IGS Antenna Working Group

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1 Preparations for the second IGS reprocessing campaign

In 2013, the IGS will perform its second comprehensive reprocessing campaign (repro2). In order to have the best possible antenna phase center information available for repro2, the IGS model `igs08.atx` was updated with satellite–specific z–offsets for all satellites launched since the release of the original model (Sect. 1.1). Besides, subtype calibrations for `JPSREGANT` antennas were introduced that show significant differences (Sect. 1.2).

1.1 Update of satellite–specific z–offsets

Since the adoption of `igs08.atx` in April 2011, one GPS (G063) and five GLONASS satellites (R742–R746) had been launched. For all those satellites, block mean values were applied until September 2012. In GPS week 1706 (16 September 2012), those were updated with satellite–specific z–offset estimates (see IGSMAIL #6650 and Tab. 1) provided by Paul Rebischung (IGN). As R743 was not put into operation until 17 September 2012, it could not be considered for the reanalysis. In contrast, the z–offsets of G062 and R801 were additionally reanalyzed, as the available estimates had been based on limited data. All other active satellites were fixed to `igs08.atx` values.

The updated values were estimated from operational SINEX files of six ACs (CODE, ESOC, GFZ, MIT, NGS and NRCan), CODE and ESOC being the only to provide offset estimates for the GLONASS satellites. Figure 1 shows the weekly z–offset estimates for G063. Usually, the quality is worse in the beginning, as the number of tracking stations is limited as long as the newly launched satellite is not set healthy.

From the weekly estimates weighted mean values per AC were derived (see Tab. 1). The maximum differences between ACs are below 5 cm for all satellites, also for those with the shortest lifetime. Due to this very good agreement and due to the fact that not all ACs analyzed the same amount of data, unweighted mean values per satellite were derived

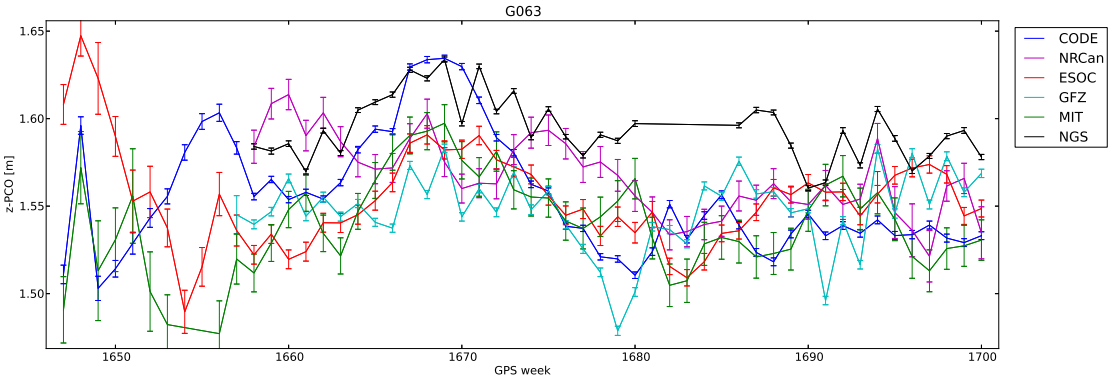

Figure 1: Weekly z–offset estimates [m] from operational SINEX files of six ACs for G063 (courtesy of P. Rebischung).

for `igs08.atx`. In some cases those final values differ considerably from the block mean values used before (correction of about 30 cm for R746 and R801), and in all cases the corrections are significant.

1.2 Consideration of `JPSREGANT` antenna subtypes

Sometime in 2000, Javad changed the setup of two of its `JPSREGANT` antenna types (`JPSREGANT_DD_E`, `JPSREGANT_SD_E`). However, the introduction of these new subtypes did not produce a new name definition and proper recognition within the IGS. Since the adoption of `igs05.atx` in November 2006, mean phase center corrections over the two subtypes were in use for both antenna types. Therefore, all stations equipped with one of the `JPSREGANT` antenna types were affected by a vertical bias of up to 2 cm since that time.

