Re-processing strategies, station selection issues, discussion points and conclusions

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Abstract

This paper summarises the processing strategy issues for the IGS Reprocessing Analysis Centres. Guidelines for the station selection are discussed in order to maximise the benefit of the reprocessing effort. Finally some of the discussion points covered in the session will be presented as well as the conclusions and recommendations.

Introduction

The reprocessing effort has been agreed among the IGS Analysis Centres and will take place in the near future once the IGS05 (the IGS ITRF2005 realisation) is officially adopted. The first reprocessing activity will commence with the reprocessing of 3 months from the start of the year 2000, this pilot project will serve to identify problems and to improve the coordination among ACs. During the 2006 IGS workshop a session was organised a position paper was prepared and presented, (Steigenberger et al, 2006) together with invited speakers to present and discuss the reprocessing open issues.

Reprocessing Analysis Centres

5 of the IGS Final Analysis Centres have agreed to participate in the reprocessing effort, additionally a newly made collaboration between TUM/TUD and GFZ, named PDR (Potsdam Dresden Reprocessing) will be the sixth AC for this effort. Additionally the regular IGS Analysis Centre Coordinator (ACC) will coordinate the reprocessing as well. The ACs and the product coordinators are listed in Table 1.

The products to be produced include GPS orbits, Earth Orientation Parameters, clocks (stations and satellites), station positions and station Troposphere Zenith Delays. All these products will be combined/compared as indicated in Table 1, the only missing combination centre is for the TZD values, which we hope to resolve soon.

Table 1: Reprocessing Analysis and Combination Centres

Abb.	Activity	Institution	SW
GFZ	AC ACC	GeoForschungsZentrum	**EPOS**
PDR	AC	GFZ Potsdam, TU Dresden Potsdam Dresden Reprocessing (formerly TUM/TUD)	**Bernese**
NGS	AC	National Geodetic Survey	**page5**
SIO	AC	Scripps Institution of Oceanography	**GAMIT**
ESA	AC	European Space Agency / ESOC	**NAPEOS (BAHN)**
EMR	AC	Natural Resources Canada	**GIPSY**
EMR	SINEX Comb.	Natural Resources Canada	
NCL	SINEX Comb.	Univ. Newcastle upon Tyne	
NRL	Timescale	Naval Research Laboratory	
UNT	-	Univ. of Nottingham	
-	TZD Comb.	-	

Station selection issues

As highlighted in the REPR position paper (Steigenberger et al, 2006), one of the main emphasis of the reprocessing effort must be to obtain long time series for station positions as part of full system solutions. By having coherent, consistent time series for the stations using the current state-of-the-art techniques a considerable improvement can be expected in the station's evolution over time and the data will be of much greater use for geodynamic and geophysical studies.

To increase the use of the maximum number of stations by at least 3 ACs at all times a short investigation was undertaken to report the actual availability of stations. This involved contacting the different interest groups in the IGS for their station needs, and to arrive at a coherent proposal so that ACs with flexibility in their station selection process can help "fill the gaps" as needed.

Station availability

Stations availability is a very big issue nowadays, we now have too many stations for the ACs to process regularly, and some stations may not have the needed data continuity despite the best efforts of the IGS Central Bureau. For this reason it is normally difficult to affect changes at the ACs to switch stations or to include new stations. All ACs have limited resources so processing all stations is simply impossible and all also have their own set of stations they are required to process for internal reasons. Therefore of the wider IGS network only the reliable and trusted stations tend to get picked for processing, leaving many others not satisfying the 3 AC coverage rule so important for good combinations of station results. In the past the situation was reversed, not enough stations were running

and so all ACs had to use what was available, which included certain more unstable or undesirable stations.

The reprocessing activity will again make the ACs confront both extreme situations in a much shorter period of time (it is projected that the entire 12 yr reprocessing should not take more that 1 yr to complete). Looking at the actual numbers of RINEX data files held at the different IGS online repositories Figure 1 has been compiled by polling each of the IGS Data Centres (DCs) ftp servers a few days per year for the last 12 years.

