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SLR GLONASS Orbit Determination

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Abstract:

The intense observation campaign during IGEX-98 provided a data set that was used to compare and calibrate SLR and microwave determined GLONASS satellite orbits. Orbit determination of the GLONASS satellites were undertaken using the SLR data observed from November 1998 to March 1999. The resulting trajectories generated from this estimation process are compared to those produced by the Centre for Orbit Determination in Europe (CODE) IGS Analysis Centre using the microwave data. The results of these comparisons are presented and conclusions given in the form of differences in the satellite trajectories (radial, along and cross track) and a set of transformation parameters between these two orbit types. The precision of the estimated set of station coordinates (SSC) -- over the five monthly solutions -- is given in the form of their repeatability. The estimated SSC are compared to the ITRF97.

SLR Data:

Five months of GLONASS SLR data (November 1998 to March 1999) observed to satellites 62, 65, 66, 68, 69, 70, 71, 72 and 79 during the IGEX-98 campaign was processed. Figure 1 shows the distribution of the 25 SLR stations that observed GLONASS during the IGEX-98 campaign.

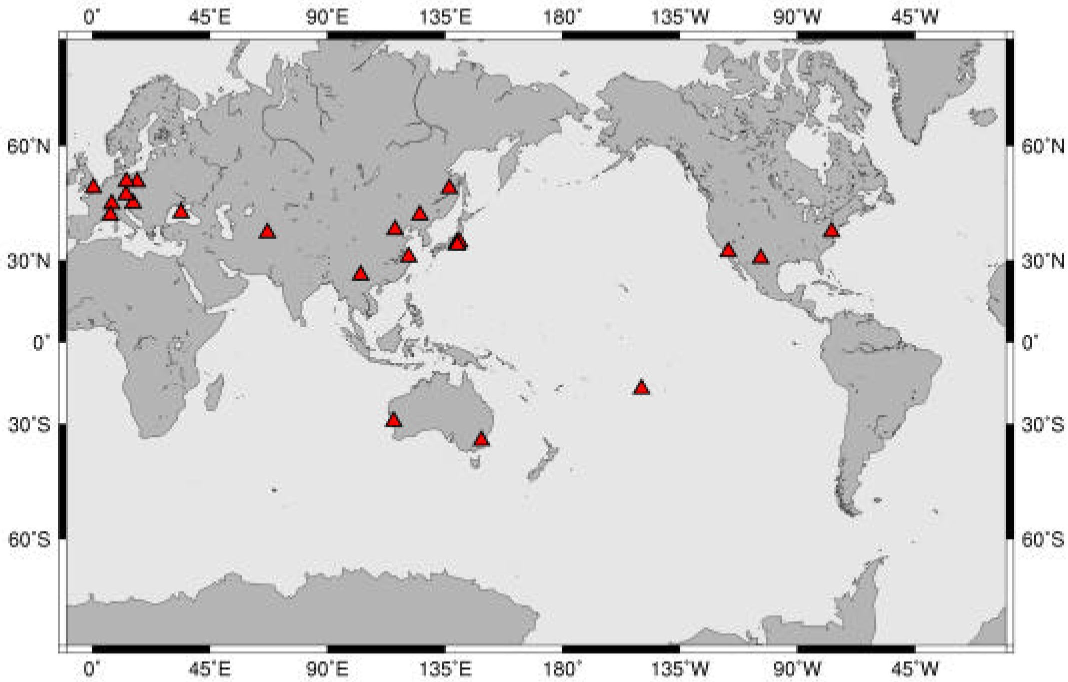


Figure 1 – Distribution of observing IGEX-98 SLR stations

Computation Standards:

The IERS Conventions 1996 (McCarthy, 1996) were closely followed. In addition, the following parameters were used for the reference frame modelling and the satellite orbit modelling. The apriori set of station coordinates were those determined in previous solutions for Lageos-1 and Lageos-2. Since, no specific Solar Radiation Pressure (SRP) Model for GLONASS was available, the ROCK IV GPS Block IIR SRP models (Fliegel and Gallini, 1992) were adopted as apriori and a SRP scale factor was estimated.

