Proposed Update of the IGS Reference Frame Realization

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Abstract

An update of the IGS Reference Frame realization "IGb00" is proposed. The focus is on 3 main aspects: first, the update of the selected set of primary reference frame stations; second, the realignment to ITRF2005 (preliminary) and third, the impact of the switch to station antenna absolute phase centers on the reference frame. The current IGb00 realization was proposed and adopted almost 3 years ago; it included 99 stations. For various reasons, about 80 stations remain useable. This situation also highlights the importance of updating the reference frame stations and the effort that must be made to maintain these key sites, avoid or eliminate discontinuities whenever possible to help ensure its stability. The proposed new realization will take advantage of additional stations, while, whenever possible, still rely on older sites to ensure continuous link to historical data. The realization will also be realigned to the ITRF2005, when officially available. The effect of switching from station antenna relative calibration "IGS_01" to the absolute calibration "IGS_T05" will also be discussed. The antenna phase center shift as well as radome addition/removal also introduces discontinuities in the station coordinates time series. Each aspect of this update will introduce a small discontinuity (rotation, translation, scale and rates) between the existing "IGb00" and the proposed realization.

1. Reference Frame Stations: A Review

IGb00 has now been in use since GPS week 1253(04/01/11). Originally, it included 99 stations. Since then 14 stations had to be removed from the realization; those are: COCO DGAR FAIR FORT IISC KOKB MAC1 MAG0 MANA NTUS SFER TRO1 YAKT YSSK. The main causes are earthquakes and equipment change. The reference stations in South East Asia were most affected due to the Sumatra earthquake. EISL was decommissioned; GOUG was in and out at the beginning of 2005. At the time IGb00 became official, the standard deviations between the IGS weekly solutions and IGb00 were ~2.0 mm / 7.9 mm horizontally/vertically. They are now ~3.3 mm /10.8 mm respectively. The uncertainty in the station velocities used to propagate the position to the current epoch is contributing to the increase in STD.

Since there are several criterions affecting the overall performance of a station, the inclusion or not of a station is somewhat subjective. Few stations, if any meet equally well all criterions. Some important ones are:

- Geometry, (other stations within 1-100-1000km ; geographical location; logs)
- Monumentation,
- Usage, (Last 1-6-12-all month)
- Collocation,
- Stability of coordinates/residuals time series. (RMS 1-6-12-all months; discontinuities; stability index; Radomes, etc.)

The initial list (348) of candidate stations in the review is the same as the list of stations provided for ITRF2005. That list was a subset of approximately ~470 all-time stations submitted by the AC's and combined. This initial list was reduced to 331 stations by removing those with short time span. To ensure continuity, the IGb00 stations were included unless there was serious reasons not to. Using the above criterions, the proposed station selection was finally reduced to 139 (See Figure 1):

ALGO ALIC ALRT AMC2 ARTU ASC1 ASPA BAHR BAKO BILI BJFS BOR1 BRAZ BRMU BRUS CAGL CAS1 CEDU CHAT CHPI CHUR COCO CONZ CORD CRO1 DAEJ DARW DAV1 DGAR DRAO DUBO FAIR FLIN GLPS GLSV GODE GOLD GOUG GRAS GUAM GUAO HARB HLFX HNLC HOB2 HOFN HOLM HRAO HYDE IISC IRKT ISPA JAB1 JOZE KARR KELY KERG KIT3 KOKB KOUR KUNM LAE1 LHAS LPGS MAC1 MADR MALI MANA MAS1 MATE MAW1 MBAR MCM4 MDO1 MDVJ METS MKEA NICO NKLG NLIB NOT1 NOUM NOVJ NRC1 NRIL NYA1 NYAL OHI2 OHI3 ONSA OUS2 PDEL PERT PETP PIE1 PIMO POL2 POLV POTS QAQ1 QUIN RABT RAMO RBAY REUN REYK RIOG SANT SCH2 SCUB SEY1 SFER STJO SUTH SYOG THTI THU3 TIDB TIXI TOW2 TRAB TRO1 TROM TSKB ULAB UNSA USNO VESL VILL WES2 WHIT WILL WSRT WTZR WUHN YAR1 YELL YSSK ZIMM.

