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THE ILRS EOP TIME SERIES

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ABSTRACT. Since 2004, ILRS has been providing on a weekly basis combined SSC/EOP solutions from 7-day arcs to support IERS for EOP computation and reference frame maintenance. At present, eight Analysis Centers and two Combination Centers contribute to the weekly official ILRS combined solution from which the main SLR contribution to the IERS EOP reference series is derived. The most recent work performed jointly by all ILRS Analysis Centers (AC) was the generation of a contribution to the next ITRF, extending the time-span coverage of the 7-day arcs combined solution to 1983-2008. In another effort we try to improve the ILRS products' latency and to minimize the delay of the SLR contribution to the IERS EOP estimation, by increasing the product generation frequency (pre-operational daily product), to once per day.

Keywords: ILRS, EOP, operational product

1. INTRODUCTION

The paper will describe the current, official ILRS EOP product, operational since January 2004, issued weekly, produced from a 7-day SLR data arc, with a minimum latency of 4 days and its further enhancement towards an ultra-rapid EOP product, with a lower latency and comparable accuracy, currently in a pre-operational phase.

The long-term ILRS contribution to ITRF2008, covering the 1983–2008 period, processed off-line with the most refined analysis strategy, using the entire SLR data set and with a careful editing of data and solution parameters concurring to it, has been assumed as a benchmark for the operational EOP products, to evaluate its current level of accuracy.

All official ILRS products are generated from a combination procedure, performed by the Combination Centers, blending the individual contributions provided by the Analysis Centers, under the recommendations and indications given by the ILRS Analysis Working Group.

A brief description of the ILRS data processing flow is given, with the ILRS components involved (Stations, Data Centers, Analysis Centers, Combination Centers), being a key factor in the sought-for trade-off between latency and accuracy of the products.

2. THE ILRS DATA PROCESSING FLOW

The International Laser Ranging Service (ILRS), Pearlman et al. (2002) provides global satellite and lunar laser ranging data and related products to support geodetic and geophysical research activities as well as IERS products to maintain an accurate International Terrestrial Reference Frame (ITRF). The ILRS collects, merges, archives and distributes Satellite Laser Ranging (SLR) and Lunar Laser Ranging (LLR) observation data sets of sufficient accuracy to satisfy the objectives of a wide range of scientific, engineering, and operational applications and experiments. In particular, the contribution of ILRS to the maintenance of the Terrestrial Reference Frame is based upon the routine operations by the observing stations and upon the routine data processing by the official Analysis and Combination Centers, as reported in the plot.

Fig. 1. The ILRS Network components: Stations, Analysis Centers and Combination Centers

Currently, eight Analysis Centers (ACs) contribute to the routine weekly production of geodetic solutions providing estimates of EOPs, Site Coordinates and Satellite State Vectors through the analysis of the LAGEOS and Etalon satellite data. In Table 1, for each AC, the start date of the routine products generation is reported in the last column.

Table 1. Current ILRS Analysis Centers

ASI	Agenzia Spaziale Italiana	Italy	Nov ‘03
BKG	Bundesamt für Kartographie und Geodäsie	Germany	May ,05
DGFI	Deutsches Geodätisches Forschungs Institut	Germany	Nov ‘03
GA	Geoscience Australia	Australia	May ‘07
GFZ	GeoForschungsZentrum Potsdam	Germany	Nov ‘03
GRGS	Groupe de Recherche de Géodésie Spatiale – Observatoire de la Cote d’Azur	France	Dec ‘07
JCET	Joint Center for Earth Systems Technology – NASA&UMBC	USA	Nov ‘03
NSGF	NERC Space Geodesy Facility	Great Britain	Nov ‘03

The SLR data (Normal Points) of the geodetic satellites are provided by the stations with a delay of 2-3 hours and the ILRS archives (CDDIS, EDC) make them available to the ACs . The ACs produce every Tuesday a 7-day arc solution, spanning from Sunday to Saturday, estimating Site Coordinates, EOPs and satellite State Vectors. Those solutions, available (in SINEX format) in the ILRS archives, produced with different S/W packages and under different analysis strategies, share a common and homogeneous estimation frequency for the selected parameters and are loosely constrained. Each official contributing solution has undergone a benchmark procedure to achieve its ILRS qualification, performed by the ILRS Analysis Working Group (AWG), under the responsibility of the coordinator.

