The BLT IGS TIGA Analysis Center

UNIVERSITÉ DU LUXEMBOURG

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NATURAL ENVIRONMENT RESEARCH COUNCIL

BIGF

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Abstract

During 2011, the consortium consisting of the NERC British Isles continuous GNSS Facility (BIGF), hosted by the University of Nottingham, and the Geophysics Laboratory (GL), University of Luxembourg, was established as the BIGF-University of Luxembourg TIGA Analysis Center (BLT). The BLT proposes to contribute minimally constrained SINEX solutions computed using the new Bernese GNSS Software V5.2 (BSW5.2) to the TIGA Working Group. Over the past few years, the University of Nottingham (UNT) has carried out reprocessing to generate its own homogeneous, satellite orbit and clock, and EOP products, for the period from 1998-2007, using an in-house modified version of the Bernese GPS software V5.0 (BSW5.0), which includes the Vienna mapping function (VMF1). In preparation for the TIGA reprocessing campaign, BLT has produced a series of preliminary solutions using this modified BSW5.0 and processing of a global network based on double-differencing (DD) and precise point positioning (PPP). These solutions are based on IGS repro1 products (ig1) and UNT products and in this study, we provide an evaluation of the UNT products, with respect to the IG1 products based on the resultant coordinate time series from the PPP and DD solutions.

Introduction

To obtain GPS time series with accuracy suitable for land movement monitoring both at the tide gauges and to observe glacial isostatic adjustment signals, GPS orbit, clock, and EOP products that are homogeneous and consistent through time are essential. The first attempt at producing GPS products of this quality was the IGS repro1 reprocessing effort, resulting in the IG1 combined products comprised of the repro1 contributions from all of the analysis centres. At the same time the University of Nottingham also developed a preliminary set of consistent homogeneous orbit, clock and EOP products, hereafter referred to as UNT products.

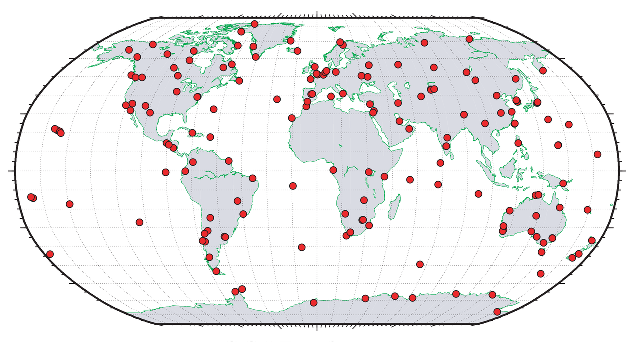

Figure 1.IGS05 reference stations

In this study, the UNT and IG1 products are compared directly to identify any obvious shortfalls in the UNT generation strategy and to ensure they are of comparable quality. Both the UNT and IG1 products were then used to produce both PPP and DD solutions to assess the relative accuracy and precision of their resulting daily position time series and computed velocities.

The final UNT products consist of satellite orbits at 900 sec. intervals, EOP with 12h intervals, and satellite and receiver clock corrections with 300 sec. intervals, all of which are consistent and homogenous. These were generated using the version of the BSW5.0 described above. The IGS05 reference frame was realized with no-net-rotation and no-net-translation conditions applied to a set of 155 IGS05 global reference stations (Figure 1). Solid Earth pole tides were modelled according to the IERS Conventions 2003 (McCarthy and Petit, 2004) and the ocean tidal loading model FES2004 (Lyard et al., 2006) was used. Absolute satellite and receiver antenna phase centre offsets were applied and first order ionospheric terms were eliminated. The UNT precise satellite orbit products were generated using 3-day orbit arcs to produce a final 24h satellite orbit arc.

The UNT and IG1 products were then each applied in separate DD and PPP solutions, using the same version of BSW5.0, the same models, and the same reference stations. However, for the DD solution the ITRF2008 reference frame was realized by applying no-net translation and no-net-scale conditions. These IG1 and UNT PPP and DD solutions were then differenced to compare their velocities and RMS values, called IG1-UNT_DD and IG1-UNT_PPP.