In order to solve that problem, several things had to happen at the same time:

- provision of subtype calibrations in `igs08.atx`
- correction of the antenna type in the affected site logs
- correction of the station coordinates in the course of an update of the IGS reference frame realization

After the correct subtypes actually installed at the affected IGS stations had been identified in most cases, the correction of the site logs could be carried out in conjunction with the switch from IGS08 to IGb08 in GPS week 1709 (7 October 2012):

- `JPSREGANT_DD_E1`: `CONZ` (RA0178), `DLFT` (RA0077), `DWH1` (RA0083), `MDVJ` (RA0195), `MTBG` (RA0085), `STR2` (???005), `UNB1` (RA0193), `UNBJ` (RA0193)
- `JPSREGANT_DD_E2`: `CAGZ` (RRA052), `KOU1` (RRA31)

Table 1: Satellite–specific z–offset estimates for the seven latest GPS/GLONASS satellites (compare IGSMAIL #6650). Besides the number of weekly estimates, the weighted mean per AC is given together with its RMS. The column `igs08.atx` shows the (block mean) values used before the update and Δigs08 is the difference between the new and the old value. All values in [m].

sat.	launch	AC	no. of weeks	weighted mean	weighted RMS	AC mean	igs08.atx	Δigs08
G062	28.05.10	CODE	102	1.5808	0.0221	**1.5973**	1.6632	−0.0659
		ESOC	102	1.5901	0.0240			
		GFZ	99	1.5986	0.0303			
		MIT	98	1.5875	0.0277			
		NGS	93	1.6078	0.0241			
		NRCan	81	1.6190	0.0258			
G063	16.07.11	CODE	54	1.5596	0.0344	**1.5613**	1.6500	−0.0887
		ESOC	54	1.5520	0.0225			
		GFZ	44	1.5477	0.0221			
		MIT	51	1.5451	0.0251			
		NGS	38	1.5946	0.0177			
		NRCan	43	1.5689	0.0208			
R742	02.10.11	CODE	43	2.3805	0.0288	**2.3811**	2.4500	−0.0690
		ESOC	42	2.3816	0.0369			
R744	04.11.11	CODE	36	2.5609	0.0322	**2.5631**	2.4500	+0.1131
		ESOC	36	2.5653	0.0437			
R745	04.11.11	CODE	35	2.6413	0.0294	**2.6372**	2.4500	+0.1872
		ESOC	35	2.6330	0.0322			
R746	28.11.11	CODE	34	2.7655	0.0322	**2.7436**	2.4500	+0.2936
		ESOC	33	2.7217	0.0327			
R801	26.02.11	CODE	20	2.0908	0.0246	**2.0668**	1.7500	+0.3168
		ESOC	17	2.0427	0.0448			

- `JPSREGANT_SD_E1`: `DLFT` (RA0043), `KHAJ` (RA0032), `MOBJ` (RA0033), `MOBK` (RA0033), `NOVJ` (RA0038), `NOVM` (RA0038), `SUNM` (RA0024), `ZIMJ` (RA0059)

- `JPSREGANT_SD_E2`: `DREJ` (RA0290, RA0292, RA0293), `FFMJ` (RA0294), `HUEG` (RA0291, RA0310), `TITZ` (RA0291, RA0311), `WTZJ` (RA0295)

- `JPSREGANT_SD_E`: `IRKJ` (RA0225(?); not corrected due to contradictory information)

More details are given in IGSMAIL #6662.

2 Updates and content of the antenna phase center model

In case the satellite constellation changes or new receiver antenna calibrations become available, the absolute antenna phase center model of the IGS has to be updated. The GPS week of the release date is coded in the model name (`igs08_wwww.atx`). Table 2 lists 12 updates in 2012. Further details can be found in the corresponding IGSMAILs whose numbers are also given.

Table 3 gives an overview of the data sets contained in the IGS phase center model. The numbers refer to `igs08_1719.atx` that was released in December 2012. For GPS and GLONASS, there are 71 and 84 file entries, respectively. These numbers are bigger than the number of actual satellites, as certain satellites were assigned with different PRN codes or almanac slots, respectively.

For Galileo, BeiDou and QZSS, the IGS model does still not provide any information. During the IGS Workshop in Olsztyn it was recommended to adopt conventional phase center offset (PCO) values for these new satellite antenna types. However, this will also require an update of the ANTEX format to consider manufacturer–defined spacecraft body frames and attitude modes. For the time being, conventional PCO values for new GNSS can be found on the web pages of the IGS Multi–GNSS Experiment (`http://www.igs.org/mgex/`).

Apart from the satellite antennas, the IGS model also contains phase center calibration values for 242 different receiver antennas. 152 of them are certain combinations of an antenna and a radome, whereas the remaining 90 antenna types are not covered by a radome. As Tab. 3 shows, `igs08_1719.atx` contains, among others, 106 absolute robot calibrations and 90 converted field calibrations.

