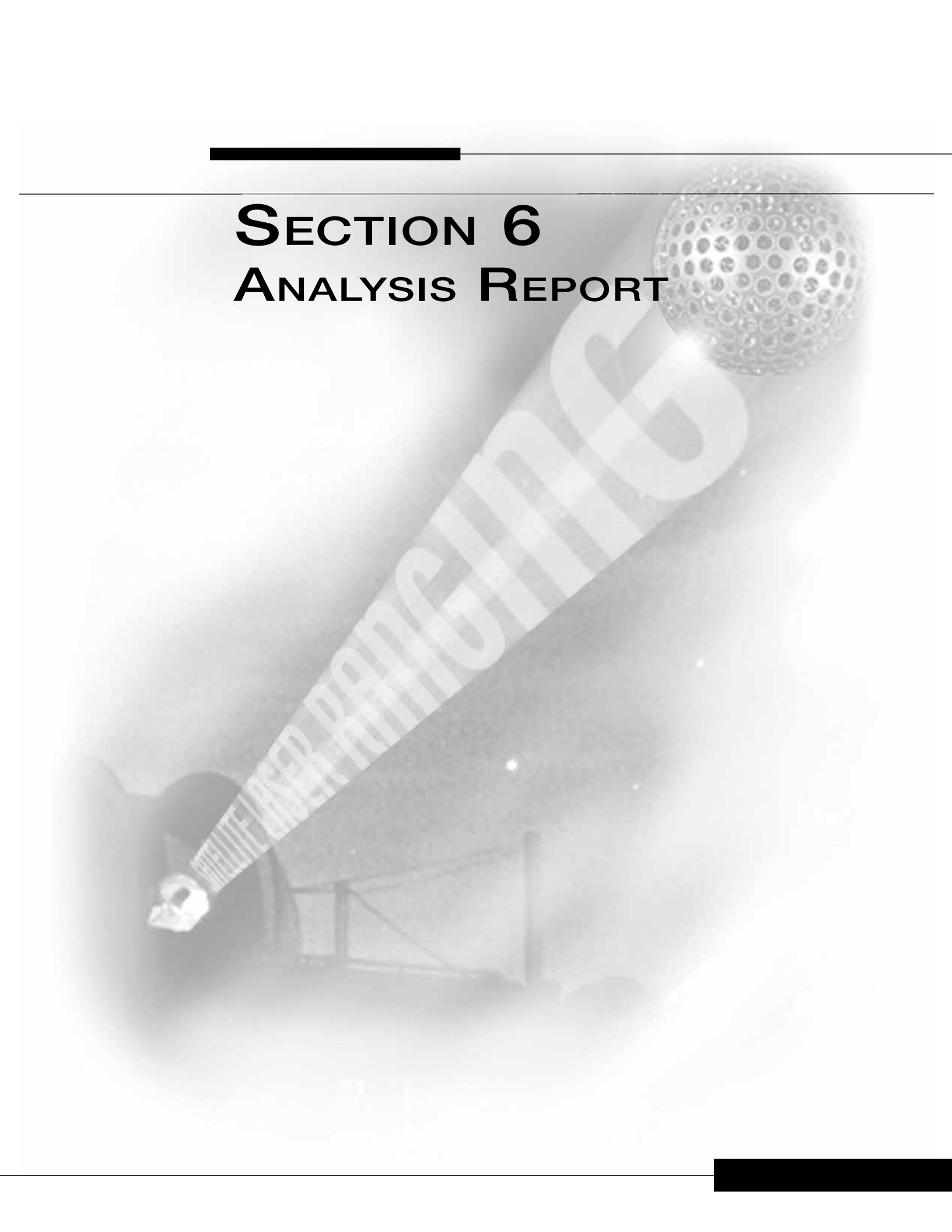
Section 6
Analysis Report



SECTION 6

ANALYSIS REPORT

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INTRODUCTION

The ILRS is an official Technique Service in the International Earth Rotation and Reference Frame Service (IERS). To fully exploit the unique aspects of the SLR observations, the ILRS Analysis Working Group (AWG) addresses various issues of SLR products, such as quality control, the estimated parameter group, the satellite data to be used, and format definition/use, optimization, and (the development of) an official combination product on the basis of the individual AC contributions. Additional products being considered are evaluated through a number of so-called pilot projects, with several initiated during the past few years, some of them successfully completed and others still ongoing. This contribution to the ILRS Report presents an update on the status and the results of these efforts. General information on AWG activities, membership and more detailed information on the pilot projects can be found on the relevant Internet pages (*http://ilrs.gsfc.nasa.gov/science/awg/index.html*).