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Product Comparison

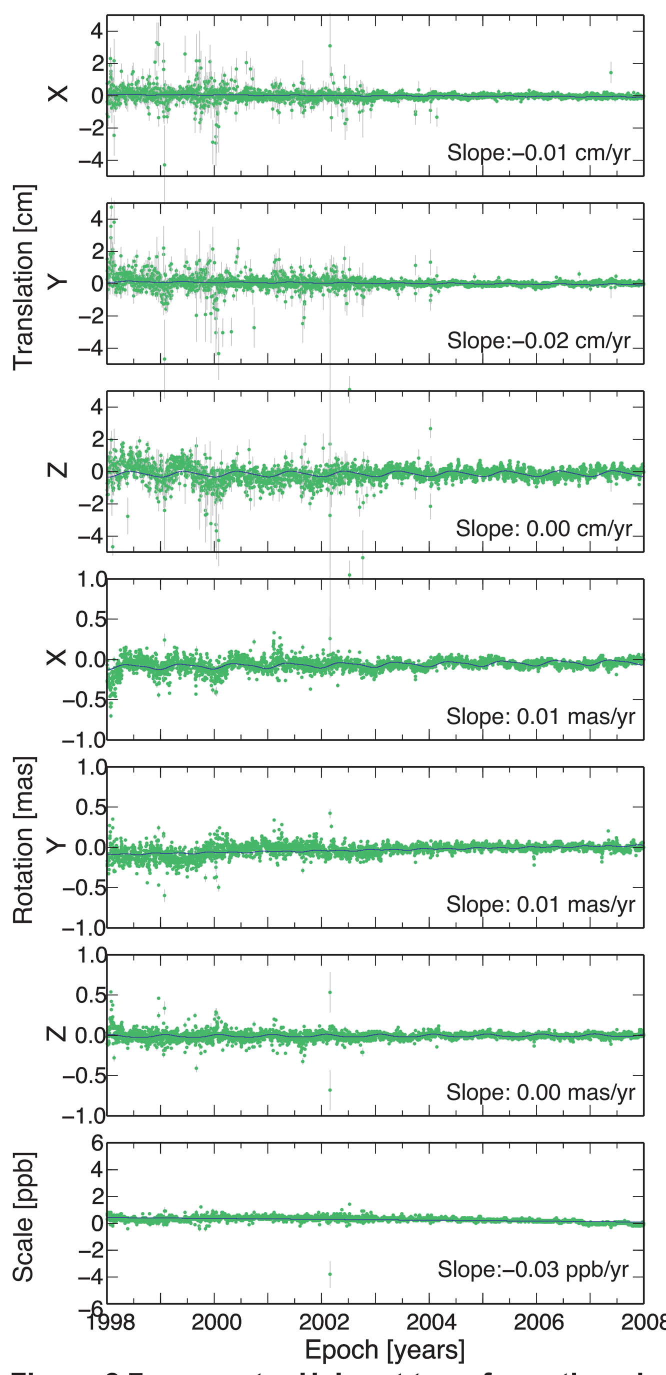


Figure 2.7-parameter Helmert transformations between IG1 and UNT 3-day orbit products.

The UNT products were compared with the IG1 products for the period from 1998 to 2007, to verify that they are of comparable quality. Figure 2 shows the 7-parameter Helmert transformations between IG1 and UNT 3-day orbit products. The differences between the IG1 and UNT orbits decrease over time with a noticeable decrease in 2003, mainly due the addition of ~20 new stations to the reference network providing a more well determined reference frame for both solutions.

The annual median values for the RMS of the 7-parameter Helmert transformations between the IG1 and UNT satellite orbits (Table 1), show the orbits converging over time with a consistent reduction in RMS from 1998 to 2007.

Table 1.The annual median values for the RMS of the 7-parameter Helmert transformations between the IG1 and UNT satellite orbits.

