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# Station Coordinates, Earth Rotation Parameters, and Low Degree Harmonics from SLR within GGOS-D

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## Abstract

*Time series of station coordinates, Earth rotation parameters, and low degree harmonics of the gravity field are generated in weekly batches from Satellite Laser Ranging (SLR) measurements by two independent German institutes, the Deutsches Geodaetisches Forschungsinstitut (DGFI) and the GeoForschungsZentrum Potsdam (GFZ) and their two software packages for parameter and orbit determination, DOGS (DGFI Orbit and Geodetic Parameter estimation Software) and EPOS (Earth Parameter and Orbit System) respectively.*

*The products are based on common standards laid down by a consortium of some more German institutes joined in the GGOS-D (Global Geodetic Observing System - Deutschland (Germany)) project. GGOS-D strives for a rigorous and proper combination of the various space-geodetic techniques. The details of the processing and model standards and the differences with the International Laser Ranging Service (ILRS) "pos&eop" products are presented. A first series covering the years 1993 to 2006 has recently been provided by DGFI and GFZ to the project, initial results are shown and compared.*

## Introduction

The overall objective of the GGOS-D project is the investigation of the technological, methodological and information-technological realization of a global geodetic-geophysical observing system. The main fields of research are the development and implementation of data collection and data management systems as well as the generation of consistent and integrated geodetic time series for the description and modelling of the geophysical processes in the Earth system. The time series have to be referred to a unique, extremely accurate reference frame, stable over decades, and should be generated in such a way that they can be made available in near real-time to all users in science and society. Methods for a careful internal and external validation shall guarantee a very high reliability.

The space-geodetic techniques, i.e. Global Positioning System (GPS), SLR, and Very Long Baseline Interferometry (VLBI) with the exception of Doppler Orbitography and Radiopositioning Integrated by Satellite (DORIS), contribute to the processing with the models and as far as possible with the same set of parameters being applied by all the participating institutions, the Forschungsgruppe Satelliten Geodaesie (FSG), the Geodetic Institute of the University of Bonn (GIUB), the GFZ, the Bundesamt fuer Kartografie und Geodaesie (BKG), and the DGFI. The SLR part is covered by two independent contributions from DGFI with its DOGS and from GFZ with its EPOS software packages. The analysis should span the period 1983 until present date. A first solution beginning in 1993 up to early 2007 has recently been provided.

## Processing

Geometric and dynamic models mainly coincide with those recommended for the routine processing of the so-called “pos&eop” product, weekly station coordinates and Earth Orientation Parameters (EOPs) based on SLR, by the ILRS (see Pearlman et al., 2002) analysis centers (DGFI and GFZ being part there as well). In case of the dynamic models however, the ocean tide model FES2004 (Letellier et al., 2007), and the gravity field model EIGEN-GL04S1 (the satellite-only solution of the EIGEN-GL04C model, see Foerste et al., 2006) have been chosen. Also the ocean tide loading site displacements as provided by Bos and Scherneck (2007) corresponding to the FES2004 are applied.

In a first step we processed weekly arcs for the years 1993 to 2006 solving for weekly stations coordinates, daily EOPs, i.e. X-, Y- pole, and UT1 at 0:00 h UTC, all piecewise linear and continuous (in case of “pos&eop” instead X-, Y- pole, and, notably, LOD at 12:00 UTC, all piecewise constant, are solved for). The GFZ solution additionally incorporates the low degree coefficients of the spherical harmonic representation of the Earth's gravity field (shortly “low degree harmonics”) of degree 0 to 2 (in case of “pos&eop” the low degree harmonics are not solved for). In order to overcome the datum defect, the coordinates, the EOPs, and the low degree harmonics are endowed with an a priori sigma of 1 meter or its equivalent.