On Wednesday, the official (ASI) and the backup (DGFI) ILRS Combination Centers (CCs) combine, under different strategies, the contributing AC solutions and deliver the official ILRS weekly solution to the ILRS archives. The combined solutions are available (in SINEX format) as loosely constrained, including all the estimated parameters, and as ITRF-framed for the EOPs only. A report file is part of the weekly solutions and is available in the archives.

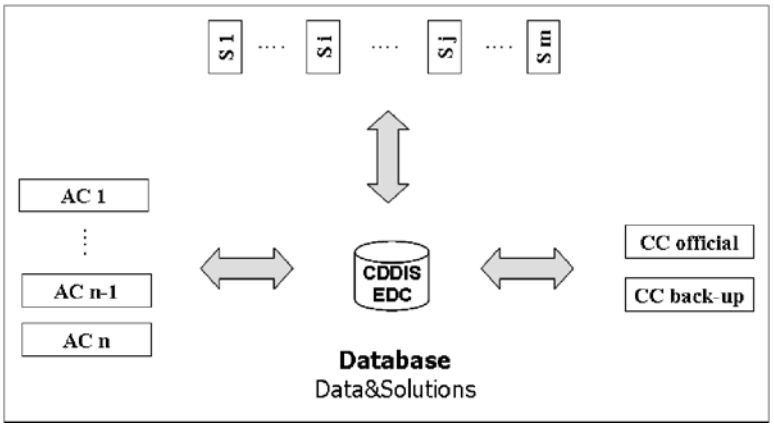

Fig. 2. The ILRS Data flow

3. THE OFFICIAL ILRS EOP DATA ANALYSIS PRODUCTS

The 7-day arc operational combined solutions delivered weekly since 2004, provide daily estimates of EOP x, y, LOD, with a minimum latency of 4 days according to the Fig.3 timeline.

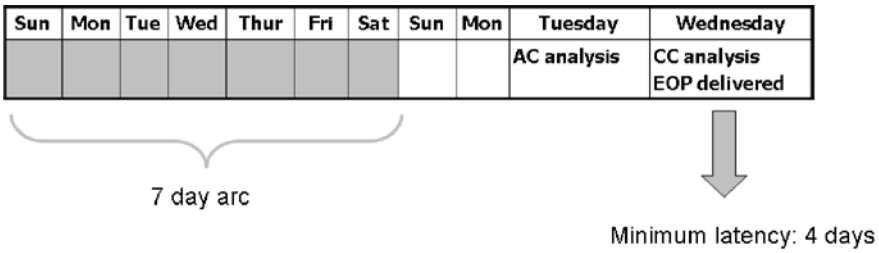

Fig. 3. The ILRS weekly EOP timeline

This rapid ILRS EOP product, i.e. the weekly product available each Wednesday on the CDDIS/EDC archives, represents the current operational ILRS contribution to the IERS EOPC04.

In the summer 2009, ILRS has contributed to the new ITRF2008 by providing also a long-term EOP series, derived by the combination of seven AC contributed solutions. The long-term series is formed by daily EOPs for the 1993-2008 period and 3-daily EOP x, y, LOD for the 1983-1992 period and represents the highest accuracy limit reachable with state-of-the-art physical modeling and analysis strategy by the ILRS. It represents a technique intrinsic accuracy limit that the operational, more rapid products should aim to reach.