Activities in 2009 and 2010

The ILRS AWG met on four occasions during the period covered in this report. AWG meetings are planned to take place on dates close to major geophysical meetings (AGU/EGU) or other (ILRS) venues, in order both to maximize AWG members' attendance and to also encourage interaction with other scientists. The 22nd AWG meeting was held April 24, from 09:00-18:00, during the spring EGU meeting in Vienna, Austria. The brief, half-day 23rd meeting followed at the end of the Fall ILRS Technical Workshop in Metsovo, Greece, on September 19, 2009. In 2010, the 24th AWG meeting was held on May 8 during the spring EGU meeting in Vienna, Austria. The 25th and final AWG meeting for this period was held October 1 in Paris, France. Details on these meetings along with the presentations from the participating groups can be found online at the ILRS web site:
http://ilrs.gsfc.nasa.gov/science/awg/awgActivities/index.html
In addition to these, several members of the AWG participated with presentations and contributions to several position papers in the Unified Analysis Workshop of the Global Geodetic Observing System (GGOS), in December 2009, in San Francisco, CA.

The main activity of the AWG is the development of a unique, best-possible (in terms of quality) analysis product that can be used by the widest possible science community, e.g. station position and EOP. An official solution for station coordinates and daily EOPs is generated by the Analysis Centers (AC) and Combination Centers (CC) on a weekly basis, and submitted to the IERS as an official ILRS contribution. These weekly results depend on high-quality laser range observations to LAGEOS, LAGEOS-2 and to the two Etalon satellites, and the ILRS network is encouraged to support this valuable work, ideally by tracking these satellites day and night, seven days a week. Two different products are distributed each week: a loose constrained estimation of coordinates and EOP and an EOP solution, derived from the previous product, fully constrained to an ITRF. The development of these products goes back to the very first days of the ILRS AWG. The currently operational products and the adopted analysis scheme were agreed upon by the AWG and run continuously in an operational mode since 2003.

In addition to the operational products, the main topics that the AWG focused on during this period were the generation of the ILRS contribution for the development of the ITRF2008 and the evaluation of the ITRF2008. From our experience during the development of ITRF2005 we had surmised that a significant improvement in future analyses would come from the improved handling of systematic errors, whether due to station problems or associated with the target satellites. In that vein the AWG started out to collect, evaluate and document all known or suspected systematic errors for all sites contributing to ITRF2008. A parallel effort was also initiated to improve the modeling of the center-of-mass (CoM) correction for each of our targets, considering the actual operational characteristics of the tracking sites.

During the reporting period, eight different ACs support the operational activities and provide products routinely: ASI, BKG, DGFI, GA, GFZ, GRGS, JCET and NSGF. ILRS has also adopted two official CCs, the primary hosted by ASI and the back-up center at DGFI. These two CCs are responsible for combining the input solutions, and the delivery of the quality-checked and combined ILRS product to IERS. In preparing the weekly combination of the individual solutions, these combination centers follow a strict timeline and have to make sure that the products are of the highest possible quality. Official weekly ILRS products from the two combination centers are available in SINEX format each Wednesday at CDDIS and EDC. All ACs are encouraged to improve the quality of their contributions further. During 2009-2010 ESA/ESOC applied as candidate AC and started undergoing the certification process.

The systematic error documentation effort led to a complete and accurate set of corrections that were adopted and used by all ACs and are now published on the ILRS web pages for use by all SLR data users in the future, in order to ensure the best and most consistent results for any application. The compilation is called the “Data Handling File” and it is put in a SINEX-like format that is machine-readable and allows the automatic use of the information in any analysis environment. It represents a living document that SLR data analysts should interrogate routinely, as it is updated by the AWG:
*http://ilrs.dgfi.badw.de/data_handling/ILRS_Data_Handling_File.sn*x

On the target characterization side, the Task Force that was formed to investigate the subject in 2008 worked diligently to produce initially two tables that listed the range of the applicable corrections for the two LAGEOS and two Etalon arrays for the current configuration of the tracking systems. Since our analysis covers several decades, from 1983 to present, it was agreed that additional work is required to generate a tool that will make available the appropriate correction for each system and any time period our analysis covers. Once this tool becomes available, the AWG will validate it and eventually adopt it for our standard analysis products. For now, the SLR data users who require higher level of accuracy than the one a fixed CoM correction provides, are directed to use the results of this group as they appear online at:

http://ilrs.gsfc.nasa.gov/network/site_information/nsgf_iCoM_LAGEOScorrections.html
http://ilrs.gsfc.nasa.gov/network/site_information/nsgf_iCoM_ETALONcorrections.html