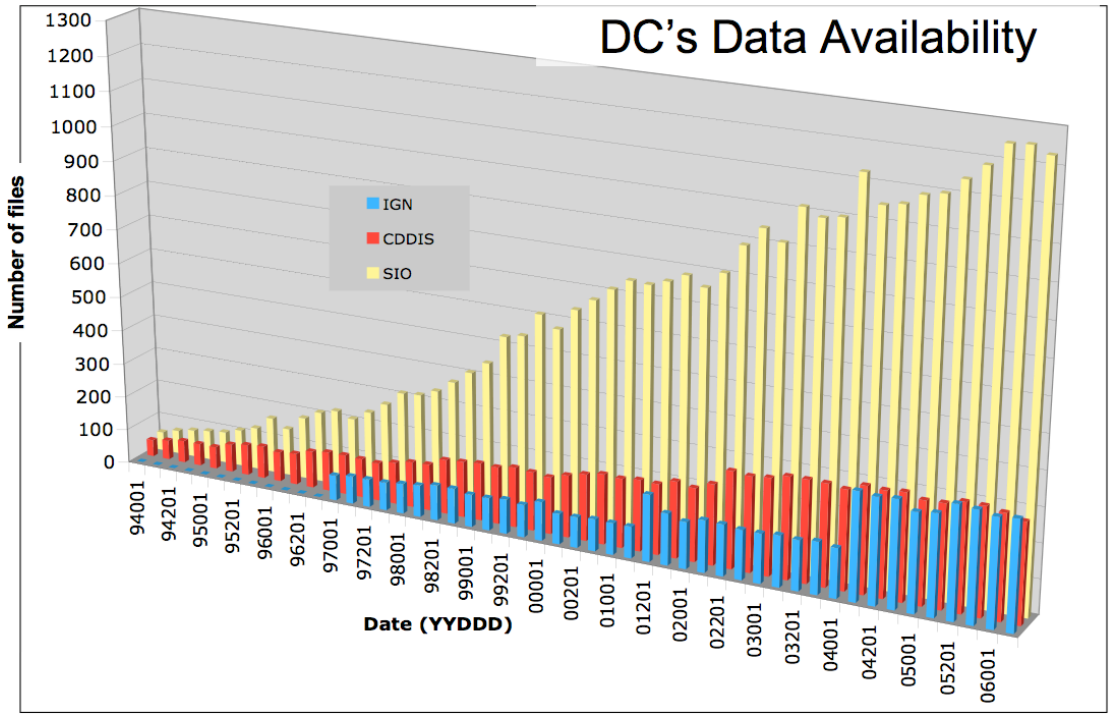

Figure 1: RINEX files available over the last 12 years at IGS DCs

The situation among the different DCs is varied. The DC SIO (lox.ucsd.edu) holds all the available IGS stations plus all the US CORS stations, which as can be seen, includes a very large number of stations. The DC CDDIS (cddis.nasa.gov) is the most reliable source for IGS GPS data (currently 300+ daily stations); it holds all the stations for which the IGS has a station log (igscb.jpl.nasa.gov) plus a few others. The IGN DC (igs.engs.ign.fr) holds most of the recent IGS stations but not the historical files, it also holds the EUREF (www.epncb.oma.be) station files. The newest IGS DC KASI (nfs.kasi.re.kr) (not pictured) holds a complete mirror of the CDDIS server.

Clearly from Figure 1 the number of stations has steadily increased over the last decade, the current number of available daily stations (300+) is beyond what any AC actually processes within the IGS, this means that either by action, inaction or internal requirement every AC makes a decision at some level as to what stations are included in their solution.

Analysis Centre station usage

As mentioned above each AC uses a certain number of stations depending on the software capability, internal requirements, historical use and recommendations. Table 2 presents the weekly use of stations for the reprocessing ACs as derived from the current IGS Final submissions. The ESA figure is a projection for when the new processing software is installed, the figure in parenthesis is the current value.

Table 2: AC station usage from IGS Finals

GFZ	SIO	NGS	ESA	EMR	PDR
180+	90+	150+	100+ (60+)	50+	160+

To gain maximum benefit from the reprocessing effort it is important to try and ensure that as many stations as possible are covered by at least three ACs. The stations vary in importance in the IGS network; some of them belong to important IGS "interest groups" and therefore the ACs should try to support these groups as far as possible.

Reprocessing station selection

As mentioned above there are a number of groups within the IGS that have an interest in making sure that certain stations get included in AC processing. The groups include; Reference Frame Stations, Co-located stations, Timing stations, NGA stations, TIGA stations (tide gauge stations with GPS receivers). The approximate numbers of stations within each group are shown in Table 3.

