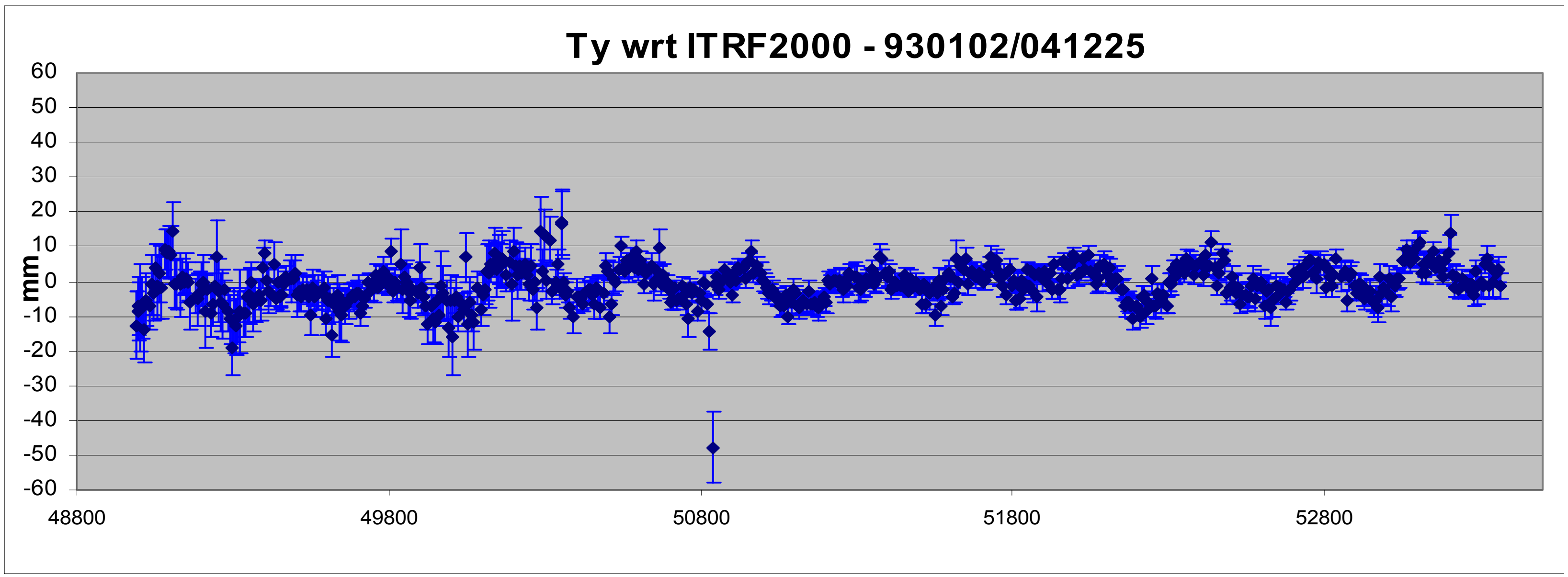
ILRSA "V3" overall checks



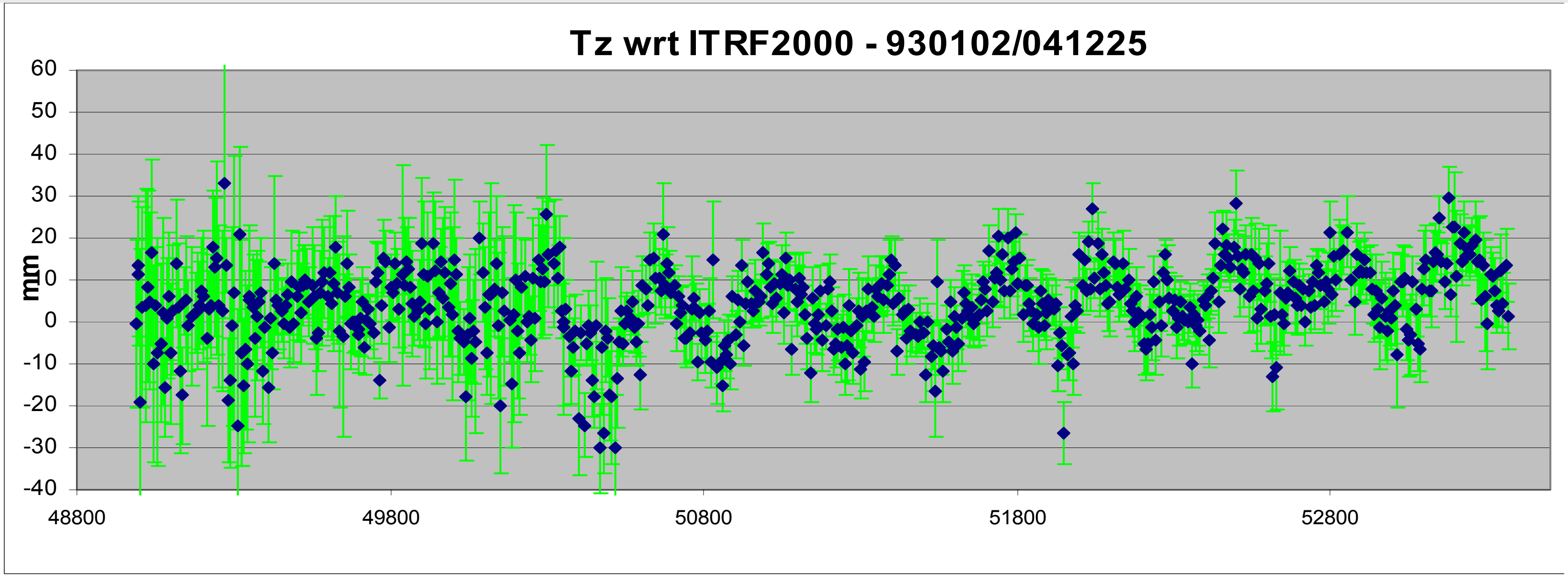


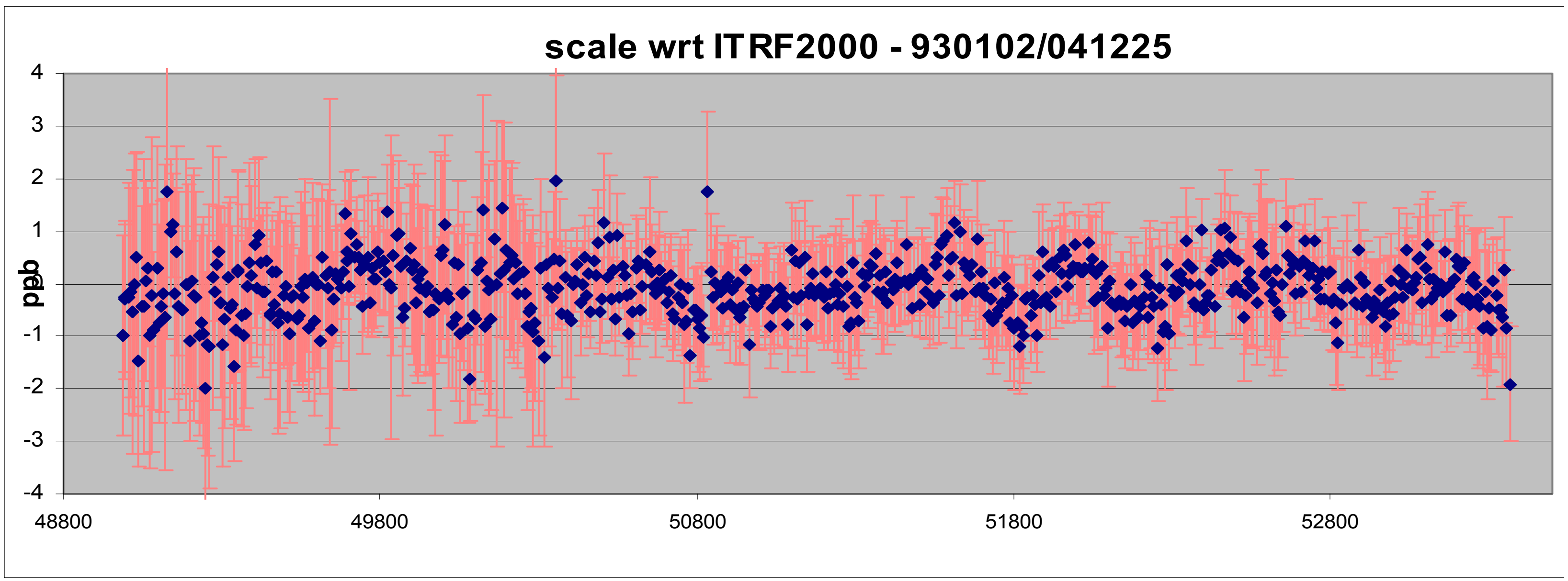
ILRSA "V3" overall checks



