Availability of SLR Normal Points at ILRS Data Centers

Krzysztof Sośnica, Daniela Thaller, Rolf Dach, Adrian Jäggi, Gerhard Beutler

ABSTRACT

SLR observations in normal point format are available from two ILRS global data centers, namely CDDIS and EDC. The data are organized in daily and monthly files. The centers have different management philosophies. In CDDIS the files contain data released within one day, whereas EDC publishes the data in daily and monthly batches, containing observations stemming exactly from one particular day and month, respectively.

In this paper, we present the statistics concerning data availability in the two data centers for the period 1994-2010, as well as inconsistencies in quantity of normal point observations from EDC and CDDIS. The total number of measurements to LAGEOS -1, -2, ETALON -1, -2, GPS -35, -36, and to about 50 GLONASS satellites is also presented. We address the number of observations gathered by every ILRS station for the particular year and the global distribution of the stations with the statistics concerning the amount of data. In conclusion we show the data distribution along the groundtracks of geodetic satellites.

1 Inconsistencies at ILRS Data Centers

The organization of normal point files differs due to different management philosophies at the two ILRS global data centers (*Pearlman et al.* 2002). At CDDIS (Crustal Dynamic Data Information System) data are labeled with the release date (i.e., independent of the measurement epoch), whereas EDC (Eurolas Data Center) publishes data files containing observations stemming exactly from one particular day. After station upgrades, laser or telescope repairs, data from those stations are sent into "quarantine", which may last for half a year or even longer. CDDIS publishes SLR observations from several previous months in one file (labeled with the release date), whereas EDC updates the observations to the files labeled with the date of the measurement.

Problems may occur with the second and third release of data (for instance after reducing the station's time bias): the same observations are available twice, three or even more times in normal point files (correctly labeled with increased data release flag in the data record). One has to pay special attention in order not to use bad data but to use only the latest release. The above mentioned aspects must be considered in particular when reprocessing SLR data, because all observations should be considered in the correct way in order to achieve best possible results.

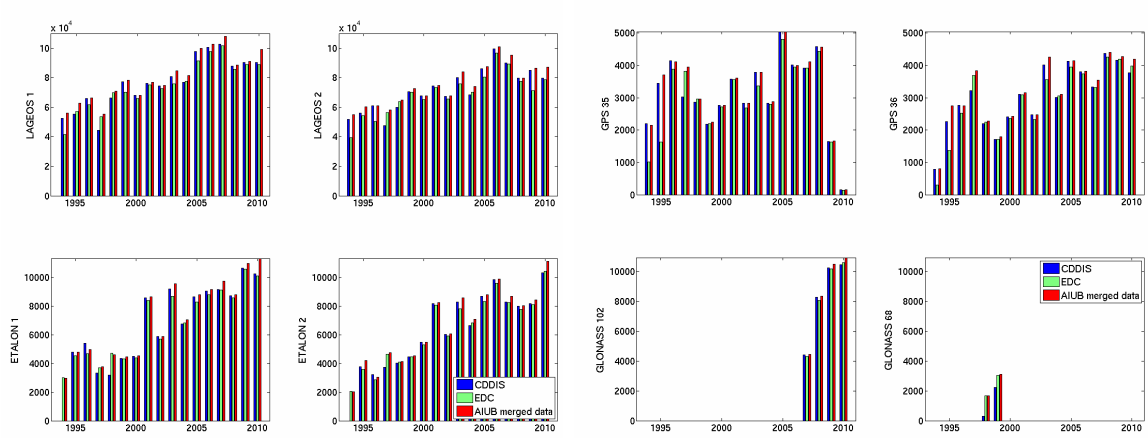

Figure 1: Number of available normal points in CDDIS, EDC and in the merged AIUB files for the time span 1994-2010. Note the different scales.

Fig. 1 shows the number of data gathered by CDDIS and EDC as well as the data merged at AIUB by taking into account both data pools. One can notice significant differences between the amount of data which is caused not only by

different management philosophies, but also by missing or multiple data. For the satellite GPS -35 the differences in the number of observations in 1994 and 1995 are about a factor of two, whereas in 2009 and 2010 the number of available data is almost the same. For the satellite GLONASS 68, which was tracked during the IGEX campaign (The International GLONASS Experiment, 1998-2000), taking into account data only from CDDIS would lead to a loss of half of all observations. In this case EDC contains the full set of measurements to this satellite, whereas the CDDIS data pool is incomplete. One has to pay attention that the files from CDDIS may include also observations from the previous year (or even older data). In general, we can conclude that a slightly bigger amount of data is available from CDDIS, but for some satellites this may be vice versa. The highest consistency between both data centers in observed for the period 2000-2009.