Apriori Reference Frame – (SSC)	AUSLIG Hybrid CSR96l01/ITRF

Direct Solar Radiation Pressure Model	ROCK (GPS Block II)
Centre of Mass Correction / Attitude	Observation Correction applied -1510, 0, 0 mm

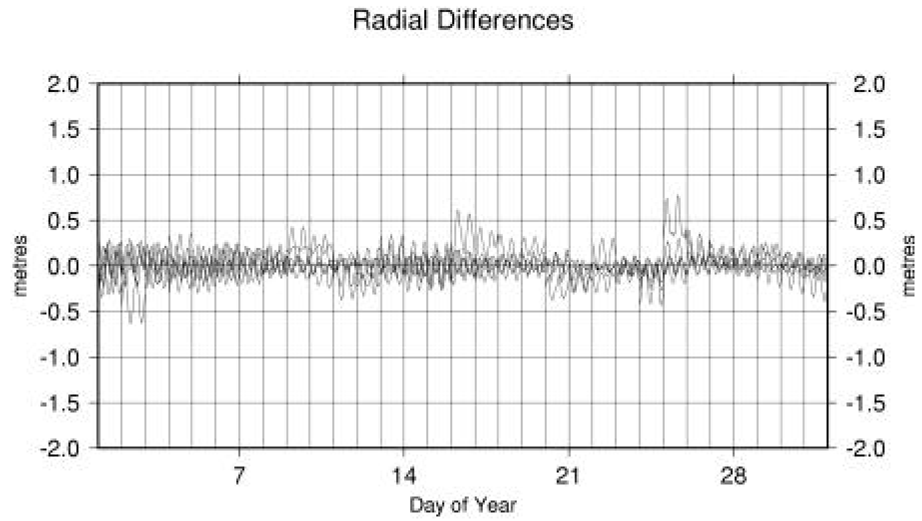
The following global and arcparameters were estimated for each monthly arc (for all satellites).