To guarantee the highest quality level of the final long-term combined product, all the AC solutions have been carefully checked for their adherence to ILRS AWG recommendations in terms of applied and estimated station bias, used dataset, solution looseness level and corrections have been performed before the combination, whenever necessary.

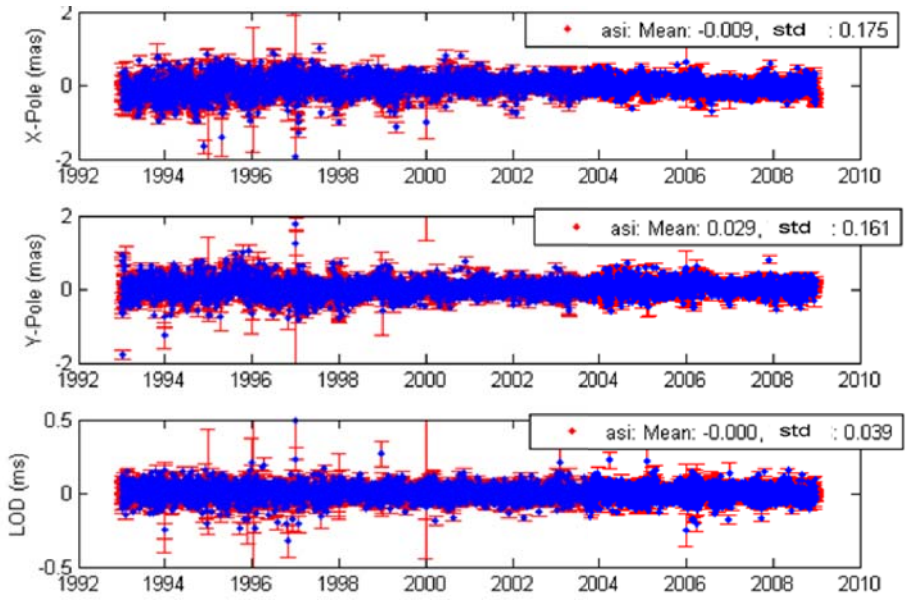

Fig. 4. Long-term ILRS EOP residuals w.r.t. IERS C04

In the plots above, the most recent part of the long-term ILRS combined EOP solution is shown. The statistics of the residuals with respect to the EOP C04 solution indicate overall accuracy values representing a benchmark for any operational SLR EOP product, subject to stringent timely constraints and therefore implicitly less accurate.

By comparing a limited overlapping period (14 months including the entire 2008) between the long-term ILRS solution and the rapid (weekly) ILRS solution, the weekly product shows a slightly worse residual WRMS (3% for EOP x and LOD, 10% for EOP y). The errors associated to the EOP estimates are comparable for the long-term and the rapid series, with average values of 0.05 mas for EOP x and y, and 0.01 ms for LOD.