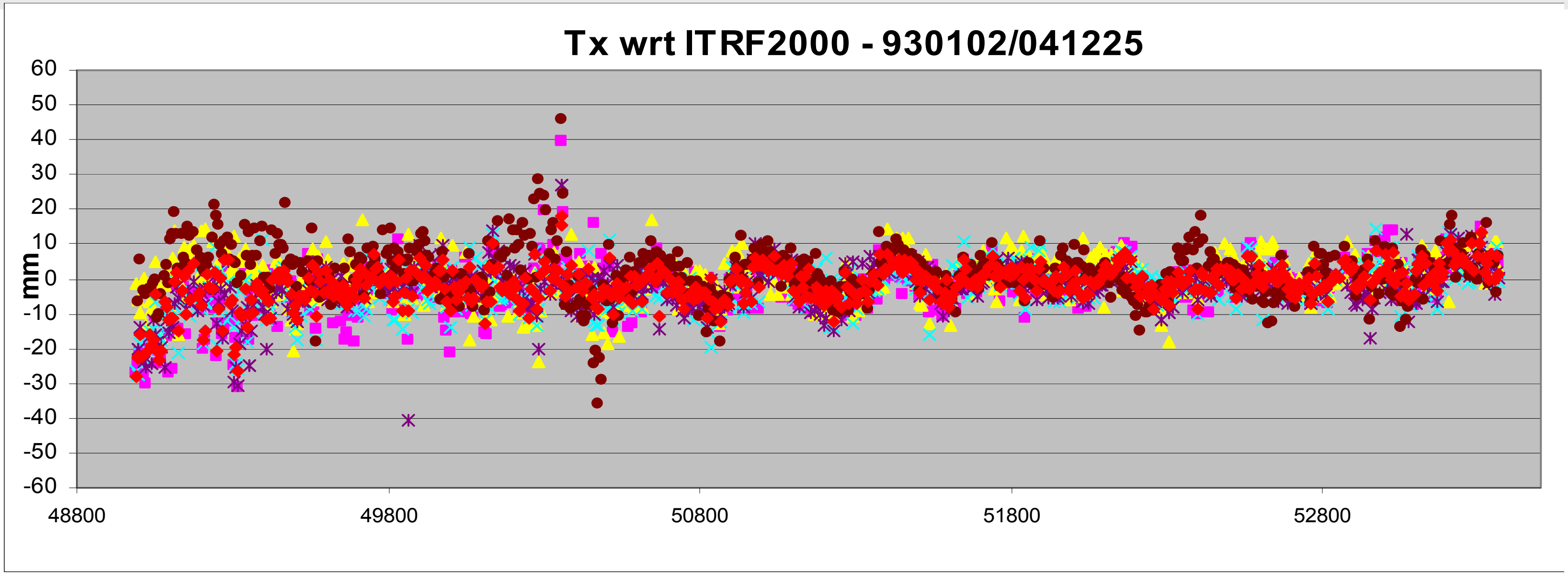


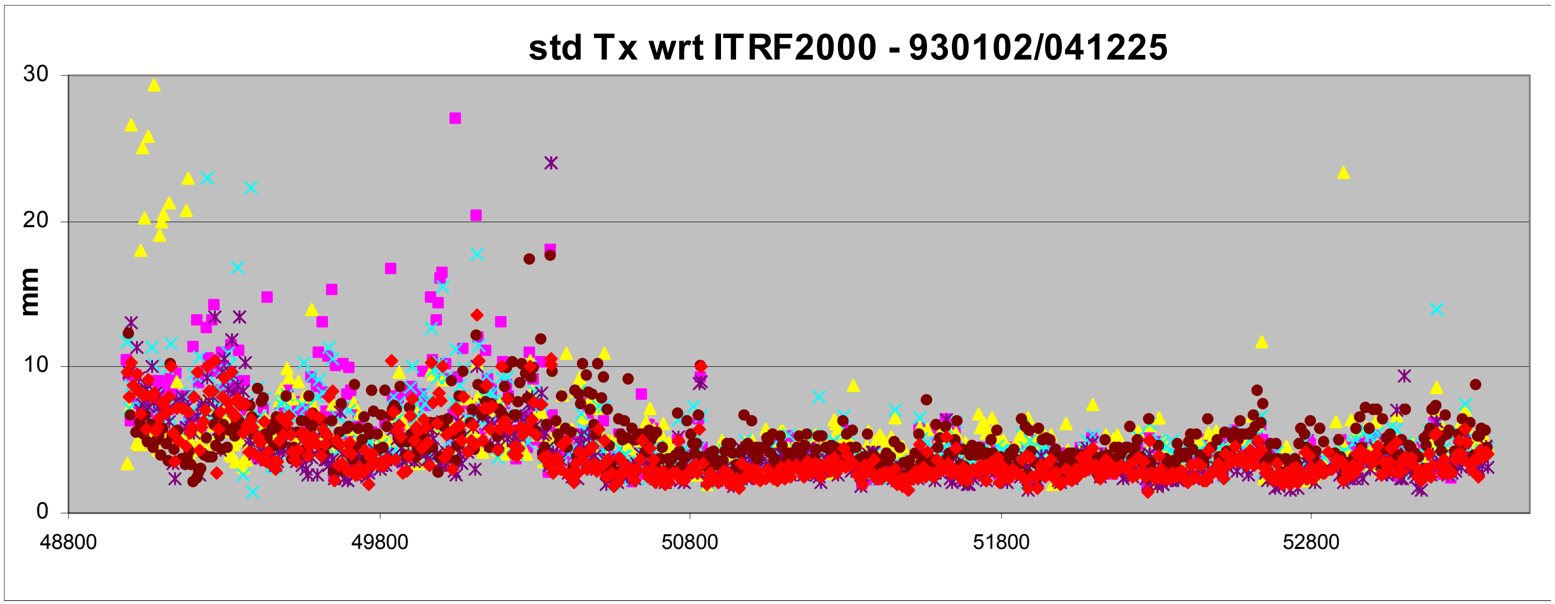
ILRSA "V3" overall checks



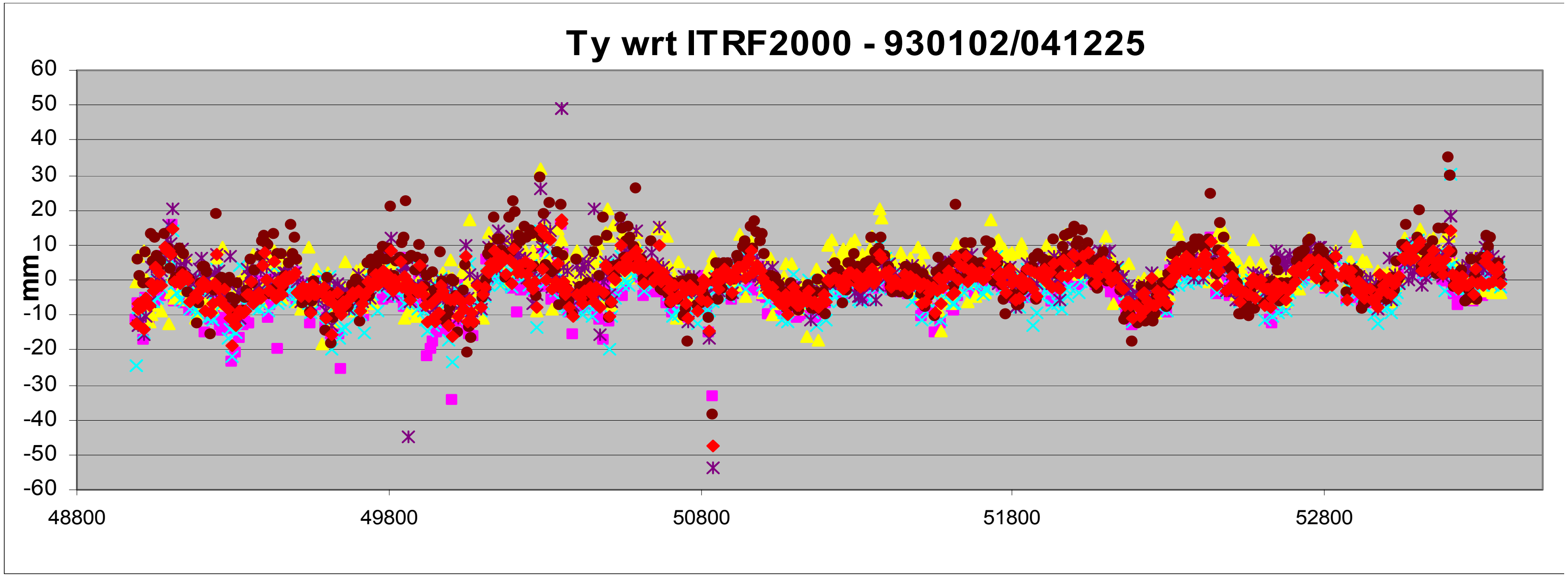


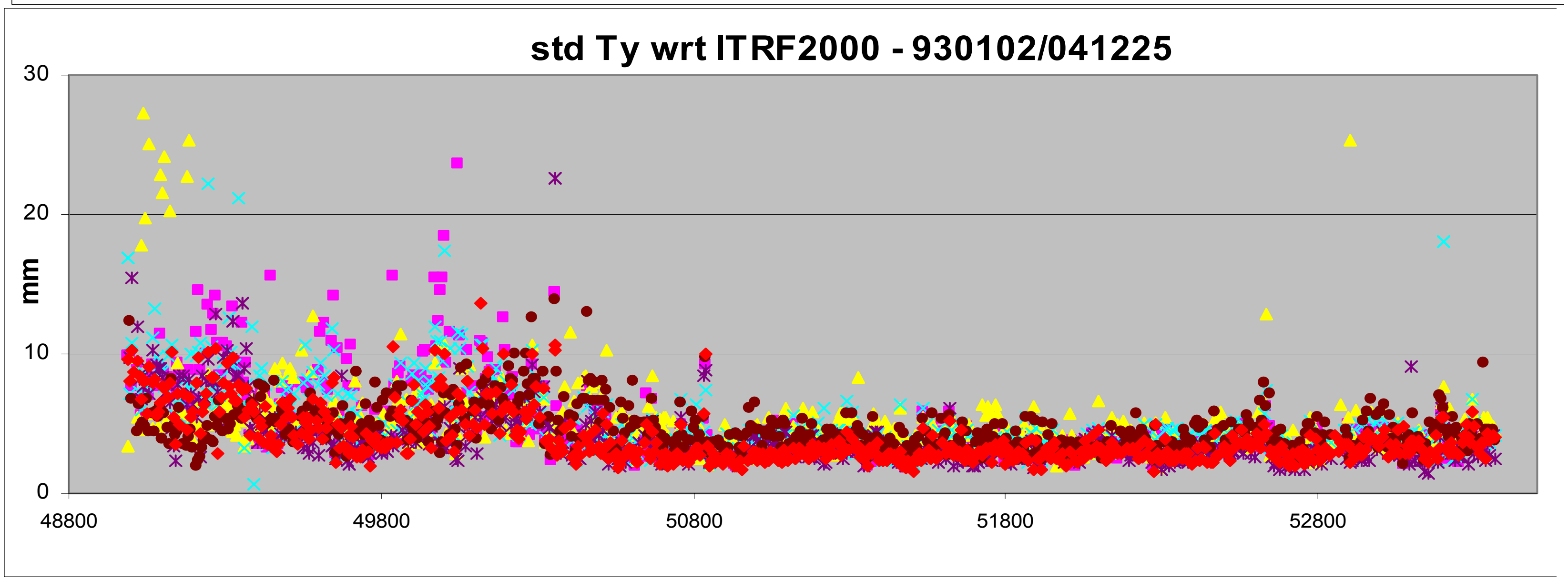
ILRSA "V3" overall checks