	1998	1999	2000	2001	2002
IG1-UNT	32.4	26.4	19.2	21.1	16.8
	2003	**2004**	**2005**	**2006**	**2007**
IG1-UNT	12.7	11.1	10.8	10.5	10.6

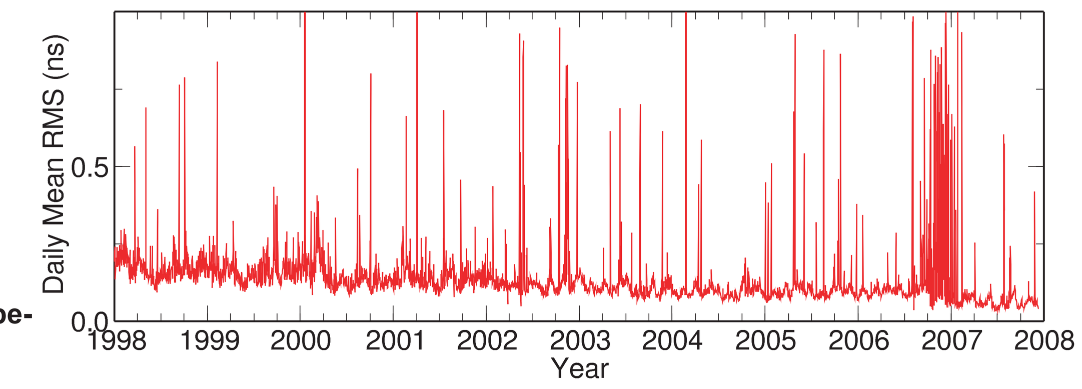
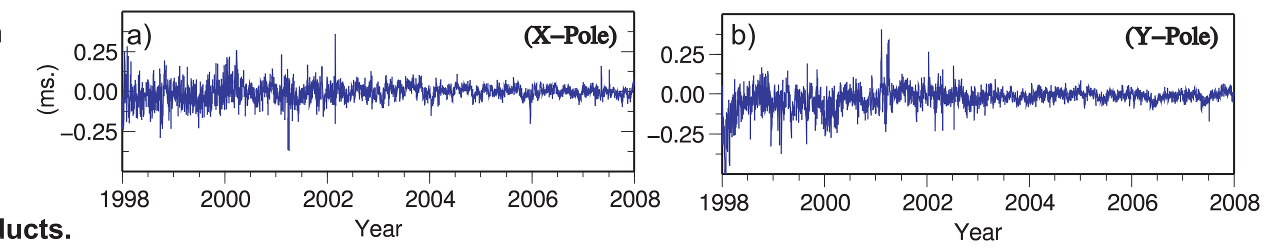


Figure 3. The daily RMS [ns] of the differences between the IG1 and UNT satellite clock products.

The daily RMS [ns] of the differences between the IG1 and UNT satellite clock products (Figure 3), show periods of increased scatter, for instance September 2006 - January 2007, which coincides with the Kuril Island and Hawaii earthquakes, directly affecting 7 reference stations. However, the long-term trend of daily mean RMS is to decrease with time from 0.2 to 0.1 ns or less as the reference network grew.

Finally, figure 4 displays the differences between the IG1 and UNT pole coordinate parameters for the X-pole (XP) and Y-pole (YP). In general, the UNT XP and YP are consistent with IG1 where the difference values for both XP and YP decrease from 0.25 to 0.10 ms or less.

Figure 4. The differences between the IG1 and UNT pole coordinate parameters [ms] for the a) X-pole (XP), and b) Y-pole (YP).



Product Evaluation using DD and PPP Position Time Series

Sample results for BRUS show that the IG1_DD and UNT_DD time series (figure 5a,b) are comparable. In contrast, the IG1_PPP time series (figure 5c) has a semi-annual signal which is removed after GPS week 1400. Another smaller change in the characteristics of the time series occurs in GPS week 1621. As these have not been reported elsewhere they are still under investigation.The UNT_PPP time series (figure 5d) show less scatter and no such periodic signal for the East component, making the UNT products appear to be consistent over time.