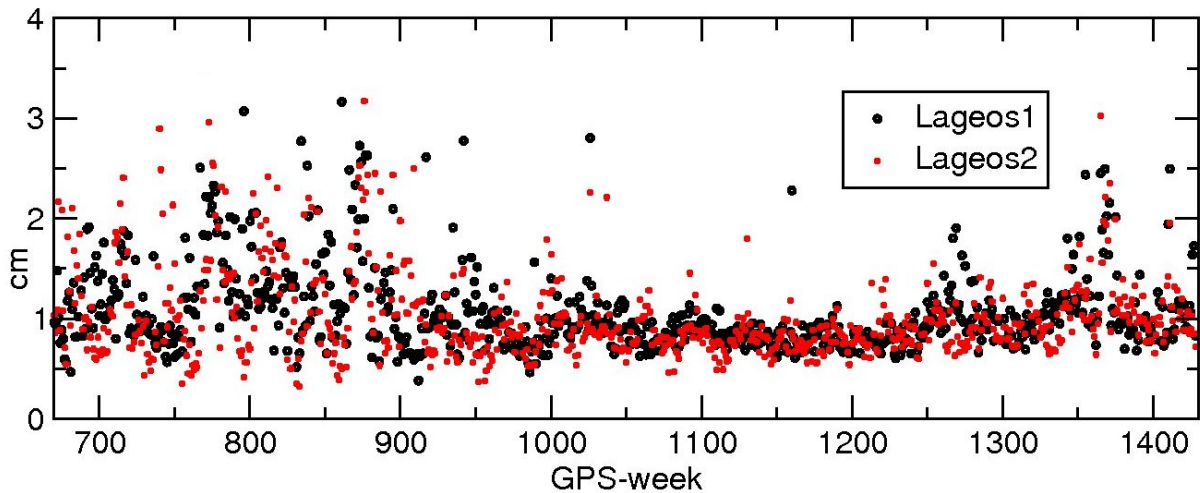
## First Results

The overall orbital fit and statistics for the whole period are shown in Table 1. The intention was to include as many stations as possible in the solutions. As a minimum however, stations should contribute with more than 10 observations per weekly arc. Besides that, iterative editing has been performed according to some criteria chosen individually by both institutes. This becomes evident in the number of observations used for the processing and the resulting orbital fit, and could end up in some differences of the solved-for parameters. In a next step, DGFI and GFZ are going to compare their editing procedures and to analyse the effect on the solution.

*Table 1. Global orbital fit of the two solutions.*

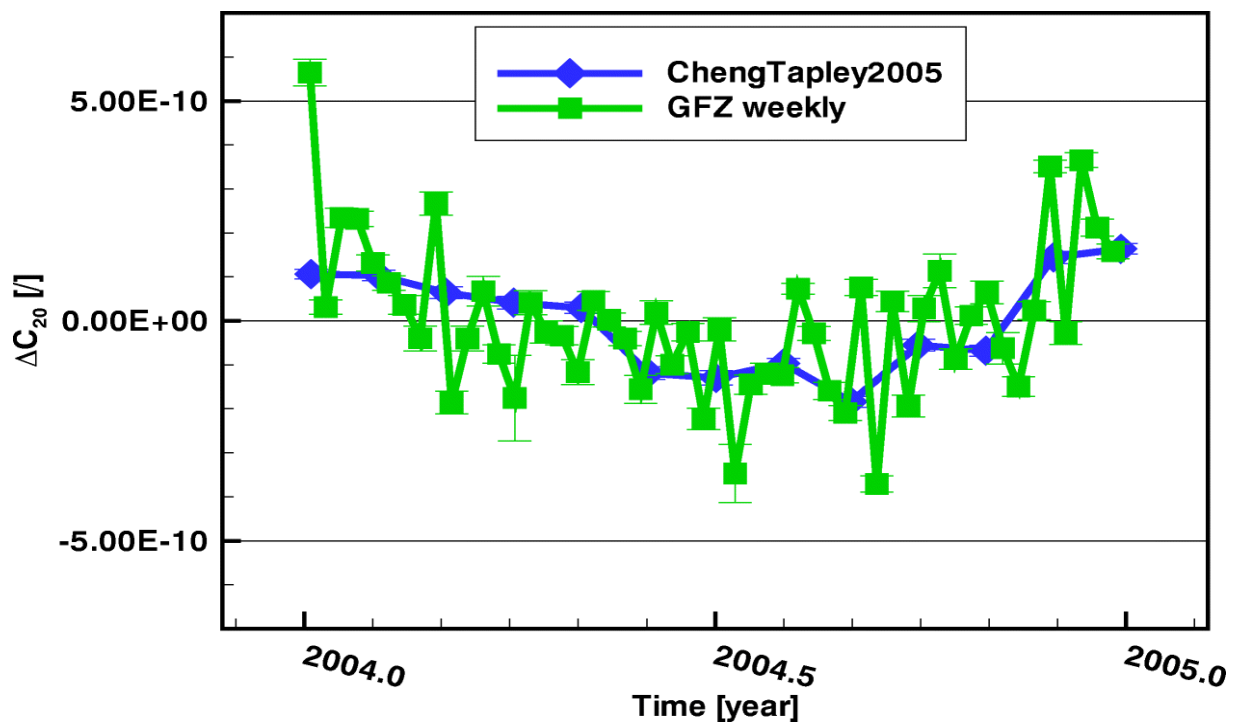
	<b>EPOS</b>	<b>DOGS</b>
<b>No. of Arcs</b>	742	759
<b>Period</b>	25-Oct-1992 - 13-Jan-2007	11-Nov-1992 - 20-May-2007
<b>Global Orbital Fit RMS (cm)</b>	1.04	1.07
<b>No. of Observations</b>	1,749,965	1,997,569
<b>No. of Observations per Arc</b>	2,358	2,632

In Figure 1 the weekly orbital fits of the DGFI solution show that some weeks are determined with worse accuracy, especially prior to 1999 or GPS week 990. This is mainly induced by some poorly performing non-core stations, the orbital fit for the core stations remains stable mostly below 1 cm all over the analysis period. In general, Lageos-1 turns out slightly more accurate than Lageos-2. Once up-to-date corrections for the Stanford-counter range bias problems or for the station dependent centre of mass corrections become available, we expect improved orbits and hence an improved quality of the resulting parameters.