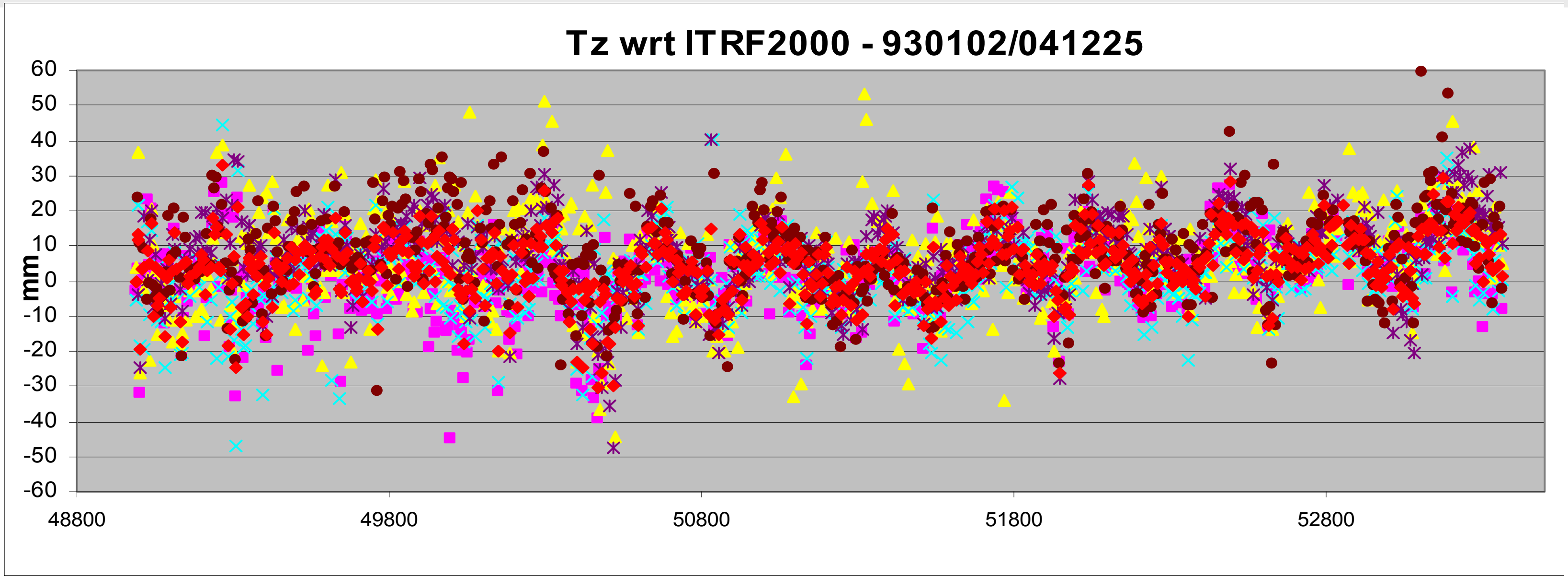


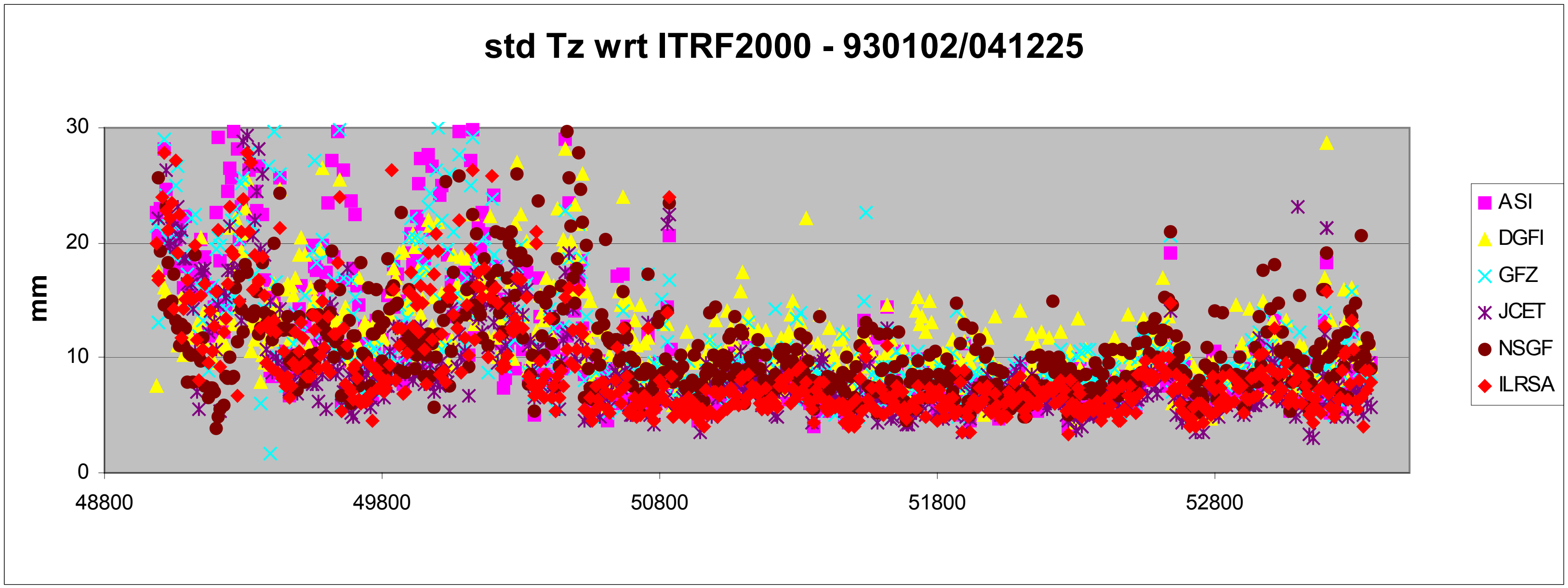
ILRSA "V3" overall checks





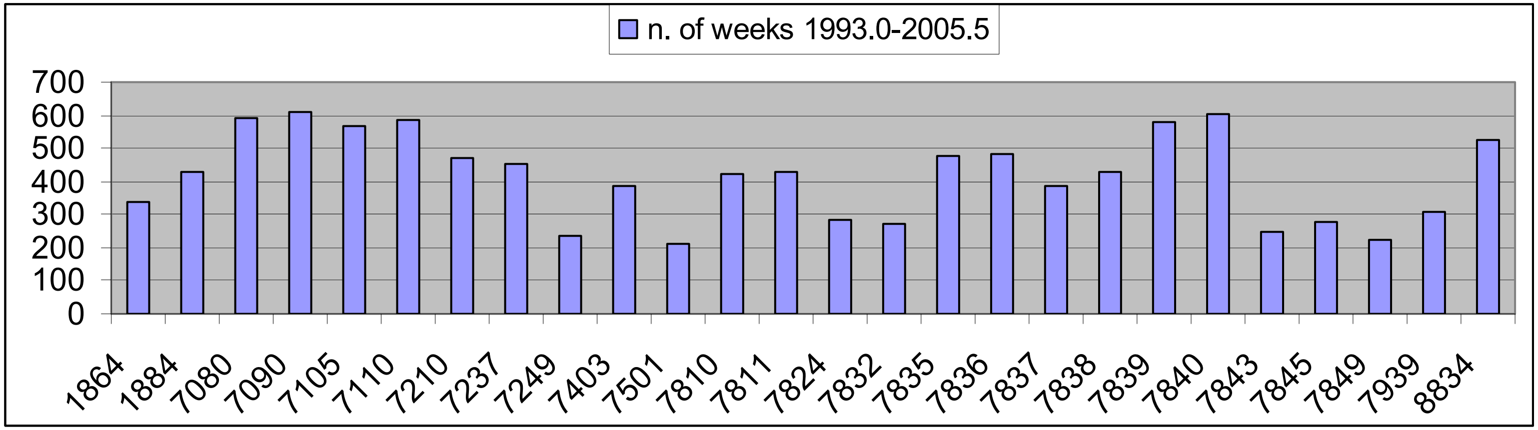
ILRSA “V3” overall checks