Of the original 99 stations in IGb00, 10 could not be retained:

AUCK EISL FORT GRAZ KSTU LAMA MAG0 NTUS URUM YAKT.

50 new stations are proposed:

ALRT AMC2 ASPA BAKO BJFS BRAZ BRMU CAGL CHPI CONZ CORD DAEJ GLPS GUAO HARB HLFX HNLC HOLM HYDE ISPA KUNM LAE1 MADR MBAR MDVJ METS NOT1 NOVJ NRIL NYA1 OHI3 OUS2 PDEL PIMO POLV QAQ1 QUIN RABT RAMO REUN REYK SCUB SEY1 SUTH TROM ULAB USNO WHIT WILL WUHN.

Antennas with radomes have been a concern in the past. Antenna changes at those sites tends to generate a discontinuity in the station coordinates. The new antennas calibration should in principle account for the total effect "antenna" and "antenna+radome" situations without causing discontinuities. If stations with radomes were to be excluded, 57 of the proposed 139 would have to be removed. They are also not randomly distributed. For example, all proposed stations in Antarctica as well as all those in north East Asia have radomes. This would cause large areas without stations. I would suggest keeping them in, and remove then only in the case of equipment change accompanied with observed discontinuity in the coordinates time series.

2. ITRF2000 to ITRF2005: An Update

Because the ITRF will be produced from the techniques weekly solutions, the IGS portion of the ITRF combination is an ideal source from which to extract the IGS realization. Zuheir Altamimi at IGN and Detlef Angerman at DGFI have graciously provided "technique specific" preliminary solutions. These solutions include all the active discontinuities that have been identified. The IGN solution also includes a constant velocity condition for solutions from a same site as well as for segments affected by discontinuities. At this time, the IGN solution has been used to generate a tentative IGS05 realization.

From the IGN solution, the most recent segment estimates for each of the stations have been extracted to generate the tentative realization. For reprocessing activities, a similar solution with all segments for the selected stations would be appropriate. To verify the quality of this realization, it was compared to the most recent 20 weeks (GPS wk 1350-1369). The IGN and DGFI combinations include data up to the end of 2005 (Wk 1355).

The "IGS05" was propagated to the epochs of the weekly solutions. The weekly solutions were then aligned (7-parameters) to the realizations, and the residuals were computed. The weekly solutions were nominally aligned to the ITRF2000 using IGb00. The statistics of the residuals for all the common stations during the 20 weeks test are:

	N(mm)	E(mm)	H(mm)
STD	2.0	1.9	5.8

The agreement between the weekly solutions and the proposed realization is excellent! It confirms that the proposed IGS05 is a good candidate.

Estimation of discontinuity/transformation between IGb00 and "IGS05" is premature. This will be done when the final alignment is done. Because this is an intra-technique solution it is not affected by the other techniques.

3. Relative to Absolute Antenna Phase Center

A test campaign to evaluate the impact of using the absolute phase center tables (igs_t05) started on GPS week 1325. The AC's modified their software to implement this change. The new tables also include satellite phase center. The AC orbit modeling software applications were also modified to estimate absolute phase center for the satellites. The proposed procedure was to duplicate the official solutions with the phase center model being the only difference. All other variables (models, network, weighting, etc.) were to remain the same. For this test, the satellite phase centers were constrained to their nominal values. This antenna phase center change caused a discontinuity in all station coordinates time series. With the current official relative calibration tables (IGS_01), all calibrations are with respect to the AOAD/M_T antenna.

A common change affects all stations mainly in the vertical, thus the scale; while another component is specific to each station. For the reference frame realization, the scale has to remain consistent with ITRF (i.e. determined from VLBI and SLR). So to remain consistent with the ITRF scale, the markers height or at least their average has to remain constant. The tests have also shown that even for a given antenna type, there are variations between stations (local effects).