Table 3: Interest group station numbers

Ref. Frame	Co-located	Timing	NGA	TIGA
100+ stations	100+ stations	~115 stations	12 stations	65+

These numbers are current station numbers and it is clear from Figure 1 that stations have been increasing steadily, so while the number of stations appears large the situation over time is rather fluid as stations have been added mainly in the later years.

Analysing the actual file available over time at the CDDIS DC (cddis.nasa.gov) is an interesting look at how the number of "interest" stations has increased over time, so as to check when coordination efforts may be needed. The plots are presented in Figure 2, below. The plots are separated by group as follows; COL.- co-located stations, REF.- reference stations, CLK.- clock stations, TIG.- TIGA stations. The NGA stations are provided to the IGS for a limited time (2000 – 2005), and since there are only a few number of stations the impact is not too relevant, but some conclusions were reached during the workshop, presented in the conclusions of this paper.

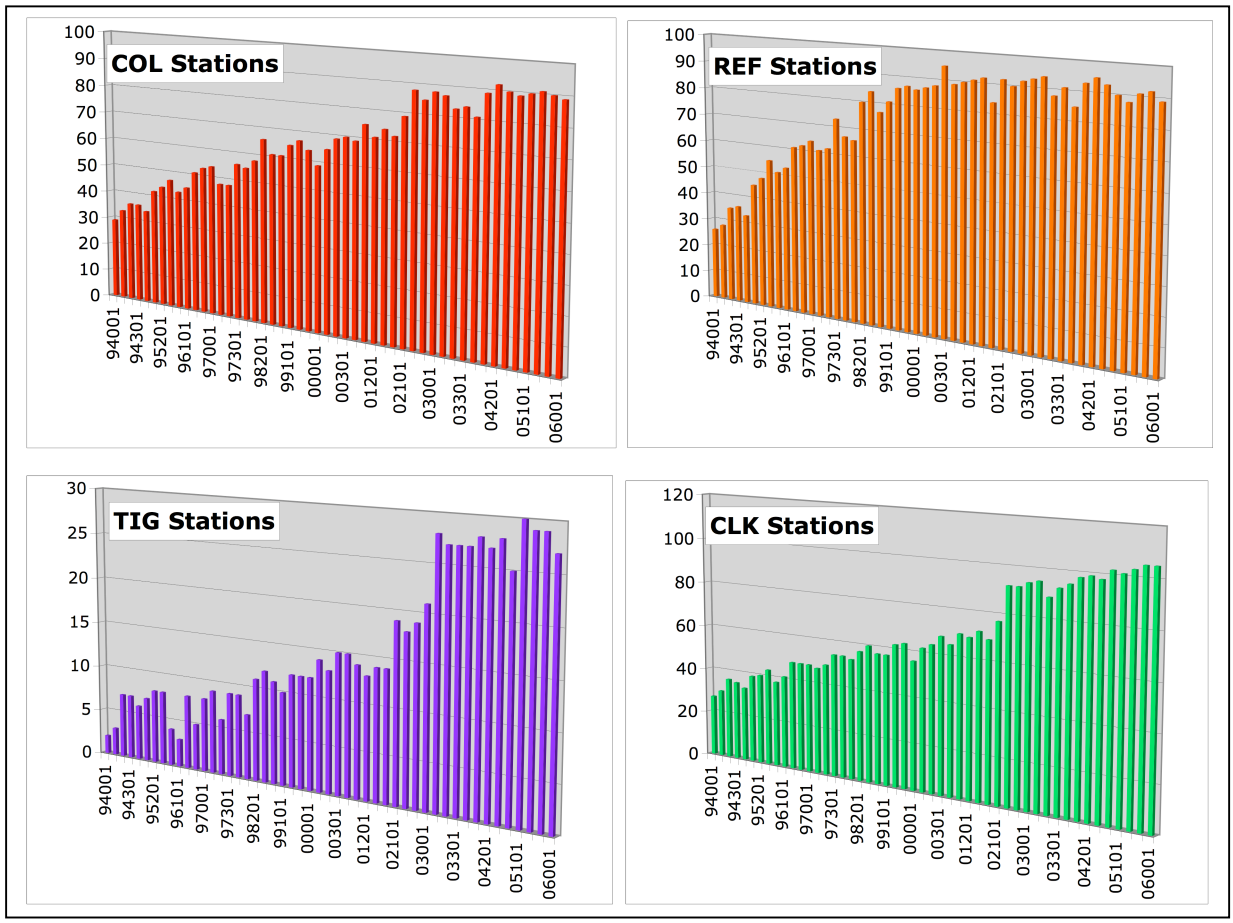

Figure 2: Station groups available over time

Figure 2 shows that the number of stations considered important for the interest groups increases as expected over time. This is of particular importance for the REF stations since the IGS realisation of ITRF2005 comes through the use of station positions and velocities. The situation for the initial years needs to be further studied by the Reference frame maintainers before the reprocessing starts, to make sure the number of available stations is enough.

