Implementing the New ILRS CRD Data Format

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Abstract

The new CRD format is now set to replace the current formats used to disseminate the ILRS data. Stations are expected to pass compliance tests and then submit their data in CRD by sometime in 2010. We have used data provided in the new format to generate test results, and put in place the process by which we will be "digesting" such data into the current analysis scheme at the JCET AC (using NASA's GEODYN). We will show results obtained using a small sample data set of NP from MLRS. These will be compared to the nominal results obtained from the exact same data set provided in the current ILRS format. Our intention is that following the Poznan workshop, the JCET AC will be ready to accept CRD data from the ILRS network in order to validate stations that wish to convert to this format.

Introduction

In anticipation of ILRS' transition to a new data format, the Consolidated Laser Ranging Data Format (CRD) [Ricklefs and Moore, 2008], we have developed a mechanism to ingest the current SLR data in CRD format in Goddard's GEODYN data analysis environment. We use this mechanism to compare results obtained from the original data in the ILRS Quick Look Normal Point (QLNP) format to those obtained with the data transmitted in the new format. The ILRS Analysis Working Group (AWG) has been tasked to validate the CRD-formatted data from each ILRS site, before that site can switch its delivery format to the new one. This contribution documents one approach for this validation task and results for the first site to successfully complete this process.

Importing CRD data into GEODYN

As most data analysis software packages, GEODYN has its own format options for the various data that it is capable to analyze. This is the result of a preprocessing software called the Tracking Data Formatter or TDF, which accepts the data in several formats, binary or ascii, and generates a binary output file that is the format recognized by GEODYN. In the case of ILRS SLR data, up to this date the data could be delivered either in the ILRS QLNP format or the Full Rate (FR) format, both of which are formatted text files. The process of importing them in GEODYN involves two steps:

- For the QLNP data:
  a. Reformatting the QLNP to the (binary) TDF input format
  b. Converting the above file to a GEODYN data (binary) input file
- For FR data:
  a. Use TDF's option to ingest data in the FR format directly, and convert the file to a GEODYN data (binary) input file in one step

The new CRD format has an entirely different structure from either QLNP or FR, with groups of records of different types, some mandatory, some optional, the content of these

records being variable and free-formatted, etc. Above all, the freedom in the way that each quantity enters each record allows a much greater precision for these quantities than the previously fixed formats allowed. The CRD format allows also for a multitude of additional parameters from the engineering qualification of the data to be passed on to the analyst, which however are by and large not necessary for the reduction of the data. This meant that instead of modifying TDF to read the CRD files directly, we could use an interim format to achieve the same effect, as long as that format could accommodate the higher precision in the CRD data records.

We chose to modify the FR format to what we internally call an "extended FR" format (x-FR), which allows for practically any precision in the most important quantities, e.g. the time, the range and the meteorological data. We then modified TDF adding an option that can handle this x-FR formatted data. This allows the data to be readily used in GEODYN with minimal changes in the code and the processing mechanics. This extension can now be used operationally to process ILRS CRD data with GEODYN while at the same time we can also handle data in any of the previously used formats. This flexibility is extremely useful, as it will become apparent in the next section.

Validation of CRD data releases

The first site to release CRD data is the McDonald Laser Ranging Station (MLRS – 7080). In order to be able in the future to validate stations efficiently when a large number of sites will be submitting CRD data simultaneously, we developed an automated procedure that compares the results on a weekly basis. The process is run in parallel to our operational weekly solution for the official Pos+EOP product. Once the data of the week have been reduced and the final fitted orbits are available, we generate a new data set for input to GEODYN: this one contains all the data from the standard (current) format, QLNP, and in addition, all the CRD data from all stations that submitted data during that week, except that in this case the tracking station number for those stations is modified: the leading digit is replaced by a "9". This way, the GEODYN input data set contains both types of data from the same station, yet we can differentiate how each group will be treated during the reduction process.