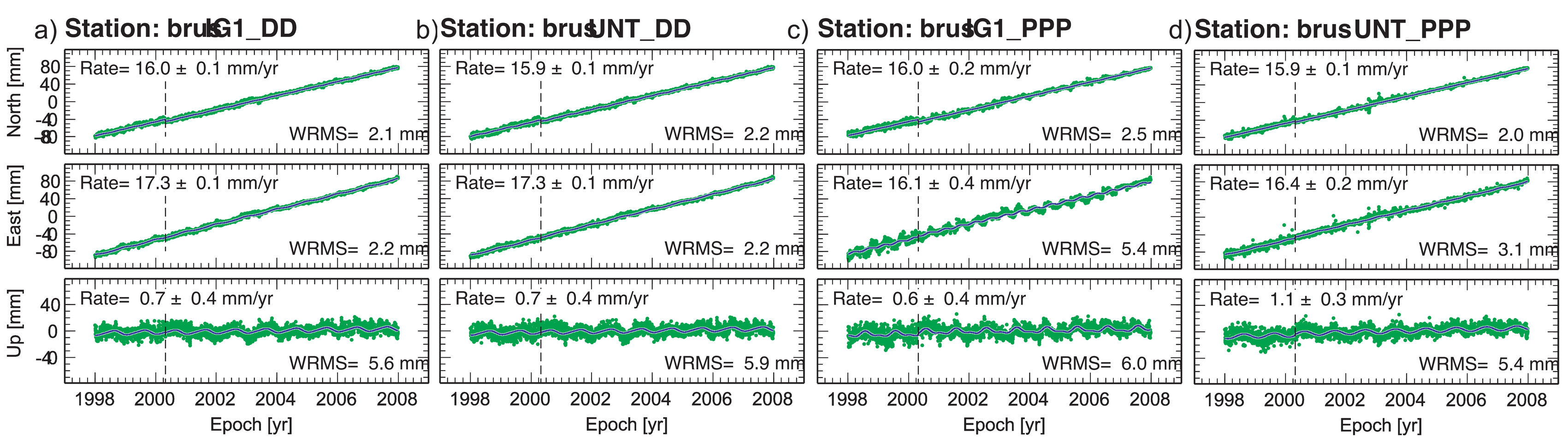


Figure 5. The daily position time series for BRUS from each of the processing strategies: a) IG1_DD, b) UNT_DD, c) IG1_PPP, d) UNT_PPP

Table 2. Mean, 1-sigma standard deviation, min, and max for the RMS differences [mm] in NEU for the IG1-UNT DD and PPP results.

	IG1-UNT_DD			IG1-UNT_PPP		
	N	E	U	N	E	U
mean	-0.09	-0.09	-0.06	0.81	1.62	0.98
SD	0.14	0.11	0.23	0.61	1.24	1.27
min	-0.61	-0.82	-0.80	-0.84	-1.13	-1.90
max	0.22	0.14	1.03	2.72	5.17	6.00

Table 3. Mean, 1-sigma standard deviation, min, and max for the velocity differences [mm/yr]] in NEU for the IG1-UNT DD and PPP results.

	IG1-UNT_DD			IG1-UNT_PPP		
	N	E	U	N	E	U
mean	0.03	0.02	0.09	0.02	0.01	-0.17
SD	0.22	0.11	0.18	0.27	1.01	0.54
min	-0.78	-0.24	-0.48	-0.78	-3.68	-1.76
max	0.46	0.4	0.77	0.95	2.64	2.09

RMS -> IG1-UNT_DD: The global plot of these values (figure 6a) shows that, although most stations display an increase in day-to-day scatter when using the UNT products, a few stations in the southern hemisphere have a reduced RMS.

RMS -> IG1-UNT_PPP: The spatial distribution of the RMS differences (IG1-UNT_PPP) for the Up component (figure 6b) shows a regional pattern with the largest improvements occurring at the equator and low-mid latitudes. Conversely, the polar regions, particularly the southern hemisphere, show more day-to-day scatter for UNT_PPP.