2 Observation Statistics

It is well known that the global distribution of the ILRS stations is imbalanced. Moreover, the stations differ in the quantity of delivered data (see Fig. 3), quality of normal points, types of observed satellites, and in the capability of tracking specific satellites during daytime or nighttime. The irregularities in the global coverage of the SLR stations result in the better fit to the limited regions. Moreover, it may produce some problems when generating Earth gravity field models based on SLR observations. Fig. 4 shows the development of the SLR network by taking into account the groundtrack of LAGEOS satellites. From 1994 till 2009 one can observe a big improvement, especially in the African, South American and Asian regions. The quality of European and Asian stations was also significantly improved. On the other hand, there is nowadays a smaller number of observations over North America than in 1994. Even if the general improvement of the SLR network is noticeable, there are still some gaps, especially over India, the Pacific and Atlantic Ocean, and the obvious gaps over Polar Regions due to the satellites' inclinations.

Fig. 2 shows the number of observations from 1994 to 2010 to four groups of satellites, namely LAGEOS -1 and -2, ETALON -1 and -2, GPS -35 and -36 and all tracked GLONASS satellites. In the case of LAGEOS, ETALON and GPS two satellites were tracked; in the case of the GLONASS satellites the number of observed satellites is indicated by the red bars. This number is usually 3-4 satellites per year with two exceptions: during the IGEX campaign all GLONASS satellites were tracked and from December 2009 Herstmonceux observes all active GLONASS satellites.

The number of observations to the LAGEOS satellites amounts from about 110,000 normal points in 1994-1998 to 200,000 in 2006-2007 (see Fig. 2). The number of observations was increasing till 2006. In 2008 there are about 40,000 less normal points than in 2007, but the situation is slowly improving again. According to Fig. 3 and Fig. 2 about 43% of all LAGEOS observations in 2005-2007 were collected by only 3 stations, namely Zimmerwald (7810), Mt Stromlo (7825), and Yarragadee (7090). In case of the ETALON satellites, there are about 5,000 observations in 1994 and 20,000 in 2010, implying that the number of normal points to the ETALONs is about 10 times smaller than to the LAGEOS satellites. One reason is that many SLR stations have problems with tracking high satellites with altitudes above 20,000 km (see Fig. 5). For GPS and GLONASS satellites the average number of observations is 6,000 and 35,000, respectively. The higher number of observations to GLONASS is not only due to bigger number of tracked satellites, but also due to the size of the retroreflector arrays (*Flohrer*, 2008). The Laser Retroreflector Array carried by GPS satellites are 19x24 cm (32 fused-quartz corner cubes), whereas GLONASS satellites have bigger reflectors, e.g. 120x120 cm (396 fused-quartz corner cubes). The larger arrays ease the tracking so that more stations are capable to track GLONASS satellites.

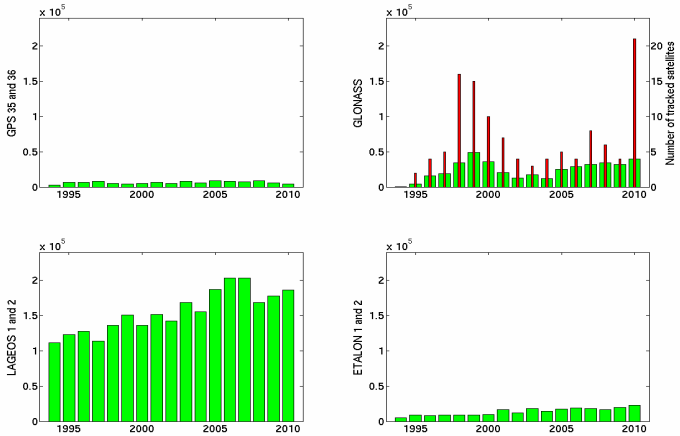

Figure 2: Number of SLR observations to LAGEOS, ETALON, GPS, and GLONASS satellites in 1994-2010.