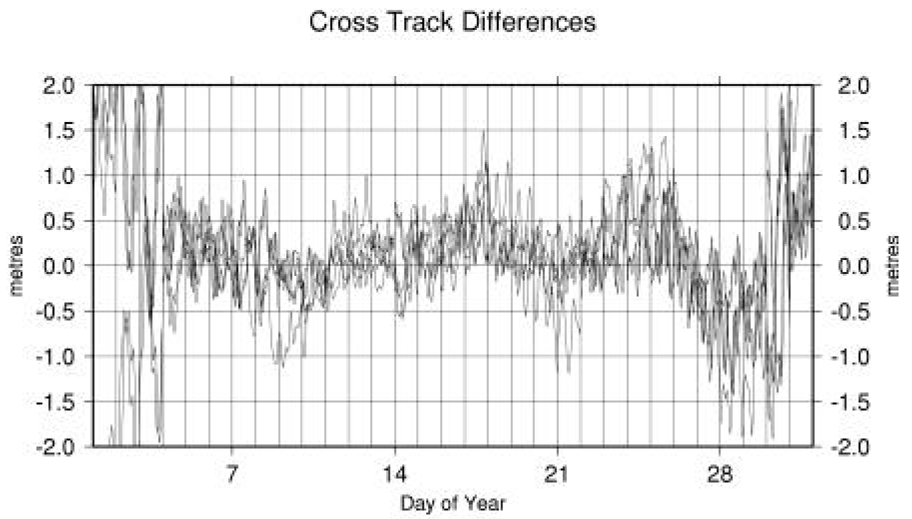
Global	• Station Coordinates • EOP

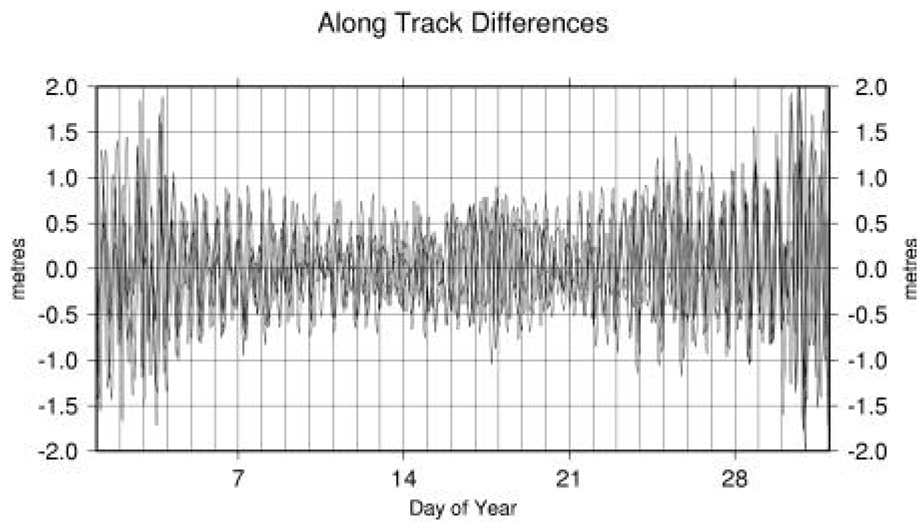
Orbit	• 30 day arc
	• 1 SRP scale factor
	• pass by pass range bias
	• pass by pass time bias
	• general acceleration
	    • constant
	    • periodic 1/rev
	    • every 5 days

Results and Analysis

Figures 2, 3 and 4 show the differences between the AUSLIG determined GLONASS SLR determined satellite trajectories and those of the Centre for Orbit Determination in Europe (CODE) microwave determined orbit trajectories. These differences are shown in the radial, along and cross track components. The mean and rms of the differences in these components for GLONASS satellites 4, 3, 9, 16 and 6 are shown in table 1. Table 2 shows the set of transformation parameters between the AUSLIG SLR orbit and the CODE microwave orbit. Table 3 lists the month-to-month repeatability of the estimated SLR station coordinates. Table 4 gives the comparison between the estimated station coordinates and the ITRF97 – after transformation.







Figures 2,3 and 4: AUSLIG SLR v. CODE --Trajectory Differences for January 1999

Table 1: Trajectory Differences – AUSLIG SLR vs. CODE for January 1999.

		dX	dY	dZ	dDIFF	dCLOCK	dRADIAL	dLONG	dCROSS	N
R04	MEAN	0.004	0.004	-0.051	0.687		-0.004	0.246	0.044	2977
R04	RMS	0.536	0.498	0.454	0.497		0.084	0.641	0.569	2977
R03	MEAN	0.004	0.007	-0.049	0.593		-0.005	0.179	0.054	2977
R03	RMS	0.424	0.414	0.409	0.416		0.060	0.520	0.495	2977
R09	MEAN	-0.011	-0.014	0.015	0.694		0.013	-0.110	-0.020	2977
R09	RMS	0.512	0.425	0.554	0.500		0.137	0.722	0.458	2977
R16	MEAN	-0.005	-0.027	-0.015	0.741		0.037	-0.108	-0.011	2977
R16	RMS	0.584	0.511	0.603	0.567		0.220	0.821	0.492	2977
R06	MEAN	-0.003	-0.010	0.052	0.868		-0.007	0.286	0.051	2977
R06	RMS	0.608	0.652	0.656	0.639		0.113	0.955	0.548	2977

	dX	dY	dZ	dDIFF	dRADIAL	dLONG	dCROSS
MEAN	-0.002	-0.008	-0.009	0.717	0.007	0.099	0.024
RMS	0.537	0.507	0.543	0.529	0.135	0.747	0.514

Table 2: Transformation Parameters – AUSLIG SLR orbit vs. CODE

Scale	:	2.6782e-10	(+/- 4.76e-09)	parts	0.27 (+/- 4.76)	ppb
Rotation X	:	2.1815e-09	(+/- 5.66e-09)	rad	0.45 (+/- 1.17)	mas
Rotation Y	:	-6.2558e-09	(+/- 5.66e-09)	rad	-1.29 (+/- 1.17)	mas
Rotation Z	:	1.1637e-08	(+/- 2.18e-11)	rad	2.40 (+/- 1.28)	mas
Translation X	:	-0.003	(+/- 0.000)	m	-0.25 (+/- 12.13)	cm
Translation Y	:	-0.008	(+/- 0.000)	m	-0.78 (+/- 12.13)	cm
Translation Z	:	-0.010	(+/- 0.000)	m	-1.02 (+/- 12.13)	cm

Table 3: Month-to-month repeatability for estimated SSC.