SLR stations

Long data history stations

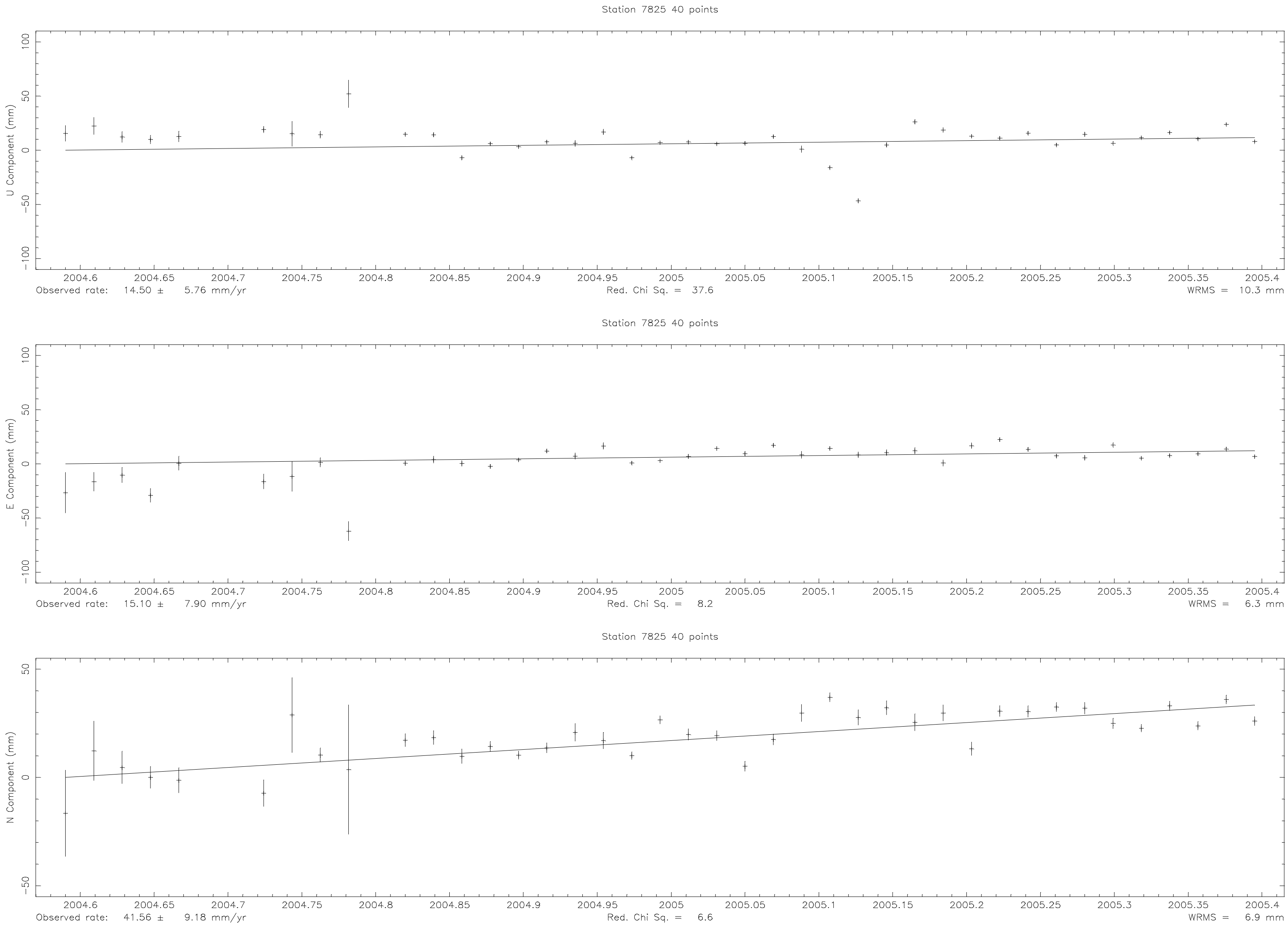


The plot above shows the stations with **more than 200 weekly position determinations in the period 1993.0 – 2005.5**.