Within the GEODYN environment, we have the option to weigh data differently for different stations. We thus choose to use the QLNP data full weight, so that the orbital fit is based on that data, and assign a zero weight to the CRD data (from the "9xyz" sites), so that while they do not affect the orbital fits and they are not considered in the computation of the statistics, we can still obtain residuals to the fitted model. The premise is that if the two groups describe the collected data correctly, then they should produce comparable residuals when compared to the same orbit.
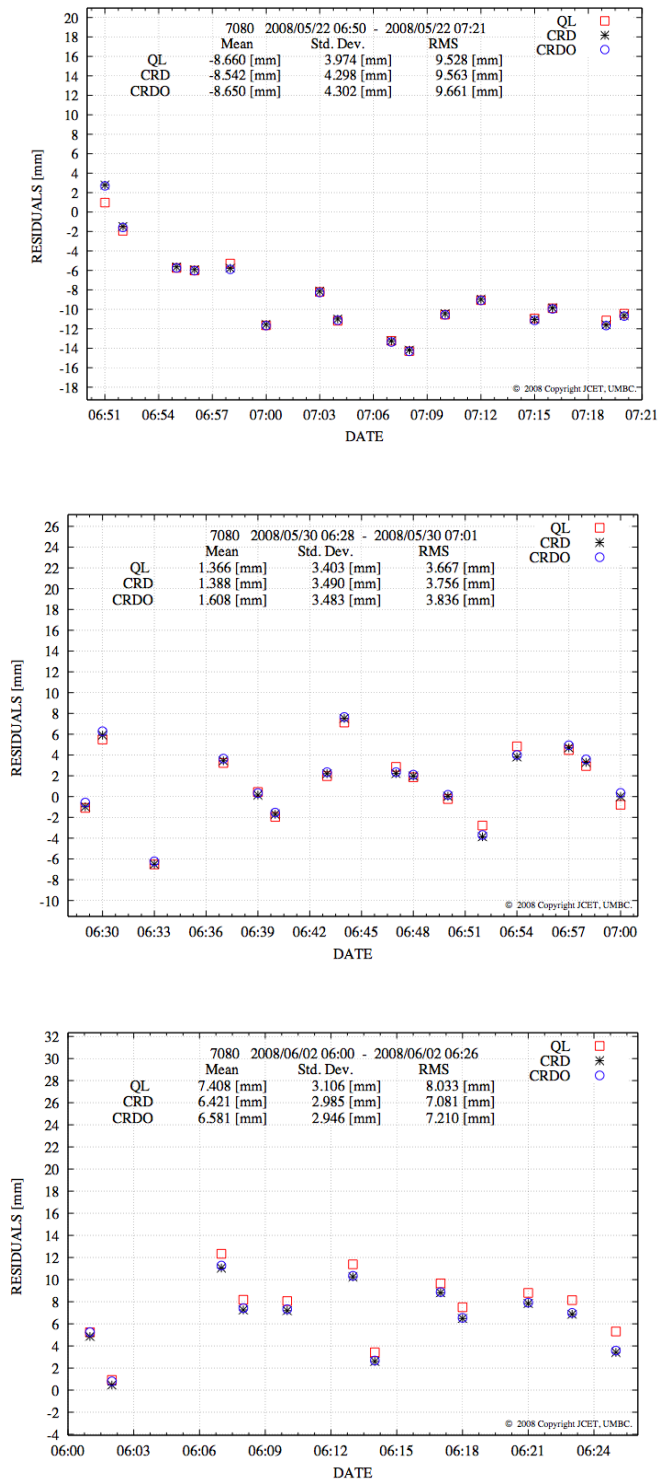
Figure 1. Visualization of residual differences from variously-formatted data. QL denotes the old ILRS format, CRD denotes data obtained from the new CRD format using an in-house developed s/w, and CRDO are those converted the ILRS-supplied s/w.

The residuals cannot be identical because as it was already mentioned, the new format affords higher precision in many of the recorded quantities, so small differences are expected and justified. A quick way to verify the consistency between these two sets of residuals is to form their statistics for each pass and to visualize them on a pass-by-pass basis (Fig. 1). Note that depending on the case, there is more or less agreement between the various formats. We have discovered that this is mostly due to the way the meteorological data are applied, i.e. whether interpolated to the observation time (as in QLNP files) or used as supplied in the CRD format. Table 1 shows the statistics for a number of MLRS LAGEOS passes collected in July and August of 2008. These results indicate that the agreement is at the 0.5 mm level, which is consistent with the fact that we do expect a small difference between the two sets due to the increased precision in some of the key recorded quantities.