STATION	PTCODE	TECH	#SOLN	X	Y	Z (mm-rms)	E	N	U (mm-rms)	01234
1864	A	L	3	21	52	39	21	59	28	-P-PP
1868	A	L	4	-	-	-	-	-	-	-PPPP
1873	A	L	1	-	-	-	-	-	-	P----
7080	A	L	4	10	16	16	14	19	10	PPPP-
7090	A	L	4	17	5	2	14	7	8	PPPP-
7105	A	L	1	-	-	-	-	-	-	---P-
7105	A	L	3	-	-	-	-	-	-	PPP--
7110	A	L	4	6	21	14	6	23	10	PPPP-
7124	A	L	5	45	37	29	41	30	41	PPPPP
7237	A	L	5	29	38	35	34	45	18	PPPPP
7249	A	L	4	43	43	61	34	21	76	PPPP-
7328	A	L	2	31	23	3	3	25	29	---PP
7335	A	L	2	0	23	27	18	14	28	---PP
7337	A	L	1	-	-	-	-	-	-	---P-
7339	A	L	2	10	18	36	20	27	24	---PP
7810	A	L	4	8	3	8	3	7	10	PPPP-
7811	A	L	3	17	29	14	23	19	21	PPP--
7820	A	L	2	-	-	-	-	-	-	---PP
7835	A	L	1	-	-	-	-	-	-	-P---
7836	A	L	4	19	9	28	12	6	32	PPPP-
7837	A	L	5	47	36	37	49	38	32	PPPPP
7839	A	L	4	7	6	5	7	2	8	PPPP-
7840	A	L	4	8	6	10	6	8	10	PPPP-
7845	A	L	5	20	31	14	30	14	21	PPPPP
7849	A	L	5	30	26	49	22	40	43	PPPPP
8834	A	L	4	3	6	10	6	4	10	PPPP-
RMS				24	26	28	23	26	29	

Table 4: Comparison of estimated SSC with ITRF97

	ID	PTCODE	DOMES	T	dX(mm)	dY(mm)	dZ(mm)	dE(mm)	dN(mm)	dU(mm)
1	7080	A	40442M006	L	-27.9	-97.5	-9.5	-3.5	-59.9	82.3
2	7090	A	50107M001	L	-81.1	24.2	10.3	62.9	36.5	44.4
3	7105	A	40451M105	L	-11.9	-111.1	-16.5	-36.9	-79.2	71.6
4	7110	A	40497M001	L	-28.1	-102.0	-16.5	20.2	-70.2	78.2
5	7810	A	14001S001	L	-1.4	-14.7	21.0	-14.4	16.8	13.1
6	7811	A	12205S001	L	36.9	-25.2	36.2	-34.9	0.1	45.7
7	7836	A	14106S009	L	0.0	0.0	0.0	0.0	0.0	0.0
8	7837	A	21605S001	L	0.0	-52.2	26.1	27.0	45.4	-24.8
9	7839	A	11001S002	L	17.4	-21.9	-5.5	-25.8	-11.8	3.4
10	7840	A	13212S001	L	5.0	-43.2	-5.4	-43.2	-7.1	-1.2
11	8834	A	14201S018	L	30.0	4.8	22.7	-2.0	-8.1	37.0
	RMS				31.4	59.4	18.5	30.8	41.3	47.0

Future Work

At the time of the computations, there was no readily available solar radiation pressure model for the GLONASS satellites. The orbit determination computations were therefore based on a GPS solar radiation pressure model as an initial guess. It is therefore proposed to continue to experiment with other empirically determined GLONASS solar radiation models – monitoring any improvement in the orbits.

The next stage is to undertake the analysis of the GLONASS microwave data and make direct comparisons between the two measurement types – with a view to combining them.

References:

Fliegel, H.F and T.E. Gallini (1992): “Global Positioning System Radiation Force Model for Geodetic Applications”, JGR, Vol.97, No B1, pages 559-568.