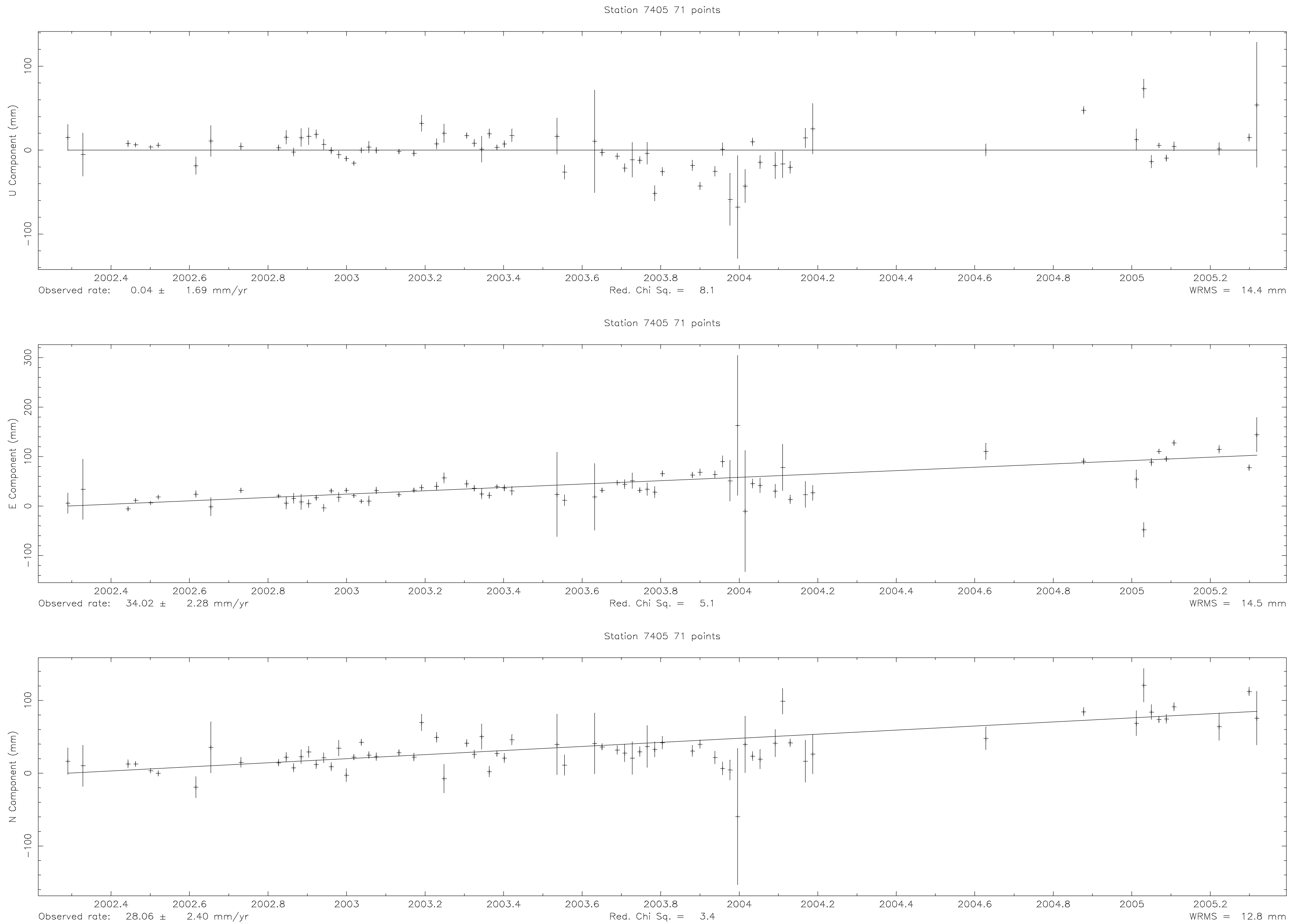
Even without considering the eventual older observations and the details of observation time distribution, they can be considered as **'strong'** from the quantitative data history point of view.

An important contribution of the ILRS combined solution to the next ITRF will be the site coordinates time series for 'young' SLR stations, i.e. those having accumulated a strong data history from 2000 onwards.