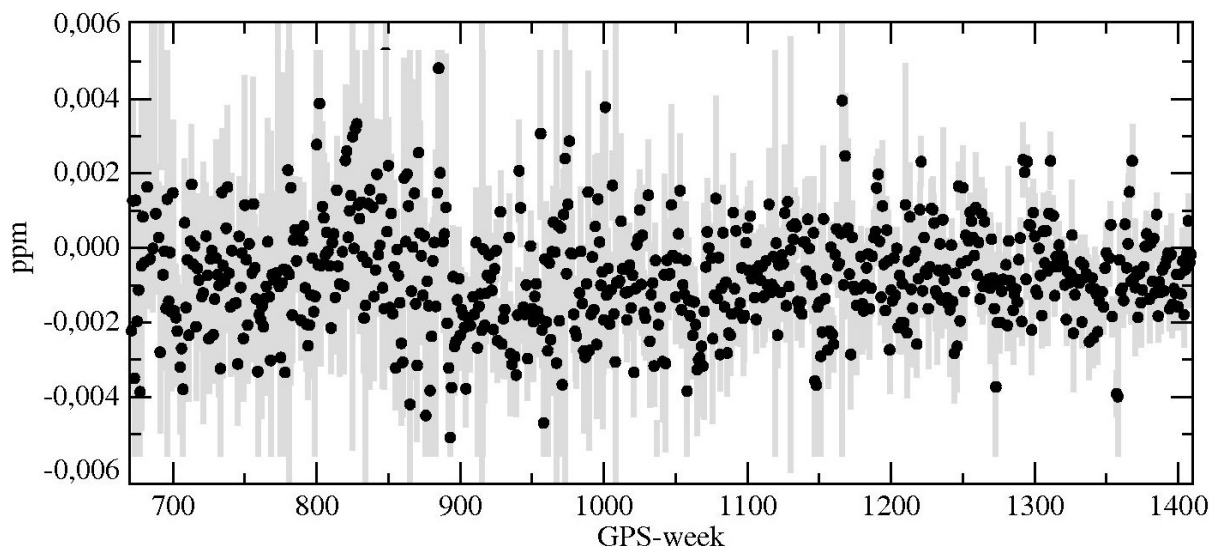
*Figure 1: Weekly orbital fits of the DOGS solutions.*

Figure 2 shows a comparison of the GFZ  $C_{20}$  time series to the recently published series by Cheng and Tapley (2005). Obviously the GFZ series shows a larger scatter, being mainly an effect of the dense resolution of the parameters and of the multitude of solved-for parameters. A generalization of the coordinate and low degree harmonic parameters would presumably stabilize the solution. Underneath the scatter, the general agreement of the curves is visible.



*Figure 2: Comparison of the EPOS  $C_{20}$  time series to the Cheng and Tapley (2005) series.*

The scale differences between the DOGS and the EPOS coordinate solutions are shown in Fig. 3. A small offset of about 1 ppb is visible and may be related to the different editing and to the fact that the GFZ solution has solved in addition for the low degree harmonics including  $C_{00}$ , the dynamic scale parameter. The alignment of the editing criteria for DOGS and EPOS, and solving for the low degree harmonics in the DOGS solution as well, should improve the agreement. Also, Fig. 3 reveals a



**Figure 3:** Scale differences between the DOGS and EPOS coordinate solutions 1993-2007.

decrease of the scatter in the course of time, demonstrating the improvement and stabilization of the SLR technique.

### Conclusions

Within the GGOS-D project, DGFI and GFZ are processing SLR data with their independent software packages DOGS and EPOS based on common, modern standards. In a first iteration, a 14 year long time series of weekly solutions for coordinates, EOPs, and, in case of GFZ, for low degree harmonics, has been generated. The standards adopted here are different with respect to those of the routine ILRS analysis centre processing.

First results show an excellent quality of the two SLR solutions. Some efforts have to be undertaken to harmonize in particular the editing of the weekly arcs and to include the low degree harmonic parameters to the DGFI solution.

The combination of all space-geodetic techniques within GGOS-D is pending, but first preliminary combinations of GPS and VLBI results indicate an excellent agreement, better than that experienced earlier during the ITRF2005 combinations by DGFI (Meisel et al., 2005).

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