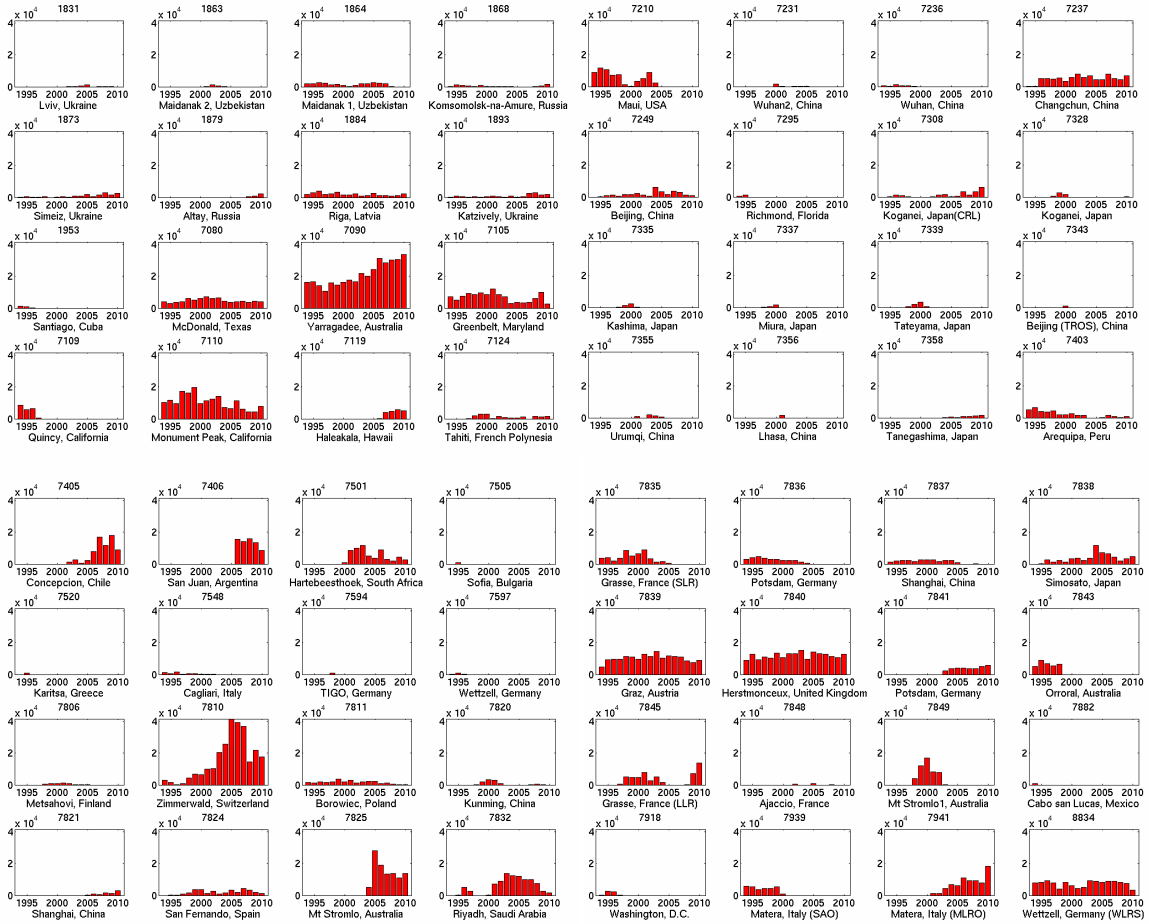

Figure 3: Total number of LAGEOS -1, -2 and ETALON -1, -2 normal points for the best performing SLR stations

Conclusions

The ILRS data centers differ in the number of available observations. Some observations are missing in one or the other center. Multiple entries for normal points can be found in CDDIS. The geometry of ILRS network has been improved since 1994 but the distribution of stations is still imbalanced. The stations differ w.r.t. the quantity of delivered normal points.

Acknowledgements

The ILRS (*Pearlman et al*. 2002) is acknowledged for providing SLR data.

References

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Correspondence

Krzysztof Sośnica
Astronomical Institute, University of Bern, Sidlerstrasse 5, CH-3012 Bern, Switzerland
sosnica@aiub.unibe.ch