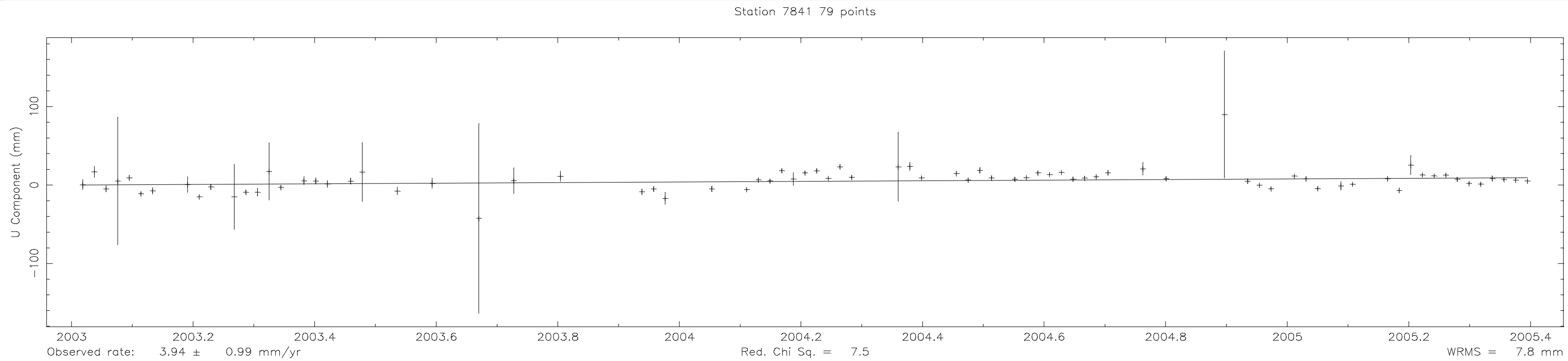
7825 – Mt Stromlo

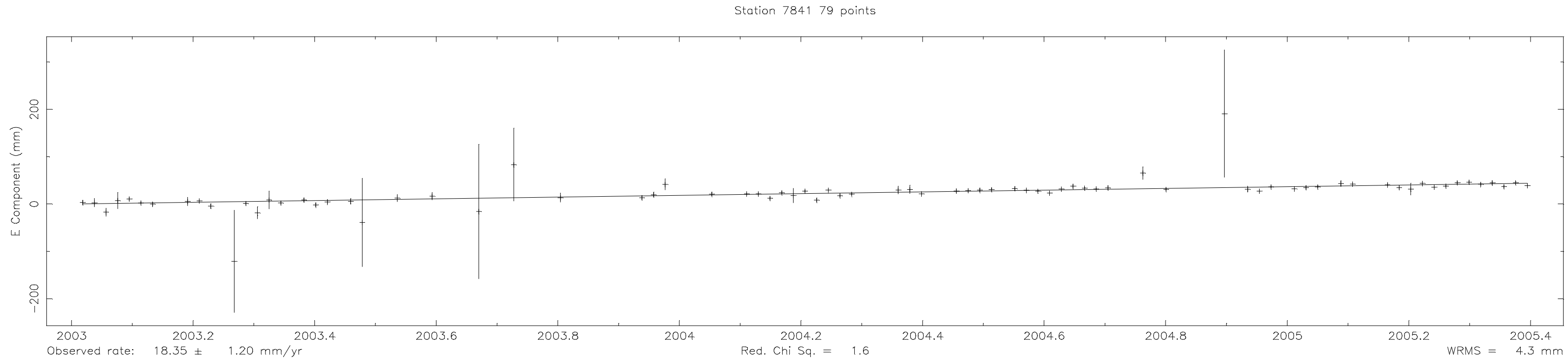


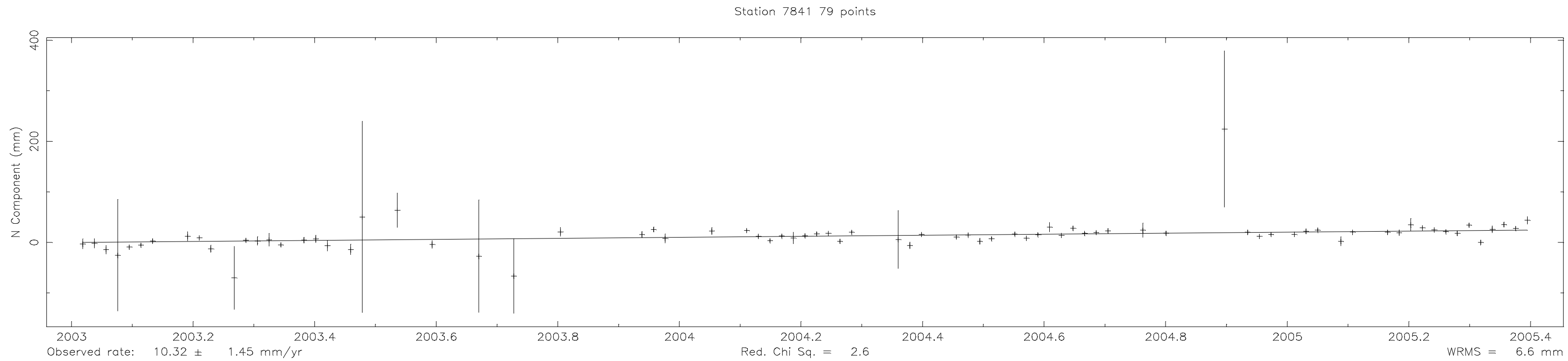
7405 - Conception



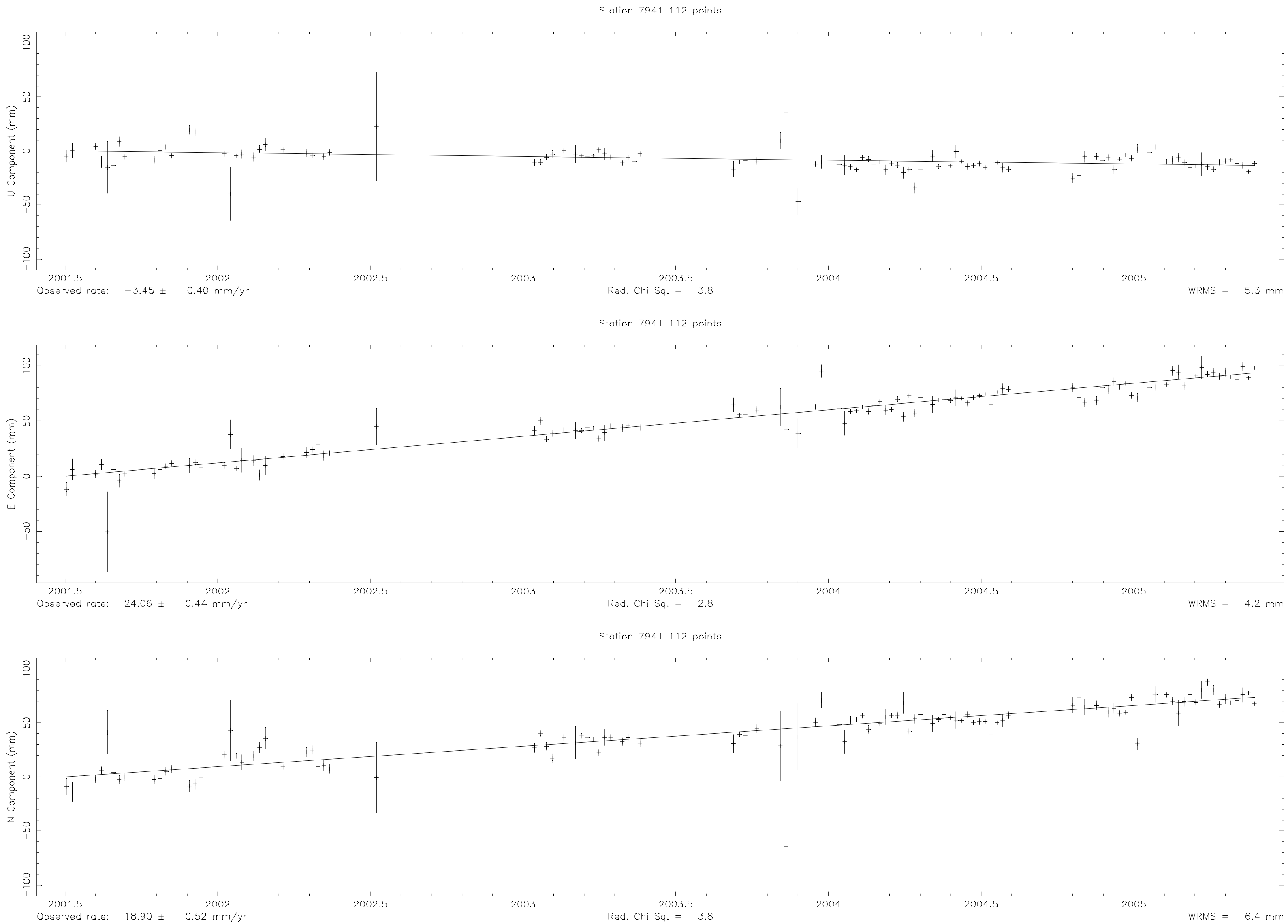
7841 – Potsdam2







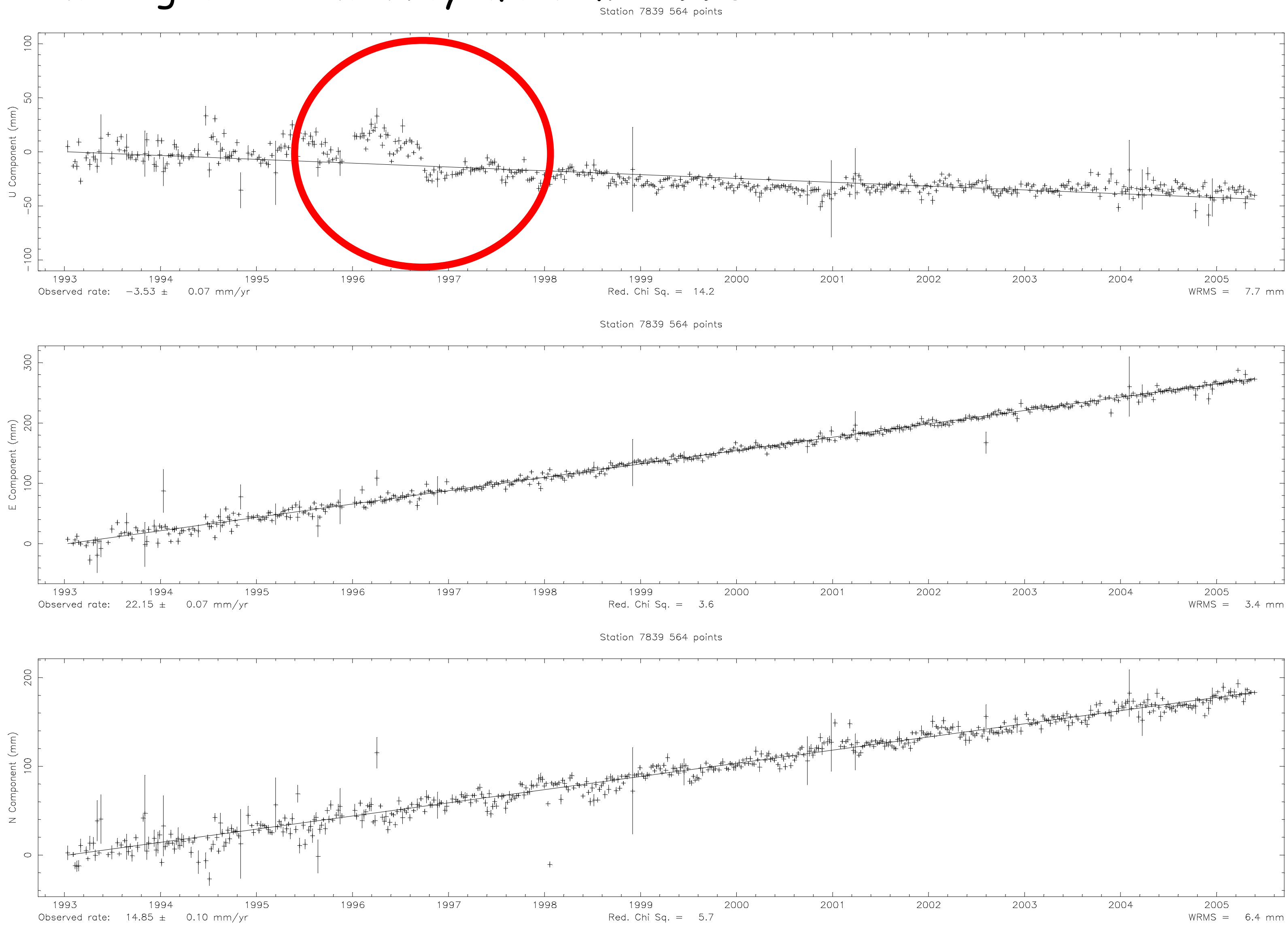
7941 – Matera MLRO



7839 – Graz

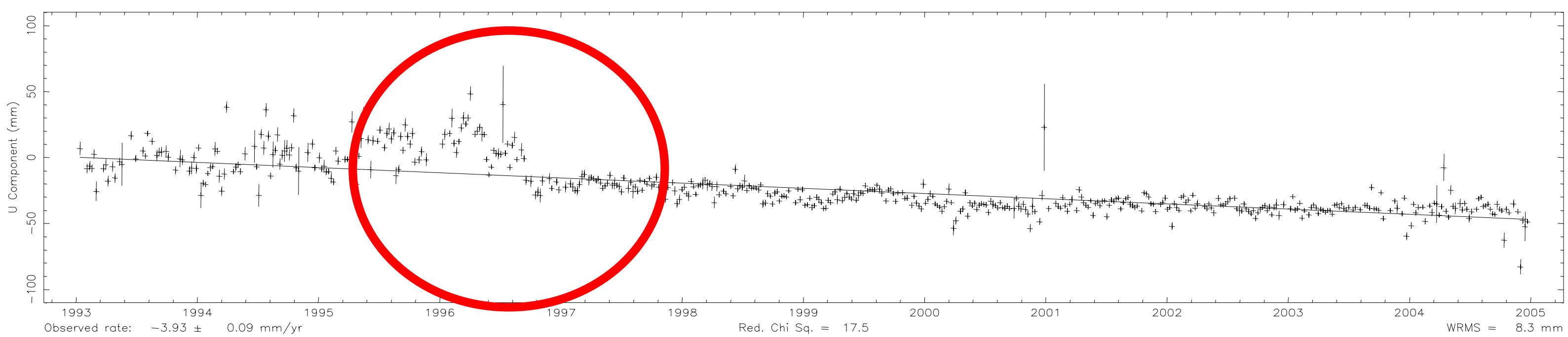
ILRSA v3

Evident height discontinuity after mid 1996



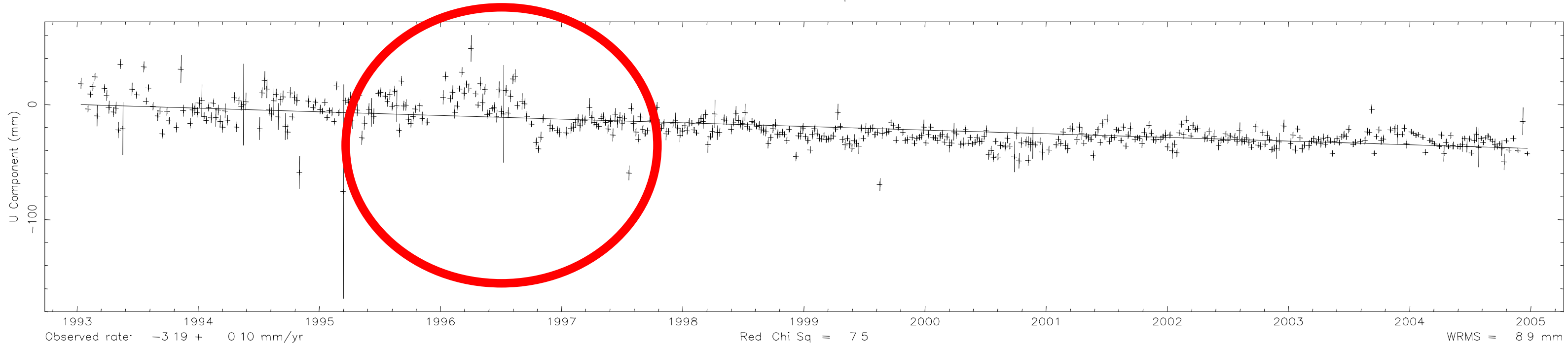
7839 – Graz
Contributing solutions

ASI: evident height discontinuity



Station 7839 528 points

DGFI : evident height discontinuity; more noisy estimates



Discontinuities summary table

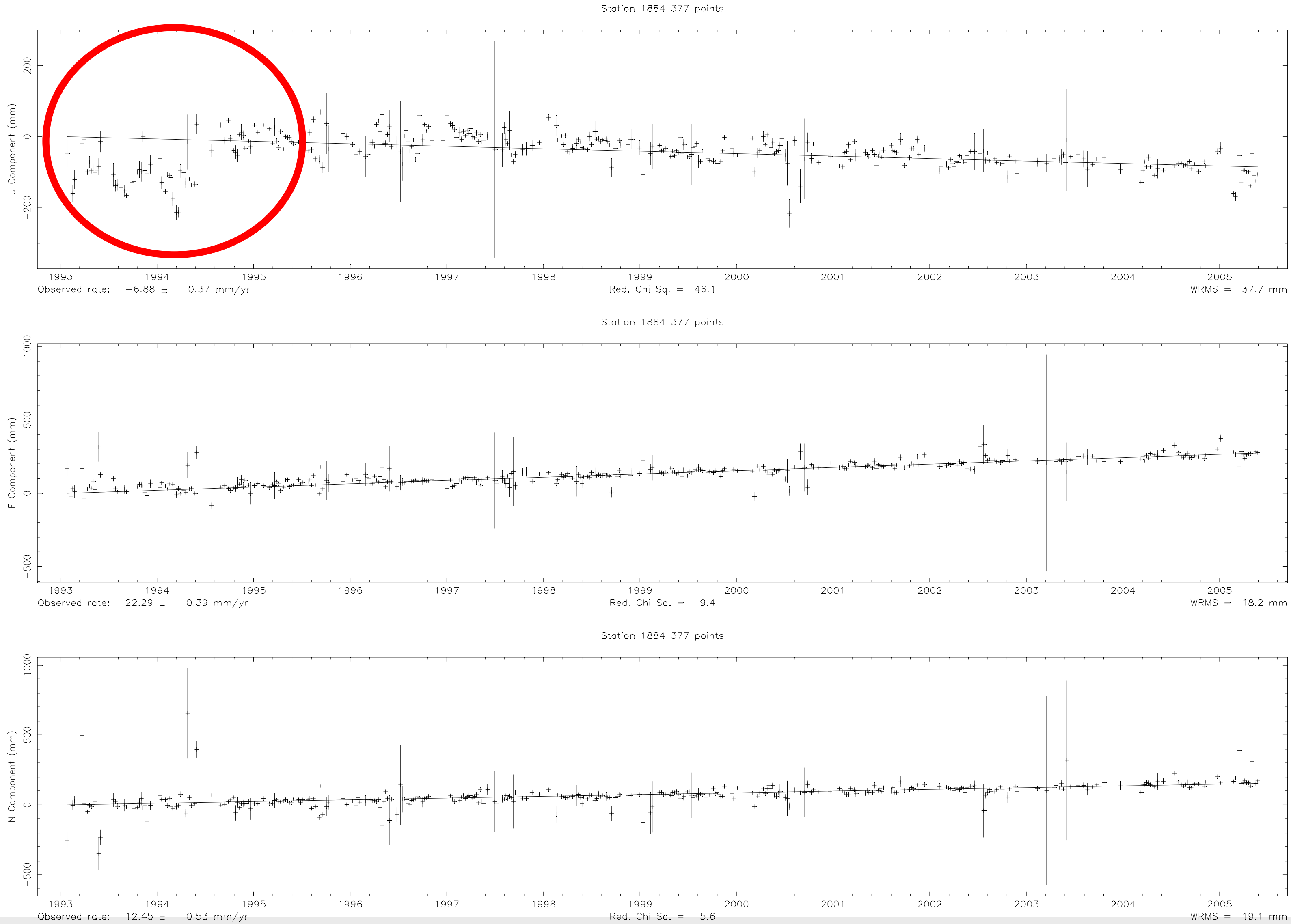
JUMPS/DRIFTS	ASI	DGFI	GFZ	JCET	NSGF