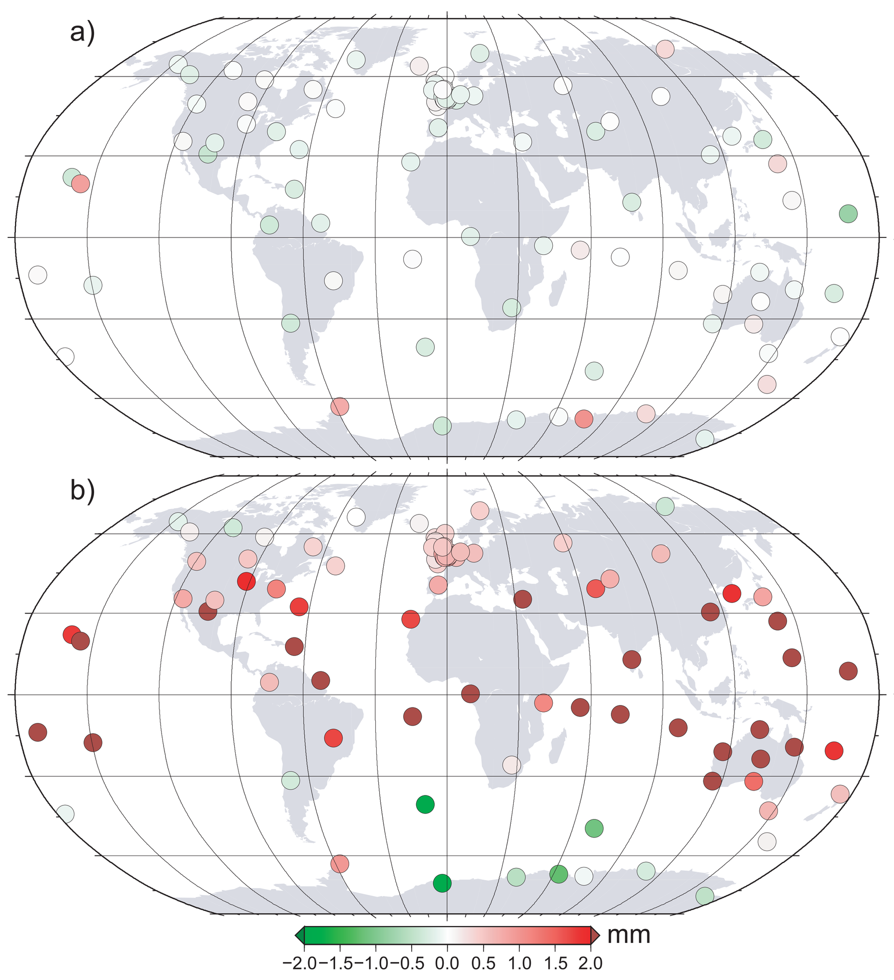


Figure 6. Global plots of RMS differences [mm] for IG1-UNT for the a) DD results, and b) PPP results.