Table 1. Residual statistics from the same orbital fit for QLNP and CRD data.

STATION	YY/MM/DD	HH:MM	Std. Dev.	Mean	RMS	Pass No.	Min	Max
70802419	2008/7/11	9:31	0.992	16.257	16.287	1	15.040	17.470
90802419	2008/7/11	9:31	2.152	15.557	15.705	1	12.590	17.630
70802419	2008/7/12	4:42	6.916	15.933	17.369	2	3.795	24.730
90802419	2008/7/12	4:42	7.035	15.701	17.205	2	3.543	24.720
70802419	2008/8/4	8:32	6.164	1.918	6.456	1	-7.832	11.080
90802419	2008/8/4	8:32	6.096	1.750	6.342	1	-7.824	10.780
70802419	2008/8/5	7:16	3.482	8.968	9.620	2	4.309	14.520
90802419	2008/8/5	7:16	3.500	8.812	9.482	2	4.158	14.410
70802419	2008/9/6	2:26	16.616	1.115	16.654	1	-24.400	24.930
90802419	2008/9/6	2:26	16.428	1.056	16.462	1	-25.310	24.500
70802419	2008/9/18	17:08	2.432	-22.455	22.586	1	-26.540	-20.400
90802419	2008/9/18	17:08	3.056	-22.693	22.897	1	-27.900	-20.090
70802419	2008/10/3	0:43	10.689	-12.649	16.561	1	-30.610	-2.797
90802419	2008/10/3	0:43	10.659	-12.643	16.536	1	-30.610	-2.827
70802419	2008/10/6	10:12	6.468	-8.319	10.538	1	-16.550	0.754
90802419	2008/10/6	10:12	6.463	-8.381	10.584	1	-16.630	0.670
70802419	2008/10/7	2:34	22.476	-1.146	22.505	2	-32.640	32.370
90802419	2008/10/7	2:34	22.326	-1.427	22.372	2	-32.970	31.670
70802419	2008/10/7	5:56	4.498	-3.343	5.604	3	-8.887	4.358
90802419	2008/10/7	5:56	4.486	-3.382	5.618	3	-8.965	4.300
70802419	2008/10/8	11:01	4.663	-4.055	6.179	5	-10.520	2.924
90802419	2008/10/8	11:01	4.682	-3.879	6.080	5	-10.420	3.078
70802419	2008/10/8	4:40	16.561	7.350	18.119	4	-29.230	30.660
90802419	2008/10/8	4:43	16.340	5.128	17.126	4	-29.030	30.690

The initial tests indicated that although the observed differences are acceptable and can be explained by the increased precision, there are also cases where the two files differ drastically. In several instances, the number of normal points in the two files differed because of the way that they were formed and the difference in the precision of the epoch time or the range values. We also encountered cases when a pass was present in one file but not in the other, although infrequently, because of modified editing criteria, again primarily as a result of the different precision. All these were communicated back to the station, so that it could be investigated if there was any s/w issue in generating the new, CRD-formatted files or a

legitimate difference as explained above. As a result of these encounters with these test cases, we formed a "benchmark" test that was delivered to all AWG AC, where all special differences between the provided QLNP and CRD files were documented. A successful replication of these results provides some assurance that all AC involved in validating CRD submissions are "seeing" the same differences, so candidate stations need only be validated by a single AC, something that will help distribute the load the AWG will face in the next months and accelerate the station validation process across the entire network.

Conclusions

We have developed a procedure to use CRD-formatted ILRS normal points in Goddard's GEODYN package and to compare them to results obtained from ILRS QLNP-formatted data for the same observed ranges. We used this procedure to process several months of MLRS data and to validate the stations CRD formation process. The performed tests revealed some differences between the two versions of formatted data, which were easily explained by the difference in precision of key recorded quantities. We used a two-week period of data from MLRS to form a "benchmark" that we have shared with the other ILRS AC that will participate in the validation of the CRD data delivered by the network in the next year.

References

Pavlis, D. E. et al., *GEODYN II, Systems Description Vol. 3 (NASA GSFC, Greenbelt, MD*, 2008.

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