KTU-GEOD IVS Analysis Center Biennial Report (2017-2018)

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Abstract This report summarizes the activities of the KTU-GEOD IVS Analysis Center (AC) in 2017 and 2018 and outlines the planned activities for the years 2019 and 2020. Accuracy improvement of UT1-UTC through using a priori GNSS troposphere gradients when analyzing VLBI observations of Intensives was our specific interest in this period.

1 General Information

In 2018, a research project related to accuracy improvement of UT1-UTC determination from IVS [1] Intensive sessions was successfully finalized. This project also constitutes one of the main parts of the MSc thesis of Mr. Mehmet Fikret Öcal [2]. He successfully defended his MSc thesis under the supervision of Dr. Kamil Teke on 31 May 2019 (see Figure 1).

The Geodesy Lab at Hacettepe University was equipped with two high-performance workstations running on Linux (Ubuntu 16.04, LTS: Long Term Support) that are dedicated to VLBI and GNSS automatic analysis. The analyses on these workstations are performed automatically using VieVS (Vienna VLBI and Satellite Software, [3]) and Bernese Software [4]. Automatic analyses are carried out on a daily basis, and corresponding products are published on the Hacettepe University Web servers [5].

1. Karadeniz Technical University, Department of Geomatics Engineering
2. Hacettepe University, Department of Geomatics Engineering

Fig. 1 A photo after the successful defense of Mehmet Fikret Öcal's MSc thesis with the examiners.

2 Staff at KTU-GEOD Contributing to the IVS Analysis Center

Members of KTU-GEOD IVS Analysis Center (AC) are listed in Table 1 (in alphabetical order) with their main focus of research and work location [6, 7]:

3 Current Status and Activities

During the report period, we focused on accuracy improvement of UT1-UTC determination from the analysis of IVS Intensive sessions using a priori GNSS troposphere gradients. IVS suggested an analysis procedure that covers the estimation of the azimuthally symmetric part of the troposphere delays (i.e., zenith wet delay [ZWD] and zenith hydrostatic

Table 1 Staff of the KTU-GEOD Analysis Center.

Name	Work Location	Main Focus of Research
Emine Tanır Kayıkçı	Karadeniz Technical Univ., Dept. of Geomatics Eng., Trabzon, Turkey.	responsible person for AC, parameter combination
Kamil Teke	Hacettepe Univ., Dept. of Geomatics Eng., Ankara, Turkey.	troposphere
Mehmet Fikret Öcal	Hacettepe Univ., Dept. of Geomatics Eng., Ankara, Turkey.	data analysis, signal processing
Özge Karaaslan	Karadeniz Technical Univ., Dept. of Geomatics Eng., Trabzon, Turkey.	data analysis, parameter estimation

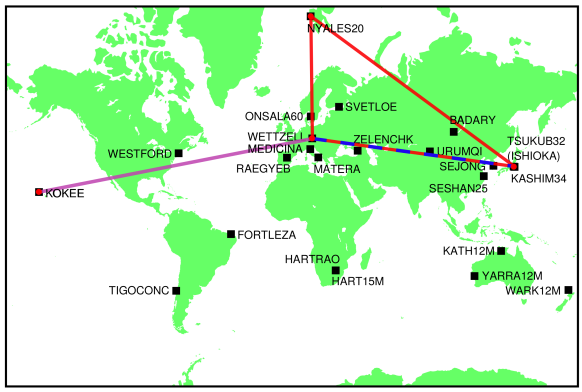

Fig. 2 VLBI stations mostly participating in IVS-R1 and -R4 sessions (black squares) as well as Intensives (red dots). INT1, INT2, and INT3 baseline vectors are plotted as purple, blue (dashed) and red lines, respectively.

Table 2 WRMS of differences of UT1 estimates from INT1 sessions and from R1 and R4 sessions.

Analysis	WRMS of UT1 differences in µs INT1 Sessions (548 UT1 pairs)
StandardUT1(A1)-R1R4	±38.0
NewUT1(A2)-R1R4	±37.7
NewUT1(A3)-R1R4	±38.8

delay [ZHD]). However, according to IVS standard analysis procedure, troposphere gradients, which have significant effect on UT1 determination, are not estimated [8]. The International GNSS Service (IGS) [9] is providing troposphere gradients from the analysis of GNSS observations for five minute intervals from 01.01.2008 onward with three weeks latency through FTP archives. We reduce troposphere gradients derived from the observations of GNSS sites co-located with VLBI stations from the observations of Intensives a priori to the parameter estimation. We have tested two different analysis strategies in addition to IVS standard analysis (A1): analysis-2 (A2) reduces troposphere east and north gradients from the observations, and analysis-3 (A3) estimates troposphere gradients additionally to A2. Thus, we analyzed all IVS Intensive sessions (INT1, INT2, and INT3) with three different analysis strategies as well as IVS-R1 and IVS-R4 sessions as a reference UT1-UTC series (see Figure 2) from the beginning of 2008 to the end of 2018. Statistical comparisons between the estimates of the Intensives (A1, A2, and A3) and standard sessions (IVS-R1 and IVS-R4) over weighted-root-mean-square (WRMS) of differences (see Table 2) showing slight differences led us to evaluate our new analysis methods over length-of-day (LOD) variations instead of UT1.

The IGS analysis centers, such as ESA/ESOC, NASA/JPL, and NOAA/NGS, are publishing Length-of-day (LOD) estimates online. LOD observations of GNSS are assumed to be more accurate than those of VLBI [9]. Thus, our LOD values calculated from UT1 estimates of IVS Intensives are compared with the LOD provided by the IGS analysis centers. These comparisons, as seen in Table 3, show that our analysis strategies, especially A2, improve the UT1-UTC estimation accuracy from IVS Intensive sessions by about 2–3 µs/day.

Table 3 WRMS differences of the LOD estimates of the analysis centers ESA(ESOC), NASA(JPL), and NOAA(NGS) with INT1 sessions in µs/day. Analysis-1, Analysis-2, and Analysis-3 series have the same epochs (1,610 values considered).

	StandardUT1(A1)	NewUT1(A2)	NewUT1(A3)
ESA/ESOC	± 34.2	± 31.6	± 33.7
NASA/JPL	± 36.9	± 34.1	± 36.2
NOAA/NGS	± 37.6	± 35.6	± 36.6

IGS troposphere zenith signal delays and gradients have been determined at five minute intervals from the analysis of the observations of hundreds of GNSS stations around the world with the PPP technique [10] us-

ing modified Bernese software [4] by the GNSS analysis center at the United States Naval Observatory (USNO) every day from July of 2011. Besides, we started to produce GNSS troposphere delays and gradients using the Bernese software with similar analysis parametrization in the scope of our research project.

4 Future Plans

In 2019 and 2020, we will be working on testing the accuracy of UT1-UTC that is observed by IVS Intensives. We will use our own GNSS troposphere delay estimates for incorporation into the analysis of Intensive sessions in addition to those of IGS. This will give us the ability to compare our troposphere gradients with those derived from IGS. A new subroutine for producing troposphere delays from PPP observation model as an alternative to Bernese software is planned to be built.

Acknowledgements

We are thankful to all the governing board of IVS. We are grateful to Karadeniz Technical University, Hacettepe University, and TU Wien for providing financial, technical and/or scientific support to KTU-GEOD IVS AC research activities.

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