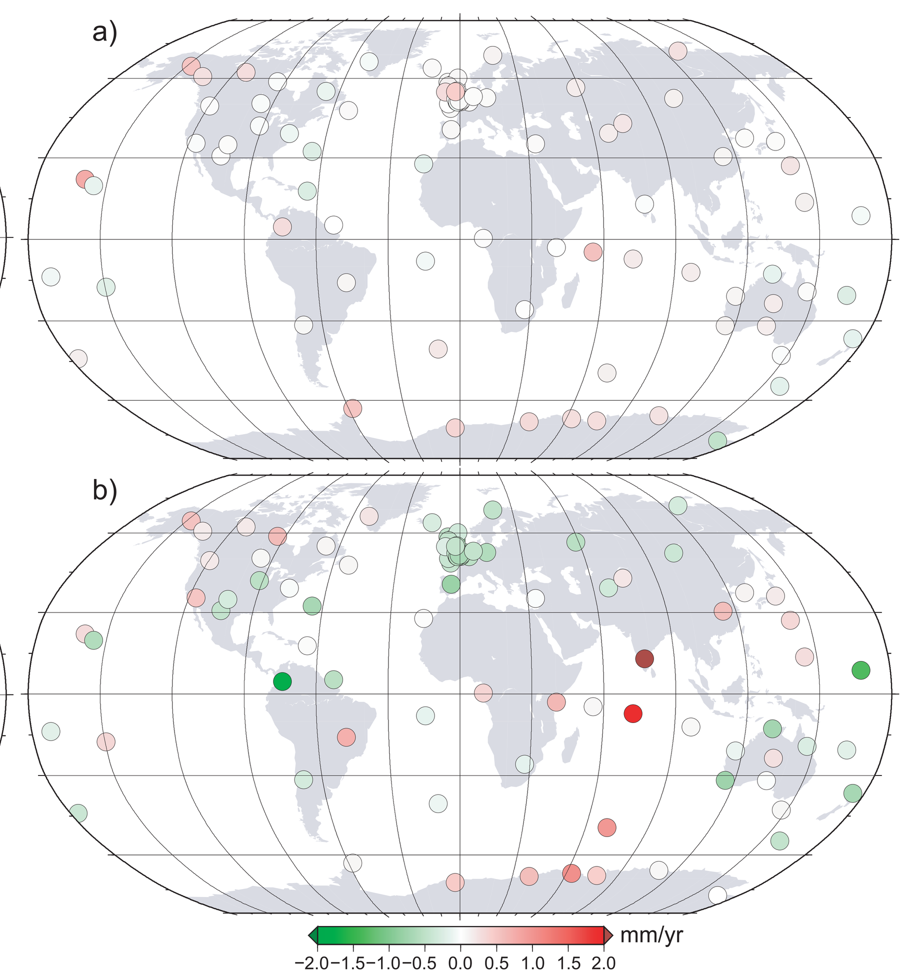


Figure 7. Global plots of Velocity differences [mm/yr] for IG1-UNT for the a) DD results, and b) PPP results.

RATES -> IG1-UNT_DD: Figure 7a (IG1-UNT_DD) shows that for most stations the UNT_DD velocities are slightly less positive or more negative than IG1, as indicated by a mean of 0.09 ± 0.18 mm/yr 1-sigma SD (Table 3) for UNT_DD.

RATES -> IG1-UNT_PPP: The velocity differences from IG1-UNT_PPP comparison are small for the north component with a mean and 1-sigma SD of +0.02 ± 0.27 mm/yr (Table 3). The east component has a large SD of ± 1.01 mm/yr (Table 3), which is reflected in the min: -3.68 mm/yr and max +2.64 mm/yr velocity differences. This is believed to be a combination of the above mentioned semi-annual signals in the IG1_PPP solutions and the fact that the integer ambiguities were not resolved. The average velocity difference of the Up component is -0.17 ± 0.54 mm/yr (Table 3), and in Figure 7b (IG1-UNT_PPP) most stations are green, indicating that the UNT products produce vertical velocities that are slightly more positive or less negative. Notably, there is also a regional pattern suggested, where all of Europe has more positive or less negative velocities for the UNT products, while Antarctica and the Indian Ocean appear to have less positive and more negative velocities.

Conclusions

We have introduced the activities of the BLT analysis centre at the University of Luxembourg and the British Isles continuous GNSS Facility (BIGF). We have presented an evaluation of the initial UNT satellite orbit and clock, as well as EOP products using the IG1 products over the period of 1998-2007. The convergence of the IG1 and UNT products as the global reference network grew, confirms that the UNT product generation strategy is fit for purpose, and of comparable accuracy to the IGS repro1 products. The DD results show the UNT products cause a slight increase in daily scatter at many stations, while the velocity variations show no regional bias between the products. The IG1 products are unsuitable for PPP, thus the IG1-UNT_PPP results differ more dramatically, but indicate that the UNT products are homogeneous, consistent, and a viable alternative to the IG1 products. The pilot UNT products will be replaced by the BLT products, which will apply the latest antenna phase centre calibrations within the IGS08 reference frame and be computed using the updated Bernese GNSS software v5.2. The BLT satellite orbit and clock, and EOP products will be BLT's contribution to the TIGA reprocessing campaign.