To improve the usefulness of the time series of combination solutions and the ancillary products, thus improve its prospects for future utilization (reliability of resulting velocities, results on historical SLR stations, etc.), the ILRS AWG agreed to extend the period covered by these solutions for our contribution to ITRF2008. The products were submitted to IERS for ITRF2008, in mid-2009, following preliminary analysis of our initial submission (later in 2008), taking into account the feedback from ITRS. The release of ITRF2008 in late 2010 followed a brief period of evaluation of candidate solutions submitted by the two ITRS Combination Centers (IGN/Paris and DGFI/Munich). Figure 6-1 shows the origin and scale components for the contributed products over the period (1983 – 2009).

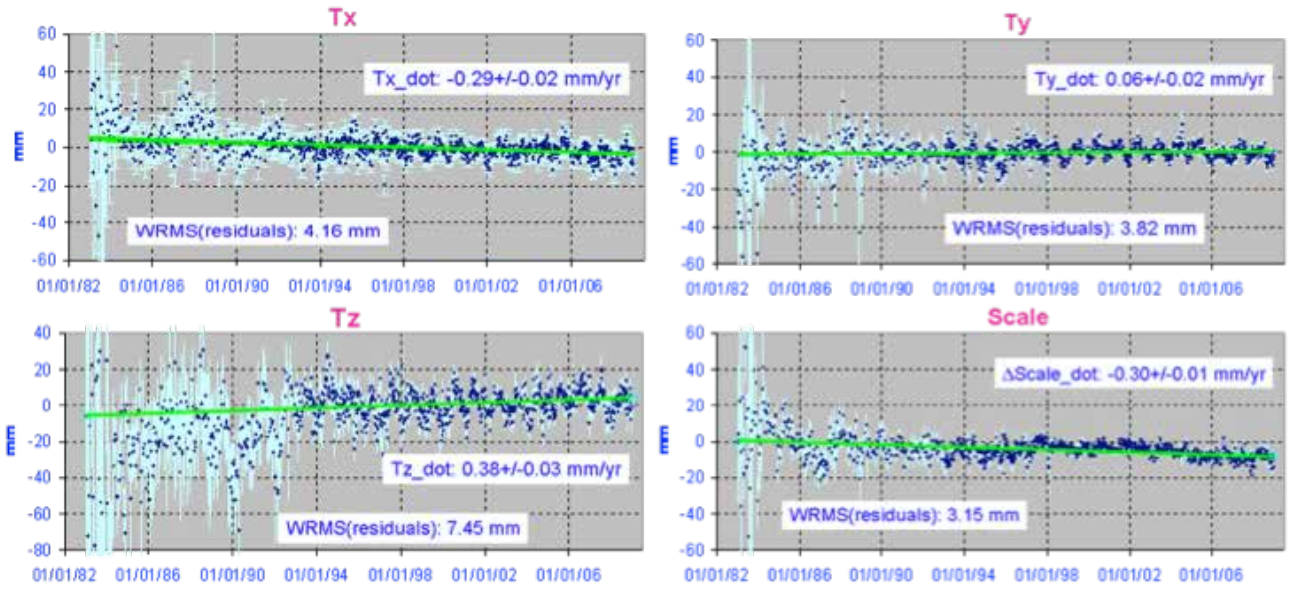

Figure 6-1: Time-series of X, Y, and Z offsets and scale factor of the ILRS-A official combination origin with respect to the reference ITRF (SLRF2005) origin (proxy for "geocenter" variations) and scale as observed by SLR (1983.0 – 2009.0).

IERS/ITRS uses the SLR solutions to exclusively determine the origin of the new ITRF2008 solution. Unlike the previous solution ITRF2005, the scale for the 2008 realization was determined through the combination of the SLR and VLBI contributions, similar to the way that was traditionally done in the past.