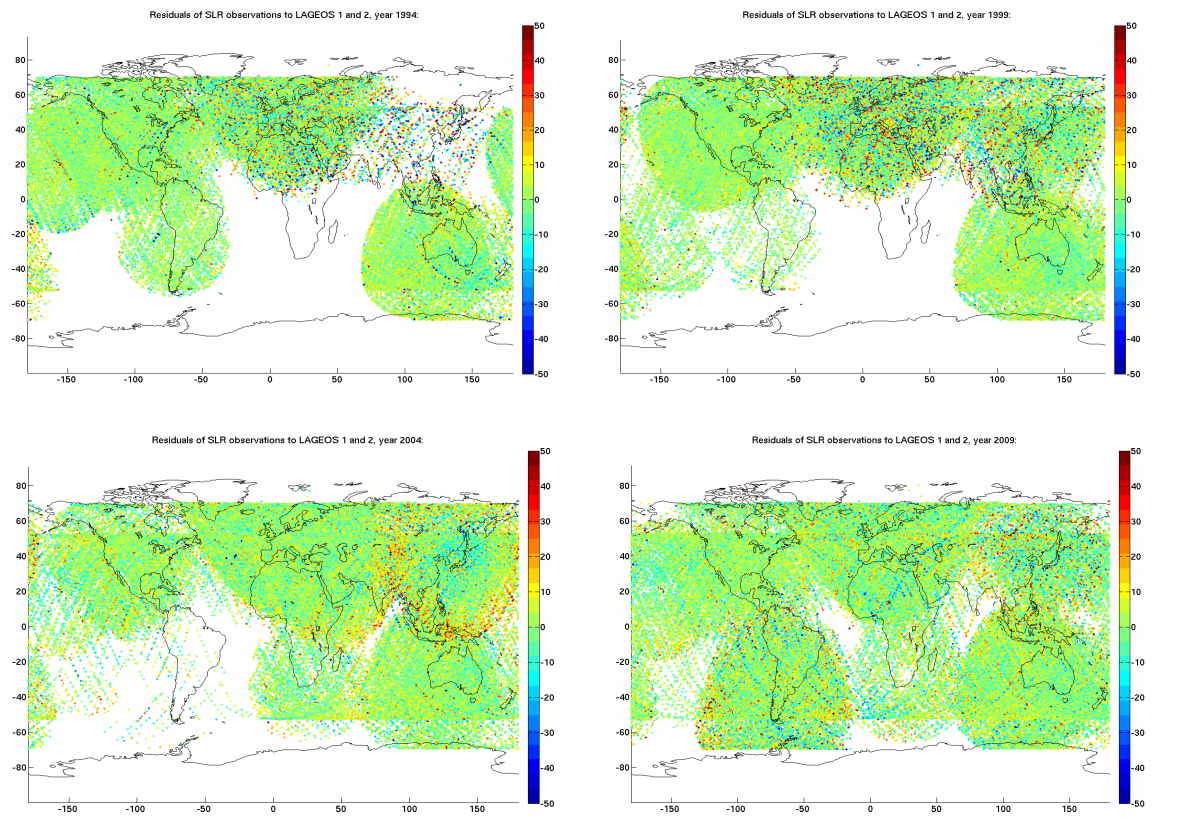

Figure 4: Groundtracks of observation residuals in mm for LAGEOS -1 and -2 in 1994, 1999, 2004 and 2009.

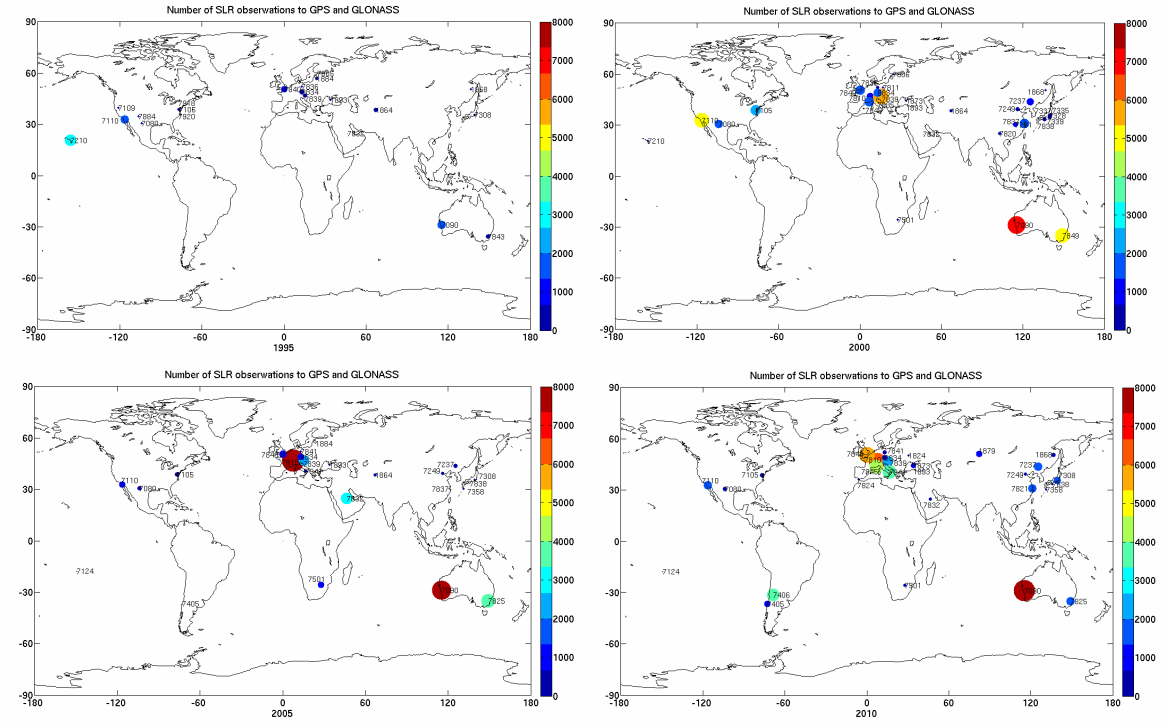

Figure 5: Number of SLR observations to GPS -35, -36 and all GLONASS satellites in 1995, 2000, 2005 and 2010.