As the IGS Site Guidelines ask for elevation– and azimuth–dependent calibration values down to 0° elevation, 141 different antenna types (106 `ROBOT` + 32 `COPIED` + 3 `CONVERTED`) are currently approved for the installation at new or upgraded IGS stations. The remaining 101 types are no longer allowed, but their calibration values are still necessary for existing installations (see Sect. 3) as well as for reprocessing purposes.

Table 2: Updates of the phase center model `igs08.atx` in 2012.

week	date	IGSMAIL	change
1673	30-JAN-12	6533	Added G049 (G24) Decommission date: G024
1682	02-APR-12	6564	Added G032 (G24) Decommission date: G049 (G24) Added `NOV533+CR NOVC`
1685	26-APR-12	6576	Added G037 (G24) Decommission date: G032 (G24)
1699	02-AUG-12	6634	Added R801 (R26) Added `RNG80971.00 NONE`
1700	06-AUG-12	6640	Added G049 (G24) Decommission date: G037 (G24)
1706	05-SEP-12	6650	z-offset updated: G062, G063, R742, R744, R745, R746, R801 (see Sect. 1.1)

1707	24-SEP-12	6662	Added R743
			Decommission date: R729
			Added `ASH701023.A NONE`
			`JPSREGANT_DD_E1 NONE`
			`JPSREGANT_DD_E2 NONE`
			`JPSREGANT_SD_E1 NONE`
			`JPSREGANT_SD_E2 NONE`
			`LEIGS08PLUS NONE`
			(compare Sect. 1.2)

1708	05-OCT-12	6670	Added G065 Decommission date: G049 (G24)
1710	18-OCT-12	6676	Added G049 (G27) Decommission date: G027
1711	23-OCT-12	6679	Added R712 (R08) Decommission date: R743

1717	03-DEC-12	—	Added `LEIAR20 NONE`
			`LEIAR20 LEIM`
			`TIAPENG3100R1 NONE`

1719	19-DEC-12	—	Added `LEIGS14 NONE`

Table 3: Number of data sets in `igs08_1719.atx` (released in December 2012).

satellite antennas	number	receiver antennas	number
GPS	71	`ROBOT`	106
GLONASS	84	`FIELD`	90
Galileo	0	`COPIED`	32
BeiDou	0	`CONVERTED`	14
QZSS	0		

3 Calibration status of the IGS network

Table 4 shows the percentage of IGS tracking stations with respect to certain calibration types. For this analysis, 440 IGS stations as contained in the file `logsum.txt` (available at `ftp://igs.org/igscb/station/general/`) on 11 January 2013 were considered. At that time, 100 different antenna/radome combinations were in use within the IGS network. The calibration status of these antenna types was assessed with respect to the phase center model `igs08_1722.atx` that was released in January 2013.

In the meantime, absolute robot calibrations comprising elevation– and azimuth–dependent PCVs down to the horizon are available for a bit more than three quarters of all IGS stations. About 8% of the stations are still equipped with antenna types for which purely elevation–dependent PCVs derived from relative field calibrations have to be applied. Besides, about 15% of the antennas in the IGS network are either covered by an uncalibrated radome or represent an unmodeled antenna subtype.

The latter category of stations is particularly disadvantageous in case the antenna is co–located with other space geodetic instruments. Therefore, several IGS entities cooperatively organized a campaign to quantify the impact of the uncalibrated radome by removing it for about two months at important co–location sites (Romero et al., 2012).

Table 4: Calibration status of 440 stations in the IGS network (`logsum.txt` of 11 January 2013, `igs08_1722.atx`) compared to former years.

date	absolute calibration (azimuthal corrections down to 0° elevation)	converted field calibration (purely elev.–dependent PCVs above 10° elevation)	uncalibrated radome (or unmodeled antenna subtype)
DEC 2009	61.4%	18.3%	20.2%
MAY 2012	74.6%	8.2%	17.2%
JAN 2013	**76.8%**	**7.7%**	**15.5%**

The improvement between 2009 and 2012 (compare Tab. 4) is mainly related to the transition from `igs05.atx` to `igs08.atx` in 2011, as several additional robot calibrations could be considered at that time. Since then, the problem associated with the `JPSREGANT` antennas (Sect. 1.2) could be nearly solved, and some inadequate antenna installations were upgraded or decommissioned.

References

Romero I., P. Rebischung, J. Ray, R. Schmid, S. Fisher, and J. Griffiths. The IGS campaign to measure position corrections for uncalibrated IGS radome stations. *IGS Workshop 2012*, 23–27 July 2012, Olsztyn, Poland, 2012.