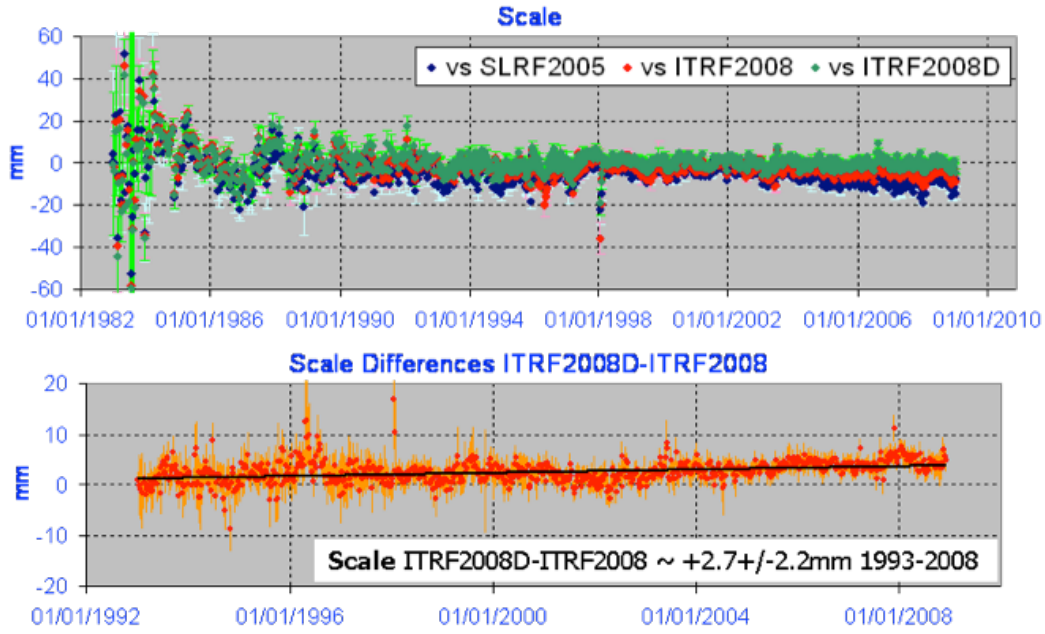

Figure 6-2: Time-series of scale factor variations as observed by SLR (1983.0 – 2009.0) compared to the two candidate ITRF2008 combinations. Note that there is no longer a trend on the SLR scale, especially when compared to ITRF2008D. The two candidate solutions differ by 0.4 ppb/y over 1993-2008.

The AWG has also supported ILRS investigations for the harmonization of the two data centers, the optimization of the tracking of the increasing number of GNSS satellites, and the redefinition of the normal points, made necessary with the recent proliferation of high repetition rate systems. All of these investigations are currently ongoing and any decisions will be reported through the usual ILRS communication channels in due time.

The AWG is for some time now considering the expansion of its list of weekly products to fill a void in the area of routinely available precise orbits for the primary SLR targets, i.e., the two LAGEOS and two Etalon satellites. At present this is only a pilot project, however, it is expected that by next year these products will be delivered routinely on a weekly basis. In order to fulfill the need of NEOS for as "fresh" as possible EOP information, the ILRS AWG developed the "daily" product, based on a 7-day arc sliding by one day each day. The results of this analysis were made available to NEOS within two days from the last observation in the analysis, and efforts are underway to further decrease the latency period. By the end of 2010 almost all ACs were able to contribute to the new product. It was further decided that when all ACs have demonstrated this capability, this product should become the official operational product (replacing the weekly one), while the weekly one will be further enhanced with additional modeling improvements that are first to be tested through dedicated Pilot Projects. These include atmospheric loading and gravity variations, and the estimation of a set of low-degree harmonics. The weekly product will thus be the one to contribute to the future ITRF realizations, since IERS is moving in the direction of adopting the same modeling enhancements for all contributed products. It is anticipated that the weekly product will be the "definitive" ILRS product, although it will be available with some additional latency due to the delayed availability of some of the required models.

In the spring of 2010 Dr. Rainer Kelm of DGFI who was in charge of the back-up combination center for the ILRS, retired. DGFI was not able to replace him and suspended the support of that activity, although Dr. Kelm continued the process until a solution was found. After some discussions with the Director of DGFI, it was agreed that JCET could take over the activity once the DGFI software were ported and implemented successfully at JCET. The activity ran in parallel at the two centers during the summer of 2010 and Dr. Kelm visited JCET in September for a brief introduction to the software and a hand-over of the operations to JCET. As of December of 2010, the ILRS-B combination product has been generated at JCET with a smooth transition and no loss of data. The ILRS AWG and JCET in particular, would like to thank Dr. Kelm for his dedication to the support of its activities and for being always available to provide valuable guidance during the transition period.

The AWG has also worked on the improvement of the quality control (QC) process from various semi real-time analyses. In an effort to provide station personnel with improved QC results, it has looked into the development of direct communication channels between the QC centers and the station managers.