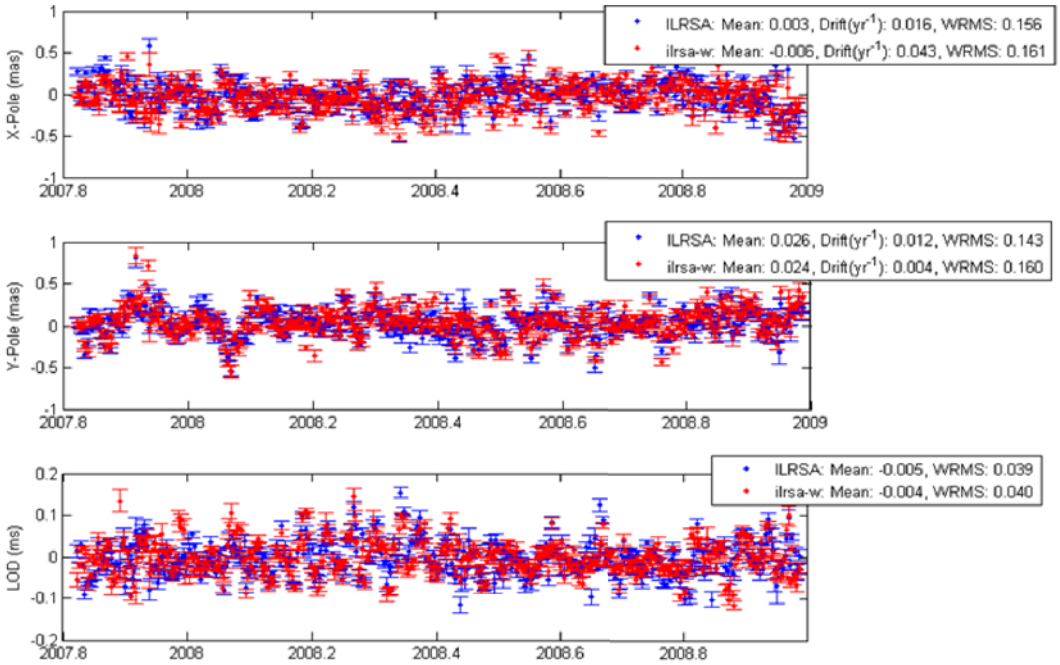

Fig. 5. Long-term and rapid ILRS EOP residuals w.r.t. IERS C04

4. FEASIBILITY AND OPERATIONAL CONSTRAINTS FOR AN ILRS EOP ULTRA-RAPID PRODUCT

In February 2008, ILRS set up a 'rolling' daily production of EOP (x, y, LOD) based on the combination of contributions from 6 AC's (ASI, BKG, GFZ, GRGS, JCET, NSGF), processing 7-day data arcs. This ultra-rapid EOP product guarantees every day a set of EOP with a minimum latency of 2 days; the product is in a pre-operational evaluation phase.

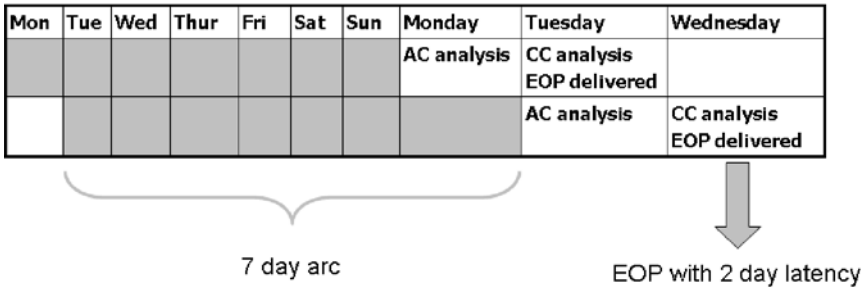

Fig. 6. The ILRS ultra-rapid EOP timeline

In the following plots, residuals over a period of one year of the ultra-rapid EOPs with respect to IERS C04 EOPs are reported, using time series from different latency estimates (2-, 3-, 4-day latency, the latter being equal to the minimum latency of the rapid weekly product); the 2-day latency estimates, as expected, are noisier and less accurate, being affected by possible incompleteness of the SLR dataset needed at the time of processing and by possible weakness of data processing scheme at the edges of the arc. EOP X and Y with a 3-day and 4-day latency show, instead, a very comparable accuracy level.