The use of the relative phase center calibration had introduced a scale bias. For the 2005-06 official solutions this bias is about 3ppb. The switch to the absolute phase center has produced an average height shift of 11.8mm over all stations, correspondingly reducing the scale bias by 1.85ppb. When using only the proposed reference frame stations the average shift is 12.1mm (1.89ppb). The shift of the horizontal components were generally smaller by a factor of at least 5. The effect (3D) of the calibration change was added to the tentative realization. The AC solutions (co2, em2, gf2, mi2) were combined and they were aligned using the new proposed reference frame realization for GPS weeks 1350-1359. The residual statistics between the weekly combined solutions and the proposed realization are:

	N(mm)	E(mm)	H(mm)
STD	2.3	2.0	6.8

Assuming the usual propagation of errors, the uncertainty contribution of the relative to absolute phase center is about:

	N(mm)	E(mm)	H(mm)
STD	1.1	0.6	3.5

A proposed reference frame realization update that includes: a proposed list of contributing stations, the use of ITRF2005 (preliminary) and an evaluation of the impact of introducing absolute antenna phase centers has been prepared.

4. References

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Kouba, J., J. Ray and M.M. Watkins, IGS Reference Frame Realization, 1998 IGS Analysis Center Workshop Proceedings, European Space Operations Centre, Darmstadt, Germany.
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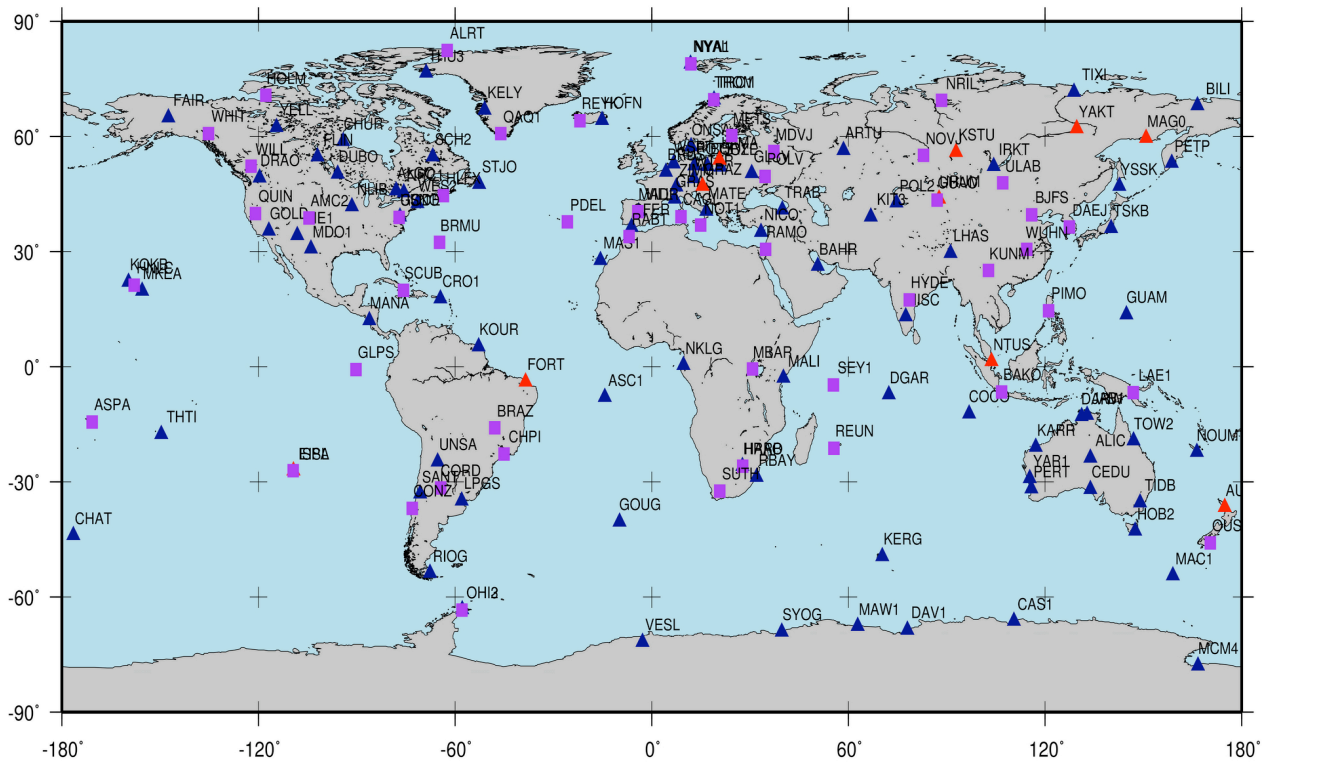

Figure 1: IGb00 to Proposed IGS05