1864 2000.E	no estimates	Y (+ 2002)	N (few data < 2003)	N (weak estimates <- RB est?)	N (few data < 2003)
1868 h drift	no estimates	Y	Y (few data)	N (weak estimates <- RB est)	Y (few data)
1884 1994.M	N (RB estimated)	Y (RB not estimated)	Too few estimates < 1994.M	Too few estimates < 1994.M	Too few estimates < 1994.M
7210 1994.B	Y (RB estimated for occ. 2313)	N	Y	Y	N (RB estimated)
7237 2002.M	Y	Y	Y	N	N (RB estimated)
7237 1998.B	Y	Y/N ?	Y	N	N
7811 1993.M	Y (opposite; RB estimated)	Y	Too few estimates < 1993.M	Too few estimates < 1993.M	Too few estimates < 1993.M
7835 1997.M	Y	N	Y/N ?	Y	N (RB estimated; noisy < 1997.M)
7839 1996.M	Y	Y	Y	Y	Y
8834 1996.M	Y	N (RB estimated?)	Y	N (RB estimated)	N (RB estimated)

ILRS planned activities

After Eastbourne ILRS AWG meeting (2 oct 05), revised individual solutions from ACs and combined solutions from CCs are expected, to take into account suggestions & decisions related to editing criteria and time series discontinuities.

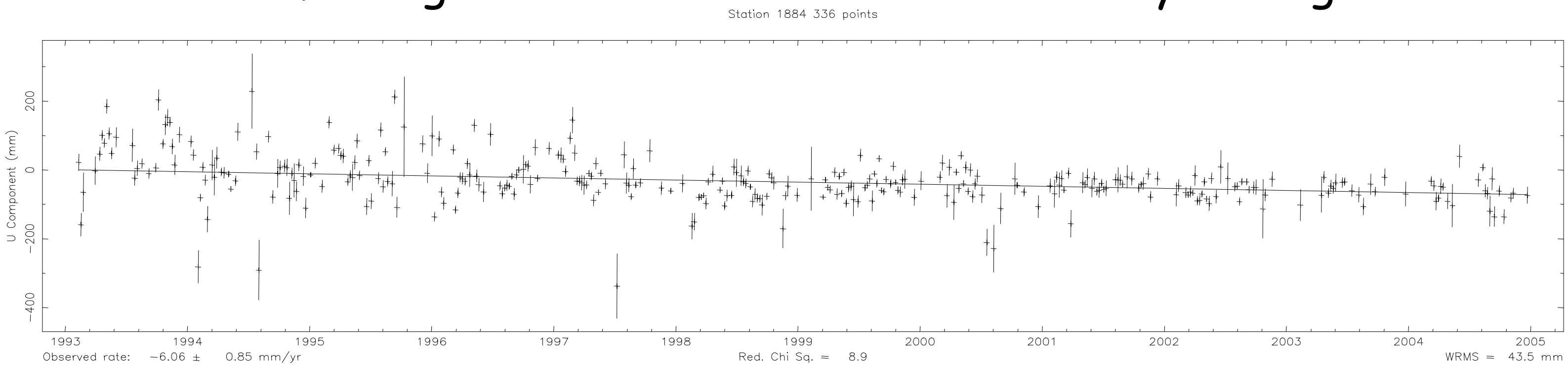
1884 – Riga
ILRSA v3

Height discontinuity is evident at the mid of 1994

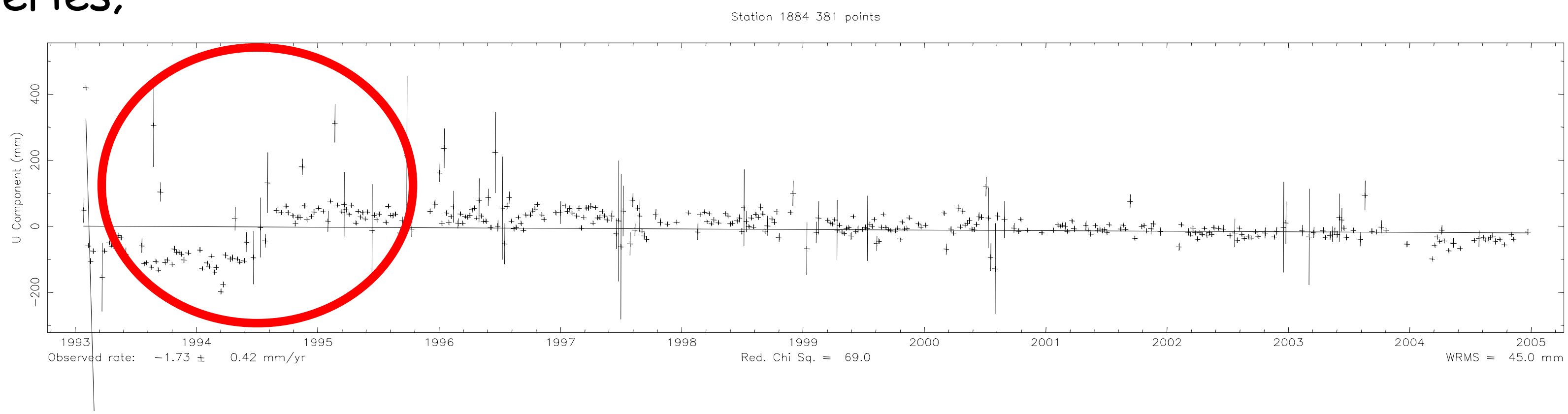


1884 – Riga
Contributing solutions

ASI estimates RB for Riga in the 93-94 -> no discontinuity in height time series;



DGFI does not estimate RB for Riga in the 93-94 -> discontinuity in height time series;



JCET, GFZ and NSGF use really very few observations from Riga in the 93-94 period.