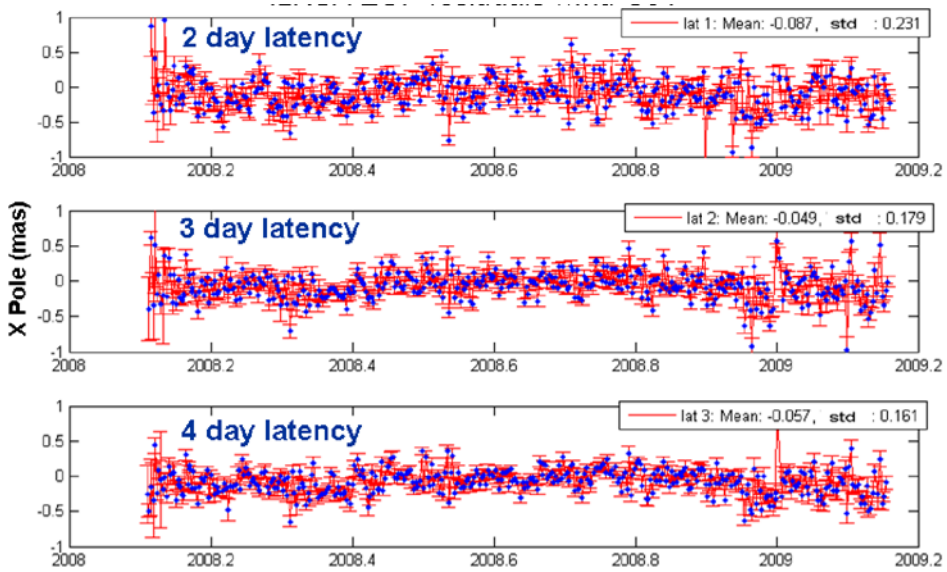

Fig. 7. Ultra- rapid ILRS EOP X residuals w.r.t. IERS C04

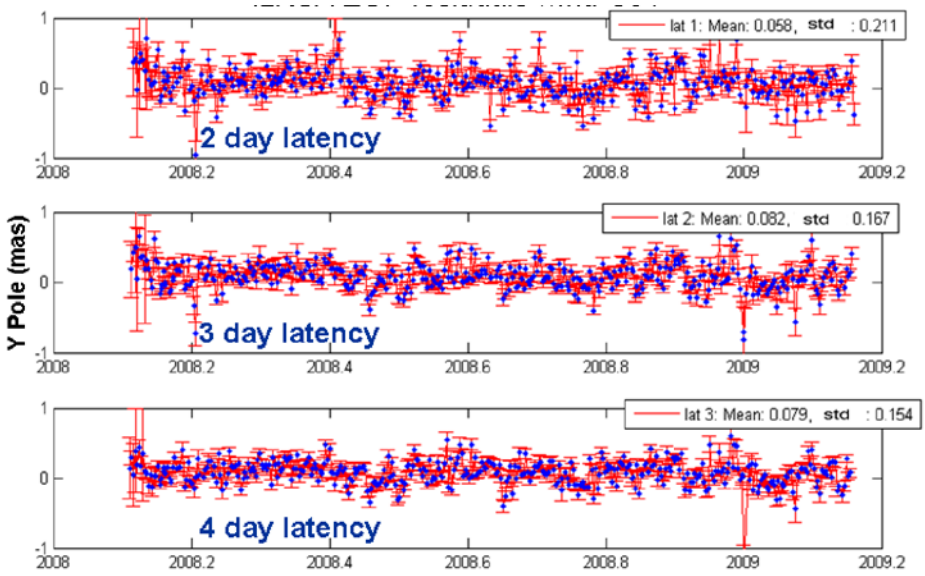

Fig. 8. Ultra- rapid ILRS EOP Y residuals w.r.t. IERS C04

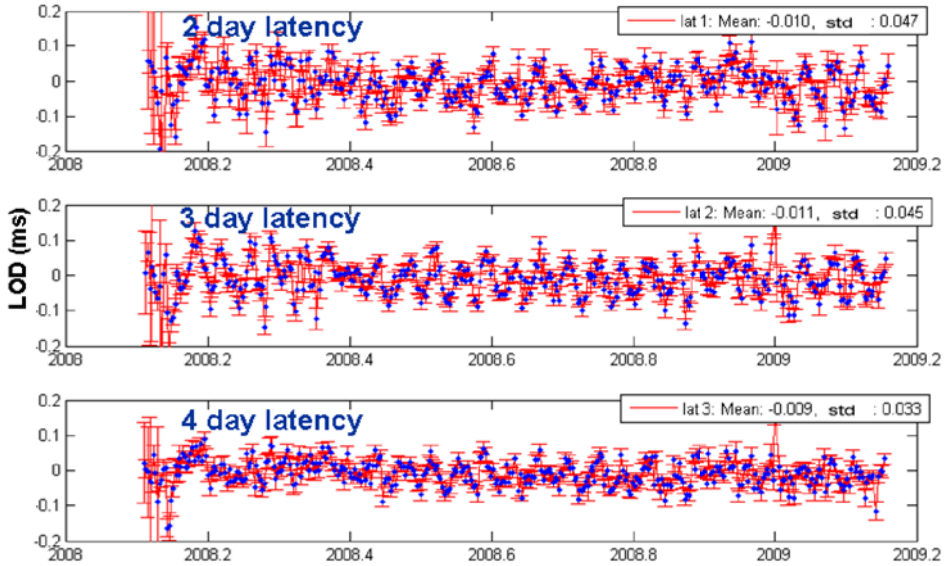

Fig. 9. Ultra- rapid ILRS LOD residuals w.r.t. IERS C04

The major discriminating factor in the use of different ILRS EOP products in support of different applications consists in the accuracy/latency trade-off. The need for the most accurate EOP estimates for an off-line reprocessing is well satisfied by the IERS accurate series, such as C04. Different needs arise for rapid and ultra-rapid positioning SLR applications, when high accuracy and low latency is required at the same time. When speeding up the ILRS EOP operational production up to a 2-day latency, accuracy decreases: in terms of WRMS of the residuals with respect to IERS C04, it worsens more than 40% for EOP X and LOD, and almost 30% for EOP Y. More accurate EOPs come from a 3-day latency daily processing; however, modifications in the data analysis strategy can be performed to enhance both the EOP accuracy and latency performances: inclusion of more AC solutions and data from more satellites in the analysis, an enhanced ultra-rapid EOP processing scheme with AC and CC solutions on the same day (Fig.10), use of longer arcs including also the data acquired on the day of the analysis to minimize the edge effect for the 'last day' estimates.