An additional issue, which simplifies the coordination of the stations as proposed by the different interest groups, is that there is significant overlap. The same stations are included in several of the lists and are important for different reasons for each of the different groups. Table 4 presents the number of stations in each group and how many are covered by the previous group, moving from left to right. It can be seen that among the three most important groups (REF, COL, CLK) there is significant overlap and so that covering for example stations in the REF and COL lists would largely satisfy the CLK list as well as some of the TIGA stations.

Therefore it can be stated that over the time of the reprocessing the stations are not all available anyway, so little coordination may be needed as they will simply be the only stations ACs can select. It is also a simplifying factor that stations are on several of the lists and therefore it is possible to provide a high degree of coverage just by ensuring that the most important lists are always covered.

Table 4: Station overlaps

Ref. Frame	Co-located	Timing	NGA	TIGA
100+ stations	100+ stations	~115 stations	12 stations	65+ stations
-	50 % in prev list	85 % in prev lists	0 % in prev lists	37 % in prev lists
100+ new stations	51 new stations	18 new stations	12 new stations	43 new stations

224 Unique stations

To ensure 3 AC solutions for each of the unique stations some coordination may, in any case, be needed as agreed during the workshop. The ACs will be contacted to learn which are the stations they intend to use for the reprocessing and any indication of possible changes. If any of the ACs has flexibility then the reprocessing coordinators will try to ensure that the maximum number of stations are covered by 3 or more ACs.

As for the NGA stations an effort will be made at IGS level to try to obtain longer time series for the stations' data provided, plus a continuous data flow of these stations. Without a longer timeline of data and without continuous data it is left up to each AC to use the station or not, no recommendation will be made to the ACs and no special coordination will apply during the reprocessing campaign.

The TIGA stations will be considered after consultation with the TIGA pilot project leaders as to the importance and relevance of the stations' solutions. As can be seen from Figure 2 a significant number of TIGA stations are available at CDDIS, and therefore if judged useful it may be a benefit that the IGS ACs process these stations in the wider context of the reprocessing campaign.

Even if after this effort some important stations are left out of the reprocessing solutions an IGS PPP effort could be envisioned to provide/complete time series of certain station data. The details of such an effort will be decided and agreed in future as needed.

Conclusions

The reprocessing session position paper (Steigenberger et al, 2006) left some issues open for discussion. After the invited presentations at the reprocessing session a discussion took place with the attendees as to what conclusions could be agreed, the following is a comprehensive list;

1. Station selection will be a list of recommendations after analysing missing stations from the AC lists.
2. NGA stations, no recommendation at this time, unless a full set of data up to the present can be secured.
3. Processing summaries need to be submitted by each AC (Steigenberger et al, 2006) both for the reprocessing and as part of the regular IGS activities as the previous existing summaries are incomplete and outdated.
4. The use of the GMF (Boehm et al., 2006) is recommended but as important is the proper use of the wet and dry parts and also the correct explanation of current practices through the new processing summary.

5. P1-C1 DCBs are to be used back to 1994 as monthly averages as provided by the joint effort of GFZ and CODE.
6. SINEX files will be provided weekly rather than daily.
7. Station position discontinuities will be handled in the SINEX files with time validity intervals.
8. Clock files will be provided with 300 sec resolution for stations and satellites. A limited 30 sec satellite clock effort could be coordinated with the IGS LEO Working Group to support their activities.
9. Reprocessed orbits should be validated with SLR.
10. The question of TZD combination/comparison is left open for the time being.

References

Steigenberger, P., I. Romero, P. Fang, (2006), Reprocessing Issues, Standardization, New models, *Proceedings IGS Workshop 2006*, Darmstadt, Germany.

Boehm, J., A. Niell, P. Tregoning, and H. Schuh (2006), The Global Mapping Function (GMF): A new empirical mapping function based on numerical weather model data, *Geophysical Research Letters*, 33 (L07304), doi:10.1029/2005GL025546.