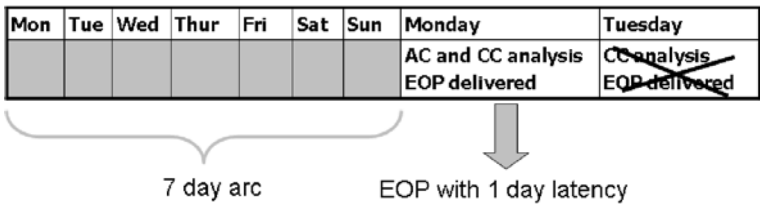

Fig. 10. The ILRS ultra-rapid EOP enhanced timeline

5. CONCLUSIONS

ILRS is presently capable of delivering different types of EOP products, with different characteristics in time coverage, latency and accuracy. The accuracy of the official operational weekly EOP, available at the CDDIS and EDC archives labeled as "ilrsa" (actually version v25) is close to the limit reachable with the state-of-the-art physical modeling and analysis strategy, as represented by the IERS C04 EOP solutions.

ILRS is able to provide routinely a daily EOP product with high quality level: the product is in a pre-operational evaluation phase and is currently being independently assessed; this ILRS ultra-rapid daily product allows to provide EOP estimates with a constant latency (3 days) lower than the minimum latency of the ILRS weekly solution (4 days) and with a comparable level of accuracy. Also 2-day latency estimates are available, with a lower accuracy level that can be further increased by adding more AC contributing solutions, by revising the length of the data arc and by tuning the analysis strategy.

REFERENCES

Pearlman M.R., Degnan J.J. and Bosworth J.M. (2002) The International Laser Ranging Service, *Advances in Space Research*, Vol. 30, No. 2, pp. 135-143, July 2002

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